Production of gallium-68 in a liquid cyclotron target: Physics and viability

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"Do not go where the path may lead. Go instead where there is no path and leave a trail."

- Ralph W. Emerson

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Nomenclature

FDG	Fluorodeoxyglucose
IBA	Ion Beam Applications
ICNAS	Instituto de Ciências Nucleares Aplicadas à Saúde
MCA	Multi Channel Analyser
SRIM	Stopping and Range of Ions in Matter
TRIM	Transport of Ions in Matter

Esboço do trabalho

O primeiro capítulo debruça-se sobre os objectivos deste trabalho bem como sobre os conceitos físicos elementares para a compreensão de todo o processo de produção de radionuclídeos num ciclotrão.

No segundo capítulo pretende-se fazer considerações teóricas sobre a viabilidade da produção de gálio-68 num ciclotrão, sendo que isto envolve estudar a escolha da reacção pretendida da qual se retirará o elemento alvo; a forma química do material alvo; as possíveis impurezas criadas durante o processo de irradiação; as quantidades de gálio-68 que em teoria se pode produzir em determinadas condições.

No terceiro capítulo, usando muita da informação feita no estudo teórico, realizou-se uma experiência que consistiu na irradiação de uma solução de cloreto de zinco (natural), com o intuito de verificar que se pode produzir gálio-68. Através da medição da actividade da solução irradiada em função do tempo, verificou-se que é produzido gálio-68 bem como os outros radioisótopos previstos nos cálculos do segundo capítulo.

No quarto capítulo apresenta-se as conclusões do trabalho bem como as sugestões para trabalho futuro, sendo que é de destacar os fortes indícios para que esta técnica de produção de gálio-68 possa vir a tornar-se uma forma comum de produção em centros com ciclotrão.

Outline

The first chapter focuses on the objectives of this work as well as the physical concepts required to understand the entire production process of radionuclides in a cyclotron.

The second chapter aims at making theoretical considerations on the viability of the production of gallium-68 in a cyclotron. This involves studying the choice of reaction from which the target material will be chosen; the chemical form of the target material; the possible impurities created during the irradiation process; the gallium-68 yields that can be obtained in theory under certain conditions.

In the third chapter, using much of the information obtained from the theoretical study, and experiment was performed in a cyclotron that consisted in the irradiation of a (natural) zinc chloride solution to show that it is possible to produce gallium-68 and in amounts that are consistent with the predicted yields from chapter 2.

In the fourth chapter the conclusions are presented as well as the suggestions for future work, leaving strong evidence that this production technique might become a standard of production in facilities with cyclotrons.

1. Introduction

1.1. Motivation and objectives

This work is essentially a theoretical and experimental physical study that aims at establishing the production viability of gallium-68 (half-life 68 min.) in a low energy cyclotron, for usage as a PET radioisotope in clinical practice as well as research studies.

The interest of radiopharmaceuticals that use gallium-68 as a tracer has been growing over the past few years due to a number of reasons.

Firstly, its simple complexation chemistry allows the production of tracers labeled with gallium-68 in an automated manner without the separation of excess precursor [Wes13].

Another highly relevant factor for the rising interest in gallium-68 has to do with one of the chelating agents used, the DOTA agent, that allows the production of diagnostic pharmaceuticals (the ones labeled with gallium-68, *e.g.*) but also pharmaceuticals for radionuclide therapy (labeled with lutetium-177). This is a highly advantageous in the sense that the diagnosed tumors are most certainly bound to be ones targeted in the radionuclide therapy [BCG+11].

The most common method to obtain gallium-68 is through a germanium-68 generator (half-life is 271 days), making it a source with an estimated lifespan of one year.

The $^{68}Ge/^{68}Ga$ generator works by using germanium-68 which continuously decays by electron capture to gallium-68. Germanium is embedded in a sorbent material that is in turn eluted with an HCl solution in order to recover the gallium found to be in its ionic form Ga^{3+}. The solution is then passed through a cation exchange column where the gallium is retained. A typical generator can be eluted every 4 h to obtain 35 mCi of gallium-68 which in turn allows for 3 doses of 4 mCi in the early stages of the generators life. This causes a restriction for the amount of gallium-68 it is possible to use each day, which is especially problematic when trying to manage a facility that requires the isotope for both clinical and research procedures [SM13].

The reason for the widespread use of generators isn't only related to its straight forward use but also due to the fact that the vast majority of nuclear medicine facilities aren't equipped with a cyclotron and the ones that are usually restrict themselves to the production of the most common isotopes. The facilities that

resort to the production of gallium-68 in their cyclotron use a solid target assembly. This assembly usually works by using a thin electrodeposited layer of zinc-68 in a copper backing that is then irradiated by the cyclotron's beam. The irradiated disk is then dropped in a automated tray that transports the irradiated disk from the cyclotron room to a chemistry module outside of the cyclotron vault, where all the chemical procedures are then performed. It's clear that the entire production facility be planned with all these constraints in mind and therefore making it hard to implement this production technique in already functioning cyclotrons, leaving a gap for a production method that can avoid these problems.

The ability to produce gallium-68 on demand and without any of the restrictions imposed by the generator's dose limit would allow for an almost unlimited dose output, a better management of the clinical examinations and would provide researchers access to more gallium-68. Such a feat would undoubtedly boost the gallium-68 research in facilities that possess a cyclotron.

In order to bridge the already mentioned gap, this work will aim at developing a new route for the production of gallium-68, avoiding all the limitations of having a solid target assembly or a generator, by using a liquid solution as a target.

1.2. Theoretical Framework

1.2.1. Nuclear Reaction

Two particles (two nuclei or a nucleus and an elementary particle, *e.g.*, a nucleon) enter into a strong nuclear interaction when they approach distances of about 10^{-13} cm. This results in a nuclear transformation and the process is called a nuclear reaction. These reactions involve momentum and energy redistributions of both particles which may lead to the creation of several other particles escaping from the region of interaction.

Depending on the particles responsible for these reaction, they can be classified as neutron-induced reactions, reactions induced by charged particles or by γ-quanta. Although the latter is associated with the electromagnetic interaction rather than the nuclear interaction, it is appropriate to label these reactions as nuclear reaction since the interaction takes place in the vicinity of the nucleus and results in its transformation.

The most common type of nuclear reaction involve a light particle a and a nucleus A, resulting in the formation of a light particle b and a nucleus B:

$$a + A \rightarrow B + b \tag{1.1}$$

or, in a shorthand notation,

$$A(a,b)B. \tag{1.2}$$

If after the interaction, A and B are the same, except for their energy and momentum, then the interaction is called elastic scattering. If A and B are different then the interaction is called inelastic scattering.

A reaction may occur in serveral competing ways:

$$a + A \begin{cases} B + b \\ C + c \\ ... \\ A* + a \\ A + a \end{cases} .$$

The initial stage is called the entrance channel while the different possible ways in which a nuclear reaction may evolve in the second stage are called the exit channels of the reaction.

Momentum and energy aren't the only quantities conserved. Other quantities such as angular momentum, which influences the angular distribution of the products of a collision, parity, which leads to some selection rules which can sometimes forbid reactions that would otherwise be possible, are also conserved.

The investigation of a nuclear reaction aims at determining the reaction channels, the relative probability of its occurence through different channels for different energies of the incident particles, finding the energy and angular distribution of the reaction products.

1.2.1.1. Compound-nucleus reaction

The compound nucleus model was introduced by Bohr in 1936 and it assumes that a enters the nucleus and suffers collisions with the nucleons of A, until it has lost all its incident energy and becomes a undistinguishable part of the nuclear constituents. This compound owes its name to the fact that both the incident particle a and the target nucleus A become lumped together in a state in which neither retain their identity. The compound nucleus is in an excited state due to the kinetic energy of a and to the binding energy released when it is absorbed into the target nucleus. By definition, this system must be unstable since it can desintegrate into a+A, or into other final states [Boh36].

The compound nucleus may execute many cycles of its natural period before it disintegrates or emits a photon. What this means, in short, is that the energy transmitted by a and distributed over all the nucleons is insufficient for any of them

to overcome the nucleus' potential. But due to the number of particles and the size of the system, the energy fluctuation is very high and some nucleons may gather enough energy to escape. This kind of reaction has a typical lifetime in the order of magnitude of 10^{-16}s [Alv02, Kra88].

1.2.1.2. Direct reaction

While the compound state is characterized by its long life in comparision with the expected transit time of incident particle across the nucleus, the reactions that occur in a time comparable to that transit time are called direct reactions. One of the most important properties of these reaction is that the energetic products of these reactions are not distributed isotropically in angle but concentrated at angles near the incident direction, which reflects that the incident particle makes one, or few, collisions with nucleons in the target nucleus and that its forward momentum is not transfered to an entire compound state

This kind of reaction occurs when there is considerable overlapping of the initial and final wave functions of the system leading to a very small transition time (10^{-22}s). The probability of this mechanism can be understood in terms of the energy of incident particle and the resulting de Broglie wavelength - as the energy increases the wavelength λ will become comparable to the size of the nucleons and therefore be more likely to interact with them [Kra88].

1.2.2. Cross-Section

In classical mechanics the probability of interaction between a point like projectile and a hard sphere is a deterministic phenomenon that depends only on the impact parameter and the area occupied by a section through the middle of the sphere, hence the name cross section. In nuclear physics, though the classical picture doens't apply, every nucleus inside a target occupies an effective area of interaction, σ. When an incoming particle strikes the target a reaction will occur if the projectile hits this effective area. In a target with thickness d, area A, and N nuclei per unit volume, the effective area for a reaction to occur is $N(dA)\sigma$ and the reaction probability will therefore be the effective area divided by the total area $N(dA)\sigma/A$ (Fig. 1.1). Taking into account that this probability must be equal to the ratio of incoming particles and outgoing (reaction) particles n_r/n_i , then,[YH10]

$$n_r = n_i N d\sigma. \tag{1.3}$$

The cross-section has dimension of an area and its unit is the barn (b), where[YH10, Alv02]

$$1\text{b} = 10^{-28}\text{m}^2.$$

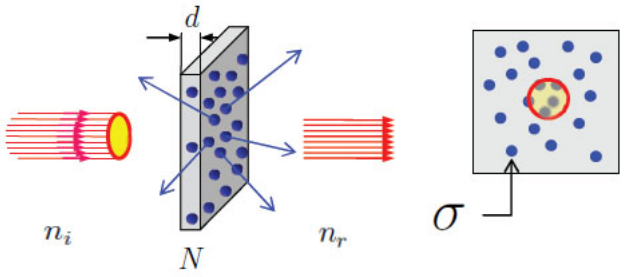

Figure 1.1.: Incoming particles, target and outgoing particles scheme.

The value of a cross section for a particular reaction depends on the energy of the incident particles due to the energy width of the reaction. Because of this, it is more suitable to express the cross section values of a particular reaction in terms of the energy of the incoming particles. The resulting function is called an excitation function(Fig. 1.2).

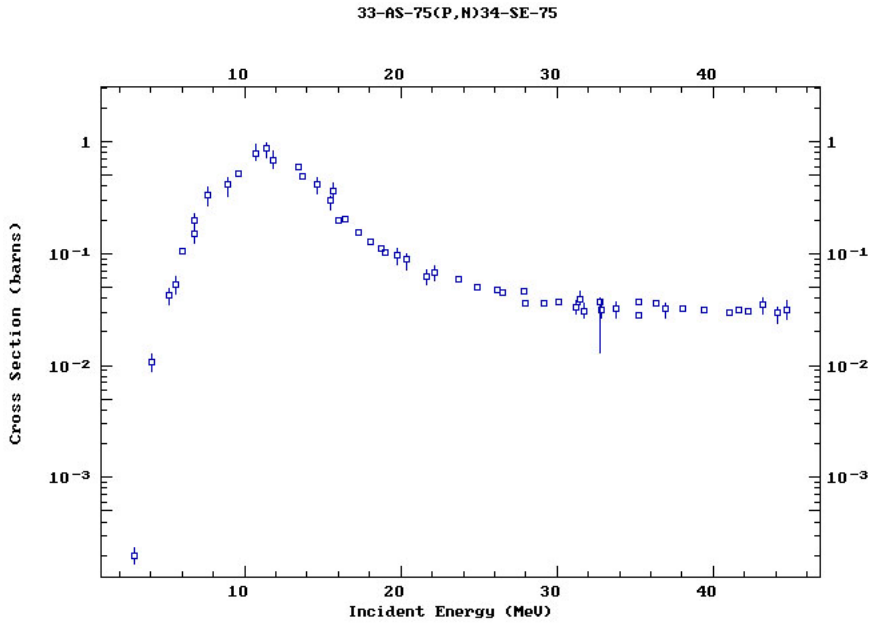

Figure 1.2.: Example of an excitation function for the $^{75}As(p,n)^{75}Se$ reaction [MQS88] .

In cyclotron physics, excitation functions play an especially important role when it comes to the choice of the energy range desired to favour a particular reaction when there are competing reactions.

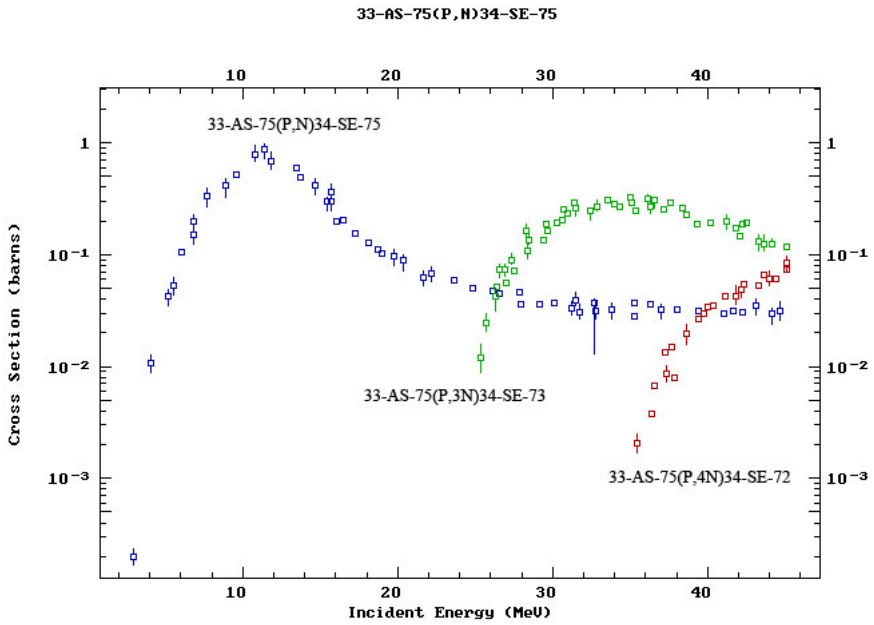

Figure 1.3.: Competing reactions and the corresponding excitation functions. Because of the overlap of the competing reactions, it is necessary to tune the energy range in order to favor a particular reaction, in this case, to favor the (p,n) reaction, the preffered energy range is 2 - 24 MeV [MQS88].

1.2.3. Energy loss of heavy charged particles

The passage of particles through matter is characterized by two features:

1. Inelastic collisions with the atomic electrons of the material;
2. elastic scattering of the nuclei.

Of the two electromagnetic processes, inelastic collisions are almost sollely responsible for the loss of energy of particles in matter. These collisions have very high cross sections ($\sigma \sim 10^{-17}\,\mathrm{cm}^2$) and the energy is transfered to the atom and causes an ionization or excitation. The energy transfered is usually a very small fraction of the particles kinetic energy, but since the number of collisions per unit of path length is usually so high in dense matter, a very high energy loss is observed in even small layers. A 18 MeV proton loses all its energy in 3.45 mm of liquid water, for example. [ZZB10]

Elastic scattering from nuclei also occurs but not as frequently as electron collisions and in general there is very little transfered energy due to the fact that most materials' nuclei usually have much larger charge number than the incident particles, which in turn means that the impact parameter, that depends on the charge of the incoming particle and the target, will be high. The inelastic collisions are statistical in nature and occur with a certain quantum mechanical probability, but since their

number per path length is so high, one can, to a good approximation, work with the average energy loss per unit path length. This quantity is called the stopping power or *dE/dx*. [Leo94]

The energy loss of particles in matter can be described by Bethe's equation when studying non-relativistic particles [Bet30]:

$$-\frac{dE}{dx} = \frac{4\pi z^2 q_e^4}{m_e v^2} NZ \ln\left(\frac{2m_e v^2}{I_0}\right); \tag{1.4}$$

where , m_e and q_e are the mass and charge of the electron respectively, z and v are the atomic number and velocity of the beam's particles and Z and N are the atomic number and number of atoms per volume unit of the target material crossed by the beam. I_0 corresponds to the value of the mean excitation potential of the atoms in the target material. It represents an average energy over all the bound electrons that can be transferred in an excitation process, including ionization. Its calculation is complex and experimental values can be found in the literature for most elements, but some semi-empirical expressions allow a good approximation:

$$\frac{I_0}{Z} = 9.1(1 + 1.9Z^{-\frac{2}{3}}) \text{ eV}. \tag{1.5}$$

For particles with relativistic velocities, Bethe's equation must be corrected [Alv02]:

$$-\frac{dE}{dx} = \frac{4\pi z^2 q_e^4}{m_e v^2} NZ \left(\ln\left(\frac{2m_e v^2}{I_0}\right) - \ln\left(1-\beta^2\right) - \beta^2\right), \tag{1.6}$$

where β represents the ratio between the projectile's velocity and the speed of light. This formula is known as the *Bethe-Bloch equation.*

When studying compound targets' stopping power, it's a good first approximation to assume that the total stopping power will be the sum of the diffent elements' stopping power. This is true to some extent and translates *Bragg's Rule* but some corrections must be made when these calculations involve some light elements. The reason for this lies in the variation of the ionization potential, I, when the compound forms itself. The valence electrons' wave functions alter themselves and therefore so does the ionization potential which will tend to increase, leading to a greater average potential for all the electrons. This effect is less obvious in heavy elements because the number of electrons that participate in the chemical bond is smaller [BK05].

1.2.3.1. SRIM

In a work that involves calculating the energy loss of particles in matter and especially in compounds, it comes as a great advantage and inevitable step to use a

very established Monte Carlo simulation computer program, and that's where SRIM (*Stopping and Range of Ions in Matter*) comes into play. SRIM is a software package which calculate the stopping and range of ions into matter using a quantum mechanical treatment of collisions. Using statistical algorithms makes the calculation efficient because it allows the ion to make jumps between calculated collisions and then the program will average the collision results over the corresponding gap.

One of SRIM's features that is especially prominent in this work is the way it calculates the stopping power of compounds. It uses a calculation method called the Core and Bond approach which suggests that the stopping power in compounds may be calculated using the superposition of stopping by atomic "cores", which would follow Bragg's rule, and then adding the contribution of the bonding electrons as a correction factor. SRIM uses this correction for compounds containing H, C, O, N, F, S and Cl because these small atoms have the largest bonding effect on stopping powers (Fig. 1.4).These corrections are not necessary for heavy atoms because experiments have shown that the deviation from Bragg's rule dissapears[Thw85] .

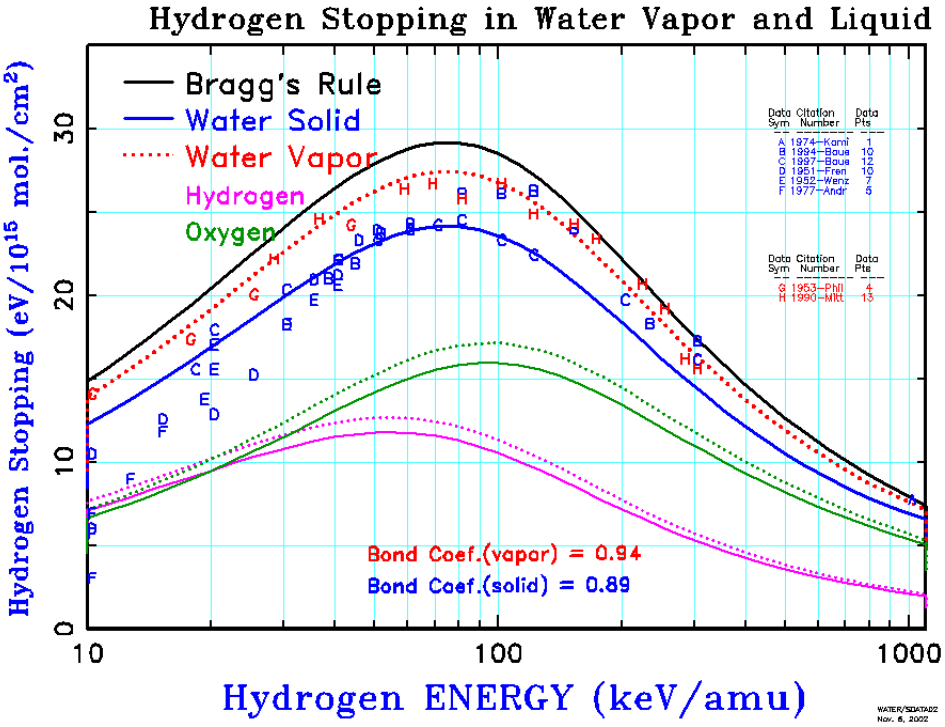

Figure 1.4.: Difference in stopping power between Bragg's rule and the Core and Bond model [ZZB10].

The most important program whithin SRIM is called TRIM (*Transport of Ions in Matter*) and it accepts complex targets made from compound materials. It can calculate 3D distribuition of the ions and the kinetic phenomenons associated with the ion's energy loss. It is especially useful to determine the average energy loss

from a large number of events and also to determine the average range of ions in a target. The output is then used not only to understand what energy the particles have when they actually strike the target, but also to calculate resulting yield from the reactions that occur [ZZB10].

1.2.4. Thick Target Yield

The amount of radionuclide that is expected to be produced by a particular nuclear reaction is obtained by the integration of the excitation function over a beam's energy range in a target. The absolute value of the produced radionuclides is of little practical interest without knowing the irradiation time for decay correction and so this has lead to a measuring standard called the *thick target yield* where "thick target" refers to the situation where the target's stopping power variation can no longer be considered infinitesimal. It is common for the *thick target yield* to be measured in a saturation condition. The saturation condition is fulfilled when the rate of decay equals the rate of production (assuming the rate of production is constant). This becomes clear when considering the following equations of decay [Alv02]:

$$\frac{dN(t)}{dt} = -\lambda N(t) + P, \tag{1.7}$$

where N(t) is the amount of radionuclides at a given time, λ is the decay constant of the radioisotope and P is the constant production rate. The solution for this equation is

$$A(t) = \lambda N(t) = P(1 - e^{-\lambda t}). \tag{1.8}$$

When t becomes sufficiently large, the exponential will tend to zero and therefore the activity and the production rate will tend to equal themselves.

The thick target yield can be calculated from the following expression:[D.J08][Alv02]

$$Y = \frac{N_A H}{M z q_e} \int_{E_{in}}^{E_{out}} \left(\frac{dE}{dx}\right)^{-1} \sigma(E) dE, \tag{1.9}$$

where N_A is Avogadro's number, z is the projectile's atomic number and q_e is the electron's charge. The integral is carried out over the beam's energy range, from the incoming energy $E_{in}$to the outgoing energy E_{out}, and the integrand is the inverse of the medium's stopping power multiplied by the cross-section for the corrresponding value of the energy.

The typical units for the thick target yield in radioisotopes production practice is the $MBq/\mu A$ *sat* where *sat* indicates that this measure refers to a saturation condition.

The results of a thick target yield mesurement must be coherent with the theoretically predicted values albeit they still represent a measurement under specific target conditions, and therefore may vary.

1.2.5. ICNAS Cyclotron

The cyclotron at ICNAS is an IBA Cyclone 18/9 (Fig. 1.5)that is capable of bombarding targets with proton or deuteron beams (18 MeV for protons and 9 MeV for deuterons). The maximum beam currents announced by IBA are 150 μA for proton beams and 40 μA for deuterons. The beams are extracted by means of carbon foils (usually called *strippers*) which retain the ions' electrons thus inverting their trajectory and then collide with the target material.

Figure 1.5.: IBA Cyclone 18/9 (picture courtesy of ©IBA).

The target is one of the main components of a cyclotron and one of the most important elements of this work. A specific target exists for each radionuclide that is produced in a cyclotron. The reason for this lies in the different characteristics of the target materials such as density, thermal conductivity, physical form, chemical properties, etc... which require that a target be planned in different ways. The choice of the physical form of the target material is usually tied with the way the preparation of the end-product (radiopharmaceutical) is done. An example of this is the production of fluorine-18 that can be done in two distinctive ways: for the production of fluorodeoxyglusose, $^{18}F - FDG$, which uses the fluoride ion, the prefered way involves the irradiation of a liquid solution with ^{18}O because the synthesis of the of the radiopharmaceutical is done by reacting liquids. But it might be of interest to produce a radiophamaceutical that uses fluorine in a gaseous form due to some methods that involve the bubbling of fluorine gas, F_2, through solutions of appropriate chemicals. In this case irradiation process is favoured by the $^{20}Ne(d,\alpha)^{18}F$ where $^{18}F_2$ is more easily isolated.

The liquid target, which ultimately will be the target of interest in this work, consists of a target chamber where the target material is inserted, a cooling mechanism, an insertion and extraction mechanism and a window to separate it from the inside of the cyclotron.

The material that the target chamber is made up of must be chosen while taking into account the following factors like the pH of the target material, its thermal conductivity which is of critical importance for the cooling of the target material, its resistance to radiation damage.

The cooling mechanism usually consists of a constant flow of cool water (~ 2 L/min.) and is injected at the rear of the target (Fig. 1.6).

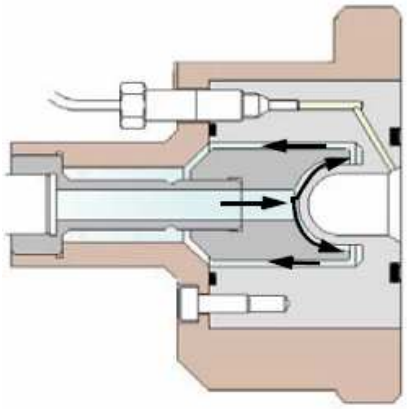

Figure 1.6.: Representation of a fluorine target with a water cooling mechanism. The arrows represent the path followed by the water around the target chamber where the beam's energy is deposited (picture courtesy of ©IBA).

2. Targetry and Yields

2.1. Methodology

To study the viability of producing gallium-68 in a liquid target, the work must be divided into two distinct parts:

- First, the research of all the available reactions that yield the desired product and the consequent choice of the target element, the choice of the solution that is to be irradiated along with its characteristics, the determination of the impurities that are created and the determination of the ways in which their production can be minimised. With all this information in hand, and also by determining the materials that constitute the cyclotron target that will be used to perform the experiment, comes the computer simulation of the irradiation in order to determine the necessary physical quantities, such as the energy loss of protons in the target solution, in order to calculate the expected yield of radioisotope;

- Secondly, the experiment, with all the implementation challenges that arise from the fact that the cyclotron is routinely used for the production of ^{18}F and ^{11}C for clinical use, which in practical terms means that before any irradiation is performed on an experimental target, every parameter must be double and triple checked to insure that no critical incident occurs that damages the cyclotron. Another critical aspect that is obvious because of the nature of the experiment, lies in the precaution needed because of the manipulation of substances with high activities or even because of the need to enter the cyclotron vault. Even after the experiment is performed, the data collection is a lengthy process ($\sim$ 48 h) which means that it must be carefuly articulated with the other tasks being performed at the facility. Other challenges include the fact that a cyclotron like the one at ICNAS, which is very oriented for the production of isotopes used in daily routine clinical practice, has very established working mechanisms such as the injection of target material (^{18}O enriched water in the case of ^{18}F and N_2 in the case of ^{11}C) as well as their extraction, but when it comes to experiments, these processes become complicated mainly by the fact that they must be done manually and are subject to unexpected problems.

2.2. Choice of reaction

One of the first decisions encountered when doing a radioisotope production study is the choice of the reaction that will be used to produce the desired radioisotope. This decision depends on three main important factors,

1. the excitation function of reaction,
2. the available projectile types
3. the maximum beam energy of the projectiles.

In the case of the cyclotron at ICNAS the available projectiles are 18 MeV protons and 9 MeV deuterons, so we must look for reactions A(p,*)Ga-68 or B(d,*)Ga-68.

The reactions that are available and that correspond to these requirements are presented in Fig. 2.1.

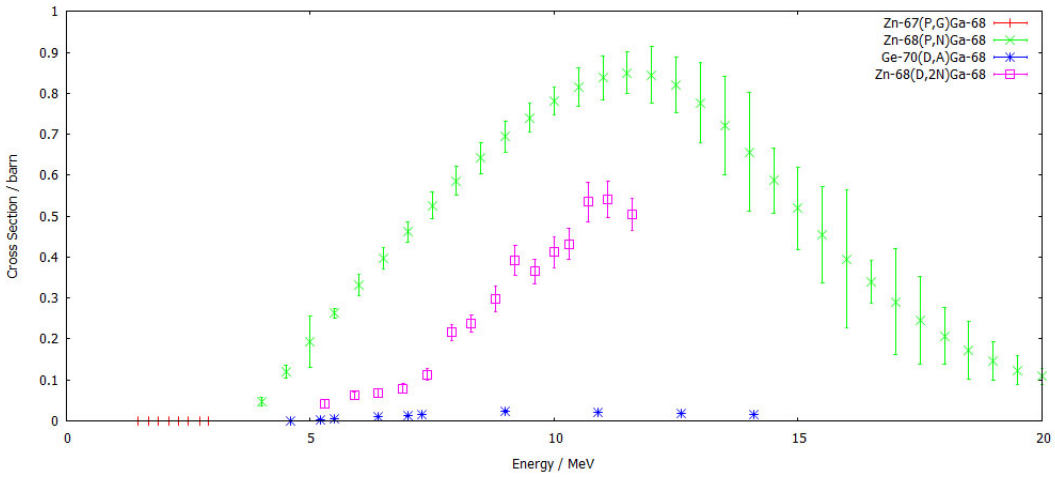

Figure 2.1.: Possible reactions' excitation functions[G.A77, GHAC63, SBT+98, OKO+68].

It is clear from the graph that the most suitable reaction is the ^{68}Zn(p,n)^{68}Ga due to its higher cross section values. Moreover the maximum value of the excitation function is well within the energy range of the cyclotron's beam allowing for a very good thick target yield.

2.3. Choice of target medium

The target medium is one of the most critical points in the production of a radioisotope. The reaction choice provides the target element but the chemical form remains undetermined. There are several factors that must be taken into account when choosing the chemical form of the target medium:

- Regarding the chemical form, it should be chosen by taking into account the isotopic composition of its elements. While it is possible that when chosing a particular element, that none of its isotopes will have an entrance channel for a reaction that may create radioactive impurities, it is certainly true that by not taking this factor into account, the risk of doing so is increased. This is particularly clear in the case of the production of fluorine-18 where the most commonly used reaction is $^{18}O(p,n)^{18}F$ and the preferred target is therefore enriched water ($H_2{}^{18}O$) instead of natural water. This is due to the fact that the isotopic abundance of ^{18}O in natural water is 0.2% whereas ^{16}O is 99.76% which would create a lot of ^{13}N (half-life 9.96 min) through the ^{16}O $(p,\alpha)^{13}N$ reaction and very little amount of ^{18}F ;
- The physical state of the target medium should be liquid because this work aims at determining its viability in a cyclotron target .

In Tab. 2.1 is a list of the most common zinc compounds used in laboratories[P92].

Table 2.1.: List of zinc compounds along with their solubility and phase.

Compound	Molar Mass / $g.mol^{-1}$	Phase (25 ºC)	Solubility in water (25 ºC) / $g.L^{-1}$	Solubility in alcohol (25 ºC) / $g.L^{-1}$
$ZnBr_2$	225.198	Solid	4470	Highly soluble
$ZnCl_2$	136.315	Solid	4320	-
$ZnCrO_4$	181.403	Solid	Insoluble	-
$Zn(CN)_2$	117.444	Solid	0.0005	-
ZnI_2	319.220	Solid	4500	-
ZnO	81.408	Solid	Insoluble	-

When deciding what compound to use some factors are of great importance:

- Solubility should be as high as possible because it is an indicator of how many target nuclei it is possible to have in the solution;
- The target solution should have as low vapor pressure as possible, as well as a high boiling temperature, because one of the critical parametres of a cyclotron target during irradiation is the pressure that builds up inside the target chamber. This is understandable if one takes into account that when the irradiation is occuring the target is sealed off from the exterior and therefore the energy deposited by the beam will make the pressure increase inside the chamber. Since highly volatile solutions have high vapor pressure, they are not suitable for cyclotron targetry;
- The compound must also be carefuly selected with respect to the by-products it might result in when irradiated. The most optimistic scenario would be one

where there are no nuclear reactions available in the chosen energy range but this is highly unlikely. The second best scenario is one where the by-product is stable and chemically inert.

The compound that respects these conditions is $ZnCl_2$ since it is highly soluble in water. An aqueous solution is more suitable because its boiling point is higher than that of an alchool. The by product of the irradiation of Cl is ^{37}Ar (Tab. 2.3) which is gaseous at room temperature, inert and therefore forms no compounds, thus being easily separable from the rest of the solution[P92].

2.4. Isotopic and non-isotopic impurities

When irradiating a $ZnCl_2$ solution it's inevitable for some impurities to be formed. There are two type of impurities:

- Isotopic impurities - different isotopes of the same target element will also produce isotopes of the desired product.
- Non-isotopic impurities are all the radioisotopes created that aren't isotopes of the desired product.

One of the ways to avoid producing isotopic impurities is to use isotopically enriched elements to make the target solution. Regarding this work specifically this would mean using zinc-68 instead of natural zinc. To demonstrate this reasoning Tab. 2.2 shows the isotopic composition of natural zinc, followed by the available reactions in the energy range and products.

Table 2.2.: Table showing the isotopic composition of zinc and available reactions in the 0 - 18 MeV range[BW11].

Isotope	Percentage of composition	(p,*) reactions in 0 - 18 MeV range
^{64}Zn	49.17	(p,α)^{61}Cu ; (p,γ)^{65}Ga; (p,n)^{65}Ga ; (p, n+p)^{63}Zn
^{66}Zn	27.73	(p,2n)^{65}Ga ; (p,γ)^{67}Ga ; (p,n)^{66}Ga ; (p,x)^{65}Zn
^{67}Zn	4.04	(p,2n)^{66}Ga ; (p,α)^{64}Cu ; (p,γ)^{68}Ga ; (p,n)^{67}Ga
^{68}Zn	18.44	(p,2n)^{67}Ga ; (p,α)^{65}Cu ; (p,n)^{68}Ga ;
^{70}Zn	0.61	(p,α)^{67}Cu ; (p,n)^{70}Ga ; (p,n+p)^{69m}Zn ; (p,x)^{67}Cu ; (p,x)^{65}Zn

Aside from the isotopic impurities created, some non-isotopic are also created due to irradiation of the other elements present in the target medium. These impurities are summarised in Tab. 2.3.

Table 2.3.: Impurities created by the irradiation of other elements present in target solution, target coating (H, O, Cl, Nb)

Elements	Isotopes	Percentage of composition	(p,*) reactions in the 0 - 18 MeV range
H	^{1}H	99.98	-
	^{2}H	0.02	(p,γ)^{3}He ; (p,n+p)^{1}H
O	^{16}O	99.76	(p,2n+2p)^{13}N ; (p,α)^{13}N
	^{17}O	0.04	(p,γ)^{18}F ; (p,n)^{17}F
	^{18}O	0.20	(p,α)^{15}N ; (p,n)^{18}F
Cl	^{35}Cl	75.76	-
	^{37}Cl	24.24	(p,n)^{37}Ar
Nb	^{93}Nb	100	(p,n+p)^{92m}Nb ; (p,n)^{93m}Mo ; (p,n+α)^{89m}Zr ; (p,x)^{89}Zr; (p,x)^{92m}Nb

The information about the radioisotopes created and summarised in the previous tables, is of little use without knowing every reaction's excitation function. The excitation functions will provide the information on how much of each radioisotope is produced and in which energy range, therefore allowing a careful tunning of the energy range desired.

Moreover, when plotted, the excitation function's must be corrected to the isotopic abundance of the elements. This means that all cross section values for reactions from the same isotope are multiplied by the isotopic abundance, so that when analysing a plot, it is straightforward to estimate how much of each isotope is produced.

In Fig. 2.3 it is clear that natural zinc is not a good target material for the production of gallium-68. This is mainly due to the competing (p,n) reactions from the other isotopes.

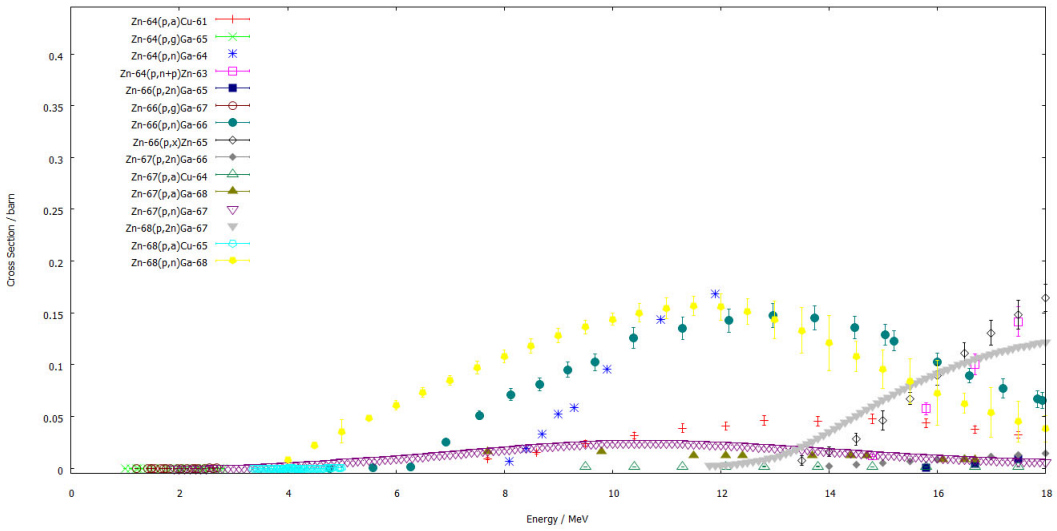

Figure 2.2.: Excitation functions of all the possible proton induced reactions in natural zinc[ESZ+81, Her97, HSS+03, How58, KCQ99, SUB+08, SBT+98] .

When using enriched zinc, the available enrichment is usually around $> 99\%$, so it's safe to consider that it's highly pure and that the only concern regarding impurities will have to do with reactions that occur with zinc-68 other than the (p,n) reaction. In Fig. 2.3 it's clear that the biggest concern should be the (p,2n)Ga-67 since it overlaps with the (p,n)Ga-68 in the 12 - 18 MeV range and so this means that ideally the beam's energy should only be around 12 MeV.

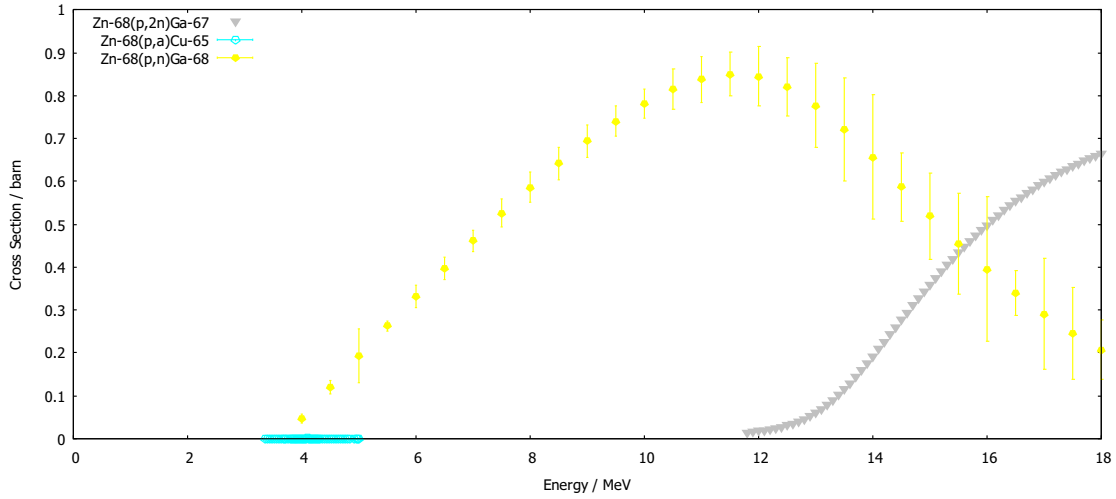

Figure 2.3.: Excitation functions of reactions that occur when using ^{68}Zn. [How58, SKR+09]

Tab. 2.3 is of particular interest because these elements are always present in the target solution and around it (in the case of niobium) no matter if the solution is made

with natural zinc or enriched zinc. Therefore, the analysis of the reactions, products and respective cross sections is critical to determine the amount of impurities created. In Fig. 2.4 the plotted cross sections clearly show that some by-products will have a considerable excitation function while others can be ignored. The isotopes that have a greater probability of being produced are ^{13}N, ^{92m}Nb and ^{89m}Zr.

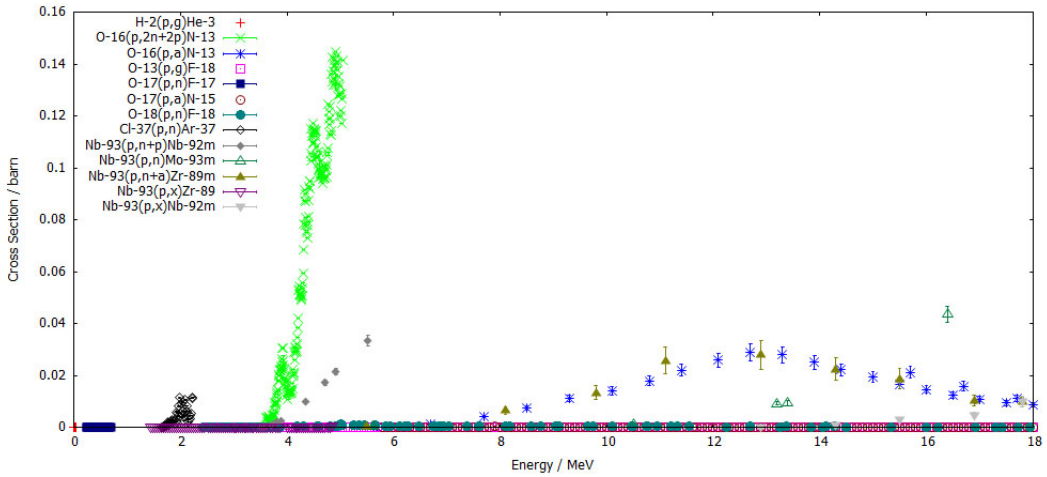

Figure 2.4.: Excitation functions of proton induced reactions in the elements present in the target solution other than zinc[ACG+62, GM59, KF74, Bai73, Ca02, MBB+97, Rol73, DHC+09].

2.5. SRIM simulation

To calculate the energy loss and range of particles during the irradiation process, a Monte Carlo simulation is performed using SRIM software (see sec. 1.2.3.1).

To be thorough when doing this kind of simulation it's necessary to understand the path that the beam follows from the moment it's extracted to the moment its energy is totally lost inside the target medium. To do so, a review of the whole target assembly is required (see Fig. 2.5).

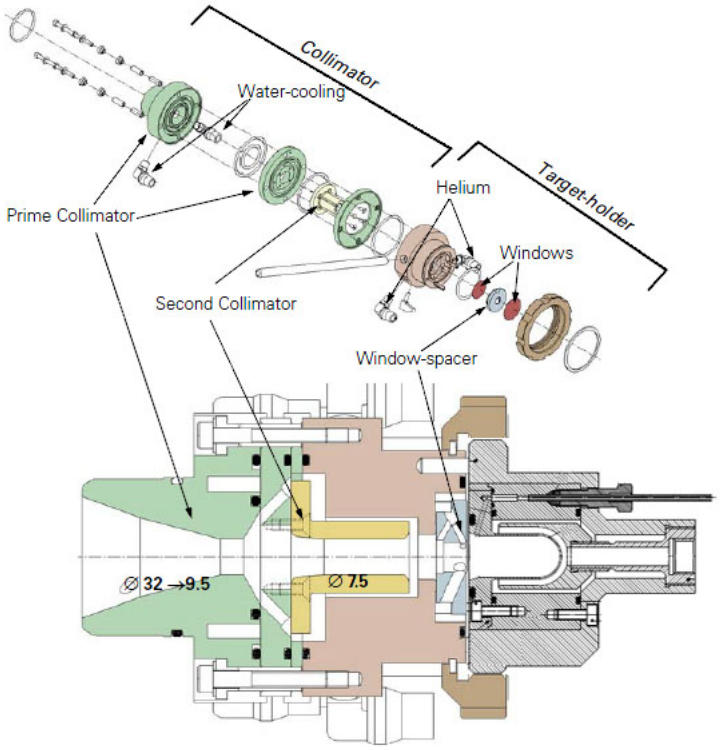

Figure 2.5.: Scheme of the target assembly (picture courtesy of ©IBA).

The following items appear in the order that the beam crosses them:

- Prime collimator - this collimator tapers from 32 mm to 9.5 mm;
- Second collimator - provides a 9.5 mm collimating channel up to the window holder;
- Vacuum side window - is a cicular disk with a 12.5 μm thickness made from titanium;
- Window holder - holds the two window foils and spreads the cooling helium flow over the window foils;
- Target window - is a disk made from niobium whose thickness must be established from the simulations.

Although the collimators play an essential part in narrowing the beam they don't contribute to its energy loss and therefore aren't included in the simulation in which the main concern is the range of the particles.

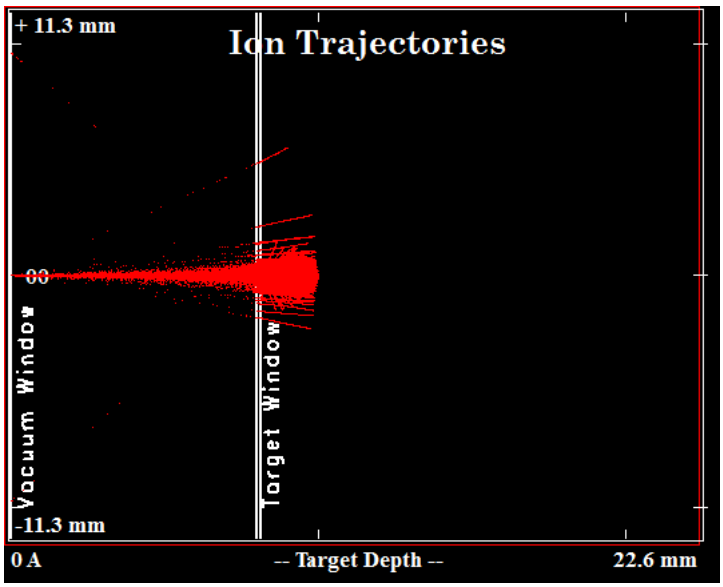

Figure 2.6.: Simulation of particles crossing the vacuum side window, the window holder, target side window and finally the target medium.

The target solution that was simulated consisted in a 1 to 1 mass proportion of zinc chloride and water.

To carry out the simulation the characteristics of the different layers must be inserted into the software. They are described in the following table:

Layer	Material	Width	Atom Stoichiometry	Density / g.cm^{-3}
Vacuum Window	Titanium	12.5 μm	1	4.518
Window Spacer	Helium	8 mm	1	0.0001787
Target Window	Niobium	125 μm	1	8.570
Target Medium	Hydrogen	14.5 mm	0.590127	1.538
	Oxygen		0.295063	
	Zinc		0.038270	
	Chlorine		0.076540	

Table 2.4.: Layers with their respective characteristics.

The density of the target solution was determined experimentally by preparing a zinc chloride solution with 5 g of zinc chloride and 5 ml of water. Since the density of zinc chloride is 2.901 g.cm^{-3}, the volume of 5 g is 1.72 cm^3 . Because the reaction is exotermic, it's expected that the total volume doesn't correspond to the simple addition of the two volumes. This was observed and the final volume was 6.5 ml instead of 6.72 ml from the simple addition. This in turn corresponds to a 1.53 g.cm^{-3} solution density.

The atom stoichiometry of the target solution was chosen to reflect the chosen mass proportion. It was determined by a simple calculation:

$$n_{H_2} = \frac{1\ \text{g}}{18\ \text{g.mol}^{-1}} \times 6.022 \times 10^{23} = 3.34 \times 10^{22}$$

$$n_{ZnCl_2} = 4.42 \times 10^{21}$$

The number of atoms from each element is then:

$$n_{H} = 3.34 \times 10^{22} \times 2 = 6.68 \times 10^{22}$$

$$n_{O} = 3.34 \times 10^{22}$$

$$n_{Zn} = 4.42 \times 10^{21}$$

$$n_{Cl} = 8.84 \times 10^{21}$$

The sum of these quantities yields the total number of atoms in a 2 g solution, and the weighted average gives the stoichiometry of the solution.

The energy of the particles is also another parameter that requires input and was chosen to be 18 MeV since it is the energy of the protons available from the cyclotron at ICNAS.

The output of the simulation is a group of files that are divided into three columns: Depth of Interaction, Ionization by Ions per unit of length, Ionization by Recoils. The results showed that the ionization by recoils is always 4 to 5 orders of magnitude smaller than the ionization by ions, as expected, and therefore they weren't taken into account.

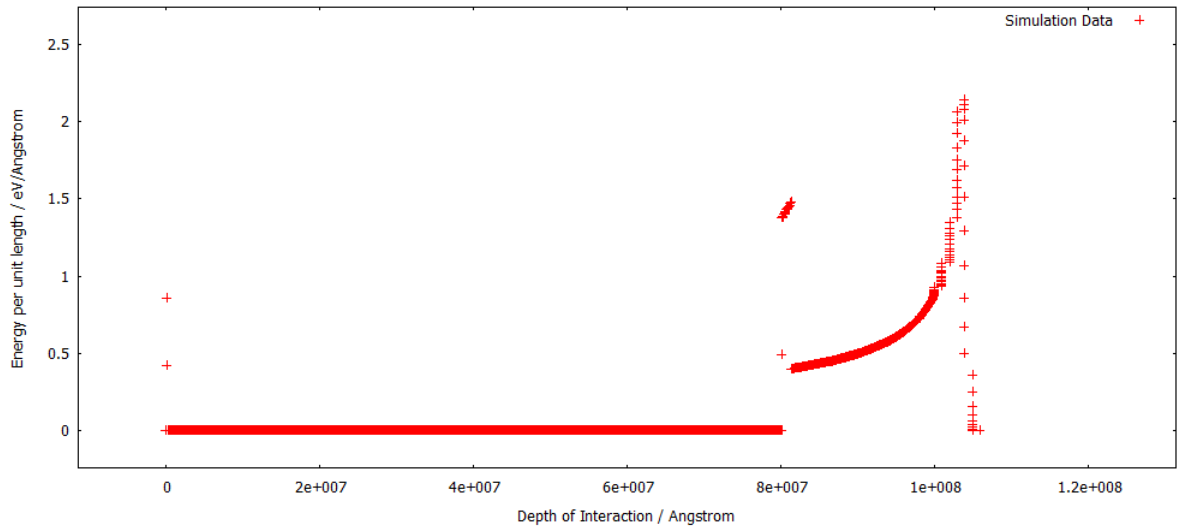

Figure 2.7.: Energy transmitted to ions per unit of length. The peak at 8 mm corresponds to the energy loss in the target window. The 8 mm to 11 mm range corresponds to energy lost inside the target solution.

By plotting and integrating the depth of interaction vs ionization (see Fig. 2.7), it's possible to determine the energy lost by the beam in every step of the calculation. The outgoing energies after crossing each layer are summarised in the following table:

Table 2.5.: Outgoing energy from beam after crossing each layer.

Layer	Outgoing energy / MeV
Vacuum Window	17.91
Window Spacer (Helium Flow)	17.88
Target Window	16.28
Target Medium	0

2.6. Thick Target Yield

To calculate the yields that can be expected from an irradiation as well as the yields expected in saturation conditions, the data from SRIM coupled with the cross section data from the EXFOR database was used and inputed into expression 1.3. The calculation was then performed in turn for each thin layer, considering the energy of the beam constant in these layers, and its respective cross section value. The final result from this calculation is the number of induced nuclear reactions in each thin layer. After summing all these reactions, the result is the total number of induced reactions by one "beam crossing". The calculations that were done in a spreadsheet format are presented in the appendix.

The values used for the calculation are:

- $d = 8.375 \times 10^4$ Å;
- $N = (4.42 \times 10^{21}) \times 0.0382$ which corresponds to total number of atoms in the target layer multiplied by the percentage of zinc-68 atoms which are the effective targets;
- σ was determined for each energy value by fitting a 7th degree polynomial curve to the excitation function values for the (p,n)Ga-68 reaction;
- n_i was chosen to be the number of incoming protons in a $1\,\mu A$ beam (6.241×10^{12} protons).

By chosing the number of projectiles to be a current instead of a number of protons, the result is the number of induced reactions per unit of time:

$$\frac{n_r}{t} = \frac{n_i}{t} N d\sigma. \tag{2.1}$$

By considering this time to be very small compared to the half-lives of the produced isotopes, the expression is equivalent to:

$$A_0 = \lambda I N d\sigma. \tag{2.2}$$

where A_0 is the induced activity, λ is the decay constant for gallium-68 and I is incoming beam current in units of projectiles per second.

This calculation is summarised in the following graph (Fig. 2.8):

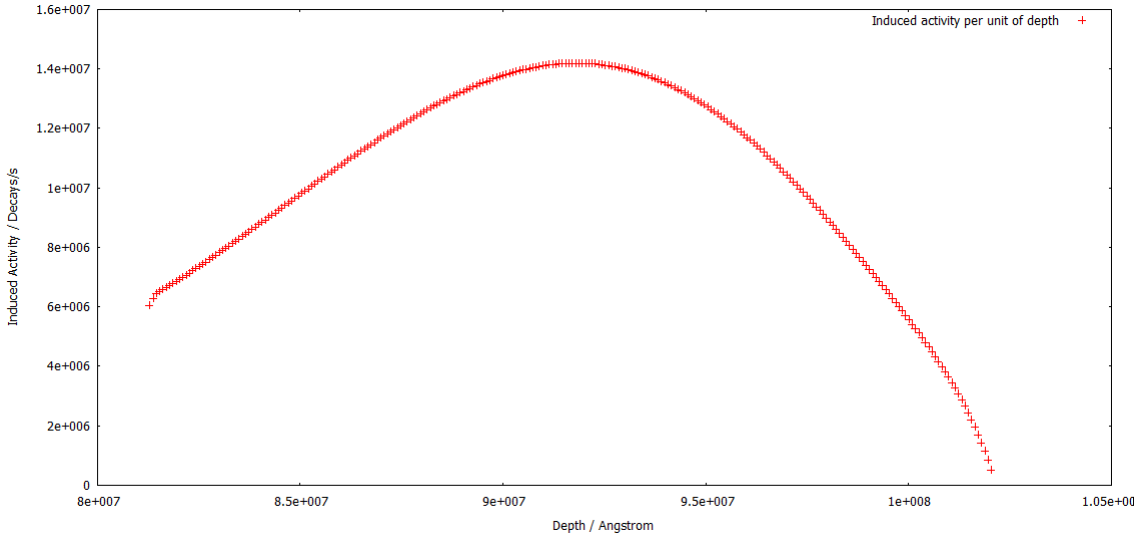

Figure 2.8.: Induced activity by a 1 μA beam by unit of depth.

The total activity for a certain irradiation time by a 1 μA beam is then given by the expression:

$$A = \int_0^t A_0(1 - e^{-\lambda t'})dt'. \tag{2.3}$$

where each value of A_0 is decay corrected depending on the time that has gone by after the reaction has been induced.

To calculate the saturation yield, one can use two methods: either do the calculation using equation 1.9 or use the calculations described above and chose $t \gg \tau_{1/2}$.

Both techniques give the same result: 404.34 MBq/μAh (10.92 mCi) activity of gallium-68 (if the target were natural zinc, the activity would be 2.052 mCi since only 18.8 % of the target would be zinc-68).

3. Results

In order to confirm the theoretical predictions made in the previous chapter and also to verify the viability of the practical implementation of the technique in a cyclotron, an experiment that consists in the preparation of a target solution, the irradiation of the solution and the extraction and measurement of the solution's activity, was planned and executed.

However, some of the beam and solution characteristics that were determined in the previous chapter were not implemented:

- the target solution was prepared using natural zinc chloride. This contradicts the conclusion that natural zinc chloride is not a good material for the production of gallium-68. There is, nontheless, an interest in using natural zinc as a target for testing purposes due to the fact that zinc-68 is a quite expensive material (circa €800/g) compared to natural zinc (€0.13/g). The reason why it's still useful for testing purposes has to do with it's chemical qualities. Since they behave exactly the same way with respect to chemical properties, one can do a fair amount of testing, without the burden of cost even though the desired product won't be achieved.
- The ideal beam energy was determined to be 12 MeV. The energy used in the experiment was 18 MeV, which after being degraded by the target window drops down to 16.3 MeV. This is far from the ideal energy determined, but it has little impact on this experiment since that energy was intended to be used when trying to avoid the (p,2n)Ga-67 reaction. In this experiment, there are far more competing reactions in all of the (p,n)Ga-68 energy range and so using a 12 MeV beam would have no pratical results.

3.1. Procedure

The procedure for this experiment involves 3 different steps:

- Preparation;
- Irradiation;
- Measurement.

For the preparation step the method chosen to prepare a solution with an equal mass ratio consisted in weighing 5 g of $ZnCl_2$ and dissolving it in 5 ml of ultra pure water.

To ensure that the $ZnCl_2$ was completely dissolved and that the solution had no deposits, the beaker was then placed in a vortex mixer and controlled by visual inspection. If little amounts of $ZnCl_2$ were still found in the beaker, the solution was heated to around 80 ^{o}C for 10 minutes. This procedure was used in every trial and after these steps were performed, none of the solutions prepared had any solid residues.

The irradiation step involves three sub-steps: the injection of the solution into the target chamber, the irradiation itself and the extraction. Ideally the injection step should be an automated process and this is the case with well established isotope production such as fluorine-18 and carbon-11, but since this is an experiment in its early stages, the injection process is made manually by accessing the cyclotron bunker and injecting the solution into the target chamber with a syringe.

Following the injection, the next step involves determining the desired beam current. The limiting factor for the beam current is the pressure that builds up inside the target due to the energy that is deposited by the beam in the solution. The niobium target side window was tested in the following way: helium was inserted into the target chamber at a pressure of 4 bar to check for possible leaks. As there were none, natural water was then inserted into the target chamber and irradiated. By slowly raising the current, the pressure inside the target increased and finally reached 40 bars (the operational pressure in all other fluorine targets used in this cyclotron). This condition was the maintained to verify that the window can withstand the pressure for some minutes.

After turning the beam off, the solution is extracted from the cyclotron using an electronic mechanism to control the opening and closing of the target valves that had to be built in-house due to the fact that it is impossible to access the cyclotron bunker after the irradiation step and therefore making it impossible to extract the solution manually. The solution was then forwarded to a conical vial inside a hot cell through a dedicated teflon line. After insuring by visual inspection of the vial that the entire solution volume is transfered, the vial is then inserted into the dose calibrator.

The measurement step is performed in a dose calibrator that is set to measure gallium-68. Since there is no available way to store the detector's output data in a computer, the activity of the sample as a function of time was collected by filming the calibrator's screen for several hours (10h-40h). The data was then extracted in 2 min. steps and inserted into a computer file for analysis.

This procedure was adopted for every trial and the results are presented in the next section.

3.2. Results and Analysis

3.2.1. Trial 1

The irradiation was performed until reaching 1 μAh, which is the integrated current. The integrated current is always used as a reference since it is very difficult to maintain a constant beam current and therefore it would be difficult to compare experiments results based on such instable parameters.

The data collected over a 10 h span was plotted and is presented in Fig. 3.1 :

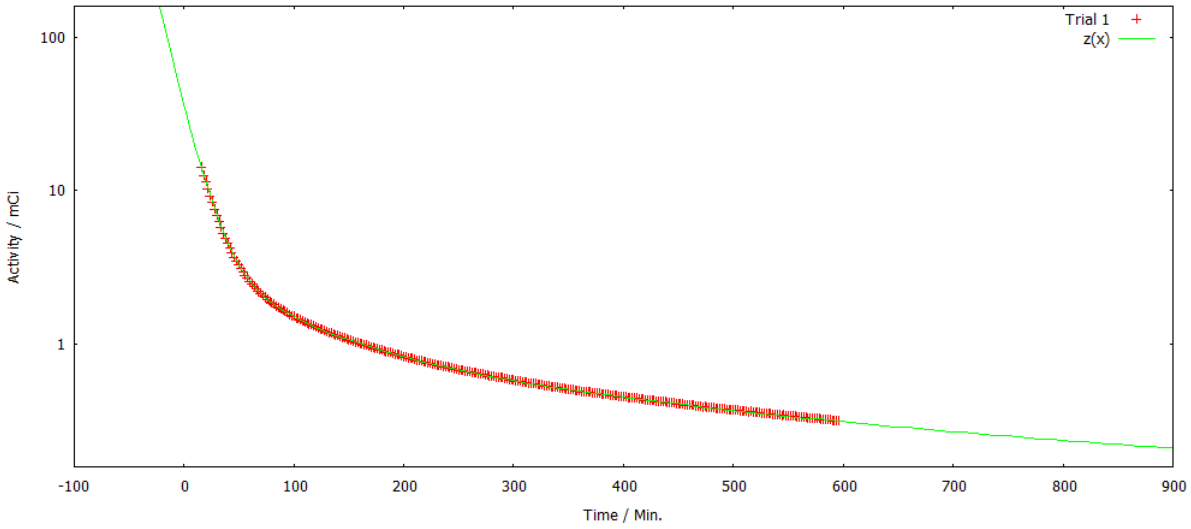

Figure 3.1.: Plot of fitted trial 1 data in a log/lin scale along with the decay curves of the expected isotopes.

The best fit (Fig. 3.1) to this data was achieved by using a 7 parameter equation with SigmaPlot 10.0 software:

$$f(x) = y_0 + a \times exp(-b \times x) + c \times exp(-d \times x) + g \times exp(-h \times x) \qquad (3.1)$$

The fit's parameters are summarised in the following table (Tab. 3.1).

Table 3.1.: Fit parameters of trial 1 data.

Parameter	Value
y_0	1.273×10^{-1}
a	33.32
b	6.847×10^{-2}
c	2.504
d	1.355×10^{-2}
g	9.03×10^{-1}
h	2.659×10^{-3}

Taking into account that 3.1 has a physical meaning that corresponds to a radioactive decay, then parameters b, d and h must be decay constants of the produced radioisotopes, and a, c and g must be the amounts produced after the beam is turned off. Since,

$$\lambda = \frac{\ln(2)}{\tau_{1/2}}$$

the corresponding half-lives are presented in Tab. 3.2.

Table 3.2.: Half-lives of the produced radioisotopes.

Parameter	$\tau_{1/2}$ / min	Expected Radioisotope	Expected $\tau_{1/2}$ / mn	Deviation / %
b	10.12	^{13}N	9.96	1.58
d	51.15	^{68}Ga	67.71	24.45
h	260.67	^{66}Ga	569.40	54.22

The main reason why the determined half-life for ^{66}Ga is so far off from the expected value seems to be tied to the measurement time (10 h) which is very close to one half-life of ^{66}Ga. This results in a poor fit and in a percentual deviation of 54% from the expected value. For the shorter half-life of ^{68}Ga, although the deviation is still significant (24.45%) it is somewhat better than that of ^{66}Ga. As for ^{13}N, it is clear that there is a very good match between the determined half-life and the expected one.

From this trial it's possible to conclude that one of the most important factors to take into account in this experiment is that the measuring time is critical since there are isotopes with very long half-lives. For the following trials, one concluded that the measurement time should be at least 3 times longer than the half-life of the longest isotope expected, which in turn corresponds to a measurement time of $\sim$ 24 h.

In this first trial, the amount created of each radioisotope wasn't a concern since the main priority was to test the procedure and to insure that the target could in fact withstand the built up pressure inside the target and that the extraction process was done without any major problem. Although the transfer from the target to the vial inside the hot cell eventually occured, the time it took was far longer than expected (20 - 25 min) compared to transfer times of 2 - 5 min in the case of the fluorine production. This effect wasn't thoroughly investigated but unusual behaviors in the transport properties and viscosity of zinc chloride aqueous solutions have been reported in the literature and may be related to this effect.[WMH$^+$84]

3.2.2. Trial 2

Before starting the experiment, the target was thoroughly cleaned with ultra pure water and a cold test was performed to insure that all systems were functional. This cold test consisted in injecting the target solution into the target chamber and then immediately extracting it without irradiation. The transfer time was coherent with the usual transfer times for the production of fluorine and the solution showed no presence of impurities, making it clear that both target and transfer lines were clean. This procedure was adopted for the next experiments too.

The irradiation was performed for 30 min until reaching 1 μAh.

The data in this trial was collected over a span of 23 h and presented as a plot in Fig. 3.2:

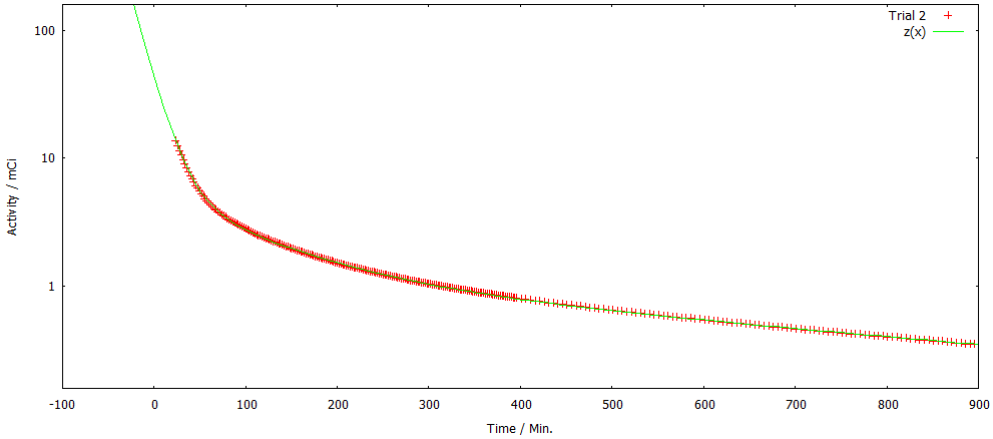

Figure 3.2.: Plot of trial 2 data.

Following the same type of analysis as done in trial 1, the data was fitted with a 7 parameter function and the determined values were:

Parameters	Values
y_0	2.296×10^{-2}
a	38.5
b	6.092×10^{-2}
c	4.229
d	9.958×10^{-3}
g	1.241
h	1.486×10^{-3}

Table 3.3.: Fit parameters of trial 2 data.

These values yield the following half-lives:

Table 3.4.: Half-lives of the radioisotopes produced in trial 2.

Parameter	$\tau_{1/2}$ / mn	Expected Radioisotope	Expected $\tau_{1/2}$ / mn	Percentual Deviation / %
b	11.37	^{13}N	9.96	12.4
d	69.60	^{68}Ga	67.71	2.7
h	466.45	^{66}Ga	569.40	18

It is clear from these results that a longer measurement time yields better fits and consequently lower deviations from the expected values.

3.2.3. Trial 3

In this trial higher beam currents were attempted and an unusual effect was observed: the beam current was set to 10 μA and the target pressure rose to gradually to 15 bars and stabilized. The beam current was then increased to 25 μA and the target pressure rose to 20 bars and immediately returned to 15 bars and once again stabilized. The beam current was then reduced to 5 μA and the pressure dropped 6 bar and gradually rose to 15 bar once again, therefore suggesting that some sort of thermal equilibrium is reached inside the target and that deviations in beam current may result in the same pressure inside the target. Under these conditions, a higher integrated current was reached with the same irradiation time (~ 30 min) used in the previous trials.

The target was irradiated for 30 min until 6 μAh were reached.

The plot of the data along with the fit:

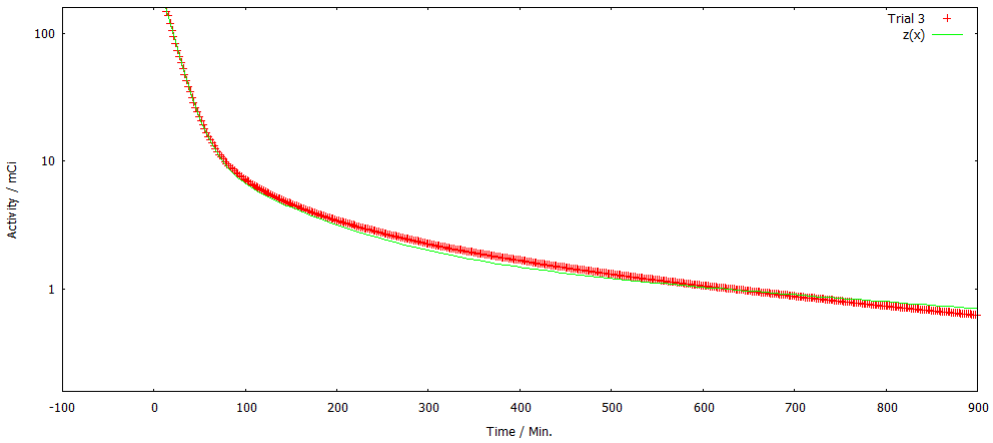

Figure 3.3.: Plotted trial 3 data along with fit.

Following the same type of analysis as done in trial 1, the data was fitted with a 7 parameter function and the determined values were:

Table 3.5.: Fit parameters of trial 3 data.

Parameters	Values
y_0	2.741×10^{-2}
a	349.2
b	6.645×10^{-2}
c	12.27
d	1.042×10^{-2}
g	2.090
h	1.256×10^{-3}

The determined half-lives were:

Table 3.6.: Determined half-lives of the radioisotopes produced in trial 3.

Parameter	$\tau_{1/2}$ / mn	Expected Radioisotope	Expected $\tau_{1/2}$ / mn	Percentual Deviation / %
b	10.43	^{13}N	9.96	4.5
d	66.52	^{68}Ga	67.71	1.78
h	551.86	^{66}Ga	569.40	3.17

In this trial, the fit indicates that at beam stop the amount of gallium-68 produced was 12.27 mCi. By using the calculation methods outlined in chapter 2 the predicted value for an irradiation of 6 μAh in a target with natural zinc is 12.32 mCi which reveals a very good accordance. If the target were to be composed by enriched zinc, this value would be 65.56 mCi.

Two days after finishing the measurement, a few drops of the solution were analysed in an MCA. This was done as a further proof of the production of all the predicted radioisotopes, and one that is difficult to observe using the method used previously is gallium-67 since it has a 3 day half-life. But since gallium-67 decays by gamma emission and not β^+ like the other gallium isotopes, one expected to observe at least three peaks corresponding to the three gamma energies with the largest decay channels (97 keV, 184 keV and 300 keV with respectively 40%, 20% and 17% relative intensity).

After measuring for 60 seconds, the resulting spectrum follows in Fig. 3.4:

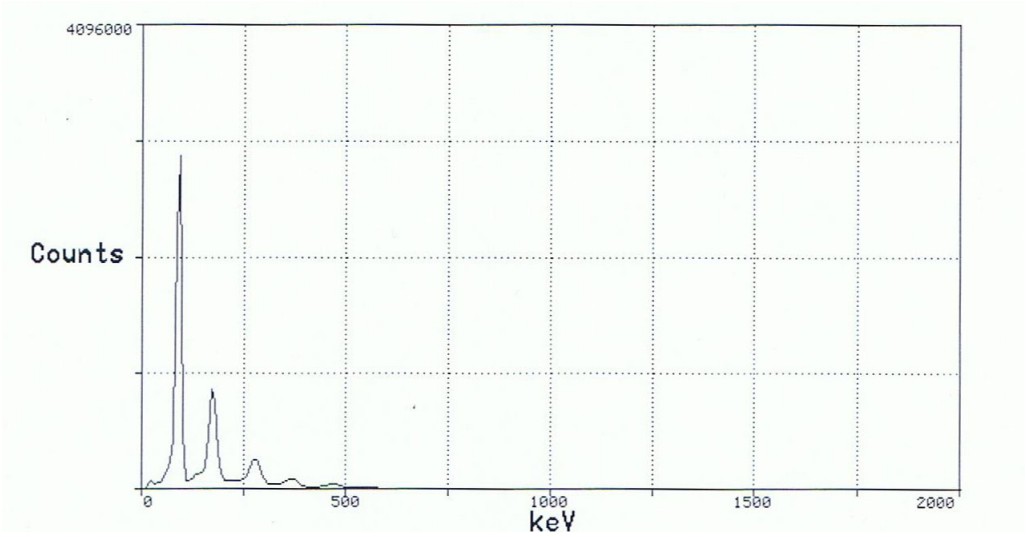

Figure 3.4.: Spectrum obtained after analysing sample in an MCA.

Although the peaks are not centered with the expected energies due to a possible miscalibration of the MCA, they belong unmistakably to gallium-67 decays due to their relative intensities and spacing.

It is necessary to take into account that there is an inherent error in the measurement of the dose calibrator that can have some impact on the measurement of the half-lives of the isotopes. This error is usually proportional to the number of counts (these radiation detectors normally follow a Poisson statistic where the error is $\sqrt{counts}$).

The analysis of the data from each trial allowed for a constant optimization of the experimental techniques that culminate with the results of trial 3, where 12.27 mCi of gallium-68 were produced.

4. Conclusions and Future Work

From the several experiments performed it's possible to conclude that the production of gallium-68 in a cyclotron with a liquid target is possible and that it may yield quantities that can be used for the synthesis of radiopharmaceuticals. A solid target assembly yields unquestionably higher amounts of gallium-68, with values of 5 Ci at end of bombardement being reported in the literature ([SKR+09]) using a 15 mn irradiation time and 150 μA beam current. A gallium-68 generator when eluted yields 35 mCi. This work has shown that if using an enriched zinc chloride solution, under the experimental conditions used, it is possible to obtain 65 mCi. There are several factors that may improve this production yield: a solution with a higher concentration of zinc chloride, higher irradiation time in order to approach a saturation condition ($\sim$ 2h $\longrightarrow$ 75 % saturation yield).

It is also important to stress that the irradiations were performed in a target originally intended to produce fluorine. The optimization of the target depth, cooling, shape, materials are all very important factors that may contribute to even further improvement of the production capabilities. One of the most relevant improvements that should be investigated is the possibility of integrating a beam degrader into the target assembly so that the beam's energy can be lowered to more optimal energies that would avoid producing ^{67}Ga through the competing reaction (p,2n).

From the data analysis it is clear that gallium-68 was produced along with the other predicted isotopes and that throughout the progression of the experiment, the growing understanding of the procedure and of the behaviour of the solution during irradiation allowed for the optimization of the entire experiment. This in turn can begin to be seen as a draft of what a full protocol for the possible production of gallium-68 to be used in patients.

Moreover, the data obtained from the experiment is in good agreement with the calculations made in chapter 2. The observation of the isotopic impurities created alongside the gallium-68 demonstrate that the nuclear reactions that occur inside the target chamber during the irradiation are in fact the ones expected.

Although this work can be seen as a proof of principle of a new production method, the complete demonstration of the technique can only be shown by irradiating a target solution with enriched zinc-68 which was shown to be the ideal target material. The study of the resulting yields and complete study of the chemical processes needed to separate the gallium from the solution and to recover the zinc-68 so that it can be used to perform further irradiations is a critical part of the entire production process.

Furthermore, though this work aimed in part at finding the most suitable chemical compound for the target material, it may be interesting to study this further and to find other compounds that behave in a more controlled manner so that some of the effects observed, like the increased transfer times and the pressure inside the target, can have less of an impact.

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A. Material and equipment

A.1. Cyclotron

Figure A.1.: IBA Cyclone 18/9

A.2. Zinc Chloride

Figure A.2.: Sigma Aldrich Zinc Chloride 98% Purity

A.3. Vortex Mixer

Figure A.3.: VELP Vortex Mixer Zx3

A.4. Scale

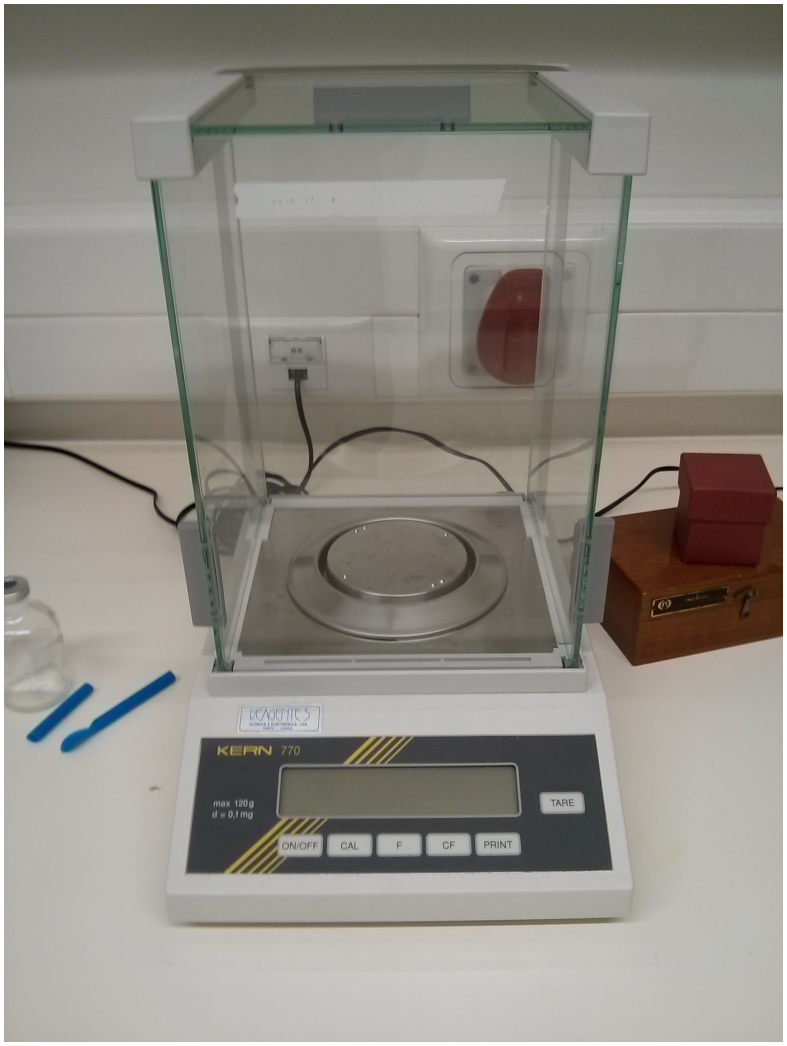

Figure A.4.: KERN 770 Scale

A.5. Dose Calibrator

Figure A.5.: Capintec CRC-55tW dose calibrator and well counter (MCA)

B. SRIM outputs and calculations

B.1. Beam degradation vs depth

The data presented here is the result of the SRIM simulation from chapter 2. With the resulting data, the beam's energy degradation was calculated for every step; using a polynomial fit of the reaction's cross section, the corresponding value of σ was also determined for every step of the calculation.

With respect to the polynomial fit of the Zn-68(p,n)Ga-68, the equation used was $f(x) = a \times x + b \times x^2 + c \times x^3 + d \times x^4 + g \times x^5 + h \times x^6 + i \times x^7$ and the determined fit parameters were:

Table B.1.: Fit parametres for the Zn-68(p,n)Ga-68 cross section.

Parameter	Value
a	-640.416
b	392.701
c	-94.3364
d	12.1984
g	-0.865649
h	0.0313612
i	-0.000452177

The fit and the cross section data was plotted:

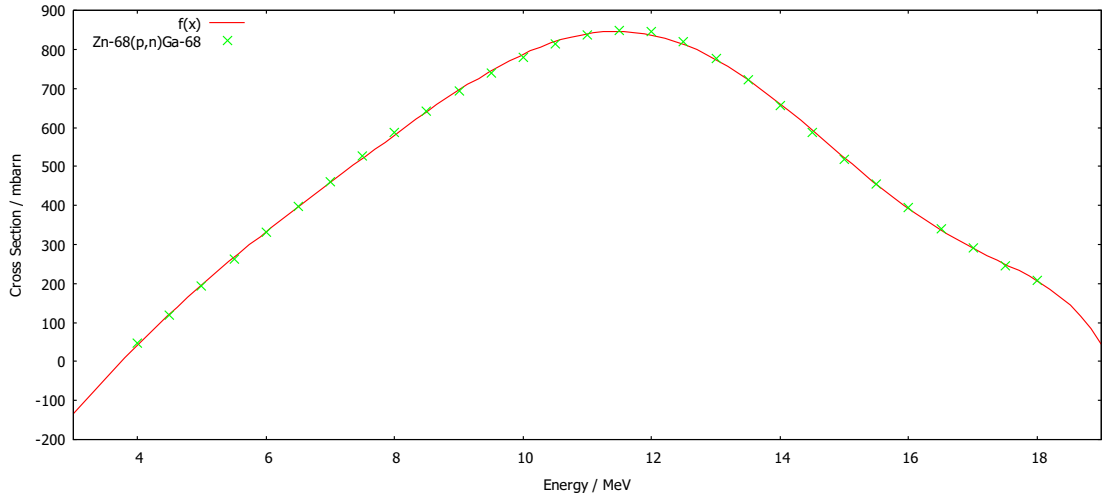

Figure B.1.: Plot of the cross section data and the fit.

The last column shows the calculation of the thick target yield by considering the yield from each thin layer and summing it to the previous one. The thick target yield is the last value in the column.

The different colors represent different parts of the beam's path: in blue the vacuum side window and the helium flow from the window cooling, in yellow the target side window, and in green the target solution.

TARGET	IONIZ.	IONIZ.	Trapezoidal	Beam	Cross Section	Thin Target
DEPTH	IONS	RECOILS	integration	energy	Zn68(p,n)Ga68	Yield
(Ang)	(eV/Ang)	(eV/Ang)	(eV)	(MeV)	(mbarn)	(MBq/uAh)
TARGET	IONIZ.	IONIZ.	INTEGRAÇÃO	ENERGIA	Secção Eficaz	
DEPTH	by	by	por	em	Interpolada	
(Ang)	IONS	RECOILS	RECT	MeV	mbarn	
0.00E+00	0.00E+00	0.00E+00	0.00E+00	18.000000		
8.38E+04	8.56E-01	1.77E-05	3.58E+04	17.964167	214.7666624	
1.68E+05	4.21E-01	1.30E-04	5.35E+04	17.910710	217.4923306	
2.51E+05	5.03E-05	0.00E+00	1.76E+04	17.893083	218.4174411	
3.35E+05	5.02E-05	0.00E+00	4.21E+00	17.893079	218.4176634	
4.19E+05	5.02E-05	0.00E+00	4.20E+00	17.893075	218.4178857	
5.03E+05	5.03E-05	0.00E+00	4.21E+00	17.893071	218.418108	
5.86E+05	5.03E-05	0.00E+00	4.21E+00	17.893066	218.4183305	
6.70E+05	5.05E-05	0.00E+00	4.22E+00	17.893062	218.4185534	
7.54E+05	5.06E-05	0.00E+00	4.23E+00	17.893058	218.4187771	
8.38E+05	5.06E-05	0.00E+00	4.24E+00	17.893054	218.4190012	
9.21E+05	5.07E-05	0.00E+00	4.24E+00	17.893049	218.4192253	
1.01E+06	5.07E-05	0.00E+00	4.25E+00	17.893045	218.4194497	
1.09E+06	5.06E-05	0.00E+00	4.24E+00	17.893041	218.4196739	
1.17E+06	5.04E-05	0.00E+00	4.23E+00	17.893037	218.4198974	
1.26E+06	5.03E-05	0.00E+00	4.22E+00	17.893032	218.4201203	
1.34E+06	5.05E-05	2.63E-10	4.22E+00	17.893028	218.4203435	
1.42E+06	5.06E-05	0.00E+00	4.23E+00	17.893024	218.4205674	
1.51E+06	5.04E-05	0.00E+00	4.23E+00	17.893020	218.4207908	
1.59E+06	5.04E-05	0.00E+00	4.22E+00	17.893016	218.421014	
1.68E+06	5.05E-05	0.00E+00	4.23E+00	17.893011	218.4212374	
1.76E+06	5.03E-05	1.58E-09	4.22E+00	17.893007	218.4214607	
1.84E+06	5.03E-05	0.00E+00	4.21E+00	17.893003	218.4216835	
1.93E+06	5.02E-05	8.36E-09	4.21E+00	17.892999	218.4219059	
2.01E+06	5.01E-05	0.00E+00	4.20E+00	17.892994	218.4221279	
2.09E+06	5.01E-05	0.00E+00	4.20E+00	17.892990	218.4223498	
2.18E+06	5.01E-05	1.69E-10	4.20E+00	17.892986	218.4225716	
2.26E+06	5.00E-05	0.00E+00	4.19E+00	17.892982	218.422793	
2.35E+06	4.98E-05	0.00E+00	4.18E+00	17.892978	218.4230138	
2.43E+06	4.99E-05	0.00E+00	4.17E+00	17.892974	218.4232345	
2.51E+06	5.01E-05	7.60E-10	4.19E+00	17.892969	218.4234558	
2.60E+06	5.02E-05	0.00E+00	4.20E+00	17.892965	218.4236778	
2.68E+06	5.02E-05	3.99E-09	4.20E+00	17.892961	218.4239	
2.76E+06	5.03E-05	0.00E+00	4.21E+00	17.892957	218.4241226	
2.85E+06	5.04E-05	0.00E+00	4.22E+00	17.892953	218.4243456	
2.93E+06	5.02E-05	0.00E+00	4.21E+00	17.892948	218.4245682	
3.02E+06	5.03E-05	0.00E+00	4.21E+00	17.892944	218.4247908	
3.10E+06	5.02E-05	7.79E-10	4.21E+00	17.892940	218.4250132	
3.18E+06	5.03E-05	0.00E+00	4.21E+00	17.892936	218.4252355	
3.27E+06	5.03E-05	7.07E-10	4.21E+00	17.892931	218.4254582	
3.35E+06	5.03E-05	0.00E+00	4.21E+00	17.892927	218.4256809	
3.43E+06	5.02E-05	9.23E-10	4.21E+00	17.892923	218.4259034	
3.52E+06	5.03E-05	5.63E-10	4.21E+00	17.892919	218.426126	
3.60E+06	5.02E-05	0.00E+00	4.21E+00	17.892915	218.4263485	

3.69E+06	5.02E-05	2.02E-10	4.21E+00	17.892910	218.4265709	
3.77E+06	5.03E-05	4.59E-10	4.21E+00	17.892906	218.4267935	
3.85E+06	5.04E-05	3.35E-10	4.22E+00	17.892902	218.4270164	
3.94E+06	5.02E-05	5.29E-09	4.21E+00	17.892898	218.427239	
4.02E+06	5.02E-05	0.00E+00	4.21E+00	17.892894	218.4274614	
4.10E+06	5.01E-05	0.00E+00	4.20E+00	17.892889	218.4276834	
4.19E+06	4.98E-05	0.00E+00	4.18E+00	17.892885	218.4279045	
4.27E+06	4.98E-05	2.36E-09	4.17E+00	17.892881	218.4281248	
4.36E+06	4.98E-05	5.30E-10	4.17E+00	17.892877	218.4283453	
4.44E+06	4.99E-05	0.00E+00	4.18E+00	17.892873	218.4285661	
4.52E+06	4.97E-05	2.43E-10	4.17E+00	17.892869	218.4287866	
4.61E+06	4.98E-05	0.00E+00	4.17E+00	17.892864	218.4290068	
4.69E+06	5.01E-05	3.18E-10	4.18E+00	17.892860	218.429228	
4.77E+06	5.01E-05	1.13E-09	4.19E+00	17.892856	218.4294497	
4.86E+06	4.99E-05	4.55E-09	4.19E+00	17.892852	218.429671	
4.94E+06	5.02E-05	8.96E-10	4.19E+00	17.892848	218.4298926	
5.03E+06	5.01E-05	1.19E-09	4.20E+00	17.892843	218.4301146	
5.11E+06	5.02E-05	1.39E-10	4.20E+00	17.892839	218.4303368	
5.19E+06	5.04E-05	0.00E+00	4.22E+00	17.892835	218.4305596	
5.28E+06	5.03E-05	0.00E+00	4.22E+00	17.892831	218.4307827	
5.36E+06	5.02E-05	2.99E-10	4.21E+00	17.892827	218.4310051	
5.44E+06	5.02E-05	1.44E-10	4.20E+00	17.892822	218.4312274	
5.53E+06	5.02E-05	9.19E-10	4.20E+00	17.892818	218.4314495	
5.61E+06	5.02E-05	9.93E-10	4.20E+00	17.892814	218.4316717	
5.70E+06	5.02E-05	0.00E+00	4.21E+00	17.892810	218.431894	
5.78E+06	5.04E-05	2.36E-10	4.21E+00	17.892806	218.4321167	
5.86E+06	5.05E-05	0.00E+00	4.22E+00	17.892801	218.43234	
5.95E+06	5.04E-05	0.00E+00	4.22E+00	17.892797	218.4325633	
6.03E+06	5.04E-05	6.45E-09	4.22E+00	17.892793	218.4327863	
6.11E+06	5.04E-05	0.00E+00	4.22E+00	17.892789	218.4330095	
6.20E+06	5.03E-05	8.81E-10	4.22E+00	17.892784	218.4332324	
6.28E+06	5.03E-05	7.69E-09	4.21E+00	17.892780	218.4334552	
6.37E+06	5.03E-05	3.11E-09	4.22E+00	17.892776	218.4336781	
6.45E+06	5.05E-05	6.39E-10	4.22E+00	17.892772	218.4339013	
6.53E+06	5.03E-05	9.33E-10	4.22E+00	17.892768	218.4341244	
6.62E+06	5.02E-05	8.49E-10	4.21E+00	17.892763	218.4343468	
6.70E+06	5.01E-05	3.09E-09	4.20E+00	17.892759	218.4345688	
6.78E+06	5.01E-05	0.00E+00	4.19E+00	17.892755	218.4347906	
6.87E+06	5.01E-05	0.00E+00	4.19E+00	17.892751	218.4350123	
6.95E+06	5.01E-05	4.13E-10	4.19E+00	17.892747	218.4352341	
7.04E+06	5.00E-05	2.57E-10	4.19E+00	17.892742	218.4354557	
7.12E+06	5.01E-05	1.65E-10	4.19E+00	17.892738	218.4356772	
7.20E+06	5.01E-05	3.00E-10	4.19E+00	17.892734	218.435899	
7.29E+06	5.03E-05	0.00E+00	4.21E+00	17.892730	218.4361214	
7.37E+06	5.05E-05	3.84E-10	4.22E+00	17.892726	218.4363446	
7.45E+06	5.04E-05	3.39E-10	4.22E+00	17.892721	218.4365679	
7.54E+06	5.03E-05	1.66E-09	4.22E+00	17.892717	218.4367909	
7.62E+06	5.04E-05	0.00E+00	4.22E+00	17.892713	218.4370139	
7.71E+06	5.05E-05	5.09E-10	4.23E+00	17.892709	218.4372373	
7.79E+06	5.10E-05	5.50E-09	4.25E+00	17.892704	218.4374621	

7.87E+06	5.08E-05	5.03E-10	4.26E+00	17.892700	218.4376873	
7.96E+06	5.02E-05	1.36E-10	4.23E+00	17.892696	218.4379108	
8.04E+06	4.92E-05	1.74E-10	4.16E+00	17.892692	218.4381309	
8.12E+06	4.94E-05	1.49E-10	4.13E+00	17.892688	218.4383492	
8.21E+06	4.97E-05	0.00E+00	4.15E+00	17.892684	218.4385685	
8.29E+06	4.94E-05	1.09E-09	4.15E+00	17.892679	218.4387877	
8.38E+06	4.98E-05	0.00E+00	4.15E+00	17.892675	218.4390072	
8.45E+06	5.00E-05	1.60E-10	3.94E+00	17.892671	218.4392156	
8.53E+06	5.00E-05	1.99E-10	3.95E+00	17.892667	218.4394245	
8.61E+06	5.01E-05	0.00E+00	3.96E+00	17.892663	218.4396337	
8.69E+06	5.03E-05	1.85E-10	3.97E+00	17.892659	218.4398434	
8.77E+06	5.03E-05	1.56E-09	3.97E+00	17.892655	218.4400535	
8.85E+06	5.04E-05	6.96E-10	3.98E+00	17.892651	218.4402638	
8.93E+06	5.04E-05	1.57E-10	3.98E+00	17.892647	218.4404742	
9.01E+06	5.03E-05	4.29E-10	3.98E+00	17.892643	218.4406844	
9.09E+06	5.01E-05	4.66E-10	3.96E+00	17.892640	218.4408939	
9.17E+06	5.01E-05	4.92E-10	3.96E+00	17.892636	218.4411032	
9.24E+06	5.02E-05	0.00E+00	3.96E+00	17.892632	218.4413128	
9.32E+06	5.01E-05	1.66E-10	3.96E+00	17.892628	218.4415223	
9.40E+06	4.98E-05	1.41E-09	3.95E+00	17.892624	218.4417311	
9.48E+06	4.96E-05	1.68E-09	3.93E+00	17.892620	218.4419387	
9.56E+06	4.95E-05	4.41E-08	3.91E+00	17.892616	218.4421457	
9.64E+06	4.97E-05	0.00E+00	3.92E+00	17.892612	218.4423528	
9.72E+06	4.97E-05	3.57E-10	3.92E+00	17.892608	218.4425603	
9.80E+06	4.98E-05	0.00E+00	3.93E+00	17.892604	218.442768	
9.88E+06	5.00E-05	1.59E-10	3.94E+00	17.892600	218.4429766	
9.96E+06	5.01E-05	4.41E-10	3.96E+00	17.892596	218.4431858	
1.00E+07	5.01E-05	0.00E+00	3.96E+00	17.892592	218.4433951	
1.01E+07	5.00E-05	1.68E-10	3.95E+00	17.892588	218.4436041	
1.02E+07	4.99E-05	0.00E+00	3.95E+00	17.892584	218.4438128	
1.03E+07	5.00E-05	0.00E+00	3.94E+00	17.892580	218.4440214	
1.04E+07	5.00E-05	4.28E-10	3.95E+00	17.892576	218.4442301	
1.04E+07	4.99E-05	0.00E+00	3.94E+00	17.892572	218.4444386	
1.05E+07	4.99E-05	0.00E+00	3.94E+00	17.892569	218.4446469	
1.06E+07	4.99E-05	2.05E-09	3.94E+00	17.892565	218.4448551	
1.07E+07	4.98E-05	0.00E+00	3.94E+00	17.892561	218.4450634	
1.07E+07	4.99E-05	1.07E-07	3.94E+00	17.892557	218.4452716	
1.08E+07	4.98E-05	0.00E+00	3.94E+00	17.892553	218.4454797	
1.09E+07	4.97E-05	0.00E+00	3.93E+00	17.892549	218.4456874	
1.10E+07	4.97E-05	2.27E-10	3.92E+00	17.892545	218.4458949	
1.11E+07	4.98E-05	2.50E-08	3.93E+00	17.892541	218.4461026	
1.11E+07	4.98E-05	2.62E-10	3.93E+00	17.892537	218.4463106	
1.12E+07	5.01E-05	9.41E-10	3.95E+00	17.892533	218.4465192	
1.13E+07	5.00E-05	0.00E+00	3.95E+00	17.892529	218.4467283	
1.14E+07	4.99E-05	2.16E-10	3.95E+00	17.892525	218.4469371	
1.15E+07	5.00E-05	0.00E+00	3.95E+00	17.892521	218.4471459	
1.15E+07	4.99E-05	2.21E-10	3.95E+00	17.892517	218.4473546	
1.16E+07	4.98E-05	7.35E-10	3.94E+00	17.892513	218.4475627	
1.17E+07	4.97E-05	4.86E-10	3.93E+00	17.892509	218.4477705	
1.18E+07	4.97E-05	7.55E-09	3.93E+00	17.892506	218.4479782	

1.19E+07	4.96E-05	1.95E-09	3.92E+00	17.892502	218.4481856	
1.19E+07	4.95E-05	0.00E+00	3.91E+00	17.892498	218.4483925	
1.20E+07	4.96E-05	1.11E-08	3.91E+00	17.892494	218.4485995	
1.21E+07	4.97E-05	0.00E+00	3.92E+00	17.892490	218.4488069	
1.22E+07	4.97E-05	0.00E+00	3.92E+00	17.892486	218.4490144	
1.22E+07	4.97E-05	0.00E+00	3.93E+00	17.892482	218.449222	
1.23E+07	4.98E-05	3.83E-09	3.93E+00	17.892478	218.4494299	
1.24E+07	4.99E-05	2.06E-10	3.94E+00	17.892474	218.4496382	
1.25E+07	5.02E-05	2.66E-08	3.95E+00	17.892470	218.4498472	
1.26E+07	4.99E-05	2.70E-10	3.95E+00	17.892466	218.4500563	
1.26E+07	4.98E-05	0.00E+00	3.94E+00	17.892462	218.4502646	
1.27E+07	5.00E-05	1.07E-09	3.94E+00	17.892458	218.450473	
1.28E+07	5.00E-05	5.79E-10	3.95E+00	17.892454	218.4506817	
1.29E+07	4.98E-05	2.63E-08	3.94E+00	17.892450	218.4508901	
1.30E+07	5.00E-05	0.00E+00	3.94E+00	17.892447	218.4510985	
1.30E+07	4.99E-05	4.16E-09	3.95E+00	17.892443	218.4513072	
1.31E+07	4.99E-05	4.98E-10	3.94E+00	17.892439	218.4515157	
1.32E+07	5.00E-05	0.00E+00	3.95E+00	17.892435	218.4517243	
1.33E+07	5.01E-05	0.00E+00	3.95E+00	17.892431	218.4519334	
1.34E+07	4.99E-05	1.67E-10	3.95E+00	17.892427	218.4521424	
1.34E+07	4.99E-05	1.05E-09	3.94E+00	17.892423	218.4523508	
1.35E+07	4.98E-05	3.00E-10	3.94E+00	17.892419	218.4525589	
1.36E+07	4.99E-05	1.26E-09	3.94E+00	17.892415	218.4527672	
1.37E+07	5.00E-05	0.00E+00	3.95E+00	17.892411	218.452976	
1.37E+07	5.02E-05	2.96E-10	3.96E+00	17.892407	218.4531852	
1.38E+07	5.01E-05	2.16E-09	3.96E+00	17.892403	218.4533946	
1.39E+07	5.01E-05	0.00E+00	3.96E+00	17.892399	218.4536038	
1.40E+07	5.00E-05	1.87E-08	3.95E+00	17.892395	218.4538129	
1.41E+07	5.02E-05	0.00E+00	3.96E+00	17.892391	218.4540222	
1.41E+07	5.03E-05	2.34E-10	3.97E+00	17.892387	218.4542323	
1.42E+07	5.00E-05	1.47E-09	3.96E+00	17.892383	218.4544419	
1.43E+07	5.00E-05	0.00E+00	3.95E+00	17.892379	218.4546509	
1.44E+07	5.00E-05	2.91E-09	3.95E+00	17.892375	218.4548597	
1.45E+07	5.00E-05	2.78E-10	3.95E+00	17.892371	218.4550685	
1.45E+07	5.00E-05	1.77E-09	3.95E+00	17.892368	218.4552774	
1.46E+07	4.98E-05	0.00E+00	3.94E+00	17.892364	218.4554858	
1.47E+07	4.97E-05	2.70E-09	3.93E+00	17.892360	218.4556936	
1.48E+07	4.98E-05	1.44E-09	3.93E+00	17.892356	218.4559015	
1.49E+07	4.98E-05	2.20E-09	3.93E+00	17.892352	218.4561095	
1.49E+07	5.00E-05	1.83E-09	3.94E+00	17.892348	218.4563178	
1.50E+07	5.01E-05	0.00E+00	3.95E+00	17.892344	218.4565268	
1.51E+07	5.03E-05	3.72E-09	3.96E+00	17.892340	218.4567365	
1.52E+07	5.00E-05	5.94E-09	3.96E+00	17.892336	218.456946	
1.52E+07	5.01E-05	2.28E-10	3.95E+00	17.892332	218.4571551	
1.53E+07	5.02E-05	5.61E-10	3.96E+00	17.892328	218.4573647	
1.54E+07	5.02E-05	2.80E-08	3.97E+00	17.892324	218.4575745	
1.55E+07	5.00E-05	0.00E+00	3.96E+00	17.892320	218.4577837	
1.56E+07	4.99E-05	1.78E-10	3.94E+00	17.892316	218.4579923	
1.56E+07	5.00E-05	0.00E+00	3.95E+00	17.892312	218.4582009	
1.57E+07	4.99E-05	3.44E-10	3.95E+00	17.892308	218.4584097	

1.58E+07	4.99E-05	2.31E-10	3.94E+00	17.892304	218.4586181	
1.59E+07	4.97E-05	0.00E+00	3.93E+00	17.892300	218.458826	
1.60E+07	4.97E-05	7.15E-10	3.92E+00	17.892297	218.4590336	
1.60E+07	4.97E-05	0.00E+00	3.93E+00	17.892293	218.4592413	
1.61E+07	4.97E-05	0.00E+00	3.93E+00	17.892289	218.459449	
1.62E+07	4.99E-05	0.00E+00	3.93E+00	17.892285	218.4596571	
1.63E+07	4.96E-05	0.00E+00	3.93E+00	17.892281	218.459865	
1.64E+07	5.10E-05	0.00E+00	4.10E+00	17.892277	218.4600817	
1.64E+07	5.09E-05	0.00E+00	4.15E+00	17.892273	218.4603011	
1.65E+07	5.09E-05	3.43E-10	4.14E+00	17.892268	218.4605201	
1.66E+07	5.11E-05	0.00E+00	4.15E+00	17.892264	218.4607396	
1.67E+07	5.11E-05	2.52E-10	4.16E+00	17.892260	218.4609596	
1.68E+07	5.12E-05	9.06E-10	4.16E+00	17.892256	218.4611799	
1.68E+07	5.11E-05	0.00E+00	4.15E+00	17.892252	218.4613996	
1.69E+07	5.10E-05	0.00E+00	4.15E+00	17.892248	218.4616193	
1.70E+07	5.11E-05	2.86E-09	4.15E+00	17.892243	218.461839	
1.71E+07	5.12E-05	1.10E-09	4.16E+00	17.892239	218.4620591	
1.72E+07	5.11E-05	0.00E+00	4.16E+00	17.892235	218.4622791	
1.73E+07	5.10E-05	1.57E-10	4.16E+00	17.892231	218.4624991	
1.73E+07	5.11E-05	5.84E-09	4.16E+00	17.892227	218.462719	
1.74E+07	5.12E-05	7.81E-10	4.17E+00	17.892223	218.4629394	
1.75E+07	5.12E-05	0.00E+00	4.16E+00	17.892218	218.4631596	
1.76E+07	5.12E-05	2.37E-09	4.17E+00	17.892214	218.4633801	
1.77E+07	5.11E-05	0.00E+00	4.16E+00	17.892210	218.4636002	
1.77E+07	5.11E-05	0.00E+00	4.16E+00	17.892206	218.4638203	
1.78E+07	5.12E-05	0.00E+00	4.16E+00	17.892202	218.4640402	
1.79E+07	5.12E-05	0.00E+00	4.17E+00	17.892198	218.4642607	
1.80E+07	5.14E-05	0.00E+00	4.18E+00	17.892194	218.4644815	
1.81E+07	5.15E-05	2.52E-10	4.19E+00	17.892189	218.4647029	
1.81E+07	5.14E-05	3.93E-10	4.18E+00	17.892185	218.4649242	
1.82E+07	5.15E-05	0.00E+00	4.19E+00	17.892181	218.4651458	
1.83E+07	5.15E-05	2.61E-10	4.19E+00	17.892177	218.4653676	
1.84E+07	5.15E-05	0.00E+00	4.19E+00	17.892173	218.4655893	
1.85E+07	5.16E-05	4.81E-10	4.19E+00	17.892168	218.4658109	
1.86E+07	5.14E-05	1.46E-09	4.19E+00	17.892164	218.4660327	
1.86E+07	5.14E-05	1.53E-10	4.19E+00	17.892160	218.4662541	
1.87E+07	5.16E-05	2.14E-10	4.19E+00	17.892156	218.466476	
1.88E+07	5.17E-05	8.99E-10	4.20E+00	17.892152	218.4666981	
1.89E+07	5.18E-05	0.00E+00	4.21E+00	17.892147	218.466921	
1.90E+07	5.18E-05	4.60E-09	4.22E+00	17.892143	218.4671443	
1.90E+07	5.19E-05	0.00E+00	4.22E+00	17.892139	218.4673677	
1.91E+07	5.18E-05	9.18E-10	4.22E+00	17.892135	218.4675908	
1.92E+07	5.16E-05	5.78E-10	4.21E+00	17.892131	218.4678134	
1.93E+07	5.17E-05	1.59E-10	4.20E+00	17.892126	218.4680358	
1.94E+07	5.16E-05	8.02E-10	4.20E+00	17.892122	218.468258	
1.94E+07	5.16E-05	0.00E+00	4.20E+00	17.892118	218.4684799	
1.95E+07	5.16E-05	0.00E+00	4.20E+00	17.892114	218.4687023	
1.96E+07	5.16E-05	0.00E+00	4.20E+00	17.892110	218.4689244	
1.97E+07	5.15E-05	0.00E+00	4.20E+00	17.892105	218.4691463	
1.98E+07	5.16E-05	2.08E-10	4.19E+00	17.892101	218.4693681	

1.99E+07	5.17E-05	2.14E-10	4.21E+00	17.892097	218.4695907	
1.99E+07	5.18E-05	0.00E+00	4.21E+00	17.892093	218.4698135	
2.00E+07	5.18E-05	1.83E-09	4.22E+00	17.892088	218.4700365	
2.01E+07	5.20E-05	1.36E-09	4.22E+00	17.892084	218.4702597	
2.02E+07	5.20E-05	2.03E-10	4.23E+00	17.892080	218.4704836	
2.03E+07	5.20E-05	6.16E-09	4.23E+00	17.892076	218.4707075	
2.03E+07	5.17E-05	5.18E-10	4.22E+00	17.892072	218.4709309	
2.04E+07	5.16E-05	6.85E-10	4.20E+00	17.892067	218.4711532	
2.05E+07	5.16E-05	4.79E-10	4.20E+00	17.892063	218.4713755	
2.06E+07	5.15E-05	8.02E-10	4.19E+00	17.892059	218.4715974	
2.07E+07	5.16E-05	4.30E-10	4.20E+00	17.892055	218.4718193	
2.08E+07	5.15E-05	0.00E+00	4.19E+00	17.892051	218.4720411	
2.08E+07	5.15E-05	0.00E+00	4.19E+00	17.892046	218.4722628	
2.09E+07	5.13E-05	4.40E-10	4.19E+00	17.892042	218.4724842	
2.10E+07	5.13E-05	9.87E-10	4.18E+00	17.892038	218.4727052	
2.11E+07	5.14E-05	1.64E-10	4.18E+00	17.892034	218.4729261	
2.12E+07	5.15E-05	2.10E-09	4.19E+00	17.892030	218.4731476	
2.12E+07	5.14E-05	1.11E-08	4.19E+00	17.892025	218.4733691	
2.13E+07	5.15E-05	1.69E-10	4.19E+00	17.892021	218.4735908	
2.14E+07	5.15E-05	1.68E-10	4.19E+00	17.892017	218.4738123	
2.15E+07	5.13E-05	9.33E-10	4.18E+00	17.892013	218.4740336	
2.16E+07	5.13E-05	7.73E-10	4.18E+00	17.892009	218.4742545	
2.16E+07	5.13E-05	0.00E+00	4.18E+00	17.892005	218.4744756	
2.17E+07	5.12E-05	1.58E-10	4.17E+00	17.892000	218.474696	
2.18E+07	5.12E-05	0.00E+00	4.17E+00	17.891996	218.4749166	
2.19E+07	5.13E-05	5.52E-10	4.17E+00	17.891992	218.4751373	
2.20E+07	5.12E-05	2.55E-10	4.17E+00	17.891988	218.4753582	
2.21E+07	5.13E-05	5.64E-10	4.17E+00	17.891984	218.4755786	
2.21E+07	5.11E-05	4.56E-10	4.17E+00	17.891980	218.4757991	
2.22E+07	5.11E-05	0.00E+00	4.16E+00	17.891975	218.4760192	
2.23E+07	5.10E-05	2.47E-10	4.16E+00	17.891971	218.476239	
2.24E+07	5.10E-05	3.00E-09	4.15E+00	17.891967	218.4764585	
2.25E+07	5.12E-05	0.00E+00	4.16E+00	17.891963	218.4766787	
2.25E+07	5.12E-05	0.00E+00	4.17E+00	17.891959	218.4768992	
2.26E+07	5.12E-05	7.21E-10	4.16E+00	17.891955	218.4771195	
2.27E+07	5.11E-05	0.00E+00	4.16E+00	17.891950	218.4773394	
2.28E+07	5.10E-05	6.10E-10	4.15E+00	17.891946	218.4775592	
2.29E+07	5.10E-05	4.85E-10	4.15E+00	17.891942	218.4777788	
2.29E+07	5.11E-05	0.00E+00	4.16E+00	17.891938	218.4779987	
2.30E+07	5.12E-05	0.00E+00	4.16E+00	17.891934	218.4782186	
2.31E+07	5.10E-05	0.00E+00	4.16E+00	17.891930	218.4784388	
2.32E+07	5.07E-05	5.07E-09	4.14E+00	17.891926	218.4786578	
2.33E+07	5.08E-05	2.41E-10	4.13E+00	17.891921	218.4788762	
2.34E+07	5.07E-05	1.43E-09	4.12E+00	17.891917	218.4790944	
2.34E+07	5.06E-05	1.98E-09	4.12E+00	17.891913	218.4793125	
2.35E+07	5.09E-05	1.56E-09	4.13E+00	17.891909	218.4795312	
2.36E+07	5.10E-05	2.29E-09	4.15E+00	17.891905	218.4797507	
2.37E+07	5.09E-05	2.81E-10	4.14E+00	17.891901	218.47997	
2.38E+07	5.05E-05	6.06E-09	4.13E+00	17.891897	218.4801883	
2.38E+07	5.08E-05	0.00E+00	4.12E+00	17.891892	218.4804065	

2.39E+07	5.10E-05	1.79E-10	4.14E+00	17.891888	218.4806257	
2.40E+07	5.09E-05	1.10E-09	4.14E+00	17.891884	218.4808448	
2.41E+07	5.09E-05	0.00E+00	4.14E+00	17.891880	218.481064	
2.42E+07	5.07E-05	0.00E+00	4.14E+00	17.891876	218.4812829	
2.42E+07	5.05E-05	0.00E+00	4.12E+00	17.891872	218.4815009	
2.43E+07	5.08E-05	4.70E-10	4.12E+00	17.891868	218.4817188	
2.44E+07	5.07E-05	0.00E+00	4.13E+00	17.891864	218.4819374	
2.45E+07	5.03E-05	9.15E-10	4.11E+00	17.891859	218.4821551	
2.46E+07	5.04E-05	0.00E+00	4.10E+00	17.891855	218.482372	
2.47E+07	5.05E-05	0.00E+00	4.10E+00	17.891851	218.4825891	
2.47E+07	5.05E-05	5.42E-10	4.11E+00	17.891847	218.4828065	
2.48E+07	5.04E-05	0.00E+00	4.10E+00	17.891843	218.4830237	
2.49E+07	5.04E-05	1.47E-10	4.10E+00	17.891839	218.4832407	
2.50E+07	5.06E-05	9.32E-10	4.10E+00	17.891835	218.4834578	
2.51E+07	5.06E-05	1.42E-09	4.12E+00	17.891831	218.4836758	
2.51E+07	5.06E-05	0.00E+00	4.12E+00	17.891827	218.4838938	
2.52E+07	5.05E-05	1.32E-09	4.12E+00	17.891822	218.4841115	
2.53E+07	5.06E-05	0.00E+00	4.11E+00	17.891818	218.484329	
2.54E+07	5.07E-05	9.68E-10	4.12E+00	17.891814	218.4845471	
2.55E+07	5.07E-05	3.91E-10	4.13E+00	17.891810	218.4847655	
2.56E+07	5.07E-05	3.41E-10	4.13E+00	17.891806	218.4849839	
2.56E+07	5.06E-05	5.16E-10	4.12E+00	17.891802	218.4852017	
2.57E+07	5.04E-05	7.70E-10	4.11E+00	17.891798	218.4854191	
2.58E+07	5.03E-05	0.00E+00	4.10E+00	17.891794	218.485636	
2.59E+07	5.04E-05	3.14E-10	4.10E+00	17.891790	218.4858529	
2.60E+07	5.05E-05	2.88E-10	4.10E+00	17.891785	218.4860699	
2.60E+07	5.07E-05	0.00E+00	4.12E+00	17.891781	218.4862879	
2.61E+07	5.07E-05	0.00E+00	4.12E+00	17.891777	218.486506	
2.62E+07	5.06E-05	6.55E-10	4.12E+00	17.891773	218.4867242	
2.63E+07	5.05E-05	5.10E-10	4.11E+00	17.891769	218.4869418	
2.64E+07	5.04E-05	1.48E-10	4.11E+00	17.891765	218.4871591	
2.64E+07	5.02E-05	0.00E+00	4.10E+00	17.891761	218.4873758	
2.65E+07	5.02E-05	1.65E-09	4.09E+00	17.891757	218.4875922	
2.66E+07	5.02E-05	0.00E+00	4.08E+00	17.891753	218.4878082	
2.67E+07	5.02E-05	0.00E+00	4.09E+00	17.891748	218.4880246	
2.68E+07	5.03E-05	0.00E+00	4.09E+00	17.891744	218.488241	
2.69E+07	5.03E-05	2.80E-09	4.09E+00	17.891740	218.4884575	
2.69E+07	5.02E-05	0.00E+00	4.09E+00	17.891736	218.4886737	
2.70E+07	5.00E-05	1.03E-09	4.08E+00	17.891732	218.4888896	
2.71E+07	4.99E-05	0.00E+00	4.07E+00	17.891728	218.4891047	
2.72E+07	4.99E-05	0.00E+00	4.06E+00	17.891724	218.4893196	
2.73E+07	5.00E-05	0.00E+00	4.06E+00	17.891720	218.4895346	
2.73E+07	5.00E-05	1.63E-09	4.07E+00	17.891716	218.4897501	
2.74E+07	5.01E-05	0.00E+00	4.08E+00	17.891712	218.4899658	
2.75E+07	5.00E-05	7.11E-10	4.07E+00	17.891708	218.4901814	
2.76E+07	5.00E-05	4.30E-10	4.06E+00	17.891704	218.4903964	
2.77E+07	5.01E-05	5.15E-10	4.07E+00	17.891700	218.4906119	
2.77E+07	5.01E-05	2.47E-10	4.07E+00	17.891696	218.4908275	
2.78E+07	5.00E-05	2.12E-10	4.07E+00	17.891691	218.4910431	
2.79E+07	4.99E-05	1.83E-10	4.06E+00	17.891687	218.4912581	

2.80E+07	5.00E-05	3.67E-10	4.07E+00	17.891683	218.4914732	
2.81E+07	5.00E-05	0.00E+00	4.07E+00	17.891679	218.4916885	
2.82E+07	4.99E-05	0.00E+00	4.07E+00	17.891675	218.4919036	
2.82E+07	4.99E-05	1.67E-10	4.06E+00	17.891671	218.4921182	
2.83E+07	4.98E-05	9.55E-10	4.06E+00	17.891667	218.4923328	
2.84E+07	4.99E-05	1.34E-09	4.06E+00	17.891663	218.4925475	
2.85E+07	4.99E-05	6.65E-09	4.06E+00	17.891659	218.4927624	
2.86E+07	4.97E-05	6.19E-10	4.05E+00	17.891655	218.4929768	
2.86E+07	4.97E-05	1.96E-10	4.04E+00	17.891651	218.4931908	
2.87E+07	4.97E-05	5.46E-10	4.04E+00	17.891647	218.4934047	
2.88E+07	4.99E-05	1.56E-09	4.05E+00	17.891643	218.4936192	
2.89E+07	5.00E-05	0.00E+00	4.06E+00	17.891639	218.4938342	
2.90E+07	5.00E-05	1.80E-10	4.07E+00	17.891635	218.4940495	
2.91E+07	4.98E-05	1.04E-09	4.06E+00	17.891631	218.4942644	
2.91E+07	4.99E-05	6.70E-09	4.06E+00	17.891627	218.4944791	
2.92E+07	4.99E-05	2.18E-10	4.05E+00	17.891622	218.4946936	
2.93E+07	4.98E-05	9.50E-10	4.06E+00	17.891618	218.4949083	
2.94E+07	4.98E-05	8.97E-10	4.05E+00	17.891614	218.4951227	
2.95E+07	4.96E-05	0.00E+00	4.04E+00	17.891610	218.4953367	
2.95E+07	4.95E-05	1.75E-09	4.03E+00	17.891606	218.4955498	
2.96E+07	4.96E-05	8.77E-10	4.03E+00	17.891602	218.4957631	
2.97E+07	4.96E-05	1.07E-09	4.04E+00	17.891598	218.4959767	
2.98E+07	4.97E-05	5.45E-10	4.04E+00	17.891594	218.4961905	
2.99E+07	4.98E-05	4.66E-09	4.04E+00	17.891590	218.4964045	
2.99E+07	4.99E-05	1.25E-09	4.06E+00	17.891586	218.4966191	
3.00E+07	4.99E-05	1.07E-09	4.06E+00	17.891582	218.496834	
3.01E+07	5.01E-05	1.32E-09	4.07E+00	17.891578	218.4970493	
3.02E+07	5.01E-05	0.00E+00	4.07E+00	17.891574	218.4972647	
3.03E+07	5.02E-05	0.00E+00	4.08E+00	17.891570	218.4974808	
3.04E+07	5.04E-05	3.17E-07	4.09E+00	17.891566	218.4976974	
3.04E+07	5.03E-05	0.00E+00	4.10E+00	17.891562	218.4979142	
3.05E+07	5.02E-05	1.44E-09	4.08E+00	17.891558	218.4981303	
3.06E+07	5.00E-05	0.00E+00	4.08E+00	17.891553	218.4983461	
3.07E+07	5.02E-05	0.00E+00	4.08E+00	17.891549	218.4985619	
3.08E+07	5.02E-05	2.07E-10	4.09E+00	17.891545	218.4987781	
3.08E+07	5.00E-05	5.13E-10	4.07E+00	17.891541	218.4989937	
3.09E+07	5.00E-05	1.34E-09	4.07E+00	17.891537	218.499209	
3.10E+07	5.02E-05	5.15E-10	4.08E+00	17.891533	218.4994248	
3.11E+07	5.00E-05	1.92E-10	4.08E+00	17.891529	218.4996406	
3.12E+07	5.02E-05	5.66E-09	4.07E+00	17.891525	218.4998562	
3.12E+07	5.00E-05	2.79E-09	4.08E+00	17.891521	218.500072	
3.13E+07	5.01E-05	5.62E-10	4.08E+00	17.891517	218.5002877	
3.14E+07	5.04E-05	1.68E-10	4.09E+00	17.891513	218.5005042	
3.15E+07	5.04E-05	0.00E+00	4.10E+00	17.891509	218.5007211	
3.16E+07	5.01E-05	4.59E-10	4.09E+00	17.891504	218.5009376	
3.17E+07	4.99E-05	1.62E-09	4.07E+00	17.891500	218.5011531	
3.17E+07	5.00E-05	0.00E+00	4.07E+00	17.891496	218.5013683	
3.18E+07	5.00E-05	4.75E-10	4.06E+00	17.891492	218.5015834	
3.19E+07	5.01E-05	2.70E-10	4.07E+00	17.891488	218.5017989	
3.20E+07	4.98E-05	0.00E+00	4.06E+00	17.891484	218.5020139	

3.21E+07	4.97E-05	0.00E+00	4.05E+00	17.891480	218.5022282	
3.21E+07	4.96E-05	0.00E+00	4.04E+00	17.891476	218.5024417	
3.22E+07	4.95E-05	0.00E+00	4.03E+00	17.891472	218.502655	
3.23E+07	4.94E-05	4.00E-10	4.02E+00	17.891468	218.5028679	
3.24E+07	4.97E-05	6.44E-10	4.03E+00	17.891464	218.5030813	
3.25E+07	5.00E-05	5.62E-10	4.05E+00	17.891460	218.5032958	
3.26E+07	4.96E-05	0.00E+00	4.05E+00	17.891456	218.5035103	
3.26E+07	5.03E-05	2.04E-10	4.06E+00	17.891452	218.5037253	
3.27E+07	5.04E-05	1.65E-10	4.10E+00	17.891448	218.5039422	
3.28E+07	5.03E-05	2.07E-10	4.09E+00	17.891444	218.5041588	
3.29E+07	5.04E-05	0.00E+00	4.10E+00	17.891440	218.5043759	
3.30E+07	5.05E-05	0.00E+00	4.11E+00	17.891435	218.5045932	
3.30E+07	5.05E-05	0.00E+00	4.11E+00	17.891431	218.5048107	
3.31E+07	5.05E-05	0.00E+00	4.11E+00	17.891427	218.5050281	
3.32E+07	5.04E-05	1.88E-09	4.11E+00	17.891423	218.5052455	
3.33E+07	5.05E-05	0.00E+00	4.11E+00	17.891419	218.505463	
3.34E+07	5.06E-05	0.00E+00	4.11E+00	17.891415	218.5056808	
3.34E+07	5.05E-05	6.56E-10	4.11E+00	17.891411	218.5058983	
3.35E+07	5.05E-05	3.34E-10	4.11E+00	17.891407	218.5061158	
3.36E+07	5.06E-05	0.00E+00	4.11E+00	17.891403	218.5063336	
3.37E+07	5.07E-05	0.00E+00	4.12E+00	17.891398	218.5065518	
3.38E+07	5.06E-05	3.11E-10	4.12E+00	17.891394	218.5067699	
3.39E+07	5.05E-05	1.42E-10	4.12E+00	17.891390	218.5069879	
3.39E+07	5.06E-05	8.43E-10	4.12E+00	17.891386	218.5072057	
3.40E+07	5.06E-05	0.00E+00	4.12E+00	17.891382	218.5074236	
3.41E+07	5.07E-05	1.72E-08	4.12E+00	17.891378	218.5076417	
3.42E+07	5.07E-05	1.95E-10	4.13E+00	17.891374	218.5078603	
3.43E+07	5.06E-05	1.68E-10	4.12E+00	17.891370	218.5080786	
3.43E+07	5.07E-05	0.00E+00	4.12E+00	17.891365	218.5082968	
3.44E+07	5.05E-05	3.73E-10	4.11E+00	17.891361	218.5085145	
3.45E+07	5.05E-05	0.00E+00	4.11E+00	17.891357	218.5087321	
3.46E+07	5.06E-05	8.38E-10	4.12E+00	17.891353	218.5089499	
3.47E+07	5.07E-05	3.27E-10	4.13E+00	17.891349	218.5091683	
3.47E+07	5.08E-05	0.00E+00	4.13E+00	17.891345	218.5093868	
3.48E+07	5.09E-05	1.50E-10	4.14E+00	17.891341	218.5096059	
3.49E+07	5.08E-05	5.36E-10	4.14E+00	17.891337	218.509825	
3.50E+07	5.07E-05	0.00E+00	4.13E+00	17.891332	218.5100437	
3.51E+07	5.07E-05	1.65E-10	4.12E+00	17.891328	218.510262	
3.52E+07	5.08E-05	9.19E-10	4.13E+00	17.891324	218.5104809	
3.52E+07	5.09E-05	3.42E-09	4.14E+00	17.891320	218.5107	
3.53E+07	5.09E-05	0.00E+00	4.14E+00	17.891316	218.5109192	
3.54E+07	5.10E-05	0.00E+00	4.14E+00	17.891312	218.5111382	
3.55E+07	5.10E-05	1.18E-09	4.15E+00	17.891308	218.5113579	
3.56E+07	5.09E-05	0.00E+00	4.15E+00	17.891303	218.5115774	
3.56E+07	5.08E-05	7.02E-10	4.14E+00	17.891299	218.5117966	
3.57E+07	5.09E-05	1.20E-09	4.13E+00	17.891295	218.5120154	
3.58E+07	5.09E-05	0.00E+00	4.14E+00	17.891291	218.5122346	
3.59E+07	5.11E-05	9.11E-10	4.15E+00	17.891287	218.5124544	
3.60E+07	5.11E-05	7.58E-10	4.16E+00	17.891283	218.5126746	
3.60E+07	5.08E-05	0.00E+00	4.14E+00	17.891279	218.5128939	

3.61E+07	5.07E-05	2.16E-10	4.13E+00	17.891274	218.5131128	
3.62E+07	5.07E-05	2.60E-10	4.13E+00	17.891270	218.5133314	
3.63E+07	5.07E-05	0.00E+00	4.13E+00	17.891266	218.5135499	
3.64E+07	5.07E-05	1.81E-10	4.12E+00	17.891262	218.5137681	
3.65E+07	5.07E-05	0.00E+00	4.13E+00	17.891258	218.5139865	
3.65E+07	5.07E-05	1.24E-08	4.13E+00	17.891254	218.5142049	
3.66E+07	5.09E-05	0.00E+00	4.14E+00	17.891250	218.514424	
3.67E+07	5.10E-05	1.42E-09	4.15E+00	17.891246	218.5146435	
3.68E+07	5.11E-05	0.00E+00	4.16E+00	17.891241	218.5148634	
3.69E+07	5.10E-05	2.10E-10	4.16E+00	17.891237	218.5150834	
3.69E+07	5.10E-05	1.70E-10	4.15E+00	17.891233	218.5153033	
3.70E+07	5.10E-05	0.00E+00	4.15E+00	17.891229	218.515523	
3.71E+07	5.08E-05	3.70E-10	4.14E+00	17.891225	218.5157424	
3.72E+07	5.07E-05	3.95E-10	4.13E+00	17.891221	218.5159611	
3.73E+07	5.07E-05	3.39E-10	4.13E+00	17.891217	218.5161797	
3.74E+07	5.06E-05	1.79E-09	4.12E+00	17.891212	218.5163977	
3.74E+07	5.06E-05	3.15E-08	4.12E+00	17.891208	218.5166156	
3.75E+07	5.06E-05	8.46E-10	4.12E+00	17.891204	218.5168336	
3.76E+07	5.06E-05	0.00E+00	4.12E+00	17.891200	218.5170519	
3.77E+07	5.07E-05	0.00E+00	4.12E+00	17.891196	218.5172699	
3.78E+07	5.05E-05	3.16E-09	4.12E+00	17.891192	218.5174879	
3.78E+07	5.02E-05	2.96E-09	4.10E+00	17.891188	218.517705	
3.79E+07	5.04E-05	5.41E-10	4.10E+00	17.891184	218.5179219	
3.80E+07	5.05E-05	0.00E+00	4.10E+00	17.891179	218.5181389	
3.81E+07	5.04E-05	2.68E-10	4.11E+00	17.891175	218.5183564	
3.82E+07	5.06E-05	0.00E+00	4.11E+00	17.891171	218.518574	
3.82E+07	5.05E-05	0.00E+00	4.12E+00	17.891167	218.5187918	
3.83E+07	5.03E-05	0.00E+00	4.10E+00	17.891163	218.5190089	
3.84E+07	5.04E-05	0.00E+00	4.10E+00	17.891159	218.5192259	
3.85E+07	5.02E-05	4.24E-09	4.09E+00	17.891155	218.5194425	
3.86E+07	4.99E-05	5.82E-09	4.08E+00	17.891151	218.5196583	
3.87E+07	5.01E-05	0.00E+00	4.07E+00	17.891147	218.5198735	
3.87E+07	5.03E-05	0.00E+00	4.09E+00	17.891143	218.5200898	
3.88E+07	5.04E-05	1.46E-09	4.10E+00	17.891139	218.5203068	
3.89E+07	5.05E-05	7.95E-10	4.11E+00	17.891134	218.5205243	
3.90E+07	5.06E-05	4.47E-09	4.11E+00	17.891130	218.5207417	
3.91E+07	5.07E-05	0.00E+00	4.12E+00	17.891126	218.5209598	
3.91E+07	5.07E-05	2.63E-10	4.12E+00	17.891122	218.5211782	
3.92E+07	5.08E-05	8.73E-09	4.13E+00	17.891118	218.5213968	
3.93E+07	5.10E-05	7.27E-10	4.14E+00	17.891114	218.5216157	
3.94E+07	5.08E-05	0.00E+00	4.14E+00	17.891110	218.521835	
3.95E+07	5.09E-05	0.00E+00	4.14E+00	17.891106	218.5220543	
3.95E+07	5.11E-05	1.70E-09	4.15E+00	17.891101	218.5222742	
3.96E+07	5.12E-05	1.59E-10	4.16E+00	17.891097	218.5224943	
3.97E+07	5.10E-05	0.00E+00	4.16E+00	17.891093	218.5227147	
3.98E+07	5.07E-05	1.11E-09	4.14E+00	17.891089	218.5229339	
3.99E+07	5.08E-05	0.00E+00	4.13E+00	17.891085	218.5231525	
4.00E+07	5.06E-05	0.00E+00	4.12E+00	17.891081	218.5233706	
4.00E+07	5.08E-05	1.77E-09	4.13E+00	17.891077	218.5235891	
4.01E+07	5.07E-05	0.00E+00	4.13E+00	17.891072	218.5238076	

4.02E+07	5.06E-05	0.00E+00	4.12E+00	17.891068	218.5240257	
4.03E+07	5.04E-05	0.00E+00	4.10E+00	17.891064	218.5242429	
4.04E+07	5.05E-05	0.00E+00	4.10E+00	17.891060	218.5244602	
4.04E+07	5.04E-05	2.09E-10	4.11E+00	17.891056	218.5246776	
4.05E+07	5.03E-05	0.00E+00	4.10E+00	17.891052	218.5248947	
4.06E+07	5.04E-05	0.00E+00	4.10E+00	17.891048	218.5251115	
4.07E+07	5.05E-05	1.55E-10	4.11E+00	17.891044	218.525329	
4.08E+07	5.03E-05	1.73E-10	4.10E+00	17.891040	218.5255463	
4.09E+07	5.02E-05	3.96E-10	4.09E+00	17.891035	218.5257628	
4.09E+07	4.99E-05	1.37E-09	4.07E+00	17.891031	218.5259783	
4.10E+07	4.99E-05	0.00E+00	4.06E+00	17.891027	218.5261935	
4.11E+07	4.99E-05	3.66E-10	4.06E+00	17.891023	218.5264085	
4.12E+07	4.99E-05	2.76E-10	4.06E+00	17.891019	218.5266234	
4.13E+07	4.99E-05	1.85E-10	4.06E+00	17.891015	218.5268382	
4.13E+07	4.99E-05	1.44E-10	4.06E+00	17.891011	218.5270533	
4.14E+07	4.98E-05	0.00E+00	4.06E+00	17.891007	218.5272681	
4.15E+07	4.97E-05	8.07E-10	4.05E+00	17.891003	218.5274825	
4.16E+07	4.97E-05	2.33E-10	4.04E+00	17.890999	218.5276964	
4.17E+07	4.96E-05	0.00E+00	4.04E+00	17.890995	218.5279104	
4.17E+07	4.96E-05	1.21E-09	4.04E+00	17.890991	218.5281243	
4.18E+07	4.96E-05	0.00E+00	4.04E+00	17.890987	218.5283381	
4.19E+07	4.96E-05	1.00E-08	4.03E+00	17.890983	218.5285515	
4.20E+07	4.95E-05	4.85E-10	4.03E+00	17.890979	218.528765	
4.21E+07	4.95E-05	0.00E+00	4.03E+00	17.890975	218.5289785	
4.22E+07	4.95E-05	5.45E-10	4.03E+00	17.890971	218.5291918	
4.22E+07	4.94E-05	2.37E-10	4.02E+00	17.890967	218.5294046	
4.23E+07	4.97E-05	0.00E+00	4.03E+00	17.890963	218.5296182	
4.24E+07	4.98E-05	3.15E-10	4.05E+00	17.890959	218.5298326	
4.25E+07	4.97E-05	3.33E-09	4.05E+00	17.890955	218.530047	
4.26E+07	4.99E-05	6.70E-09	4.05E+00	17.890951	218.5302614	
4.26E+07	4.99E-05	0.00E+00	4.06E+00	17.890946	218.5304766	
4.27E+07	4.97E-05	0.00E+00	4.05E+00	17.890942	218.5306913	
4.28E+07	4.99E-05	4.33E-10	4.05E+00	17.890938	218.5309059	
4.29E+07	4.97E-05	0.00E+00	4.05E+00	17.890934	218.5311201	
4.30E+07	4.96E-05	2.10E-10	4.04E+00	17.890930	218.531334	
4.30E+07	4.95E-05	7.54E-10	4.03E+00	17.890926	218.5315476	
4.31E+07	4.94E-05	2.74E-10	4.03E+00	17.890922	218.5317607	
4.32E+07	4.92E-05	3.37E-10	4.01E+00	17.890918	218.5319729	
4.33E+07	4.89E-05	4.85E-10	3.99E+00	17.890914	218.5321842	
4.34E+07	4.90E-05	0.00E+00	3.98E+00	17.890910	218.5323952	
4.35E+07	4.91E-05	4.09E-10	3.99E+00	17.890906	218.5326066	
4.35E+07	4.91E-05	2.59E-10	3.99E+00	17.890902	218.532818	
4.36E+07	4.92E-05	3.13E-10	4.00E+00	17.890898	218.53303	
4.37E+07	4.94E-05	4.55E-09	4.01E+00	17.890894	218.5332425	
4.38E+07	4.95E-05	0.00E+00	4.02E+00	17.890890	218.5334556	
4.39E+07	4.96E-05	0.00E+00	4.03E+00	17.890886	218.5336688	
4.39E+07	4.96E-05	1.72E-10	4.04E+00	17.890882	218.5338824	
4.40E+07	4.94E-05	1.41E-10	4.03E+00	17.890878	218.5340957	
4.41E+07	4.93E-05	5.76E-10	4.02E+00	17.890874	218.5343084	
4.42E+07	4.94E-05	0.00E+00	4.01E+00	17.890870	218.5345208	

4.43E+07	4.94E-05	7.10E-09	4.02E+00	17.890866	218.5347338	
4.43E+07	4.97E-05	1.78E-10	4.03E+00	17.890862	218.5349474	
4.44E+07	4.98E-05	3.58E-10	4.05E+00	17.890858	218.5351617	
4.45E+07	4.99E-05	0.00E+00	4.05E+00	17.890854	218.5353762	
4.46E+07	4.99E-05	0.00E+00	4.06E+00	17.890850	218.5355913	
4.47E+07	4.99E-05	1.01E-09	4.06E+00	17.890846	218.5358065	
4.48E+07	4.99E-05	0.00E+00	4.06E+00	17.890842	218.5360216	
4.48E+07	4.99E-05	4.56E-08	4.06E+00	17.890838	218.5362364	
4.49E+07	5.00E-05	4.73E-10	4.07E+00	17.890834	218.5364518	
4.50E+07	5.04E-05	3.64E-10	4.09E+00	17.890830	218.5366684	
4.51E+07	5.03E-05	3.61E-09	4.10E+00	17.890825	218.5368856	
4.52E+07	5.01E-05	0.00E+00	4.08E+00	17.890821	218.5371018	
4.52E+07	5.02E-05	8.68E-10	4.08E+00	17.890817	218.5373179	
4.53E+07	5.02E-05	1.76E-10	4.09E+00	17.890813	218.5375342	
4.54E+07	5.03E-05	0.00E+00	4.09E+00	17.890809	218.5377508	
4.55E+07	5.05E-05	6.78E-10	4.10E+00	17.890805	218.5379679	
4.56E+07	5.05E-05	2.50E-10	4.11E+00	17.890801	218.5381857	
4.57E+07	5.06E-05	2.91E-10	4.11E+00	17.890797	218.5384036	
4.57E+07	5.05E-05	8.11E-10	4.11E+00	17.890793	218.5386214	
4.58E+07	5.05E-05	1.30E-09	4.11E+00	17.890789	218.5388388	
4.59E+07	5.04E-05	2.62E-10	4.11E+00	17.890784	218.5390562	
4.60E+07	5.06E-05	5.19E-10	4.11E+00	17.890780	218.5392739	
4.61E+07	5.07E-05	0.00E+00	4.12E+00	17.890776	218.5394924	
4.61E+07	5.08E-05	1.78E-09	4.13E+00	17.890772	218.539711	
4.62E+07	5.08E-05	8.98E-10	4.14E+00	17.890768	218.53993	
4.63E+07	5.07E-05	2.50E-09	4.13E+00	17.890764	218.5401488	
4.64E+07	5.05E-05	3.88E-10	4.12E+00	17.890760	218.540367	
4.65E+07	5.05E-05	0.00E+00	4.11E+00	17.890756	218.5405846	
4.65E+07	5.03E-05	4.22E-10	4.11E+00	17.890751	218.540802	
4.66E+07	5.04E-05	8.27E-10	4.10E+00	17.890747	218.5410191	
4.67E+07	5.06E-05	2.54E-10	4.11E+00	17.890743	218.5412368	
4.68E+07	5.07E-05	7.53E-09	4.12E+00	17.890739	218.5414549	
4.69E+07	5.08E-05	2.57E-09	4.13E+00	17.890735	218.5416737	
4.70E+07	5.07E-05	0.00E+00	4.13E+00	17.890731	218.5418927	
4.70E+07	5.09E-05	0.00E+00	4.14E+00	17.890727	218.5421119	
4.71E+07	5.09E-05	1.66E-10	4.14E+00	17.890723	218.5423311	
4.72E+07	5.06E-05	0.00E+00	4.13E+00	17.890718	218.5425499	
4.73E+07	5.05E-05	3.12E-08	4.12E+00	17.890714	218.5427679	
4.74E+07	5.04E-05	0.00E+00	4.11E+00	17.890710	218.5429853	
4.74E+07	5.05E-05	3.30E-10	4.10E+00	17.890706	218.5432024	
4.75E+07	5.06E-05	6.08E-09	4.11E+00	17.890702	218.5434201	
4.76E+07	5.05E-05	3.58E-10	4.11E+00	17.890698	218.5436379	
4.77E+07	5.00E-05	1.61E-10	4.09E+00	17.890694	218.5438546	
4.78E+07	5.04E-05	1.19E-09	4.08E+00	17.890690	218.5440708	
4.78E+07	5.04E-05	1.40E-09	4.10E+00	17.890686	218.5442879	
4.79E+07	5.02E-05	1.36E-09	4.09E+00	17.890682	218.5445046	
4.80E+07	5.04E-05	0.00E+00	4.09E+00	17.890677	218.5447213	
4.81E+07	5.08E-05	7.33E-09	4.11E+00	17.890673	218.5449391	
4.82E+07	5.04E-05	0.00E+00	4.12E+00	17.890669	218.5451572	
4.83E+07	5.01E-05	2.54E-10	4.09E+00	17.890665	218.5453737	

4.83E+07	5.00E-05	1.78E-09	4.07E+00	17.890661	218.5455893	
4.84E+07	5.00E-05	9.33E-10	4.06E+00	17.890657	218.5458045	
4.85E+07	5.00E-05	0.00E+00	4.07E+00	17.890653	218.5460201	
4.86E+07	4.99E-05	0.00E+00	4.06E+00	17.890649	218.5462354	
4.87E+07	4.97E-05	1.40E-10	4.05E+00	17.890645	218.54645	
4.87E+07	5.05E-05	2.71E-10	4.07E+00	17.890641	218.5466658	
4.88E+07	4.99E-05	7.51E-10	4.09E+00	17.890637	218.5468822	
4.89E+07	5.07E-05	2.92E-10	4.10E+00	17.890633	218.5470992	
4.90E+07	5.07E-05	0.00E+00	4.13E+00	17.890628	218.5473178	
4.91E+07	5.06E-05	4.23E-10	4.12E+00	17.890624	218.547536	
4.92E+07	5.08E-05	5.59E-10	4.13E+00	17.890620	218.5477546	
4.92E+07	5.08E-05	1.62E-10	4.13E+00	17.890616	218.5479735	
4.93E+07	5.09E-05	0.00E+00	4.14E+00	17.890612	218.5481927	
4.94E+07	5.09E-05	1.67E-10	4.14E+00	17.890608	218.5484118	
4.95E+07	5.07E-05	3.81E-10	4.13E+00	17.890604	218.5486307	
4.96E+07	5.06E-05	0.00E+00	4.12E+00	17.890600	218.5488491	
4.96E+07	5.05E-05	1.73E-10	4.11E+00	17.890595	218.5490669	
4.97E+07	5.06E-05	0.00E+00	4.11E+00	17.890591	218.5492844	
4.98E+07	5.06E-05	1.64E-10	4.12E+00	17.890587	218.5495026	
4.99E+07	5.06E-05	0.00E+00	4.12E+00	17.890583	218.549721	
5.00E+07	5.07E-05	0.00E+00	4.13E+00	17.890579	218.5499395	
5.00E+07	5.09E-05	0.00E+00	4.13E+00	17.890575	218.5501582	
5.01E+07	5.08E-05	0.00E+00	4.14E+00	17.890571	218.5503775	
5.02E+07	5.08E-05	2.03E-09	4.13E+00	17.890567	218.5505964	
5.03E+07	5.07E-05	1.41E-10	4.13E+00	17.890562	218.5508152	
5.04E+07	5.07E-05	7.25E-10	4.12E+00	17.890558	218.5510335	
5.05E+07	5.07E-05	0.00E+00	4.13E+00	17.890554	218.5512522	
5.05E+07	5.06E-05	3.64E-09	4.13E+00	17.890550	218.5514707	
5.06E+07	5.07E-05	1.80E-10	4.12E+00	17.890546	218.5516891	
5.07E+07	5.08E-05	0.00E+00	4.13E+00	17.890542	218.5519075	
5.08E+07	5.09E-05	1.50E-08	4.14E+00	17.890538	218.5521268	
5.09E+07	5.09E-05	0.00E+00	4.14E+00	17.890533	218.5523462	
5.09E+07	5.09E-05	2.08E-09	4.14E+00	17.890529	218.5525657	
5.10E+07	5.08E-05	1.36E-09	4.13E+00	17.890525	218.5527847	
5.11E+07	5.07E-05	1.27E-09	4.13E+00	17.890521	218.5530034	
5.12E+07	5.08E-05	1.51E-10	4.13E+00	17.890517	218.5532221	
5.13E+07	5.06E-05	0.00E+00	4.13E+00	17.890513	218.5534406	
5.13E+07	5.05E-05	0.00E+00	4.11E+00	17.890509	218.5536583	
5.14E+07	5.05E-05	7.20E-10	4.11E+00	17.890505	218.5538759	
5.15E+07	5.04E-05	6.95E-10	4.11E+00	17.890500	218.5540934	
5.16E+07	5.05E-05	2.62E-10	4.11E+00	17.890496	218.5543109	
5.17E+07	5.05E-05	2.24E-09	4.10E+00	17.890492	218.5545282	
5.18E+07	5.04E-05	3.67E-09	4.10E+00	17.890488	218.5547456	
5.18E+07	5.03E-05	0.00E+00	4.10E+00	17.890484	218.5549626	
5.19E+07	5.03E-05	5.08E-10	4.09E+00	17.890480	218.5551793	
5.20E+07	5.02E-05	6.45E-10	4.08E+00	17.890476	218.5553957	
5.21E+07	5.01E-05	1.75E-10	4.08E+00	17.890472	218.5556121	
5.22E+07	4.99E-05	3.01E-06	4.07E+00	17.890468	218.5558278	
5.22E+07	4.99E-05	3.20E-10	4.06E+00	17.890464	218.556043	
5.23E+07	4.99E-05	1.40E-10	4.06E+00	17.890460	218.556258	

5.24E+07	5.01E-05	1.67E-09	4.07E+00	17.890456	218.5564737	
5.25E+07	5.02E-05	0.00E+00	4.08E+00	17.890451	218.5566899	
5.26E+07	5.03E-05	0.00E+00	4.09E+00	17.890447	218.5569066	
5.26E+07	5.03E-05	0.00E+00	4.09E+00	17.890443	218.5571234	
5.27E+07	5.04E-05	1.75E-10	4.10E+00	17.890439	218.5573405	
5.28E+07	5.08E-05	3.14E-10	4.12E+00	17.890435	218.5575587	
5.29E+07	5.09E-05	5.31E-10	4.14E+00	17.890431	218.557778	
5.30E+07	5.09E-05	0.00E+00	4.14E+00	17.890427	218.5579973	
5.31E+07	5.11E-05	2.54E-09	4.15E+00	17.890423	218.5582173	
5.31E+07	5.11E-05	3.64E-10	4.16E+00	17.890418	218.5584375	
5.32E+07	5.11E-05	9.66E-10	4.16E+00	17.890414	218.5586578	
5.33E+07	5.09E-05	0.00E+00	4.14E+00	17.890410	218.5588773	
5.34E+07	5.08E-05	5.53E-08	4.14E+00	17.890406	218.5590965	
5.35E+07	5.08E-05	0.00E+00	4.13E+00	17.890402	218.5593154	
5.35E+07	5.08E-05	1.94E-10	4.13E+00	17.890398	218.5595343	
5.36E+07	5.08E-05	0.00E+00	4.13E+00	17.890394	218.559753	
5.37E+07	5.08E-05	6.86E-10	4.13E+00	17.890390	218.5599719	
5.38E+07	5.09E-05	7.63E-10	4.14E+00	17.890385	218.560191	
5.39E+07	5.08E-05	1.69E-10	4.14E+00	17.890381	218.5604102	
5.40E+07	5.09E-05	1.30E-08	4.13E+00	17.890377	218.5606291	
5.40E+07	5.13E-05	3.55E-10	4.16E+00	17.890373	218.5608495	
5.41E+07	5.12E-05	1.88E-08	4.17E+00	17.890369	218.5610705	
5.42E+07	5.12E-05	1.72E-10	4.17E+00	17.890365	218.5612912	
5.43E+07	5.11E-05	3.49E-09	4.16E+00	17.890360	218.5615114	
5.44E+07	5.10E-05	0.00E+00	4.15E+00	17.890356	218.5617315	
5.44E+07	5.12E-05	1.79E-10	4.16E+00	17.890352	218.5619516	
5.45E+07	5.13E-05	0.00E+00	4.17E+00	17.890348	218.5621725	
5.46E+07	5.11E-05	1.62E-10	4.16E+00	17.890344	218.5623931	
5.47E+07	5.12E-05	4.48E-09	4.16E+00	17.890340	218.5626137	
5.48E+07	5.14E-05	2.77E-10	4.17E+00	17.890335	218.5628348	
5.48E+07	5.14E-05	5.57E-10	4.18E+00	17.890331	218.5630563	
5.49E+07	5.14E-05	3.40E-10	4.18E+00	17.890327	218.5632777	
5.50E+07	5.14E-05	1.45E-10	4.18E+00	17.890323	218.5634994	
5.51E+07	5.13E-05	0.00E+00	4.18E+00	17.890319	218.5637208	
5.52E+07	5.14E-05	0.00E+00	4.18E+00	17.890315	218.5639423	
5.53E+07	5.17E-05	0.00E+00	4.19E+00	17.890310	218.5641643	
5.53E+07	5.16E-05	2.18E-10	4.20E+00	17.890306	218.564387	
5.54E+07	5.14E-05	9.43E-10	4.19E+00	17.890302	218.5646091	
5.55E+07	5.12E-05	0.00E+00	4.18E+00	17.890298	218.5648305	
5.56E+07	5.13E-05	0.00E+00	4.17E+00	17.890294	218.5650512	
5.57E+07	5.12E-05	1.91E-10	4.17E+00	17.890289	218.5652721	
5.57E+07	5.09E-05	3.65E-10	4.16E+00	17.890285	218.5654923	
5.58E+07	5.08E-05	1.71E-10	4.14E+00	17.890281	218.5657116	
5.59E+07	5.08E-05	4.69E-10	4.13E+00	17.890277	218.5659304	
5.60E+07	5.03E-05	1.06E-09	4.12E+00	17.890273	218.5661484	
5.61E+07	5.01E-05	9.20E-10	4.09E+00	17.890269	218.566365	
5.61E+07	5.00E-05	5.34E-09	4.07E+00	17.890265	218.5665809	
5.62E+07	5.04E-05	1.40E-09	4.08E+00	17.890261	218.5667971	
5.63E+07	5.04E-05	9.64E-10	4.11E+00	17.890257	218.5670146	
5.64E+07	5.03E-05	1.84E-10	4.10E+00	17.890252	218.5672319	

5.65E+07	5.02E-05	1.03E-09	4.09E+00	17.890248	218.5674488	
5.66E+07	5.02E-05	2.58E-10	4.08E+00	17.890244	218.5676652	
5.66E+07	5.03E-05	1.77E-10	4.09E+00	17.890240	218.567882	
5.67E+07	5.02E-05	0.00E+00	4.09E+00	17.890236	218.5680989	
5.68E+07	5.01E-05	7.30E-10	4.08E+00	17.890232	218.5683152	
5.69E+07	5.01E-05	1.74E-10	4.07E+00	17.890228	218.5685309	
5.70E+07	5.09E-05	0.00E+00	4.11E+00	17.890224	218.5687487	
5.70E+07	5.02E-05	2.80E-10	4.11E+00	17.890220	218.5689667	
5.71E+07	5.01E-05	4.49E-09	4.08E+00	17.890216	218.569183	
5.72E+07	5.01E-05	9.20E-09	4.07E+00	17.890212	218.5693989	
5.73E+07	5.02E-05	2.23E-10	4.08E+00	17.890207	218.569615	
5.74E+07	5.02E-05	2.02E-10	4.08E+00	17.890203	218.5698314	
5.75E+07	5.02E-05	1.63E-09	4.08E+00	17.890199	218.5700478	
5.75E+07	5.01E-05	6.37E-09	4.08E+00	17.890195	218.5702637	
5.76E+07	4.99E-05	1.68E-09	4.07E+00	17.890191	218.5704794	
5.77E+07	5.00E-05	8.64E-10	4.07E+00	17.890187	218.5706948	
5.78E+07	5.02E-05	7.99E-10	4.08E+00	17.890183	218.5709107	
5.79E+07	5.02E-05	0.00E+00	4.08E+00	17.890179	218.571127	
5.79E+07	5.03E-05	0.00E+00	4.09E+00	17.890175	218.5713439	
5.80E+07	5.03E-05	4.35E-09	4.10E+00	17.890171	218.571561	
5.81E+07	5.04E-05	0.00E+00	4.10E+00	17.890167	218.5717782	
5.82E+07	5.03E-05	2.11E-09	4.09E+00	17.890163	218.5719951	
5.83E+07	5.02E-05	0.00E+00	4.09E+00	17.890158	218.5722118	
5.83E+07	5.01E-05	5.19E-10	4.08E+00	17.890154	218.5724281	
5.84E+07	5.01E-05	6.82E-09	4.08E+00	17.890150	218.5726442	
5.85E+07	5.00E-05	0.00E+00	4.07E+00	17.890146	218.5728598	
5.86E+07	4.99E-05	5.48E-09	4.07E+00	17.890142	218.5730752	
5.87E+07	4.99E-05	0.00E+00	4.06E+00	17.890138	218.5732903	
5.88E+07	4.99E-05	0.00E+00	4.06E+00	17.890134	218.5735055	
5.88E+07	4.99E-05	4.41E-09	4.06E+00	17.890130	218.5737205	
5.89E+07	4.99E-05	0.00E+00	4.06E+00	17.890126	218.5739358	
5.90E+07	5.01E-05	1.67E-10	4.07E+00	17.890122	218.5741515	
5.91E+07	4.99E-05	4.57E-09	4.07E+00	17.890118	218.5743671	
5.92E+07	4.97E-05	1.78E-10	4.05E+00	17.890114	218.5745817	
5.92E+07	4.99E-05	3.93E-10	4.05E+00	17.890110	218.5747965	
5.93E+07	5.00E-05	7.20E-10	4.07E+00	17.890106	218.575012	
5.94E+07	5.00E-05	2.58E-09	4.07E+00	17.890102	218.5752278	
5.95E+07	5.02E-05	0.00E+00	4.08E+00	17.890097	218.5754437	
5.96E+07	5.02E-05	1.14E-09	4.09E+00	17.890093	218.5756604	
5.96E+07	5.02E-05	1.49E-10	4.09E+00	17.890089	218.5758769	
5.97E+07	5.02E-05	5.75E-10	4.09E+00	17.890085	218.5760934	
5.98E+07	5.02E-05	5.95E-10	4.08E+00	17.890081	218.5763096	
5.99E+07	5.02E-05	0.00E+00	4.09E+00	17.890077	218.5765262	
6.00E+07	5.02E-05	3.31E-09	4.09E+00	17.890073	218.5767427	
6.01E+07	5.01E-05	0.00E+00	4.08E+00	17.890069	218.5769591	
6.01E+07	5.01E-05	4.45E-10	4.08E+00	17.890065	218.5771751	
6.02E+07	5.00E-05	1.21E-09	4.08E+00	17.890061	218.577391	
6.03E+07	5.01E-05	1.61E-10	4.07E+00	17.890057	218.5776069	
6.04E+07	5.01E-05	3.76E-07	4.08E+00	17.890053	218.577823	
6.05E+07	5.02E-05	1.96E-10	4.08E+00	17.890048	218.578039	

6.05E+07	5.03E-05	1.18E-09	4.09E+00	17.890044	218.5782556	
6.06E+07	5.03E-05	4.45E-10	4.10E+00	17.890040	218.5784726	
6.07E+07	5.05E-05	2.68E-09	4.10E+00	17.890036	218.57869	
6.08E+07	5.05E-05	4.53E-09	4.11E+00	17.890032	218.5789075	
6.09E+07	5.06E-05	2.05E-09	4.12E+00	17.890028	218.5791257	
6.09E+07	5.06E-05	2.52E-10	4.12E+00	17.890024	218.5793439	
6.10E+07	5.05E-05	7.44E-10	4.12E+00	17.890020	218.579562	
6.11E+07	5.05E-05	4.47E-10	4.11E+00	17.890016	218.5797797	
6.12E+07	5.05E-05	2.80E-10	4.11E+00	17.890012	218.5799976	
6.13E+07	5.05E-05	4.69E-10	4.11E+00	17.890007	218.5802154	
6.14E+07	5.05E-05	3.76E-10	4.11E+00	17.890003	218.5804331	
6.14E+07	5.06E-05	1.50E-10	4.11E+00	17.889999	218.5806508	
6.15E+07	5.06E-05	1.57E-10	4.12E+00	17.889995	218.5808688	
6.16E+07	5.08E-05	0.00E+00	4.13E+00	17.889991	218.5810874	
6.17E+07	5.09E-05	0.00E+00	4.14E+00	17.889987	218.5813068	
6.18E+07	5.11E-05	1.97E-10	4.15E+00	17.889983	218.5815266	
6.18E+07	5.11E-05	0.00E+00	4.16E+00	17.889979	218.5817469	
6.19E+07	5.10E-05	0.00E+00	4.16E+00	17.889974	218.5819671	
6.20E+07	5.10E-05	0.00E+00	4.15E+00	17.889970	218.5821871	
6.21E+07	5.07E-05	3.55E-10	4.13E+00	17.889966	218.5824062	
6.22E+07	5.08E-05	1.57E-09	4.13E+00	17.889962	218.5826251	
6.23E+07	5.08E-05	9.53E-10	4.13E+00	17.889958	218.5828442	
6.23E+07	5.09E-05	3.14E-09	4.14E+00	17.889954	218.5830635	
6.24E+07	5.11E-05	4.19E-10	4.15E+00	17.889950	218.5832832	
6.25E+07	5.08E-05	3.65E-08	4.15E+00	17.889945	218.5835029	
6.26E+07	5.07E-05	1.41E-10	4.13E+00	17.889941	218.5837217	
6.27E+07	5.08E-05	5.87E-10	4.13E+00	17.889937	218.5839406	
6.27E+07	5.07E-05	1.46E-10	4.13E+00	17.889933	218.5841594	
6.28E+07	5.07E-05	6.01E-10	4.13E+00	17.889929	218.5843781	
6.29E+07	5.08E-05	3.75E-09	4.13E+00	17.889925	218.5845971	
6.30E+07	5.06E-05	0.00E+00	4.13E+00	17.889921	218.5848159	
6.31E+07	5.07E-05	4.63E-10	4.12E+00	17.889916	218.5850341	
6.31E+07	5.11E-05	1.59E-10	4.14E+00	17.889912	218.5852536	
6.32E+07	5.10E-05	1.63E-10	4.15E+00	17.889908	218.5854736	
6.33E+07	5.10E-05	3.54E-10	4.15E+00	17.889904	218.5856935	
6.34E+07	5.12E-05	8.18E-10	4.15E+00	17.889900	218.5859135	
6.35E+07	5.11E-05	7.14E-10	4.16E+00	17.889896	218.5861341	
6.36E+07	5.09E-05	1.69E-10	4.15E+00	17.889892	218.5863542	
6.36E+07	5.09E-05	1.26E-09	4.15E+00	17.889887	218.5865739	
6.37E+07	5.06E-05	4.96E-09	4.13E+00	17.889883	218.5867926	
6.38E+07	5.05E-05	4.80E-10	4.11E+00	17.889879	218.5870105	
6.39E+07	5.07E-05	2.92E-09	4.12E+00	17.889875	218.5872286	
6.40E+07	5.08E-05	3.01E-10	4.13E+00	17.889871	218.5874474	
6.40E+07	5.06E-05	1.23E-09	4.12E+00	17.889867	218.5876659	
6.41E+07	5.02E-05	9.73E-10	4.10E+00	17.889863	218.5878833	
6.42E+07	5.06E-05	7.06E-10	4.10E+00	17.889859	218.5881006	
6.43E+07	5.08E-05	0.00E+00	4.13E+00	17.889854	218.5883192	
6.44E+07	5.10E-05	0.00E+00	4.14E+00	17.889850	218.5885384	
6.44E+07	5.11E-05	0.00E+00	4.16E+00	17.889846	218.5887586	
6.45E+07	5.06E-05	3.58E-10	4.14E+00	17.889842	218.5889781	

6.46E+07	5.08E-05	1.95E-10	4.13E+00	17.889838	218.5891968	
6.47E+07	5.06E-05	3.44E-09	4.12E+00	17.889834	218.5894152	
6.48E+07	5.08E-05	0.00E+00	4.13E+00	17.889830	218.589634	
6.49E+07	5.04E-05	0.00E+00	4.12E+00	17.889826	218.5898524	
6.49E+07	5.01E-05	2.58E-09	4.09E+00	17.889821	218.5900692	
6.50E+07	4.96E-05	0.00E+00	4.05E+00	17.889817	218.5902841	
6.51E+07	5.00E-05	1.92E-09	4.06E+00	17.889813	218.590499	
6.52E+07	5.01E-05	1.46E-09	4.08E+00	17.889809	218.5907149	
6.53E+07	5.00E-05	6.19E-09	4.07E+00	17.889805	218.5909309	
6.53E+07	4.99E-05	0.00E+00	4.06E+00	17.889801	218.5911461	
6.54E+07	5.00E-05	2.07E-09	4.07E+00	17.889797	218.5913618	
6.55E+07	5.02E-05	2.39E-09	4.08E+00	17.889793	218.591578	
6.56E+07	5.01E-05	1.16E-09	4.08E+00	17.889789	218.5917943	
6.57E+07	5.01E-05	1.20E-09	4.07E+00	17.889785	218.5920101	
6.58E+07	5.01E-05	0.00E+00	4.08E+00	17.889781	218.5922263	
6.58E+07	5.01E-05	0.00E+00	4.08E+00	17.889777	218.5924426	
6.59E+07	5.01E-05	0.00E+00	4.08E+00	17.889773	218.5926589	
6.60E+07	5.01E-05	1.53E-08	4.08E+00	17.889769	218.5928748	
6.61E+07	5.02E-05	4.95E-10	4.08E+00	17.889764	218.5930911	
6.62E+07	5.02E-05	3.79E-10	4.08E+00	17.889760	218.5933076	
6.62E+07	5.02E-05	0.00E+00	4.09E+00	17.889756	218.5935243	
6.63E+07	5.02E-05	5.42E-09	4.08E+00	17.889752	218.5937408	
6.64E+07	5.00E-05	0.00E+00	4.08E+00	17.889748	218.5939571	
6.65E+07	5.02E-05	9.93E-10	4.08E+00	17.889744	218.5941733	
6.66E+07	5.03E-05	0.00E+00	4.09E+00	17.889740	218.59439	
6.66E+07	5.03E-05	5.31E-09	4.09E+00	17.889736	218.5946066	
6.67E+07	5.03E-05	9.96E-10	4.09E+00	17.889732	218.5948236	
6.68E+07	5.04E-05	3.80E-09	4.10E+00	17.889728	218.5950407	
6.69E+07	5.03E-05	0.00E+00	4.10E+00	17.889724	218.5952578	
6.70E+07	5.02E-05	2.19E-10	4.08E+00	17.889719	218.5954743	
6.71E+07	5.01E-05	4.30E-10	4.08E+00	17.889715	218.5956906	
6.71E+07	5.02E-05	6.01E-08	4.08E+00	17.889711	218.595907	
6.72E+07	5.01E-05	0.00E+00	4.08E+00	17.889707	218.5961233	
6.73E+07	5.01E-05	1.79E-09	4.07E+00	17.889703	218.596339	
6.74E+07	5.00E-05	1.37E-09	4.07E+00	17.889699	218.596555	
6.75E+07	4.99E-05	0.00E+00	4.07E+00	17.889695	218.5967706	
6.75E+07	4.99E-05	1.09E-09	4.06E+00	17.889691	218.596986	
6.76E+07	5.00E-05	1.13E-08	4.06E+00	17.889687	218.5972014	
6.77E+07	5.00E-05	3.26E-09	4.07E+00	17.889683	218.5974173	
6.78E+07	4.99E-05	7.35E-10	4.07E+00	17.889679	218.5976329	
6.79E+07	4.98E-05	0.00E+00	4.06E+00	17.889675	218.5978481	
6.79E+07	4.99E-05	0.00E+00	4.06E+00	17.889671	218.5980631	
6.80E+07	5.01E-05	0.00E+00	4.07E+00	17.889667	218.5982788	
6.81E+07	5.03E-05	2.82E-10	4.09E+00	17.889662	218.5984954	
6.82E+07	5.04E-05	8.02E-10	4.10E+00	17.889658	218.5987127	
6.83E+07	5.03E-05	1.49E-10	4.10E+00	17.889654	218.5989299	
6.84E+07	5.03E-05	7.90E-10	4.09E+00	17.889650	218.5991469	
6.84E+07	5.03E-05	2.21E-10	4.09E+00	17.889646	218.5993637	
6.85E+07	5.03E-05	2.96E-10	4.09E+00	17.889642	218.5995807	
6.86E+07	5.04E-05	0.00E+00	4.09E+00	17.889638	218.5997976	

6.87E+07	5.03E-05	3.48E-10	4.10E+00	17.889634	218.6000148	
6.88E+07	5.03E-05	1.52E-10	4.09E+00	17.889630	218.6002318	
6.88E+07	5.02E-05	0.00E+00	4.09E+00	17.889626	218.6004485	
6.89E+07	5.01E-05	3.50E-09	4.08E+00	17.889622	218.6006646	
6.90E+07	5.03E-05	4.62E-10	4.09E+00	17.889617	218.6008813	
6.91E+07	5.05E-05	2.06E-09	4.10E+00	17.889613	218.6010988	
6.92E+07	5.05E-05	1.02E-09	4.11E+00	17.889609	218.6013168	
6.93E+07	5.07E-05	8.11E-10	4.12E+00	17.889605	218.601535	
6.93E+07	5.08E-05	3.62E-10	4.13E+00	17.889601	218.601754	
6.94E+07	5.07E-05	0.00E+00	4.13E+00	17.889597	218.6019731	
6.95E+07	5.07E-05	0.00E+00	4.13E+00	17.889593	218.6021918	
6.96E+07	5.06E-05	0.00E+00	4.12E+00	17.889589	218.60241	
6.97E+07	5.06E-05	7.64E-10	4.12E+00	17.889584	218.6026282	
6.97E+07	5.05E-05	1.38E-09	4.11E+00	17.889580	218.6028461	
6.98E+07	5.04E-05	9.36E-10	4.11E+00	17.889576	218.6030639	
6.99E+07	5.07E-05	7.42E-10	4.11E+00	17.889572	218.6032818	
7.00E+07	5.09E-05	0.00E+00	4.13E+00	17.889568	218.603501	
7.01E+07	5.12E-05	0.00E+00	4.16E+00	17.889564	218.6037212	
7.01E+07	5.11E-05	2.30E-09	4.16E+00	17.889560	218.6039419	
7.02E+07	5.12E-05	9.46E-09	4.16E+00	17.889556	218.6041622	
7.03E+07	5.12E-05	3.41E-10	4.17E+00	17.889551	218.6043831	
7.04E+07	5.10E-05	4.56E-08	4.16E+00	17.889547	218.6046038	
7.05E+07	5.09E-05	1.07E-09	4.15E+00	17.889543	218.6048238	
7.06E+07	5.08E-05	1.87E-10	4.14E+00	17.889539	218.6050431	
7.06E+07	5.06E-05	1.16E-08	4.13E+00	17.889535	218.6052619	
7.07E+07	5.05E-05	6.64E-10	4.11E+00	17.889531	218.60548	
7.08E+07	5.06E-05	5.63E-10	4.11E+00	17.889527	218.6056981	
7.09E+07	5.10E-05	0.00E+00	4.13E+00	17.889522	218.605917	
7.10E+07	5.10E-05	2.25E-09	4.15E+00	17.889518	218.6061371	
7.10E+07	5.08E-05	0.00E+00	4.15E+00	17.889514	218.6063568	
7.11E+07	5.09E-05	1.48E-10	4.14E+00	17.889510	218.6065763	
7.12E+07	5.11E-05	6.40E-10	4.15E+00	17.889506	218.6067961	
7.13E+07	5.11E-05	2.13E-09	4.16E+00	17.889502	218.6070166	
7.14E+07	5.11E-05	4.36E-10	4.16E+00	17.889498	218.6072369	
7.14E+07	5.14E-05	0.00E+00	4.17E+00	17.889493	218.6074579	
7.15E+07	5.12E-05	4.28E-09	4.17E+00	17.889489	218.607679	
7.16E+07	5.13E-05	0.00E+00	4.17E+00	17.889485	218.6079002	
7.17E+07	5.15E-05	1.11E-08	4.18E+00	17.889481	218.6081219	
7.18E+07	5.14E-05	0.00E+00	4.19E+00	17.889477	218.6083439	
7.19E+07	5.14E-05	0.00E+00	4.18E+00	17.889472	218.6085655	
7.19E+07	5.14E-05	9.16E-09	4.18E+00	17.889468	218.6087871	
7.20E+07	5.11E-05	0.00E+00	4.17E+00	17.889464	218.6090083	
7.21E+07	5.13E-05	0.00E+00	4.17E+00	17.889460	218.6092292	
7.22E+07	5.11E-05	1.32E-08	4.16E+00	17.889456	218.6094498	
7.23E+07	5.13E-05	2.72E-10	4.17E+00	17.889452	218.6096707	
7.23E+07	5.09E-05	5.74E-10	4.16E+00	17.889447	218.6098913	
7.24E+07	5.05E-05	1.07E-09	4.13E+00	17.889443	218.6101101	
7.25E+07	5.02E-05	3.90E-08	4.09E+00	17.889439	218.6103271	
7.26E+07	5.02E-05	0.00E+00	4.09E+00	17.889435	218.6105438	
7.27E+07	5.04E-05	0.00E+00	4.09E+00	17.889431	218.6107608	

7.27E+07	5.03E-05	1.82E-09	4.10E+00	17.889427	218.610978	
7.28E+07	5.03E-05	0.00E+00	4.09E+00	17.889423	218.6111948	
7.29E+07	5.08E-05	1.72E-09	4.11E+00	17.889419	218.6114129	
7.30E+07	5.09E-05	3.24E-10	4.14E+00	17.889415	218.6116322	
7.31E+07	5.07E-05	8.91E-08	4.13E+00	17.889410	218.6118513	
7.32E+07	5.04E-05	1.73E-08	4.11E+00	17.889406	218.6120691	
7.32E+07	5.04E-05	1.08E-09	4.10E+00	17.889402	218.6122866	
7.33E+07	5.05E-05	1.46E-09	4.11E+00	17.889398	218.6125043	
7.34E+07	5.05E-05	0.00E+00	4.11E+00	17.889394	218.6127222	
7.35E+07	5.04E-05	4.48E-09	4.10E+00	17.889390	218.6129397	
7.36E+07	5.04E-05	7.71E-09	4.10E+00	17.889386	218.6131573	
7.36E+07	5.03E-05	0.00E+00	4.10E+00	17.889382	218.6133747	
7.37E+07	5.03E-05	5.18E-10	4.10E+00	17.889378	218.6135918	
7.38E+07	5.04E-05	6.12E-10	4.09E+00	17.889374	218.6138088	
7.39E+07	5.04E-05	1.30E-09	4.10E+00	17.889369	218.6140262	
7.40E+07	5.05E-05	0.00E+00	4.11E+00	17.889365	218.614244	
7.41E+07	5.08E-05	0.00E+00	4.12E+00	17.889361	218.6144626	
7.41E+07	5.10E-05	3.69E-10	4.14E+00	17.889357	218.6146818	
7.42E+07	5.10E-05	4.06E-09	4.15E+00	17.889353	218.6149017	
7.43E+07	5.10E-05	5.43E-08	4.15E+00	17.889349	218.6151217	
7.44E+07	5.10E-05	1.22E-09	4.15E+00	17.889345	218.6153418	
7.45E+07	5.07E-05	0.00E+00	4.13E+00	17.889341	218.6155608	
7.45E+07	5.06E-05	1.77E-09	4.12E+00	17.889336	218.6157794	
7.46E+07	5.06E-05	0.00E+00	4.12E+00	17.889332	218.6159976	
7.47E+07	5.07E-05	2.15E-10	4.12E+00	17.889328	218.6162161	
7.48E+07	5.05E-05	3.96E-09	4.11E+00	17.889324	218.616434	
7.49E+07	5.05E-05	4.44E-10	4.11E+00	17.889320	218.6166518	
7.49E+07	5.04E-05	4.93E-09	4.11E+00	17.889316	218.6168695	
7.50E+07	5.05E-05	5.96E-10	4.11E+00	17.889312	218.6170873	
7.51E+07	5.05E-05	0.00E+00	4.11E+00	17.889308	218.6173049	
7.52E+07	5.04E-05	7.54E-10	4.11E+00	17.889304	218.6175227	
7.53E+07	5.04E-05	4.22E-10	4.10E+00	17.889299	218.6177403	
7.54E+07	5.05E-05	1.78E-08	4.11E+00	17.889295	218.6179579	
7.54E+07	5.05E-05	0.00E+00	4.10E+00	17.889291	218.6181755	
7.55E+07	5.02E-05	7.96E-10	4.10E+00	17.889287	218.6183928	
7.56E+07	5.01E-05	0.00E+00	4.08E+00	17.889283	218.6186093	
7.57E+07	5.00E-05	2.77E-10	4.07E+00	17.889279	218.6188254	
7.58E+07	4.99E-05	5.67E-10	4.06E+00	17.889275	218.6190407	
7.58E+07	4.99E-05	1.83E-09	4.06E+00	17.889271	218.6192561	
7.59E+07	5.00E-05	1.44E-09	4.07E+00	17.889267	218.6194717	
7.60E+07	4.98E-05	8.08E-10	4.06E+00	17.889263	218.6196871	
7.61E+07	5.00E-05	5.13E-10	4.06E+00	17.889259	218.6199023	
7.62E+07	5.01E-05	1.96E-10	4.07E+00	17.889255	218.6201182	
7.62E+07	5.02E-05	6.00E-10	4.08E+00	17.889250	218.6203345	
7.63E+07	5.02E-05	0.00E+00	4.09E+00	17.889246	218.6205511	
7.64E+07	5.03E-05	4.45E-09	4.09E+00	17.889242	218.6207678	
7.65E+07	5.04E-05	5.97E-10	4.10E+00	17.889238	218.6209851	
7.66E+07	5.02E-05	3.46E-10	4.09E+00	17.889234	218.6212022	
7.67E+07	5.04E-05	8.97E-09	4.10E+00	17.889230	218.6214195	
7.67E+07	5.05E-05	9.17E-10	4.10E+00	17.889226	218.621637	

7.68E+07	5.04E-05	7.18E-09	4.11E+00	17.889222	218.6218549	
7.69E+07	5.06E-05	0.00E+00	4.11E+00	17.889218	218.6220729	
7.70E+07	5.08E-05	3.78E-10	4.13E+00	17.889214	218.6222918	
7.71E+07	5.08E-05	1.40E-10	4.13E+00	17.889209	218.6225107	
7.71E+07	5.08E-05	5.92E-10	4.13E+00	17.889205	218.6227299	
7.72E+07	5.08E-05	7.48E-10	4.13E+00	17.889201	218.6229491	
7.73E+07	5.06E-05	5.48E-10	4.13E+00	17.889197	218.623168	
7.74E+07	5.06E-05	0.00E+00	4.12E+00	17.889193	218.6233862	
7.75E+07	5.07E-05	2.44E-09	4.12E+00	17.889189	218.6236049	
7.76E+07	5.04E-05	2.08E-10	4.12E+00	17.889185	218.6238232	
7.76E+07	5.04E-05	4.91E-10	4.10E+00	17.889181	218.6240407	
7.77E+07	5.02E-05	1.74E-10	4.09E+00	17.889176	218.6242575	
7.78E+07	5.01E-05	2.02E-08	4.08E+00	17.889172	218.6244739	
7.79E+07	5.00E-05	0.00E+00	4.07E+00	17.889168	218.62469	
7.80E+07	5.00E-05	3.22E-10	4.07E+00	17.889164	218.6249059	
7.80E+07	5.00E-05	0.00E+00	4.06E+00	17.889160	218.6251214	
7.81E+07	4.98E-05	2.01E-09	4.06E+00	17.889156	218.6253366	
7.82E+07	4.98E-05	3.33E-10	4.05E+00	17.889152	218.6255515	
7.83E+07	4.95E-05	0.00E+00	4.04E+00	17.889148	218.6257658	
7.84E+07	4.95E-05	5.51E-10	4.02E+00	17.889144	218.6259792	
7.84E+07	4.96E-05	1.80E-10	4.03E+00	17.889140	218.626193	
7.85E+07	4.94E-05	1.56E-10	4.03E+00	17.889136	218.6264068	
7.86E+07	4.94E-05	0.00E+00	4.02E+00	17.889132	218.6266202	
7.87E+07	4.98E-05	1.81E-10	4.04E+00	17.889128	218.6268342	
7.88E+07	5.02E-05	4.01E-10	4.07E+00	17.889124	218.6270502	
7.89E+07	5.06E-05	9.49E-10	4.10E+00	17.889120	218.6272677	
7.89E+07	5.09E-05	2.51E-10	4.13E+00	17.889116	218.6274868	
7.90E+07	5.10E-05	0.00E+00	4.14E+00	17.889111	218.6277065	
7.91E+07	5.11E-05	1.61E-10	4.16E+00	17.889107	218.6279268	
7.92E+07	5.10E-05	1.31E-09	4.16E+00	17.889103	218.6281472	
7.93E+07	5.09E-05	2.36E-09	4.15E+00	17.889099	218.628367	
7.93E+07	5.05E-05	2.00E-10	4.12E+00	17.889095	218.6285854	
7.94E+07	5.05E-05	1.99E-09	4.11E+00	17.889091	218.6288034	
7.95E+07	5.04E-05	1.61E-09	4.11E+00	17.889087	218.6290212	
7.96E+07	5.02E-05	0.00E+00	4.09E+00	17.889083	218.6292381	
7.97E+07	5.03E-05	0.00E+00	4.08E+00	17.889078	218.6294547	
7.97E+07	5.03E-05	3.56E-10	4.10E+00	17.889074	218.6296719	
7.98E+07	5.06E-05	3.47E-09	4.11E+00	17.889070	218.6298897	
7.99E+07	5.05E-05	5.26E-09	4.11E+00	17.889066	218.6301078	
8.00E+07	5.03E-05	1.71E-09	4.10E+00	17.889062	218.6303251	
8.01E+07	5.05E-05	0.00E+00	4.10E+00	17.889058	218.6305427	
8.02E+07	4.96E-01	3.33E-06	2.02E+04	17.868883	219.7090107	
8.02E+07	1.38E+00	1.25E-04	7.63E+04	17.792608	223.9441039	
8.03E+07	1.38E+00	5.74E-05	1.12E+05	17.680415	230.6329045	
8.04E+07	1.39E+00	5.19E-05	1.13E+05	17.567775	237.9066847	
8.05E+07	1.40E+00	1.16E-04	1.13E+05	17.454583	245.7848649	
8.06E+07	1.40E+00	6.97E-05	1.14E+05	17.340627	254.2932816	
8.06E+07	1.41E+00	6.02E-05	1.14E+05	17.226300	263.4081842	
8.07E+07	1.42E+00	1.34E-04	1.15E+05	17.111336	273.1518148	
8.08E+07	1.43E+00	9.01E-05	1.16E+05	16.995644	283.5315952	

8.09E+07	1.43E+00	1.21E-04	1.16E+05	16.879290	294.5376639	
8.10E+07	1.44E+00	9.34E-05	1.17E+05	16.762554	306.1333672	
8.10E+07	1.44E+00	6.74E-05	1.17E+05	16.645244	318.3234504	
8.11E+07	1.45E+00	8.57E-05	1.18E+05	16.527266	331.1015496	
8.12E+07	1.46E+00	4.81E-05	1.19E+05	16.408570	344.4546296	0
8.13E+07	1.47E+00	7.30E-05	1.19E+05	16.289517	358.3181626	0.93060785
8.14E+07	1.48E+00	1.61E-04	1.20E+05	16.169583	372.7268202	1.89863723
8.15E+07	4.01E-01	4.09E-06	7.65E+04	16.093050	382.1369412	2.89110615
8.15E+07	4.02E-01	7.55E-06	3.27E+04	16.060384	386.2016022	3.89413162
8.16E+07	4.02E-01	1.83E-05	3.27E+04	16.027715	390.2943657	4.90778663
8.17E+07	4.02E-01	1.09E-05	3.27E+04	15.994997	394.4202283	5.93215715
8.18E+07	4.02E-01	4.86E-05	3.27E+04	15.962256	398.575167	6.96731869
8.19E+07	4.03E-01	8.83E-05	3.28E+04	15.929461	402.7626215	8.0133557
8.19E+07	4.04E-01	7.04E-05	3.28E+04	15.896643	406.9774836	9.07033936
8.20E+07	4.05E-01	3.77E-05	3.29E+04	15.863737	411.2278533	10.1383619
8.21E+07	4.05E-01	2.87E-05	3.30E+04	15.830778	415.5081542	11.217501
8.22E+07	4.06E-01	4.08E-05	3.30E+04	15.797742	419.8208684	12.3078409
8.23E+07	4.07E-01	4.92E-05	3.31E+04	15.764655	424.1619261	13.4094553
8.24E+07	4.08E-01	4.13E-05	3.32E+04	15.731484	428.5347791	14.5224266
8.24E+07	4.07E-01	3.99E-05	3.32E+04	15.698316	432.9273023	15.6468059
8.25E+07	4.08E-01	1.73E-05	3.32E+04	15.665112	437.3435727	16.782655
8.26E+07	4.10E-01	1.41E-05	3.33E+04	15.631856	441.7851377	17.9300396
8.27E+07	4.10E-01	1.09E-04	3.34E+04	15.598477	446.2603603	19.089047
8.28E+07	4.12E-01	2.46E-05	3.35E+04	15.565020	450.7626646	20.2597475
8.28E+07	4.13E-01	6.03E-05	3.36E+04	15.531466	455.2937278	21.442216
8.29E+07	4.13E-01	5.42E-05	3.36E+04	15.497909	459.839821	22.6364913
8.30E+07	4.13E-01	2.22E-05	3.36E+04	15.464308	464.405677	23.8426249
8.31E+07	4.14E-01	1.68E-05	3.37E+04	15.430643	468.9931233	25.0606728
8.32E+07	4.15E-01	1.65E-05	3.38E+04	15.396892	473.6041927	26.2906964
8.32E+07	4.16E-01	2.70E-05	3.38E+04	15.363128	478.2279209	27.5327285
8.33E+07	4.17E-01	1.39E-05	3.39E+04	15.329253	482.8769671	28.7868349
8.34E+07	4.17E-01	1.51E-05	3.39E+04	15.295308	487.5444732	30.0530635
8.35E+07	4.18E-01	3.70E-05	3.40E+04	15.261304	492.2279993	31.331456
8.36E+07	4.19E-01	4.77E-05	3.40E+04	15.227290	496.919959	32.6220342
8.37E+07	4.19E-01	5.07E-05	3.41E+04	15.193186	501.6302028	33.9248456
8.37E+07	4.19E-01	3.43E-04	3.41E+04	15.159050	506.3497869	35.2399146
8.38E+07	4.21E-01	2.38E-05	3.42E+04	15.124853	511.0815521	36.5672727
8.39E+07	4.23E-01	7.25E-04	3.43E+04	15.090572	515.827888	37.9069577
8.40E+07	4.23E-01	8.53E-05	3.44E+04	15.056148	520.5956582	39.2590254
8.41E+07	4.23E-01	4.19E-04	3.45E+04	15.021693	525.3683466	40.6234885
8.41E+07	4.25E-01	8.17E-05	3.45E+04	14.987183	530.1483002	42.0003659
8.42E+07	4.25E-01	4.82E-05	3.45E+04	14.952634	534.9320388	43.3896674
8.43E+07	4.25E-01	1.28E-04	3.46E+04	14.918012	539.7231635	44.7914121
8.44E+07	4.27E-01	1.92E-05	3.47E+04	14.883332	544.5185895	46.2056114
8.45E+07	4.29E-01	2.07E-05	3.48E+04	14.848523	549.3270284	47.6322989
8.45E+07	4.29E-01	1.66E-05	3.49E+04	14.813670	554.135439	49.0714746
8.46E+07	4.28E-01	2.93E-05	3.49E+04	14.778783	558.9413425	50.523132
8.47E+07	4.29E-01	3.10E-05	3.49E+04	14.743899	563.7383835	51.987248
8.48E+07	4.30E-01	2.14E-05	3.49E+04	14.708951	568.5348727	53.4638213
8.49E+07	4.32E-01	6.78E-05	3.50E+04	14.673913	573.3331307	54.9528564

8.50E+07	4.34E-01	1.09E-04	3.52E+04	14.638683	578.1457251	56.4543905
8.50E+07	4.34E-01	4.37E-05	3.53E+04	14.603379	582.9553055	57.9684159
8.51E+07	4.34E-01	2.07E-05	3.53E+04	14.568047	587.7543333	59.494905
8.52E+07	4.35E-01	7.23E-05	3.53E+04	14.532712	592.5383866	61.0338192
8.53E+07	4.35E-01	2.19E-04	3.54E+04	14.497288	597.3178764	62.5851463
8.54E+07	4.36E-01	1.70E-05	3.55E+04	14.461823	602.0849685	64.1488544
8.54E+07	4.37E-01	2.14E-05	3.55E+04	14.426295	606.8415541	65.7249161
8.55E+07	4.38E-01	4.11E-05	3.56E+04	14.390737	611.5819502	67.3132893
8.56E+07	4.39E-01	3.20E-05	3.57E+04	14.355051	616.3177443	68.9139621
8.57E+07	4.39E-01	3.66E-05	3.57E+04	14.319323	621.0364822	70.5268901
8.58E+07	4.40E-01	4.38E-05	3.58E+04	14.283557	625.7362786	72.1520243
8.59E+07	4.42E-01	2.98E-05	3.58E+04	14.247710	630.4215037	73.7893268
8.59E+07	4.43E-01	2.19E-05	3.60E+04	14.211696	635.1020849	75.4387854
8.60E+07	4.44E-01	6.60E-05	3.61E+04	14.175608	639.7643984	77.1003528
8.61E+07	4.45E-01	2.26E-04	3.62E+04	14.139449	644.4068359	78.7739773
8.62E+07	4.46E-01	3.73E-05	3.62E+04	14.103257	649.0232189	80.4595913
8.63E+07	4.47E-01	4.85E-04	3.63E+04	14.066932	653.6249594	82.1571567
8.63E+07	4.46E-01	2.83E-05	3.64E+04	14.030574	658.1979327	83.8665989
8.64E+07	4.46E-01	2.18E-05	3.63E+04	13.994248	662.7328911	85.587819
8.65E+07	4.47E-01	3.08E-05	3.63E+04	13.957933	667.2314326	87.3207225
8.66E+07	4.49E-01	6.20E-05	3.65E+04	13.921469	671.712086	89.065263
8.67E+07	4.49E-01	2.20E-05	3.65E+04	13.884929	676.1643035	90.8213666
8.67E+07	4.50E-01	6.63E-05	3.66E+04	13.848338	680.5838321	92.5889484
8.68E+07	4.52E-01	1.79E-05	3.66E+04	13.811697	684.9693054	94.3679199
8.69E+07	4.53E-01	1.96E-05	3.68E+04	13.774867	689.3356807	96.1582316
8.70E+07	4.55E-01	3.28E-05	3.70E+04	13.737899	693.6754594	97.9598144
8.71E+07	4.56E-01	4.18E-04	3.71E+04	13.700817	697.9841269	99.7725875
8.72E+07	4.57E-01	3.05E-05	3.71E+04	13.663709	702.2502529	101.59644
8.72E+07	4.57E-01	1.83E-05	3.72E+04	13.626502	706.4808191	103.431281
8.73E+07	4.59E-01	1.15E-04	3.73E+04	13.589209	710.672968	105.277009
8.74E+07	4.60E-01	4.27E-05	3.74E+04	13.551816	714.8268741	107.133525
8.75E+07	4.61E-01	3.16E-05	3.74E+04	13.514386	718.9340267	109.000708
8.76E+07	4.62E-01	2.87E-05	3.75E+04	13.476837	723.0022201	110.878457
8.76E+07	4.63E-01	1.84E-05	3.76E+04	13.439193	727.0273739	112.76666
8.77E+07	4.63E-01	3.56E-05	3.77E+04	13.401494	731.0037065	114.66519
8.78E+07	4.64E-01	4.72E-05	3.77E+04	13.363823	734.9214751	116.573895
8.79E+07	4.66E-01	3.60E-05	3.78E+04	13.325975	738.8006571	118.492675
8.80E+07	4.69E-01	8.56E-05	3.81E+04	13.287903	742.6441959	120.421437
8.80E+07	4.71E-01	2.43E-05	3.82E+04	13.249654	746.4453487	122.360071
8.81E+07	4.70E-01	3.17E-05	3.82E+04	13.211412	750.1843896	124.308417
8.82E+07	4.70E-01	2.90E-05	3.82E+04	13.173168	753.8613525	126.266312
8.83E+07	4.71E-01	2.49E-05	3.83E+04	13.134898	757.47739	128.233598
8.84E+07	4.72E-01	4.17E-04	3.84E+04	13.096530	761.0381644	130.210132
8.85E+07	4.73E-01	2.70E-05	3.84E+04	13.058113	764.537807	132.195755
8.85E+07	4.74E-01	2.00E-05	3.85E+04	13.019572	767.9817507	134.190323
8.86E+07	4.75E-01	1.19E-04	3.86E+04	12.980958	771.3641564	136.193675
8.87E+07	4.77E-01	2.44E-05	3.88E+04	12.942201	774.6895375	138.205664
8.88E+07	4.78E-01	2.24E-05	3.89E+04	12.903347	777.9524489	140.226128
8.89E+07	4.78E-01	2.89E-05	3.89E+04	12.864408	781.1506219	142.254897
8.89E+07	4.80E-01	1.35E-04	3.90E+04	12.825422	784.2796655	144.291793

8.90E+07	4.82E-01	4.79E-05	3.92E+04	12.786266	787.3480991	146.336658
8.91E+07	4.85E-01	2.65E-05	3.93E+04	12.746953	790.353099	148.389328
8.92E+07	4.85E-01	4.63E-05	3.95E+04	12.707501	793.2916093	150.449629
8.93E+07	4.85E-01	2.01E-05	3.95E+04	12.668051	796.1520527	152.517359
8.93E+07	4.86E-01	3.96E-04	3.95E+04	12.628549	798.9374273	154.592324
8.94E+07	4.88E-01	2.99E-05	3.96E+04	12.588952	801.6495285	156.674332
8.95E+07	4.88E-01	4.30E-05	3.97E+04	12.549223	804.2895766	158.763197
8.96E+07	4.89E-01	2.09E-05	3.98E+04	12.509453	806.8502392	160.858712
8.97E+07	4.90E-01	3.80E-05	3.99E+04	12.469598	809.3333672	162.960676
8.98E+07	4.93E-01	4.95E-05	4.00E+04	12.429628	811.7395268	165.06889
8.98E+07	4.95E-01	2.54E-05	4.02E+04	12.389391	814.0760563	167.183172
8.99E+07	4.95E-01	4.94E-05	4.03E+04	12.349062	816.3310554	169.30331
9.00E+07	4.95E-01	1.42E-04	4.03E+04	12.308741	818.4980581	171.429076
9.01E+07	4.97E-01	2.47E-05	4.03E+04	12.268418	820.5770815	173.560242
9.02E+07	4.99E-01	2.40E-04	4.05E+04	12.227899	822.5769481	175.696602
9.02E+07	5.01E-01	6.70E-05	4.07E+04	12.187207	824.4948446	177.837943
9.03E+07	5.02E-01	6.96E-04	4.08E+04	12.146378	826.3275465	179.984044
9.04E+07	5.03E-01	1.69E-04	4.09E+04	12.105512	828.0695174	182.134669
9.05E+07	5.04E-01	6.31E-05	4.10E+04	12.064516	829.7237493	184.28959
9.06E+07	5.06E-01	2.40E-05	4.11E+04	12.023413	831.2881245	186.448575
9.07E+07	5.07E-01	5.04E-05	4.12E+04	11.982207	832.7613847	188.611385
9.07E+07	5.08E-01	3.89E-05	4.13E+04	11.940956	834.1406013	190.777778
9.08E+07	5.11E-01	3.29E-05	4.15E+04	11.899475	835.4307571	192.947521
9.09E+07	5.13E-01	2.44E-05	4.17E+04	11.857783	836.6293824	195.120377
9.10E+07	5.15E-01	3.45E-05	4.18E+04	11.815946	837.7330896	197.2961
9.11E+07	5.15E-01	8.33E-05	4.19E+04	11.774079	838.7380172	199.474433
9.11E+07	5.16E-01	2.39E-04	4.20E+04	11.732113	839.6451836	201.655122
9.12E+07	5.17E-01	1.18E-04	4.20E+04	11.690091	840.4529389	203.837908
9.13E+07	5.18E-01	3.61E-05	4.21E+04	11.647969	841.1614687	206.022535
9.14E+07	5.21E-01	2.87E-05	4.23E+04	11.605716	841.7703887	208.208743
9.15E+07	5.23E-01	2.26E-05	4.25E+04	11.563232	842.2797787	210.396275
9.15E+07	5.25E-01	4.12E-05	4.26E+04	11.520610	842.6871712	212.584864
9.16E+07	5.26E-01	4.12E-05	4.27E+04	11.477868	842.9914691	214.774244
9.17E+07	5.26E-01	4.28E-05	4.28E+04	11.435100	843.19154	216.964143
9.18E+07	5.28E-01	5.91E-05	4.29E+04	11.392185	843.2874127	219.154291
9.19E+07	5.31E-01	3.22E-05	4.31E+04	11.349071	843.27807	221.344415
9.20E+07	5.34E-01	3.00E-05	4.34E+04	11.305692	843.1619664	223.534237
9.20E+07	5.35E-01	4.09E-05	4.35E+04	11.262216	842.9384248	225.723479
9.21E+07	5.35E-01	4.52E-05	4.36E+04	11.218649	842.6070431	227.911861
9.22E+07	5.37E-01	2.07E-05	4.37E+04	11.174991	842.1674474	230.0991
9.23E+07	5.40E-01	3.74E-05	4.38E+04	11.131150	841.6180259	232.284913
9.24E+07	5.41E-01	3.35E-05	4.39E+04	11.087200	840.9590103	234.469014
9.24E+07	5.42E-01	2.13E-05	4.41E+04	11.043093	840.1891132	236.651115
9.25E+07	5.43E-01	1.35E-04	4.42E+04	10.998907	839.3092921	238.830932
9.26E+07	5.45E-01	1.63E-04	4.43E+04	10.954620	838.3189596	241.008176
9.27E+07	5.47E-01	5.66E-05	4.44E+04	10.910243	837.2181963	243.182561
9.28E+07	5.48E-01	2.90E-05	4.45E+04	10.865694	836.0045985	245.353795
9.28E+07	5.49E-01	2.56E-05	4.46E+04	10.821061	834.6802655	247.521589
9.29E+07	5.51E-01	9.11E-05	4.48E+04	10.776292	833.2435534	249.685652
9.30E+07	5.52E-01	4.21E-05	4.49E+04	10.731441	831.6960844	251.845696

9.31E+07	5.54E-01	1.14E-04	4.50E+04	10.686399	830.0339219	254.001423
9.32E+07	5.56E-01	6.06E-05	4.52E+04	10.641192	828.257538	256.152536
9.33E+07	5.59E-01	2.94E-05	4.54E+04	10.595779	826.3648771	258.298734
9.33E+07	5.61E-01	2.56E-05	4.56E+04	10.550224	824.3582553	260.43972
9.34E+07	5.62E-01	3.39E-05	4.57E+04	10.504498	822.2362125	262.575195
9.35E+07	5.65E-01	3.63E-05	4.59E+04	10.458627	819.9999406	264.704862
9.36E+07	5.67E-01	3.10E-05	4.61E+04	10.412575	817.6475215	266.828419
9.37E+07	5.69E-01	2.62E-05	4.62E+04	10.366417	815.1829789	268.945576
9.37E+07	5.69E-01	5.40E-05	4.63E+04	10.320109	812.6041455	271.056035
9.38E+07	5.70E-01	1.78E-04	4.64E+04	10.273737	809.916337	273.159514
9.39E+07	5.73E-01	4.08E-05	4.65E+04	10.227198	807.1140011	275.255714
9.40E+07	5.76E-01	4.47E-05	4.67E+04	10.180474	804.1962307	277.344336
9.41E+07	5.78E-01	1.01E-04	4.70E+04	10.133503	801.1590594	279.425071
9.42E+07	5.79E-01	3.92E-05	4.71E+04	10.086408	798.01065	281.497628
9.42E+07	5.82E-01	1.43E-04	4.73E+04	10.039139	794.7480418	283.561712
9.43E+07	5.85E-01	4.17E-05	4.74E+04	9.991696	791.3717836	285.617027
9.44E+07	5.88E-01	5.73E-05	4.77E+04	9.943949	787.8724729	287.663254
9.45E+07	5.90E-01	2.69E-05	4.80E+04	9.895990	784.2570457	289.700091
9.46E+07	5.93E-01	4.10E-05	4.82E+04	9.847823	780.5260044	291.727239
9.46E+07	5.94E-01	3.14E-05	4.83E+04	9.799564	776.6892698	293.744421
9.47E+07	5.97E-01	5.29E-05	4.85E+04	9.751111	772.7396685	295.751346
9.48E+07	5.99E-01	9.16E-05	4.87E+04	9.702447	768.6763384	297.747718
9.49E+07	6.02E-01	1.27E-04	4.89E+04	9.653552	764.4983325	299.733238
9.50E+07	6.05E-01	5.00E-05	4.91E+04	9.604468	760.2098166	301.707621
9.50E+07	6.07E-01	2.00E-05	4.93E+04	9.555131	755.8061301	303.670567
9.51E+07	6.09E-01	2.34E-04	4.95E+04	9.505654	751.2982842	305.621805
9.52E+07	6.11E-01	4.64E-05	4.96E+04	9.456010	746.6850211	307.561062
9.53E+07	6.14E-01	3.73E-05	4.98E+04	9.406217	741.9694217	309.488072
9.54E+07	6.15E-01	9.21E-05	5.00E+04	9.356200	737.1455242	311.402553
9.55E+07	6.20E-01	3.17E-05	5.03E+04	9.305946	732.2132446	313.304224
9.55E+07	6.22E-01	3.56E-05	5.05E+04	9.255413	727.1694078	315.192796
9.56E+07	6.23E-01	6.67E-05	5.06E+04	9.204811	722.0366164	317.068037
9.57E+07	6.26E-01	1.52E-04	5.08E+04	9.153998	716.802049	318.929683
9.58E+07	6.30E-01	6.34E-05	5.11E+04	9.102908	711.4604214	320.777456
9.59E+07	6.31E-01	3.53E-05	5.13E+04	9.051587	706.0177921	322.611094
9.59E+07	6.33E-01	4.40E-05	5.14E+04	9.000171	700.4905156	324.430377
9.60E+07	6.38E-01	2.42E-05	5.17E+04	8.948434	694.8559827	326.235025
9.61E+07	6.42E-01	3.11E-05	5.21E+04	8.896335	689.1108991	328.024753
9.62E+07	6.45E-01	3.93E-05	5.24E+04	8.843942	683.2642479	329.799297
9.63E+07	6.46E-01	4.95E-05	5.25E+04	8.791450	677.3397554	331.558453
9.63E+07	6.50E-01	5.58E-05	5.28E+04	8.738682	671.3195898	333.301974
9.64E+07	6.53E-01	3.82E-05	5.30E+04	8.685662	665.2083963	335.029624
9.65E+07	6.56E-01	3.64E-05	5.33E+04	8.632402	659.0095742	336.741174
9.66E+07	6.60E-01	7.19E-05	5.35E+04	8.578917	652.7270416	338.436407
9.67E+07	6.63E-01	1.58E-04	5.38E+04	8.525085	646.3483878	340.115074
9.68E+07	6.66E-01	3.69E-04	5.41E+04	8.470980	639.8846353	341.776954
9.68E+07	6.70E-01	4.27E-05	5.44E+04	8.416593	633.336745	343.421828
9.69E+07	6.73E-01	3.12E-04	5.46E+04	8.361993	626.7155855	345.049505
9.70E+07	6.76E-01	3.64E-05	5.49E+04	8.307059	620.0086821	346.659764
9.71E+07	6.80E-01	6.01E-04	5.52E+04	8.251858	613.22672	348.252409

9.72E+07	6.84E-01	5.31E-05	5.55E+04	8.196371	606.3697943	349.827245
9.72E+07	6.87E-01	3.44E-05	5.57E+04	8.140658	599.4478836	351.384104
9.73E+07	6.91E-01	4.64E-05	5.61E+04	8.084563	592.4441053	352.922774
9.74E+07	6.96E-01	1.78E-04	5.65E+04	8.028105	585.3633103	354.443053
9.75E+07	7.02E-01	1.88E-04	5.69E+04	7.971215	578.1995188	355.944727
9.76E+07	7.05E-01	6.93E-05	5.72E+04	7.914031	570.9724375	357.427631
9.77E+07	7.10E-01	9.55E-05	5.76E+04	7.856423	563.6684393	358.891565
9.77E+07	7.12E-01	1.26E-04	5.79E+04	7.798512	556.3056292	360.336377
9.78E+07	7.17E-01	3.82E-05	5.82E+04	7.740333	548.8910594	361.761932
9.79E+07	7.21E-01	8.10E-05	5.85E+04	7.681856	541.4238892	363.168094
9.80E+07	7.23E-01	7.75E-05	5.88E+04	7.623065	533.9047059	364.554728
9.81E+07	7.27E-01	7.78E-05	5.90E+04	7.564063	526.3493968	365.921739
9.81E+07	7.32E-01	4.83E-05	5.94E+04	7.504680	518.7391605	367.268985
9.82E+07	7.38E-01	5.47E-05	5.98E+04	7.444894	511.0735947	368.596322
9.83E+07	7.43E-01	3.84E-05	6.03E+04	7.384584	503.3400395	369.903574
9.84E+07	7.48E-01	5.59E-05	6.07E+04	7.323891	495.5589924	371.190618
9.85E+07	7.53E-01	3.10E-04	6.11E+04	7.262812	487.7326415	372.457335
9.85E+07	7.58E-01	5.62E-05	6.14E+04	7.201385	479.8683304	373.703628
9.86E+07	7.63E-01	6.73E-05	6.19E+04	7.139464	471.9497604	374.929354
9.87E+07	7.70E-01	3.47E-05	6.24E+04	7.077051	463.9793892	376.134381
9.88E+07	7.74E-01	5.36E-05	6.29E+04	7.014186	455.9645405	377.318591
9.89E+07	7.79E-01	1.89E-04	6.31E+04	6.951049	447.930189	378.481936
9.90E+07	7.86E-01	6.17E-05	6.37E+04	6.887346	439.8405053	379.62427
9.90E+07	7.88E-01	3.68E-05	6.41E+04	6.823256	431.7200048	380.745514
9.91E+07	7.96E-01	2.96E-04	6.45E+04	6.758767	423.5684255	381.845586
9.92E+07	8.02E-01	8.46E-05	6.50E+04	6.693809	415.3778212	382.924387
9.93E+07	8.08E-01	4.62E-05	6.55E+04	6.628298	407.1385993	383.981789
9.94E+07	8.16E-01	1.63E-03	6.61E+04	6.562230	398.8507724	385.017667
9.94E+07	8.20E-01	6.22E-05	6.66E+04	6.495663	390.5215826	386.031912
9.95E+07	8.28E-01	2.14E-04	6.70E+04	6.428677	382.1606902	387.024442
9.96E+07	8.35E-01	6.07E-05	6.77E+04	6.361016	373.7354207	387.995091
9.97E+07	8.43E-01	7.29E-05	6.83E+04	6.292732	365.2509419	388.943704
9.98E+07	8.49E-01	2.40E-04	6.89E+04	6.223844	356.7077497	389.87013
9.98E+07	8.57E-01	1.15E-04	6.94E+04	6.154484	348.1195624	390.77425
9.99E+07	8.64E-01	8.33E-05	7.01E+04	6.084431	339.4557191	391.655869
1.00E+08	8.73E-01	4.89E-04	7.08E+04	6.013640	330.7064019	392.514765
1.00E+08	8.80E-01	8.24E-05	7.10E+04	5.942640	321.9319278	393.350872
1.00E+08	8.86E-01	3.34E-04	7.24E+04	5.870208	312.9751903	394.163718
1.00E+08	8.97E-01	1.07E-04	7.22E+04	5.797978	304.0309462	394.953333
1.00E+08	9.07E-01	8.10E-05	7.31E+04	5.724906	294.9616376	395.719394
1.00E+08	9.13E-01	1.78E-04	7.46E+04	5.650268	285.6671205	396.461316
1.00E+08	9.25E-01	2.50E-04	7.44E+04	5.575826	276.3554143	397.179054
1.01E+08	9.35E-01	1.25E-04	7.63E+04	5.499563	266.760769	397.871873
1.01E+08	9.44E-01	1.55E-04	7.61E+04	5.423449	257.1157118	398.539642
1.01E+08	9.55E-01	1.08E-04	7.69E+04	5.346518	247.282199	399.181873
1.01E+08	9.65E-01	1.46E-04	7.87E+04	5.267779	237.111809	399.797689
1.01E+08	9.77E-01	5.00E-05	7.86E+04	5.189140	226.8288885	400.386799
1.01E+08	9.87E-01	1.37E-04	7.95E+04	5.109611	216.2811052	400.948514
1.01E+08	1.00E+00	1.51E-04	8.15E+04	5.028089	205.2903474	401.481685
1.01E+08	1.02E+00	5.51E-05	8.17E+04	4.946407	194.0704453	401.985716

1.01E+08	1.03E+00	8.46E-05	8.38E+04	4.862584	182.3107772	402.459206
1.01E+08	1.04E+00	6.44E-05	8.39E+04	4.778722	170.2640578	402.901408
1.01E+08	1.06E+00	2.66E-04	8.51E+04	4.693647	157.7194735	403.31103
1.01E+08	1.08E+00	2.09E-04	8.75E+04	4.606144	144.4358148	403.686152
1.02E+08	1.09E+00	1.42E-04	8.78E+04	4.518380	130.6795877	404.025547
1.02E+08	1.11E+00	9.55E-05	8.91E+04	4.429321	116.2273589	404.327408
1.02E+08	1.12E+00	1.81E-04	9.14E+04	4.337881	100.8156573	404.589241
1.02E+08	1.14E+00	2.64E-04	9.17E+04	4.246177	84.71483788	404.809259
1.02E+08	1.16E+00	9.17E-05	9.44E+04	4.151727	67.38717996	404.984274
1.02E+08	1.18E+00	2.26E-04	9.50E+04	4.056744	49.12269434	405.111853
1.02E+08	1.21E+00	1.07E-04	9.69E+04	3.959881	29.54519742	405.188587
1.02E+08	1.24E+00	8.11E-05	1.00E+05	3.859648		
1.02E+08	1.26E+00	2.19E-04	1.01E+05	3.758382		
1.02E+08	1.28E+00	1.68E-04	1.03E+05	3.655201		
1.02E+08	1.31E+00	1.26E-04	1.07E+05	3.548688		
1.02E+08	1.35E+00	1.42E-04	1.08E+05	3.440906		
1.03E+08	1.38E+00	3.50E-04	1.12E+05	3.328941		
1.03E+08	1.43E+00	1.93E-04	1.14E+05	3.215161		
1.03E+08	1.47E+00	4.47E-04	1.17E+05	3.097937		
1.03E+08	1.51E+00	2.59E-04	1.22E+05	2.975637		
1.03E+08	1.57E+00	2.67E-04	1.25E+05	2.850926		
1.03E+08	1.62E+00	1.39E-04	1.29E+05	2.721868		
1.03E+08	1.69E+00	2.24E-04	1.36E+05	2.586174		
1.03E+08	1.75E+00	2.58E-04	1.39E+05	2.446805		
1.03E+08	1.83E+00	1.11E-03	1.47E+05	2.299746		
1.03E+08	1.92E+00	3.57E-04	1.52E+05	2.147800		
1.03E+08	1.99E+00	5.09E-04	1.58E+05	1.989684		
1.03E+08	2.06E+00	7.36E-04	1.66E+05	1.823775		
1.04E+08	2.11E+00	3.39E-04	1.69E+05	1.654842		
1.04E+08	2.14E+00	4.67E-04	1.72E+05	1.482783		
1.04E+08	2.14E+00	5.62E-04	1.75E+05	1.307549		
1.04E+08	2.08E+00	5.58E-04	1.71E+05	1.136973		
1.04E+08	2.01E+00	4.89E-04	1.67E+05	0.969548		
1.04E+08	1.88E+00	5.13E-04	1.57E+05	0.812190		
1.04E+08	1.71E+00	6.22E-04	1.45E+05	0.666976		
1.04E+08	1.51E+00	3.94E-04	1.32E+05	0.534853		
1.04E+08	1.29E+00	5.06E-04	1.14E+05	0.421262		
1.04E+08	1.07E+00	3.49E-04	9.56E+04	0.325697		
1.04E+08	8.58E-01	2.81E-04	7.90E+04	0.246688		
1.04E+08	6.74E-01	8.95E-04	6.20E+04	0.184642		
1.04E+08	5.03E-01	1.60E-04	4.83E+04	0.136384		
1.05E+08	3.63E-01	1.37E-04	3.51E+04	0.101313		
1.05E+08	2.53E-01	1.22E-04	2.49E+04	0.076374		
1.05E+08	1.59E-01	1.30E-04	1.69E+04	0.059475		
1.05E+08	1.01E-01	4.74E-05	1.06E+04	0.048923		
1.05E+08	6.78E-02	2.16E-05	6.85E+03	0.042074		
1.05E+08	4.26E-02	1.24E-05	4.52E+03	0.037550		
1.05E+08	2.27E-02	8.62E-06	2.64E+03	0.034907		
1.05E+08	1.37E-02	7.58E-06	1.49E+03	0.033414		
1.05E+08	6.80E-03	2.12E-06	8.32E+02	0.032582		

1.05E+08	3.23E-03	2.83E-06	4.06E+02	0.032176		
1.05E+08	4.52E-04	1.05E-06	1.51E+02	0.032025		
1.05E+08	0.00E+00	0.00E+00	1.83E+01	0.032007		
1.06E+08	0.00E+00	0.00E+00	0.00E+00	0.032007		