MATANEL FOUNDATION

ACTIVITY REPORT

Program: *Participation of Israel Laureate in the International Expo-Sciences Luxembourg*

 Participation awarded as a prize in the context of the 32nd European Union Contest for Young Scientists EUCYS 2020/2021

Year: 2022

Please present your activity report according to the following lines. The whole report will not exceed 2 or 3 pages (as word document).

Name of the Program: *"Participation of Israel Laureate in the International Expo-Sciences Luxembourg"*
Participation awarded as a prize in the context of the 32nd European Union Contest for Young Scientists EUCYS 2020/2021

Year of activity: 2022

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Website / Facebook address of the organization: https://www.fjsl.lu

Number of active participants in the program: 1 -Uri Sadan-Yarchi

Estimated number of impacted participants: 1 -Uri Sadan-Yarchi

Give the actually state of the program (where the program stands at the date of the activity report, no more than ten lines):

The Matanel Foundation sponsorship enables the Fondation Jeunes Scientifiques Luxembourg to award one exceptional young Israeli laureate who participated at the European Union Contest for Young Scientists EUCYS 2020/2021 with the opportunity to participate in the International Expo-Sciences Luxembourg, which took place from the October 6th to October 9th 2022.
This science exhibition is an opportunity for visitors to discover the issues that captivate the future researchers, handle some of their fascinating prototypes and discover new rising areas of expertise. Delegations from all over the world come to meet and share with the national laureates and the Luxembourg public in this non-competitive Science exhibition. Through more than 45 booths, the young scientists look forward to

presenting a wide range of unique innovations and research, from engineering, and environmental protection to political science, in direct interaction with visitors.

The main achievements during the last year of activity (main achievements, number of events, number of participants, etc.):

The Expo-Sciences, presented a great opportunity for young scientists to present their project to the Luxembourgish public, as well as meeting and collaborating and exchanging with like-minded laureates from around the world.

The main achievement of Expo-Sciences is to offer a scientific and cultural exchange to young laureates from all over the world. In 2022 was the fist stand alive edition of Expo-Sciences, as for the previous years the event was held along with the Jonk Fuerscher Contest. Last year there were 61 participants, from 18 different countries, including: Germany, Luxembourg, Belgium, Mexico, Danmark, Tunisia, Turkey, Austria, Italy, France, Spain, Bulgaria, Nigeria, Portugal, Czech Republic, Estonia and Israel.

The evaluation (methodology, results, comparisons with the precedent year, conclusions for the future…):

The advantages of the Expo-Sciences exhibition are the opportunities given to the laureates to have a scientific and cultural exchange, learn about the different researches done and the different cultures from each participant, as well as to provide a network with like-minded young laureates from all over the world.

On the one hand, the participants are presenting their projects and learning about the research and methods of the others. On the other hand, they get to socialize and interact with each other during different activities such as escape room puzzle, laser tag and cultural night where they present their country and traditions and learn about the others.

Furthermore, socializing activities allow them to get to know other participants, on a more personal and social level, build new friendships and thus underlining the importance of the social and human part of science.

As can be seen from the numbers and positive feedback from the participants, the first stand alone edition of Expo-Science was a success and well received. For the following years the Expo-Science will continue to have stand alone editions and grow into its own event and identity.

Provisional guidelines for the advancement of the program in the next year:

The main improvement that could be made would be to encourage even more national laureates to participate, as last year's edition only 17 of the 61 participants were national, and take the opportunity of interacting and meeting outstanding international laureates.

Please join the Evaluation Report, the Financial Report and the list of the participants to the program (**as PDF documents**)

Please see the documents "1. Evaluation report", "2. Financial report"
The participant is: Uri Sadan-Yarchi

Please join photos – as **JPG files** – and any link or any other document connected to the program which seems relevant to you – as **PDF document**.

Please see the attached document "3. 6 pictures, 2 movies and 1 podcast"

Please join a 5 minute movie which presents your institution and the particular project supported by the Matanel Foundation. The movie should be accessible to the philanthropic world and to other potential donors.

Short movie of the FJSL's Expo-Sciences Luxembourg 2022:

https://youtu.be/DZ4zjvuFxOQ

Evaluation report, analysing the pros and cons of the program and the benefits of participating.

Overall, the benefits and advantages of the program outweigh the limitations currently experienced due to the virtual organisation. Below a table of Pro's and Con's:

Expo- Sciences Participation PRO's	Expo- Sciences Participation CON's
Meeting several young scientists from different countries and cultures	Small number of Luxembourgish laureates participating in the activities (due to school work load)
Exchange of ideas, traditions and cultures	
Fun and dynamic activities for the young scientists to interact and get to know each other	
Visiting and getting to know Luxembourg	
Opportunity to present the research to the Luxembourgish public	
Discovering new friendships, areas of interest and potential projects	
Various topics of interesting workshops to choose from	

Conclusion:

In conclusion, Expo Sciences Luxembourg provides an exciting opportunity for young scientists to come together, share their ideas and culture, and create new friendships. The exchange of ideas, traditions, and cultures that takes place at such events can be eye-opening and provide a unique perspective on the world. The fun and dynamic activities offered by the exhibition also allow for an enjoyable and memorable experience. Additionally, the chance to present research to the Luxembourgish public and attend workshops on various topics of interest makes the event even more enriching. Overall, Expo Sciences Luxembourg is an excellent platform to discover new areas of interest and potential projects, while also fostering a sense of community and collaboration among young scientists from around the globe. And efforts are being made to involve even more

Luxembourgish laureates in the activities in order for them to also enjoy the cultural and scientific exchange.

Cultural Night- Presenting your country

Cultural Night

Closing ceremony


Thank You!

Expo Sciences luxembourg- Awards Distribution
https://youtu.be/EcBbymofZw0

Expo Sciences 2022- Official Closing ceremony
https://youtu.be/G-YGjQGAwSI

FJSL Podcast - Jonk Fuersher voices
Interview with Uri Sadan-Yarchi from minute 1:03 to 8:58
https://open.spotify.com/episode/078DrRXAZDK3nLgymvqiTQ?si=XiHChl1fQbmMxQJQnTxYrQ

Uri Sadan-Yarchi testimonial:

“The city (Luxembourg) is really amazing, both the architecture and landscapes”

“The environment in the Expo-Sciences […]People that share the same ideas, from different countries with the same mindsets[…]Exchanging ideas with people that know what I mean, it is really nice”

“I have been talking to some friends from Germany now, Bulgaria with projects in physics/mathematics/computer science, which is really interesting because I really like those too”

Using cylindrical capsule and magnetic fields to achieve ignition conditions in the ICF method

Uri Sadan Yarchi

Introduction

Studies of the UN[1] have shown that in 2050 the world population will grow to approximately 9.8 billion people. Along with the predictions of future electricity consumption per person per year, we can evaluate that in 2050 the global consumption will be 2.5-3 times more than today.

Nuclear fusion could be the solution to this future problem.

Inertial confinement fusion (ICF) is a method to perform nuclear fusion in which a set of lasers are being used to heat a spherical capsule filled with deuterium and tritium (isotopes of hydrogen). The immense heat is causing an implosion, that heats the capsule even more. If the system that created is dense and hot enough, then the capsule could meet ignition conditions and perform fusion. In the process, the particles can perform nuclear reaction with one another. This reaction can create large amounts of energy, and potentially be used as an energy source.

So far, nuclear fusion has not been performed successfully. Because energy gain due to the reactions cannot overcome the energy losses that are created during the process. The energy loss is caused by three main factors: heat transferred outside of the capsule, radiation, and the expansion of the capsule.

Today, the most common capsule is the spherical capsule. That is because its ratio of volume to surface area, that allow for ideal initial conditions to nuclear fusion. From this aspect, a cylindrical capsule is inferior to a spherical capsule, due to its worse volume to surface area ratio. Upon first inspection, we should use the spherical capsule to perform nuclear fusion, but the cylindrical capsule's geometry could maybe make it more efficient. On the contrary of a sphere, a cylinder has only one main axis. This allows as to use a magnetic field in the process. The magnetic field has the ability to affect some of the system's mechanisms and perhaps make the cylindrical capsule as/ more efficient than spherical capsule.

In this theoretical study we explored the limitations of the system due to these three energy loss factors to find the conditions for overcoming them. We show that in cylindrical geometry the ICF process can be as efficient as spherical geometry, and find the minimal magnetic field necessary for that.

Results

Energy balance

A general equation to represent the energy balance in the system can be written as:

$$Ww + Wc + Wr \leq Wf$$

We examine each mechanism separately and write an expression that will describe its nature. We use the system's density, temperature, and radius (ρ, T, R) to write these expressions.

Nuclear reactions

Generally, if there are more reactions, more energy will be released. The number of collisions depends on the number of particles in the system, their velocities, and the volume of the system. The temperature is a measure to the average kinetic energy, thus from the relation $\frac{m \cdot v^2}{2} = 3/2 K_B \cdot T$ we can say that $v \sim \sqrt{T}$. In order that the particles will be close enough to make a reaction, the velocities need to be large enough to overcome the repulsive force between the particles (Coulomb's Law). Also, not every interaction will lead to reaction. This probability is a function of the particles' velocities, and it will be represented as $P(T)$. In addition, both the particle density (ρ) and their absolute amount in the system will affect the number of reactions (more particles leads to more reactions). If we will mark Q as the amount of heat that released from every reaction, we could say that the total amount of energy that nuclear reactions yield to our equation can be represented as:

$$\mathbf{W}\boldsymbol{f} \sim \boldsymbol{\rho}^2 \cdot \sqrt{\mathbf{T}} \cdot \mathbf{P}(\boldsymbol{T}) \cdot \boldsymbol{Q} \cdot \frac{4\boldsymbol{\pi}}{3} \boldsymbol{R}^3$$

Mechanical work

As the temperature rises, the particles begin to move in high velocities and thus start to hit the walls of the capsule. In other words, a work is done by the particles, which translates to energy loss. The work done by the particles is given by: $w = P \cdot A \cdot \Delta x$, where P is the pressure and A is the surface area of the capsule. We could substitute the relation

$P \propto \rho \cdot T$, divide by Δt and get that the total amount of energy that is lost due to the mechanical work of the particles is:

$$\boldsymbol{W}_{\boldsymbol{work}} \sim \boldsymbol{\rho} \cdot \boldsymbol{T}^{\frac{3}{2}} \cdot \mathbf{4}\boldsymbol{\pi}\boldsymbol{R}^{\mathbf{2}}$$

Electronic heat convection

During the fusion process a temperature difference between the capsule and the outside environment is created. Due to this difference the system will aspire to reach balance. Energetic electrons from inside the system will collide with low energy electrons outside of the system. This interaction will transfer heat from the center of the capsule to the outside environment. The energy flux represents the amount of energy that passes through a surface per time. In our case, the amount of heat that passes through the capsule's surface. The flux is given by: $S = k_C \cdot \frac{\Delta T}{\Delta R}$, where k_C represents the rate that electrons hit other particles. In our case $\Delta R = R$ since the heat is transferred from the center of the capsule to its surface. $\Delta T = T - T_0$ is the temperature difference between the capsule and the outside environment. Since the temperature outside the system is very small relative to the capsule's temperature ($T \gg T_0$) we could write $\Delta T = T$. The surface area of the capsule is $4\pi R^2$ so we can express the total energy lost from heat convection as:

$$\boldsymbol{w_{Con} \sim k_C \cdot 4\pi R \cdot T}$$

Electronic heat convection

Generally, as the system's temperature rises, and these temperatures are high enough to make to deuterium-tritium gas into plasma. In other words, the bonds between the electron and deuterium's and tritium's nuclei breaks. In the system there are groups of electrons and positive ions – each with density ρ. As mentioned, the particles velocity can be represented as $v \sim \sqrt{T}$.

As the electron move throughout the capsule, they feel an electrical force from the positive ions and their trajectory changes. In this diversion a radiation called "Bremsstrahlung radiation" is emitted from the system in the form of X-ray radiation. In similar to the nuclear reaction mechanism, the volume and density of the system, contributes to the total number of interactions. Also, the probability of interaction between electron to positive ion is given by $P_r(T)$. If we will mark Q_r the amount of energy lost from each electron-ion interaction, the total energy loss caused by radiation can be expressed by:

$$\boldsymbol{w_{rad} \sim \rho^2 \cdot \sqrt{T} \cdot P_r(T) \cdot V \cdot Q_r}$$

Now we can derive the full energy balance equation:

$$\boldsymbol{a_C\, K_C\,(T) \cdot T \cdot X^0 + a_W \cdot T^{\frac{3}{2}} \cdot X^1 + a_R\, P_R\,(T) \cdot T^{\frac{1}{2}} \cdot X^2 = a_F\, P_F\,(T) \cdot T^{\frac{1}{2}} \cdot X^2}$$

Where $X = \rho R$ and the constants a_C (heat convection), a_W (mechanical work), a_R (radiation) and a_F (nuclear reactions) are to simplify the equation. Their values[4]:

- $a_f = \frac{4\pi}{3}$
- $a_C = \frac{16\pi}{7}$
- $a_W = 8\pi\left(\frac{2k_B}{m_i}\right)^{3/2} = 1.351 \cdot 10^{13}\left[\frac{cm^3}{sec^3 \cdot K^{3/2}}\right]$

- $a_F = \frac{\pi}{3}\frac{\epsilon_\alpha}{m_i^2} = 3.364 \cdot 10^{41} \left[\frac{cm^2}{g \cdot sec^2}\right]$

This equation will determine for which values of temperature, radius and density of the system, the nuclear reactions will yield more than the energy that was lost in the process. In Fig.1 the ignition curve is shown, and it describes all the values of (ρ, T, R) in which the energy from the reactions is equal to the energy that was lost due to the other mechanisms. Each point above the curve represents a state of positive energy balance, and each point below the curve represents a state of negative energy balance.

Implosion

The mechanical work mechanism described the expansion of the system. In order to bring the system to high enough temperature and density for ignition, first we must shrink the system by igniting it with powerful lasers. Now, the mechanical work mechanism describes a behavior that yields energy to the system. The mathematical expression will change to $w_{work} = -a'_w \cdot v_0 \cdot T \cdot X$,where v_0 is the implosion velocity of the system, and a'_w is the correction to the numerical constant
of the mechanism, and its value is $a'_w = 8.31 \cdot 10^8$.

Changing to cylindrical geometry

Firstly, since we developed the energy balance equation for a spherical system, we need to modify it to a cylindrical system. This could be done by changing each mechanism's expression of spherical surface area/volume to a cylindrical one. Thus, the equation for cylindrical geometry can be written as:

$$\frac{1}{2}\, a_C\, K_C\,(T) \cdot T \cdot X^0 + \frac{1}{2}\, a_W\, T^{\frac{3}{2}} \cdot X^1 + \frac{3}{4} a_R\, P_R\,(T) \cdot T^{\frac{1}{2}} \cdot X^2 = \frac{3}{4} a_F\, P_F\,(T) \cdot T^{\frac{1}{2}} \cdot X^2$$

In FIG we can see the cylindrical system disadvantage, as its ignition curve is located above the ignition curve for spherical geometry. In other words, higher temperature and density (more resources) values need to be achieved to reach ignition.

Plasma behavior under magnetic field[5]

A magnetic field interacts with charged particles via the magnetic force. This force is also called Lorenz Force and its value is $F_L = qvB$. The direction of the force is perpendicular to the velocity vector of the particle. Thus, for a particle with some initial velocity, the magnetic force acts as a centrifugal force, and the particle will move in a circular motion.

Escape of alpha particles

Alpha particles are composed out of two protons and two electrons, and they are being created in the nuclear reactions. Due to the high velocities that are given to the particles during the process, some alpha particles could escape the system during the fusion process. This translates to an energy loss.

Several different physical factors are affecting the escape of alpha particles. Firstly, as the system's radius is larger, the percentage of alpha particle that will leave the system will be smaller. Due to this fact, we rather have a large system radius, so fewer particles will not leave the system and less energy will be gone.

In addition, there is another physical factor the that describes the motion of the alpha particles – the mean free path. This value is a measure to the average path a particle is traveling until it hits another particle. As the mean free path rises, the particle will hit less particle on it way out. In our case, it means that the chance that a particle will leave the system without any nuclear reaction rises. The mean free path is given by[3] $l_a = 0.107\frac{\theta^{\frac{3}{2}}}{\rho L_a}$, where θ is the system's temperature in [Kev] and L_a is called Coulomb's logarithm, and it is a constant with the value of 7.

We will define $\bar{R} = \frac{R}{l_a}$ to be the ratio between the system's radius and the mean free path. As this ratio will be larger, the particle will hit more particles until it will leave the system. That also means that the chance for a particle to leave the system without any reactions will get smaller, and more energy will remain in the system.

f_α is a function that describes the relative number of alpha particles that kept their energy within the system. This function can be described as[10]:

$$f_\alpha = \frac{x_a + x_a^2}{1 + \frac{13x_a}{9} + x_a^2}$$

Where[3] $x_\alpha = \frac{8}{3}\bar{R}$.

I will mention previous derivations of the energy balance equation, did not took into account the leakage of alpha particles from the system. f_α will represent that effect in the energy balance equation.

To examine x_α under the effects of a magnetic field, we will use the dimensionless variable b that is defined by[3] $b = \frac{R}{r_L}$. In our case, r_L is the radius of rotation of the alpha particles inside the system. As r_L will be smaller, the particles will be closer to the center of the capsule and less could escape. Therefore, we want that the value of b will be as large as possible. Furthermore, r_L is dependent on the magnetic field by $r_L = \frac{mv}{qB}$, thus, f_α itself is dependent on the magnetic field.

The corrected form for x_α is given by[3] $x_\alpha = \frac{8}{3}\left(\bar{R} + \frac{b^2}{\sqrt{9b^2+1000}}\right)$.

We can see that as the magnetic field gets larger, f_α will approach to 1. In other words, larger magnetic field – fewer particles will leak.

Finding the magnetic field's value

As mentioned, the magnetic field interacts with charge particle – including electrons. Therefor, the electronic heat convection will also be affected with the introducing of the magnetic field. In similar that f_α will describe the effects on the alpha particles, f_c will describe the effects of the magnetic field on the heat convection. f_c can be expressed as $f_c = \frac{1}{1+x_e^2}$ where $x_e = \omega_e \cdot \tau_e$.

τ_e is the average time of interactions of electrons from the system, with electrons from the outside environment. ω_e is the frequency of the circular motion of the electrons. These two variables can be expressed as[10]:

$$\tau_e = \frac{3m_e^{\frac{3}{2}} \cdot T^{\frac{3}{2}}}{4\sqrt{2\pi} \cdot L_e \cdot e^4 \rho} \qquad \omega_e = \frac{eB}{m_e c}$$

We will evaluate the required magnetic field, that will create similar conditions between spherical and cylindrical geometry. We will examine the minimum point of the ignition curve, as it represents most achievable values for (ρ, T, R). From the definition of b and the values of (ρ, T, R) from the selected point, we can find the $b = 1.21 \cdot 10^{-7} \cdot B$. We estimated the value of b and thus we could estimate that the required magnetic field is $\mathrm{B} \sim 1.25 \cdot 10^8 [G]$.

Minimal implosion velocity in cylindrical geometry

As found, the minimal implosion velocity for spherical geometry is $v_{min} = 2.4 \cdot 10^7 \left[\frac{cm}{sec}\right]$. In order that cylindrical geometry will be more efficient than spherical geometry, the value of the minimal implosion velocity will need to be less then $v_{min} = 2.4 \cdot 10^7 \left[\frac{cm}{sec}\right]$. the minimal velocity for the spherical case was calculated with the assumption that there is no leakage of alpha particles. But, if the system is losing more energy, then if in cylindrical geometry a velocity less then $v_{min} = 2.4 \cdot 10^7 \left[\frac{cm}{sec}\right]$ will be achieved, then it will also be more efficient the case of spherical geometry with alpha particle leakage.

To calculate the minimal implosion speed, we will use the energy balance equation in its cylindrical-implosion form:

$$\frac{1}{2} \cdot f_c \cdot a_C K_C(T) \cdot T \cdot X^0 - \frac{1}{2} \cdot a_w' \cdot v_0 \cdot T \cdot X + \frac{3}{4} \cdot a_R P_R(T) \cdot T^{\frac{1}{2}} \cdot X^2 = 0$$

Our goal is for the ignition curve and the implosion cure to cross, and as mentioned, we will choose the minimum point for the wanted cross area. Now we can substitute the values for (ρ, T, R) and the magnetic field that was found, and derive that the minimal implosion velocity for cylindrical geometry is:

$$v_0 = 1.19 \cdot 10^7 \left[\frac{cm}{s}\right]$$

This velocity is smaller than the minimal implosion velocity in spherical geometry. As mentioned before, the implosion velocity is a measure to the required initial energy (in this case, the lasers) thus, by using a cylindrical capsule and a magnetic field, we found a more efficient system to perform ICF nuclear.

Finally, we can calculate that required electric current that will generate the required magnetic field is $I = 1831.5[A]$. By comparing it to experimental results[6], this current can be made in a laboratory, and therefor the results of this project can be implemented - it will not be the case if we would find a current that cannot by made in a lab.

Discussion and conclusions

In this project we examined the ICF process for a cylindrical capsule and the usage of a magnetic field. In particular, how the magnetic field effects the ignition conditions, in respect to the more common spherical capsule.

Firstly, we looked at the mechanisms that effects the energy of the system during the process. We wrote an expression to each mechanism that will describe its nature, using the system's temperature, radius and density. With these expression we could write the energy balance equation of the system, from which we could find needed conditions to achieve ignition. Afterwards, we converted the equation to describe a cylindrical capsule. We introduced the effect of leakage of alpha particles, and by using the modified equation we could find the required magnetic field to eliminate this effect. Then, we found the minimal implosion velocity of the capsule, under the magnetic field that was found. Finally, we calculated the electrical current required to produce the magnetic field and that its value is achievable in a laboratory.

As we found, the minimal implosion velocity for cylindrical geometry is:

$$v_0 = 1.19 \cdot 10^7 \left[\frac{cm}{s}\right]$$

We can evaluate how much energy is saved by using the examining the different implosion velocities in different states of the system. We can look at the ratio between those velocities as a measure to the ratio between the required initial energy in each state.

The effect on the leakage of alpha particles yields:

$$\left(\frac{2.9 \cdot 10^7}{3.49 \cdot 10^7}\right)^2 = 0.69$$

In NIF laboratories, United States, the initial energy is $E_0 = 2[MJ]$. Thus, the initial energy in the system where the magnetic field effects the alpha particles is:

$$E_0' = E_0 \cdot 0.69 = 1.38[MJ]$$

In a similar way, we can examine the effect of the magnetic field on the heat convection. The velocities ratio and the modified initial energy are:

$$\left(\frac{1.19 \cdot 10^7}{2.9 \cdot 10^7}\right)^2 = 0.168 \qquad E_0' = E_0 \cdot 0.168 = 0.336[MJ]$$

It is important to mention that it is a significant improvement in the initial energy that required to achieve ignition. This is due to the effects of the magnetic field, that can be used in cylindrical geometry, and here lays the advantage of the cylindrical capsule over the spherical capsule. Also, making such a large magnetic field requires a non-negligible amount of energy, so it does not make need for future research of spherical capsule redundant, but poses the cylindrical geometry as a method worthy to further research in the future.

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3. Basko, M. M., Kemp, A. J. & Meyer-Ter-Vehn, J. Ignition conditions for magnetized target fusion in cylindrical geometry. *Nucl. Fusion* **40,** 59–68 (2000).

4. R. Kishony, E. Waxman, D. S. Inertial confinement fusion ignition criteria, critical profiles and burn wave propagation using self-similar solutions. *Phys. Plasmas 4* (1997).

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Figures

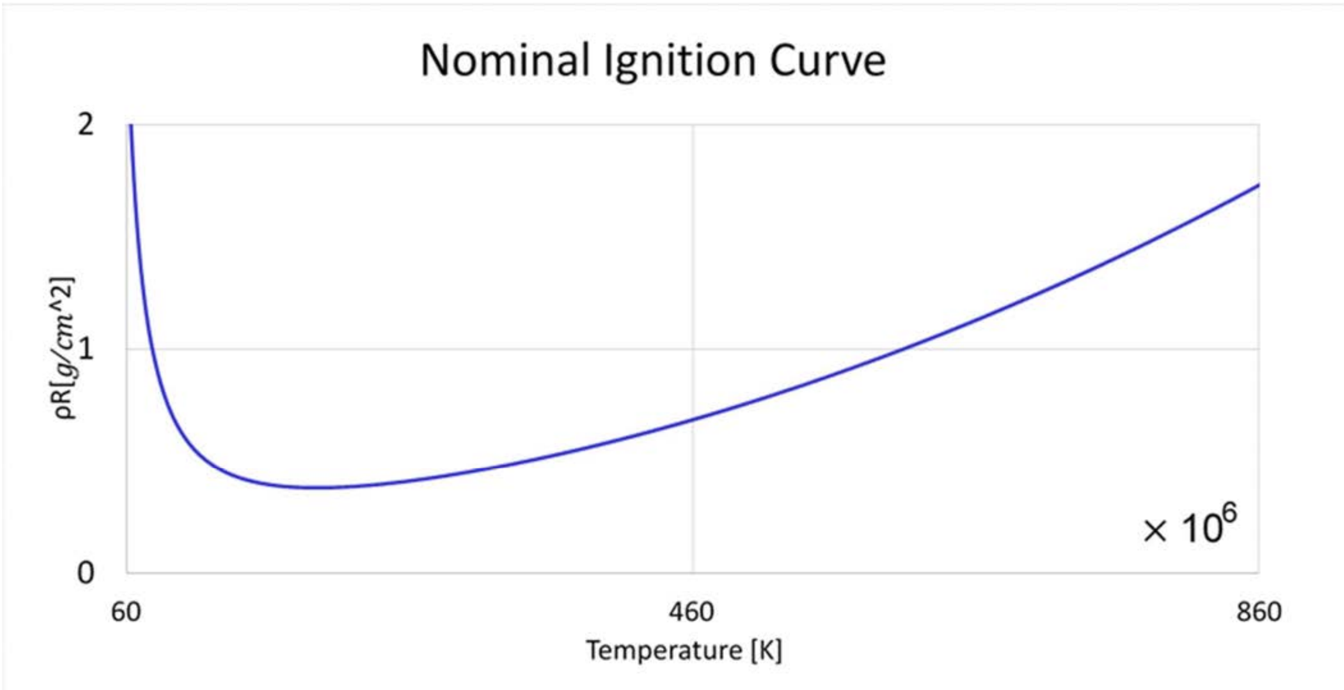


Figure 1: Nominal ignition curve that describes the values for T, R, ρ for which the system is at energy balance

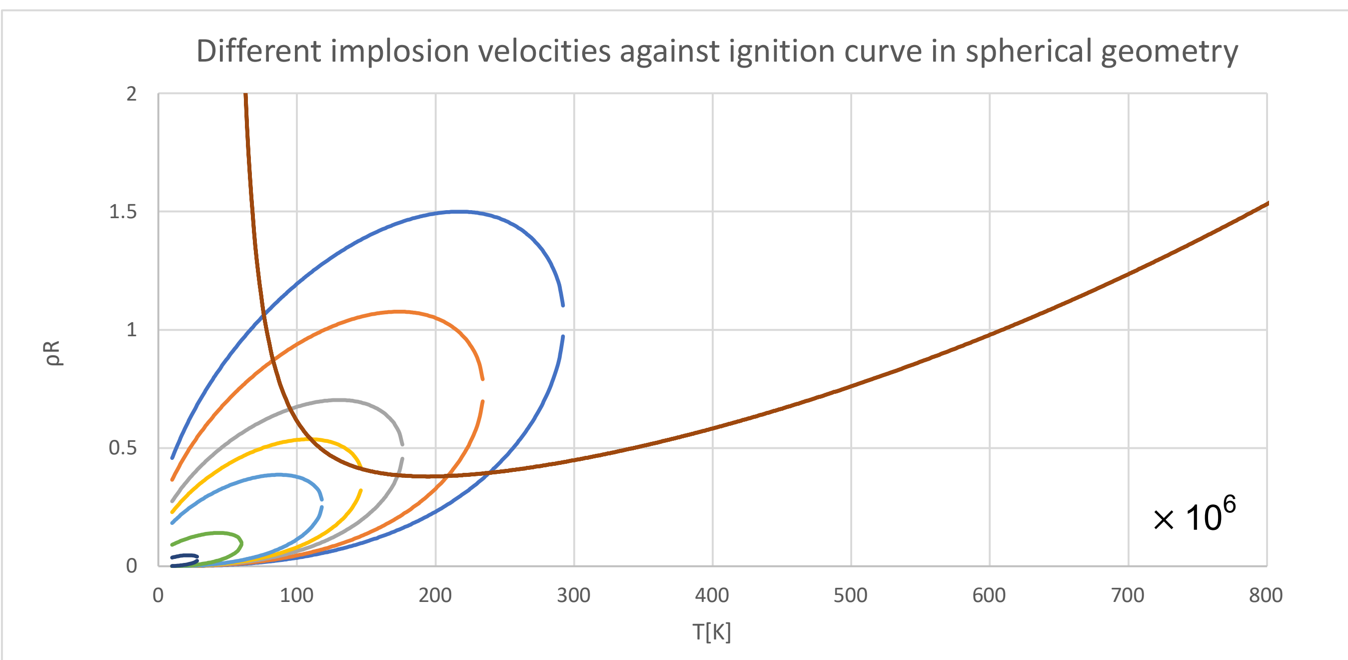


Figure 2: A range of different implosion velocities' curves, and the minimal velocity to cross the ignition curve is in yellow and with the value of: $2.4 \cdot 10^7 \left[\frac{cm}{sec}\right]$

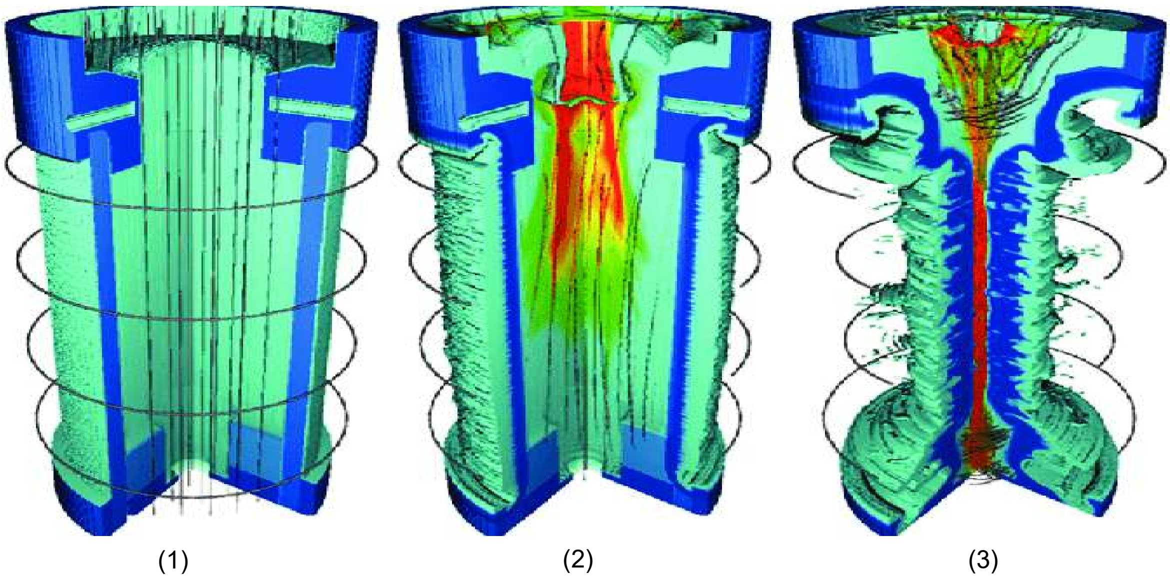


Figure 3: (1) Inserting electrical current through the main axis of the capsule and creating a magnetic field (2) pre-heat the capsule with laser through its main axis (3) compressing the capsule using the magnetic field (the picture was taken from sandia nation)

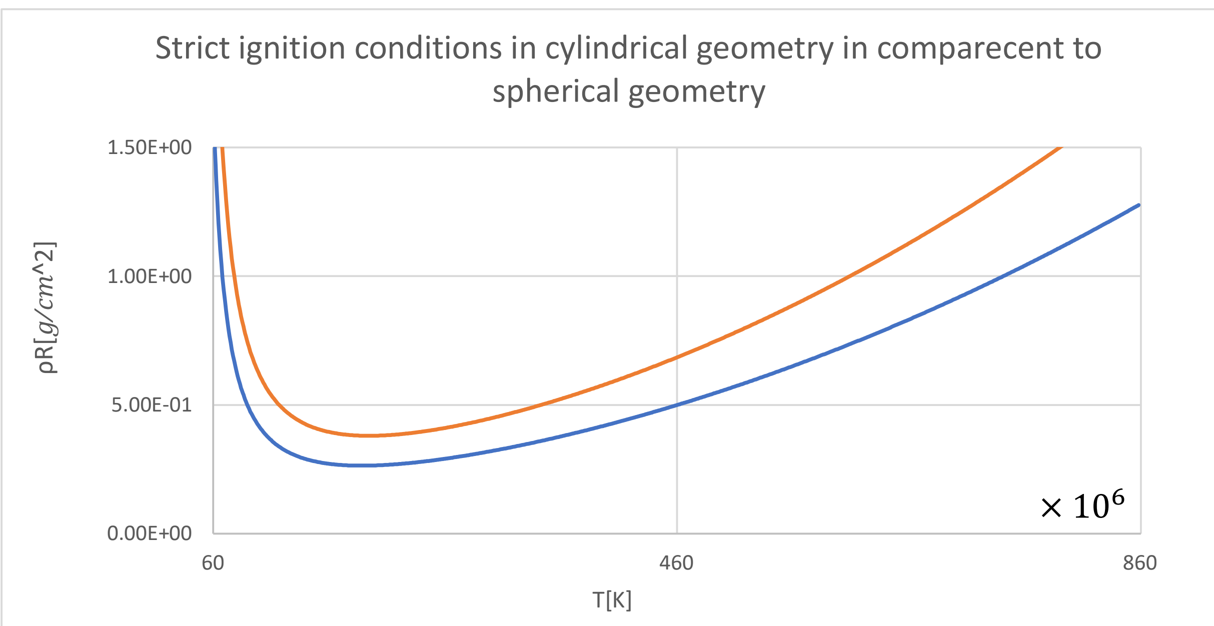
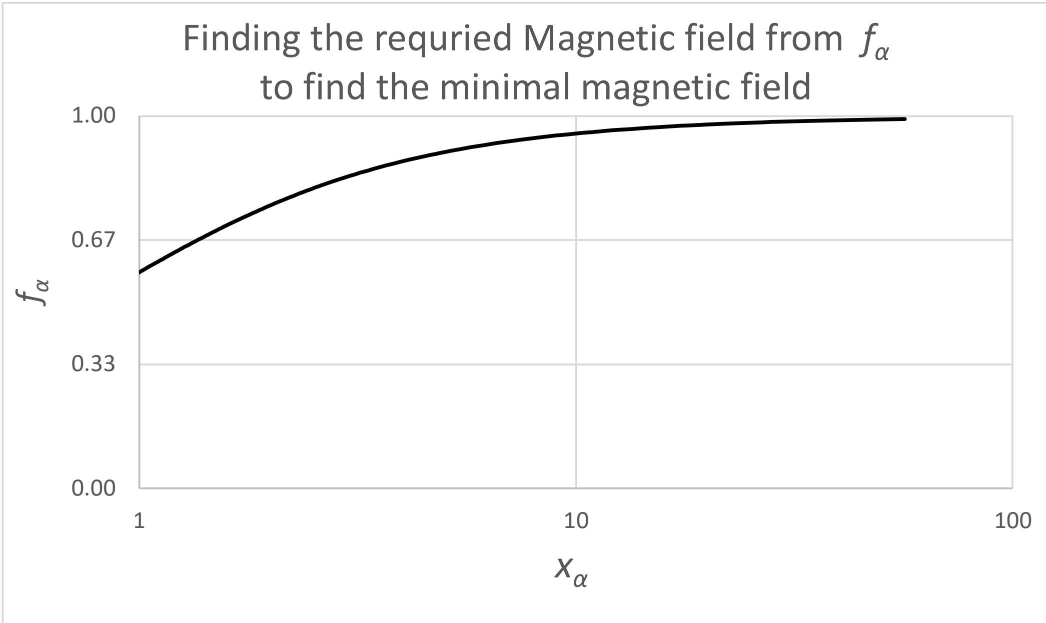


Figure 4: In orange: the nominal ignition curve for a cylindrical capsule, in blue: the nominal ignition curve for a spherical capsule

(a)



(b)

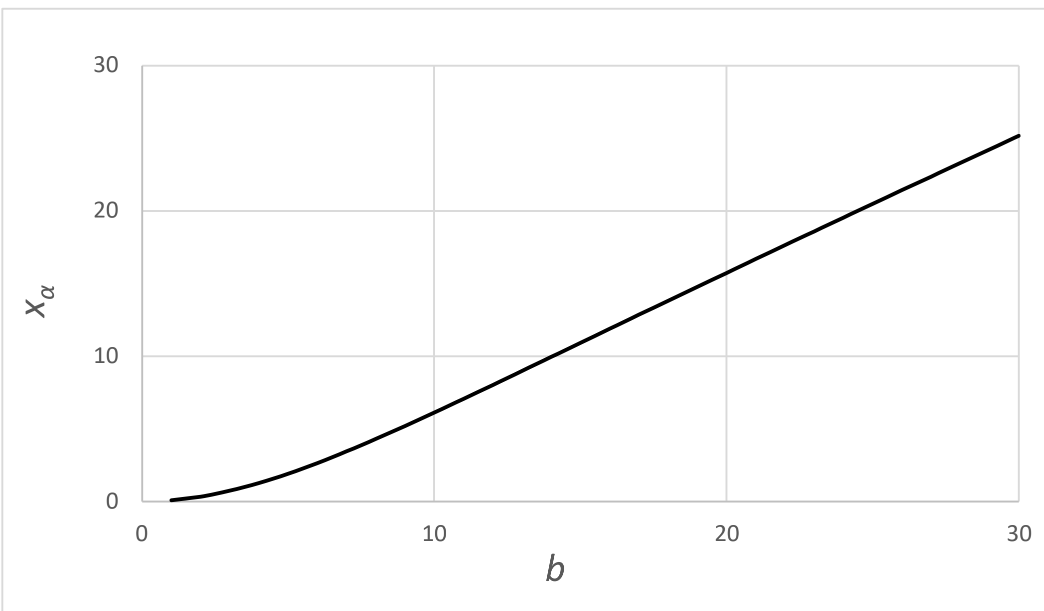


Figure 5: Minimal magnetic Field required for ICF in cylindrical geometry (a) Values of f_α vs x_α to determine the suitable value for x_α such that $f_\alpha \sim 1$ (b) Values of x_α vs b to determine the suitable value for b such that $x_\alpha \sim 10$

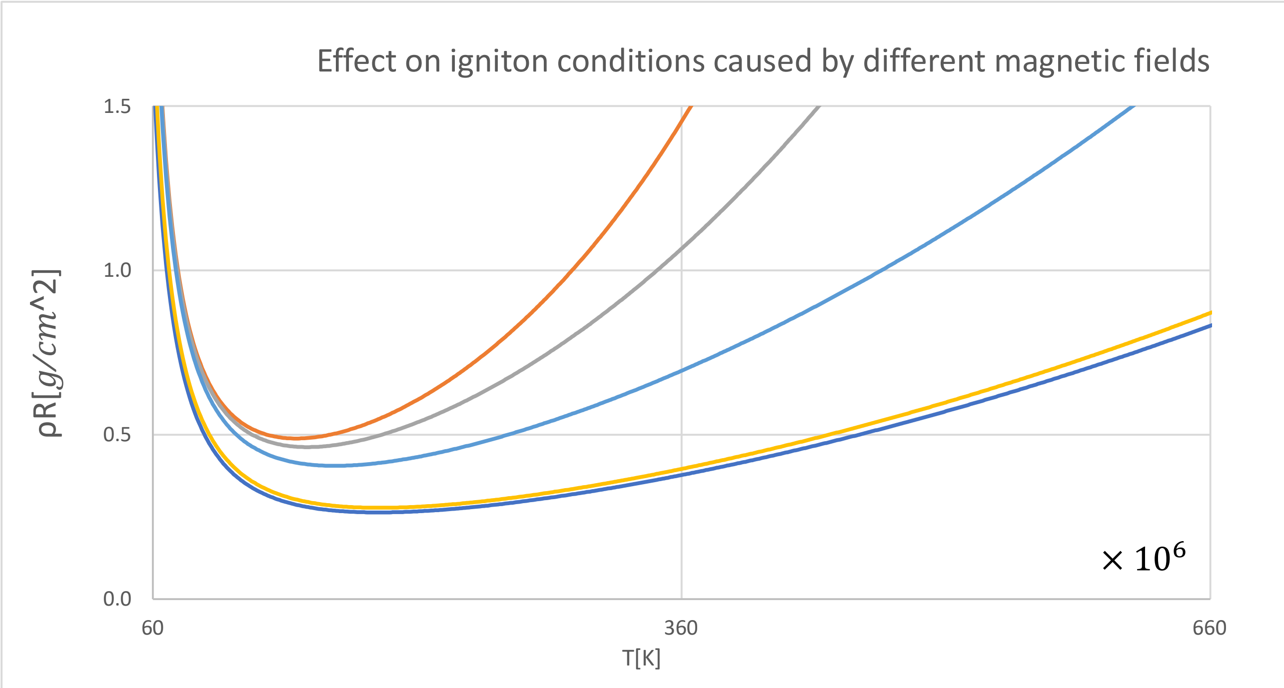


Figure 6: The nominal curve of cylindrical capsule under fields ranging from $B = 10^6[G]$ to $B = 10^8[G]$.

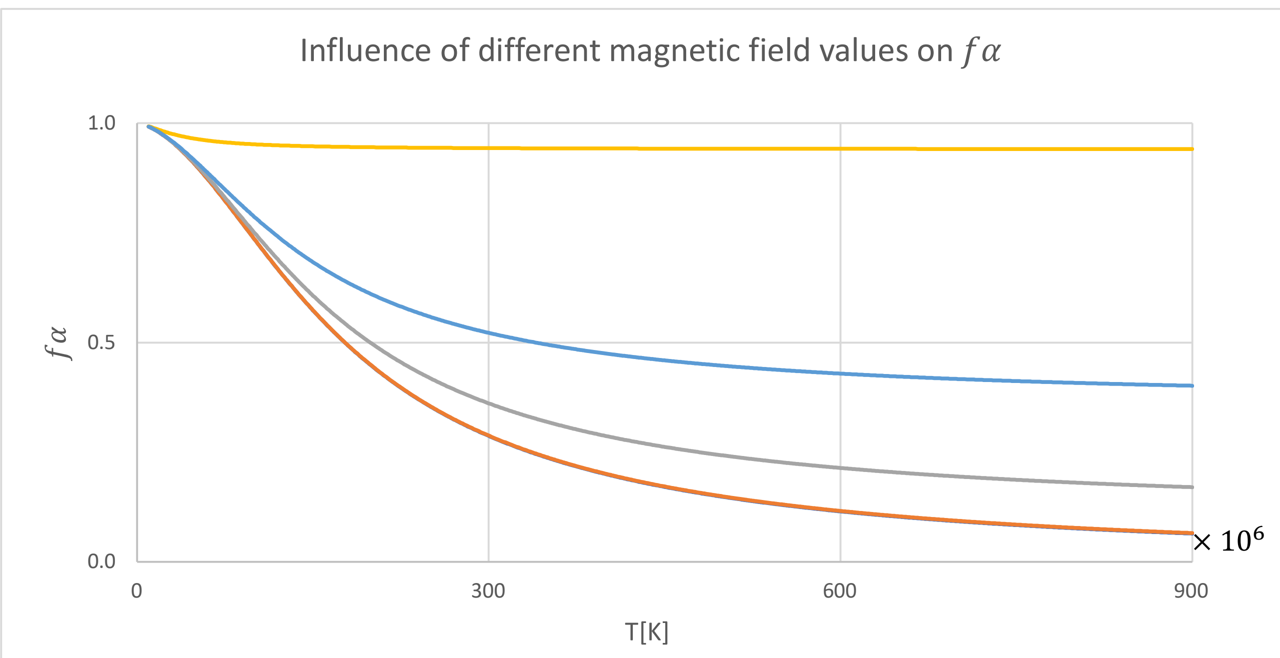


Figure 7: . In yellow, shown the dependence of $f\alpha$ under field of $B = 10^8[G]$. As expected $f\alpha$ (10^8) ~1, thus there is almost no leakage of alpha particles.

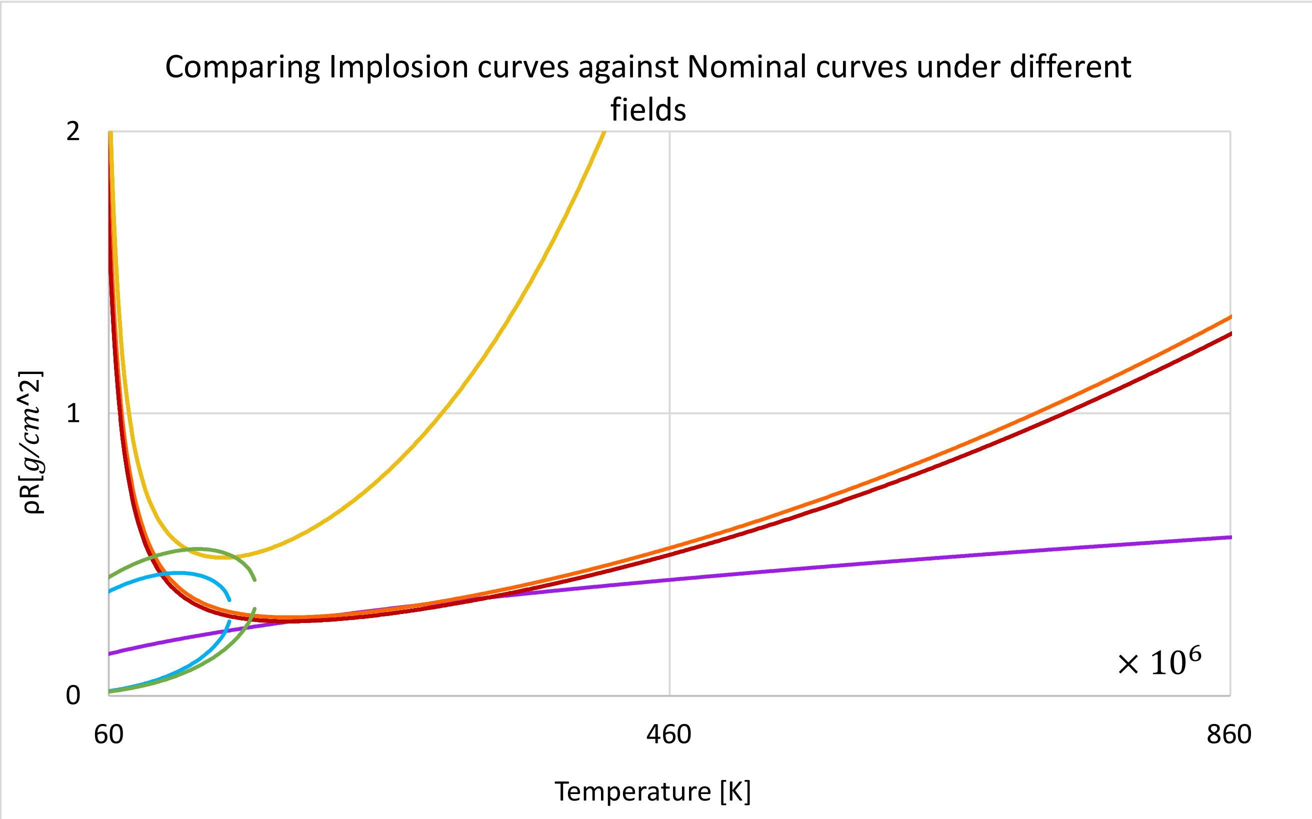


Figure 8: The nominal curve (in red), considering alpha particles leakage but without a magnetic field (in yellow) and considering alpha particles leakage but with a magnetic field (in orange). Also, the three matching implosion velocities curves:

$$v = 2.9 \cdot 10^7 \left[\frac{cm}{s}\right] \qquad v = 3.49 \cdot 10^7 \left[\frac{cm}{s}\right] \qquad v = 1.19 \cdot 10^7 \left[\frac{cm}{s}\right]$$

Respectively.