A Dissertation
on

MAKING OF n_TOF TARGET GEOMETRY,ENERGY DISTRIBUTION & NUTRON SPALLATION STUDY USING FLUKA

Submitted in the partial fulfillment of the requirements of the degree of

MASTER OF TECHNOLOGY

In

NUCLEAR SCIENCE & ENGINEERING

By

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CERTIFICATE

*This is to certify that the Major project (AP-811) report entitled "***MAKING OF n_TOF TARGET GEOMETRY, ENERGY DISTRIBUTION & NEUTRON SPALLATION STUDY USING FLUKA***" is a bonafide work carried out by Mr.* **Hemant Kumar** *bearing Roll No.* **2K14/NSE/10***, a student of Delhi Technological University, in partial fulfillment of the requirements for the award of Degree in* **Master of Technology** *in* "**Nuclear Science & Engineering**". As per declaration given by the student this work has not been submitted to any other university/institute for the award of any degree or diploma.

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DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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DATE: (2K14/NSE/10)

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First and foremost I would like to thank my parents for their blessings, support and guidance throughout my academic career.

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HEMANT KUMAR

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Abstract

This Thesis consists on making of n_TOF target geometry, energy distribution & Neutron spallation using FLUKA Monte Carlo simulation. The accuracy of the Monte carlo code falls on the accuracy of the probability distribution, it means the physical models implemented in FLUKA and the experimental data from ENDF(Evaluated Nuclear Data File, USA), JEFF (Europian data file), JENDL(Japan) etc. used for the multi-algorithm for transport of low-energy neutron.

in the FLUKA manual most work in the design and development has been the placed and improved of sound and modern physical models. Microscopic models are used when possible, consistency between reactions is ensured, conservation laws are enforced and the results are compared with experimental data.it is the advantage of this simulation that Where no experimental data are available, predefined library is provided by the code for expected data . As a result the predictions are obtained with a minimal set of free parameters for energy, targeted projectile combinations.

In this thesis we have shown that how geometry is formed using fluka, because this is just a introduction of fluka and just demonstrate energy distribution & Neutron spallation. It gives us useful data for using the proton beam or for other beam for application in some medical or some other experimental use. for performing a experiment regarding a particle physics it cost much money that's why it's better to use real simulation like FLUKA for better understanding regarding the particle interaction.

CHAPTER 1

1.1 INTRODUCTION

FLUKA is a Monte carlo simulation for transport and interaction of magnetic force and hadronic particles in any target material over a large energy range. it's a multi-purpose, multi-particle code which will be applied in many various fields. explicit attention has been dedicated to following the assorted parts of the hadronic and magnetic force cascades. Thus the code characteristics at intermediate energies build it particularly reliable in treating issues within the fields of radiotherapy and radiation protection. The FLUKA code is used for many purpose particle physics code for tracing the particle transport and interaction with matter. It is used in lots of variety of applications in high energy experimental physics and engineering also for accelerator driven systems, shielding, detector or target design, neutrino physics, dissymmetry, activation and medical physics etc. As explained in the FLUKA manual most work in the design and development has been the placed and improved of sound and modern physical models. Microscopic models are used when possible, consistency between reactions is ensured, conservation laws are enforced and the results are compared with experimental data.it is the advantage of this simulation that Where no experimental data are available, predefined library is provided by the code for expected data . As a result the predictions are obtained with a minimal set of free parameters for energy, targeted projectile combinations. FLUKA can simulate the interaction and transport in matter for about 60 different elementary particles ranging from 1 keV to thousands of TeV but it depends on the particle type; charged hadrons, neutrons, muons, electrons, and corresponding antiparticles as well as photons and heavy ions. The FLUKA physics and all possible are explained in detail in the FLUKA manual which are easily accessible on fluka site.

The accuracy of the Monte carlo code falls on the accuracy of the probability distribution, it means the physical models implemented in FLUKA and the experimental data from ENDF(Evaluated Nuclear Data File,USA), JEFF(European data file), JENDL(Japan) etc. used for the multi-algorithm for transport of low-energy neutron.

The uncertainty of the estimators are calculated by statistical fluctuations as well as system error. The systematic error is usually acceptable below 10%, while One should also keep in mind that the variance is subject to fluctuations just like the mean. The statistics can be improved by variance reduction techniques and one simple way in FLUKA is the combination of Splitting and Systematic errors depends on the physical models in the Monte carlo code, the algorithms, program debugs and the data uncertainty in the experimental data values. It also depends on the implemented geometry, simplifications or missing details as well as the material composition. Even with a correct code the human factor plays its role in e.g. user defined subroutines, incorrectly input lies, wrong units, incorrect normalization or bad biasing.

1.2 A SHORT HISTORY OF FLUKA

The FLUKA code started being developed in 1962 by J. Ranft and H. Geibel, WHO initiated the code for elementary particle beams. The name FLUKA (from FLUktuierende KAscade) came eight years later, since at that point the code was principally used for applications regarding event-to-event fluctuations in measuring. Between 1970 and 1987 the event of the code was distributed within the framework of a collaboration between CERN and therefore the groups of urban center and Finnish capital. That version was essentially for shielding calculations. Since 1989 FLUKA is being developed among INFN (National Institute of Nuclear Physics) with the private collaboration of A. Fassò (CERN) and J. Ranft (Leipzig). One of the most aims is developing associate degree general-purpose, general code with new physics models. Presently terribly little was left of the 1987 version. In 1990 MCNPX formally started victimization FLUKA for its high energy half. In 1993 FLUKA was interfaced to GEANT3 (for the hadronic half only). This interface did not follow the next FLUKA developments and it is so currently obsolete. Since 2002 FLUKA is associate degree INFN project, with the most aim of providing an improved diffusion of the code and stimulating all those studies which will be of interest for applied analysis, with target measurement, medical physics and, additional usually, biological science. The INFN project is carried on in strict collaboration with CERN and the University of Houston. additional info will be found within the FLUKA site.

CHAPTER 2

2.1 Installation

FLUPIX is Linux Live CD, with pre-installed FLUKA, flair have already all the necessary tools for performing fluka runs. In the packages you will find a complete list of the packages currently included in the ISO image.

2.2 Requirement

LINUX RAM >1GB DISK SPACE >5GB

2.3 POINS to be follow:

1. Download and Install from **Virtual box** the appropriate binary for your platform.
2. Download **flupix-iso** and the auxiliary flupix-vdi.zip files, from the download section of the FLUKA web site
3. Start Virtualbox and create a virtual machine using the following settings in the wizard.

After download the .iso and virtual disk image wizard will ask for

Name - FLUPIX

OS type- LINUX16.04

BASE MEMORY- CLICK HARD DISK

4. Change setting according to-

-Mount .ISO file

-Click on the folder icon

-Then add

-Search for the .iso file

-Click select

Because this fluka version is latest so you may enabled following featured only in this type , as audio and USB enabled feature are new for this

In the Hard Disks tab add the two disks:

-click on add icon Audio - select the right host audio driver linux direct sound

USB- enable usb controller

Enable USB 2.0 controller

Insert your USB drive

Click on add button to add a new filter one .

5. If someone is not comfortable to doing these things they can follow below steps.

you can create a disk for swapping and saving the data or use the pre-exist ones from the flupix-vdi.zip file. Locate the .Virtual Box installation directory. Let's assume that <user> is your user name. Unpack the content of flupix-vdi.zip in the following location based on your OS system.as we are using-

“LINUX /HOME/<USER NAME>/.VIRTUAL BOX/VIRTUAL HARD DISKS”

-again click on add icon on the “chose a hard disk image file”

-locate the flupix.vdi and click open

Now the flupix.vdi will appear as a IDE Primary Master Do the same for the "swap.vdi" as a IDE Primary Slave.

2.4 RUNNING THE FLUPIX

Select the FLUPIX icon in the Virtual Box machine and click start.

2.5 SOME POINTS TO KNOW EVERY FLUPIX USERS

1. if you wants to move from main ubuntu to virtual machine then pres Ctrl-Alt.

2. To transfer data between host and guest system create a shared folder and mount it from linux. There is a small tool in /usr/local/bin/vboxmount to allow easy mount of a VBox shared folder inside FLUPIX. The steps are the following:

CHAPTER 3

3.1 between Protons and Matters

When a nucleon beam is irradiating a fabric, as human tissue or a water phantom, the particles can move with the particles within the material. There square measure primarily 3 reactions that dominates; stopping, scattering and nuclear interaction.

3.1.1 Stopping

Stopping is caused by the protons interacting with atomic electrons. The protons move with electrons throughout the complete manner through the fabric, however because the speed decreases, the time the nucleon is among them of one lepton will increase. Hence, the energy transfer is raised. This ends up in the characteristic general peak for significant charged particles, a pointy increase in dose at a distance determined by the energy of the nucleon.

3.1.2 Scattering

Scattering is caused by static Coulomb between the protons and atomic nu-clei. These square measure elastic nuclear reactions. The scattering angle will increase for nuclei with high mass.

Nuclear interaction

Nuclear is caused by protons colliding with atomic nuclei causing a non elastic nuclear reaction. Protons enter the nucleus and interact with it, and another nucleon is released. For low energy protons, the electrostatic repulsion between the proton and the nucleon pre-vents this from happening, but this is for proton energies much larger than 100 keV (Tavernier, 2010). The emitted particle can be a proton, neutron or a cluster of nucleons and are called secondary particles or secondary’s. The biological effect of the generation of secondary particles is small(Gottschalk, 2012). However, the secondary particles move on and will transfer their energy other places. While the scattered protons typically change the direction with only a few degrees, the secondary particles may make a large angle with the beam .

3.2 Between neutrons and matter

Protons are charged particles reacts powerfully with matter, neutrons is considerably less reactive. Neutrons haven't any charge and may so travel a far longer distance. Neutrons with totally different energies move otherwise. the various nucleon categories square measure shown in table two.1.

Neutrons move with matter after they impinge on different atoms. this will be either nonlinear or elastic reaction. For the elastic reactions the mechanical energy is preserved, except for the nonlinear reactions the nucleus the nucleon collides with is left in an excited state. Hence, the nonlinear scattering threshold equals rock bottom excited state of the fabric. A nucleon also can be captured in reactions like (n,°), (n,2n) {and several a number of different and several other reactions (Paganetti, 2012).

Nucleon energy classification

Class	Energy vary
Thermal	En <0.5 eV
Intermediate	0.5 ev E keV
Fast	10 kev < E<20 MeV
Relativistic	E=20 MeV
High-energy	E=100 MeV

3.2.1 Relativistic Neutron

Neutrons with energies larger than fifty MeV regenerates lesser energy neutrons by nuclear reactions. Neutrons will move with one baryon within the nucleus and thereby evaporate different particles from the nucleus. once there's no additional energy left for particle emission, the remainder of the excitation energy is free as a electromagnetic radiation. However, the nucleus should still be hot.

3.2.2 Fast Neutron

Fast neutrons may additionally regenerate additional neutrons. Their energy area unit reduced by many elastic and inelastic reactions, till they're reduced to intermediate then thermal neutrons or endure capture because the energy decreases the chance for inelastic reactions decreases. inelastic reactions dominates for energies on top of ten MeV, whereas there are a unit nearly solely elastic scattering for nucleon energies below one MeV.

3.2.3 Thermal Neutron

The neutrons with lowest energy area unit referred to as thermal neutrons. The name relies on the very fact that they're in approximate equilibrium with the system close particles. Thermal neutrons do solely move with alternative atoms by elastic scattering, as a result of they are doing not have enough energy to excite alternative atoms. They diffuse concerning, till they bear capture.

CHAPTER 4

4.1 Simulation of proton beam targeted on lead target

Here we are going to simulate nucleon generation and energy collection on a target made up with the lead material .The target have a rectangular form and is dipped in a water container with layer of water which is used for cooling and moderation. The neutrons are generated by 3.5 GeV beam of proton, impacting with 0^0 angle on the horizontal plane.

By default there are some cards, the cards are filled with some default values so we will leave them.

There are mainly four part of the input window :

1.0 putting input values for BEAM and BEAMPOS.

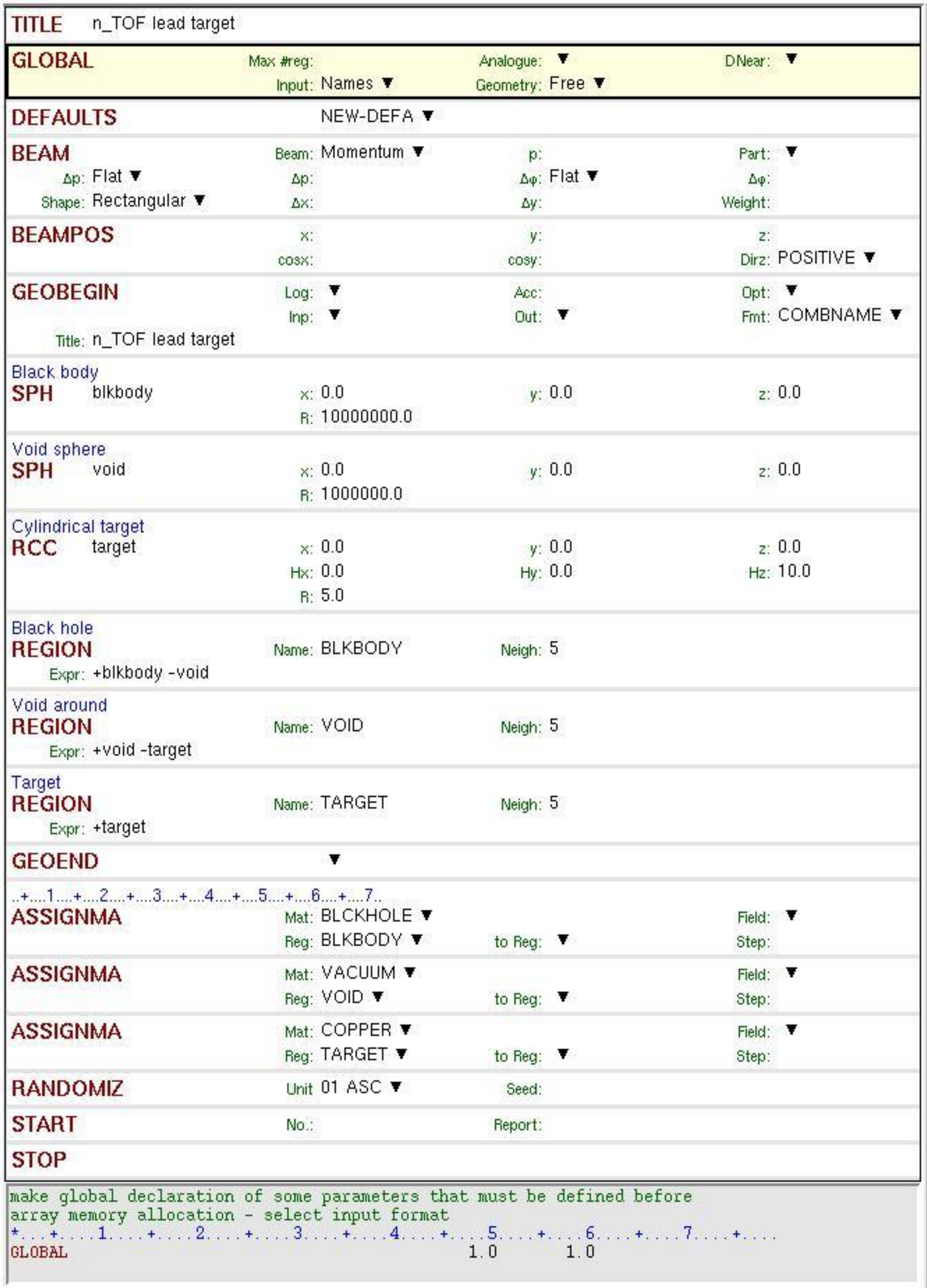
2.0 Starting the geometry inputs and provide the reason till the geoend.

3.0 Then assignment of the materials.

4.0 Then add the scoring USRBIN ,USRCOLL,RESNUCLE etc. cards for seeing the output

This is the inputs cards arrangement, if we opens the fluka we will be able to see this window first a fall.

Simulation have already filled up some defaults value



4.1.1 BEAM

```
..+....1....+....2....+....3....+....4....+....5....+....6....+....7....+...
BEAM     3.5     -0.082425    -1.7   0.0   0.0   0.0PROTON
```

- 3.5 GeV/c [WHAT(1)] proton beam [SDUM] with weight 1 [WHAT(6)]
- Gaussian momentum distribution: 0.082425 GeV/c FWHM [WHAT(2)]
- Gaussian angular distribution: 1.7 mrad FWHM [WHAT(3)]
- no beam width along x (point-like source) [WHAT(4)]
- no beam width along y (point-like source) [WHAT(5)]

4.1.2 BEAMPOS

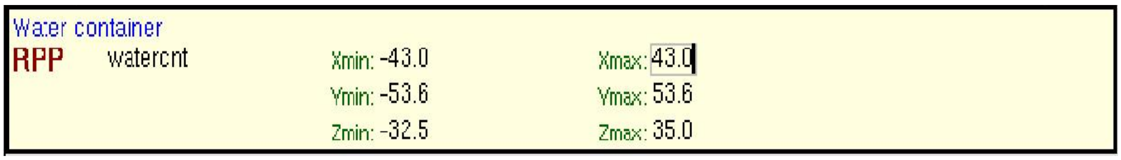
```
...+....1....+....2....+....3....+....4....+....5....+....6....+....7....+...
BEAMPOS        0.0          0.0       -0.1      0.0      0.0     0.0
```

- x-coordinate: 2.2632 [WHAT(1)]
- y-coordinate: -0.17365 [WHAT(2)]
- z-coordinate: -10.0 cm [WHAT(3)]
- direction cosine with respect to the x-axis: -0.17365 [WHAT(4)]
- direction cosine with respect to the y-axis: 0.0 [WHAT(5)]
- WHAT(6) is not used , beam points in the positive z-direction starting at (0,0,-1)

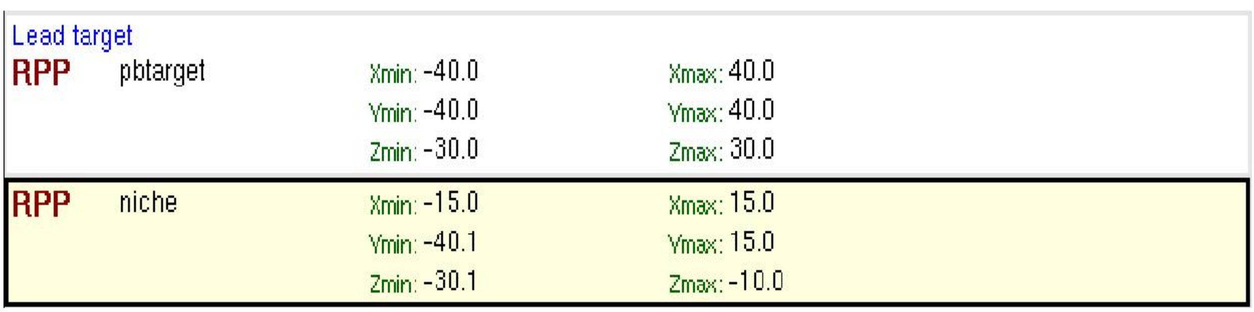
4.1.3 GEOMETRY

After putting the values of Beam and Beampose we will fill the values of geometry card.now we will make two parallelepipeds named as niche and pbtarget.these parrallelepipeds are placed incide the water container.for detection of the neutrons and for decreasing the energy nof the neutrons**.**

- First a fall delete all the RCC cards.
- Now add the RCC card by choosing the option + on the menu bar.
- Chose the option geometry then bodies as RPP.
- Now put the values of the RPP dimension as Xmin and Xmax.
- Change the comment by right clicking



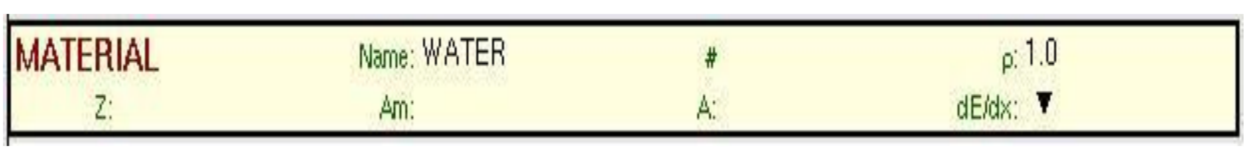
- Again repeat the above process
- Now write the comment as lead target and niche
- Again put the Xmin ,Ymin,and Zmin corresponding to them put Xmax, Ymax,and Zmax values as shown the below.



- Now change the name of the first region title as water container with the expression as **+watercnt-(+pblead –niche)** and name the second resion as lead target and expression as +pbtarget-niche.with name as WATERCNT and TARGET simultaneously . then window will seems like below.

- **Now its time to creat materialand compound database**.

To create manually the water material:
After putting the geoend card add tho cards as MATERIAL and COMPOUND and
Here we are filling the water vmaterial into the water container and describing the water compound as two molecule of hydrogen and one for oxygen.
F1 and f2 are the frequency of the atoms and M1 and M2 are shows the material kind of. In the material we have to show the value of the water dencity as 1.0 .

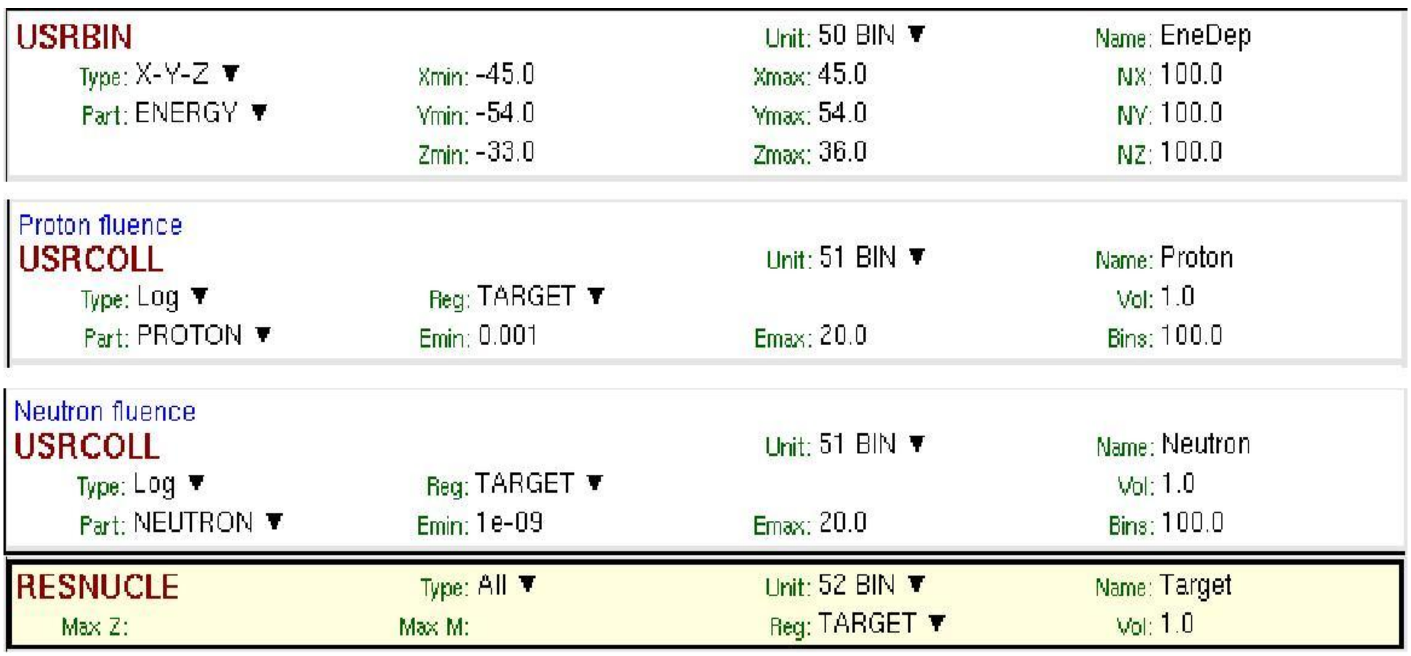


- To assign the materials to the regions we need to modify and add the necessary

ASSINMEt cards as shown below

After the **COMPOUND** card add a **LOWMAT** card from the **Media** group, to specify that we want to use Self Shielded Lead for the low-energy neutron cross section.

- Add a few scoring cards, As **USRBIN,USRCOLL** and **RESNUCLi** as shown below.



- Set some primary particles in the **START** card for a test run.

CHAPTER 5

5.1 How a detector works

Accelerators at CERN are made to speed up the particle .before colloid with the detector so that some useful information could be taken into consideration. The detectors gather the information as their speed, mass and charge from that physicists will summering the theory regarding that particle founded into the particle collision. This method of detecting the particle is not as simple there is a list of detectors which are using in this system on which detector layer different different counties are working on that detector and then assemble to them at the LHC, CERN. also with these detectors we needs most powerful electro magnets for providing the curved path to the particle.

Because these particles which have been created into thye collision travel into the straight path that's why a list of high electromagnets are to be needed into the LHC.

Now a days we are using latest detectors so each detectors needs to have some specific identification at different difference places in to the circle of LHC.eg. ALICE,CMS…etc.

5.1.1 Tracking devices

Tracking devices work on the particle path over which charged particle travels in the material. however a particle have some charge of assign some electrical signal on which behalf our detector makes us liable to trace the path of the particle. these traces have been stored into the computer program based o the path of the particle and correlate the information to the other particles so that differentiation could be possible in to the charge, mass and spin of the particle.

There is a kind of lepton as muons which are very less interactive to the material so to detect the muons we have to made a detector named as CMS at the CERN .which creates some different particle on interaction of the muons that different particle has to be detect.

5.1.2 Calorimetre

Due to the passes of the particle through the material they feel some columbic attraction or repulsion based on the material atoms and nucleus. so calorimeter comes into account for measuring the particle absorbed energy. based on the kind of phenomena happen after on the collision ,because some of the particle goes directly reversed which incident directly head on collision with nucleus. This energy slowing phenomena and collision whole sole depends on the density of the material. calorimeter is made up usually with layer of active and passive energy absorbing with high density material.

Electrically charge particle as electron and proton detection depends on the electromagnetic calorimeter because only these are the hadrons which have charge.so electromagnetic calorimeter stop the charged particle but unable to detect or to stop the electrically discharge particle as muons and neutrons.

5.1.3 Particle identification detectors

When a charged particle travels quicker than light weight particle through a given medium, it emits Cherenkov radiation at some degree angle that completely depends on its speed. The speed of particle are often calculated from this angle then speed of this particle will be add to often measuring the momentum. So that after collection of the whole information we are able to say that this is the totally different particle which have detected in to the detector.

Finally on the behalf of collision we can say that this is not following the current theory of the particle and likewise it is a some kind of a new particle

CHAPTER 6

6.1 Essential particles to be known

6.1.1 Hadrons

In natural philosophy, a fundamental particle as hadrons could be a composite particle product of quarks control along by the color force in an exceedingly similar method as molecules square measure control along by the magnetic attraction force.

Hadrons square measure classified into two families: baryons, product of three quarks, and mesons, product of one quark and one elementary particle. Protons Associate in Nursing neutrons square measure samples of baryons; pions square measure an example of a hadron. Hadrons containing quite 3 valence quarks (exotic hadrons) are discovered in recent years. A tetraquark state (an exotic meson), named the Z(4430)−, was discovered in 2007 by the young woman Collaboration and confirmed as a resonance in 2014 by the LHCb collaboration. 2 pentaquark states (exotic baryons), named $P^{+}_{c}(4380)$ and $P^{+}_{c}(4450)$, were discovered in 2015 by the LHCb collaboration.[3] There square measure many a lot of exotic fundamental particle candidates, and different colour-singlet quark combos may additionally exist.

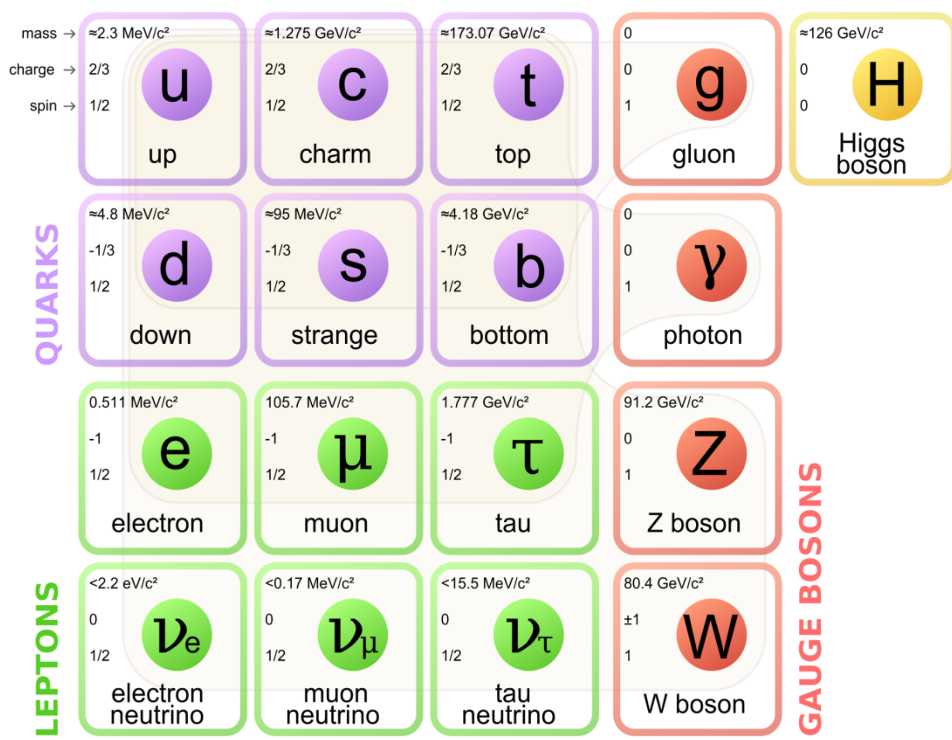
Of the hadrons, protons square measure stable, and neutrons certain inside atomic nuclei square measure stable. different hadrons square measure unstable below standard conditions; free neutrons decay with a half-life of concerning 611 seconds. by experimentation, fundamental particle physics is studied by colliding protons or nuclei of significant components like lead, and detecting the lose material or fragmented particles within the created particle showers

6.1.2 Laptons

A lepton is AN elementary, half-integer spin (spin 1⁄2) particle that doesn't bear robust .2 main categories of leptons exist: charged leptons (also called the electron-like leptons), and neutral leptons (better called neutrinos). Charged leptons will mix with alternative particles to create varied composite particles like atoms and positronium, whereas neutrinos seldom act with something, and square measure consequently seldom ascertained. the simplest celebrated of all leptons is that the negatron.

There square measure six kinds of leptons, called flavours, forming three generations. the primary generation is that the electronic leptons, comprising the negatron (e−) and negatron lepton (ν_e); the second is that the muonic leptons, comprising the (mu-meson)lepton (μ−) and muon lepton (ν_μ); and also the third is that the tauonic leptons, comprising the letter of the alphabet (τ−) and also the letter of the alphabet lepton (ν_τ). Electrons have the smallest amount mass of all the charged leptons. The heavier muons and taus can apace be converted into electrons and neutrinos through a method of particle decay: the transformation from a better mass state to a lower mass state. therefore electrons square measure stable and also the most typical charged lepton within the universe, whereas muons and taus will solely be created in high energy collisions (such as those involving cosmic rays and people disbursed in particle accelerators).

Leptons have varied intrinsic properties, as well as charge, spin, and mass. in contrast to quarks but, leptons aren't subject to the fundamental interaction, however they're subject to the opposite three elementary : gravitation, electromagnetism (excluding neutrinos, that square measure electrically neutral), and also the weak force.



CHAPTER 7

7.1 Present and future application of fluka

In nucleon time of flight scattering, a kind of dead nucleon scattering, the initial position and speed of a pulse of neutrons is mounted, and therefore their final position and the time when the heart beat that the neutrons area unit detected area unit measured. By the principle of conservation of momentum, these pairs of coordinates could also be reworked into momenta and energies for the neutrons, and therefore the experimentalist could use this data to calculate the momentum and energy transferred to the sample. Inverse pure mathematics spectrometers are attainable. during this case, the ultimate position and speed area unit mounted, and therefore the incident coordinates varied.

7.1.1 Radiological Studies for the LCLS Beam

The particle accelerator Coherent source of illumination (LCLS), a pioneer solid x-ray with no electron optical laser is presently beneath construction at the Stanford particle accelerator Center. it's expected that by 2009 LCLS can deliver optical maser pulses of unprecedented brightness and short length, which can be employed in many forefront analysis applications. This new project encompasses major style challenges to the radiation protection like the numerous sources and therefore the variety of surveyed objects. so as to type those, the showers from various loss sources are tracked on an in depth model covering 1/2 mile of LCLS accelerator by means of the town intra nuclear cascade codes FLUKA. This article covers the FLUKA studies of heat load; prompt and residual dose and environmental impact for the LCLS beam abort system.

7.1.2 Beta Beam Task

The acceleration of high intensity, radioactive particle beams to highest energies may be a new field for accelerator physics and needs novel style solutions. thus far no profound studies on the topic are created. the target is to try an abstract style Study (CDS), covering all accelerator physics aspects, to demonstrate the feasibleness of a Beta Beam facility. the ultimate report can contain: the optics style of the accelerator chain, beam dynamic simulations of crucial processes, a loss management conception, initial stage technical styles demonstrating the feasibleness of crucial hardware, a facility layout and a value estimate.

The combination of EURISOL with a Beta Beam would create optimum use of the large potential synergies and provides a world category facility attracting not solely the nuclear, however conjointly lepton and high energy physics communities.

7.1.3 CERN Nutrino To gran Sasso(CNGS)

The CNGS project aims at work the 'oscillation' of neutrinos. The project is impelled by the results obtained at the Superkamiokande detector in Japan and supported by different experiments, perceptive neutrinos made by cosmic rays within the atmosphere. These experiments live a major deficit within the flux of detected muon-type neutrinos.

The options of this 'anomaly' can be explained by the hypothesis of lepton oscillation, i.e. the conversion of a given lepton kind into another throughout their travel from the supply to the detector (for example, muon-type to tau-type lepton oscillation). The CNGS facility aims at directly detective work such lepton oscillations And confirming this fascinating hypothesis with by artificial means made neutrinos from an accelerator.

A beam made at the CERN Super Proton Synchrotron accelerator can comprises solely muon-type neutrinos. Neutrinos move terribly seldom with matter, and these particles will thus pass undisturbed underground to their destination, the gran Sasso National Laboratory (LNGS) of the INFN in Italian Republic, 730 Km from CERN. This laboratory settled a hundred and twenty Km to the east of Rome, exists since 1987 and plenty of experiments are conducted there by international collaborations. LNGS is presently getting ready to deal with house huge detector specially designed to detect the rare tau-neutrinos created by "oscillation" from muon-neutrinos on the approach between CERN and LNGS.

The CNGS project's mandate is that the construction of the new lepton beam facility at CERN, not as well as the work required for the detectors at LNGS. CNGS has been approved by the CERN Council at its Dec 1999 meeting.

CHAPTER 8

8.1Nuclear reaction

When the target nuclei is colloid with various particle then there are possibly many types of reaction will take place.

8.1.1 Elastic Scattering

When no energy is transferred between the target nucleus and also the incident particle, the method is understood as 208Pb elastic scattering

208Pb (n, n) 208Pb, Q = 0.

8.1.2 Inelastic Scattering

When energy is transferred, the method is named inelastic scattering

40Ca (a, a') 40mCa, Q =\= 0.

where a and a' have totally different kinetic energies.

In cases once the incident particle could be a difficult nuclide, it should even be left in excited state,

208Pb (12C, 12mC) 208mPb

This method is named mutual excitation.

8.1.3 Capture Reactions

Both charged and neutral particles is captured by nuclei for instance,

197Au (p, g) 198Hg

238U (n, g) 239U

Neutron capture reactions square measure wont to manufacture several radioactive nuclides.

8.1.4 Rearrangement Reactions

The absorption of a particle amid the emission of 1 or additional particles is named as transcription reaction.

197Au (p, d) 196mAu

4He (a, p) 7Li

27Al (a, n) 30P

54Fe (a, d) 58Co

54Fe (a, 2 n) 56Ni

54Fe (32S, 28Si) 58Ni

Various transcription reactions modification range the amount of the quantity of neutrons and also the number of protons of the target nuclide.

8.1.5 Fission Reactions

Typical and well-known neutron-induced fission reactions are:

235U (n, three n) fission product

239Pu (n, three n) fission product

These reactions unleash energy. The free neutrons induce more reactions, inflicting continuous chain reactions.

8.1.6 Fusion Reactions

The fusion reaction of heavy hydrogen and H is especially attention-grabbing due to its potential of providing energy for the long run.

T (d, n) He.

CHAPTER 9

Result

there are four projection of lead target geometry **Front,Top,Left and Back .**

blue colour shows water filled container as shown in the plot.and lead target is in the dark.

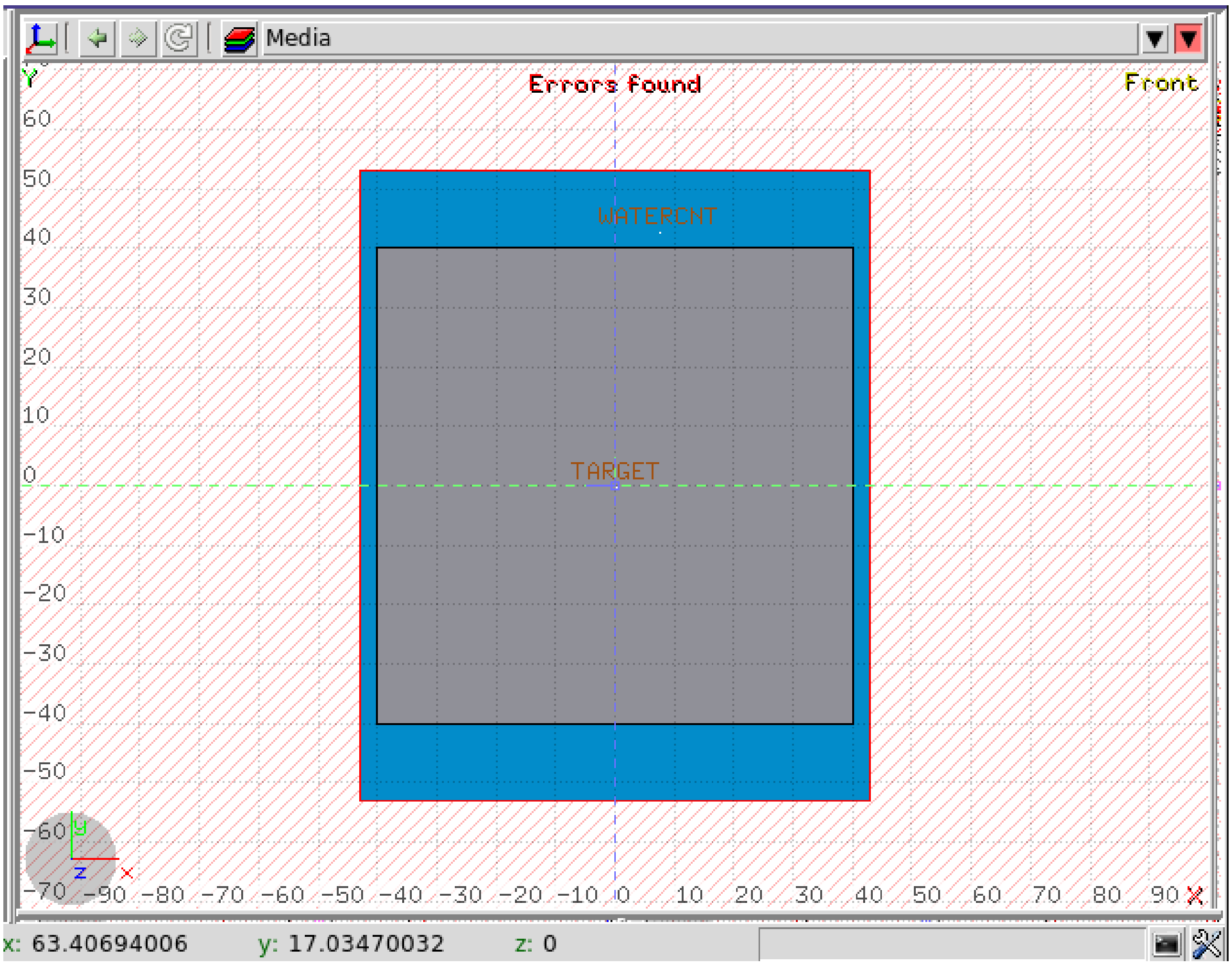


Fig.9.1 front view of lead target geometry covered with water container

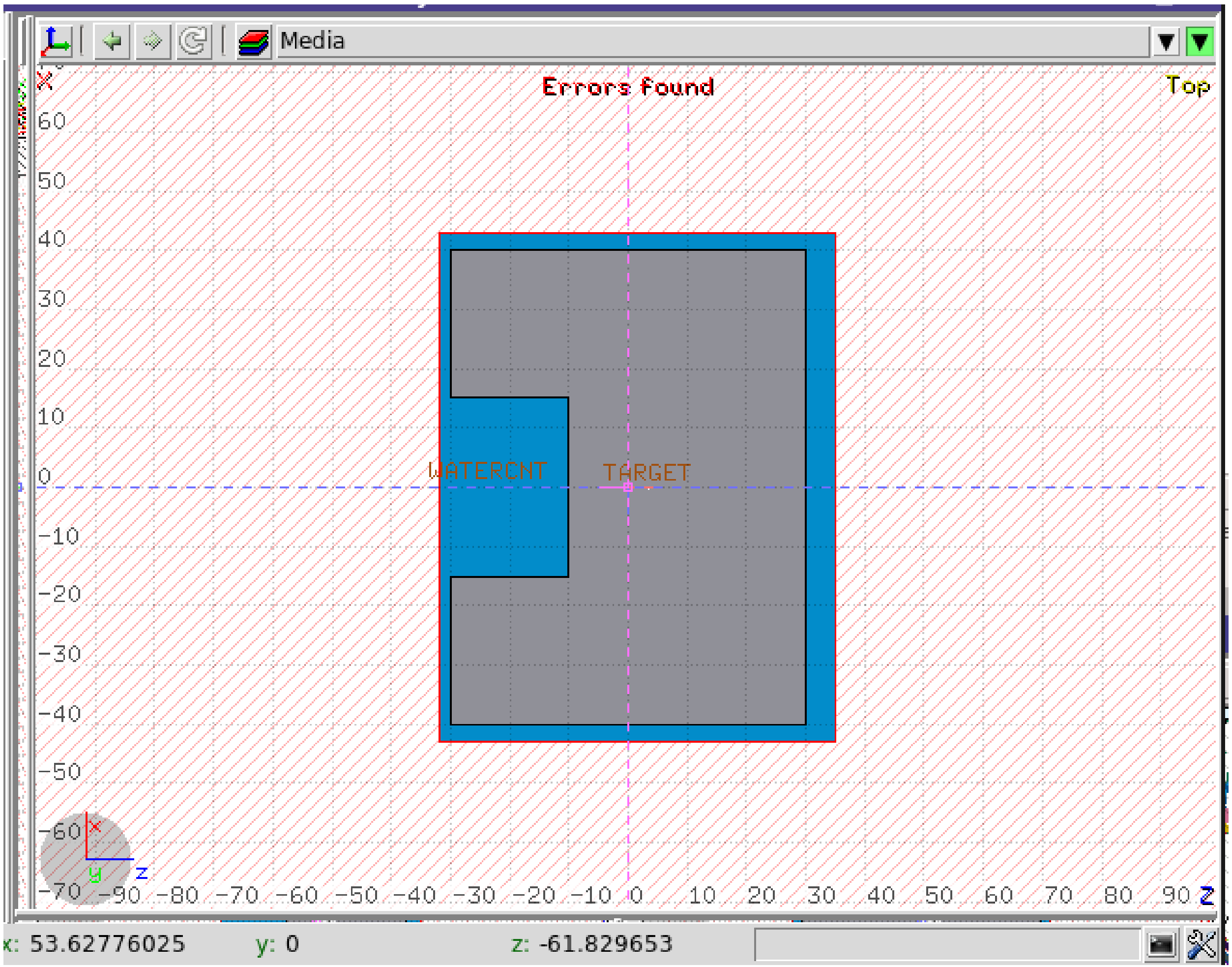


Fig. 9.2 top view of lead target geometry covered with water container

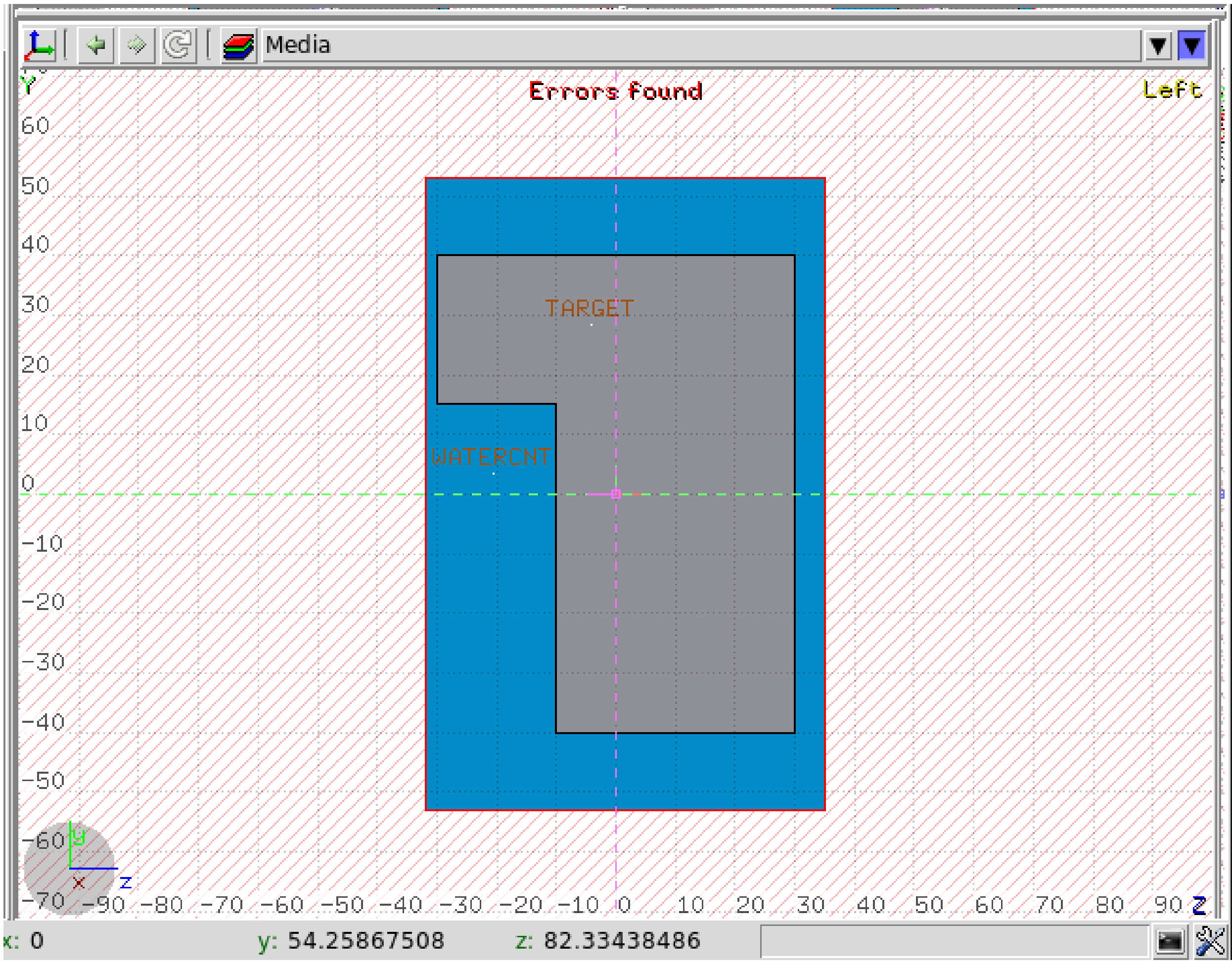


Fig. 9.3 left view of lead target geometry covered with water container

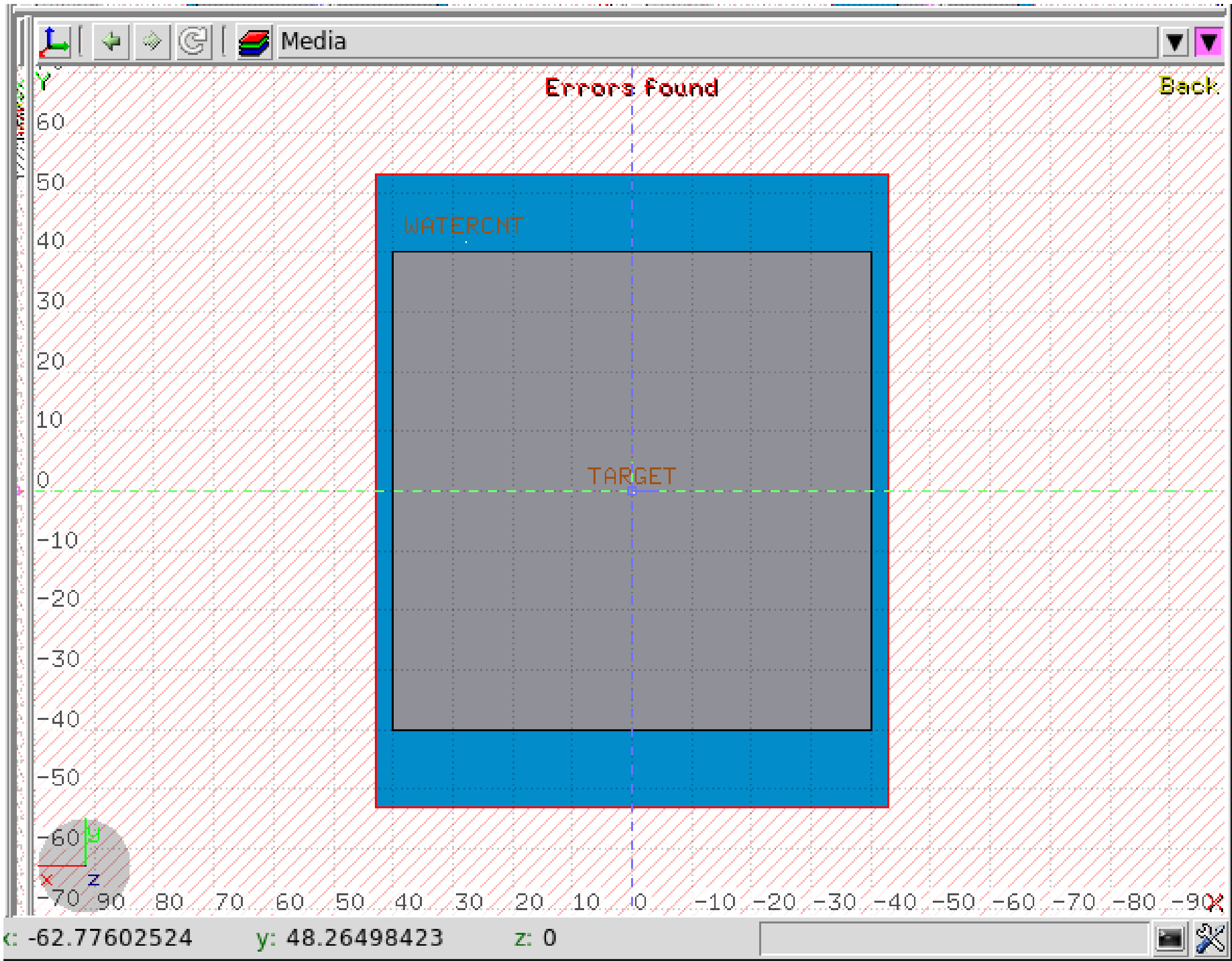


Fig. 9.4 back view of lead target geometry covering with water container

Here are three plot regarding to the proton energy deposition on the lead target,nutron spallation proton flux. likewise same plot will be there on fluka simulation output window after successful running, data merging then plotting.

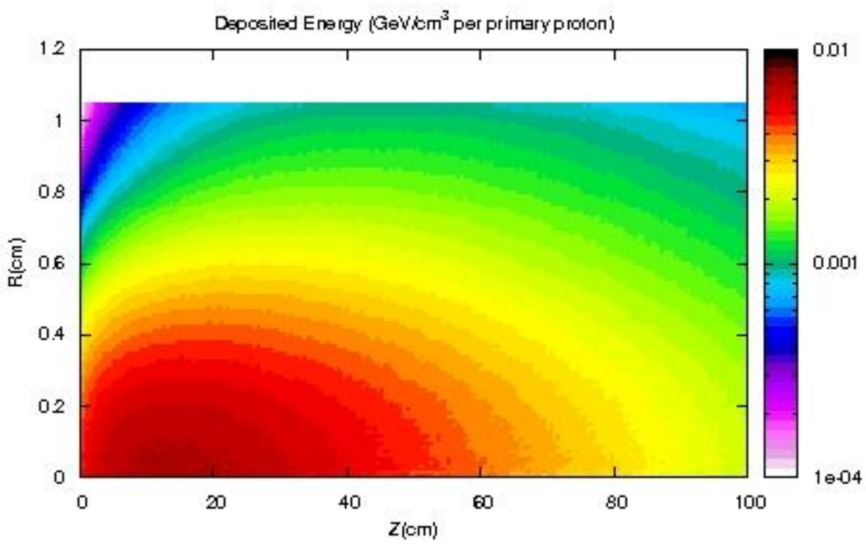


Fig. 9.5 energy deposited by proton on the lead target

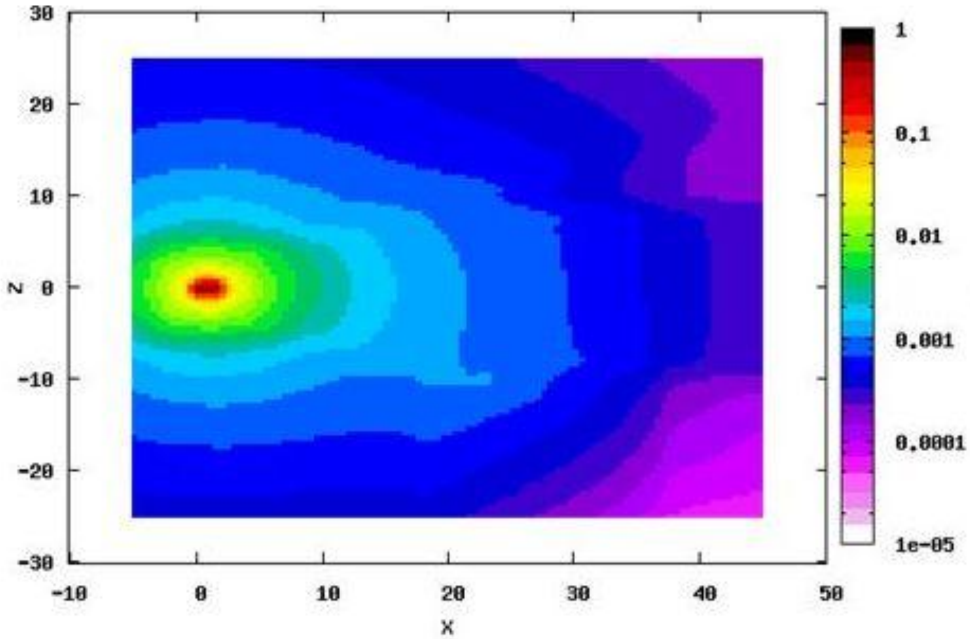


Fig.9.6 Nutron spallation

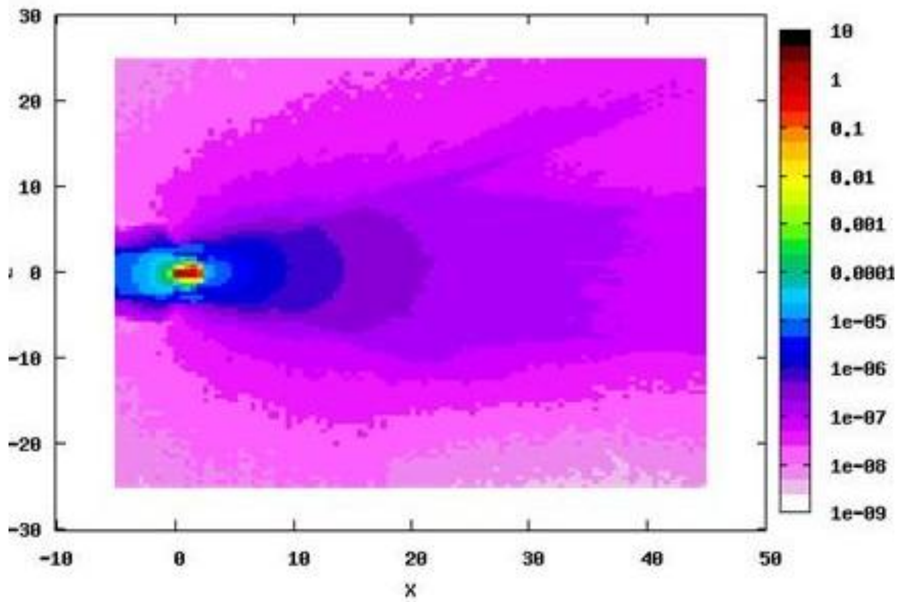


Fig.9.7 proto flux

CONCLUTION

The objective of this work was to design a lead target covered with a water container and also to investigate the neutron flounce through a lead target from neutrons originated from a proton beam irradiating through a water container by Monte Carlo simulations.

On a longer term more aperture could be included in the geometry, taking the impact from the aperture into account. Since neutron generation from a significant impact on lead target the total neutron generation in proton therapy, this would give some valuable information that could change the amount of neutrons generated and also the energy spectrum of the neutrons.

Fluka is not a tool kit but based on a real simulation which work on the monte carlo simulation so in some word I would like to say that it is only beginning to nuclear particle interaction and detection and also for designing of real parts used into the eg.LHC, medical radio therapy etc.

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