Fast Radiation Simulation and Visualized Data Processing Method

Wang Jinlong[1, a] , Andrew Rusanov [1], Li Zhangmin[1], Alberto Cruz [1], Zhu Yancong [1]
（1. Guangdong Hengju Medical Technologies Co.,Ltd.）

Abstract： Typical FLUKA simulation time for a primary number 10^6 is 1~2 hours on a standalone computer, in order to get a better statistics, the general way is to increase the primary, for a complicated shielding case the primary number is up to 10^9. Thus a fast radiation simulation method is introduced which is called Multicore FLUKA. Flair and SimpGEO are good additional tools for FLUKA, they are helpful to geometry model, compile an input file and visualize the standard FLUKA output. What more, Gun plot is powerful to merge multi data to figures. Full beam line radiation is also discussed.
Key words: Proton therapy, FLUKA, Flair, SimpGEO, Gun plot

1. Introduction

In order to get a full understanding of the radiation in a proton therapy facility, the geometry model and sources are complicated in FLUKA simulation [1]. High primary number (up to $10^{8\sim9}$) is almost the only way to guarantee a good statistics. Thus a fast radiation simulation is developed for such kind work to reduce the simulation time. We name this method Multicore FLUKA, as the python program can start a parallel computing on several server/node computers, and every node is quad core or even better. Multicore program can finish a 10^8 primary simulation in 5 hours with 10 nodes, while the standalone computer has to spend more than 100 hours do the same work. What more, the Multicore program can transfer the files automatically between master computer and nodes.

Flair and SimpGEO are helpful pre/post processing tools for FLUKA, they have good user interface and make the modeling and input file compiling faster and easier [2][3]. Gun plot is powerful to merge multi data to figures [4]. Full beam line with magnet field in dipole and quadruple will make the most ideal simulation.

2. Fast radiation simulation

Fast radiation simulation, or Multicore FLUKA is a python program which can run several cycles at same time on cluster with several nodes in order to reduce the simulation time.

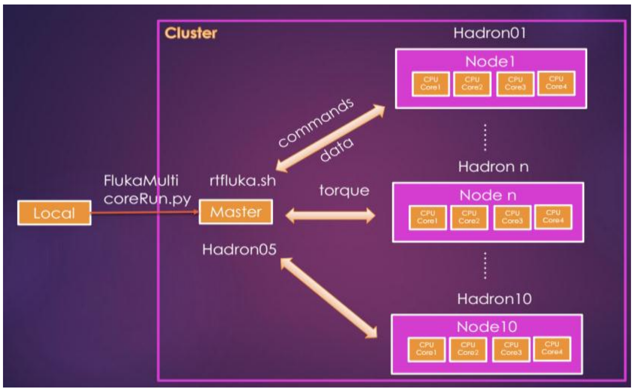

Fig 1 Multicore FLUKA

Wang Jinlong: Accelerator Physics Engineer, Beam diagnostics, Pencil Beam Scanning Nozzle, Radiation Shielding.
wangjl@hj-medical.com

Fig 1 shows the work flow of Multicore FLUKA. After the input file is ready on local computer, the python program ‘FlukaMulticoreRun.py’ will distribute parallel simulation to Node-n through a master computer. A shell script ‘rtfluka.sh’ is called to change the random number for each cycle. The Multicore program is also developed when user routines are employed, in this case another script ‘compile.sh’ will be called.

Multicore FLUKA is proved to be powerful in the radiation work of Sun Yat-Sen Proton Hospital [1]. Dose distribution in Fig 2 is smooth and clear. The primary number is 9×10^{8} for every source simulation. However, we still spent 1~2 months.

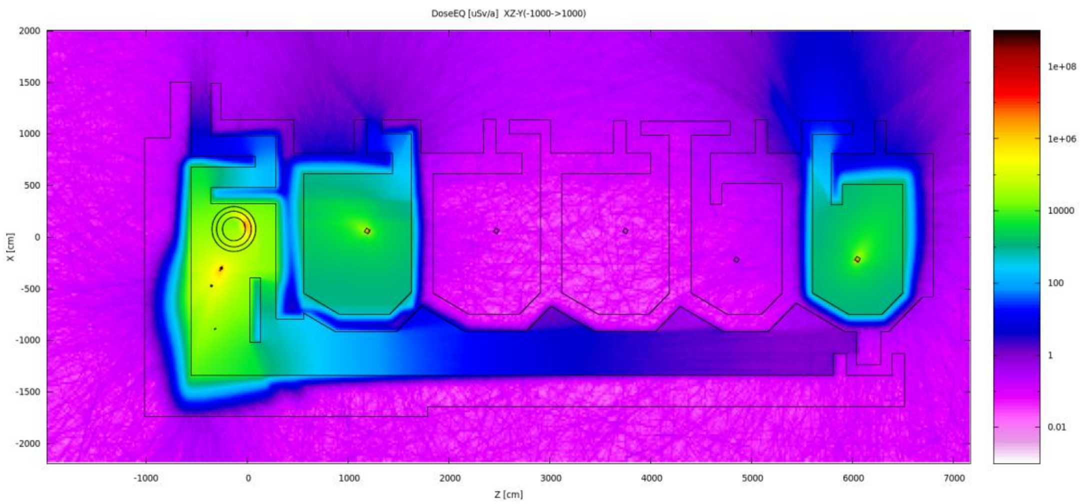

Fig 2 Dose distribution of proton therapy

3. Complicated model

The building of the PT hospital is quite complicated, although some structures do not relate to radiation are ignored or simplified. GEO modeling directly by FLUKA is difficult, and the 3D model from CAD software such as NX, Solid works, etc. is different format from FLUKA. Thus Flair and SimpleGEO is necessary, Fig 3 shows the 3D SimpleGEO geometry of treatment level in proton therapy facility. There are cyclotron room, 3 gantry rooms and 2 fixed beam rooms.

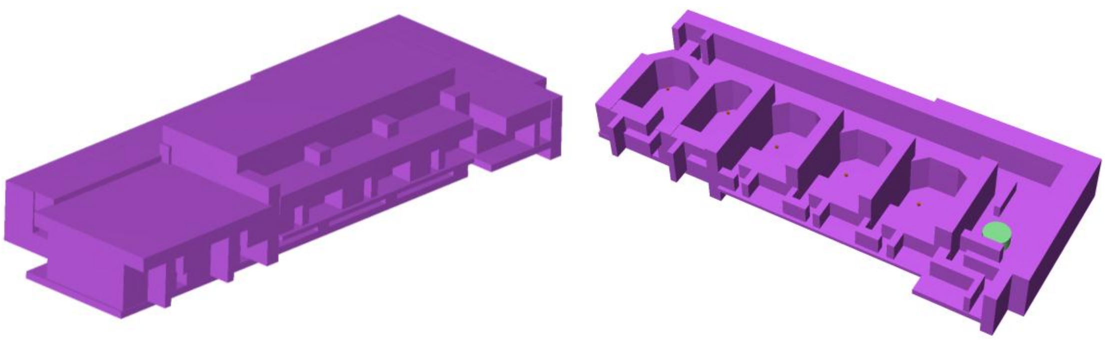

Fig 3 3D SimpleGEO geometry of proton therapy facility

Fig 4 is the Flair geometry model. Which has a higher accuracy and easy debug than SimpleGEO. Directly import complicated SimpleGEO model always cause errors and difficult to figure out the reason. Thus

SimpleGEO model is always used for data visualize.

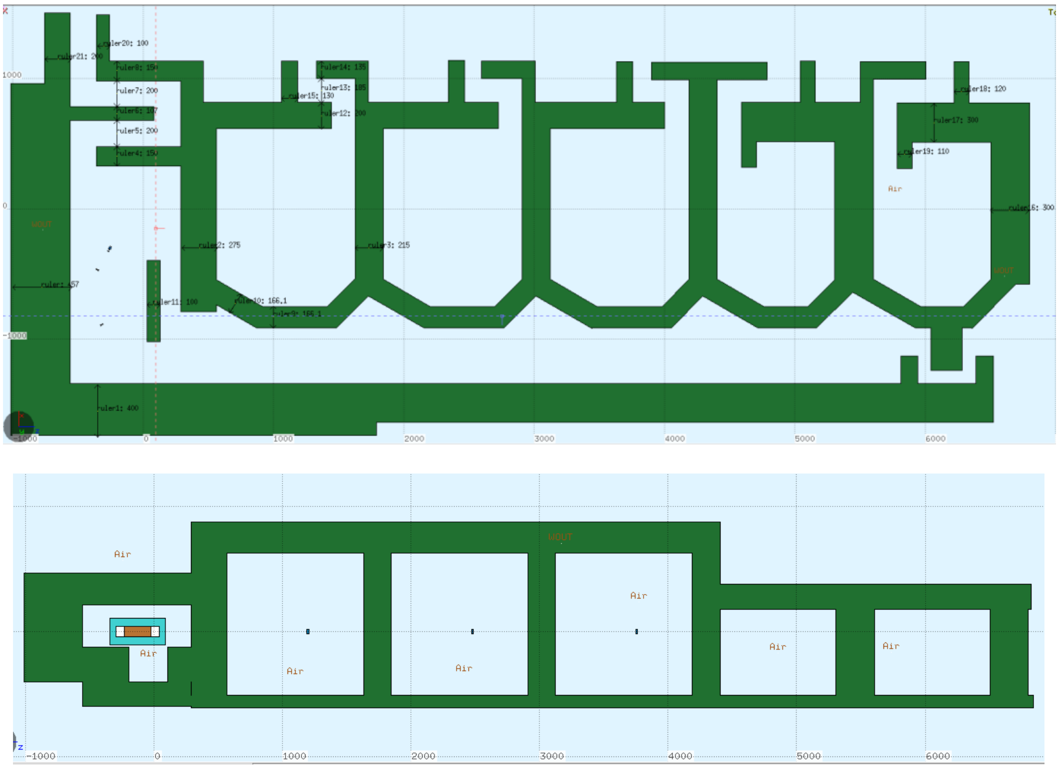

Fig 4 Flair Geometry model

For a degrader and collimator model, Flair has to use many parameters to define the angle, the rotation, there are few bodies in Flair lib. However, SimpleGEO is more like CAD, easy to create bodies and can rotated to any angle easily.

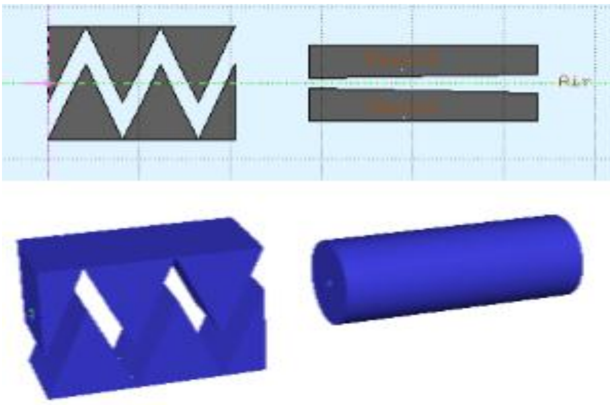

Fig 5 Degrader and collimator model

4. Visualized data processing

DaVis3D is one plugin tools of SimpleGEO, it's a novel post processing tool for FLUKA output data. Fig 6 is the 3D dose distribution in a simplified fix beam treatment room displayed by DaVis3D.

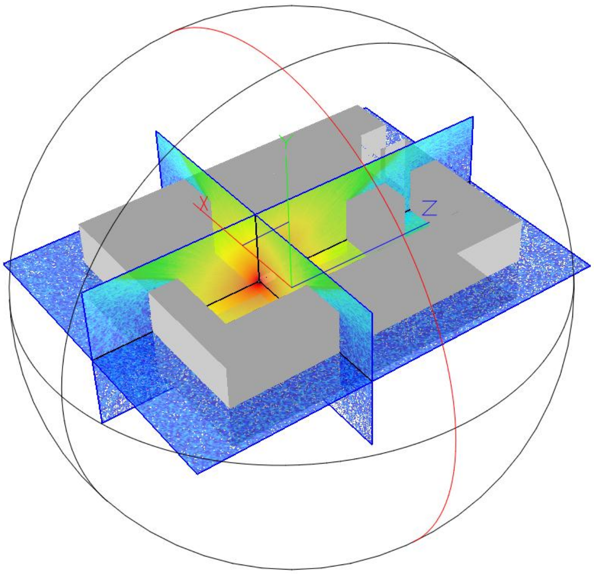

Fig 6 3D dose distribution by DaVis3D

It can generate profiles in each axis, as shown in Fig 7. Obviously, the shielding wall stop particles and statistics outside the wall is not as good as inside. Thus the primary should be increased.

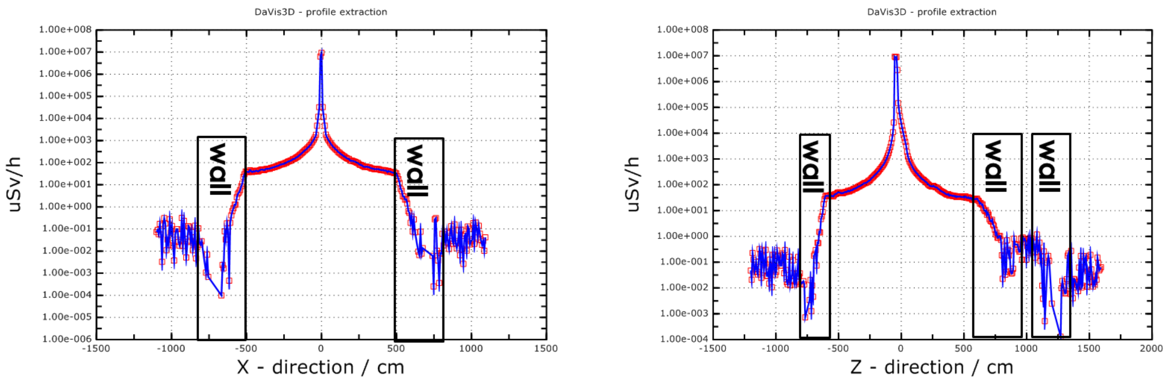

Fig 7 Profile extraction

For radiation calculation, geometry of degrader and collimator can be simplified as in Fig 8. Beam size will increase in graphite degrader and decrease after tantalum collimator, increase in target again.

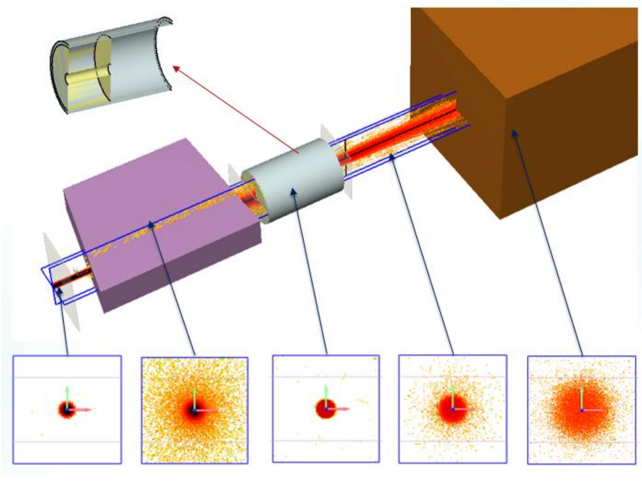

Fig 8 Geometry of degrader & collimator and beam shape

5. Data Merge

Flair can merge data directly from the output for one simulation. But for different sources we need flexible merge tool which can set the weight of source, set color palette, and contour plot. Thus Gun plot is a good choice. Fig 9 shows the merged annual dose of all sources with their weight.

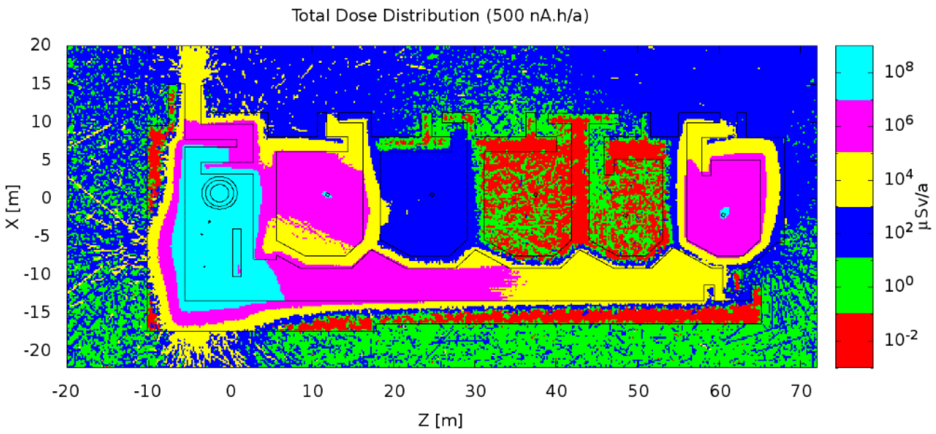

Fig 9 Total Dose Distribution of the Proton Therapy Facility

6. Full Beam Line Simulation

The most ideal simulation is to have a full beam line with magnet field in dipole and quadruple, and all the slits are adjusted to the correct efficiency. This method can get an accurate dose distribution. Fig 10 is an example, but only the accelerator room. This work will be left for the future.

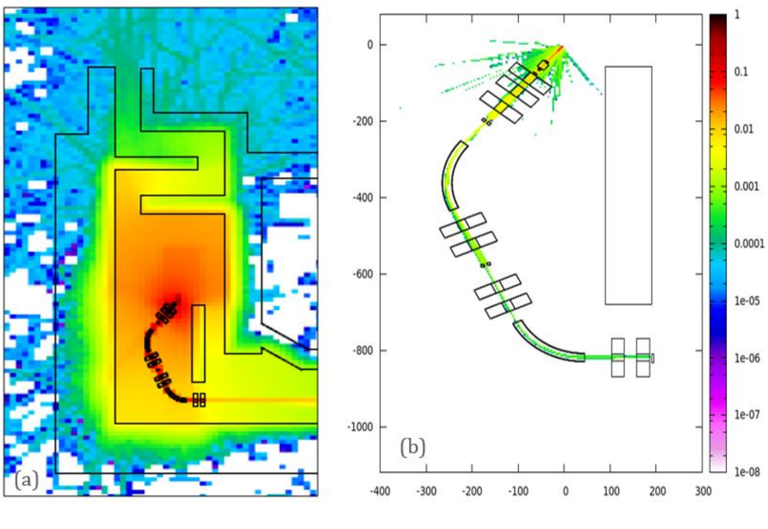

Fig 10 Full Beam Line Model, (a) Dose Distribution, (b) Proton Flux Beam Line

7. Summary

Multicore FLUKA, Flair, SimpleGEO and full beam line are important tool or method for radiation shielding. Multicore FLUKA can save simulation time and liberate the researcher to focus on physics, it is flexible and can satisfy the user requirement. Flair and SimpleGEO are used for modeling and visualized data processing. Full beam line is an ideal method which can present the most accurate radiation distribution, but need more investigation in the future.

Reference

[1] J. L. Wang, Z. M. Li et al., Radiation Caculation For Sun Yat-Sen Proton Hospital. 2015.

[2] Author: Vasilis Vlachoudis. Website: http://www.fluka.org/flair.

[3] Author: Christian.Theis, Website: www.cern.ch/theis/simplegeo.

[4] Web access: http://sourceforge.net/projects/gnuplot.