A study of radiation backgrounds using FLUKA simulation code in CEPC

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Outline

- Overview of different backgrounds
- FLUGG: FLUKA with Geant4 geometry
- Results of radiative bhabha
- Compare results of FLUKA and GEANT4
- Summary

Beam backgrounds

- Synchrotron radiation
  The most important background because the huge number of photons
- Radiative bhabha
- Incoherent pair production
  Dominant background induced by the beamstrahlung.
- γγ → hadron events

http://indico.ihep.ac.cn/event/6253/session/8/ - 20160829

FLUKA

We intend to study the beam backgrounds using the transport MonteCarlo program – FLUKA.

- It can be convenient to count all kinds of physical quantities, such as deposited energy, particle flux, tracking length and so on.
- Card input： we only need input parameters in a defined format and then get the FLUKA input file.
- Runs spanning several hours of CPU

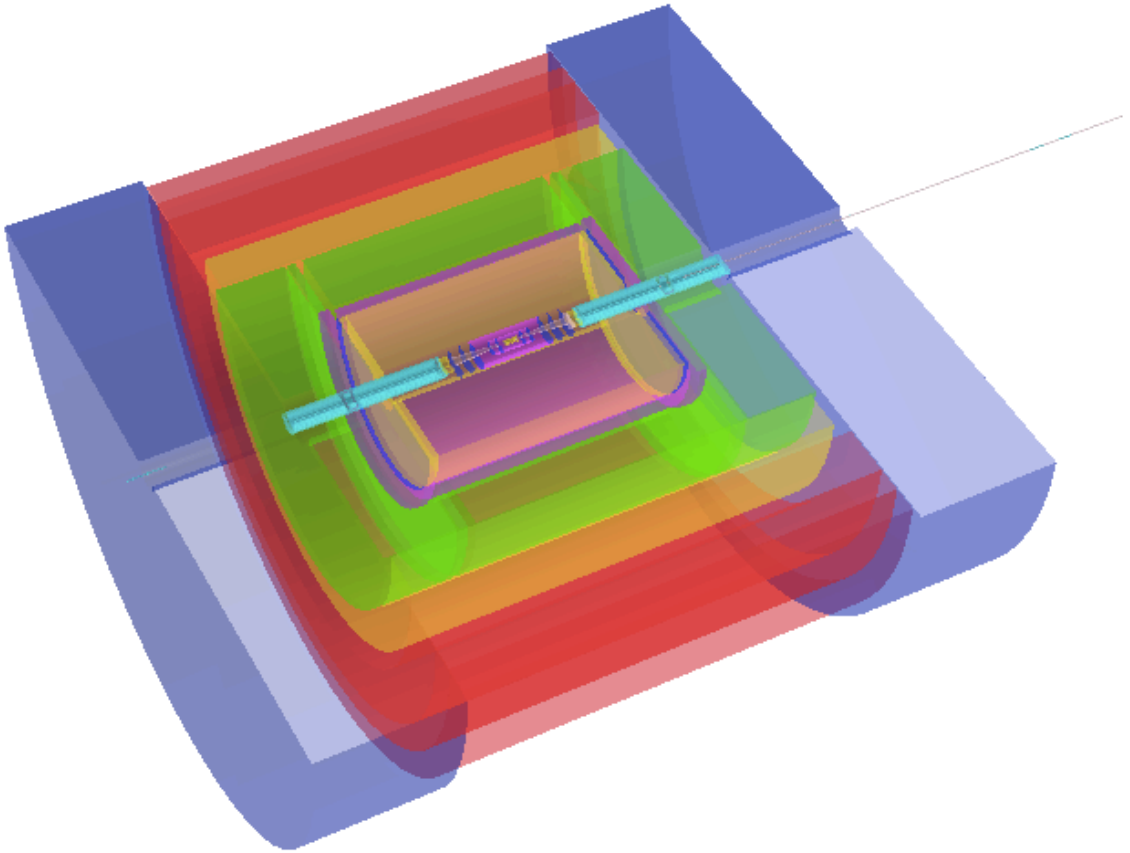
FLUGG

FLUGG is an electron and hadron MonteCarlo simulation package that integrate the GEANT4 geometrical description in to the FLUKA code.

- Allow the transport code in FLUKA to efficiently access very complex geometries by means of GEANT4 routines.
- Simulation of particles behavior using the whole of the FLUKA physics package.

We are be able to run FLUKA and GEANT4 MonteCarlo simulations with the same geometry description.

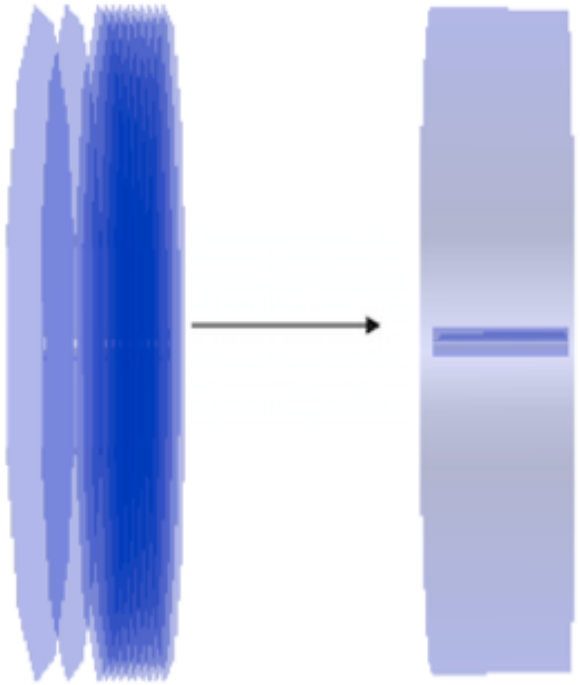
CEPC_o_v2 model



Tube
VTX
FTDisks
LumiCal
QD0/QF1
TPC
Ecal
Hcal
Coil
Yoke

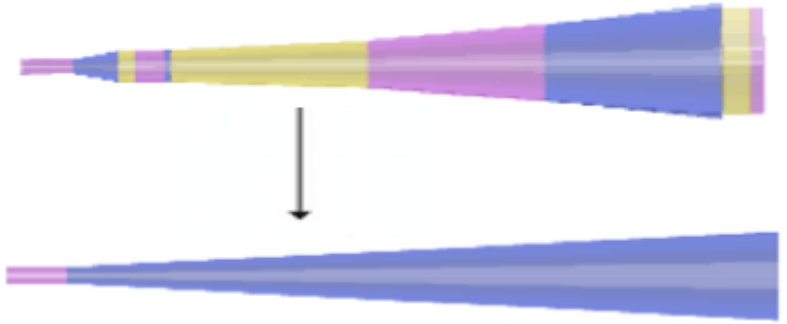
A simplfied CEPC detector model

For example



YokeEndcap

The system of 12 layers of YokeEndcap detector is simplified to a hollow cylinder.



beam pipe

The beam pipe consisting of several parts is simplified to a cone like object.

Radiation sources

Option BEAM and BEAMPOS are used as FLUKA input to define the particle source.
BEAM: defines the particle energy (or momentum)
BEAMPOS: controls their starting position and direction.

But for particle sources with more complicated features in energy, momentum and direction, or even with more than one type of particle, the user must compile and link a special subroutine SOURCE to sample these primary particles.

The radiation sources we used are all generated by Qinglei Xiu and are analyzed from deposited energy, Si 1MeV n-equivalent flux, or other physical quantities we are interested in.

A scoring option in FLUKA - USRBIN

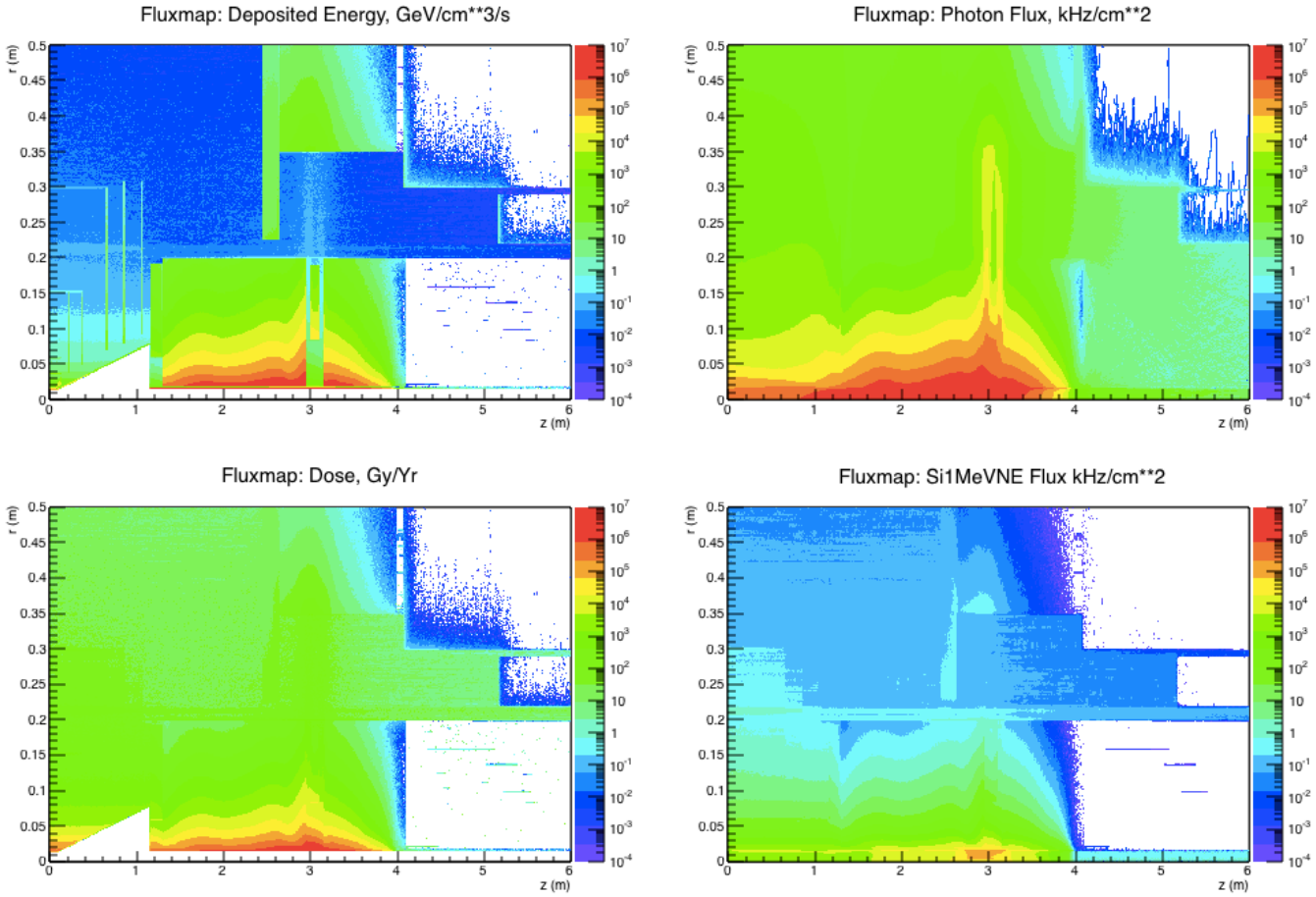
The quantities can be scored by the option USRBIN which is a typical scoring card in FLUKA.

The scoring option setup the deposited energy, Si 1MeV neutron flux, dose, or other physical quantities.

To achieve the object function FLUSCW and COMSCW must be activated by option USERDUMP and USERWEIG respectively.

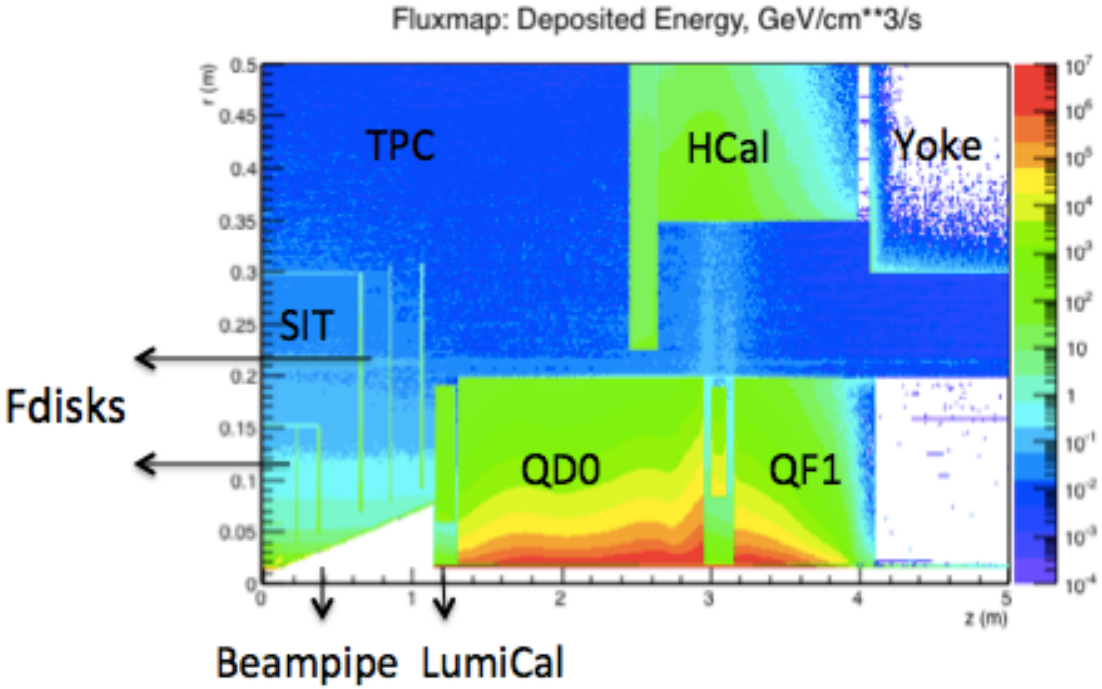
```
* … + …. 1…. + …. 2 …. + …. 3 …. + …. 4 …. + …. 5 …. + …. 6 …. + …. 7 …
USRBIN      11    ENERGY    51.0      50.0     0.0     600.0edep  0.2cm
USRBIN     0.0          0.0      0.0    500.0     1.0     600.0&
```

Results of radiative bhabha



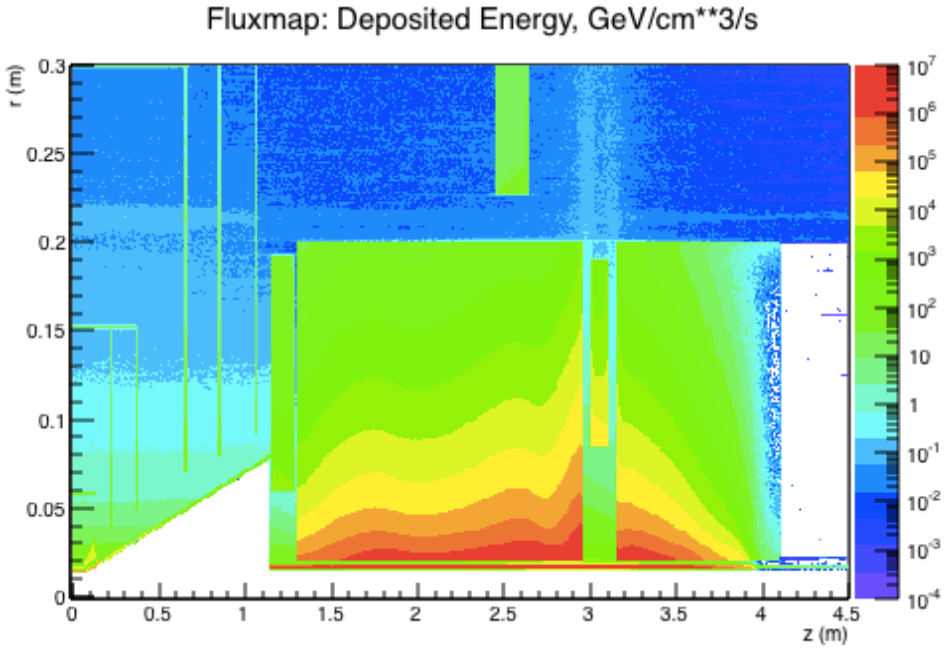
- This figure shows the distribution of deposited energy(GeV/cm^3/s), photon flux(kHz/cm^2), the yielded dose(Gy/Yr), and the Si1MeVNE flux(kHz/cm^2) in the Z-R plane.

Deposited energy



- We analyze the simulation results only in the region of 600cm×50cm in (Z,R) plane. The color band in the right side gives the magnitude of the deposited energy from 10^{-4} to 10^{7};
- From this picture we can get the information of the sub-detector geometries.

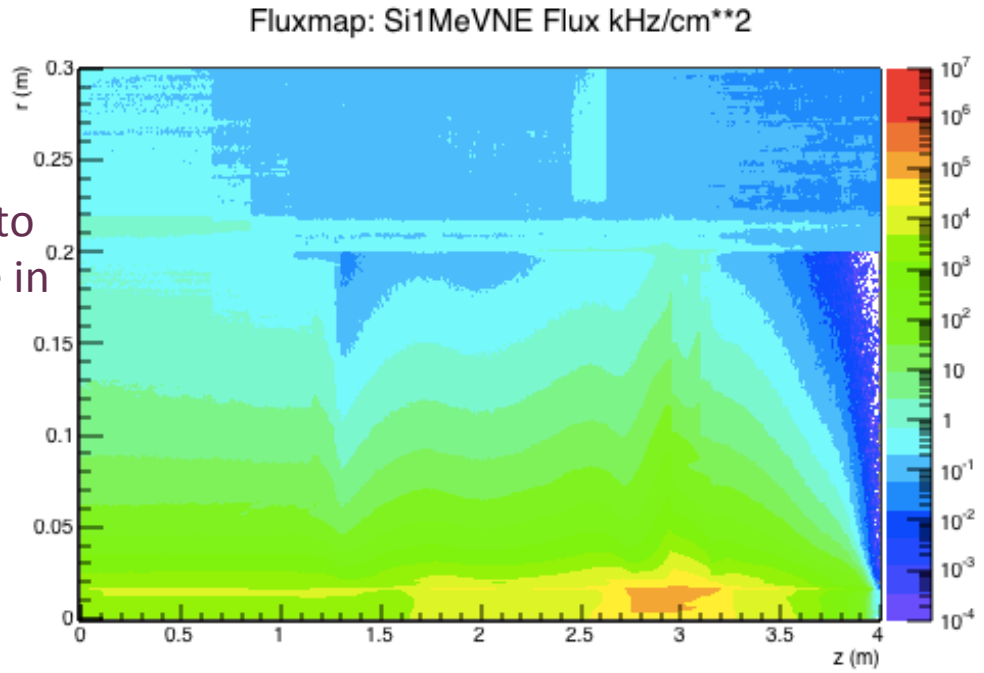
Deposited energy



- In the first picture we can see the wall of the vacuum beam pipe with no energy deposition inside;
- There are mainly two locations (QD0 and QF1) where the deposited energy is considerable, the maximal value is 1.94e+07GeV/cm^3/s located at (Z, R)=(2.96m, 0.017m);
- The deposited energy decreases in several magnitude orders along the radial direction from R=0.017 to R=0.25m.

Si 1MeV n-equivalent flux

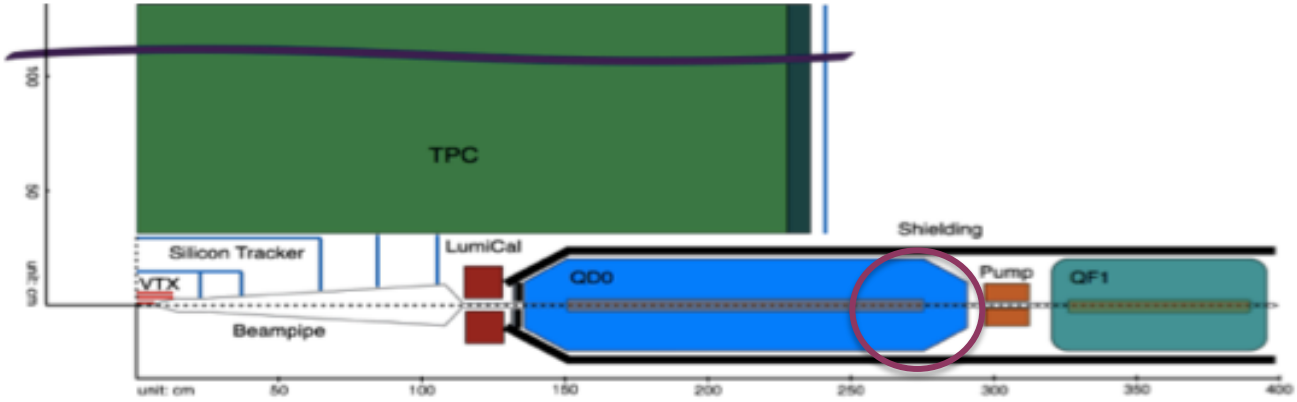
It is a quantity often used to quantify radiation damage in silicon due to NIEL(Non ionizing energy Losses).



The map of 1MeV n-equivalent flux looks like uniform below R=0.1m. Its maximum is 1.2e+5kHz/cm^2 located at (Z, R)=(2.83m, 0.016m);

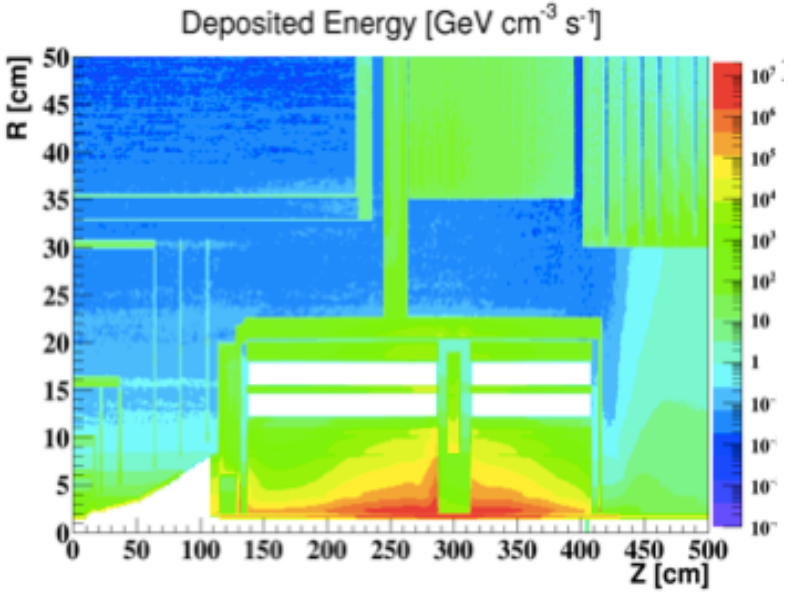
Hot Point

	unit	value	Z(cm)	R(cm)
Deposited Energy	GeV/cm^3/s	1.94e+07	296	1.7
Photon Flux	kHz/cm^2	9.82e+06	291	1.7
Si1MeVNE Flux	kHz/cm^2	1.16e+05	283	1.6
Dose	Gy/Yr	7.56e+06	296	1.9

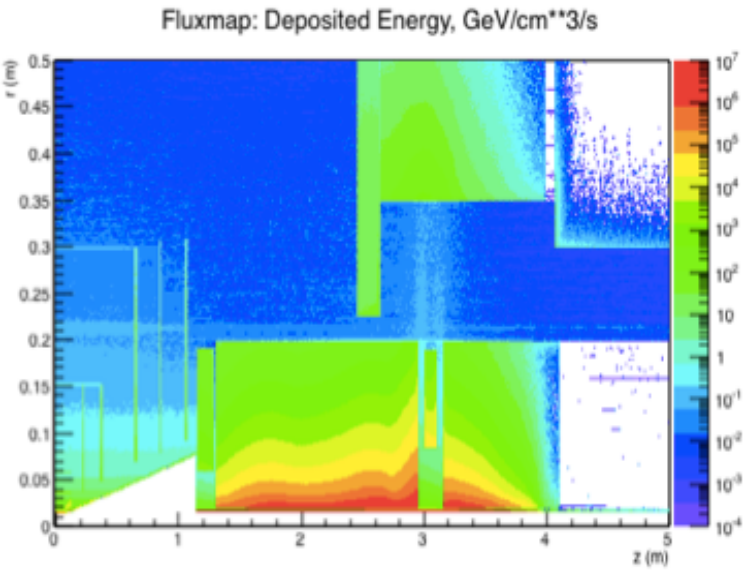


Layout of the MDI of CEPC

Compare Results of FLUKA and GEANT4



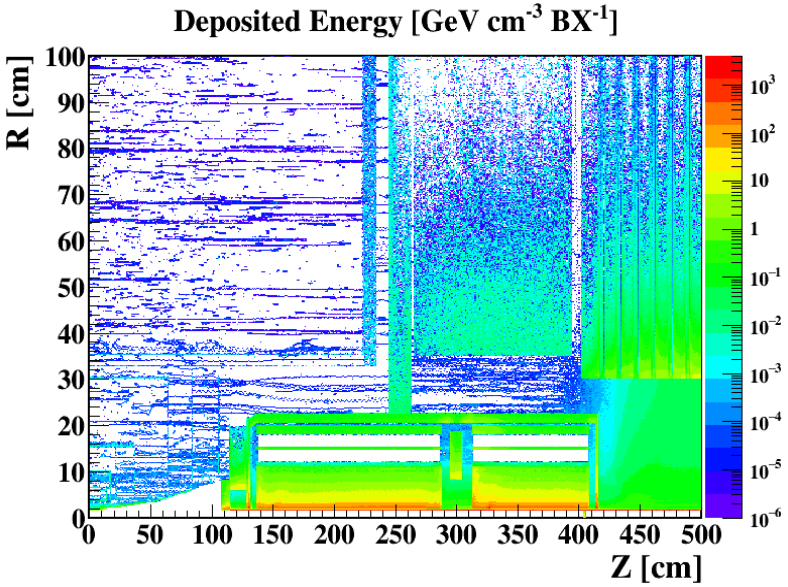
GEANT4



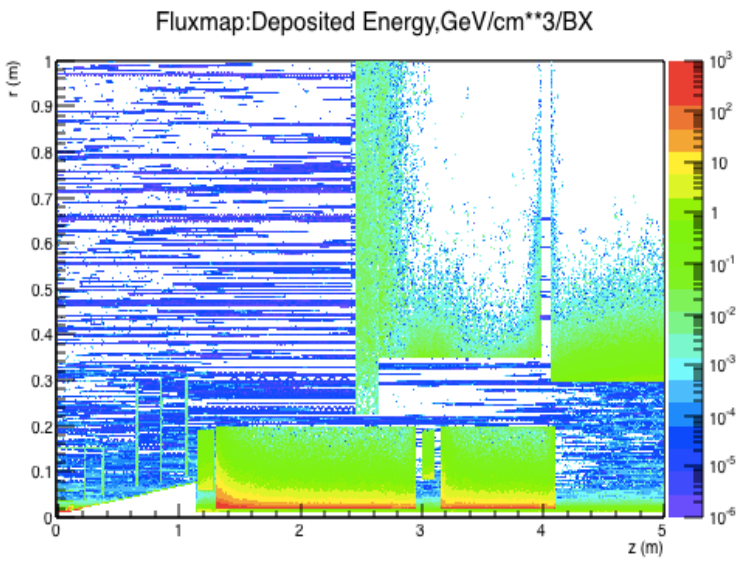
FLUKA

- In order to verify the results from FLUKA, we also used a simulation code GEANT4 to calculate the deposited energy of Radiative Bhabha.
- In this study, it is found that the FLUKA results was in good agreement with the GEANT4.

Compare Results of FLUKA and GEANT4



GEANT4



FLUKA

- The maps show the 2-D deposited energy distribution of SR photons –Quadrupole Magnets.
- The SR photons are generated around the range of -1.5m – -4m along the Z axis, which are close to the IP.

Summary

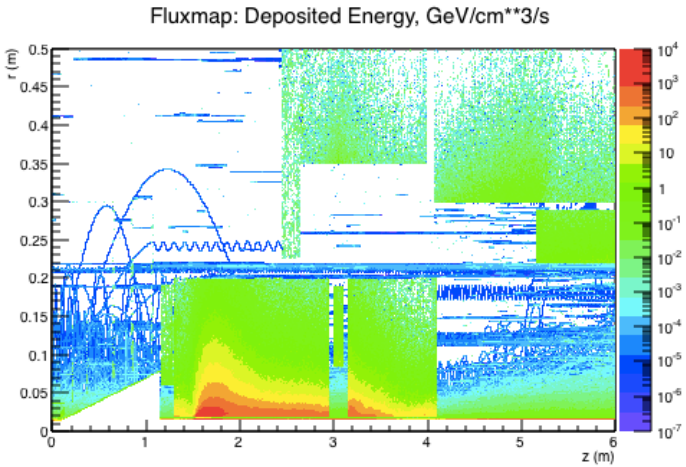
- In-depth analysis of the above physical quantities by FLUKA.
- Reconfirm the normalization in the FLUKA MonteCarlo simulation
- Need a collimators system to prevent the SR photons from the last bending magnet.

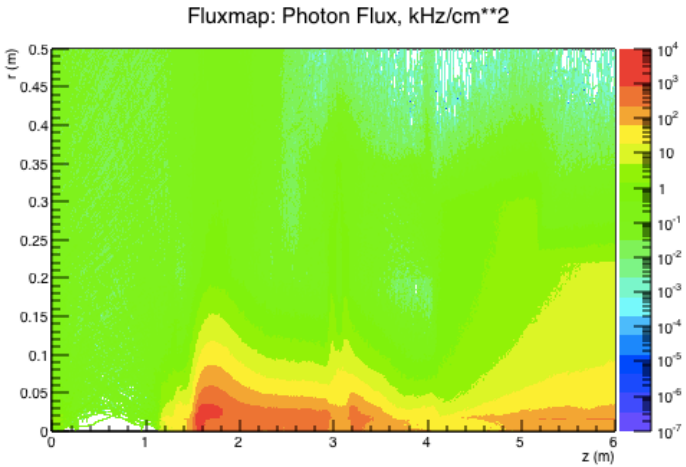
THANKS

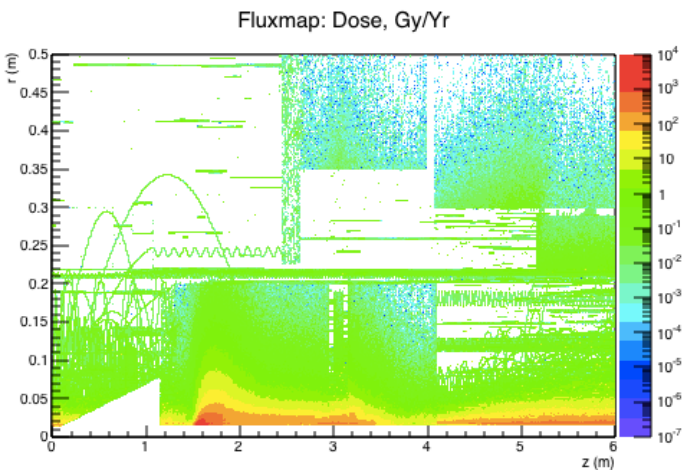
Backup

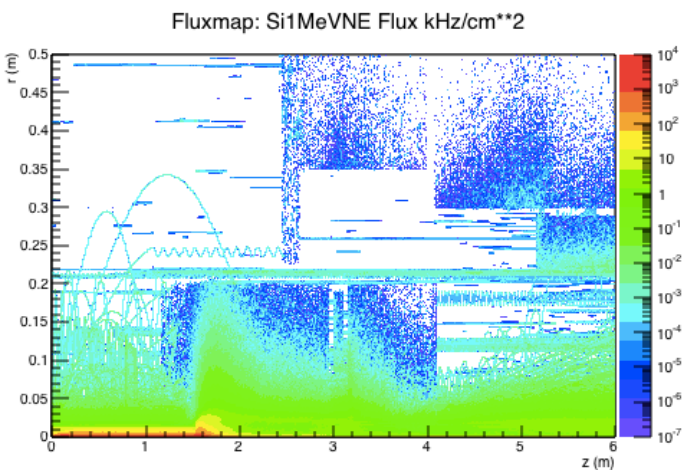
The results of the other backgrounds

Incoherent pairs

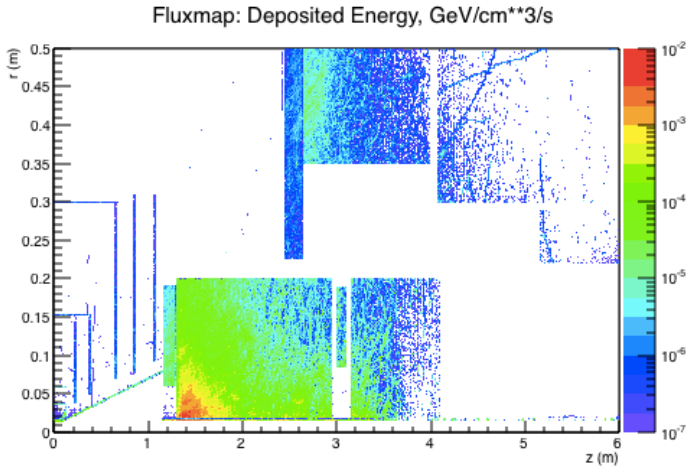


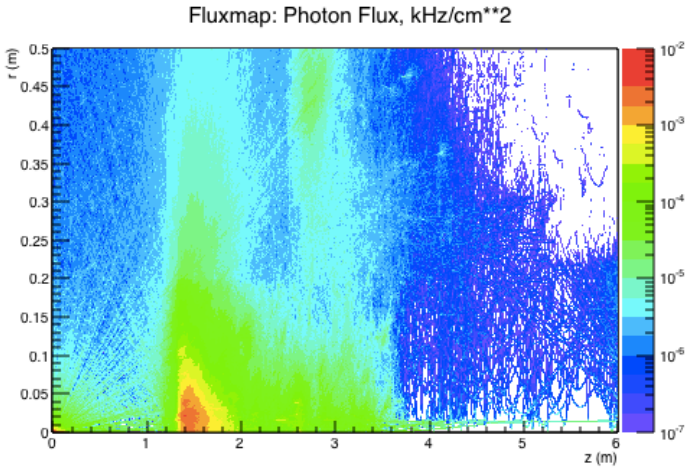


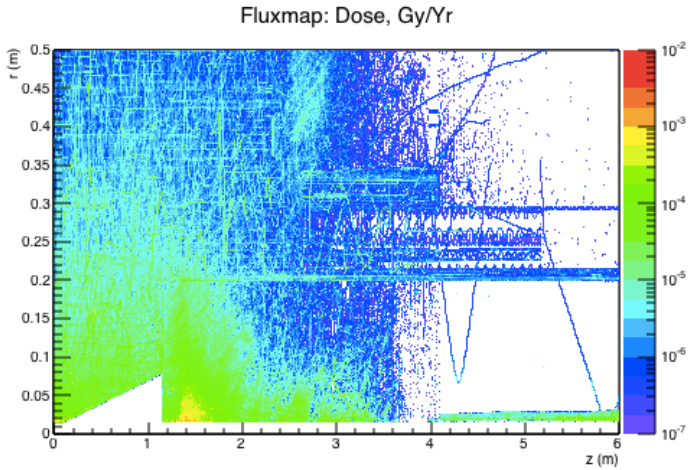


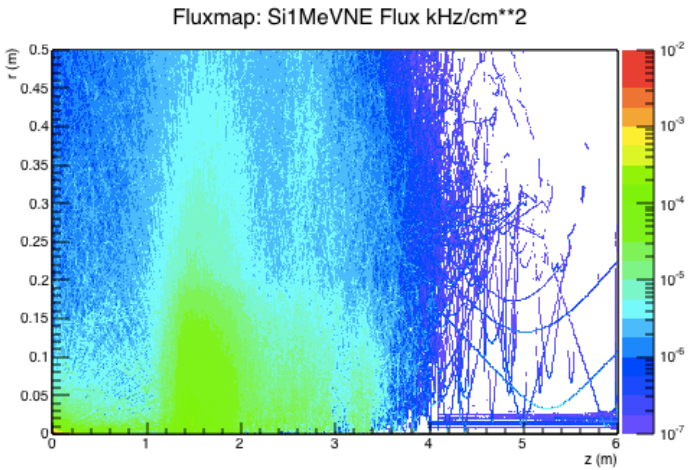


γγ → hadrons events

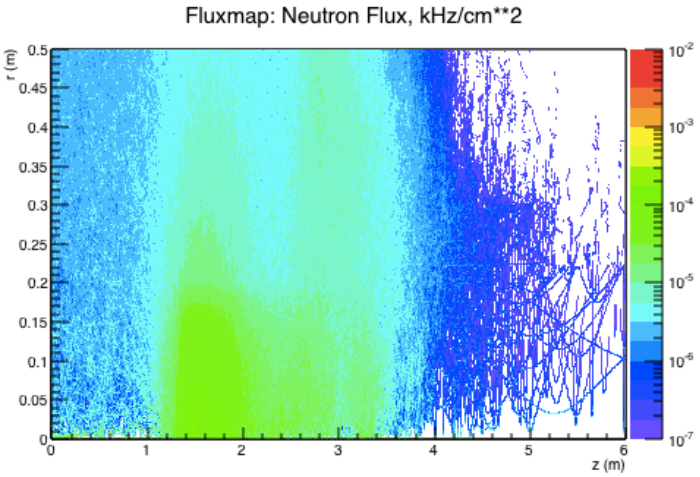


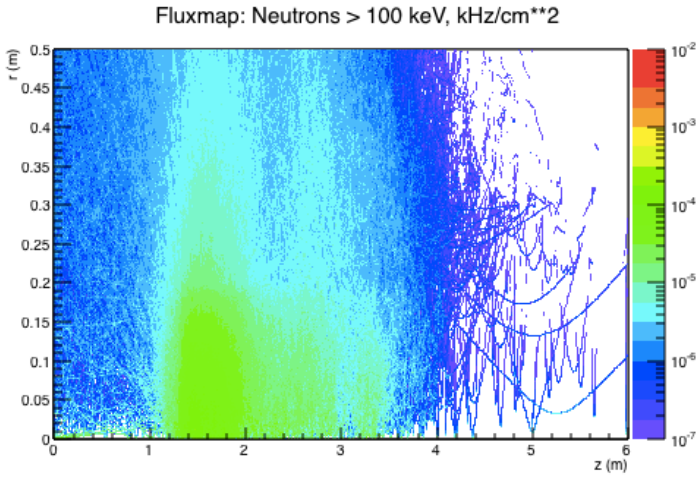


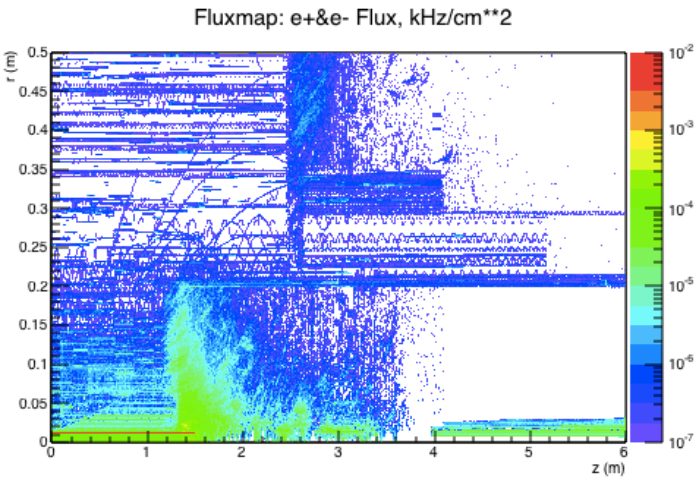


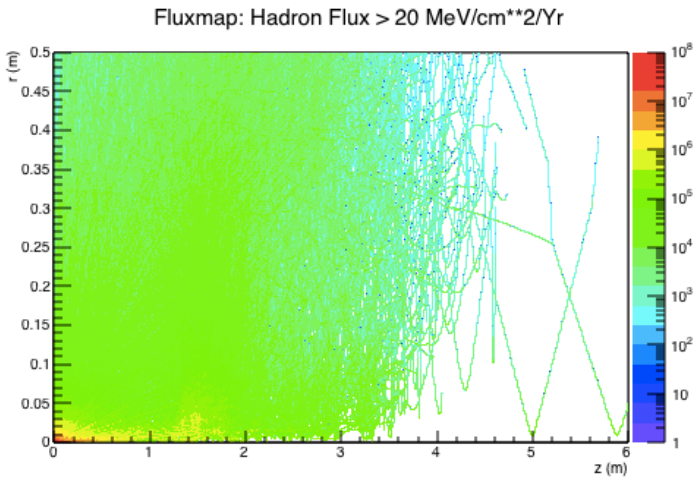


γγ → hadrons events

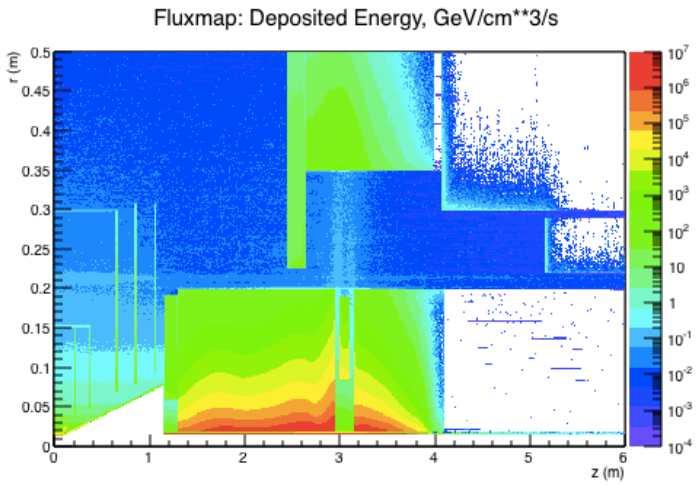


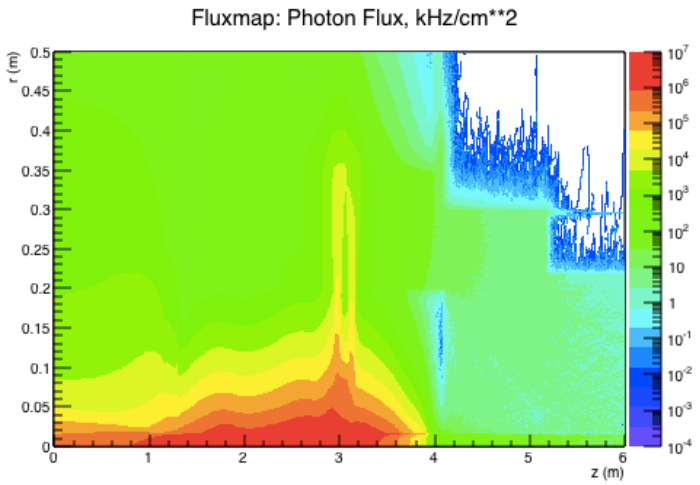


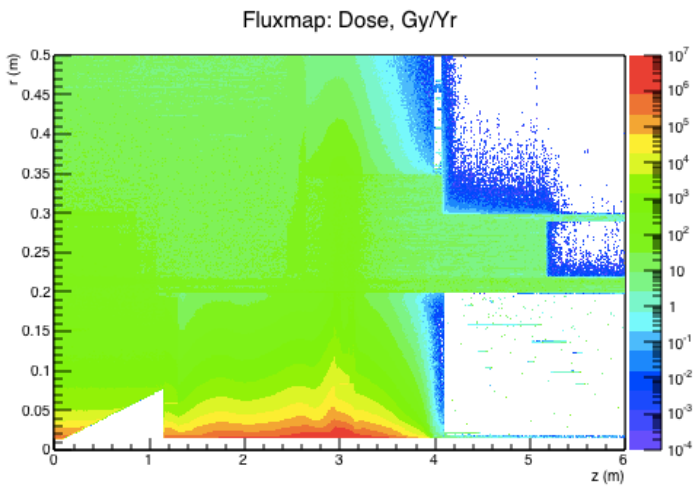


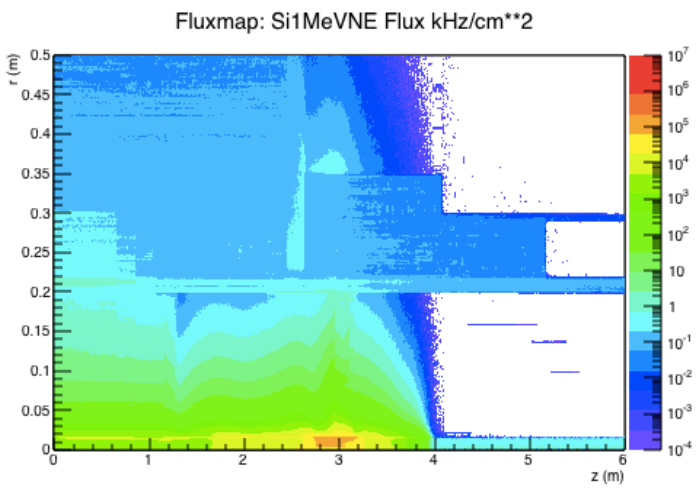


Radiative bhabha

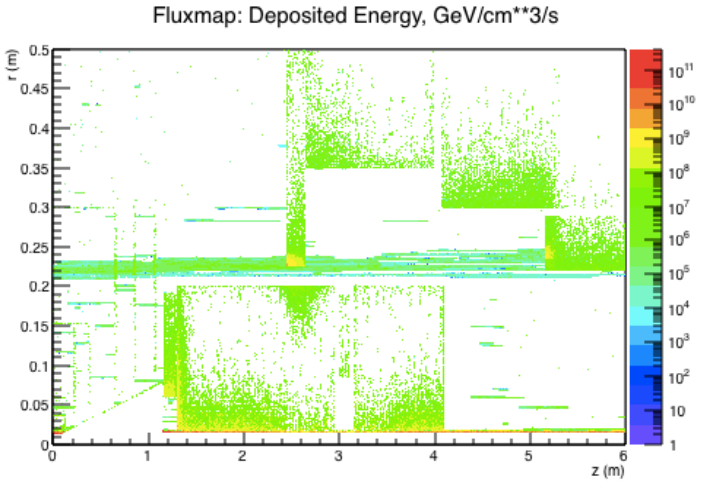


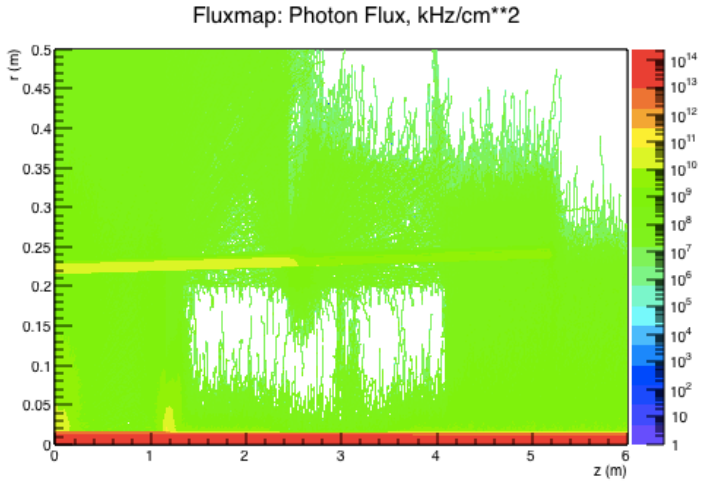


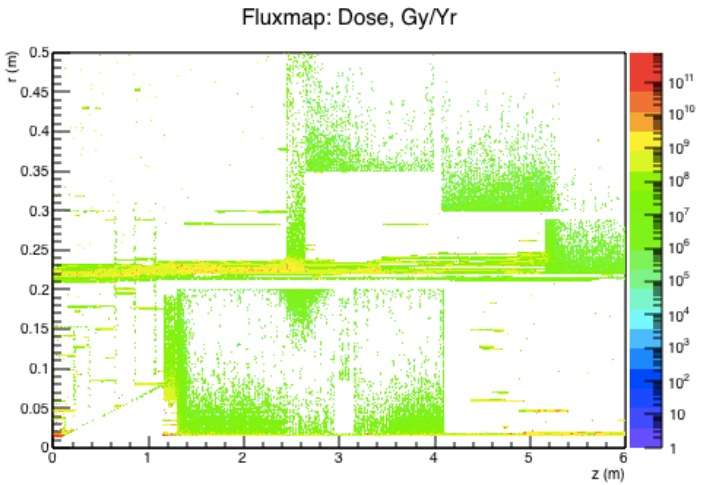


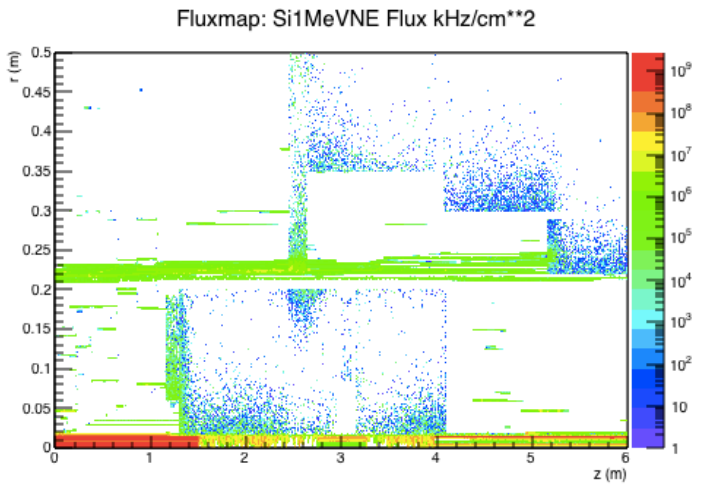


Synchrotron radiation – Dipole Magnets

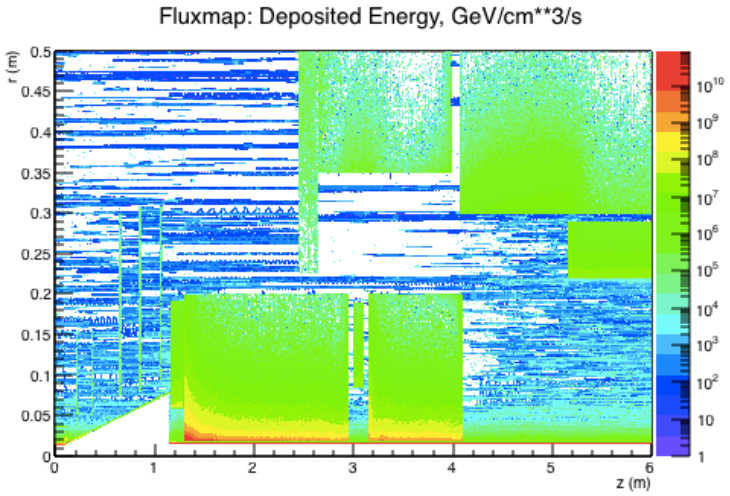


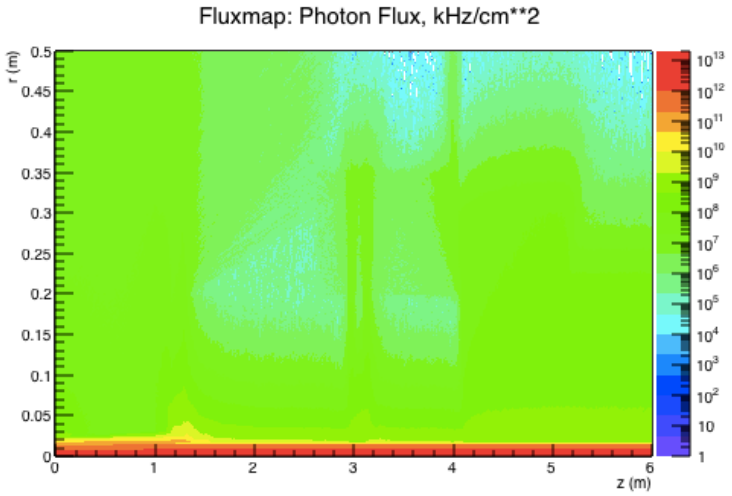


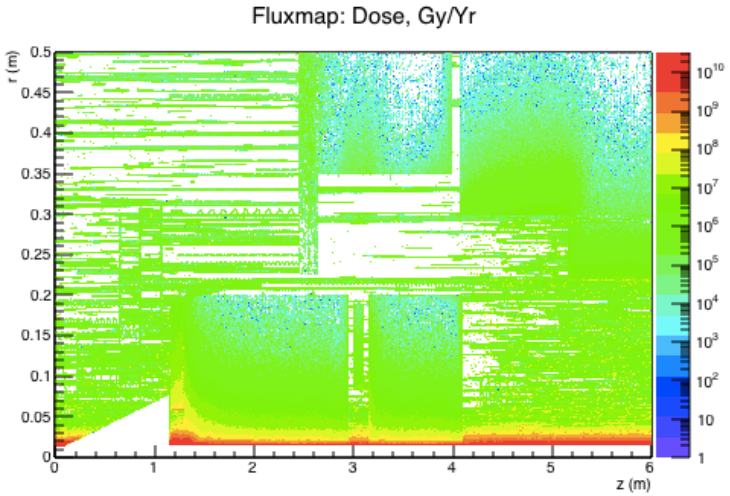


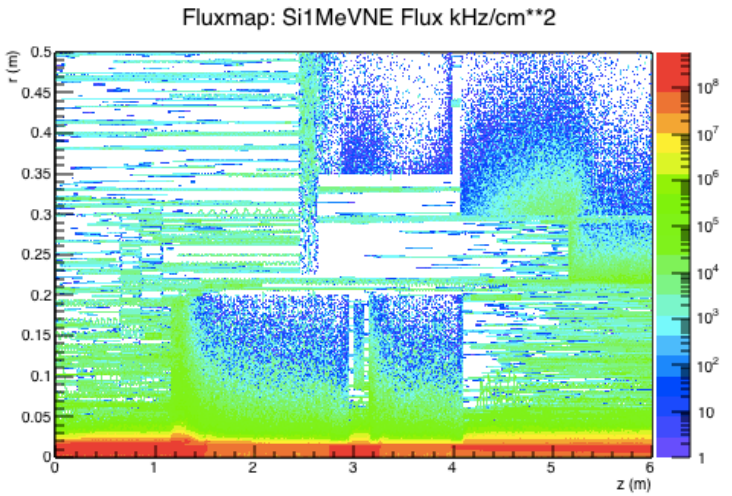


Synchrotron radiation–Quadrupole Magnets

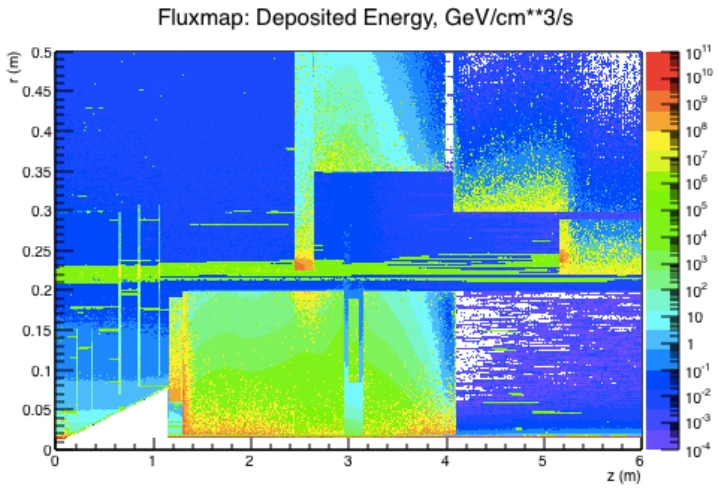


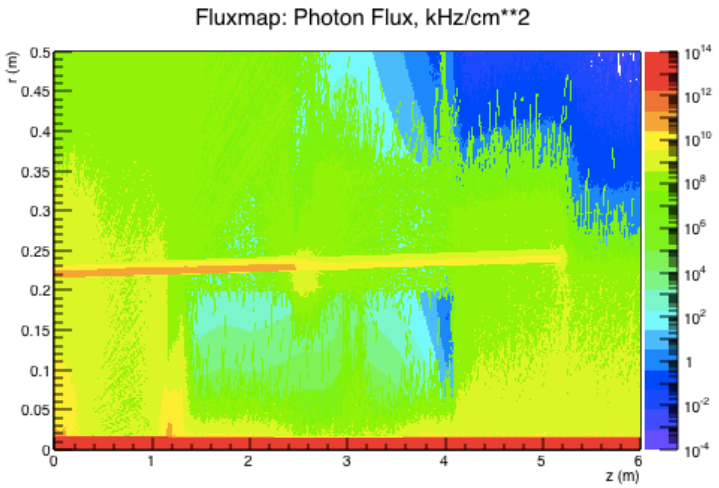


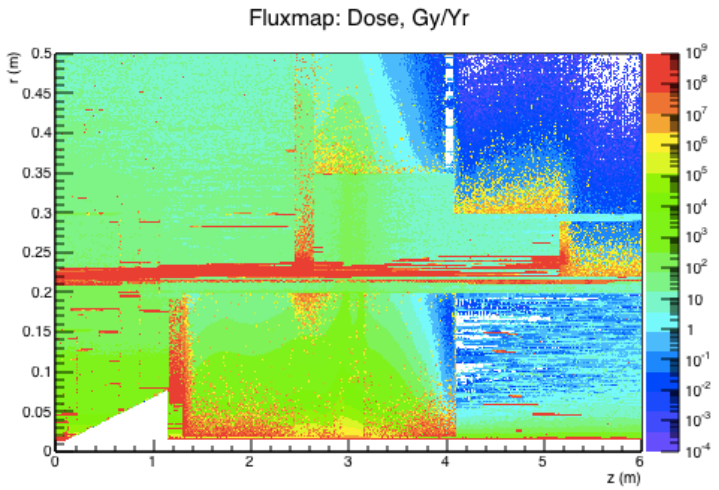


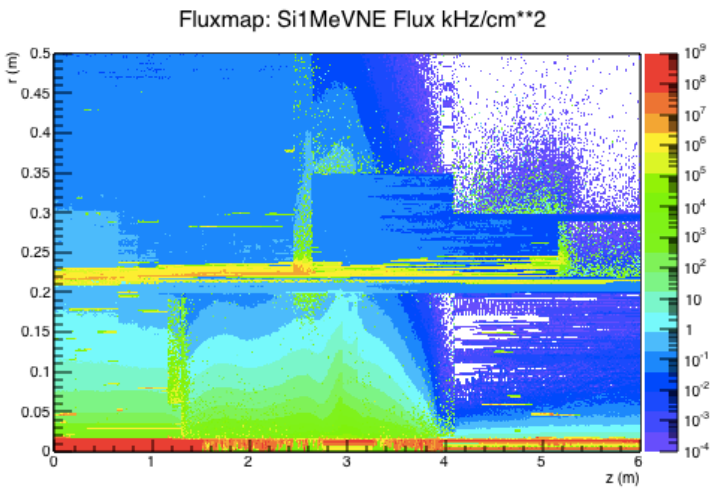


Summary

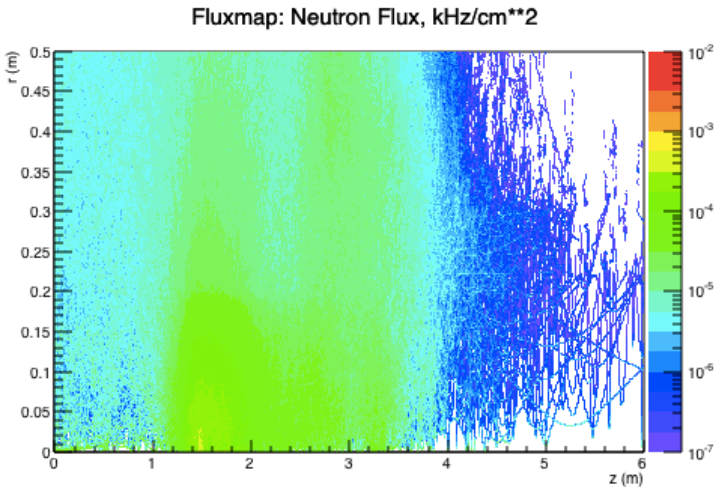

Fluxmap: Deposited Energy, GeV/cm**3/s
r (m)
z (m)

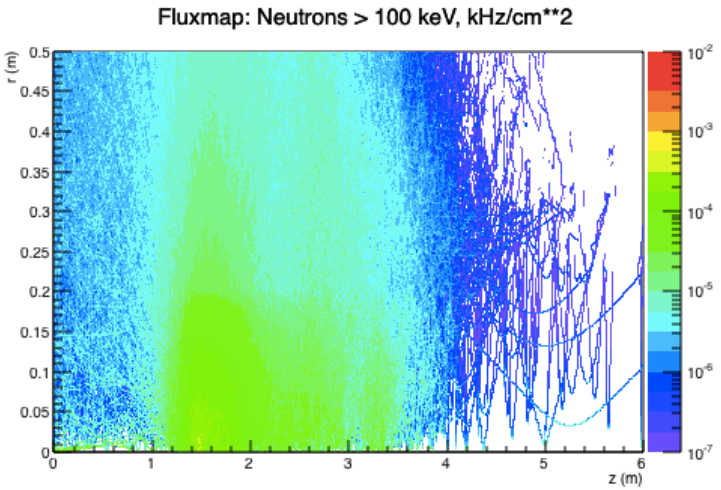

Fluxmap: Photon Flux, kHz/cm**2
r (m)
z (m)

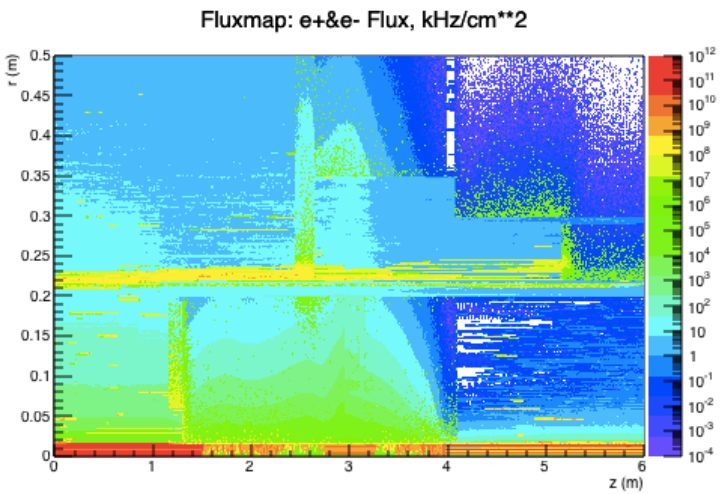

Fluxmap: Dose, Gy/Yr
r (m)
z (m)

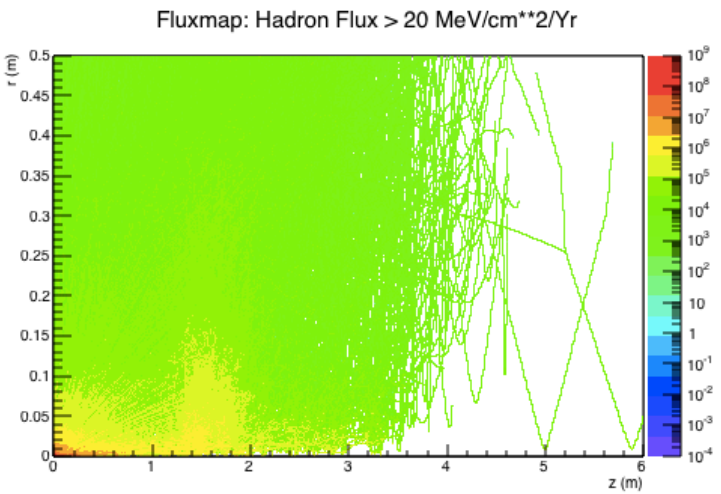

Fluxmap: Si1MeVNE Flux kHz/cm**2
r (m)
z (m)

Summary

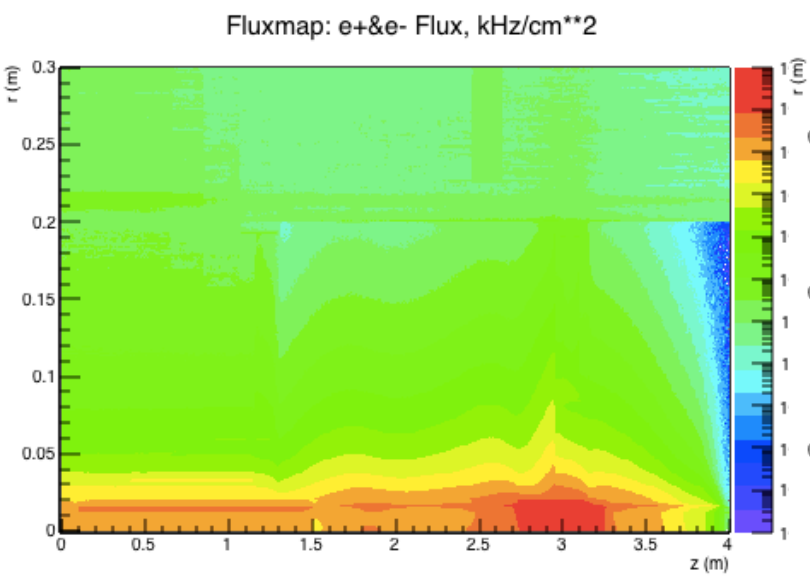

Fluxmap: Neutron Flux, kHz/cm**2
r (m)
z (m)

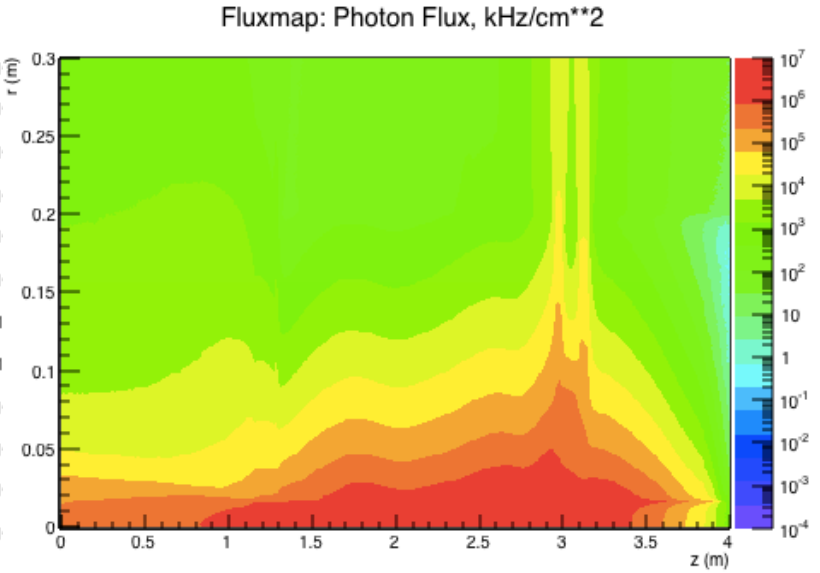

Fluxmap: Neutrons > 100 keV, kHz/cm**2
r (m)
z (m)


Fluxmap: e+&e- Flux, kHz/cm**2
r (m)
z (m)


Fluxmap: Hadron Flux > 20 MeV/cm**2/Yr
r (m)
z (m)

Si 1MeV n-equivalent flux





I think 1MeV n-equivalent flux in mainly determined by photons; The contribution of electrons to it is negligible.