

# SoLID Simulation

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SoLID Jlab Physics Division  
Brainstorming Session

2012/01/06



**12 GeV Upgrade**  
Future Science at Jefferson Lab

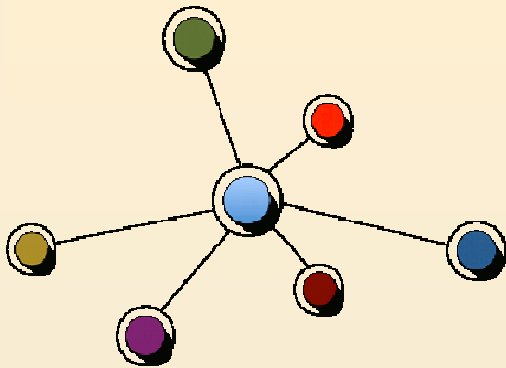
# Outline

- History
- SoLID GEMC simulation framework
- Simulation study
  - Choosing Magnet
  - PVDIS Baffle Design
  - EM background
  - Neutron background
- Summary

# History

- Comgeant, Geant3 based simulation program.
  - geometry/sensitivity/digitization/field as input files and detached from main code, run different settings without recompilation.
  - Successfully used for PVDIS and SIDIS proposals.
- 
- As Geant3 development has stopped, we want to move on from Geant3, Fortran based framework to Geant4, C++ based framework for the next 10 years of design, running and analysis.

# GEMC (GEant4 MonteCarlo)



GEMC

Used by CLAS12

- C++ program that simulates particles through matter using the [Geant4](#)
- Detector information are stored in mysql database. configuration changes are immediately available to users without need of recompiling the code.
- Hit process factory: associate detectors with external digitization routines at run time.
- perl script I/O to database, no need to know C++ or Geant4 to build detector and run the simulation.

GEOMETRY,  
BANKS,  
DIGITIZATION  
DATABASE

network

GEMC

# GEMC interface

Batch mode

Various GEMC Options:

- ◆ Control
- ◆ General
- ◆ Generator
- ◆ Luminosity
- ◆ Mysql
- ◆ Output
- ◆ Physics
- ◆ Verbosity



# GEMC interface

## Interactive mode

### Run Control

The Run Control window features a sidebar with icons for Run Control, Camera, Detector, Infos, and G4Dialog. The main panel has tabs for Primary Particle, Primary Beam, and Secondary Beam. The Primary Particle tab is active, showing a dropdown for Particle Type set to 'e-'. Below this are sliders for p, theta, and phi. The Primary Beam tab shows Beam Values and Vertex Values. The Secondary Beam tab shows Vertex Values. At the bottom, there are controls for the Number of Events (Set N: 1 X 1) and a Beam On button.

Primary Particle | Primary Beam | Secondary Beam

Particle Type:

Value Dispersion

p:

theta:

phi:

| Beam Values |                 | Vertex Values |                |
|-------------|-----------------|---------------|----------------|
| p:          | 5500 ± 5500 MeV | (x,y,z):      | (0, 0, 100) mm |
| theta:      | 28.5 ± 6.5 deg  | radius:       | 5 mm           |
| phi:        | 0 ± 180 deg     | delta z:      | 200 mm         |

Vertex

Value Dispersion

vx:  radius:

vy:  dvz:

vz:

Number of Events

Set N:  X  Number of Events: 1

Beam On

Exit

### Detector

The Detector window shows a list of volumes in a tree view. The Camera Control window shows settings for the camera, including Move, Projection, theta, phi, Pan, Zoom, Background Color, and Screenshot. The Visualization Options are also visible.

Volumes

- BaBar\_SIDIS\_absorber
  - BaBar\_SIDIS\_absorber\_largeangle
  - BaBar\_SIDIS\_absorber\_shower
- BaBar\_SIDIS\_cherenkov
  - BaBar\_SIDIS\_cherenkov\_CHRT
  - BaBar\_SIDIS\_cherenkov\_heavygas\_chere...
- BaBar\_SIDIS\_ec\_forwardangle
  - BaBar\_SIDIS\_ec\_forwardangle\_preshower
  - BaBar\_SIDIS\_ec\_forwardangle\_shower
- BaBar\_SIDIS\_ec\_largeangle
  - BaBar\_SIDIS\_ec\_largeangle\_ec\_largeangle
- BaBar\_SIDIS\_gem
  - BaBar\_SIDIS\_gem\_plateinner1
  - BaBar\_SIDIS\_gem\_plateinner2
  - BaBar\_SIDIS\_gem\_plateinner3
  - BaBar\_SIDIS\_gem\_plateinner4
  - BaBar\_SIDIS\_gem\_plateinner5
  - BaBar\_SIDIS\_gem\_plateinner6
- BaBar\_SIDIS\_mrpe
  - BaBar\_SIDIS\_mrpe\_ec\_largeangle
- BaBar\_SIDIS\_sc
  - BaBar\_SIDIS\_sc\_sc
- BaBar\_SIDIS\_solenoid
  - BaBar\_SIDIS\_solenoid\_coil\_CRYO
  - BaBar\_SIDIS\_solenoid\_yoke\_SY01

Camera Control

Move:  Projection:

theta

phi

Pan

Pan Strength

Zoom

Background Color

Screenshot

Visualization Options

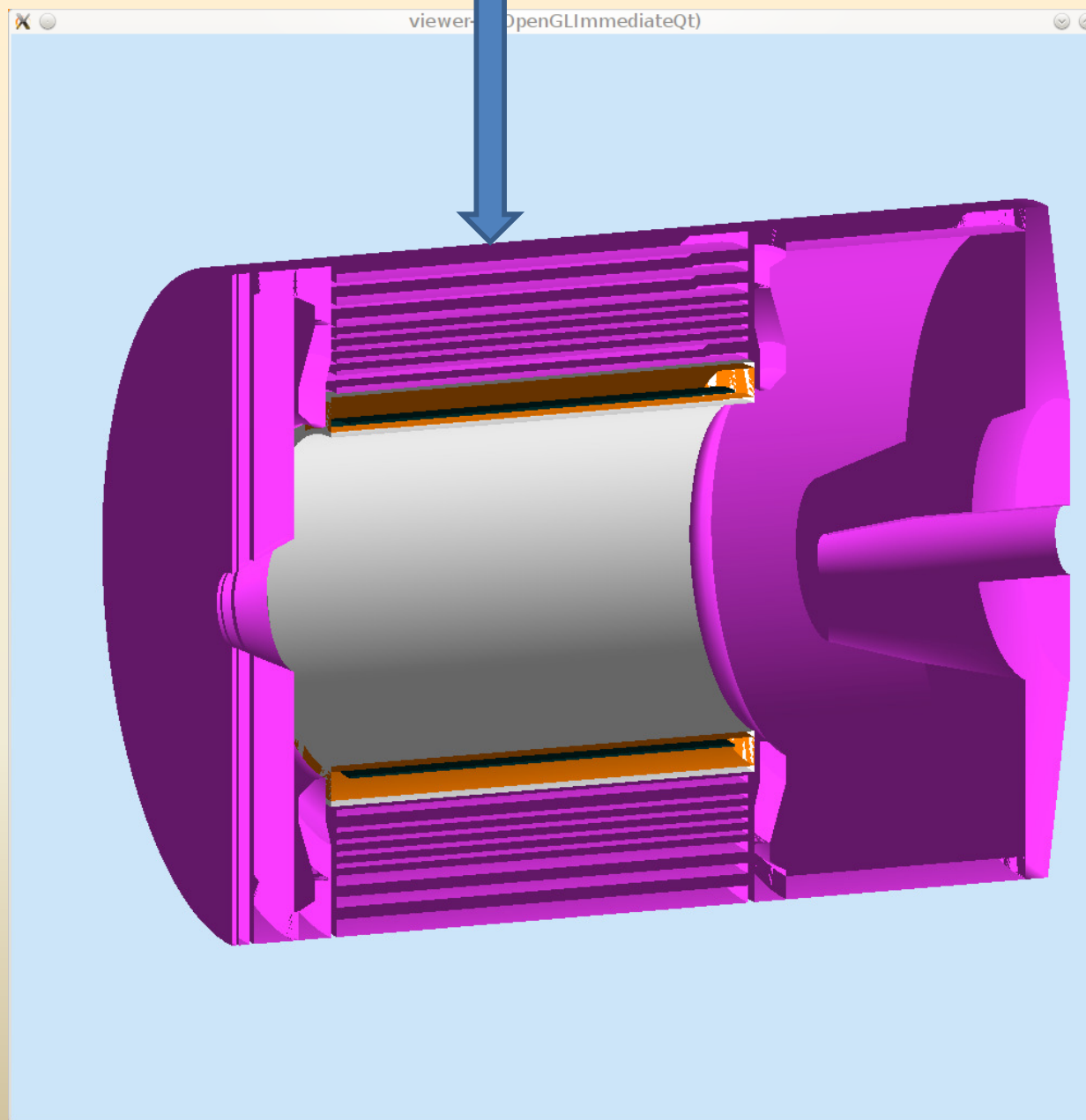
Anti-Aliasing

Sides per circle

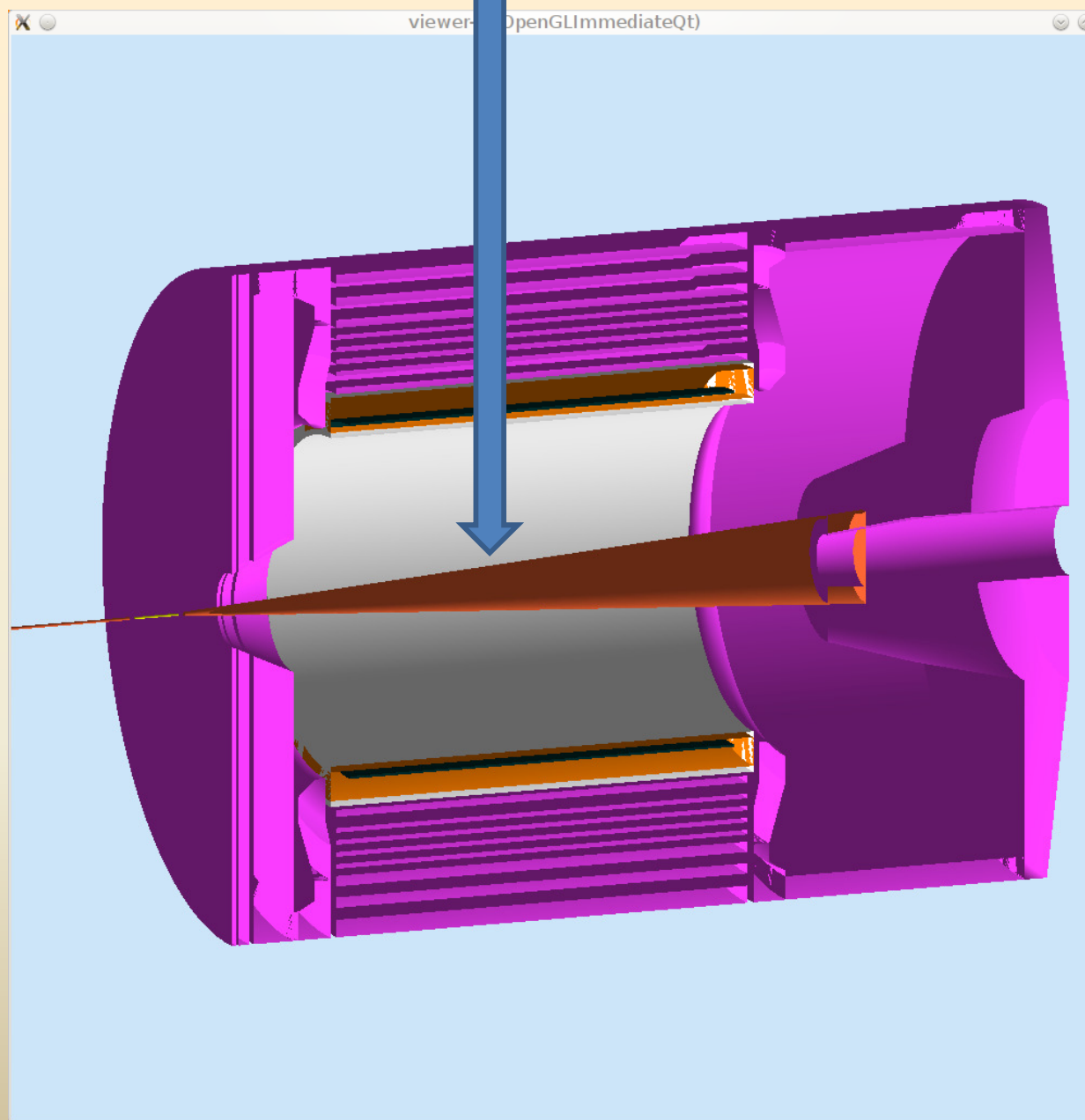
Auxiliary Edges

Camera

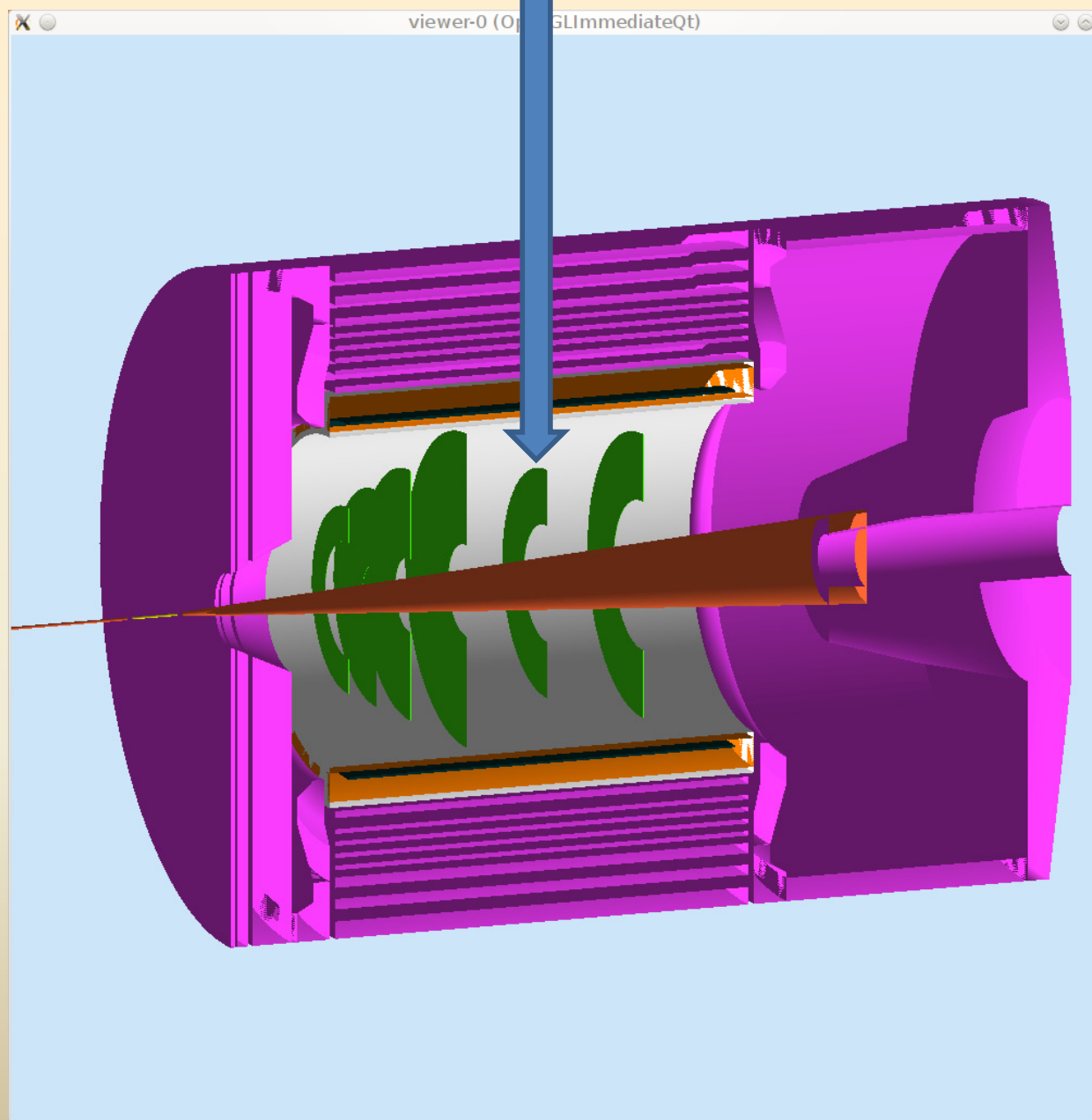
# Magnet/coil/yoke



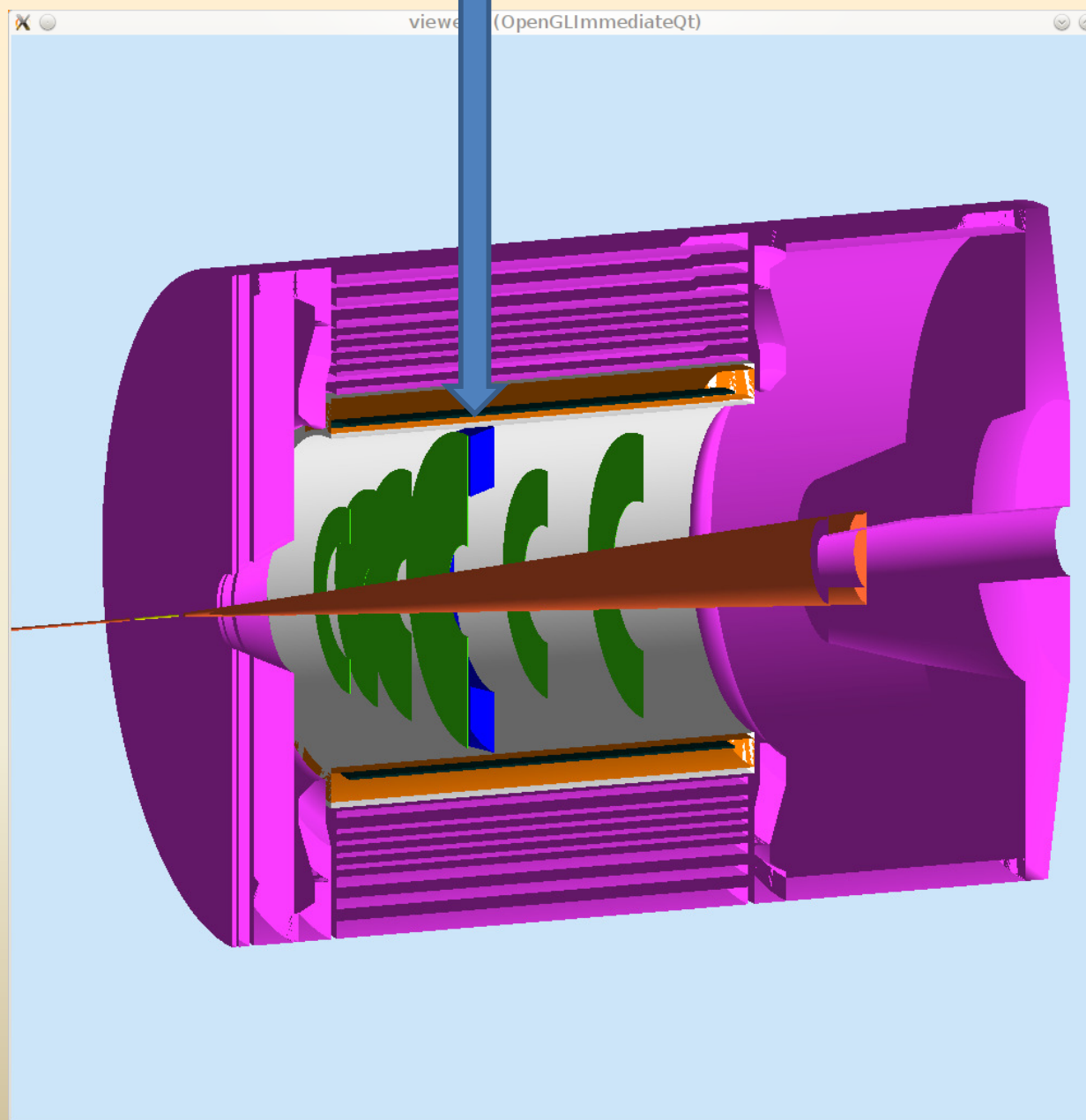
# Target/Beam line



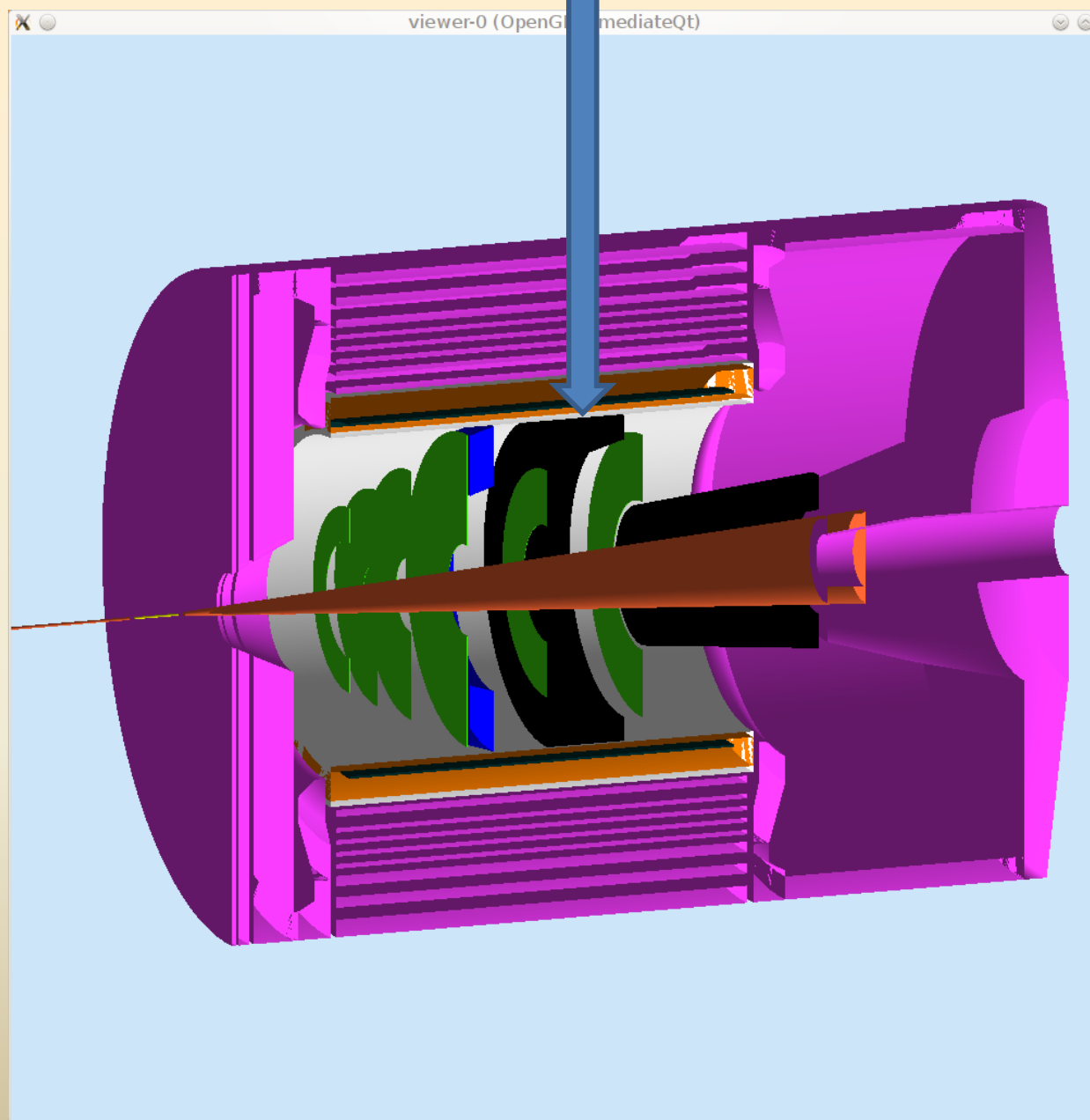
GEM



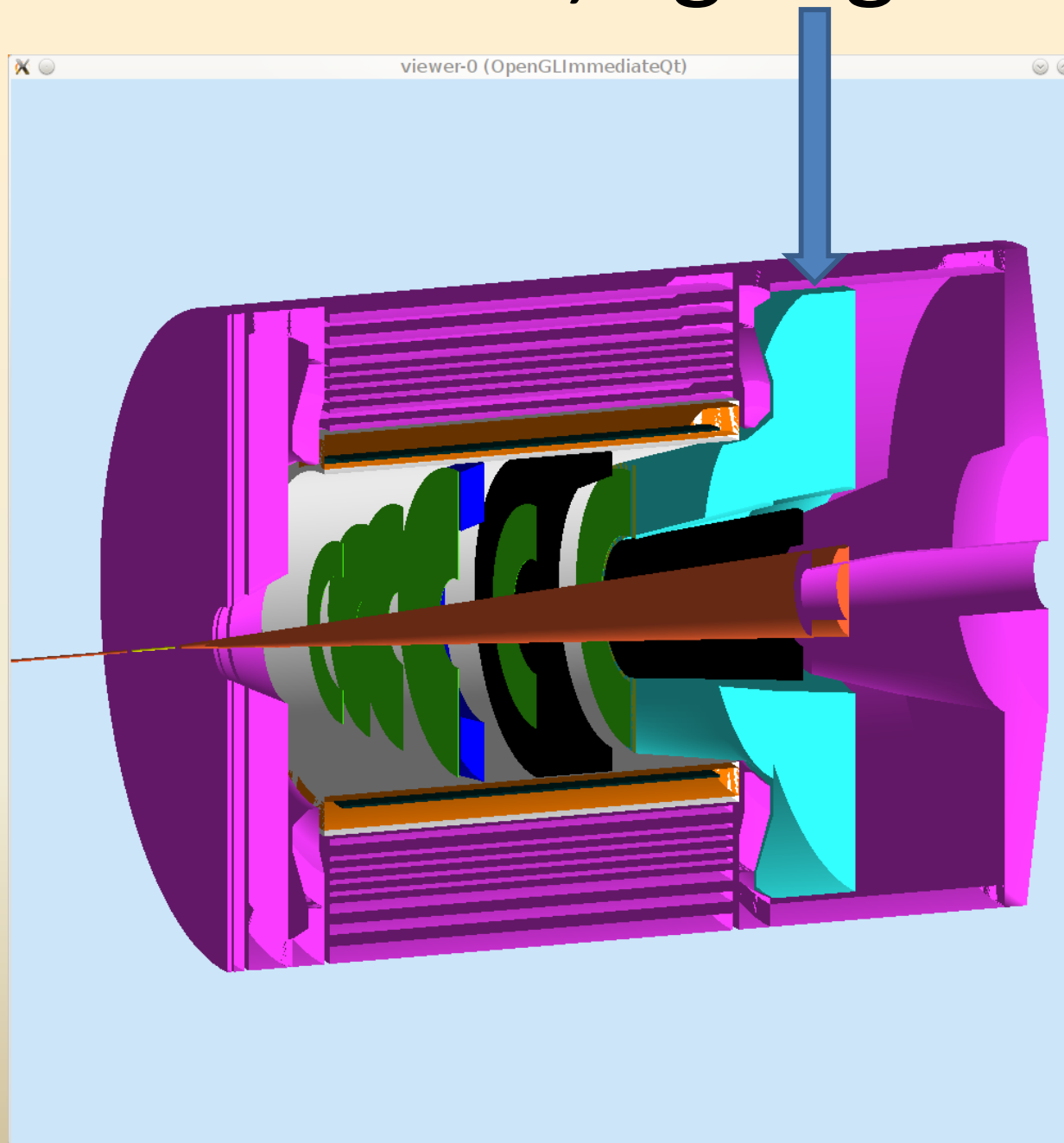
# EC, large angle



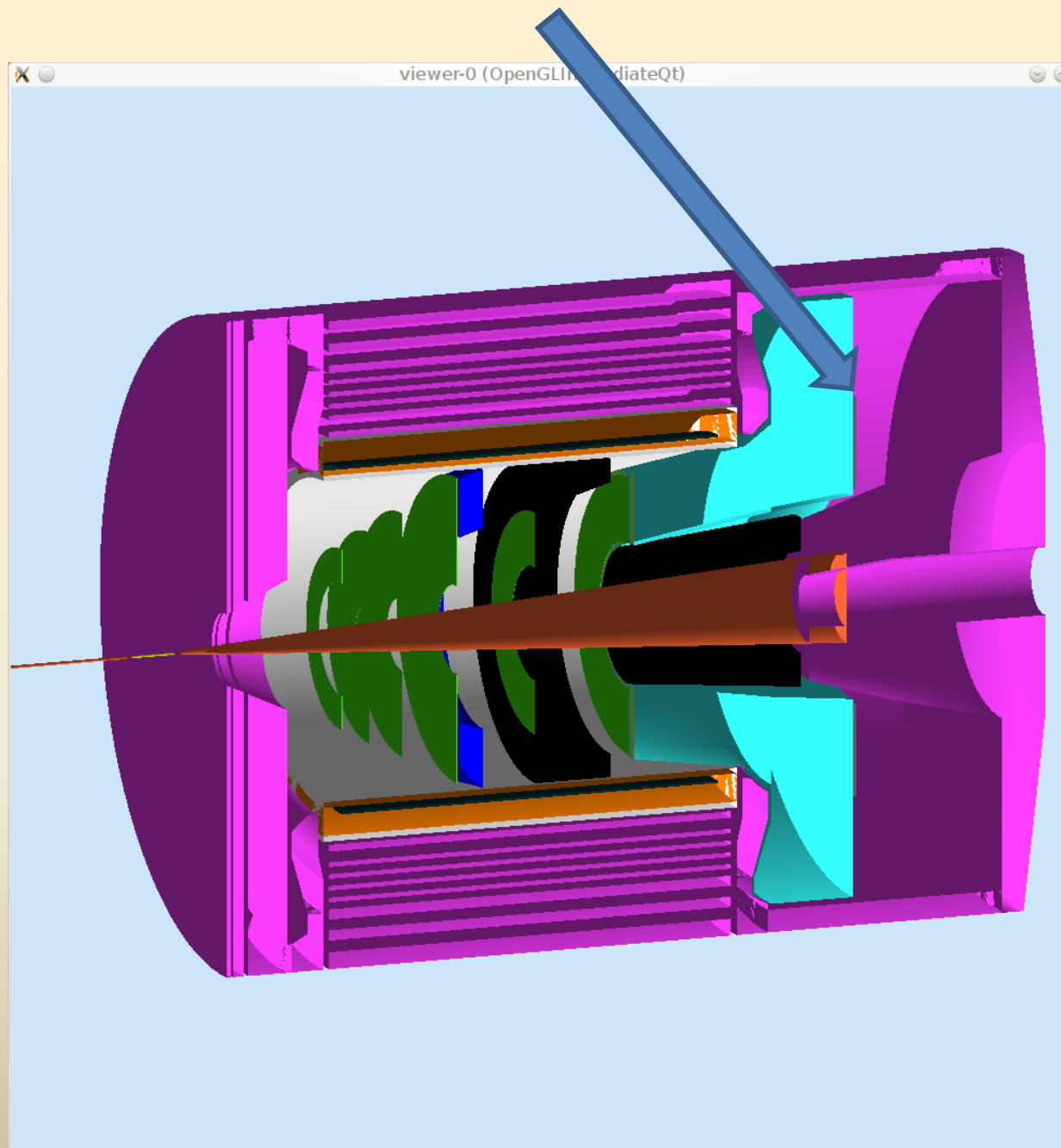
# Collimator



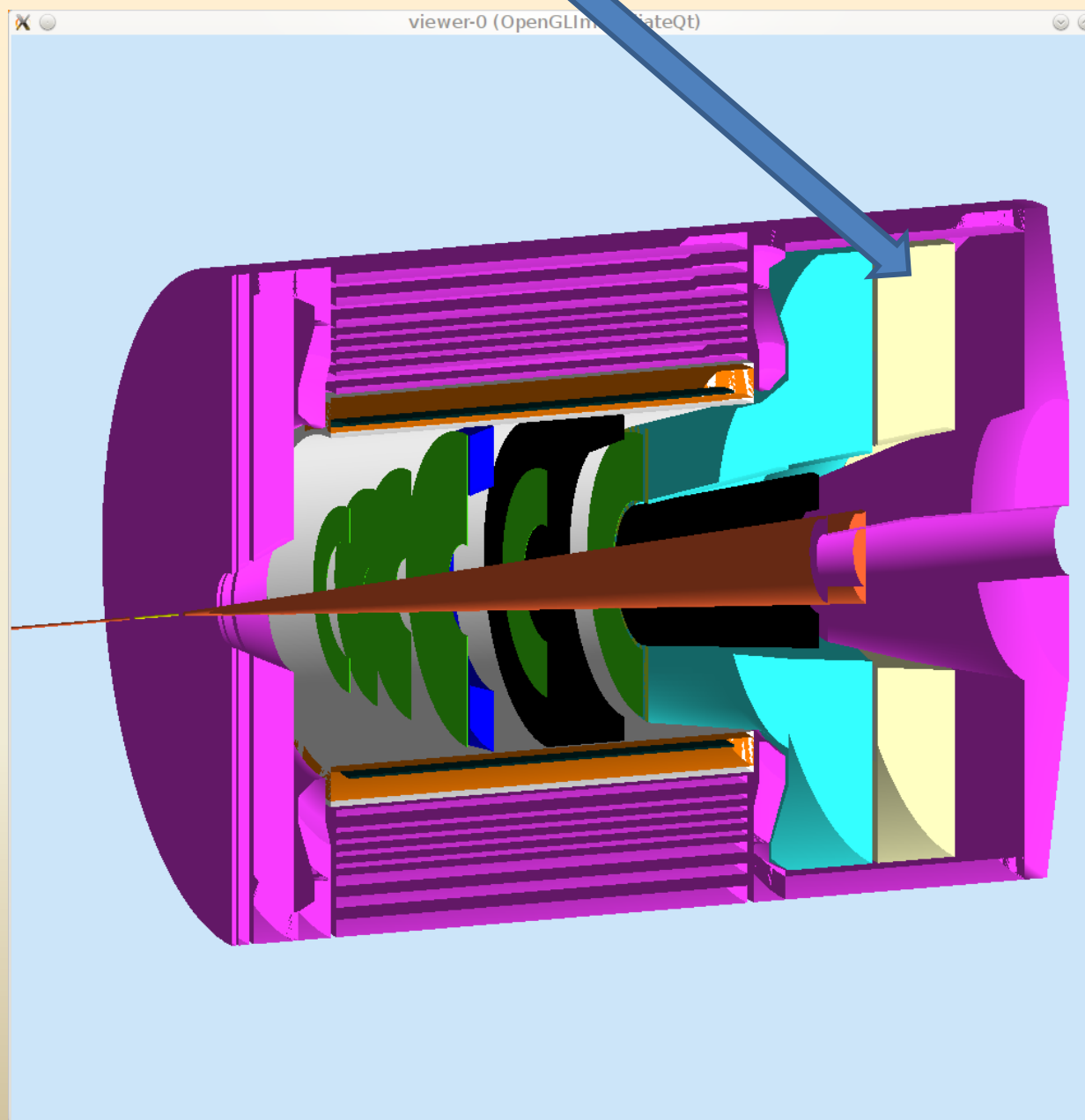
# Cherenkov, light gas



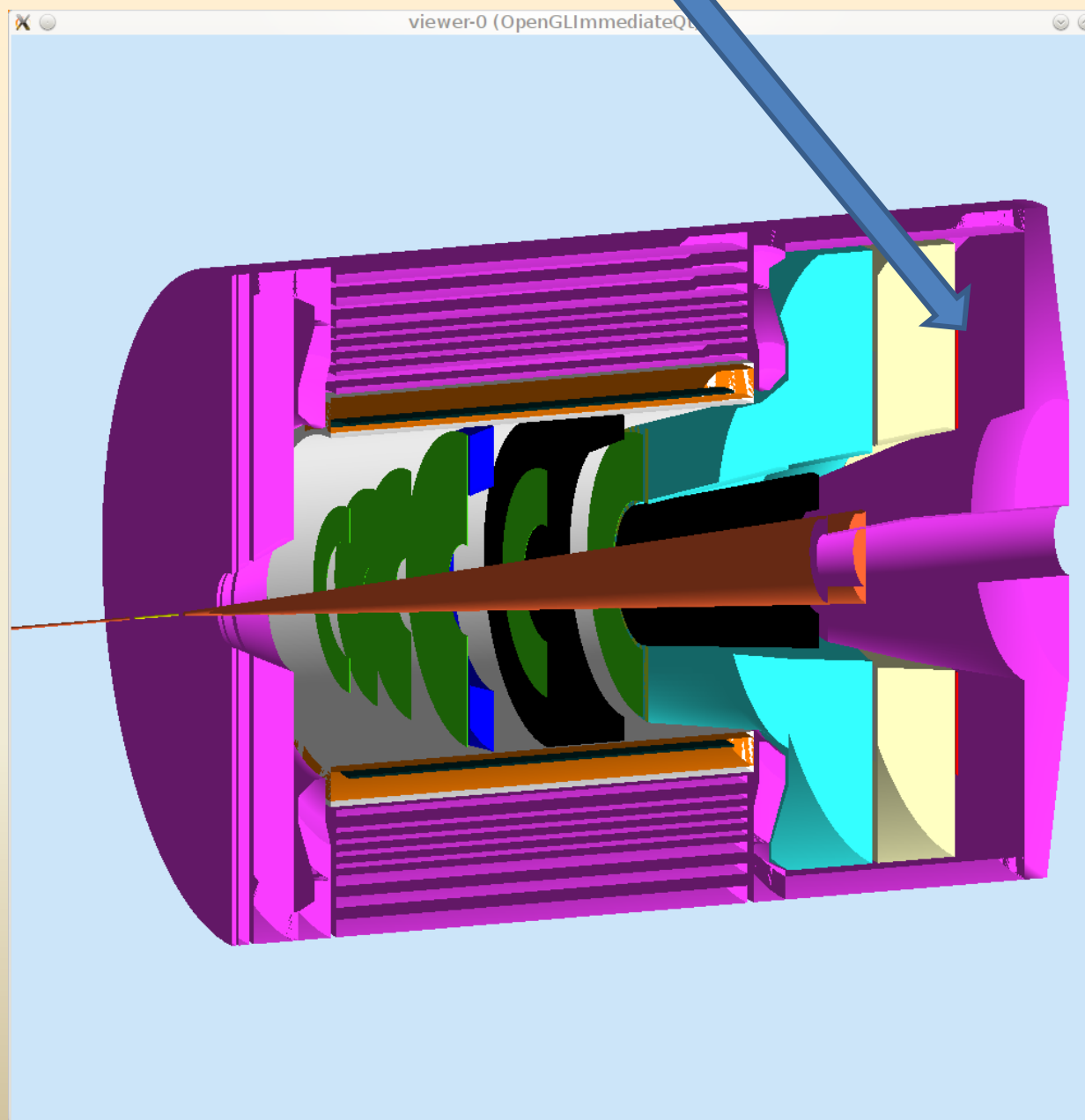
# Scintillator



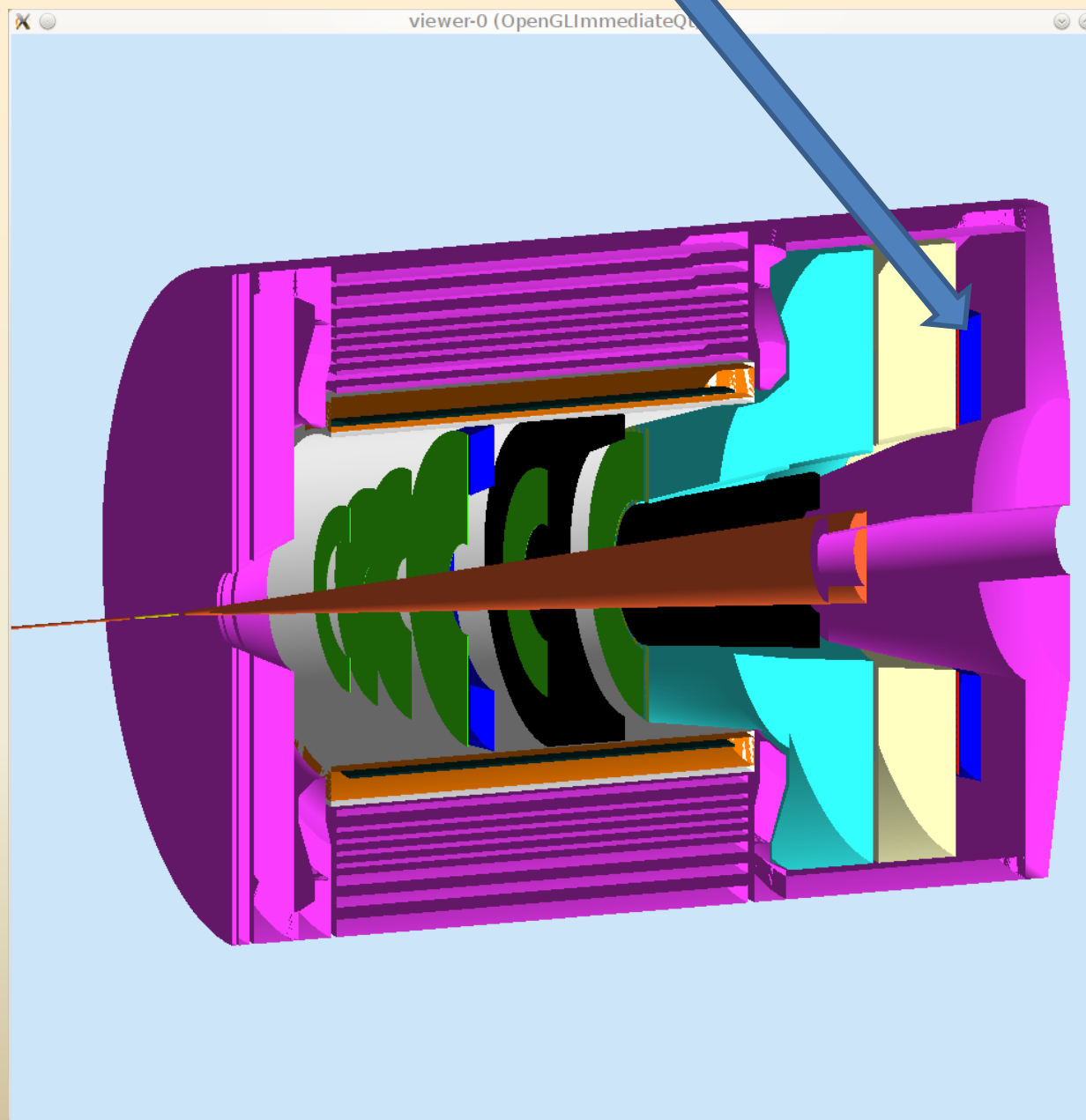
# Cherenkov, heavy gas



# MRPC (Multigap Resistive Plate Chambers)



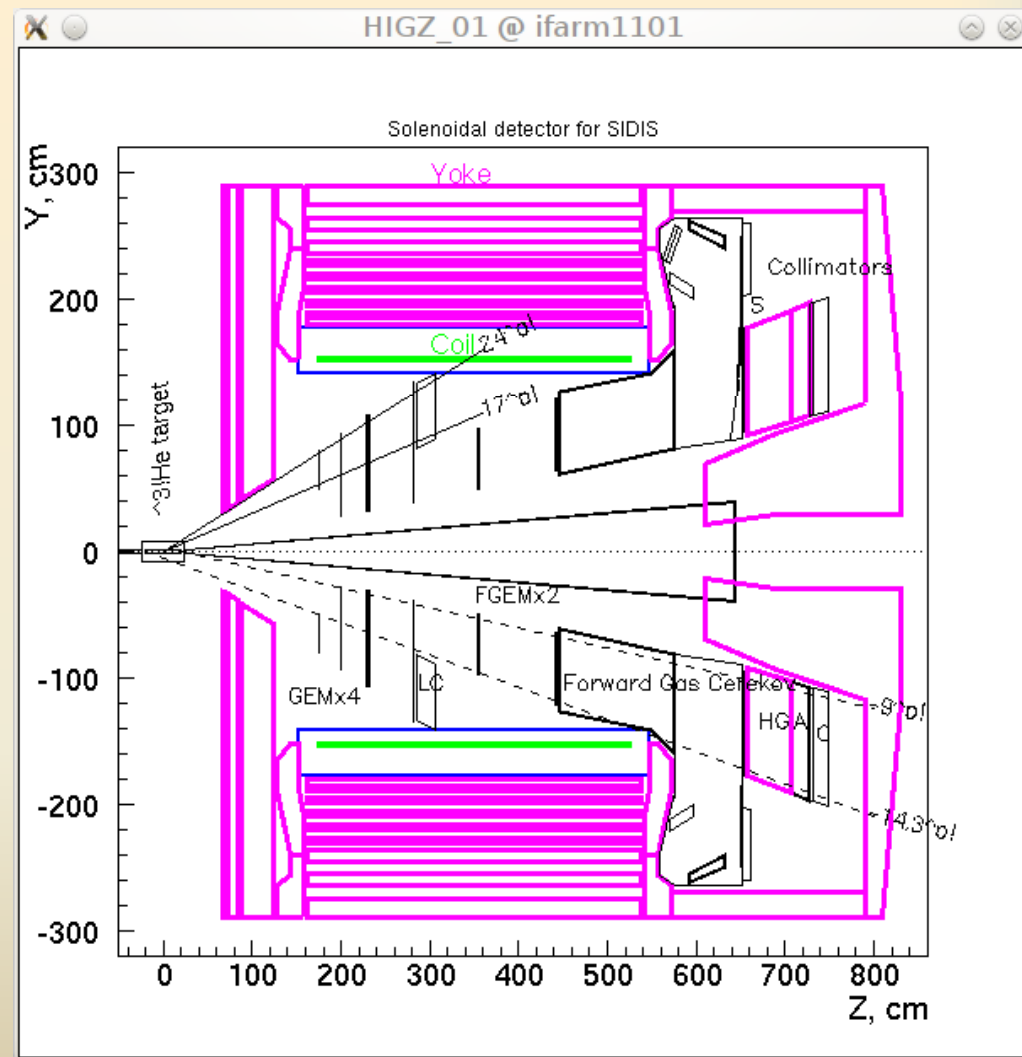
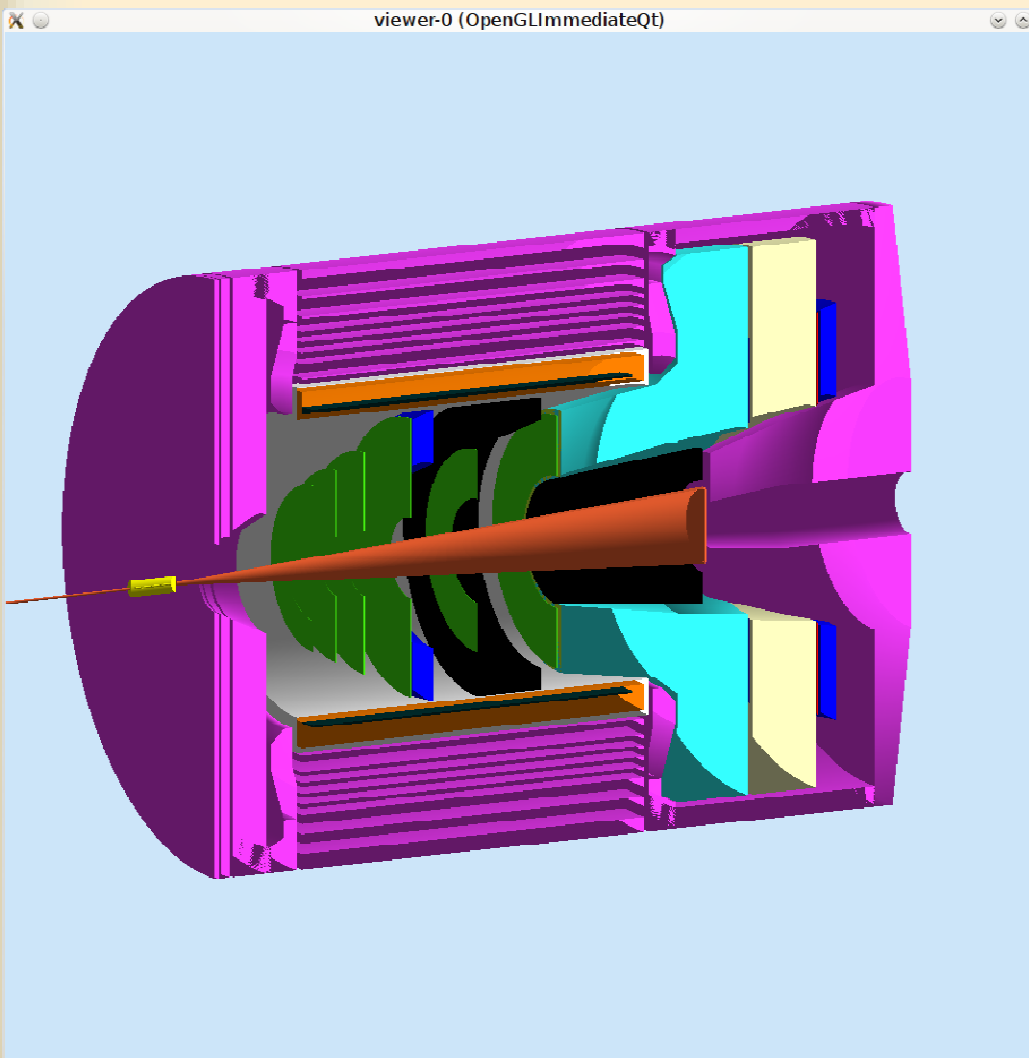
# EC, forward angle



# SIDIS with BaBar Magnet

3D Geant4

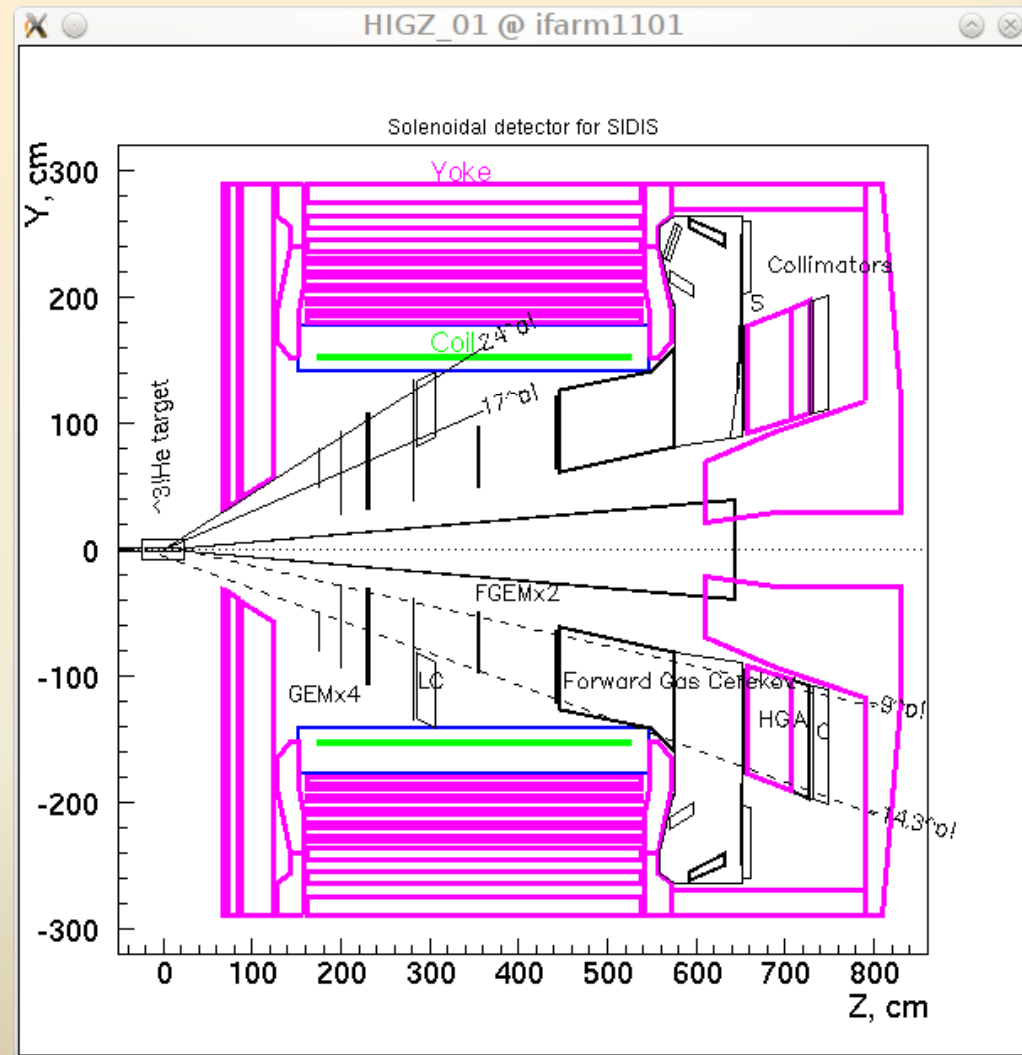
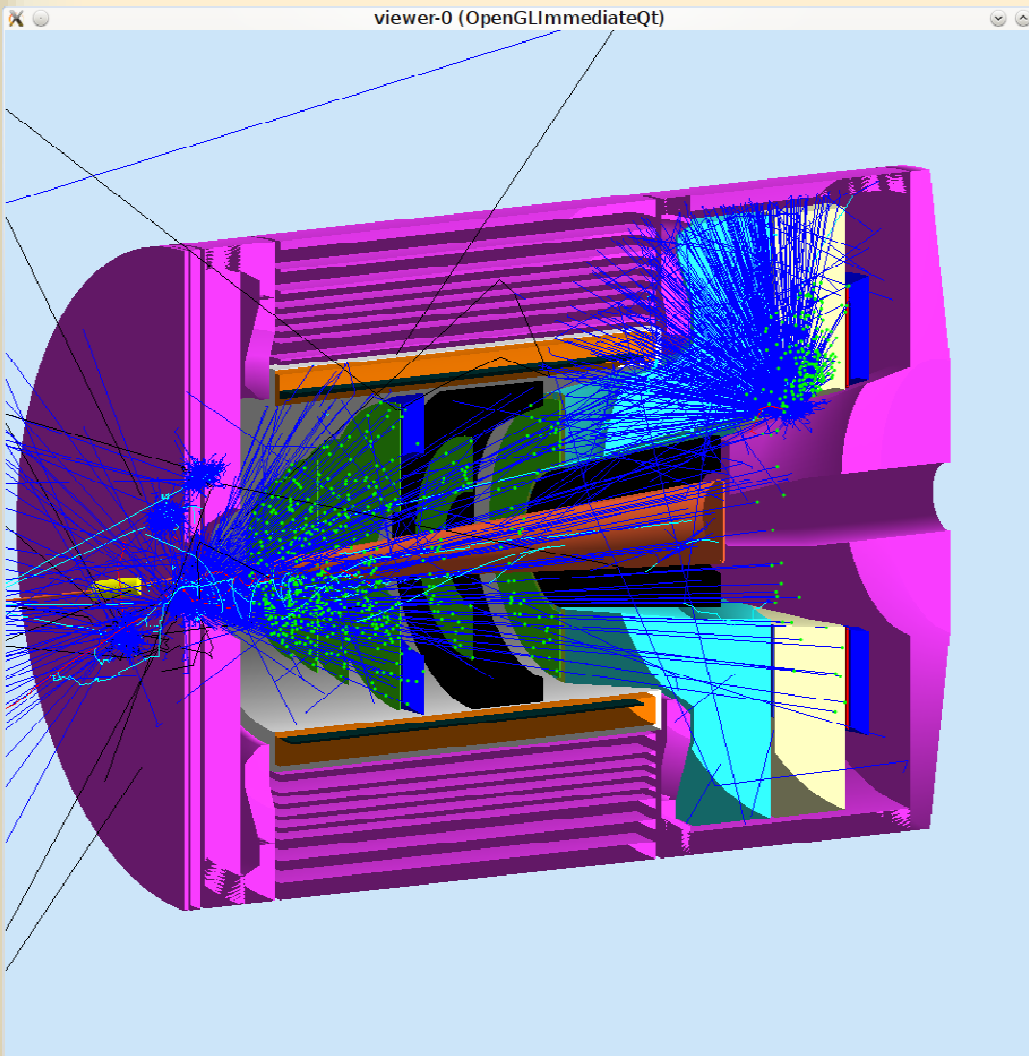
2D Geant3



# SIDIS with BaBar Magnet

3D Geant4

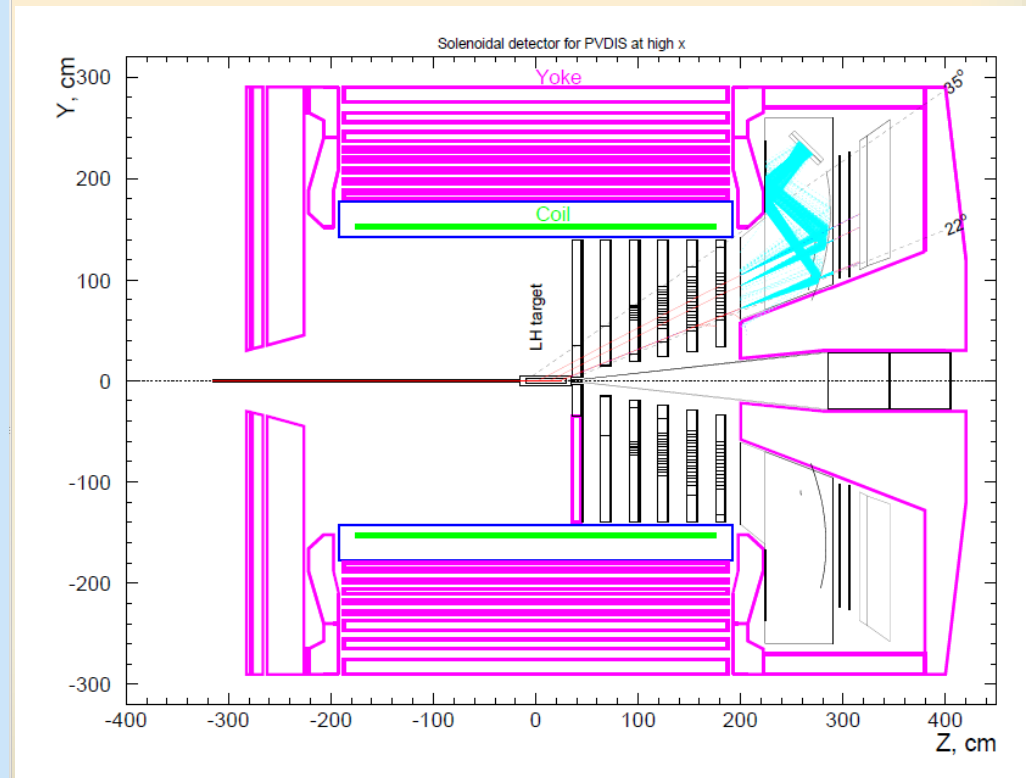
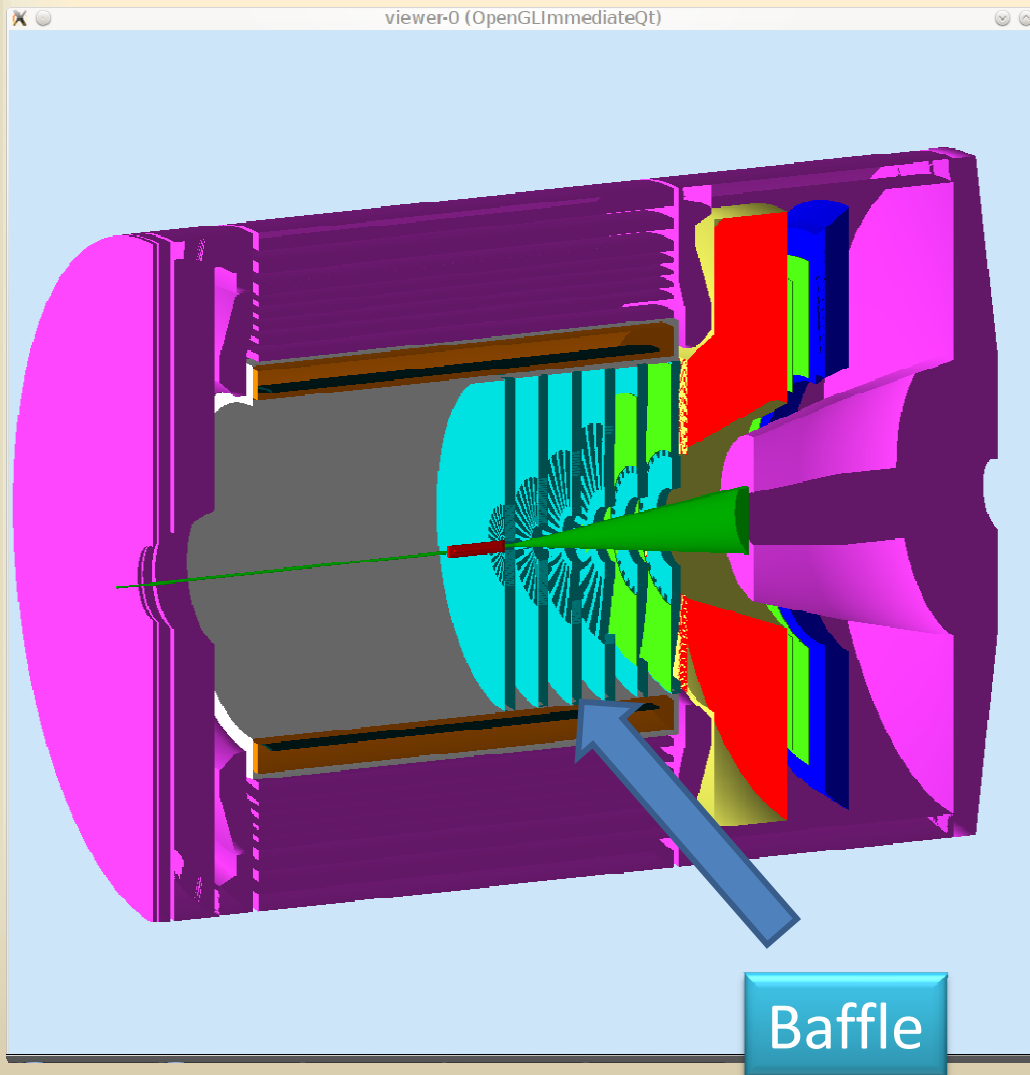
2D Geant3



# PVDIS with BaBar Magnet

3D Geant4

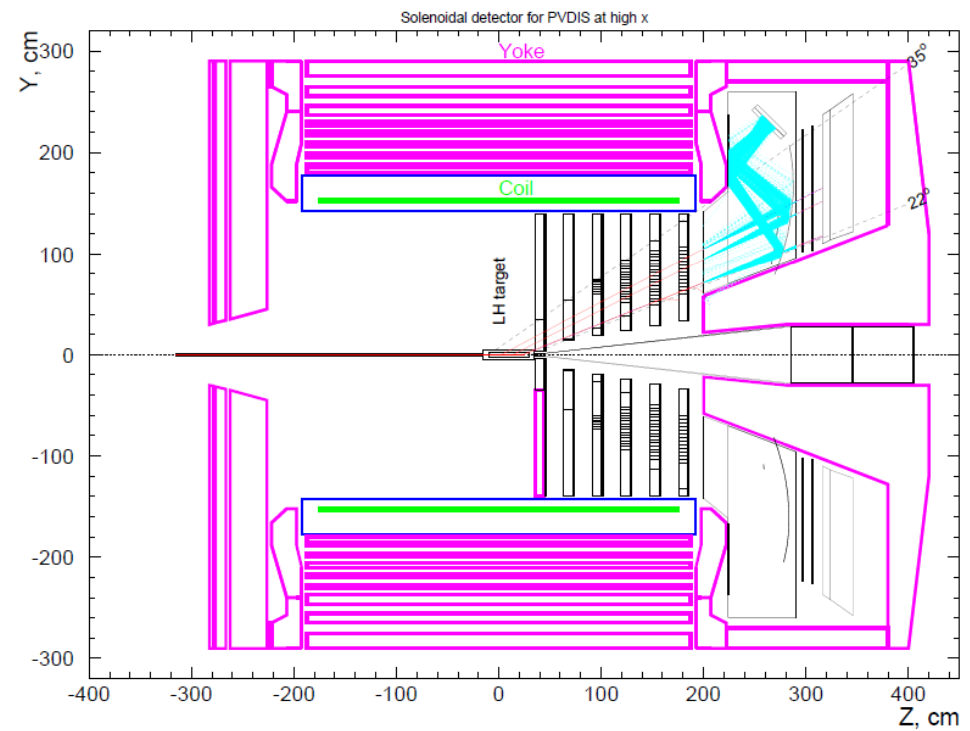
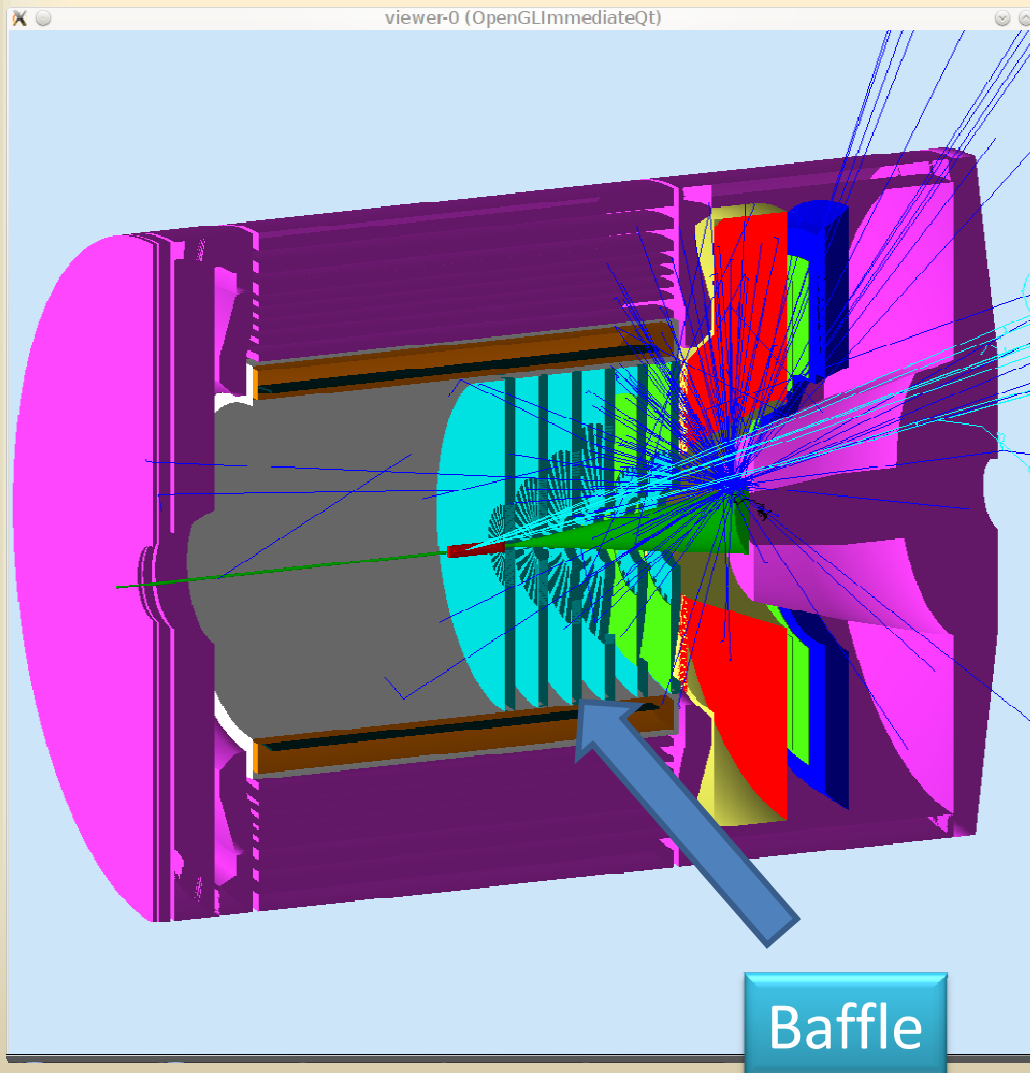
2D Geant3



# PVDIS with BaBar Magnet

3D Geant4

2D Geant3



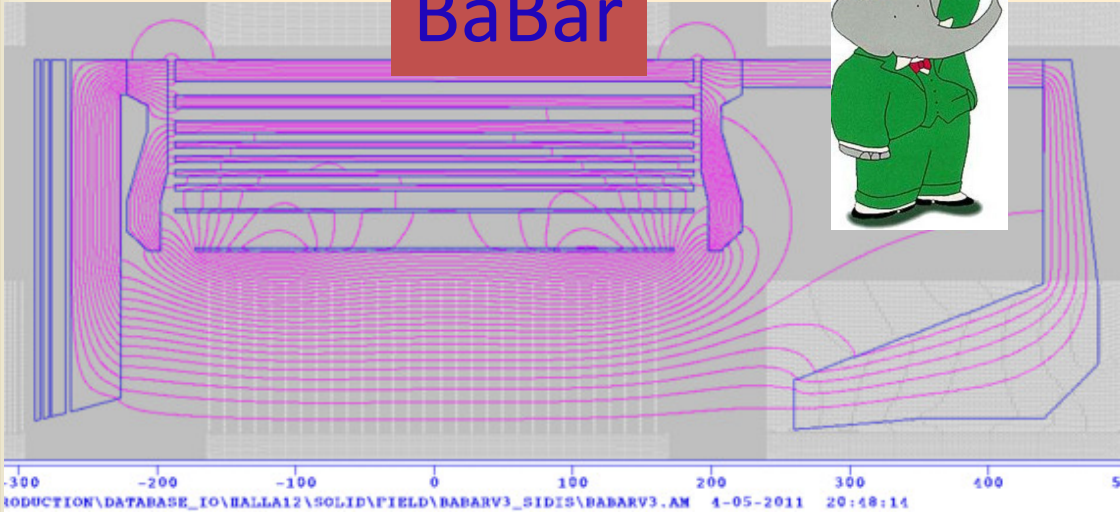
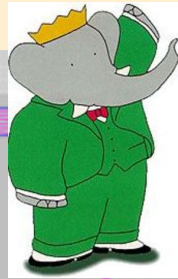
# SoLID Simulation Framework (GEMC)

- [gemc.jlab.org](http://gemc.jlab.org)
- Geant4, C++, Qt, OpenGL
- geometry/sensitivity/digitization/field in mysql databases ([soliddb.jlab.org](http://soliddb.jlab.org))
- Customized hit processing for various detectors.
- ***Unified individual detector simulation and the whole SoLID simulation.***
- ***It can be used for other projects.***

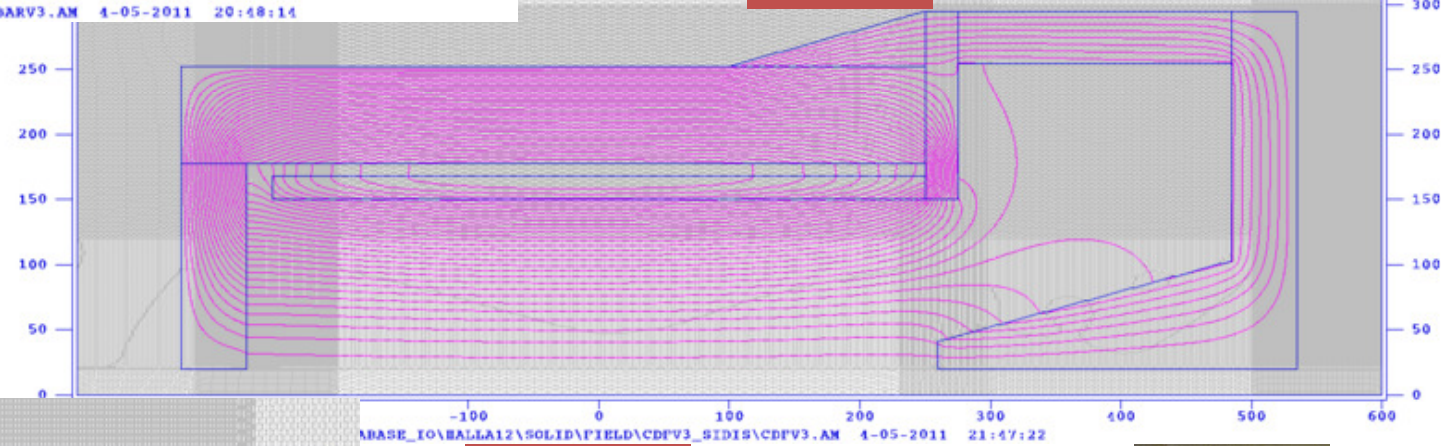
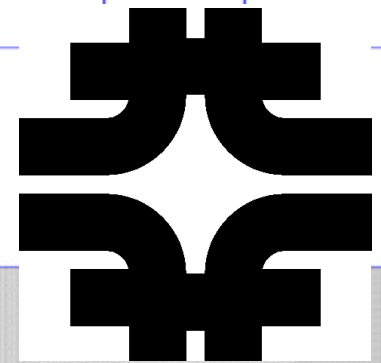
# Magnet Option

Poisson 2D

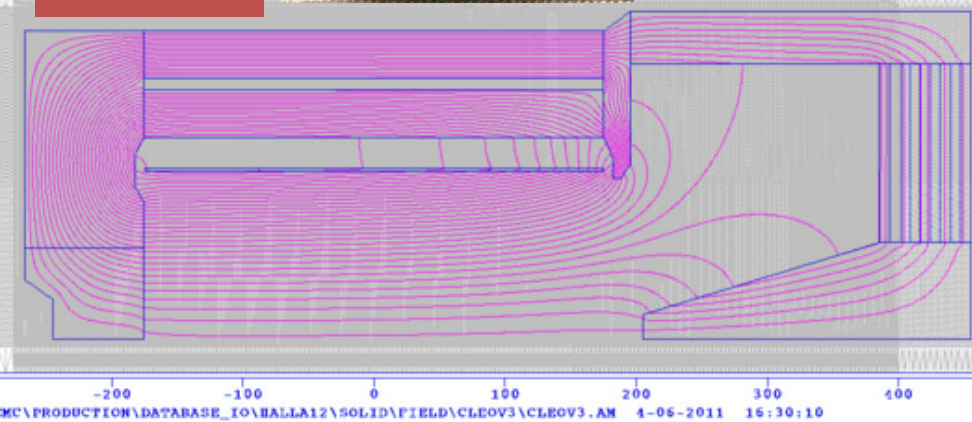
BaBar



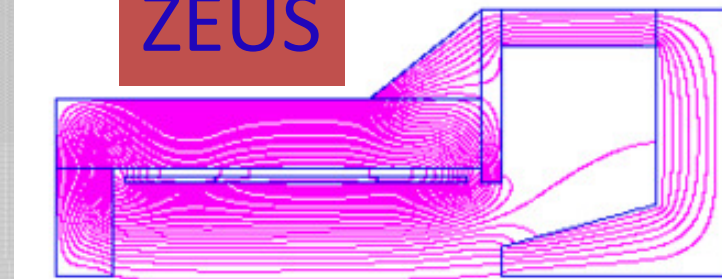
CDF



CLEO



ZEUS

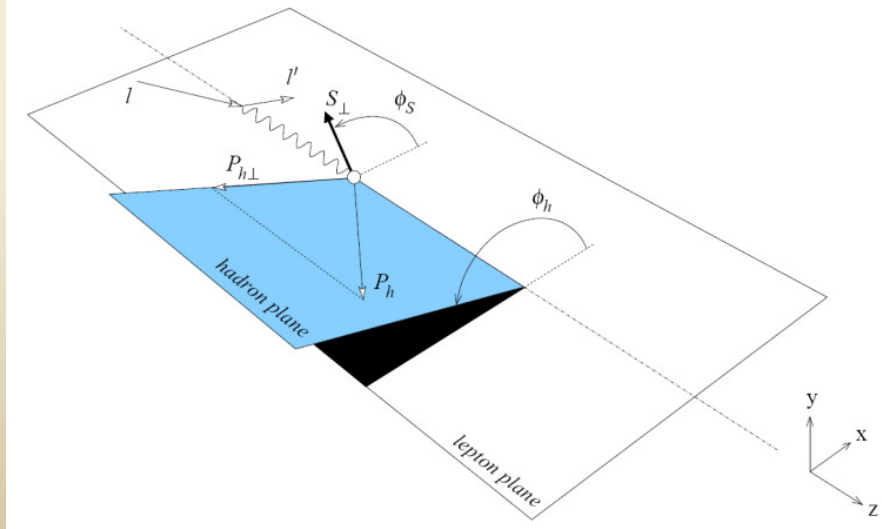
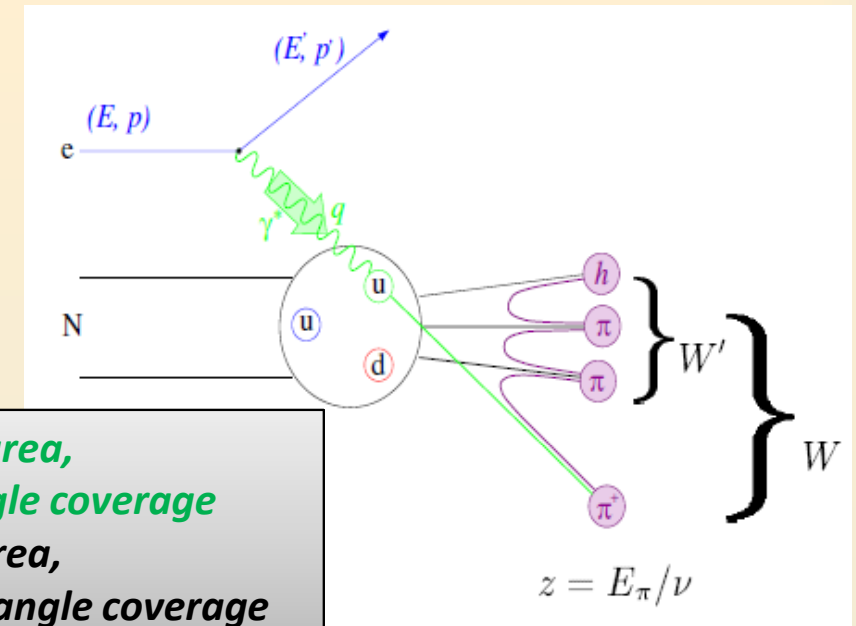
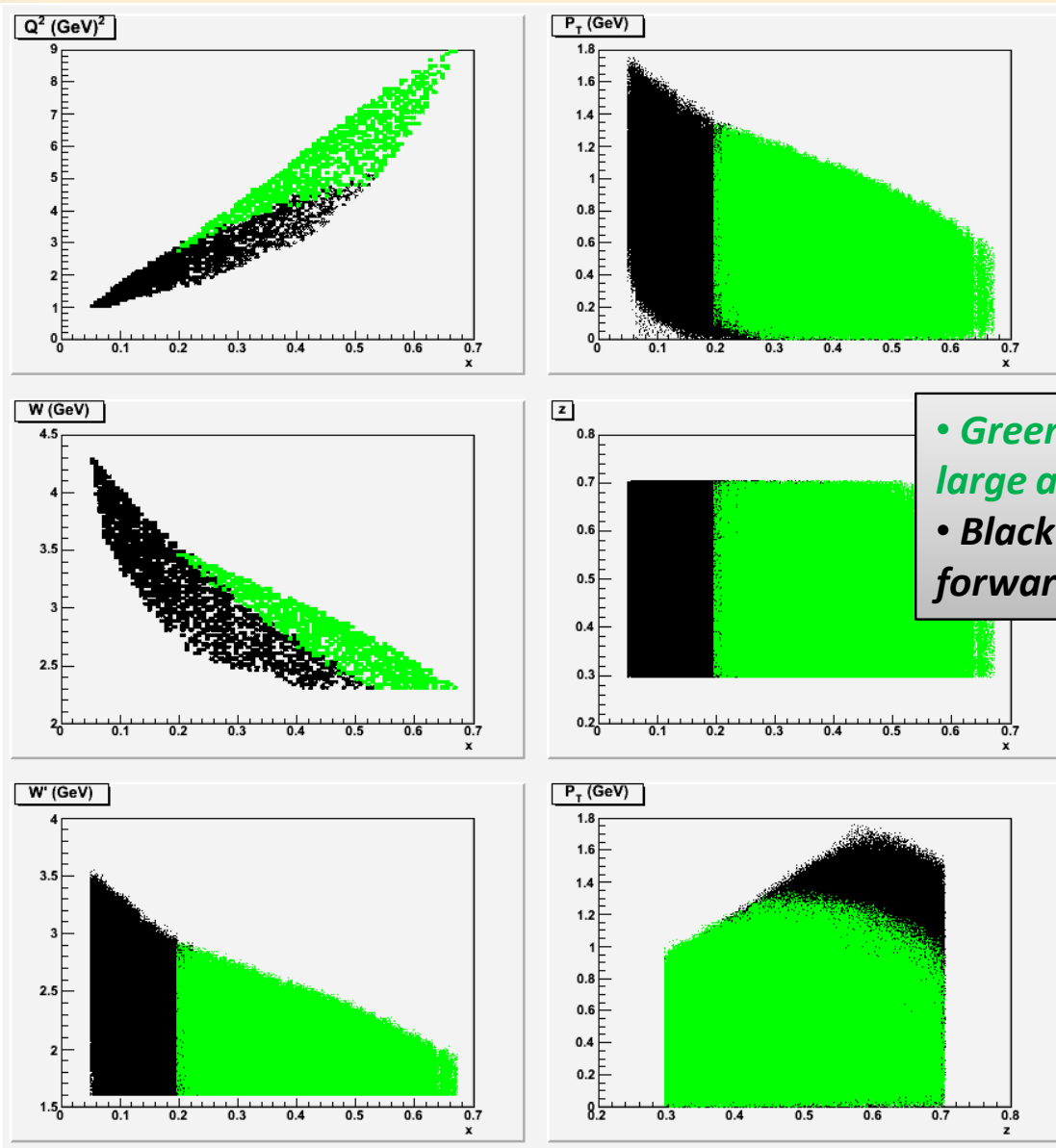


# Magnet Comparison

|                                      | BaBar                       | CLEO                          | ZEUS                         | CDF      | Glue-X                |     | Ideal  |
|--------------------------------------|-----------------------------|-------------------------------|------------------------------|----------|-----------------------|-----|--------|
|                                      |                             |                               |                              |          | Old SLAC              | New |        |
| Cryostat Inner Radius                | 150 cm                      | 150 cm                        | 86 cm                        | 150 cm   | 90 cm                 |     | 100 cm |
| Length                               | 345 cm                      | 350cm                         | 245cm                        | 500 cm   | 350 cm                |     | 250 cm |
| Central Field                        | 1.49T                       | 1.5T                          | 1.8T                         | 1.47T    | 2 T                   |     | 1.5T   |
| Flux Return Iron                     | Yes                         | Yes                           | No                           | No       | No                    |     |        |
| Cool Icon                            | Yes                         | Yes                           | Yes                          | No       | No                    |     |        |
| Variation in Current density with z? | 2x more in end than central | 4.2% more in end than central | 40% more in end than central | No       | Yes                   | Yes |        |
| Available                            | Probably Not??              | Probably                      | Probably                     | Probably | One will be available |     | 23     |

# SIDIS Kinematic Coverage@11GeV

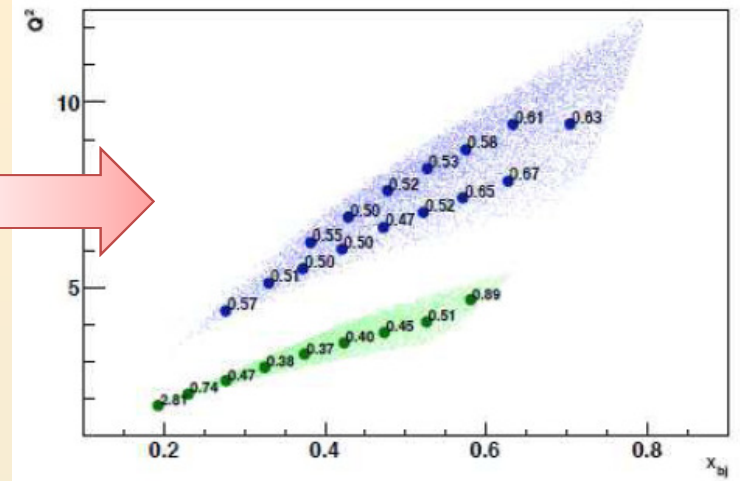
BaBar



# Magnet Choice

PVDIS FOM is not sensitive to different magnet option.

SIDIS Kinematic Coverage@11GeV favors BaBar/CLEO.



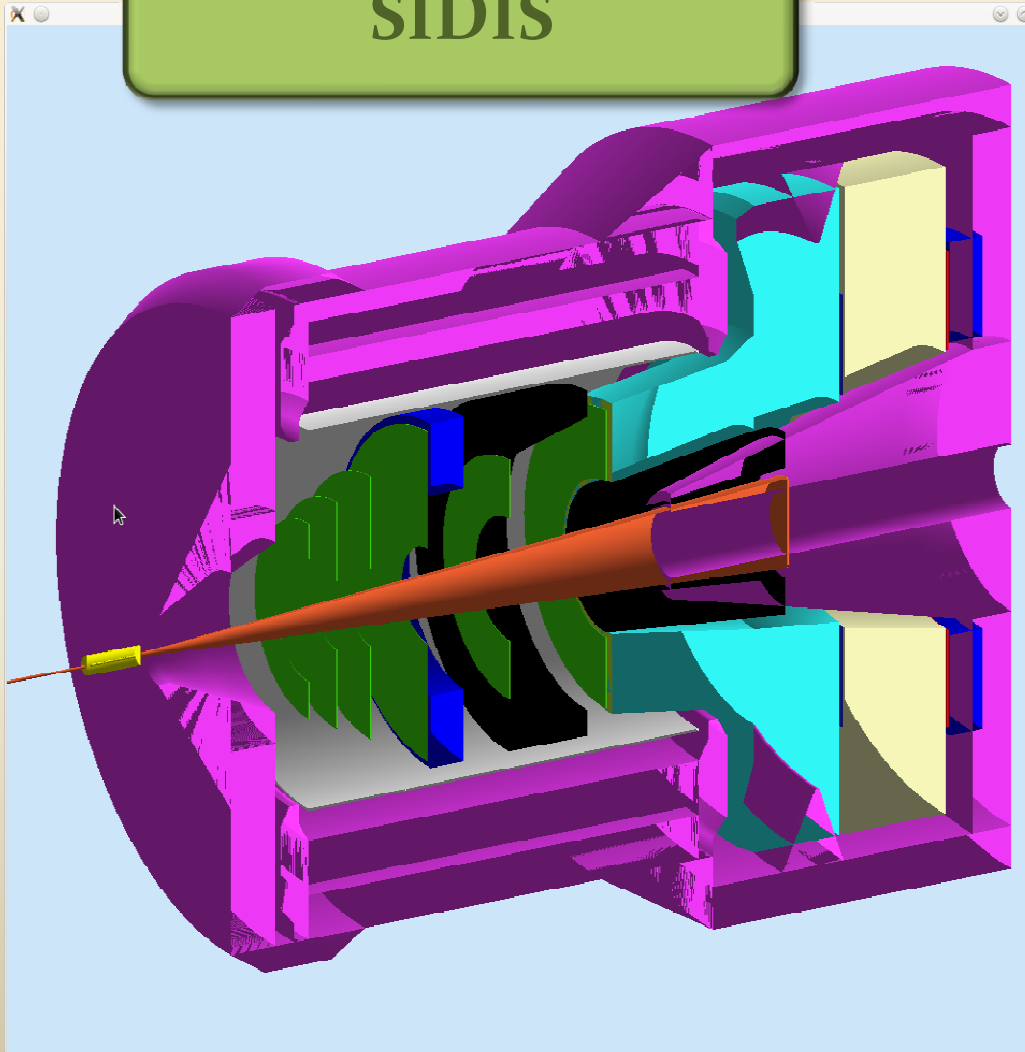
|                | ZEUS      | BaBar/CLEO | CDF       | Glue-X    | Ideal     |
|----------------|-----------|------------|-----------|-----------|-----------|
| x              | 0.05-0.58 | 0.05-0.65  | 0.05-0.64 | 0.05-0.64 | 0.05-0.65 |
| z              | 0.3-0.7   | 0.3-0.7    | 0.3-0.7   | 0.3-0.7   | 0.3-0.7   |
| Q <sup>2</sup> | 1-6       | 1-9        | 1-7.2     | 1-8       | 1-9       |
| W              | 2.3-4.2   | 2.3-4.4    | 2.3-4.2   | 2.3-4.2   | 2.3-4.3   |
| W'             | 1.6-3.4   | 1.6-3.5    | 1.6-3.4   | 1.6-3.4   | 1.7-3.5   |
| P <sub>T</sub> | 0-1.45    | 0-1.7      | 0-1.45    | 0-1.45    | 0-1.6     |

# CLEO magnet and yoke

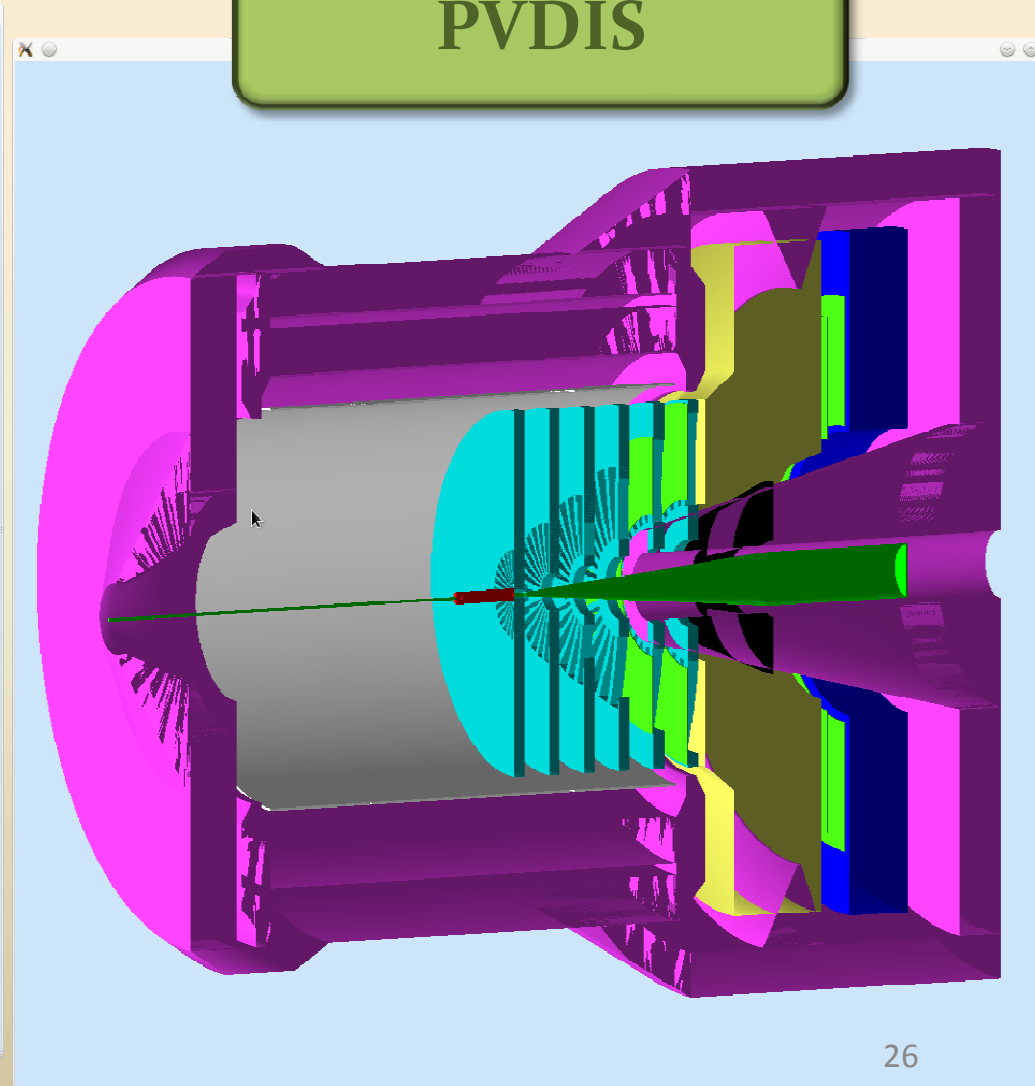
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## *design in progress*

SIDIS

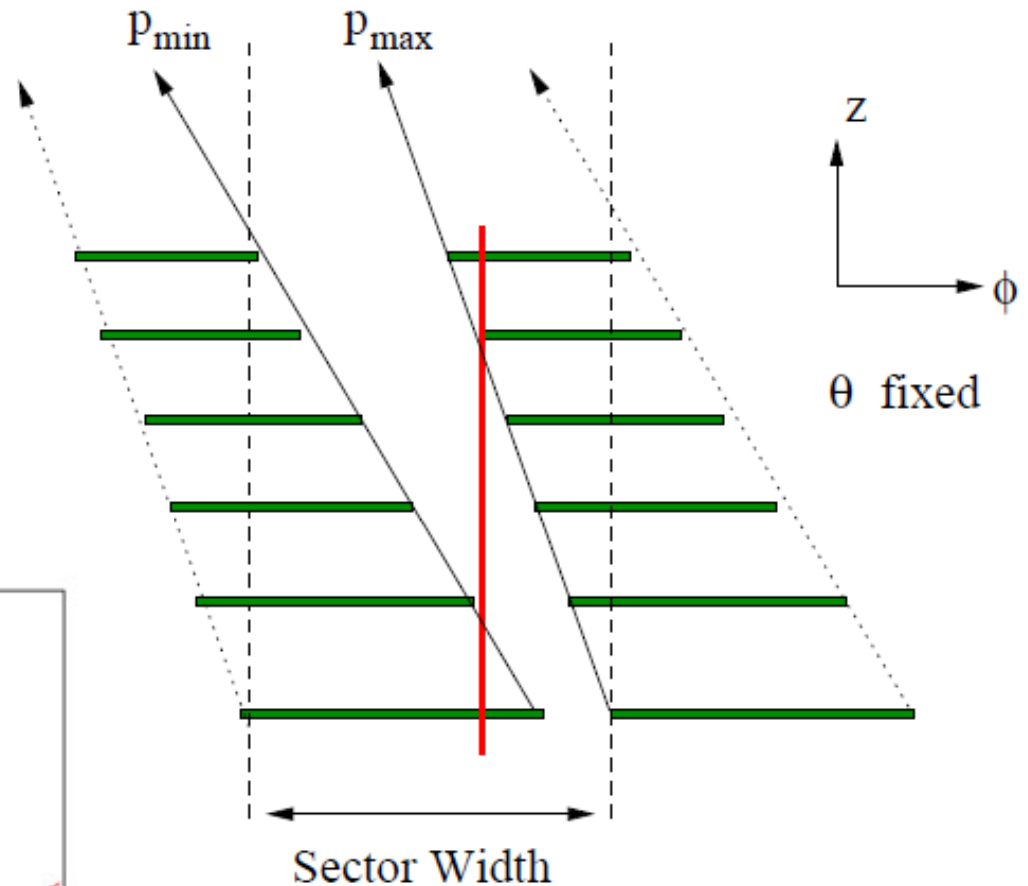


PVDIS

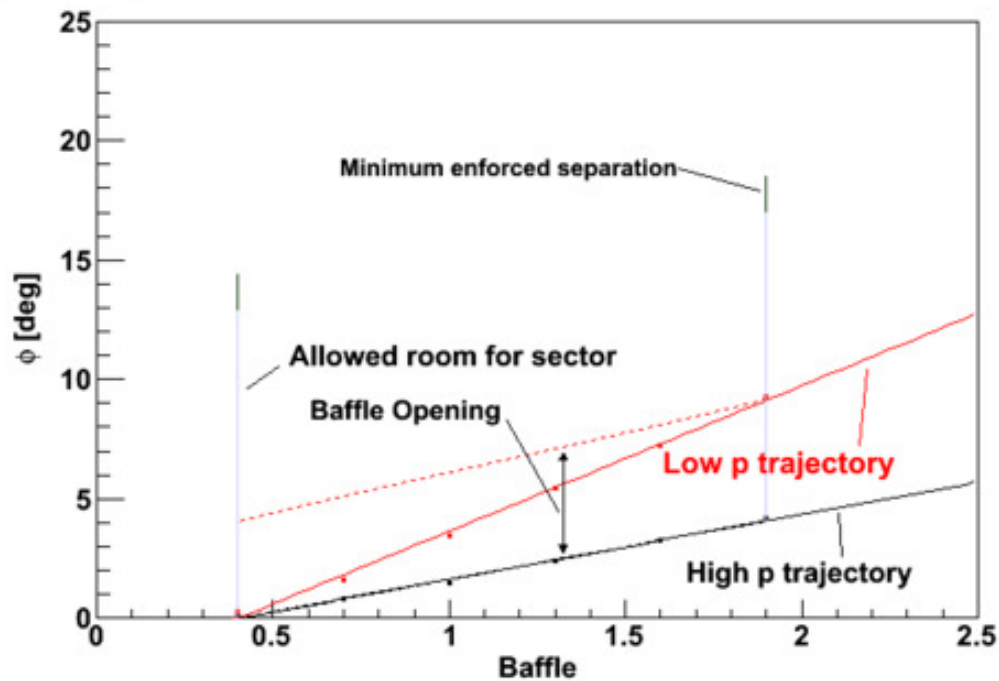


# PVDIS Baffle Design

Luminosity  $10^{39}/\text{s}/\text{cm}^2$



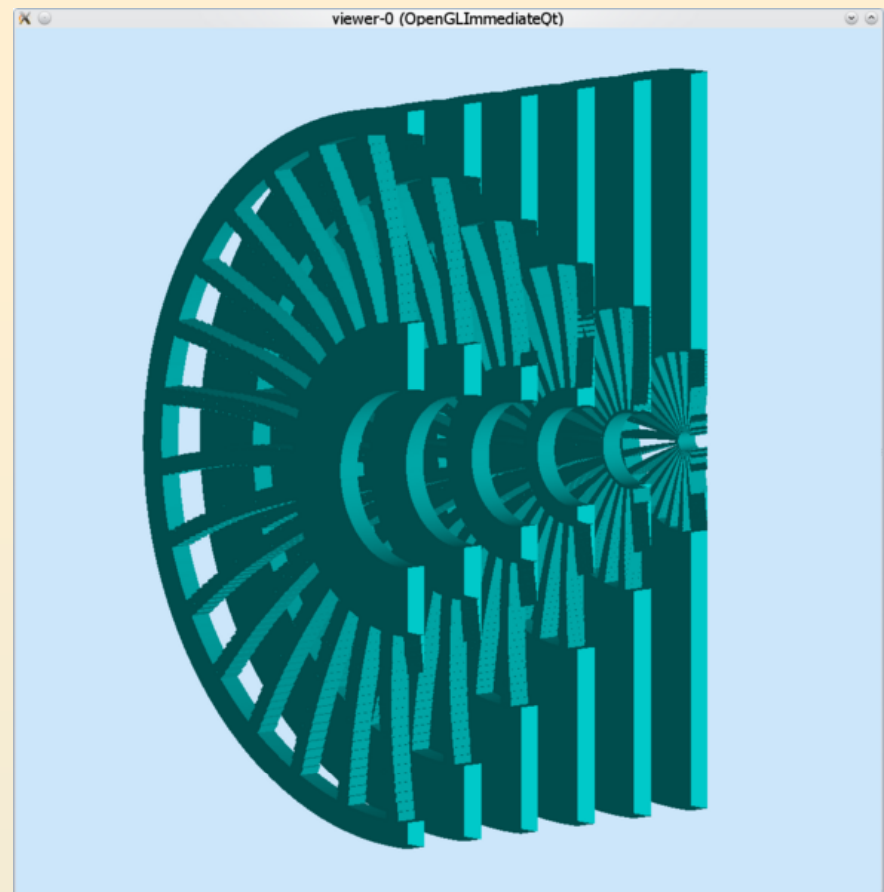
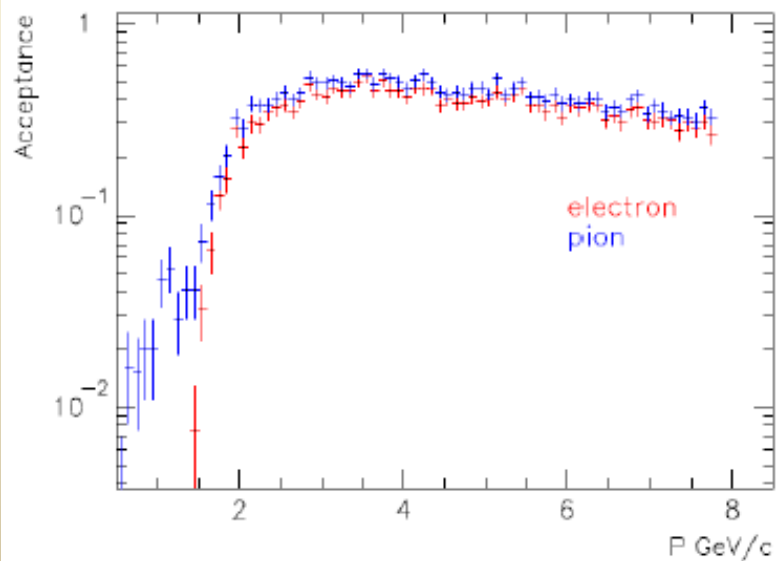
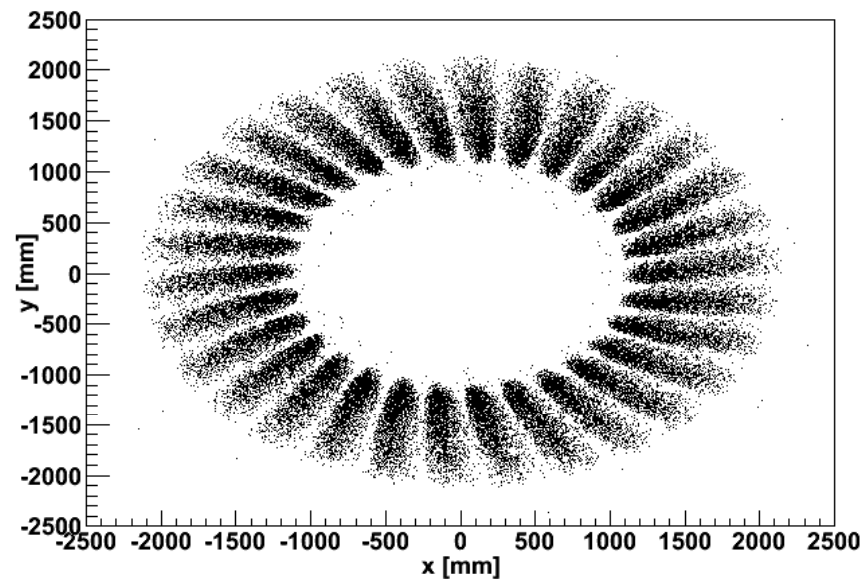
Block 0



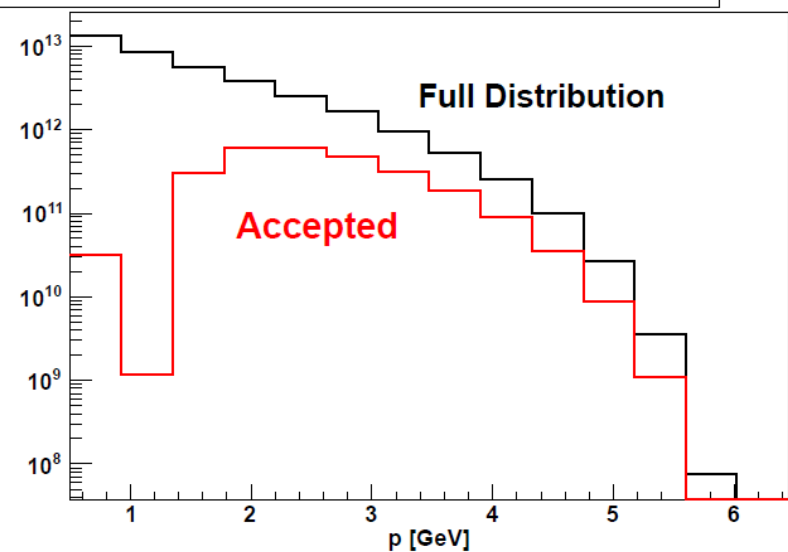
# PVDIS Baffle

Reduce background by 50

x vs. y at last baffle



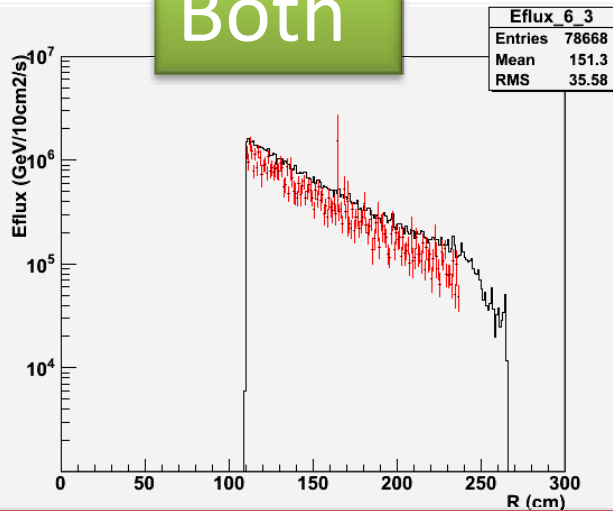
Event Distribution - My baffles, BaBar, DIS e-



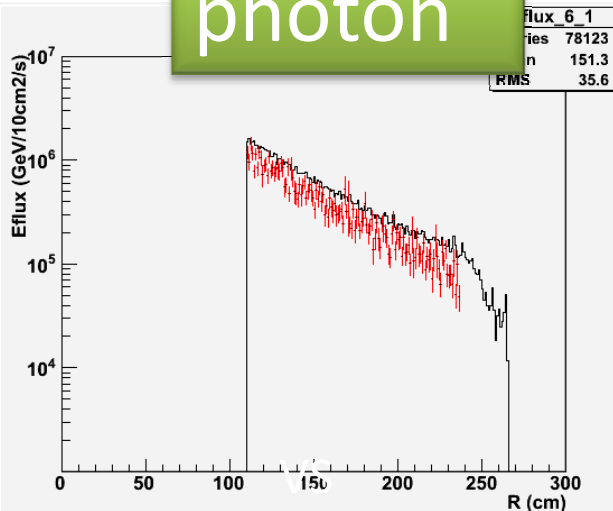
# PVDIS EM Background (on EC, no baffle)

red Geant3, black Geant4

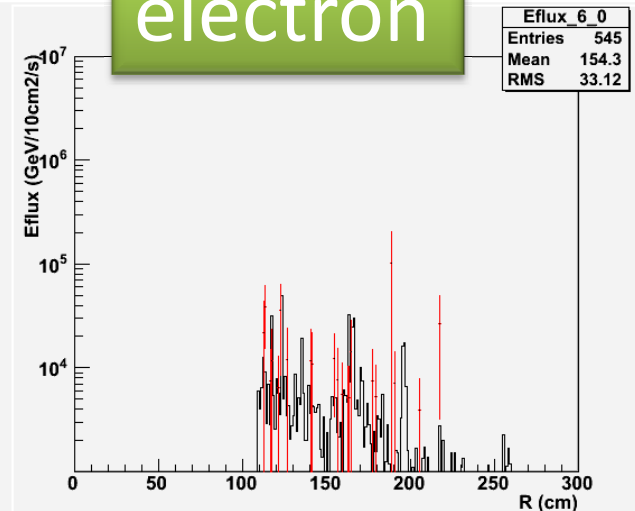
Both



photon



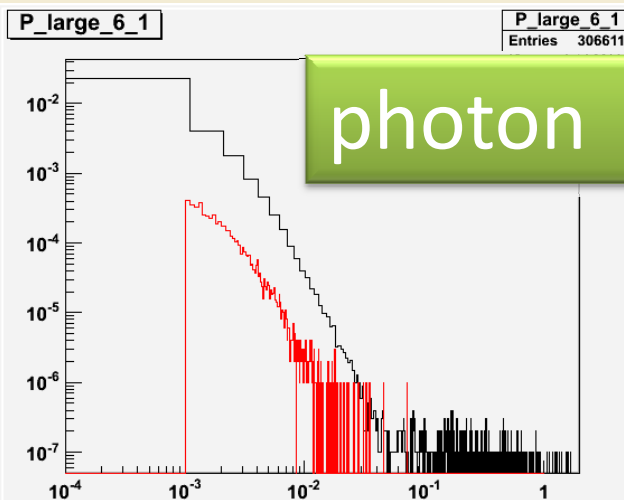
electron



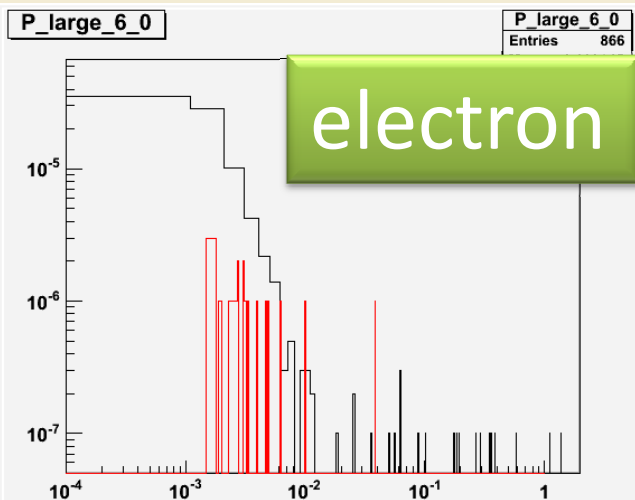
Energy Flux VS R

For Energy Flux,  
Geant4 shows  
~30% larger than  
Geant3

photon



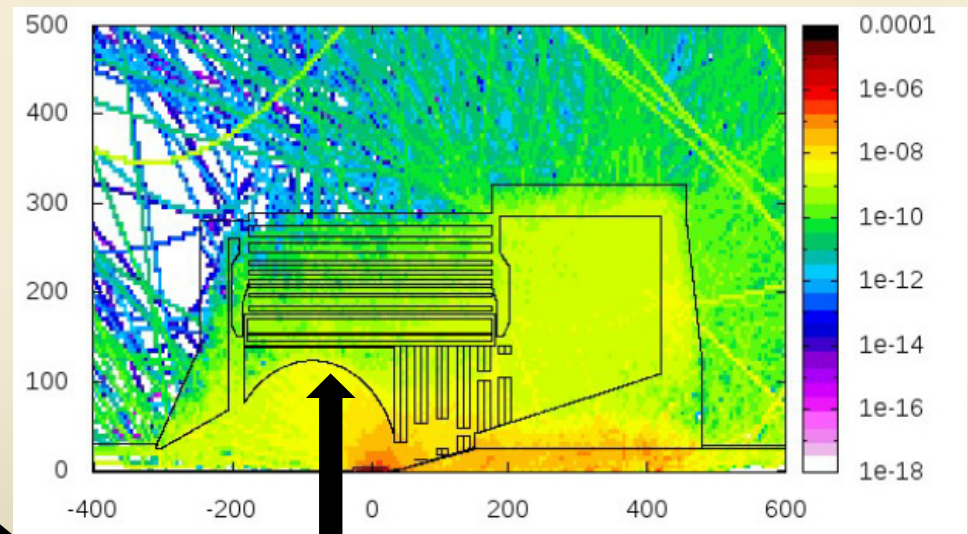
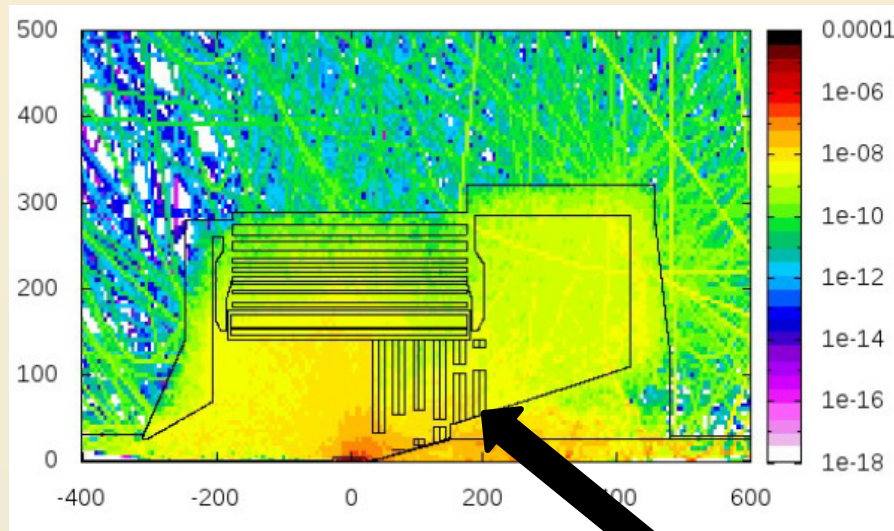
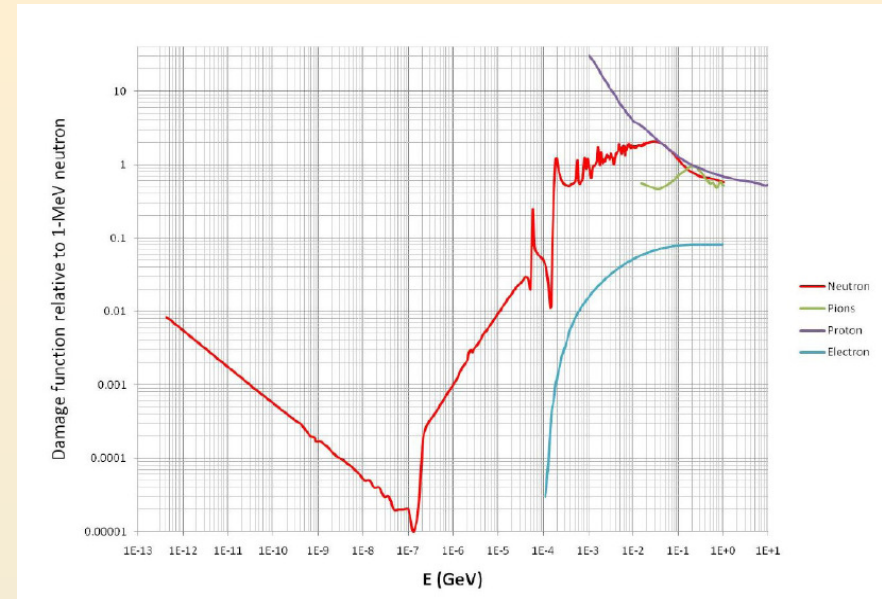
electron



Momentum Distribution

# Neutron Shielding

Use FLUKA for study



boron polyethylene  
shielding

# Summary

- SoLID simulation framework is successfully built base on GEMC with Geant4 and C++.
- A lot of subsystem design and simulation progresses have been made. More studies are under way.
- In preparation for the director review.

# Thanks

- Maurizio Ungaro
  - Paul Reimer
- Seamus Riordan
  - Lorenzo Zana
- Simona Malace
  - Eric Fuchey
  - Yang Zhang
- Eugene Chudakov
  - Xin Qian