

Low Energy MuSR

INSTRUMENT SIMULATION
USING
GEANT4 AND FEMLAB

Overview

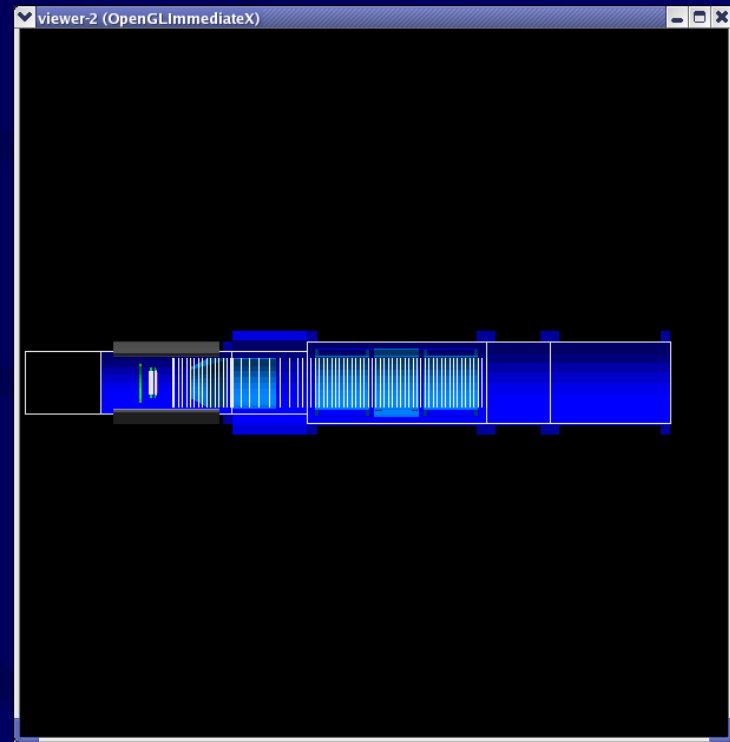
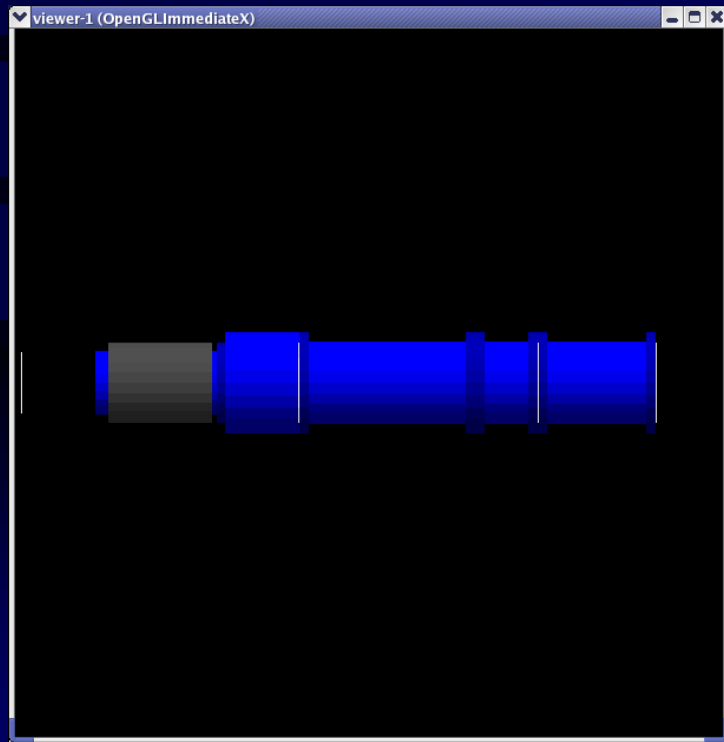
- Generalities: geometry, physics
- Muons Physics Simulation
- Electric Field Implementation
- Sensitive Detectors Simulation
- Conclusion

Computing the Geometry

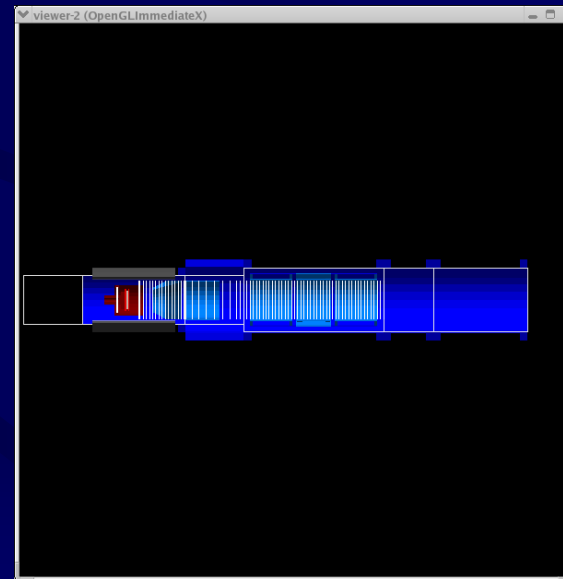
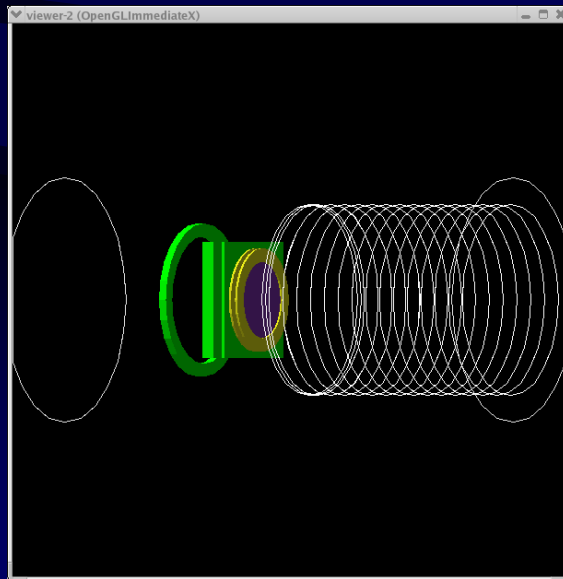
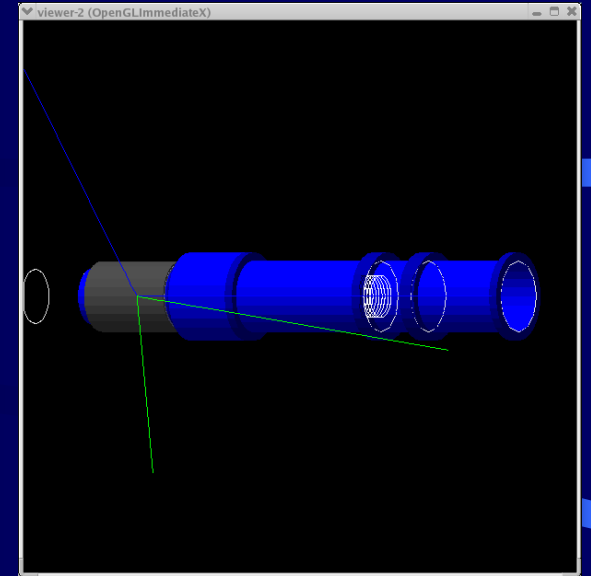
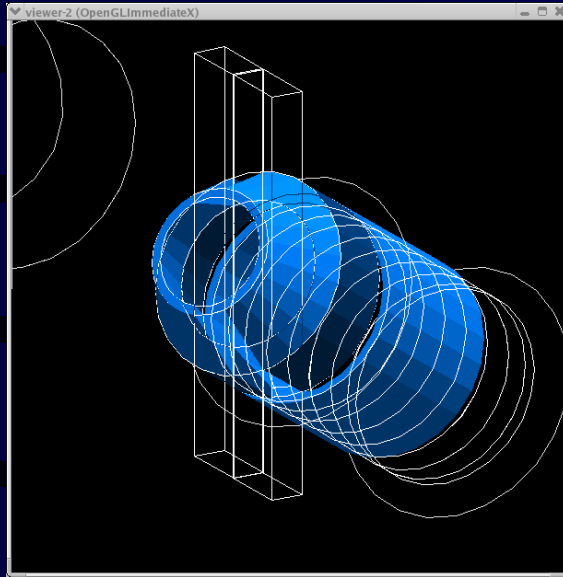
- GEANT4 Volumes Hierarchy
 - Solids:
 - Shapes, Dimensions
 - Logical Volumes
 - Materials Definition
 - Fields Computation
 - Physical Volumes
 - Position in a Mother Logical Volume

Computing the Geometry

From trigger detector to cryo/mcp detectors



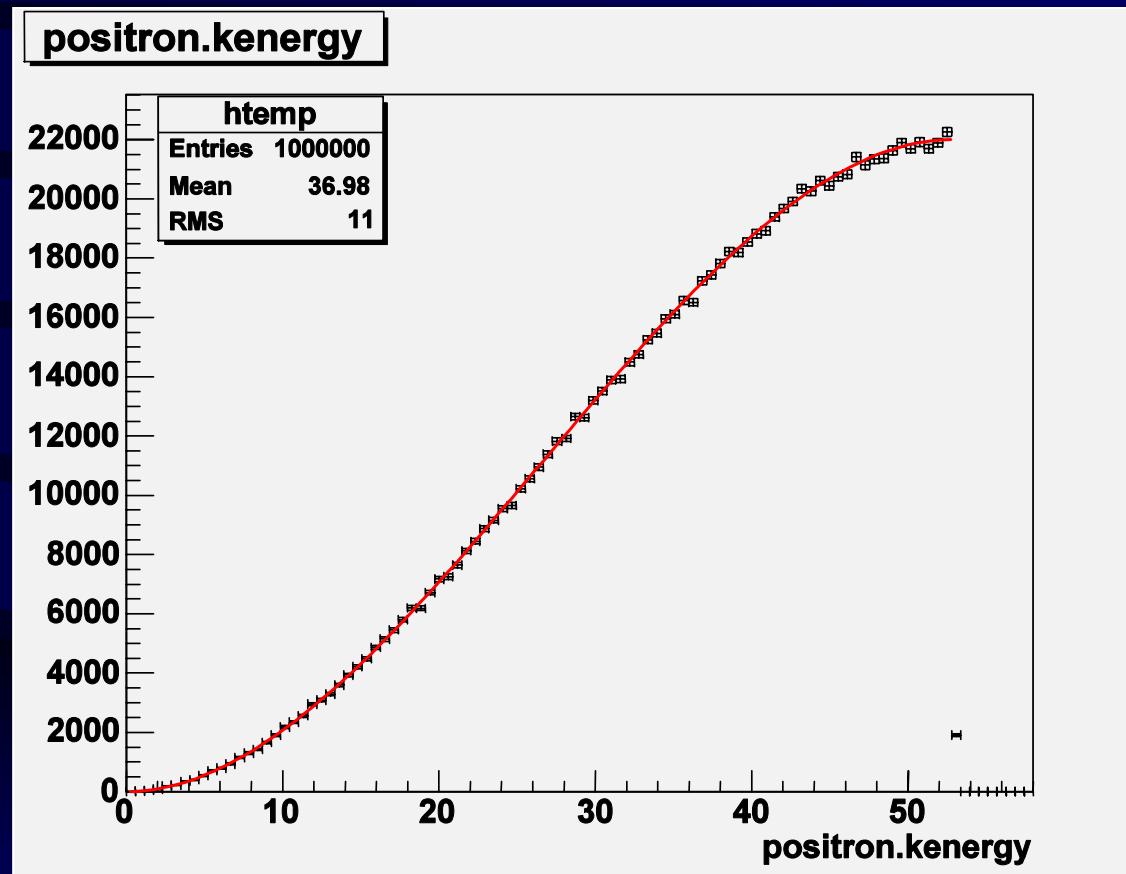
Geometry



Muons Physical Behaviours

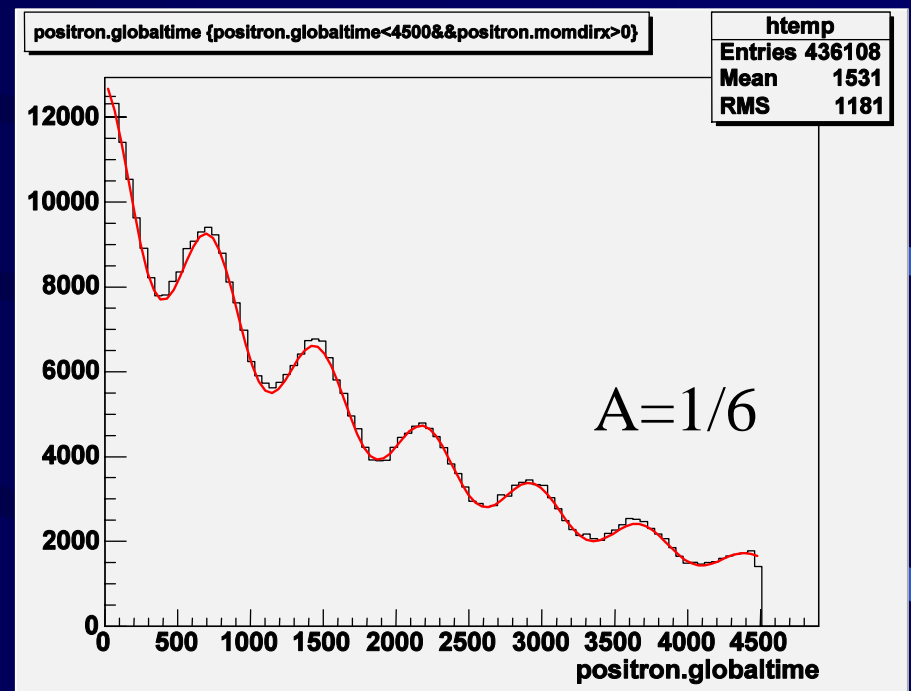
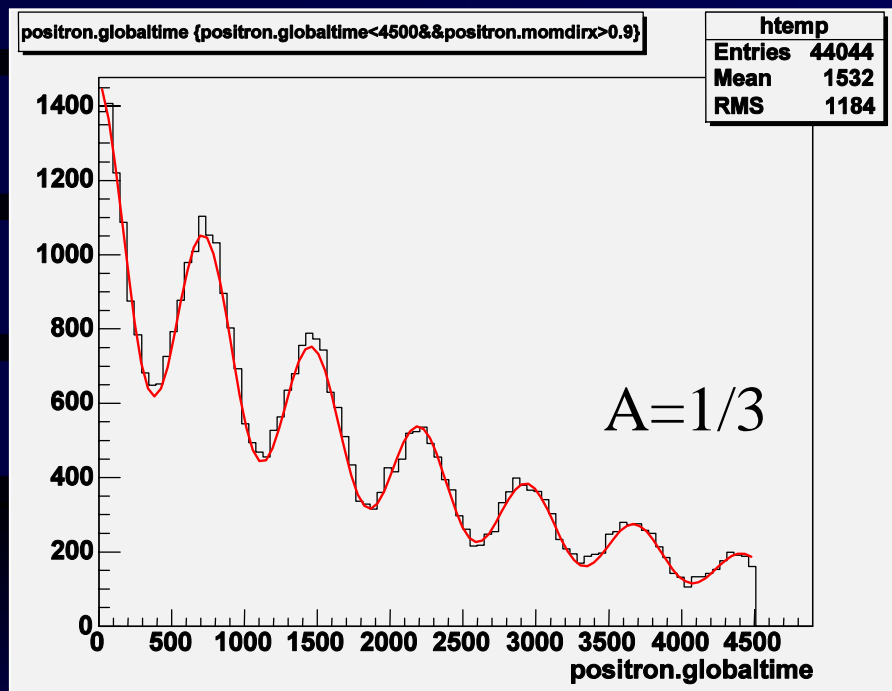
- Polarized Muon Decay
 - Michel's Spectrum for positron kinetic energy
 - $N(w) = w^2(3-2w)$ where $w = E_{e^+}/E_{e^+_{\max}}$
 - $D(w) = (2w-1)/(3-2w)$, asymmetric factor
 - Asymmetry:
 - $N(\theta, t) = N_0 * \exp(-t/\tau) * (1 - A(\theta) \cos(\omega t))$
 - $A = 1/3$ for small solid angles θ
 - $A = 1/6$ for large solid angles θ
 - A is the asymmetry when there is no magnetic field

Muons Physical Behaviour



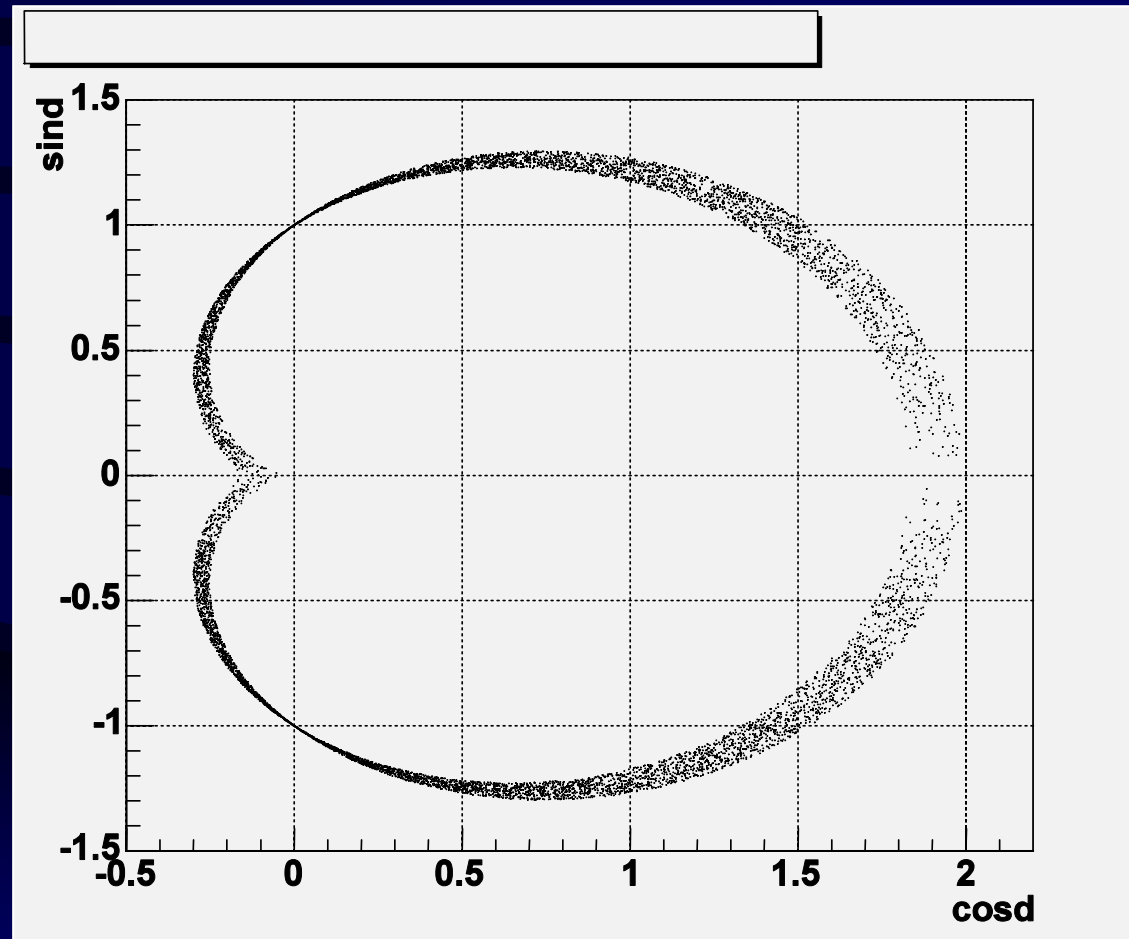
Positron Energy Michel's spectrum _ 1G events

Muons Physical Behaviour



Asymmetric factor and spin rotation effect

Muons Physical Behaviours



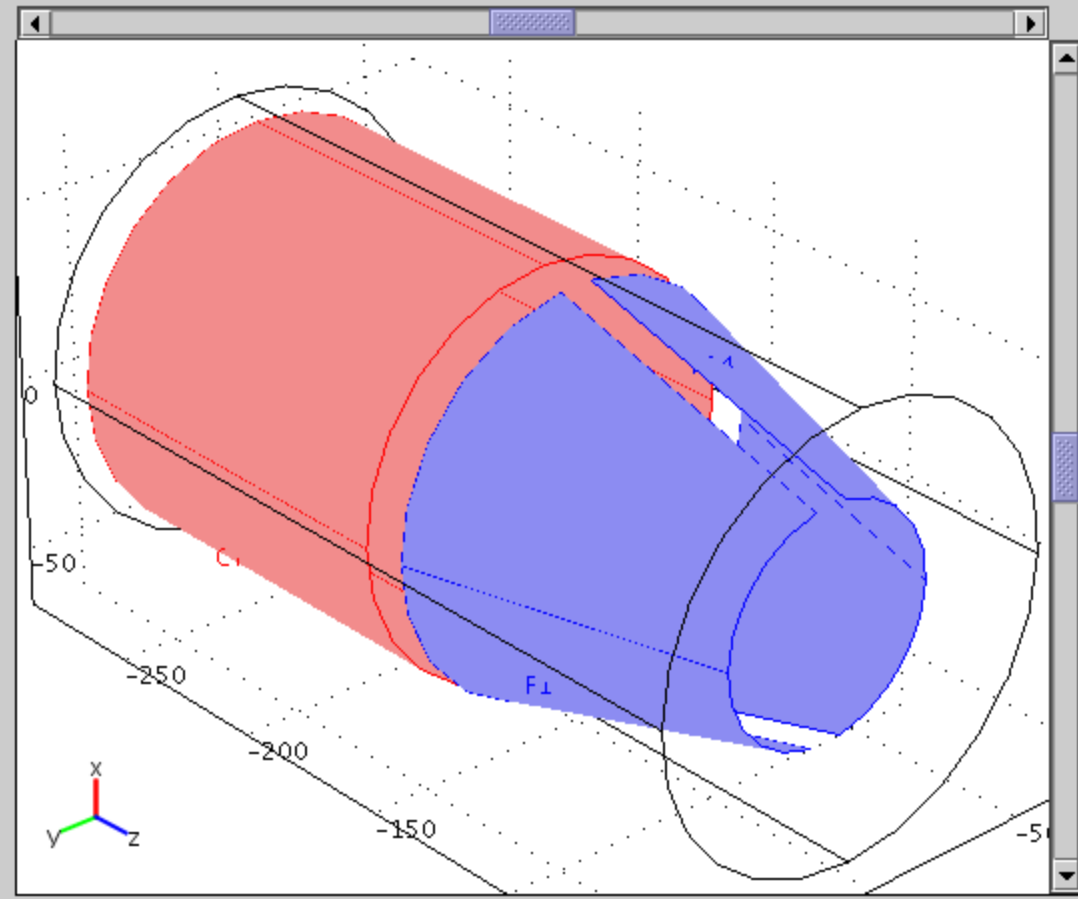
Relation between positron energy and emission angle

Electric Field

- Trigger Detector Field
- Third Lens Field
- Conical Anode Field
- Field Maps Generation with FEMLAB
- Introducing Field Maps

FEMLAB - Geom1/Electrostatics, Generalized (qv) : ConicalAnode.fl

File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help



Number of degrees of freedom: 63660
Solution time: 145.879 s
Saved FEMLAB Model file ConicalAnode.fl

(633.159, 777.808, 891....) AXIS GRID EQUAL CSYS Memory: (33.9 / 36.5)

Femlab interface

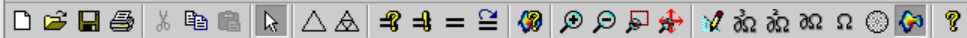
The screenshot displays the FEMLAB software interface. The main window shows a 3D model of a conical anode structure, with a green shaded region representing the anode. The model is plotted on a coordinate system with x, y, and z axes. The x-axis ranges from -50 to 50, and the z-axis ranges from 0 to -250. The model is divided into two parts: a conical top section and a cylindrical bottom section. The top section is shaded green, and the bottom section is also shaded green. The bottom section is a cylinder with a diameter of 50 units and a height of 250 units. The top section is a cone with a height of 100 units and a base diameter of 50 units. The model is plotted on a coordinate system with x, y, and z axes. The x-axis ranges from -50 to 50, and the z-axis ranges from 0 to -250. The model is divided into two parts: a conical top section and a cylindrical bottom section. The top section is shaded green, and the bottom section is also shaded green.

The 'Boundary Settings - Electrostatics, Generalized (qv)' dialog box is open, showing the following settings:

- Equation: $V = V_0$
- Boundary selection: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14. Select by group, Interior boundaries.
- Boundary sources and constraints: Boundary condition: Electric potential.
- Quantity: J_0 , J_n , σ , d , V_{ref} , D_0 , p_s , q , g , V_0 .
- Value/Expression: J_0 : 0, 0, 0; J_n : 0; σ : 0; d : 1; V_{ref} : 0; D_0 : 0, 0, 0; p_s : 0; q : 0; g : 0; V_0 : 0.
- Description: Current density, Normal current density, Conductivity, Thickness, Reference potential, Electric displacement, Surface charge density, Conductance to ground, Normal flow, Electric potential.

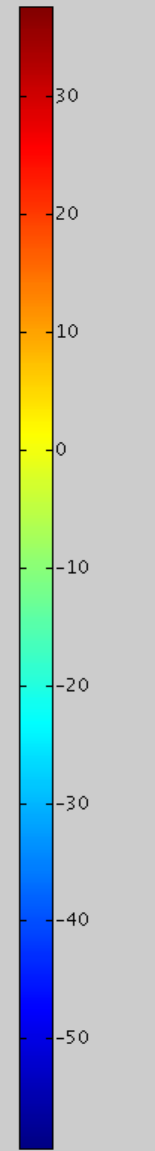
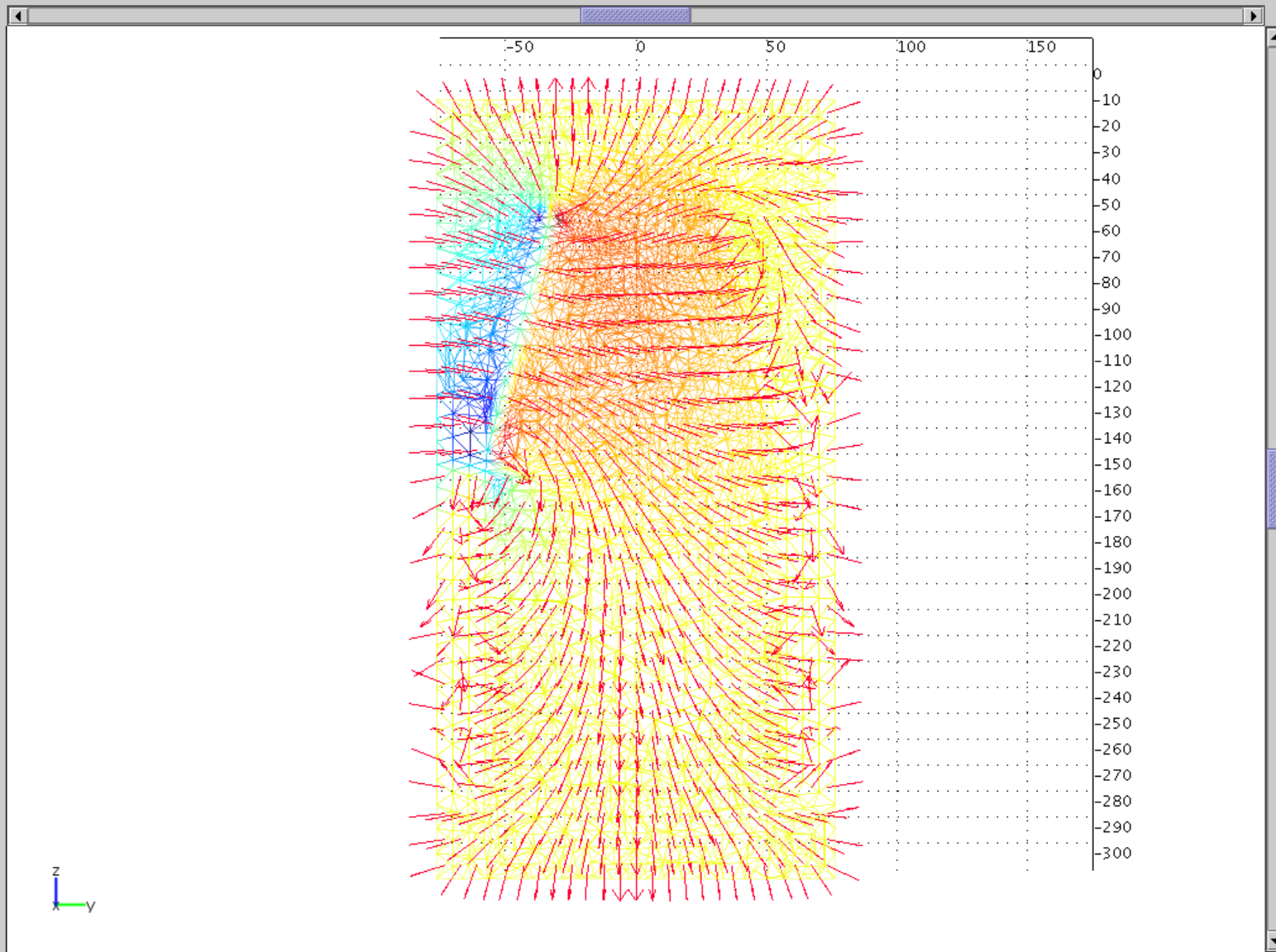
At the bottom of the FEMLAB window, the following information is displayed:

- Number of degrees of freedom: 63660
- Solution time: 145.879 s
- Saved FEMLAB Model file: ConicalAnode.fl
- Memory: (33.7 / 36.5)



Slice: Electric field, y component Arrow: Electric field

Max: 37.704

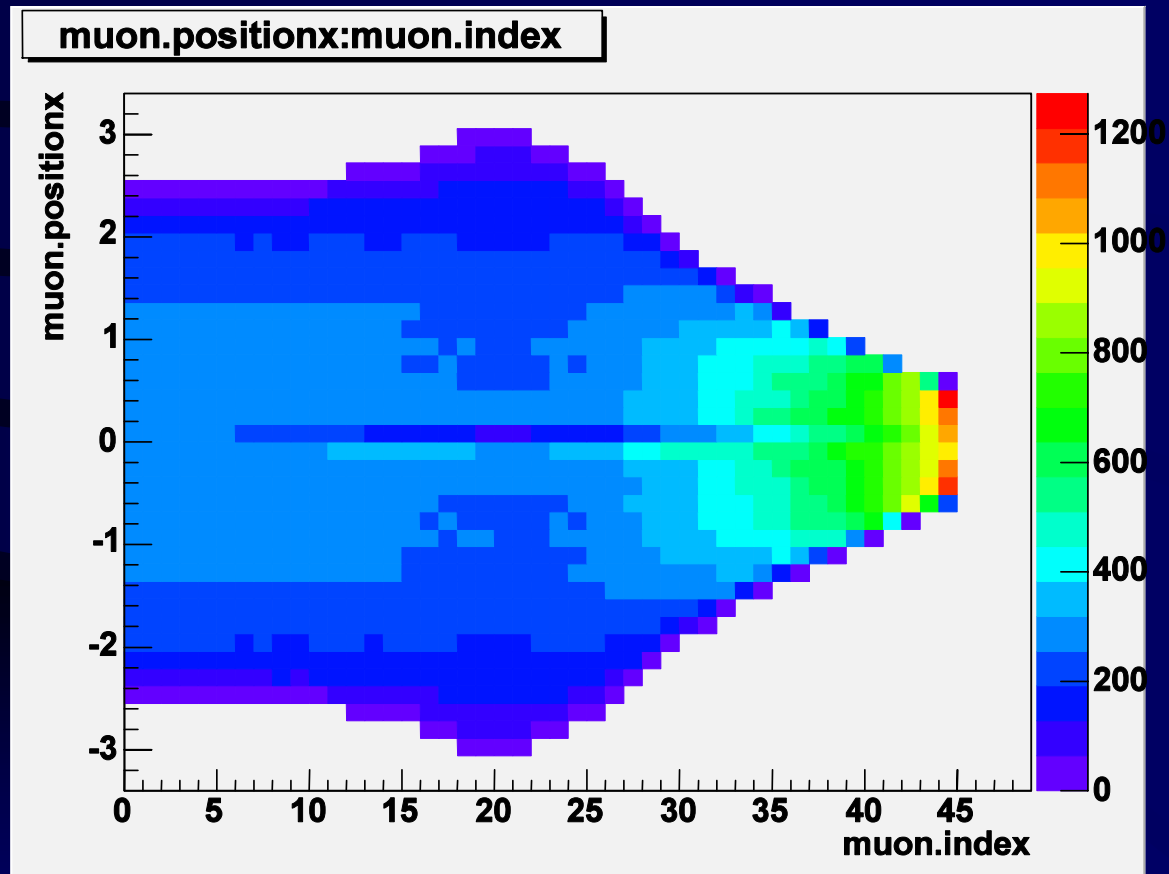


Min: -59.273

Field Map Introduction

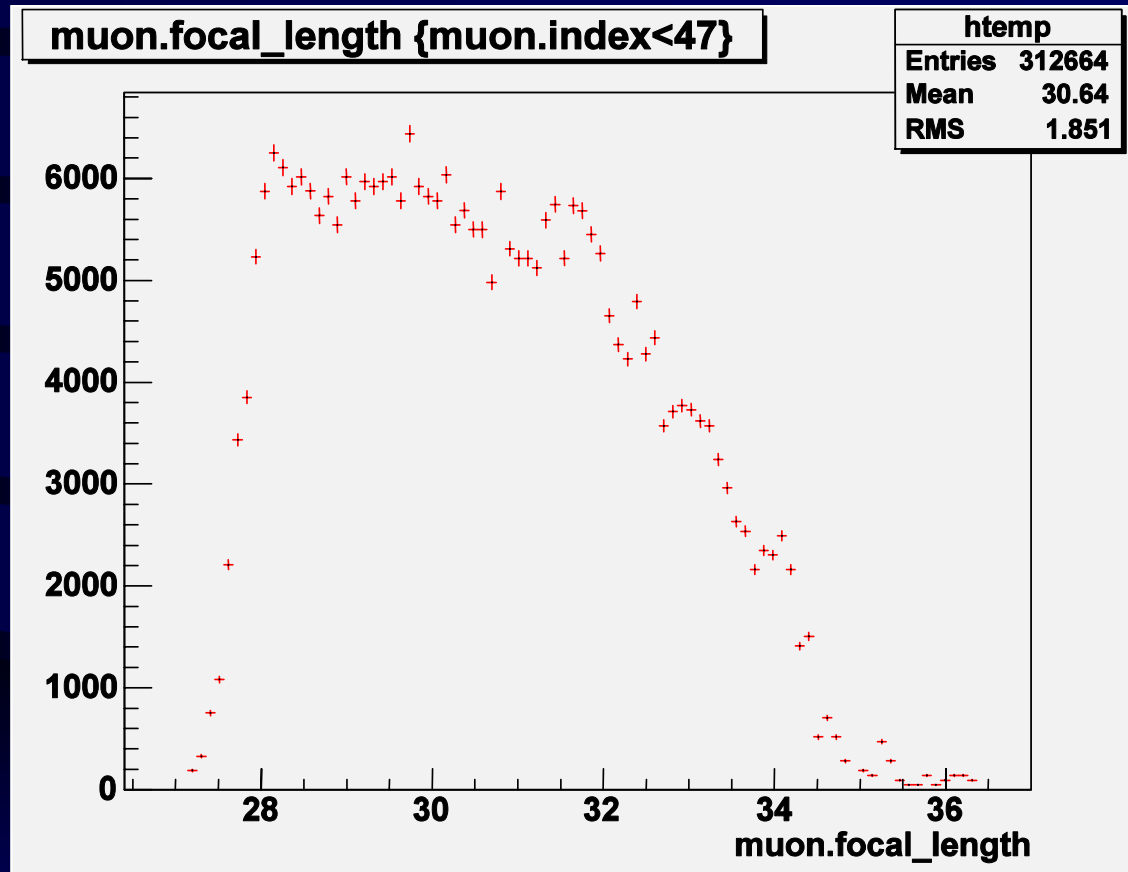
- Export Field Map Files
- New Classes:
 - LEMuSRElectricField.cc/hh
 - LEMuSRElFieldMix.cc/hh
 - Redefined G4ChordFinder.cc/hh
 - Tests with dummy planes

Third Lens Field Test



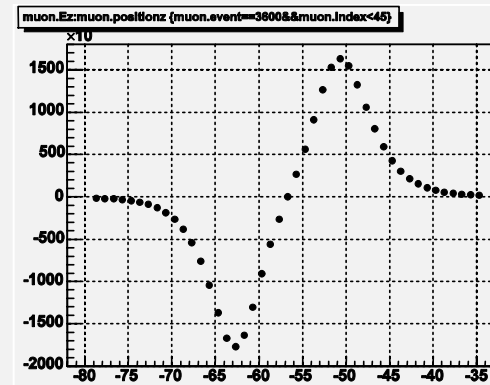
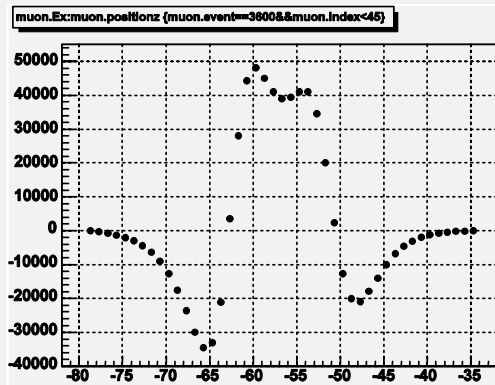
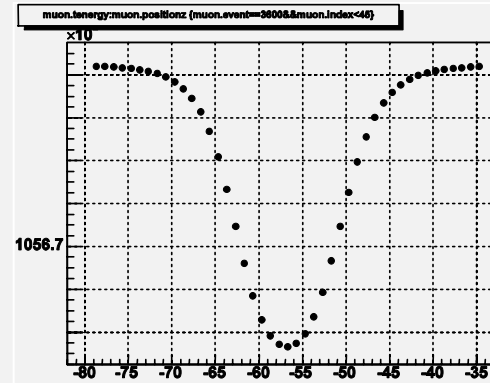
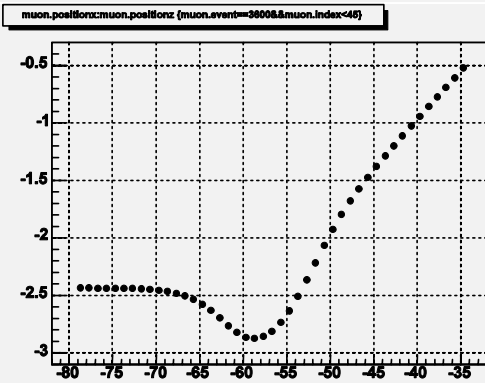
Beam Profile in the third lens and focalization

Third Lens Field



Focal Length of the third lens

Third Lens Data



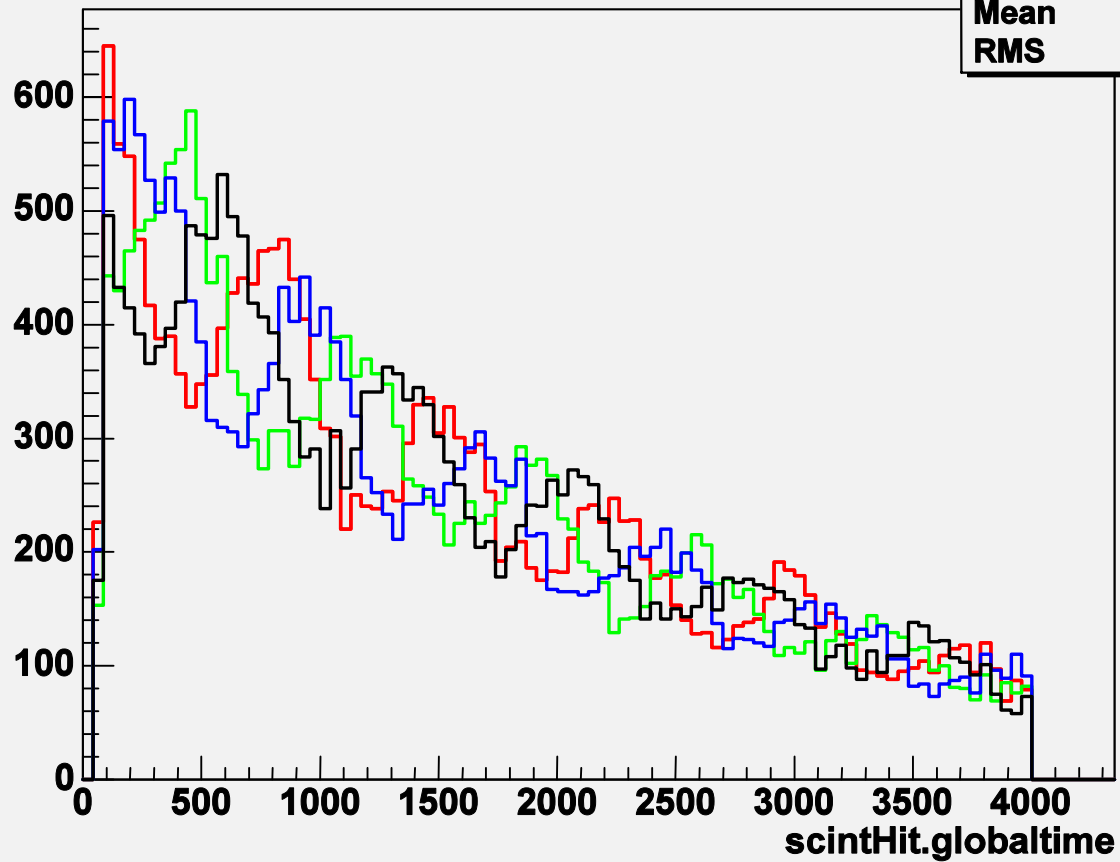
Sensitive Detectors

- Inner/Outer Scintillator
- Cryostat
- Multiple Channel Detector
- Hits
- Hits Collection
- ROOT Analysis

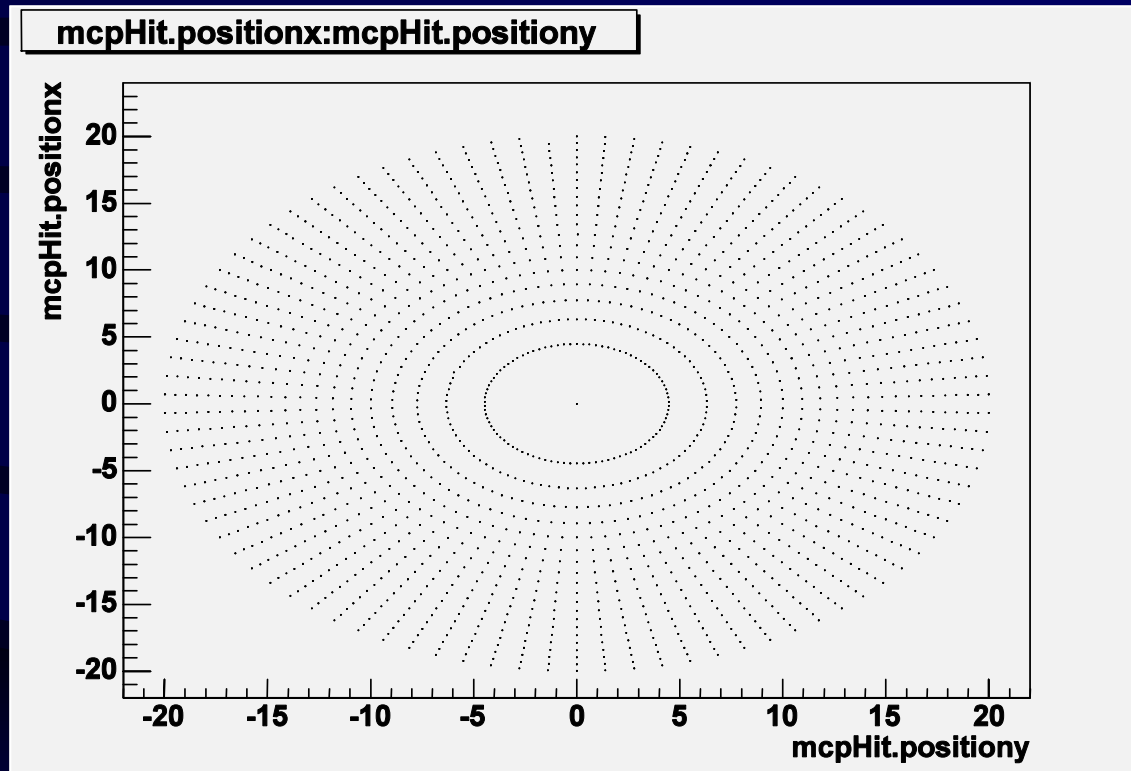
Scintillators Counts

scintHit.globaltime {scintHit.globaltime<4000&&scintHit.momdirx>0.9}

htemp	
Entries	21886
Mean	1475
RMS	1050



MCP Beam Spot



Spot for a simulation without anode

Conclusion

- Physical interactions well defined
 - Muon physics
- Useful combination for Electric Fields
 - Generating field map using femlab
 - Including field maps in the simulation
 - Mind step and binning
- Sensitive detectors