Low Energy MuSR

INSTRUMENT SIMULATION USING GEANT4 AND FEMLAB

Overview

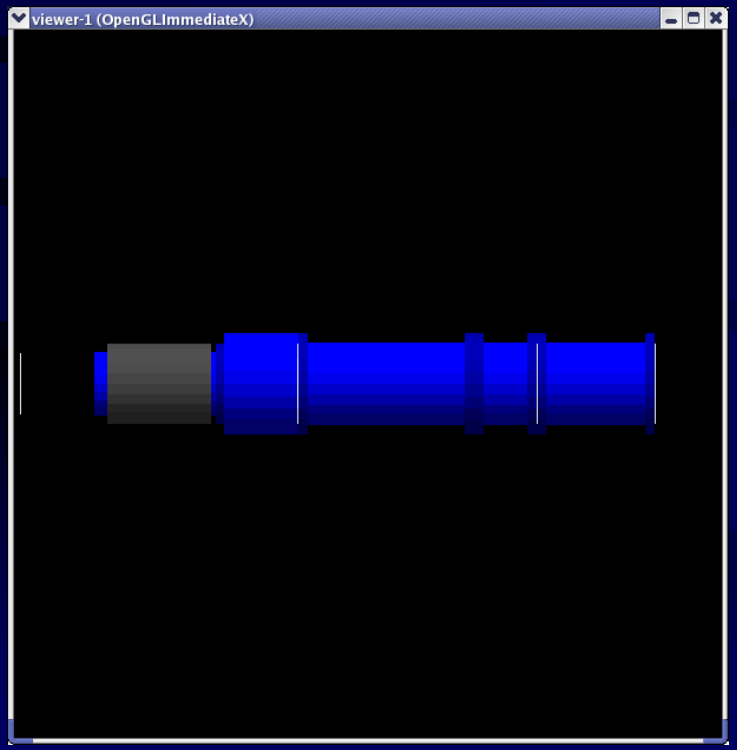
- Generalities: geometry, physics
- Muons Physics Simulation
- Electric Field Implementation
- Sensitive Detectors Simulation
- Conclusion

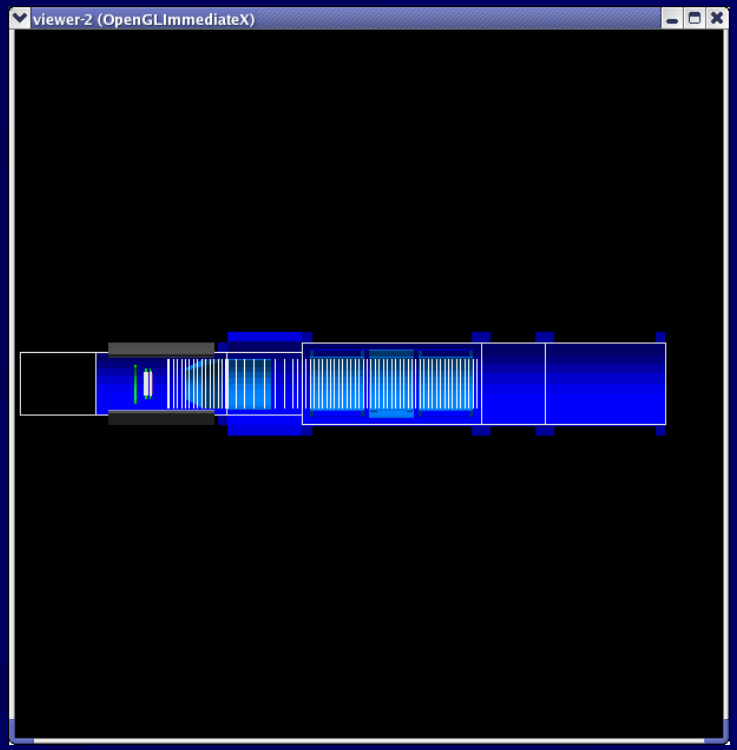
Computing the Geometry

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

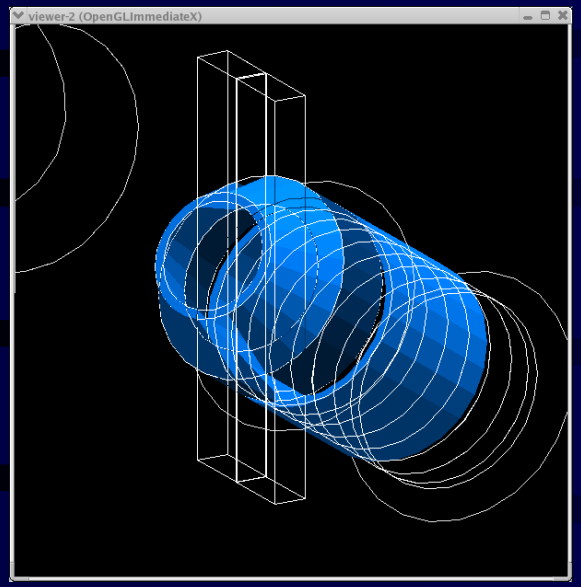
Computing the Geometry

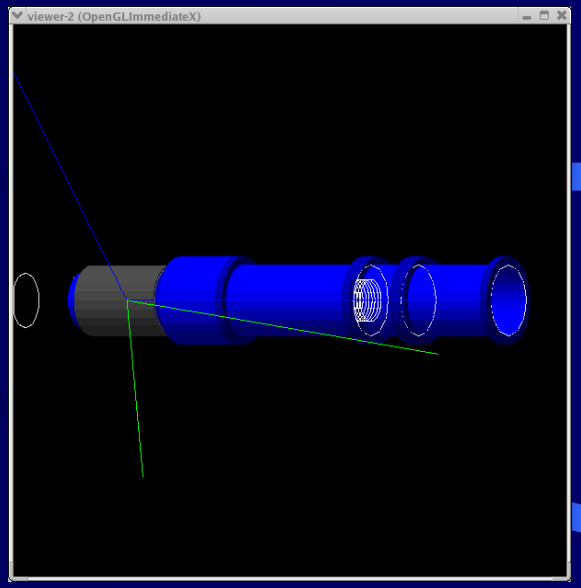
From trigger detector to cryo/mcp detectors

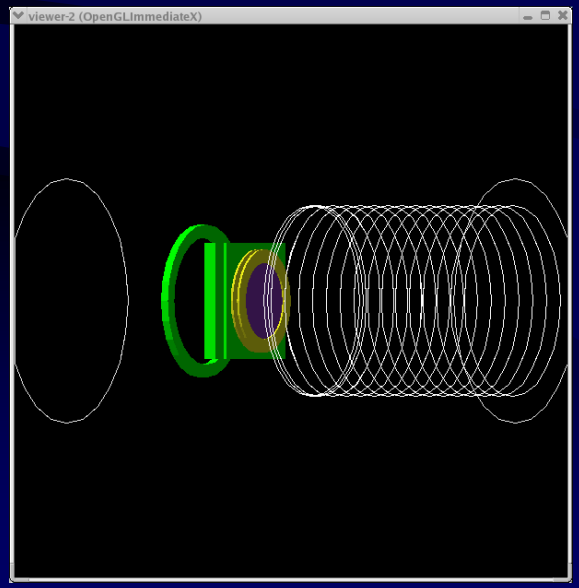




Geometry


viewer-2 (OpenGLImmediateX)


viewer-2 (OpenGLImmediateX)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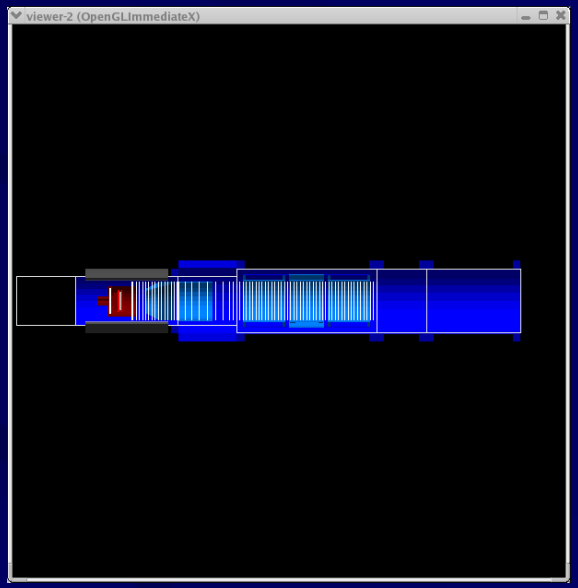
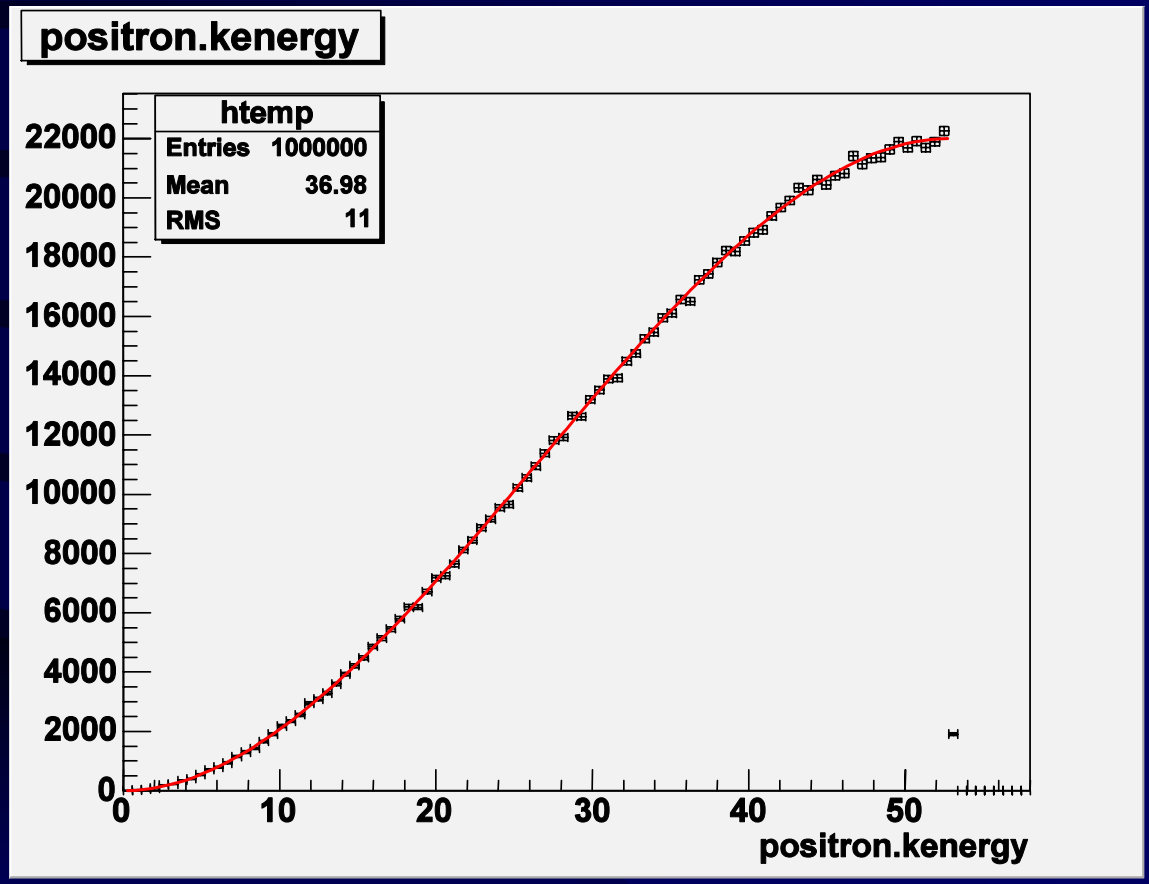

viewer-2 (OpenGLImmediateX)

Muons Physical Behaviours

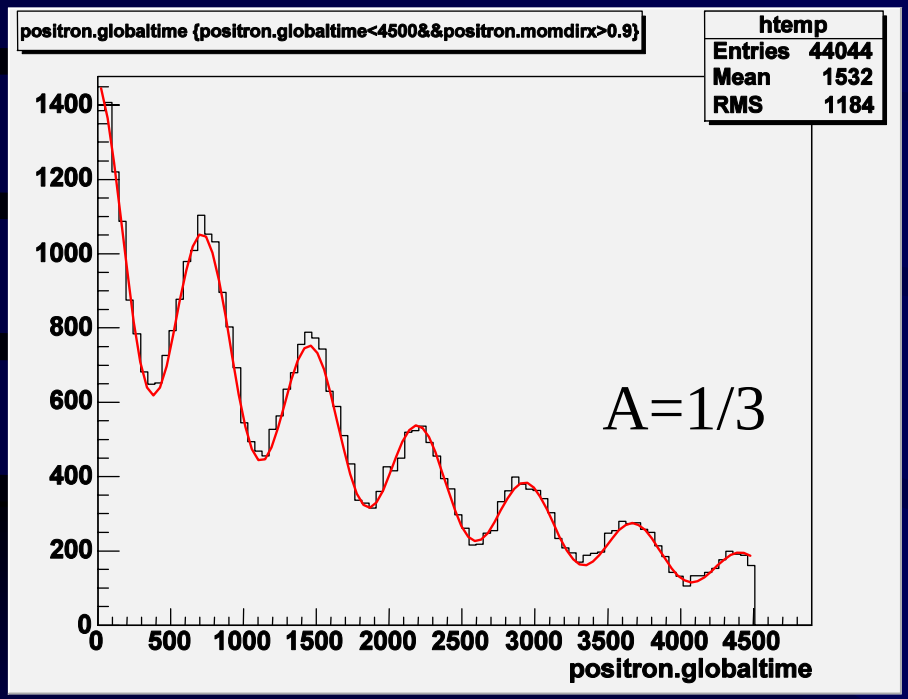
- Polarized Muon Decay
  - Michel's Spectrum for positron kinetic energy
    - $N(w)= w^2(3-2w)$ where $w = E_{e}+/E_{e+_{max}}$
    - $D(w)= (2w-1)/(3-2w)$, asymmetric factor
  - Asymmetry:
    - $N(\theta,t)=N_0*\exp(t/)*(1-A(\theta)\cos(\omega t))$
    - $A=1/3$ for small solid angles θ
    - $A=1/6$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

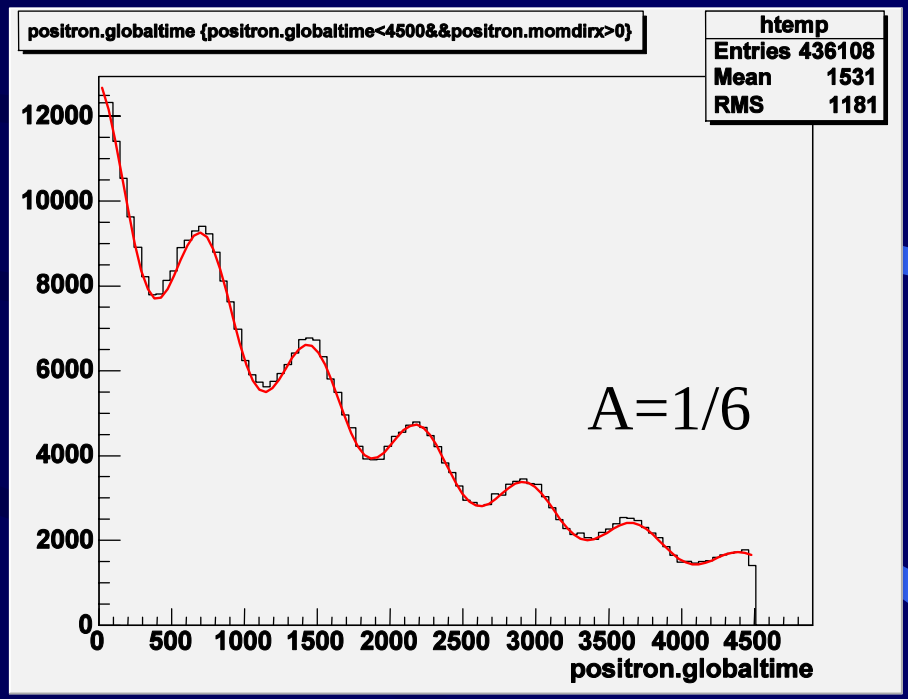
Muons Physical Behaviour



Positron Energy Michel's spectrum _ 1G events

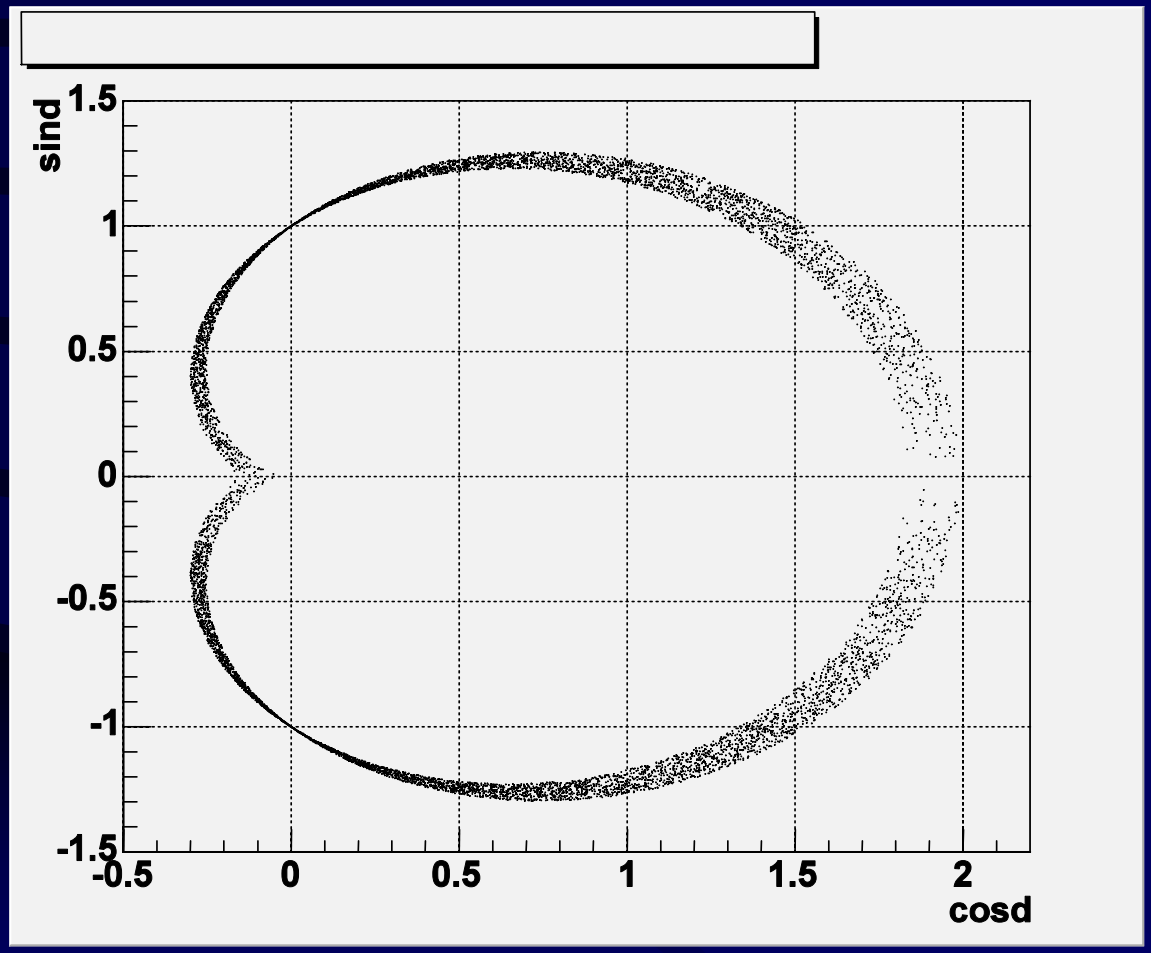
Muons Physical Behaviour





Asymmetric factor and spin rotation effect

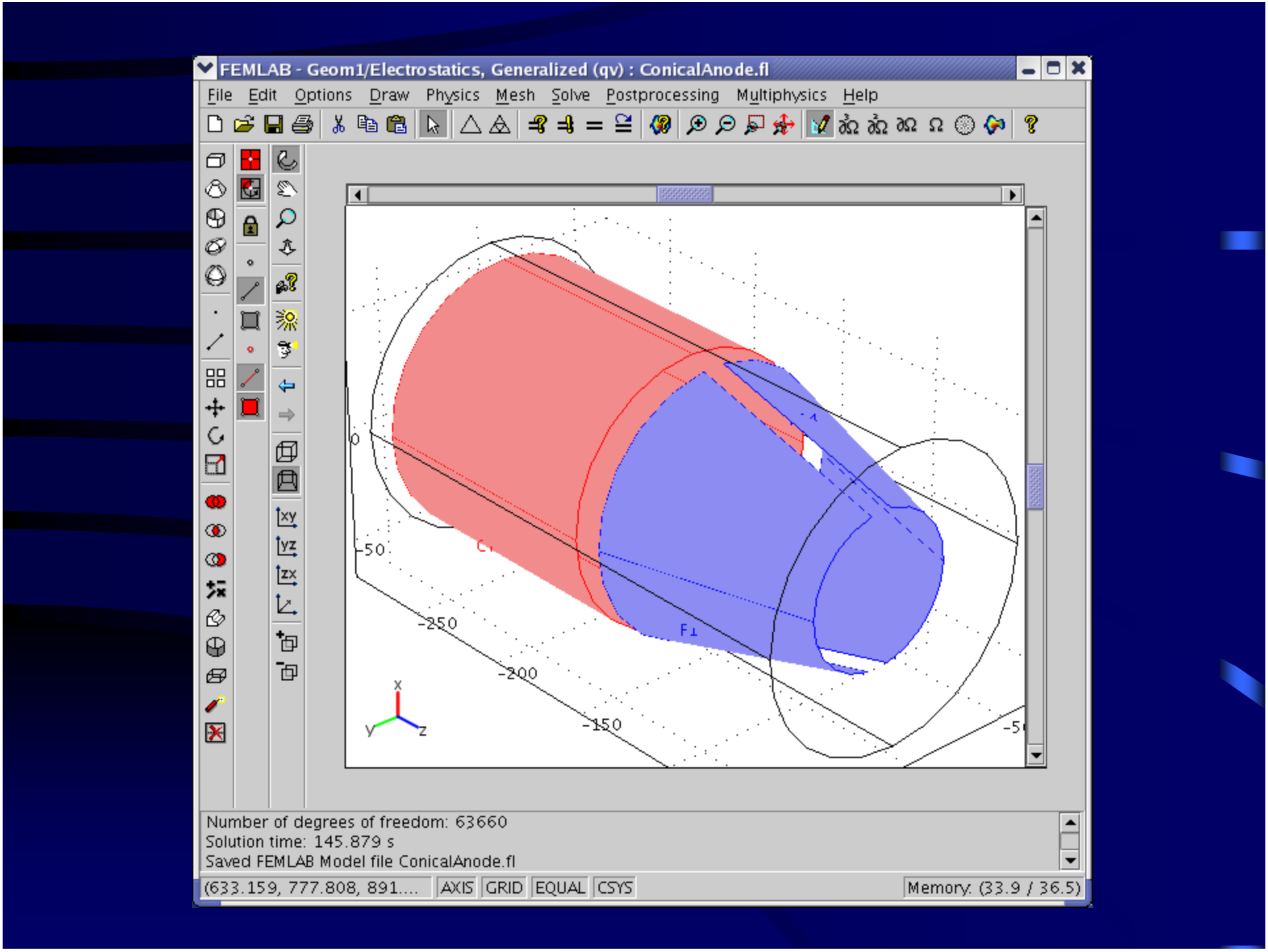
Muons Physical Behaviours



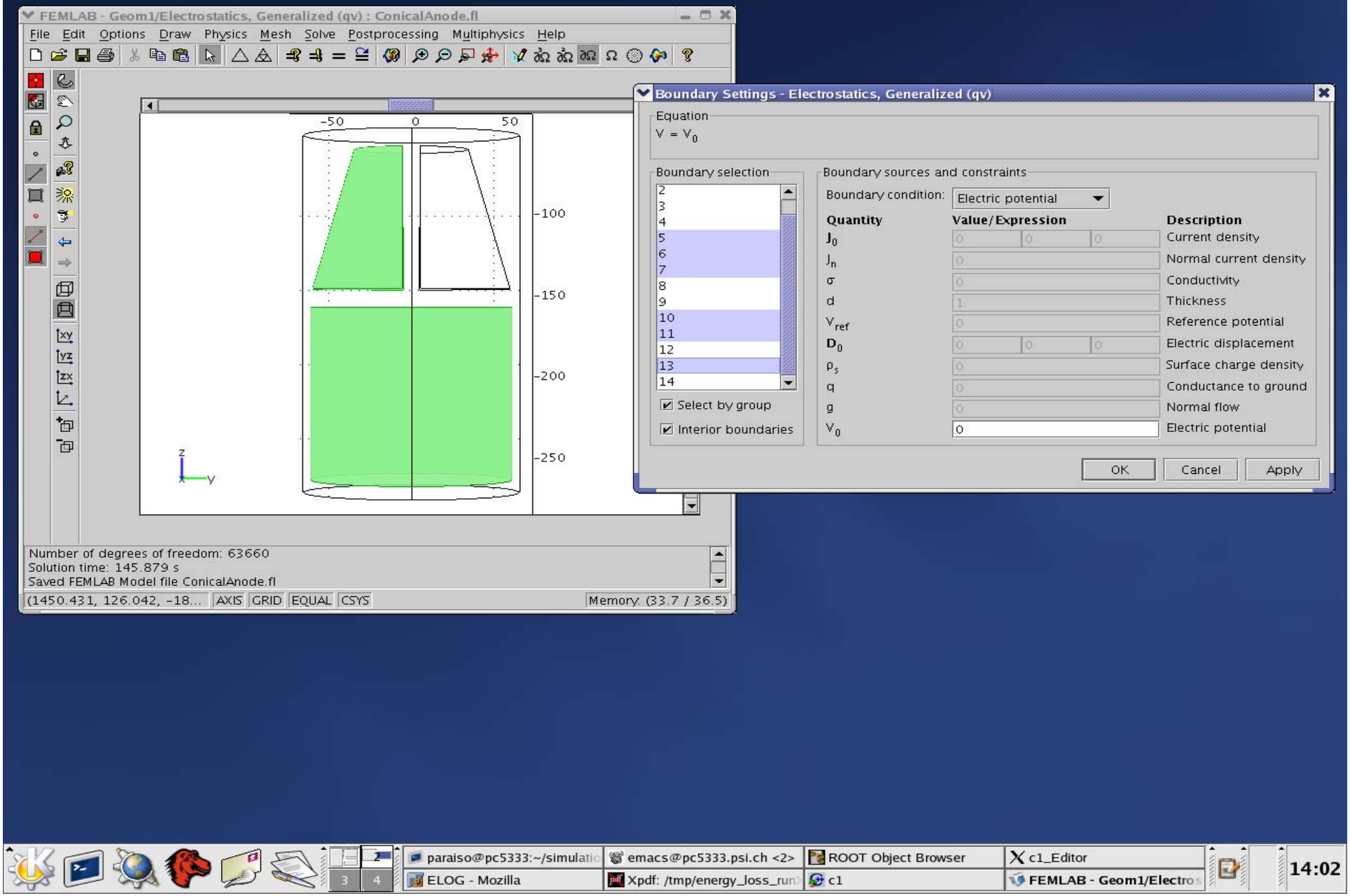
Relation between positron energy and emission angle

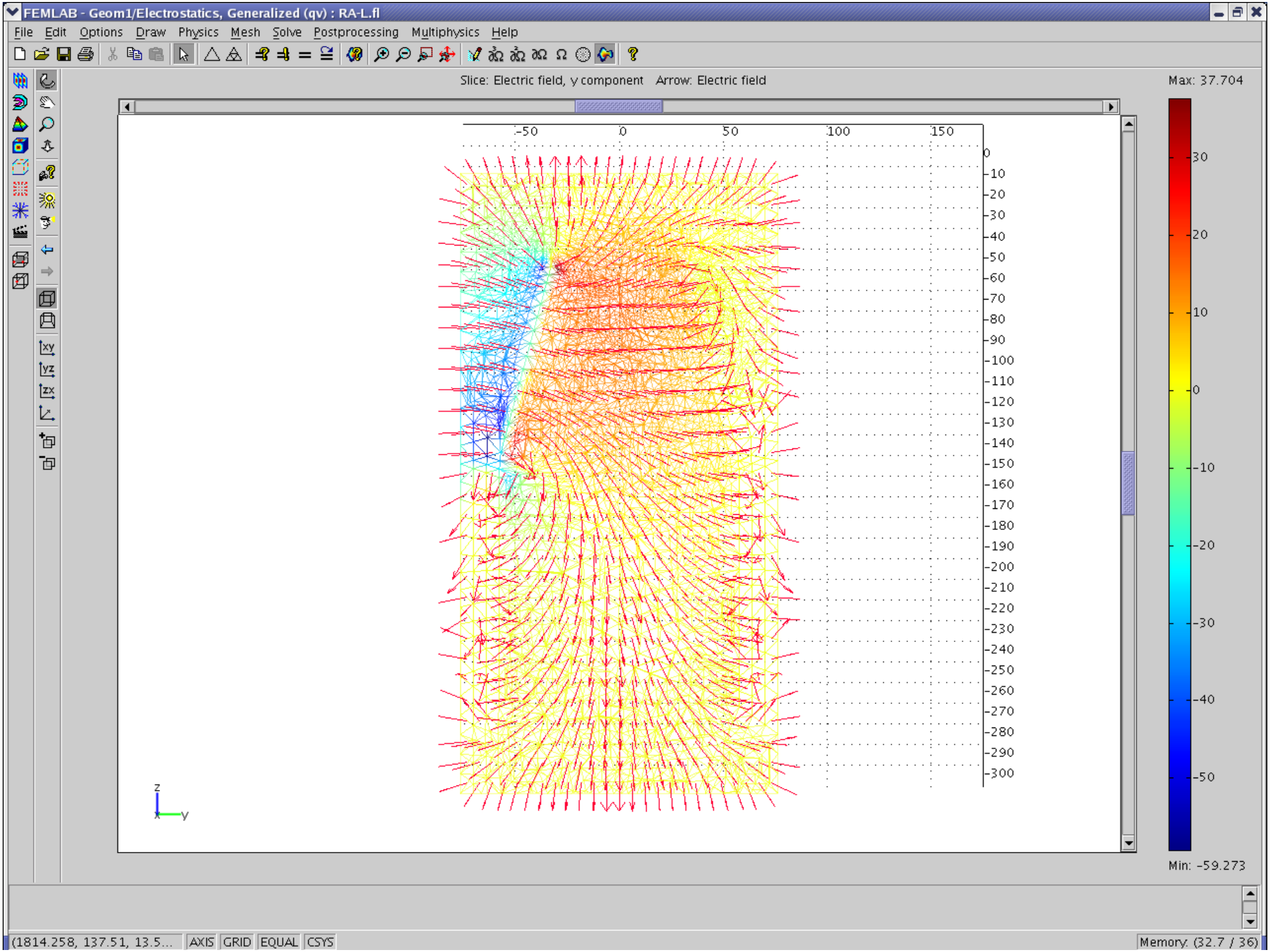
Electric Field

- 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
-50
-250
-200
-150
F1
x
y
z
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

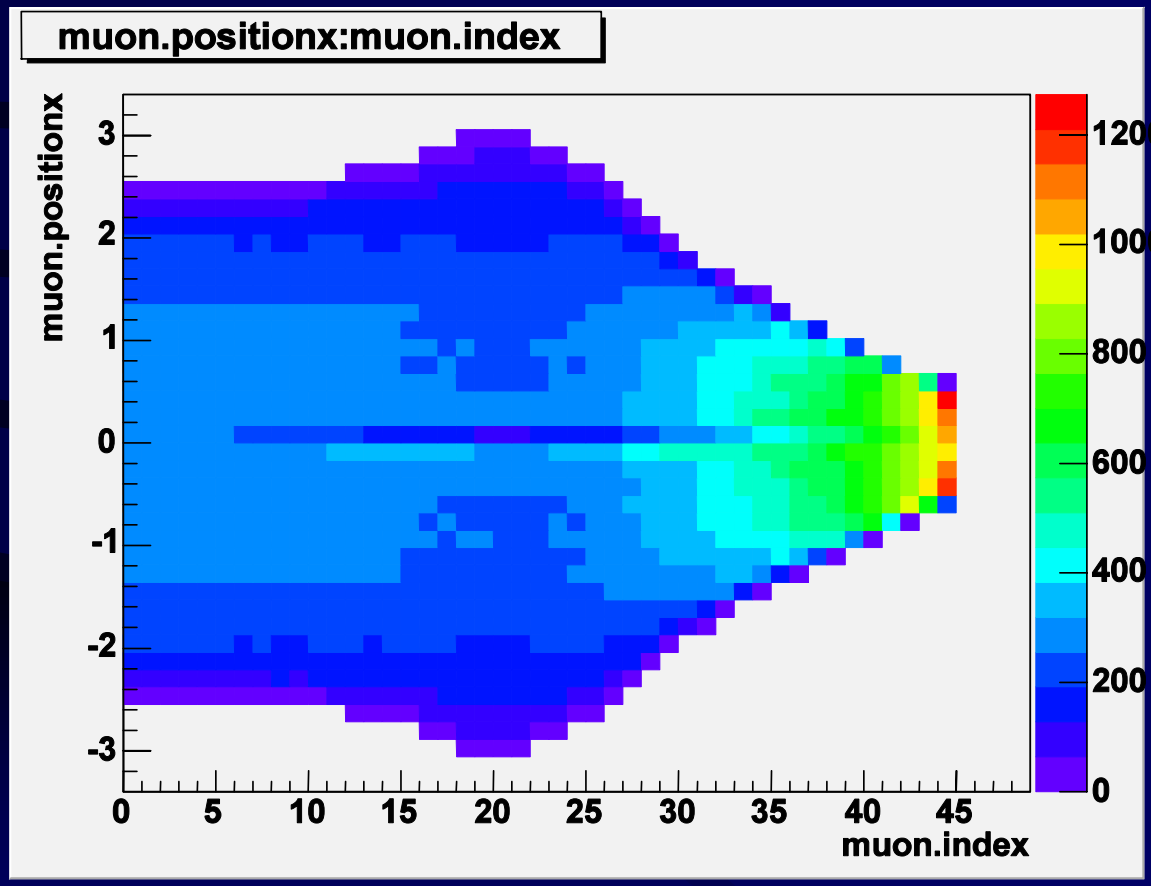



FEMLAB - Geom1/Electrostatics, Generalized (qv) : RA-L.fl
File Edit Options Draw Physics Mesh Solve Postprocessing Multiphysics Help
Slice: Electric field, y component Arrow: Electric field
Max: 37.704
Min: -59.273
-50 0 50 100 150
0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -220 -230 -240 -250 -260 -270 -280 -290 -300
30 20 10 0 -10 -20 -30 -40 -50
z x y
(1814.258, 137.51, 13.5... AXIS GRID EQUAL CSYS
Memory: (32.7 / 36)

Field Map Introduction

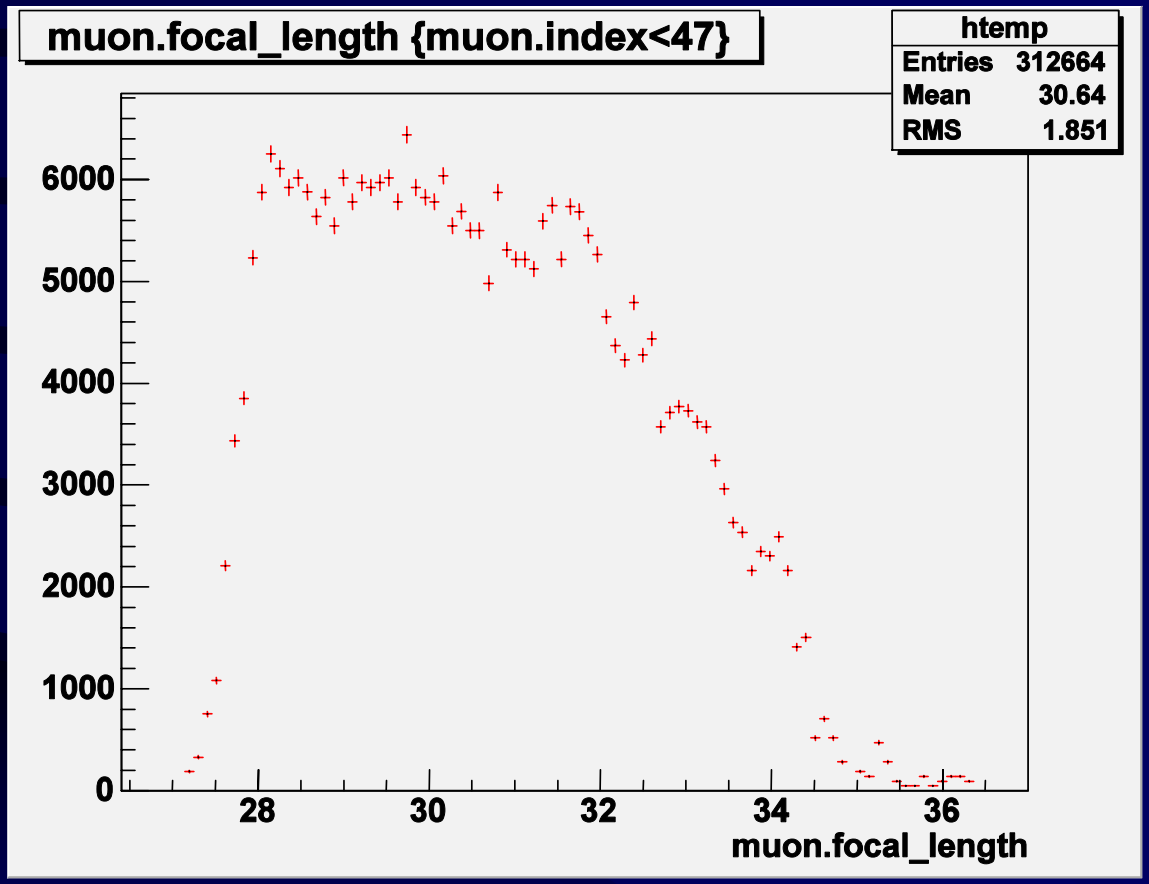
- Export Field Map Files
- New Classes:
  - LEMuSRElectricField.cc/hh
  - LEMuSRElFieldMix.cc/hh
  - Redefined G4ChordFinder.cc/hh
  - Tests with dummy planes

Third Lens Field Test



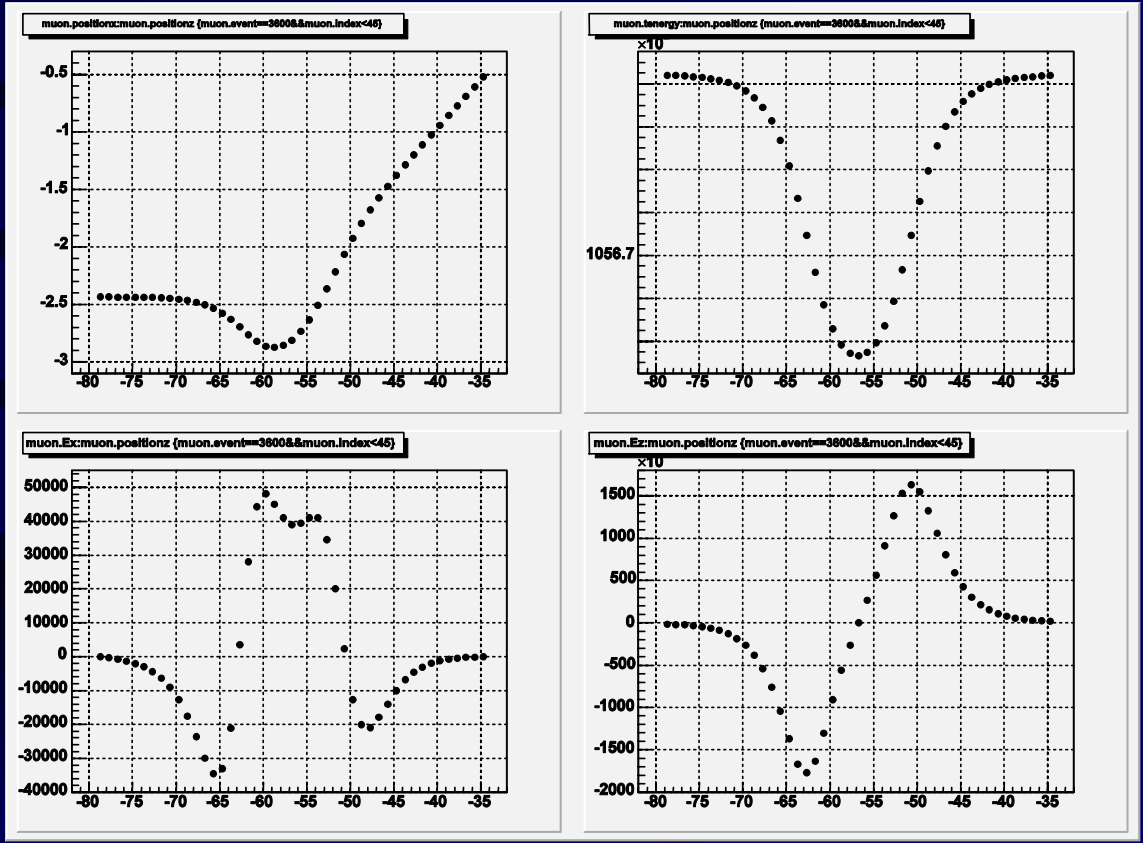
Beam Profile in the third lens and focalization

Third Lens Field



Focal Length of the third lens

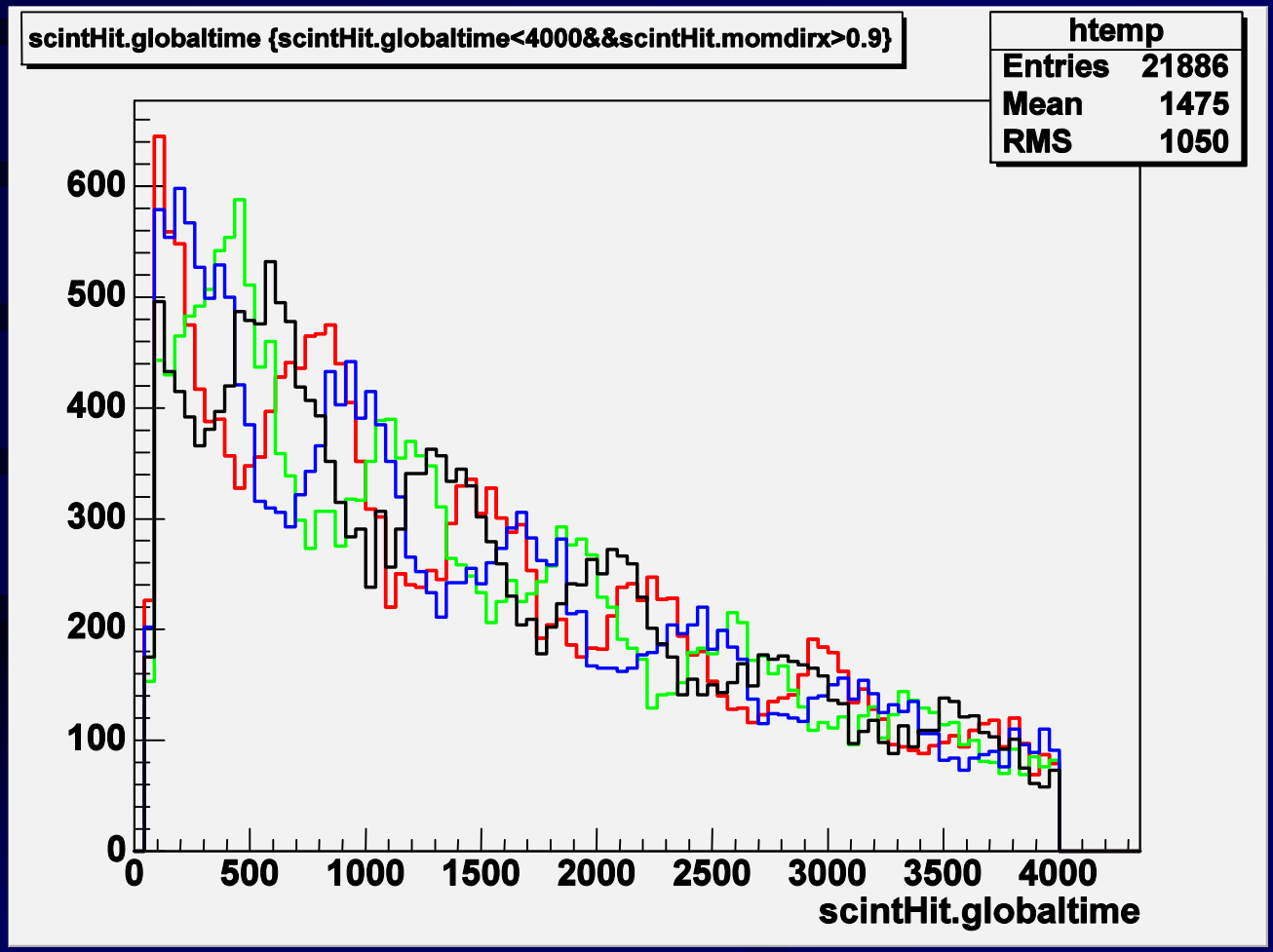
Third Lens Data



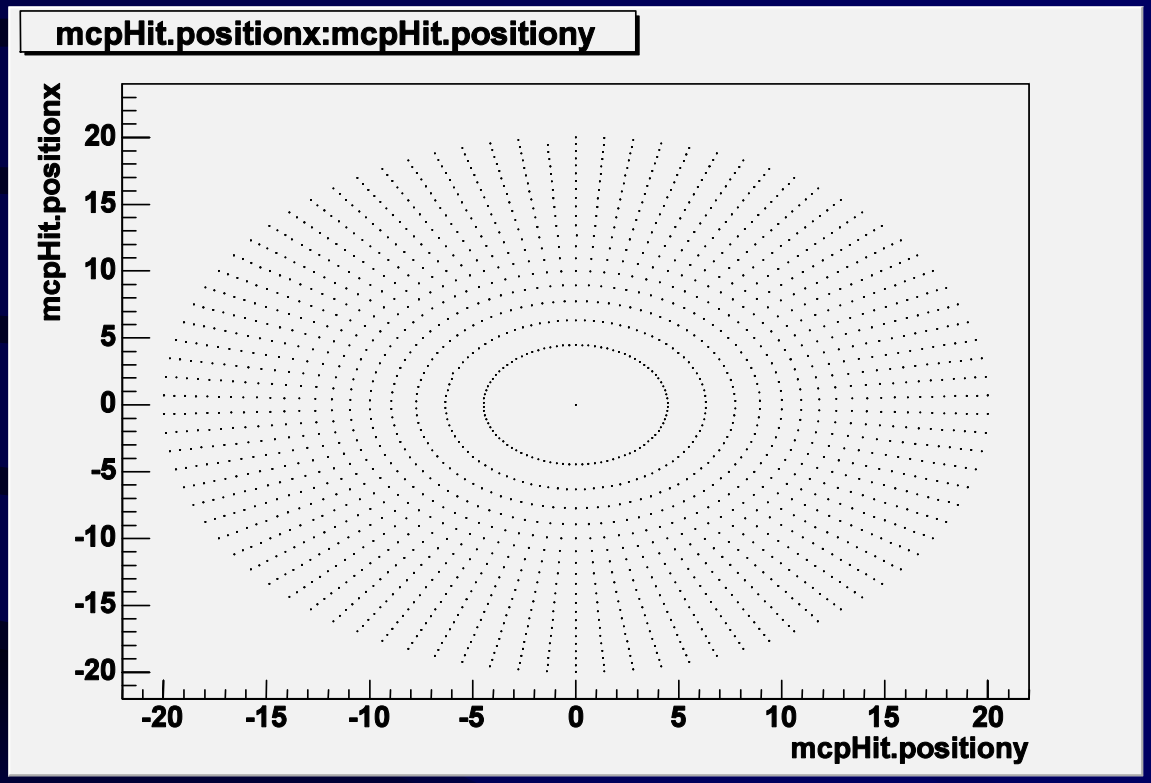
Sensitive Detectors

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

Scintillators Counts



MCP Beam Spot



Spot for a simulation without anode

Conclusion

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