μ-> e γ with converted γ TOF needs

Fritz DeJongh

- Goal: Path to 10^{-16} sensitivity using
  - Intense stopped muons beams from Project-X
  - Monolithic pixel detectors
  - Time of flight

Existing Branching Ratio Limits

MEGA: $< 1.2 \times 10^{-11}$ (1999)

Using converted photons

converter: 9% radiation length (in each of 3 layers)

6% duty cycle

1.5×10^{7} stopped muons/sec

MEG: $< 2.4 \times 10^{-12}$ (2010)

Using LXe calorimeter

Expects to reach few x 10^{-13}

Moving forward with the converted photon approach:

- Use project X to increase $R\mu$ (the rate of stopped muons) and signal rate
- Problem: Accidental coincidence rate increases as $R\mu^2$ (instantaneous)
- Need
  - 100% duty cycle
  - Thin converter
  - Thin detectors
    - Resolution limited only by energy loss and multiple scattering

Accidental Coincidences: "Effective Branching Ratio" of Background

$$B_{acc} = \left(\frac{R_\mu}{d}\delta t_{e\gamma}\right) \quad \text{timing, duty cycle}$$

$$(\delta x) \quad e^+ \text{ energy resolution}$$

$$\left(\frac{\delta y}{15}\right)^2 \quad \gamma \text{ energy resolution}$$

$$\left(\frac{\delta\theta^2_{e\gamma}}{4}\right) \quad \text{opening angle}$$

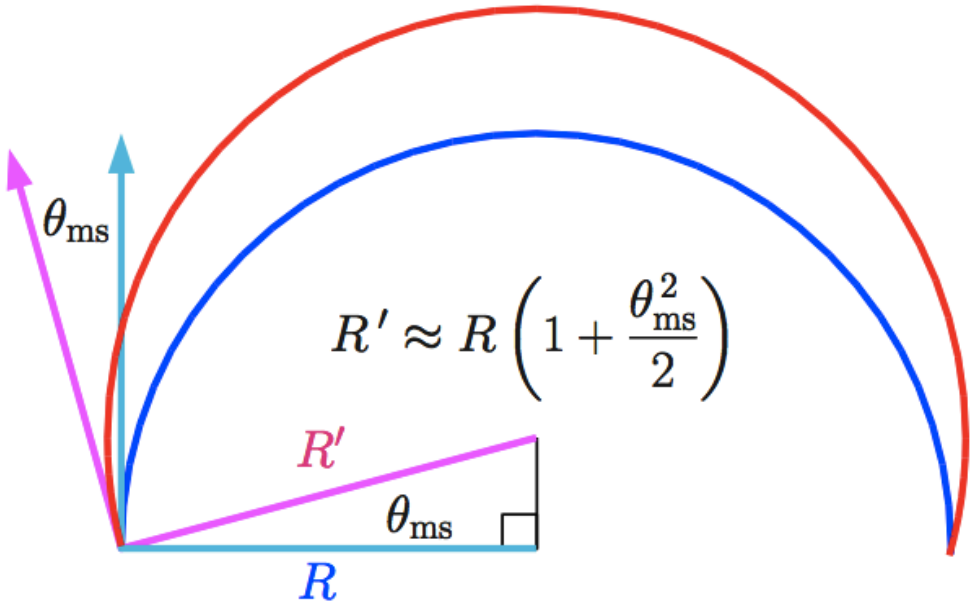
$$\left(\frac{(2\delta\theta_z L_{\gamma T})^2}{A_T}\right) \quad \text{traceback angle}$$

Kuno, Okada, RMP73,151 (2001)
MEGA Collaboration, PRD65,112002 (2002)

To get tof, possibilities are:
- Tof in pixels (Gigatracker)
- External timing detectors

Measuring electron and positron energies

Use double pixel layers to measure position and direction at points on the helix trajectory of a track in a B field



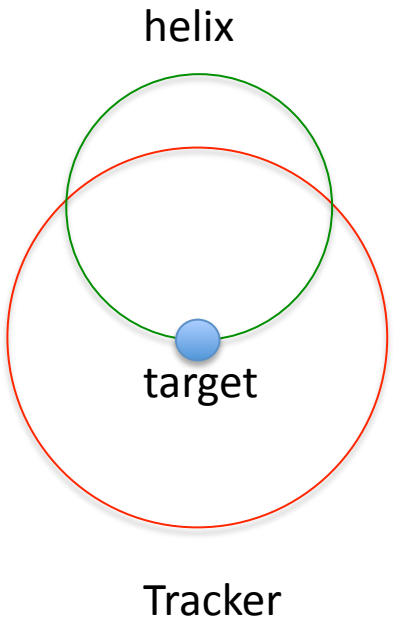
Geometry: Try to arrange to obtain measurements 180° apart on the circle

If successful:

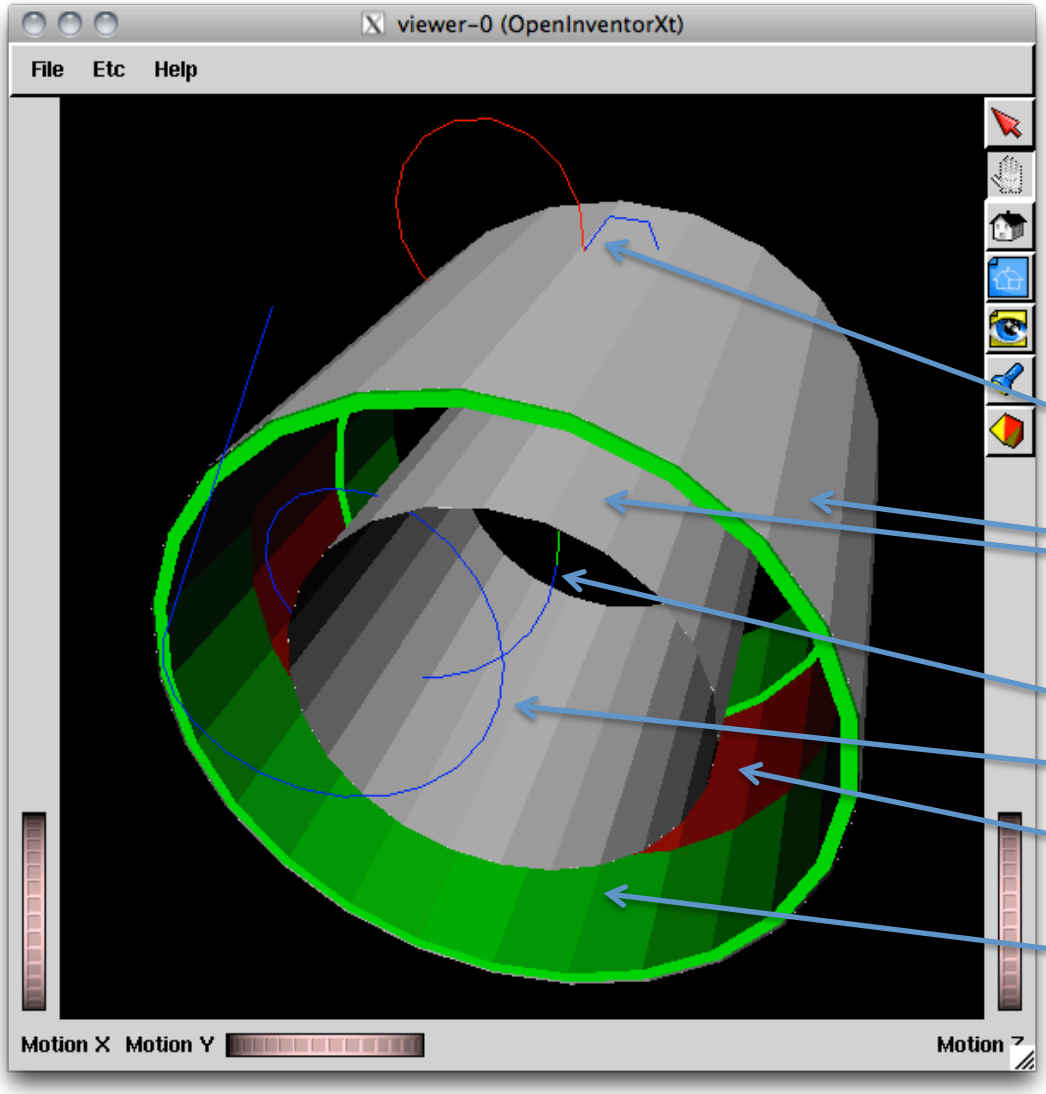
- Multiple scattering affects resolution only at 2nd order
- Energy loss in pixels becomes the limitation

Path length uncertainty ~20 ps

Would like tof resolution as good as this!


helix
target
Tracker

The simple minded geometry seems to work. Needs many m^2 pixel tracking



Target radius ~2 cm

B = 0.5 T
Positron R = 35 cm

Converted photon

Double pixel layers
R = 47 cm and 75 cm

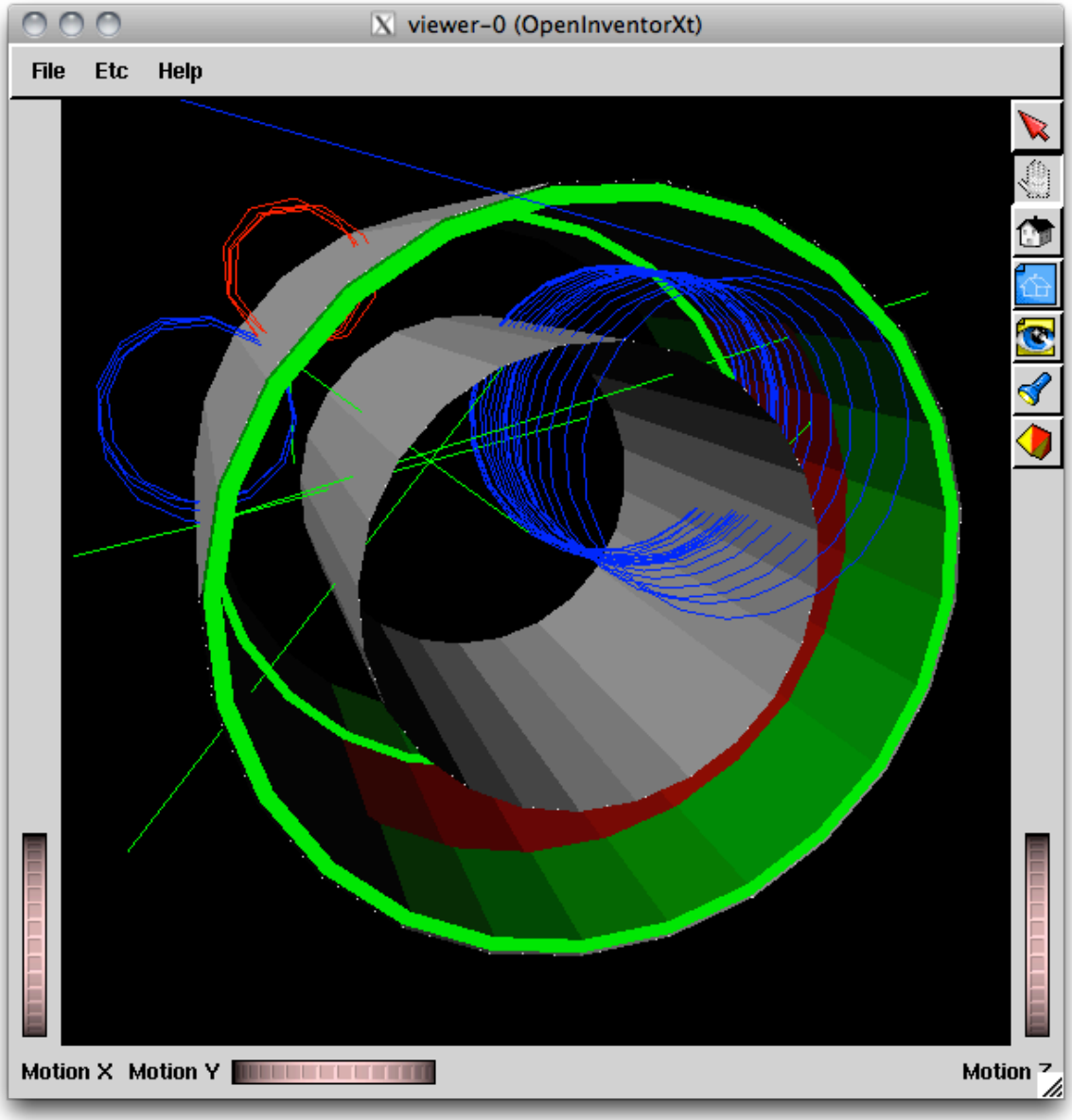
μ -> *e* γ decay from stopped muon

Positron

Converter

Calorimeters or tof
triggering, tof

Transverse geometry is nice theoretically but has some problems…



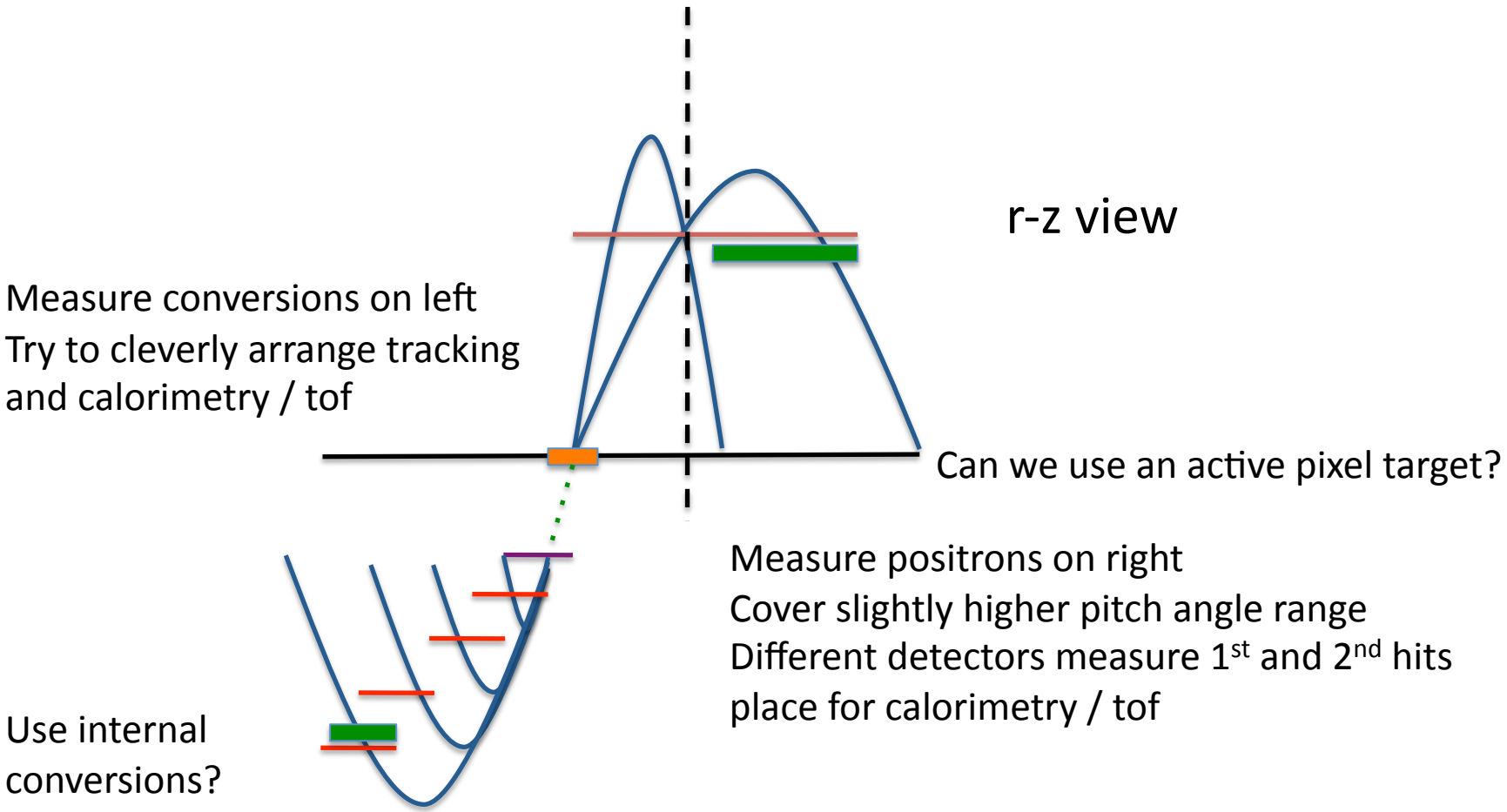
Other problem:

Need target extended in z (~150 cm) since gamma is pointing in from so far out.

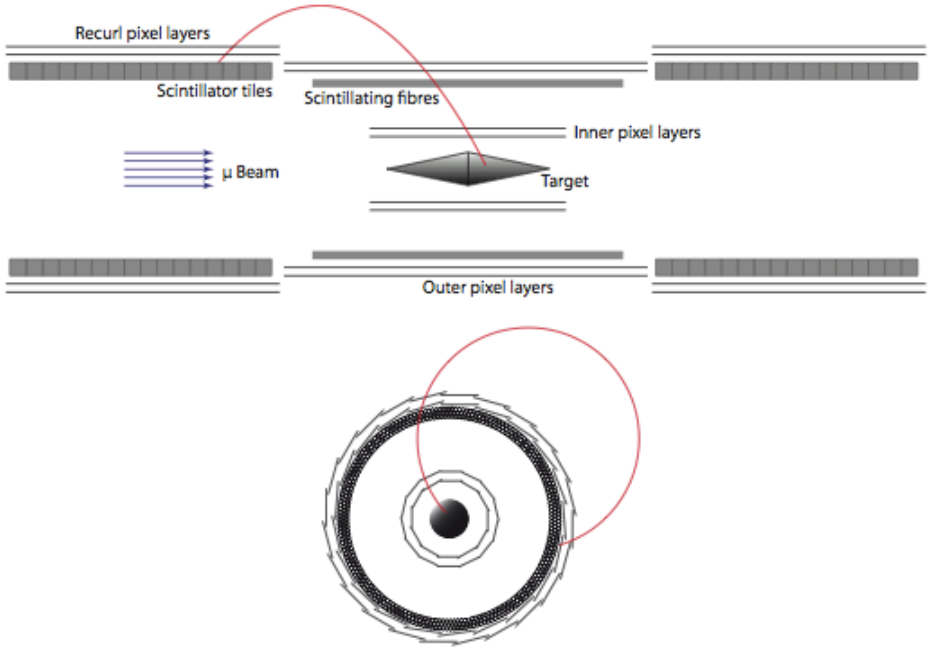
Putting calorimetry / tof On sides doesn't work…

They could go inside converter if they're not too thick

Is there a small target solution? Requires moving converter way in (so gamma can point to a given fraction of the target)
Trickier geometry, occupancy issues, etc.



Comments on μ -> e^+ e^+ e^-: PSI LOI aims to use 10^9 μ/sec
Ultimate sensitivity goal: α x 10^{-14}



Scintillating fibres provide tof but degrade tracking resolution

PSI μ3e LOI

Summary

- Would like wide-area tof with 20 ps resolution.
- Working on geometry:
  - If tof is thin enough, could go inside gamma converters
  - Might be able to find places to put it behind tracker in some possibilities, in which case mass is less of an issue.