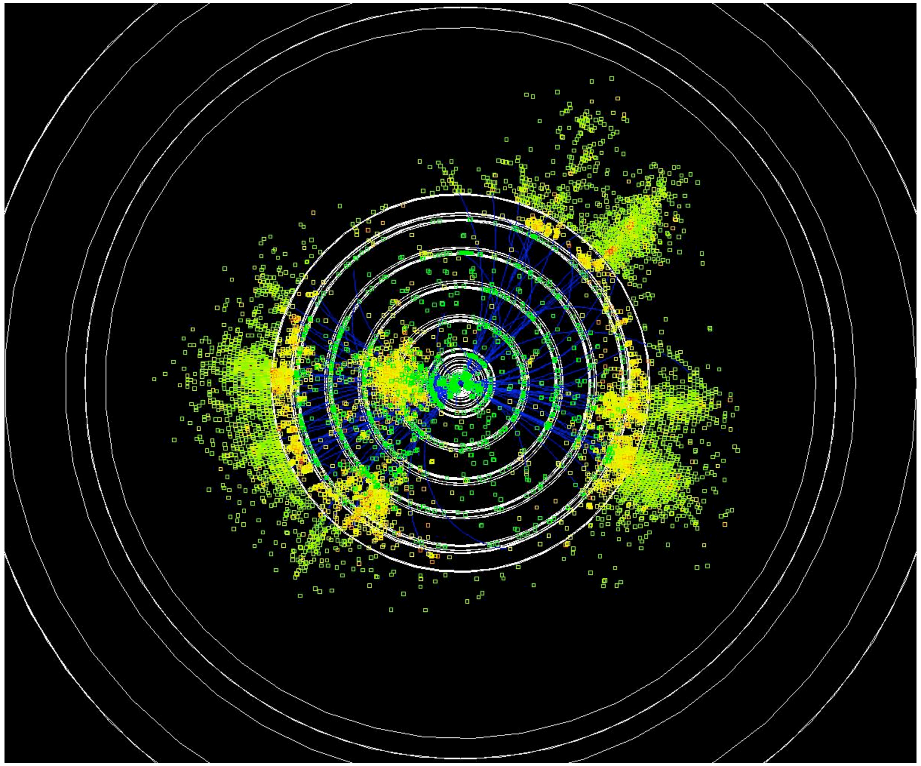
Mask studies for CLIC

Status report
on behalf of Andrey Sapronov LNP JINR

Contents

- Motivation
- Geant4 model of CLIC forward region
- Geometry description
- Preliminary background studies
- Summary and next steps



Motivation for CLIC

Large Beamstrahlung background at CLIC

- Due to the higher energy, 3 TeV
- Due to smaller beam size (~40 nm, ~1 nm)

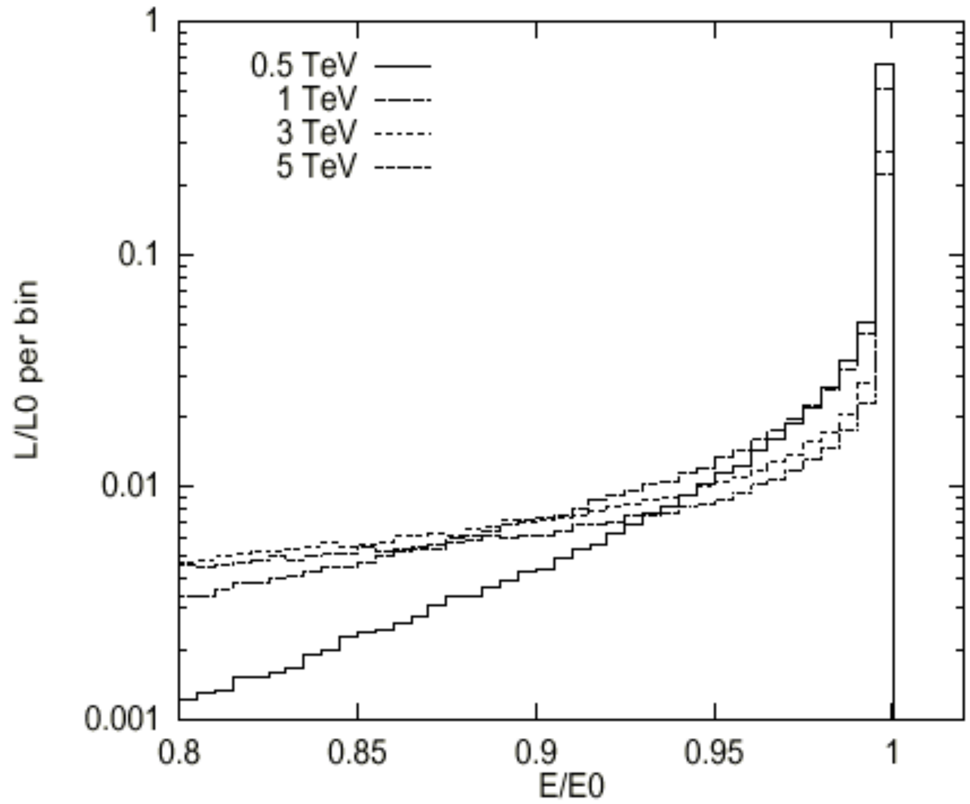
Per bunch crossing:

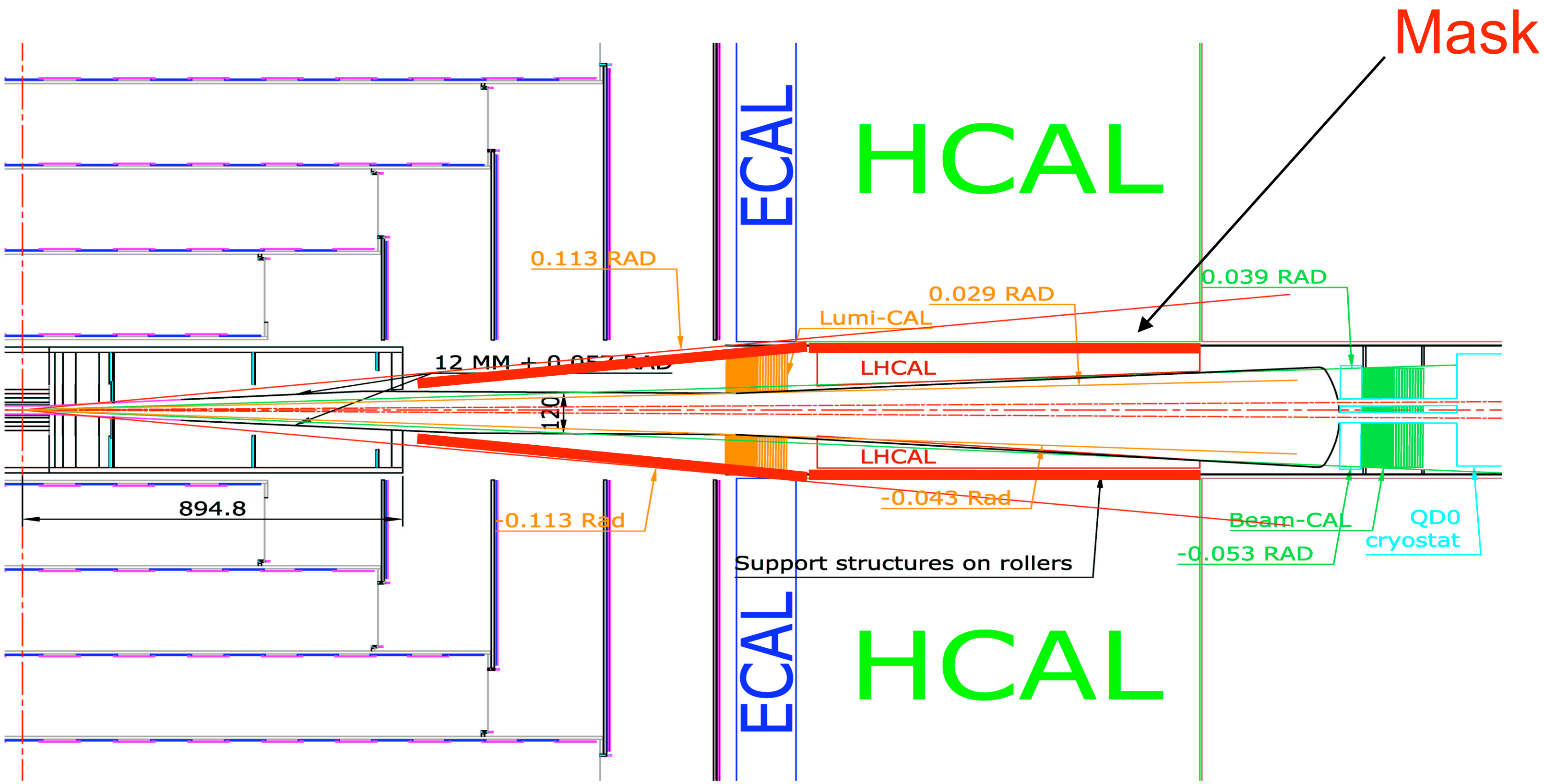
$N_{coh} = 3.8\times10^{8}$

$E_{coh} = 2.6\times10^{8}$ TeV

$n_{incoh} = 0.3\times10^{6}$

$E_{incoh} = 22.4\times10^{6}$ GeV



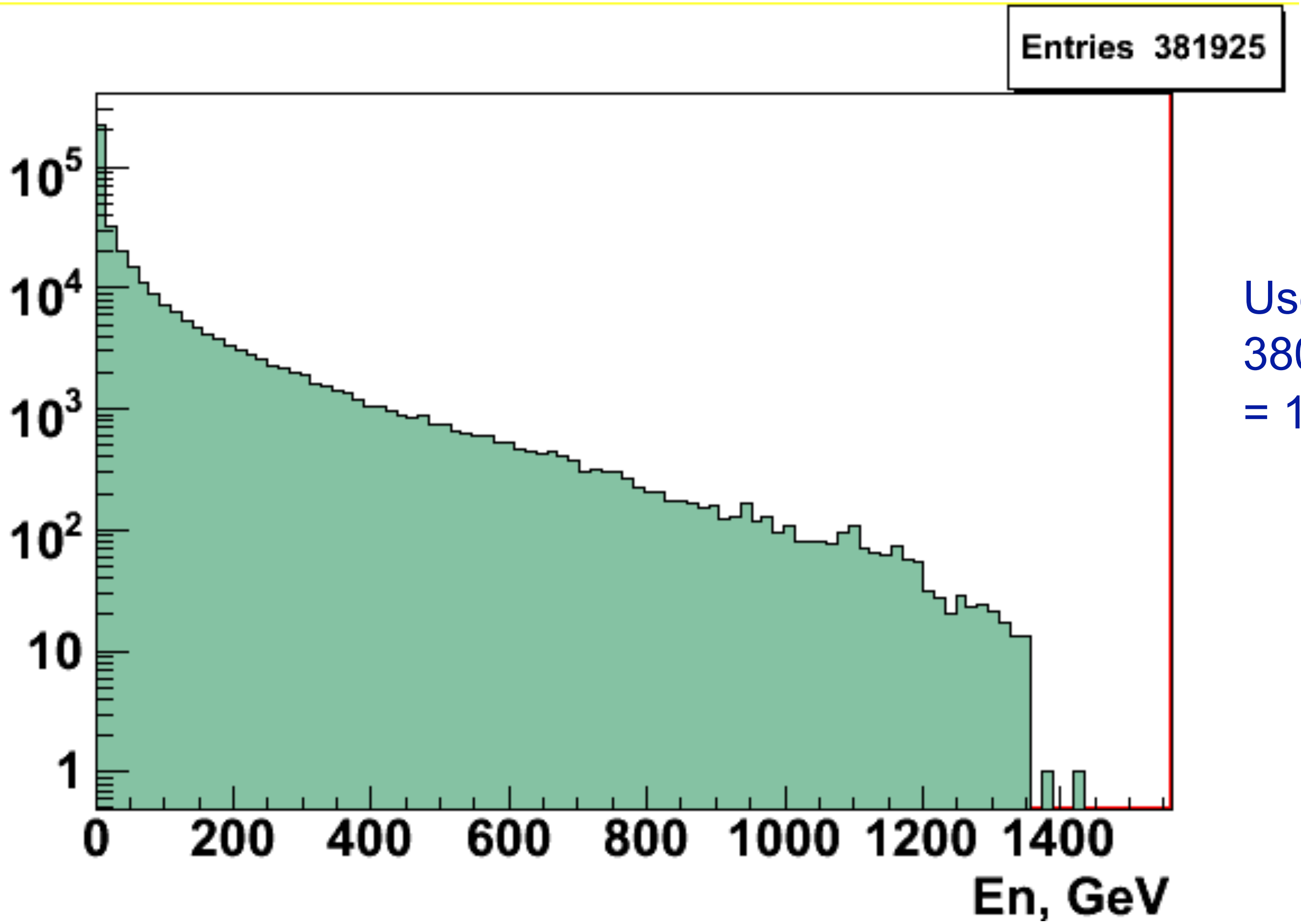


High levels of backscattered beamstrahlung background ➔ need for **Mask** to protect tracker and calorimeters.

- Simulate the forward region
- Perform background estimation
- Optimize the mask parameters for effective shielding

The dangerous background are mainly the backscattered photons, e+- and neutrons. They are produced from the e+- pairs compound of the beamstrahlung which collide with forward region detectors.

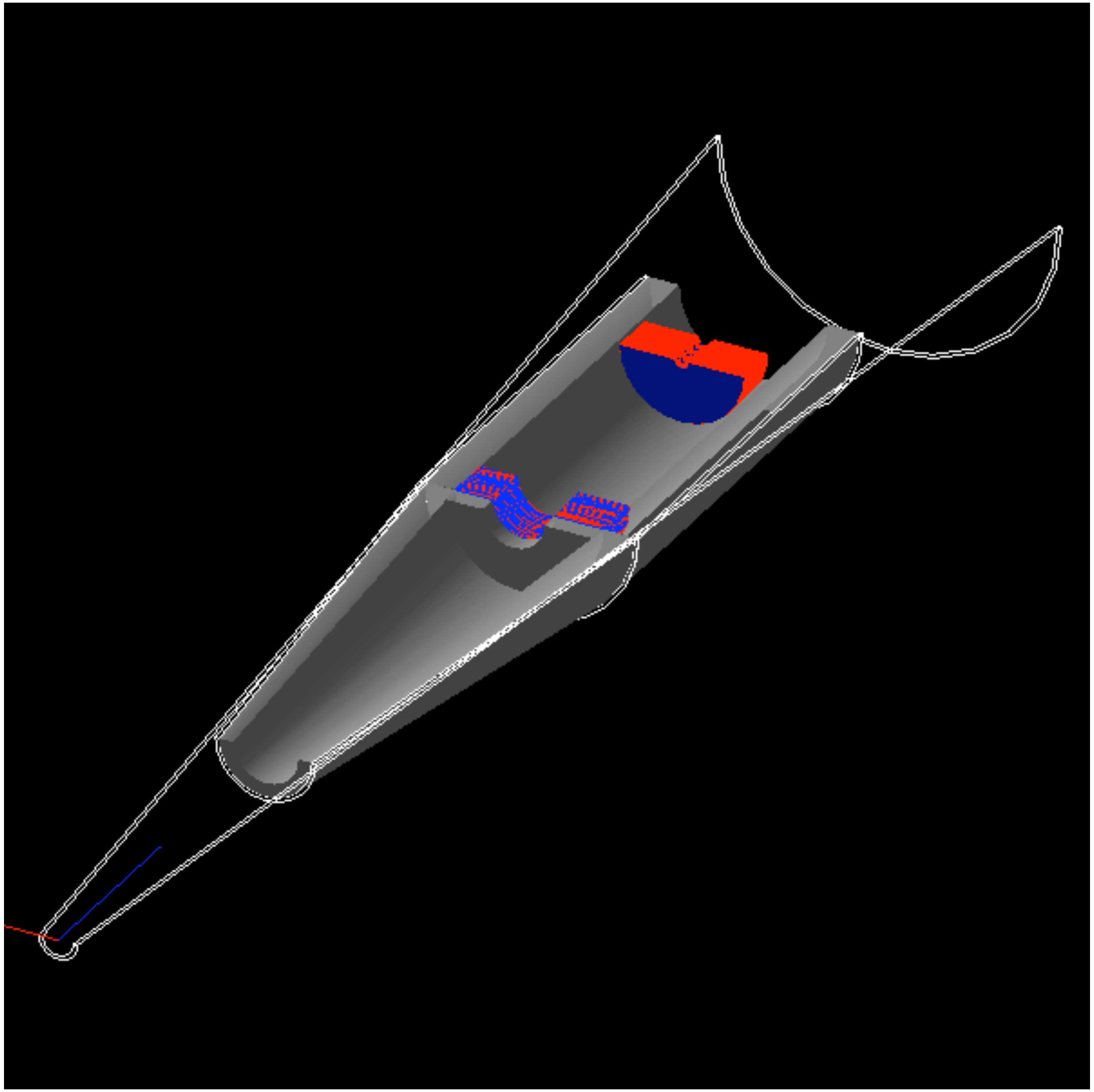
Beamstrahlung pairs energy distribution



Used for simulation:
380000 coherent pairs
= 1 per mille of bunch crossing

Simulation: Geant4.9.0p01

Physics list: QGSP_BERT_HP
(quart-gluon string compound,
Bertini cascade High precision)

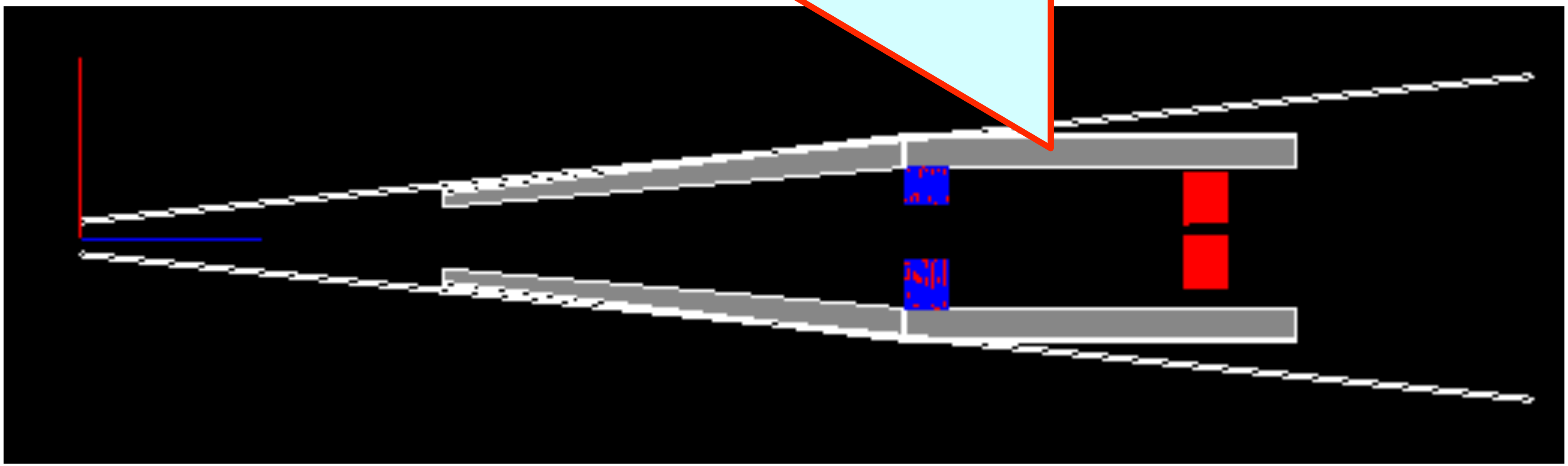


Geometry:

- Defined in config file
- Variable crossing angle
- Several magnetic field options: solenoid, (anti)DiD, fieldmap (so far only ILC format)

Mask parameters

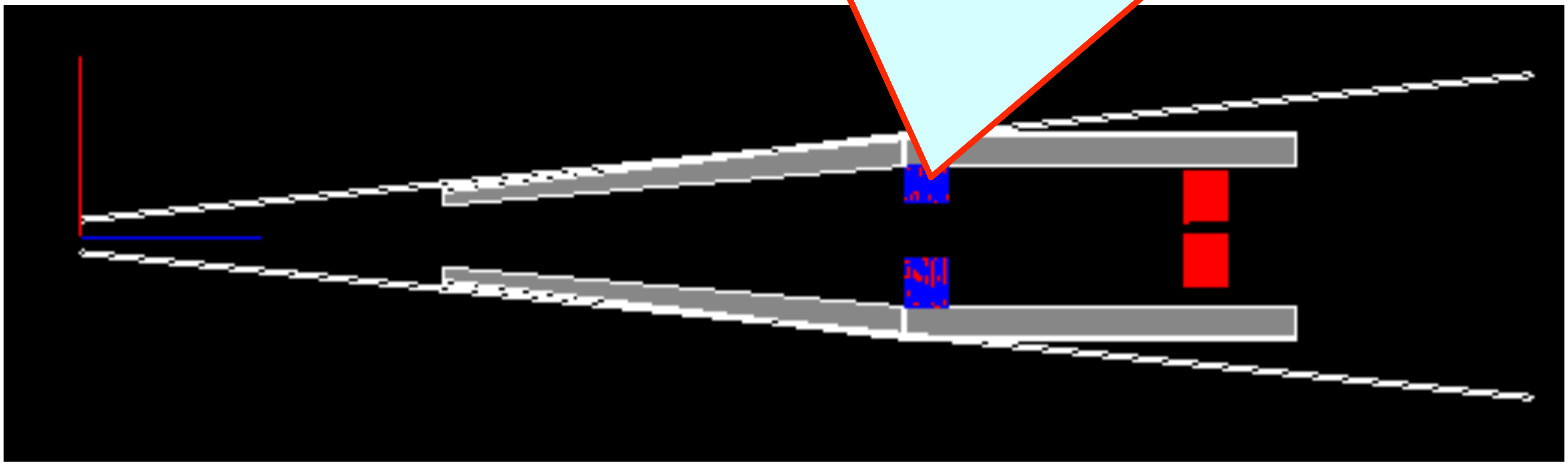
- **aligned to z (detector) axis**
- **starting point, z_start 1000 mm**
- **joint position, z_joint 2270 mm**
- **end point, z_end 3350 mm**
- **inner angle, theta_i 85 mrad**
- **outer angle, theta_m 120 mrad**
- **material: tungsten + polyethylene coating (<= 0 mm)**



Geometry:

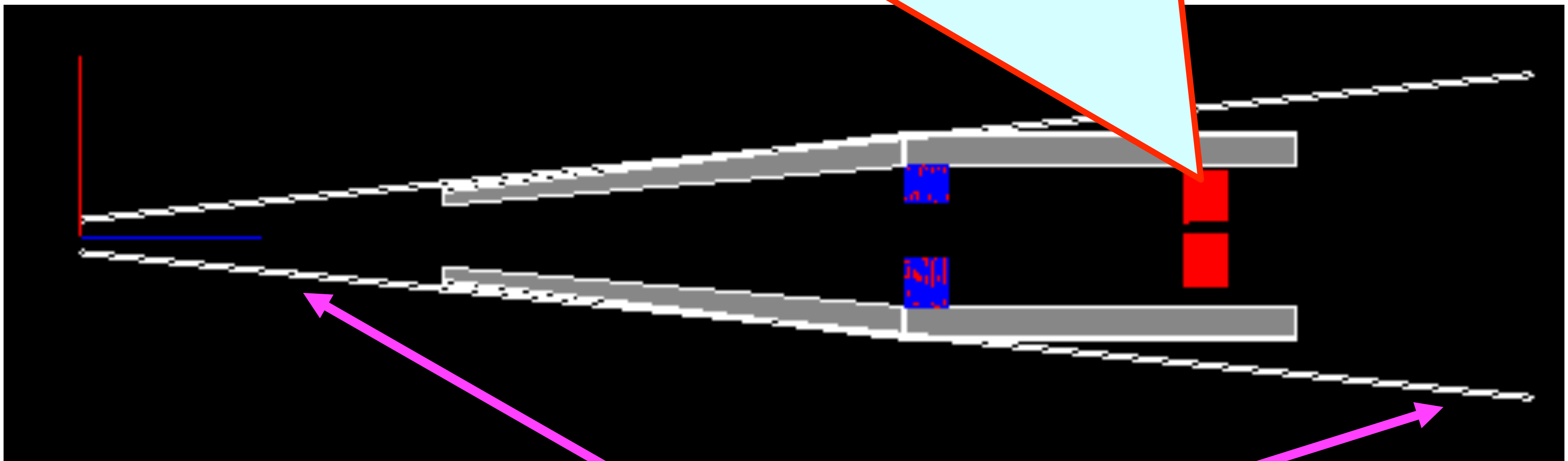
LumiCal parameters

- **aligned to outgoing beam axis**
- **5 cm of graphite in front**
- **number of layers n_lrs 30**
- **inner radius, r_inner 80 mm**
- **outer radius, r_outer limited by mask**
- **absorber thkns, d_abs 3.5 mm**
- **sensor thkns, d_sens 0.5 mm**
- **material: tungsten / silicon**



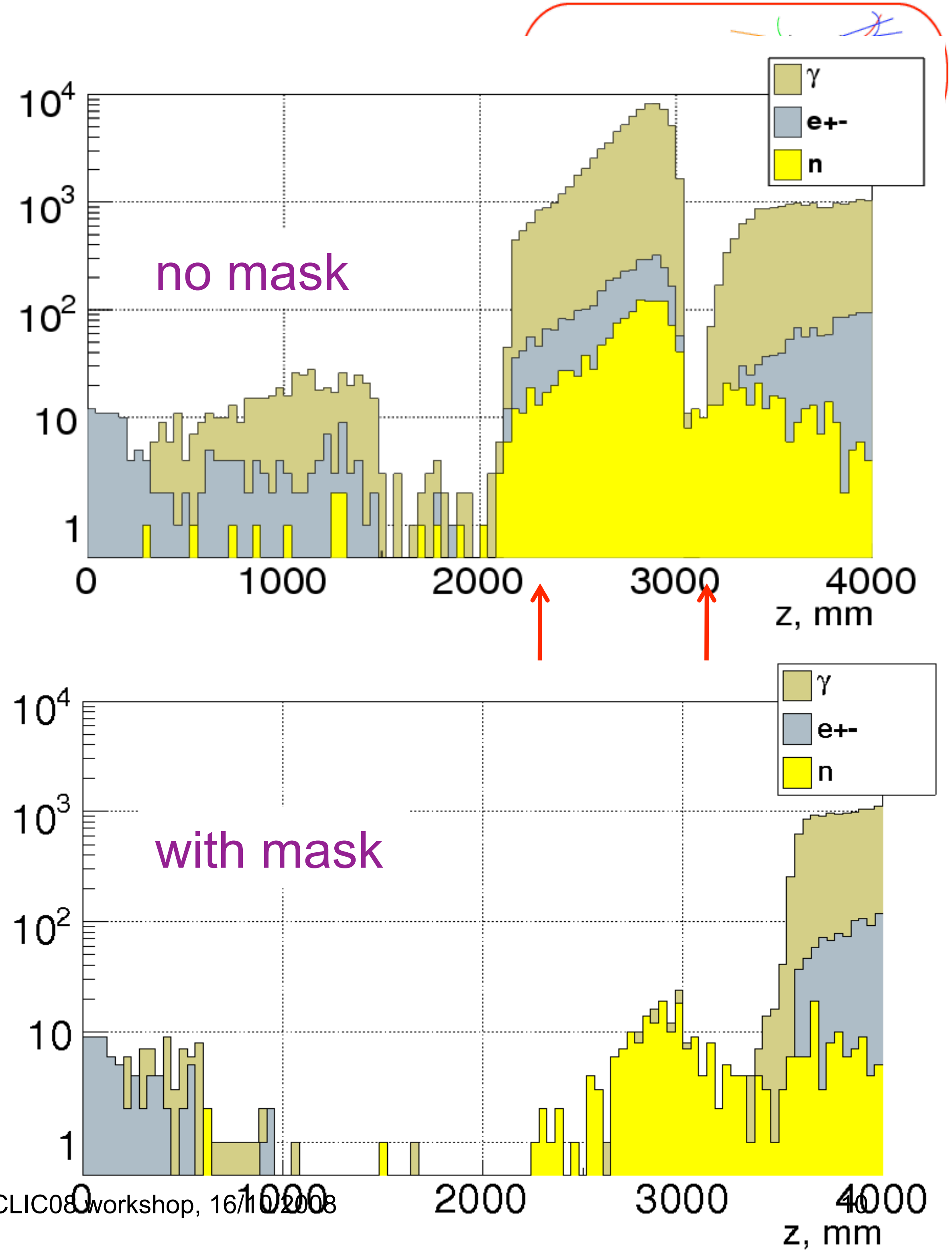
Geometry:
BeamCal parameters

- **aligned to outgoing beam axis**
- **number of layers, n_lrs 30**
- **distance from ip, z_pos 3100 mm**
- **inner radius, r_inner 20 mm**
- **outer radius, r_outer 160 mm**
- **absorber thkns, d_abs 3.5 mm**
- **sensor thkns, d_sens 0.5 mm**
- **material: tungsten / diamond**

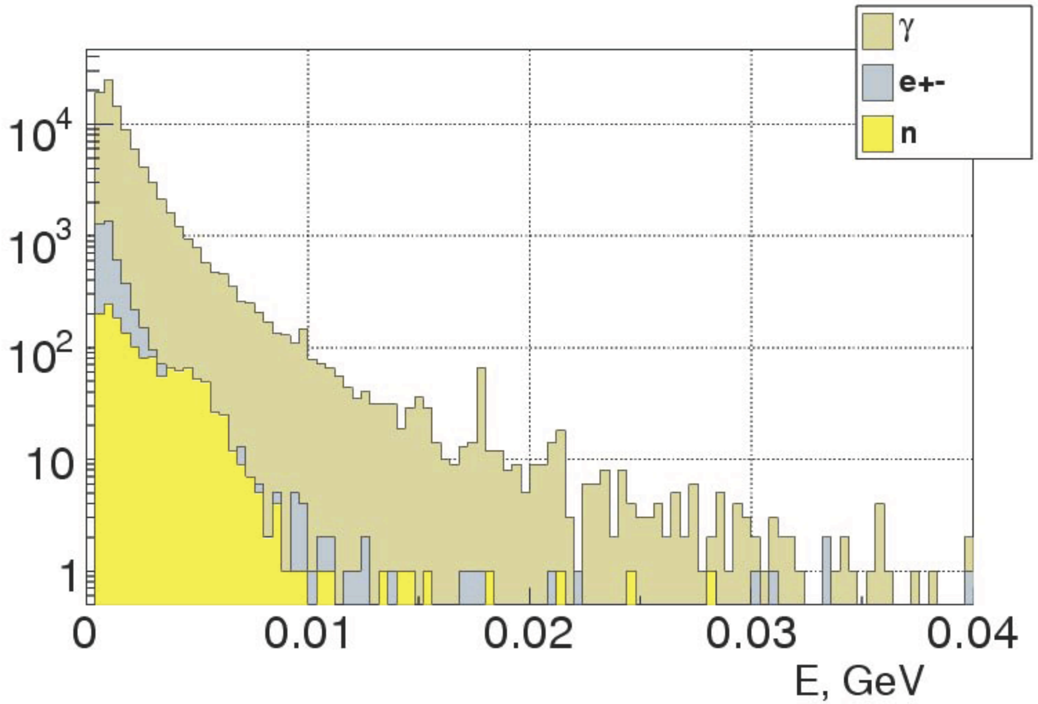


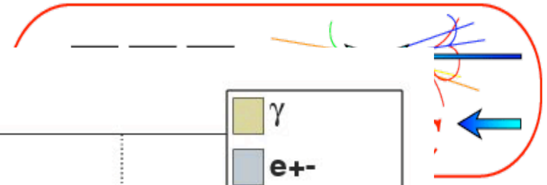
\+ dummy volume to catch the particles directed to tracker and calorimeter endcaps

Preliminary background studies:
mask effectiveness,
spatial distribution of background
hits in the dummy volume:



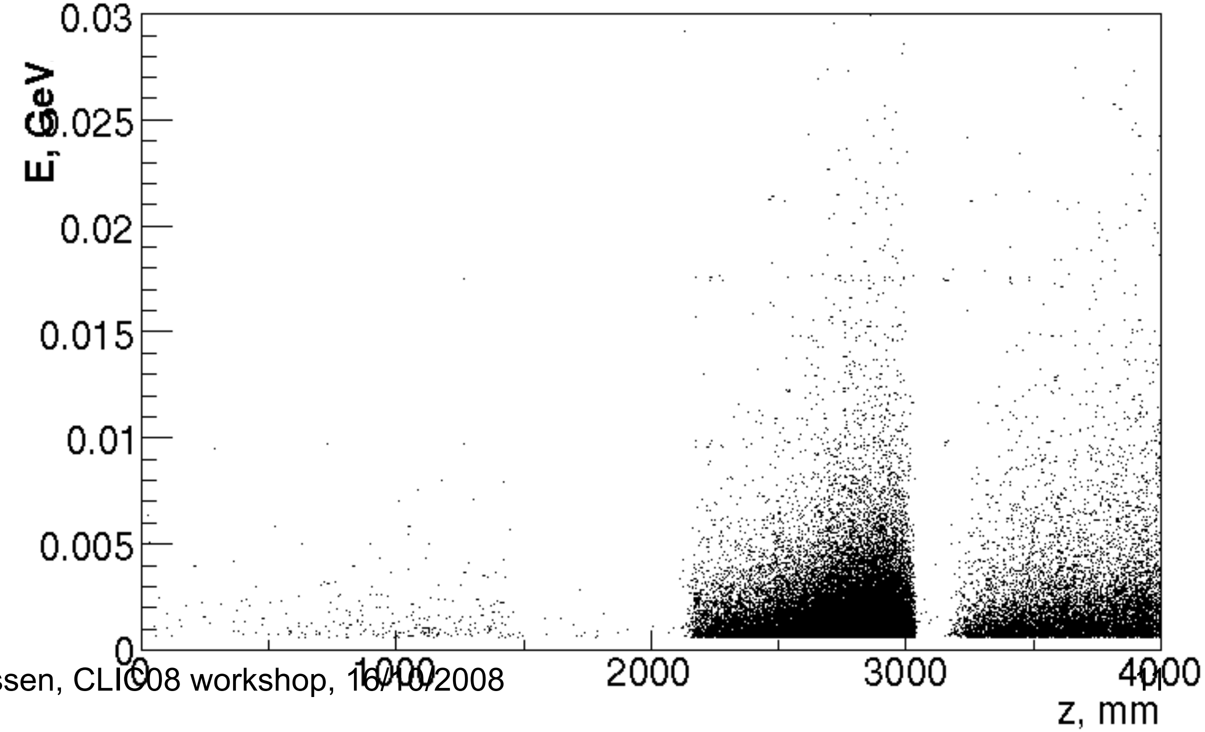
Background energy spectrum (without mask)



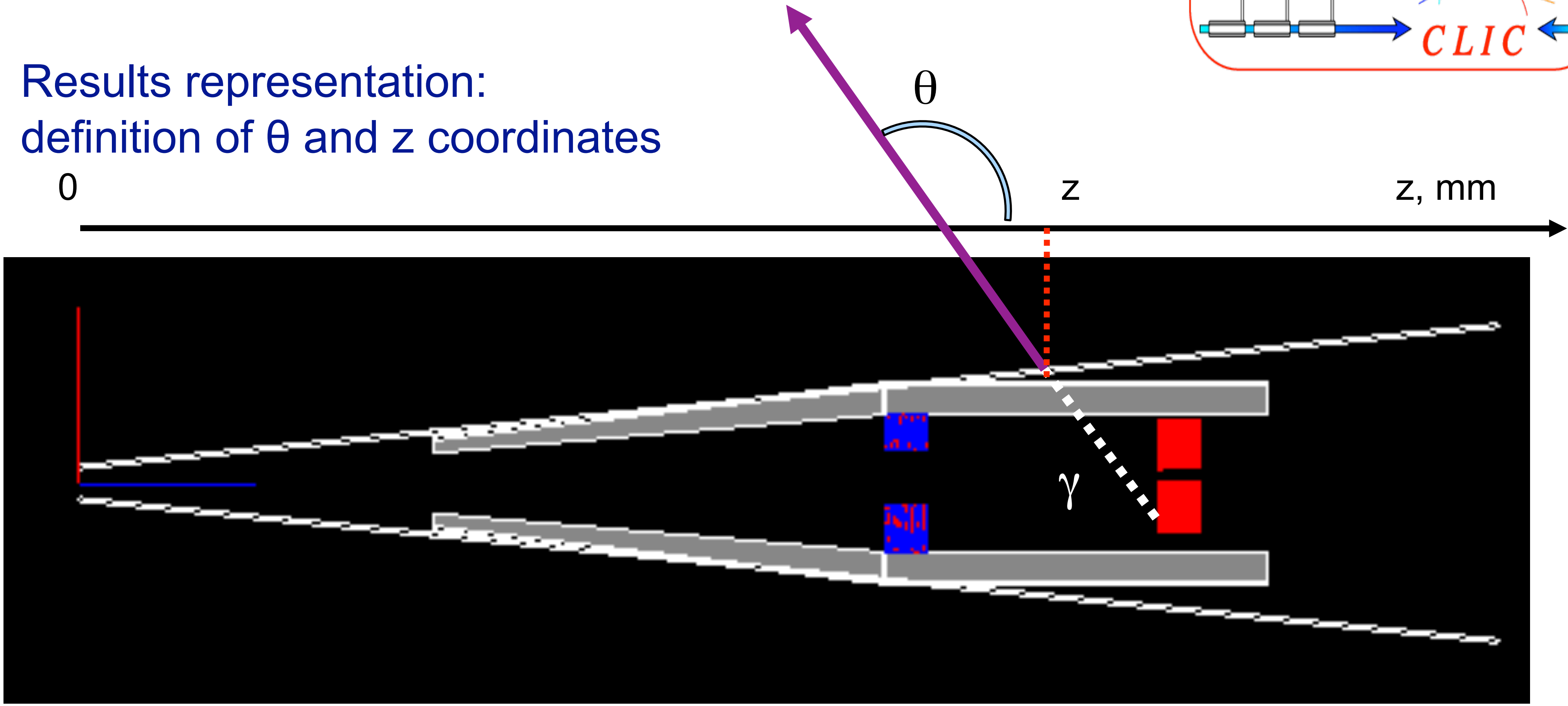


Energy vs Z

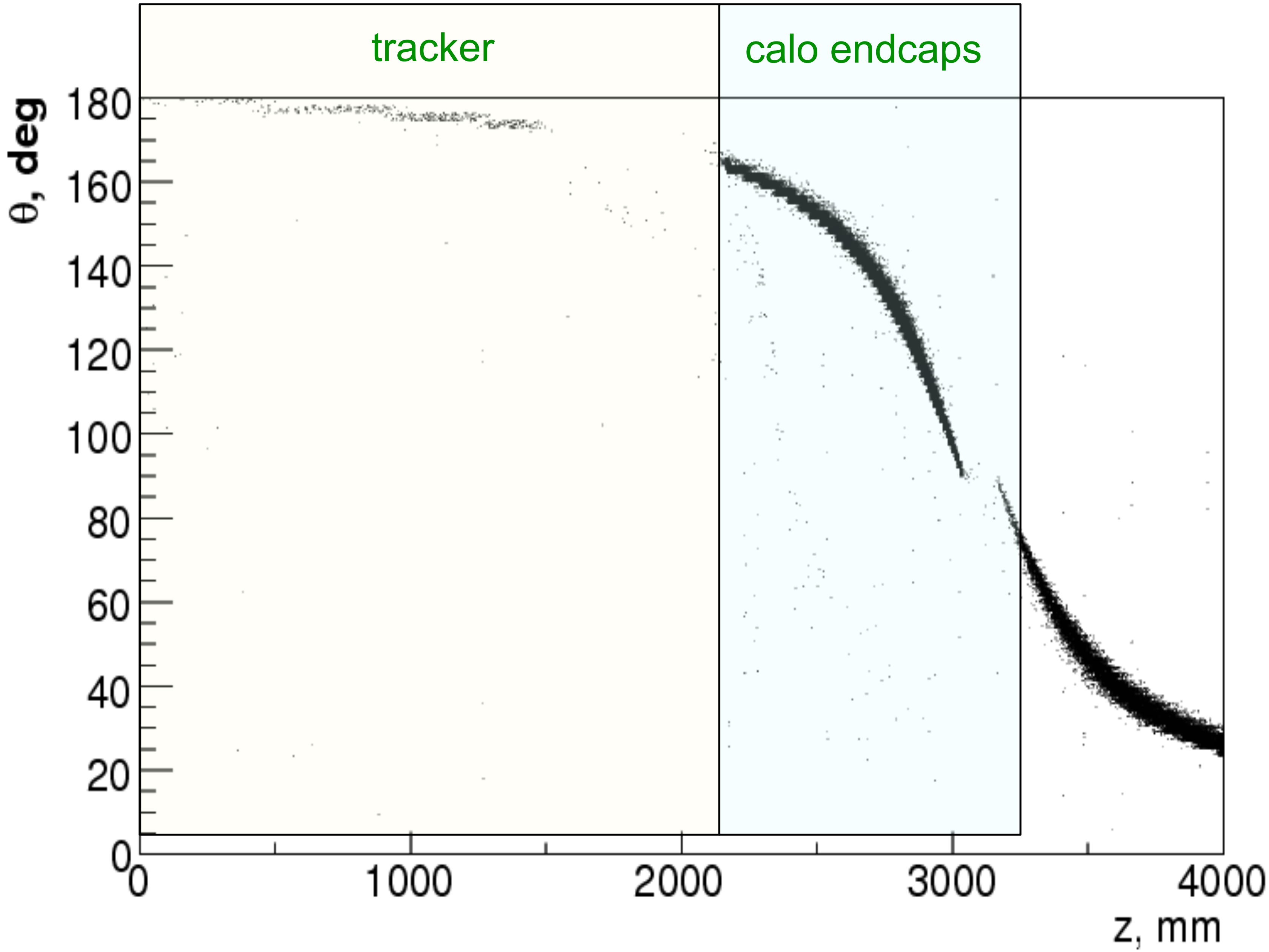
Photons (no mask)



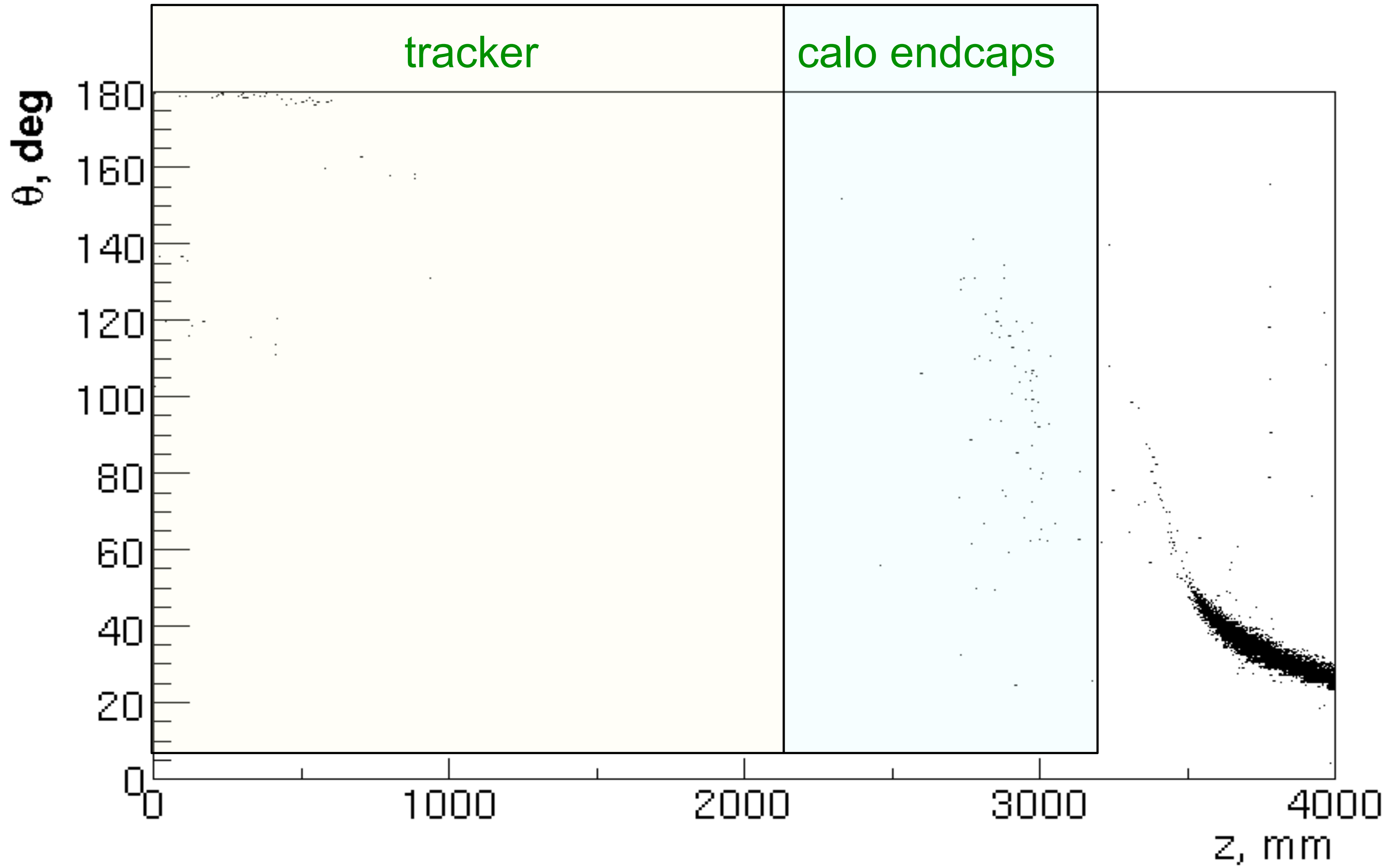
Results representation:
definition of θ and z coordinates



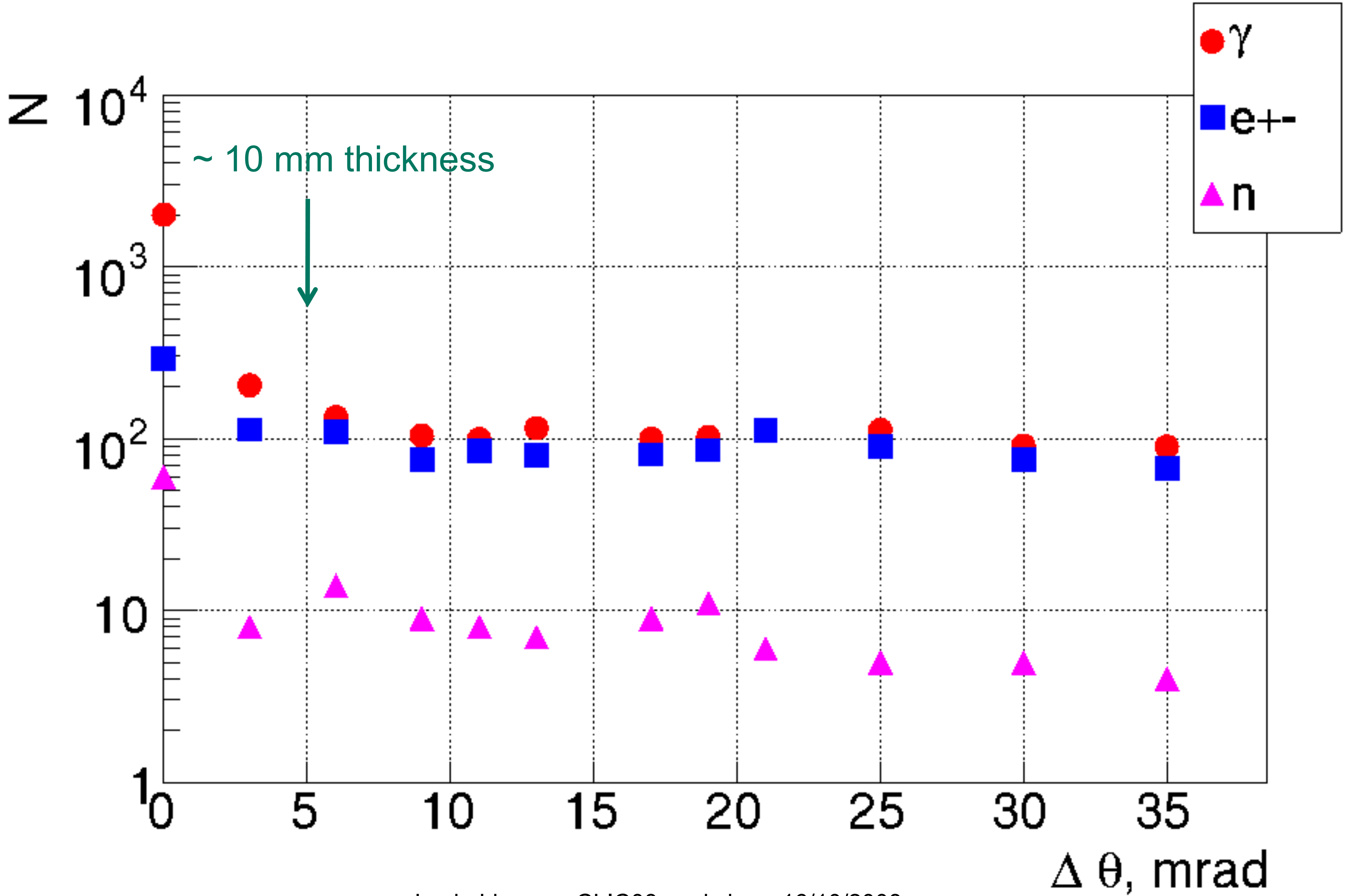
Theta-z scatterplot for photons no mask



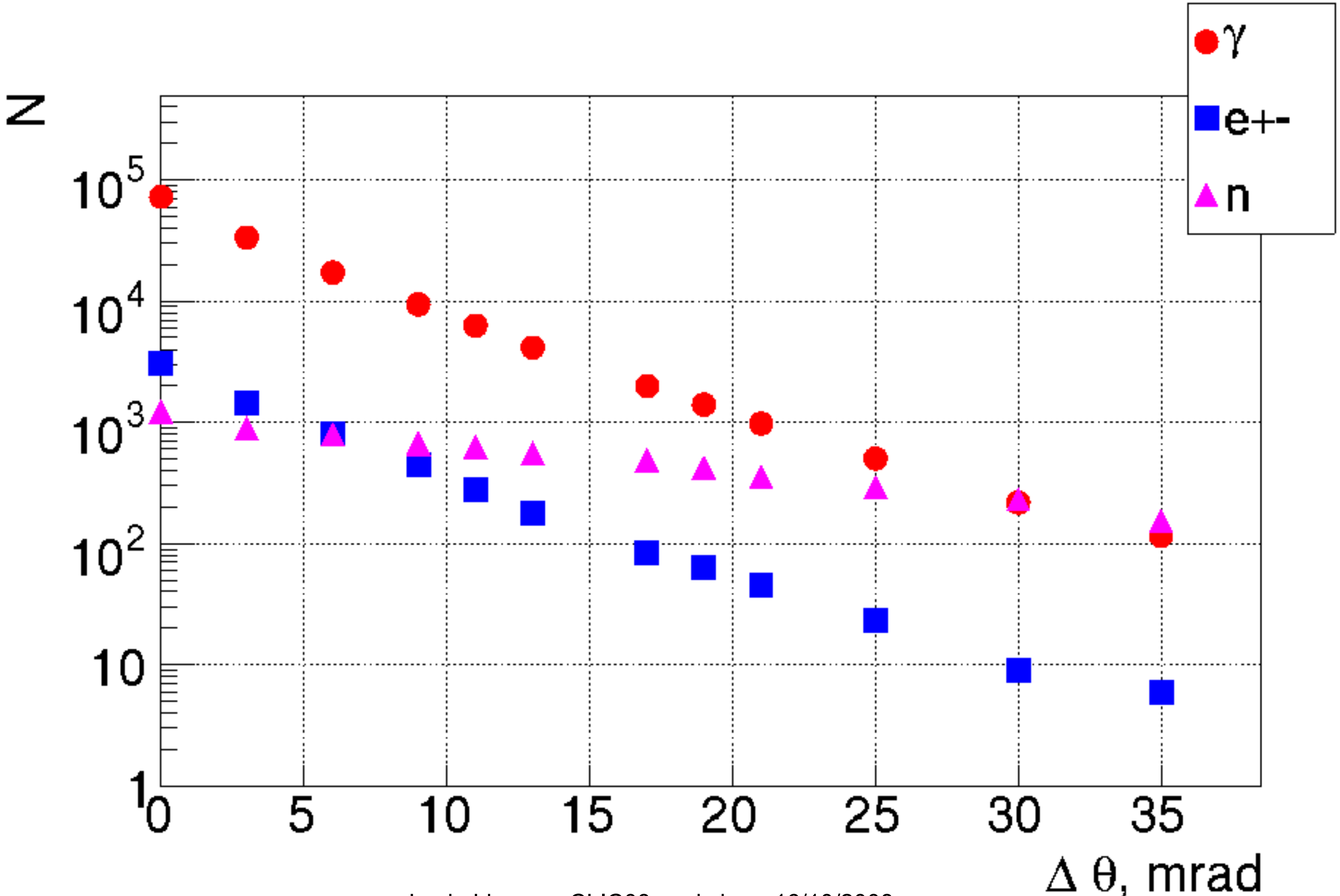
Theta-z scatterplot for photons with mask



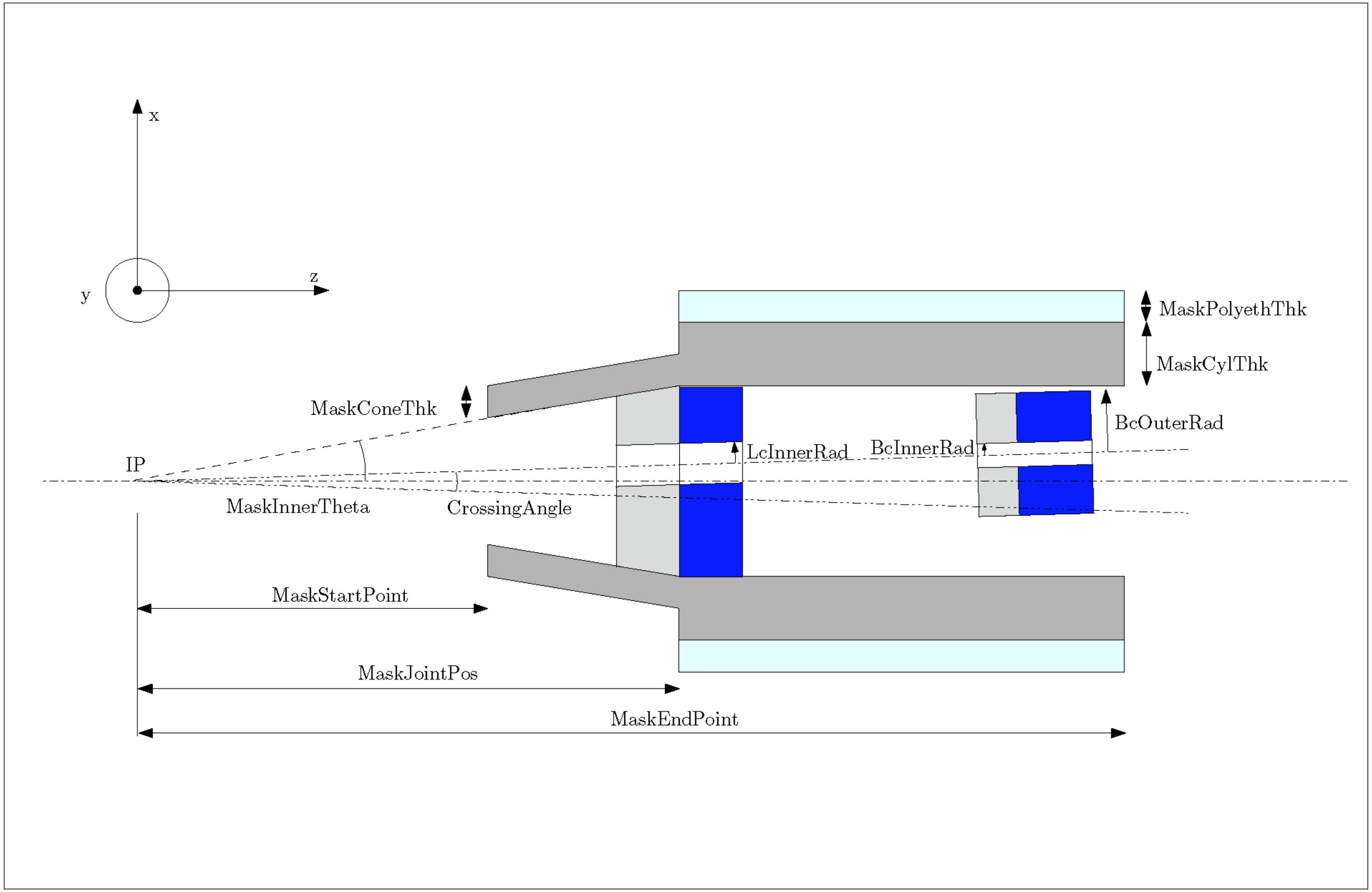
Number of particles going to the **tracker** depending on the mask opening angle ($\Delta\theta = \theta_{out} - \theta_{in}$)



Number of particles going to the **calorimeter** depending on the mask opening angle ($\Delta\theta = \theta_{out} - \theta_{in}$)



On the basis of the result, shown on the last 2 slides, Andrey changed the geometry of the mask.
He also added 5 cm graphite in front of BeamCal



Summary/conclusions of work done

- **Geant4 simulation** for forward region of the CLIC detector was set up
- It can be configured with relatively **variable geometry settings**

- **Preliminary background estimates** were made:
- The main tracker background goes through the mask opening, the rest can be stopped with much less material than intended.
- The EM compound of the background in calorimeters may be reduced relatively well, whereas the neutron shielding is not as effective.

Following first results, modifications to software were implemented:

•New mask geometry

•Carbon layer (5 cm) at front face of BeamCal

Next steps:

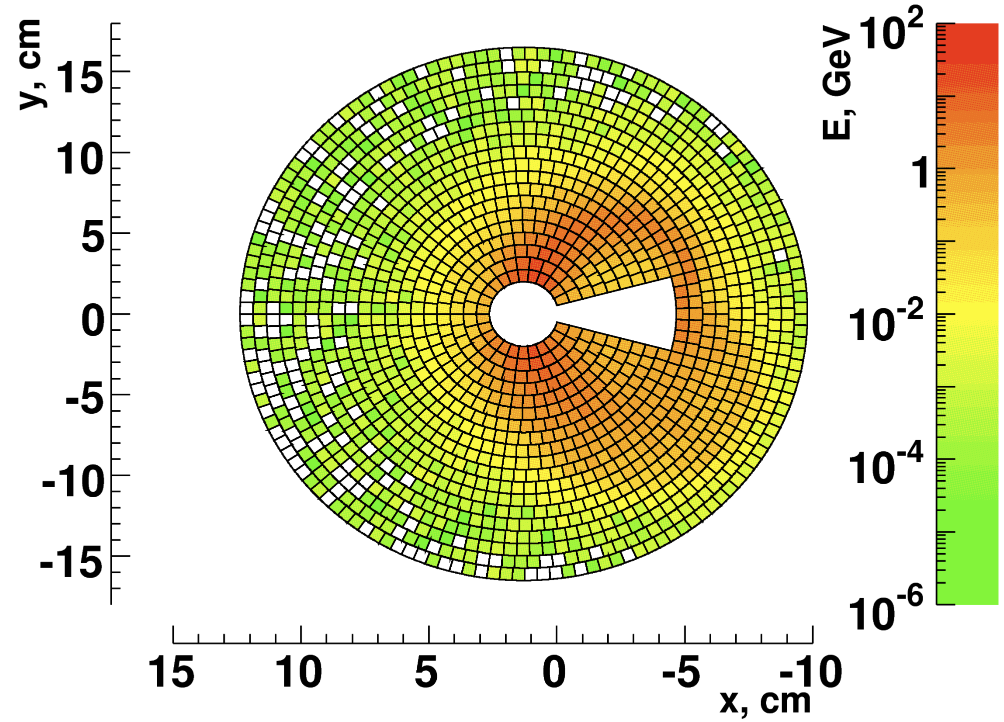
- Continue the **background studies with the new mask geometry**
  - Perform studies as a function of polyethylene coating thickness
  - Numerical results (absolute values of reduction and of #background left, occupancy)
  - Look into optimal extension of conical part to protect the vertex detector
  - Remnants at high-z values. Do they affect accelerator instrumentation?
  - Vary the inner radius of BeamCal (10 mrad?)
  - Include the beam pipe
  - Calculate radiation levels
- The spatial energy distribution of the **beamstrahlung background at the BeamCal face** plane for different magnetic field types at 20 mrad crossing angle => Will allow to see whether there is a lot of background in the incoming beam region and how it is distributed.
- Can **BeamCal** be used **for machine/luminosity feedback at CLIC ?**
- Functionality and optimisation of **LumiCal at CLIC**

Thank you !

Spare slides

ILC example

20 mrad, DiD



14 mrad, antiDiD