Cerenkov Detectors for LUXE Compton System

Ruth Jacobs

LUXE technical meeting
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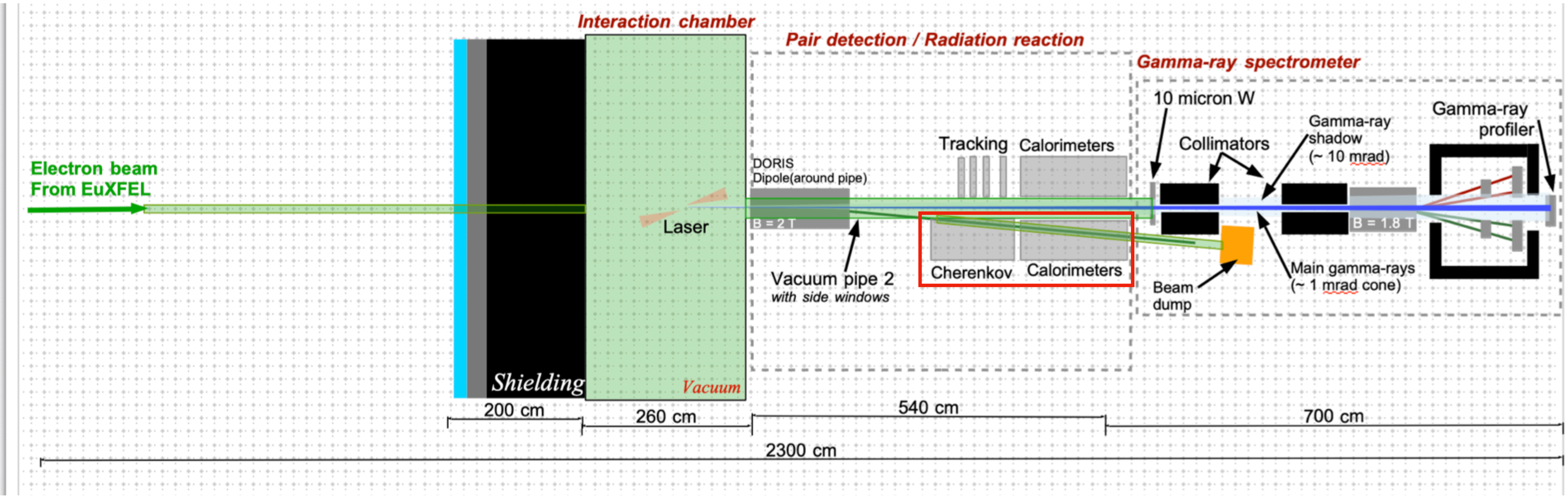
Introduction

LUXE Trident setup



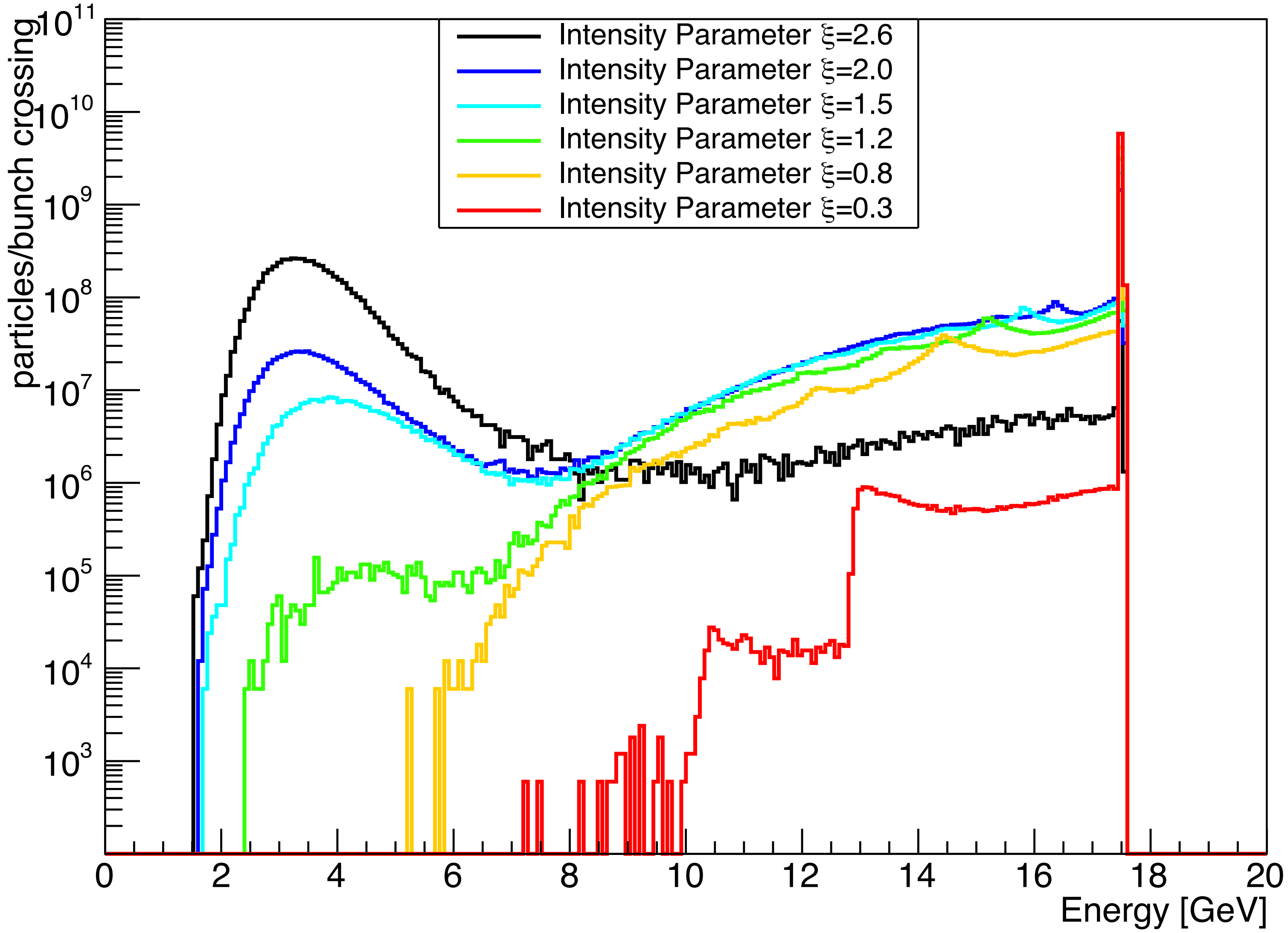
Initial Brems spectrometer in LUXE:

- precise knowledge of Brems spectrum important for LUXE measurements
- principle: - dipole magnet spectrometer (2T)

  - e^+/e^- from interaction of XFEL electron beam with target
    → energy spectrum directly related to photon spectrum

  - count e^+/e^- as function of displacement in spectrometer (→ energy!)
    → segmented Cerenkov counters

What do we measure?

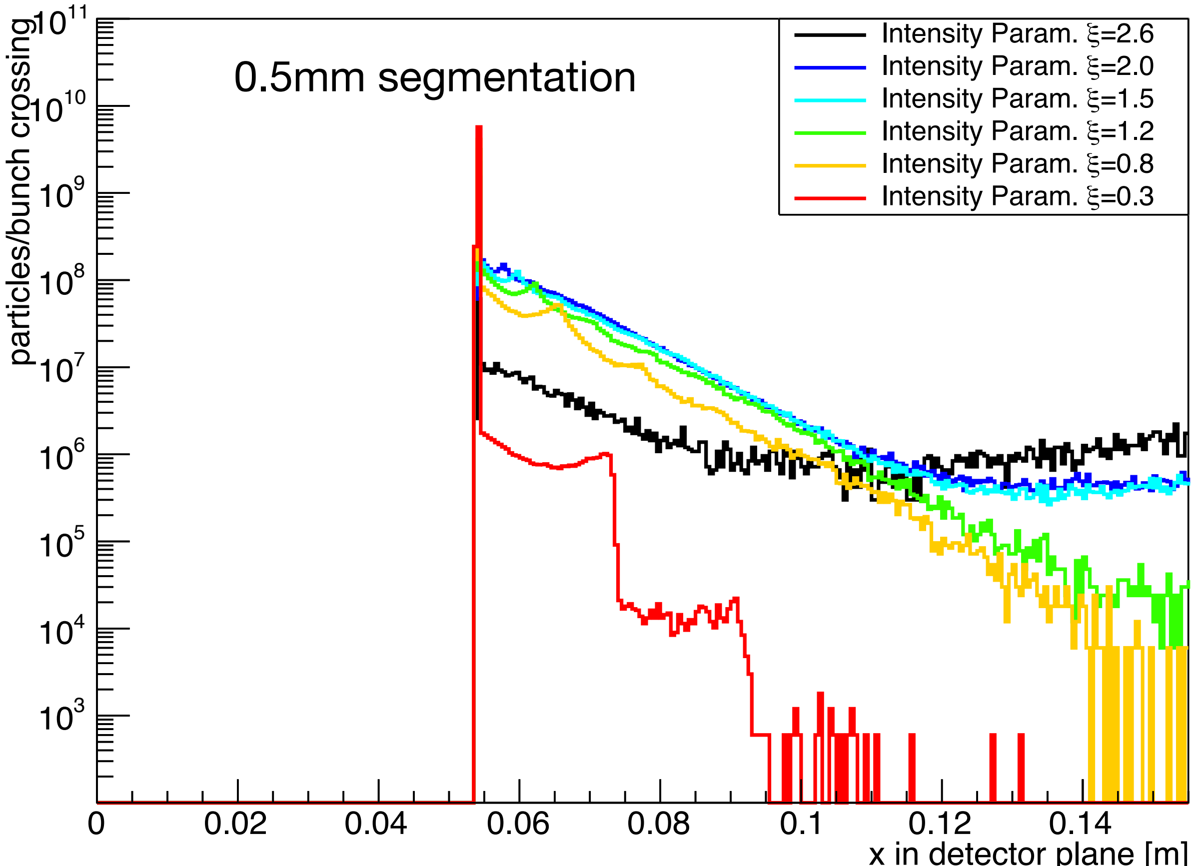


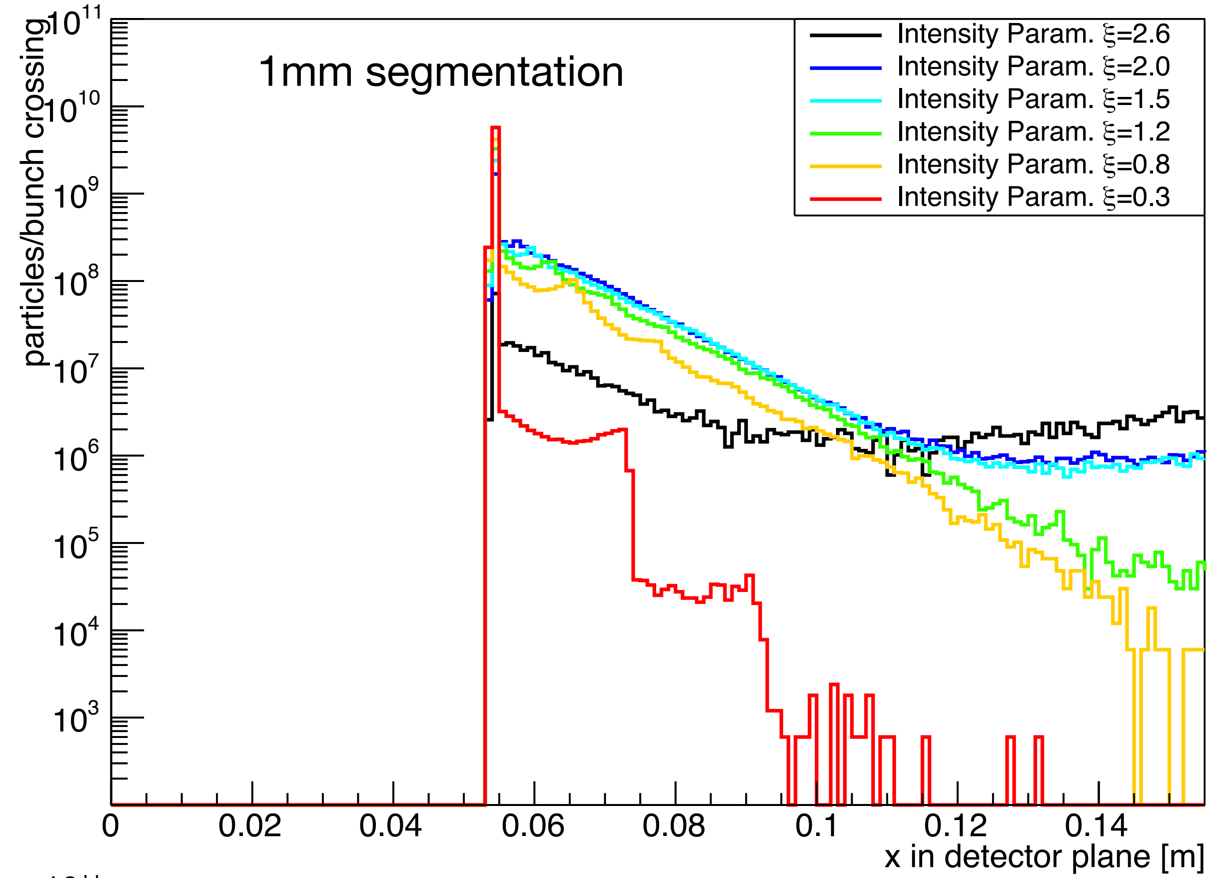
Compton- Electrons in LUXE:

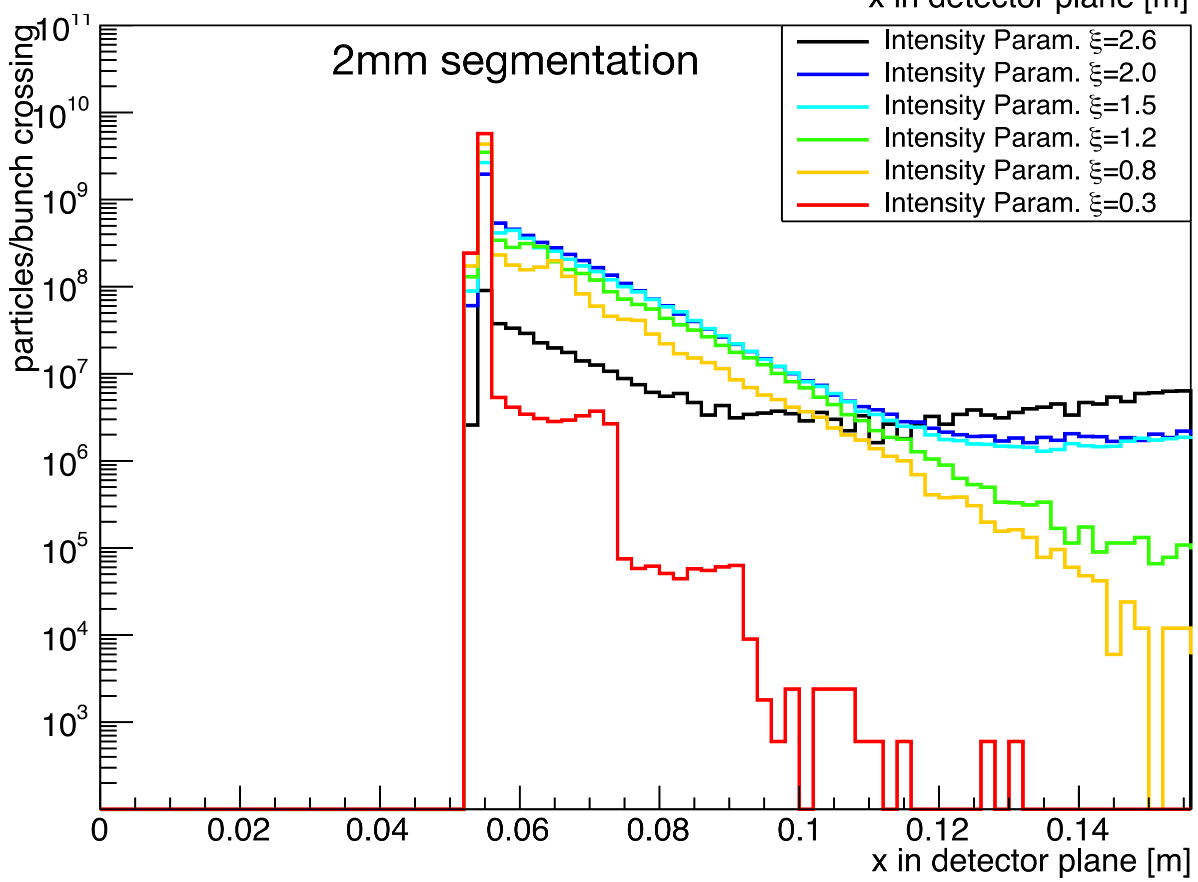
- 1) Linear Compton Scattering: - need to demonstrate that we can measure Compton spectrum
  - use for alignment?
- 2) Non-linear Compton Scattering: - measure higher-order edges
- 3) Trident electrons: - probably not many/case for the Scintillators?

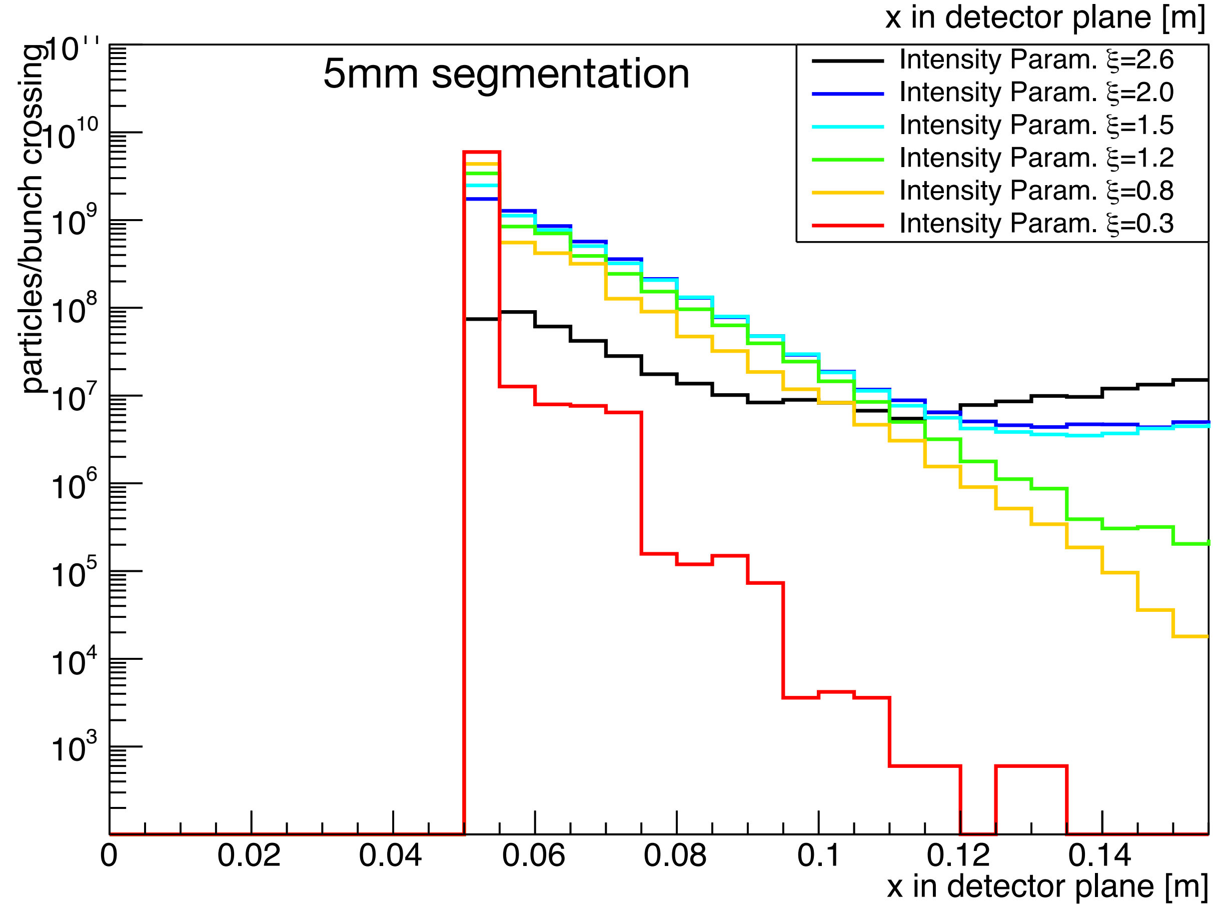
Segmentation

2T Magnet
distance IP-magnet 1.35m
distance magnet-detector 0.92m





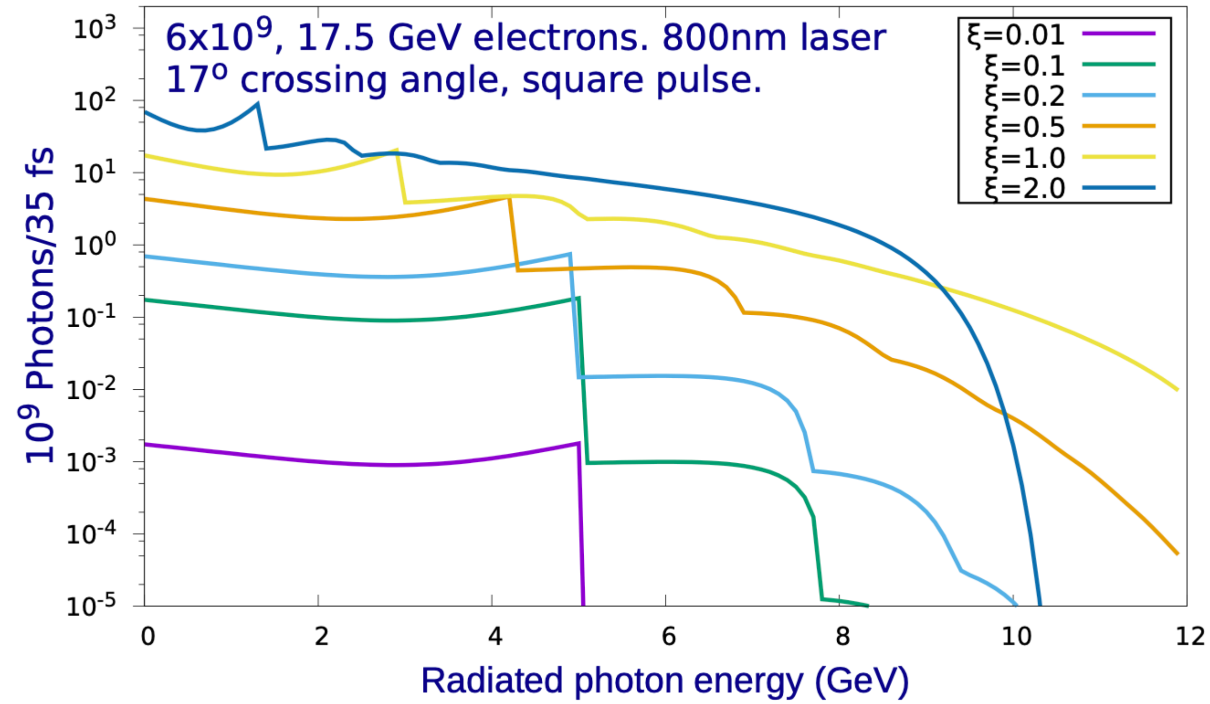




Possible Objectives

1.) Shift of the first compton edge

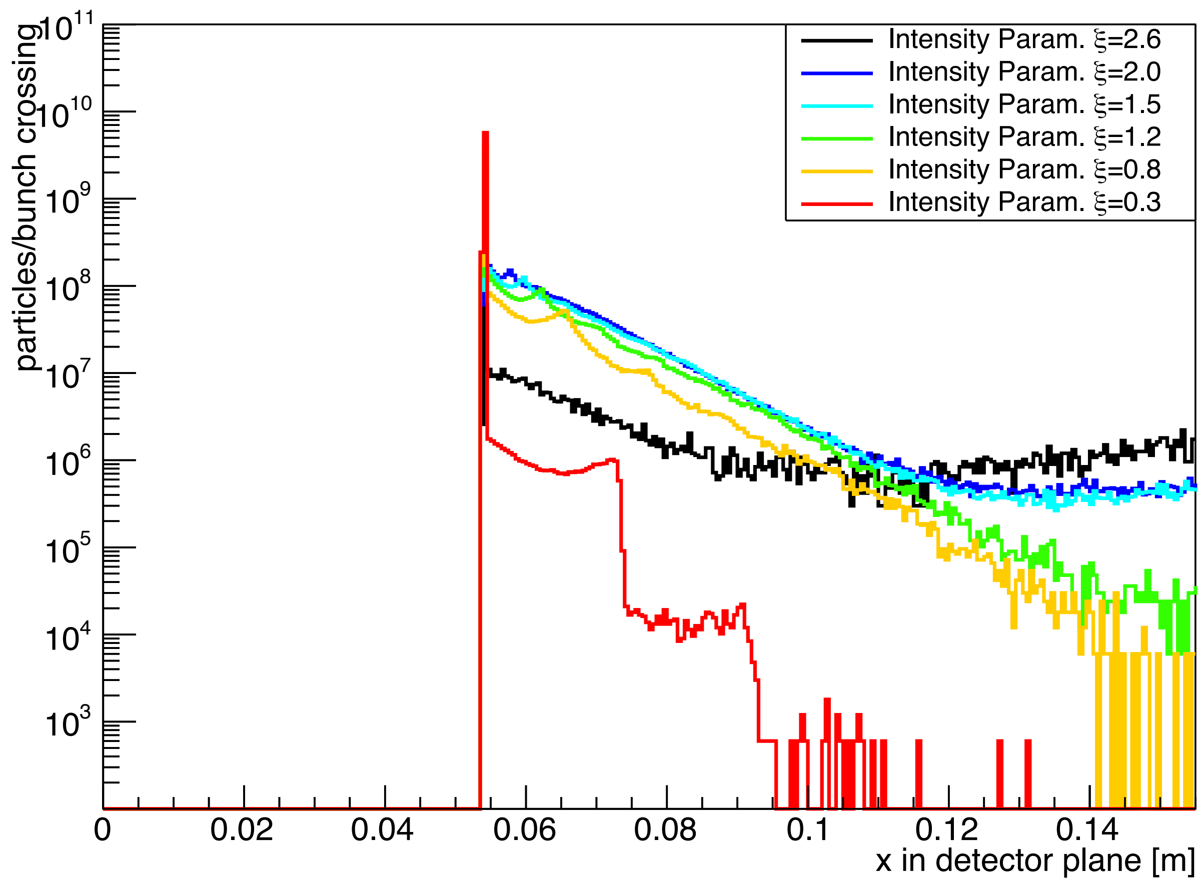
- resolve position of first compton edge
- demonstrate $1/\sqrt{1+\xi^2}$ behaviour



2.) Resolve higher-order edges

- proof-of-principle: may be enough to resolve jumps in rate?

To resolve edges, looks like we can do with a small, finely segmented detector.



Compton Edge Finding

- edge will be smeared out by finite detector resolution
- need to find a good estimate of the edge position

1.) Half-Max position

- fit the peak and find half-maximum position
- possible for low-ξ (linear compton)
- for non-linear compton this does not work as easily

2.) Differentiate!

- use the point of minimum slope (turning point) as estimate for the edge

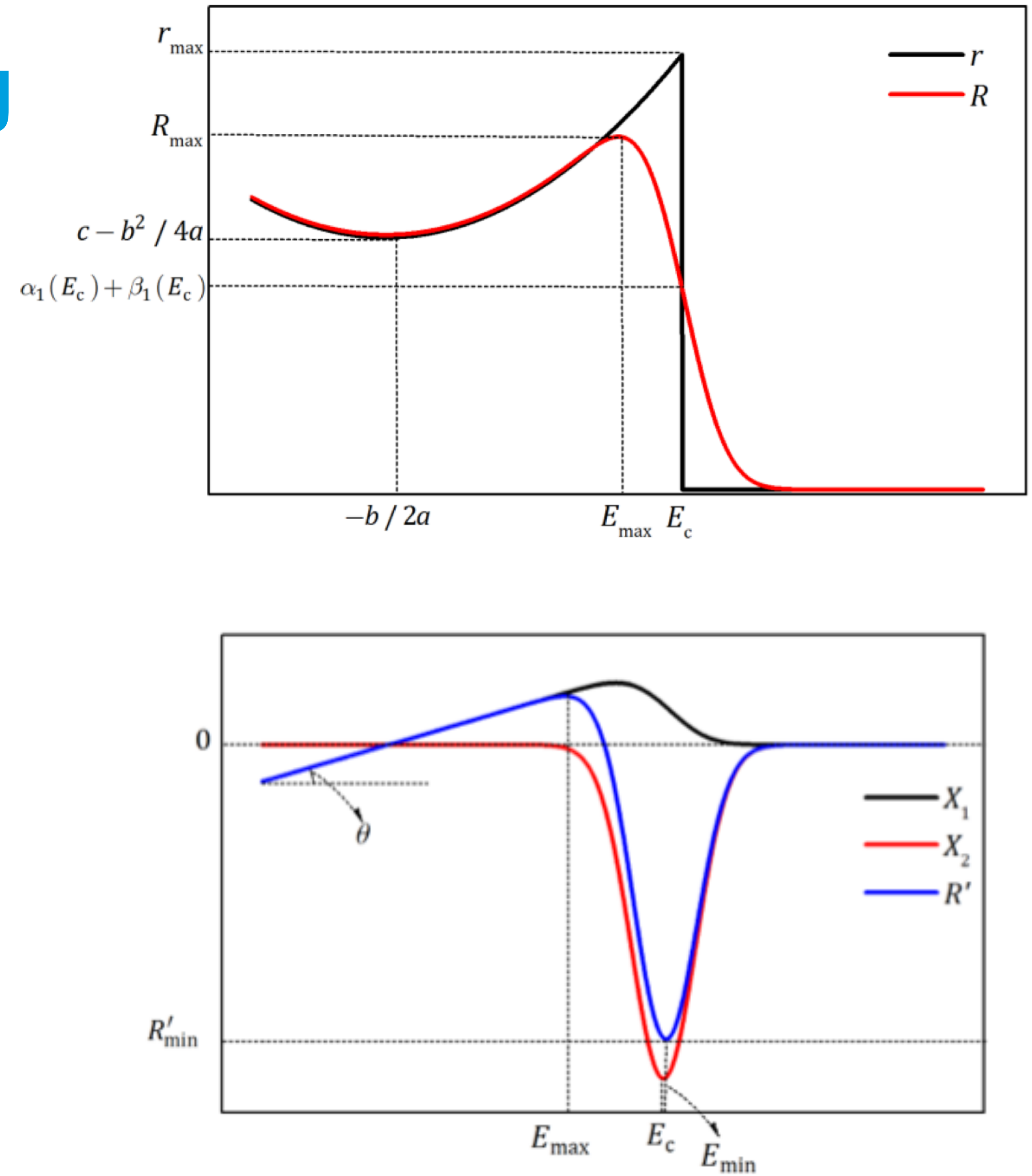


Figure 2. Differentiation of the ideal and the real response functions

Differentiation method for localization of Compton edge in organic scintillation detectors

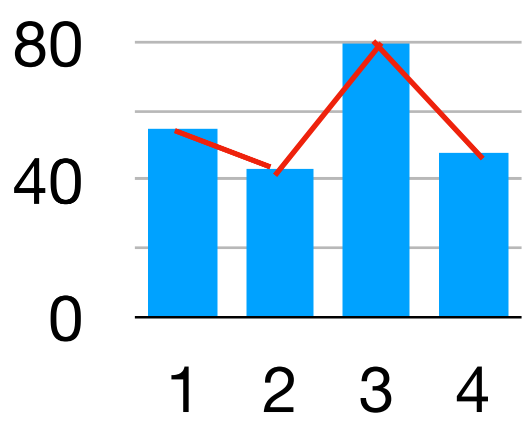
M.J. Safari*[1], F. Abbasi Davani[2], H. Afarideh[1]

[1]Department of Energy Engineering and Physics, Amir Kabir University of Technology, PO Box 15875-4413, Tehran, Iran
[2]Radiation Application Department, Shahid Beheshti University, PO Box 1983963113, Tehran, Iran
*email: mjsafari@aut.ac.ir

Edge Finding?

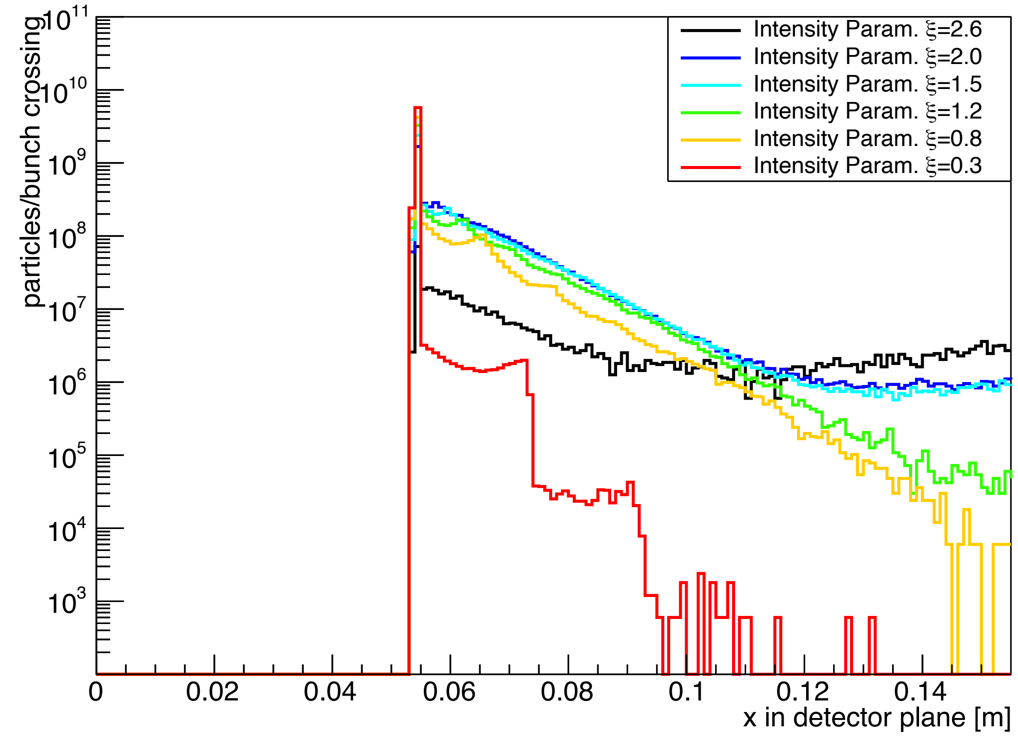
Differentiation Prescription (super crude, just to demonstrate)

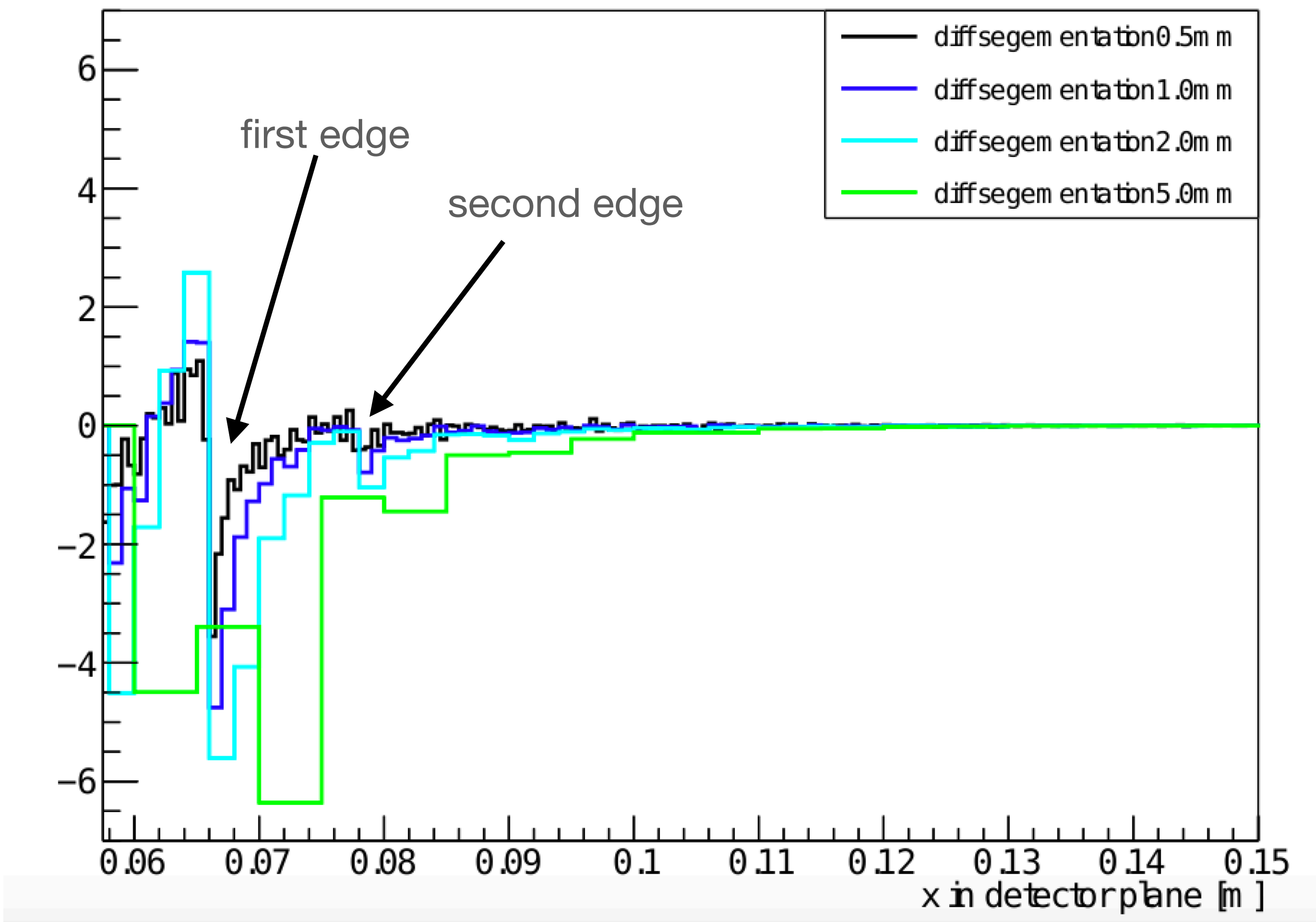
- get electron x distribution
- calculate slope bin-by-bin



- find the bin with minimum slope → edge

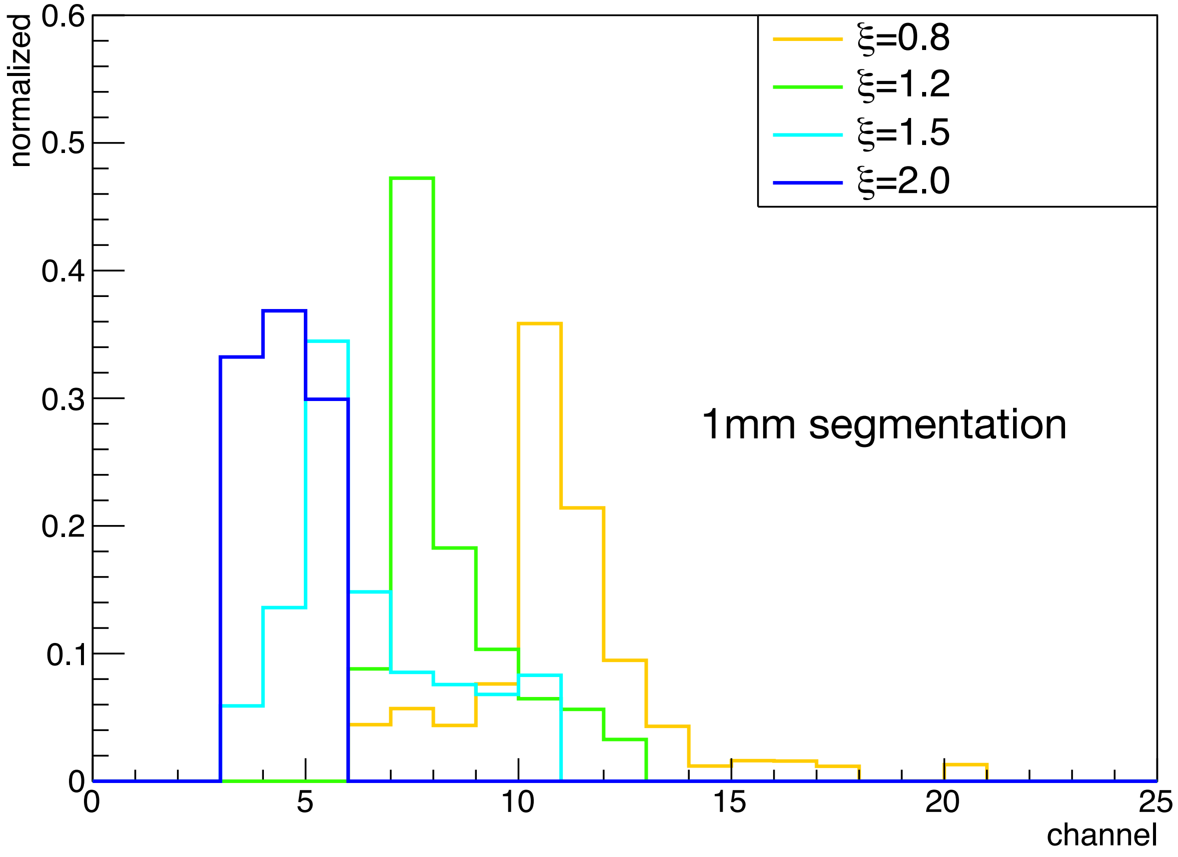
- in reality need to define a window where to look for the first edge
- for high xi this gets difficult, as you get closer to the beam

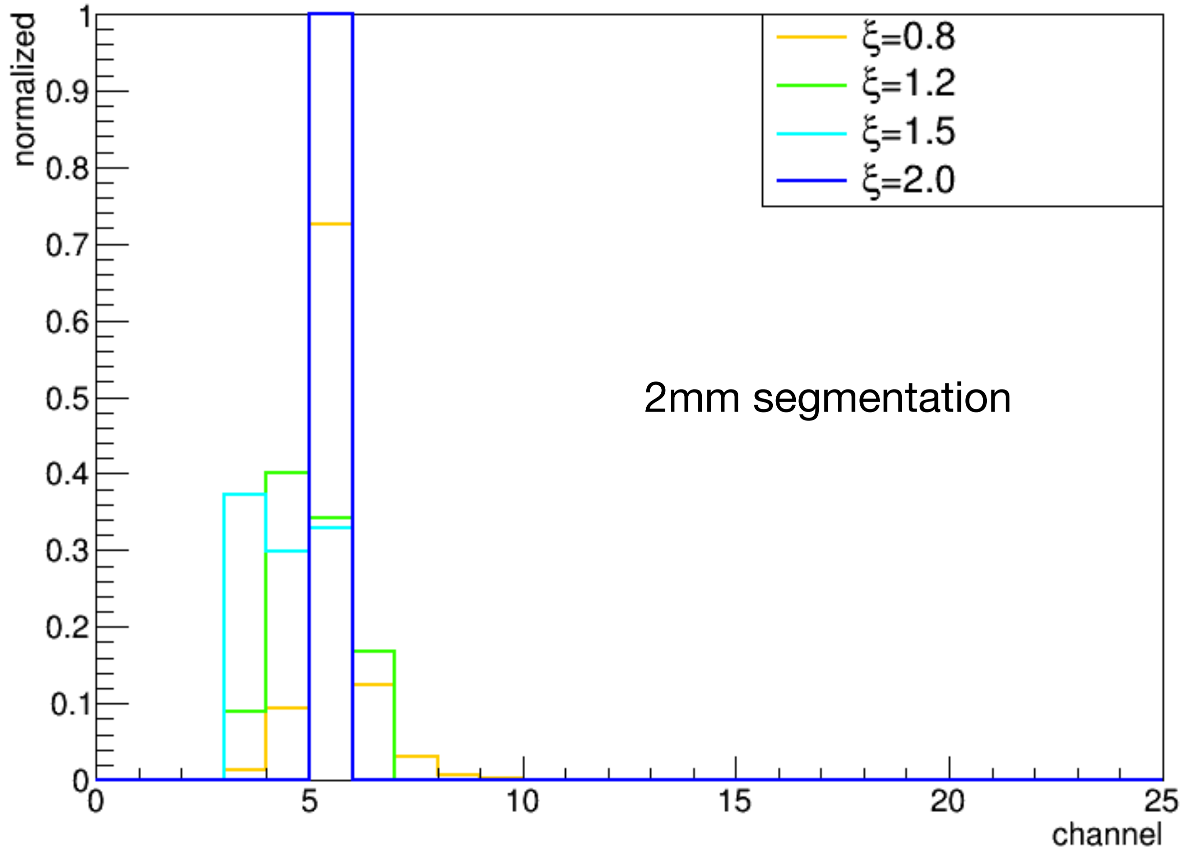




The width of the minimum (i.e. error) depends on the segmentation!

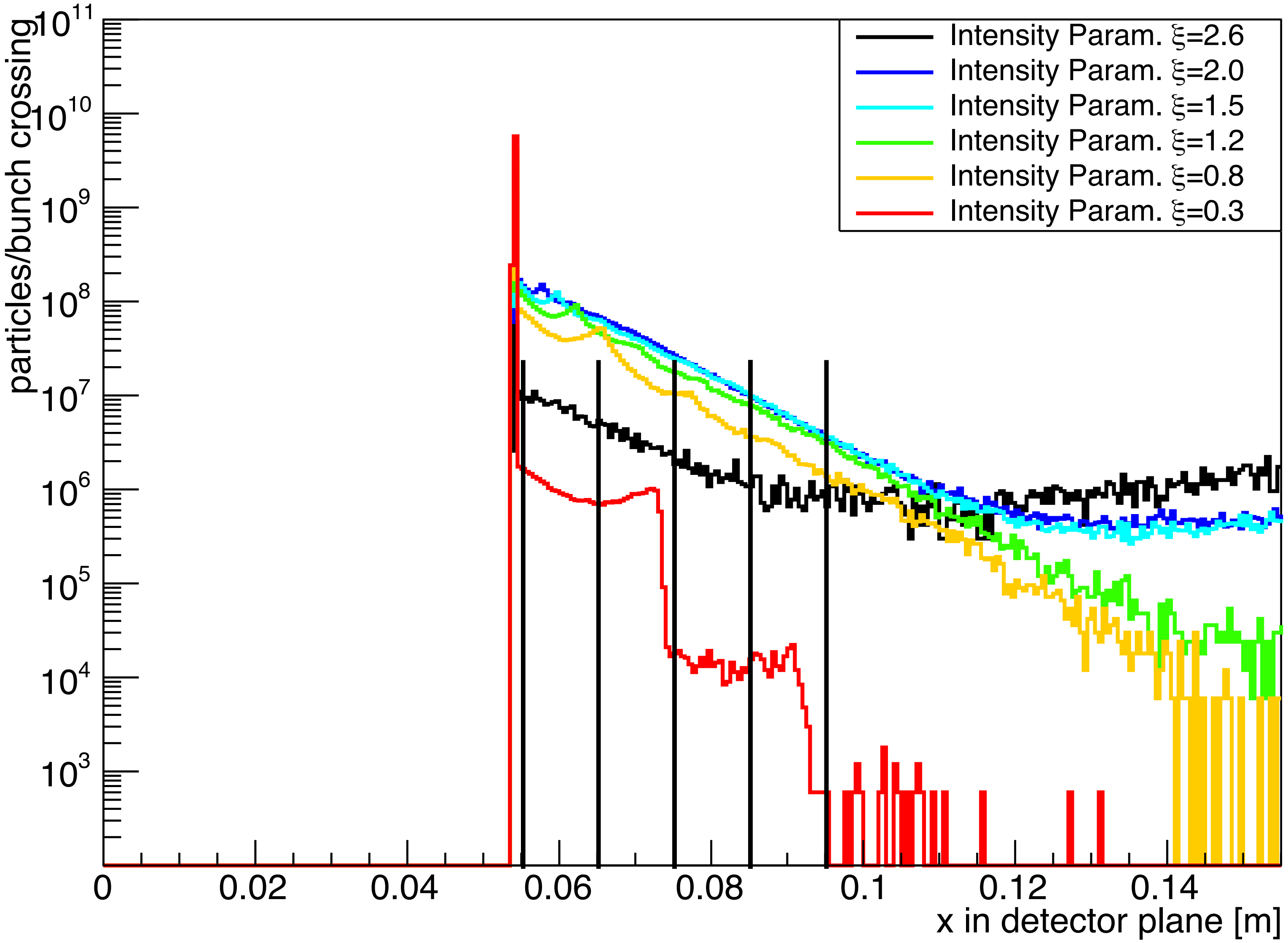
Toy study: First Edge finding





- run lcpolmc emulation with different segmentations
- take QDC count distributions from each channel, fit, determine mean and sigma
- throw 10000 toys based on this
- differentiate and find the minimum slope in first edge region
  → Edge position
- 1mm channels can resolve edge up to ξ=1.2
  2mm channels can resolve edge up to ξ=0.8
- 1mm channel width probably also technically (anode PMT segmentation!) is as low as we can go!

Alternative?

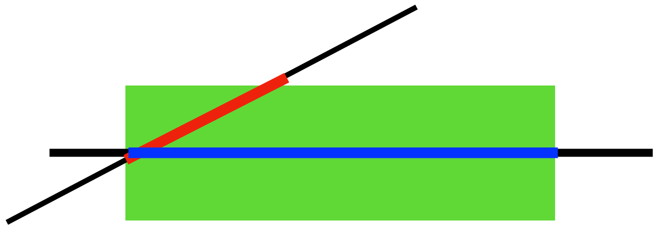


- coarser detector of 10x10mm or 5x5mm channels
- monitor the ratio between different orders
- could use “small version” of a few channels of Brems detector

Some thoughts about Alignment

Need for Alignment:

- main problem: detector tilt (tilt → less distance traversed in channel, less Cerenkov photons)
- for Brems setup we are less affected, have almost “square” channels
- for Compton setup we want to be more finely segmented in x
- current design with a planar detector: particles will enter at an angle in any case (for Trident ≤5°, for Brems ≤45° (!)) → emulate?



Use the linear Compton spectrum at low LASER intensity to align the detector?

- if the spectrum is well known we can use it to align/calibrate our detector
  → dedicated linear compton runs?
- can calibrate/linearize the photodetector independently using calibration LEDs
- for polarimetry setup in TB, used finely segmented Photodetectors to measure asymmetries in light distribution
  → could work for Brems setup (coarser), but for Compton, segmentation is limited by PMT anode
- cross-calibrate with the Scintillators/Tracker/Forward photon spectrometer?
- Ideas for montoring the alignment during LUXE runs?

Summary

Cerenkov Detectors for Compton:

- objective could be to resolve Compton edges
- for this, need a small, finely segmented detector (with current geometry)
- 1mm segmentation: can resolve edges up to xi=1.5

<u>Drawbacks:</u>

- at the limit of what we can do with segmented anode PMTs (min. anode width 0.8mm)
- would mean extra detector (albeit a small one :))

<u>Alternative:</u>

- double-use Cerenkov with coarse segmenation, just monitoring the ratios of rates of different order

Alignment

- correct channel tilt
- polarimetry: use segmented anode PMTs to measure light distribution across channel
  → might be problematic for finely segmented channels
- we naturally have particles coming in at an angle
- use linear compton spectrum for calibration