

# **Converted and nonconverted photons in the TPOL calorimeter**

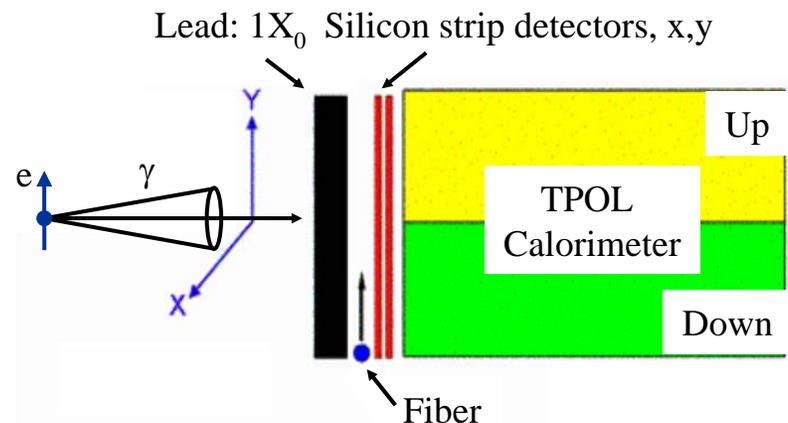
**Measuring differences in data and comparison to GEANT  
expectations**

Blanka Sobloher  
POL2000 meeting, 26th February 2008

# The case - converted and nonconverted photons

- Preradiator of  $1X_0$  of lead causes 54% of the Compton photons to convert
  - Conversion is necessary to get charged particles measurable by silicon planes
  - An eta-y (or average energy response) measured with combined silicon and calorimeter data is therefore representative for the case of some special converted photons
- **Is there a difference between converted and nonconverted photons?**
  - Any difference should have a direct influence on the way we model our data
  - This would include estimations of an Analyzing Power using some eta-y
  - Induces need of extrapolation of a 'silicon eta-y' to a 'polarimeter eta-y'

➤ **If so, can this difference be estimated and used for an extrapolation to the polarimeter case?**



# Case study - Compton edges in a table scan

- Choosing different cuts
  - No clusters: enrich nonconverted photons
  - Many clusters: enrich converted photons
  - No cuts at all: full mixture of converted and nonconverted photons

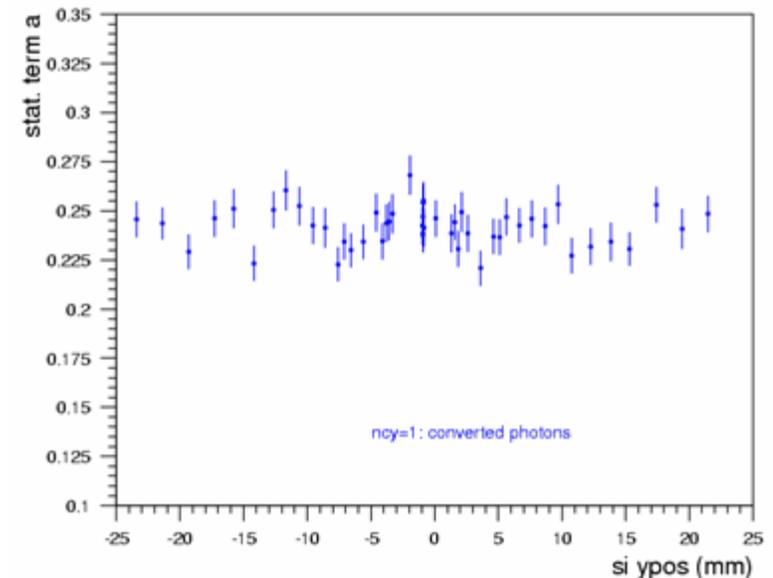
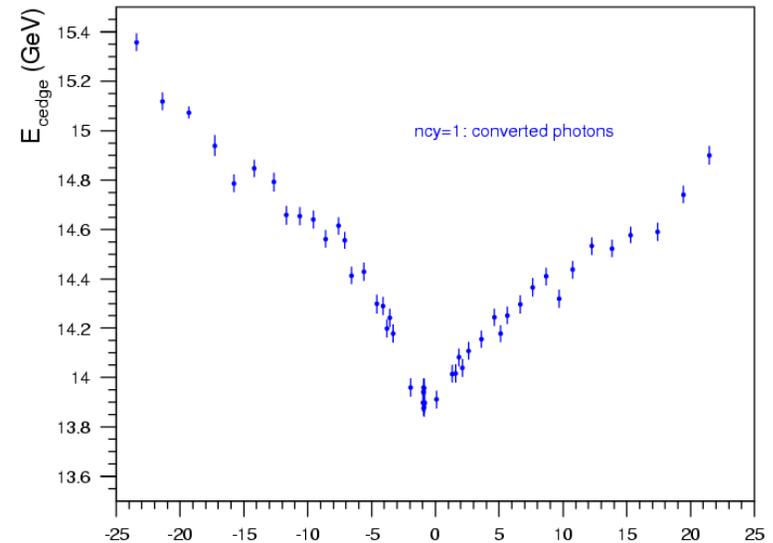
➤ Compton edges are moving!

- Fit of Compton edge

- Convolved Compton spectrum with resolution (only statistical term)

$$\frac{\sigma}{E} = \frac{a}{\sqrt{E}}$$

➤ Resolution also changes



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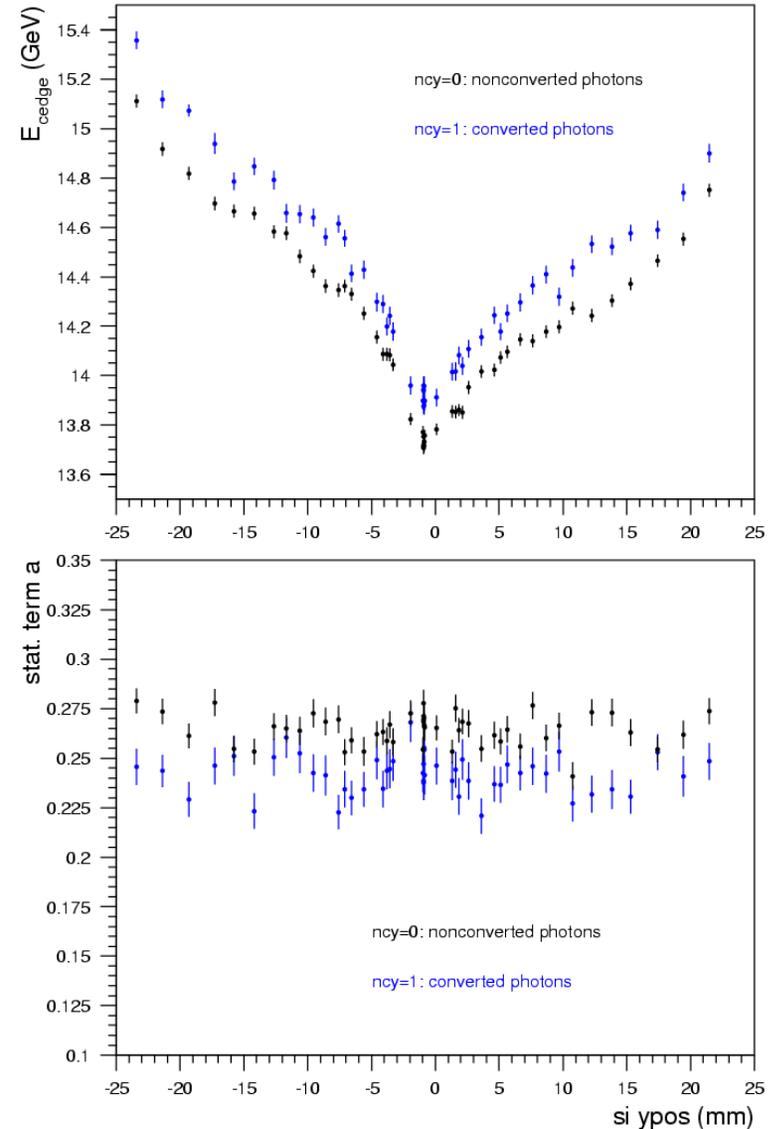
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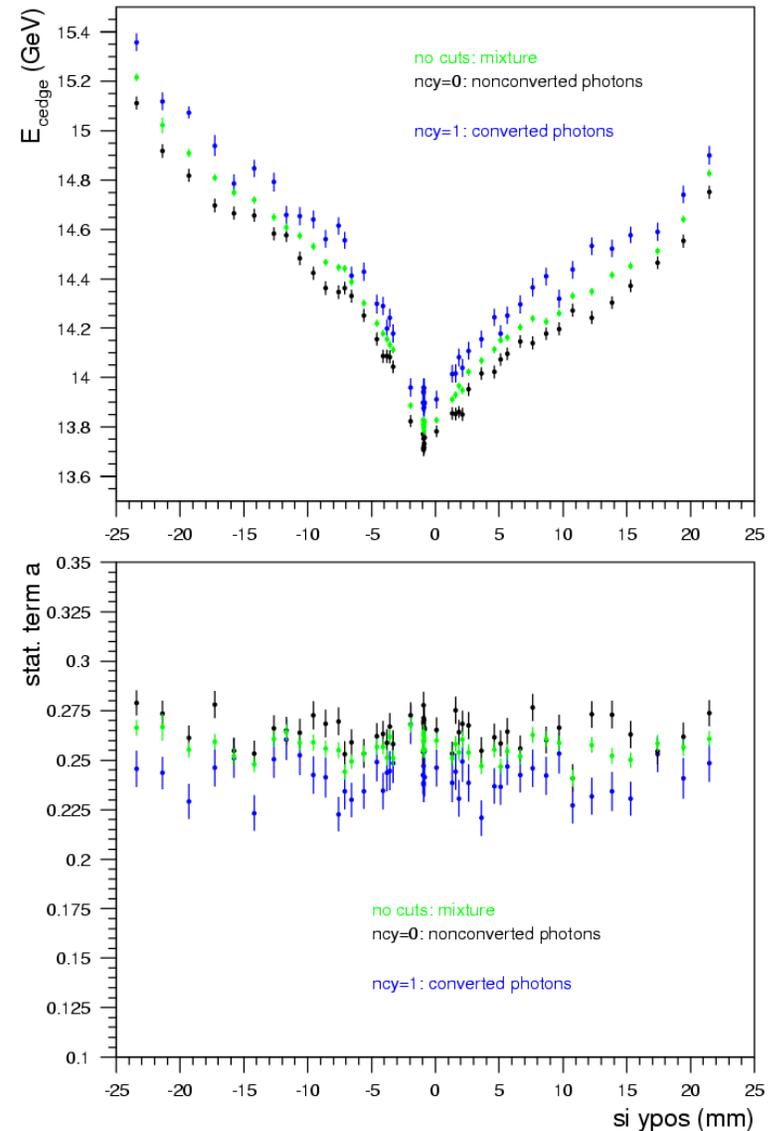
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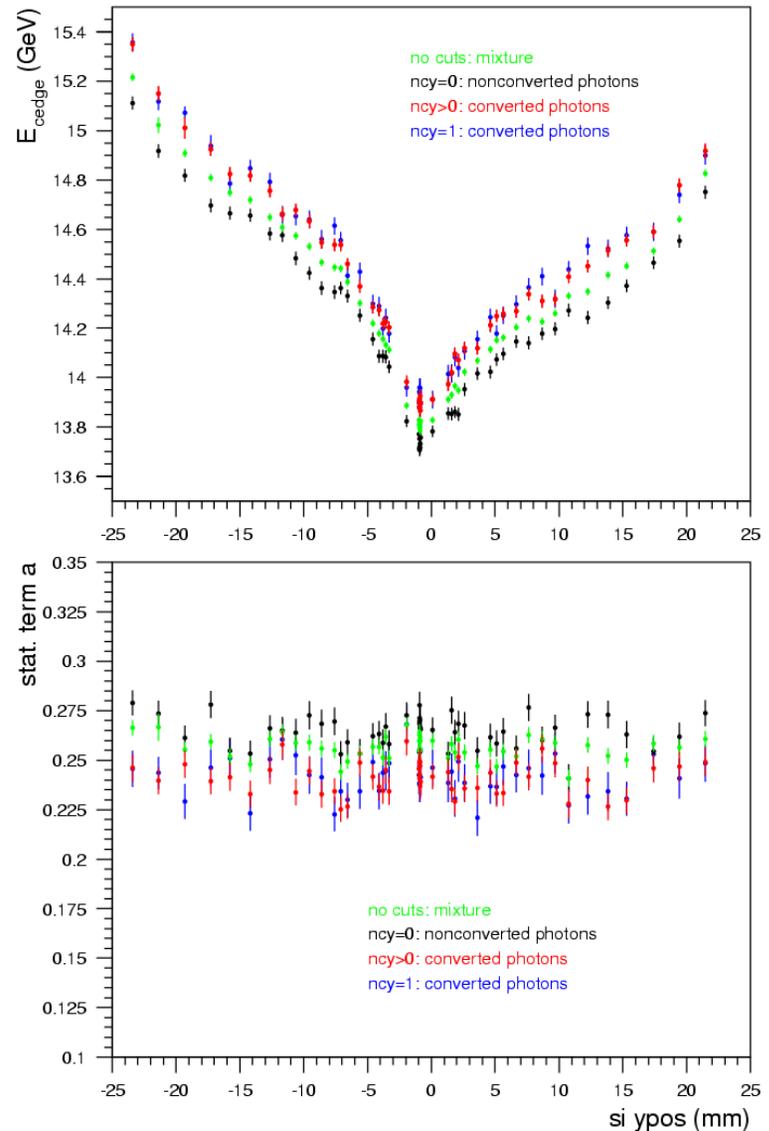
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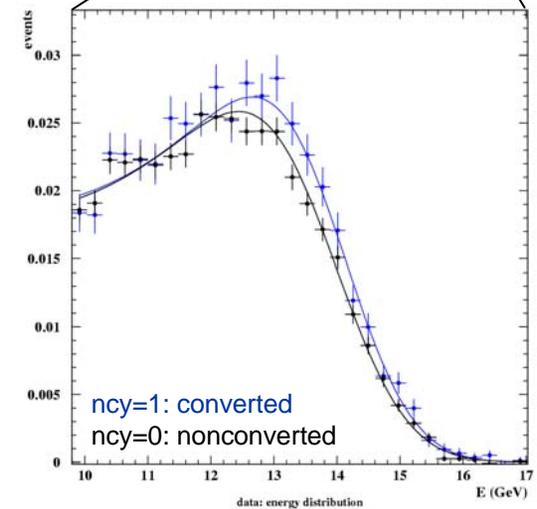
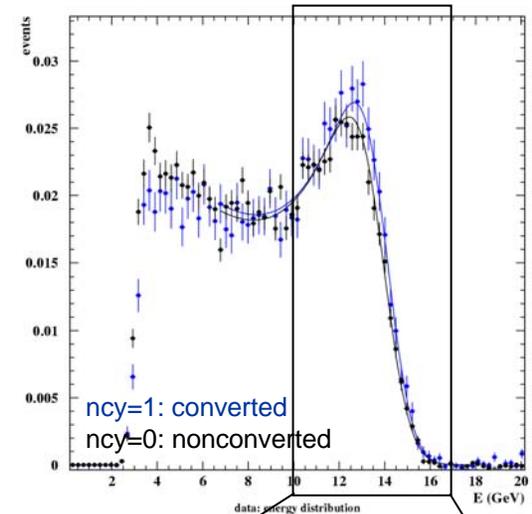
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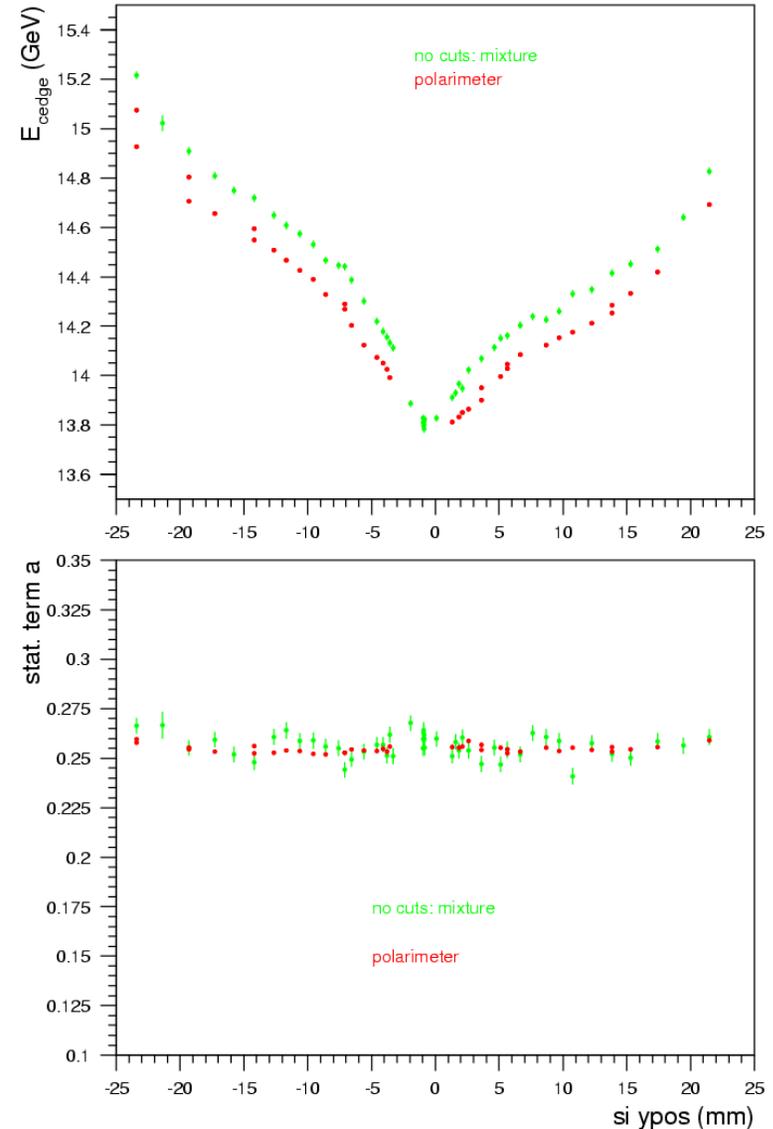
# Case study - Is it an artefact of the edge fit?

- Are the moving edges an artefact of the edge fit?
  - Compare silicon data with enriched converted and nonconverted photons
    - Not an artefact!
    - The edges are really moving!



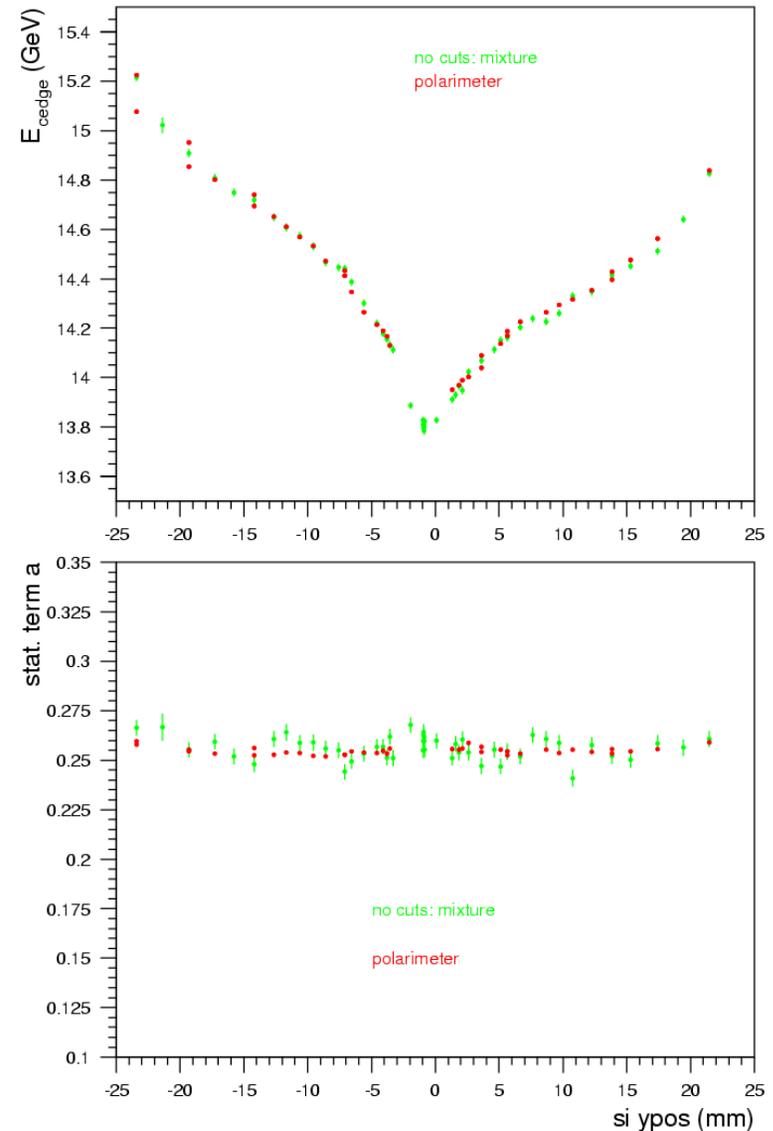
# Case study - Compton edges in a table scan

- Comparing fits of Compton edges
  - No cuts on silicon data
  - Polarimeter data taken at the same time
- Compton edges in the polarimeter data
  - Applied the same conversion factor for ADC channels -> GeV as in Silicon data
  - Global scale difference of 1% observable
    - Might be due to different signal handling
- Compton edges in the polarimeter data show the same structure as seen with the combined silicon-calorimeter data!
- Energy resolutions in the fit are equivalent!



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## A bit of shower theory - What could induce such a difference?

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- 1st guess: preradiator represents dead material in front of the calo
  - Upon conversion some energy is lost in the preradiator
  - Fluctuations of the energy loss should contribute to the energy resolution
    - Converted photons should have - on average - less energy than nonconverted photons
    - Converted photons should have a worse energy resolution

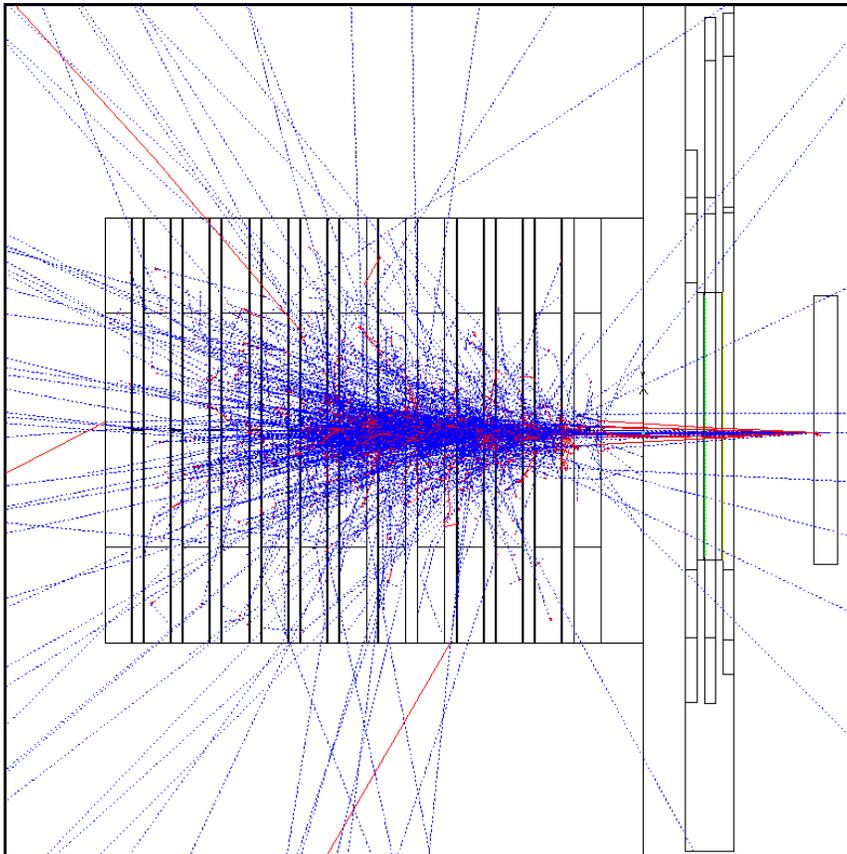
→ Obviously not the case here...
- 2nd guess: energy leaking from the calorimeter
  - ❖ The TPOL calorimeter has finite lateral sizes and is only around  $20X_0$  deep
  - Lateral there should be no difference between the sizes of showers of converted and nonconverted photons
  - But showers induced by photons start on average  $9/7 X_0$  deeper inside the calorimeter than those of charged particles
    - Photon showers are less contained on the backplane
    - Longitudinal leakage is therefore larger for photons than for converted photons and its fluctuation should contribute to the energy resolution

→ Looks better in both aspects...

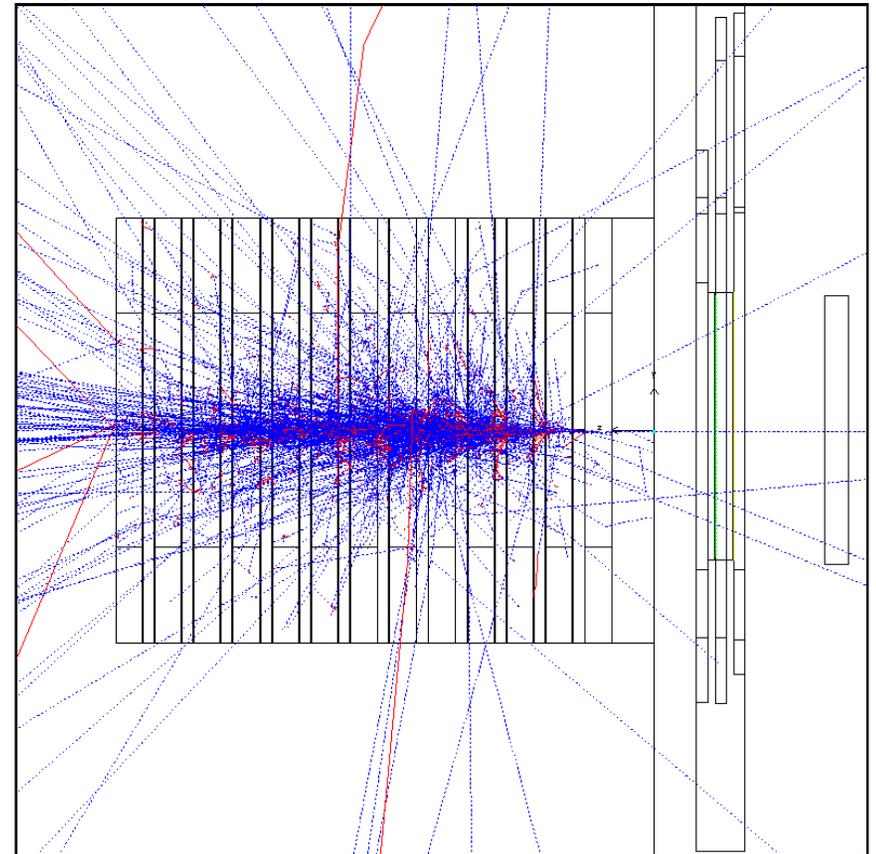
# Energy leakage - Illustration with Geant MC

- 2nd guess: energy leaking from the calorimeter
  - examples of showers in the Geant MC:

9GeV converted photon



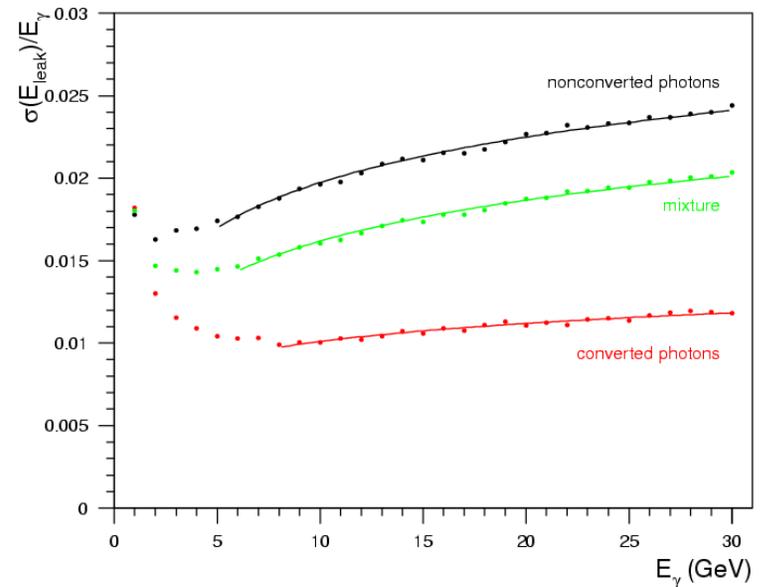
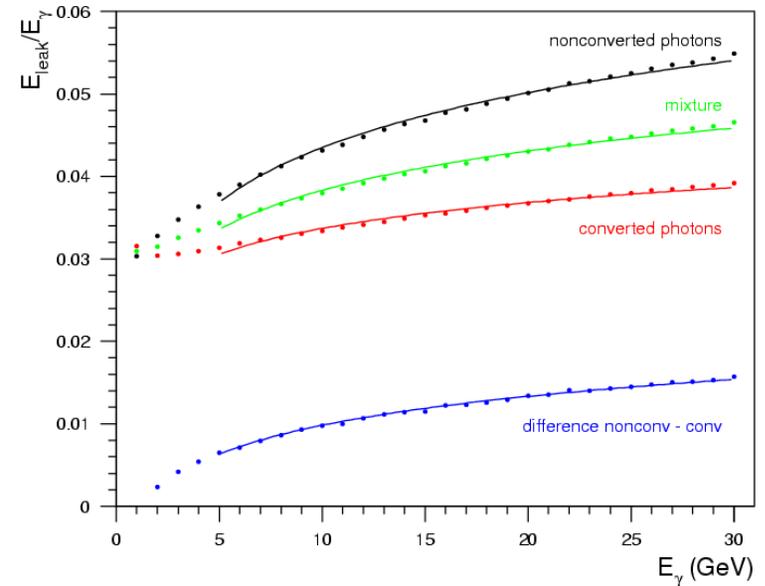
10GeV nonconverted photon



by R. Ciesielski

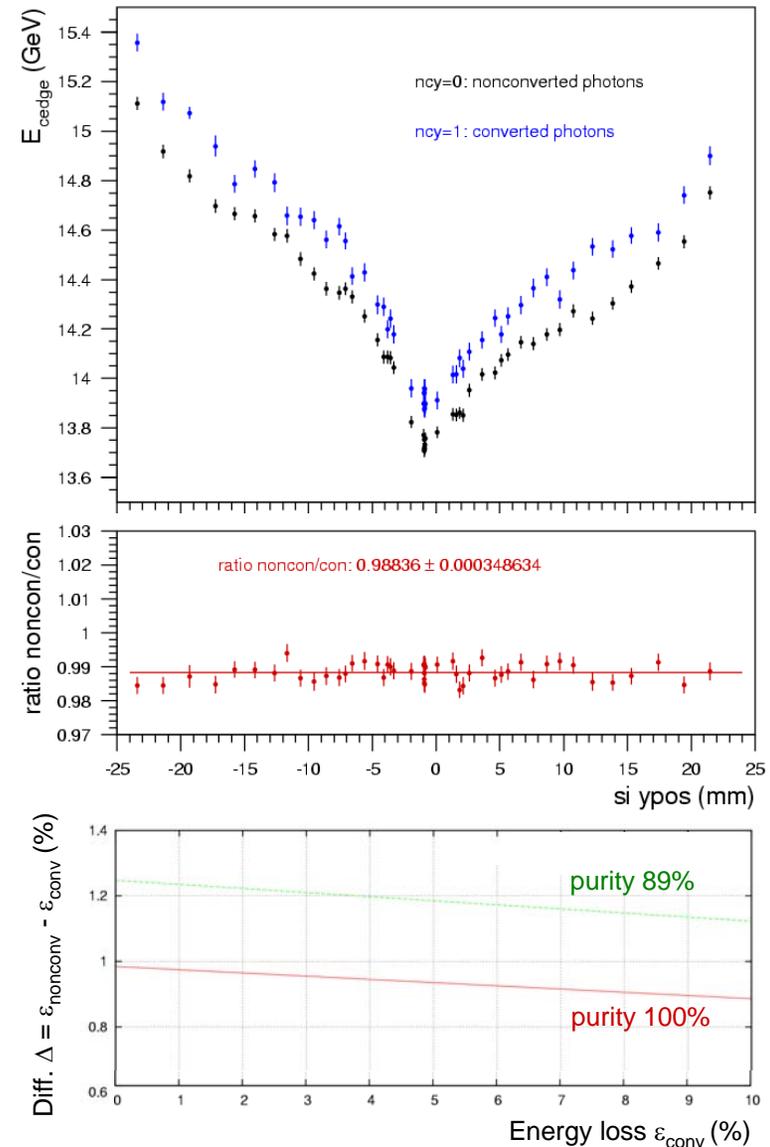
# Energy leakage - In the GEANT Monte Carlo

- Fractional mean energy leaking from the calorimeter
  - shows approx.  $\log(E)$  behaviour as expected
  - leveling off at low energies possibly due to lateral leakage
  - And yes, photons lose more than converted ones!
- Fractional width of energy leaking from the calorimeter
  - Fluctuations are highly non-gaussian
  - show also approx.  $\log(E)$  behaviour
  - And yes, photons fluctuate more than converted ones!
    - Fluctuations should contribute to the energy resolution, presumably via a constant term.



# Energy leakage - Can it account for the observed differences?

- Compare silicon data samples with enriched converted and nonconverted photons
  - Ratio shows a constant behaviour
    - overall energy response as function of  $y$  same for all types of events
    - especially lateral leakage doesn't change on that scale
  - Measure relative difference
    - Enriched photon sample: Require no clusters at all in x- or y-plane
    - Complete mixture with given conversion fraction of 54%
    - Impurities by converted photons leaving no cluster and efficiency for uncorrelated hits  $> 0$
    - Very low-energetic overlaid Bremsstrahlungs photons can be enriched: they convert with a lower fraction
    - Measured difference can be displayed as a function of one absolute value
- Size of difference is very well in agreement with the expectations from the GEANT MC!

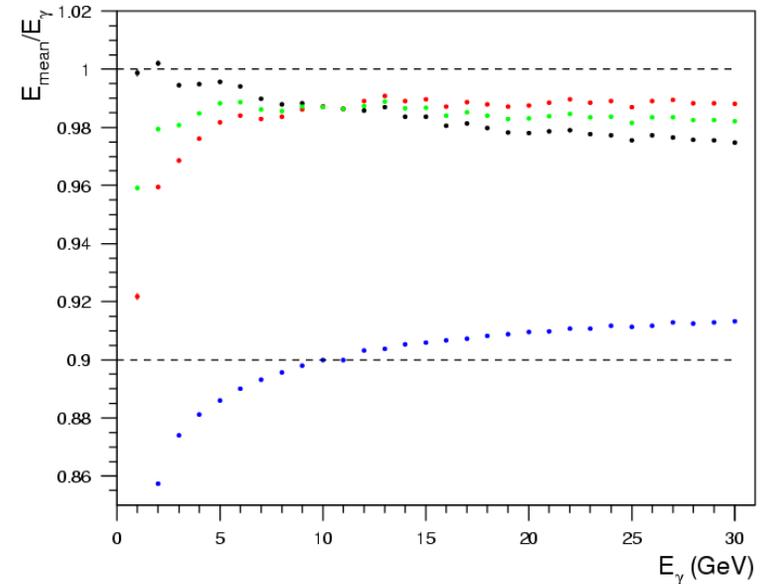


# Resolution - In the GEANT Monte Carlo

- Different energy loss still visible after signal processing
  - Not the absolute height, but the differences are interesting: same as observed from leakages
- Resolution differs, photons have a worse resolution than converted ones
- Multiplication by  $\sqrt{E}$  reveals there is more than just the statistical term!
  - Fitting with a constant term gave best results

$$\left(\frac{\sigma}{E}\right)^2 = \left(\frac{a}{\sqrt{E}}\right)^2 + b^2$$

- Same statistical term: well within  $1\sigma$
  - Constant terms differ, here:
    - nonconverted photons 3.14%, converted photons 2.11%
    - both together 2.70%, higher than expected from pure mixture (2.58%)  $\rightarrow$  it's not only mixing two spectra with different resolutions but also different absolute scales!
- Size of the constant terms are equivalent to the observed differences in resolutions of the edge fits!

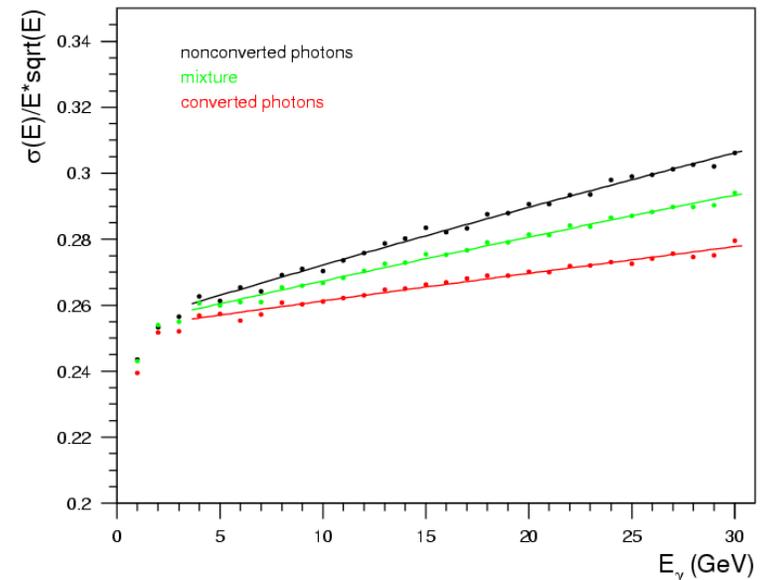
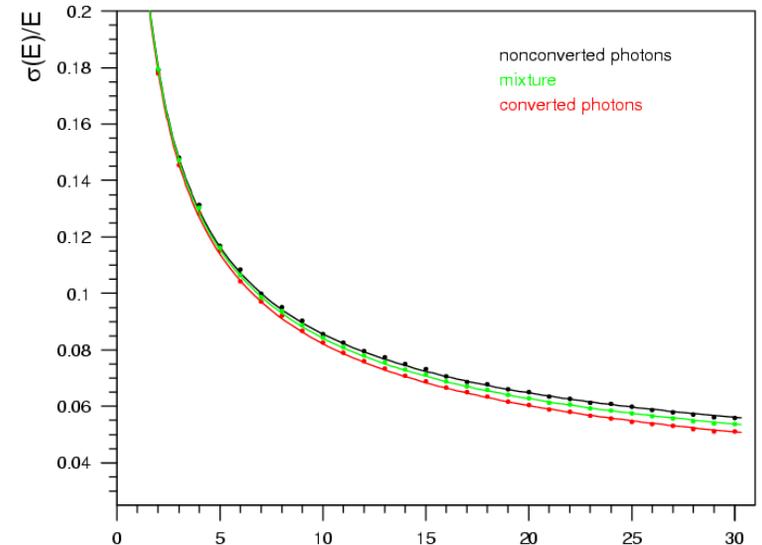


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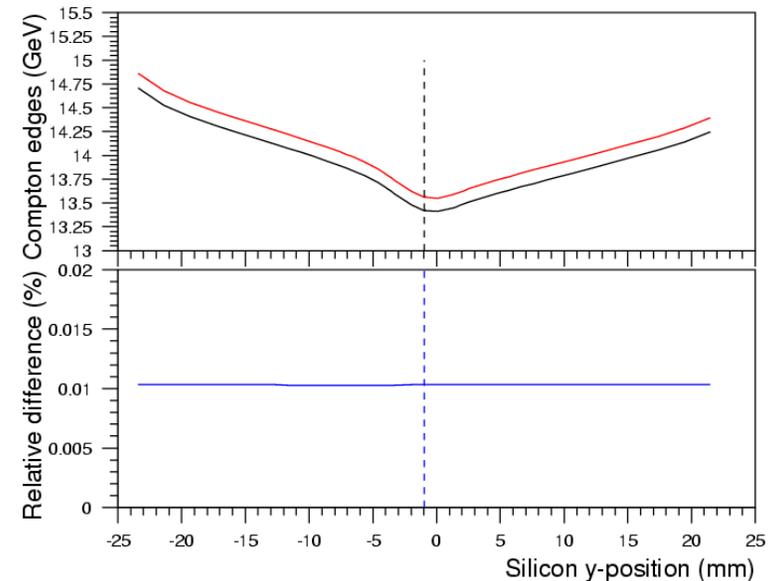
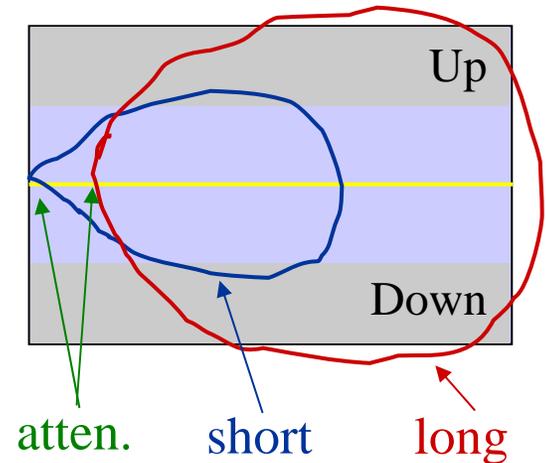
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# Effects on eta-y - given a specific shower modelling

- Retrospective: modelling eta-y means modelling the shower and taking also the effects of a calorimeter into account
  - 3 additive components: short core, long halo and an attenuation due to multiple particles at the beginning of either the long one or both
  - Hardware effects like gap or W-PB border...
- Two main shower components also related to the longitudinal shower development
  - Only the long one will leak and change the fraction of the energy shared between the components
  - But the induced difference is negligible! Also for an Online-Analyzing Power!
  - Expect more differences from the 3rd attenuation component itself → need extrapolation of 'silicon eta-y' to 'polarimeter eta-y'
- But impact on attempts modelling the complete spectrum possibly not negligible!
- ❖ Remember: given the preradiator the Compton spectrum we know is actually the superposition of two spectra with different energy resolutions, which have also different absolute scales of up to 140MeV!



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