Linearity of the TPOL calorimeter in Geant Simulation

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Linearity of the Calorimeter - Almost, but not perfectly

- Geant setups as tuned to data
- Use particle gun with energies of 1 to 30GeV (precise)
- Beam size as given by beam optics, but no Compton spread
- Tune gains to get response for class ‚all' of 14GeV at 14GeV (and no offset)

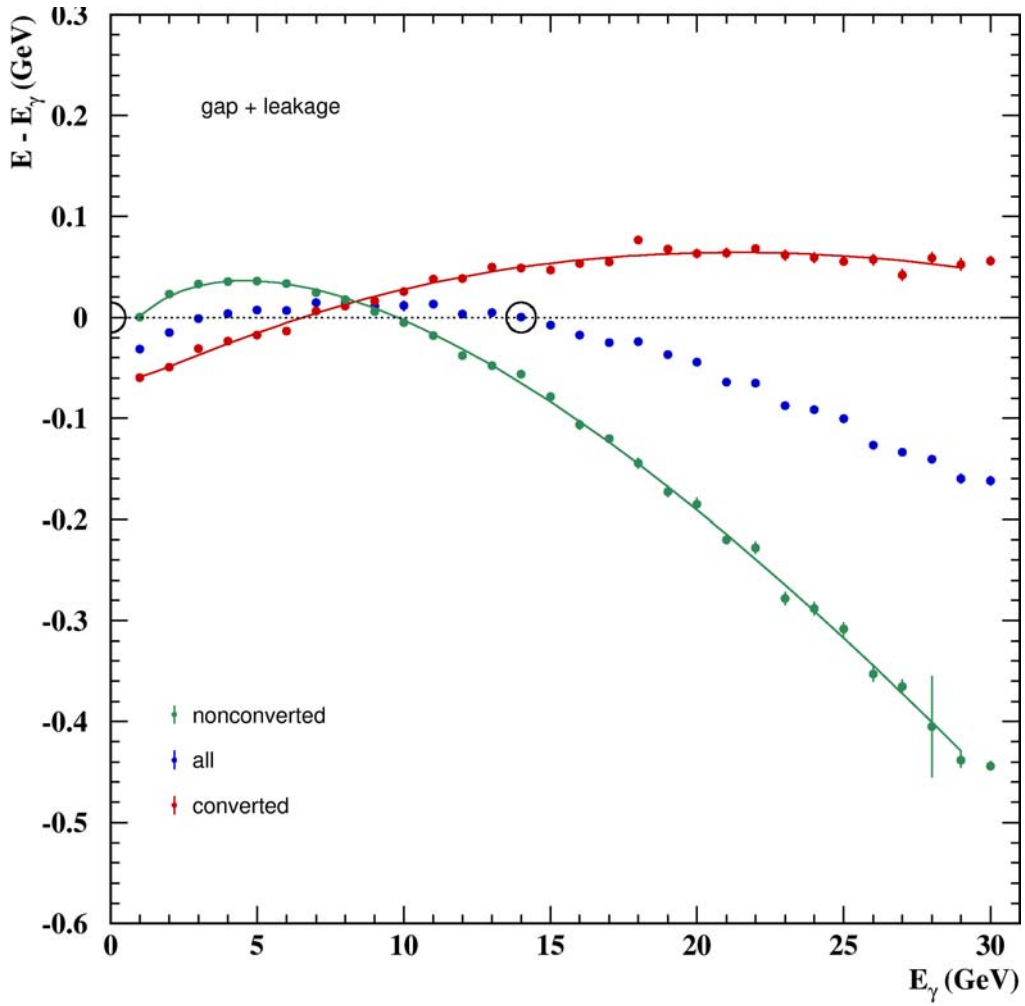
  → Similar to data, where calibration is done at the Compton edge
- Response is mostly linear, but shows small nonlinearity

  → Offset at 0, different for converted and nonconverted photons

  ➢ Different nature of both classes

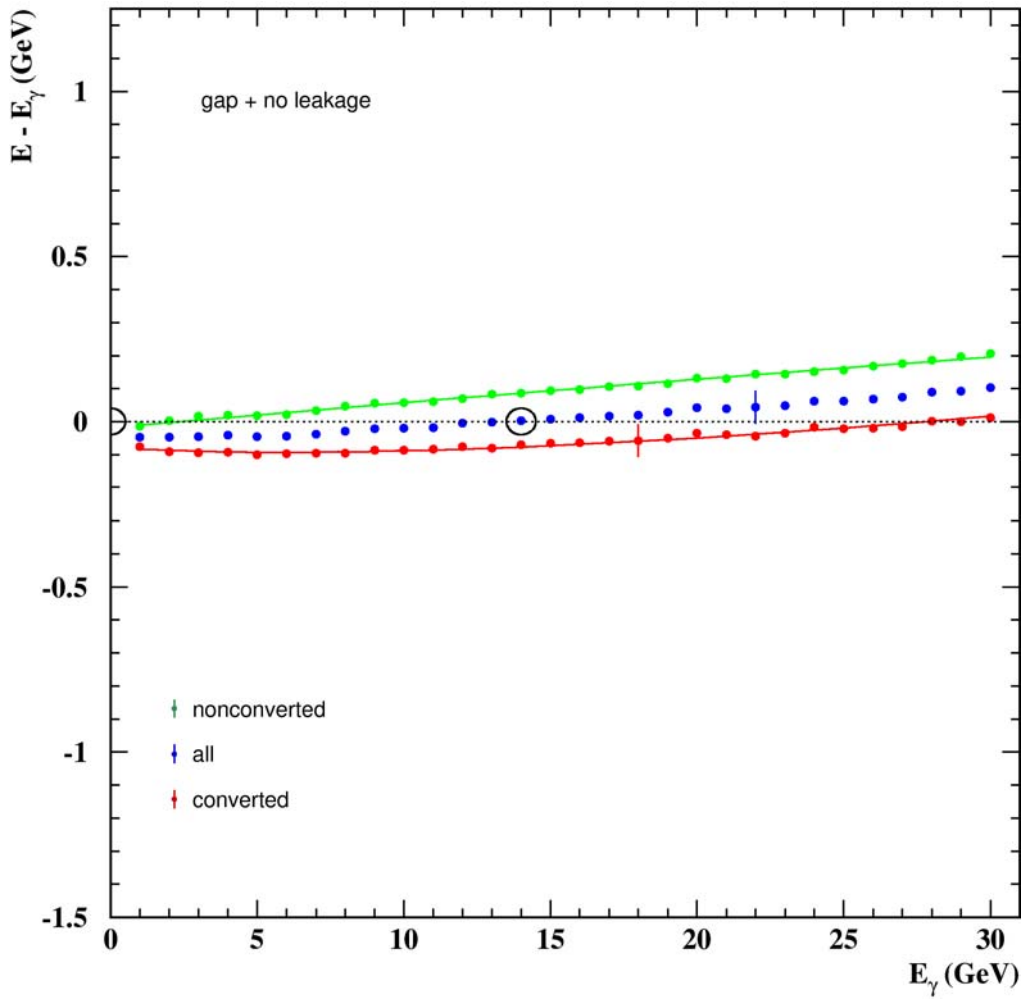
  → Different curvature for converted and nonconverted photons

  ➢ Given by differences in leakage from the backplane



Linearity of the Calorimeter - Infinite Calorimeter Depth

- Increase depth of the calorimeter
  - → 3x layer number ≈ $57X_0$
  - → No longitudinal leakage anymore
- Response is getting linear
  - → Offsets still remain
  - → Reason for the slope, when calibrating with the hook at 14GeV
- Offsets: Driven by gap in the center?



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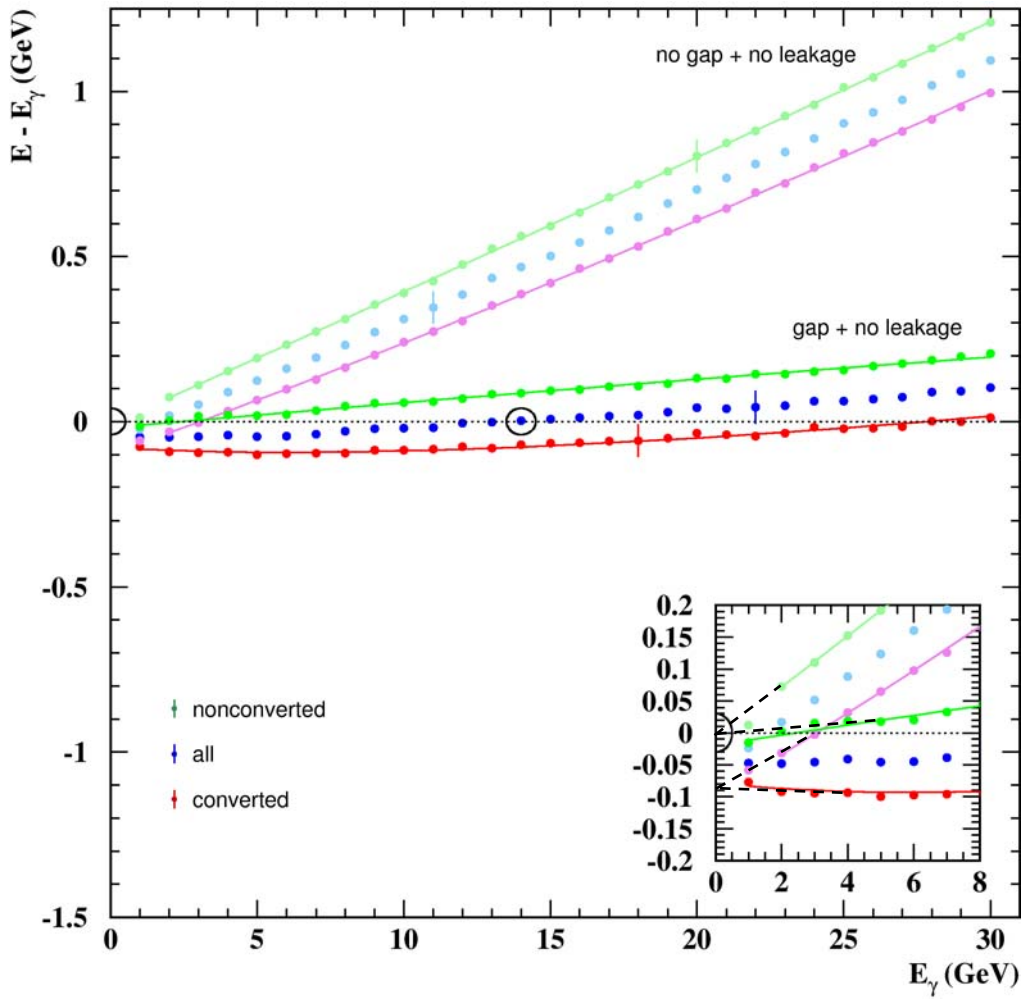
- Offsets: Driven by gap in the center?
- Setup without a gap
  - → Shows strong linearity too
  - → All energies loose in the gap
    - ➢ Explains different slope
- Nonconverted photons have mostly no offset, only very small energies loose a bit more
  - → Granularity of the calorimeter, some threshold for the measurement of a photon
- Converted photons loose upon conversion
  - → Offset to nonconverted photons
- Offsets not driven by the gap, but are due to differences between the photon classes



Linearity of the Calorimeter - Infinite Calorimeter Depth

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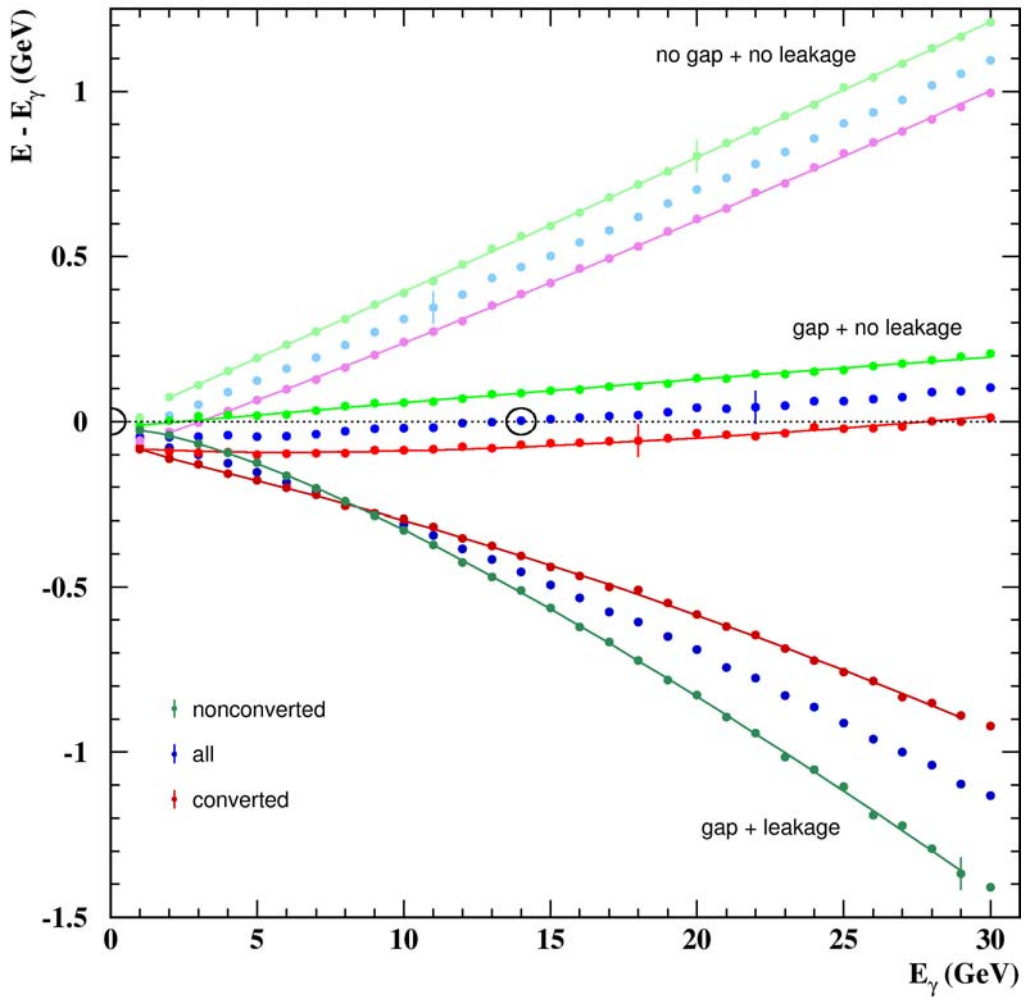
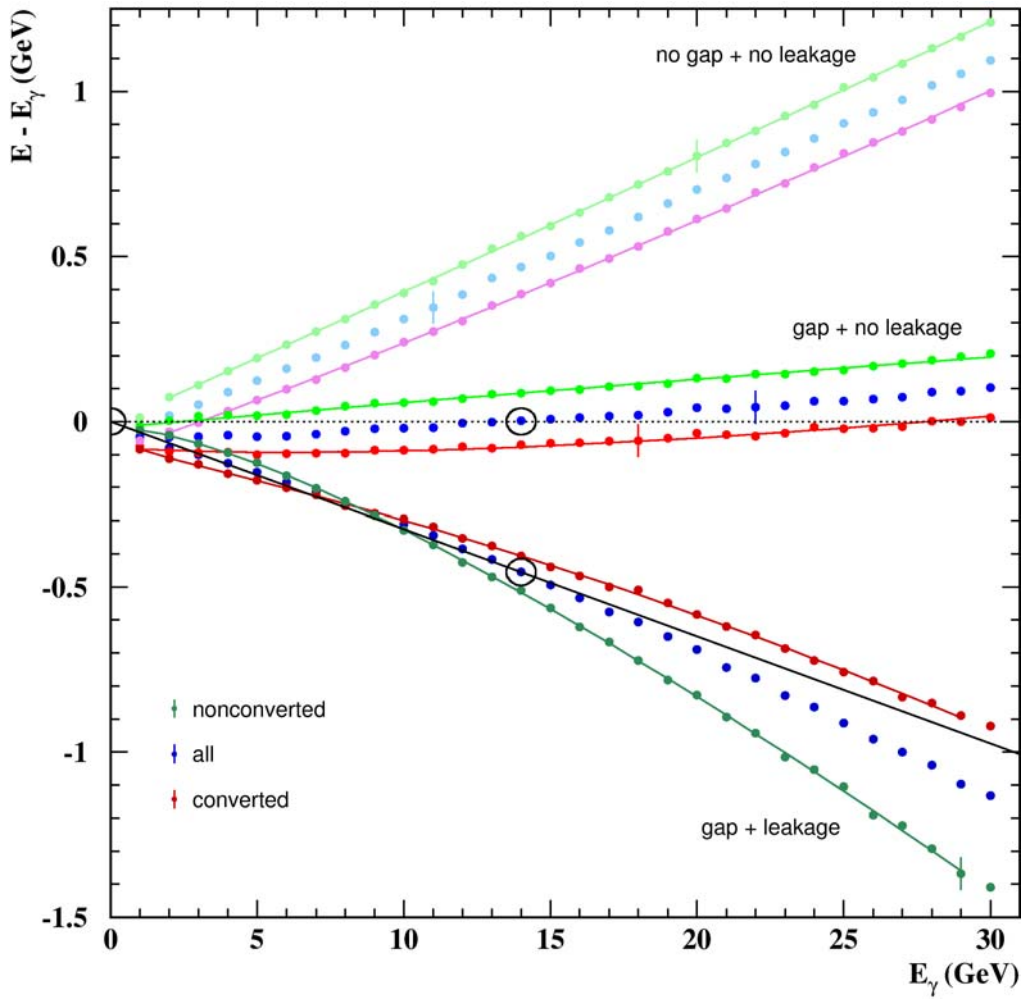
  - → 3x layer number ≈ $57X_0$
  - → No longitudinal leakage anymore
- Response is getting linear
  - → Offsets still remain
  - → Reason for the slope, when calibrating with the hook at 14GeV
- Decrease depth again to 12 layers
  - → Longitudinal leakage becomes significant
    - ➢ Nonconverted photons loose stronger than converted photons
  - → Response is not entirely linear anymore



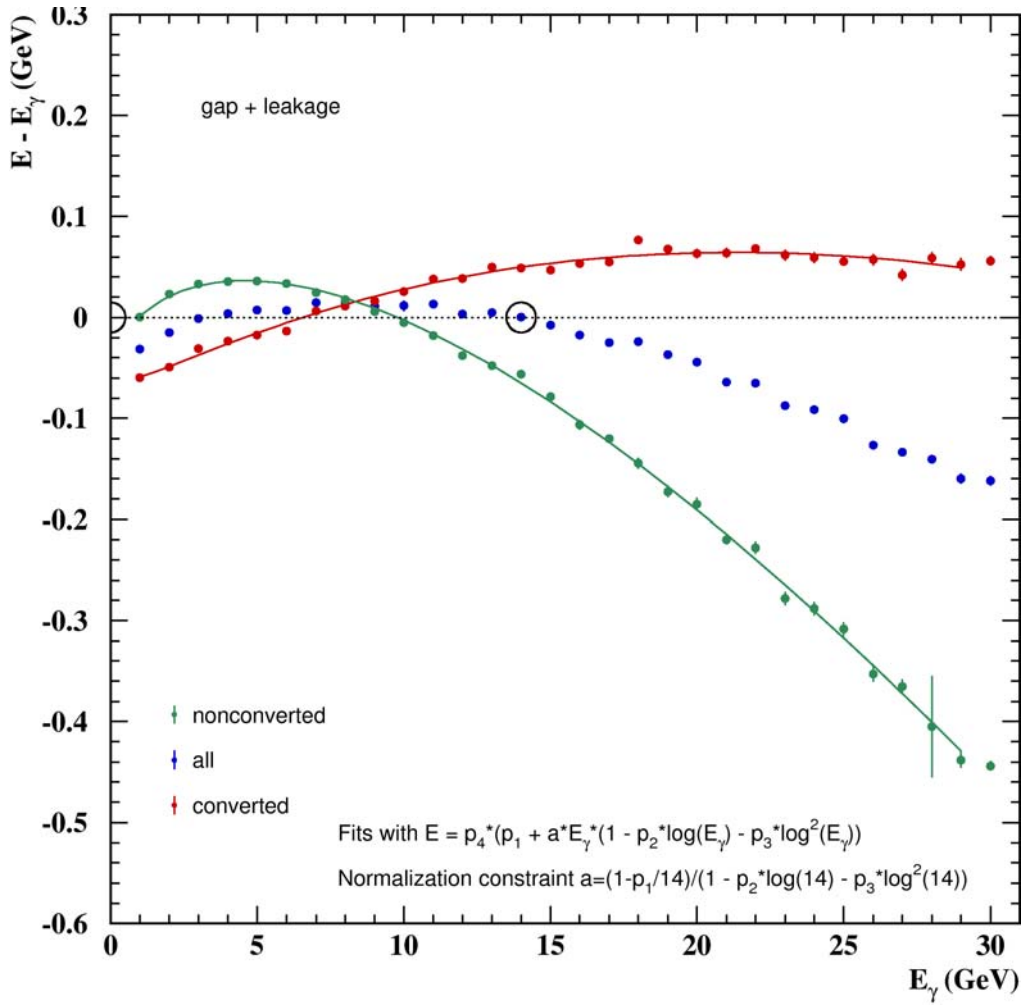
Linearity of the Calorimeter - Infinite and finite Calorimeter Depth

- Increase depth of the calorimeter
  - → 3x layer number ≈ $57X_0$
  - → No longitudinal leakage anymore
- Response is getting linear
  - → Offsets still remain
  - → Reason for the slope, when calibrating with the hook at 14GeV
- Decrease depth again to 12 layers
  - → Longitudinal leakage becomes significant
    - ➢ Nonconverted photons loose stronger than converted photons
  - → Response is not entirely linear anymore
- Change calibration hook to that of leaking setup



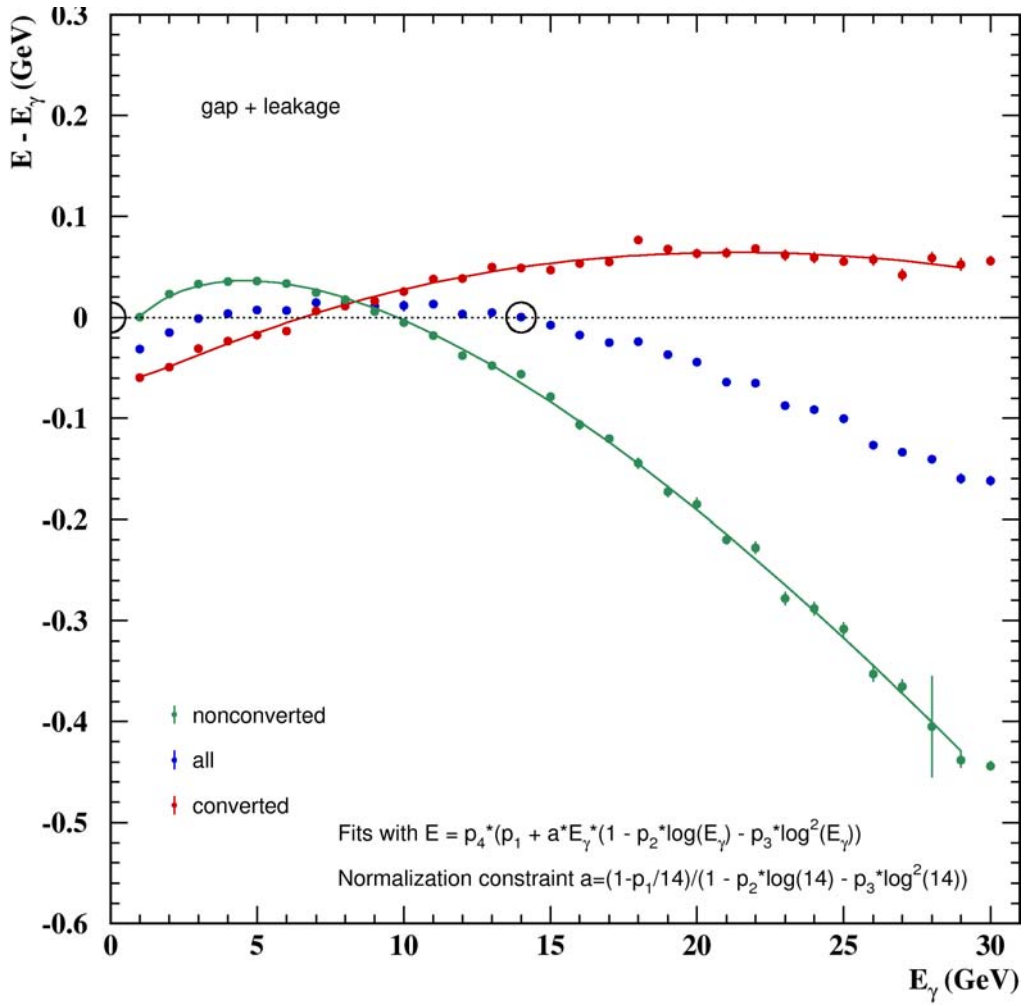
Linearity of the Calorimeter - Finite Calorimeter Depth

- Increase depth of the calorimeter
  - → 3x layer number ≈ $57X_0$
  - → No longitudinal leakage anymore
- Response is getting linear
  - → Offsets still remain
  - → Reason for the slope, when calibrating with the hook at 14GeV
- Decrease depth again to 12 layers
  - → Longitudinal leakage becomes significant
    - ➢ Nonconverted photons loose stronger than converted photons
  - → Response is not entirely linear anymore
- Change calibration hook to that of leaking setup
  - → Slopes of both converted and nonconverted photons can be understood



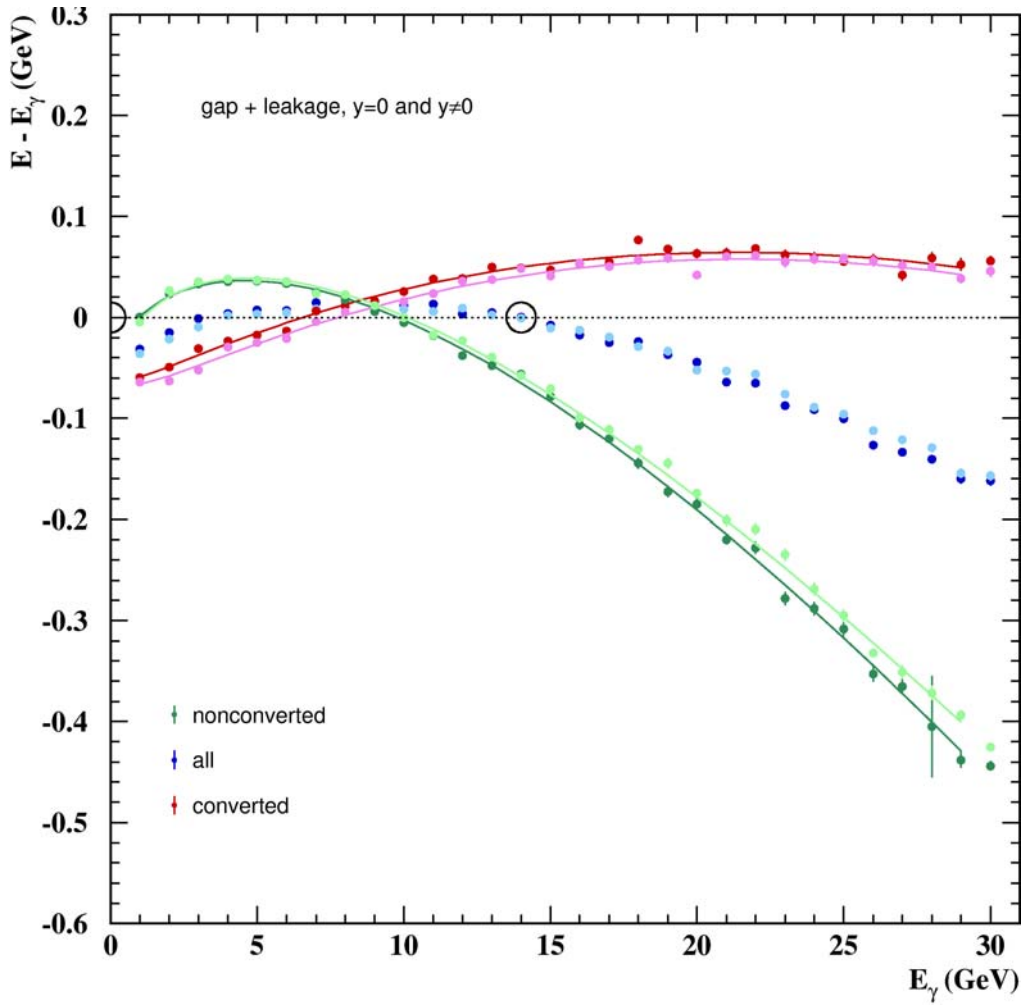
Linearity of the Calorimeter - Finite Calorimeter Depth

- Setup with 12 layers
  - → Longitudinal leakage becomes significant
    - ➢ Nonconverted photons loose stronger than converted photons
  - → Response is not entirely linear anymore
- Parametrization of curves
  - → Assumes a linear part
  - → Some decrease by log(E) and/or $\log^2(E)$ due to leakage
  - → Constraint parameter assures that ‚Form' = 14GeV at 14GeV
  - → With a gain parameter p_4 the parametrization of the ‚form' then prooves to be independent of the calibration
  - → ‚Form' different for converted and nonconverted photons



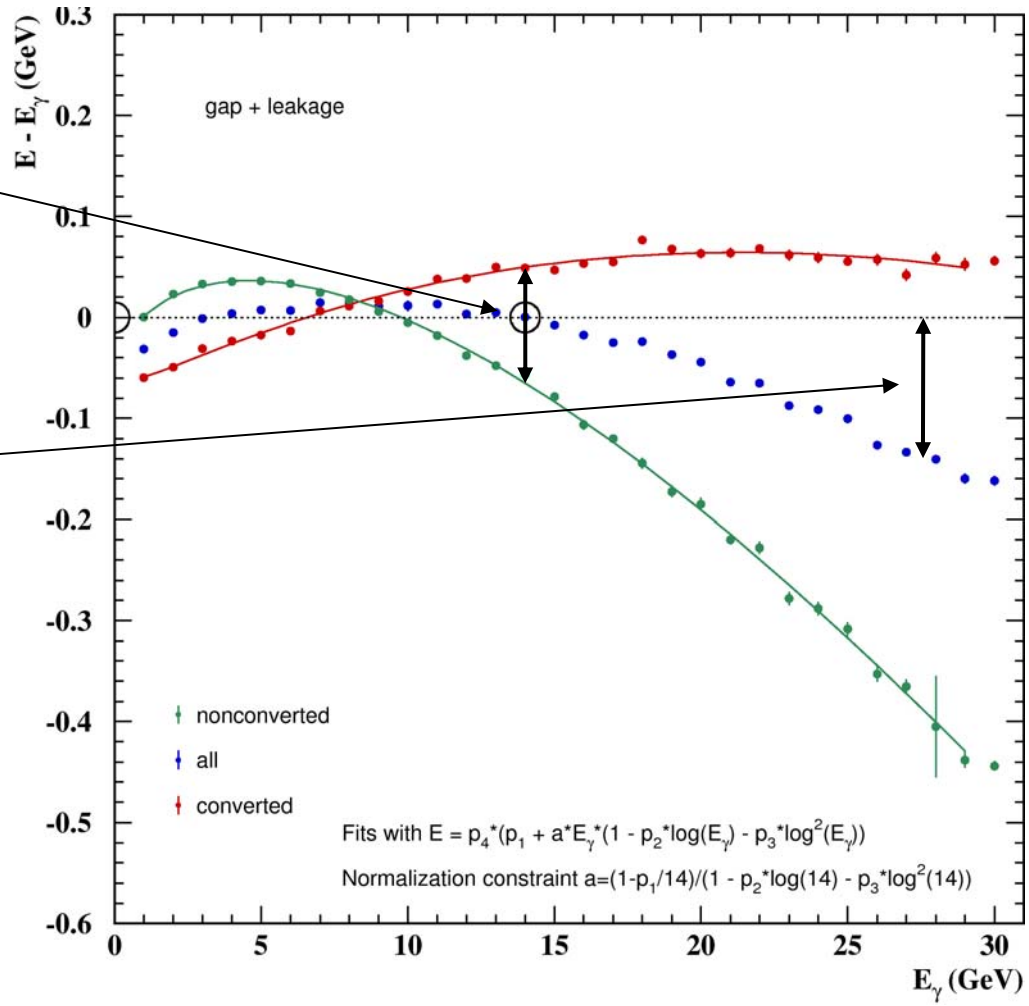
Linearity of the Calorimeter - Linearity independent of y

- Setup with 12 layers
  - → Longitudinal leakage becomes significant
    - ➢ Nonconverted photons loose stronger than converted photons
  - → Response is not entirely linear anymore
- Parametrization of curves
  - → Assumes a linear part
  - → Some decrease by log(E) and/or $\log^2(E)$ due to leakage
  - → Constraint parameter assures that ‚Form' = 14GeV at 14GeV
  - → With a gain parameter p_4 the parametrization of the ‚form' then prooves to be independent of the calibration
  - → ‚Form' different for converted and nonconverted photons
- ‚Form' is also independent of y



Linearity of the Calorimeter - Consequences

- Setup with 12 layers
  - →Longitudinal leakage becomes significant
- The difference of converted and nonconverted photons at 14 GeV
  - →Essentially the same difference as that between Compton edges of the classes
- The residual off the class ‚all' at 27.5GeV
  - → ≈140MeV in this setup
  - → Size depends strongly on the precision of the calibration hook at 14GeV -> large deviations possible, for small miscalibrations!
  - → The bremsstrahlung's edge appears to be shifted downwards by this amount
  - →Analysis for pedestal shifts should take this into account!



Summary - Linearity in Geant and in the parametrized response

- Non-linearities in the energy response are small but not non-existent
  - → Can be explained with longitudinal leakage
  - → Can be parametrized by a gain independent form using
    - ➢ A linear dependence, diminshed by log(E) and/or $\log^2(E)$ terms
- Gain independent form has different parameters for converted and nonconverted photons
  - → But is independent of the vertical position y (no gap influence here)
- Implemented in the parametrized response
  - → Being gain independent, the difference between converted and nonconverted photons is still given by the model
- All 8 vertical and horizontal dependencies are implemented by now
  - → Energies for UD and LR channels, energy aymmetries for UD and LR channels
  - →Parmaterized according to results obtained with table scans
- Next steps
  - → Validation of the implementation
  - → Energy resolution of the parametrized response is not trivial, needs more study
    - ➢ There is a constant term due the energy dependence of the response and the beam size!
    - ➢ And then there are the more sophisticated correlations…