Transverse Profiles in Electromagnetic Showers with the CALICE AHCAL

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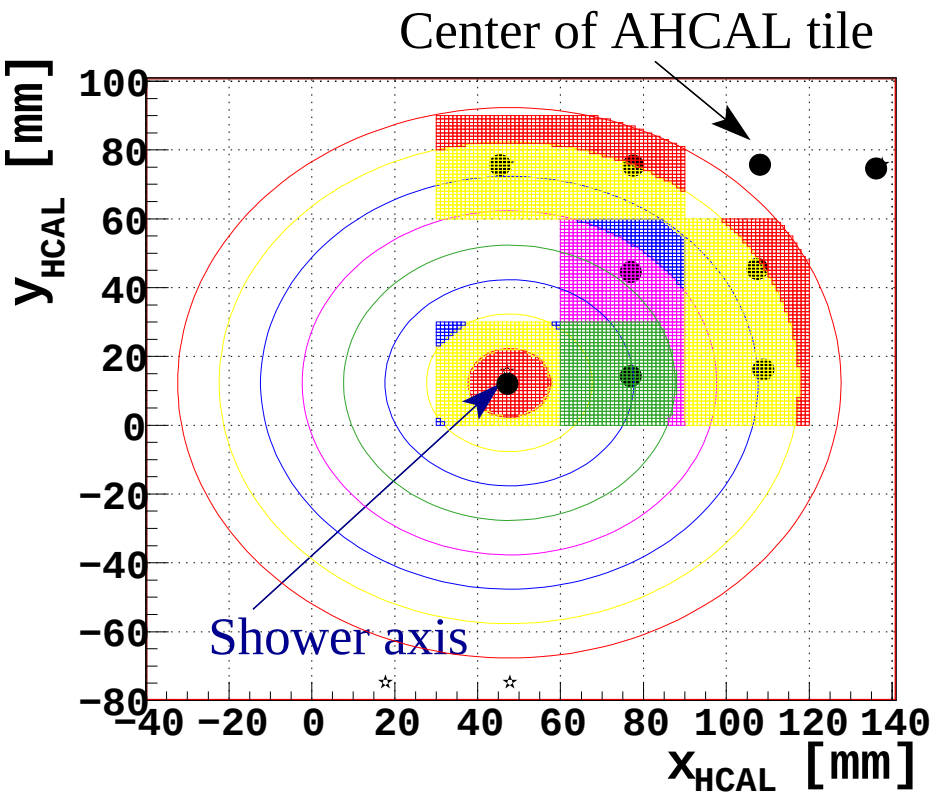
Transverse Profiles: Reminder

- Get the shower axis based on TBTrack
- Look in rings centered at the shower axis
- Sum up the energy in each ring, weighted by the fraction of the tile area in the specific ring
- Divide by the ring area $\Rightarrow$ **energy density vs radial coordinate**:

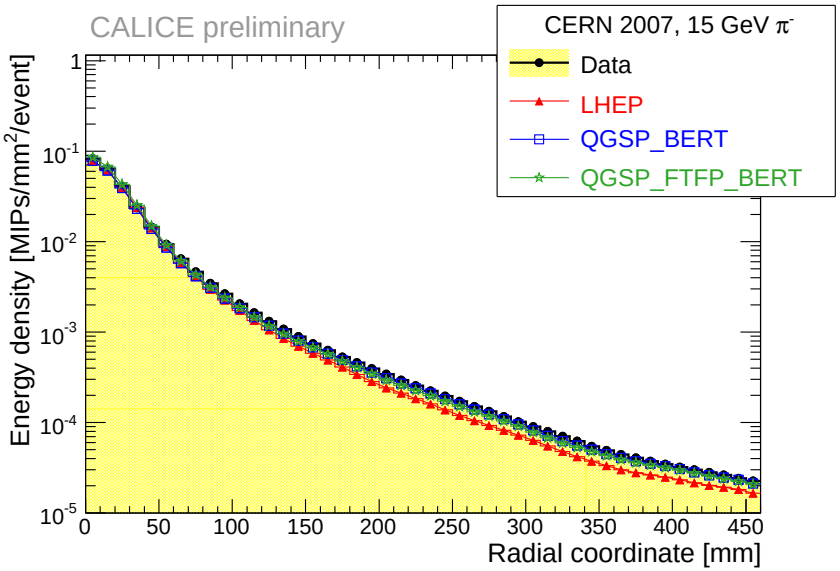
$$R = \sqrt{(x_i - x_{track})^2 + (y_i - y_{track})^2}$$

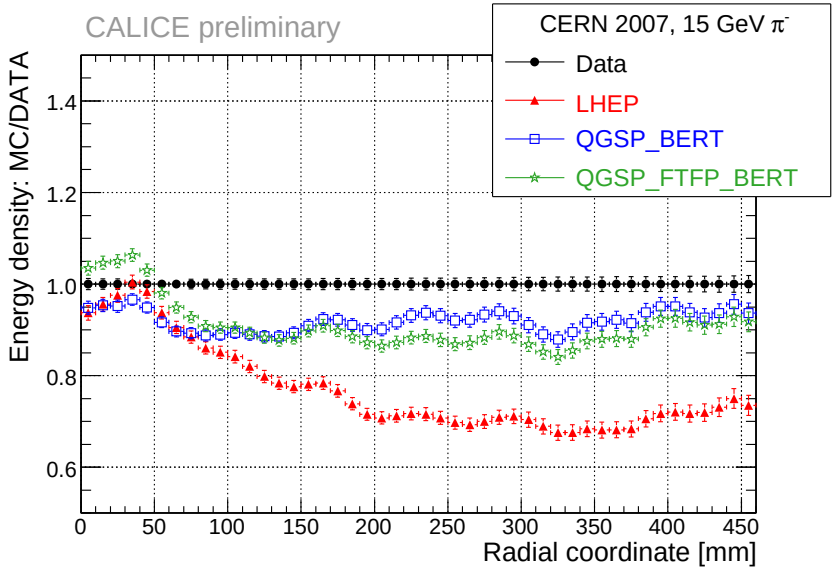
$\Rightarrow$ transverse profiles

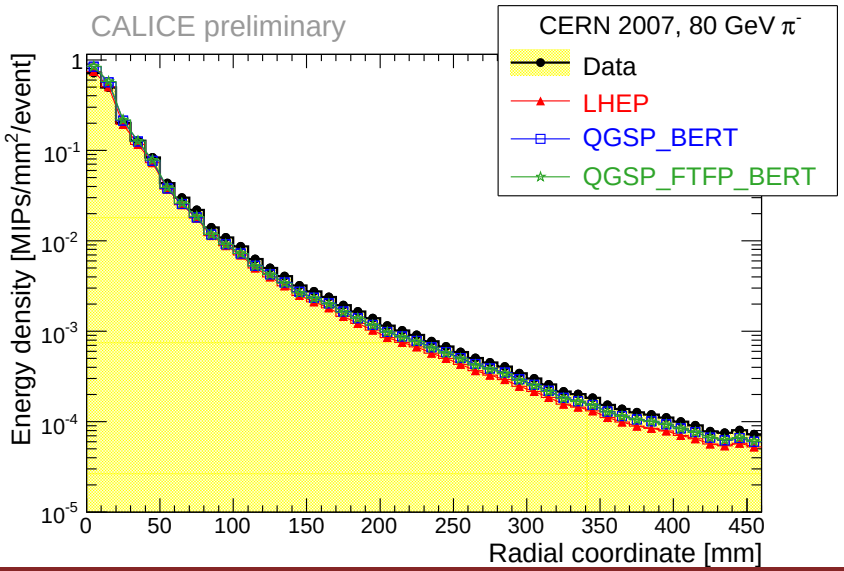


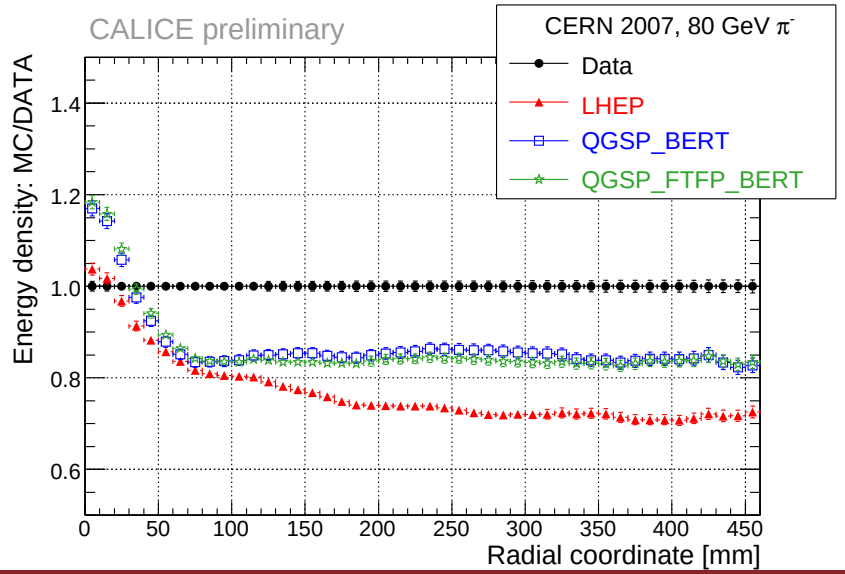
Transverse Profiles in HADRON Showers

- Strange step observed in **hadron** showers (CALICE Analysis Note CAN-011e)









Transverse Profiles in ELECTROMAGNETIC Showers

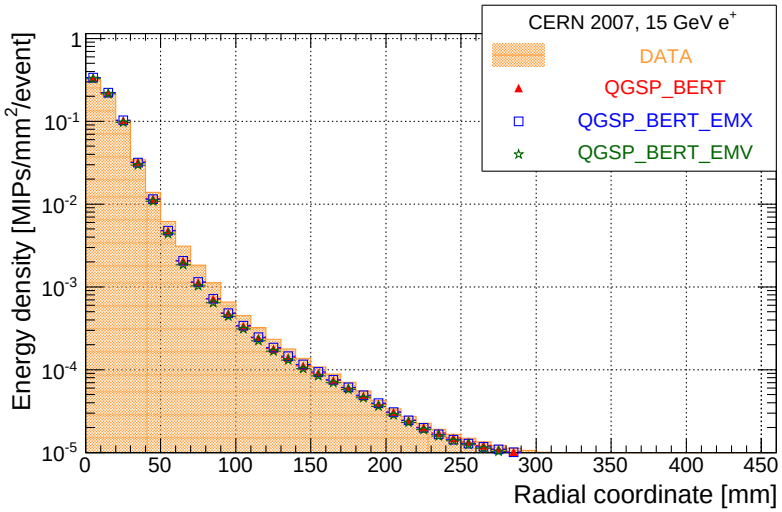
- Transverse profiles in hadron showers: strange dip observed in the shower core $\Rightarrow$ what about electromagnetic case?
- Similar strange dip observed with our standard physics lists
- Many checks done to overrule obvious reasons (see talk given in Analysis Meeting on 7th December):
  - Rejection of possible muon ($N_{HCAL} > 100$) and pion contributions (Cherenkov)
  - Restriction to central calorimeter area
  - Detector effects: runs with beam at $(0,\ 0)$ and at other positions
  - Cross-talk between tiles
  - MIP cut value
  - Alignment of AHCAL layers
  - Treatment of saturation correction
  - Shape of beam profile
  - Mokka implementation: virtual vs real tiles
  - Gun position in MC (effect from soft neutrons)
  - Analysis software (Beni, Marina)

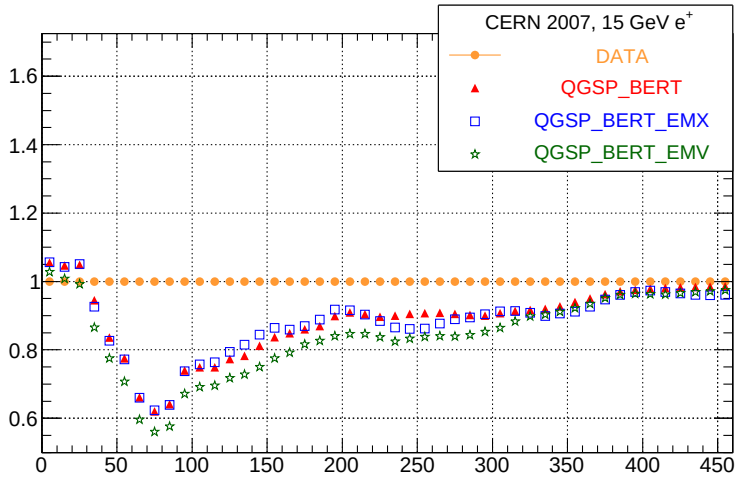
Transverse Profiles in ELECTROMAGNETIC Showers

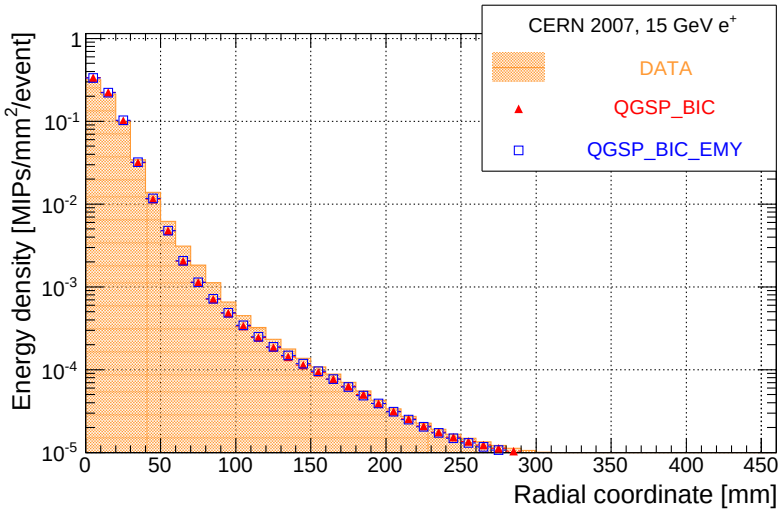
- Use GEANT4 (v9.3.) physics lists with special EM options
- **QGSP_BERT_EMV** (EM option 1): modification for e^- and e^+ transport with respect to default EM physics (V = variant)
- **QGSP_BERT_EMX** (EM option 2): kills e^- and γ's produced below threshold for all EM processes (X = eXperimental)
- **QGSP_BIC_EMY** (EM option 3): best precision, recommended for hadron therapy

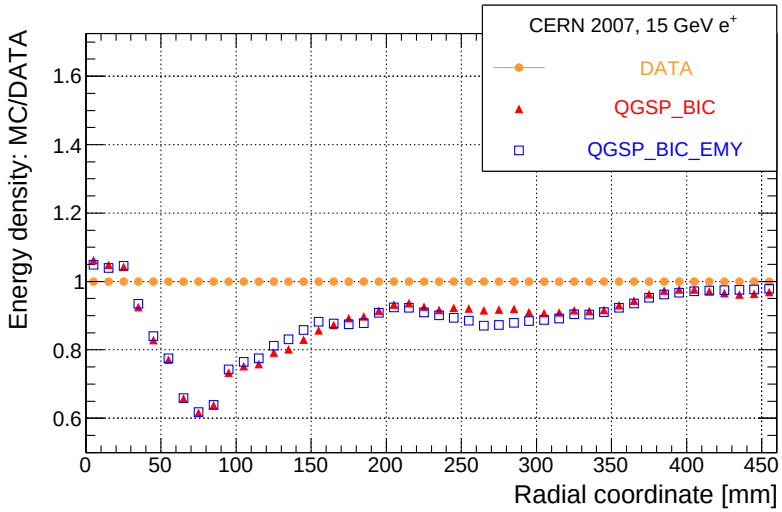
Transverse Profiles in ELECTROMAGNETIC Showers: Results

- Distance relative to the shower axis (+ weights)



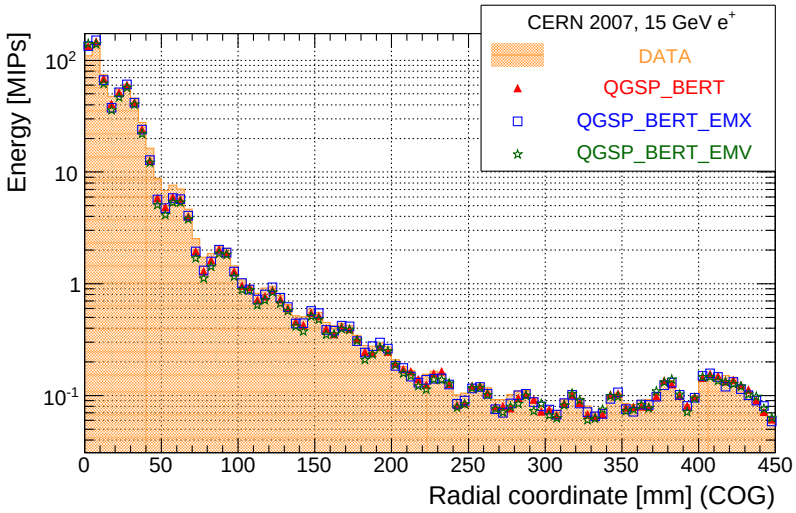


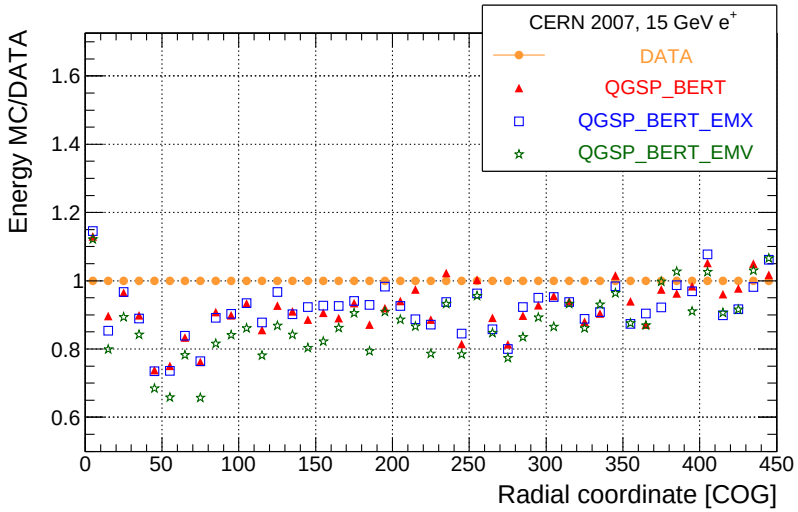


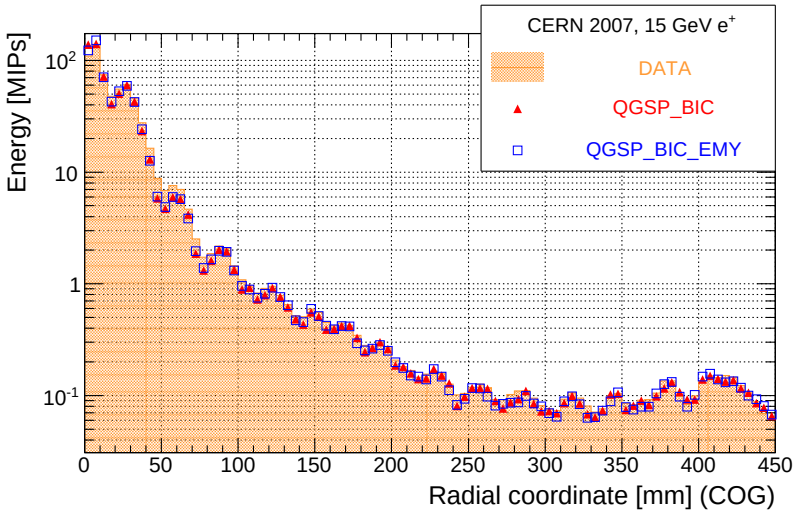


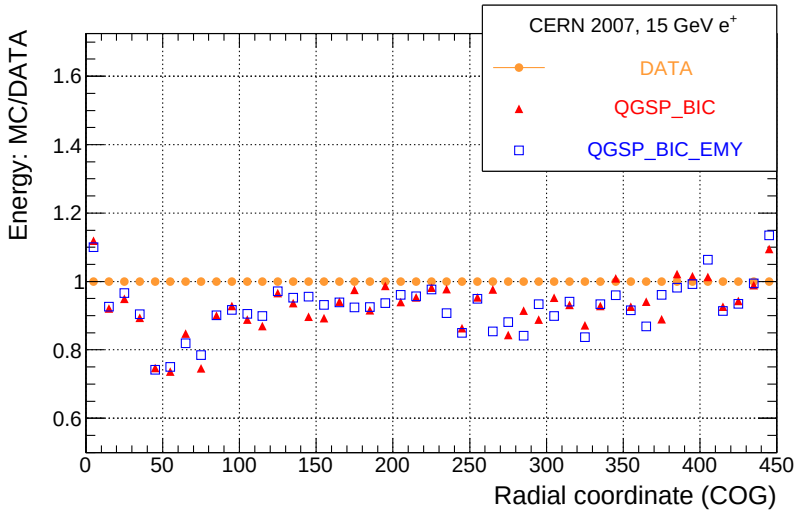
Transverse Profiles in ELECTROMAGNETIC Showers

- Distance relative to the barycenter (no weights)









Transverse Profiles in ELECTROMAGNETIC Showers

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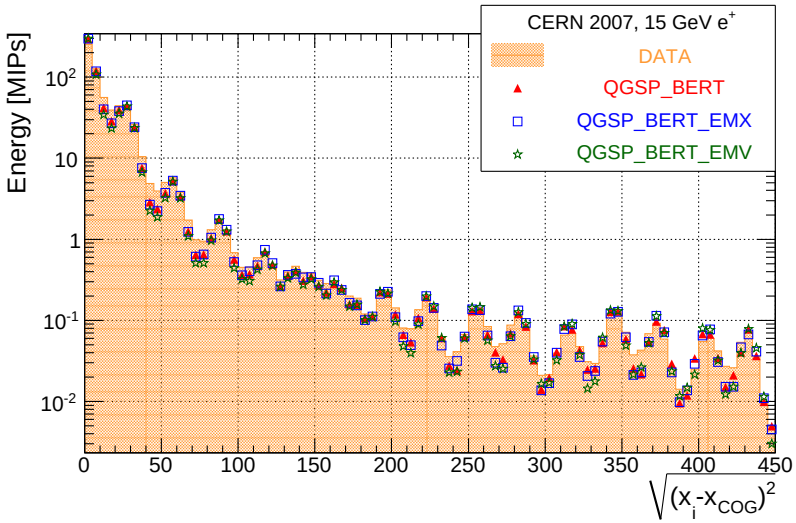
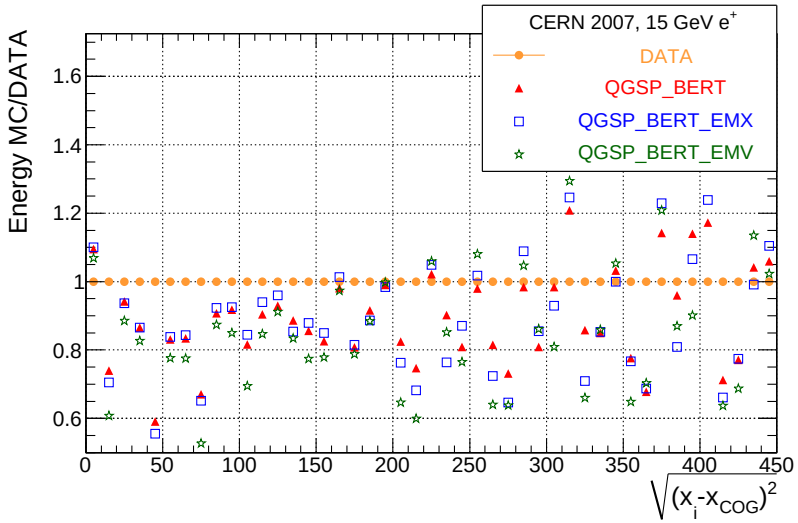
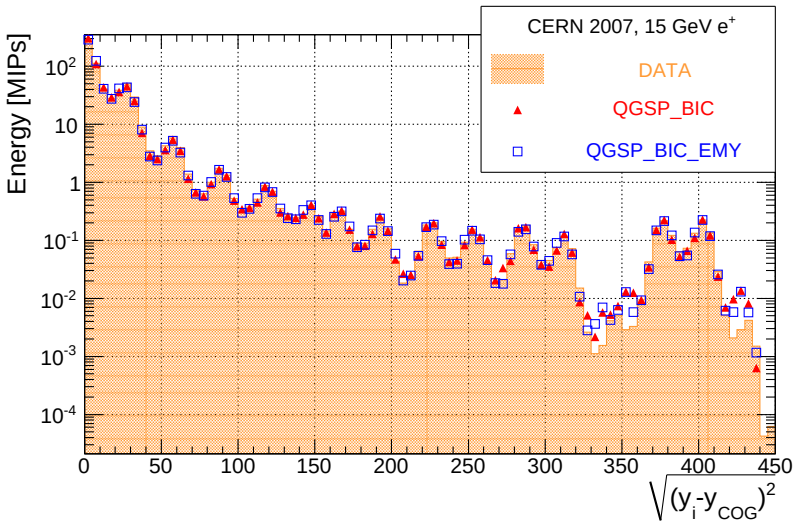
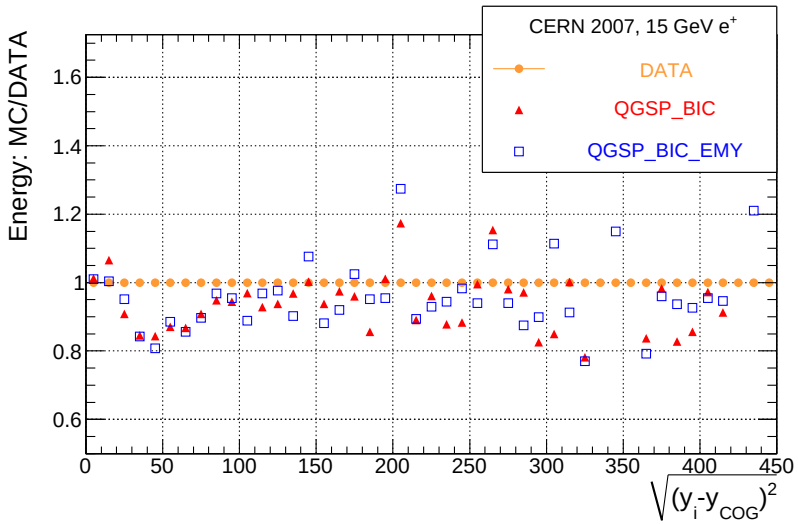


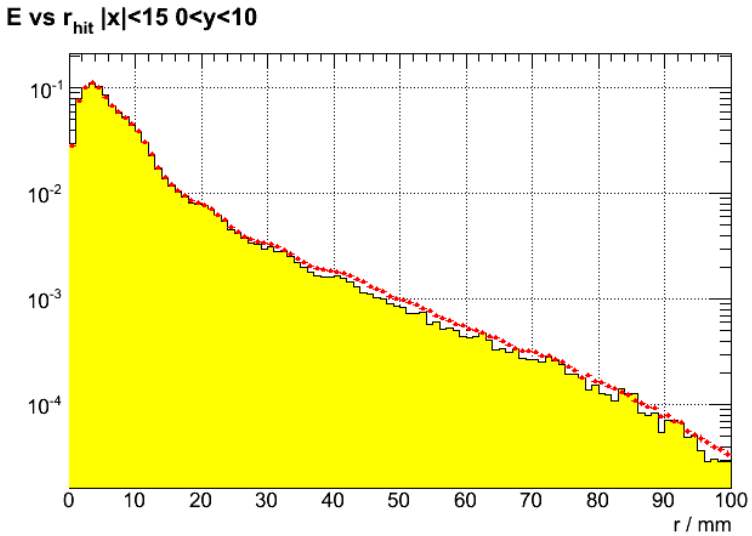


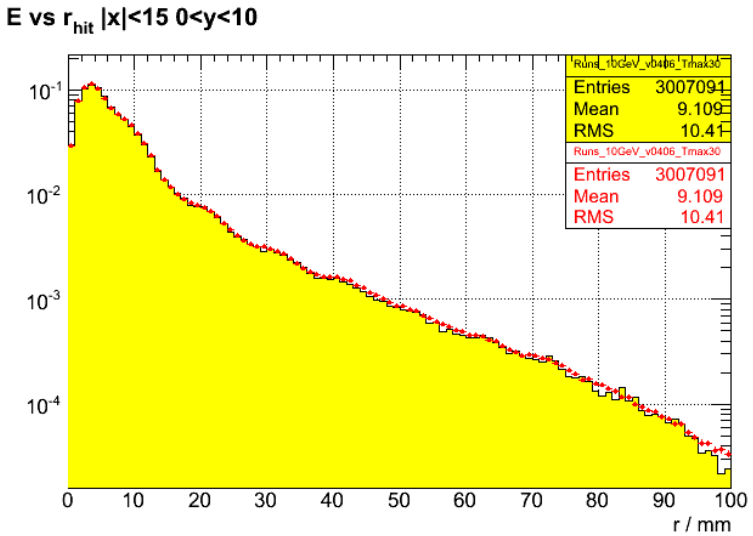


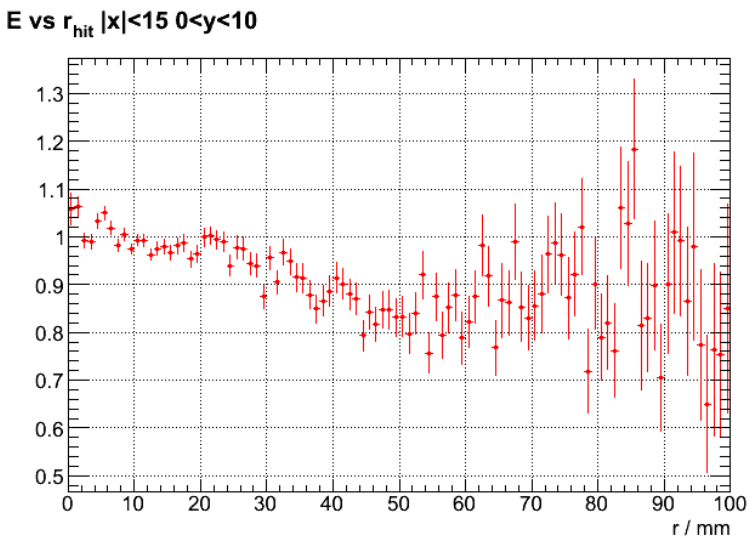


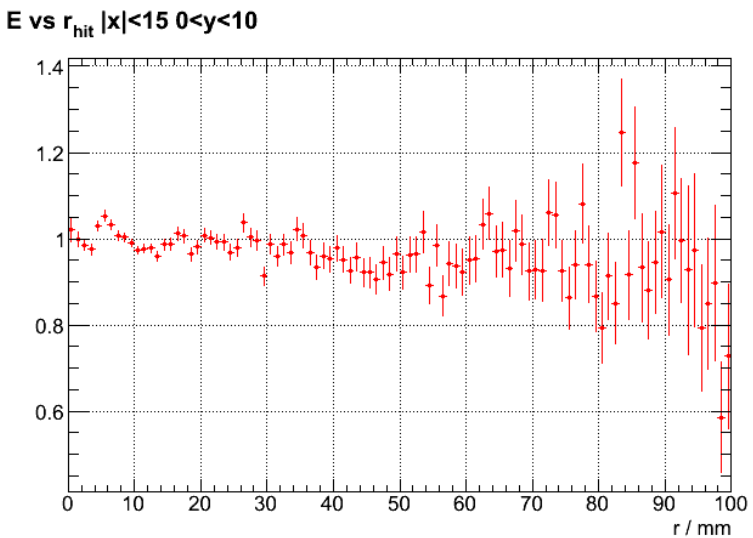
Transverse Profiles in CALICE ECAL (David)

- Distance relative to the barycenter (no weights)
- Selected events in the centre of the ECAL's active area
- Right plot: with cut to remove double cluster events









Conclusions and Overview

- One possibility: dip due to **double clusters** in data and not MC
  - First look at energy in the first 2 AHCAL layers did not show any second peak
  - David: mean distance between double clusters in ECAL $\sim$ 4 cm $\Rightarrow$ it may be possible that they cannot be seen in AHCAL (3×3 cm^2)
  - Observed in 2006/2007 CERN beam
  - What about FNAL beam?
  - What about rotated beam? (Beni)

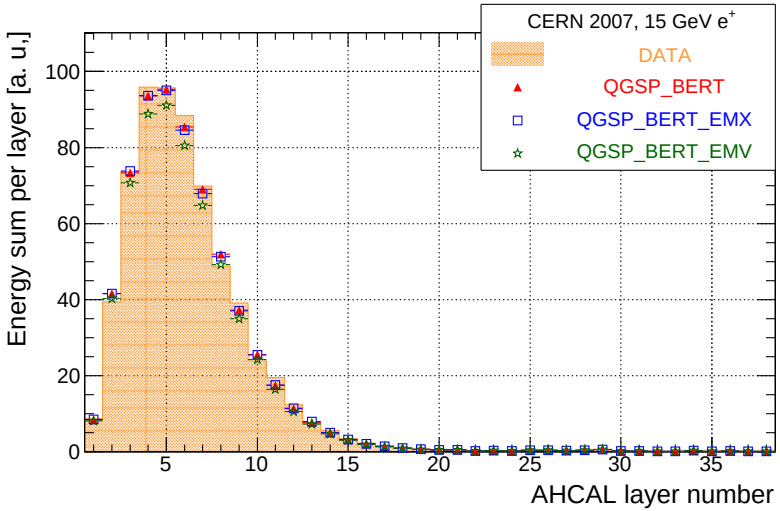
- Suggestions from GEANT4 developers, as result of extensive discussions from Friday (5.03.2010): use significantly different MC models
  - **Livermore**: low energetic EM models (describe interactions of electrons and protons with matter down to about 250 eV, using interpolated data tables based on the Livermore library)
  - **Penelope**: PENetration and ENergy LOss of Positrons and Electrons - new set of physics processes for γ, e^- and e^+

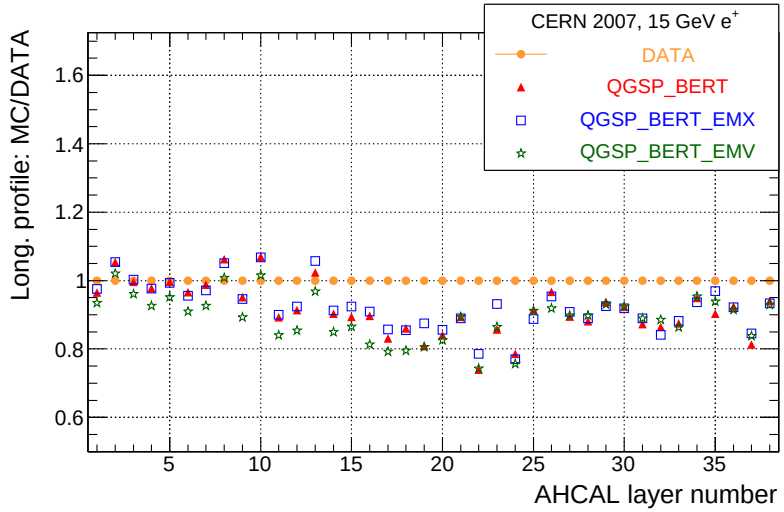
Acknowledgements

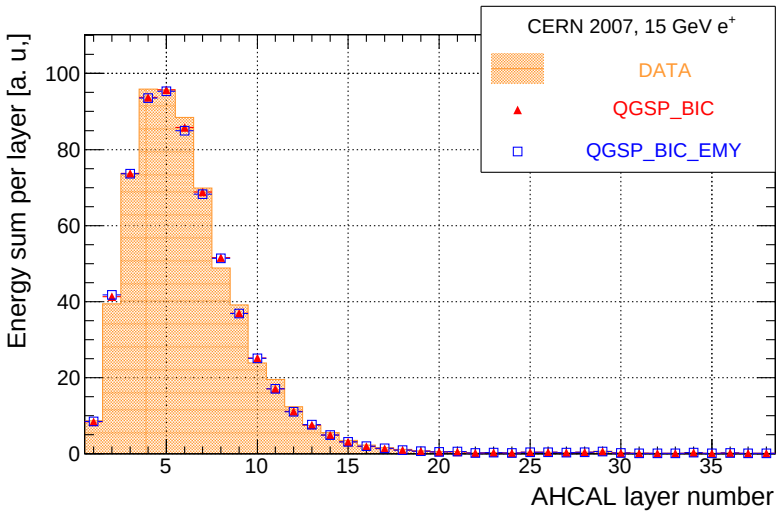
Many thanks to David, Erika, Felix, GEANT4 developers (John Apostolakis et al.), Sergey and Beni for discussions and analysis help

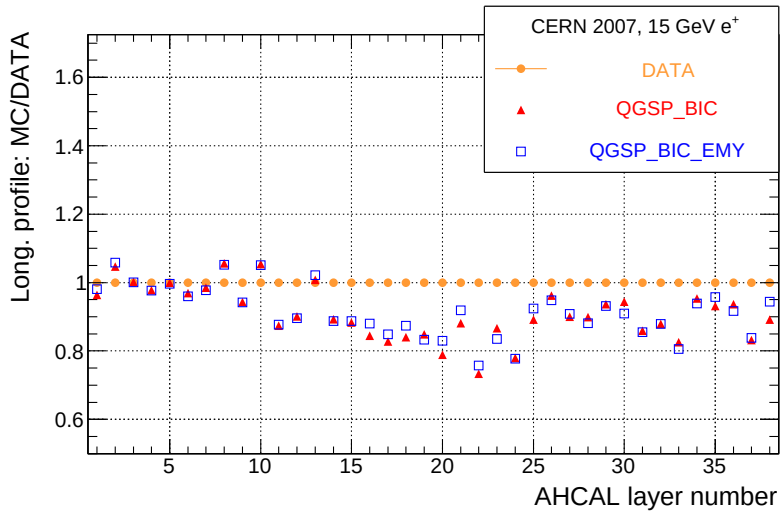
BACK-UP SLIDES

Longitudinal Profiles in ELECTROMAGNETIC Showers

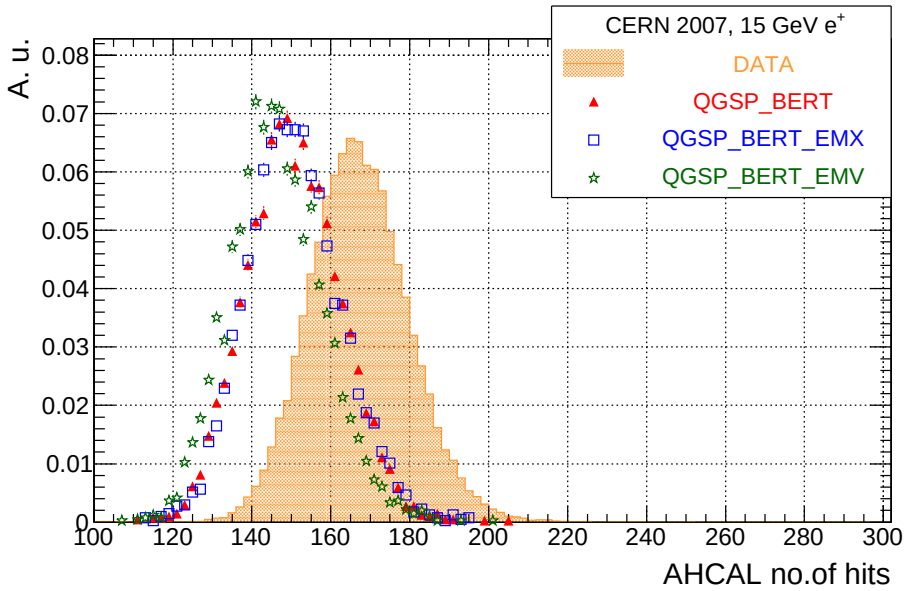


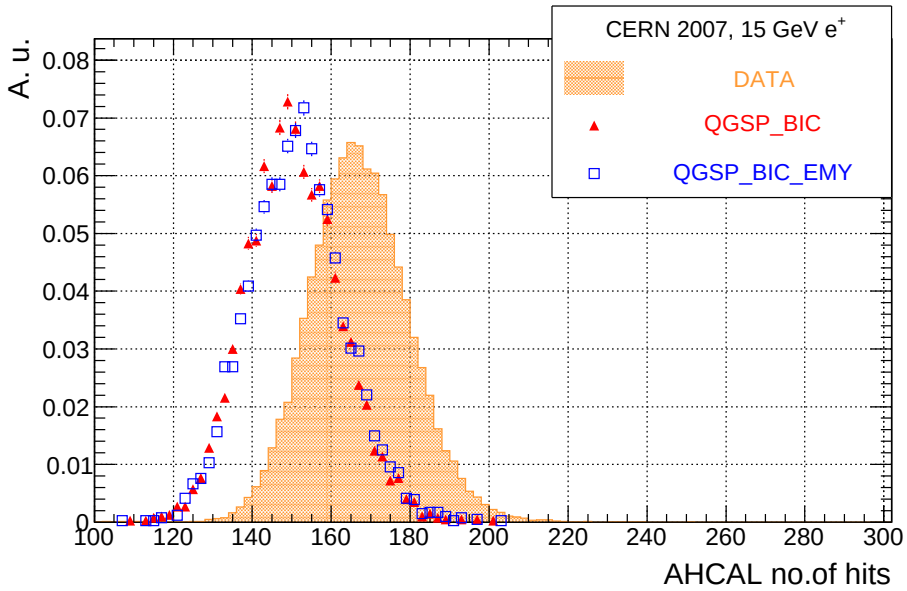


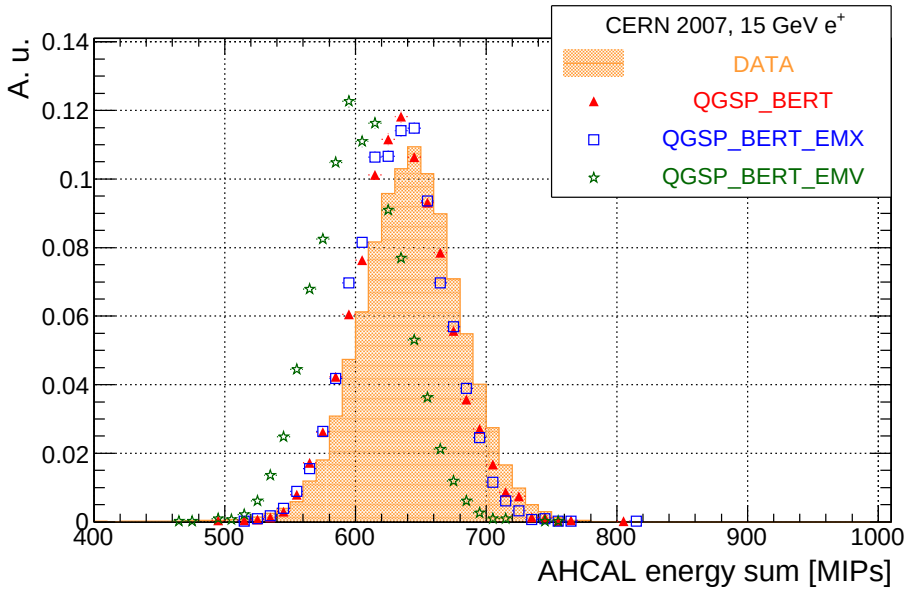


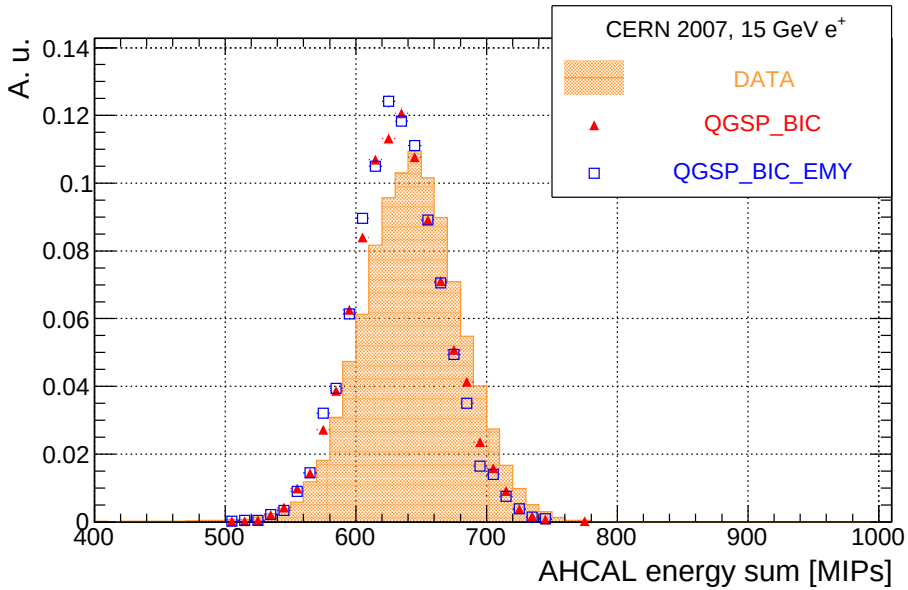


Control Plots









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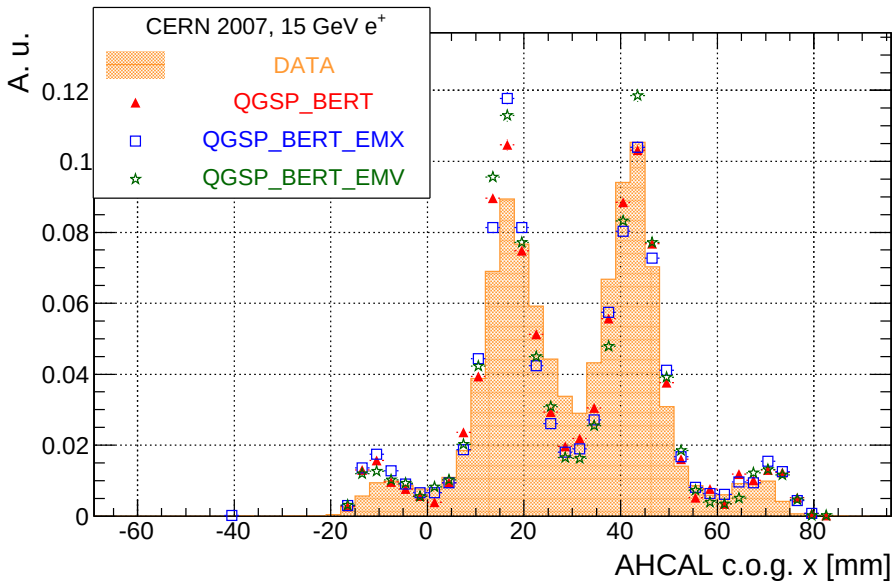

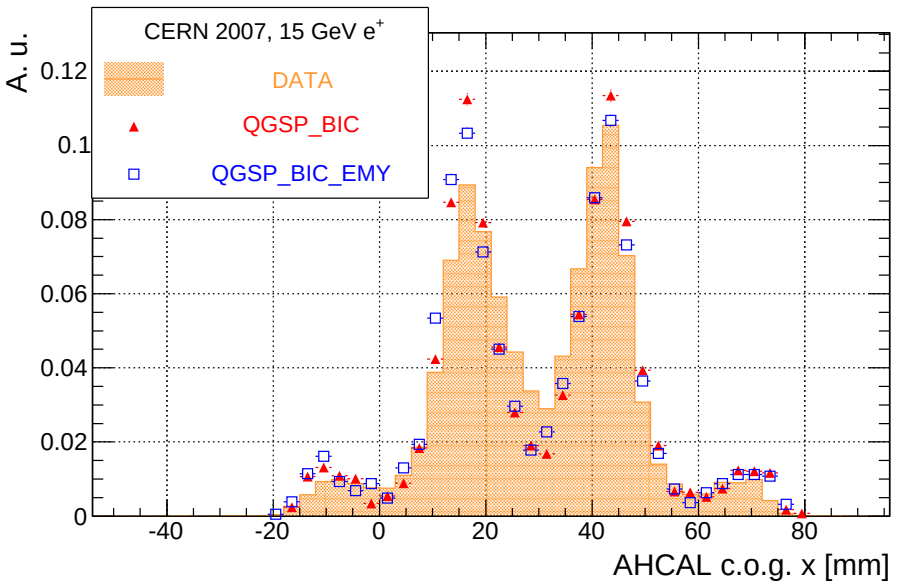

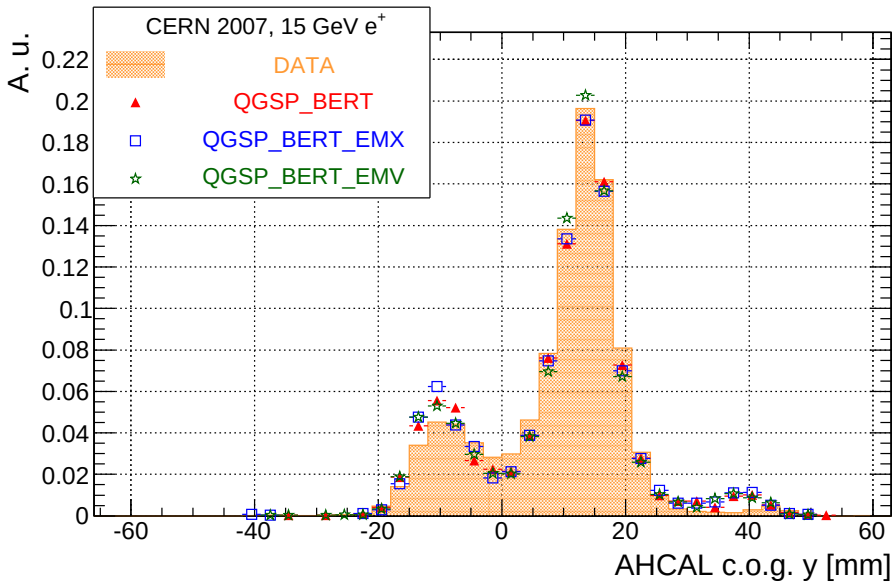

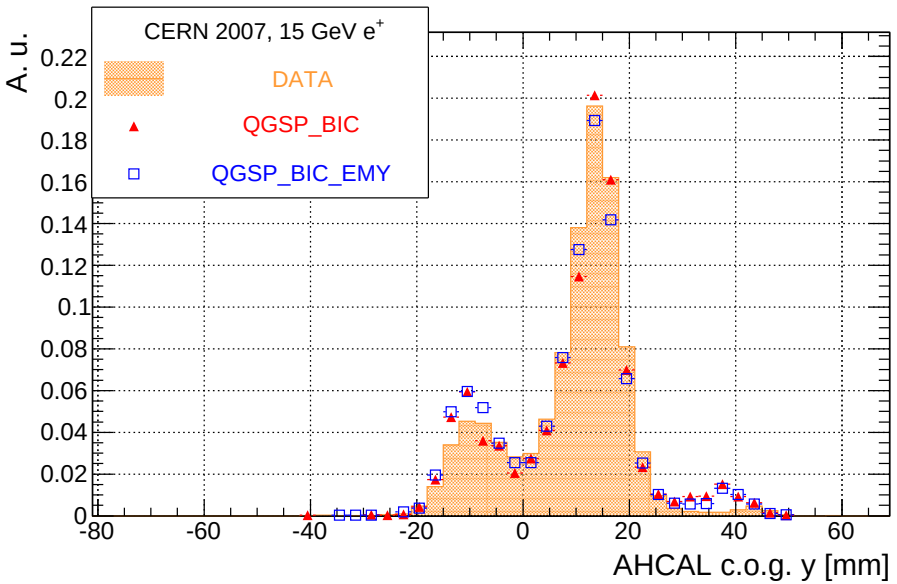

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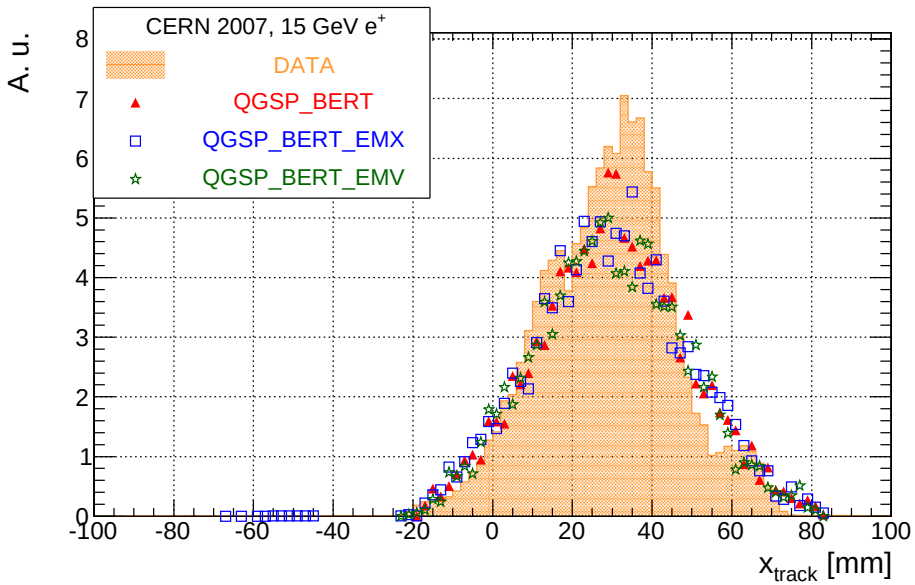

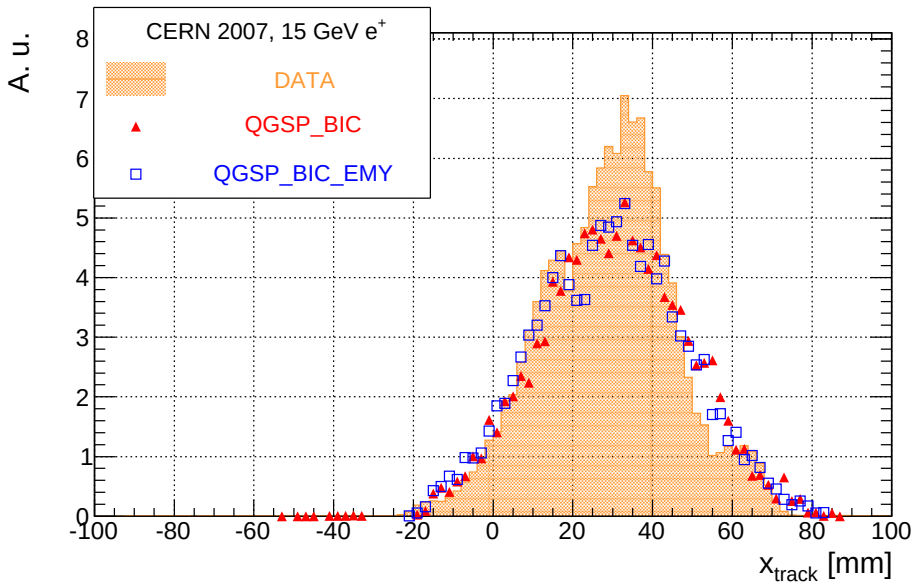

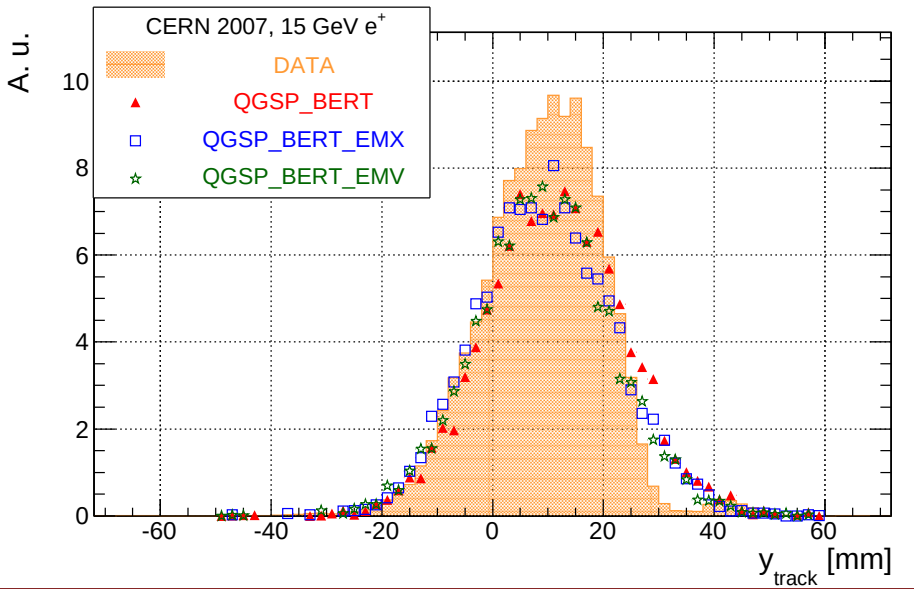

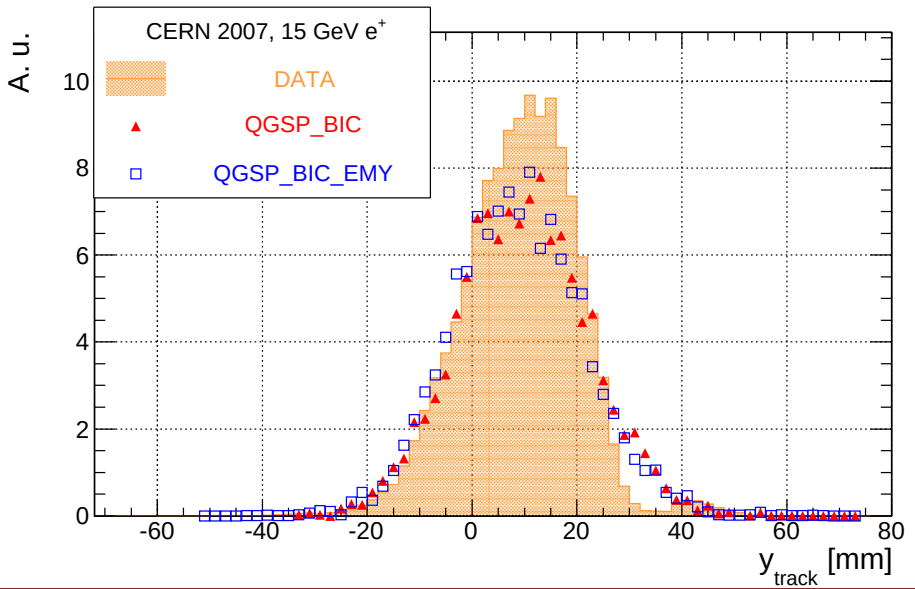

Shower Radius

$$\frac{\sum_i E_i \cdot R_i}{\sum_i E_i}$$