Paper 1: High-Energetic Pions in a Highly Granular Calorimeter

Ivan Marchesini, Uni. Hamburg, 2012-02-20

Content

- Repetition of the **electromagnetic validation** of the AHCAL:
  - check EM scale with up-to-date calibrations;
  - check MC response after recently fixed mokka bugs;
  - no fiducial volume: EM scale to be applied to pions;
  - combine CERN+FNAL electron data.

- Hadronic dataset: **CERN 2007** pion data, 8-100 GeV.
- Setup: SiW-ECAL + Iron AHCAL + TCMT.
- For direct comparison with FNAL low-energy data (Nils' talk) require the **shower start. in AHCAL**.
- Move to Geant4 **9.4**.

- Geant4 validation for **hadronic showers**:
  - pion response;
  - longitudinal and radial development of pion showers.

Electromagnetic Validation

Response

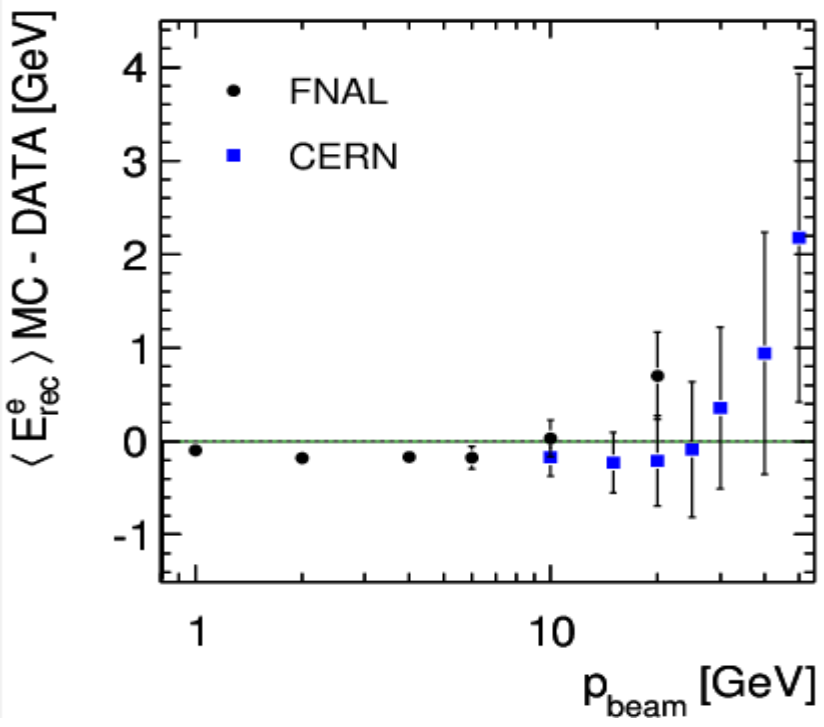
- Combined FNAL+CERN data: reduce fit errors and extend to low energies.
- Good agreement with EM paper.

$$\underset{\text{GeV}}{\langle E^{e}_{rec} \rangle} = \underset{\text{MIP}}{\langle E^{e}_{vis} \rangle} \cdot u - v$$

	u [Mip2GeV]	*v* [MIP]
EM Paper	42.4 ± 0.6	-1.4 ± 7.0
Data	42.4 ± 0.3	-1.1 ± 0.9

Response

- Good agreement Mip2GeV MC/Data, but discrepancy in the offset: ~120 MeV effect, non-perfect treatment of **threshold+noise**.
- Residual **saturation**-simulation issues at high energies within calibration uncertainties (~2%).

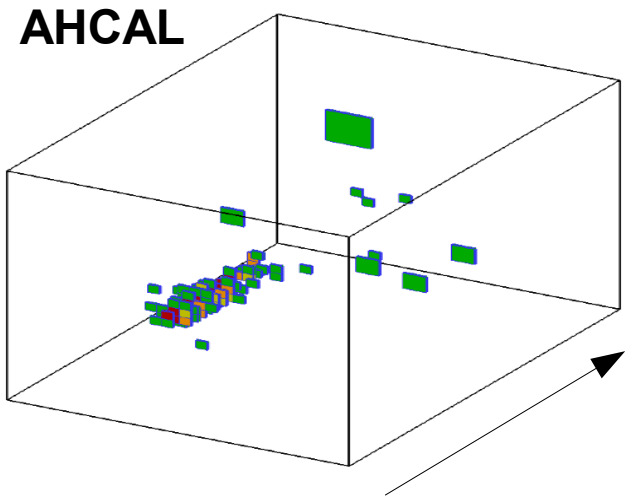


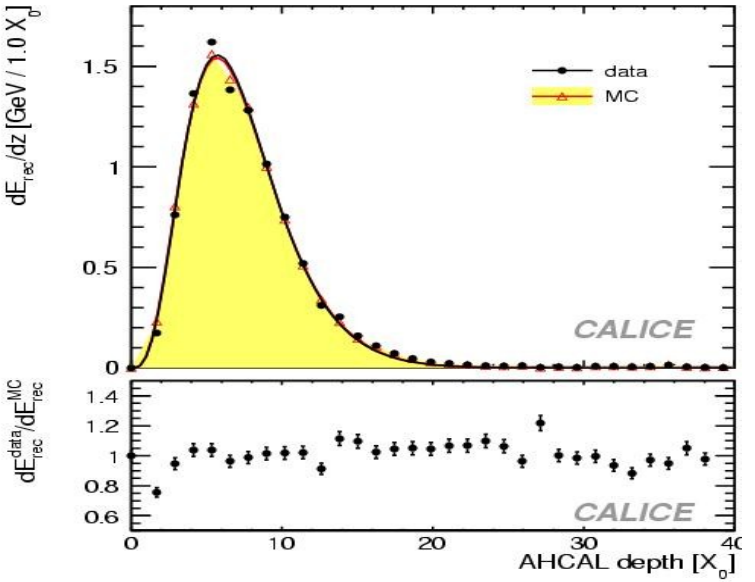
$$\langle E^e_{rec} \rangle = \langle E^e_{vis} \rangle \cdot u - v$$

GeV MIP

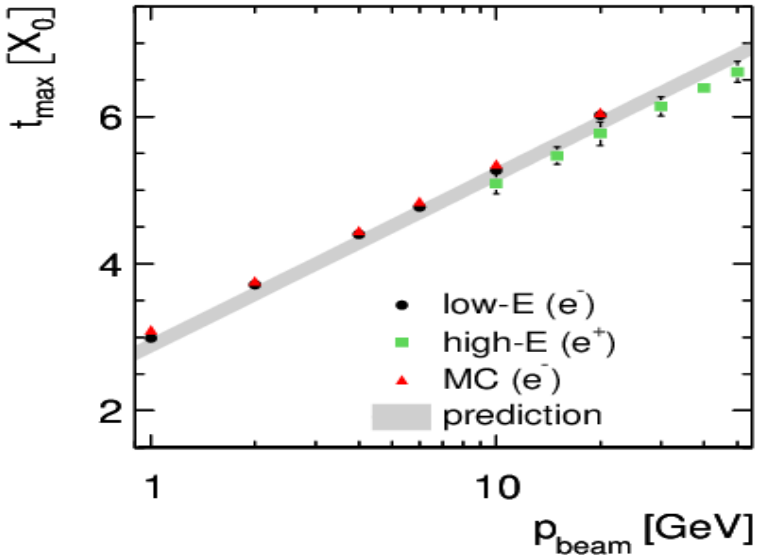
	u [Mip2GeV]	*v* [MIP]
EM Paper	42.4 ± 0.6	-1.4 ± 7.0
Data	42.4 ± 0.3	-1.1 ± 0.9
MC	42.8 ± 0.1	-6.6 ± 0.5

Longitudinal Development

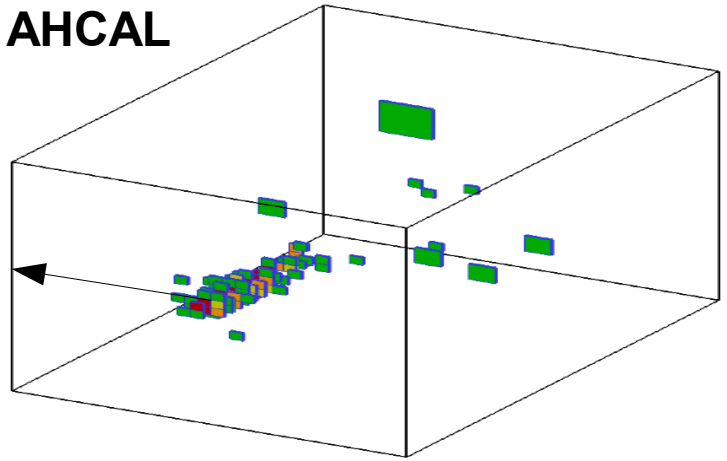


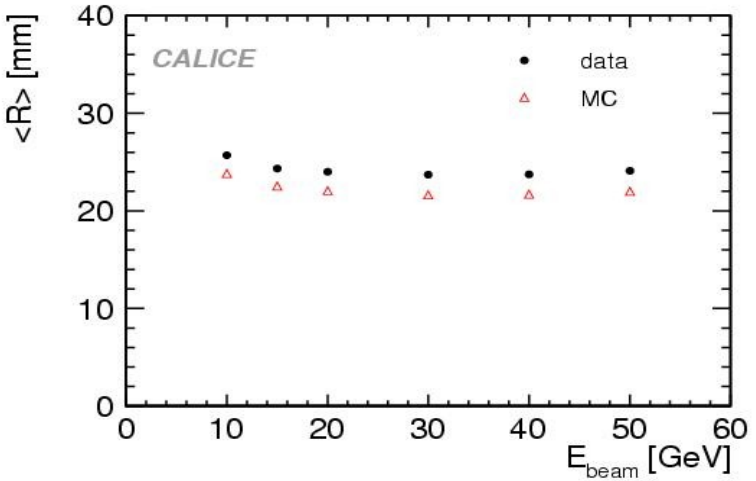


- Fine segmentation:
  - detailed reconstruction of the shower development;
  - precise determination of **shower maximum**.
- Good agreement data/MC and CERN/FNAL.

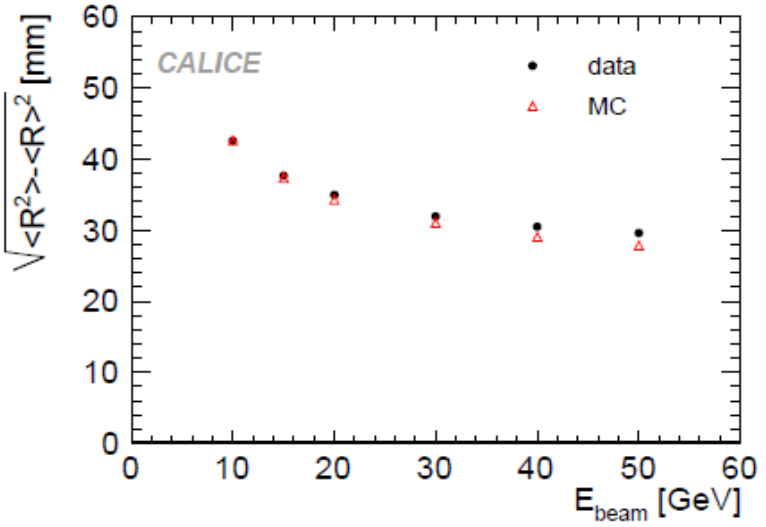


Radial Development



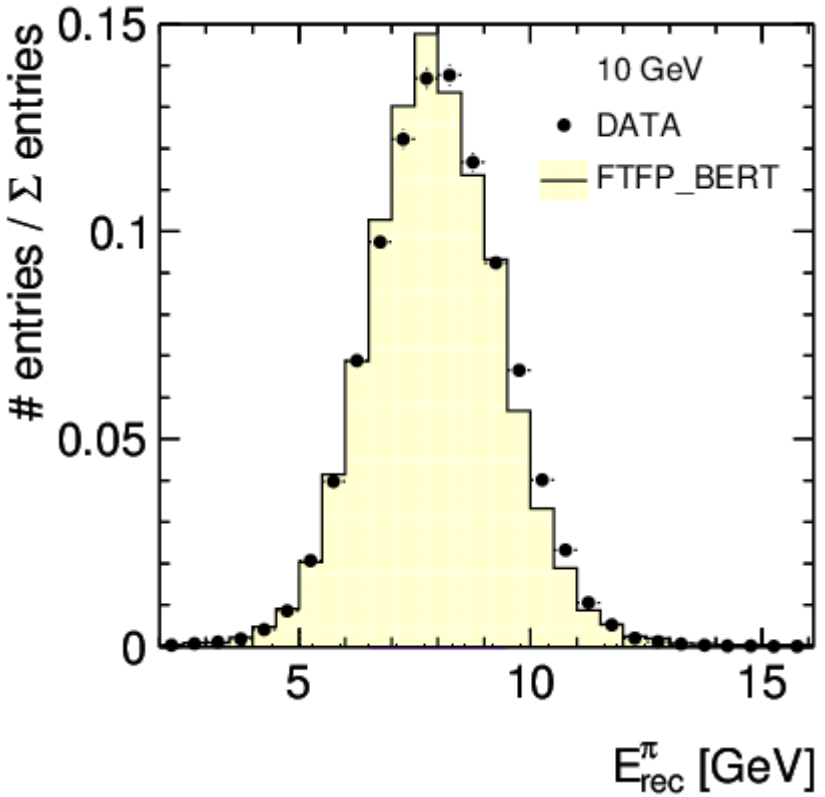


- Residual discrepancies data/MC.
  - Data give **9%** broader showers.
  - **Energy-independent** effect.
- Probable contribution of two causes
  - cross-talk;
  - EM shower modeling (e.g. seen by ATLAS too).
- σ_R better agreement.



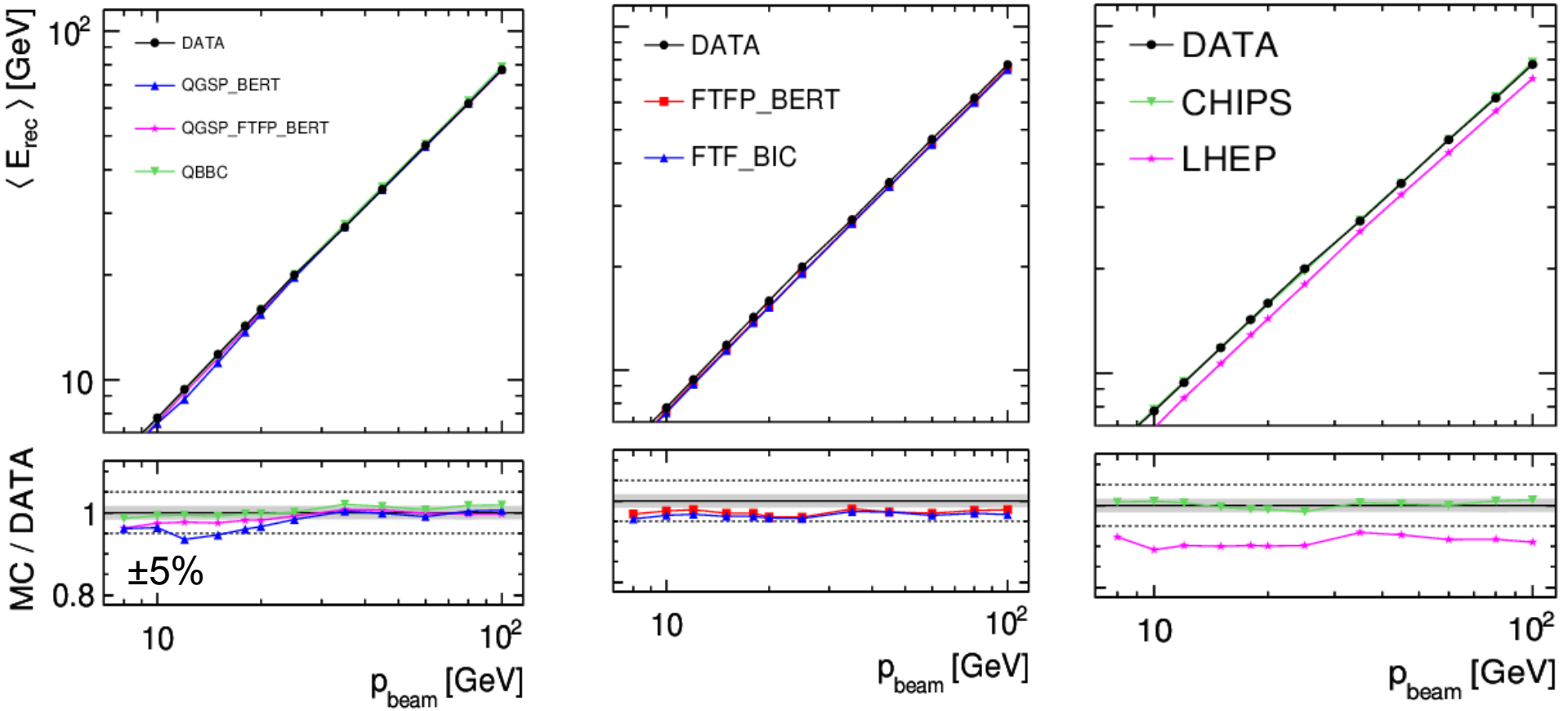
Hadronic Response

Response



- MIP track in ECAL.
- Containment cut: shower starting point in first 5 layers AHCAL.
- No TCMT: known worse calibration.

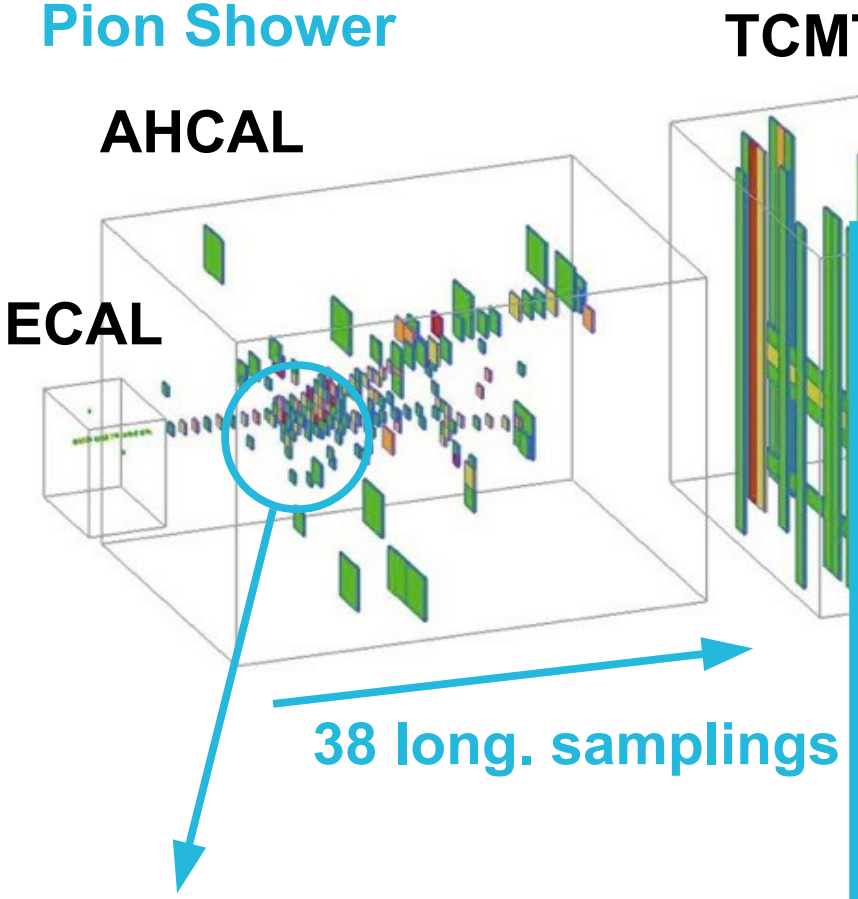
Response: Data vs MC



- Excellent agreement of QGS lists at high energies.
- Excellent improvement of CHIPS with respect to previous versions.

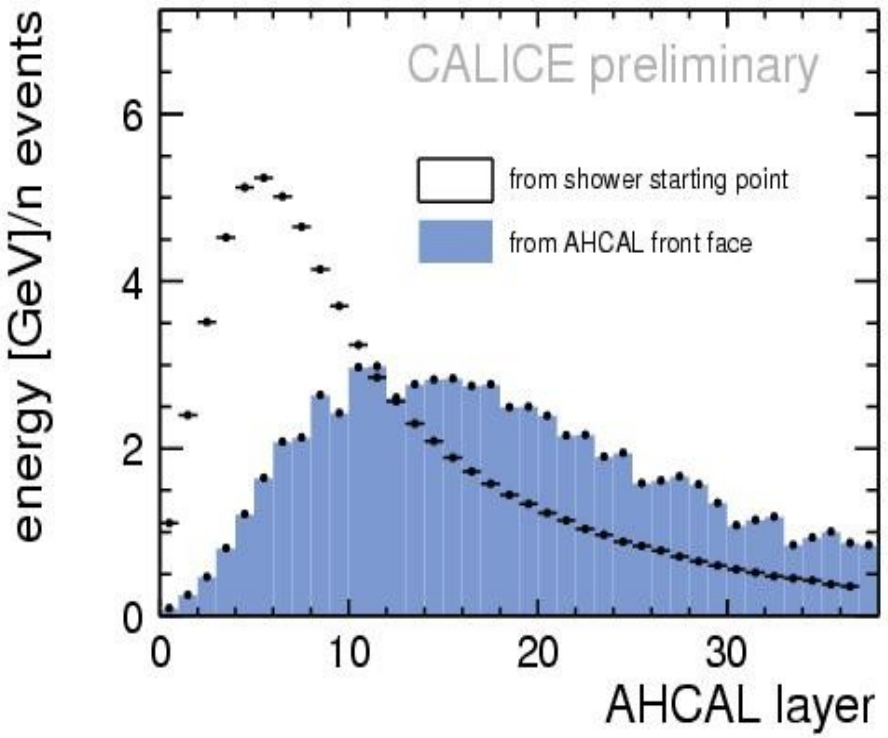
Longitudinal Development

Pion Shower

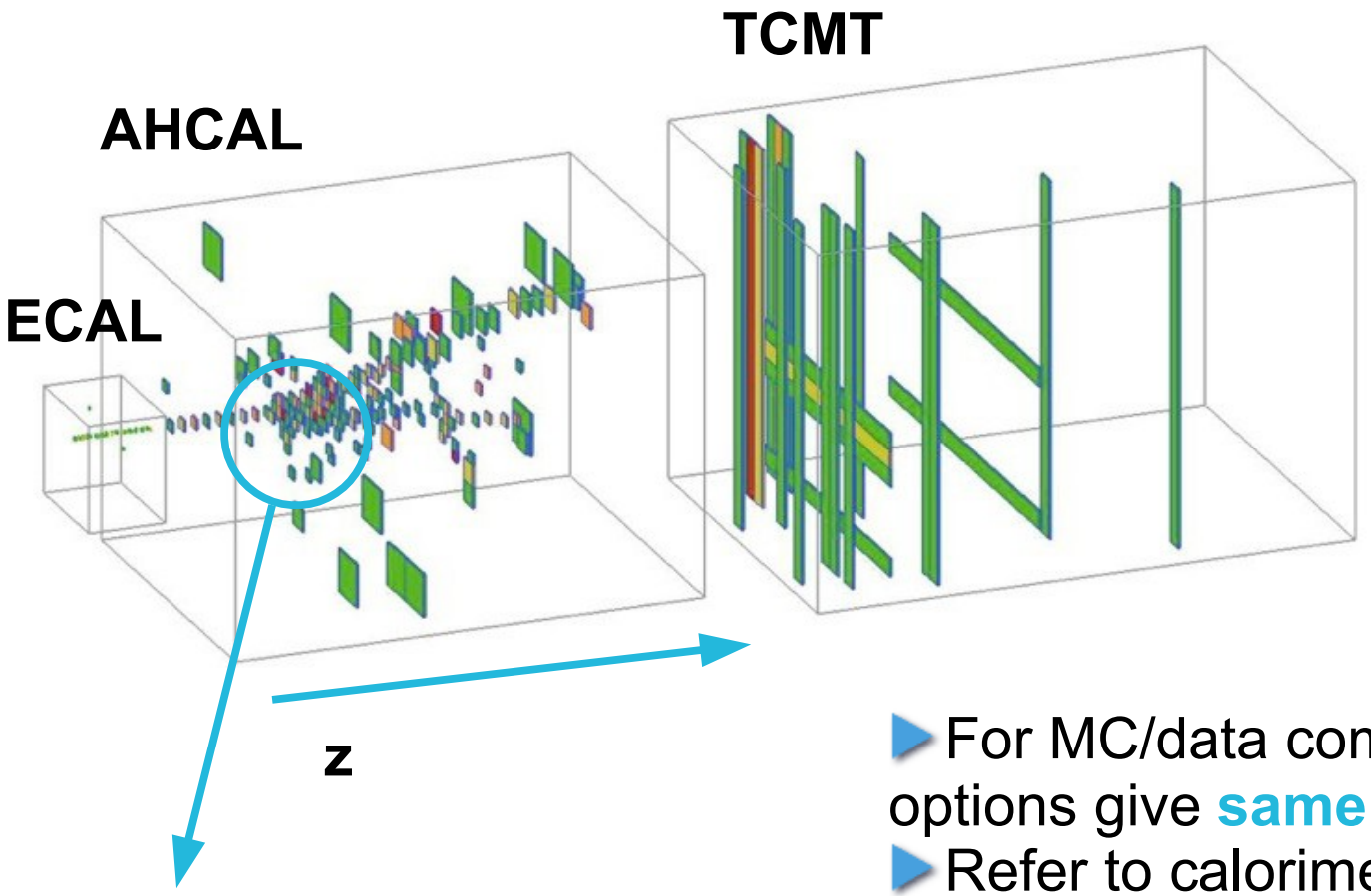


Identify shower starting point: development without fluctuations of initial interaction.

Longitudinal profile (80 GeV)



Longitudinal Development

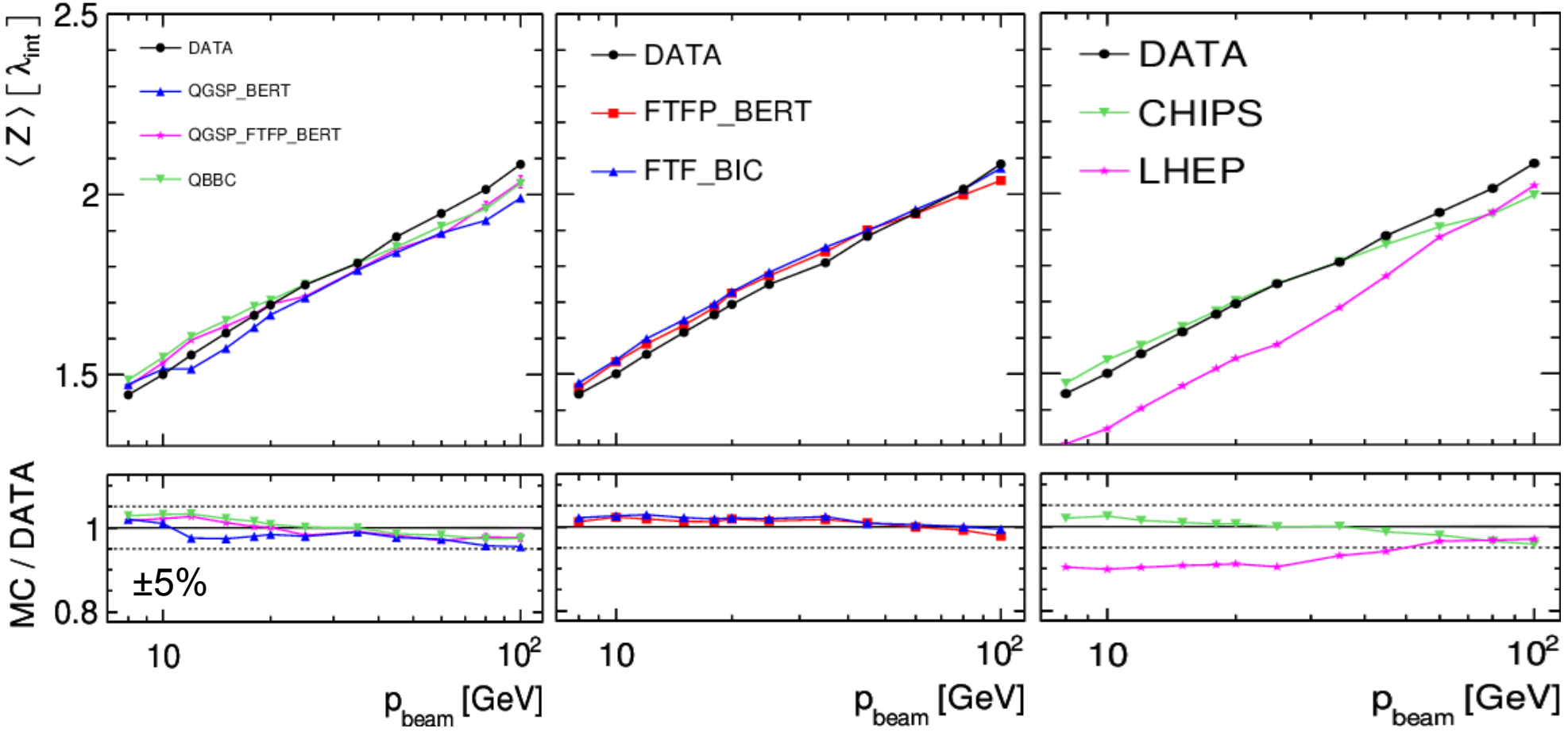


Identify shower starting point: development without fluctuations of initial interaction.

- For MC/data comparison two options give **same message**.
- Refer to calorimeter front-face:
  - algorithm-independent;
  - compare to low energies (Nils' talk).

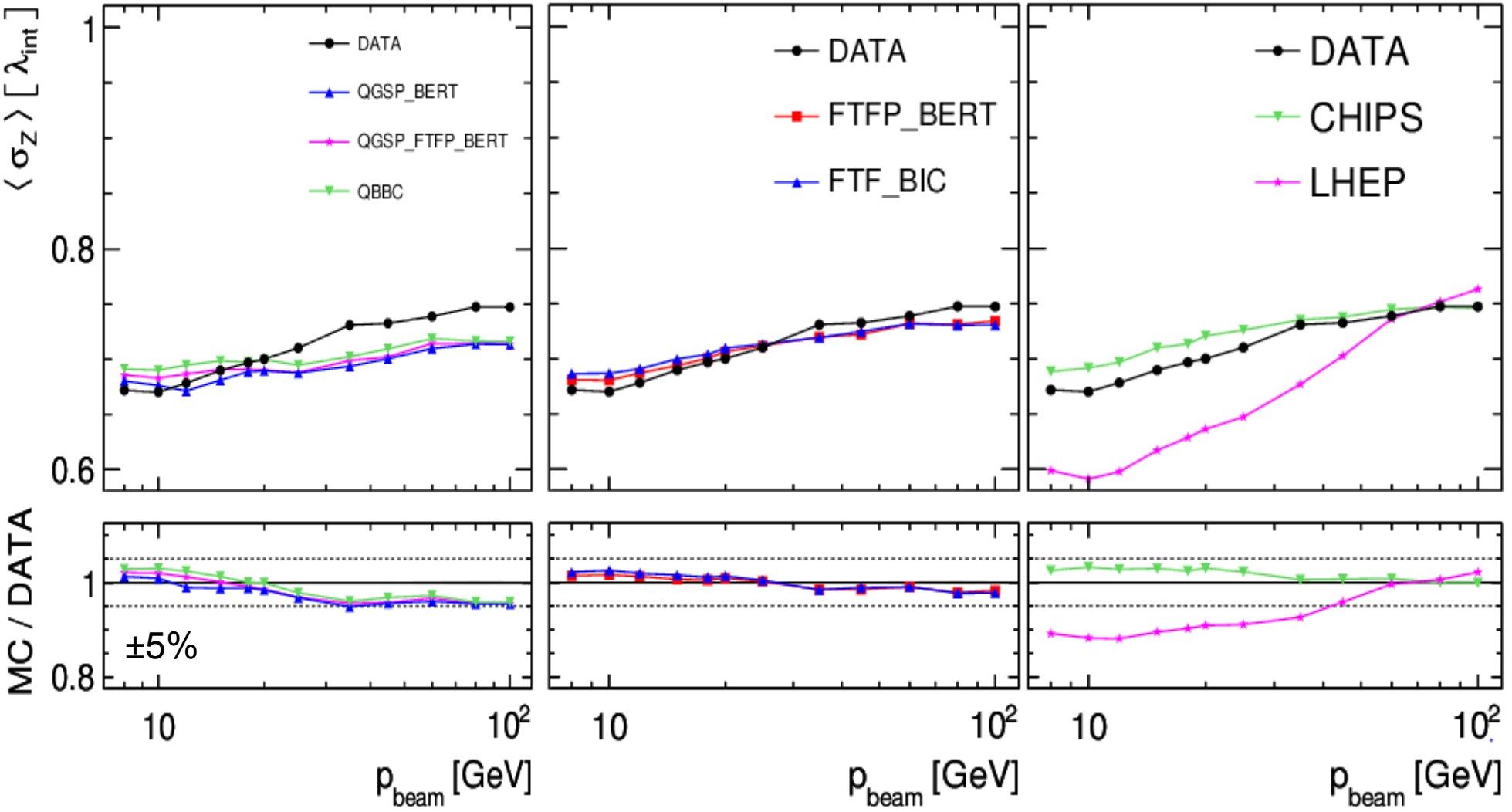
$Mean_z$: Data vs MC

1 layer = 0.1 λ



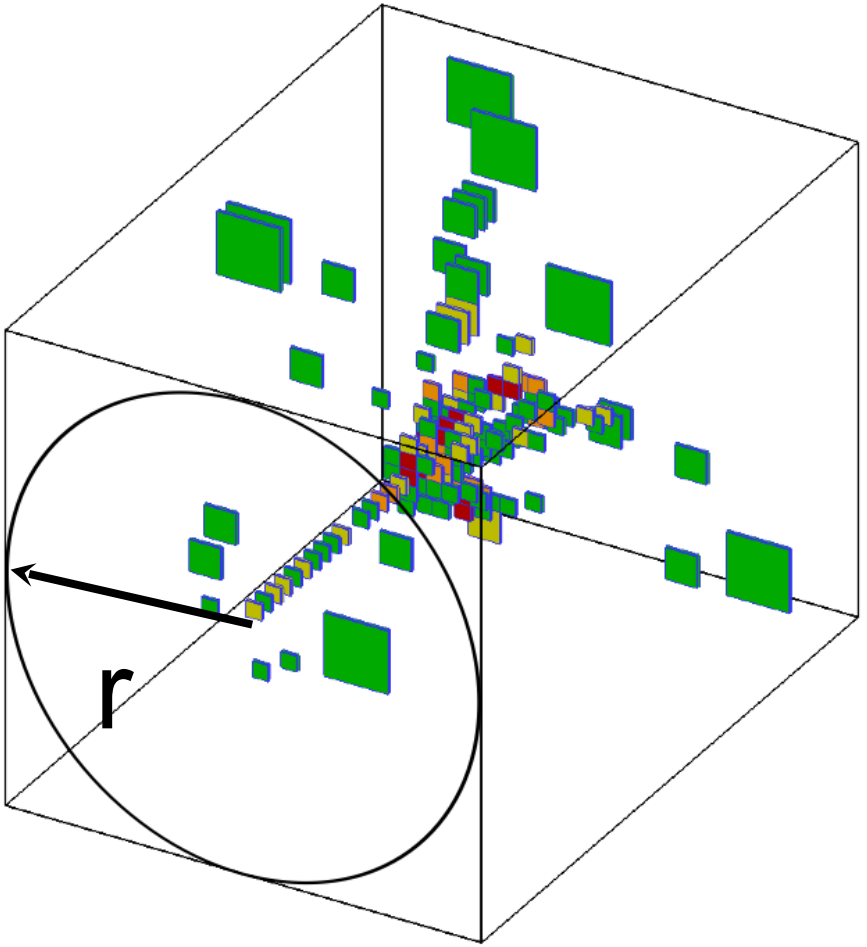
- Excellent agreement of FTF lists.
- Energy-dependent trend of QGS lists, but disagreement < 5%.

σ_z: Data vs MC



- Similar message as mean.

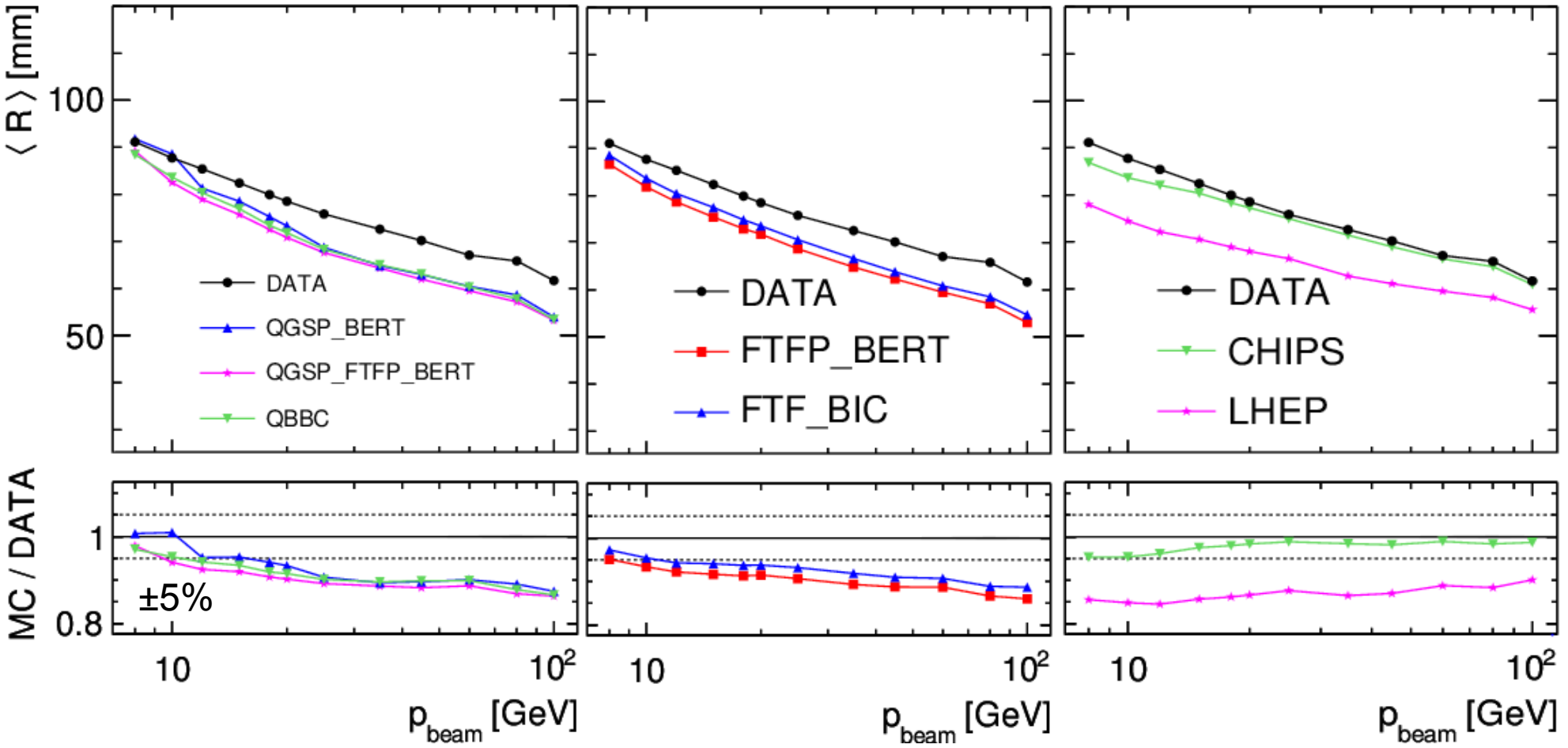
Radial Development



$$R = \frac{\Sigma(E_i \cdot r_i)}{\Sigma E_i}$$

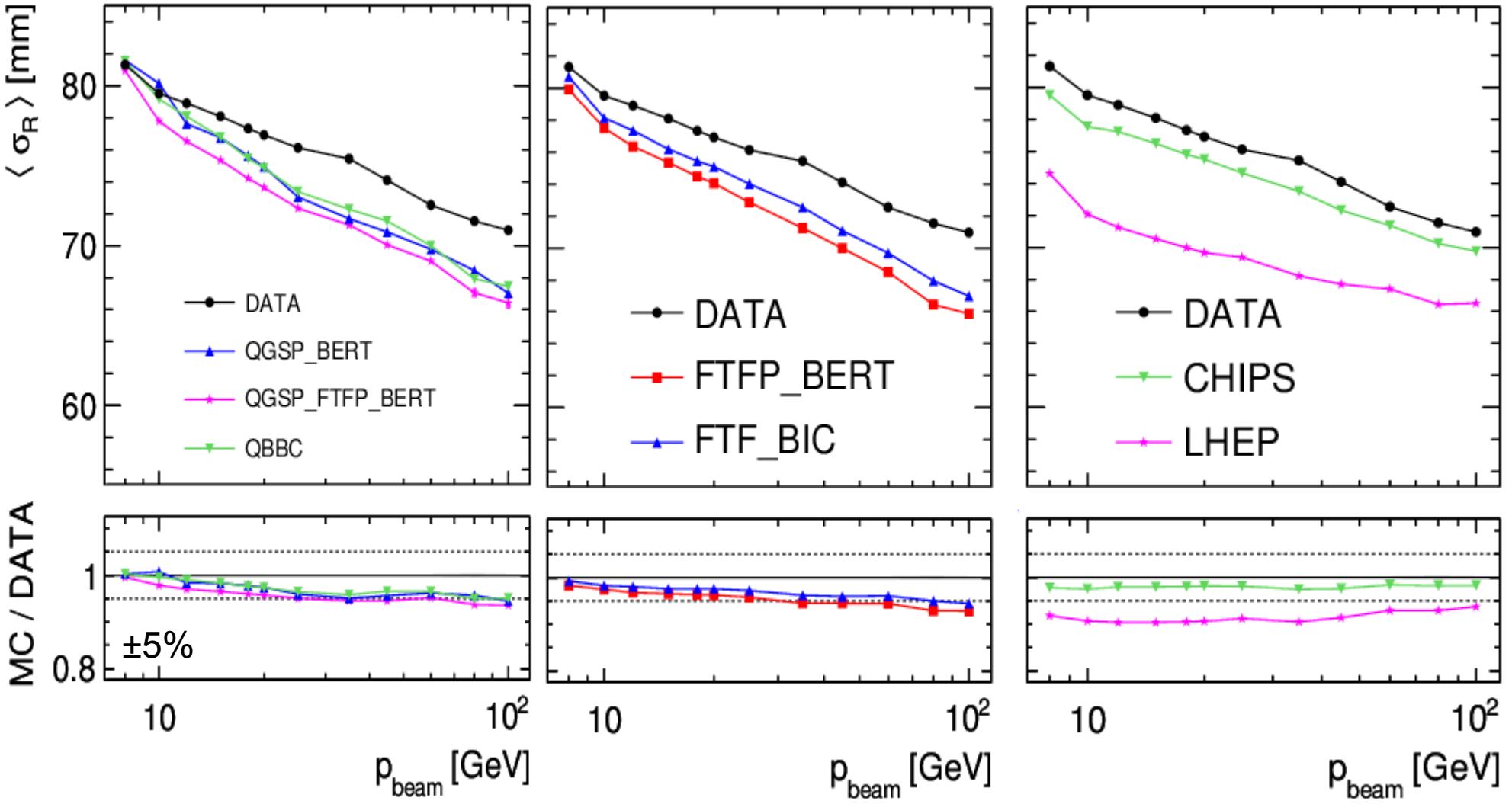
Cell size: 30 mm.

$Mean_R$: Data vs MC



- Data broader than MC, as EM, but **energy dependence** not seen in EM. Only CHIPS agrees with data, but not possible to draw firm conclusions, due to **EM discrepancy**.

σ_R: Data vs MC

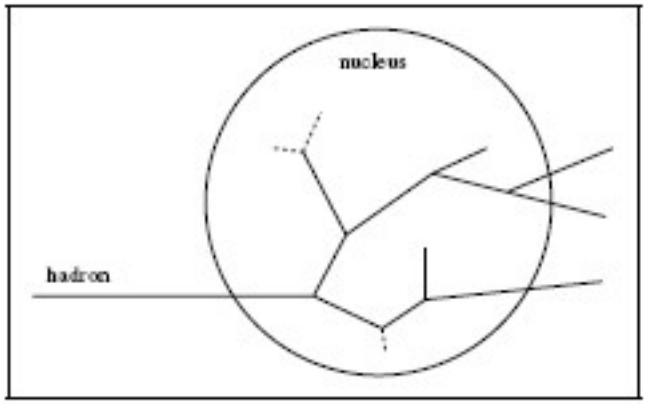


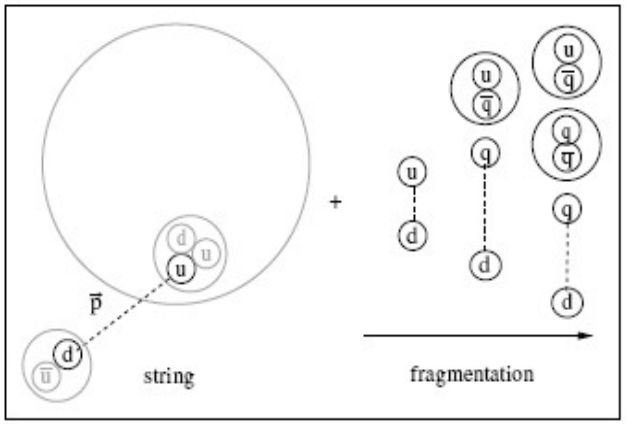
Conclusions

- Analysis repeated with most up-to-date software.
- Compatibility with FNAL analysis: allow direct comparison.
- Good agreement data/MC for response/longitudinal observables.
- Known remaining discrepancy in the radial development, also for EM showers.
- Soon available also:
  - lateral/longitudinal profiles with MC decomposition.
  - observables sensitive to event-to-event fluctuations, such as sigmas of mean_Z, σ_Z, mean_R, σ_R distributions.
  - a few historical plots with older Geant4 versions.

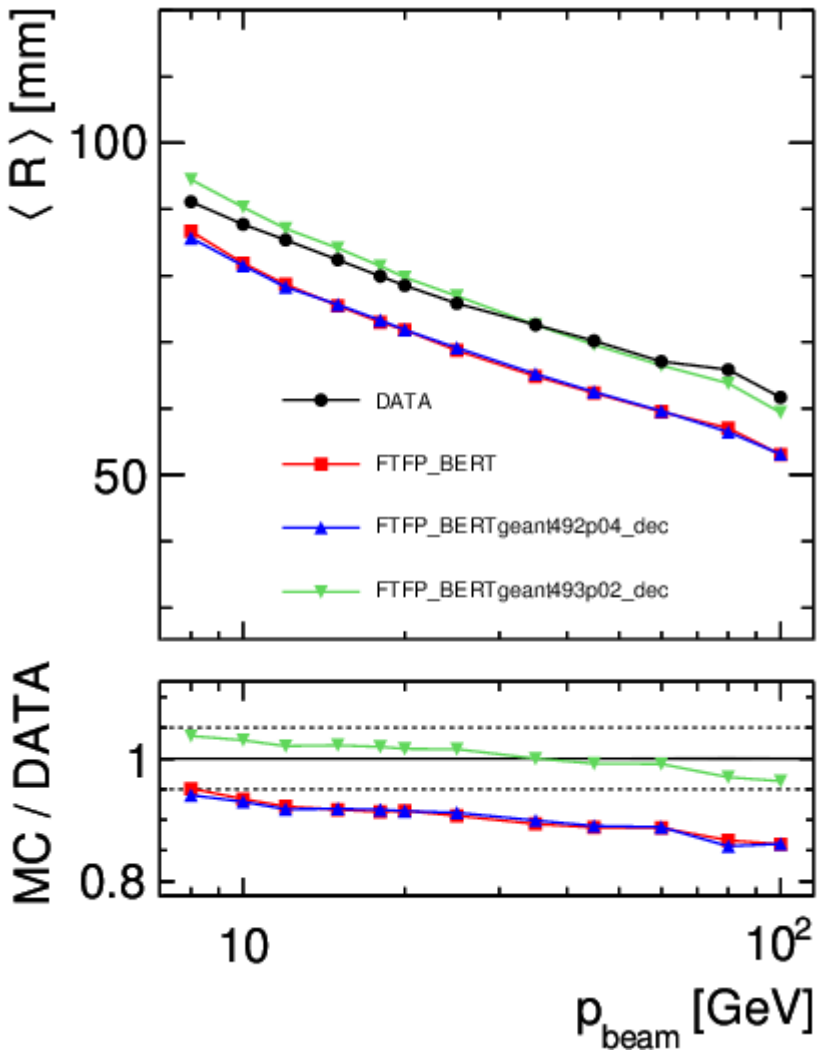
- Paper draft soon ready for review.

End





Backup


⟨ R ⟩ [mm]
100
50
DATA
FTFP_BERT
FTFP_BERTgeant492p04_dec
FTFP_BERTgeant493p02_dec
MC / DATA
1
0.8
10
10²
p_beam [GeV]