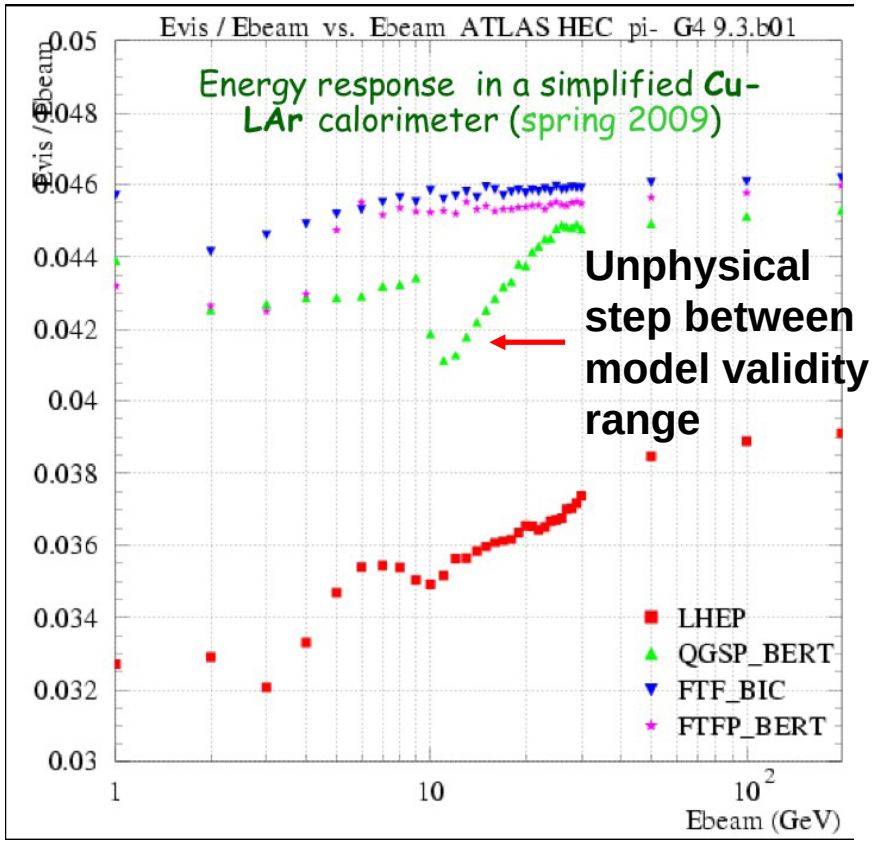
Discussion of MC models validation studies

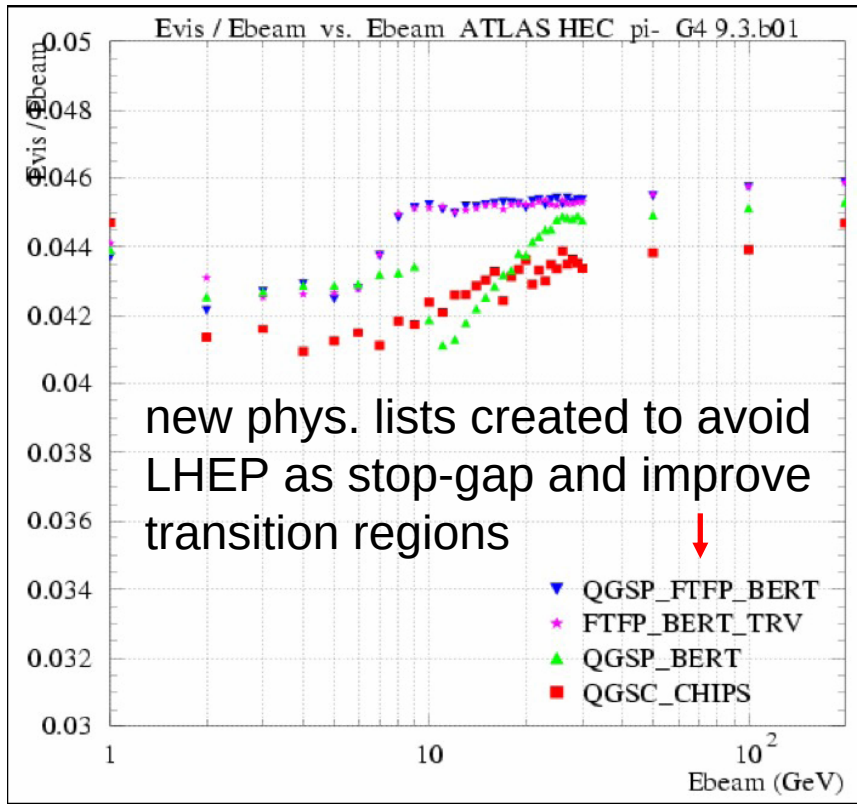
Erika Garutti

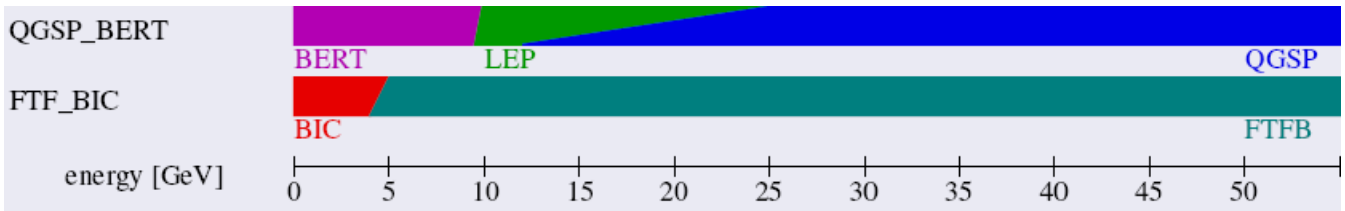
CALICE analysis meeting

from 2009 EUDET meeting

hadronic models in Geant4 in a wide range of energies







Vladimir Grichine

from the last EUDET meeting

Improvements in FTF

1. 3 new things are introduced in FTF for pp- and pA-interactions:
   a) Phase space restrictions at low mass string fragmentation
   b) Correction of multiplicity of intra-nuclear collisions
   c) Tuning of RTIM parameters

2. Good results are obtained for pp- and pA-interactions, especially for description of HARP-CDP data. The description of HARP-CDP data on pA-interactions (Be, C, Cu, Ta, Pb) is the best among other models!

3. The best low energy partner of FTF is the Bertini model. The corresponding transition region is 3 – 8 GeV/c.

4. It would be well to improve the Bertini model. Improving of the Binary model is heavily desirable!

Vladimir Uzhinsky

from the last EUDET meeting

...duction (CHIPS Phys. List status)

- The CHIPS physics list is an experimental physics list, which simulates (** in all physics lists, * in many other physics lists):
  - all inelastic hadron-nuclear reactions (all particles, all energies)
  - photo/lepto-nuclear reactions**(including neutrino-nuclear reactions)
  - elastic hadron-nuclear reactions (all particles, all energies)*
  - stopping for all negative hadrons** + μ^- and τ^- leptons
  - synchrotron radiation (all particles, not only for e^-/e^+) important for γ-nuclear

Important open issue:

- The low energy (LE) neutron cross-sections are not implemented because the low energy inelastic nA cross-sections can not be implemented in the open code toolkit ($\rightarrow$ callorimeter response overestimation).

➔ Expected too high reconstructed energy

Mikhail Kosov

from the last EUDET meeting

...ant issues for calorimeter simulation

Production of γ's in hadron EM decays of π^0,η, η′, ω, Σ^0 etc., switching distributed hadronic energy to short range electromagnetic cascades

- usually a source of γ's are π^0's; in CHIPS + direct γ's & massive mesons (η, ω)
- π^0+γ+η energy is better for the short range deposition estimate than just π^0's energy.

➔ f_{EM} should be more accurate then in other models

- The quasi-elastic and diffraction parts of the inelastic cross-sections
  - In CHIPS both problems are solved in the first order, and can be improved.
  - Quasi-elastic & diffraction are very important for the longitudinal shower shape
    - Both quasi-elastic and diffraction effectively reducing the real inelastic cross-section
    - That is why sometimes an artificial reduction of the inelastic cross-section to the "production" cross-section level helps to improve simulation results.

➔Expected too long shower (as opposed to other lists which predict Too short showers since they don't include diffraction)

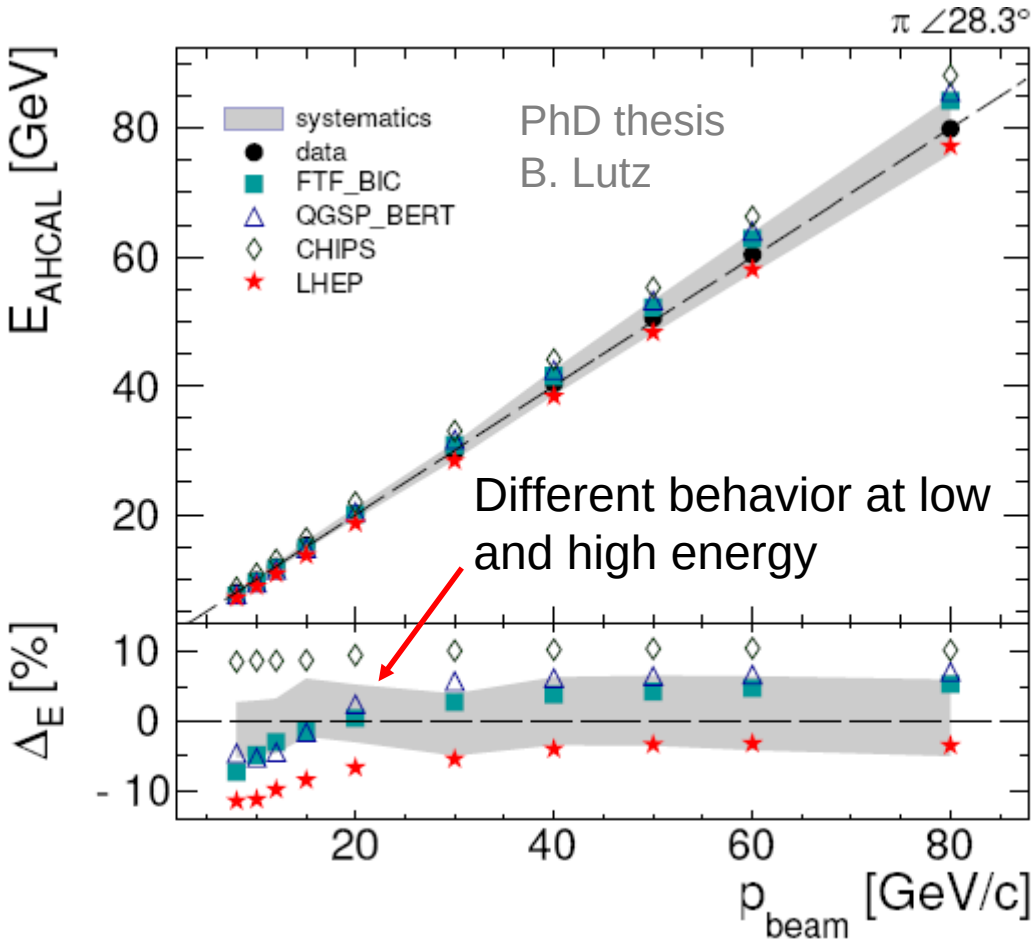
Additional recommendation emerged during discussion

➔Check the multiplicity of particles after the first interaction

!!! Possible on very highly segmented calorimeters

Mikhail Kosov

Energy deposited in AHCAL



Geant 4.9.3 final version (12/2009)

CHIPS: no transition region, only available from version 4.9.3.p01

transition region between models visible as step

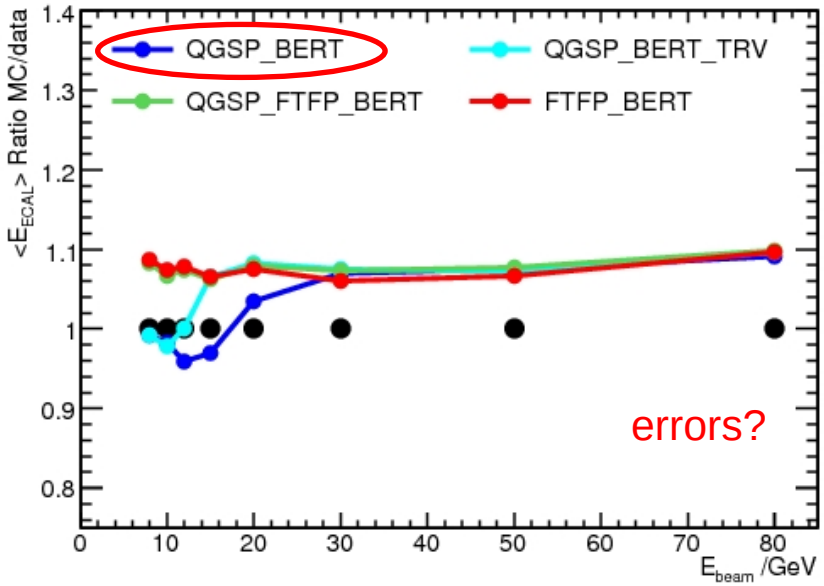
←As expected CHIPS over estimates reconstructed E but no E-dependent transition region

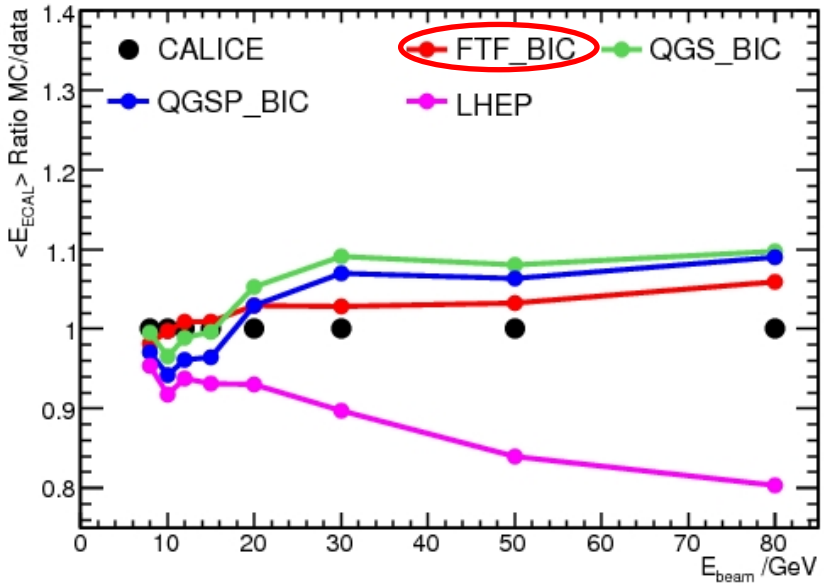
string+cascade within errors — only CHIPS flat like data

Alexander Kaplan

Energy deposited in ECAL

Show trend of <E(MC)>/<E(Data)> vs beam energy





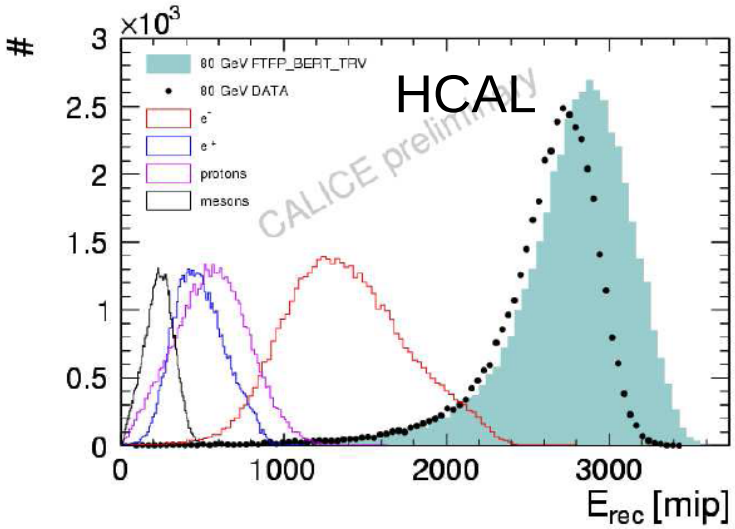
- Steps seen as Geant4 makes transitions between models
- Most models within 10% of data, but tend to overestimate at high energies
- Closest overall seems to be FTF_BIC

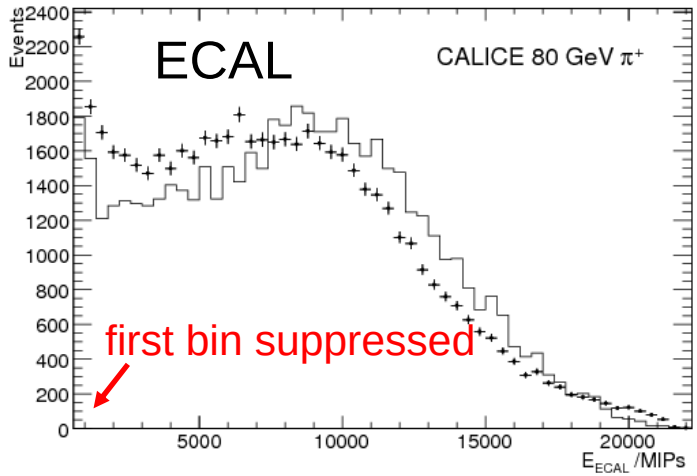
- FTF_BIC and QGSP_BERT much closer in HCAL
- QGSP_FTFP_BERT and FTFP_BERT show no E-dependence (like CHIPS)

➔ to be confirmed for HCAL

remarks on energy deposited

- different “meaning” of energy deposited in ECAL / HCAL
  ➔ ECAL much larger leakage

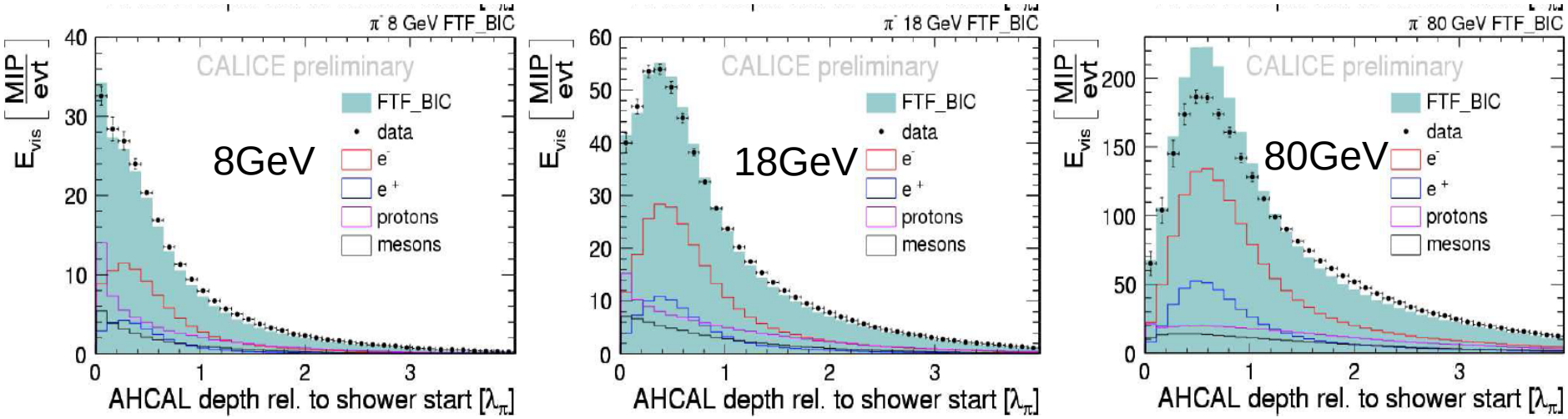




- start to work on the determination of e/π and present the fraction of energy deposited to the total
- put more emphasis to model without steps in transition region (QGSP_FTFP_BERT, FTFP_BERT, CHIPS)
  ➔ work with the authors to get scale right

Longitudinal shower profile (HCAL)

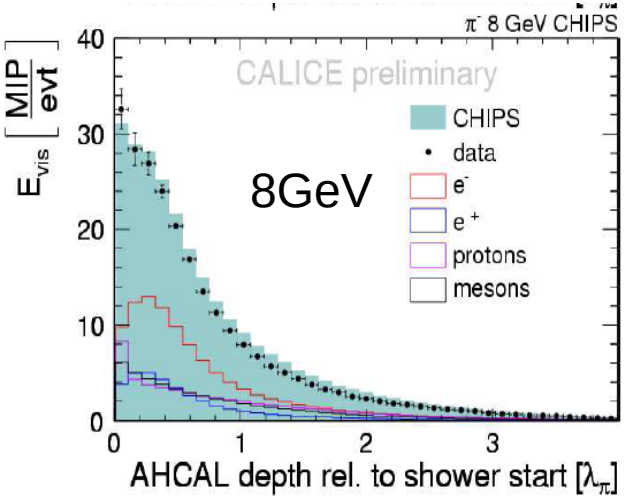
shower development from first hadronic interaction

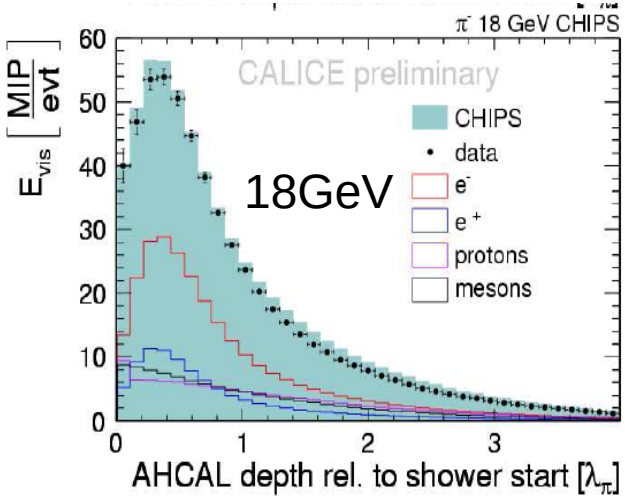


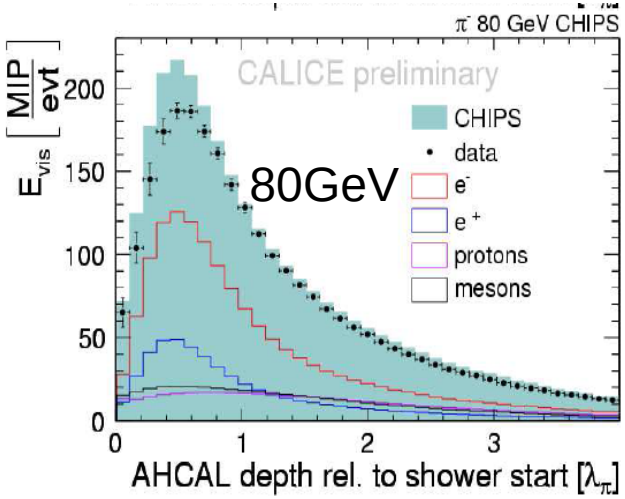
Most models are ok <20 GeV, >25 GeV models predict too short shows

Longitudinal shower profile (HCAL)

shower development from first hadronic interaction







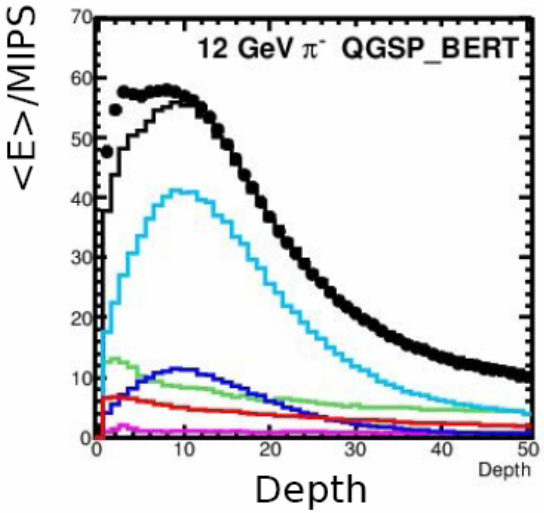
As expected from (un-tuned) diffractive processes CHIPS too long shower

longitudinal shower profile (ECAL)

Longitudinal Energy Profiles

Sensitivity to different shower components

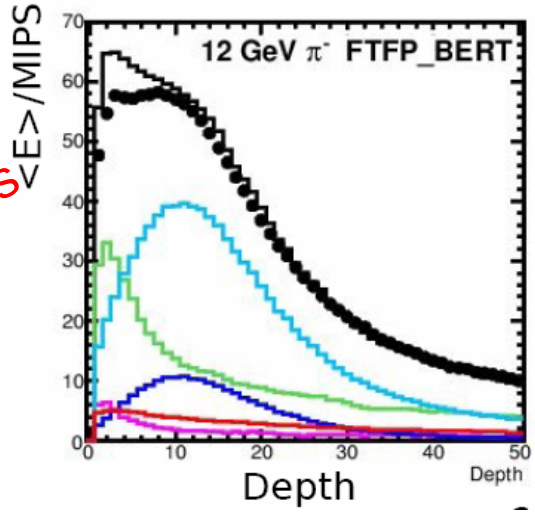
Too few protons



Shower Components:

- electrons/positrons
  knock-on, ionisation, etc.
- protons
  from nuclear fragmentation
- mesons
- others
- sum

Too many protons



Significant Difference between Models

- Particularly for short range component (protons)

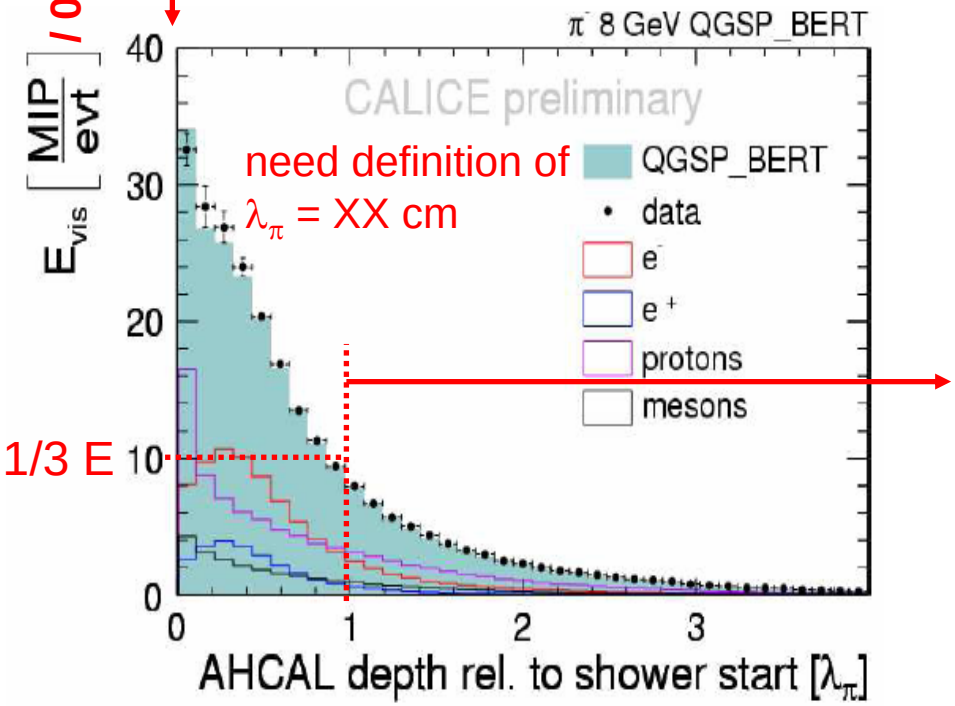
Granularity of SiW Ecal allows (some) disentangling of components

Further studies for shower decomposition are ongoing

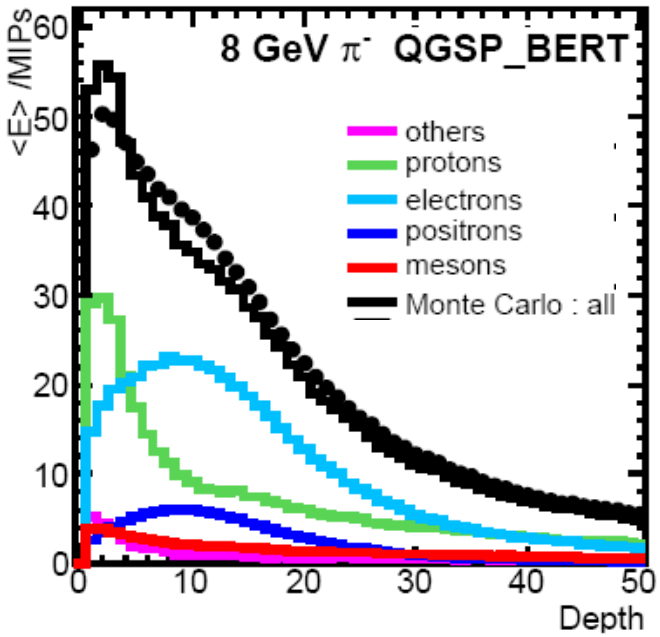
comparing results ECAL/HCAL

need to add bin size

HCAL



ECAL



<1/5 E

desirable to express x axis in units of λ
➔ 1 ECAL layer ~0.03 λ

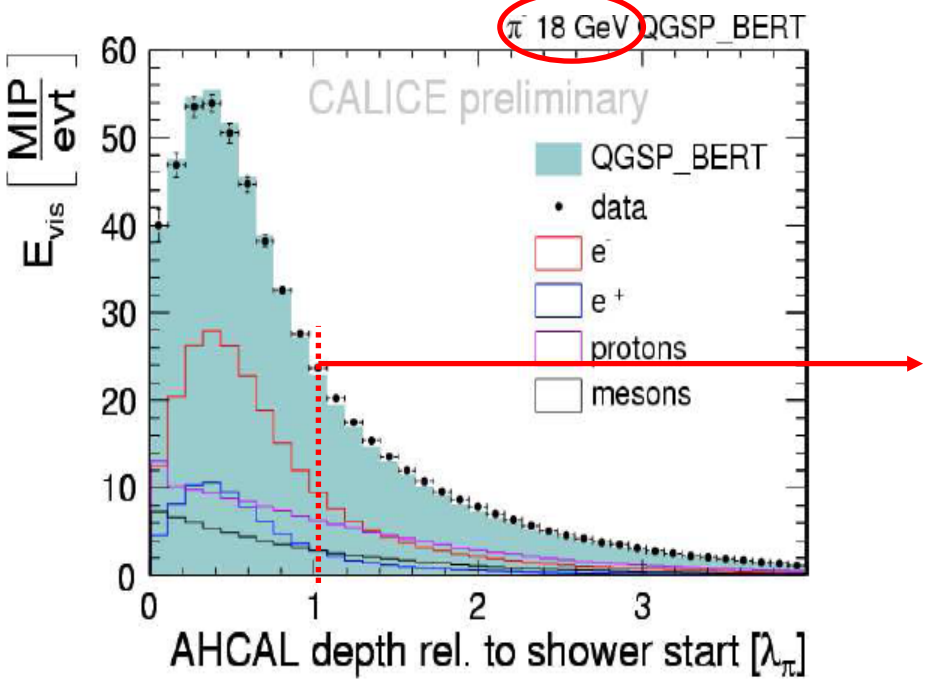
QGSP_BERT: in HCAL better agreement than in ECAL ➔ W / Fe ?!
➔ will be soon validated by WHCAL
- similar enhancement of protons after first interaction

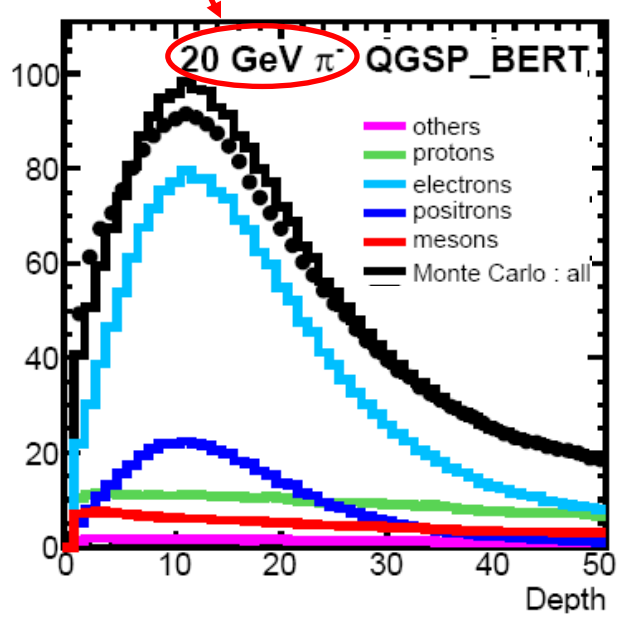
comparing results ECAL/HCAL

HCAL

provide same energy where possible

ECAL



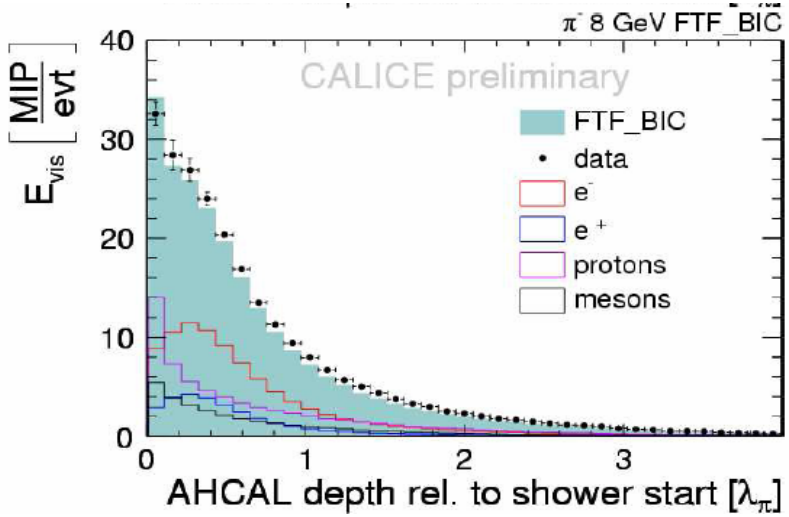


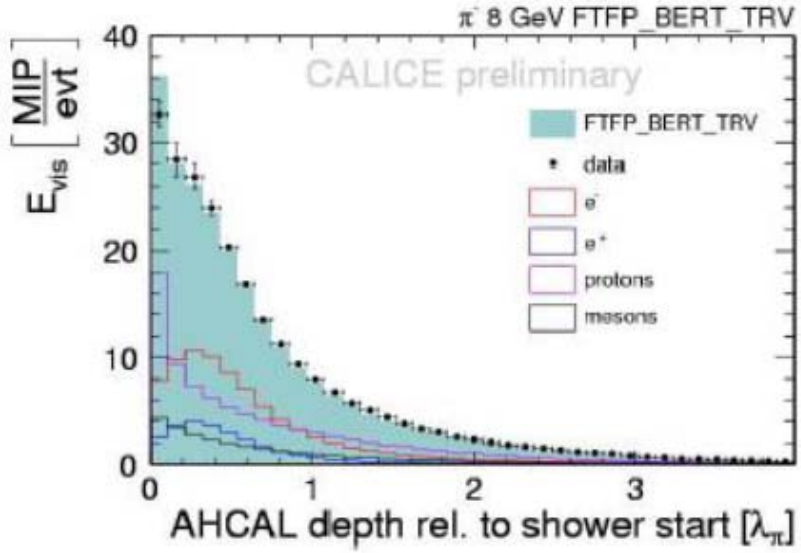
QGSP_BERT: in HCAL better agreement than in ECAL ➔ W / Fe ?!
➔ will be soon validated by WHCAL
- proton/meson content decreases faster in HCAL, in ECAL flat ➔ ?!
- need to show fractions

comparing results ECAL/HCAL

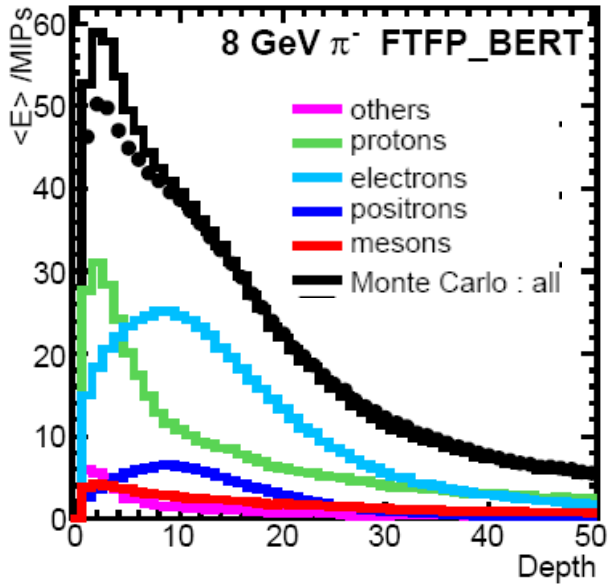
provide comparison to same models

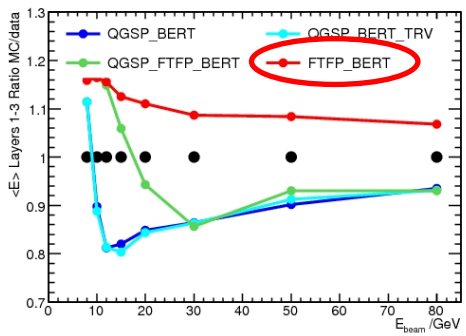
HCAL

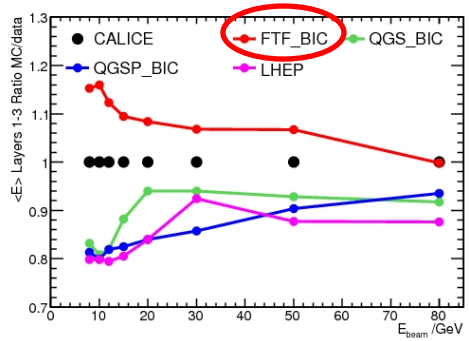




ECAL







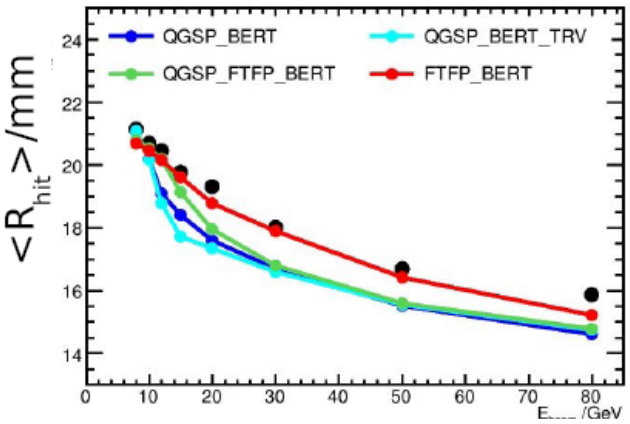
FTF_??: hard to compare one-to-one, maybe BIC lower then BERT after first interaction

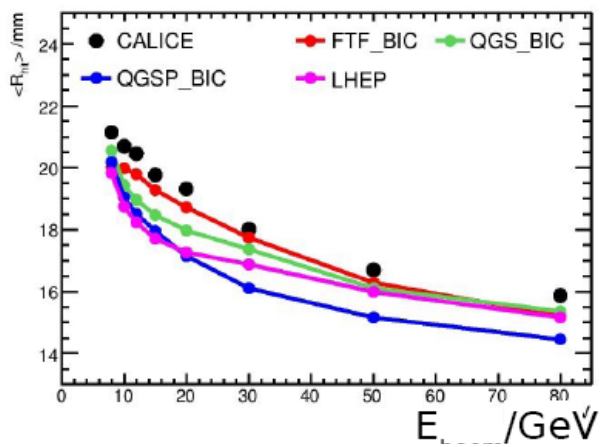
remarks on longitudinal shower profile

- FTF_BERT ➔ get new transition range
- more detailed studies comparing FTF_BIC/FTF_BERT
- more work on comparison ECAL/HCAL needed
  - ➔ are there biases on shower shape from event selection?
  - ➔ are there differences due to W / Fe ?
- try to develop a common plot style (useful for comparison)
- try to compare same models and same energies
- LHEP fails badly everywhere, let us leave it out !!!
- CHIPS: quite promising, work with author to provide a new tune of diffractive processes

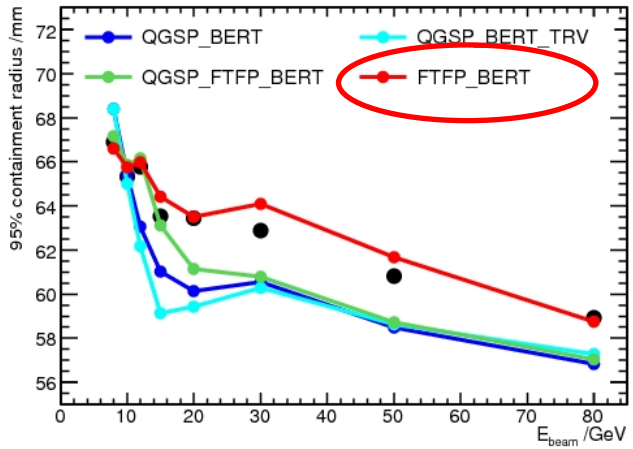
Transverse shower profile (ECAL)

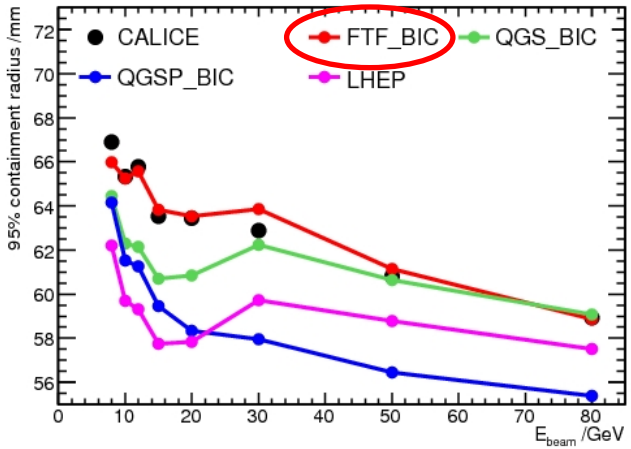
Shower Radius





$R_{95\%}$



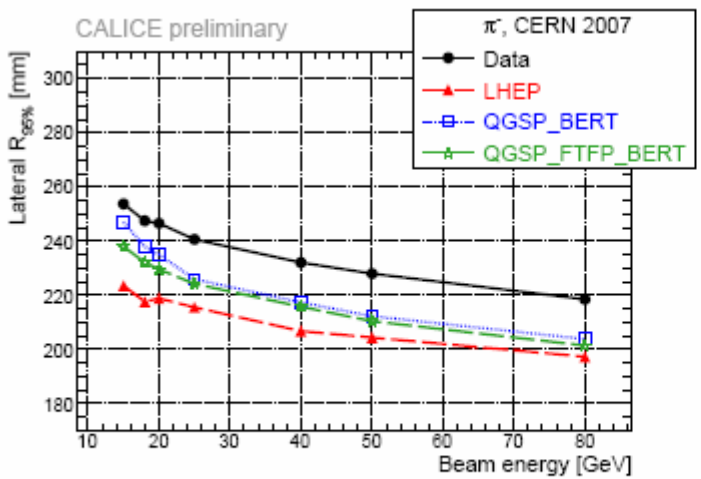


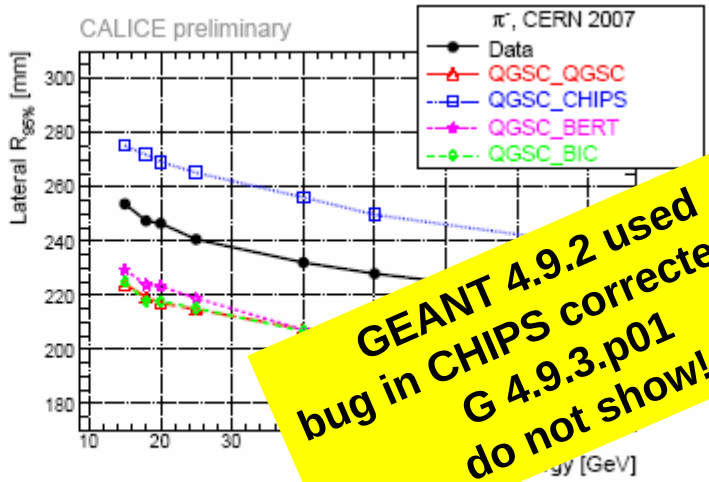
➔ FTFP_BERT best

➔ try new FTF_BERT [TR 3-8 GeV] and CHIPS

Transverse shower profile (HCAL)

$R_{95\%}$





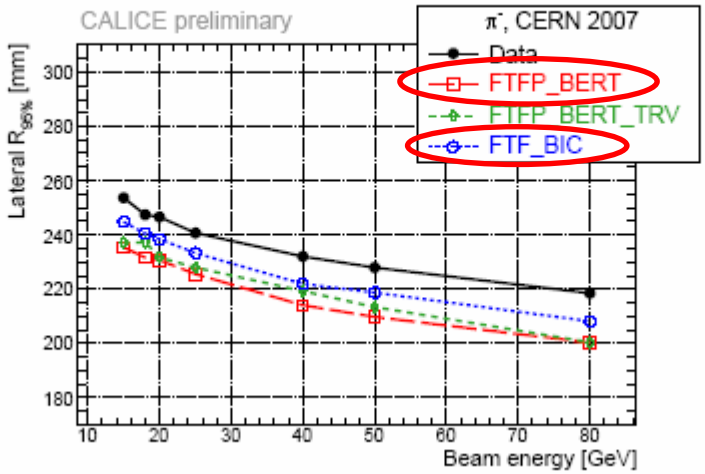
GEANT 4.9.2 used bug in CHIPS corrected in G 4.9.3.p01 do not show!

(a)

old analysis with known problems (see next slide)

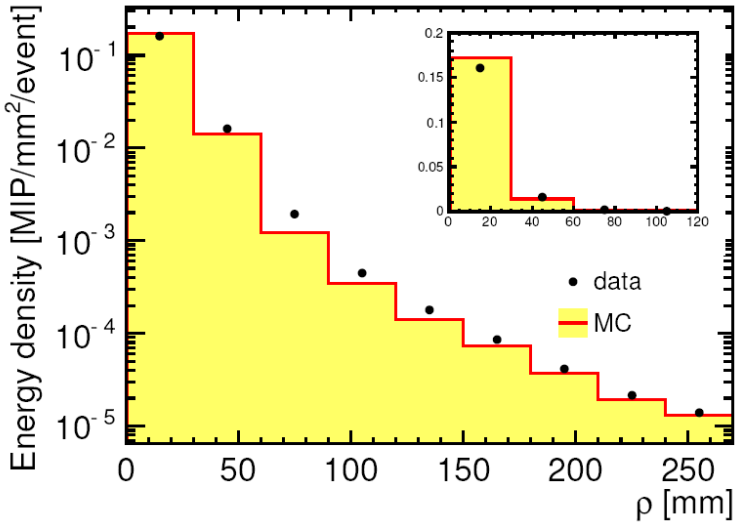
FTF_BIC closest to data

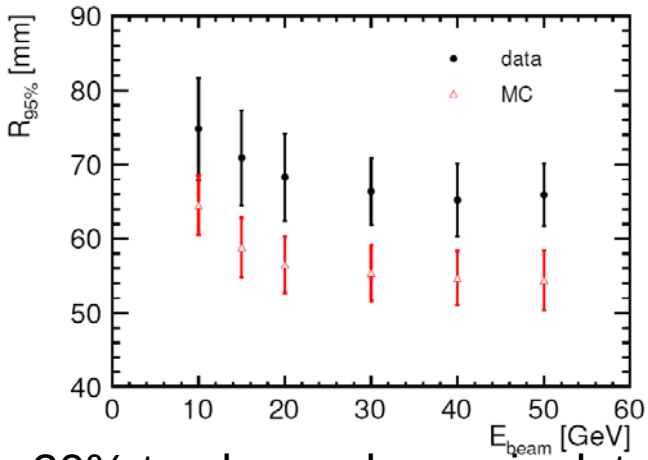
don't look at CHIPS (C) in this version ➔ need update



EM transverse shower profile

HCAL

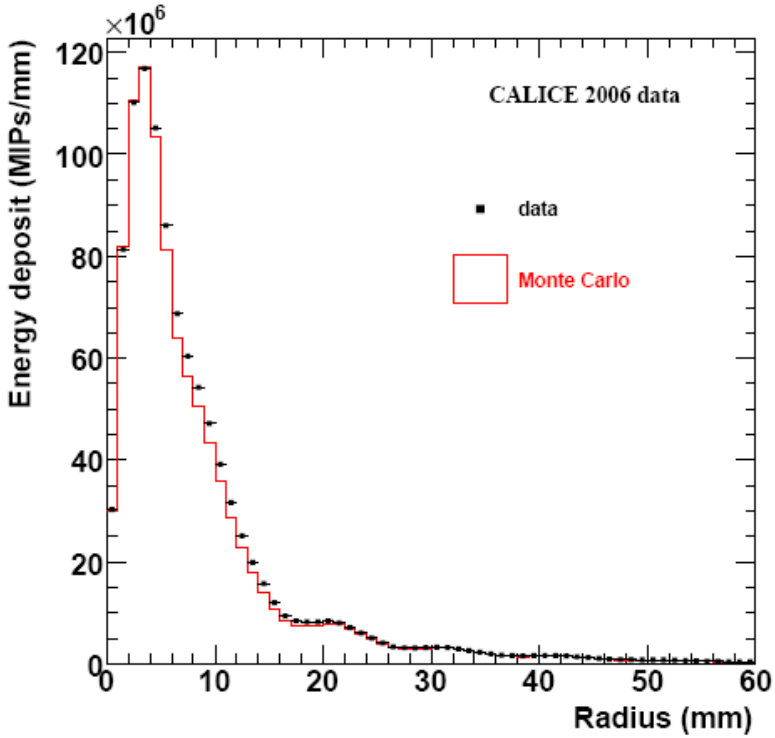




~20% too large shower in data

➔ unsolved instrumental effect

ECAL

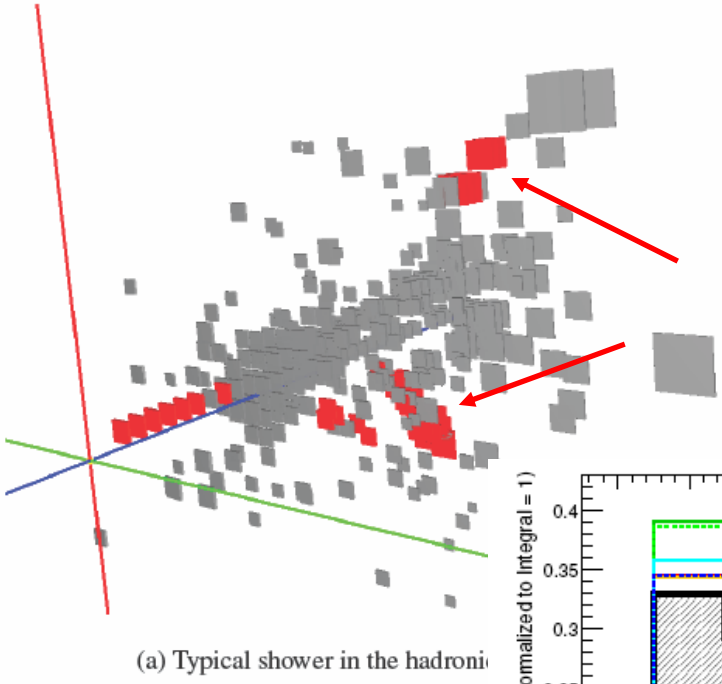


ECAL paper [NIM A608 (2009) 372]

"… 95% of the shower energy is contained within 30.5 mm (i.e. less than four pads), to be compared with 29.9 mm in the case of the simulated showers."

~2% agreement data/MC

AHCAL Track multiplicity

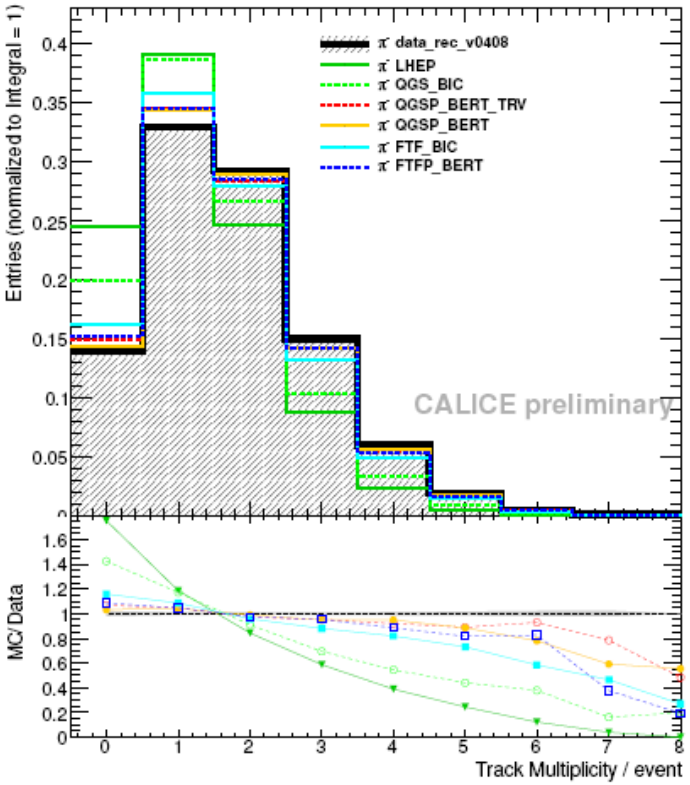


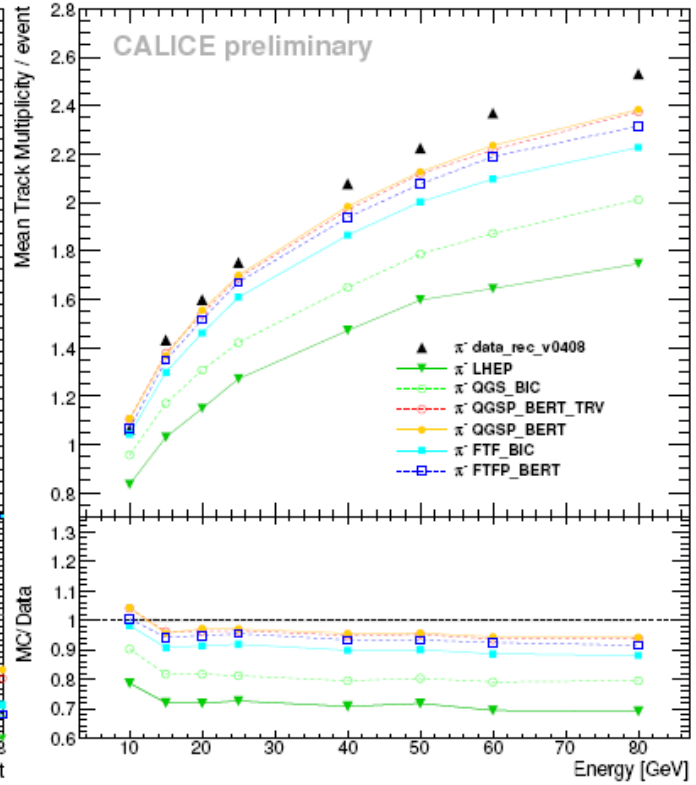
(a) Typical shower in the hadroni

Count number of track segments in AHCAL hadronic shower

➔ try detailed comparison with ECAL (ongoing)

request from G4: multiplicity after the first hard interaction



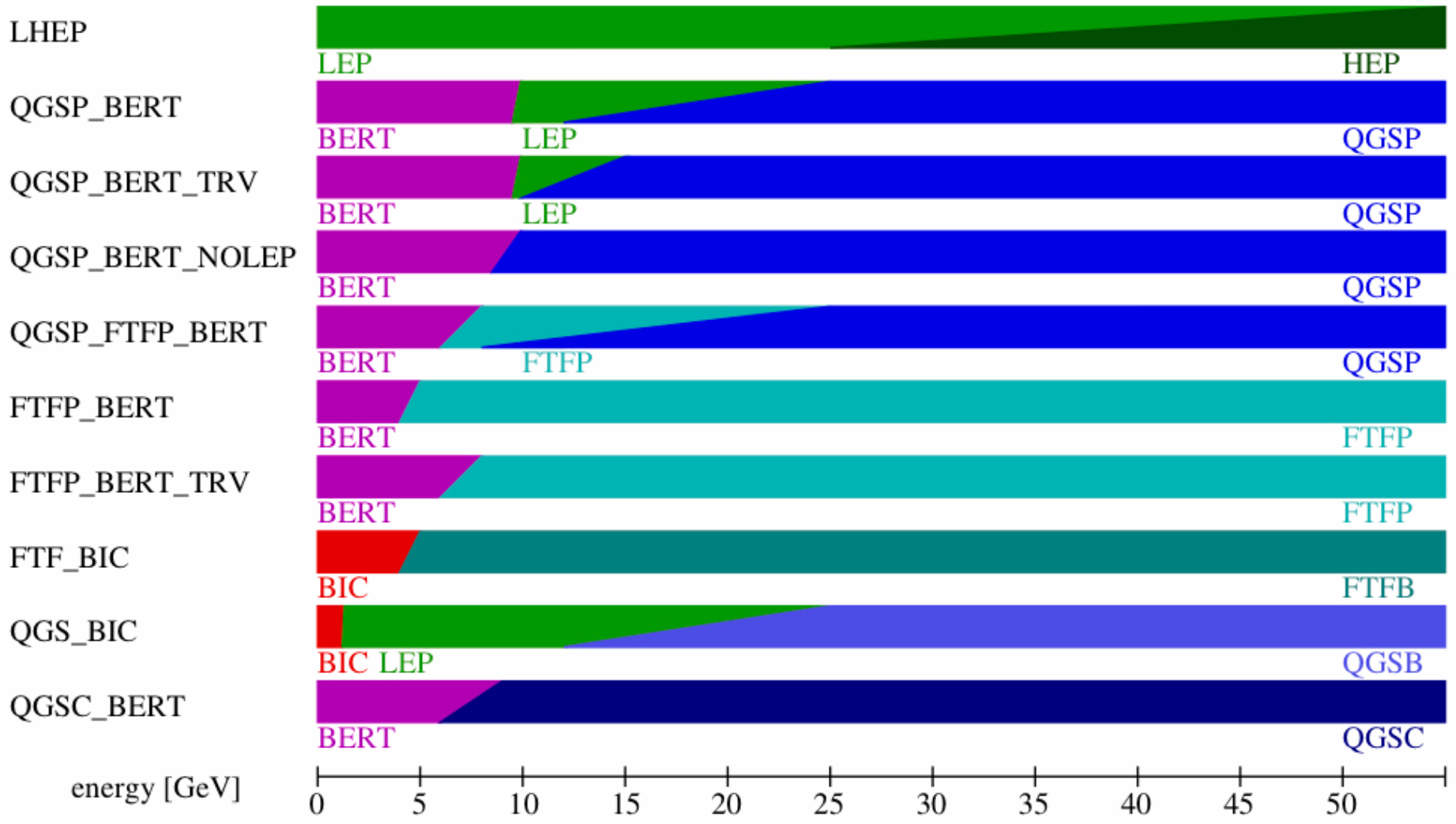


Conclusions

- <u>out of the discussion with G4 people:</u>
  - test CHIPS new version and try to improve tuning
  - investigate multiplicity of tracks after first hard interaction
  - use variables sensitive to proton/neutron content to compare CHIPS and models with HP package turned on
  - show improvement vs time, i.e. compare G4.9.3 to G4.9.2(1)

- <u>internal for us:</u>
  - work more on ECAL/HCAL comparison (and comparability)
  - pin down differences between W / Fe physics
  - keep up to date with newest models

    ➔ run “standard” analysis author independent ?



All are hybrids of several models; random selection between alternatives in the transition region in order to smooth behaviour.