Summary of the Integrated LC detector tests + Test beam data and Geant 4 validation (JRA3 and NA2)

Erika Garutti

5th EUDET annual meeting
DESY, 30 Oct. 2010

2009: *hadronic models in Geant4 in a wide range of energies*

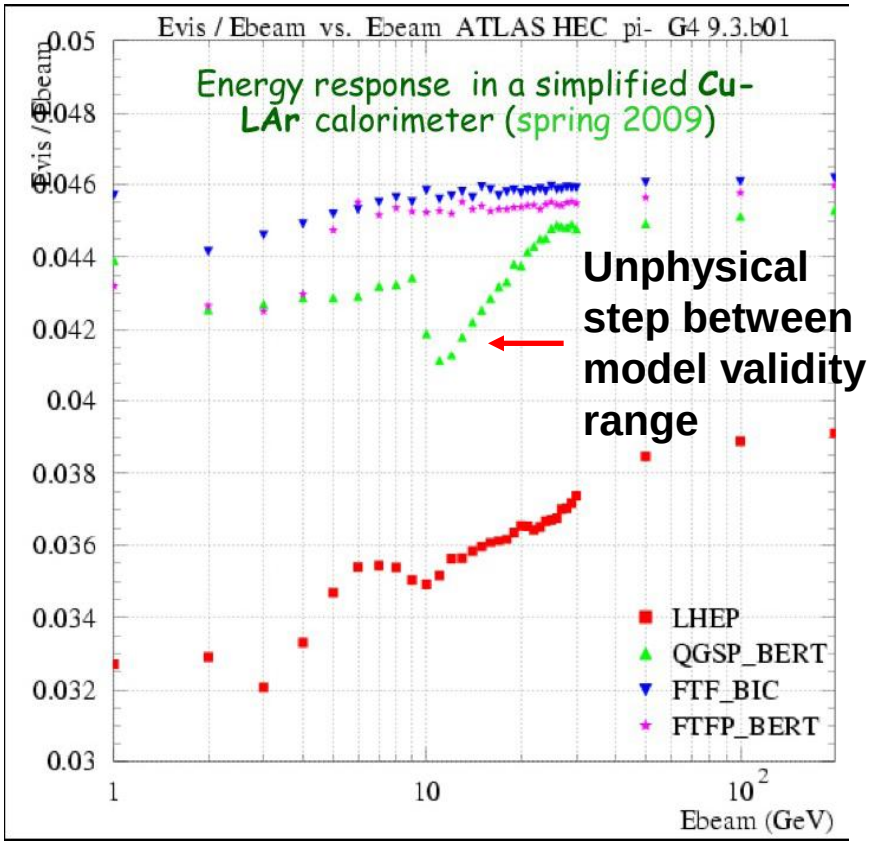
Results of Models Comparisons

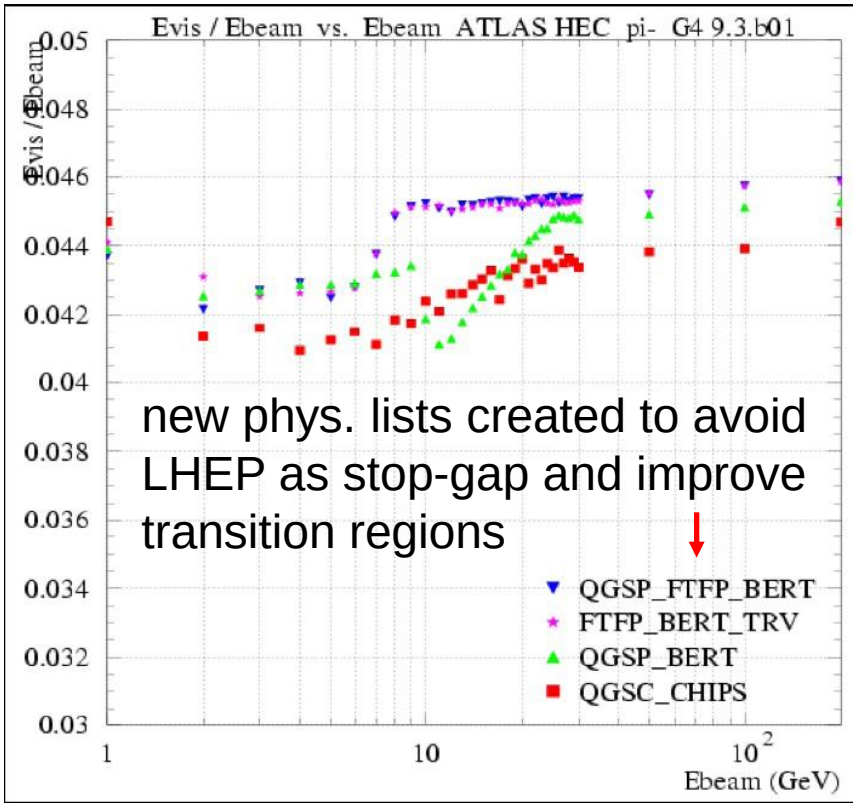
(plots ->backup)

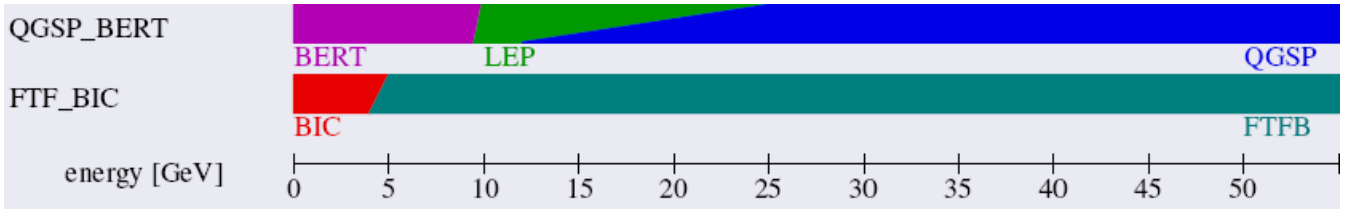
- Comparisons between models indicate
  - LEP (parameterised) differs from all other models
    - Confirmed in thin-target: aim to eliminate use
  - Bertini and Binary Cascade models produce excess energy in protons (and neutrons) above 3-5 GeV
  - Fritiof produces too many π^0 's below ~6 GeV
  - Quark-Gluon-String results stable down to ~ 9 GeV
    - Use could be extended down to 9-10 GeV
  - Energy non-conservation in FTF/BIC - being fixed
- RMS are similar for almost all models
- Suggestion on a likely better choice of the transition regions, and/or model mixing (see next slide)

Vladimir Grichine

2009: *hadronic models in Geant4 in a wide range of energies*



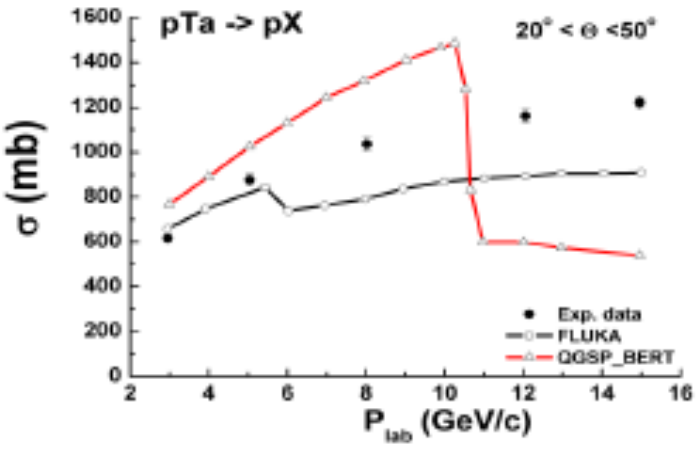


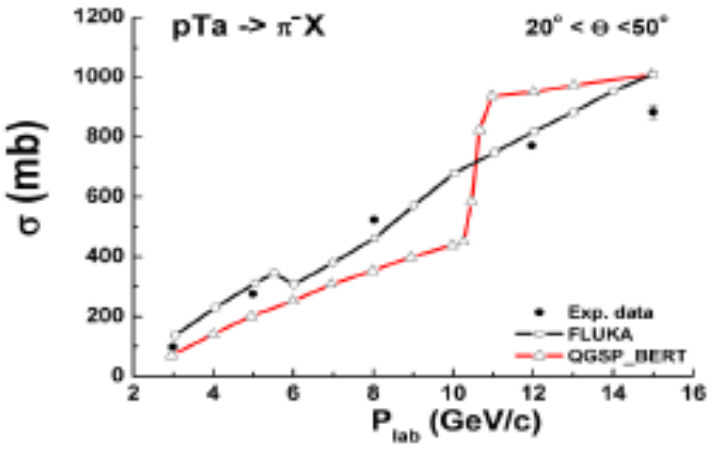


Vladimir Grichine

FTF – improvements and validation

HARP-CDP hadroproduction data: Comparison with FLUKA and GEANT4 simulations.
HARP-CDP Collaboration (A. Bolshakova *et al.*) CERN-PH-EP-2010-017, Jun 2010. 21pp.
Submitted to Eur.Phys.J.C, e-Print: arXiv:1006.3429 [hep-ex]





All MC models (Geant4, LAQGSM, DPMJET, UrQMD) assume that there is a change in the hadron-nucleus interaction mechanism at Plab ~4 – 10 GeV/c.

Questions:
1. Is there a real transition in the nature? What is its physics?
2. What can we do to improve the MC models?

Vladimir Uzhinsky

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!

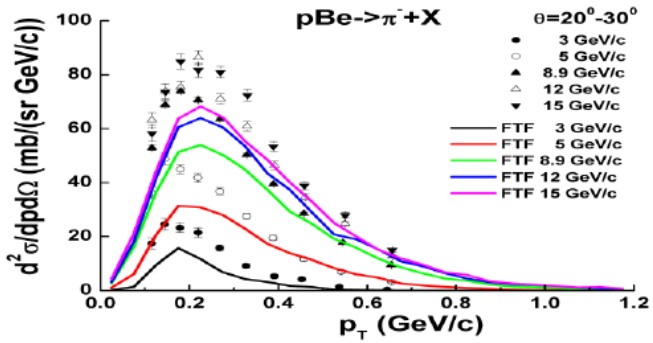
Vladimir Uzhinsky

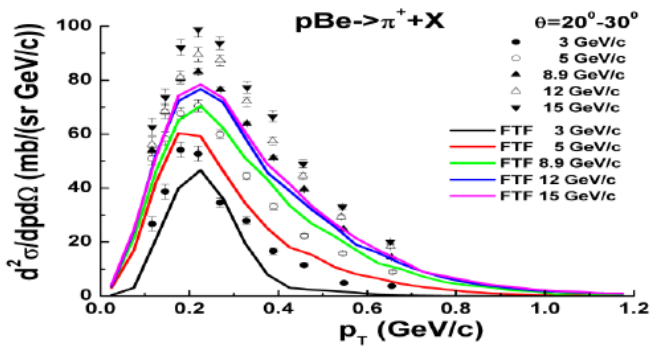
Improvements FTF

Why does not the HARP-CDP group use the FTF-BERT Physics List announced as one of the best PL for LHC collaborations?

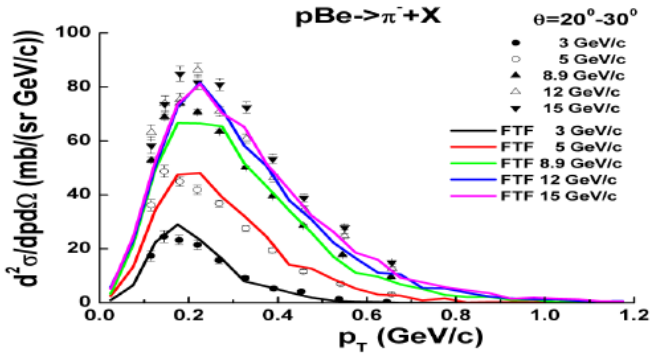
How well does the FTF model evolve.

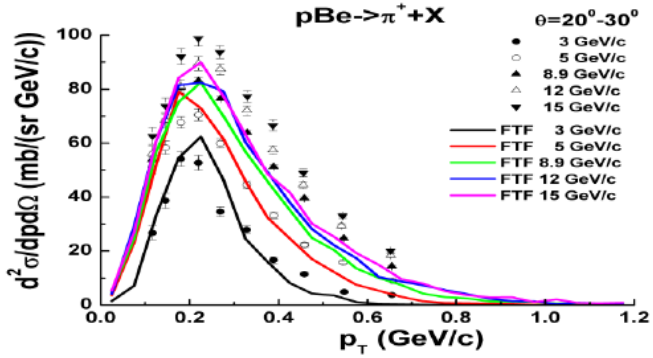
FTF, June 2010





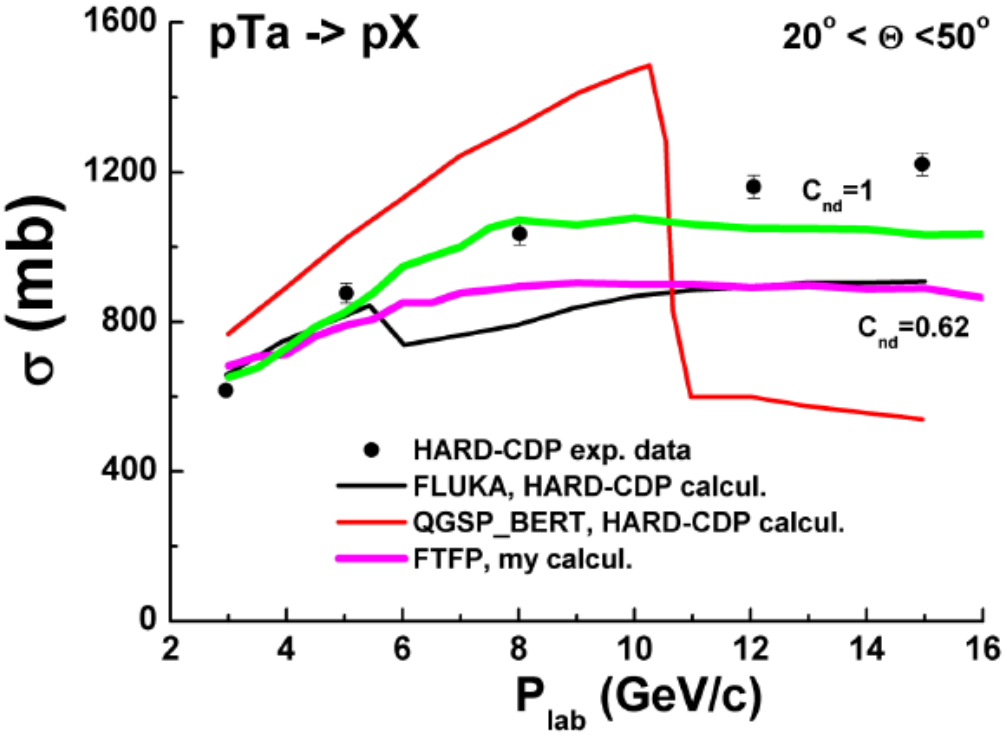
FTF, September 2010





FTF model is going in the right direction! But it was very heavily to improve it.

FTF compared to HARP-CDP



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Vladimir Uzhinsky

Introduction (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

Important 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.

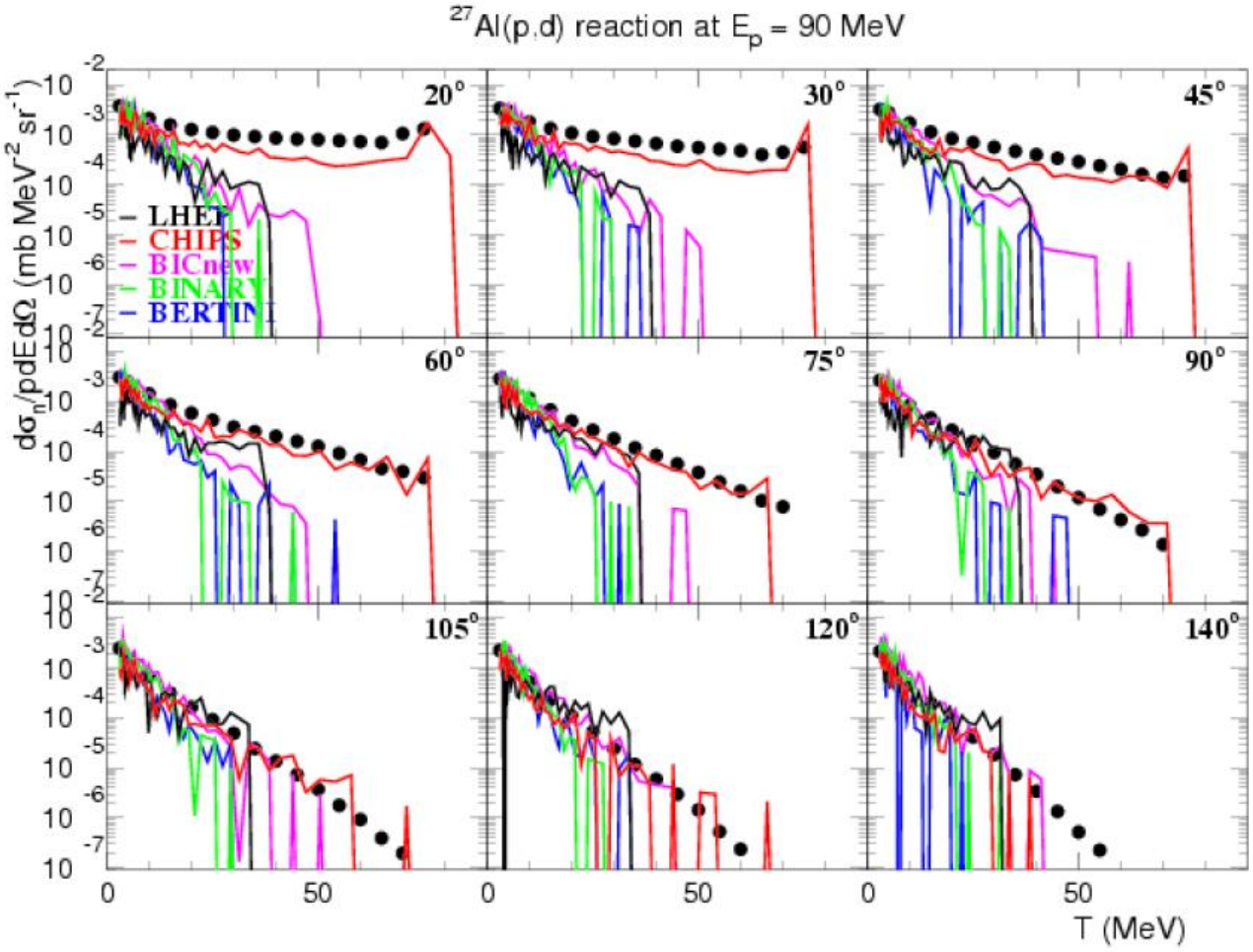
➔Expected too long shower (as opposed to other lists which predict Too short showers since they don't include diffraction)

Additional recommendation emerged during discussion
➔Check the multiplicity of particles after the first interaction
!!! Possible on very highly segmented calorimeters

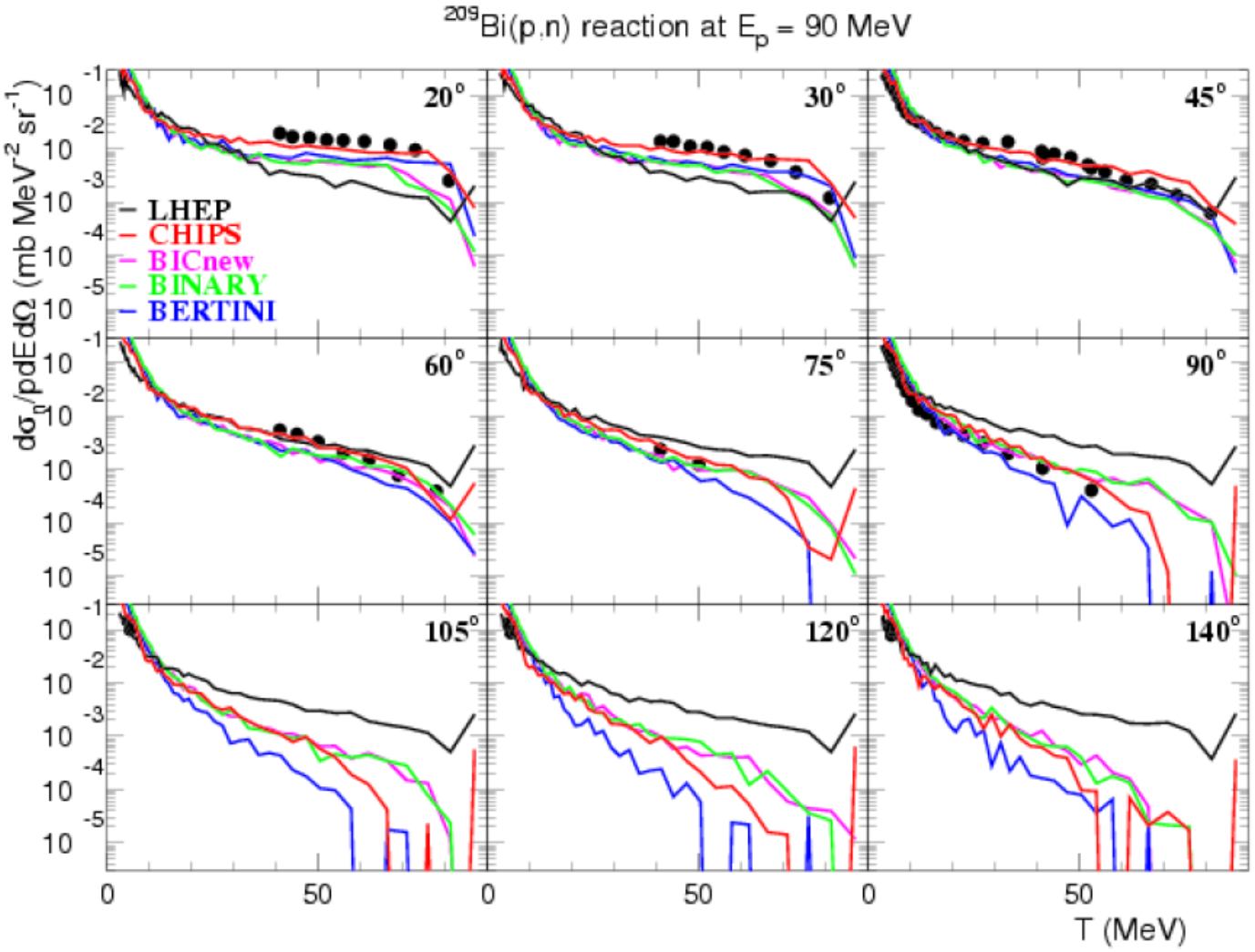
Mikhail Kosov

CHIPS validation – Low Energy

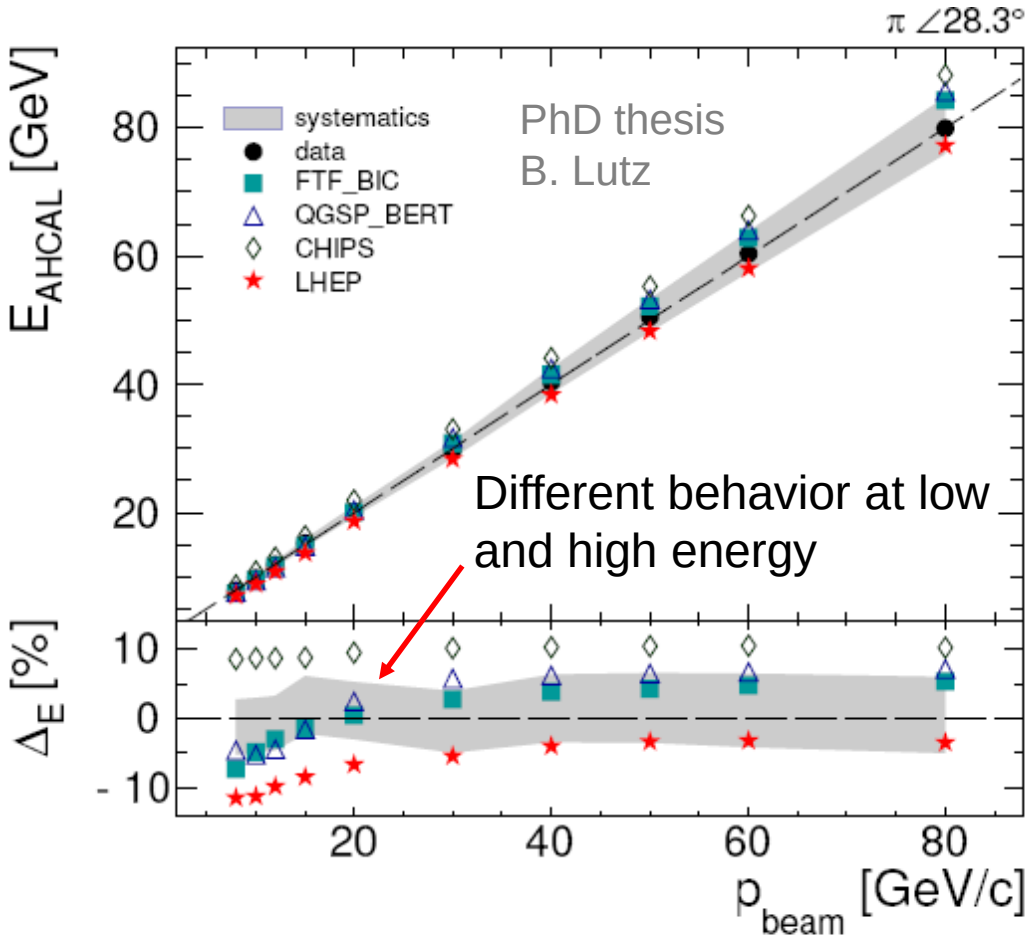
- In spite of the open source restrictions the CHIPS fit for low energy nA non-elastic cross-sections was presented
  - Non-elastic means inelastic + (n,γ), whilst fission is a part of inelastic
  - 411 isotopes for inelastic, (n,γ), and fission reactions are covered



CHIPS validation – Low Energy



CALICE: AHCAL MC validation



Geant 4.9.3 final version (12/2009)

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

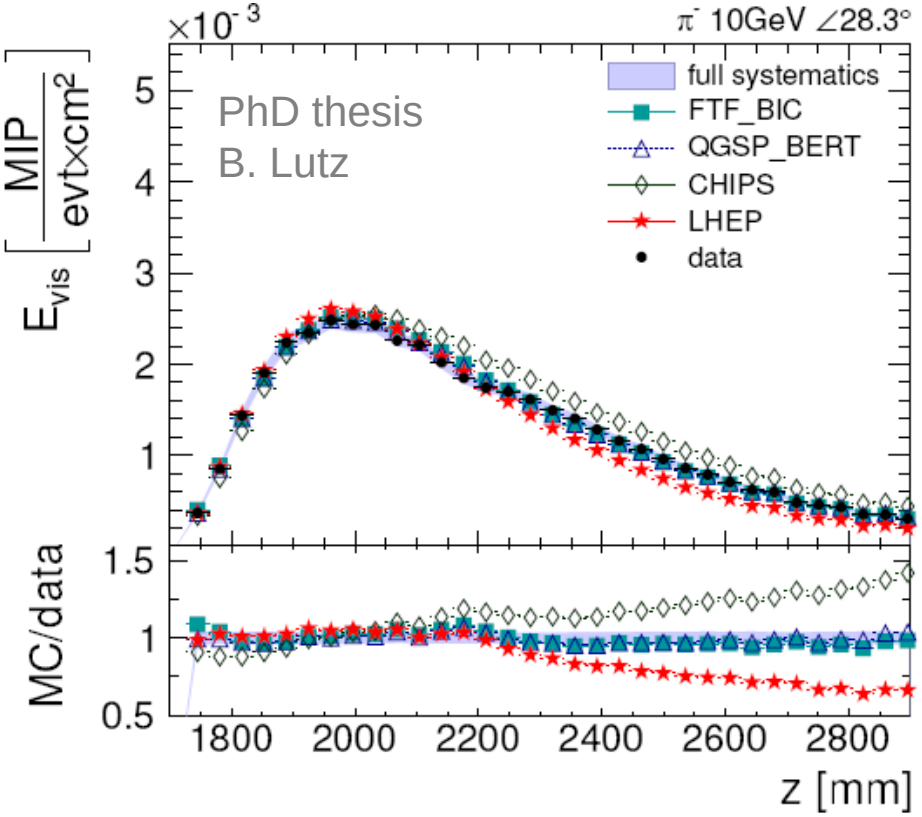
←As expected CHIPS over estimates reconstructed E but no E-dependent transition region

string+cascade within errors — only CHIPS flat like data

Alexander Kaplan

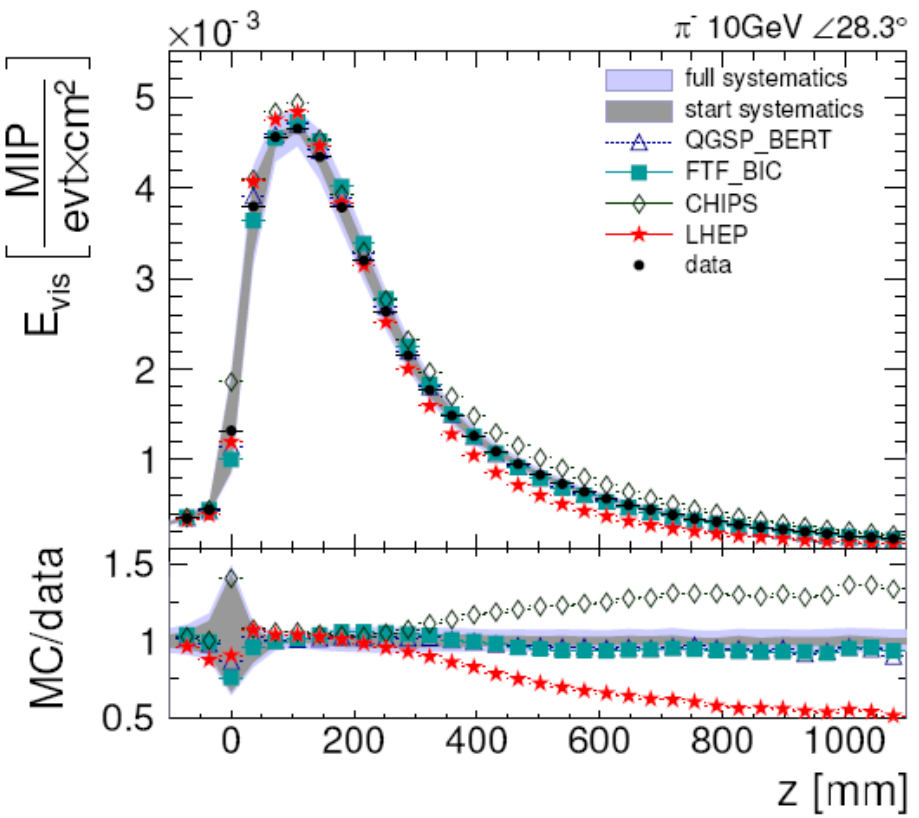
CALICE: AHCAL longitudinal shower profile

from calorimeter front face



cascade models good — CHIPS/LHEP wrong tails

from shower starting point



increased sensitivity with profile from starting point

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

Alexander Kaplan

Working conclusions on model validation

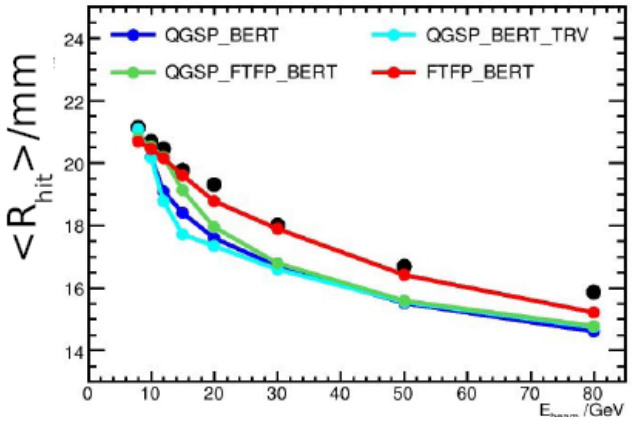
High granularity • new level of detail in test of hadron shower models

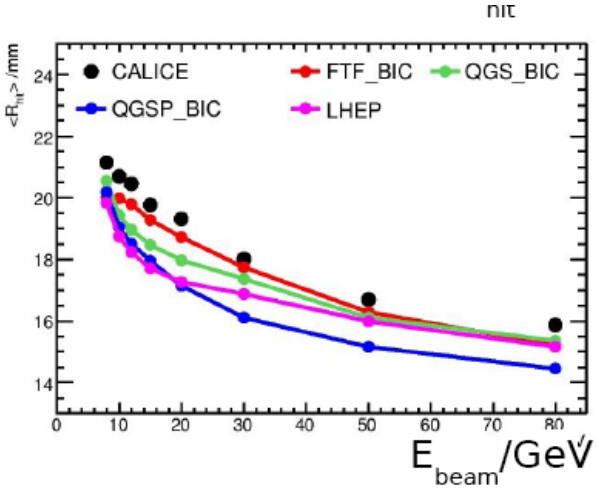
➔FTF best match with Bertini to be checked

- QGSP_BERT & FTF_BIC
  - Reasonable description of response and resolution
  - Good description of low energy shower shape
  - Fail to describe high energy shower shape (String Models)
  - Largest difference in the shower core
- LHEP
  - Outperformed in almost all aspects
  - Should be replaced in other physics lists
- CHIPS ➔ Quite promising after discussion with author !
  - Least successful physics list in the tested version
  - Less artifacts than compound lists
  - Needs further development

CALICE: ECAL MC validation

Shower Radius



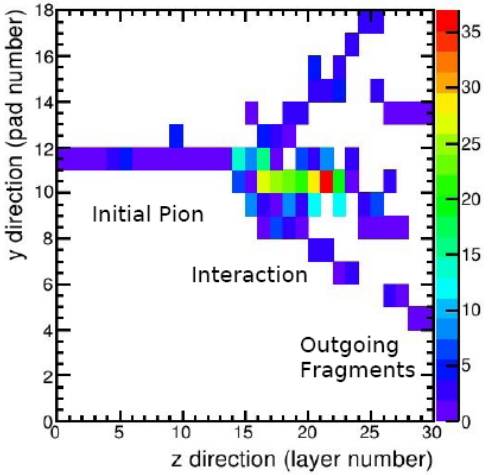


Transverse shower profile ➔ FTFP_BERT best

➔ to be compared to FTF_BERT with transition region 3-8 GeV

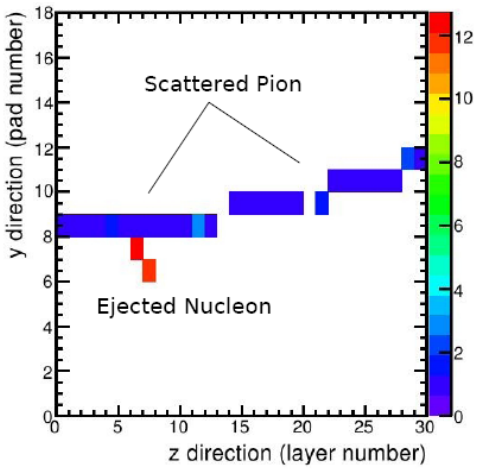
Using the imagine capability of ECAL ➔ multiplicity of particles after first interaction can be measured!

Complex and Impressive



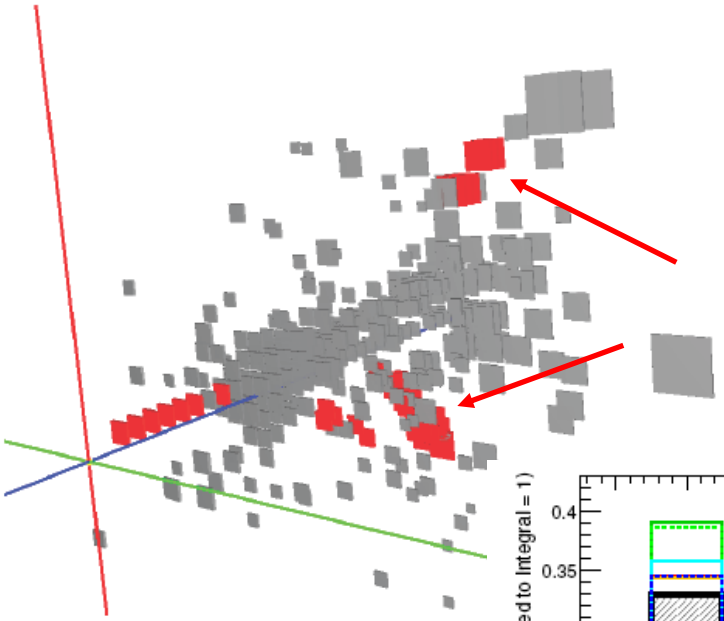
Inelastic Reaction in SiW Ecal

Simple but Nice



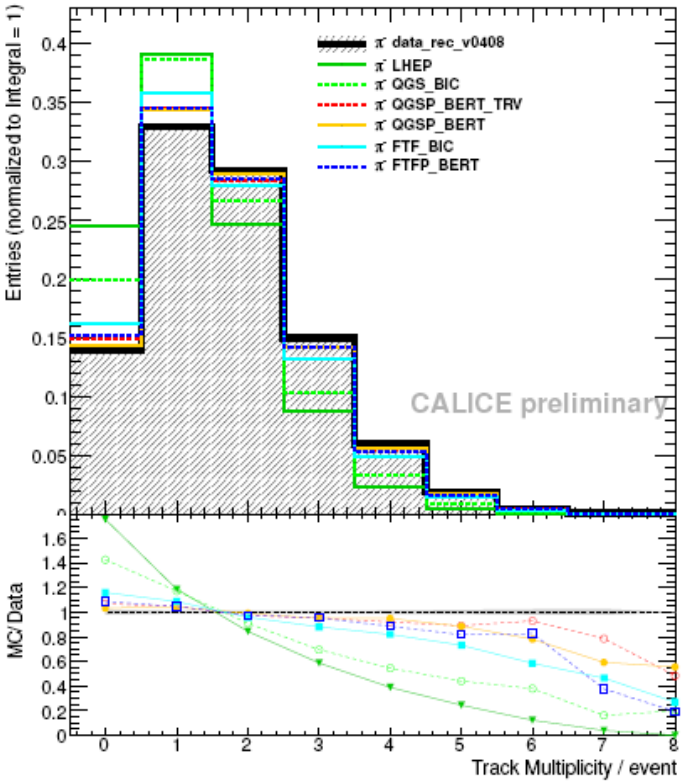
Nucleon Ejection in SiW Ecal

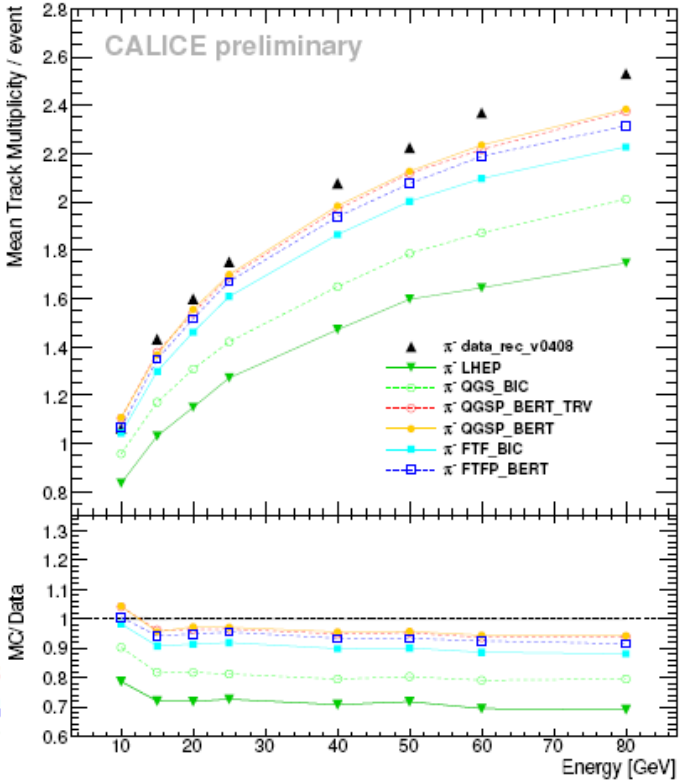
AHCAL Track multiplicity



(a) Typical shower in the hadroni

Count number of track segments in AHCAL hadronic shower

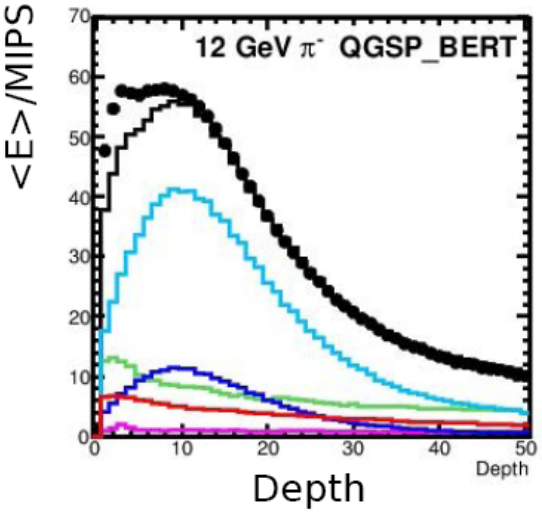




CALICE: ECAL MC validation

Longitudinal Energy Profiles

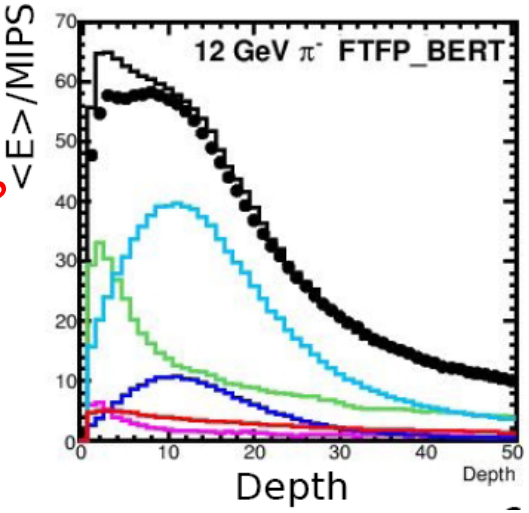
Sensitivity to different shower components



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

Energy depositions in different calorimeter depths

Layer 1-3:

Nuclear breakup

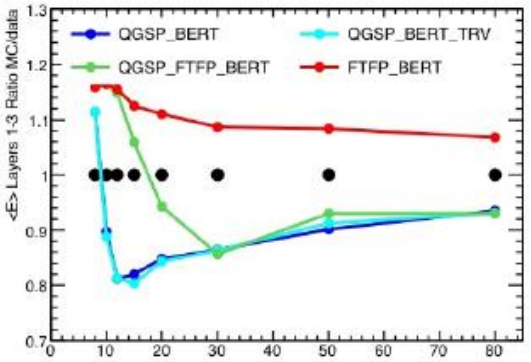
Layer 5-20:

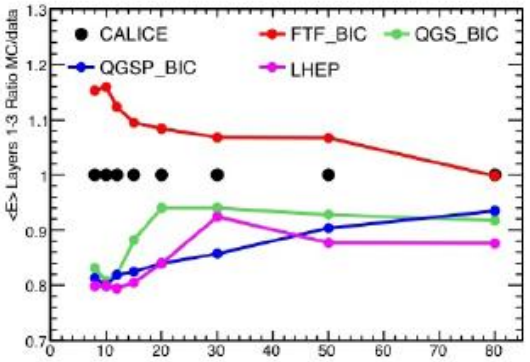
elm. component

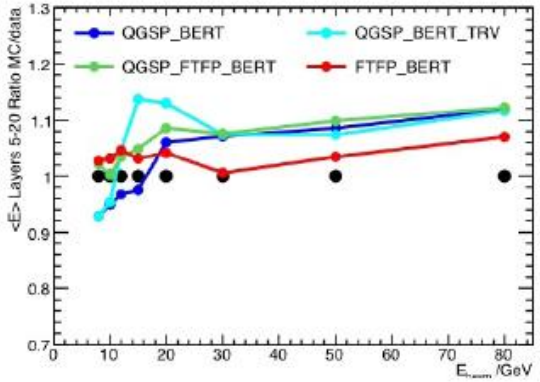
try to access a variable proportional to "f_{EM}"

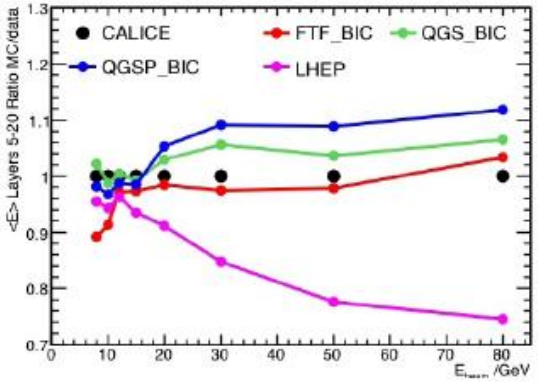
Layer 30-50:

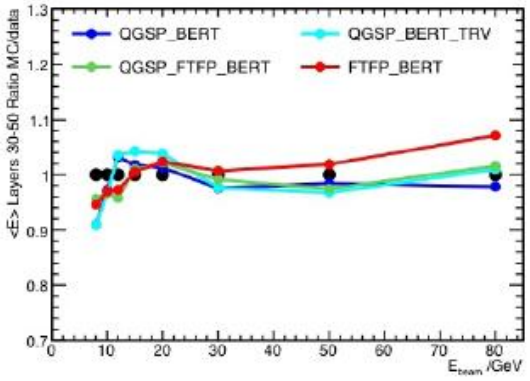
Shower hadrons

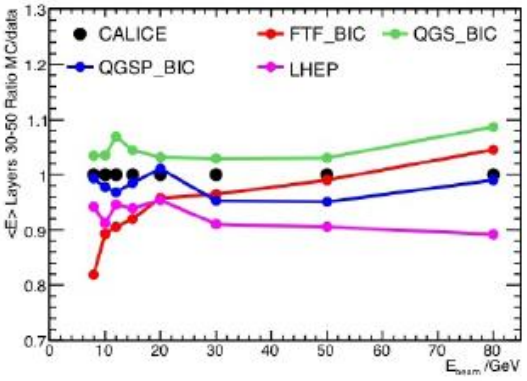












Conclusions

- Very successful JRA3 + NA2 session
- Fruitful exchange between model authors and calo analyzers
- New suggestions and ideas for MC validation with CALICE data

Thank you to all participants !!!