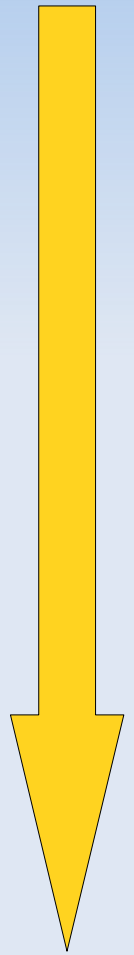
Summary of the Integrated LC detector tests + Test beam data and Geant 4 validation (JRA3 and NA2)

Vincent Boudry
LLR, École polytechnique

EUDET annual meeting
U. of Geneva
20/10/2009

Session in total

- Mix of 2 sessions
- 4 talks
  - Vladimir Grichine:
    Development and validation of hadronic models in Geant4 in a wide range of energies
  - Riccardo Fabbri:
    CALICE test beam data and hadronic shower models
  - Erika Garutti for Vasily Morgunov
    Simulation studies on a combined calorimeter and magnetic spectrometer set-up
  - Imad Laktineh:
    Calorimeter and Si tracking for PFLOW studies



Time ?

EUDET Annual meeting, Geneva, 19-21 October 2009

Development & Validation of Geant4 Hadronic Models in a Wide Energy Range

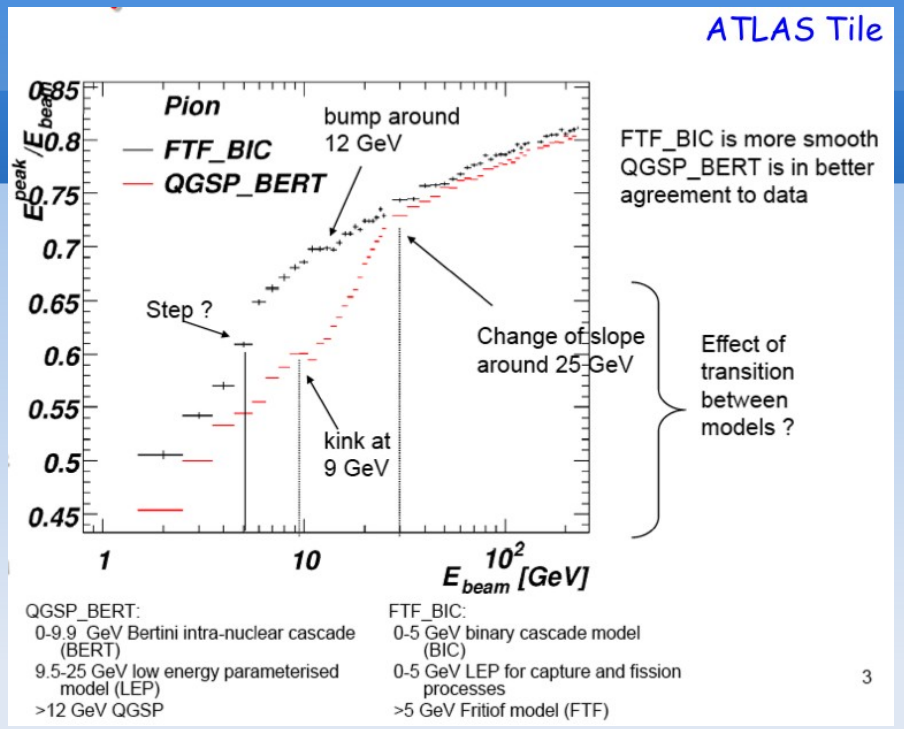
J.Apostolakis, A. Dotti, G.Folger,
V.Grichine, V.Ivanchenko, M.Kossov,
A.Ribon, V.Uzhinsky, D.Wright*

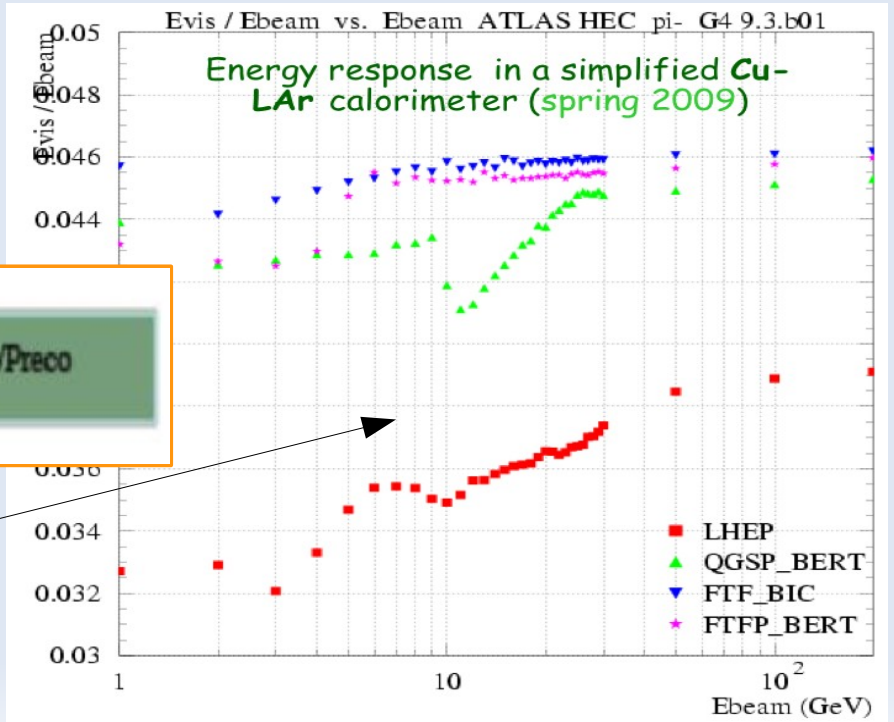
CERN PH/SFT, *SLAC

π's long. shower profiles

- ATLAS TileCal TB @ 90° (2008-09)
  - MC/Data within ±10% up to 10 λ. (π's) -(20%-40%) at 10 λ (protons)
- Unphysical discontinuities vs E_{beam} (CMS reported, ATLAS confirmed)
  - very worrysome for jets
- Due to Physical models transitions

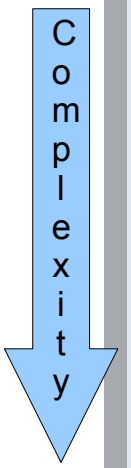
  - confirmed on sim of simple setup





The problem analysis road-map

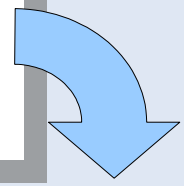
- Reproduce the problem with simplified calorimeter
  - Compare different Physics models (from Lists)
- Understand the microscopic origins of the differences between models
  - Identify differences that are/can-be important
  - Need to confirm by comparing to thin-target data
- Improve use of hadronic models in Physics Lists:
  1. Change the transition regions between models
     - in existing Physics Lists (e.g. to avoid key deficiencies)
  2. Create novel mixtures of models in new Physics Lists
     - potentially with fewer models/transitions
  3. Improve the hadronic models (best but takes more time)



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)

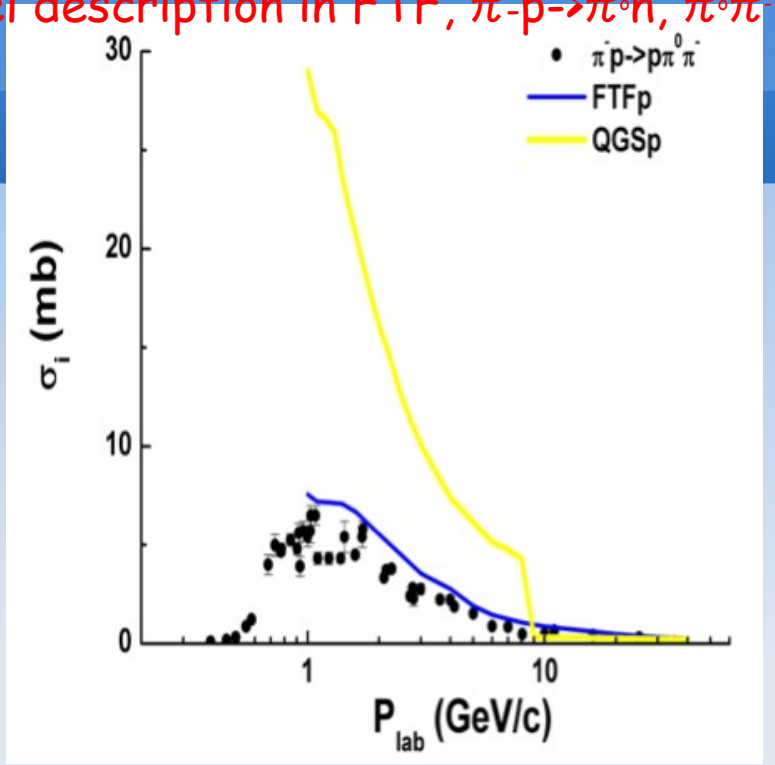


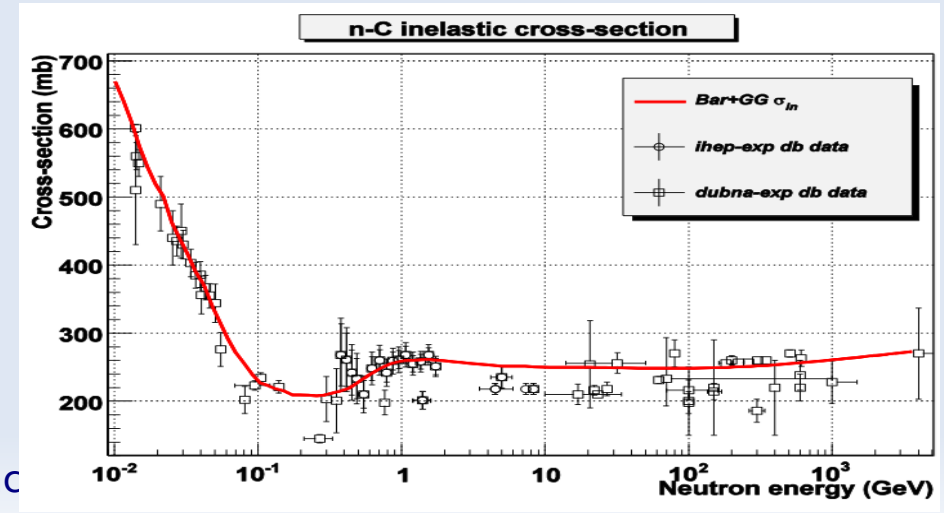
Experimental Physics Lists available in 9.3.b01

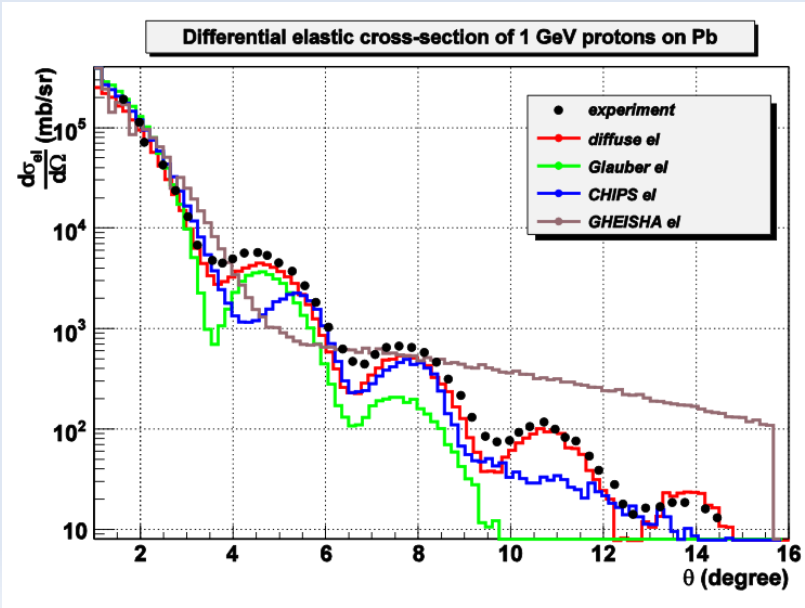
test of G4 (cont)

- Models compar (1000's jobs)
  → copy transp 9
  - many differences
  - ⇒ Improvement of models
    - Binary channel description in FTF, π-p->π°n, π°π-p
    - new p-A spectrums (HARP data) ($d\sigma^2/dp/d\Omega$ vs P_T in GeV range)
    - n-C model over 0,01—103 GeV range
    - Diffractive el. σ p-Pb(1GeV)

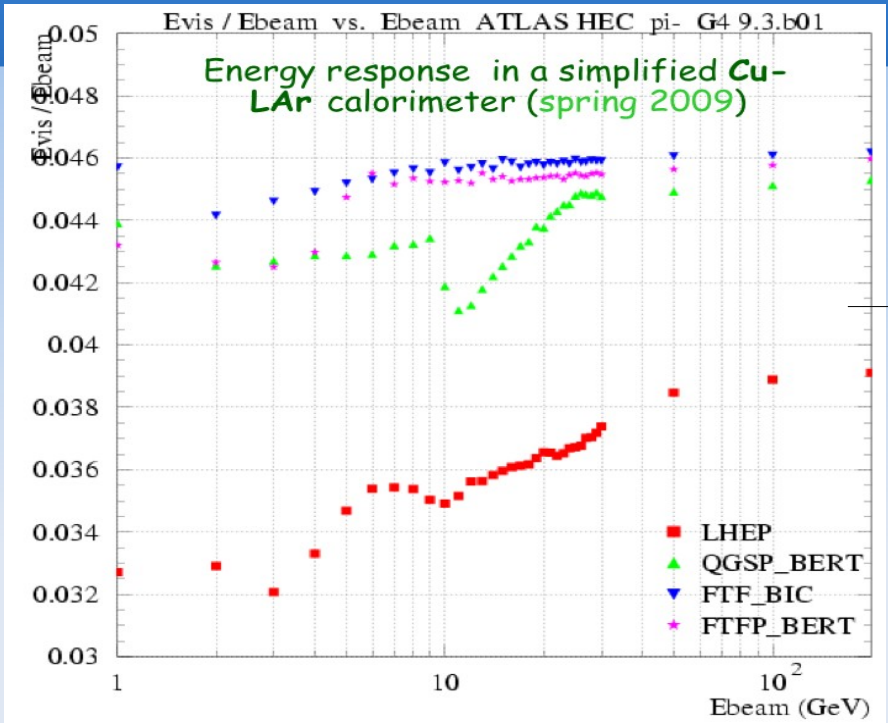
Binary channel description in FTF, π-p->π°n, π°π-p

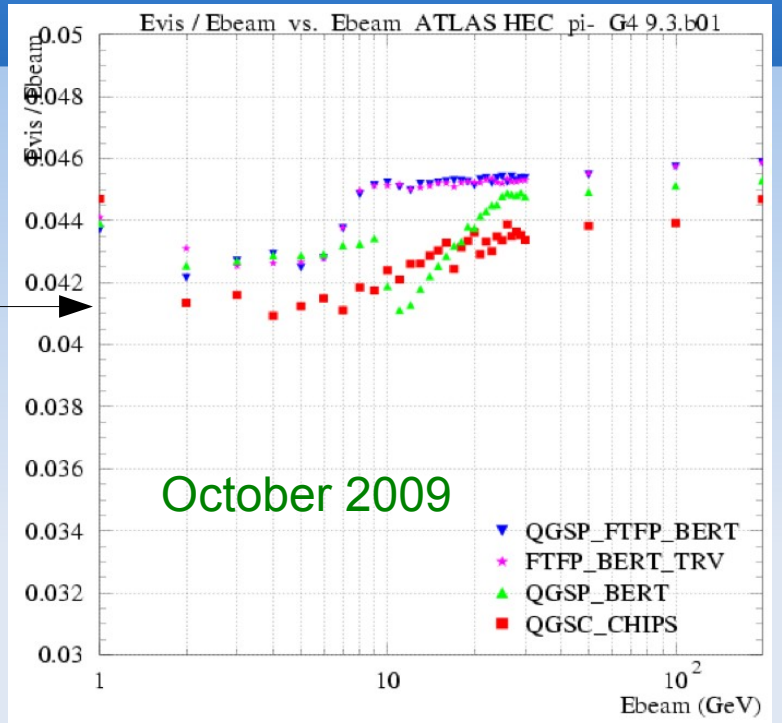






Outlook





- Comparison G4 models → hints of validity range
- Useful to compar with other sims (Fluka, MCNPX, Dubna cascade...)
- Todo:
  - **more thin-target data** in 1—20 GeV range
  - improve/extend models
  - Link model-level feature to calo observables
    - not only visible energy

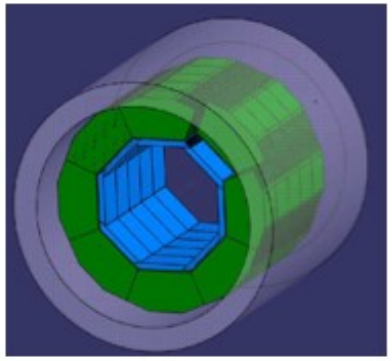
CALICE Test Beam Data and Hadronic Shower Models

Riccardo Fabbri

on behalf of the *CALICE* Collaboration

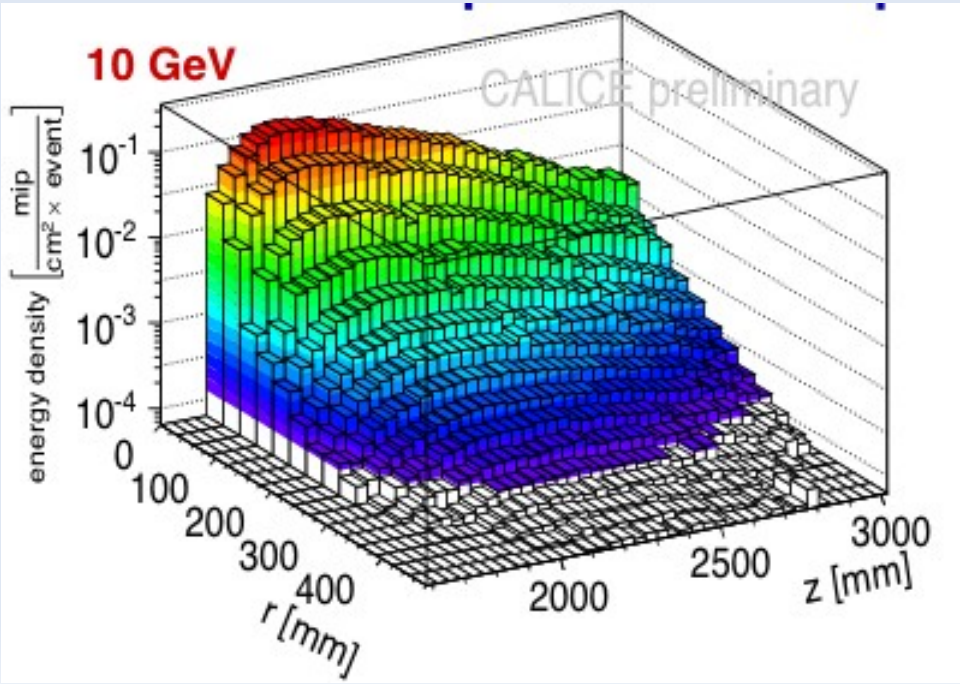
EUDET Annual Meeting **Geneva, 19 October 2009**

- **CALICE and Calorimeters**
- **AHCAL Response to Positron Showers**
- **Investigation of Hadron Showers**
- **Monte Carlo Comparison with Data**
- **Including the ECAL in Hadron Analysis**
- **Conclusions and Outlook**



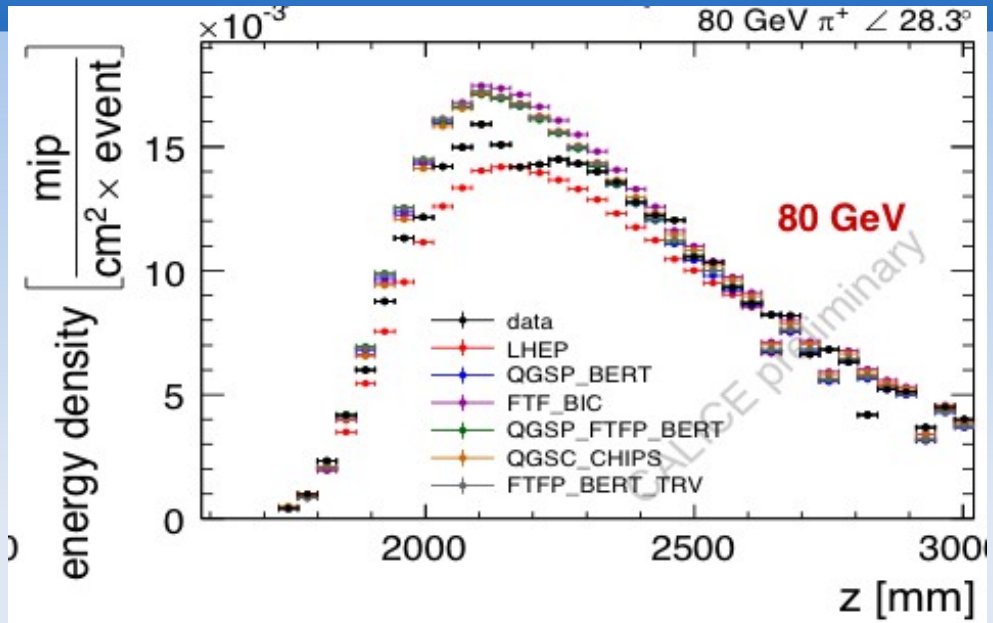
CALICE TB for test of G4 (Riccado Fabbri)

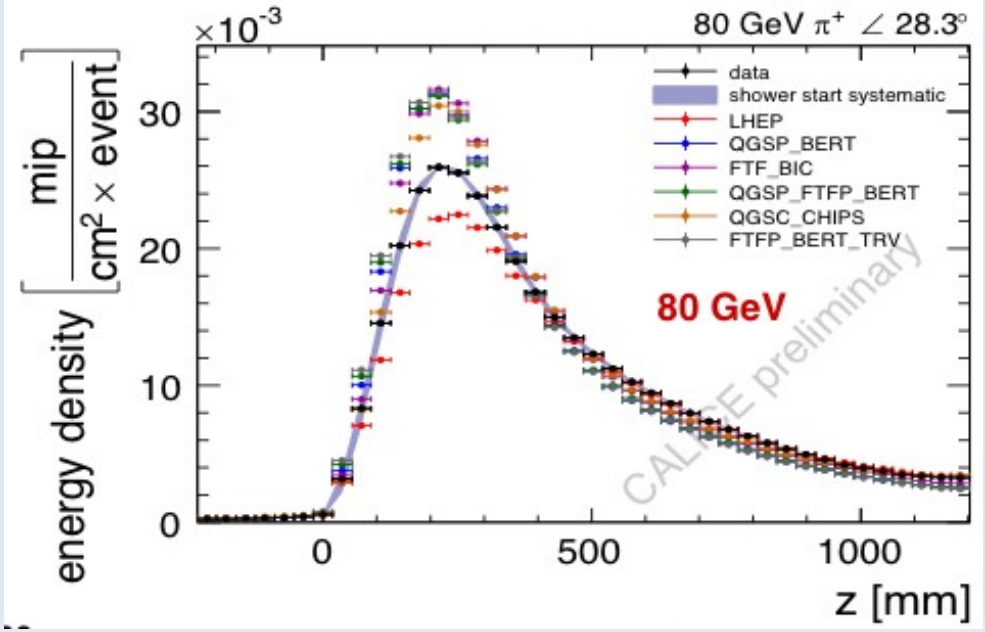
- Many TB data : ECAL (SiW|ScintW) + AHCAL|DHCAL + TCMT @ CERN, FNAL since 2006 → 2010…
- for the Analog HCAL
  - with 2007 data
  - Positron data + muon data [p6] → calibration of the AHCAL response
    - 10% Data-MC agreement
  - Longitudinal & lateral profiles with unprecedented spatial precision



Longitudinal profile comparison

- ⇒ shower start estimation
  - ⇒ leakage correction
- Direct model comparison
  (⚠ still preliminary ⚠)
  - “Typically, models predict higher density in the shower maximum and lower density in the tails”





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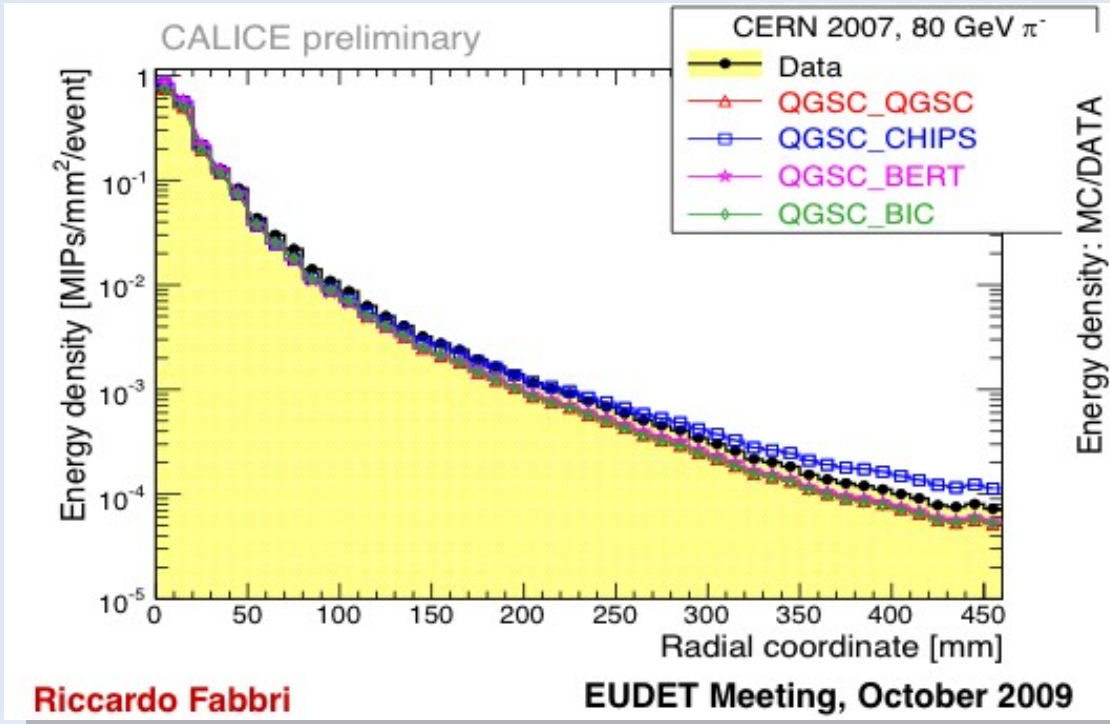
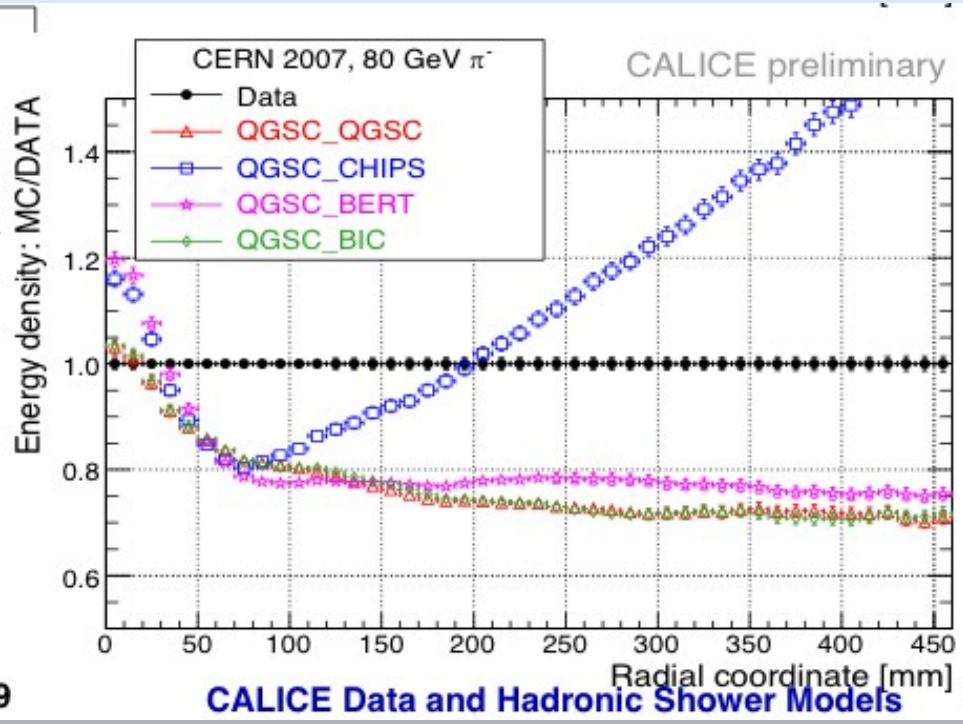
Lateral profiles

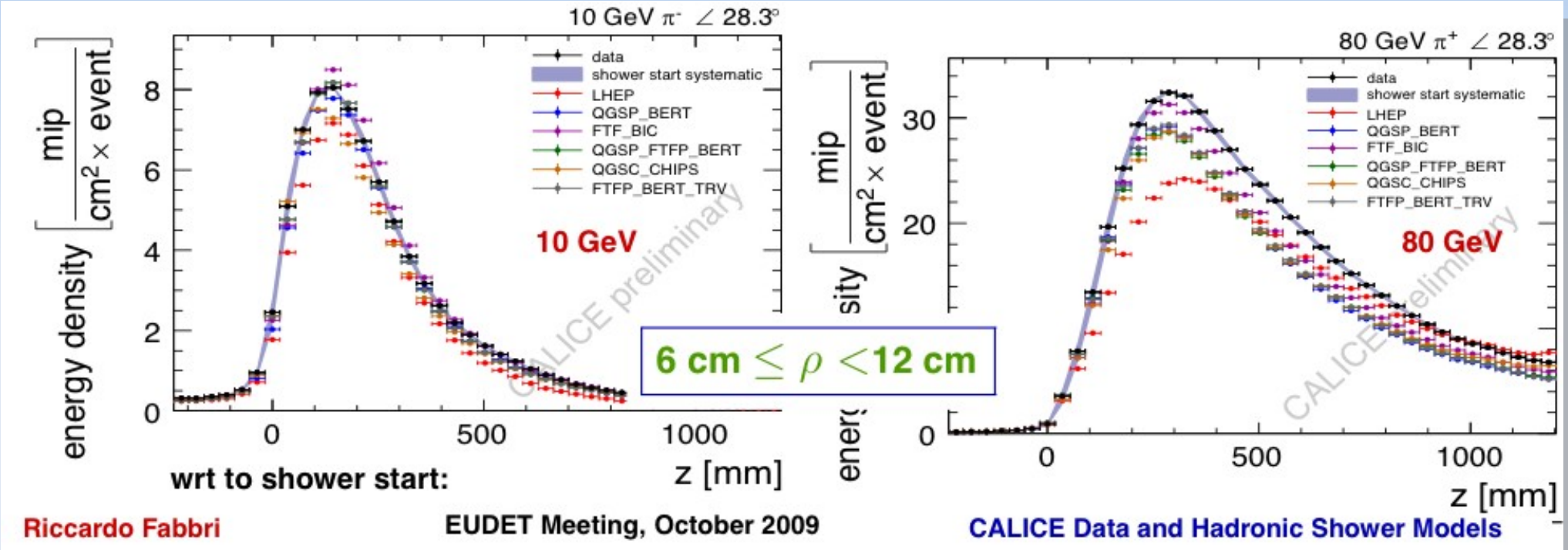
- wrt the primary track
  - dE/dr typically OK ~<20%;
    - core overestimated,
    - tails under-estimated
      - except QGSP_Chips [in ß vers.], more neutrons…
  - Shower radius vs Ebeam → all narrower than data (except QGSP_Chips)





Differential profiles

- Long profile in bins of ρ (0; 6; 12; 18; 18; 24 cm)



- "Typically, Models predicts higher density in the shower core"
- "Better agreement at relatively large radial distance"
- "Large radial distance better described @ low E (undershoot @ high E)

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Calice TB data & MC models Outlook

- AHCAL + TCMT
  - improvement of resol (as expected)
- ECAL + AHCAL (CERN 2007)
  - higher segmentation → sensibility to ≠ contrib in had. shower
    - Analysis ongoing
- Conclusion
  - CERN 2007 shown only → CERN 2006-07 & FNAL 08-09 avail.
  - EM response well understood
  - Had shower corrected for shower start
    - long, lat, differential → constraint on MC model
    - Agreement @ 20% level with well spotted discrepancies
  - Discussions & exchanges with G4 experts on-going…

Simulation studies on a combined calorimeter and magnetic spectrometer set-up

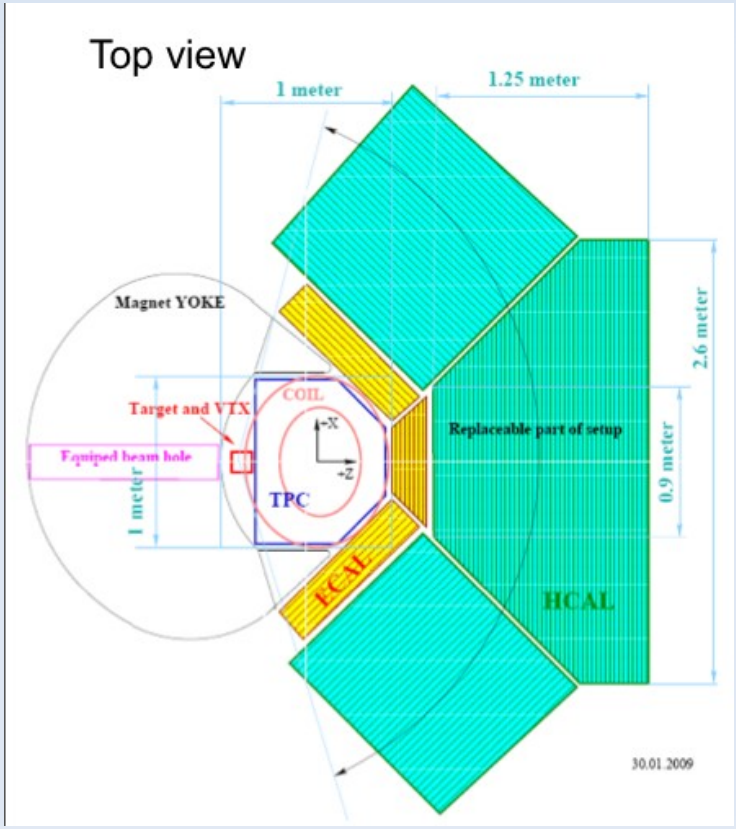
Erika Garutti
on behalf of Vasily Morgunov

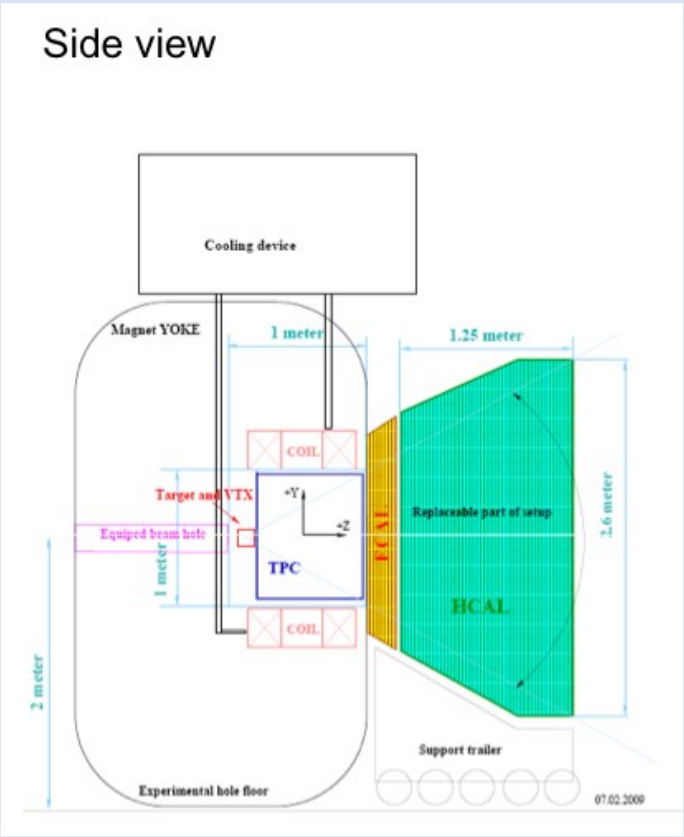
4th EUDET annual meeting
Geneva, 19-21 October 2009

Sim studies of combined calo setup

- Idea: test PFA algo with pseudo jets
  - simulation of target + combined instrument
- Toy Set-up MC
  - TPC in a coil + 120° of ECAL+HCAL

KEY QUESTION:
is the expected pseudo-jet energy resolution of this experiment sufficient to validate PFLOW ?



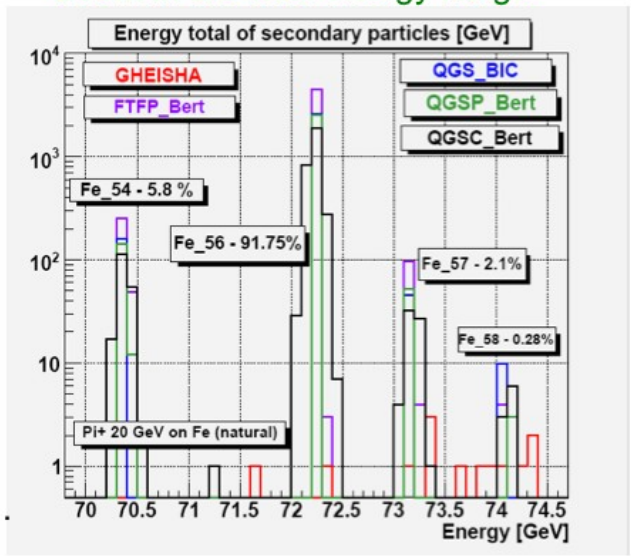


Simulation of various models

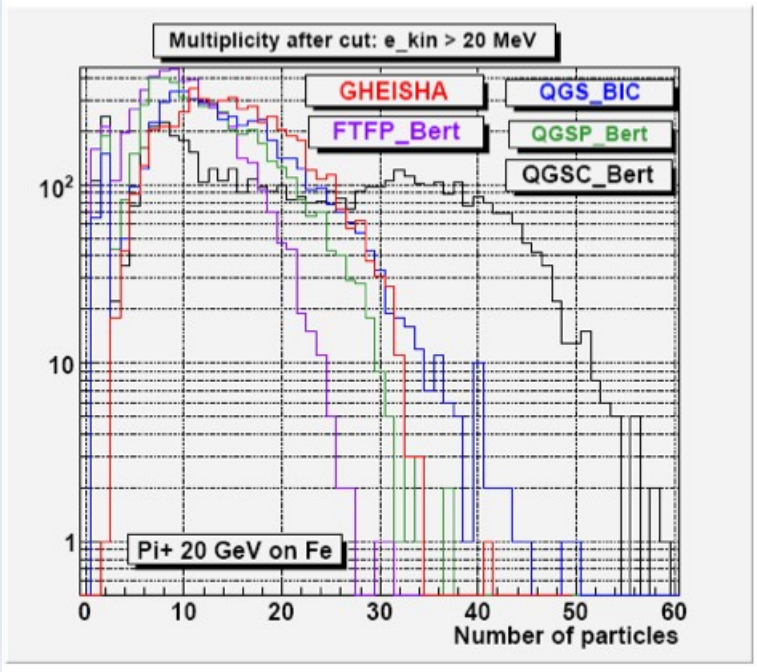
Simulate the energy spread and particle multiplicity at various stages:

- after the first nuclear interaction in the target
- leaving the target
- at the calorimeter front
- of the reconstructed PFLOW objects (PFO)

zoom in the total energy range



- Thorough analysis:
  - Energy conservation in MC
    - **20 GeV** π on Fe → effect of isotopes
  - after a thin target (~1 IA in target)
    - multiplicity vs Physics list
      → large spread
    - E spectrum:
      - <E>_TB ~ 1 GeV
        vs 5-10 GeV @ ILC
      - ⇒ Higer energy needed



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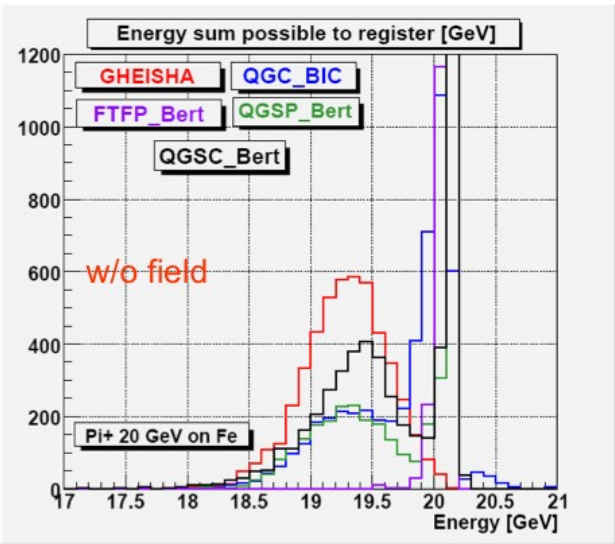
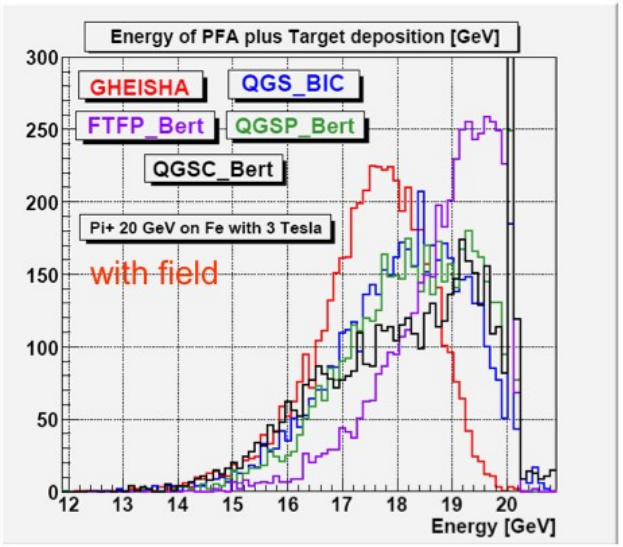
Calo front face

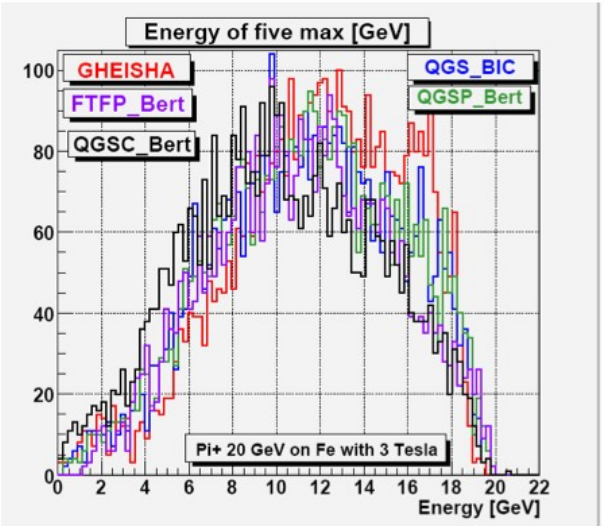
- 1.5-3 GeV loss with/wo B
- 5 most energetic particles in jets
  - good agreement

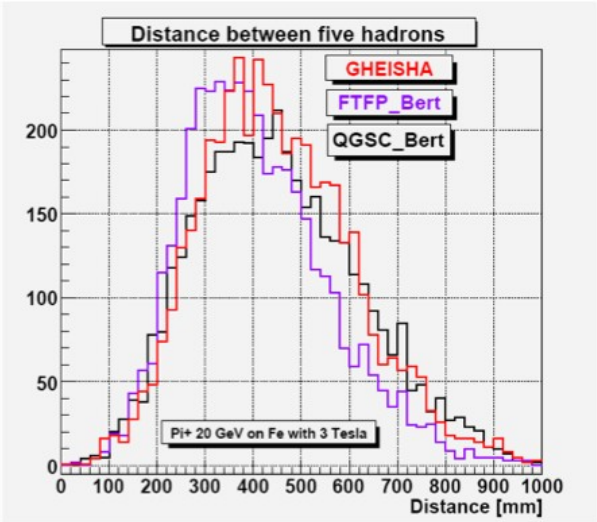




Five most energetic particles

Some good news:
Spectra and angular distributions of the most energetic particles are in a rather good agreement for all GEANT4 physics lists





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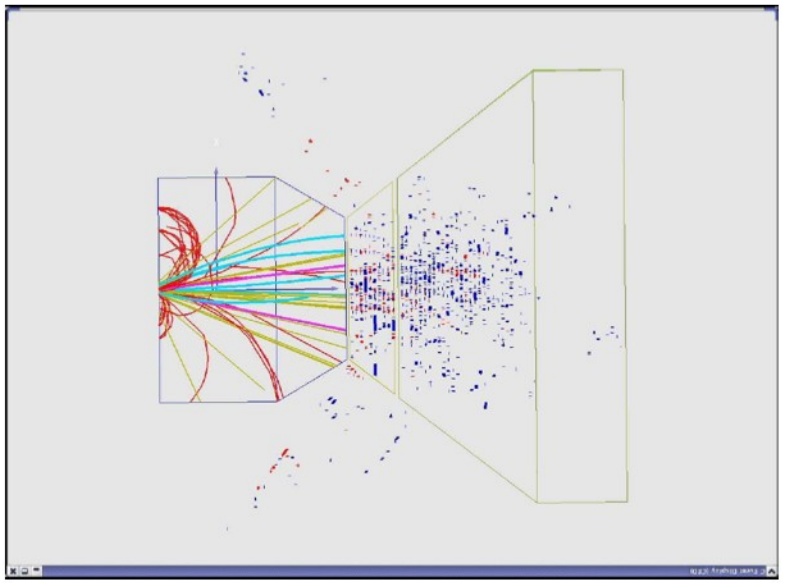
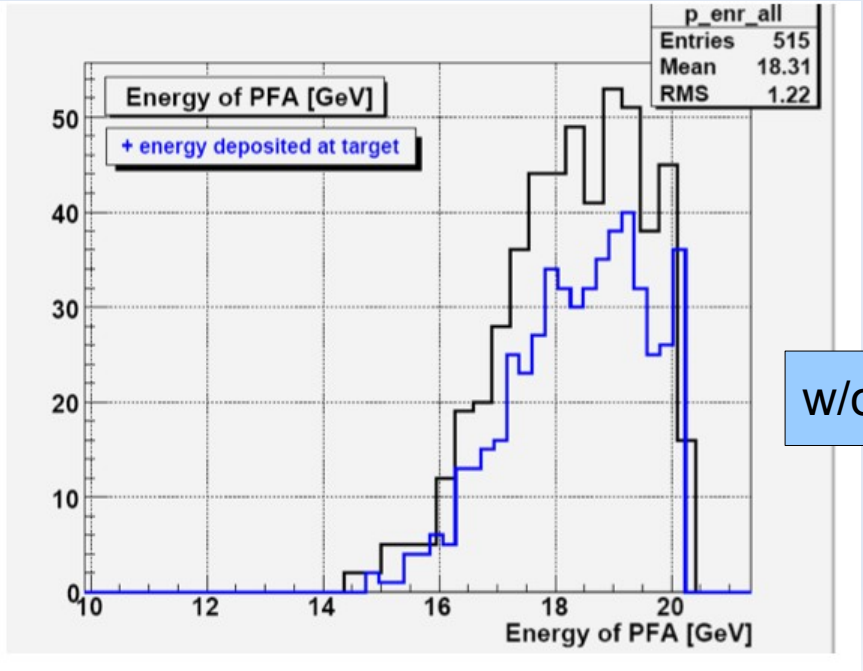
In calorimeter

- "Shoulders" are useful
- Reconstructed PFO
  - σ(E)/E of 30%/√E → 1.3 GeV@ 20 GeV
  - seems feasible (for one model)
  - For a realistic setup (1 m³), no shoulder
    - 4 GeV spread → "**HOPELESS**"

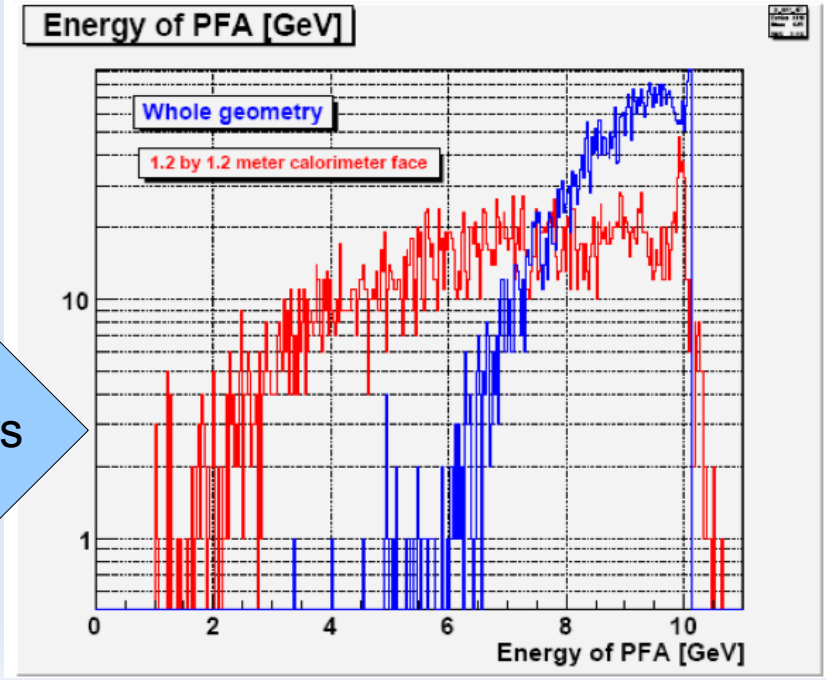
Simulated events



Pion+; 20 [GeV]; 0.8 Tesla; Thin target.
Energy lost in target = 1.818 [GeV]; Sum = 18.74 [GeV];
Sum of PFO energies = 16.93 [GeV]; E calo = 14.33 [GeV]



w/o shoulders



Conclusion

A combined calorimeter-spectrometer project is too large and too expensive to be realistic

Such a project will have a small running time because it needs small statistics to prove PFA

A device with smaller calorimeter will not be able to prove PFA

Some open issues for optimization studies could be:

- replace large tracker with more compact silicon tracker
- add shoulder veto counters to simulation

In the end one has to unfold the "jet energy spread" by simulations

➔ Only indirect test of PFlow possible

The real problem of this type of physics is to measure inelastic exclusive hadron cross–sections on nuclei for intermediate energy range

➔ Better design an ad hoc nuclear physics experiment

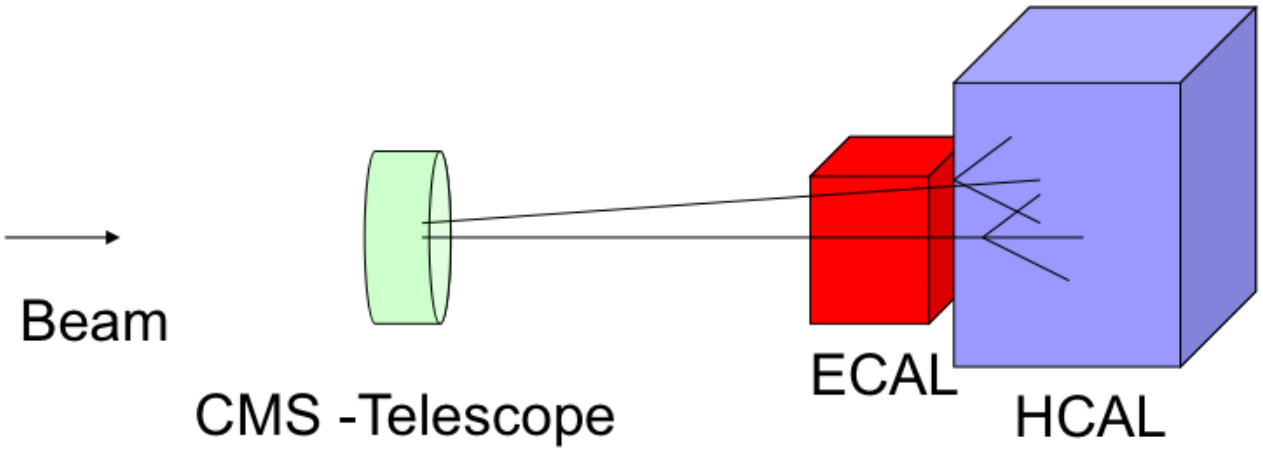
Combined test for Linear Collider

Imad Laktineh

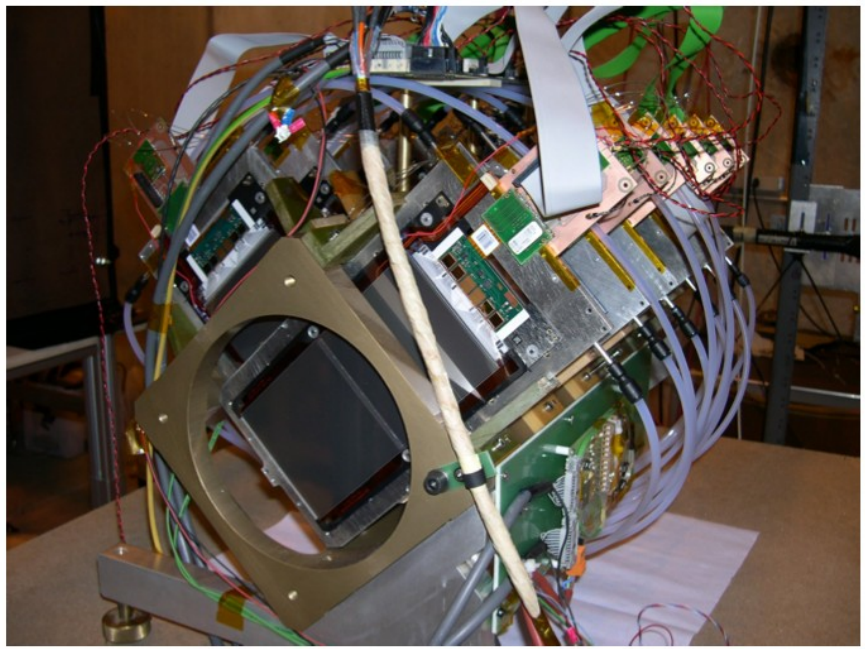
Some ideas for a combined test

- Goal:
  - Compare data from different options for ILC detectors
  - need for common DAQ
  - Test different elemental particle configuration
    - Charged & neutral part together: → target + B
    - Charged with same E → high intensity beam
    - Both together
- Setups
  - Tracker + ECAL + HCAL
    - High intensity beams @ SPS → 10^7 part /spill (16s) .
      - 5 MHz clock → 8% pile-up
      - beam profile: 2×2 cm² → 30×30cm²
    - Trackers → telescopes:
      - EUDET 0.7×0.7 cm²; few µm; 200 ns ∫ time
      - CMS : 10×10 cm²; 30µm; 100 ns
        seems better suited for this kind of combined tests

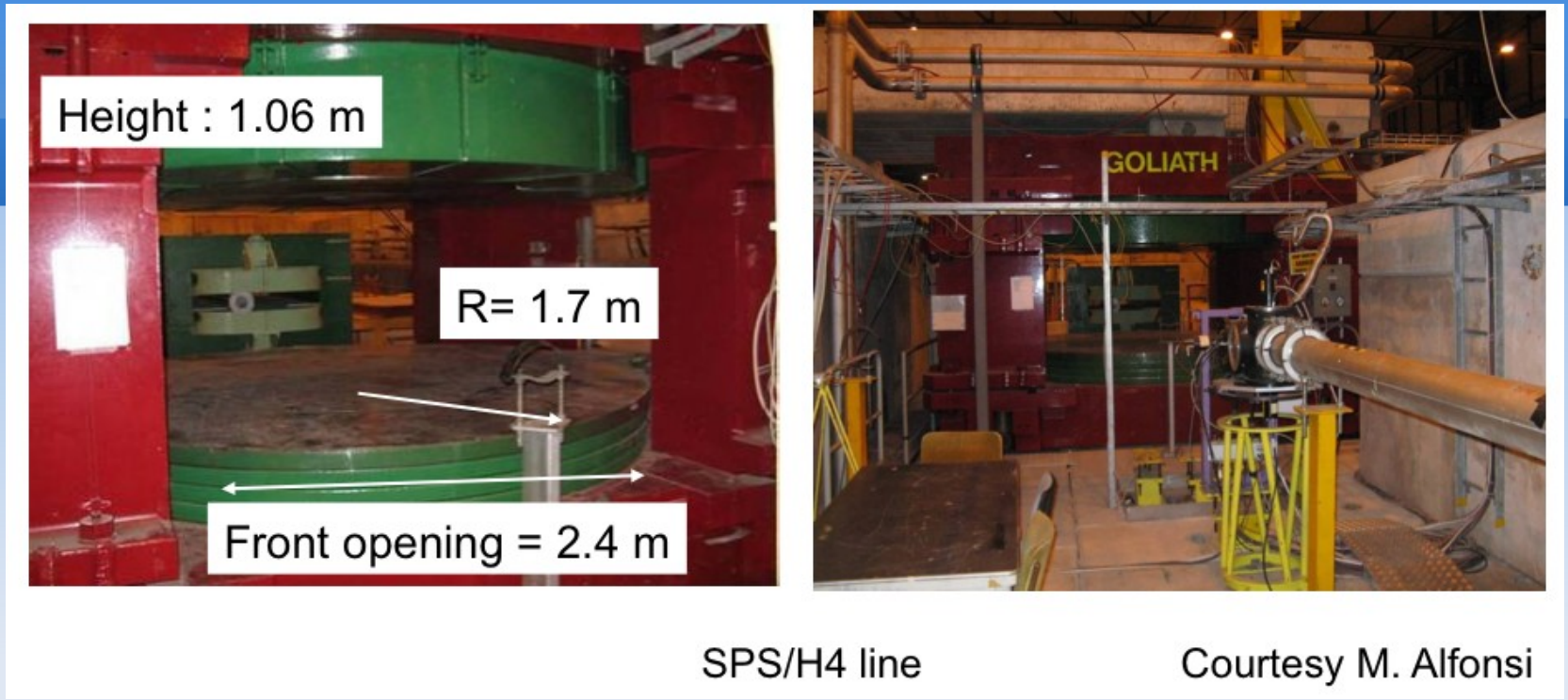
Charged particles with the same energy



→Variable distance to accommodate divergent beams
→Acquisition based on Xdaq system
→ Mechanical structure to be developed



- Optionnally with µVTX, TPC
  - need target
  - need B field



- 1.4 T enough ? Calo inside ?
- Conclusions:
  - PFA Simple case study possible at low cost with existing instruments
    - More complex tests stil need further evaluation
- Discussion : what is needed to test PFA
  - 2 particle separation useful (vs soft pile-up)
  - Is it enough ?

Interesting session with advances in MC models
Better MC absolutely needed for PFA studies