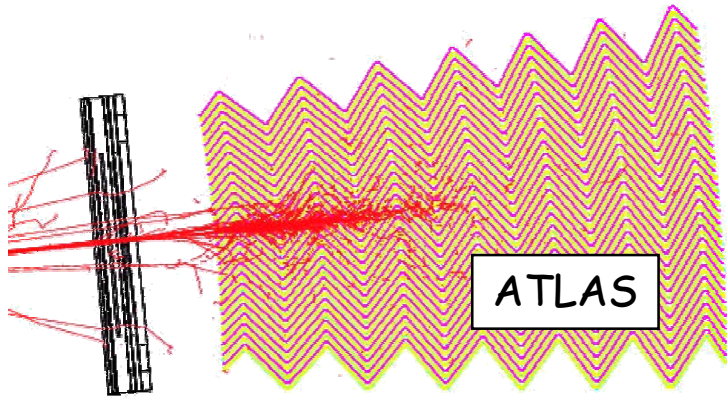
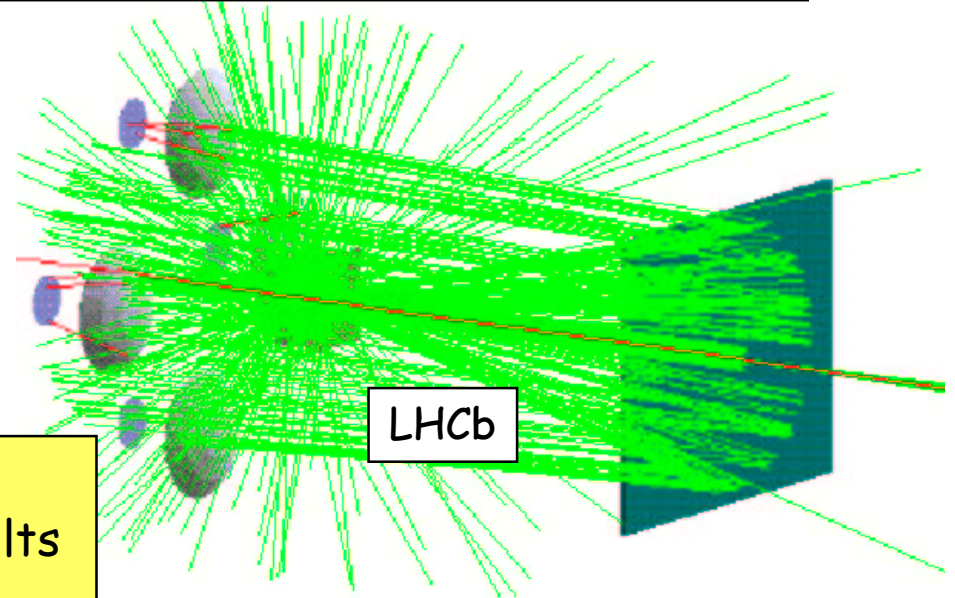


The Simulation physics-validation sub-project

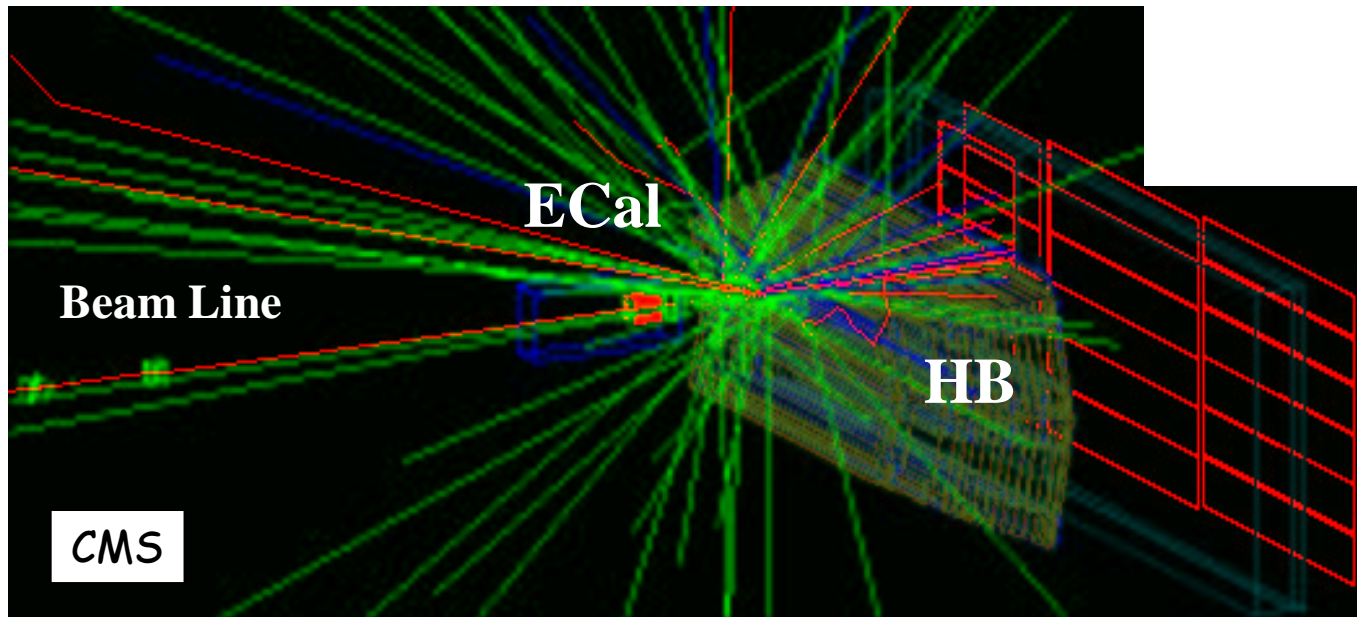


ATLAS



LHCb

- Goals and plans
- Examples of work done so far and first results
- Examples of on-going work

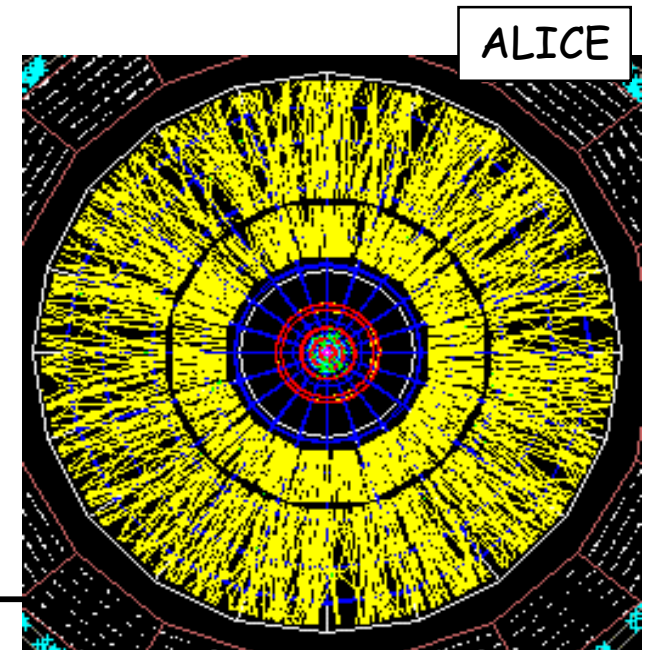


Beam Line

ECal

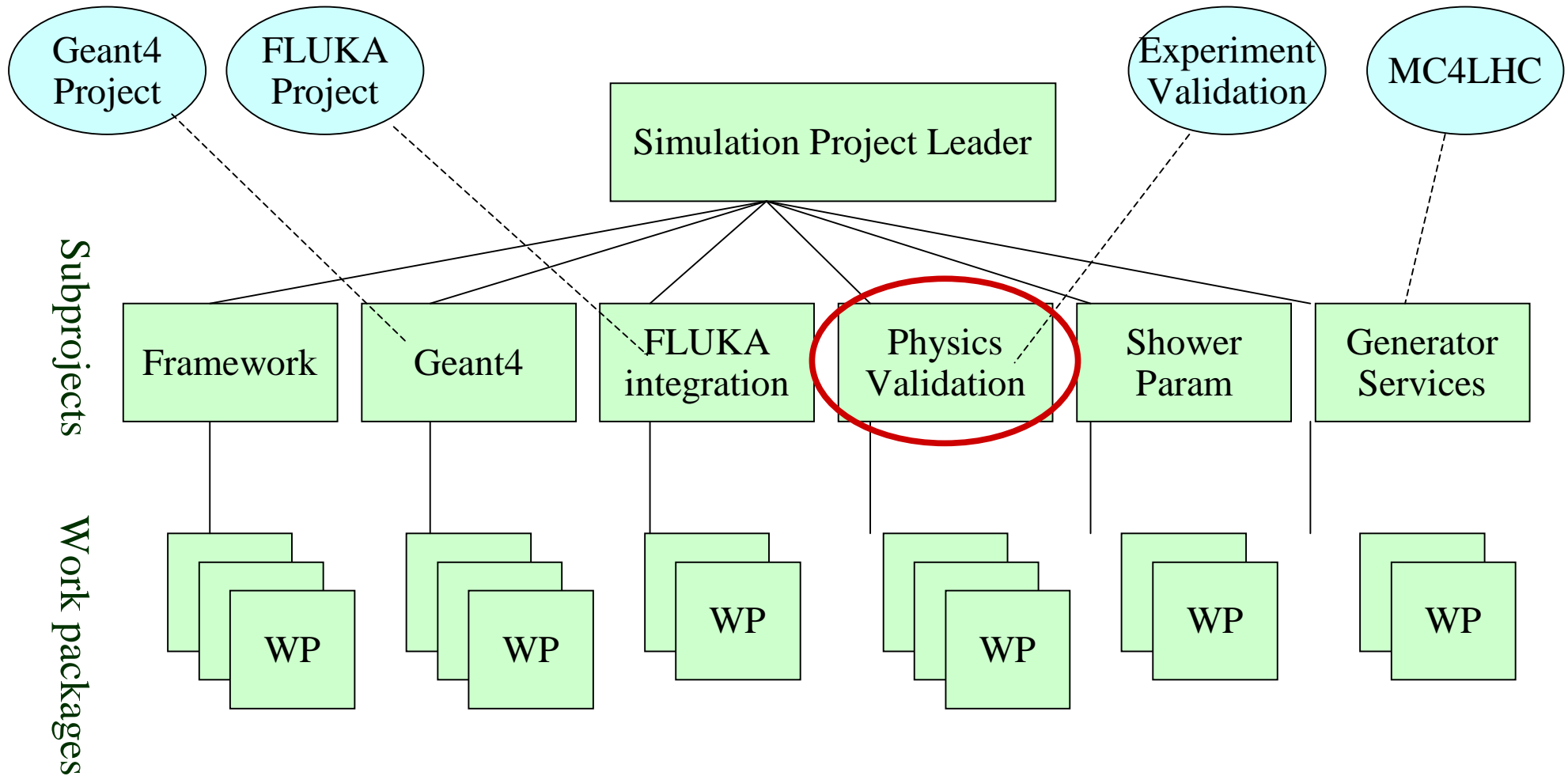
HB

CMS



ALICE

Simulation Project Organization



Physics Validation : assess adequacy of the Simulation physics and environment for LHC physics

What do we need to validate ?

- Physics of shower packages (G4, FLUKA) : this is the main goal.
- Adequacy and usability of simulation environment:
e.g. CPU, memory, interactivity, as well as generators, MCTruth, ...

Validation will be based mainly on

- Comparisons with LHC detector test-beam data
- Simulations of complete LHC detectors
- "Simple benchmarks" : thin targets, simple geometries

Note :

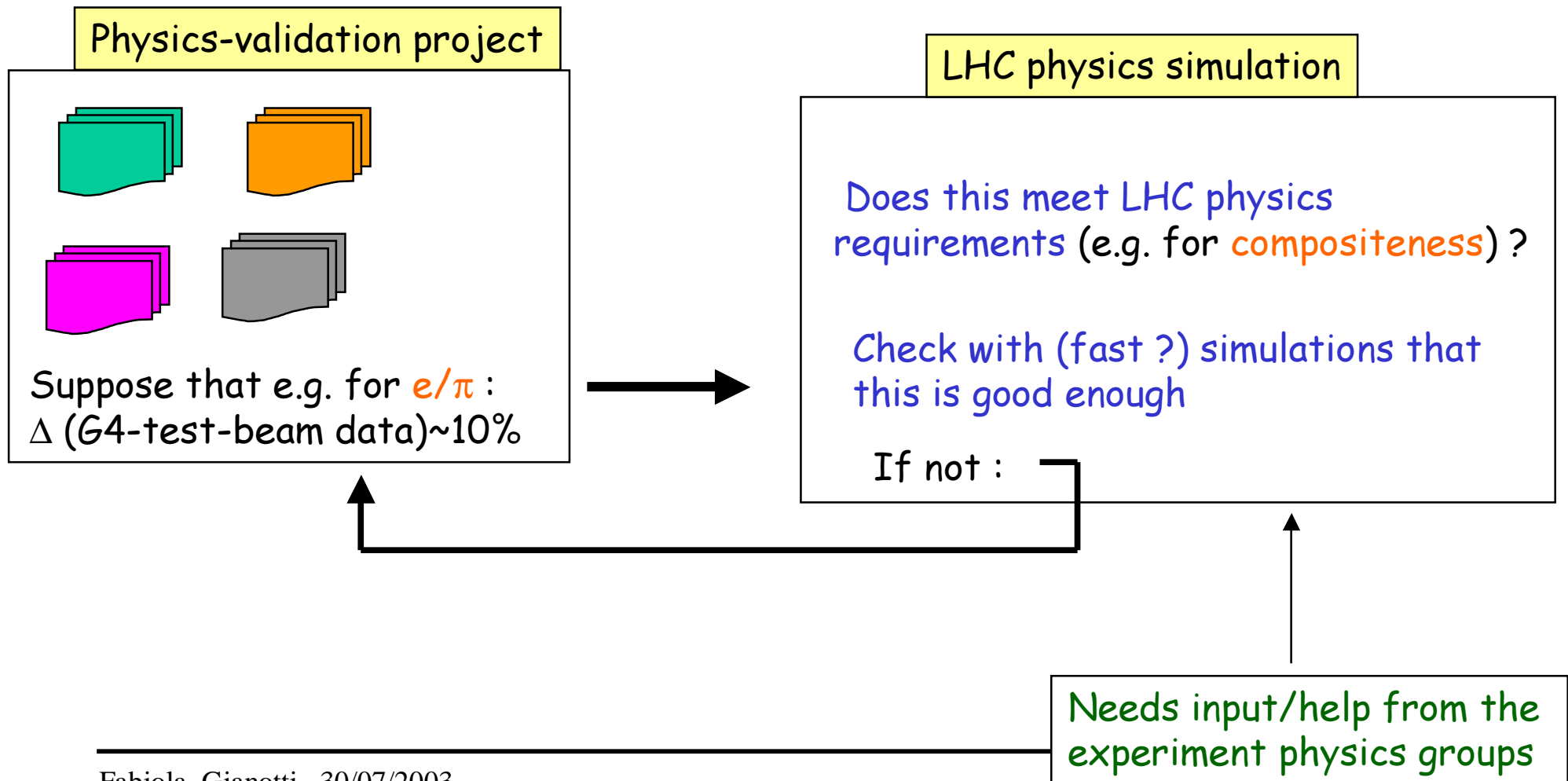
- a lot of work already done in the experiments and by G4 and FLUKA teams
- a lot of work will still be done by the experiments and by the experts
- aim of the LHC-wide LCG project:
 - get people work together on issues of common interest → synergy
 - study coherence of results across experiments and sub-detector technologies
 - help a given experiment also in areas where it cannot commit effort in this moment

More details : break-down of the activity ...

- WP1 - Impact on LHC physics (LHC physics requirements, impact of simulation inadequacy on LHC physics , etc.)
- WP2 - Input from the LHC test beams (available data, dedicated test beams ?)
- WP3 - Geometry for physics validation (test-beam and LHC-like geometry of experiments in G4/Fluka and maybe G3)
- WP4 - EM physics validation (comparisons with test-beam data, simple benchmarks, define optimized/recommended physics lists)
- WP5 - Hadronic physics validation (comparisons with test-beam data, simple benchmarks, define optimized/recommended physics lists)
 - WP5a - Calorimetry
 - WP5b - Tracking
 - WP5c - Background radiation
- WP6 - Special needs (e.g. transition radiation, special framework functionality)
- WP7 - Physics validation from outside LHC (collect most relevant results)
- WP8 - Validation of the simulation environment (infrastructure, MCtruth, etc.)
- WP9 - Editorial, organizational (WEB page, prepare benchmark suite, write reports)

What do we mean by " validation" ?

Dominant limitations and systematic uncertainties in LHC physics studies (both for searches and precision measurements) should not come from imperfect simulation



What will be the output of the project ?

- "Certification" that simulation packages and framework/environment ok for LHC physics
- Understanding of weaknesses and strengths of G4/FLUKA (complementarity ?)
- Uncertainties and inadequacies of G4/FLUKA
→ contribution to systematic errors of measurements when data will be available
- Recommended optimized physics lists, balancing technical performance against physics
- Simulation benchmark suite with relevant plots and tests for automatic (or semi-automatic) validation of future releases
- Final report(s) summarizing the work
-

High-level (somewhat ambitious ...) milestones

- first cycle of EM physics validation by Summer 2003
- first cycle of HAD physics validation by end 2003
- further iterations in 2004 : additional experiment test-beams (e.g. ATLAS combined test-beam); framework and infrastructure validation; etc.
- write final report(s) end 2004 ?

People

- The success of the project depends on :
 - the active participation of the experiments
 - the help and fast feedback of G4/FLUKA physics experts
 - strong interactions and common work with other Simulation sub-projects
- **Most manpower within the experiments:** e.g. comparisons simulation/test-beam data
- In addition, from LCG/EP-SFT (as of today):
 - J. Beringer is working on "simple benchmarks"
 - A. Ribon is working on hadronic interactions in the ATLAS pixel detector
 - G. Daquino will study/validate the G4 radiation background simulation in LHCb
 - M. Gallas will work either on CMS or on ATLAS G4 test-beam simulations

Organization

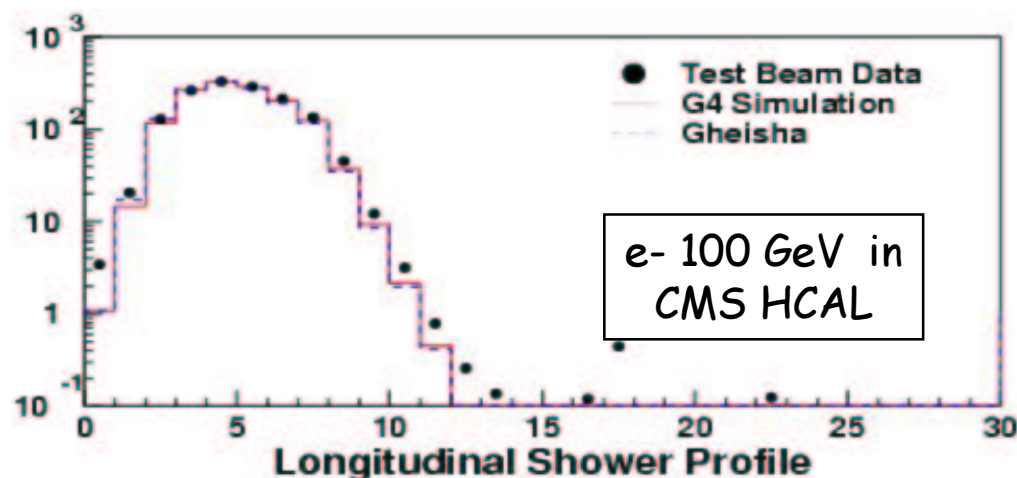
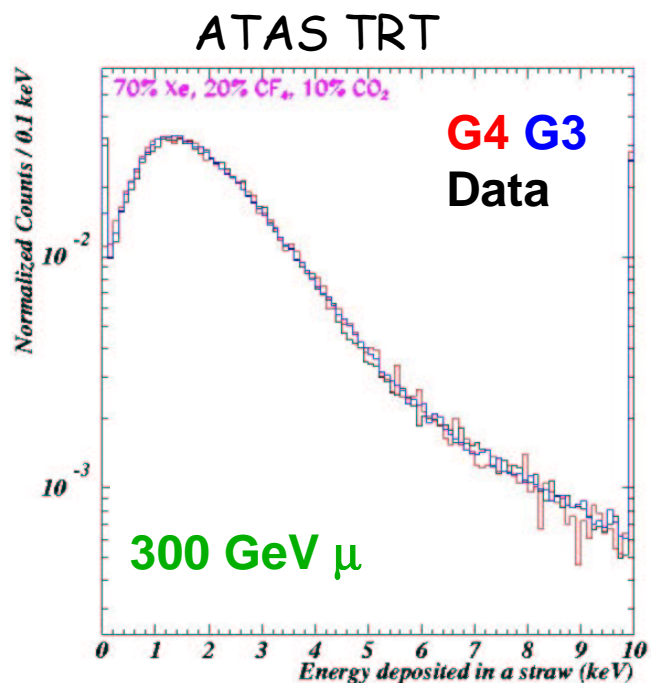
- WEB page (created and maintained by J. Beringer) :
<http://lcgapp.cern.ch/project/simu/validation>
- Meetings : usually the first Wednesday of the month, at 14:00-16:00, Room 32-1-A24
- In addition: "simple benchmarks" meetings (J.Beringer, F.G., G4/FLUKA experts)

Examples of work done so far:

- ① Physics validation studies made by experiments revisited
- ② Progress with *G4* hadronic physics :
 - pion shower profiles in the ATLAS HEC calorimeter
 - hadronic interactions in the ATLAS pixel detector
- ③ First results from simple benchmarks
- ④ Start to collect information/plots/results on WEB page

Three Physics validation meetings and three "Simple benchmarks" meetings so far

① Physics validation studies made so far by experiments : examples

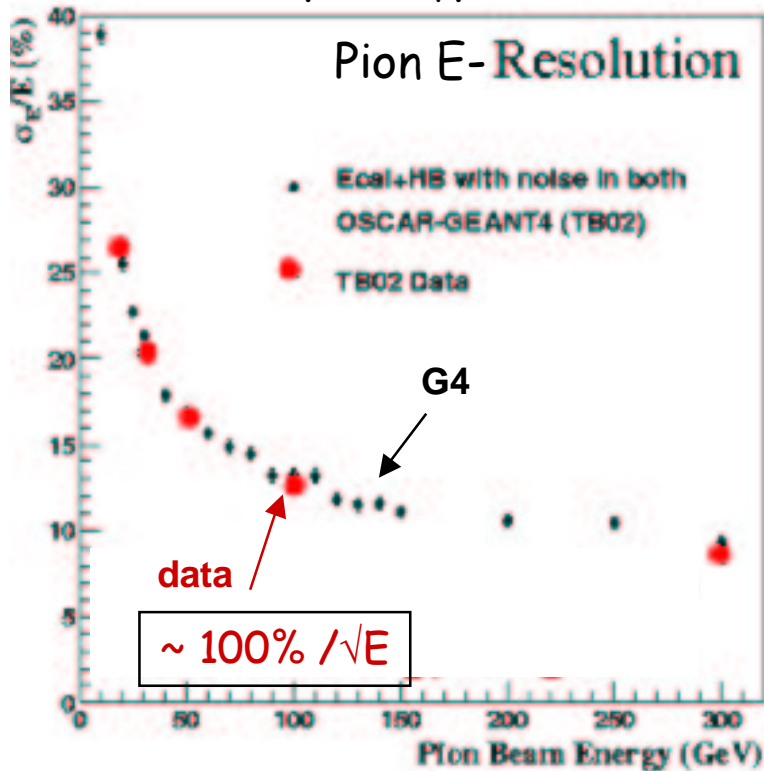


EM physics ~ ok. In progress:
 -- study "subtle" variables like lateral shower shapes, tails.
 -- test coherence across various sub-detector technologies

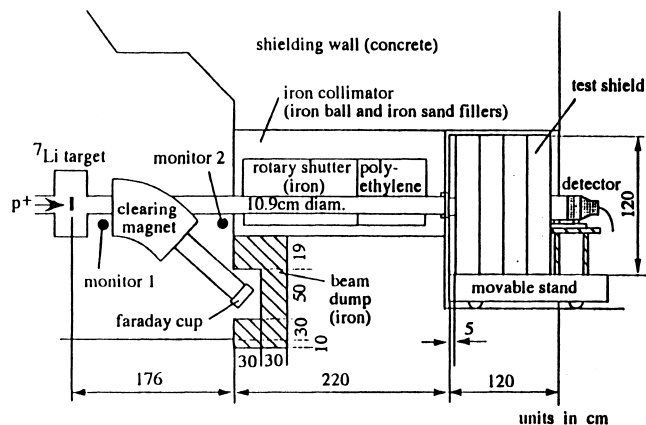
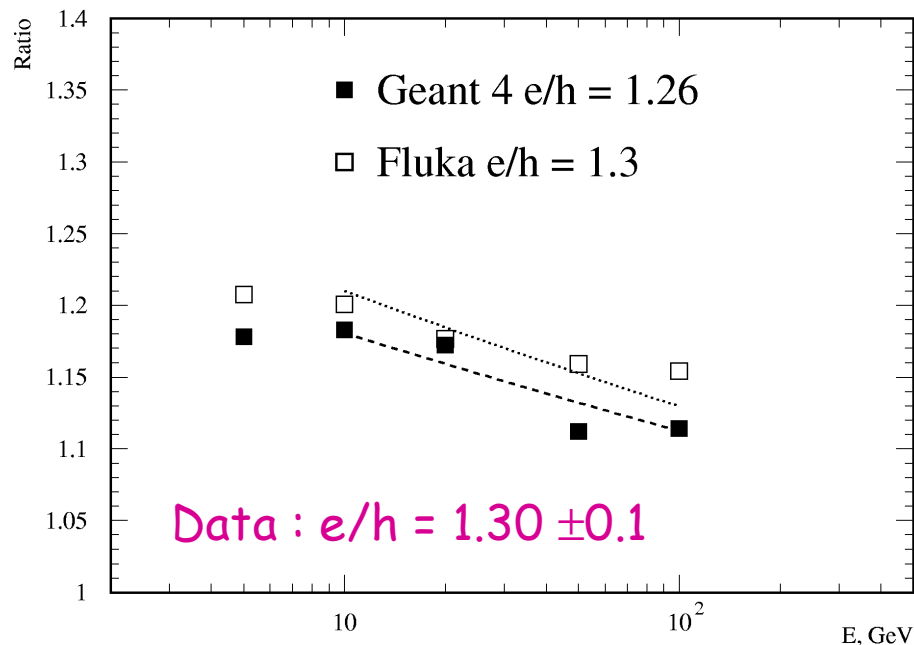
| Thickness | No filter | | Filter D263 | | LHCb RICH Cherenkov angle |
|-----------|-------------------|-----------------|-------------|-----------------|---------------------------|
| | θ_c (mrad) | σ_θ | θ_c | σ_θ | |
| 4 cm | 250.0 | 5.4 | 247.1 | 5.0 | DATA G4 |
| | 248.7 | 4.0 | 246.8 | 3.1 | |
| 8 cm | 246.8 | 5.8 | 245.4 | 4.8 | |
| | 245.0 | 3.9 | 243.7 | 3.0 | |

HAD physics (more difficult) : very good progress, but requires more work

CMS ECAL prototype +HCAL

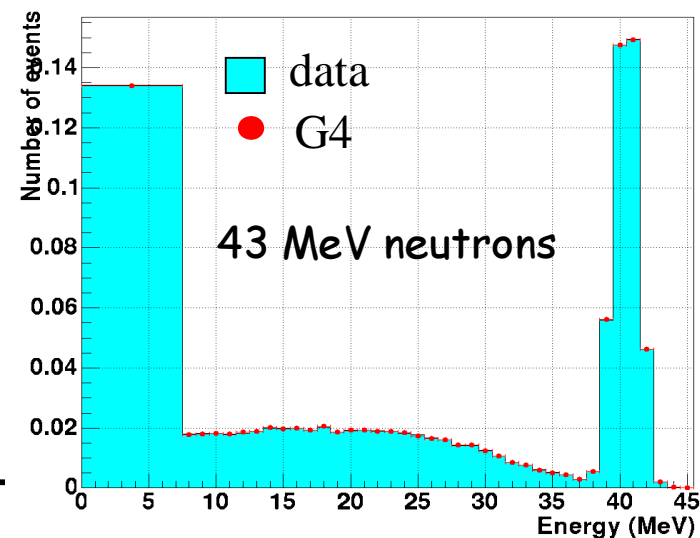


ATLAS Tilecal e/ π ratio



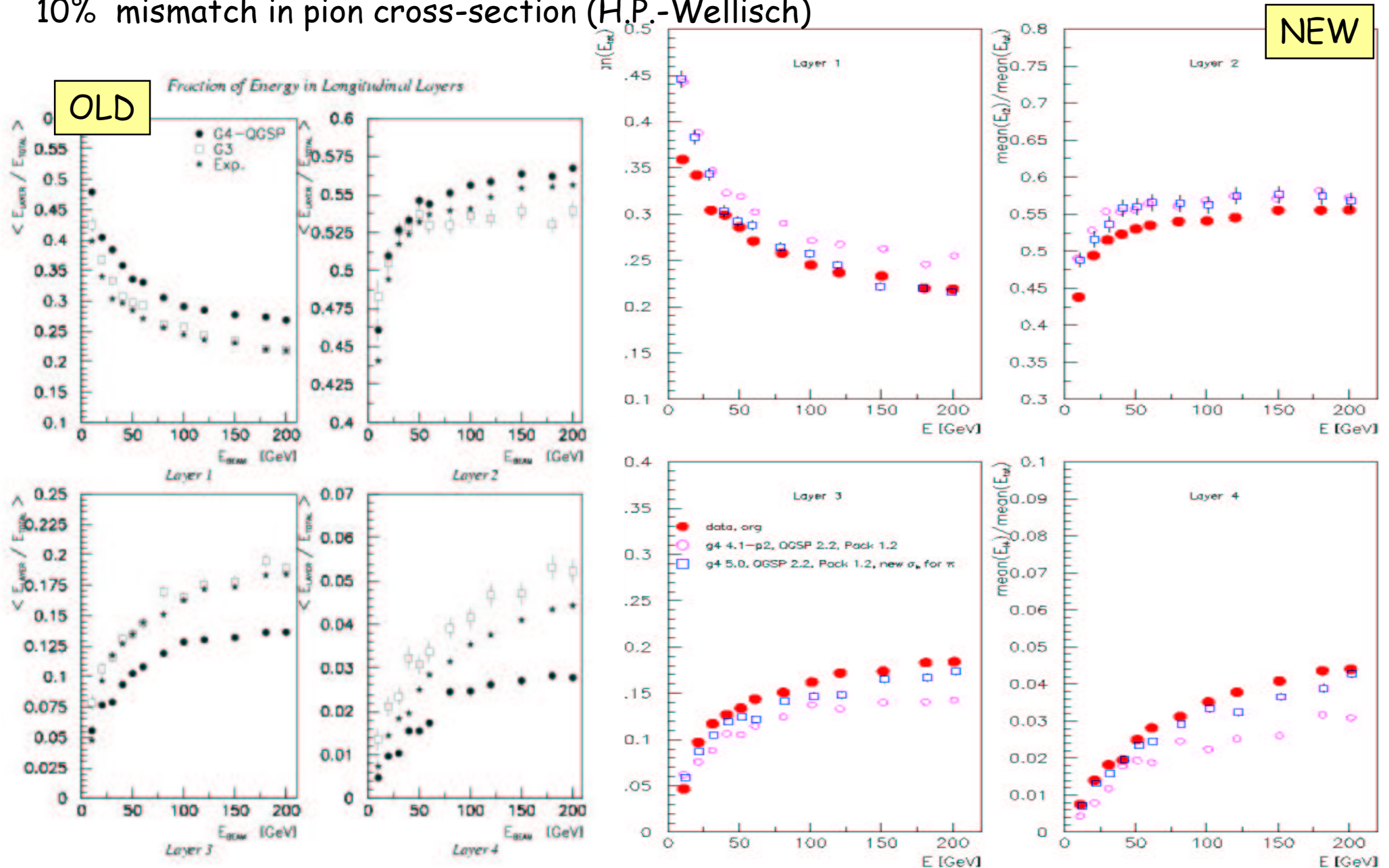
ALICE studies of TIARA facility

Energy Spectrum



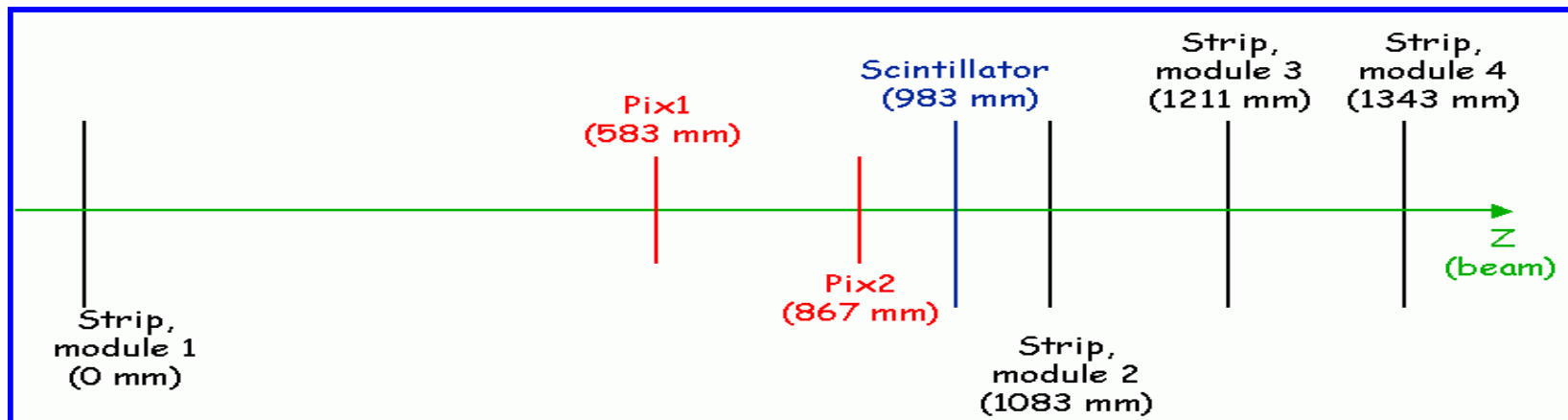
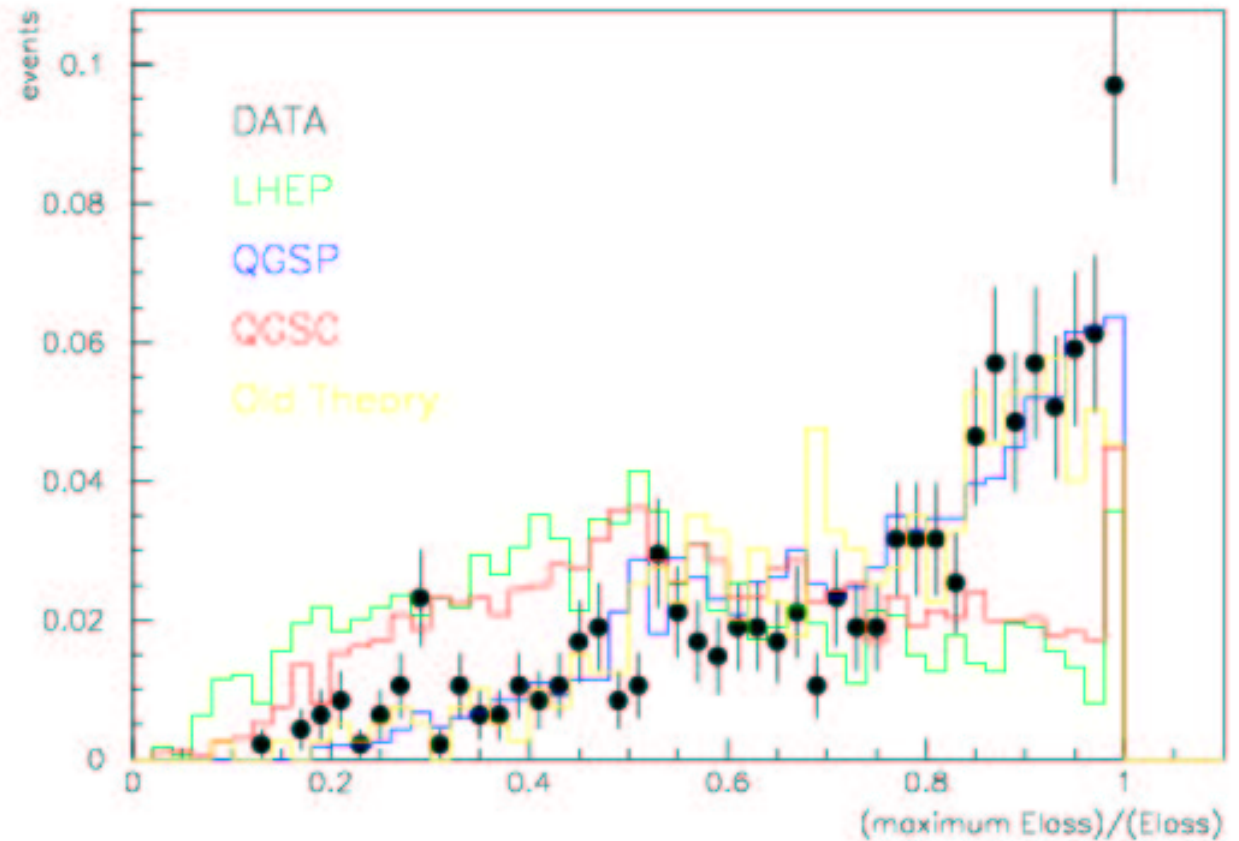
② Progress with G4 hadronic physics

Improved pion shower profile in the ATLAS hadronic end-cap calorimeter after fixing 10% mismatch in pion cross-section (H.P.-Wellisch)



② Progress with G4 hadronic physics

Hadronic interactions in ATLAS pixels with most recent G4 physics lists (A.Ribon)



③ First results from simple benchmarks (J.Beringer with I.Gonzalez)

- Simulation of (complex) particle interactions in HEP detectors based on **correct description of individual microscopic interactions** between incident particles and detector sub-atomic particles.
- These cannot be studied in simple/easy way with LHC detector simulations, where multiple-interactions/showers/cascades occur. In addition, **this complex phenomenology may average out problems at the microscopic level.**



- Study in parallel **simple benchmark layouts based on thin targets and compare G4, FLUKA and experimental data for single incident particles of various energies.**
- Benchmarks chosen if experimental data available and if relevant to LHC
- **Should repeat these studies with each new release of simulation packages**
→ prepare a (semi-) automatic test suite

Chosen benchmarks to get started:

- examples of (p, xn) double differential cross-sections
- pion absorption below 1 GeV (important for e/π , pion E-resolution, etc.)
- rapidity plots in H/Ar/Xe at 200 GeV (bubble chambers data)
- others in the future ... ?

Status:

- software infrastructure in place
- first results on (p, xn) cross-sections and comparisons with Los Alamos data

- Incident p energies: 113, 256, 597, 800 MeV
- Thin (~ 3 mm) targets (Al, Fe, Pb, ...)
→ ≤ 1 interaction per incident proton
- Neutron detectors at 5 angles
- References:

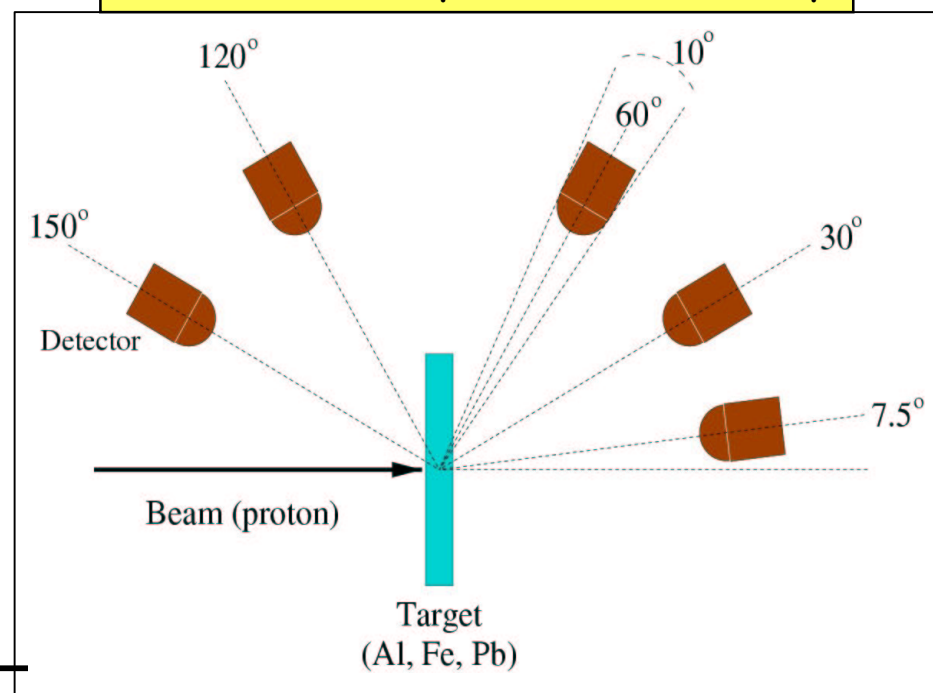
Nucl Sci Eng 102 (1989) 310

Nucl Sci Eng 110 (1992) 289

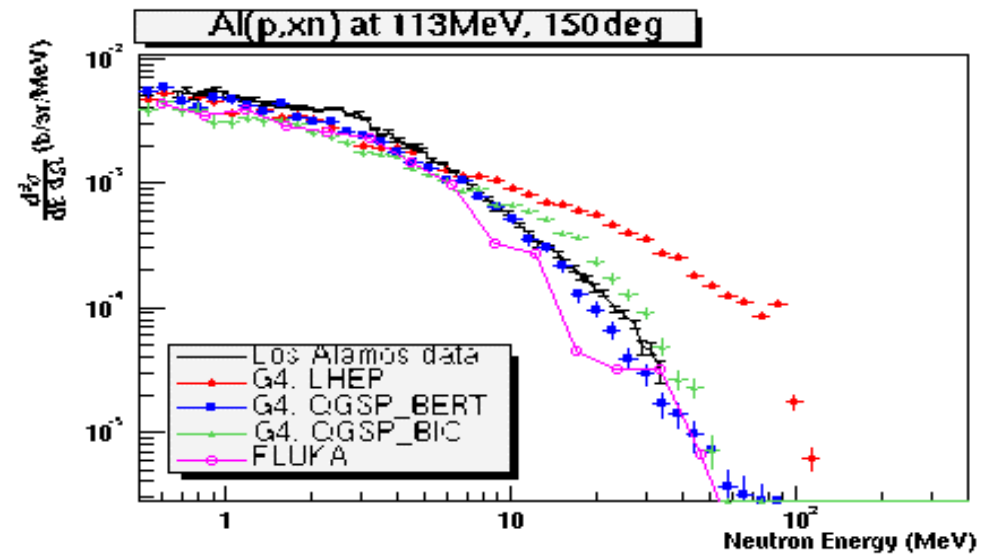
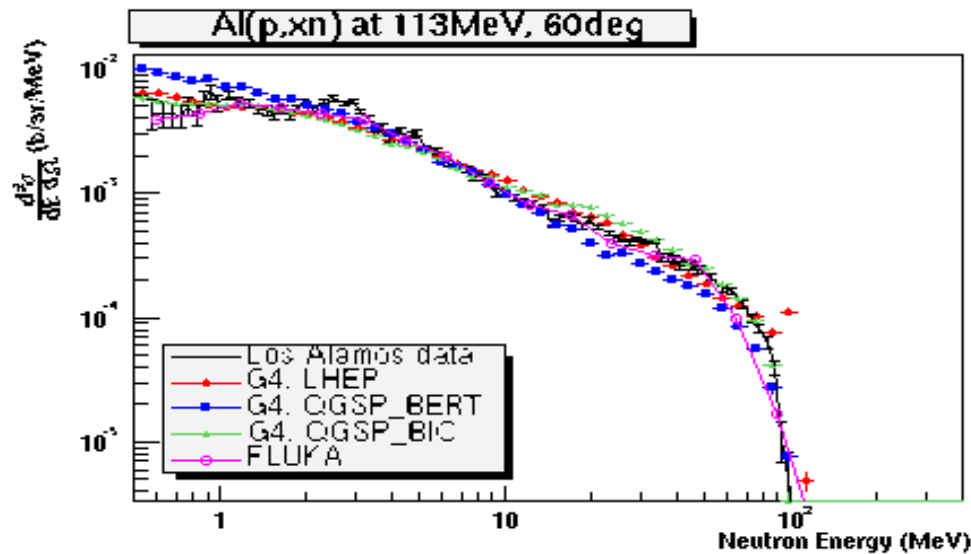
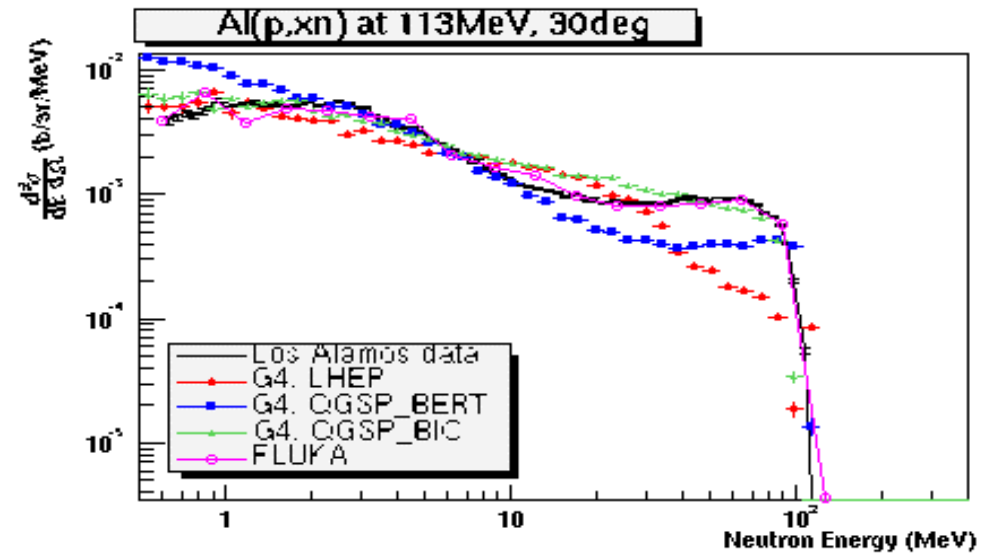
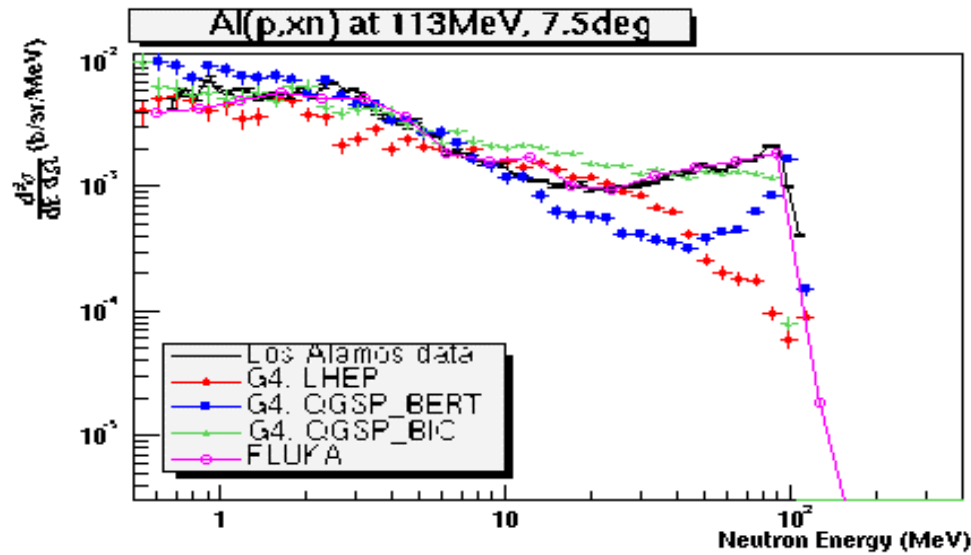
Nucl Sci Eng 112 (1992) 78

Nucl Sci Eng 115 (1993) 1

Los Alamos experimental set-up



Preliminary



④ Start to collect information/plots/results on WEB page

Have a look at :

<http://lcgapp.cern.ch/project/simu/validation>

Examples of on-going work:

- Most recent G4 hadronic physics lists which describe well ATLAS HEC and Tilecal data will be tested by LHCb and CMS.
- Documentation of hadronic physics lists for LHC being prepared by H.-P. Wellisch (ready by July 30th meeting ?).
- All experiments are taking test-beam data with many sub-detectors this Summer
→ expect new extensive round of comparison results in Autumn
- Two FLUKA activities starting:
 - update ATLAS Tilecal test-beam simulation
 - simulate hadronic interactions in ATLAS pixel test-beam set-up
- 1-day meeting in November or December to discuss validation item by item (e.g. electron energy resolution, hadronic shower profile) across experiments
→ complete first cycle of physics validation