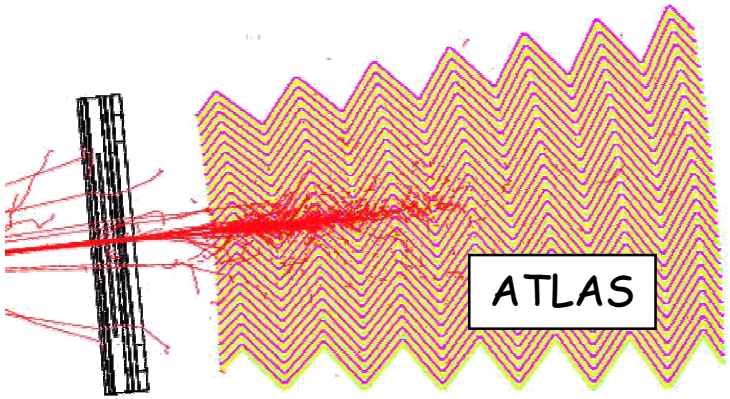
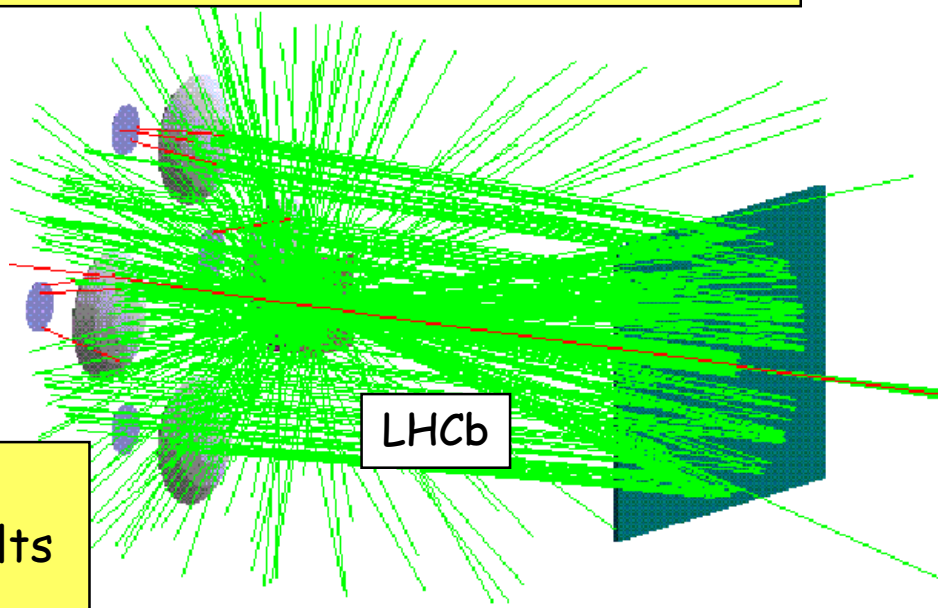
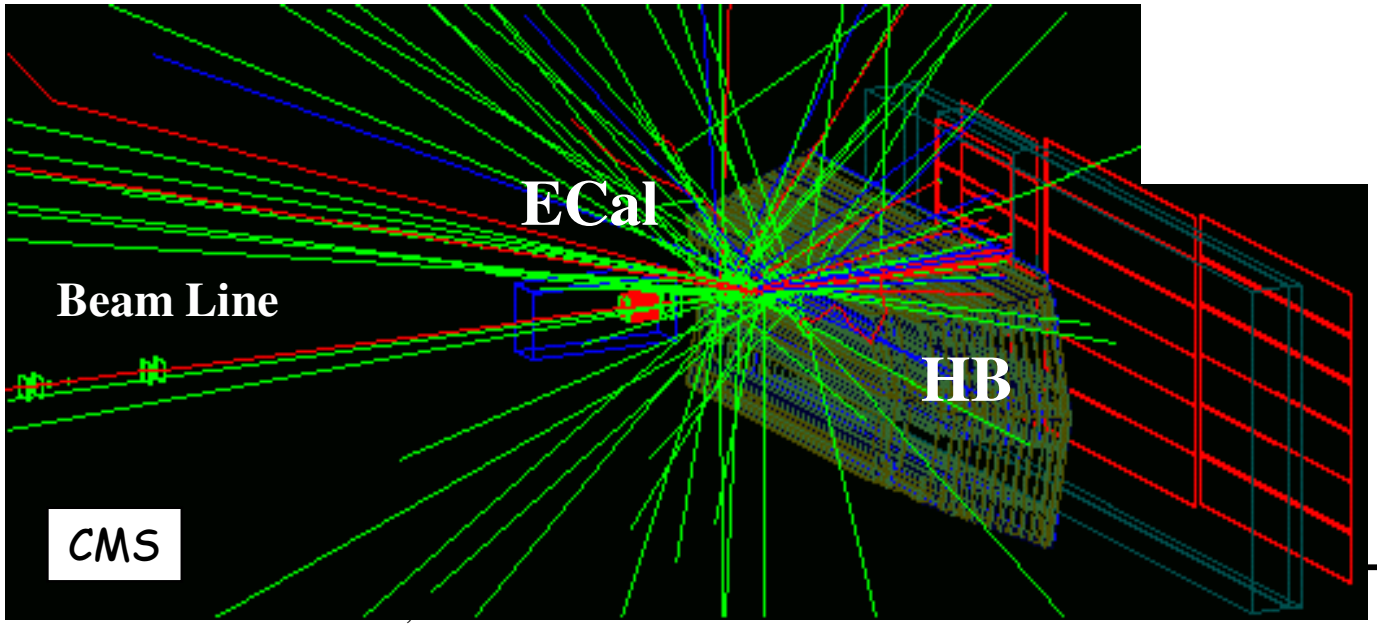
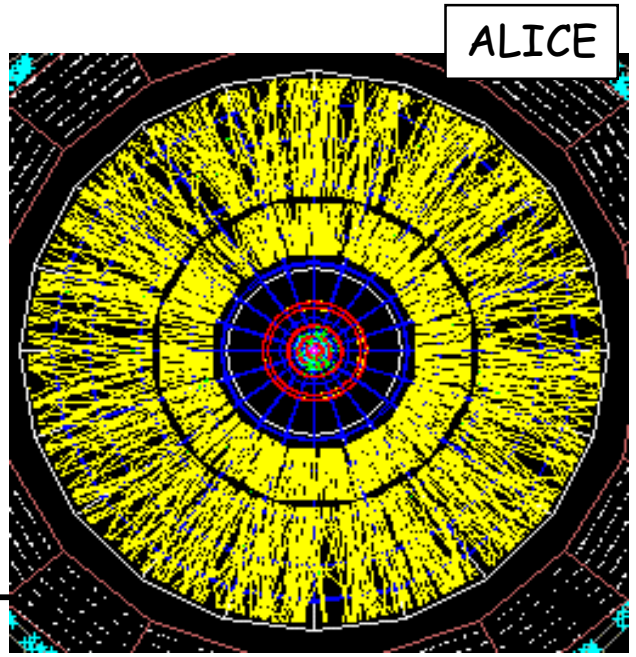
The Simulation physics-validation sub-project



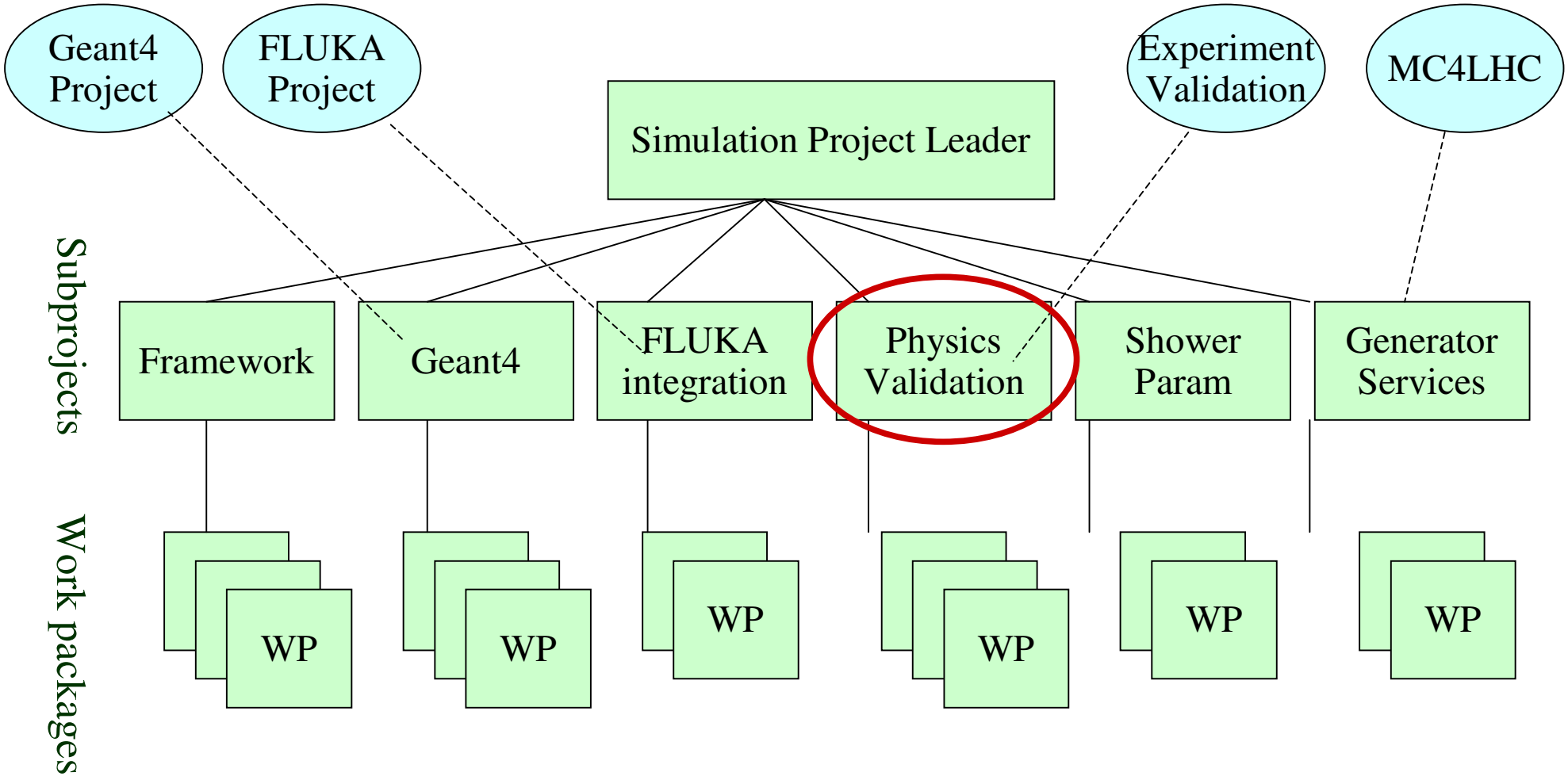


- Goals and plans
- Examples of work done so far and first results
- Examples of on-going work





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

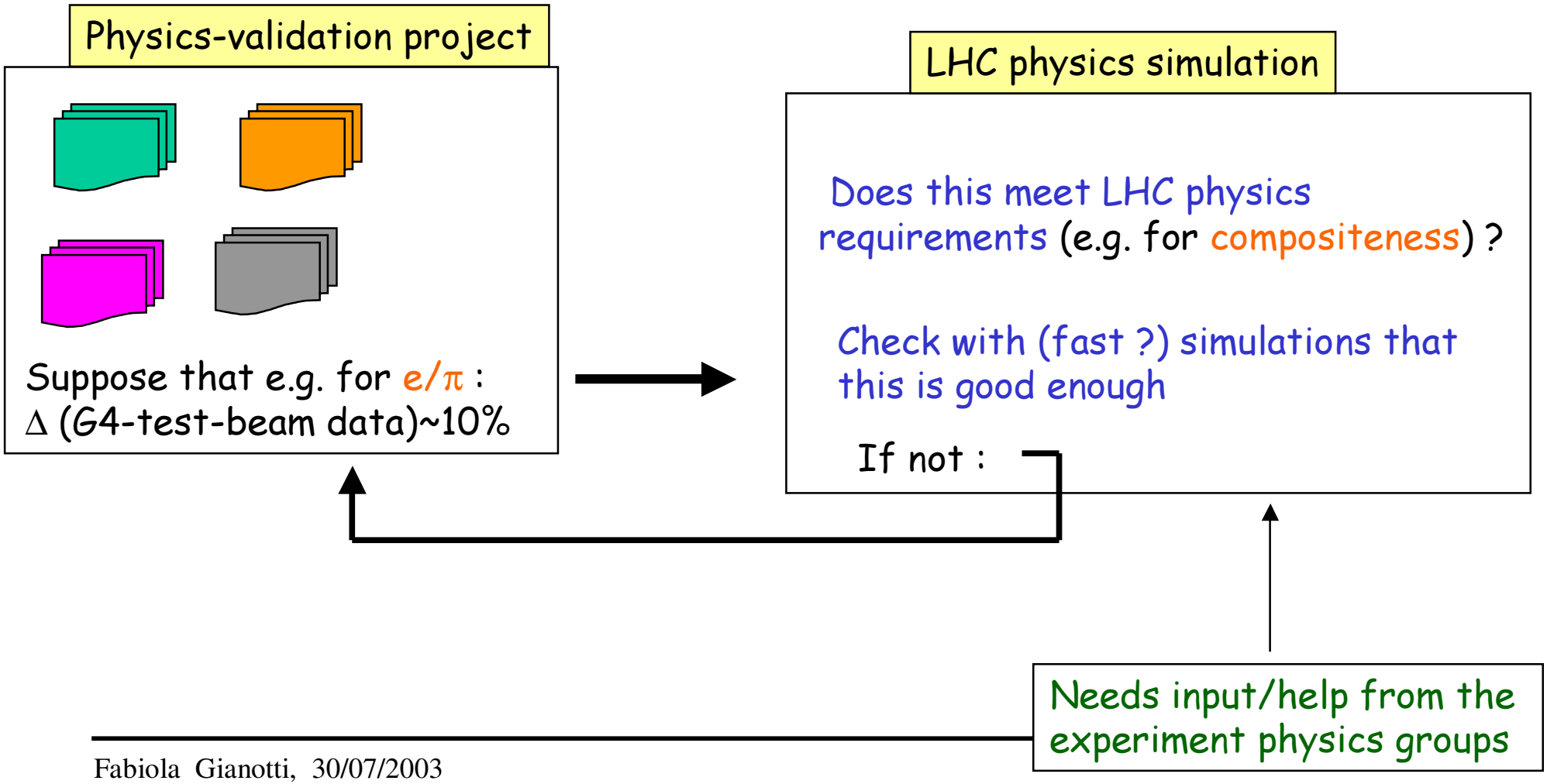
Note :
- a lot of work already done in the experiments and by G4 and FLUKA teams
- a lot of work will still be done by the experiments and by the experts
- aim of the LHC-wide LCG project:
  -- get people work together on issues of common interest → synergy
  -- study coherence of results across experiments 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:

❶ Physics validation studies made by experiments revisited

❷ Progress with G4 hadronic physics :
-- pion shower profiles in the ATLAS HEC calorimeter
-- hadronic interactions in the ATLAS pixel detector

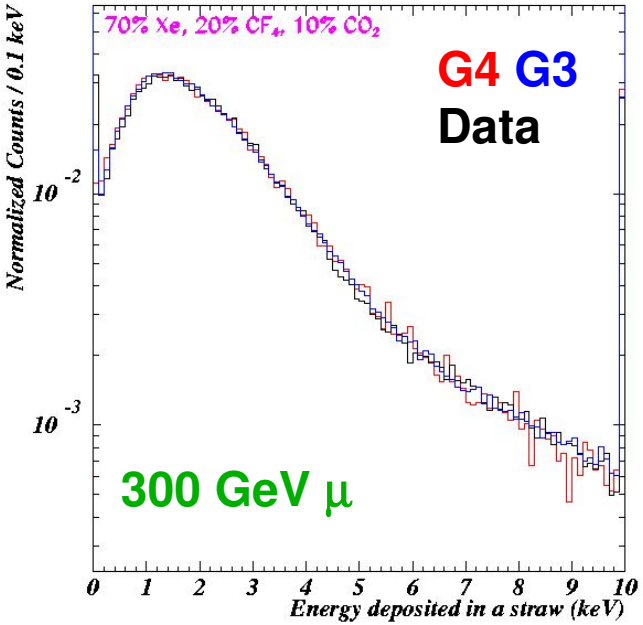
❸ First results from simple benchmarks

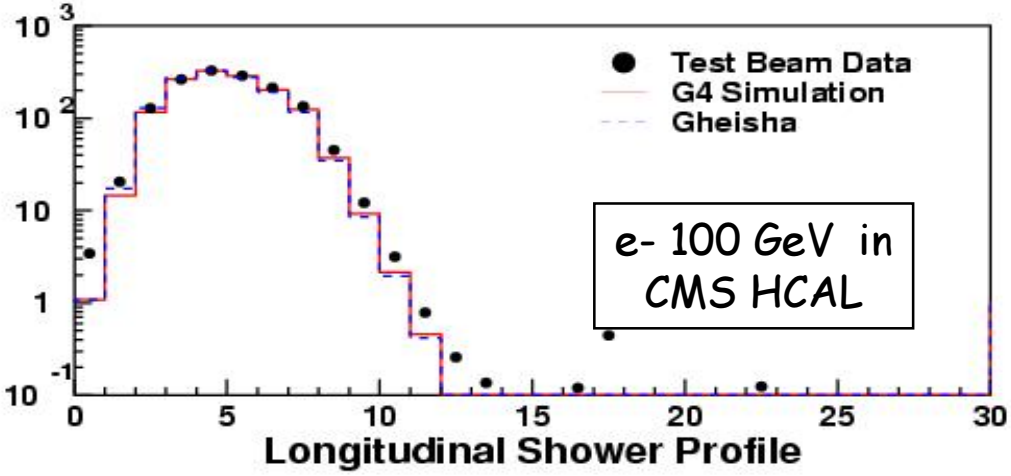
❹ Start to collect information/plots/results on WEB page

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

❶ Physics validation studies made so far by experiments : examples

ATAS TRT





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

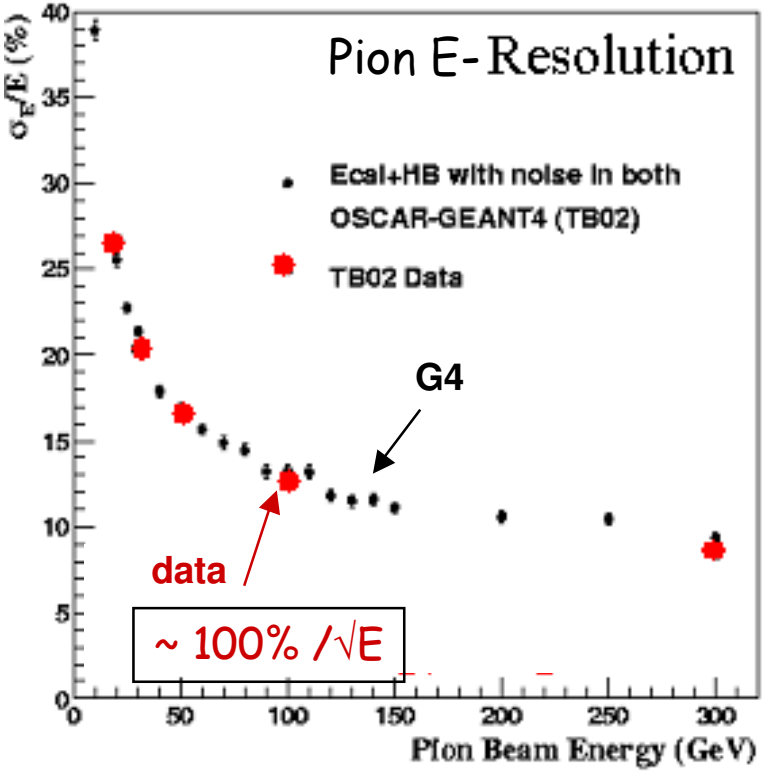
Thickness	No filter		Filter D263	
	θ_c (mrad)	σ_θ	θ_c	σ_θ
4 cm	250.0	5.4	247.1	5.0
	248.7	4.0	246.8	3.1
8 cm	246.8	5.8	245.4	4.8
	245.0	3.9	243.7	3.0

LHCb RICH Cherenkov angle

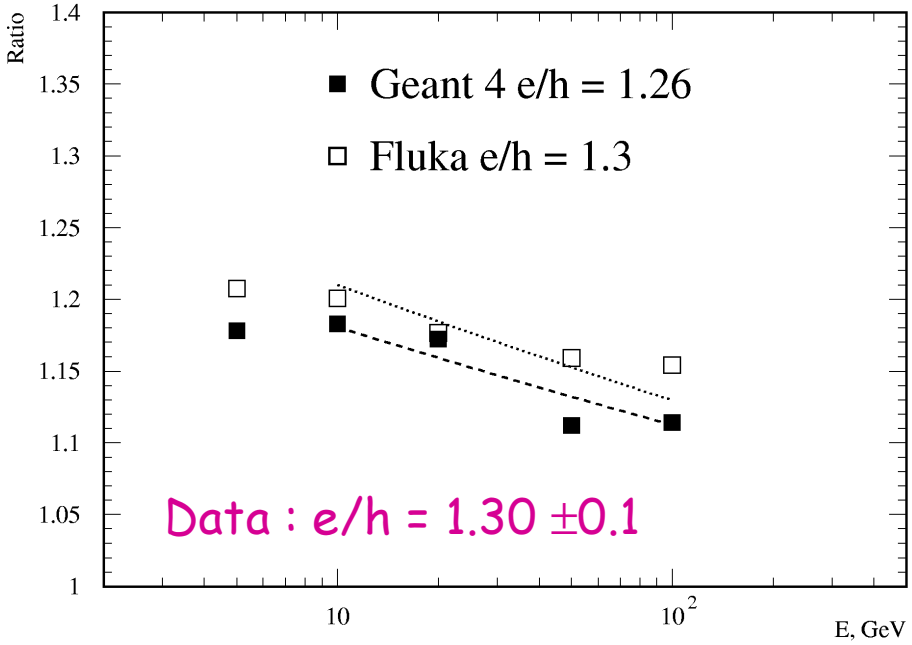
DATA
G4

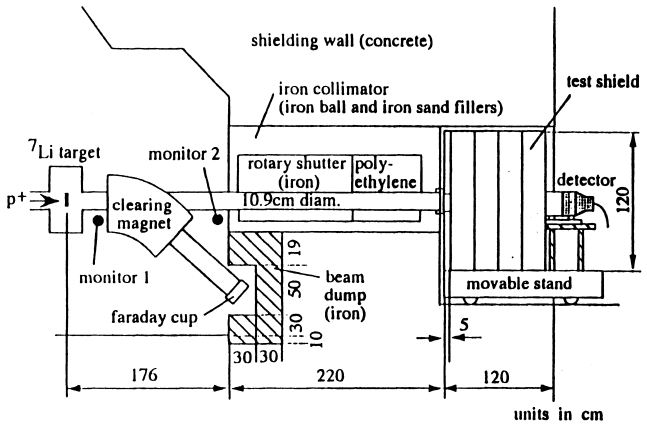
HAD physics (more difficult) : very good progress, but requires more work

CMS ECAL prototype +HCAL

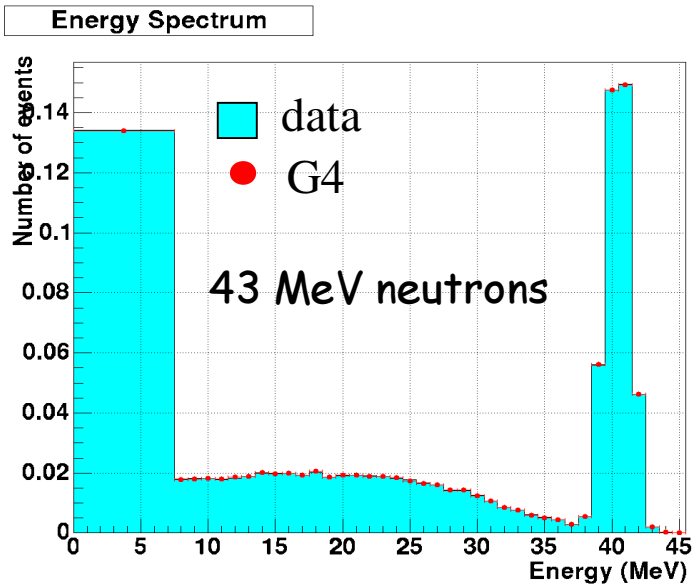


ATLAS Tilecal e/π ratio





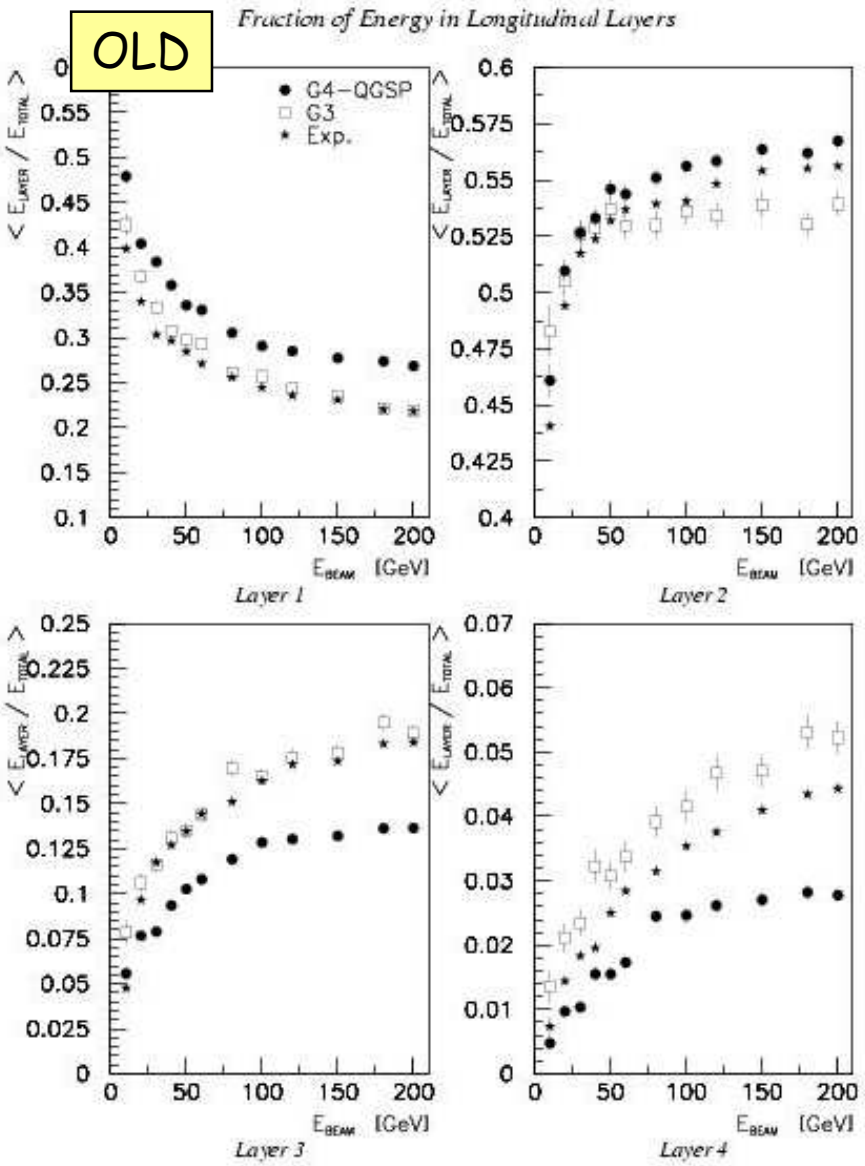
ALICE studies of TIARA facility



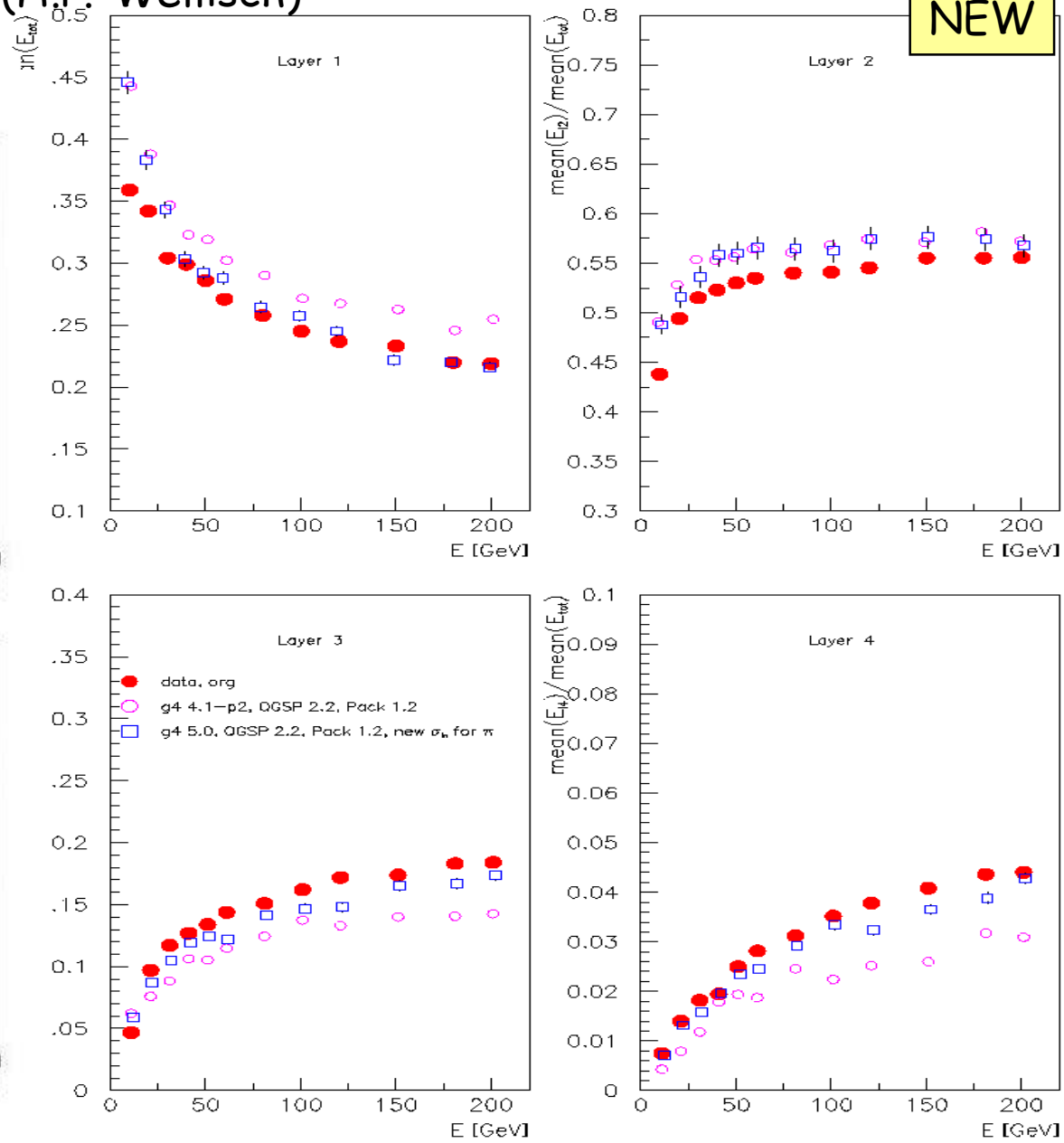
❷ Progress with G4 hadronic physics

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

OLD

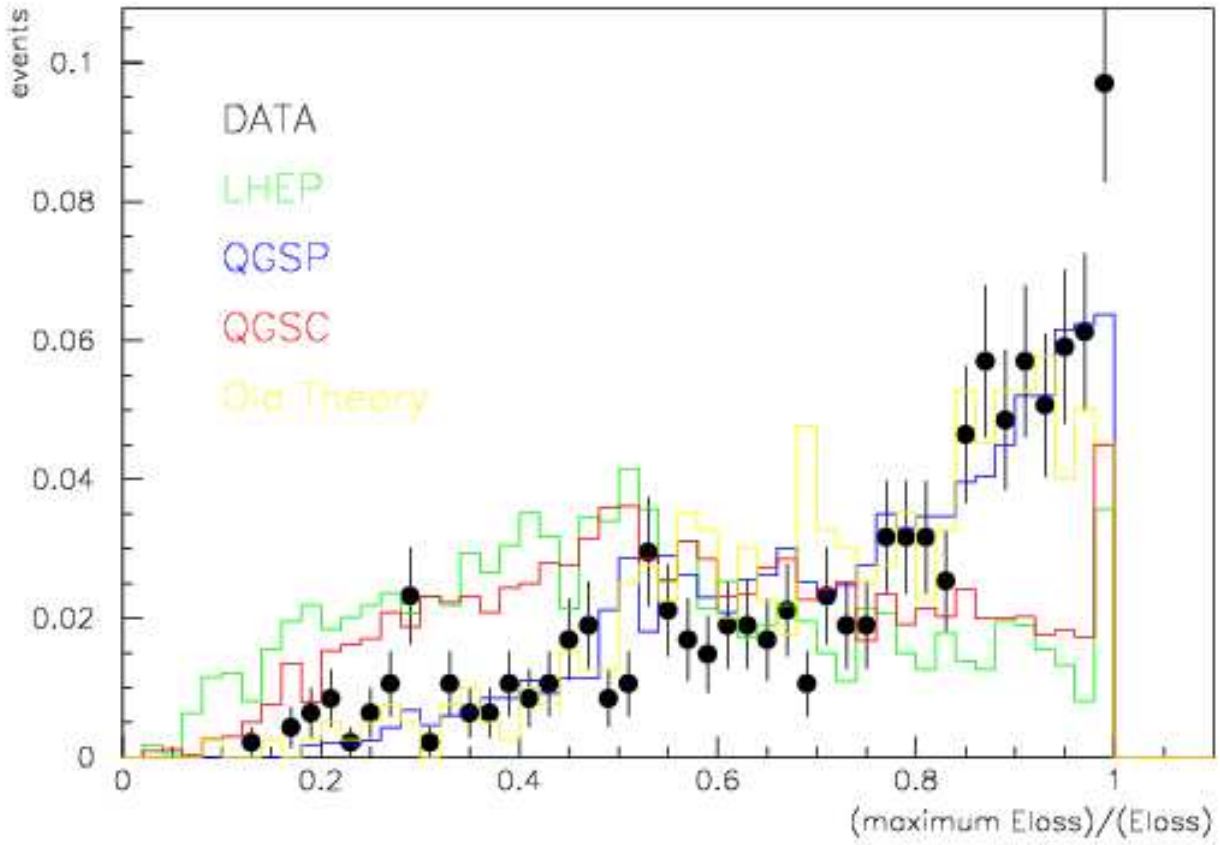


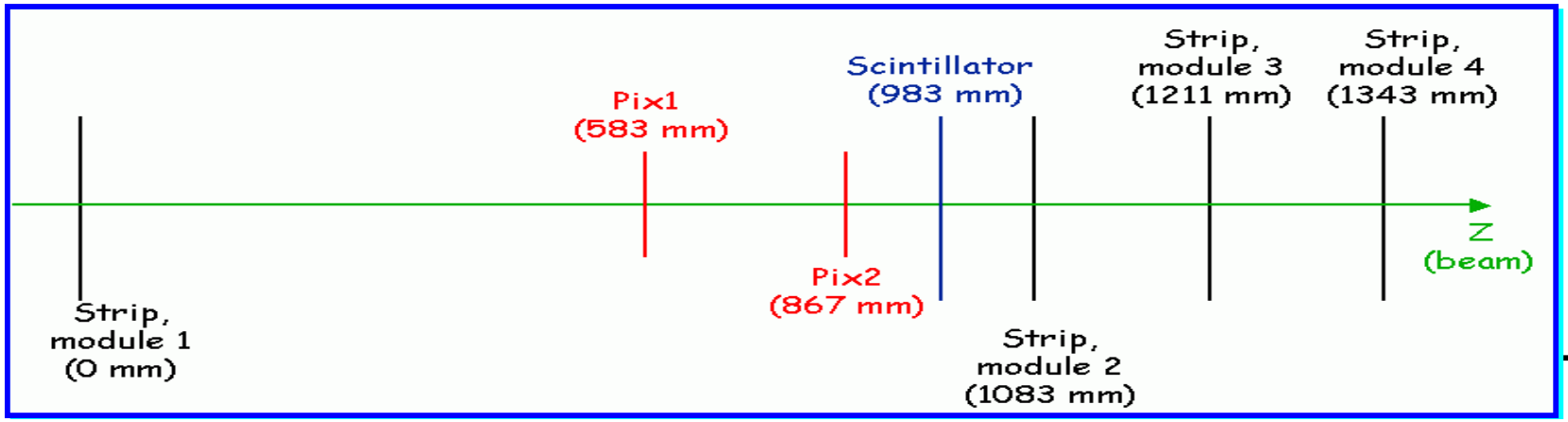
NEW



❷ Progress with G4 hadronic physics

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





❸ 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 … ?

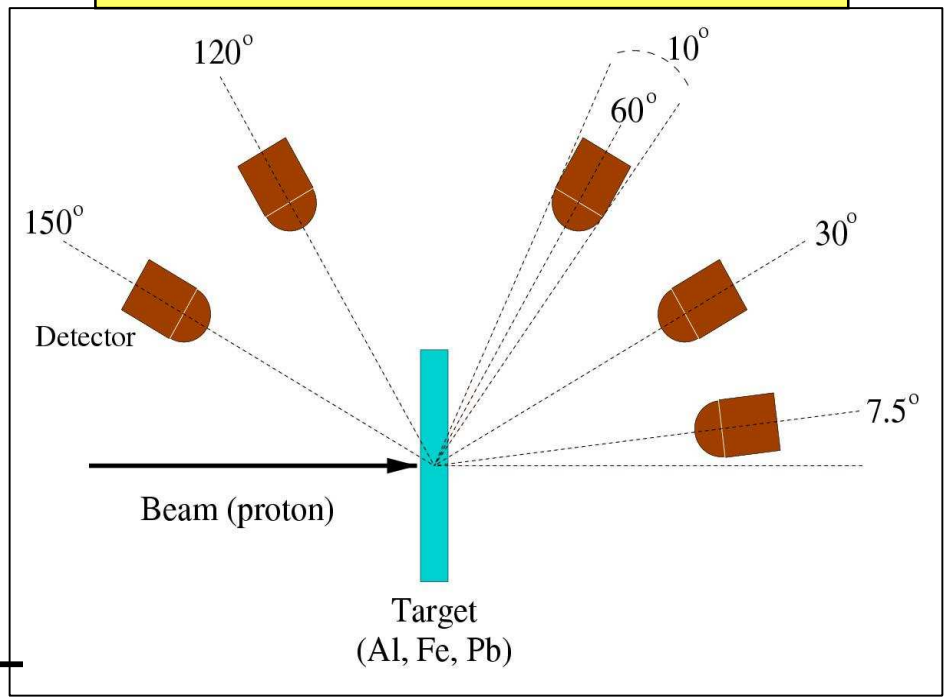
Status:

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

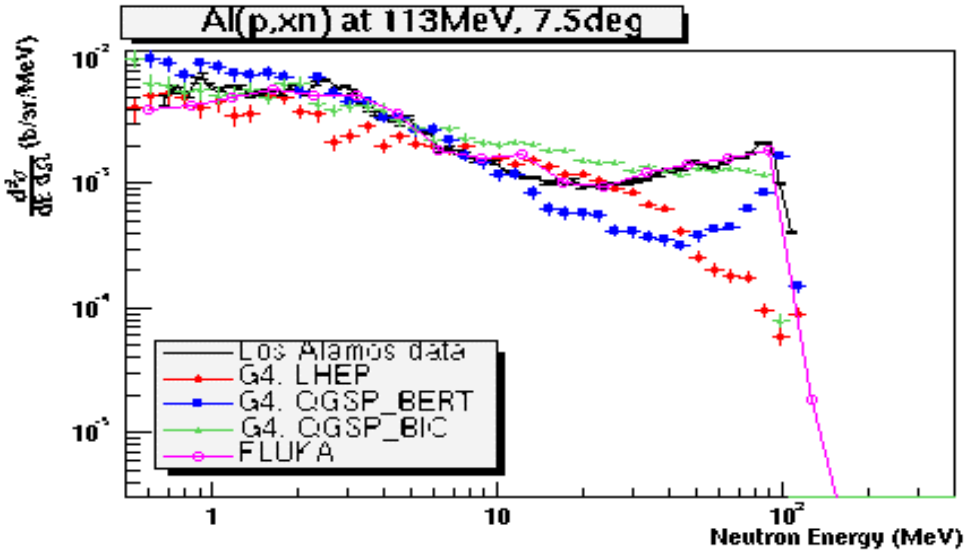
- Incident p energies: 113, 256, 597, 800 MeV
- Thin (~ 3 mm) targets (Al, Fe, Pb, …)
  → ≤ 1 interaction per incident proton
- Neutron detectors at 5 angles
- References:

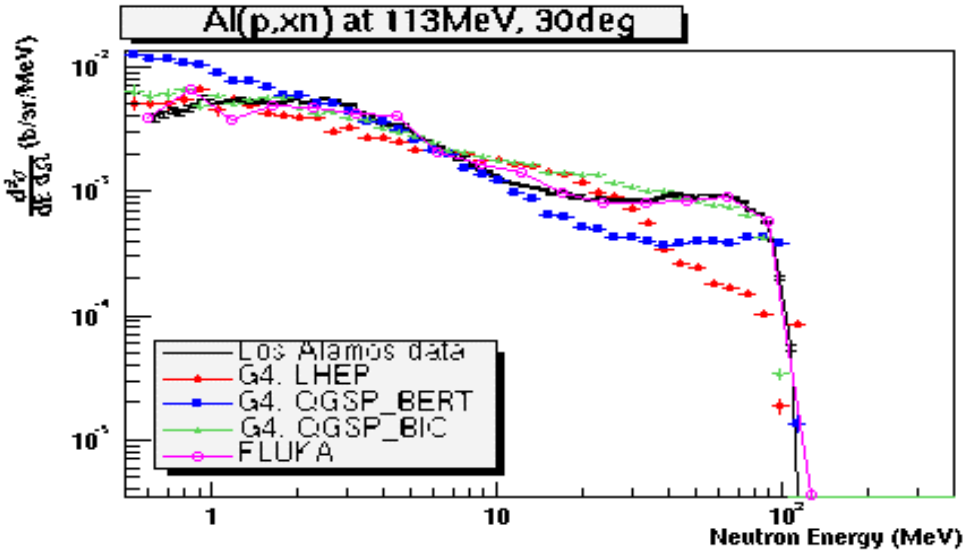
  Nucl Sci Eng 102 (1989) 310
  Nucl Sci Eng 110 (1992) 289
  Nucl Sci Eng 112 (1992) 78
  Nucl Sci Eng 115 (1993) 1

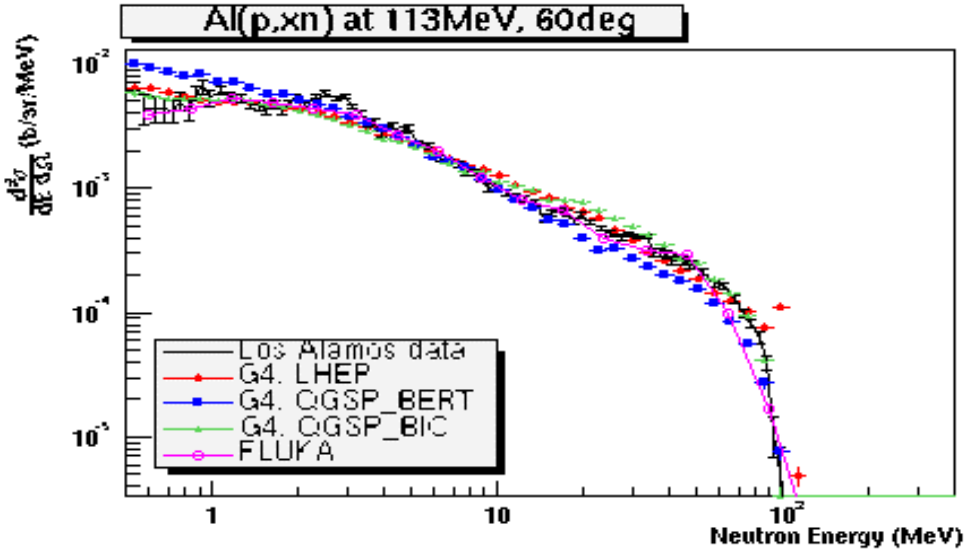
Los Alamos experimental set-up

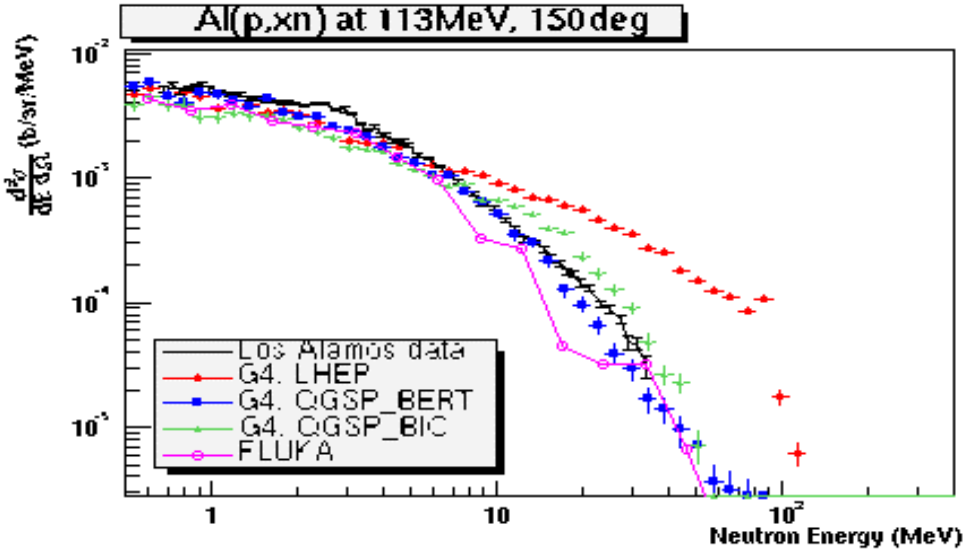


Preliminary









Fabiola Gianotti, 30/07/2003

❹ 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