Geant 4

Status of Geant4 Hadronic Validation

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20th Geant4 Collaboration Workshop

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Outline

- Model vs Thin target – status and highlights
- Physics Lists
  - Shower Shapes
  - Thick targets – SATIF Benchmark
  - New developments (NuBeam, Shielding(M), physics lists factory…)
- Validation Repository
- Summary

Model Validation (I)

- Cascades (Bertini, Binary, INCL++)
  - Low and intermediate energies
  - Pion, baryon (p, n, pbar) production
  - Tested regularly (test47) or at least periodically (test30, test35)
  - Fairly stable through the 4.10.1 development cycle
  - Plenty of results archived (test47) up to 4.10.1.ref08…
  - …but not all the results – need to consolidate
  - Also, based on recent communications with users, additional tests are being implemented to address specific topics, e.g. kaon and pion interaction cross-sections, kaon interaction with nuclei (proper handling of kaon decay), etc.

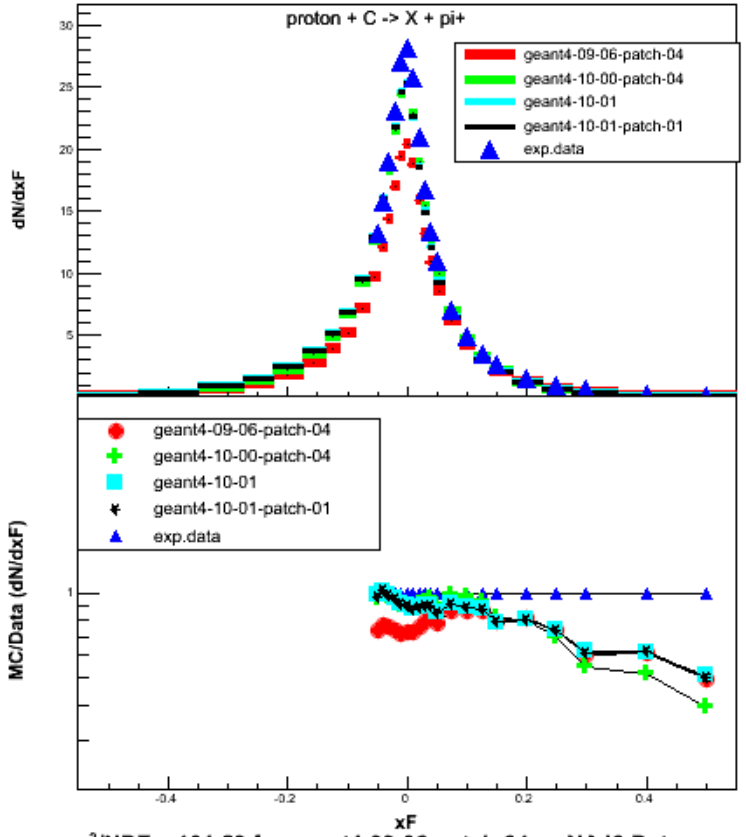
Model Validation (II)

- String models (QGS, FTF)
  - High (test19, test22) and intermediate (test47-FTF) energy
  - Regularly tested
  - Pion, baryon production
  - Previous (4.10.0) worrisome changes to FTF on 4.10.0 were fixed in4. 10.1; agreement with exp.data noticeable improved
  - New FTF development towards p,pion+A->n in the intermediate energy range is carefully monitored
  - **New development in QGS is carefully monitored**
  - Test47 recently expanded to test p+A->pbar by FTF
  - All results archived up to 4.10.1.ref08
  - Plans to expand and include more experimental datasets

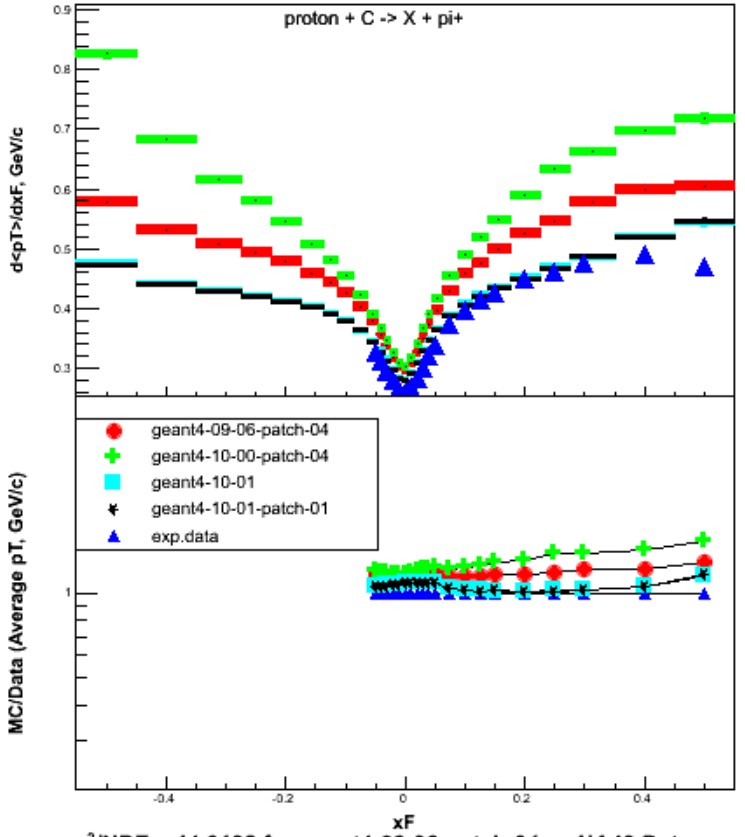
Evolution of FTF (High Energy)

158GeV/c p+C -> π^+

<mult> vs xF and <pT> vs xF; data from NA49



χ^2/NDF = 101.53 for geant4-09-06-patch-04 vs NA49 Data
χ^2/NDF = 67.097 for geant4-10-00-patch-04 vs NA49 Data
χ^2/NDF = 54.3406 for geant4-10-01 vs NA49 Data
χ^2/NDF = 54.6469 for geant4-10-01-patch-01 vs NA49 Data

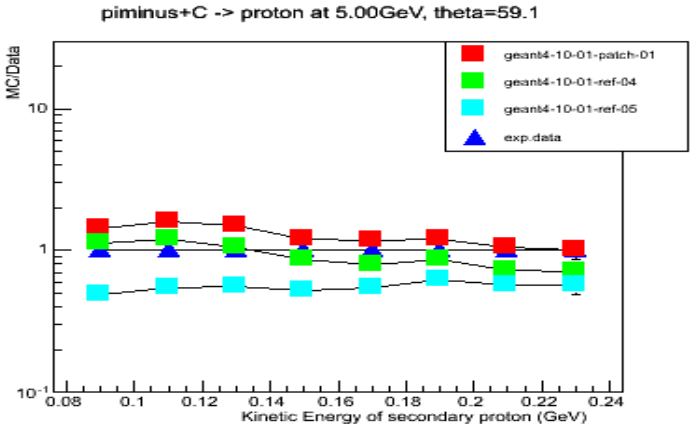


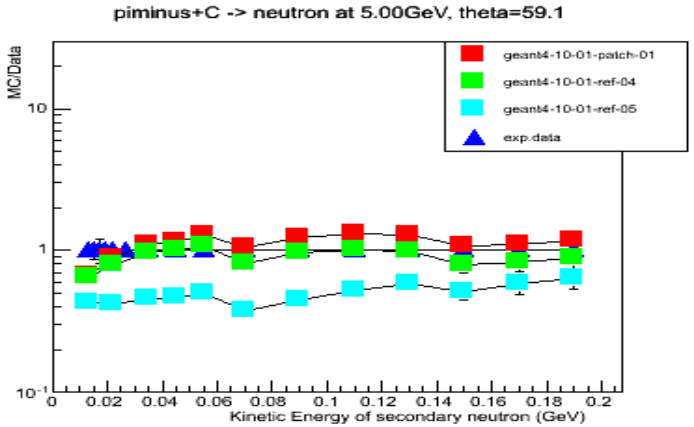
χ^2/NDF = 44.0192 for geant4-09-06-patch-04 vs NA49 Data
χ^2/NDF = 105.764 for geant4-10-00-patch-04 vs NA49 Data
χ^2/NDF = 6.81441 for geant4-10-01 vs NA49 Data
χ^2/NDF = 7.04449 for geant4-10-01-patch-01 vs NA49 Data

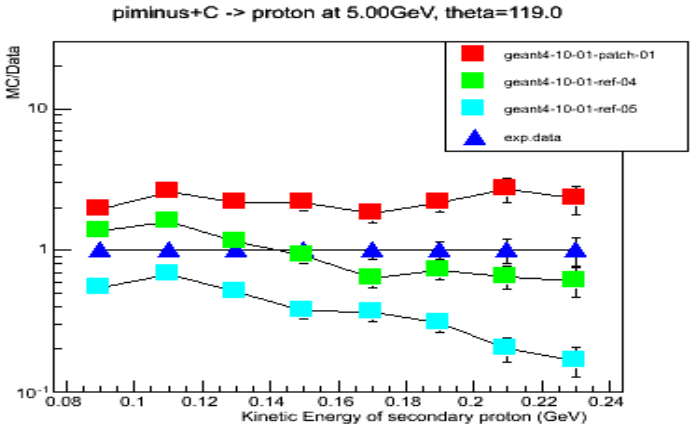
Evolution of FTF (Intermediate Energy)

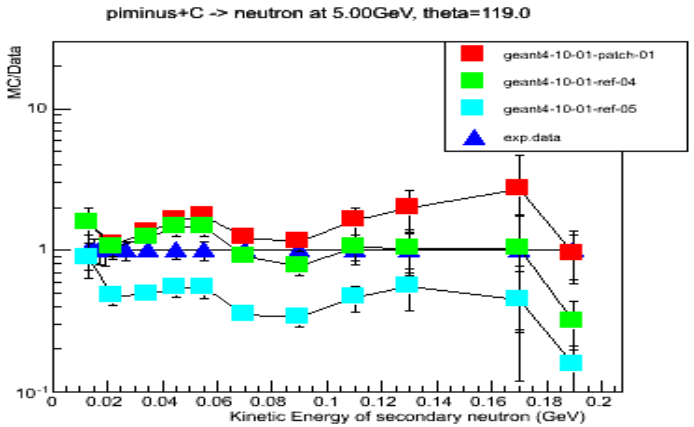
5GeV/c π^-+C -> p,n

MC/Data vs Ekin of secondary; data from ITEP









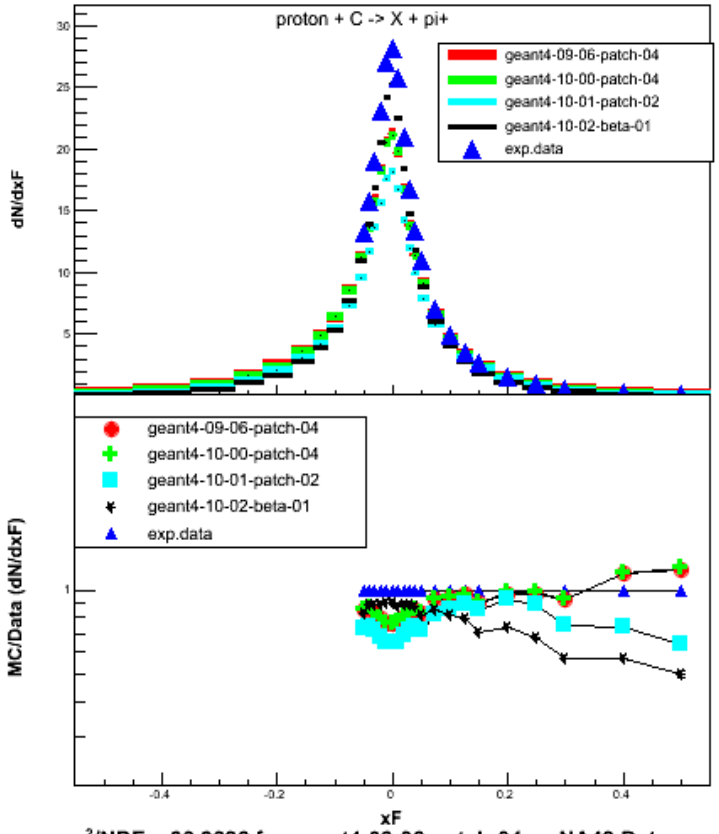
ftfp vs (ITEP) Data
χ^2/NDF = 49.7461 for geant4-10-01-patch-01
χ^2/NDF = 6.47533 for geant4-10-01-ref-04
χ^2/NDF = 24.5958 for geant4-10-01-ref-05

ftfp vs (ITEP) Data
χ^2/NDF = 5.75509 for geant4-10-01-patch-01
χ^2/NDF = 2.57057 for geant4-10-01-ref-04
χ^2/NDF = 19.0275 for geant4-10-01-ref-05

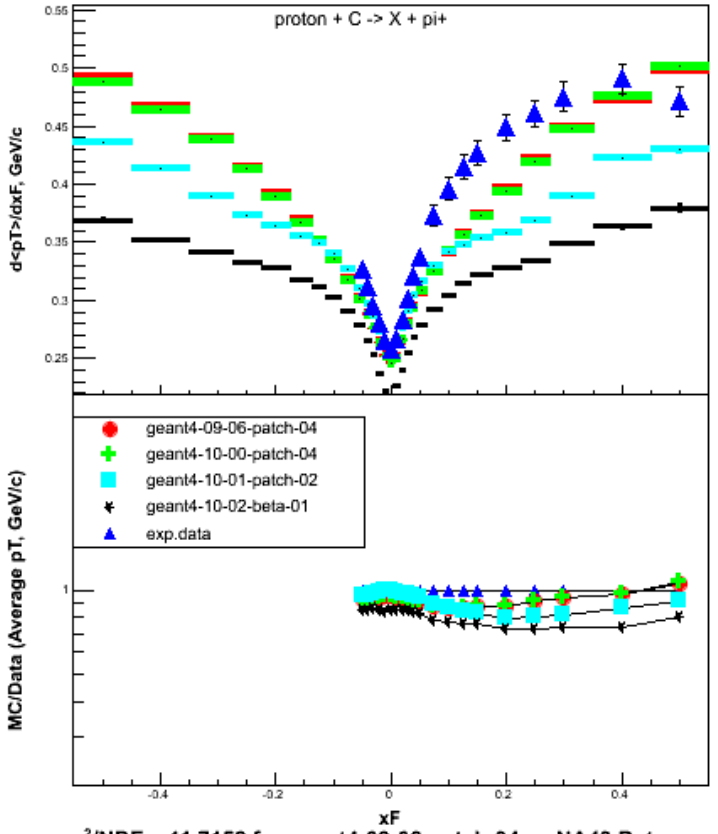
Evolution of QGS (High Energy)

158GeV/c p+C -> π^+

<mult> vs xF and <pT> vs xF; data from NA49



χ^2/NDF = 36.3626 for geant4-09-06-patch-04 vs NA49 Data
χ^2/NDF = 36.7379 for geant4-10-00-patch-04 vs NA49 Data
χ^2/NDF = 104.566 for geant4-10-01-patch-02 vs NA49 Data
χ^2/NDF = 80.1344 for geant4-10-02-beta-01 vs NA49 Data



χ^2/NDF = 11.7152 for geant4-09-06-patch-04 vs NA49 Data
χ^2/NDF = 11.8102 for geant4-10-00-patch-04 vs NA49 Data
χ^2/NDF = 18.7212 for geant4-10-01-patch-02 vs NA49 Data
χ^2/NDF = 62.2574 for geant4-10-02-beta-01 vs NA49 Data

Model Validation (IV)

- Capture and annihilation (Bertini, FTF, mu- capture)
  - Earlier problems with mu- capture (stuck jobs) is now fixed
  - No other major changes since 4.10.0
  - Regularly tested; results archived up to 4.10.1.ref08
- Gamma-Nuclear (Bertini)
  - Fairly stable through 4.10.1 development cycle
  - Regularly tested; results archived up to 4.10.1.ref08
- Light Ions (Binary light ion, INCL++, QMD)
  - Tested from time to time (test30)
  - Sporadic results in the archive - need to consolidate
- Precompound & de-excitaion
  - **Recent developments**
  - **Several presentations in the recent past (test30/IAEA)**
  - **Need to archive results**
- Radioactive Decays
  - **Recently picked up**
  - **Recent comprehensive report from the dedicated Workshop**
  - **Request from Dennis W. to start archiving results – need to converge**

Model Validation (V)

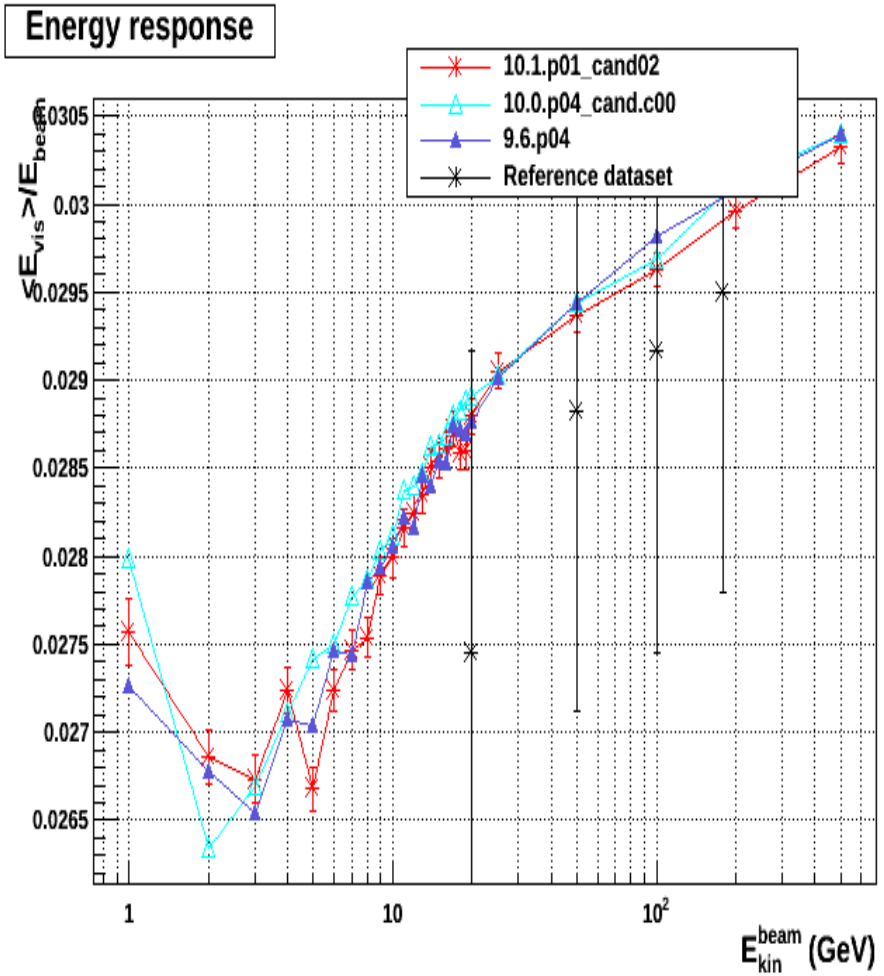
- Low energy neutrons (HP and LEND)
  - Periodic presentation but no archived results (?)
- Elastic scattering, coherent scattering
  - Very interesting results are presented from time to time but it definitely needs to be consolidated and archived
- Electro-nuclear dissociation, Wison abrasion, ablation:
  - No validation, no plots

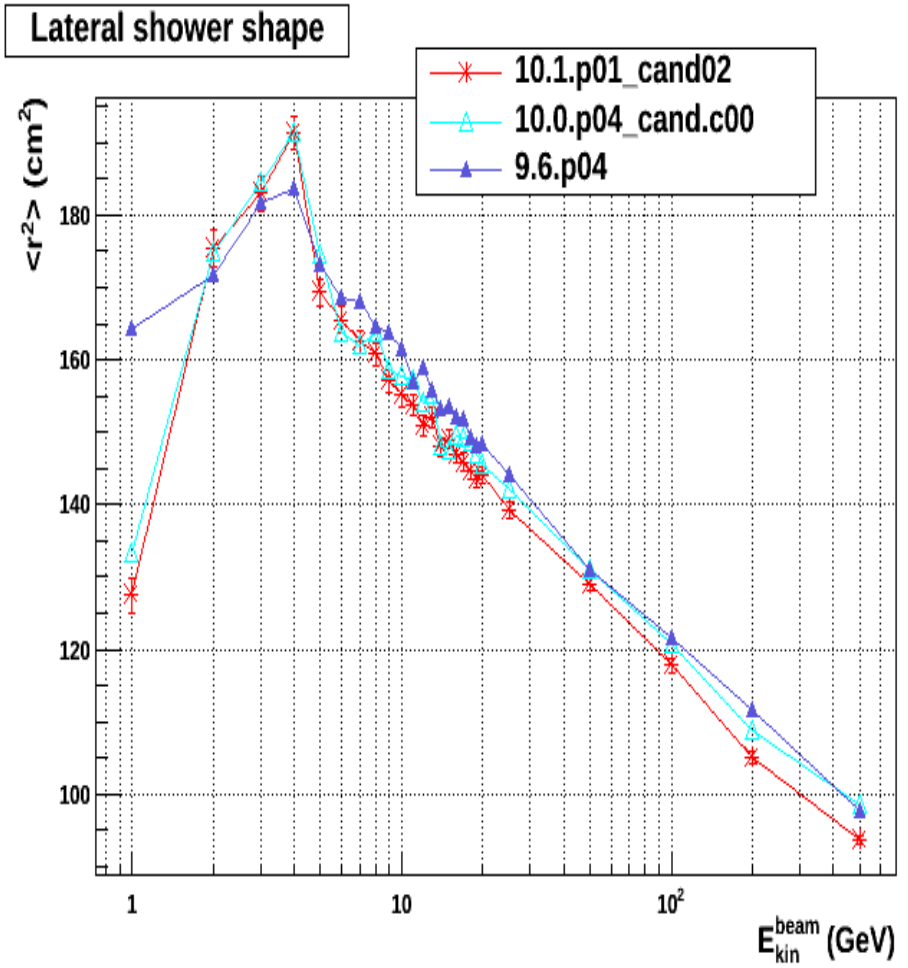
Physics Lists: Shower Shapes

- SimplifedCalo tests
  - Regularly tested, with the focus on the production physics lists
  - Highlights:
    - Improvements/development in FTF
    - Development of QGS
    - Various other (not necessarily in the hadronic domain)
- Feedback from CALICE
  - Extensive efforts through the users community
  - Recent invited report in Geant4 HAD group meeting
  - Talk by Alberto R. in Plenary-1 (9/28)
  - Detailed talk by Andrea D. in Parallel-7A (10/1)

Energy Response and Lateral Shower Shape

FTFP_BERT simulation of Iron-Scintillator calorimeteric module response to a pion-induced shower





Physics Lists: SATIF BNL Benchmark (thanks to T.Koi)
Focus on Shielding Studies

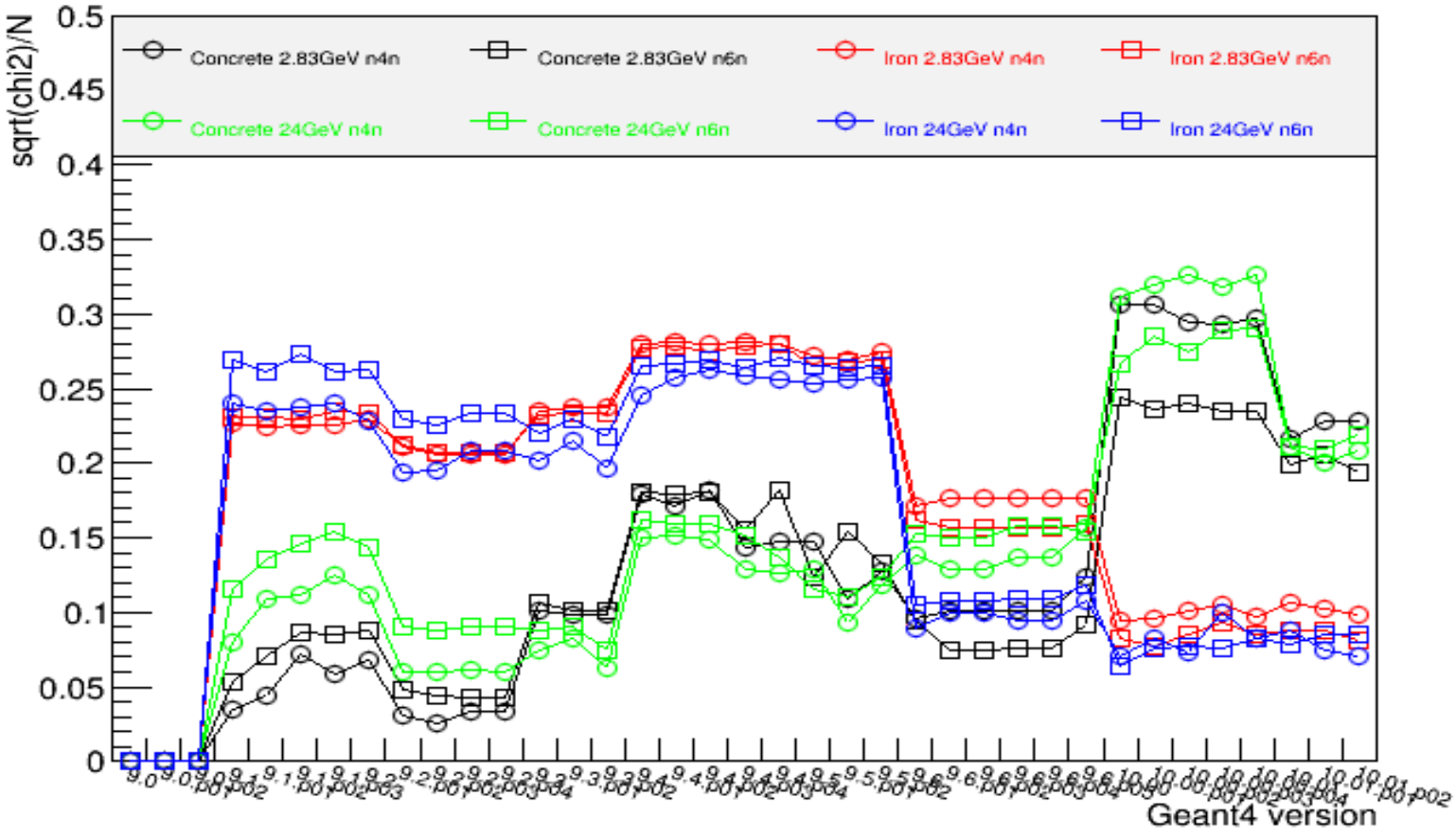
- Deep penetration experiments through steel and concrete shields for neutrons generated at mercury target irradiated by 2.83-and 24-GeV protons
- Benchmark problem
  - Accelerator (Organization): AGS (Brookhaven National Laboratory)
  - Projectile (Energy) : Proton (2.83 and 24 GeV)
  - Target Material : Mercury
  - Shielding Material : Steel and Concrete
    - implemented as Cylindrical Geometry for better simulation efficiency
  - Measured Quantities : Neutron Reaction Rate
    - 209Bi(n,4n)206Bi Threshold Energy of 22.6 MeV
    - 209Bi(n,6n)204Bi Threshold Energy of 38.1 MeV
    - Reaction rate of them are given as a function of neutron flux from SATIF organizer
    - A Possible reference of the data is N. Matsuda, et al., "Analyses of Benchmark Problems for the Shielding Design of High Intensity Proton Accelerator Facilities", JAEA-Technology 2008-030 (2008).
- **Ongoing efforts; regular results**

Physics Lists: SATIF Benchmark

χ^2 vs Geant4 version

Study is done for all reference physics list

FTFP_BERT



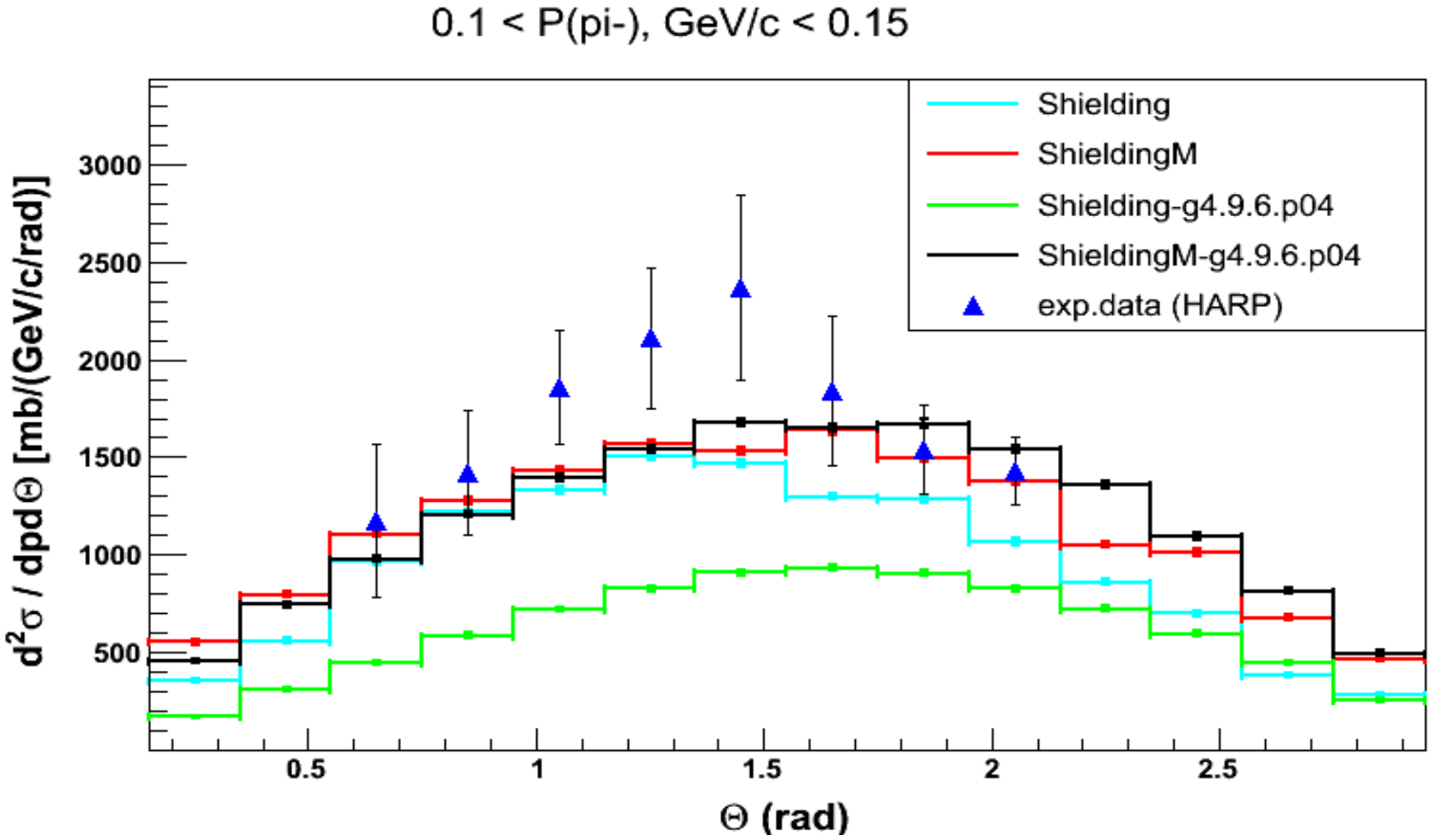
χ^2 is calculated between SATIF data and Geant4 predictions

Physics Lists: New Developments

- Test23 – "test bench" for **new** (special purpose) physics lists
  - NuBeam: INCL++ has been tested in the intermediate energy range for light targets (C, Be) towards potential use, but so far FTF results appear to be closer to the data (HARP)
  - Shielding(M): been monitored in the intermediate energy range for heavy target (Ta)
  - Results archived up to 4.10.ref08
- Test38 added for newly introduced configurable physics lists

Evolution of Shielding and ShieldingM Physics Lists between 4.9.6.p04 and 4.10.1.p02

8GeV/c p+Ta -> π^-; data from HARP

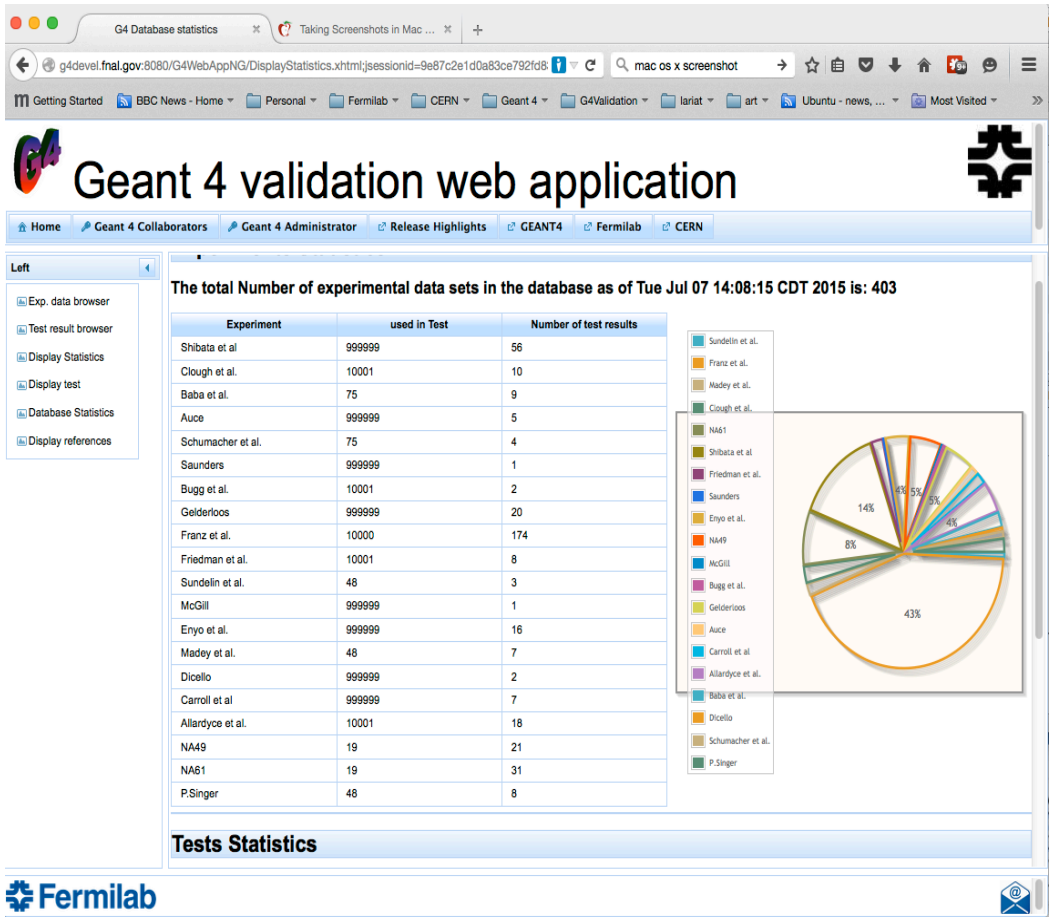


Validation Repository

For details, see talks by Hans W. in Plenary-3 and Parallel-5A

Plenty of upgrades

- Improved and expanded features of the Web Application
- Largely expanded collection of exp.data
- Steadily growing collection of simulated results



Summary

- Validation round are performed on the regular basis:
  - Major releases
  - Development releases
- Most of the hadronic models/processes are covered
  - Previously “orphan” models/processes are being incorporated in the validation efforts (slowly but surely)
- Feedback is regularly provided to the model development processes
  - Performance of FTF has largely improved at high energies
  - Ongoing FTF development aims improvements at intermediate energies
  - Development of QGS is being closely monitored
- Some models/processes are still not covered
- Validation of physics lists is a very important part of the efforts
- Large amount of results archived
  - Results from major release are available to users
- Major upgrade in the Validation Repository
- More additions and improvements to the validation suite are in the plans