Hadronic Validation Highlights

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Geant4 Collaboration Meeting
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Outline

- Trends in thin target validation Validation (FTF, QGS, BERT)
  - high energy models
  - cascade models
- The need for thick target validation
  - SATIF neutron data
  - TARC
- Validation Suite
  - survey of frequency
  - DoSSiER
  - suggestions for future

Validation Team

- Thanks to the people doing the work
  - Julia Yarba
  - Hans Wenzel
  - Vladimir Uzhinsky
  - Alberto Ribon
  - Tatsumi Koi
  - Vladimir Ivantchenko
  - Anton Ivantchenko
  - Vladimir Grichine
  - Krzysztof Genser
  - Andrea Dotti
  - Sunanda Banerjee

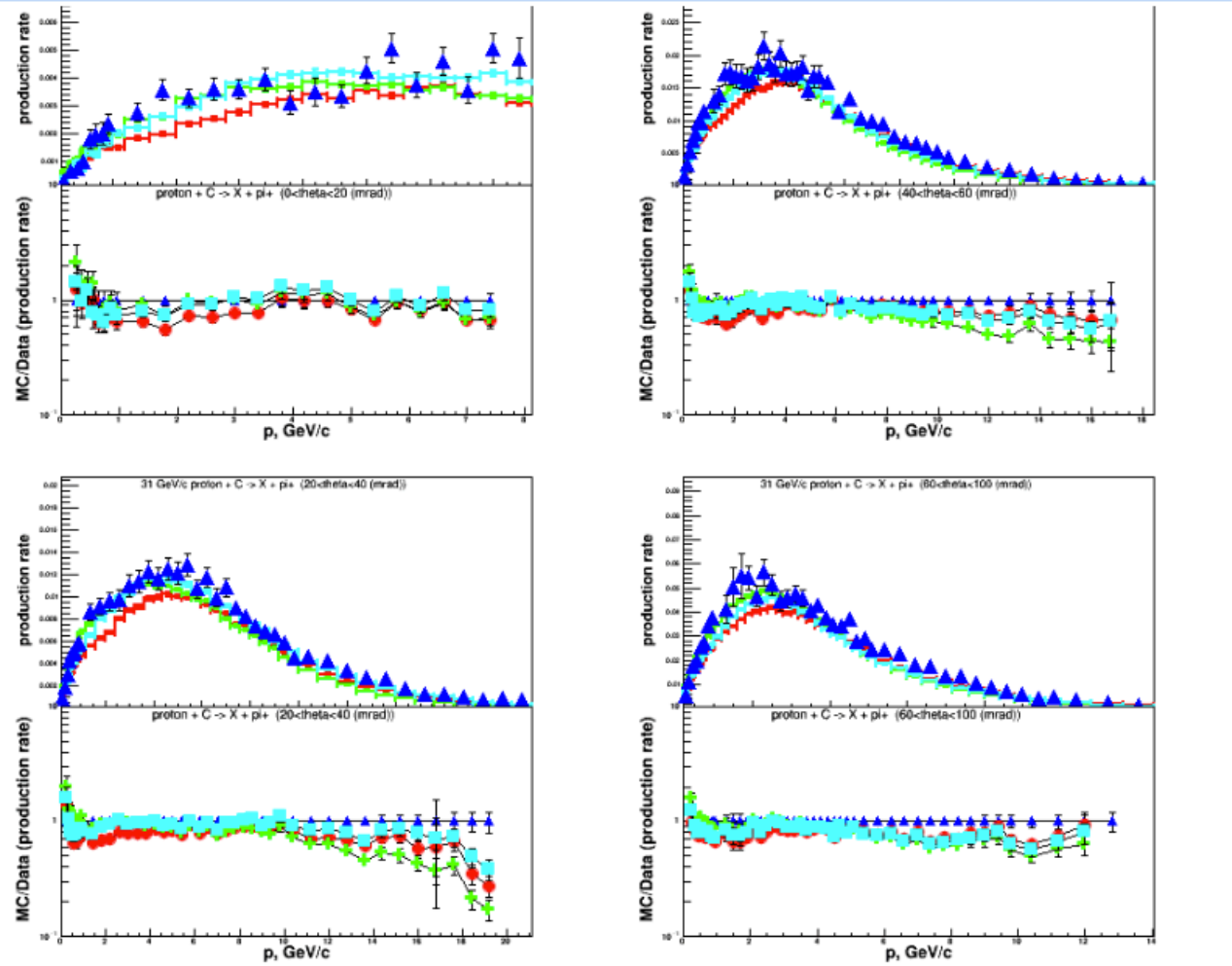
Trends: FTF and QGS

- FTF comparison to data stable since 10.1
  - improved since 9.6
  - not much improvement since 10.1
  - some worsening of agreement during tuning then return to stable results → has all that can be done been done?

- Work on QGS has shown up in validation
  - worsening agreement with data (result of tuning?)
  - still too early to say where this is going, but must be watched

- In both cases (FTF and QGS):
  - too much reliance on p+p and p+C data

Test19 Validation Results (FTFP, 31 GeV)

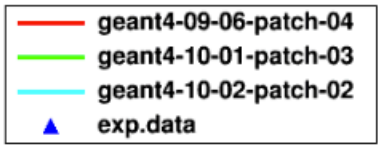


MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins

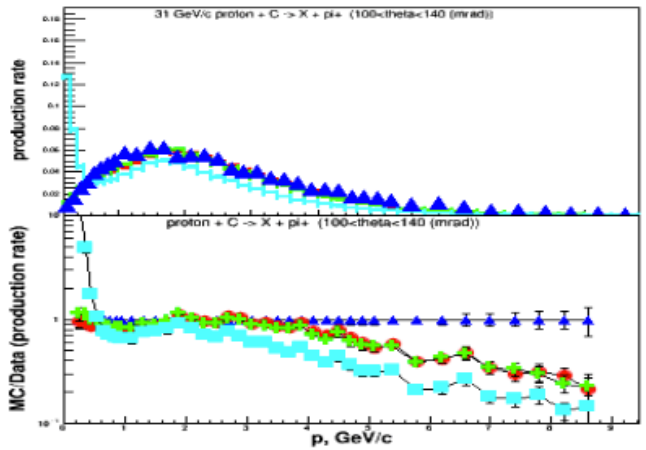
χ^2/NDF = 7.78867 for geant4-09-06-patch-04 vs NA61 Data

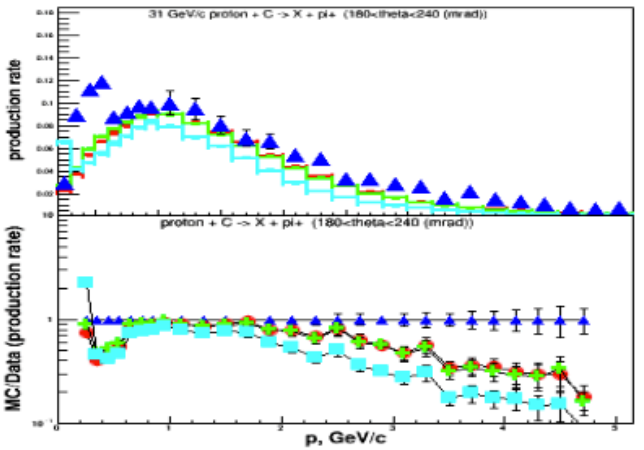
χ^2/NDF = 5.13371 for geant4-10-01-patch-03 vs NA61 Data

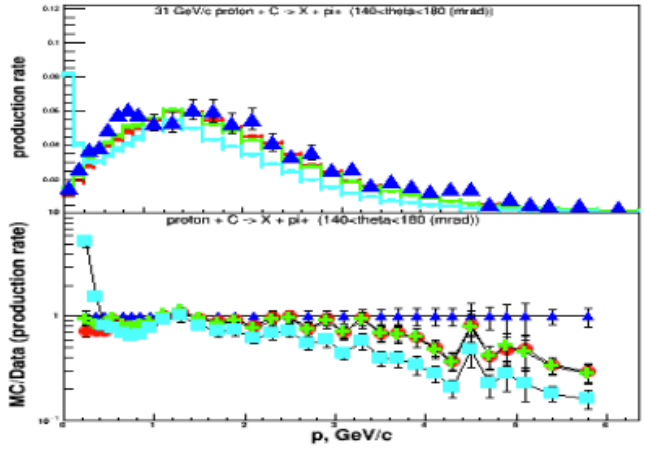
χ^2/NDF = 5.38571 for geant4-10-02-patch-02 vs NA61 Data

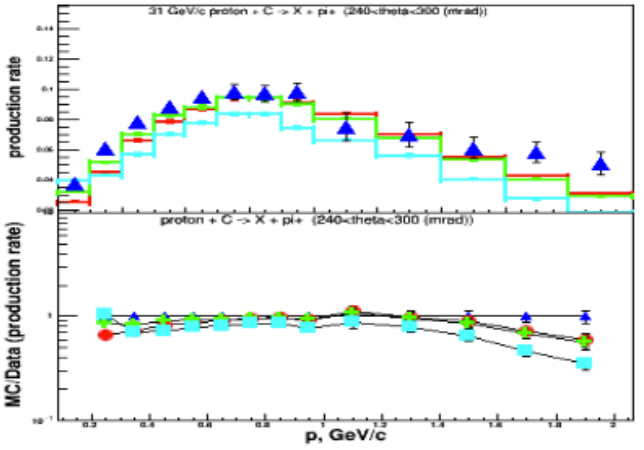


Test19 Validation Results (QGSP, 31 GeV)

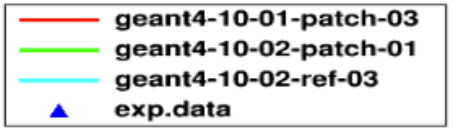








MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
χ^2/NDF = 35.1526 for geant4-10-01-patch-03 vs NA61 Data
χ^2/NDF = 35.2945 for geant4-10-02-patch-01 vs NA61 Data
χ^2/NDF = 558.146 for geant4-10-02-ref-03 vs NA61 Data

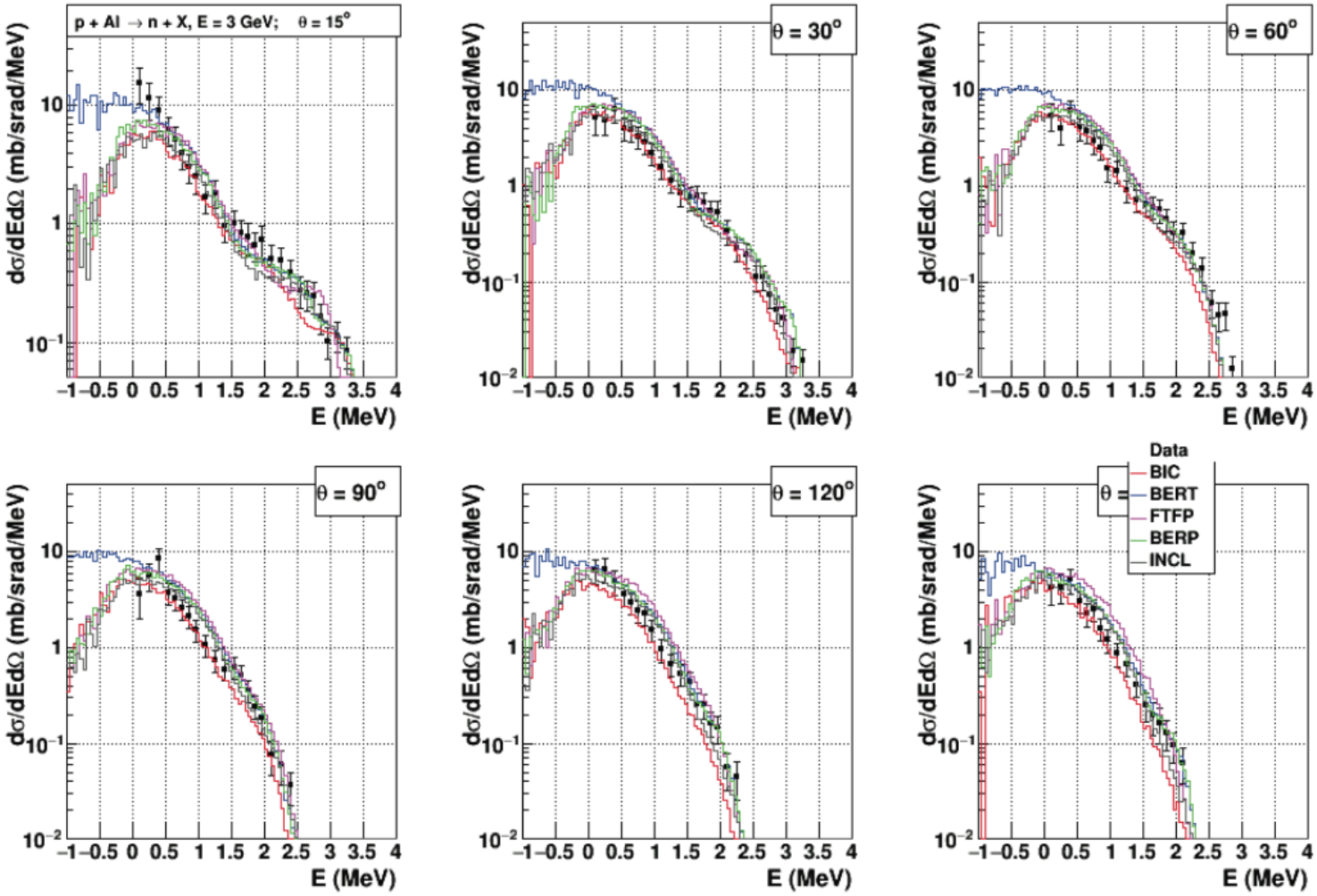


Trends: Cascade Models

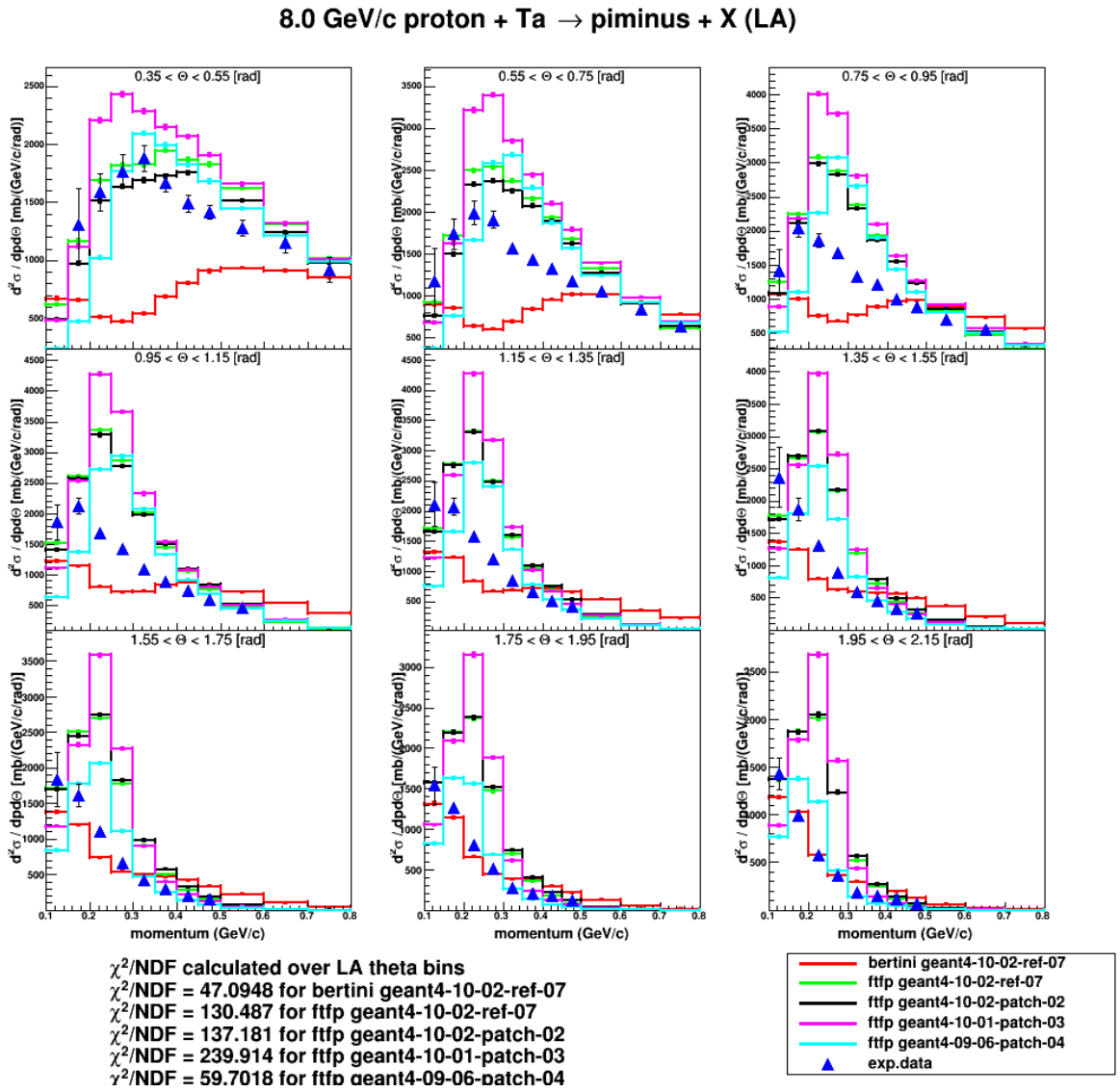
- Bertini, Binary, INCL++
  - all stable for several releases
- Highlighted problems
  - consistent overproduction by Bertini of low energy neutron flux
  - Bertini also under-produces d, t, 3He, alpha
  - gamma-nuclear validation based on too few data sets (3 below 700 MeV, 1 at 5 GeV)
- FTF in cascade range (few GeV)
  - consistent overproduction of neutrons at medium energies
  - favorable or superior comparisons with Bertini at 8 GeV

Test30 Validation Results (V. Ivantchenko)

BERT, BERP, BIC, FTFP, INCL



BERT vs. FTF at 8 GeV on Ta (through 10.2 ref07)



BERT vs. FTF at 8 GeV: General Conclusions

- Differences in FTF are modest between 10.2 p02 and 10.2 ref07
  - but non-negligible for pion-induced reactions

- At large angles (in HARP Ta data) FTF better than BERT
  - BERT better than FTF at backward angles
  - FTF better almost everywhere else
  - same is true for lighter elements

- Preference not so clear for p/n production
  - FTF and BERT comparable for medium to light nuclei
  - FTF especially good for Cu
  - BERT better for Pb, U

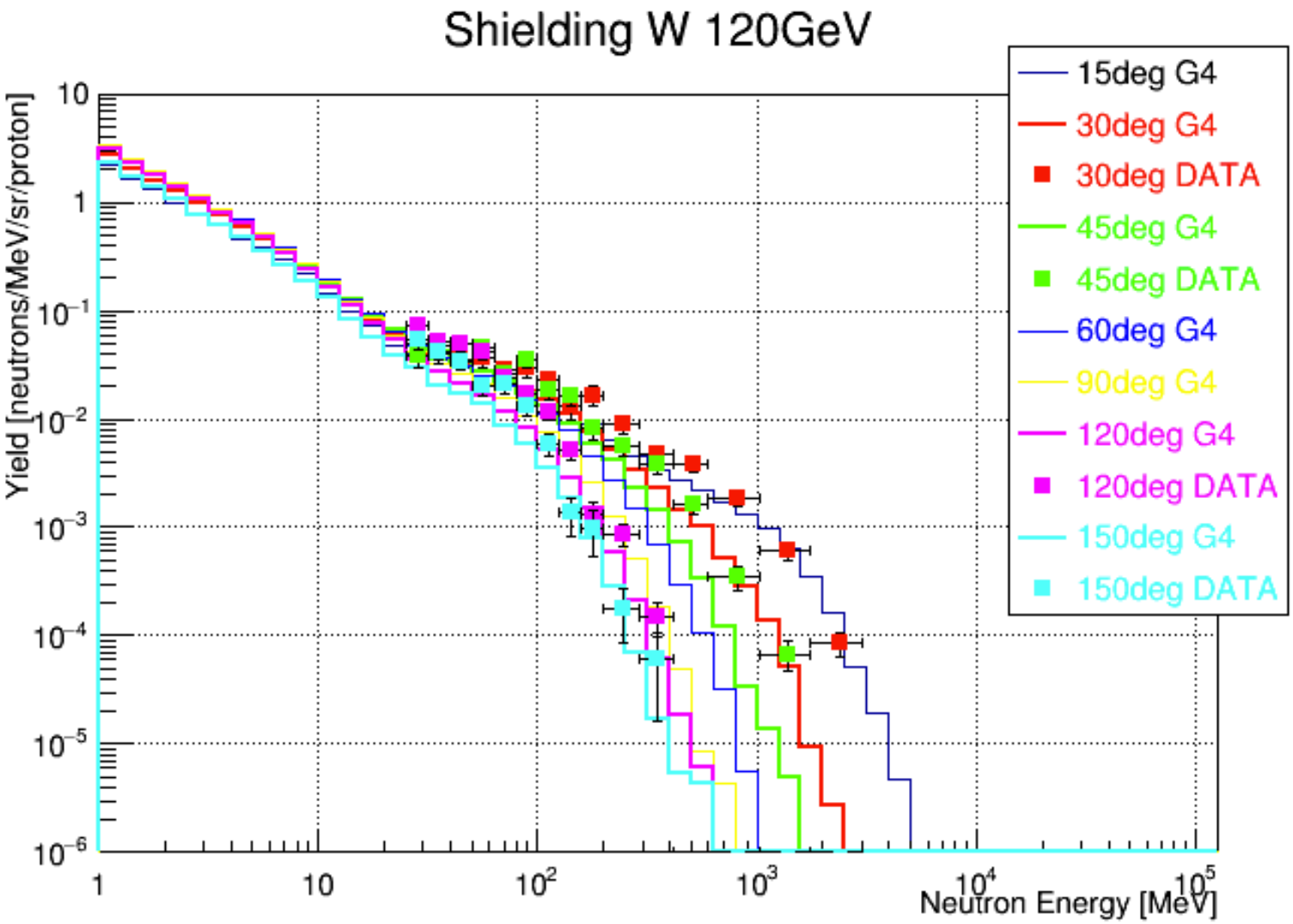
Thick Target Validation

- The bulk of our non-calorimeter validation relies on thin-target tests
  - closest to single interaction situation
  - fewer experiment- and target-related issues

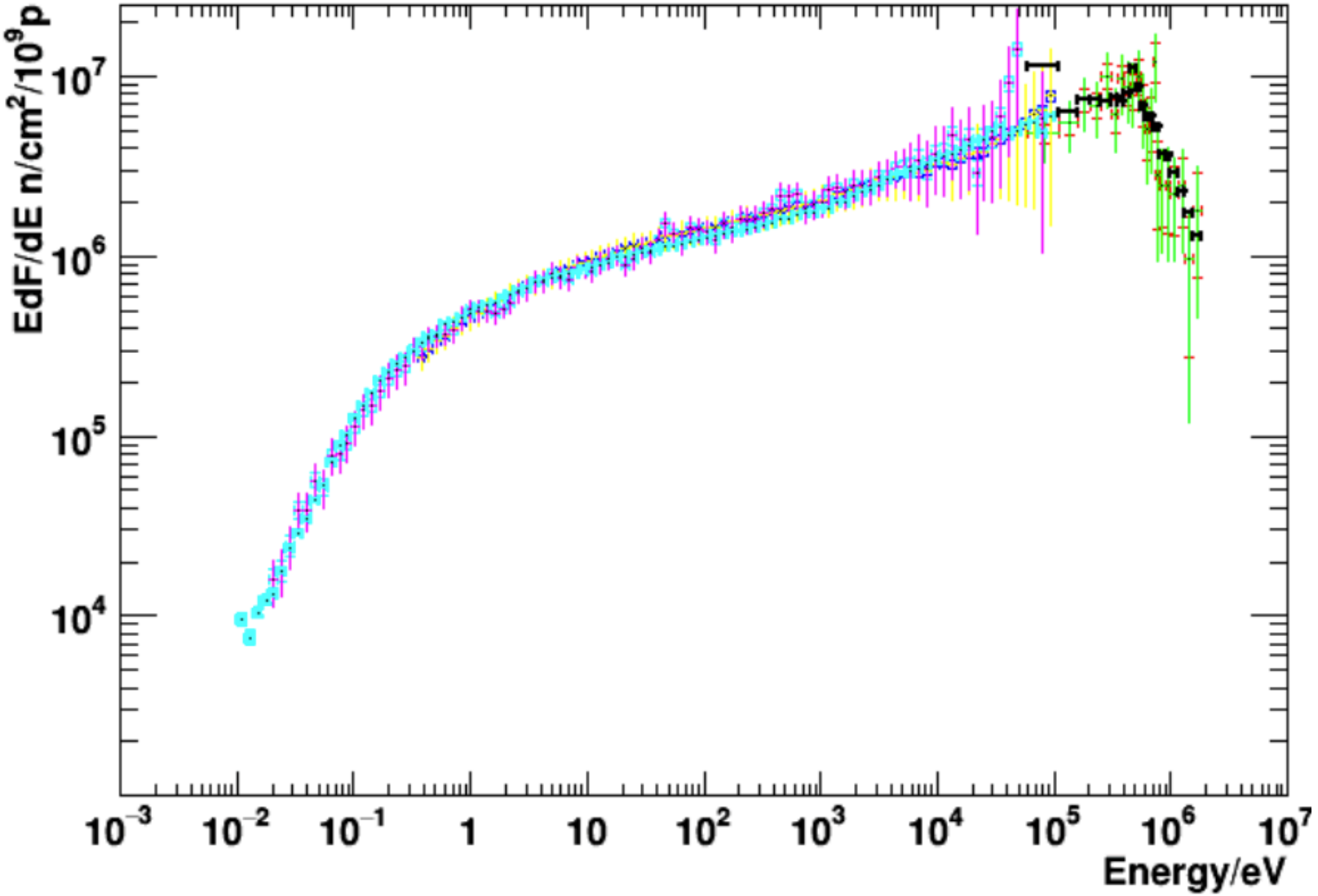
- However, this biases our decisions on:
  - model tuning
  - model choice in physics lists

- Add more thick target validation
  - may provide sensitivity to small angle scattering that thin target data cannot
  - also to validity of cross sections

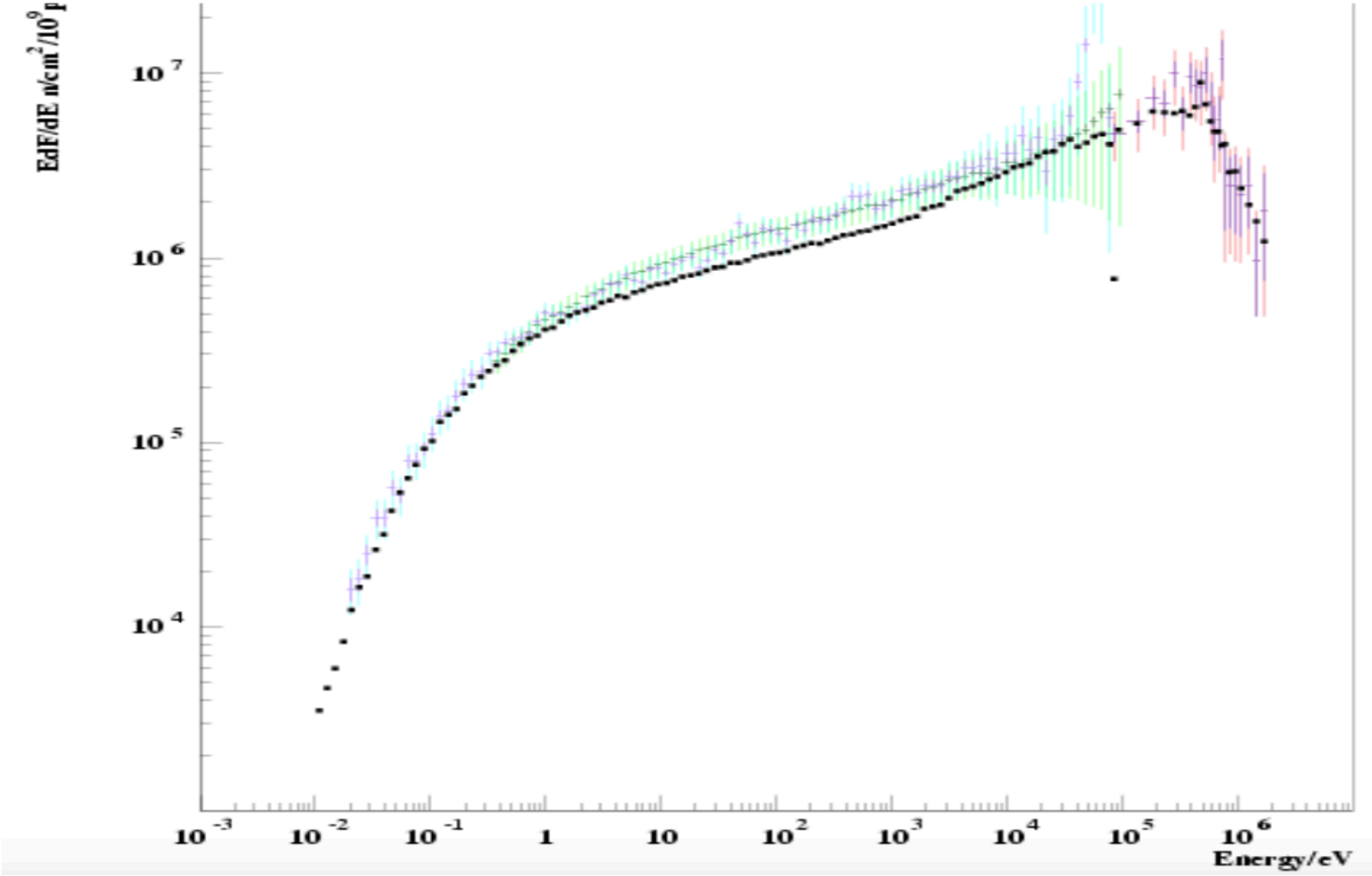
Neutron Validation Results (FTFP)



TARC: 2.5 GeV/c p + Pb → n fluence (Binary 2015)



TARC: 2.5 GeV/c p + Pb → n fluence (Binary 2008)



Hadronic Validation Test Survey

- Currently in the validation database
  - data from 22 separate experiments
  - 13 hadronic-related test categories
  - 415 data sets
  - 10642 simulation test results
  - more tests and experiment data to come
  - goal: updates with every release

- It's a big job
  - developer/tester must generate and submit plots
  - evaluation, too
- How are we doing?

Survey of Validation Frequency

Test name	Description	Last update	Last update added to repository
test19	high E models	10.2 p02	10.2 p02
test22	FTF model	9.6 ?	9.6 ref04
test23	physics lists	10.3 beta	10.3 beta
test30	HARP data	10.3 beta	9.6 ref00
test35	HARP and PS214	10.2	9.6 ref00
test45	thick targets	9.4 ?	9.4 ref00
test47	intermediate E	10.2 p02	10.2 p02
test48	stopping	10.2 p02	10.2 p02
test75	gamma-nuclear	10.2 p02	10.2 p02
HadrIon	ions, thick tgts	9.4 ?	9.4 ref00
IAEA	spallation	9.6 ?	9.6 ref00
Testfragm	ions, thin tgts	9.6 ?	9.6 ref00
simplifiedCalo	shower shapes	10.3 beta	9.6 p02

Results of Survey

- 5 tests done and updated regularly
- 3 tests done regularly, but results not added to DB
  - reasons cited: performing comparison tests, making plots is a lot of work, uploading images of test results is not easy
- 5 tests not done or updated for some time
  - in most of these cases developer of test no longer in Geant4
- How can this be made easier?
  - see proposals below

Proposed Improvements

- One of the current problems is with uploading images
  - validator must
    - run test
    - make comparison plot
    - upload image of plot
    - repeat N times per release

- Try instead to access data directly in DB and let software run tests, make plots
  - work on this is underway
  - see parallel session 5A on DoSSiER

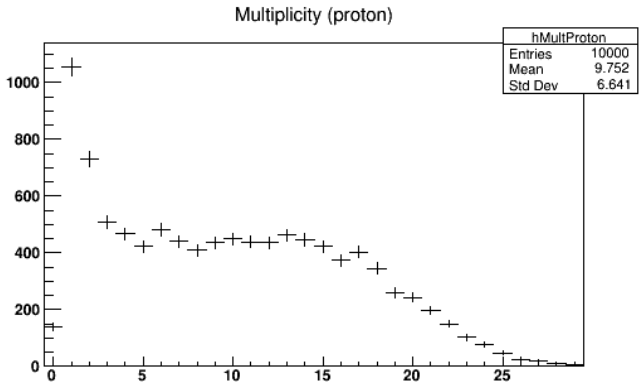
Proposed Improvements

- Another possibility
  - Application being developed to run single interactions (first prototype discussed at FNAL meeting last year)
  - Same thing used by developers to test models
  - But instead using a universal application (e.g. process independent) that uses the process as configured in physics list

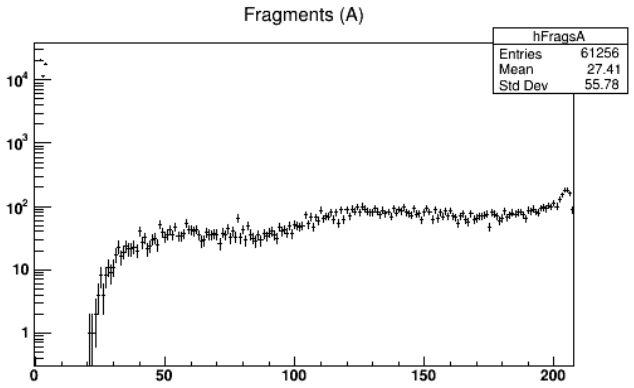
  - **Output**: (total) cross-section; properties of secondaries (spectra, angular distributions, multiplicities…). Comparison with data (currently Bertini validation suite; Omega Exp pi0 production, HARP pi production)

    Validation macros/plots ready for: Hadronic Inelastic and Elastic, n-Capture, Gamma-nuclear
  - Expect to be in production (DoSSiER interface) by 10.3

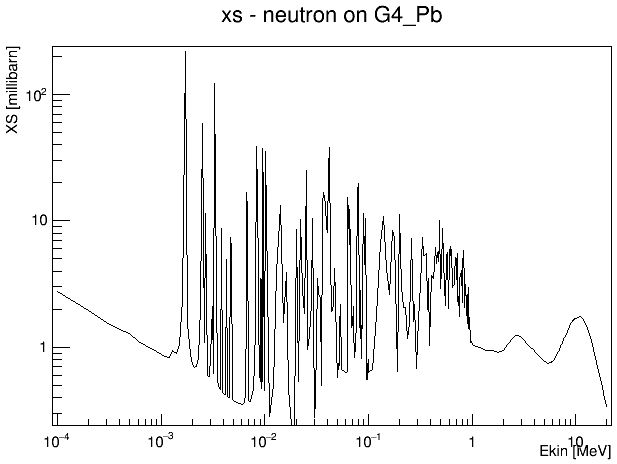
Output Examples

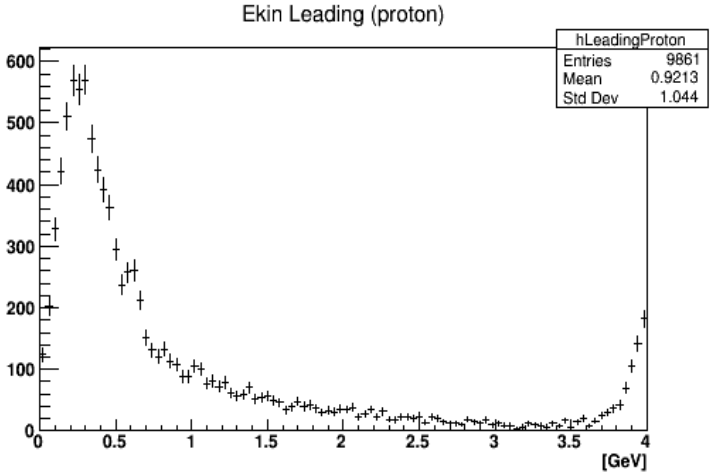


n-Capture on G4_Pb
As simulated in FTFP_BERT



p+G4_Pb@4GeV
As simulated in FTFP_BERT





Recommendations

- High energy models
  - with changes continuing in both FTF and QGS, need to expand validation basis at high energy end
    - add existing data at 100 GeV
  - we currently judge performance mainly on p+p and p+C data
    - use data sets with other projectiles, targets

- More thick target tests
  - we have some of these but not a lot → our decisions more heavily influenced by thin target comparisons
  - add SATIF neutron data to regular tests

- Global comparison is important for valid conclusions

Future Development

- More thick target tests
  - SATIF, neutrons, others
- Gamma-nuclear
  - lots of data to add:
    - 1, 2, 3, 4.5 GeV for C, Al, Cu, Pb
  - currently only 0.3, 0.668, 0.68 and 5 GeV
  - becoming important for “heavy photon” searches
- Radioactive decay
  - several tests each for α, β^-, β^+, EC and IT
  - currently none
  - important for medical, space