Parallel 4A (Hadronic): Validation

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16th Geant4 Collaboration Meeting

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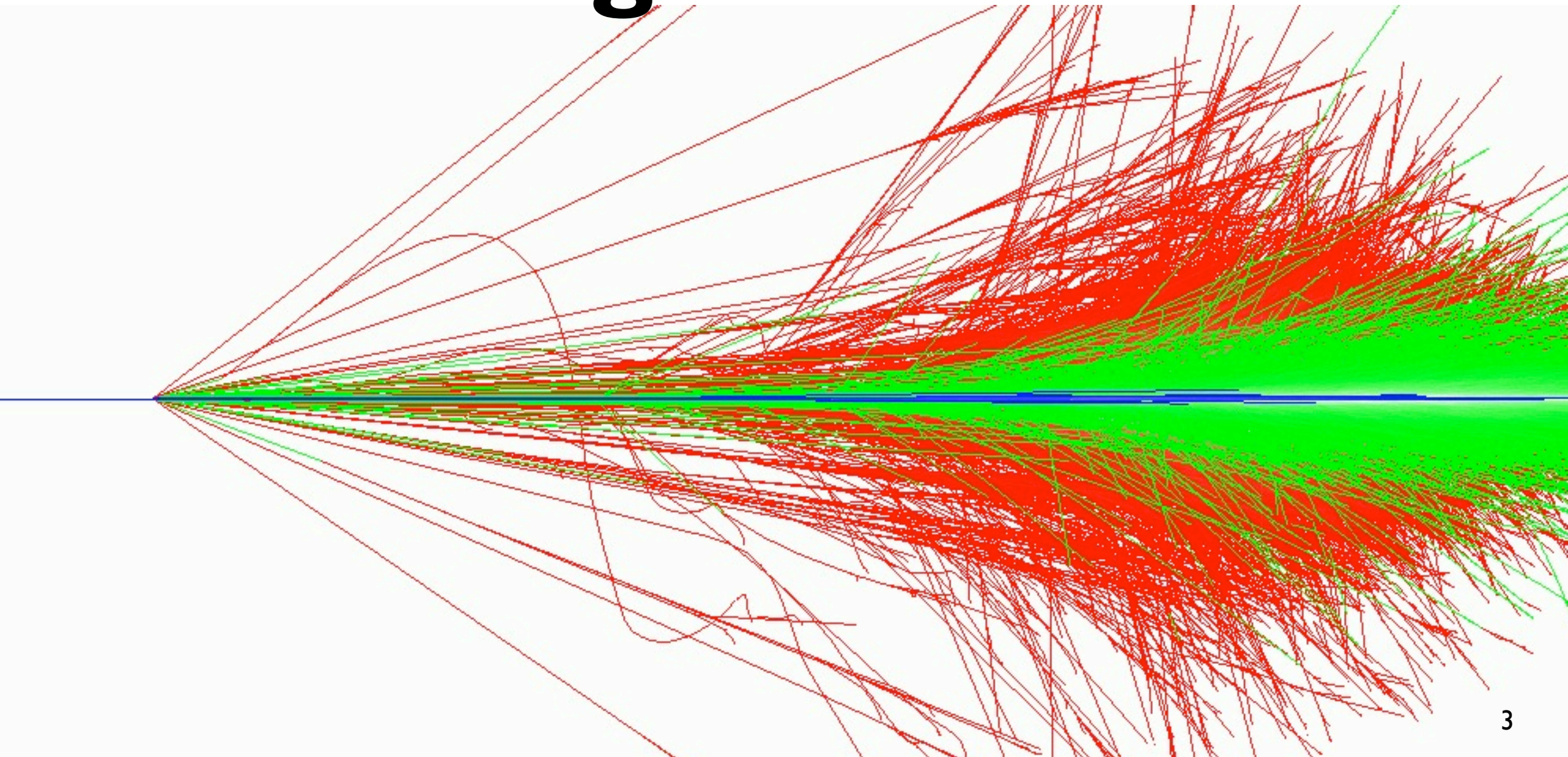
Validation Session

- 6 Talks covering new / updated fields of the validation of hadronic physics
- Areas covered:
  - High Energy Physics
  - Intermediate and Low-E Models
  - Ion Interactions Physics
- New Validation data-set at high E (10-100 GeV): extends region not perfectly covered

- **Main conclusions shown here**
- See Also Plenary 8; Parallel 5A; Plenary 3; Plenary 4

Thin-target Validation



- Tested new interface in Bertini to G4Precompound model (to possibly remove internal model)
  - Including rigorous checking of E/p conservation
- Tested forward pion production

- Since 9.5.beta new Low-E neutron libraries are available
  - New model (LEND) is being tested
  - "New" user of these models: ATLAS (cavern background)
  - Comparison with original DB data and (initial attempt) FLUKA

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Summary

- Results for ref08 show that there is no major bugs in cross section after migration to new design
- Bertini+Preco is added to test30 and working fine
  - Reduction of low-energy proton/neutron production
  - There are issues with energy balance
  - CPU is acceptable
- There are underestimation of forward pion production practically in all models
  - Re-scattering simulation should be improved
  - Shower shape may be affected
- Proton production by QGS is wrong below 15 GeV
  - QGSP_FTFP_BERT and FTFP_BERT Physics Lists seems to be more precise then QGSP_BERT

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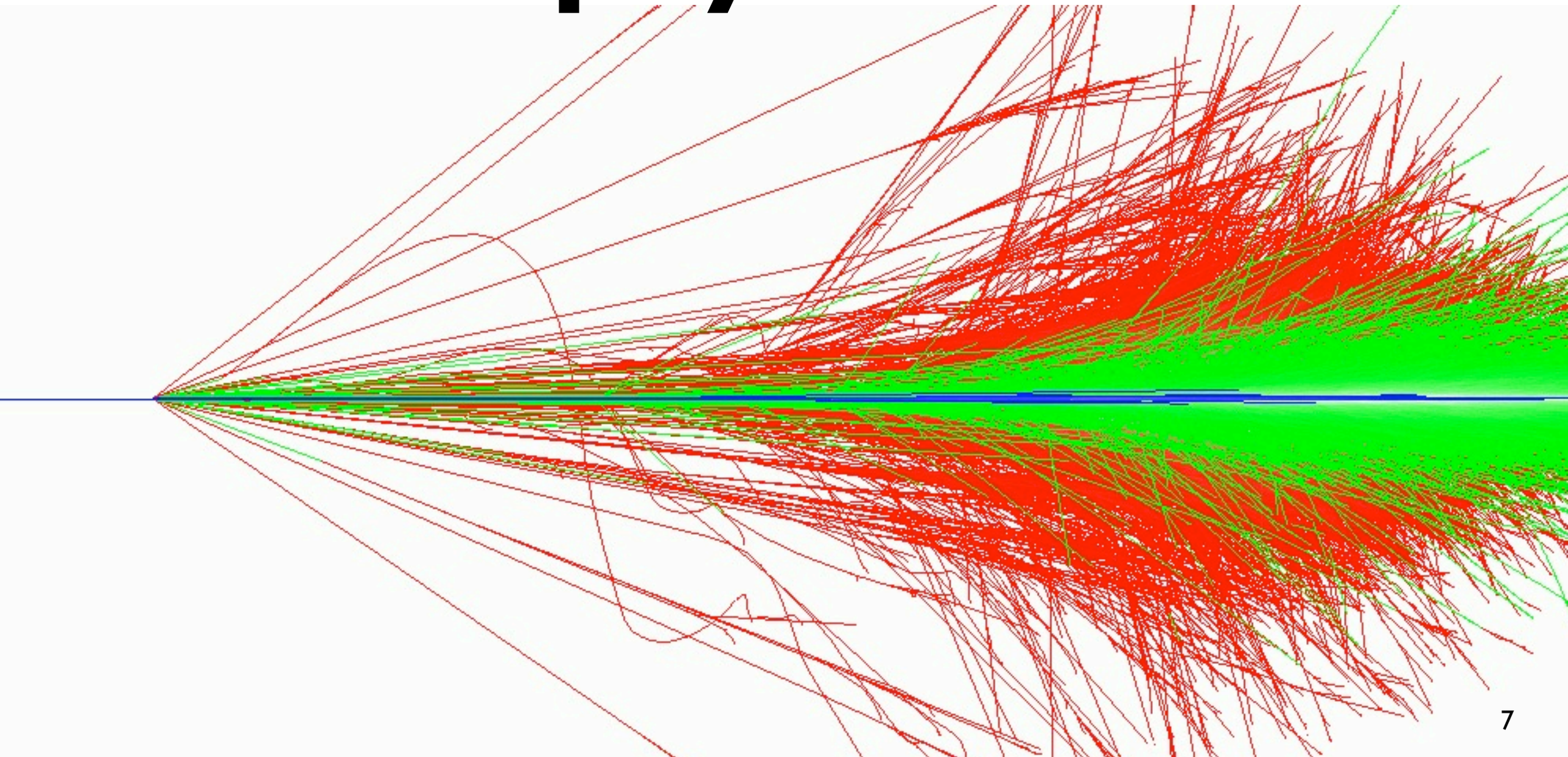
Summary

- In generalized comparison between HP and LEND
  - Good agreements, but noticeable difference in the shape and position of thermaliztion peak
  - Above difference also seen in the comparison to the other simulation.
- In Atlas cavern background comparison
  - "G4NEUTRONHP_NEGLECT_DOPPLER" option boosts the calculation speed with negligible impact to the results
  - "QGSP_BERT_HP" gives the most close result to other simulation
  - Doing re-calculation with the latest version of Geant4 and data libraries (NDL3.15, LEND:ENDFVII.0) are preferred.
- In Single interaction level comparison
  - Generally good agreements to parents ENDF data
  - Several important issues, those are not only simple bugs but also related to the limitation of data driven model are also extracted by this level comparison

Ion-Ion physics



- Extending Ion/Ion validation
- Main user: Space Domain, HEP (NA61/SHINE requirements, ALICE)

- **Four tests currently used for ion/ion validation:**
  - IAEA benchmarks (isotope production 0.5-2 GeV/u)
  - Neutron production (thin target) 10-600 MeV/u
  - Neutron production (thick target) 20-800 MeV/u
  - Fragmentation and cross-sections 1-200 GeV/u

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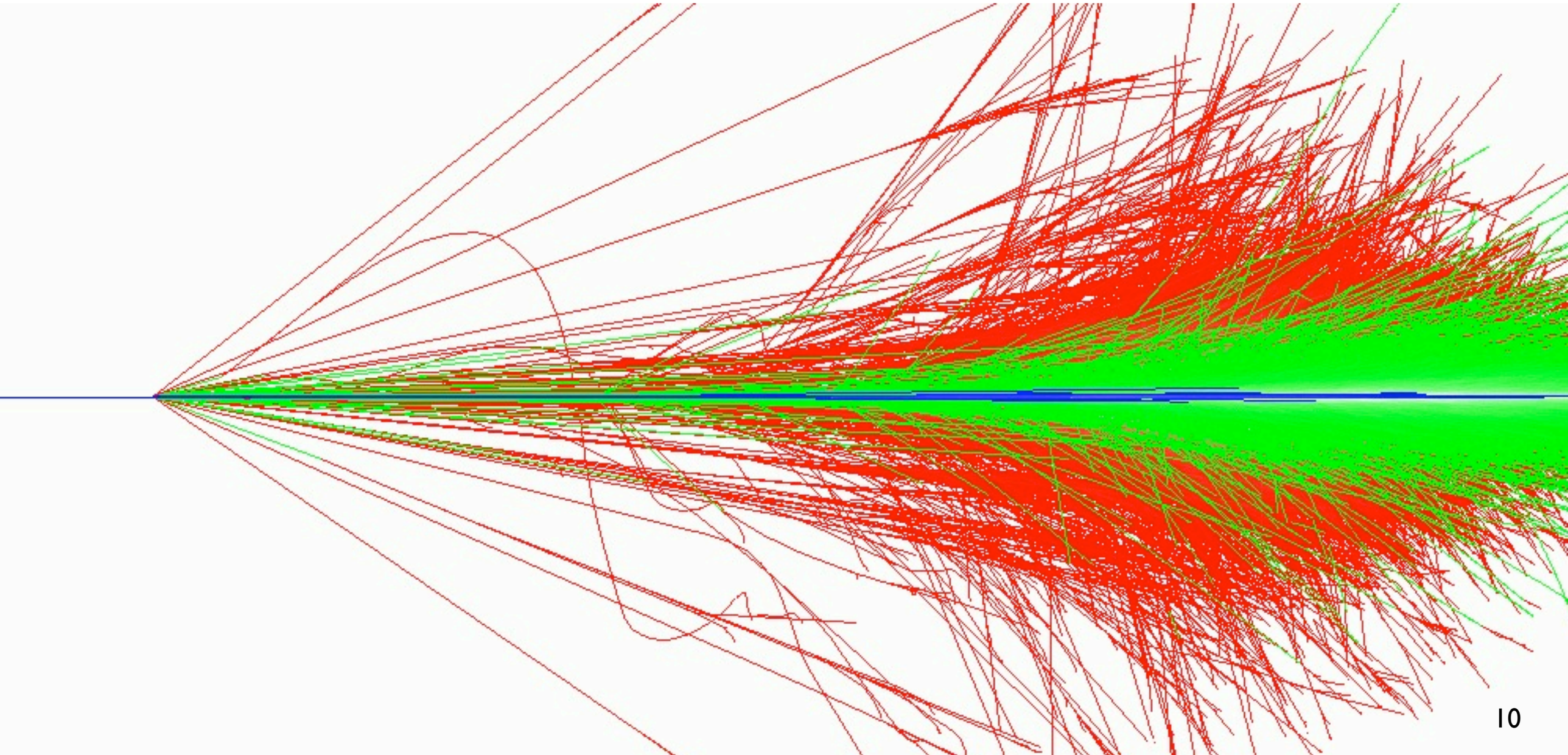
Conclusions

- Testing suite for Ion/Ion interaction validation significantly extended
  - neutron production below 1 GeV/u is available
  - fragmentation XS at low and high energies

- There are problems in Geant4 models for Ion/Ion interactions
  - At low energy (>100 MeV/u) in all models
  - At high energy – FTF cannot provide fragmentation
  - DPMJET-II.5 has limitation (projectile Z < 27)

- Thick target benchmark proposed by IAEA some time ago show problems in interpretation of data at forward angles

New HE benchmark



- New data source is now being used
  - MIPP Experiment at FNAL
- HE proton beams (58, 85, 120 GeV) on targets
- Neutron production (cross-sections and momentum spectrum) measurements

Observations

- New set of thin target data is now available for testing the models for hadronic interactions at high energies.
- None of the existing models (among these four: QGSP, FTFP, CHIPS, HEP) can describe the experimental data well.
- These models match with the data in some regions and deviate significantly in other regions.
- So simulation of hadronic interactions within GEANT4 still needs improvement.

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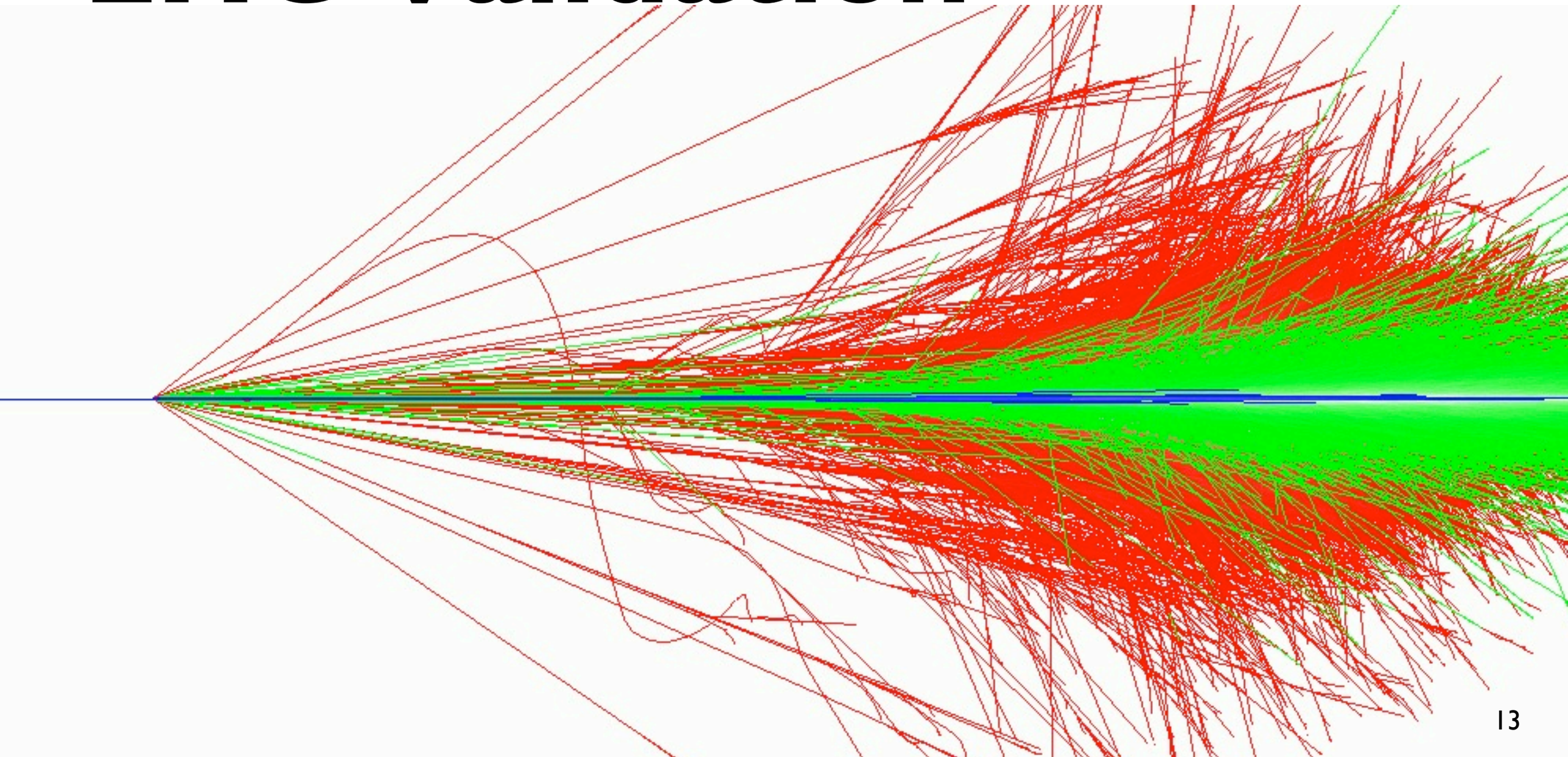
LHC Validation



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Summary & conclusions

- Up to now, overall satisfactory behavior of Geant4 simulations with respect to **LHC collision data**. **Test-beams data** are still providing more stringent validation for Geant4 simulations, especially for hadronic showers
- Need to keep a balance between **stability** and **new features/improvements** between Geant4 releases
- Focus on a **few physics lists**, relying on a **few key models**
- Energy response and energy resolution are the two most important observables for LHC physics, followed by longitudinal and lateral shower profiles. For ILC/CALICE the top observable is the lateral shower profile
- Growing attention to “other particles”, besides the traditional pions and protons

Conclusions

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- **Smoothness** issue resolved with FTF based lists
- **Response** is higher of few %
  - FTFP_BERT is higher in 10-20 GeV region w.r.t. QGSP_BERT (good since no LEP is used there)
    - However this brings too much up jet-response in ATLAS: (high-E jets are composed of low-E particles!). Same behaviour observed for hadronic tau-decays (private communication)
  - Scintillator based calorimeters are challenging: need to further study role neutron elastic scattering
- **Resolution** is too good (should focus on π^0 production validation)
- Forward physics (q.e., diffraction) needs attention
- Low-E neutrons play an important role for lateral profile