

Linear Collider Physics List: An Update

Linear Collider Simulation Workshop
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Outline

- Review of linear collider physics list
- Update of constituent models
- Tips for use
- Validation
- Plans
- Physics list web page

Physics List Review

- SLAC supports the Geant4 linear collider physics list LCPHYS
- It is available for download at:
 - `cvs -d :pserver:anonymous@cvs.freehep.org:/cvs/lcd co LCPhys`
- Newest version (V00-00-01) recently released and tested against Geant4 7.0
- Now in use by several people
 - `feedback appreciated`
 - `problems: dwright@slac.stanford.edu`

Physics List Review (EM, decay)

- All applicable standard EM processes are used
 - multiple scattering, ionization, bremsstrahlung, e^+/e^- pair production, Compton scattering, photo-electric effect, annihilation, gamma-nuclear, electro-nuclear
- One decay process process handles all long-lived decays

Physics List Review (hadronic)

- For incident (π , K, p, n) energies of ~20 GeV to 100 TeV:
 - (QGSP) Quark Gluon String + PRE (Precompound) models
- For all others (Λ , Σ , p-bar, ...) with energies 20 GeV to 100 TeV:
 - HEP (High Energy Parameterized model)
- For all particles, except light ions, with energies between 9.5 GeV and 25 GeV
 - LEP (Low Energy Parameterized model)

Physics List Review (hadronic)

- For incident π , p , n with energies < 10 GeV
 - Bertini cascade model
- For K , p -bar, n -bar, ... with energies < 10 GeV
 - LEP
- At rest processes for π^- , K^- absorption, p -bar, n -bar annihilation
- Neutron capture, neutron-induced fission
- Elastic hadron-nucleus scattering (same model for all hadrons)
- For light ions (d , t , ^3He , α)
 - Elastic scattering
 - LEP model for inelastic (d , t , α)

Updates of Constituent Models

- HEP (High Energy Parameterized model)
 - phi asymmetry in pion secondaries angular distribution fixed
- G4GammaNuclearReaction
 - recently (last week) added to physics list for gammas < 3.5 GeV
 - between 3 and 20 GeV use Quark-Gluon String with Precompound
- G4ElectroNuclearReaction
 - also recently added for electrons and positrons at all energies
- G4ionIonisation
 - model extended down to ions of charge 2
 - replaces G4hIonisation for α , ${}^3\text{He}$

Tips for Use (1)

- Physics list was written to be as readable and open as possible
 - It is easy to change
 - Caveat: the existing physics list is our guess at the best physics for this application – changes may have un-intended consequences
 - Please communicate beneficial changes to us
- Do not mix standard and low energy EM processes
 - It' possible but not recommended
- Always use multiple scattering, ionization and bremsstrahlung processes together and in the proper order

Tips for Use (2)

- Usually, two or more hadronic models are patched together to cover the entire energy range
 - The energy boundary between models is effectively a tuning parameter
 - Take care not to push models too far
 - EM models – no worries
 - Hadron elastic scattering – no worries
 - LEP model: 0 – 50 GeV
 - HEP model: 20 GeV – 10 TeV
 - Bertini cascade: 0 – 12 GeV
 - QGSP: 12 GeV – 100 TeV
 - Make sure there is a little overlap in energy ranges

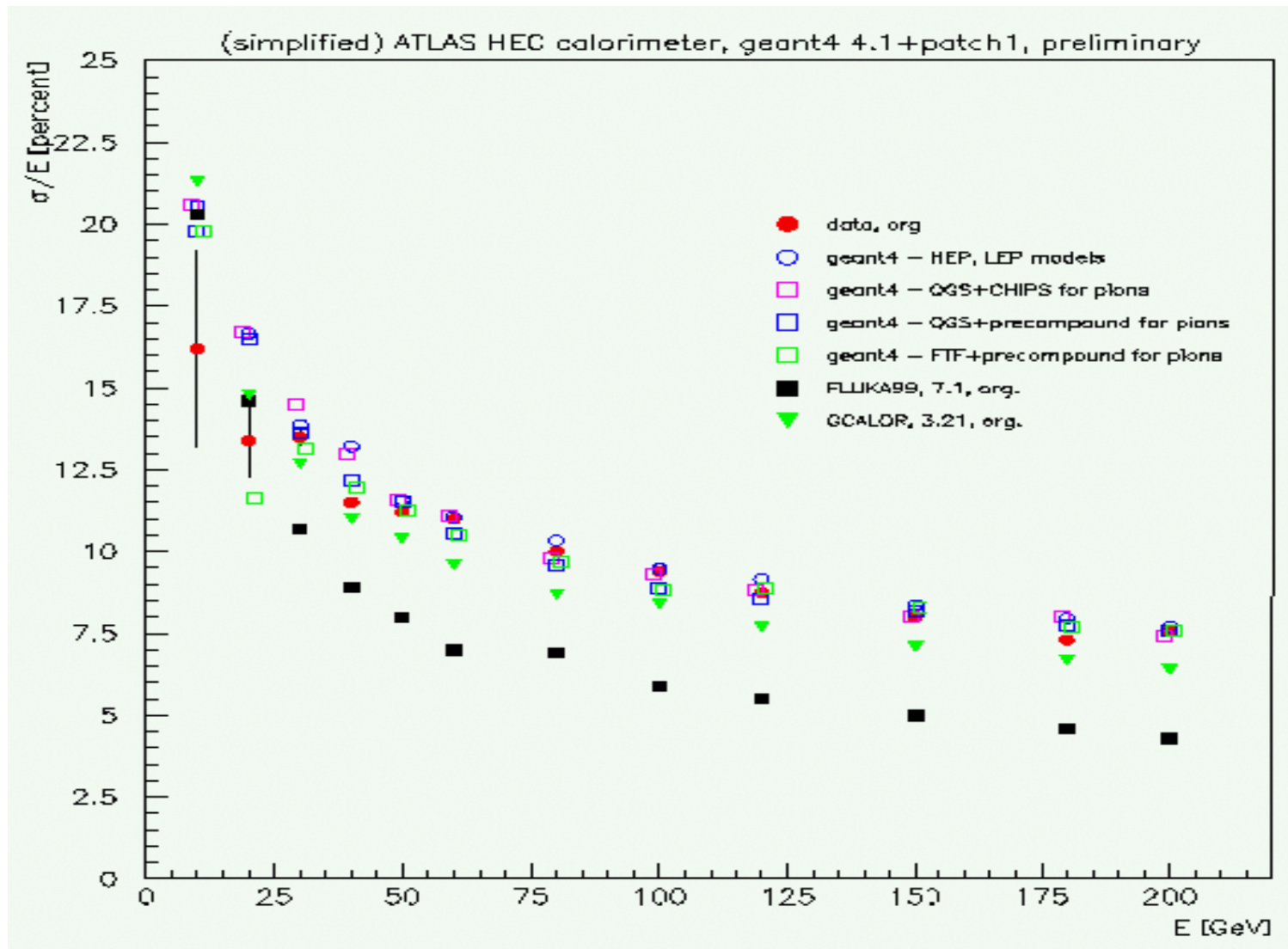
Tips for Use (3)

- The LEP and HEP models are your friends
 - Can be used for all particles
- For advanced users: model swapping
 - The Binary cascade model can be substituted for the Bertini
 - Good over roughly same energy range
 - The FTF model can be substituted for the QGS model
 - Requires some knowledge of the Geant4 hadronic framework
 - Good from 10 GeV to 20 TeV
- Conclusion: above tips are sufficient to cover nearly all linear collider physics list needs

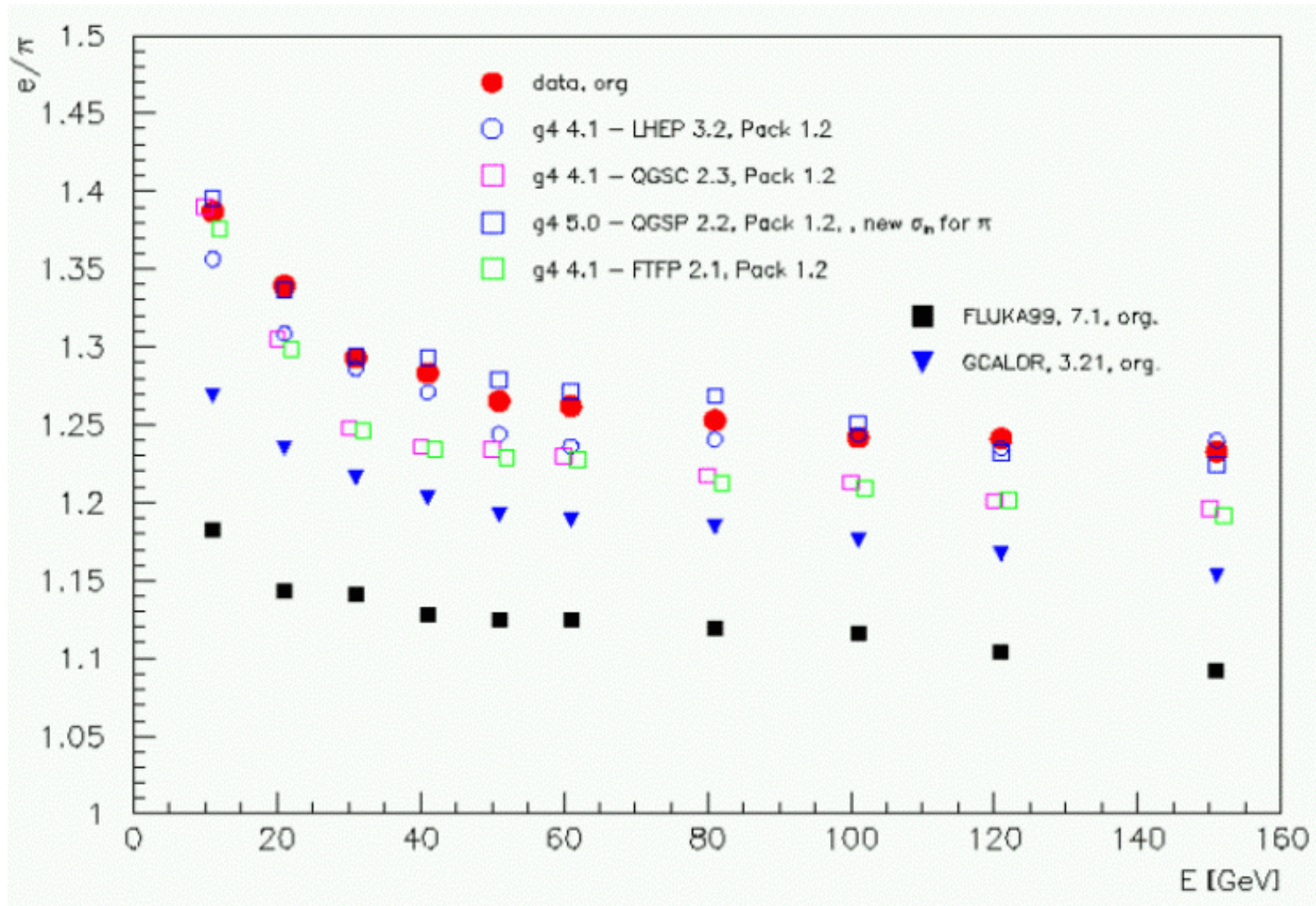
Testing and Validation

- Tests of component models
 - QGS, LEP, HEP, Bertini cascade
- Tests of the LC physics list
 - pp collisions (provided by T. Koi)
 - thin target tests with other materials (coming soon)
 - semi-realistic detector tests (coming later)
- Tests of other physics lists (from Geant4 distribution)
 - Hadronic interactions test page:
<http://www.slac.stanford.edu/~tkoi/G4HadInt.html>

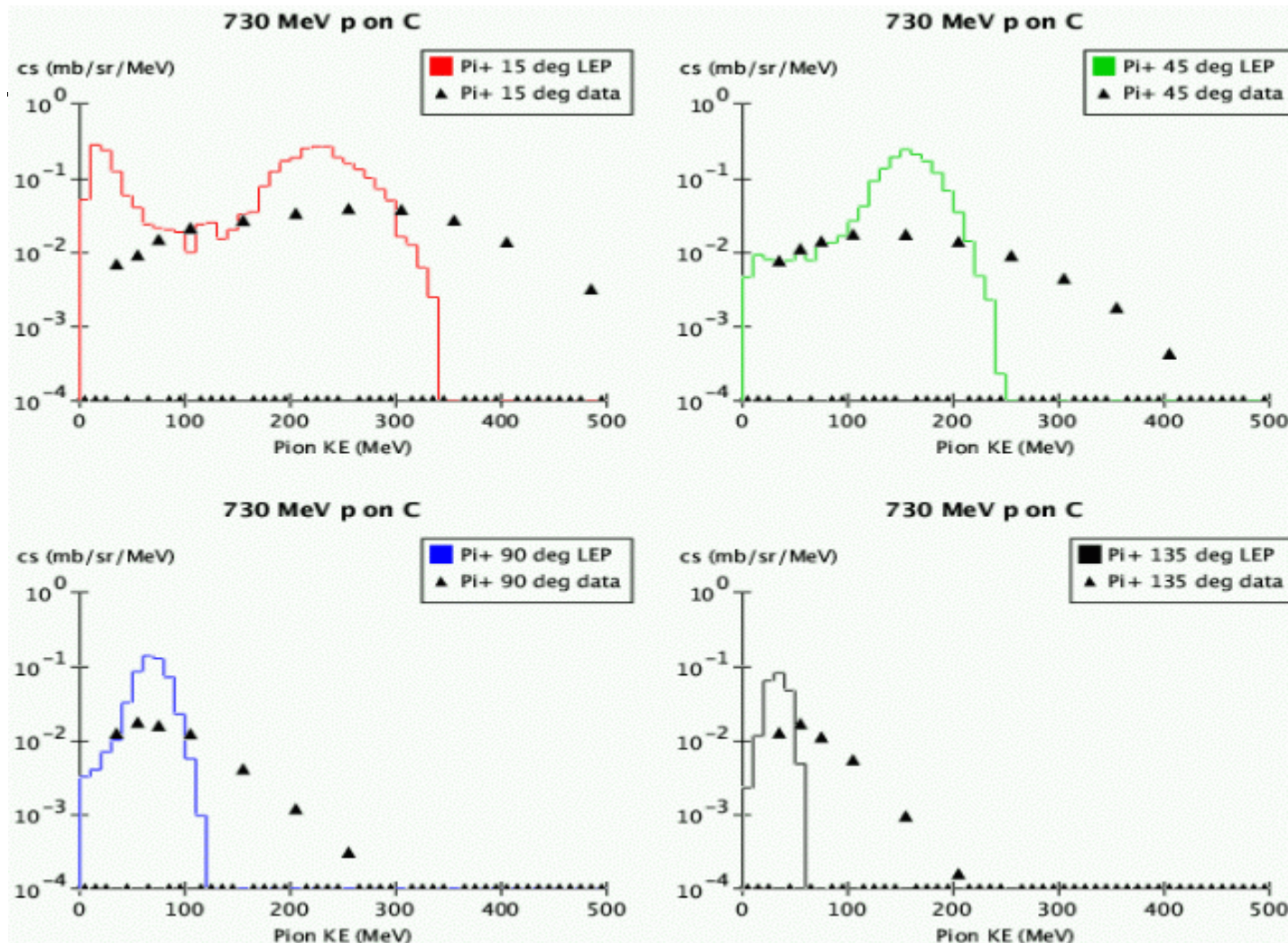
Test of High Energy Models



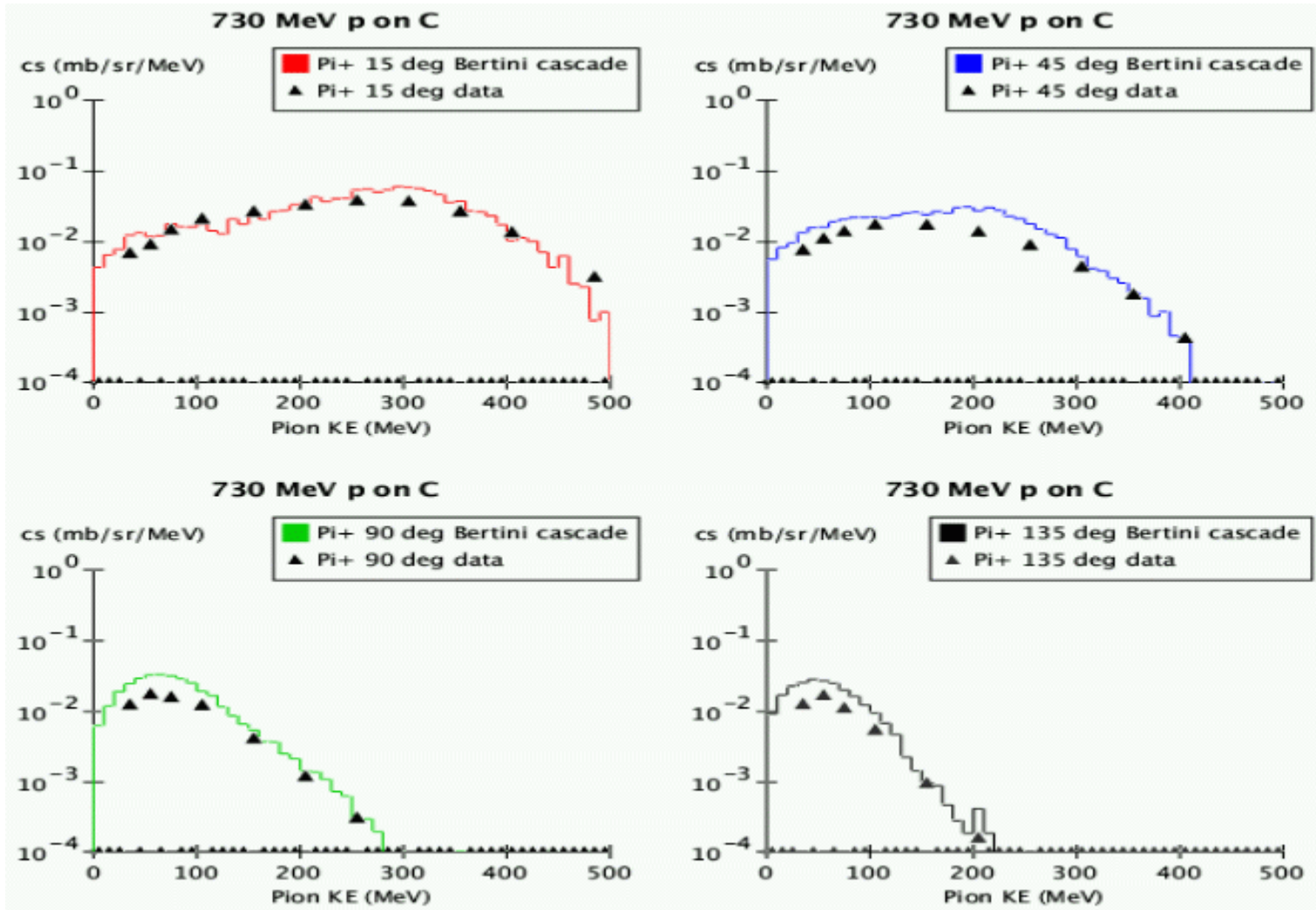
Test of High Energy Models



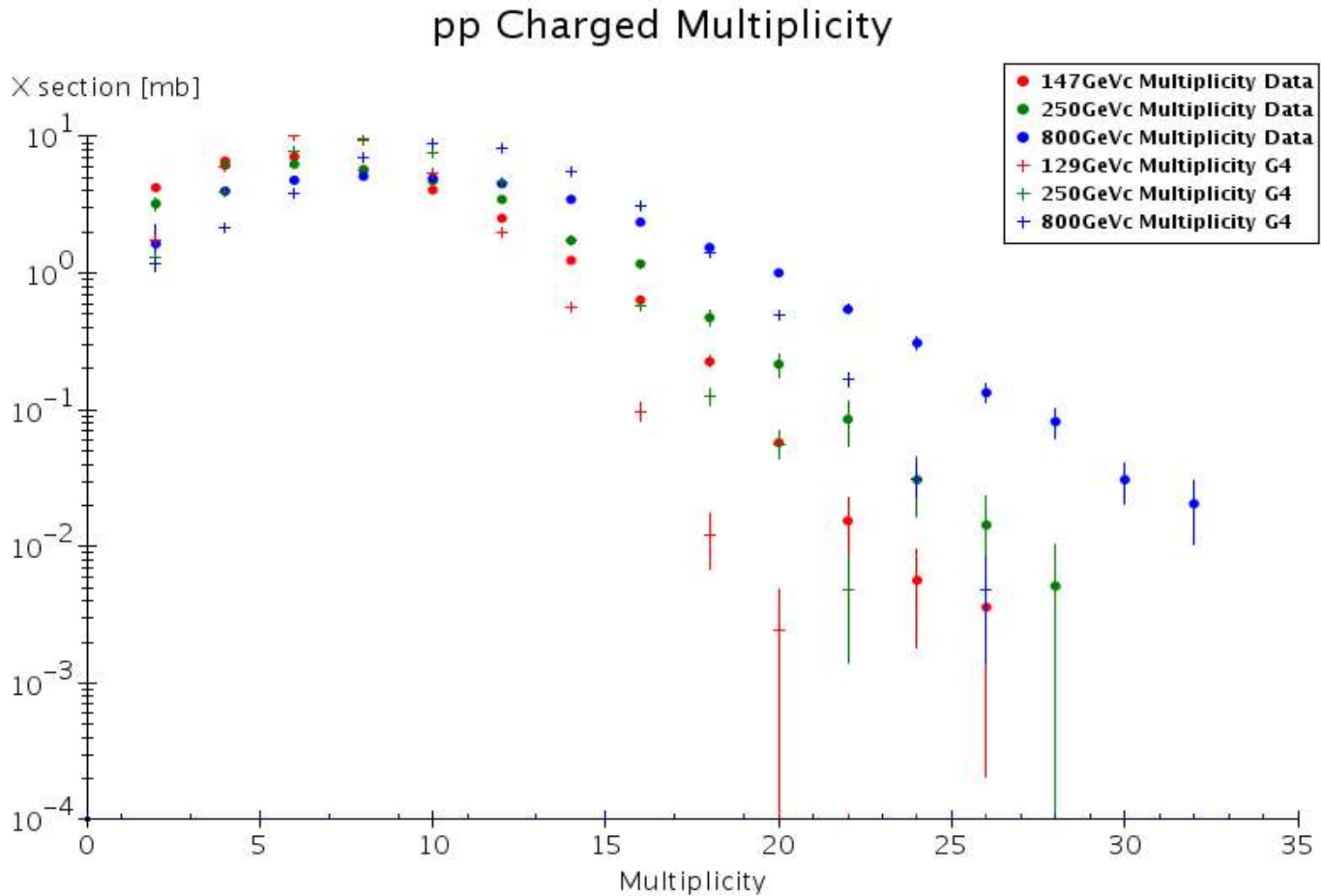
Test of Medium Energy models



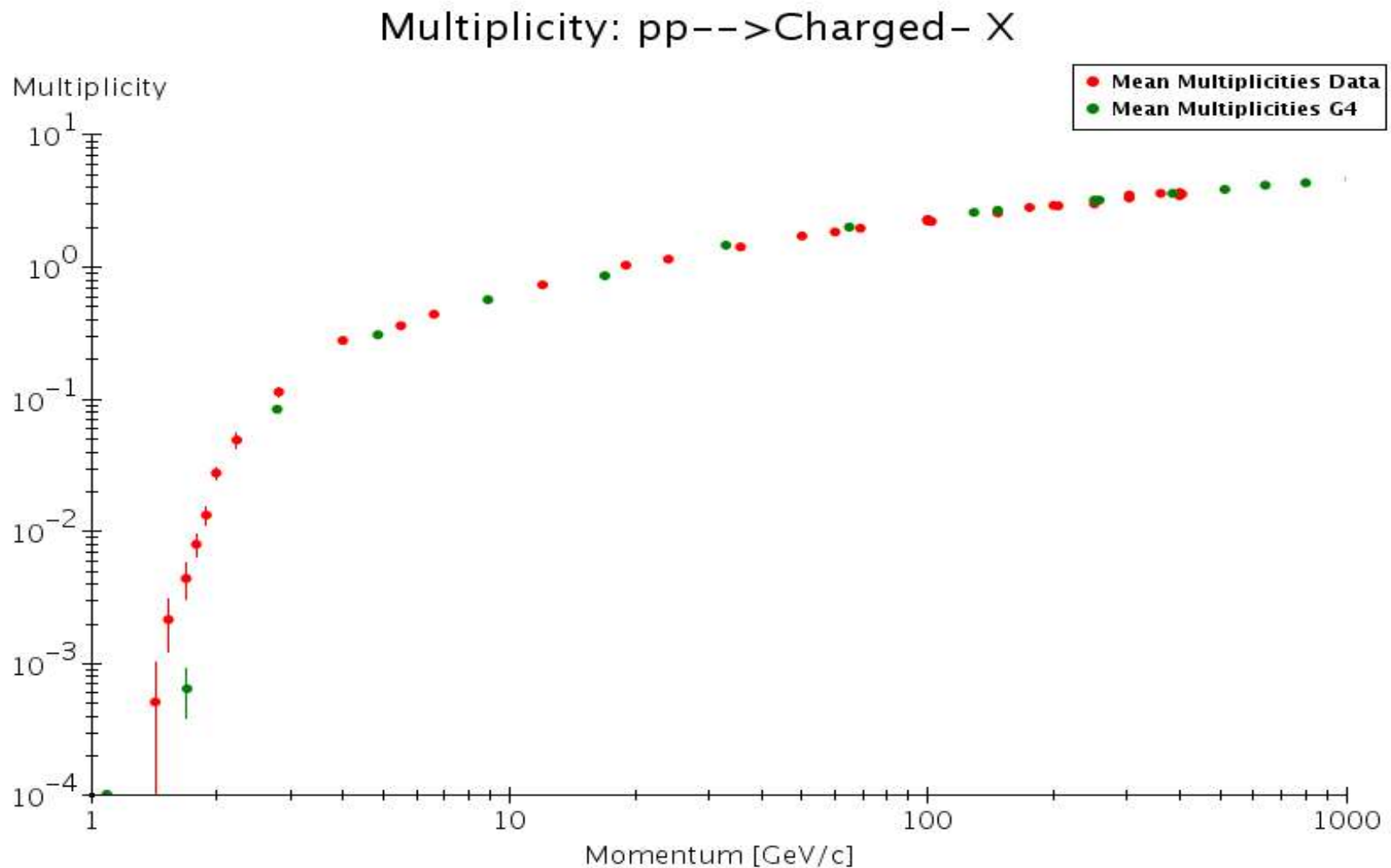
Test of Medium Energy Models



pp collisions using LCPhys



pp collisions using LCPhys



Plans

- Extend Bertini cascade to kaons, hyperons
- Add hadronic interactions (G4BinaryLightIonReaction) for light ions (to replace LEP model)
- Add mu-nuclear reactions
- Validation gap: 1 – 15 GeV
 - Recently found some 10 GeV p on Ta pion production data
 - HARP beginning to release results
 - Looking for test beam data in this range

Physics List Web Page

- On SLAC home page www.slac.stanford.edu
 - [/comp/physics/geant4/slac_physics_lists/ilc/ilc_physics_list.html](http://comp/physics/geant4/slac_physics_lists/ilc/ilc_physics_list.html)
- Goal: to provide
 - access to code
 - detailed documentation
 - regression tests and plots
 - validation tests and plots
- Plans
 - User-operated testing and plotting