Testing Suite for Validation of Geant4 Hadronic Generators

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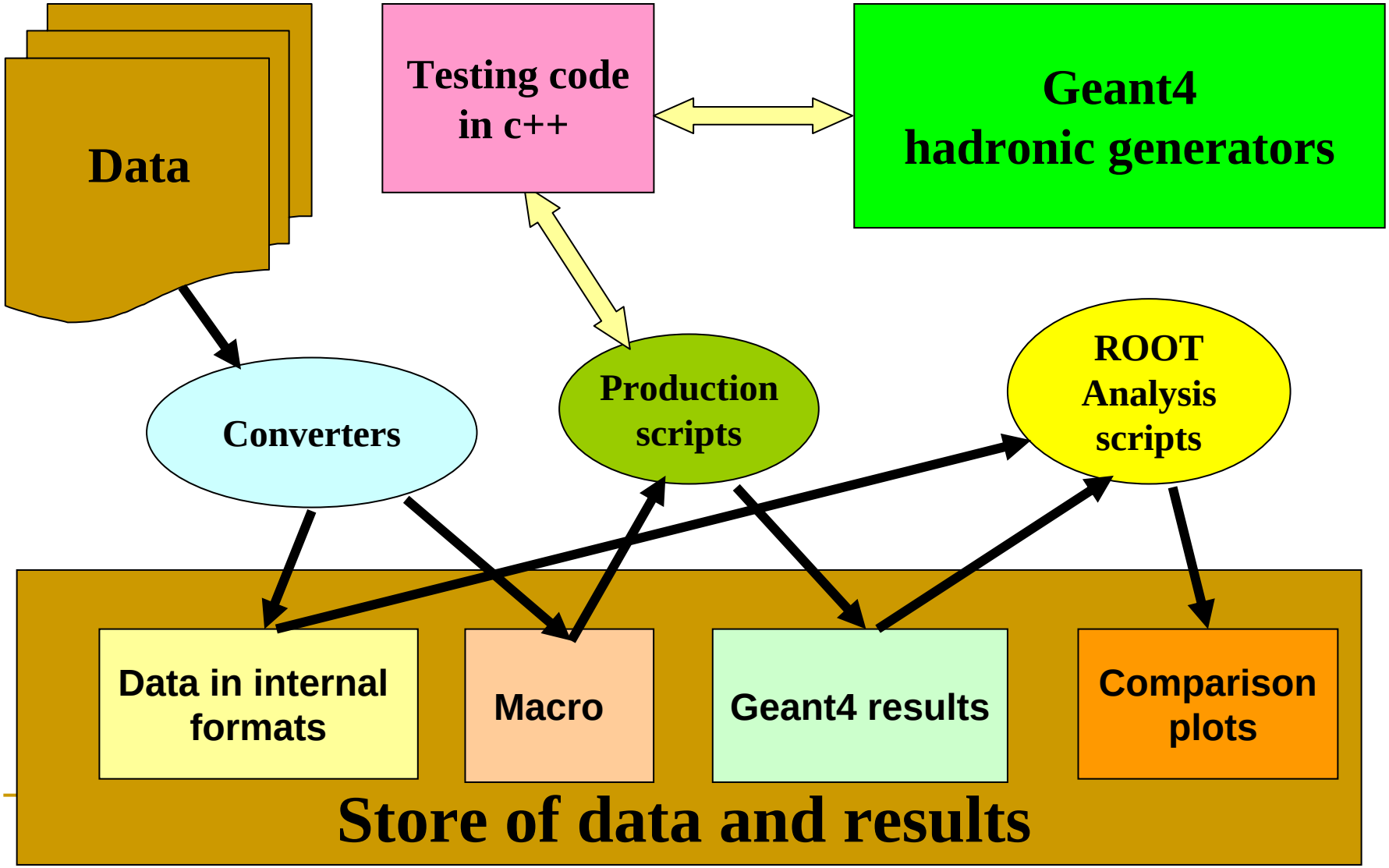
Validation suite for thin target data on hadron inelastic interaction

- Exist since 2002
- Neutron production by p, d, α, ^{12}C with E <= 3 GeV
  - p + A -> n + X
  - d + A -> n + X
  - α + A -> n + X
  - ^{12}C + A -> n + X
- Pion production by protons and pions P<13 GeV/c
  - P + A -> $\pi^{\pm}$ + X
- About 100 thin target setups
- Data versus Geant4 models
- Control on differential spectra
- Model level test

- Models under testing:
  - PreCompound
  - Binary Cascade
  - Binary Ion cascade
  - Bertini Cascade
  - Wilson-Abrasion model
  - LHEP
  - QGSP
  - QGSC
  - FTFP
- A new model or data can be easily included
  - Test30 – general
  - Test35 – HARP data

Current software

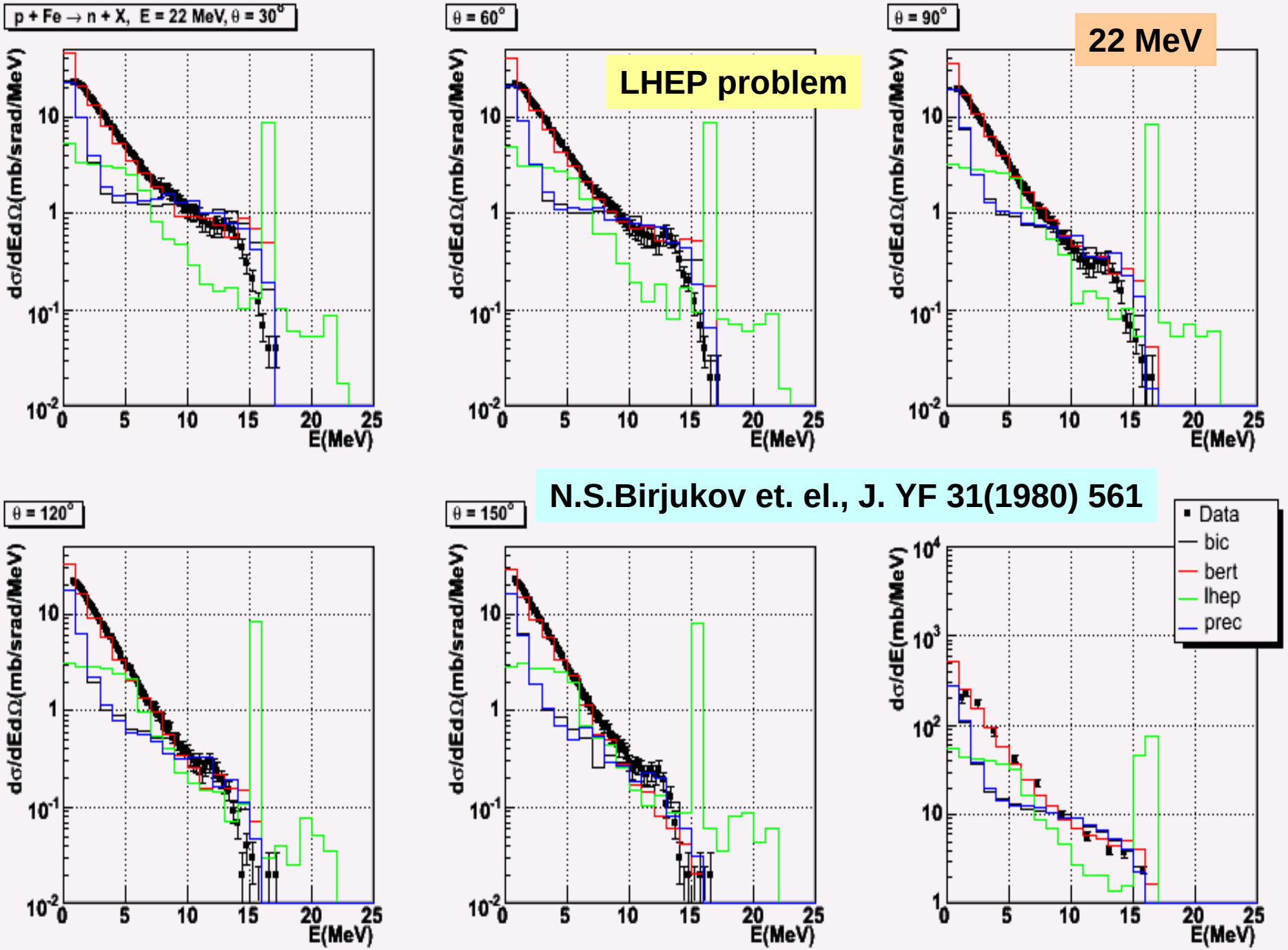


Updated validation infrastructure at CERN

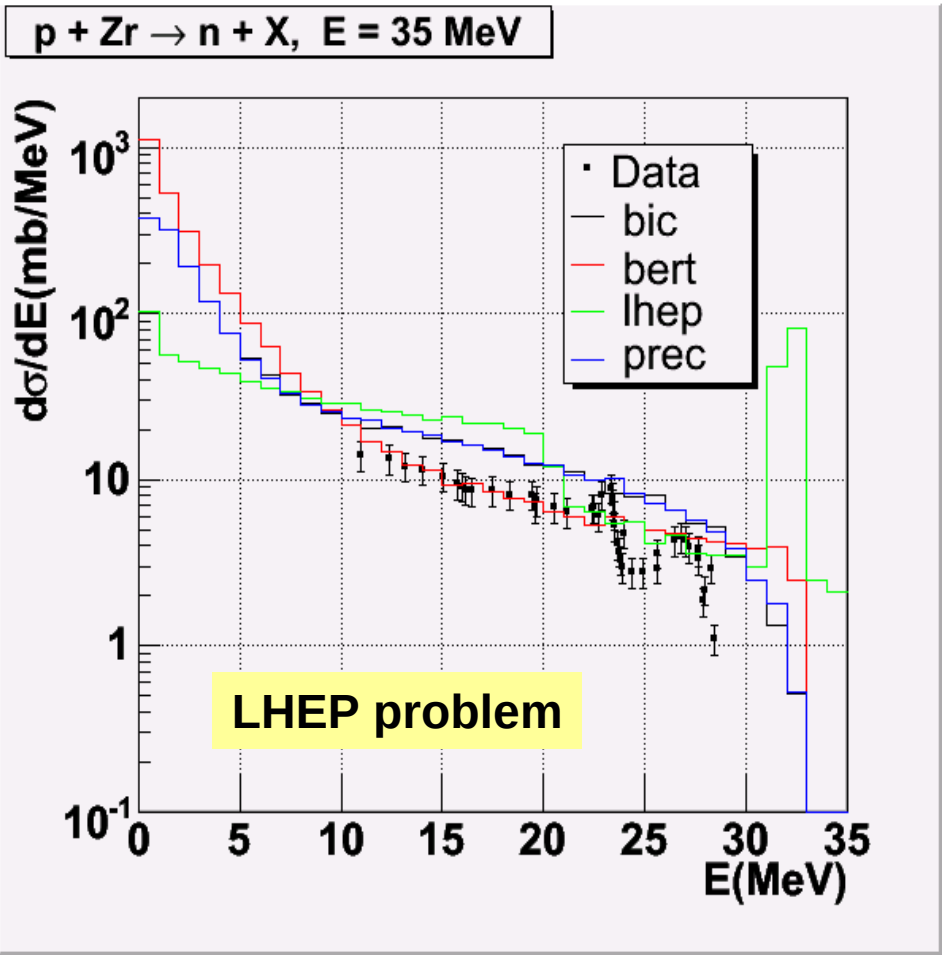
- Thanks to S.Giani and J. Panman
- Software and results stored at AFS public
  - **AFS dedicated volume with backup**
  - **Started from g4 8.1**
  - **Test data and scripts in CVS**
- Driving by scripts
- ROOT based analysis
- From g4 8.1 running at LXBATCH
  - **Complete run needs from few days to one week**
- Directories are structured by tag name

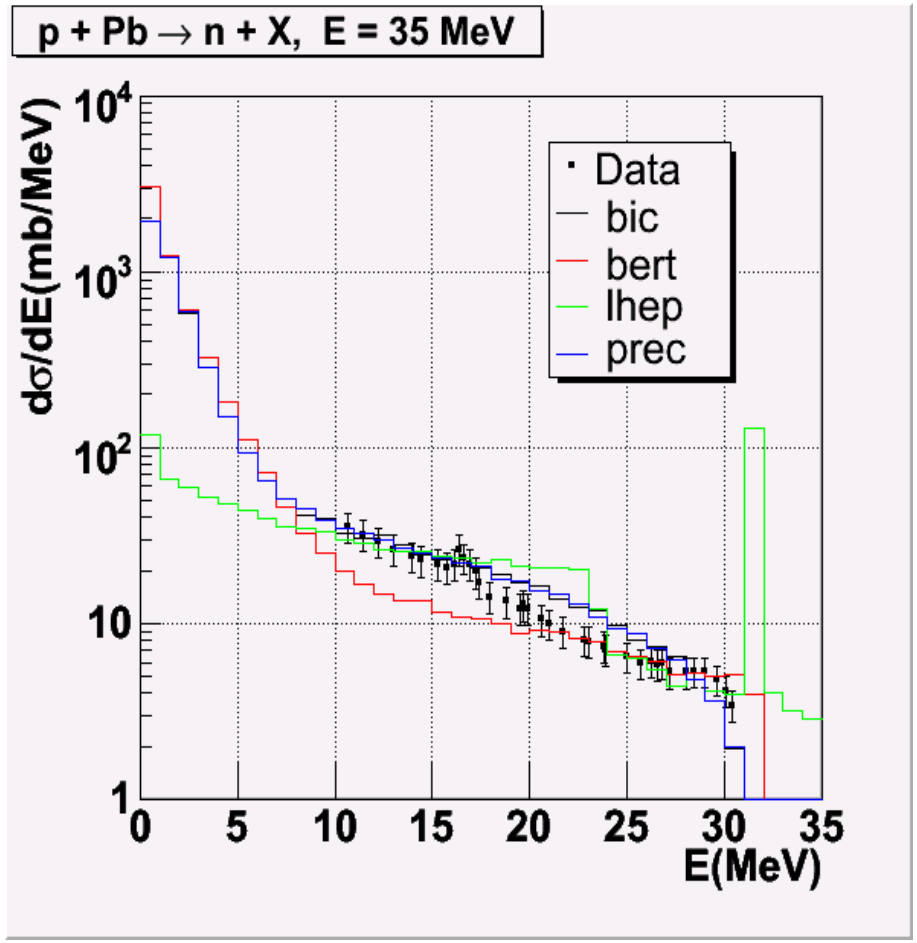
$VFHAD/test30/data/pn_al_256
/pn_al_1500
$VFHAD/test30/geant4-08-01-ref-00/pn_al_256/r.out
/pn_al_256/bic.paw
/pn_al_256/bert.paw

- Results for g4 9.0 and 9.0ref01 will be shown below
  - **Focus on problematic plots!**

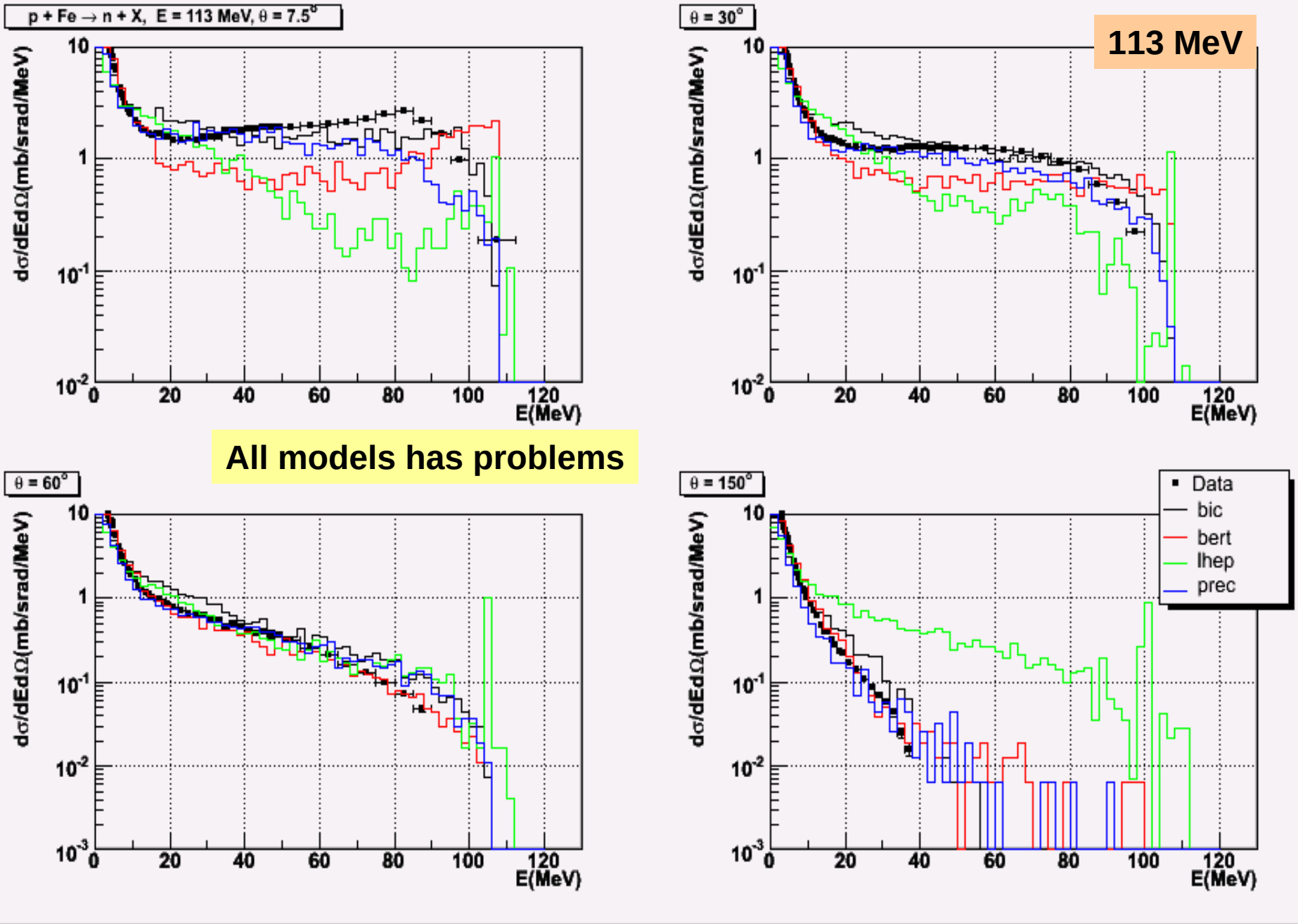

p + Fe → n + X, E = 22 MeV, θ = 30°
θ = 60°
θ = 90°
22 MeV
LHEP problem
N.S.Birjukov et. el., J. YF 31(1980) 561
θ = 120°
θ = 150°
dσ/dEdΩ(mb/srad/MeV)
dσ/dE(mb/MeV)
E(MeV)
Data
bic
bert
lhep
prec

Neutron production by 35 MeV proton beam in heavy targets

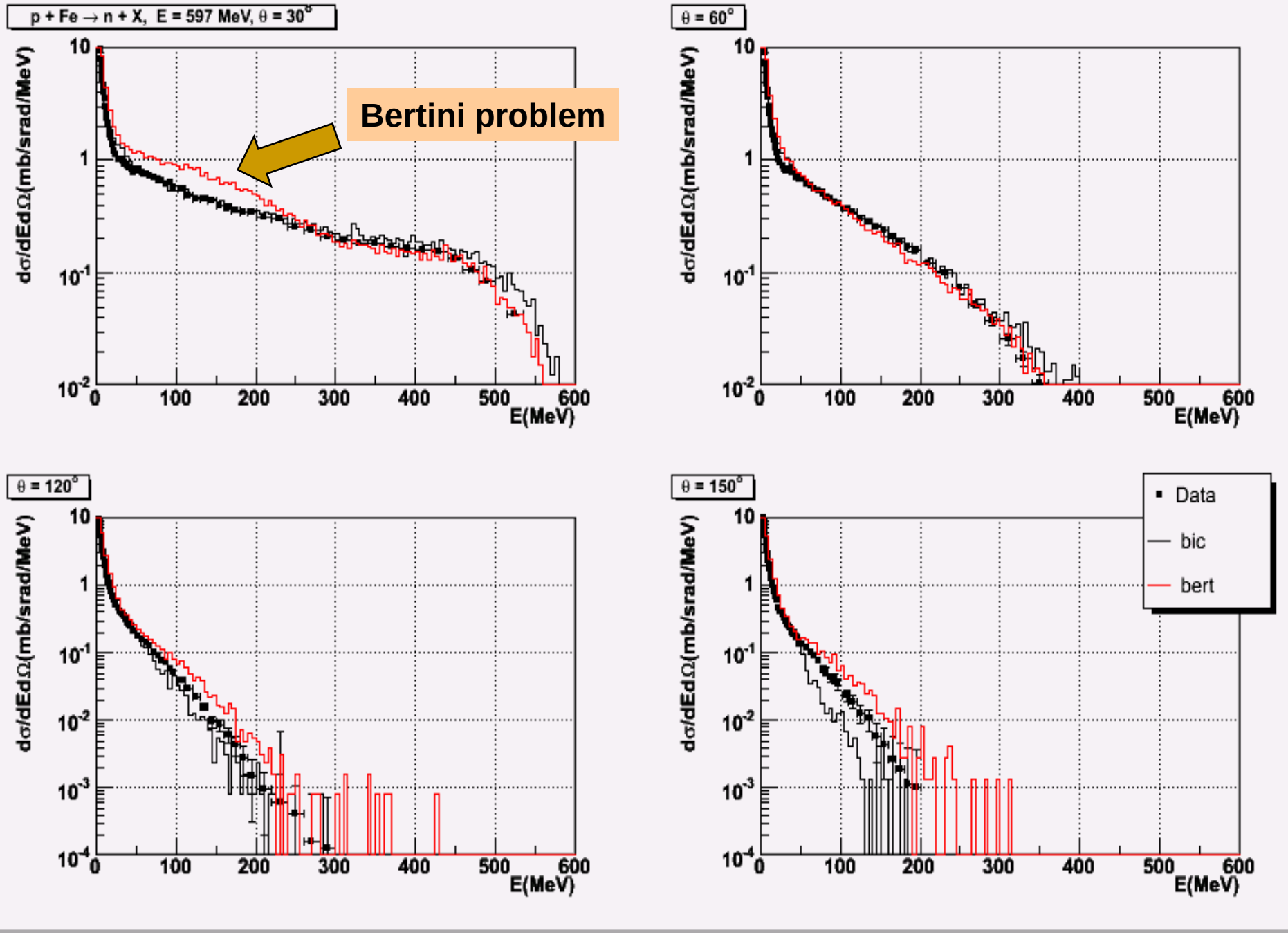




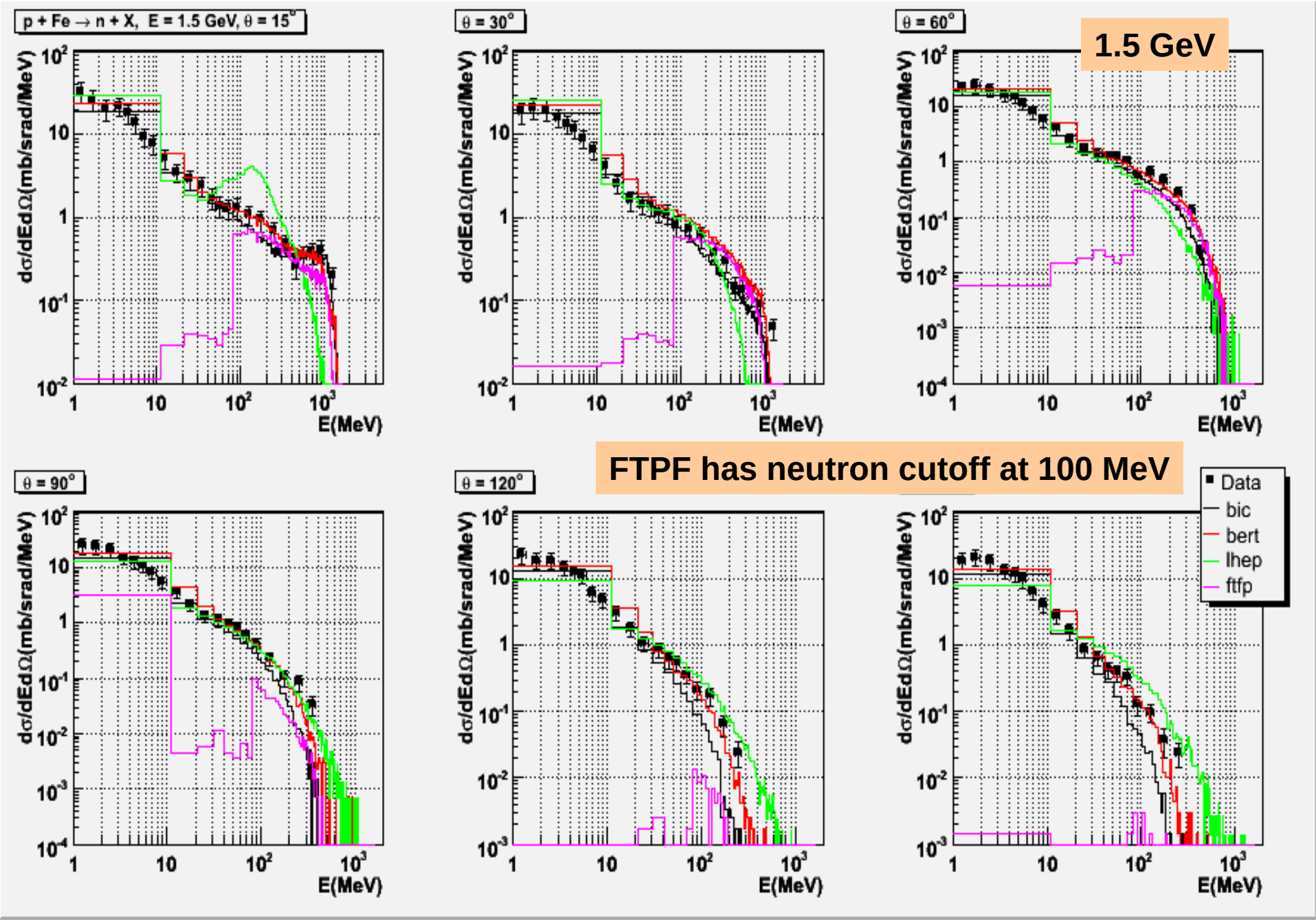
M.Blann et. el., Nucl. Phys. A 257 (1976) 15



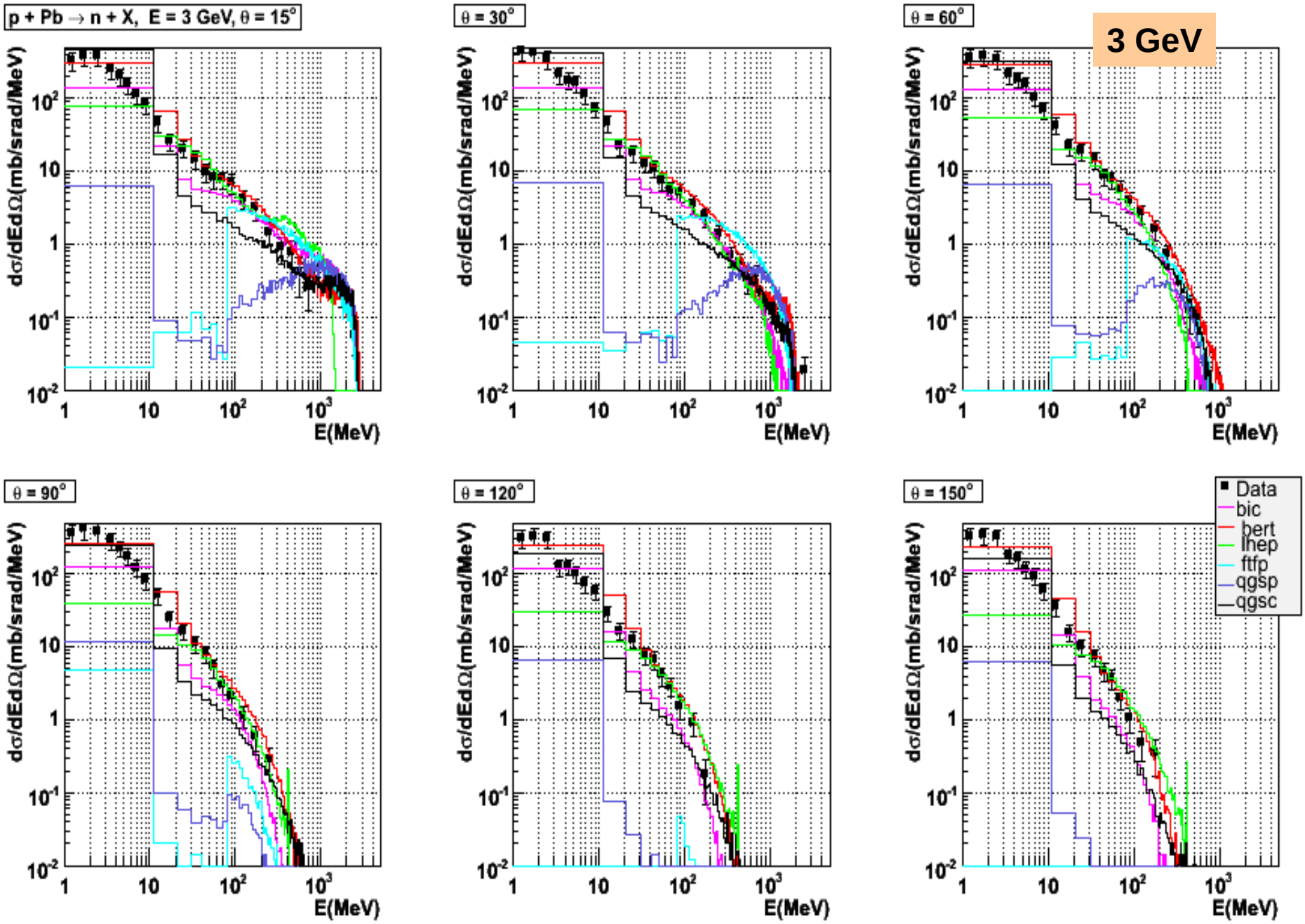
M.M.Meier et. el., J. Nucl. Sci. Eng. 102 (1989) 310



W.B. Amian et. el., J. Nucl. Sci. Eng. 115 (1993) 1



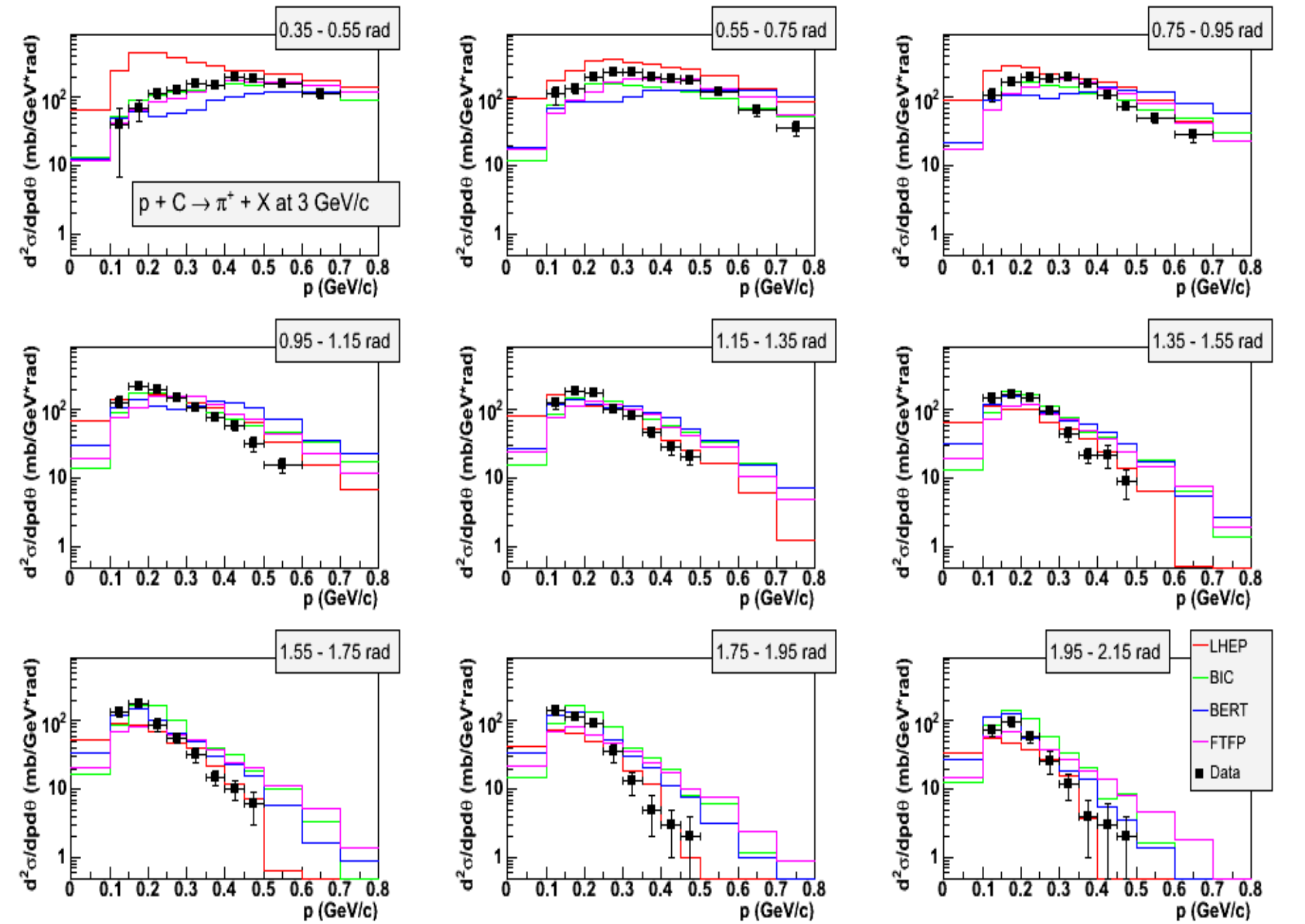
K. Ishibashi et. el., J. Nucl. Sci. & Technology 34 (1997) 529



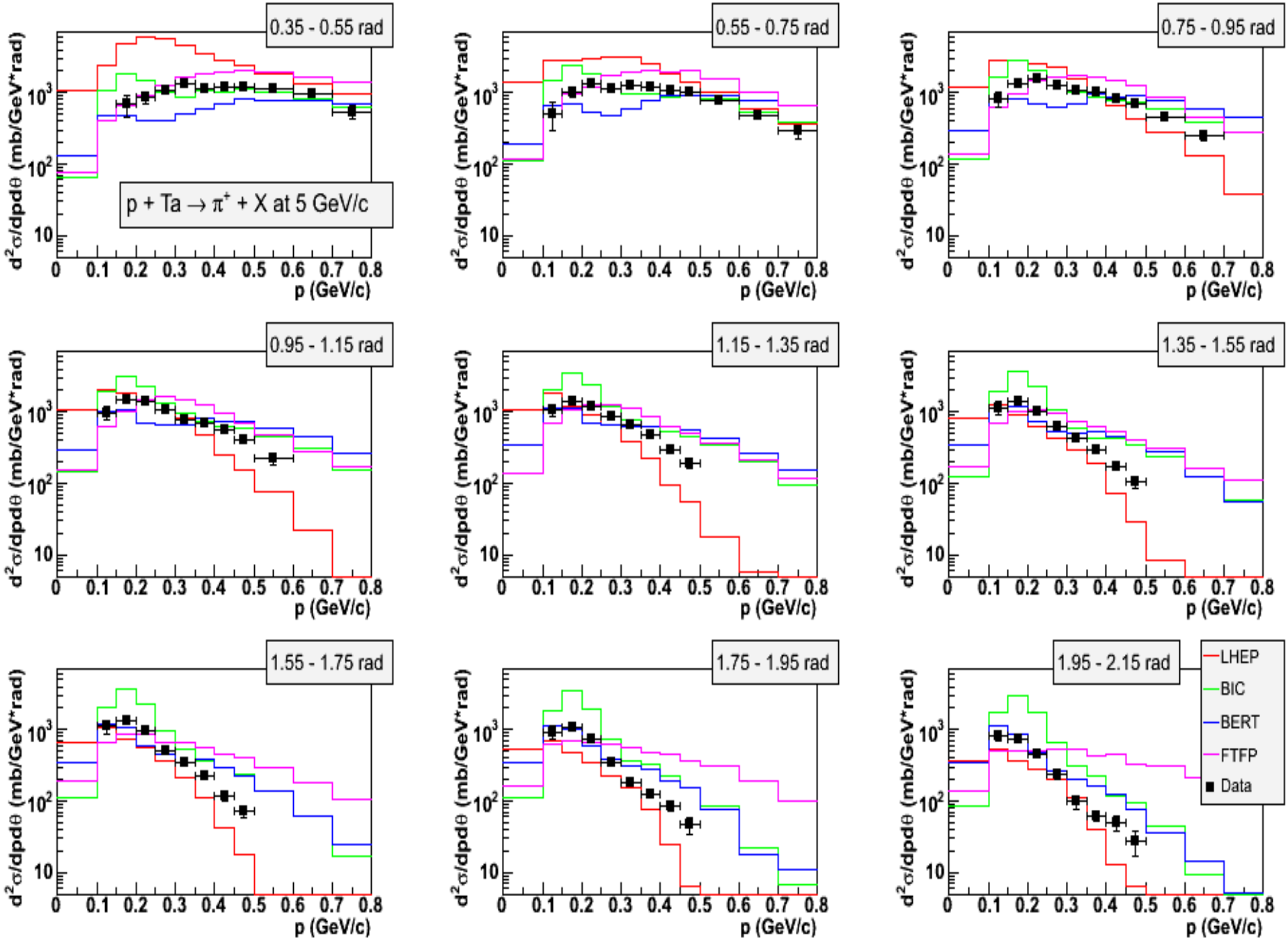
K. Ishibashi et. el., J. Nucl. Sci. & Technology 34 (1997) 529

Neutron production summary (g4 9.0)

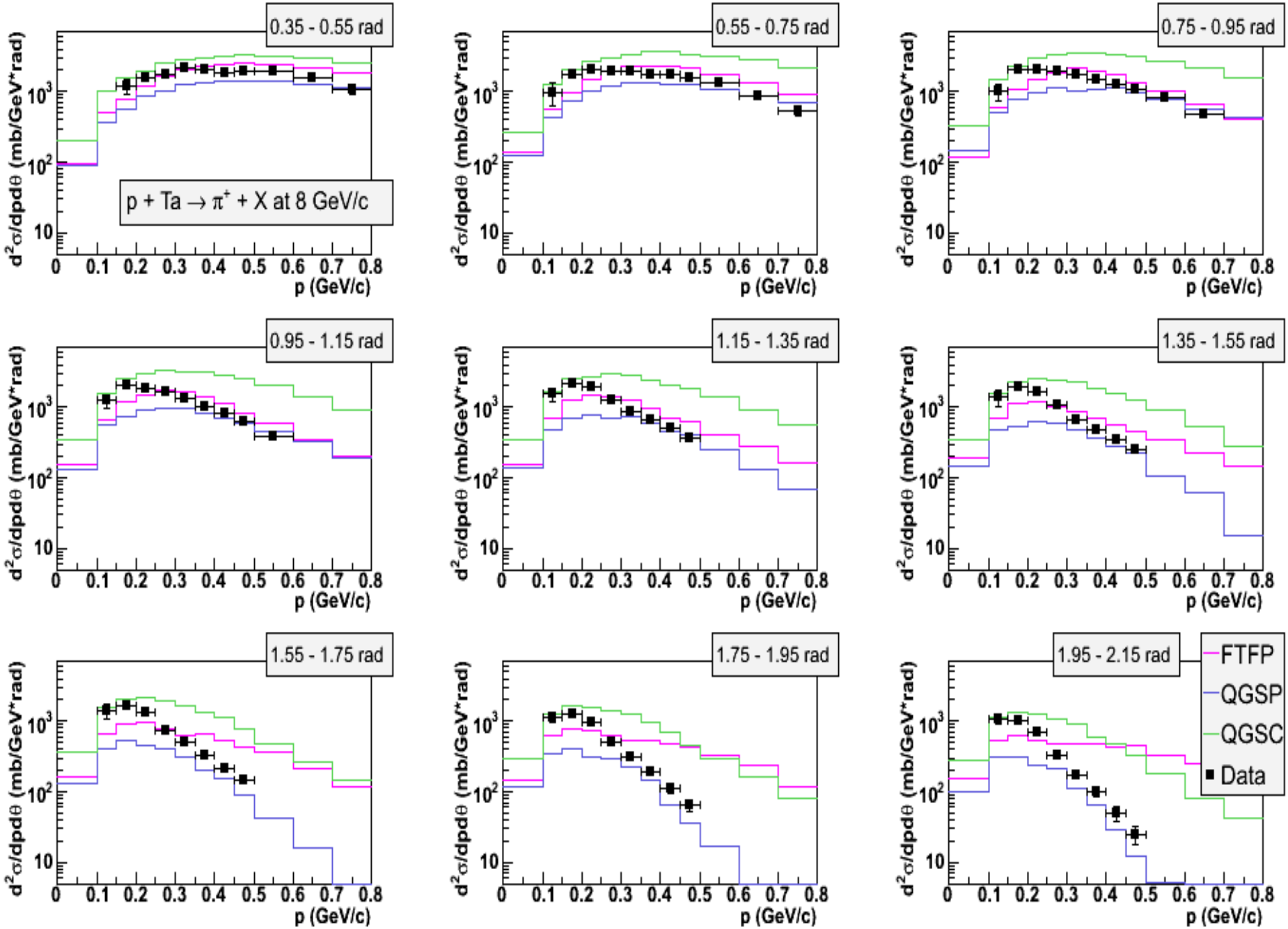
- Pre-Compound and Binary Cascade have problem for light nuclei and low energy
  - **Partially fixed with g4 9.0ref01**
- Quasi- elastic part of models at 113 MeV and below requires improvements for all models
- For Bertini Cascade at 600 MeV there is a problem in neutron spectra
- Binary Cascade underestimate neutron production above 1 GeV
- Bertini Cascade overestimate neutron flux
- LHEP needs improvements at all energies
- FTFP and QGSP have a cut off 100 MeV for neutron production
  - QGSC has evaporation spectra without cut-off



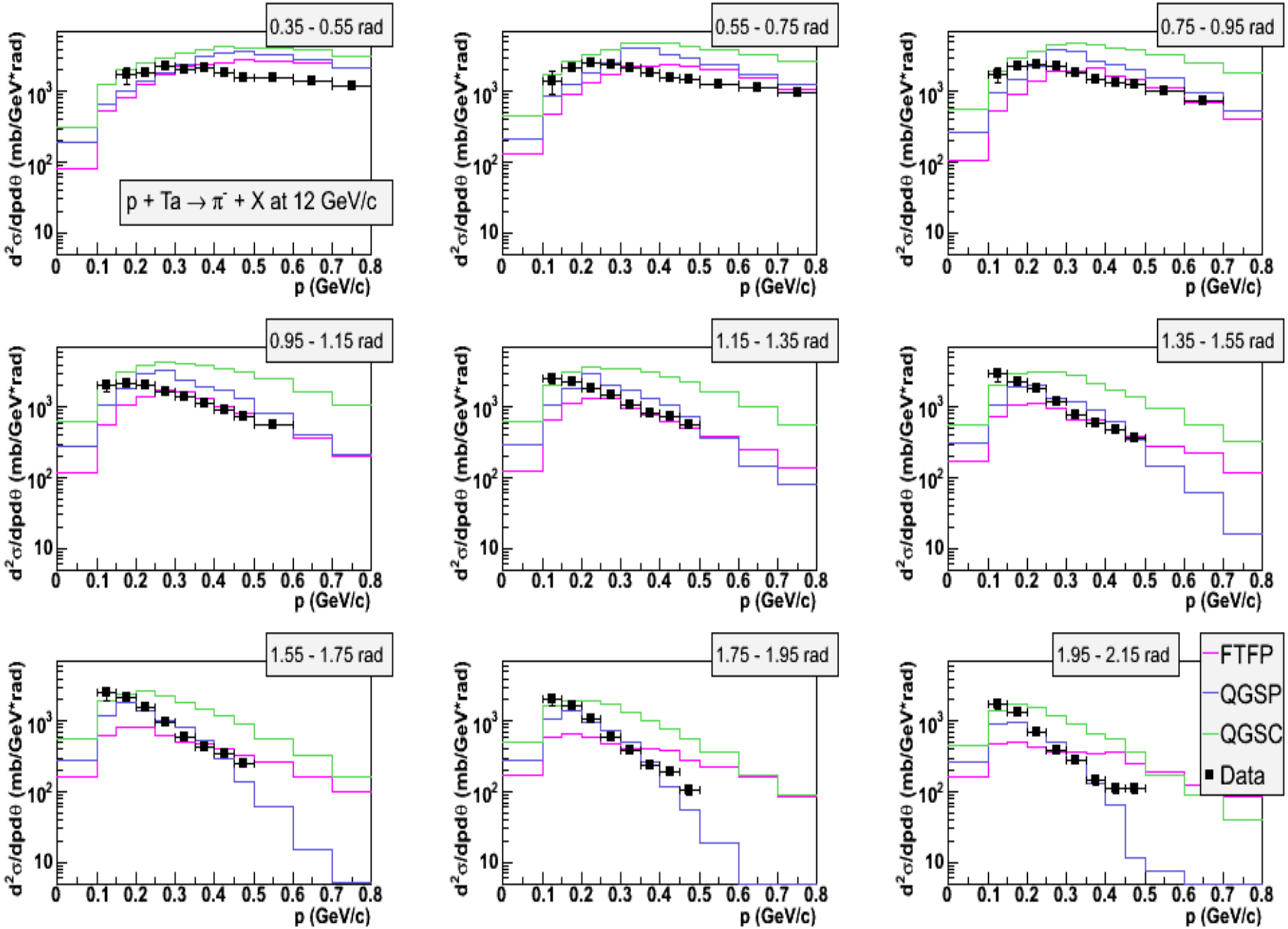
G. Catanesi et. el., Eur. Phys. J. C51 (2007) 787



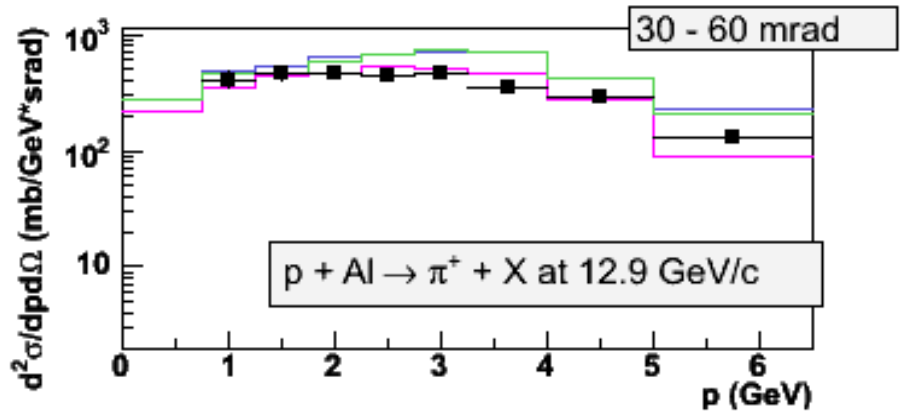
G. Catanesi et. el., Eur. Phys. J. C51 (2007) 787

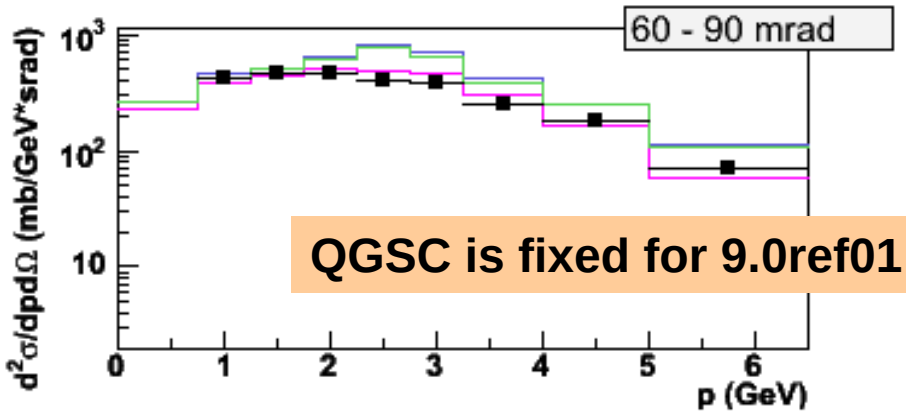


G. Catanesi et. el., Eur. Phys. J. C51 (2007) 787

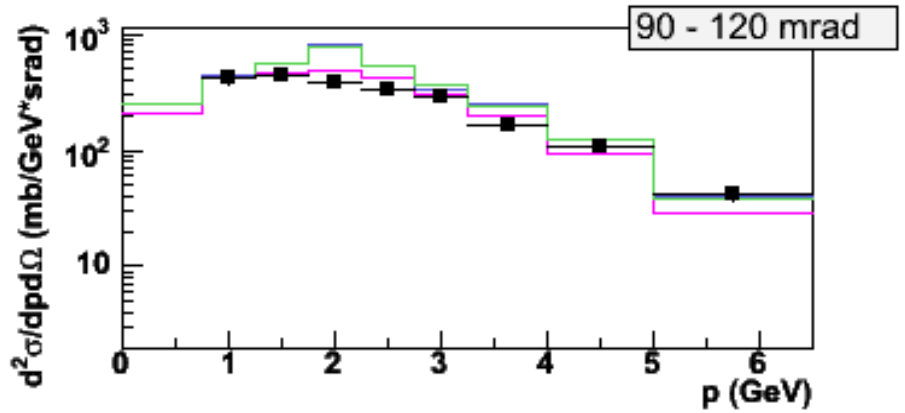


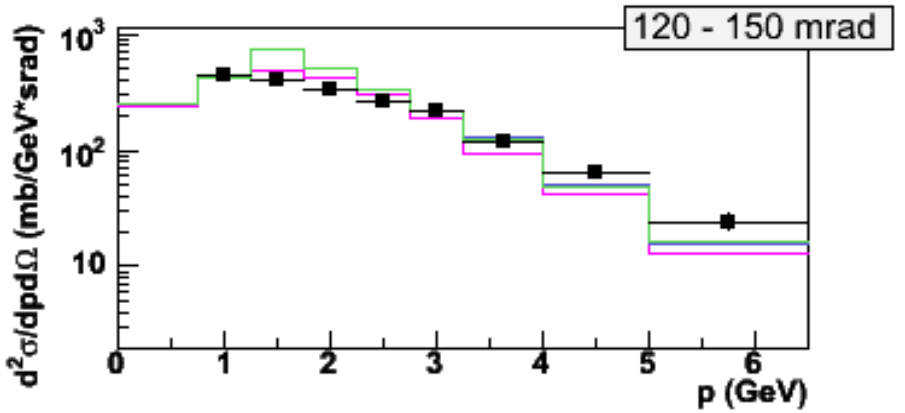
G. Catanesi et. el., Eur. Phys. J. C51 (2007) 787

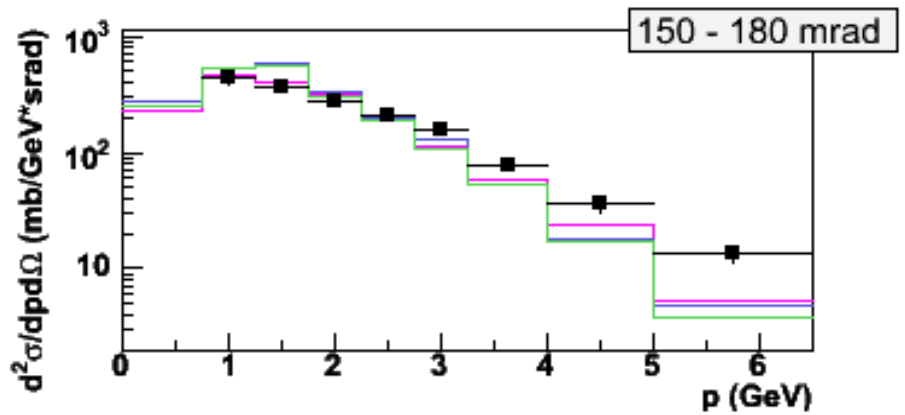


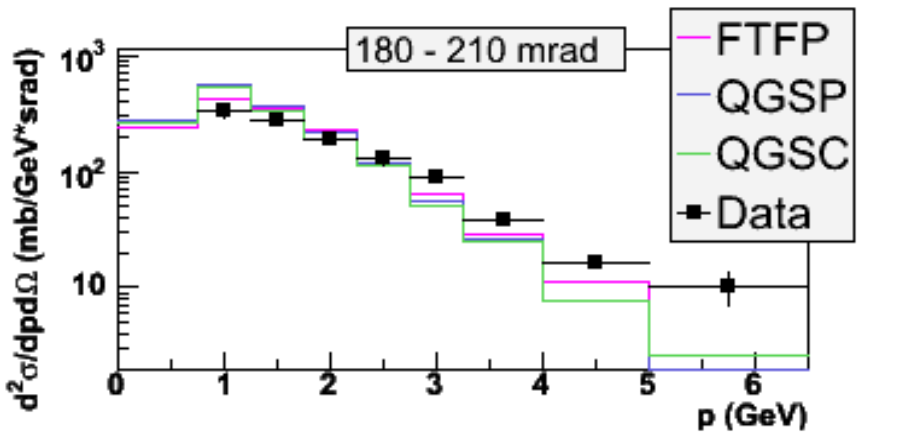


QGSC is fixed for 9.0ref01









G. Catanesi et. el., Nucl. Phys. B 732 (2006) 1

Summary for pion production (g4 9.0)

- Most of the models overestimate backward production of pions with higher momentum
  - Shower shape may be effected
- LHEP overestimate forward production of pions and well reproduce spectra at large angles
- Revised FTFP model is the best for forward production but does not reproduce spectra in backward hemisphere
- Revised QGSP reproduce data better than QGSC
- QGSC significantly overestimate pion flux at large angles
  - Addressed with g4 9.0ref01

Conclusion remarks

- Testing infrastructure at CERN have been updated in 2007
- About 100 thin target setups are available
  - data are selected
  - set of Geant4 models per data set are selected
  - scripts are prepared to provide “production” style of work
- New/old problems of hadronic generators are identified
- Only small part of plots is shown
  - access to results via web (thanks to G. Folger)
- Software in cvs and allows extensions

Short term improvements

- Complete software for data existing in the suite (about 40% of data sets)
- Add plots on energy-momentum balance
- Add new models
  - RPM (new parameterized model)
  - ABLA
- Complete data set for the HARP data
  - Depend on HARP publications release
- Web interface to be improved?
  - Should it be free or password protected?
  - Should we optimize directory structure?

Long term proposals

- Welcome contributions from other G4 members, for example,
  - Proton inclusive – histograms are there, data required
  - Gamma spectra – histograms are there, data required
  - Light ions – better clone to new test
  - High energy validation – better clone to new test
- Add software for automatic histograms comparison between different reference tags
- Add subscribe mechanism, so developers are informed about new comparisons done?
- We need to extend the approach to about 10000 plots to control major aspects of G4 hadronics
- Production can be run by stt in long-term perspective