

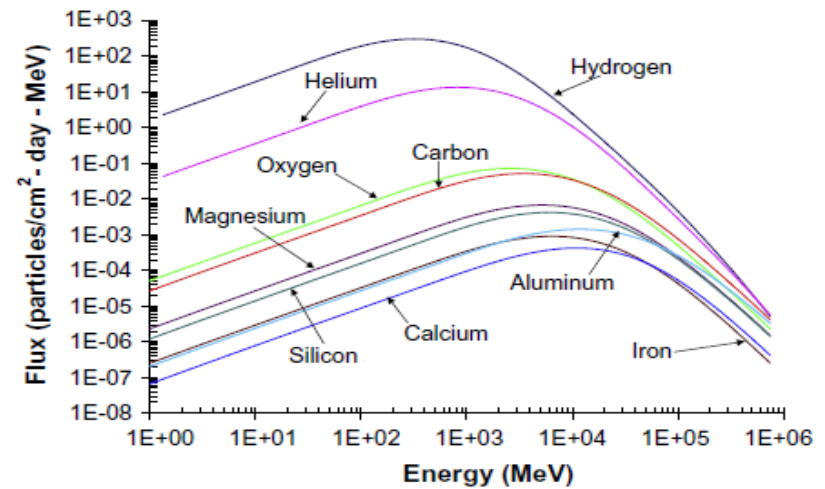


GEANT4 MODELS FOR ION/ION INTERACTIONS

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(under the ESA Technology Research Program)

SPACE APPLICATIONS OF GEANT4 ION/ION MODELS (ESA PROJECT A06041)



Ions flux on the Earth orbit

- Proton component of Cosmic Rays dominates
 - Geant4 simulation for proton incident is reasonable
- Radiation damage provided by ions is significant
 - Simulation precision for Geant4 Ion/Ion interactions is lower than that for protons
 - Validation of ion/ion interactions is limited
- This work is also useful for other applications:
 - LHC experiments
 - NA61 (requested for DPMJET interface)
 - Hadron therapy communities

MODELS AND PHYSICS LISTS FOR ION/ION INTERACTIONS

○ Models

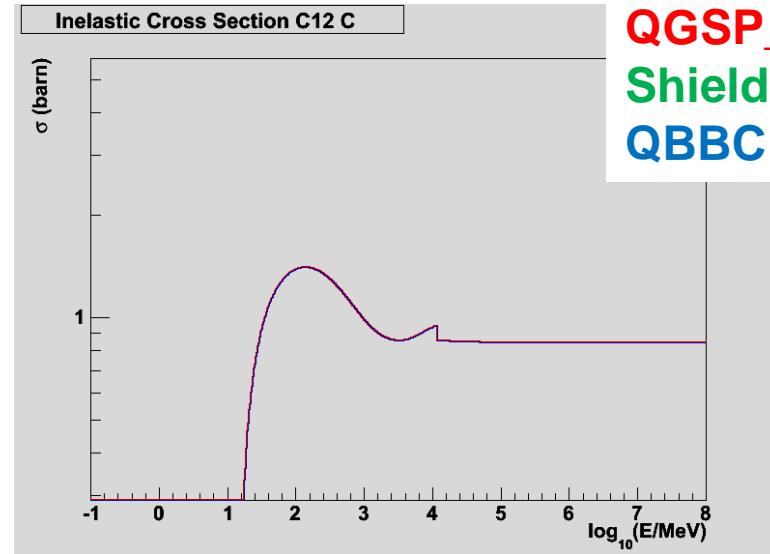
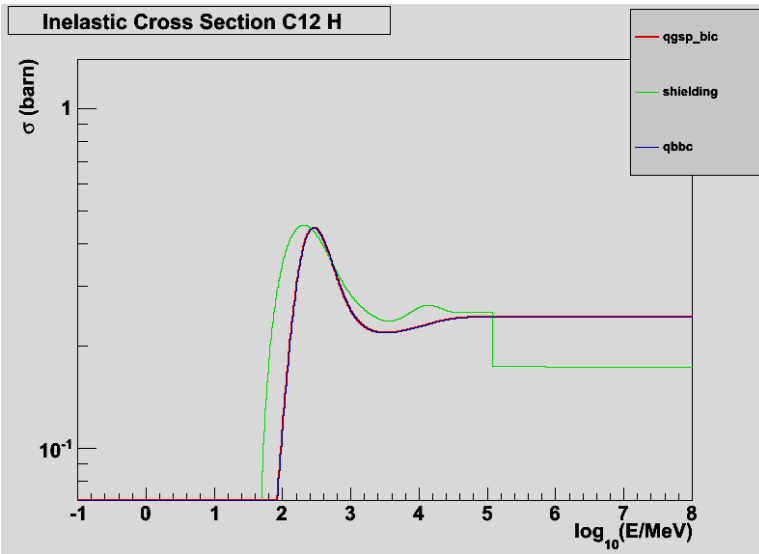
- BIC_ion
- QMD
- CHIPS
- INCL
- Abrasion

○ Physics Lists

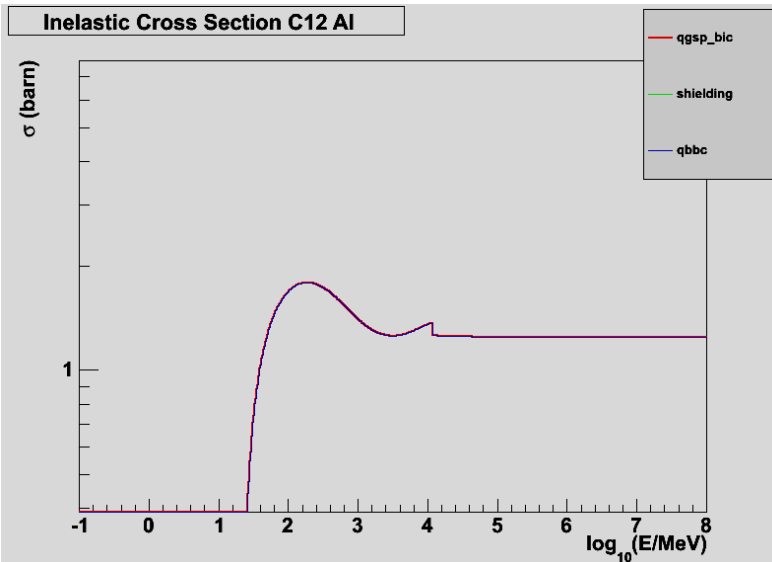
- QBBC and QGSP_BIC
- Shielding
- CHIPS
- QGSP_INCL_ABLA
- DPMJET-II.5 on top of any Physics List
- FTFP_BERT in the future

GEANT4 ION/ION CROSS SECTIONS

C12 on Hydrogen, Carbon, and Aluminum



QGSP_BIC
Shielding
QBBC



Shape is not smooth

Steps between Tripathi and Shen models

Axen-Wellish, Tripathi, and Shen for Hydrogen

DPMJET-II.5 INTERFACE

- High energies ($E/A > 10$ GeV/u) Ion/Ion interactions
- Software was provided by P. Truscott – it is a version prepared in MARS-REM project sponsored by ESA few years ago on base of the original DPMJET-II.5 FLUKA code
- Our experience with DPMJET interface
 - Initially installation at SLC4 32 bit gcc3.4.6 was achieved
 - Installation completely fails at SLC5 default compiler gcc4.1
 - Installation at SLC5 64 bit gcc4.3.2 and higher was achieved
 - HADR02 extended example is created (g4 9.5beta)
 - it can be used for all energies and any Physics lists thanks to Hisaya modification of G4VModularPhysicsList interface allowing substitute ion builder
 - Current version of the interface to DPMJET-II.5 is limited $Z < 27$



VALIDATION RESULTS

6

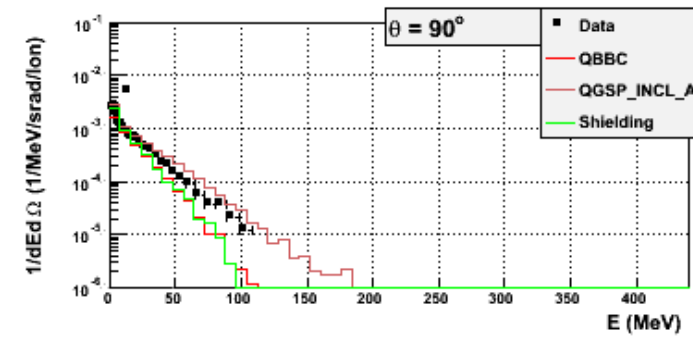
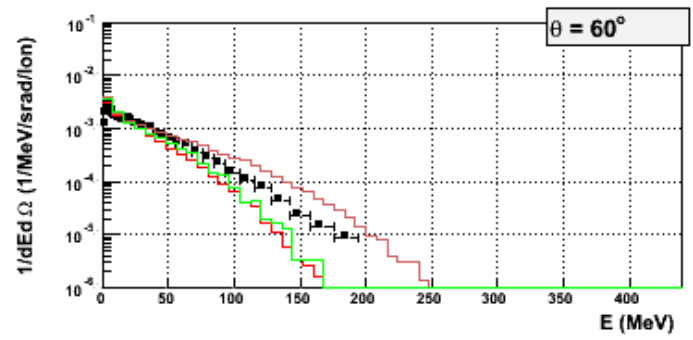
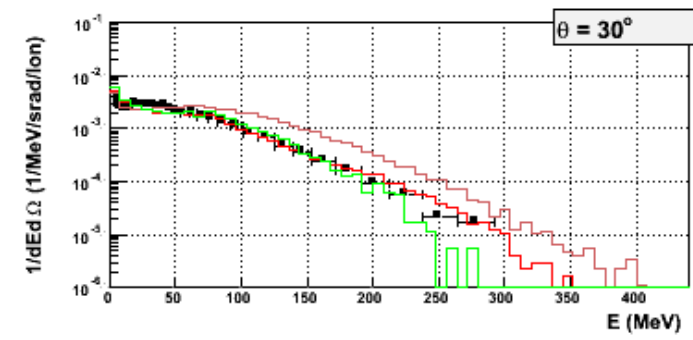
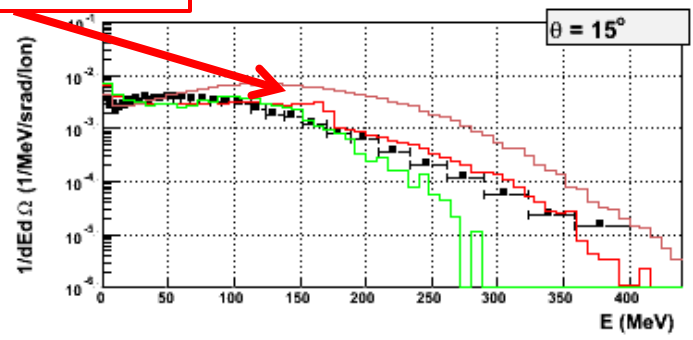
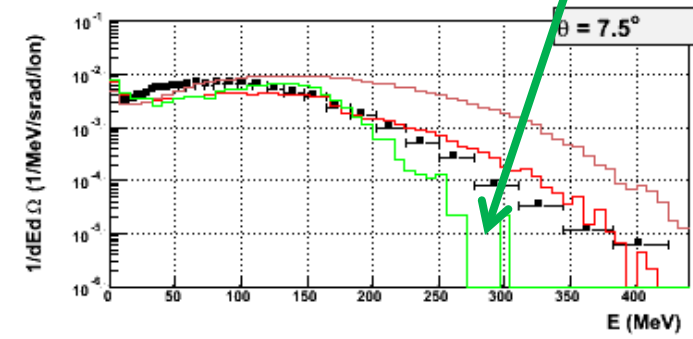
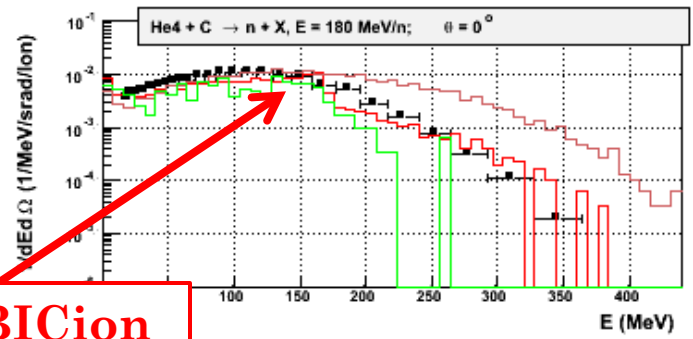
Test30 - thin target test, DDXS

Test45ion – Ion/Ion thick target test, NY

HADR02 – high energy thick target test, fragments XS

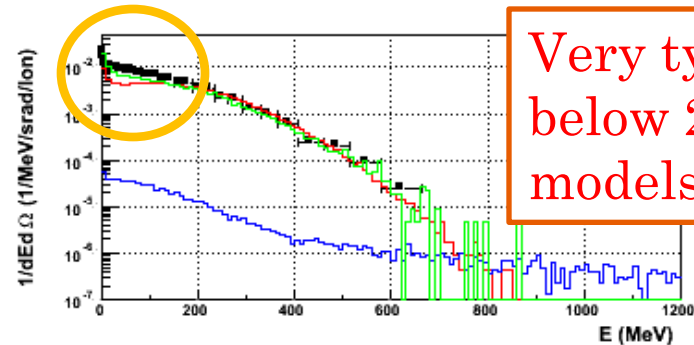
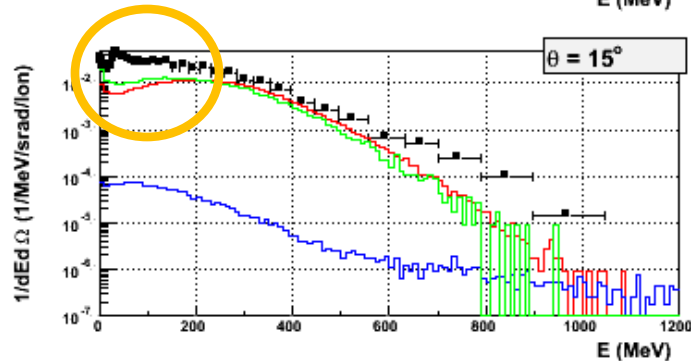
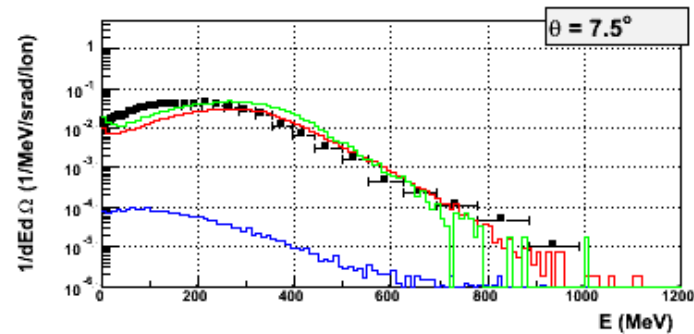
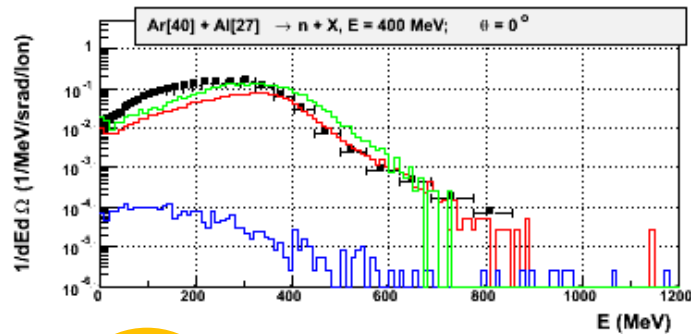
THICK TARGETS NEUTRON YIELD: C(He4,N) 180 MeV/U (G4.9.4)

QMD
Statistic?

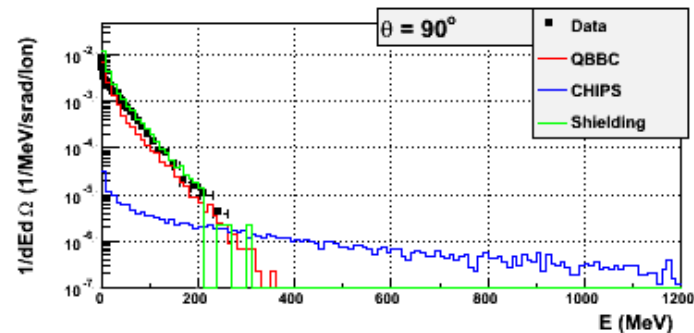
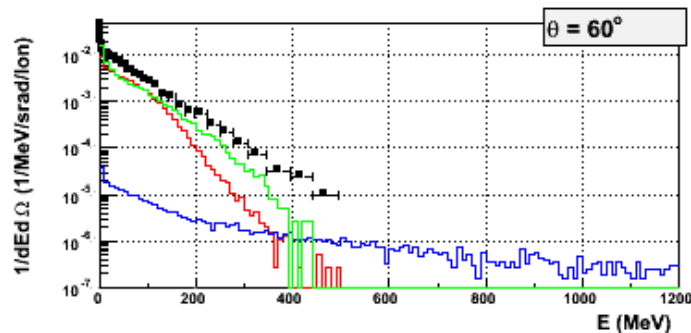


Steps in BICion

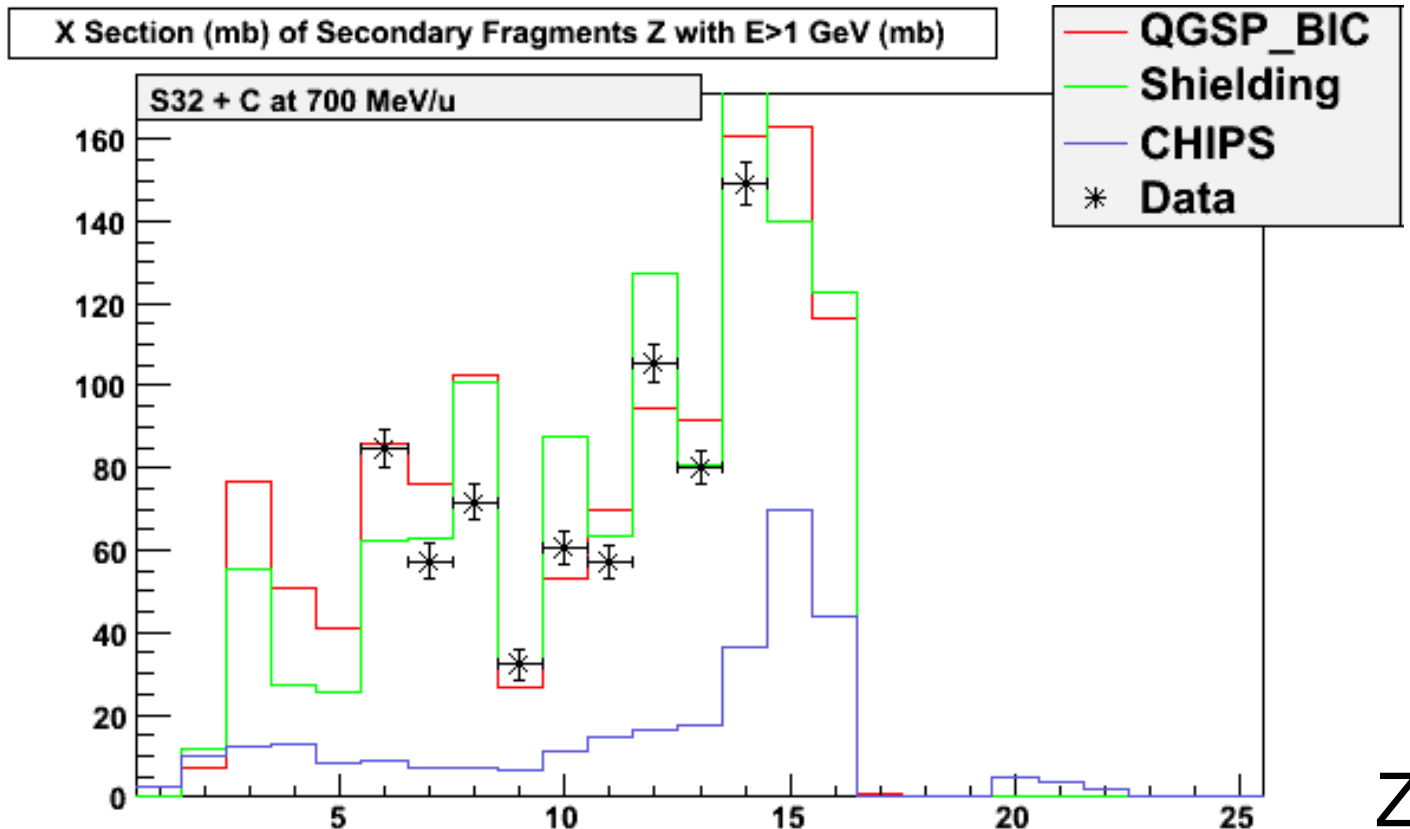
THICK TARGET NEUTRON YIELD: AL(AR40,N) AT 400 MeV/U (G4.9.4)



Very typical -
below 200 MeV
models are wrong



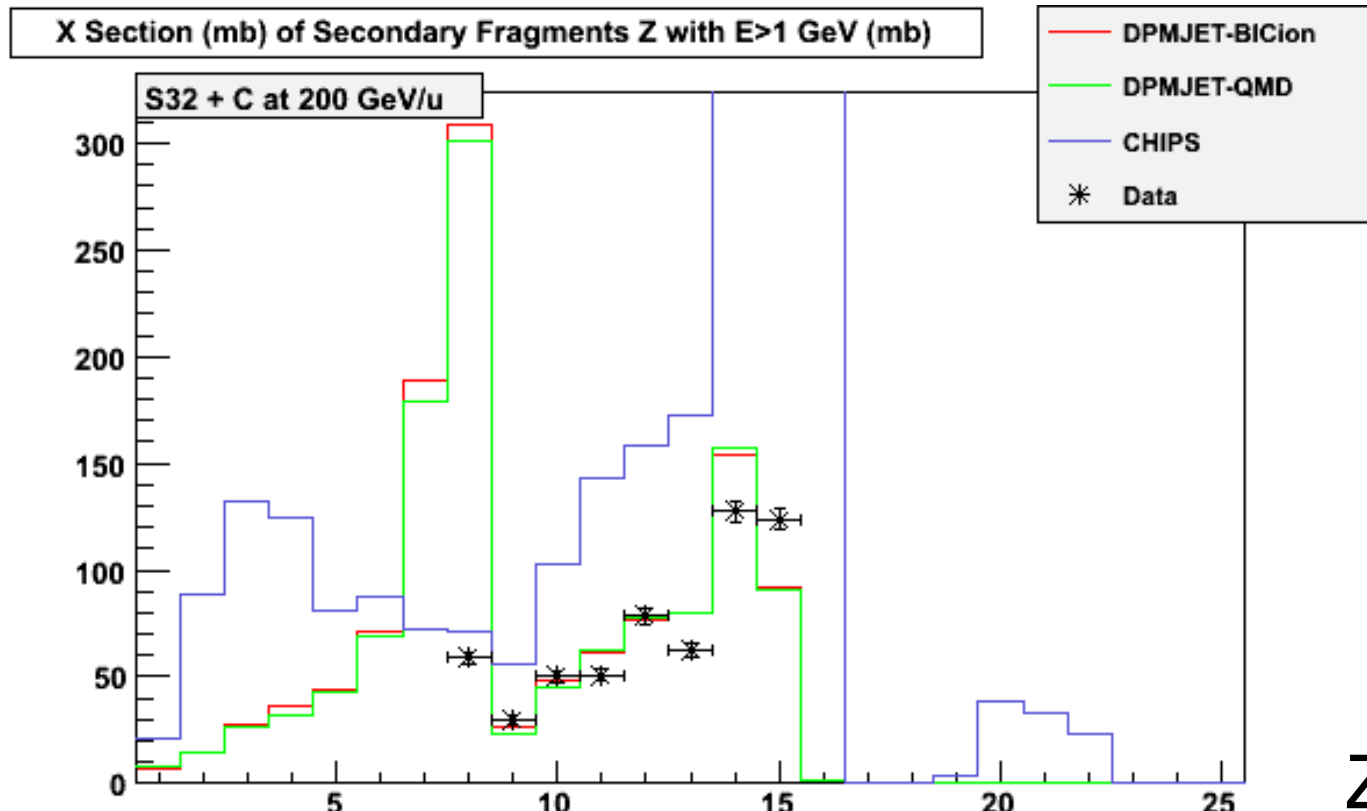
S32 ON CARBON AT 700 MEV/U (9.4.REF07)



Good fragmentation cross section modeling for both QGSP_BIC and QMD



S32 ON CARBON (15 MM) AT 200 GEV/U (9.4.REF07)



DPMJET reproduces with some precision fragments cross sections

CONCLUSIONS ION/ION MODELS

- BICion and QMD are stable and precise for energies 100 MeV/u - 10 GeV/u
- Problems below 50 MeV (Parallel session 4A)
- Nuclei's fragmentation (Parallel session 4A)
- DPMJET-II.5 model is precise for many targets at high energies, but has problems too
- FTF and CHIPS are expected to be an alternative for energies above 10 GeV/u

WHAT CAN BE DONE?

- Continue validation of models. Regular runs of tests and availability on the web?
- **Models improvements**
 - Problems in BICion
 - QMD profile at low energies
 - FTF, CHIPS and INCL are expected to be used
- **Ion/Ion Inelastic Cross Section improvements**
 - Only one cross section database is available