AccApp09 4-8 May 2009, Vienna (Austria)

Satellite Meeting on Spallation Reactions

Results obtained with PHITS

Japan Atomic Energy Agency

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Overview of PHITS

PHITS code

High-energy part

Bertini
INC

JAM
INC

JQMD
QMD

First stage model

GEM

De-excitation model

Nuclear data
JENDL-3.3, JENDL-HE, ENDF-B/VI, LA150, …..

Low-energy part

Process for benchmark analyses

- Survey

  examine the contents of target and detector information.
  target: material, size (thickness and width), density.
  detector: size, angle, distance.

- Calculate

  perform the calculations

- Check

  compare calculation results to experimental data.

⇨ We hope to pursue incorporation of information on target and detectors into EXFOR.

Results of neutron DDXs

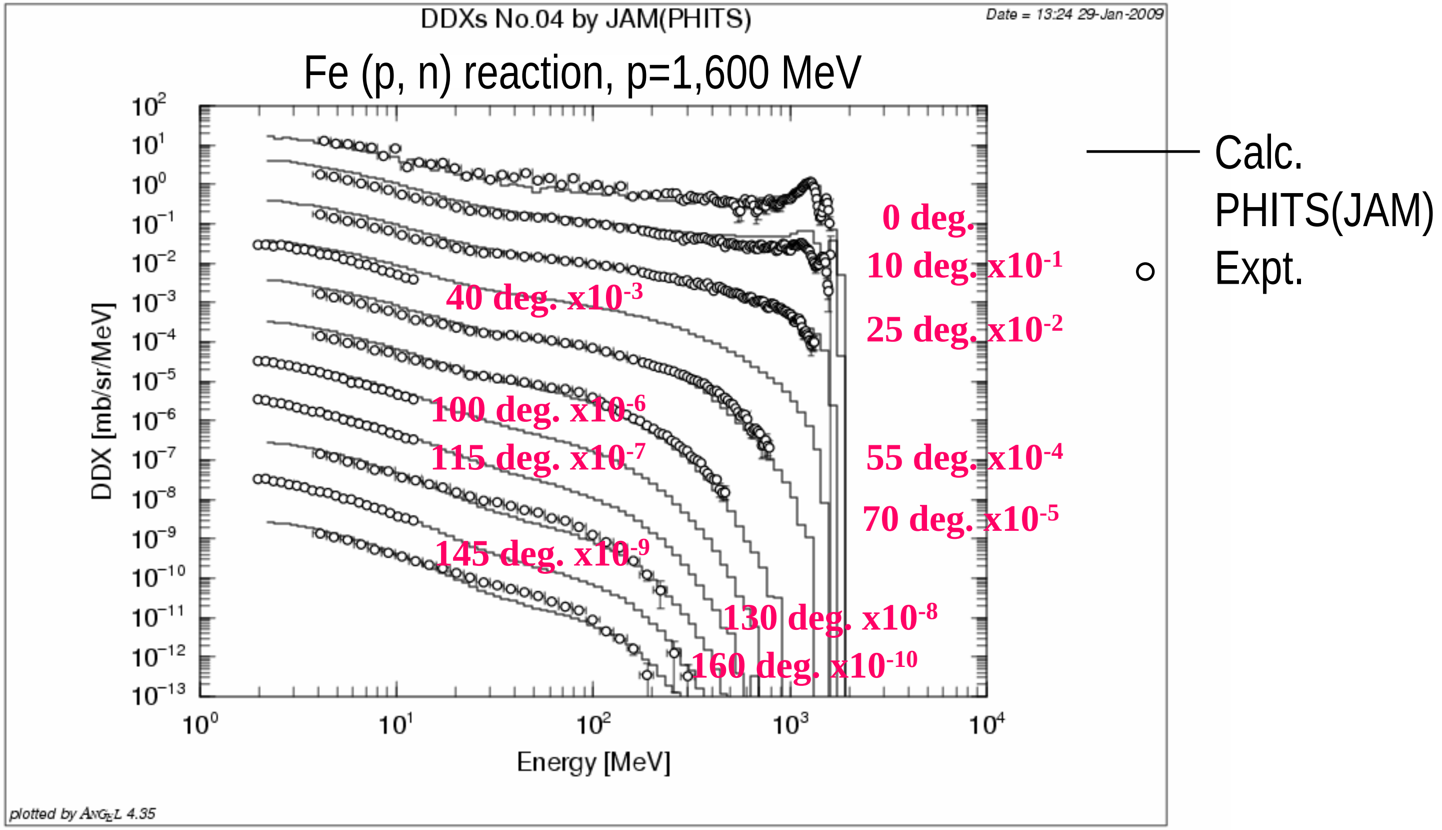


Figure 1 neutron DDX for Fe target bombarded with 1600 MeV protons

Expt.: S. Leray et al., PRC 65 (2002) 044621

Summary of neutron DDXs

- Bertini and JAM calculations were performed.
- Calculation results obtained using these code were compared to the experimental data, which were in good agreement within a factor of two on the whole.

Results of neutron multiplicity

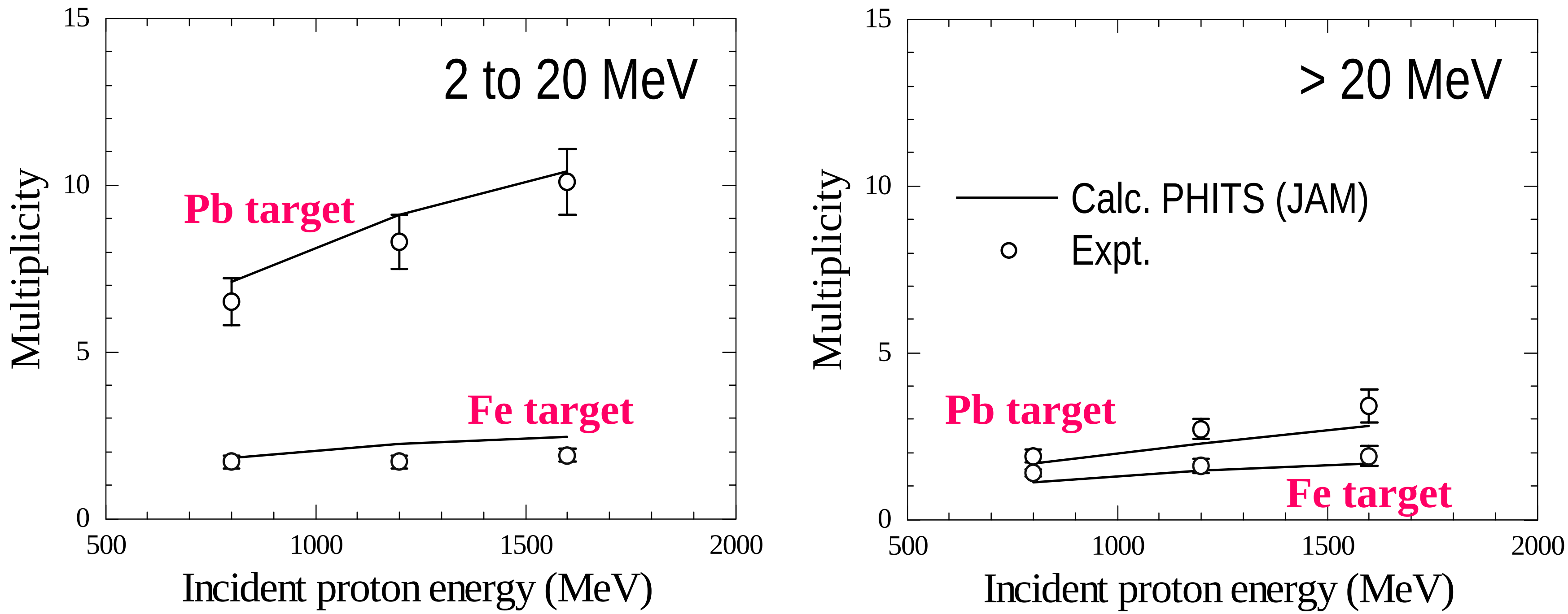
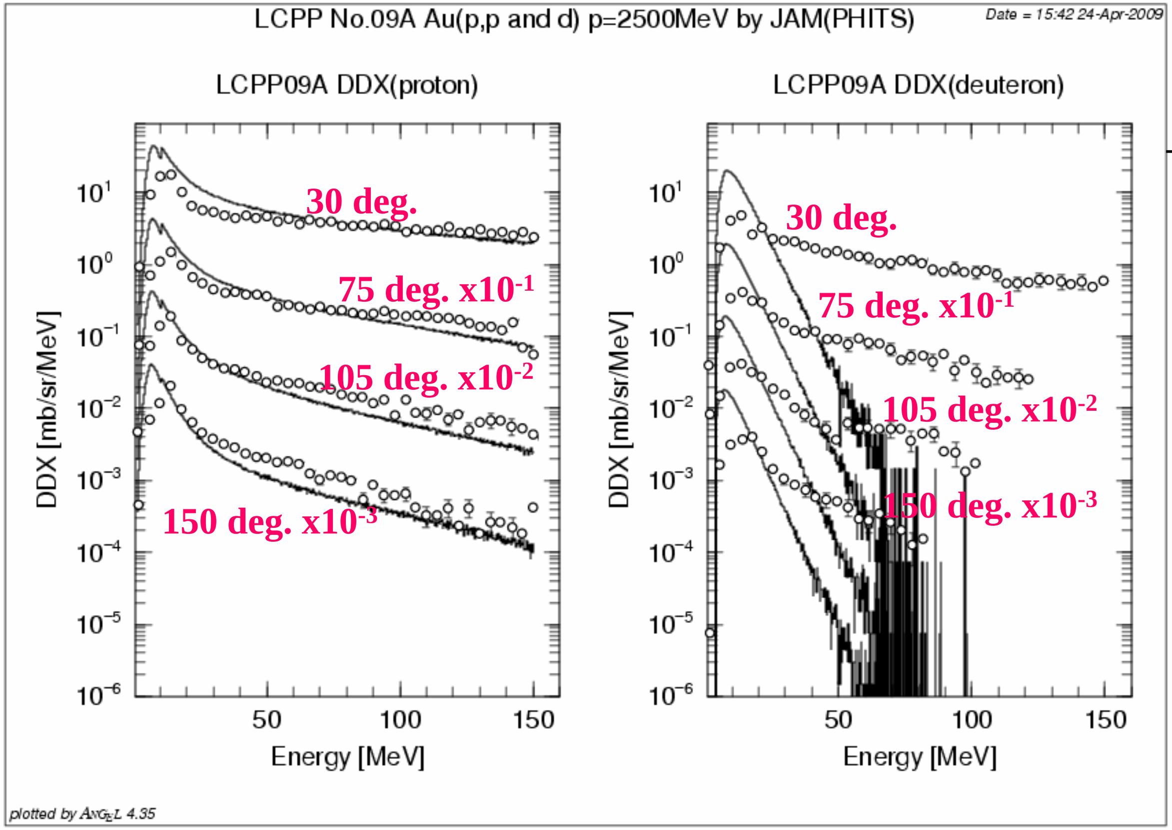


Figure 2 neutron multiplicity distributions for Fe and Pb target bombarded with 800, 1200 and 1600 MeV protons

Summary of neutron multiplicity

- Calculations of neutron multiplicity distributions were done by using the Bertini, JAM and JQMD code.
- These calculations tend to be smaller than the experimental value in the >20 MeV. In constants, the calculations are larger than the experiments from 2 to 20 MeV.

Results of p, d, t, ^{3}He and α DDXs



Calc.

—— PHITS (JAM)

○ Expt.

Figure 3 proton and deuteron DDX for Fe target bombarded with 1600 MeV protons

Summary of p, d, t, ^{3}He and α DDXs

- Calculation results using Bertini, JAM and JQMD for proton DDXs were agreed with the experimental value within a factor of tree on the whole.
- These code could not reproduce the experimental data for the other light charged particles (d, t, ^{3}He and α).

Results of excitation functions

ground-state & independent

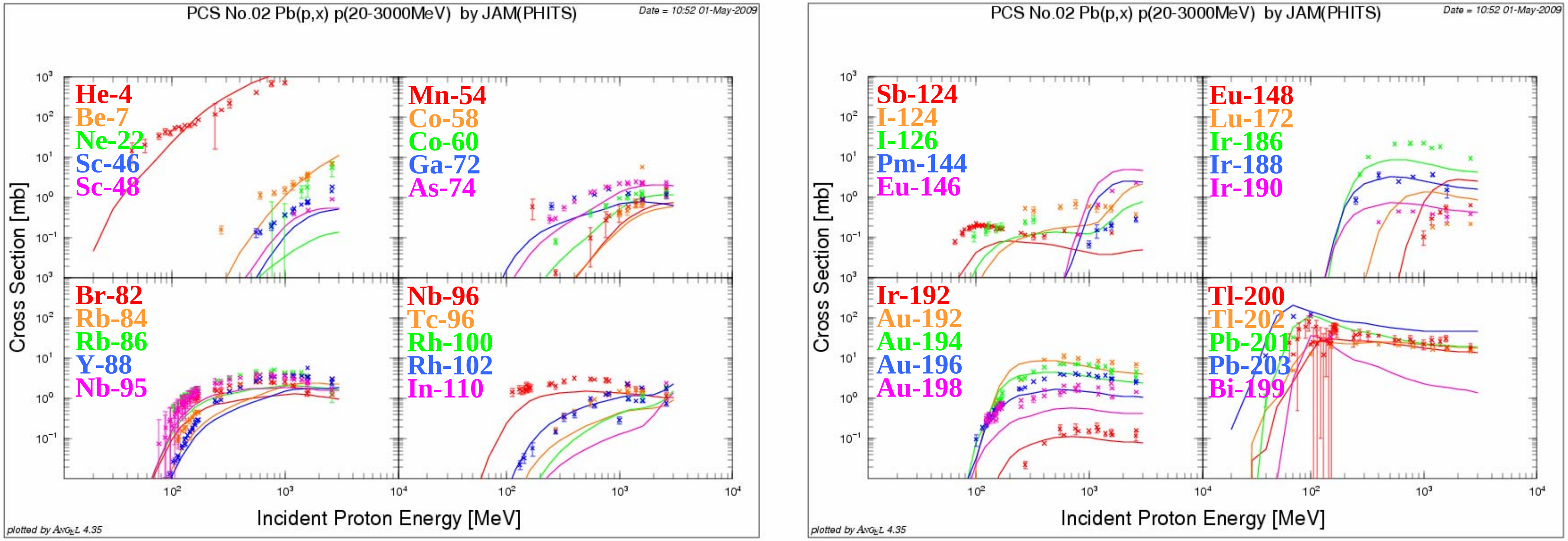


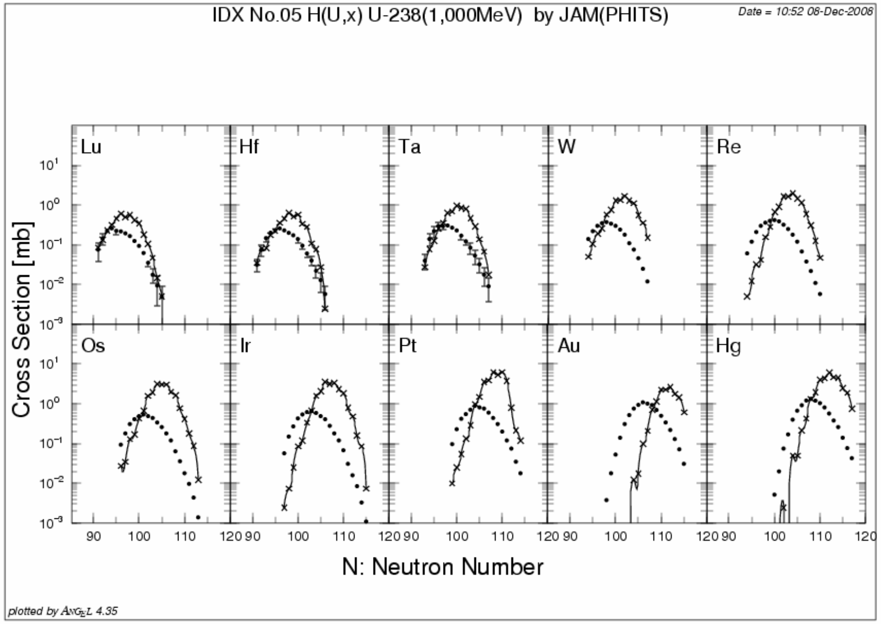
Figure 4 excitation functions for Pb target bombarded with 20 to 3000 MeV protons

Summary of excitation functions

- Calculations by Bertini and JAM were performed.
- Comparisons between the calculation results obtained by Bertini and JAM code and experimental data were in good agreement on the whole.

Results of isotopic distribution CS

Isotopic distribution cross-section in inverse kinematics



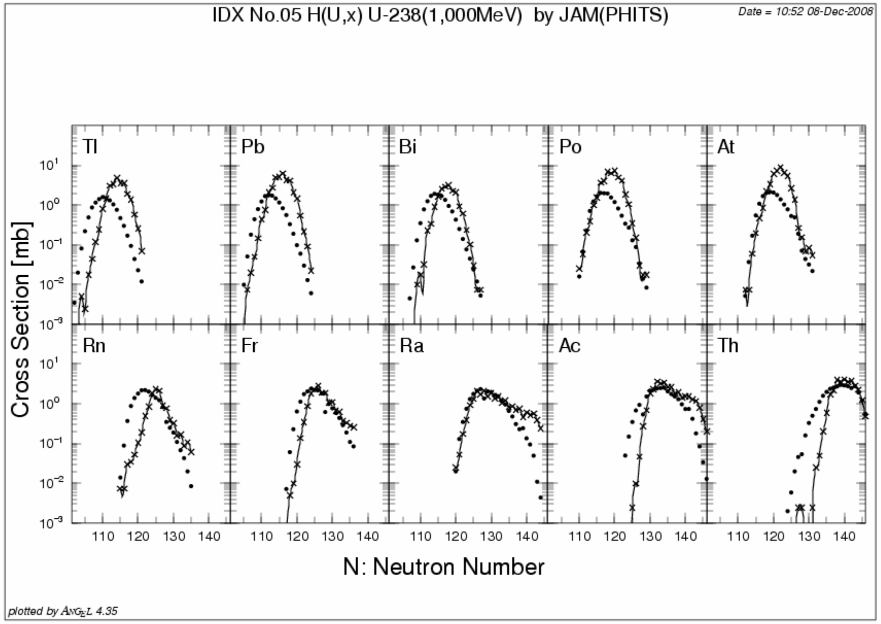


Figure 5 isotopic distribution CS for U-238 target bombarded with 1000 MeV protons

Summary of isotopic distribution CS

- Calculations of isotopic distribution cross-section in inverse kinematics were performed using the Bertini, JAM and JQMD code.
- On the whole, calculation value were agreed well with the experimental value.

Results of pion DDXs

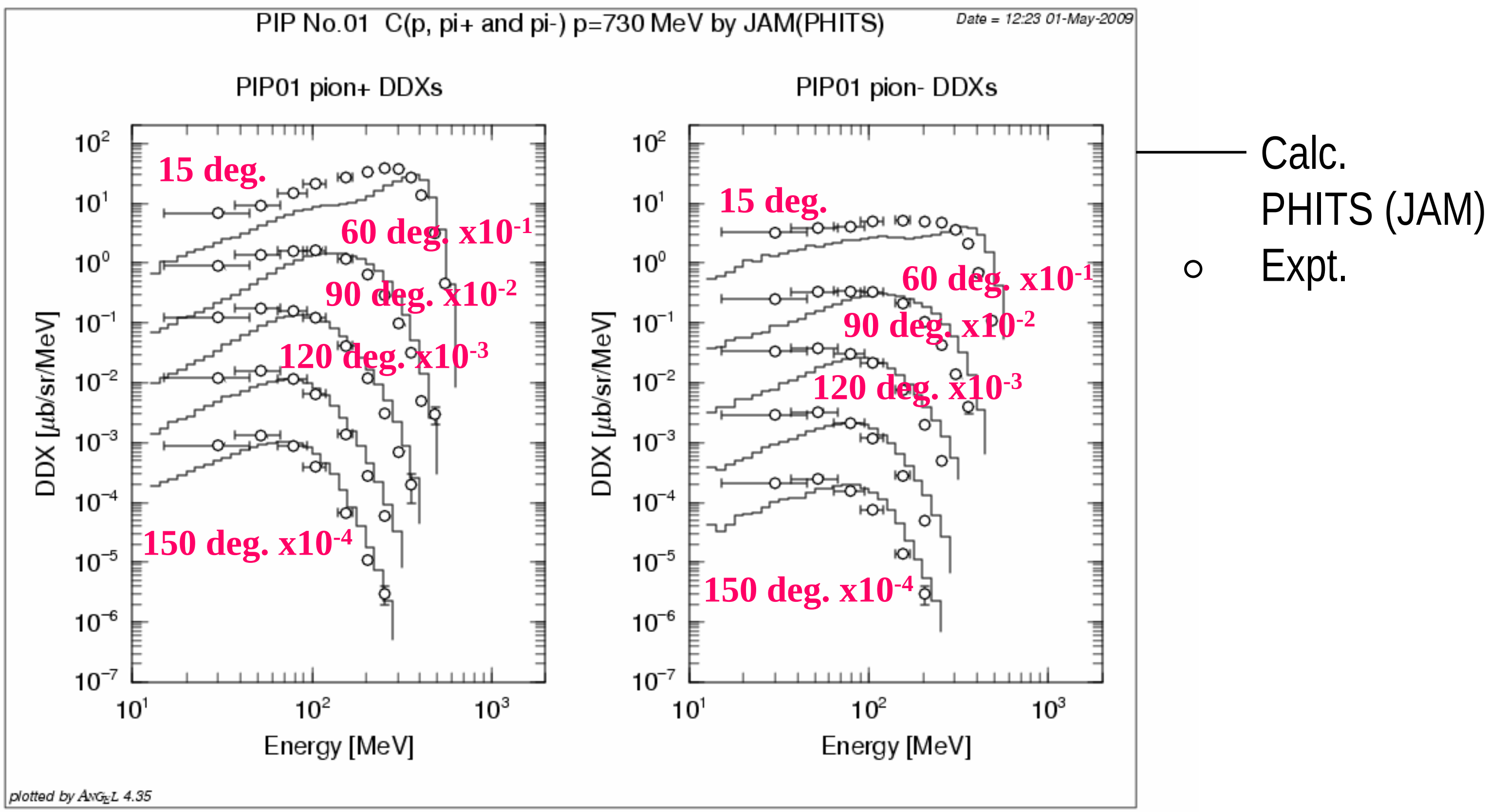


Figure 6 pion DDX for C target bombarded with 730 MeV protons

Summary of pion DDXs

- Bertini and JAM calculations were done.
- Results for pion production DDXs obtained these code were in good agreement with the experimental data within a factor of two at pion energies above 100 MeV. On the other hand, the results tend to be lower than the experiments blow 100 MeV.

Summary

- Benchmark calculations were done using the PHITS (Bertini, JAM and JQMD) code.
- Almost calculations agreed with the experimental data, except for d, t, ^{3}He and α emission.

- There was not enough time.
- I hope to get the information about the target and detectors simply by reading the EXFOR.