Recent Verifications in MARS15

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Fermilab

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OUTLINE

- Benchmarking Stages
- Inclusive Nucleon Production
- Inclusive Pion and Kaon Yields
- Nuclide Yields and Heavy-Ions
- Thick Target Yields for Heavy Ions
- Coulomb Scattering
- Three KEK Experiments with 12-GeV protons
- Photo-Neutron Yields
- 120-GeV CERF Experiment at CERN

Code Benchmarking

1. **Debugging:** Code should calculate what is supposed to calculate
2. **Validation:** Results should agree with established (analytic) result for specific cases
3. **Comparison:** Two codes should agree if the model is the same
4. **Verification:** Code should agree with measurements

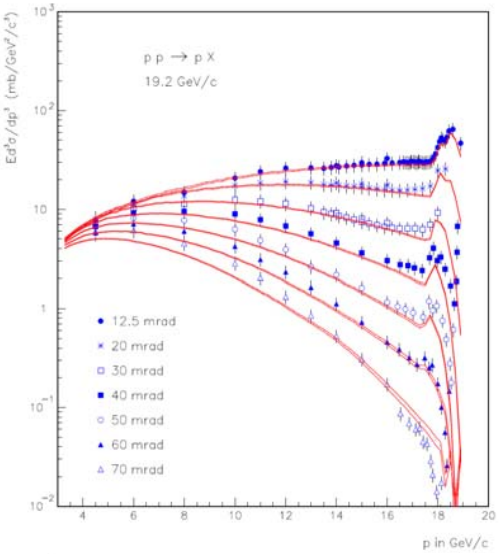
MARS15 Benchmarking

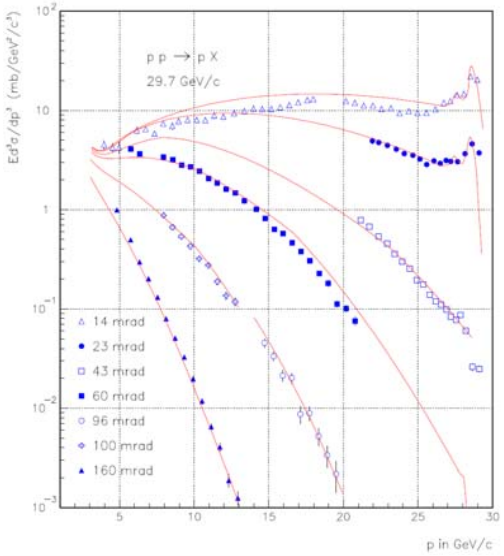
Debugging, validation and comparisons are done for the MARS code continuously once new model or algorithm is implemented, new problem is attacked, a colleague provides interesting results from his/her code.

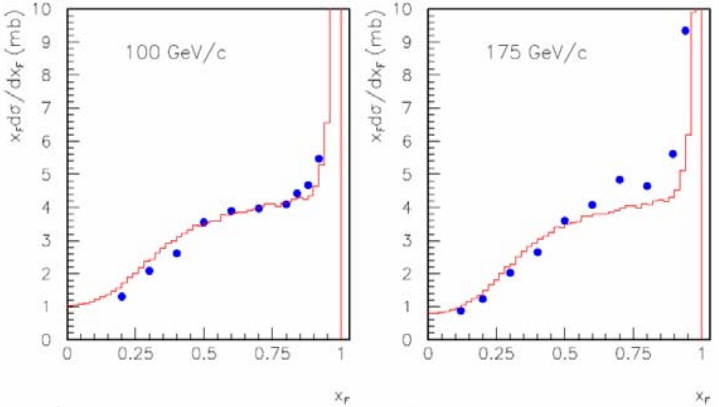
Numerous verifications were performed at Fermilab over last two decades in accelerator, shielding, targetry and detector applications.

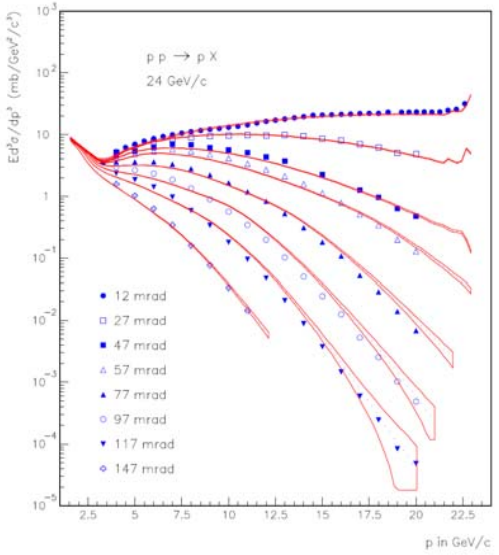
This talk is about very recent verifications.

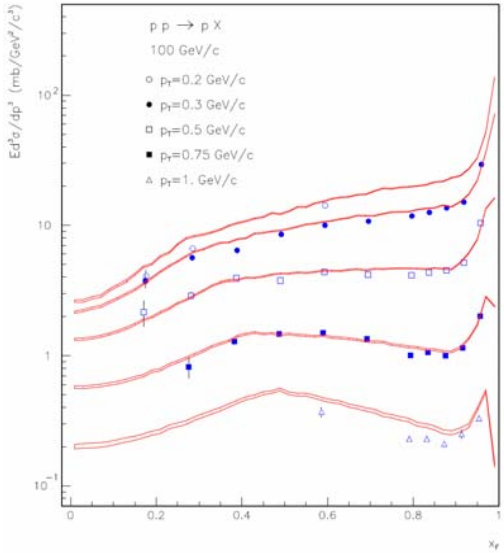
pp → pX at 19.2 to 21300 GeV/c



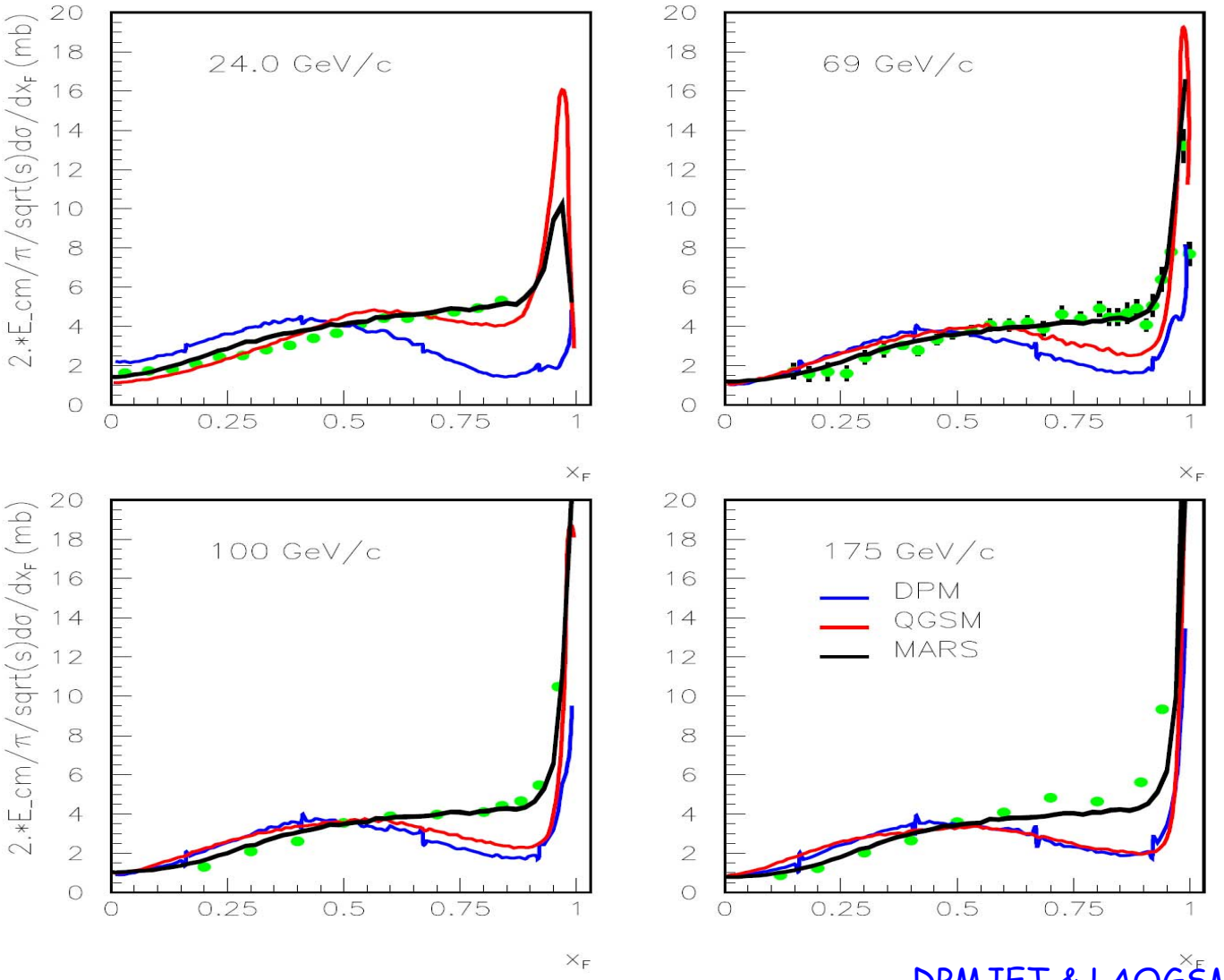






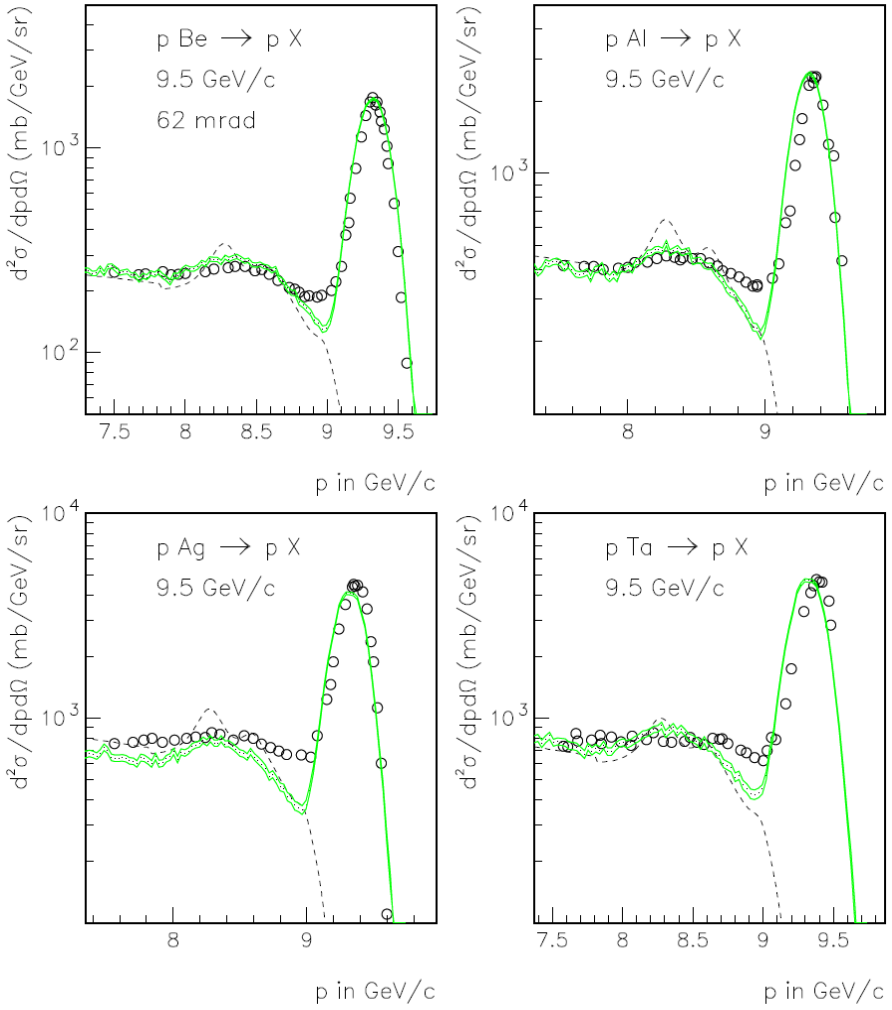


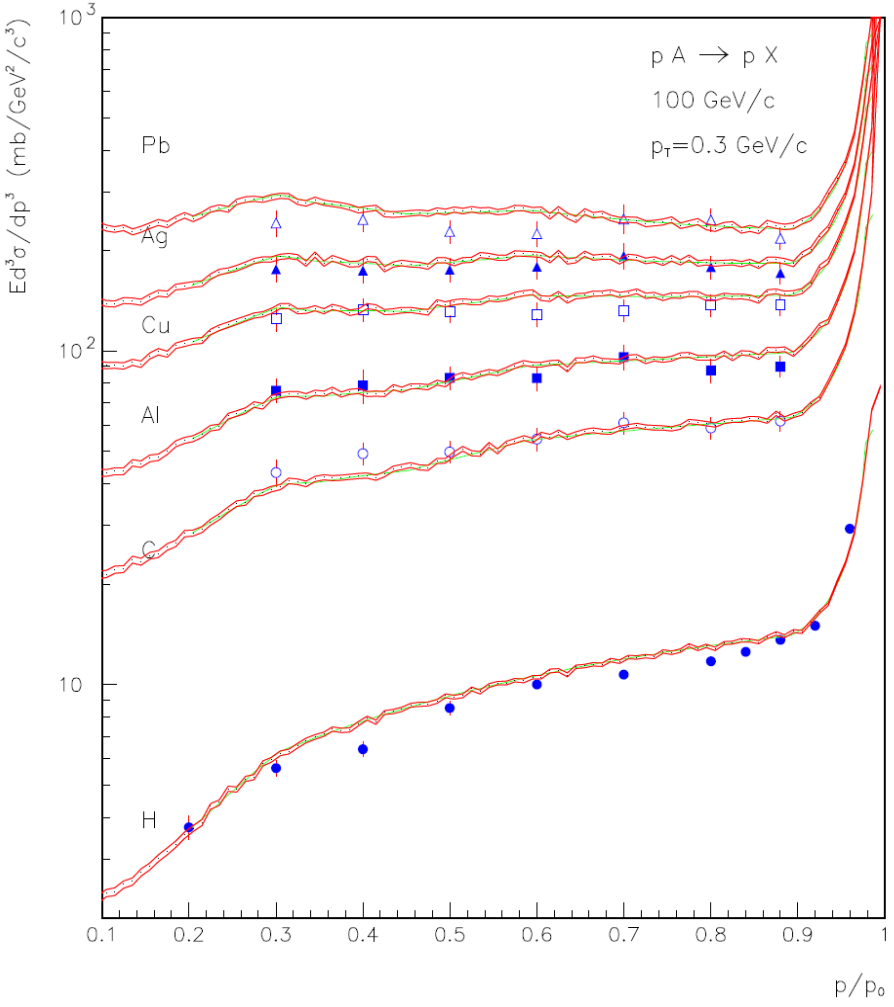
DPMJET, LAQGSM and MARS15 for pp → pX



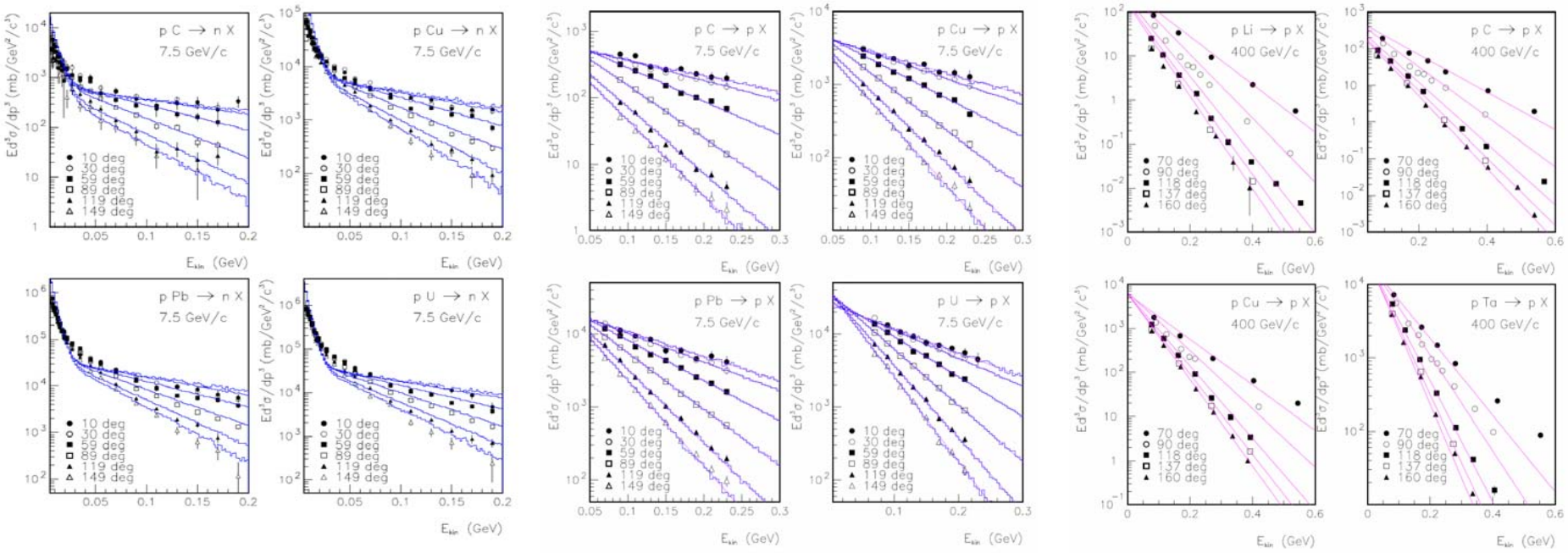
DPMJET & LAQGSM by M. Baznat

pA → pX at 9.5 and 100 GeV/c

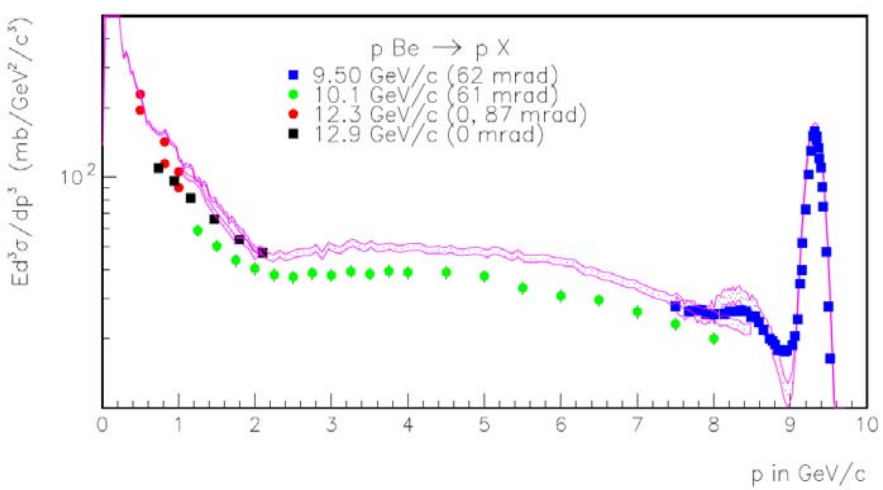


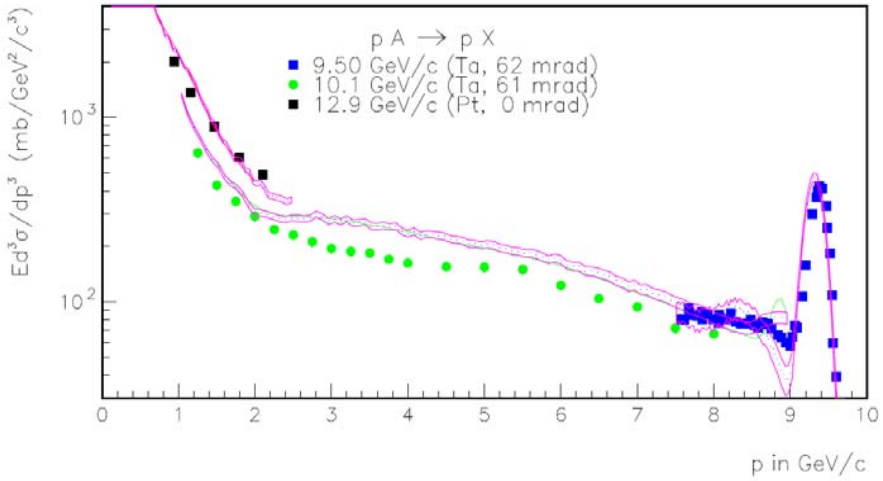


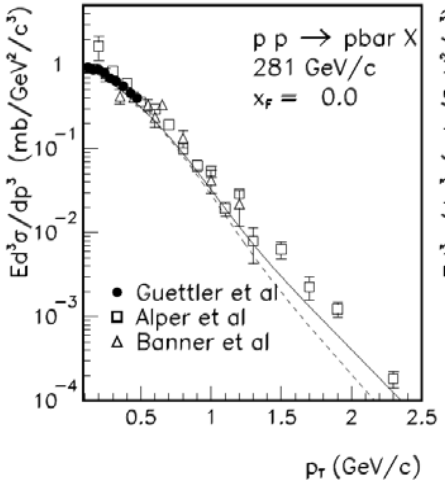
LOW-ENERGY NUCLEON PRODUCTION

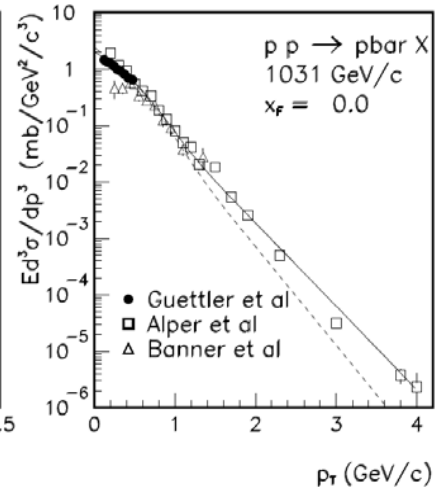


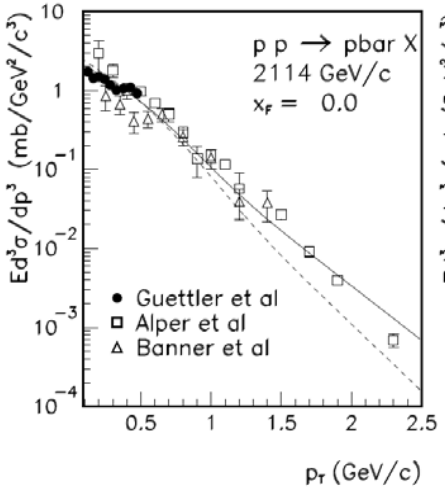
PROTON AND PBAR PRODUCTION

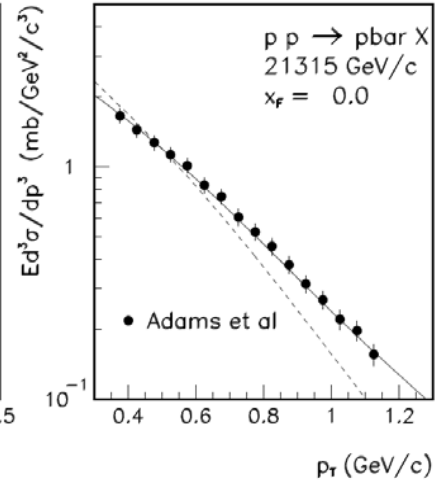




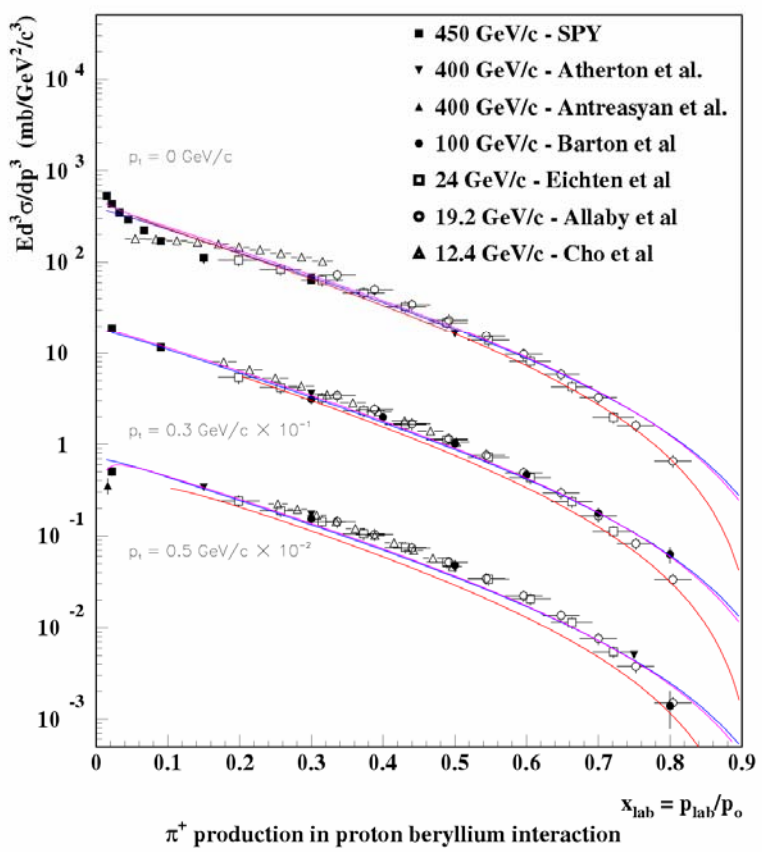




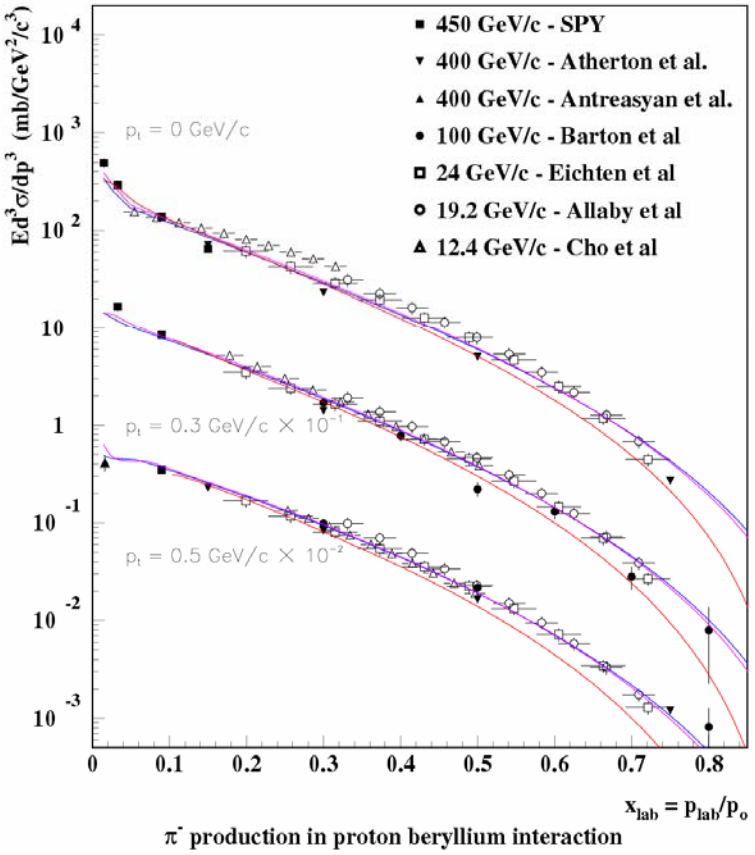




Pion Production on Beryllium at 12 to 450 GeV

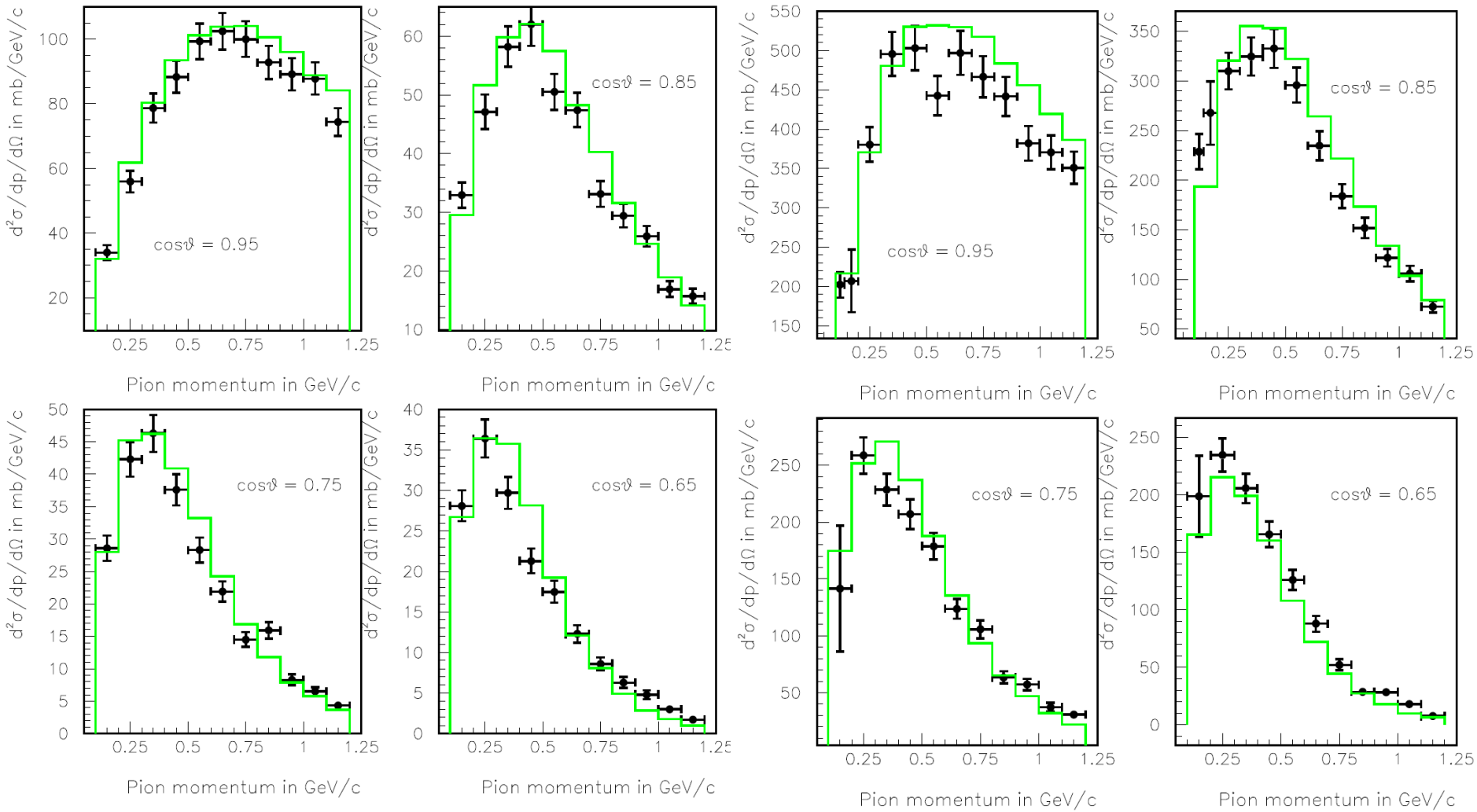


π^+ production in proton beryllium interaction



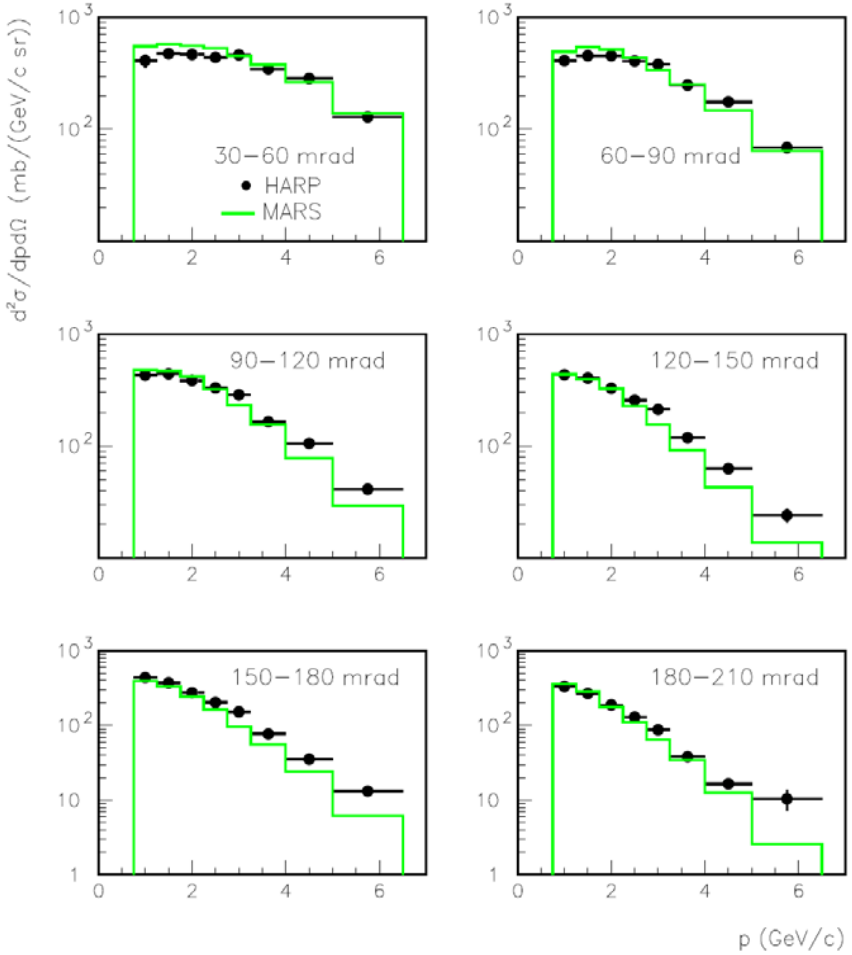
π^- production in proton beryllium interaction

MARS15 vs E910 Experiment for 12.3 GeV/c pA→ π^-

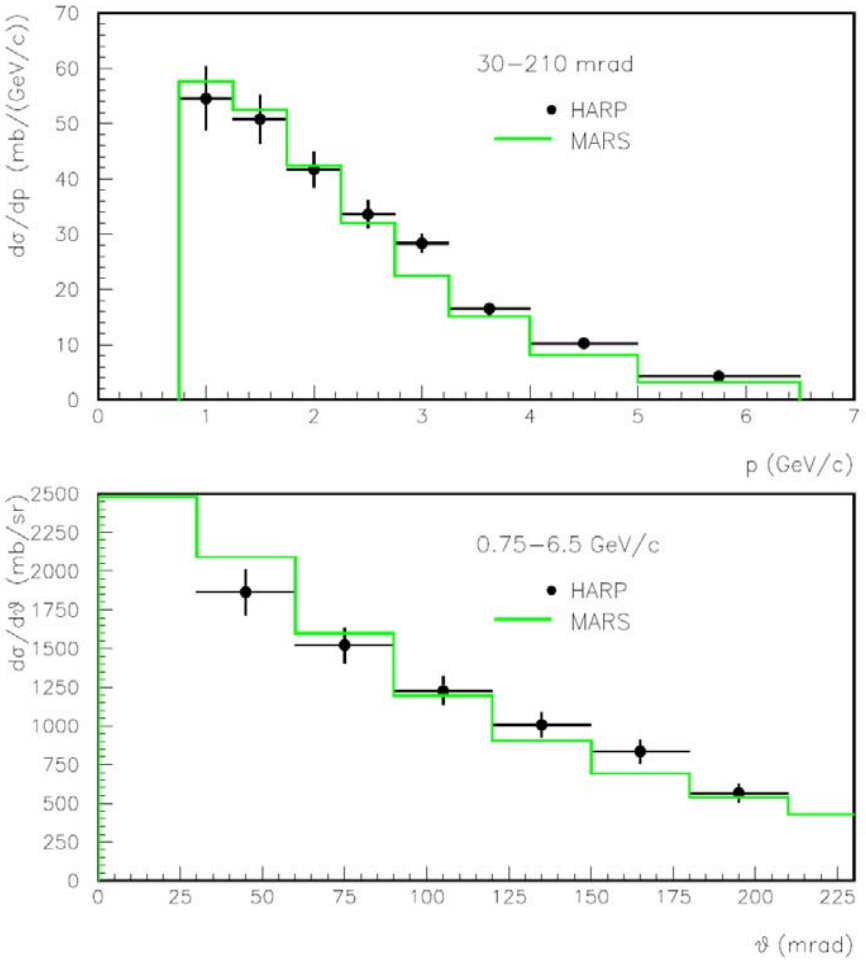


Beryllium **Copper**

MARS15 vs HARP for 12.9 GeV/c pAl → π^+

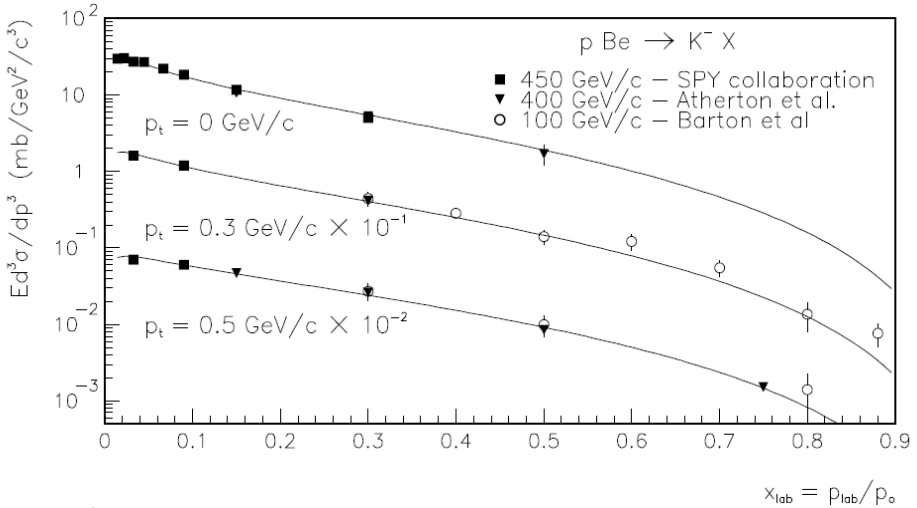


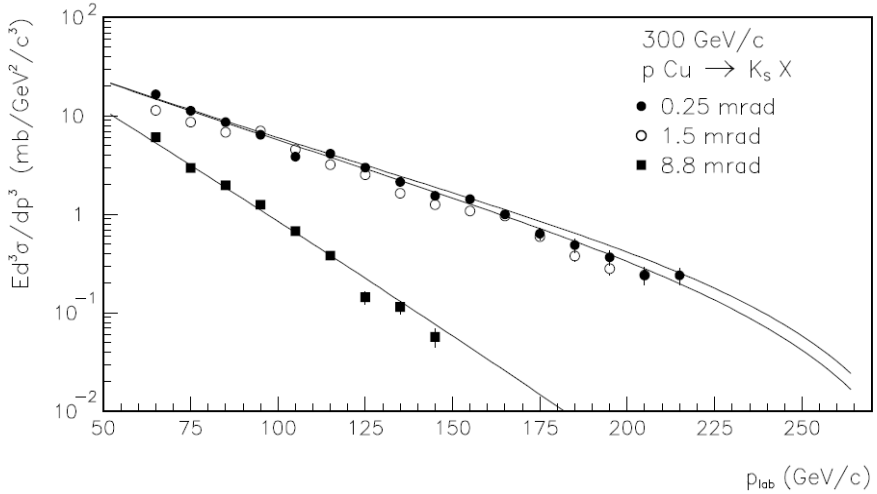
π^+ production in proton aluminum interaction at 12.9 GeV/c

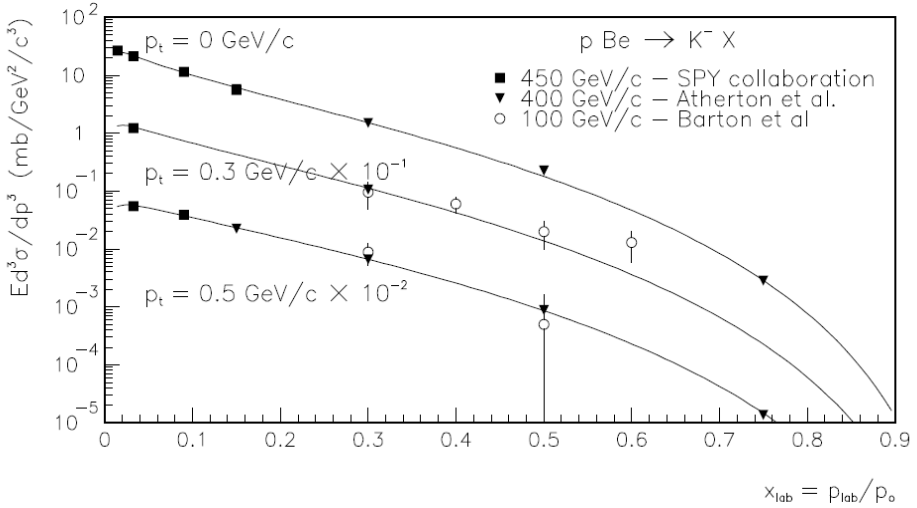


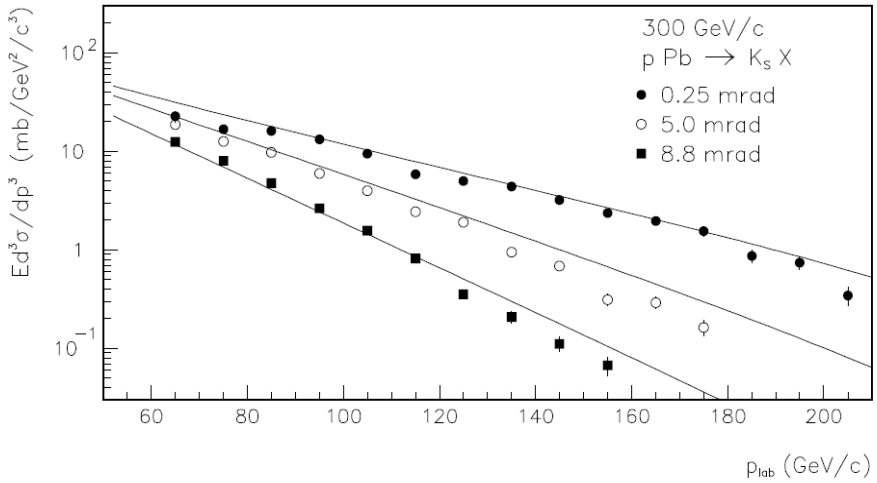
π^+ production in proton aluminum interaction at 12.9 GeV/c

K^- and K_s Production



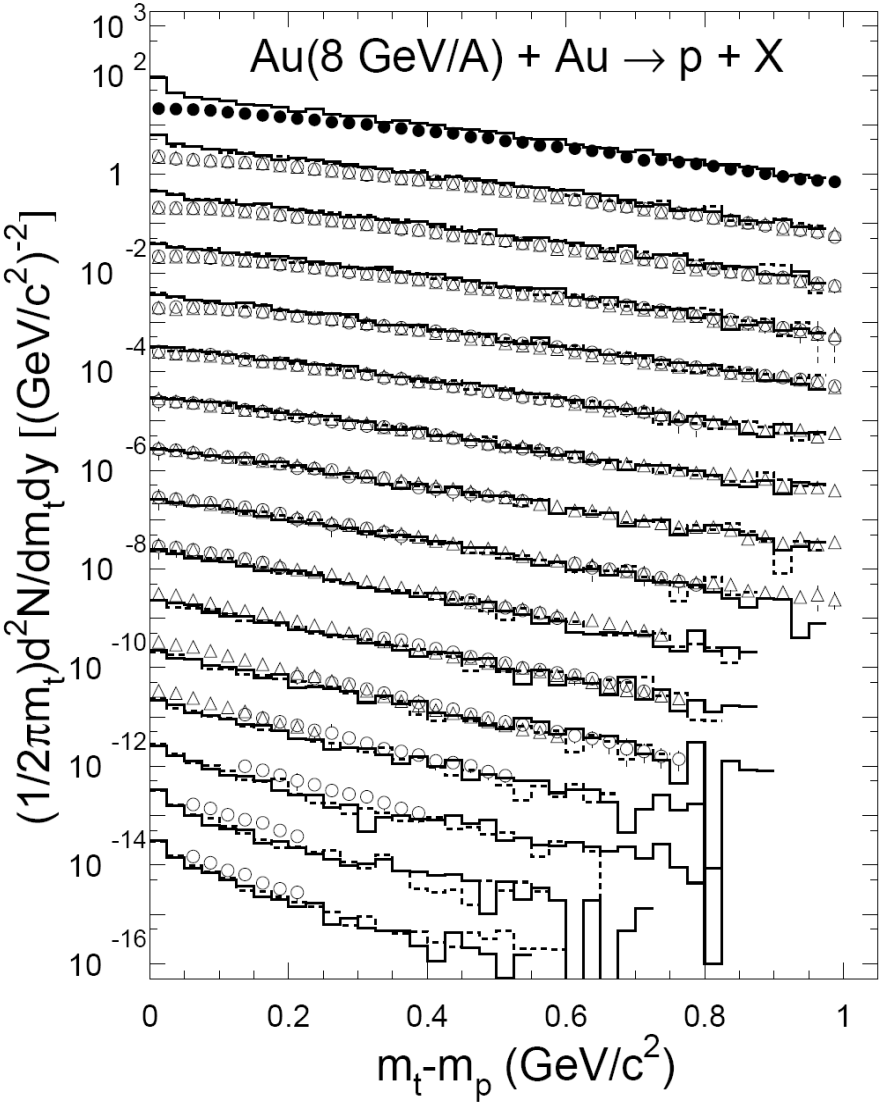


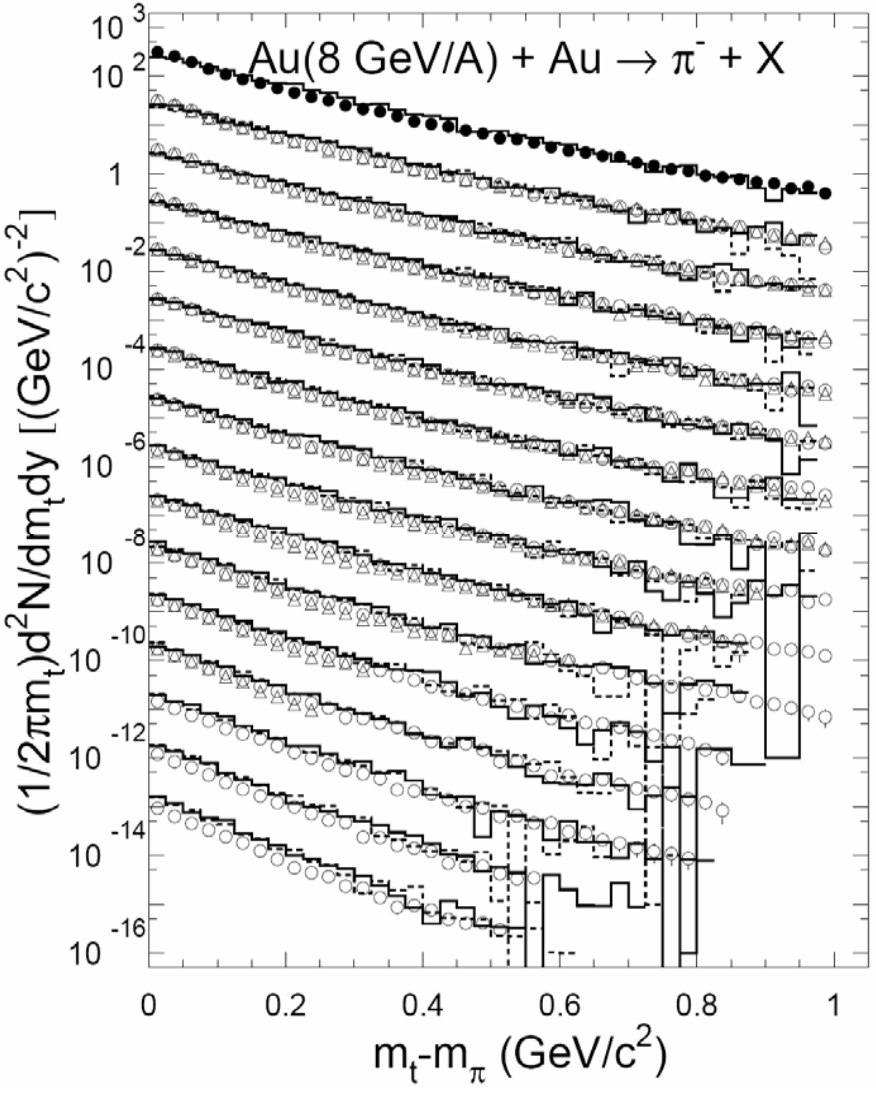




300 GeV/c p+Cu, Pb -> K_s

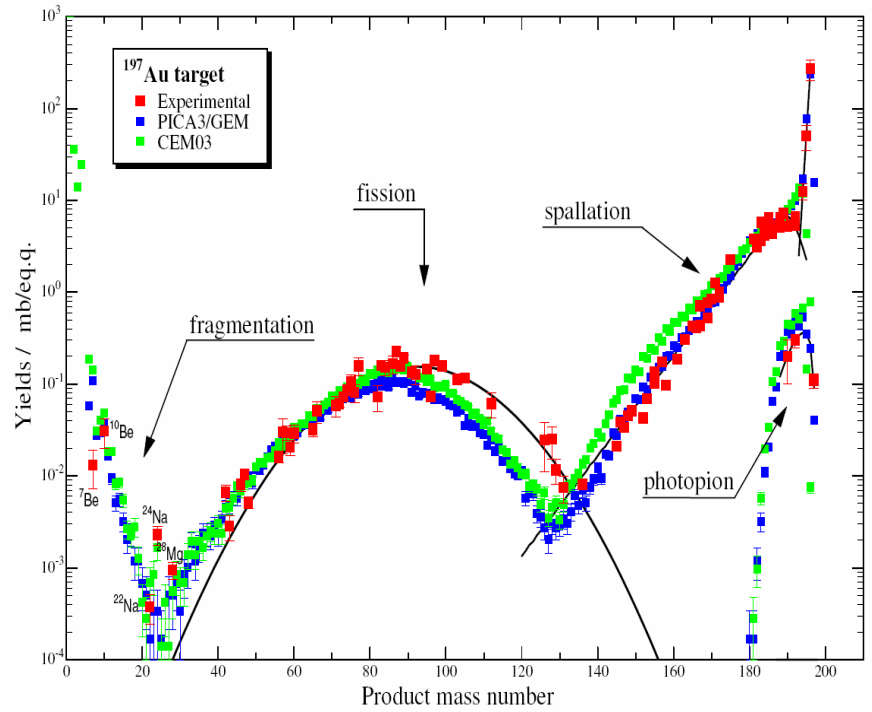
MARS15/LAQGSM03 for Au+Au at 8 GeV/A

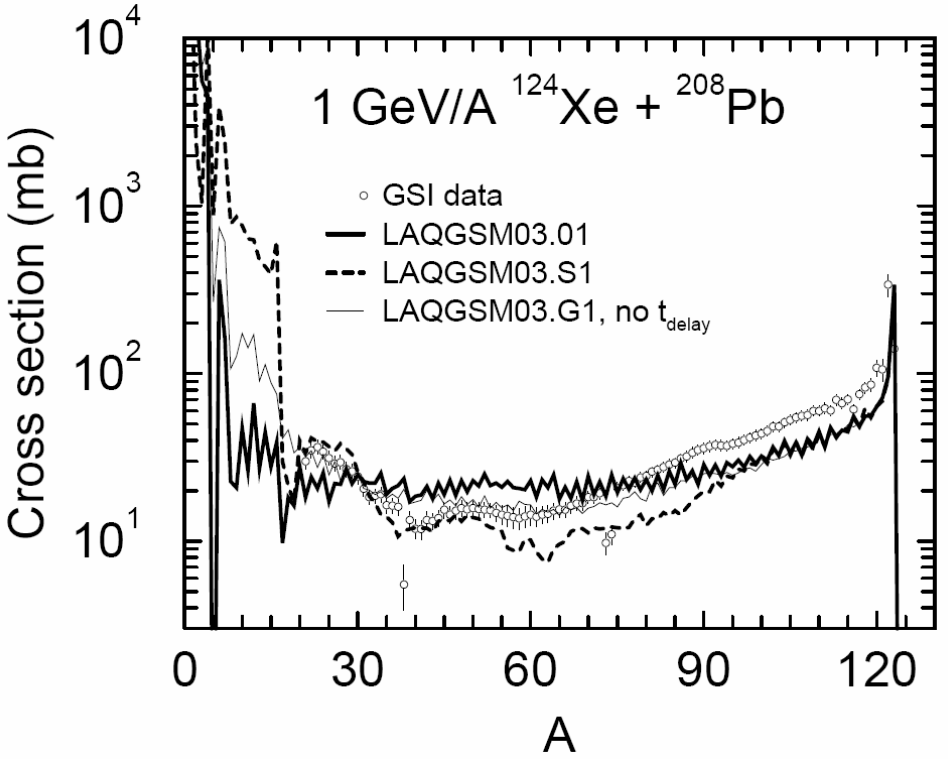




Nuclide Production

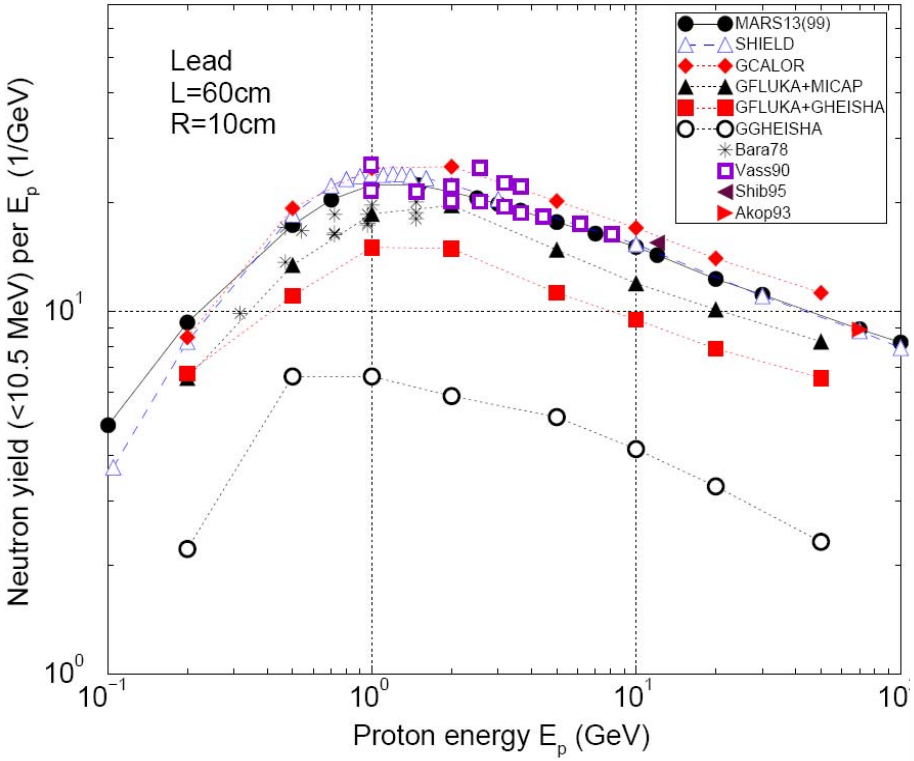
Bremsstrahlung (Emax=1 GeV) on gold

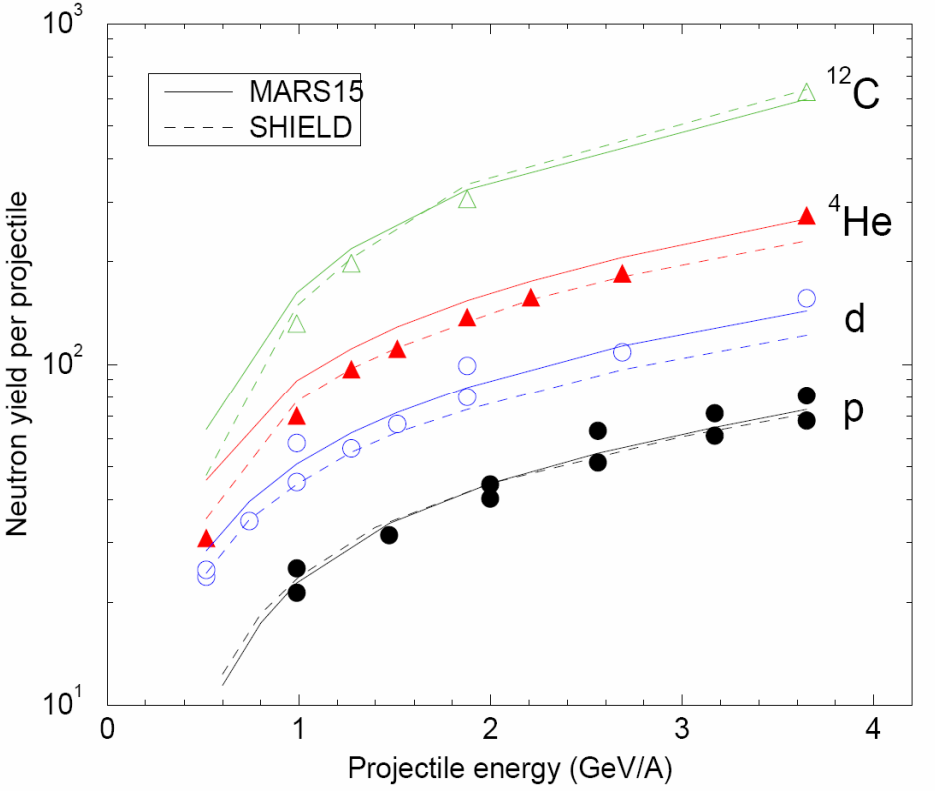




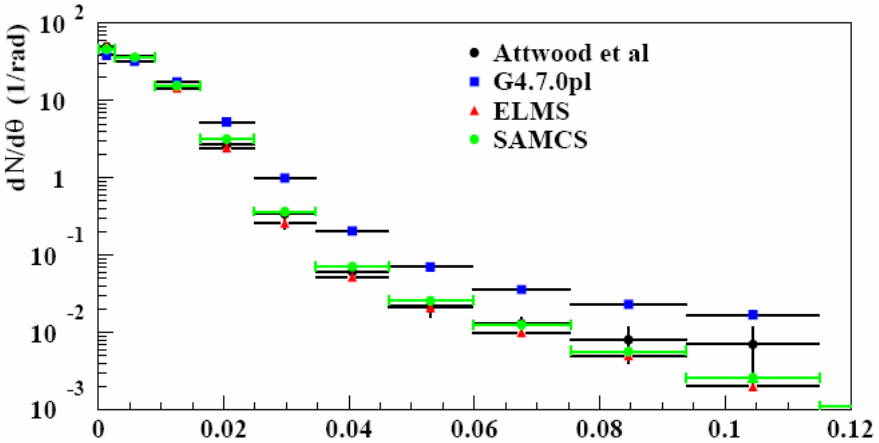
See comprehensive talk on CEM and LAQGSM by S. Mashnik

Neutron Yield from Lead Absorber for p, d, α and C

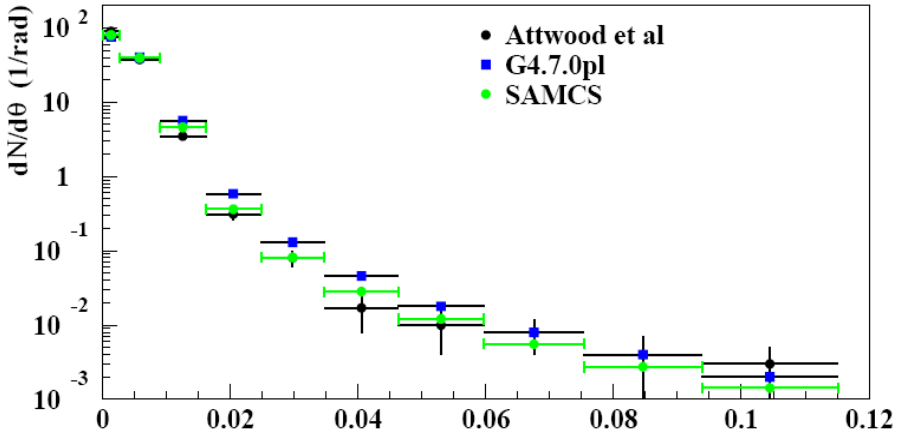




172 MeV/c Muon Coulomb Scattering: LH_2 and Li



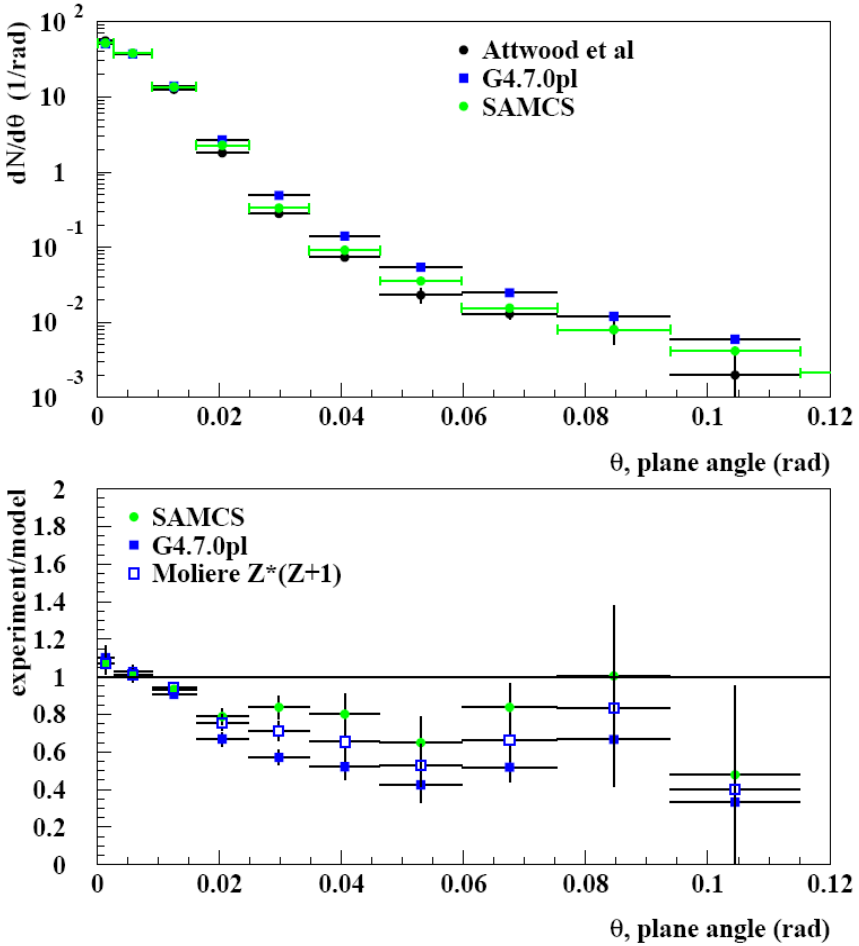
Angular distribution of 172 MeV/c muon after 109 mm of liquid hydrogen



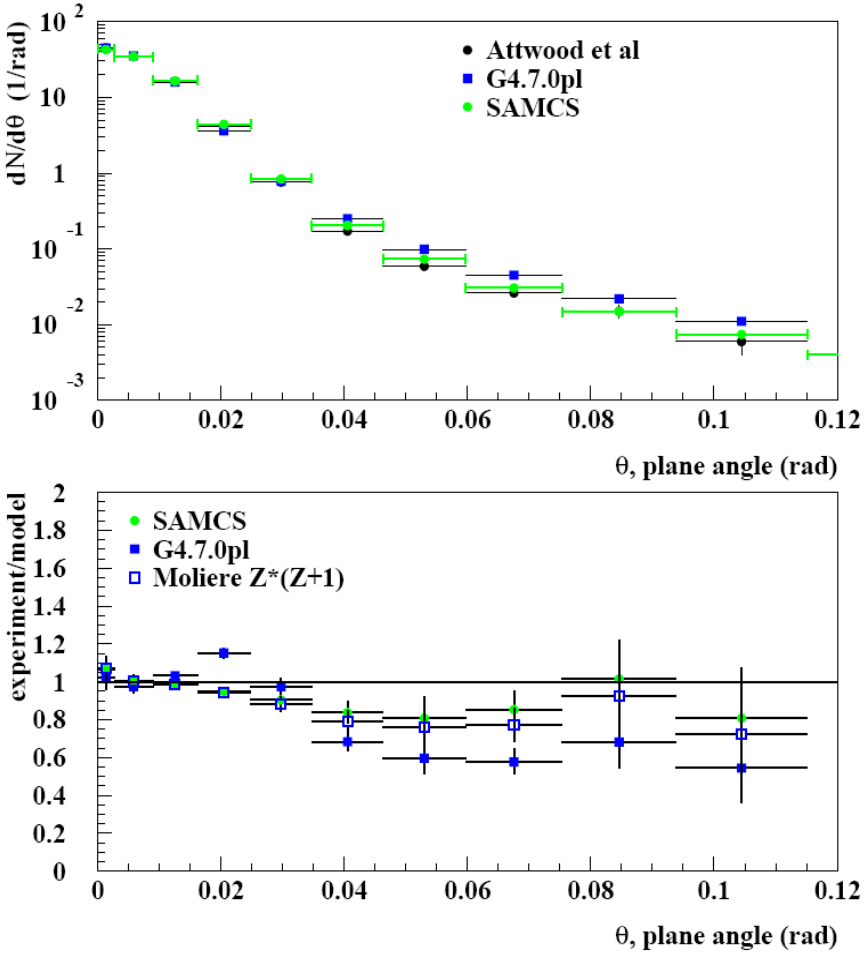
Angular distribution of 172 MeV/c muon after 6.415 mm of lithium

SAMCS by S. Striganov

172 MeV/c Muon Coulomb Scattering: CH_2 and Fe

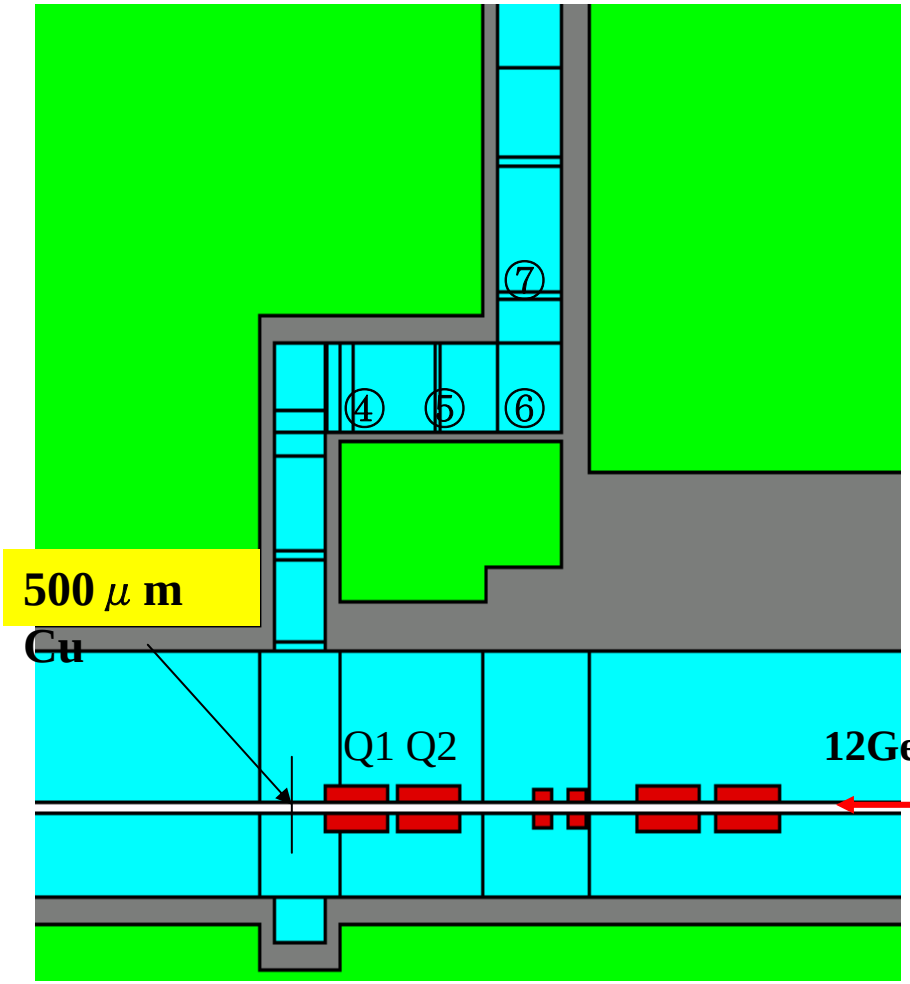


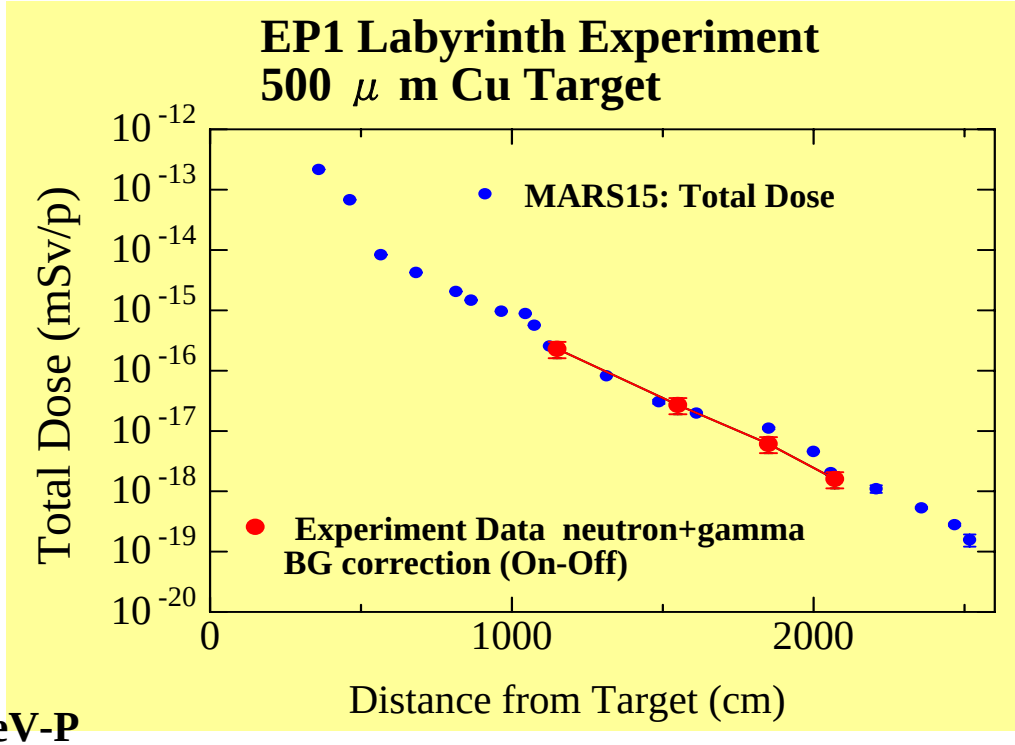
Angular distribution of 172 MeV/c muon after 4.74 mm of CH_2



Angular distribution of 172 MeV/c muon after 0.24 mm of iron

EP1 Labyrinth at KEK: 12-GeV p on Cu-Target





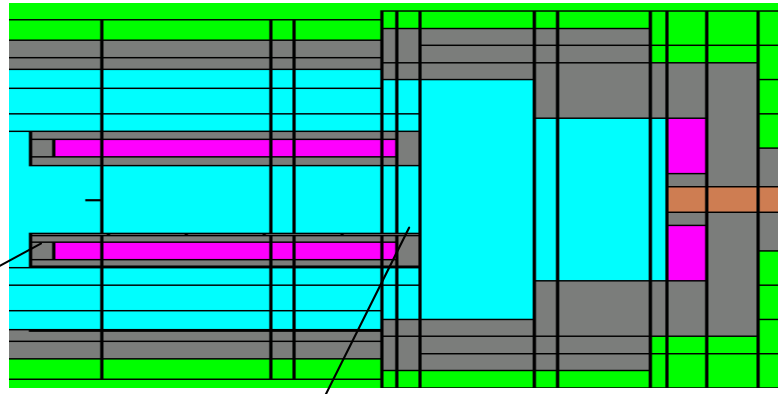
Courtesy: Takenori Suzuki

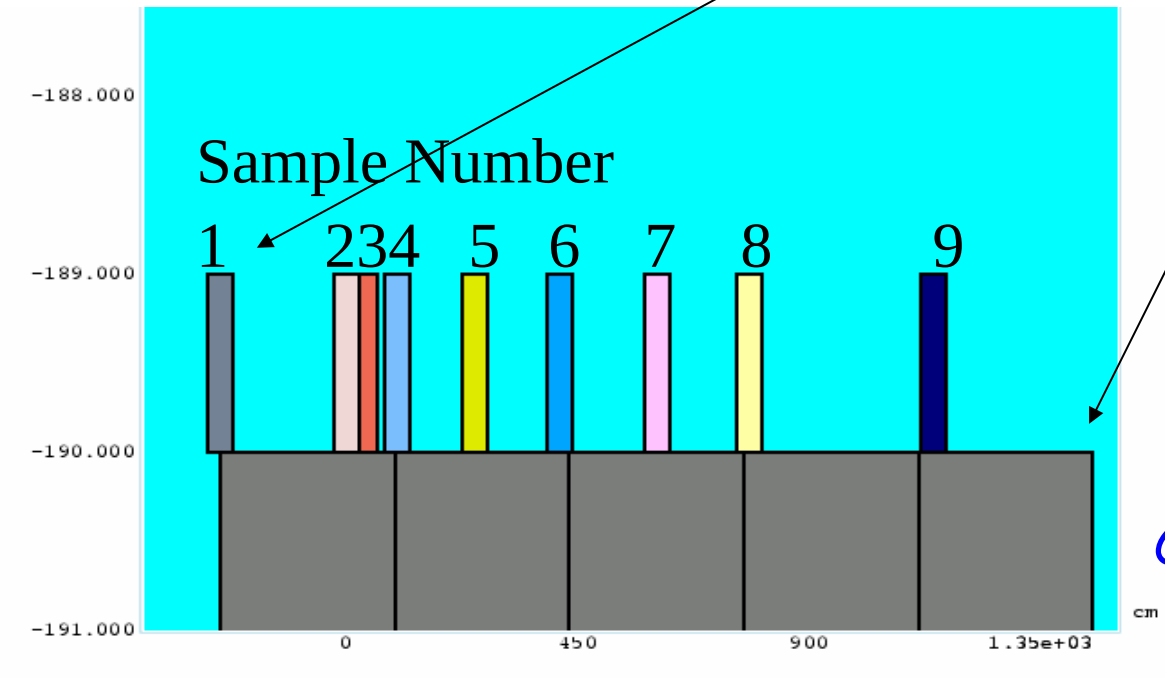
12-GEV Protons on K2K Target

Au sample : 50cmL × 50cmH

Experiment: 0.001cm thickness

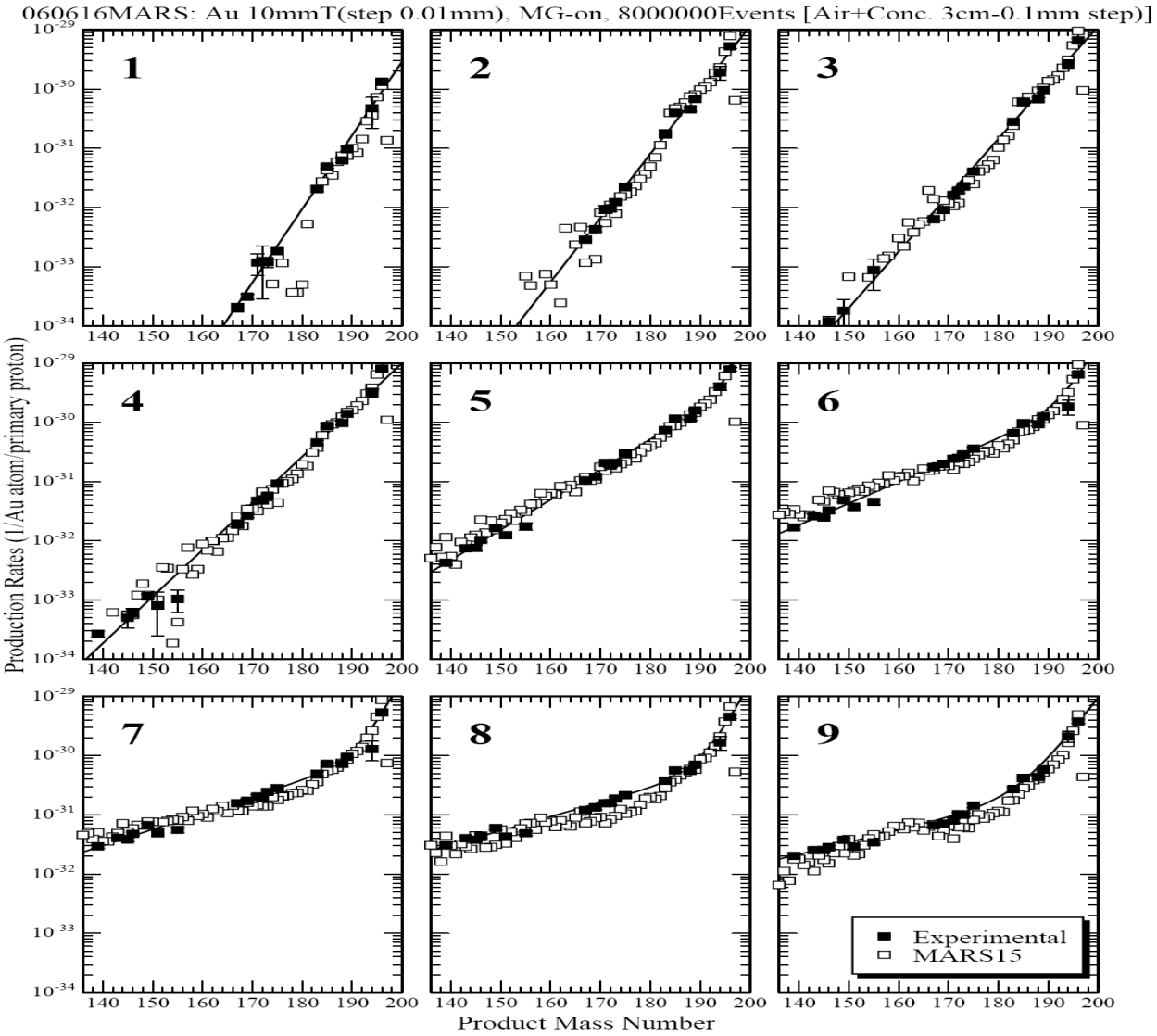
Calculation: 1cm thickness





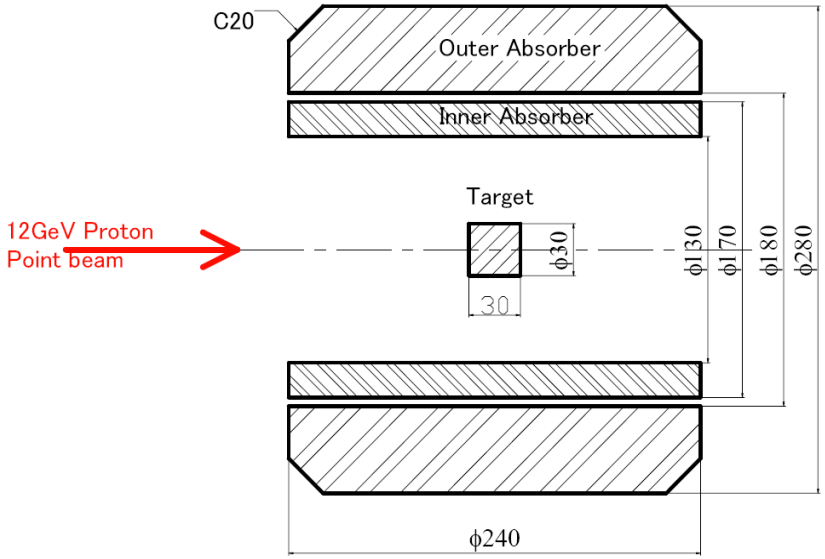
Courtesy: H. Matsumura

Foil Activation at K2K Target Station



Courtesy: H. Matsumura

12-GeV Protons on KEK Copper Target



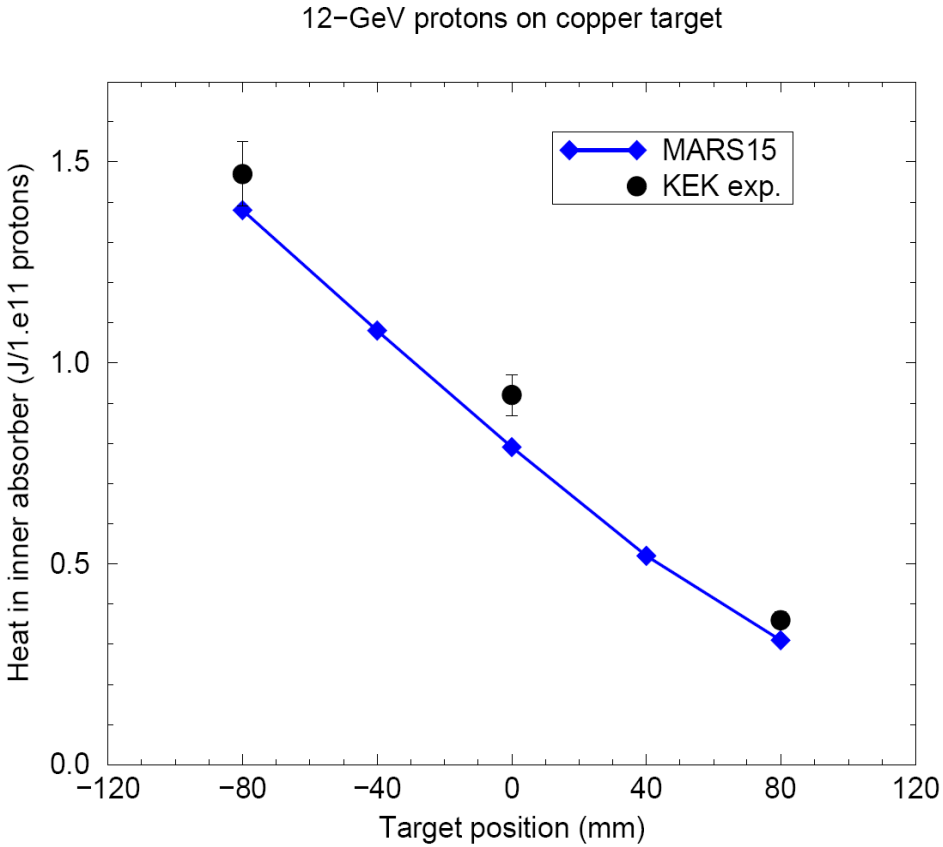
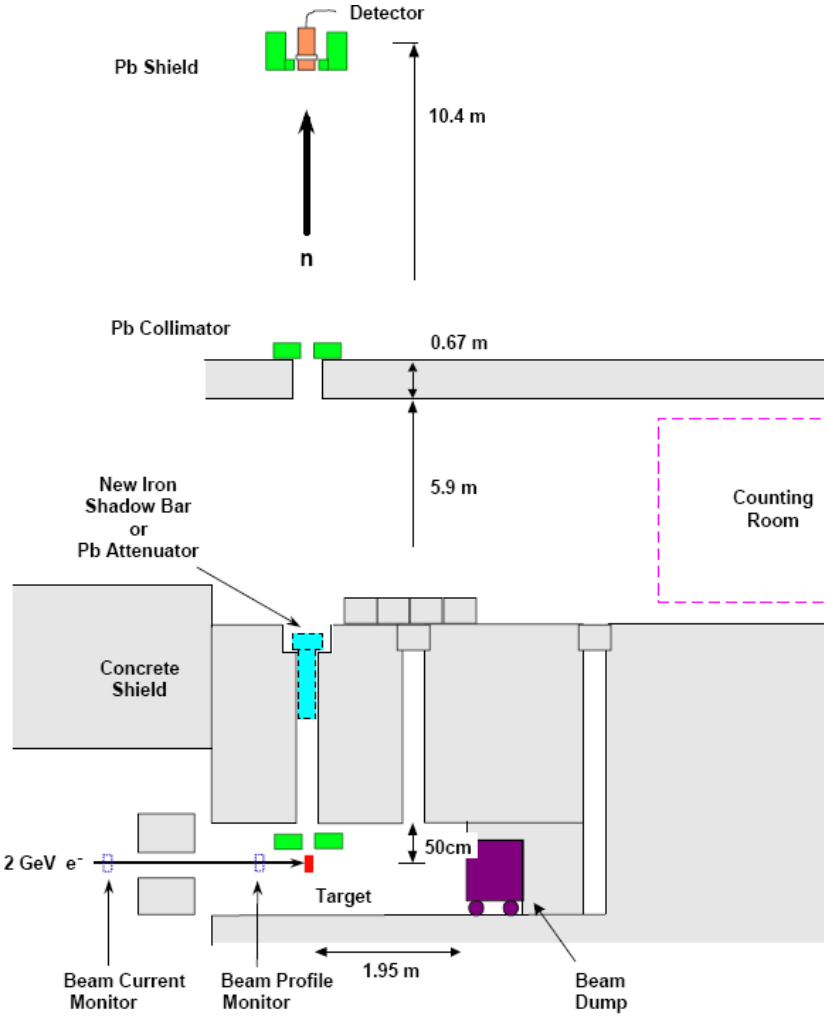
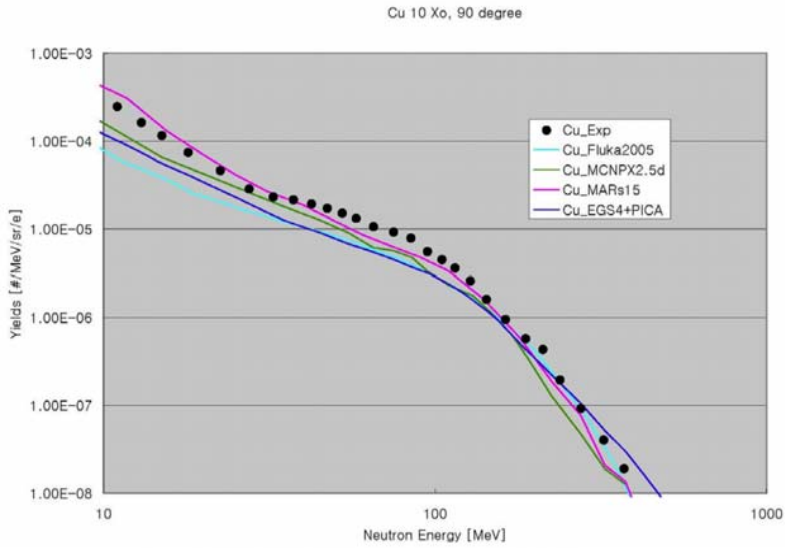
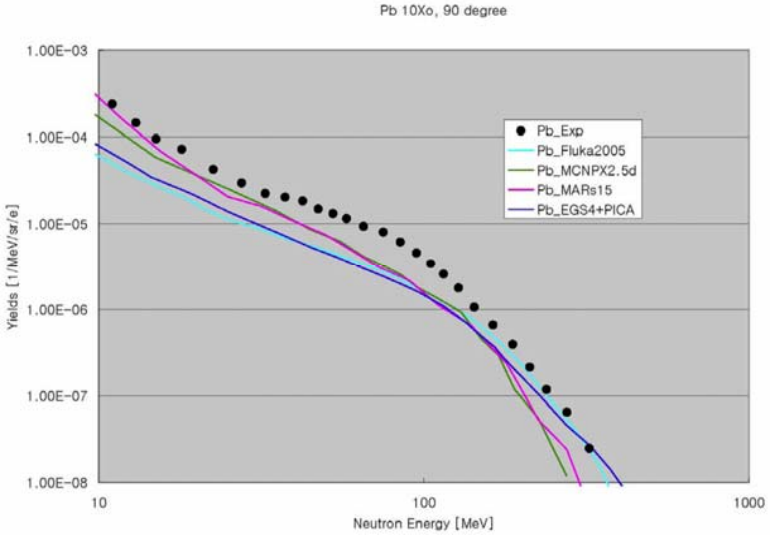


Photo-Neutron Yields from Thick Targets for 2-GeV e-

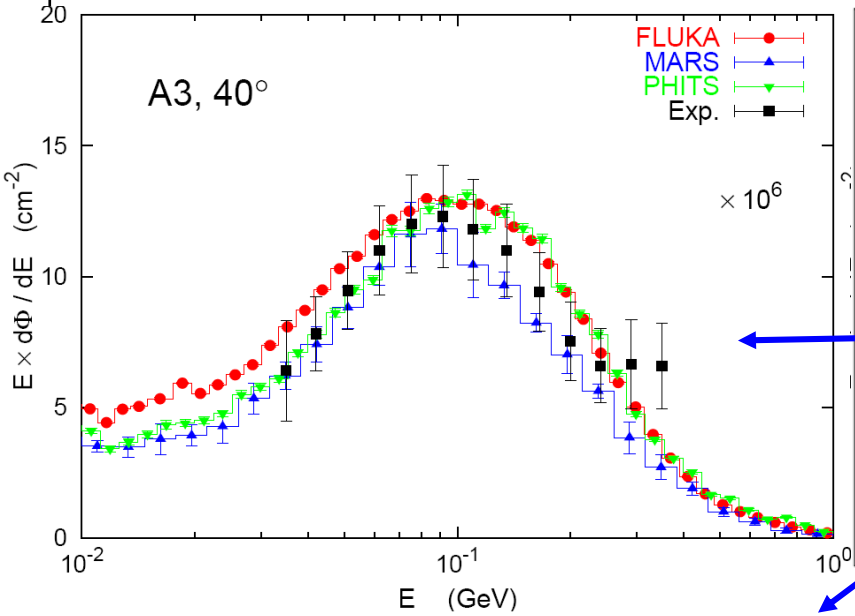


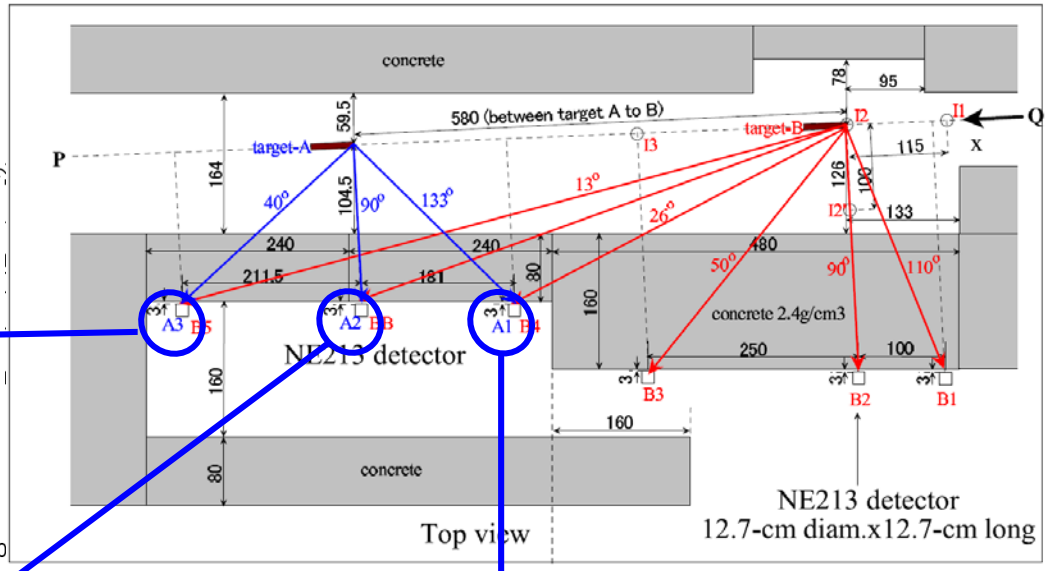


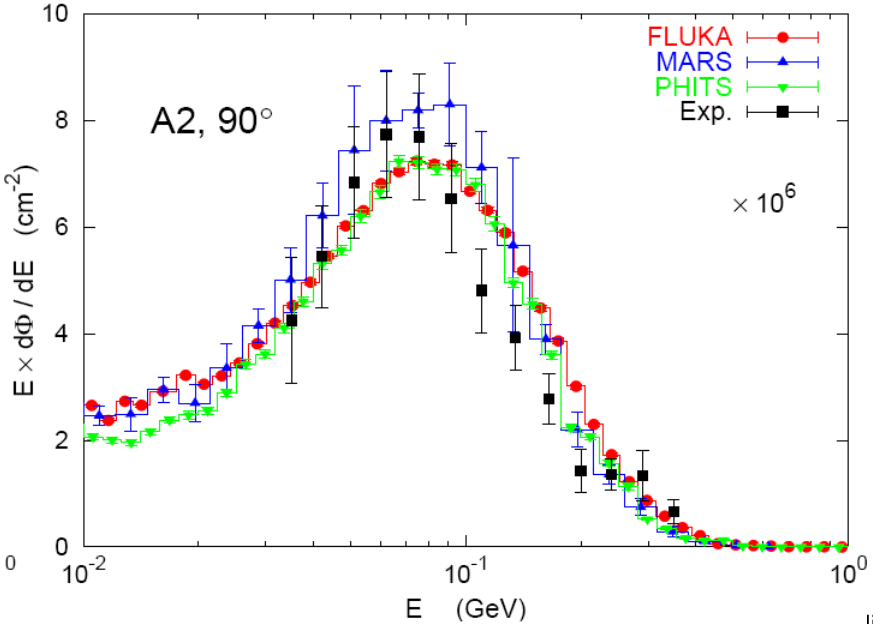


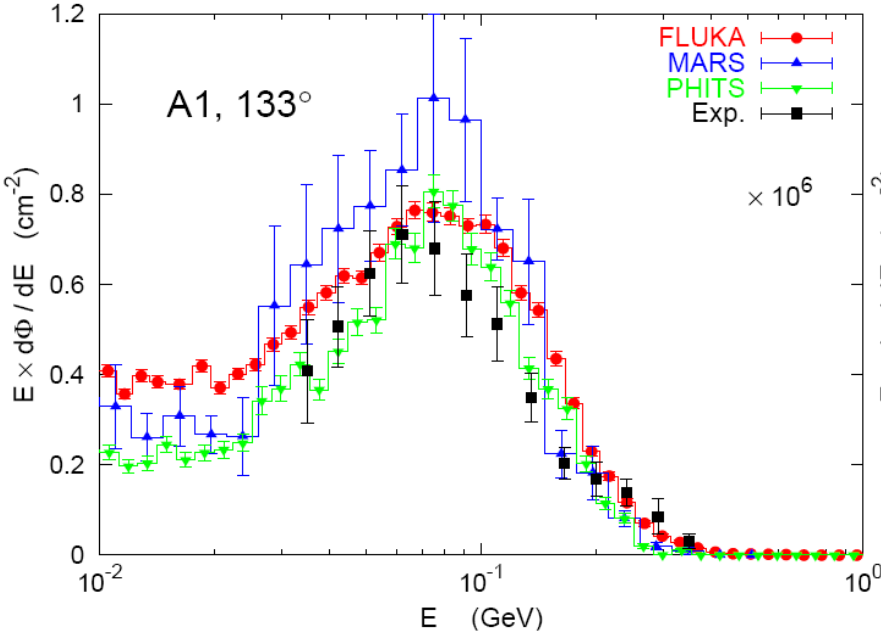
Courtesy H.S. Lee

120-GeV p/π on CERF Cu-Target: Concrete, 80cm





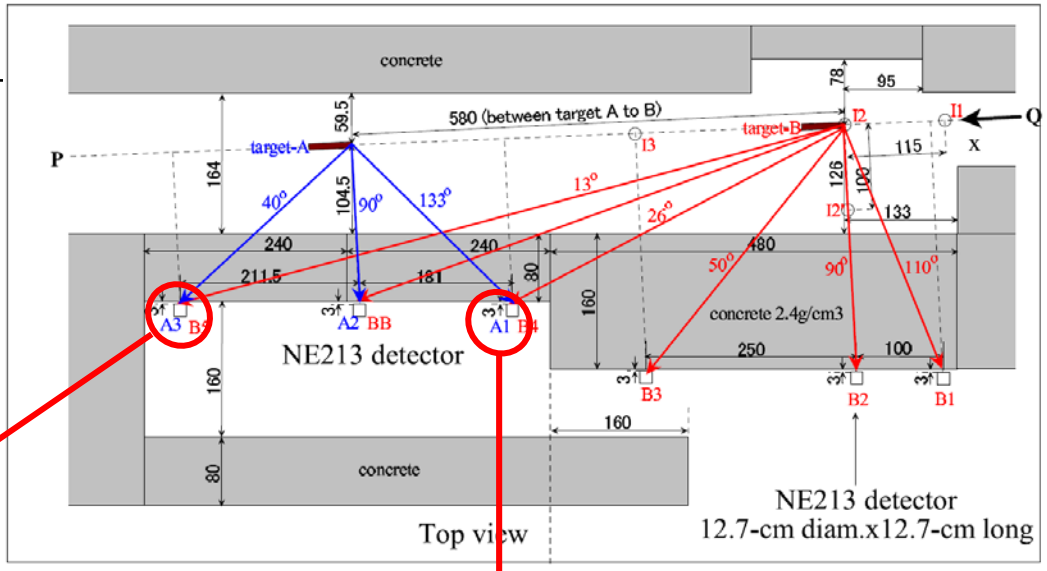


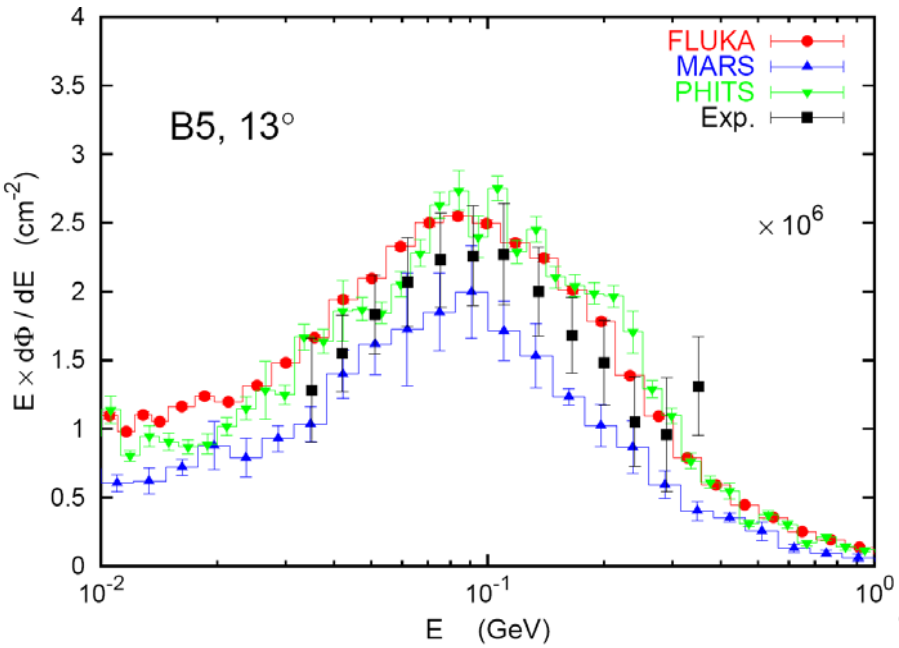


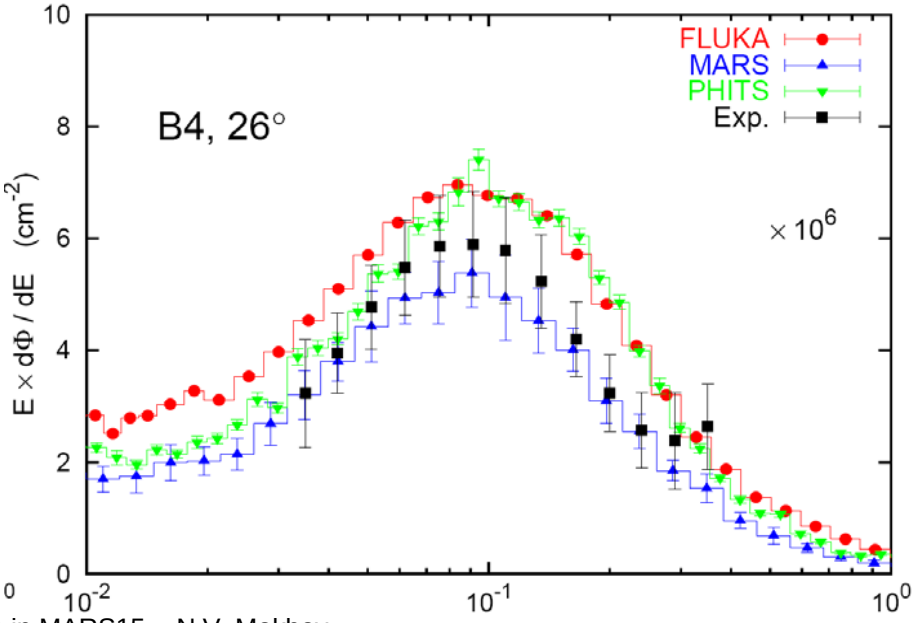
Courtesy: S. Roesler & N. Nakao

120-GeV p/π on CERF Cu-Target:

Concrete, 80cm





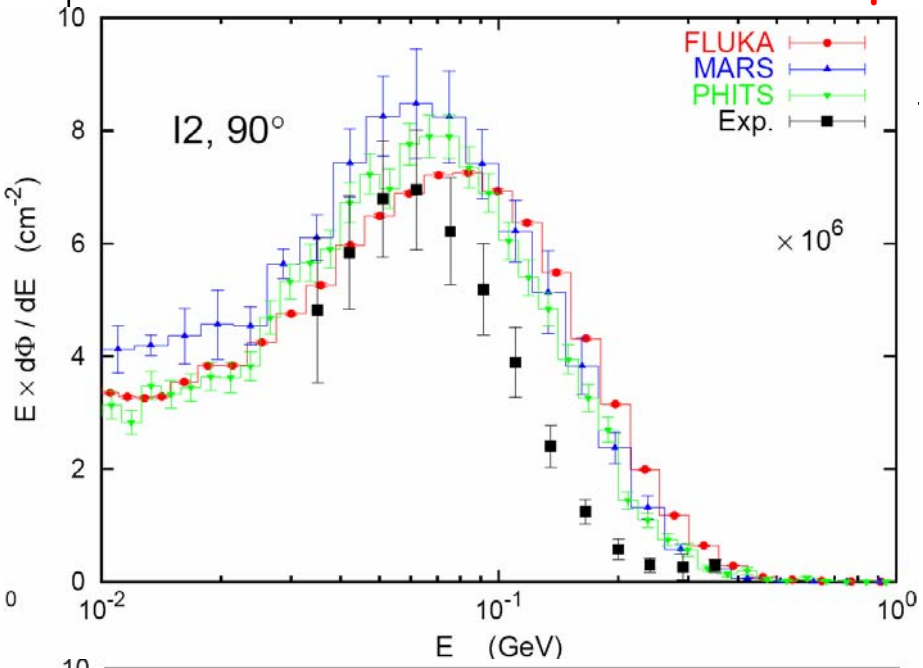


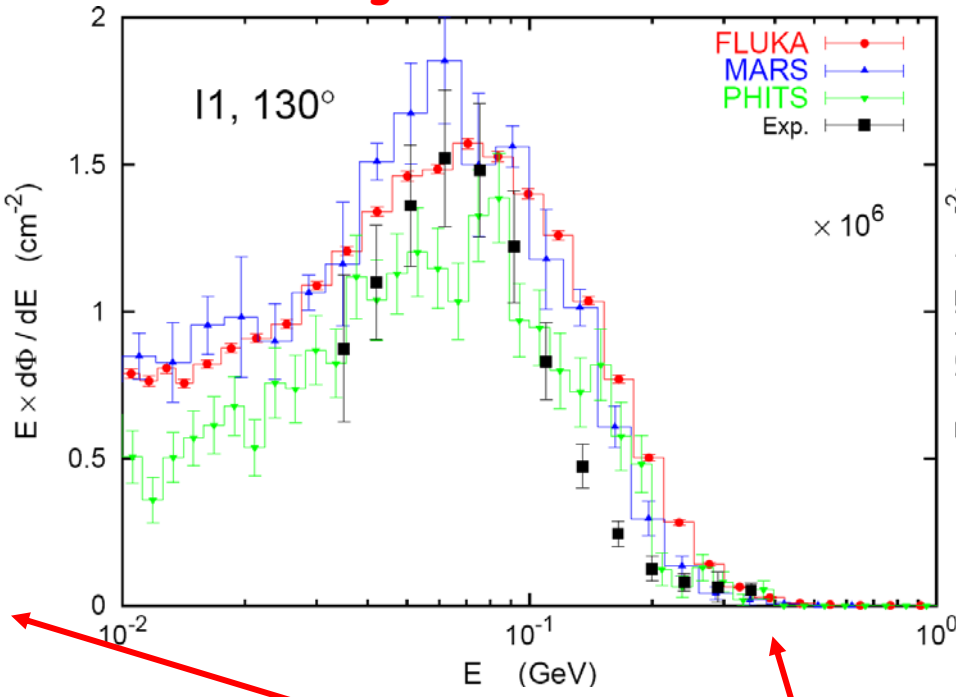
on in MARS15 - N.V. Mokhov

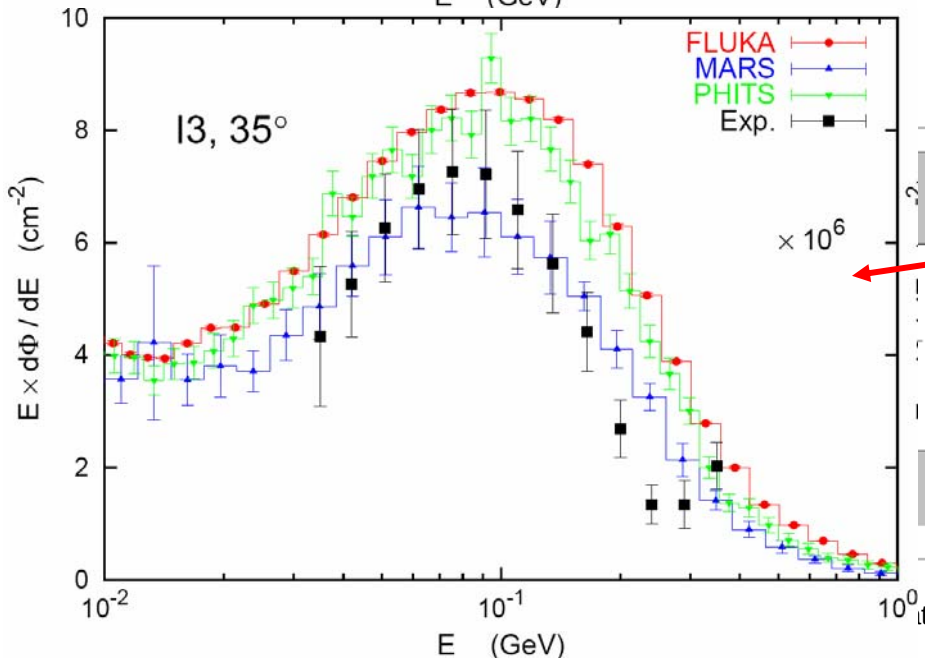
Courtesy: S. Roesler & N. Nakao

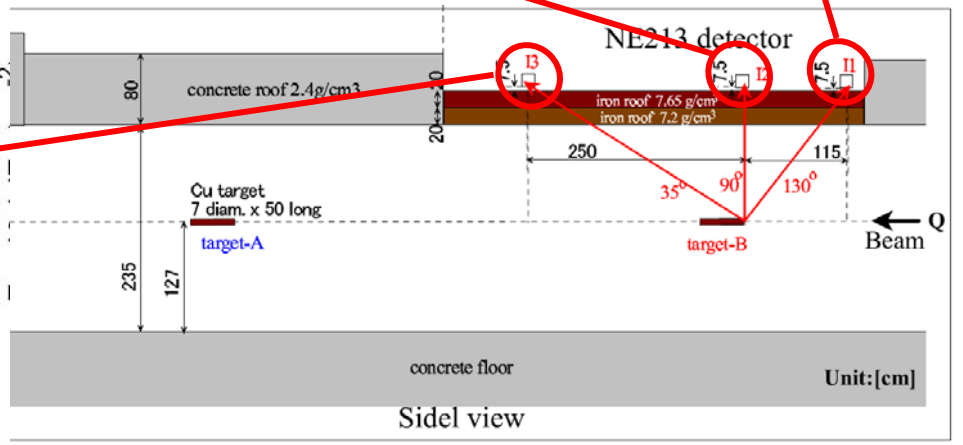
120-GeV p/π on CERF Cu-Target:

Iron, 40cm









Courtesy: S. Roesler & N. Nakao

Recent Benchmarking at SATIF-8 by H. Hirayama

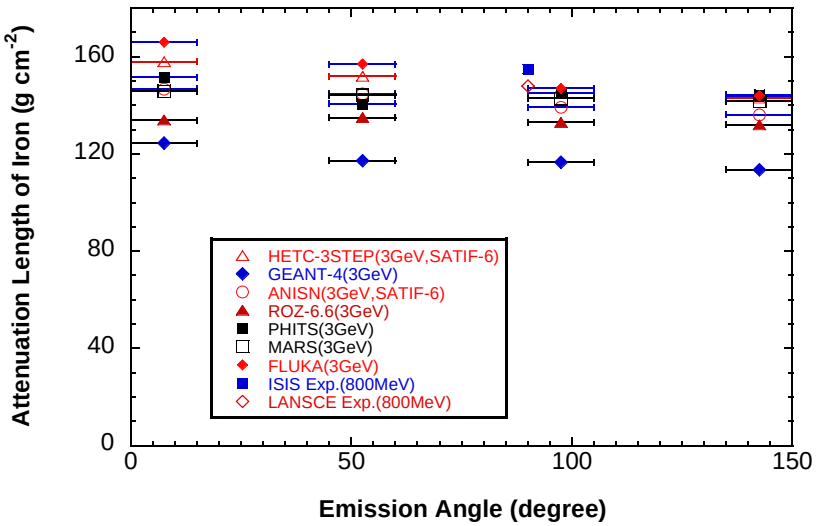


Fig. 9 Comparison of the neutron attenuation length of iron for secondary neutrons from a Hg target with 3 GeV protons.

Dose equivalent attenuation for neutrons above 20 MeV in a 6-m iron slab for normal incident parallel beam of neutrons with energy spectra generated in Hg and Fe targets by protons from 0.2 to 24 GeV.

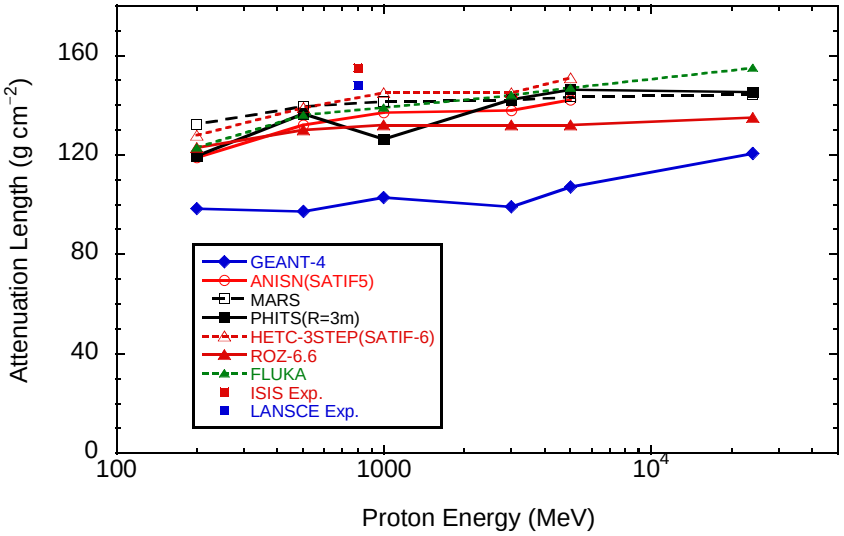


Fig. 15 Comparison of the neutron attenuation length of iron for secondary neutrons emitted to 90 degrees from iron and Hg (24 GeV) targets with protons.

MODELING BEAM ACCIDENT AT TEVATRON

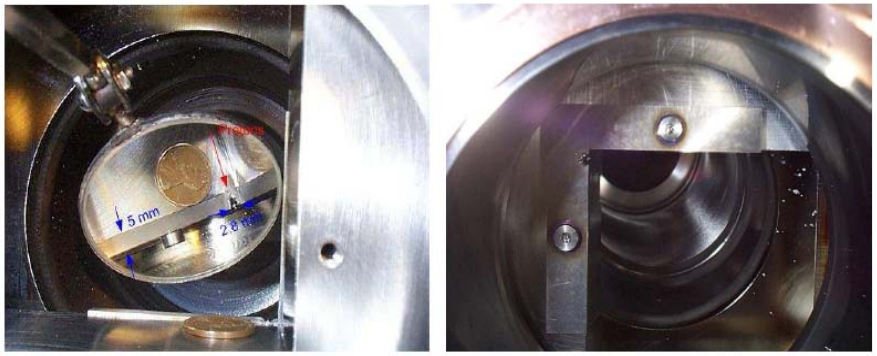
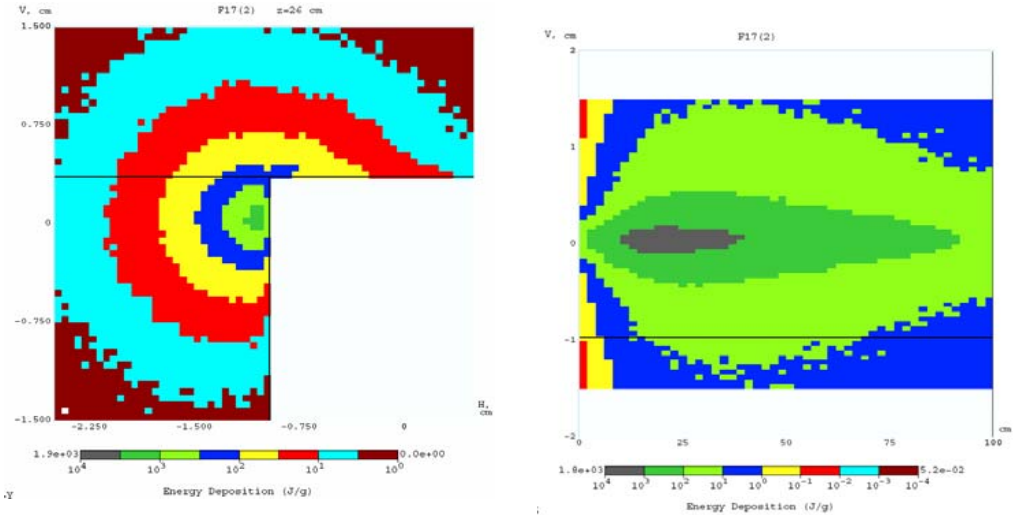
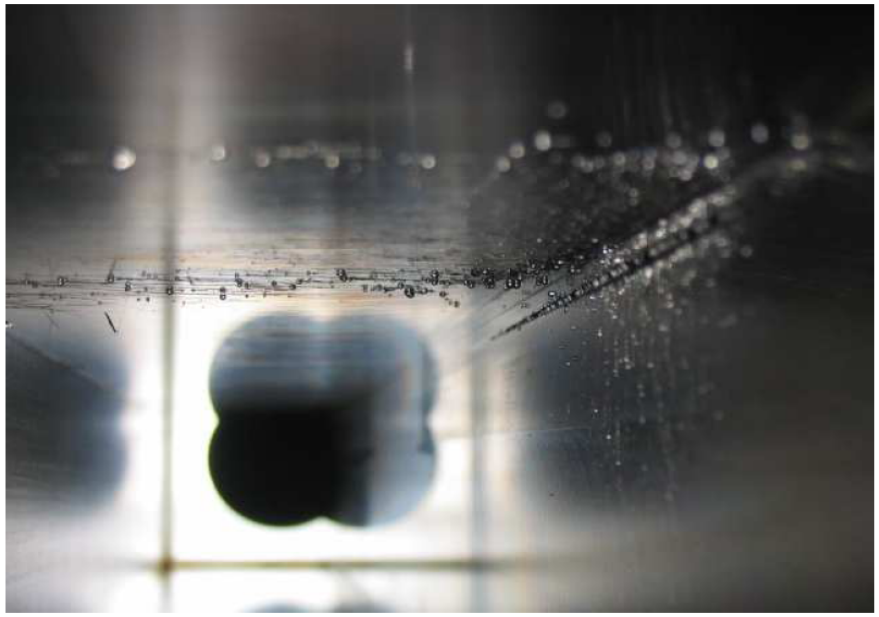


Figure 5: Damage to D49 5-mm thick tungsten primary collimator.





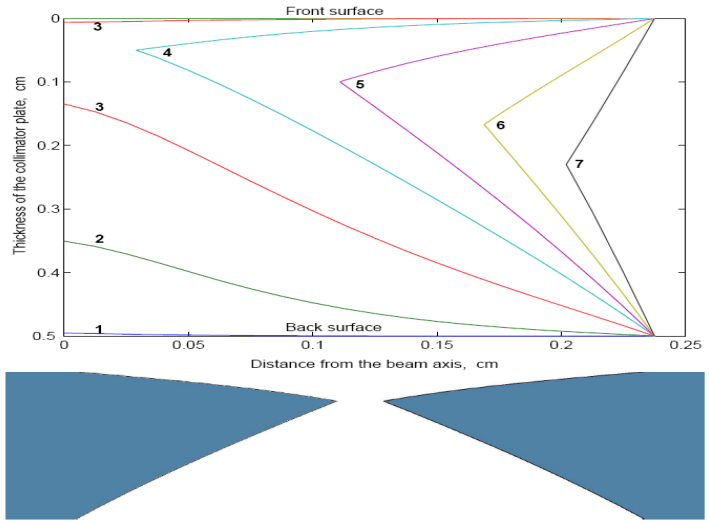


Figure 18: Top: evolution of the front and back surfaces of the tungsten collimator plate from t=0.4 ms (1) through t=1.6 ms (7) with Δt=0.2 ms. Bottom: shape of the hole in the collimator plate at 1 ms.