

GRAND VERIFICATION

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Fermilab**

HSSW06
Fermilab

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OUTLINE

- task1 - HARP and 4 codes
- task2b - NA49 (proton-proton collisions) and 5 codes
- task2a - NA49 (proton-carbon collisions) and 6 codes
- task3 - IHEP (thick target) and 2 codes
- task4 - PAL (photo-neutron production) and 2 codes
- task5 - KEK (energy deposition) and 4 codes
- task6 - CDHS (shower profile) and 2 codes
- task7 - toy model (energy deposition in thick target) and 4 codes

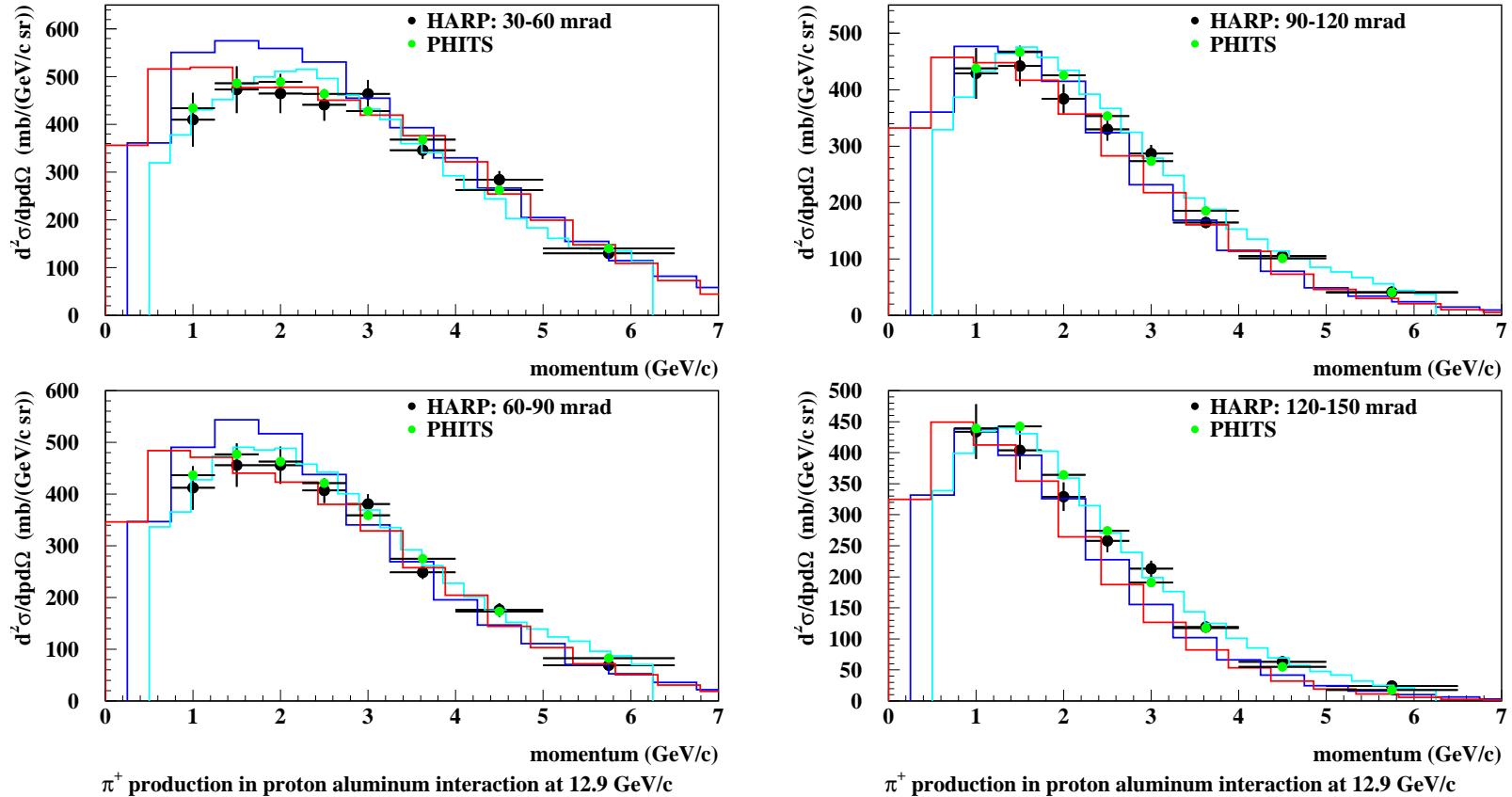
TASK 1

HARP collaboration measured double differential cross section of positive pion production in proton-aluminum interaction at 12.9 GeV/c (Nucl. Phys. B732, 1 (2006)).

Models:

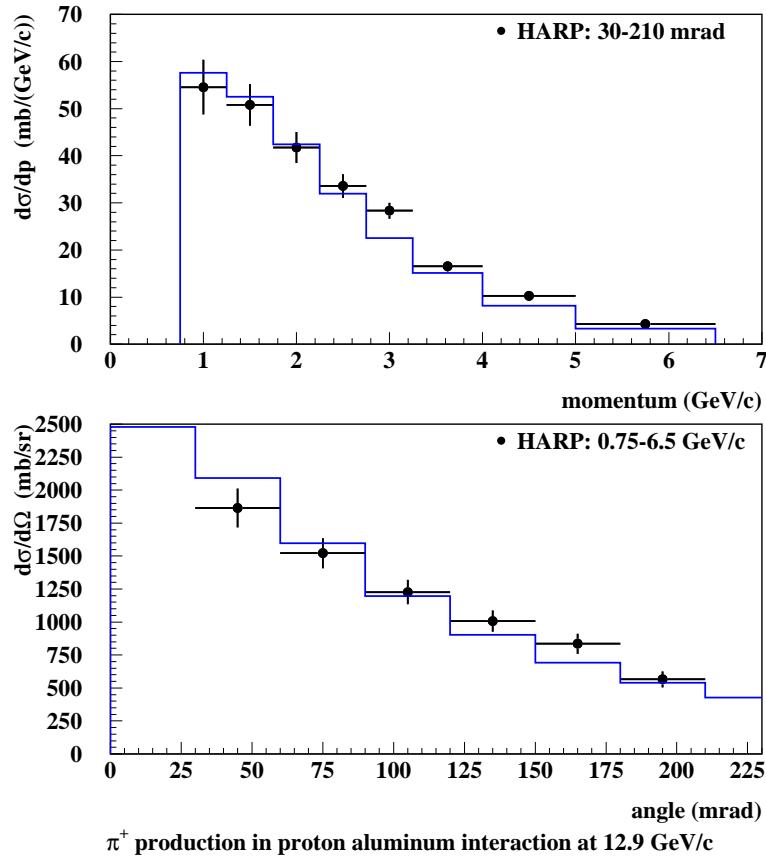
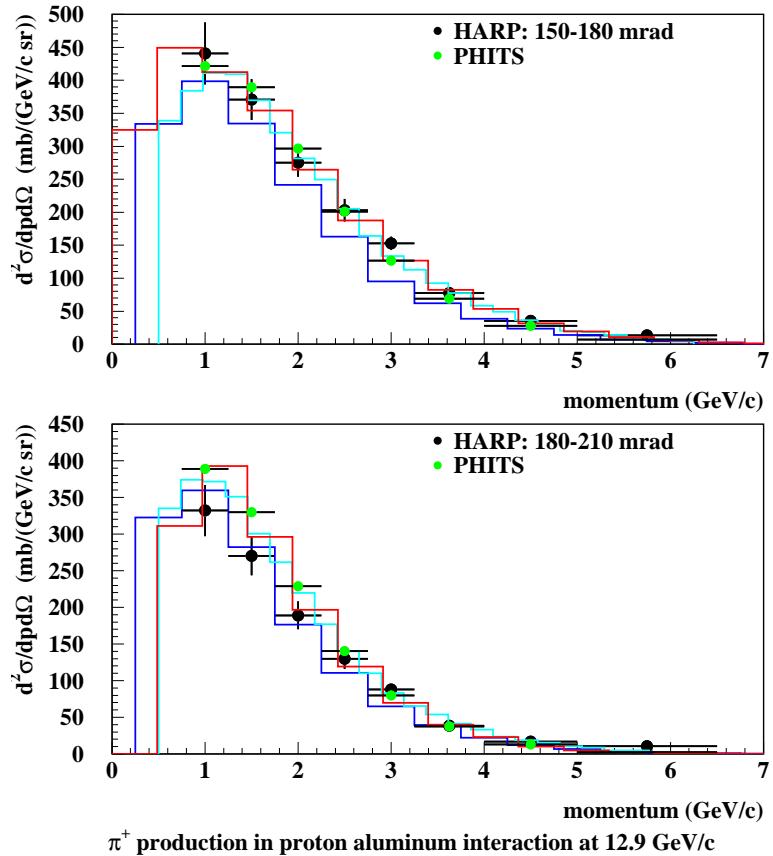
- PHITS 2.13 by N. Matsuda
- LAQGSM 03 by Konstantin Gudima
- FLUKA 2005 by Paola Sala
- MARS15 by Sergei Striganov

TASK 1



Black symbols - HARP data, green symbols - PHITS, red line - LAQGSM, cyan line - FLUKA, blue line - MARS

TASK 1



Black symbols - HARP data, green symbols - PHITS, red line - LAQGSM, cyan line - FLUKA, blue line - MARS

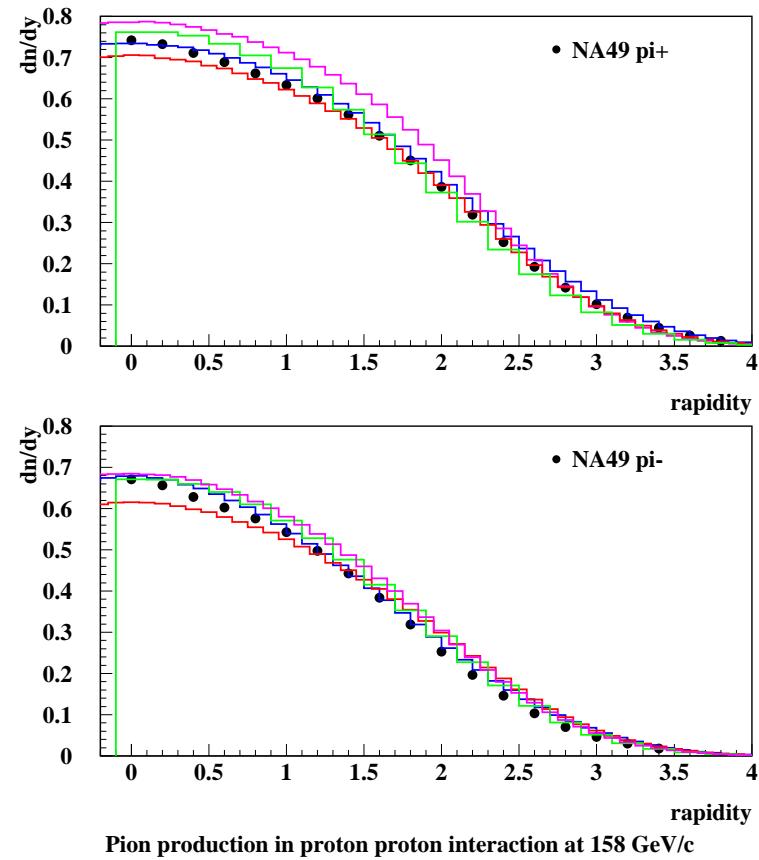
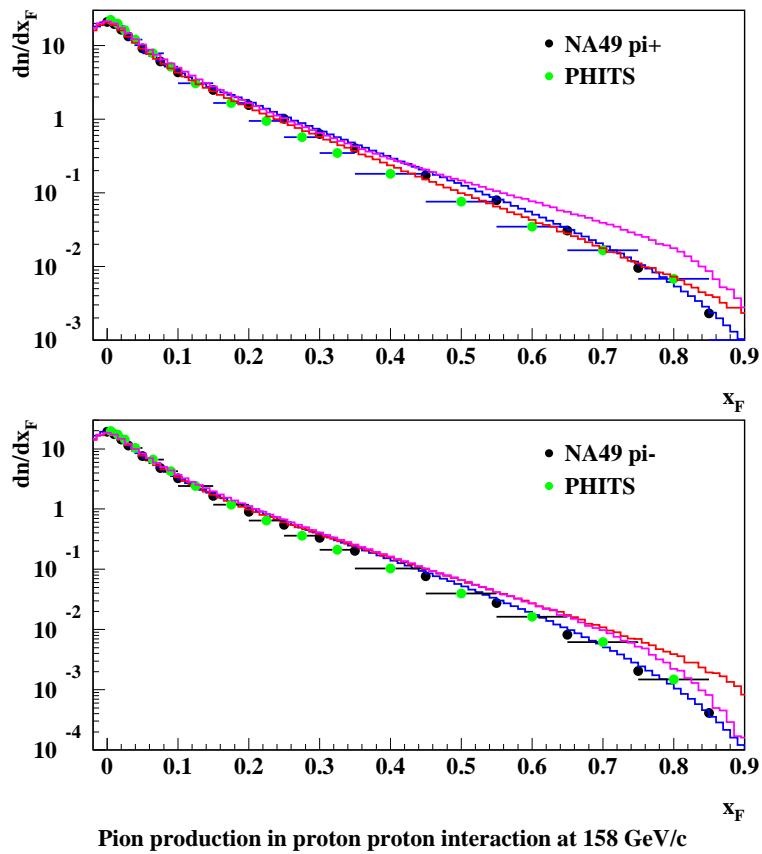
TASK 2B

NA49 collaboration measured one and double differential cross section of charged pion production in proton-proton interaction at 158 GeV/c (Eur. Phys. J. C45, 243 (2006)).

Models:

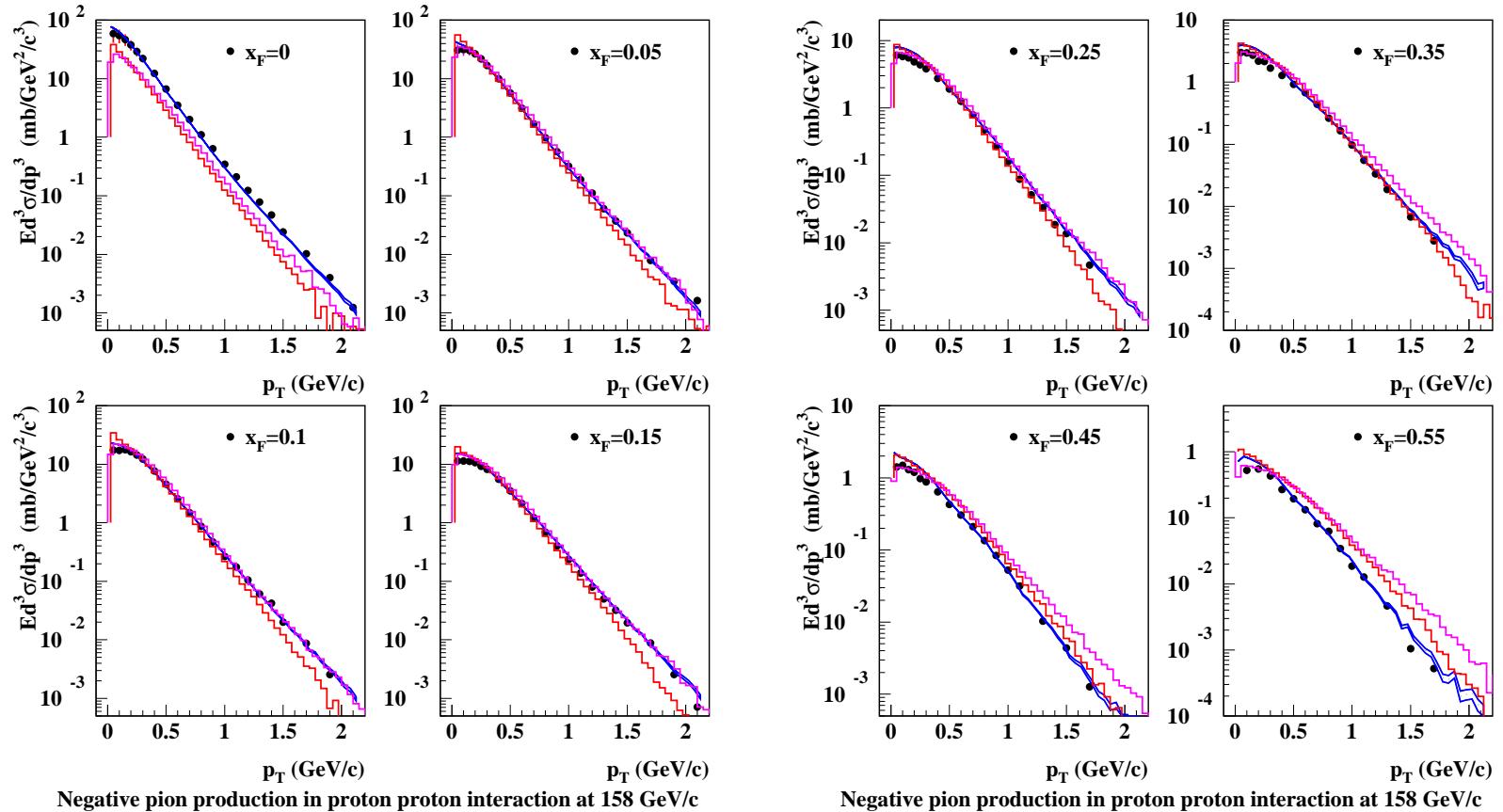
- PHITS 2.13 by N. Matsuda. Provided double differential cross was calculated for different bins than other codes and data.
- LQGSM 03 by Konstantin Gudima
- FLUKA 2005 by Paola Sala
- MARS15 by Sergei Striganov
- DPMJET III by Mircea Baznat

TASK 2B



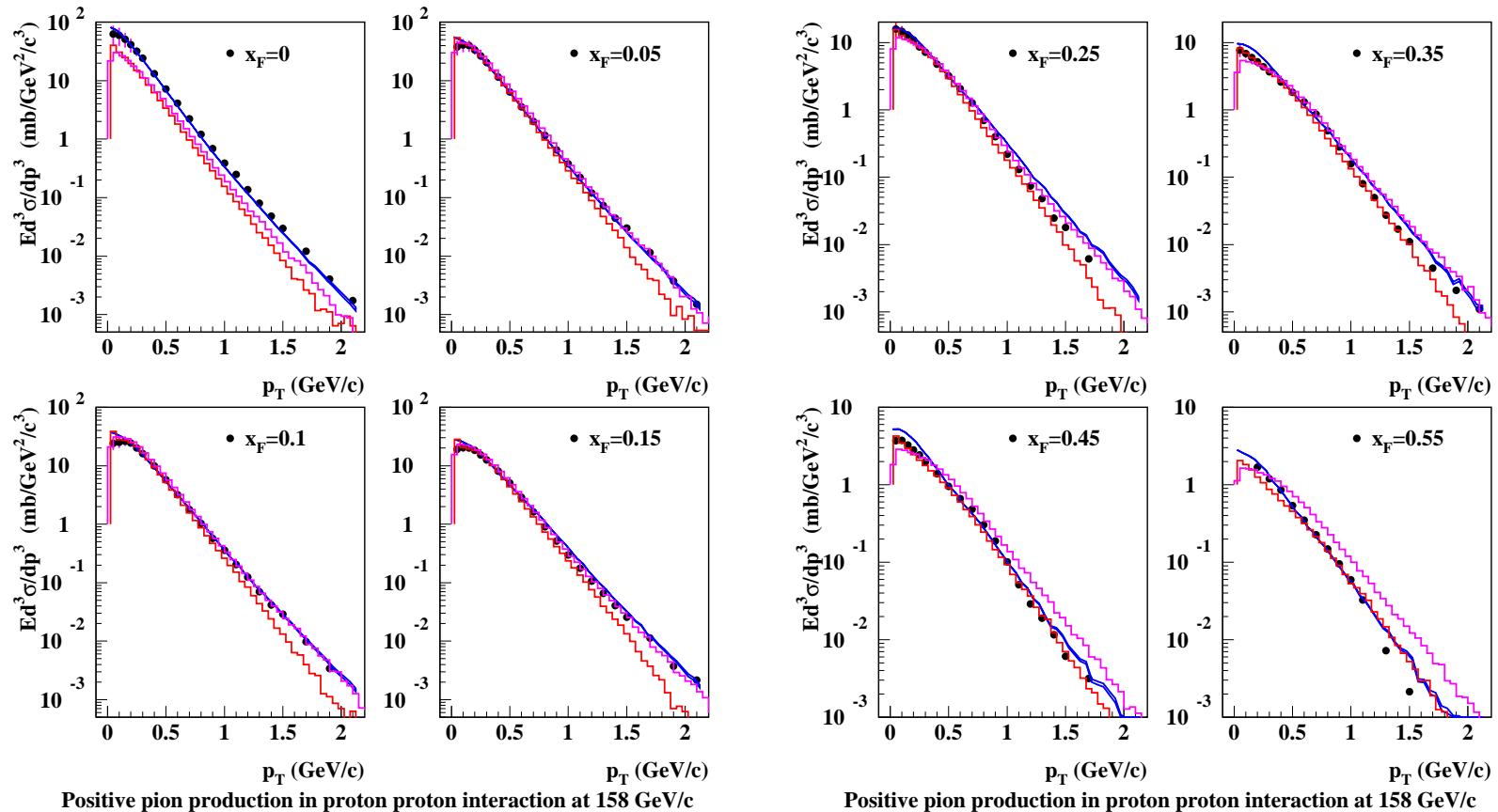
Black symbols - NA49 data, green symbols, line - PHITS, red line - LAQGSM, cyan line - FLUKA, blue line - MARS, magenta line -DPMJET

TASK 2B



Black symbols - NA49 data, red line - LAQGSM, blue line - MARS, magenta line - DPMJET

TASK 2B



Black symbols - NA49 data, red line - LQGSM, blue line - MARS, magenta line - DPMJET

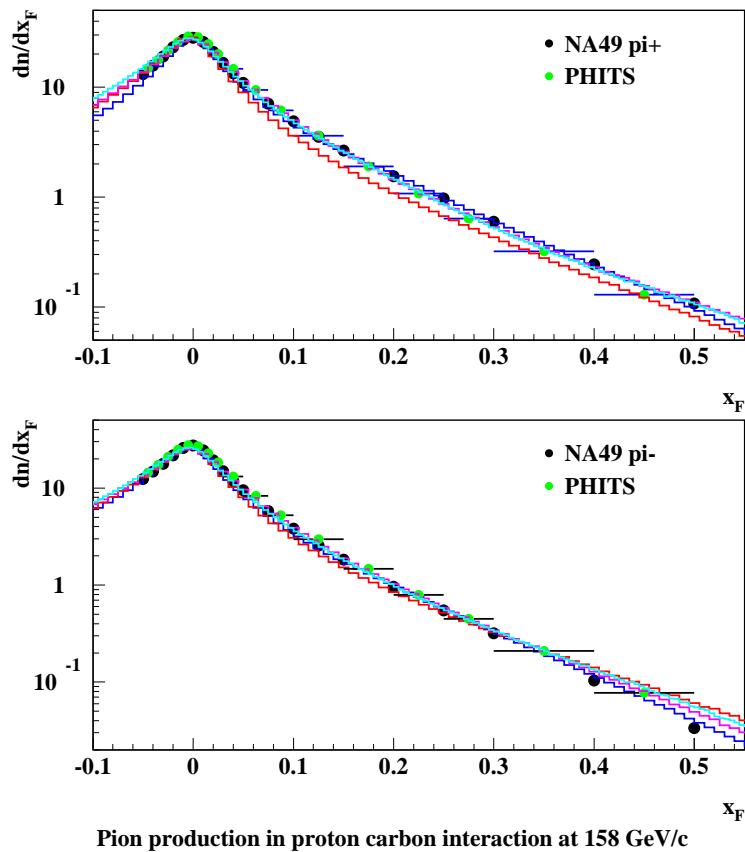
TASK 2A

NA49 collaboration measured one and double differential cross section of charged pion production in proton-carbon interaction at 158 GeV/c (hep-ex/0606028 (2006)).

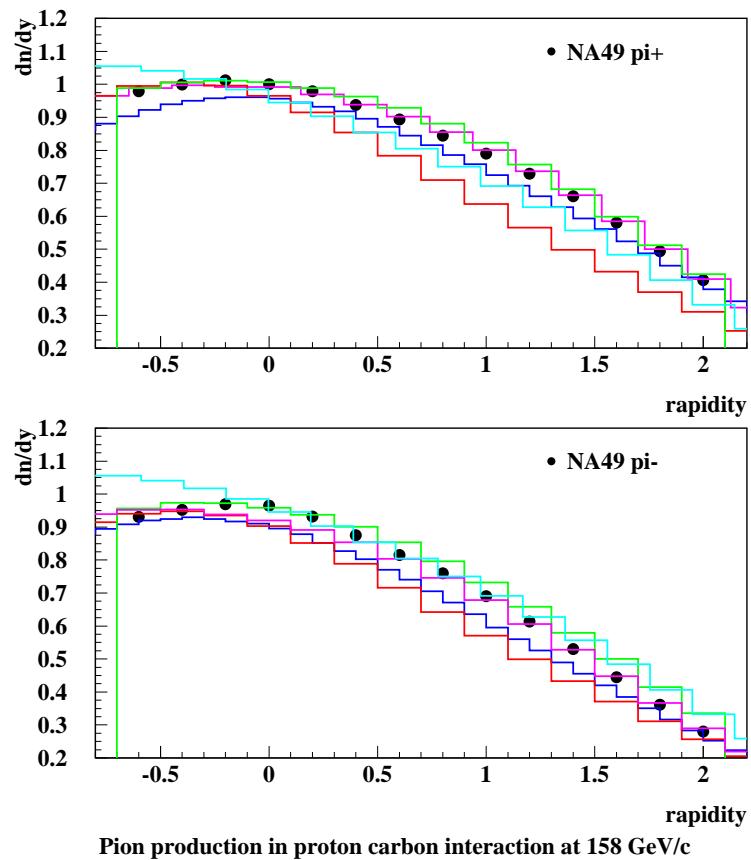
Models:

- PHITS 2.13 by N. Matsuda. Provided double differential cross was calculated for different bins than other codes and data.
- LQGSM 03 by Konstantin Gudima
- FLUKA 2005 by Paola Sala
- MARS15 by Sergei Striganov
- DPMJET III by Mircea Baznat
- G4 (QGS) by Gunter Folger. One dimensional distributions were not provided

TASK 2A



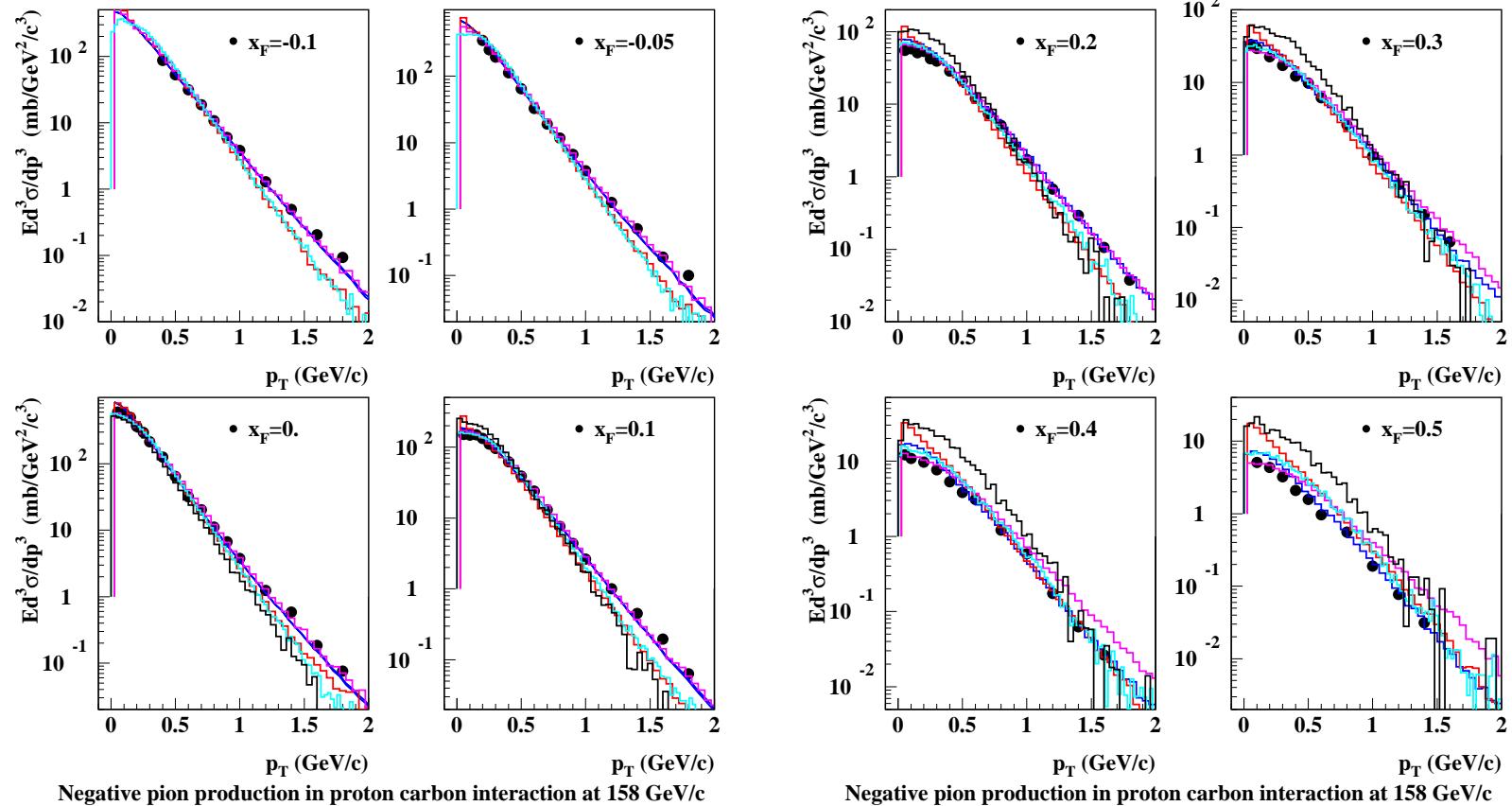
Pion production in proton carbon interaction at 158 GeV/c



Pion production in proton carbon interaction at 158 GeV/c

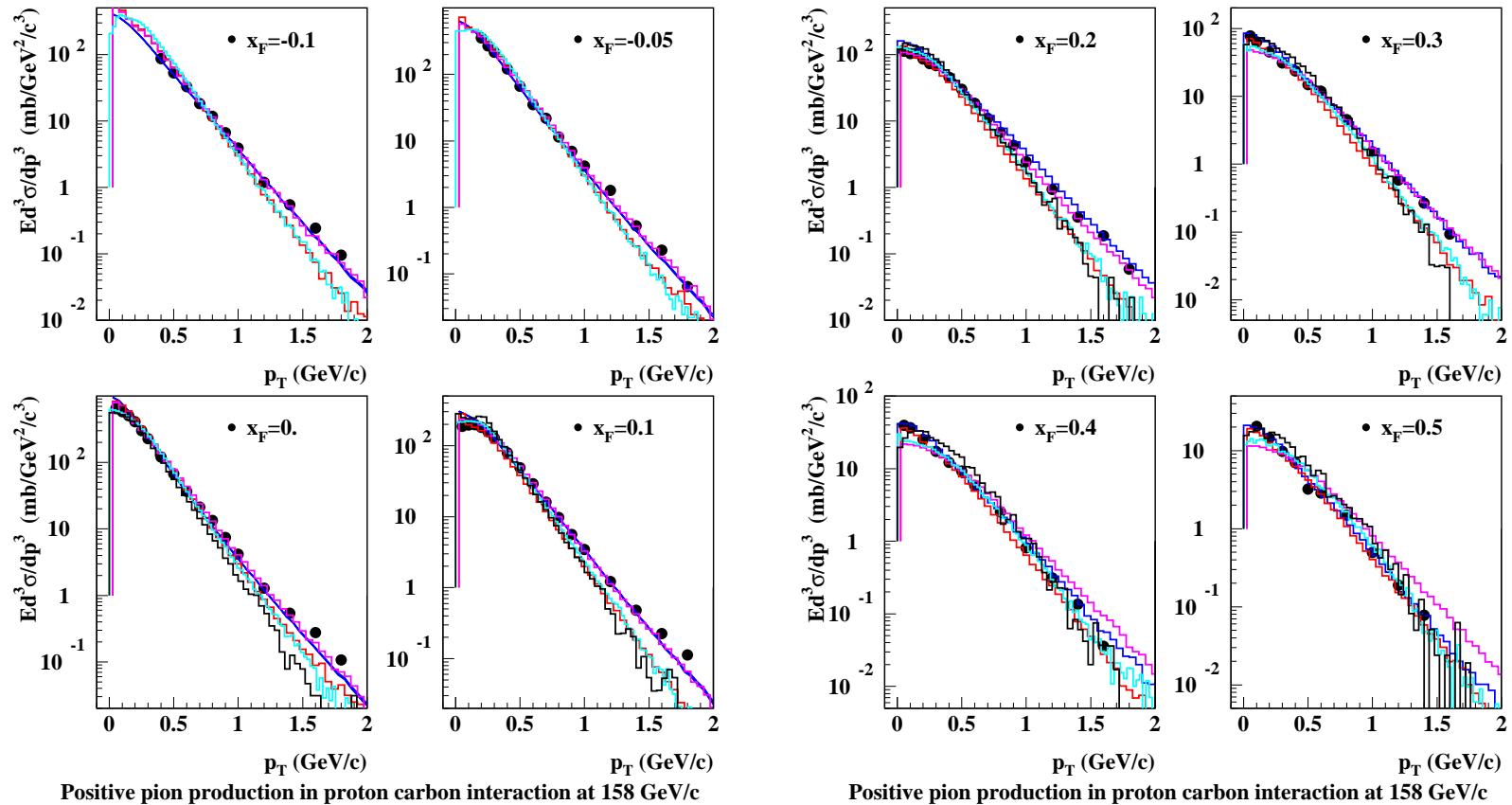
Black symbols - NA49 data, green symbols, line - PHITS, red line - LAQGSM, cyan line - FLUKA, blue line - MARS, magenta line - DPMJET

TASK 2A



Black symbols - NA49 data, red line - LAQGSM, blue line - MARS, black line - G4,
magenta line -DPMJET

TASK 2A



Black symbols - NA49 data, **red line** - LQGSM, **blue line** - MARS, black line - G4, **magenta line** -DPMJET

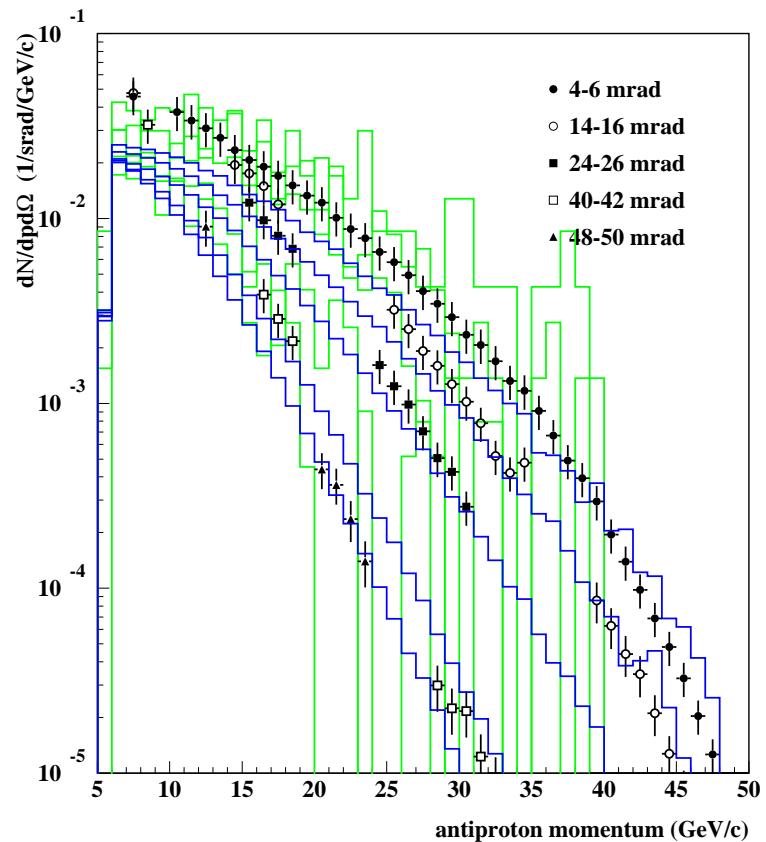
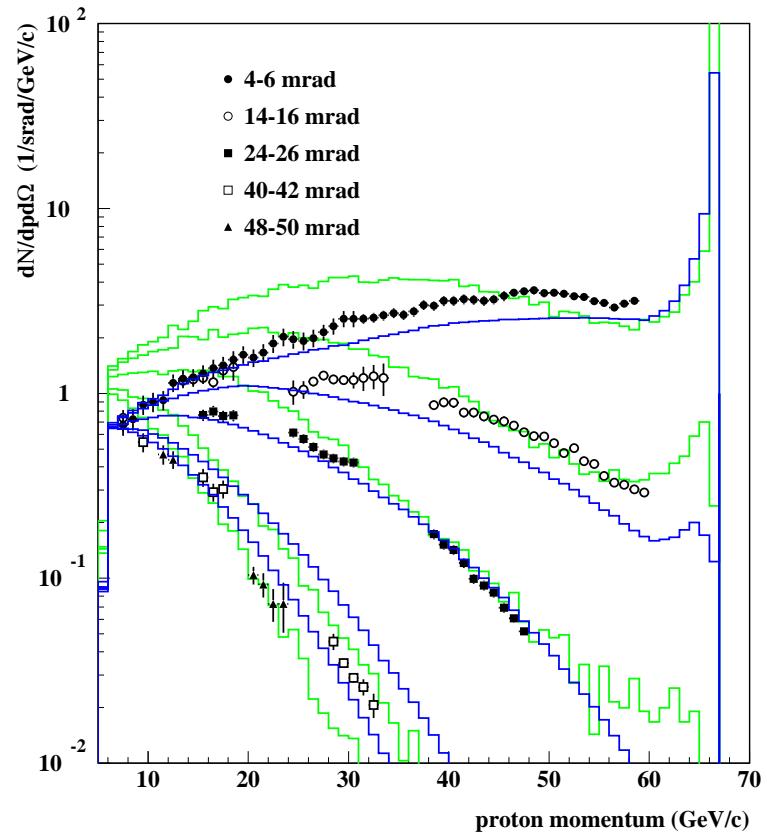
TASK 3

Double differential cross sections of charged particles produced in proton interaction with thick target at 67 GeV/c were measured in IHEP (Protvino). Aluminum target was 60 cm long with radius of 3 cm. Beam was a Gaussian with $\sigma_x = \sigma_y = 0.17$ cm. (Sov. Jour. Nucl. Phys. 31, 644 (1979)).

Models:

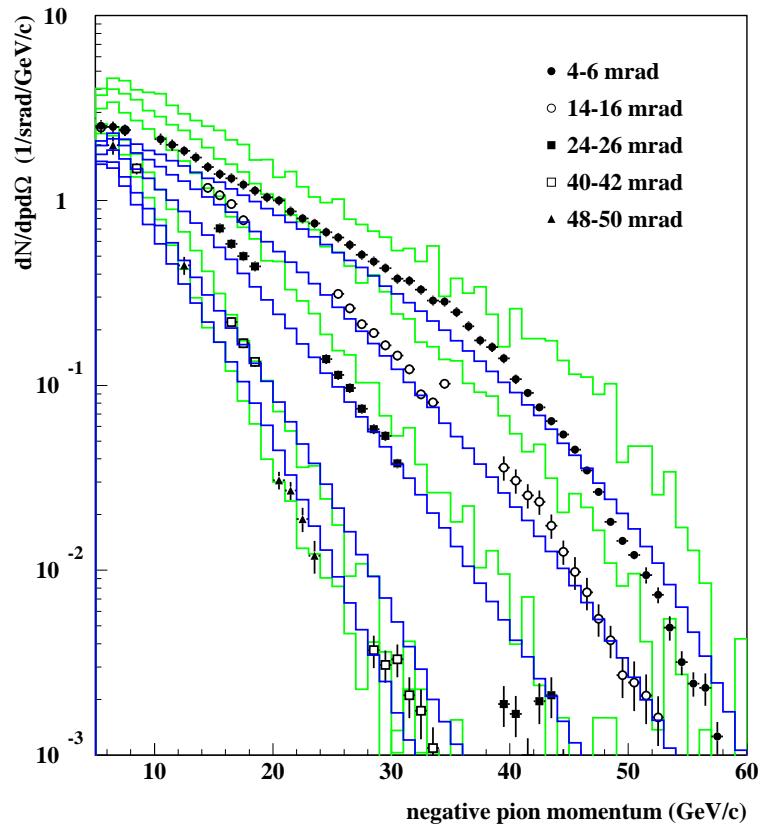
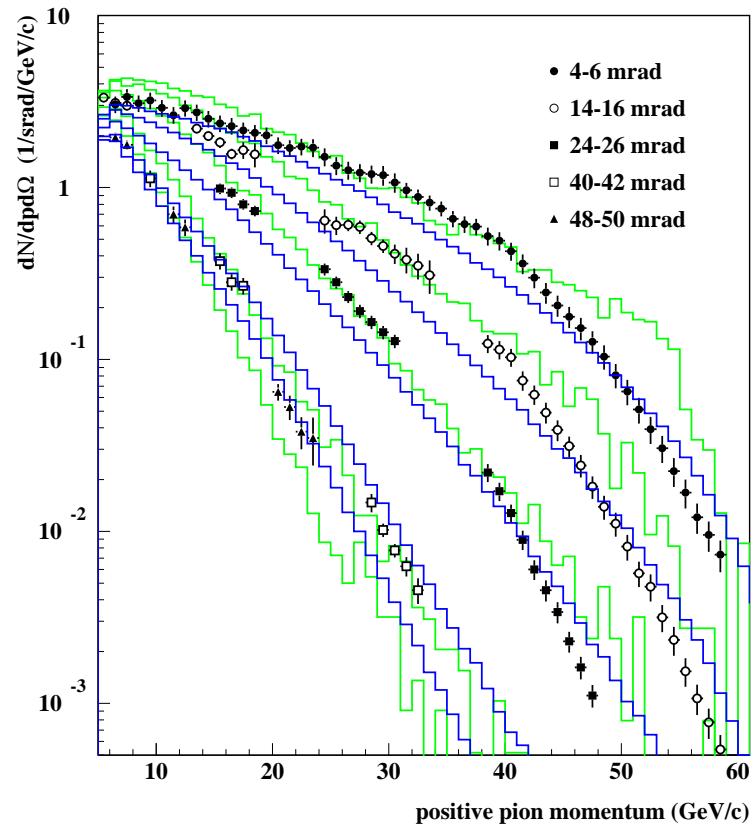
- PHITS 2.13 by N. Matsuda.
- MARS15 by Sergei Striganov

TASK 3



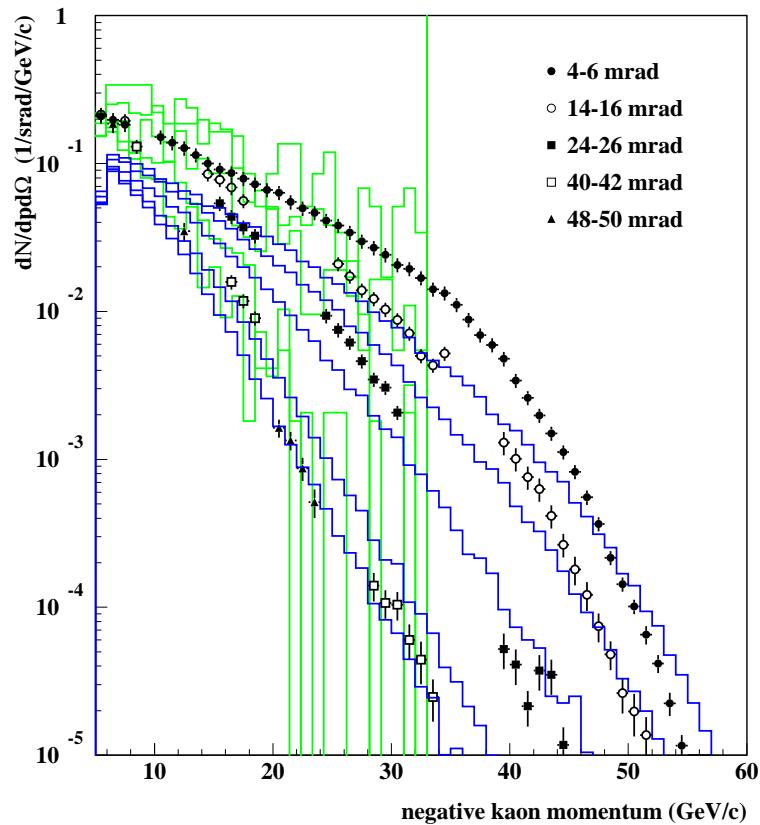
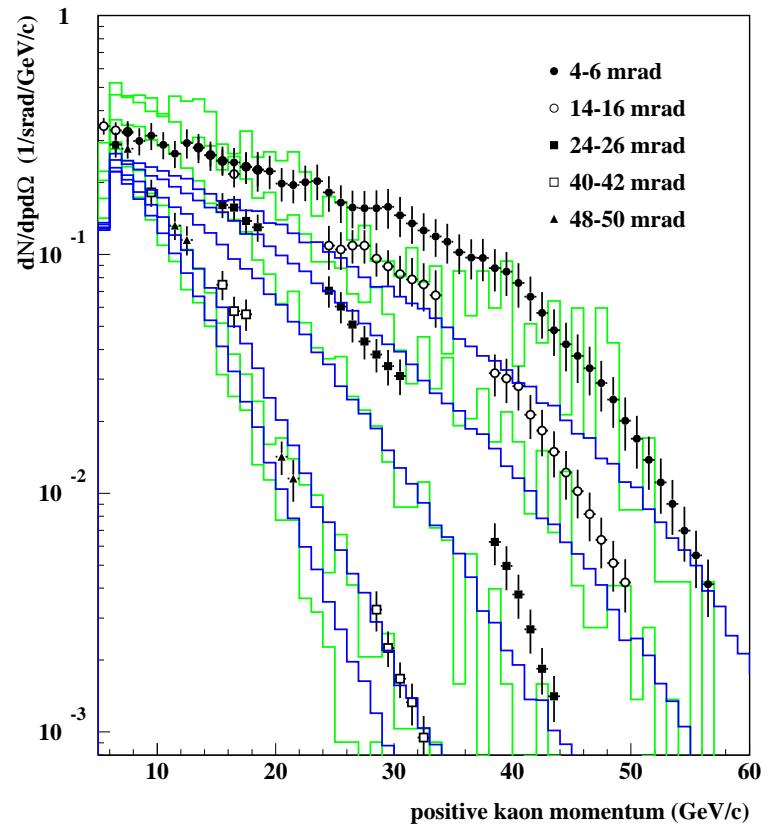
Symbols - IHEP data, green line - PHITS, blue line - MARS

TASK 3



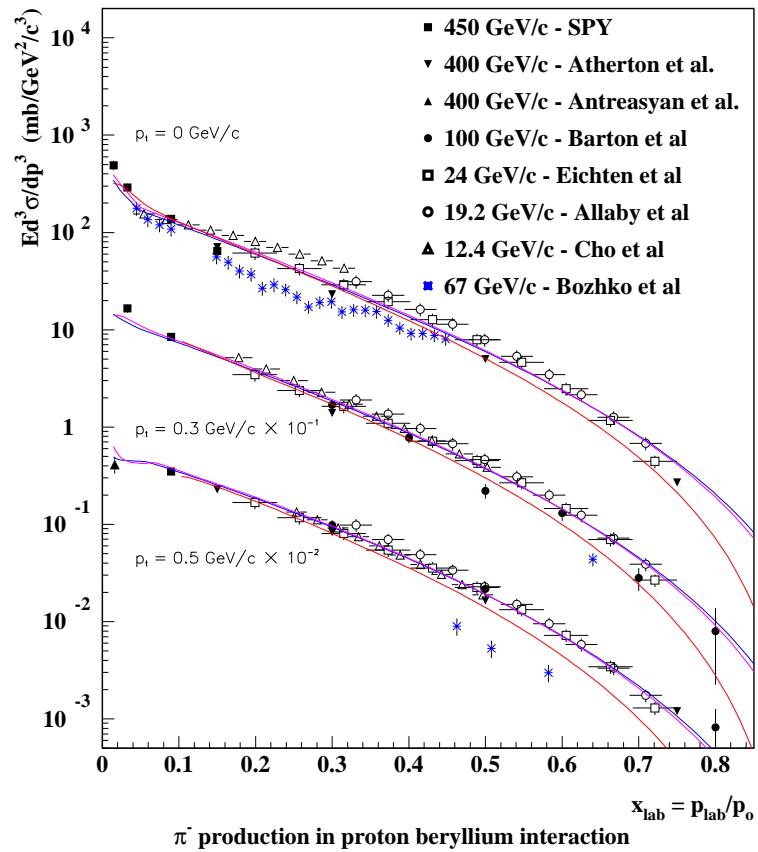
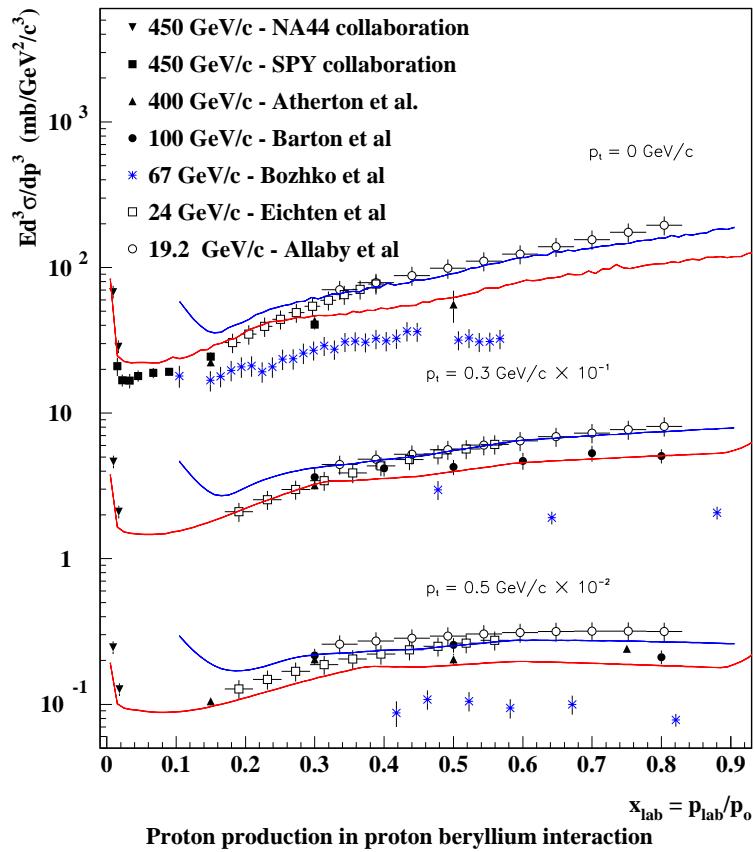
Symbols - IHEP data, green line - PHITS, blue line - MARS

TASK 3



Symbols - IHEP data, green line - PHITS, blue line - MARS

TASK 3



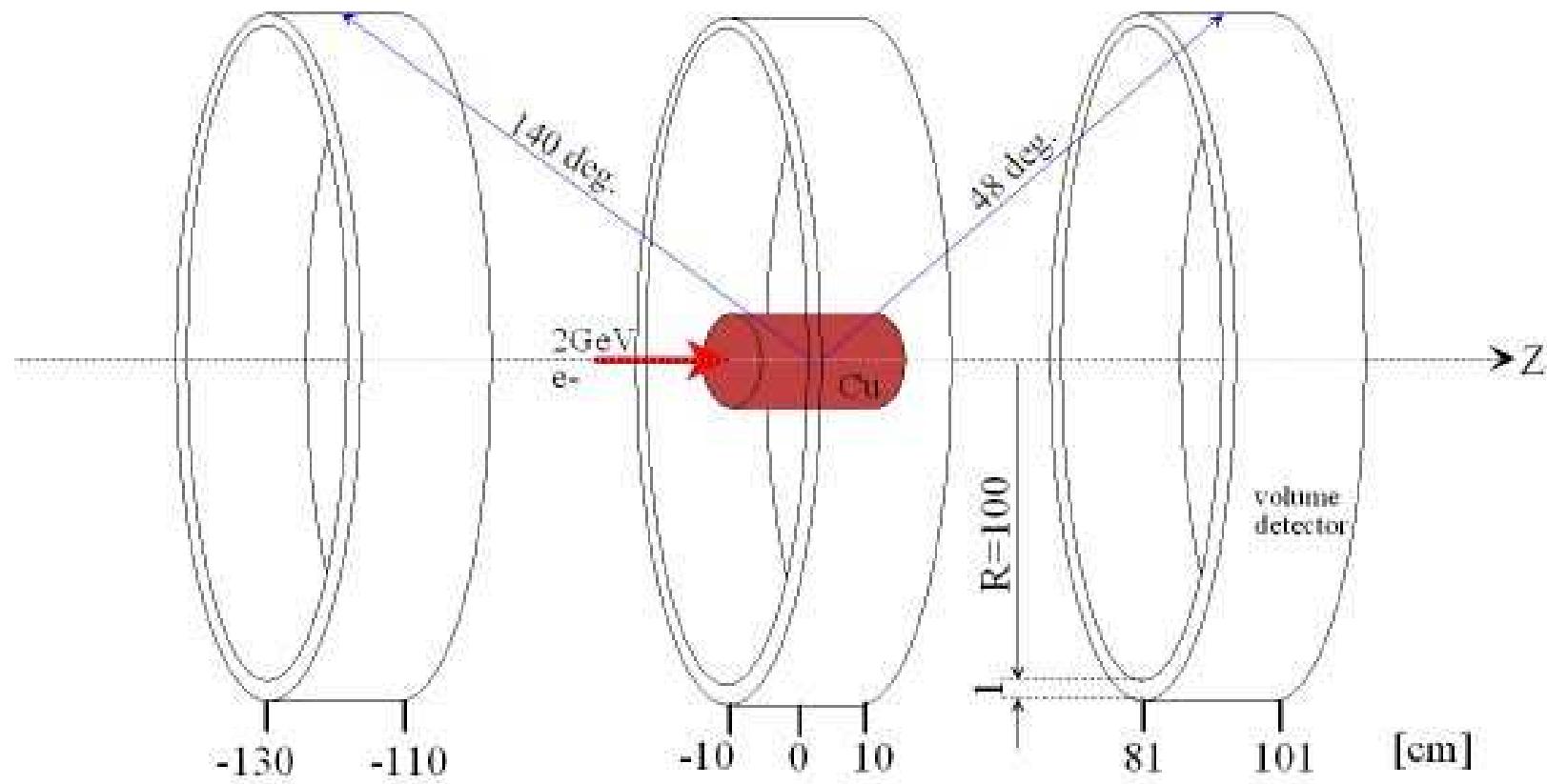
TASK 4

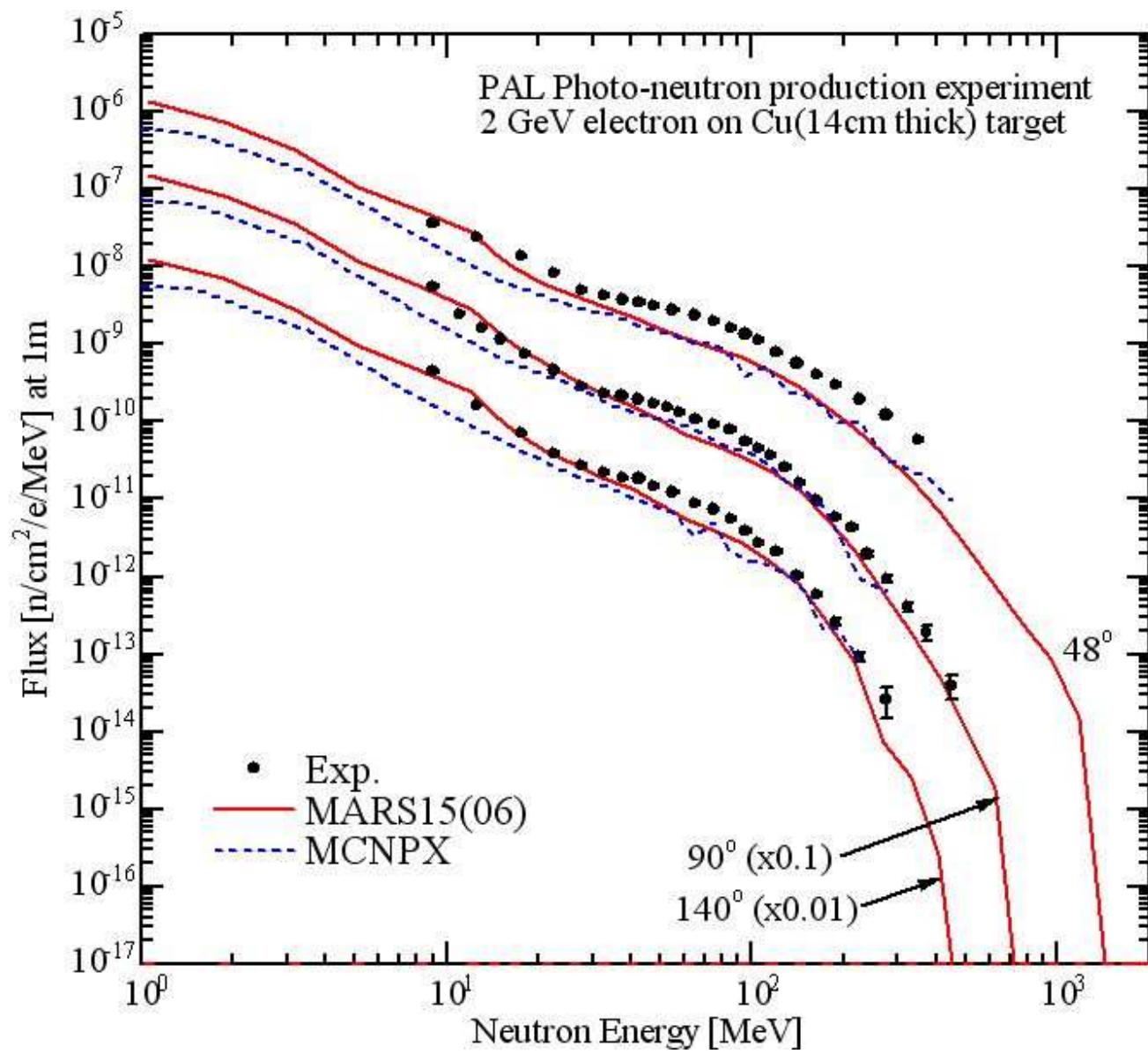
Thick target is irradiated by a 2 GeV electron beam. Cooper target is 14-cm long with radius of 2.5 cm. Electron beam is point-like. Neutron spectra are measured at 48,90, and 140 degrees. (PAL experiment (2004)).

Models:

- MCNPX by experimental group
- MARS15 by Noriaki Nakao

TASK 4





TASK 5

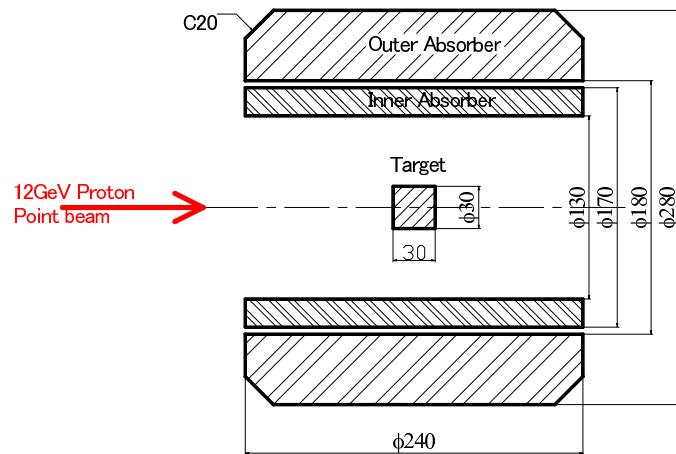
Energy deposition in absorber around target. Protons with kinetic energy 12 GeV interact with cooper target (length is 3cm, radius - 1.5 cm). Calculate total energy deposited in the inner target for 5 positions of target center.

Models:

- PHITS 1.83 by N. Matsuda.
- MARS15 by Nikolai Mokhov
- MCNPX 2.40 by N. Matsuda
- G4(QDSP) and G4(LHEP) by Dennis Wright

TASK 5

計算条件メモ



単位 : (mm)

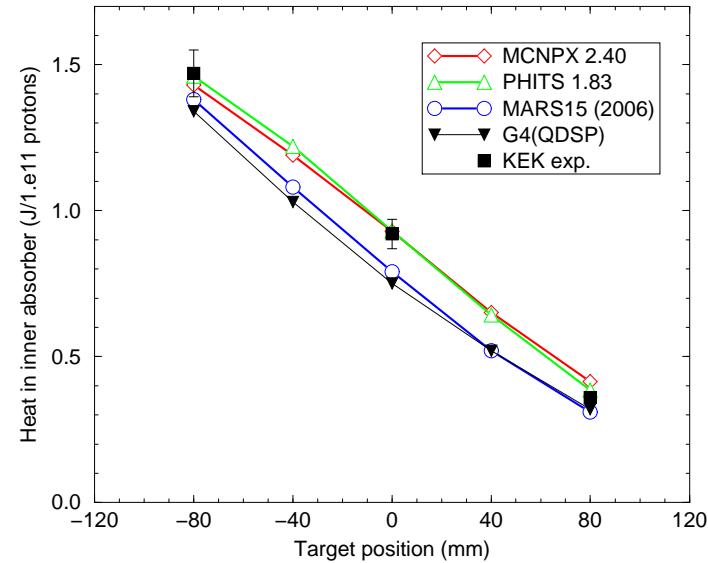
outer absorber は C20 だけ面取りしてある。

材料 : Target、inner absorber、outer absorber は銅製。

63Cu -6.19 % density of 63Cu in natural copper

65Cu -2.77 % density of 65Cu in natural copper

入熱分布を計算する。



TASK 6

Iron-scintillator calorimeter consists of 16 modules. Each module contains five sub-modules, 2.5 cm thick iron + 0.5 cm thick scintillator plates. Plates have a cylindrical shape of 75 cm radius.

Incident particles are negative pions with kinetic energy of 10,20,50,100, and 300 GeV.

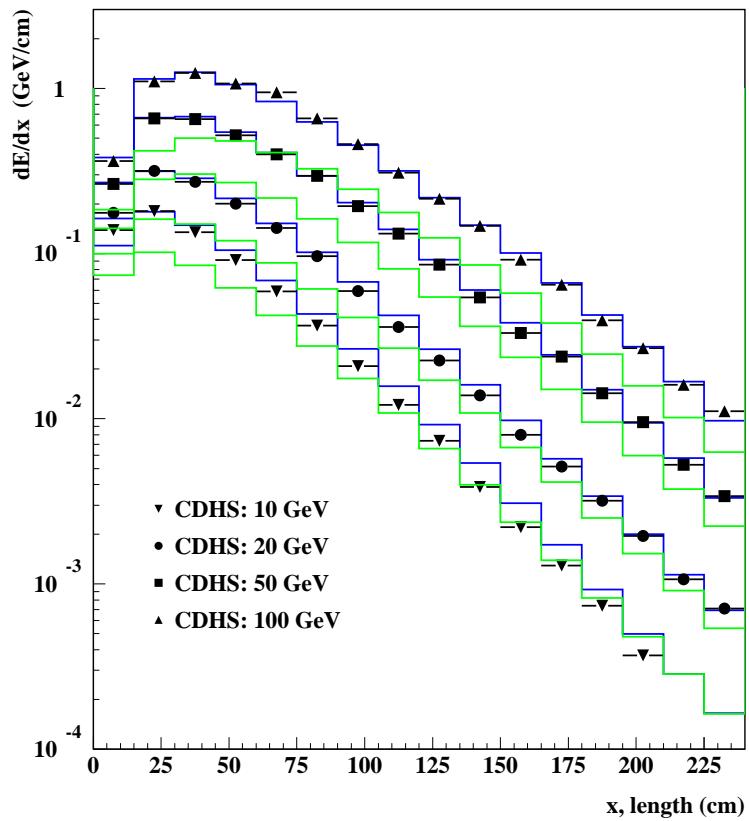
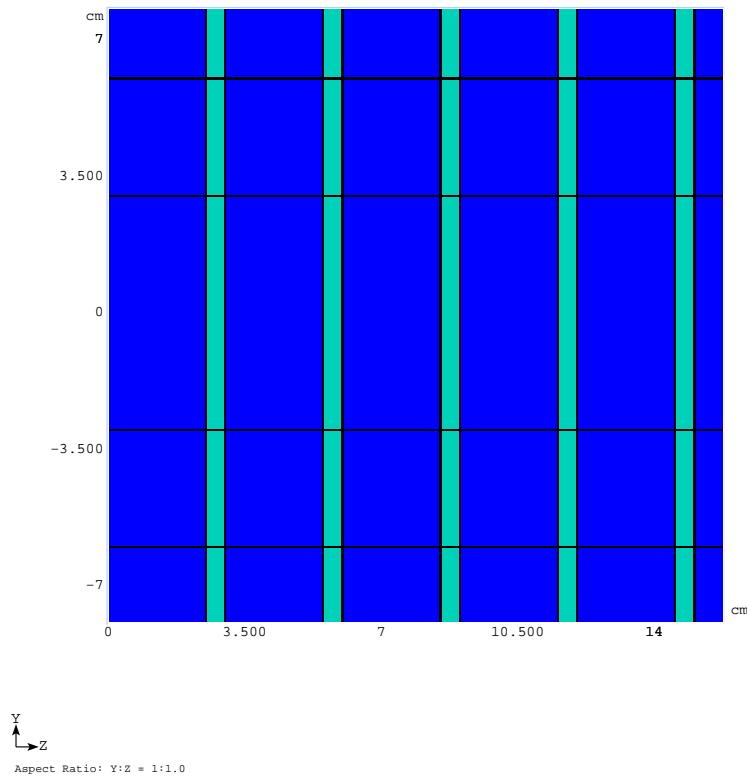
Calculate energy deposition in each of 16 modules and radial distribution in module #1,3,6,9.

Experimental data is from I Int. Conf. on Calorimetry in HEP, 525, FNAL, 1990.

Models:

- PHITS 2.13 by N. Matsuda
- MARS15 by Noriaki Nakao

TASK 6



Black symbols - CDHS data, green line - PHITS, blue line - MARS

TASK 7

Energy deposition profile in a thick target for proton beam energy of 1, 20 and 50 GeV.

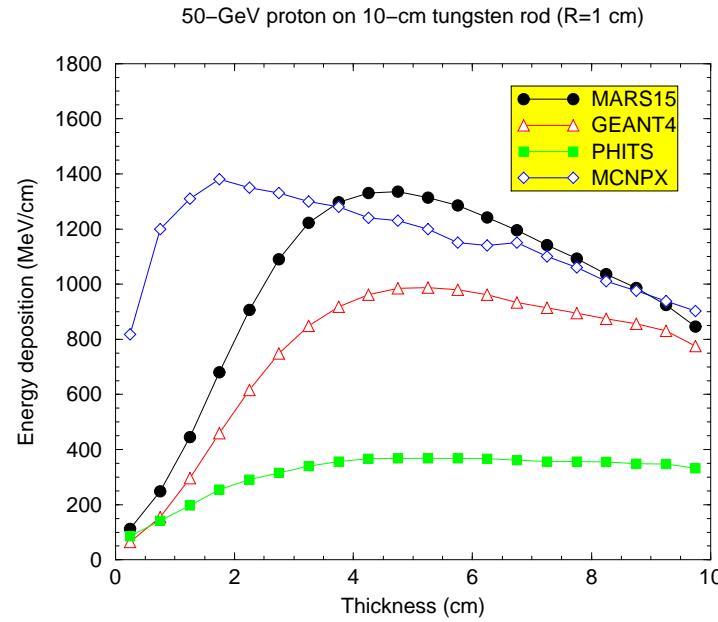
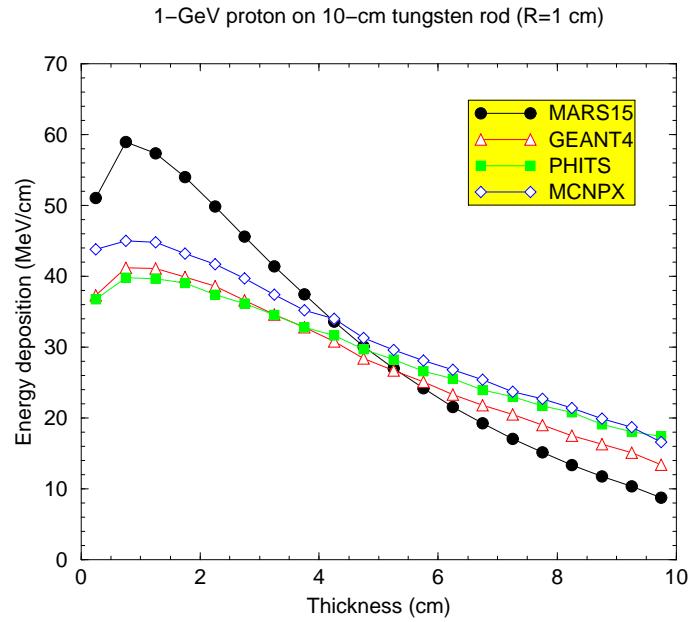
A point-like proton beam with $E_{kin} = 1, 20$ and 50 GeV on a tungsten target which is 10-cm long with a radius of 1 cm.

Calculate energy deposition (MeV/cm) in each of the twenty longitudinal bins, $\Delta_z = 0.5$ cm.

Models:

- PHITS 2.13 by N. Matsuda
- MARS15 by Nikolai Mokhov
- G4 by Dennis Wright
- MCNPX by Laurie Waters

TASK 7



Notes: (1) No electromagnetic shower transport above 1 GeV in PHITS and MCNPX.
(2) MARS15 results from an unofficial developer version.