MARS SIMULATION OF THE MERCURY TARGET EXPERIMENT

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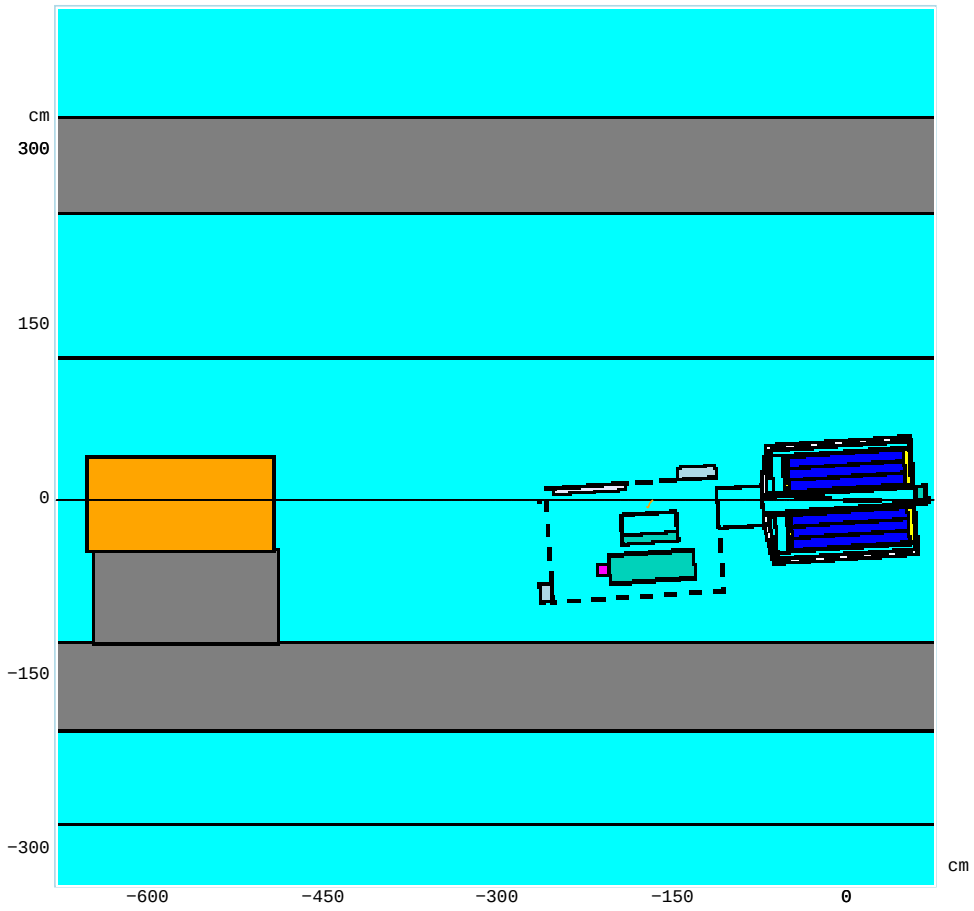
OUTLINE

- MARS code
- Geometry description
- Fluxes, doses and residual activities
- Particle production

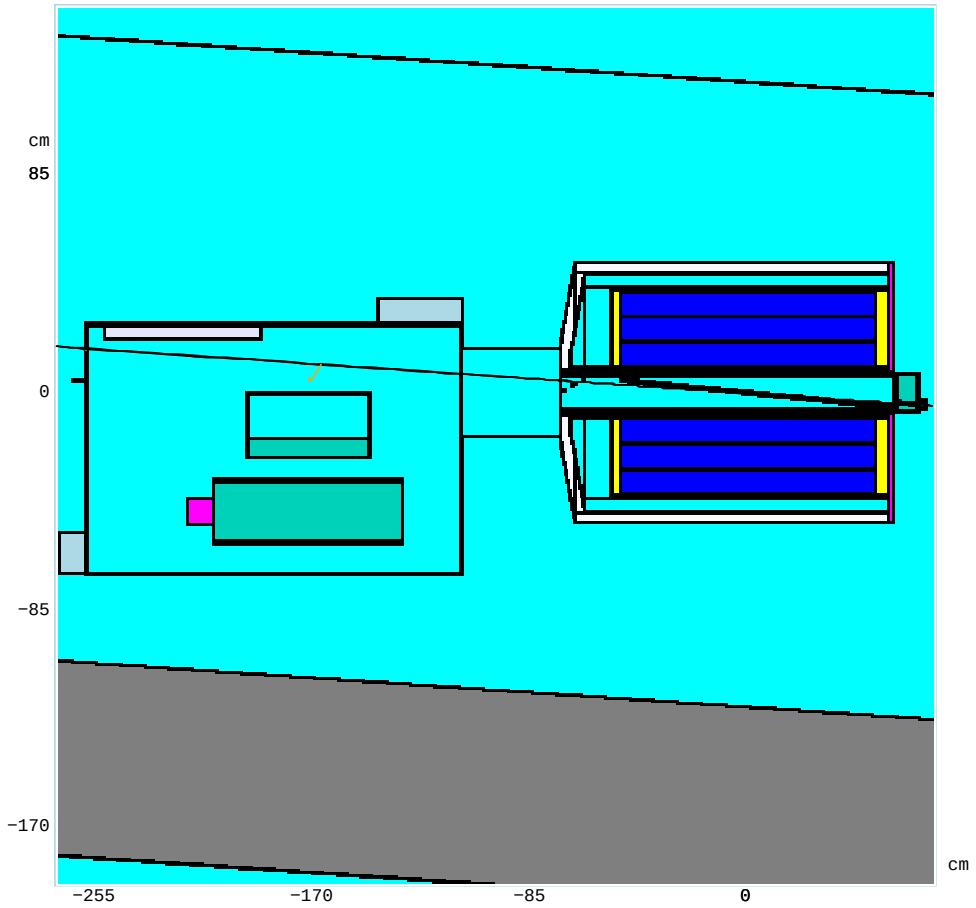
MARS CODE

MARS code system is a set of Monte Carlo programs for detailed simulation of hadronic end electromagnetic cascades in an arbitrary geometry of accelerator, detector and spacecraft components with particle energy ranging from a fraction of an electron volt up to 100 TeV. The original version of the MARS code was created about 30 years ago and is developed since then in IHEP (Protvino), SSCL and FNAL. The current MARS15 version combines the well established theoretical models for strong, weak and electromagnetic interactions of hadrons and leptons with a system which can contain up to 10^5 objects, ranging in dimensions from microns to hundreds of kilometers, made up to 100 composite materials, with arbitrary 3-D magnetic and electric fields.

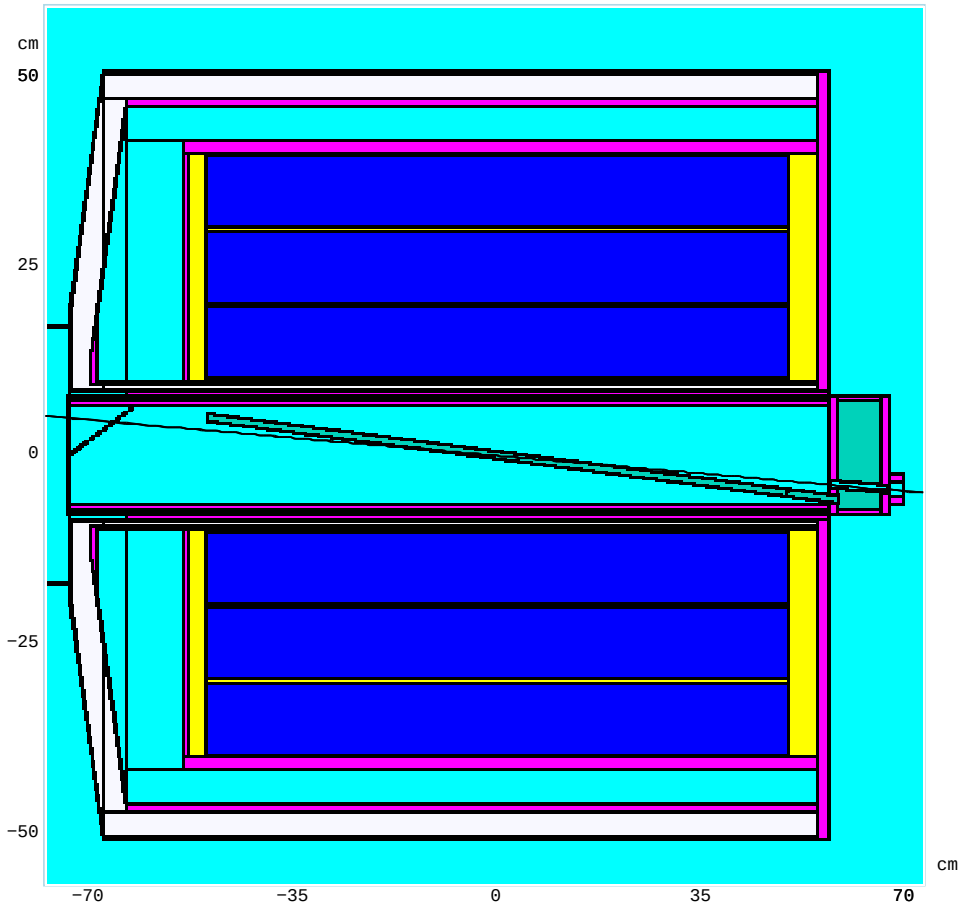
The code is used in numerous applications worldwide (US, Japan, Europe, Russia) at existing accelerator facilities, in planned experiments, accelerator projects and in cosmic ray physics. Its reliability has been demonstrated in many benchmarks studies.



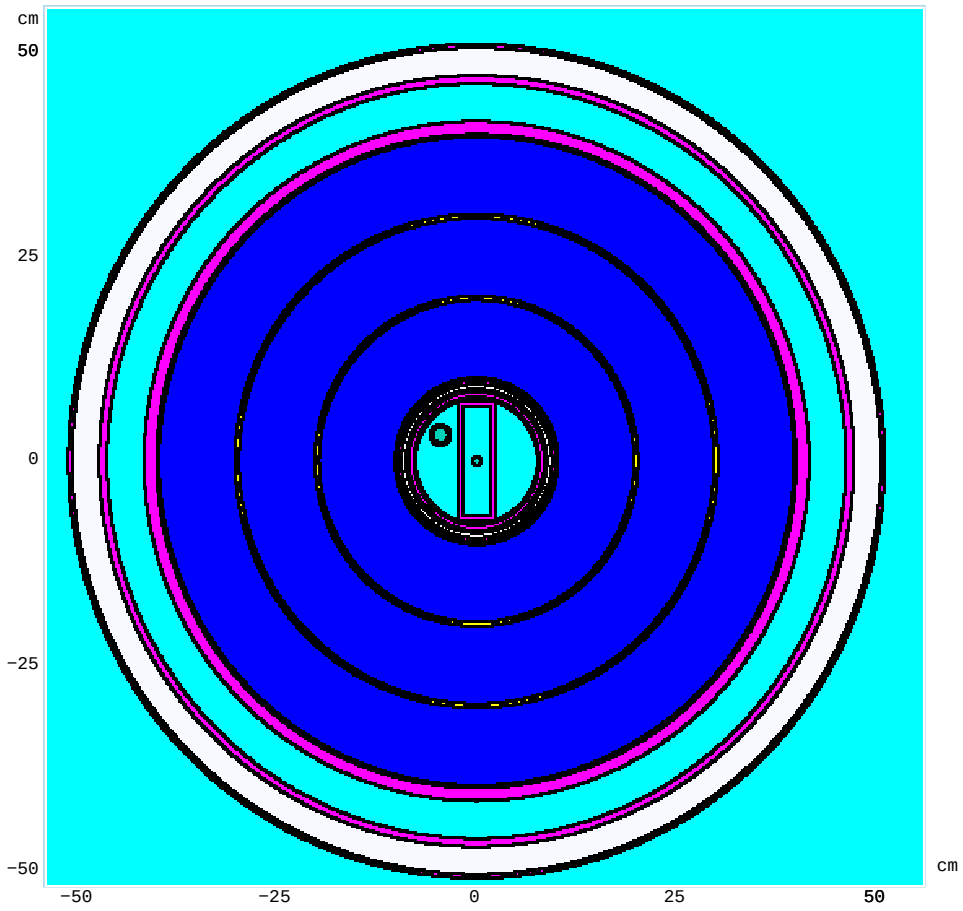
General view. XZ projection.



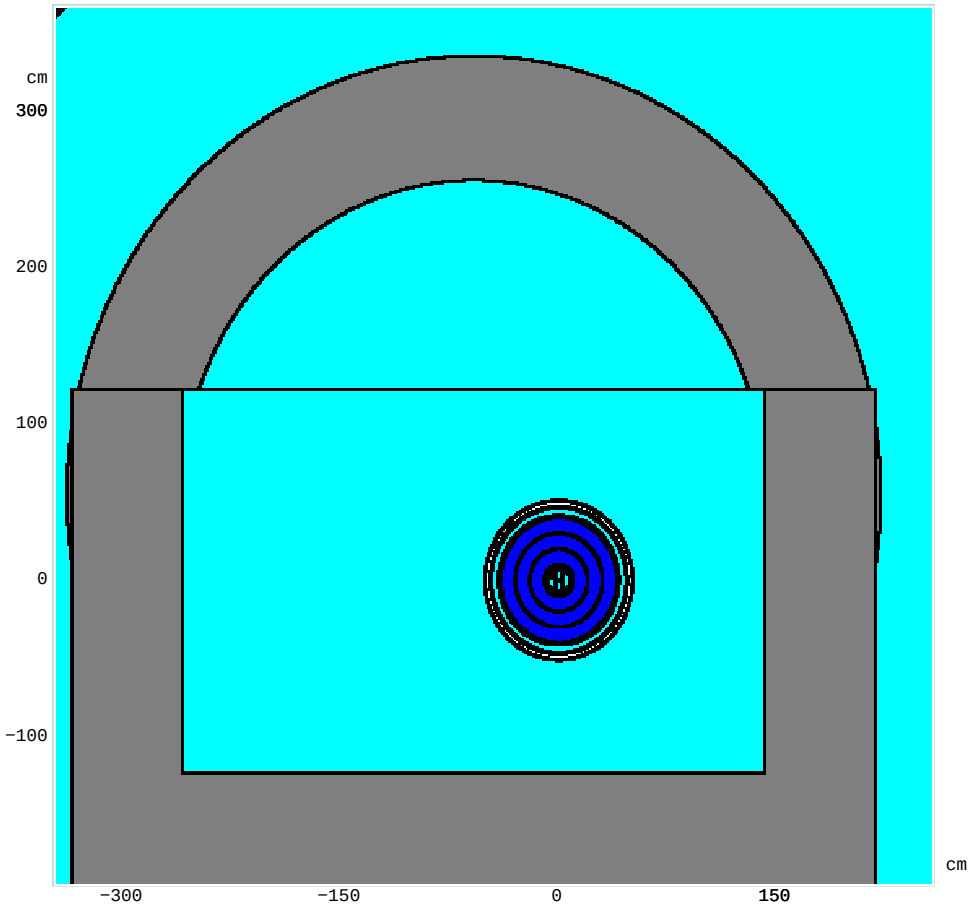
Magnet and secondary containment. XZ projection.



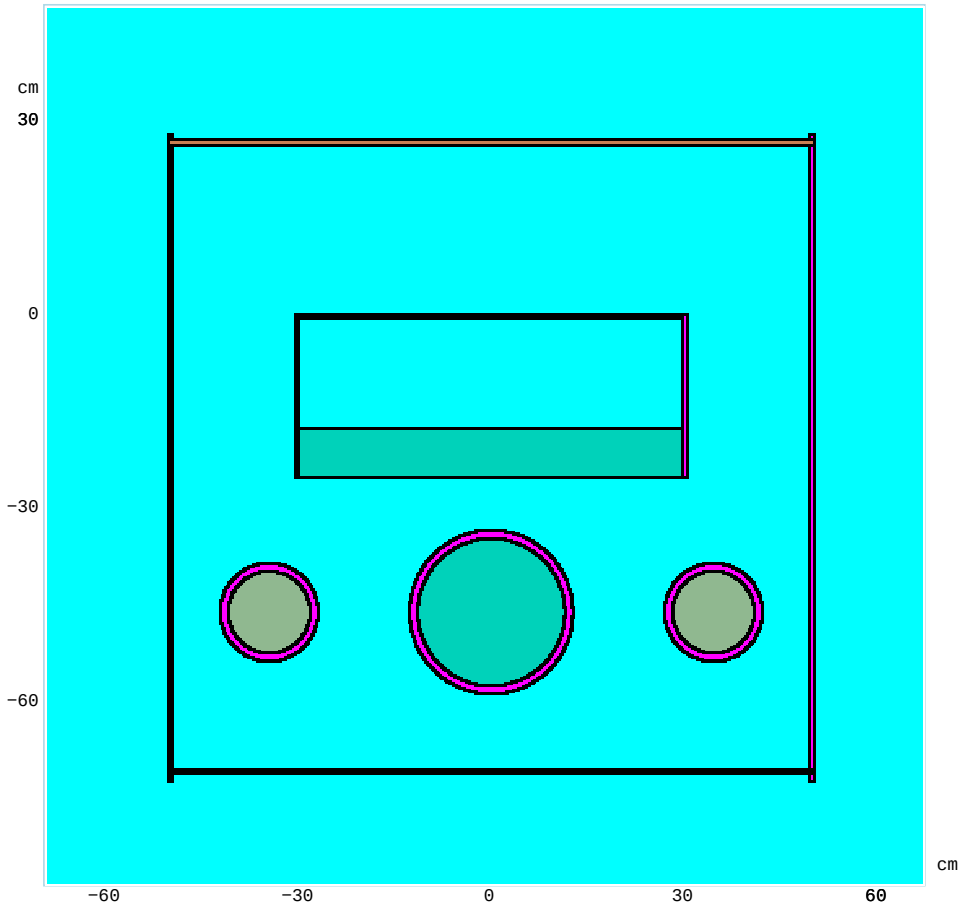
Solenoid and cryostat. XZ projection.



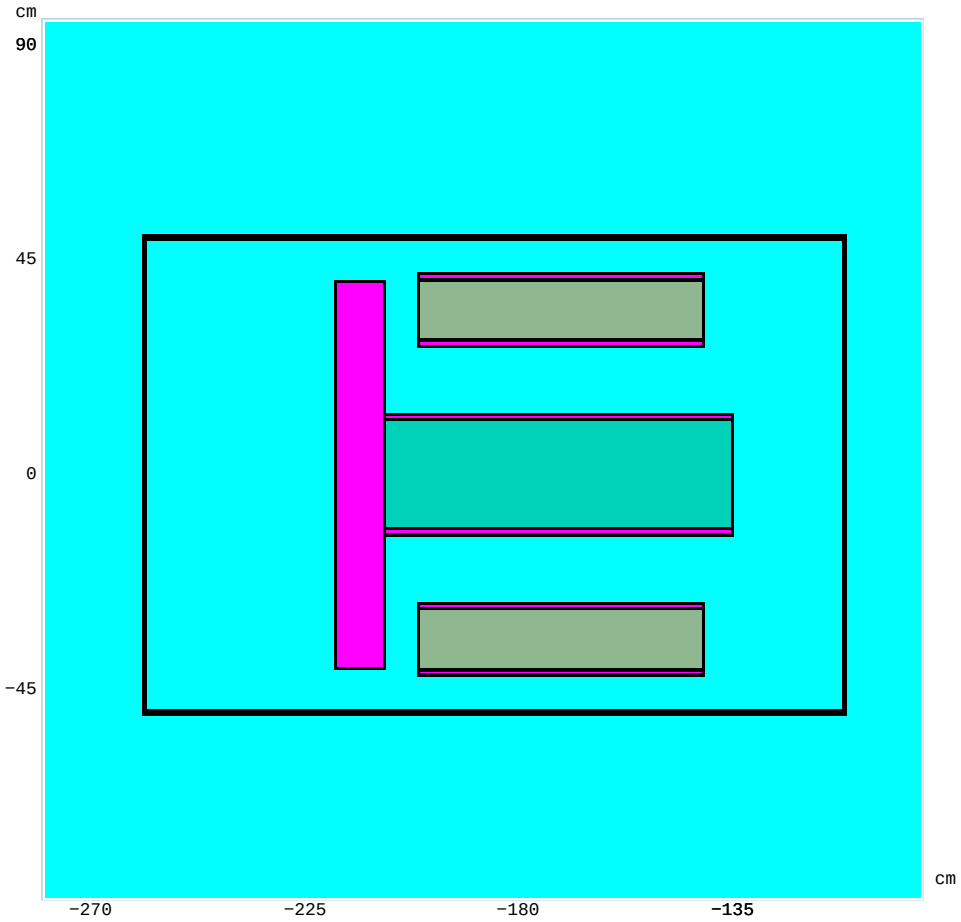
Solenoid and cryostat. XY projection.



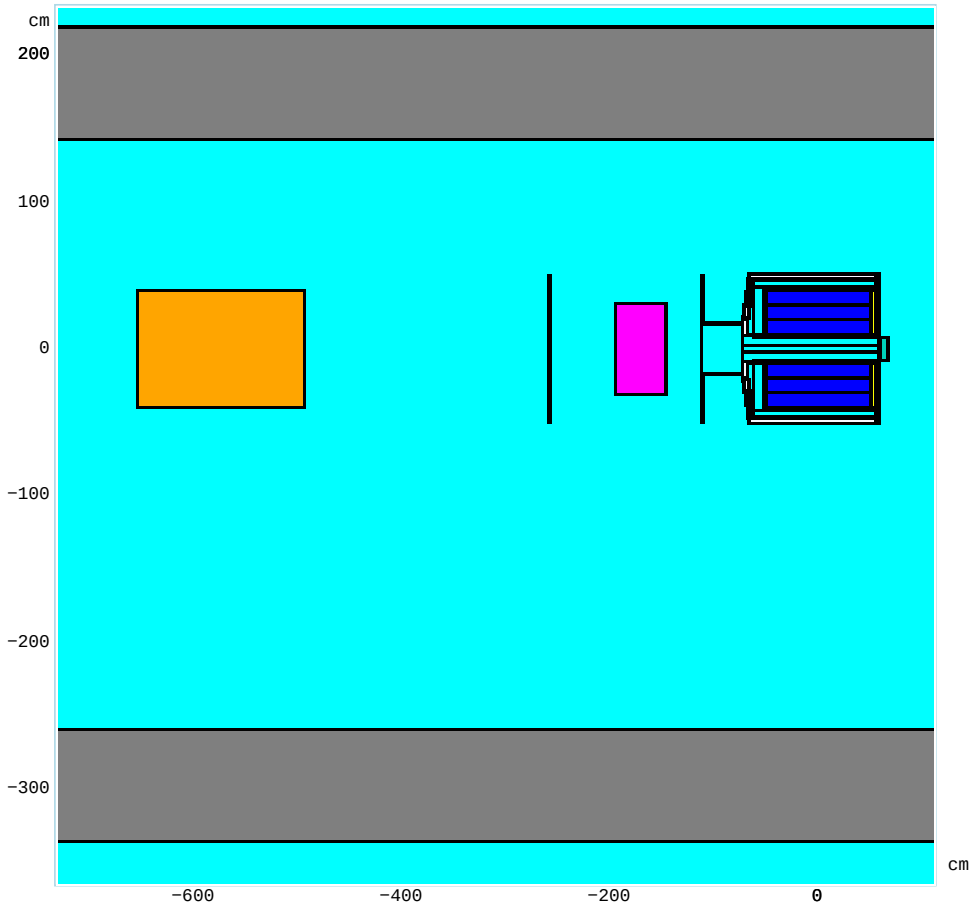
XY projection at solenoid center.



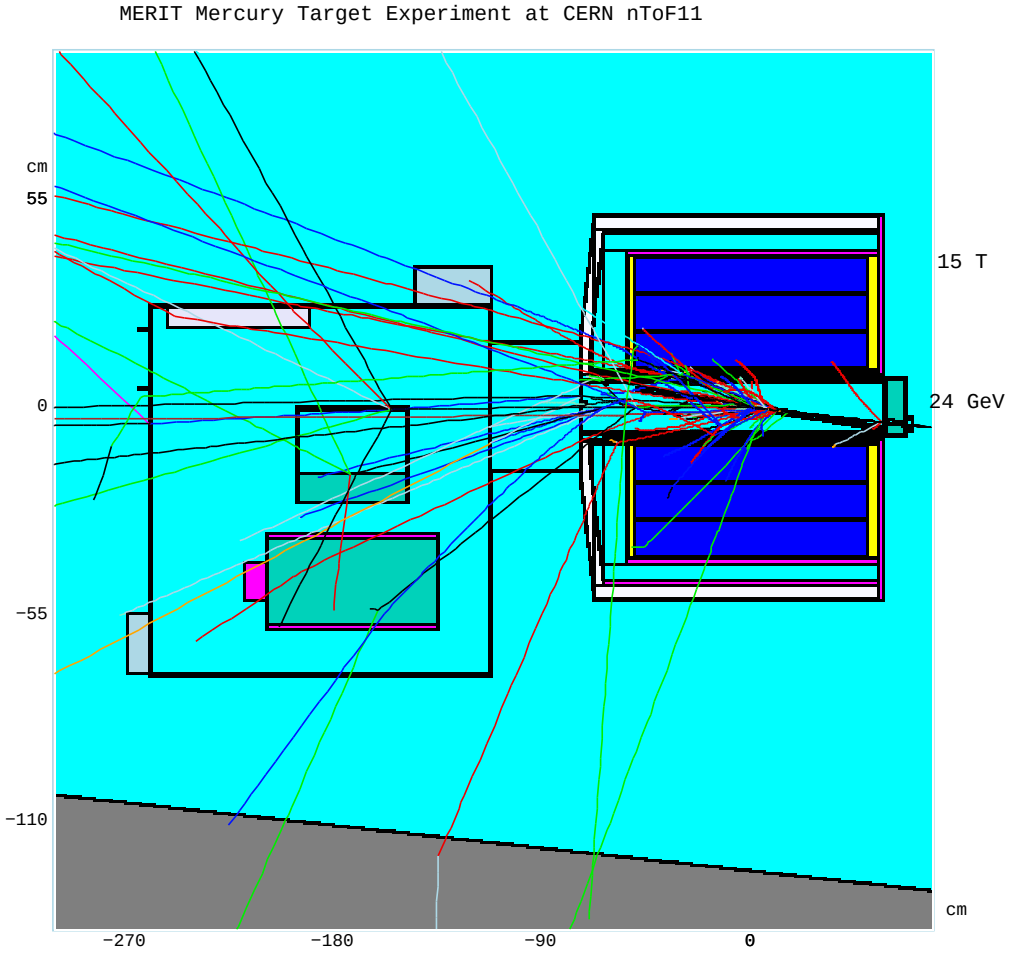
XY projection of secondary containment.



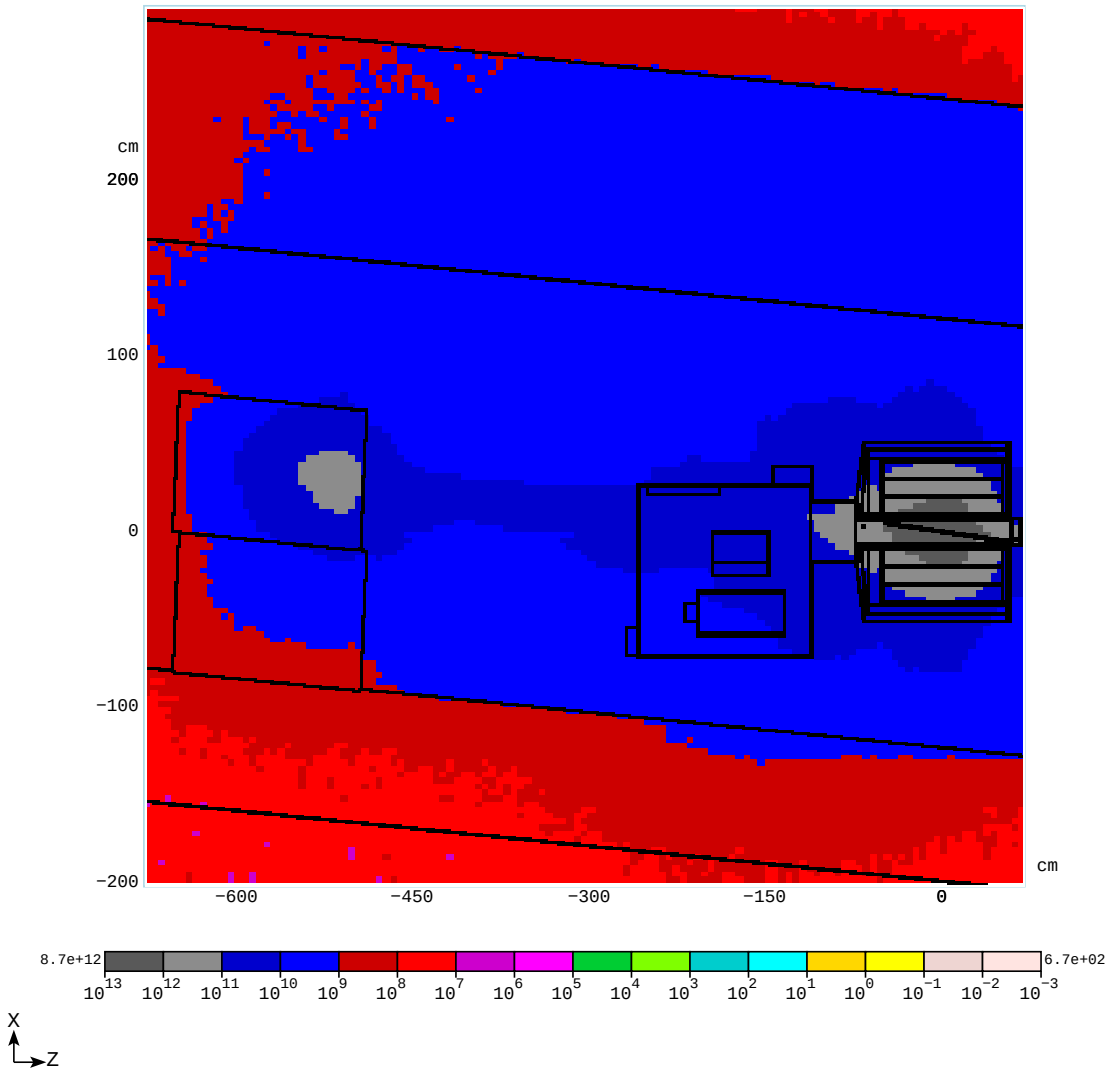
YZ projection of secondary containment.



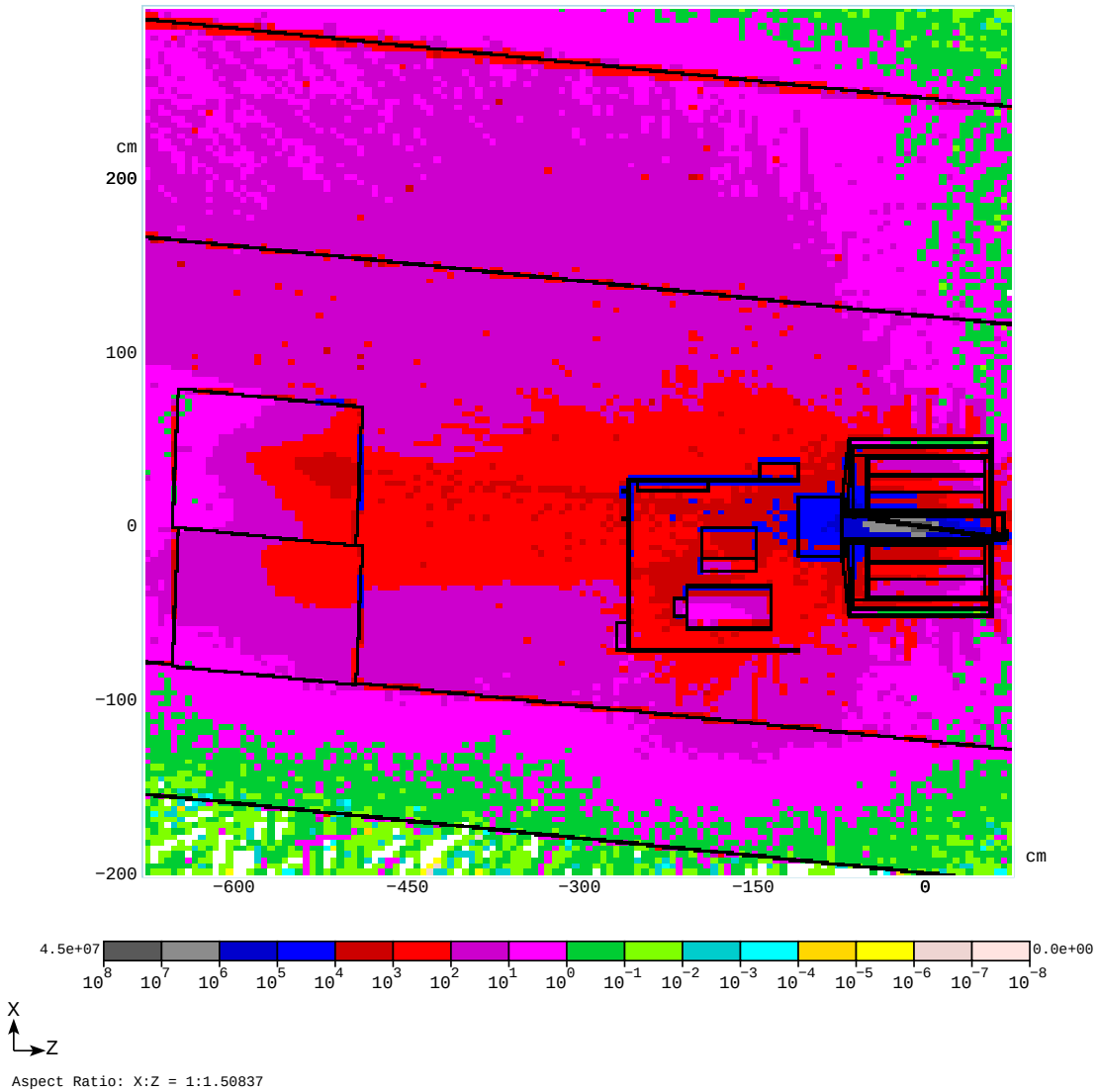
General view. YZ projection.



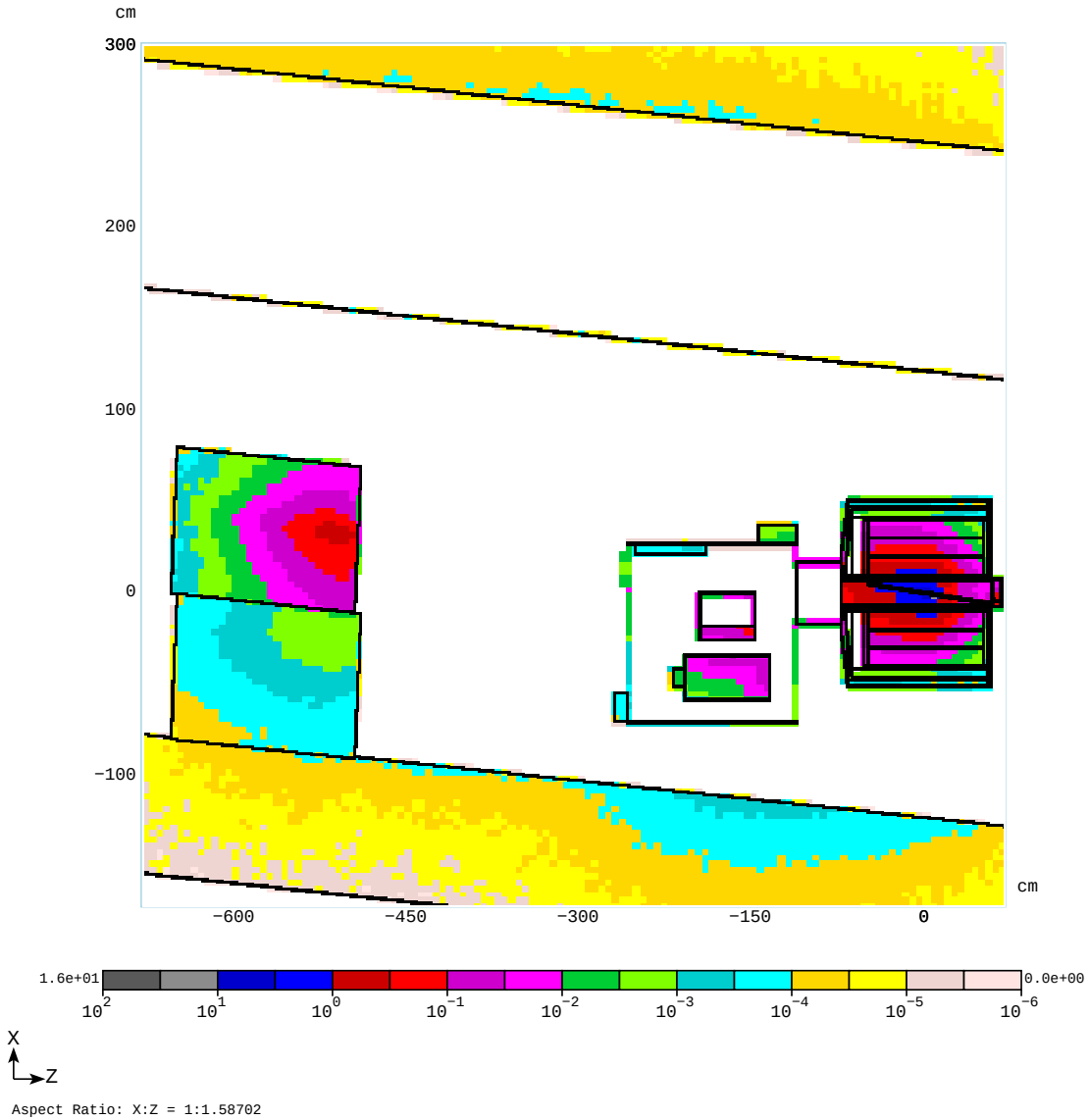
Beam on mercury target. XZ projection.



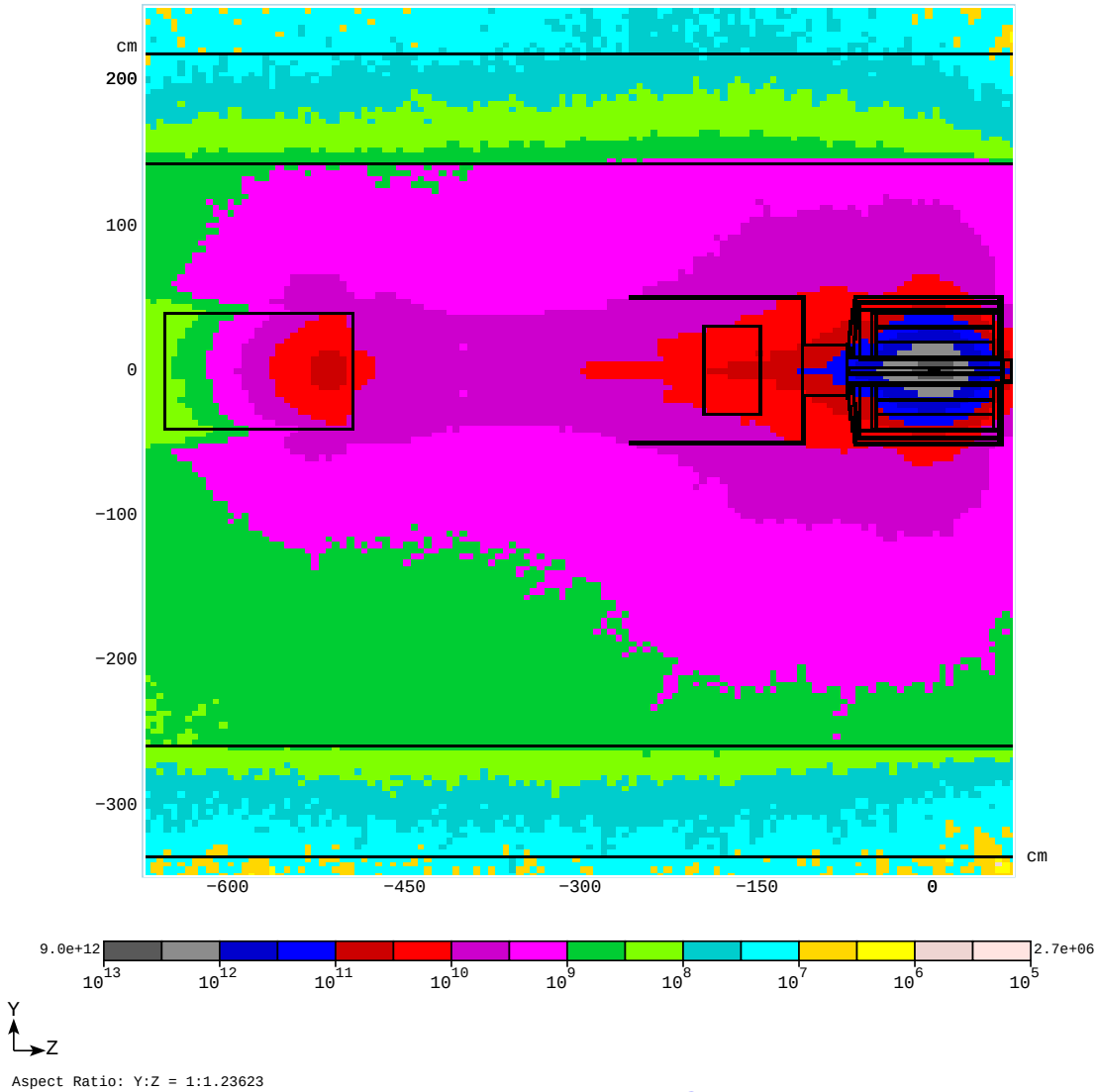
Total flux in $1/\mathrm{cm}^2/3 \cdot 10^{13}$ protons.



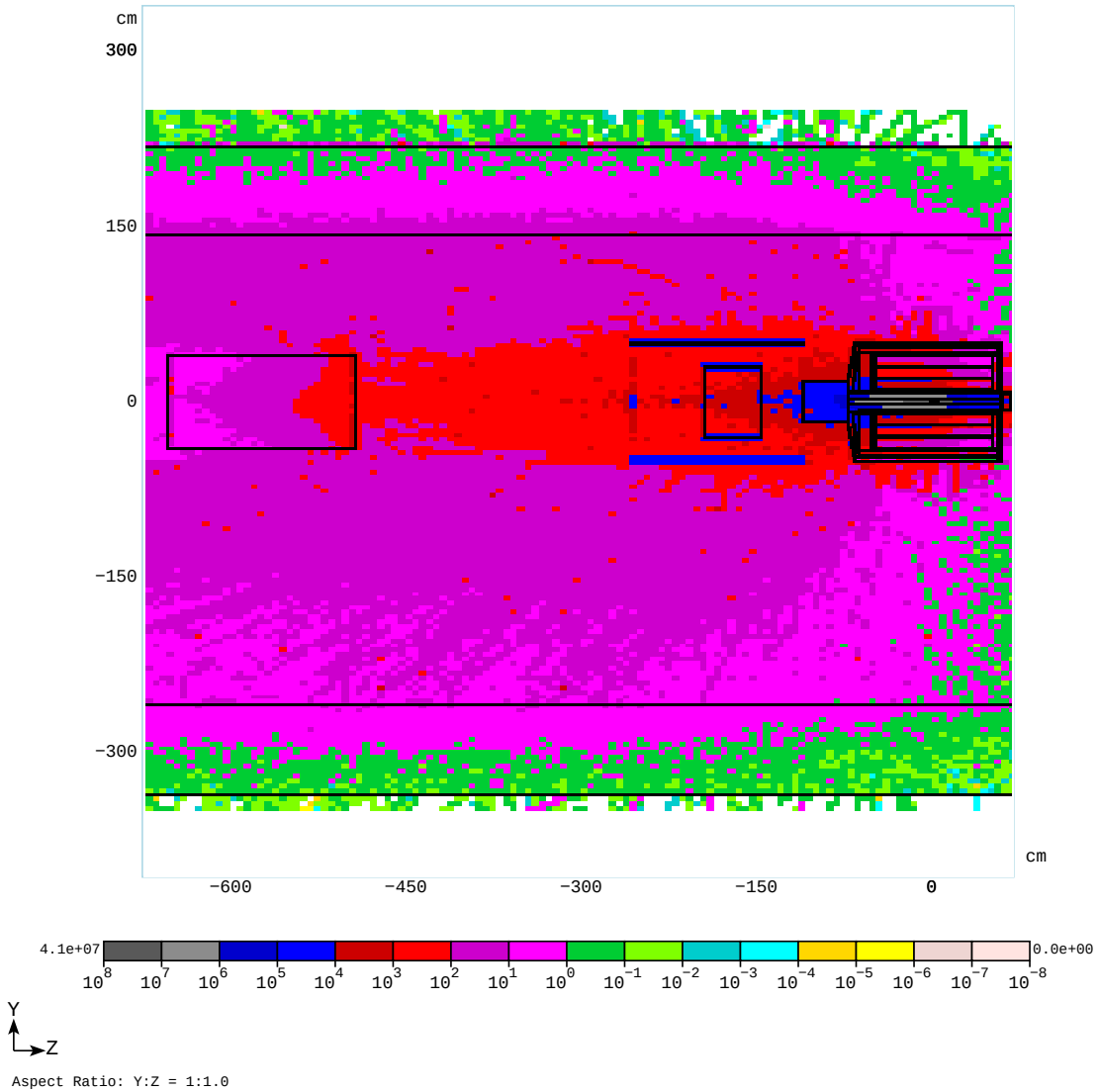
Absorbed dose in Grey/$3 \cdot 10^{15}$ protons.



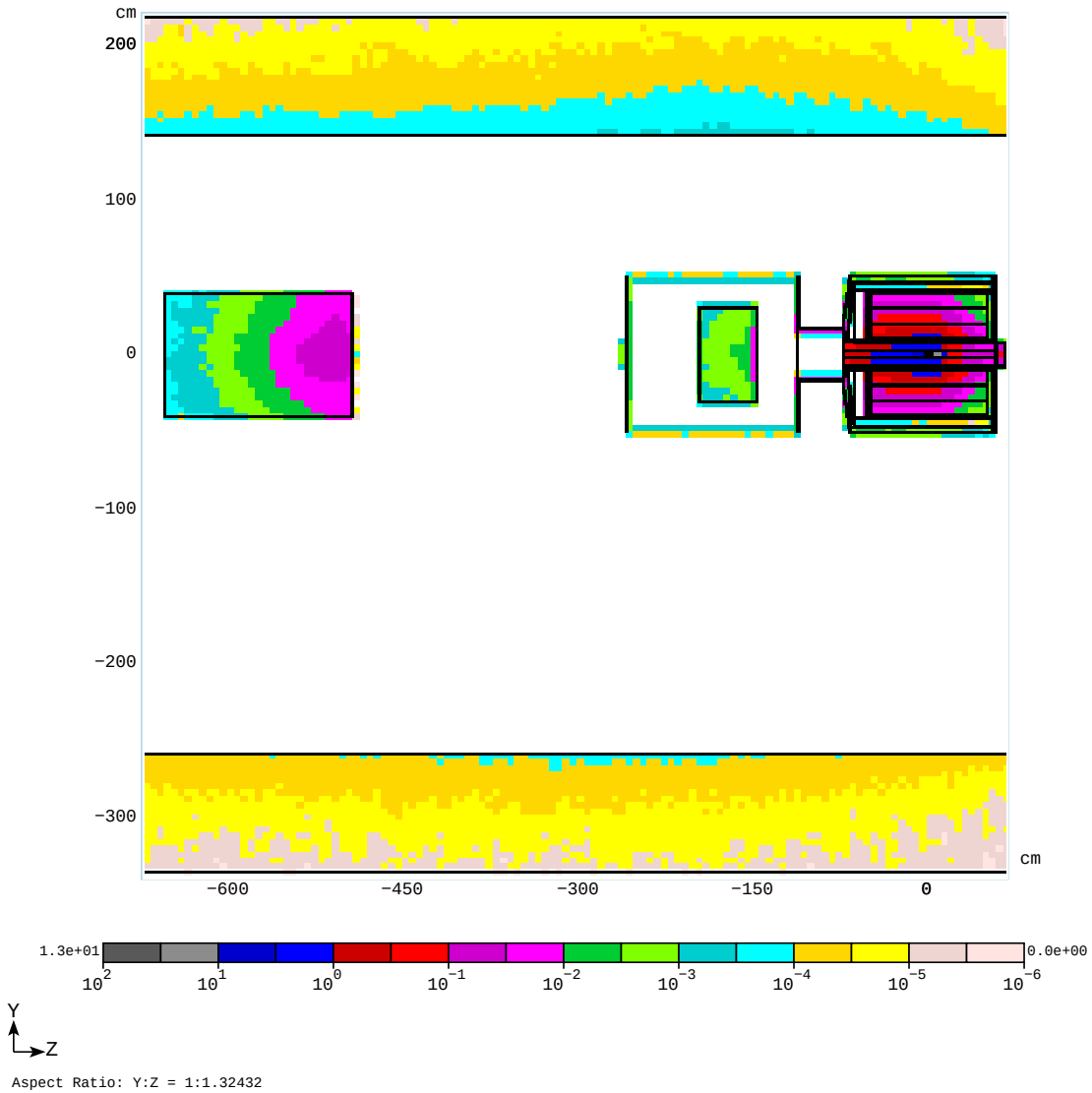
30/1 residual dose in mSv/hr. $3 \cdot 10^{15}$ protons/30 day.



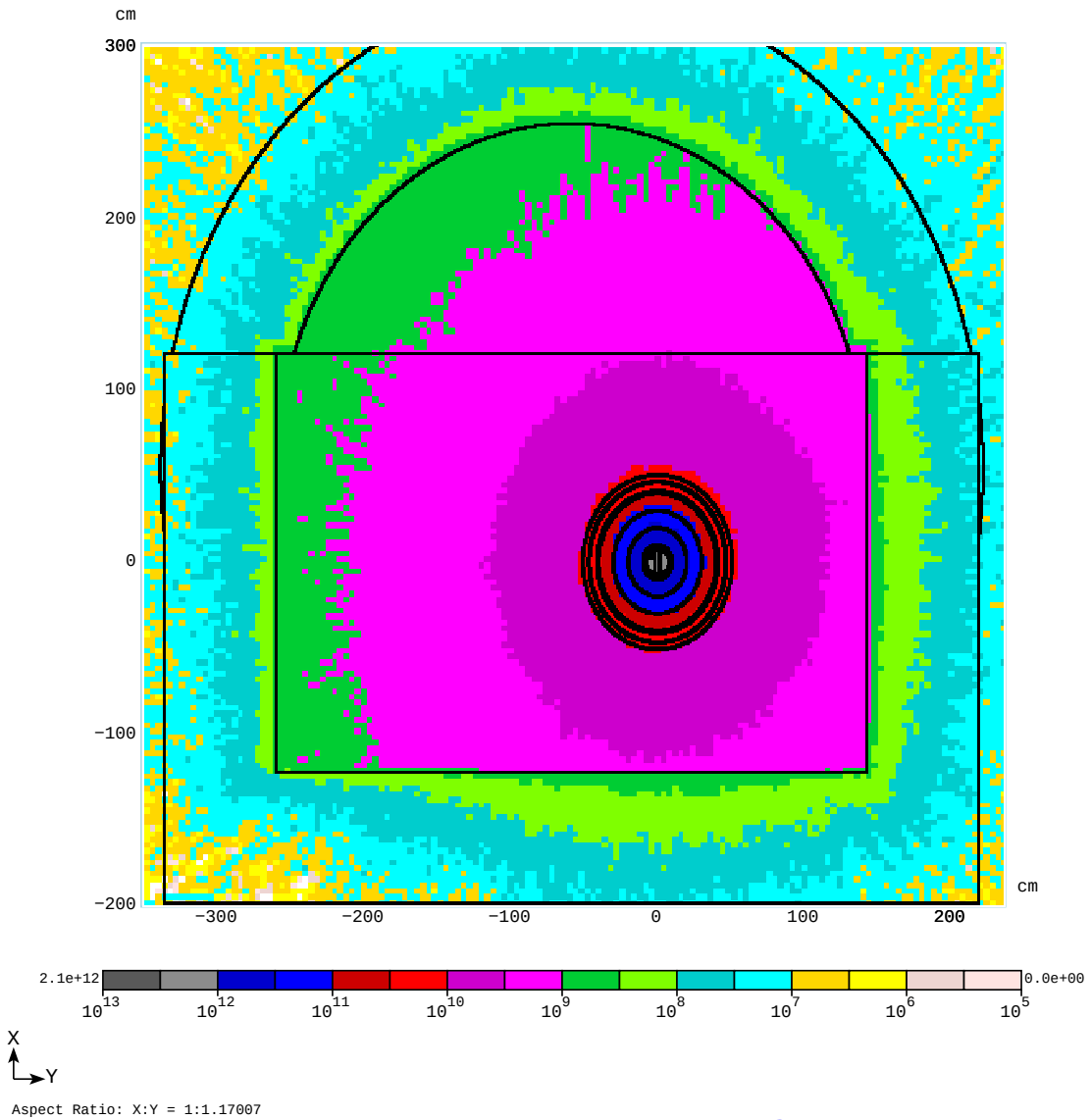
Total flux in $1/\mathrm{cm}^2/3 \cdot 10^{13}$ protons.



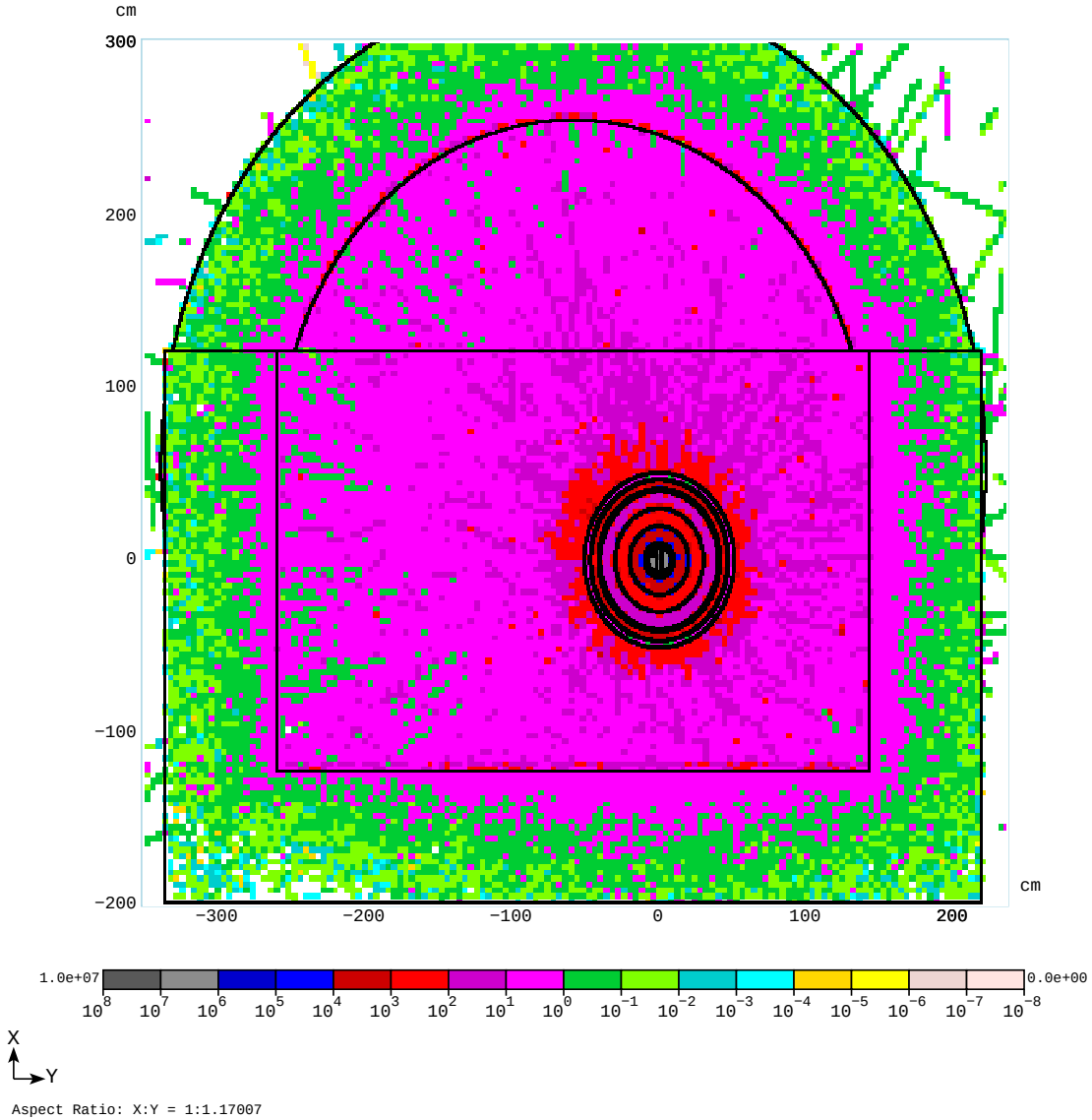
Absorbed dose in Grey/$3 \cdot 10^{15}$ protons.



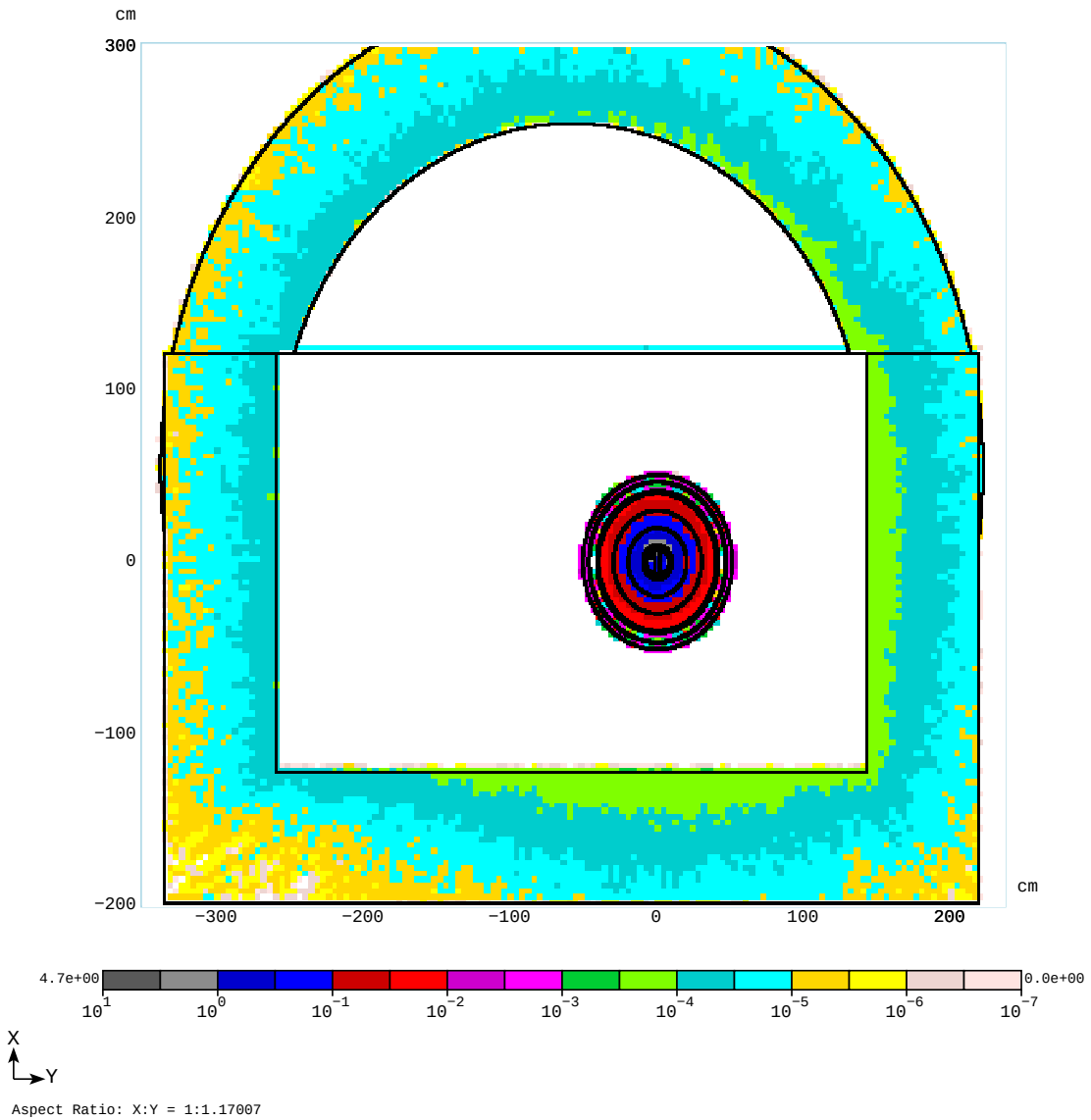
30/1 residual dose in mSv/hr. $3 \cdot 10^{15}$ protons/30 day.



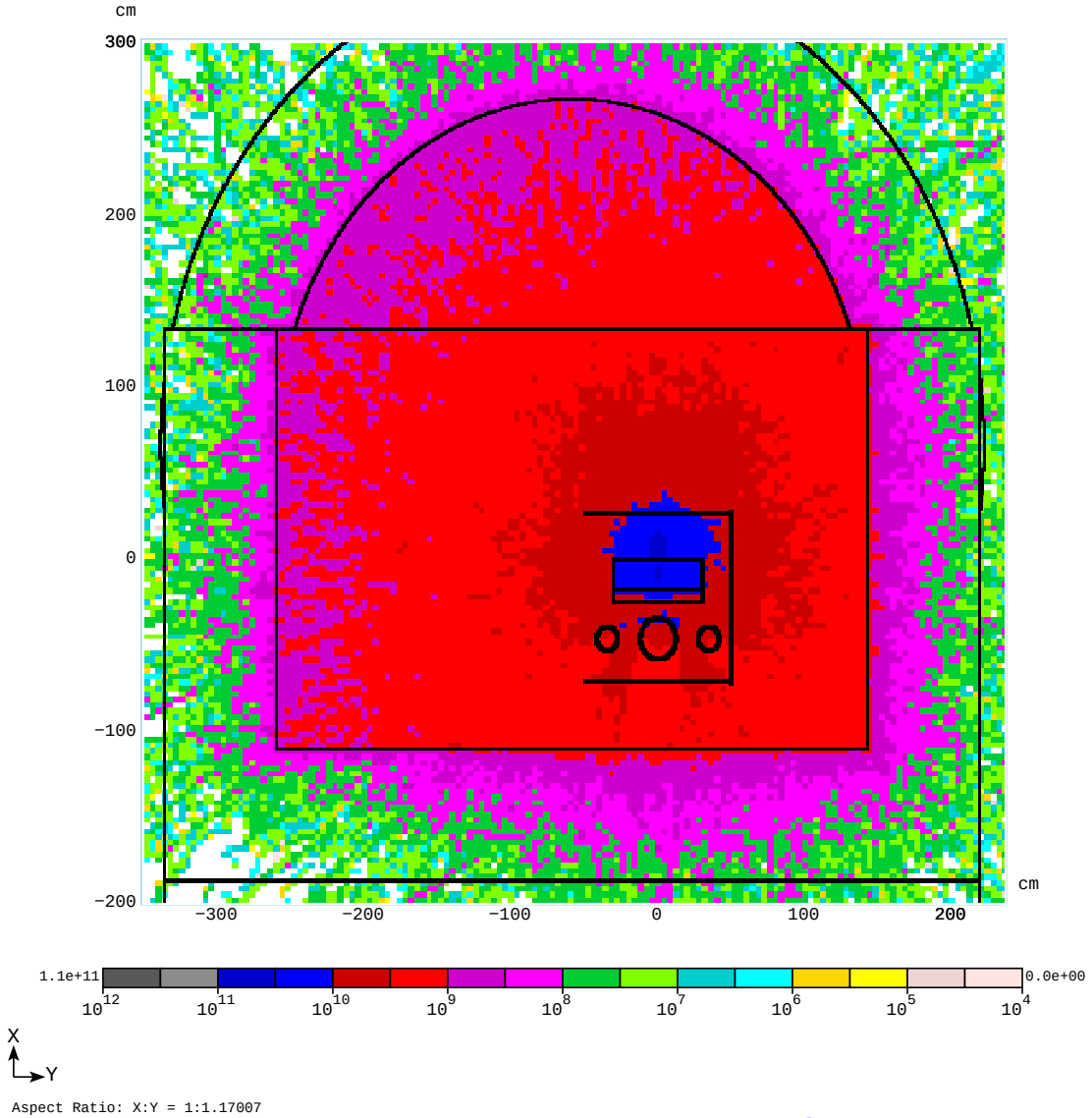
Total flux at Z=0 cm in $1/cm^2/3 \cdot 10^{13}$ protons.



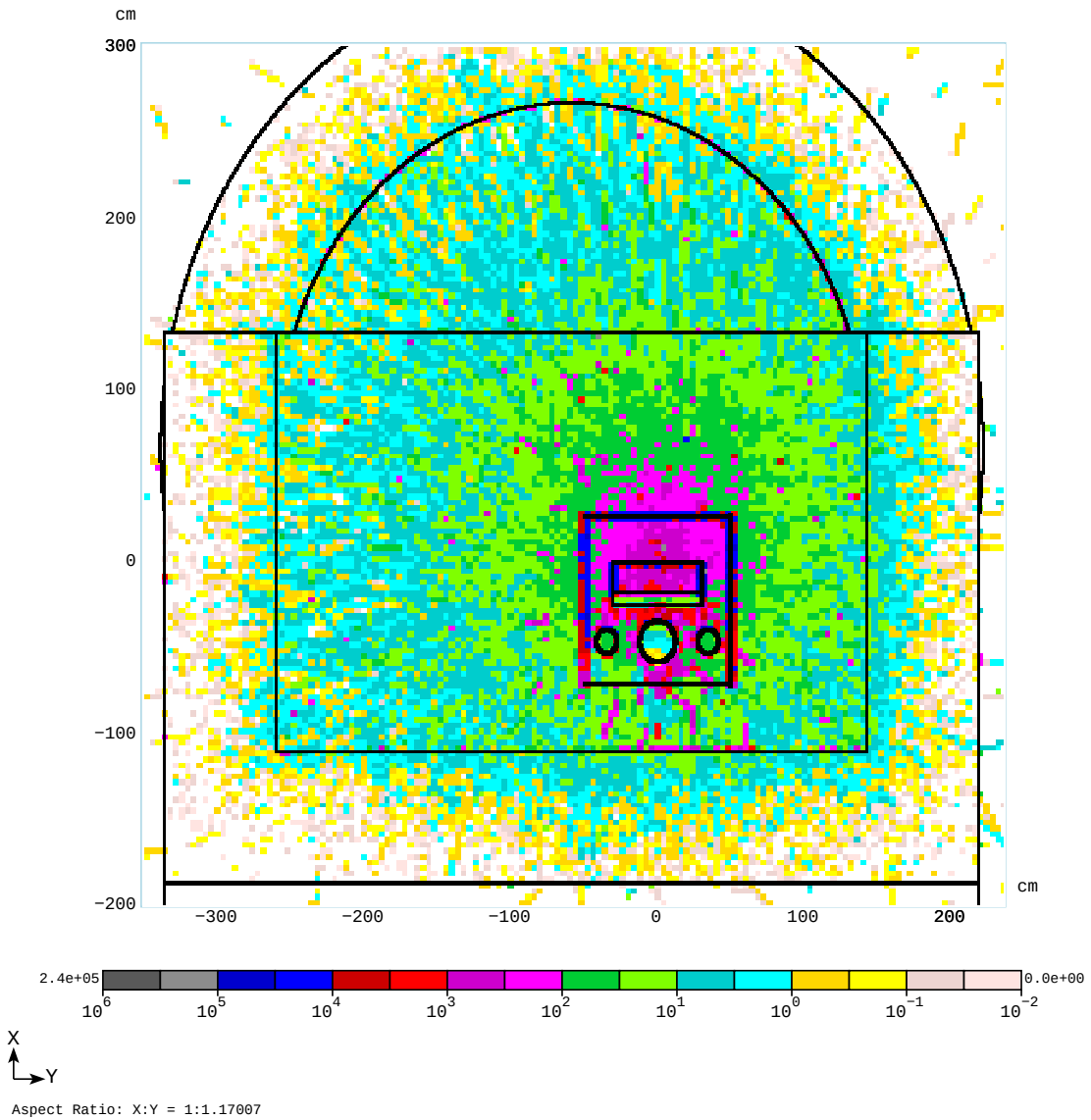
Absorbed dose in Grey/$3 \cdot 10^{15}$ protons at Z=0 cm.



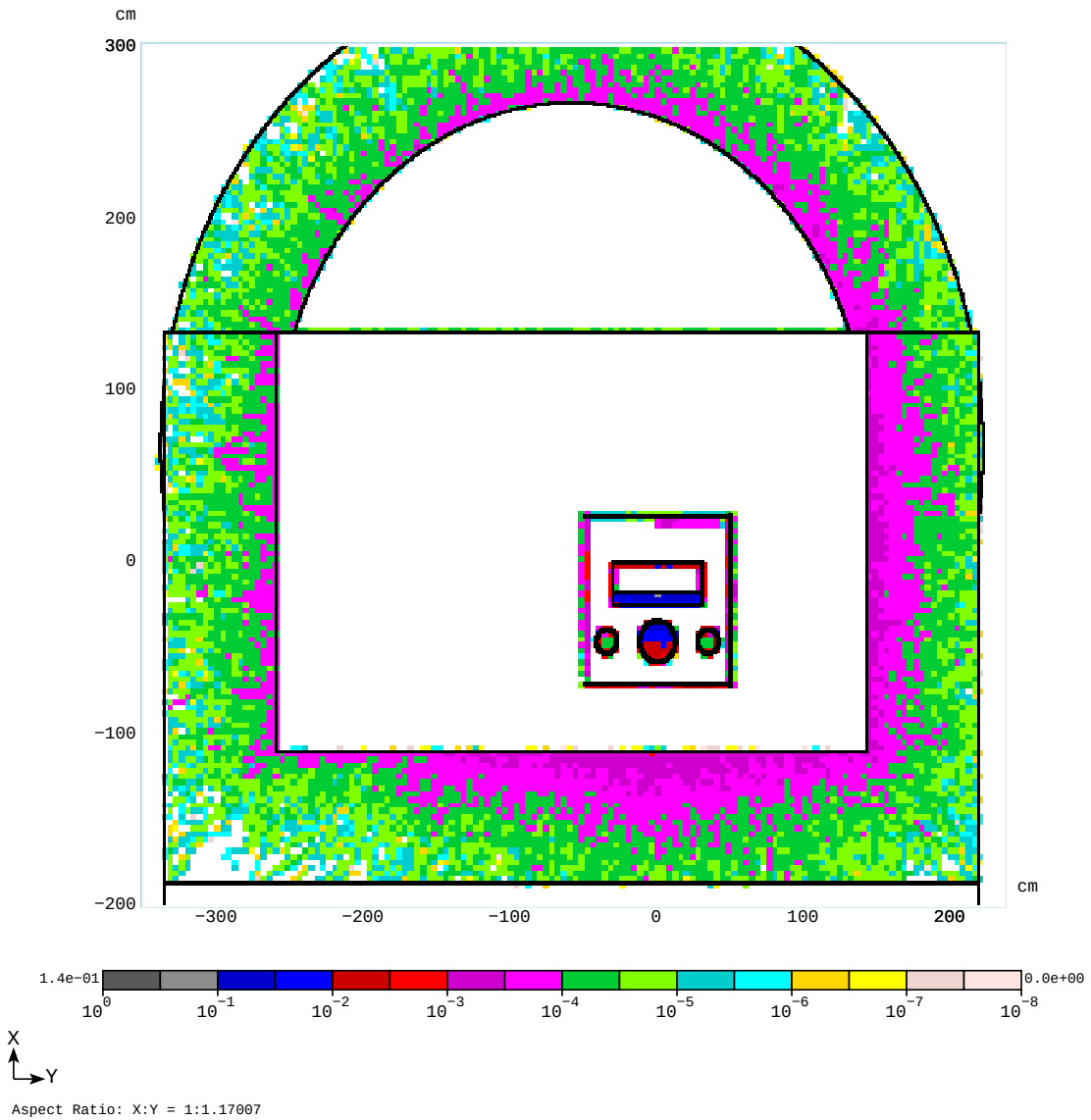
30/1 residual dose at Z=0 cm in mSv/hr. $3 \cdot 10^{15}$ protons/30 day.



Total flux at Z=-180 cm in $1/cm^2/3 \cdot 10^{13}$ protons.



Absorbed dose in Grey/$3 \cdot 10^{15}$ protons at Z=-180 cm.



30/1 residual dose at Z=-180 cm in mSv/hr. $3 \cdot 10^{15}$ protons/30 day.

FLUXES, DOSES AND RESIDUAL ACTIVITY

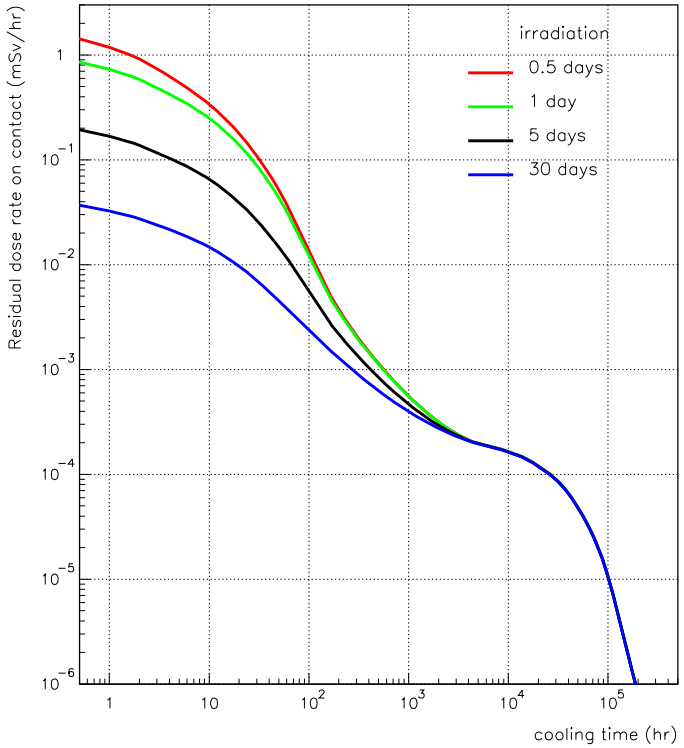
Absorbed dose in mercury vapor analyzer:

- position 1 - 630 Grey = 63 krad
- position 2 - 14 Grey = 1.4 krad
- acceptable level for electronic devices 5-10 krad
- material composition should be specified. Standard MARS mixture ELEC=N-Si-Pb was used in this calculation.

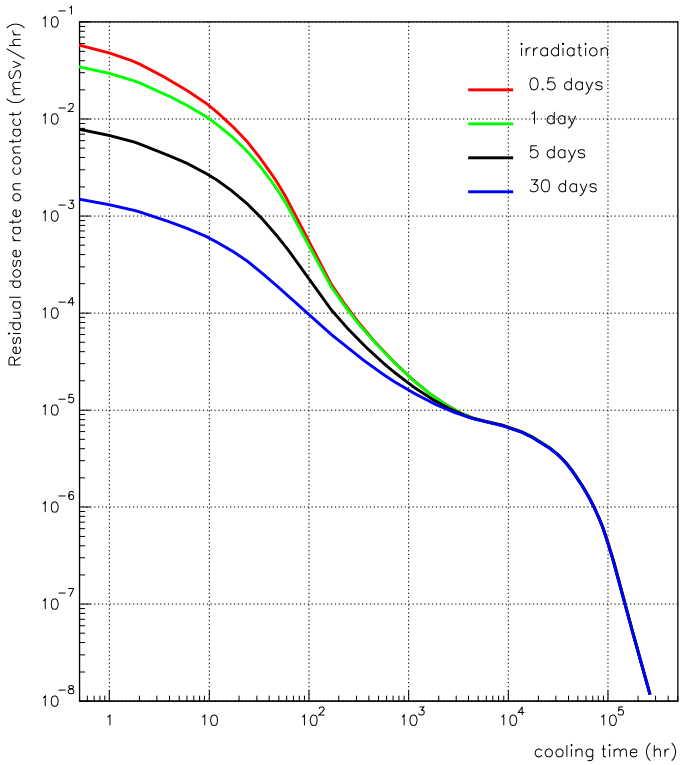
FLUXES, DOSES AND RESIDUAL ACTIVITY - II

Residual dose rate in a tissue-equivalent body on contact after 5 day of irradiation and 1 hour of cooling:

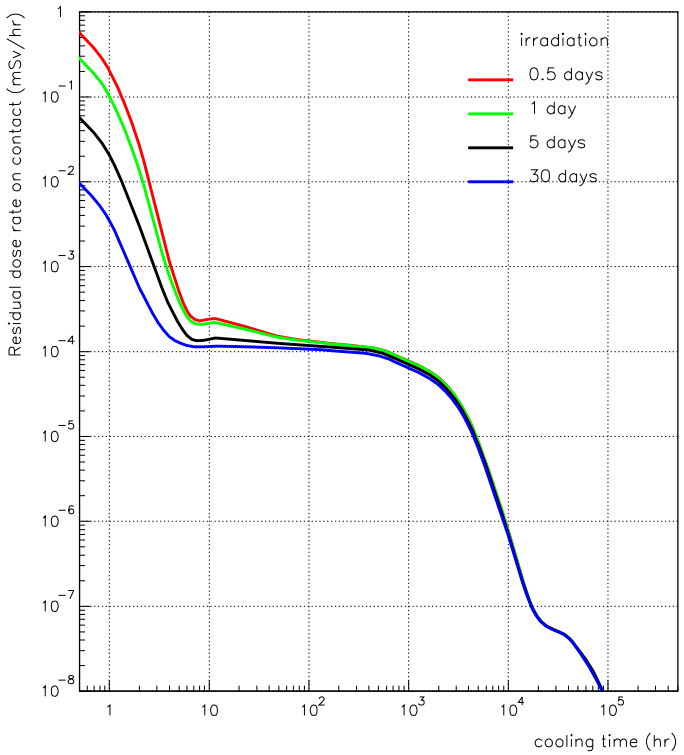
- mercury vapor analyzer (position 1) - 0.17 mSv/hr
- mercury vapor analyzer (position 2) - 0.007 mSv/hr
- hydraulic fluid (Quintolubric 880) in pump - 0.021 mSv/hr
- mercury vapor filter - 0.18 mSv/hr
- acceptable level are about 1 mSv/hr at FNAL, 0.1(?) mSv/hr at CERN
- material composition of filter should be specified. Pure carbon was used in this calculation. Sulfur/iodine component should be included.



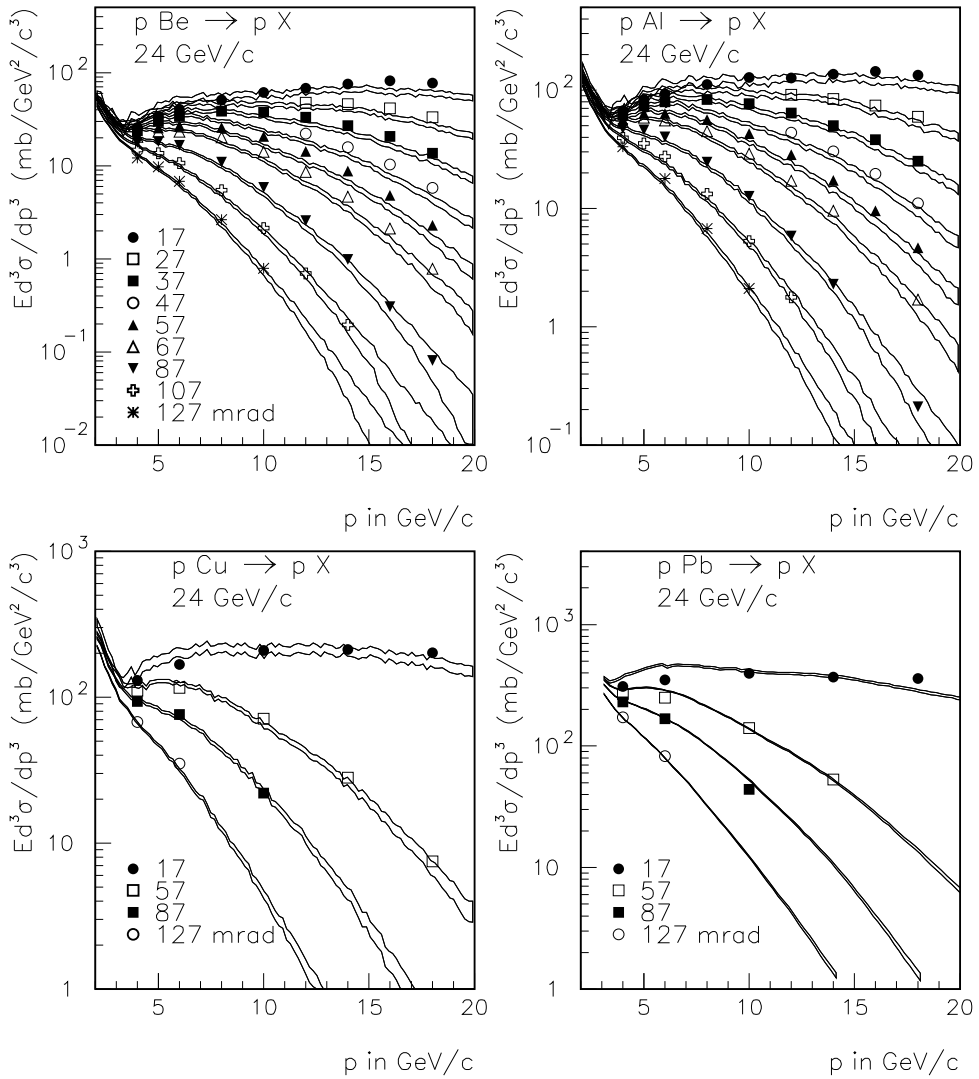
Residual dose in contact with mercury vapor analyzer (position 1).

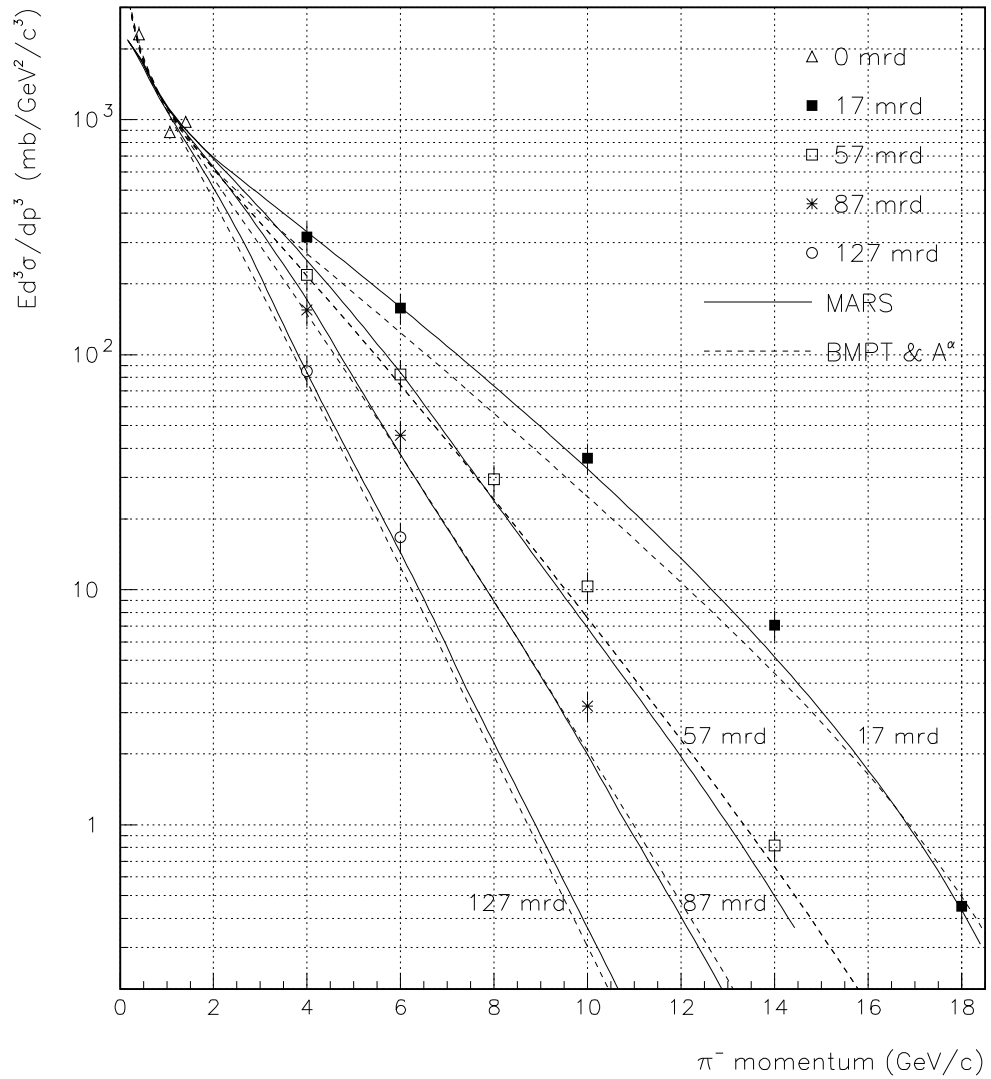


Residual dose in contact with mercury vapor analyzer (position 2).

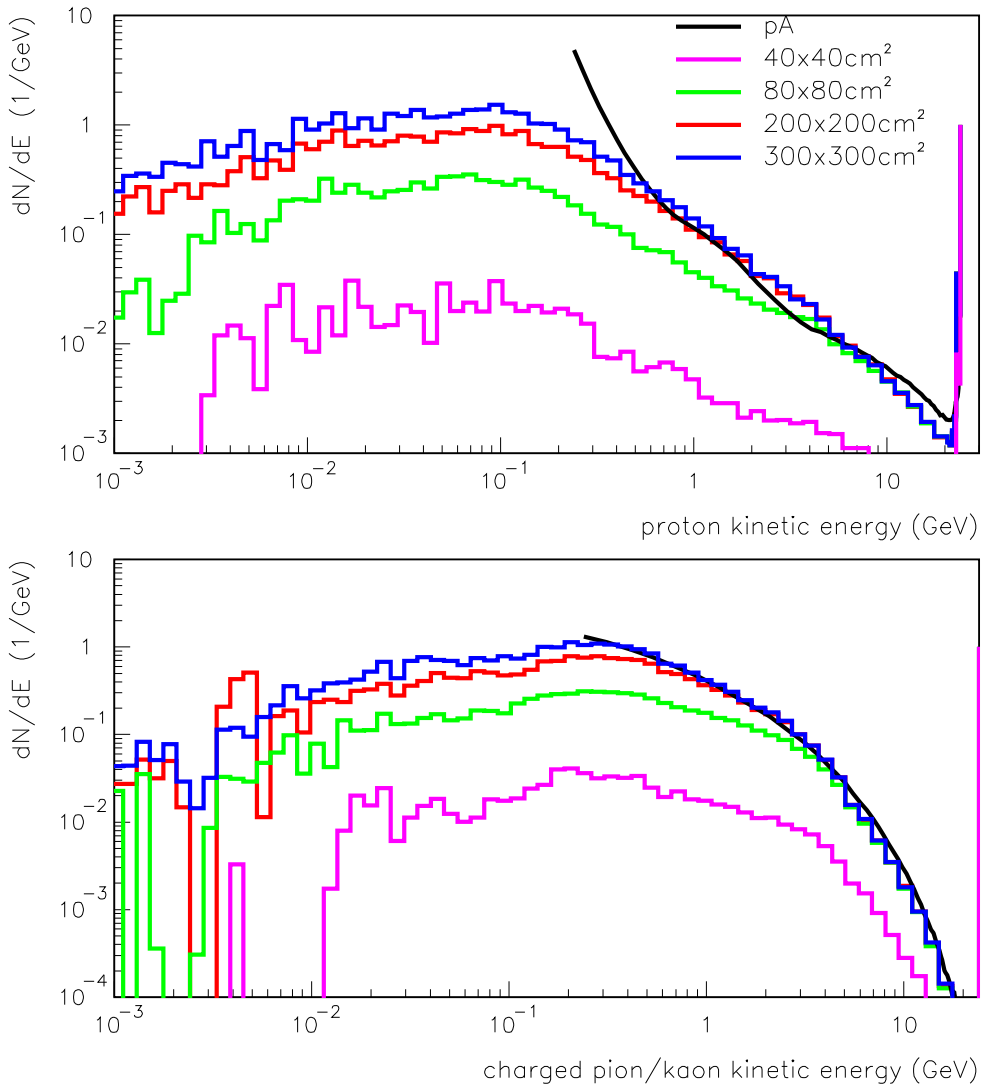


Residual dose in contact. Quintolubric hydraulic fluid.

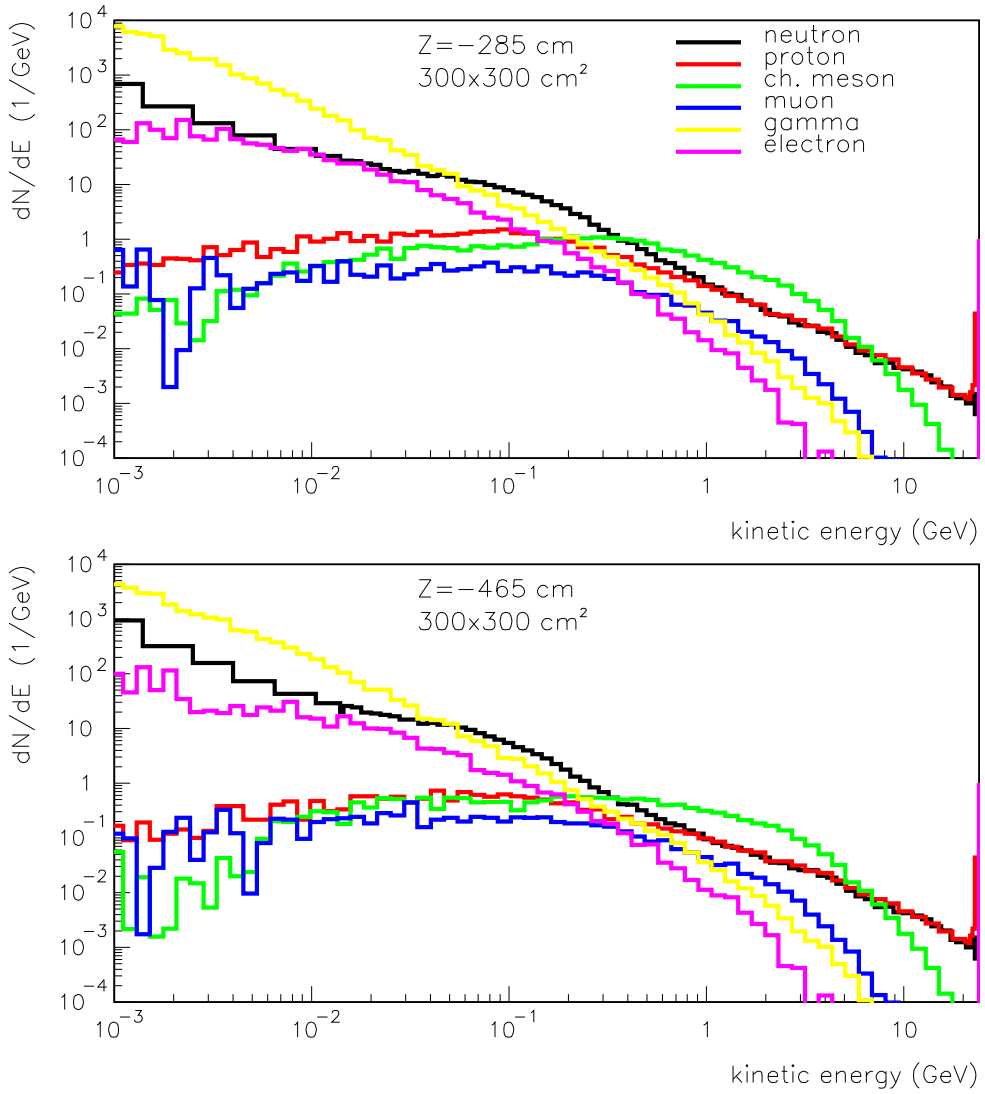

p Be → p X
24 GeV/c
17
27
37
47
57
67
87
107
127 mrad
Ed³σ/dp³ (mb/GeV²/c³)
p in GeV/c
p Al → p X
24 GeV/c
p Cu → p X
24 GeV/c
p Pb → p X
24 GeV/c

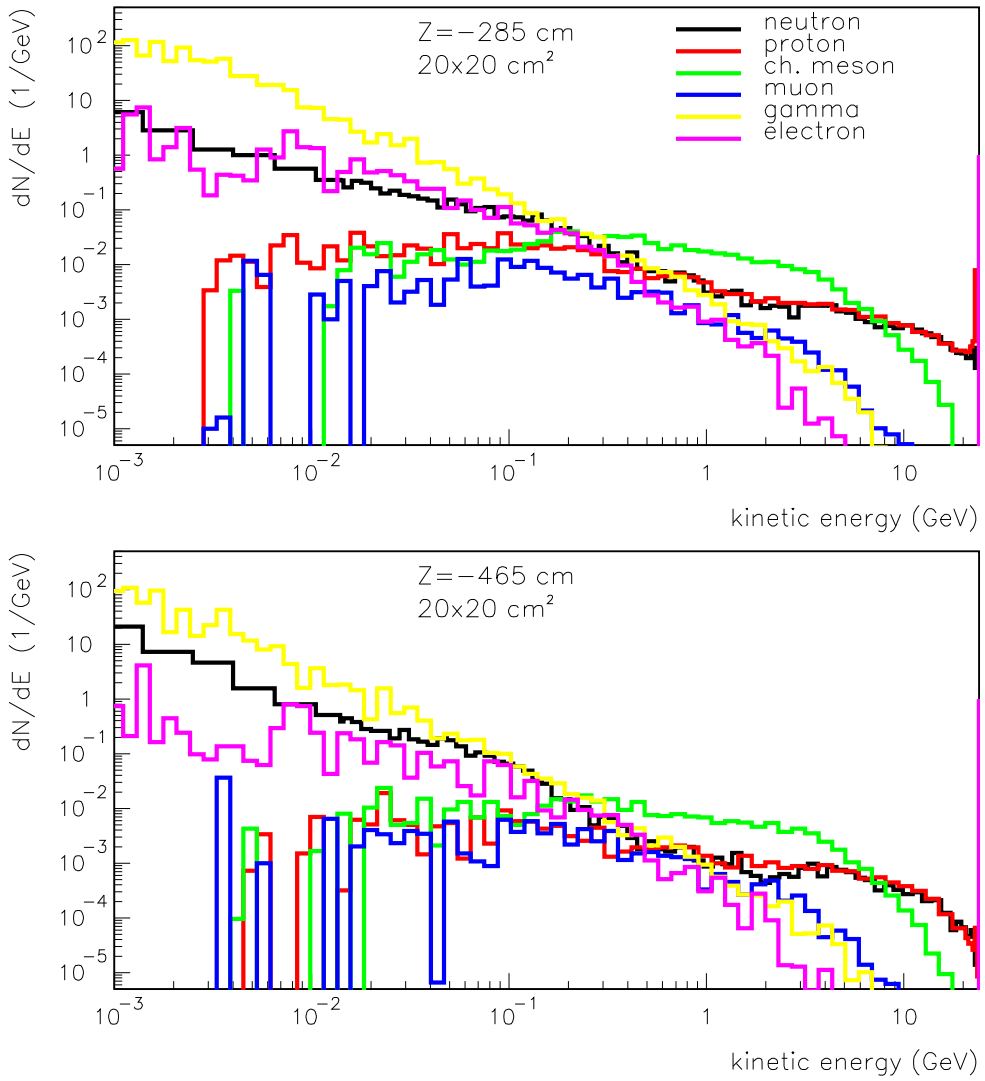


Proton copper interaction at 24 GeV/c



Energy spectra, 280 cm from interaction point.

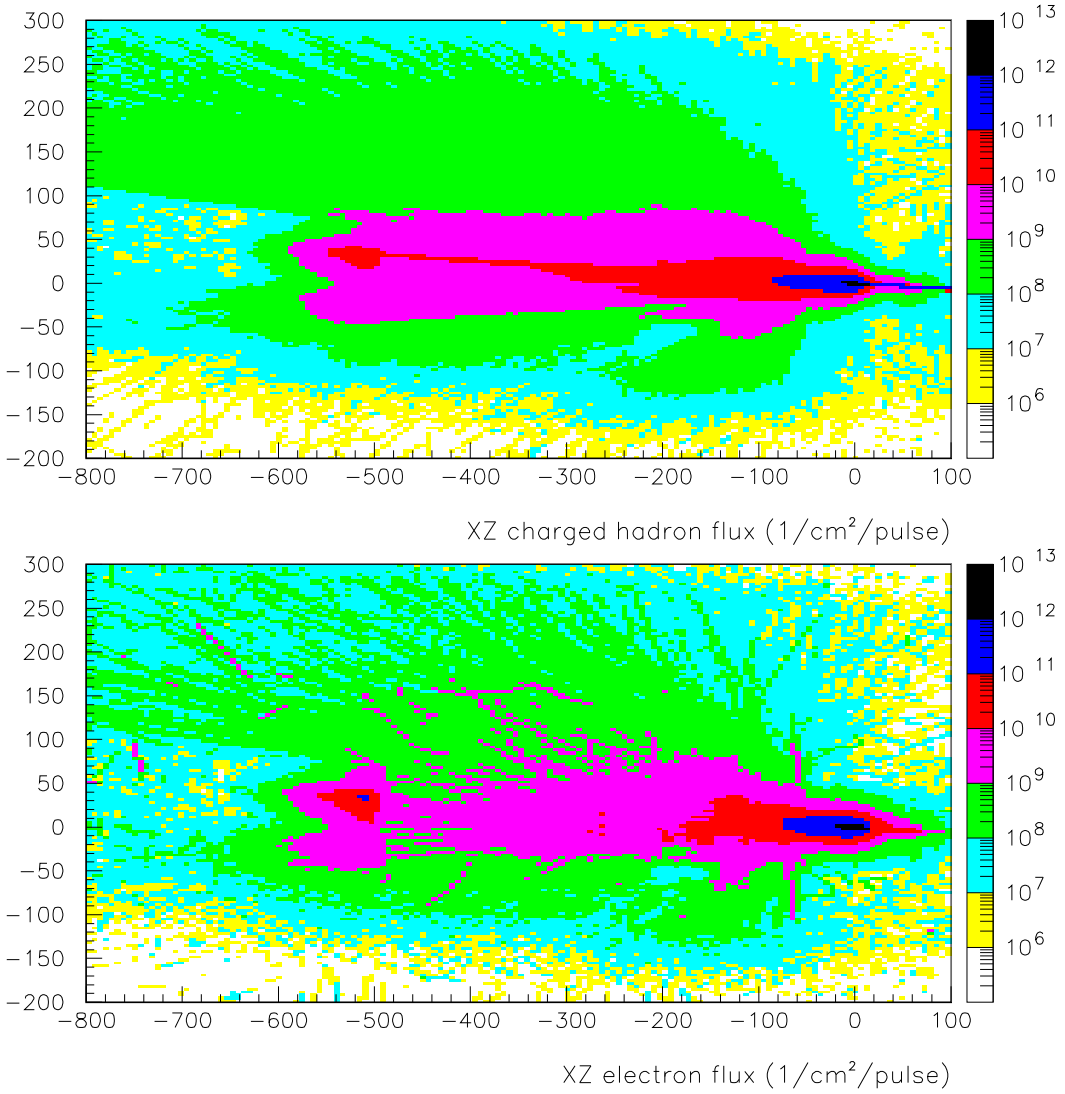

Z=−285 cm
300x300 cm²
neutron
proton
ch. meson
muon
gamma
electron
dN/dE (1/GeV)
kinetic energy (GeV)
Z=−465 cm
300x300 cm²
dN/dE (1/GeV)
kinetic energy (GeV)


Z=−285 cm
20x20 cm²
neutron
proton
ch. meson
muon
gamma
electron
dN/dE (1/GeV)
kinetic energy (GeV)
Z=−465 cm
20x20 cm²
dN/dE (1/GeV)
kinetic energy (GeV)

PARTICLE PRODUCTION

Table : Average number of secondary particle per proton on target.

Z, cm	Size, cm^2	n	p	$\pi^{\pm}/k^{\pm}$	μ	γ	$e^{\pm}$
465	$300 \cdot 300$	6.12	0.5	0.99	0.16	18	0.95
465	$40 \cdot 40$	0.46	0.043	0.11	0.01	1.38	0.06
285	$300 \cdot 300$	5.94	0.78	1.31	0.19	31.5	1.62
285	$40 \cdot 40$	0.29	0.14	0.26	0.02	2.85	0.20



Fluxes of charged particle per pulse. $3 \cdot 10^{13}$ proton in pulse.

CONCLUSIONS

- absorbed dose and activation of mercury vapor analyzer mounted onto downbeam end of secondary containment do not exceed acceptable levels
- activation of hydraulic fluid in the pump is low enough, activation in the hydraulic lines should be lower then in the pump
- activation of mercury vapor filter is low, but material composition of filter should be specified
- geometry description should be enhanced to calculate radiation levels near DVB (full description of TT2 tunnel already obtained from Adrian Fabich)
- energy&sspatial beam distribution should be included (comprehensive description already obtained from Adrian Fabich and Harold Kirk)