# FLUKA calculation for MuCh

Anna Senger

FLUKA

*"The FLUKA code: Description and benchmarking"* G. Battistoni, S. Muraro, P.R. Sala, F. Cerutti, A. Ferrari, S. Roesler, A. Fasso`, J. Ranft, Proceedings of the Hadronic Shower Simulation Workshop 2006, Fermilab 6--8 September 2006, M. Albrow, R. Raja eds., AIP Conference Proceeding 896, 31-49, (2007)

*"FLUKA: a multi-particle transport code"* A. Fasso`, A. Ferrari, J. Ranft, and P.R. Sala, CERN-2005-10 (2005), INFN/TC_05/11, SLAC-R-773

FLAIR

V.Vlachoudis *"FLAIR: A Powerful But User Friendly Graphical Interface For FLUKA"* Proc. Int. Conf. on Mathematics, Computational Methods & Reactor Physics (M&C 2009), Saratoga Springs, New York, 2009

*https://cbm-wiki.gsi.de/foswiki/bin/view/Radiationstudies*

# Outline

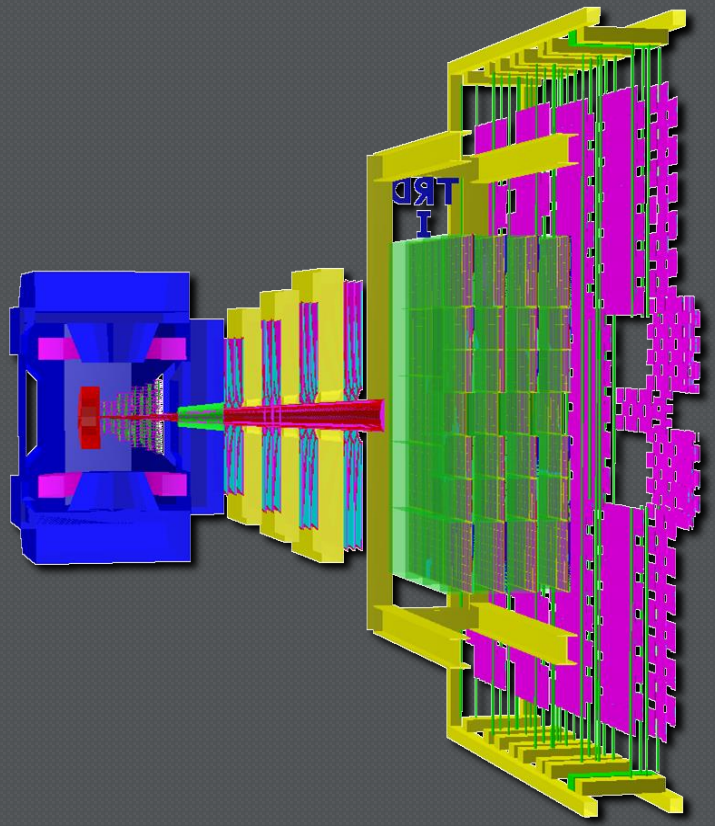
- Simulation input and conditions
- Particle rates
- Radiation doses
- Activation of absorbers and detector components

# Simulation conditions

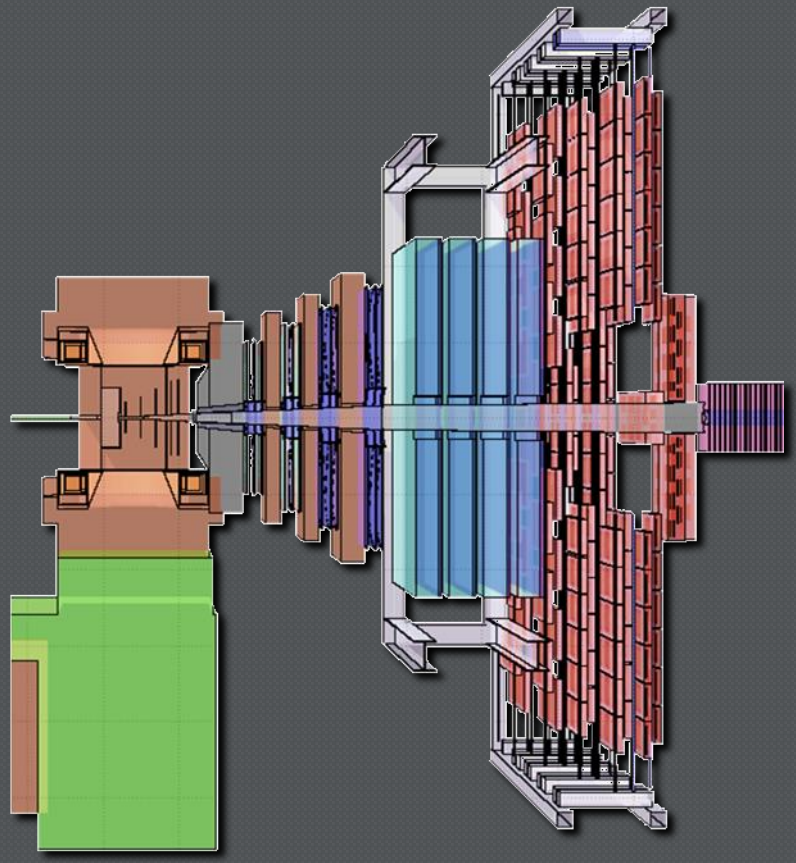
- SIS100 beam energies: 2 and 10 AGeV
- 250 μm Au target
- $10^9$ Au/s beam intensity
- 2 months of run
- 50% magnetic field for Au @ 2 AGeV

# Muon setup of CBM

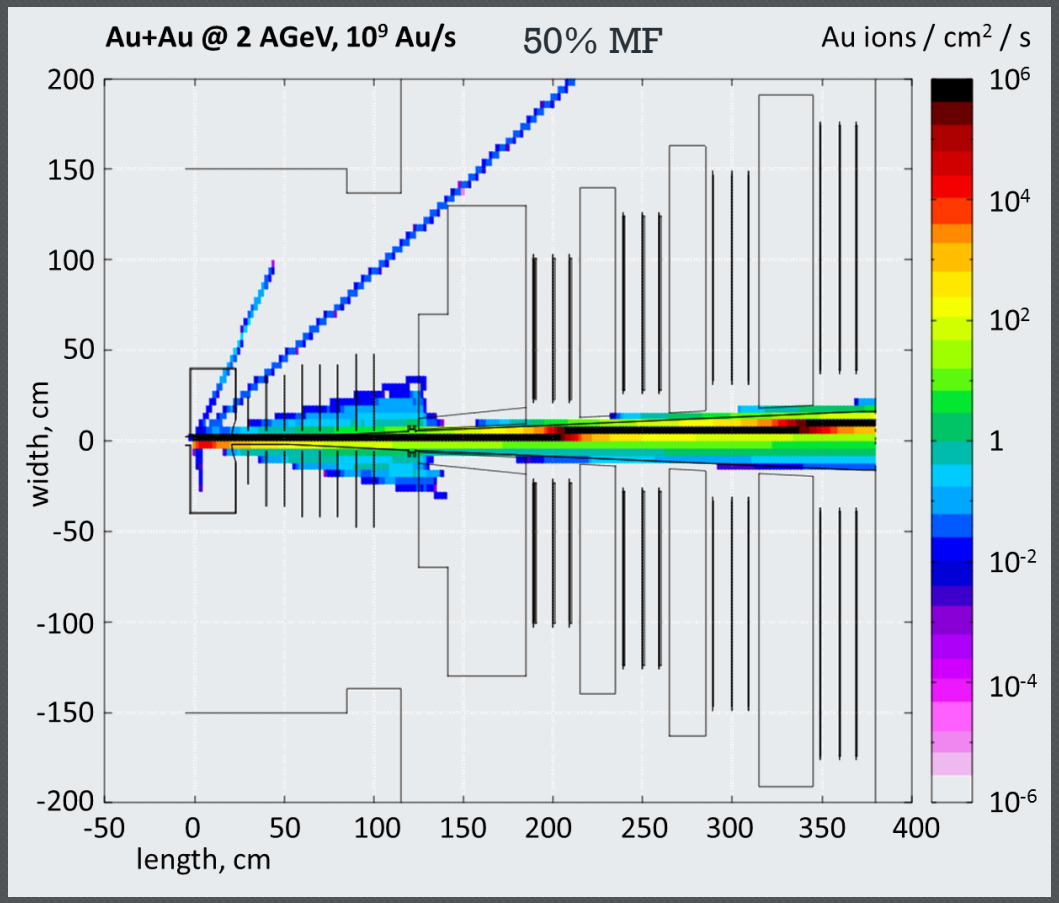
CBMROOT




FLUKA



# Experimental conditions




*Experimental conditions for SIS100 beam energies:*

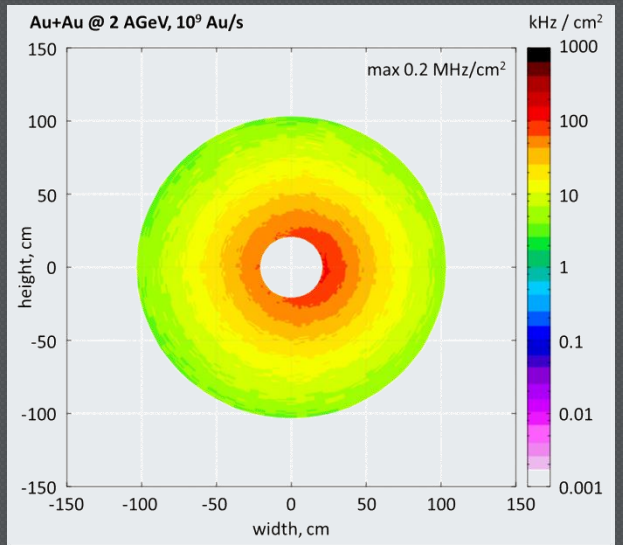
- *strong deflection of the beam in the magnetic field of the dipole*
- *beam profile is dominated by multiple scattering in the target*

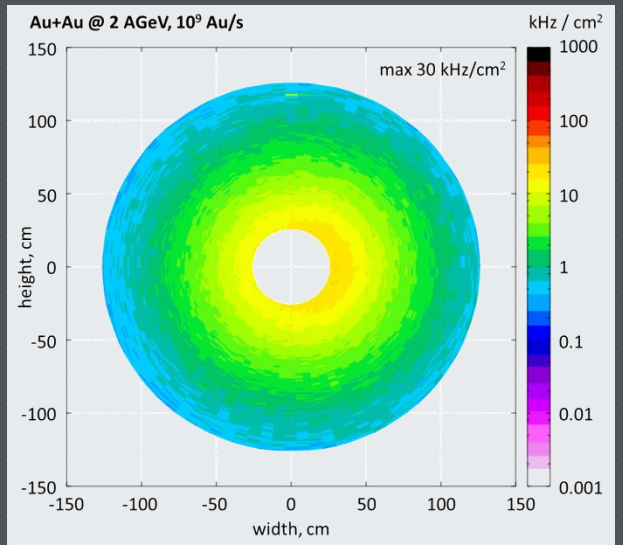
# Particle rates and radiation doses

*MuCh TDR: max rate for first station is 200 kHz/cm²*

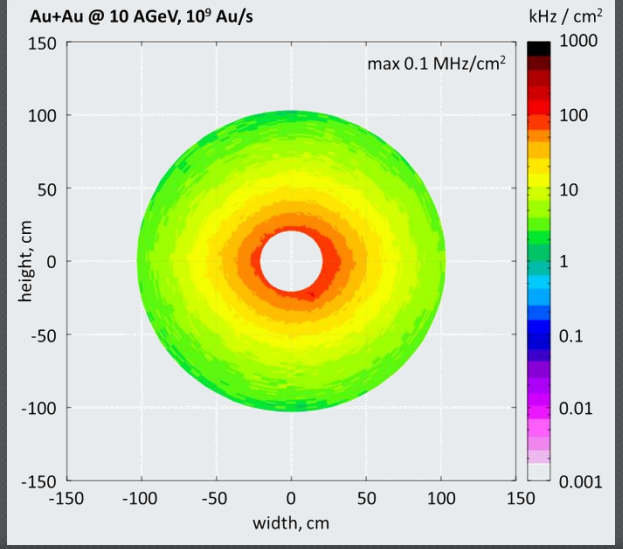
# Particle rates: MuCh 1 and 2

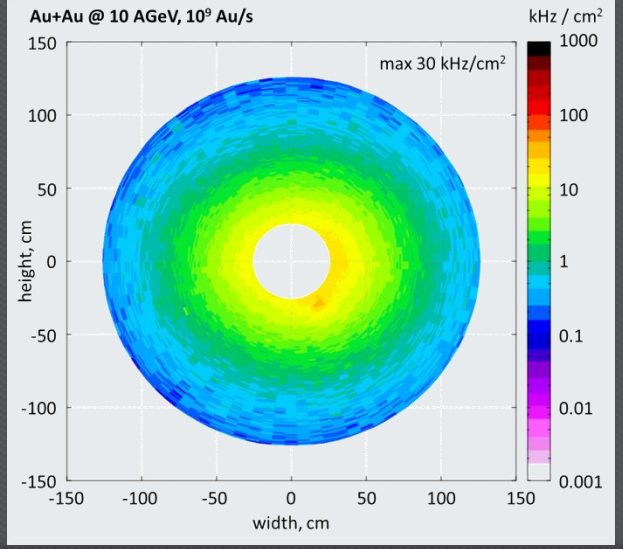
Au @ 2 AGeV




Au @ 10 AGeV

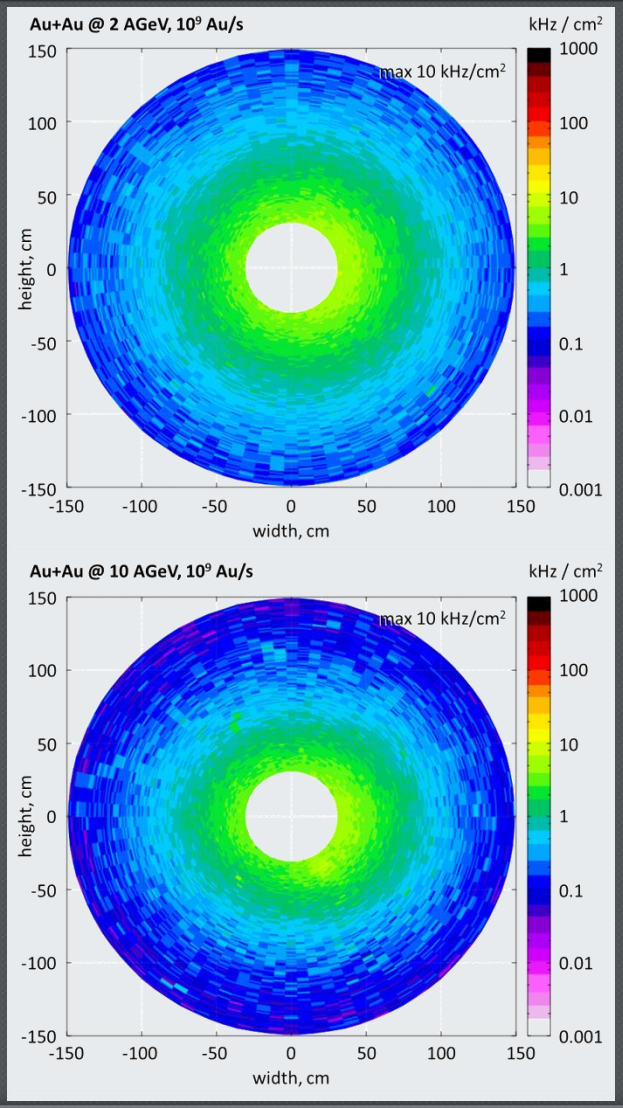


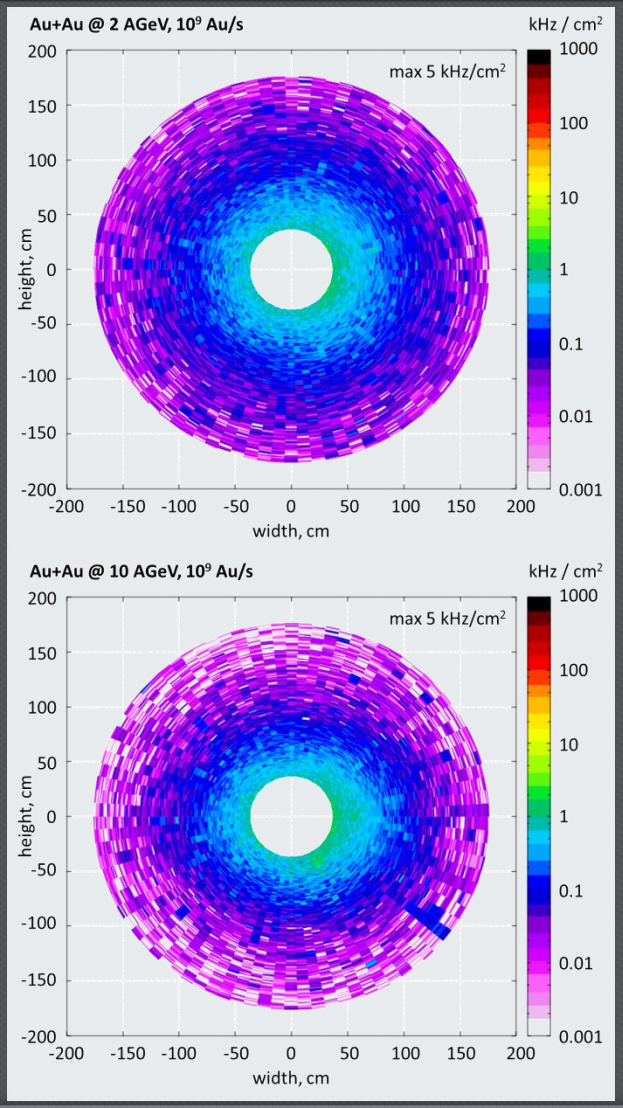



# Particle rates: MuCh 3 and 4

Au @ 2 AGeV

Au @ 10 AGeV

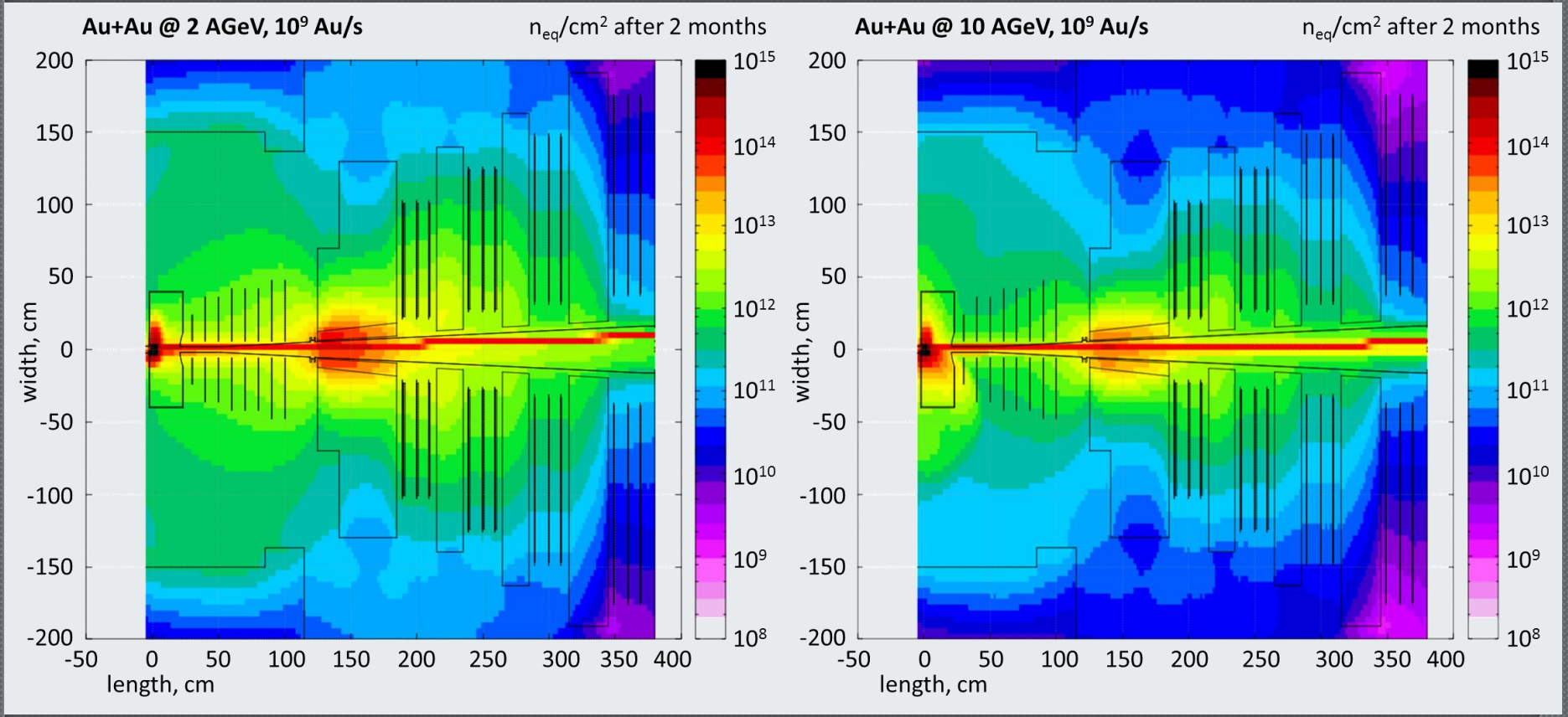


# Non-ionizing energy loss

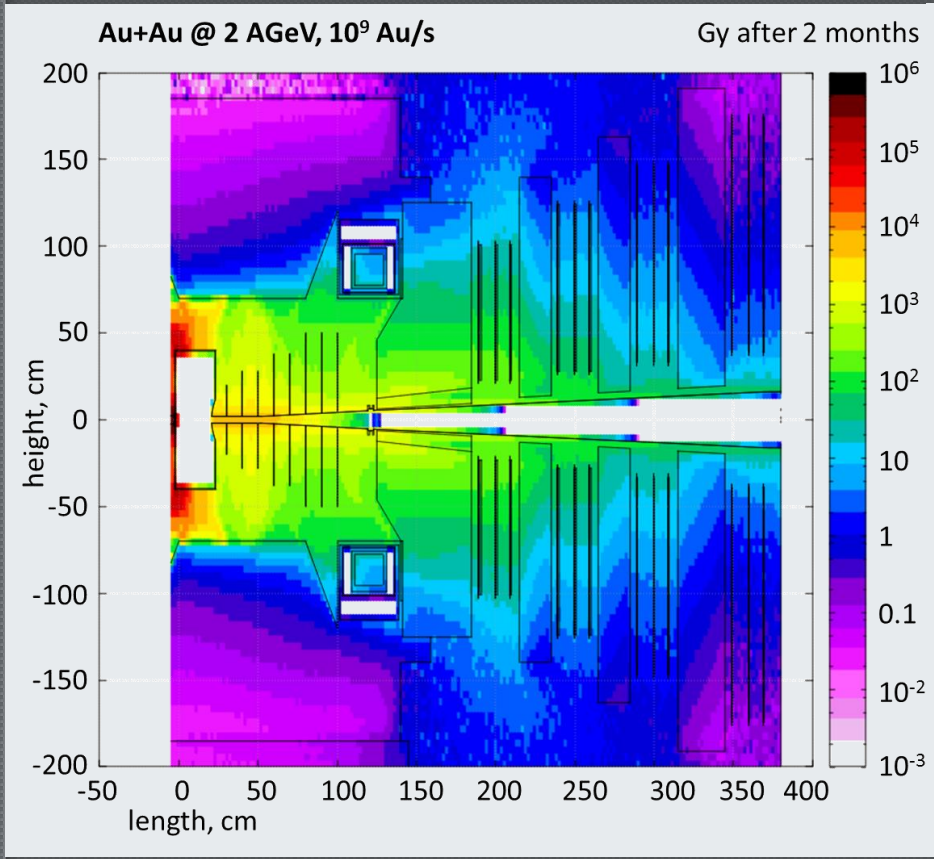
Au @ 2 AGeV

Au @ 10 AGeV

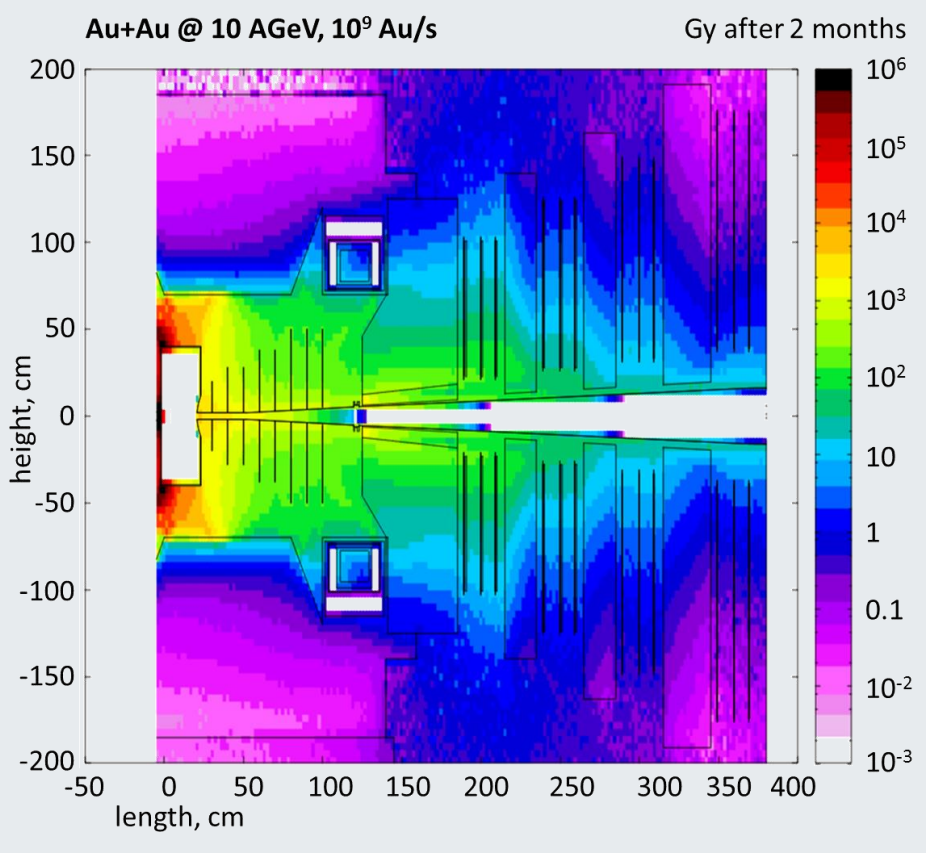


# Ionizing energy loss

Au @ 2 AGeV

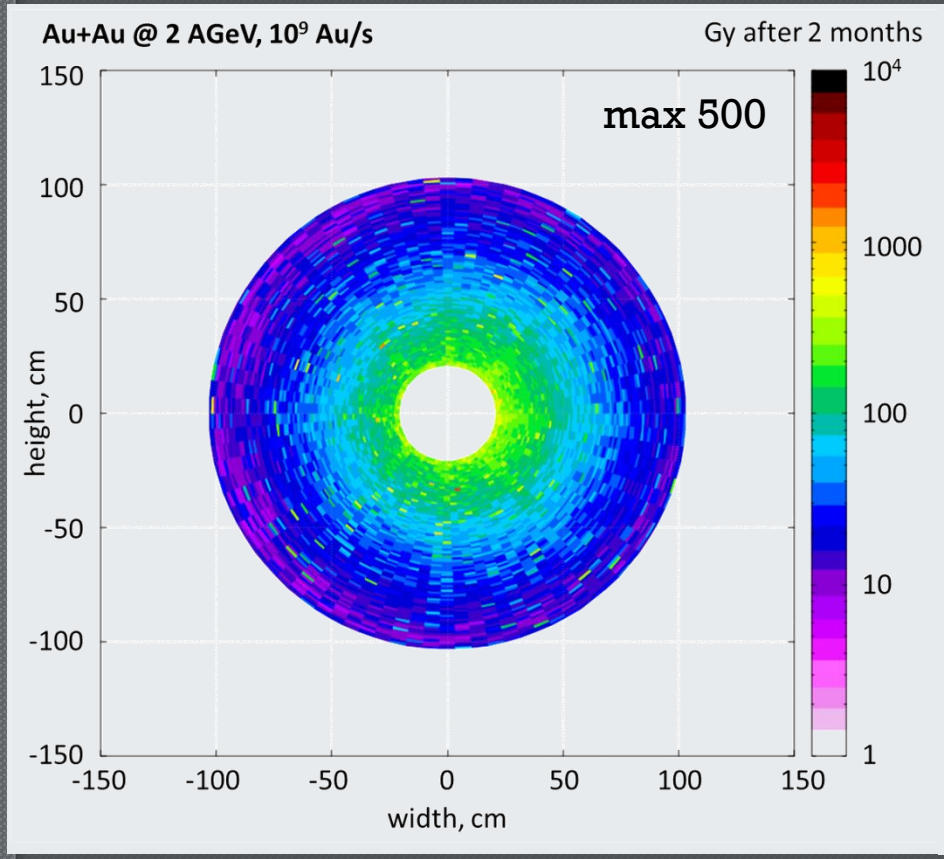



Au @ 10 AGeV

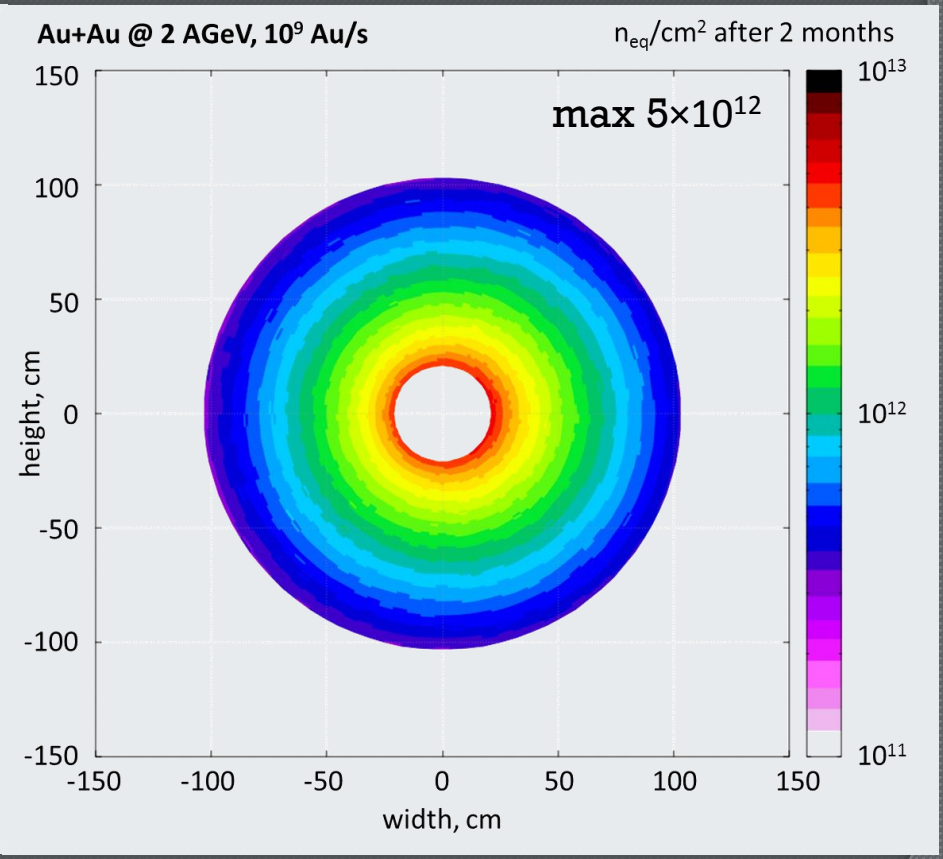


# 2 AGeV, first station

Ionizing dose




Non-ionizing dose



# Activation of absorbers and detectors

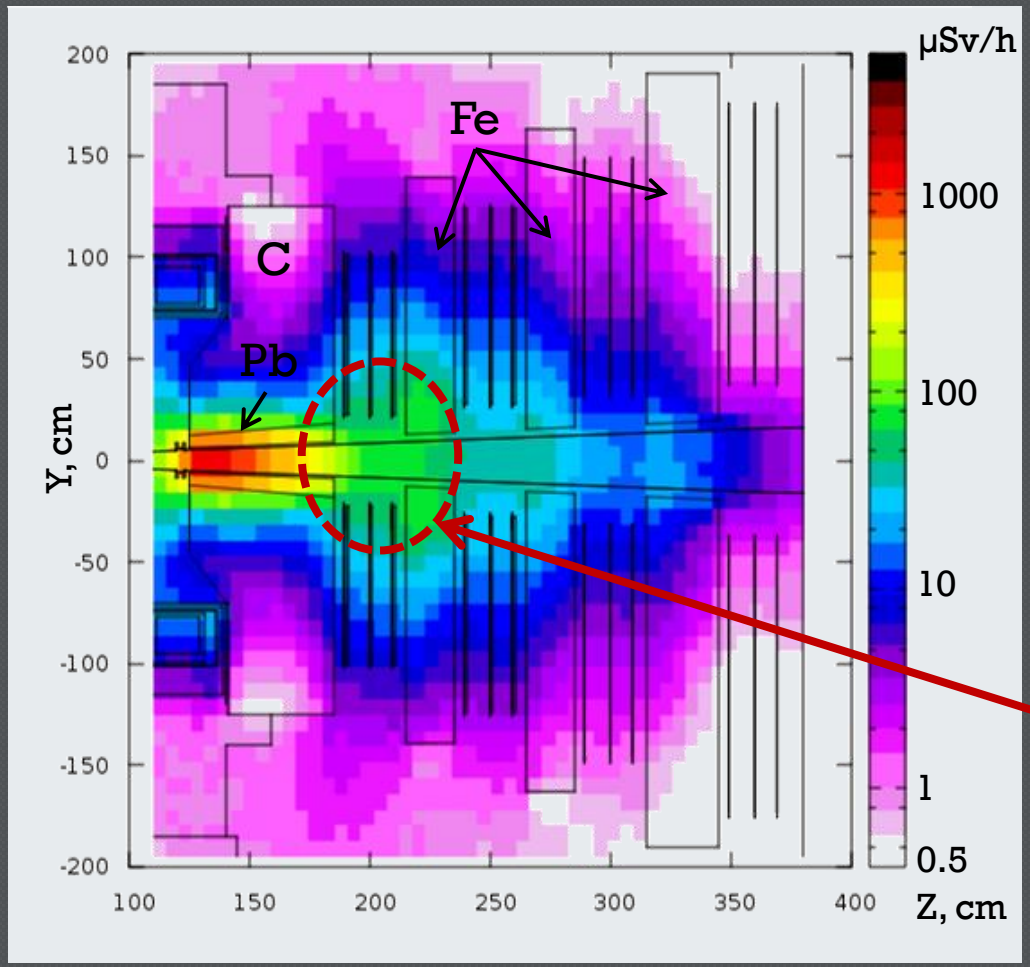
# Limits for radiation rate

## for occupationally exposed persons (OEP)

- ≤ 0.5 μSv/h – background radiation level
- > 0.5 μSv/h – OEP can work ONLY with personal dosimeter
- 100 μSv is one-time dose limit
- 20 mSv – limit for OEP per year
- 400 mSv – limit of total (lifetime) dose for OEP

# Activation at 1 day after run

*without activation of target and magnet yoke*

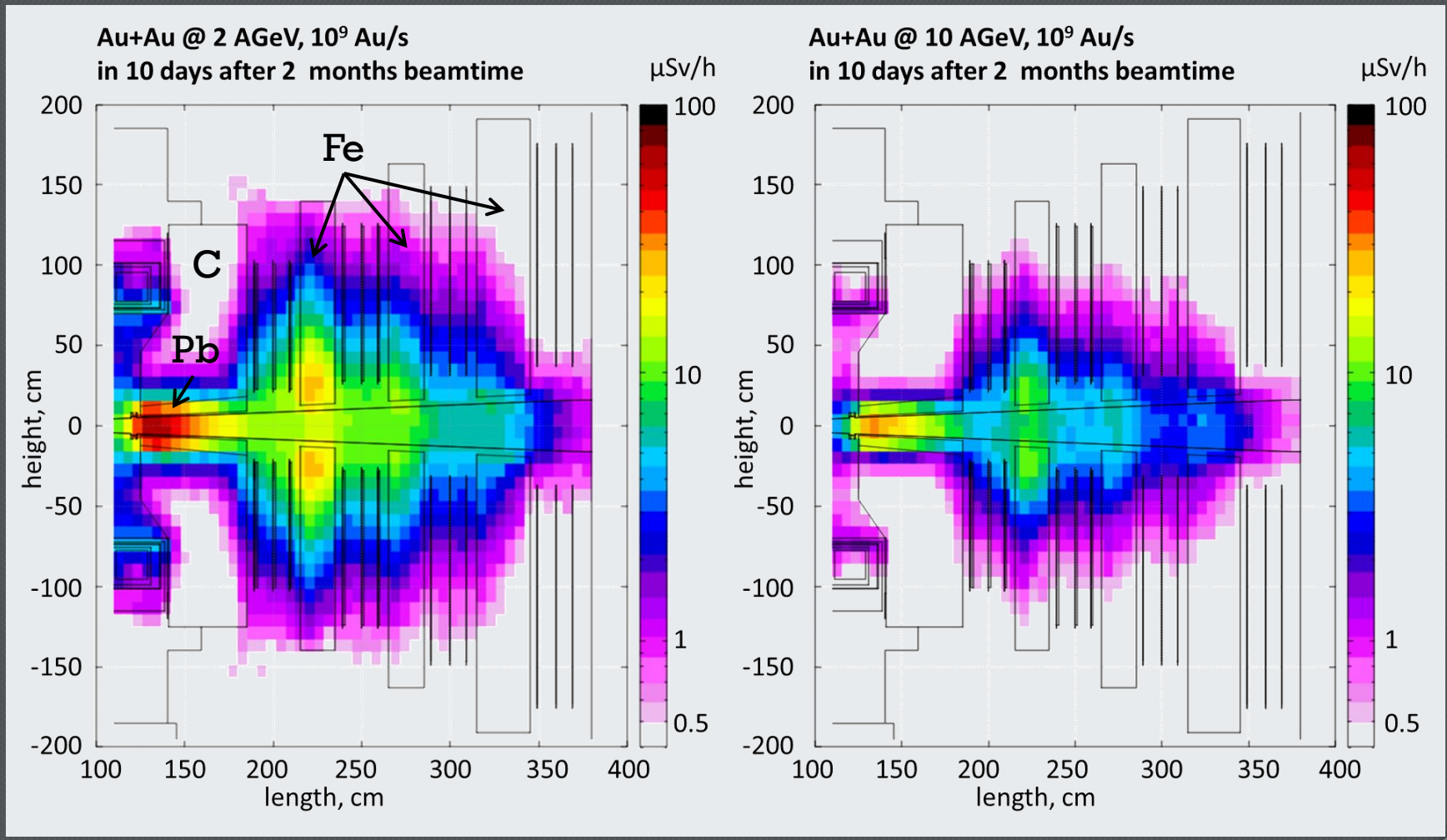



Au+Au @ 2 AGeV
$10^9$ Au/s
2 months beamtime

~ 50 μSv/h
after 2 hours OEP will reach
100 μSv (one-time dose limit)

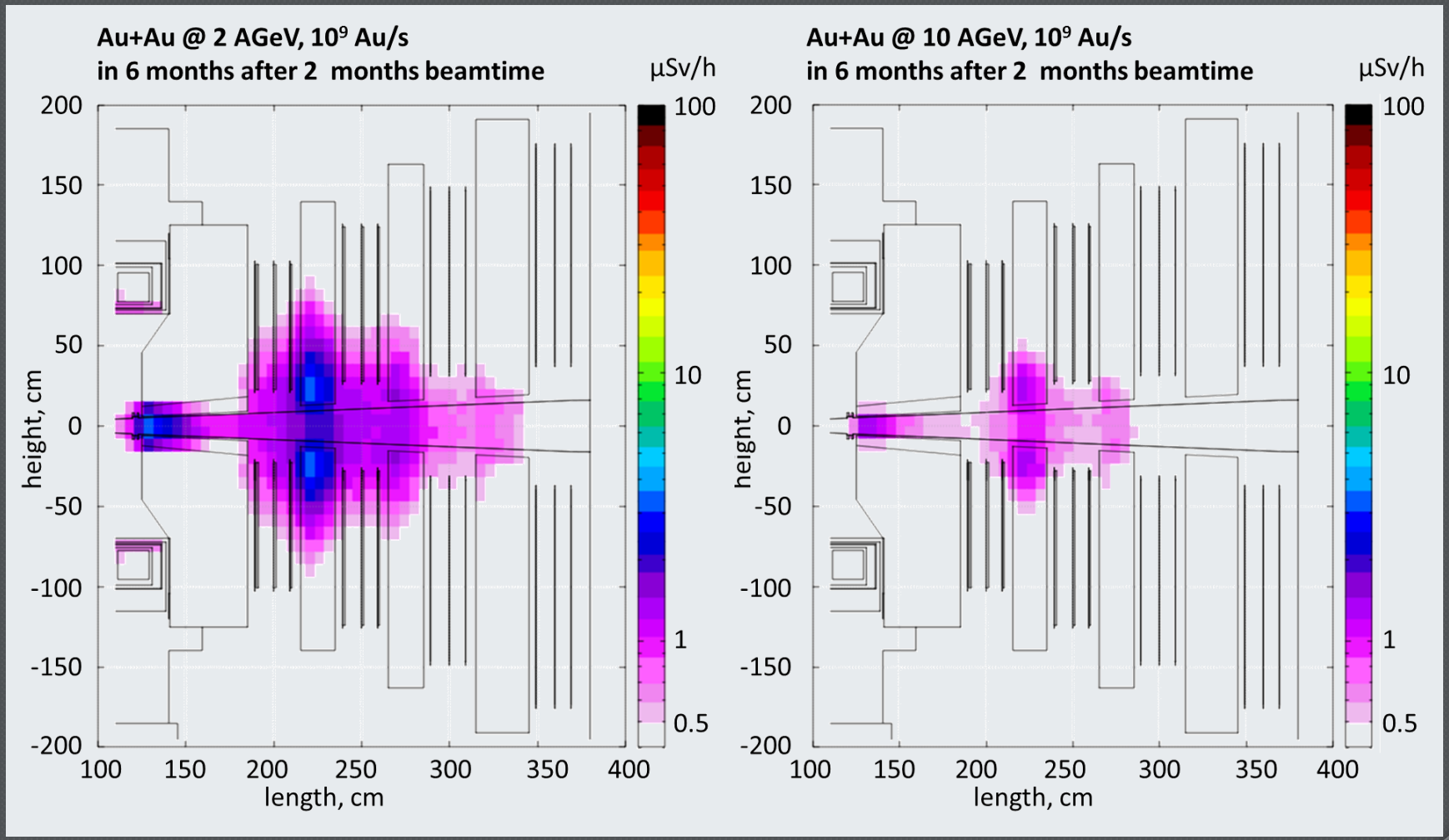
# Activation at 10 days after run

*without activation of target and magnet yoke*



# Activation at 6 months after run

*without activation of target and magnet yoke*



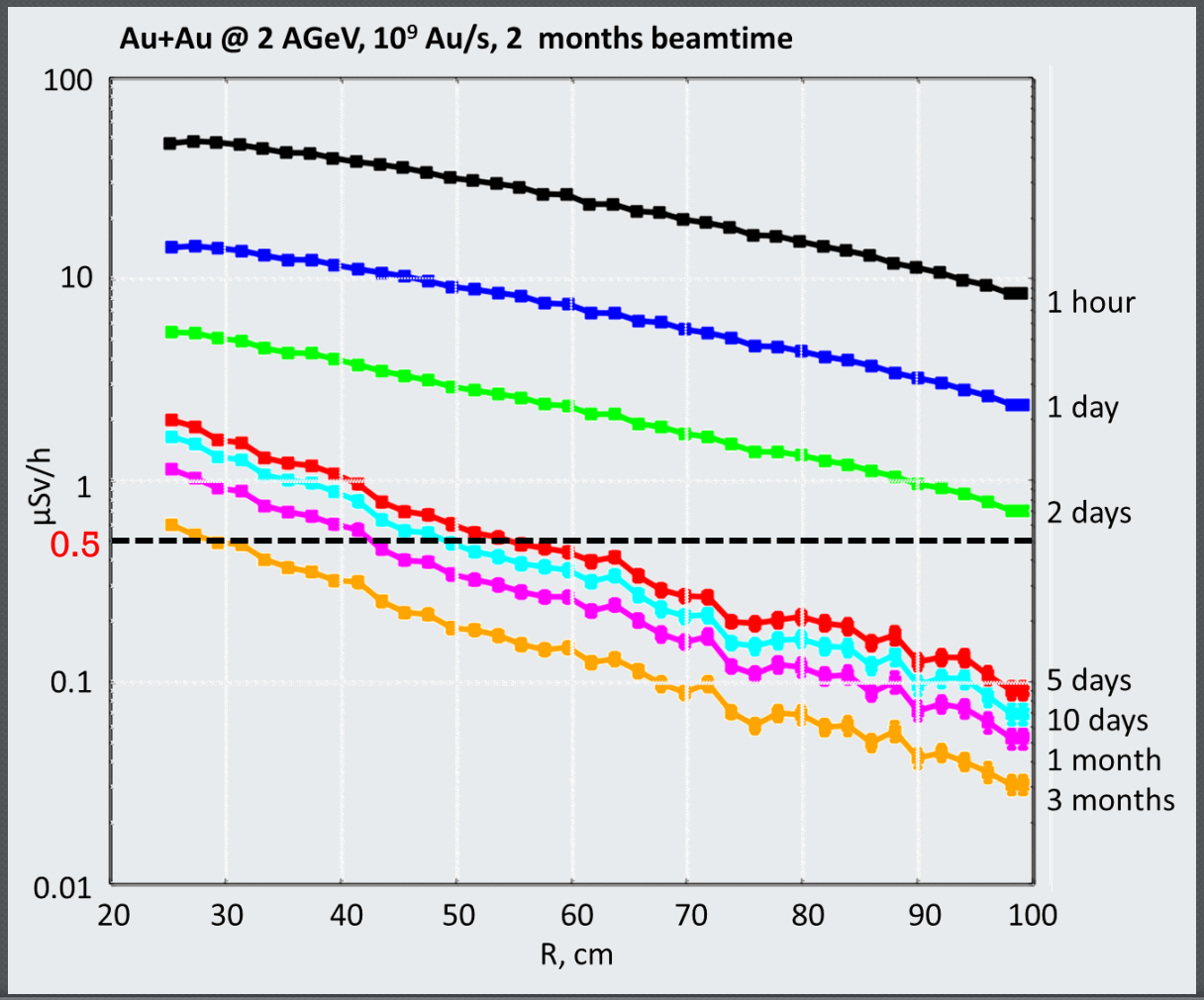
# Detector components

Anand:

- copper blocks of 16 mm x 11 mm (in x and y) and 3 mm thick (in Z). There are 18 of them on each GEM module
- 35 micron thickness copper plane on the drift and the readout planes
- 10 microns copper at 2 mm gaps, pertaining to each GEM layer of the triple GEM module
- 80 stainless-steel screws of about 2 mm diameter (in x-y) and 10 mm in length (Z-direction)
- 40 stainless steel supports of 9 mm in Z and 10mm x 4 mm in width (x and y)

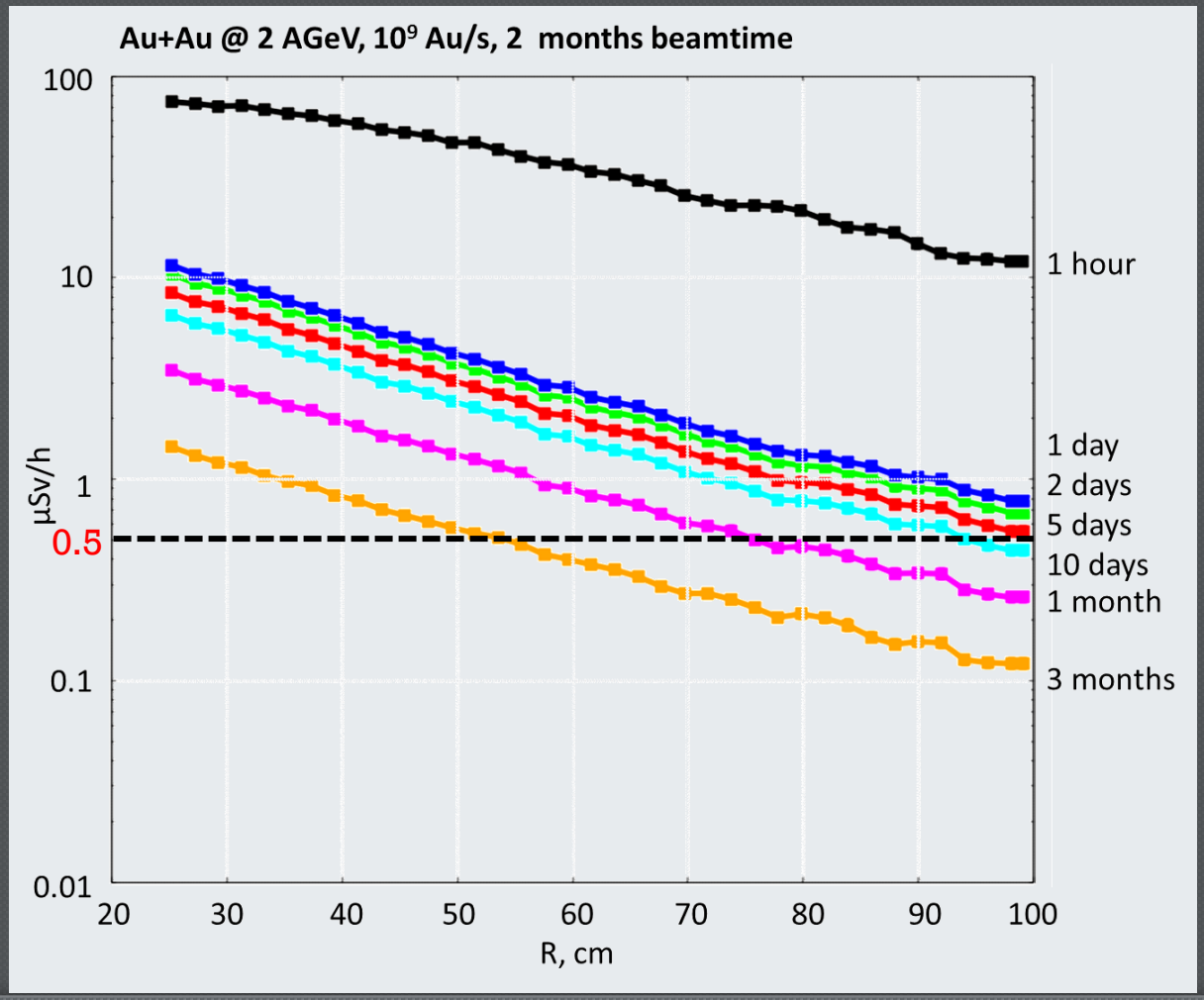
# 3 mm Cu

Au+Au @ 2 AGeV, $10^9$ Au/s, 2 months beamtime
first MuCh station



# 1 cm stainless-steel

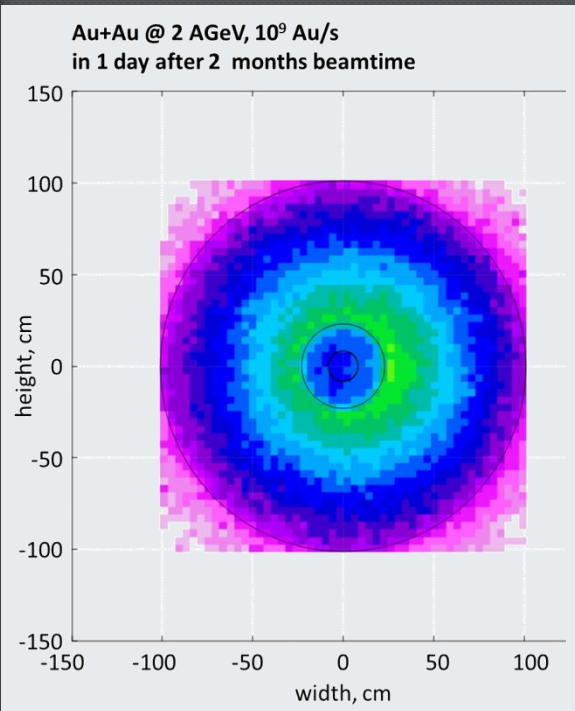
Au+Au @ 2 AGeV, $10^9$ Au/s, 2 months beamtime
first MuCh station



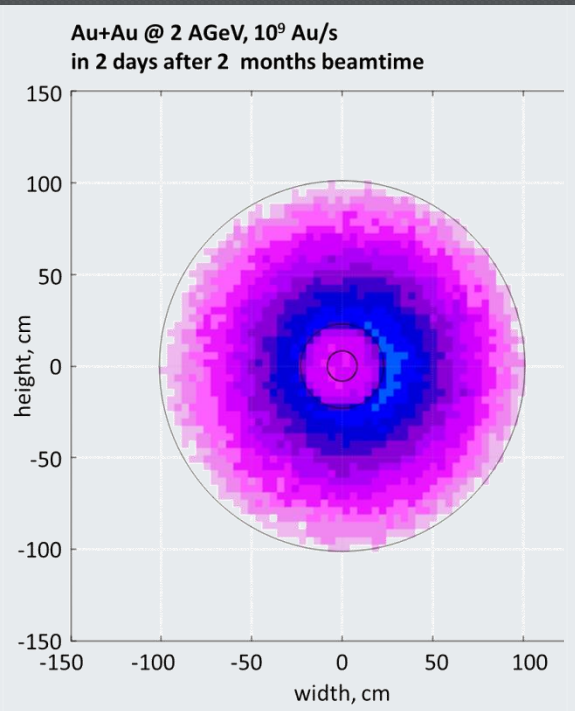
# Al cooling plate activation

Au+Au @ 2 AGeV, $10^9$ Au/s, 2 months beamtime
first MuCh station

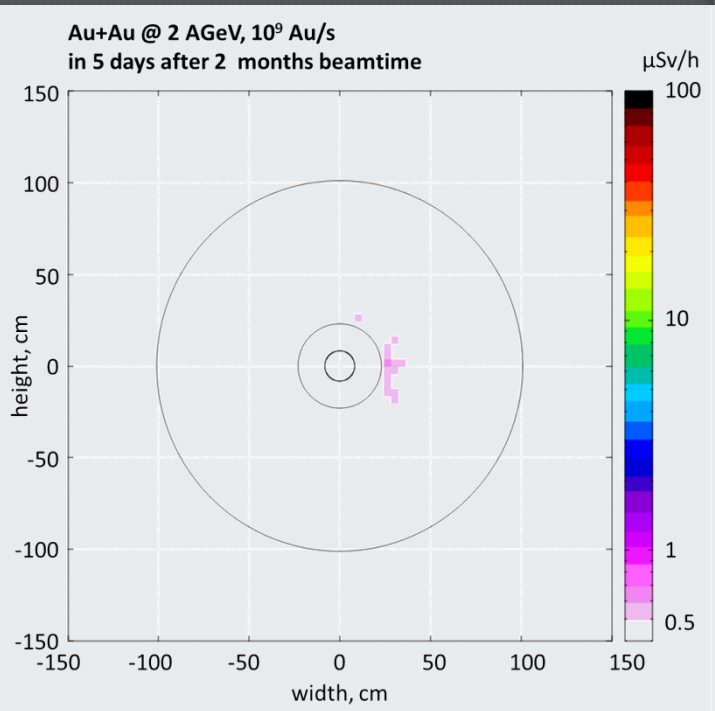
after 1 day




after 2 days




after 5 days



# Conclusions

- FLUKA simulations performed for $10^7$ Au+Au collisions at SIS100 energies over 2 months
- Radiation doses for first detector station up to 500 Gy and $5\times10^{12}$ $n_{eq}/cm^2$
- Activation: detectors accessible one day after beam shut down for OEP

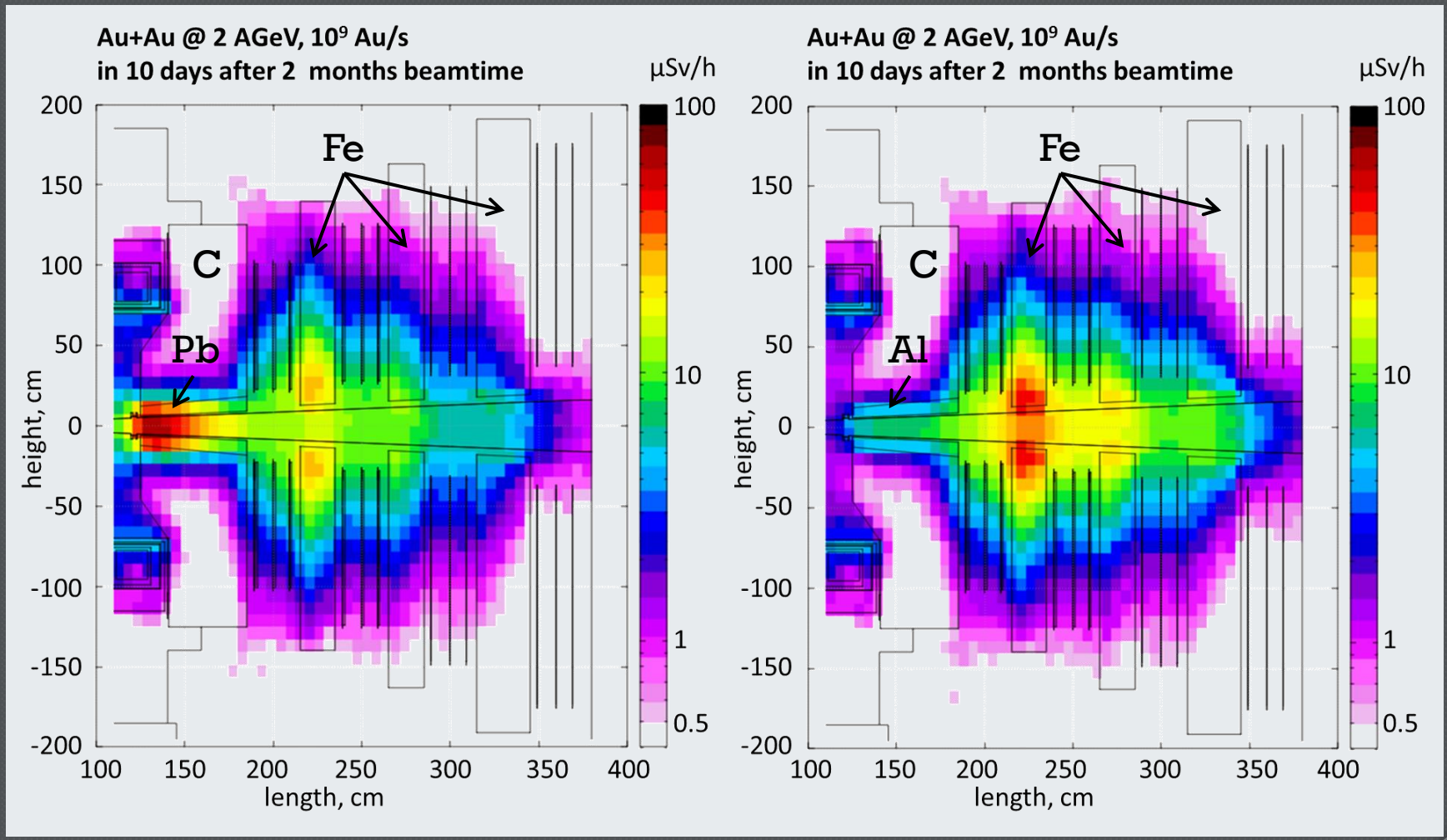
# Backup

# Solutions

- Develop special procedure for absorber dismounting and storage
- Replace high radioactive materials by low radioactive

# Activation in 10 days: Al vs Pb

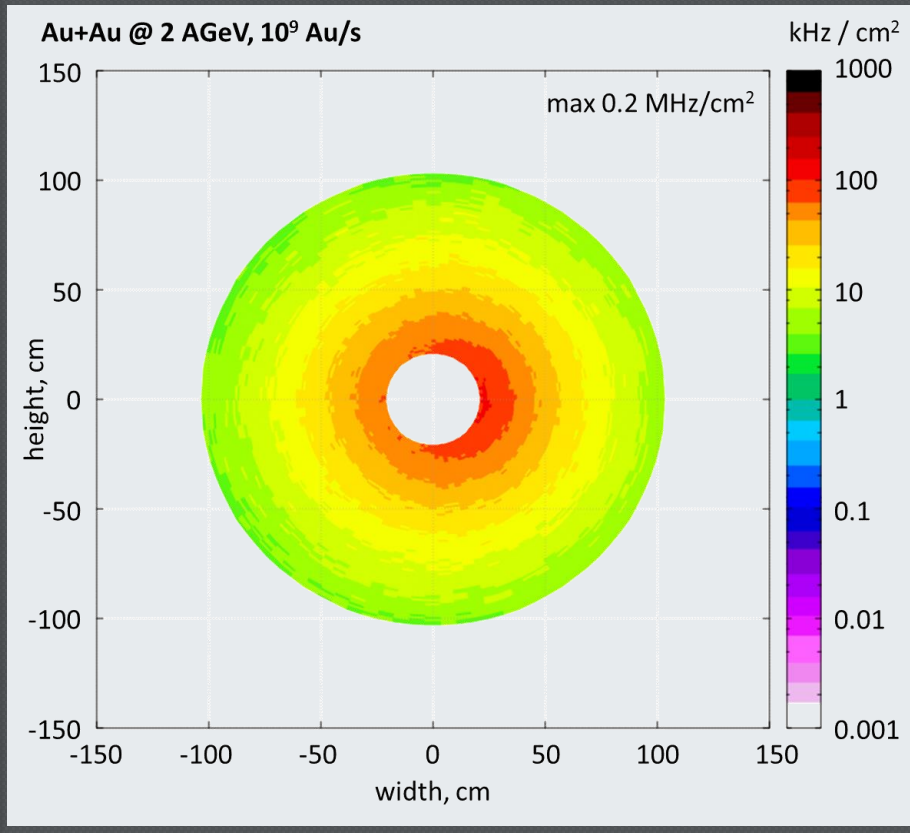
*without target and magnet yoke activation*



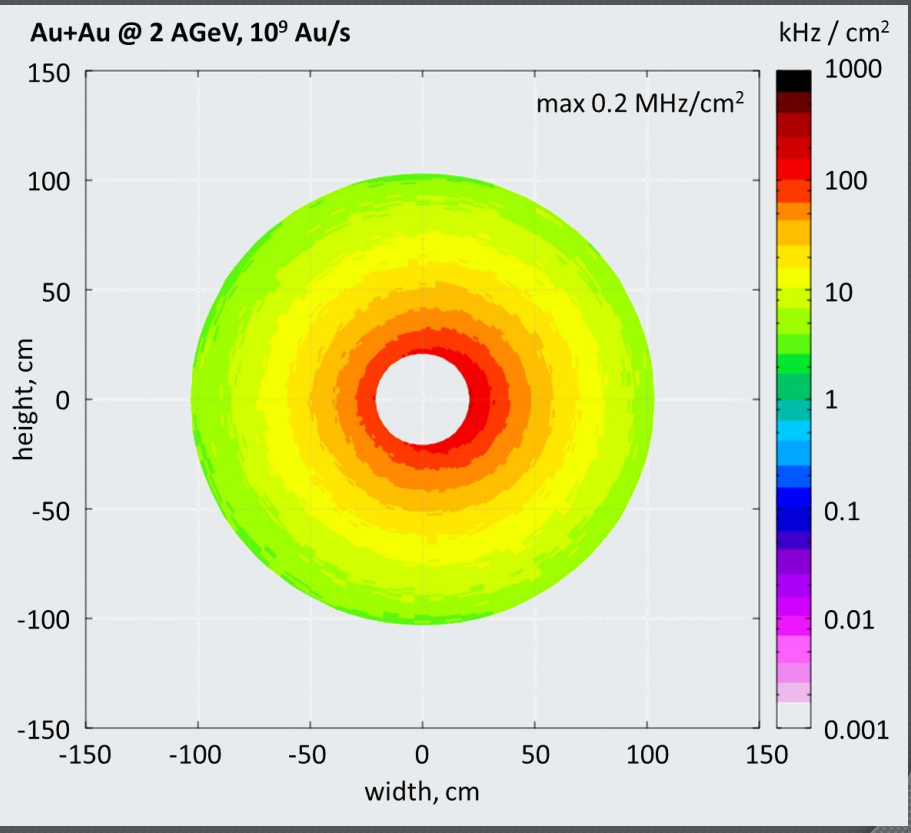
# Particle rate: Au @ 2 AGeV

## First station

with Pb in first absorber

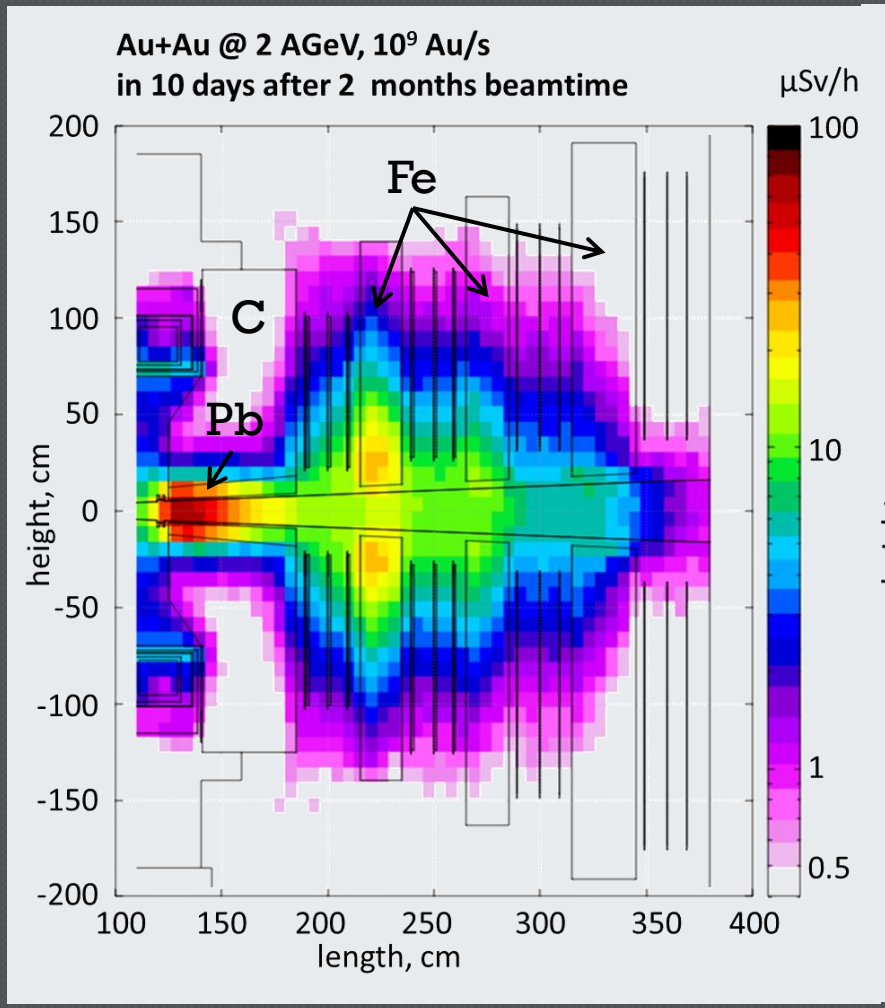


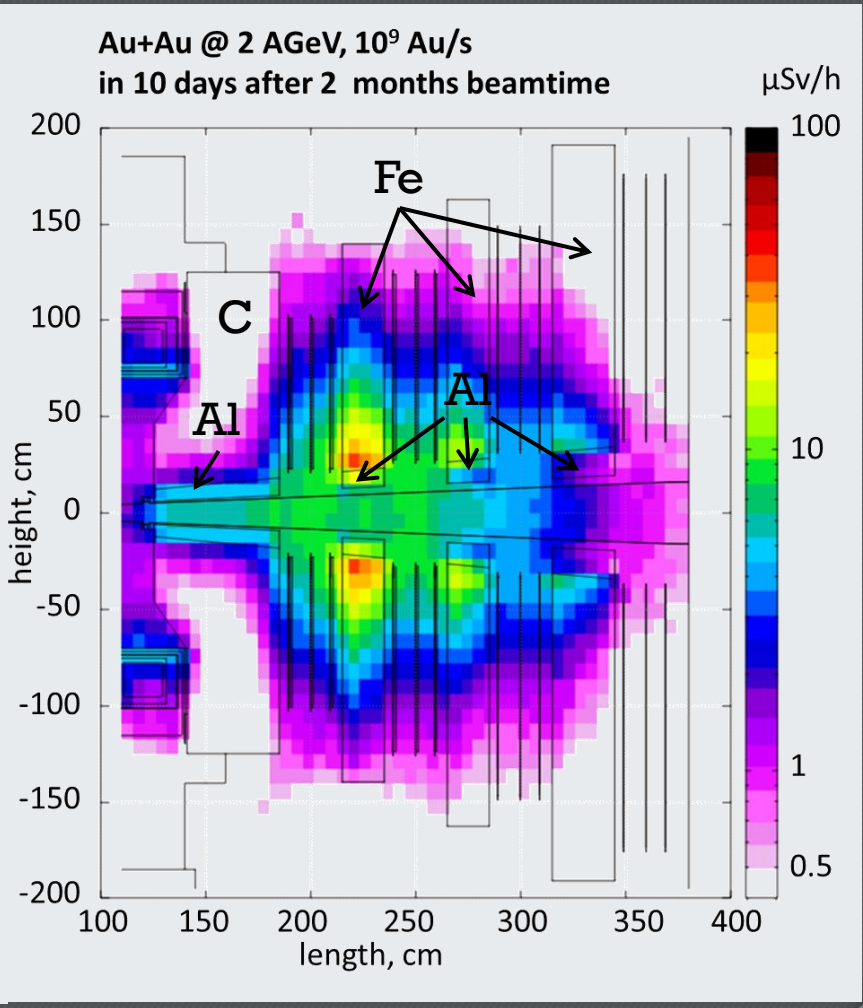

with Al in first absorber



# Activation in 10 days: more Al

*without target and magnet yoke activation*

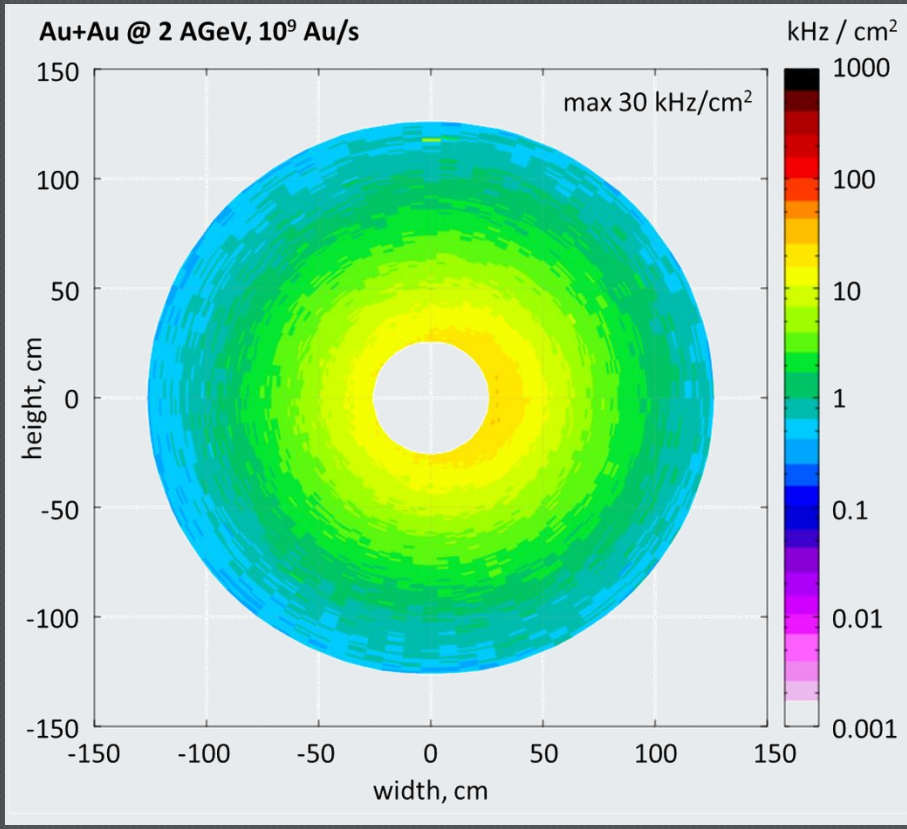


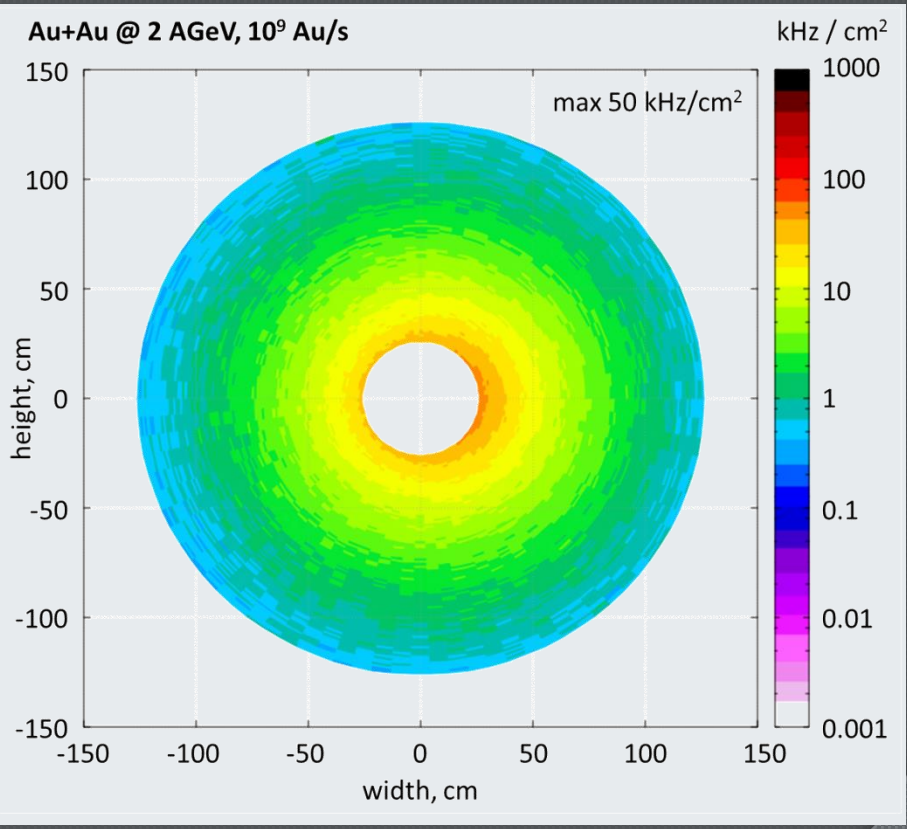
# Particle rate: Au @ 2 AGeV

## Second station

Fe absorber




Fe absorber with Al

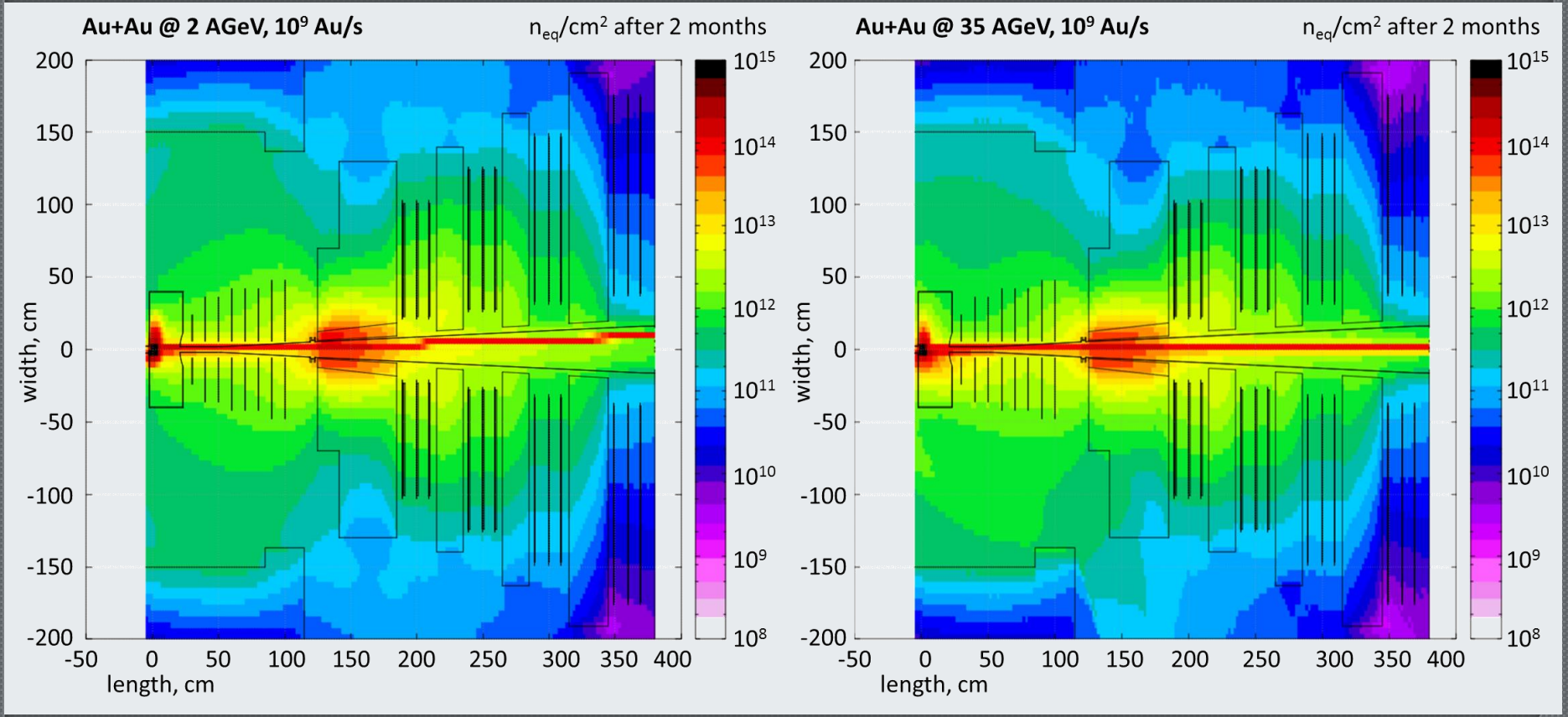


# Comparison of 2 and 35 AGeV Au beam

# Non-ionizing energy loss

Au @ 2 AGeV

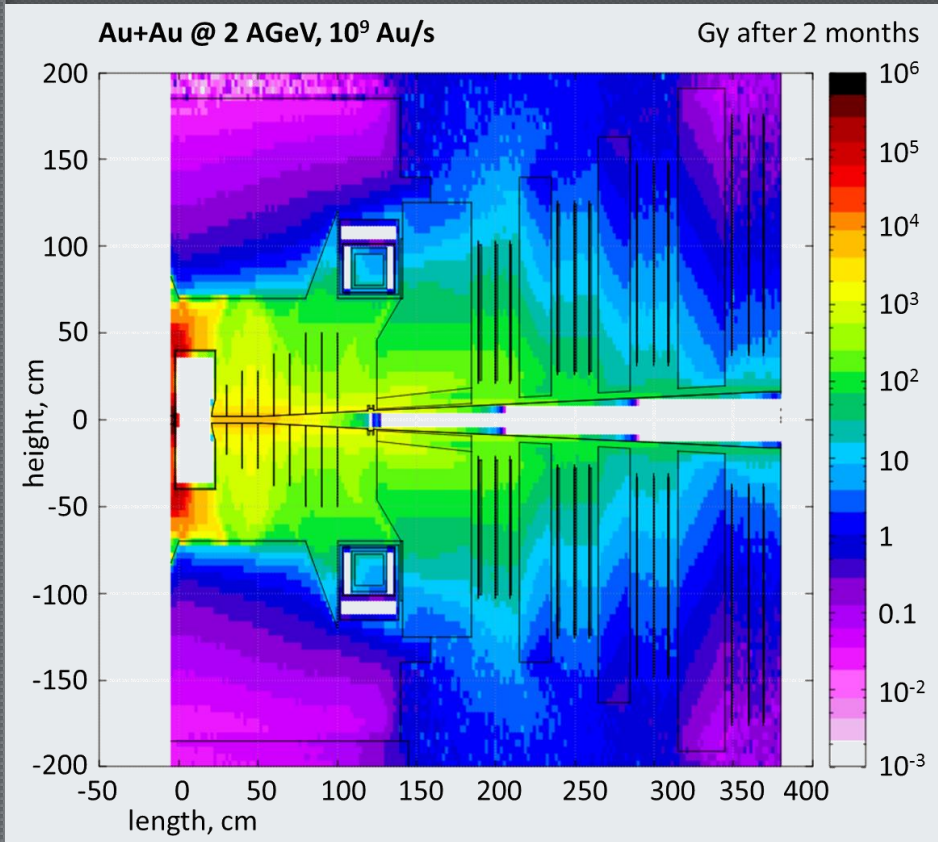
Au @ 35 AGeV

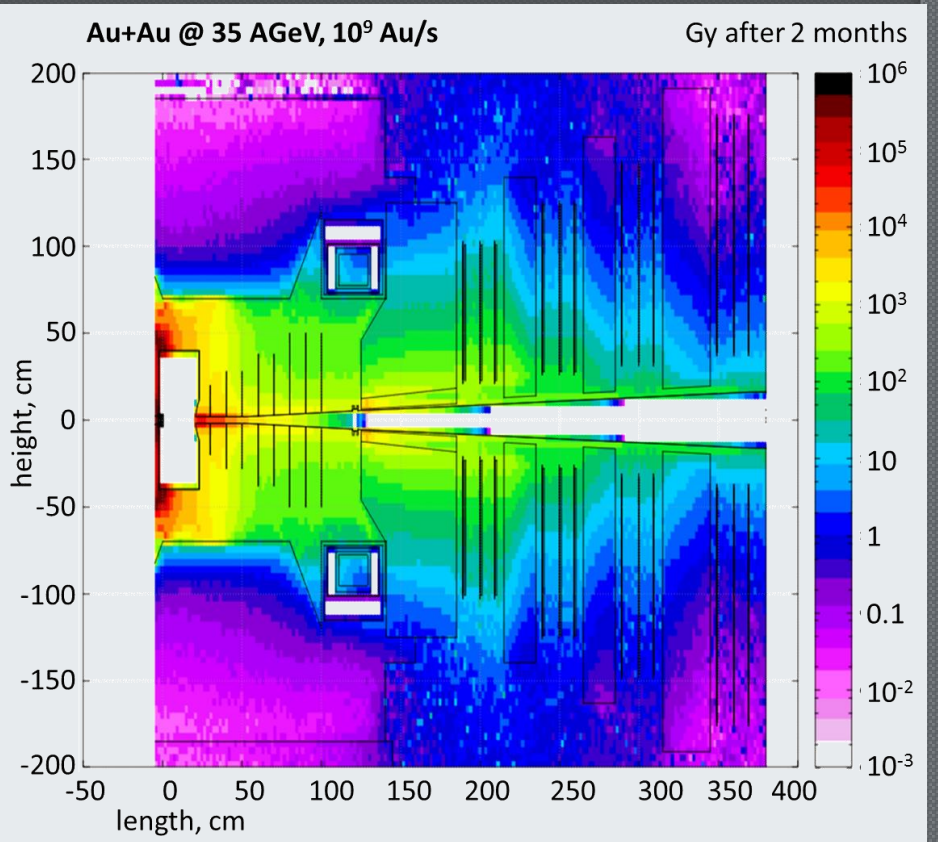


# Ionizing energy loss

Au @ 2 AGeV

Au @ 35 AGeV

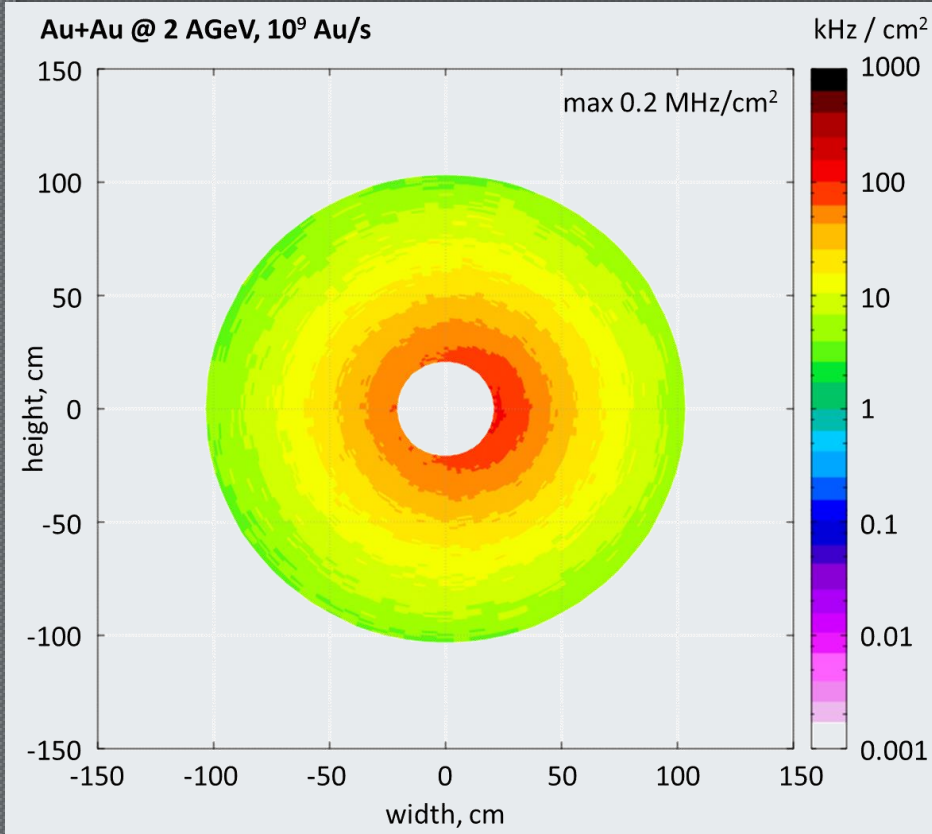


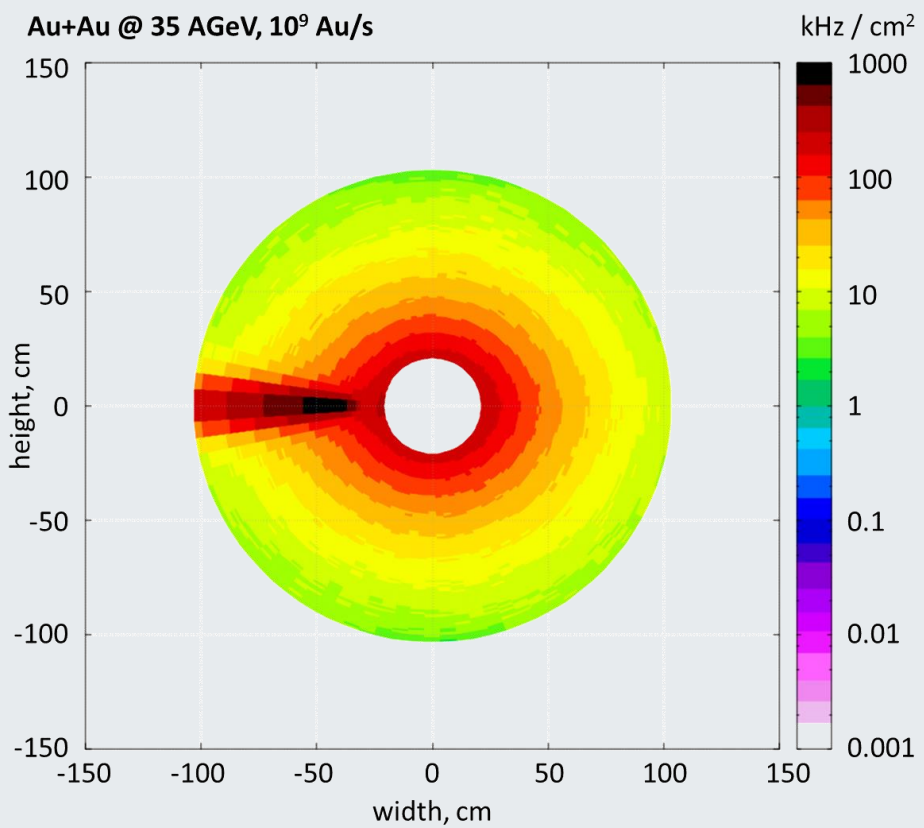



# Particle rate: first station

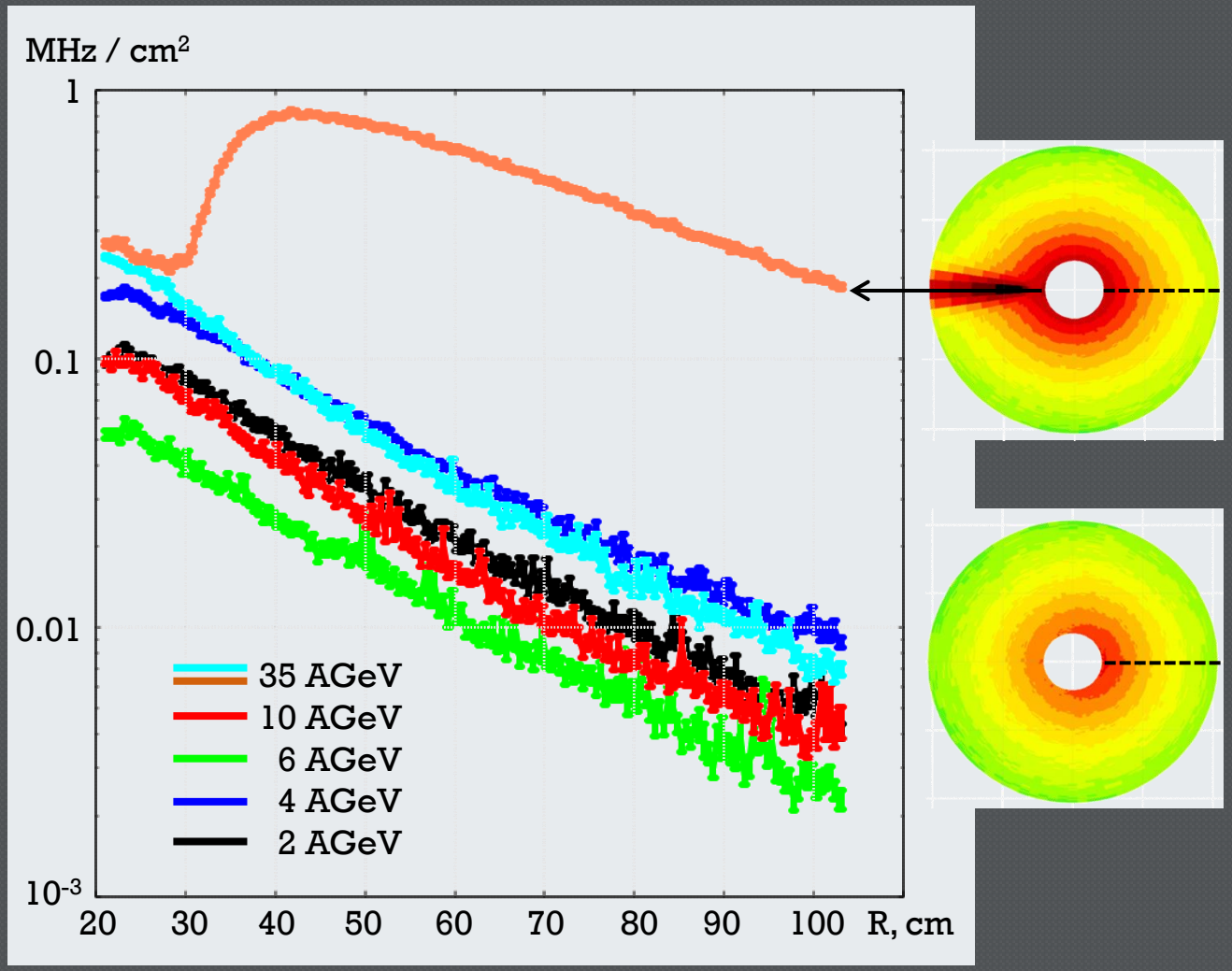
Au @ 2 AGeV

Au @ 35 AGeV



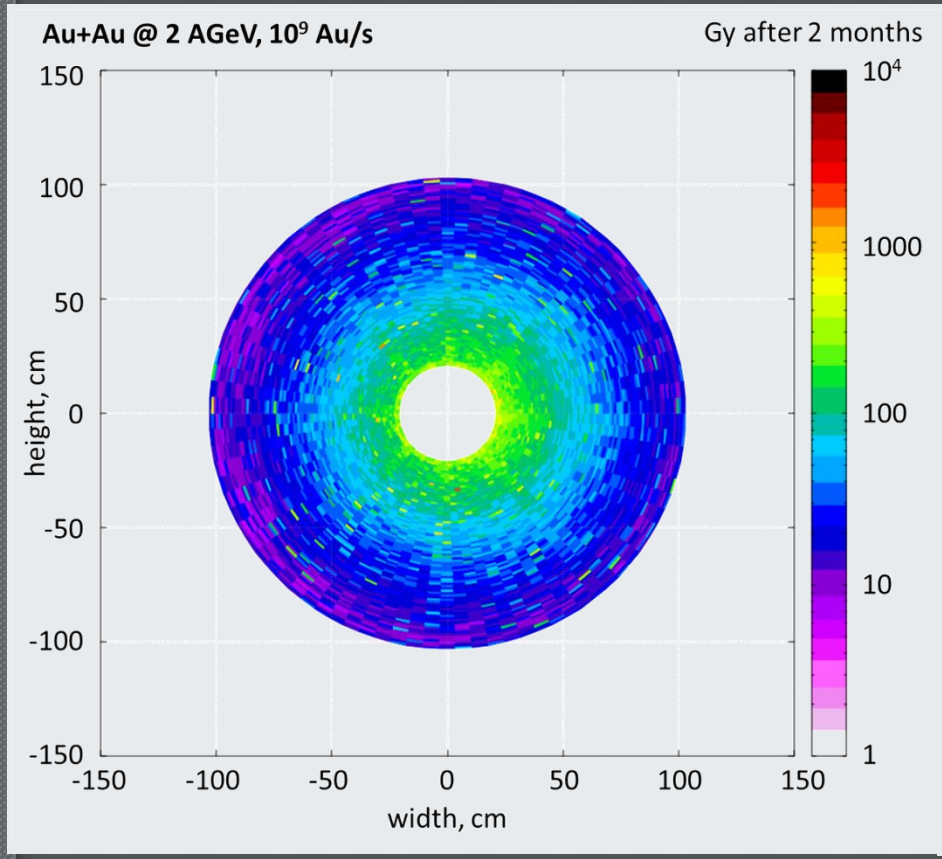



# Particle rate: first station

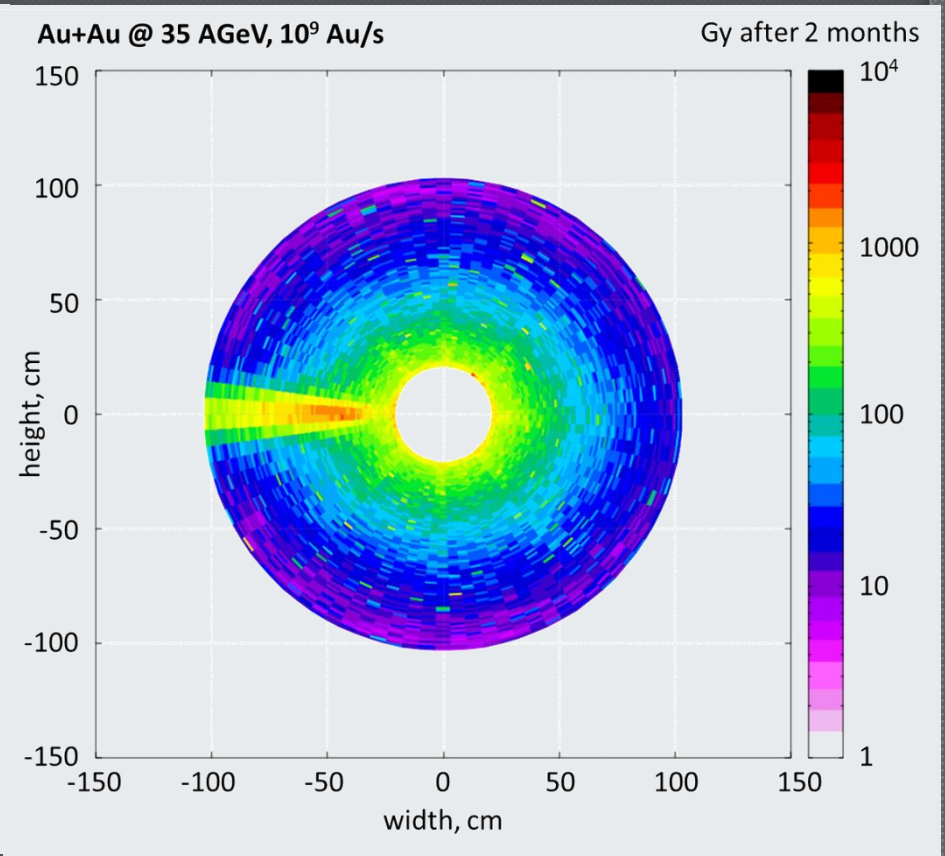


# Ionizing dose: first station

Au @ 2 AGeV

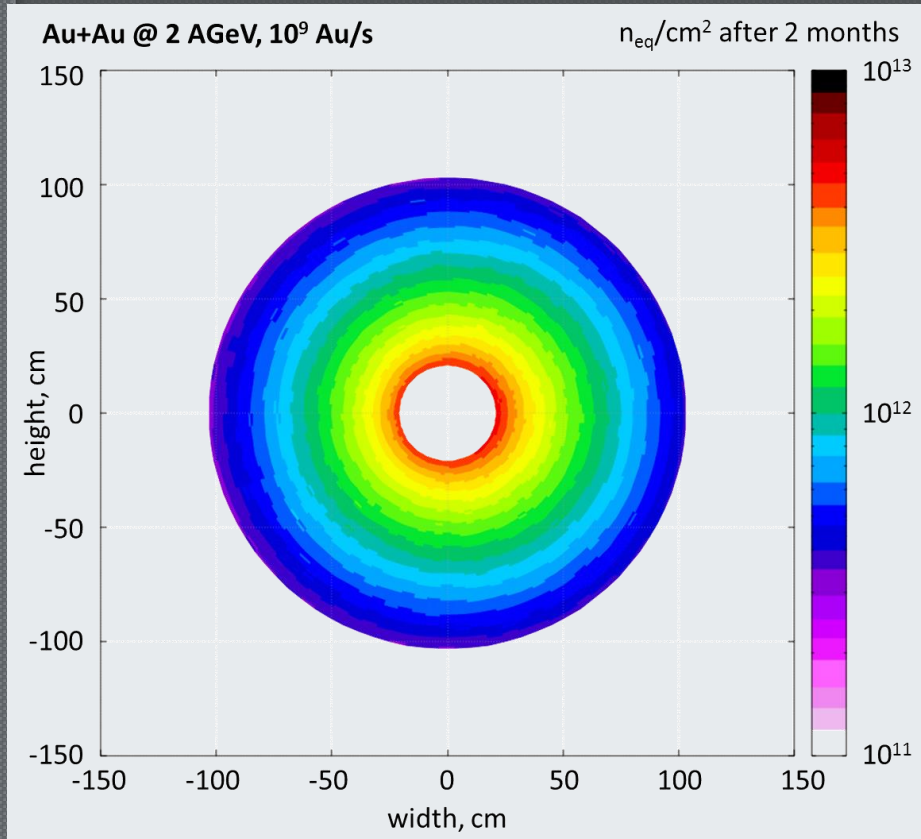



Au @ 35 AGeV

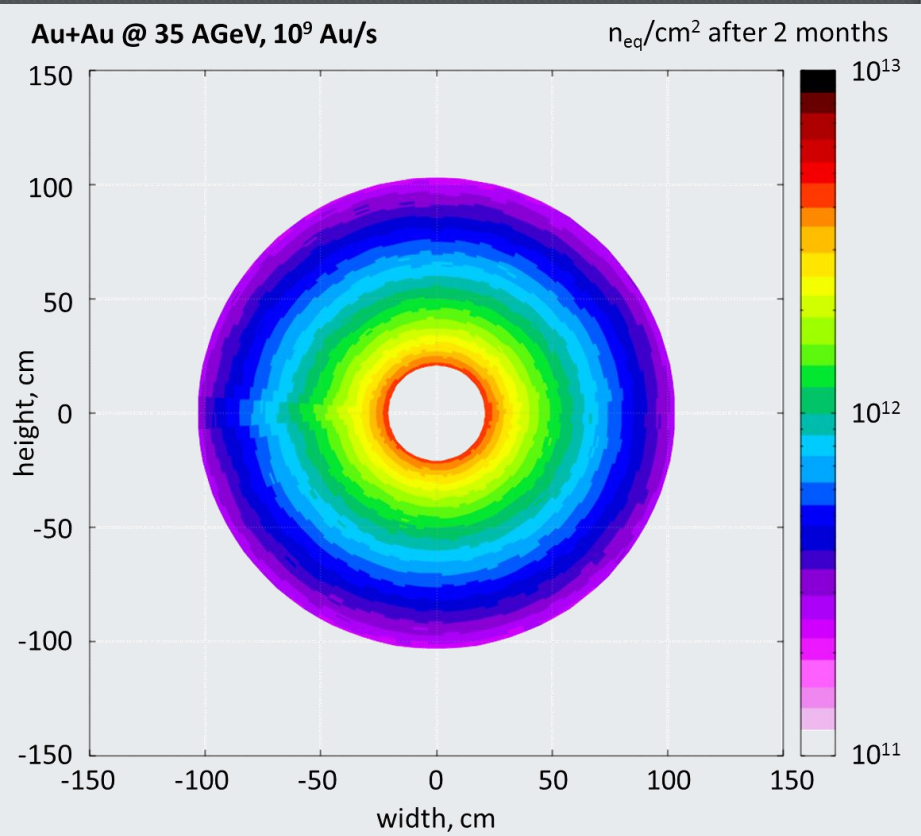


# Non-ionizing dose: first station

Au @ 2 AGeV




Au @ 35 AGeV

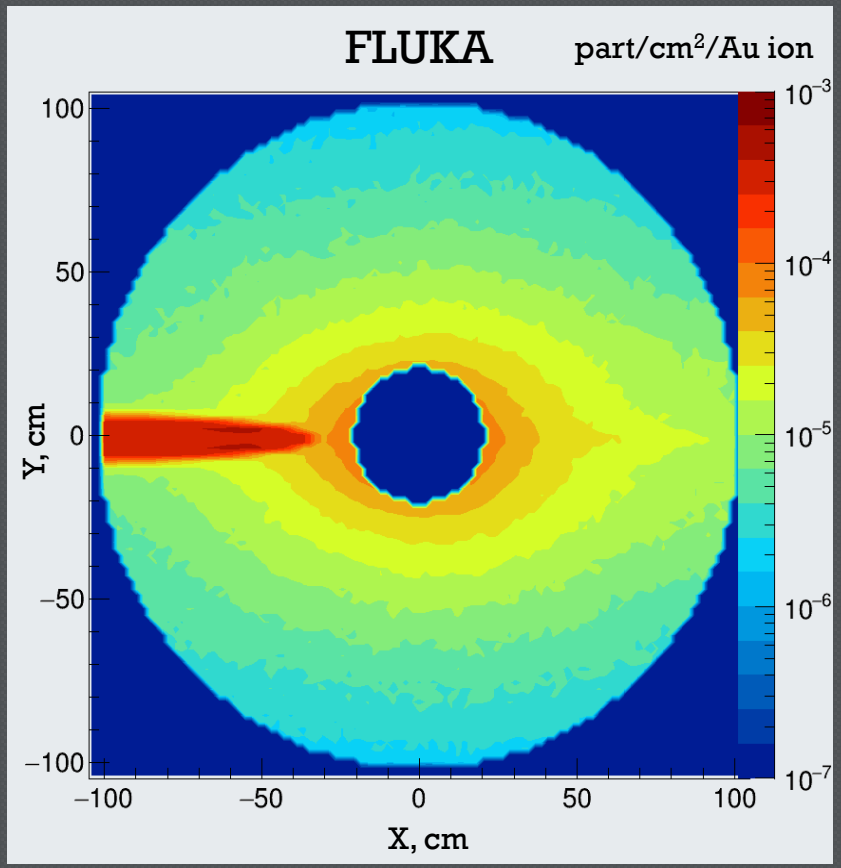


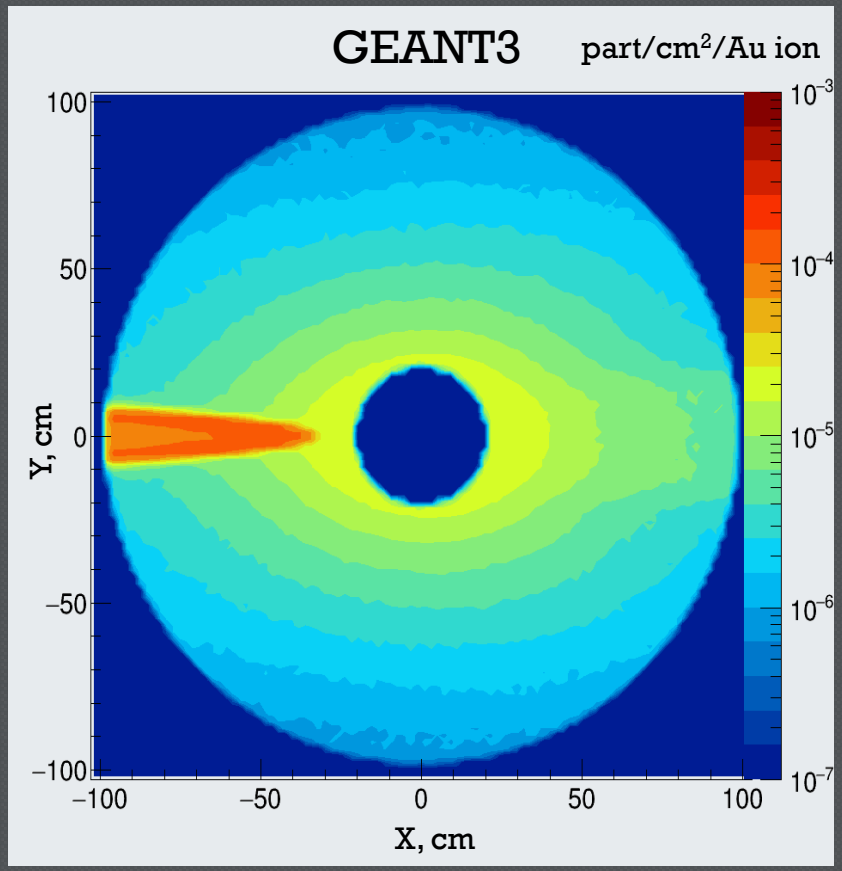
# FLUKA vs. GEANT3

1.89 m from the target (without absorbers)

Au+Au @ 35 AGeV

## all charged particles



# FLUKA vs. GEANT3

1.89 m from the target (without absorbers)

Au+Au @ 35 AGeV

## electrons