Simulation updates from the Cherenkov detector

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Introduction

- Two simulation efforts to discuss today from the Cherenkov group:
  - **Geant4:** simulating optical photon behavior in straws with different configurations
  - **FLUKA:** measuring dose around Cherenkov table to choose locations for electronic readouts

- Last week: finished first test beam with new 4-straw stainless steel + air medium prototype
  - ARES linac @ DESY

prototype:

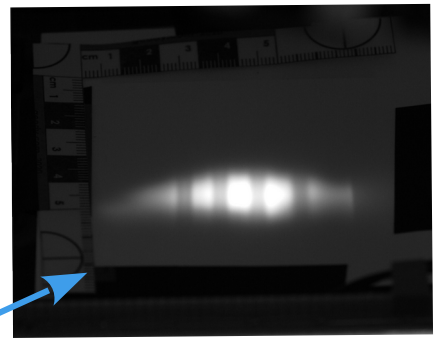
straws:
3.2 mm diameter
0.1 mm thickness

SiPMs
(5 types)

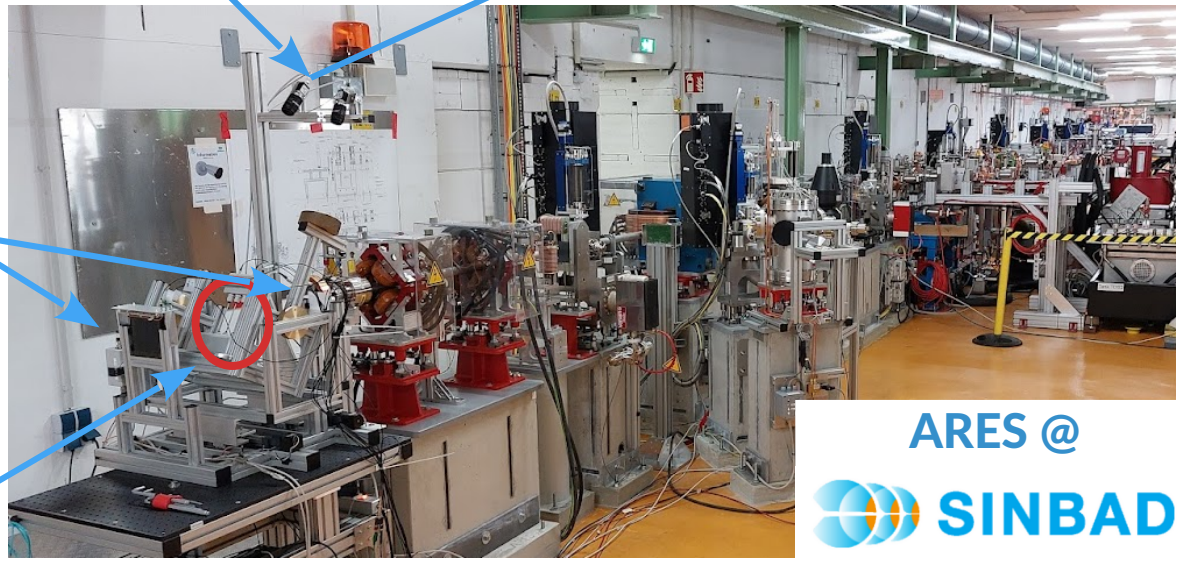
Prototype + test beam

- **ARES 45m linac:**
  - 150 MeV electrons
  - 1-100 pC / bunch
  - 10 Hz rate
  - 5 minute walk

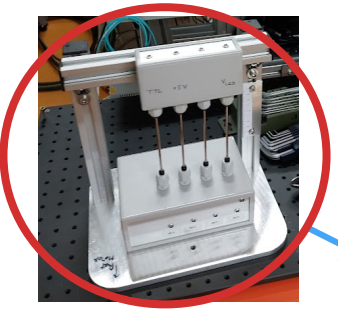
Special thanks to:
Axel Berggren
Karsten Gadow and Michelle Klotz
& the entire ARES team



2 cameras



2 scint. screens



assembly for rotating + positioning prototype

ARES @ SINBAD

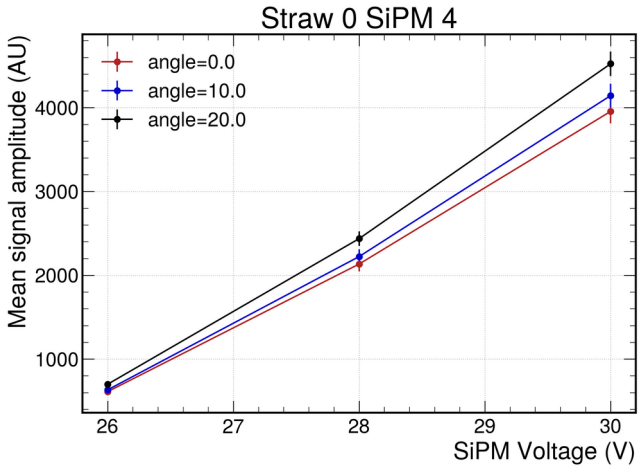
Test beam

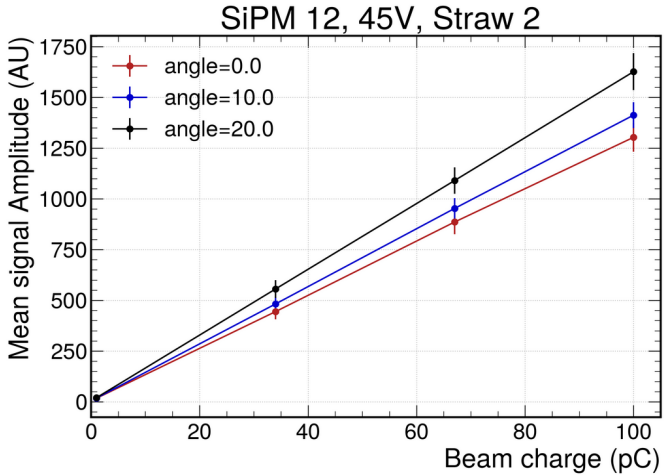
- Measured several configurations
  - **Angle:** 0, 10, 20 (degrees)
  - **Beam charge:** 1, 34, 67, 100 (pC)
  - **SiPM Voltages** (various)
  - **SiPM** type, **Straw** target

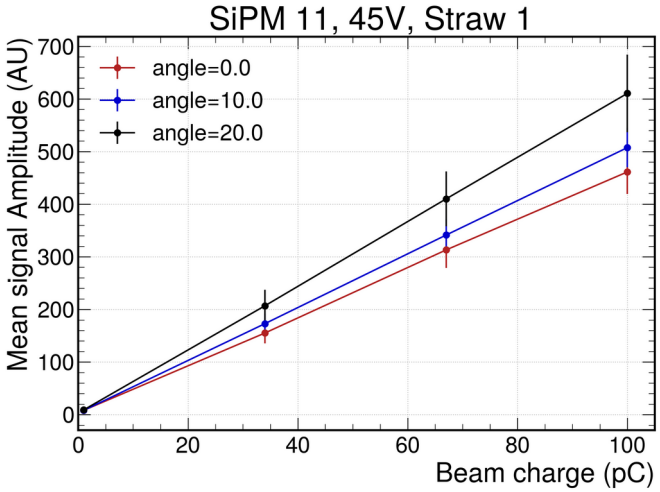
SiPMs:

4,5 → Onsemi MicroFC 30035
6,7 → Onsemi MicroFC 30050
8,9 → Onsemi MicroFJ 60035
10,11 → Hamamatsu S14160-3010
12,13 → Hamamatsu S14160-3015

All 3mm x 3mm
Varying thickness





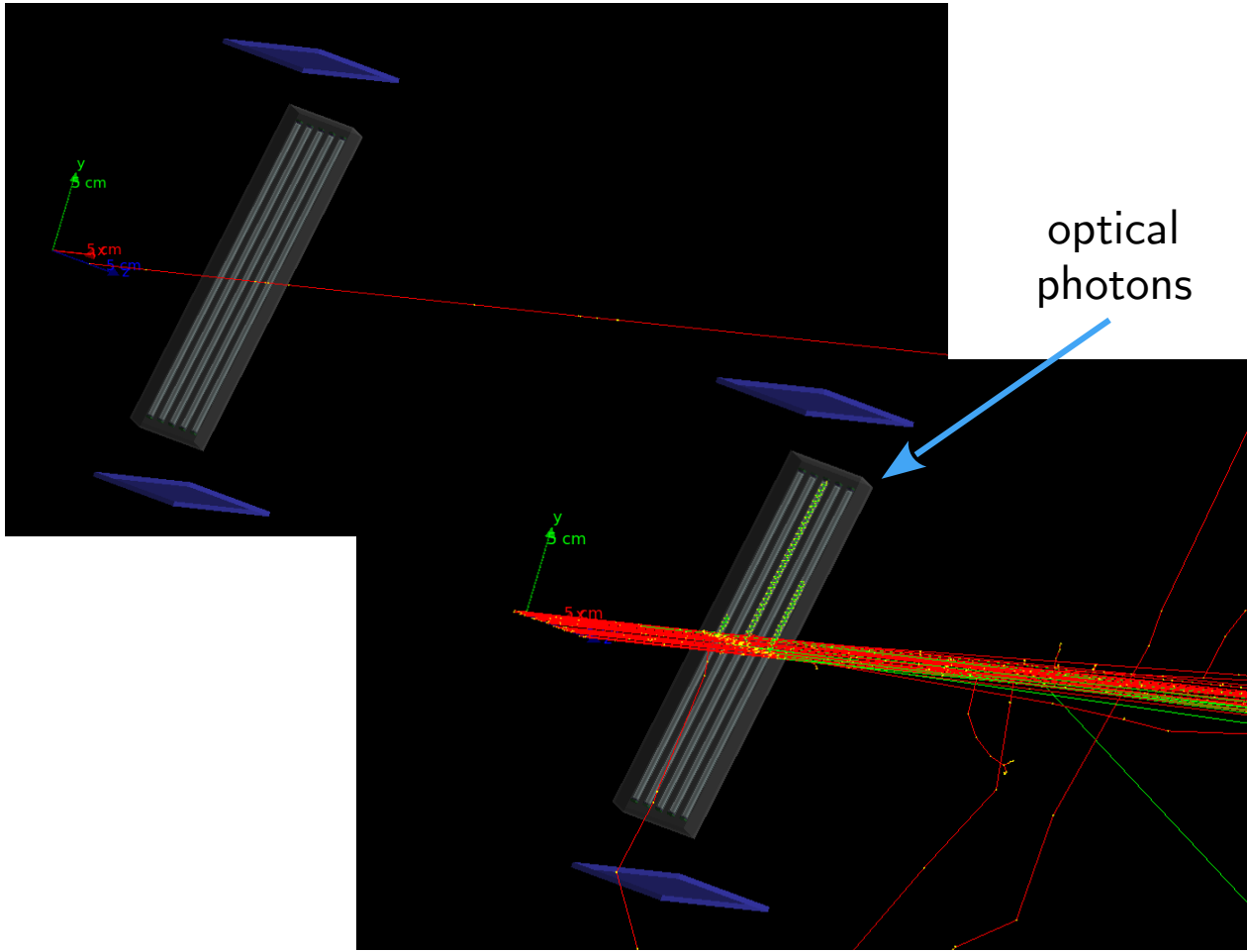


Geant4 Cherenkov simulation

Started by Antonios:

flexible sim to model Cherenkov light production & detection

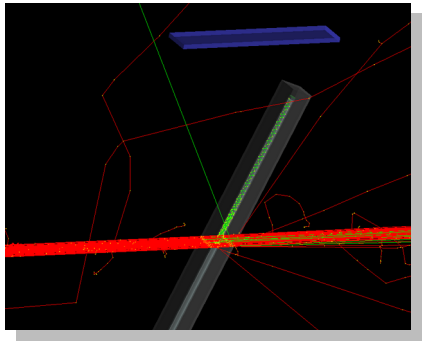
- **Customizable geometry:**
  straw number and placement
  can be set in Geant macro
  → *no source code edits required*
  - Straws match prototype
    3.2 mm diameter, 0.1mm thickness
    Stainless steel
- **Optical photons:**
  Inside of straws allows for production and propagation
- **Silicon volumes**
  to check for detection

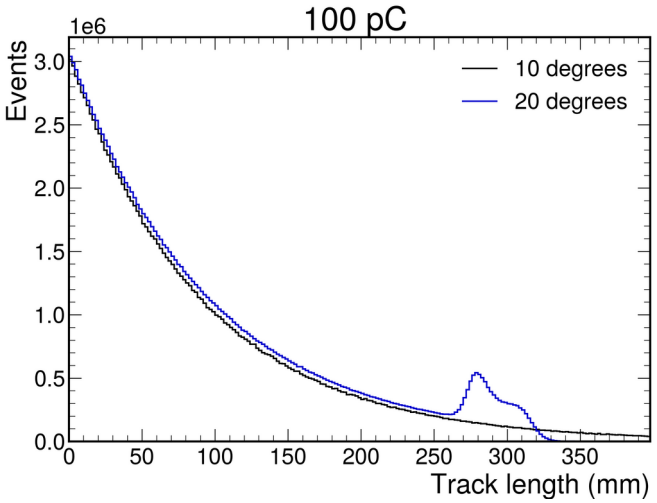


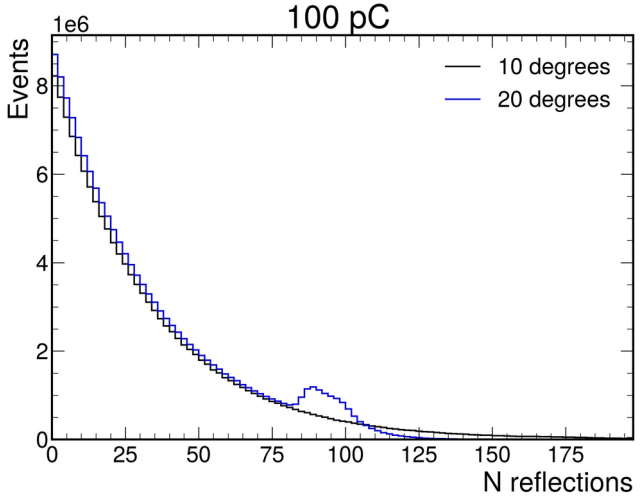
Cherenkov straw simulation

- Checks on optical photon behavior:
  - **Track length** of photon in straw
  - Number of **reflections**

→ Stepping action has been studied carefully



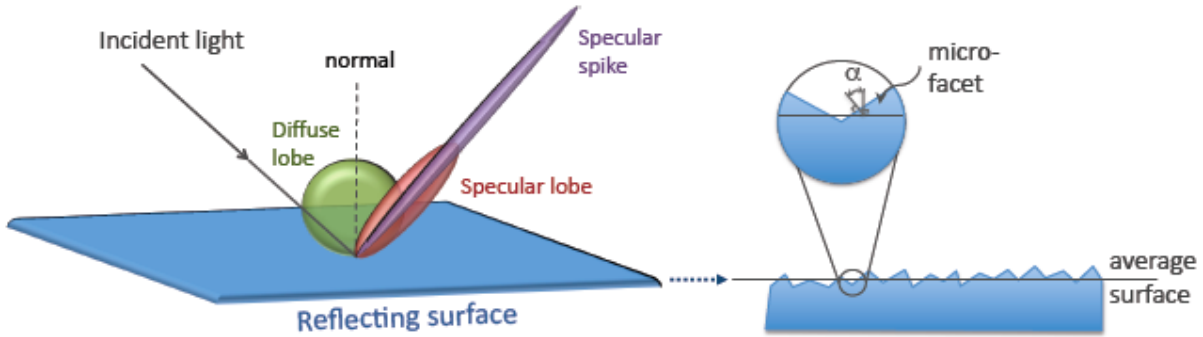




Cherenkov straw simulation

Key parameters

- Reflectivity
- Polishing
  (surface model)



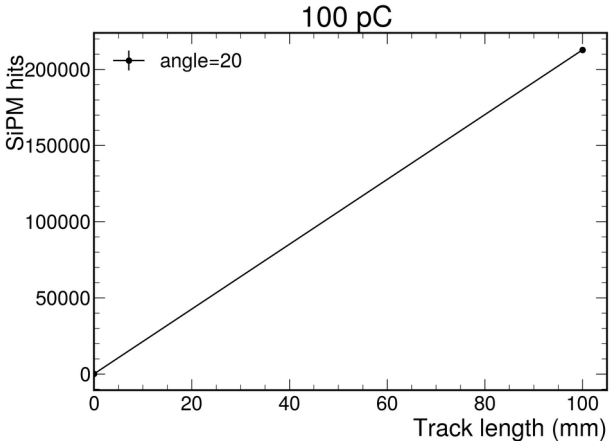
- ## Matching to data
  - Plan to perform **2-parameter fit**

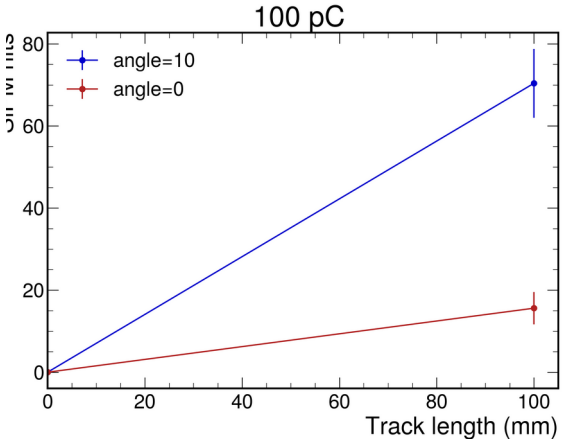
    → Optical photon simulation in Geant4 generally needs tuning to match observations
  - Other parameters (attenuation, efficiency, ...) seem to have *less effect*

Cherenkov straw simulation

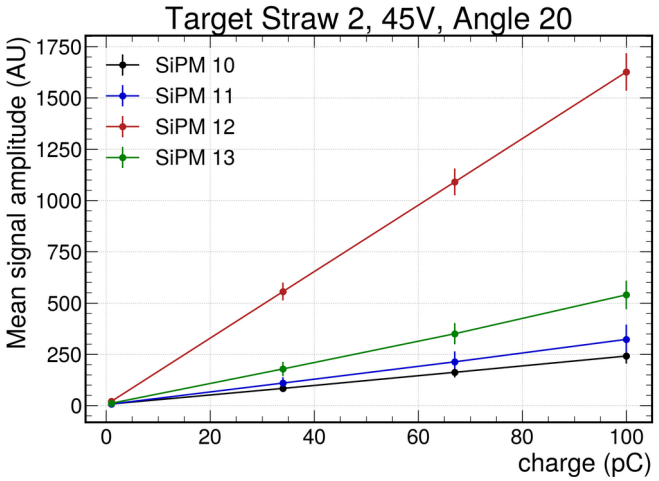
- **SiPM hits**
  - *Very* steep fall-off at low angles

    → partly due to artificially narrow beam (no angular spread)





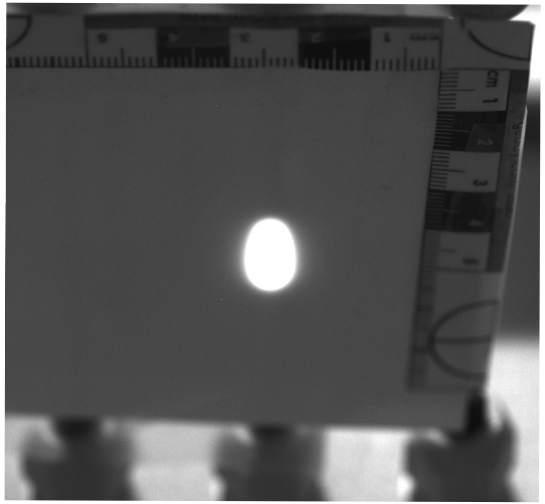
  - However, important from test beam: **scattering** may also be underestimated

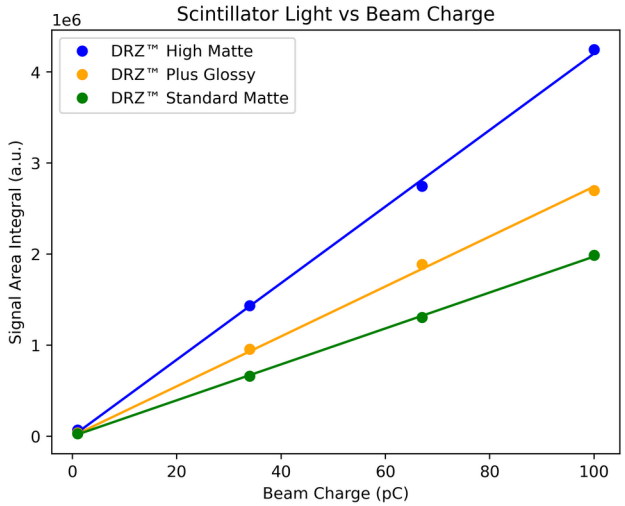


Incorporating info from test beam

- Measurements of **beam size** taken **before & after straws** via scintillator screen cameras
- **Wider beam** than expected, still less than 1 cm @ straws
- Need to assess beam spread, scattering from screen, scattering from straws

Setup by Luke Hendriks



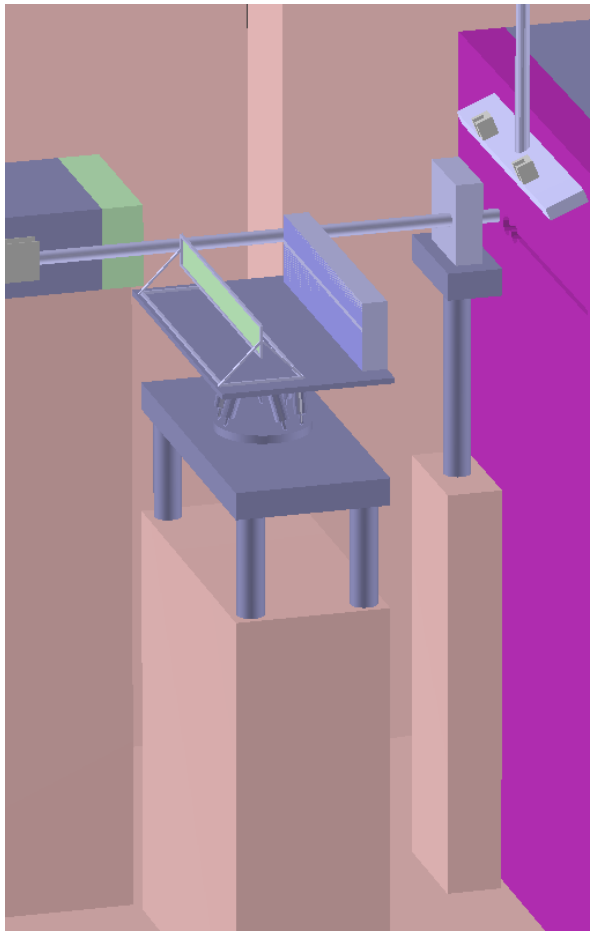


Radiation studies: goals

- **Goal:** understand dose rates for electronics
  $\rightarrow$ 2 key locations:
  - **Frontend electronics board**

    Upper part of Cherenkov box, between shielding and box
    - Minimal readout, temperature sensors
  - **Digitizer + Power supply**

    Beneath Cherenkov mounting table
- **Idea**
  - Use existing fluka setup to estimate dose
    - Thanks to Stewart Boogert!
  - Some work left to run with ideal geometry

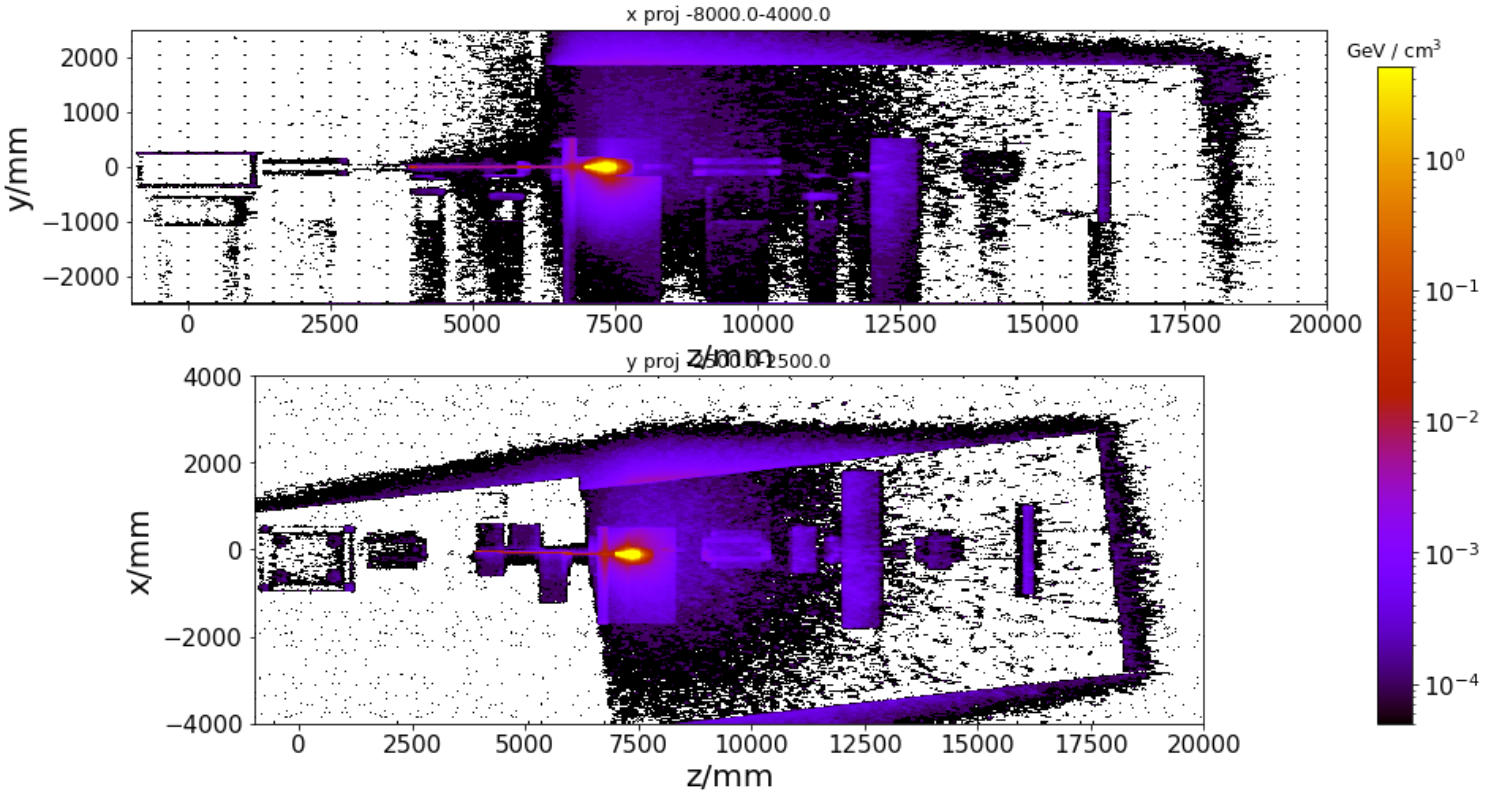


Radiation studies: fluka setup

- **Starting point:** Stewart Boogert & Kyle Fleck's Fluka setup, normalized per 1.5 * 10^9 e- bunch

  Beam Energy 16.5 GeV, spread of 0.1 GeV

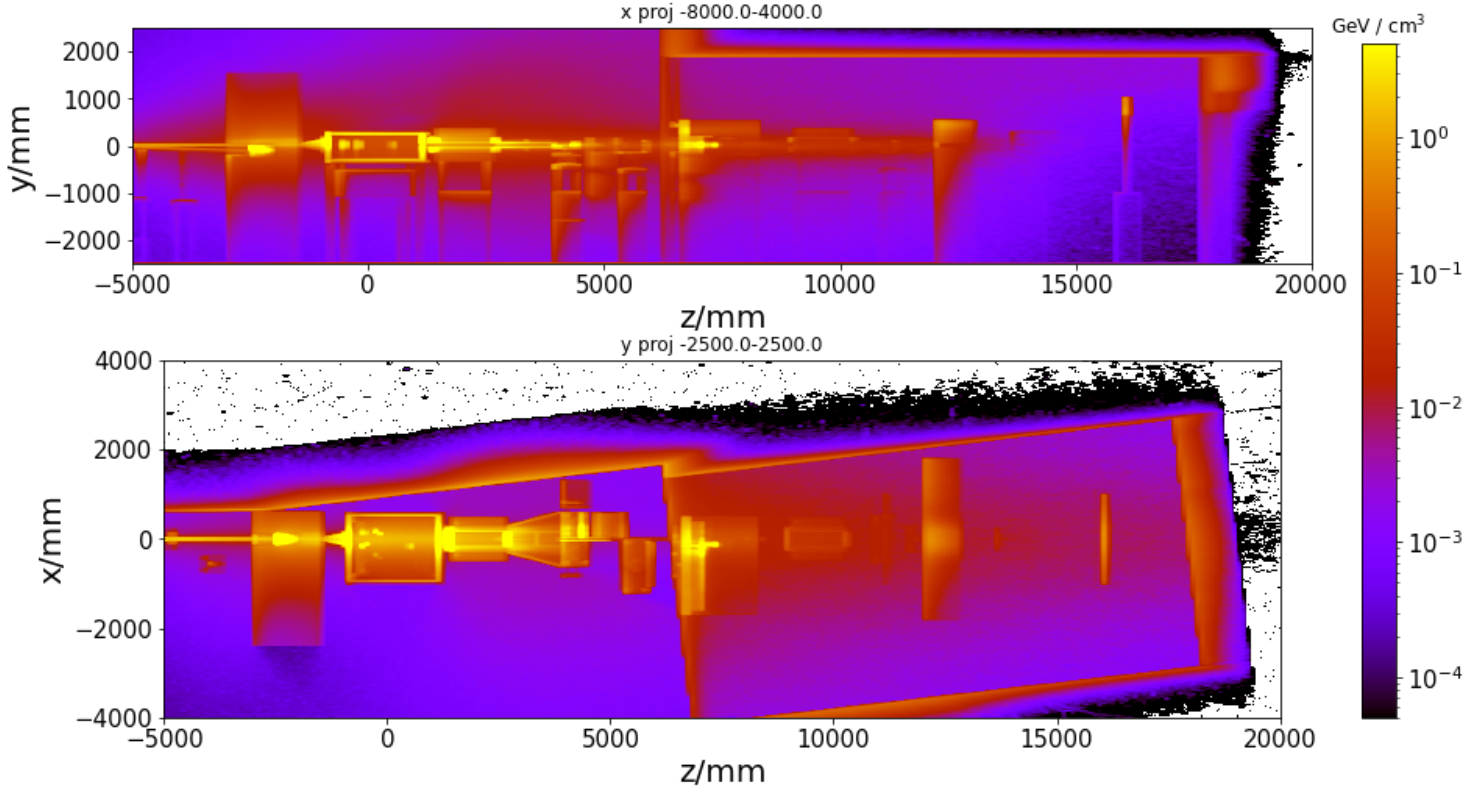
Energy deposition:



Radiation studies: fluka setup

- More recent test: spread beam Energy, 6 GeV – 16.5 GeV

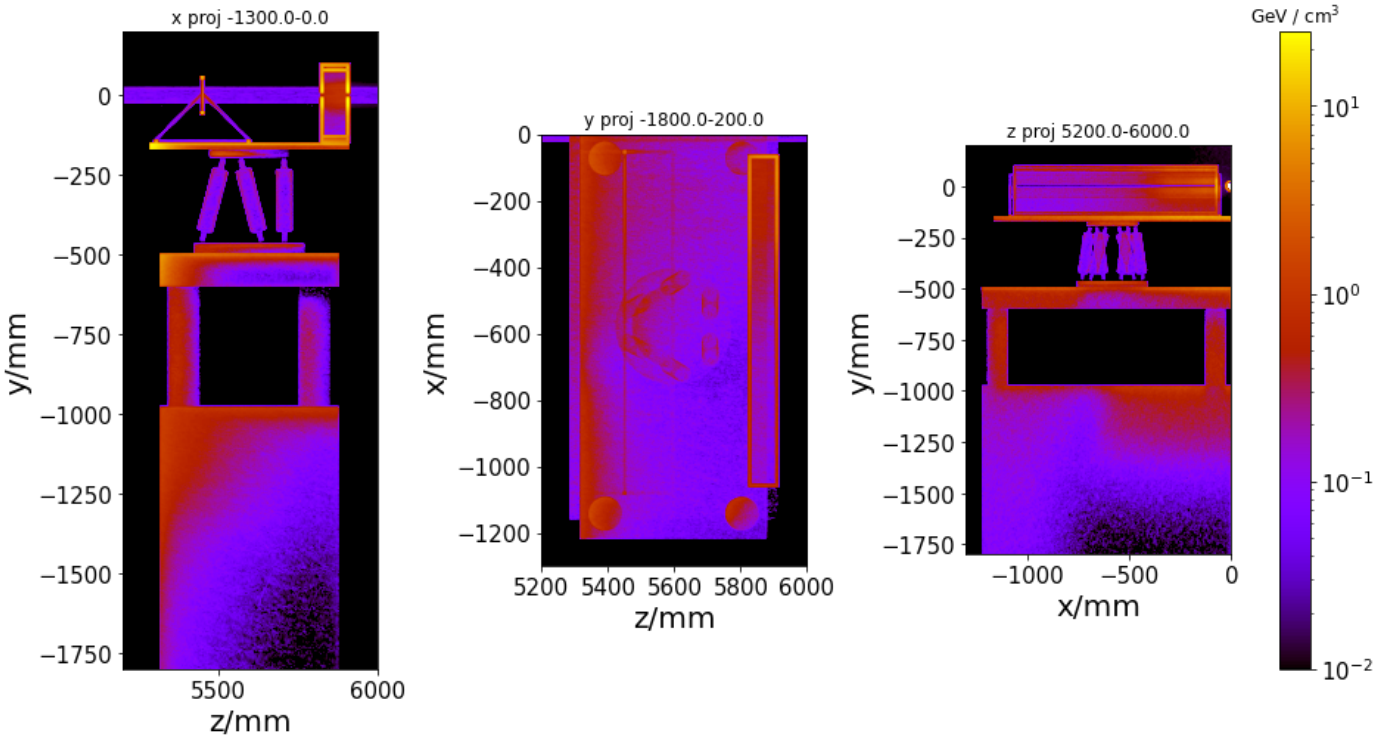
Energy deposition:



Radiation studies: plots

- Added `usrbnn` fluka cards track dose, energy deposition in 3D region limited to Cherenov table

- **Energy Deposition:**
  - Projected by mean…

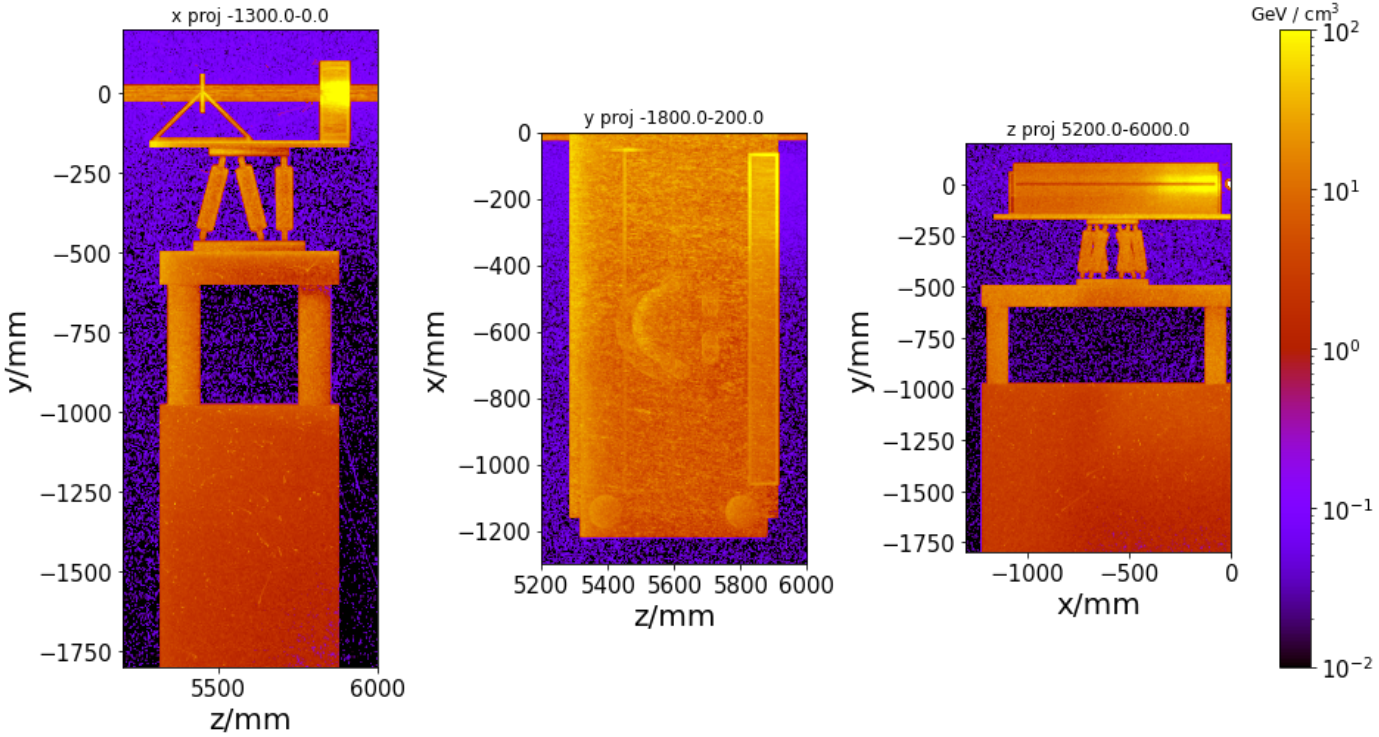


Radiation studies: plots

- Added `usrbnn` fluka cards to track dose, energy deposition in 3D region limited to Cherenkov table

- **Energy Deposition:**
  - Projected by mean…

    …or max



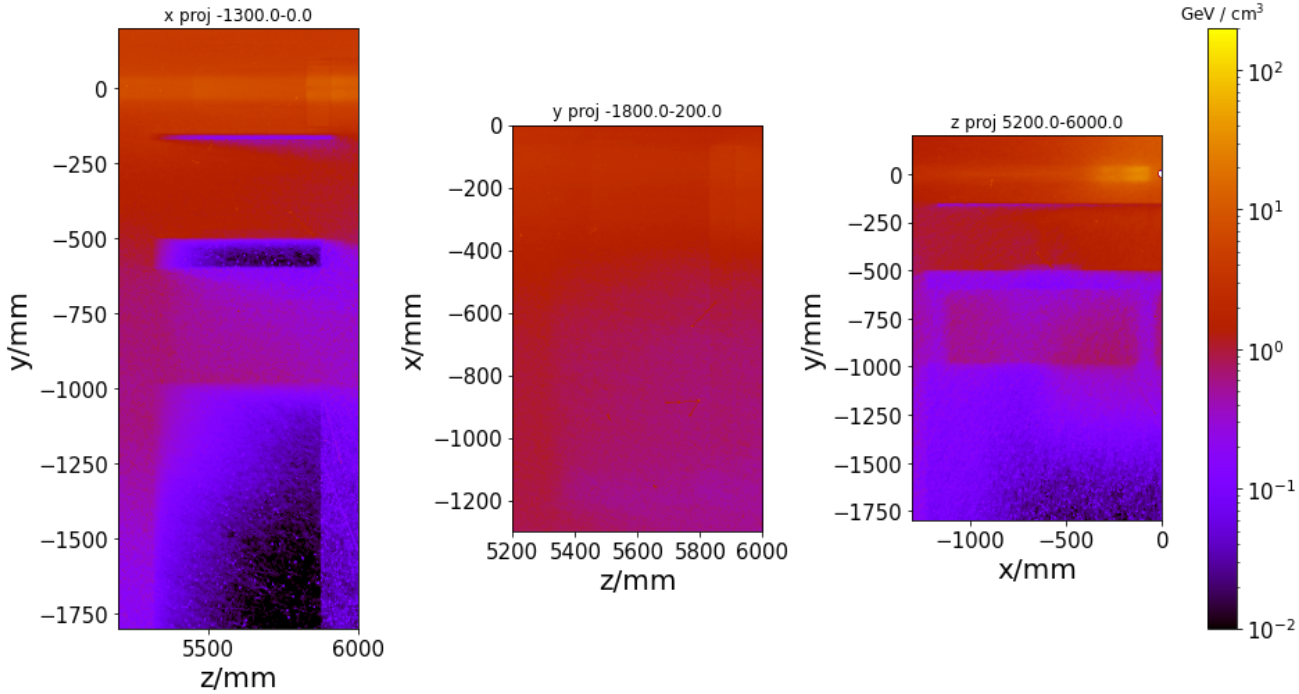
Radiation studies: plots

- Added `usrbnn` fluka cards to track dose, energy deposition in 3D region limited to Cherenkov table

- **Dose:** want to avoid projecting out important effects by taking mean/avg

  → slices

Mean dose projection

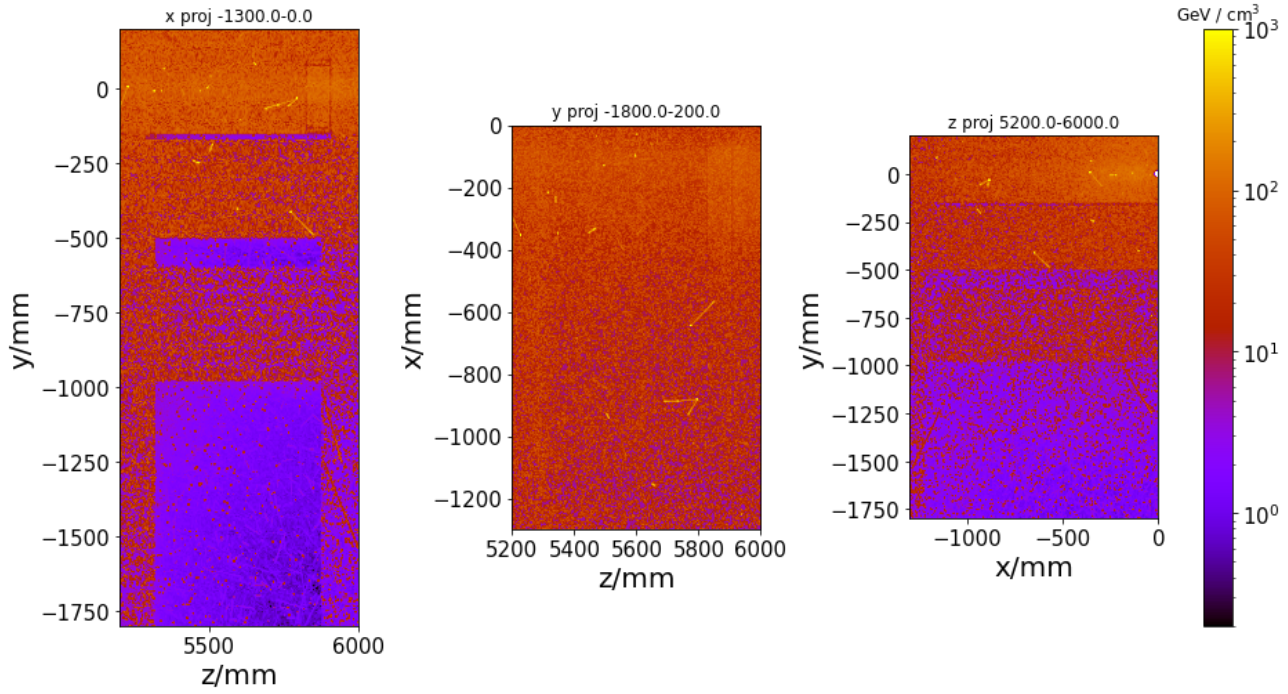


Radiation studies: plots

- Added `usrbnn` fluka cards to track dose, energy deposition in 3D region limited to Cherenkov table

- **Dose:** want to avoid projecting out important effects by taking mean/avg $\rightarrow$ slices

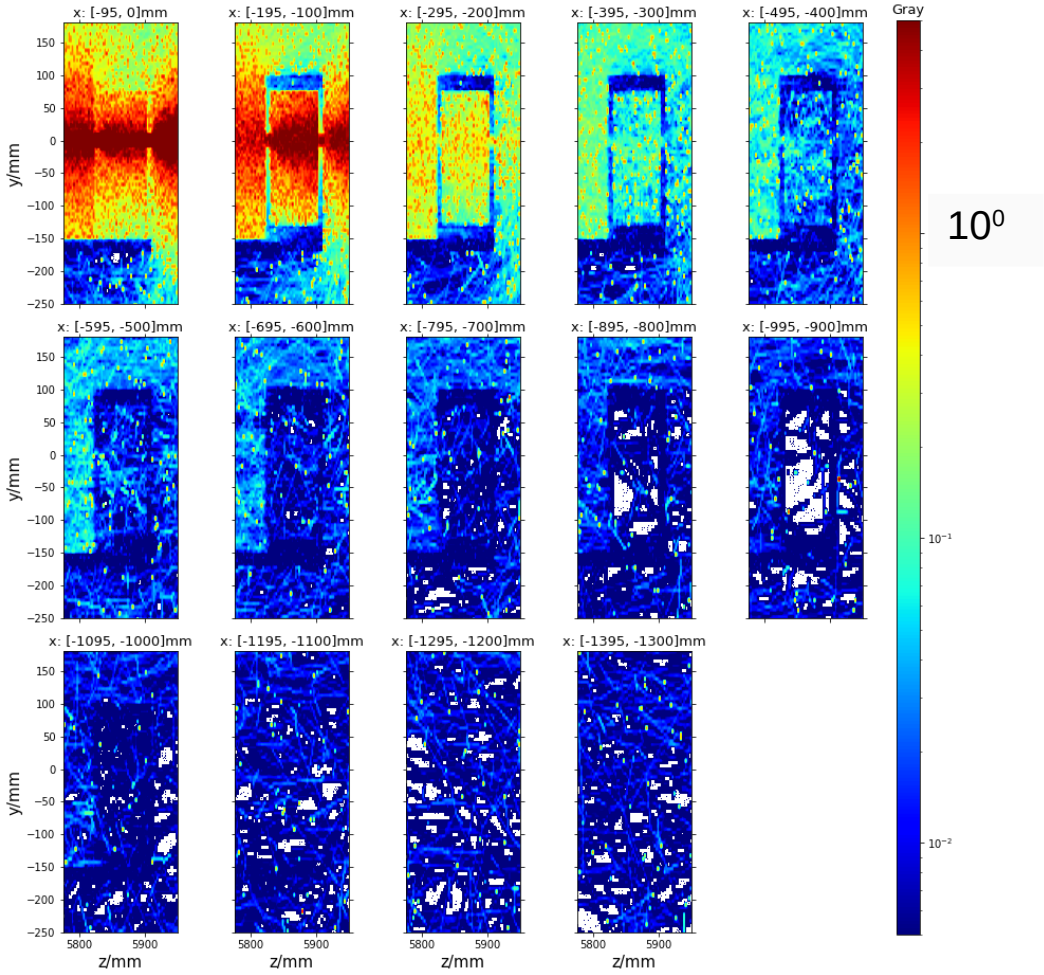
Max dose projection



Radiation studies: dose slices

Y-Z plane

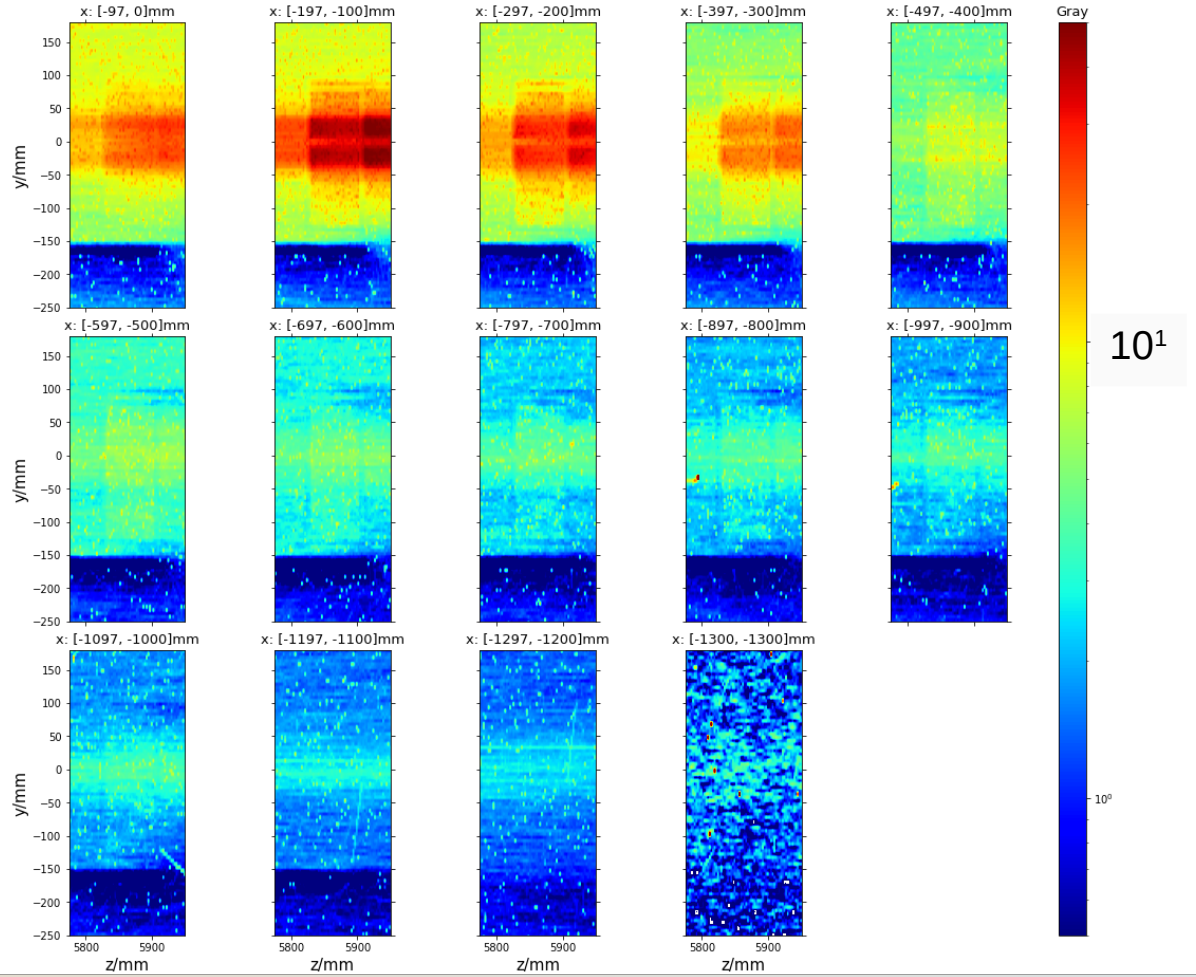
Beam energy narrow



Radiation studies: dose slices

Y-Z plane

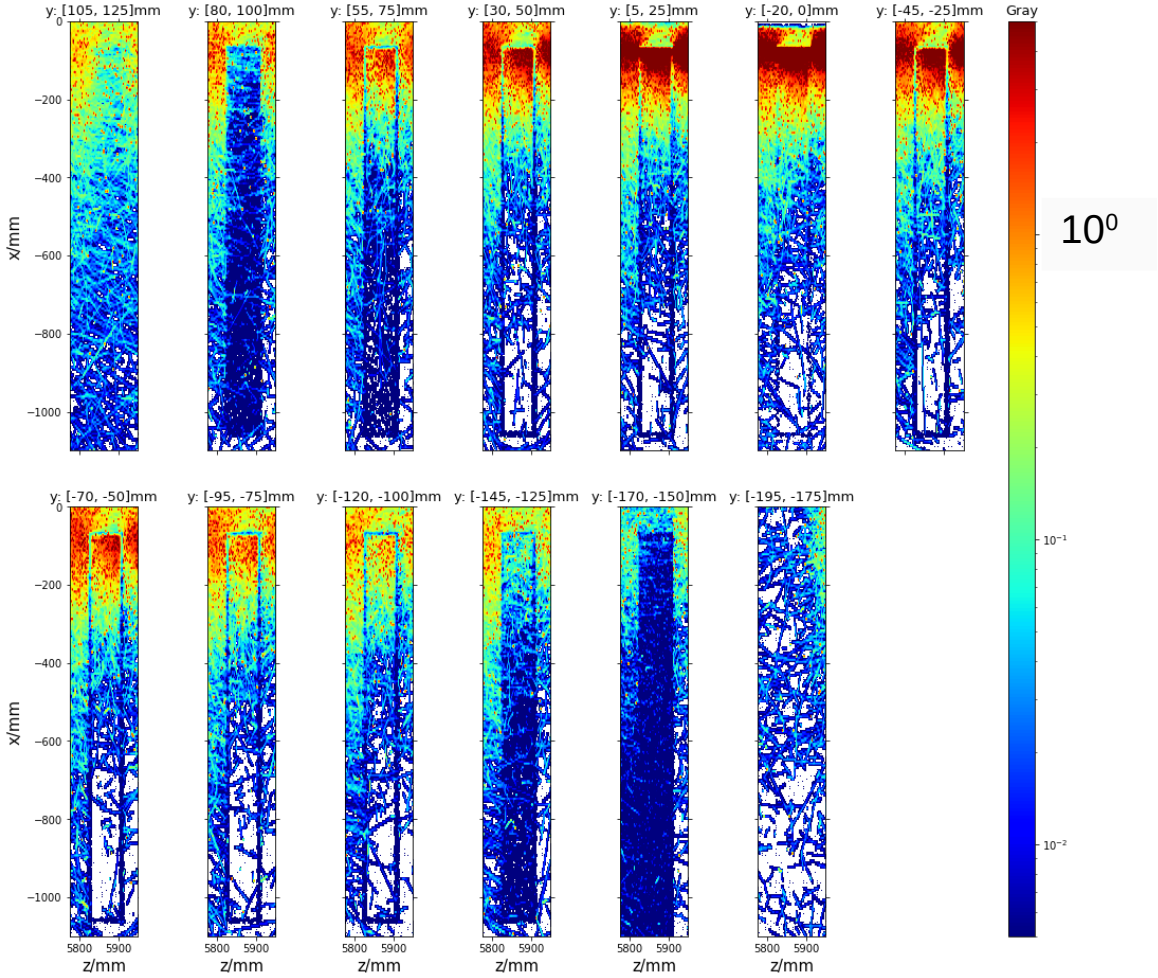
Beam energy wide



Radiation studies: dose slices

X-Z plane

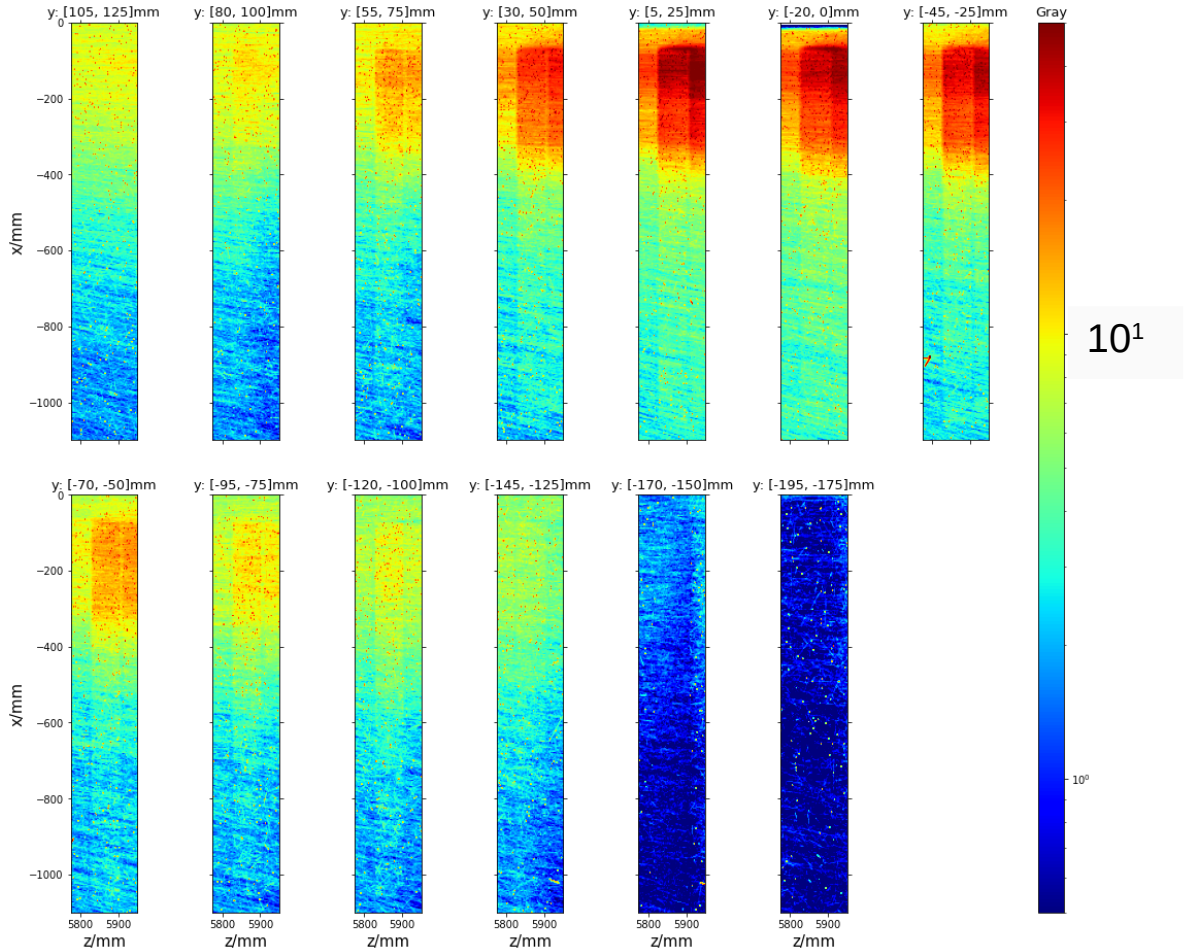
Beam energy narrow



Radiation studies: dose slices

X-Z plane

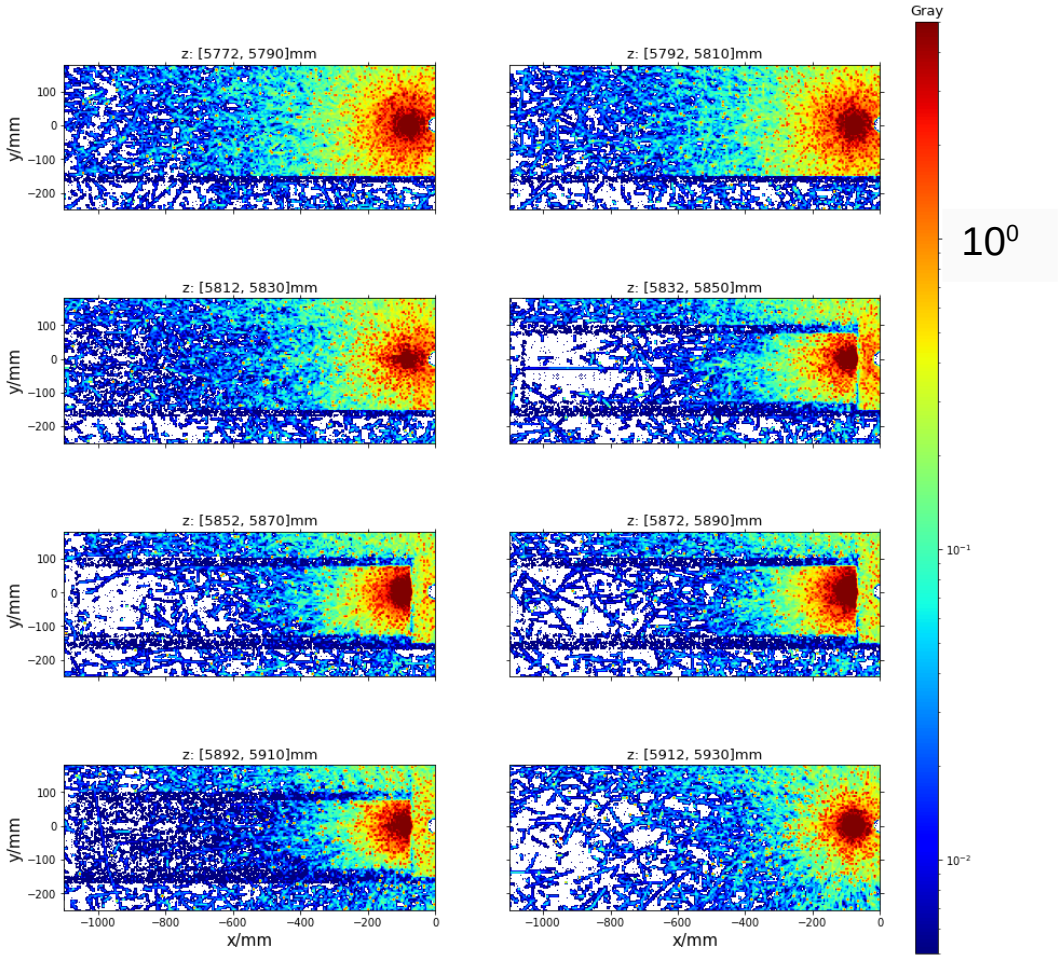
Beam energy wide



Radiation studies: dose slices

X-Y plane

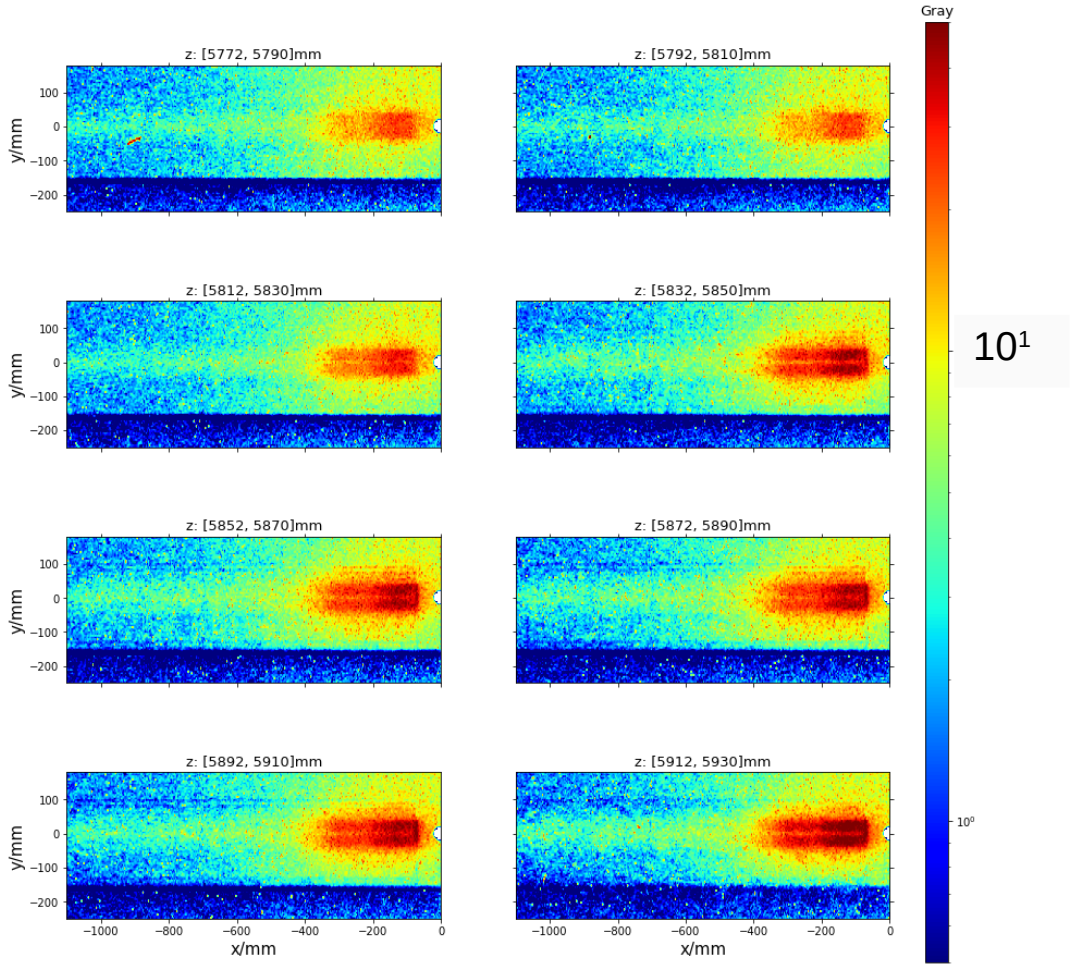
Beam energy narrow



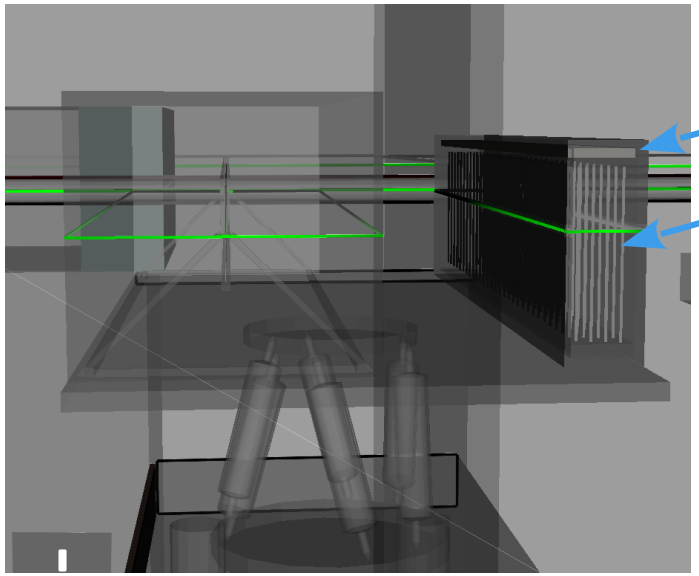
Radiation studies: dose slices

X-Y plane

Beam energy wide



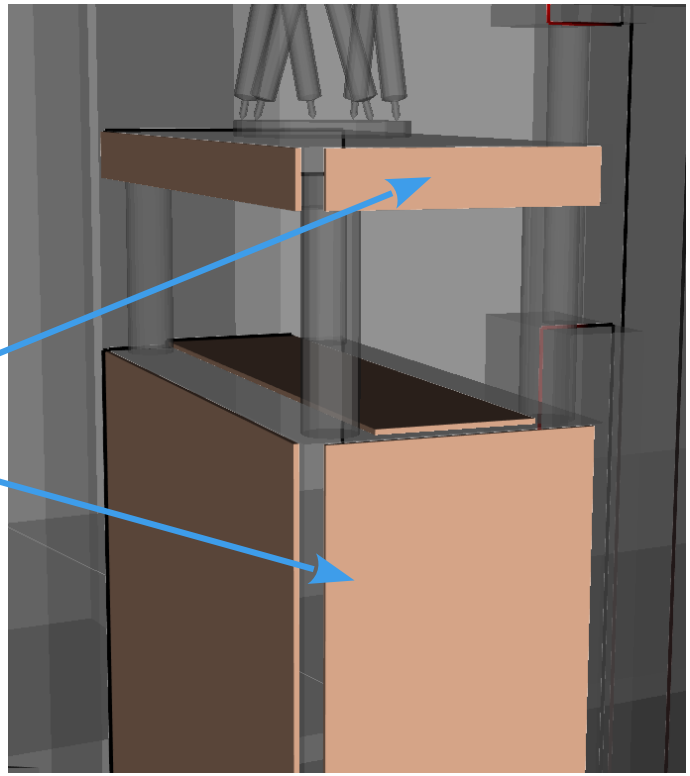
GDML geometry modifications



Thicker Si board for front-end electronics

Stainless steel straws

Si “boards” for digis, power supply



- Thanks to Stewart for tutorial in `pyg4ometry`
- Conversion to Fluka input... *ongoing*
- Want to be careful to follow same recipe as other studies

Next steps

- **Geant4**
  - Add beam angular dispersion, accelerator parameters
    → improve realism
  - Test dependence on key config parameters + fit to data

- **Fluka**
  - Finalize Cherenkov table geometry for dose study

    → Possibly simplify other locations
  - Add materials cards to converted geometry,
    understand what was added in previous gdml→fluka conversion