THE UNIVERSITY OF WARWICK

# FLUKA Energy Deposition Studies for IDS120j - Update

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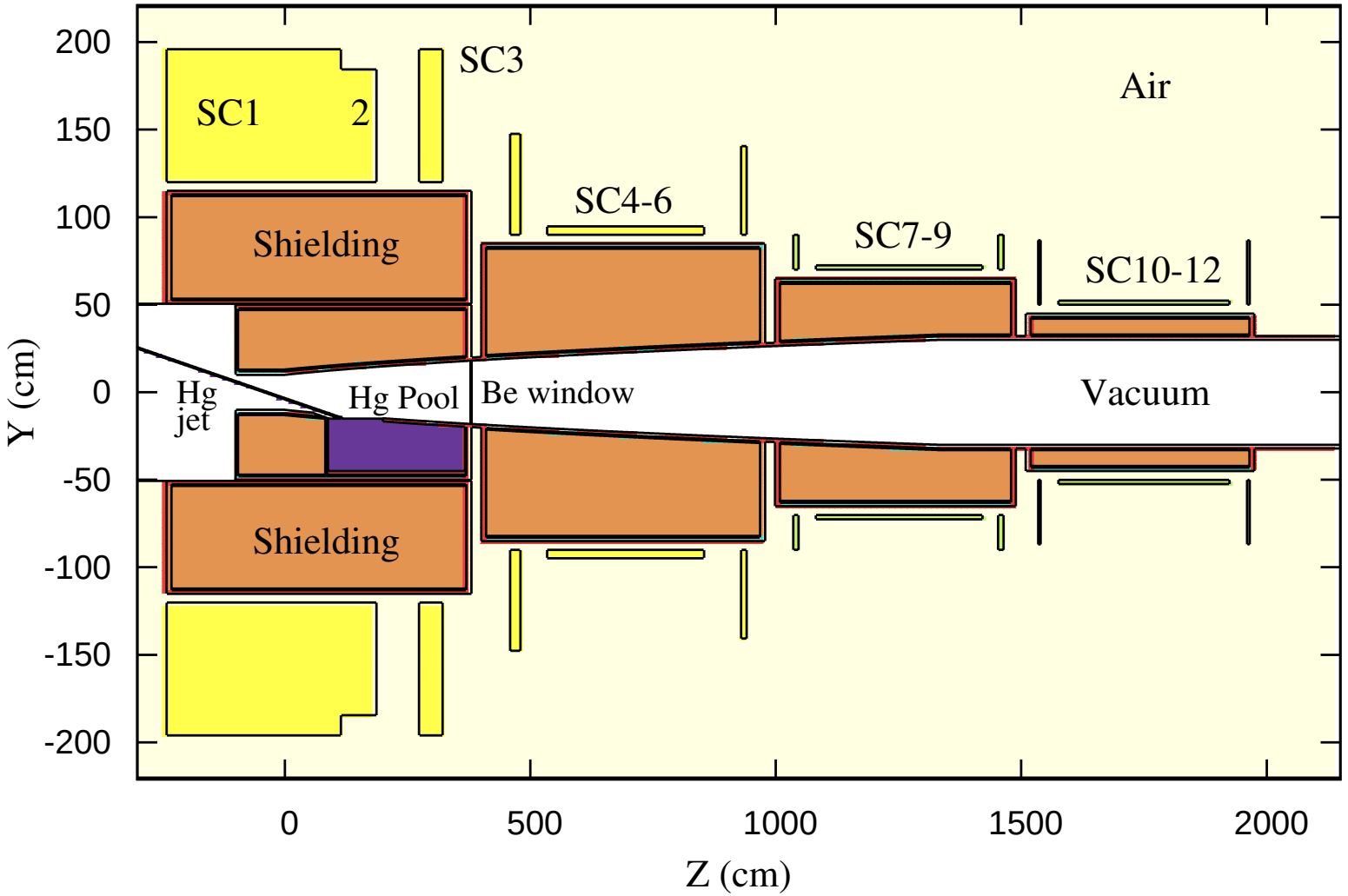
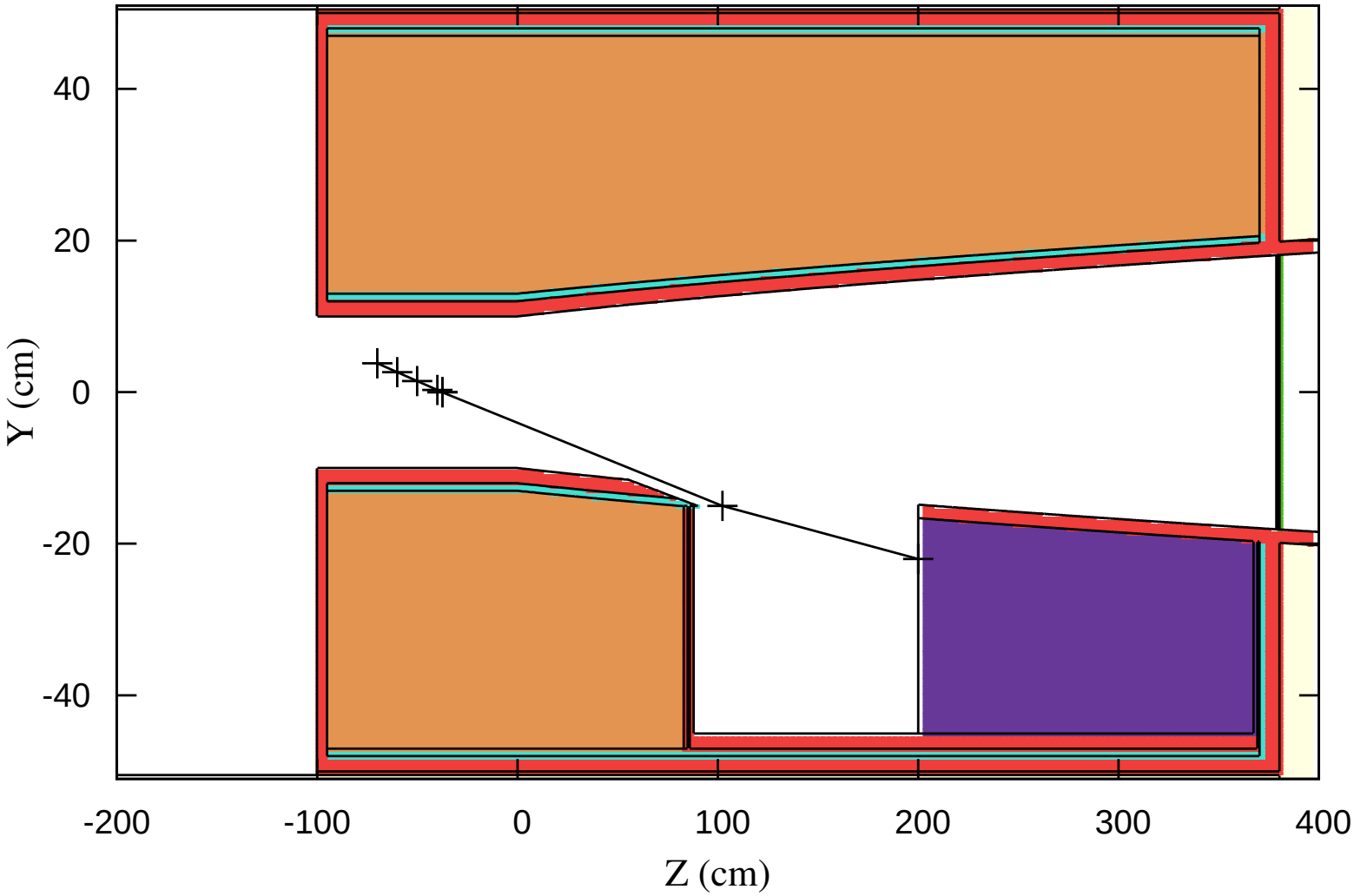
# Introduction

- Using Fluka 2011.2.13 for energy deposition study of IDS120j geometry
  - 100,000 simulated events: $\times 10$ trials for uncertainty estimates
- Hg jet: $r = 0.4\,\mathrm{cm}$, tilt $\theta = 97\,\mathrm{mr}$
- Gaussian proton beam $\sigma_x = \sigma_y = 0.12\,\mathrm{cm}$, KE $= 8\,\mathrm{GeV}$
- Corrected "P12" starting point: jet-beam intersection at z = -37.5 cm
  - Central proton beam trajectory goes into Hg pool, instead of shielding
  - Previous trajectory affected power deposition in SC4
- Shielding: 60% W + 40% He ($\rho_{eff} = 9.48\,\mathrm{g/cc}$)
- Proton rate $= 3.125 \times 10^{15}$ s$^{-1}$ for 4 MW (8 GeV, 50 Hz)
- Multiply (average) energies by proton rate to get deposited power

# Fluka model of IDS120j geometry



# Proton Beam Trajectory




Removing first part of Hg pool, plot shows the trajectory of the proton beam center.

# Power deposition in SC coils

| Region | P (kW) |
|---|---|
| SC Coil 1 | $0.386 \pm 0.050$ |
| SC Coil 2 | $0.082 \pm 0.020$ |
| SC Coil 3 | $0.016 \pm 0.008$ |
| SC Coil 4 | $0.025 \pm 0.009$ |
| SC Coil 5 | $0.006 \pm 0.004$ |
| SC Coil 6 | $0.002 \pm 0.002$ |

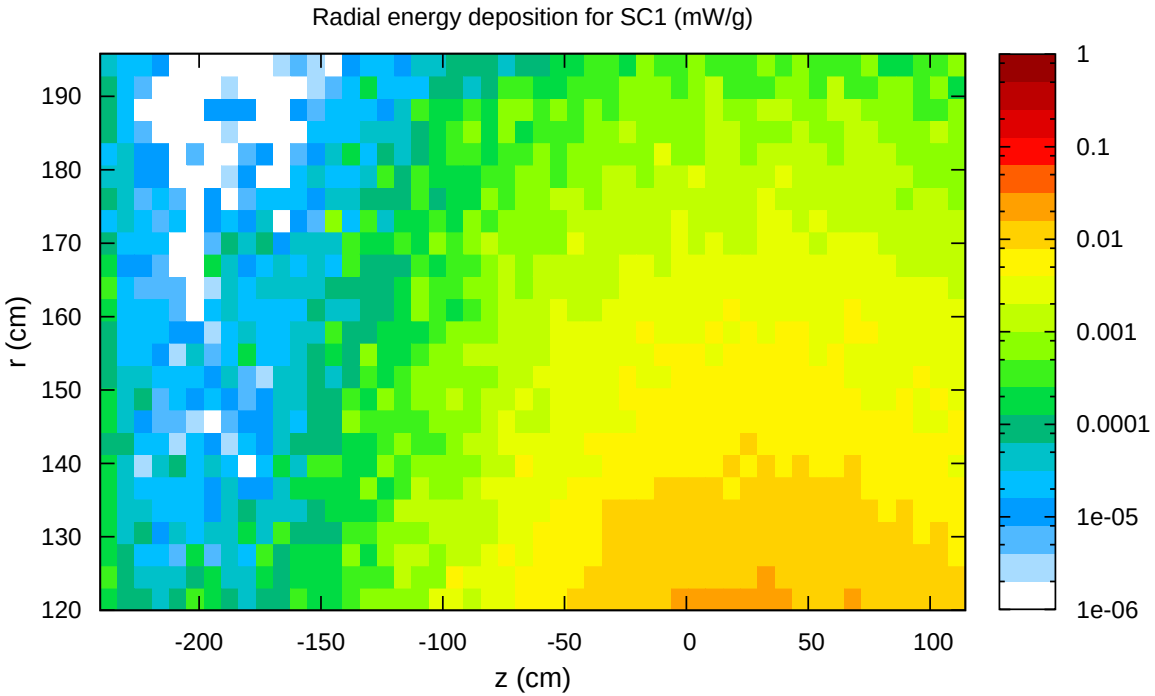
| Region | P (kW) |
|---|---|
| SC Coil 7 | $0.008 \pm 0.007$ |
| SC Coil 8 | $0.014 \pm 0.007$ |
| SC Coil 9 | $0.005 \pm 0.004$ |
| SC Coil 10 | $0.061 \pm 0.020$ |
| SC Coil 11 | $0.135 \pm 0.027$ |
| SC Coil 12 | $0.020 \pm 0.010$ |

Total SC power deposition $\approx 0.8\,\mathrm{kW}$

# Power deposition in all regions

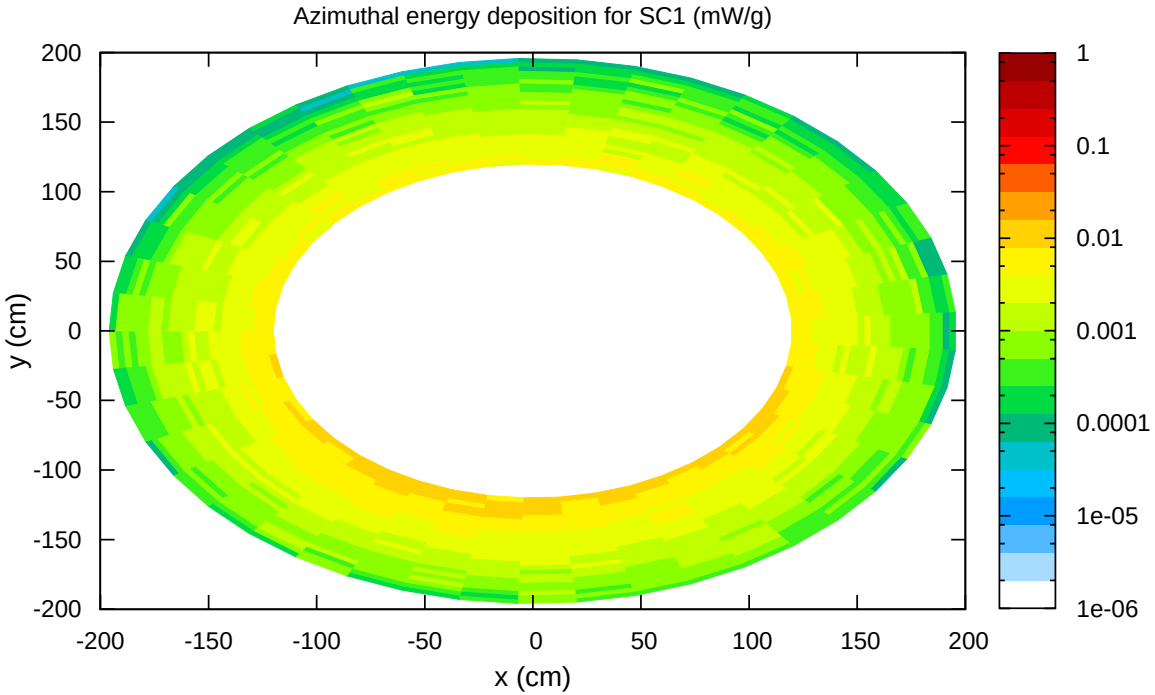
| Region | P (kW) |
|---|---|
| SC coils 1–12 | $0.76 \pm 0.07$ |
| Lower Shielding for SC1–3 ($r < 50\,\mathrm{cm}$) | $1565.5 \pm 8.2$ |
| Upper Shielding for SC1–3 ($r > 50\,\mathrm{cm}$) | $53.6 \pm 0.6$ |
| Shielding for SC4–6 | $35.4 \pm 1.3$ |
| Shielding for SC7–9 | $11.4 \pm 0.7$ |
| Shielding for SC10–12 | $6.2 \pm 0.6$ |
| Beam pipe & steel sh. vessels up to Be window | $757.4 \pm 6.9$ |
| Beam pipe & steel sh. vessels from Be window | $77.8 \pm 1.7$ |
| Hg Pool Container Vessel | $12.4 \pm 0.5$ |
| Hg Jet | $431.8 \pm 2.9$ |
| Hg Pool | $342.8 \pm 7.3$ |
| Be Window | $8.4 \pm 0.1$ |
| Total | $3303.5 \pm 13.5$ |

Total in Hg jet + pool $\approx 775\,\mathrm{kW}$

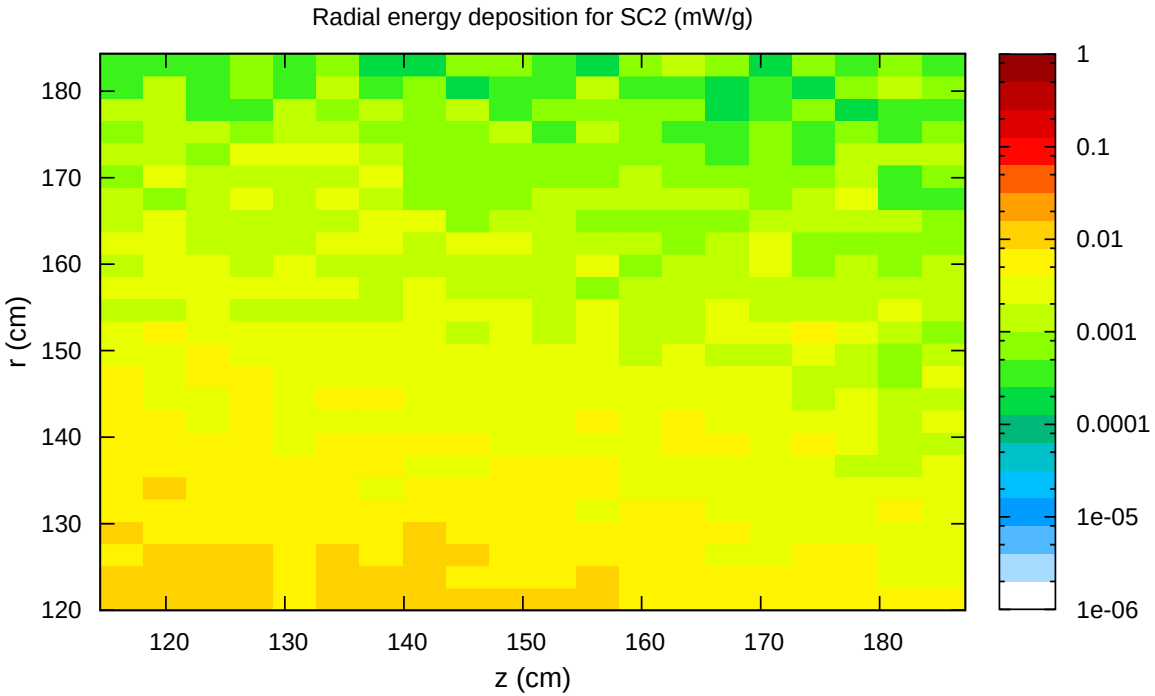



# SC1 power deposition

Radial $P_{\text{peak}} \approx 0.02\,\text{mW/g}$

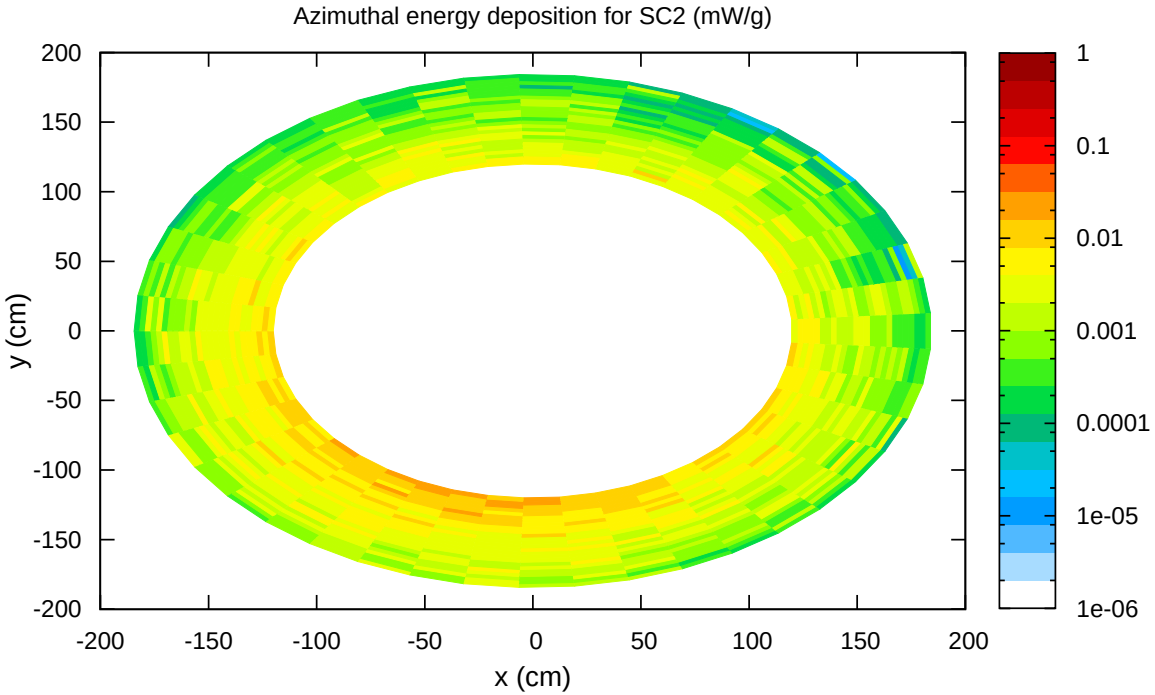



Azimuth $P_{\text{peak}} \approx 0.01\,\text{mW/g}$

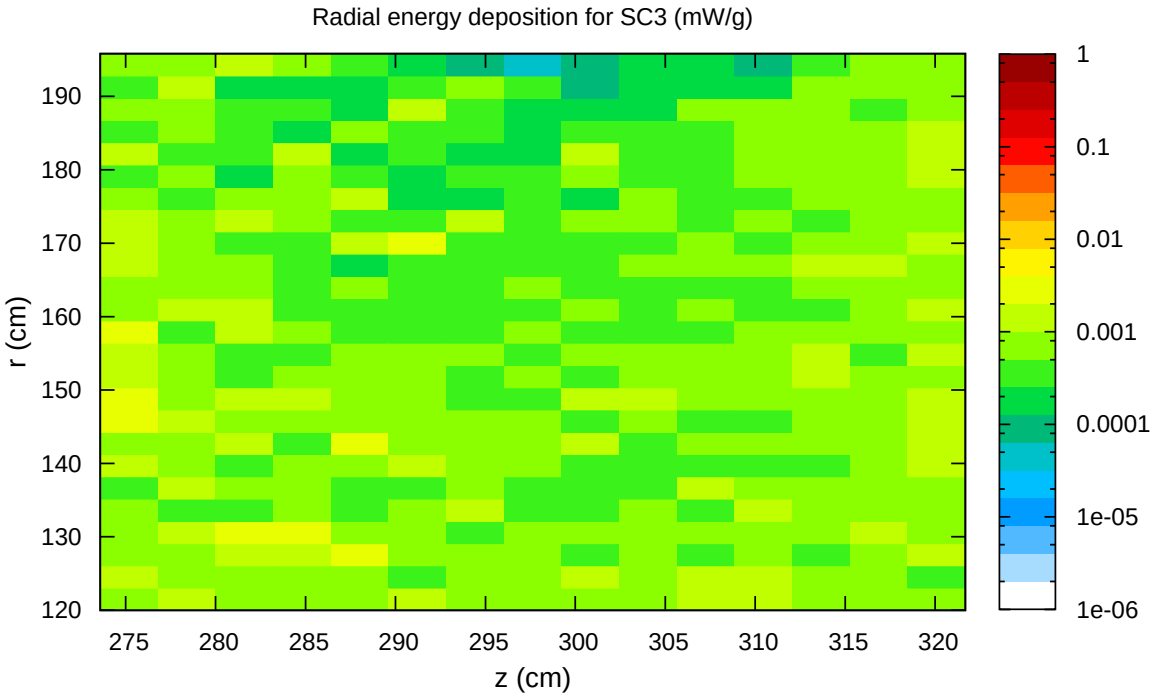



# SC2 power deposition

Radial $P_{\text{peak}} \approx 0.01\,\text{mW/g}$

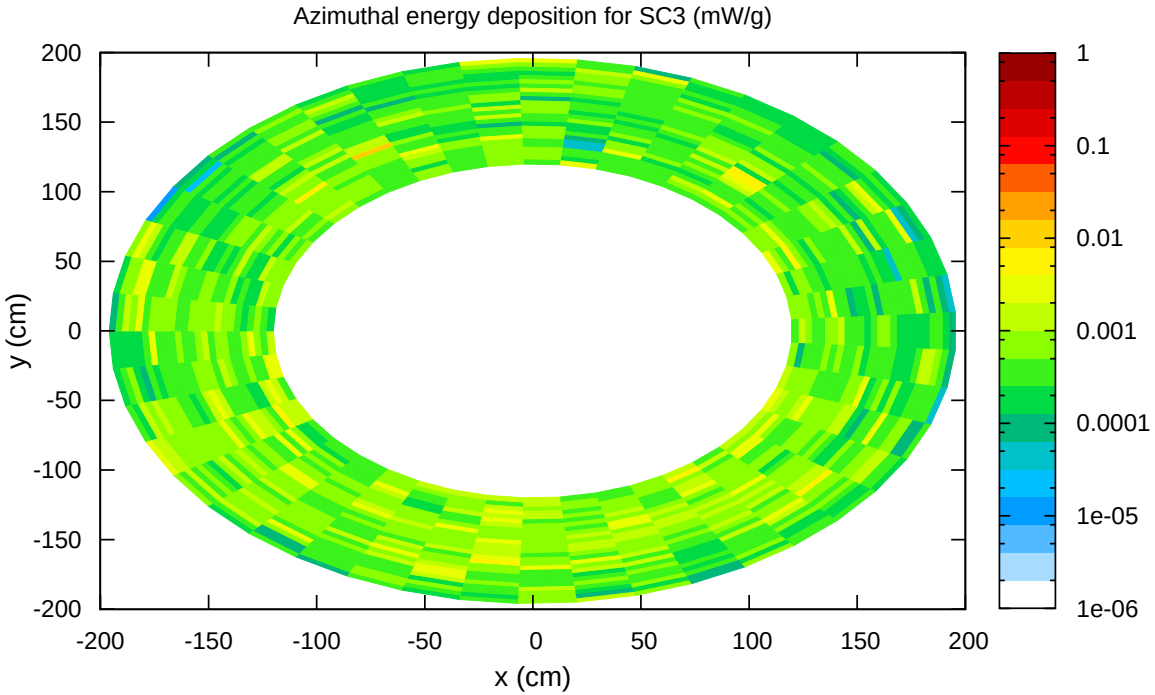



Azimuth $P_{\text{peak}} \approx 0.03\,\text{mW/g}$

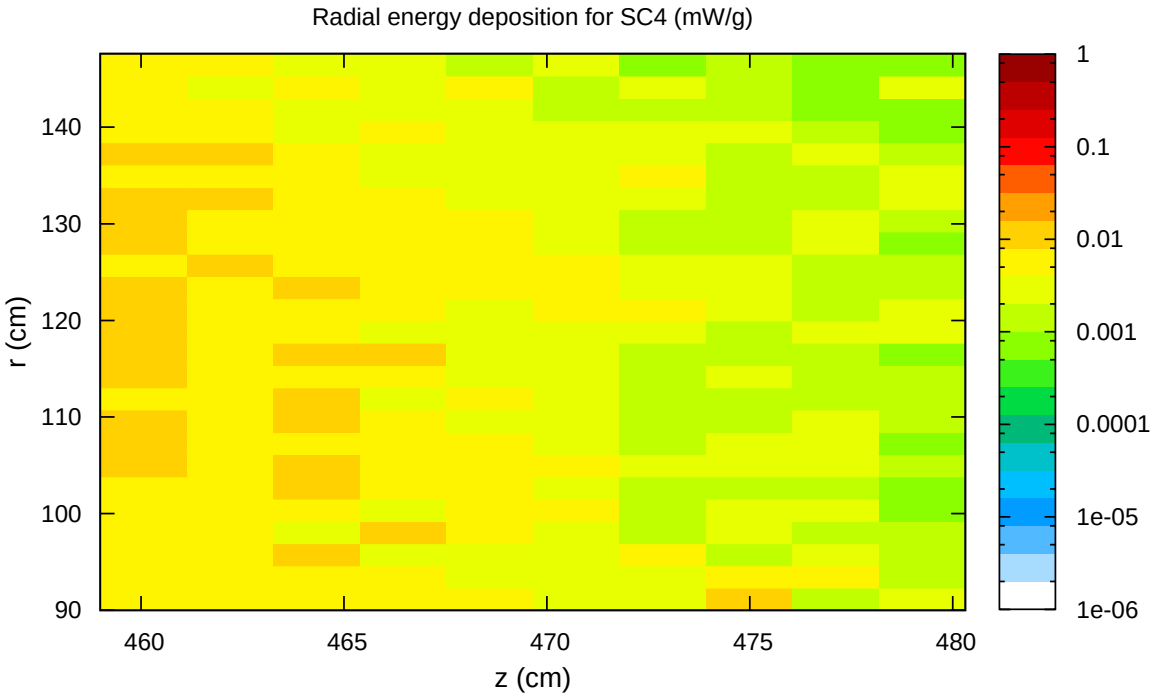



# SC3 power deposition

Radial $P_{\text{peak}} \approx 0.01\,\text{mW/g}$

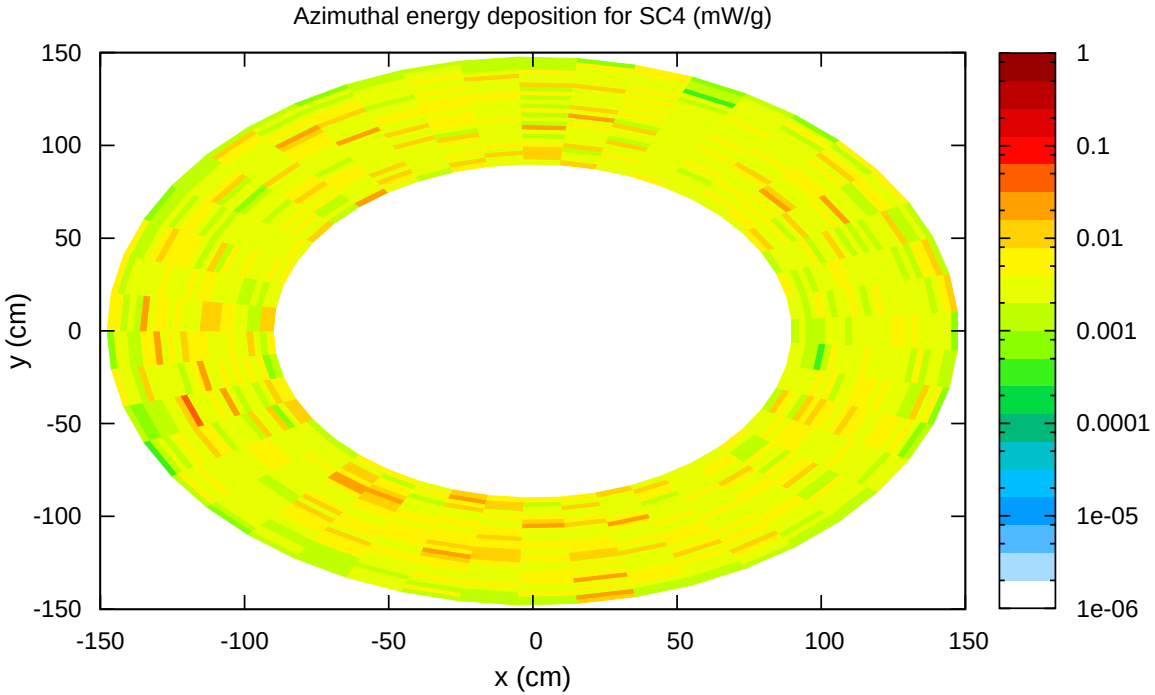



Azimuth $P_{\text{peak}} \approx 0.01\,\text{mW/g}$

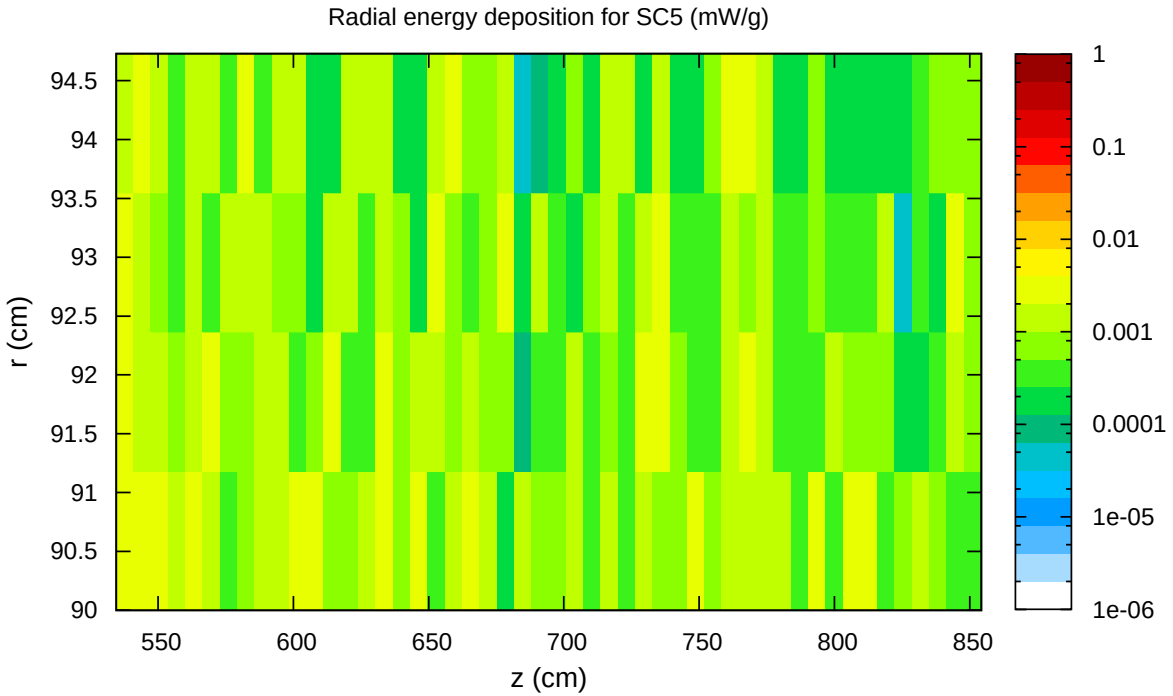



# SC4 power deposition

Radial $P_{\text{peak}} \approx 0.01\,\text{mW/g}$

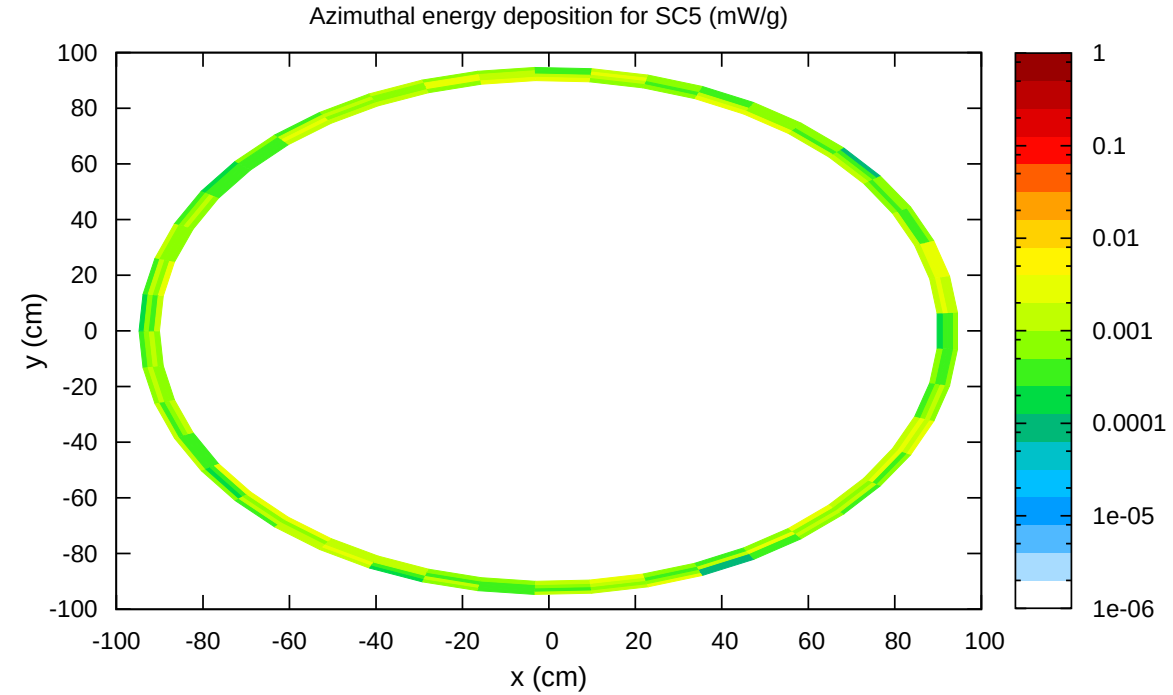



Azimuth $P_{\text{peak}} \approx 0.04\,\text{mW/g}$

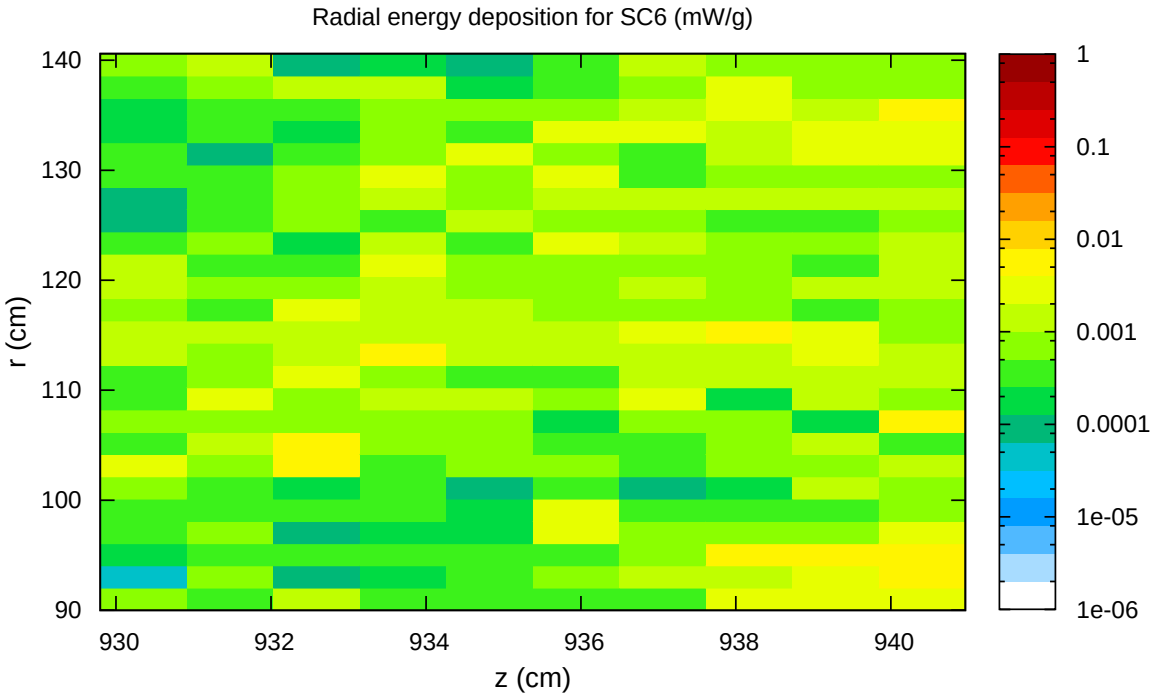



# SC5 power deposition

Radial $P_{\text{peak}} < 0.01\,\text{mW/g}$

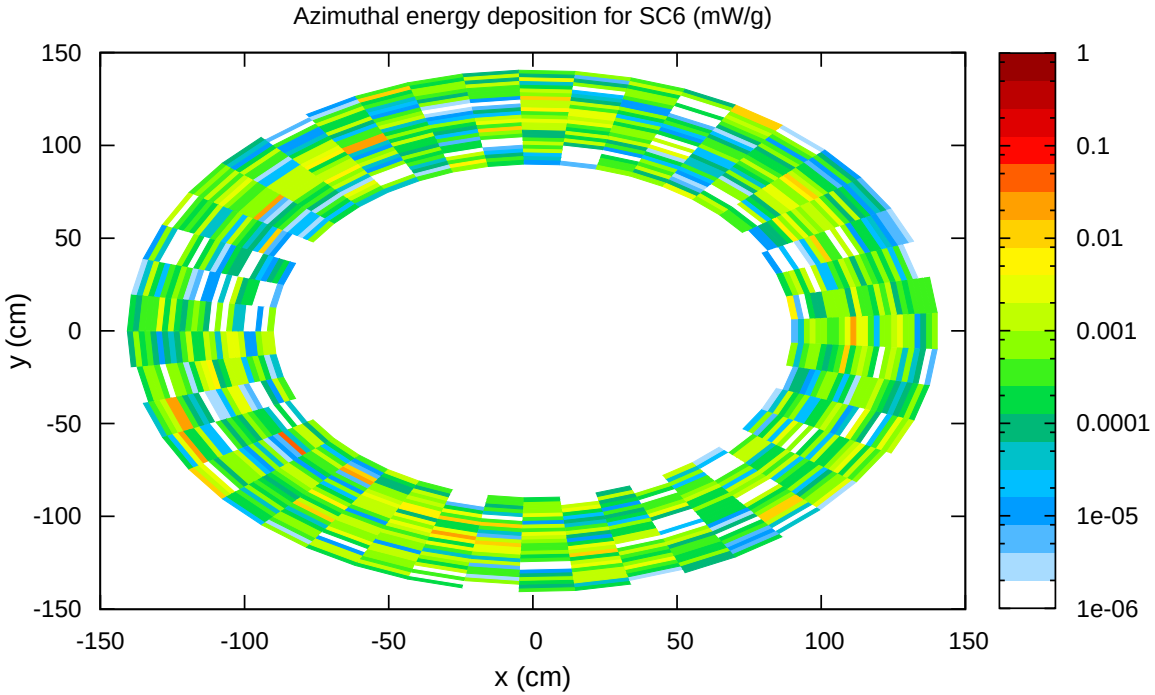



Azimuth $P_{\text{peak}} < 0.01\,\text{mW/g}$

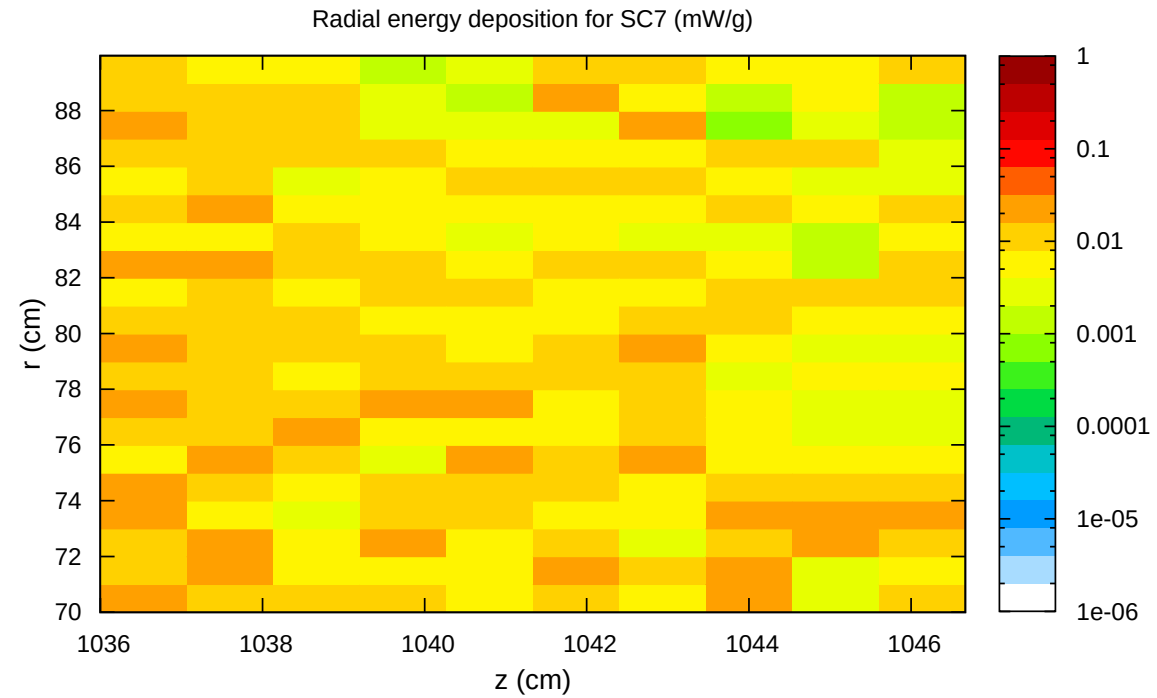



# SC6 power deposition

Radial $P_{\text{peak}} \approx 0.01\,\text{mW/g}$

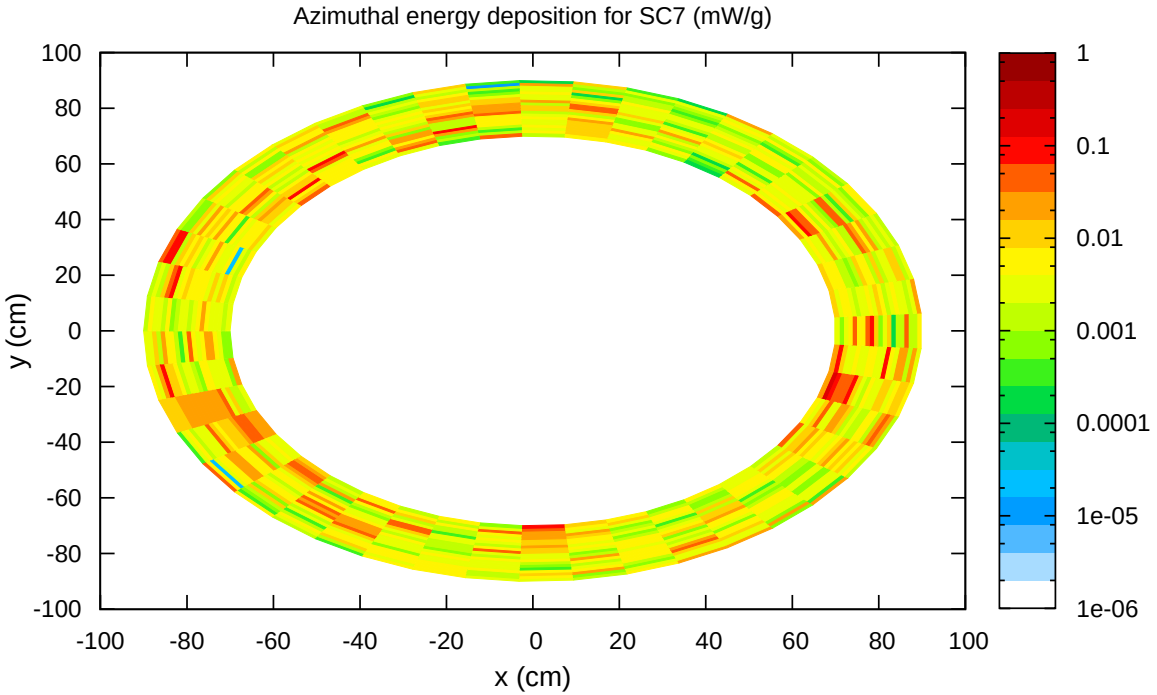



Azimuth $P_{\text{peak}} \approx 0.04\,\text{mW/g}$

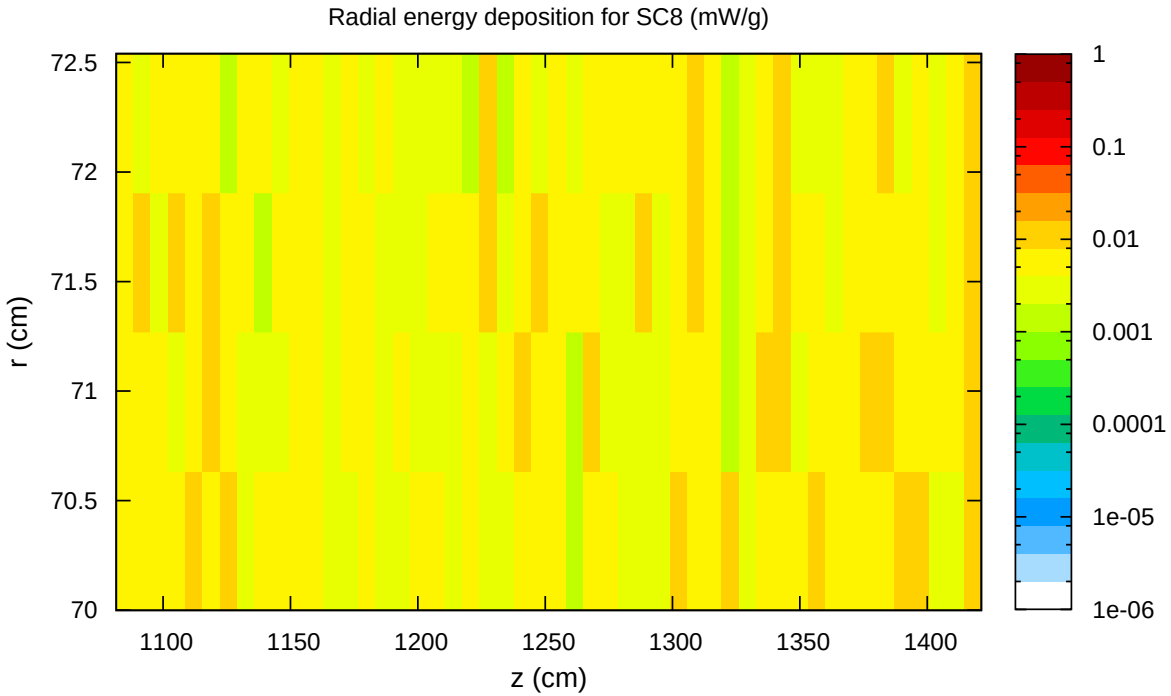



# SC7 power deposition

Radial $P_{\text{peak}} \approx 0.03\,\text{mW/g}$

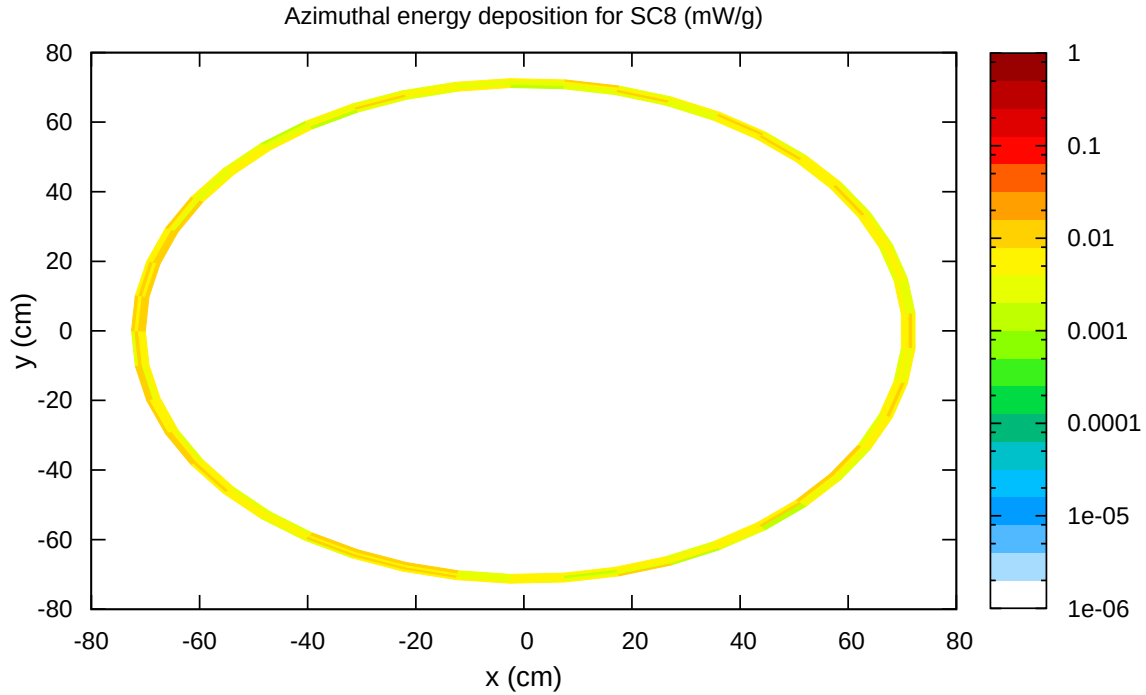



Azimuth $P_{\text{peak}} \approx 0.15\,\text{mW/g}$

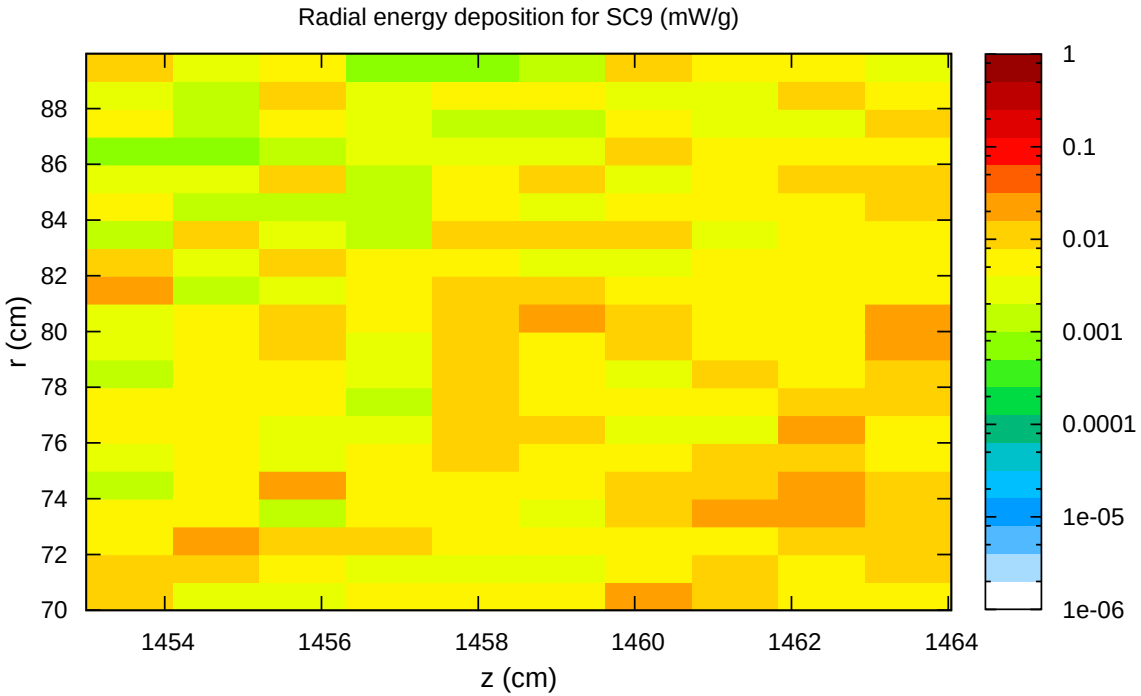



# SC8 power deposition

Radial $P_{\text{peak}} \approx 0.02\,\text{mW/g}$

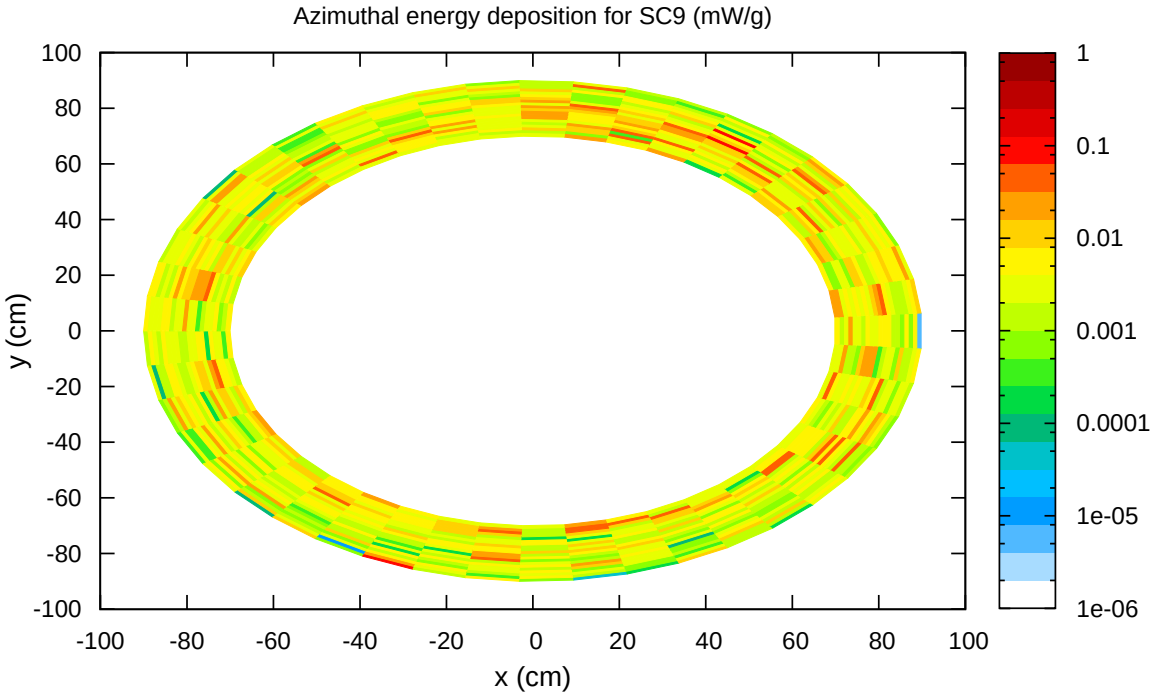



Azimuth $P_{\text{peak}} \approx 0.02\,\text{mW/g}$

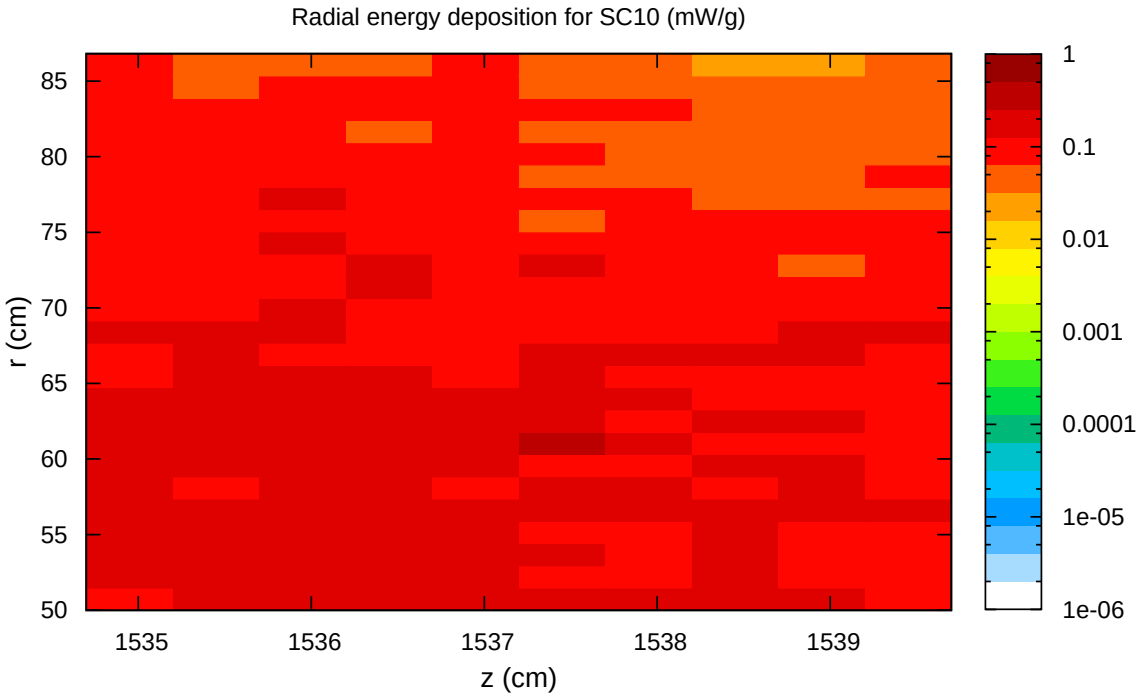



# SC9 power deposition

Radial $P_{\text{peak}} \approx 0.03\,\text{mW/g}$

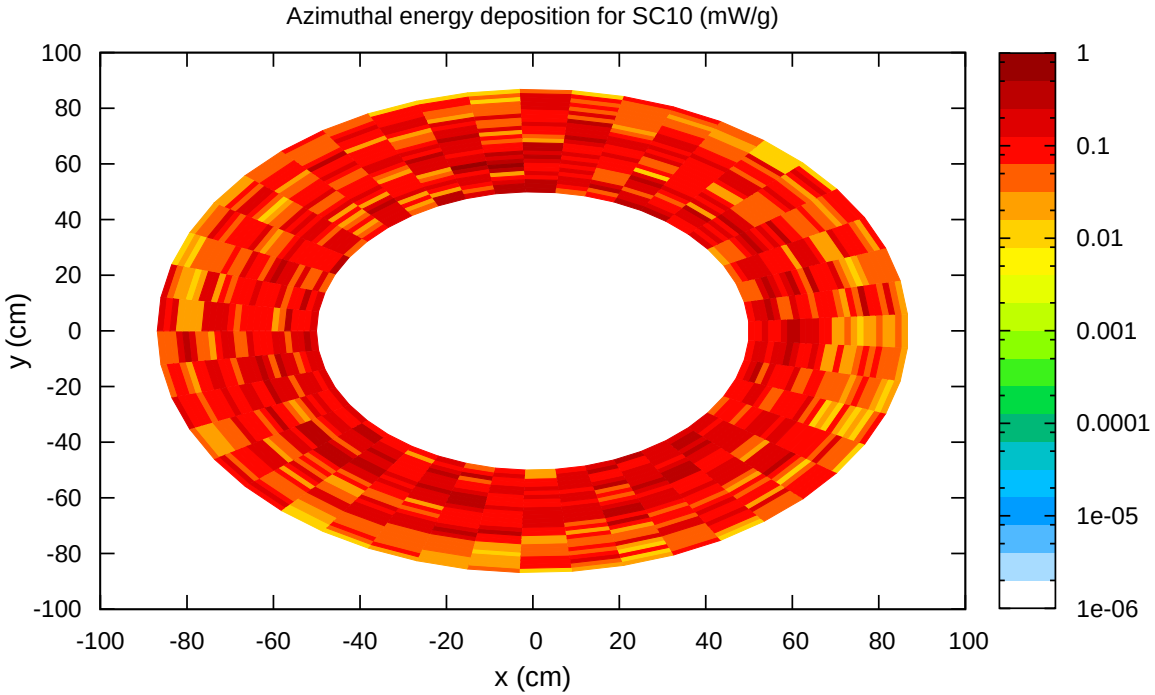



Azimuth $P_{\text{peak}} \approx 0.09\,\text{mW/g}$

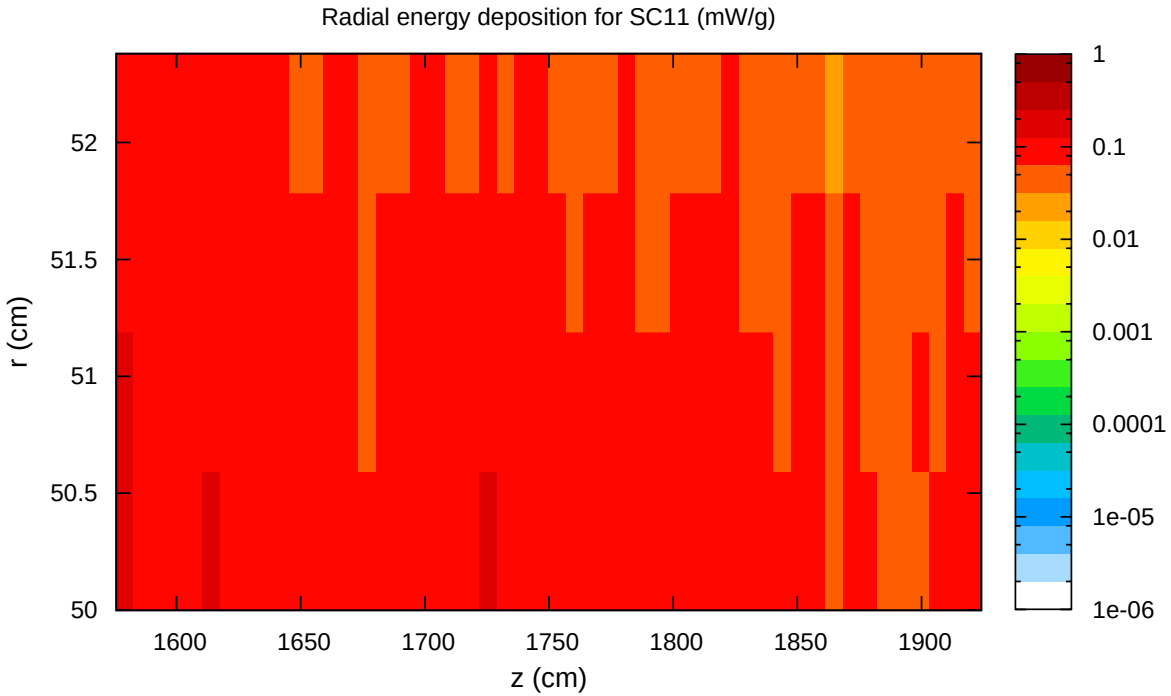



# SC10 power deposition

Radial $P_{\text{peak}} \approx 0.26\,\text{mW/g}$

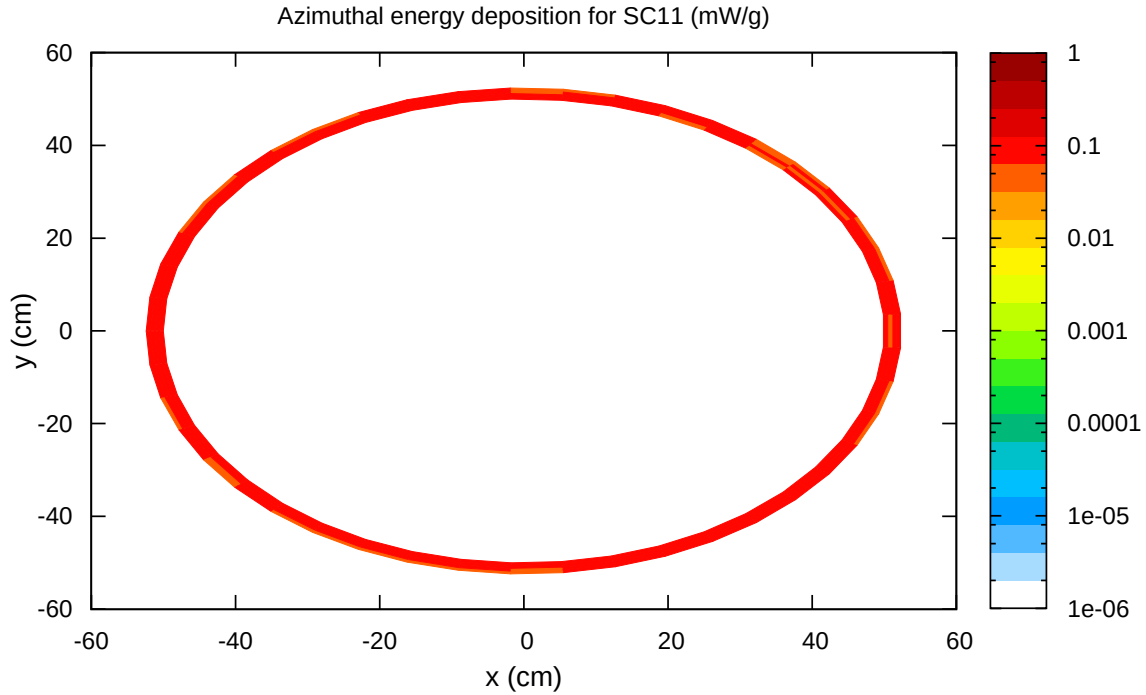



Azimuth $P_{\text{peak}} \approx 0.62\,\text{mW/g}$

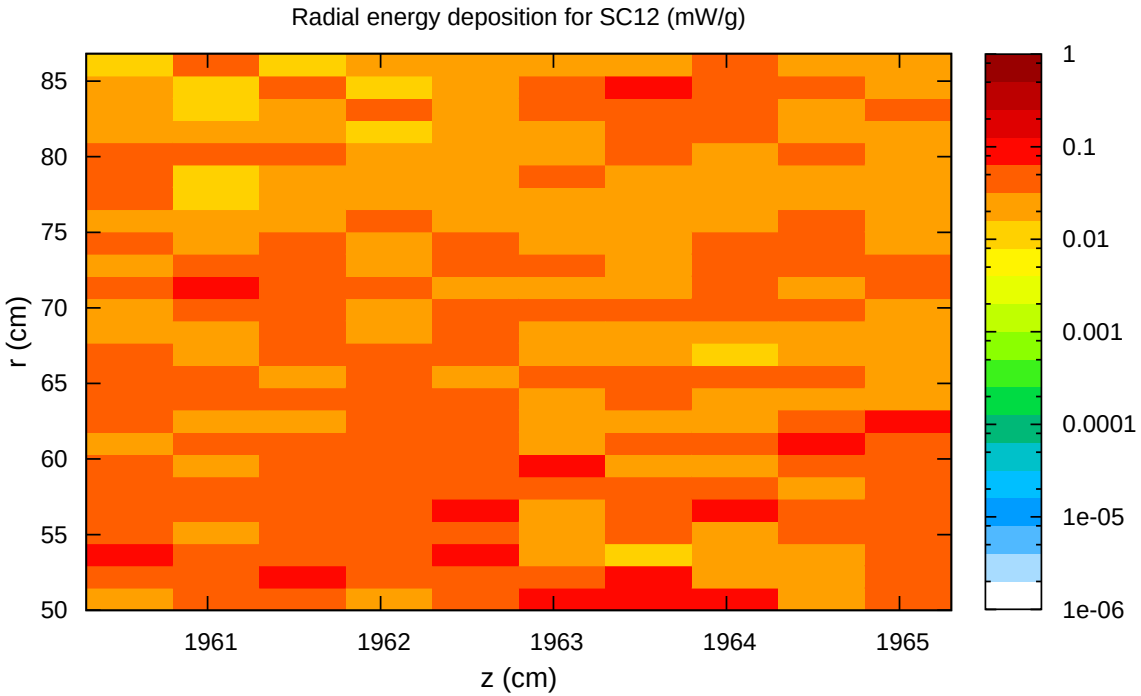



# SC11 power deposition

Radial $P_{\text{peak}} \approx 0.14\,\text{mW/g}$

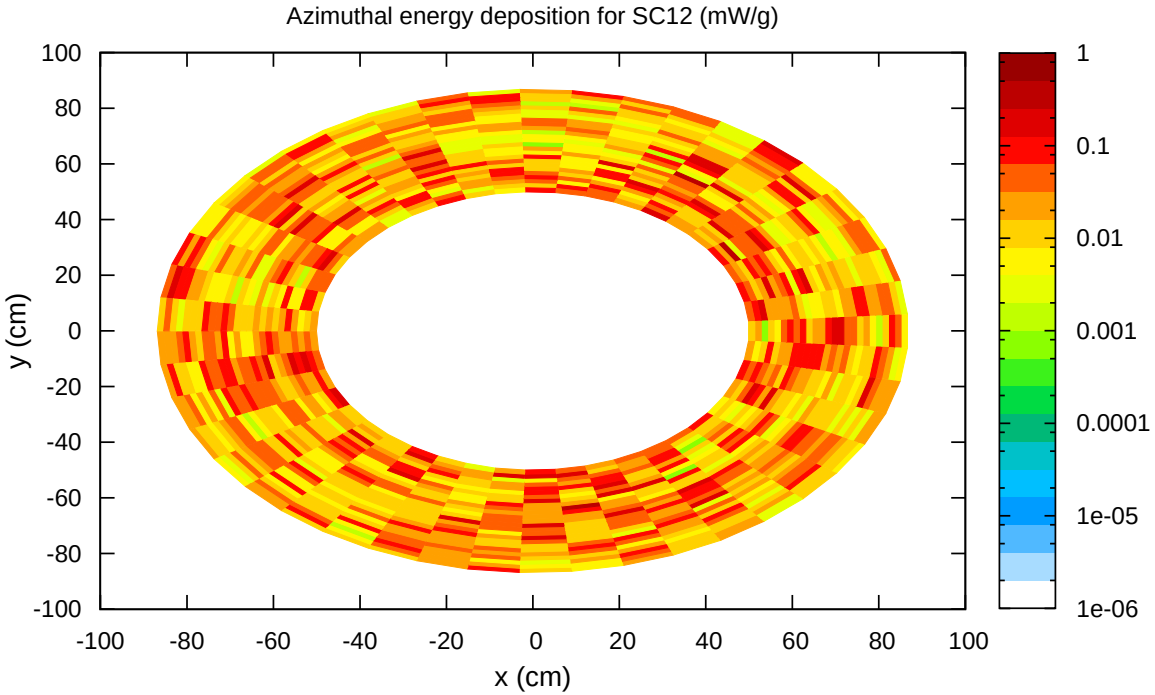



Azimuth $P_{\text{peak}} \approx 0.11\,\text{mW/g}$




# SC12 power deposition

Radial $P_{\text{peak}} \approx 0.10\,\text{mW/g}$




Azimuth $P_{\text{peak}} \approx 0.31\,\text{mW/g}$

# Summary

- Shown Fluka energy deposition results for IDS120j geometry
  - Correction to proton trajectory: beam centre enters Hg pool
- Total power deposition in SC coils below 1 kW
- Most coils have peak energy density below 0.1 mW/g, except for:
  - SC7 has maximum azimuthal peak energy density $\approx 0.15$ mW/g
  - SC10,11,12 have very large peak energy densities, well above ITER limit
- SC4 is OK now, with correction to proton trajectory
- We need more shielding for downstream coils: 7 and 10-12.