EURISOL DS PROJECT

MULTI-MW FISSION TARGET ISSUES

(Beam Window & Transverse Film Target)

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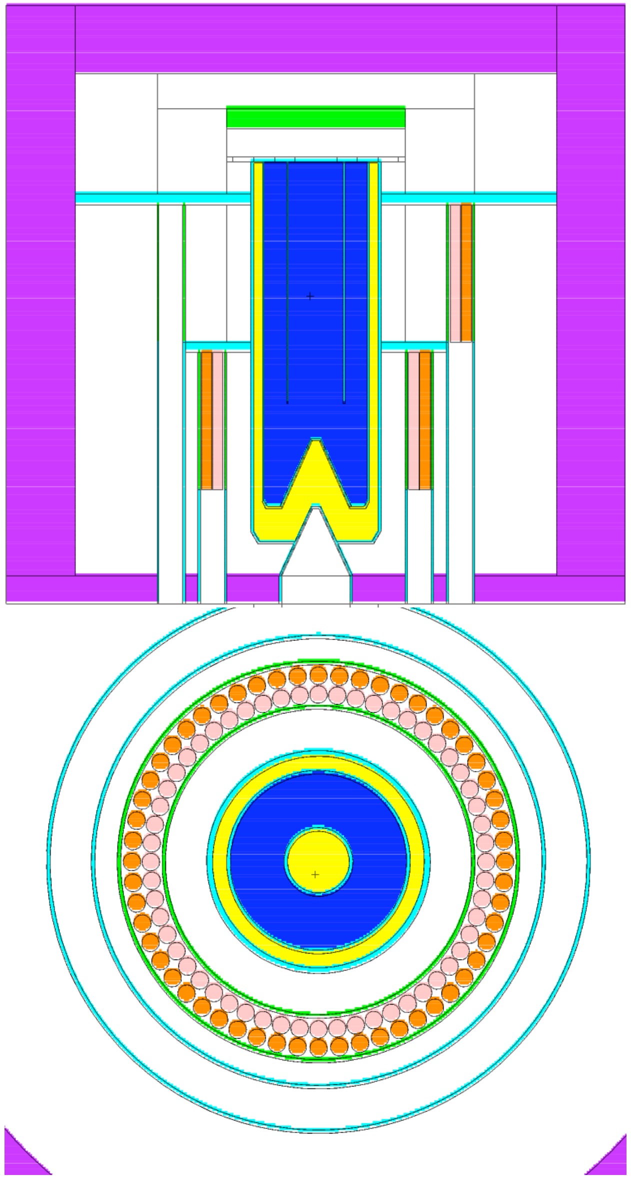
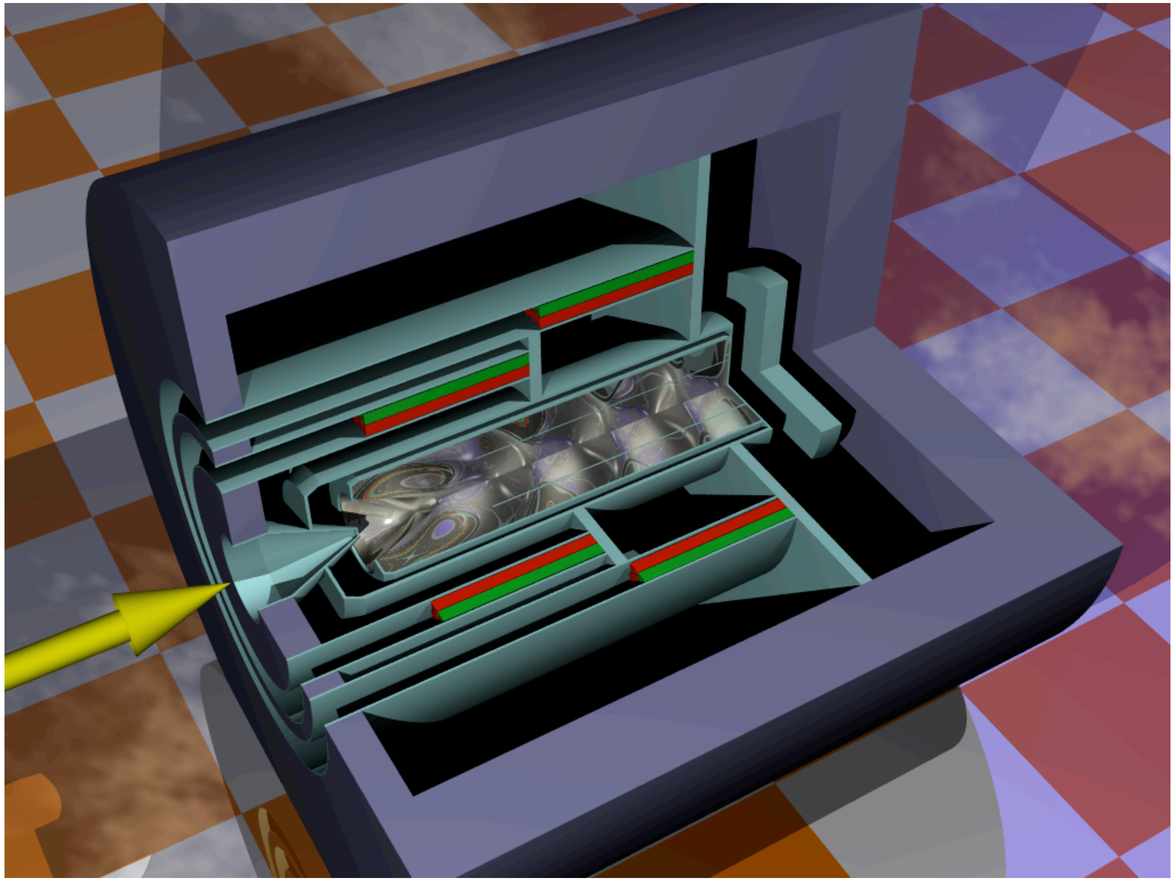
Overview

1. Larger Proton Beam
   - Beam Window Issues
   - Larger Proton Beam - Sigma = 25 mm
2. Transverse Film Windowless Target
   - Neutronic Parameters
   - Energy Densities
   - Fission Yields
3. Conclusions

Precise Model Geometry

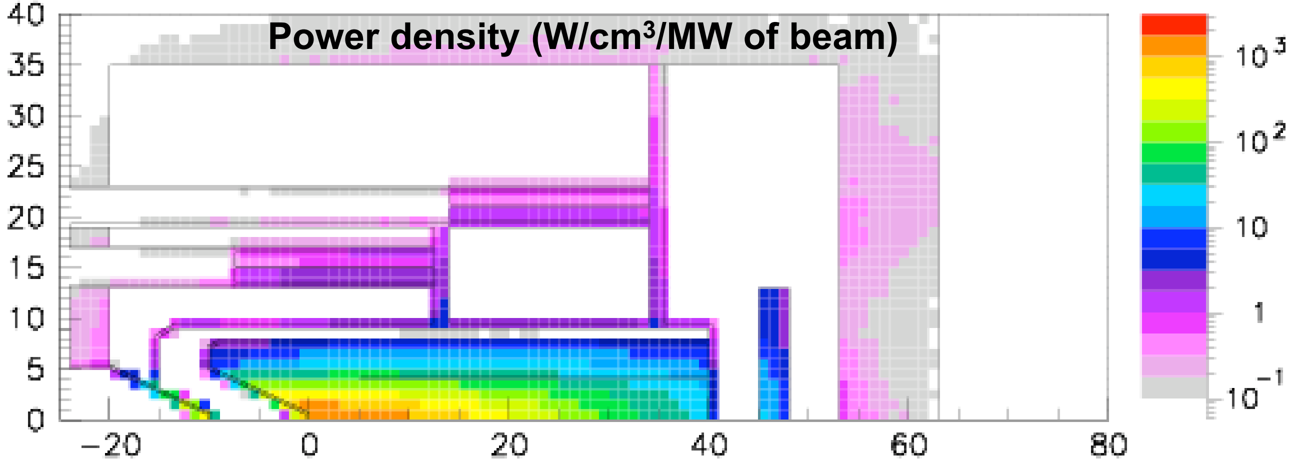


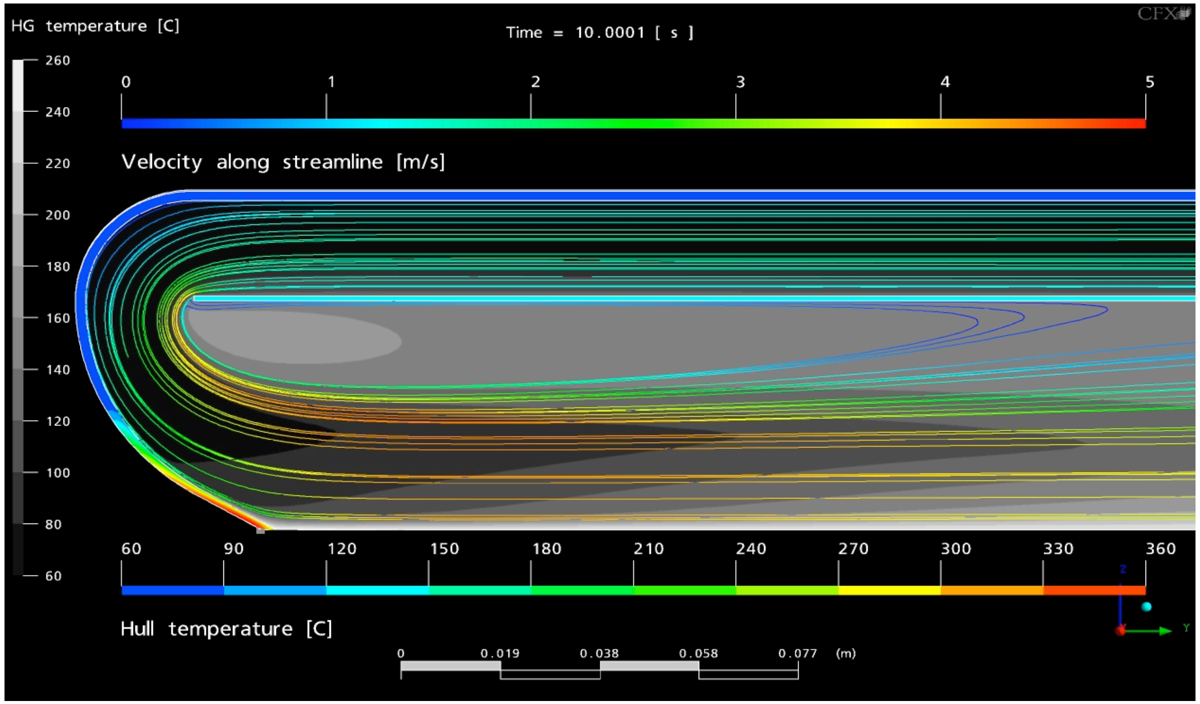


- Reasonable charged particle confinement and power densities.
- High neutron fluxes, confined within the assembly.
- Large fission rate densities.
- Proven design (SNS and ESS), technically “simple” concept.

Energy Deposition in the Target

EURISOL Design Study



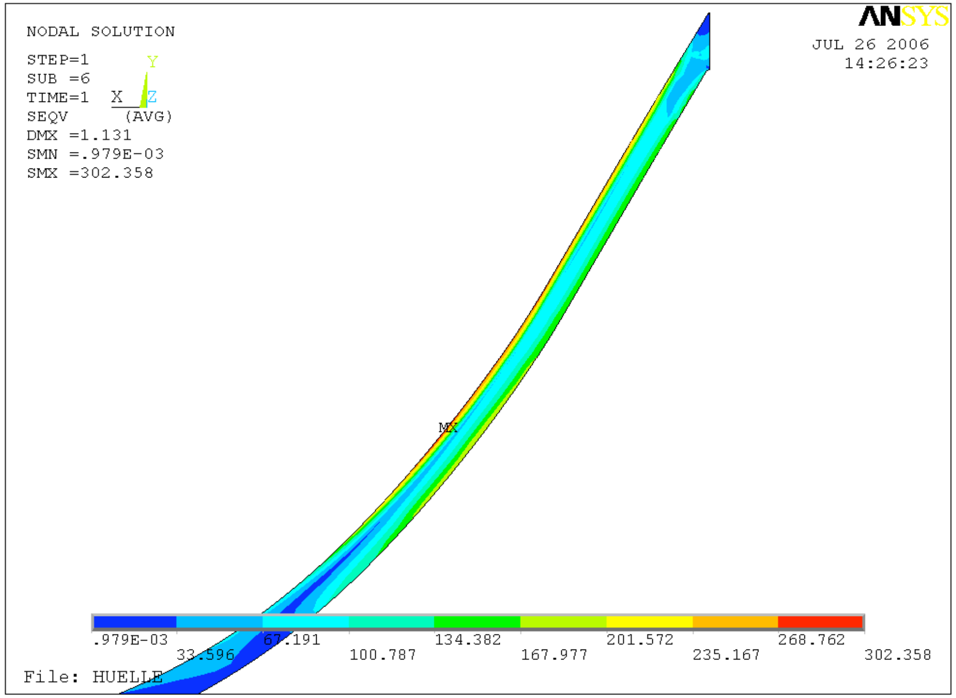


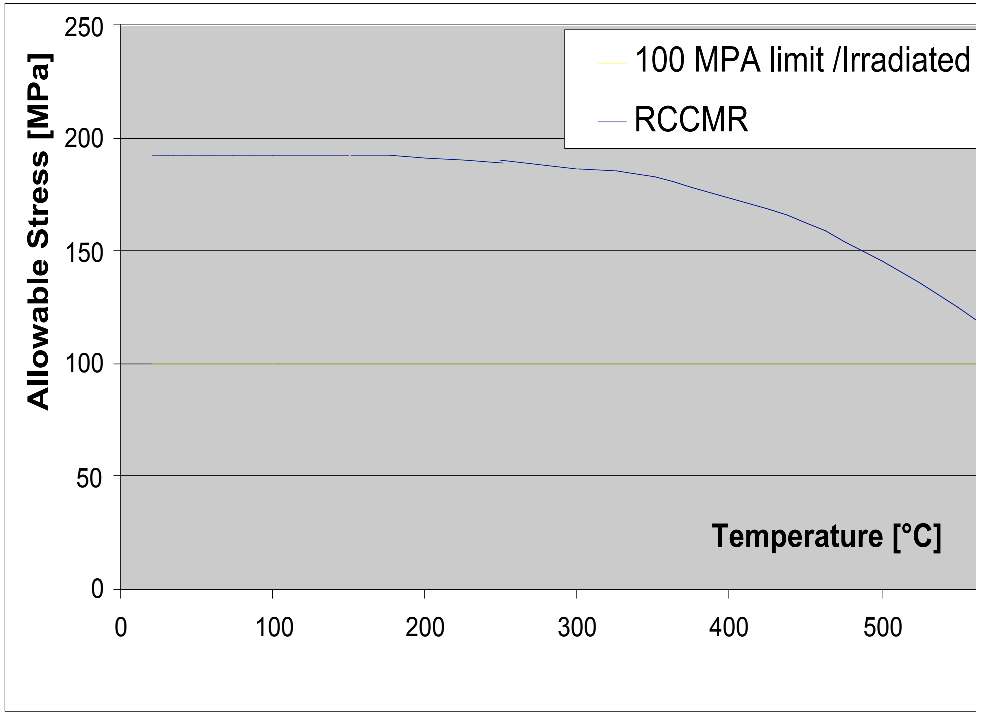
- Acceptable power densities in the Hg. Flow pattern not optimised; maximum temperature ~260 °C.

- Acceptable maximum temperature in the beam window (~350 °C).

- Large temperature gradient in the window, inducing mechanical stresses above the acceptance limits.

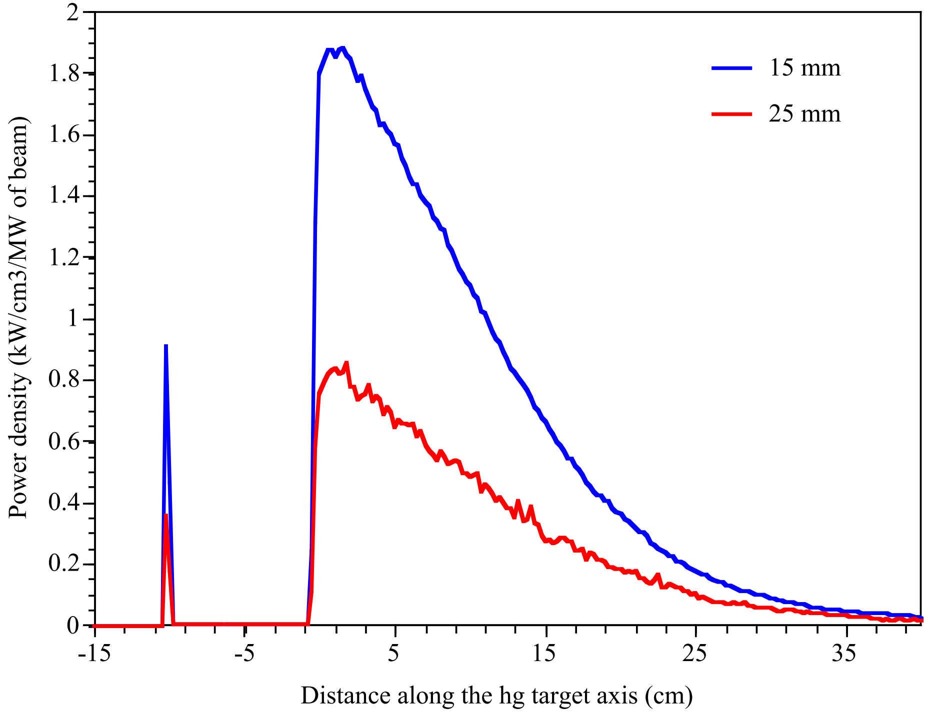
Results for outer annular inflow - Hg -Von Mises stress

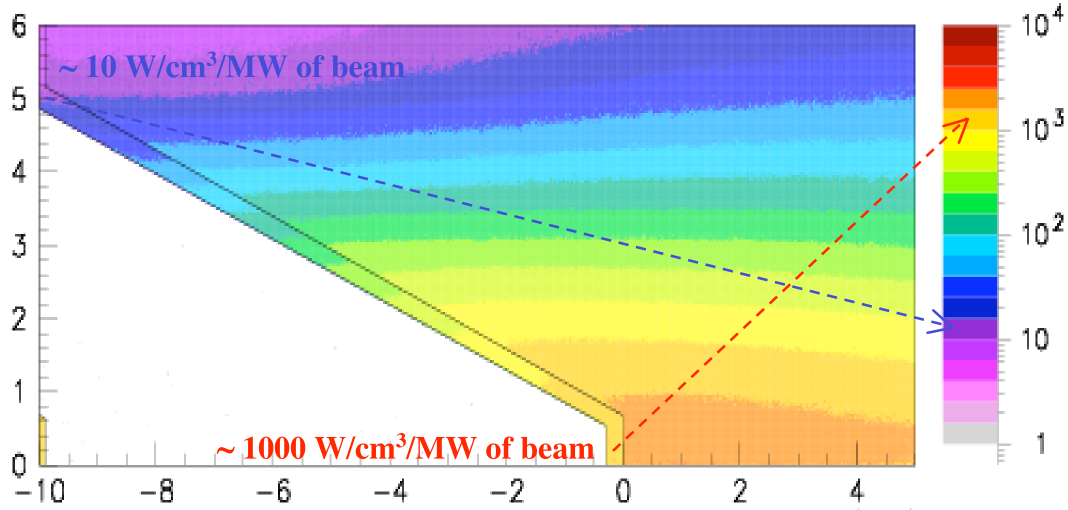


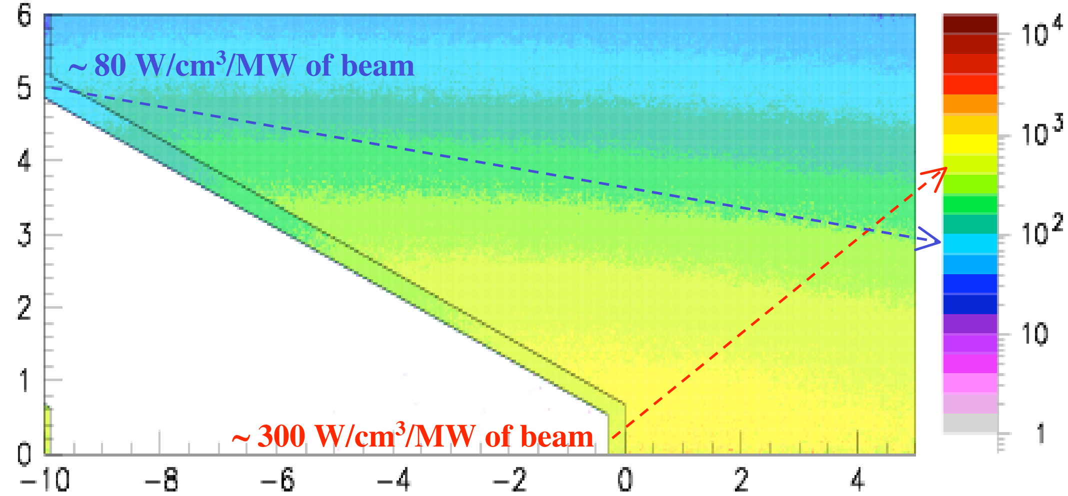


Resulting Von Misses stress in the beam window **~ 300 MPa**, considerably higher than the maximum allowable stress for irradiated steels (100 MPa). This is due to the greater thru-thickness temperature gradients along the beam window. Possibility of cracking due to tensile stress.

Energy Deposition in the Window



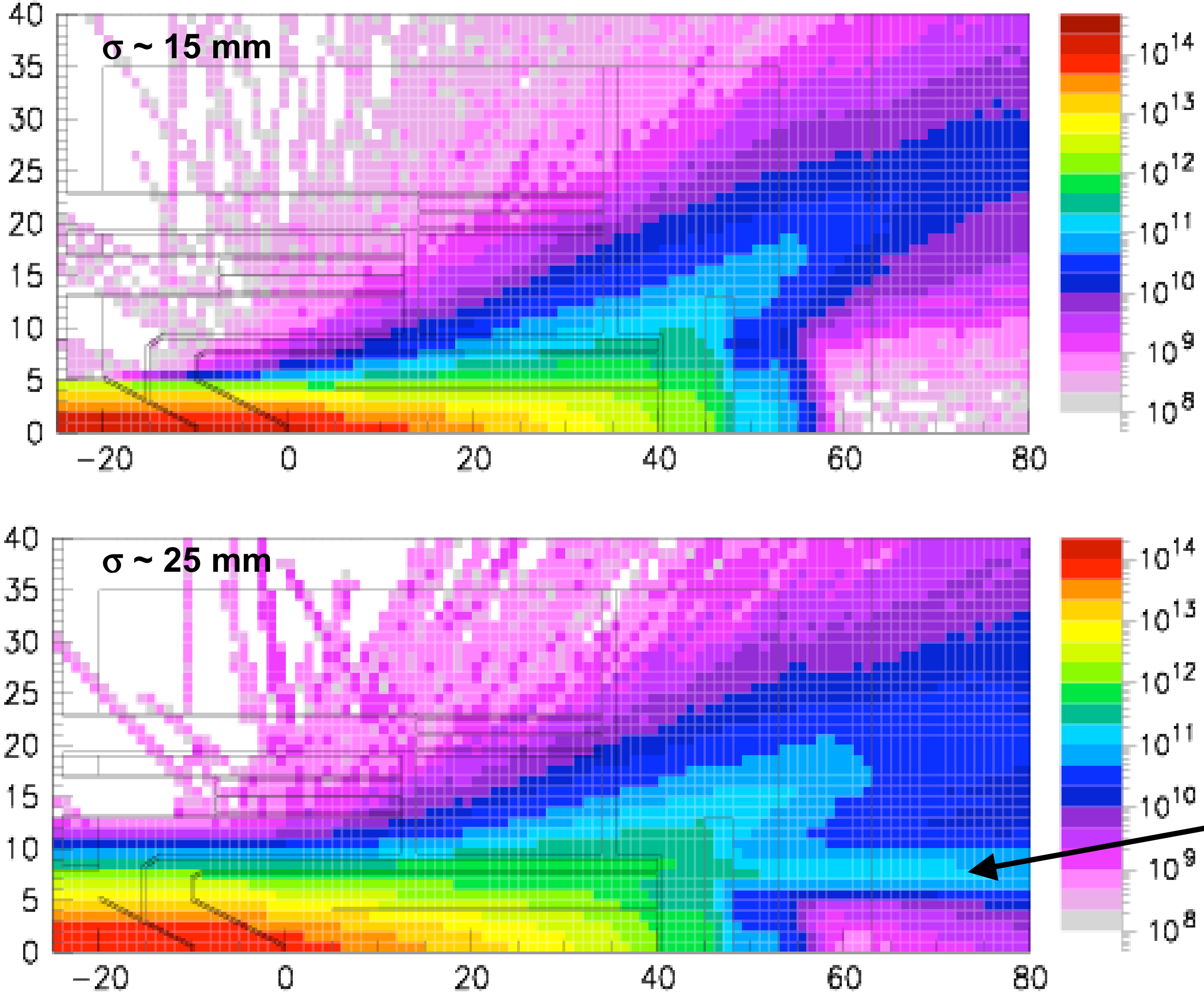




- Max. power density: 1.8 vs 0.8 (kW/cm^3/MW of beam).
- Beam window: 0.9 vs 0.3 (kW/cm^3/MW of beam).
- Significant differences in power density gradients in the beam window.

Impact in Neutronics of a larger Sigma

Primary flux (Primaries/cm^2/s/MW of beam)

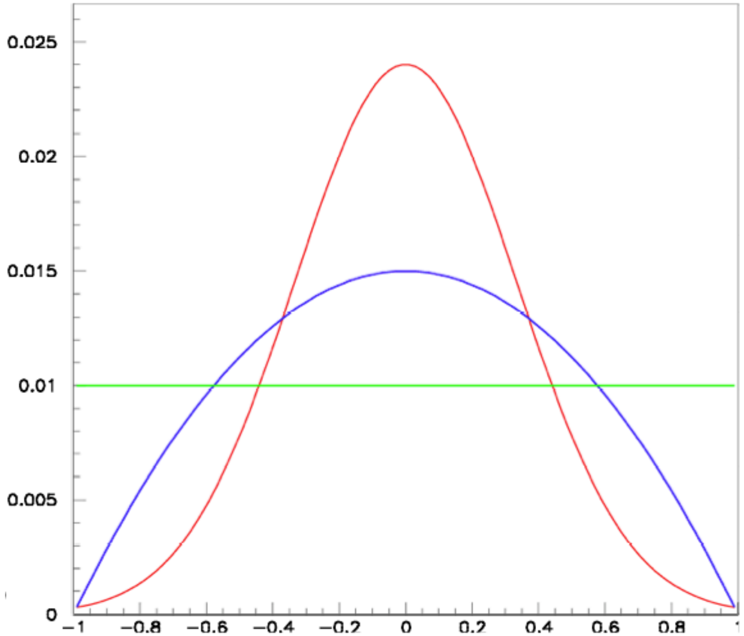


- Small primary contamination in the fission targets.
- Similar neutron fluxes.
- Some primary escapes at starting at ~20 cm from the impact point, from protons scattered at low angles.
- For σ = 25 mm, primary proton streaming in the forward direction, along the Hg target surface.

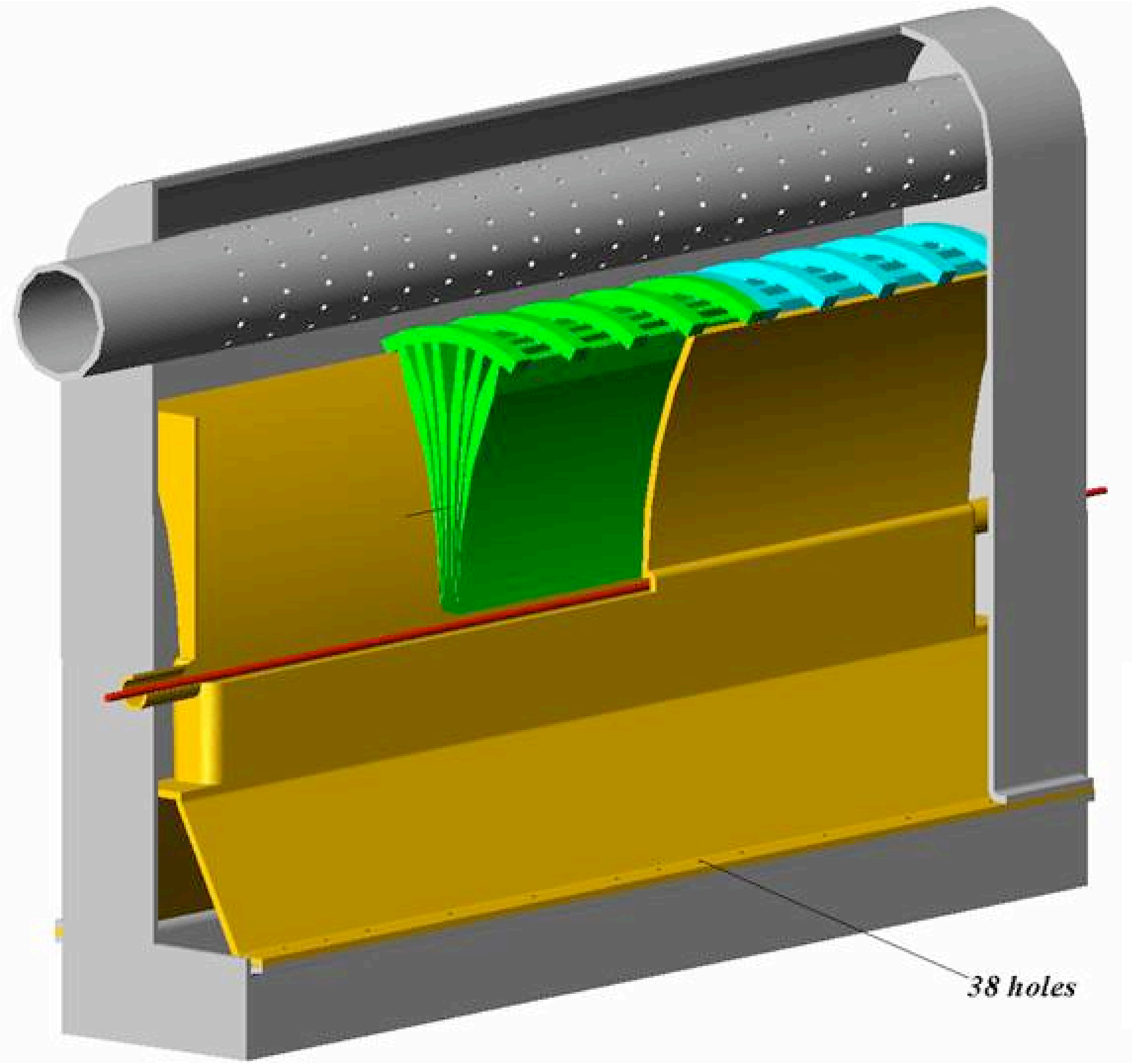
Conclusion

- For a 15 mm Gaussian beam, power densities and temperature increase in the Hg flow stay below limits. Temperature gradients in the beam window produce unacceptable mechanical stresses, increasing the risk of breaking the window.

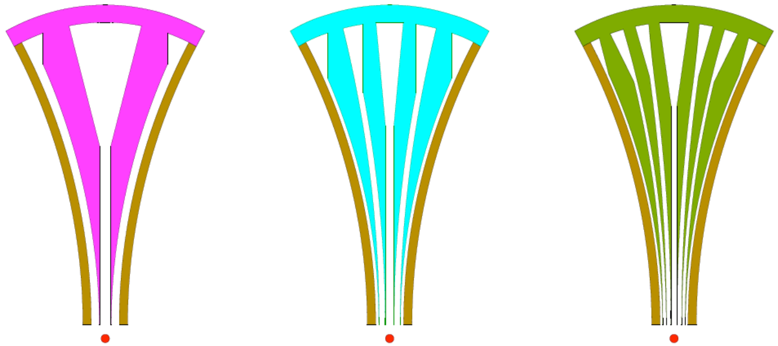
- A larger beam distribution, i.e. 25 mm, reduces the **power gradients** in the window but results in **high-energy proton escapes** in the forward direction. Need to optimise the geometry, work on the beam shape and provide a collimation system, to avoid proton streaming. A beam dump could also be foreseen.



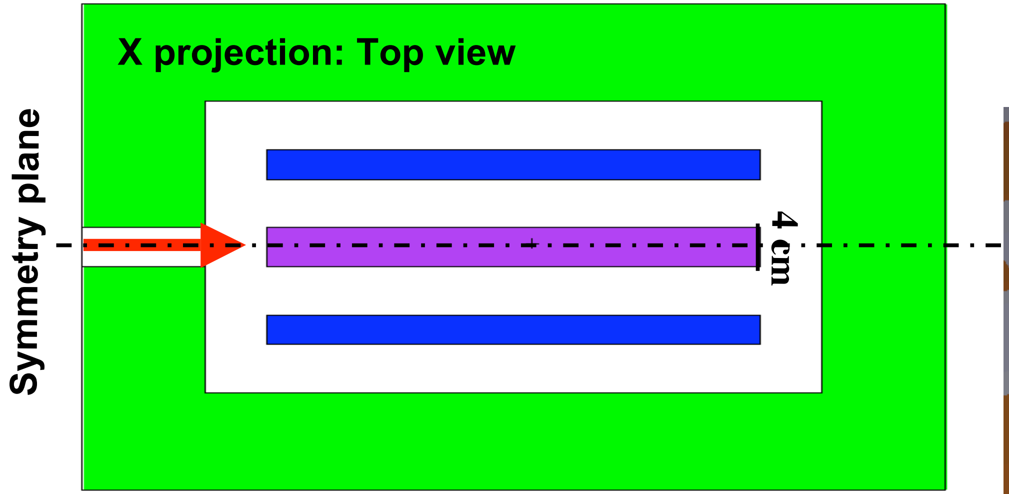
Transverse Hg Film Target

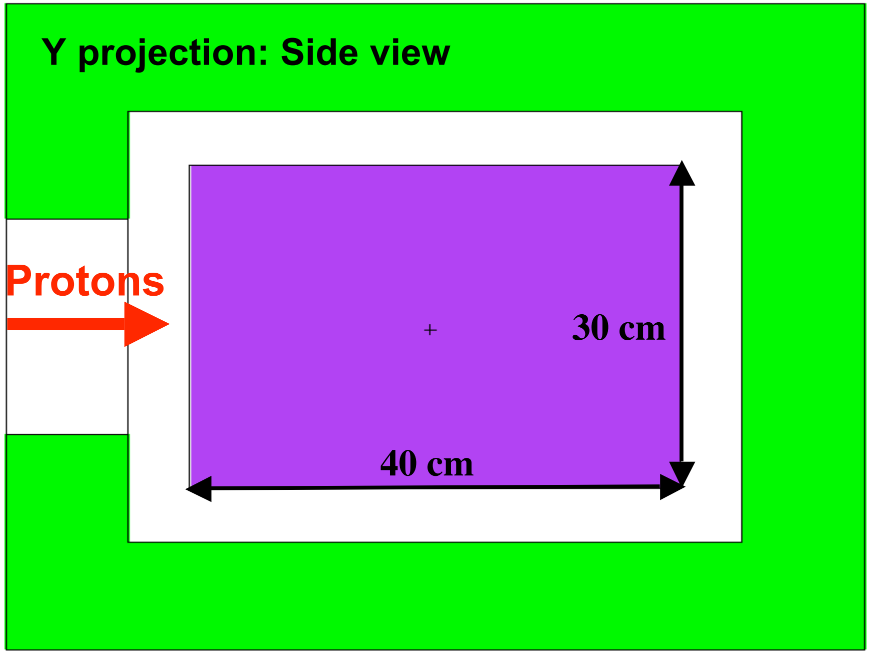


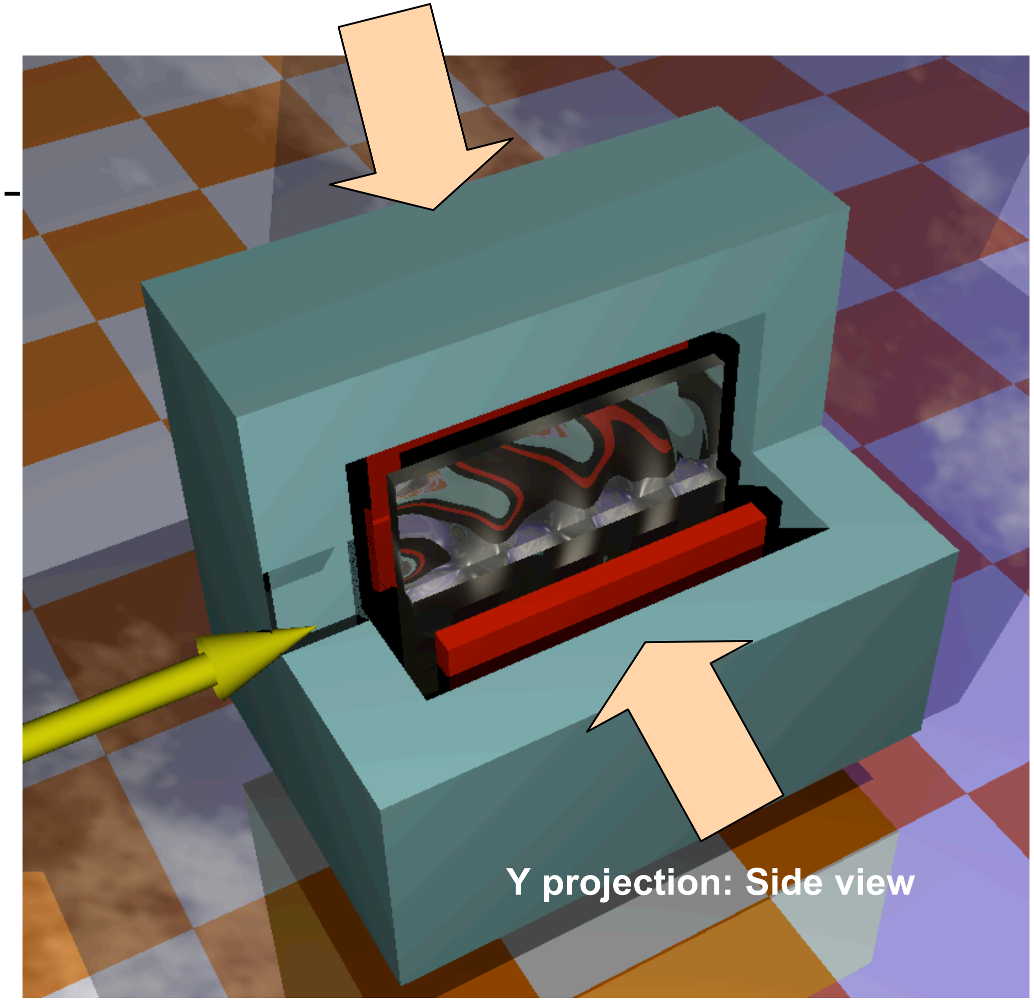
- Allows for different velocities in the Hg flow by changing the distance between of the flow-guides, according to the local heat deposition.
- Total Hg flow rate ~12 l/s. Local velocity for a 3 mm gap ~4.4 m/s -> 118 K temperature increase for a beam σ ~2 mm.



Simplified Transverse Target Model



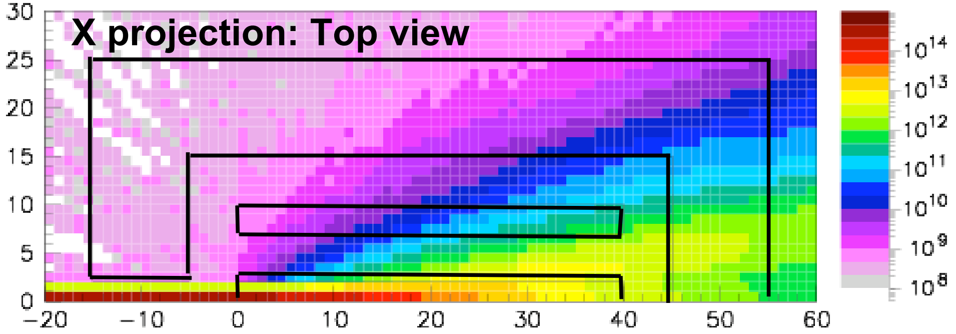


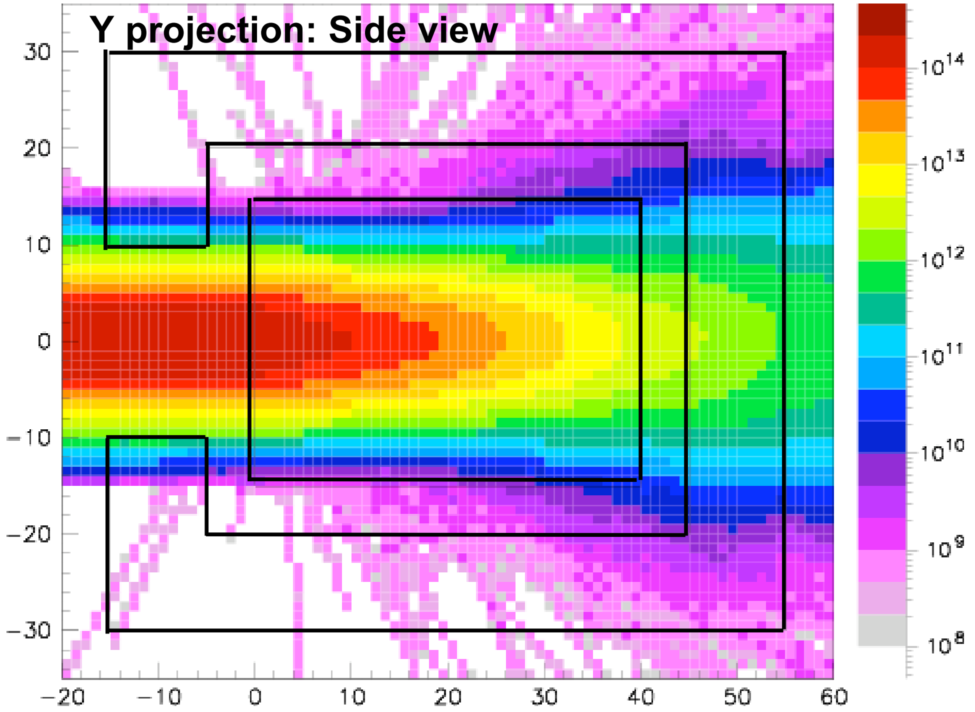


- **Beam distribution: σ_x~4 mm, σ_y~30 mm**

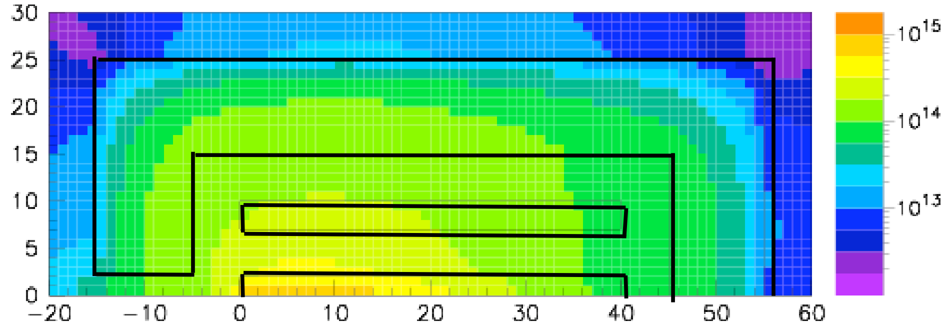
Primary and Neutron Distribution

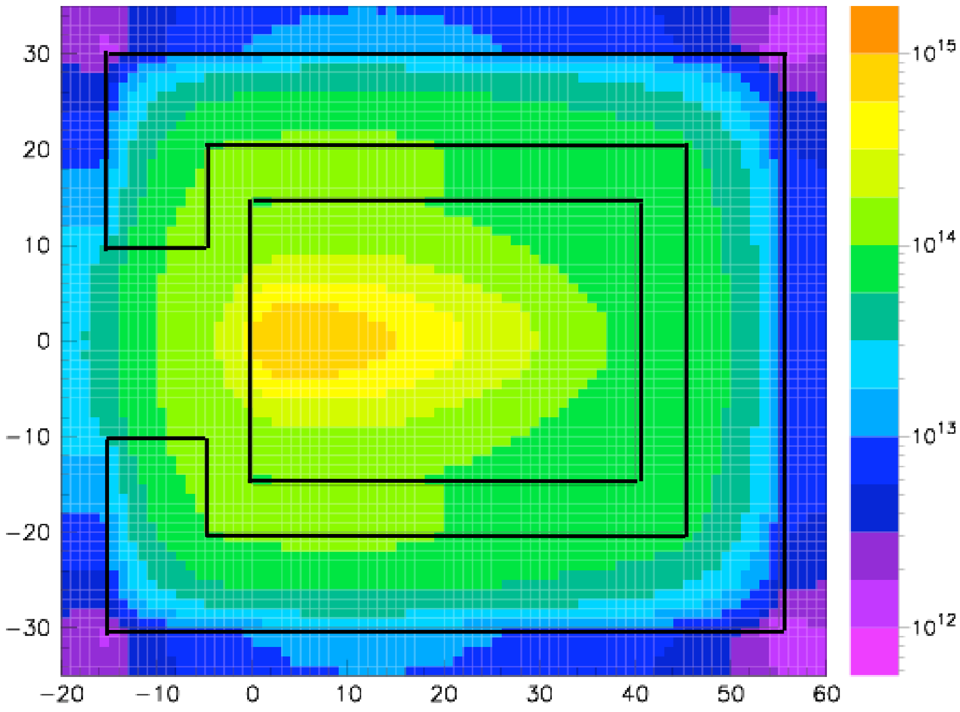
Primary flux (Primaries/cm^2/s/MW of beam)





Neutron flux (Neutrons/cm^2/s/MW of beam)





Neutron Balance, Fission and Power Densities

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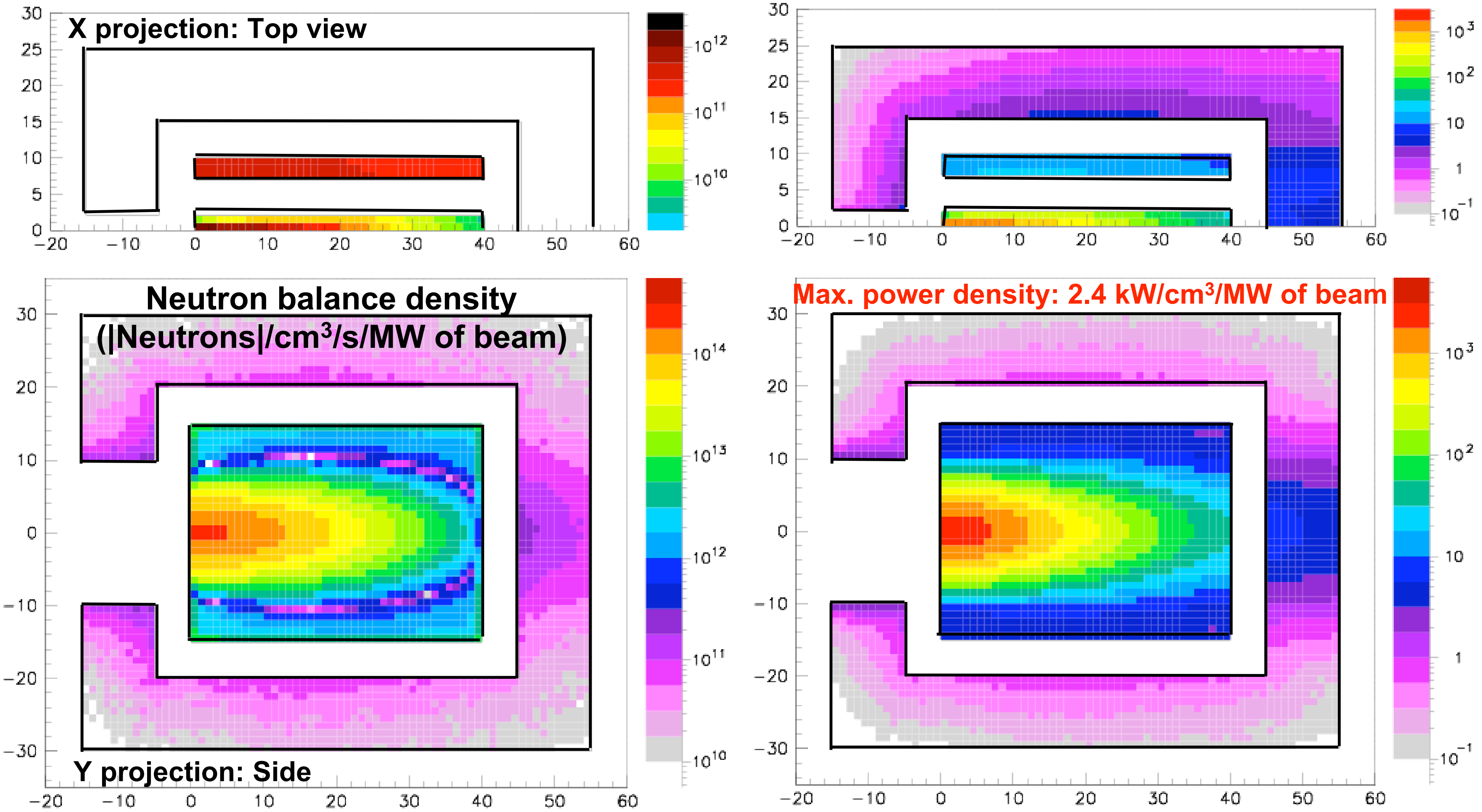
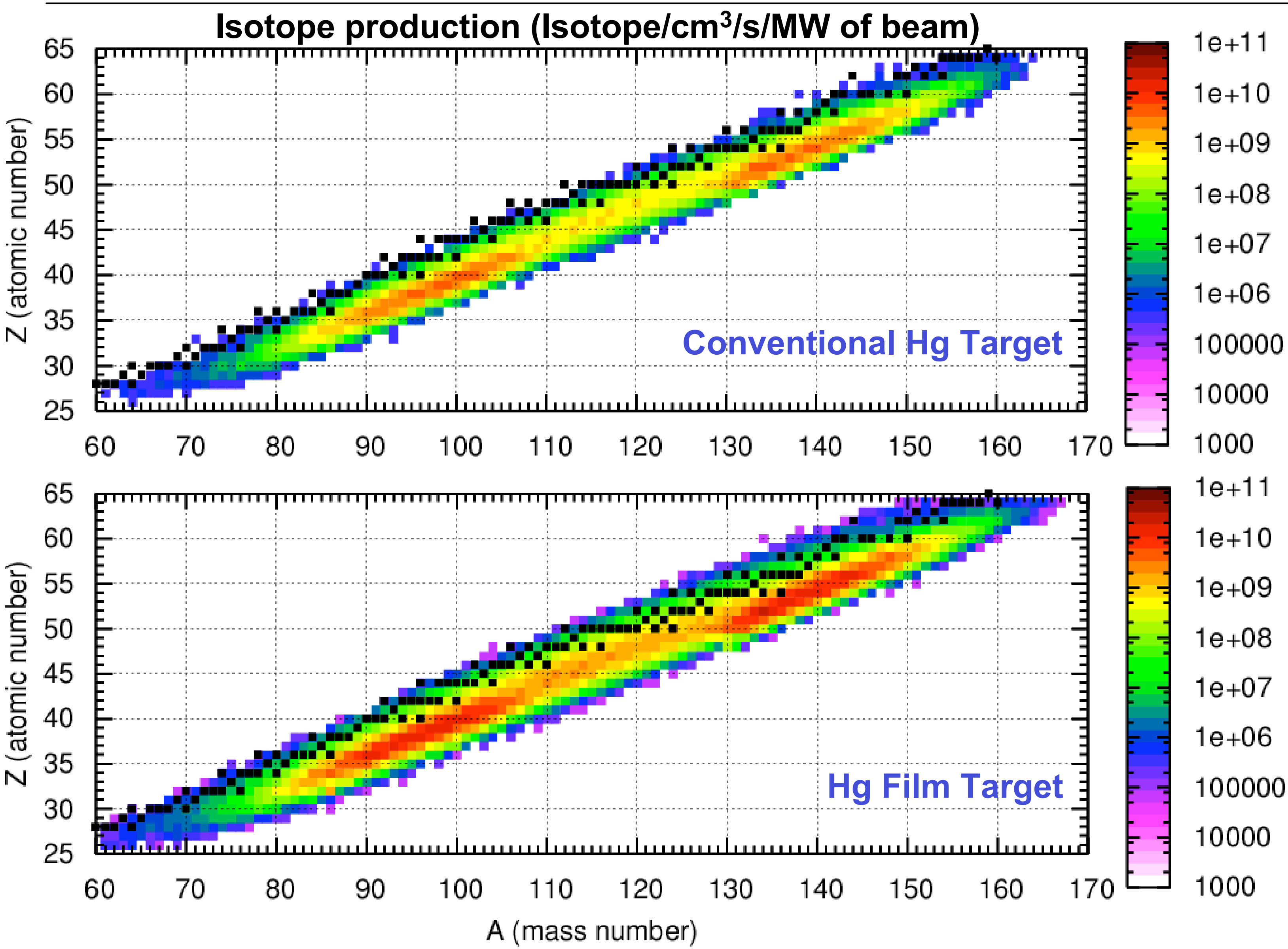
Fission density (Fissions/cm^3/s/MW of beam) | **Power density (W/cm^3/MW of beam)**



Radioactive Ions Production



UC_3 Targets:

- **Natural Uranium (0.7% U-235)**
- **Density: 3 g/cm^3**

Conclusions

- The Hg film option presents a feasible alternative to the conventional target design, if the mechanical problems of the beam window remain unsolved.

- Small temperature increase in the Hg film at reasonable flow speeds.

- Important radioactive ion yields, similar to those in the Hg-jet, with a technically simpler solution.

- Large high-energy particle escapes, requiring a beam dump and improved shielding, due to the displaced neutron source. Radiation damage to nearby structures.