Recirculating Electron Beam Photo-converter for Rare Isotope Production

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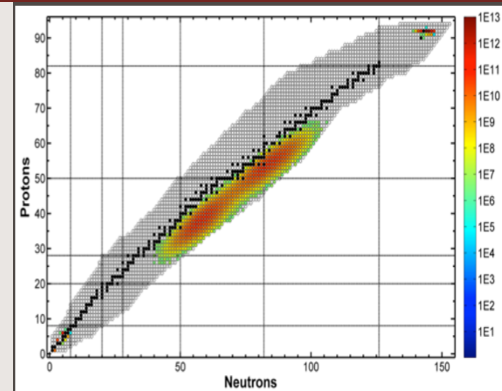

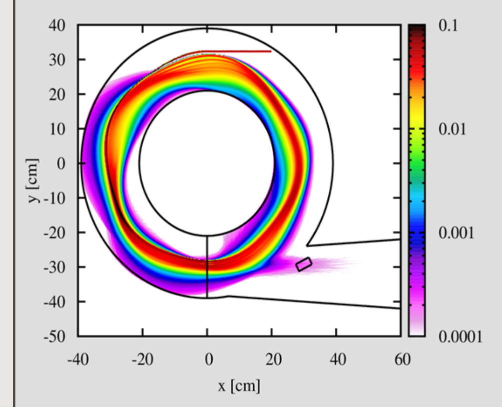

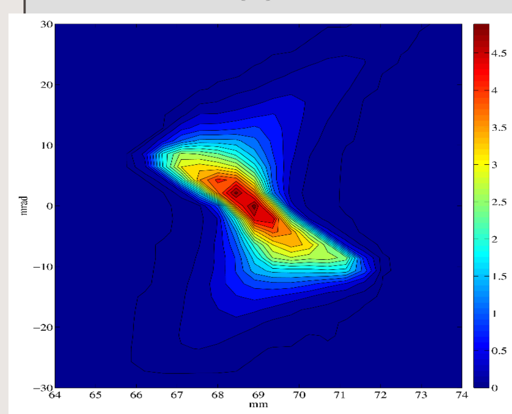

Acknowledgment & Motivation

RIB Group
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- **To design an e-to-γ Converter-Target that can take high intensity electron beam**

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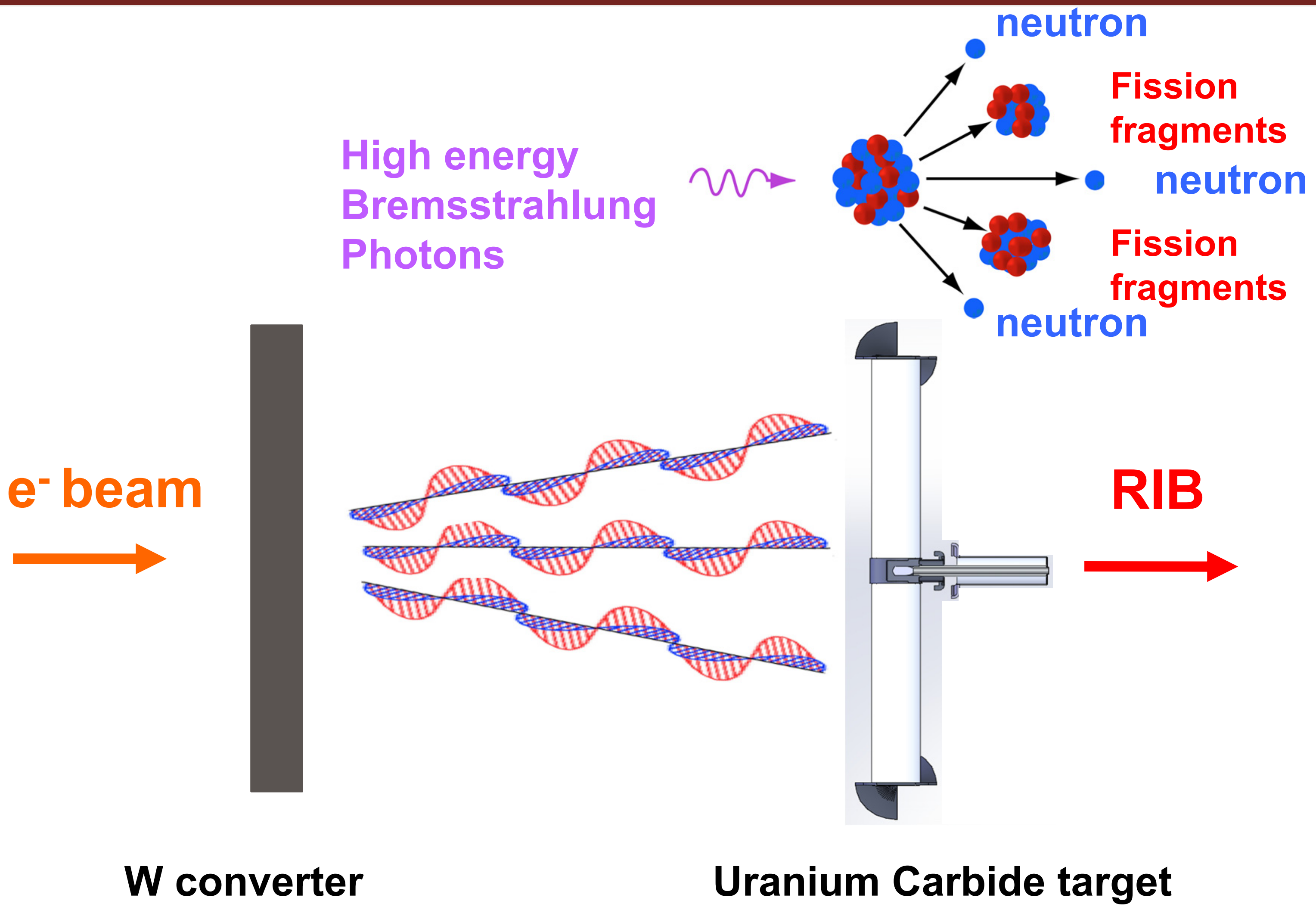
Schematics of Photo-fission



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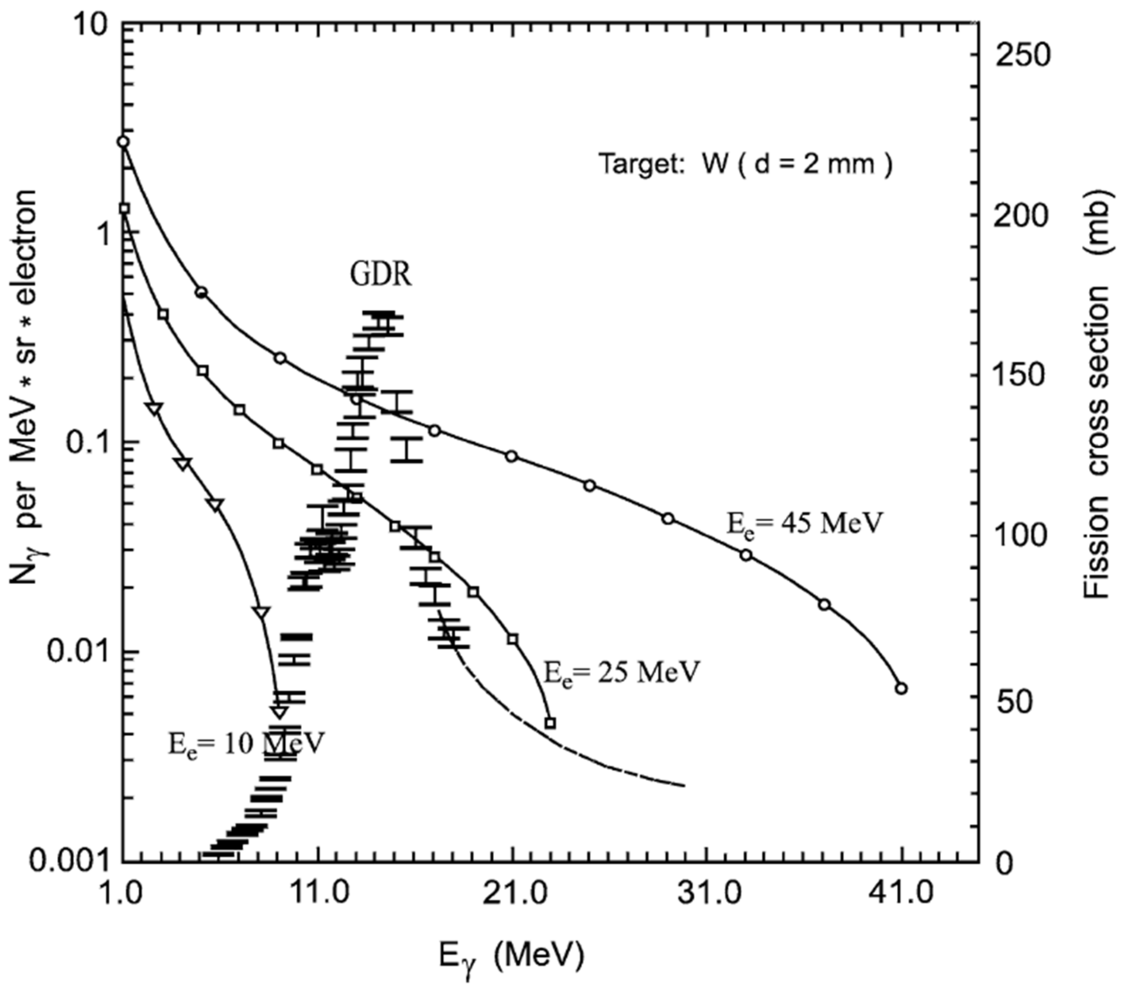
Bremsstrahlung Photons

Yu.Ts. Oganessian et al. / Nuclear Physics A 701 (2002) 87c–95c

[4] J.T. Caldwell et al., Phys. Rev. C 21 (1980) 1215.

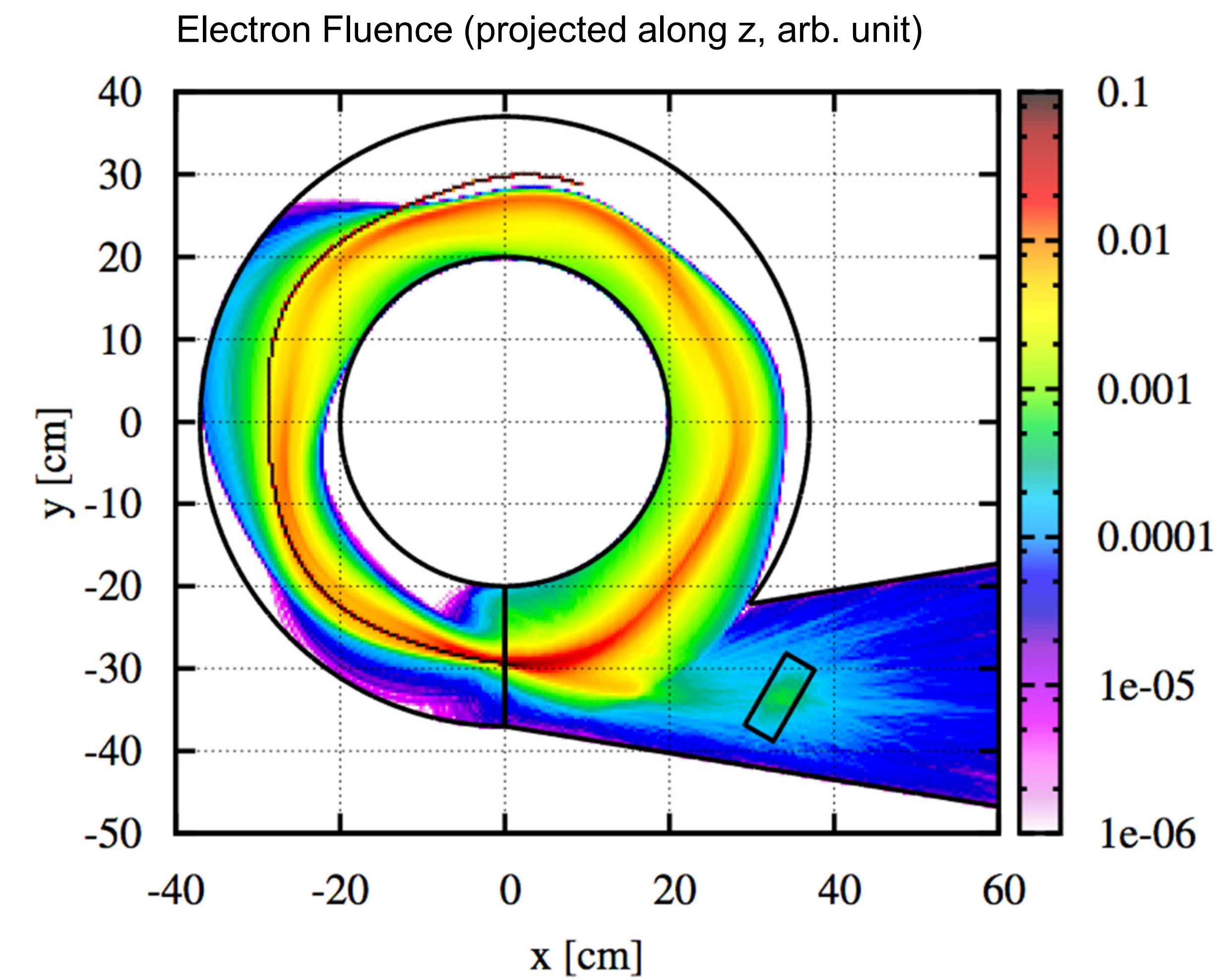


5 Sector Spiral Scaling FFAG – Electrons (I)

CW beam injection

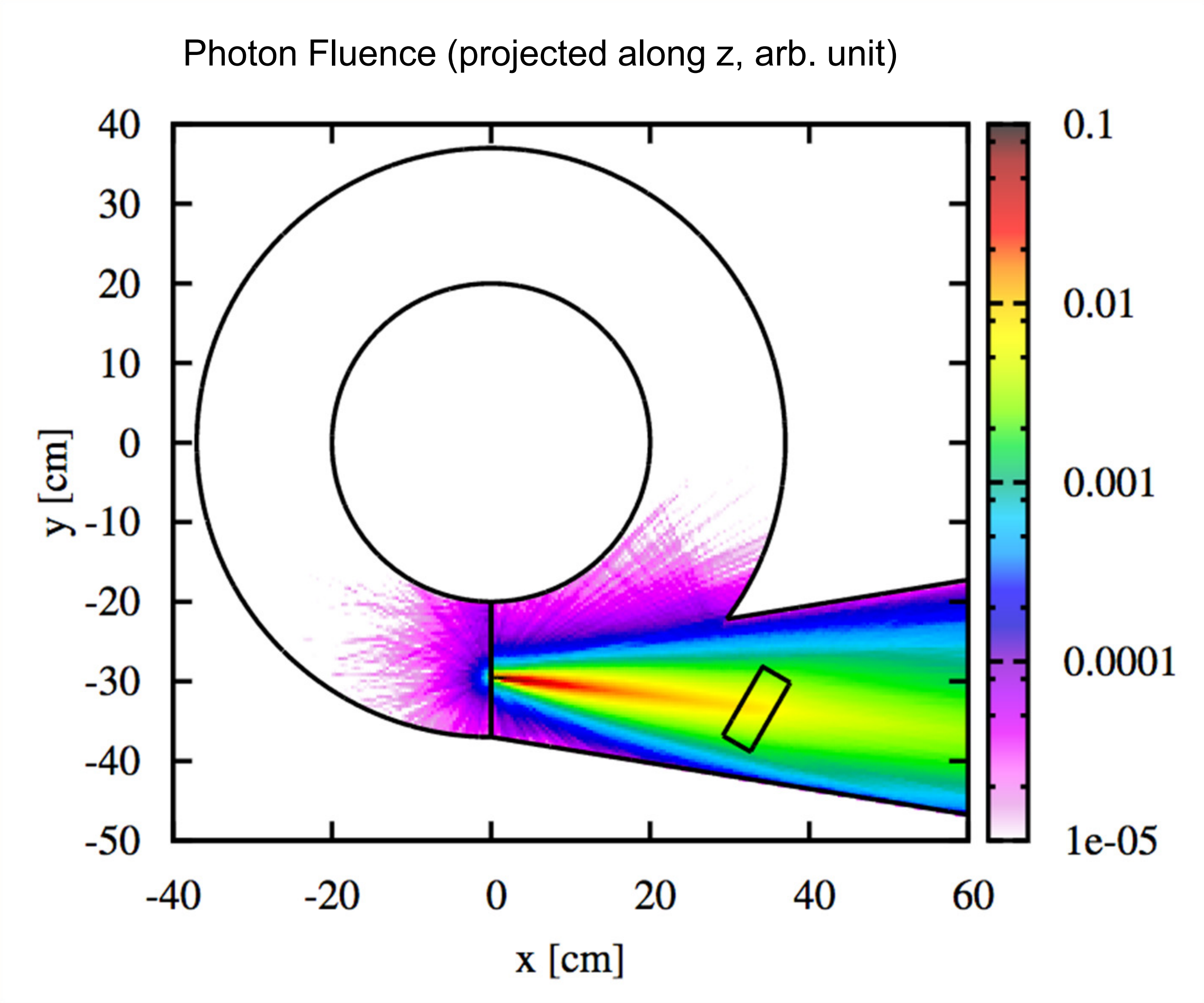
- Thick converter (1-2mm)
-> e- loose enough energy to create a turn separation
-> place an injection septum
- Phase advance between converter and the injection point ~180°
-> large angles from scattering through the foil DO NOT contribute to the beam size at the injection point (Note: beam size at injection point comes only from dispersion)

FLUKA simulations



5 Sector Spiral Scaling FFAG – Photons (I)

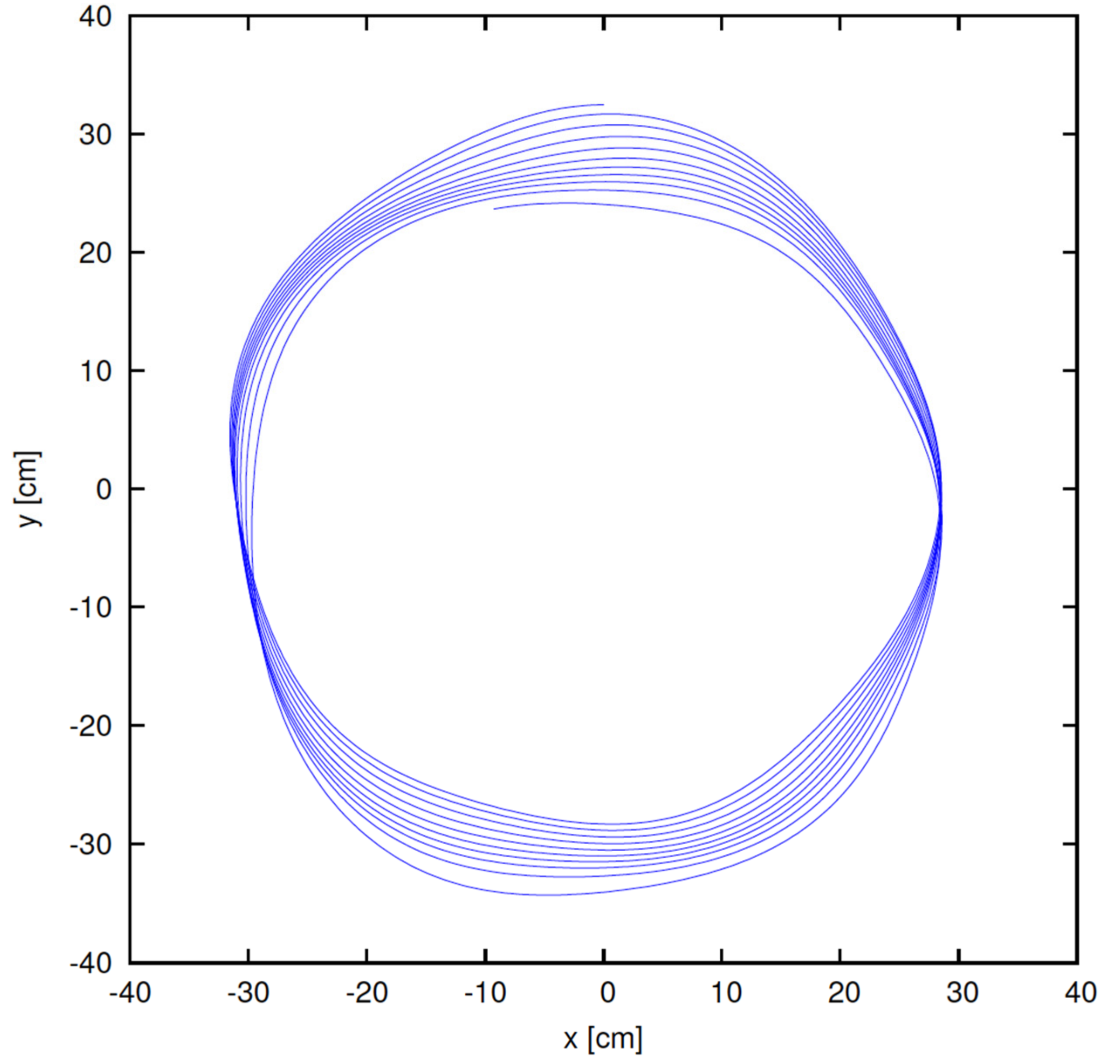
Corresponding photon cone



Turn separation for Thin Converter

- Orbit shift due to the **integer resonance v_r = 1**
- we drive with a controlled first harmonic field error

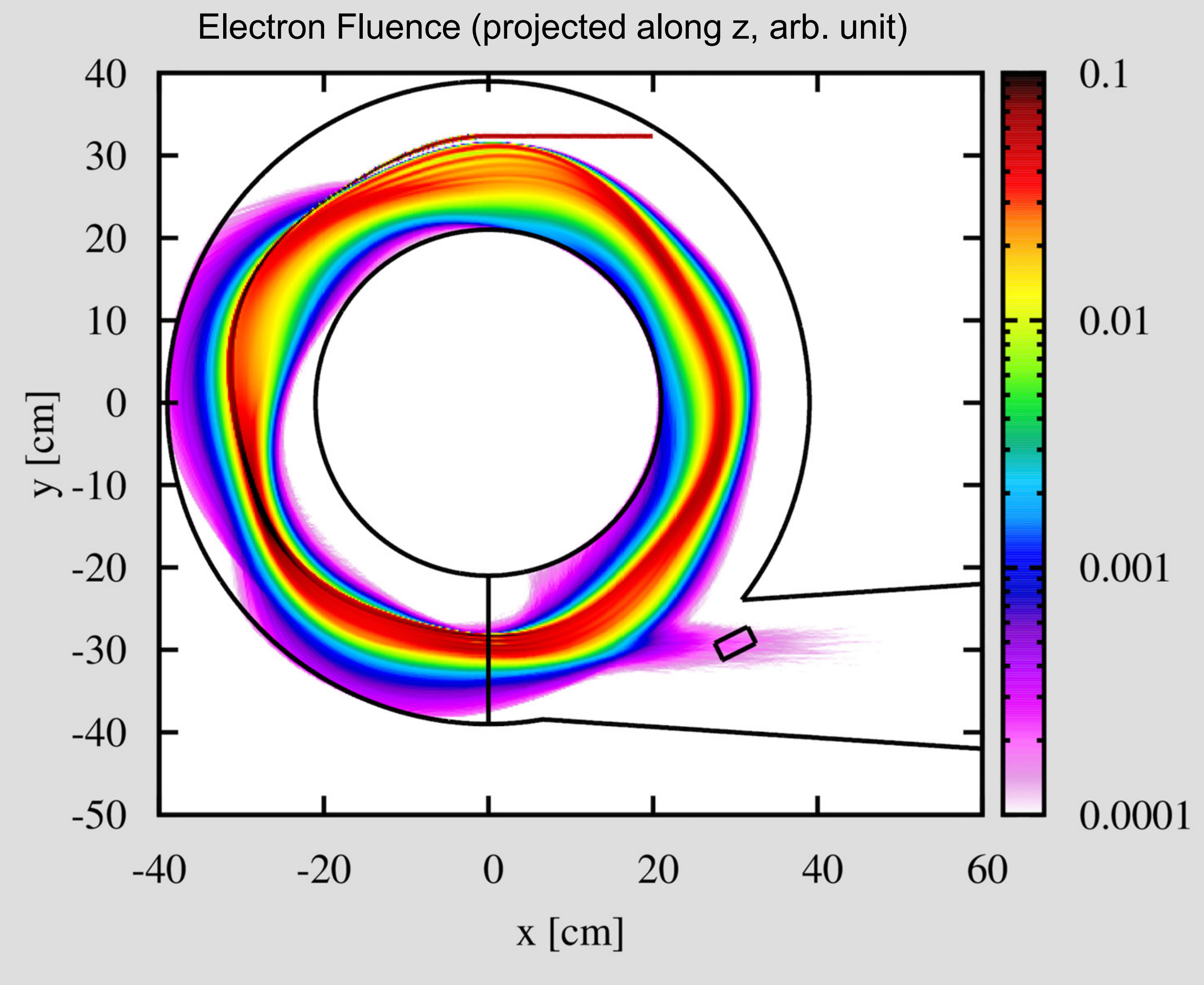
-> to get turn separation of 5mm for arbitrary thin converter



5 Sector Spiral Scaling FFAG – Electrons (II)

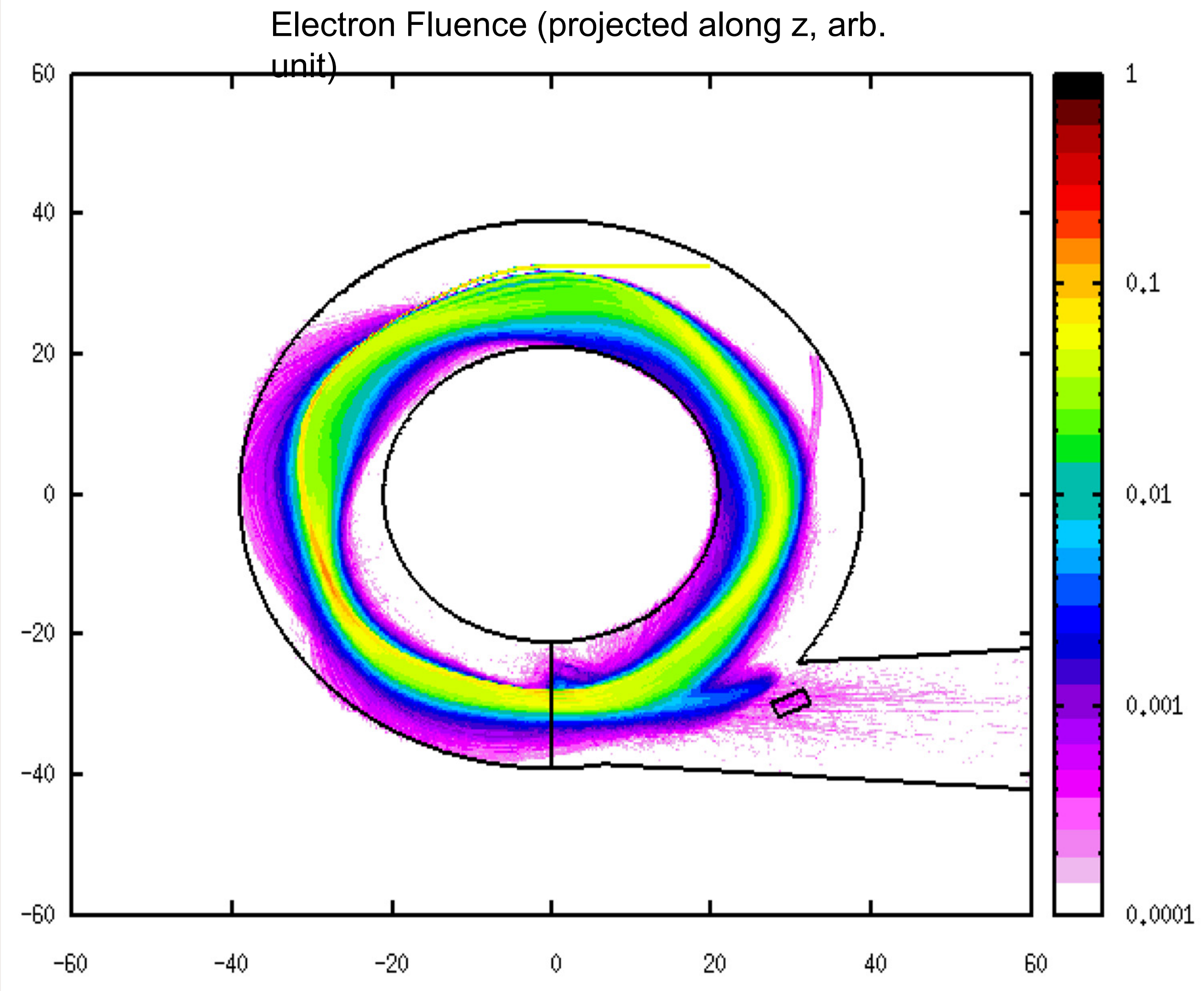
- 0.1mm thick converter
- 10 -12 turns of electrons

- Injected beam in horizontal direction: 50 MeV electrons
- 5 sectors
- geometrical field index k = -0.1
- spiral angle χ = 65°
- Maximum field < 0.9 T
- Radial tune
  $\nu_r = 0.997$
- Vertical tune
  $\nu_{rz} = 1.23$



Low energy electrons

- Using very thin convertor foil secondary electrons with low energies get trapped in the magnetic flux lines



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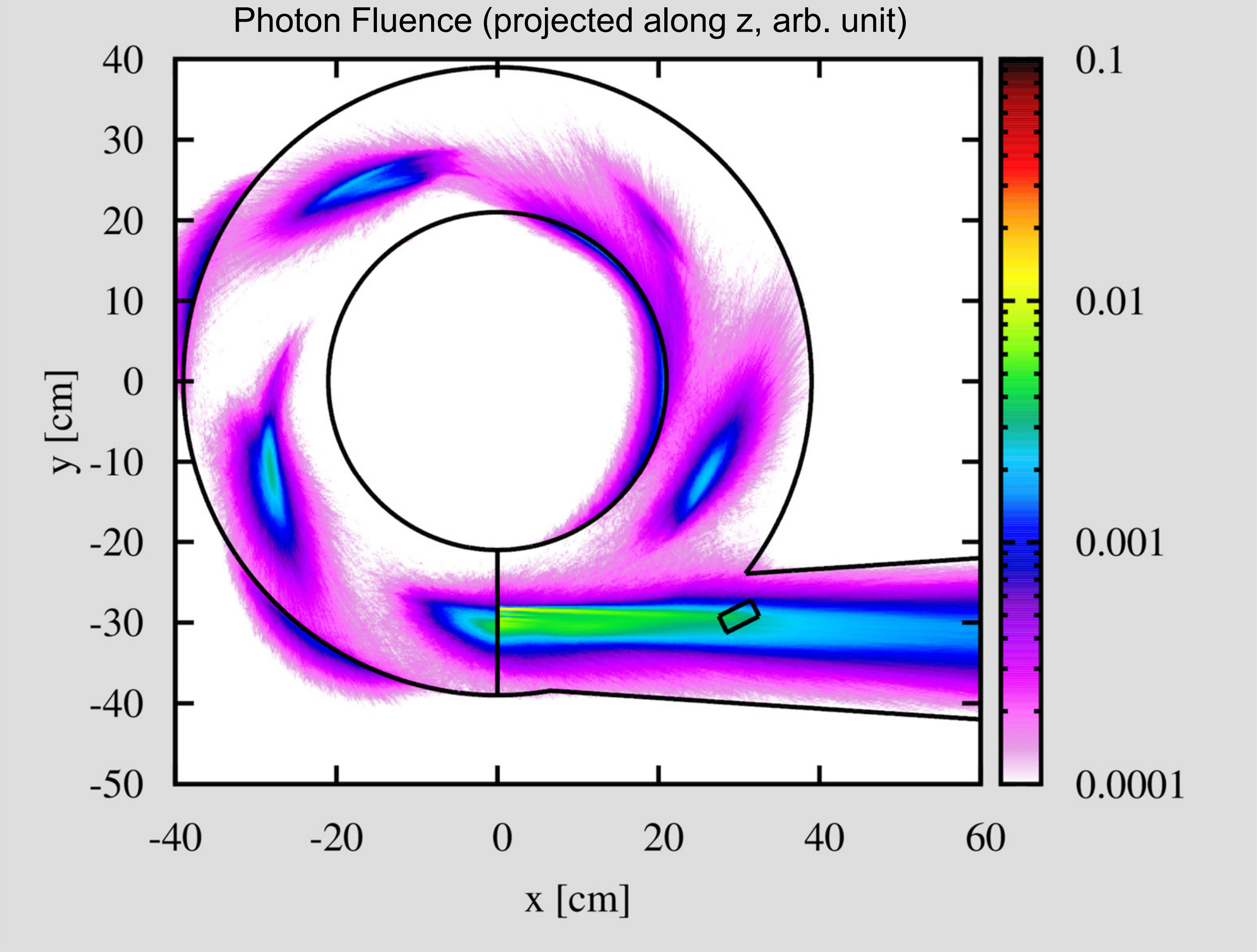
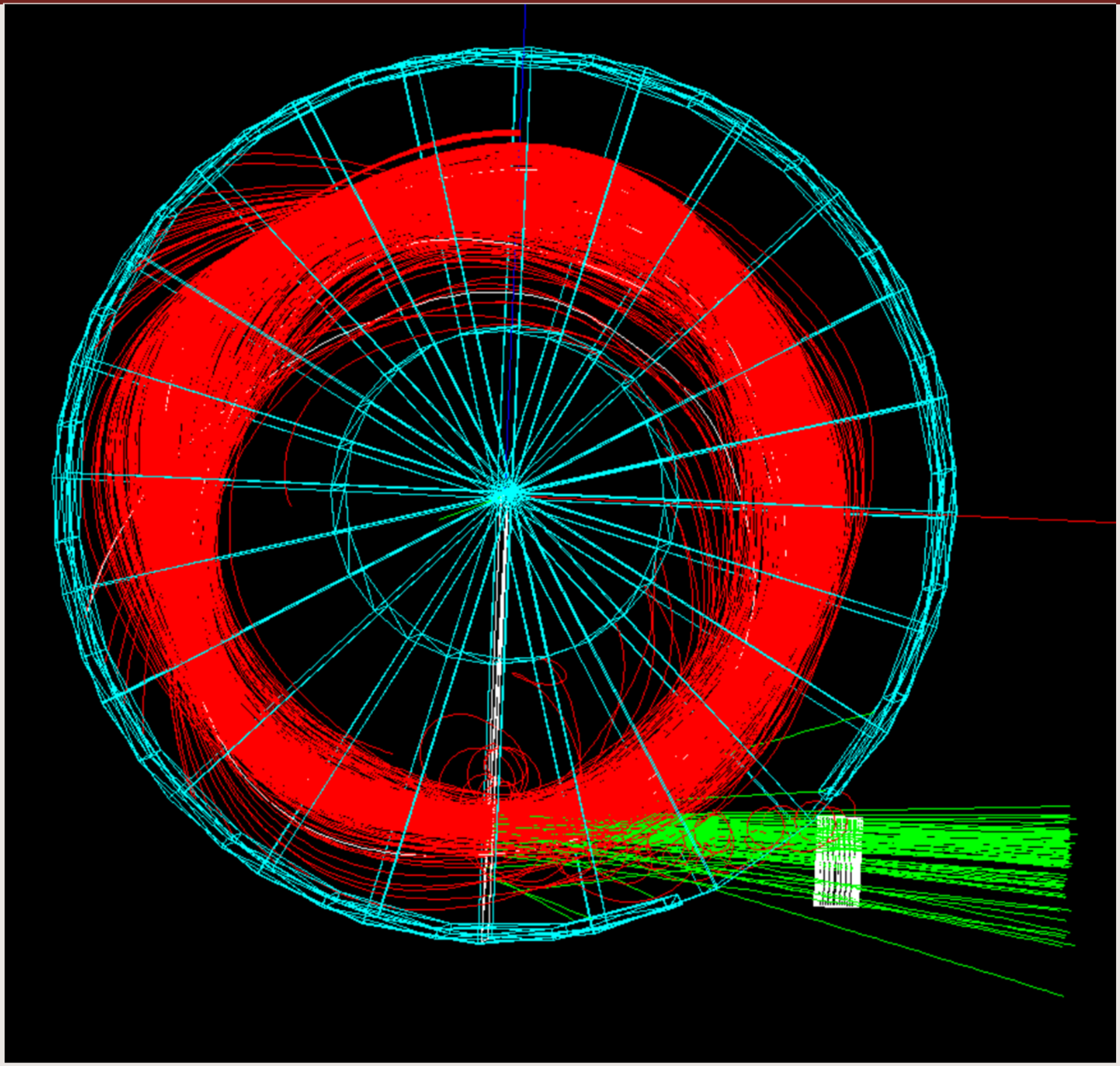
5 Sector Spiral Scaling FFAG – Photons (II)

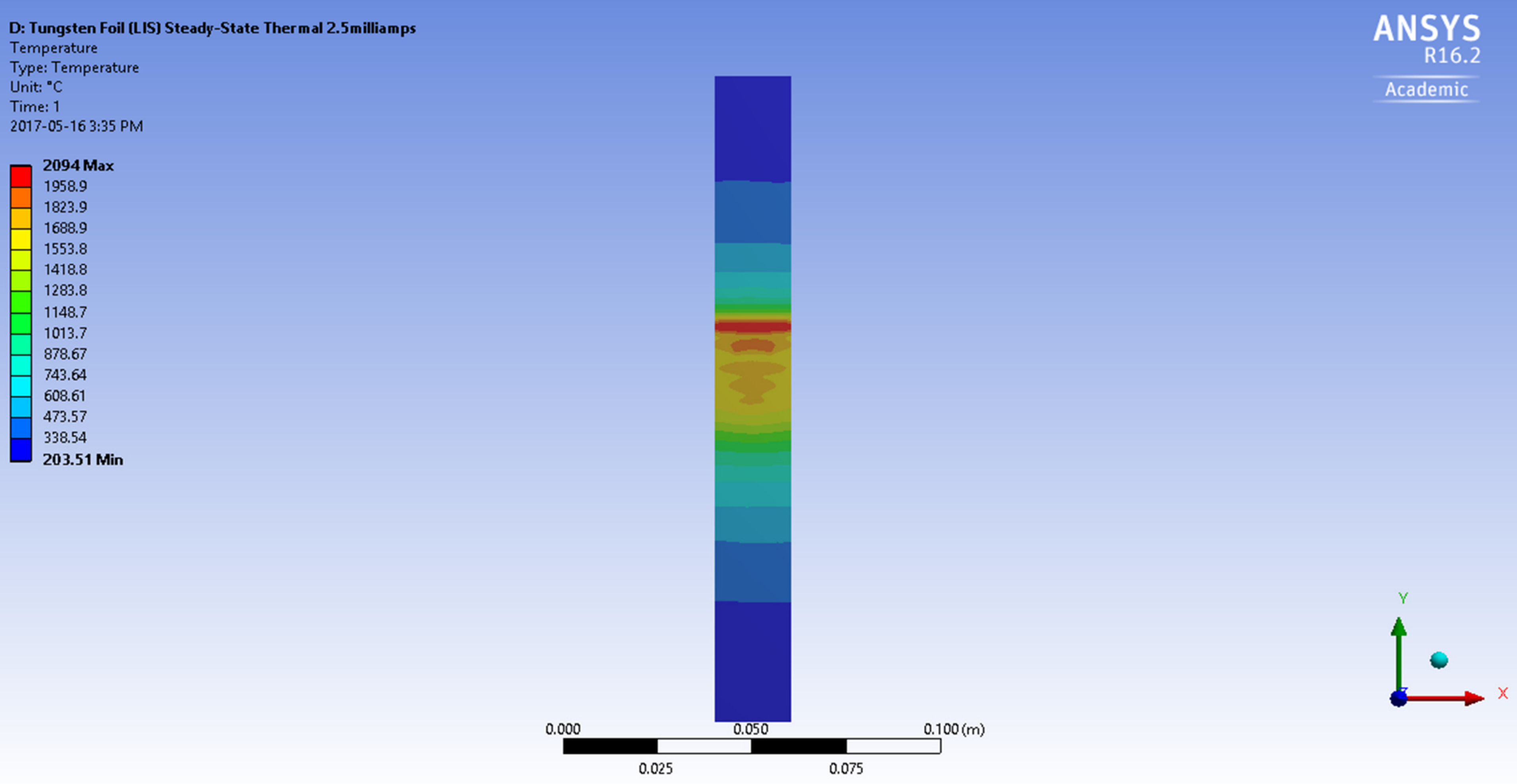
Corresponding photon cone



Electrons & Photons – Geant4

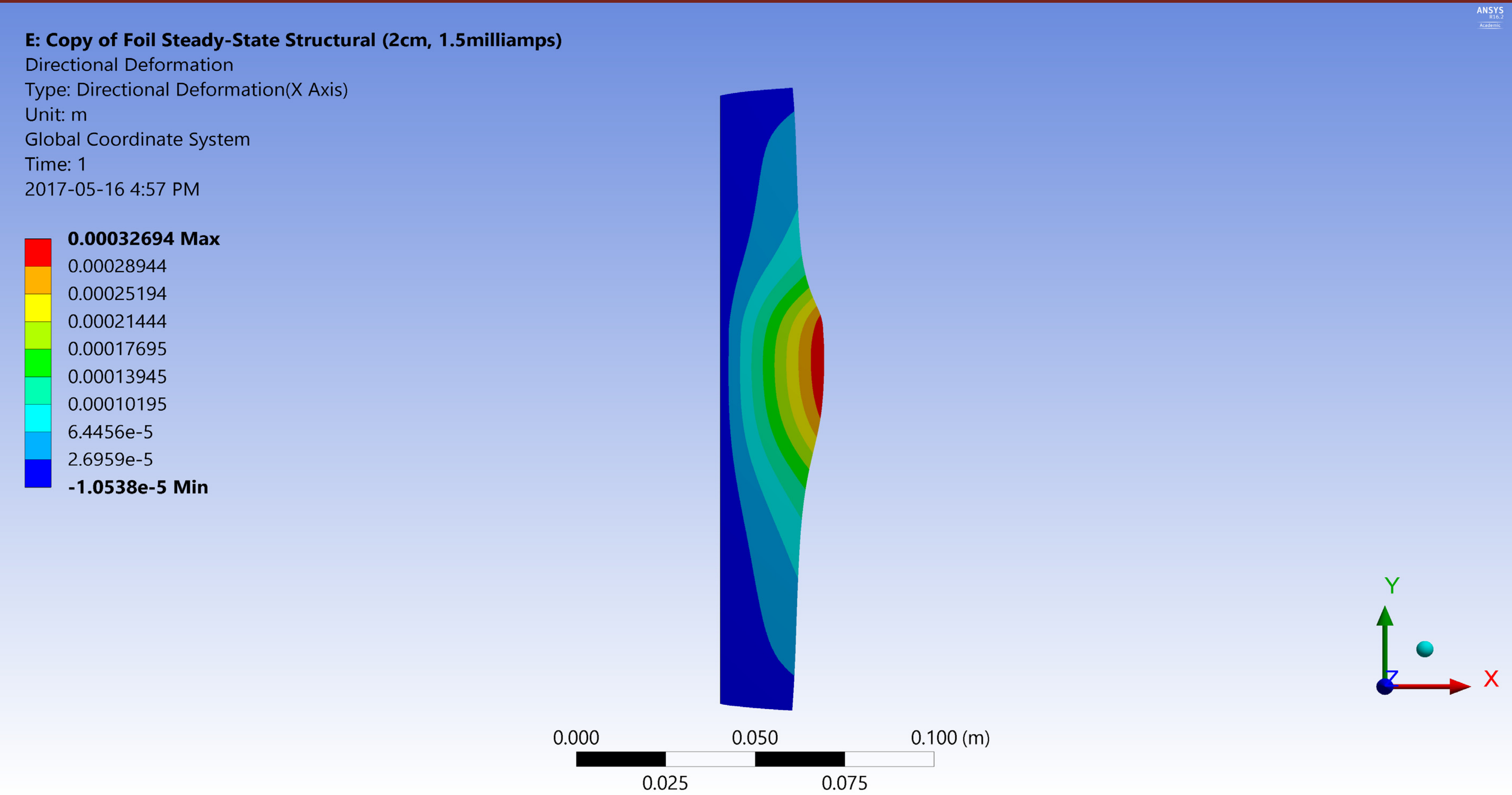


Converter Thermal Analysis 1.5mA - ANSYS

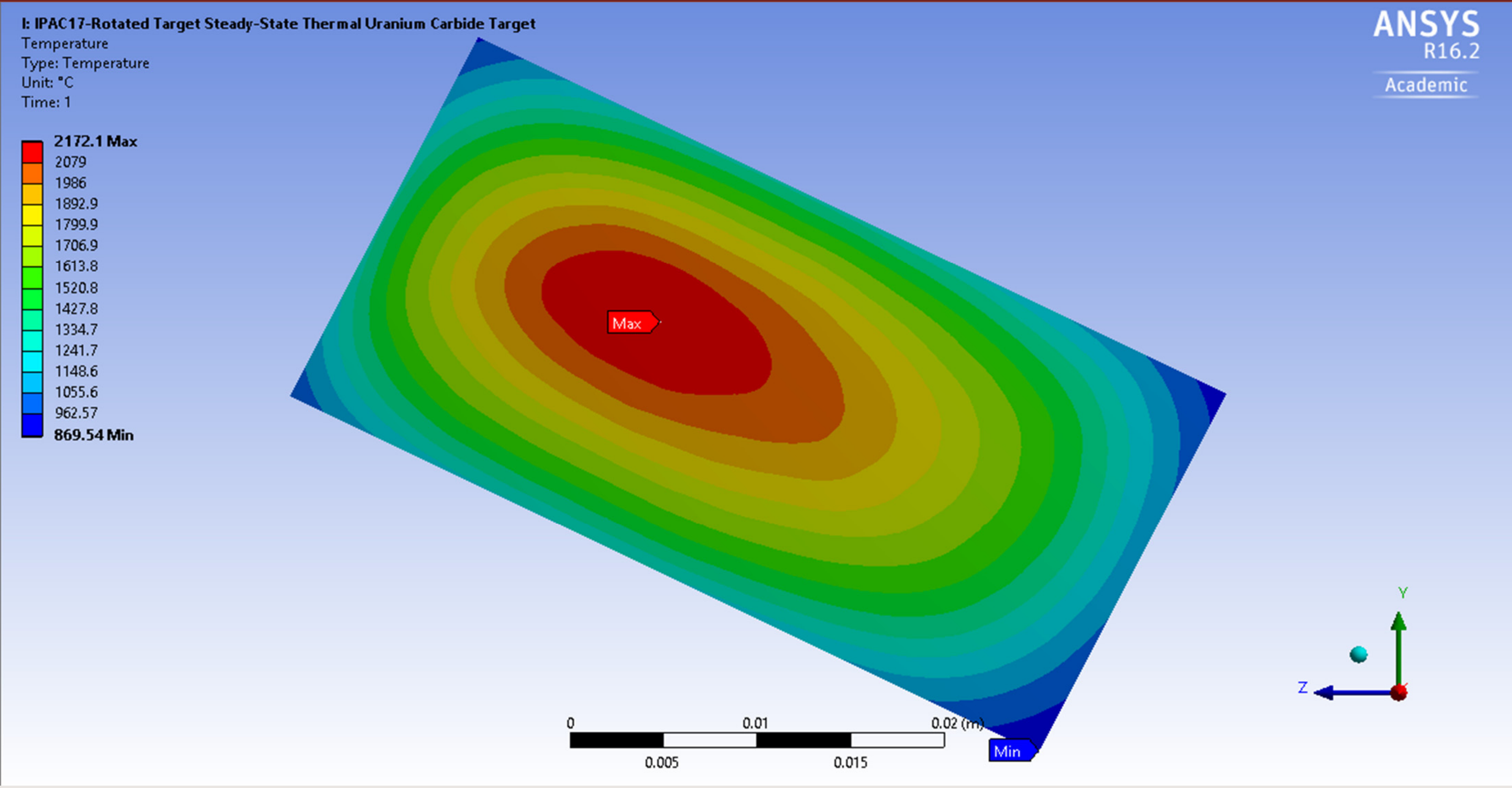


0.1 mm W converter foil coated with 60 µm black rhenium -> emissivity 0.9

Structural Analysis 1.5mA - ANSYS



Target Thermal Analysis 1.5mA - ANSYS



- **Target container coated with 60 µm black rhenium -> emissivity 0.9**

Summary

- Electron beam energy: 50 MeV and 75 MeV
- Converter: 0.1 mm W foil
- Uranium Carbide Target: ρ=3.5g/cm^3 V=16cm^3 Target thickness=14g/cm^2

Beam Energy [MeV]	Beam Intensity [mA]	Fission Rate [fissions/sec]	Max Temperature in Converter [C]	Power in Converter [W]	Max Temperature in Target [C]	Power in Target [W]	Total Power [kW]
75	1.5	3×10^{11}	2094	1210	2172	849	112.5
50	2.5	2.35×10^{11}	2451	1540	1834	670	87.5

Design advantages:

- Significant reduces the charged particles interaction with the uranium target (mainly: photons interact with the target) -> less energy deposition on the target
- Photon cone is more a collimated photon band
- Safety: in case of a converter failure the target is protected
- Water cooling system (external) away from the electron beam (water radiolysis/hydrogen)
- Design can be optimized further: (1) better tune -> wider beam spot on the Converter -> allows for higher beam intensities;

(2) getting the photons more efficiently to the target

Thank you!
Merci!

Suggestions ?

Questions?

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