Recirculating Electron Beam Photo-converter for Rare Isotope Production

CYC2016

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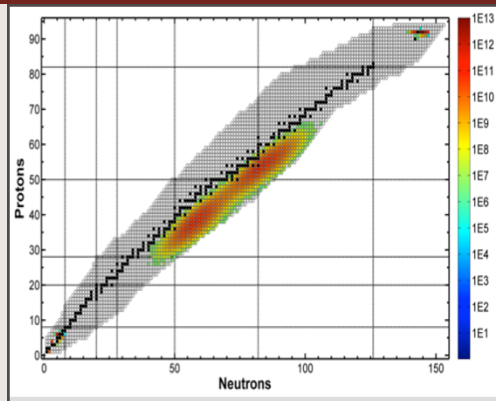
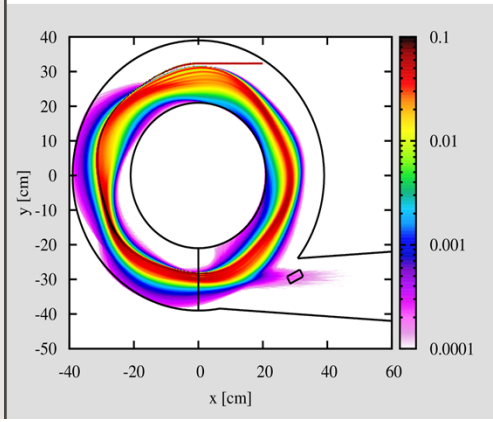
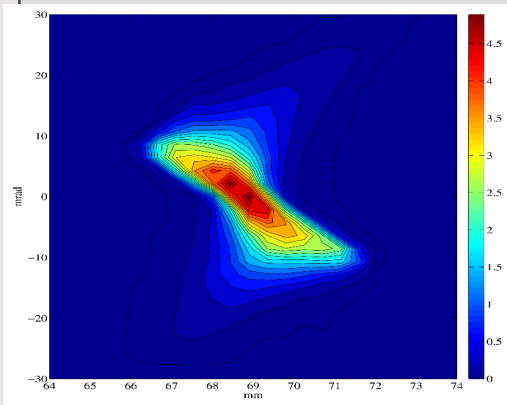
TRIUMF







Acknowledgment & Motivation

Beam Physics Group
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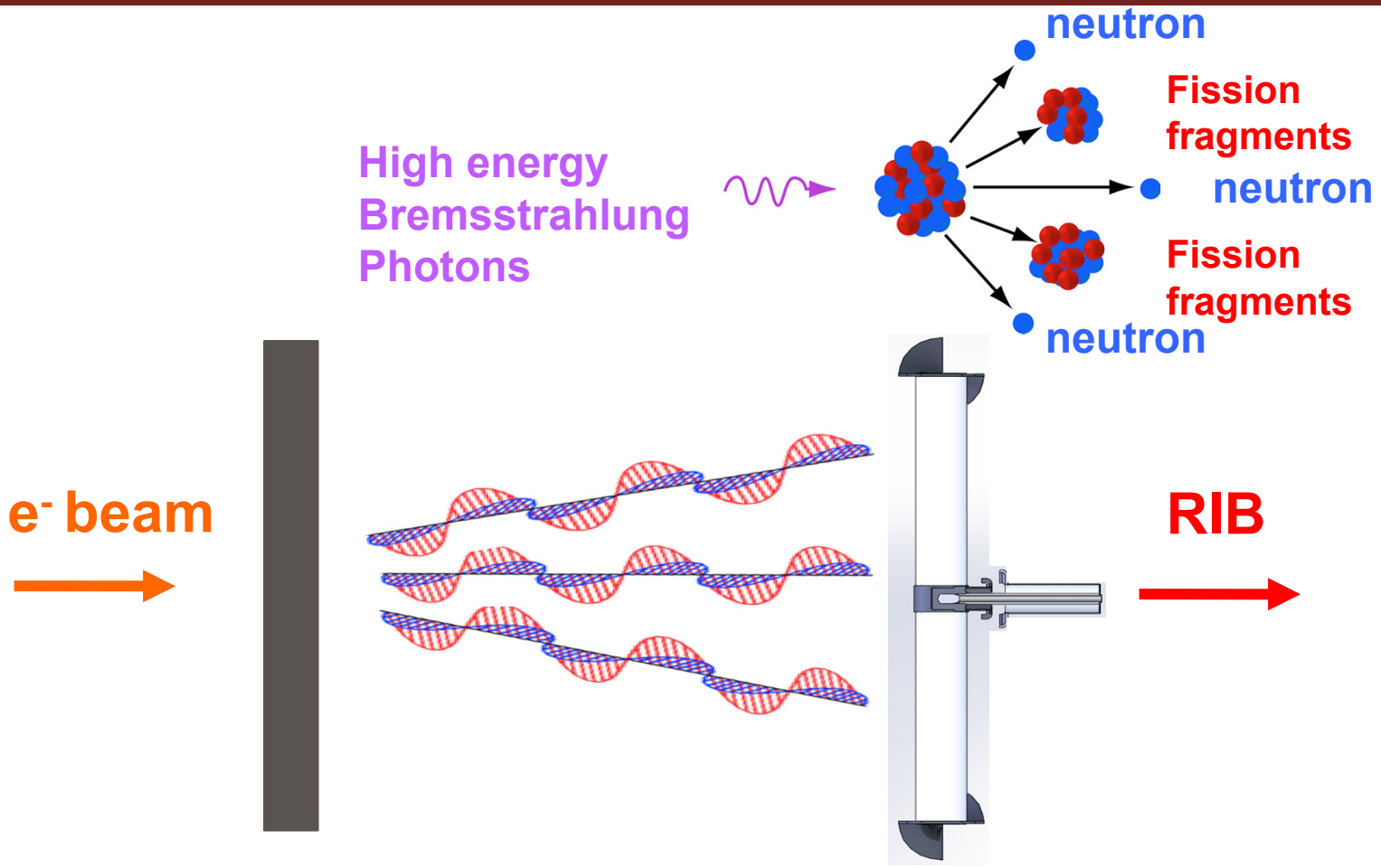
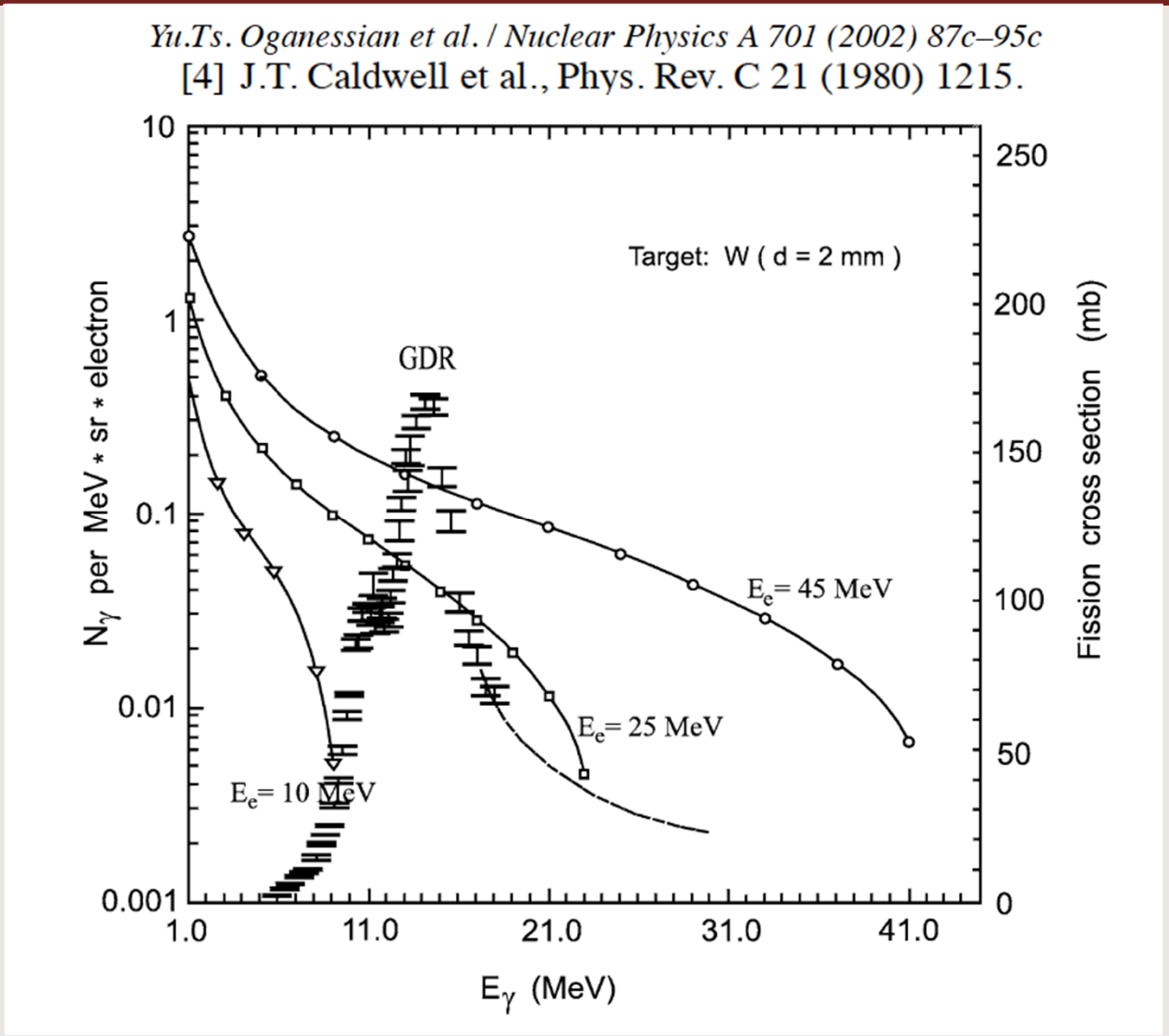
RIB Group
Aurelia Laxdal
Ayan Sen
Sriram Ganesh – Waterloo University student

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

Schematics of Photo-fission



Bremsstrahlung Photons

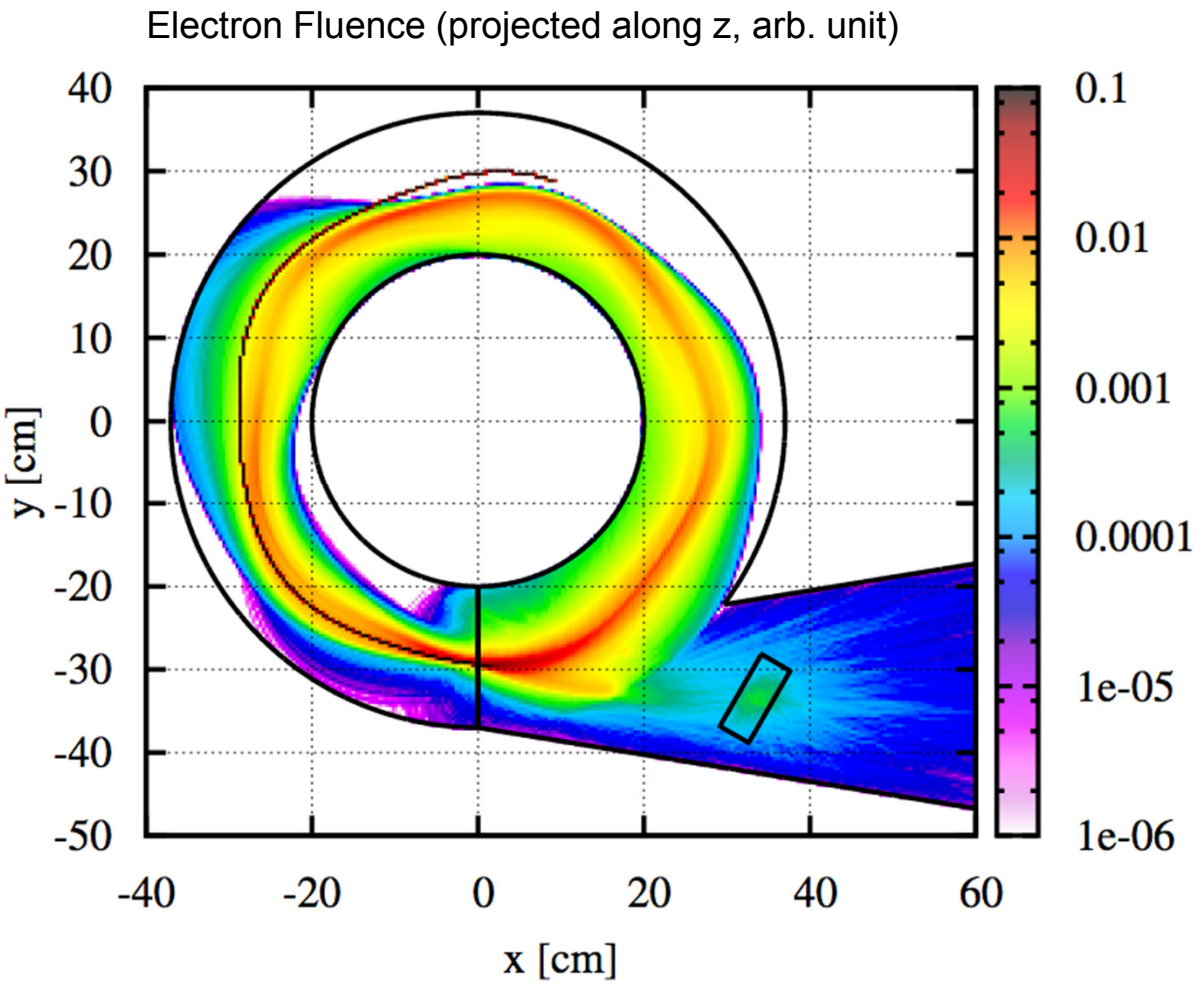


5 Sector Spiral Scaling FFAG – Electrons (I)

CW beam injection

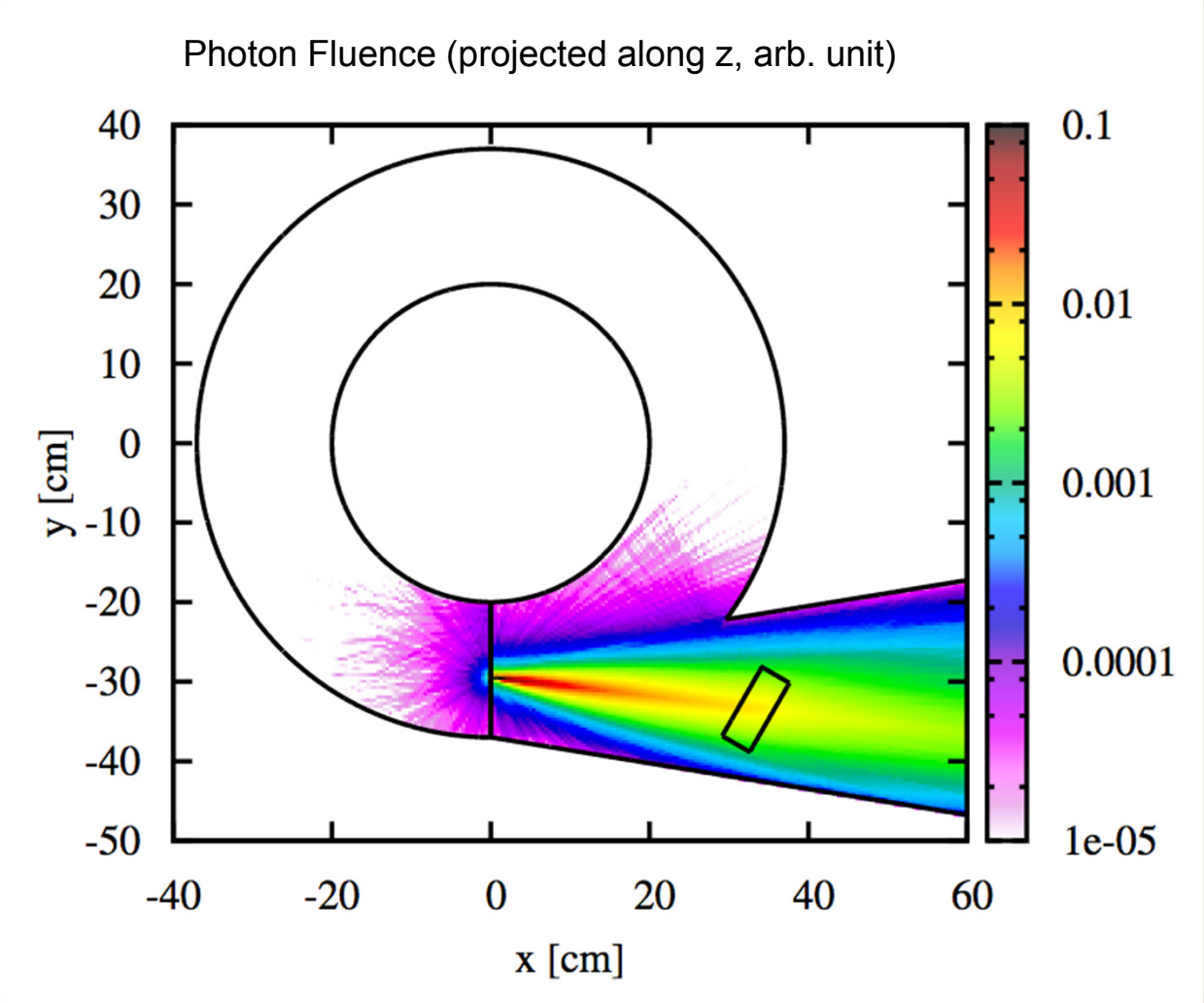
- Thick converter (1-2mm)
-> e- loose enough energy to create a turn separation
-> place an injection septum
- Phase advance between converter and the injection point -180°
-> large angles from scattering through the foil DO NOT contribute to the beam size at the injection point

FLUKA simulations



5 Sector Spiral Scaling FFAG – Photons (I)

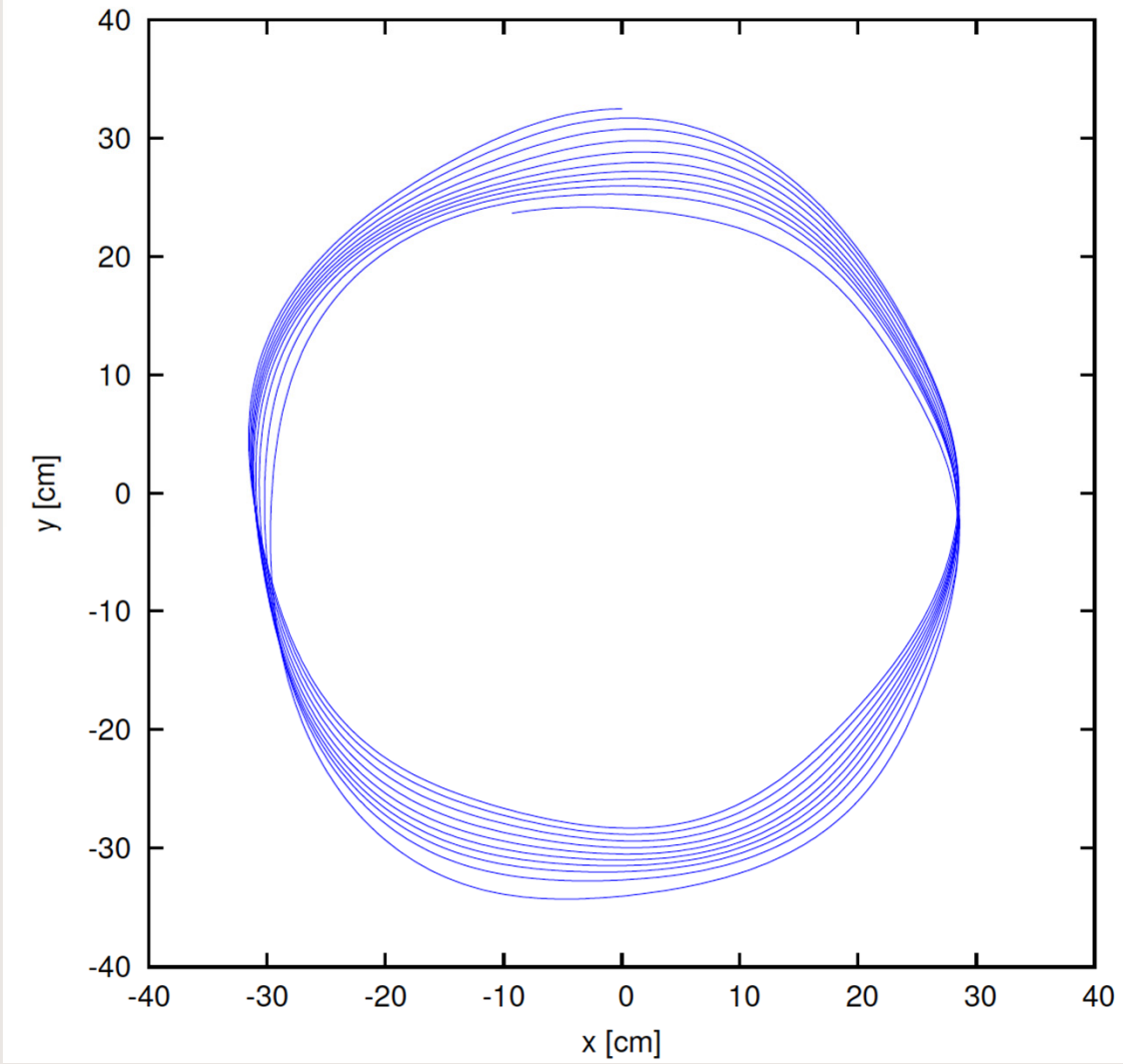
Corresponding photon cone



Turn separation for Thin Converter

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

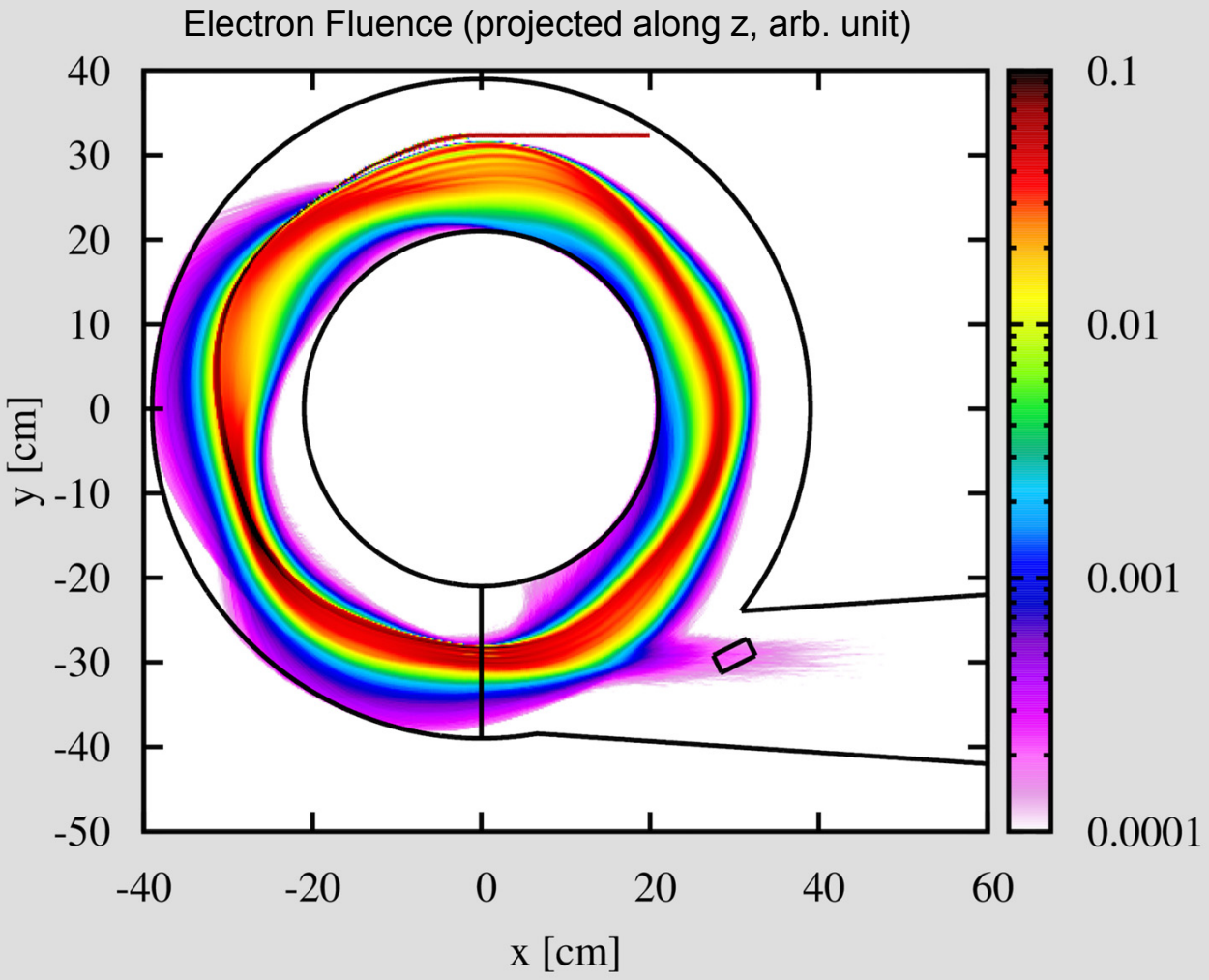
-> to get turn separation of 5mm for arbitrary thin converter



5 Sector Spiral Scaling FFAG – Electrons (II)

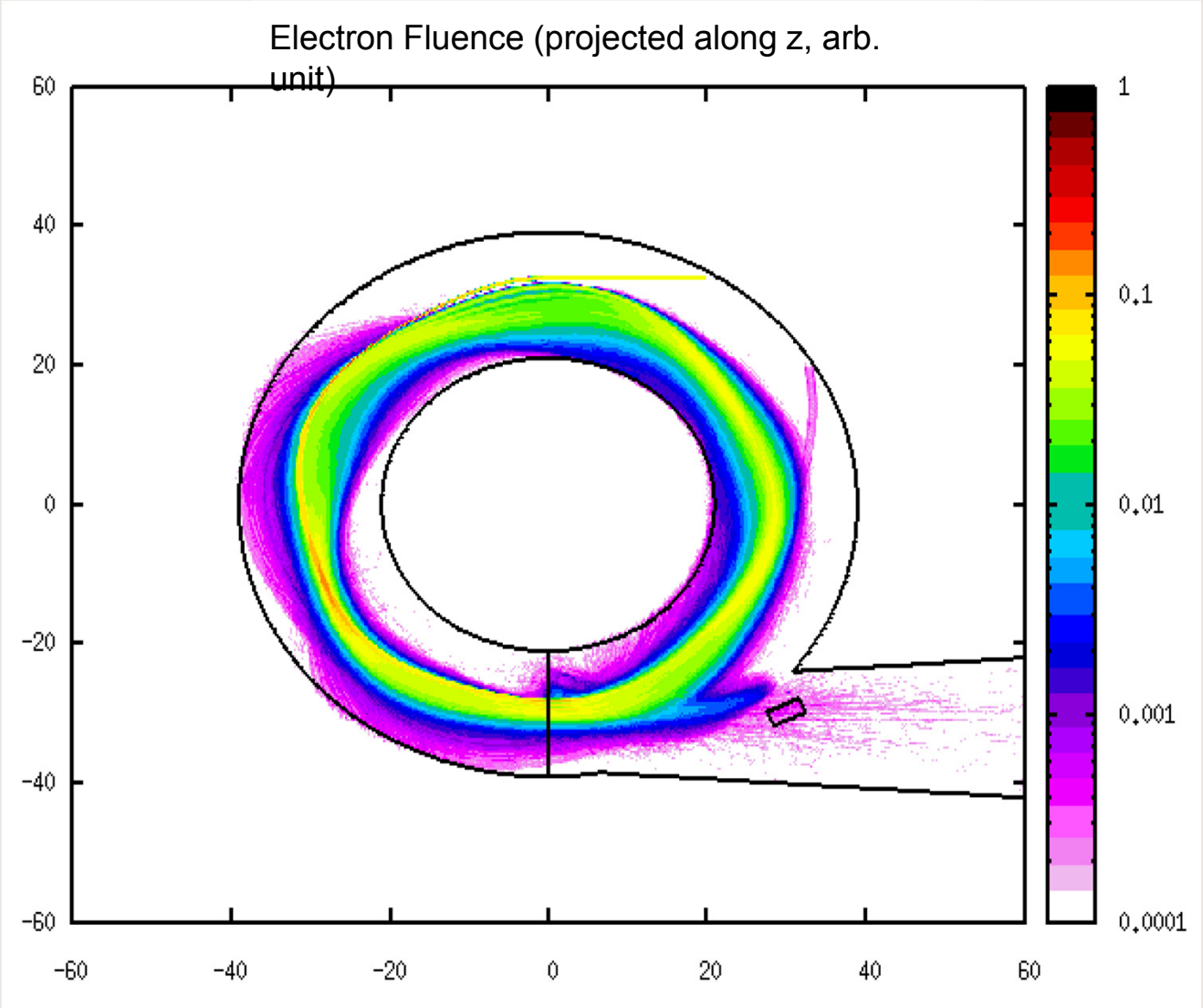
- 0.1mm thick converter
- 10 -12 turns of electrons

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



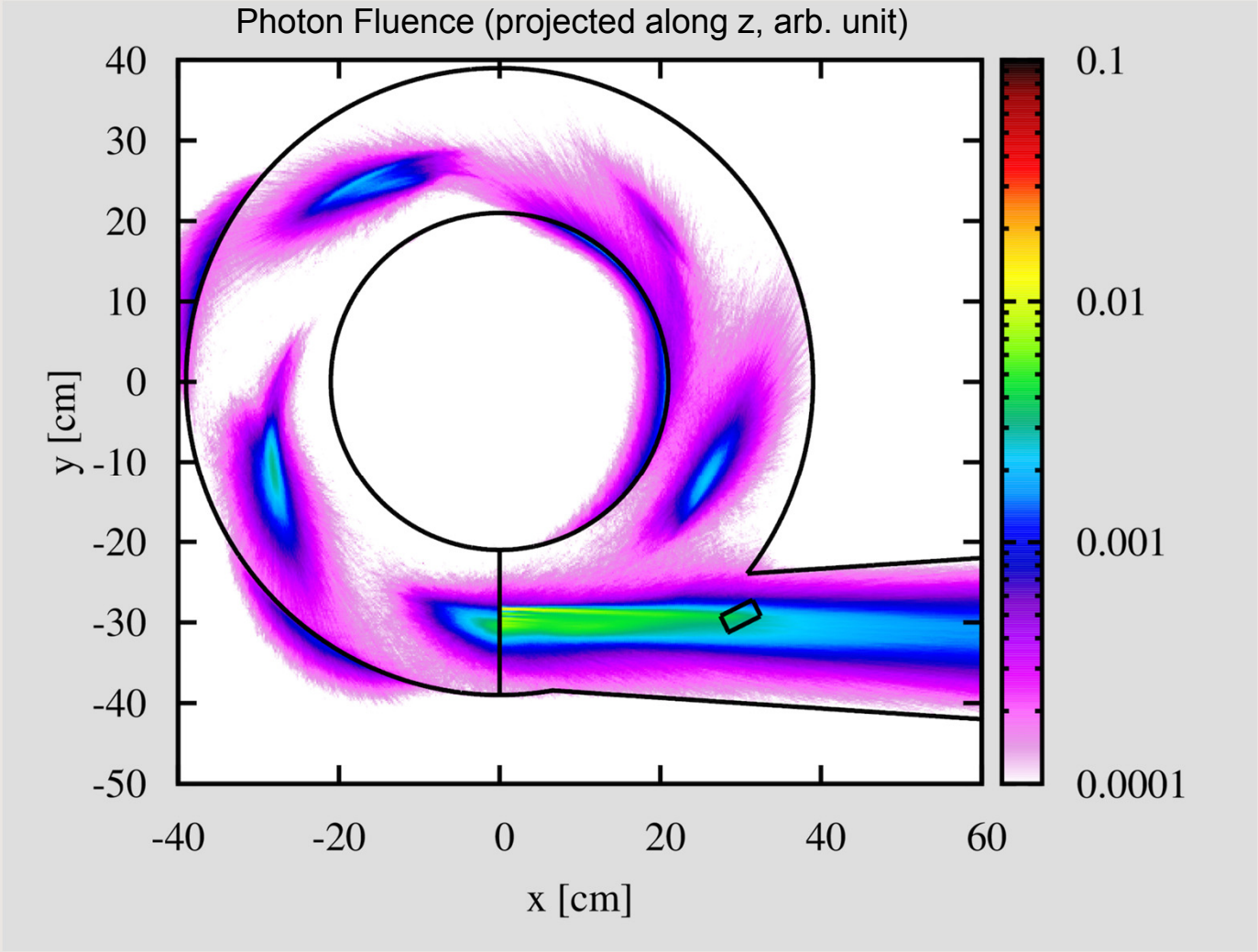
Low energy electrons

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

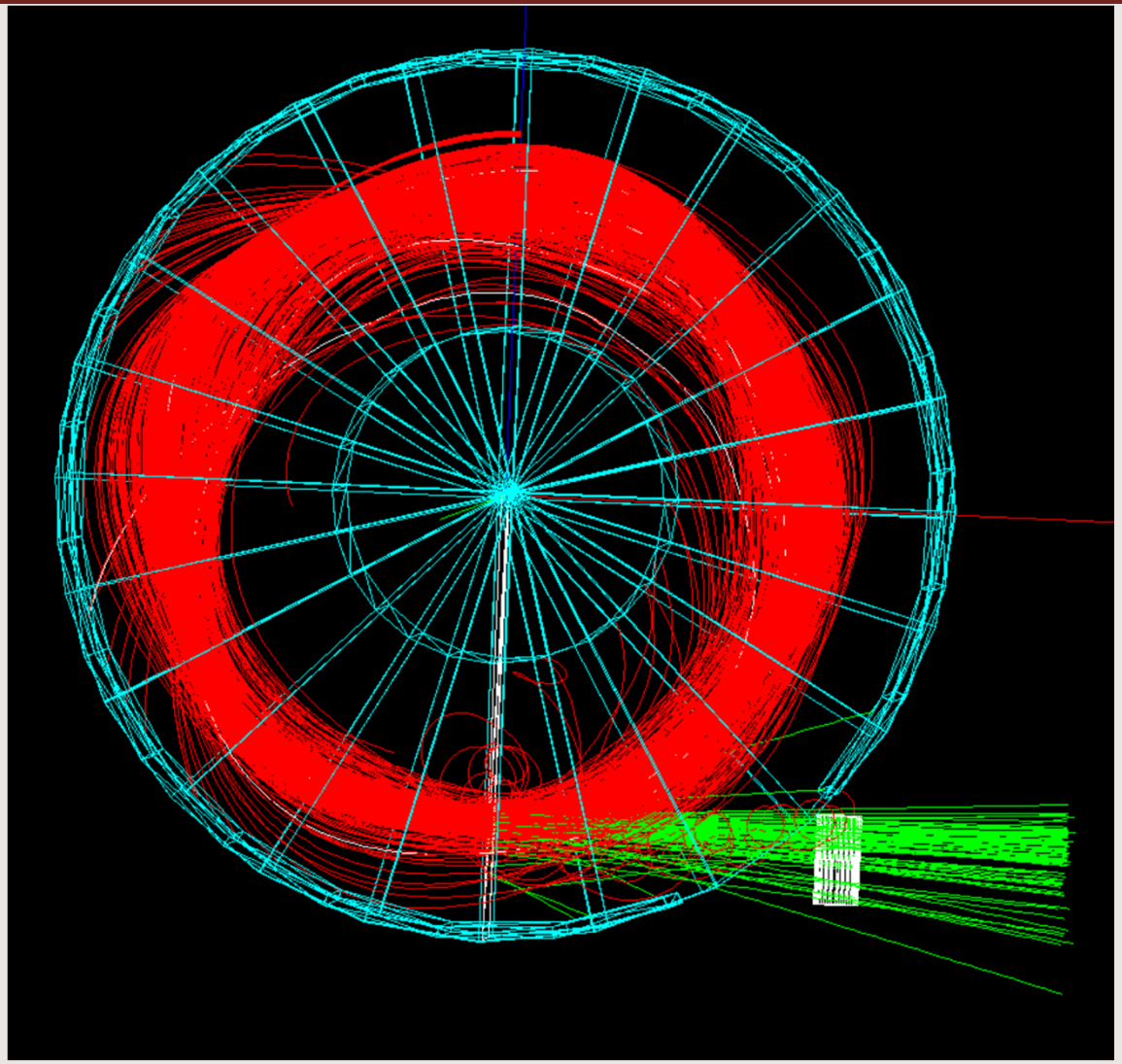


5 Sector Spiral Scaling FFAG – Photons (II)

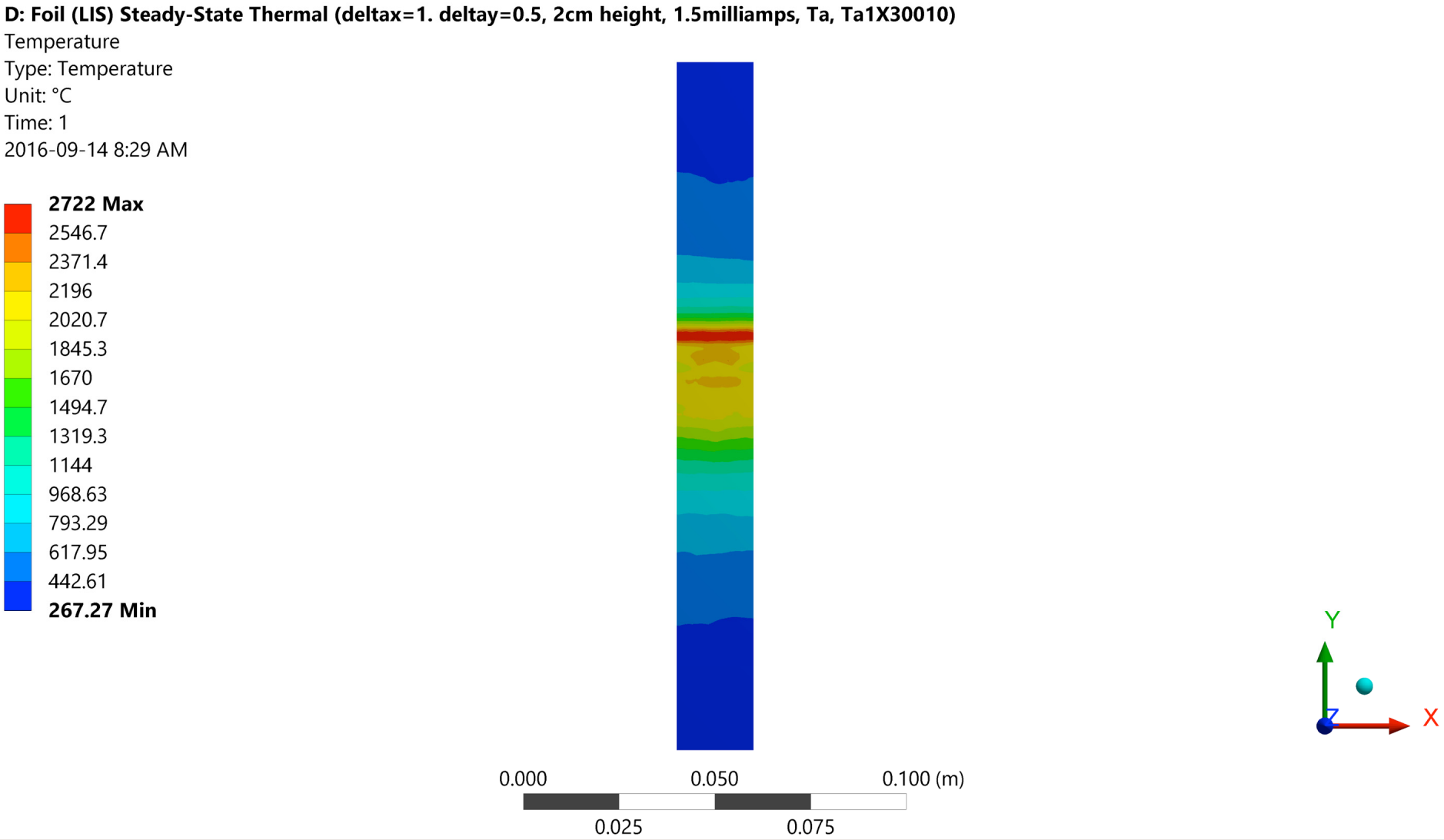
Corresponding photon cone



Electrons & Photons – Geant4

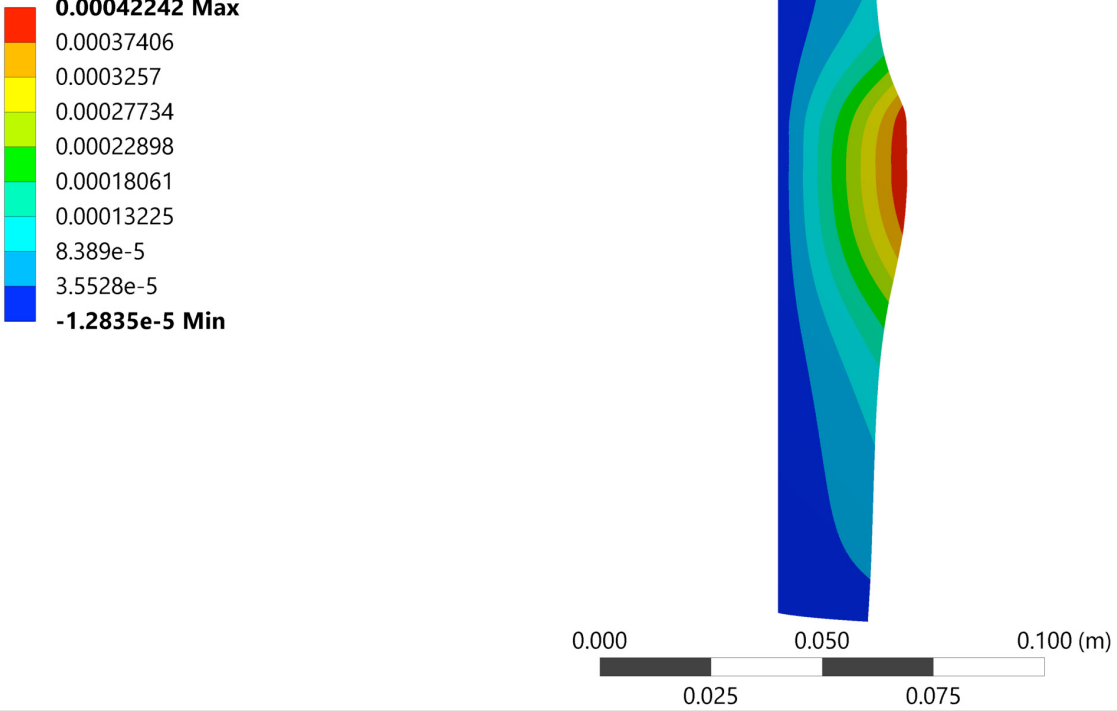


Converter Thermal Analysis 1.5mA - ANSYS

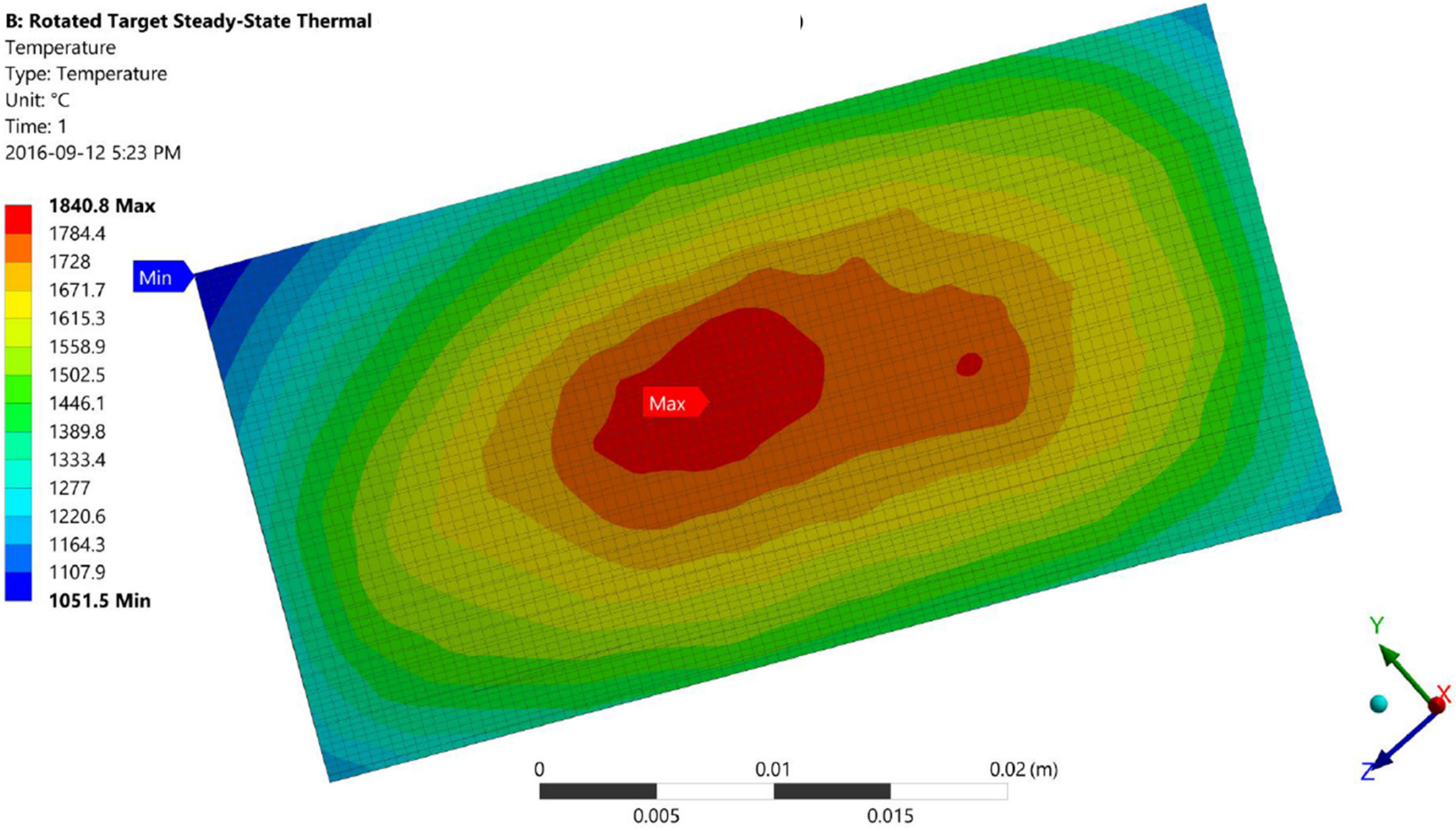


Structural Analysis 1.5mA - ANSYS

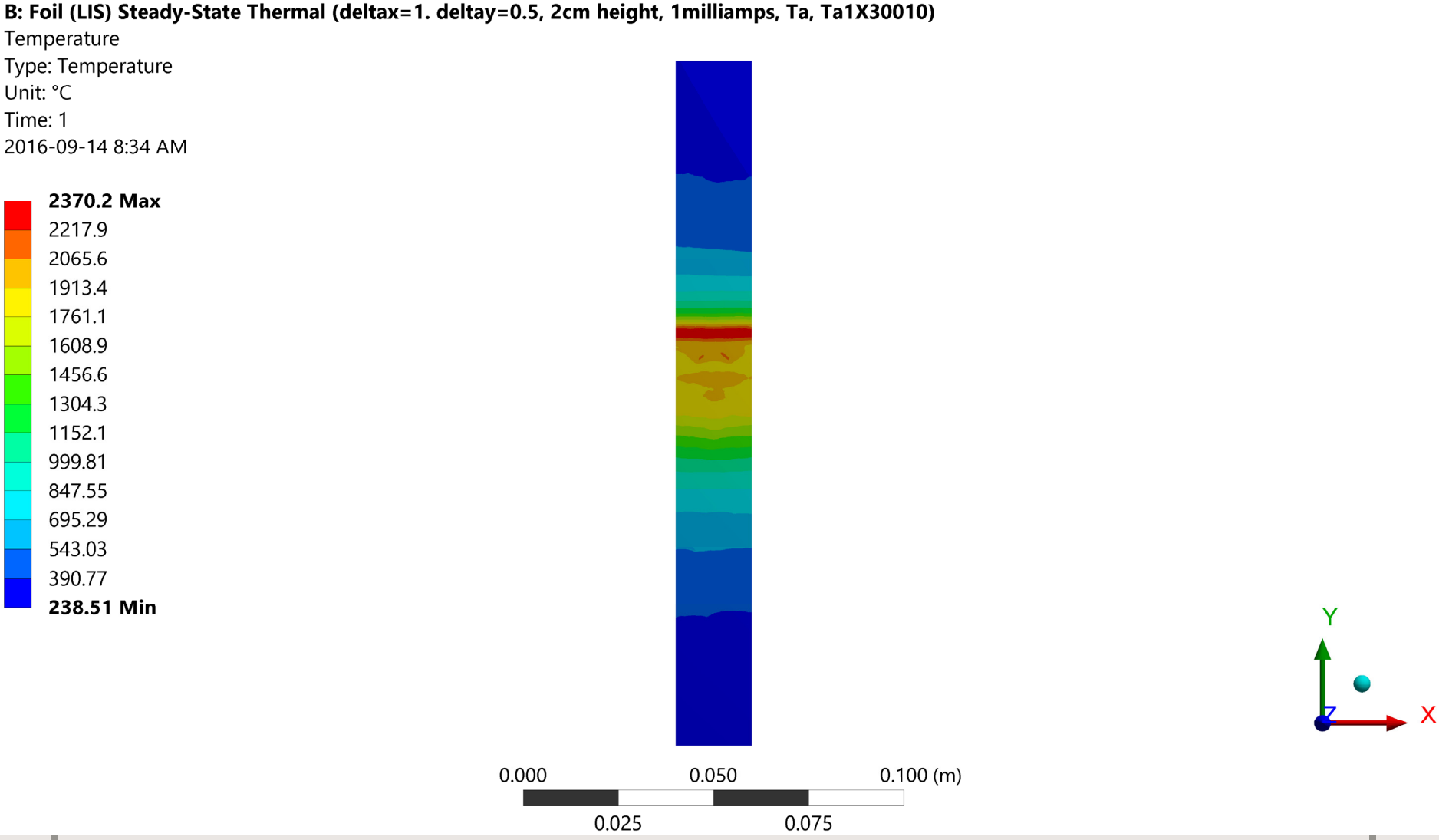
E: Foil Steady-State Structural (2cm, 1.5milliamps)
Directional Deformation
Type: Directional Deformation(X Axis)
Unit: m
Global Coordinate System
Time: 1
2016-09-14 8:53 AM



Target Thermal Analysis 1.5mA - ANSYS



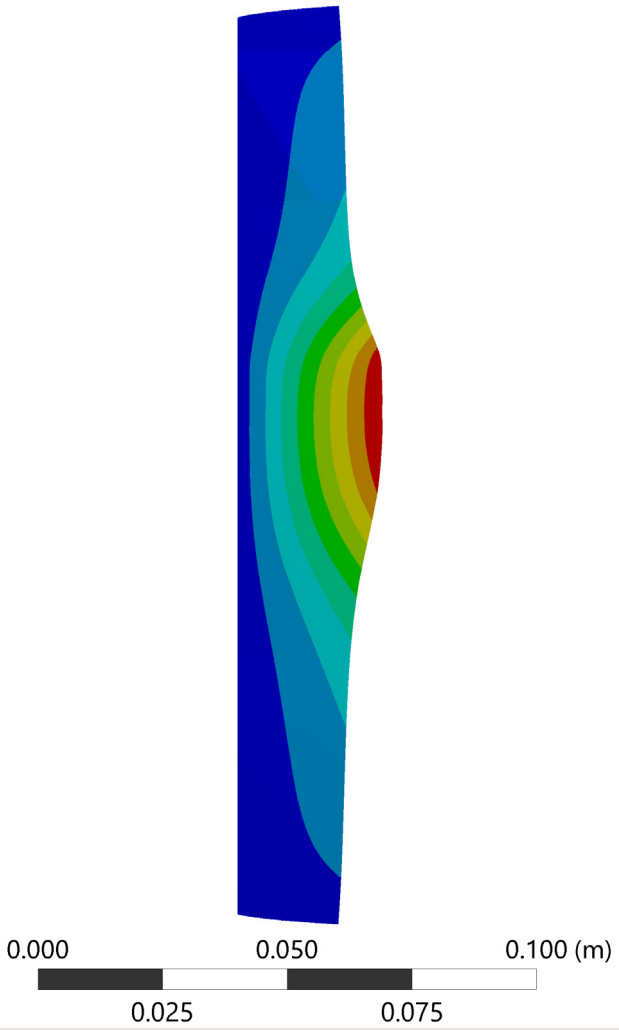
Converter Thermal Analysis 1mA - ANSYS

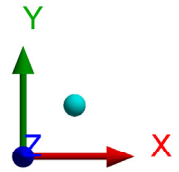


Structural Analysis 1mA - ANSYS

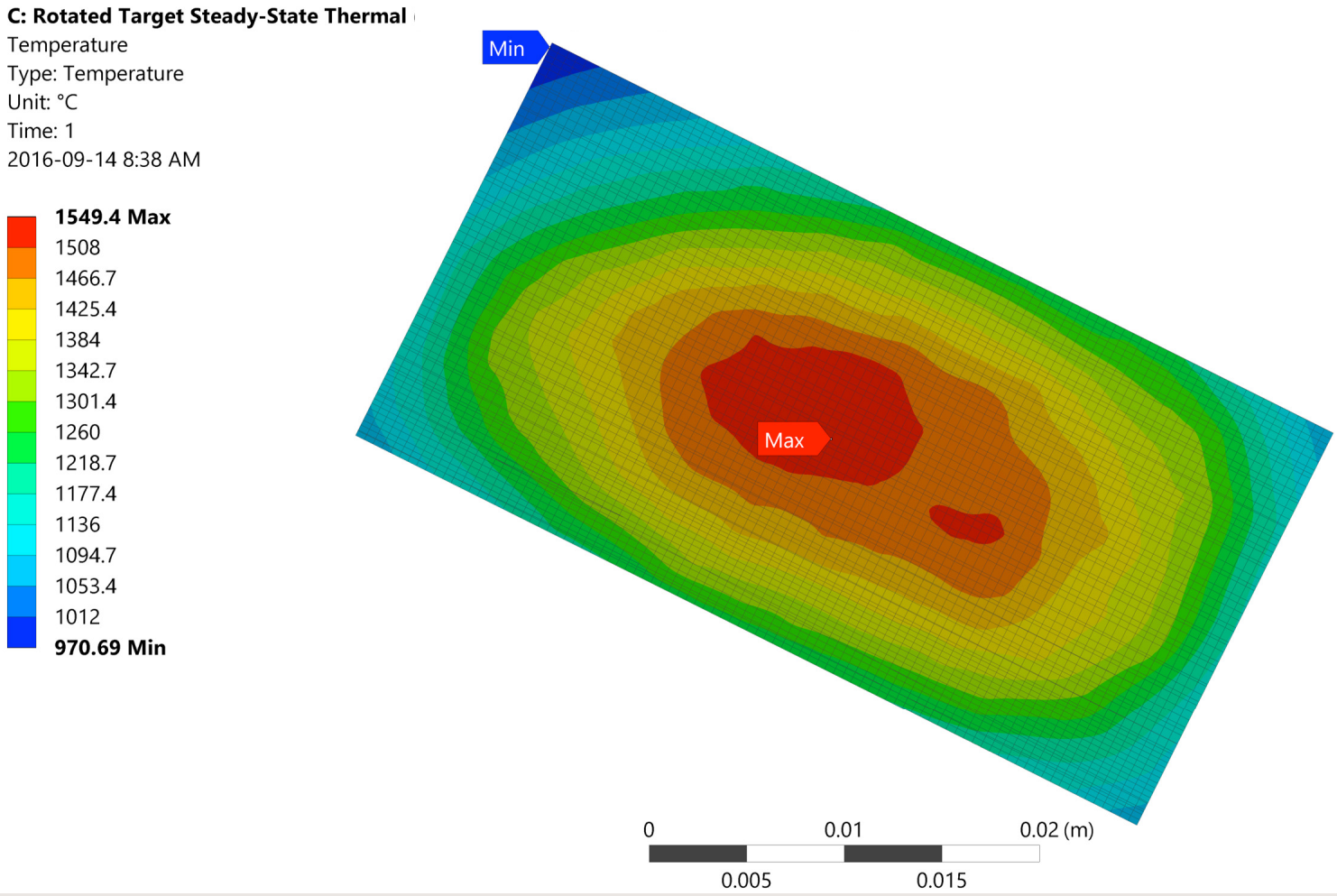
C: Foil Steady-State Structural (2cm, 1milliamps)
Directional Deformation
Type: Directional Deformation(X Axis)
Unit: m
Global Coordinate System
Time: 1
2016-09-14 8:36 AM

0.00036878 Max
0.00032652
0.00028426
0.000242
0.00019975
0.00015749
0.00011523
7.297e-5
3.0711e-5
-1.1547e-5 Min





Target Thermal Analysis 1mA - ANSYS



Summary

- Electron beam energy 50MeV
- Converter: 0.1 mm Ta foil
- Uranium Carbide Target: density = 3.5 g/cm^3 volume = 16 cm^3

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]
1.5	1.5 x 10^{11}	2722	921	1840	414	75
1	1 x 10^{11}	2370	614	1549	276	50

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 photon band
- Safety: in case of a converter failure the target is protected
- Water cooling system (external) away form the electron beam (water radiolysis)
- Design can be optimized further: (1) better tune -> wider beam spot on the Converter -> allows for higher beam intensities;
  (2) guiding the photons efficiently to the target

Linné et Léonie

TRIUMF

Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire
et en physique des particules

Thank you!
Merci!

Suggestions ?

Questions?

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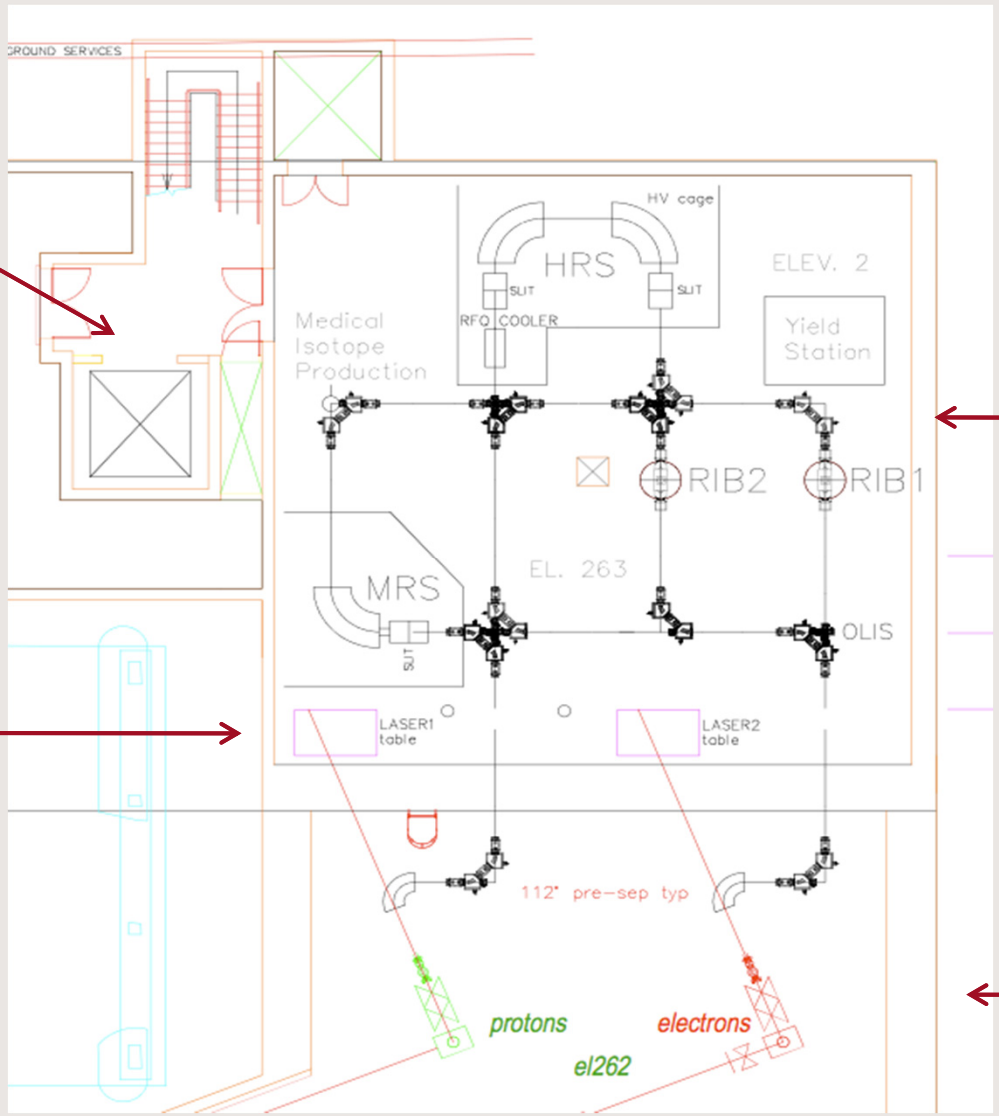
ARIEL Target Stations – Future R&D

Low Occupancy Area



Access Control Area

Laser Tables

Target Stations