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ELBEX beam dumps design at INFN Padova

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Electron beam dump, conceptual design as XTD20

- Dimensions and distances confirmation
- Angular positioning / inclination?
- γ beam pipe distance / interference?

- Requirements/ existing know-how / experience on cooling “granularity”?

- Concrete shield specs? thickness, 0.5m?
- Height of assembly from floor, support frame?
- Which degree of freedom for position adjustment of shield / support frame w.r.t. floor?
    - range of position adjustment?

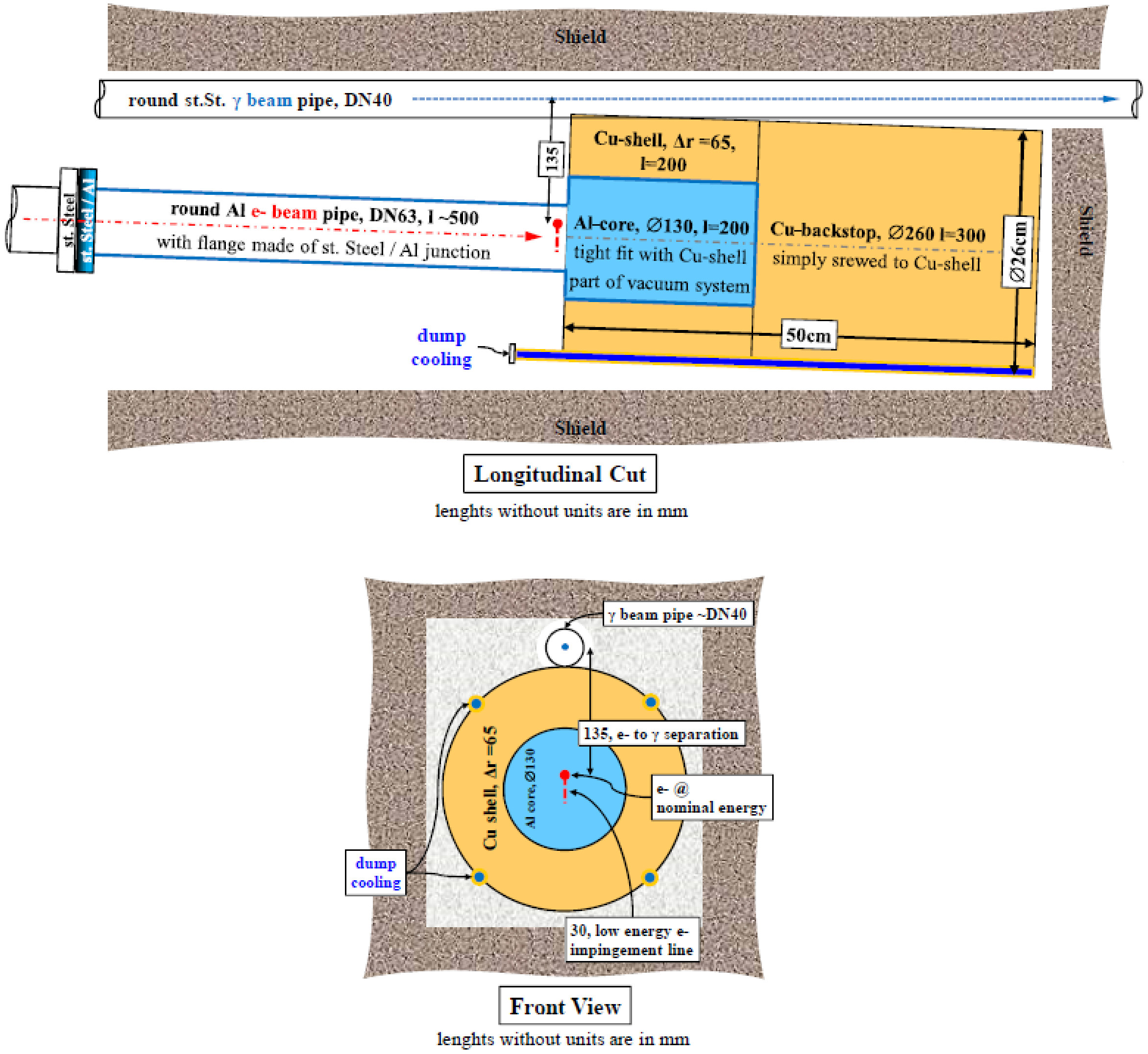
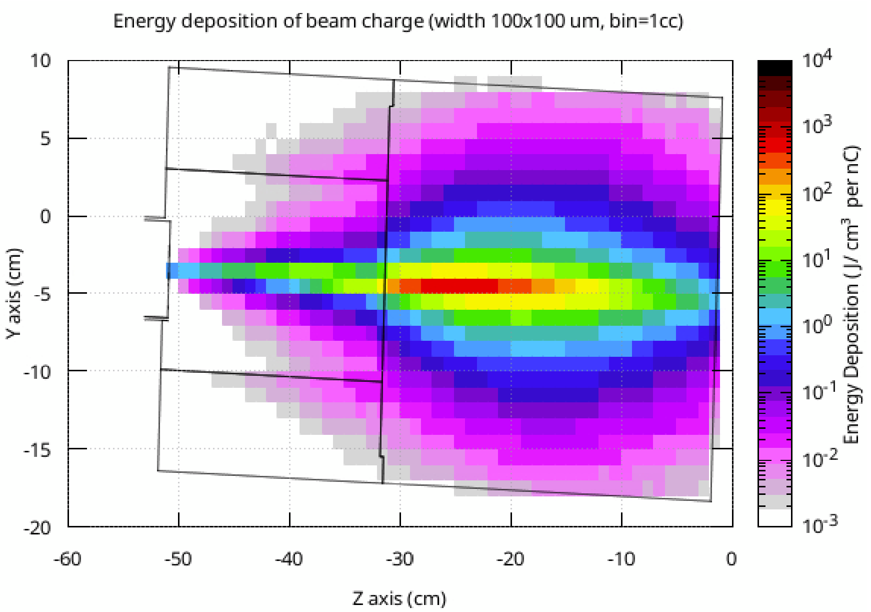
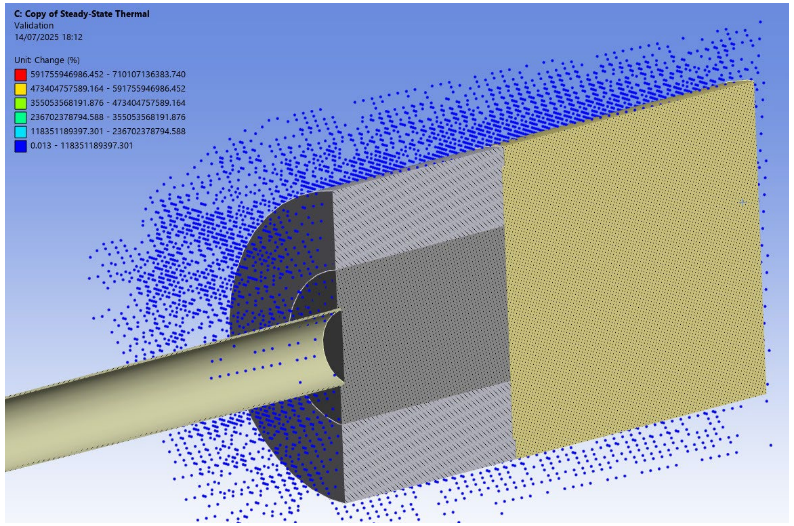


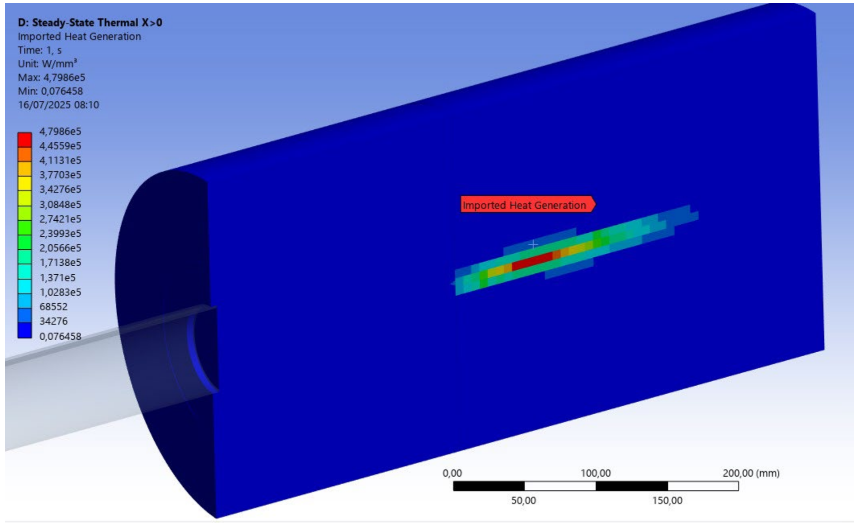
Figure 6.1: *Schematical layout of the LUXE beam dump.*

Electron beam dump, prelim. FEA simulations @ July

First results of import of Fluka output of power density

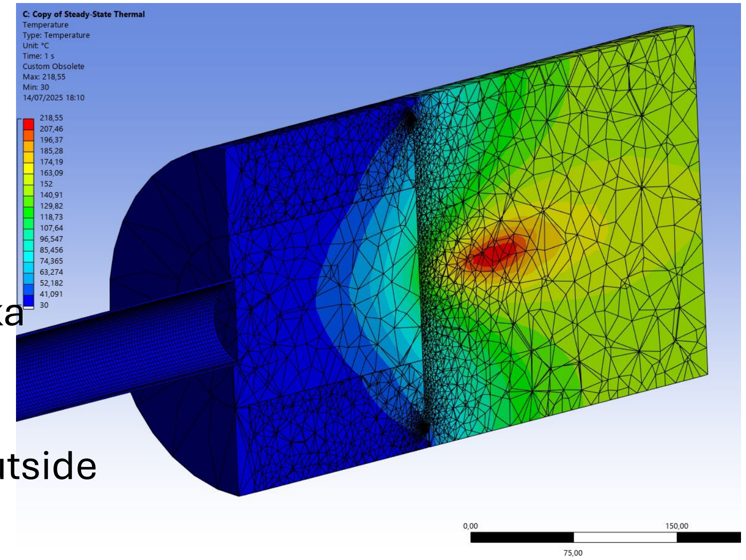


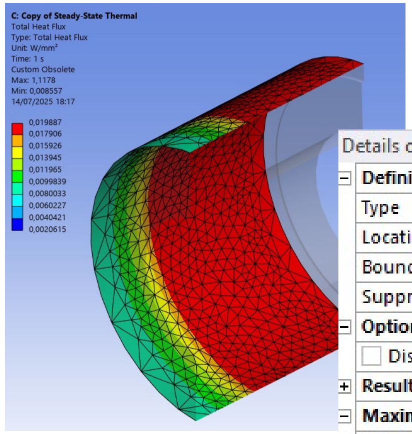




Still preliminary, to be refined and tested more…

- Overall reaction of temperature constraint congruent, 20 kW
- Geometrical distribution is congruent with Fluka map
- Power peak in the copper instead aluminum
  - => lower temperature ~ 220°C if cooled outside





Details of "Reaction Probe"

Definition	
Type	Reaction
Location Method	Boundary Condition
Boundary Condition	Temperature
Suppressed	No
Options	
Display Time	End Time
Results	
Maximum Value Over Time	
Heat	-19525 W
Minimum Value Over Time	
Heat	-19525 W
Information	

Electron beam dump, updated FEA thermal simulations

Importing Fluka output of power density released for different core materials:

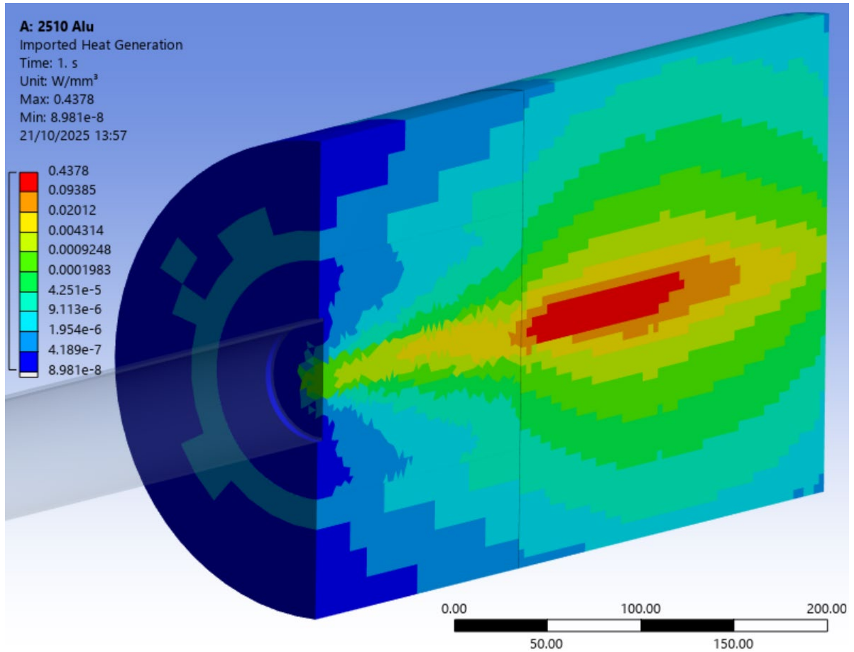
- Data produced by Sergii / Fluka for different cases of cores made of Al, Pb, W
- Discrepancy to verify between Fluka output and expected power, by factor 10^6 !!
  hopefully only due to units conversion
- Overall power after input data scaling: 9.9 kW on simulation geometry = half dump => 19.8 kW overall on beam dump on all cases

- Different materials imply different distribution/position of heat generation + effect of different thermal conductivity, assumed:
  - Pb: 35 W/mK
  - Al: 150 to 170 W/mK (from room temperature to 150°C)
  - W: 170 W/mK
  - Cu: 400 W/mK
- Constraint: uniform temperature constraint on full outer cylindrical surface :
  - 30°C, to account / guess Dt between coolant and ducts walls
  - Very roughly representing uniform water cooling on the periphery … to be improved
- Assumed all 3 parts (core, shell, backstop) in perfect thermal contact each other ….

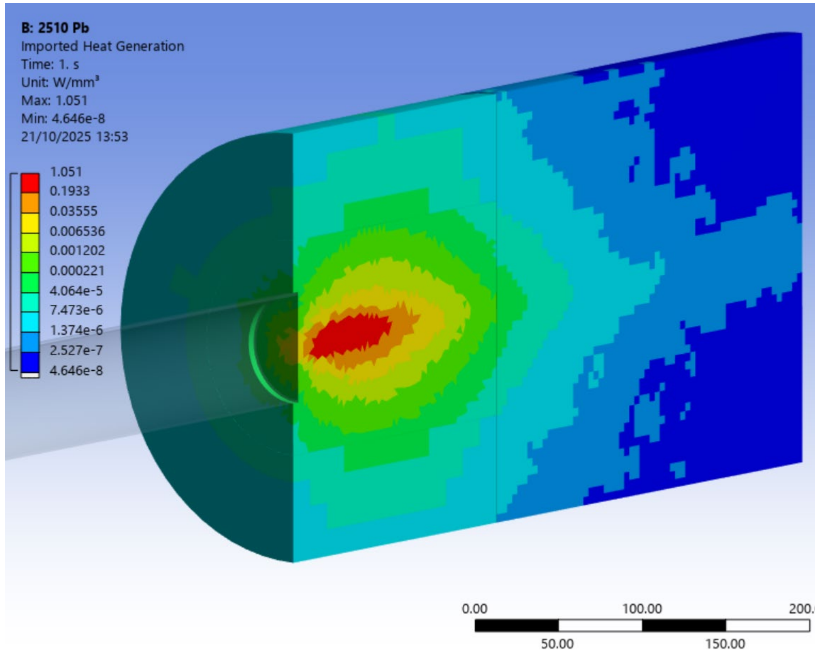
Electron beam dump, updated FEA thermal simulations

Heat power density (as imported from Fluka output /10^6, logarithmic scale) :

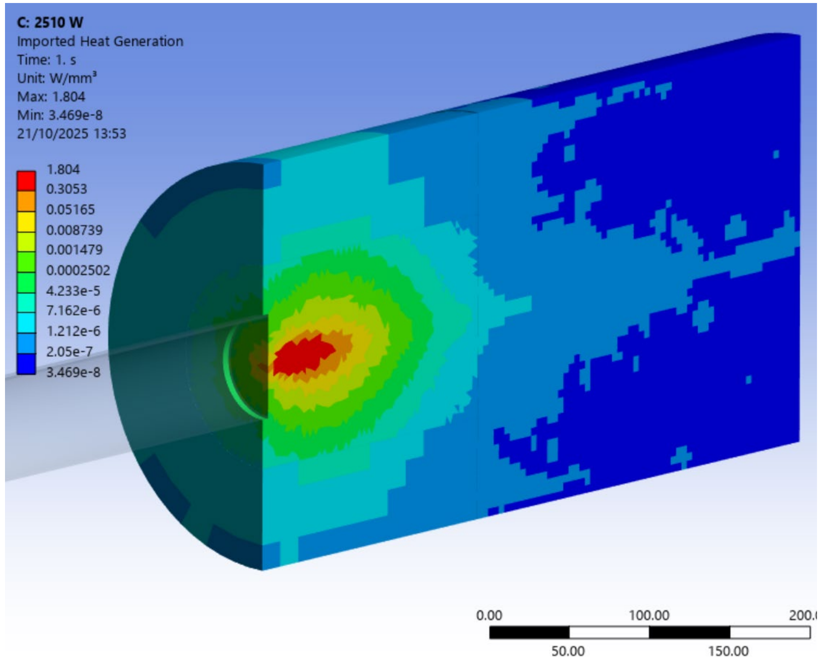
Aluminum: ~ 0.44 W/mm3 (on Copper)



Lead: ~ 1 W/mm3



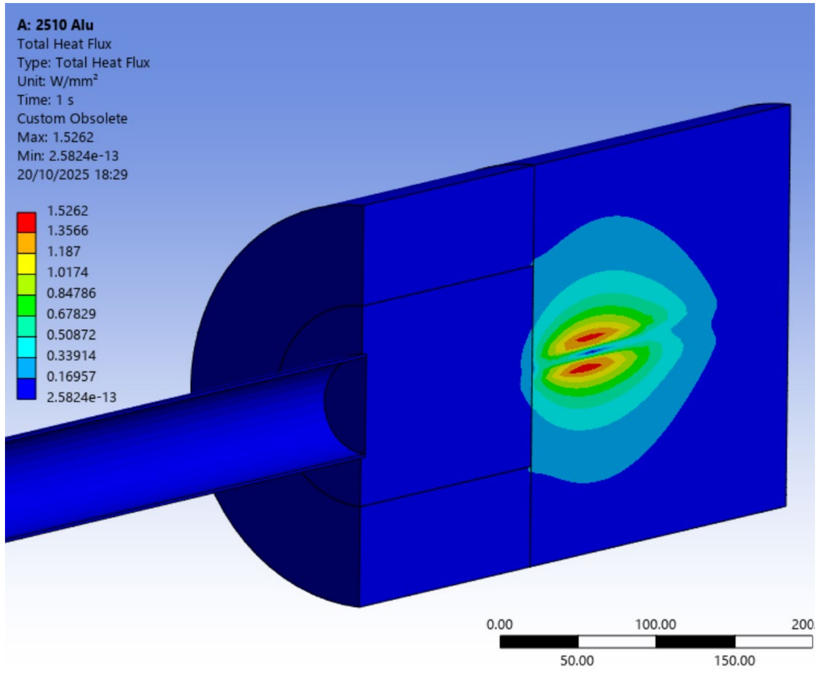
Tungsten ~ 1.8 W/mm3

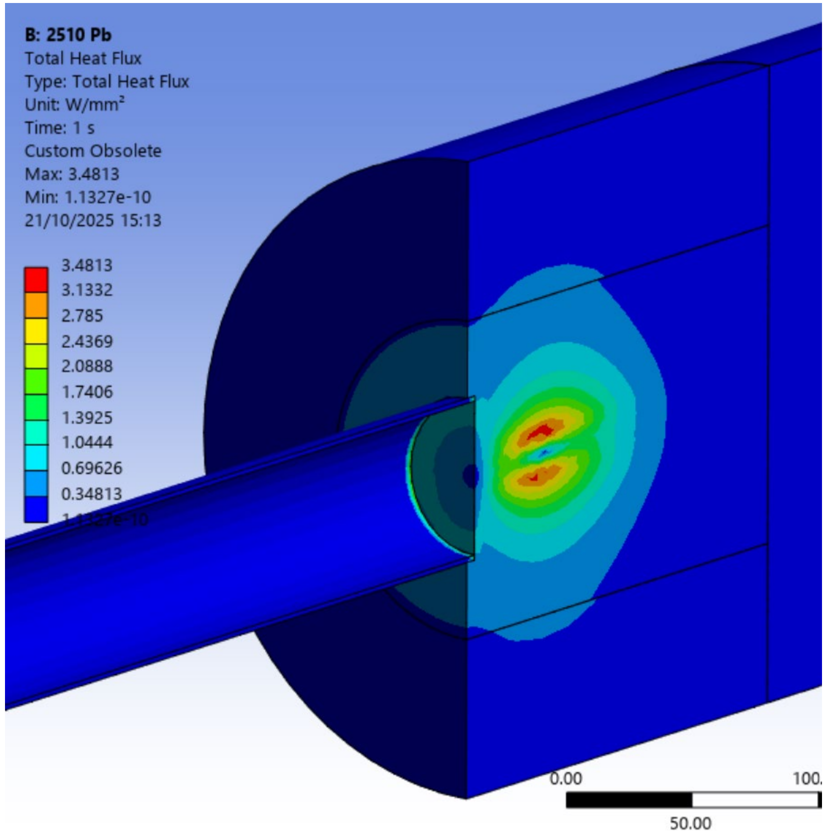


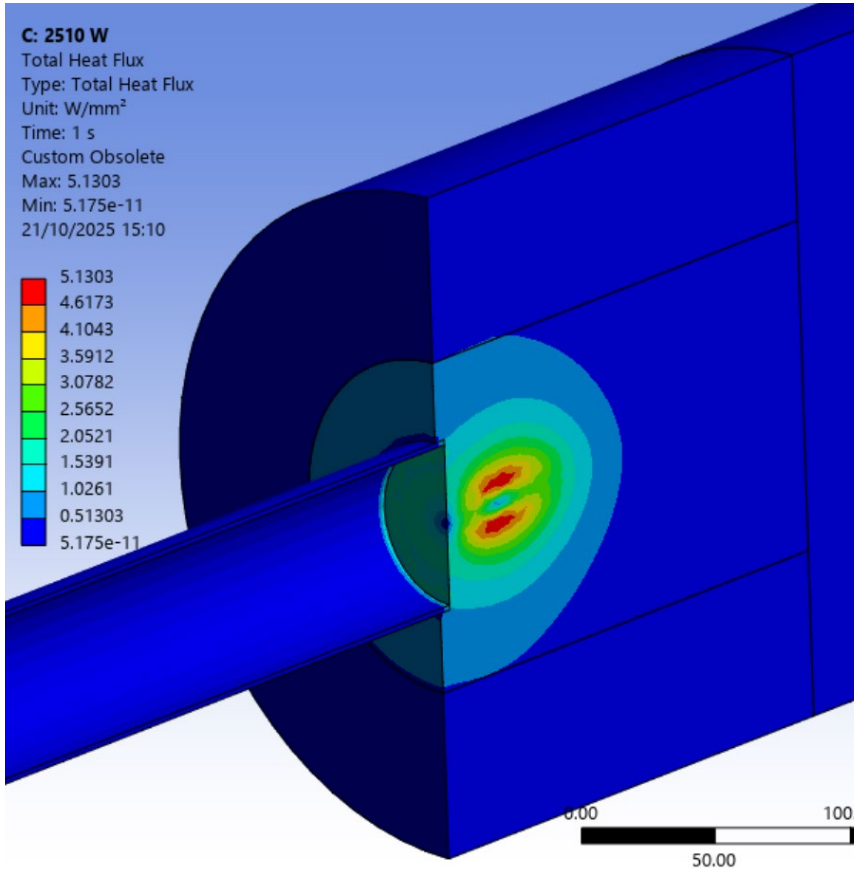
Electron beam dump, updated FEA thermal simulations

Internal heat flux :

Aluminum: ~ 1.5 W/mm2 (on Copper) Lead: ~ 3.5 W/mm2 Tungsten ~5 W/mm2



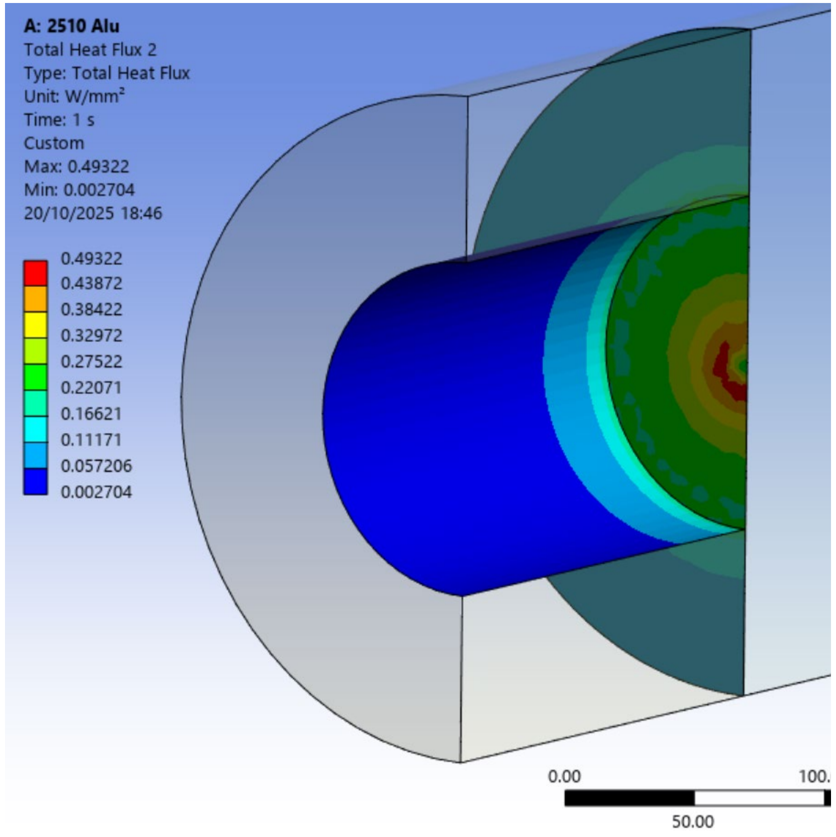




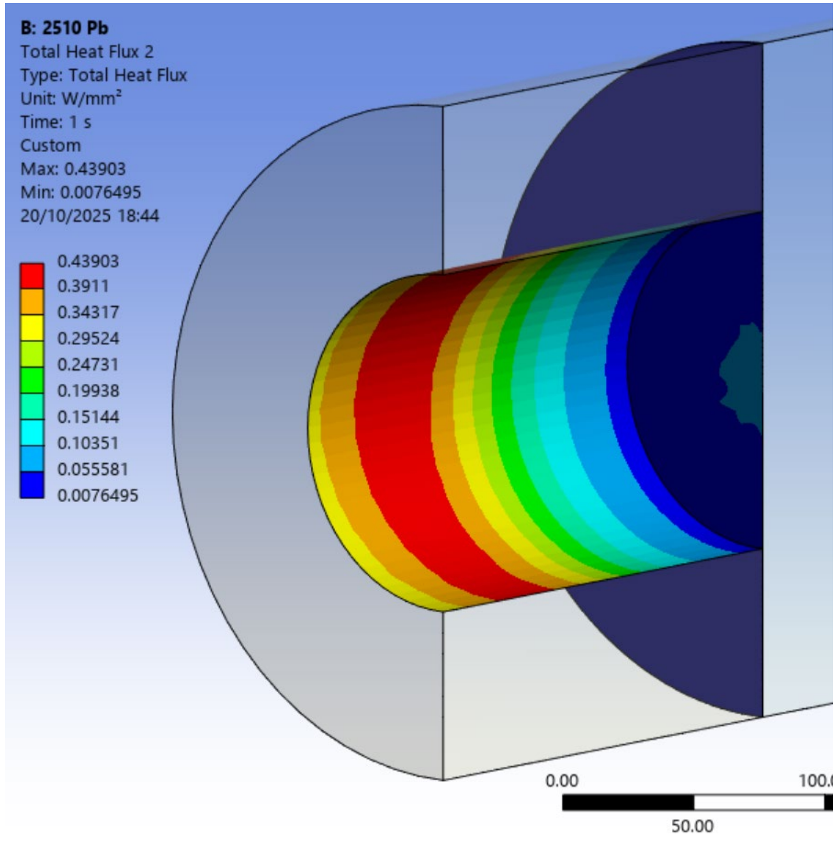
Electron beam dump, updated FEA thermal simulations

Core to shell and backstop - heat flux :

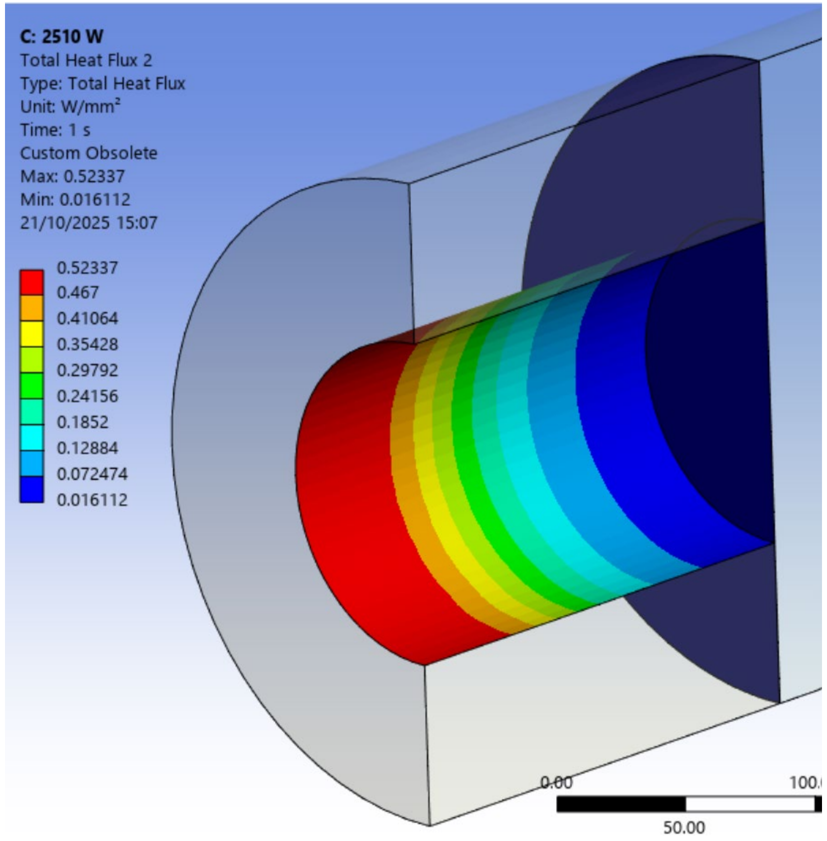
Aluminum: ~ 0.49 W/mm2



Lead: ~ 0.44 W/mm2



Tungsten: ~ 0.52 W/mm2



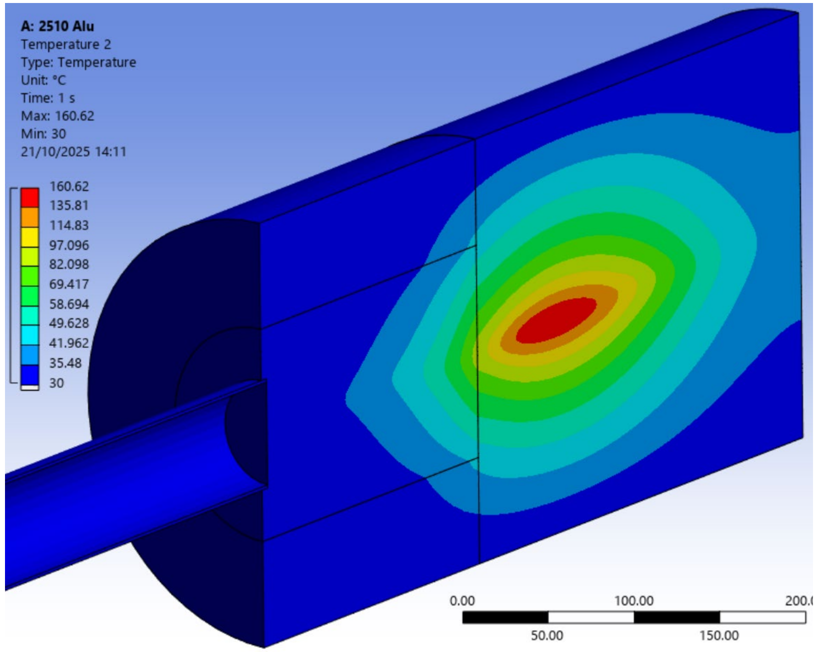
Electron beam dump, updated FEA thermal simulations

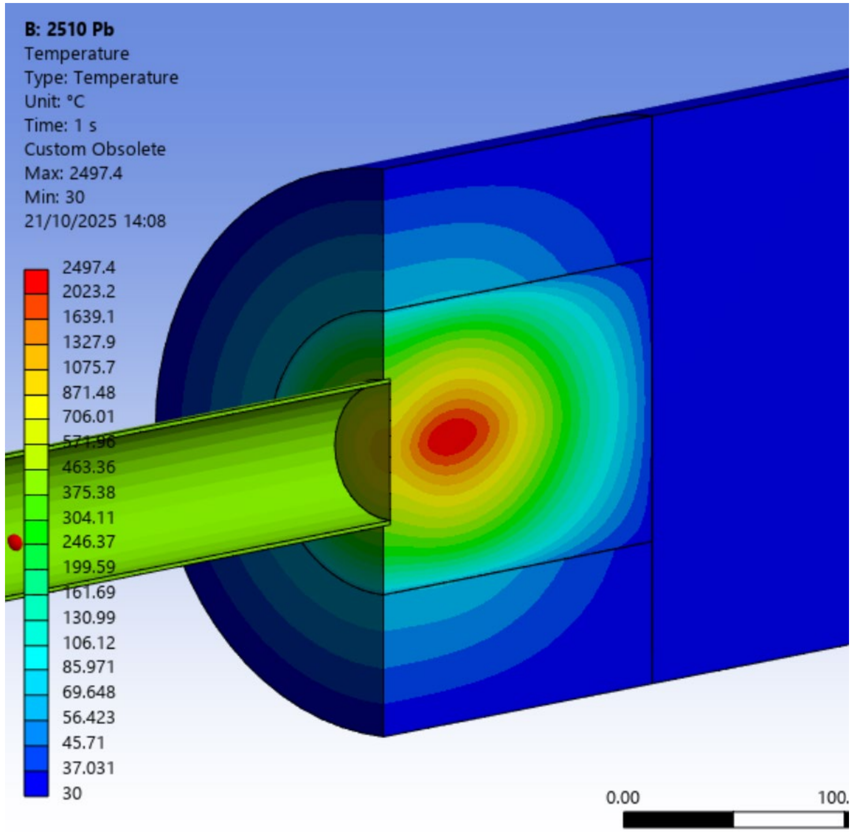
Temperature (logarithmic scale)

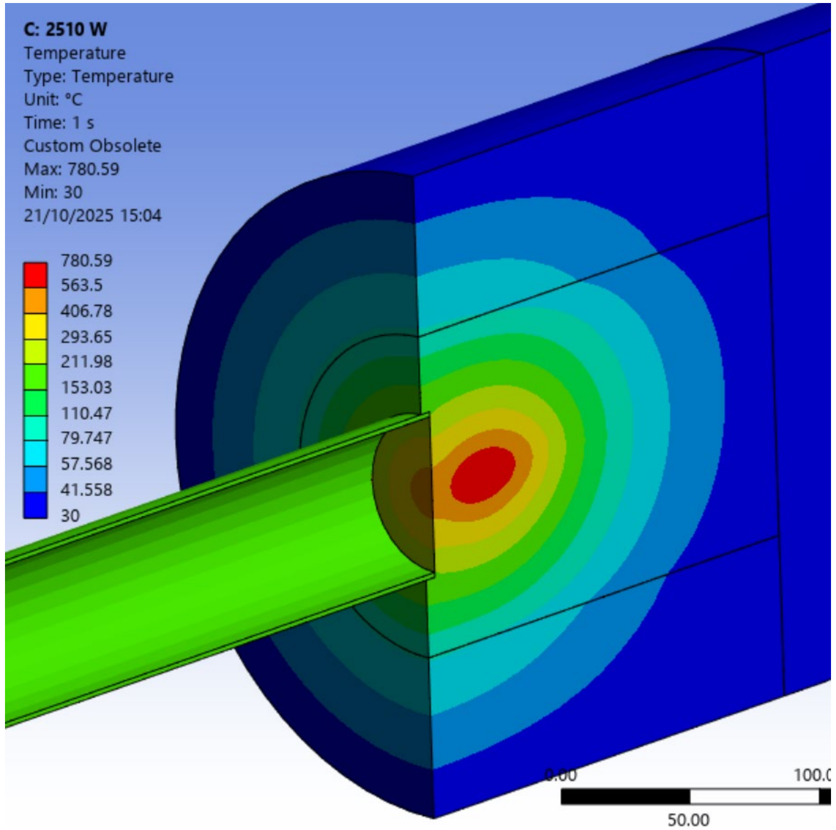
Aluminum: ~ 161°C (on Copper)

Lead: ~ 2497°C!!

Tungsten: ~ 780°C







Temperature depending on heat load concentration and material conductivity

Aluminum core and copper dump => best choice in term of temperature control

Best with low density material to spread/reduce power peak (need length) and very good thermal conductivity

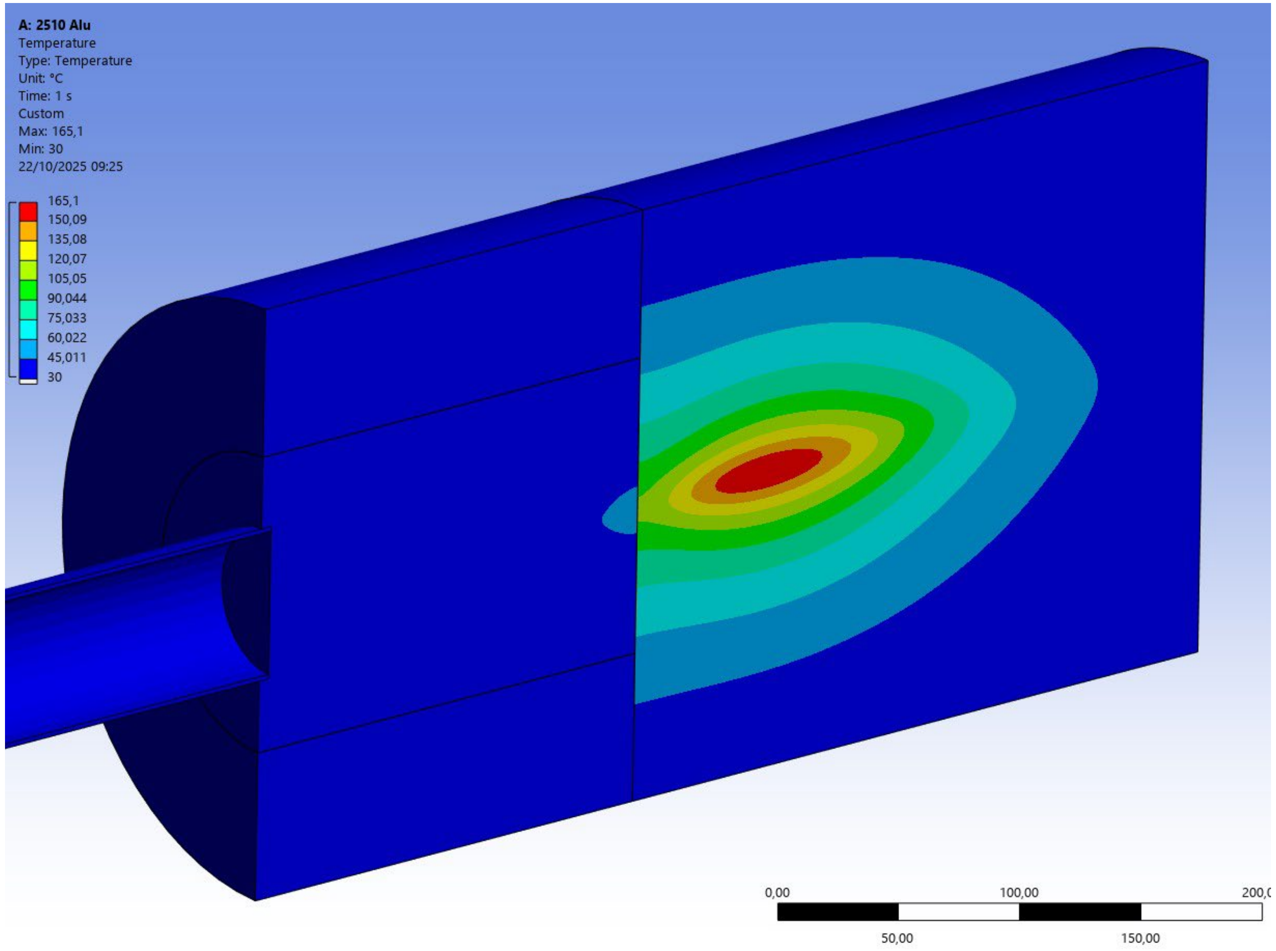
Electron beam dump, updated FEA thermal simulations

Also tested:

- Adding cooling on back face (effect negligible)
- Removing thermal contact between backstop and core + shell: up to +5°C

- Without thermal contacts, reaction of temperature constraints:
- ~ 280W on shell (~ 2.8%)
- ~ 9620W on back copper

Cooling of Al core and Cu shell negligible => with this power distribution, front part don’t need active cooling, contact and convection could be enough



Electron beam dump, position w.r.t. beam deflection "point"

```
Input from Ruth:
Dump diameter 26cm, length 50cm
Beam pipe diameter 4cm
Height of beam axis above tunnel floor 1.4m
Electron energy 40GeV
⇒ …… deflection angle of 0.9° and minimum horizontal distance of 9.6m between the dipole and the
   dump to fit the cylindrical part of the dump just underneath the beam pipe.
⇒ …… dump … to be lifted up by 1.13m on some support structure.
```

Assuming:

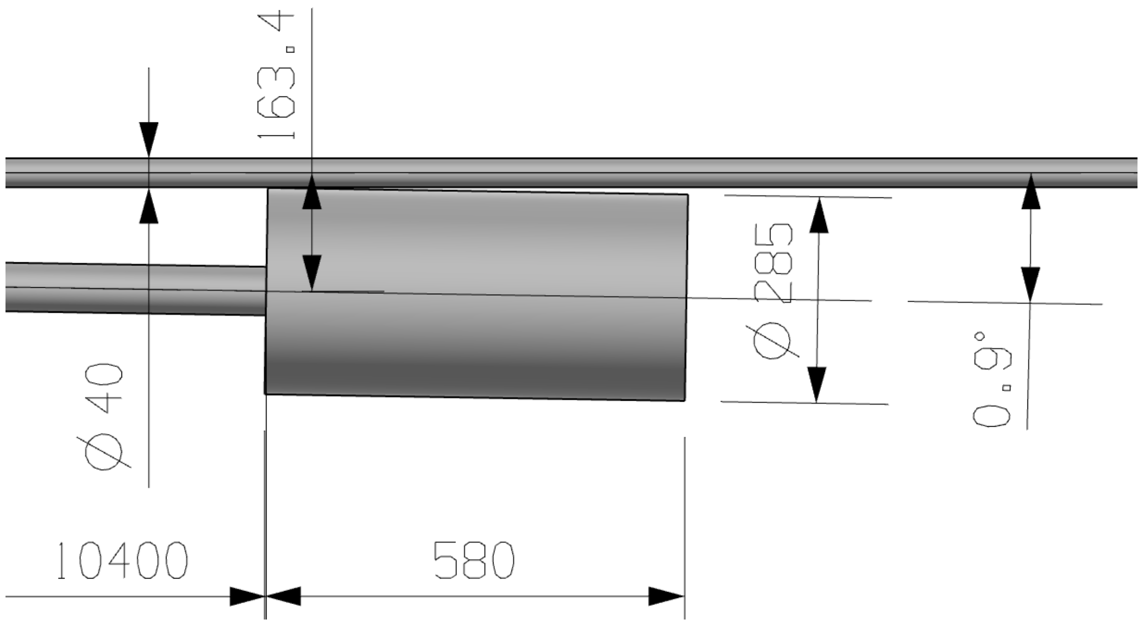
- point-like deflection of 0.9°
- dump tangent to γ beam pipe
- Φ beam dump 285 mm

min. distance between nominal deviation point and dump to avoid interference with γ beam pipe:

Beam splitting @ ~ 10.4m if Φ 285 mm, ϕ 40 mm

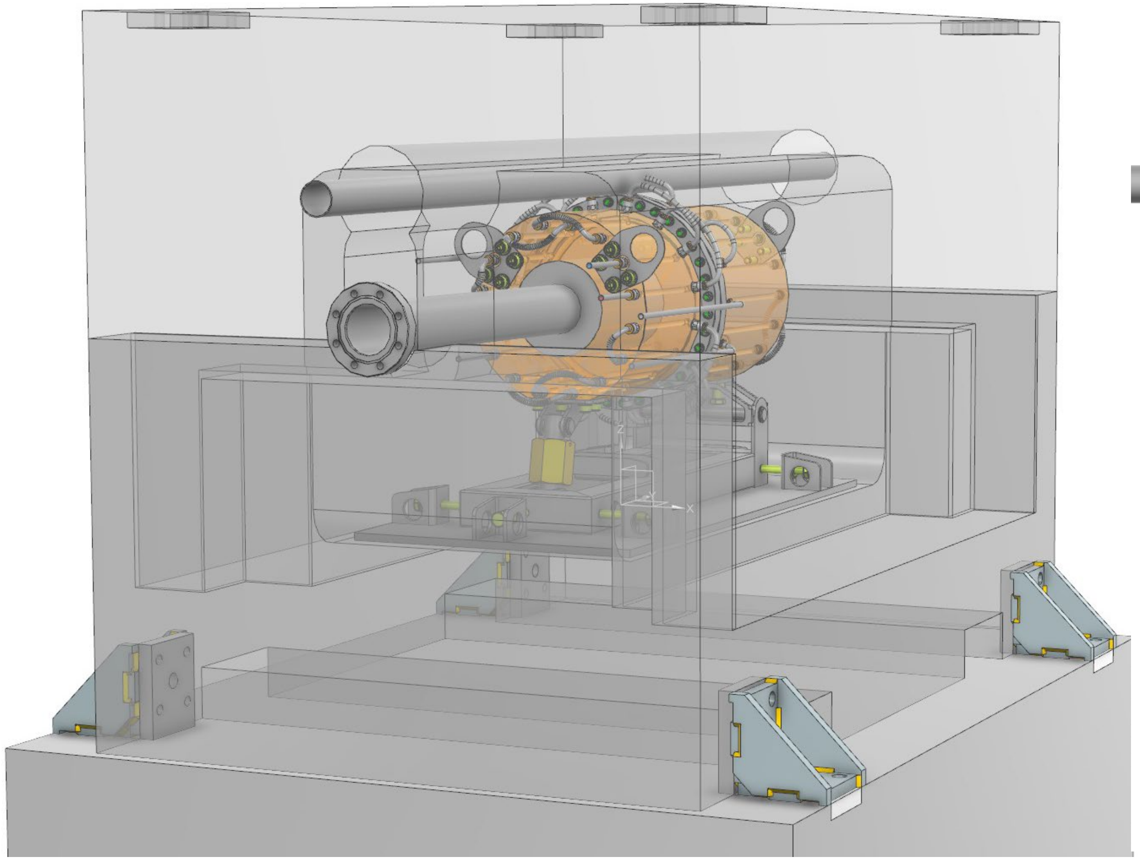
Beam splitting @ ~ 11.3m if Φ 285 mm, ϕ 60 mm

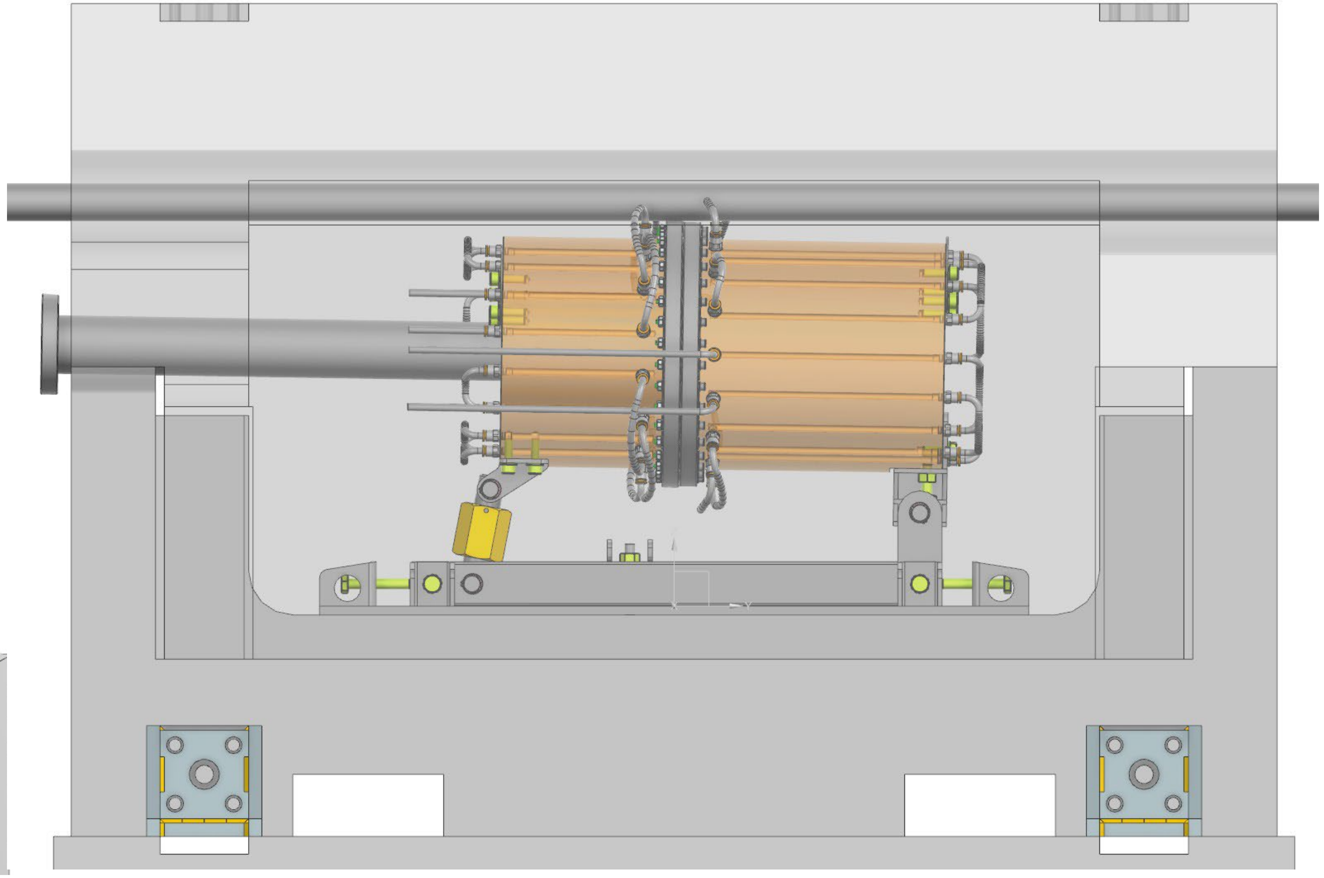
If beam splitting @ ~ 9.6 m, Φ 285 mm, ϕ 40 mm
=> 12 mm interference on "Cu shell edge"



Electron beam dump, current design status, preliminary proposal

- Preliminary design of dump with cooling loops on outer diameter
- 3 points adjustable support to adjust beam dump angle and high
- Adjustable and lockable base frame w.r.t. concrete, to adjust position/orientation in the horizontal plane
- Interference with γ beam pipe implies larger cut to allow adjustment
- 20 cm thick concrete shield, ~ 20kN weight





Thanks !