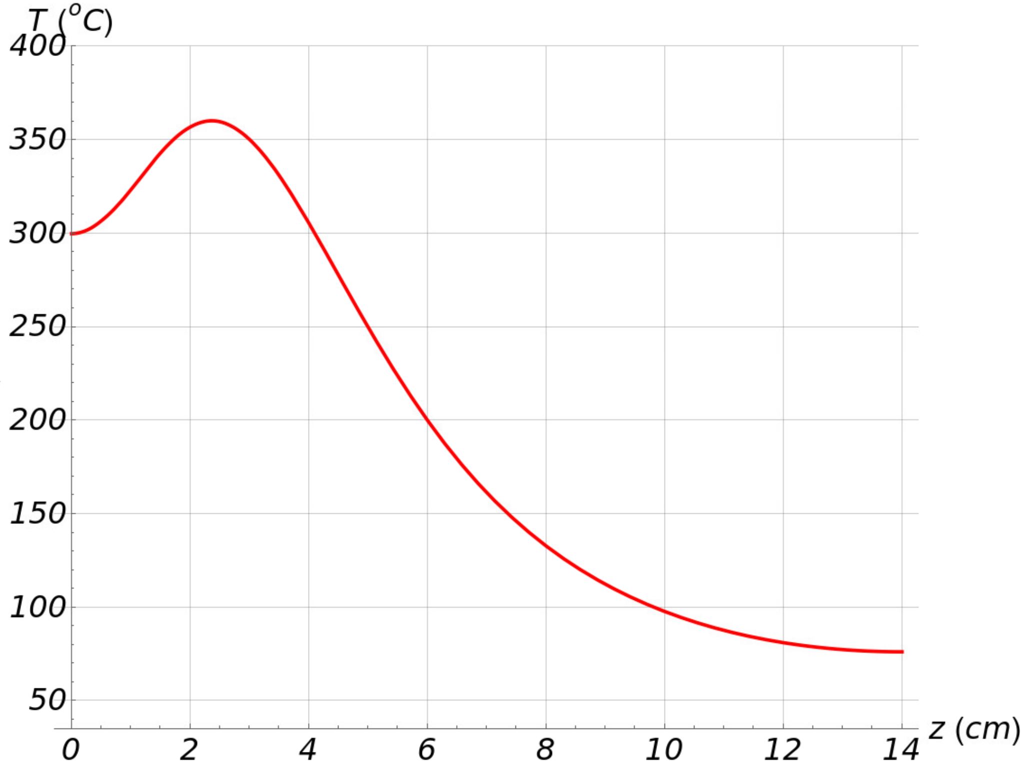
Tungsten Plug Temperature Estimates with a 20% Radiator

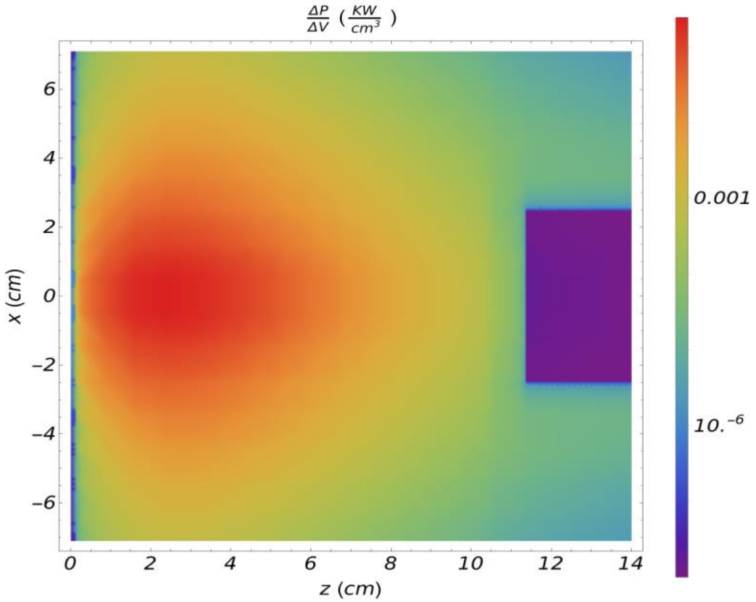
Hovanes Egiyan

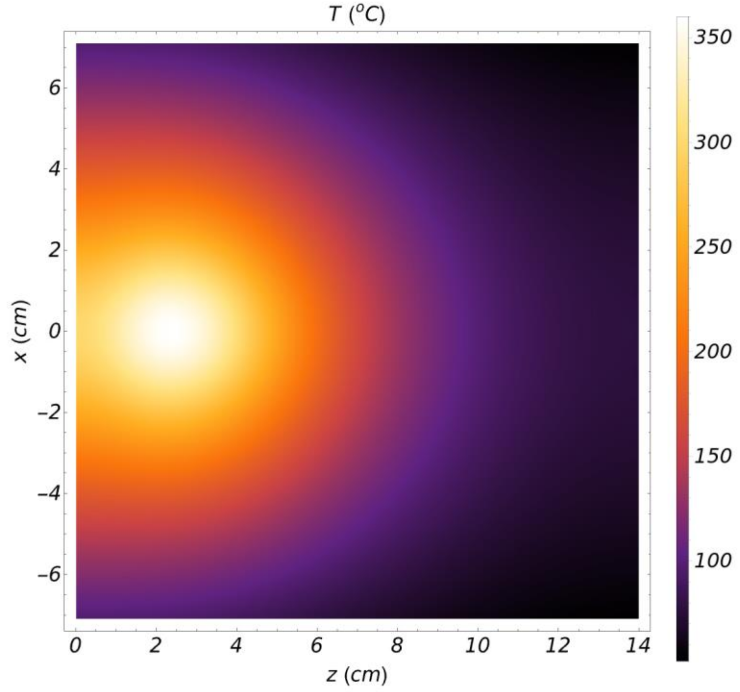
Simplified Approach

- I multiplied the power deposition density from Vitaly by a factor of x2.
  - Does not account for a wider beam spot at the KPT.
- Power deposition in "tungsten plug area" of P~11.4 KW.
  - Missing power at the back since Vitaly used 10cm W-plug in FLUKA.
- Cooing only from the four sides of the cube, like what is in the engineering model.
  - Water temperature T=35 ^{0}C
  - Heat exchange coefficient 5000 W/(K m^2).
  - Thermal conductivity 146 W/(m K).
  - No colling from upstream or downstream of the tungsten block.



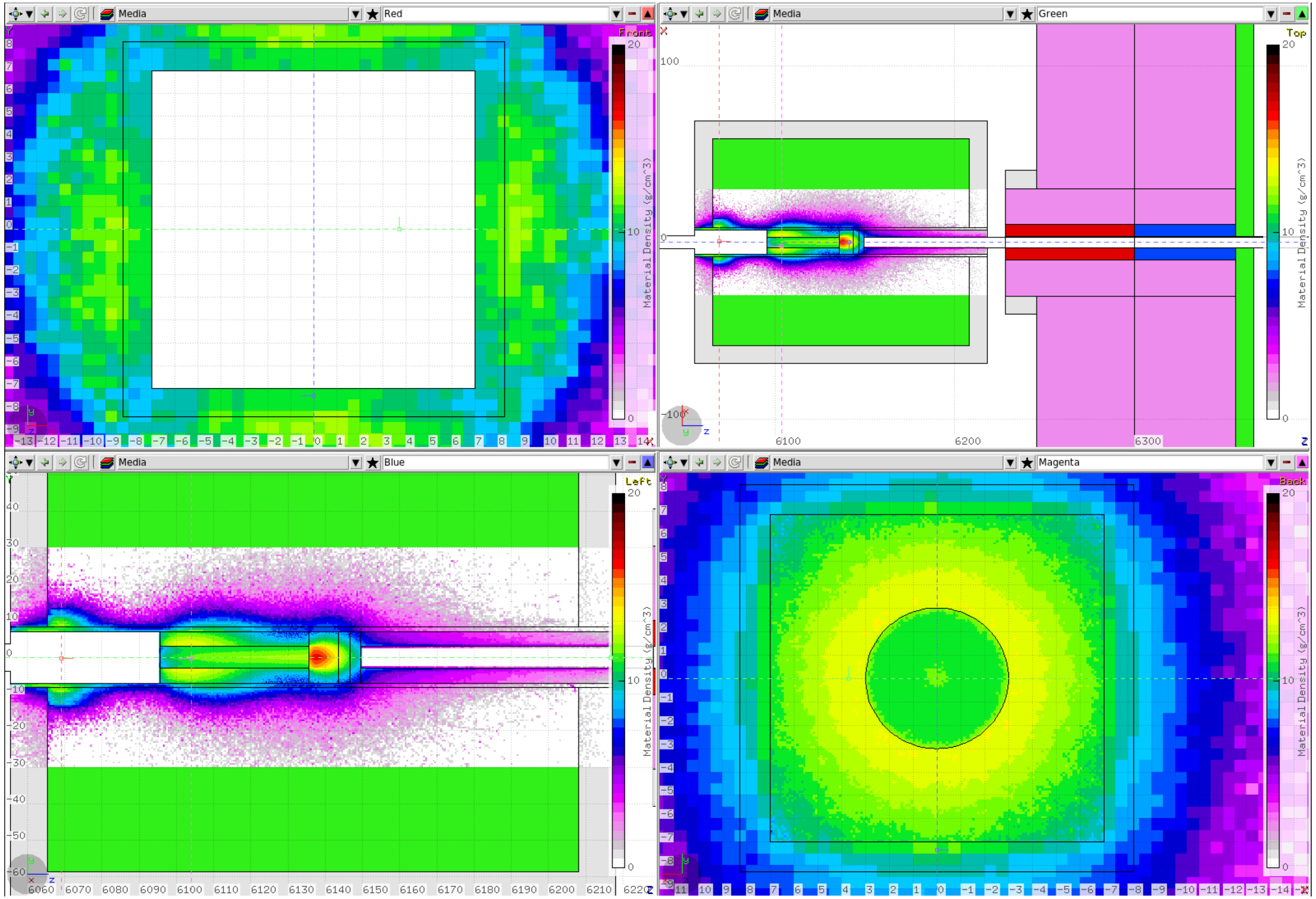
Power deposition data from Vitaly x2

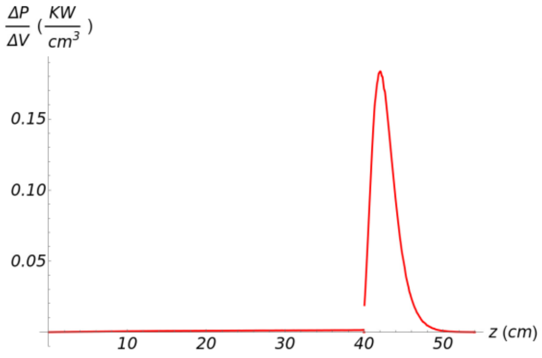




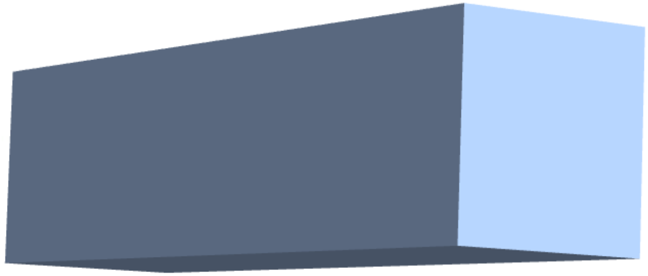
FLUKA Input

- Use power deposition from Pavel's FLUKA model with a 20% radiator.
- Be target is D=6cm wide.
- There is a copper box all around Be target.
- 14 cm long tungsten block after the Be target.
- No Active Collimator in FLUKA.
- Power deposition in the plug is about the same as for Vitaly's model 10% radiator
  - Total power in the file is 9.4 KW.
  - Power deposited in the plug itself is 5.8 KW.
  - The copper around beryllium receive ~2.8 KW.
  - Be-target receives ~420 W of power.
  - ~1.5 KW is missing from ~10.9 KW of the photon beam power of 20% radiator.
- Increase of power deposition seems to happen be before (~0.4 KW) and around the Be target (~2.8 KW) .
- Cooling may be required for the all length of the photon beam channel in the KPT.
  - There is steel pipe/support in the engineering model lining the KPT photon beam channel that can be cooled.

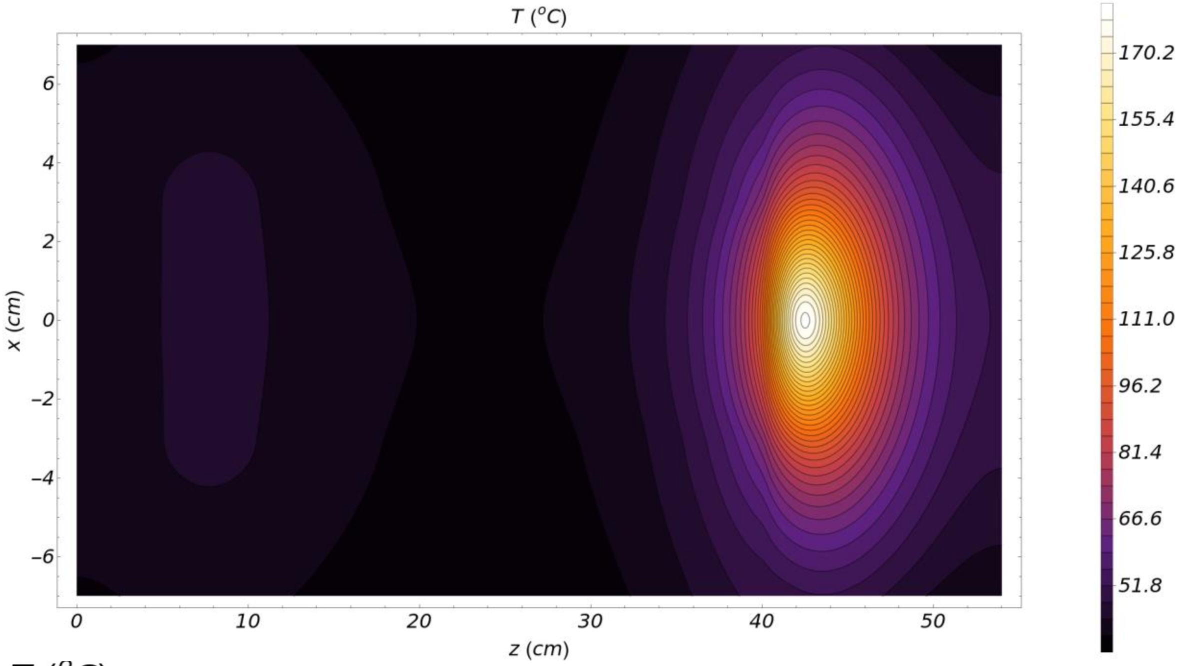


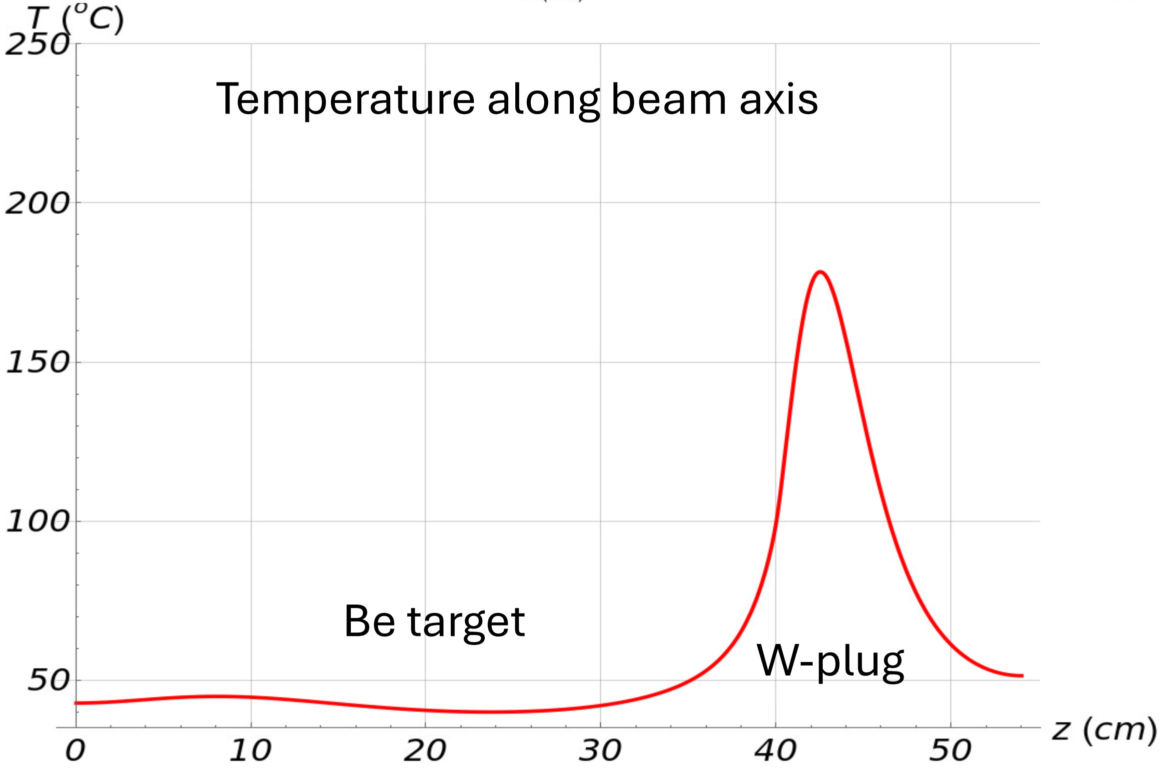


Solid Block

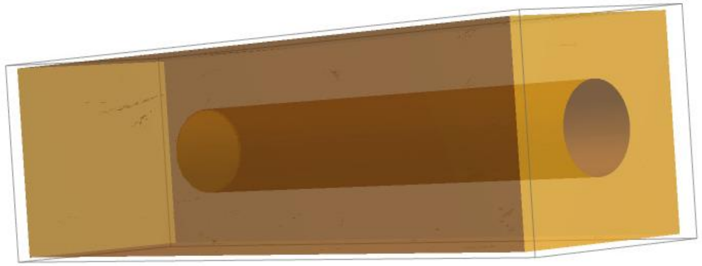


- Assume a solid block for the volume of copper, beryllium, and tungsten.
  - Thermal conductivity 146 W/(m K) for W, 216 W/(m K) for Be, 385 W/(m K) for Cu.
- Cooled from four sides directly with cold water
  - Underestimate temperature everywhere.
  - Water temperature T=35 ^{0}C
  - Heat exchange coefficient 5000 W/(K m^2).
- T_{max}~180 ^{0}C is even lower than T_{max}~205 ^{0}C with 10% radiator and plug length of 10 cm.
  - Probably because of larger cooling area.
  - Tungsten block is now CuW compound.
- If only W-block is cooled, the upstream end of Be-target may reach T~500 ^{0}C with no other way of heat dissipation.
  - Need to cool the sides of the whole target&plug block, or possibly the whole photon beam channel.



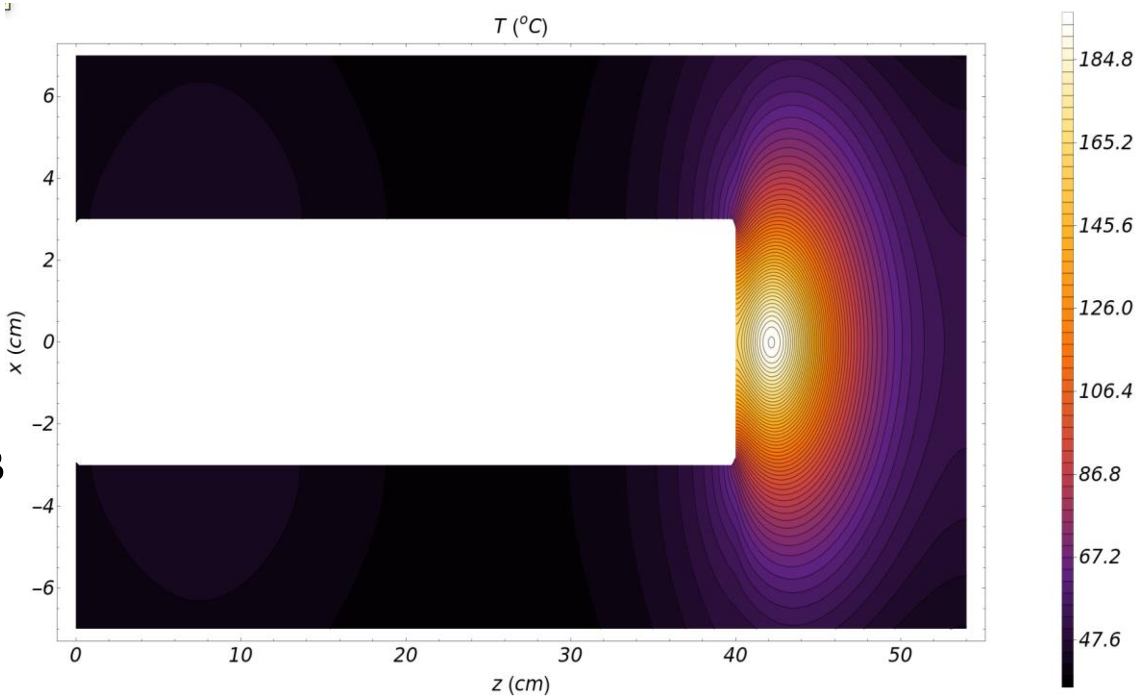


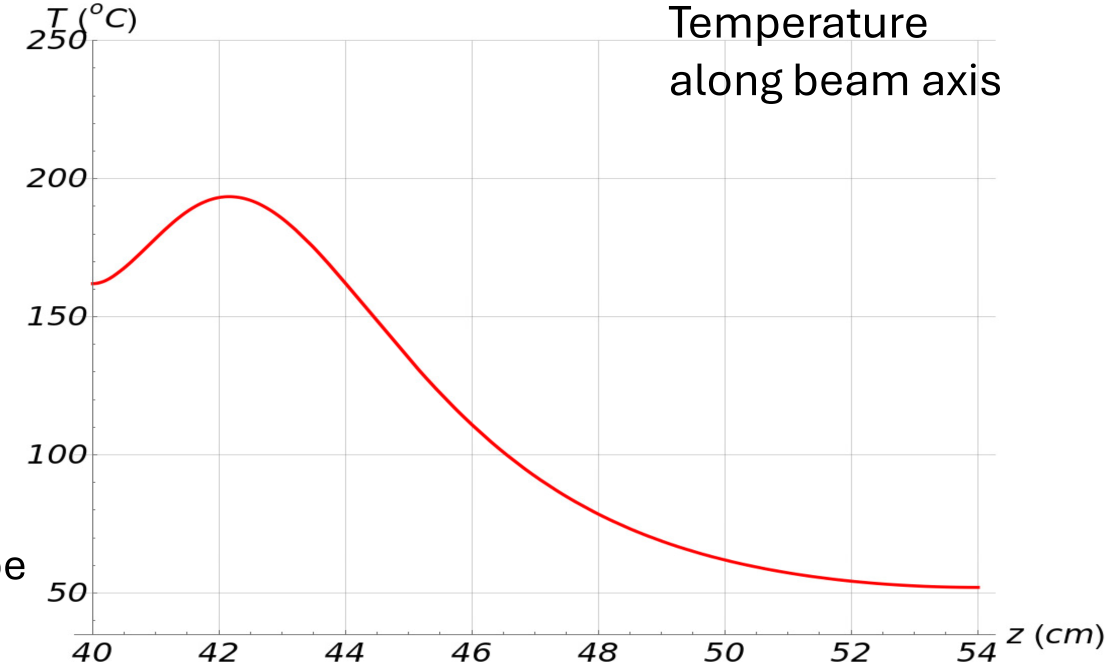
No Be-target



- Solid block of tungsten and copper, but the Be target cylinder removed.
  - Thermal conductivity 146 W/(m K) for W and 216 W/(m K) for B
- Cooled from four sides with water
  - No heat flow to or from Be target, or upstream or downstream ends of the solid block.
- T_{max}~195 ^{0}C in the W-plug is even lower that the one with 10% radiator and plug length of 10 cm.
  - A little bit higher temperature compared to previous slide probably because the heat flow upstream is blocked by the "missing" Be-target volume.
- This will need to be evaluated and designed by Tim.

- From point of view of the tungsten plug temperature distribution, 20% radiator is feasible.
  - The spread of the γ-beam due to multiple scattering seems to be significant requiring cooling of the larger areas in KPT.





Temperature along beam axis

W- plug 10 cm, 10% radiator

Engineering design for KPT and the cave mostly exist.

- K_L beamline and KFM still needs to be designed.
- Likely to have engineering drawings ready by the fall of 2025.

May be rejected or commented on at the ERR-II due to high detector rates.

- Implementing and answering such comments may take a long time and resources.

W-plug ~14cm, 10% radiator

More engineering design is needed.

- KPT plug needs to be redesigned.
- K_L beamline and KFM still needs to be designed.
- Factor of ~2 less statistics.

Should be possible to be ready by ERR-II.

- May get an ERR-II recommendation to evaluate a >10% radiator option to fully benefit from the beam time.

W-plug ~14 cm, >10% radiator

More extensive efforts are needed.

- KPT plug and cooling, and possibly AC, need to be redesigned.
- K_L beamline and KFM still needs to be designed.
- Small modifications to CPS engineering design may be needed.
- Will recover full projected luminocity

May be difficult to be ready by the fall.

- We need to pass ERR-II to be schduled for installations.

A decision needs to be made very soon!