

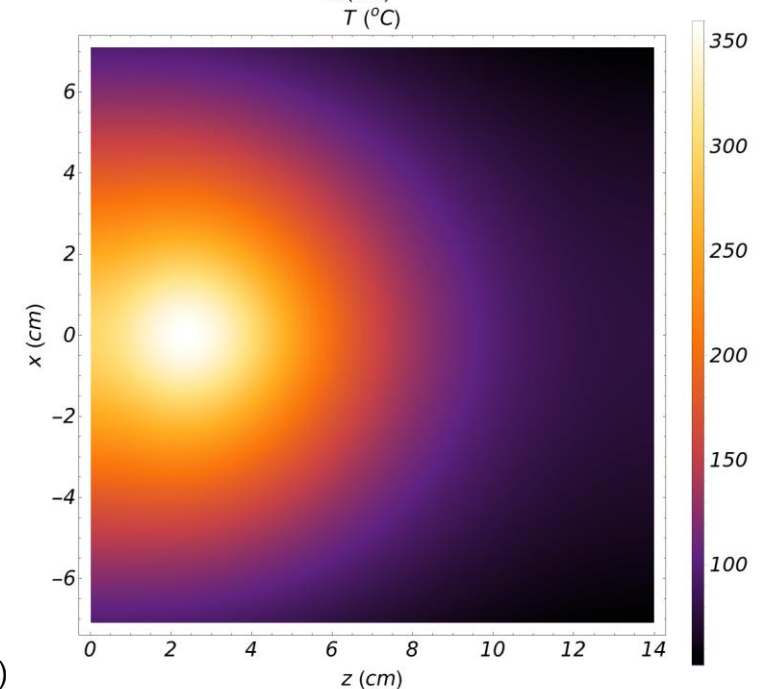
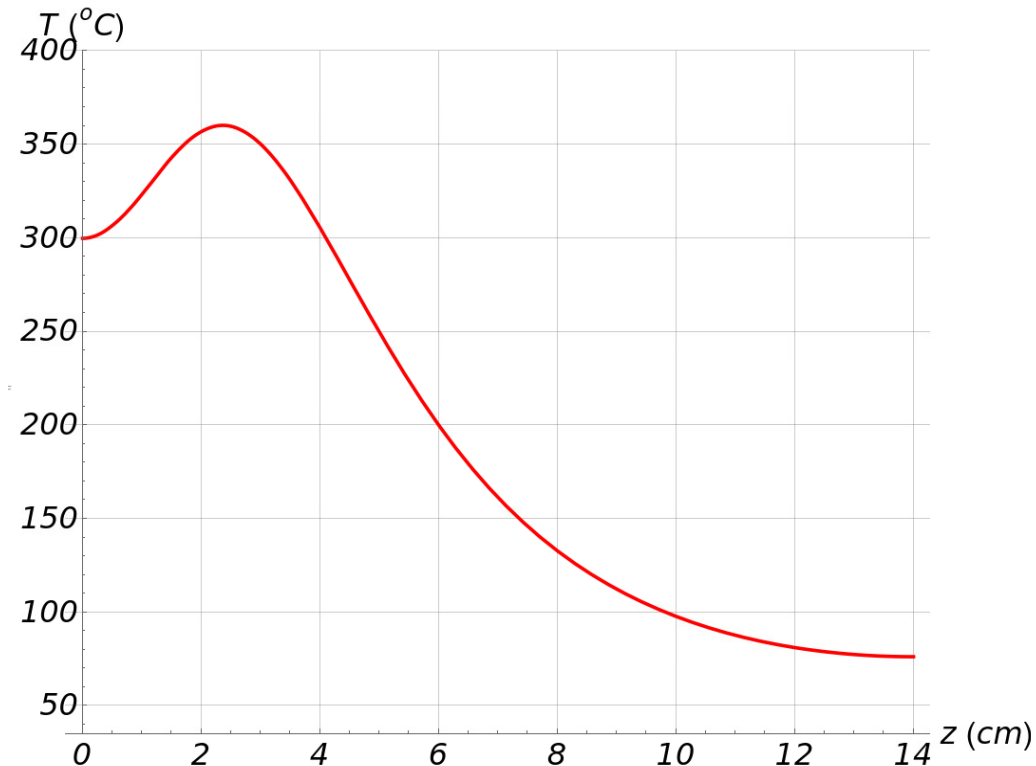
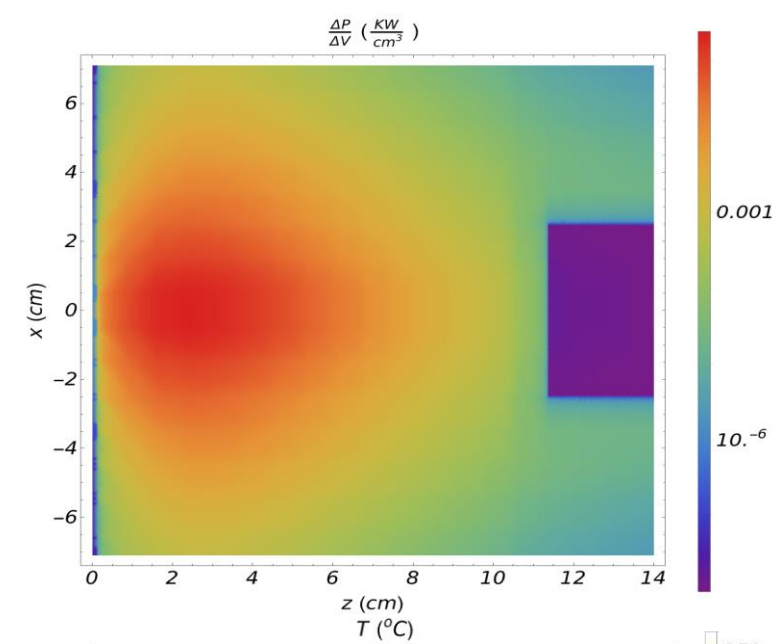
Tungsten Plug Temperature Estimates with a 20% Radiator

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Simplified Approach

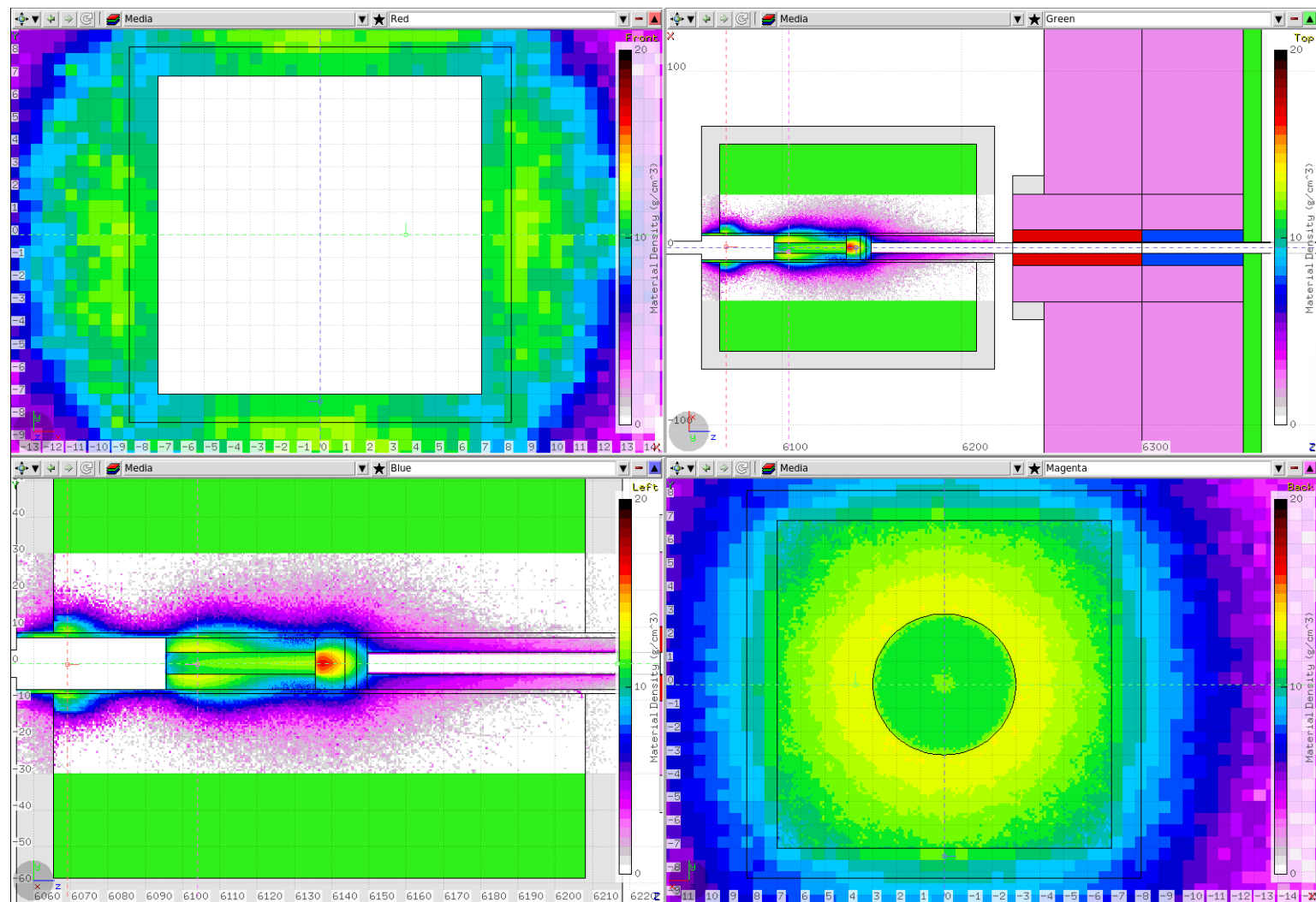
- I multiplied the power deposition density from Vitaly by a factor of x2.
 - Does not account for a wider beam spot at the KPT.
- Power deposition in "tungsten plug area" of $P \sim 11.4$ KW.
 - Missing power at the back since Vitaly used 10cm W-plug in FLUKA.
- Cooling only from the four sides of the cube, like what is in the engineering model.
 - Water temperature $T = 35$ °C
 - Heat exchange coefficient 5000 W/(K m²).
 - Thermal conductivity 146 W/(m K).
 - No cooling from upstream or downstream of the tungsten block.

Power deposition data from Vitaly x2

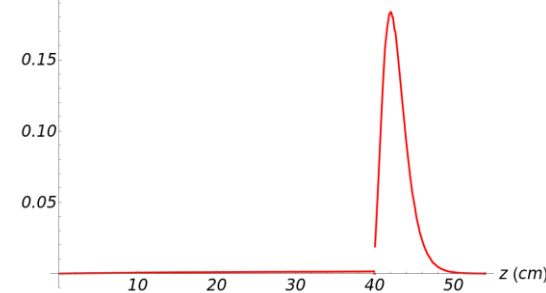


FLUKA Input

- 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.



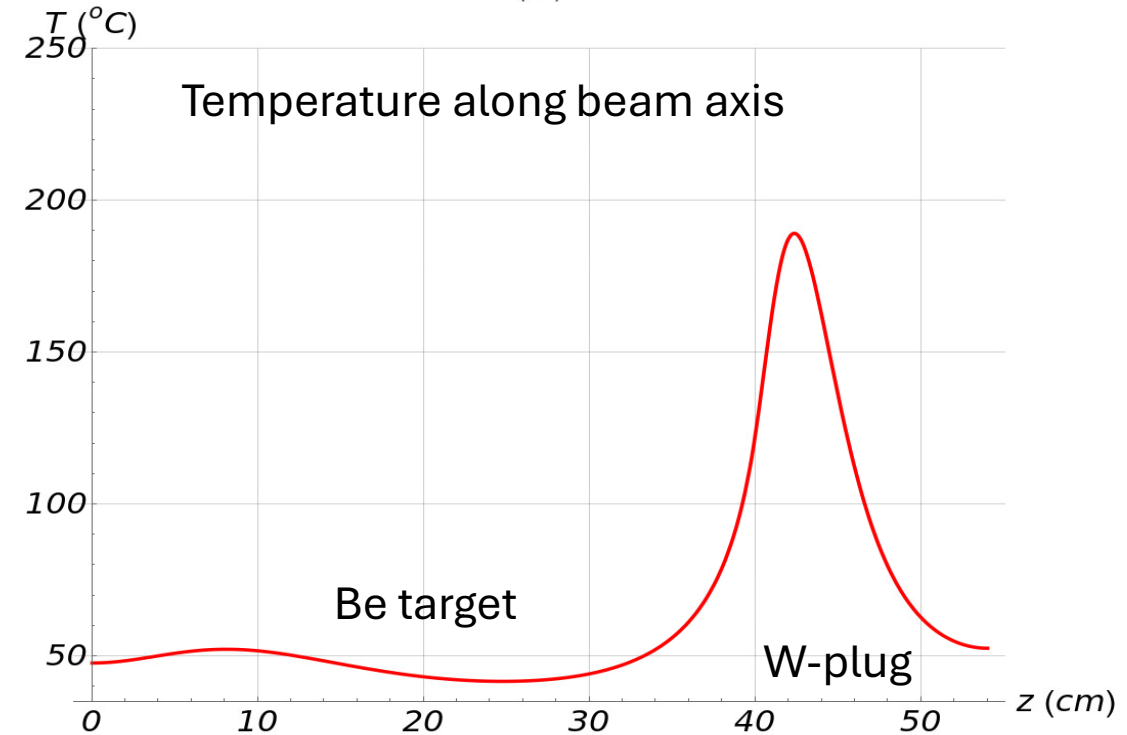
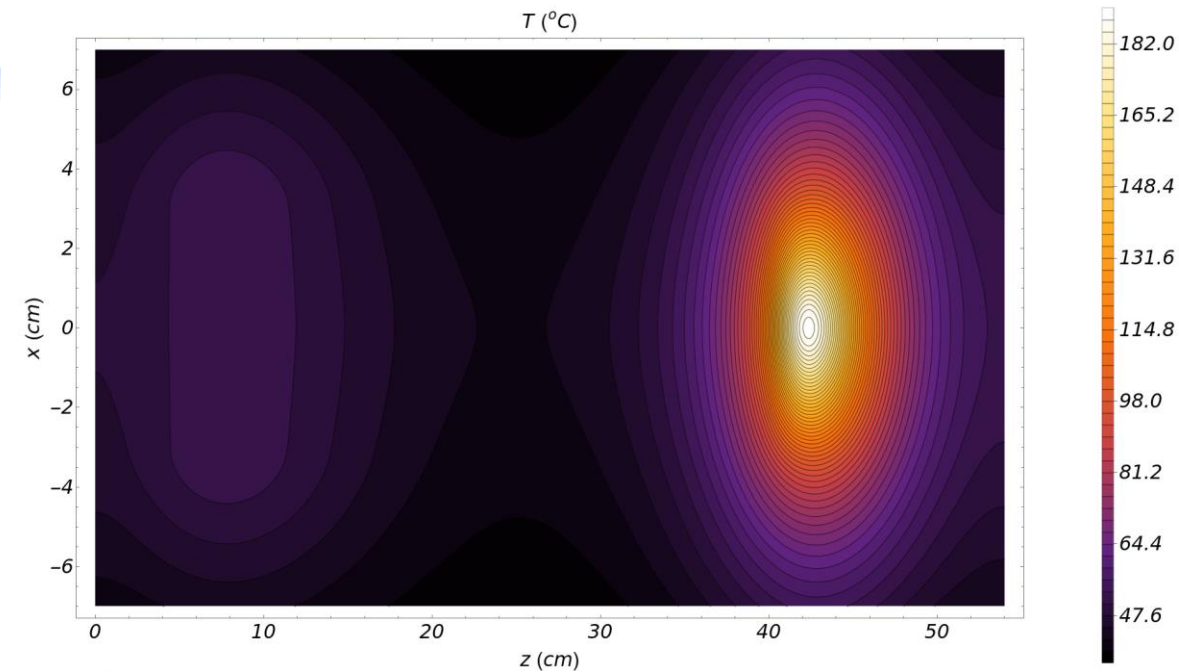
$$\frac{\Delta P}{\Delta V} \left(\frac{\text{KW}}{\text{cm}^3} \right)$$



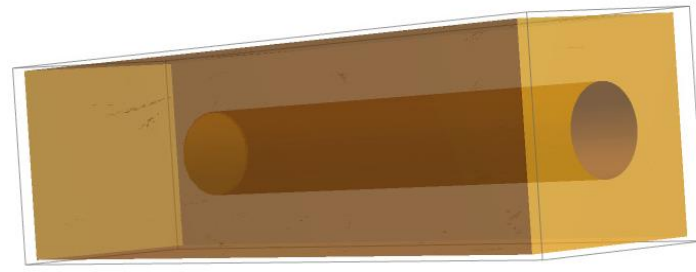
Solid Block



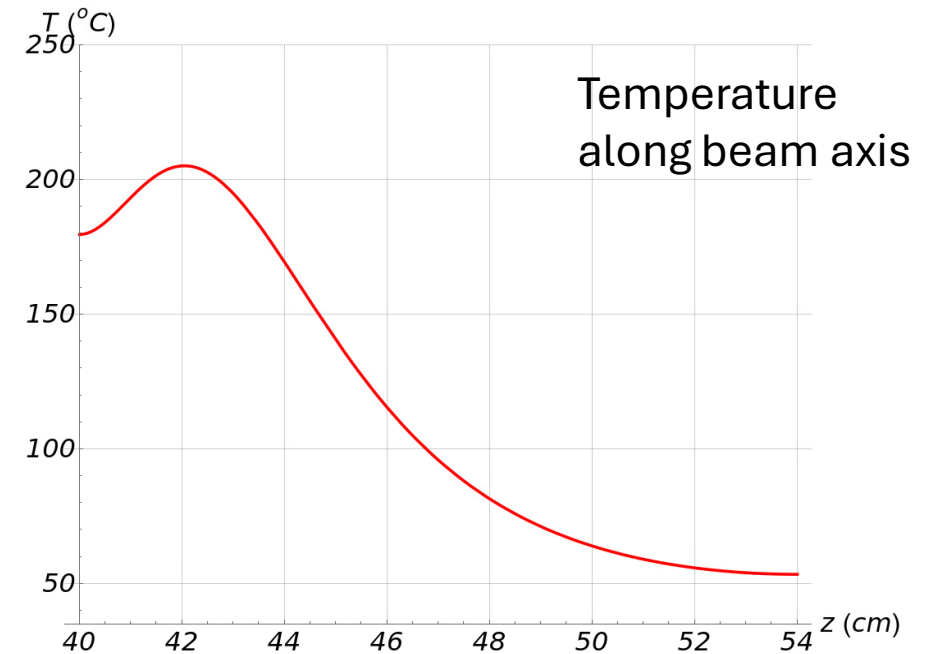
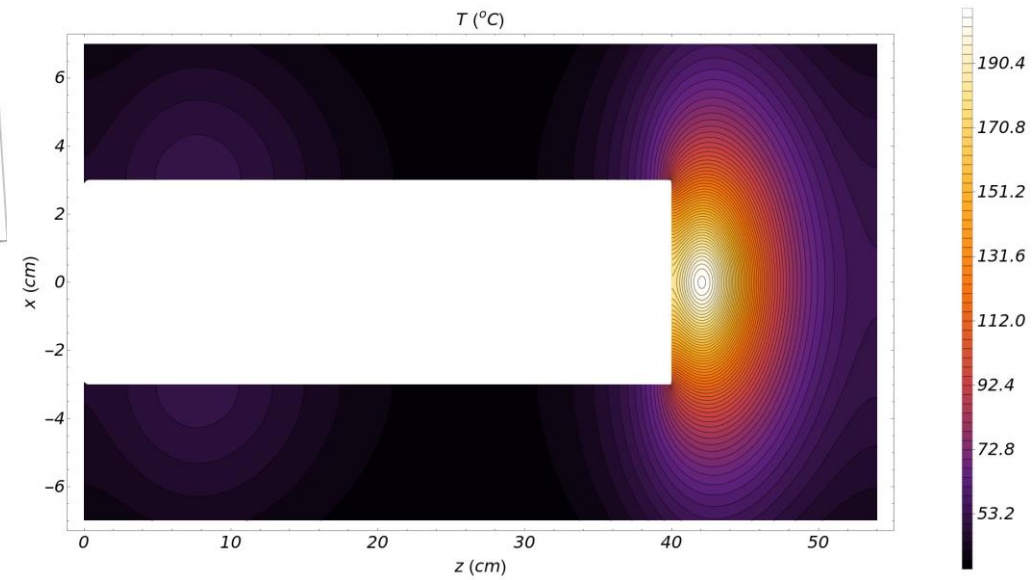
- Assume a solid block for the volume of copper, Be, and W, and assume all is made of tungsten material.
 - Overestimate temperature everywhere.
 - Thermal conductivity 146 W/(m K).
- Cooled from four sides directly with cold water
 - Underestimate temperature everywhere.
 - Water temperature $T=35\text{ }^{\circ}\text{C}$
 - Heat exchange coefficient 5000 W/(K m²).
- $T_{\text{max}} \sim 190\text{ }^{\circ}\text{C}$ is even lower than $T_{\text{max}} \sim 205\text{ }^{\circ}\text{C}$ 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 $T \sim 500\text{ }^{\circ}\text{C}$ 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, all made of tungsten but the Be target cylinder removed.
 - The rest is assumed to be made of tungsten.
 - Thermal conductivity 146 W/(m K).
 - Overestimate temperature
- Cooled from four sides with water
 - No heat flow to or from Be target.
- Similar $T_{\max} \sim 205$ °C in the W-plug to the one with 10% radiator and plug length of 10 cm.
 - Probably because the heat flow upstream is blocked by the Be target area.
- 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.



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 luminosity

May be difficult to be ready by the fall.

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

A decision needs to be made very soon!