CPS meeting 06/12/2023

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Outline

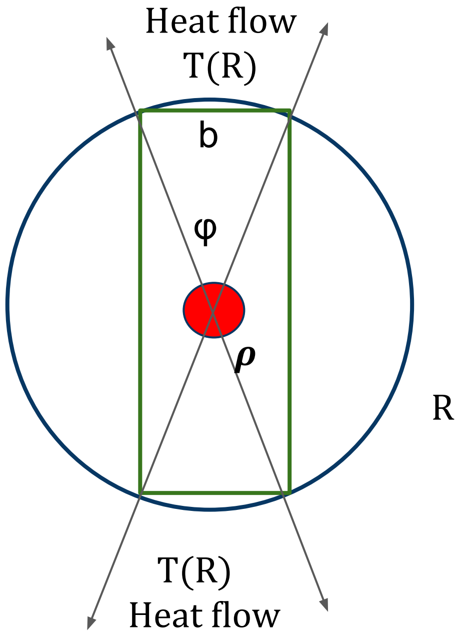
Problem of Absorber Temperature. Qualitative consideration.

New FLUKA simulations :

1. Radiation map from beam halo $r<0.5$ cm.
2. Radiation map for optimized shield (to meet 25 rem/hr requirement).
3. Energy deposition maps in Absorber to compare ANSYS and MATHEMATICA.

Now we have 15 maps (13+2) for temperature field calculations.

Why Mathematica predicts lower temperature for a current CPS version.



Energy flow : $(dP/dV)\pi\rho^2\,\Delta z = -k\,(dT/dr)\,r 2\varphi\,\Delta z$,

$(dP/dz) = (dP/dV)\pi\rho^2$

$(dT/dr) = -(2k\varphi)^{-1}(dP/dz)\,r^{-1}$

Integration from R to r yields

$T(r) - T(R) = (2k\varphi)^{-1}(dP/dz)\ln(R/r)$

$\varphi = \sim b/R$

$T(\rho) - T(R) \propto (R/b)\times(dP/dz)\ln(R/\rho)$

T(R) is determined by T° of coolant, contact area, and heat transfer coefficient (tabulated empirical value).

In Feb. version φ ~ 0.5

In current version φ ~ 1.5

Expected T(r)-T(R) is ~**3 times lower** compared Feb. version.

ANSYS **T=250 C** vs Mathematics **T=90 C**.

(https://wiki.jlab.org/klproject/images/f/f2/Cps_absorber_temp_tim_02_27_23.pdf)

And ~**2 times lower** compared PD version due to twice higher (dP/dV) term.

Comments to the video.   What is the wedge effect?

1) Consider e-**beam as a cylinder diameter D** with uniform density; direction $\mathbf{n_b}=(0,\sin(\alpha),\cos(\alpha))$, where α pitch angle to the beam axis.

2) For a **squared or wedge-like** channels the **hot spot is a cross section of a cylinder with a plane**.

   Plane orientations: $\mathbf{n_1}=(0,1,0)$ -for **squared** channel, or $\mathbf{n_2}=(\pm\cos(\varphi),\sin(\varphi),0)$ - for 2 **wedge** planes obtained as $\pm\varphi$ - rotation of yz-plane around z-axis.

   Impact angle is determined by $(\mathbf{n_b},\mathbf{n_1})=\sin(\alpha)$ or $(\mathbf{n_b},\mathbf{n_2})=\sin(\alpha)\sin(\varphi)=\sin(\vartheta)$ - pitch to wedge plane.

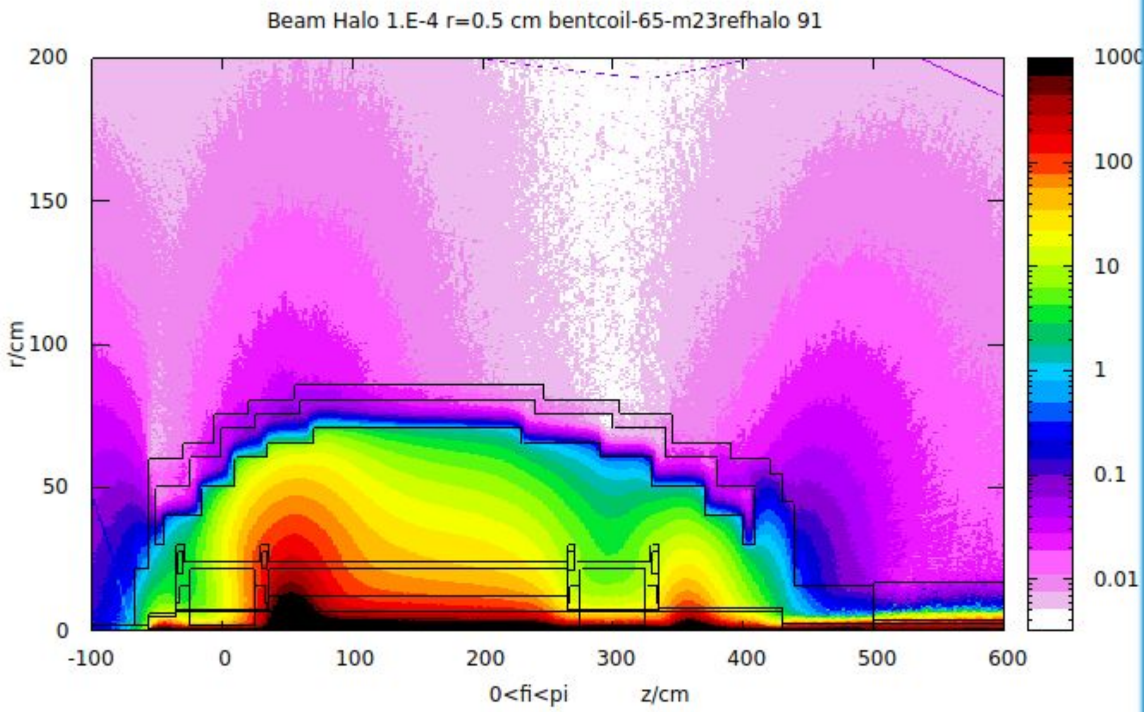
3) But in both cases the **intersection is an ellipse** with the area **$S=\pi D\times L$**, where **L** - ellipse large axis.

4) Pitch angle **$\vartheta \sim D/L$**.

5) Maximum **L is constrained by the length** of the **beam channel** ($L<L_c\sim 2$ m), or the **wedge** ($L<L_w\sim 0.5$ m).

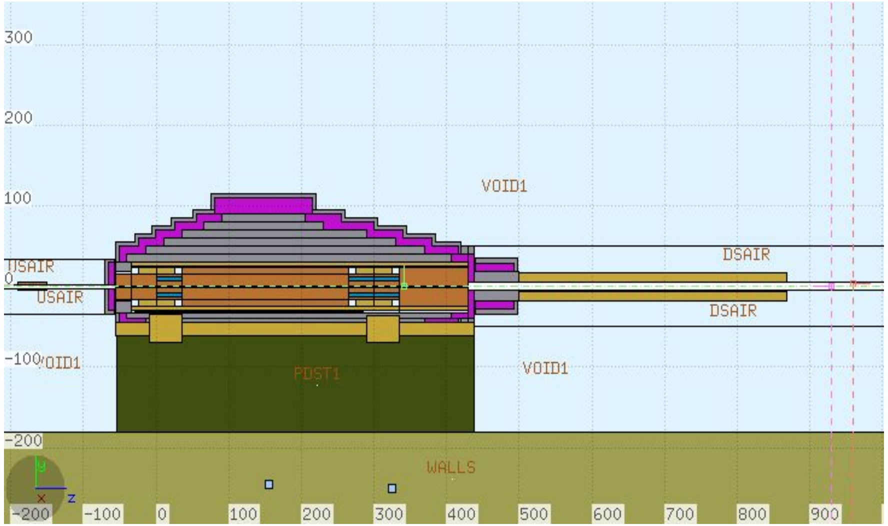
- **Therefore max $dP/dS \propto \vartheta \propto L^{-1}$ for the wedge is $L_c/L_w = 4$ times higher.**

Beam halo. Prompt Dose Equivalent around CPS.

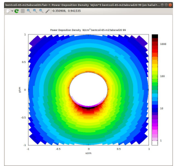


- Annular beam halo r=0.5 cm; halo fraction in the e-beam =1.E-4
- Scaled PDE from the beam pedestal is below 1 rem/h. May be neglected.
- Energy deposition map inside Absorber is available for T-calculations.

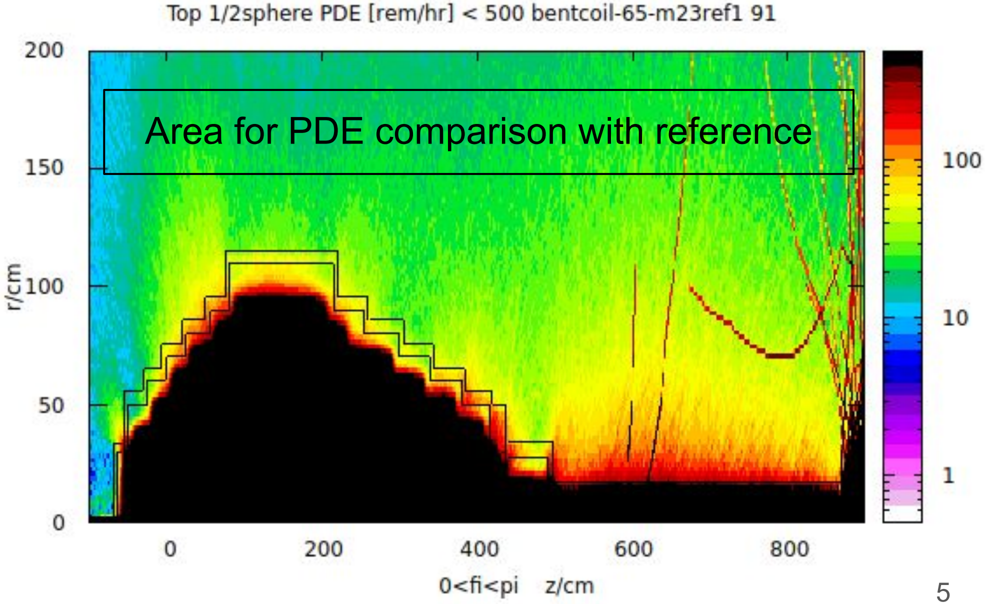
Prompt Dose Equivalent Map (rem/hr) < 500 ; $B=0.9B_n$



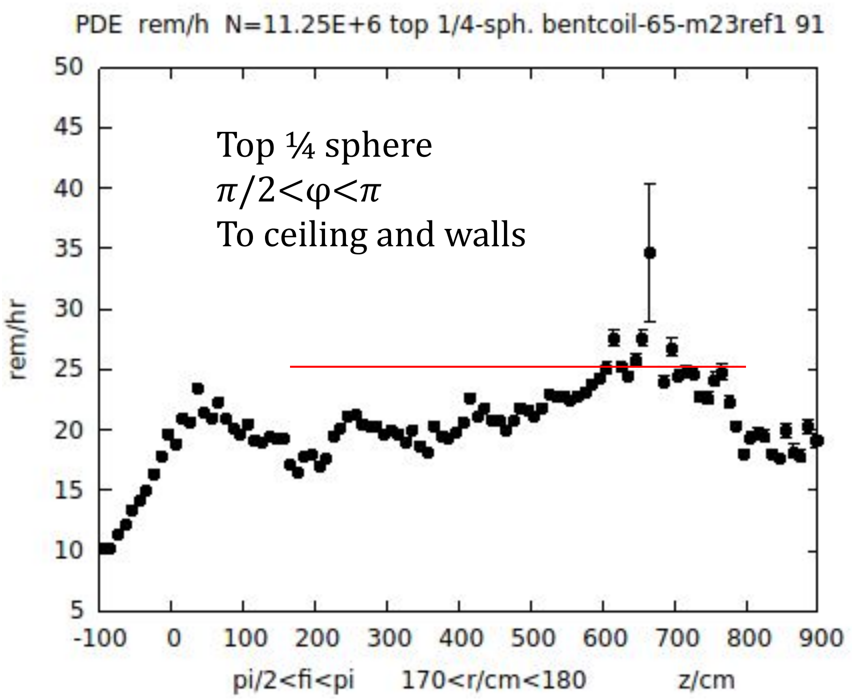
Modified shielding. Not yet optimized.
Max Radius changed from 86 to 110 cm.
May be not necessary.

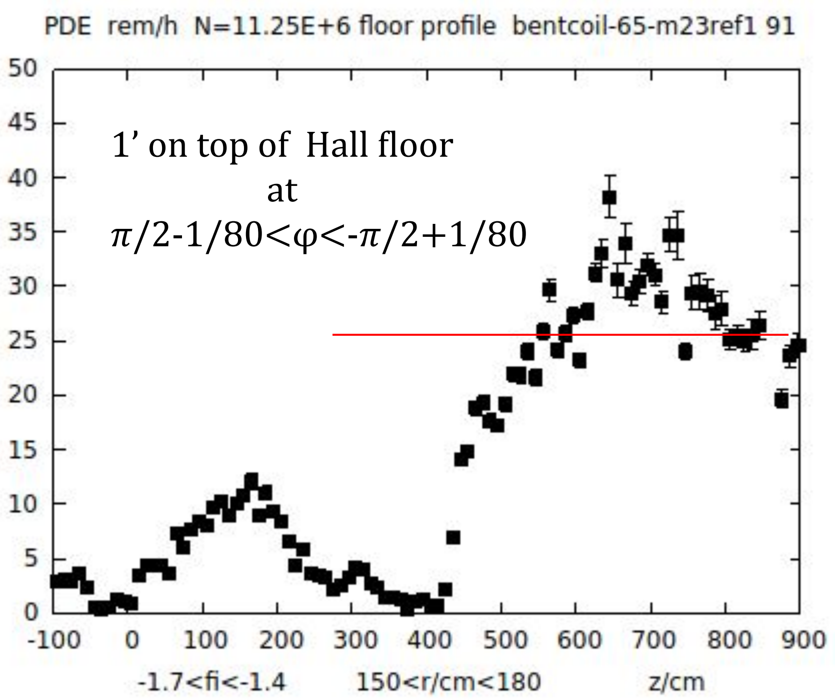


PDE r vs z map in rem/hr
z- profiles at the next slide.



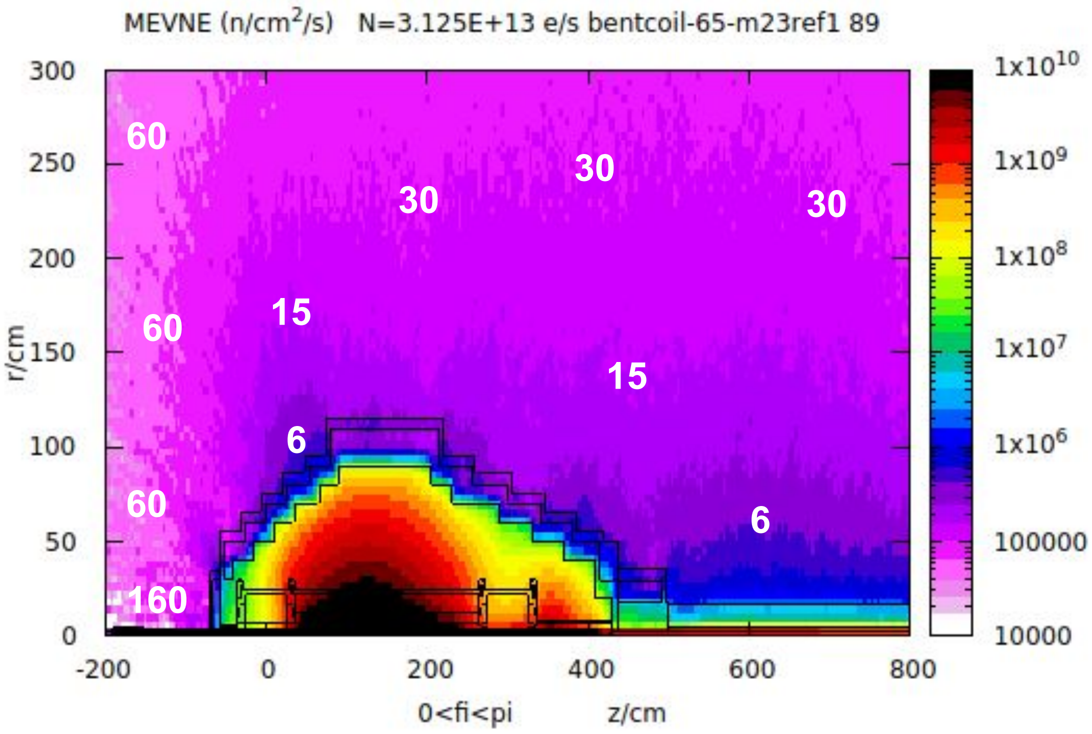
Prompt Dose Equivalent (rem/hr) at r=150-180 cm from beam axis.





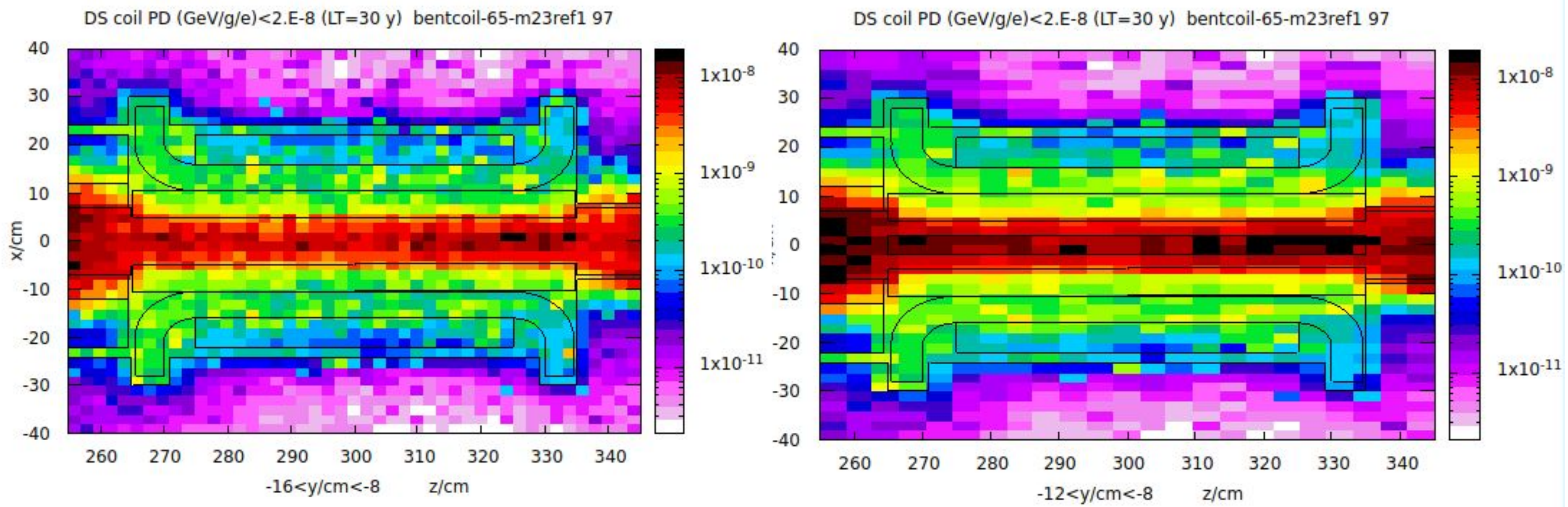
- PDE (rem/hr) **meets the specification of the PAC48 proposal**: PDE<25 rem/h at floor level=> 1.5 m.

SIMEVNE (n/s/cm^2) and Si-electronics life time at 1.E+14 n/cm^2



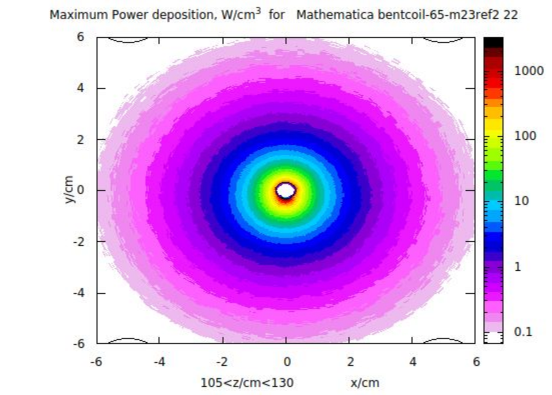
- At 1' distance from CPS surface Si LT = 1.E+14/5.E+5 =2E+8 s =6 years.
- Coil LT ~>300 years of continuous operation. B=0.9B_n

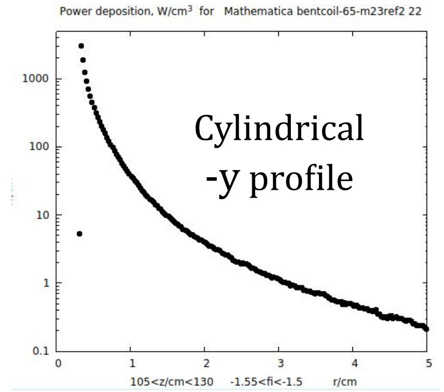
Prompt Dose in downstream coil and its lifetime.

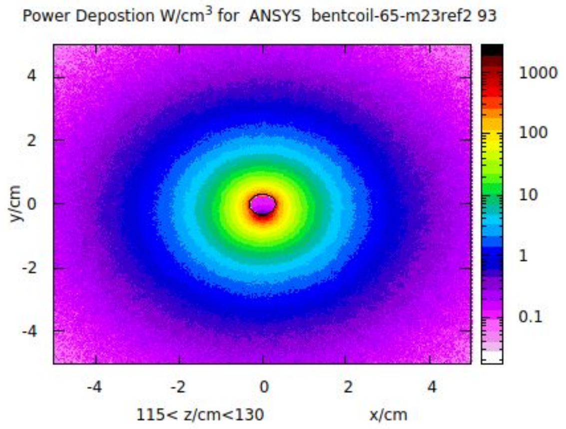


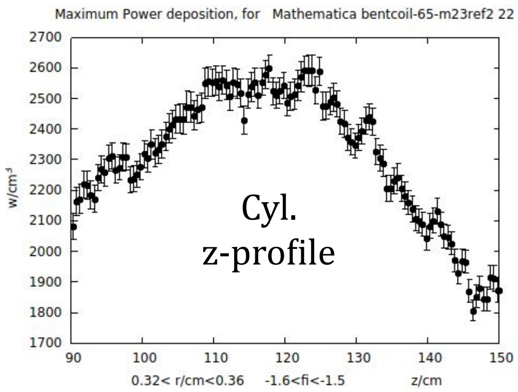
- A **thicker layer of tungsten** collar results in coil Dose<1.E-9 GeV/g/e.
- Translate to Coil LT > 300 years of continuous operation.
- Magnetic field $B=0.9\ B_n$

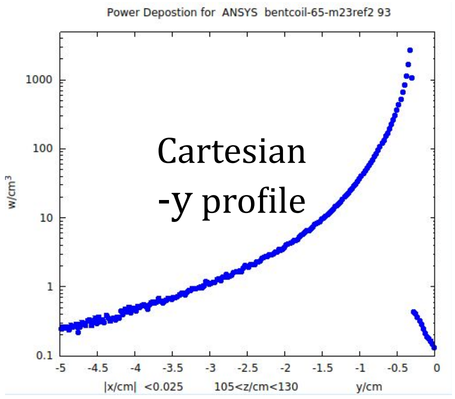
Power deposition maps to compare ANSYS and MATHEMATICA

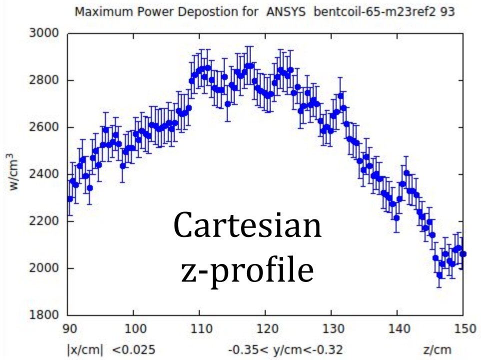












- Cartesian and Cylindrical profiles are very close.

Next week plan

1. FLUKA simulations for 3.5 mm beam sigma.
2. Material weight.
3. Activation.
4. CPS optimisation.