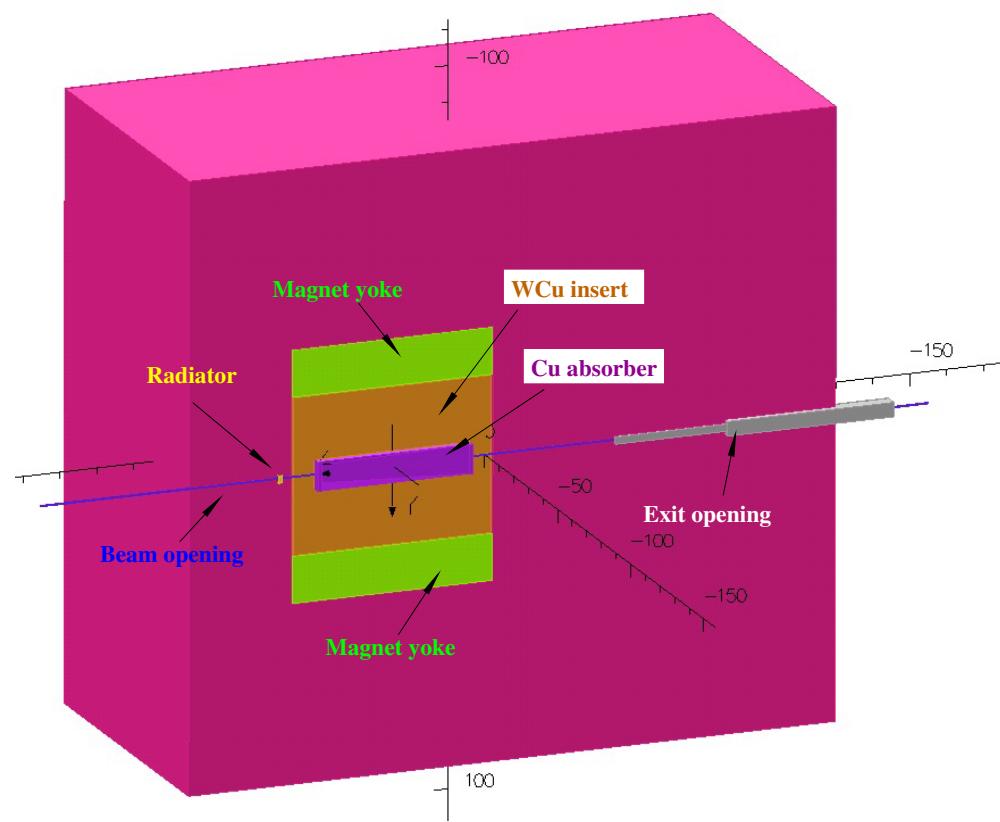
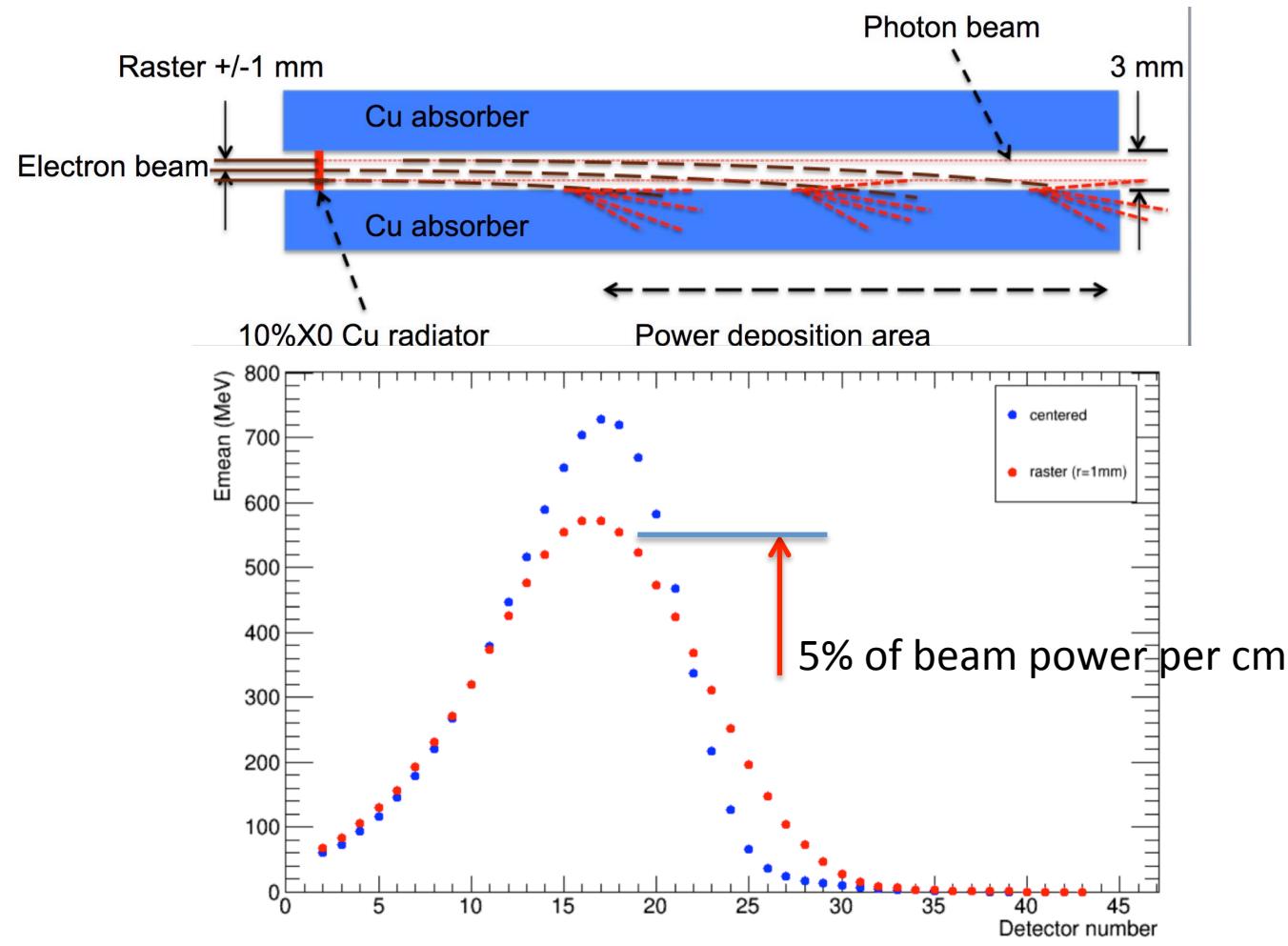


# Power absorber in CPS

B. Wojtsekhowski



# Longitudinal distribution of the beam power



From meetings 12 and 26 June, 2020

## **SHIELDING AND MAGNET MODEL (Josh)**

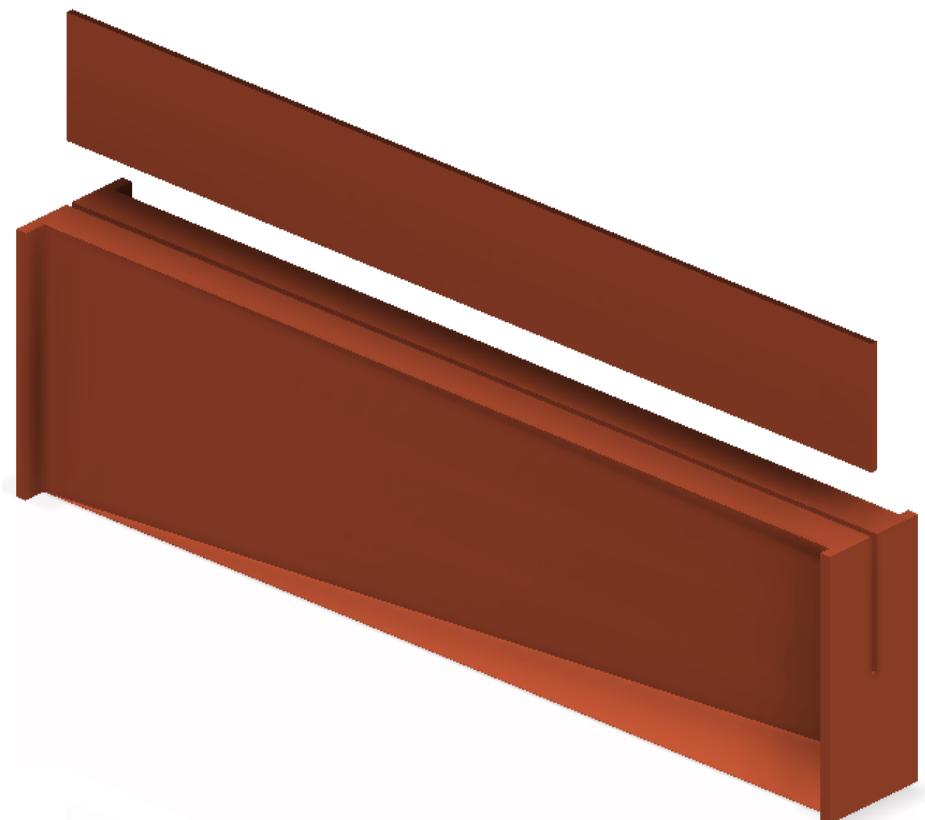
- Cu Core - was split into two pieces following advice from previous meeting
  - No need to cut symmetrically, one side could be flat
  - Ask Target Group about machining options
- Cooling of the Cu Core
  - **Action Item:** Repeat cooling calculation using Josh's model (Gabriel)
    - all cooling in W-Cu area: make flat, rectangular cooling channel outside (c
    - investigate optimal cooling by changing fractions of Cu and W-Cu areas u
    - investigation includes both distance and water temperature (<100 degree

# CPS Core: Split vs Slot Shimmed, by Josh

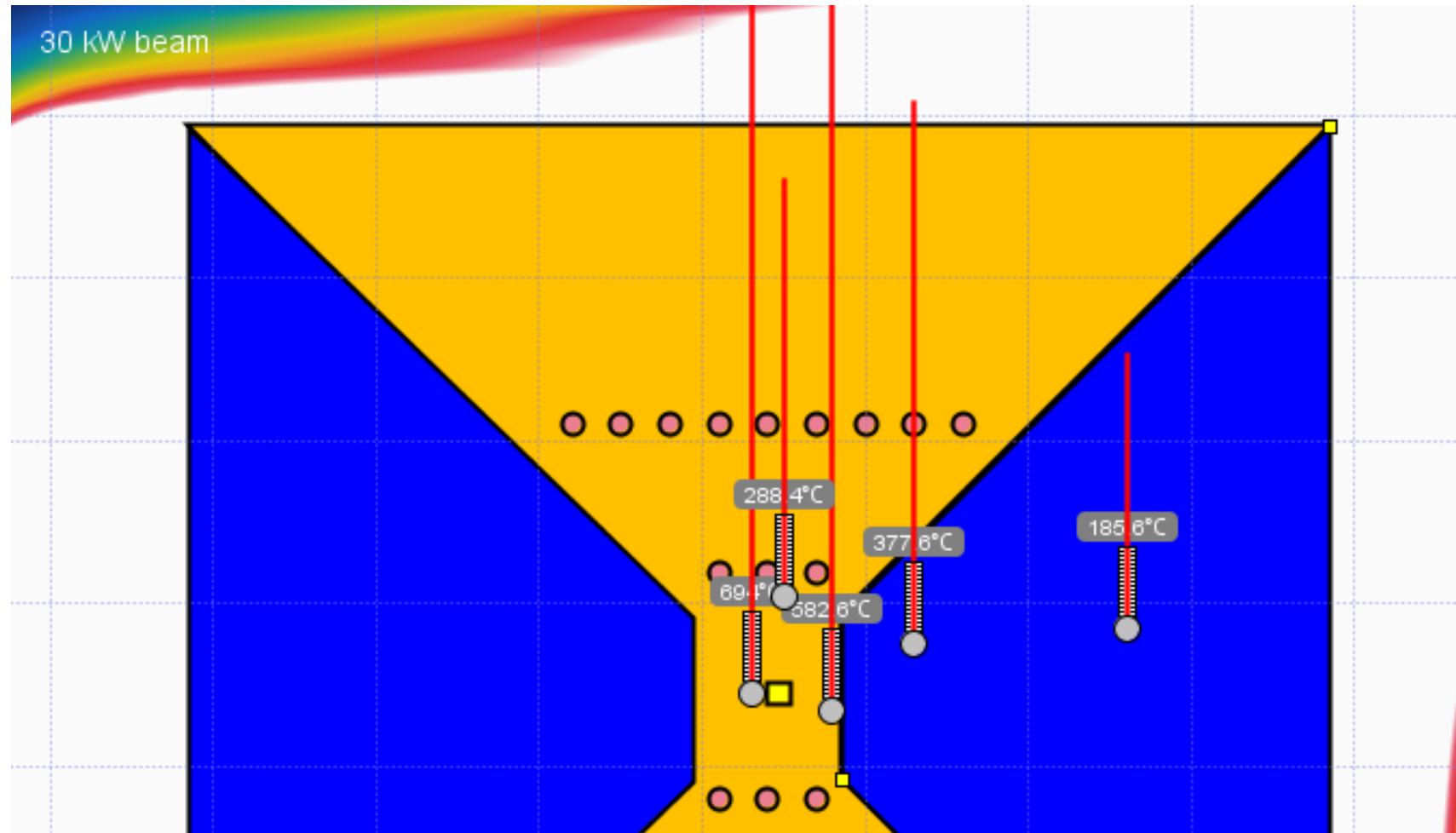
CPS Core bifurcated on long axis



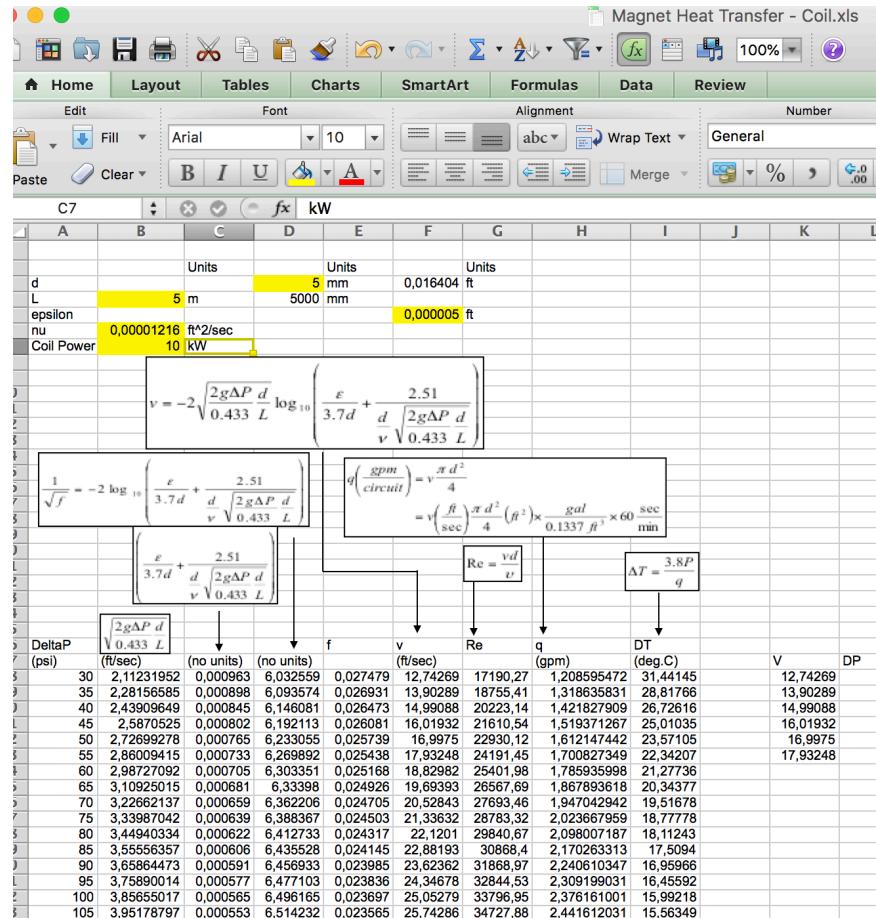
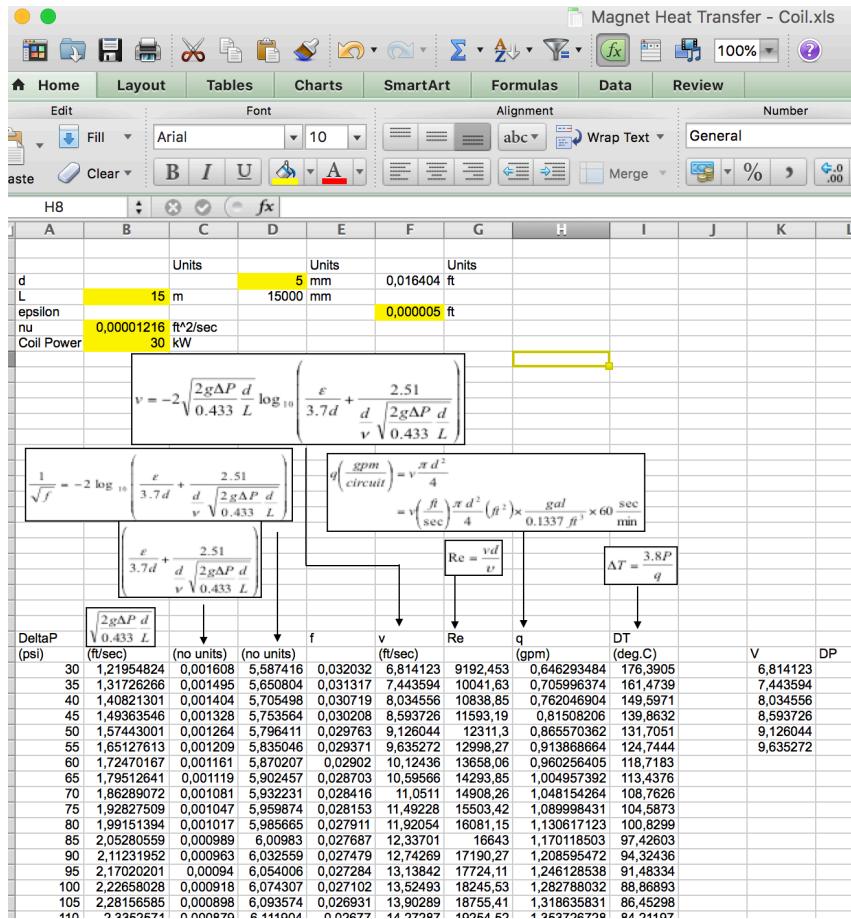
CPS Core with slot and shim

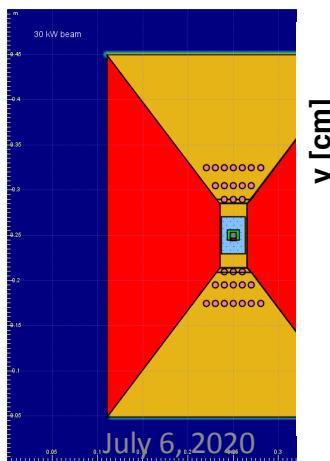
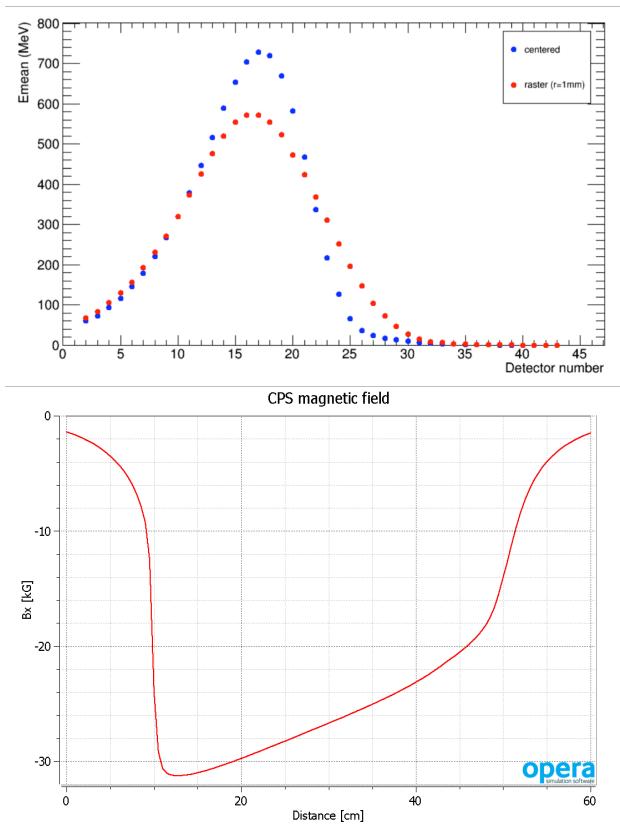


# Cooling by water, by Gabriel

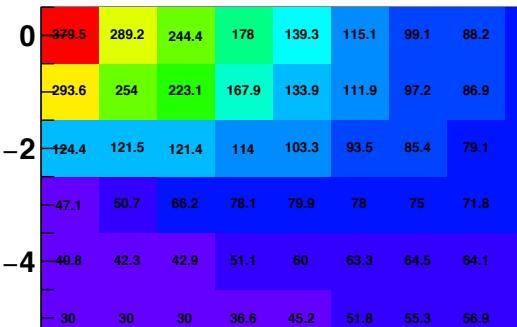


# Cooling by water



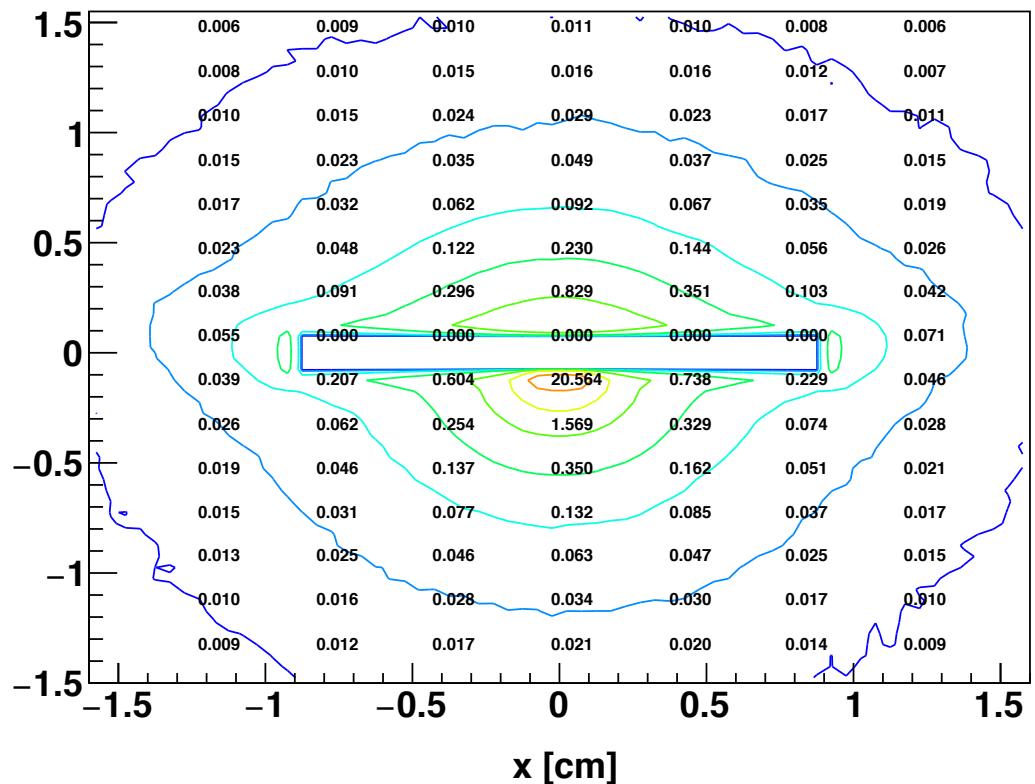


The Cu core, beam of 30 kW,  
at maximum power density location



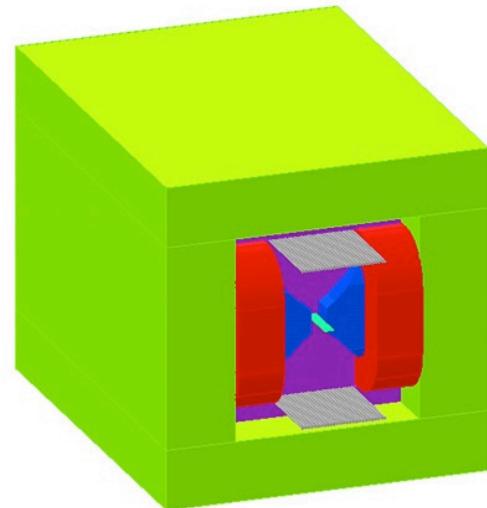
## CPS Power Deposition Density [ $\text{kW}/\text{cm}^3$ ] $-18.0 < z < -17.5 \text{ cm}$

**Bin Size= 0.5x0.5x5 mm      Power = 0.64 kW**



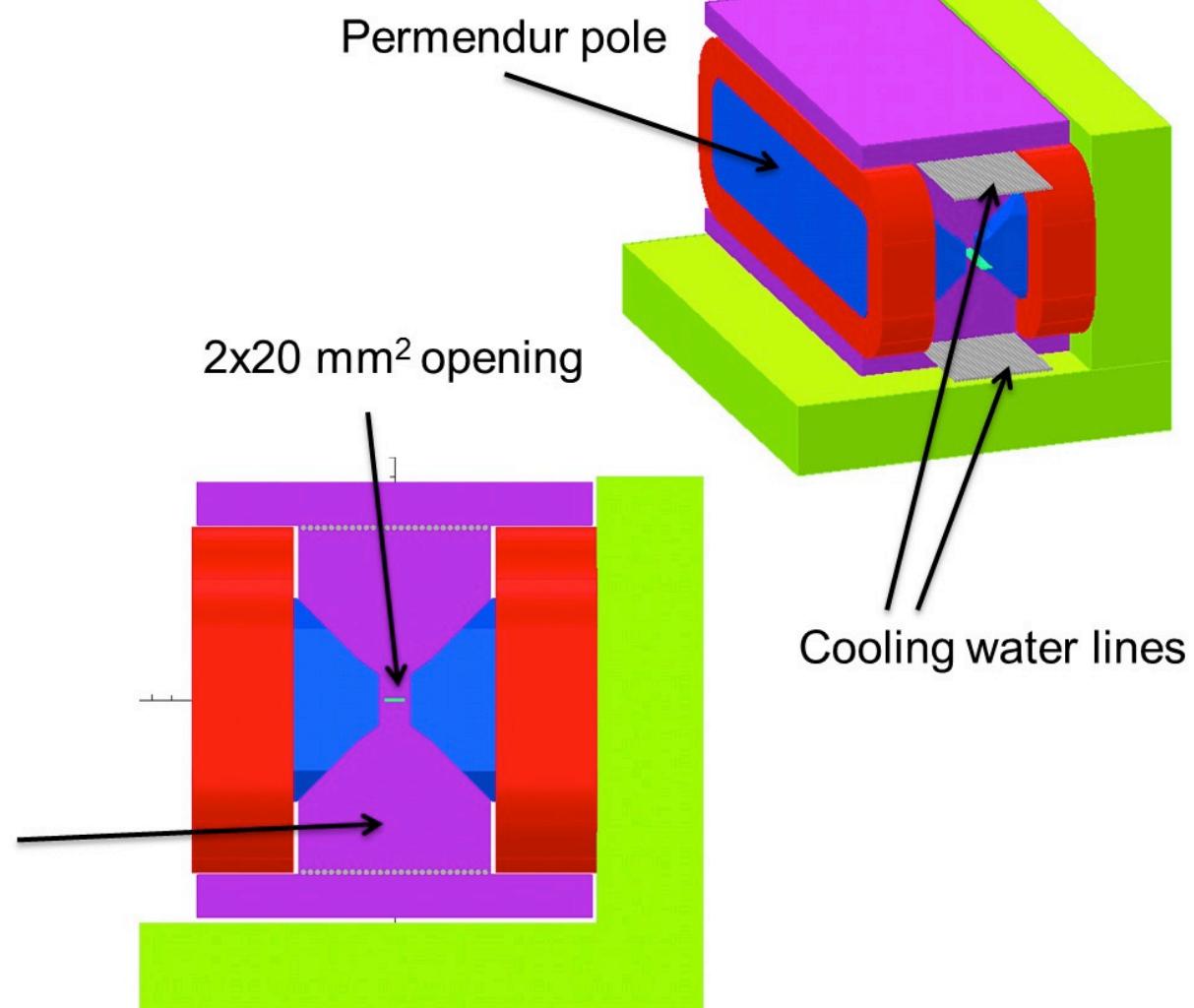
Slot was 2 mm x 20 mm

# Compact Photon Source



Power 30 kW x 750 A  
32 mm gap 2.0 Tesla

WCu power  
absorber and  
radiation shielding



## Thermal elongation and related stress

Copper thermal expansion,  $\alpha = 17 \cdot 10^{-6}$  per deg. K

Copper Young module,  $E = 1.2 \cdot 10^6$  kg/cm<sup>2</sup>

$$\delta l = \alpha \cdot \Delta T \cdot l \sim 17 \cdot 10^{-6} \times 400 \times 200 = 1.4 \text{ mm}$$

$$\sigma = E \cdot \frac{\delta l}{l} = \alpha \cdot \Delta T \cdot E =$$

$$17 \cdot 10^{-6} \times 400 \times 10^6 \text{ atm} = 7200 \sim 10 \times \sigma_Y$$

# Thermal elongation and stress

## PROBLEM 3: FIXED-FIXED BEAM

[PREVIOUS](#)[HOME](#)[NEXT](#)

The equations for all 3 thermal load cases are shown below, the colors represent temperature field (white is high and black is low). The equations give the axial deformation  $u$  of the beam, the deflection  $w$  of the beam, and the axial stresses in the beam.

Boundary Conditions:

$$u(x=0) = 0$$

$$w(x=0) = 0$$

$$\beta(x=0) = 0$$

$$u(x=L) = 0$$

$$w(x=L) = 0$$

$$\beta(x=L) = 0$$



Case A:

$$u(x) = 0$$

$$w(x) = 0$$

$$\sigma_x(x, y) = -\alpha E \Delta T$$

! Buckling !

Case B:

$$u(x) = 0$$

$$w(x) = 0$$

$$\sigma_x(x, y) = -\alpha E \Delta T \frac{x}{L}$$

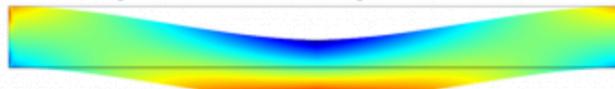
! Buckling !

Case C:

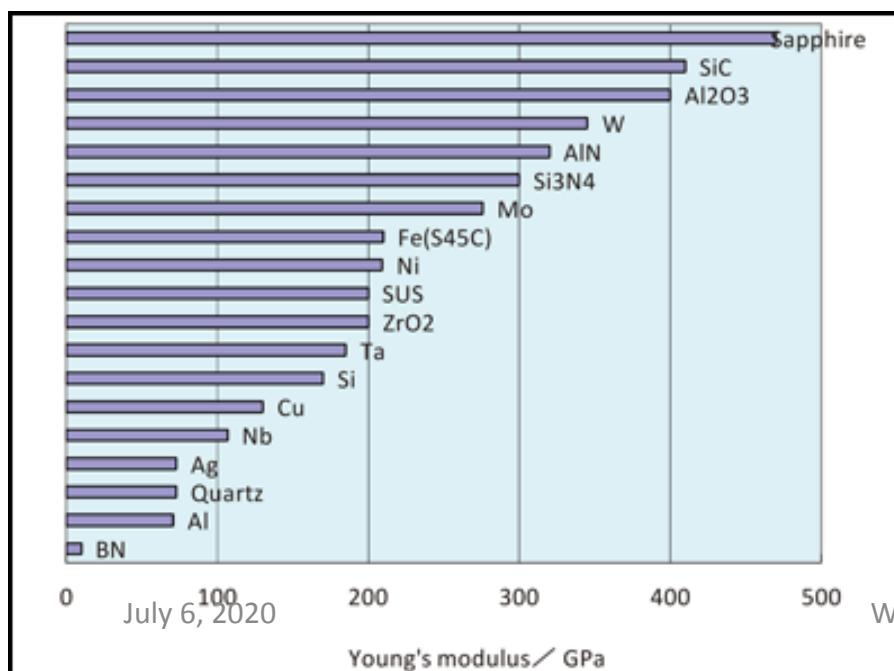
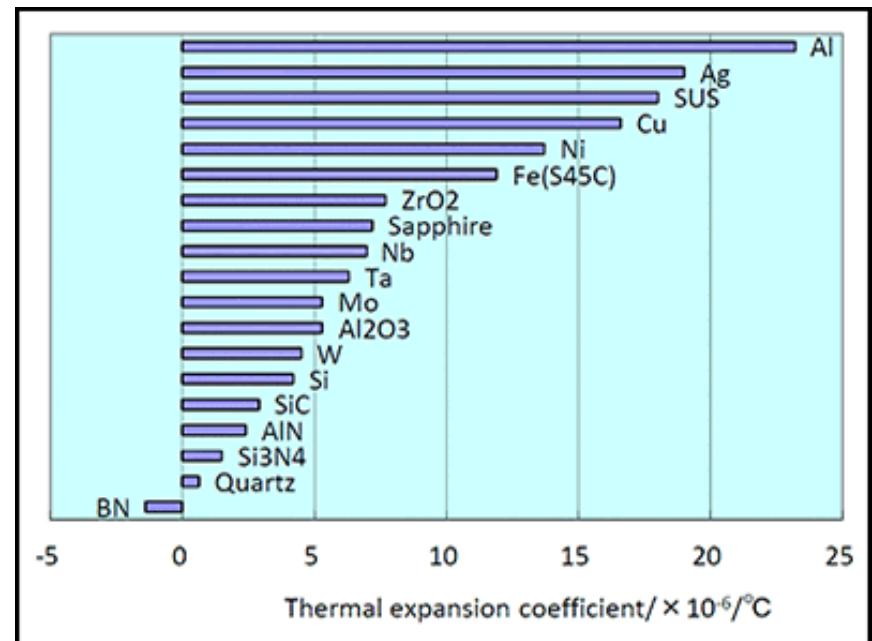
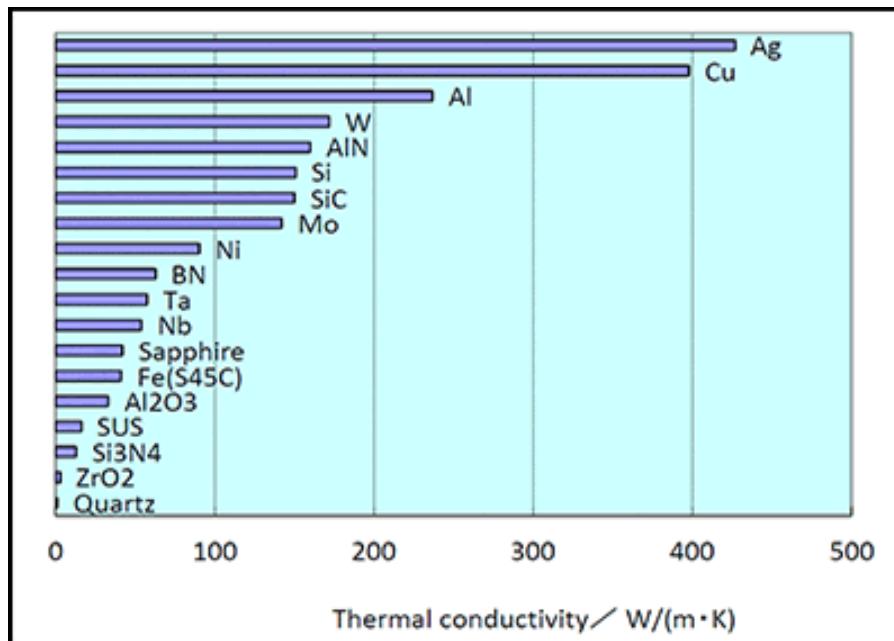
$$u(x) = 0$$

$$w(x) = -\frac{\alpha}{2H} \Delta T \left( \frac{x^4}{L^2} - 2 \frac{x^3}{L} + x^2 \right)$$

$$\sigma_x(x, y) = \frac{\alpha E \Delta T}{2} \frac{y}{H} \left( 12 \frac{x^2}{L^2} - 12 \frac{x}{L} + 1 \right)$$



# Materials



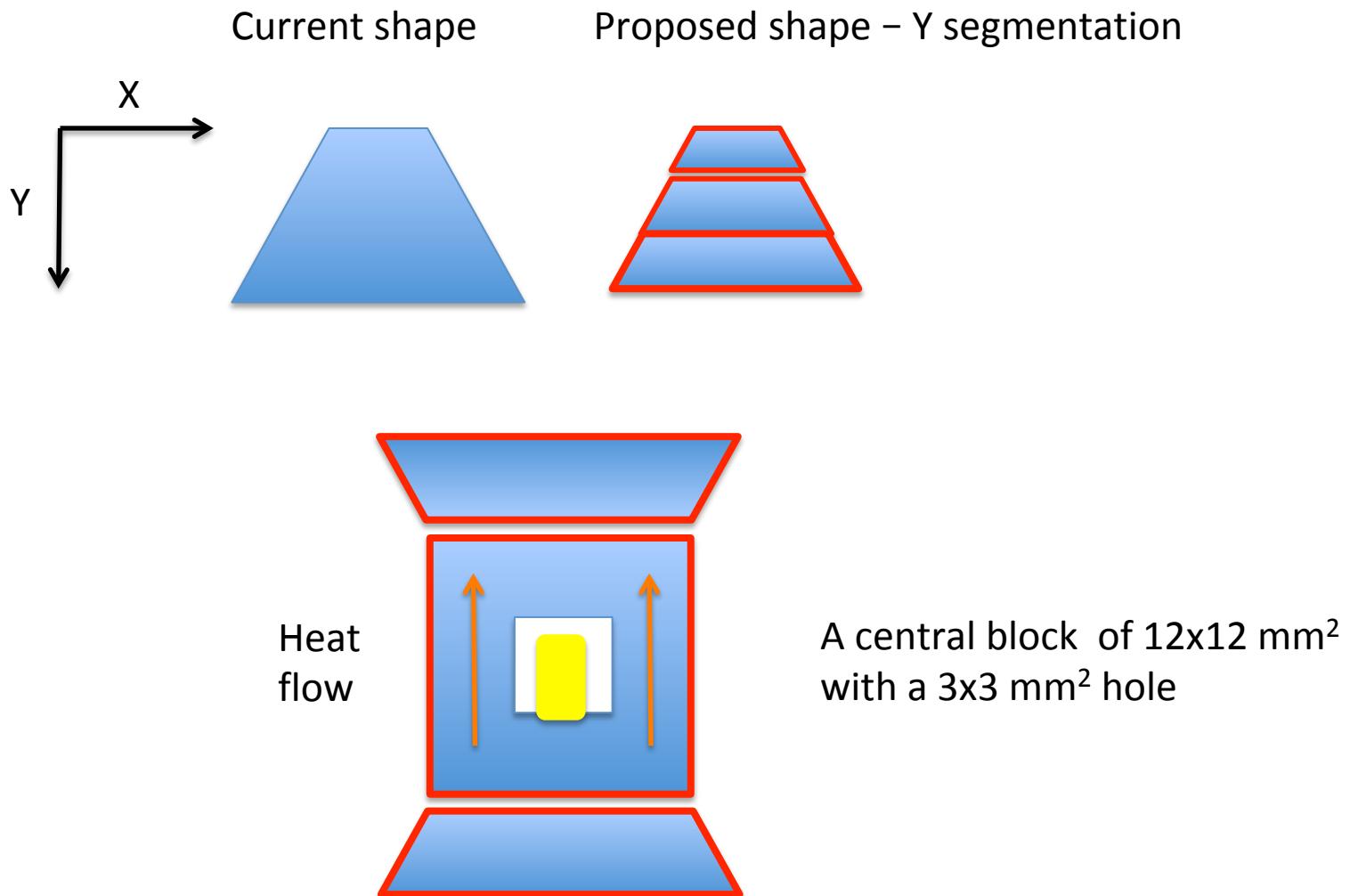
Wojtsekowski

2D case for wedge shape

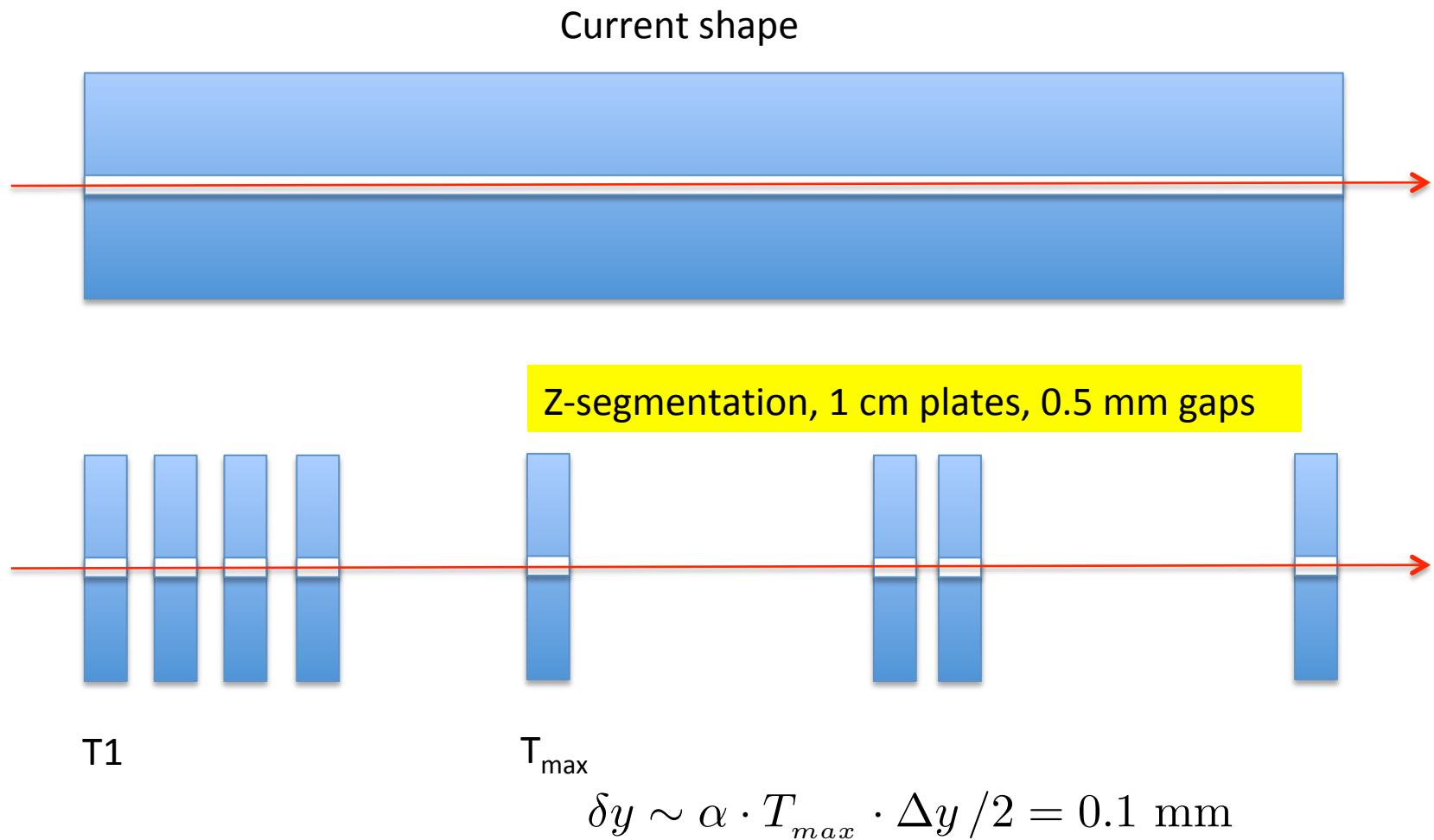
$$Q = \frac{dT}{dy} \cdot \lambda \cdot x(y)$$

$$T(y) = A \frac{Q}{\lambda} \cdot \ln \frac{y_{min}}{y} + B$$

# Reduction of the deformation risk by a few design changes



# Reduction of the deformation risk by a few design changes



# Reduction of the deformation risk by a few design changes

- 1) Z-segmentation of the absorber
- 2) Moderate (2 atm) compaction pressure
- 3) Zn coating of the Cu plates for contact/sliding
- 4) Tilted bottom side by 0.2 degree, with a step at the end
- 5) Wider magnet gap => less up-down difference
- 6) 10-20 cm longer magnet, reduce field, lower  $T_{max}$

## Proposed development plan

- A) Calculate field for longer magnet with wider gap
- B) Calculate 3D power distribution for modified scheme
- C) Calculate 3D temperature field in **the absorber** and **poles**
- D) Calculate stress distribution in the segmented absorber
- E) Design of a simplified test setup for temp. cycling
- F) Built a prototype (without a magnet)
- G) Test is with 5 seconds with 30 kW pulse