Pb rotating target design

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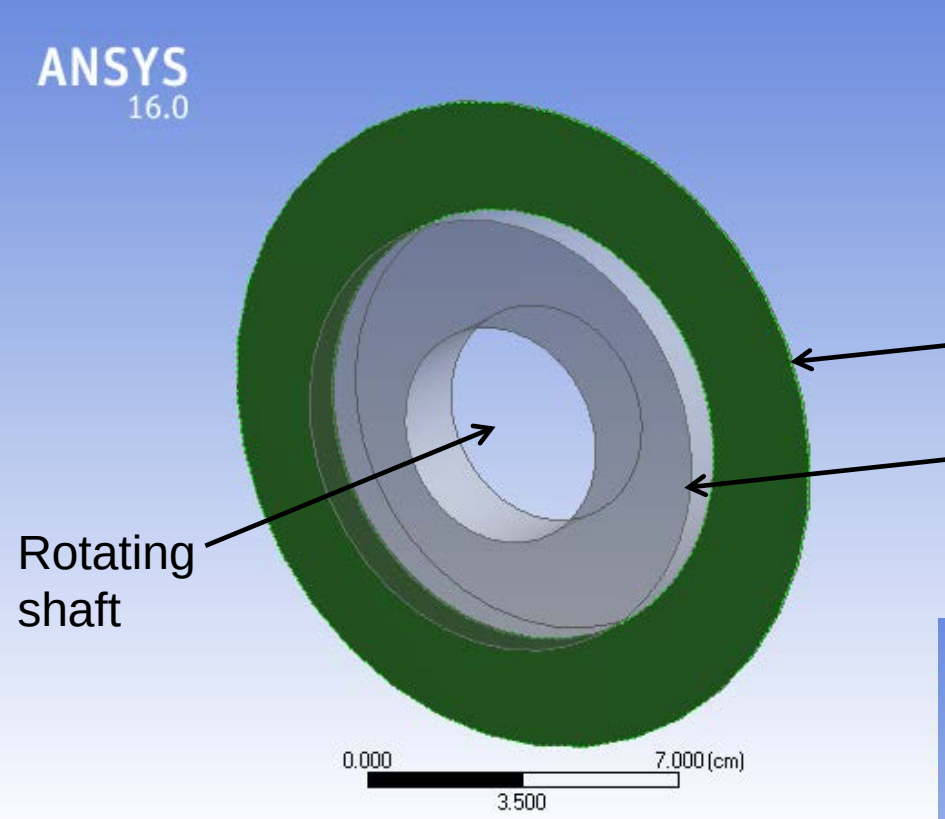
Pb Rotating targets thermally analyzed by CFDFAC

- Computational Fluid Dynamics Facility (CFDFAC) runs ANSYS-CFD and does (mostly) targets design@jlab and can access up to 512 CPUs
- CFDFAC can thermally analyze gases, liquids and solids under a range of conditions (phase transitions, chemical reactions etc.) in steady-state or transient mode
- The reason for doing rotating Pb was to see if a concept target could be found for prex2, a bare Pb unmelting target at 70 μA beam rastered at 5x5 mm^2 or 6x4 mm^2 with cooling and low frequency rotation (1-4 Hz)
- Studied several models with cooling on the rotating shaft or on the outer rim
- Franco and Guido asked me to study a 0.1 mm thick Pb wafer

Bare Pb rotating target designs

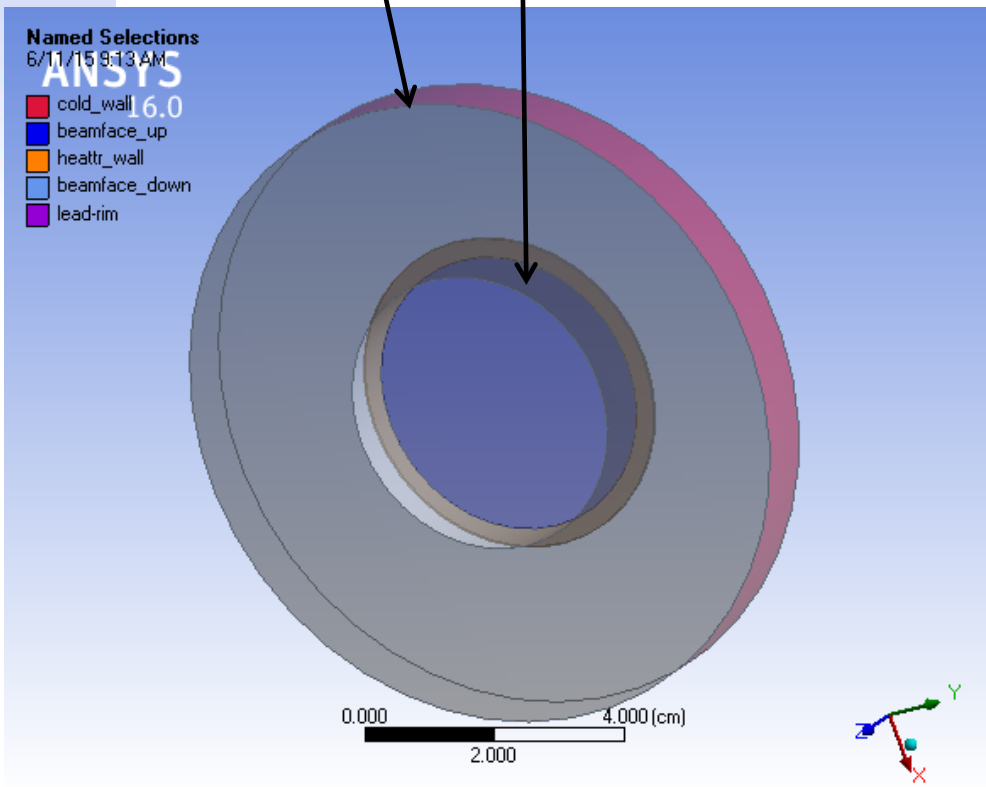


Cu puck

Rotating shaft

Pb outer cylindrical wheel

Pb inner cylindrical wheel



Simulation Conditions

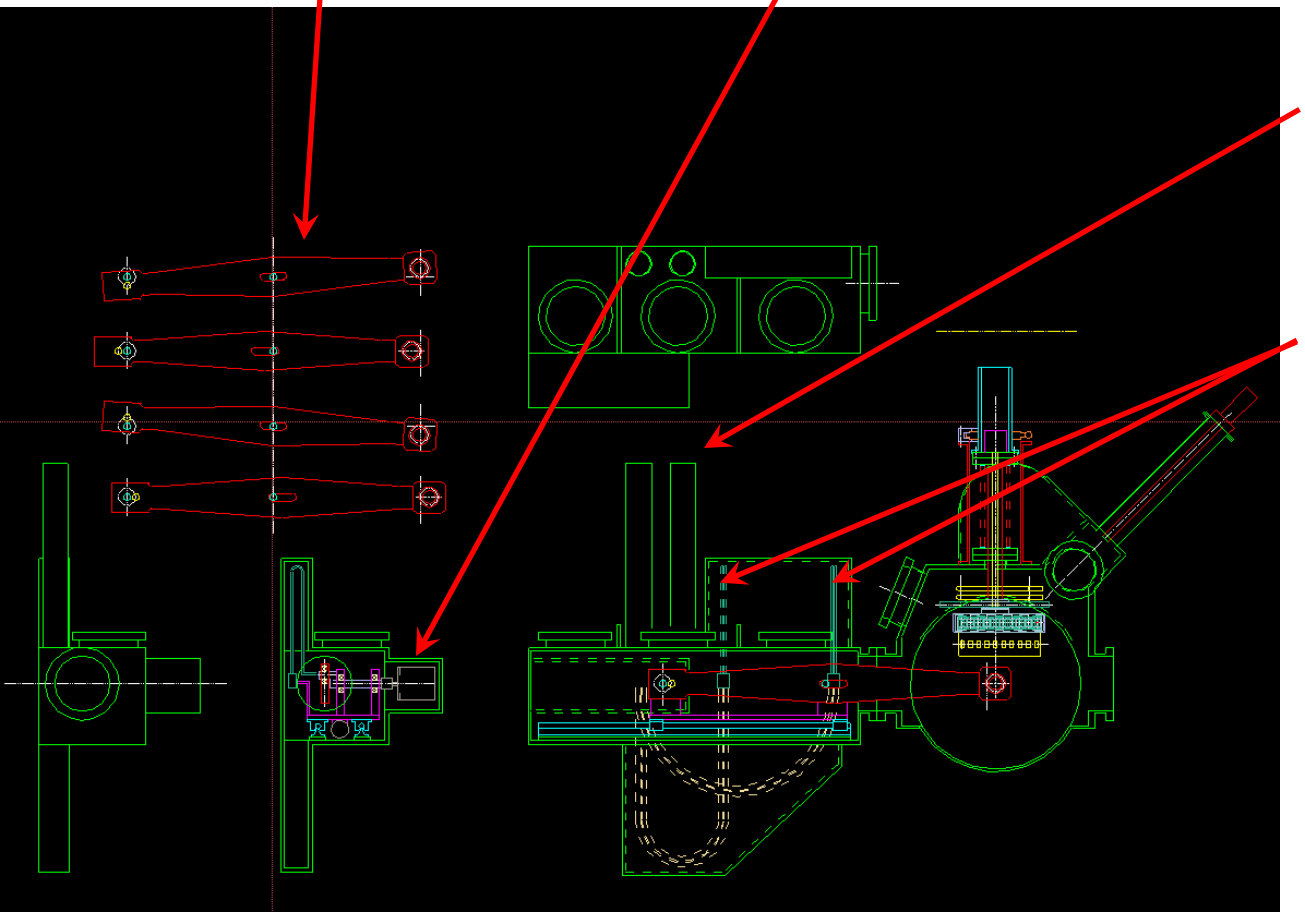
- The Pb wafer, 0.1 mm thick, is 30-40% sandwiched in Cu, which is in contact with a coolant line (taken to be 15 K for these studies, so max temperature should be scaled with the available coolant temperature)
- 2 cm of Pb is radially exposed, the beam circumference is 1 cm from the cold mass
- Studies were done in transient mode with conduction only (radiative heat was not accounted for to be more conservative)
- Pb and Cu properties were corrected for temperature dependence
- The expected beam heating power is 10 W at 50 μA
- Beam spots smaller than 1 mm require very fine meshes, which can substantially increase the computational time

Rotating Target Mechanism Concept

- Studies were done with low frequency rotating targets 1-4 Hz
- Mechanism bellow could do even 30 Hz for 1 month, all metal pantograph with Ti tubing to take the shearing motion of the coolant lines, no bellows

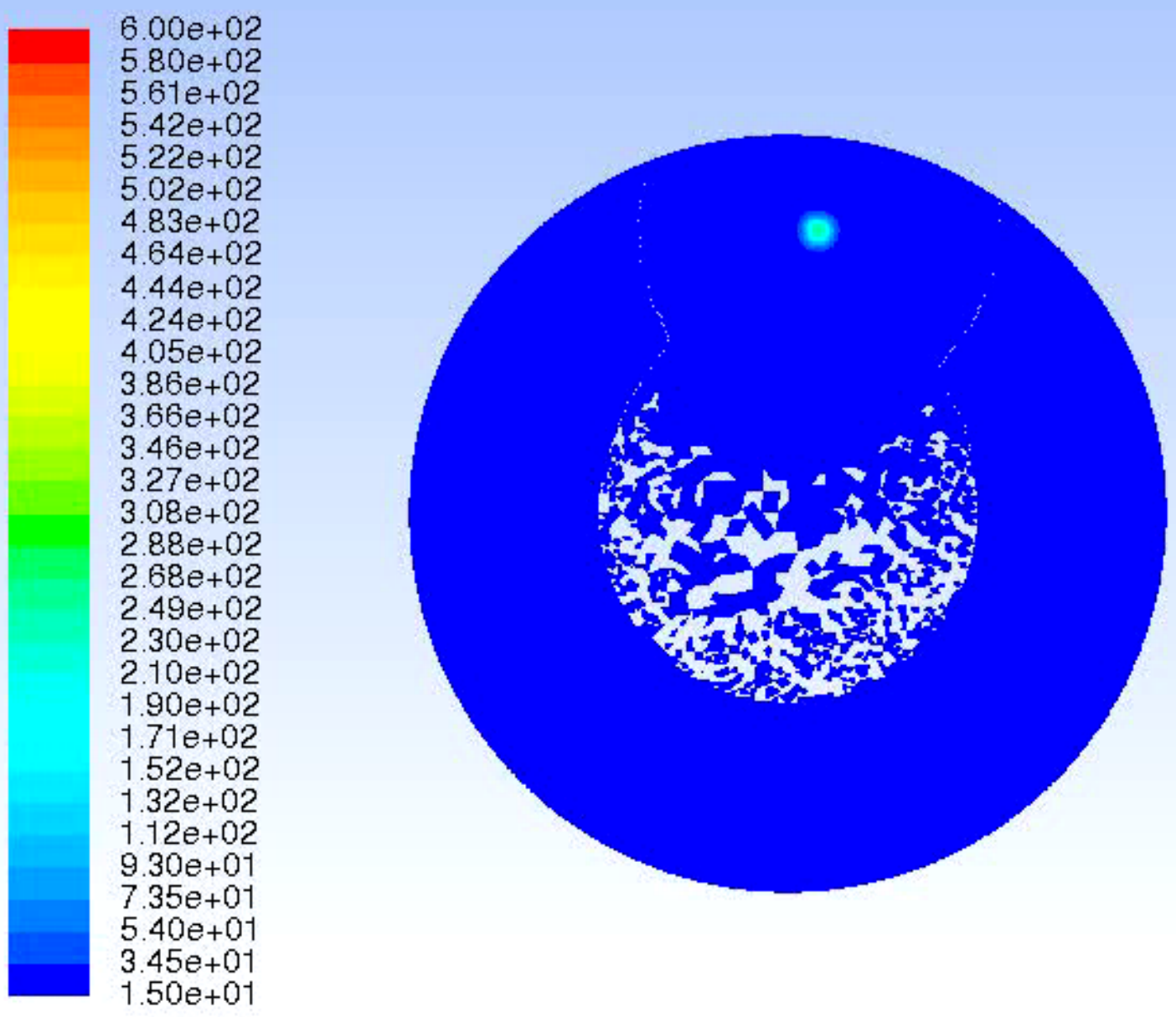
Pantograph mechanism

Motor



Coolant lines for the rotating target

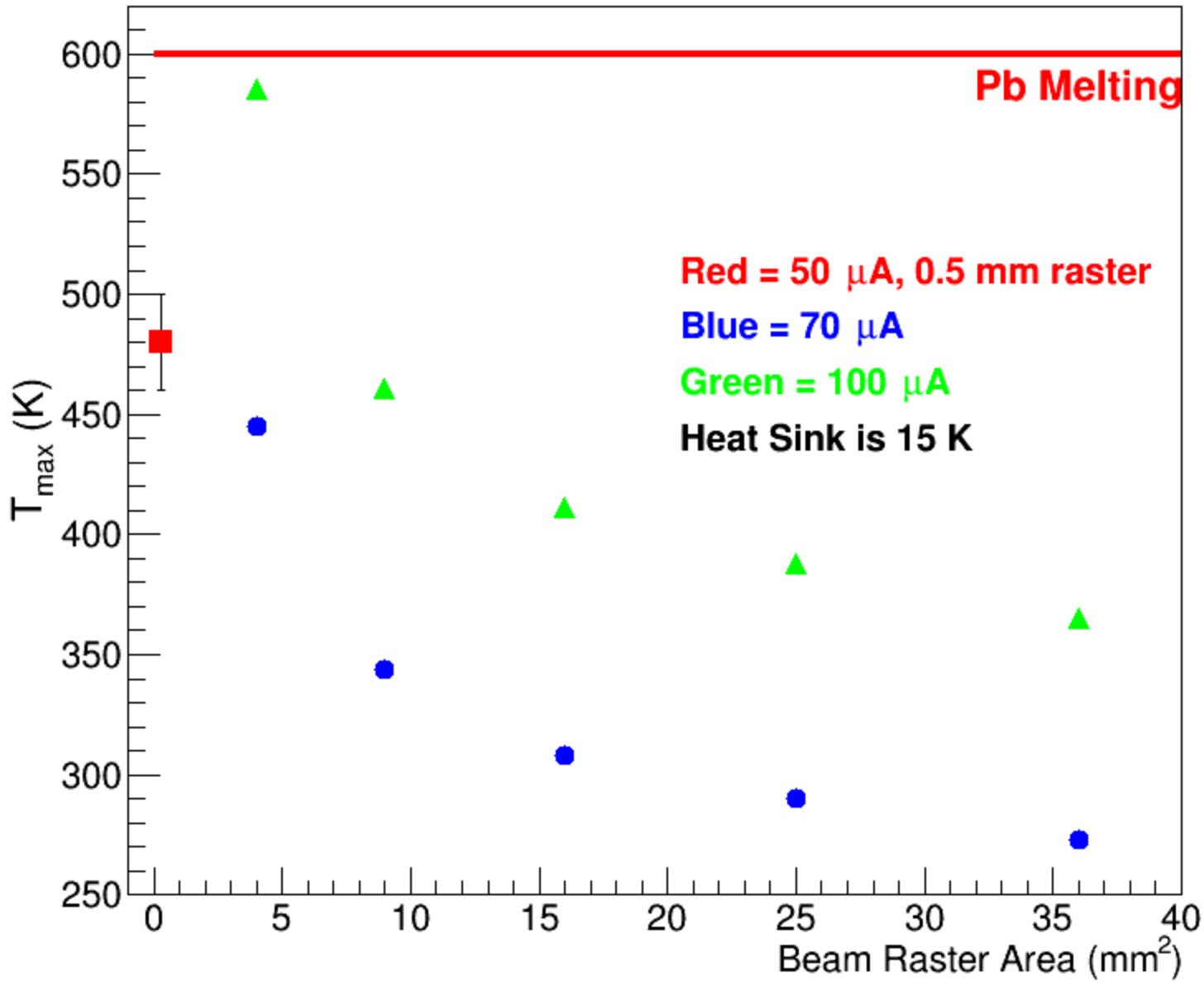
Ti tubing connected to flexible coolant lines, positions in beam and parked



Contours of Static Temperature (k) (Time=1.7000e-02)

Sep 02, 2015

ANSYS Fluent Release 16.0 (3d, dp, pbns, lam, transient)


T_{max} in 0.1 mm Pb target
Pb Melting
Red = 50 μA, 0.5 mm raster
Blue = 70 μA
Green = 100 μA
Heat Sink is 15 K
T_{max} (K)
Beam Raster Area (mm^2)
600
550
500
450
400
350
300
250
0
5
10
15
20
25
30
35
40

Pb wafer heating test?

- There is a possibility to do a Pb wafer heating test with a laser under vacuum conditions with or without cooling the frame
- FEL has (at least one) 10 W laser the we could use in one of their labs (we are planning on using it for an APEX W foil heating test)
- We'll need a disposable vacuum chamber and a Pb frame with/without cooling
- We could measure the temperature on the frame and on the wafer and learn how it actually behaves under almost in-situ heating
- Dave Meekins said they could duplicate the prex1 frame or part of it
- If the collaboration is interested we could set it up in a month or two

Summary

- CFDFAC predicts that a rotating Pb bare target 0.1 mm thick cryogenically cooled with perfect contacts could take 50 μA beam and heat less than 500 K with a beam raster of 0.5x0.5 mm^2 while rotating less than 2 Hz
- Still need to do beam spots of 0.2 mm (unrastered beam) and study the dependence of max temperature with the rotational frequency
- A laser heating test would help benchmark the calculations
- The target designs presented here were done by Wayne Sachleben
- All the work presented here was supported by CFDFAC