Heat Flow Mockup - Review

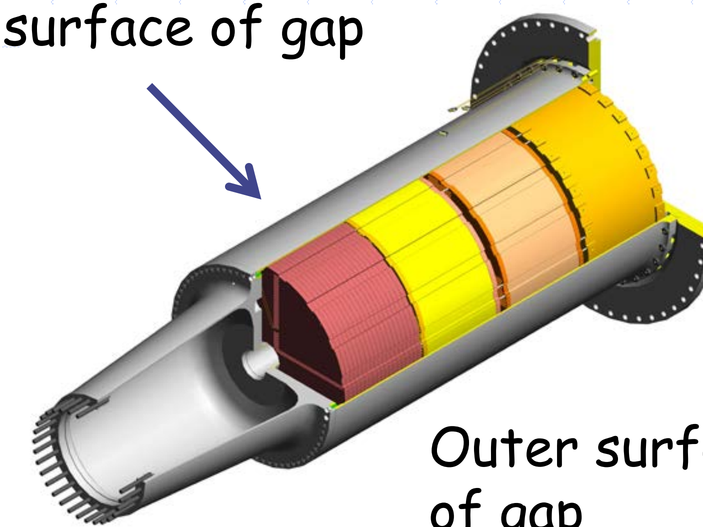
J. Rutherfoord, R.Walker

13 May 2014

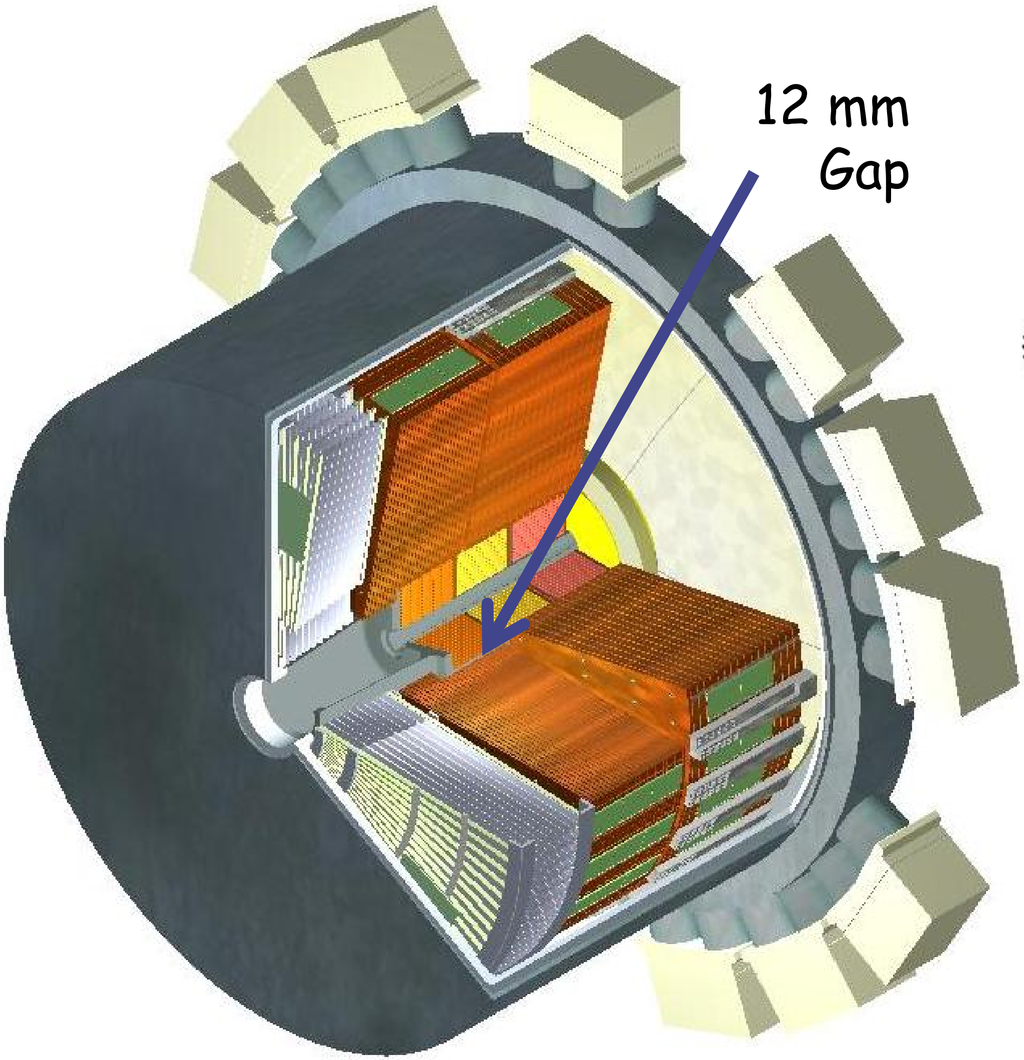
Does the LAr boil at the HL-LHC?

- At 1×10^{34} cm^{-1} s^{-1} about 30 Watts of heat is deposited in each FCal, 18 W in FCal1
- This heat flows radially to the LN_2 cooling coils located on the walls of the end cap cryostat cold vessel.
- The greatest impedance to this heat flow is at the 12 mm LAr-filled gap between the FCal support tube and the inner bore of the HEC

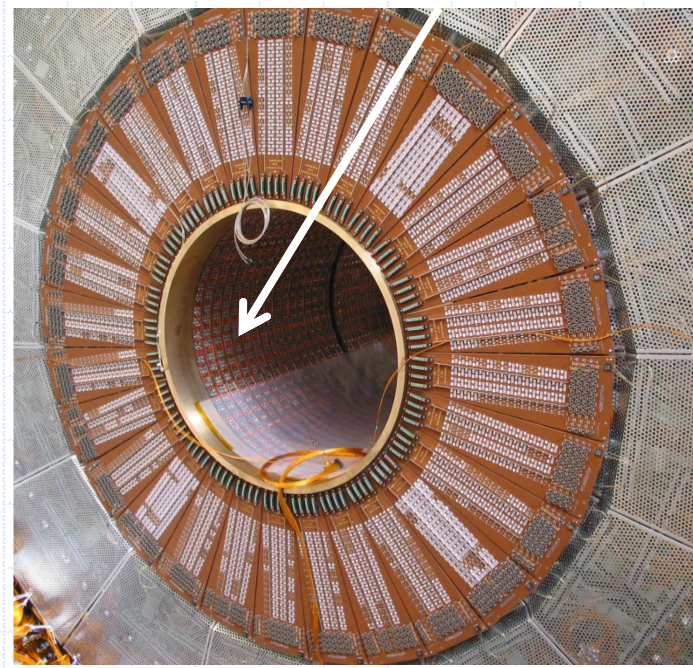
Inner surface of gap



12 mm
Gap



Outer surface
of gap



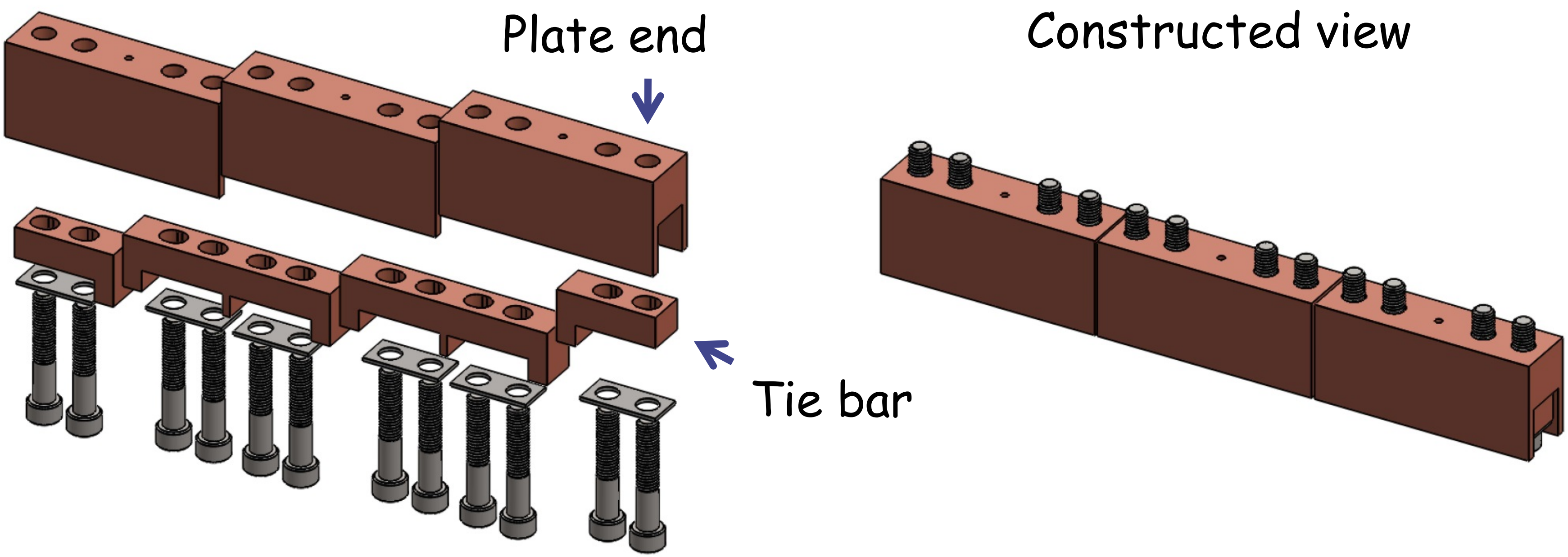
For full-size drawings see

- http://atlas.physics.arizona.edu/Arizona_Atlas_Downloads/HeatFlow/
- File name is in upper right corner of each slide
- Engineering drawings are in a sub-directory

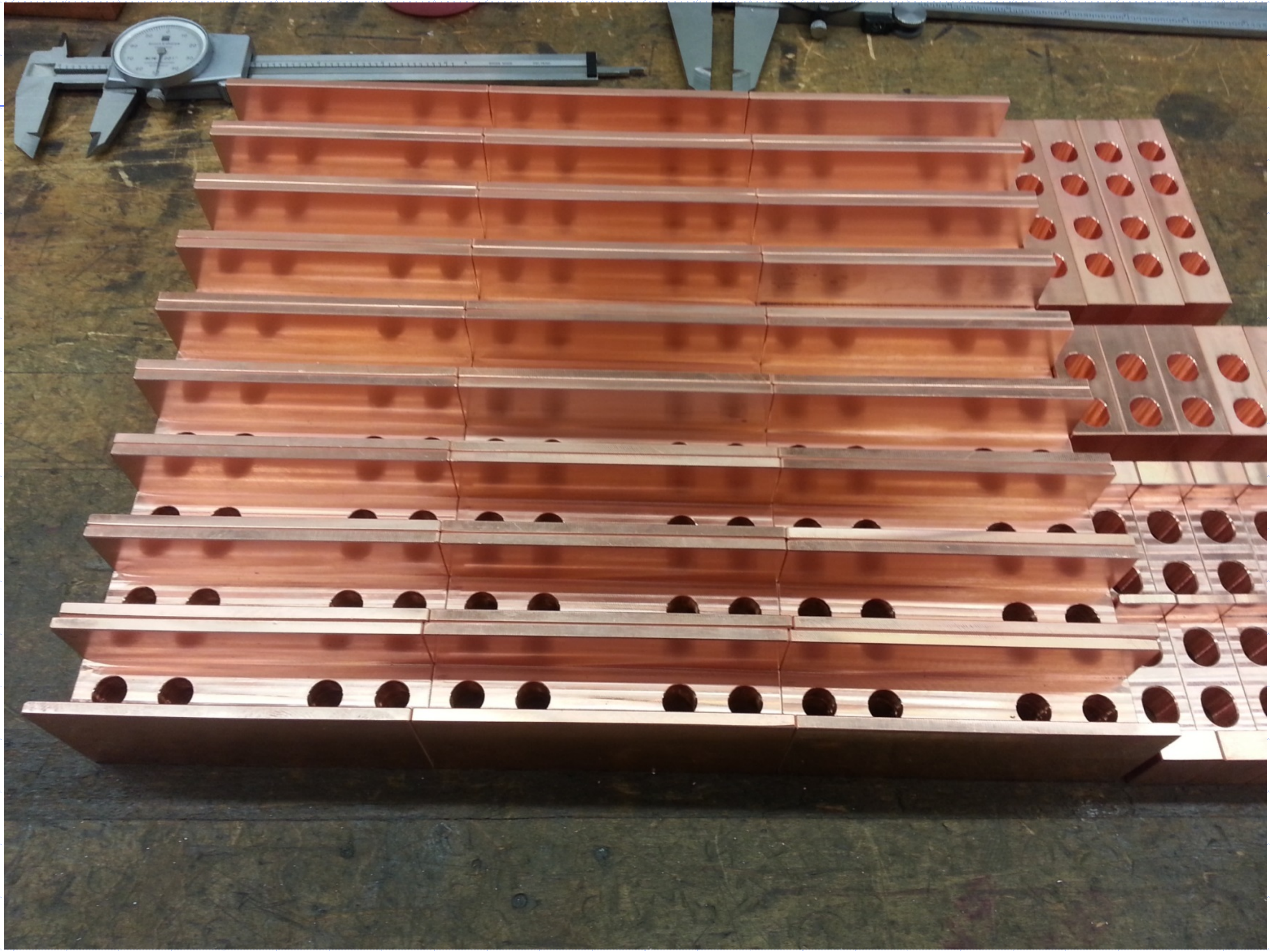
High η end of 3 HEC Absorber Plates

Flattened out

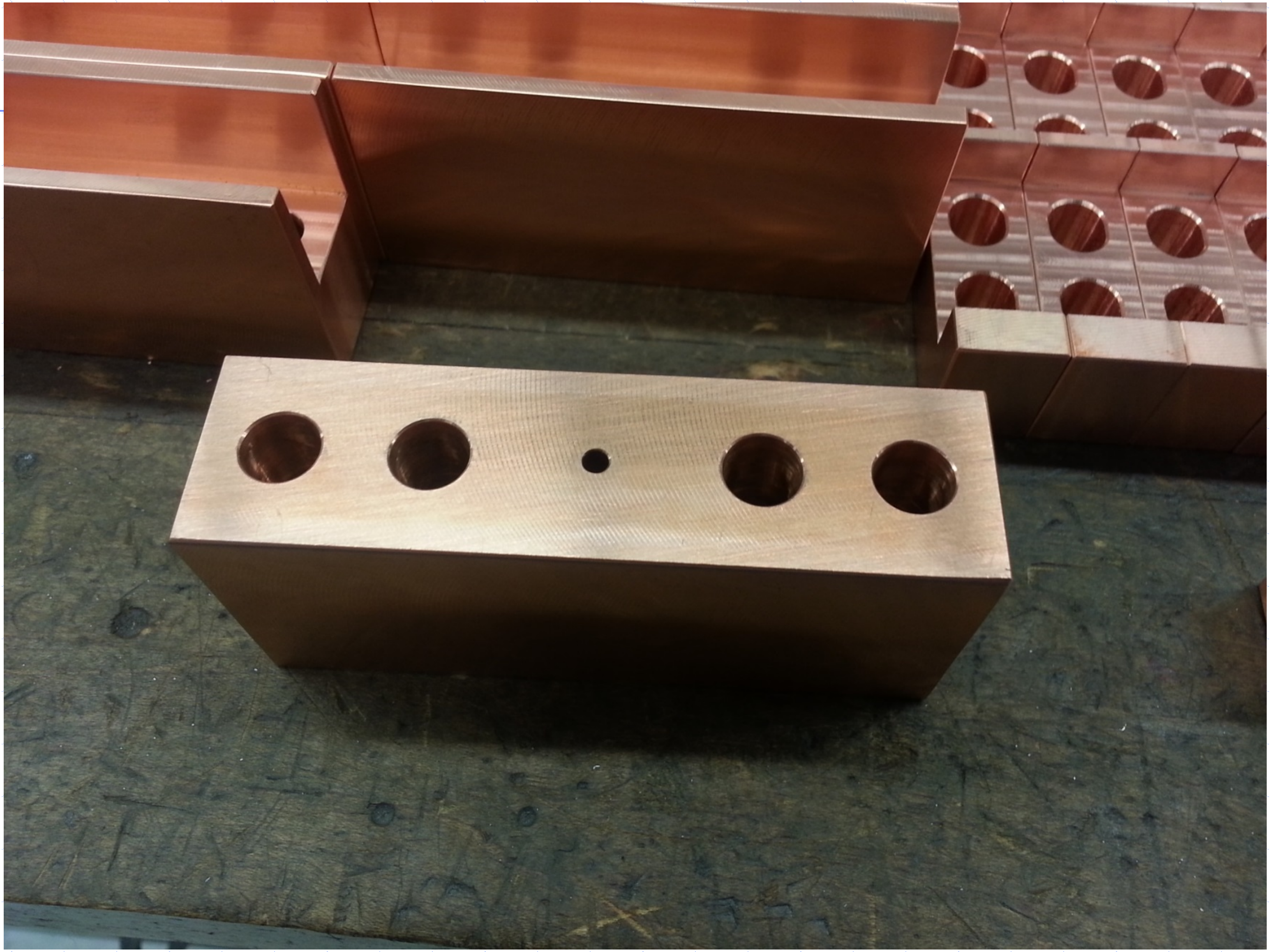
Exploded view



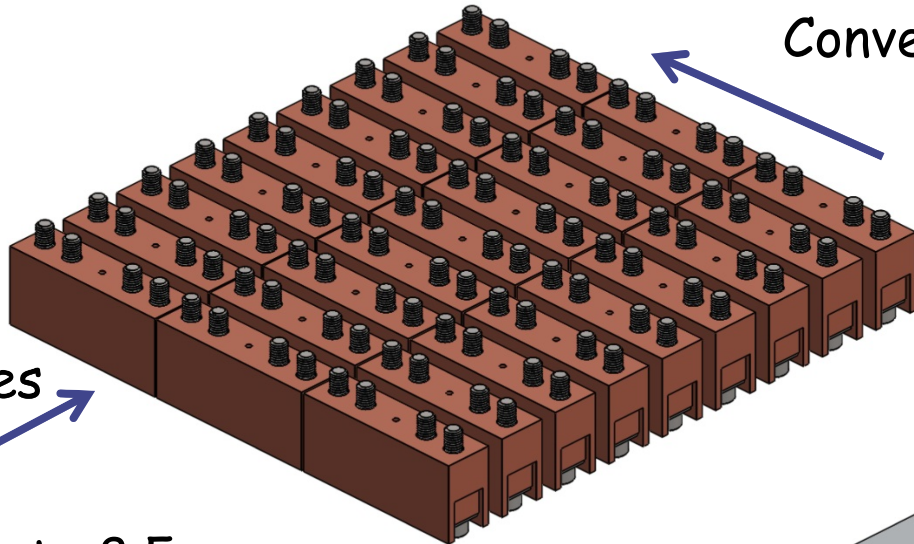
HEC absorber plates and tie bars



HEC absorber plate ends



Nine layers of HEC absorber plate ends

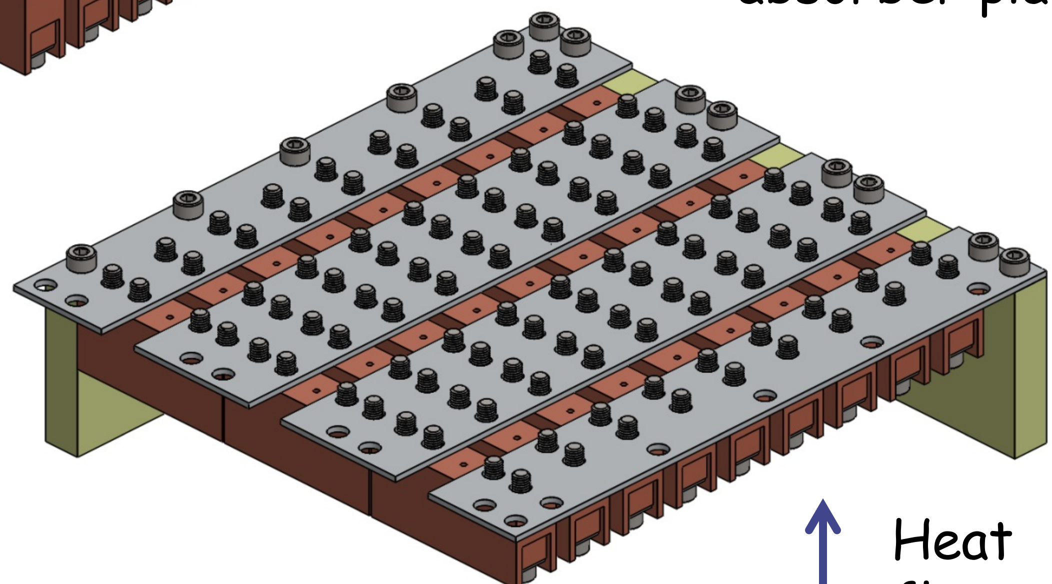


Convective flow direction

Particles

Note 8.5 mm gaps between absorber plates

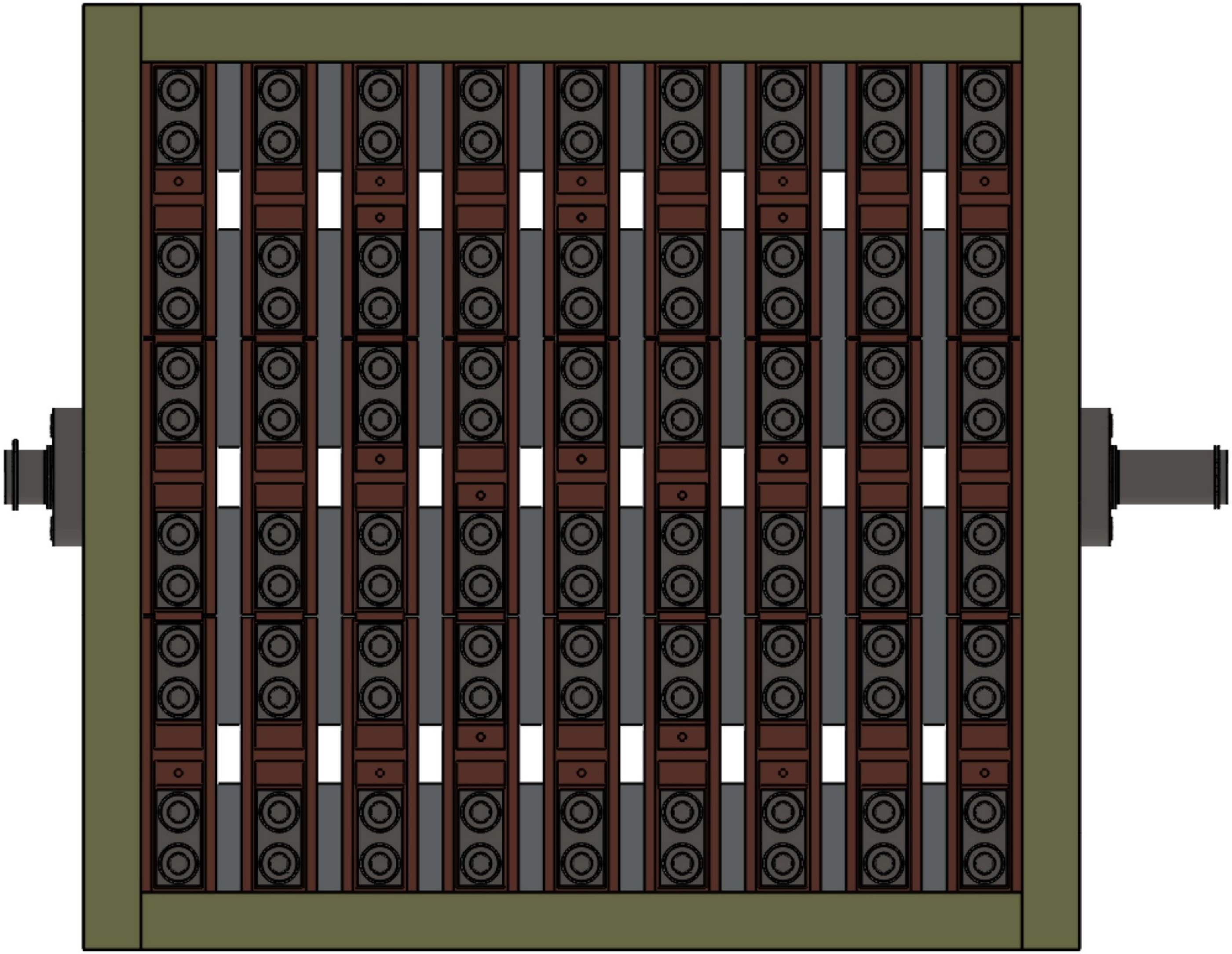
"Strong back" and two sides of box to hold HEC absorber plates in place



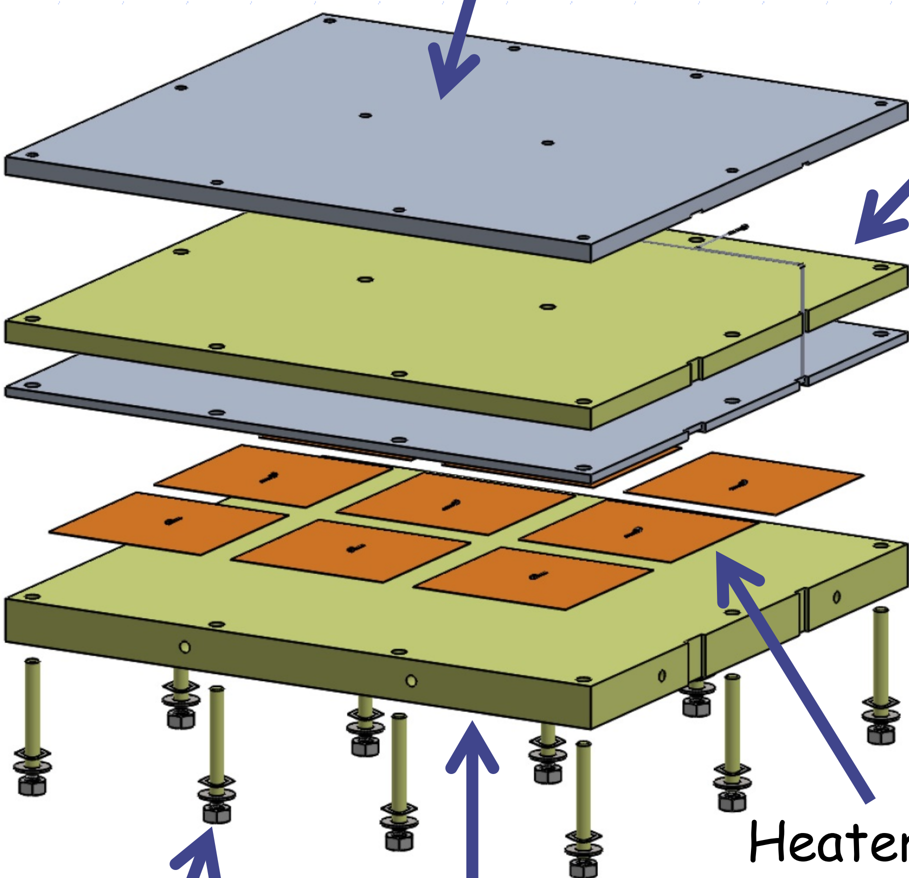
12 mm LAr Gap is below the plate ends

Heat flow

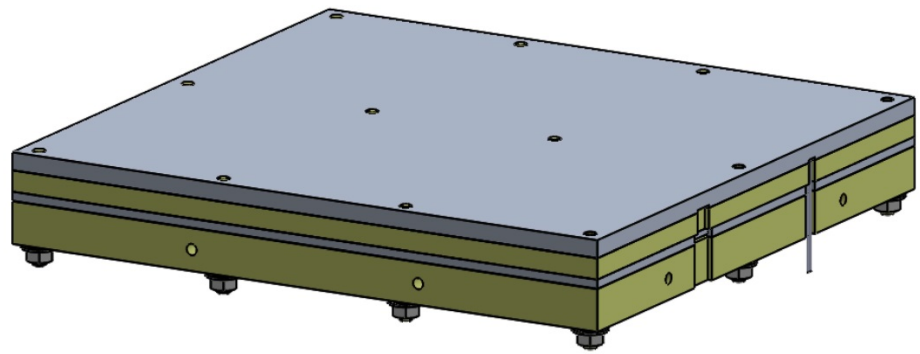
View from the LAr side



Exploded view

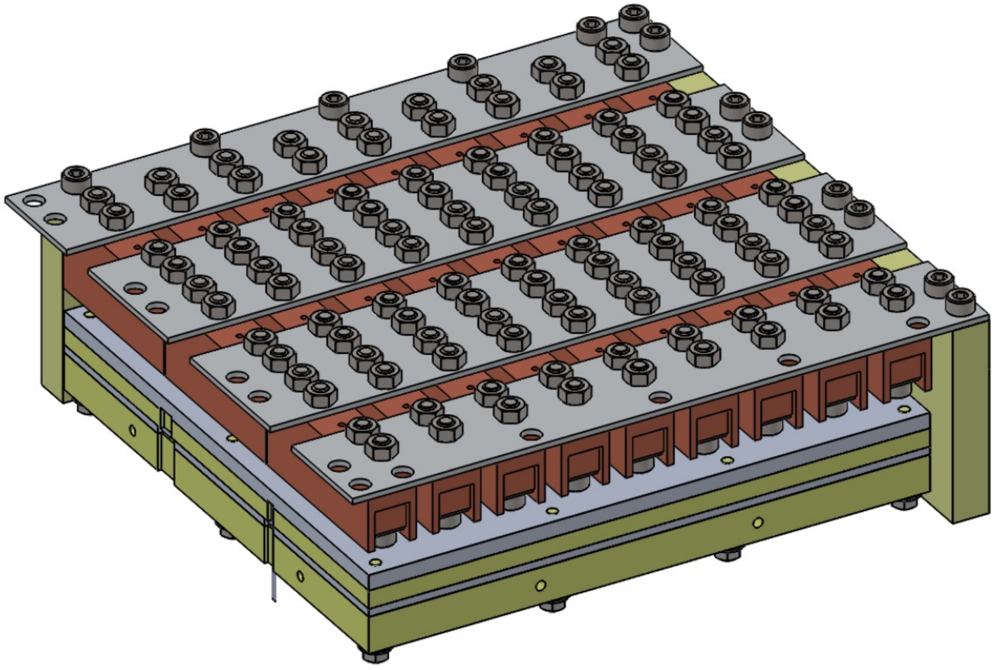


Assembled plates

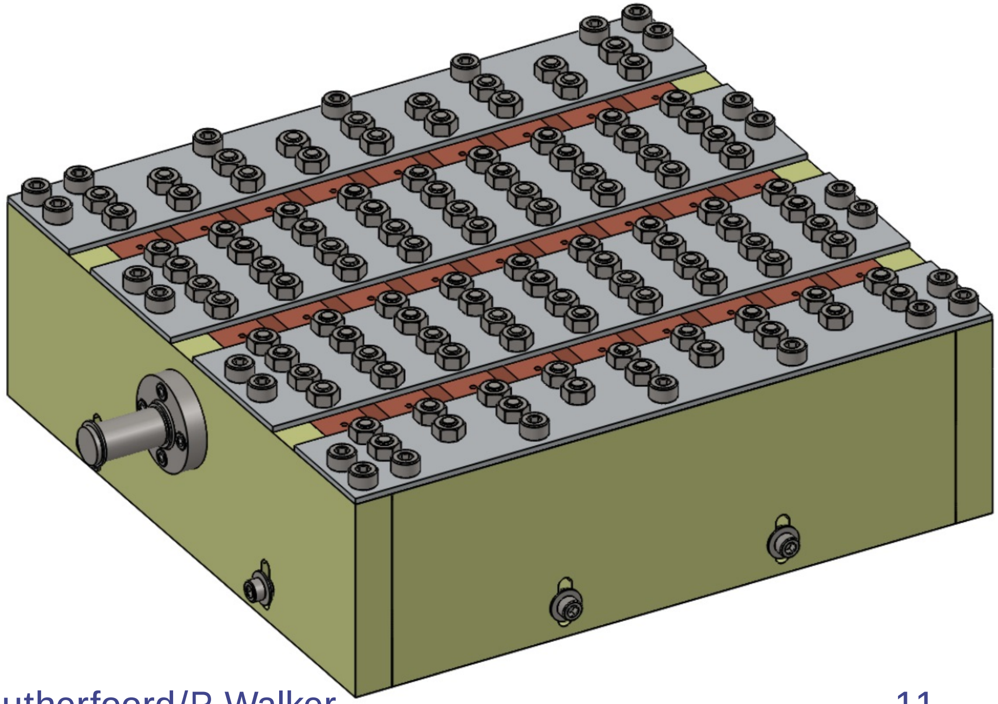


12 mm LAr Gap is above the Al Support Tube

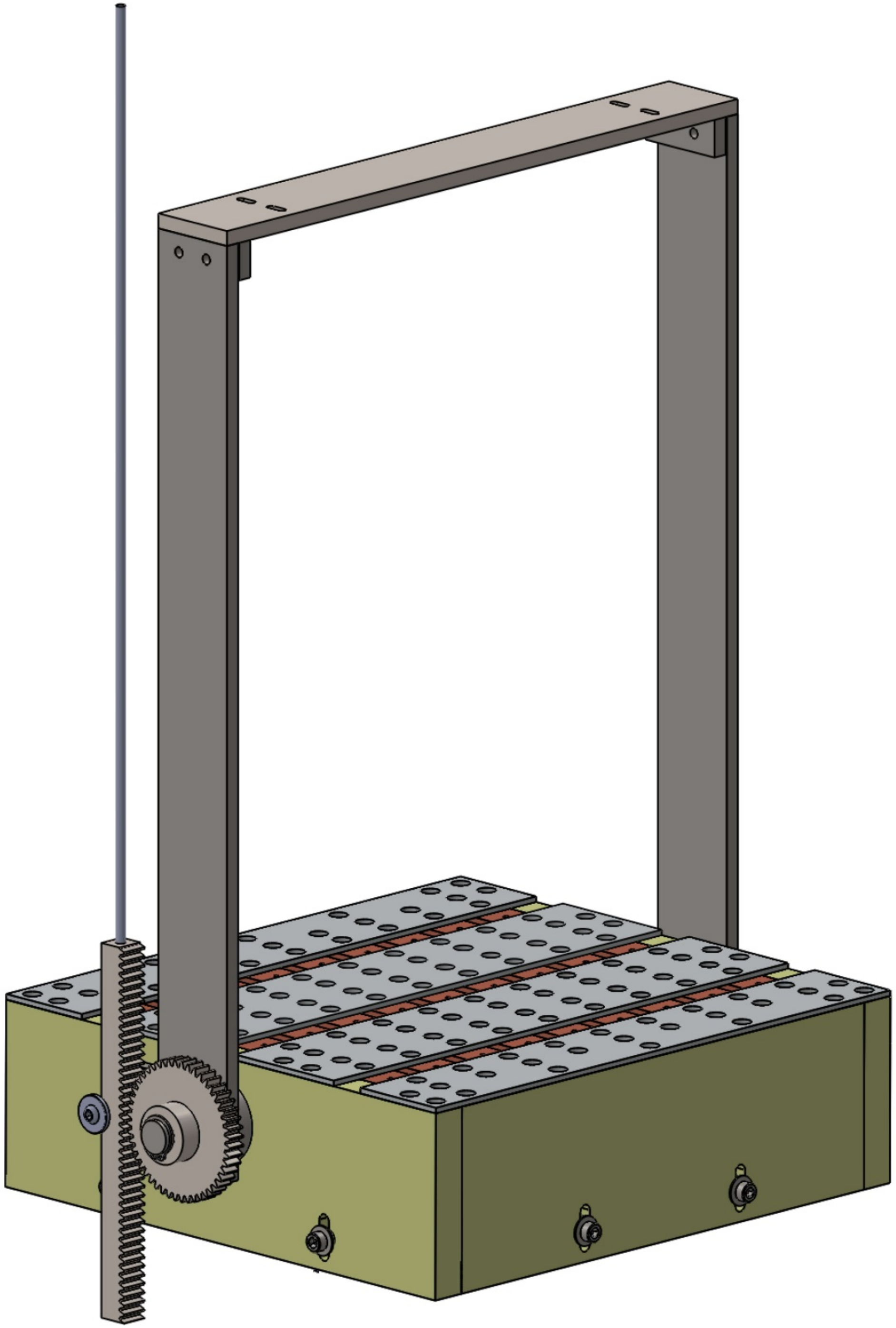
HeatFlow001B



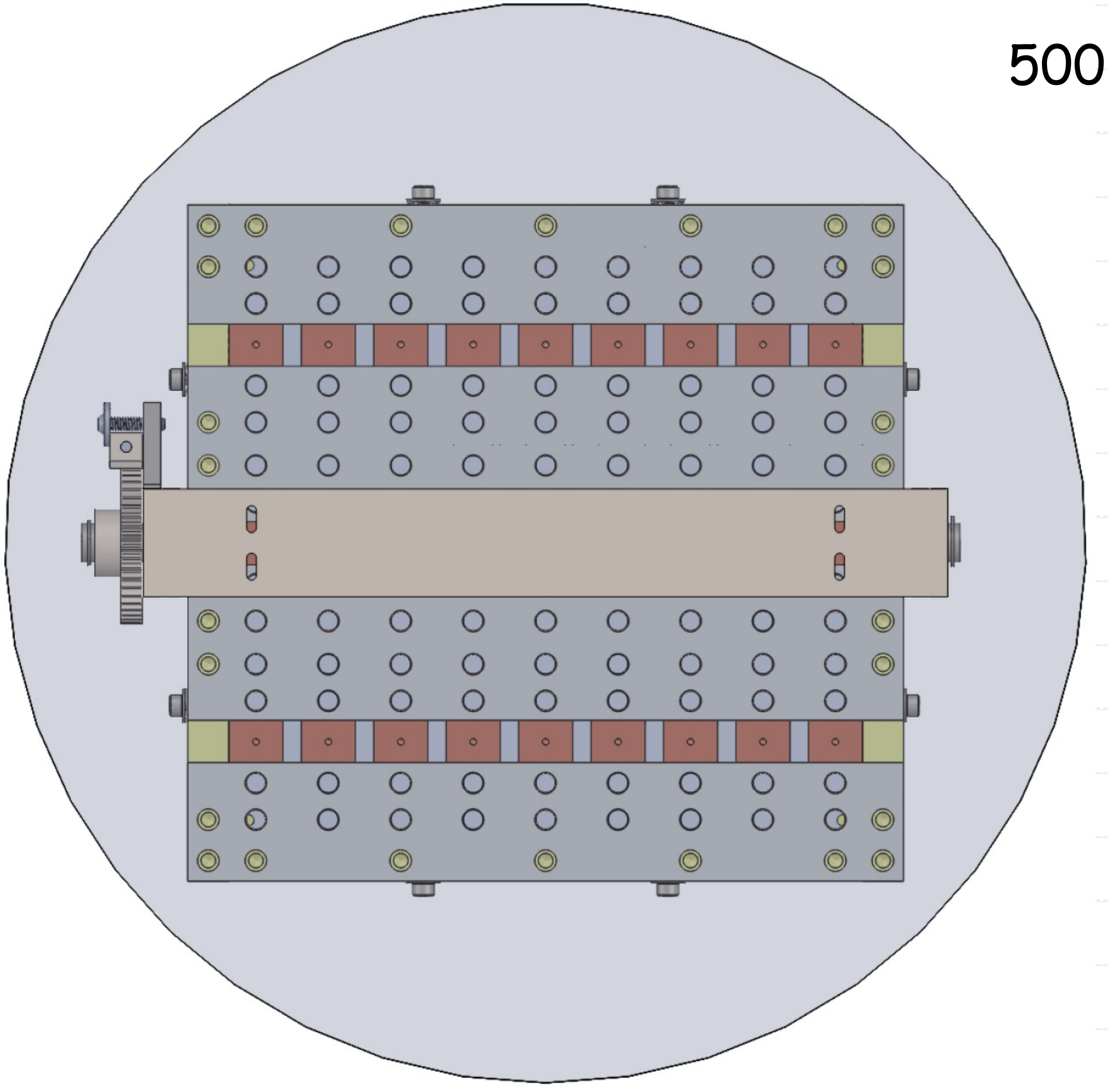
Assembled plates mounted in box. Sides and bottom are G10.



HeatFlow001B



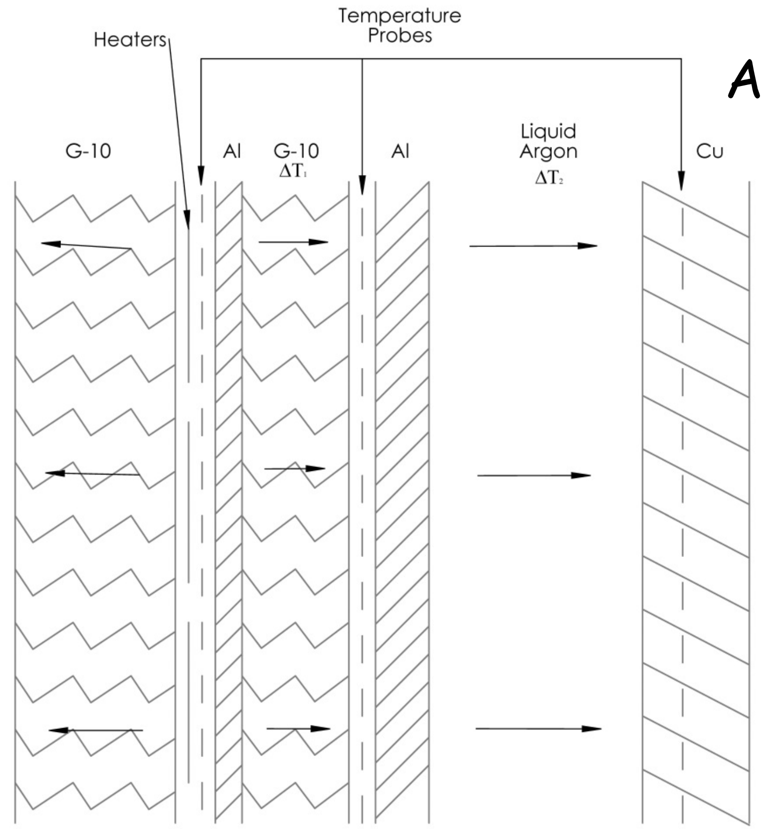
Heat Flow box in cryostat



AZHF000

Concept drawing

- G10 on left is insulator
- G10 on right determines heat flow rate via ΔT_1 and known conductivity
- Al plates are "perfect" conductors
- Heat flow through G10 on right also flows thru LAr gap
- ΔT_2 determines effective thermal conductivity of LAr gap
- Heat flow is also determined by power to heaters and balance between heat flow to left and to right.



Al Plate Area: $0.0800m^2$

At 75W in FCal1
or $L=3.6x10^{34}$
or heater @ 10W
ΔT_1=2K
ΔT_2=0.8K With Convection
=4k Without

Run up to:
Running Voltage = 35V
Total Heating @ Full Power = 22W
Wire heat leakage = ~1W

G10-CR chosen so that

$$\Delta T_2^{min} < \Delta T_1 < \Delta T_2^{max}$$

What else is needed for the test?

- The following two slides list items which we foresee as essential for the test
- We need to assign responsibility for these items
- Johan and Torsten can help
- What have we forgotten?

Necessary items

- Cryostat top plate with ...
  - Temp probe readout signals feedthru
  - Heater power feedthru
  - Plunger feedthru
- Cryostat to run with ...
  - High pressure (2 bar?)
  - Wide temperature differential between freezing and boiling (6 - 8 K) Ambient 86 K
  - LN2 cooling loops in the liquid – Up to 23 W

Necessary items (con't)

- Re-design "hanger" to fit top plate
- Heater Power Supply (9) and control
- Temp probe readout and DAQ
- DAQ programming (Lukas Schroeder?)
- HexCell (Arizona, Schacht, Chekukaev)

DiscussionTopics

Discussion Topics
04/28/2014

TopPlate/Cooling

- Adapt to existing top plate or make new one for experimental setup
  - One set feedthru position for rotation
    - From cryostat center R-193mm +7.5-8° off axis of rotation. (will change due to larger gear)
- Do we supply Temperature sensor feedthru, and heater feedthru?
  - Are we adapting to existing sizes?
- Experiment hanger redesign for adaptation?
- Cooling requirements (heat from setup)
  - Hand calculation: ~20W overall heating
  - From simulation: ~23W
  - Temp differential in LAr ~5-7K
    - Run at "high" pressure?
    - Super-cool?
  - LAr purity not a concern

Readout and Control

- Heater
  - Power supply?
    - 9 lines (2wires/line) w/ variable output settings
    - Estimated max required voltage ~35V
      - Heater designed for 115V
  - Monitor both voltage and current to calculate the power
  - Feedthru?
    - MDC Vacuum part# 9132006 (20 pins 2.75" feedthru in stock)
    - Air side connector has 20day lead time (delivered last week of May)
- Temperature
  - Feedthru
    - Connectors?
  - DAQ hardware?
  - Software program to record temperatures
    - Arno Straessner's student starting in May?
  - Calibration?
  - Designed under the assumption CERN provides temperature readout hardware.
    - What is the computer interface?

DiscussionTopics

Assembly and shipping

- Stuff HexCell into gaps in Cu absorbers.
  - Where to get HexCell?
- How much assembly should be done prior to shipping?
  - Ship fully assembled so just have to connect to top plate and make connections?
- Ship by date?
  - May 30?
    - Heaters have 5 week lead time.
      - Estimated delivery May28-29?
    - Parts manufacturing timeline = 3 weeks from start
- Assembly/user instructions?
  - Includes:
    - Any assembly needed to be done at CERN
      - Setup prior to running
      - Any information relevant to data collection/running

Go to Timeline.pdf

in http://atlas.physics.arizona.edu/ Arizona_Atlas_Downloads/HeatFlow/

- This file outlines the steps we foresee from now to the end of June.

Present Estimated Cost

- Arizona parts - $17.1 K +