# G.A.Kirby

# Content of Presentation

- Low temperature data for magnet-materials (Cu, NbTi,Insulation)
  Specific heat, thermal conductivity, resistivity …….
- HEPAC Old DOs program calculates:
  helium properties at different temp and pressures
- \\Srv2_div\cryo\TOOLS\CRYODATA\HEPAK3.4
- Computational Fluid Dynamics.
  https://edms.cern.ch/document/624664/1 .
  - MQY study. Heat Conduction through coil with a simple annular heating. (study completed)
  - MQY study. Convection of helium through MQY structure.
    (study in progress)

# ** Hunt for data **

## Materials

NbTi

Cupper

Kapton

Epoxy

Stainless Steel

Iron

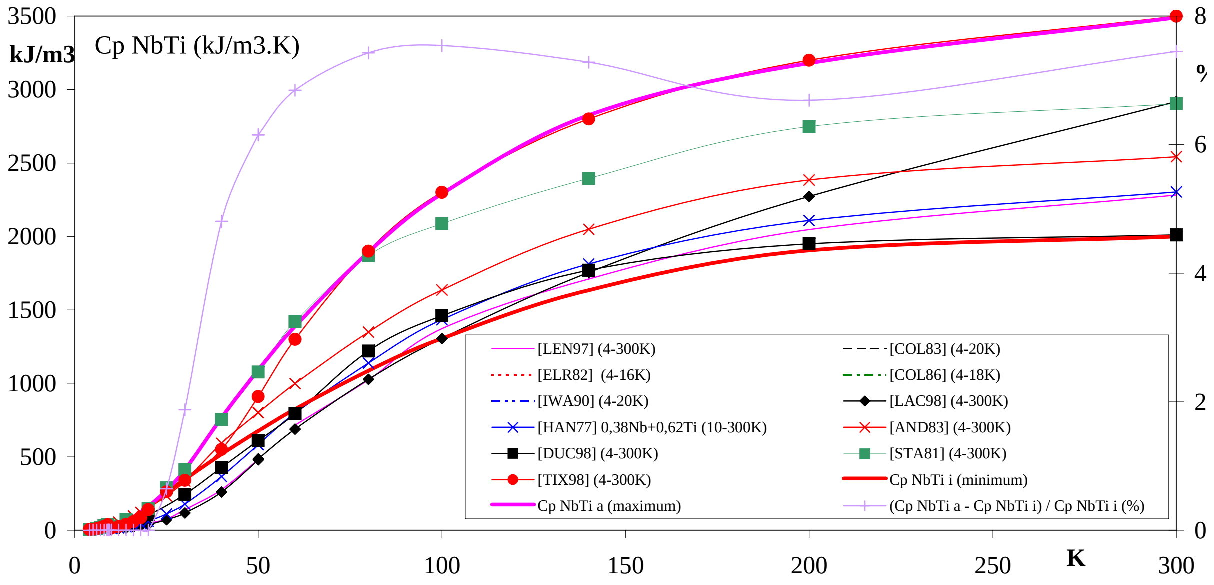
## Cryogenic Material Properties

Cp

Resistivity

Conductivity

........




| | Cp NbTi (B,T) in J/m³.K |
|---|---|
| T < 20 K | TcB= 9.2 * (1 - B / 14.5) ^ 0.59<br>If T < TcB Then Cp = 49.1 * T ^ 3 + 64 * B * T<br>Else Cp= 16.4 * T ^ 3 + 928 * T |
| T < 50 K | Cp = -0.217724 * T ^ 4 + 11.983792 * T ^ 3 + 553.712993 * T ^ 2 - 7846.120813 * T + 41382.928569 |
| T < 175 K | Cp = [-0.00000000482 * T ^ 4 + 0.00000297583 * T ^ 3 - 0.00071625148 * T ^ 2 + 0.08302230116 * T - 1.53178 ] * 10^6 |
| T < 500 K | Cp = [-0.0000000000629 * T ^ 4 + 0.0000000929657 * T ^ 3 - 0.0000516653121 * T ^ 2 + 0.0137062419692 * T + 1.23554 ] * 10^6 |
| T < 1000 K | Cp = [-0.000000257 * T ^ 2 + 0.000955466 * T + 2.450087571 ] * 10^6 |

# 4.5K thermosyphon and 1.9K conduction

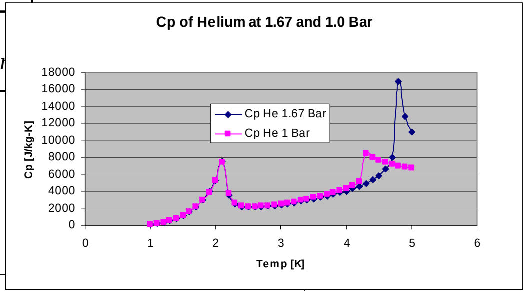
$$Q = \dot{M}.Cp.\Delta T_{Heli}$$

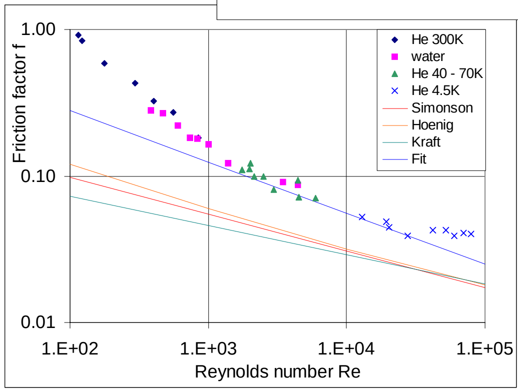
$$\dot{M} = \frac{Q}{Cp.\Delta T_{Heliu}}$$

$$Buoyancy = V.(\rho_{4.8K} - \rho_{4.5K}).g$$

$$P = \frac{2f}{D_h \rho}\left(\frac{M}{A_h}\right)^2$$

$$\dot{M} = A_h \sqrt{\frac{P D_h \rho}{2f}}$$



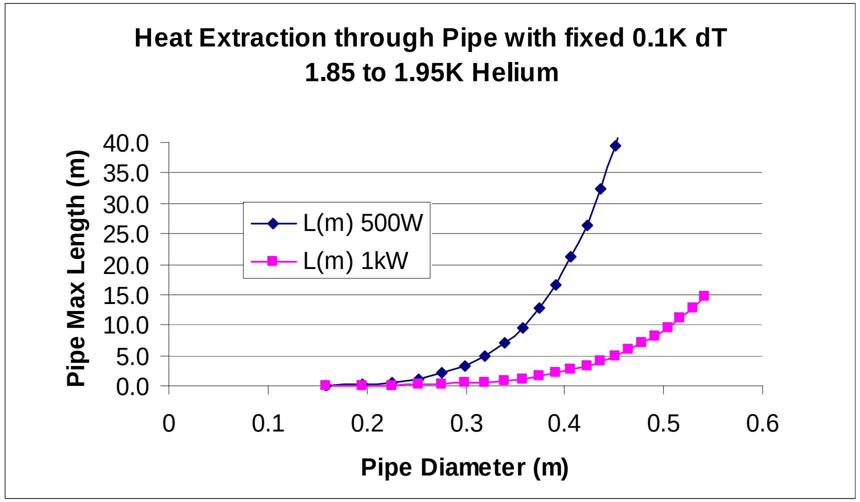

$$\mathrm{Re} = \frac{M}{A_h}\frac{D_h}{\mu}$$

>10^5 its turbulent

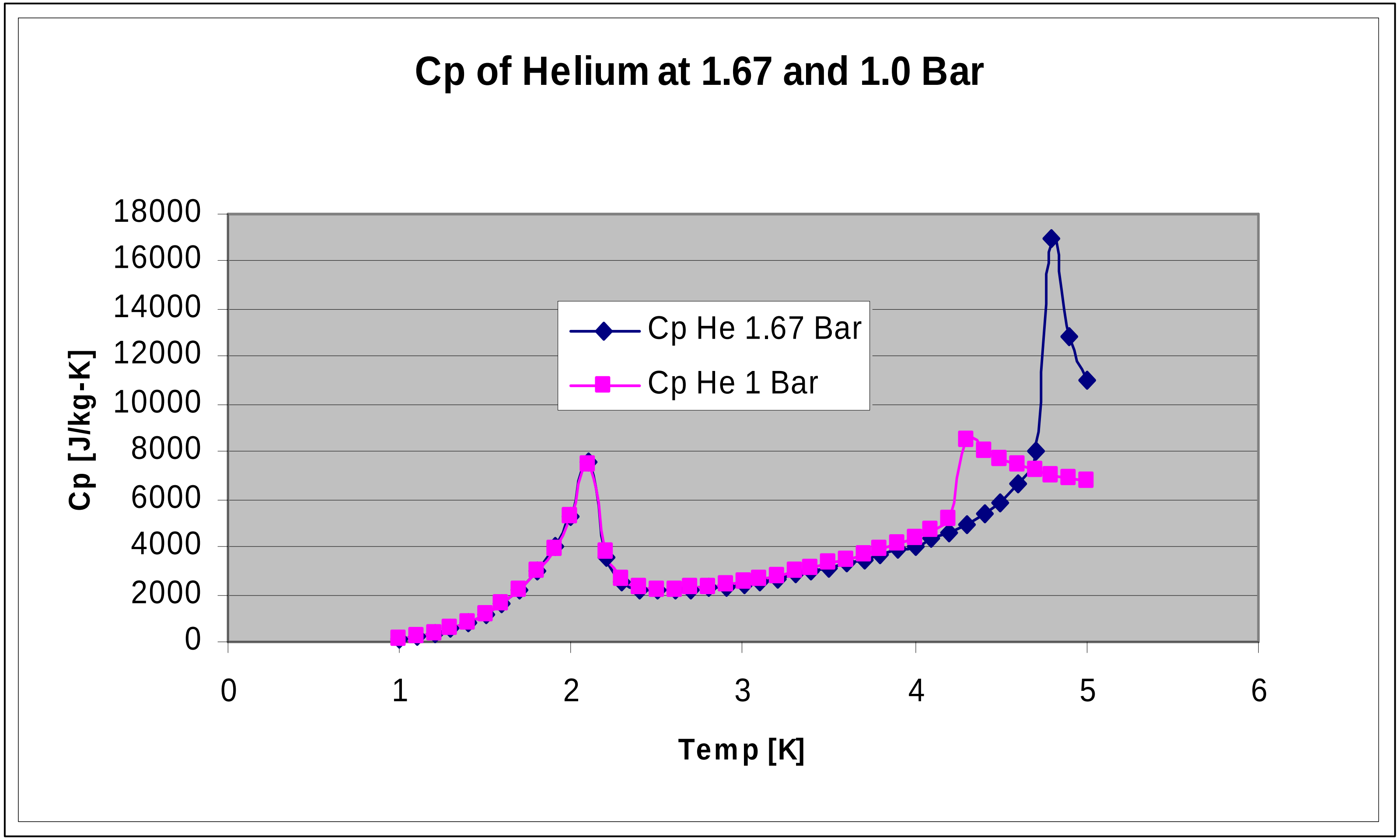
$$Nu = 0.259\,\mathrm{Re}^{0.8}\,\mathrm{Pr}^{0.4}\left(\frac{\theta_w}{\theta_b}\right)^{-0.716}$$

Van Sciver,
“Helium Cryogenics”, pp. 143 - 144

$$\Delta T = \frac{q^3 L}{1200}$$



# HePAC




Old Dos Program that give Helium many properties.

BUT needed updating to new system before Dos disappears or changes !

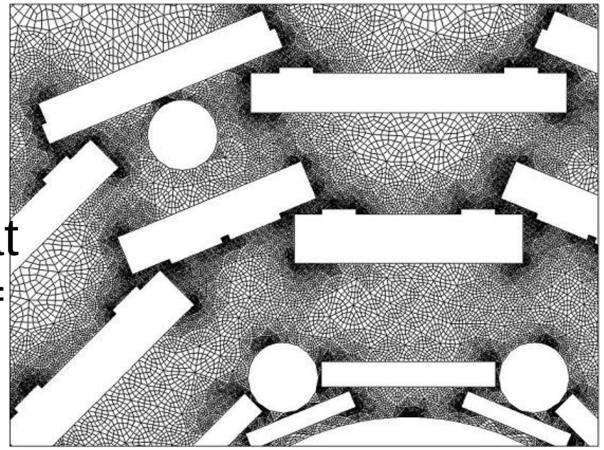
\\Srv2_div\cryo\TOOLS\CRYODATA\HEPAK3.4

# Computational Fluid Dynamics

**TS/CV/Detector Cooling - CFD Team**

✓ Computational Fluid Dynamics (CFD) is an analysis of fluid flow, heat transfer and associated phenomena in physical systems using numerical methods.

✓ The basis of computational fluid dynamics is the reduction of the continuum differential equations describing the dynamics of the fluid (Navier-Stokes + mass and energy conservation equations) into a system of algebraic equations at a finite number of "grid" points, and the solving of the equations at these limited number of points only.



# A wide range of application fields

Aerospace

Automotive

Biomedical

Buildings

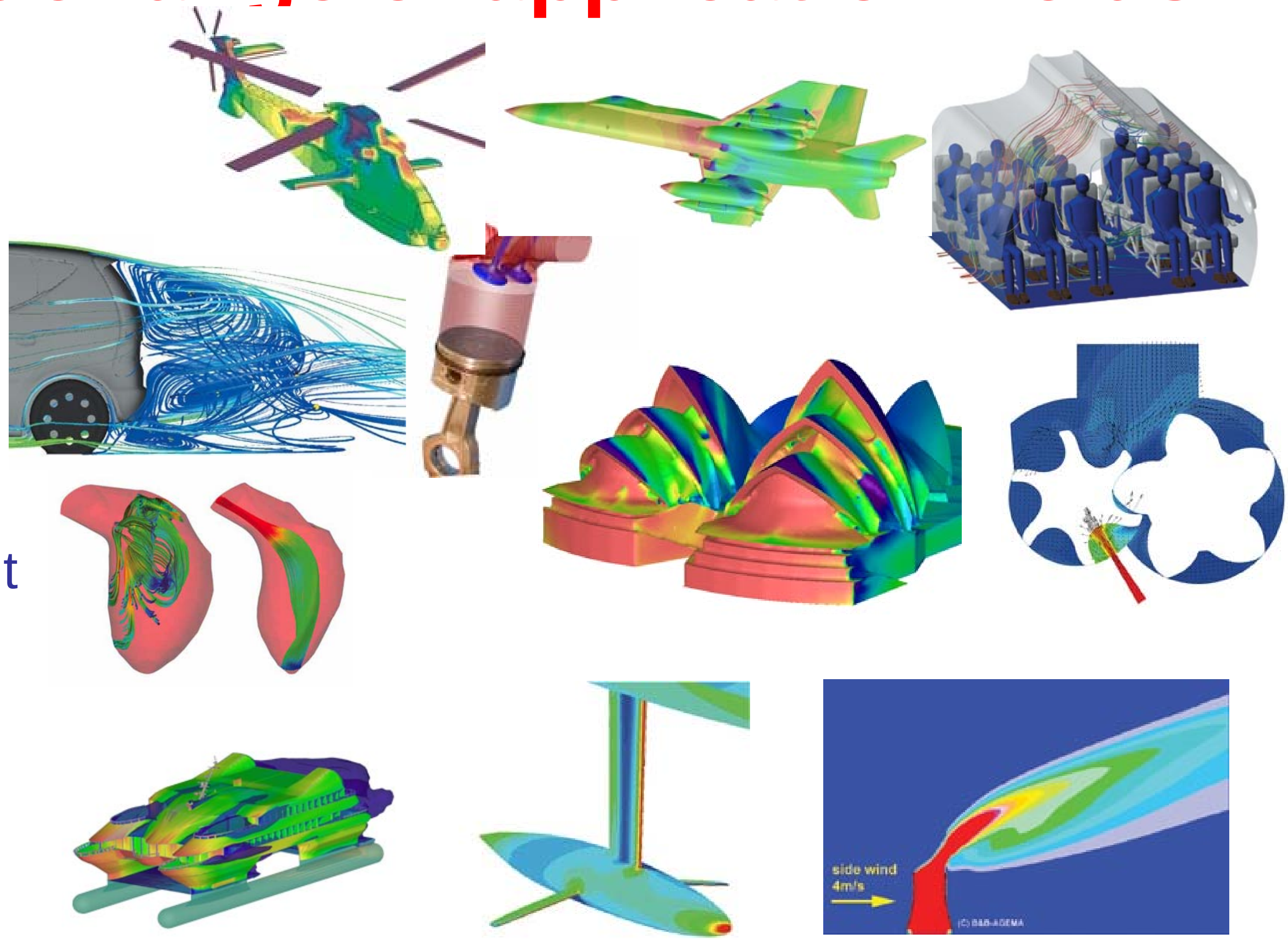
Chemical

Environment

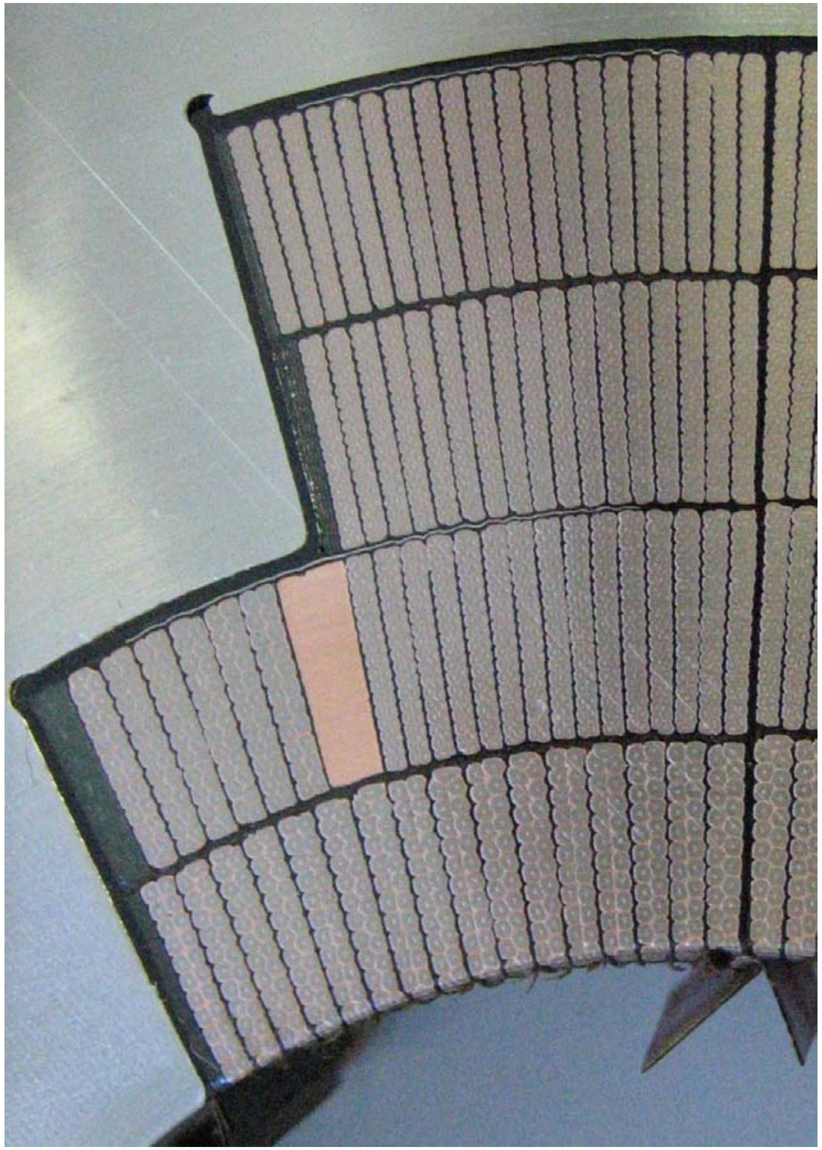
Marine

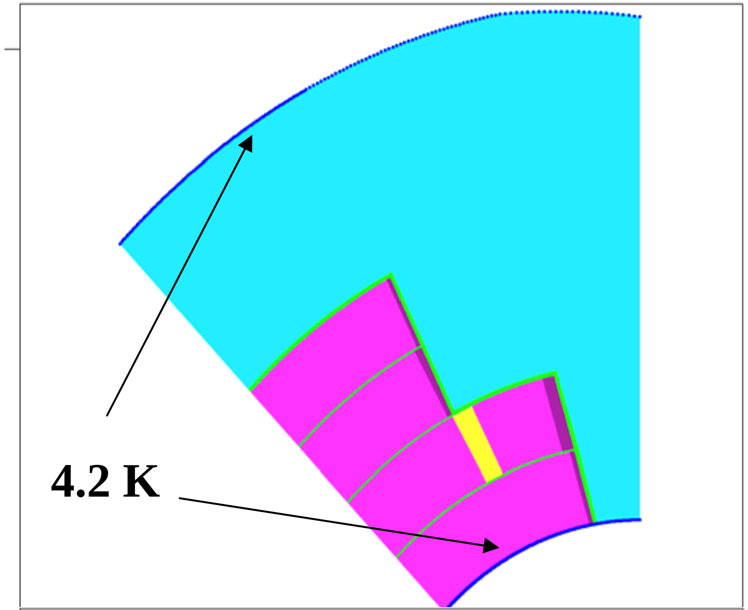
Power gen.

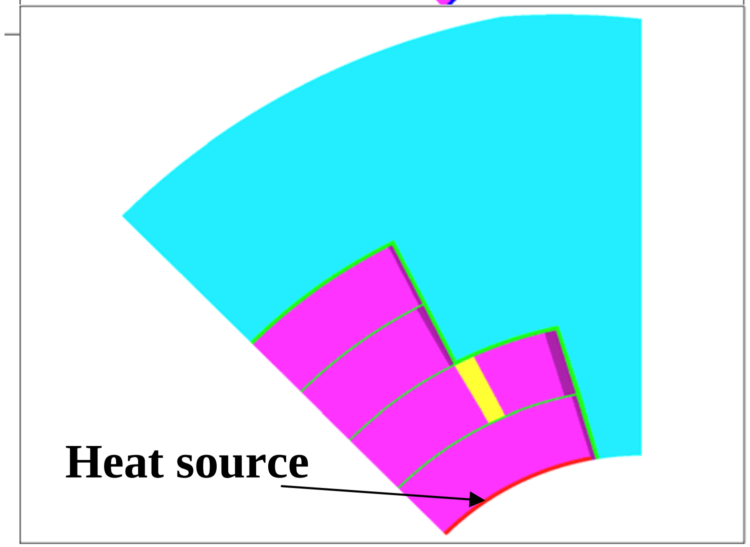
Turbo-
machinery



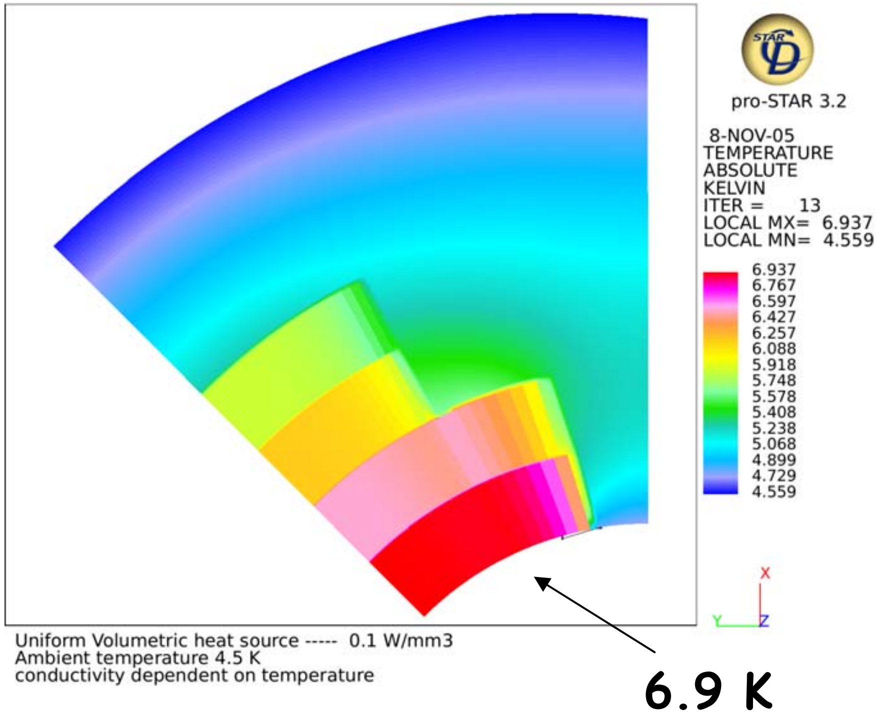
# MQY study. Heat Conduction through coil with a simple annular heating at inner radii.

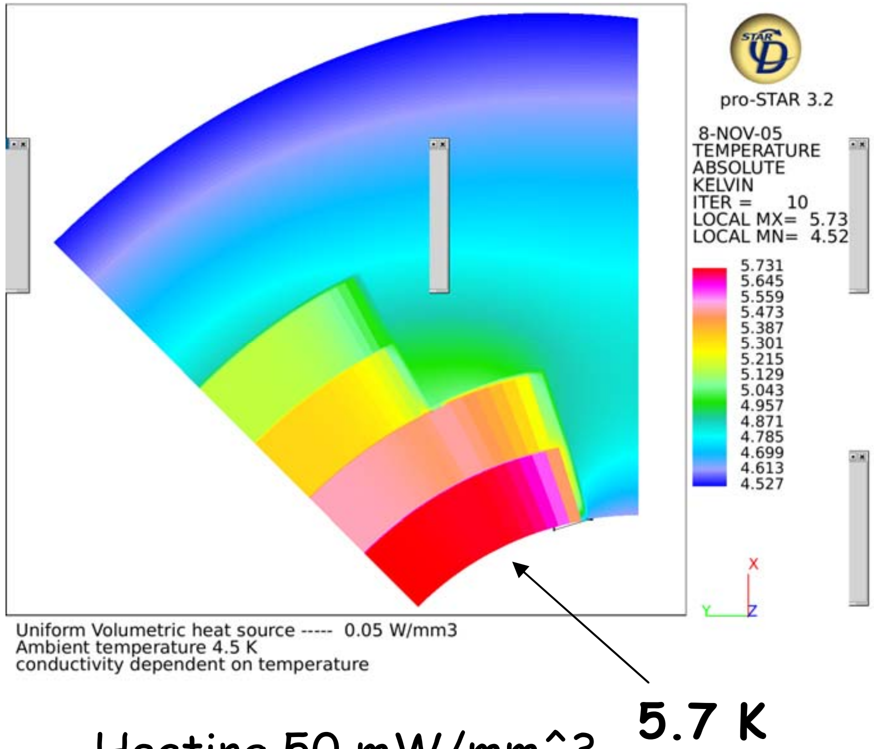




# Conduction heat distribution results

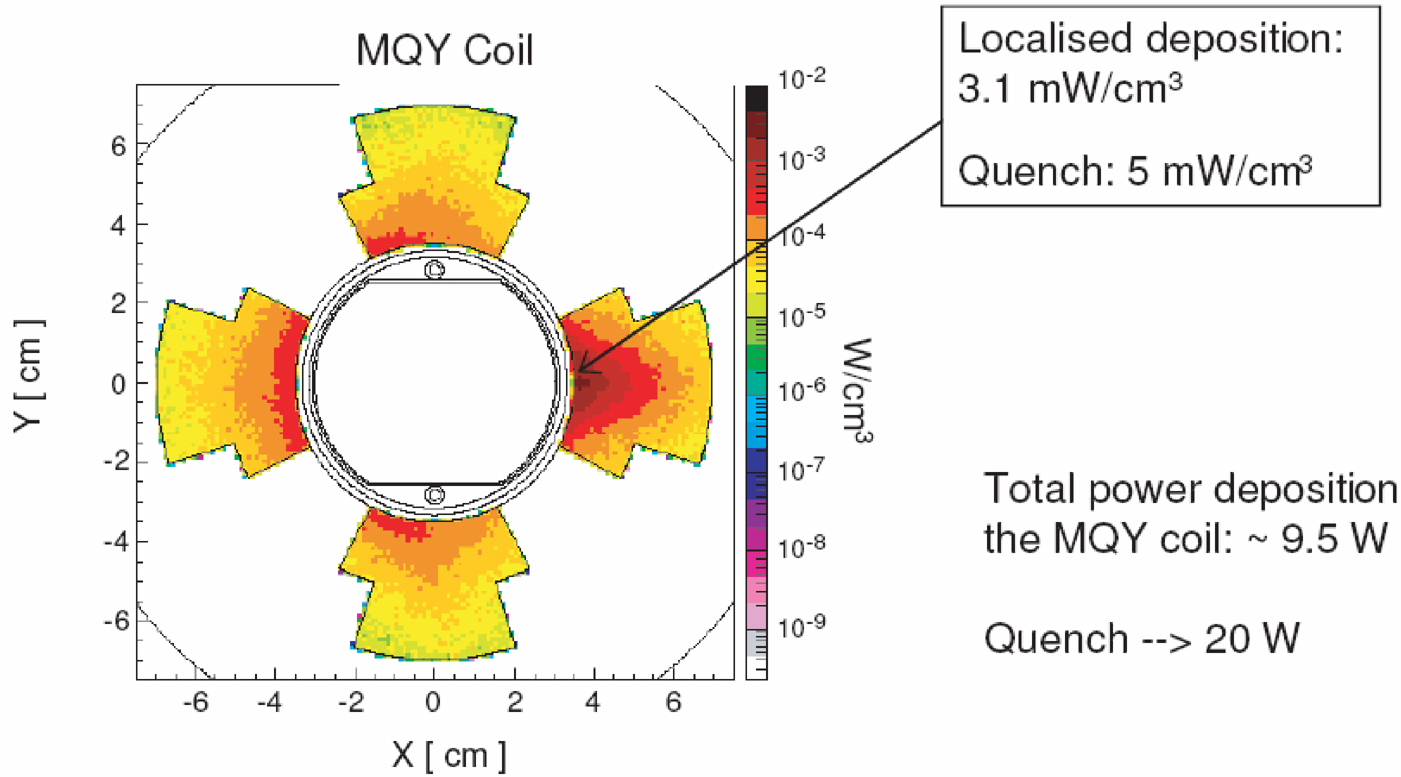



Heating 100 mW/cm^3
Into 2mm annulus

Heating 50 mW/mm^3
Into 2mm annulus

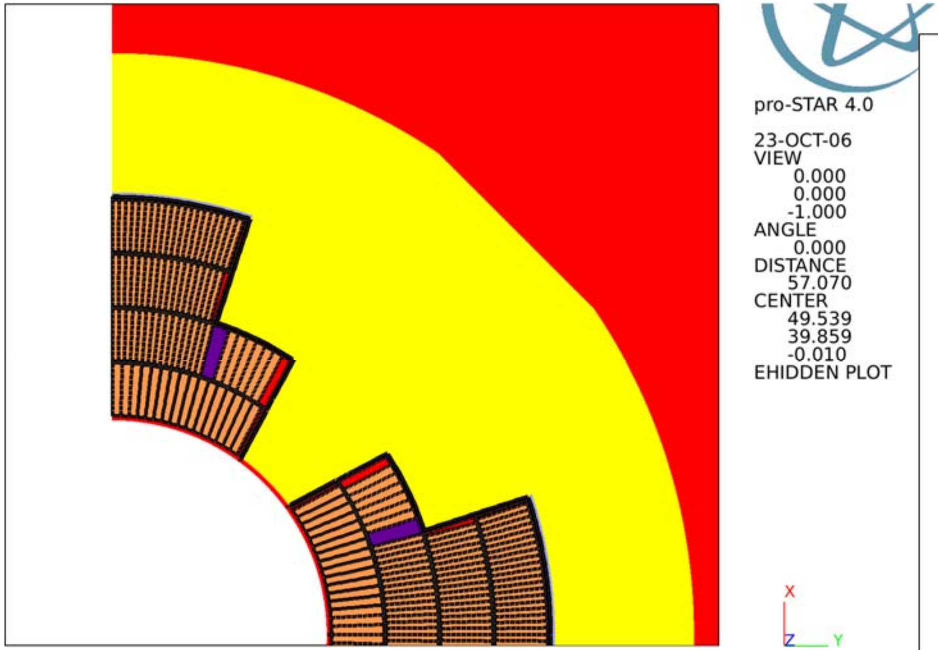
# Heat load

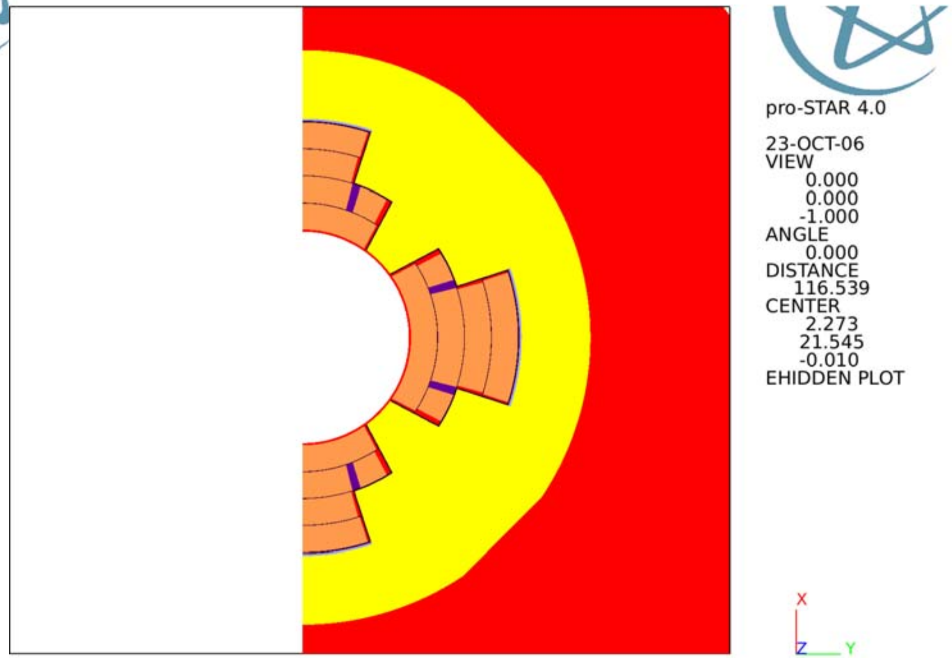


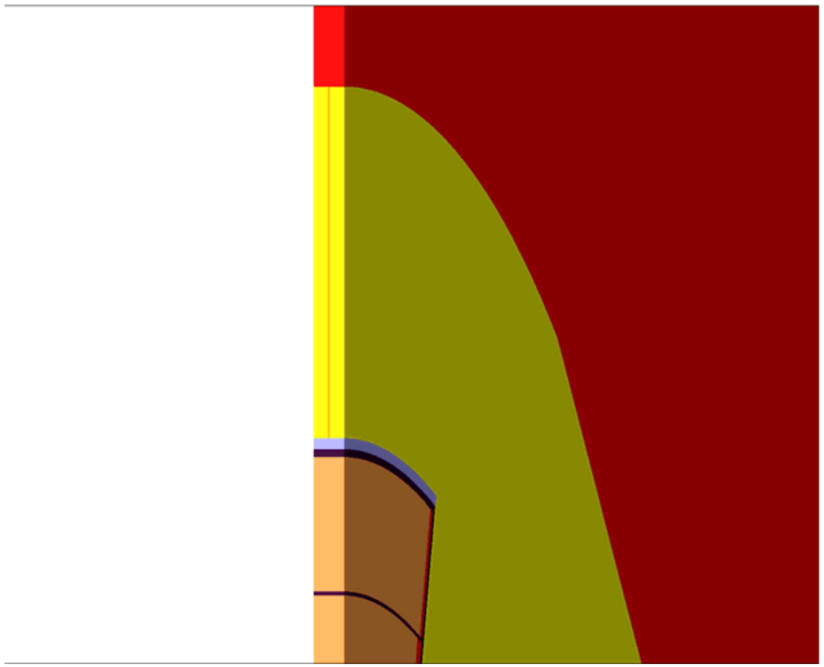

Total power deposition in the MQY coil: ~ 9.5 W

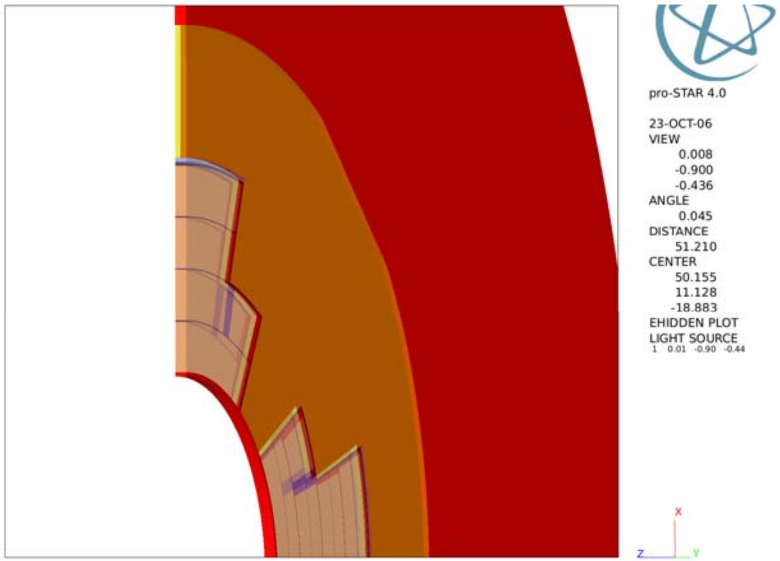
Quench --> 20 W

# Convection heat transfer through MQY at 4.5K



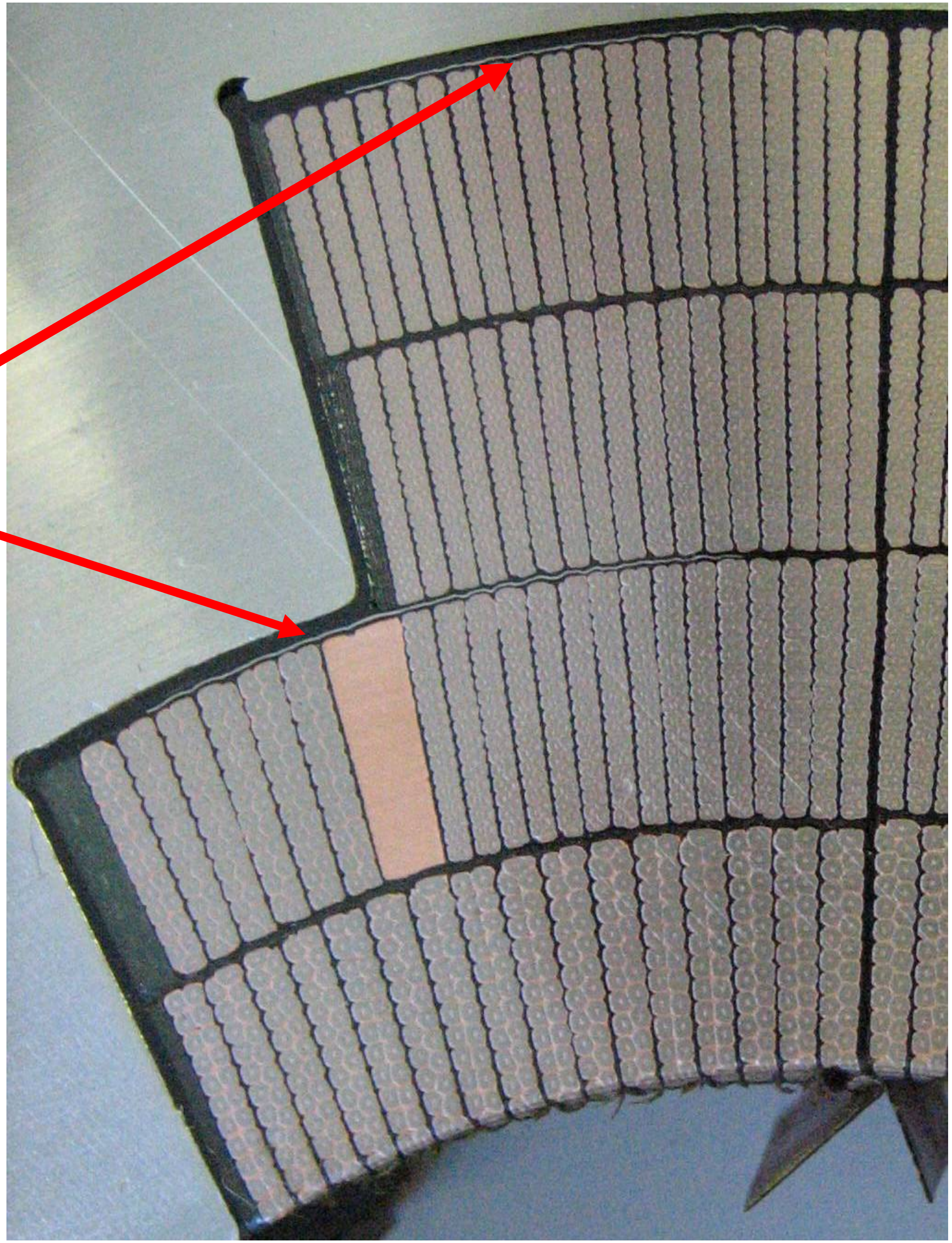





# Future tests

Quench heaters



# The end