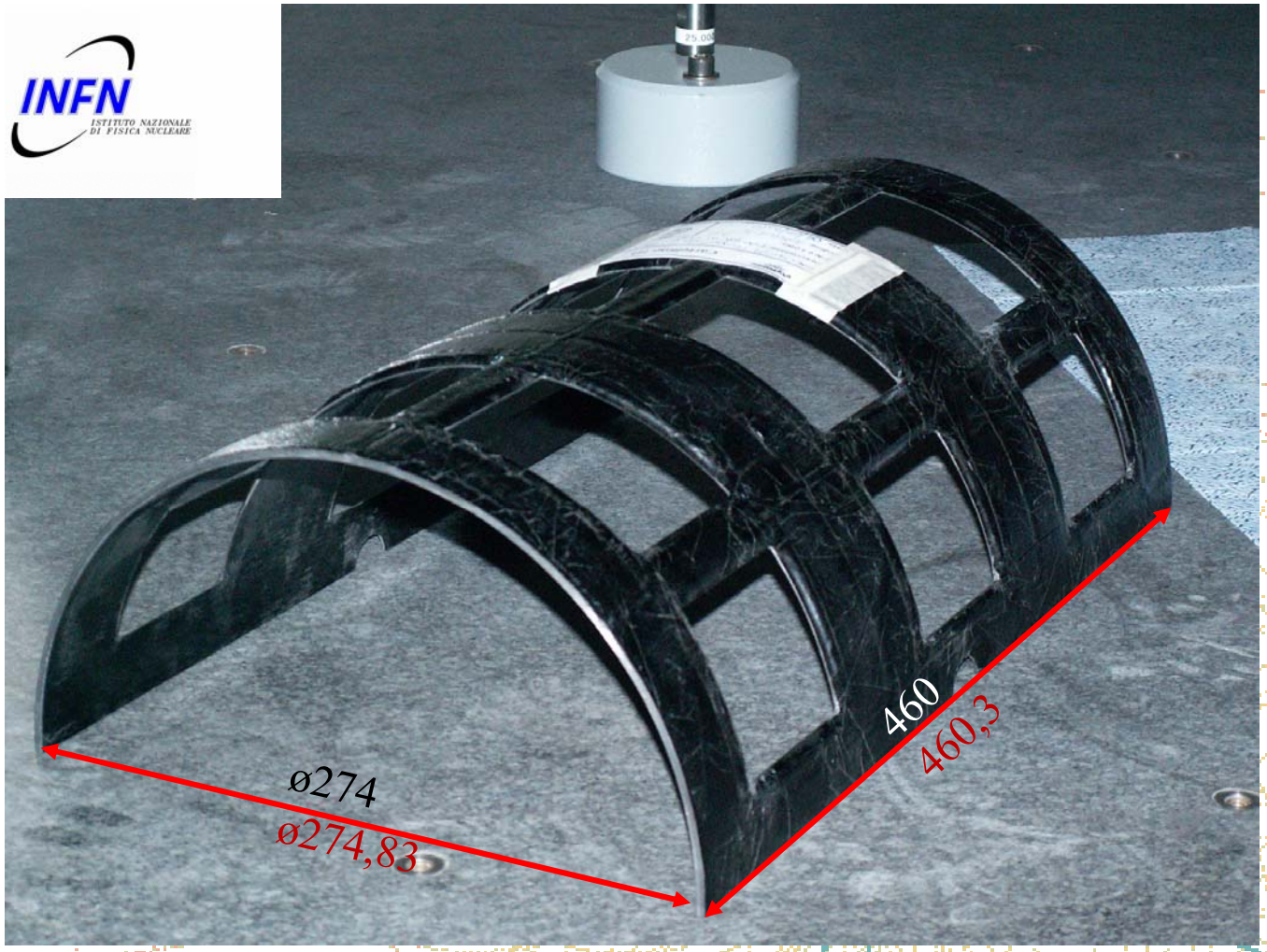
MVD UPDATES

- Mechanics
  - Frame *(manufacturing & test)*
  - Carbon foams *(Characterization: mechanical & thermal)*
- Cooling
  - Big disk thermal behaviour *(FE analysis & test)*

    ..on behalf of S. Coli



A prototype of half frame has been delivered in June.
Geometrical properties has been surveyed.
Overall dimensions are in line with the tolerances requested.

Flanges and ancillary parts are under construction.
Load test is in preparation.
Environmental behavior test will follow.

CARBON FOAMS DETAILED STUDY

➢ The aim is to find the response of the foams to the radiation field.

- POCO FOAM & POCO HTC
- Young's Modulus (E) & Thermal Conductivity Coeff. (K)

Stress vs. Strain relation using strain gages

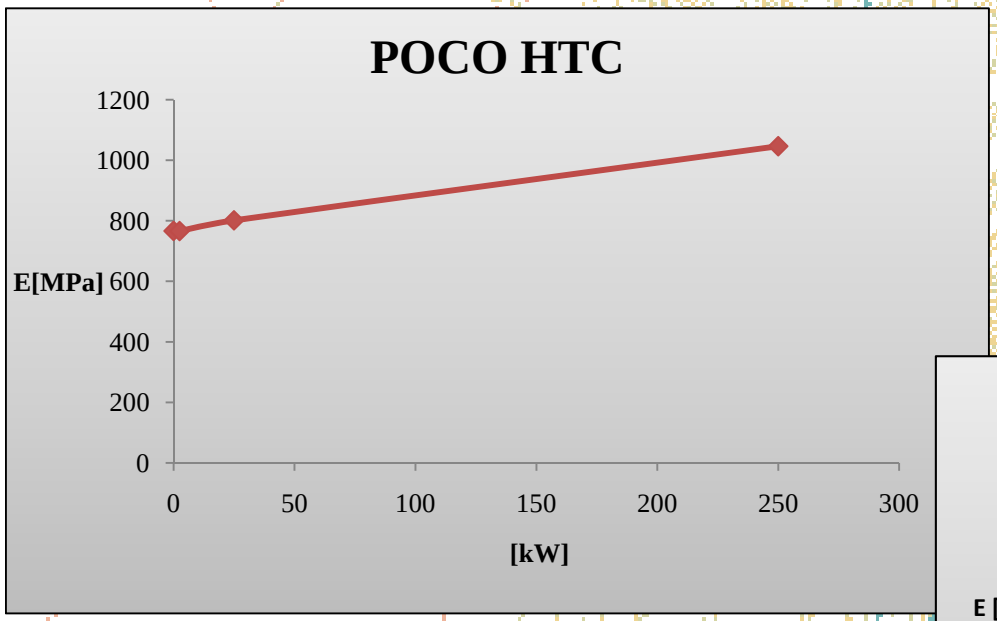
Searle's bar method

- Samples irradiated at TRIGA MARK II reactor in Pavia.
- Four samples per type foam have been irradiated (*t=1000 s)*
- One sample per type foam non irradiated used as reference.

Power [kW]	**Flow density [n/s·cm^2]**
250	$1{,}871 \cdot 10^{13}$
100	$7{,}484 \cdot 10^{12}$
25	$1{,}871 \cdot 10^{12}$
2,5	$1{,}871 \cdot 10^{11}$

CARBON FOAMS DETAILED STUDY

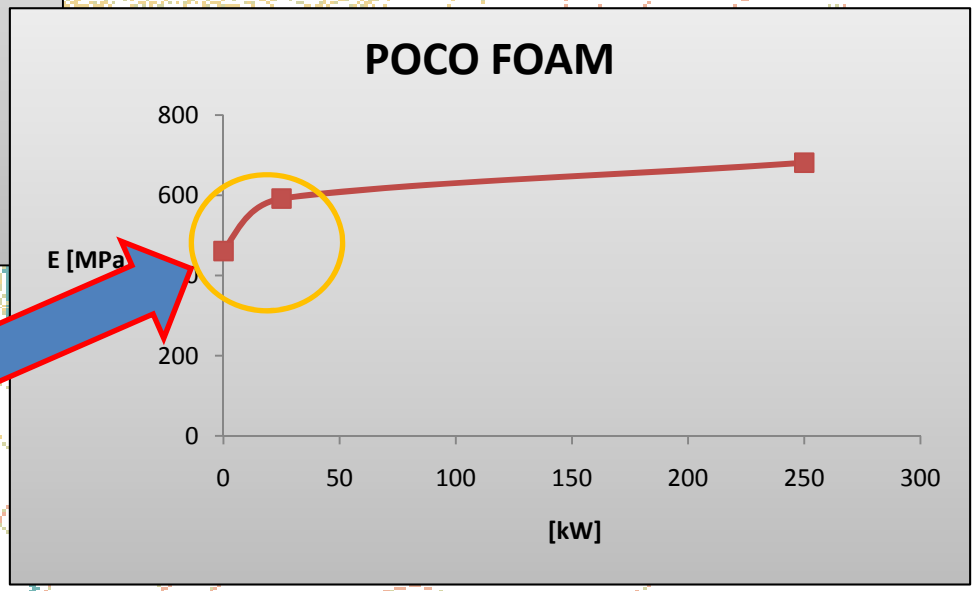
Young's Modulus - Results



Y's Modulus increased by radiation:

~25% → POCO HTC

~30% → POCO FOAM

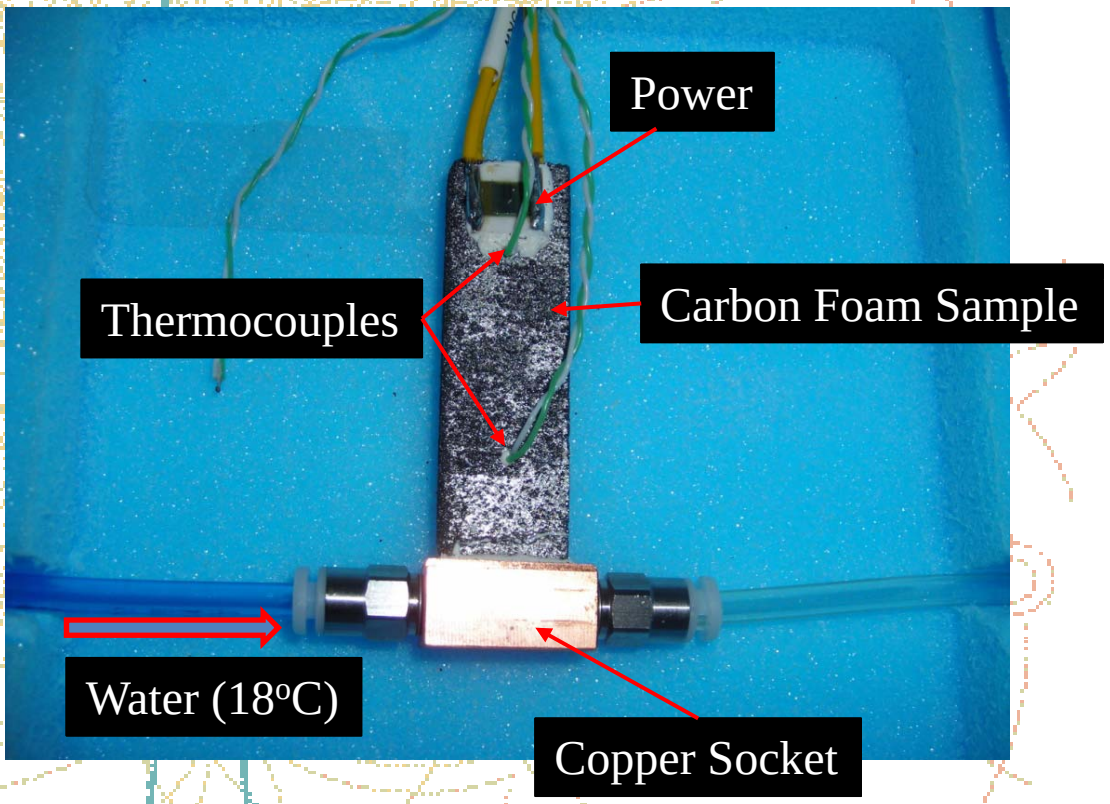


Anomalous behaviour !

CARBON FOAMS DETAILED STUDY

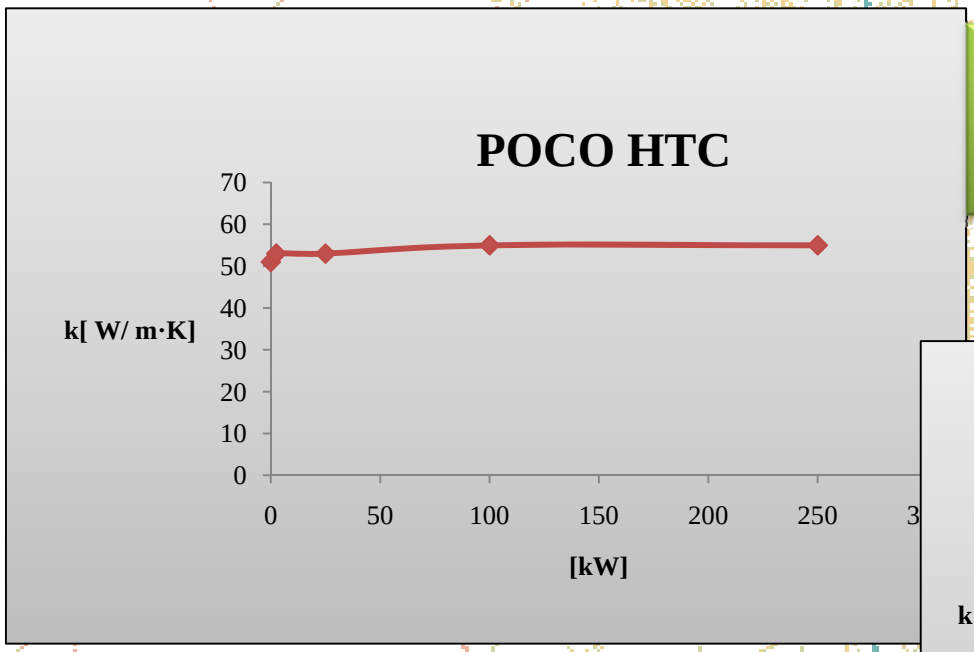
Thermal Conductivity – Searle's Method

$$K = \frac{W \cdot d}{\Delta t \cdot S}$$

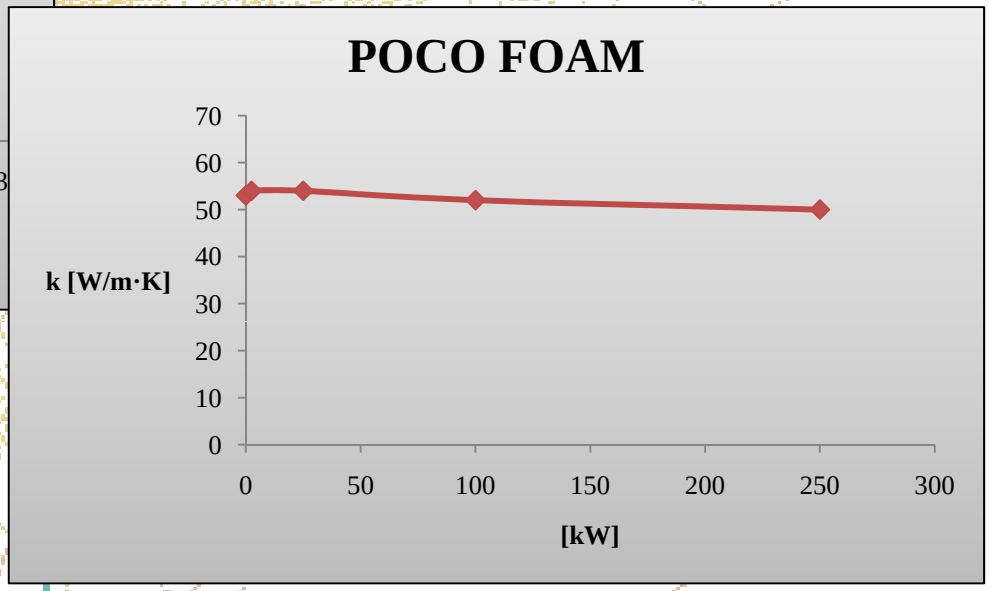


CARBON FOAMS DETAILED STUDY

Thermal Conductivity - Searle's Method - Results



RADIATION DOES NOT INDUCE CHANGES IN THE THERMAL CONDUCTIVITY COEFFICIENT

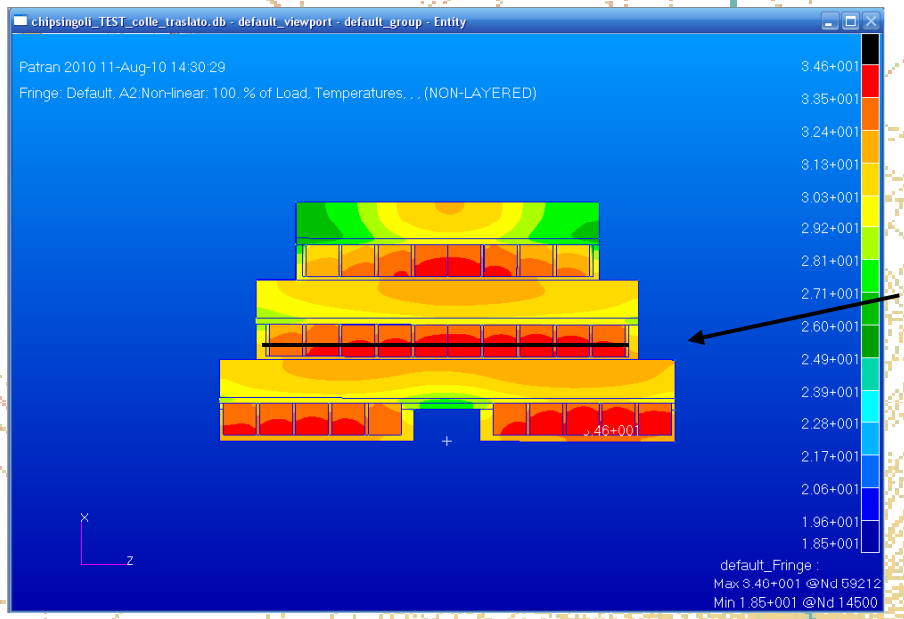


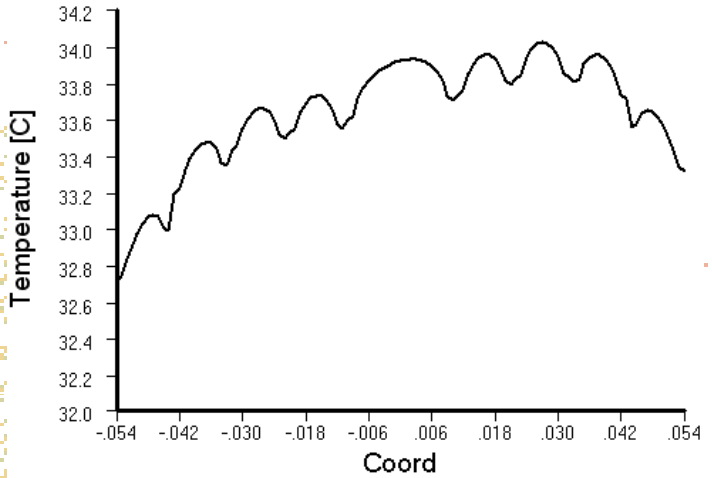
MVD PIXEL COOLING

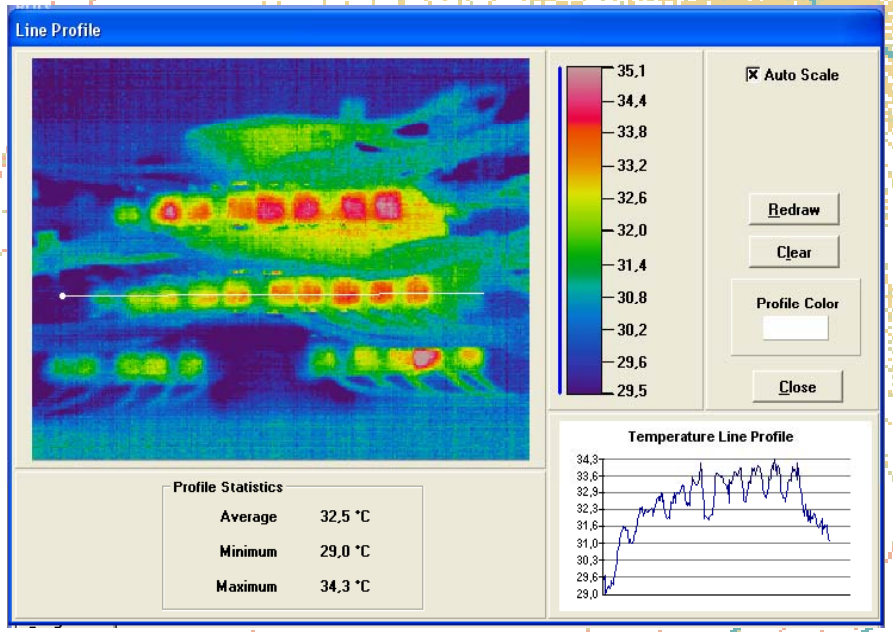
S. COLI

- **FEM vs. TEST results on the first half disc prototype (to tune FEM parameters in the models)**
- **FEM MODEL of TEST prototype vs. FEM MODEL of "REAL" disc**
- **POSSIBLE IMPROVEMENTS in:**
  - **CARBON FOAM THICKNESS;**
  - **COOLING TUBE DIAMETERS;**
  - **COOLING TUBES NUMBER.**
- **CFD simulation of PIXEL volume (Barrels and discs)**

FEM vs. TEST RESULTS on half disc prototype: 1 W/cm^2 (54 W)

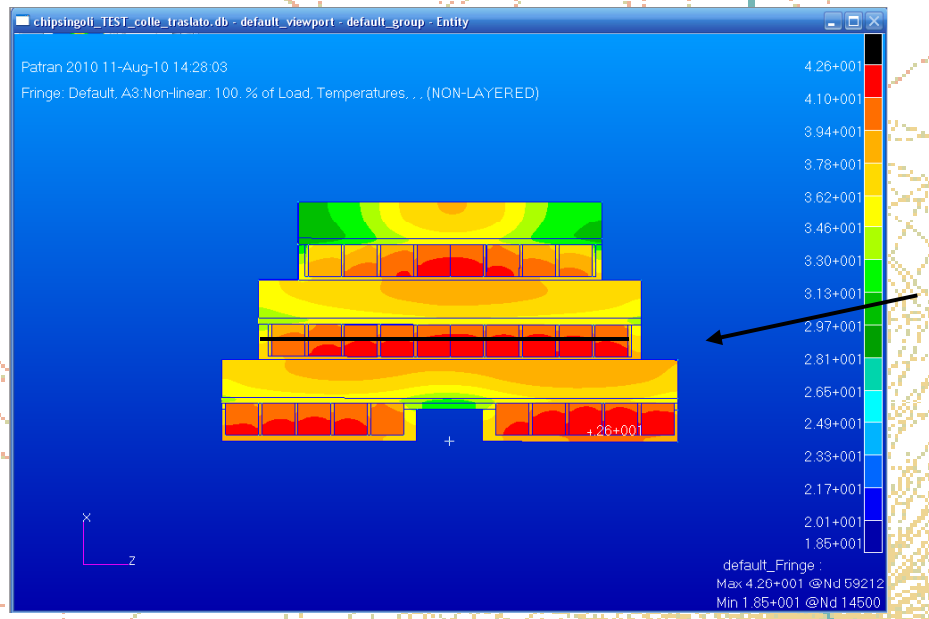


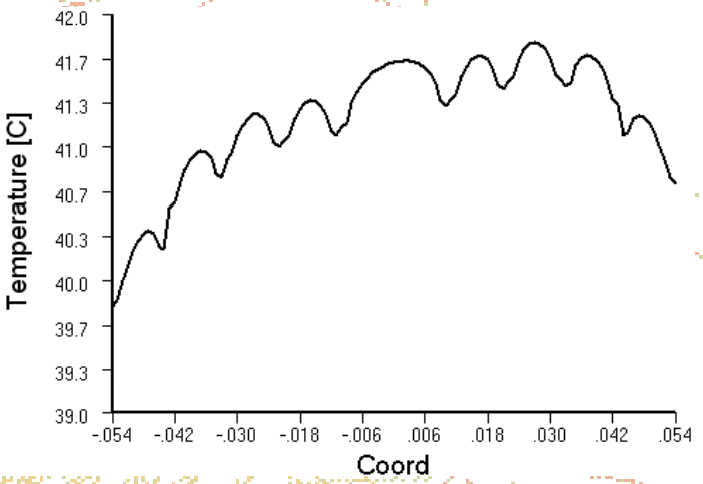


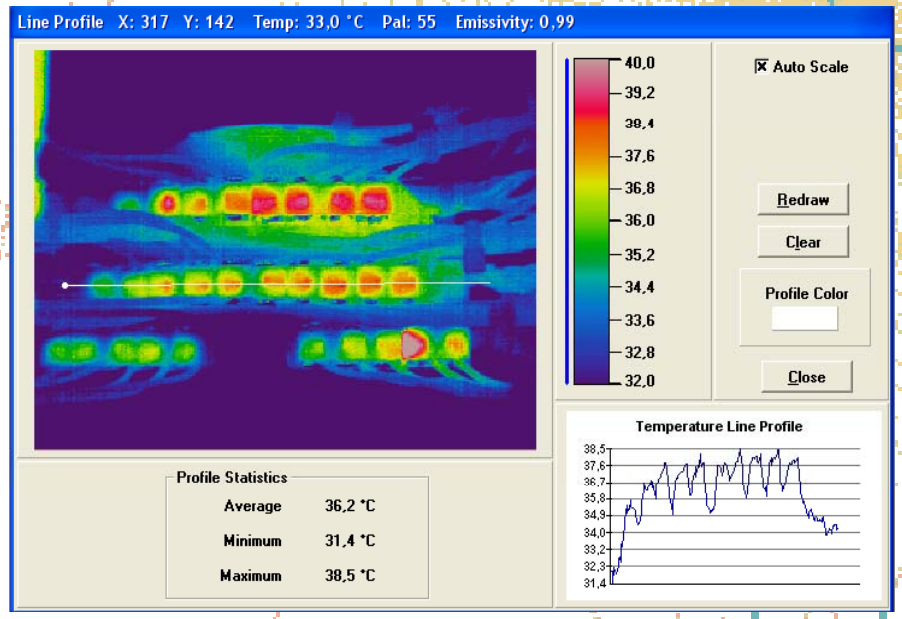


- **Total Power 54 W (1 W/cm^2).**
- **Cooling pipe diameter 2 mm**
- **Cooling flow 0,3 lit/min**
- **Chiller cooling water: 18°C.**
- **FEM cooling water: 18,5°C.**
- **HTC therm. conductivity= 50 W/m·K**
- **Ideal contacts**
- **Glue: 0,6 W/m·K**

FEM vs. TEST RESULTS on half disc prototype : 1.5 W/cm^2 (81 W: Nominal Power)

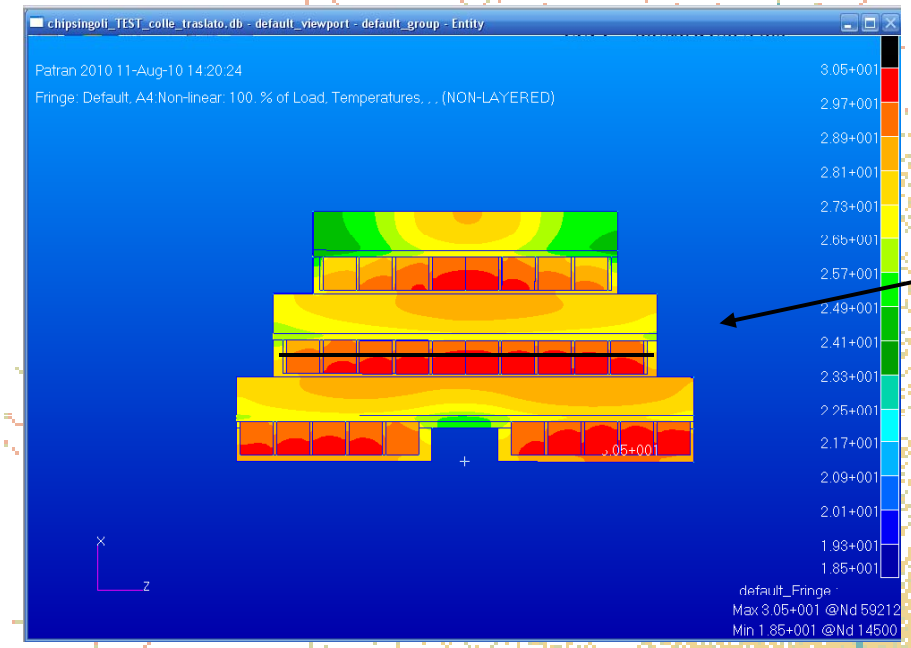


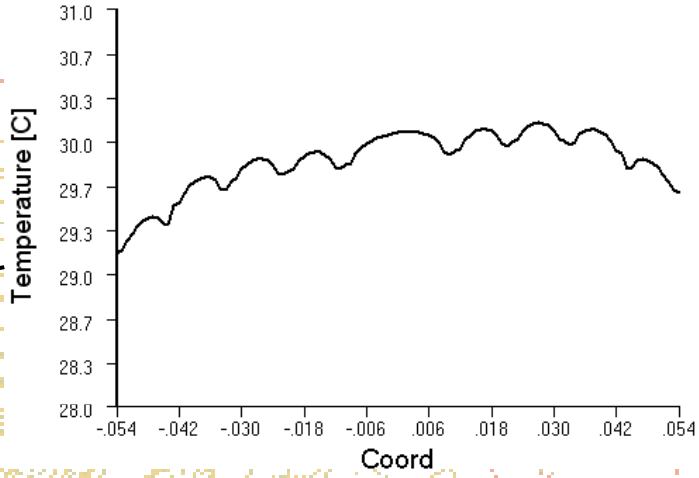


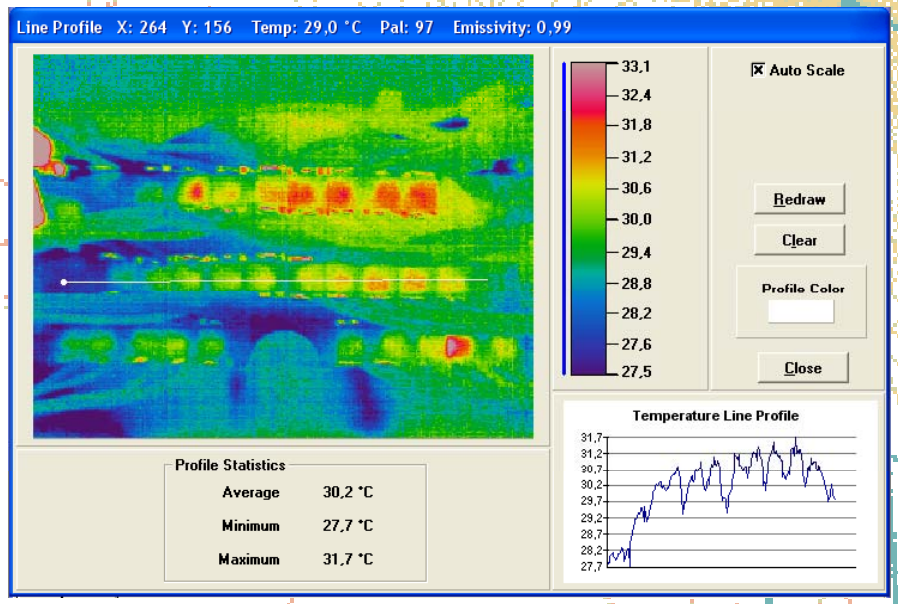


- **Total Power 81 W (1.5 W/cm^2).**
- **Cooling pipe diameter 2 mm**
- **Cooling flow 0,3 lit/min**
- **Chiller cooling water: 18°C.**
- **FEM cooling water: 18,5°C.**
- **HTC therm. conductivity= 50 W/m·K**
- **Ideal contacts**
- **Glue: 0,6 W/m·K**

FEM vs. TEST RESULTS on half disc prototype : 0.75 W/cm^2 (40,5 W)

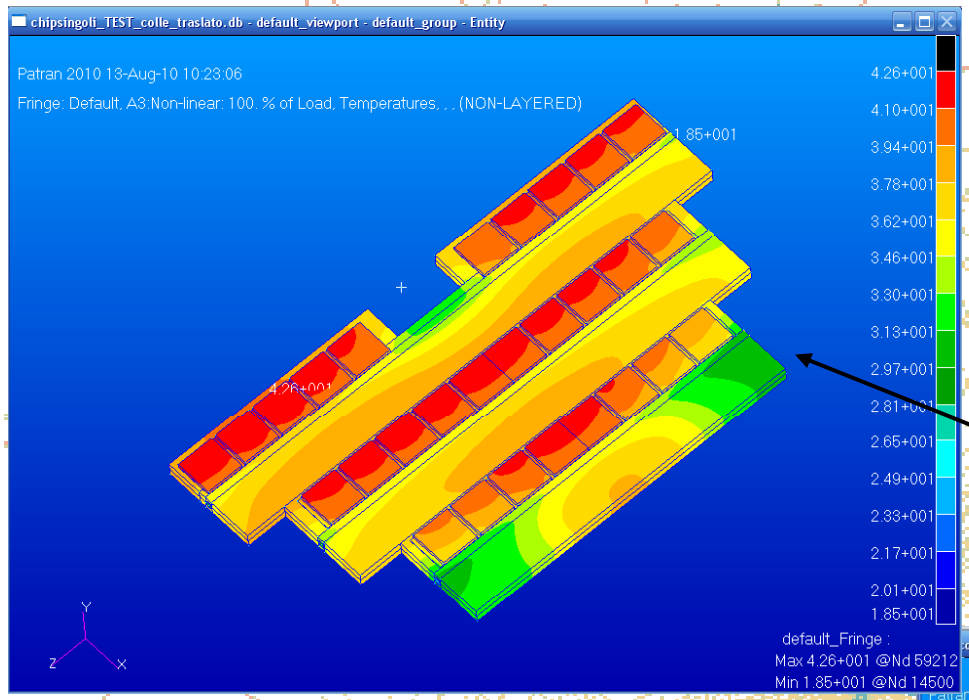


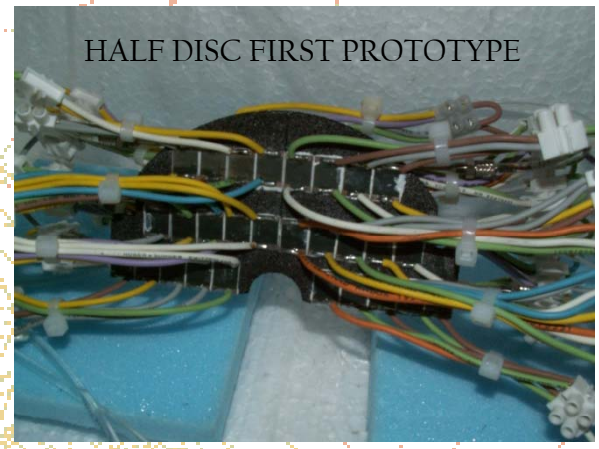




- **Total Power 40,5 W (0.75 W/cm^2).**
- **Cooling pipe diameter 2 mm**
- **Cooling flow 0,3 lit/min**
- **Chiller cooling water: 18°C.**
- **FEM cooling water: 18,5°C.**
- **HTC therm. Conductivity= 50 W/m·K**
- **Ideal contacts**
- **Glue: 0,6 W/m·K**

FEM RESULTS: FEM MODEL of TEST PROTOTYPE vs. FEM MODEL of "REAL" DISC

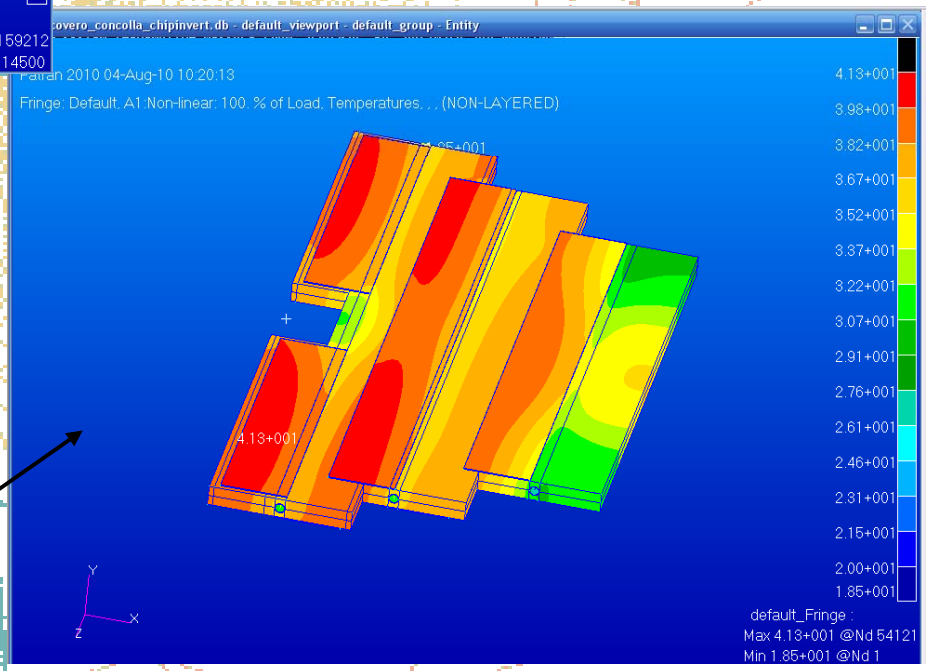




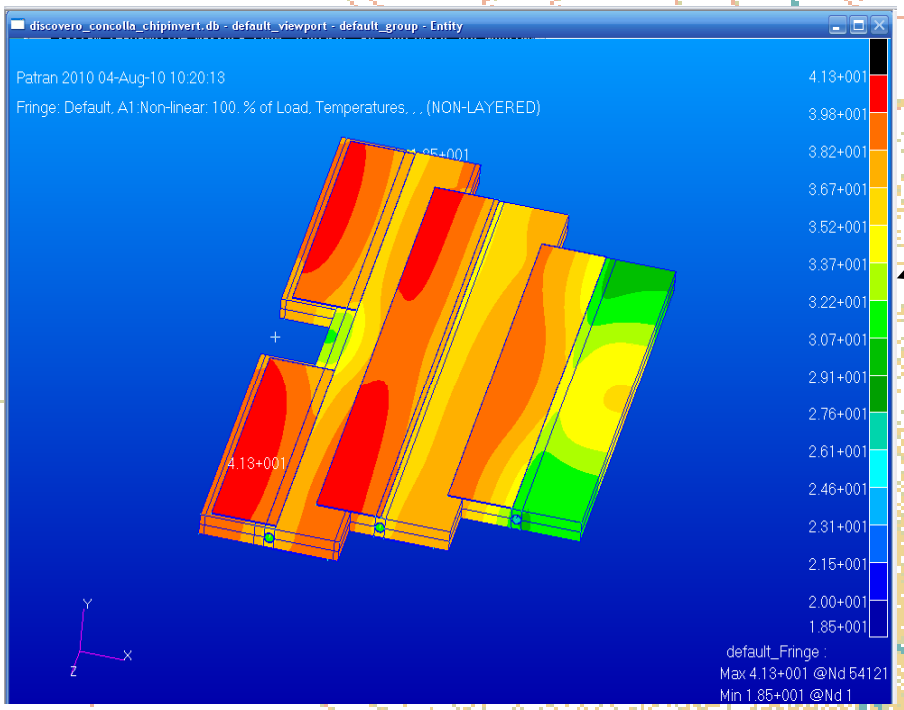
FEM MODEL of Test prototype with dummy chip (resistances)

- **Total Power 81 W**
- **Cooling pipe diameter 2 mm**
- **Cooling flow 0,3 lit/min.**
- **FEM cooling water: 18,5°C.**
- **HTC therm. conductivity= 50 W/m·K**
- **Ideal contacts**
- **Glue: 0,6 W/m·K**

FEM MODEL of PIXEL DISCS

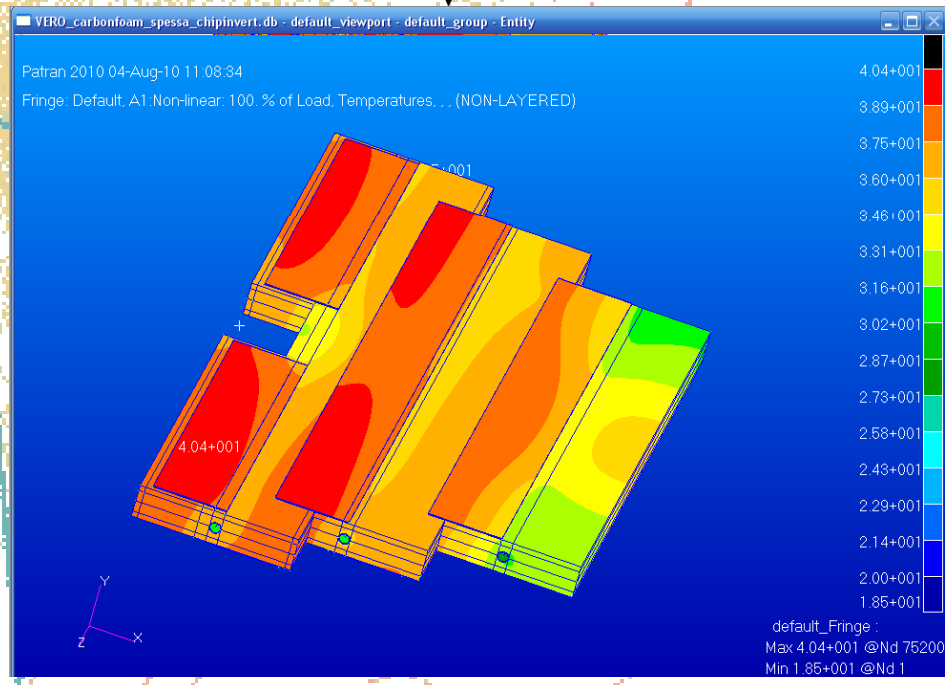


POSSIBLE IMPROVEMENTS: INCREASE IN CARBON FOAM THICKNESS



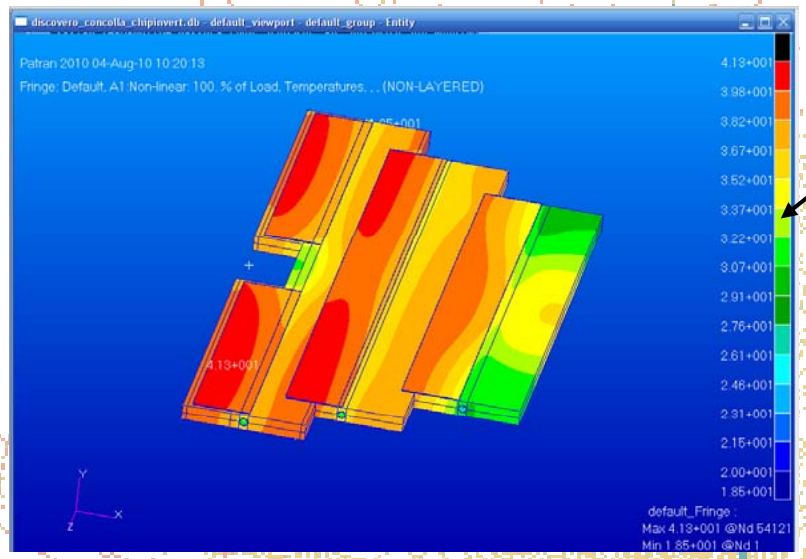
Carbon Foam thickness = 4 mm

Carbon Foam thickness = 6 mm



- **Total Power 81 W.**
- **Cooling pipe diameter 2 mm**
- **Cooling flow 0,3 lit/min**
- **FEM cooling water: 18,5°C.**
- **HTC therm. conductivity= 50 W/m·K**
- **Ideal contacts**
- **Glue: 0,6 W/m·K**

POSSIBLE IMPROVEMENTS: INCREASE IN COOLING TUBE DIAMETER

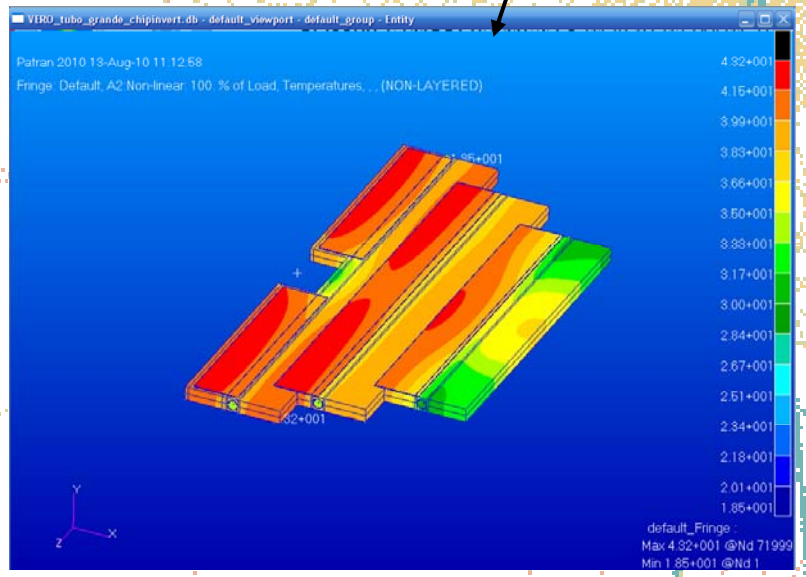


COOLING TUBE DIAMETER= 2 mm
Cooling flow 0,3 lit/min

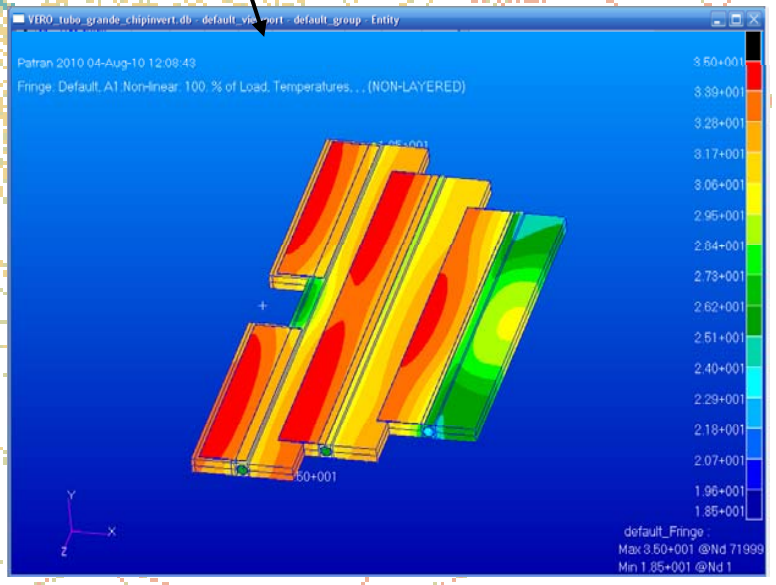
- **Total Power 81 W.**
- **FEM cooling water: 18,5°C.**
- **HTC therm. conductivity= 50 W/m·K**
- **Ideal contacts**
- **Glue: 0,6 W/m·K**

COOLING TUBE DIAMETER= 3 mm

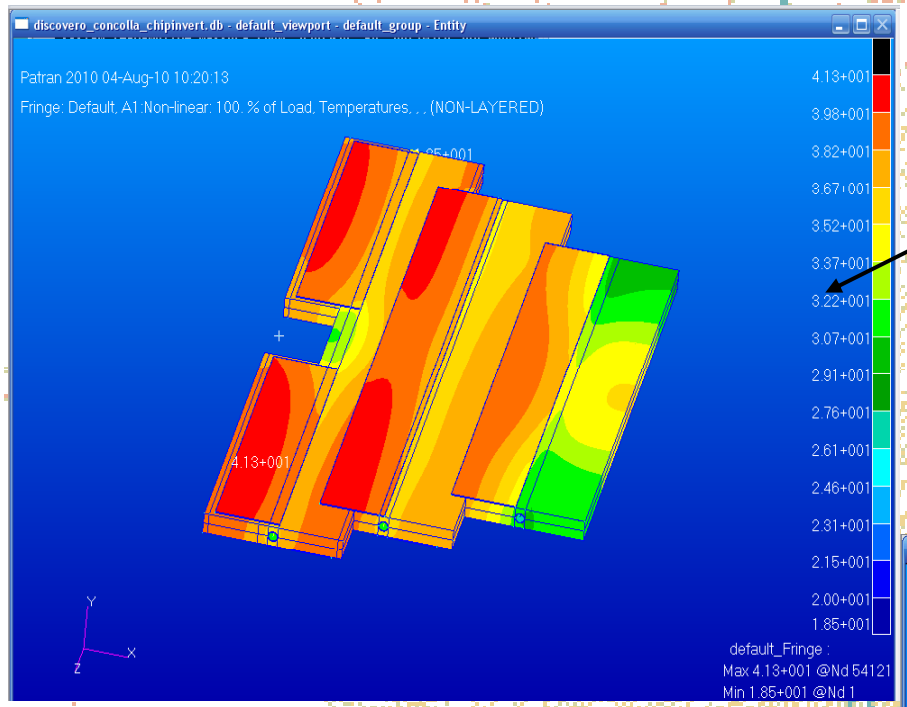
Cooling flow= 0,42 lit/min



Cooling flow= 0,6 lit/min



POSSIBLE IMPROVEMENTS: INCREASE IN COOLING TUBES NUMBER

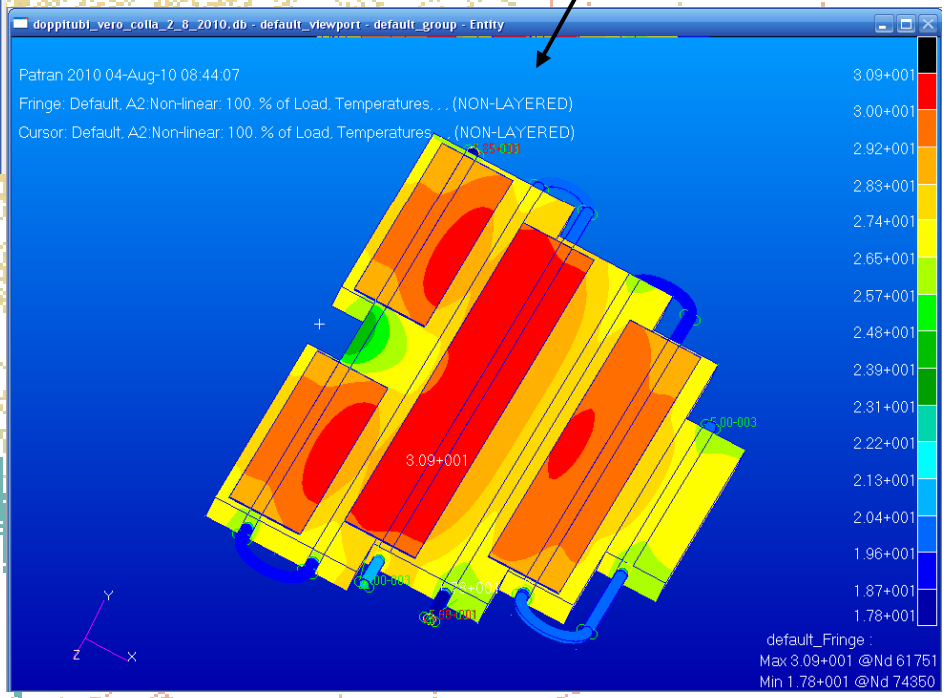


3 Cooling TUBES

3 Linear tubes
3 Inlet manifold
3 Outlet manifold
Minimum pressure drop

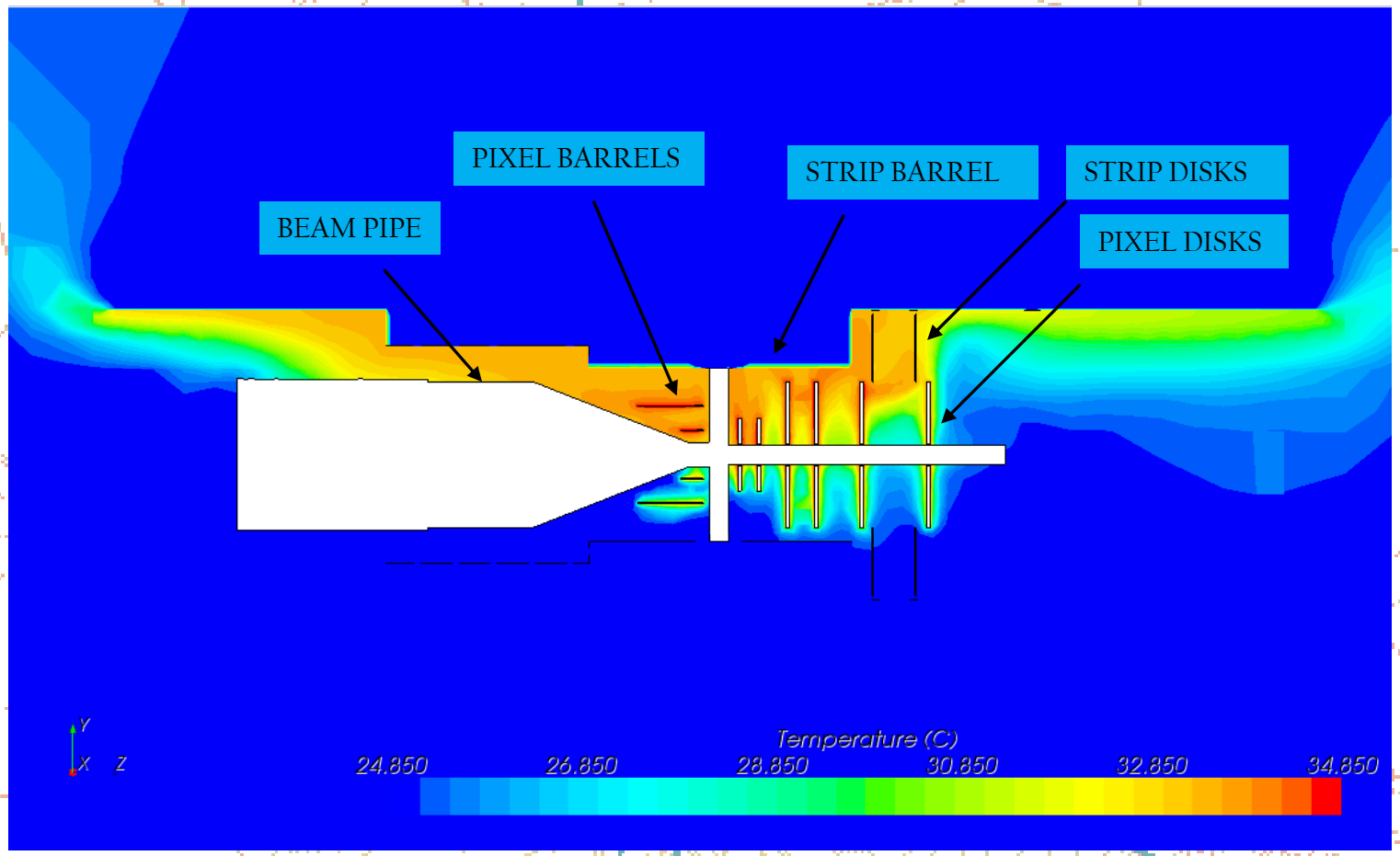
6 Cooling TUBES

2 Serpentine tubes
2 Inlet manifold
2 Outlet manifold
Allowed pressure drop ??



- **Total Power 81 W.**
- **Cooling pipe diameter 2 mm**
- **Cooling flow 0,3 lit/min**
- **FEM cooling water: 18,5°C.**
- **HTC therm. conductivity= 50 W/m·K**
- **Ideal contacts**
- **Glue: 0,6 W/m·K**

CFD SIMULATION



- **Pixel barrel and pixel disks at 35°C.**
- **Ambient air in the hall at 25°C.**
- **Forced convection in the hall = 100 W/m^{2}K (to simulate the air conditioning).**
- **Other parts adiabatic.**
- **Visible gravity effects.**

SUMMARIZING:

- ✓ The prototype of the FRAME delivered:
  - Geometry checked & accepted → construction technology fixed.
  - Structural & environmental test will follow.

- ✓ Carbon foams behaviour:
  - Radiation alters the mechanical properties, but not the thermal properties.

- ✓ Thermal study of the big disk:
  - FEM vs. TEST with dummy chips → good correlation.
  - FEM with "real" chips at nominal power → max temp. of 42 °C
  - Improvement studies:
    - Disk thickness increased → more material with no effect on temp.
    - Tube diameter increased (3 mm)→ max temp 35 °C, more flow & material.
    - Tube number increased → max temp. 30 °C, more material & critical pressure drop.

- ✓ CFD simulation:
  - Effect on strip part & external tracker.

G. GIRAUDO *GRONINGEN 31-07-2010*