



# QUAD cooling

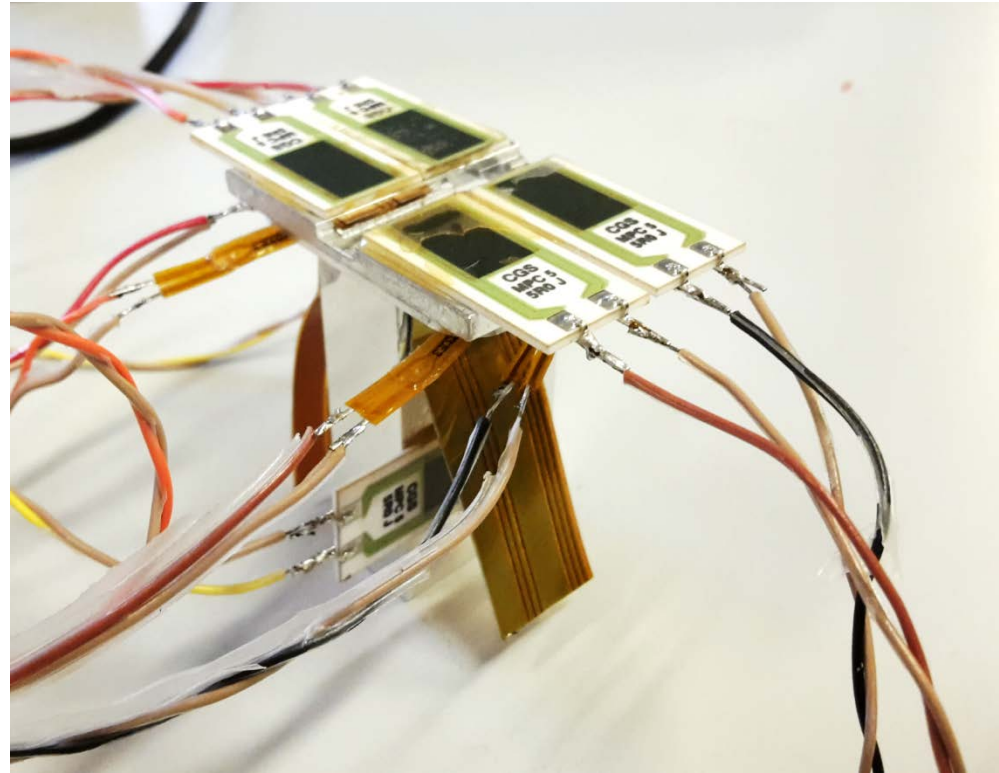
Fred Hartjes

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Nikhef/Bonn LepCol meeting  
January 30, 2017

# Thermal test setup

- Thermal QUAD
- No O-ring groove
  - Joint between stump and coca partly filled with 2011/2020 Araldite
- Flexes simulated by SCT flex
- 4 heaters 5  $\Omega$  on Coca
  - Simulating TPX3 chip
- 1 heater on stump
  - Simulating the LV regulation
- 4 NTCs on backside Coca
- 1 NTC on stump

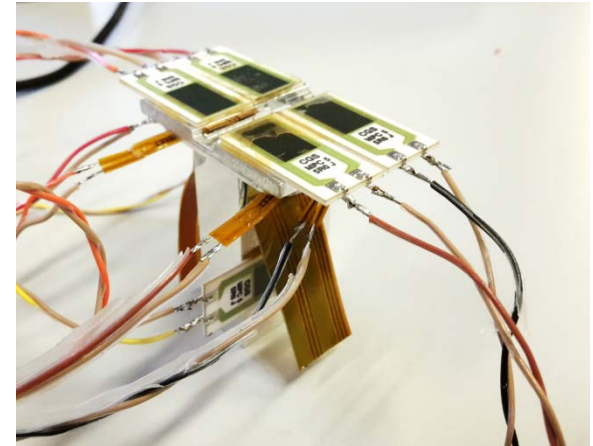


- Test in air, no external cooling
- Total power in: 9.3 W

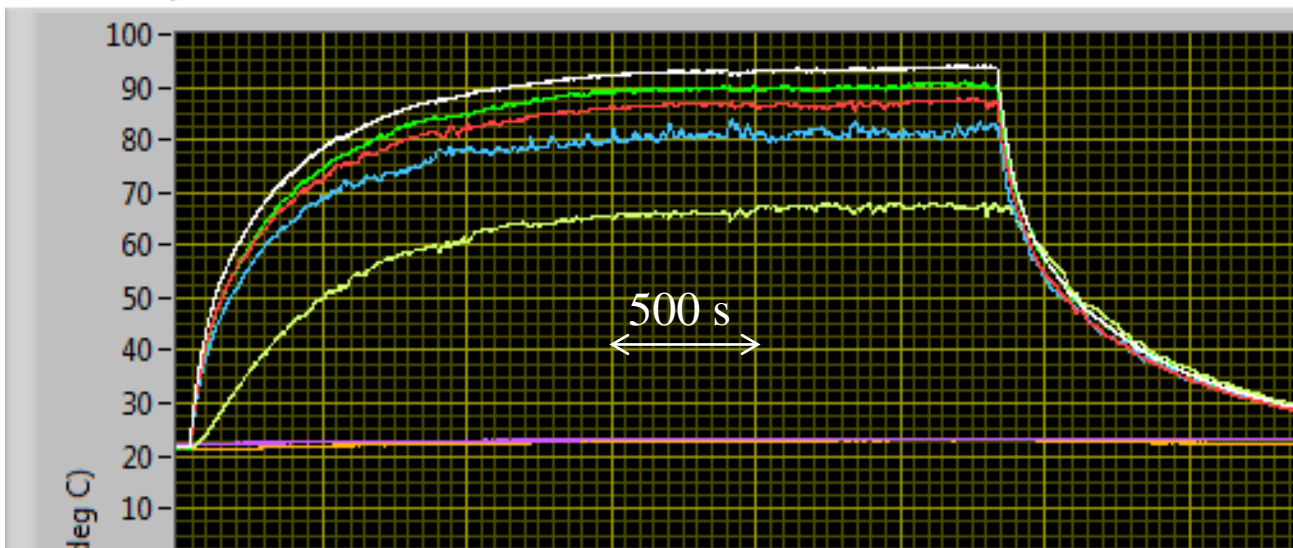
Plot 0 – 3: Coca  
 Plot 4: stump  
 Plot 5, 6: environment

- Coca temp raising to  $\sim 90$  °C
- Stump raising to 67 °C
- $\Rightarrow$  Coca – stump = 23 °C

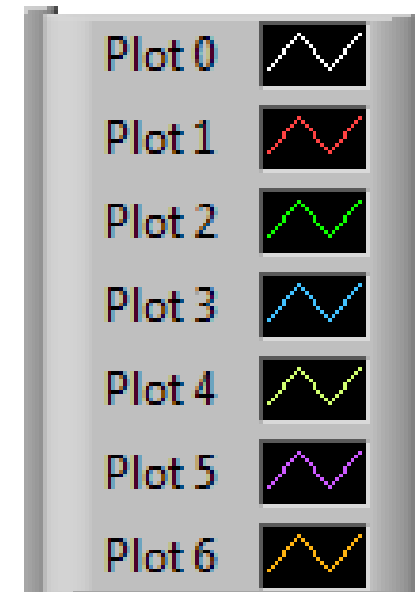
# Test in air



QUAD temperatures

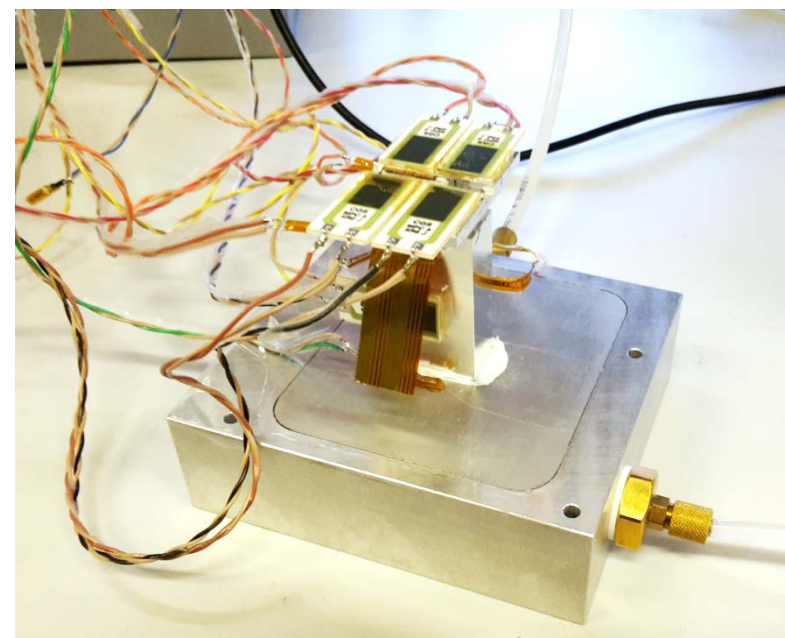


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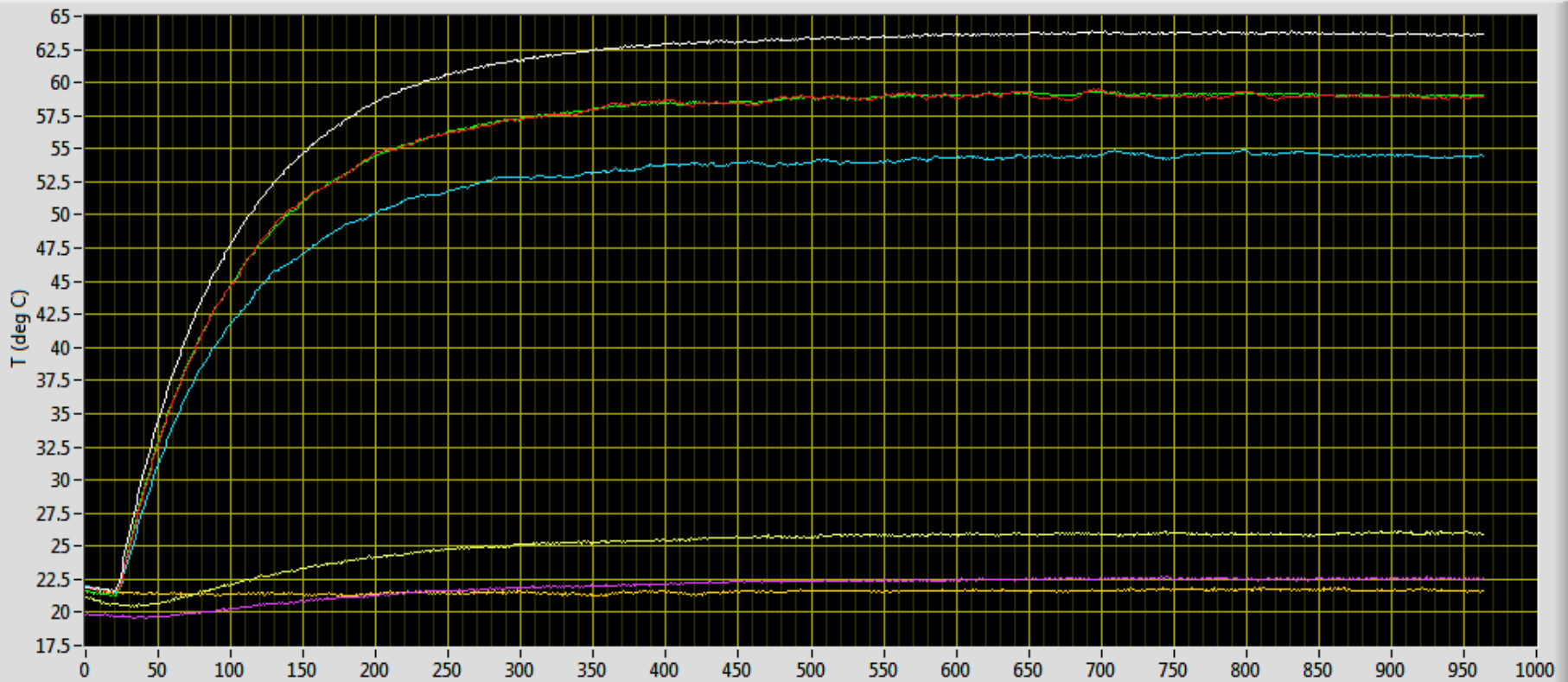


# Stump water cooled

- Put on water cooled plate using thermal grease
- Coca temp down to  $\sim 60$  °C
  - 40°C temperature raise
- Stump down to 26 °C
  - 5°C temperature raise
- => some 35 °C across the joint coca - stump



QUAD temperatures

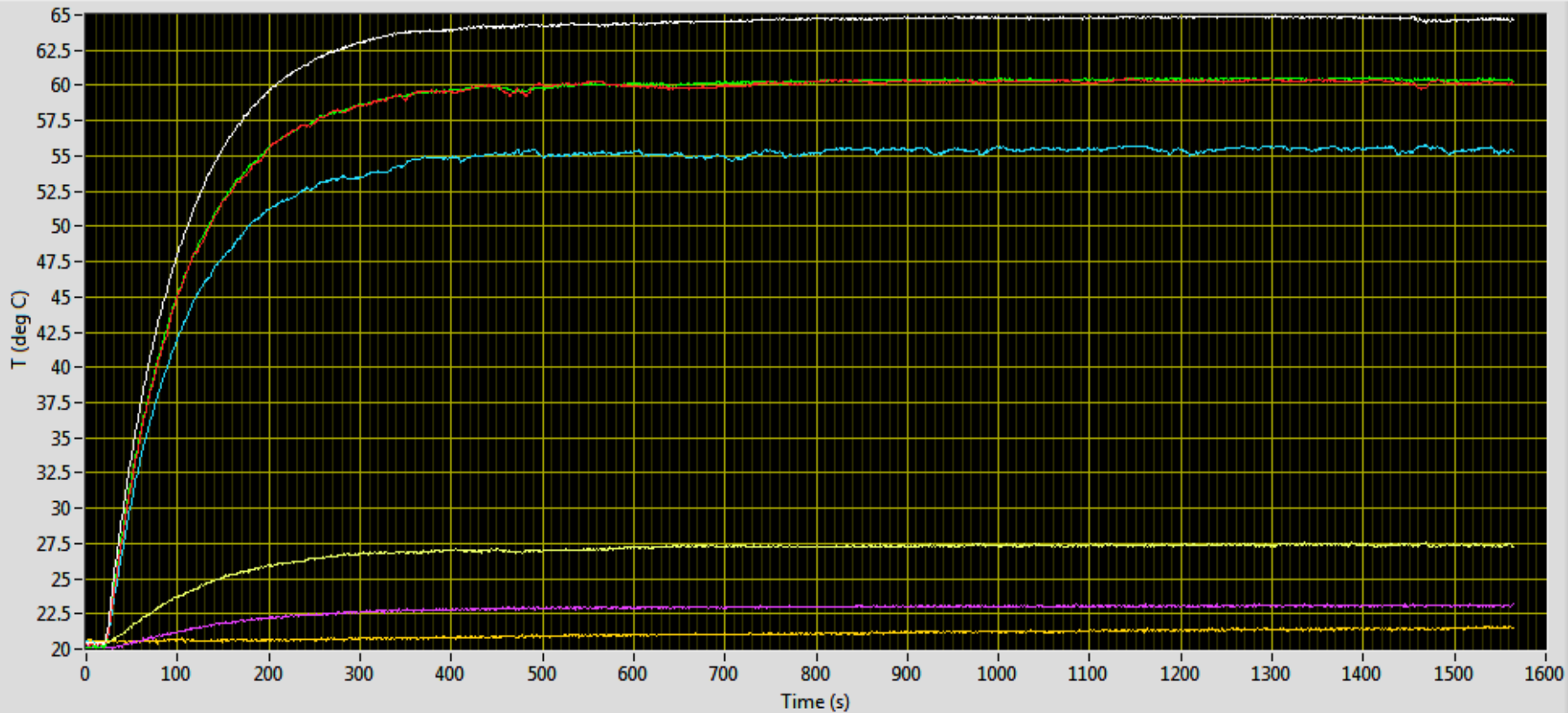


Plot  
Plot  
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Plot  
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Plot

# Stump resistor also powered

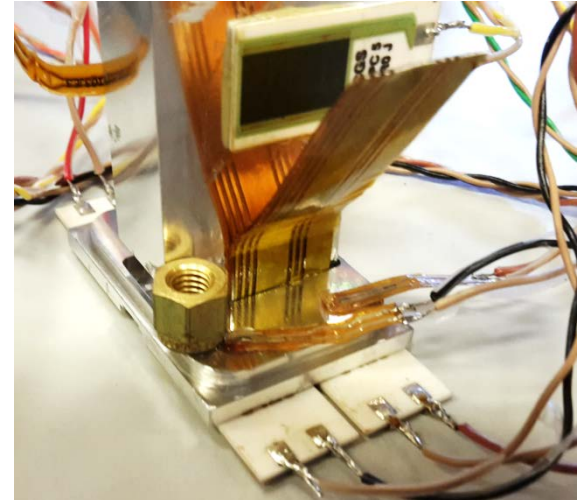
- Stump now 27.5 °C
  - 1.5 °C higher than unpowered stump
  - => stump well cooled by thermal grease

QUAD temperatures

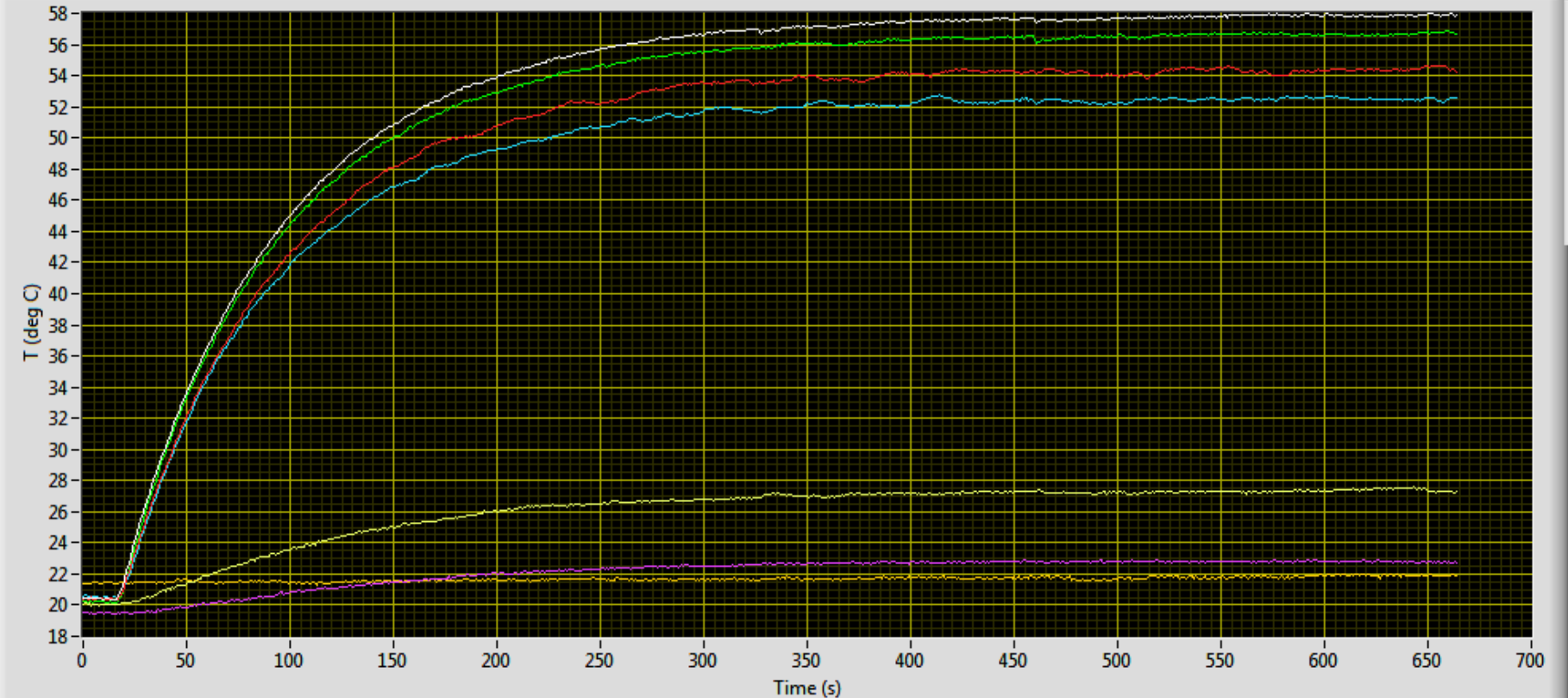


# Adding small brass item

- Coca 5 °C lower
- Increasing the contact surface helps

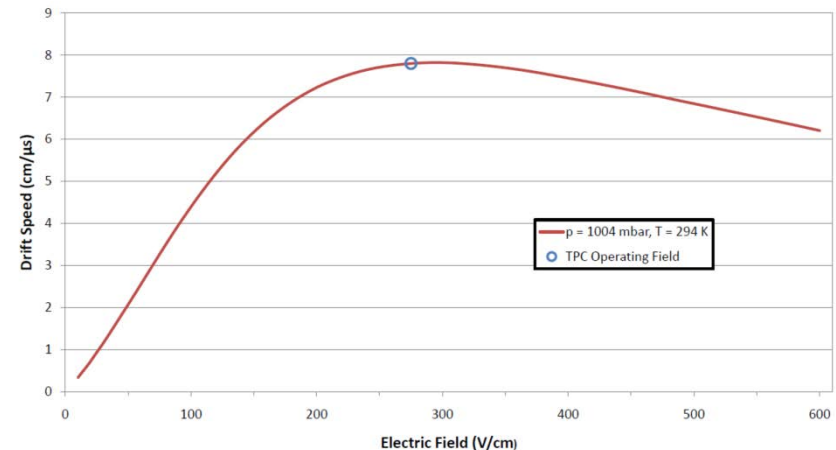


QUAD temperatures



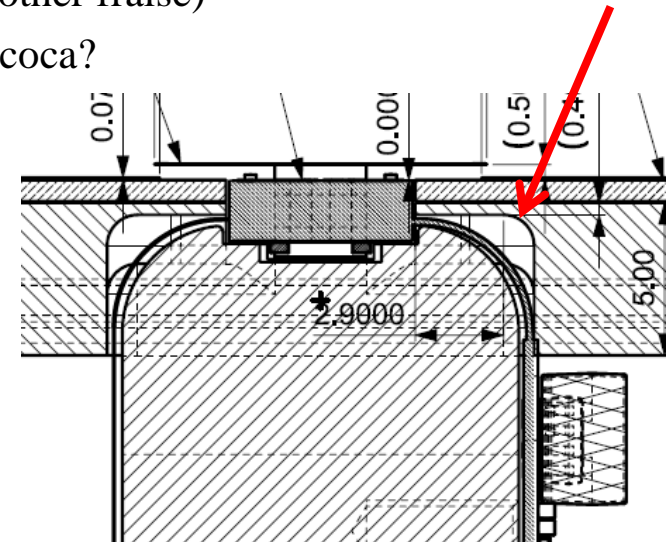
# Discussion

- What can we tolerate on temperature raise?
  - Change in gas gain
  - Change in drift velocity
- Dominating parameter: field relative to gas density  $E / (P/T)$
- We do have to cool the stump
  - Cold plate
  - Water/CO2/ .... connection to stump
- Assume 15 °C raise in temperature (5%)
  - Gain
    - Same effect as if  $V_{\text{grid}} 330 \text{ V} \Rightarrow 345 \text{ V}$
    - $\Rightarrow \sim \sqrt{2}$  increase in gain
  - Electron drift
    - (almost) no effect in XY
    - $\sim 1\%$  effect in Z across 1 cm?
      - 100  $\mu\text{m}$  deviation??



# How to proceed?

- Presently some 40 °C coca temperature raise with well cooled stump
- 15 °C might be possible
  - Making the gap between coca and stump smaller (other fraise)
  - Increasing the contact surface between stump and coca?
  - Using glue with better thermal conductivity
    - Araldite 2020 with Boron-nitride filler
- Some fundamental research needed
  - Measure the thermal resistance of
    - Araldite 2011
    - Araldite 2020 (low viscosity)
    - Araldite 2020 + Boron Nitride
    - .....
- In addition
  - We also need gluing jigs for the QUAD
  - Gluing flex + PCB to the stump (minimum glue layer)
  - Gluing coca to the stump (correct position, perpendicular)







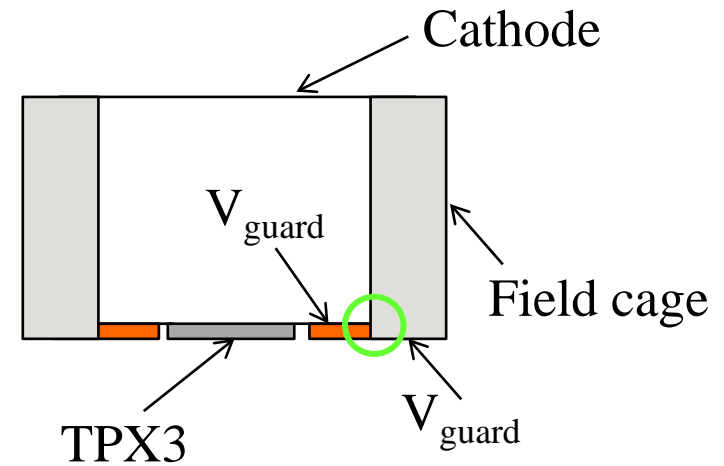
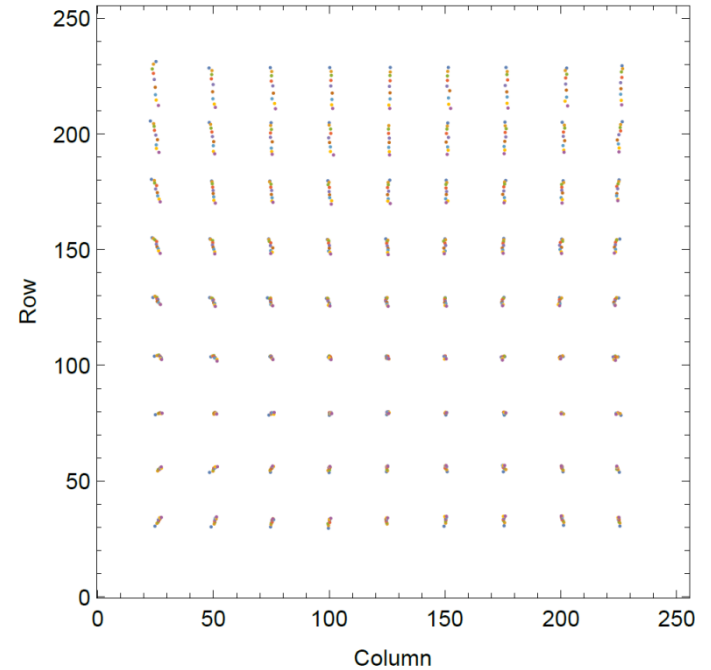
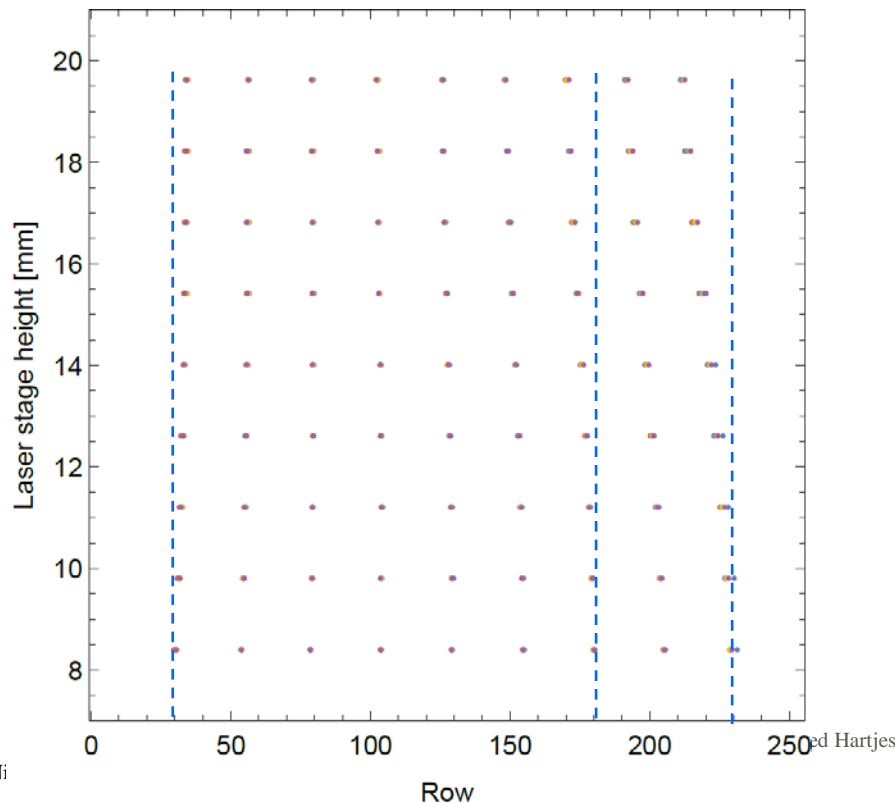
# Drift field problems at the single chip module

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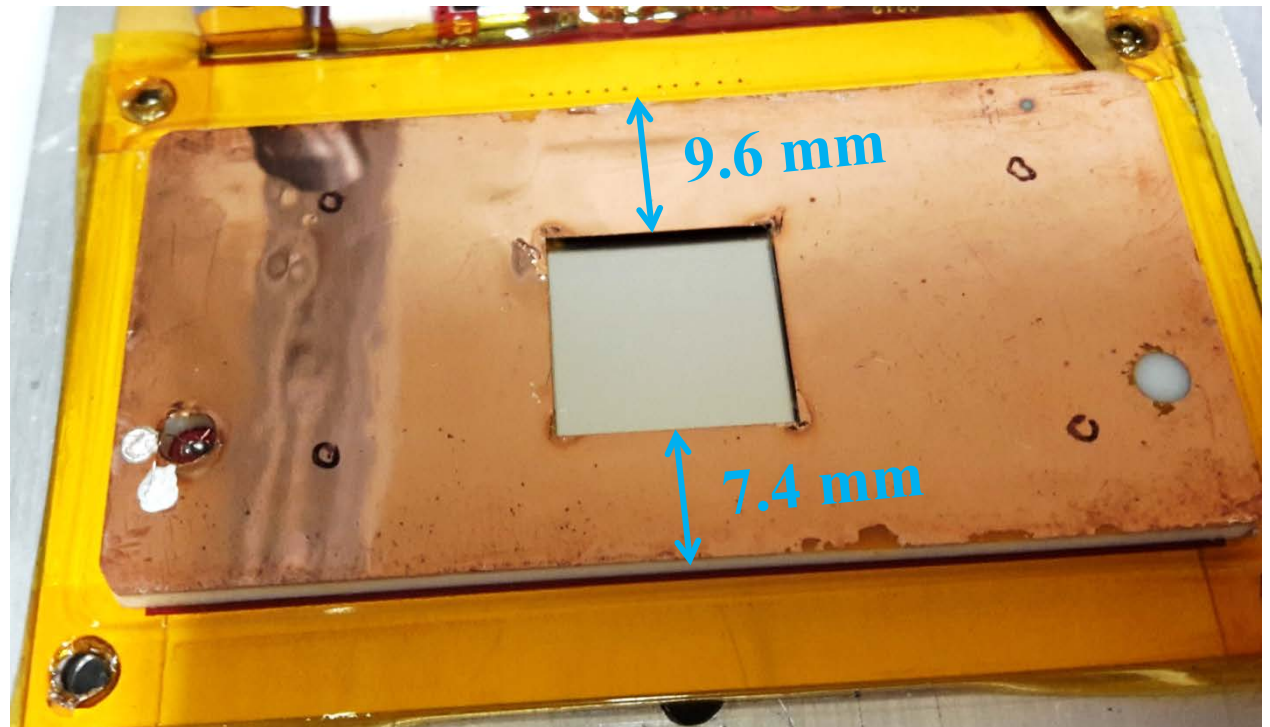
# Strong bend of the drift paths on one side

- $> 1$  mm across 12 mm path
- Drift path bend towards centre
  - Fanning in effect
- Mismatch of 40 V between the guard and the field cage



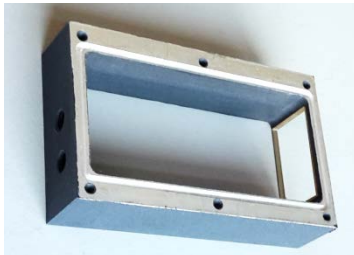


## Present field cage and guard



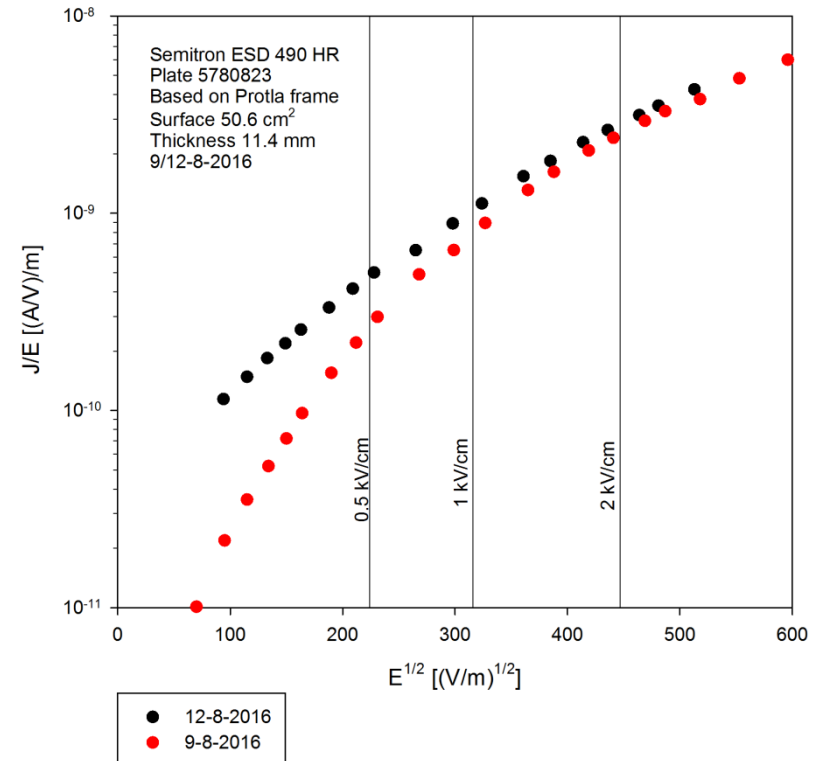
# Alternative causes

- Cage made of conductive plastic (Semitron ESD 490 HR)
- Very low cage current at 200 V/cm
- => field shaping possibly less good
- Much better field shaping at higher fields expected
  
- Training effect
  - Making internal connections in the material
  - Conductivity at low fields significantly increases after once ramped to a high field



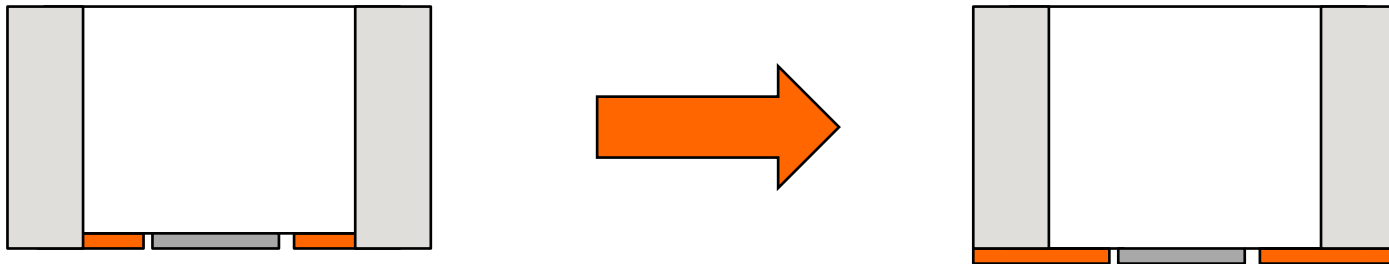
E (V/cm)	I <sub>cage</sub> (nA)
200	0.7
300	1.3
400	2.8

Conductivity (J/E) vs square root E field (E<sup>1/2</sup>)



# Improvement of the homogeneity of the drift field

- New guard electrode placed **under** the field cage
  - In production, expected ~ mid February



- Increasing the cage current by training
  - Ramping once to a high field (5 kV/cm)