Updates on 2S Module FEA

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Tracker Upgrade Meeting
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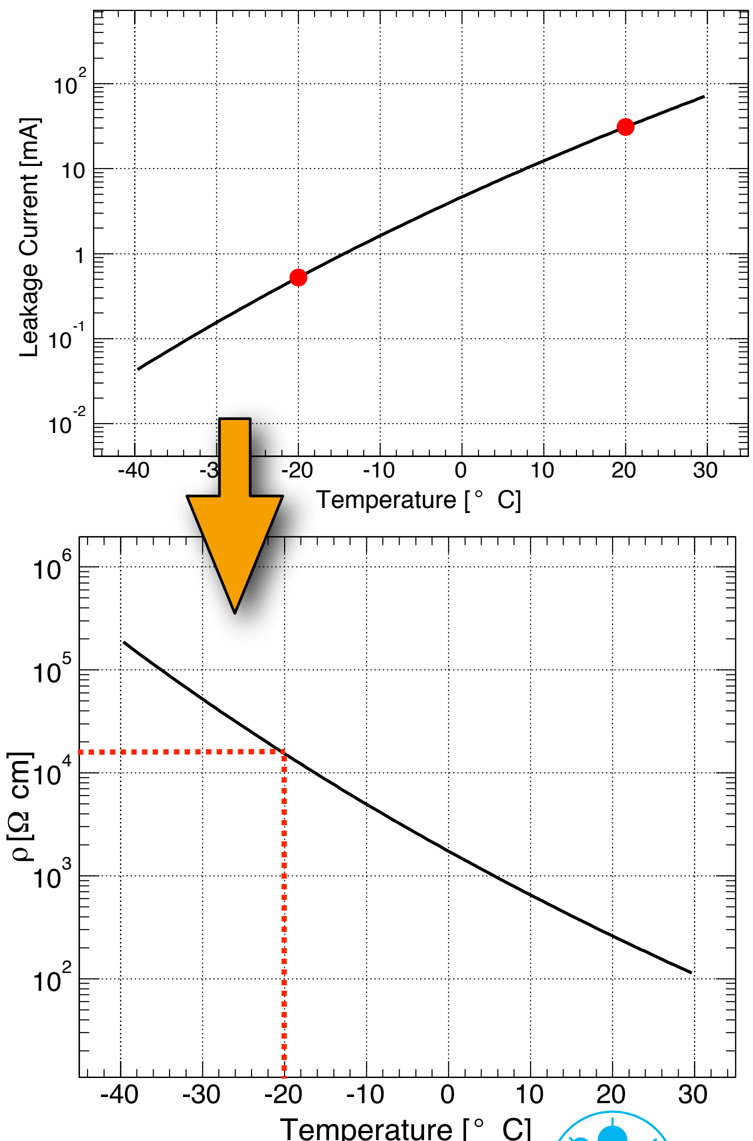
HELMHOLTZ
ASSOCIATION

Outline

- FEA of 2S module with ANSYS
- thermal runaway of current 2S module design
- FEA of 2S module including cooling blocks
- FEA of 2S module optimized for 8 inch waver

‚Real‘ Sensor Power Consumption

- power consumption is a function of temperature
- we want/need a load with temperature dependent power consumption per finite element
- In ANSYS one can treat the sensor like a resistor
  - temperature dependence of power consumption is modeled via temp. dependence of resistivity
  - one ‚silicon‘ material definition per
    - irradiation
    - sensor thickness



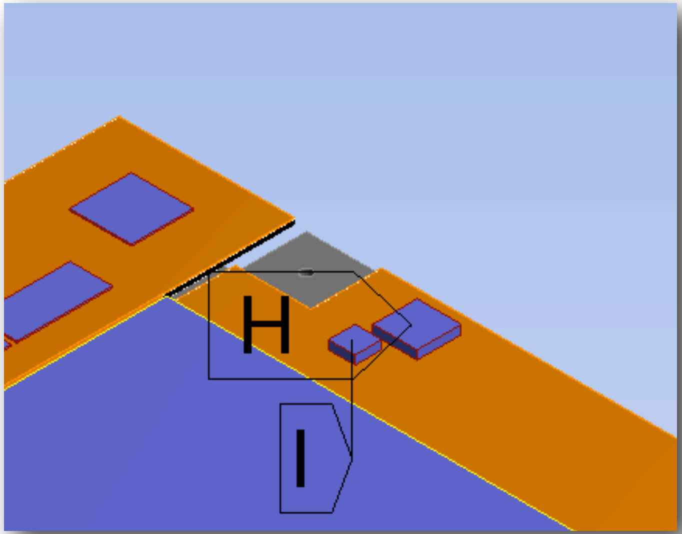
- ‚Old‘ behavior (constant power) can be modeled by material definition with constant resistivity

Updated Power Consumptions of DCDC Converter and GBT

- up to now
  - 80 % efficiency assumed for the DCDC converter
  - heat was generated by 7 mm x 7 mm ‚box'
- efficiency of 70 % is a more realistic value
  - total power of components on module: 1.22 W (CBCs) + 0.4 W (concentrators) + 0.5 W (GBTX) + 0.2 W (GBLD) + 0.1 W (GBTIA) = 2.42 W
  - power dissipation of converter: 0.3 x 2.42 W / 0.7 = 1.04 W
- heat is generated by
  - chip (75 %): 0.78 W ➟ **H**

    thermal properties of QFN package and thermal vias are not yet implemented
  - coil (25 %): 0.26 W ➟ **I**

    needs better modeling



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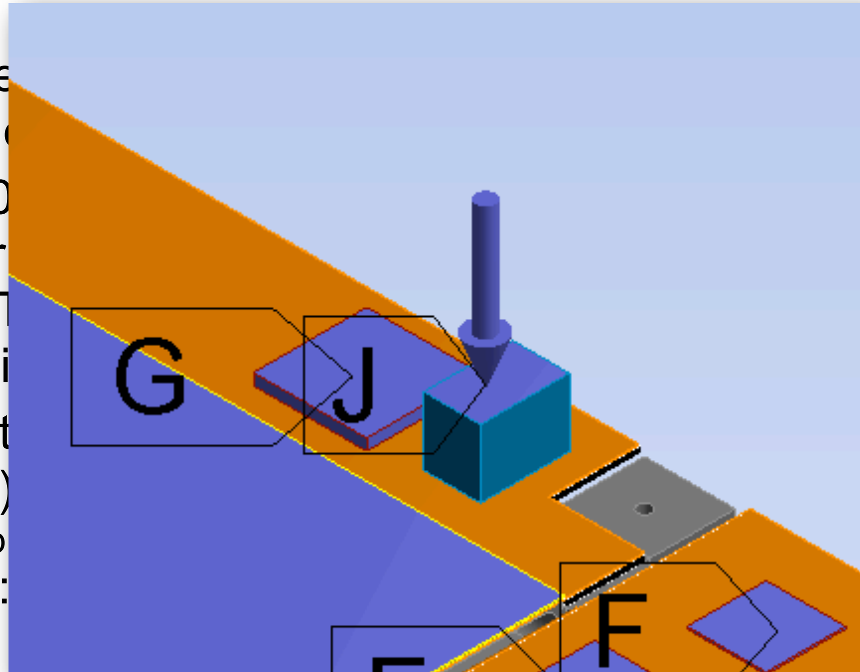
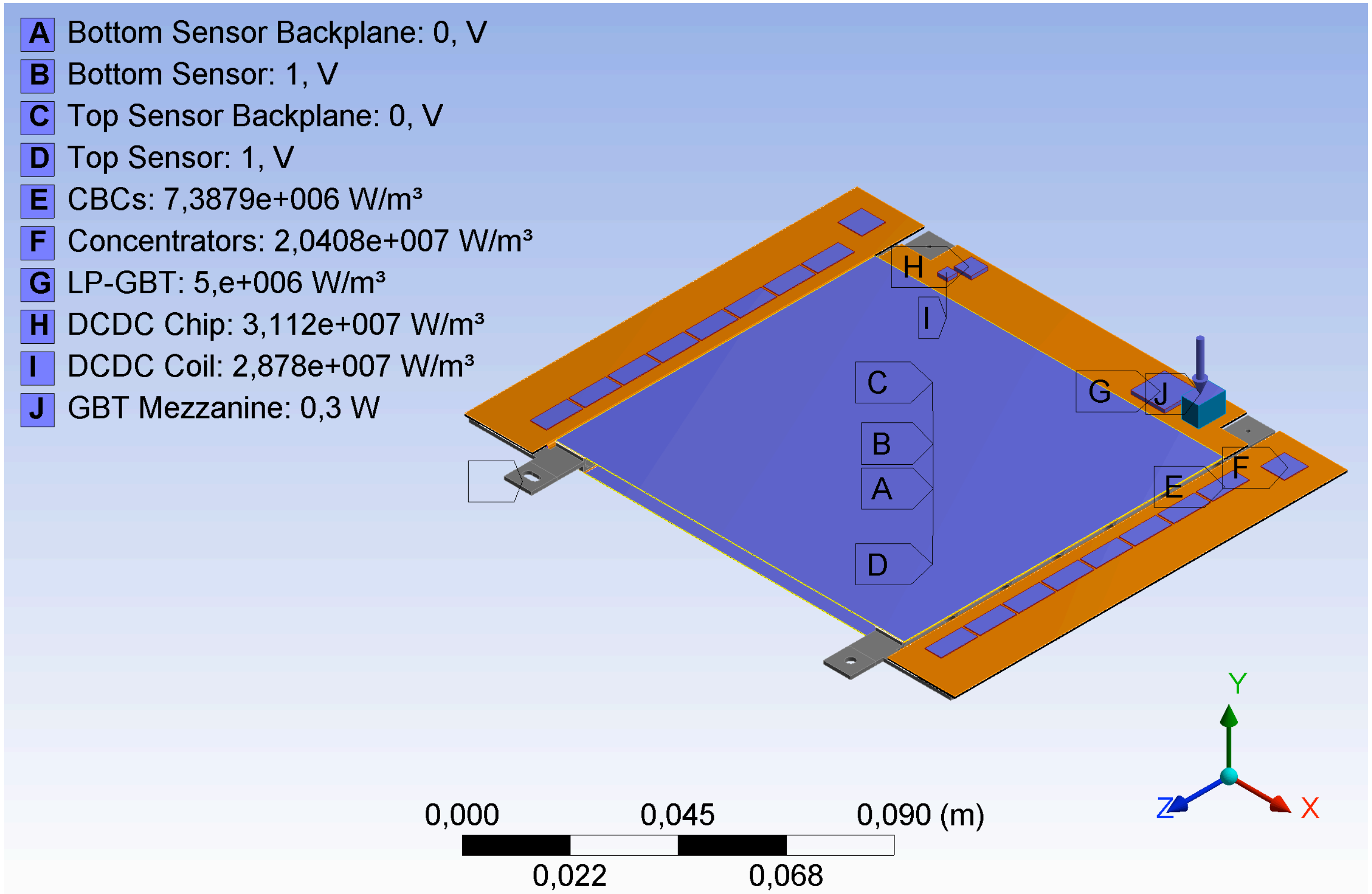


- power dissipation of LP-GBT is now split into GBTX, GBLD and GBTIA components
  - GBTX is 10 mm x 10 mm in size ➟ **G**
    thermal properties of QFN package and thermal vias are not yet implemented
  - GBLD and GBTIA are placed on a mezzanine card
    not yet implemented
    at the moment modeled via heat flux through connector ➟ **J**

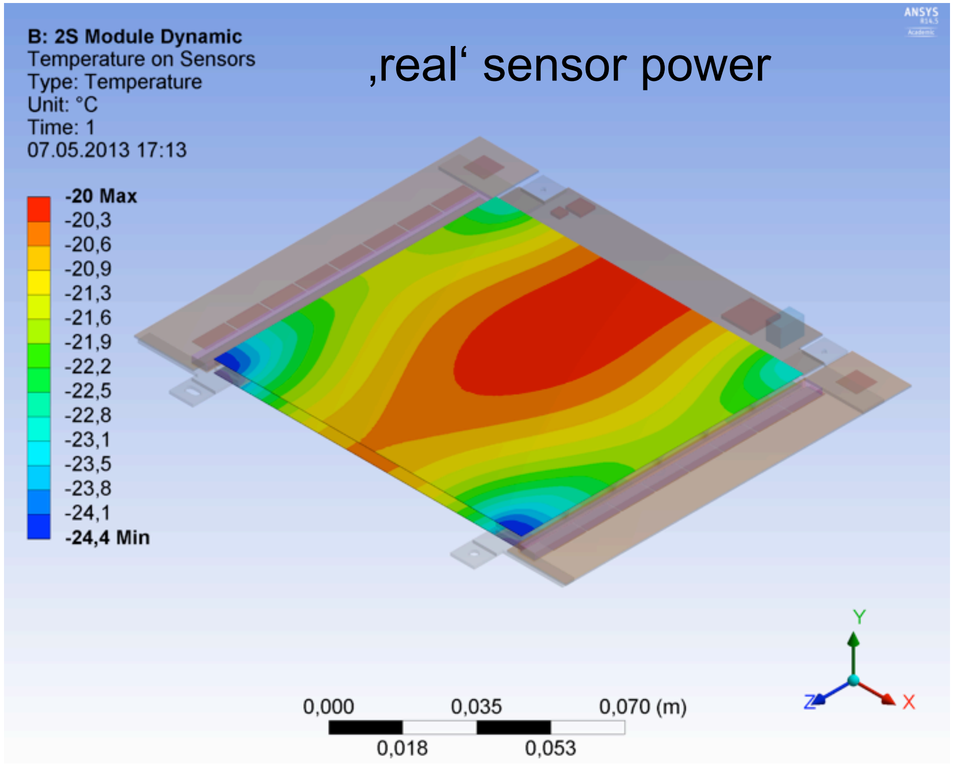
2S Module - Thermal Loads

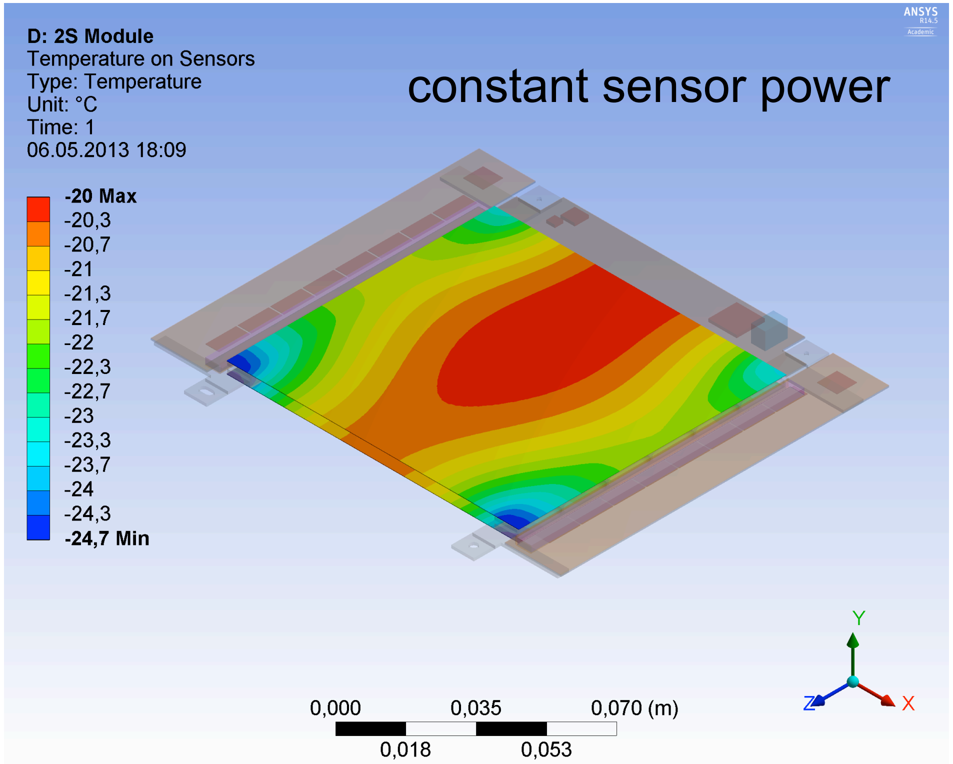


> power consumption of sensors (200 µm) calculated for
  - fluence: 6e14 neq/cm^2
  - damage constant: 5.3e-17
  - @ -20°C: 503 mW

factor 2 compared to previous studies

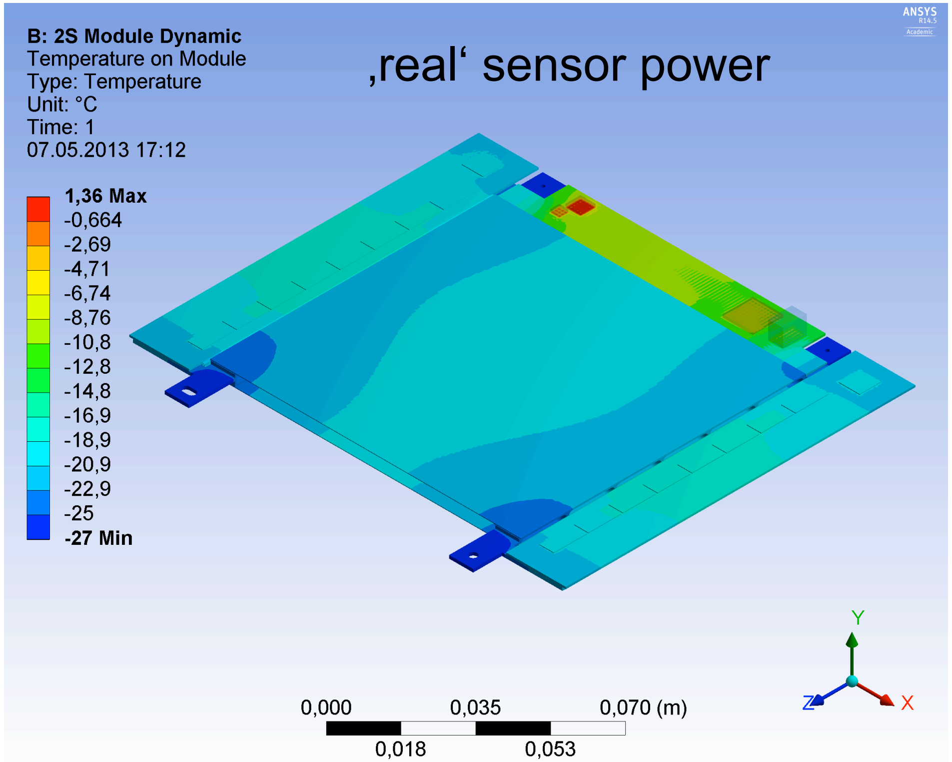
2S Module - Thermal Results (Sensors)

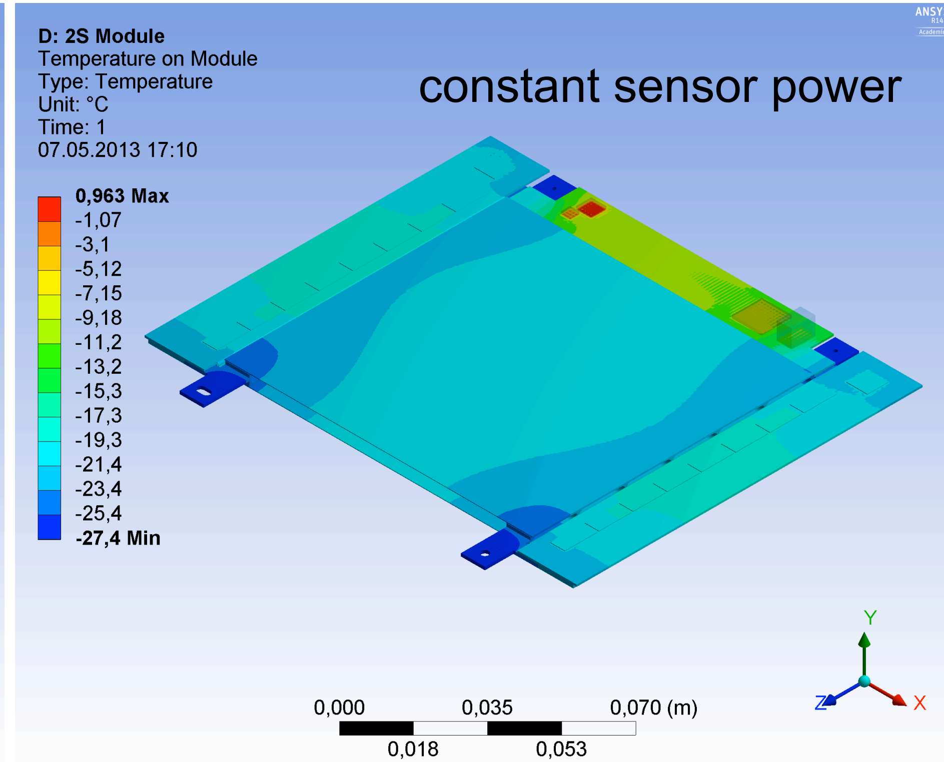




- ‚real‘ sensor power: temperature of cooling contacts tuned to obtain -20°C max. T on sensors
- temperature gradient on sensors smaller in case of ‚real‘ sensor power
  - less heat generated at corners where temperature is smaller

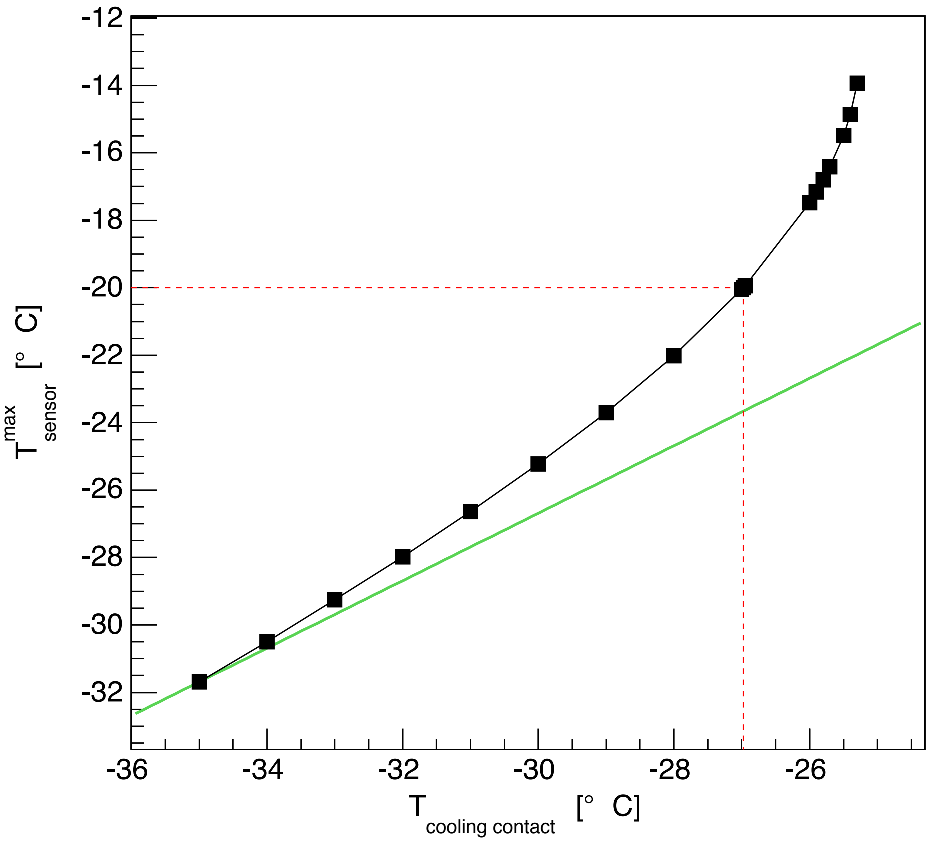
2S Module - Thermal Results (Module)

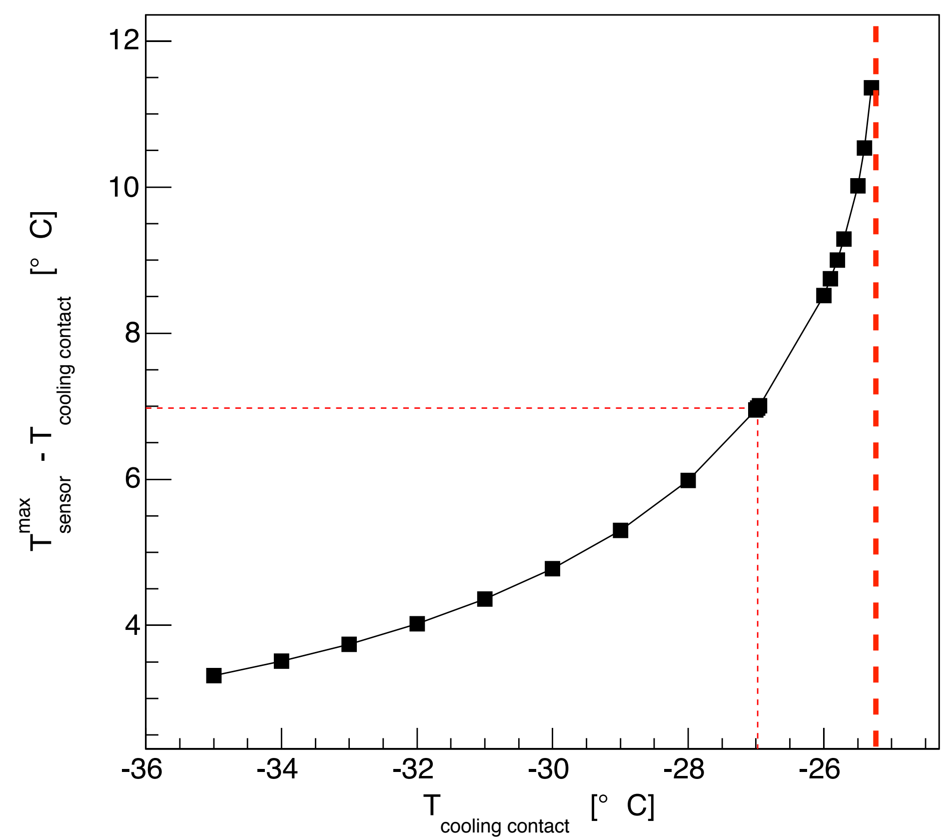




- ‚real‘ sensor power: temperature of cooling contacts tuned to obtain -20°C max. T on sensors
- cooling contacts have to be kept at -27°C to obtain -20°C max. T on sensors

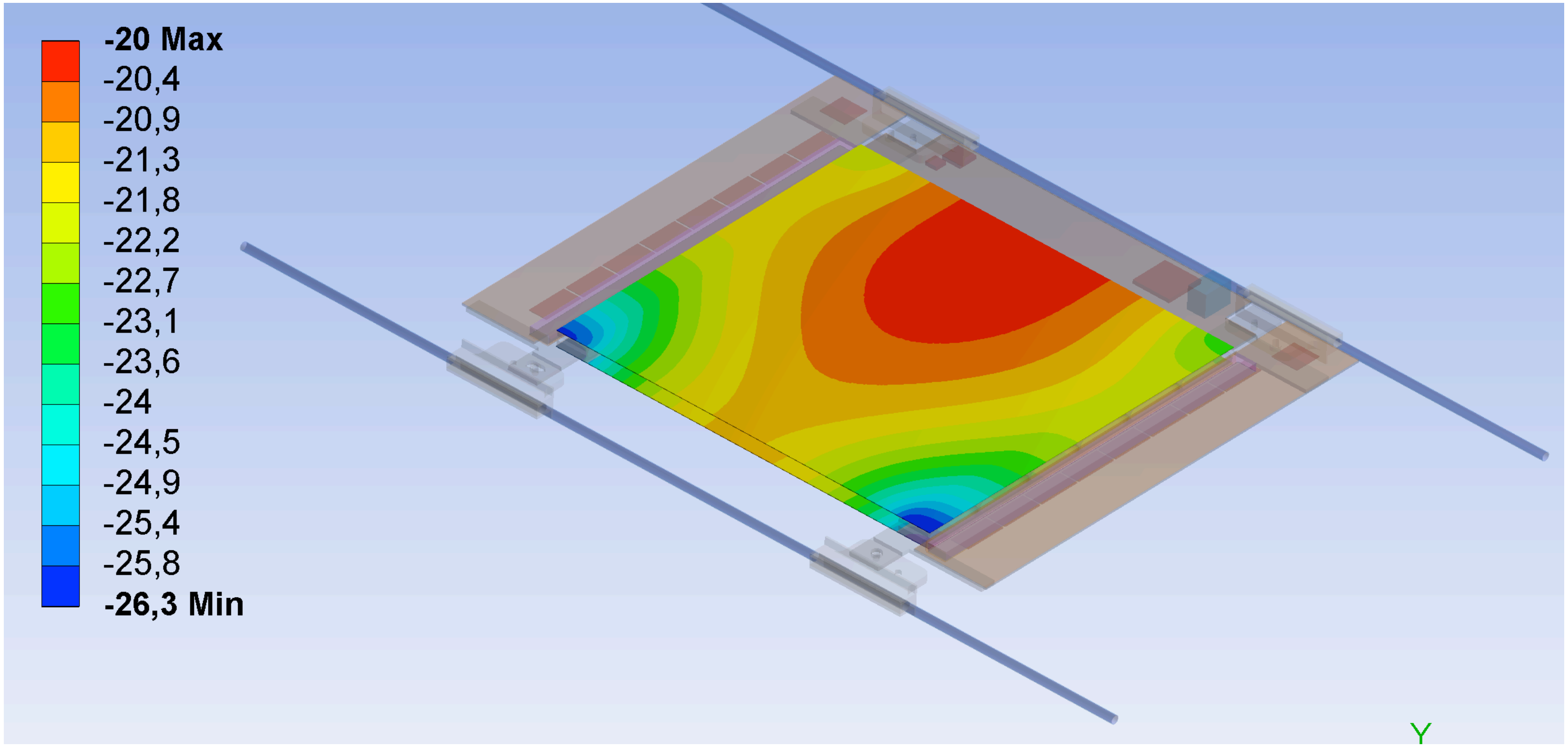
2S Module - Thermal Runaway





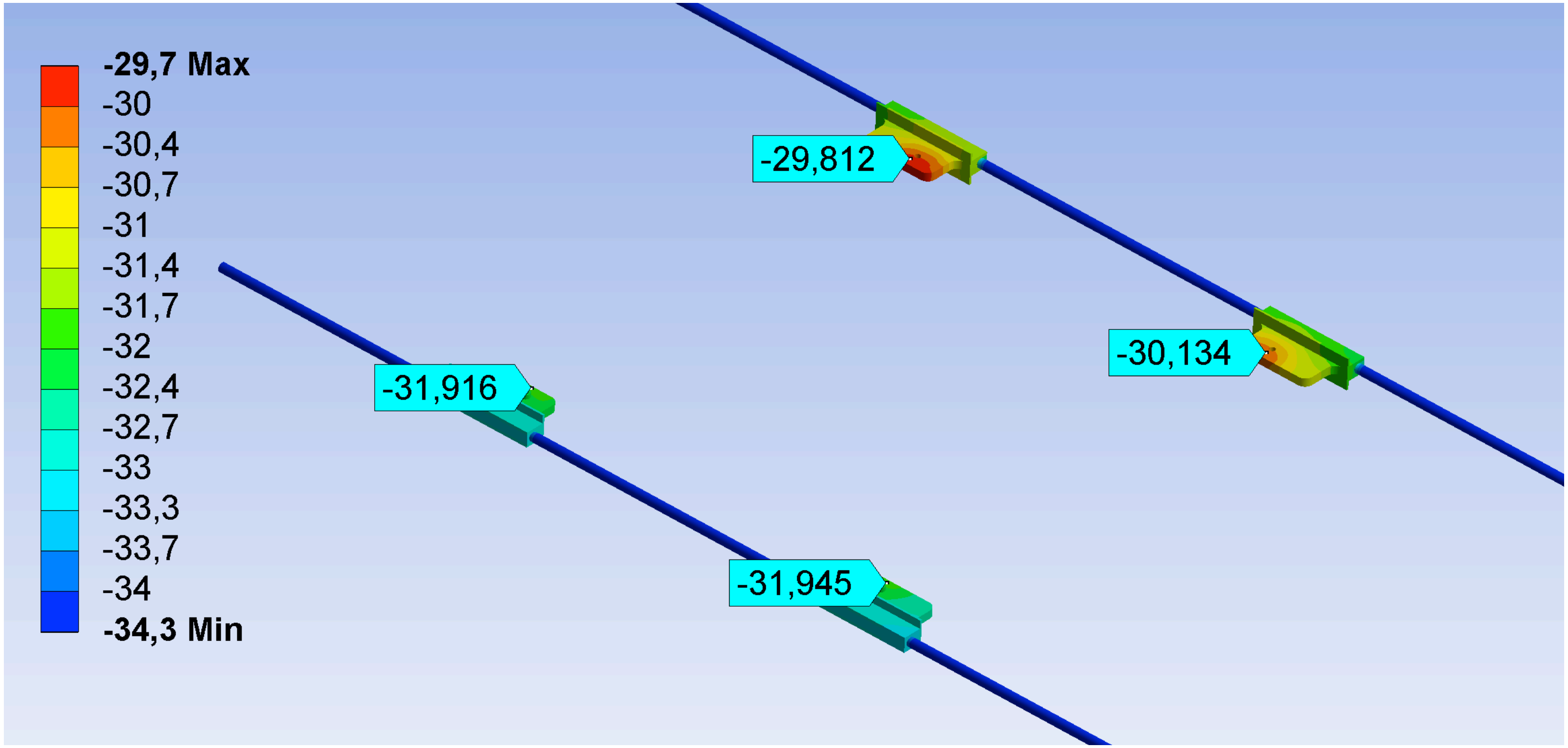
- cooling contacts have to be kept at -27°C to obtain -20°C max. T on sensors
- thermal runaway reached at ~ -25.2 °C

2S Module on Cooling Blocks



- calculated for constant sensor power dissipation
- heat transfer coefficient of interface (module to cooling block) is 10000 W/m^2/K
- heat transfer coefficient from pipe to CO2 is 5000 W/m^2/K
- coolant has to be at -34.3 °C obtain -20°C max. T on sensors
- temperature gradient on sensors increased from 4.7 °C to 6.3 °C
- reason for change is the asymmetry due to the power dissipation on service board

2S Module on Cooling Blocks



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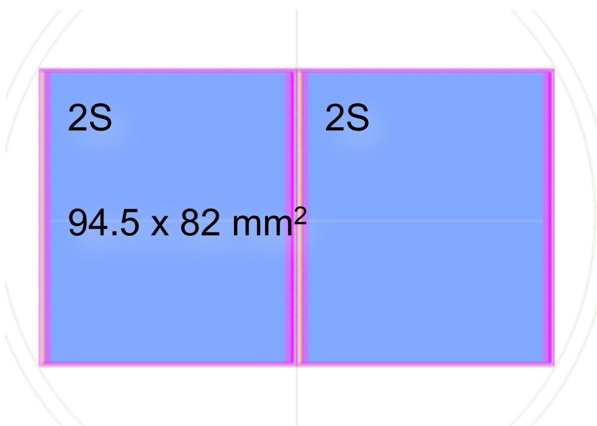
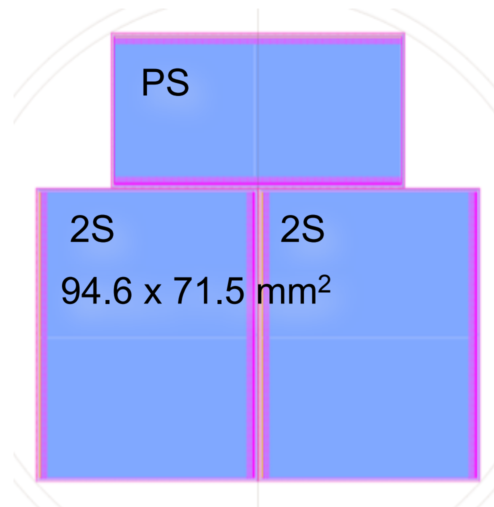
Recap: 2S Module Options with 8 Inch Wavers

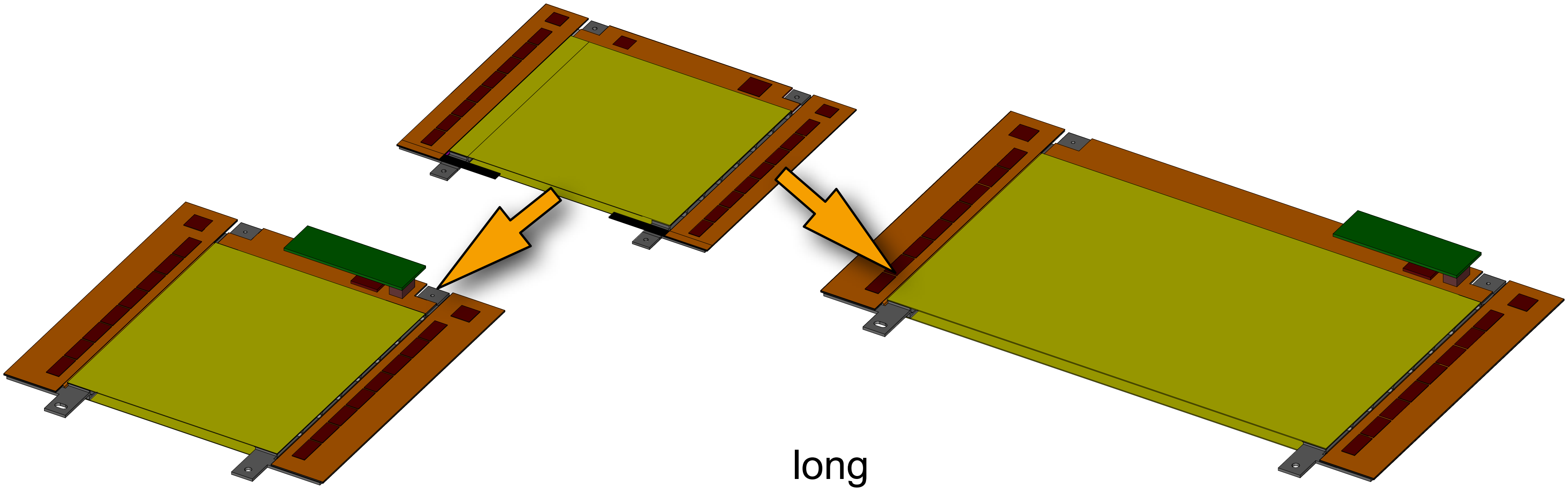
- HEPHY has established contact to Infineon as a possible vendor for sensors
  - they offer a 8inch production
  - cost of 8inch waver is about the same as for a 6inch waver
  - 8inch offers 84% more area
  - reduction of cost
- this has implications on the sensor dimensions, electronics and modules





- many more options under discussion and feasible
  - Option 1 - PS and 2S sensors on same waver
  - Option 2 - 2S sensor split in two ➟ 4 sensors per module
  - Option 3 - 4cm long strips at inner radii, 8cm long strips at outer radii

2S Module Options: Short & Long



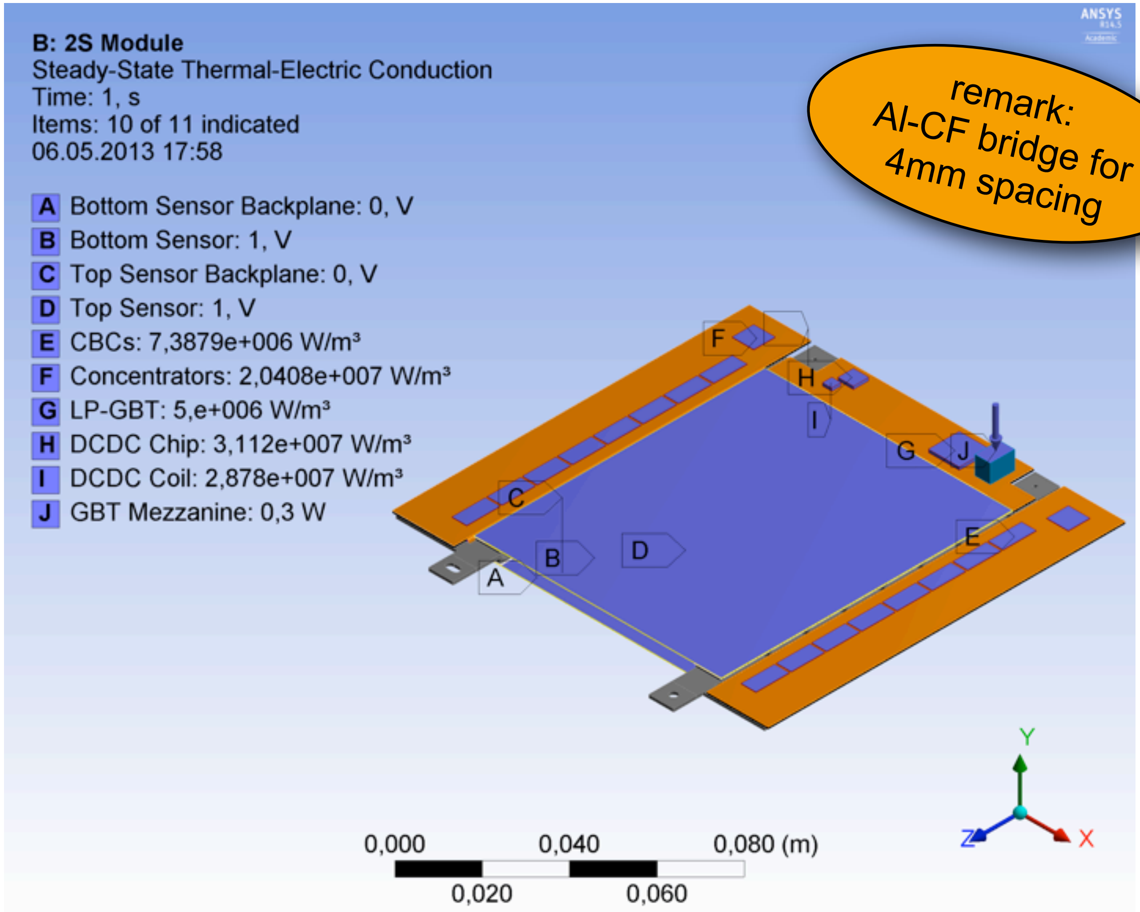
long

short

- space on service board is rather tight - 8 cm instead of 10 cm
- no change in mechanics
- smaller heat generation by sensor
- shorter distance from sensor center to cooling

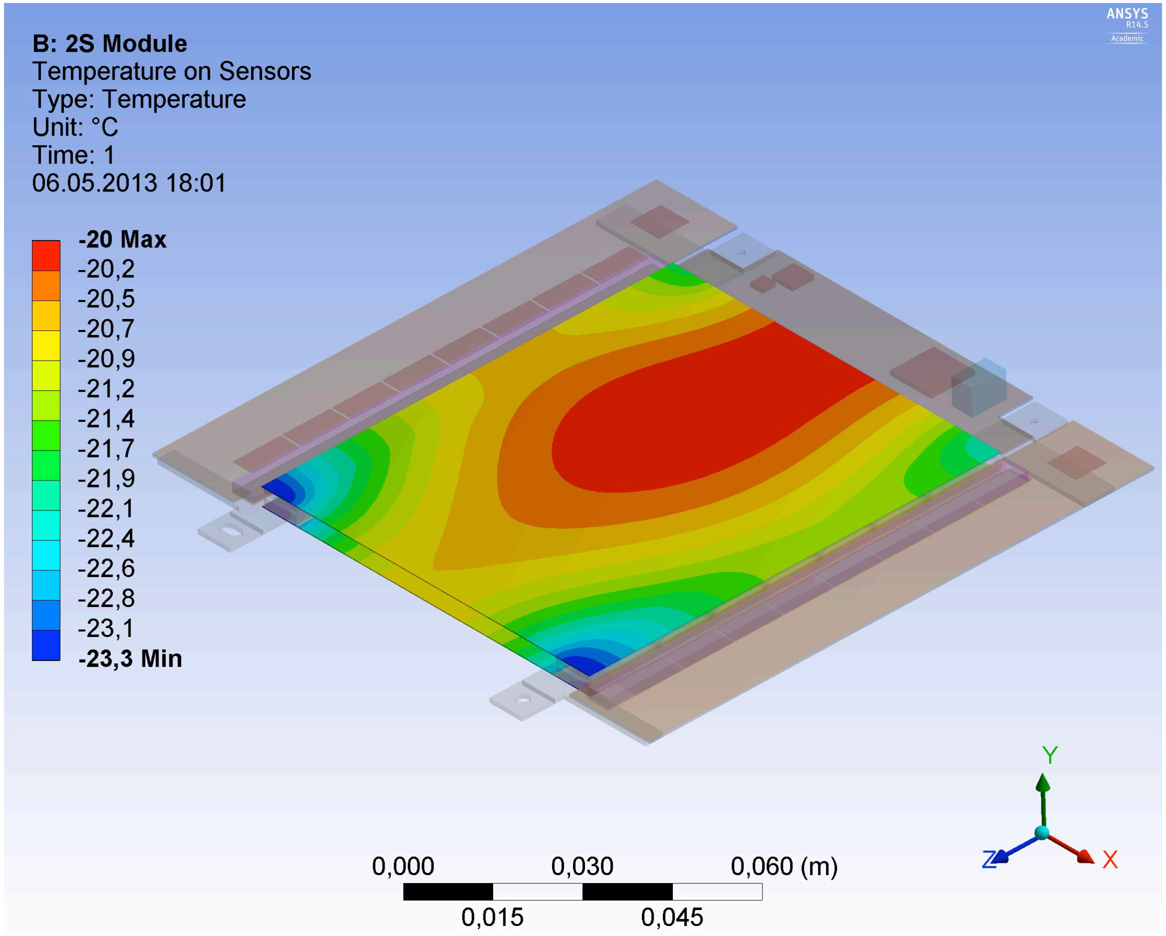
- plenty of space on service board - module is now 16 cm long
- mechanics might become tricky
- might only be possible with 300 um sensors
- heat generation by sensor will be larger - needs to be checked
  - factor 1.5 due to thickness, however fluence is smaller (r >= 85cm)
- longer distance from sensor center to cooling - might need additional cooling contact in the middle

2S Module Short - Thermal Loads



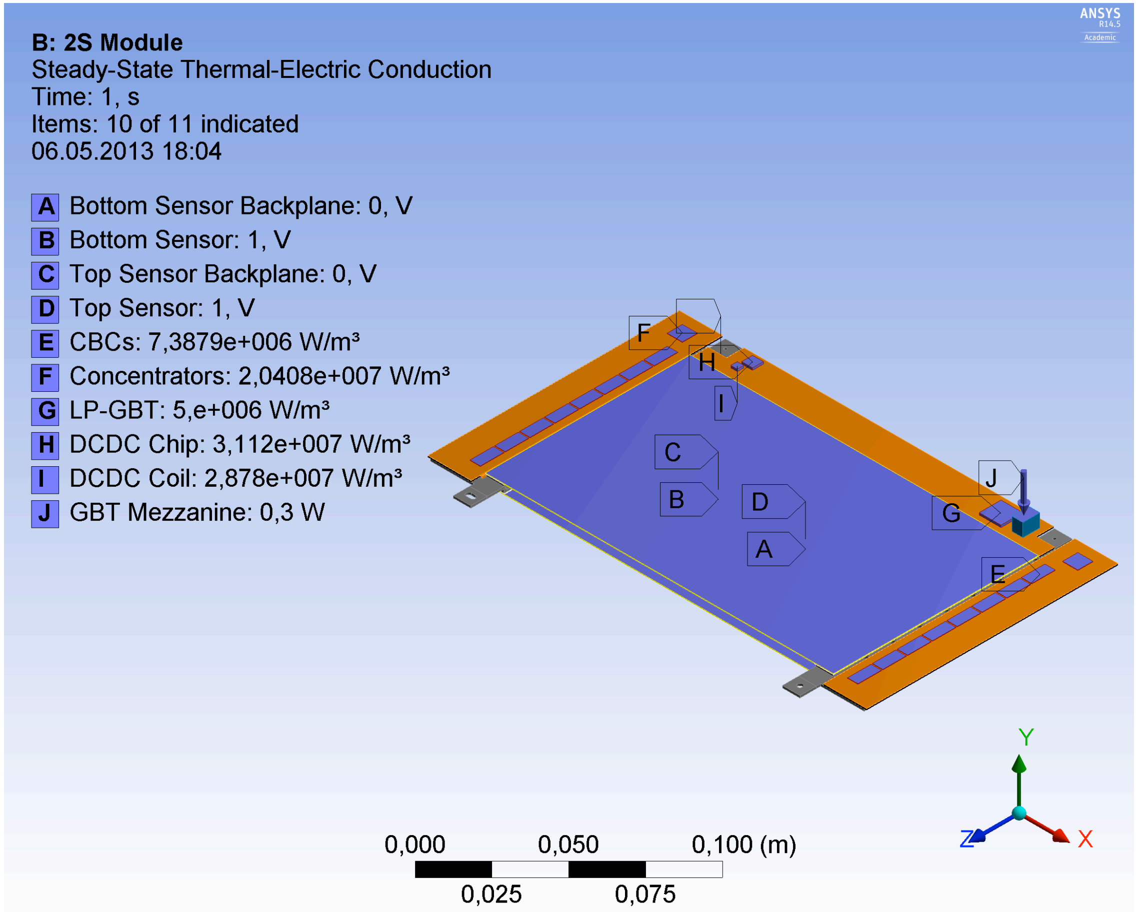
- power consumption of sensors (200 μm) calculated for
  - fluence: 6e14 neq/cm^2
  - damage constant: 5.3e-17
  - @ -20°C: 503 mW

2S Module Short - Thermal Results



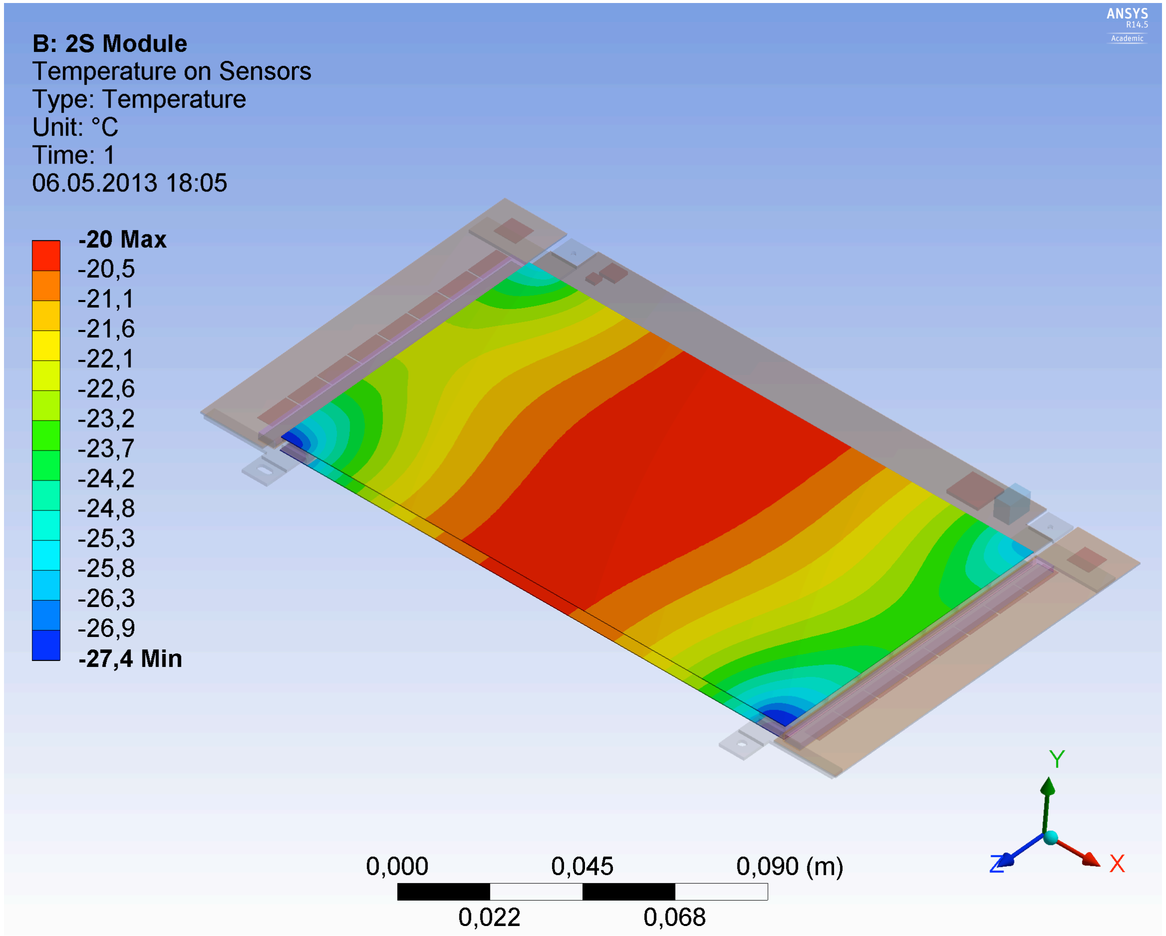
- smaller temperature gradient compared to std. 2S module (as expected)
  - lower power consumption compared to std. 2S module
  - smaller distance of center of sensors to cooling

2S Module Long - Thermal Loads



- power consumption of sensors (300 µm) calculated for
  - fluence: 4e14 neq/cm^2
  - damage constant: 5.3e-17
  - @ -20°C: 1006 mW

2S Module Long - Thermal Results



- 2S module with 16 cm long sensor needs additional thermal management
  - e.g. conductive foil
  - additional cooling contact in the middle ➟ 6 mounting points