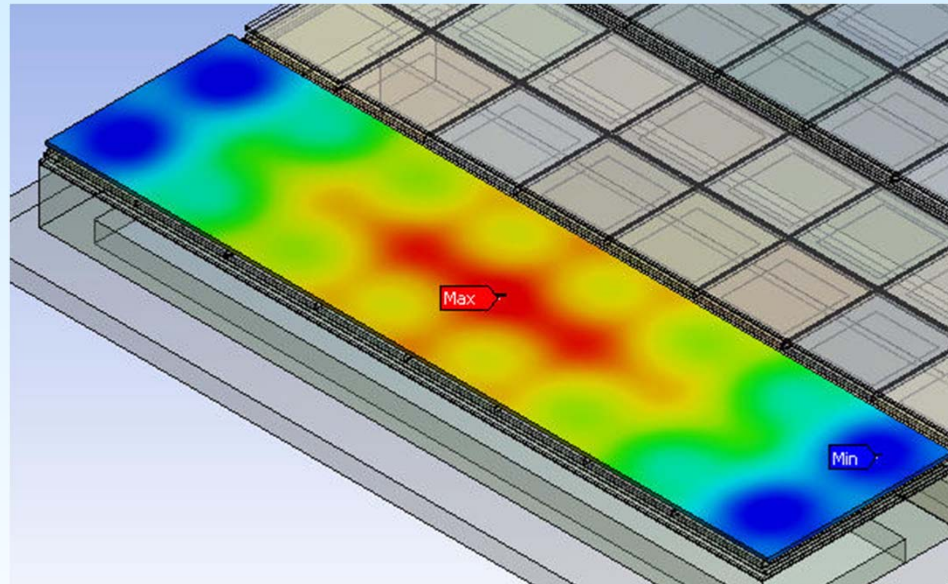
Thermal Simulations

How to cool away 32 Watts



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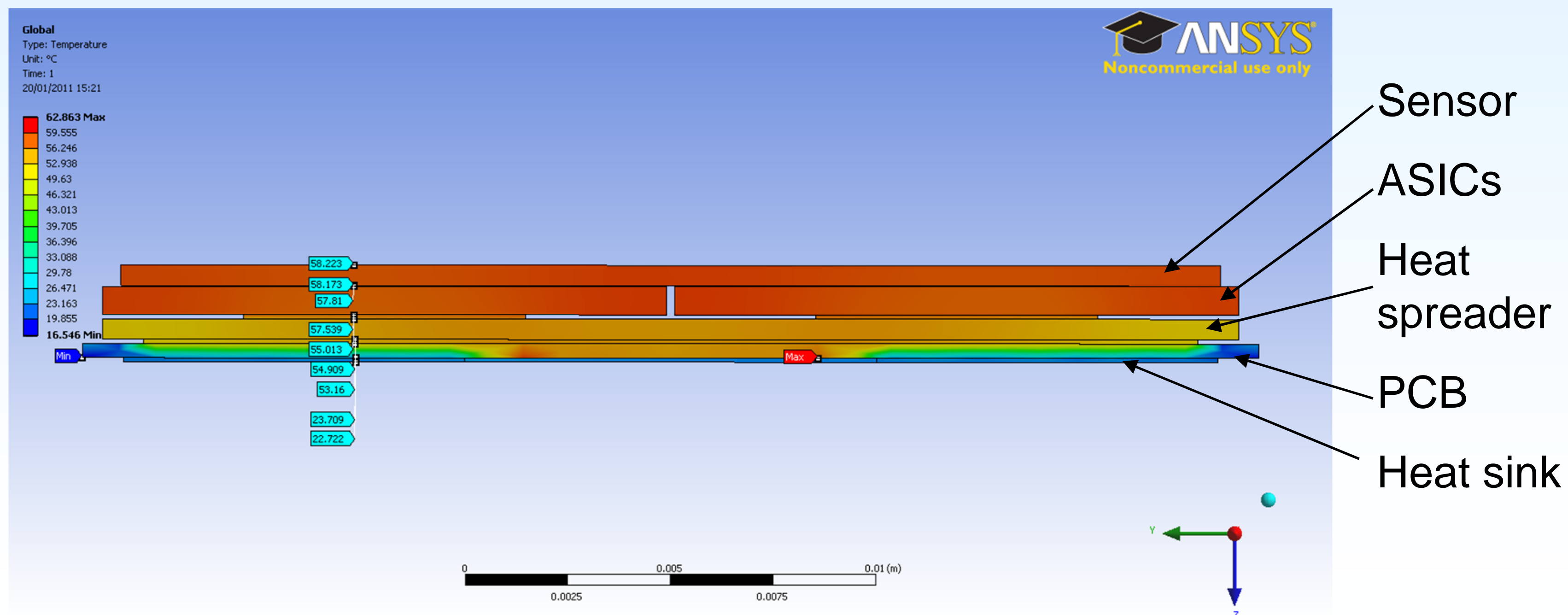
Work so far

- Implemented current layout design into ANSYS
- Used current experience from Si-λ Medipix project to make assumptions on glue type / fill factor etc.
- Assuming vacuum operation (only heat conduction to thermal sink)



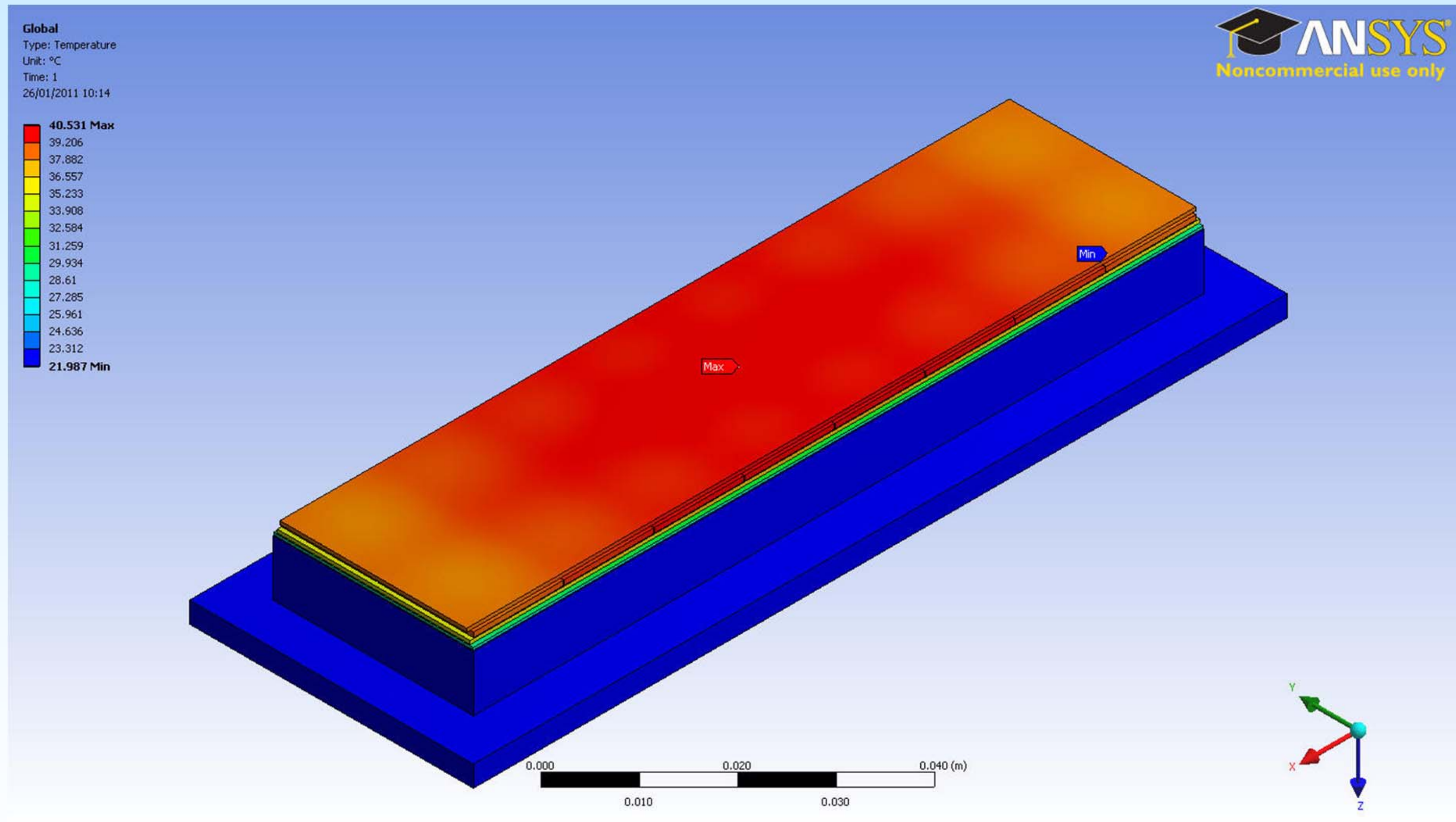
Materials and parameters

Element	*Material*	*Thickness [µm]*	*Th. Cond. (X/Y)[W/m*K]*
Sensor	Silicon	500	148
Bump bonds	Indium	20	0,459/1e-9
ASIC	Silicon	700	148
Glue	EPOTEK	100	1,37
Heatspreader	Silicon	500	148
Glue	EPOTEK	100	1,37
Flexprint	Capton/Cu	350	0,4/34,7
Ceramic	Al_2O_3(?)/Ag	2400	3/12
Glue	EPOTEK	100	1,37
Heatsink	-	-	-

Why not standard PCBs?

- Standard PCB material (FR4) is a good thermal isolator (~0.23 W/m*K)
- Simulation showed vertical dT of up to 40 K
- Including copper traces, thermal vias and a solid copper core does not solve the problem (dT ~ 35 K)
- Alternatives are:
  - Flexprint (4*80 µm capton, 3*10 µm copper)
    - Very thin (0.35mm)
    - Flexible
  - Ceramics
    - Uses silver traces (420 W/m*K)
    - Can be designed with thermal vias

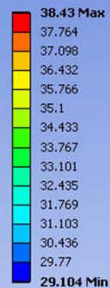
Simulation results (global)

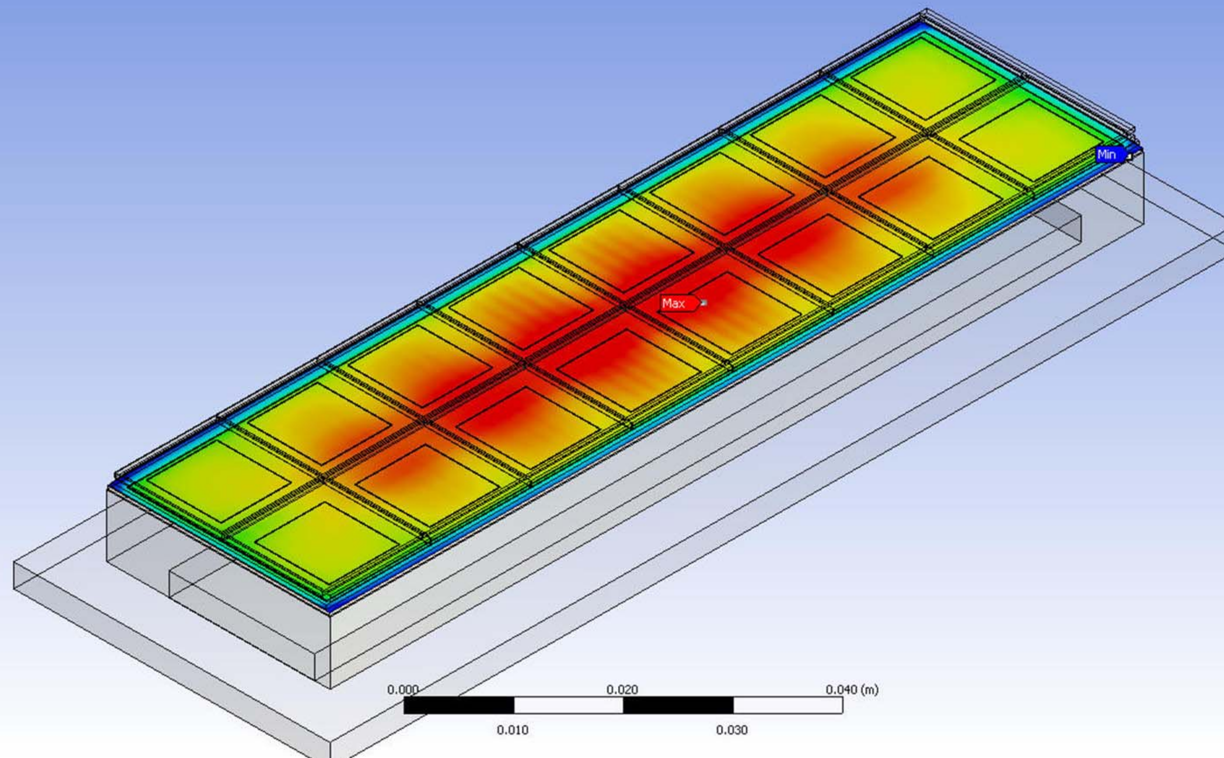


- Large vertical dT of ~18 K
- Largest temperature drop in flexprint

Simulation results (PCB)

PCB top
Type: Temperature
Unit: °C
Time: 1
26/01/2011 10:23





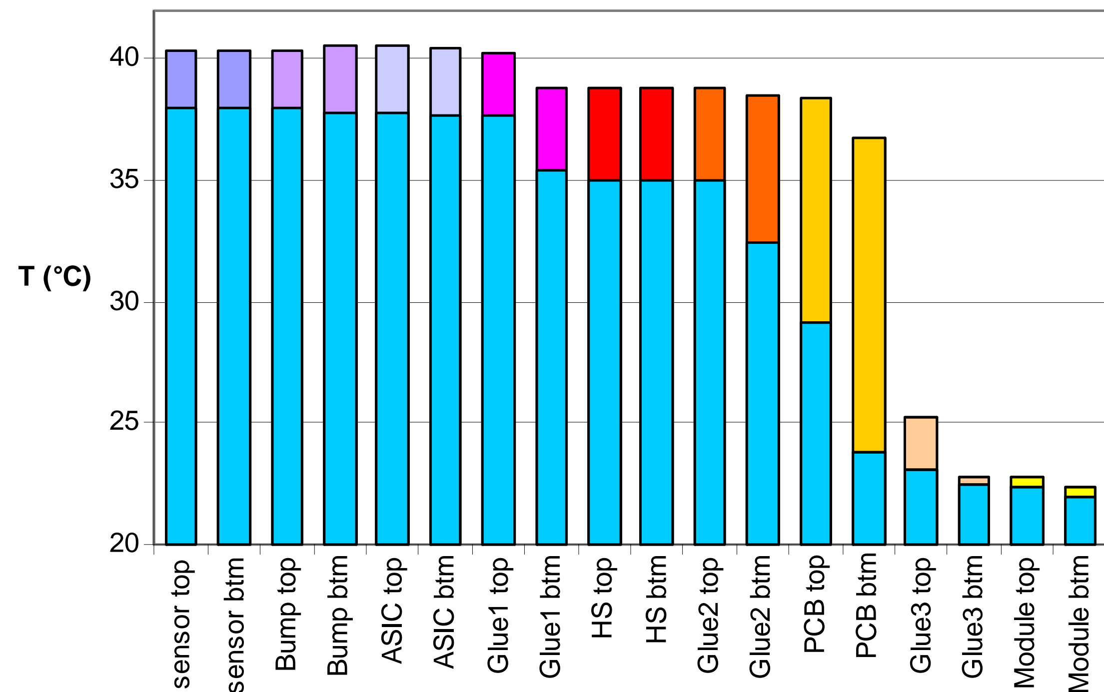
- Lateral dT in flexprint ~ 13 K
- Problems with differential thermal expansion?

Simulation results (Sensor)

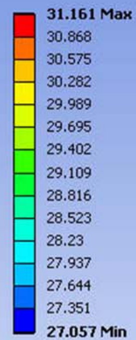
- Lateral dT ~ 3 K
- Seems ok if shear forces can be avoided
- But vertical dT of ~ 18 K might be worrisome

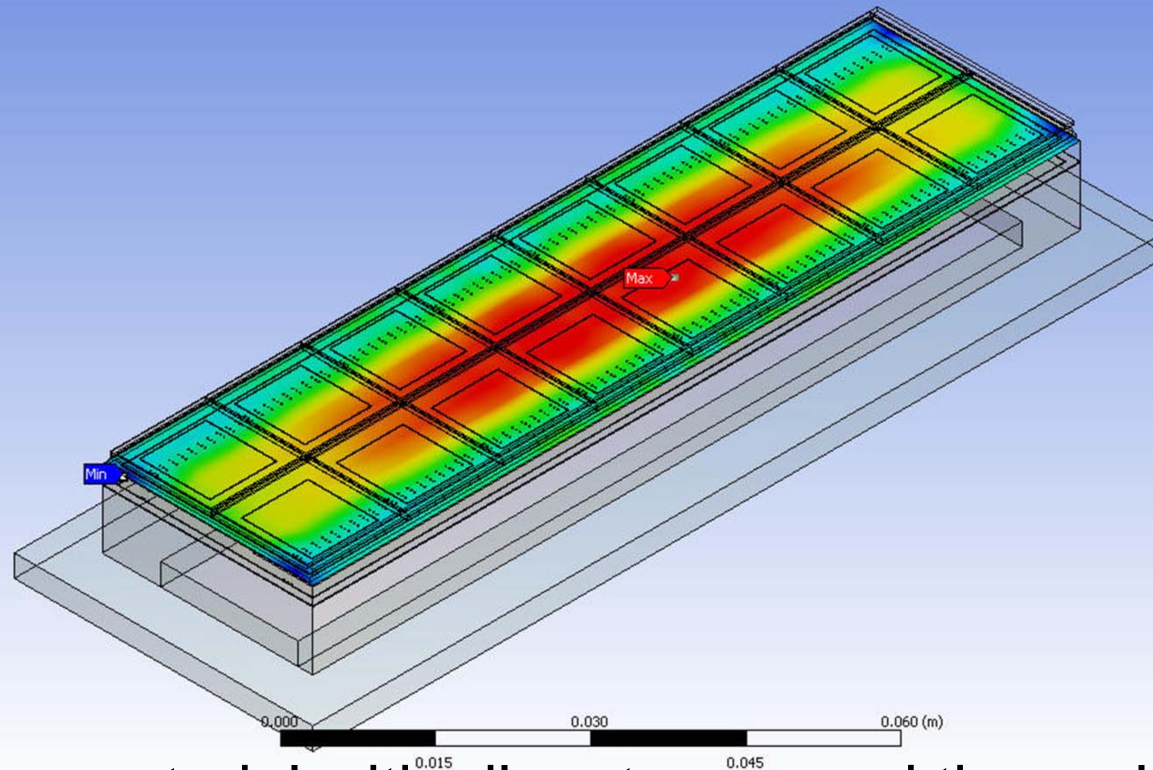
Summary on current design

- Most problematic parts are PCB and glue
- Some improvement possible in the area coverage of the glue
- PCB design might require thinking about a new concept
- Large vertical dT can to some extend be compensated by lower sink temperature



Alternate PCB design

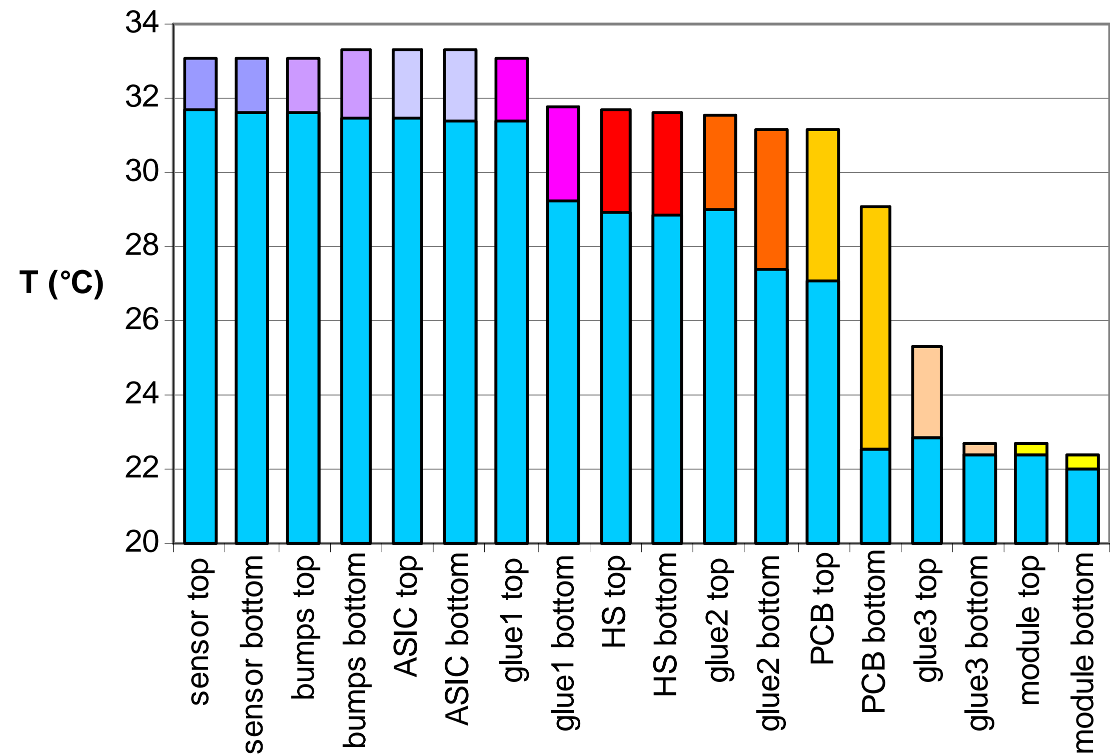




- Ceramics material with silver traces and thermal vias
- Concept in use for Medipix project Ge-λ
- Lateral dT=1.4 K, vertical dT=9.7 K (in sensor)

Summary on alternative design

- Almost 8 K less vertical dT
- Same improvement possible in the area coverage of the glue
- Silver vias and traces provide superior thermal conductivity
- Ceramics material is thick compared to Flexprint (2.4 mm to 0.35mm)



Summary and Outlook

- Thermal simulations using conservative estimates (2W/chip, 50% glue coverage) have been performed
- As expected standard PCBs cannot be used
- Gluing will be the bottleneck
  - Full face gluing for heatspreader mandatory
  - Glue coverage on ASICs vital
- Flexprint and ceramic will probably both work
- Current design favors ceramic PCBs

Outlook

- Simulations of whole quadrant including cooling block
- Incorporation of CO_2-Cooling

  -> Can it be done by a Desy summer-student?