Silicon Staves for the ATLAS sLHC Upgrade

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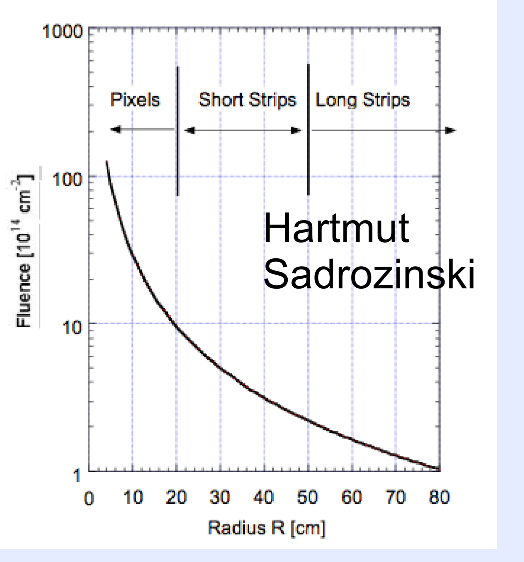
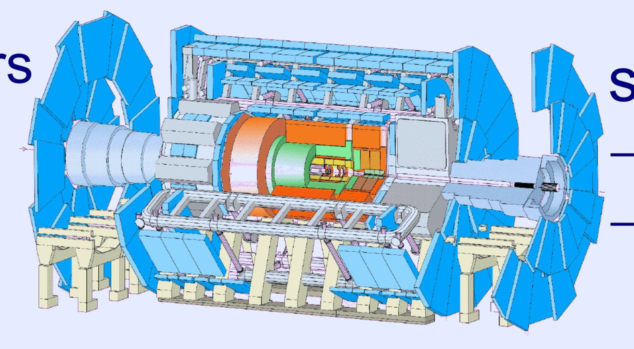
ATLAS Upgrade and the sLHC

Planned luminosity upgrade of the LHC to the sLHC ($10^{35}cm^{-2}s^{-1}$) in 2018
Why upgrade:
- Allow collection of up to 6000 fb^{-1} of data
- Needed for precision measurements (couplings, particle properties)
- Studies of rare decays (FCNC, Higgs)

BUT: in order to fully benefit from the increased luminosity, the existing performance of the ATLAS detector needs to be maintained.



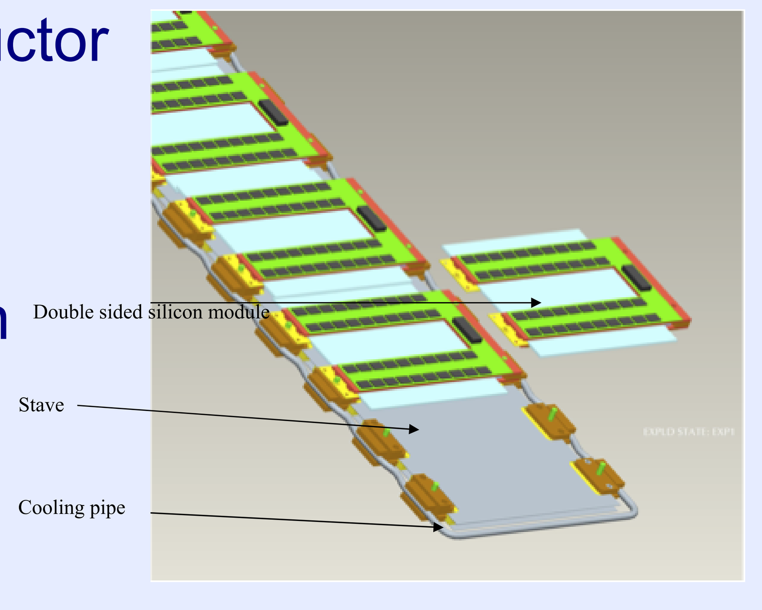
Main challenges are:
→ Higher radiation dose $10^{15} n_{eq}\,cm^{-2}$ for inner strip layers
→ More charged particles in the tracking system leading to a high occupancy.

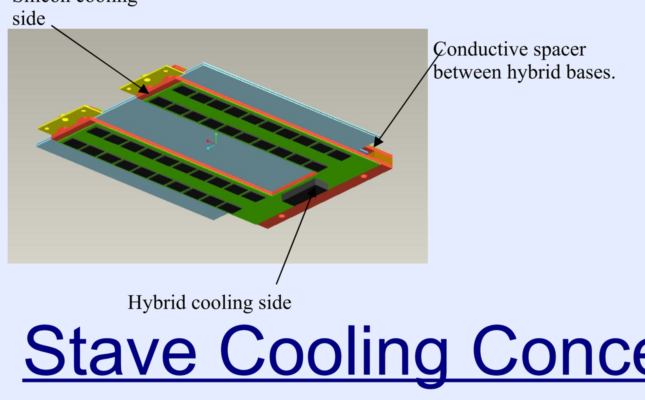


To maintain the resolution of the present ATLAS silicon tracking system we need:
→ Finer segmentation
→ Factor of 10 improvement in radiation hardness

Stave Concept

Upgrade for ATLAS Semiconductor Tracker (SCT) and Transition Radiation Tracker (TRT)
- Compact design
- Material and service reduction
- Highly integrated design

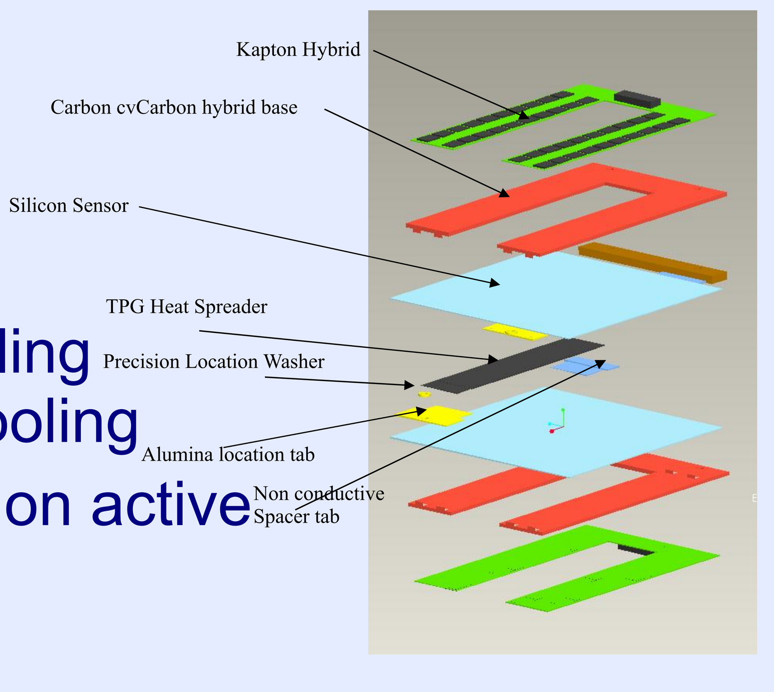




Stave Cooling Concept:

- Double-sided silicon module
- Aluminum and TPG heat spreader
- 2-ended-cooling :
  - Cooling flow for silicon cooling
  - Cooling return for hybrid cooling
- Design requires direct gluing on active side of detector:
  - → Better heat transfer
  - → Material reduction
- Never done so far. We need to understand:

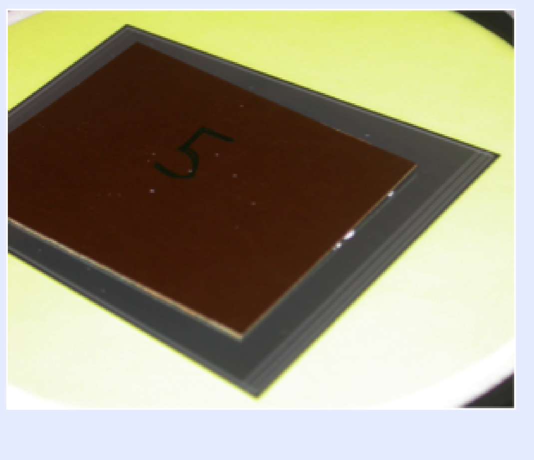
→ How does this affect the detector properties ?
→ Is there a glue radiation hard enough for this purpose ?



Approach:

Use ATLAS SCT strip sensors (CiS):
Measure CV-IV curves:
- Before and after gluing
- During curing process
- After thermal cycling
- After 25 MeV proton irradiation at FZ Karlsruhe

Pertinax is used to mimic hybrid, glue only on passivated region, kept away from bias ring



Glues under test:

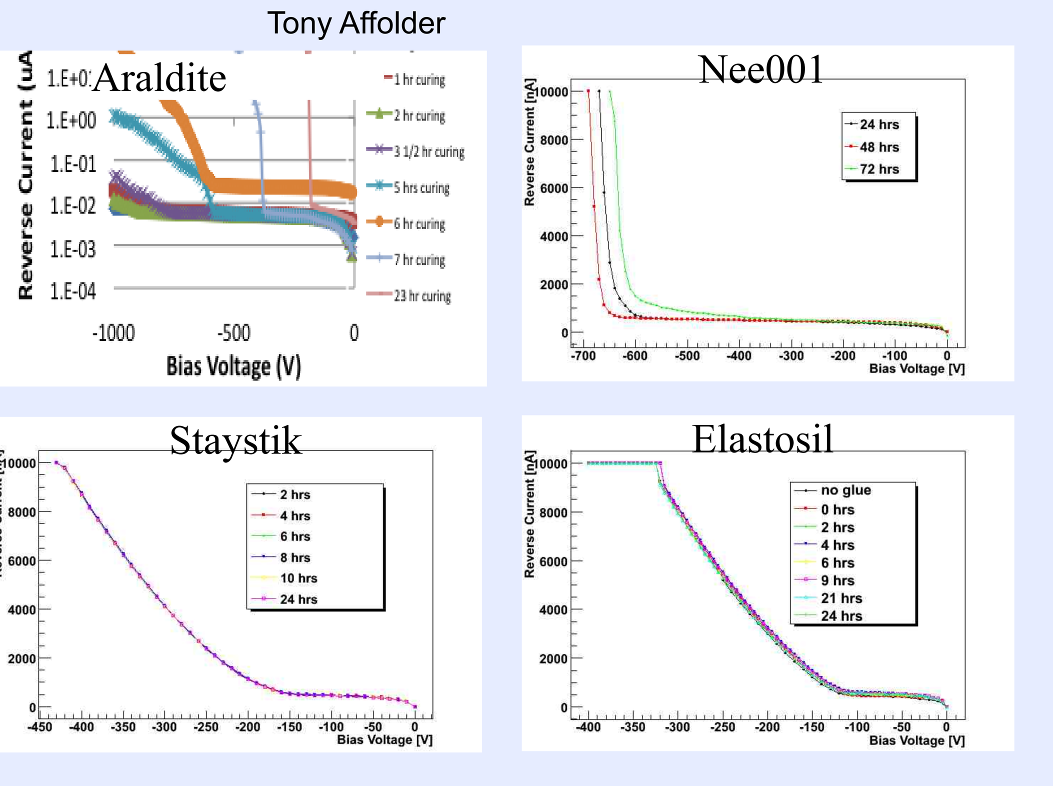
Staystik:	Nee001:	Elastosil:	Araldite(Liverpool):
▪ Thermalconduction film	▪Silicone glue	▪Siliconebasis	▪Epoxidbasis
▪ low temperature application	▪24-48 hrs. cure under pressure of 2-3 kg/cm	▪24 hrs cure	▪ 24 hrs cure
▪ Bonding range: 125-200°C			
▪Thermal conductivity : 0.25-0.3 W/mK	▪Thermal conductivity : 0.24 W/mK	▪Thermal conductivity: 1.79 W/mk	▪Thermal conductivity: 0.87 W/mK
	▪CMS, HeraB	▪radiation hard	▪ ATLAS Endcap/Barrel, CMS Endcap/Barrel

Glue Test Results

Curing:

Araldite leads to clear degrading of breakdown voltage

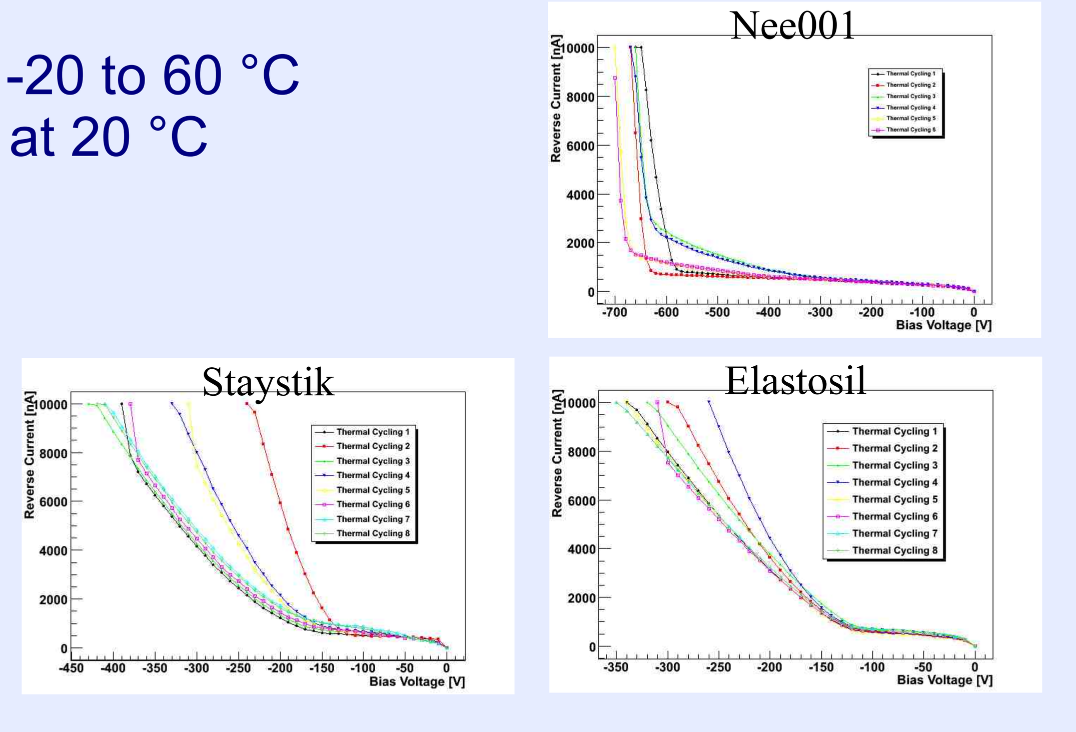
No differences in breakdown behaviour seen for Nee001, Staystik and Elastosil



Thermal Cycling:

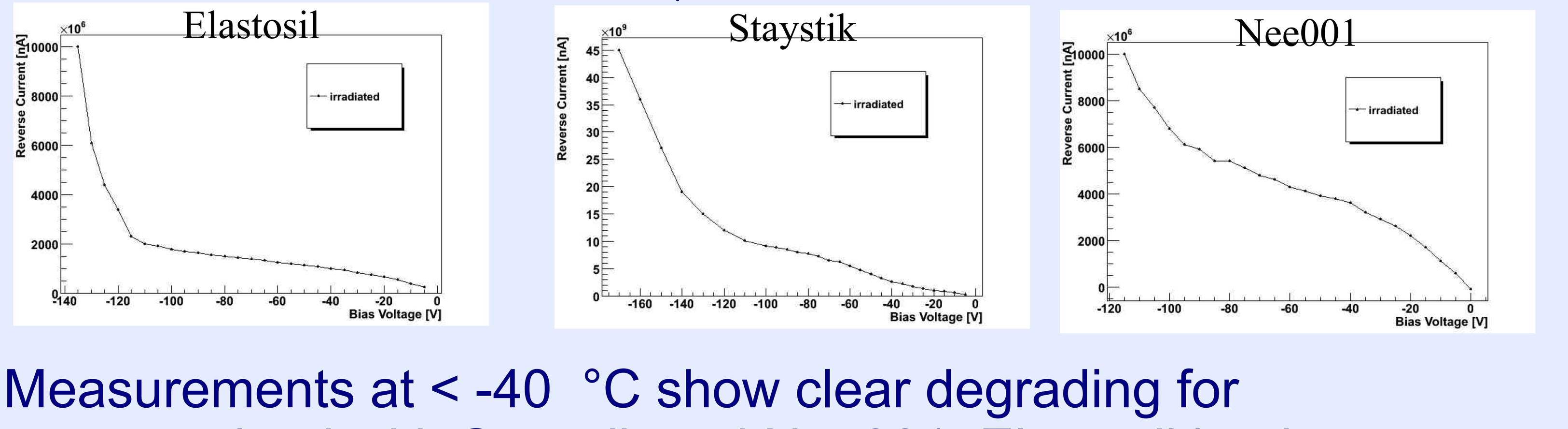
Thermal cycling from -20 to 60 °C
Measurements taken at 20 °C

Visible differences are due to fluctuations in the humidity



Irradiation:

Sensors irradiated to $10^{15} n_{eq}\,cm^{-2}$ over 1.5 cm wide area.



Measurements at < -40 °C show clear degrading for sensors glued with Staystik and Nee001, Elastosil leads to no differences in breakdown voltage

Conclusion and Outlook

- No differences have been seen in breakdown voltage for Staystik, Nee001 and Elastosil during curing and thermal cycling
- Irradiation shows strong degradation of breakdown voltage for Nee001
- Gluing with Elastosil or Staystik exhibits no large differences after radiation
- Further investigation needed to understand effects of radiation on the different glues
- → Staystik and Elastosil seem to be radiation hard enough and are suitable for gluing on the active side of the detector