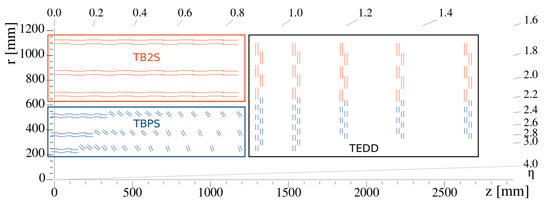
Prototyping and Reception Testing for the CMS Phase II Tracker Upgrade.

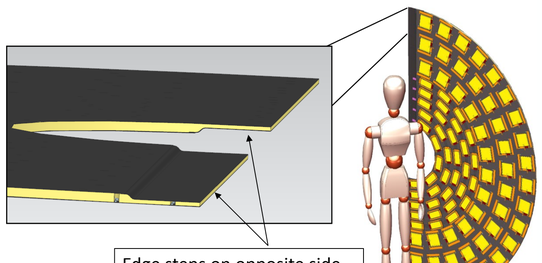
Oskar Reichelt for the DESY CMS Group
FH behind the scenes, 20th November 2019, DESY

New CMS Tracking Detector

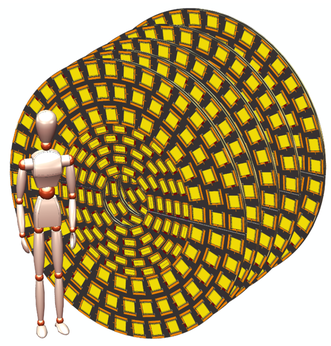


- The Dee is the central element of the TEDD design
  - A half disk of highly integrated CFRP sandwich with embedded inserts, cooling elements and pipes
- The Dee is designed with a step on the opposite sides of its straight edge to allow Dee to Dee assembly
  - Rotational symmetry between both Dees requires step in opposite sides and even number of cooling sectors

• Two Dees	➞	Disk
• Two Disks	➞	Double Disk
• Five Double-Disks	➞	TEDD



Dee

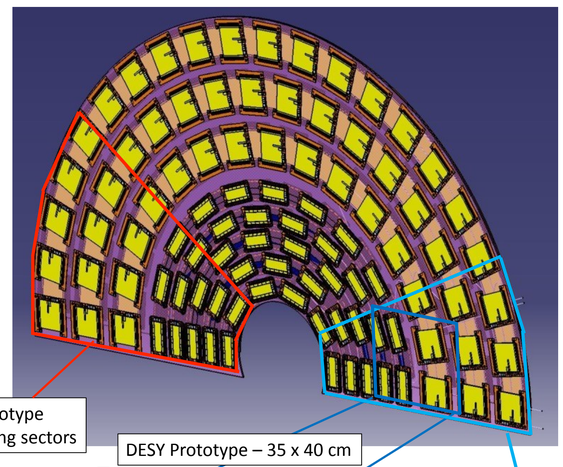


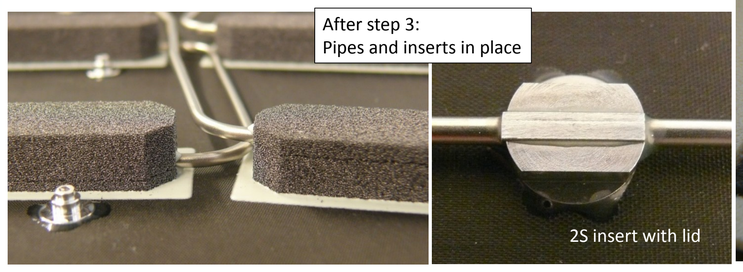
TEDD

Dee Prototyping

Dee Prototyping is taking place at two institutes IPNL (Lyon) and DESY

- The final object should serve exactly the same purpose, however the two institutes are following slightly different assembly sequences
- First prototypes:
  - Transition area between PS and 2S modules
  - Module positioning and cooling inserts
  - Edge of Dee
  - Two cooling sectors
- Both institutes currently produce a full-sized Dee Prototype
  - Production with industrial partners

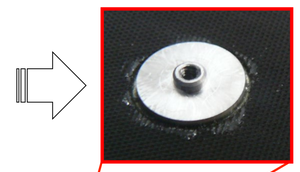




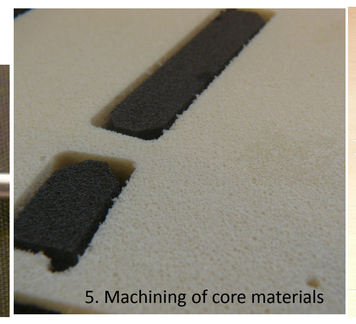
Dee Assembly Sequence

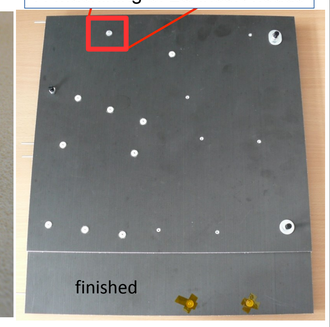
Structure is assembled from bottom to top, using one assembly plate

1. Carbon fiber facing and all lower inserts placed on the alignment plate
2. PS Carbon foam blocks are bonded to the lower facing
3. Cooling pipe is bonded to cooling inserts and carbon foam blocks
4. Airex foam core is glued on top of the pipe and the lower facing
5. Core & carbon foam materials are machined to same level
6. Upper carbon fiber facing is bonded
7. 2S inserts on both sides of support structure are machined



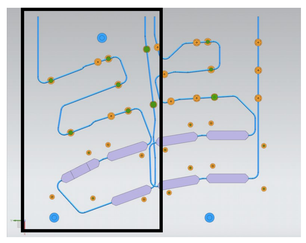
7. Machining of 2S insert heads

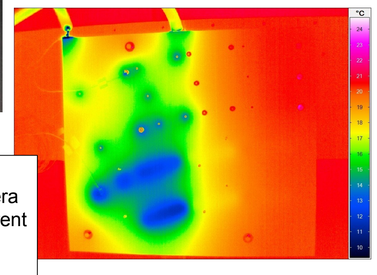


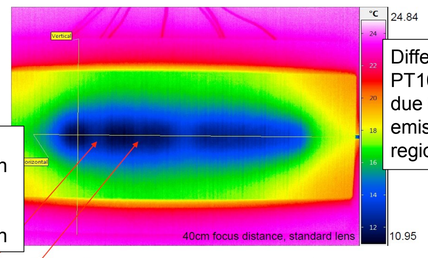


Thermal Imaging

- Aim to study thermal performance especially in regions with inserts/carbon-foam to facing couplings
  - Confirm proper thermal coupling
  - Investigate voids or poor thermally coupled regions
- Structures will be cooled and measurements will be performed by IR camera
  - After temperature is stabilized
  - Verified by comparing to local PT100 measurements



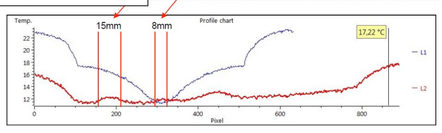




Difference between PT100 and IR camera due to surface different emissivity in some regions

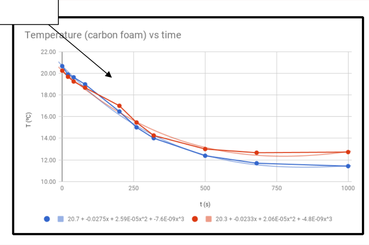
Left carbon foam
200 µm bump: 15, 8 mm width

Right carbon foam
100 µm bump: 15, 8 mm width

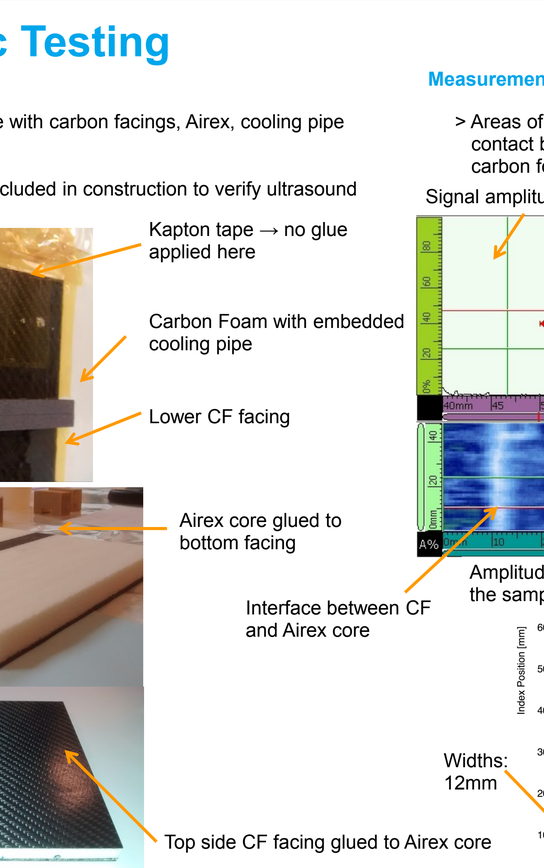


Cooling inlet

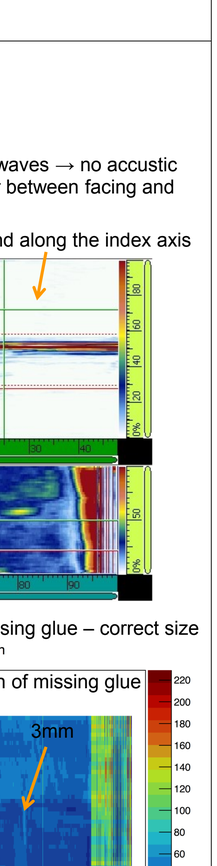
Cooling outlet



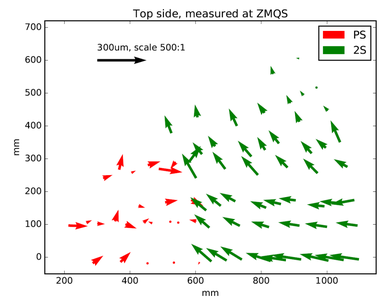
Metrology

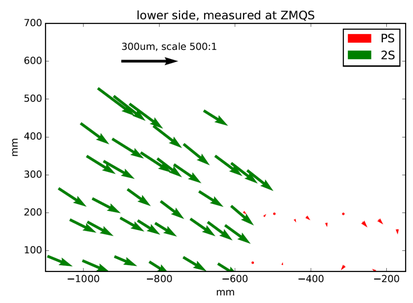


1 Cooling Sector Prototype:
- Measurement of module mounting inserts
- Comparision with CAD modell
- Deviations are within specifications



Metrology arm in DESY Laboratory

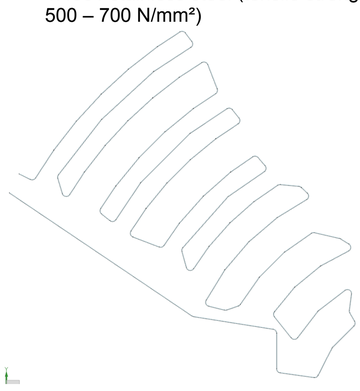




Pressure Test

- Cooling pipe sectors each with
  - ~ 7 m long pipe with ~80 bends
  - 200 W average heat load
- Cooling pipe
  - 2.2/2.5 mm inner/outer diameter
  - 1.4301 stainless steel (tensile strength 500 – 700 N/mm²)

4 mm end piece soldered for Swagelok connector



Straight test pipe tested up to 400 bar without damage.
Damage expected above approx. 700 bar
Why? Tensile strenth is comparable with equivalent stress
At 160 bar: equivalent stress: 122.8 N/mm²
At 400 bar: equivalent stress: 307.1 N/mm²
At 700 bar: equivalent stress: 537.4 N/mm²

Ultrasonic Testing

Sample Construction

> Sandwich structure with carbon facings, Airex, cooling pipe and carbon foam

> Purpose defects included in construction to verify ultrasound measurements

Measurement Results

> Areas of missing glue reflect ultrasound waves → no accustic contact between facing and Airex core or between facing and carbon foam

Signal amplitude at single transducer... … and along the index axis

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

Oskar Reichelt

project engineer

e-mail: oskar.reichelt@desy.de
DESY CMS Group