

# DT Contributions to ATLAS

## ITk Pixel Outer Barrel

09<sup>th</sup> December 2021

Ricardo Tavares Rego

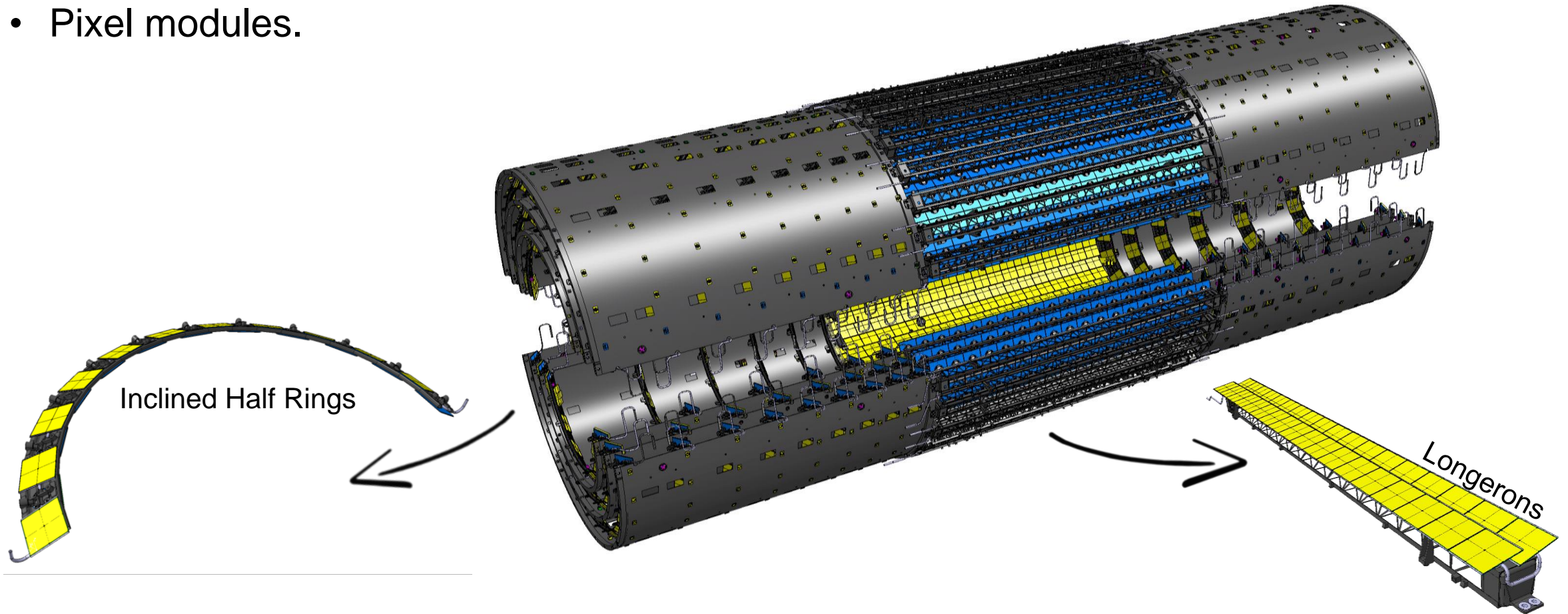
*On behalf of the DT group ITk OB contributors*



EP-DT  
Detector Technologies

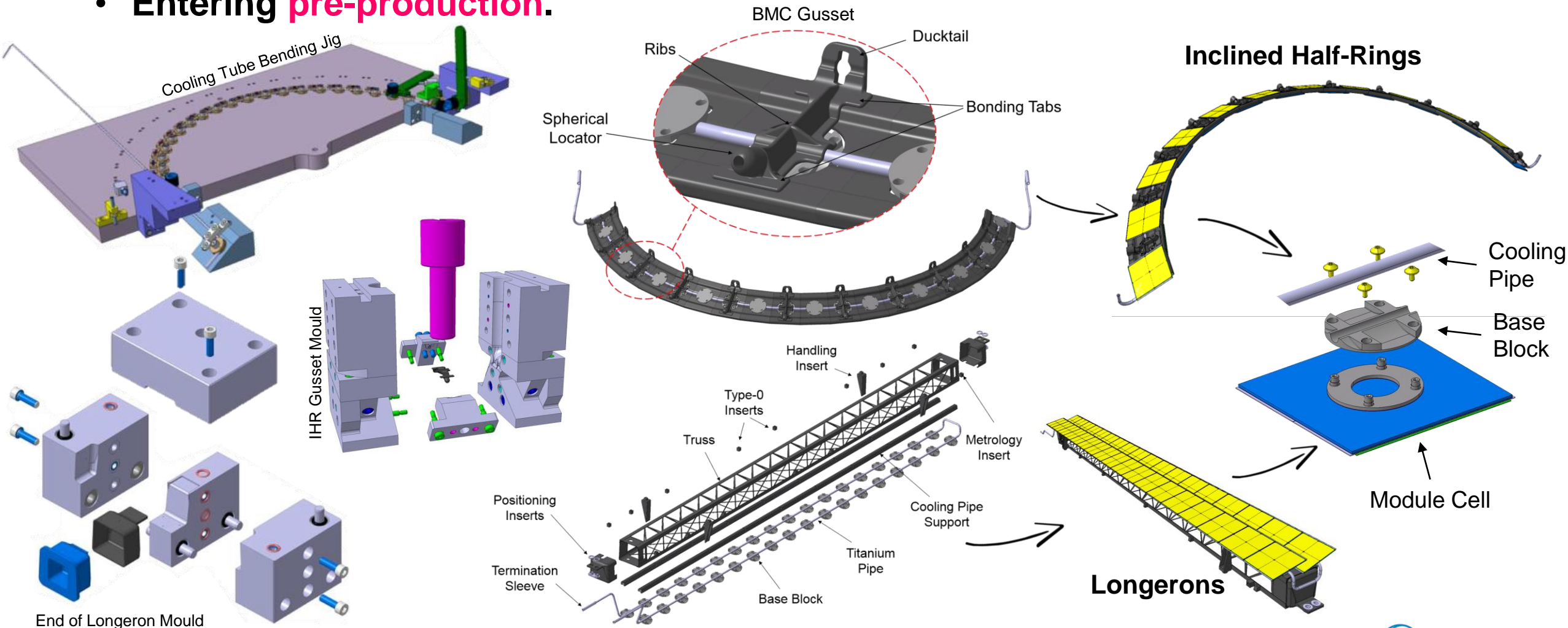
# DT Contributions to ATLAS ITk Pixel OB

- ITk Pixel Outer Barrel (OB) design and integration:
  - Local Supports;
  - Global Mechanics;
  - Pixel modules.



# OB Local Supports: Design

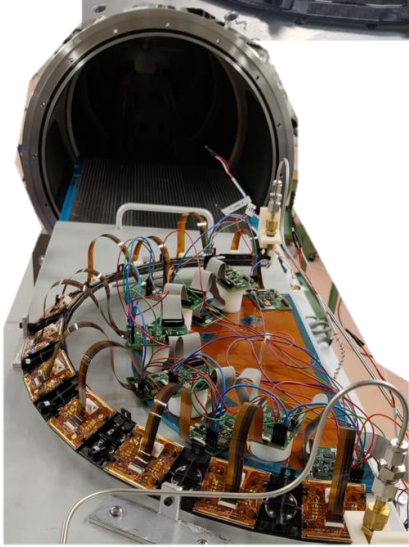
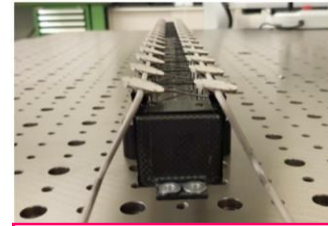
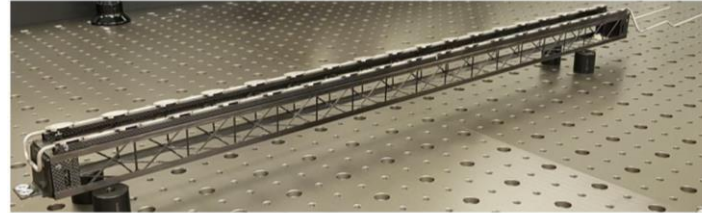
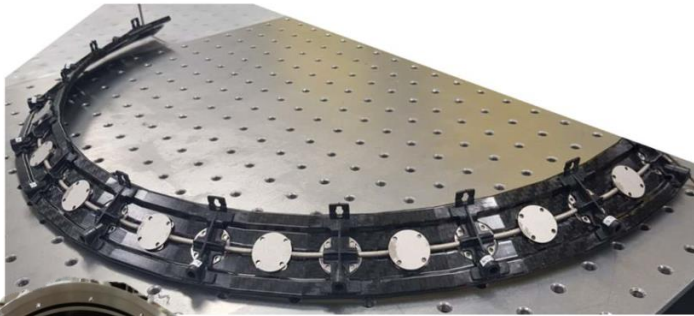
- Detailed design completed – in close collaboration with Université de Genève:
  - **FDR successfully passed in October 2021** – EDMS 2632352;
  - **Entering pre-production.**



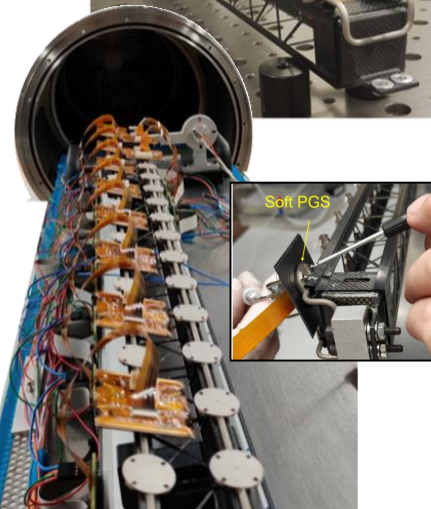


# OB Local Support: Prototyping and Testing

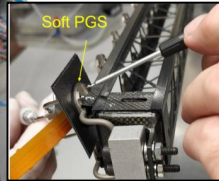
- Full size prototypes of longerons, inclined half rings and cells were built:
  - Qualify manufacturing procedures;
  - Validate thermal and mechanical performance.
- Samples are also produced for material qualification.



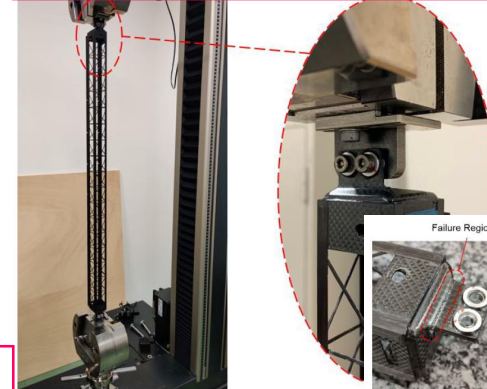
IHR Thermal Prototype



Longeron Thermal Prototype



Longeron Traction Test



Glue DCB for Mode I fracture Tests



Glue Thermal Conductivity Sample

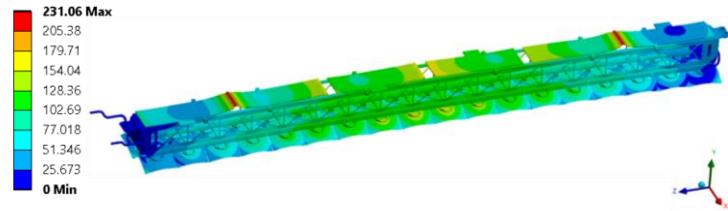


# OB Local Supports: FEA

- Detailed FEA to qualify the design:
  - Thermo-mechanical (stability);
  - Thermo-electrical performance at the end of-life.

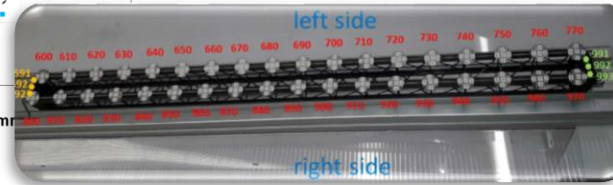
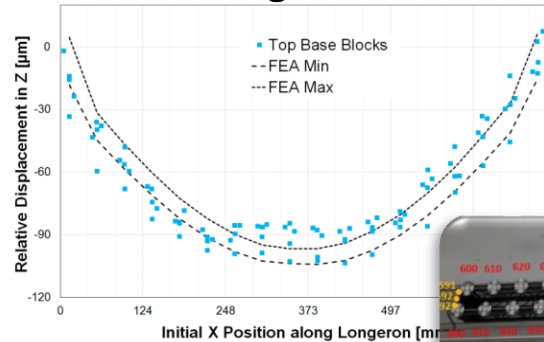
## Stability Analysis

Total Deformation [ $\mu\text{m}$ ]  
[Scaled x50]

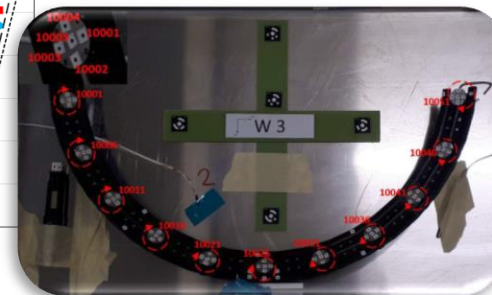
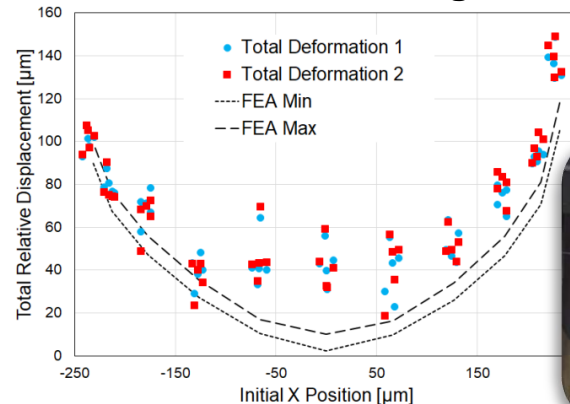


Good correlation with the experimental results!

## Longeron

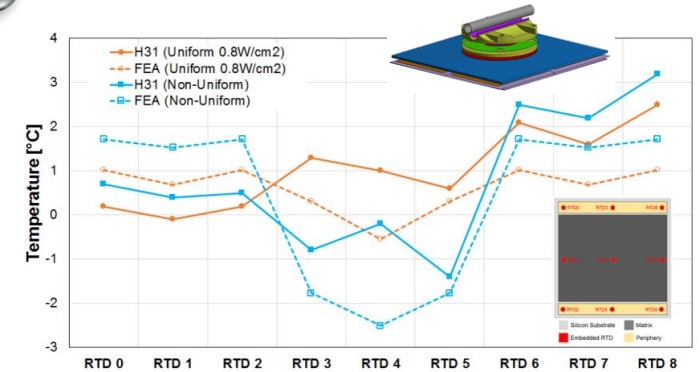
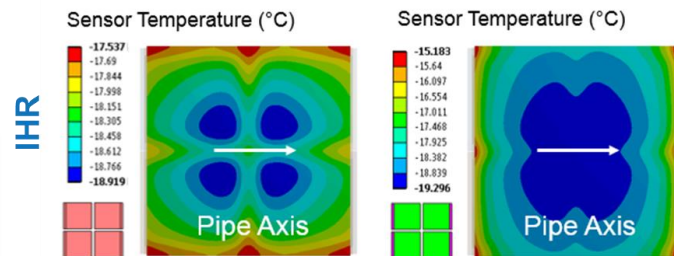
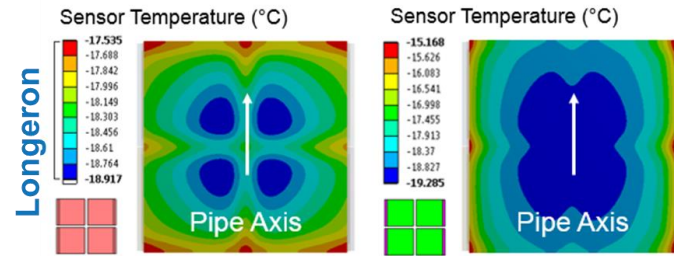


## Inclined Half Ring



## Thermo-electrical Analysis

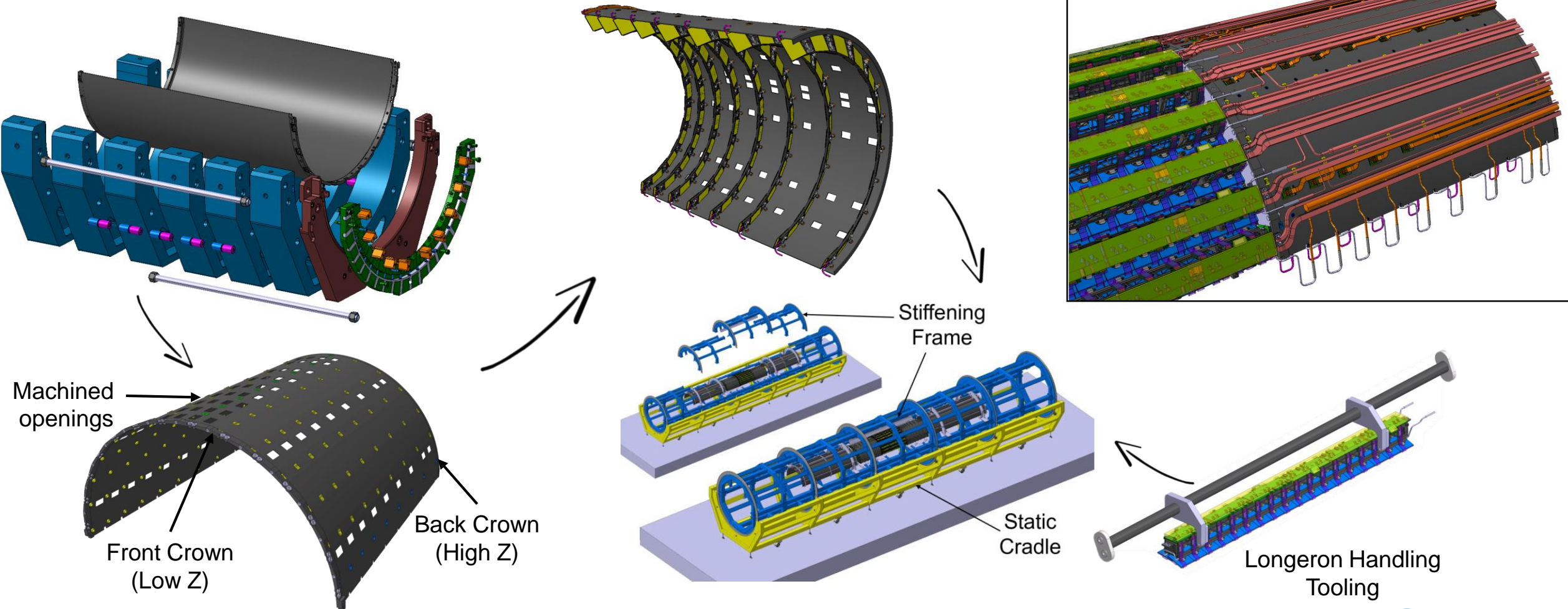
$T_{\text{CO}_2} = -35^\circ\text{C}$ ; 100% Type-0 Power;  $3.0 \cdot 10^{15} \cdot n_{\text{eq}}/\text{cm}^2$





# OB Global Mechanics: Design

- PDR successfully passed in December 2020 – EDMS 2438127;
- Currently in the detailed design and qualification phase:
  - FDR in the end of 2022.

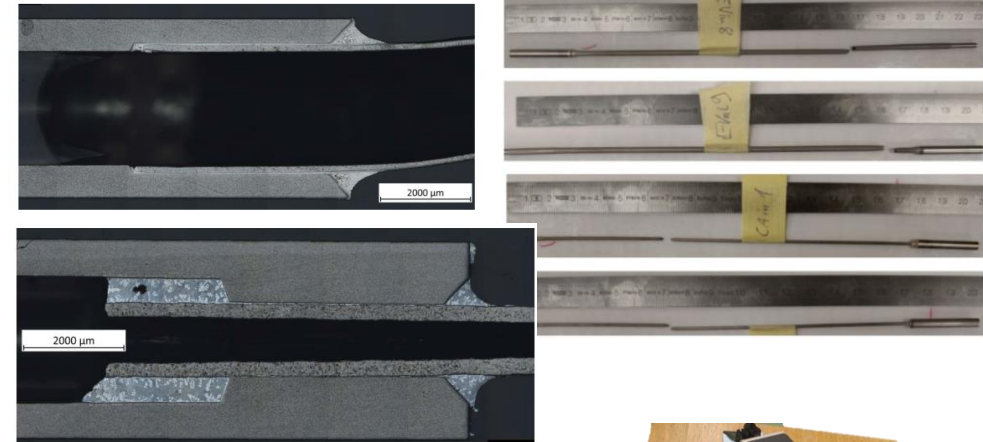




# OB Global Mechanics: Prototype and Testing

- Production of full size prototypes, testing samples and mock-ups for complete design qualification:
  - Shells prototypes;
  - Thermo-fluid prototypes;
  - Brazing and weld testing;
  - Services mock-ups.

Brazed Samples Tests



*With the collaboration of the EN department*

Services Mock-up



Thermo-fluidic Prototypes



IUL4 Thermo-fluidic prototype

Seven-longeron Thermo-fluidic prototype



Shells Prototypes

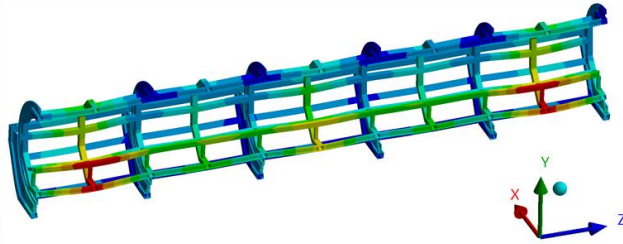
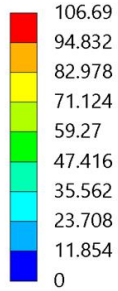


# OB Global Mechanics: FEA

- OB design:
  - Detailed analysis of the OB global model in the detector configuration;
  - Studies of intermediate assembly stages and tooling;
  - Failure scenarios.

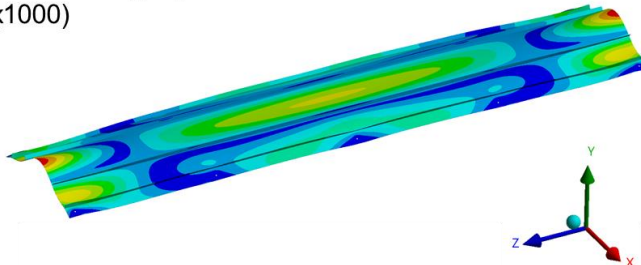
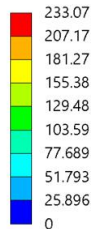
## Tooling Analysis

Total Deformation [ $\mu\text{m}$ ]  
(True Scale)



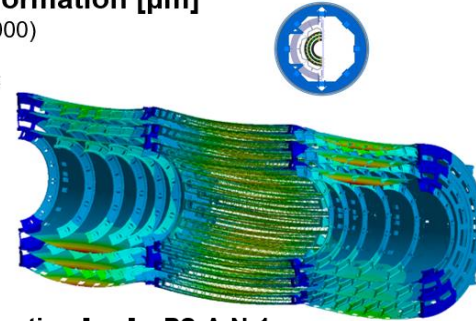
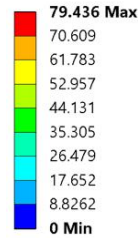
## Service Support Shells Analysis

Total Deformation [ $\mu\text{m}$ ]  
(Scale : x1000)

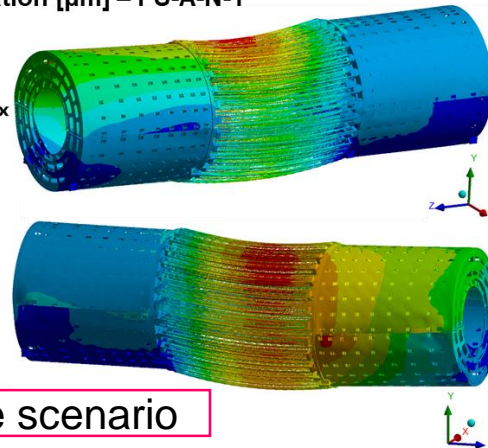
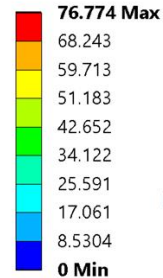


## Intermediate Assembly Stage

Total Deformation [ $\mu\text{m}$ ]  
(Scaling x1000)



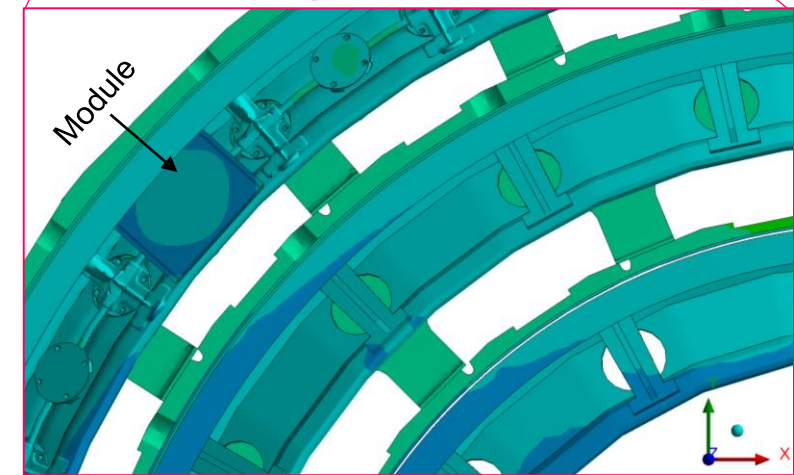
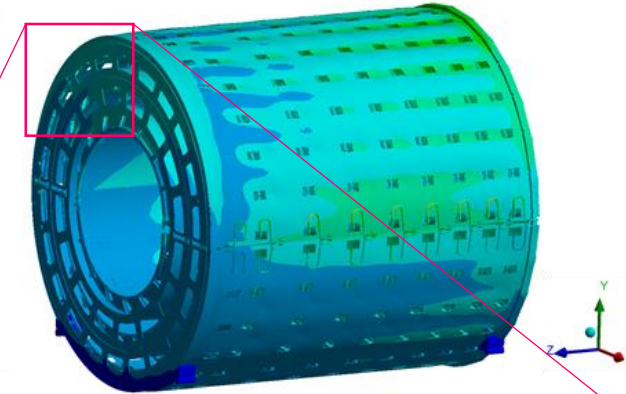
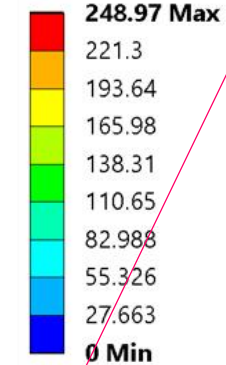
Total Deformation [ $\mu\text{m}$ ] – PS-A-N-1  
(Scaling x1000)



## Failure scenario

## Detailed IU – Thermo-mechanical Analysis

Total Deformation [ $\mu\text{m}$ ]  
(Scaling x100)

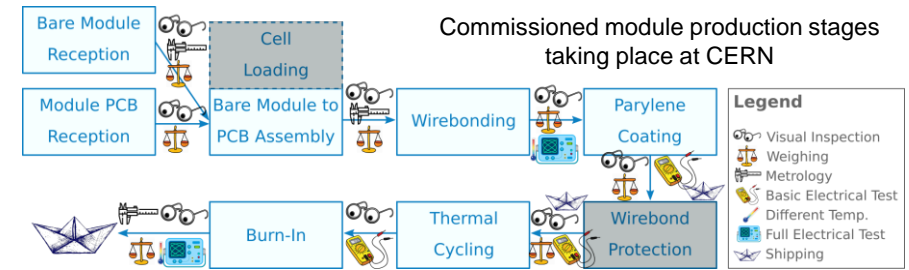


Detailed L4 Rings  
(CFRP ring, gussets, cooling tube and modules at some positions)

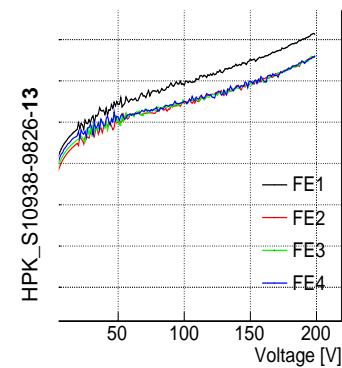
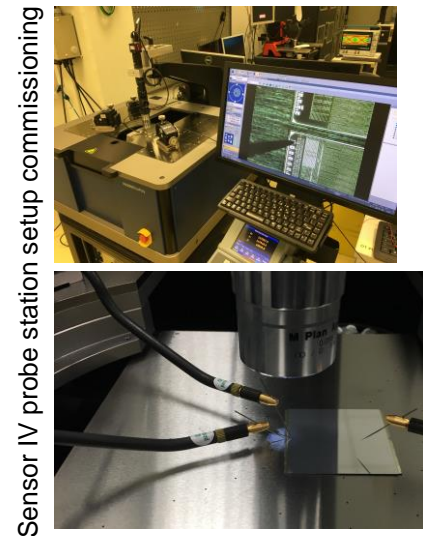
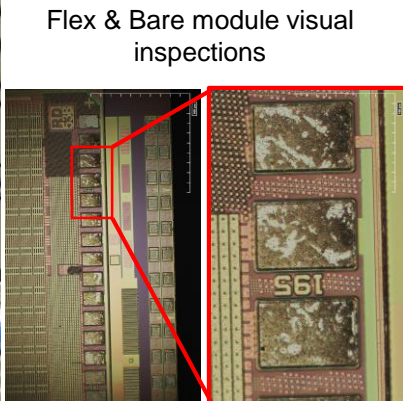
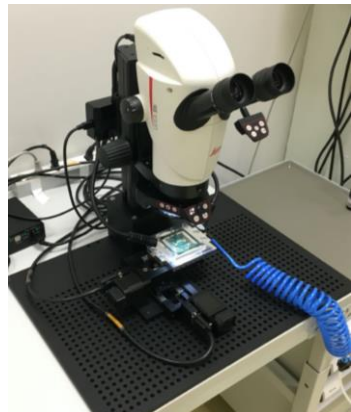
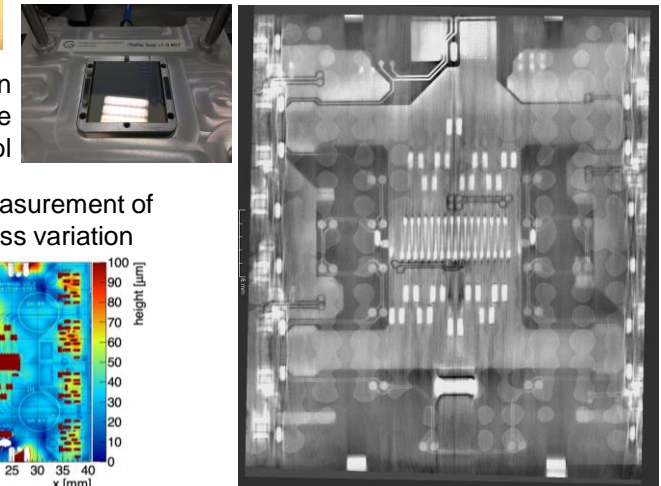


# Modules – Key Developments in Module Production

- Building module assembly production line:
  - All equipment installed & successfully commissioned: custom designed jigs, metrology instrumentation, visual inspection, test systems, etc.;
  - Closely working with the wire-bonding lab for the bonding.
- Total number of real assemblies built in 2021: **22**
  - 3/3 Thick RD53A Quad modules;
  - 7/7 Thin RD53A Quad modules;
  - 8 Thick RD53A Quad modules (for SP chain tests);
  - 4 ITkPixV1.0 modules.

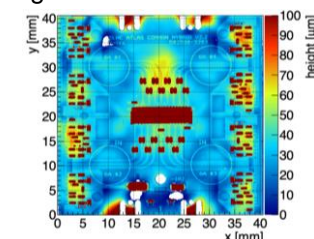


During production CERN will assemble up to 1200 quad modules for the outer barrel layer.



Introduction of shims for glue thickness control

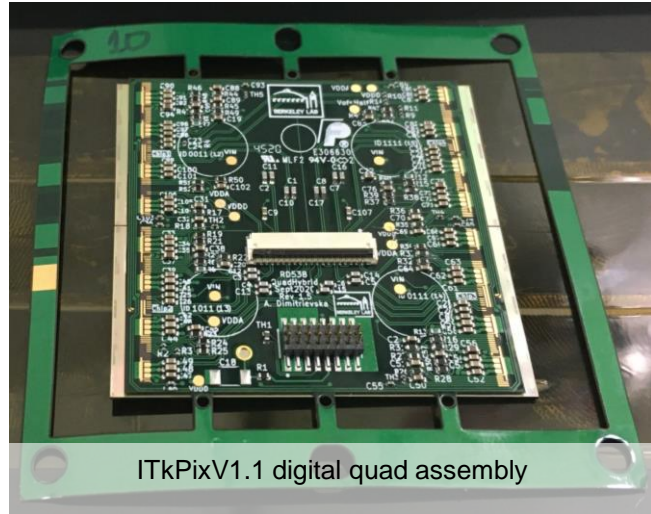
Metrology measurement of glue thickness variation



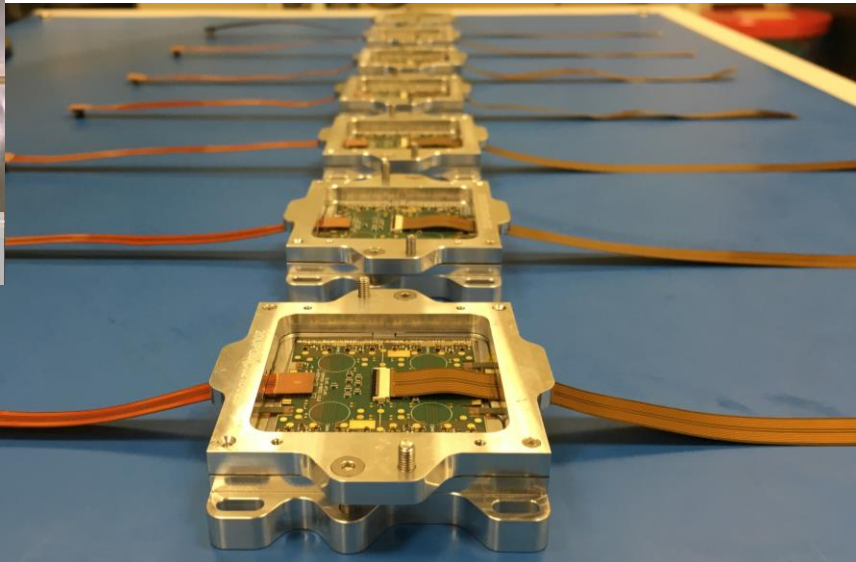


# Modules– Key Developments in Module Production (continued)

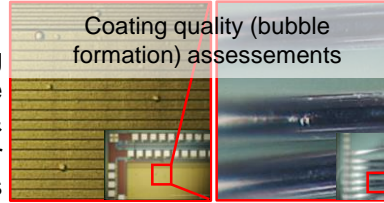
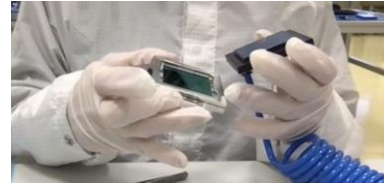
- Preparing for final assembly tooling;
- Evaluation tests planned for early 2022;
- Quad prototype assemblies with ITkPixV1.1 FE will be made in early 2022 to qualify production flow;
- Pre-production to start in spring 2022.



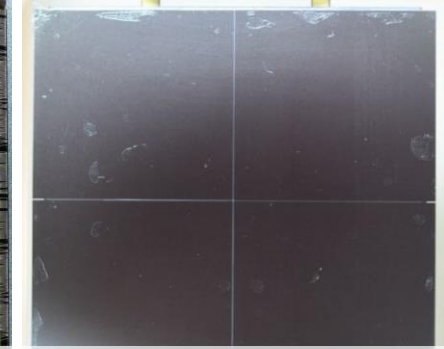
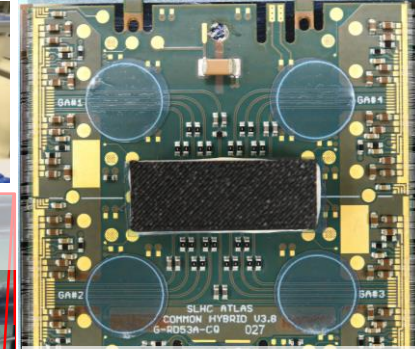
ITkPixV1.1 digital quad assembly



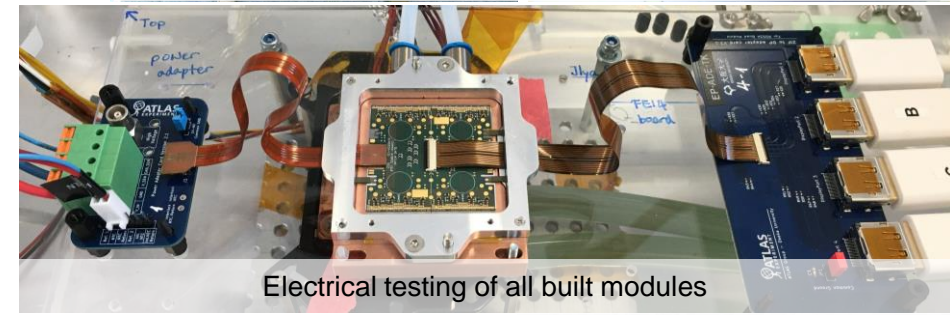
7 assembled quad RD53A modules



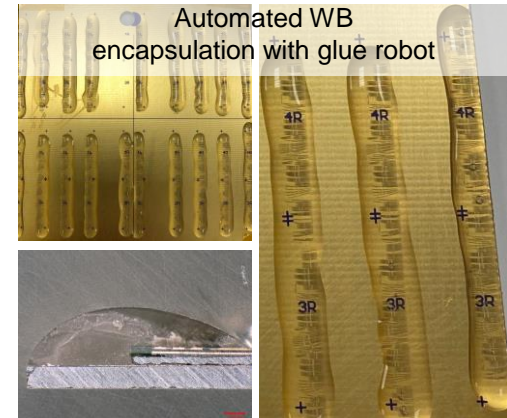
Parylene masking procedure developments & external vendor qualifications



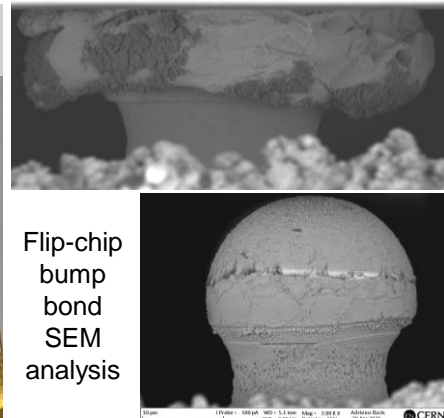
Masking of top & bottom surfaces



Electrical testing of all built modules



Automated WB encapsulation with glue robot

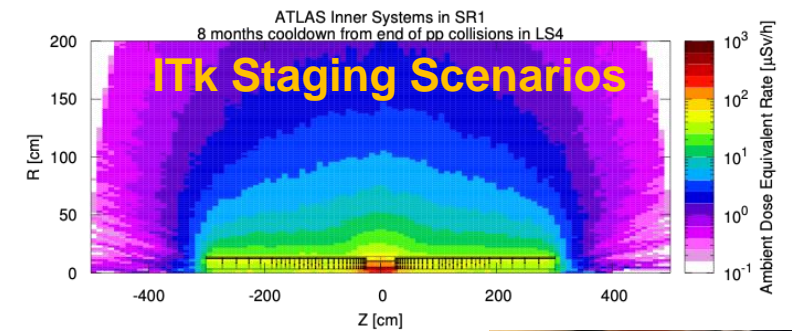


Flip-chip bump bond SEM analysis



# Radiation Protection and Material Safety

- ITk Radiation Protection & Irradiation:
  - Decommissioning Coordination for ID;
  - VR Intervention planning with motion capture;
  - Evaluation of various ITk staging scenarios for feasibility in respect of radiation dose limits at CERN;
  - Dose calculations for upcoming interventions (IS exchange);
  - Support for sample irradiation.
- ITk Material Safety - Support for ATLAS TC Safety team:
  - Justification for using non-compliant material;
  - Fire risk assessment for the different phases (construction, integration SR1, installation in UX15, early commissioning);
  - Defining procedures and compensatory measurements in close contact with HSE;
  - Follow up of derogation requests with HSE.



# Team

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Abhishek Sharma (ADE)  
Krzysztof Sliwa  
Remus Vrancianu  
Julian Weick

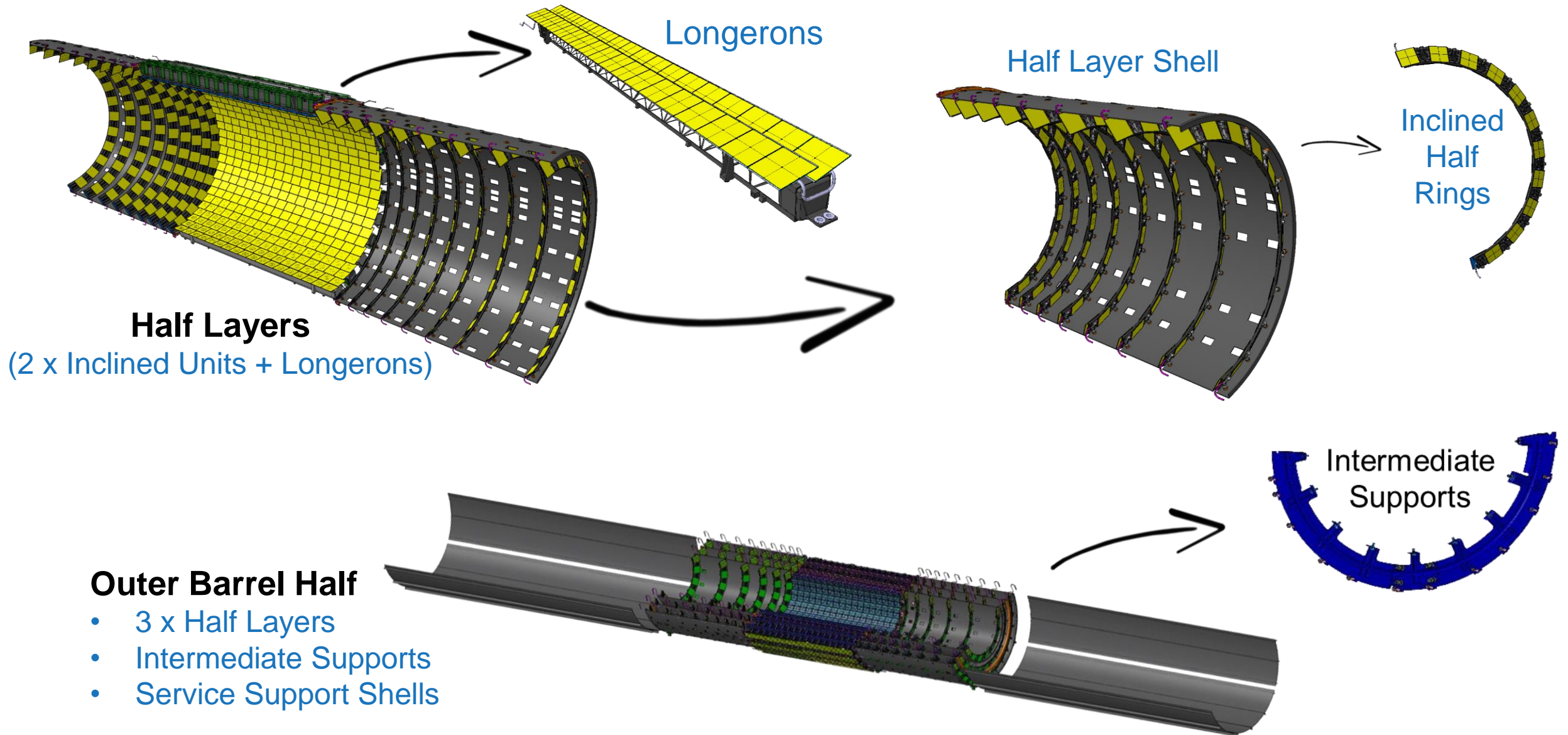


# Questions?

# Spare Slides

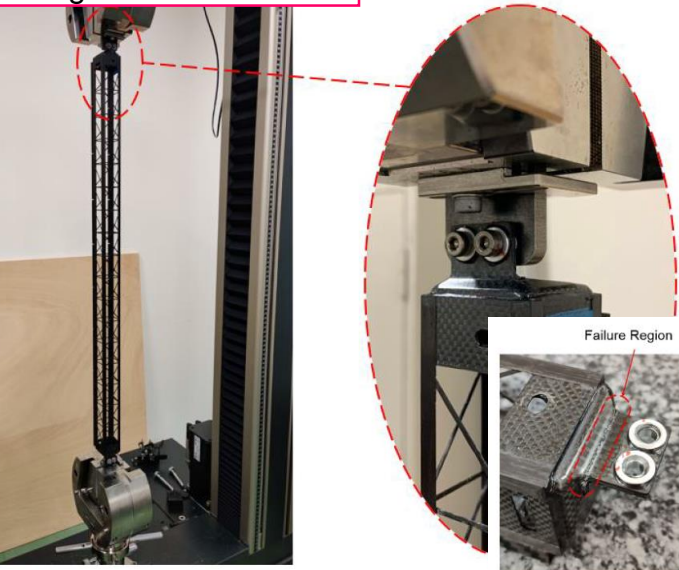


# ITk Pixel OB Overview

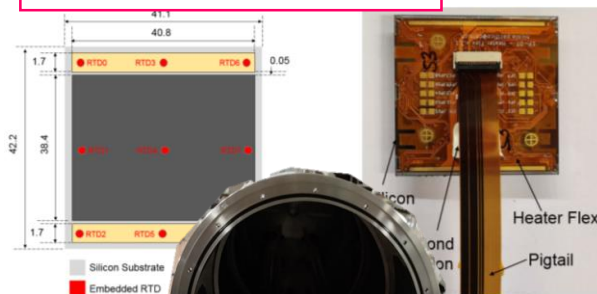


# OB Local Support: Prototyping and Testing (continued)

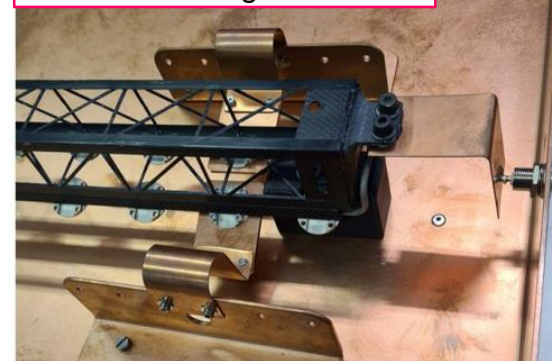
Longeron Traction Test



Thermal Tests



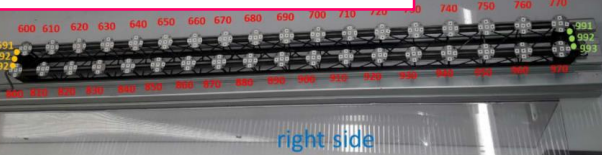
Grounding Tests



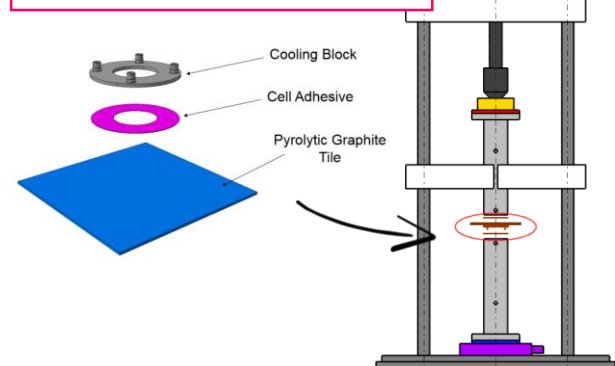
Glue Mechanical Tests



Thermo-mechanical Tests



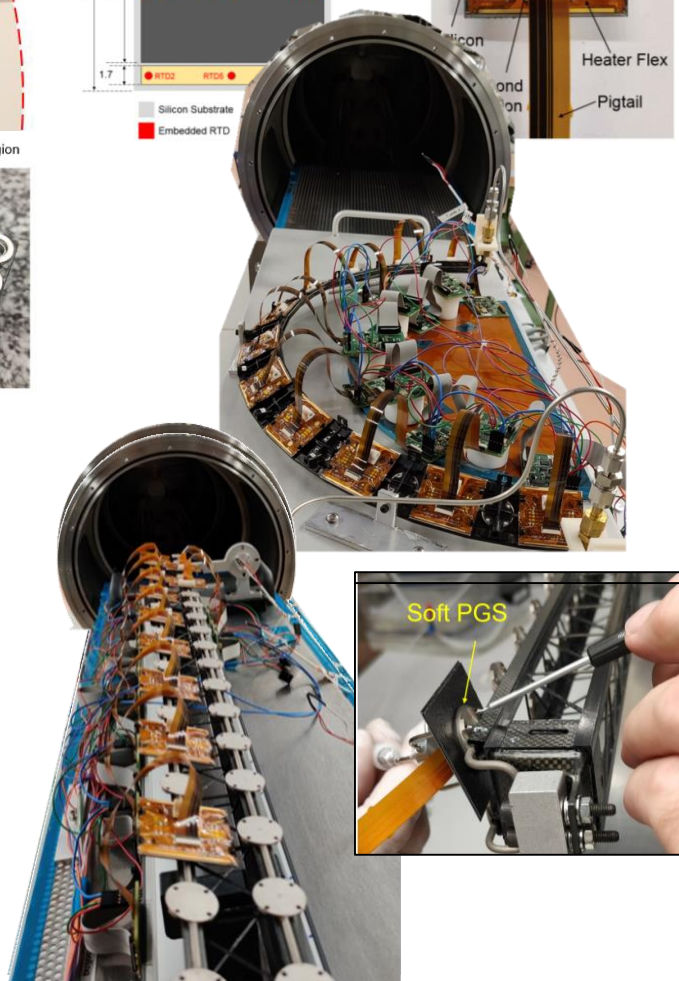
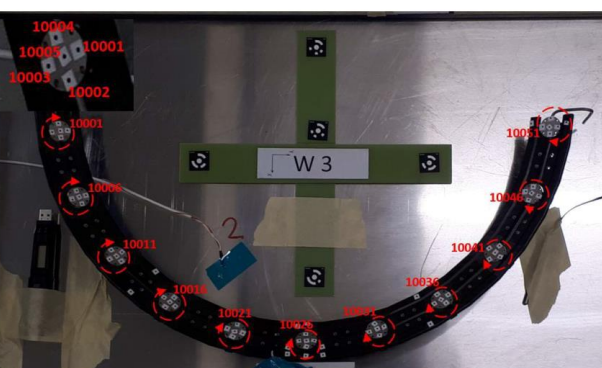
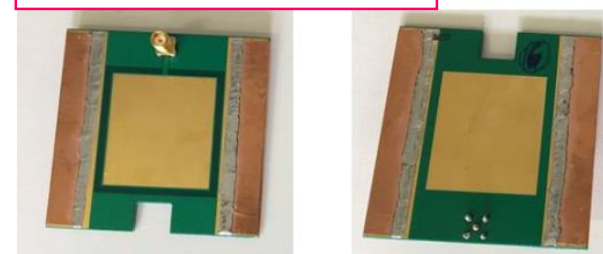
Bare Cell Thermal Test



Glue Thermal Tests



Glue Electrical Tests

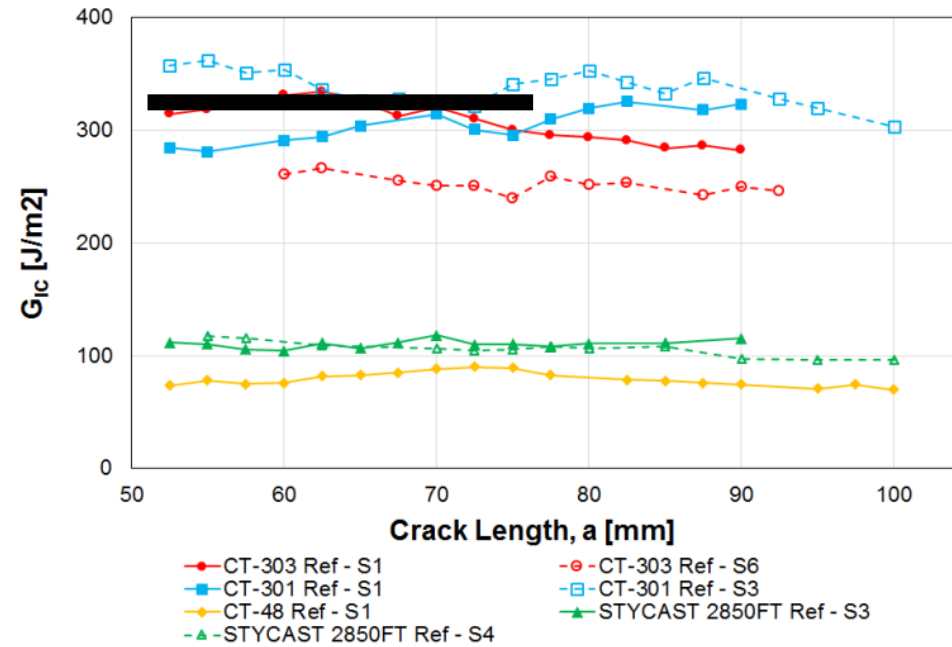




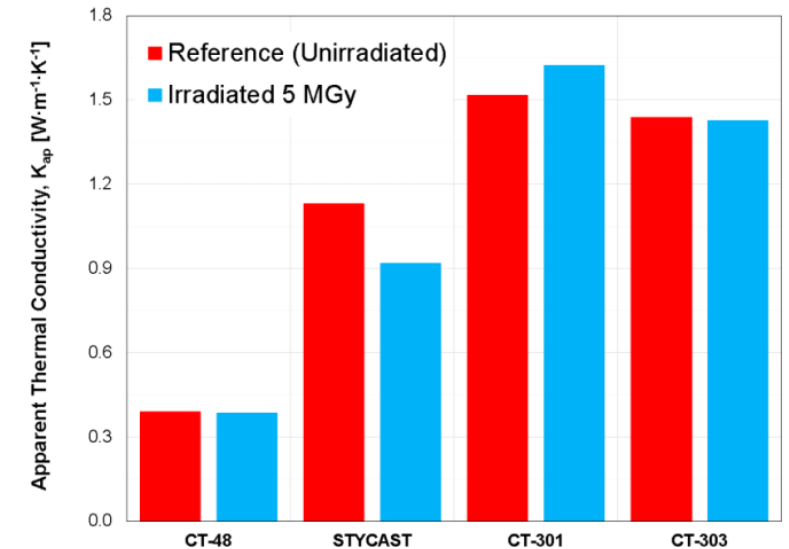
# OB Local Support: Prototyping and Testing (continued)

- Samples are also produced for material qualification (before and after irradiation-5MGy):
  - Thermal performance;
  - Mechanical performance.

## Glue Mechanical Tests



## Glue Thermal Tests

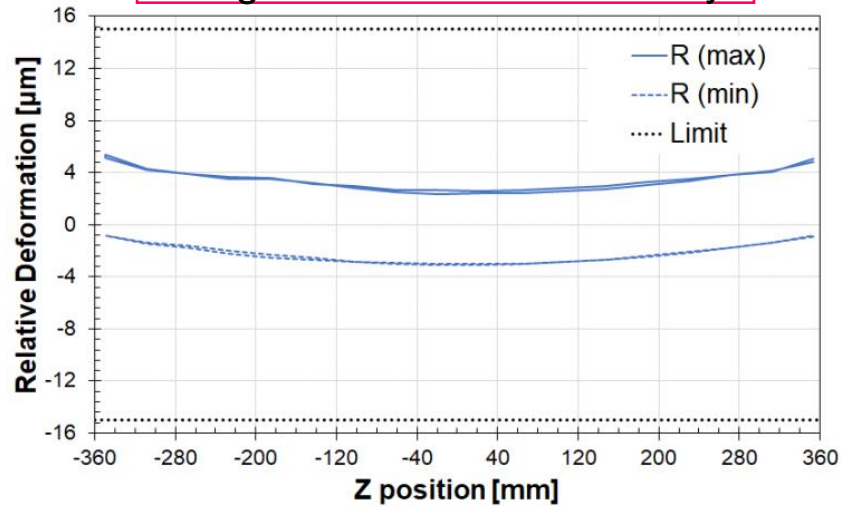




# OB Local Supports: FEA (continued)

	Time Scale	Load Cases
Short Term	1-2 days	$\Delta T_{CO_2} [\pm 1^\circ C]$ and $\Delta Power [\pm 10\%]$
Long Term	2-3 months	$\Delta T_{CO_2} [\pm 3^\circ C]$ and $\Delta M [+40\%]$

Longeron Short Term Stability



IHR Long Term Stability

