IB mechanics and FEA studies

Rosario Turrisi

Activities and people in Padova

In this talk:

Detector activities

- Mechanical support design
- Mechanical and thermal load simulation

R. Turrisi INFN - TL

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C. Pantouvakis	PhD st.
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M. Turcato	CAD d.

and contributions by:

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M. Tessaro	Techn.

Istituto Nazionale di Fisica Nucleare Sezione di Padova

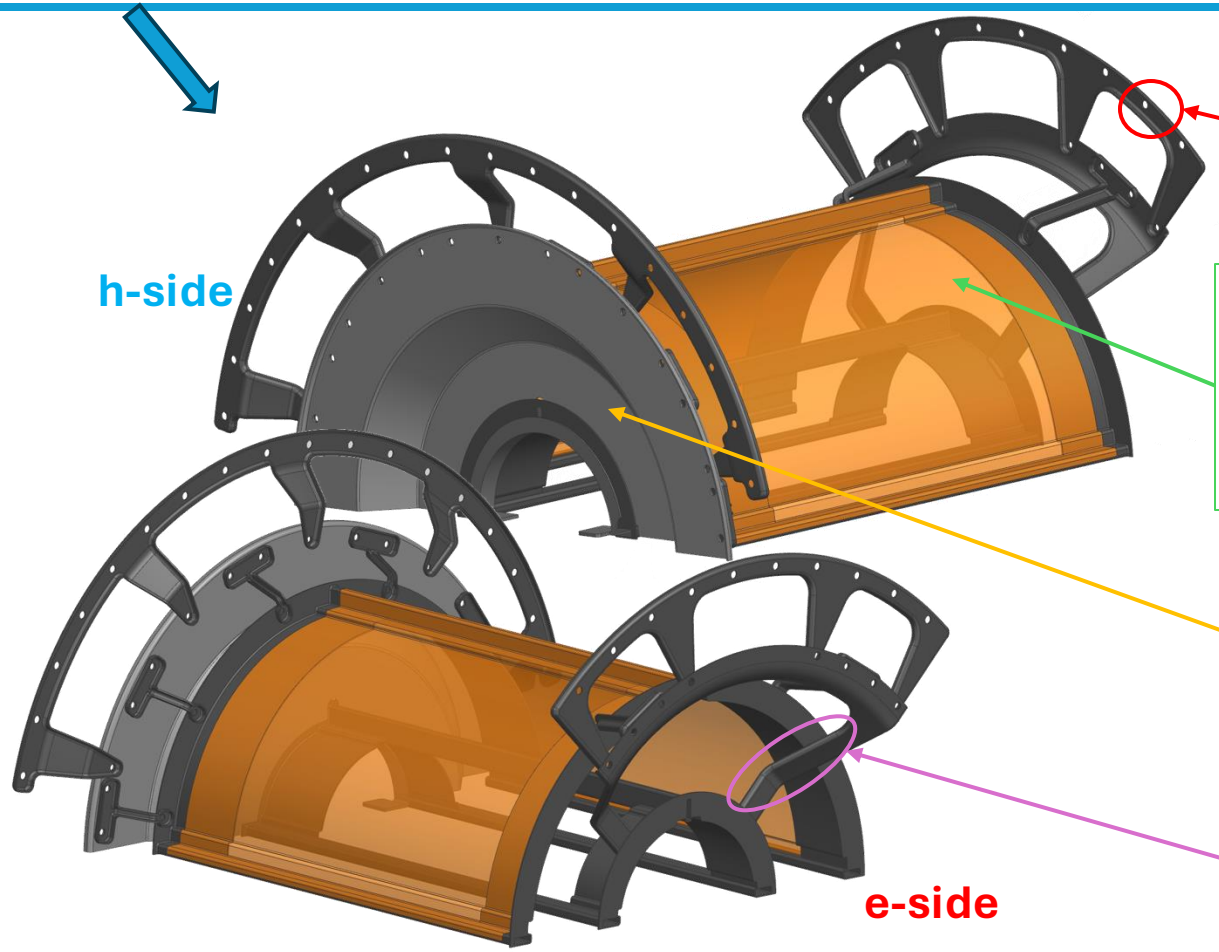
Dipartimento di Fisica e Astronomia “G Galilei”

Total FTE = **2.55** ‘’INFN’’
+ ~0.5 FTE targeted, time-limited contributions
+ Mech. WS. 0.2 FTE

ePIC-Padova **responsibility**: design & production of SVT – IB support

Short description contributed to pre-TDR, chapter 8.3.3.1

Current design – just the support (already different from pre-TDR!)



anchor points

(brownish orange surface) L2 screen, dual role:
- protection
- air flow guidance

full half-cone on h-side only to support FPC's+''cables''

bent arm, probably to be redesigned to improve stiffness

Disclaimer:
at this stage, L2 is icluded, without services, even if mechanics/assembly procedure not defined, for accurate design and integration.

Material:
- CFC

Production:
- single cooking (difficult), **or**
- separate parts cooking, then glueing

Working to define:
- number of fabric layers ? →
- thickness ?
- uni/bi-directional fabric ?

1. Mechanical support design
2. Mechanical and thermal load simulation

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Current design: cables and sensors included

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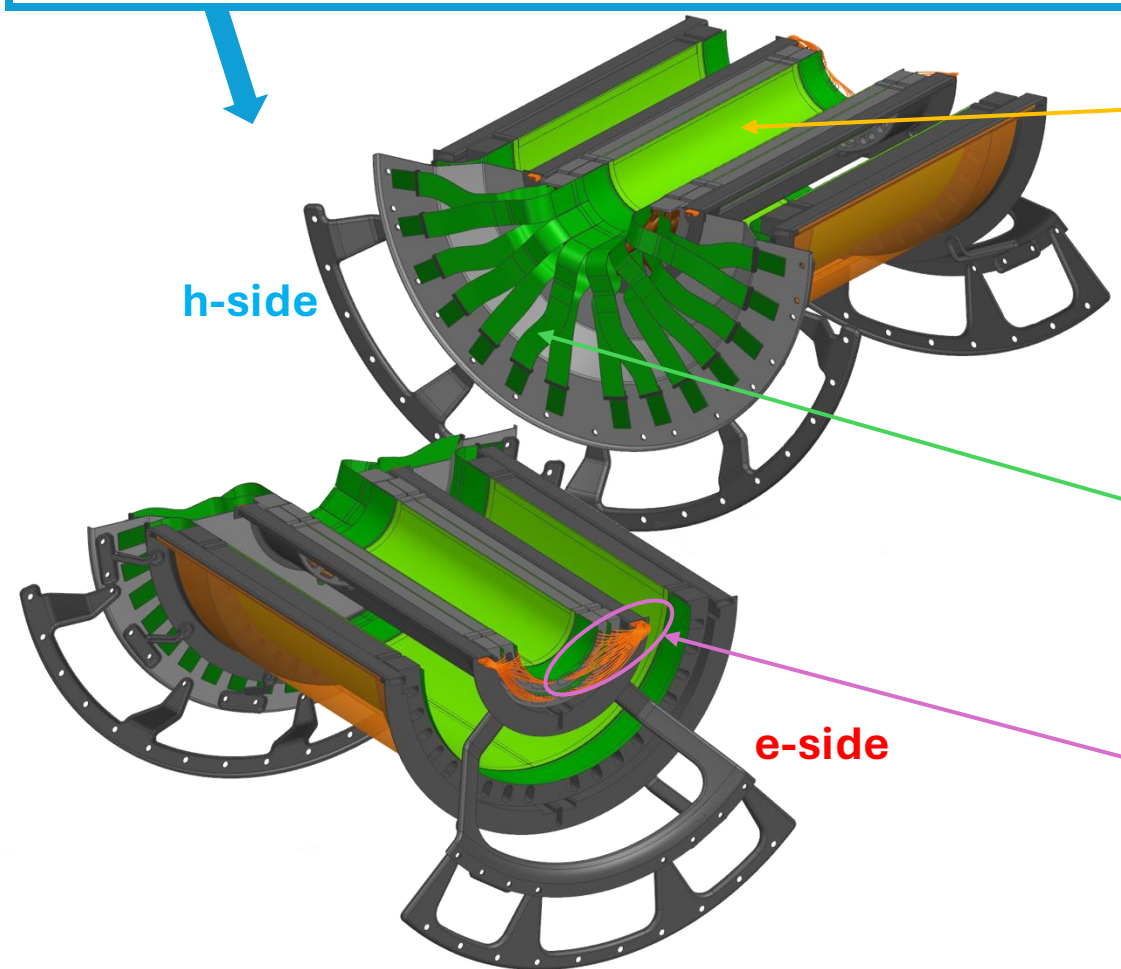
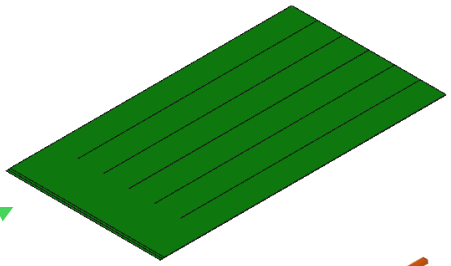
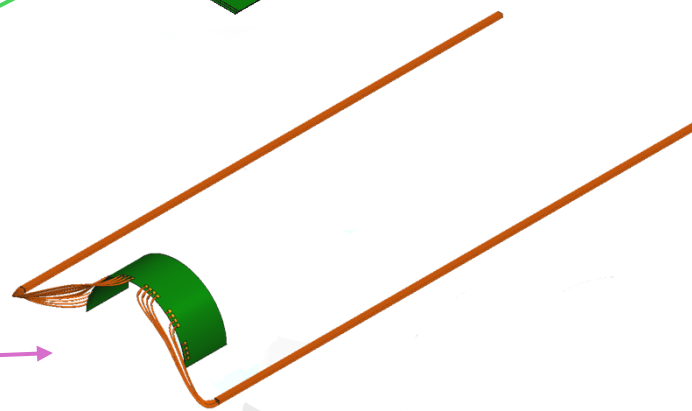


silicon sensors

FPC in the current ''guess'' derived from ITS3:
3 layers, 750 μm thick.
Note: pointing at a cable NOT STRAIGHT-CUT:
to be discussed if it is feasible, could ease assembly/integration



e-side power cables, here 1mm, under study (STFC-UKRI)

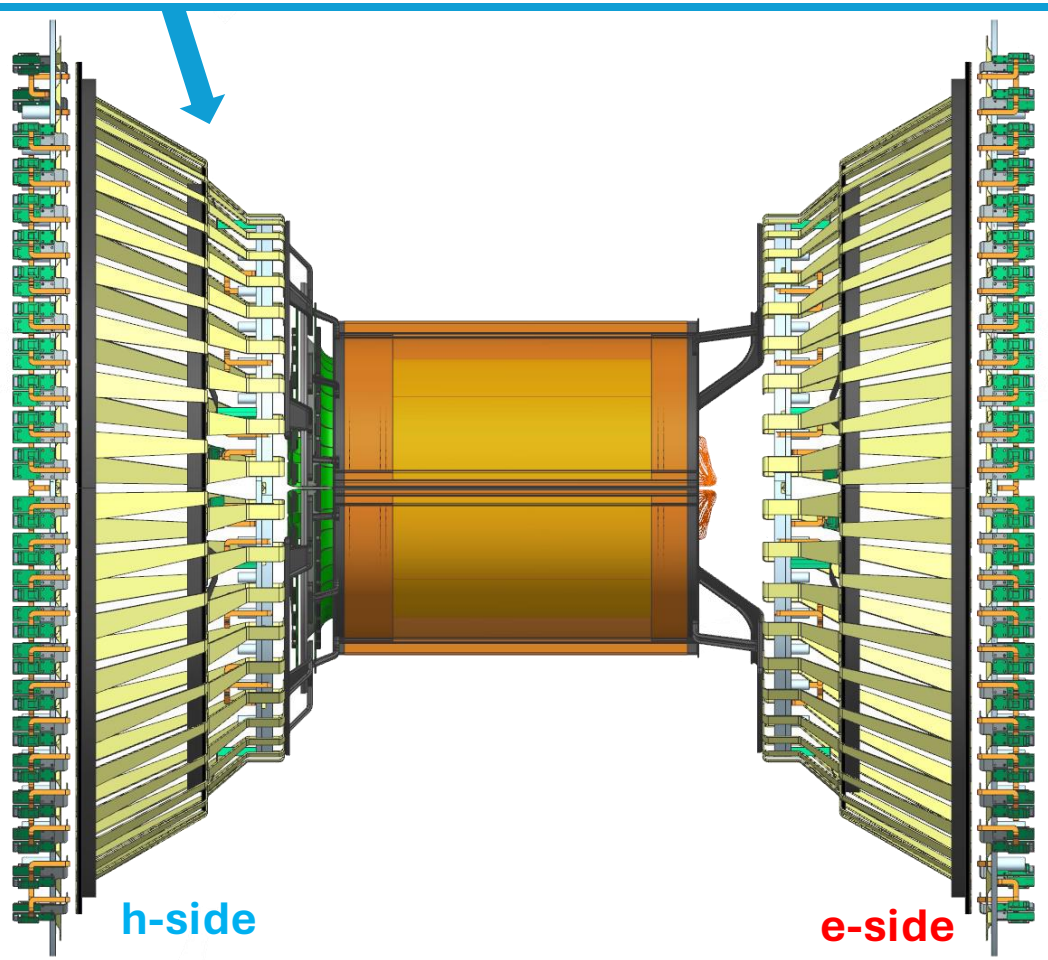


1. Mechanical support design
2. Mechanical and thermal load simulation

ePIC-Padova **responsibility**: design & production of SVT – IB support

Short description contributed to pre-TDR, chapter 8.3.3.1

Current design: integration in the general project



Disclaimer:
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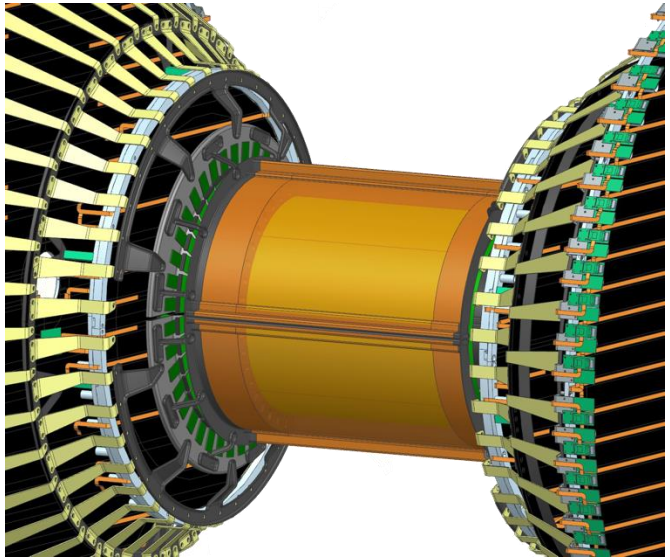
Last version of the design has been included in the ''general CAD'': no clashes
To be done: clarify correct routing of services, namely outgoing positions of cables/cooling pipes.



1. Mechanical support design
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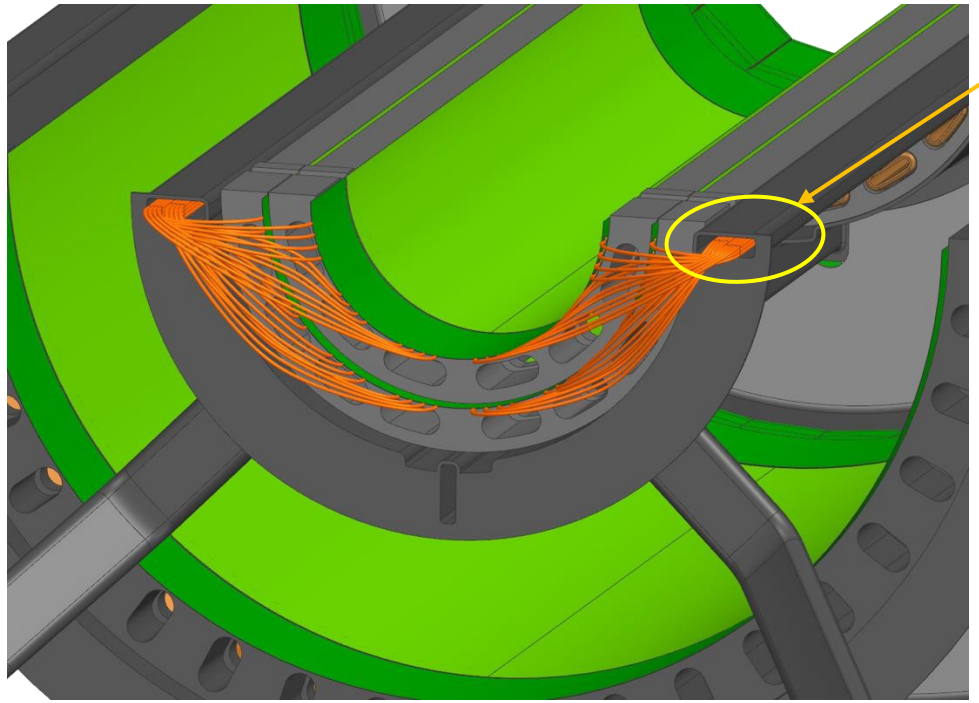
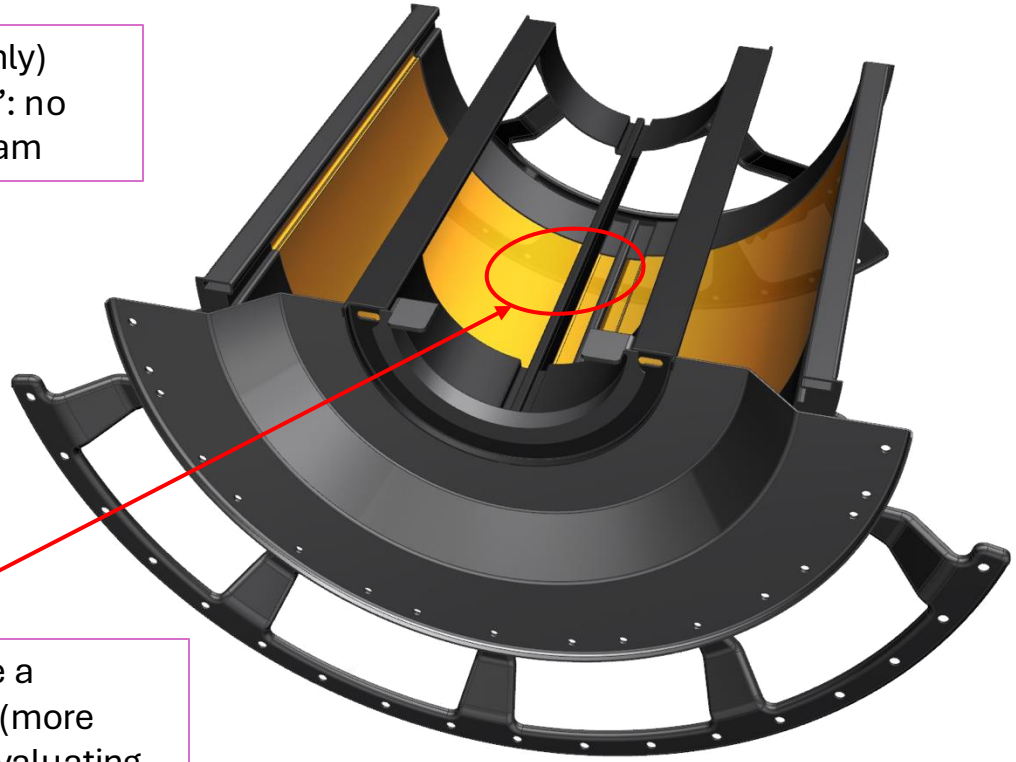


Now e-side cables (power only) running inside the side "ribs": no need to reworking carbon foam

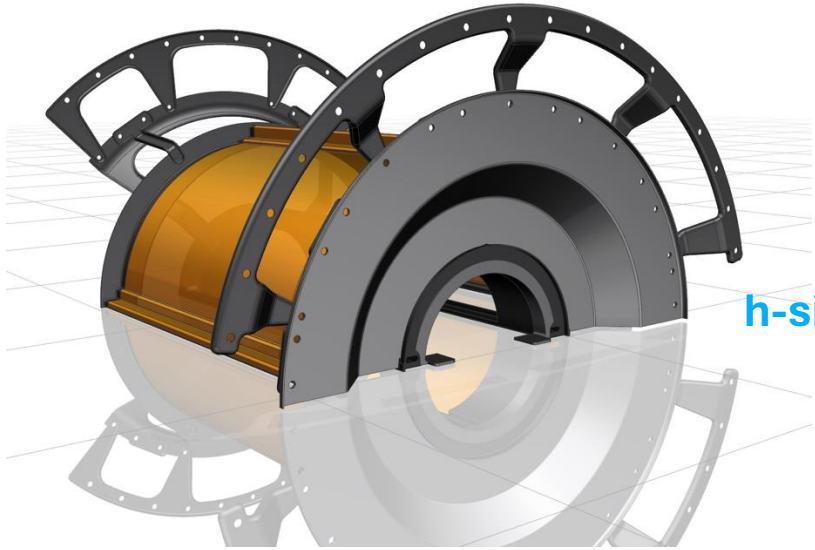


Central longheron could be a weakpoint of the structure (more sensitive to oscillations): evaluating alternatives to strengthen saving on the material budget

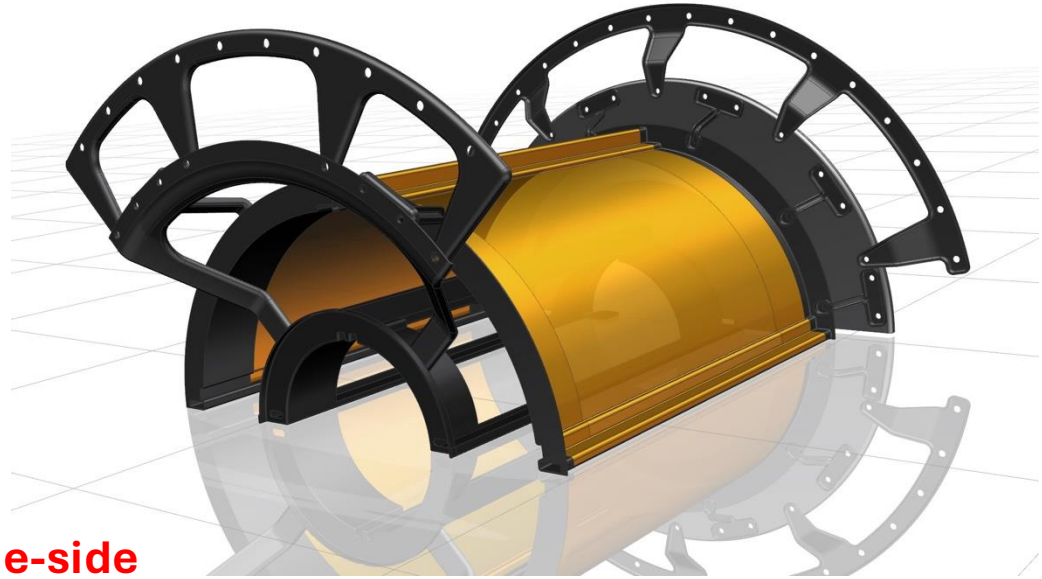
e-side

h-side

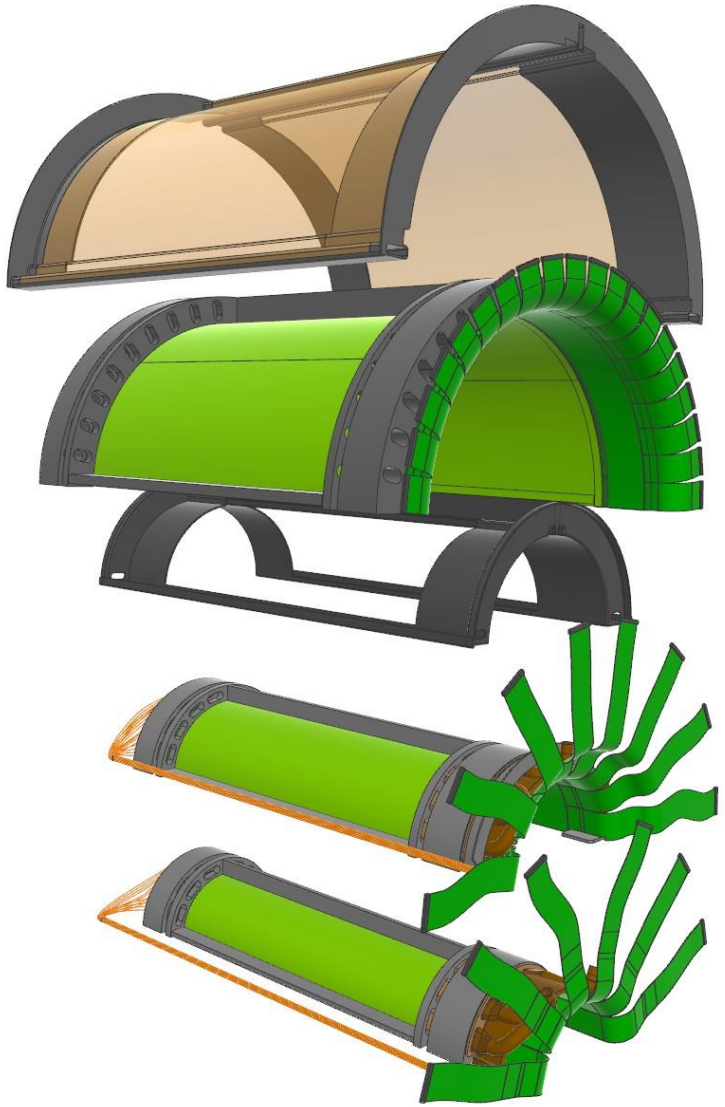
1. Mechanical support design
2. Mechanical and thermal load simulation



h-side

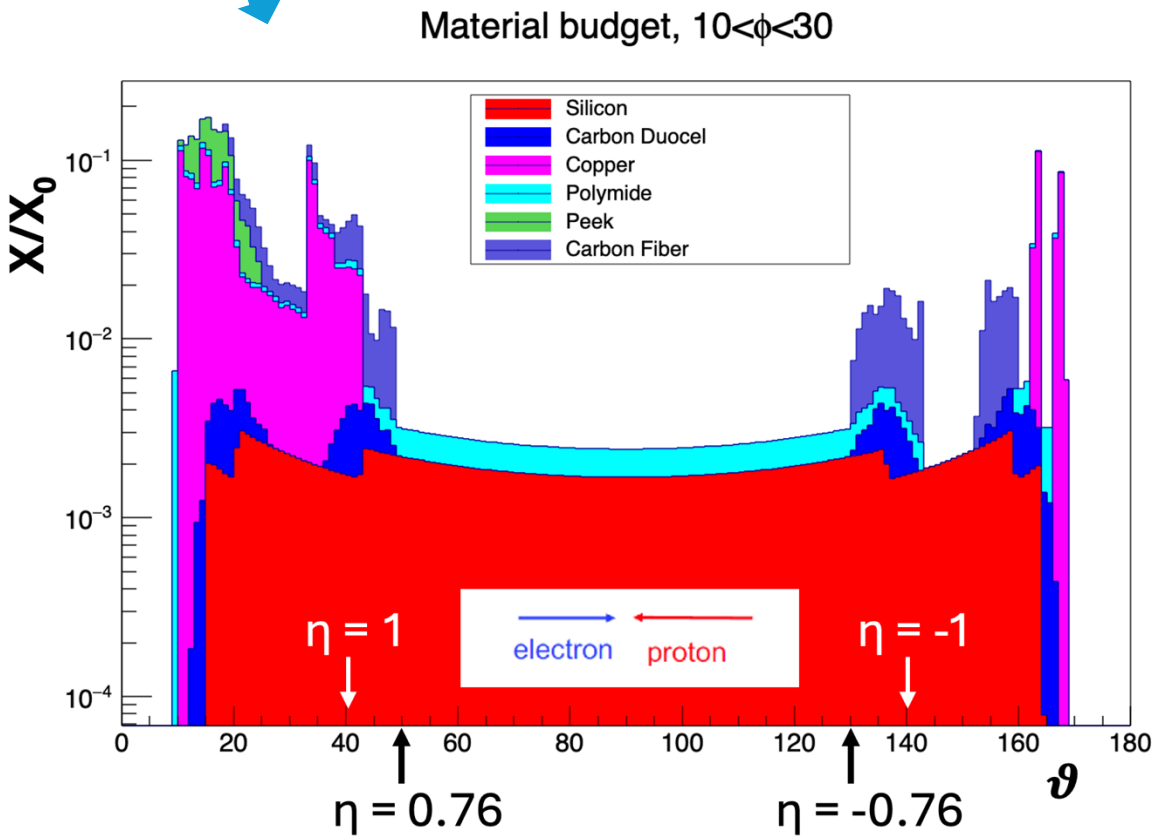


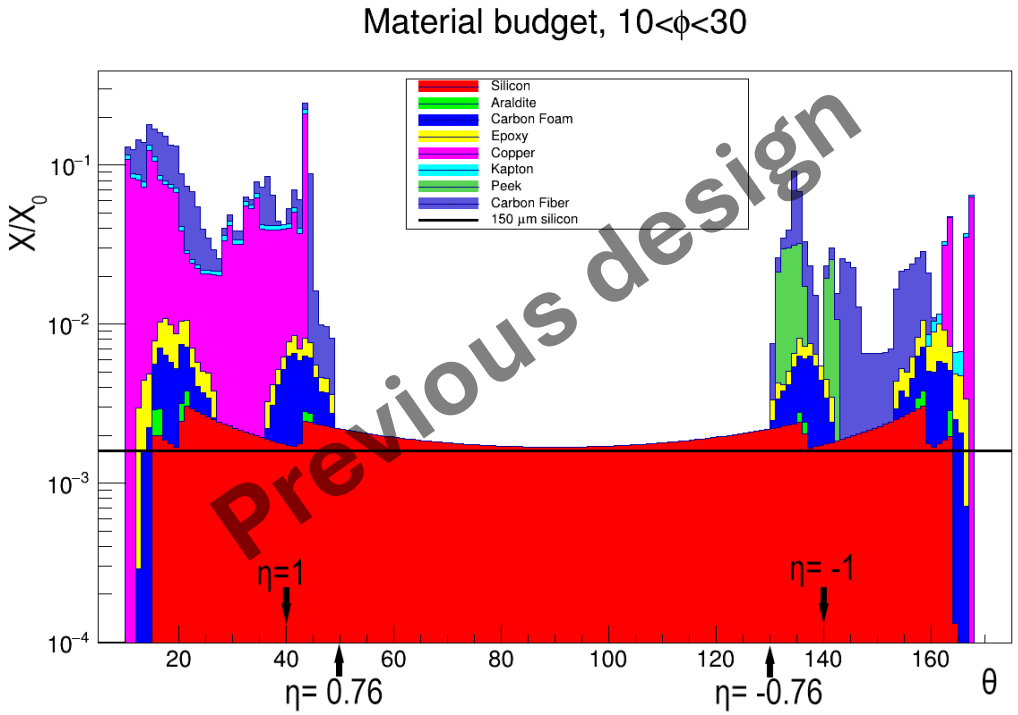
e-side



h-side

Material budget evaluation





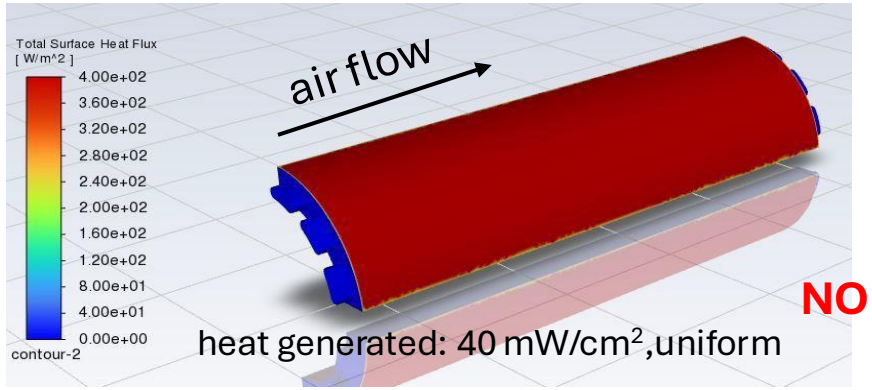
CAD project imported in GEANT4 (done via mesh: prone to volumes overlaps!), usual ''geantino" run.

- WIP: try MRADSIM* to translate geometry from CAD to GEANT4
- improvements from the previous version

* http://mradsim.com

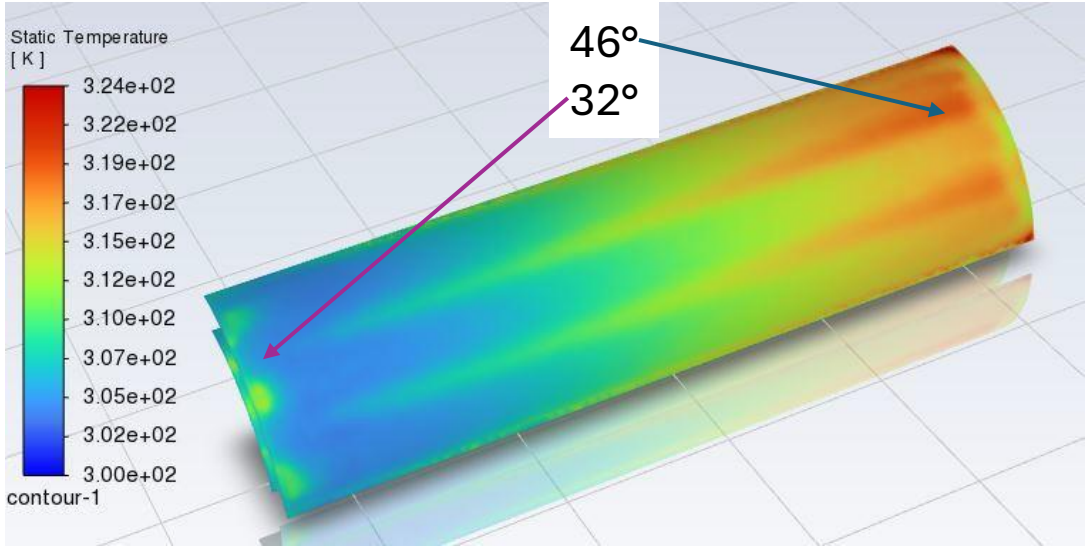
Ansys Fluent simulation

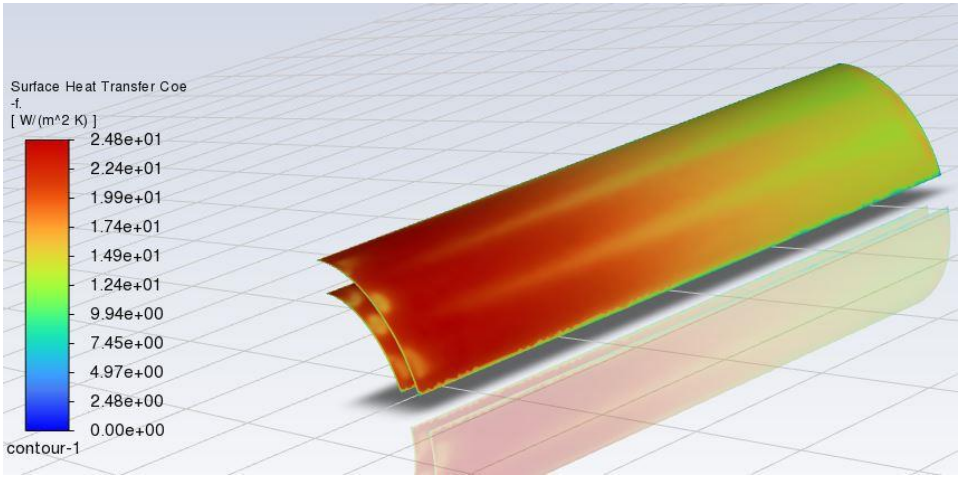
- Heavily dependent on mesh definition→ air speed lower than previous simulations when higher granularity is set (for the same heat transfer)
- Quarter-barrel simulation L0+L1
- Turbolence (critical for proper cooling) not easily set



NO LEC!

V_{IN}= 15 m/s = 54 kph





Heat exchange coefficient, spans ~ 1 order m.

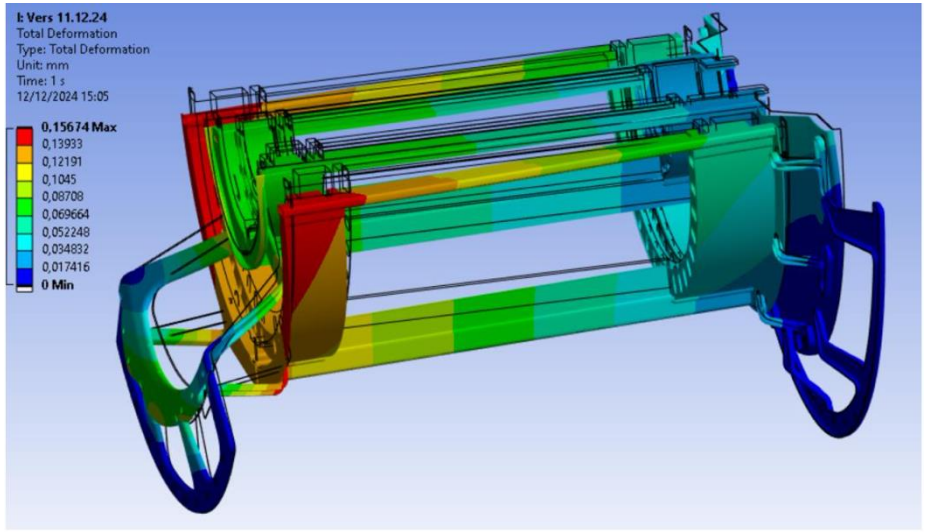
WORK IN PROGRESS!

1. Mechanical support design
2. Mechanical and thermal load simulation

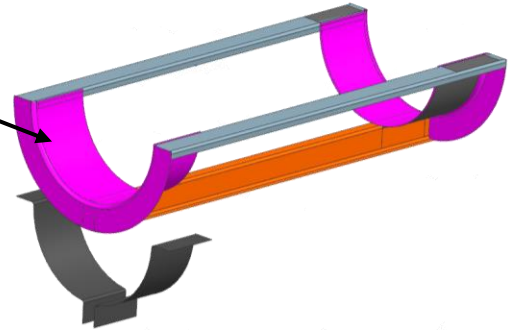
Deformation, last design
Load safety factor 1.5
L2 ''extrapolated'' by L0/L1
Load of single parts with safety factor 1.5:

- FPC 3.22 N (L0+L1+L2)
- air manifolds 1.53 N (L0+L1) 6.2 N (L2)
- copper cables 2.1 (L0+L1) 2.7 N (L2)

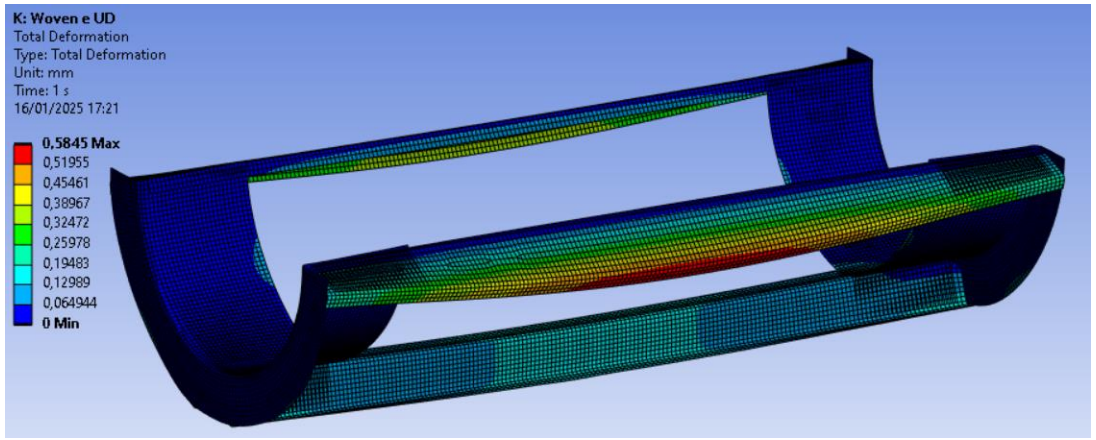
Peak deformation: the ''arms'' on the e-side, likely to be modified



What if... separate parts then glued? – same loads as on the left
First guess of the behavior with 200 µm unidirectional fabric, single layer but the ''pink'' half rings which have 2 layers



Deformation: 300 µm close to the sensors, 600 µm on the edge of longherons...
→ Good starting point towards effective production strategy and limited material budget



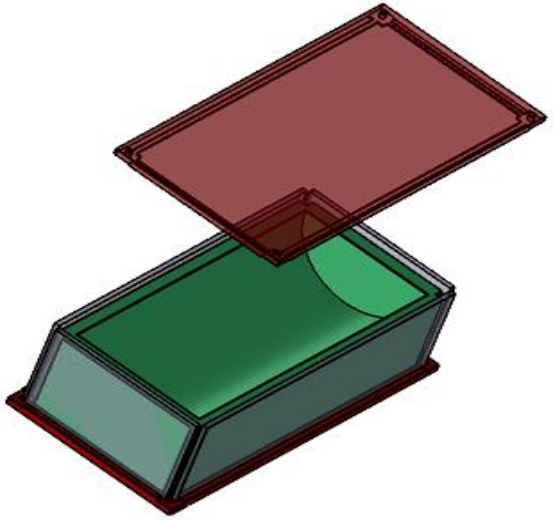
WORK IN PROGRESS!

First design of boxes

Necessary for safe handling/transportation of bent sensors of the SVT inner layers between different laboratories around the world

Design of boxes under development : aim at simplicity, robustness and durability

Keep it simple: a plexiglass container with polystyrene holder of the sensors



Outlook

(mostly for 2025)

Mechanical support design

- Development of production strategy in close collaboration with companies (2 available at the moment)
- First prototype of support in carbon composite (probably various ‘’flavors’’ of composite)
- Production of air manifolds 3D printed

Mechanical and thermal load simulation

- Refine Fluent simulations
- Mechanical load/modal simulations qualification via tests on prototype
- Dummy thermal load tests (assembled in Bari)


That's all Folks!
...and thanks for your attention!

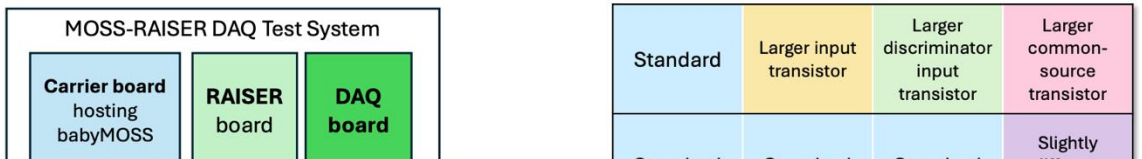
BACKUPS

1. Test and characterization
2. Mechanical support design
3. Mechanical and thermal load simulation
4. Production center

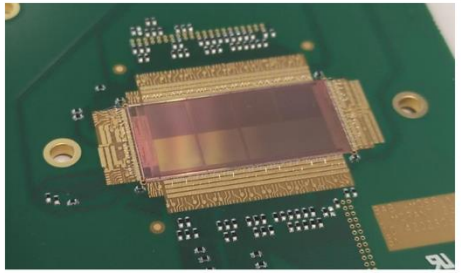
Activity in synergy with **ALICE/ITS3**

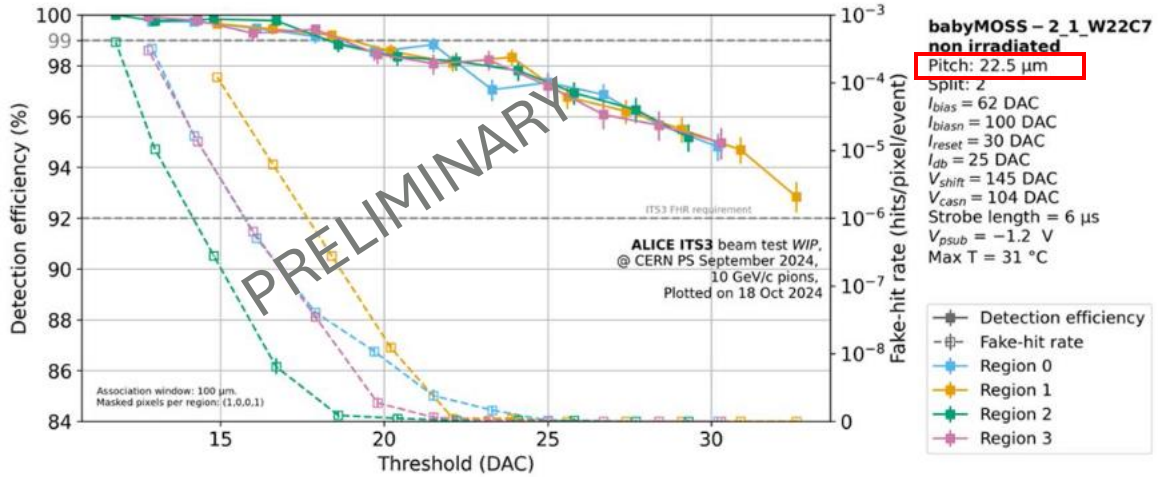
- ePIC is co-funding one PhD grant (C. Pantouvakis)

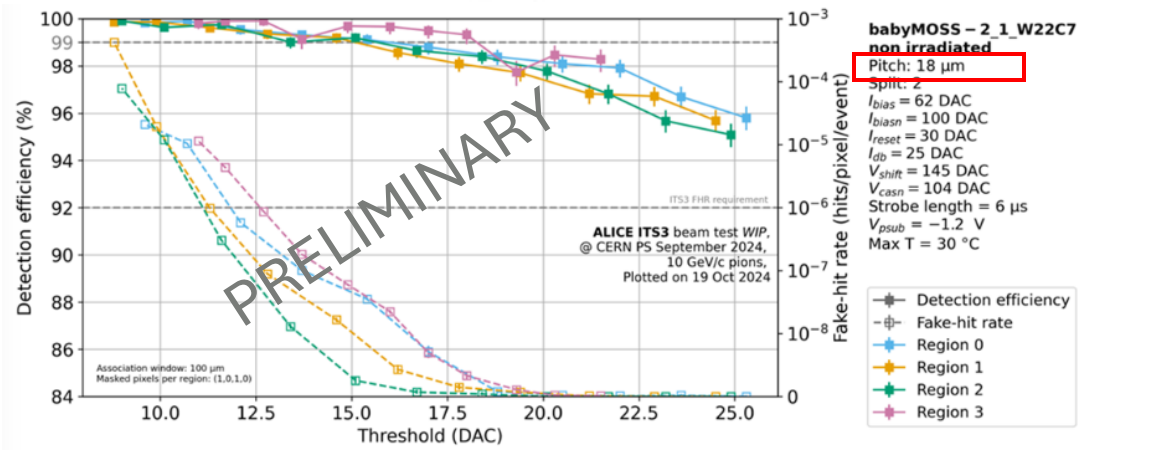
- APTS tests bent/flat sensors, w/-w/o irradiation (published)
- Baby moss tests: first results, analysis ongoing



Standard	Larger input transistor	Larger discriminator input transistor	Larger common-source transistor
Standard	Standard	Standard	Slightly different layout







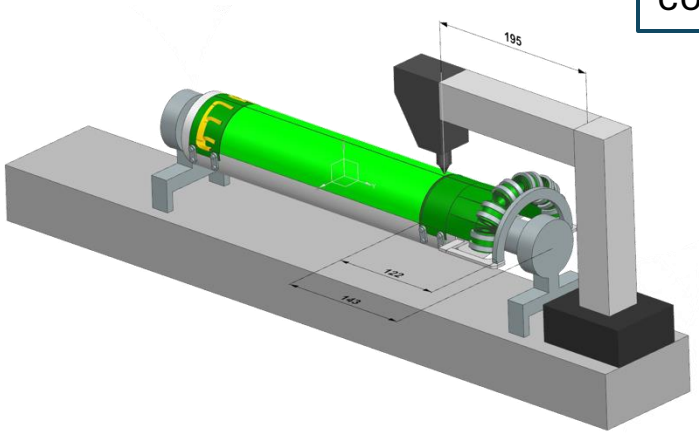
1. Mechanical support design
2. Mechanical and thermal load simulation
3. Production center

Goal: set up a barrel production center in Padova
- currently L0+L1 only are INFN responsibility
- Availability has been verified:
  - Clean room equipped with measuring machine
  - Technicians

Key element is the procurement of a wirebonder with two critical features:
- mechanical structure which can fit the mandrel with sensor+cables
- head movements xyzφ to perform wedge bonding both in x and y direction if needed
- automatic AND manual operation for maximum versatility

Under discussion the funding within INFN

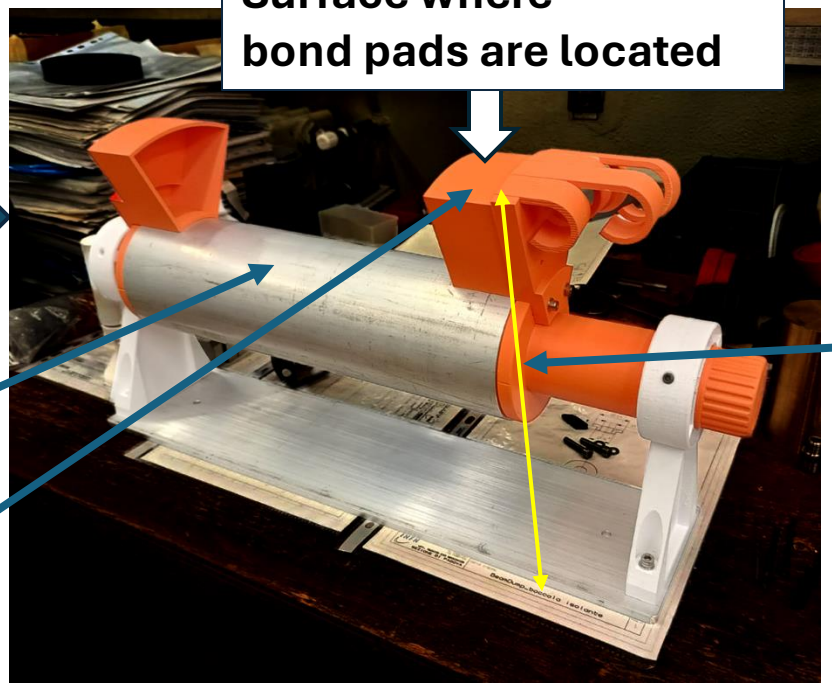
A candidate:
Bondtec 56XXi series



Mock-up of the mandrel + cables' supports to test the mechanical compatibility with the wirebonder

L1 radius

L2 radius + FPC supports



The team:

- two experimental physicists
- 4 months-person from the INFN-Pavia mechanical workshop
- 1 month-person from the INFN-Pavia electronic workshop

Activities:

1) design and construction of dedicated boxes for IB L0/L1 layers transport
2) thermal test of the sensors/support structure coupling with glue in a climatic chamber

Model : Genviro 030LC
Temperature range : from -70 °C to +90 °C
Humidity range : from 10% to 98 %
Dimensions : 330 mm x 280 mm x 330 mm

Thermal and humidity cycles will be performed in Pavia to test the bent sensors-support (‘’local’’) mechanics coupling