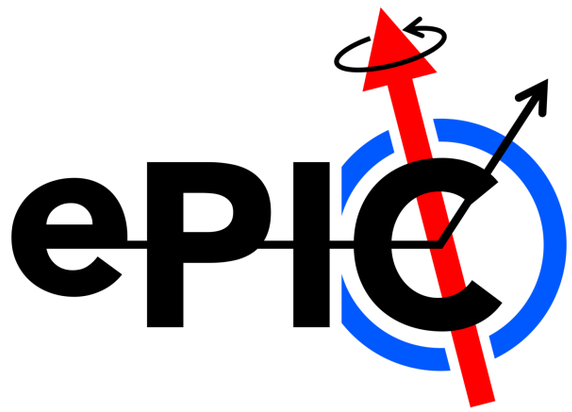


Bending and assembly of the L0 and L1 layers

Domenico Colella*
on behalf of the SVT-IB INFN team

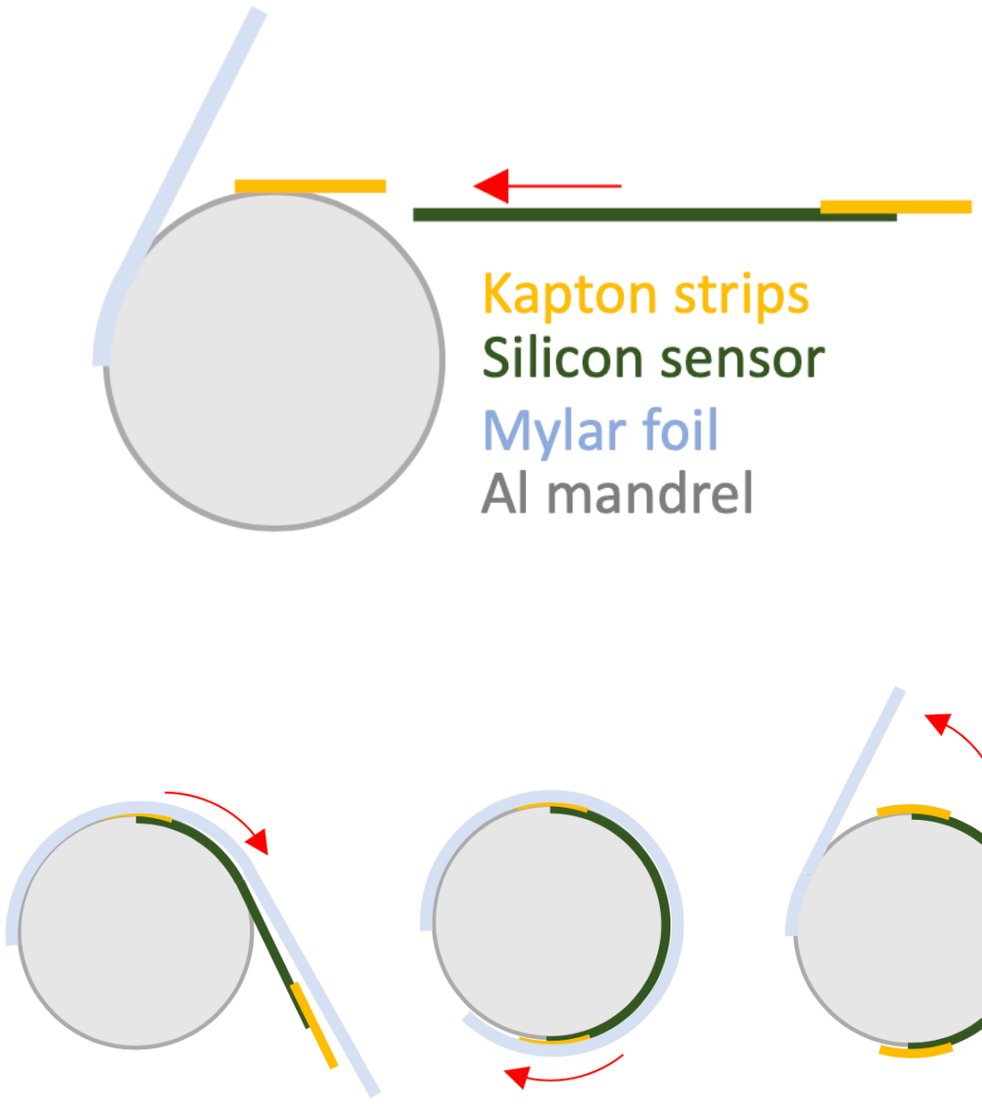
* INFN and University of Bari

Contents

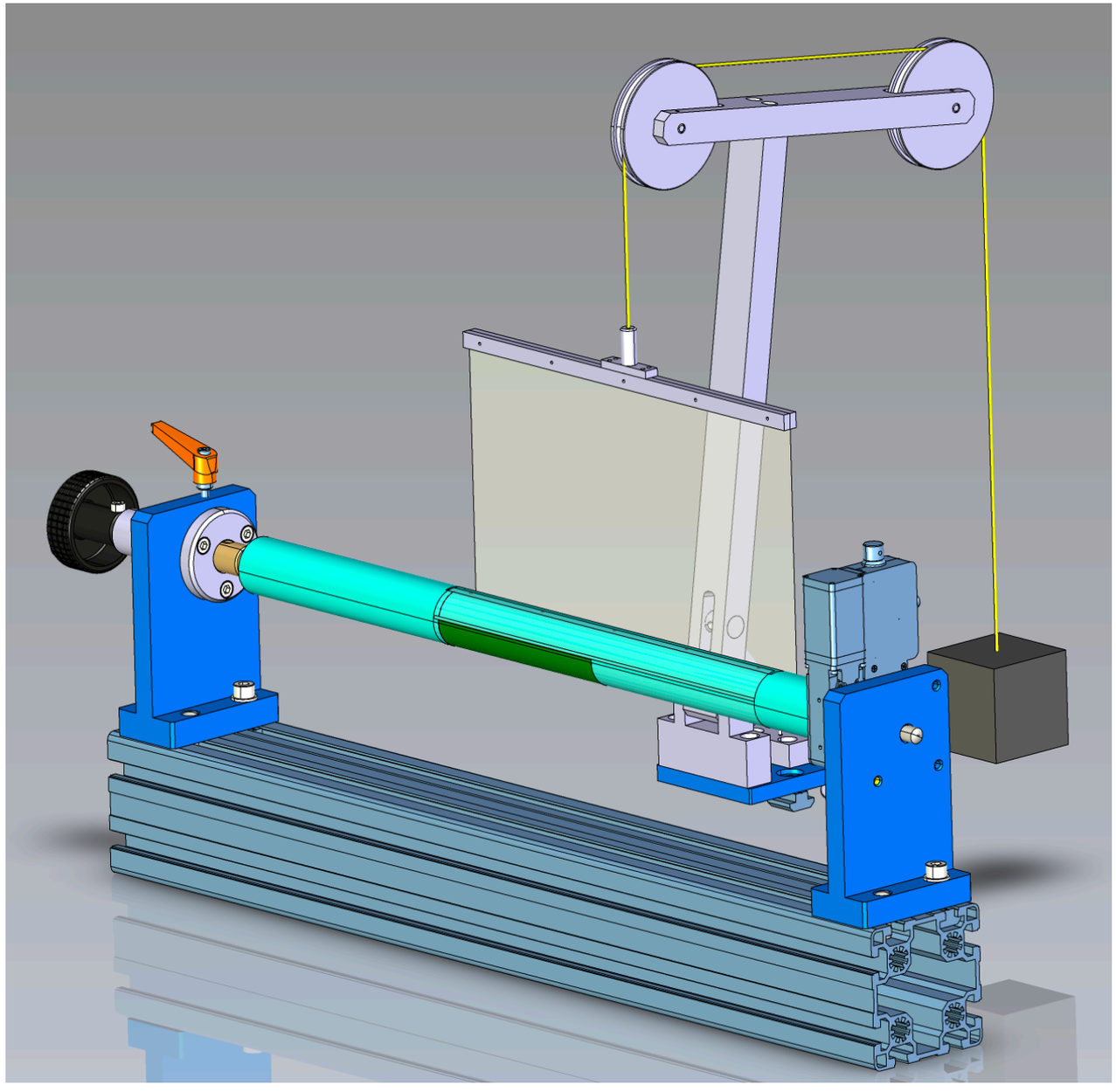
1. Silicon sensor bending technique
   - ITS3 approach
   - SVT alternative approaches and first tests
2. Local support structures
   - Support structures
   - Gluing tools
3. Prototyping campaign plan

1. Silicon sensor bending technique

Technique developed within the ITS3 R&D

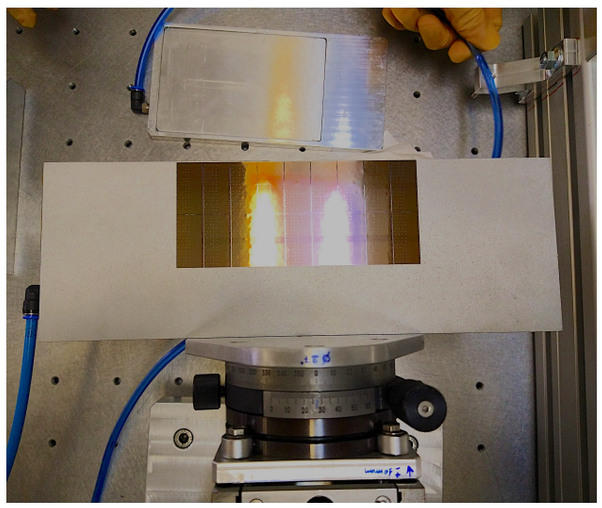


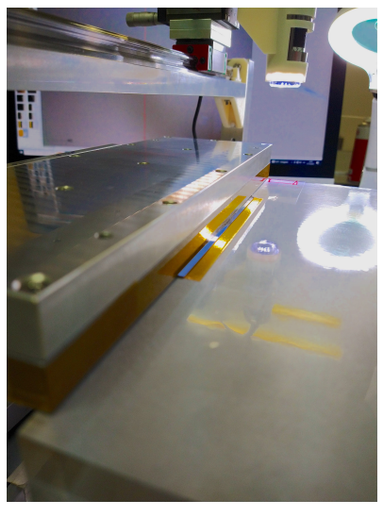
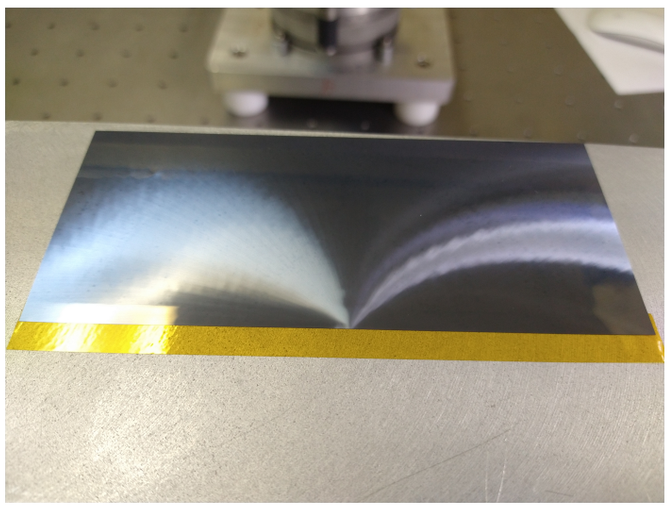
From ITS3 TDR (CERN-LHCC-2024-003)



1. Silicon sensor bending technique

1) Adhesive tape on the silicon sensor



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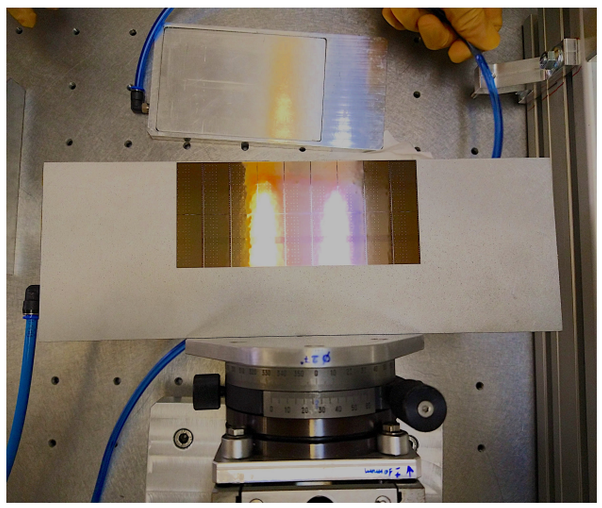
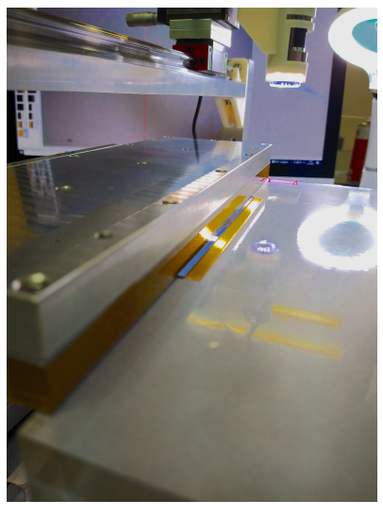
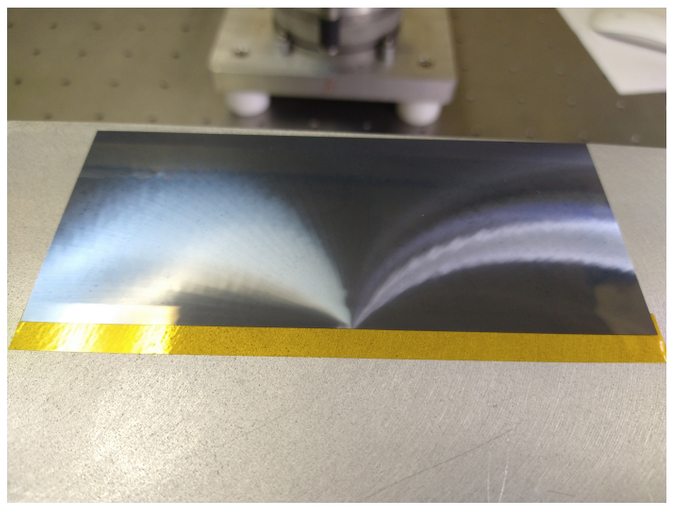
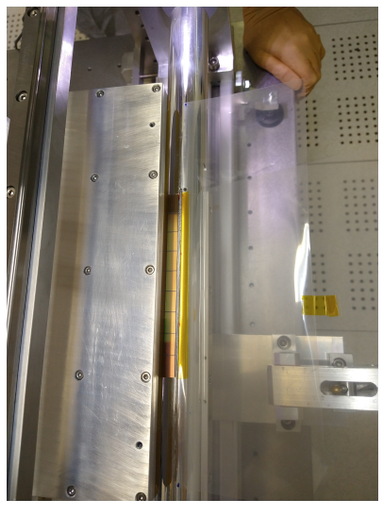
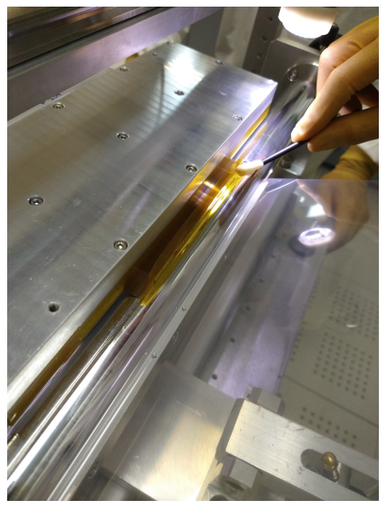
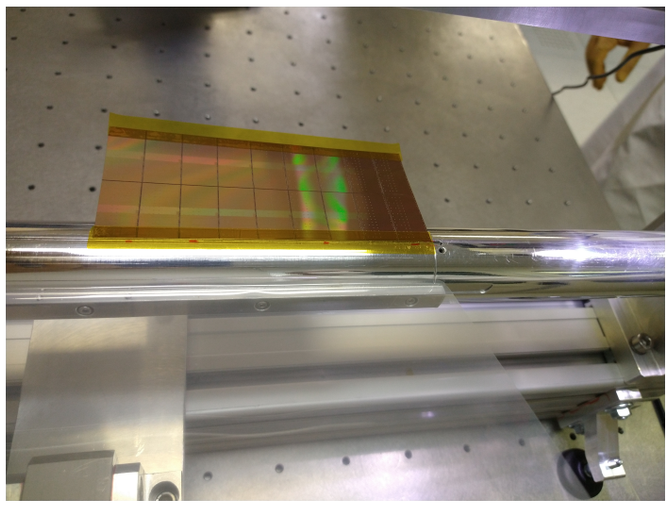


2) Alignment to the mandrel already equipped with a second adhesive tape strip

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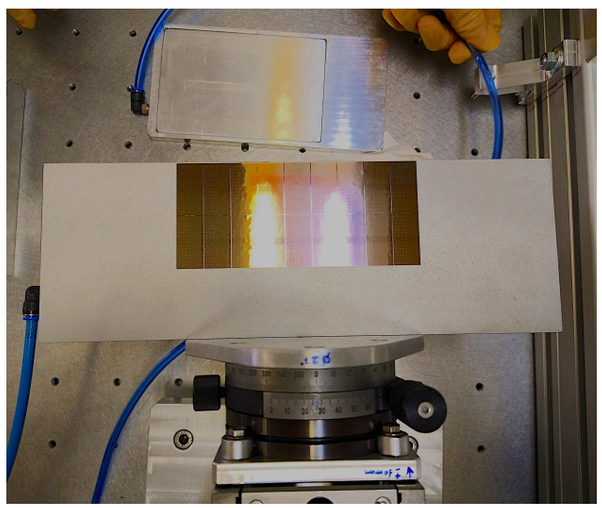
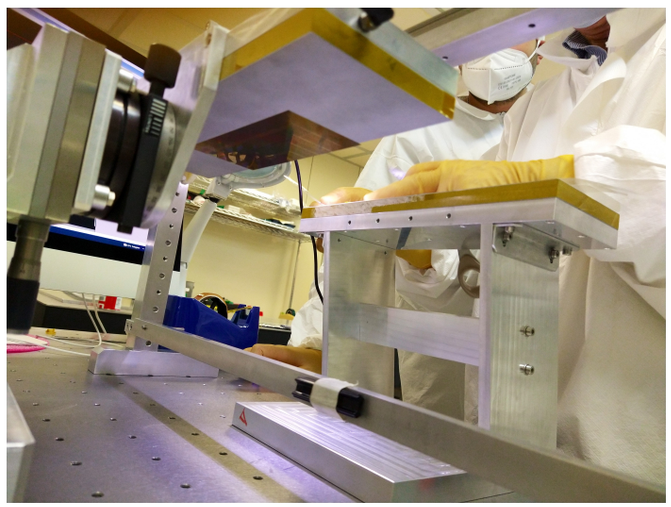
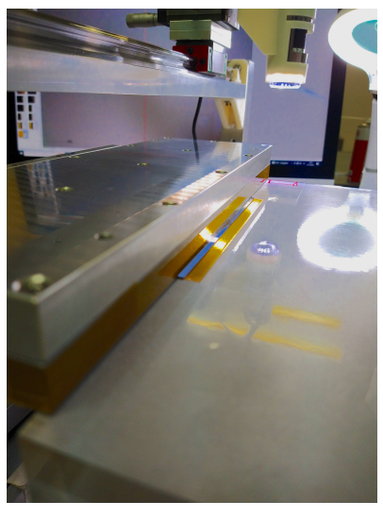
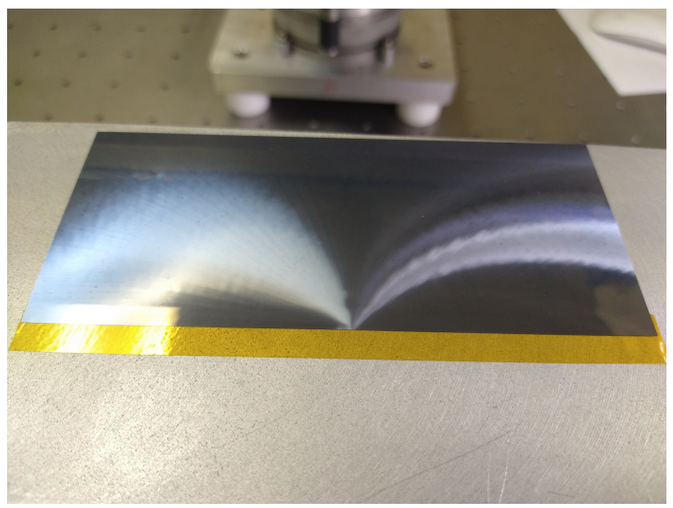

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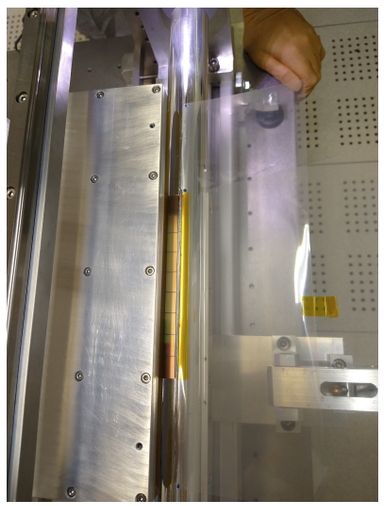
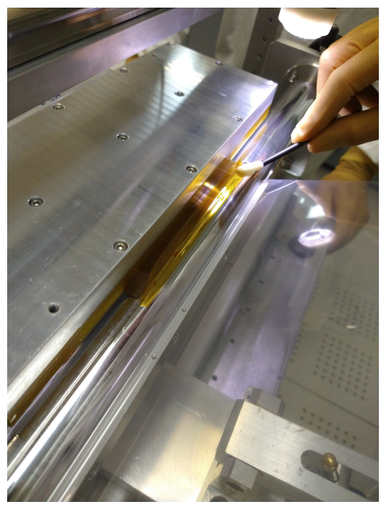
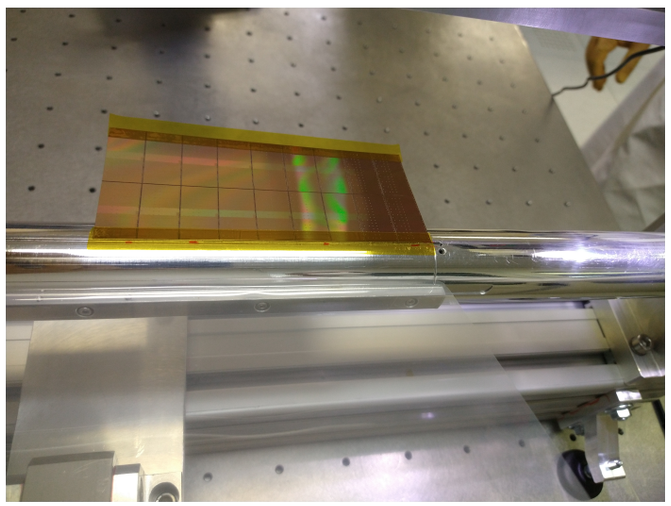
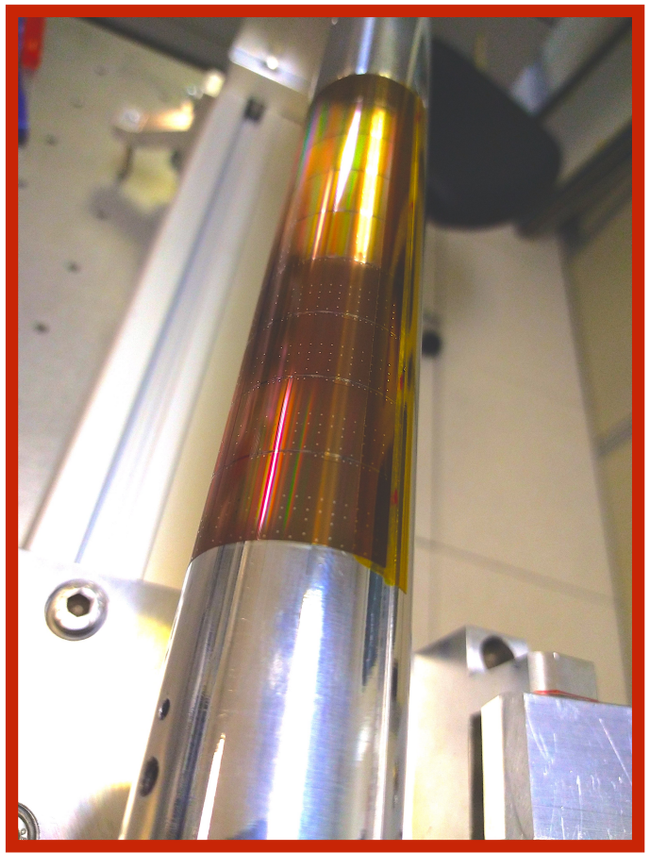

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- two in L0 and L1,
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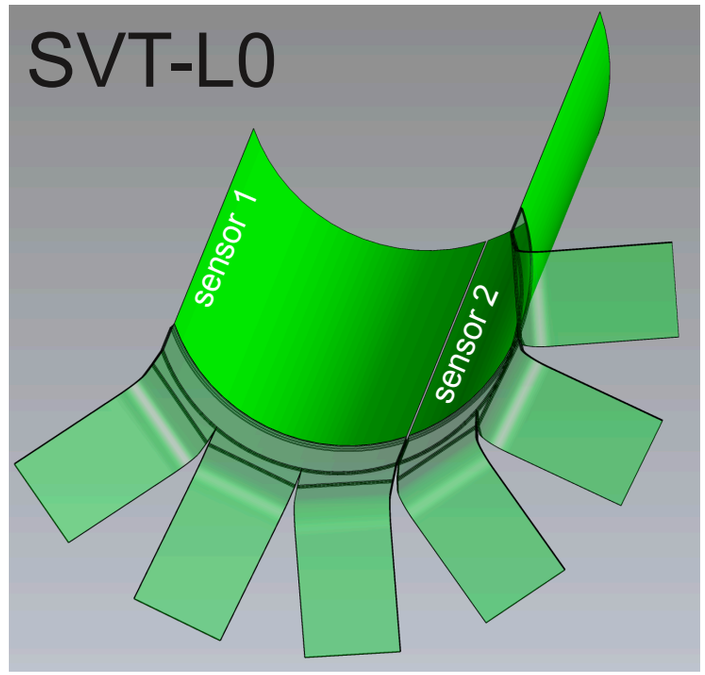

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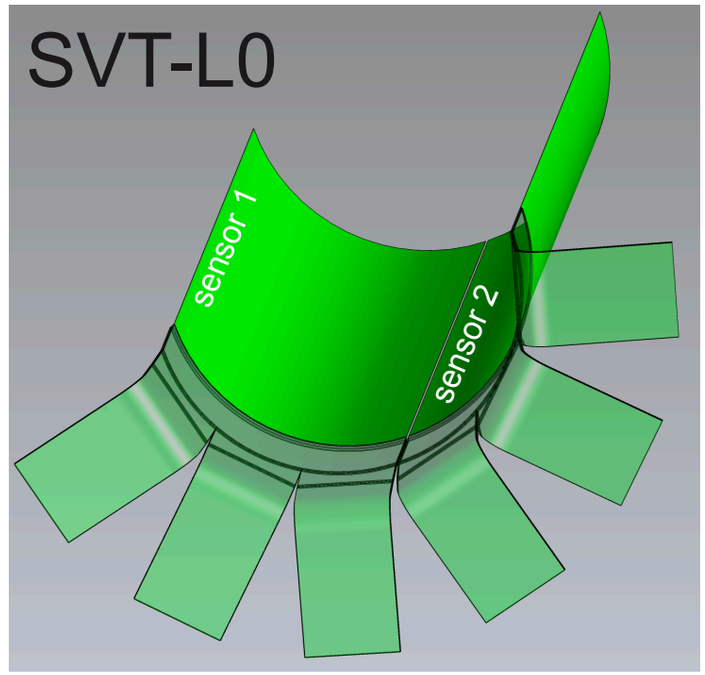

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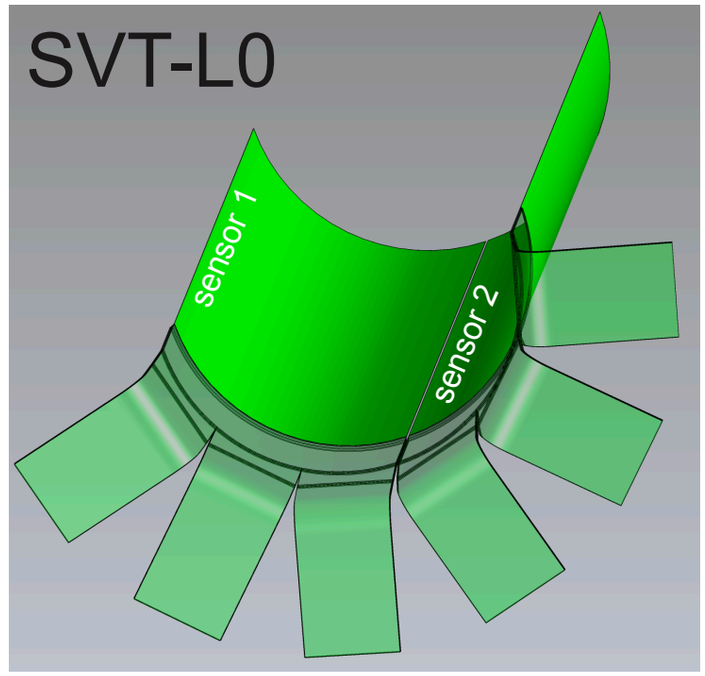

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The two sensors are aligned, “connected” and bent as single object (à la ITS3).

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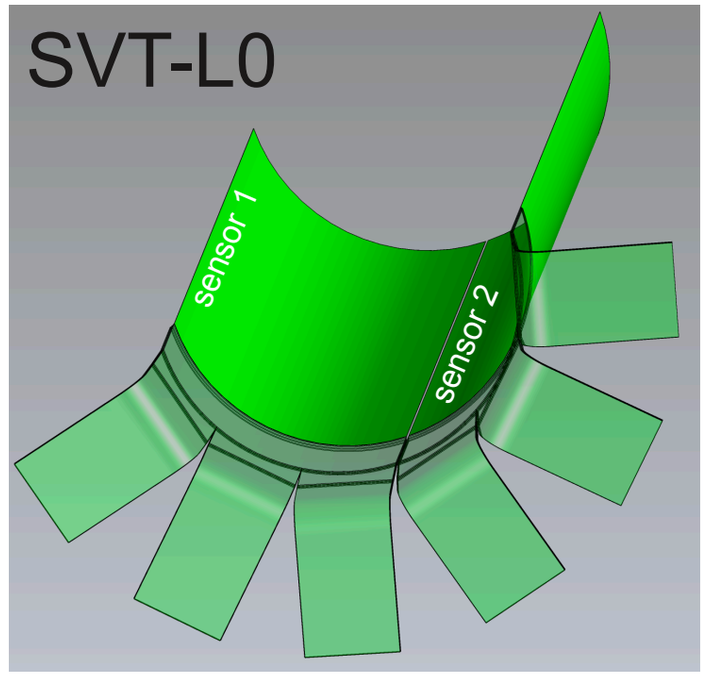

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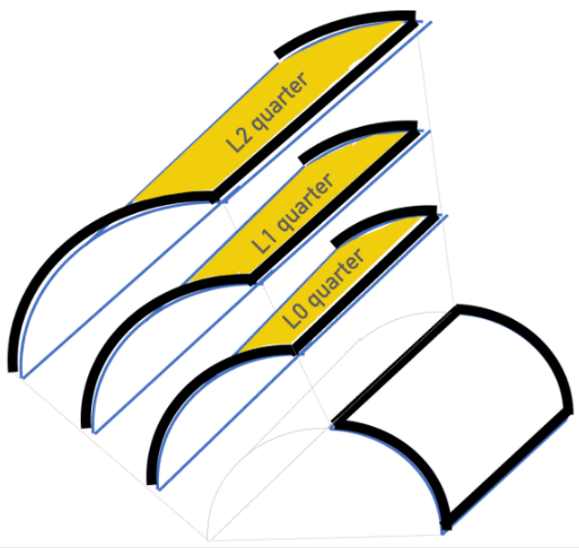

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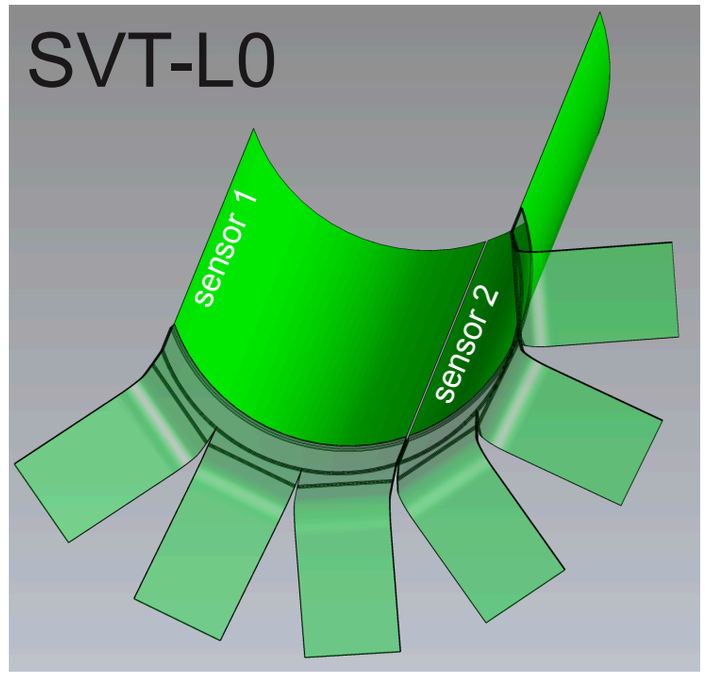

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Pros. - tools already developed, reduced sensor separation, better alignment

Cons. - bending more difficult, (potentially) slightly larger material budget

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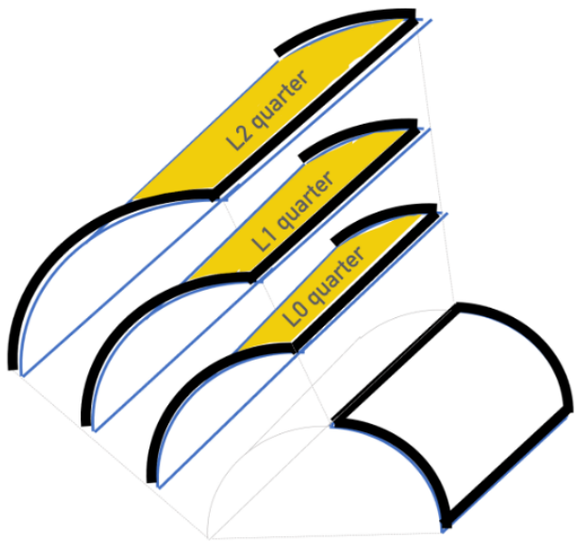

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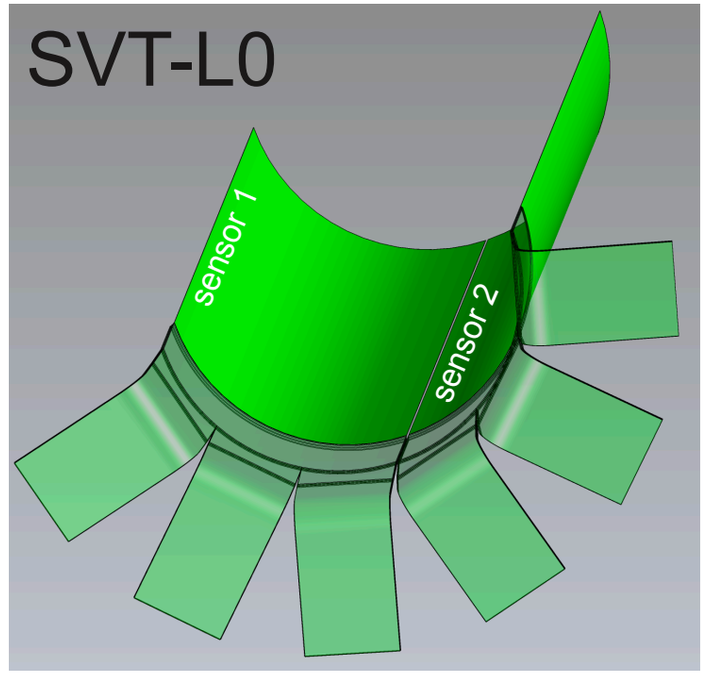

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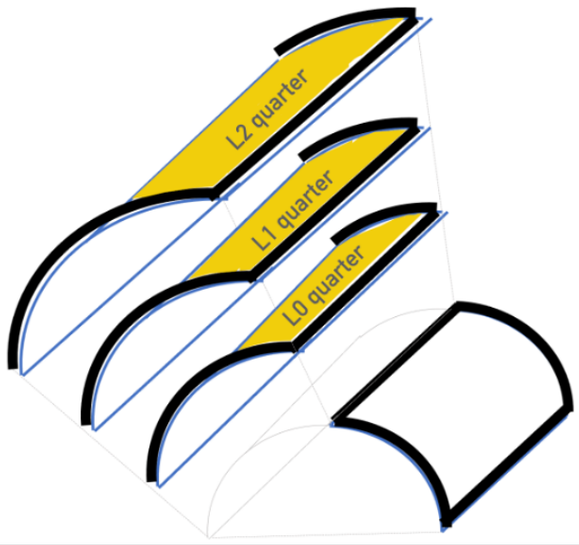

1. Silicon sensor bending technique

Single object bending

Embedding strategy

Bare+tape strategy

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Single object bending

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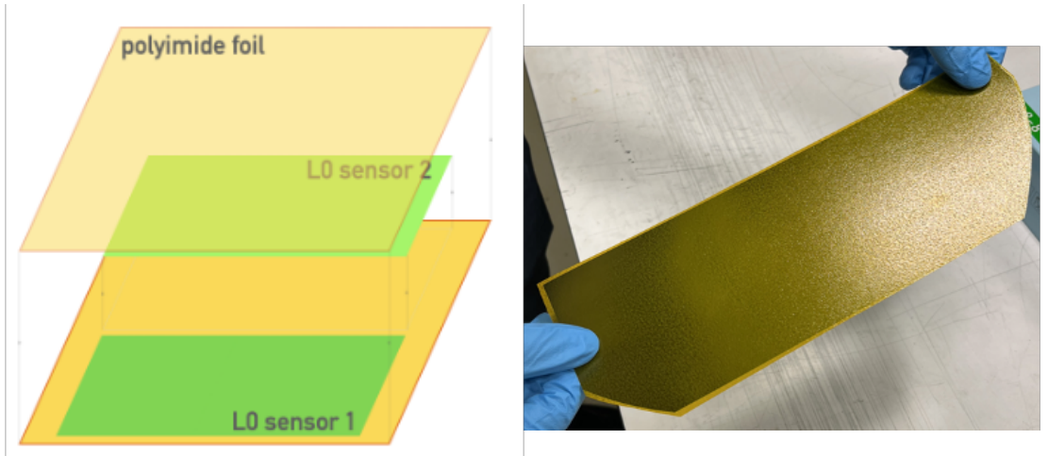

- R&D started within ITS3, but extended one required
  (thermal and pressure stress on the sensor during the gluing, air bubbles, access to the soldering pads)

Bare+tape strategy

1. Silicon sensor bending technique

Single object bending

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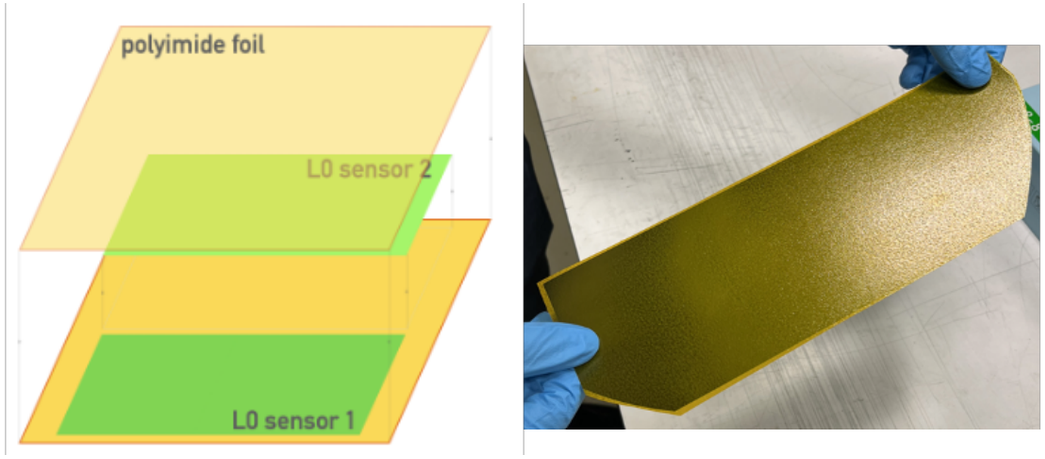

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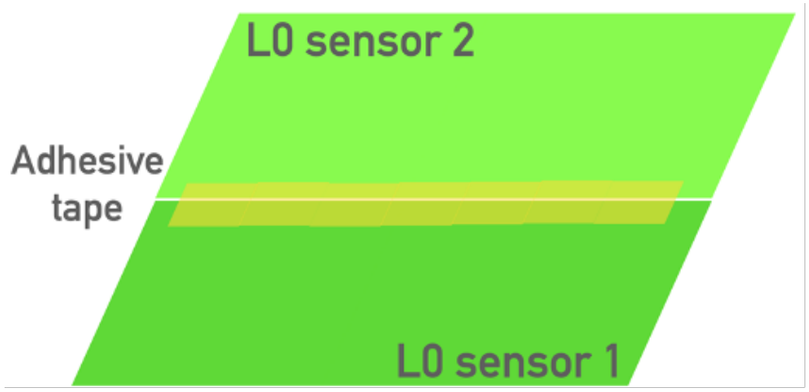

- Reduced amount of kapton
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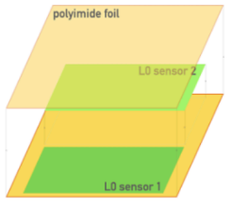

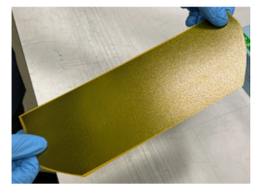

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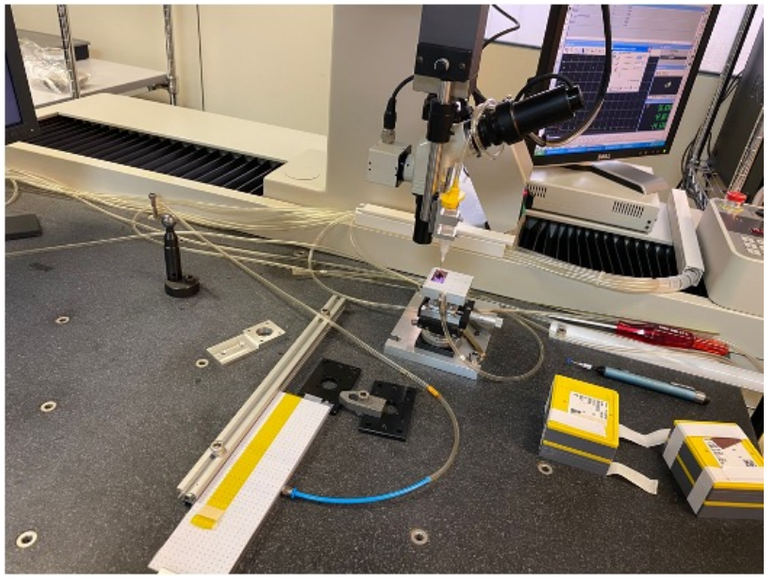
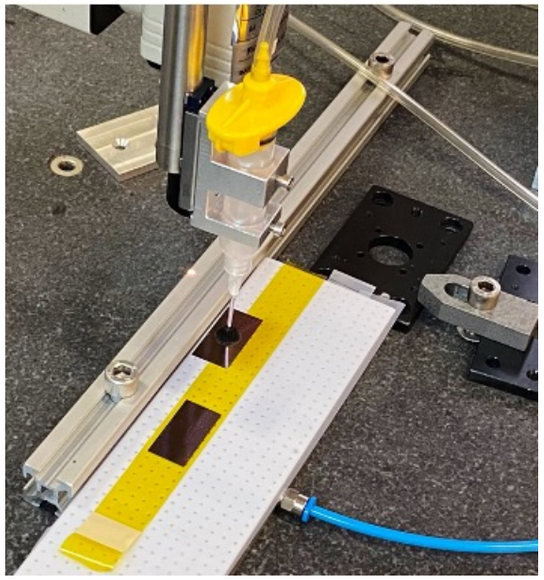
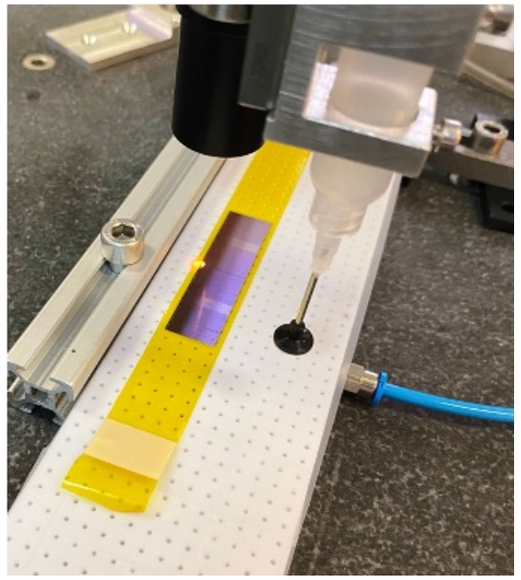
1. Silicon sensor bending technique

Single object bending

Mitutoyo machine equipped with alignment vacuum tool

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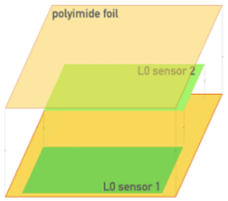

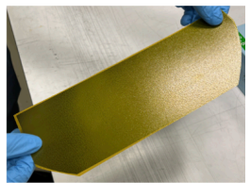

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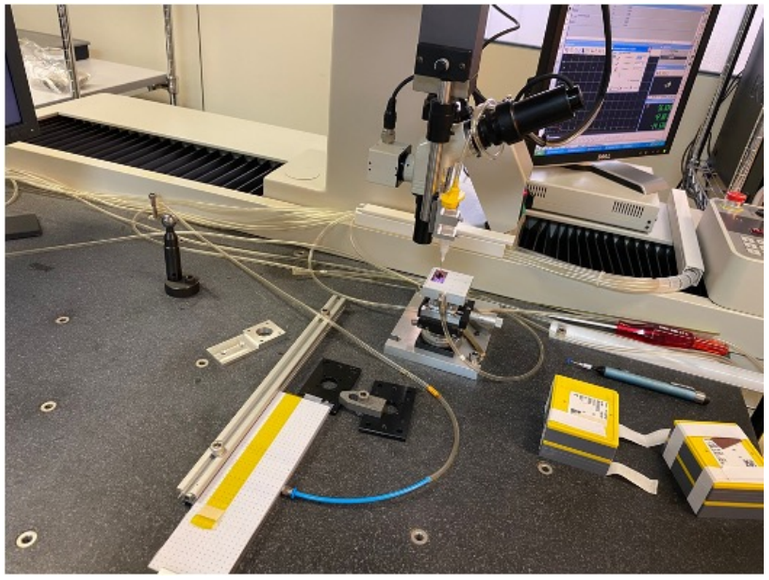
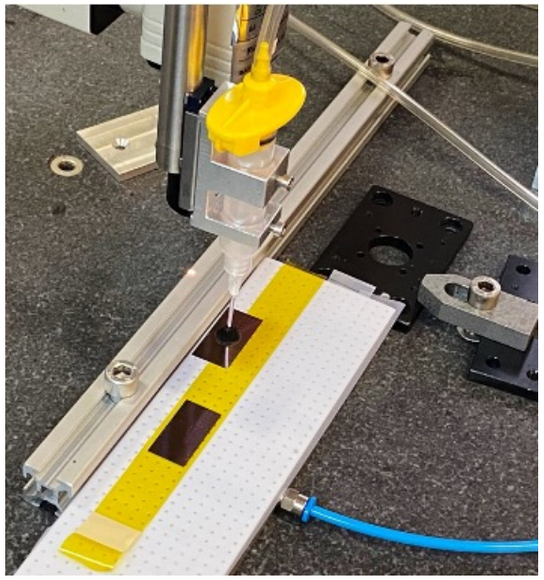
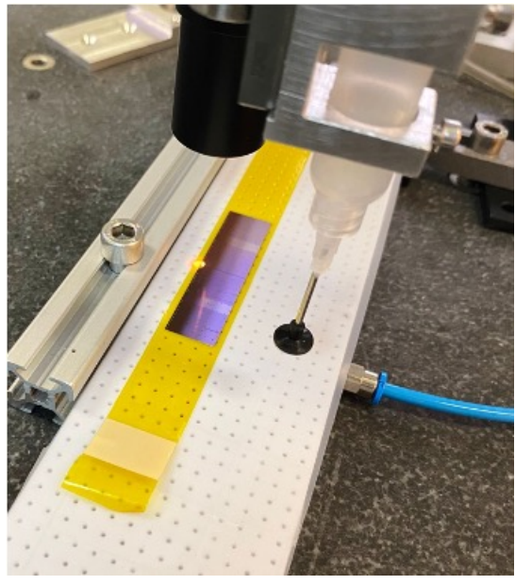
1. Silicon sensor bending technique

Single object bending

Mitutoyo machine equipped with alignment vacuum tool

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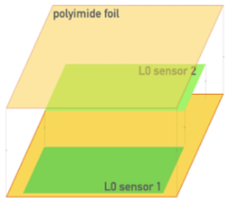
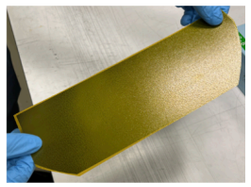
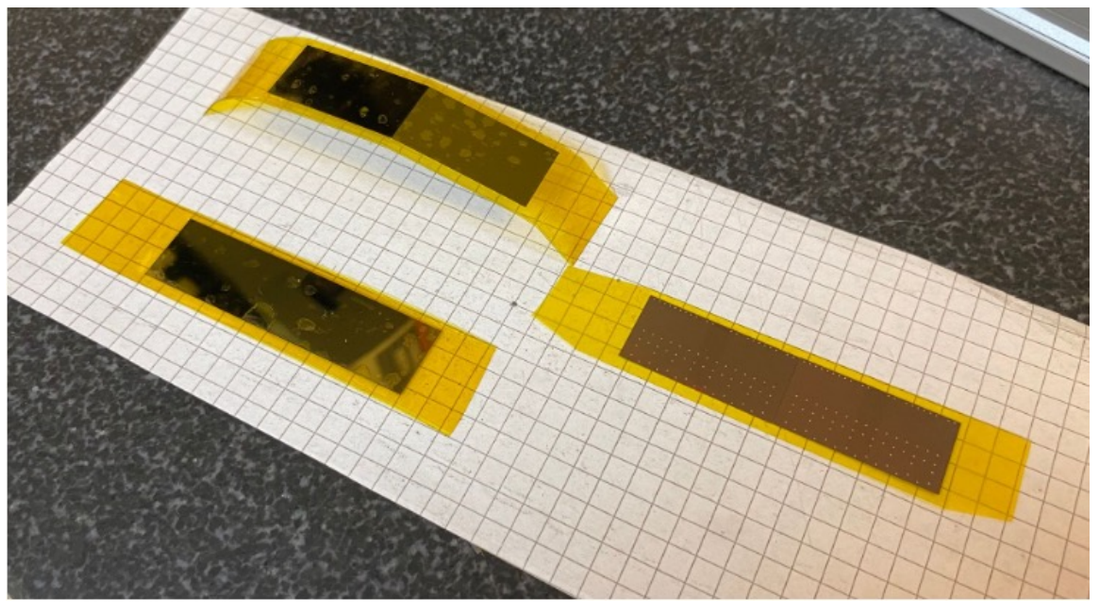




- R&D started within ITS3, but extended one required
  (thermal and pressure stress on the sensor during the gluing, air bubbles, access to the soldering pads)

- 100 µm thick silicon encapsulated in 40 µm thick adhesive tape at 1.8 mm bending radius
- Conclusions:
  - precise silicon positioning (~10 µm)
  - breakage expected from sensor thickness
  - cusp at the sensors connection
  - dedicated effort required



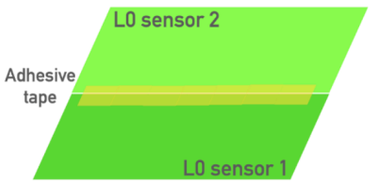
1. Silicon sensor bending technique

Single object bending

Test conditions:

- 50 µm ALPIDE sensors (30 mm x 15 mm)
- bending radius 18 mm
- adhesive tape thickness: from 12 µm to ~60 µm

Bare+tape strategy



- Reduced amount of kapton
- Feasibility to be verified

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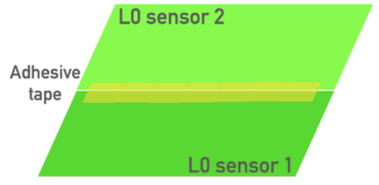

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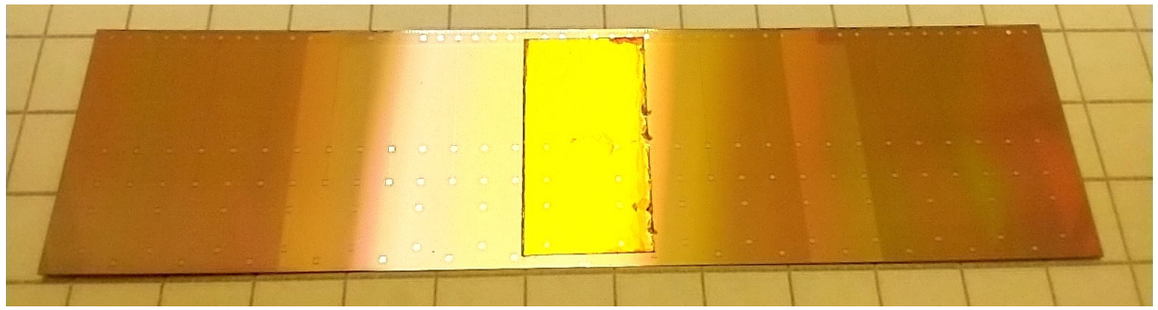

Two sensors alignment:
- Mitutoyo machine equipped with vacuum tool
- iterative procedure to achieve high precision/parallelism under improvement
- procedure to be extended to large size objects → vacuum jig to be modified

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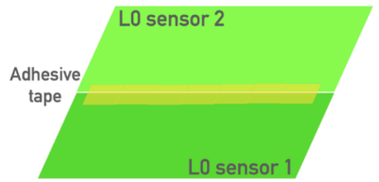

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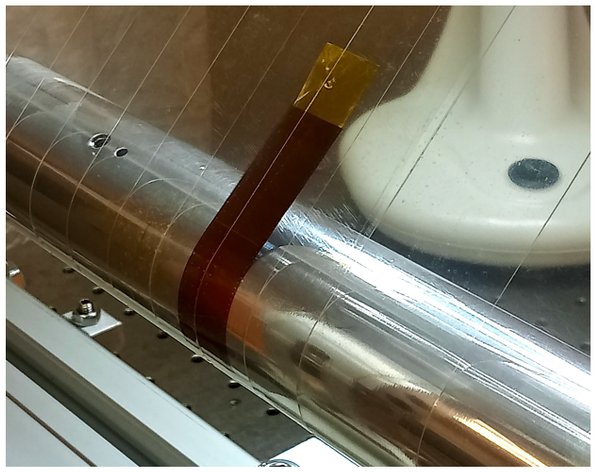
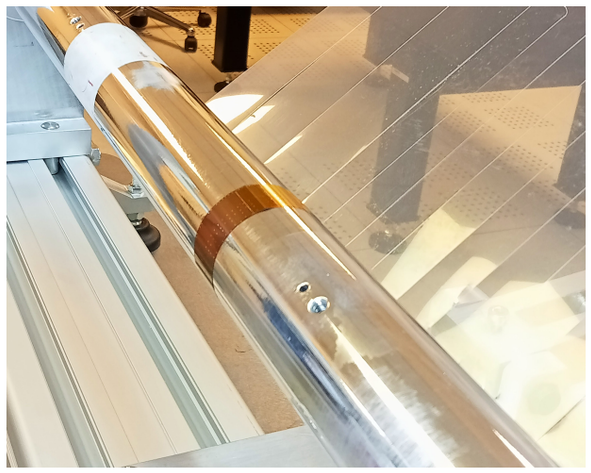
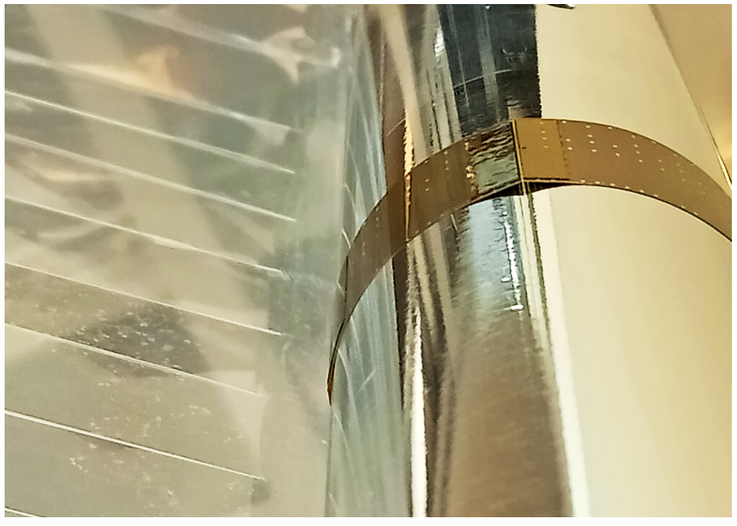






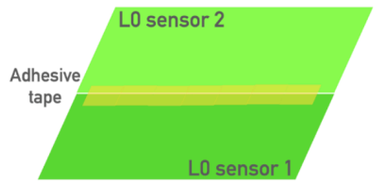
Attempt	Adhesive tape thickness	Result	Note
#1	12 μm	breakage	Close to tape-to-mandrel edge
#2	12 μm	success	Cusp at sensors junction
#3	40 μm	success	Reduced cusp
#4	60 μm	breakage	Cusp not reduced wrt 40 μm Breakage (probably) due to already stressed silicon

1. Silicon sensor bending technique

Single object bending

Test conditions:
- 50 μm ALPIDE sensors (30 mm x 15 mm)
- bending radius 18 mm
- adhesive tape thickness: from 12 μm to ~60 μm

Bare+tape strategy



- Reduced amount of kapton
- Feasibility to be verified

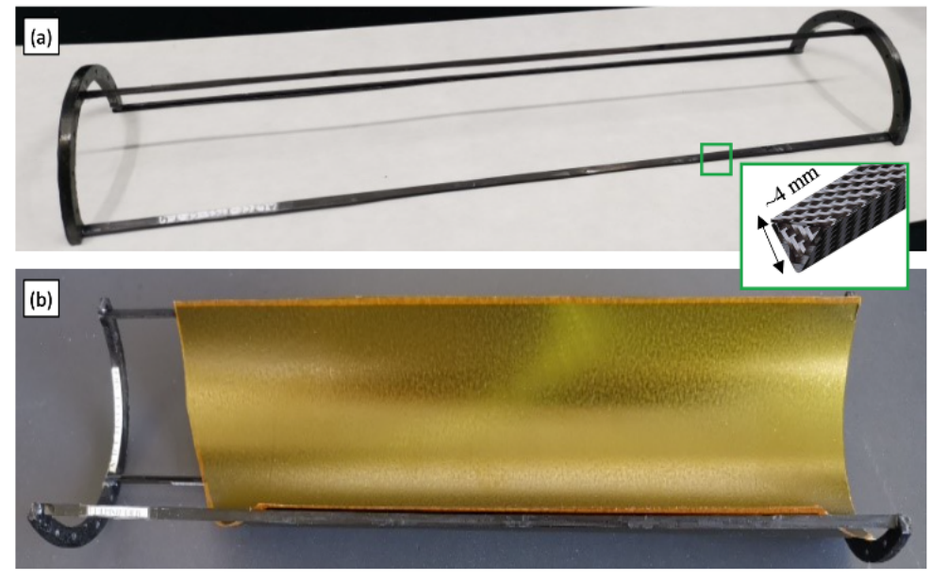
Next tests:
- material: 2 ALPIDE (50 μm) + large size silicon pieces (not regular shape)
- parameter to be explored:
  - adhesive tape thickness: increase to verify reduction of cusp height
  - tape width: present 18 mm (half on each sensor)
- verify effect of support structure in cusp height reduction

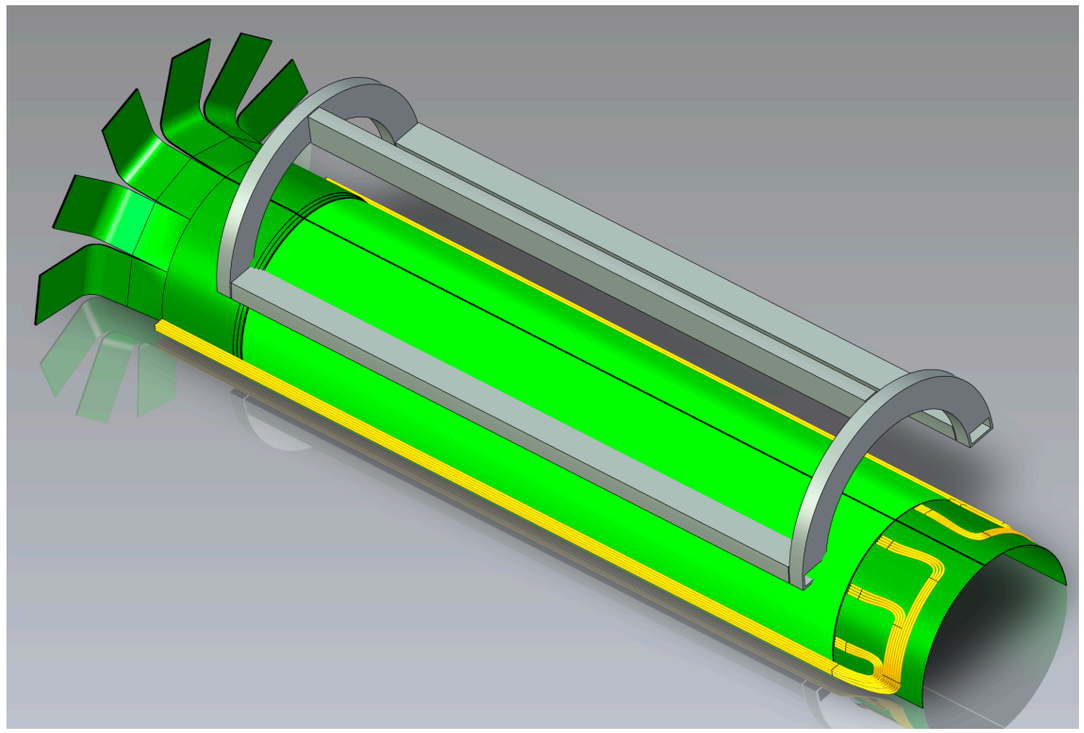
2. Local support structures

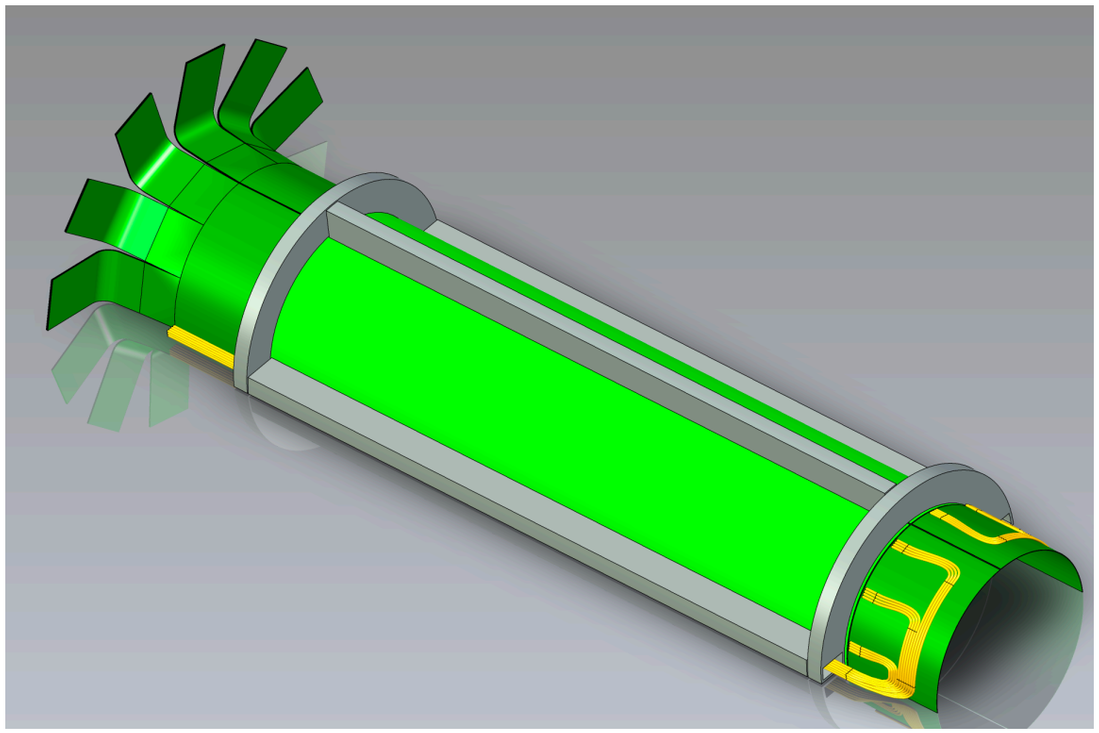
Single light support structures:

- able to self supporting the sensors of a single half-layer → Needed to avoid a shell externally to L1 (for mechanical; still to be verified for cooling)
- obtained by gluing two half-rings and three logerons
- made of combination of carbon foam (for half-rings) and carbon fibre (for longerons)

G. Feofilov et al., **ITS3 WP4** 10 October 2023







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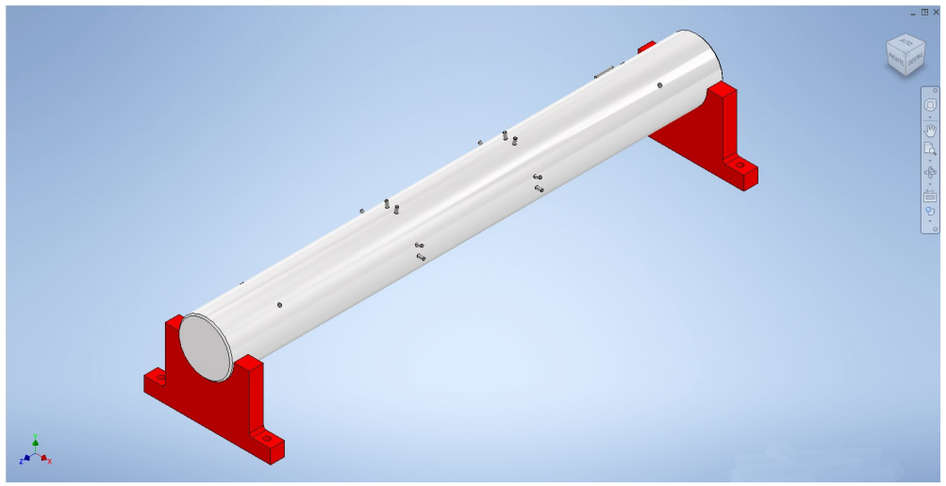
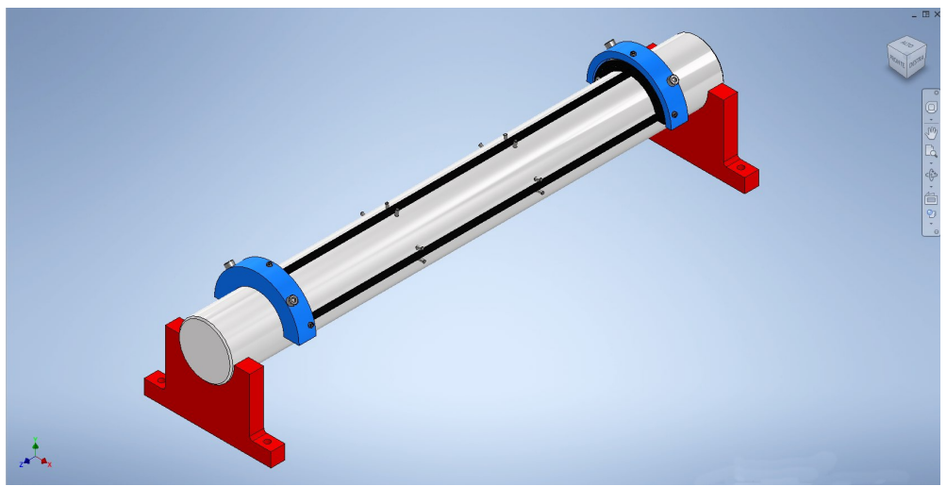
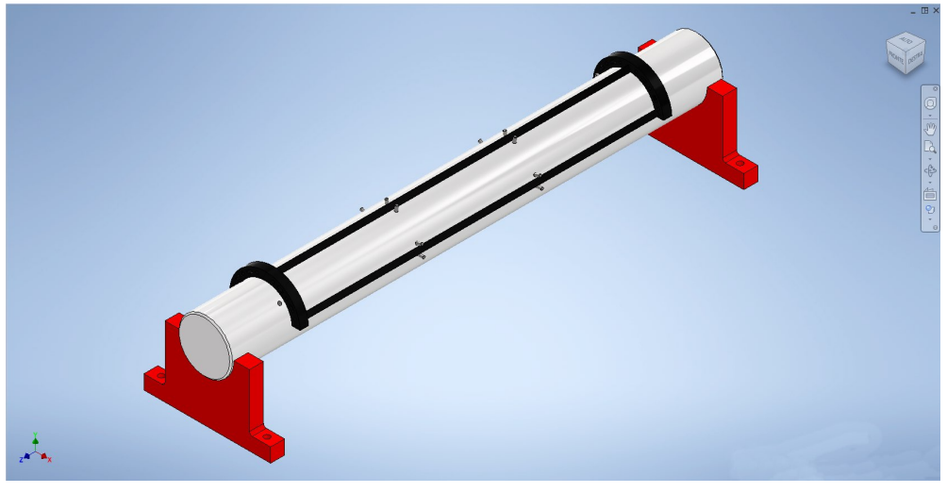
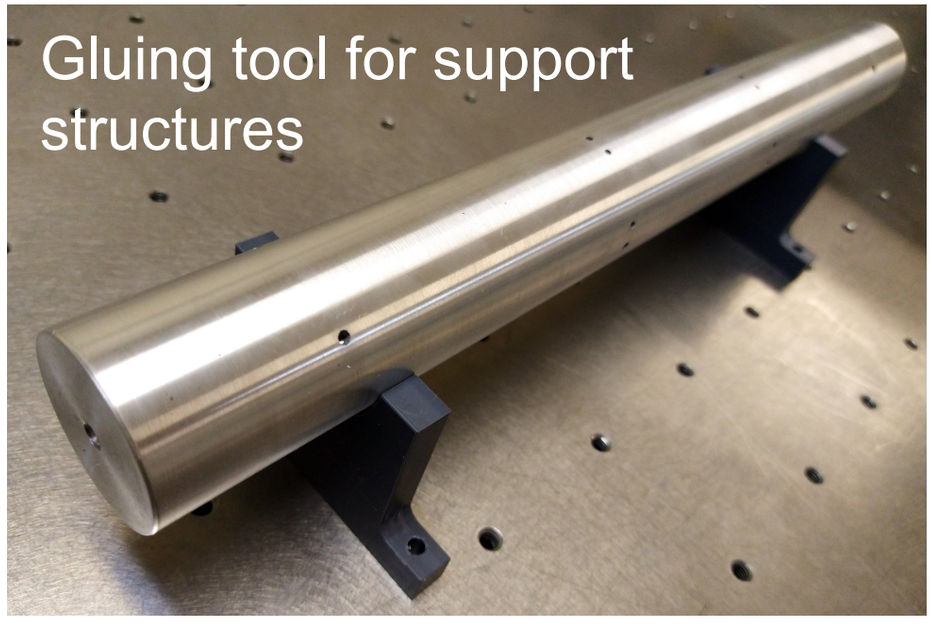




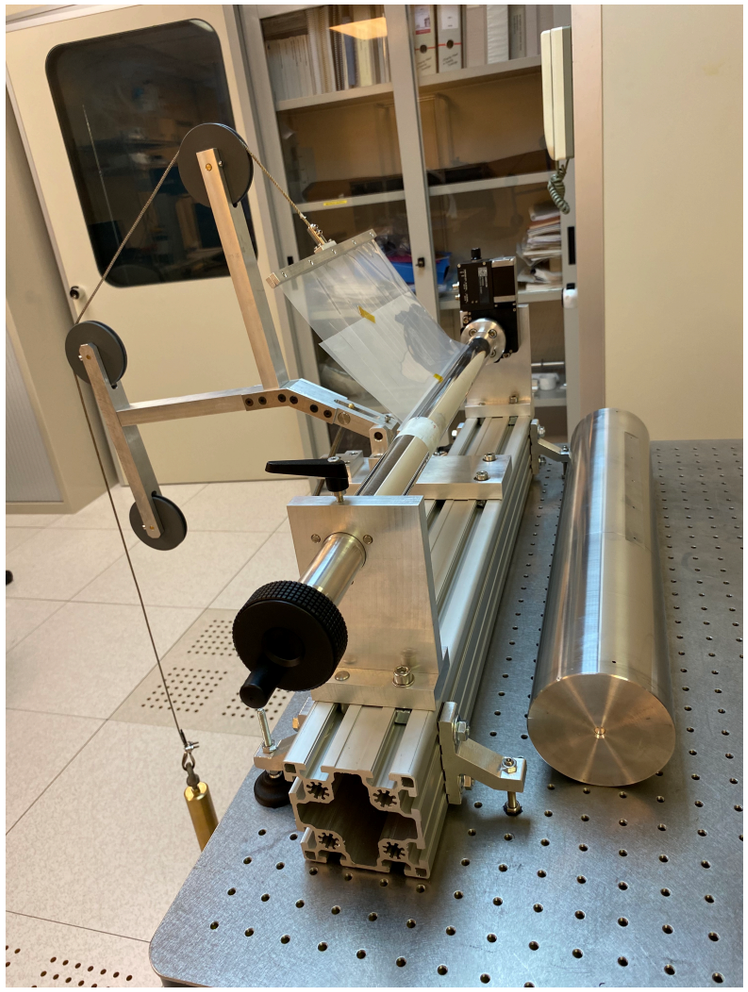


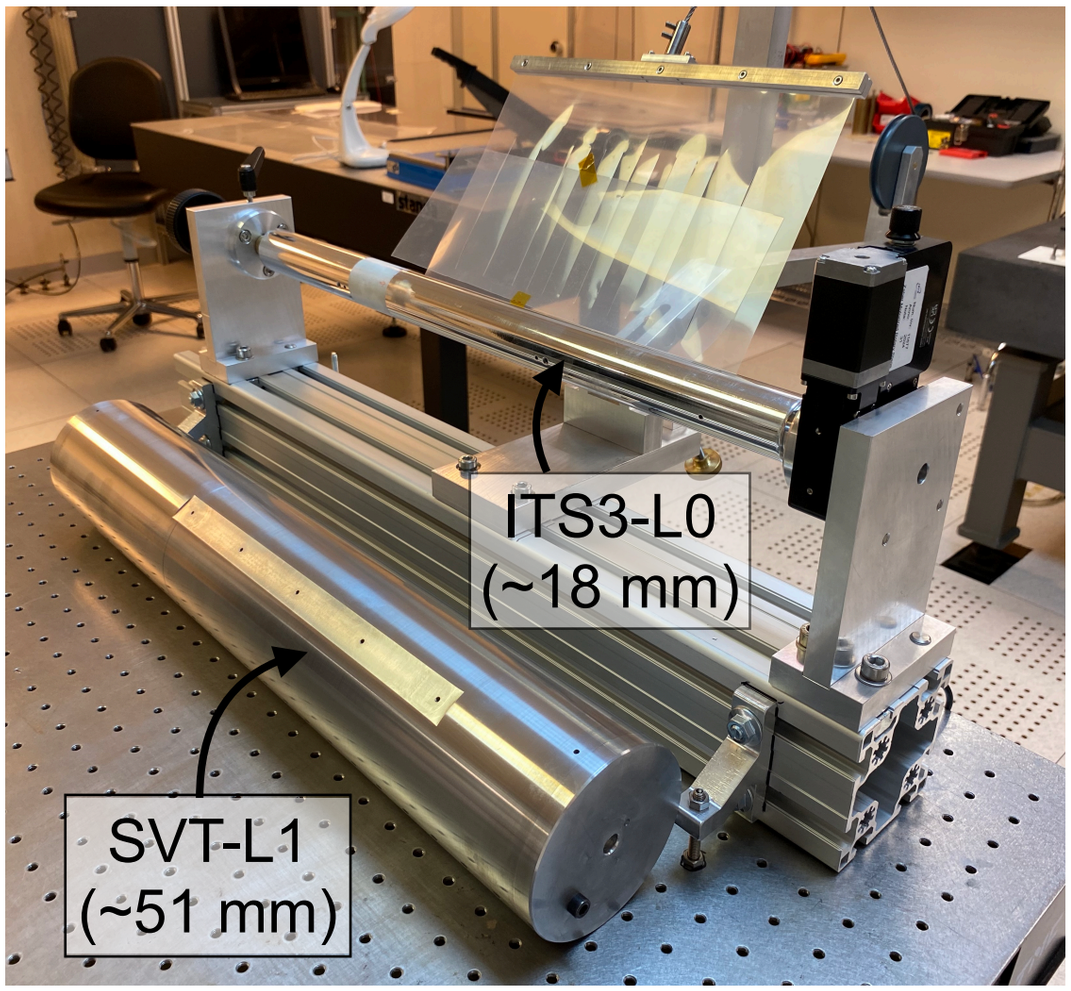


3. Prototyping campaign plan

Setup and tools update:

- Dedicated bending setup available
- First version of L1 mandrel available
  - Producer for high quality mandrels identified





3. Prototyping campaign plan

Prototype assembly general goals

- single layer assembly
- L0 and L1 layers connection
- air-cooling mechanism verification

Prototype	Components	Goal
IBL01_P1 (half-layer)	• 2 naked silicon L1 sensors • L1 local support structure (3-D printed) • outer support shell (machined in PEEK)	• finalize half-layer assembly procedure
IBL01_P2 (half-barrel)	• IBL01_P1 + • 2 naked silicon L0 sensors • L0 local support structure (3-D printed)	• finalize half-barrel assembly procedure
IBL01_P3 (half-layer)	• 2 naked silicon L1 sensors • L1 local support structure (carbon foam) • outer support shell (carbon fiber, to be defined)	• thermal chamber test
IBL01_P4 (half-barrel)	• IBL01_P3 + • 2 naked silicon L0 sensors • L0 local support structure (carbon foam)	• thermal chamber test
IBL01_P5 (half-barrel)	• 2+2 silicon L0+L1 **sensors with heaters from CERN** • L0+L1 local support structures (carbon foam) • outer support shell (carbon fiber, to be defined) • **air distribution inlet et outlet** (to be designed) • PT1000 sensors (to be glued on heater surface)	• wind tunnel test

3. Prototyping campaign plan

Required material/actions (on the critical path):

➡ Dummy silicon sensor available:
- Needed for P1-4
- 2 month estimated production time (by Rui) from the dummy silicon reception

➡ Carbon foam:
- Needed for P3-5
- procurement and machining need to be arranged

➡ Simulation:
- Needed for P1-5 to:
  - define the cooling system
  - verify if shell external to L1 is needed mechanically and thermally (confine volume)
- manpower need to be assigned

➡ Carbon fiber shell(s)
- if needed (see previous point), procurement and machining need to be arranged

Backup

3. Prototyping campaign plan

Prototype assembly general goals
- single layer assembly
- L0 and L1 layers connection
- air-cooling mechanism verification

Prototype	Components	Goal
IBL01_P1 (half-layer)	• 2 naked silicon L1 sensors • L1 local support structure (3-D printed) • outer support shell (machined in PEEK)	• finalize half-layer assembly procedure
IBL01_P2 (half-barrel)	• IBL01_P1 + • 2 naked silicon L0 sensors • L0 local support structure (3-D printed)	• finalize half-barrel assembly procedure
IBL01_P3 (half-layer)	• 2 naked silicon L1 sensors • L1 local support structure (carbon foam) • outer support shell (carbon fiber, to be defined)	• thermal chamber test
IBL01_P4 (half-barrel)	• IBL01_P3 + • 2 naked silicon L0 sensors • L0 local support structure (carbon foam)	• thermal chamber test
IBL01_P5 (half-barrel)	• 2+2 silicon L0+L1 **sensors with heaters from CERN** • L0+L1 local support structures (carbon foam) • outer support shell (carbon fiber, to be defined) • **air distribution inlet et outlet** (to be designed) • PT1000 sensors (to be glued on heater surface)	• wind tunnel test

Requires dummy silicon sensors.
To validate 2-sensor connection and bending, local support structure, external shell, etc.

Requires, in addition to dummy silicons, local support in carbon foam (material procurement and machining) and carbon fibre support and shell (TBC by simulations; if needed, material procurement and machining).

Requires:
- dummy silicons with heaters
- air distributor (design, production)
- preliminary FPC (design, production)
- transport solution to wind tunnel facility