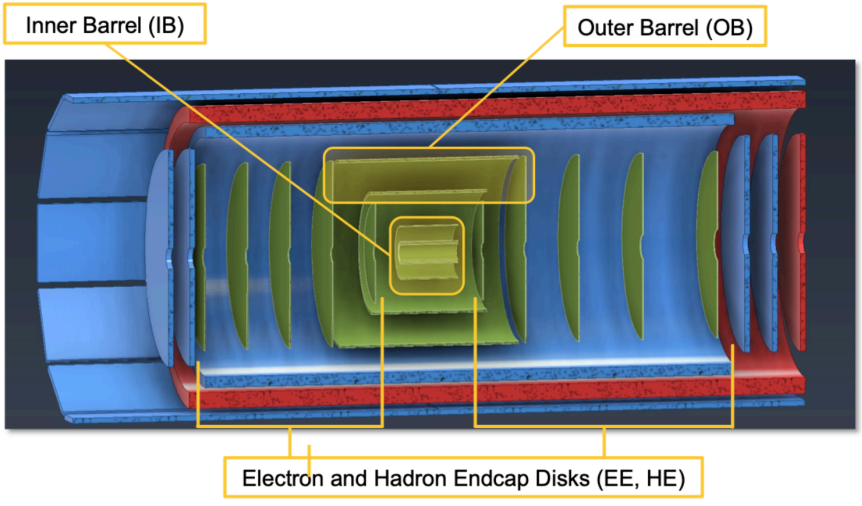
Progress on ePIC SVT @Bari

D. Colella, D. Elia et al.
(including support from INFN Bari services)

Meeting on Silicon Pixel activities in Bari, 25.3.2024

- **Inner Barrel (IB)**
  - Three layers, L0, L1, L2,
  - Radii of 36, 41, 120 mm
  - Length of 27 cm
  - X/X_0 ~ 0.05% per layer
  - Curved, thinned, wafer-scale sensor
- **Outer Barrel (OB)**
  - Two layers, L3, L4
  - Radii of 27 and 42 cm
  - X/X_0 ~0.25% and ~0.55%
  - More conventional structure w. staves
- **Electron/Hadron Endcaps (EE, HE)**
  - Two arrays with five disks
  - X/X_0 ~0.25% per disk
  - More conventional structure

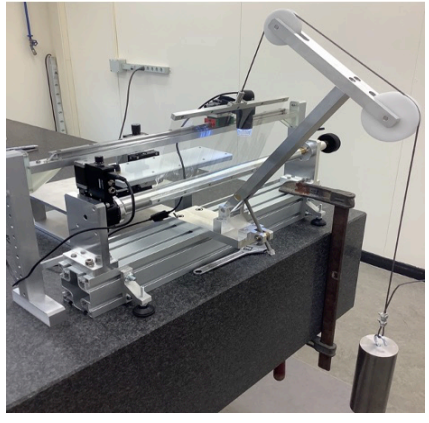


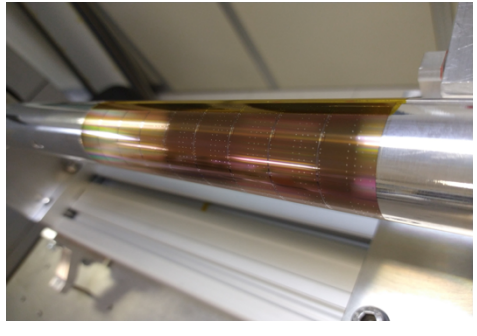
- **Lengths for L2—L4 increase so as to project back to z = 0; disk radii adjust accordingly**

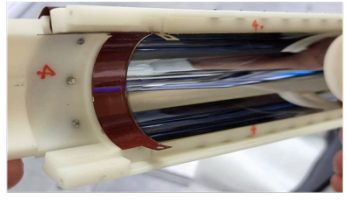
ePIC SVT IB interested institutions

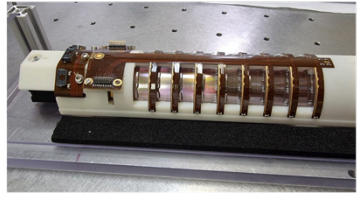
INFN (DE for Bari, Padova, Pavia, Trieste)

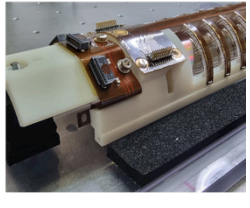
- **Focus on L0/L1**
- **Mechanics/conceptual design of the IB innermost layers:**
  - ✓ definition of the bending and assembly procedure
  - ✓ development of the layer support structure
  - ✓ explore interconnection to sensors
- **Cooling:**
  - ✓ build dedicated prototype same as for mechanics studies (suitable for wind tunnel tests)
  - ✓ test of thermal properties for embedded silicon in a thermal chamber
- **Workforce (FTE in 2024):**
  - ✓ Research: ~2-3
  - ✓ Mech Eng & CAD: ~0.5
  - ✓ Mech Tech: ~0.5











ePIC SVT IB interested institutions

Towards SVT IB concept → map of interests/contributions:

- integrated design of the 3 innermost layers including mechanics, cooling, readout and powering, up to the electrical/optical interface:
  - ✓ develop bending procedure, eg L0 (similar for L1)
  - ✓ extend to L2 considering additional issues
  - ✓ design L0/L1 and L2 support structures
  - ✓ integration of the cooling needs
  - ✓ development of the edge FPC(s)
- choice of the cooling:
  - ✓ simulation studies with ANSYS
- thermo-mechanical prototypes:
  - ✓ build prototypes for both L0/L1 and L2
  - ✓ perform dedicated tests of prototypes in wind tunnel
  - ✓ test of embedded silicon thermal properties in a thermal chamber
- support structure within the subsystem to keep everything together
  - ✓ connection of L0/L1 to L2
  - ✓ explore needs for a (light) supporting external shell (to L2)

ePIC SVT IB layout and concept

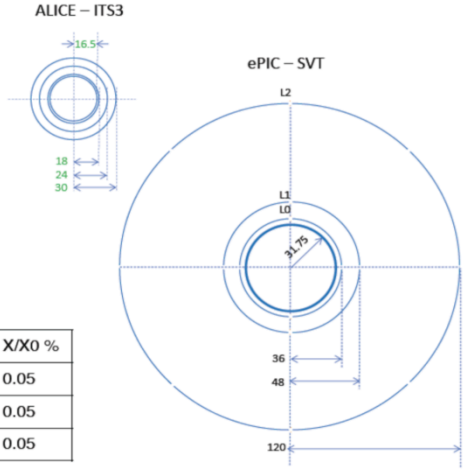
Basic assumptions:

- use the ALICE ITS3 wafer-scale sensor
- adapt ITS3 detector concept to the (larger) ePIC radii

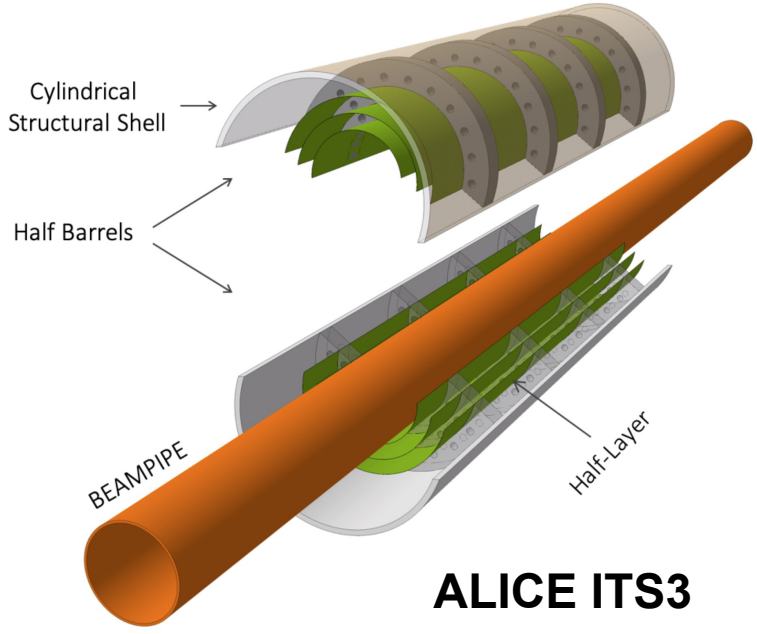
→ ***mechanics, services and cooling of the SVT IB need specific development***

ePIC SVT Inner Barrel (IB) layers

- Re-use ITS3 wafer-scale sensor
  - L0: 3x12 RSU + endcaps
  - L1: 4x12 RSU + endcaps
  - L2: 5x12 RSU + endcaps
- Number of sensors per layer
  - L0: 4
  - L1: 4
  - L2: 8



ePIC SVT IB	r [mm]	l [mm]	X/X0 %
L0	36	270	0.05
L1	48	270	0.05
L2	120	270	0.05



ALICE ITS3

ePIC SVT IB layout and concept

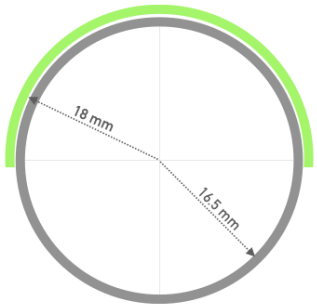
Towards SVT IB concept:

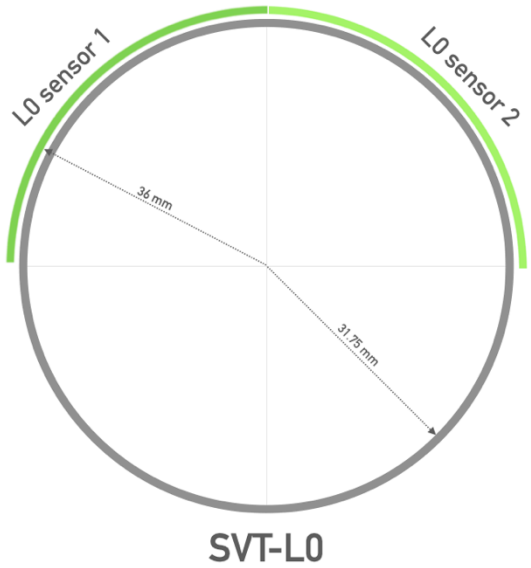
- integrated design of the 3 innermost layers including mechanics, cooling, readout and powering, up to the electrical/optical interface:
  - ✓ develop bending procedure, eg L0 (similar for L1):

Main differences & challenges wrt ITS3:

- x2 larger radius (18 → 36 mm)*
- need to bend 2 sensors for each half-layer

  * will increase to ~19/~38 mm with ITS3 ER2/3 sensors





Possible strategies:

1. **embedding (2 sensors):** try to exploit "embedding" the two sensors in kapton foils and bend them as a single object → **half-layer based assembly**
2. **independent bending:** bend each of the two sensors separately and glue them on independent support structures → **quarter-of-layer based assembly**

ePIC SVT IB layout and concept

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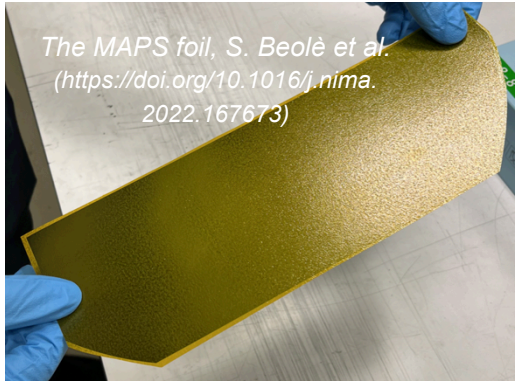
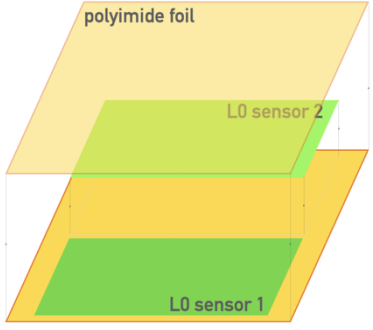
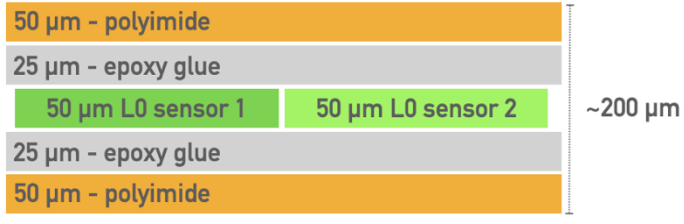
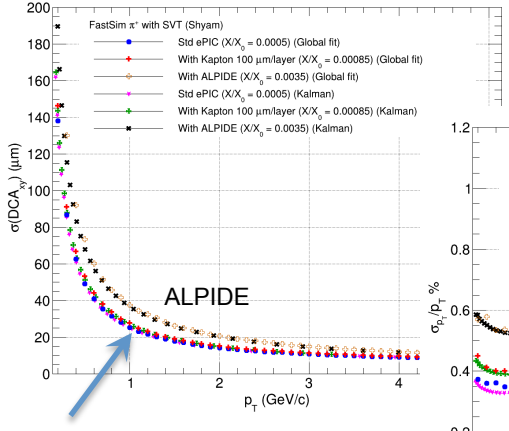


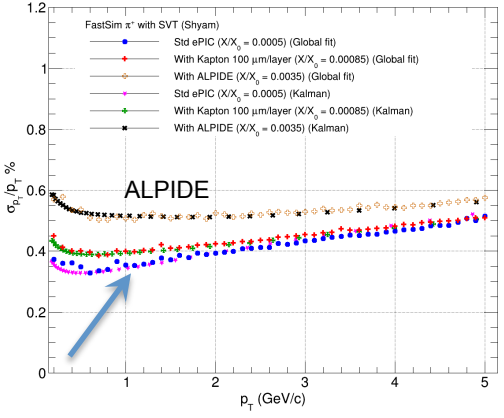




Limited effect of the additional material budget due to kapton foils (S. Kumar et al.)



65 nm MAPS w/ and w/o kapton



ePIC SVT IB layout and concept

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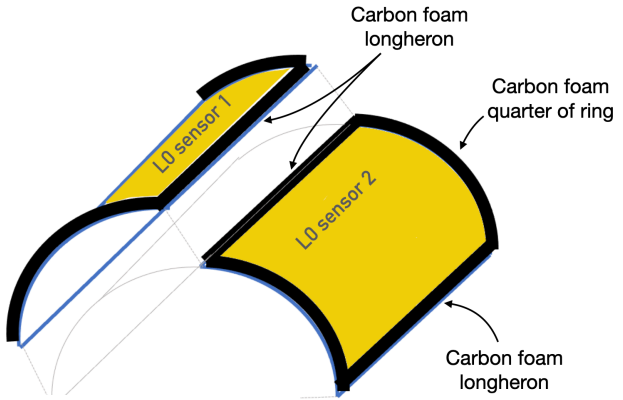
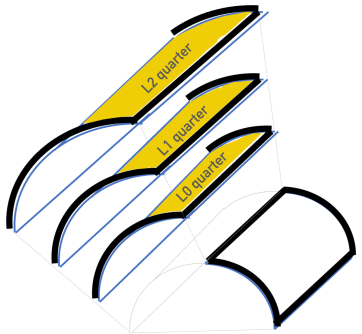


Independent (single sensor) bending strategy:

- avoids complications connected to embedding
- introduces further steps and potential issues on positioning procedure and mechanical stability of the bent sensors
- implies that the full IB (or maybe L0+L1) would be built in mechanically independent quarters to be precisely positioned together in the subsequent final assembly*



*This basically follows the same strategy used by ITS3 for bending the single sensors (kept on the mandrel by adhesive tape) and assemblying the detector (glueing from outermost to innermost) → the assemby of SVT IB will proceed in quarters of layers and not (as for ITS3) in half-layers

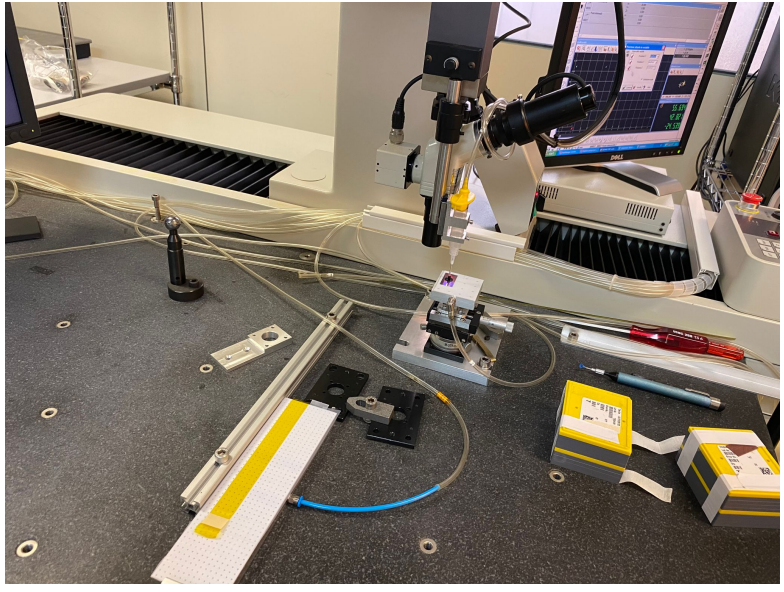
Sensor encapsulation and bending

First tests performed in clean room @INFN Bari:

- sensor encapsulation in kapton adhesive tape
- encapsulated sensor bending

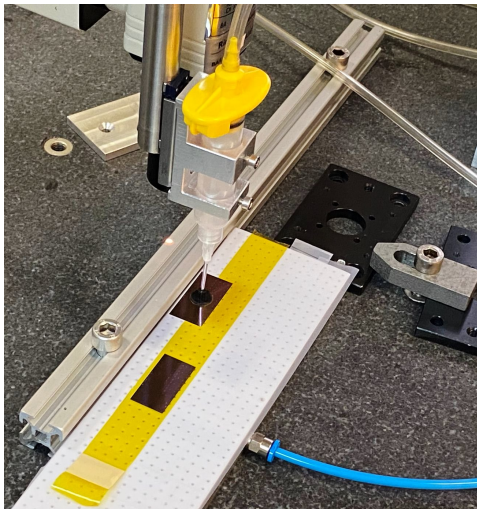
Synergy with ITS3/ALICE 3

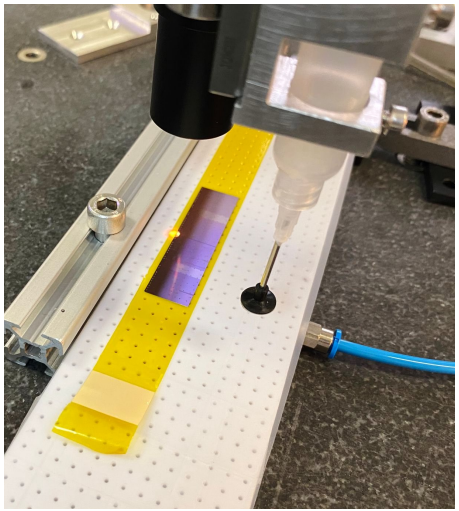
Mitutoyo machine equipped with alignment vacuum tool



Sensor encapsulation and bending

- sensor encapsulation in kapton adhesive tape
  - ✓ available material:
  - **kapton tape** (20 mm width, 40 μm thickness)
  - **ALPIDE sensors** (15 mm x 30 mm, 100 μm thickness, not working samples)
  - ✓ precise positioning of the sensors on kapton:





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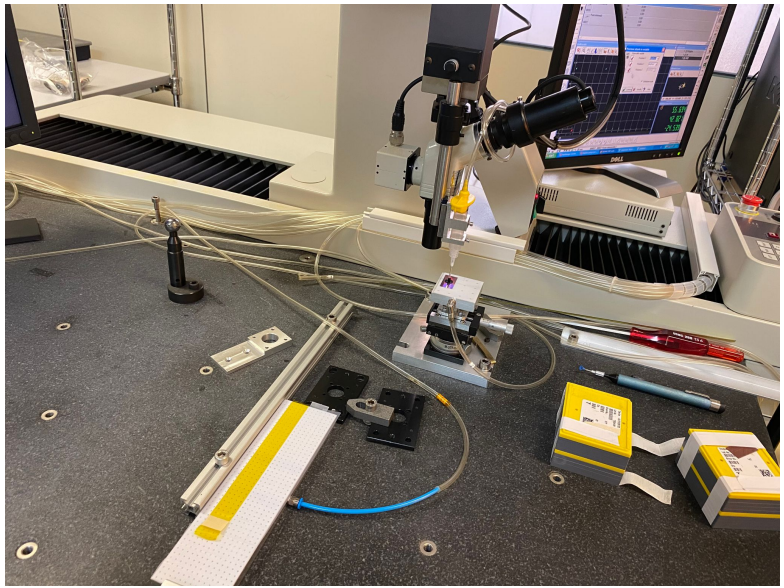

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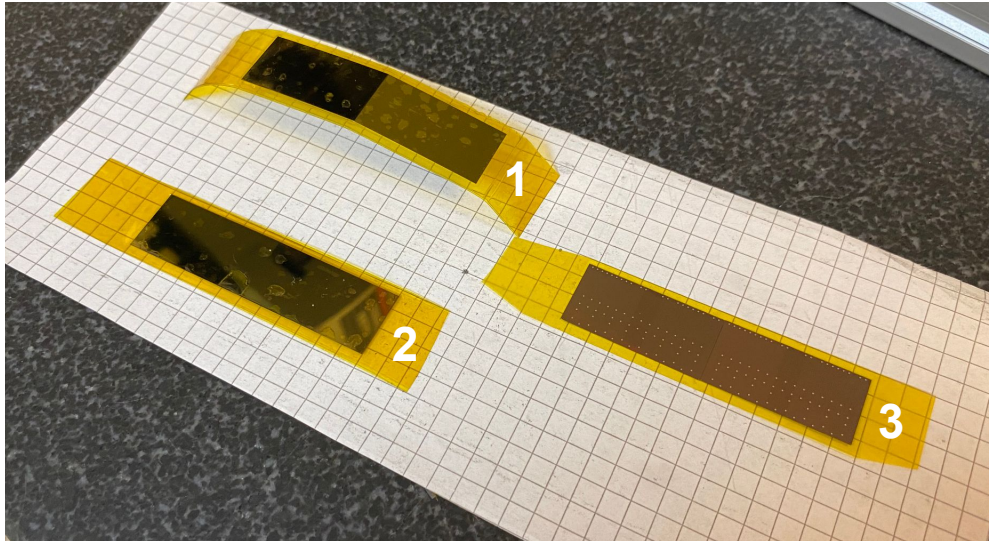


Three different samples:

- **S1**:
  - encapsulated sensors
  - top kaption positioning by hand
- **S2**:
  - encapsulated sensors
  - top kaption by dedicated tool
- **S3**:
  - single kapton layer (kapton on one side of the sensors only)

Sensor encapsulation and bending

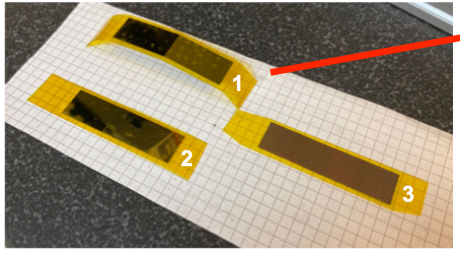
- encapsulated sensor bending:
  - ✓ using the setup developed for ITS3 bending
  - ✓ the mandrel had the radius of the innermost ITS3 layer (R ~18mm)
  - ✓ main aim: (re-)excercising the procedure, checking behavious of the encapsulated samples

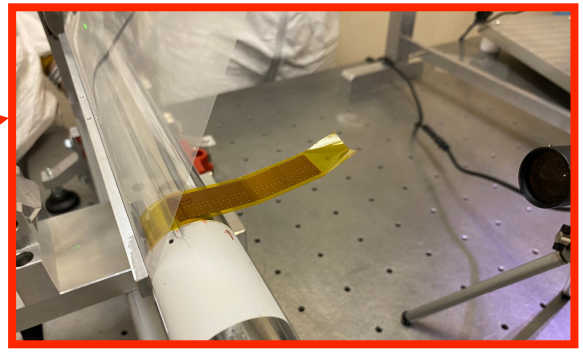
Synergy with ITS3/ALICE 3

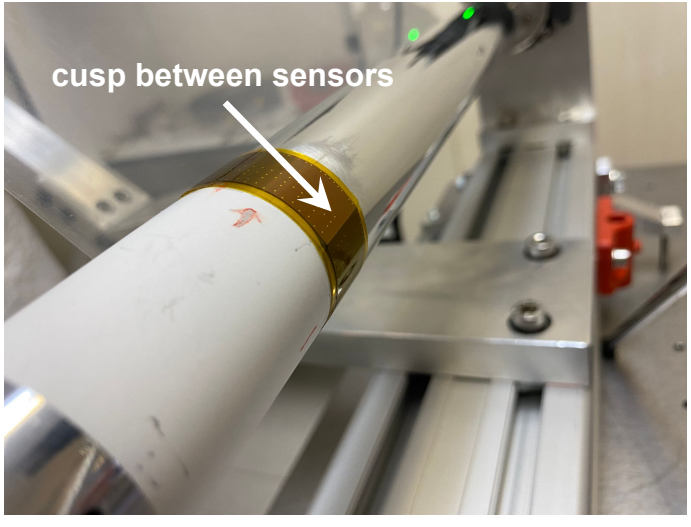
Sensor encapsulation and bending

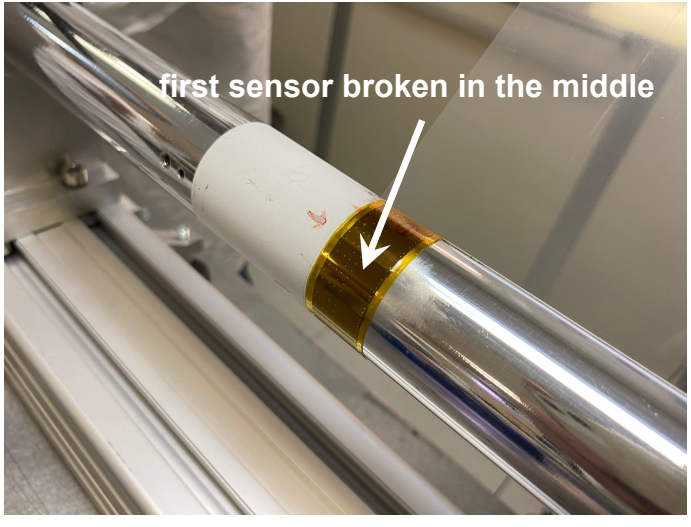
- encapsulated sensor bending:

S1:
- encapsulated sensors
- top kaption positioning by hand





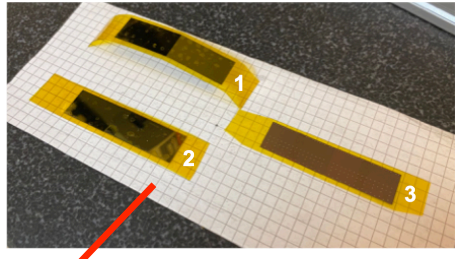


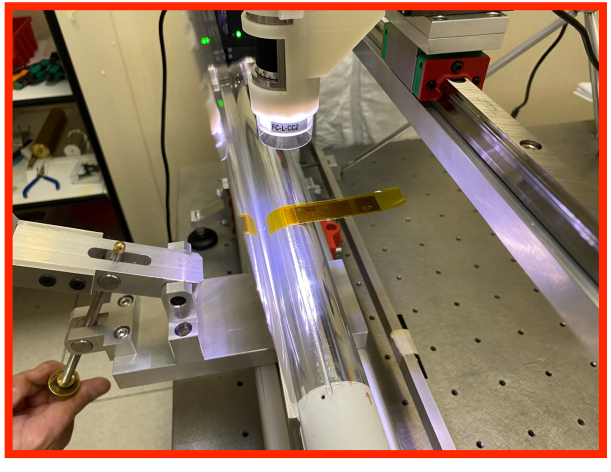


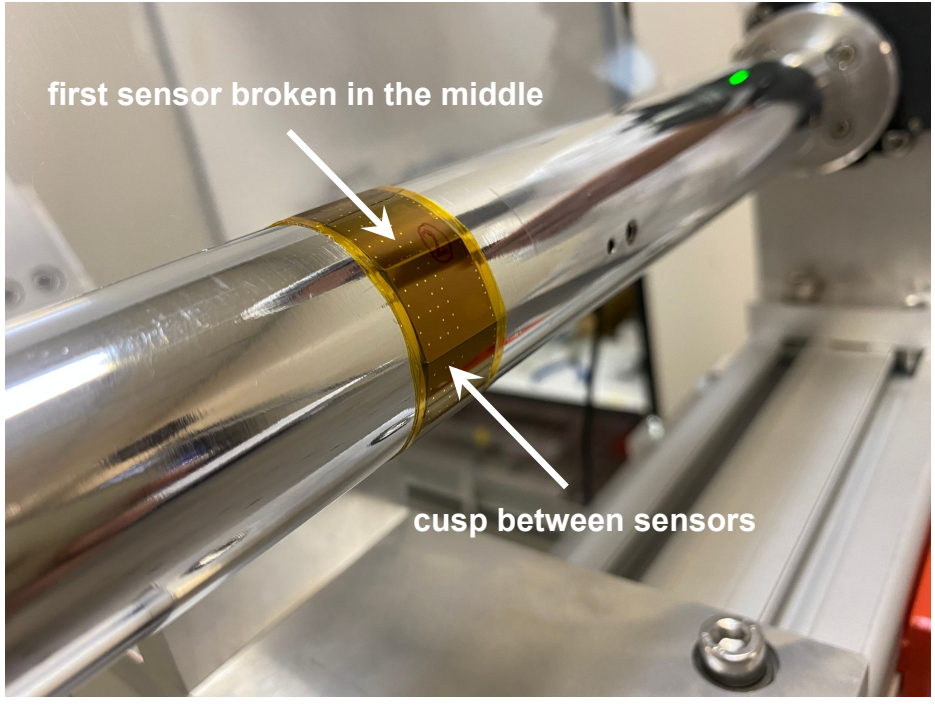
Sensor encapsulation and bending

- encapsulated sensor bending:

S2:
- encapsulated sensors
- top kaption positioning by dedicated tool



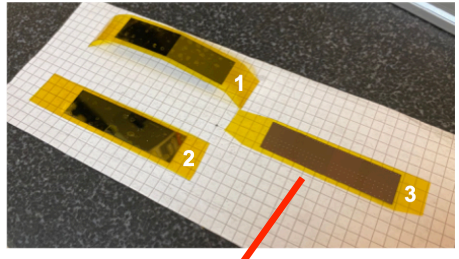


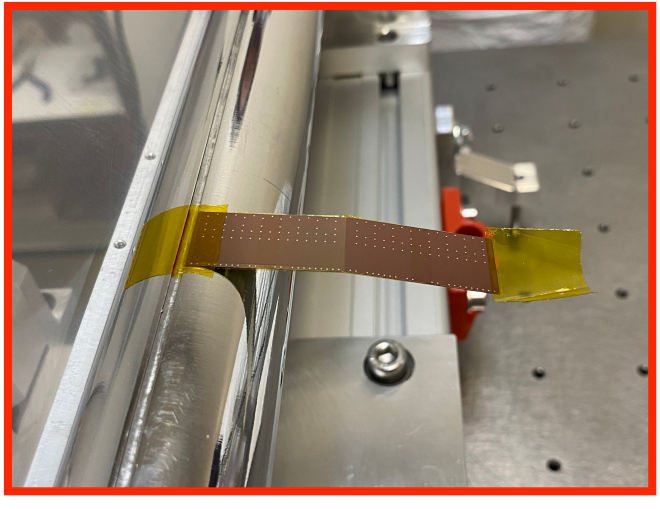


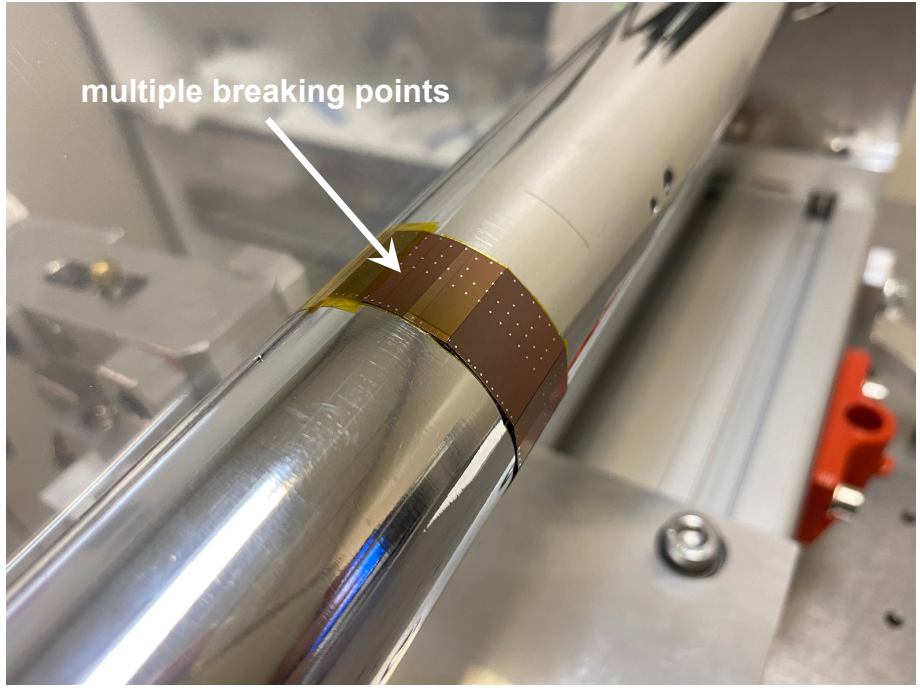
Sensor encapsulation and bending

- encapsulated sensor bending:

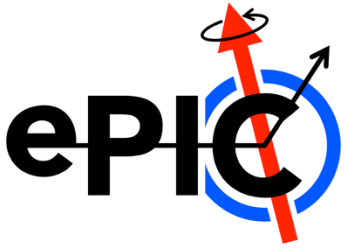
S3:
- single kapton sample







Sensor encapsulation and bending



First tests performed in clean room @INFN Bari:

- sensor encapsulation in kapton adhesive tape
- encapsulated sensor bending

Conclusions:

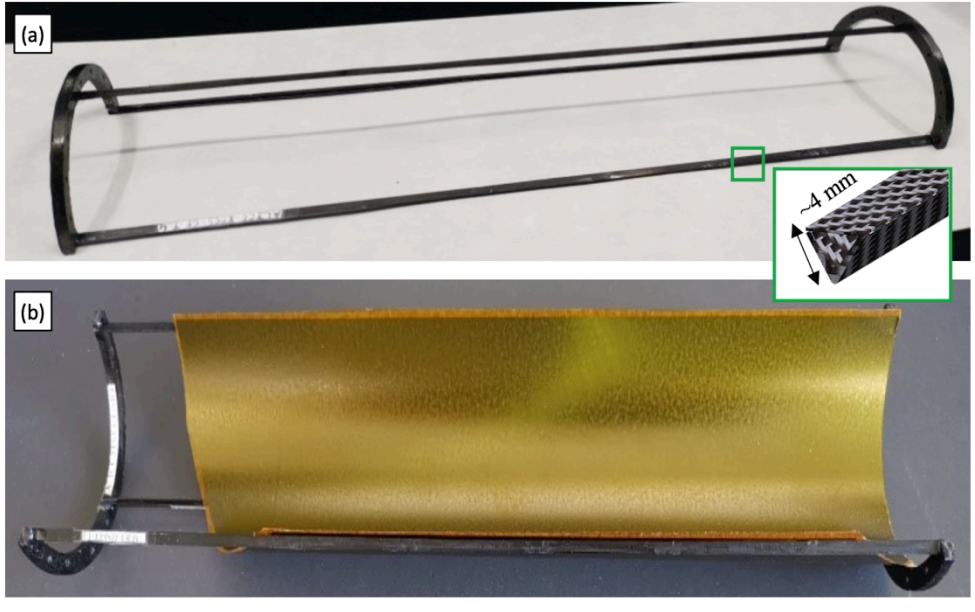
- encapsulation:
  - ✓ excercised precise positioning of kapton and sensors (precisions ~10 μm)
  - ✓ better ideas of additional tooling needed for large sensors / kapton foils → design ongoing
- bending:
  - ✓ (re-)excercised bending procedure used for ITS3 superALPIDE prototypes
  - ✓ understood additional tooling needed (both for ITS3 and SVT)
  - ✓ need SVT dedicated setup (including new mandrel) → design/fabrication/procurements ongoing
  - ✓ 100 μm sensors too thick for bending tests (independent of the encapsulation)
    - → need to switch to larger and thinner sensors (and larger adhesive kapton foils)
    - → ongoing, connected to procurements for thermo-mechanical prototypes (see Georg)

Local support structure

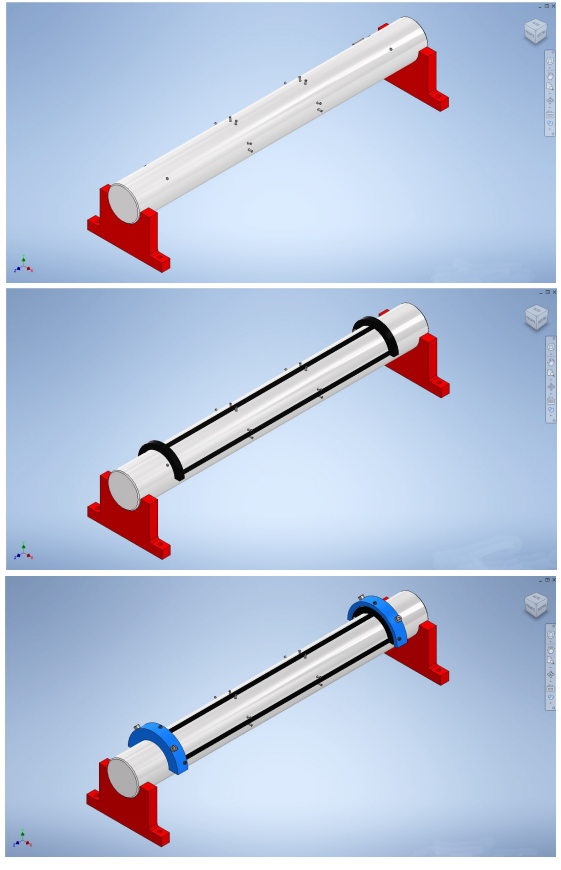
First design and printing of a light support structure:

- obtained by glueing 2 half-rings and 3 longerons

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



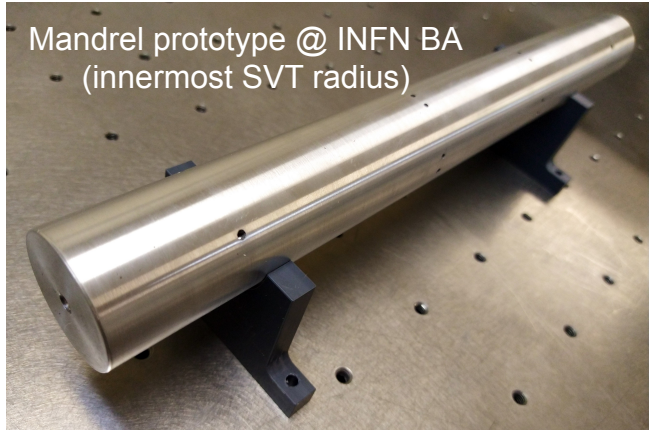
CAD @ INFN Bari



Local support structure

First design and printing of a light support structure:

- obtained by glueing 2 half-rings and 3 longerons
- 3-D printed in carbon addicted material
- (partially) in carbon foam for prototype assembly?



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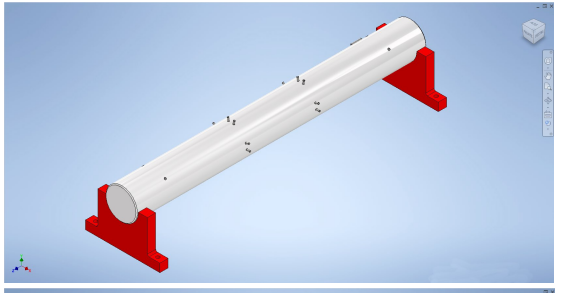

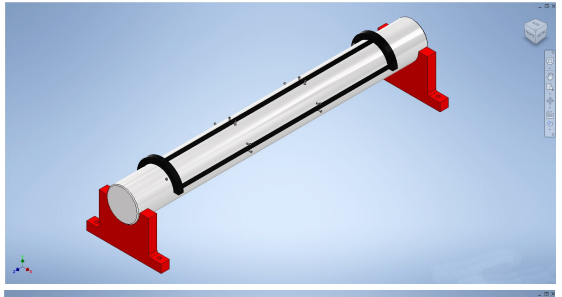

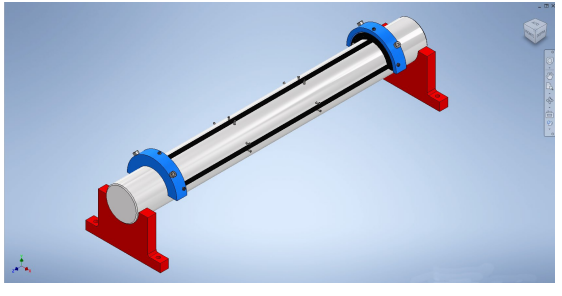

Next steps

Finalize bending tool design/production and layer assembly procedure

- material needs for R&D
  - ✓ naked silicon (common order to DISCO for IB, OB and DISKS) → ongoing
  - ✓ adhesive polyimide kapton foils (60 x 100 cm^2, 13 μm thick) → order submitted
  - ✓ 3-D printed support structures → design refinement ongoing, produced @ INFN BA
- dedicated SVT tooling and bending setup
  - ✓ tools for precise sensor/kapton positioning being modified → design ongoing
  - ✓ bending setup being duplicated → design+production @ INFN BA + procurements ongoing
  - ✓ mandrel → investigating high-quality prodution by a local agency (being tested, also for ITS3)

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Towards prototype assembly:

- final goal:
  - ✓ single layer: heaters/encapsulated silicon supported by local mechanics
  - ✓ L0 and L1 layers connected by global mechanics
- material needs for prototype assembly:
  - ✓ encapsulated silicon/heaters → ongoing with CERN (in common for IB, OB and DISKS)
  - ✓ machined carbon foam → to be explored