SVT IB design update

- preliminary bending/assembly concept and setup preparation
- plans for (L0/L1) prototype campaign
- first design of global mechanics
- further activities on FPC, L2 and cooling
- action plan

Domenico Elia (INFN Bari)
for the SVT IB groups @ INFN, MIT and LBNL

IB preliminary assembly concept

First steps towards developing 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**

Initial idea of embedding sensors in kapton layers seems not optimal:

- additional material budget
- quite sizeable R&D effort compared to the expected timeline

(some developments ongoing for ITS3, worth following them anyway)

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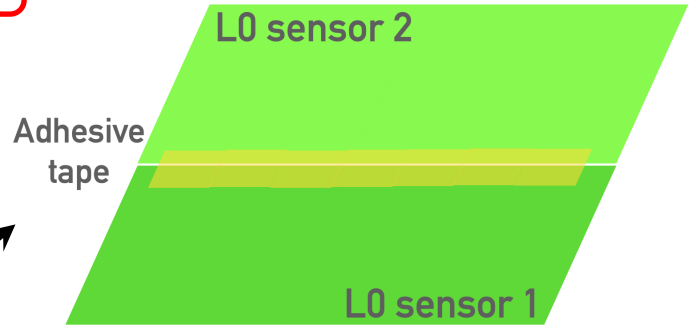


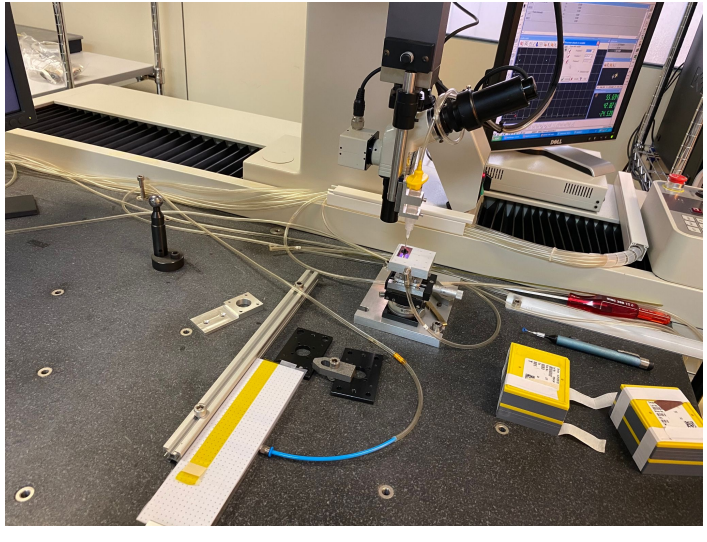
Kapton-tape connection between sensors currently being evaluated/excercised

IB preliminary assembly concept

First steps towards developing SVT IB concept:

- required upgrade of the bending setup:
  - ✓ preliminary SVT-dedicated setup being assembled @INFN Bari
    - most of the components already available (procurements + local production)
    - external contact for high-quality mandrel in place (successful production for ITS3)

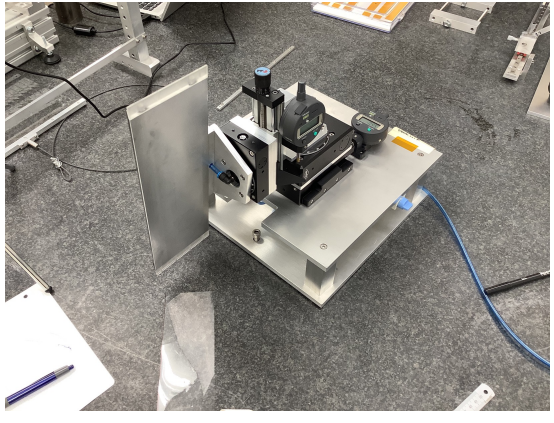
Mitutoyo machine equipped with alignment vacuum tool

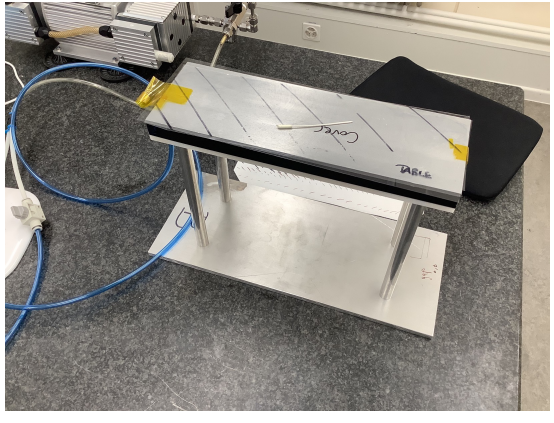


IB preliminary assembly concept

First steps towards developing SVT IB concept:

- required upgrade of the bending setup:
  - ✓ some tools need specific (re-)design to allow further tests already planned:
    - on real-size components (silicon dummies being produced → see later in these slides)
    - oriented to verify if 2-sensor bending (→ half-barrel assembly) works
  - → eg most of the vacuum holder tools need to be enlarged (accommodate 2 sensors)
  - → CAD designs (also for mandrels) almost finalized, production will start soon (@INFN Bari)

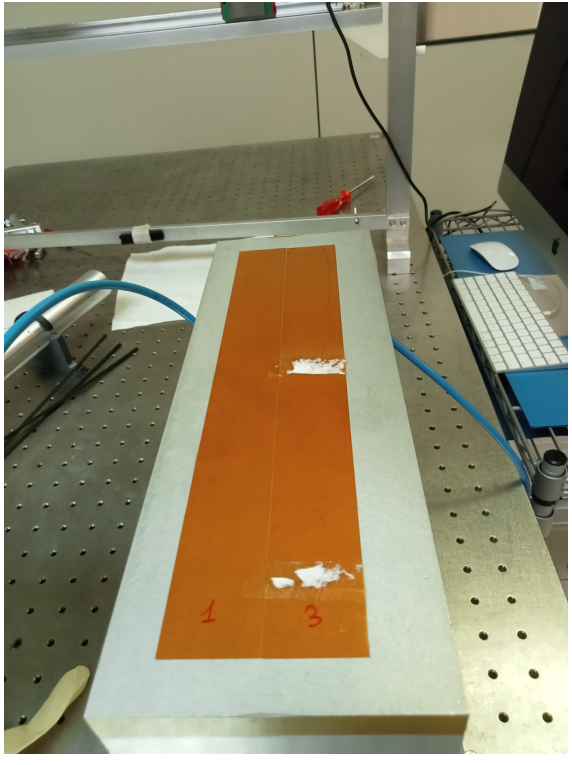




IB preliminary assembly concept

First steps towards developing SVT IB concept:

- what can be done meanwhile to exercise the procedure:
  - ✓ use existing ITS3 setup and available material (no silicon dummies yet):
    - kapton foils, 200 mm x 300 mm, 50 um thick
    - adhesive kapton tape
    - one of the preliminary mandrels with R ~ 18 mm (i.e. half of the SVT L0 radius)
  - → precise cutting of kapton to produce 2 objects that can mimic 2 “half-sensors” of ITS3 L0 (30 mm x 270 mm)
  - → exercise precise positioning of the 2 fake-sensors and the adhesive tape connection between them
  - → use tooling and mandrel to bend the 2 objects as a single one, as we would do for true silicon sensors, to understand if we need to revise procedure/setup etc



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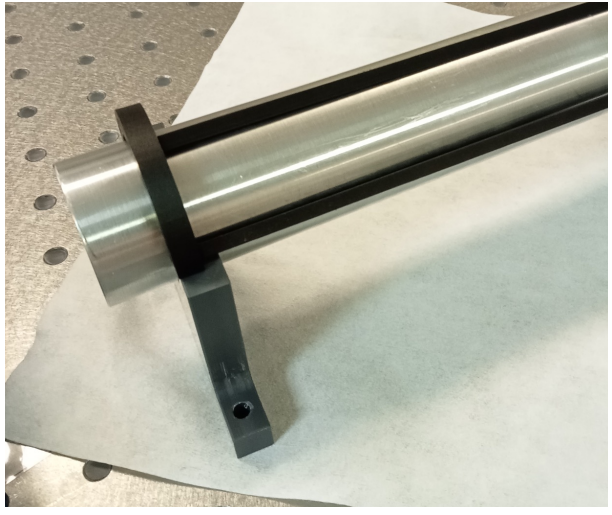
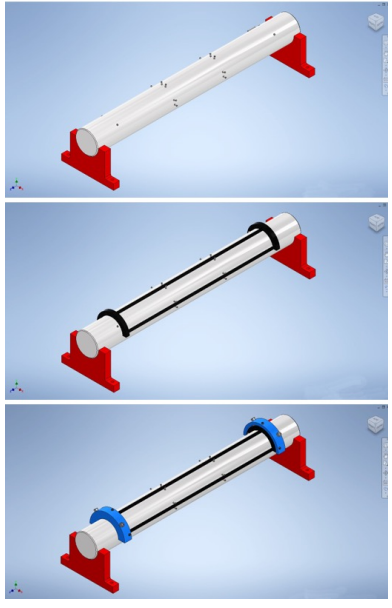
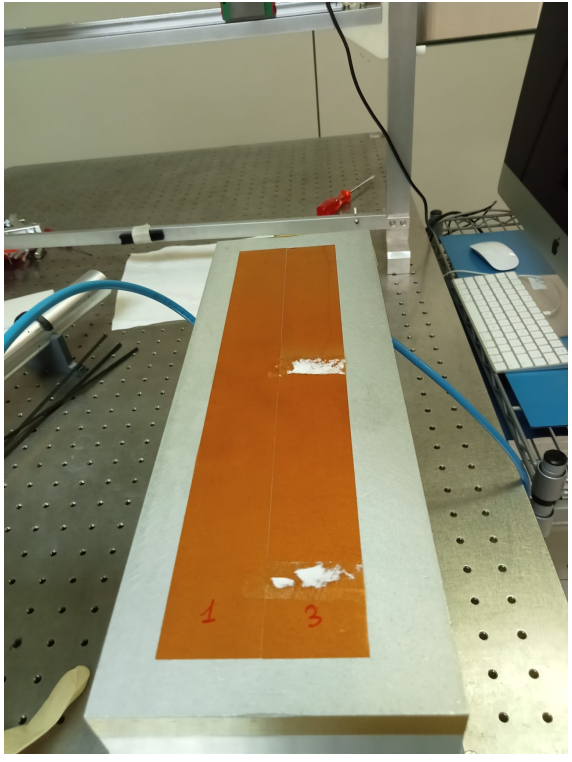






  - ✓ aim to complete exercise with glueing local support

IB prototype production plan

Tentative sequence for L0-L1:

Prototype	Components	Goal	Date
IBL01_P1	• 2 naked silicon L1 sensors • L1 local support structure (3-D printed) • outer support shell/frame (machined in PEEK)	• finalize half-layer assembly procedure	2024/10
IBL01_P2	• IBL01_P1 • 2 naked silicon L0 sensors • L0 local support structure (3-D printed)	• finalize half-barrel assembly procedure	2024/10
IBL01_P3	• 2 naked silicon L1 sensors • L1 local support structure (carbon foam) • outer support shell (carbon fiber, to be defined)	• thermal chamber test	2024/11
IBL01_P4	• IBL01_P3 • 2 naked silicon L0 sensors • L0 local support structure (carbon foam)	• thermal chamber test	2024/11
IBL01_P5	• 2+2 silicon L0+L1 sensors with heaters • L0+L1 local support structures (carbon foam) • outer support shell (carbon fiber, to be defined) • air distribution inlet & outlet (to be designed) • PT1000 sensors (to be glued on heater surface)	• wind tunnel test	2024/12

IB prototype production plan

Tentative sequence for L0-L1:

First half-layer and half-barrel: requires dummy silicon sensors from DISCO also to validate 2-sensor connection and bending, design local support structure, external shell etc

First half-layer and half-barrel for themal chamber test: requires dummy silicon sensors from DISCO but also

- carbon foam local support (procurement and machining to be defined)
- carbon fiber outer support shell (to be defined if needed and eventually designed → some simulation studies needed, procurement and machining to be defined)

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

First half-barrel for wind tunnel test: requires dummy silicon sensors with heaters from CERN but also

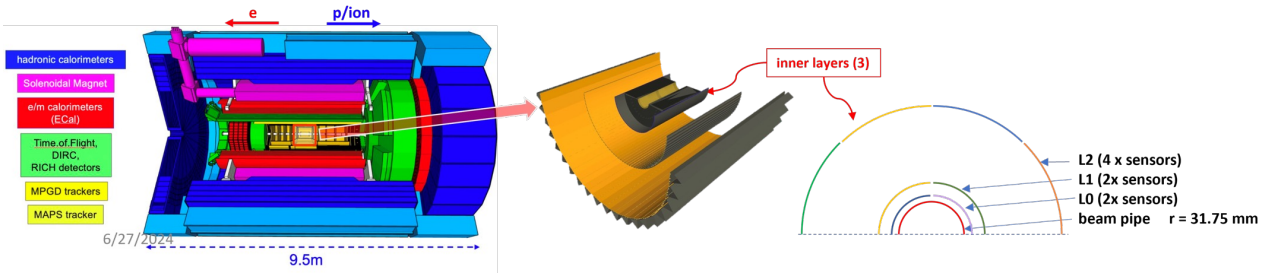
- air distributors (to be defined if needed and eventually designed/produced)
- could eventually benefit of some preliminary FPC (mechanical) prototype (check of volumes, transport etc)
- transport issues to wind tunnel facility

IB prototype production plan

On the critical path:

- dummy silicon sensor available:
  - ✓ P1-2: validate bending, then half-layer and -barrel assemblies
  - ✓ P1-4: asses if local support structure can made half-layer/barrel self-standing (no external shell)
- carbon foam:
  - ✓ procurement and machining need to be defined
  - ✓ P3-5: asses if local support structure can made half-layer/barrel self-standing (no external shell)
- simulation:
  - ✓ P1-5: understand if outer supporting shell is thermally needed (confine volumes)
  - ✓ P1-5: understand if outer supporting shell is mechanically needed
- carbon fiber shell(s)
  - ✓ if needed (see previous points), procurement and machining need to be defined
- L2 prototyping
  - ✓ needs to be planned and added to L0-L1 prototypes, discussion ongoing
  - ✓ to be eventually matched to global mechanics mock-up for a full IB prototype

First design of global mechanics

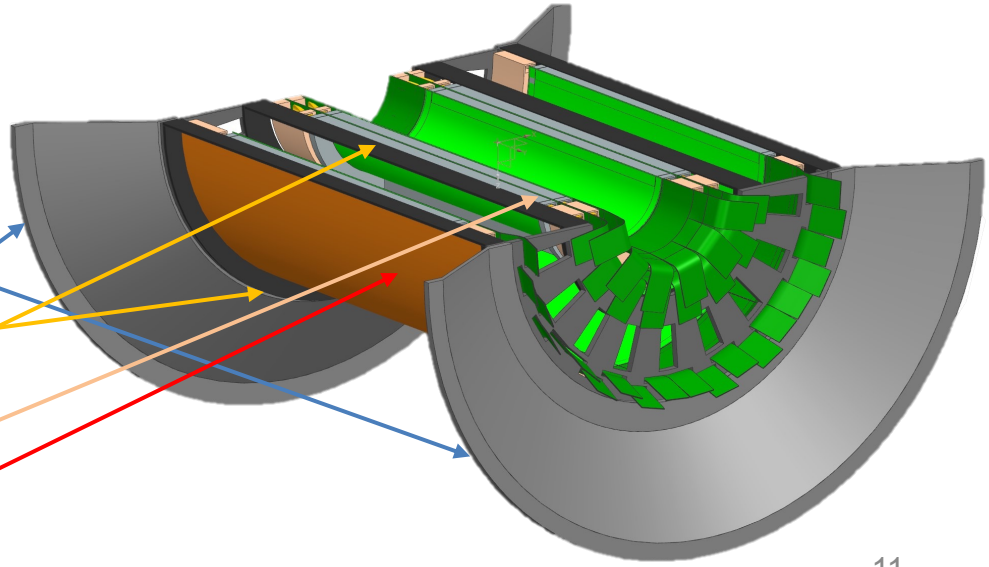


Updated radii from ITS3 TDR sensor size + 0.5 mm spacing between sensors
L0 → r = 37.5 mm
L1 → r = 50 mm
L2 → r = 125 mm

Development ongoing @INFN PD

Material of the support: likely, carbon fiber composite (CFC)

- Half-cones to support IB and connect to OB
- Frame to support the sensors on the (RVCF?) half-rings and longerons
- Cable ducts (CFC?)
- Light-material wall (kapton?) to protect L2 and minimize X/X_0 in the sensitive area

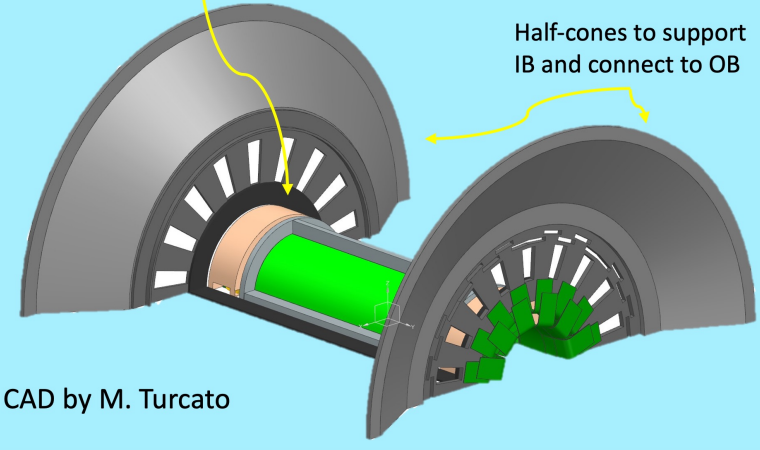


First design of global mechanics

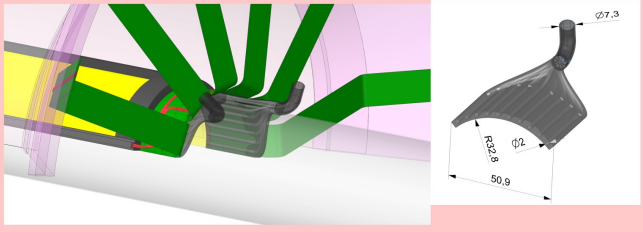
L0+L1 on global support

Frame to hold the half-rings and longerons supporting the sensors

Half-cones to support IB and connect to OB



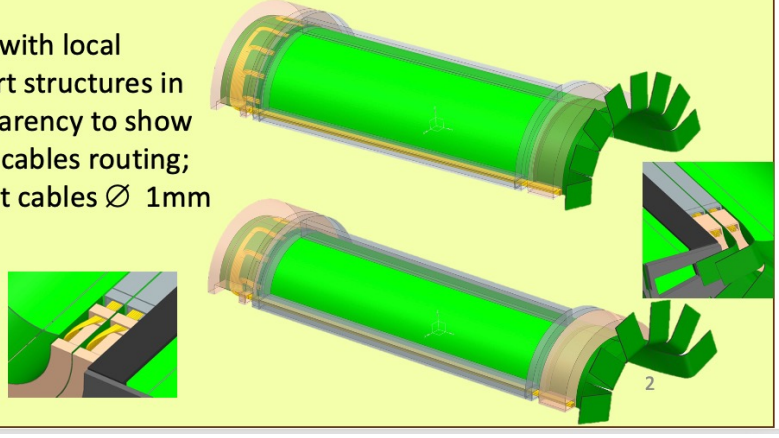
CAD by M. Turcato



A first guess of air flow collector between L0 and L1

n.b. in this drawing the collector is *below* L0 – drawing being updated

L0+L1 with local support structures in transparency to show e-side cables routing; current cables ∅ 1mm



First design of global mechanics

Summary of activities and plans in Padova:

- CAD model of global IB support development
  - tight contact with MIT for L2 integration
- Production of mock-ups for various tests, mainly assembly and integration procedures
  - First 3D print after summer break, for a ‘’first-guess” assembly test
- FEA thermal analysis started – reference for mechanical model refinement after verification on mock-up with heaters
- Procedure developed for CAD → GEANT4 translation (two PhD students) to cross-check material choices with thickness maps
- Mitutoyo measuring machine available in clean room for mechanical survey
- Full procedure from flat sensor to L0+L1 on final support to be implemented locally, as a second production center (with INFN-Bari)
  - Main challenge: procurement of wire-bonder, but gathered interest from a few projects available to co-funding (under discussion)

Team of this work: M. Benettoni, P. Rebesan (engineers), M. Turcato (CAD designer), R. Turrisi

- In collaboration with INFN-Bari
- In view of assembly and mock-ups/support production 2 el.+2 mech technicians will join (not full FTE)

Furter activities and plans

IB FPC design @Daresbury STFC (Marcello B.):

- Received mechanical model from Padova for L0 and L1
  → import mechanical shape into Cadence Allegro, to start;
- Scheduled presentation from RPTE LTU on WP3 meeting on 11/07
  → RPTE LTU to present existing work on Al-FPCs for bent sensors;
- Several tests on the low TRL OB FPC prototypes made by RPTE LTU
  → synergetic with IB FPC
- To meet with INFN Trieste (Mino C.) to grow effort
  → confirmed interest from Trieste on:
  ✓ collaboration with Daresbury LAB and SVT WG3/4 for FPC design adaptation from ITS3 version to the SVT constraints and characteristics
  ✓ SVT FPC prototyping and qualification tests
  ✓ production quality control

Tentative timeline for prototypes:

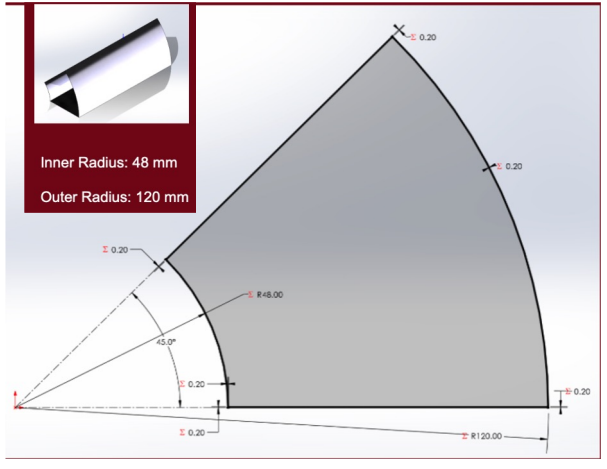
→ first mechanical prototype designed: ~end August

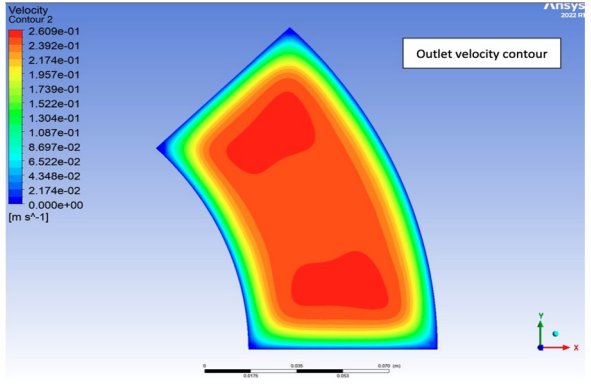
→ first prototype realized: ~October/November (depending of flux of info from CERN, etc)

Furter activities and plans

Activity on L2 @MIT (Ivan, Camelia et al):

- ANSYS studies (Tricia Smith)
  a. Working on implementing a realistic geometry, and testing the base setup
  b. In contact w/ LBNL/Nikki:
    i. they have already an ANSYS sim established for beam studies
    ii. need to decide how much overlap on the studies to aim for (for sanity checks, but also for efficient use of time)
- Mechanics
  a. Thinking ways to decouple local mechanics from cooling
  b. Two approaches being considered:
    a. L2 attaches to the external shell
    b. L2 holds on L1
    c. Both approaches needs to be validated vs mechanical stability and cooling
    d. In contact w/ Domenico/Rosario
      i. to understand and define some boundary conditions about cooling, in order to think further about mechanics of L2, e.g: where we should expect the air to come from and how (horizontal, at an angle, flux or diffusion)
- Prototyping phase can be started only after have conceived the mechanical structure to keep in place the 4 L2 modules





Furter activities and plans

Activities on L2 and SVT IB cooling simulation:

- MIT
  - design of the external layer L2, including local mechanics and wire-bonding to FPCs
  - ANSYS-based simulations for cooling (in collaboration with LBNL)
  - contribution/setting-up wind tunnel facility and tests for the whole IB (in collaboration with LBNL)
- LBNL
  - ANSYS-based simulations for cooling (in collaboration with MIT)
  - contribution/setting-up wind tunnel facility and tests for the whole IB (in collaboration with MIT)
  - design of the cones connecting IB, OB and (first)DISKS
  - cooling design, study beam-pipe bake-out issues

Furter activities and plans

Next action items:

- proceed with design of local mechanics for L0-L1 by INFN BA (help from INFN PD)
  - ✓ currently working on bending and interconnection excercise with (kapton) dummies
  - ✓ plan for prototype campaign ready and starting
  - ✓ need to move to silicon dummies (including thermo-mechanical samples) asap
- proceed with design of local mechanics for L2 by MIT assuming external shell is present
  - ✓ contacts with INFN PD started
- proceed with design of global mechanics including external shell to L2 by INFN PD (via iterations/discussions with MIT)
  - ✓ currently working on global mechanics design
  - ✓ need interations for L2 and with OB/global-SVT mechanics/installation issues etc
- start thinking to connection of L0-L1 to L2 by INFN PD (in coll. with INFN BA and MIT)
- proceed with ANSYS simulation of IB by MIT and LBNL
  - ✓ need to cross-check with global integration?

Backup

Dummy sensor production

Georg V. @SVT general meeting January 31, 2024

Thermo-mechanical dummies for ALICE

- Corrado's ITS group has been using 40 µm thick silicon with a Kapton/Cu encapsulation to provide heating for the verification of design and air cooling for ITS3
  - Silicon supplied by DISCO HI-TEC EUROPE, Germany
    - Supplied as 12" wafers, diced to ALICE's specifications
    - Because they needed large sensors, but to make good use of the wafers included several dummies that have corners chopped off
    - Cost was EUR8800 for 14×12" wafers
  - Encapsulation has been done by Rui De Oliveira at CERN
    - Glue 2 layers of Kapton, 12µm Kapton with 5 µm copper on top, naked 12µm Kapton on the bottom - pattern the top copper to create a resistor.
    - Have contacted him already and he so far estimated a price of CHF7000
      - 2 off the inner layer sensors (approx. 60x270mm),
      - 2 off the middle layer (approx. 80x270mm)
      - 4 off the outer layer sensors (approx. 100x270mm).
      - 40 off approx. 20x110mm,
      - 12 off approx. 20x130mm
    - These would be delivered on 300×300 mm^2 foils (~8 off)

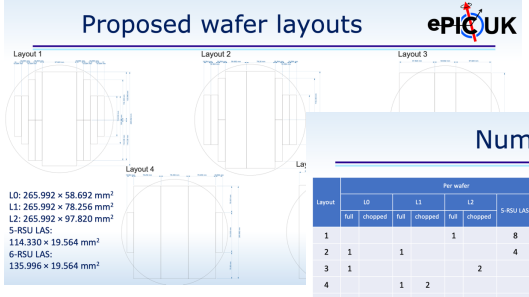
2

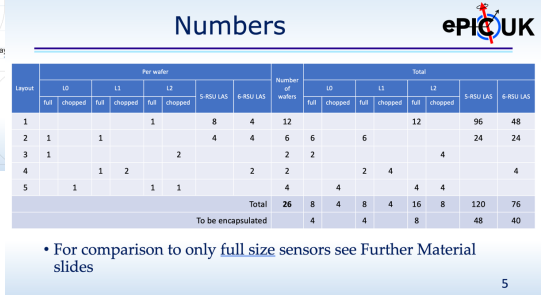
Dummy sensor production

Updated status and expected timeline:

- silicon dummies from DISCO (Nikki/LBNL):
  - ✓ updated cost: 19000 USD
  - ✓ needed to include DISCO within LBNL registered vendors (ongoing)
  - ✓ time estimate for shipping (diced and thinned wafers): not available yet, coming soon

- heater encapsulation from Rui de Oliveira @CERN (Domenico/INFN):
  - ✓ updated cost: 9000 CHF
  - ✓ need to submit order as soon as ready to go (no showstopper with INFN/CERN)
  - ✓ lead time estimate: 8 weeks





Layout	Per wafer								Number of wafers	Total							
	L0		L1		L2		5-RSU LAS	6-RSU LAS		L0		L1		L2		5-RSU LAS	6-RSU LAS
	full	chopped	full	chopped	full	chopped				full	chopped	full	chopped	full	chopped		
1					1		8	4	12					12		96	48
2	1		1				4	4	6	6		6				24	24
3	1				2				2	2				4			
4			1	2			2		2			2	4				4
5		1			1	1			4		4			4	4		
Total									**26**	8	4	8	4	16	8	120	76
To be encapsulated										4		4		8		48	40