SVT IB overview and plans

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

SVT IB @ workfest agenda

(This) Overview talk:

- ongoing activities and plans, involved groups
- plans for prototyping campaign
- preliminary construction timeline

Detailed activity reports:

- Bending and Assembly of the L0 and L1 layers @ INFN Bari (D. Colella)
- Progress on Inner Barrel mechanics design @ INFN Padova (R. Turrisi)

SVT IB interests & contributions

Latest figure @ April 2024 SVT general meeting:

- 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)

SVT IB interests & contributions

Specific activities from design to contruction:

- INFN:
  - ✓ L0 & L1 concept/prototyping/construction (should include bending, wire bonding, testing etc.)
  - ✓ IB global mechanics design/prototyping/production
  - ✓ ER2/3 sensor test and characterization
  - ✓ ageing tests in climate chamber
  - ✓ IB FPC prototyping/qualification/production quality control
- MIT:
  - ✓ L2 concept/prototyping/contruction (same as above for L0 & L1)
  - ✓ wafer probing of sensors
  - ✓ ANSYS-based simulations
  - ✓ wind tunnel development and related tests
- LBNL:
  - ✓ cooling → prototypes and simulation, air inlet & outlet, beam-pipe bake-out, wind tunnel tests
  - ✓ service cones and how they connect to IB & first disc
  - ✓ interest in entire IB design & construction as well → workforce to be checked, alsot to be fit in with other efforts
- STFC:
  - ✓ IB FPC design/prototyping, possible interest in production

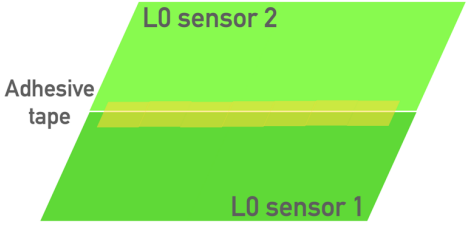
Ongoing activity and plans @INFN

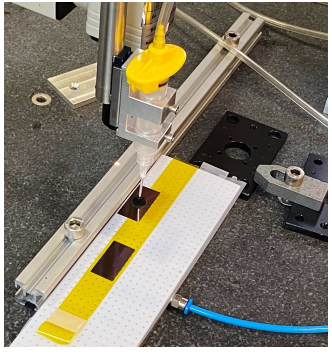
More in **D. Colella's** presentation

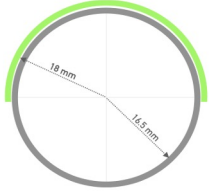
INFN BARI:

- Design, prototyping and construction of SVT L0-L1 barrel:
  - ✓ exploiting experience with bending and interconnection for ITS3
  - ✓ investigating two possible bending/assembly strategies:
    - ✓ **2-sensor bending**: try to "connect" the two sensors with kapton tape and bend them as a single object
    - ✓ **independent bending**: bend each of the two sensors separately and glue them on independent support structures

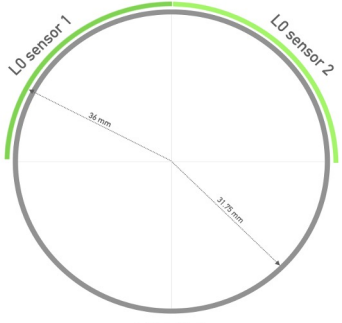
half-layer based assembly (a la ITS3)





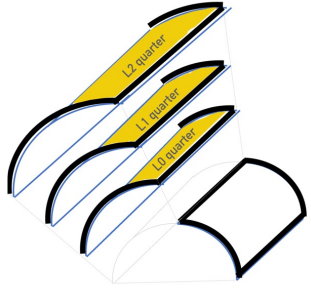


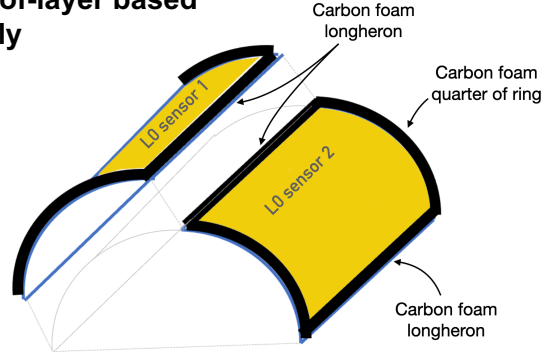
ITS3-L0



SVT-L0

quarter-of-layer based assembly





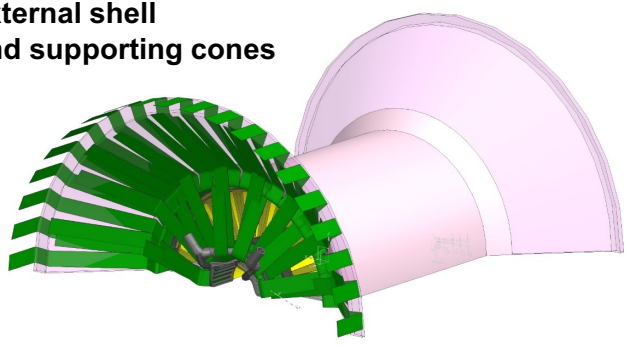
Ongoing activity and plans @INFN

More in **R. Turrisi's** presentation

INFN PADOVA:

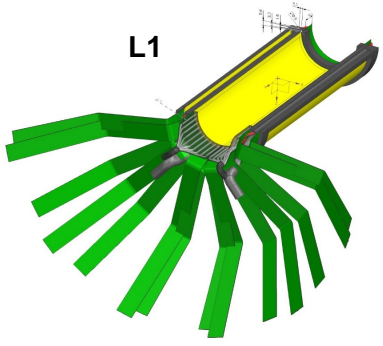
- Developing CAD model of global IB support development
  - tight contact with MIT for L2 integration
- Production of mock-ups for various tests, mainly assembly and integration procedures
  - First 3D print after summer break, for a ''first-guess'' assembly test
- FEA thermal analysis started – reference 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

external shell and supporting cones

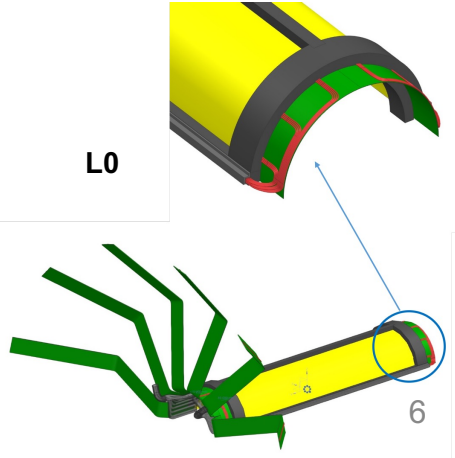


CAD design by M. Turcato

L1



L0



Ongoing activity and plans @INFN

INFN PAVIA:

- Setting up for tests in a climatic chamber Galli Genviro-030LC:
  - ✓ used in the past for ageing tests of ALPIDE chips assemblies for ALICE ITS2
  - ✓ plan to use it for checking possible deterioration of the SVT inner layer assemblies (including prototypes) in conditions of controlled/high temperature and/or humidity

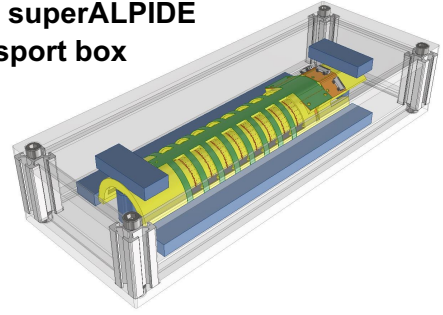
inner volume	30 liters
inner dimensions	330 x 280 x 330
temperature range	-70 °C ÷ +180 °C
humidity range	10% ÷ 98%
temperature precision	± 0.1 °C ÷ ± 0.3 °C
temperature uniformity	± 0.5 °C ÷ ± 1.5 °C
humidity precision	± 1 ÷ ± 3 %
temperature gradient	± 3 °C/min
internal heat dissipation	100 W
power	1.4 ÷ 2.4 kW

Ongoing activity and plans @INFN

INFN PAVIA:

- Setting up for tests in a climatic chamber Galli Genviro-030LC
- Starting on design and production of transportation boxes:
  - ✓ to be used for transport of SVT inner layer assemby prototypes in Italy and final detector assemblies in US → different prototypes will be needed along the various phases
  - ✓ two options currently under discussion:
    - plexiglass box where detectors are kept still by foam sponge
    - box similar to that for ALICE ITS2 OB staves, smaller in size

ITS3 superALPIDE transport box



ITS2 OB stave transport box:

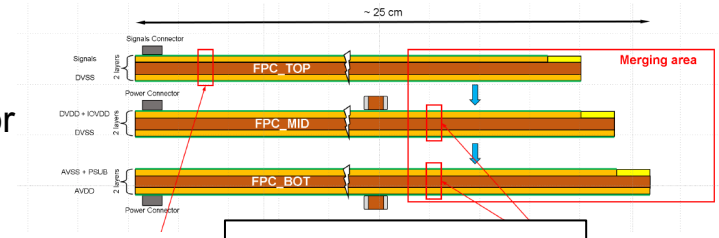
- wire ropes recommended to achieve about 10 Hz cut-off frequency
- arbitrary low acceleration can be achieved at the cost of space: about linear in average acceleration

Ongoing activity & plans @INFN

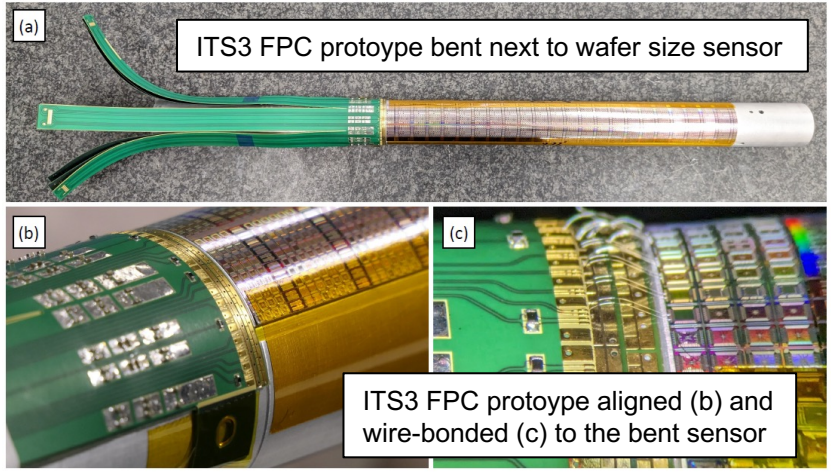
INFN TRIESTE:

- Startintg activity on SVT IB FPC:
  - ✓ in collaboration with Daresbury LAB and SVT WGs for FPC design adaptation from ITS3 version to the SVT constraints and characteristics
  - ✓ SVT FPC prototyping and qualification tests
  - ✓ production quality control
- Existing expertise from ITS2 OB FPCs:
  - ✓ definition of production specifications
  - ✓ vendor search and production tendering
  - ✓ qualification tests
  - ✓ final integration with power bus
  - ✓ vendor search and quality assurance

ITS TDR: CERN-LHCC-2024-003



ITS3 FPC layer stack-up



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;
- Presentation from RPTE LTU within 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:

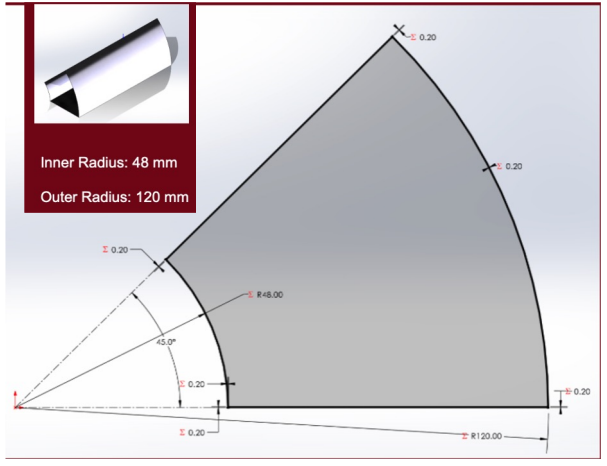
→ first mechanical prototype designed: ~end August

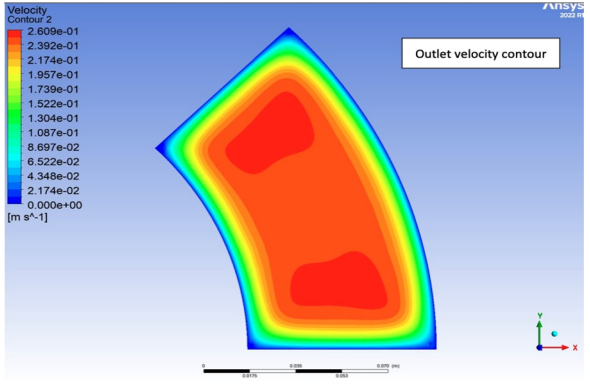
→ first prototype realized: ~October/November (depending of flux of info from CERN, etc)

Furter activities and plans

Activity on L2 @MIT (Ivan C. 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 need to be validated vs mechanical stability & 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

Need to check currently available workforces both at MIT and LBNL

→ changes in manpower availability @MIT need to be discussed in the project and if needed planning has to be adapted accordingly asap

Prototype production plan

Tentative sequence for L0-L1:

More in **D. Colella's** presentation

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

Prototype production plan

Update on dummy production:

- silicon dummies from DISCO (Nikki/LBNL):

G. Viehhauser

Layout	Per wafer (full/chopped)					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
1	1/2	1/-				8	8	16	8							
2	-/1		1/1			8		8			8	8				
3	-/1	-/1	1/-			8		8		8	8					
4				8/2	8/2	8							64	16	64	16
Total						**32**	8	32	8	8	16	8	64	16	64	16
To be encapsulated							4		4		8		48		40	

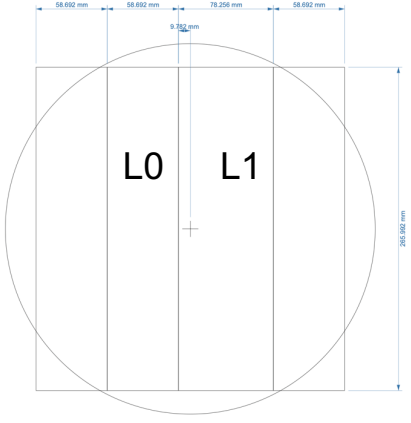
Prototype production plan

Update on dummy production:

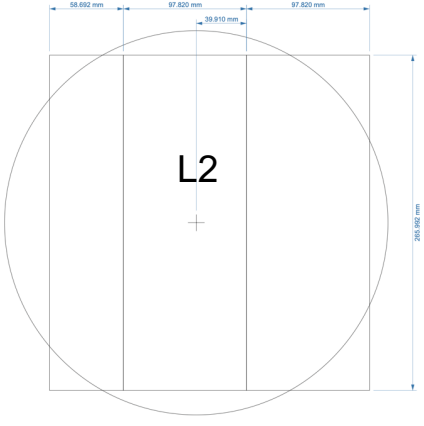
- silicon dummies from DISCO (Nikki/LBNL):
  - ✓ total cost (diced and thinned wafers): ~19000 USD
  - ✓ needed to include DISCO within LBNL registered vendors
  - ✓ wafers arrived 2 weeks ago @LBNL
  - ✓ fraction to be sent at CERN (heater encapsulation) agreed
  - ✓ shipped at CERN, arriving before this next weekend

- 1st wafer box containing (all to be encapsulated):
  - 4 wafers of layout 2
  - 3 wafers of layout 3
  - 6 wafers of layout 4
- 2nd wafer box containing:
  - 1 wafer of layout 3 (to be encapsulated)
  - 8 wafers of layout 1
    - 4 to be encapsulated
    - 4 for INFN

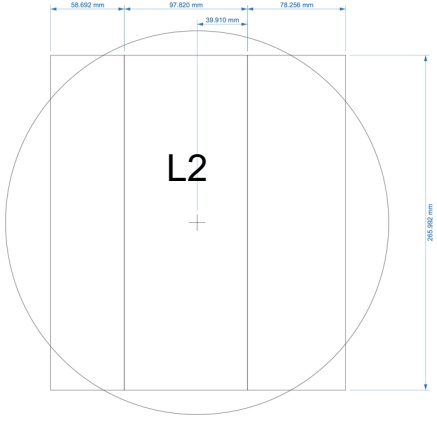
Layout 1



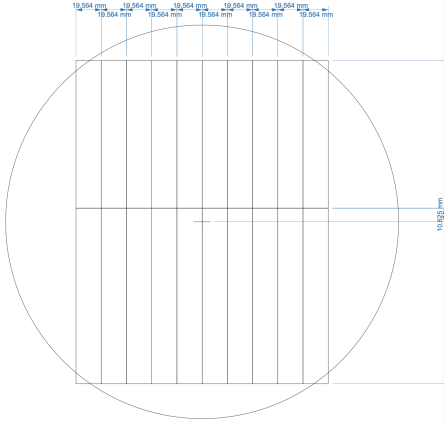
Layout 2



Layout 3



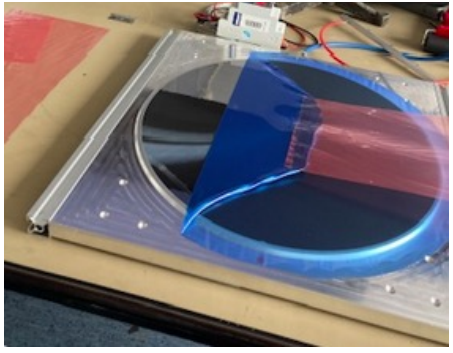
Layout 4

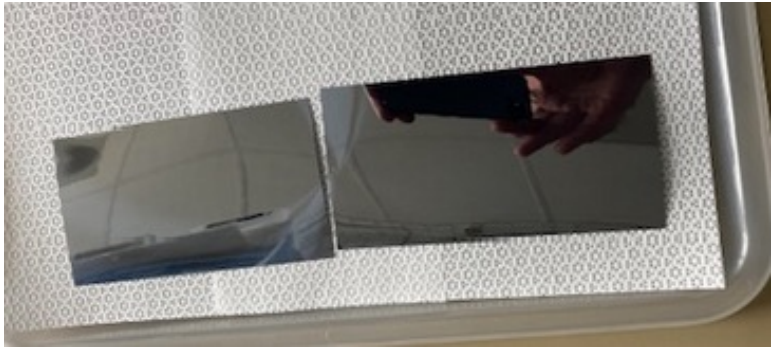


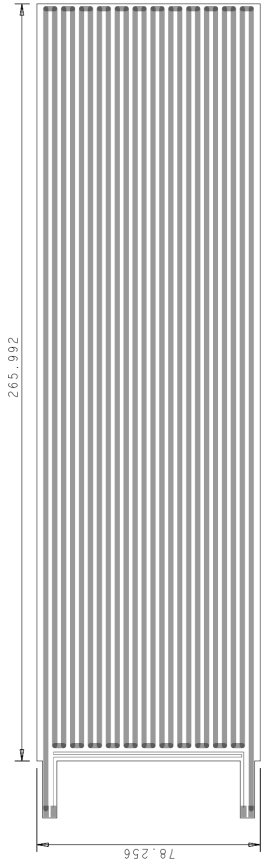
Prototype production plan

Update on dummy production:

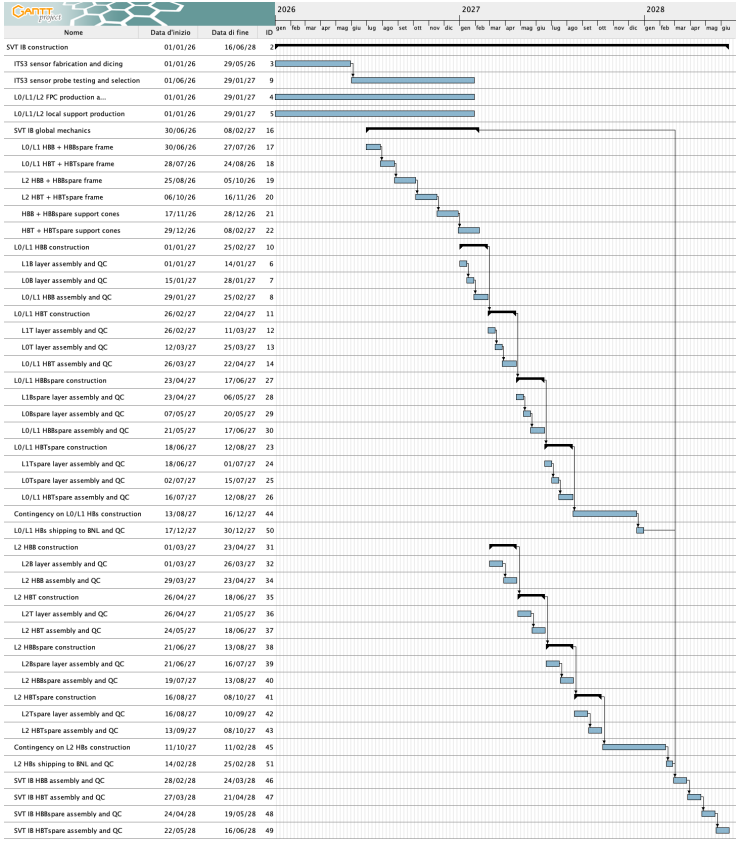
- heater encapsulation from Rui de Oliveira @CERN (Domenico/INFN):
  - ✓ cost: ~9000 CHF
  - ✓ lead time estimate (end April): 8 weeks → to be re-checked with Rui
  - ✓ unexpected step: need to peel-off silicon from wafer boxes
  - ✓ agreed with them a technician from Bari will do it at CERN last week of August
  - ✓ almost 50 boxes needed, currently being procured via CERN
  - ✓ material to Bari by beginning Sept. (no encapsulated L0, L1 & chopped samples)
  - ✓ material to Rui to start encapsulation by end of August







Preliminary construction plan



Main ingredients:

- start: middle 2026 (constrained by ER3 sensor selection)
- global mechanics production: ~5 months
- 4 L0-L1 HBs (2 + 2 spares) considered in the plan
  - each HB assembly: ~40 days
  - final contingency: ~3 months
- 4 L2 Layers (2 + 2 spares) considered in the plan
  - each L2 Layer assembly: ~40 days
  - final contingency: ~3 months
- shipping to BNL and assembly 4 IB HBs: ~4 months
- end: middle 2028
- commissioning to be added

First discussion within the SVT IB groups ongoing

To be integrated in the SVT global plan