Giornate Nazionali EIC_NET

27-28 Giugno 2024

INFN in-kind contribution to SVT IB

Domenico Elia

for the SVT INFN groups (BA, PD, PV and TS)

Outline

- detector layout and concept
- SVT DSC: institutions, interests, organization
- SVT project timeline
- INFN involvement: R&D activity and construction plans
- INFN in-kind contribution and proposed funding profile

INFN in-kind contribution to SVT IB

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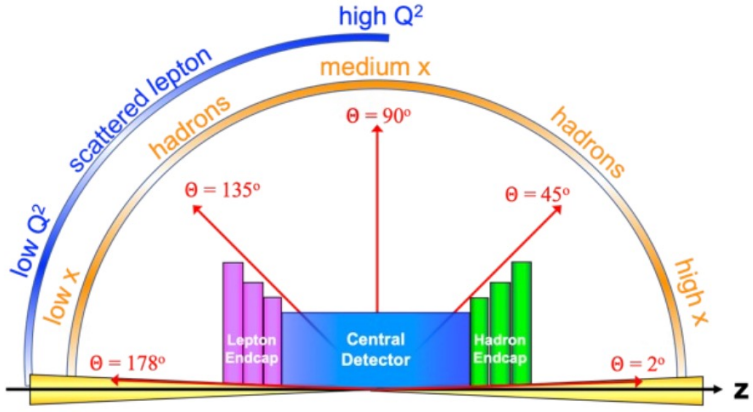
for the SVT INFN groups (BA, PD, PV and TS)

SVT layout and concept

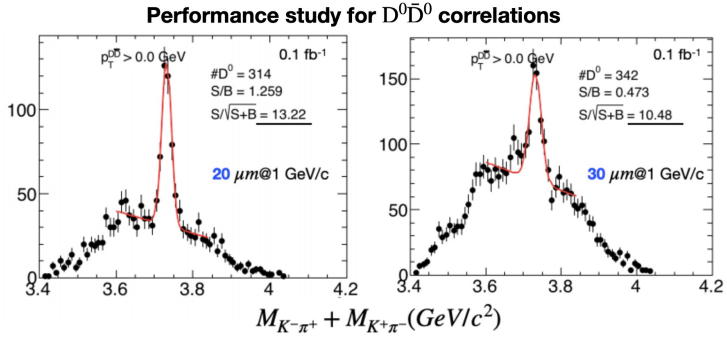
Performance requirements:

- https://eic.jlab.org/Requirements/index.html
- based on physics in the Yellow Report

Find more in the talk by **Shyam Kumar**



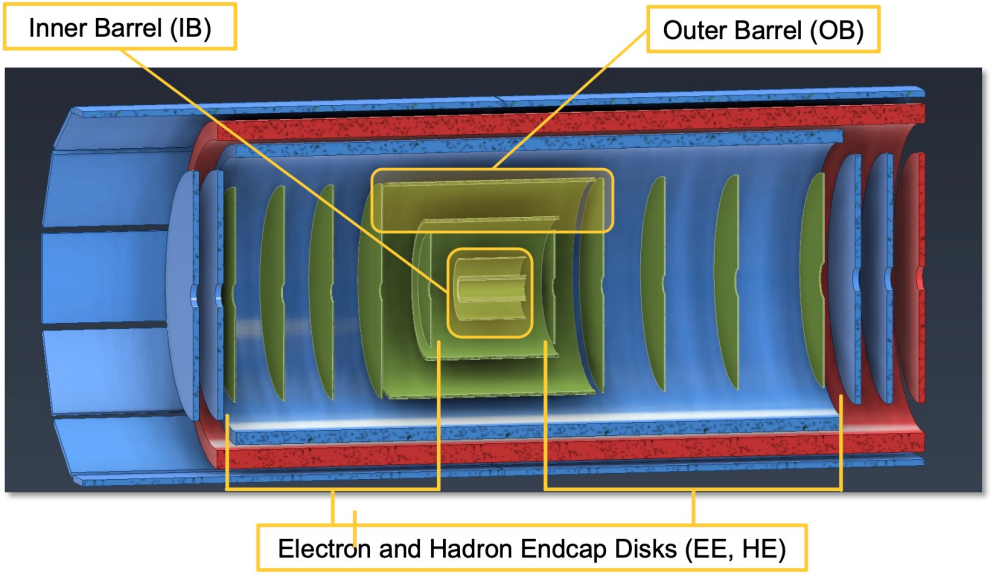
	Momentum Resolution	Spatial Resolution
Backward (-3.5 to -2.5)	~0.10%×p⊕2.0%	~ 30/pT μm ⊕ 40 μm
Backward (-2.5 to -1.0)	~ 0.05%×p⊕1.0%	~ 30/pT μm ⊕ 20 μm
Barrel (-1.0 to 1.0)	~0.05%×p⊕0.5%	~ 20/pT μm ⊕ 5 μm
Forward (1.0 to 2.5)	~0.05%×p⊕1.0%	~ 30/pT μm ⊕ 20 μm
Forward (2.5 to 3.5)	~0.10%×p⊕2.0%	~ 30/pT μm ⊕ 40 μm



SVT layout and concept

Three main sub-systems:

- **Inner Barrel (IB)**
  - ✓ 3 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)**
  - ✓ 2 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)**
  - ✓ 2 arrays with 5 disks each
  - ✓ X/X_0 ~0.25% per disk
  - ✓ More conventional structure



Lengths L2 → L4 increase so as to project back to z = 0; disk radii adjust accordingly

SVT layout and concept

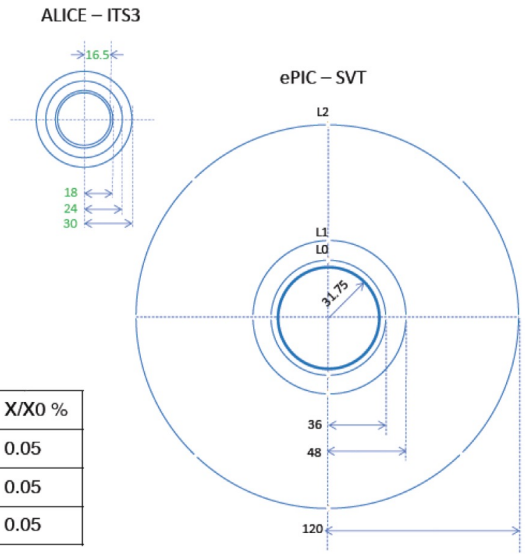
Basic assumptions for the IB:

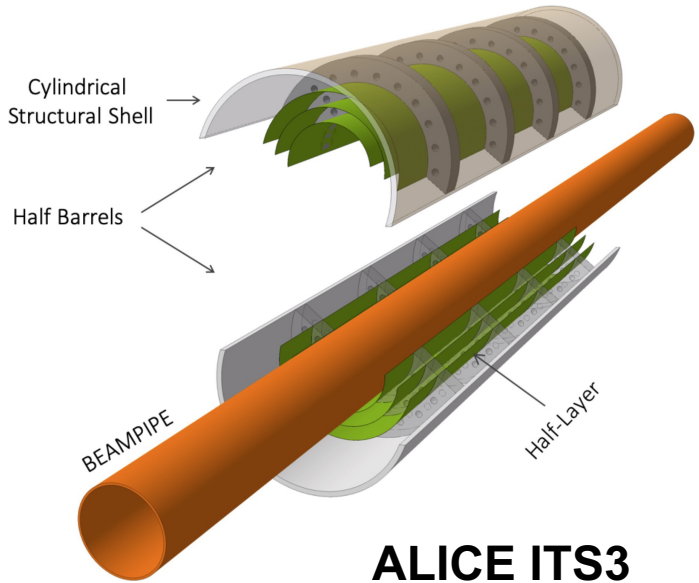
- use the ALICE ITS3 wafer-scale sensor
- adapt ITS3 detector concept to the (larger) ePIC radii

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

- 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

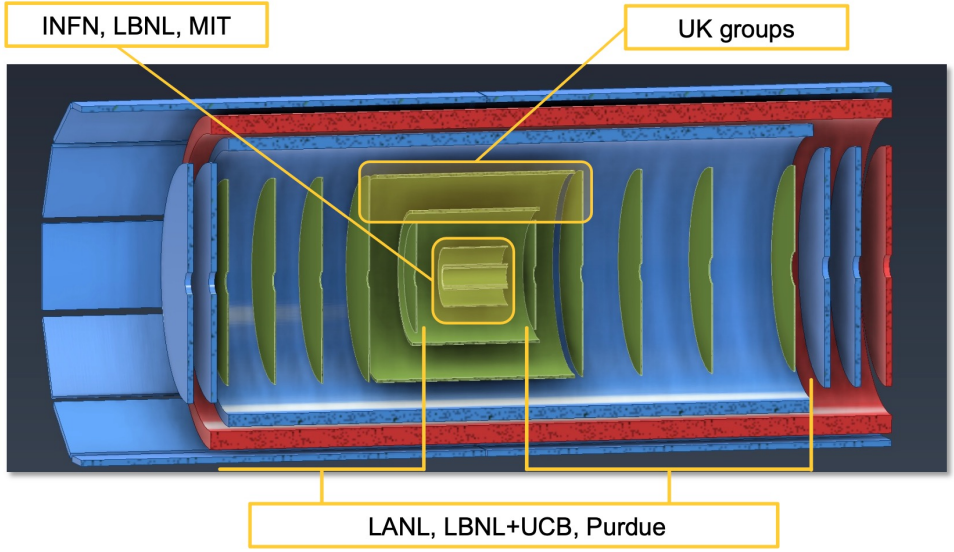
Detector Subsystem Collaboration

SVT DSC participating institutions:

Extensive Si-detector experience in the ALICE, ATLAS, CMS, sPHENIX, STAR collider experiments

Detector Subsystem Collaboration

SVT DSC institutional interests:



Subsystem coordination:

- IB: INFN (D. Elia)
- OB: Oxford (G. Viehhauser)
- HE/EE: LBNL (N. Apadula)

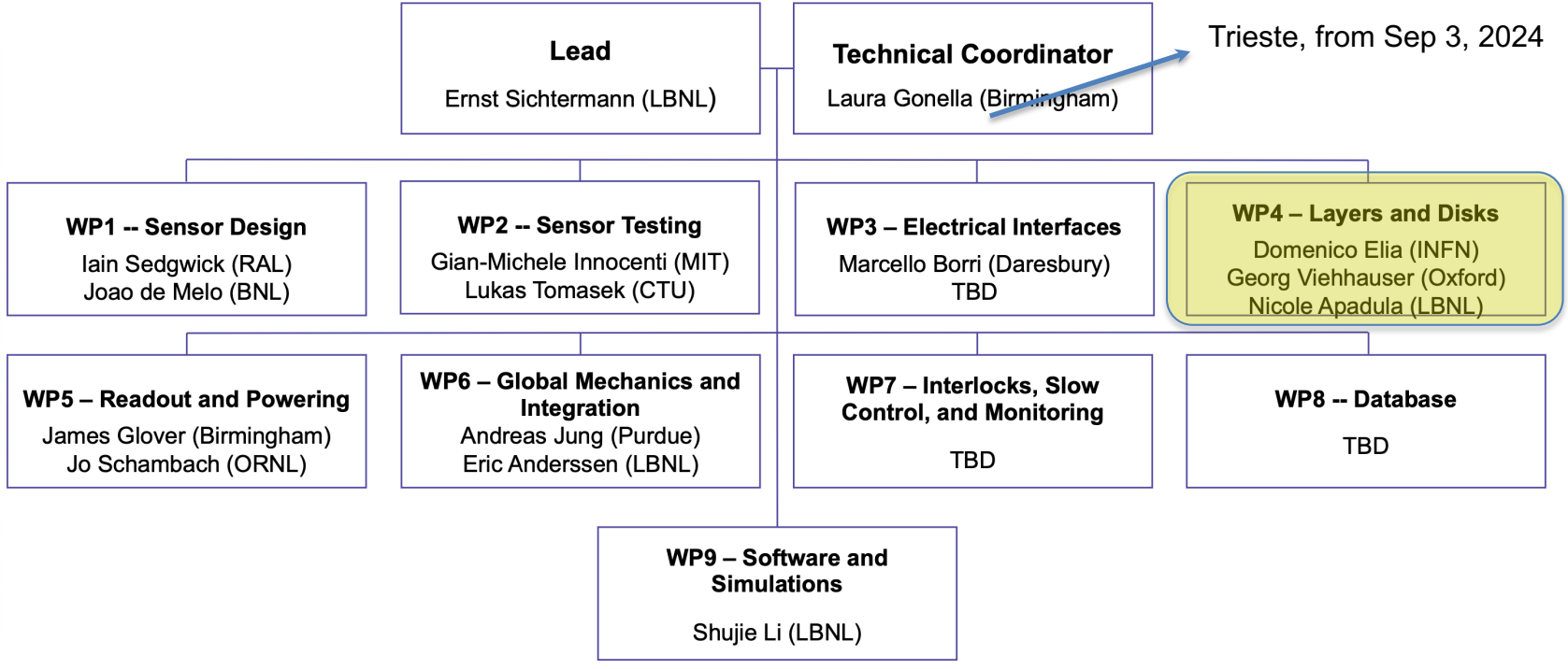
Sensor and IC design: BNL, LBNL, MIT, RAL – further groups in characterization

Readout: ORNL, MIT

Additional groups expressed interest

Detector Subsystem Collaboration

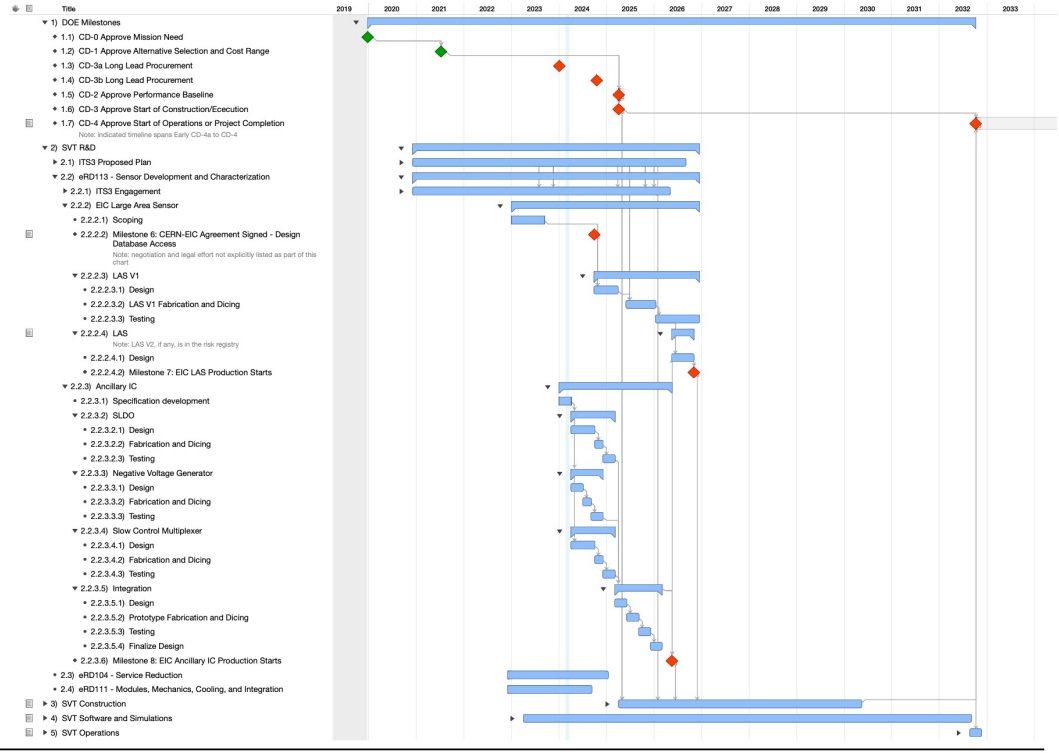
SVT DSC organization:



SVT project timeline

E. Sichtermann @PTDR March 2024

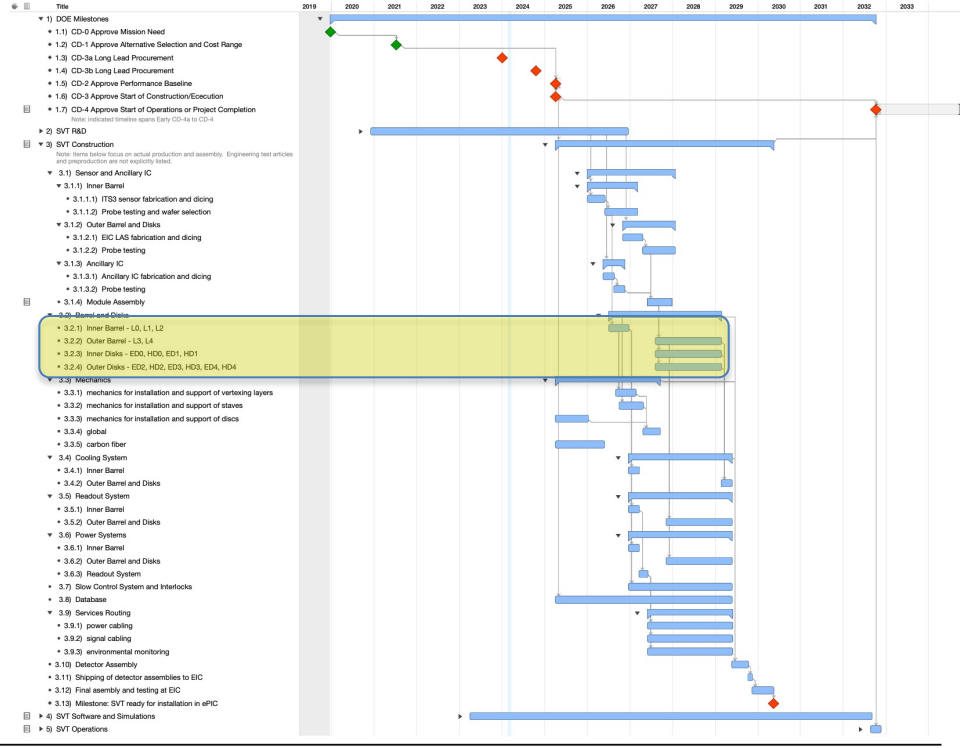
- Sensor development:
  - ITS3 wafer scale sensor development (ER2, ER3) for IB 2024 – 2026,
  - EIC-LAS development for OB and Disks complete and ready for production start in calendar Q4 2026,
  - Ancillary IC development for EIC-LAS complete and ready for production start in calendar Q2 2026.



SVT project timeline

E. Sichtermann @PTDR March 2024

- Construction:
  - Engineering test articles following R&D in 2025—2026,
  - Pre-production phase of about 1 year for IB; 2 years for OB,
  - Production and QA through calendar Q2 2029 followed by assembly,
  - Current plan is shipment of surveyed and assembled half barrels and disks to BNL in calendar Q4 2029,
  - Final assembly and testing at BNL through calendar Q1 and Q2 2030, prior to installation in ePIC.
- SVT schedule is compatible with Project requirements, being finalized.



SVT project timeline

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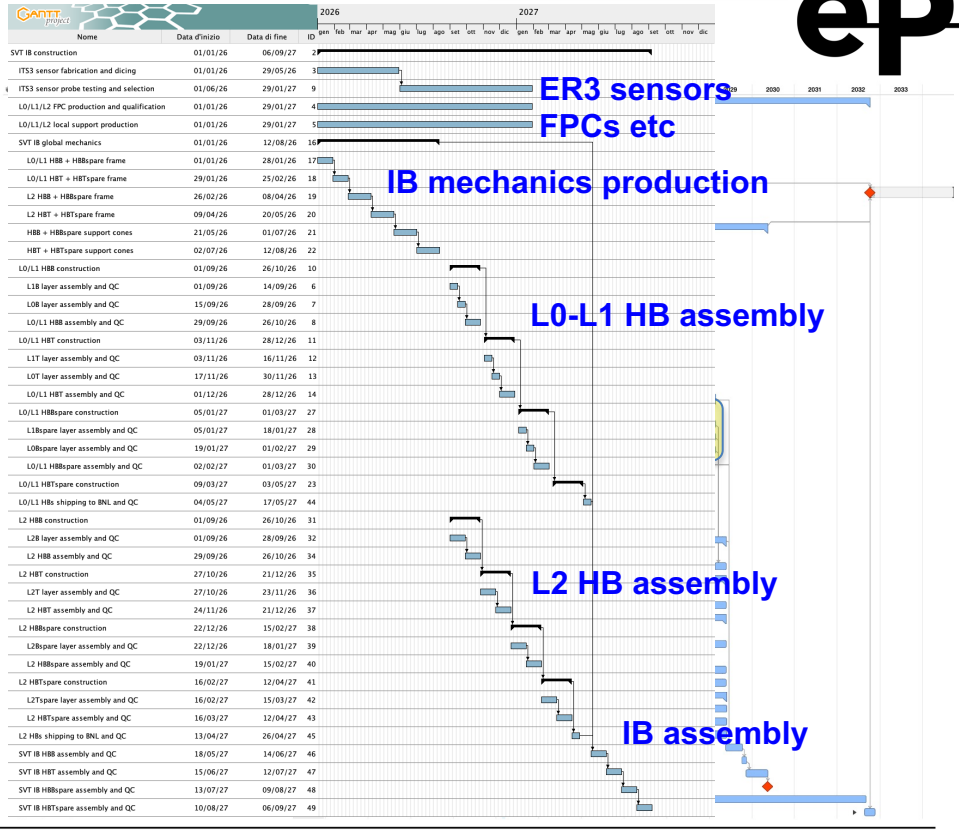
Still under discussion:



INFN involvement in SVT

Participation and main interests:

- currently involved groups: BA, PD, PV and TS
- interest focused on the IB (overlap/synergies with ALICE ITS3)
- main R&D activities along the last 2-3 years:
  - ✓ bending and interconnection issues (BA, TS)
  - ✓ test of MLR1 (APTS and DPTS) structures (BA, PD, TS)
  - ✓ start development of IB concept design, local and global mechanics (BA, PD)
  - ✓ investigate thermal chamber test and transport issues (PV)
  - ✓ tracking/vertexing simulation (BA)

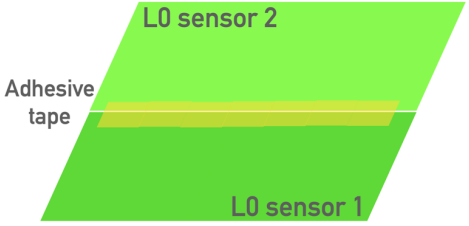
INFN involvement in SVT

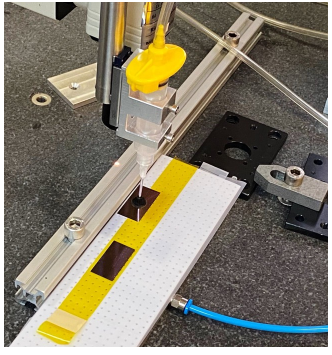
See talk by **Maria Teresa Camerlingo**

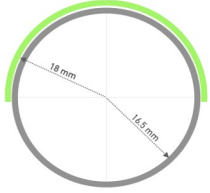
BARI:

- 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 exploit “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

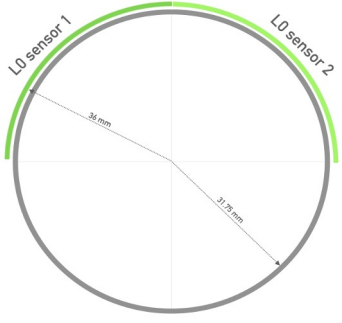
half-layer based assembly (a la ITS3)





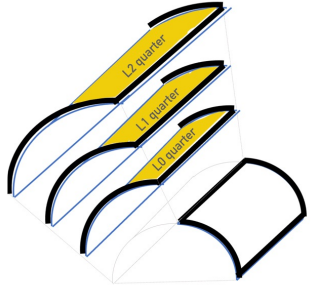


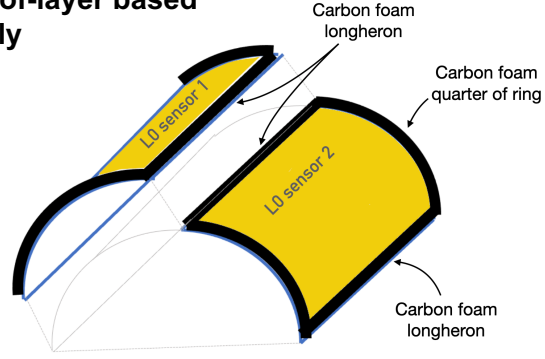
ITS3-L0



SVT-L0

quarter-of-layer based assembly





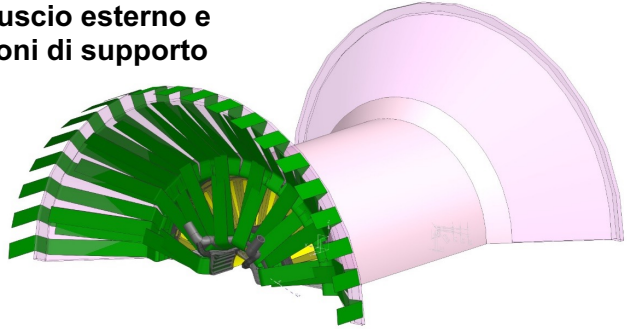
INFN involvement in SVT

See talk by **Rosario Turrisi**

PADOVA:

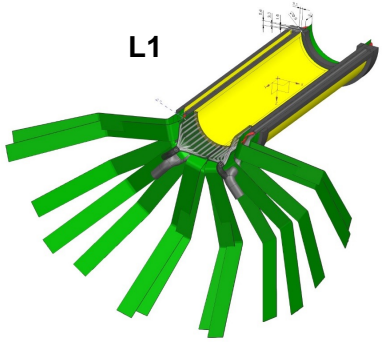
- Costruzione meccanica globale SVT:
  - ✓ responsabilità disegno e realizzazione meccanica globale Inner Barrel SVT:
    - realizzazione mock-up necessari alla qualificazione della procedura di integrazione sensori e servizi
    - realizzazione prototipo/i supporto finale
  - ✓ In fase di indagine:
    - studio vibrazioni indotte da flusso aria per raffreddamento sensori con utilizzo galleria del vento (dotazione UniPD?) e sensori confocali cromatici per rilevamento posizione con risoluzione (sub)micrometrica

guscio esterno e coni di supporto

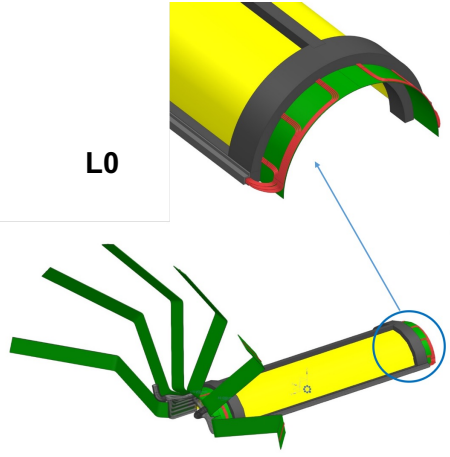


CAD design by M. Turcato

L1



L0



INFN involvement in SVT

PAVIA:

- Testing in 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

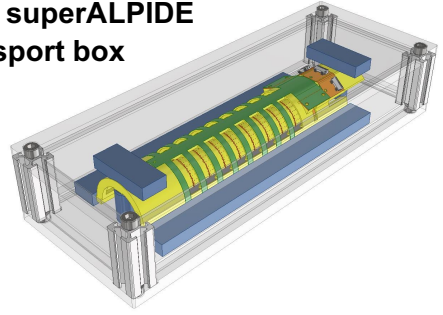
inner volume	30 liters
inner dimensions	330 x 280 x 330
temperature range	-70 °C ÷ +180 °C
humidity range	10% ÷ 98%
temperature precision	± 0.1 °C ÷ ± 0.3 °C
temperature uniformity	± 0.5 °C ÷ ± 1.5 °C
humidity precision	± 1 ÷ ± 3 %
temperature gradient	± 3 °C/min
internal heat dissipation	100 W
power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

INFN involvement in SVT

PAVIA:

- Testing in climatic chamber Galli Genviro-030LC:
- 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:

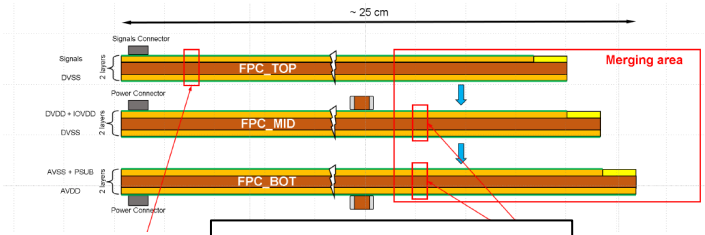
- wire ropes recommended to achieve about 10 Hz cut-off frequency
- arbitrary low acceleration can be achieved at the cost of space: about linear in average acceleration

INFN involvement in SVT

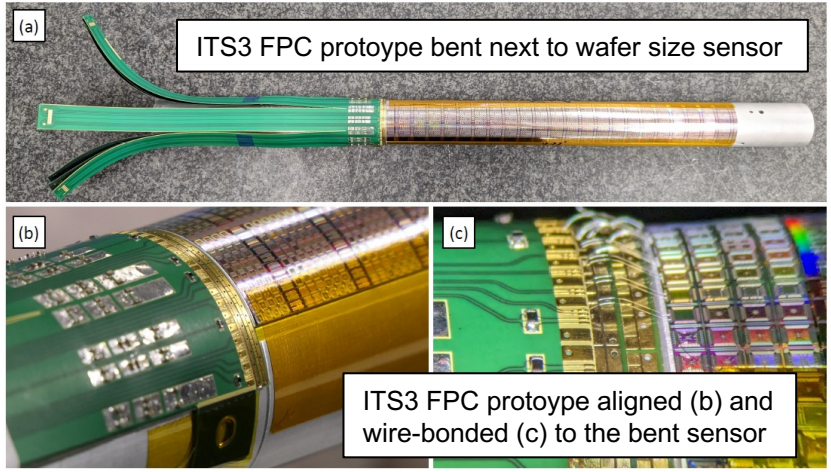
TRIESTE:

- Activity on SVT IB FPC:
  - ✓ collaboration with Daresbury LAB and SVT WP3/4 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



INFN involvement in SVT

Participation and main interests:

- currently involved groups: BA, PD, PV and TS
- interest focused on the IB (overlap/synergies with ALICE ITS3)
- main R&D activities along the last 2-3 years:
  - ✓ bending and interconnection issues (BA, TS)
  - ✓ test of MLR1 (APTS and DPTS) structures (BA, PD, TS)
  - ✓ start development of IB concept design, local and global mechanics (BA, PD)
  - ✓ investigate thermal chamber test and transport issues (PV)
  - ✓ tracking/vertexing simulation (BA)
- participation to the DOE-funded eRD projects in FY23 and 24:
  - ✓ eRD111 – Silicon vertex (sensors excluded), INFN contact: D. Elia
    - 30 kUSD for FY23, 45 kUSD for FY24 (75 kUSD, all groups)
  - ✓ eRD113 – Sensor development and characterization, INFN contact: R. Turrisi
    - 30 kUSD for FY23, 45 kUSD for FY24 (75 kUSD, all groups)
  - ✓ generic RD – Additive power&data redistribution layers, INFN contact: G. Contin (50 kUSD, TS)

INFN involvement in SVT

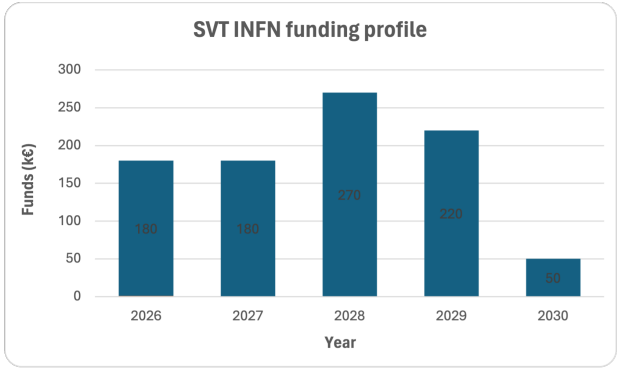
Plans for construction:

- INFN IKC for SVT IB (overall 900 k€):
  - ✓ sensors, including characterization and test
  - ✓ design, prototyping and construction of the two innermost layer barrels (L0-L1)
  - ✓ design, prototyping and production of the IB global mechanics
  - ✓ qualification, test and production of the FPCs
- sharing of the responsibilities within the INFN groups:
  - ✓ **BA**: leading IB project, main assembly centre of the two innermost layers
  - ✓ **PD**: development and production of the global SVT IB mechanics and backup assembly/production centre for the two innermost layers
  - ✓ **PV**: test of the special gluing of the sensors with support structure (climatic chamber), development of dedicated transport boxes and shipping/handling to BNL
  - ✓ **TS**: qualification, test and production of the SVT IB FPC

INFN funding profile for SVT

Based on following assumptions:

- prototyping till 2026, construction ~2027 (2028?)
  - ✓ strongly dependent from ER2-ER3, sensor testing etc
  - ✓ some contingency for spares (may extend to 2029)
- spread of funding for sensors and FPC till 2030
  - ✓ project buffering may help overall INFN funding for ePIC



Prototyping → Construction → Spares

Profilo spesa SVT 2026-2030						
Item	**2026**	**2027**	**2028**	**2029**	**2030**	**Tot**
Design e produzione tool sensor bending setup	15	10	10			35
Design e produzione local support structure L0-L1, carbon foam etc	10	10	10			30
Produzione e test prototipi, assembly finale e spare L0-L1	20	10	10			40
Design e produzione prototipi e soluzione finale global mechanics IB	10	20	20	20		70
Design e produzione prototipi e soluzione finale box trasporto	5	10	10			25
Test e produzione prototipi e soluzione finale FPC	20	20	60	50		150
Contributo run di produzione sensori	100	100	150	150	50	550
Profilo	**180**	**180**	**270**	**220**	**50**	**900**

INFN funding profile for SVT

Comparison:

1) assumed with buffering from project

Profilo spesa SVT 2026-2030						
Item	**2026**	**2027**	**2028**	**2029**	**2030**	**Tot**
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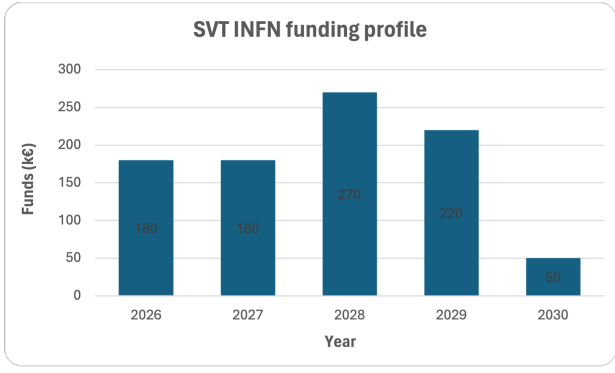

2) no buffering

Profilo spesa SVT 2026-2030						
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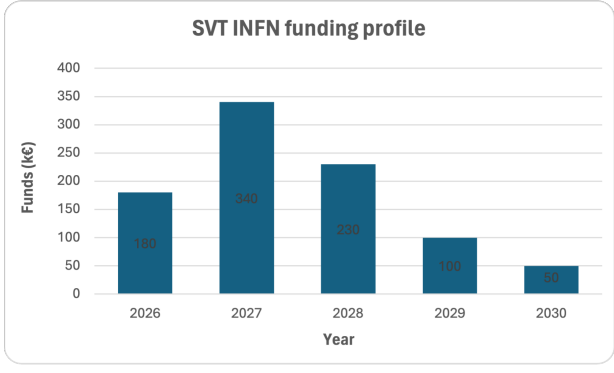


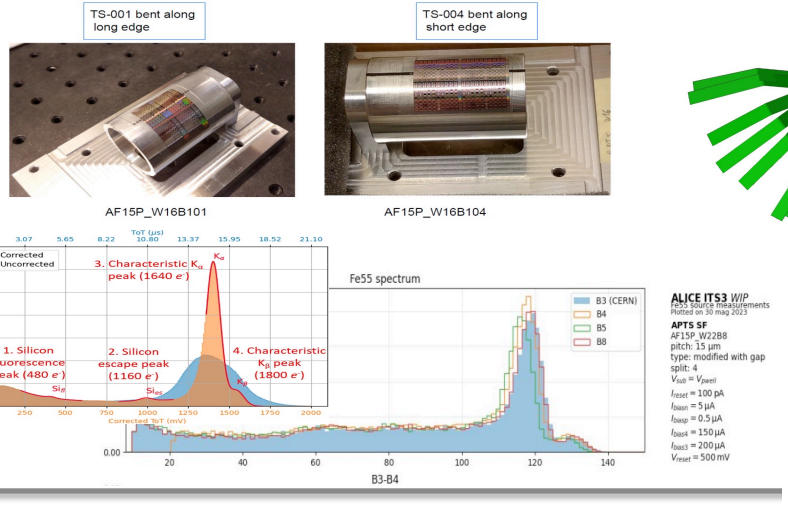
Backup

INFN involvement in SVT

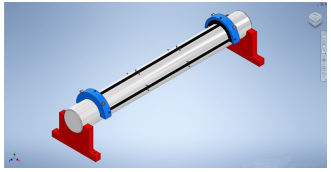
Participation and main interests:

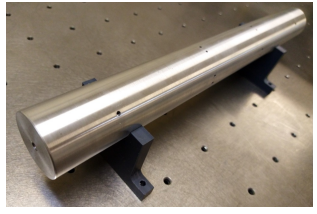
- currently involved groups: BA, PD, PV and TS
- interest focused on the IB
- main R&D activities along the last 2-3 years:

Bending and test of APTS/DPTS @PD, TS

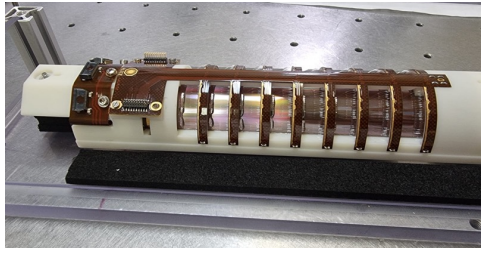


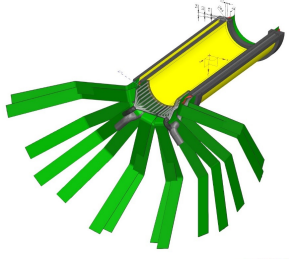
SVT L0-1 local mechanics design @BA



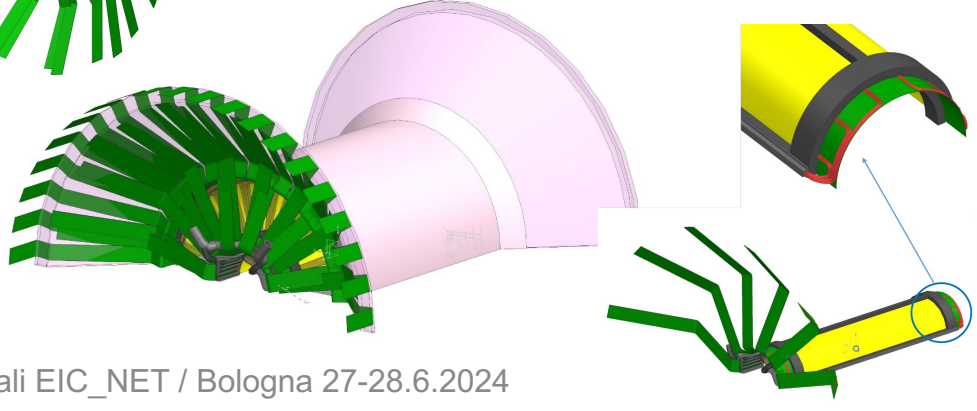


Bending/interconnection ITS3 super-ALPIDE





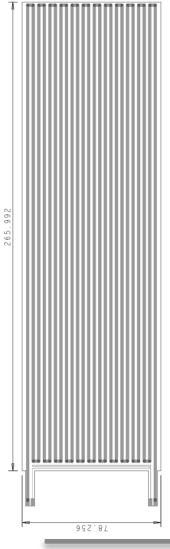
SVT IB global mechanics design @PD

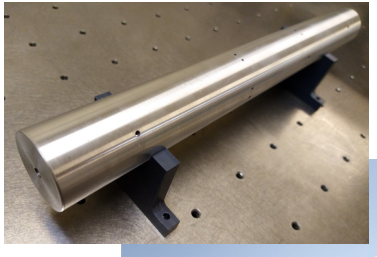


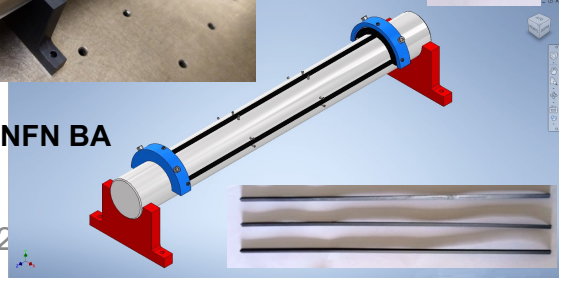
INFN involvement in SVT

BARI:

- Design, prototyping and construction of SVT L0-L1 barrel:
  - ✓ exploiting experience with bending and interconnection for ITS3
  - ✓ investigating two possible bending/assembly strategies
  - ✓ preliminary SVT-dedicated setup assembled:
    - all components already available (procurements + local production)
    - external contact for high-quality mandrels already in place
  - ✓ first ideas on local support structure being developed
    - based on the assumption of 2-sensor bending works
  - ✓ prototype campaing planned for the coming months
    - starting with dummies in kapton 50 um tick
    - will proceed soon with dummy silicon ordered to DISCO
    - will also include thermo-mechanical prototpyes (CERN)







CAD @INFN BA

INFN involvement in SVT

PADOVA:

- Costruzione meccanica globale SVT:
- Secondo punto di produzione layer interni L0-L1 di SVT:
  - ✓ possibilità di produzione tooling per piegamento sensori MAPS
    - mandrini prodotti in OM INFN-Pd
    - lavorazione superficie per rugosità <0.1 ai LNL (plasma) o ditta esterna (rettifica e doratura), da verificare la qualità e convenienza dei due processi
  - ✓ processo completo (piegamento, wire-bonding FPC, posa/incollaggio supporto, etc.) dipende da disponibilità macchina wire-bonder (gli FPC devono essere fissati prima di rimuovere il sensore dal mandrino):
    - la particolare operazione (bonding su superficie curva), le dimensioni del supporto e la procedura di fissaggio FPC e fissaggio su supporto definitivo pongono condizioni sul tipo di macchina bondatrice (bore, manovrabilità testa, non necessariamente automatica)
    - market survey in corso
    - contatti per coinvolgimento altri progetti interessati per acquisto condiviso con limitato contributo INFN

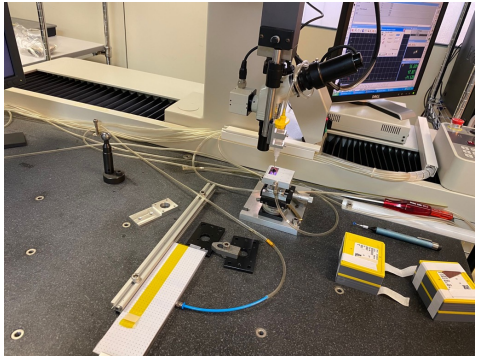
INFN involvement in SVT

Group infrastructures and resources:

Group	Infrastructure	Resources	FTE/year
Bari	Camera pulita CAD e officina meccanica Servizio elettronica	Electronic technician: Mechanical engineer: Mechanical designer: Mechanical technician:	0.1 0.2 0.2 0.3
Padova	Camera pulita CAD e officina meccanica Servizio elettronica	Electronic technician: Mechanical engineer: Mechanical designer: Mechanical technician:	0.3 0.2 0.3 0.3
Pavia	CAD e officina meccanica Servizio elettronica	Electronic technician: Mechanical engineer: Mechanical designer: Mechanical technician:	0.1 0.2 0.2 0.2
Trieste	CAD e officina meccanica Servizio elettronica	Electronic engineer: Electronic technician: Mechanical technician:	0.1 0.2 0.1

INFN involvement in SVT

Group infrastructures and resources:



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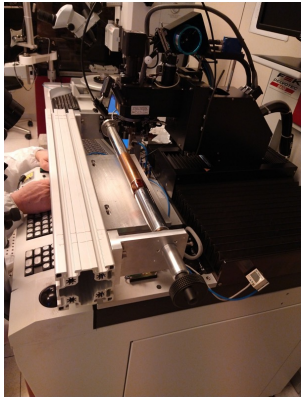
Mitutoyo with alignment vacuum tools

Sensor bending setup

Delvotec G4 wirebonder



@INFN PV

Climatic chamber Galli, Genviro-030LC