SVT: meccanica IB
(più una varia)

Rosario Turrisi

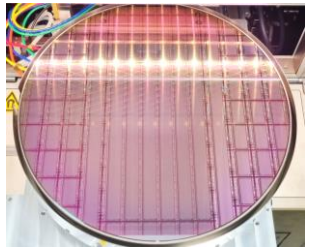
EIC_NET/Pd

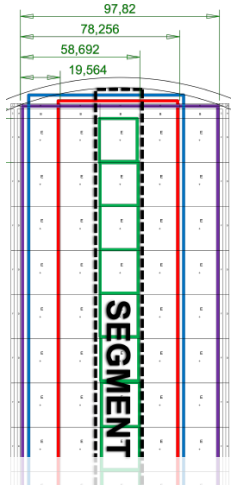
- Attività 2025
  1. test e caratterizzazione rivelatori al silicio in sinergia con ALICE/ITS3 e NA60+
  2. costruzione meccanica globale Silicon Vertex Tracker Inner Barrel (SVT-IB)
  3. punto produzione layer interni L0, L1 ?
- Risorse ‘’esterne’’:
  - Un contratto PhD cofinanziato al 45% da DoE (C. Pantouvakis)
  - Anche quest’anno attratti fondi DoE per R&D: eRD113 (test and characterization of MAPS) → assegnati ~20 k€, probabilmente destinati a hardware (v. dopo)

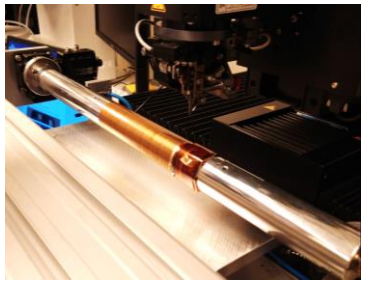
Generalities about SVT

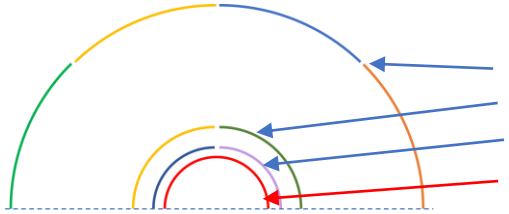
From DIS to exclusive process → high precision tracking hermeticity →
- high position resolution sensors
- low mass → low power

From ALICE/ITS3 development → 65 nm TPSCo technology with bent silicon sensors!

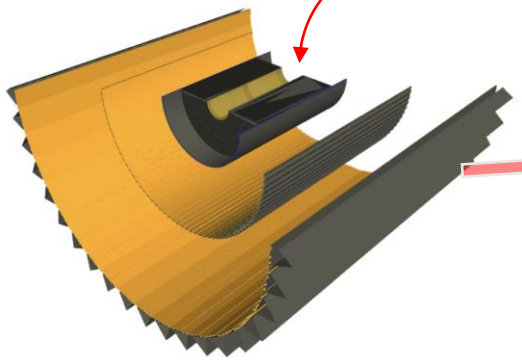


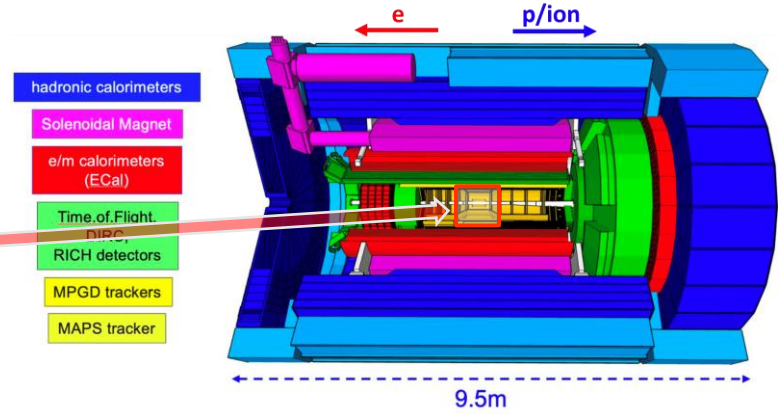






inner layers (3)

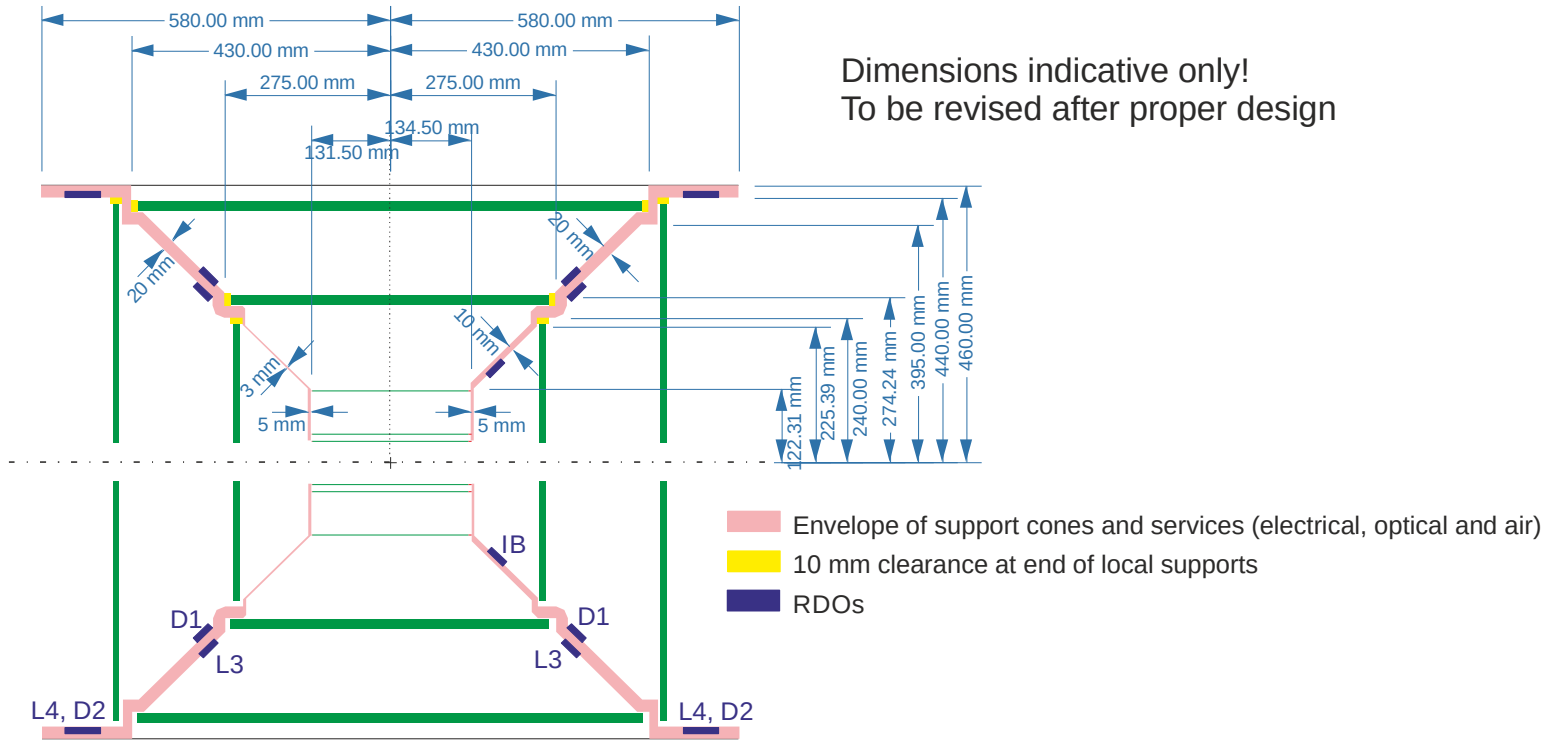




- Thinned down to 50 μm
- Pitch 21 × 23 μm
- 40 mW/cm^2 power dissipation (~800mW/ cm^2 in the LEC)
- 0.05% X /X_0 (just the sensor)
- ~ 3.3 g Si/sensor

General thoughts about global support

- Assembly procedure drives the design of the support
- Need to have as low as possible X, at least in the e-side
- Preliminary design with best-guess quotes (from G. Viehauser)
- OB/IB supports are two separated objects



Dimensions indicative only!
To be revised after proper design

- Just a reminder about properties one wants to find in the materials of the support/services (probably not exhaustive):
  - low X_0
  - hydrophobic
  - insulating
  - thermal and chemical stability
  - chemically not ‘‘dangerous’’ (e.g. no fluorine)
  - no flammability (and at least highly self-extinguishing)

- carbon fiber composites
- carbon foams
- kapton (and maybe other polymides)

not all properties are always satisfied…but can work on this
e.g. CF is hygroscopic…and conductive at high frequency!
but can be treated with parylene coating…

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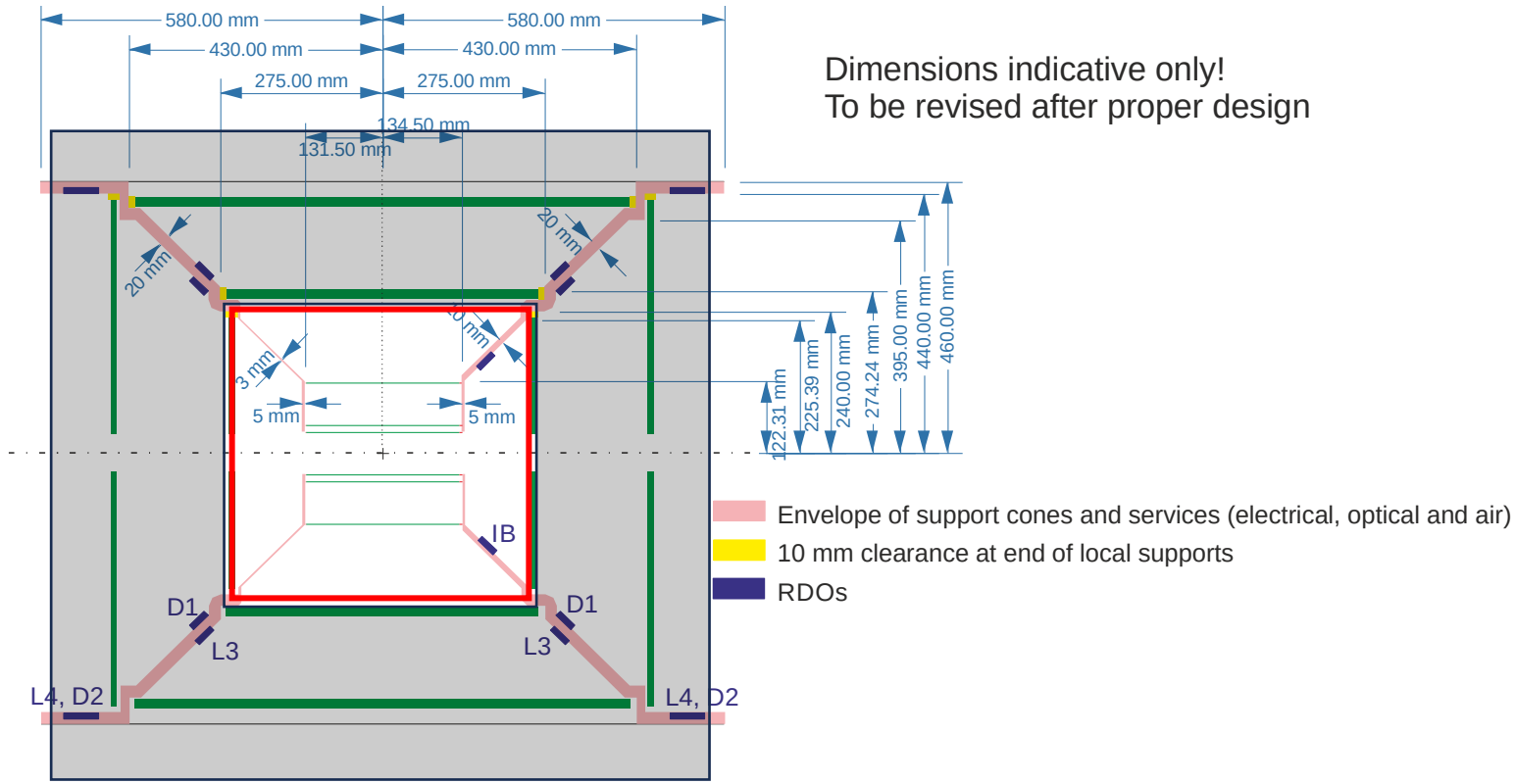

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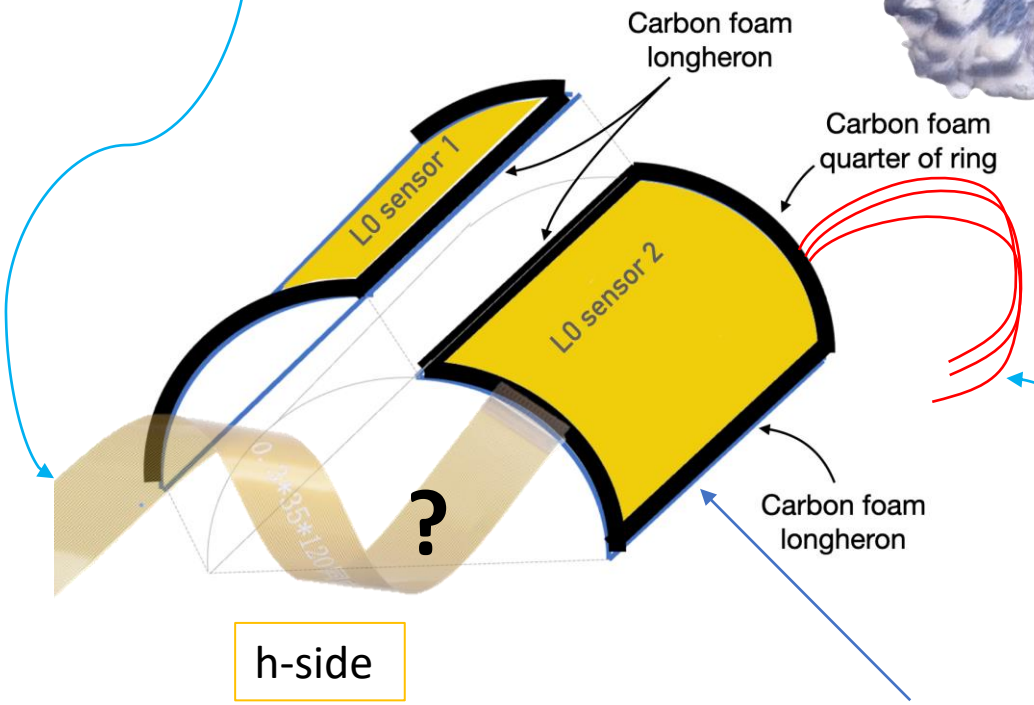
Starting points for services

FPC's ITS3-inspired, but with mandatory differences, to be updated along the way…

now 250*20*0.75 mm

Cooling: a first guess on air distribution on the layers



e-side

cables or FPC's?

we tried with the first hypothesis as a placeholder, to figure out the possible routing – one cable per phase/ground, **1 mm** ∅

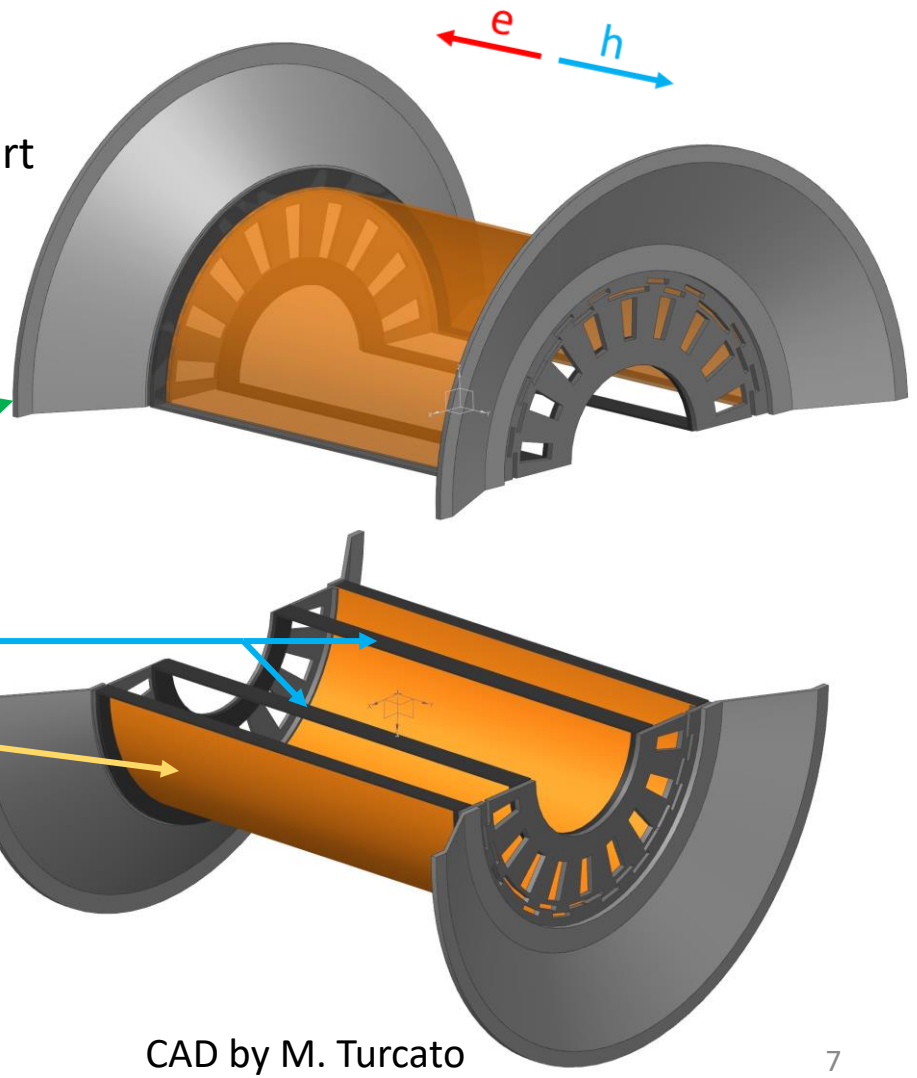
h-side

"meccanica locale"

SVT IB global support design

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

IB half barrel support

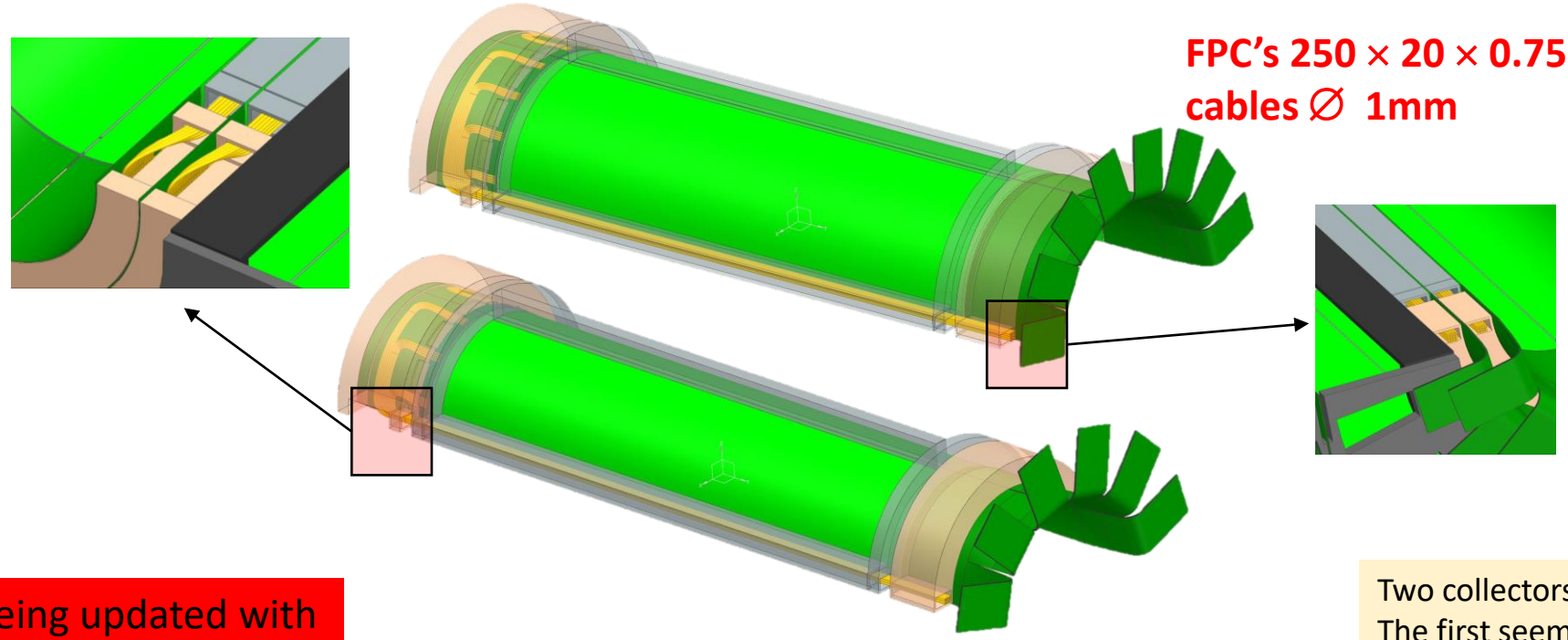


Material of the support: likely, carbon fiber composite (CFC)

- Symmetric design e-h side, but for cables routing
- Half-cones to support IB and connect to OB
- Frames to support the sensors (on their local mechanics)
- Light-material wall (kapton or other polymide) to protect L2 while minimizing X/X_0 in the sensitive area

CAD by M. Turcato

L0-L1 local mechanics

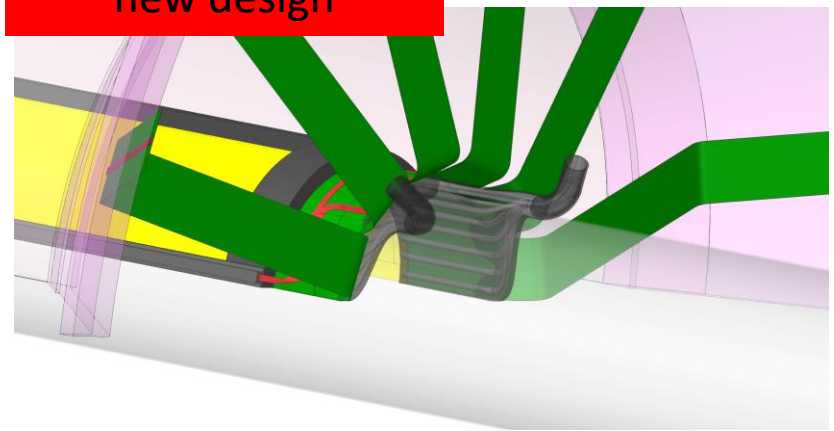


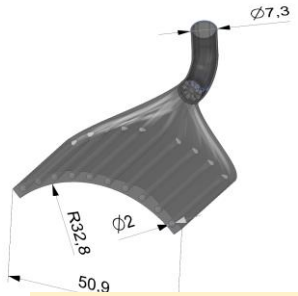
FPC's 250 × 20 × 0.75mm
cables ∅ 1mm

L0+L1 with local support structures in transparency to show e-side cables routing

WARNING: here cable trays are alternative to carbon foam → to be discussed!

Being updated with new design





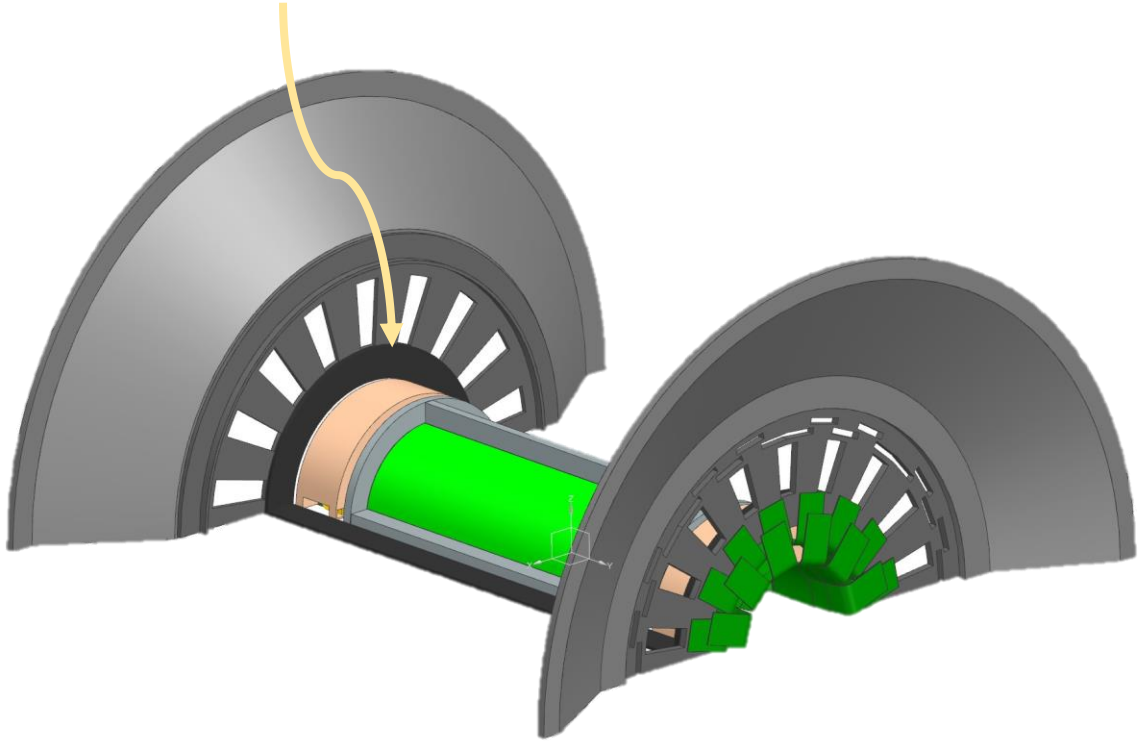
Two collectors: with internal channels or single volume. The first seems to favor uniformity of air flow (test ''quick and dirty'')

A first guess of air flow collector between L0 and L1
n.b. in this drawing the collector is *below* L0 – drawing being updated

SVT IB mechanical support L0-L1 + L2

L0+L1 on global support

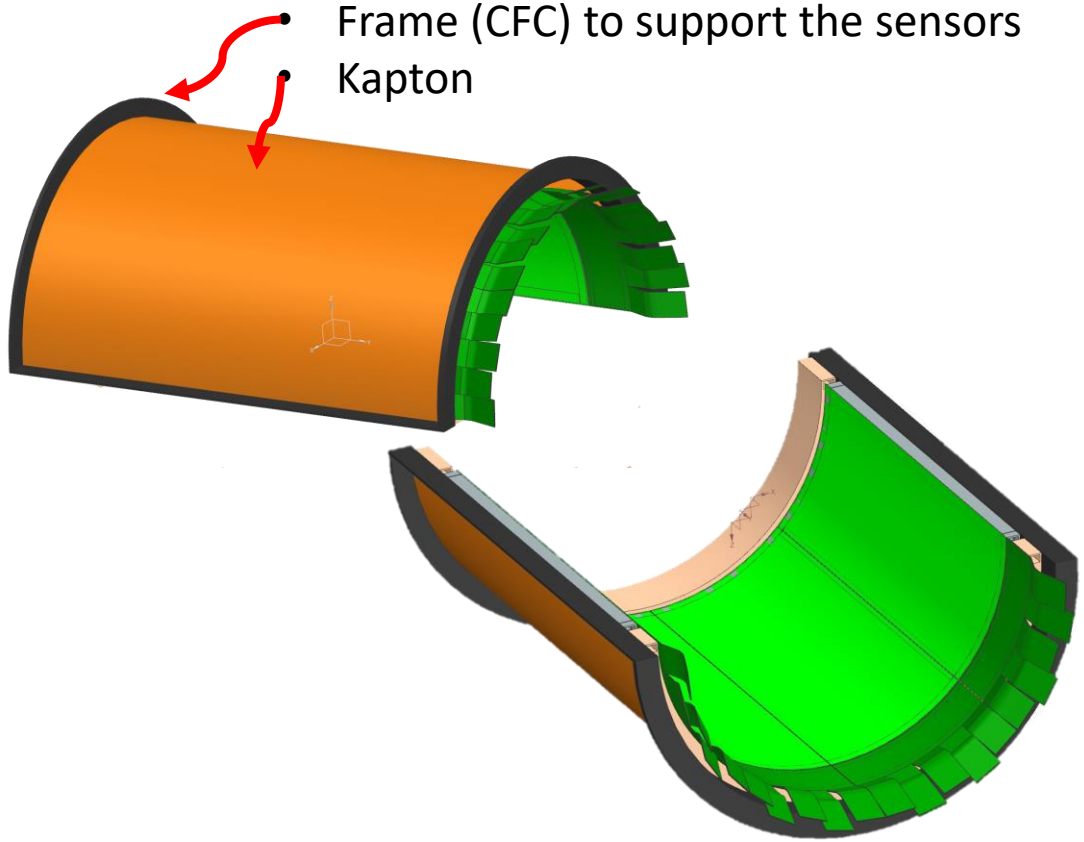
Frame to hold the half-rings and longerons supporting the sensors



L2 on its frame (current guess - working out details with MIT)

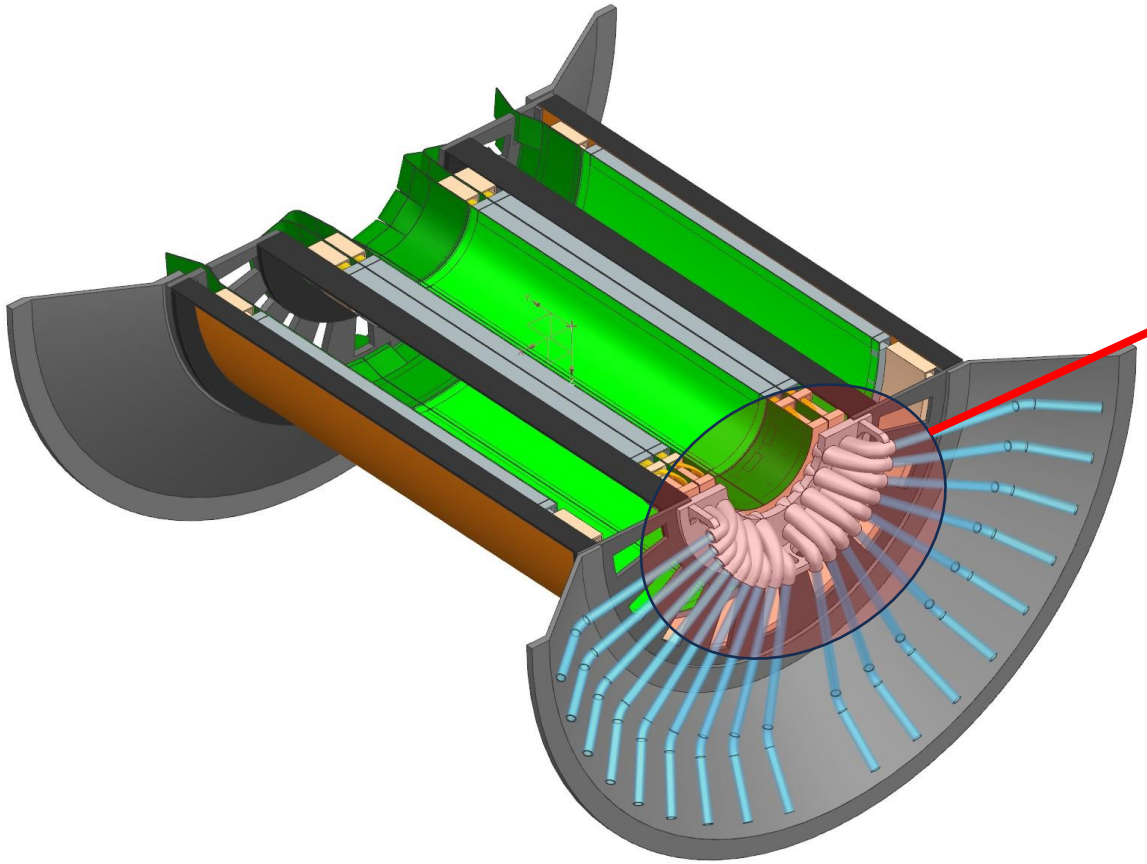
Frame (CFC) to support the sensors

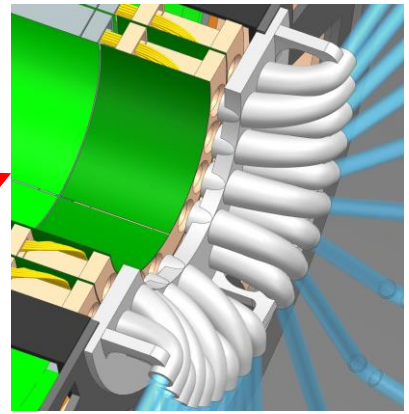
Kapton

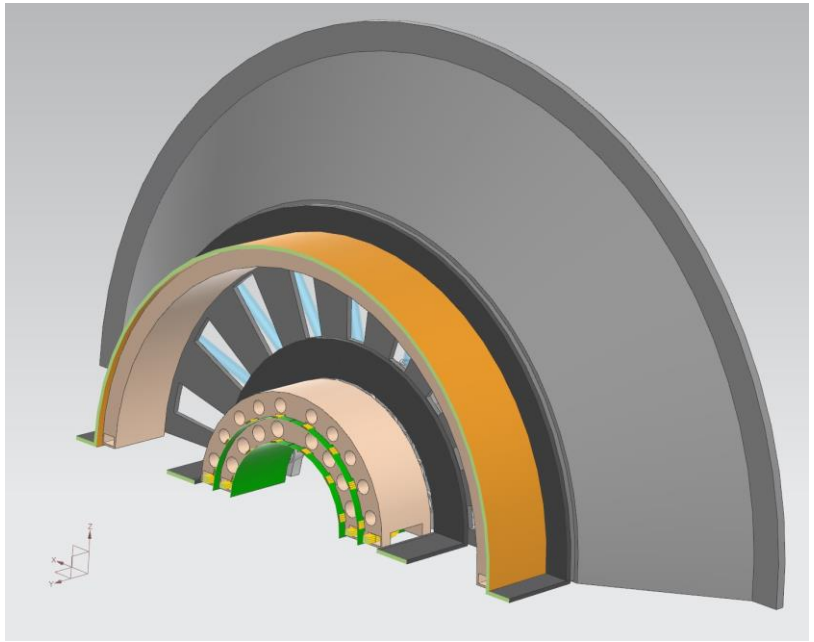


Alternative cooling routing

- Alternative to avoid overlap with FPC’s
- Material budget to be verified with GEANT4 simulation
- Assembly procedure to be studied on mock-ups







Test it

- Mock-ups at increasing level of detail will be produced
  - first is coming after the summer break, 3D printed with common PVC wire
  - test assembly procedure, alternatives for routing of services, etc.
  - updating the design as long as details come in: FPC not a big issue (should not be much different from what is around), cooling still under study

- Mechanical precision
  - Prototypes and final supports will undergo a quotes survey with Mitutoyo measuring machine
  - On the same bench (best mechanical stability) a vibrational test can be performed with a position measurement tool (confocal chromatic sensor), looking for air flow-induced vibrations, with air flow from air distributors and in wind tunnel

Mitutoyo Euro C-A7106
700 mm bore, 0.05 μm step

PVC-wire 3D printed air distributor

PRECITEC CHRocodile mini
confocal chromatic sensor, 4 kHz/10kHz sampling, axial resolution <=400 nm
(to be procured)

Summary - activities and plans

- 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
- The team: M. Benettoni, P. Rebesan (Engineers), M. Turcato (CAD Designer), RT
  - work done in collaboration with INFN Bari

BUT…

Is it wise to have a single production center for a much critical piece of detector?

Is it worth to establish technical skills and tools for future silicon detectors?

Secondo centro produzione half-barrel?

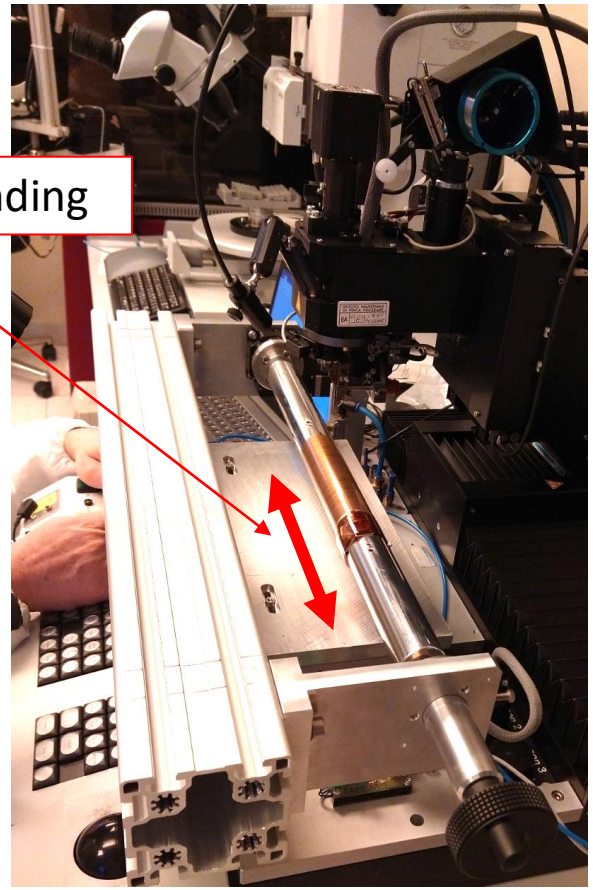
- Tooling per il piegamento già sviluppato per ITS3, da adattare ai diametri di SVT (Bari)
- Verificata la disponibilità del supporto tecnico INFN-PD
  - modifiche del tooling e sua realizzazione (UT, OM)
  - bending dei sensori e bonding (OE)
- Attività sviluppo silici (MAPS e non solo) già presente in sezione, coordinata da P. Giubilato
  - Impegno attuale nell'attività di test e caratterizzazione dei sensori ALICE/ITS3-ePIC/SVT
- Fasi produzione half-barrel SVT:

  piegamento sensori → bonding FPC/cavi → installazione ''meccanica locale'' (supporto sensore)→ trasferimento su supporto definitivo
- Il bonding è realizzato posizionando FPC/cavi sul mandrino cilindrico
- Questo implica l'utilizzo di una macchina bondatrice con alcune caratteristiche particolari:
  1. testa orientabile (solo automatiche, costo da 150 k€ in su e complessità di utilizzo: necessita spesso di programmazione anche per un solo wirebonding! (varie ore di lavoro preparatorio), come emerso finora da una breve esplorazione del mercato e contatti con esperti
  2. testa fissa ma con ingombri tali da accettare un mandrino eventualmente modificato: macchina molto più semplice da utilizzare (più adatta a test e sviluppo, in generale a produzioni piccole, ~10-100 bond) e quindi più attraente anche per altri progetti

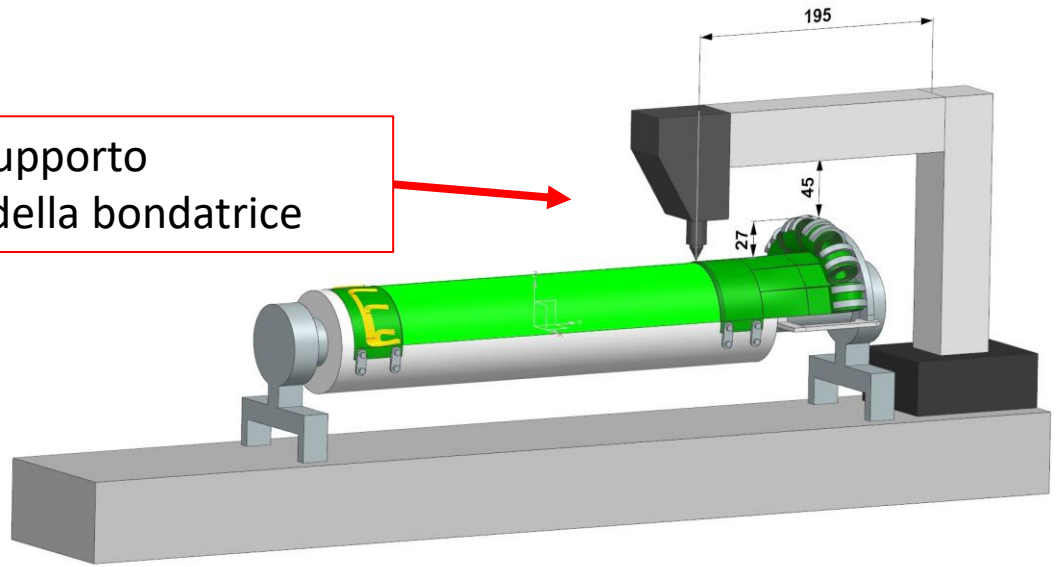
Secondo centro produzione half-barrel?

In una bondatrice manuale (a sinistra) la direzione del bonding è fissata→ spazio insufficiente per mandrino più FPC
Una bondatrice automatica (a destra la Delvotec in uso a Bari) ha la testa girevole e posizionabile a piacere

Direzione del bonding



CAD per definire gli ingombri di un supporto modificato e verificare l'adattabilità della bondatrice



La richiesta

- A Padova interesse generale per R&D di sensori al silicio per upgrade di esperimenti LHC (CMS, ALICE), futuri acceleratori (FCC, IMCC), fisica medica e applicazioni spaziali
- Interesse per una microbondatrice per attività R&D e piccole produzioni (a Padova disponibile un modello obsoleto e non più affidabile), che sarà gestita dal Servizio Tecnologie Avanzate di nuova costituzione in sezione (più un contributo del Direttore – da definire)
- Richiesta di 15+15 k€ SJ (FCC_ee, RD_MuCol) presentata in CSN1
- Finanziamento DoE disponibile ad ePIC-Padova 20 k€
- Si richiedono 20 k€ SJ alla presentazione di offerta per una bondatrice con le caratteristiche tecniche adatte e alla conferma delle altre fonti di cofinanziamento


THANK YOU
FOR YOUR
TIME

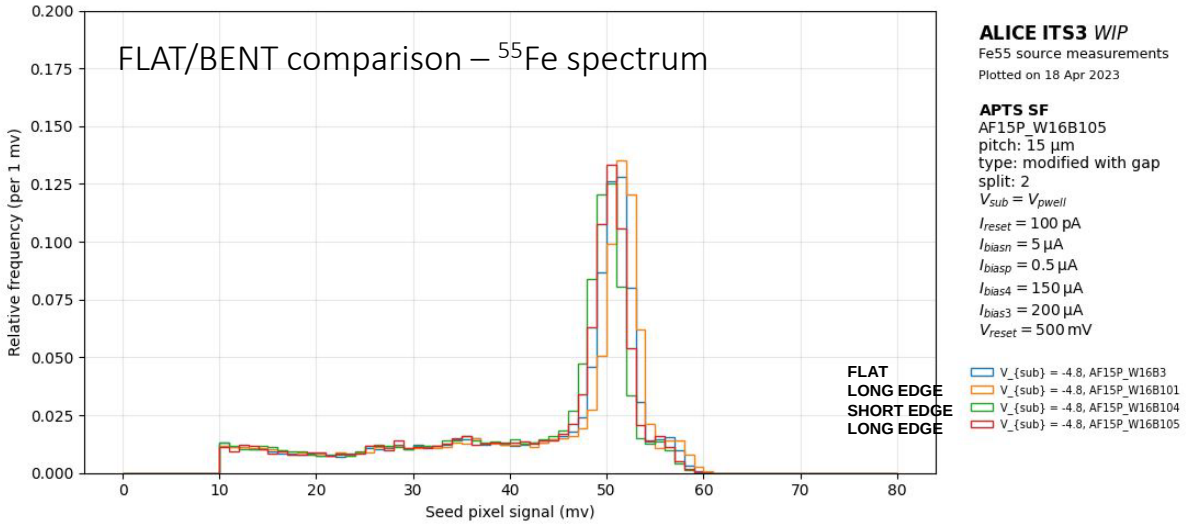
Backups

Dettagli attività - 1

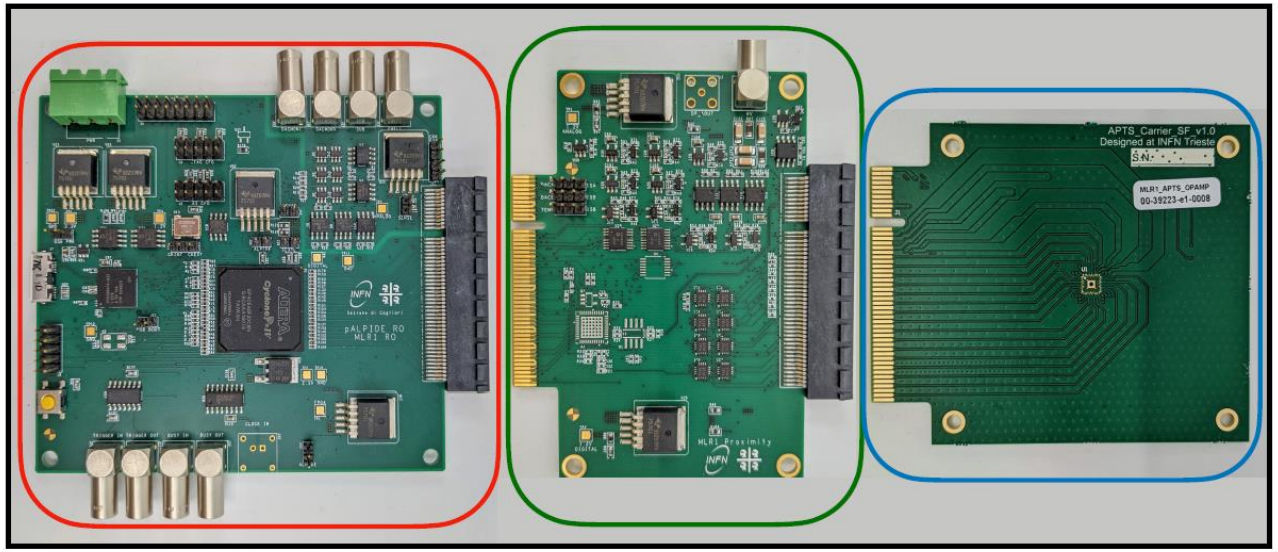
Sviluppo MAPS ‘’ALICE/ITS3-driven’’. Attività di test e caratterizzazione in (per adesso) completa sovrapposizione con NA60+ ed ePIC.

Personale staff e studenti con esperienza nei test pre-post bending, pre-post irradiazione (partecipazione anche a test-beam e.g. a FNAL)

- Test effettuati su APTS (Analogic Pixel Test Structures) prodotti nel run MLR1 (Multiple Layer Reticle 1) per ITS3, contenente alcune varianti di MAPS per la definizione del *design*, prima sottomissione in tecnologia 65nm a TPSCo
- Sviluppo sistema di test per nuove strutture ‘’stitched’’ ancora in corso
- 2025: preparazione test sui sensori del prossimo *engineering run*
- V. anche presentazione ALICE

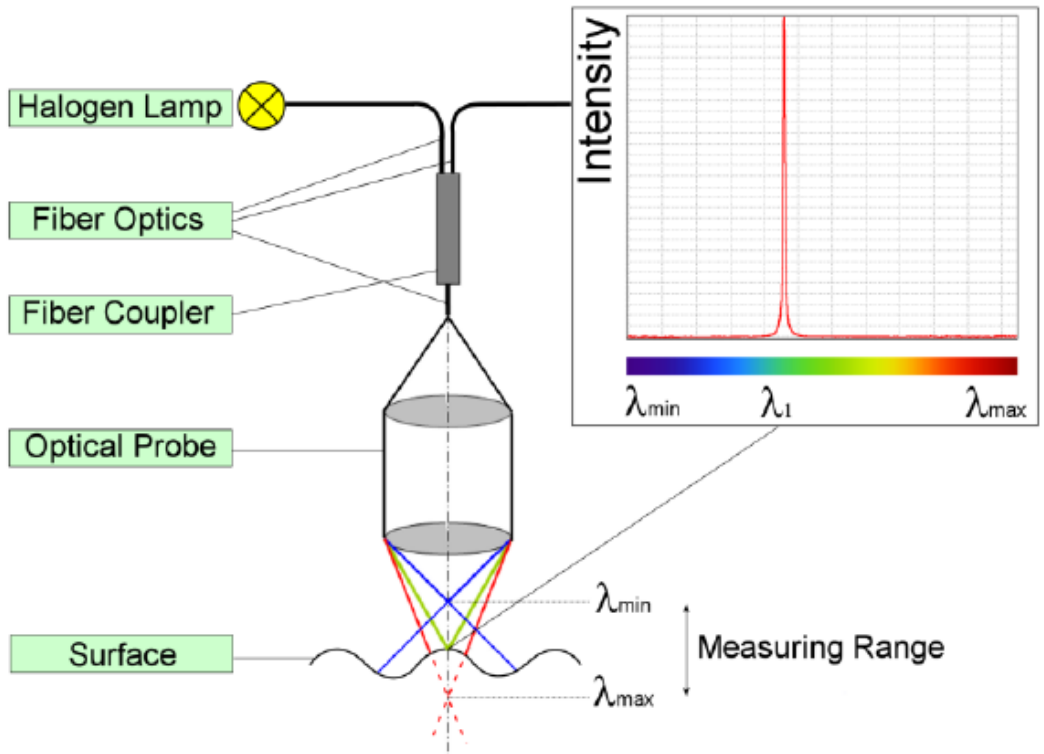


DAQ board | Proximity board | Carrier board



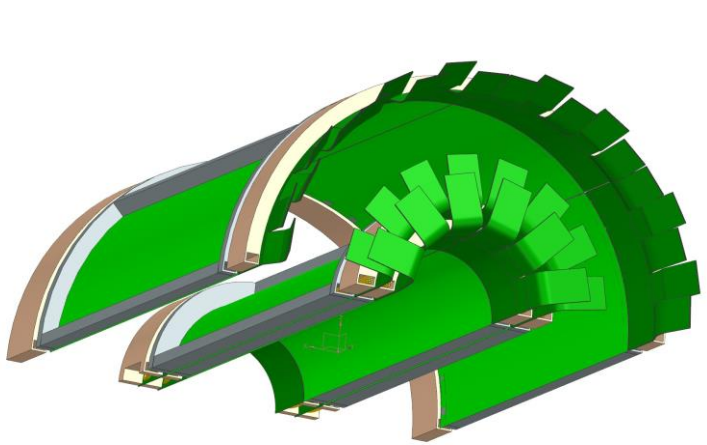
Elettronica per i test dei chip APTS

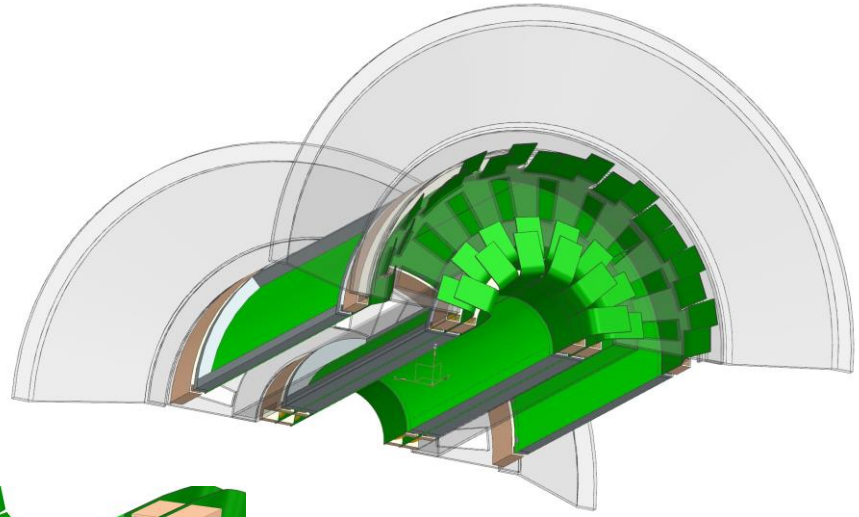
Chromatic Confocal Distance Measurement

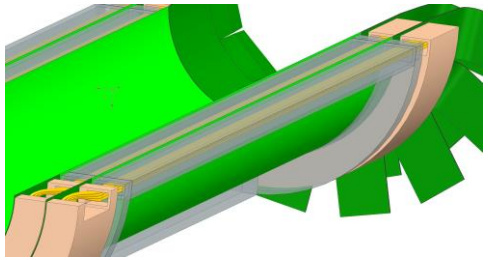


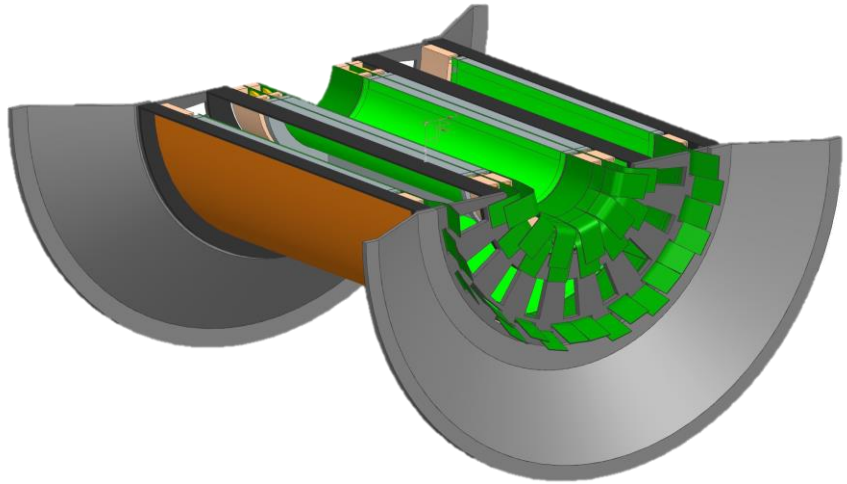
SVT IB half barrel assembled

Final mechanical assembly (cooling is missing):









CAD by M. Turcato