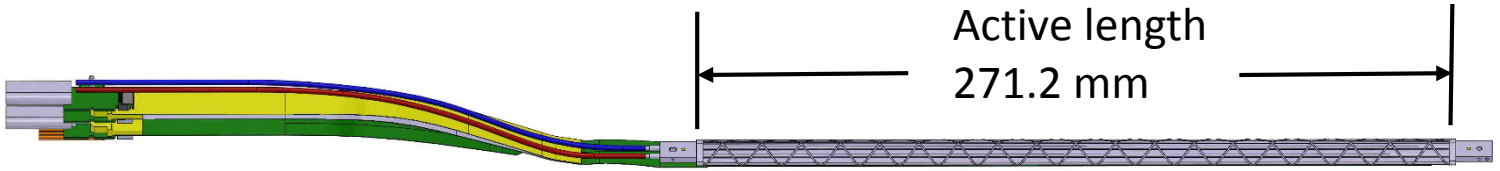
Develop telescope with ALICE inner tracker staves for LDRD project. Followed up by the mechanical integration of **LANL** *MAPS inner tracker for the proposed sPHENIX experiment*

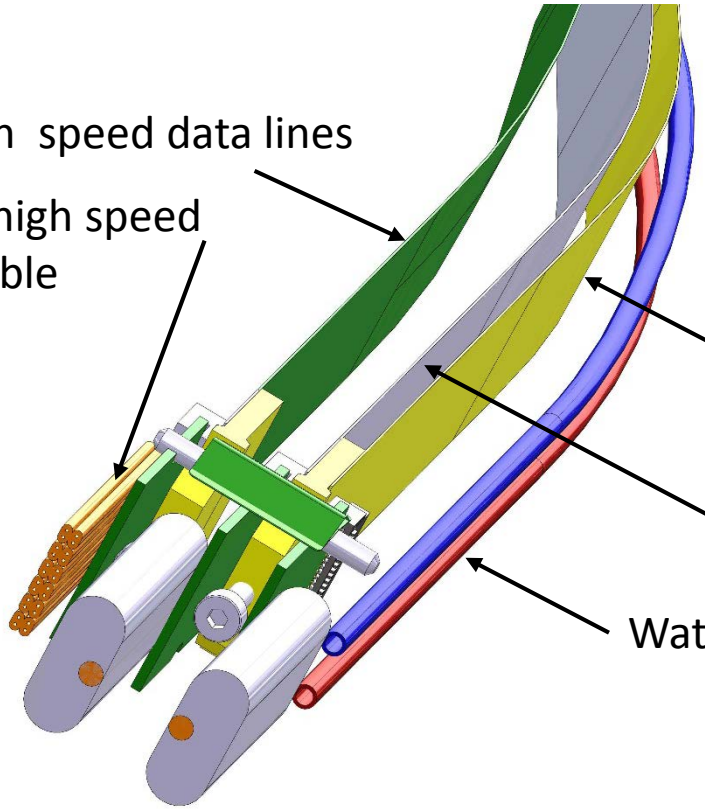
Walter Sondheim, Hubert Van Hecke, P-25

December 5th, 2016

ALICE inner tracker stave:

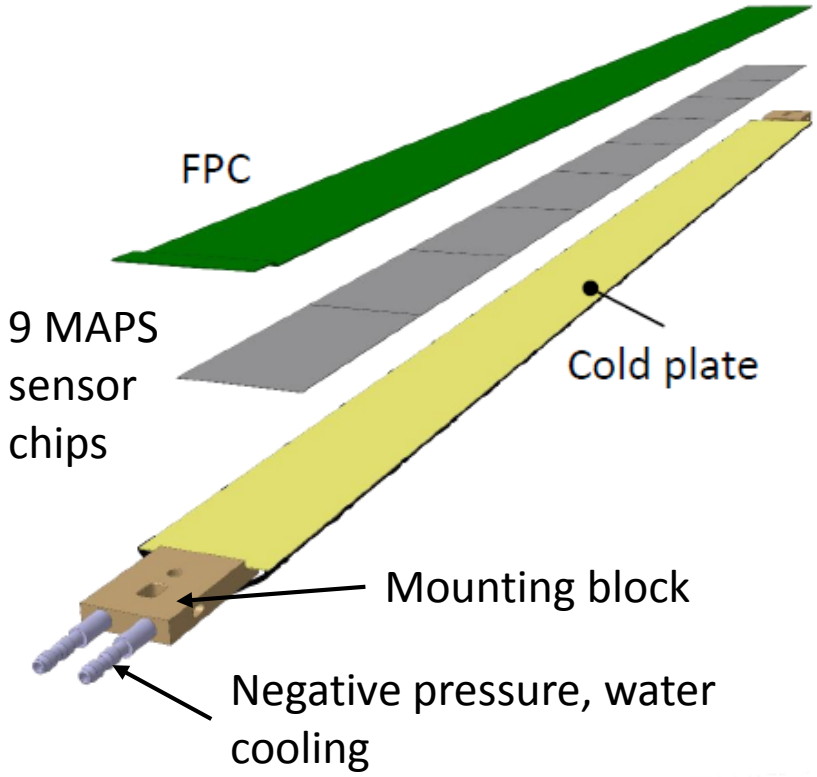


Active width 15.0 mm

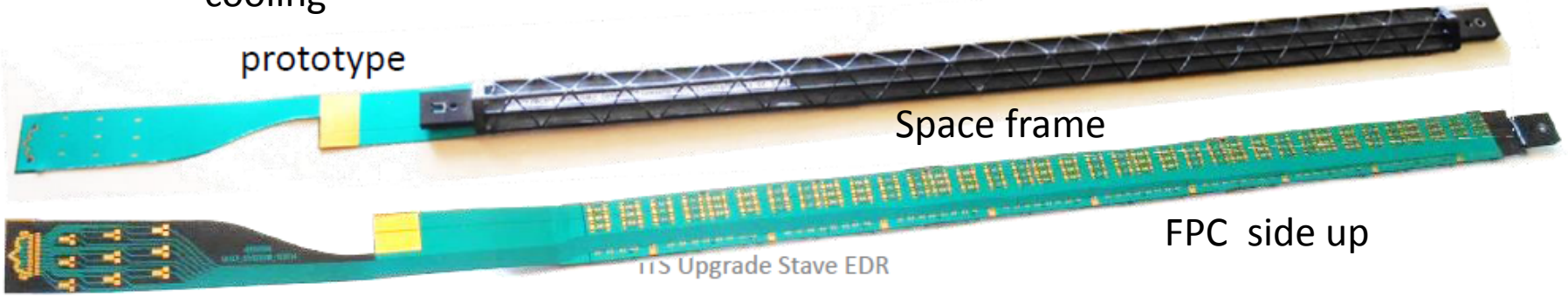


Power dissipation in one stave assembly; 0.041 watts/cm**2, 1.7 watts for 9 MAPS chips. A safety factor of 2 will be assumed for construction

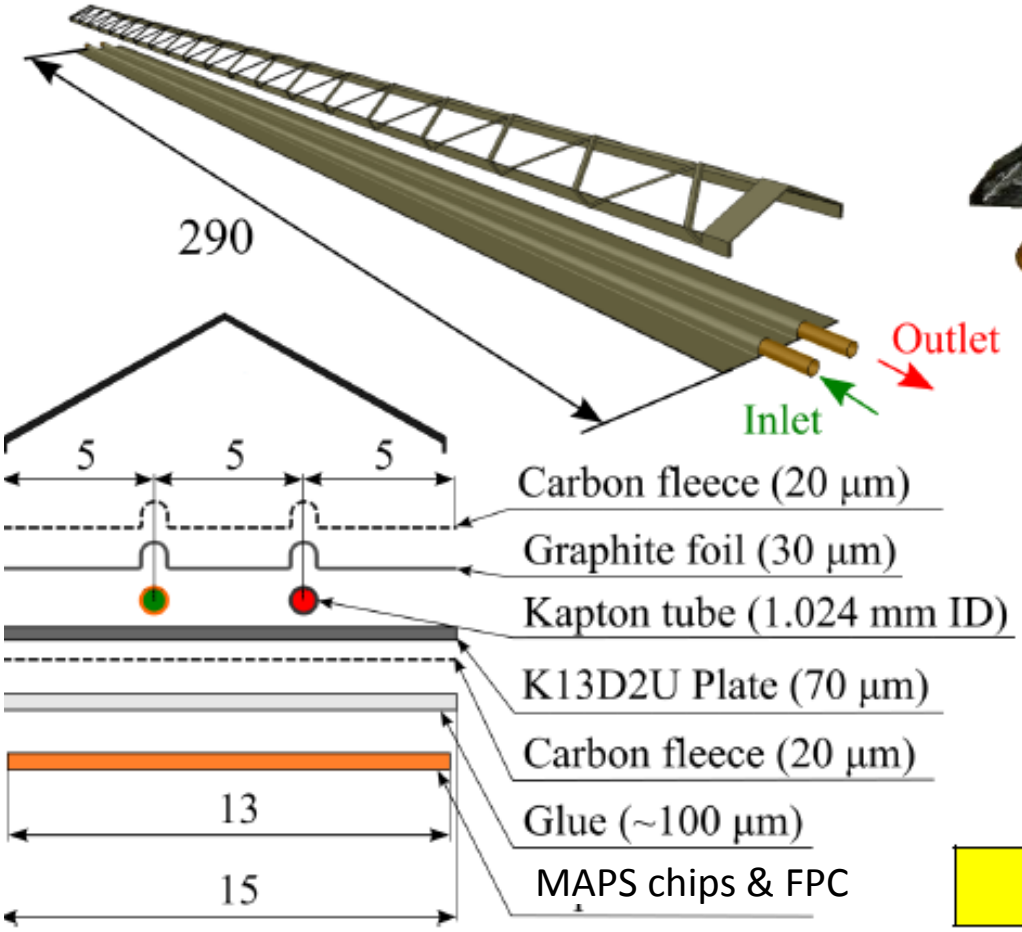
ALICE inner tracker stave assembly:

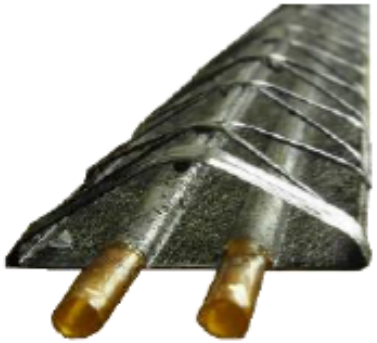


- The three Layers of the IB are segmented in the azimuthal direction in identical detector modules called Staves, consisting of an Hybrid Integrated Circuit (HIC) mounted on a carbon fibre mechanical support structure.
- The HIC includes a row of 9 silicon pixel sensors bonded to a Flexible Printed Circuit (FPC). The area covered by the chips is 15x271.2 mm^2, including a gap of 150 μm between adjacent chips.
- The mechanical support is conceived as a single light structure integrating a Space Frame, providing the required stiffness, and a Cold Plate, a sheet of high-thermal conductivity carbon fibre with embedded polyimide cooling pipes, on top of which the HIC is glued with the chips facing it, in order to maximize the cooling efficiency.



Detail of construction stave assembly:



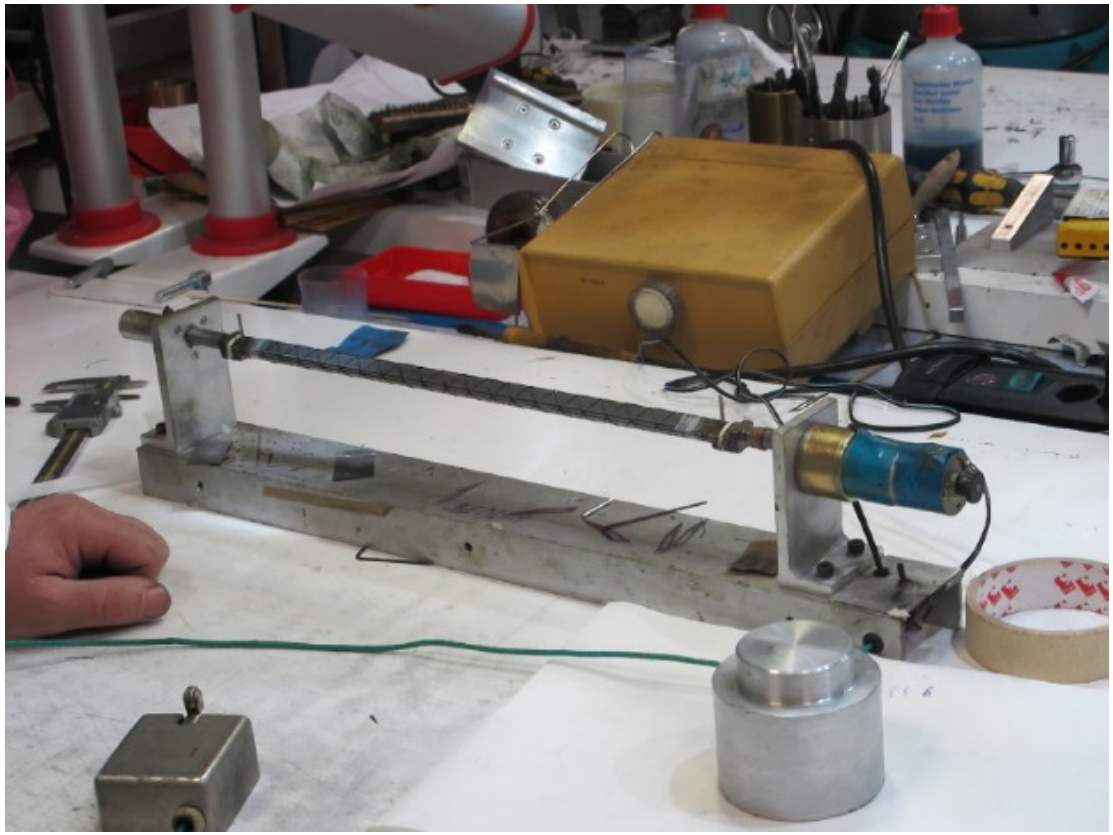


Weight: 1.7 g *(structure only*)*

ALICE inner tracker stave production:

ALICE inner tracker production stave with cooling tubes and filament support

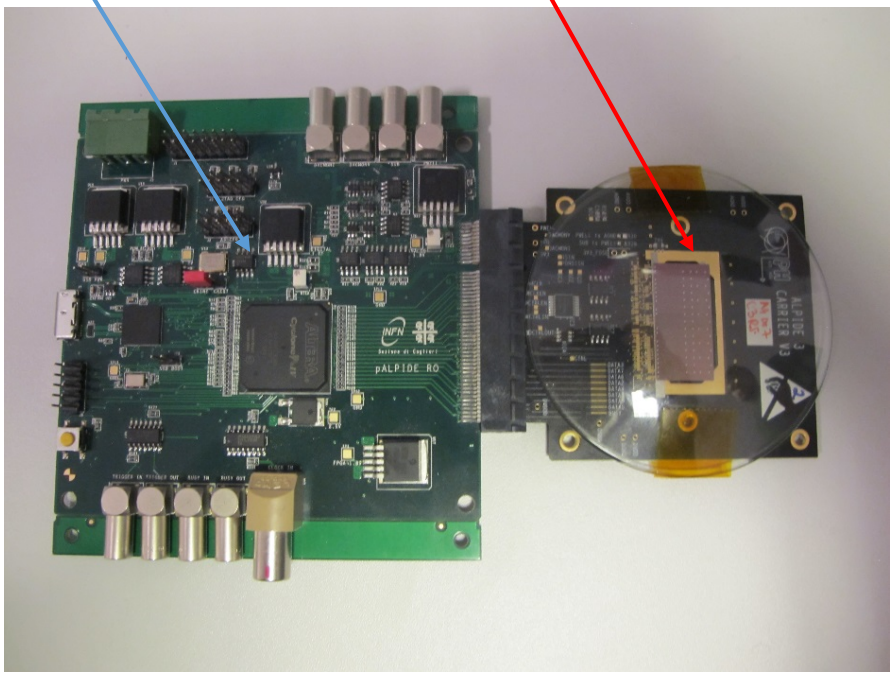
ALICE inner tracker stave filament winding



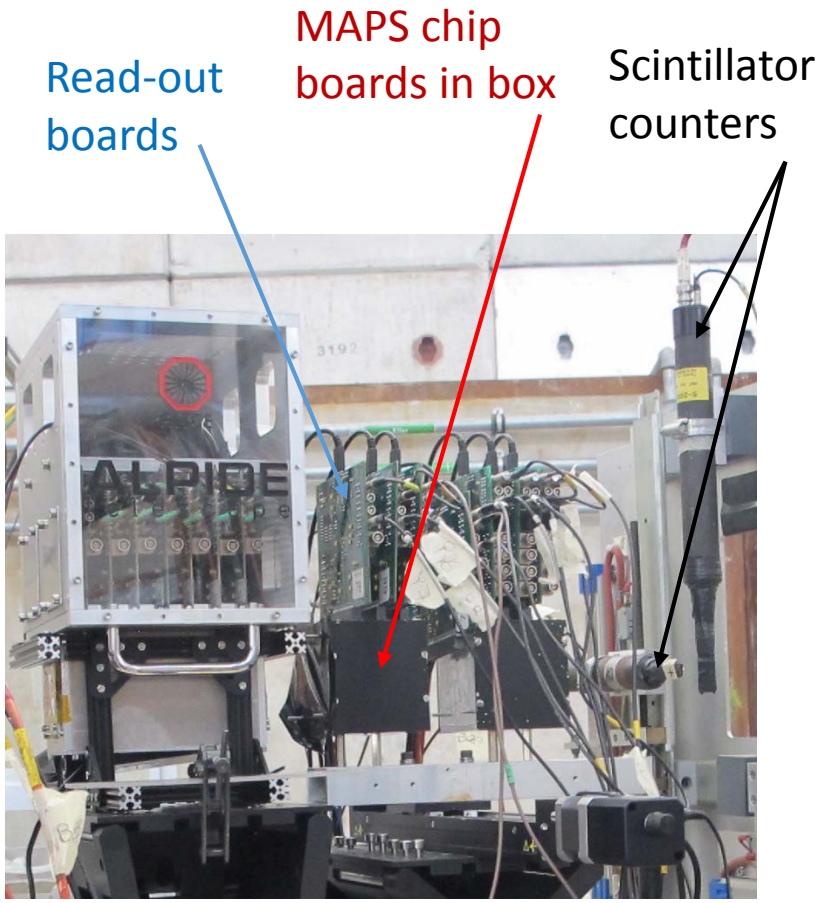
ALICE prototype inner barrel assembly:

Prototype inner tracker half barrel layers showing staggered layer overlap to maintain continuous coverage in *phi*

ALICE single chip module & single chip modules in a telescope configuration:



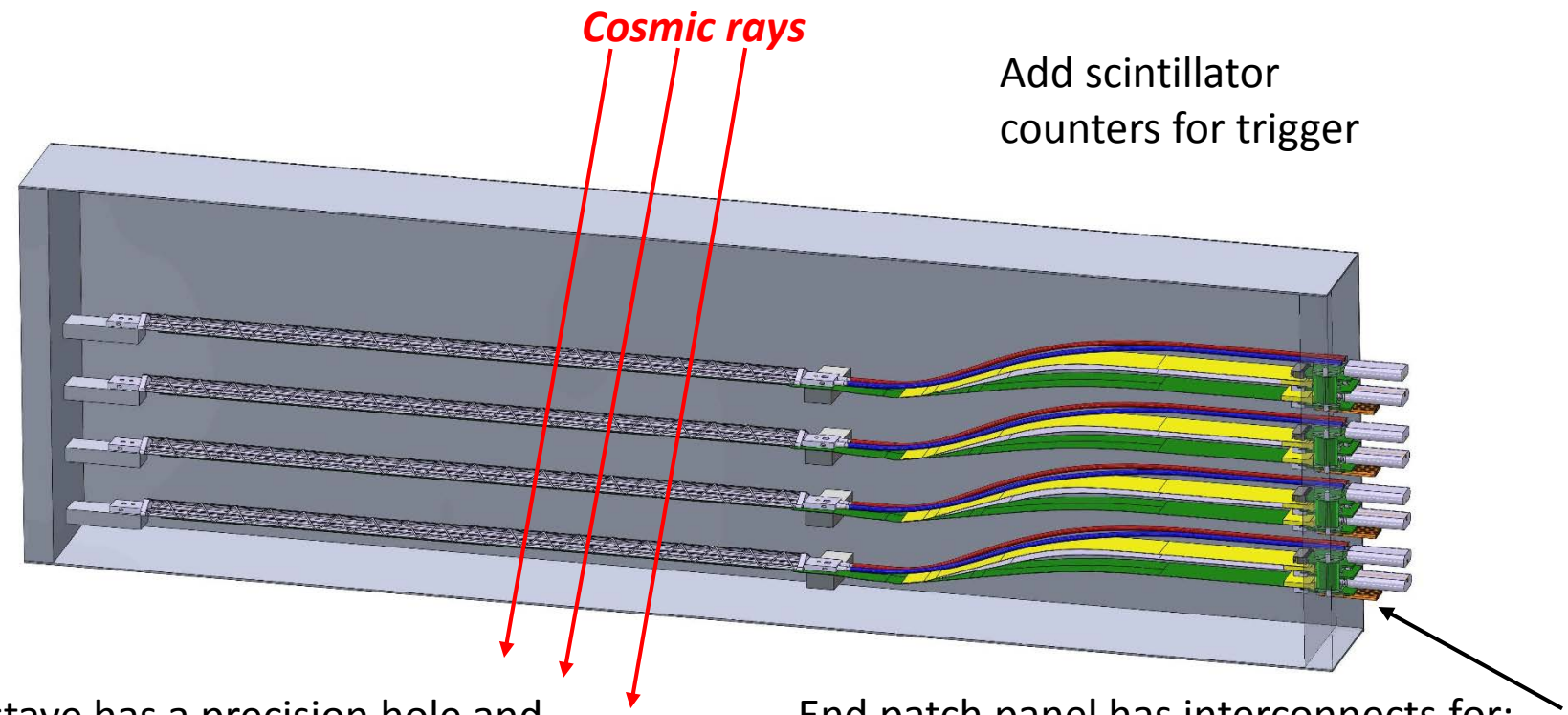
Single MAPS chip test module



6 single MAPS chip modules in test beam.

LANL four stave telescope assembly:

Aluminum box with 4 ALICE inner tracker layer 0 stave assemblies.
Box overall dimension 572.4 X 169.7 X 50.8 mm, inert gas atmosphere @ STP



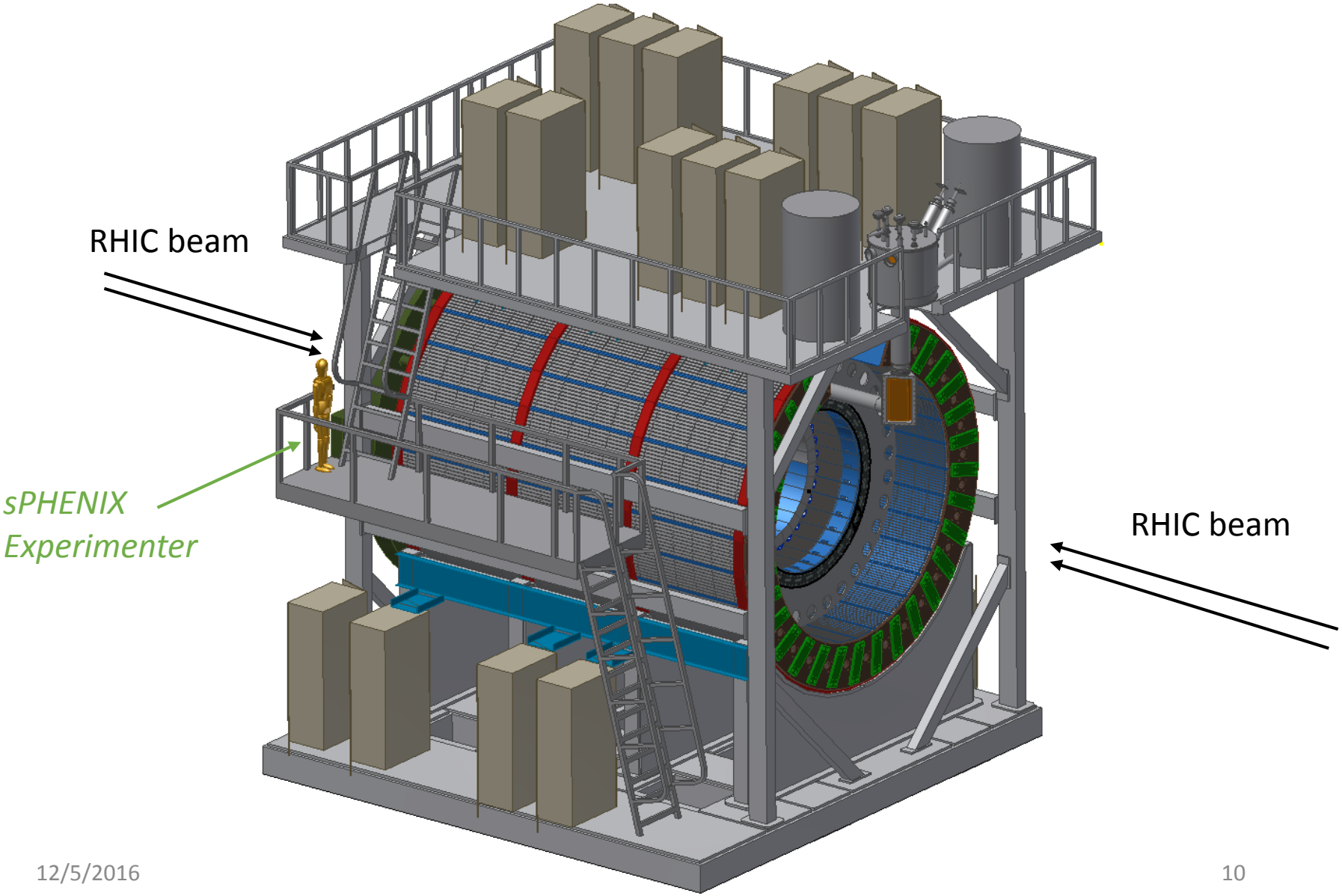
Each stave has a precision hole and slot at either end for precise location to mounting blocks

End patch panel has interconnects for;
Analog power
Digital power
High speed data lines
Water cooling

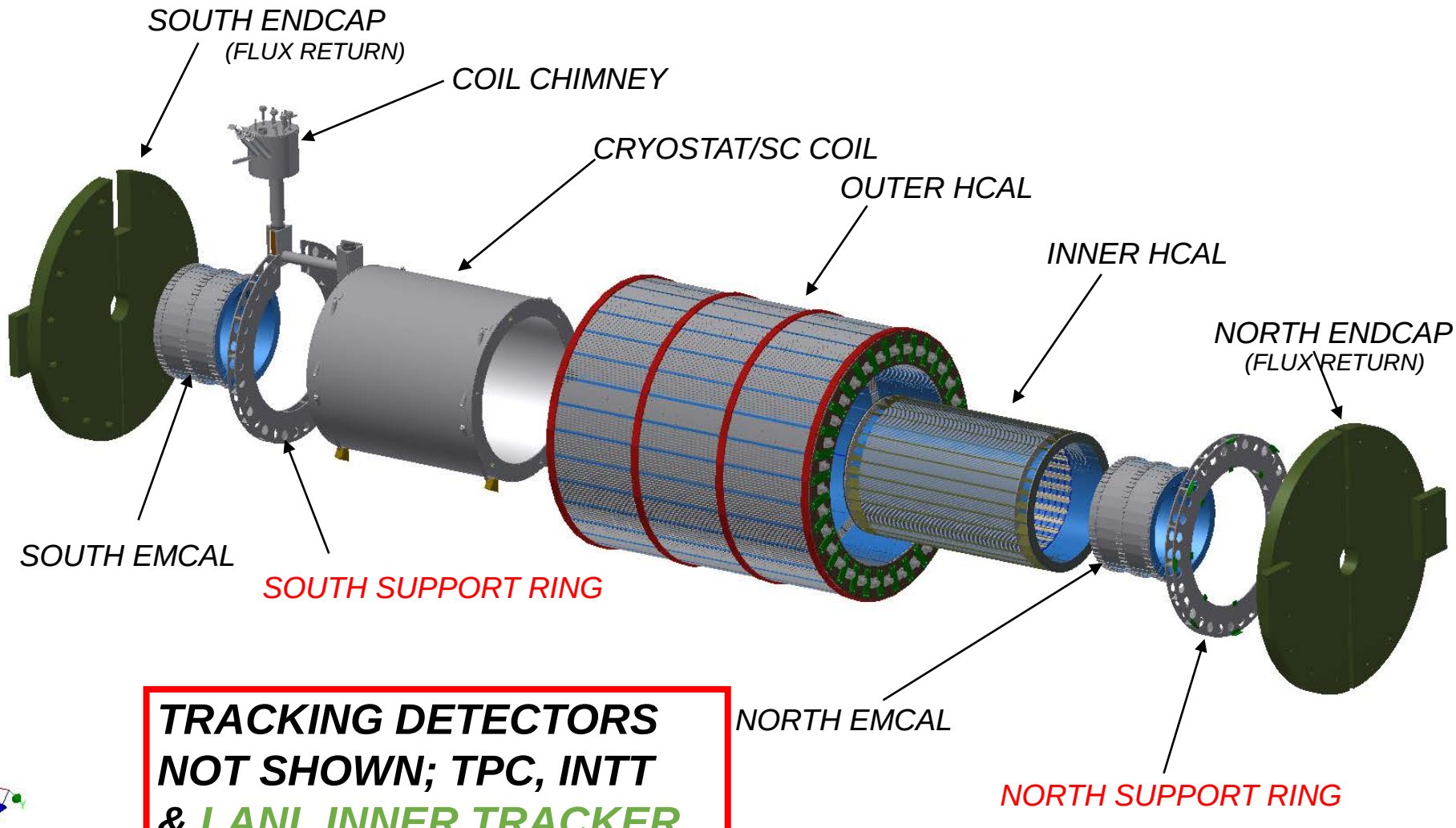
LANL telescope stave design parameters:

- Material budget: Material/layer: ~0.3%X0
- Geometrical:
  - Lengths in Z: 271.2 mm for each layer.
  - Number of MAPS chips/layer: 9
- Chip power dissipation < 50.0 mW/cm**2
  - total power per stave 1.7 watts, 6.8 watts for telescope assembly, add 100% overhead for a total of 13.6 watts
- Operational T <30 °C, max. Negative pressure water cooling, 1.02 mm diameter polyimide (Kapton) tubing.
  - Tested at flow rates from 3 to 7.5 L/hr, ΔT 2.4 – 1.7°K/chip
  - Verified pressure drop <4.35 psi @ 3.0 L/hr flow
  - 4 loops, 12 liters/hour flow rate each loop

Current sPHENIX proposed layout:

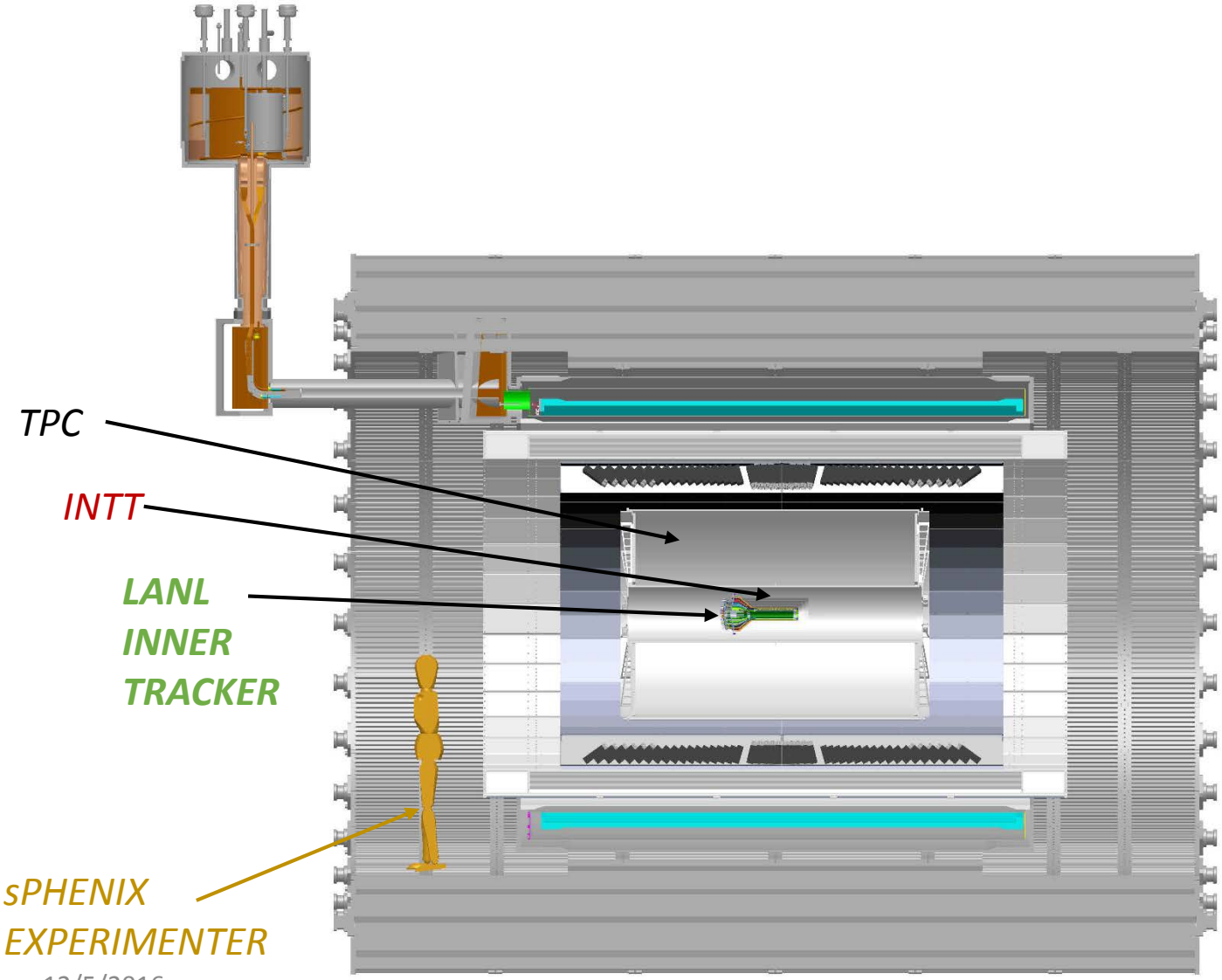


Current sPHENIX detector exploded view:

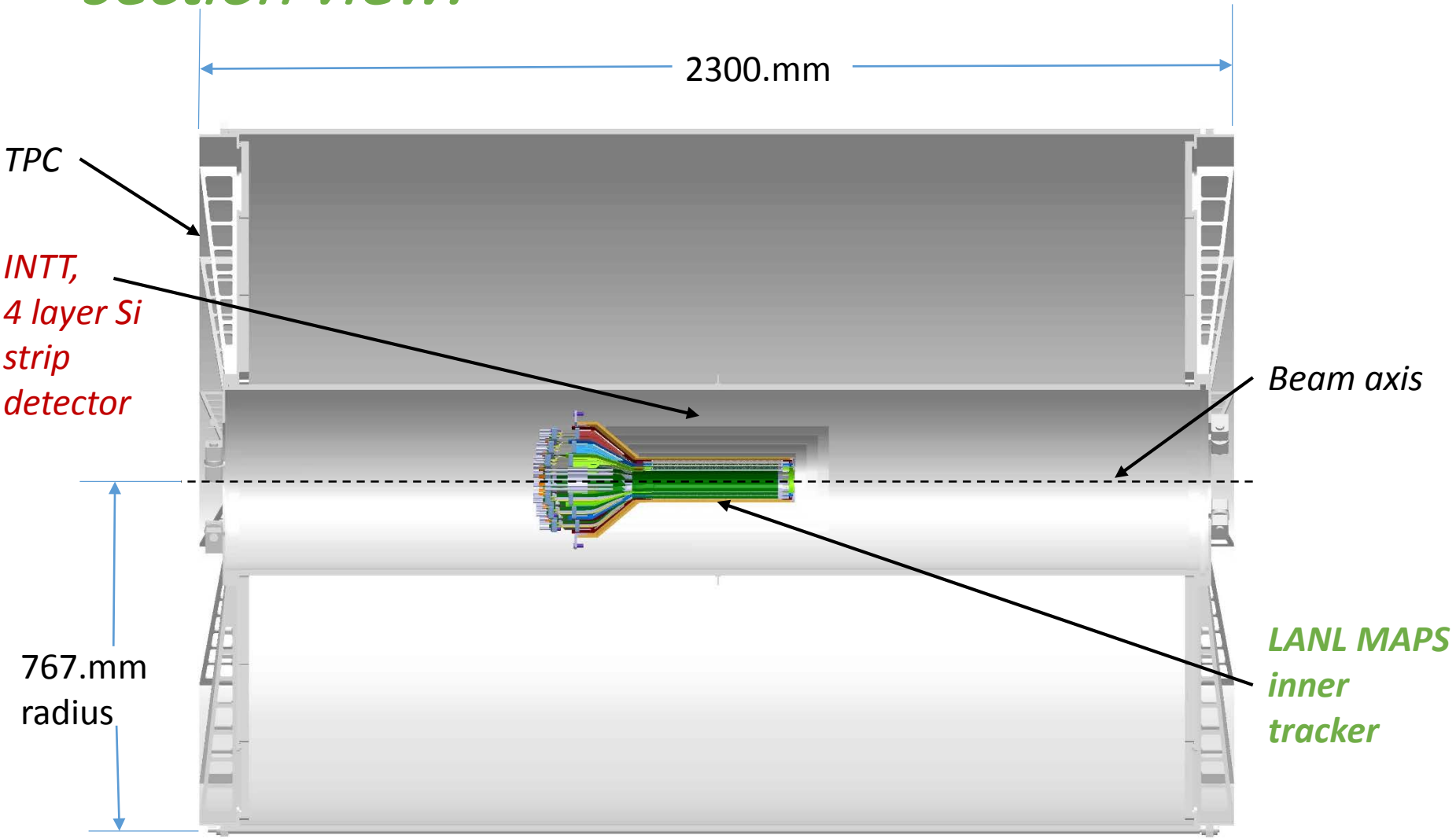


TRACKING DETECTORS NOT SHOWN; TPC, INTT & LANL INNER TRACKER

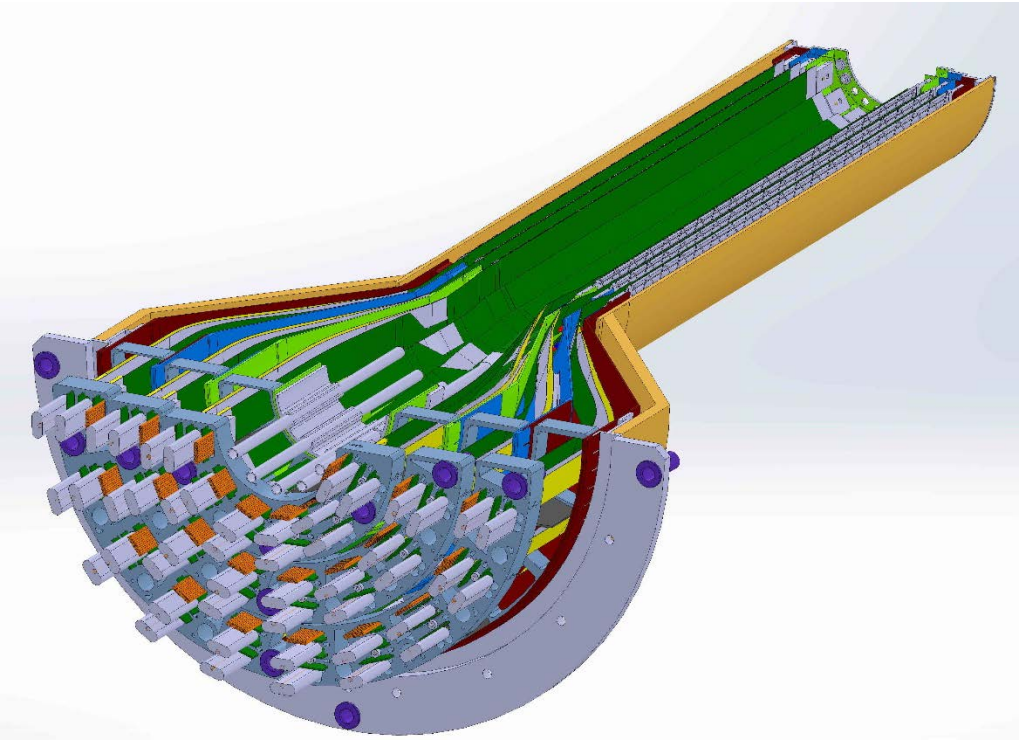
CAD model for sPHENIX detector sectioned, with tracking elements:



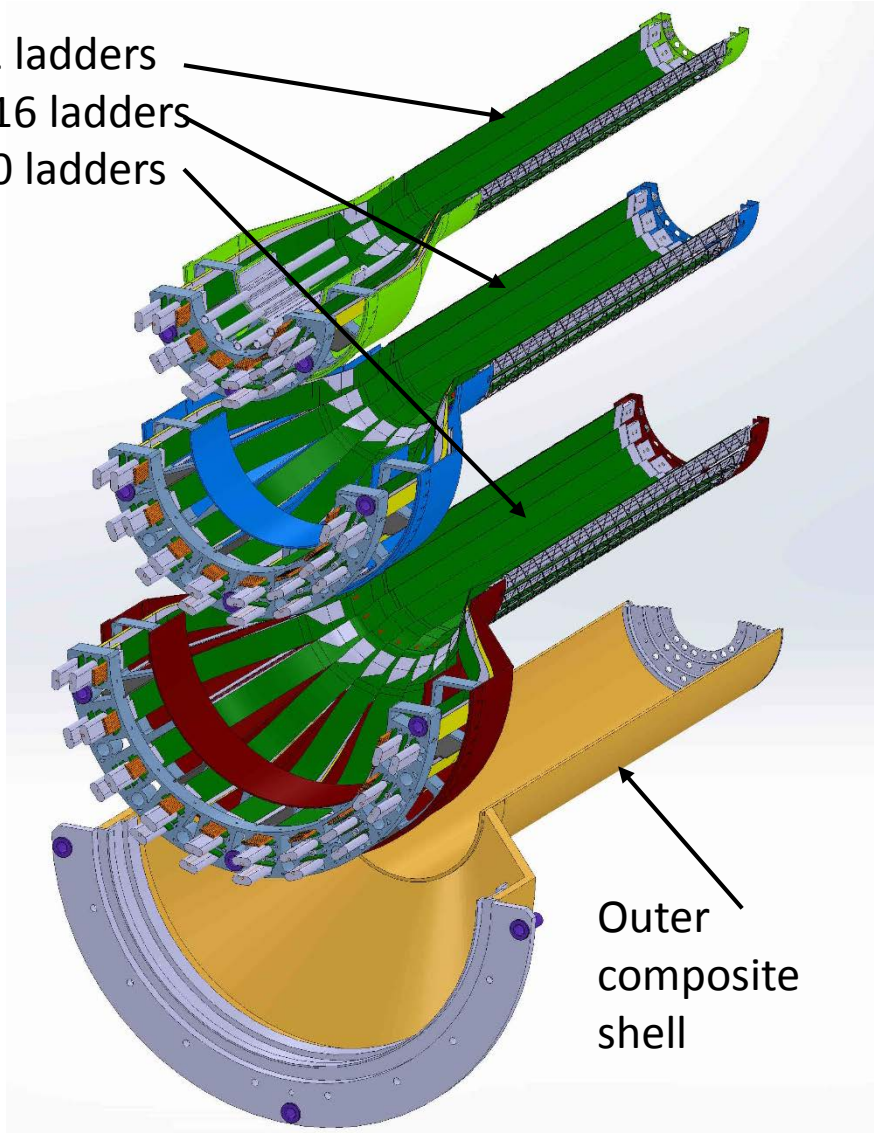
CAD model of the three tracking systems, section view:



LANL MAPS inner tracker, exploded view of layers, section view:

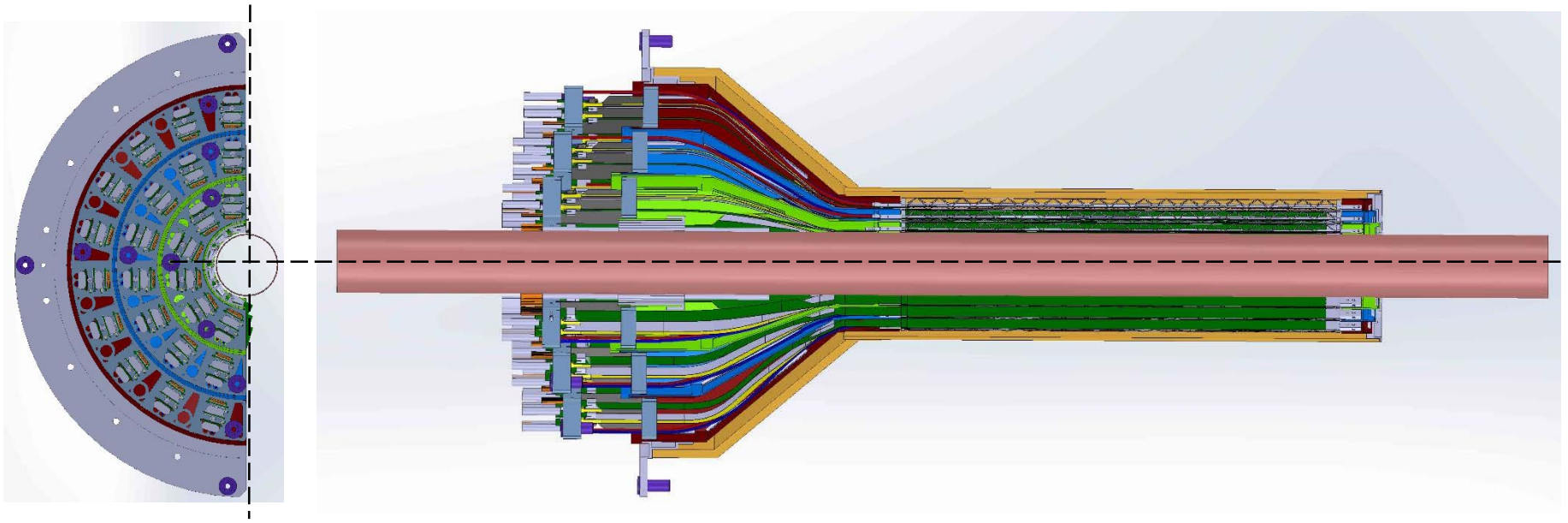


Half assembly view

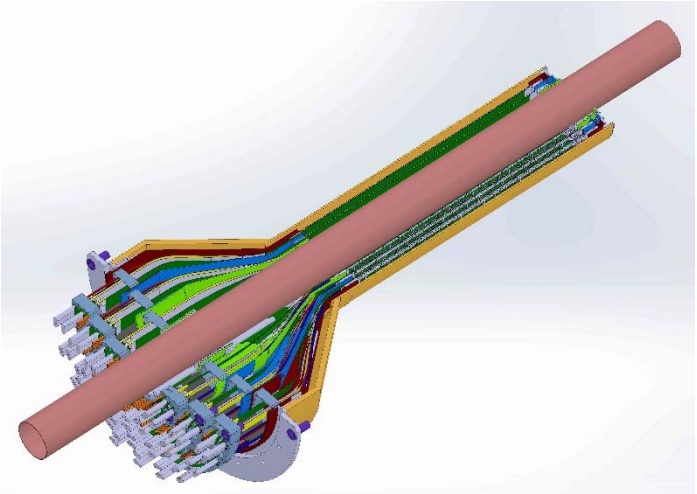


Exploded view showing the three layers

3 layer LANL MAPS inner tracker:



LANL inner tracker, 3 layers of silicon MAPS detectors with sPHENIX beryllium beampipe, OD of beampipe is 41.5 mm, ID of LANL inner tracker 42.9 mm.

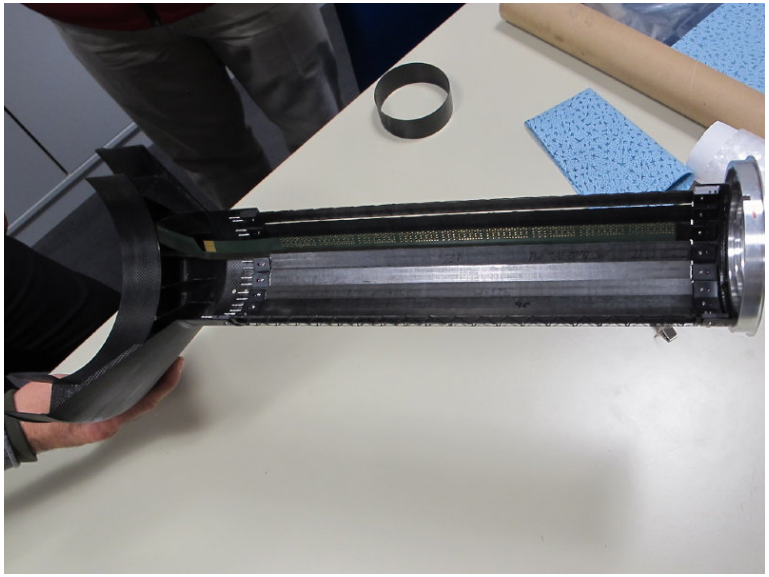


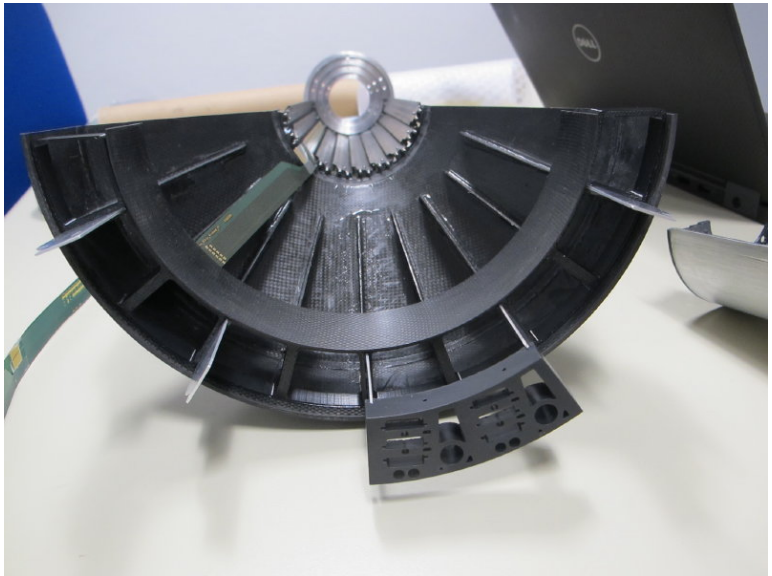
Summary:

- Mechanical construction of the carbon composite stave/space-frame is well underway at CERN
  - *Much work needed on perfecting stave assembly between MAPS chips and FPC to give highest yield after adhesive bonding and wire bonding, in process at CERN*
- Integration of entire tracking assembly with sPHENIX needs development – *risk level medium but requires full participation of sPHENIX to mitigate*
- Can a single cooling system be implemented for entire sPHENIX tracking system - *this will be a part of the entire integration of the sPHENIX detector system*

Backup:

Prototype ALICE inner tracker composite stave assembly:

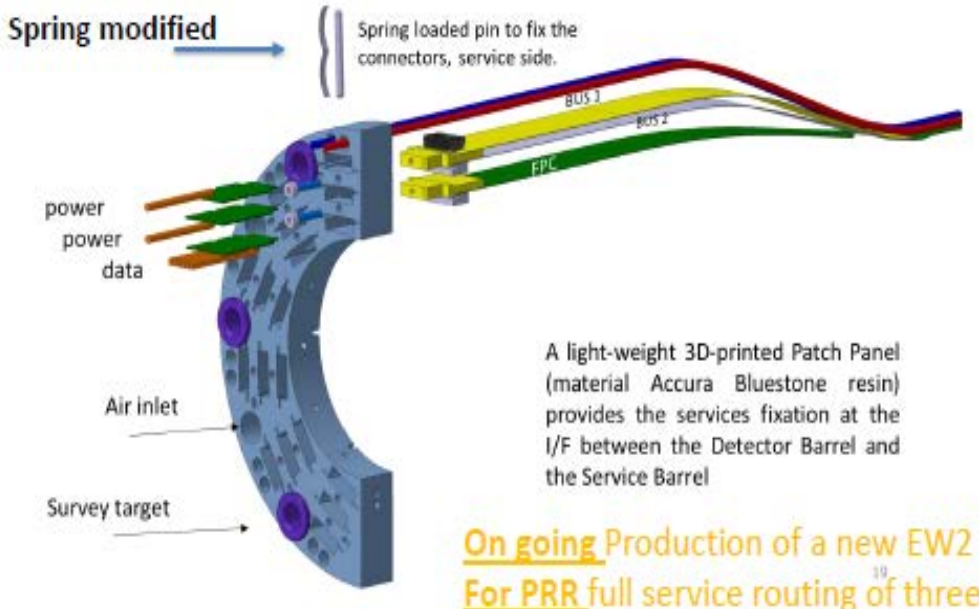




Inner tracker staves mounted to prototype support ends.

Inner tracker service patch panel prototypes:

IB service PPanel mockup



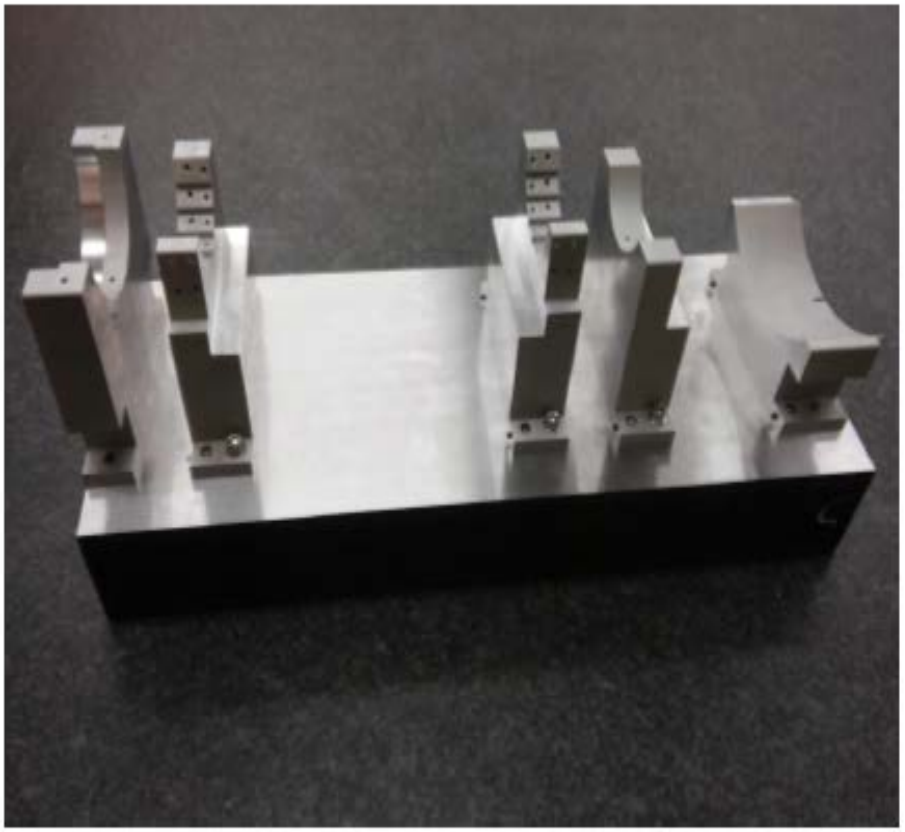
A light-weight 3D-printed Patch Panel (material Accura Bluestone resin) provides the services fixation at the I/F between the Detector Barrel and the Service Barrel

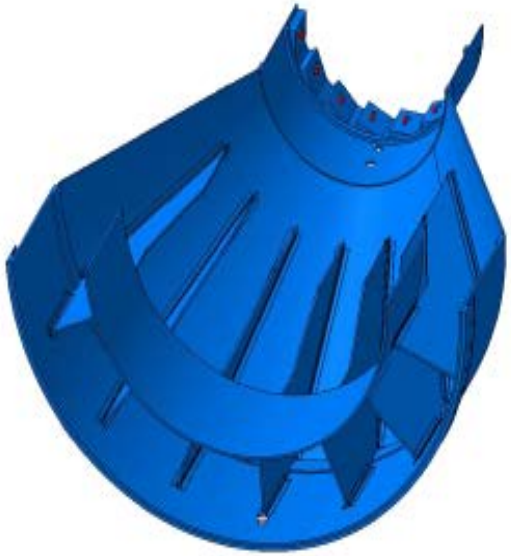
3d printed

On going Production of a new EW2 PP by the end of the week (Accura 25)

For PRR full service routing of three staves of EW2

Inner tracker composite shell prototypes:





On going Composite parts and mould production for EW1
For PRR EW 1 metrology and ruby pads gluing