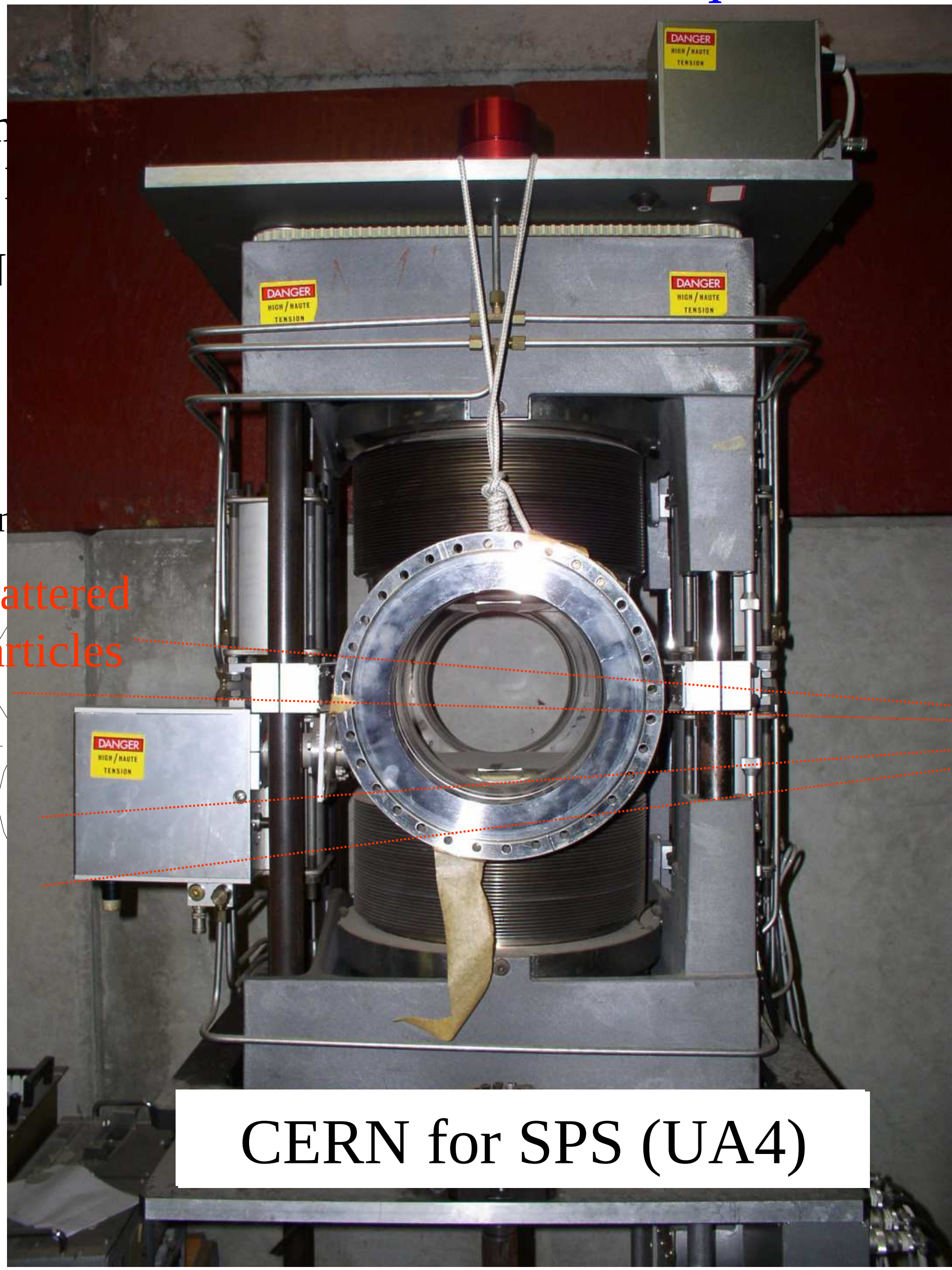
# Roman Pots

**Marco Oriunno**
**SLAC, PPA**

# The Roman Pot technique

1. The Rom ear beam physics: 
2. A CERN



# Constraints/Requirements for the LHC

## LHC

- High intensity beams with multi bunch structure
- UHV Vacuum compatibility
- RF Compatibility, low impedance
- Harsh radiation environment for material, joints, lubrication
- Machine Protection and LHC beam collimations :
    - Horizontal Plane > 10$\sigma$ (Asynchronous beam dump failure)
    - Vertical plane > 10$\sigma$ (Halo)

## TOTEM

- Very close to the beam operation (10$\sigma$ ~ 0.8mm)
- Secondary vacuum separation for detectors and cables (no outgassing)
- High mechanical reliability of the thin window on the pot
- Shielding of RF pick-up on the detector/electronics
- High resolution, precision and repeatability of the movements

# Common problems = common solutions

Roman Pots are in many aspects identical to the LHC collimators

In facts :

Movable devices in the LHC beam

Almost the same requirements for vacuum and RF

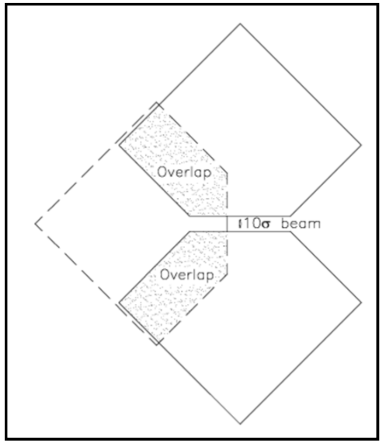
Close to the beam operation ~ 10$\sigma$

Same Engineering Team (TS-MME group at CERN)

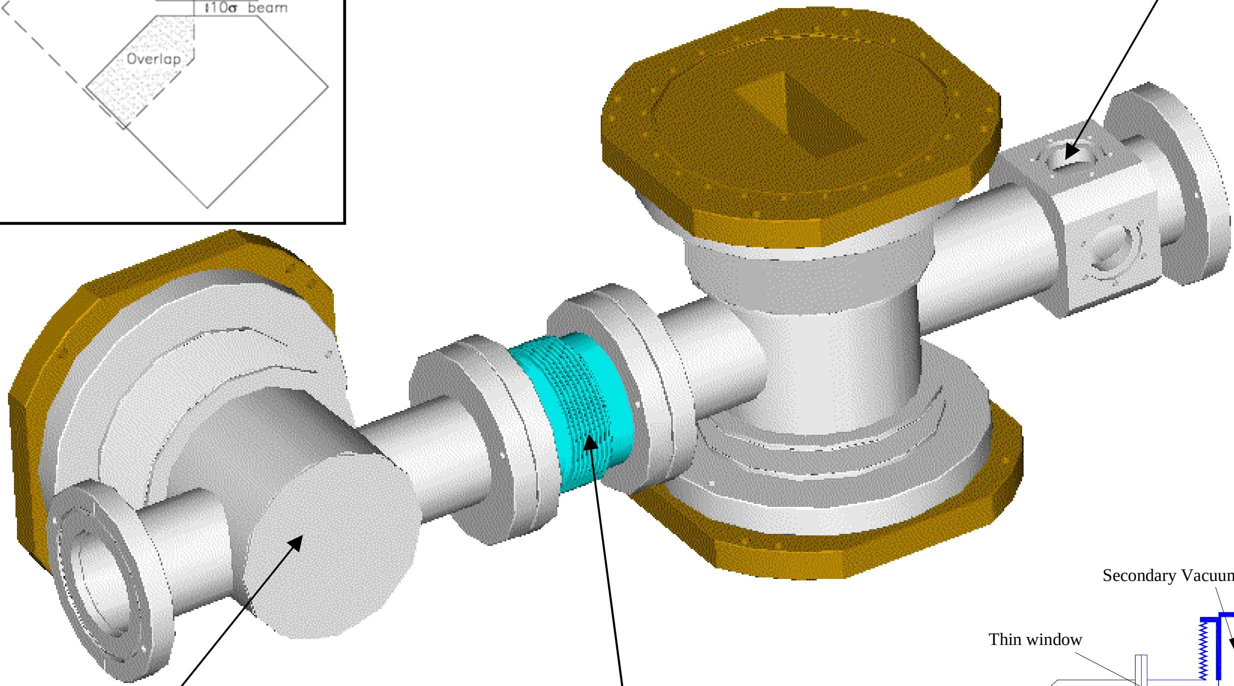
Same movements (motors, resolvers, positioning detectors, drivers)

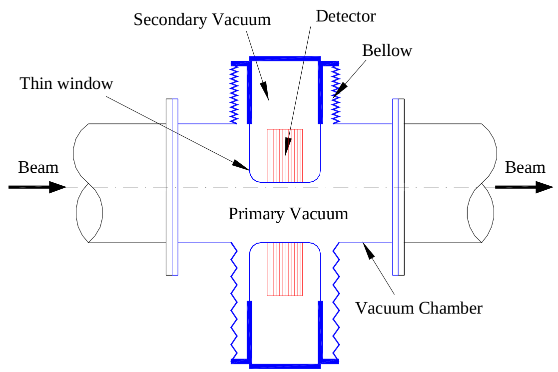
Same controls hardware/software through the LHC Control room

# Roman Pot for the LHC: the features




Integrated beam position monitor

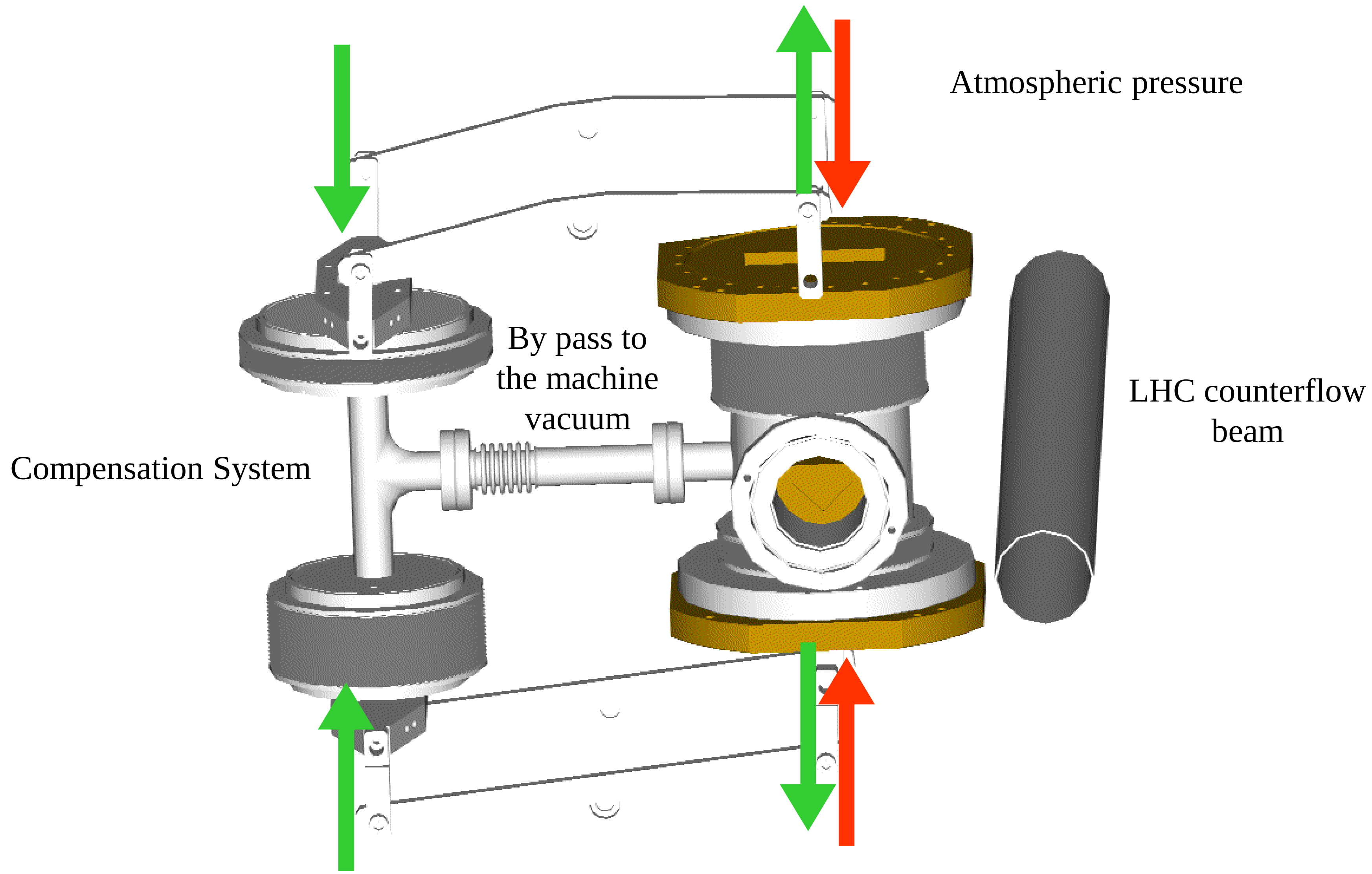




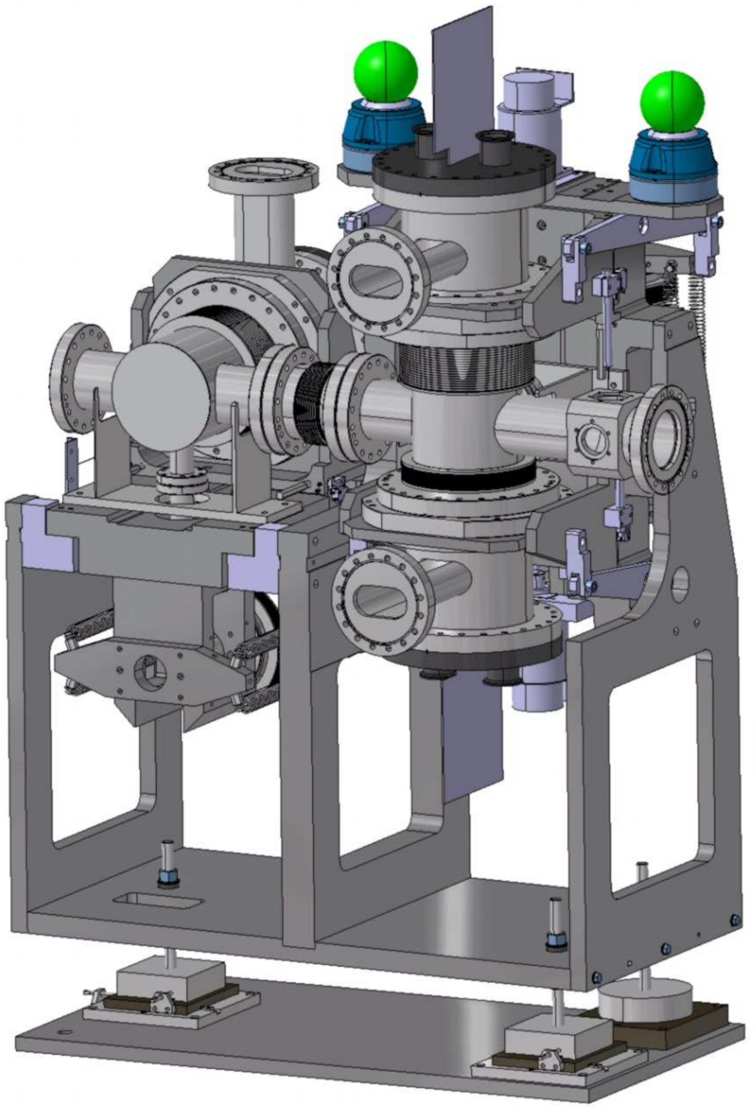

Horizontal Pot : physics, overlap for tracks alignment

Interconnection vacuum bellow : bake out and RF

# The compensation system



# The Roman Pot unit



- Three measurement pots : two verticals, one horizontal
- Integrated beam position monitor
- Interconnection bellow between horizontal and vertical pots
- Vacuum compensation system interconnected to the machine vacuum
- Individual stepper motors to drive the pots
- Adjustable jacks to align the RP unit in the tunnel

# Choice of materials

The materials and the treatments of the vacuum chambers must be compliant with the basic requirements of the LHC Vacuum :

- All surfaces in contact with the machine vacuum need to be bakeable
- 316LN for flanges, Pot and Beam Position Monitor
- 316L for bellows and vacuum chamber
- Low impedance copper coating on inner surface

The external support structures are manufactured with lightweight Aluminum alloy 6082, to have reasonable weights and costs.

All the vacuum joints are in metal: Conflat or Helicoflex

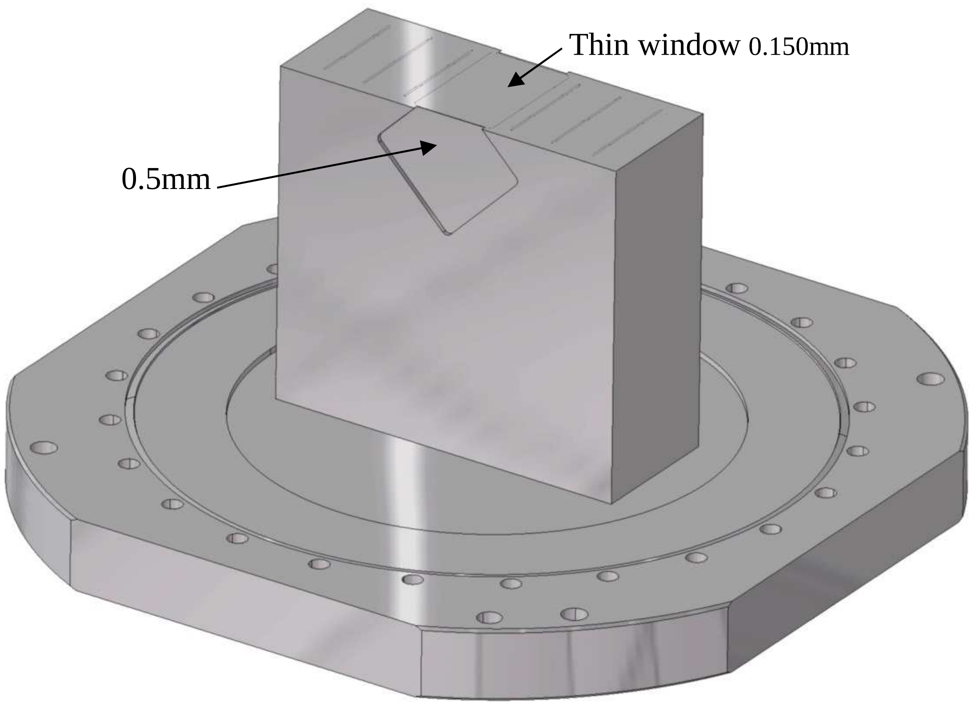
Full metal Sliding mechanisms (rails, screw, bearings)

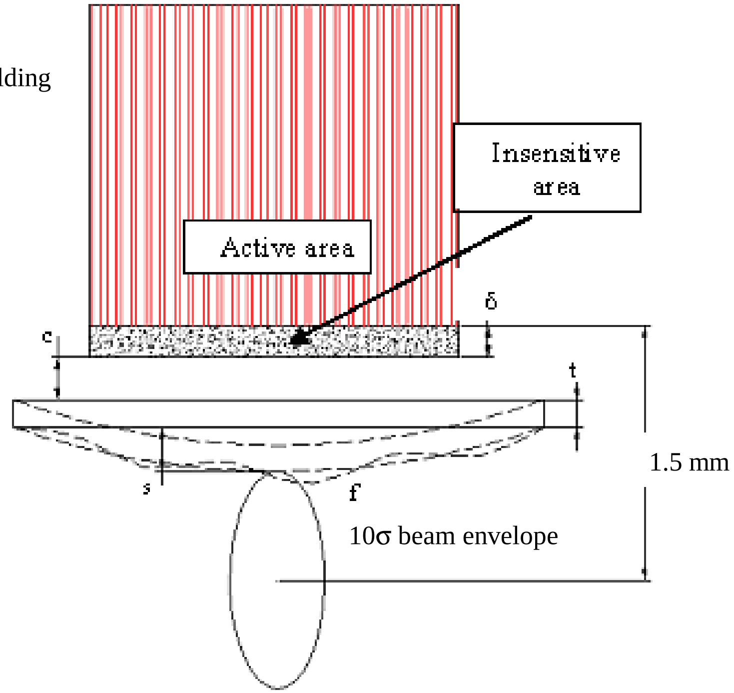
Non metallic materials only used in the detector assembly

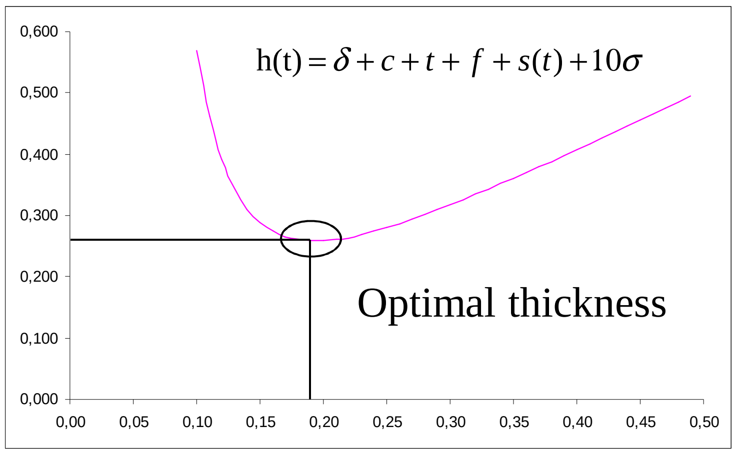
# The pot and the thin window

Strength, Robustness, UHVacuum tightness, Thin, Flatness, Radiation length, RF Pick up shielding

- Several joining technologies and geometries have been prototyped
- Requirements of planarity ≤ 50 microns
- High reliability along the full life cycle
- Capability to stand atmospheric pressure with a safety factor 1.5
- Safe and not impaired by the bake out (temporary cooling)
- Absence of residual deformations induced by thermal and mechanical loads

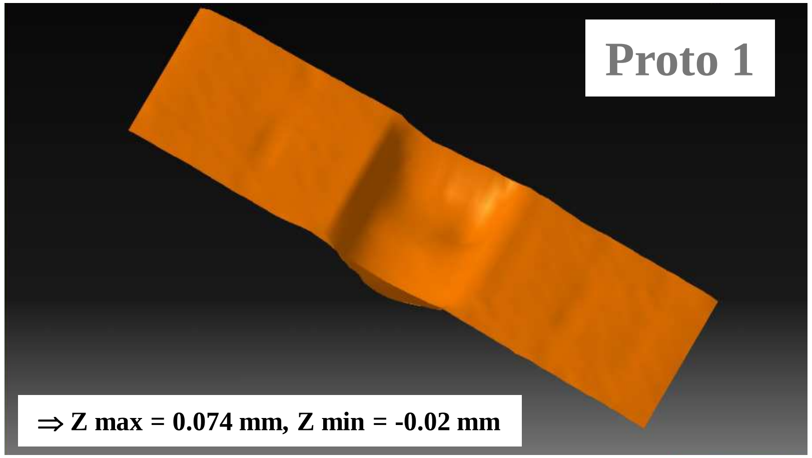


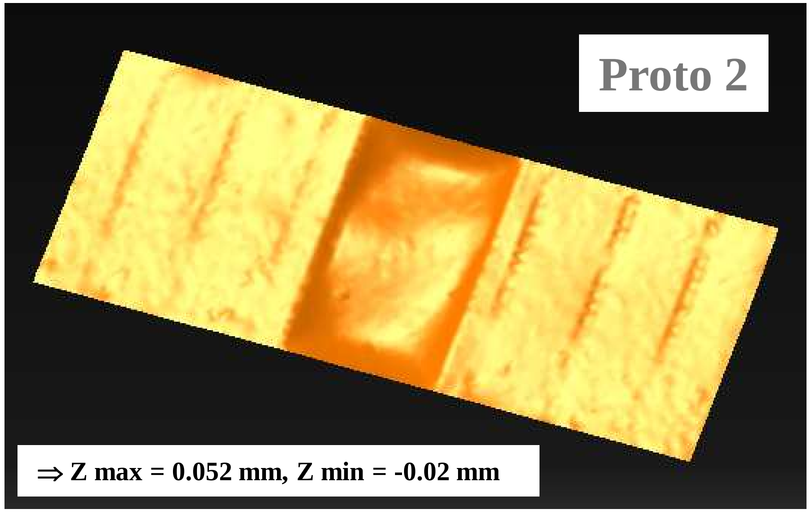




M.Oriunno, SLAC

# Thin window technology



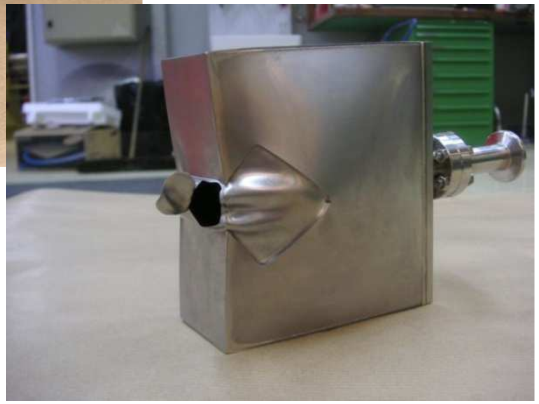



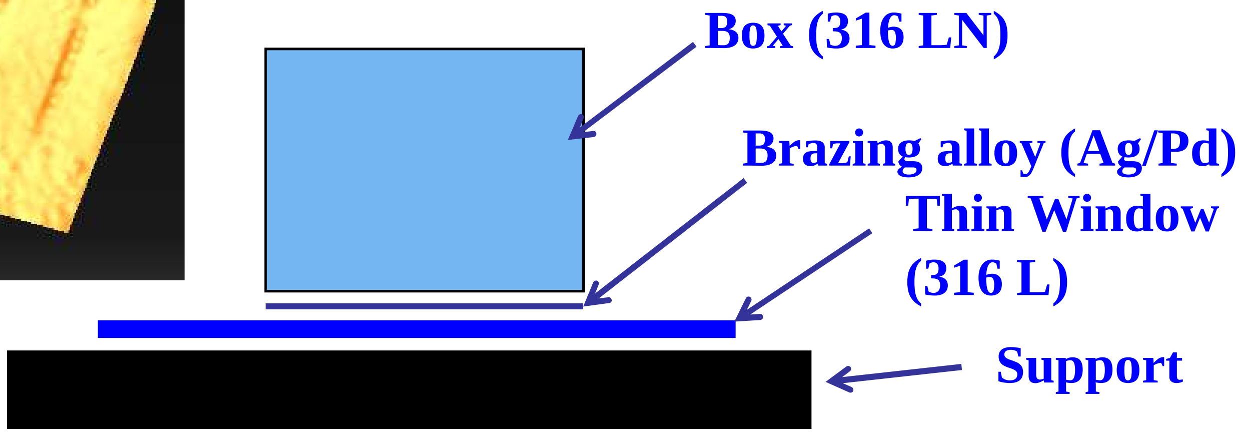

**Vacuum Tightness**

No leaks detected in the detector noise threshold $2x10^{-12}$mbar.l/sec

Ultimate pressure test

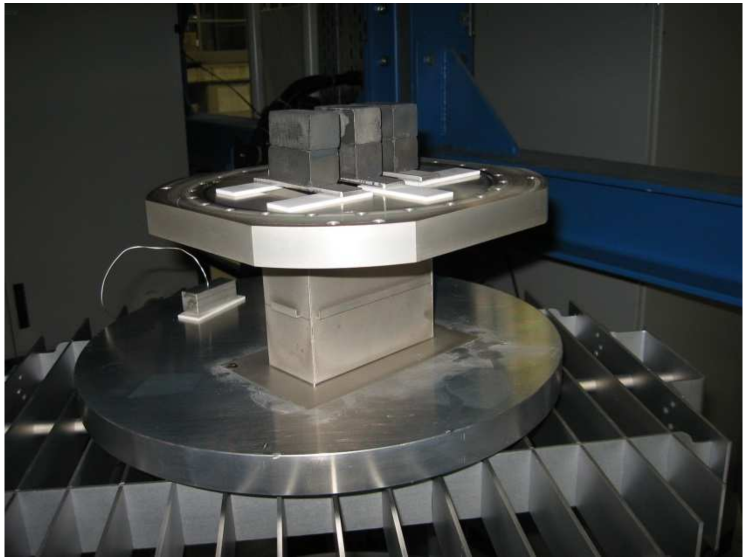
83 bars

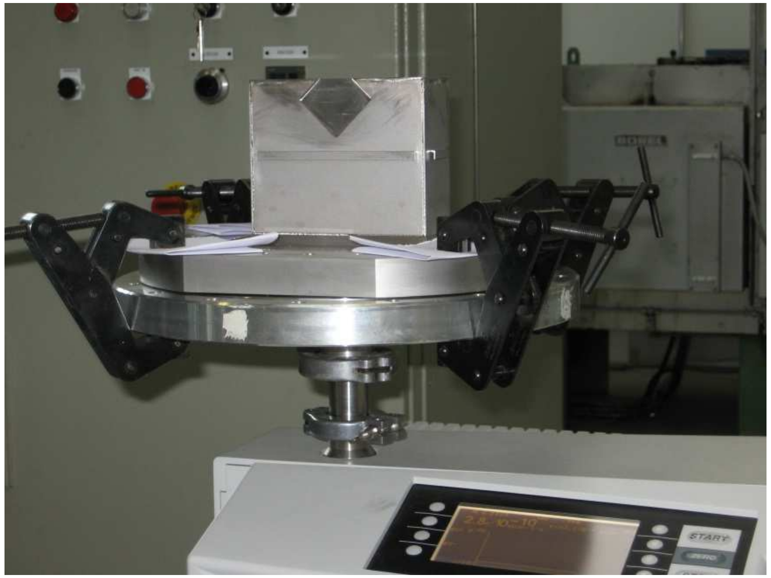


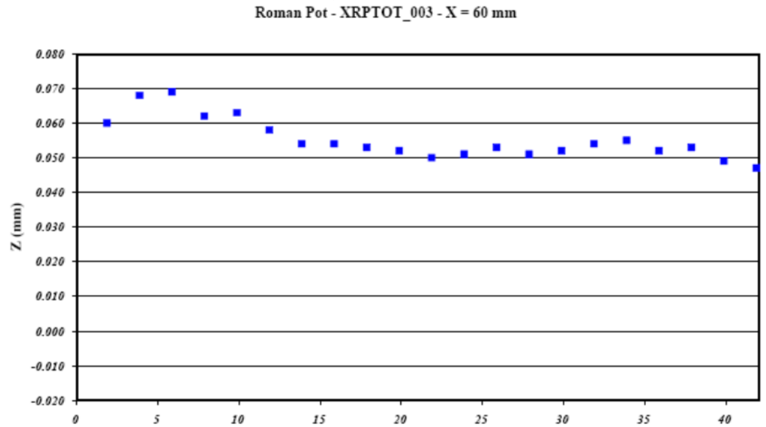


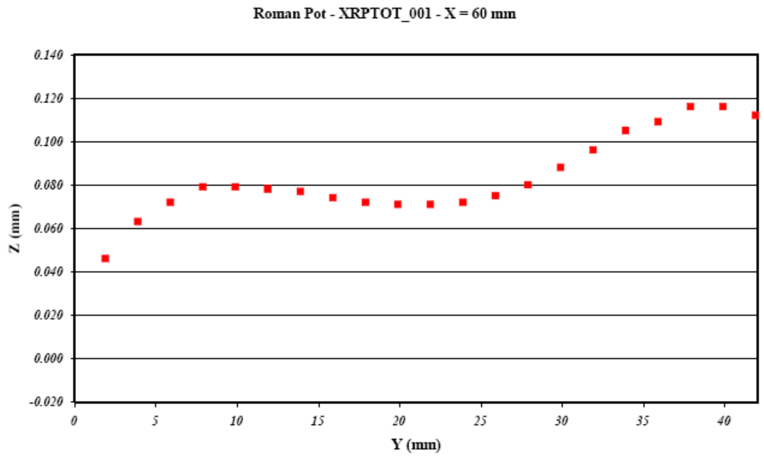
# The first 3 pots (Nov. 2006)

1. They are the very first full pots
2. Planarity is not so good as the summer prototypes
3. Potential error source: the assembly and manufacturing procedure



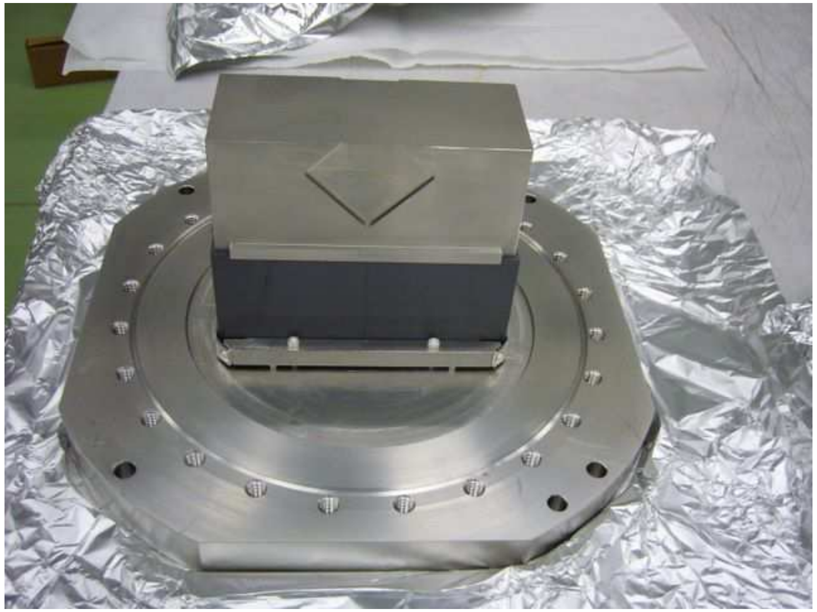


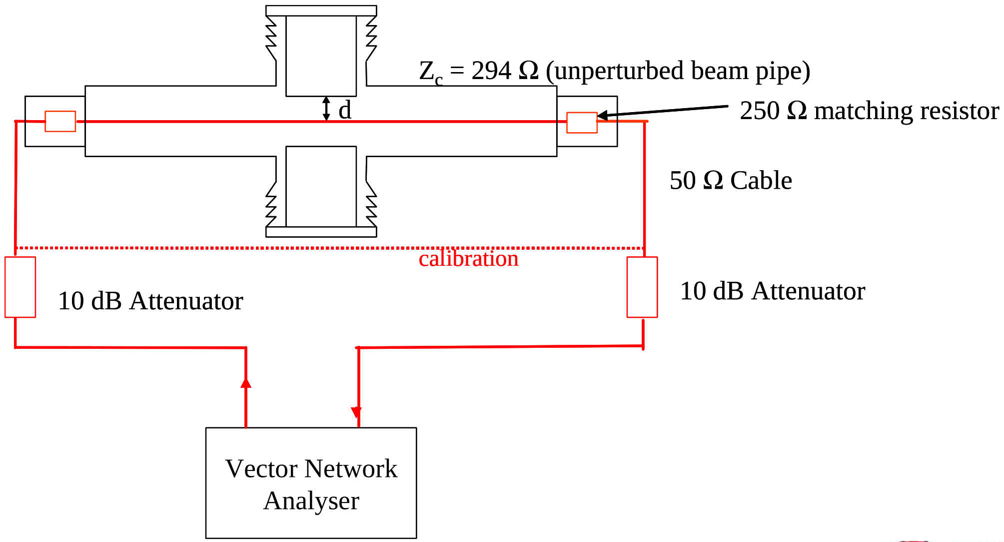


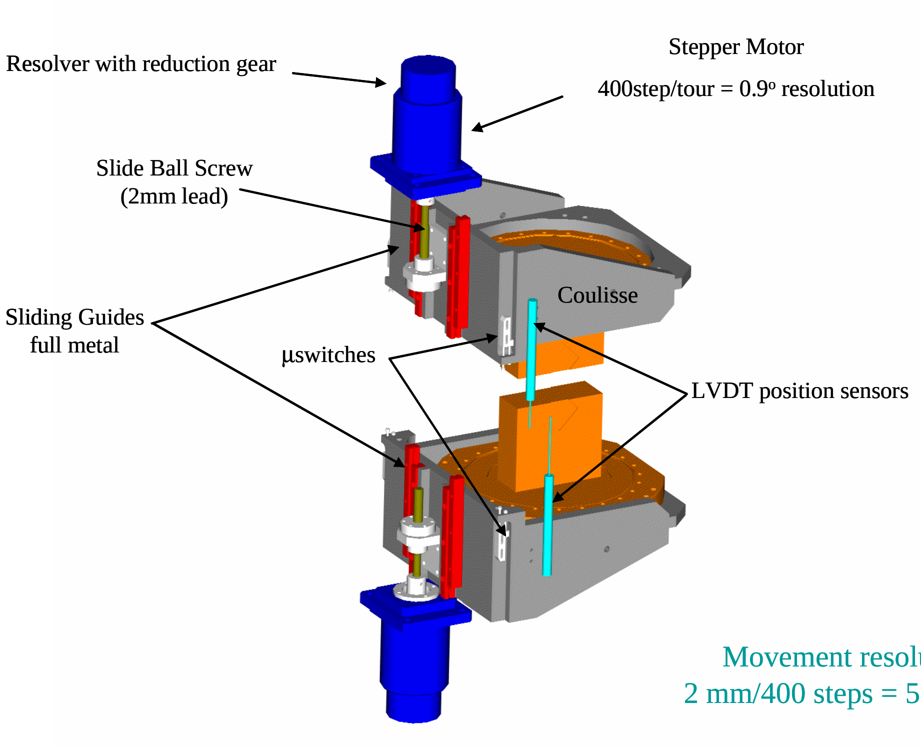
RF issues (beam coupling impedance)

- Beam coupling impedance of RP without ferrites: ≤ 1200 Ω
  $Z_L/n \leq 18$ m Ω @ 740 MHz resonance
  Q = 114
  P ≤ 200 W
- Good improvement with ferrites (factor 1/5)
  $Z_L/n \leq 3.6$ m Ω
  Q = 23
  P ≤ 40 W
- Ferrites included into the new RP design





# The mechanisms (same as the LHC collimators)




Movement resolution
2 mm/400 steps = 5 µm (σ/16)

Technical solution common with the LHC collimators

Same motors and instrumentation are used

Low costs for R&D and procurement

•Micro-stepping 400steps/360º give enough resolution

•Present Nominal resolution -> 2mm lead/400step = 5 microns

•Precision relies on the screws quality and their connection with the motor

•Radiation hardness is an issue (1Mrad from the TDR to be confirmed), found on the market customized motors certified up 1Grad…space applications= high costs.

•Revolvers to be coupled with motors: calibration of the assembly

• Inductive LVDT for relative positioning: resolution 0.1% of the travel -> expected precision 10 microns

• Pressure Gauges for the secondary vacuum, interlock with the electronics

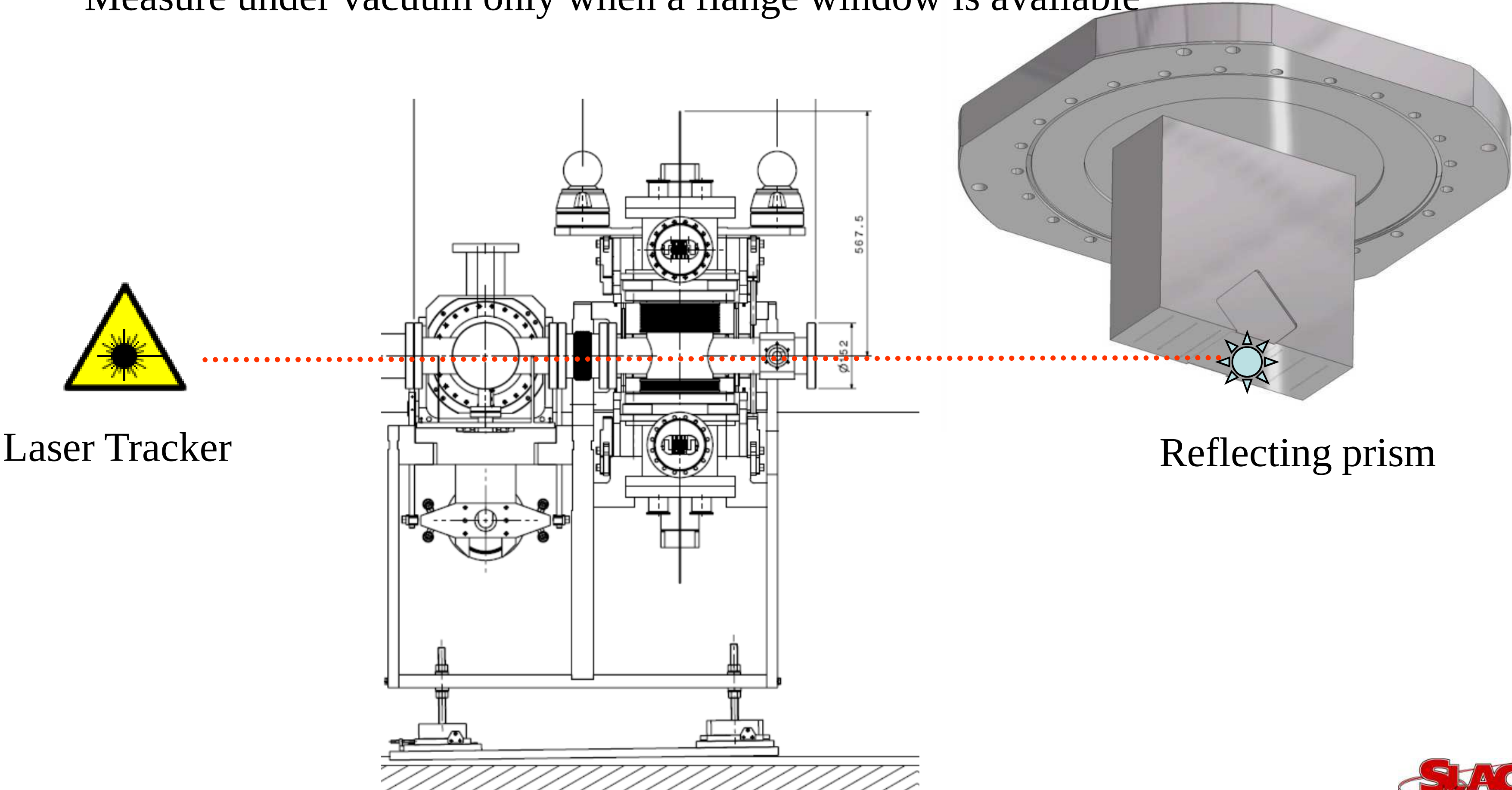
# Metrology

Scanning of  the position of the pots w.r.t. the nominal axis and the BPMs

Final motors installed

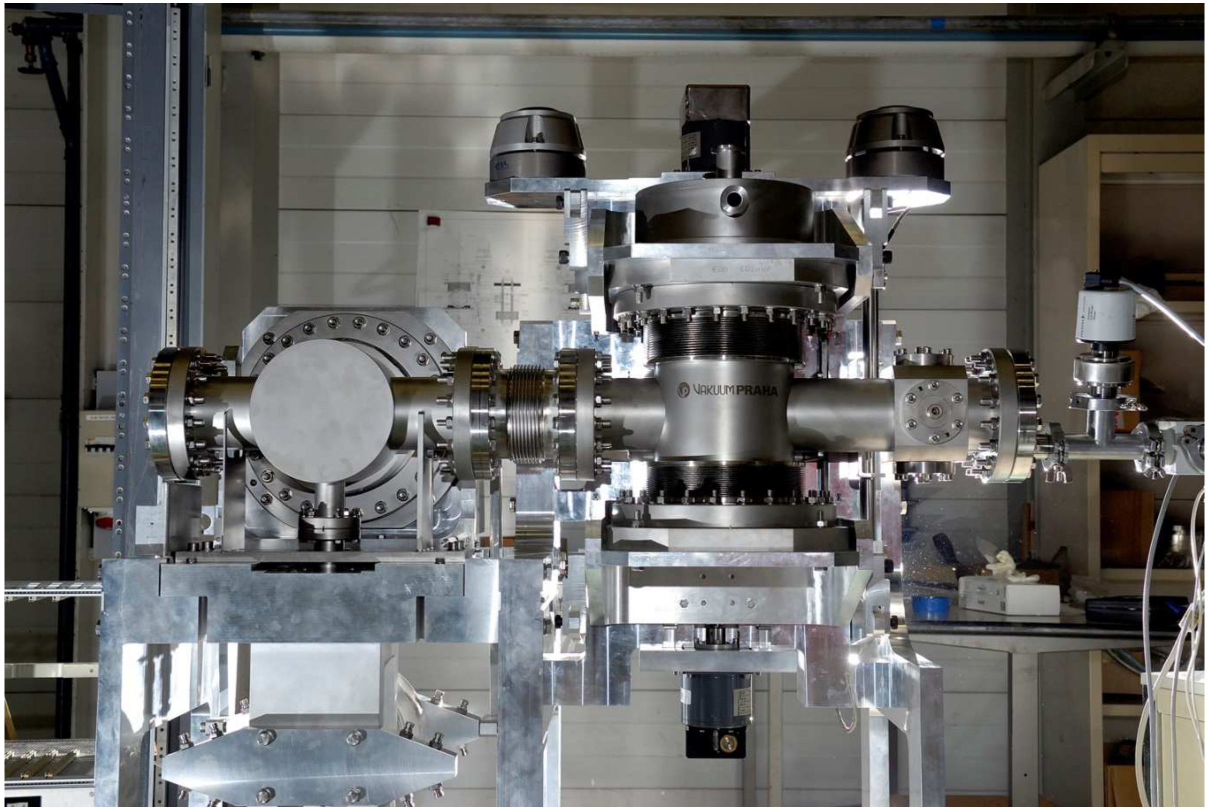
First measure without vacuum

Measure under vacuum only when a flange window is available



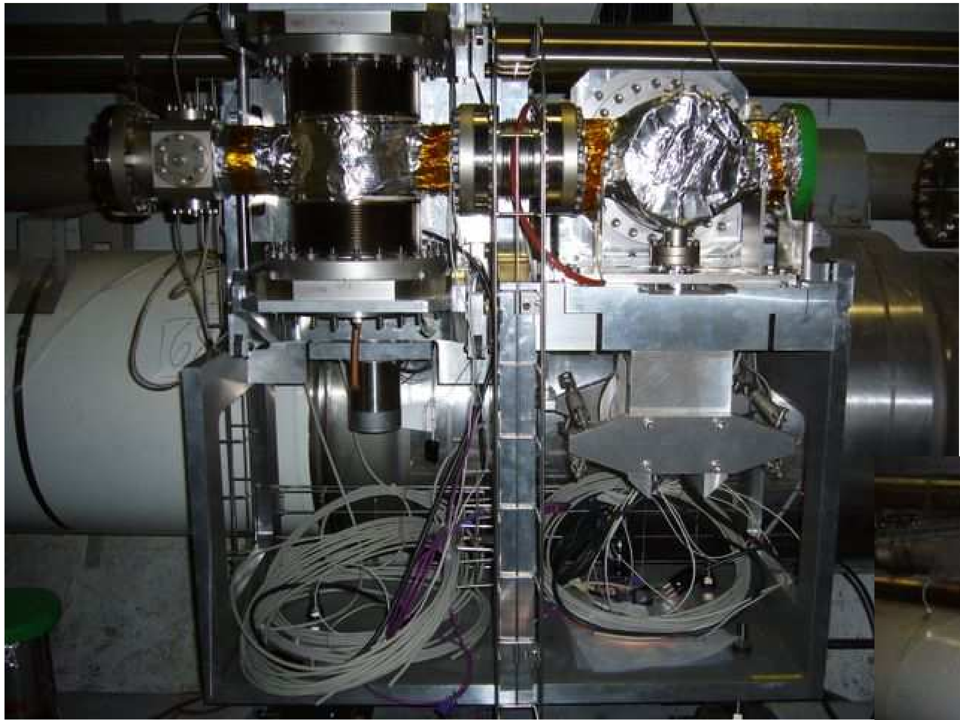
# Roman Pot

## Validation



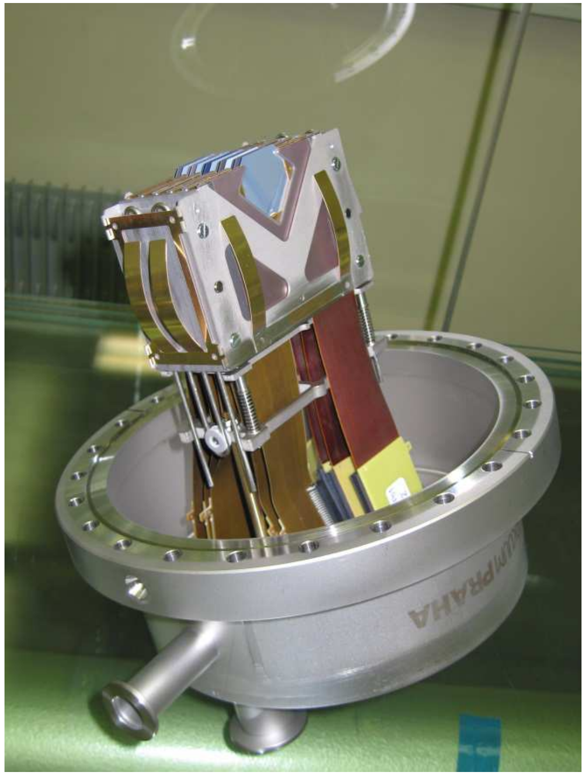

- Validation of the mechanical assembly
- Vacuum tests done up to $10^{-7}$mbar
- Spectrum analysis of the cleaning done by VakuumPraha
- Internal alignment and metrology
- Bake out test
- Final RF test

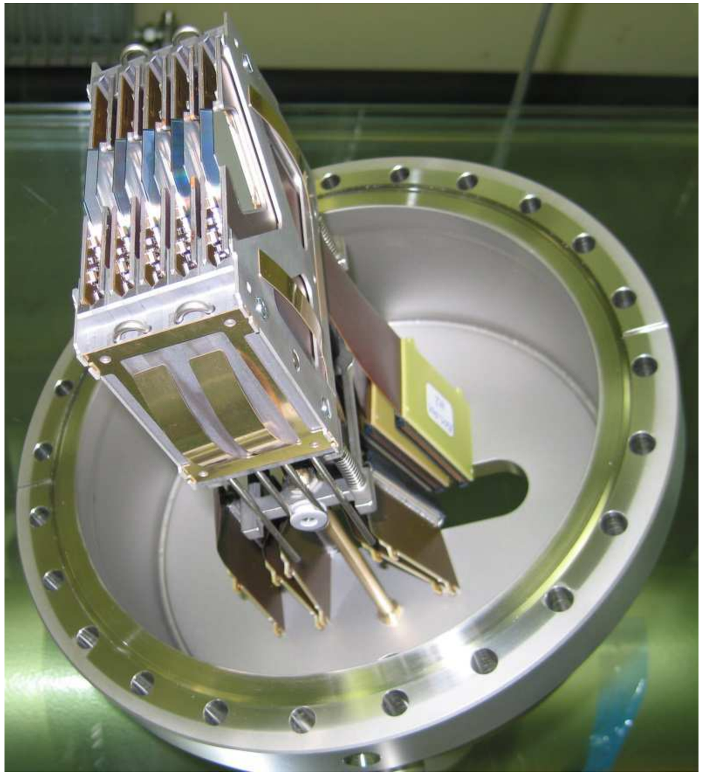
# 8 Roman Pot Stations Installed in the LHC in June 2007



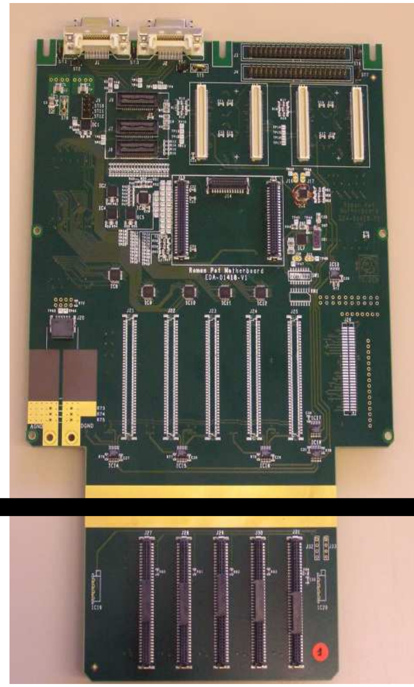
# Technical Status (2)

## First Roman Pot Detector Package Assembled





Roman Pot Motherboard connecting the detector packages in the vacuum to the outside world



Vacuum flange

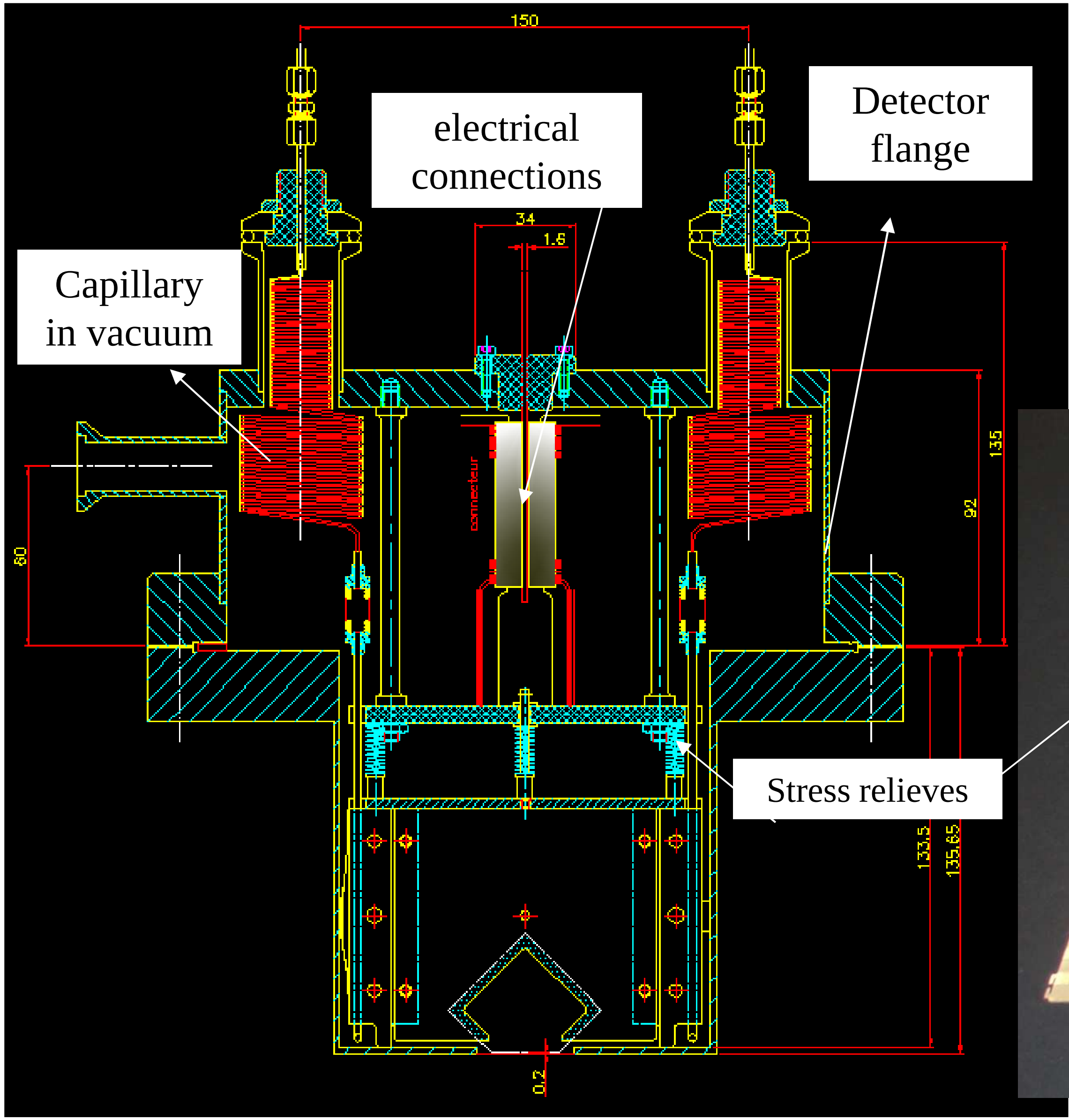
Feed-through

Connectors to detector hybrids

To be installed in the tunnel by end of April.
3 – 5 more assemblies to be mounted before LHC start-up.

Roman Pot Motherboard completed and currently under test.

# Thermo-mechanical design



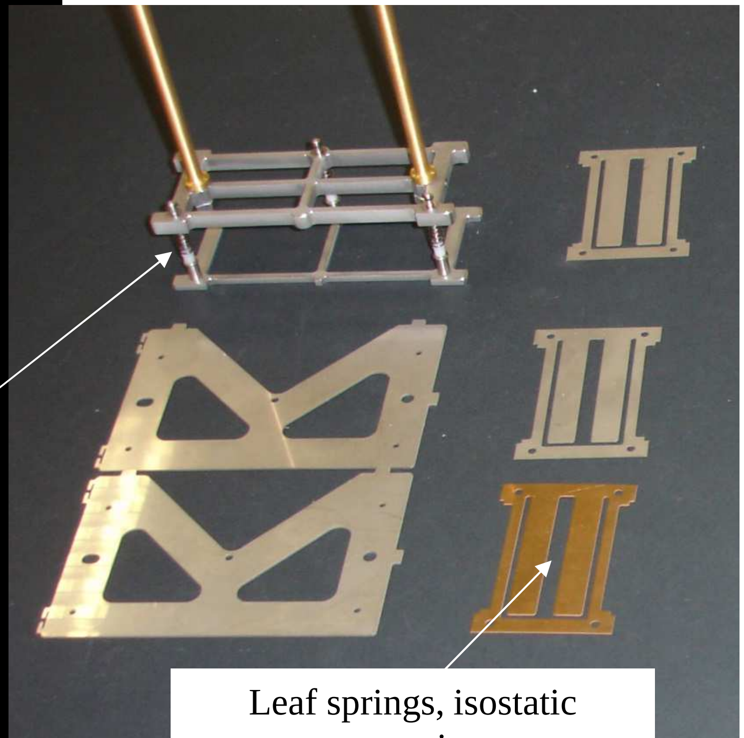

Mechanical stability < 20 µm

Window-Detector edge < 100 µm

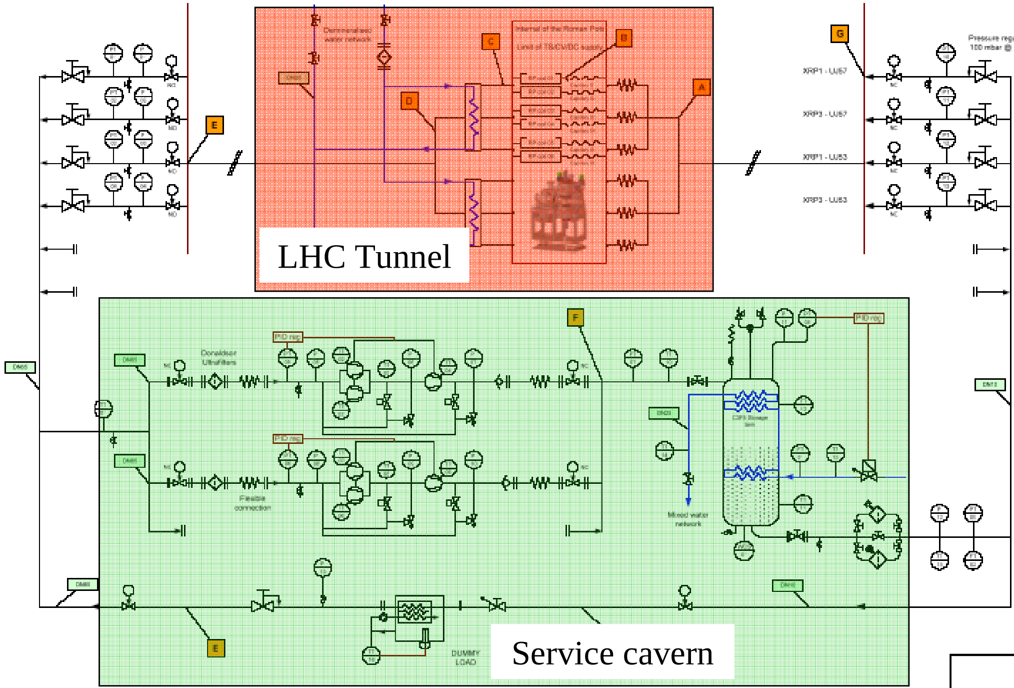
Radiation hardness 1kGy/yr

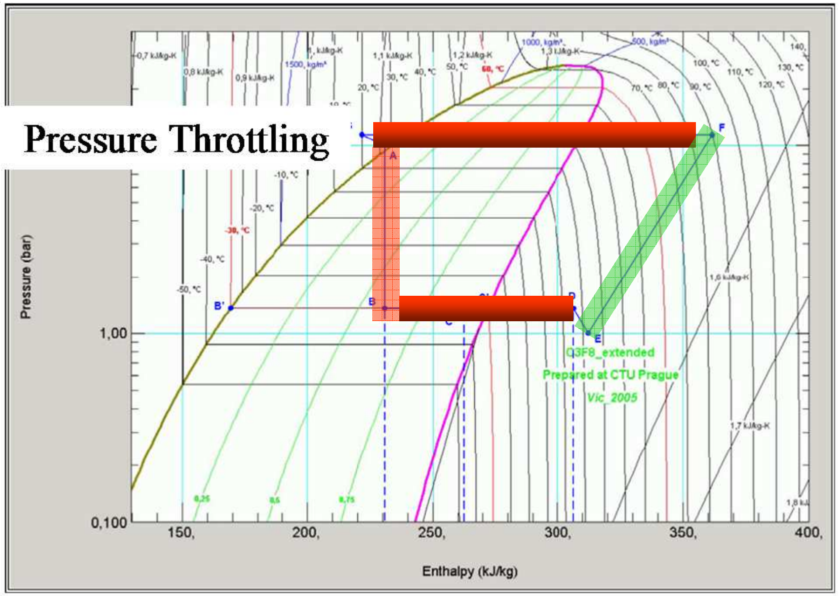
Operation under vacuum

Limited maintenance



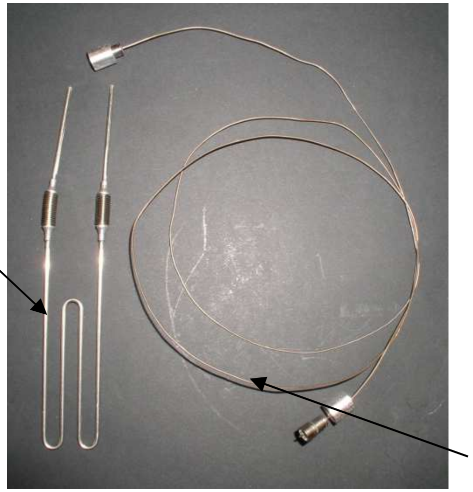
# Evaporative Cooling system




| Requirements: | |
|---|---|
| Dielectric Coolant fluid | C3F8 |
| Small pressure drops over long distance (300m) | |
| Radiation hardness (oil free compressors) | |
| Fluid evaporation temperature | -30 ° C |
| Silicon sensor operation temperature | -15 ° C |
| Maximum ΔT between sensors and fluid | 10 ° C |
| Expected heat load per single Pot | 50 W(saf.fact.3) |
| Cooling channels granularity | 4 |
| Total cooling capacity | 1200 W |

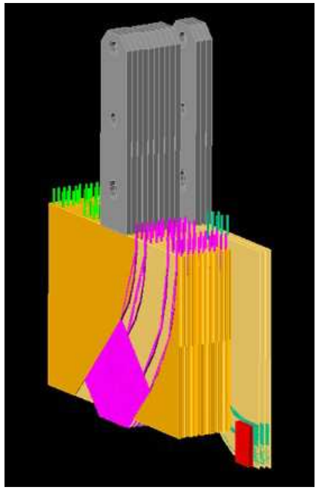
Evaporator



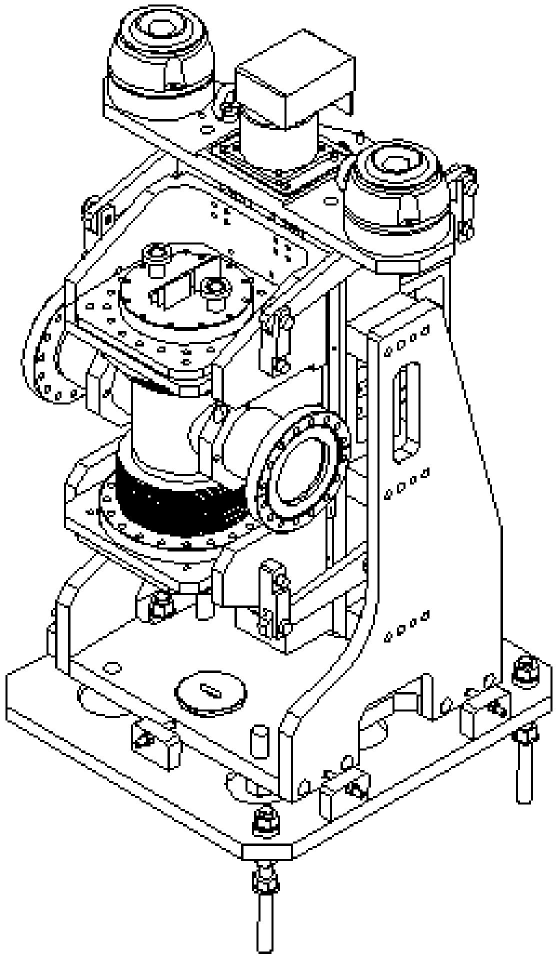
Capillary : Simple, robust, low cost, rad hard

# ATLAS Roman Pot design

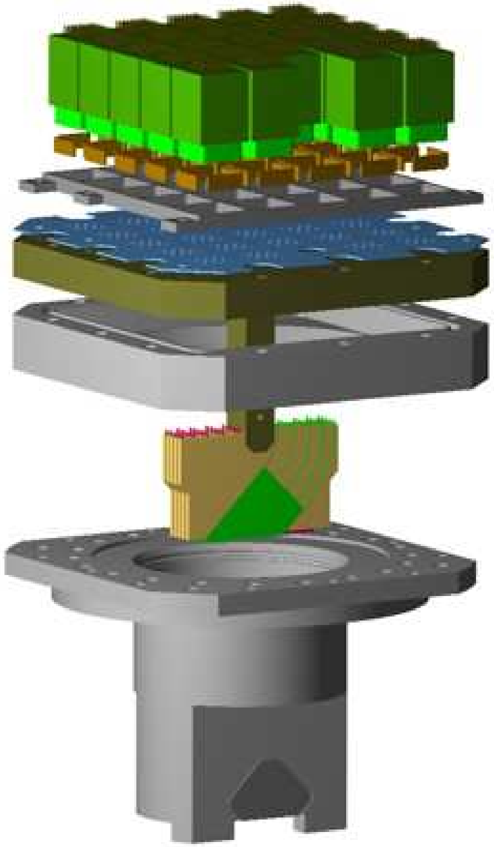
- Strategy adopted for design
  - Roman Pot Unit design as TOTEM
  - Specialized ATLAS Pots
    - Same technology as TOTEM
    - Different shape
      - Suited to different detector technology adopted
      - Extrusions for overlap detectors

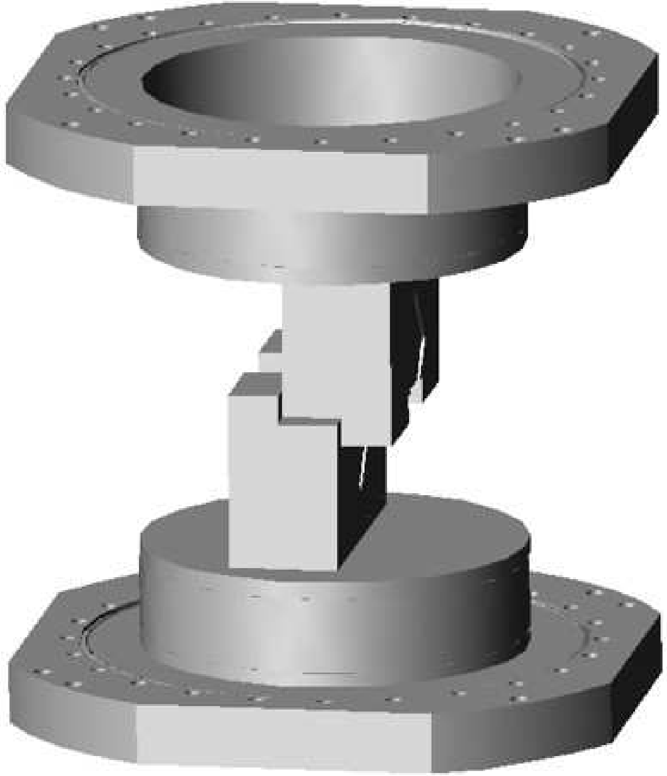


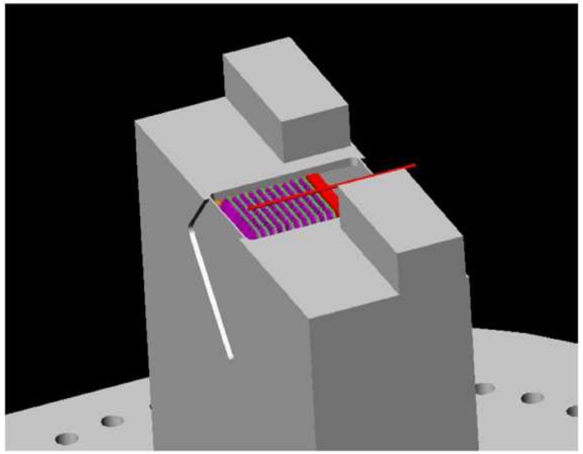
Fiber Tracker



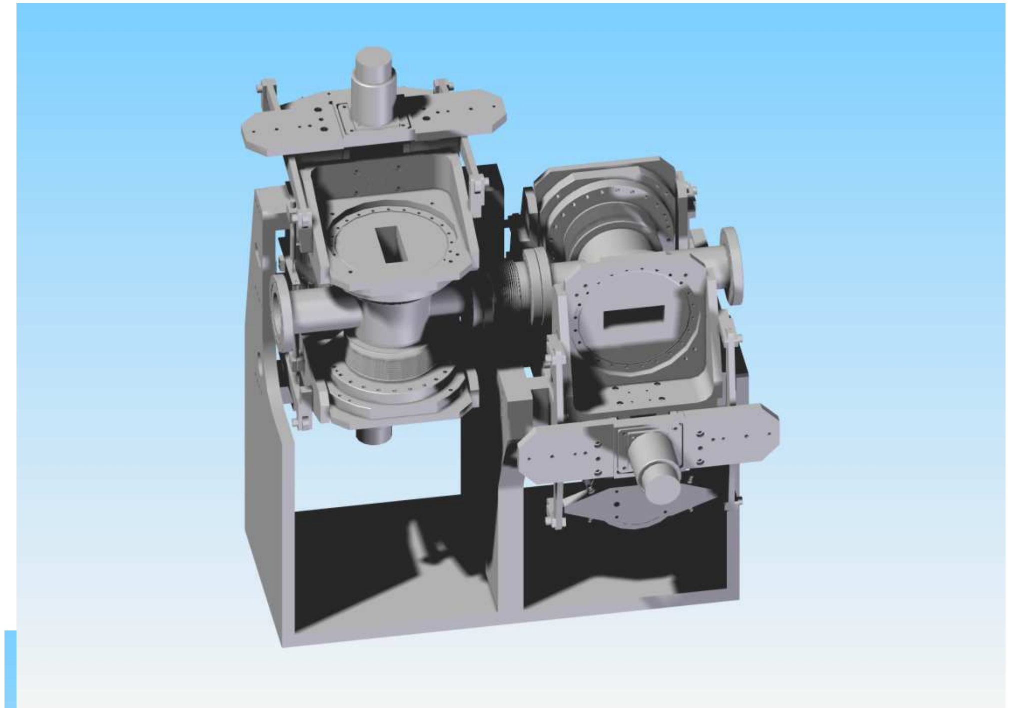
# ATLAS specific: the Pot as a consequence

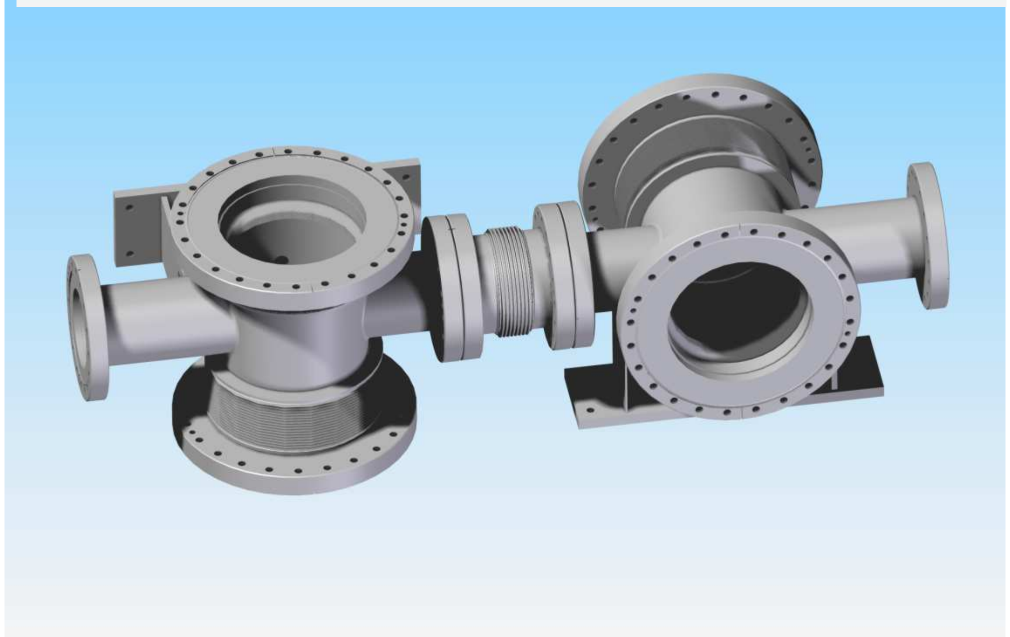






# SLAC variant for the Crystal experiment





Two vertical + two horizontal pots

Same design for the vacuum chamber

Mall modifications for the mechanical stands

All vacuum chambers should be produced by the same company which made all the LHC Roman pots

- fabrication tooling for free,
- specific experience on the product: 4 years from R&D, prototyping and mass production

Supports and stands can be manufactured in any reasonable good workshop : CERN, INFN, SLAC