Measuring the geometry of the new small-diameter Monitored Drift Tube (sMDT) chambers constructed for the HL-LHC upgrade of the ATLAS Muon Spectrometer

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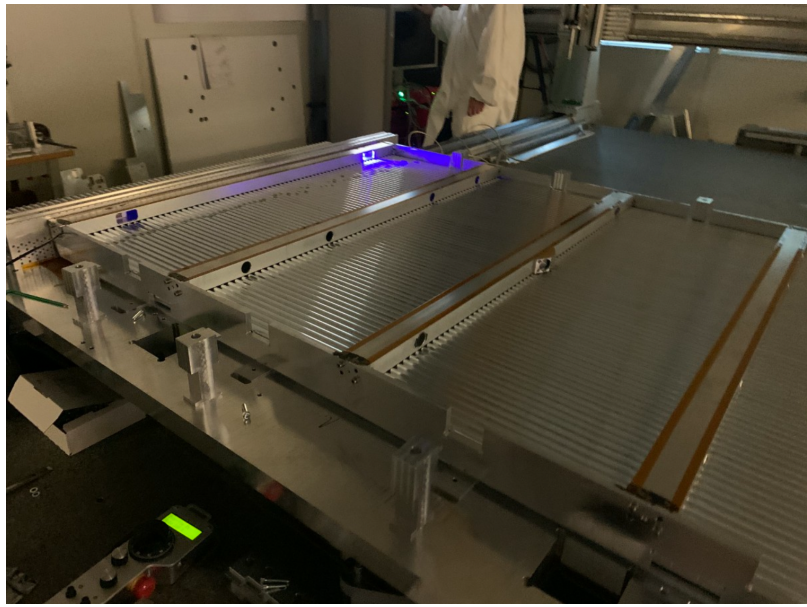
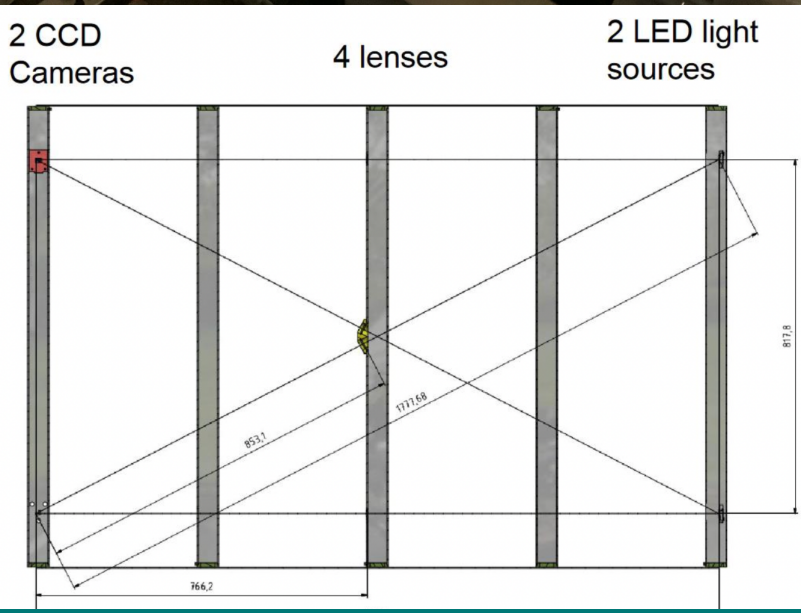
Introduction

- Daniel previously discussed the quality assurance process for the chambers and introduced the measurements made during this process
- This talk will discuss the procedures and results of the chamber geometry measurements in more detail
- Measurements discussed:
  - platform positions
  - wire positions
  - gravitational deformation (sag)
  - torsion
- Chambers are required to have a sense wire positioning accuracy of less than $20\mu m$

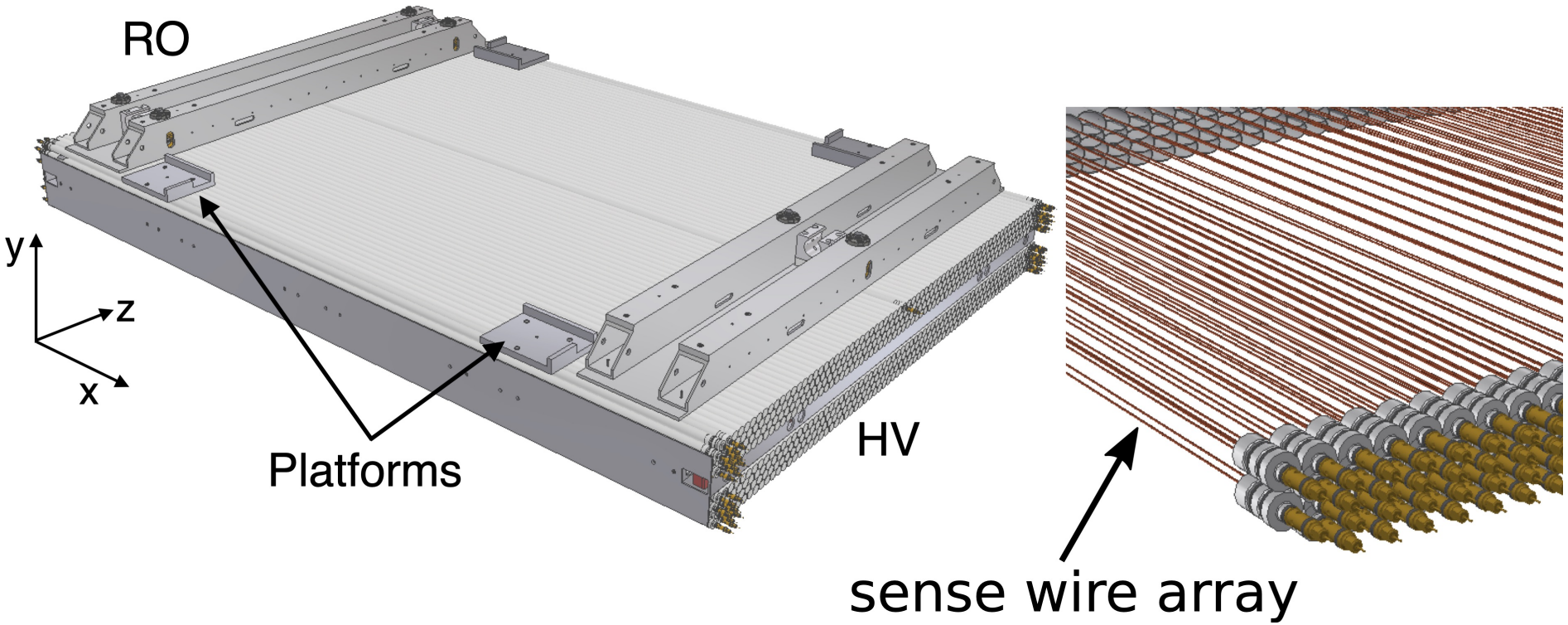
IPA system

- The in-plane alignment system (IPA) is used to monitor the torsion of the chambers
- An optical system with two LEDs and two CCDs
- Located between drift tube layers 4 and 5
- Calibrated on the assembly table before chamber is lifted





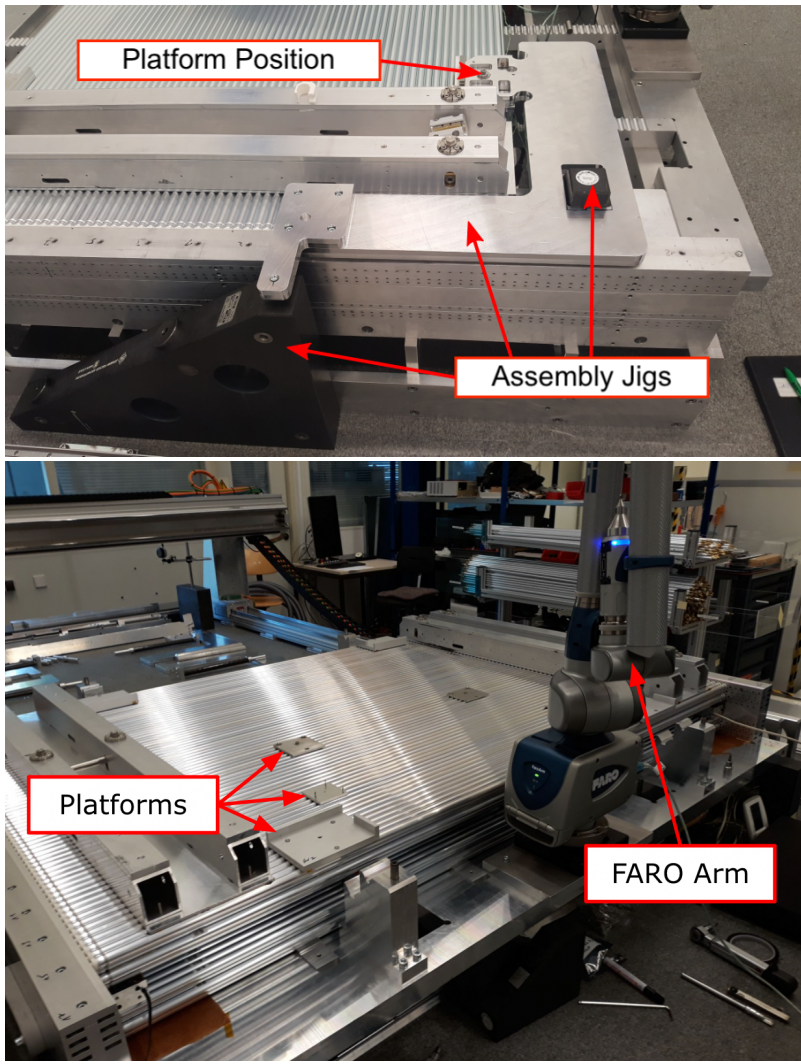
Sense Wire Array



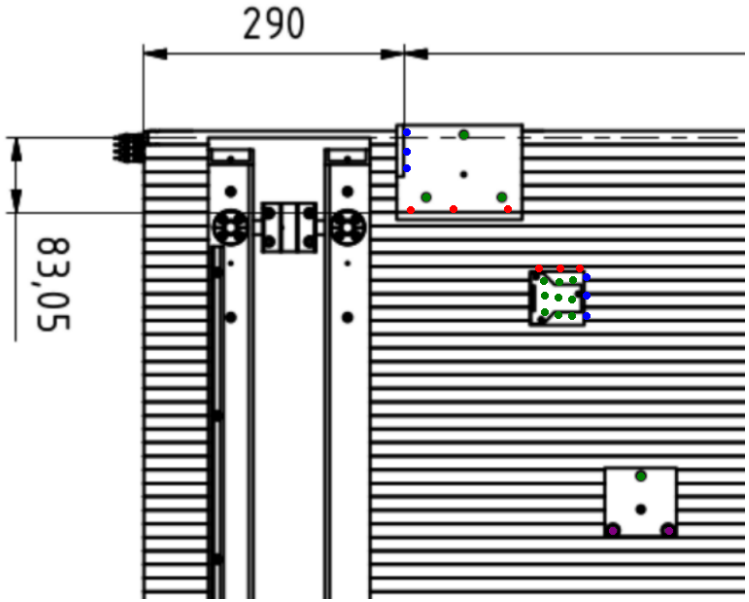
- Optical sensors for the global alignment system are mounted on the platforms

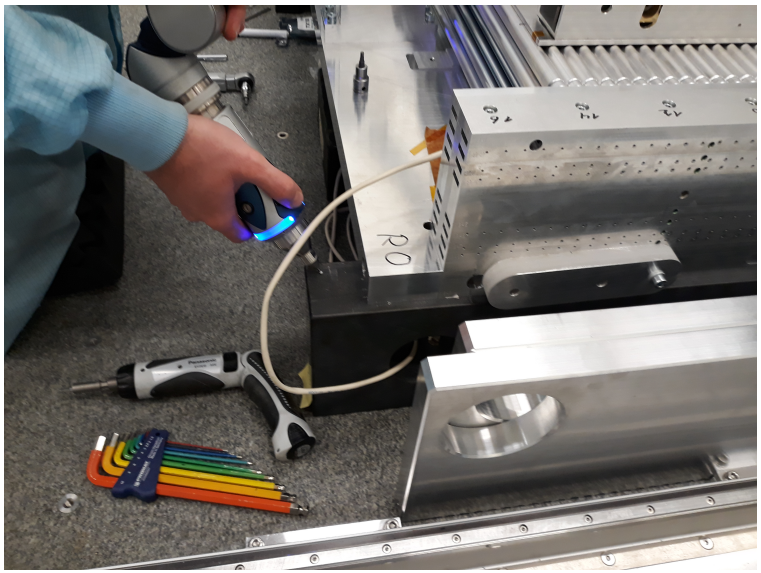
Platform Positions

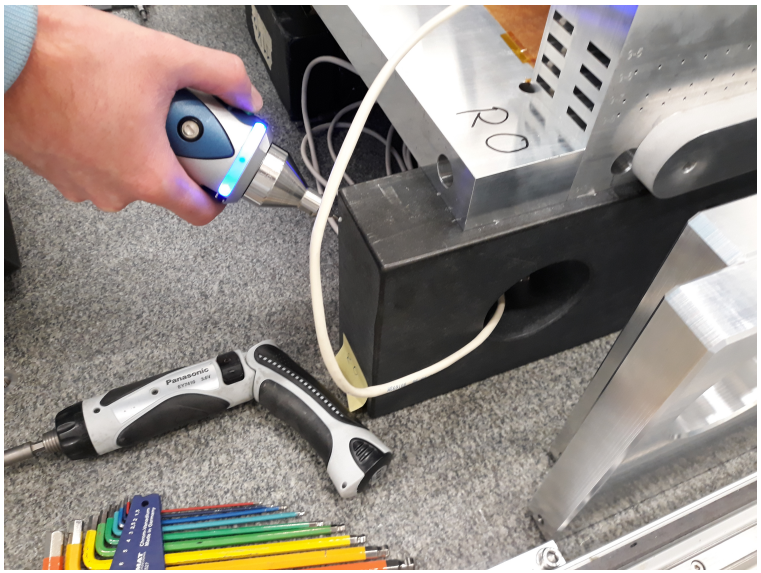
- Platforms glued in position using the assembly jigs
- Precise platform positions are then measurements using a 3D electromechanical feeler arm (FARO arm)
- Measurements performed before the chamber is lifted
- Position of the platforms relative to the sense wire array has to be known with an accuracy of $30\mu m$



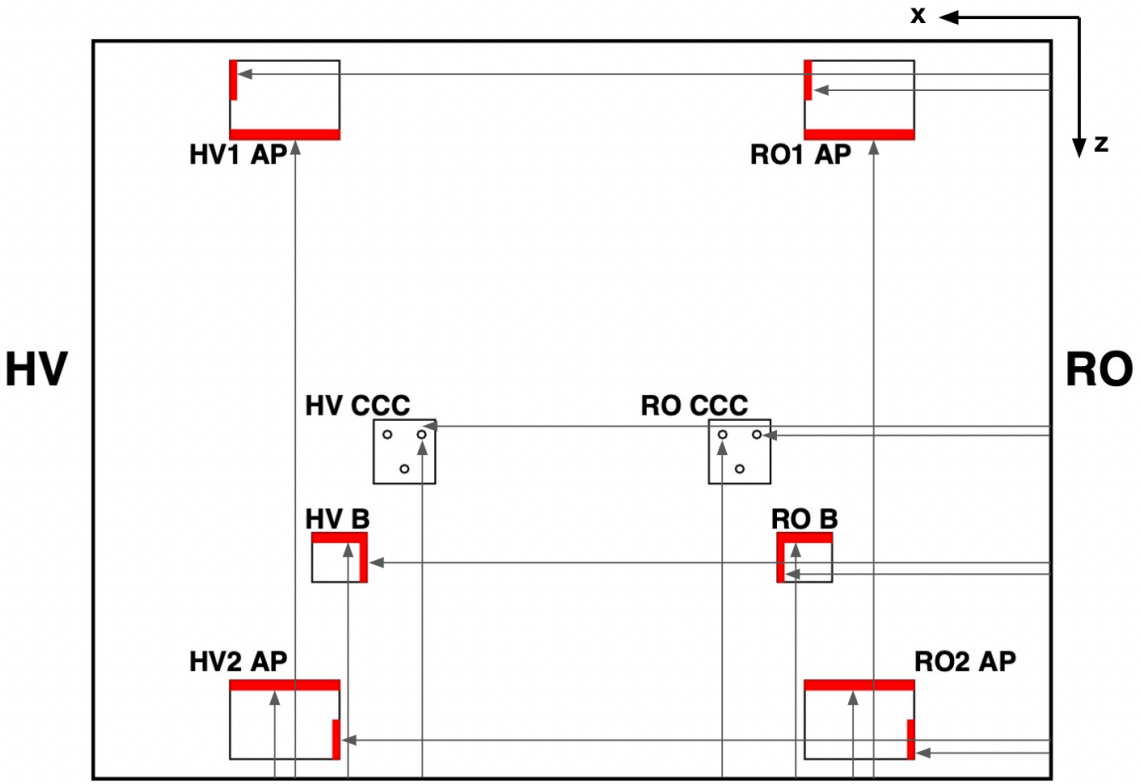
Platform Position Measurements

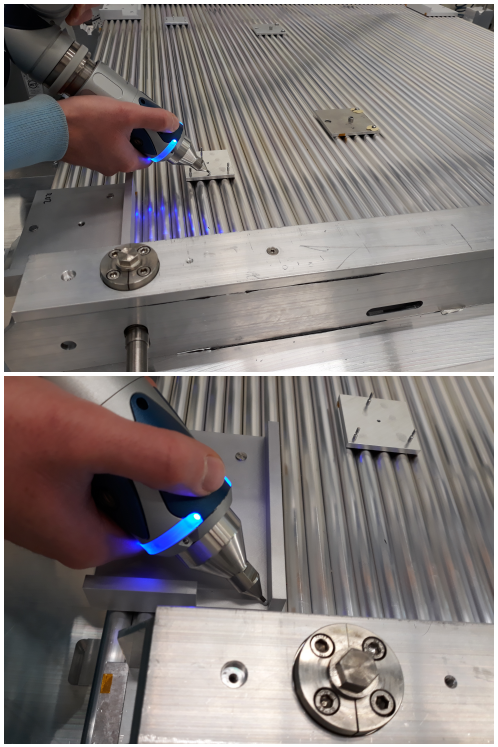






Platform Positions Schematic

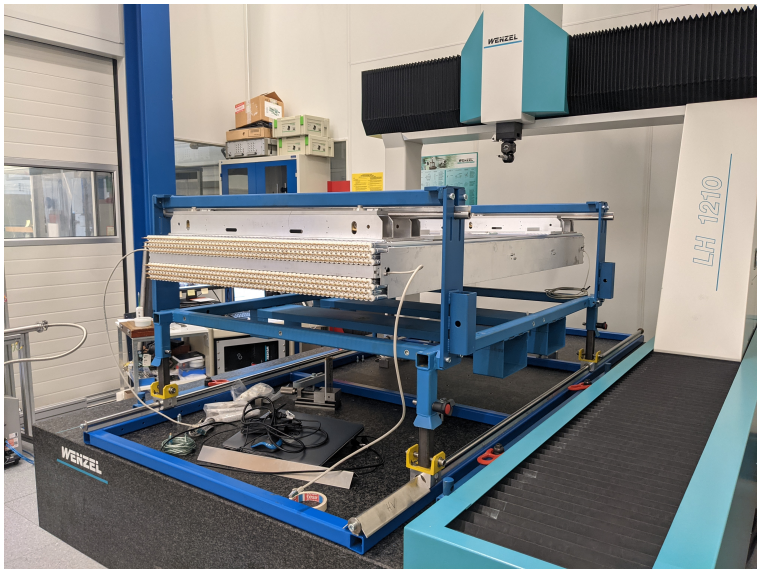


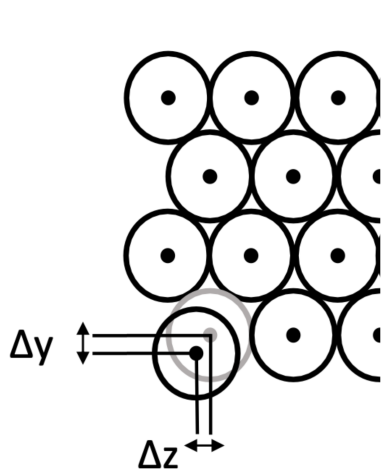


- This method allows the platforms positions relative to the sense wire array to be measured with an accuracy of $10\mu m$

Wire Position Measurements

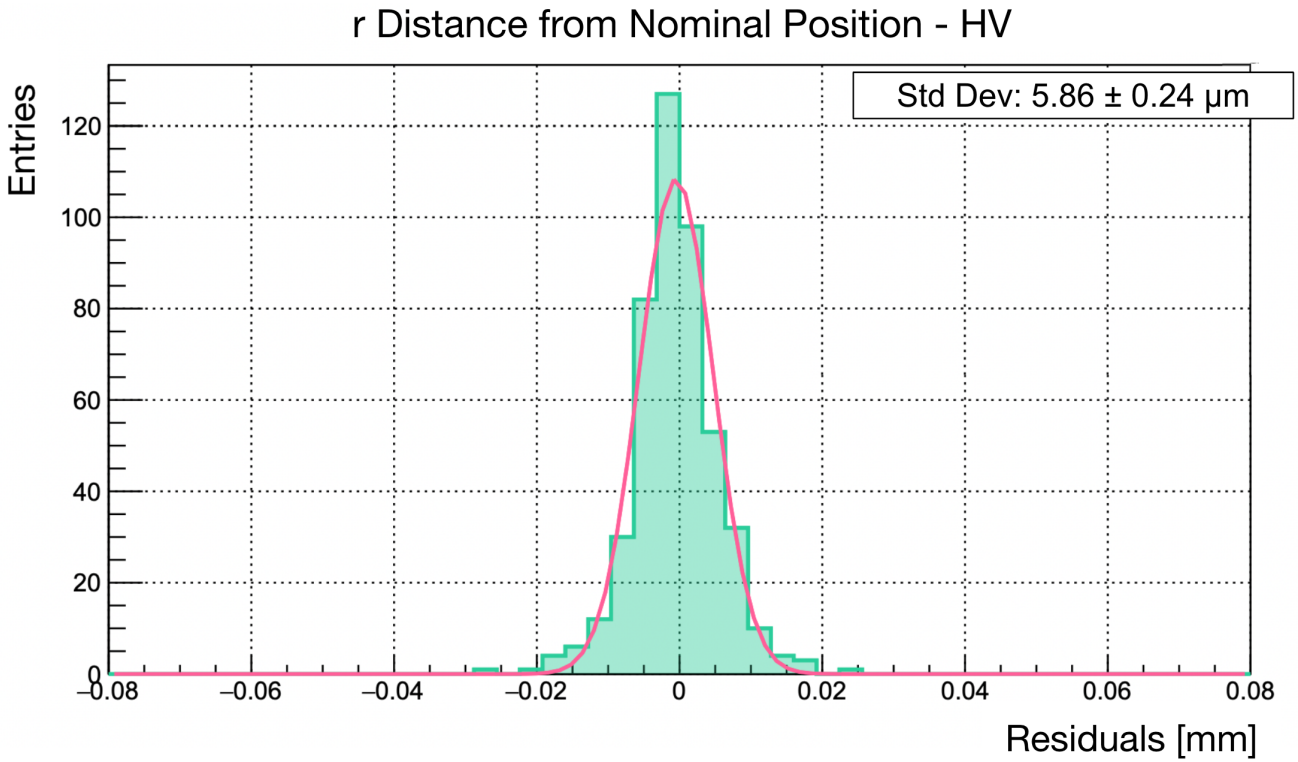
- An automated coordinate measuring machine (CMM) is used to measure the position of the 464 endplugs on the HV and RO side
- The probe tip measures 4 points around each endplug
- From this the position of the wire in the tube can be determined
- Measurement is performed after the platform is lifted so some gravitational deformation will occur





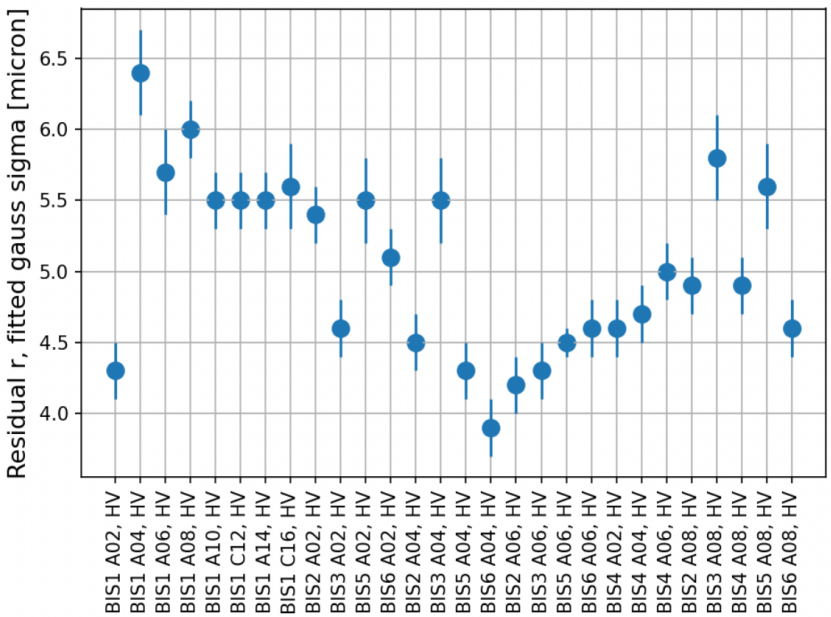
Wire Positions - Module 28

- Measure the radial distance from the nominal position of the wires, r
- Shown below for the HV side of Module 28:

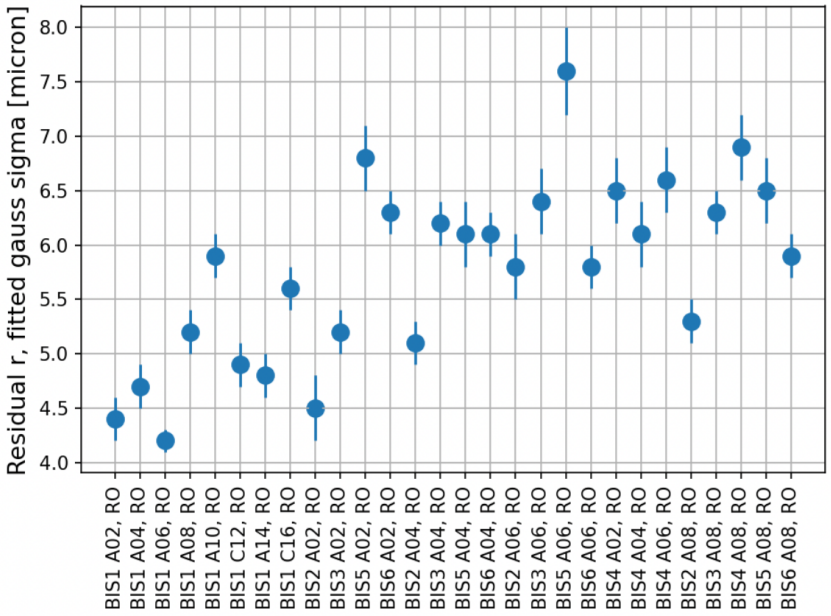


Wire Positions - Overview

- High voltage (HV) side:



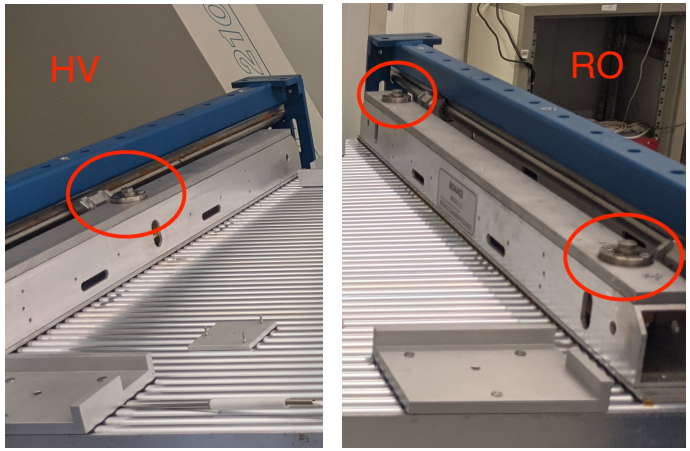
- Read out (RO) side:

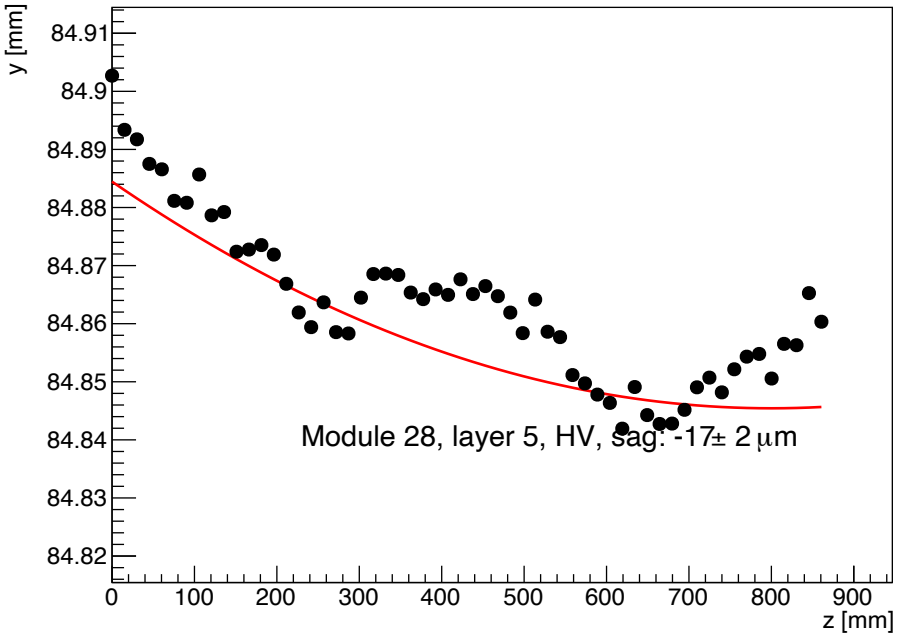


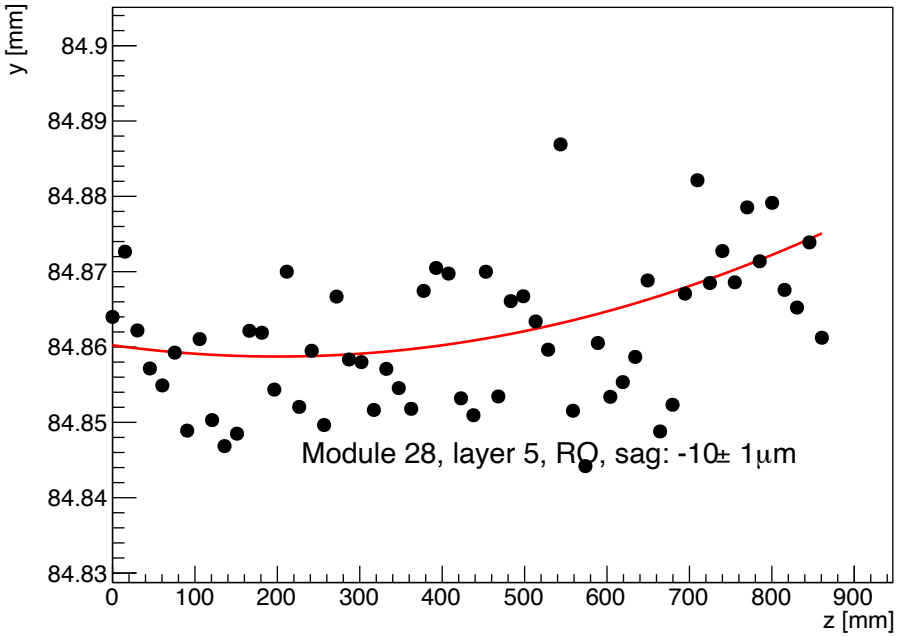
- Standard deviation of r is less than $8\mu m$ for all chambers

Gravitational Deformation (Sag)

- Gravitational deformation causes some sag in the chamber
- The HV side has 1 mounting point while the RO side has 2

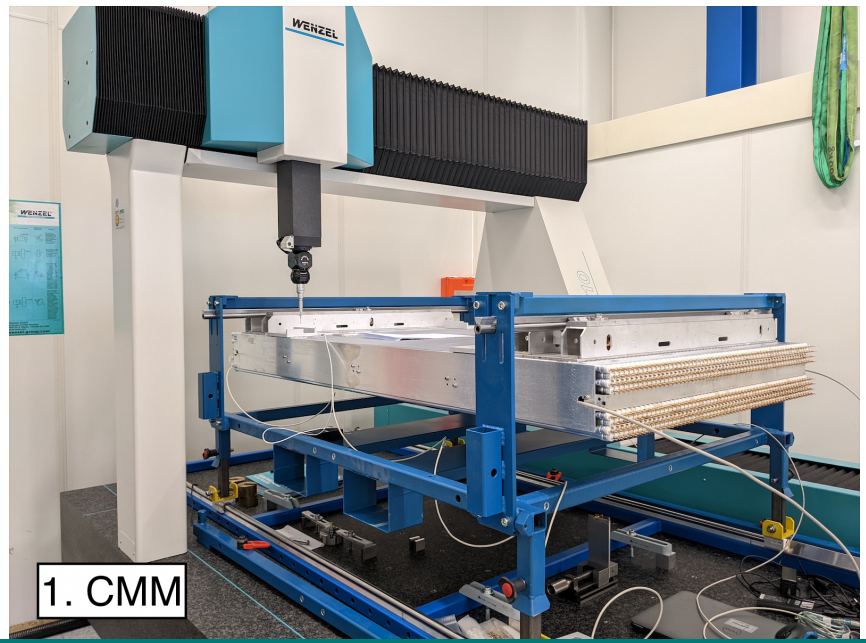


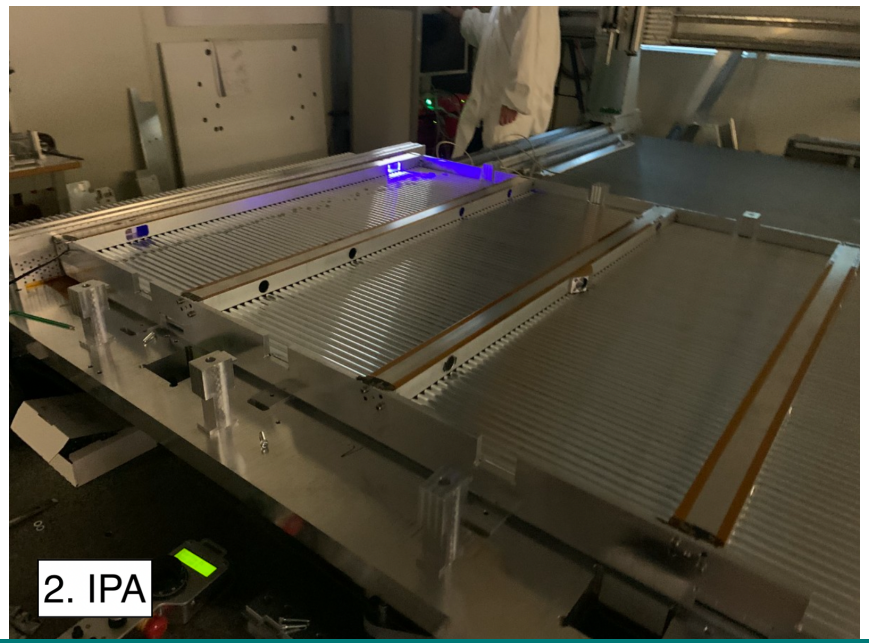




Torsion Measurements

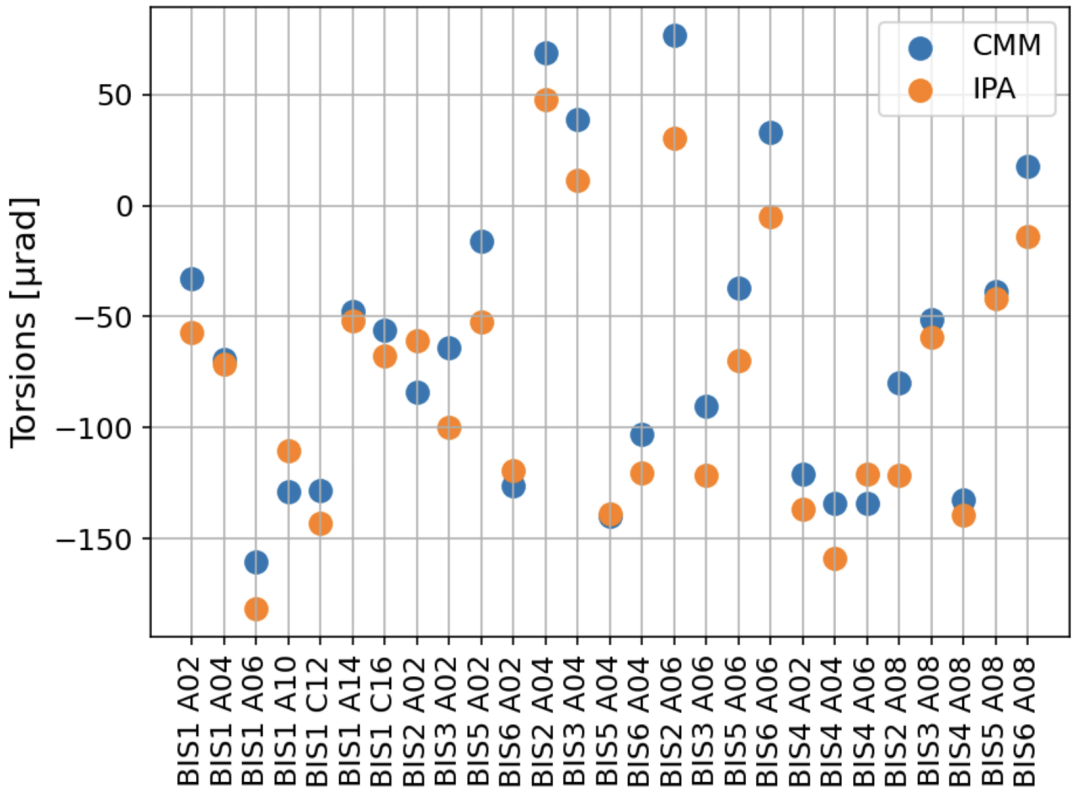
- The torsion of the chambers can be calculated in two ways:
  1. Using the CMM to measure position of the wires in layer 8 simultaneously for the RO and HV sides
  2. Comparing measurements from the in-plane alignment system (IPA) before and after the chamber is lifted
- The result of the torsion measurement from the CMM is used to validate the result from the IPA





Torsion Measurements - Results

- Torsion measurements from the CMM and IPA are compared for each chamber:



- Average difference between CMM and IPA torsion measurements is $< 20\mu m$

Conclusions

- Taking multiple readings and using a local reference point enable the platform positions to measured with an accuracy of $10\mu m$
- The wire positions are measured relative to the nominal sense wire array with an accuracy better than $10\mu m$
- The effect of gravitational deformation on the chamber geometry is negligible compared to the torsion
- The IPA system is used to monitor the torsion, which is verified using the CMM

BACKUP