Mechanical precision is a key-aspect of the high-rate capable Micromegas detectors for the upgrade of the Small Wheels of the ATLAS muon spectrometer. 32 SM2 quadruplets will be built by four German institutes with cathodes and strip-anodes made of stable honeycomb sandwiches. To achieve a single plane resolution below 100 µm, the deviation from planarity of a single detector plane must not exceed 80 µm over the whole active area. The global position of the readout strips has to be within 30 µm for a single readout-plane of 3 PCB’s, as well as between all four planes of a quadruplet.

Precision tooling is used for the correct positioning of readout PCB’s and readout sandwich planes. For quality control of the planarity of the sandwich planes a laser distance sensor combined with a coordinate measurement system has been developed. Deviation from planarity below 10 µm can be easily resolved.

We present key features of the challenging construction procedure to achieve this high level of precision as well as our alignment strategies. This includes the construction and commissioning of a 2.5 m² lightweight rigid structure (stiffback), which has an overall planarity below 20 µm RMS and the measurement of the the blow up of outer planes of a quadruplet due to 2 mbar overpressure of the Ar:CO2 detector gas, the standard situation in ATLAS.

### Design and Construction of Tooling

#### Coordinate Measurement Machine (CMM)
- Laser triangulation sensor on a XYZ translator (CMM)
- Dimensions of the CMM: X = 2270 mm, Y = 1680 mm, Z = 120 mm
- Resolution of translation: σ_{cmm} = 10 µm
- Measurement accuracy: < 10 µm
- Topology measurement: object surface scan - granite table surface scan

#### Laser Triangulation
- Measurement of a trapezoidal plane of 2 m² in 1.45 h with a modularity of ≈ 1.5 cm, 7000 data points
- Accuracy of repeated measurement: < 20 µm
- Deviation from a measurement with a tactile sensor: σ_{laser-tactile} = 15 µm

#### Laser Interconnects
- Overpressure of detector gas inside Micromegas 2 – 3 times
- Blow up of Micromegas ⇒ Need of fixation to keep surfaces flat
- Six interconnects at dedicated positions to minimise blow up
- ANSYS simulation shows ≈ 50 µm blow up

#### Topology of Testpanel
- Panel sucked to granite table during measurement
- Side 1: RMS 21.7 µm, ∆L_{x,y,z} = 190 µm
- Side 2: RMS 24.8 µm, ∆L_{x,y,z} = 160 µm
- Correction of systematic effect in future

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### Alignment Frame for Precise Relative and Global Positioning of Three PCBs
- Aluminum frame with inserts for precision pins
- Machining of all inserts in a single step (eight inserts) ⇒ Precise positions
- Aligning PCBs by attaching pins in frame to washers on PCBs

### Positioning of Alignment Washers on Readout PCBs
- Subdivision of active detector planes in three PCBs
- Need of a precise alignment between readout PCBs
- Parallelism requirement: 2250 µm ≈ 30 µm
- Positioning of two washers per PCB on to precision markers on PCB
- Using of telecentric camera to locate marker through PCB
- Washer positioning accuracy < 5 µm
- Alignment of PCBs with an alignment frame having pins fitting into the washers

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