Construction of a sTGC Prototype for the ATLAS Muon Upgrade

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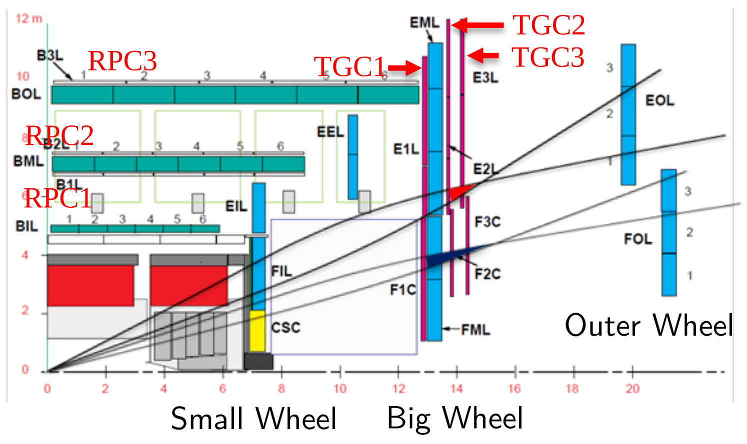
Introduction: ATLAS Muon Spectrometer

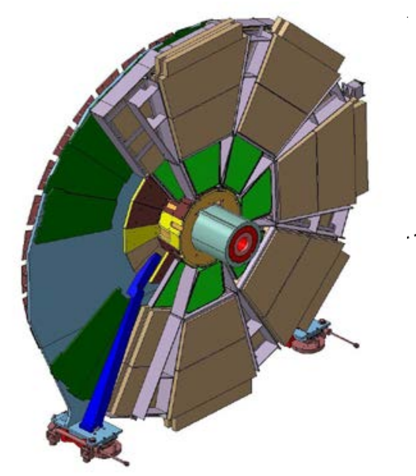


Cross-sectional view of ¼ ATLAS Detector

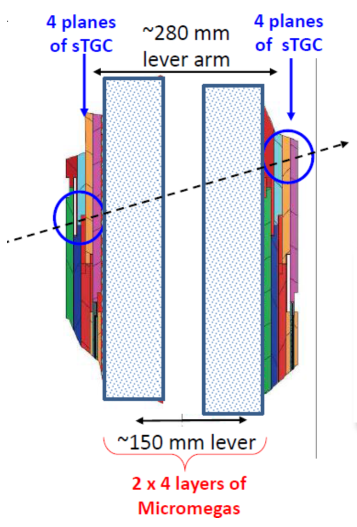
- Present Muon Level-1 Trigger
  - End-Cap: (TGC1+)TGC2+TGC3 / Barrel: RPC1+RPC2(+RPC3) — for low(high) p_T muons
- Muon Tracking: Monitor Drift Tube (MDT)

Introduction: ATLAS muon New Small Wheel (NSW) Upgrade Project

- To profit from LHC high luminosity (2-7x10^{34} cm^{-2}s^{-1}) runs after LS2 in 2018, the innermost station (Small Wheel) at the end-cap of the ATLAS Muon Spectrometer will be replaced with the New Small Wheel. The NSW will:
  - provide a Level-1 segment pointing to the primary collision point, with an angular resolution of 1 mrad, to remove fake muons.
  - need to operate in high rate (up to ~15 kHz/cm^2) radiation environment while providing Level-1 trigger and high precision muon tracking.



NSW Mechanical Structure

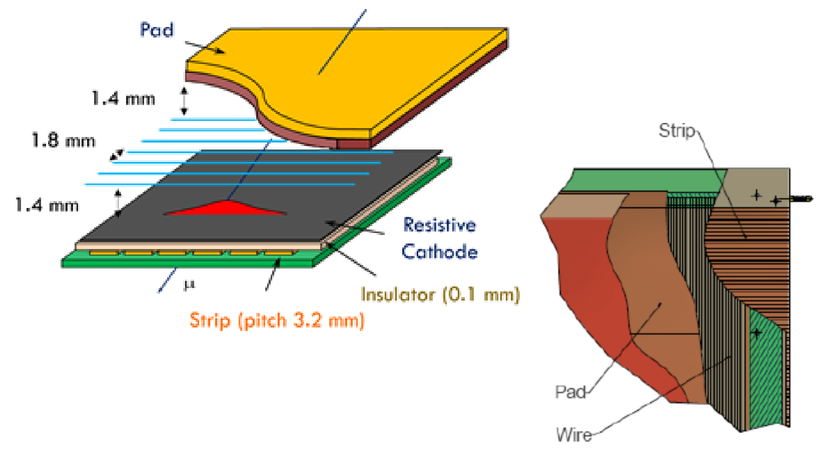


Cut View of the NSW Detector Layout

- Two detector technologies: Micromegas (Primary tracking detector) + small-strip Thin Gap Chamber (sTGC, Primary trigger detector)

See poster “Design and Construction of Large Size Micromegas Chambers for the Muon Spectrometer Upgrade of the ATLAS Experiment” by P. Loesel

Primary Trigger Detector-sTGC

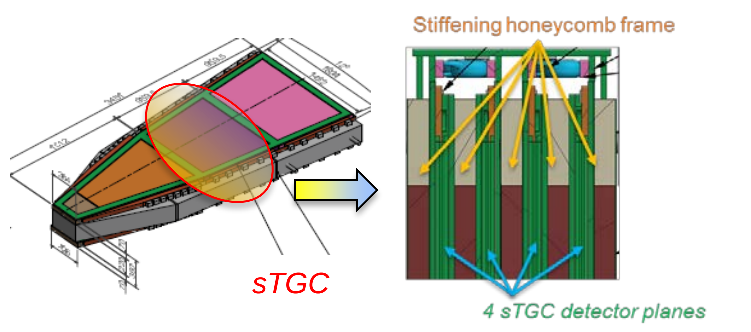


Single sTGC detector structure

sTGC basic parameters	
Cathode-anode spacing	1.4 mm
Wire spacing	1.8 mm
Cathode resistivity	100-200 kΩ/□
Strip width/ pitch	2.7/ 3.2 mm
Cathode-strip layers spacing	0.1 mm

Construction Precision Requirements for ATLAS Muon NSW Detectors

To maintain excellent reconstructed muon transverse momentum resolution, NSW detectors have to be constructed with an accuracy of ~ 40 μm, including contributions from readout strip position accuracies and parallelism of electrode planes.



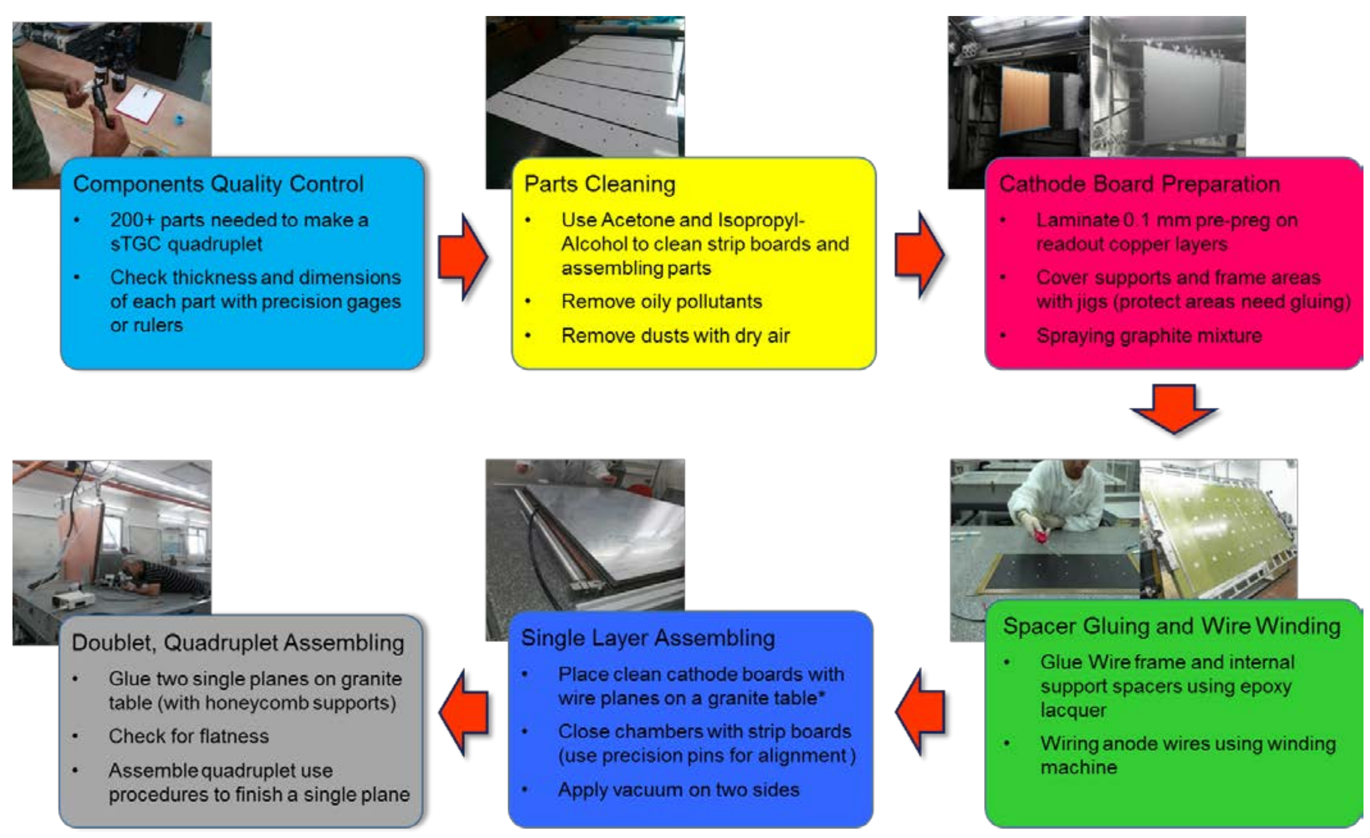
One NSW Sector *sTGC Quadruplet Cut View*

sTGC operated at quasi-saturated mode is less sensitive to small gas gap deformations. Key requirements for achieving precision spatial measurement:

- Make very precise strip boards with strip position accuracies of 40 μm RMS.
- Machined reference at the outer side of cathode boards which allows for precise strip alignment
- Use same composite material (FR-4) everywhere to avoid mechanical deformations due to environmental parameter variations.

Constructing a sTGC Prototype Module

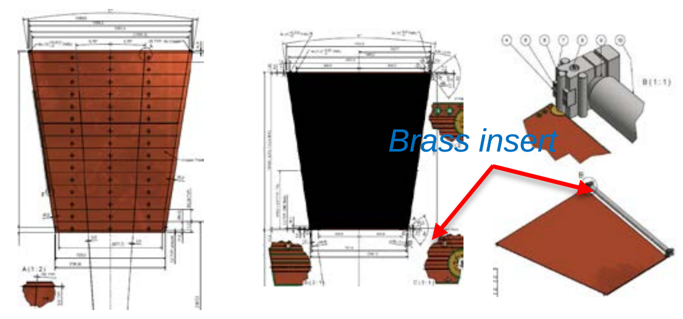
- A 1.3 m x 1.1 m sTGC prototype is constructed to qualify materials, tackle construction problems and gain experiences for serious mass production of NSW sTGC detectors
- General procedures to construct a sTGC quadruplet:



** Granite tables have flatness deviations of less than 20 μm.*

Cathode Boards and Cathode Spraying

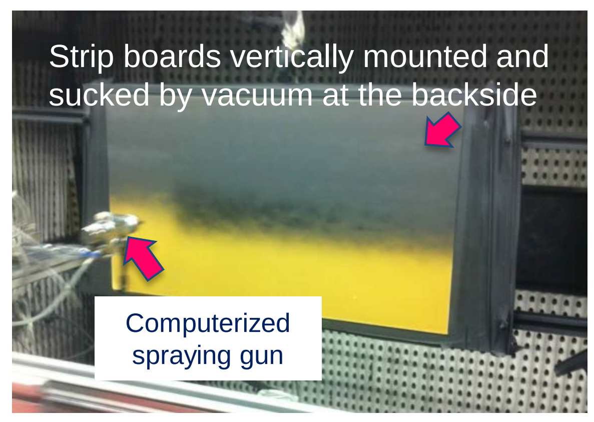
- Pad boards & precision strip boards



Machined pad board *Precision strip board*

- Strip/pad board thickness deviation: ~ 30 μm RMS
- Strips machined with precision computer numerical controlled (CNC) machines.
- Brass inserts machined in one-go with strips: for position reference and multi-layer alignment.

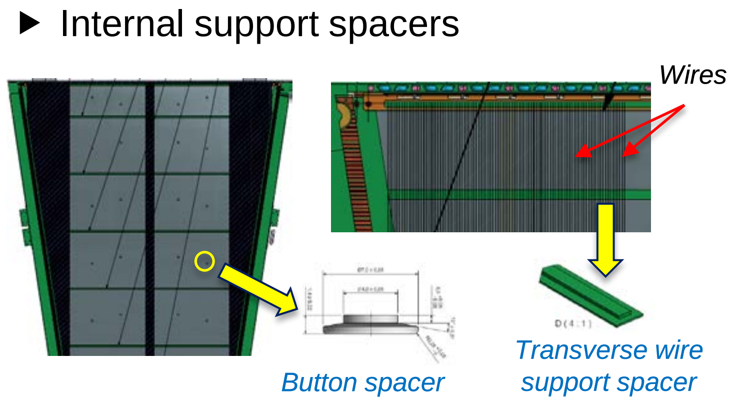
- Cathode graphite mixture spraying



- Cathodes are sprayed in the room with controlled environment (≤ 25% RH, ≥ 25 °C).

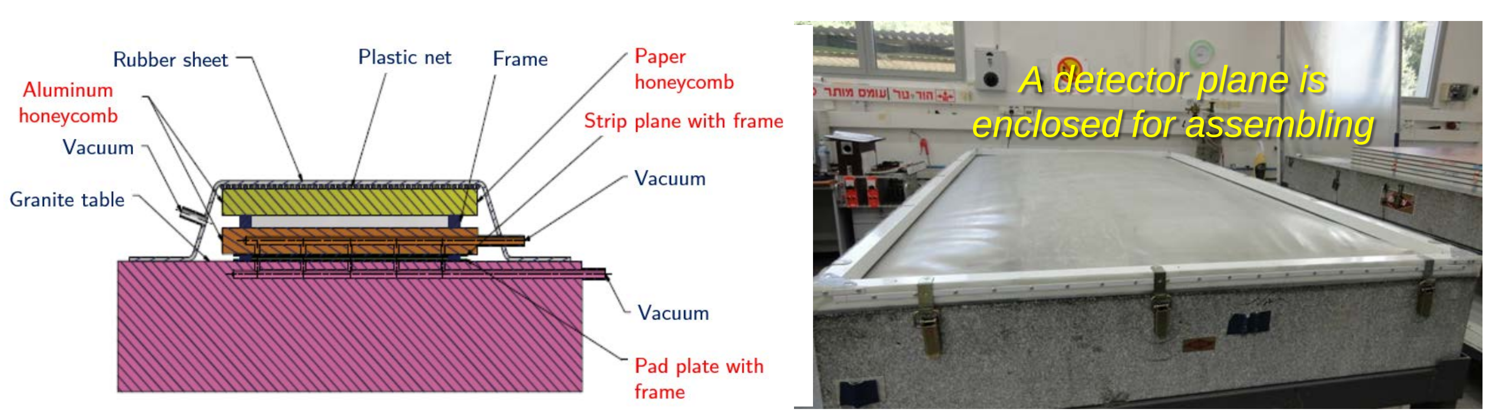
sTGC Quadruplet Assembling

- Internal support spacers



- “T” shape spacers to reduce field.
- Machined flatness to 30µm precision.

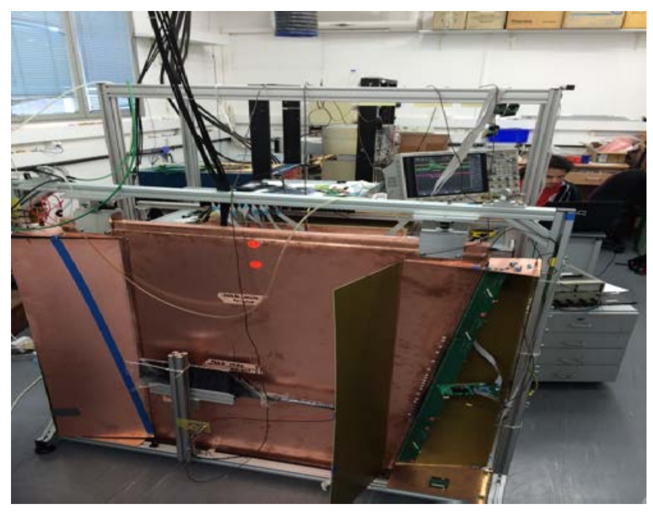
- Assembling on granite tables



Assembling a detector plane on a granite table

Tests of sTGC Prototype Quadruplet and Results

- Tests：
  - Check whole detector flatness (Flatness of each layer within expected deviation of 50 μm RMS)
  - Check gas tightness
  - Check readout channels (no missing channels, excessive noisy channels)



Assembled 1.3 m x 1.1 m sTGC Quadruplet

- Results：

A 1.3 m x 1.1 m sTGC quadruplet module was successfully constructed. Before moving to mass production of ATLAS NSW sTGC detectors, construction of a second prototype module is planned to further validate the constructional techniques and qualify materials.

Beam test results of the first sTGC prototype: See the poster “*Test Beam Results with a Full Size sTGC*” by S. Rettie and D. Mori.

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