Performance Studies of Micromegas Chambers for the ATLAS New Small Wheel Upgrade Project

ICNFP 2015, Crete, Greece, 23-30 August 2015

Stefanos Leontsinis[1,2], Konstantinos Ntekas[1,2]

on behalf of the ATLAS Muon Collaboration

[1]National Technical University of Athens, [2]Brookhaven National Laboratory

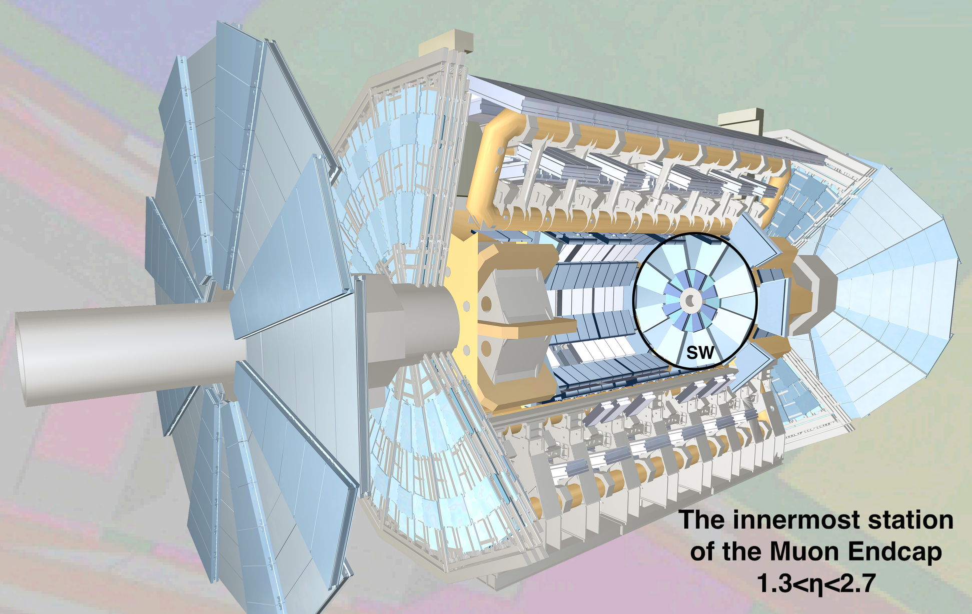
ATLAS New Small Wheel (NSW) Upgrade

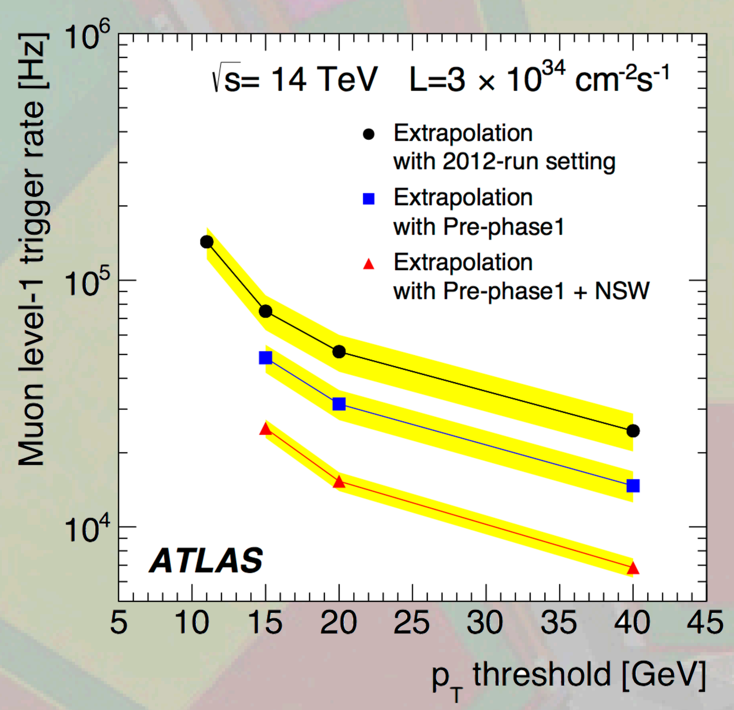
The ATLAS upgrade is motivated primarily by the high background radiation that is expected at $\mathcal{L} = 5 \times 10^{34}\,\mathrm{cm^{-2}s^{-1}}$, after the High Luminosity LHC upgrade. This will lead to a particle flux $\sim 15\,\mathrm{kHz/cm^2}$ in the SW region.

- The present SW detectors MDT, CSC & TGC will become inefficient owing to the increased rate
- The Muon trigger rate will exceed the available bandwidth mostly because of fake endcap muon triggers (90% is coming from background)

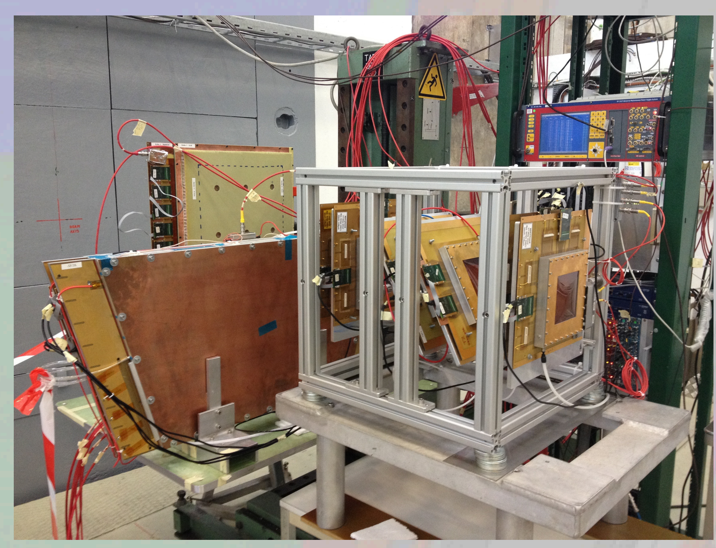
sTGC & **Micromegas** detectors, both providing tracking and trigger information, will be combined into a fully redundant NSW system!

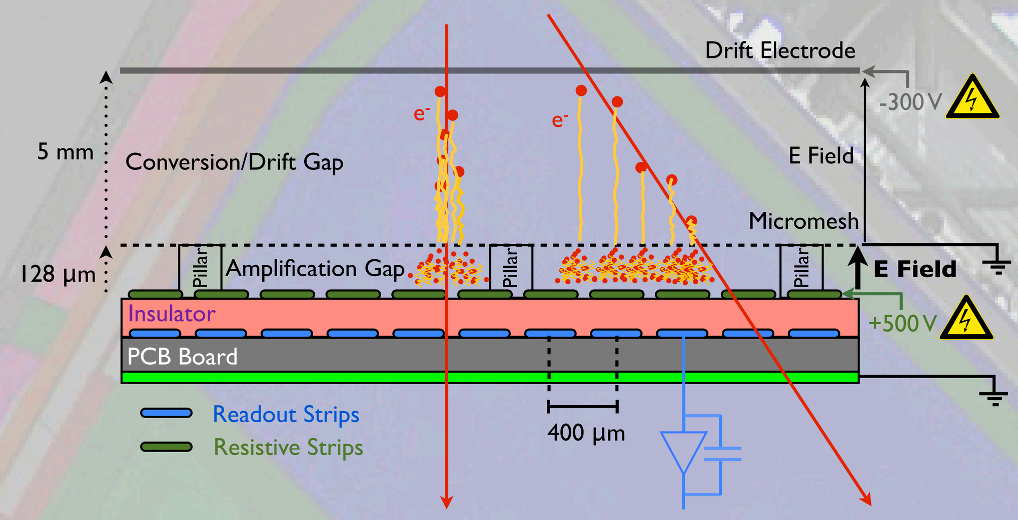
- Minimise the fake triggers by reconstructing high quality ($\sigma_\theta \sim 1\,\mathrm{mrad}$) IP pointing segments (Online)
- Efficient precision tracking for the expected rate of $15\,\mathrm{kHz/cm^2}$ (Offline)





Resistive Micromegas Detector (MM)





MICRO MEsh GAseous Structure

Planar structure consisting of two asymmetric E-field regions, separated by a thin metallic micro mesh

- $E_{drift} \simeq 0.6\,\mathrm{kV/cm}$, $E_{amp} \simeq 39\,\mathrm{kV/cm} \Rightarrow$ Gas gain $\sim 10^4$ For the commonly used gas mixture Ar+7% CO_2
- The detector becomes spark tolerant by adding a layer of resistive strips

Signal Formation

- Ionisation e^- drift towards the mesh (95 % transparent) in ~ 100 ns and the avalanche formation takes place in the amplification region in less than 1 ns with fast ion evacuation (~ 200 ns)
- Charge on the readout strip is partly induced signal and partly capacitively coupled to it from the resistive strip

The performance of resistive MMs with different characteristics has been studied in several test beams (p/e 10 GeV/c , π/μ 120 GeV/c)

Spatial Resolution

Micromegas wll be the main precision tracker of the NSW
→ Required spatial resolution $\leq 100\,\mu\mathrm{m}$

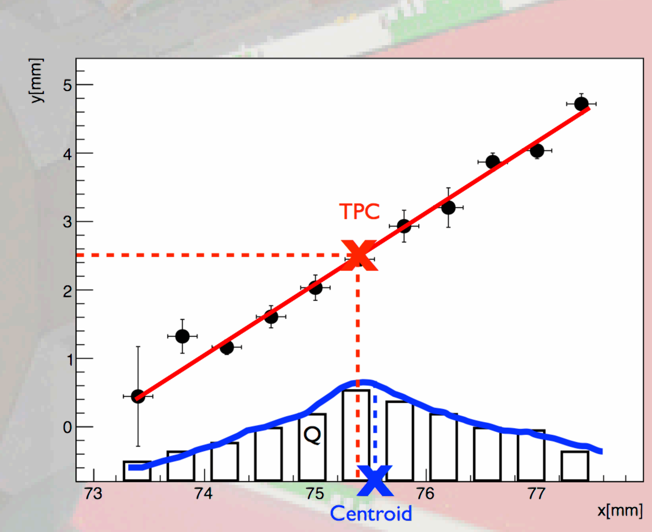
Hit & Track reconstruction

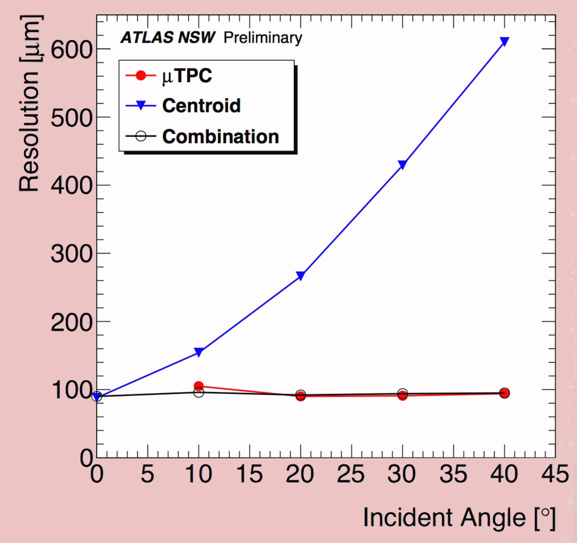
- Using charge amplitude (**Centroid** hit). Accuracy rapidly decreasing for larger track angles
- Using drift time (**μTPC** segment). Performance improving with increasing cluster size
- **Tracks expected @ NSW 8° − 30°** ⇒ **So we are relying mostly on μTPC**

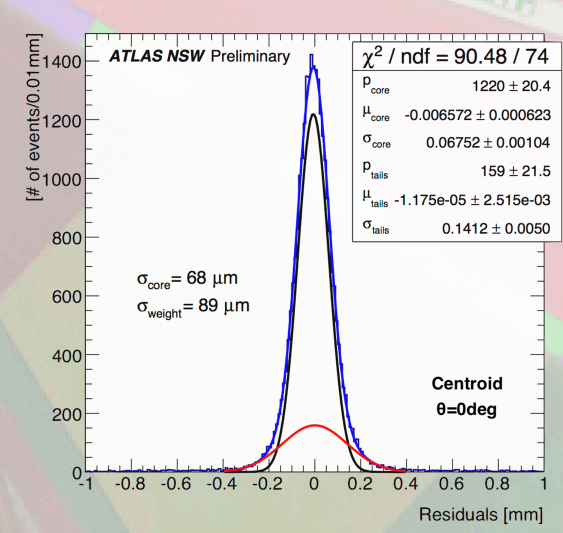
Refinement of μTPC recipe (Significant improvement)

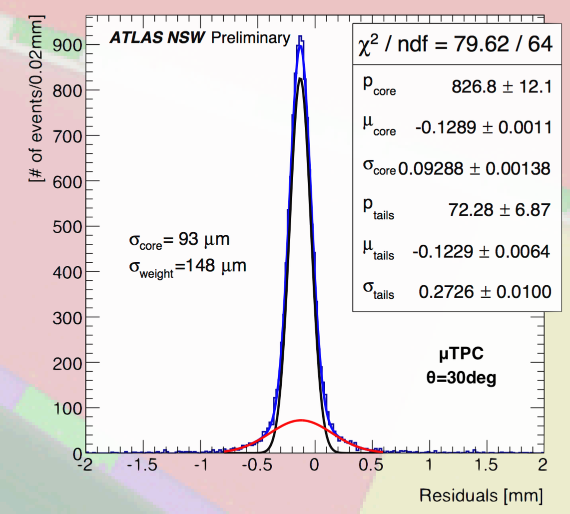
- Correct for capacitive coupling between strips
- Fine tuning of the primary e^- position assignment along the strip width
- Implement pattern recognition techniques for track identification (Hough transform)
  - Double tracks identification
  - Noise filtering

Combination of centroid & μTPC provides spatial resolution $< 100\,\mu\mathrm{m}$ **independently of the track incident angle**

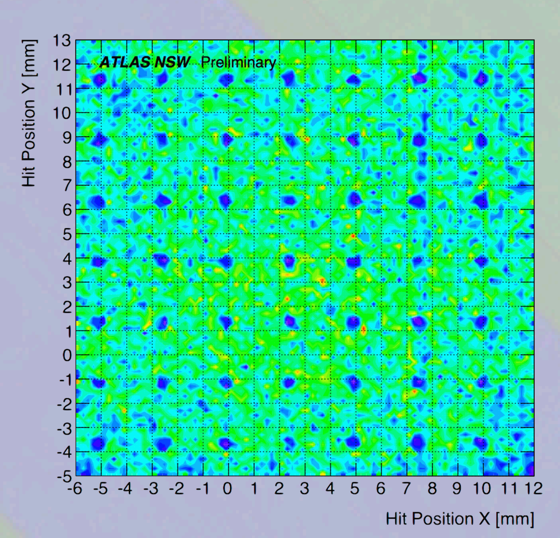




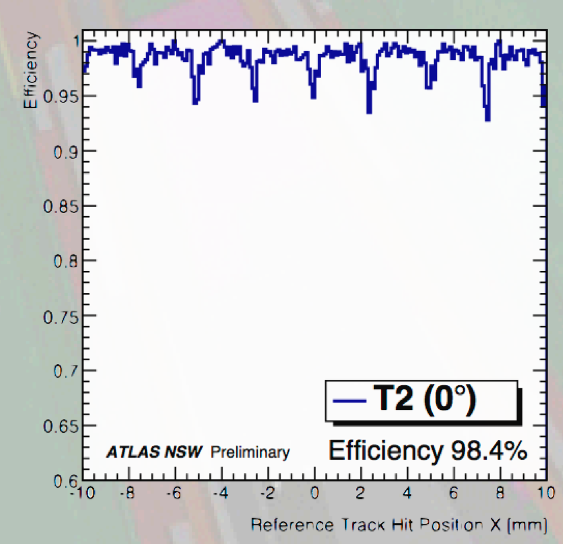


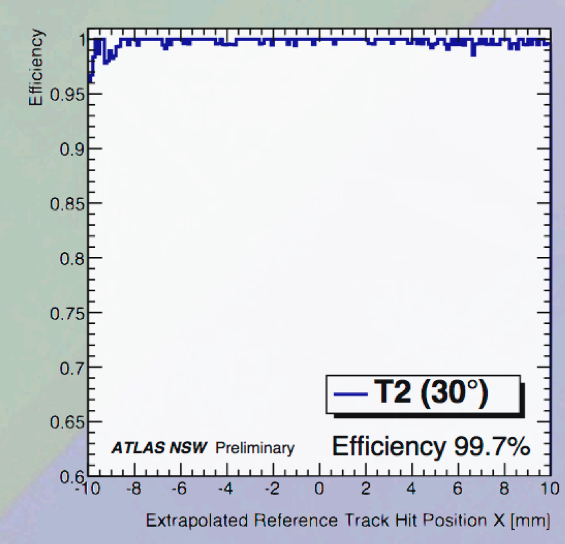


Efficiency Studies



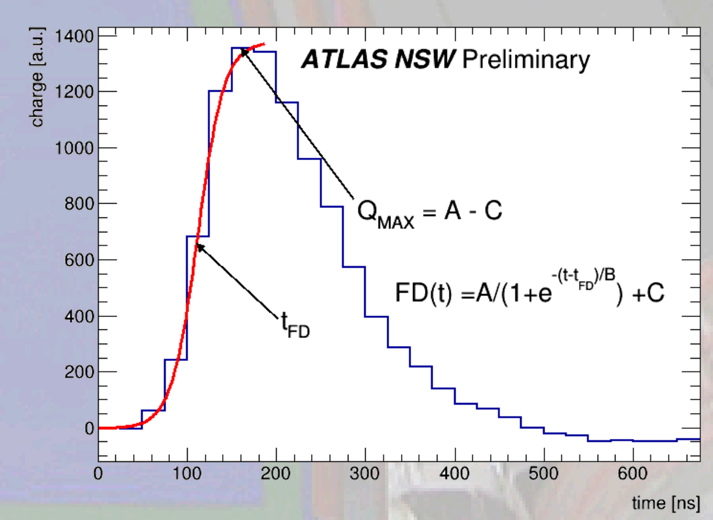
- Measurement of the efficiency as a function of the extrapolated reference track hit position
- The efficiency dips (~ 5%) appearing every 2.5 mm, in the case of the perpendicular tracks, correspond to the pillar structure supporting the mesh
- When the chambers are inclined the particles traverse the chambers under an angle inducing signal in a larger number of strips compared to the 0° case. In this case we expect efficiency to be unaffected by the pillars

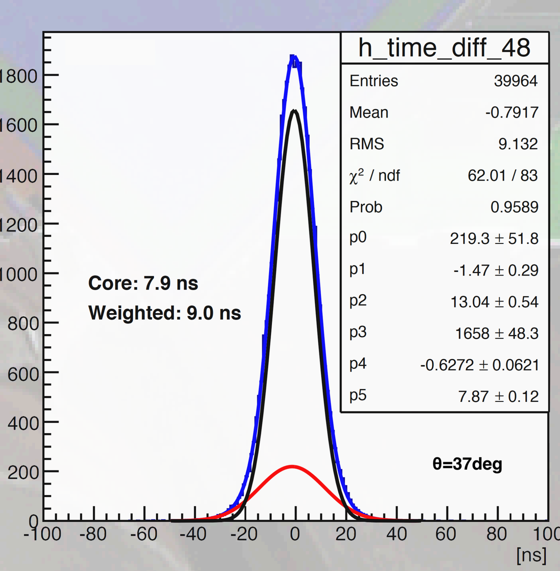




Timing Resolution

- Using the earliest time difference between two MM chambers the single plane timing resolution is measured to be 7.9 ns for the case of 37° chamber inclination angle
- The measured timing resolution is a convolution of the MM detector response, the timing uncertainty of the front-end electronics and the uncertainty introduced by the timing extraction procedure (analysis dependent)
- The current tests are based on the APV25 front-end chips, while for the MM in the NSW the new VMM chips will be used (will be able to provide a more precise timing measurement)





The present poster was co-funded by the European Union (European Social Fund ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) 2007-2013. ARISTEIA-1893-ATLAS MICROMEGAS.