Small-strip Thin Gap Chamber R&D for STAR forward tracking

Qinghua Xu
Shandong University

RHIC-AGS user meeting, June 12, 2018

Thanks to colleagues:

SDU: Chengguang Zhu, Chi Yang, Fuwang Shen, Changyu Li, Fangang Kong, Qian Yang, Li Yi

BNL: Lijuan Ruan, Tonko Ljubicic Zhangbu Xu ……

sTGC for Muon Spectrometer Upgrade ATLAS

- Structure of sTGC:

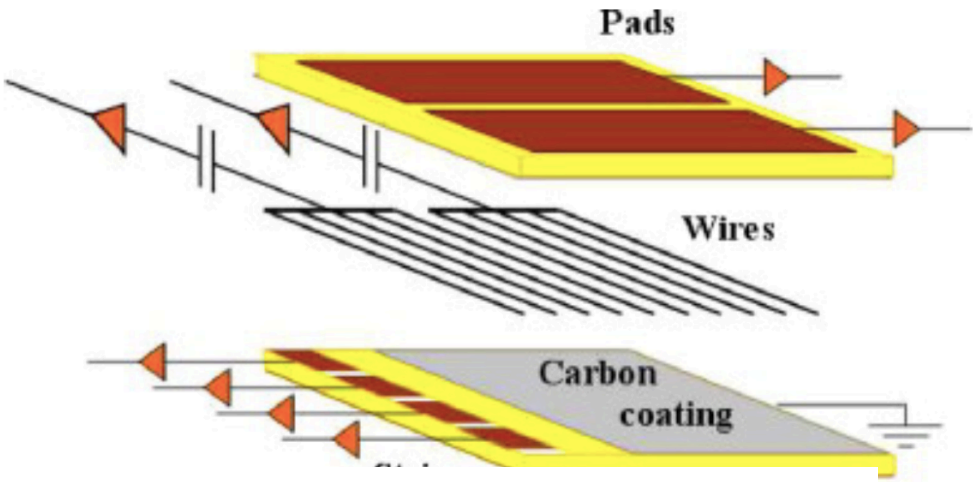
Wire: Au-plated tungsten wire Φ50um, 1.8mm pitch

Copper strip: 3.2mm pitch

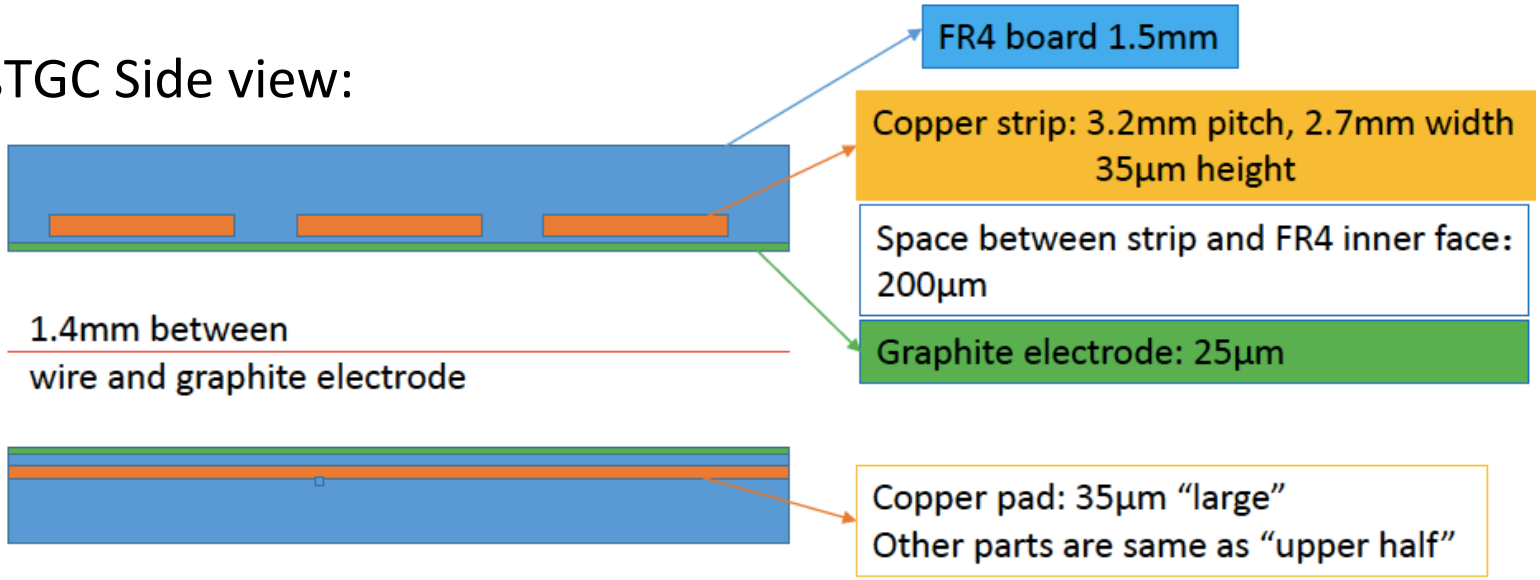
Height of one layer: 5.8mm

Gas: 55% n-pentane+45%CO2

HV: 2900V

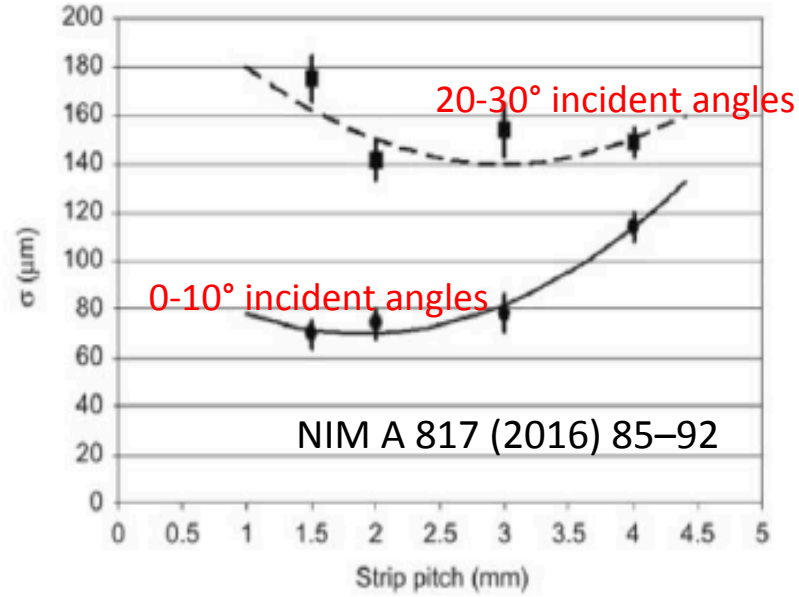


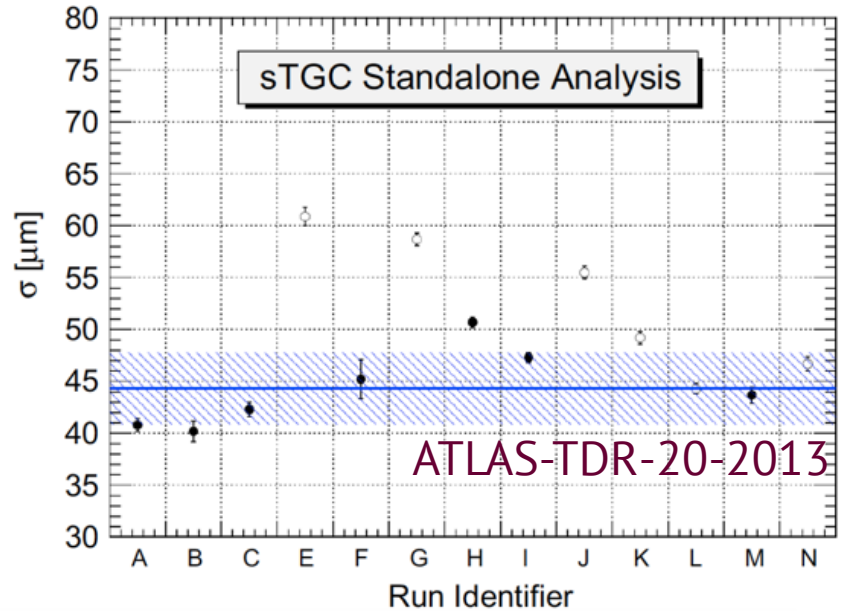
- sTGC Side view:



sTGC space resolution- from ATLAS upgrade

- Space resolution of ~100um can be obtained with one layer:

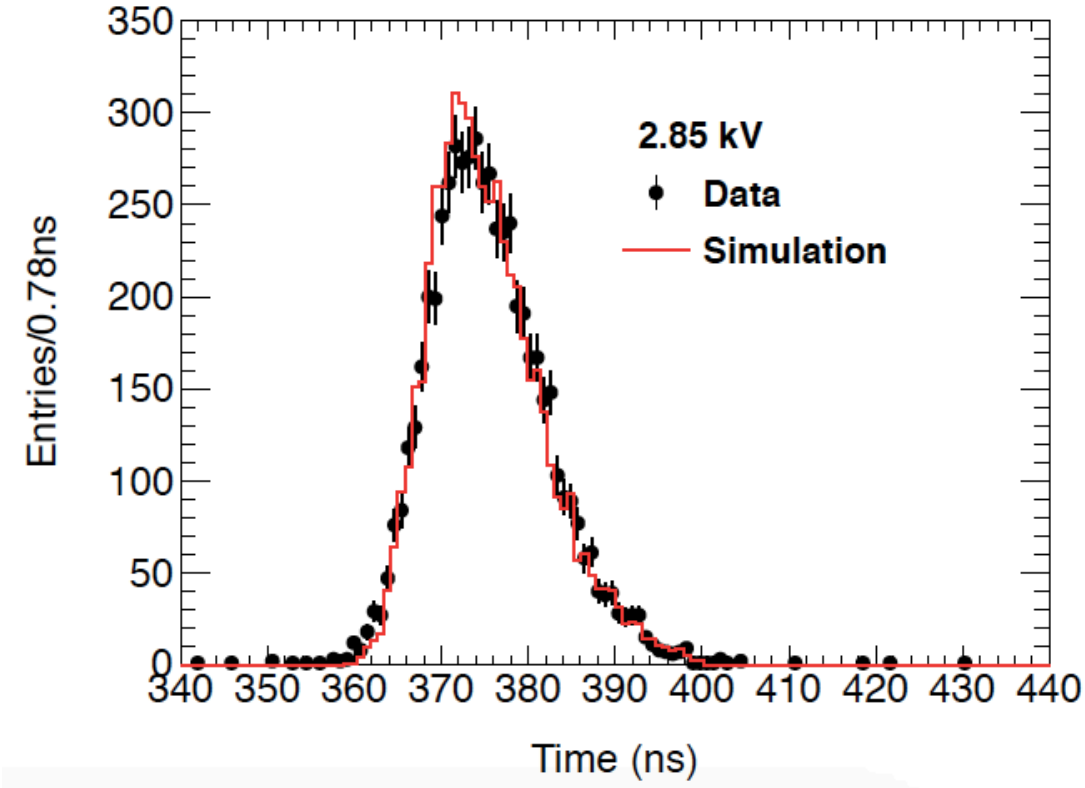




- ✓ Resolution ~100um at muon incident angle 0°-10° using TOT(time over threshold) of signals with prototype
- ✓ Resolution ~50um from beam test with incident angle 0 at several place of the first full size module
- ✓ Might be degraded ~75um due to position scale and non-parallelism
  - improvement with shorter strips (100cm-70cm ATLAS sTGC)

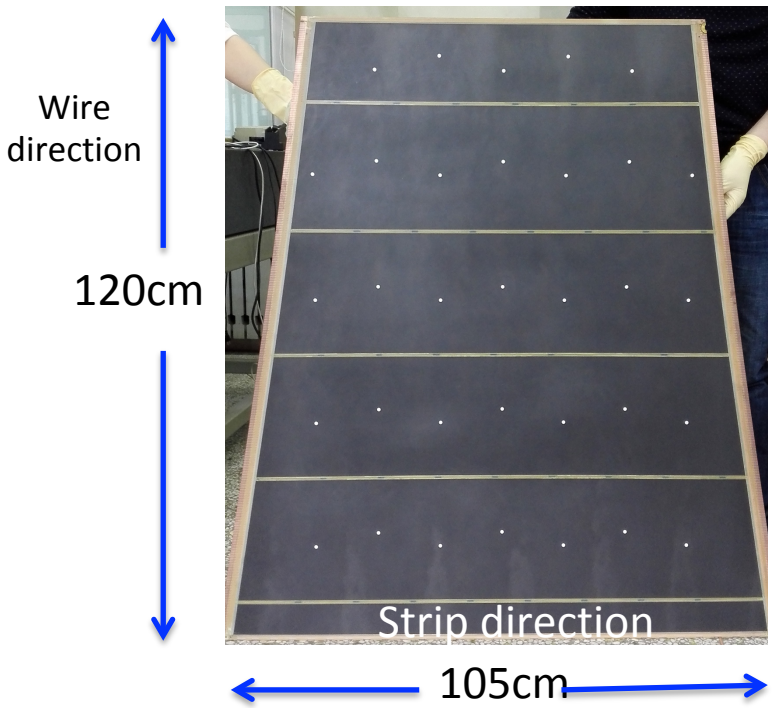
sTGC time response- from ATLAS upgrade

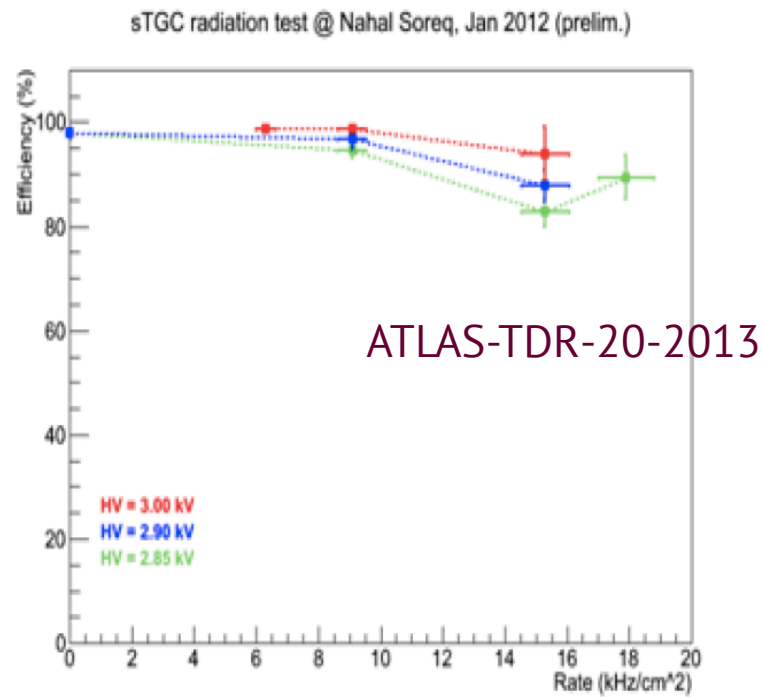
- 95% of the total hits are contained within a 25 ns time window
  -Fast response and good time resolution



ATLAS-TDR-20-2013

sTGC flux tolerance- from ATLAS upgrade

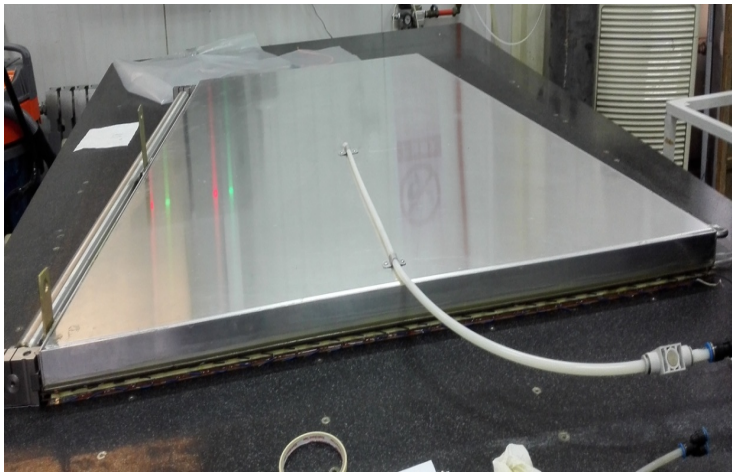


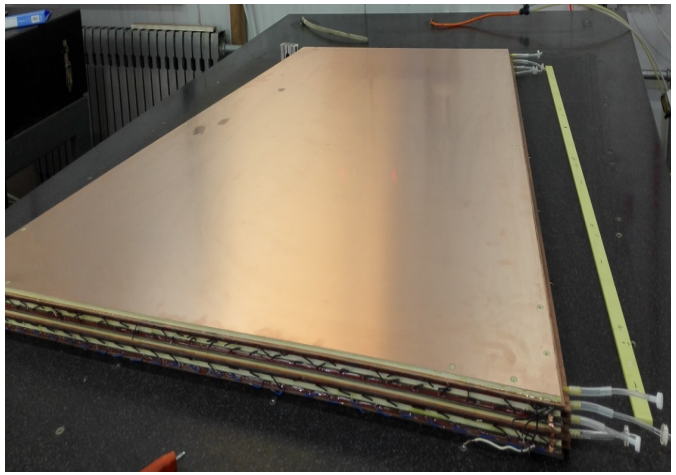


- ✓ The ground use sprayed graphite (resistance 200kΩ)
- ✓ The resistance is designed to be small enough to evacuate the avalanche charge quickly, but resistive to the fast signals, so that the charge can be picked up by the strip/pad outside of graphite
- ✓ It can work in radiation environment up to 16 kHz/cm^2

sTGC construction- from ATLAS upgrade

- sTGC Construction requirements:
  1. Strips position deviation relative to nominal tolerance <75um.
  2. Uniformity of cathode board, tolerance 25um on periphery, and 37.5um at other area.
  3. Mechanical parts tolerance < 20um for constant anode-cathode distance.
  4. Wire pitch tolerance 100 um.
  5. Accumulated thickness/flatness tolerance for a module <200um.

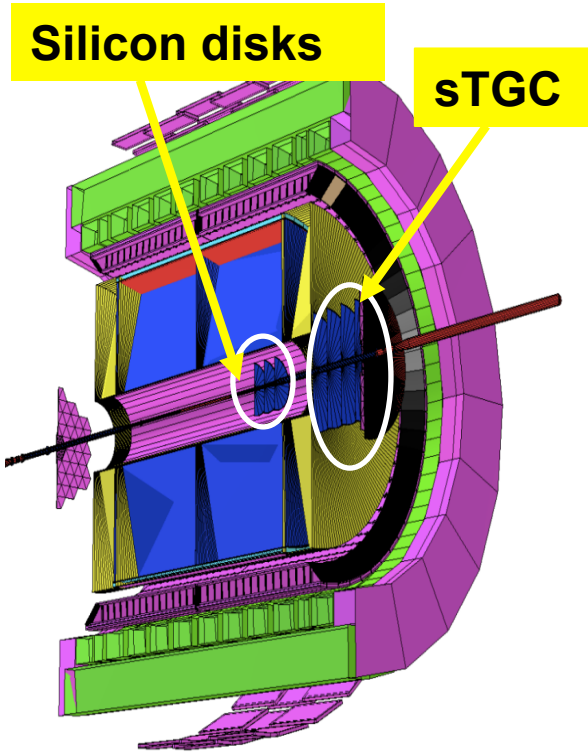




- ATLAS group at SDU is producing 40 4-layer sTGC modules

Forward Tracking upgrade at STAR

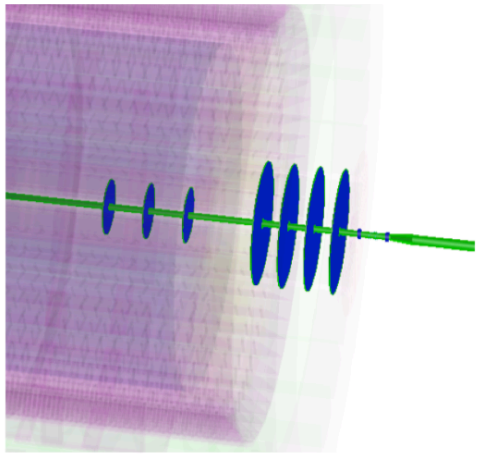
STAR Forward Tracking System ($2.5 < \eta < 4.0$)**:**

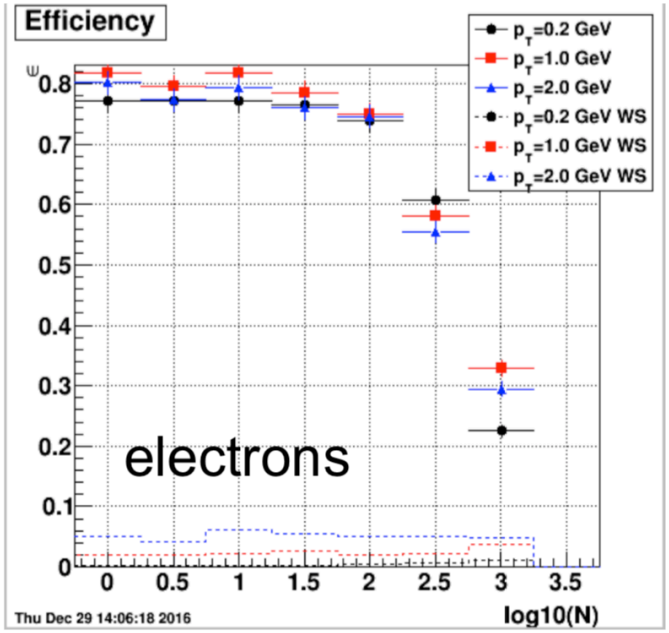


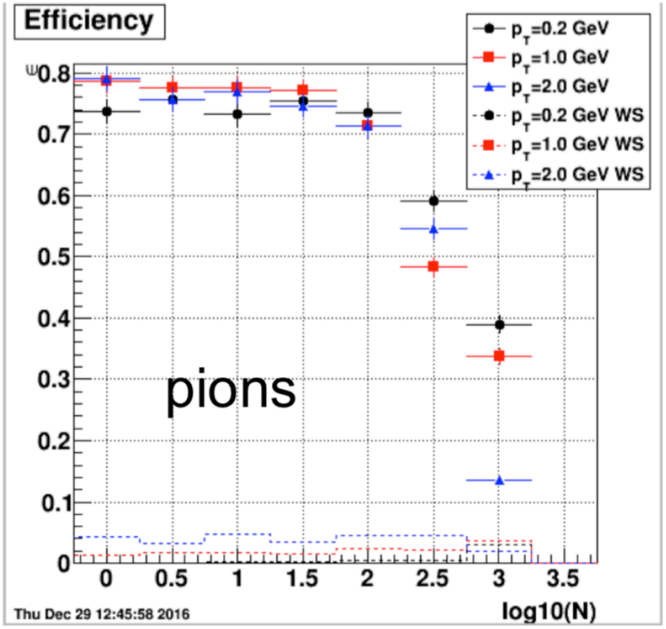
- 3 layers of silicon mini-strip disk
  - ✓ Location from IP: 90, 140, 187 cm
  - ✓ Successful experience of STAR Intermediate Silicon Tracker (IST) detector.
- 4 disks of Small-Strip Thin Gap Chamber (sTGC) wheel
  - ✓ Location from IP: 270, 300, 330, 360 cm
  - ✓ Two layers, size 120cm x 120cm
  - ✓ Significant reduction of the project cost
  - ✓ Possible reuse of STAR TPC electronics for readout
- Detector requirements
  - ✓ Momentum resolution: 20-30% for $0.2 < p_T < 2$ GeV/c (AA)
  - ✓ Tracking efficiency: 80% at 100 tracks per event (AA)
  - ✓ Charge separation (pp/pA)

STAR FTS simulation

- FTS in STAR simulation framework
  - ✓ 3 silicon + 4 sTGC
  - ✓ Tracking efficiency 70%~80% for tracking number 10~100
  - ✓ Wrong charge sign: a few percent
  - ✓ Equivalent to 6 silicon disks option





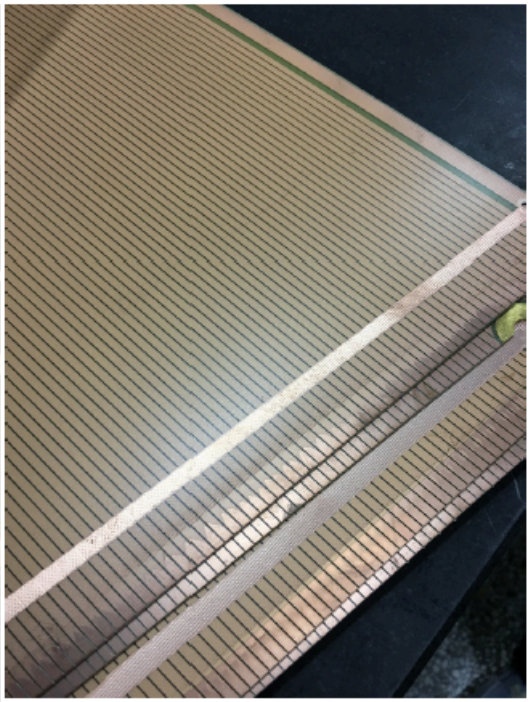


sTGC R&D plan and FTS schedule

- 1st sTGC prototype for STAR to be made at SDU in 2018
  - ✓ ¼ size of ATLAS sTGC in length
  - ✓ 30cmx30cm module with 2 layers

LDRD@BNL

- Test ATLAS sTGC module using STAR iTPC DAQ in 2018

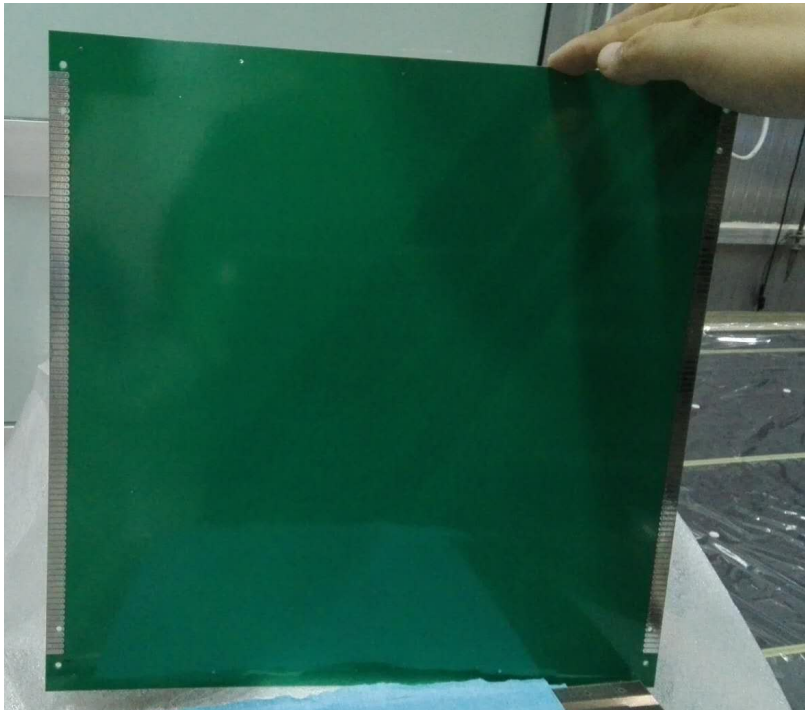


FTS Milestones and Schedule:

- 05/2019 Technical Design Report
- 07/2019 Production Readiness Review
- 09/2019 Start Procurements and Assembly
- 09/2020 Install FTS into STAR
- 01/2021 Start Commissioning of FTS

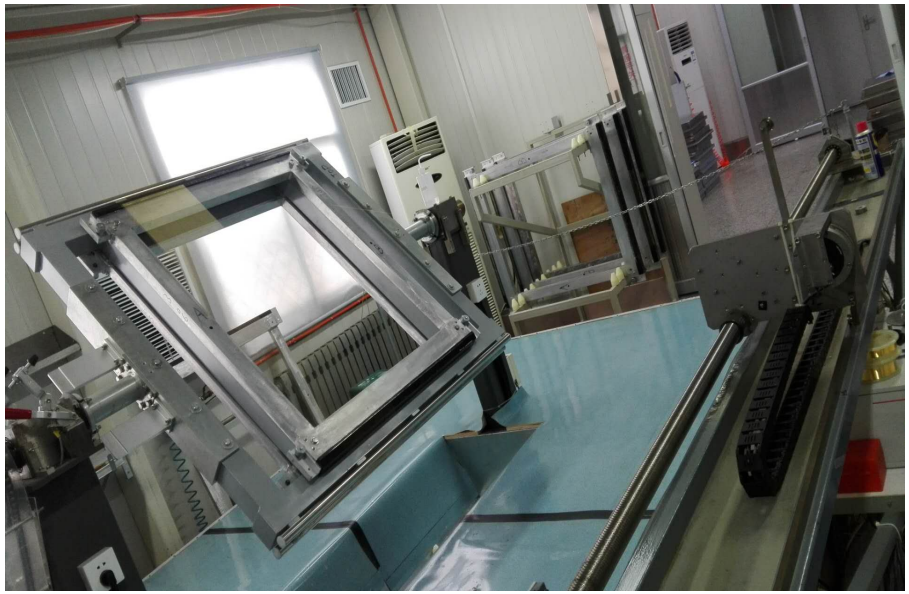
sTGC prototyping for STAR

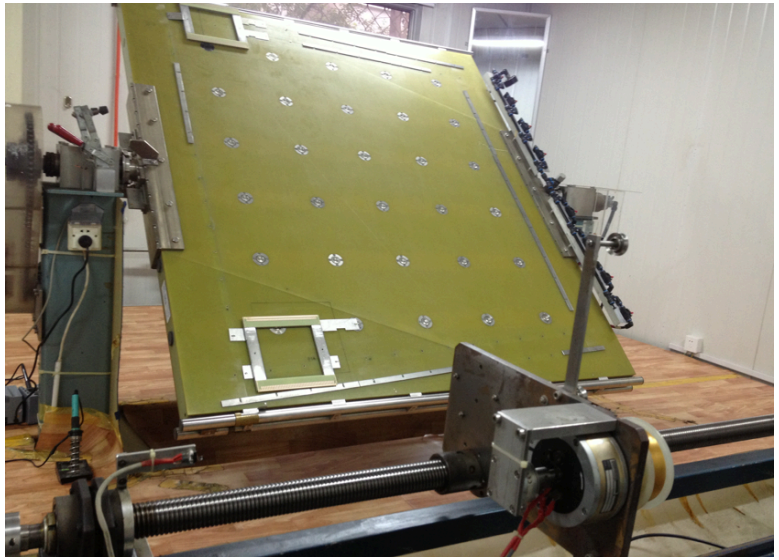
- 1st sTGC prototype for STAR forward upgrade
  - ✓ 30cmx30cm module with 2 layers
  - ✓ Strip width 2.7mm, pitch 3.2mm, length 30cm.
  - ✓ Wire pitch 1.8mm, tension 350g.
  - ✓ HV 2900V

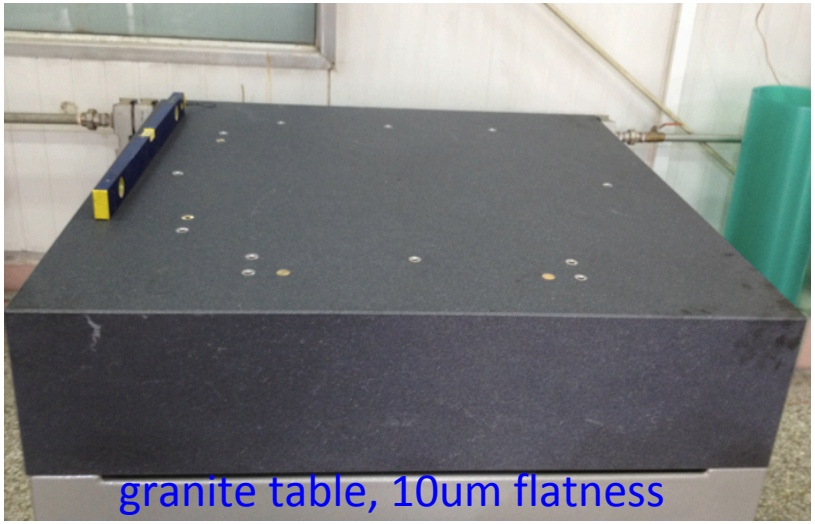


Winding machine at SDU

- 2 winding machine at SDU
  - ✓ One for STAR-iTPC
  - ✓ One for ATLAS sTGC
  - ✓ Tension precision 6%
  - ✓ Pitch tolerance 100um

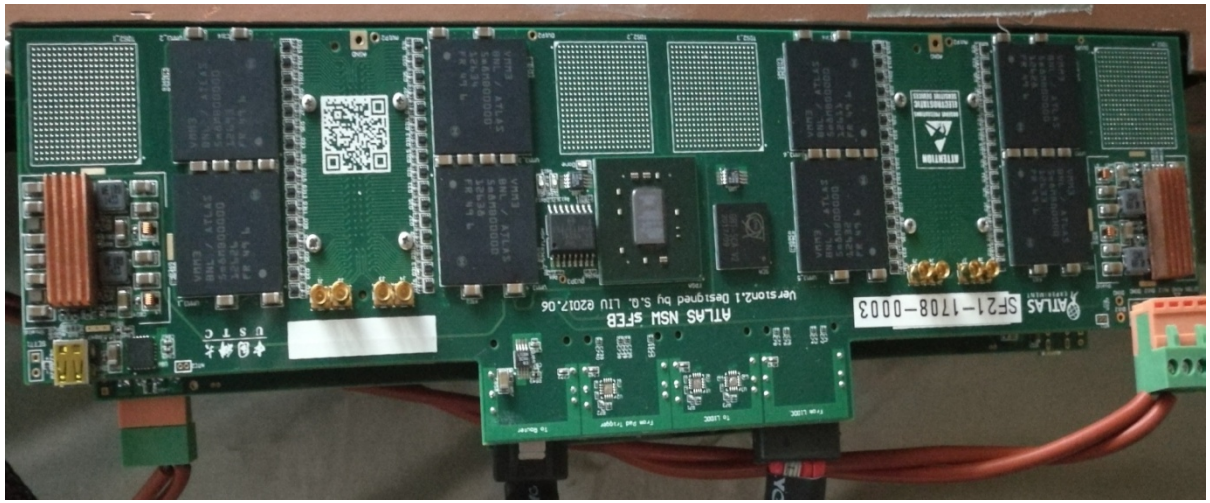






sTGC readout electronics option

- Reusing the current STAR TPC electronics, based on ALTRO ASIC.
  - reduce cost dramatically
- Same as STAR iTPC Project based on SAMPA ASIC
  ~$300K for 19200 channels.
- Use the original ATLAS electronics VMM, designed at BNL

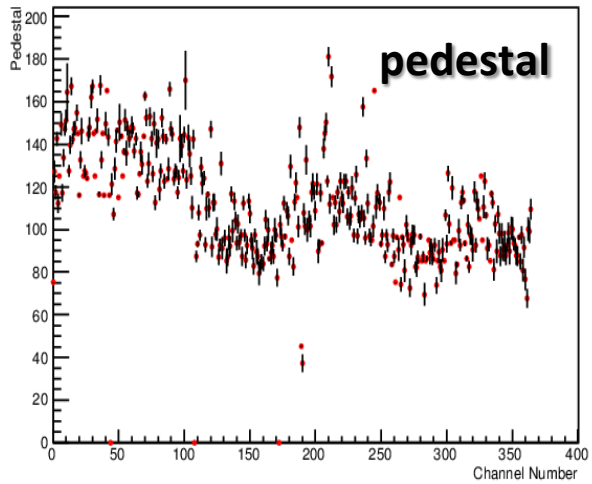


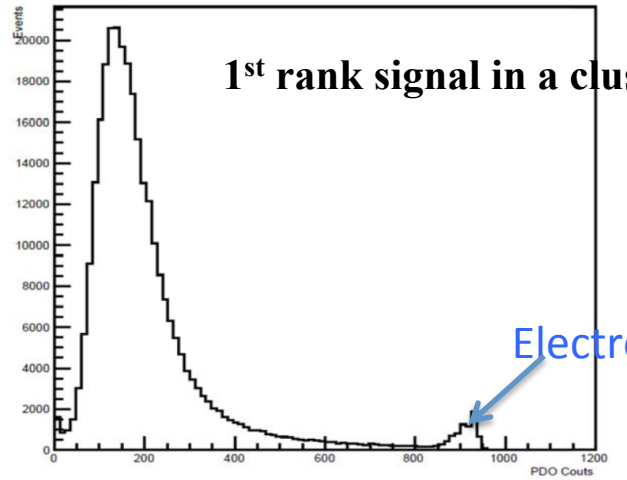
VMM3.0

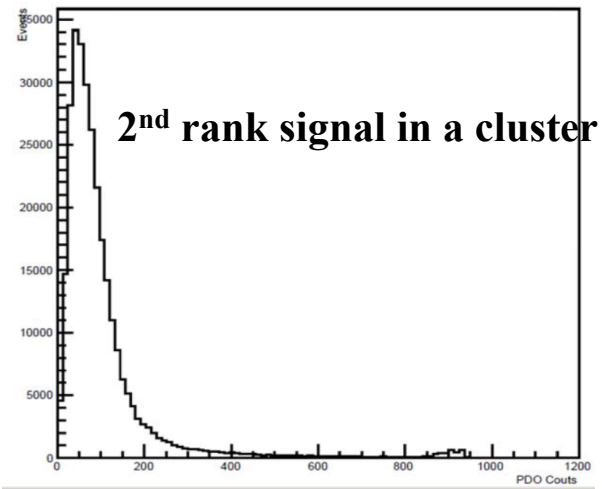
Testing bench at SDU

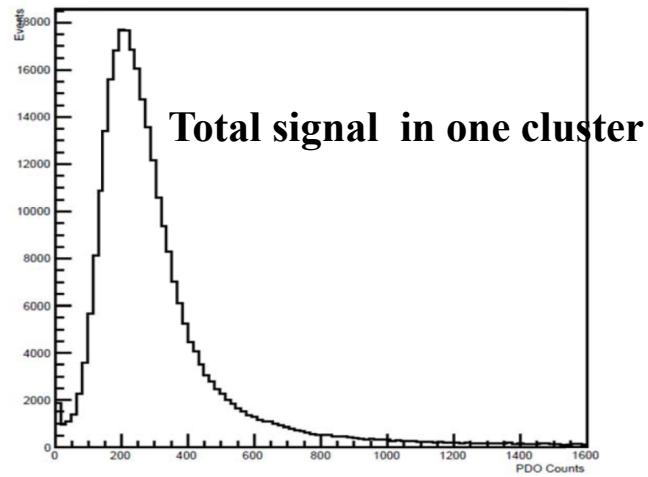
- ✓ Two layers of scintillator (Top and Bottom) provide triggering.
- ✓ Two TGC detectors provide 2d position
- ✓ Testing using cosmic ray

sTGC strips test with ATLAS VMM3



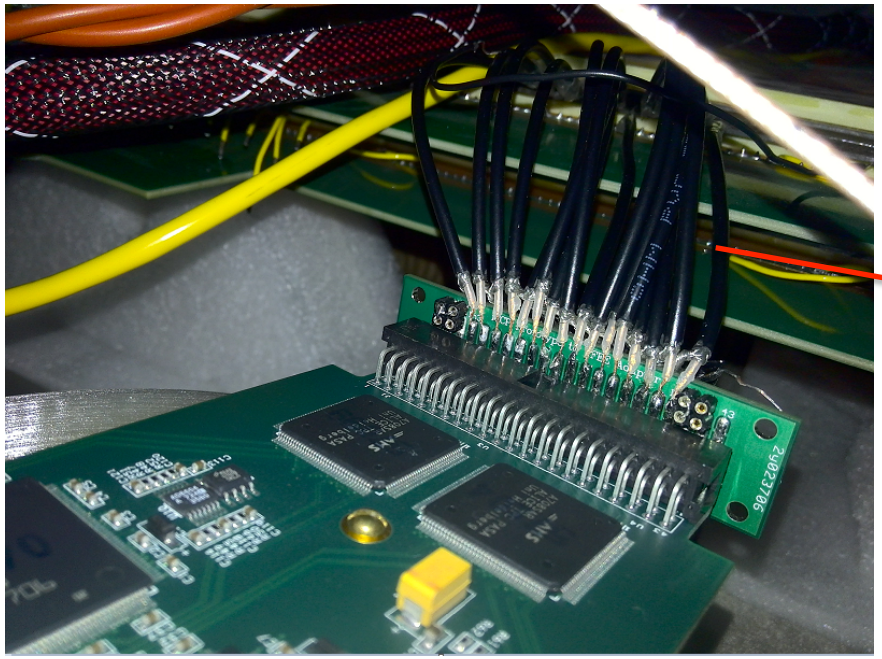


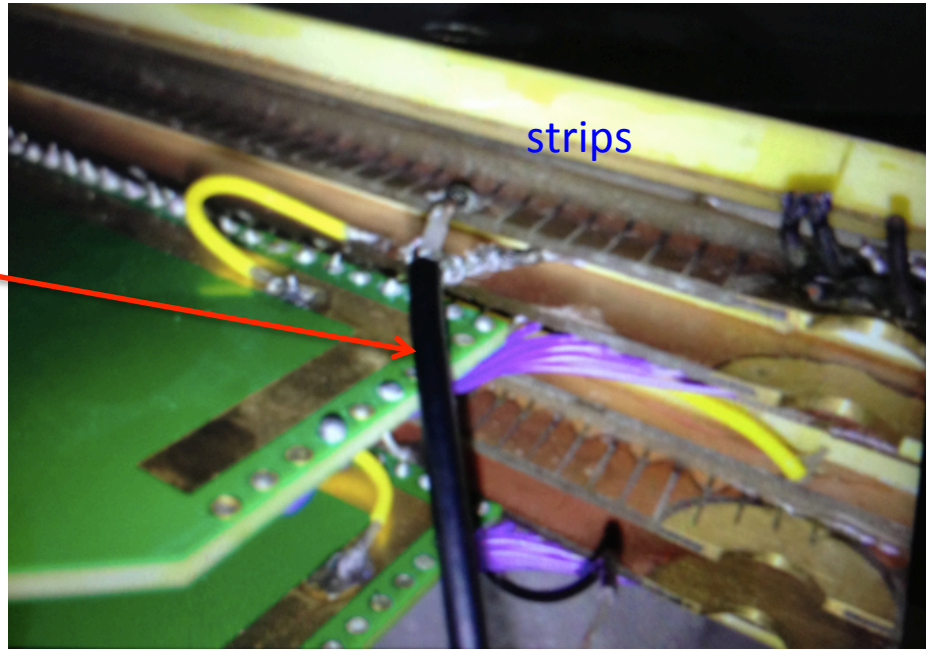




HV=2900V，gain=1mv/fC，Peaktime=50ns，total signal ~250 fC from one cluster
Fired channel in one cluster ~3.5

sTGC strips test with STAR-TPC ALTRO ASIC



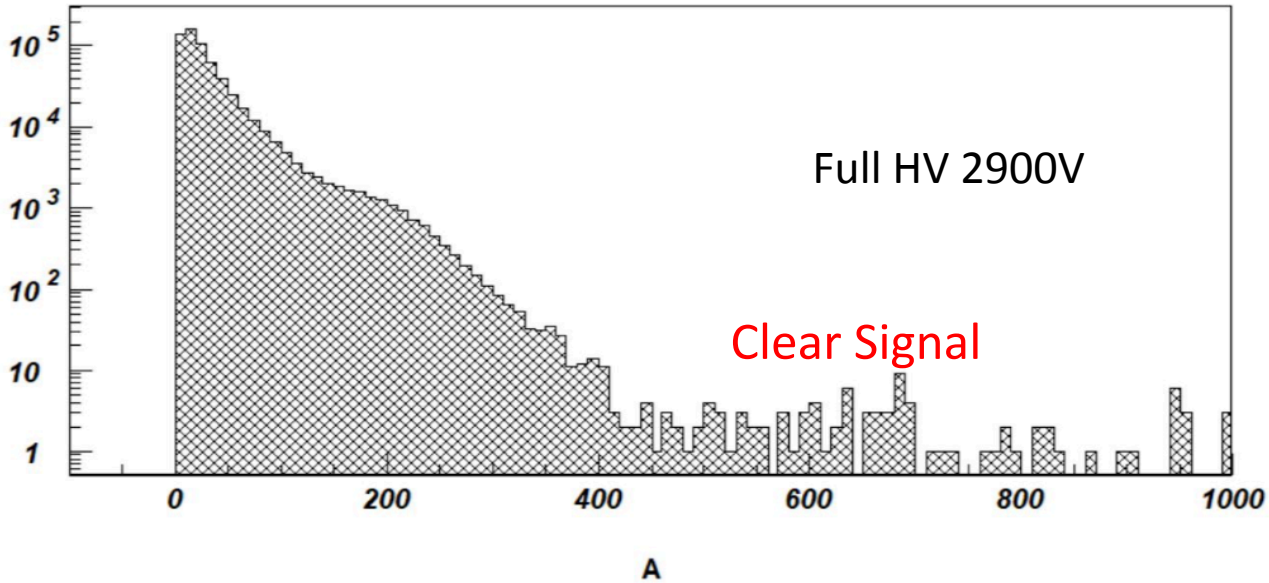


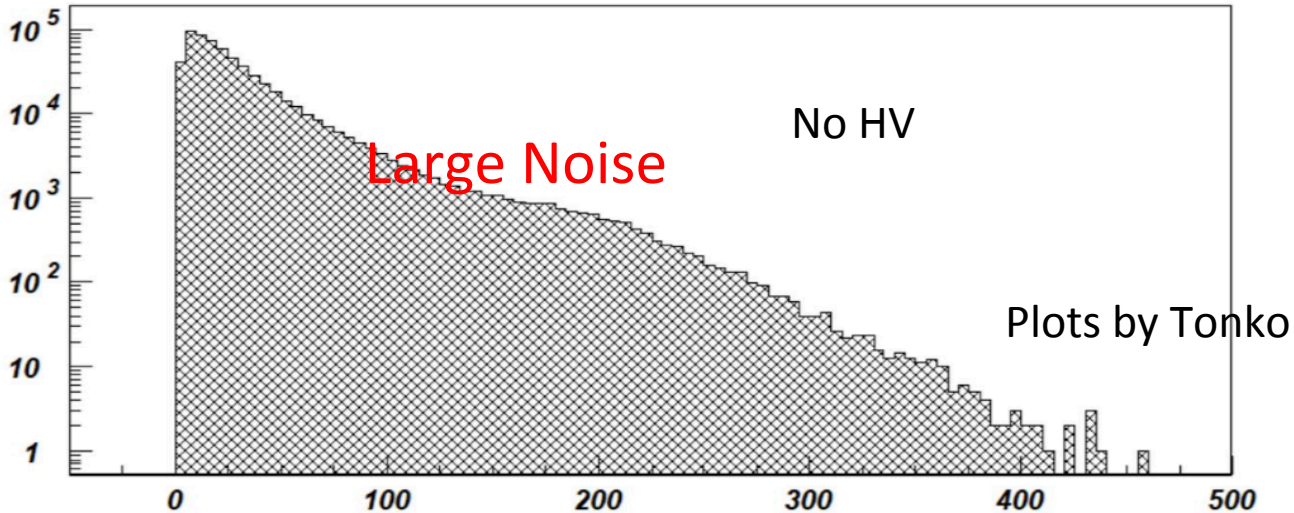
- 4 sTGC strips connected with STAR FEE 16 channels;
- Other channels of FEE is unoccupied.

Cables soldered/used to connect strip and STAR FEE, which may introduce noise

ADC spectrum from strip readout

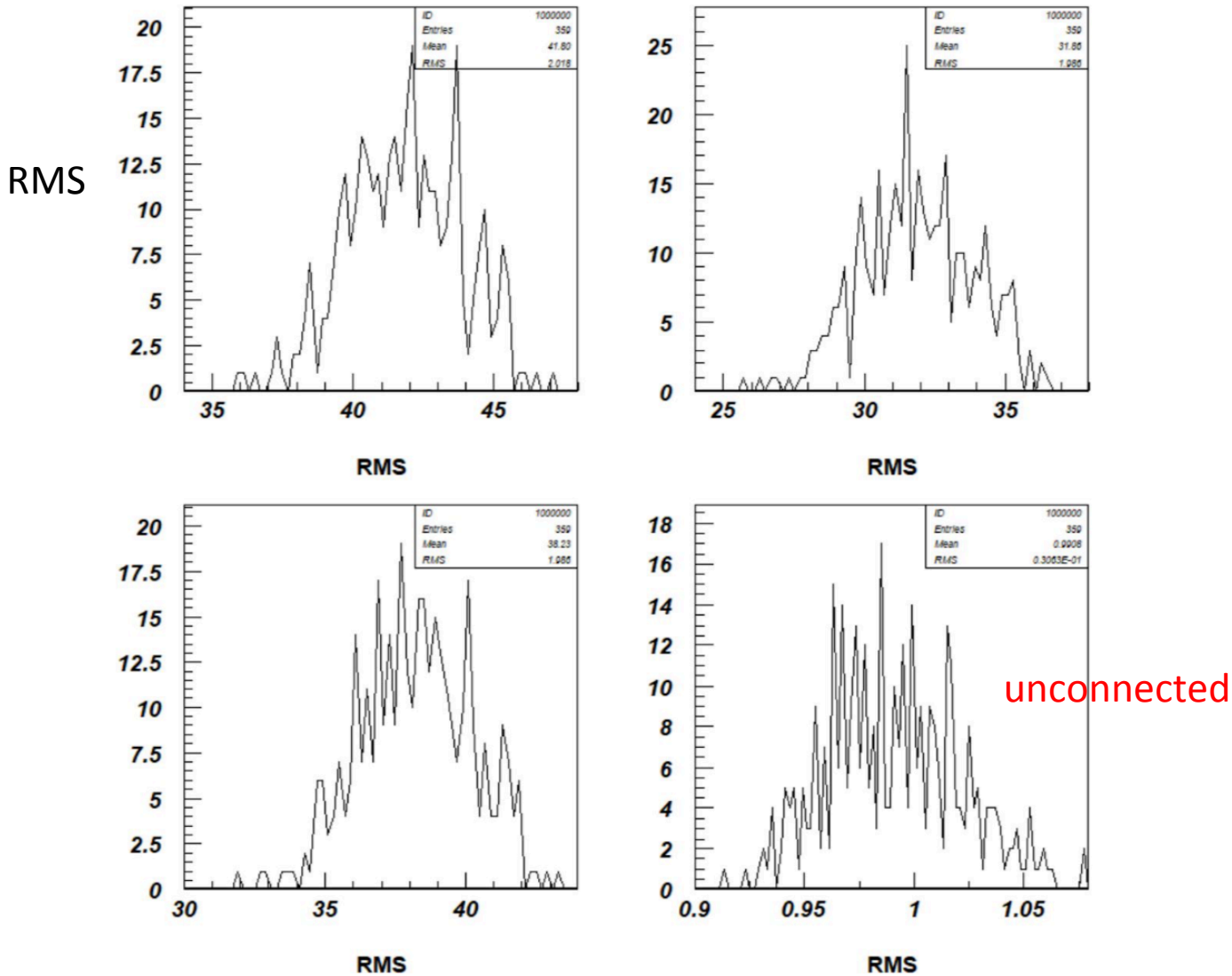
- ADC spectrum :





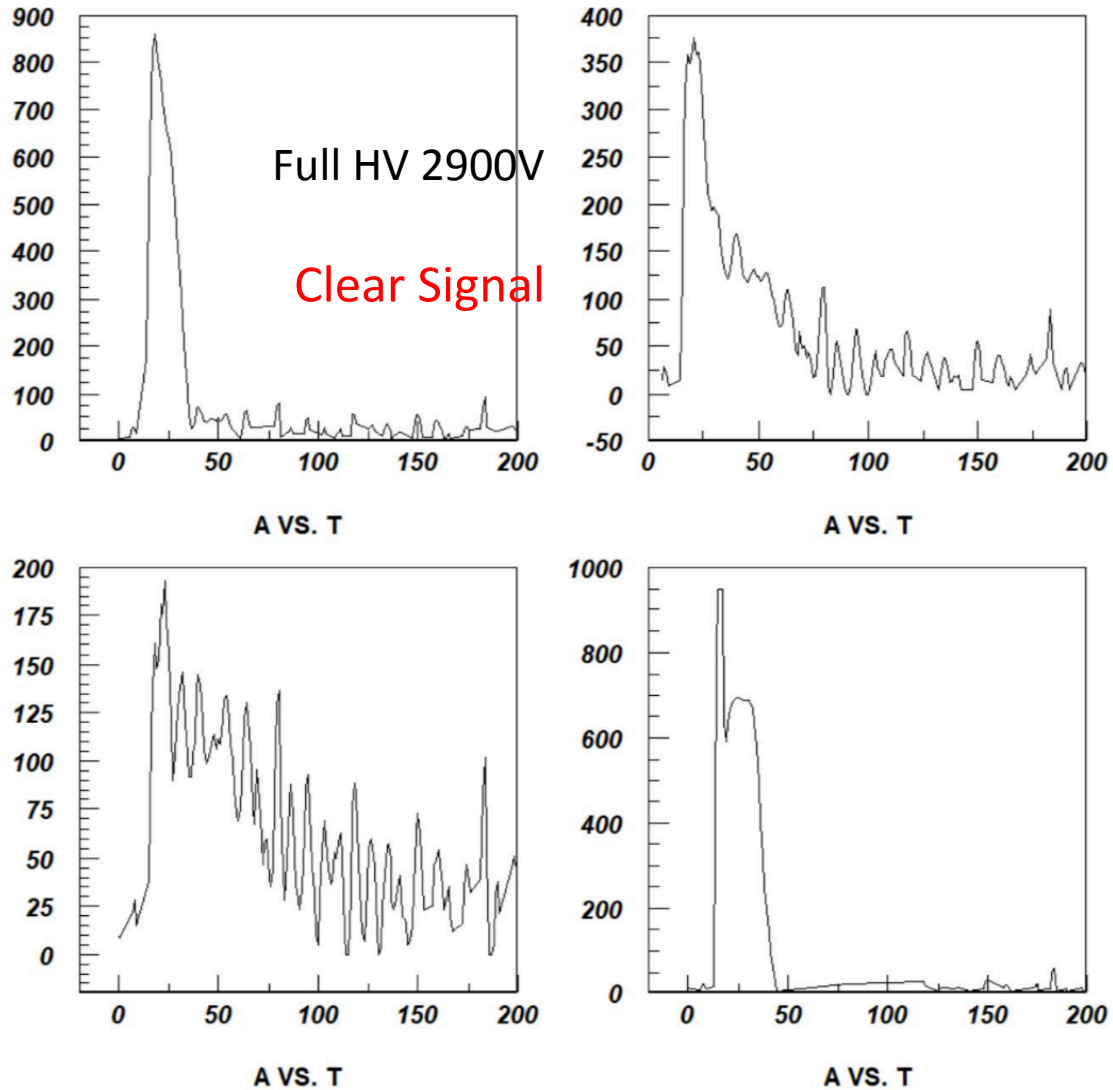
RMS of pedestal from single channel

- 3 connected channel vs. one unconnected: noise relatively large



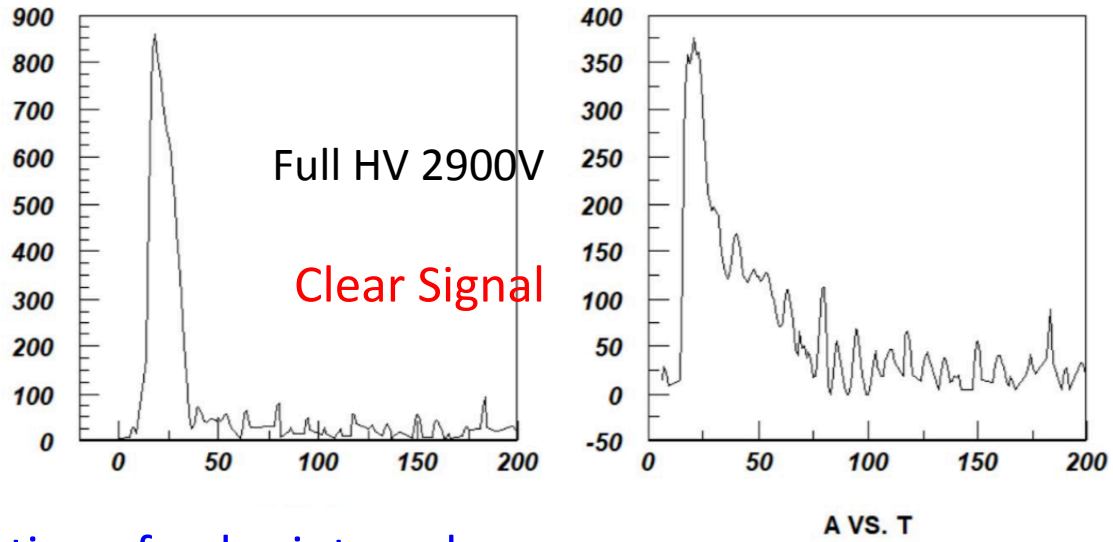
ADC spectrum from strip readout

One event: ADC vs. time bin in 4 channels

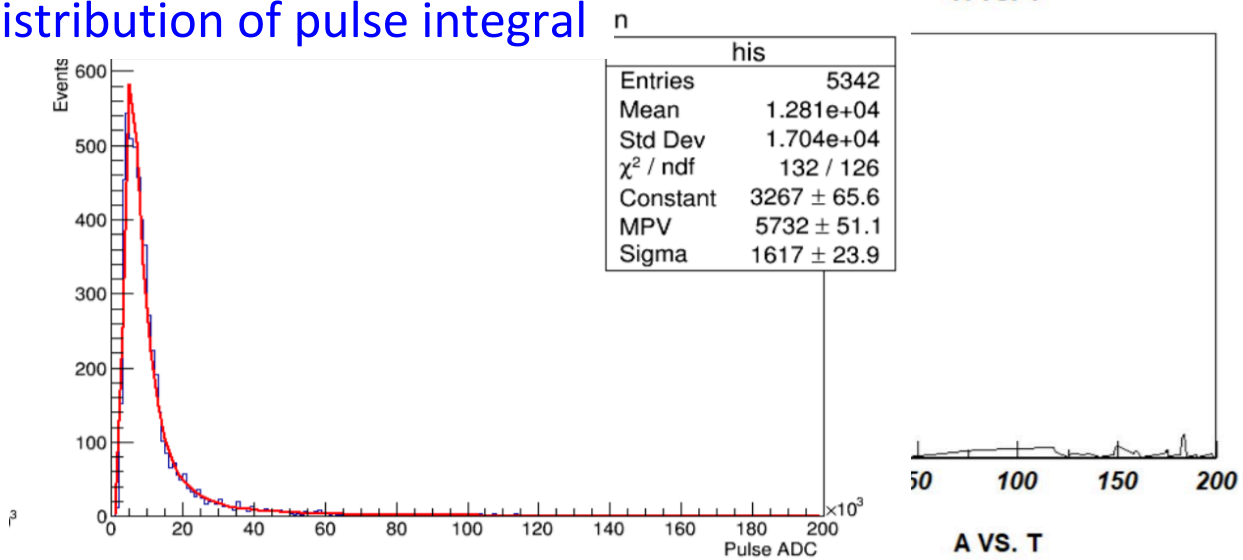


ADC spectrum from strip readout

One event: ADC vs. time bin in 4 channels



ADC Distribution of pulse integral



Summary

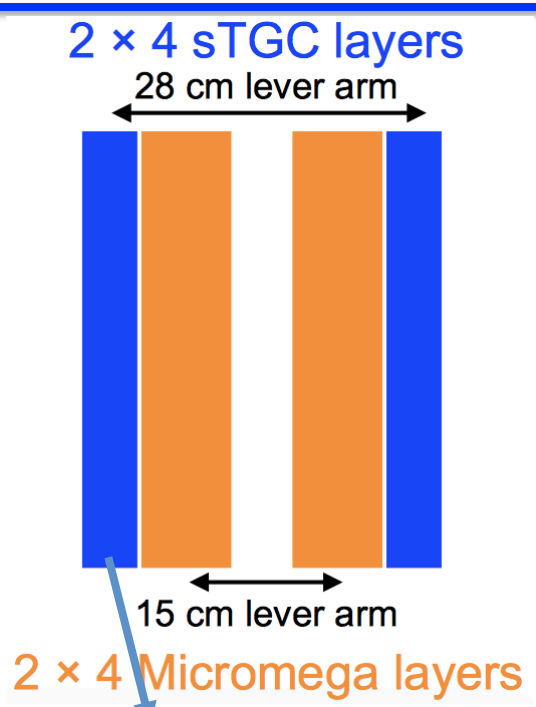
- sTGC provide an cost-effective option for forward tracking with similar performance at STAR forward upgrade.
- The position resolution can reach ~100um in one dimension. One disk with two layers (one rotate 90°) can provide good x-y position resolution.
- Strip signal seen by testing ATLAS sTGC module using STAR TPC electronics.
- 1st 30cm x 30cm sTGC prototype with two layers will be made in 2018 at SDU and tested in 2019 at STAR.

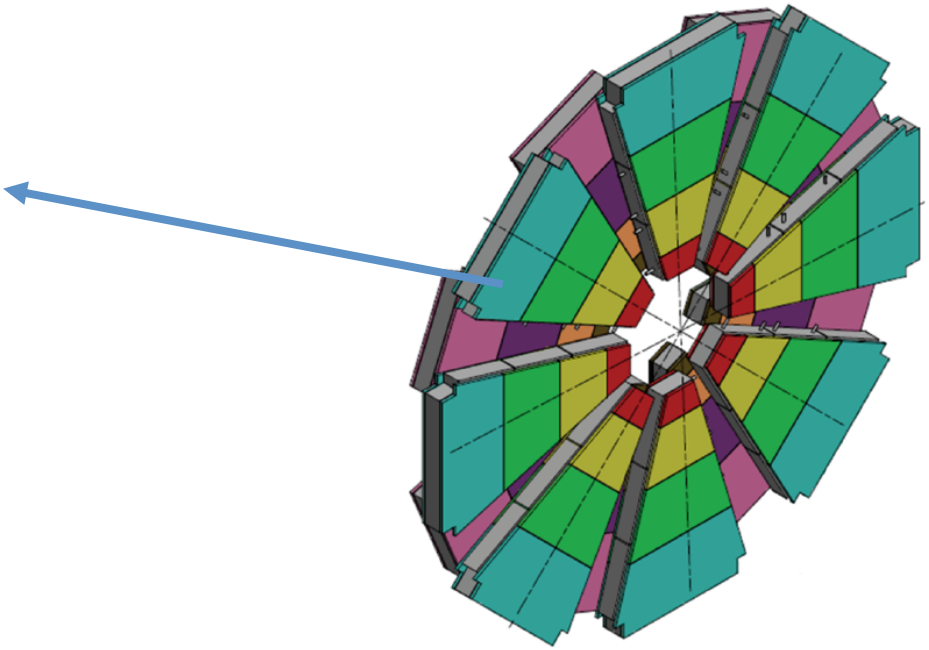
Summary

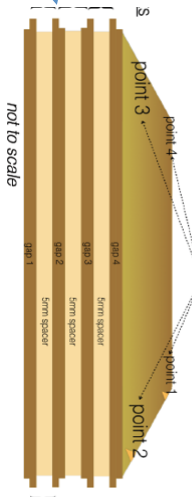
- sTGC provide an cost-effective option for forward tracking with similar performance at STAR forward upgrade.
- The position resolution can reach ~100um in one dimension. One disk with two layers (one rotate 90°) can provide good x-y position resolution.
- Strip signal seen by testing ATLAS sTGC module using STAR TPC electronics.
- 1st 30cm x 30cm sTGC prototype with two layers will be made in 2018 at SDU and tested in 2019 at STAR.

Thanks!

New Small Wheel Layout of ATLAS







- ✓ sTGC and MM(MicroMegas detector) are selected to compose the NSW
- ✓ Both sTGC & MM used for the online trigger and offline track-segment reconstruction
- ✓ Muon trigger ~20kHz