

The sTGC Prototyping and Performance Test for the STAR Forward Upgrade



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Abstract

The STAR experiment at RHIC is implementing a new Forward Tracking System (FTS) which consists of a Forward Silicon Tracker (FST) and a Forward sTGC Tracker (FTT). The small-strip Thin Gap Chambers (sTGC) at STAR are designed to provide precision position measurements of about 100um for the charged particles at high luminosity, covering the forward rapidity region ($2.5 < \eta < 4$). The extended rapidity coverage in particle tracking enables lots of physics opportunities in pp, pA and AA programs beyond 2020 at STAR.

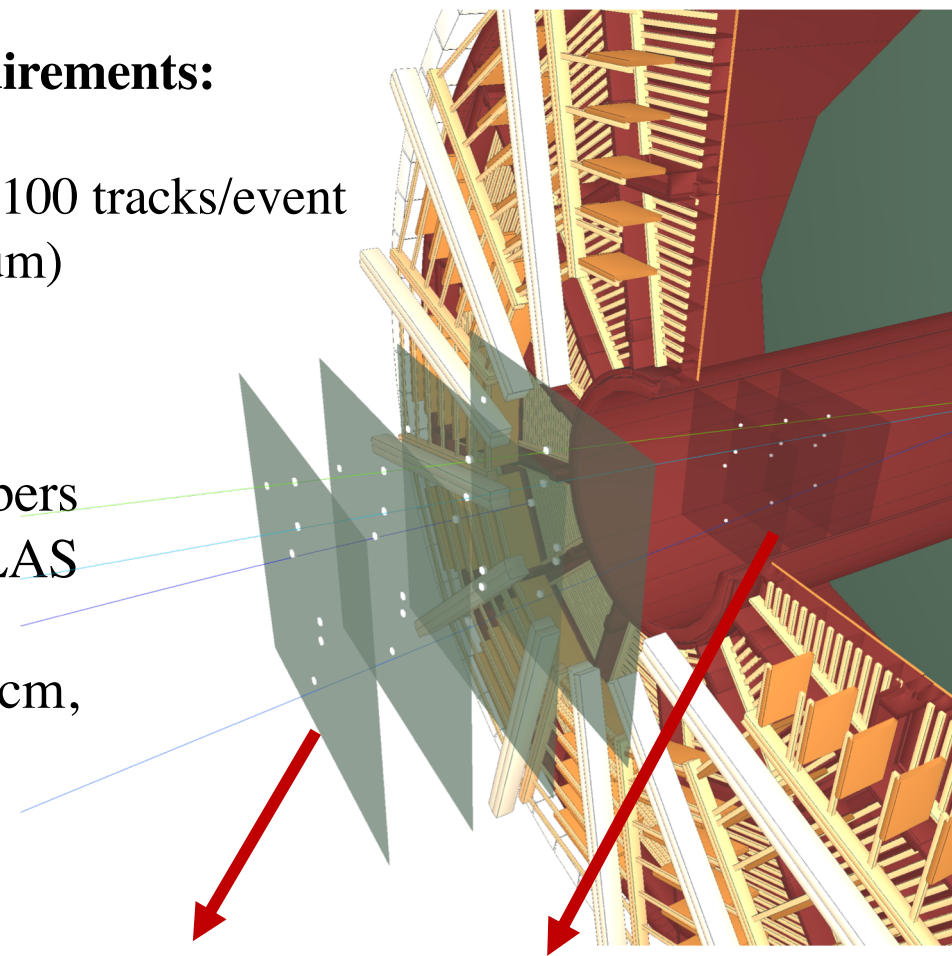
sTGC Prototyping

Forward Tracking System

Forward sTGC tracking requirements:

- 4 tracking points
- Tracking efficiency $\sim 95\%$ @ 100 tracks/event
- Position resolution (100-200um)
- Momentum resolution $< 30\%$

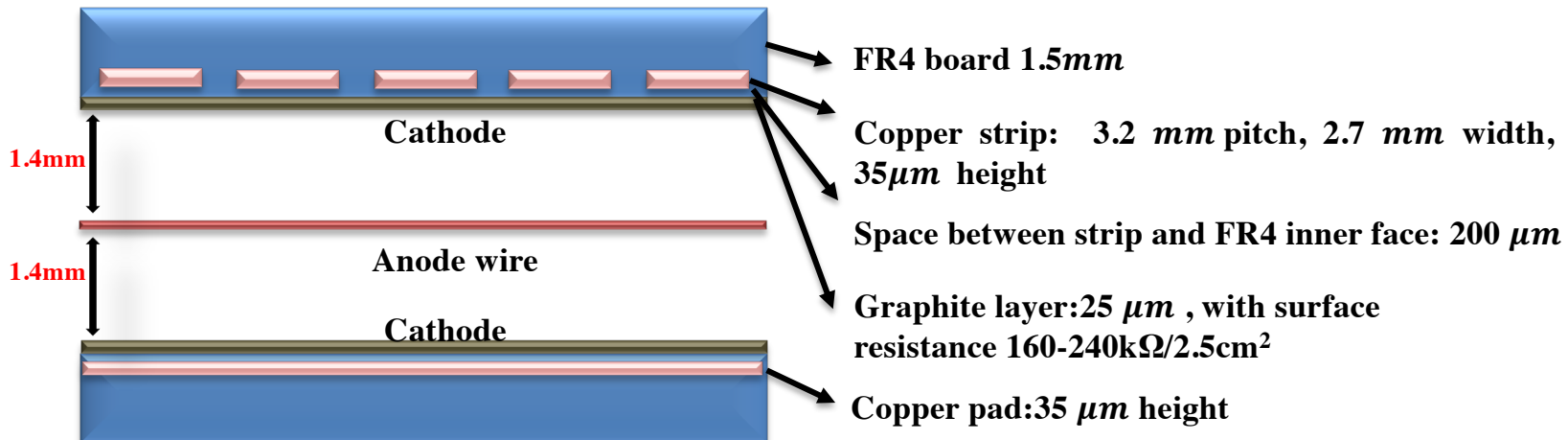
- small-strip Thin Gap Chambers (sTGC) designed by the ATLAS experiment.
- sTGC at $z = 273$ cm, 303cm, 333cm, 363cm.



4 sTGC disks + 3 Silicon disks

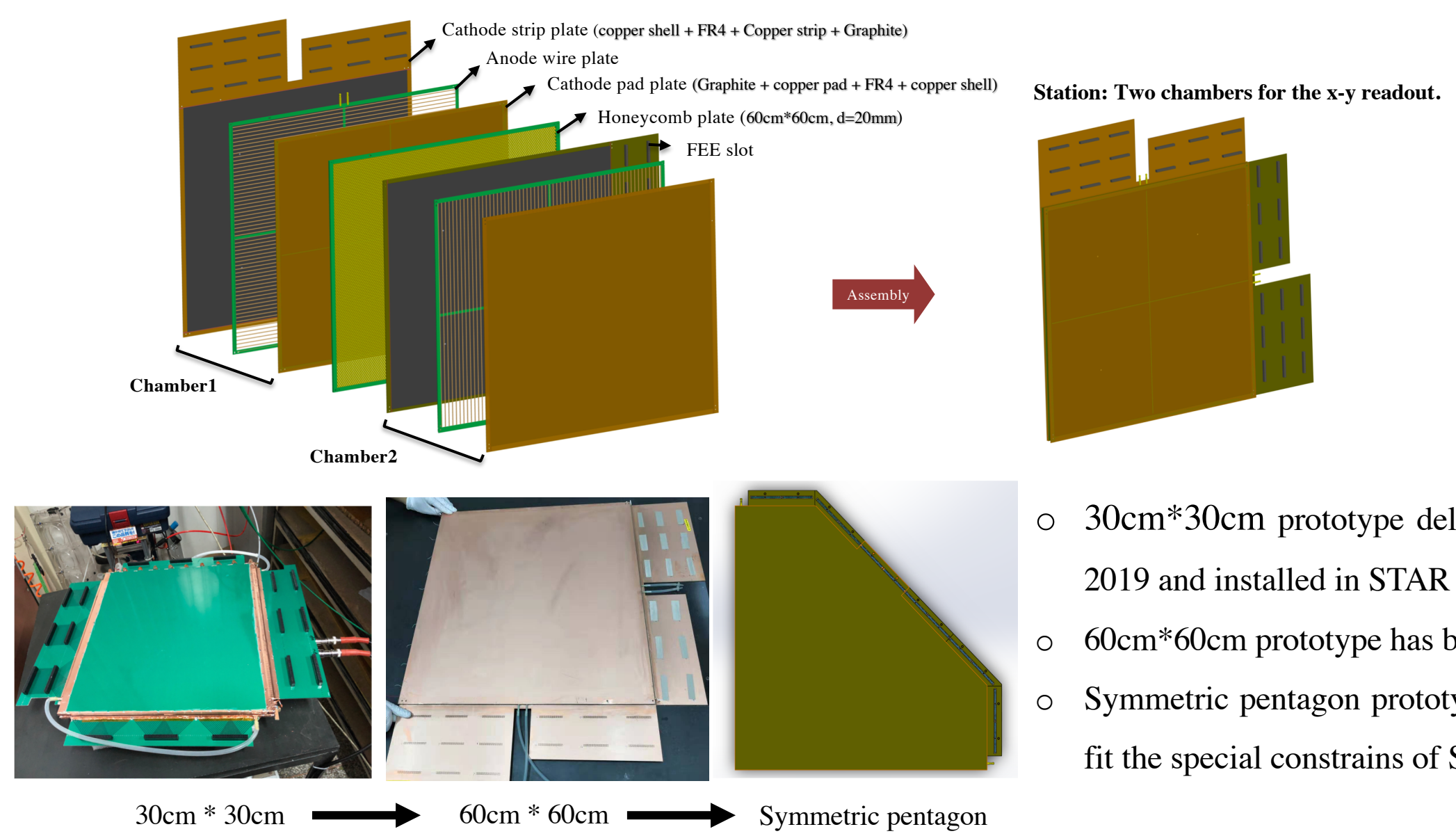
sTGC Geometry

sTGC layout-side-view



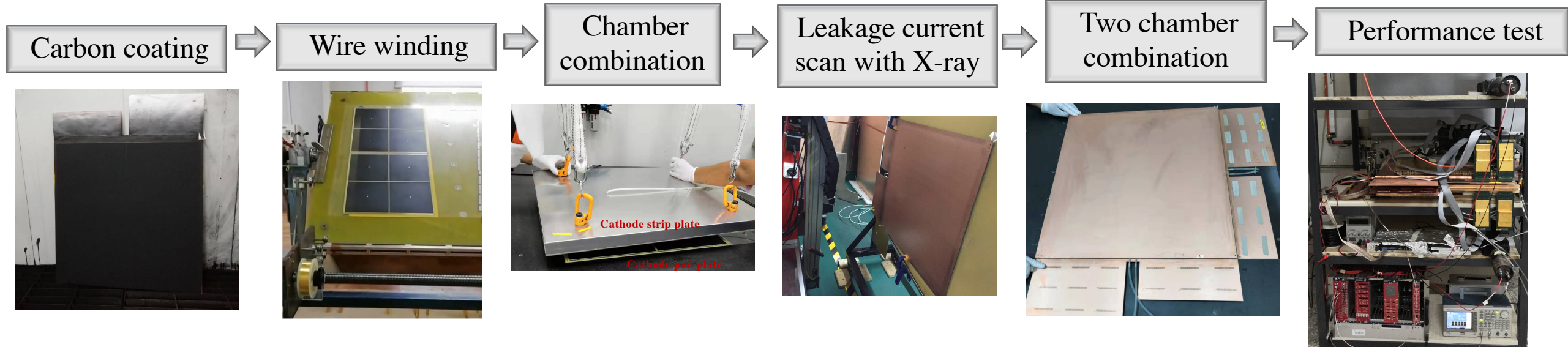
- Anode:** 50μm gold-plated tungsten wire, wire pitch 1.8mm, the wire tension 350g;
- Readout:** copper strips, perpendicular to anode wires, outside of cathode

Different Prototypes



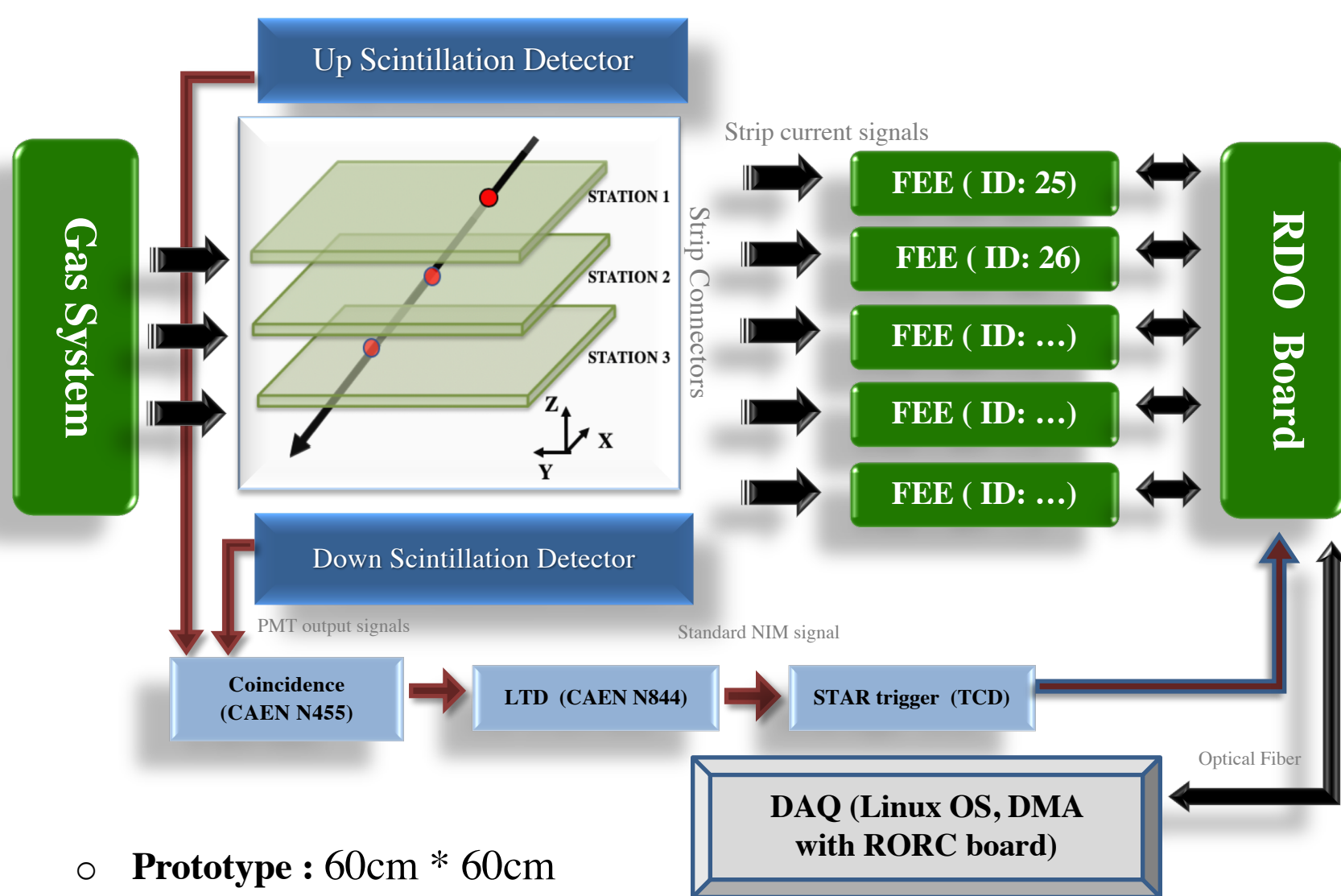
- 30cm*30cm prototype delivered to BNL in Jan. 2019 and installed in STAR on Jun. 5, 2019.
- 60cm*60cm prototype has been built and tested.
- Symmetric pentagon prototype has been design to fit the special constrains of STAR.

sTGC Prototype Production Procedure



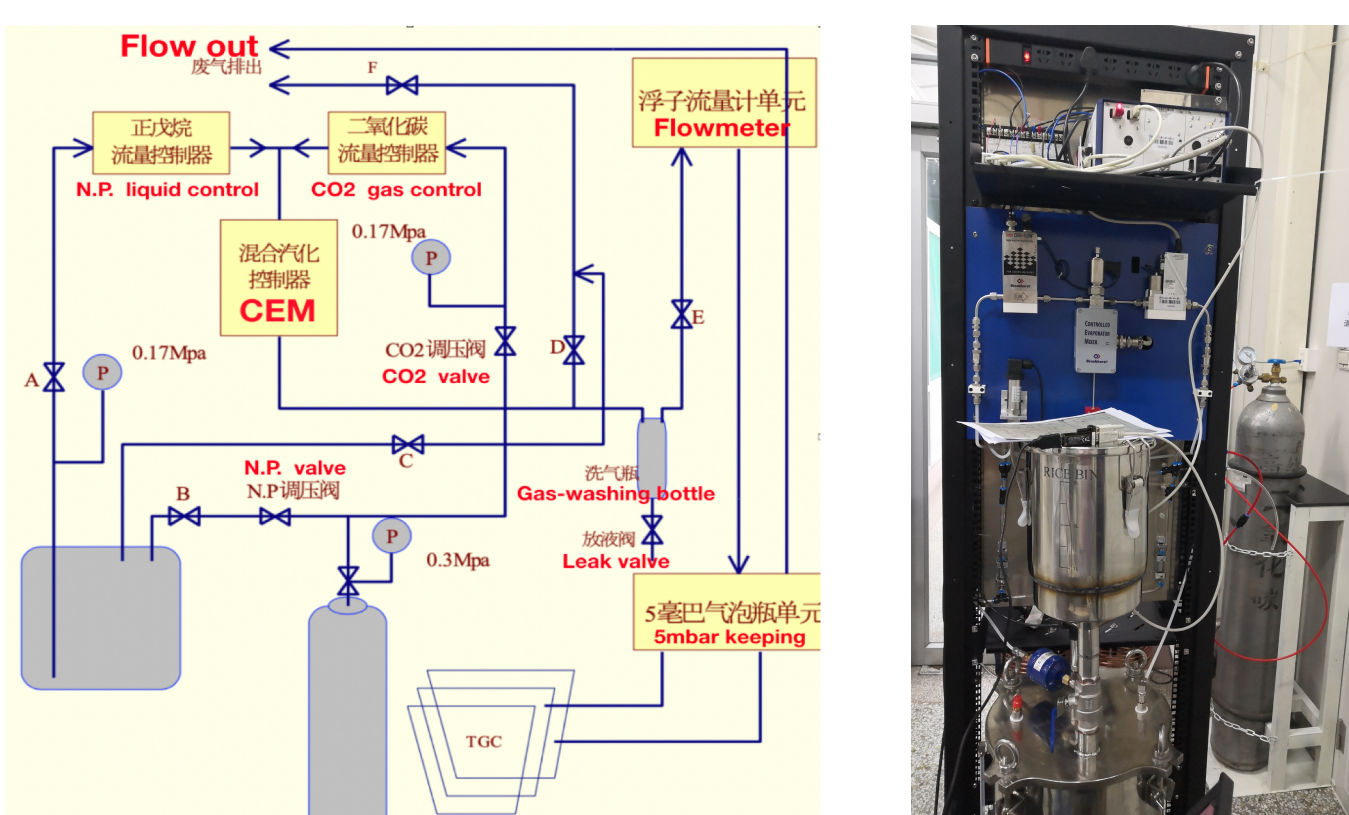
sTGC Performance Test

Test System



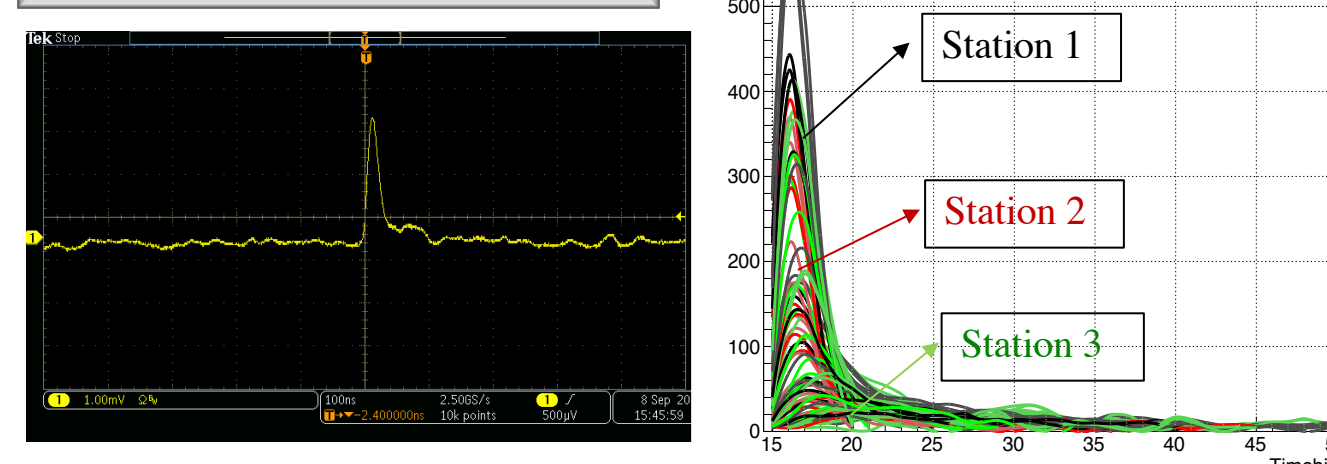
- Prototype: 60cm * 60cm
- Readout area: 22*10cm²
- Gas: 45% n-Pentane + 55% CO₂
- HV: 2700V

Gas System: Control Evaporation Mixing



With the CEM system, mixed gas is obtained by mixing liquid and gas.

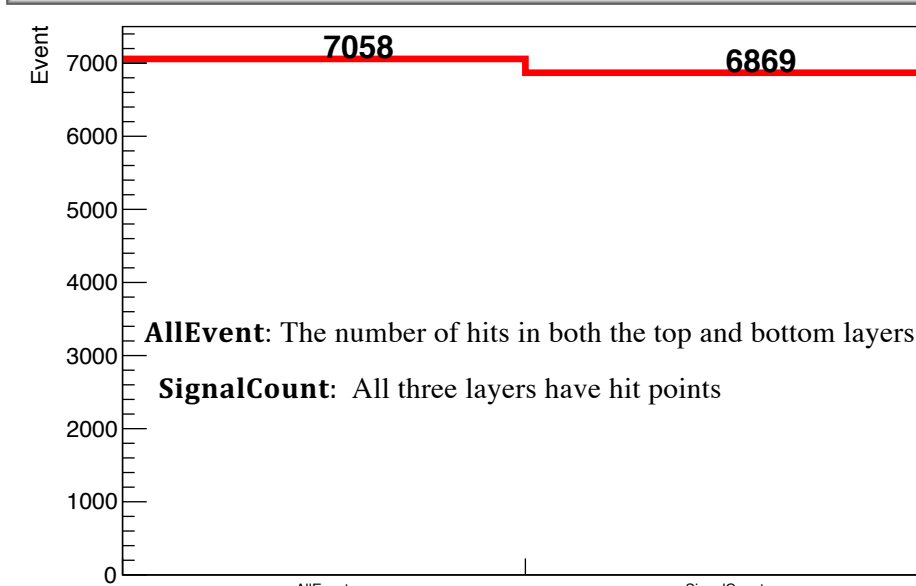
Cosmic Ray Pulses



Cosmic ray signal feature:

- Time continuous (> 300 ns);
- The fired strips should be continuous (> 3 strips)
- The charge of each Timebin (> 16 ADC);

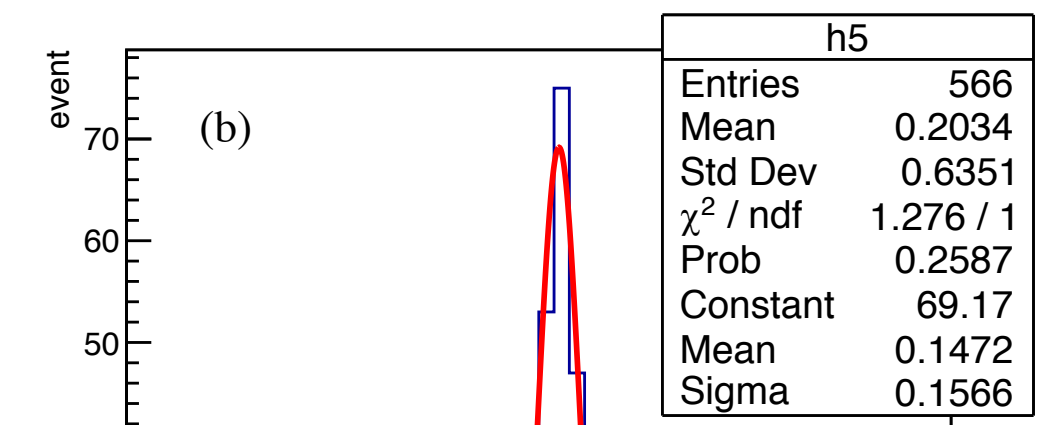
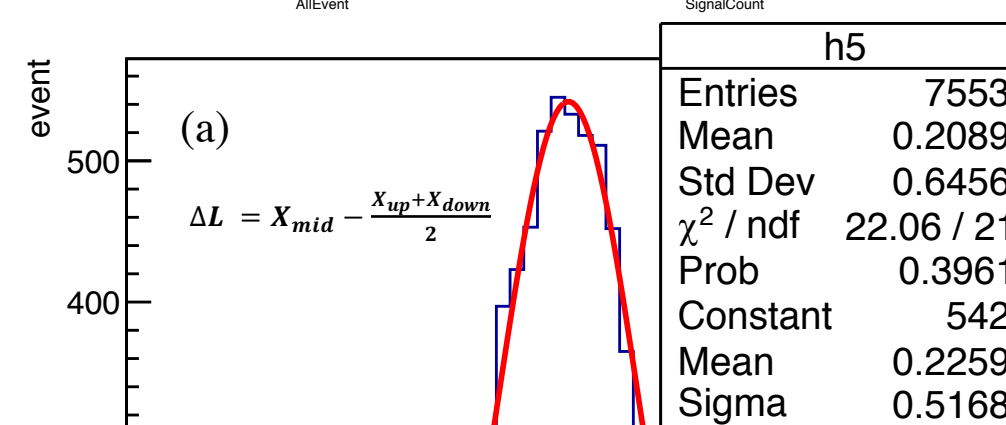
Detection Efficiency and Position Resolution



$$\text{Cut: } X_{\text{mid}} - \frac{X_{\text{up}} + X_{\text{down}}}{2} < 10 \text{ mm } (\sim 3 \text{ strips});$$

$$\text{Efficiency} = \frac{\text{SignalCount}}{\text{AllEvent}} = 98.3\%$$

Detection efficiency of sTGC is more than 98% at 2700V.



(a) The position resolution is about 500um what rotation and shift correction.

(b) To eliminate the influence of mid-layer shift in z direction, one selects events with an angle between 89.4° and 90.6° for the cosmic rays. Resulting the position resolution is about 100um without rotation and shift correction.

Summary and Next to do

Three different sTGC prototypes for STAR have been designed and built. A 30cm*30cm prototype has been run in STAR in 2019 during the BES-II. A 60cm*60cm prototype has been tested and delivered to BNL in Feb. 2020. A Symmetric pentagon prototype has been designed and will be completed by the end of 2020. The detection efficiency of the 60cm*60cm prototype is more than 98% at 2700V. The position resolution without rotation and shift correction is about 500um. Event with cosmic rays having an angle between 89.4° and 90.6°, the position resolution is about 100um without rotation and shift correction.

