sTGC R&D at SDU for STAR ☆ Forward Upgrade

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- Prototype production
- QA and performance test
- Pentagon prototype design

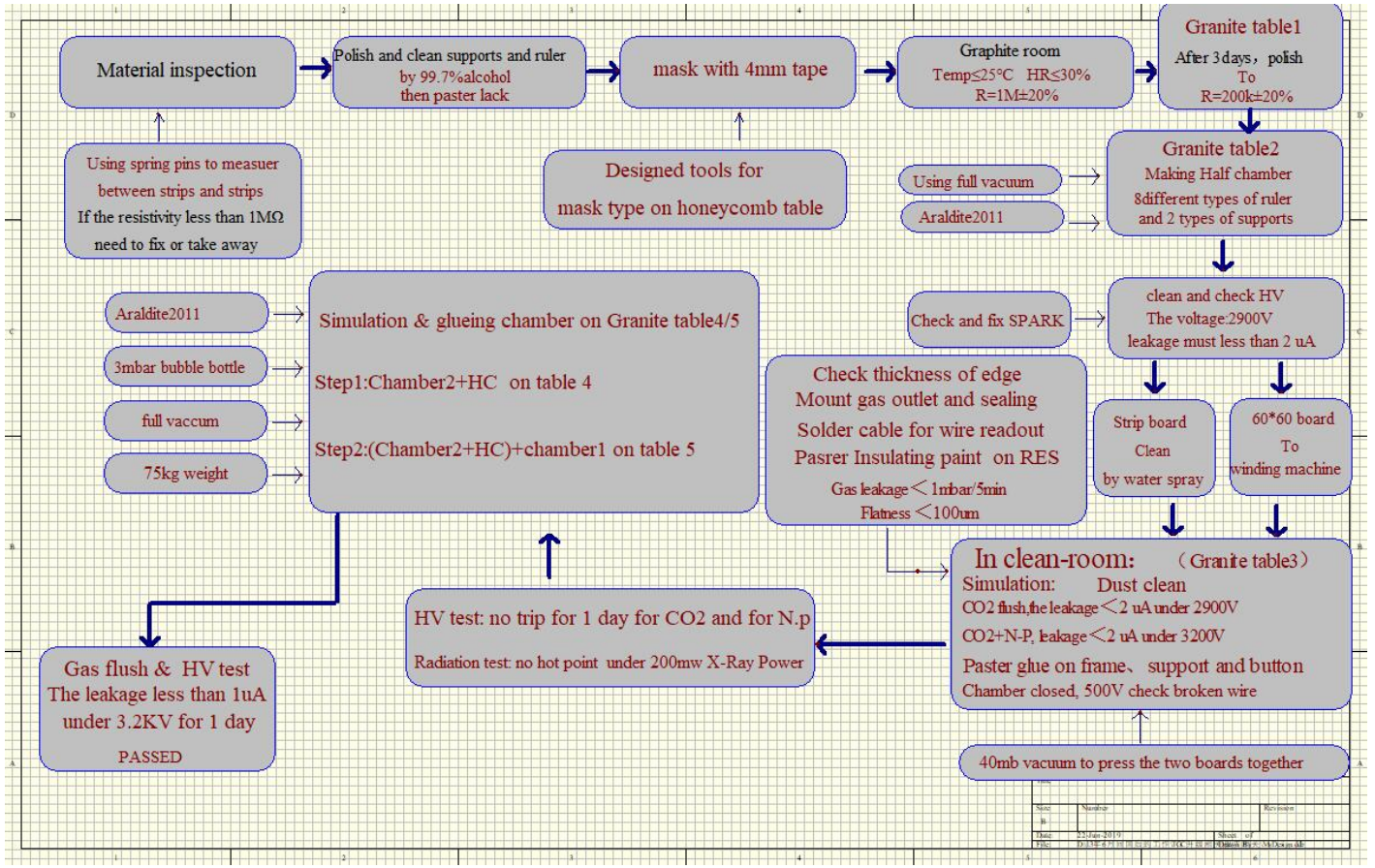
sTGC Production Procedure

- Carbon Coating
- Wire Winding
- Two Halfs Combination
- X-ray Scan
- Two Chambers Combination
- Performance Test

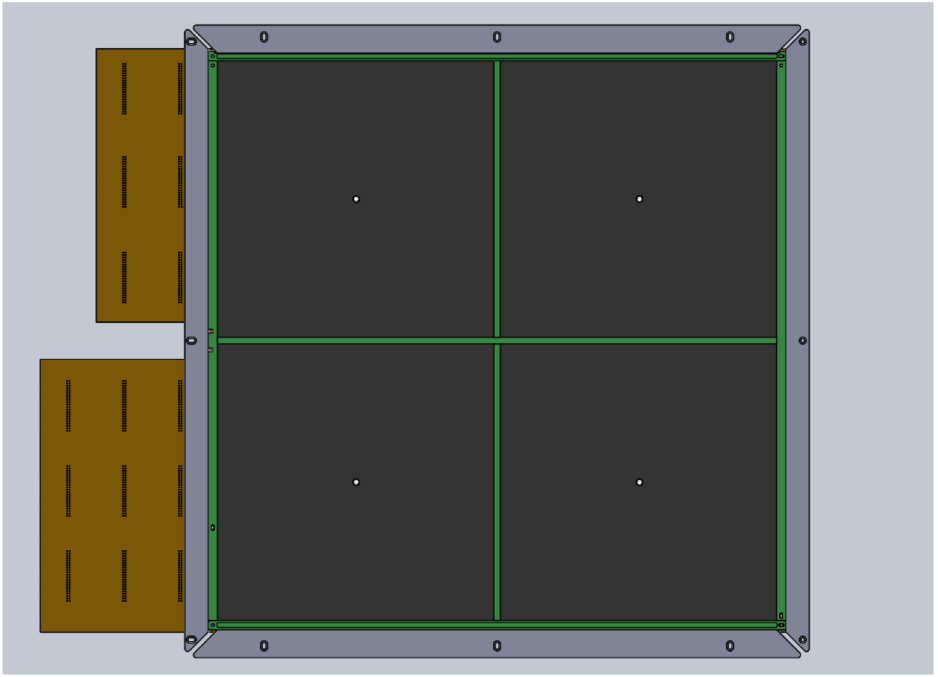
Same clean room as iTPC production

sTGC Production Procedure

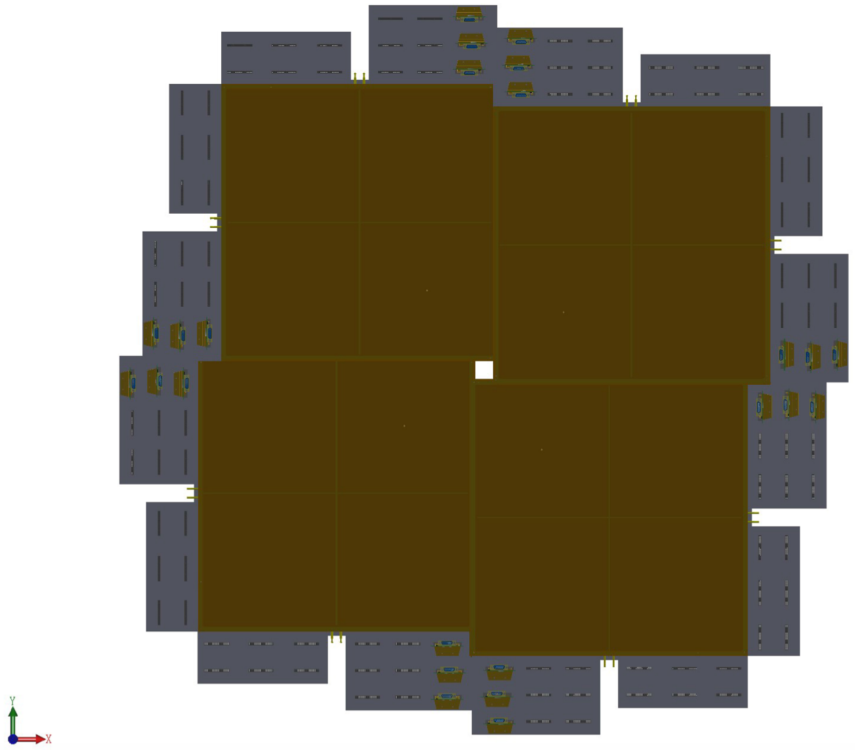
- Carbon Coating
- Wire Winding
- Two Halfs Combination
- X-ray Scan
- Two Chambers Combination
- Performance Test



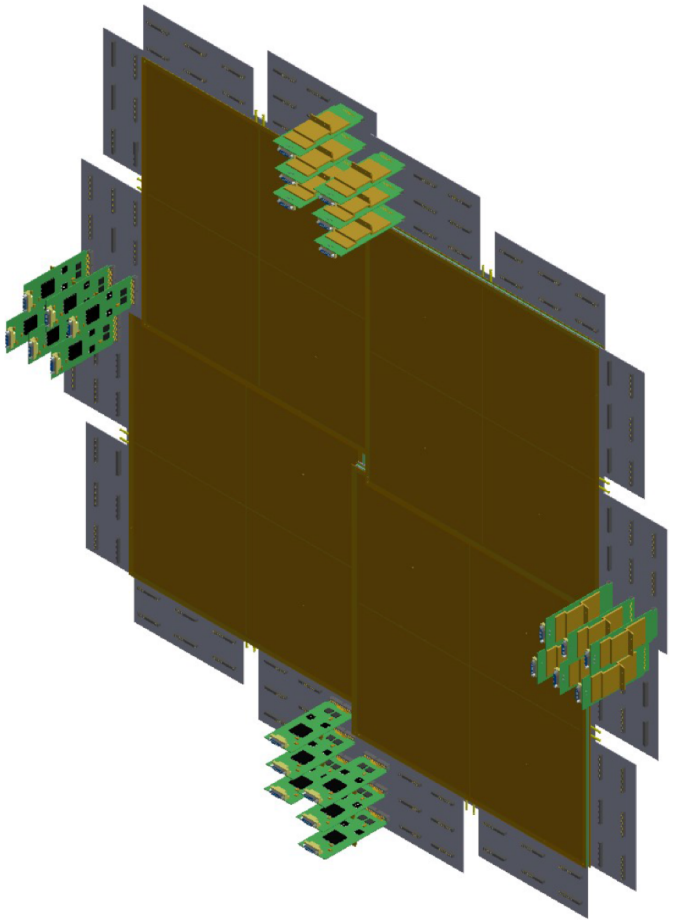
60cmx60cm Prototype Design



Drawing for strip layer



Endcap view for the whole layer

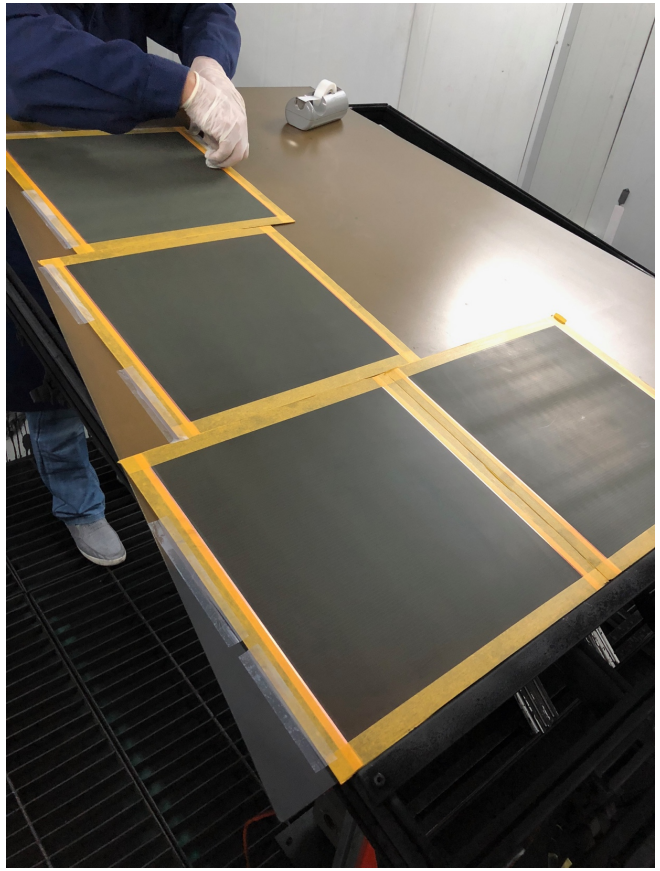


With several FEEs inserted

- ✓ 60cmx60cm active area
- ✓ No adapter to avoid introducing more noise
- ✓ Match TPX electronics

Graphite Spraying

Automatic graphite sprayer



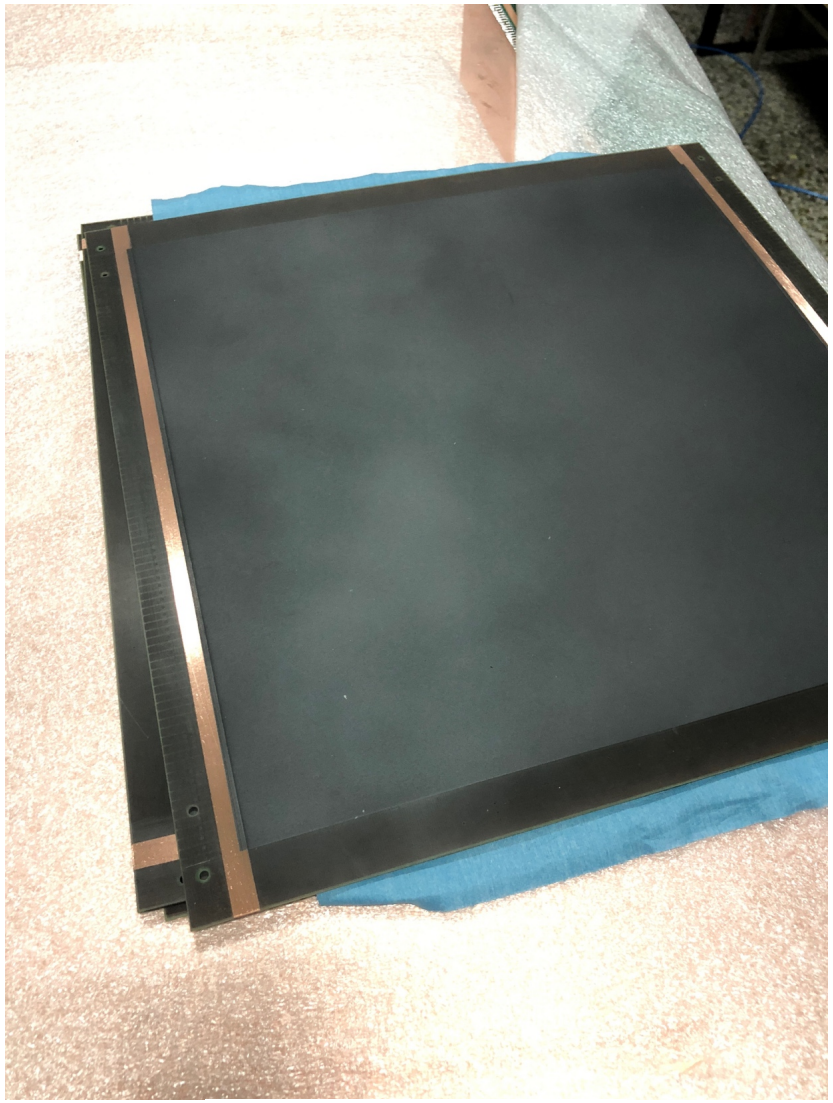
PCBs can be sprayed together

Surface Polishing

Polish to surface resistance：
~200kΩ/2.5cm^2

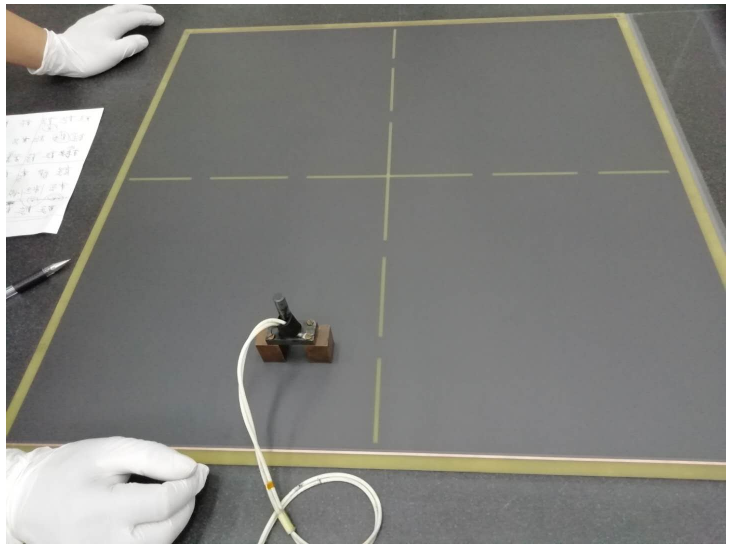
Measure -> Polish -> Measure …….

After spraying



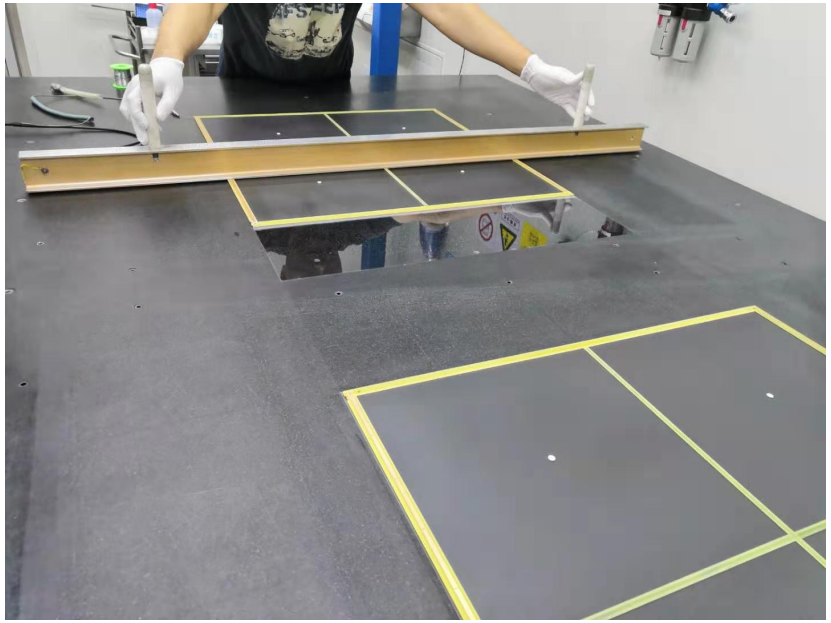
Before polishing

Polishing



Measuring

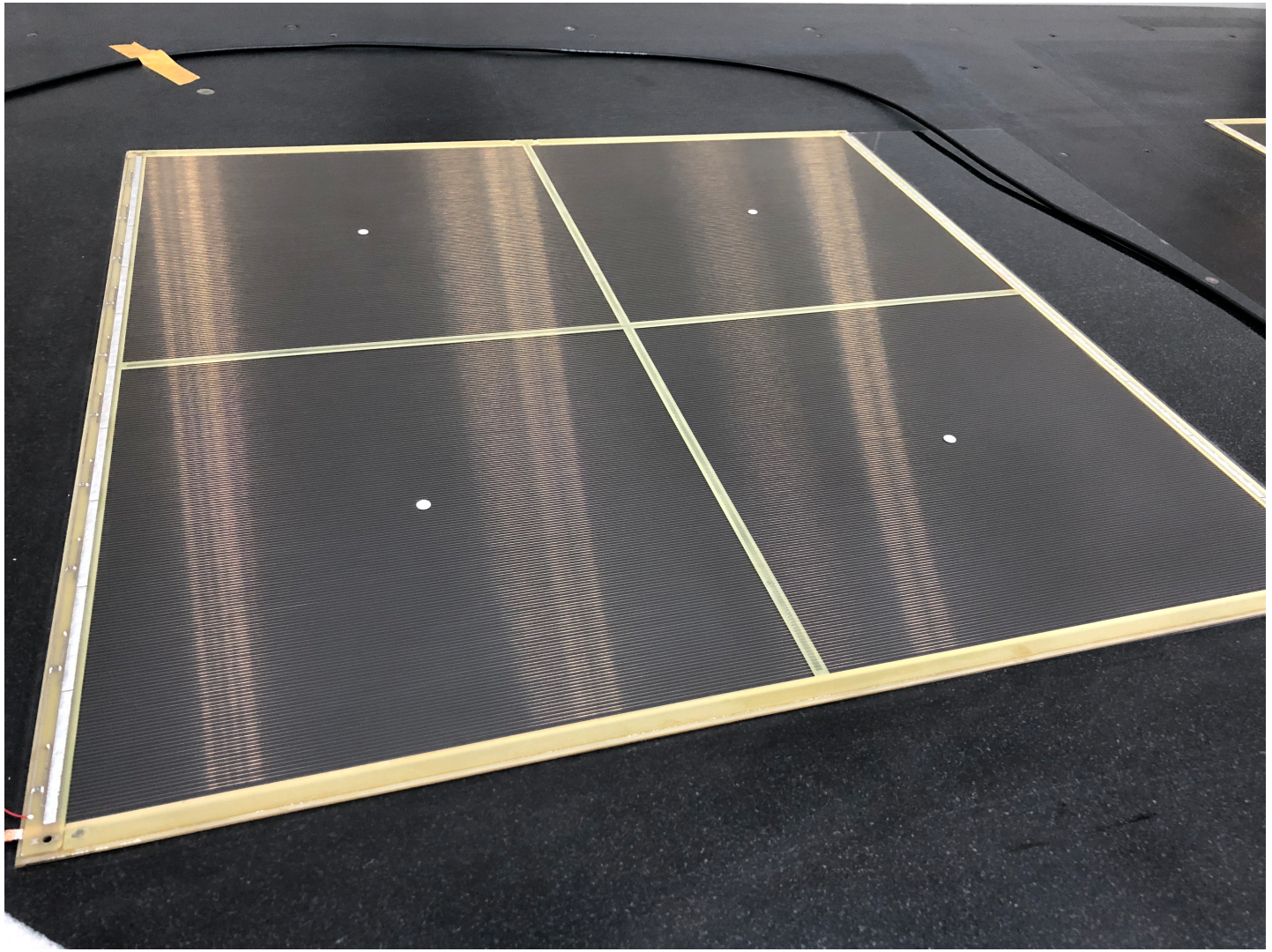
Wire Mounts and Supporting Structure Installation



Quick HV scan

Tooling for supporting structure position constrain

A Wire Plane with Wires



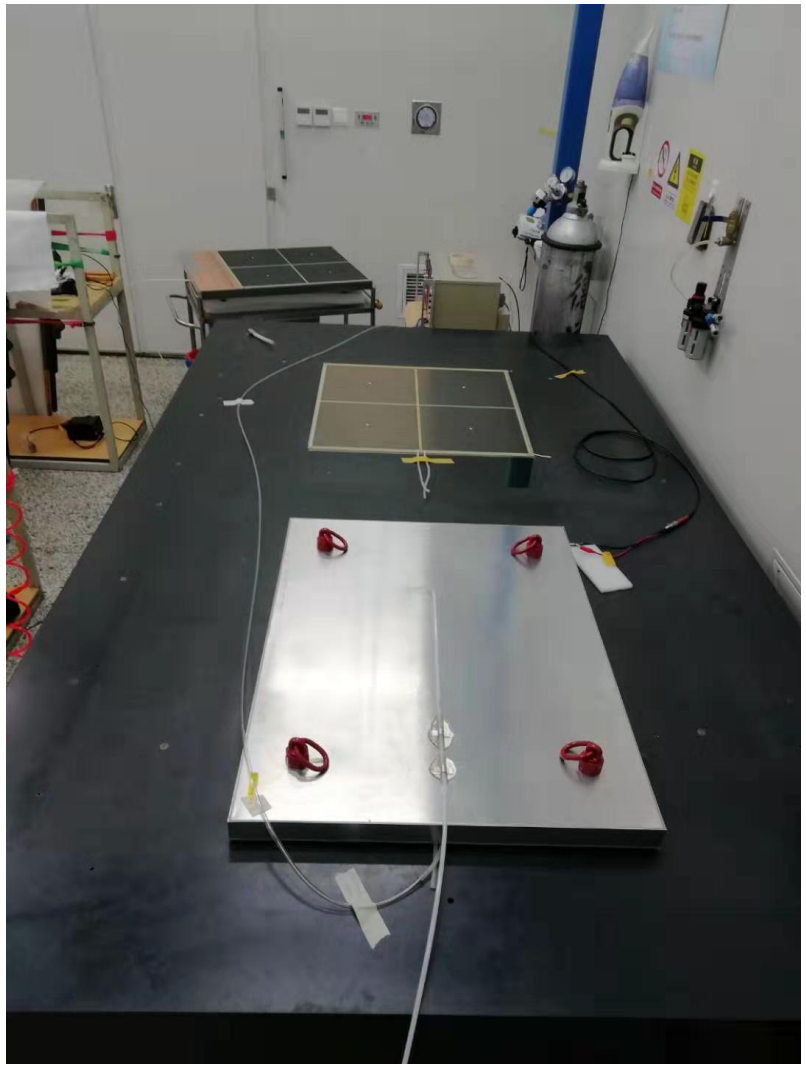
Ready to be bonded to the PPPCB half to build a chamber

Wire Winding

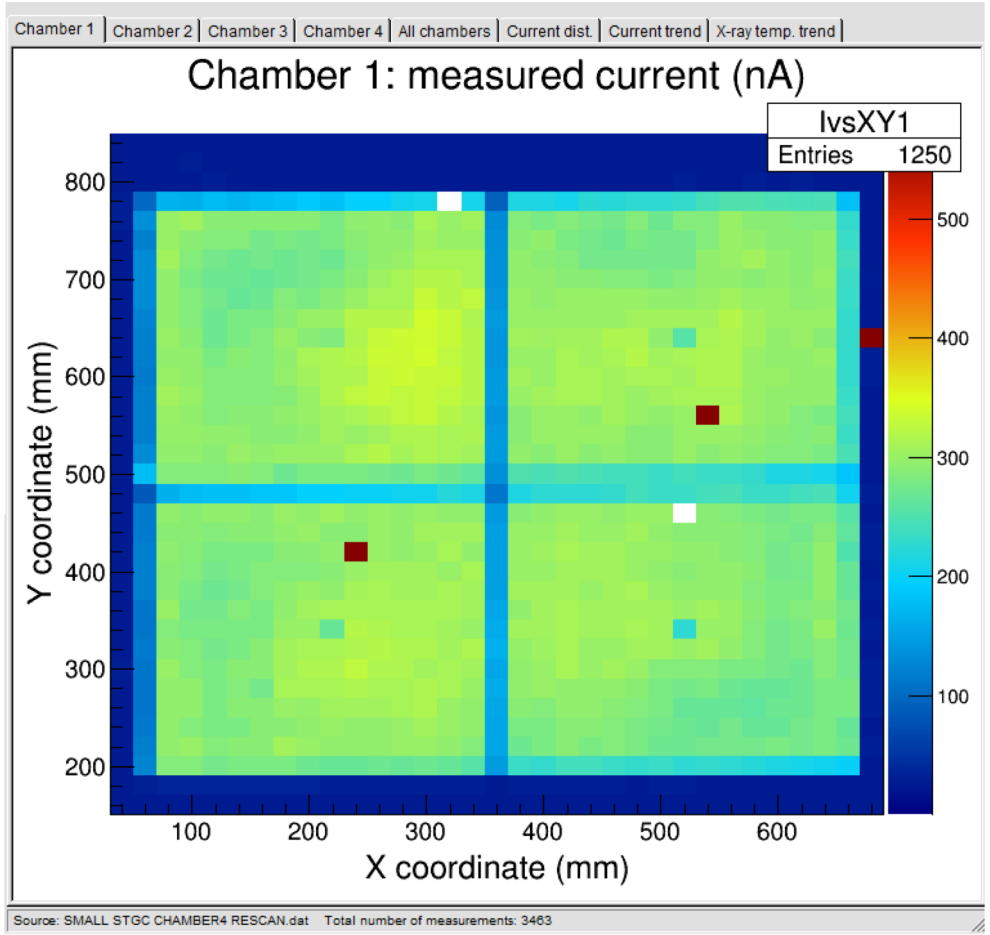
- ✓ Wires on the side wire mounts of the PCB base
- ✓ Wire tension and pitch are kept by the winding machine
- ✓ Use ATLAS sTGC winding machine
- ✓ Wires are soldered on the wire mounts after winding
- ✓ 4 or 8 wire planes can be winded together

Combine the Upper and Lower Halfs

Two halfs combining



X-ray scan

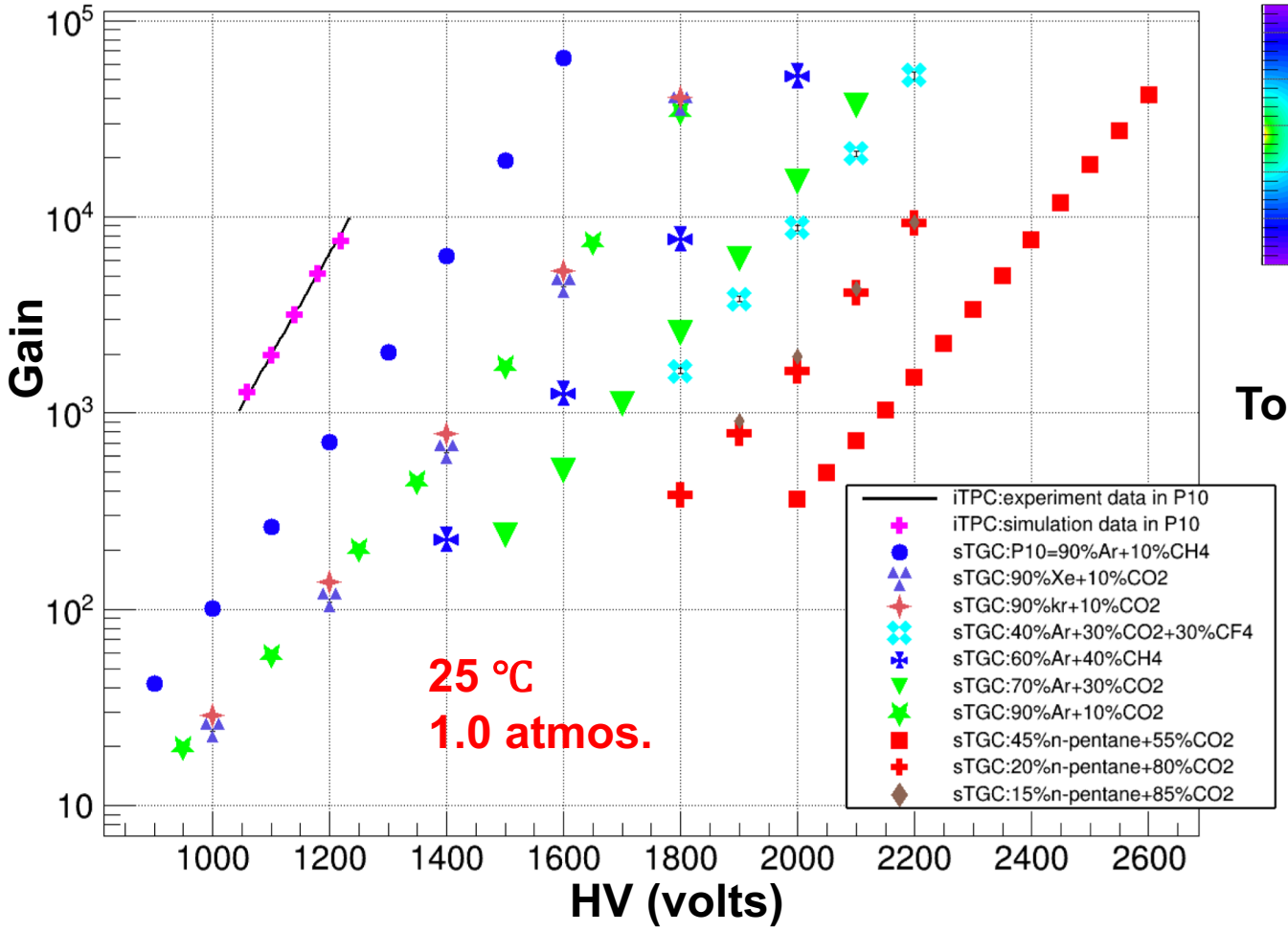


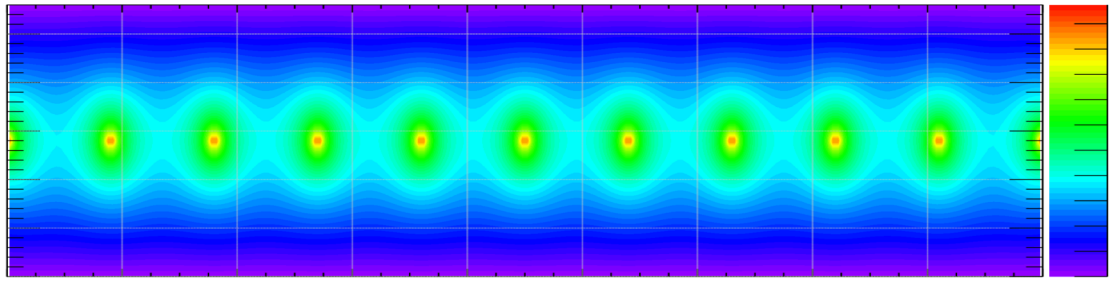
Garfield++ Simulation on sTGC Gain

Simulation is consistent with the measurement for iTPC

F. Shen et al., NIM.A, 896 (2018) 90–95

Need at least one experimental curve to constrain for sTGC



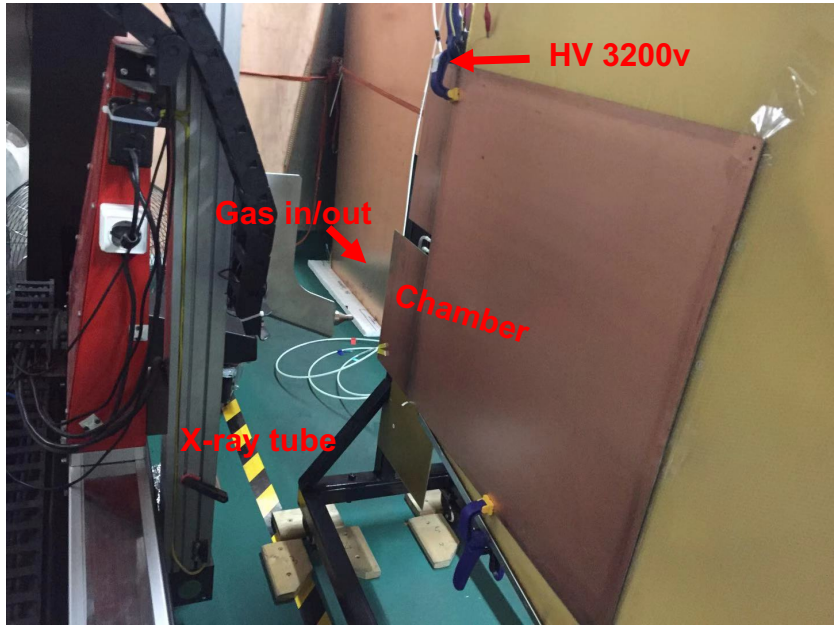


To provide references for different gas options:

- **N-pentane+CO_2**
- **Ar+CH_4**
- **Ar+CO_2**
- **Xe+CO_2**
- **Kr+CO_2**
- **Ar+CO_2+CF_4**

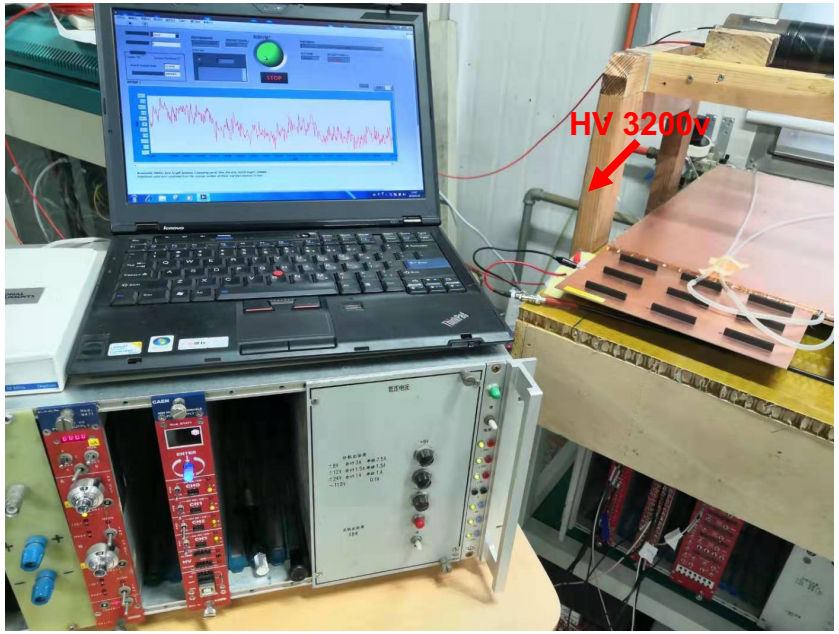
X-ray Scan and Leakage Current Test

X-ray scan



(a)

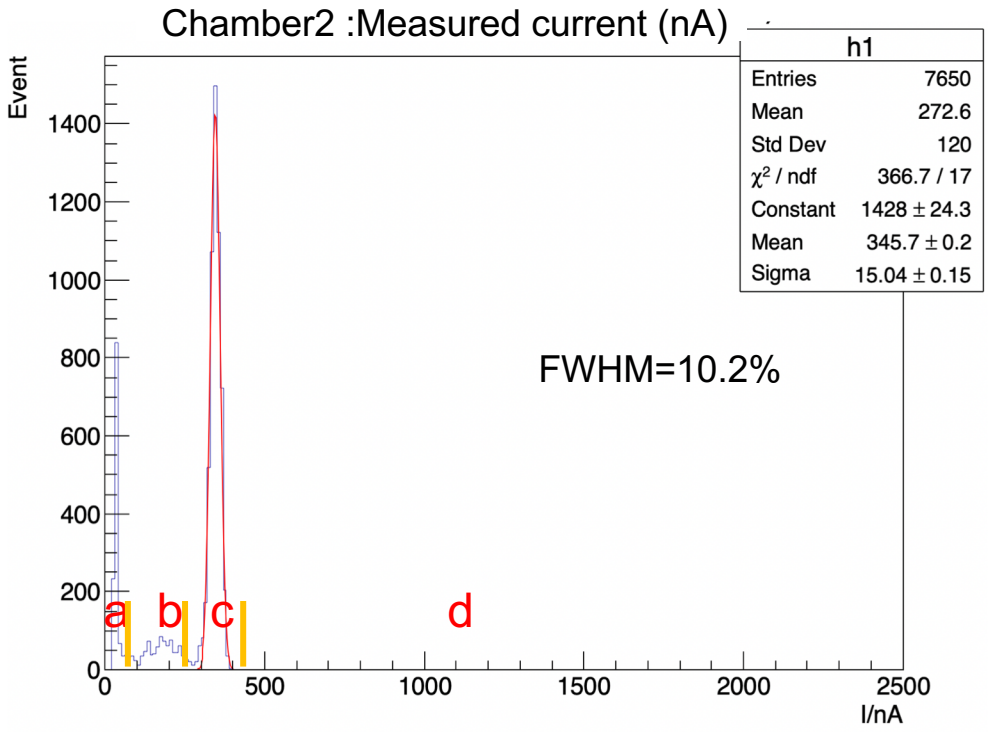
Leakage current test

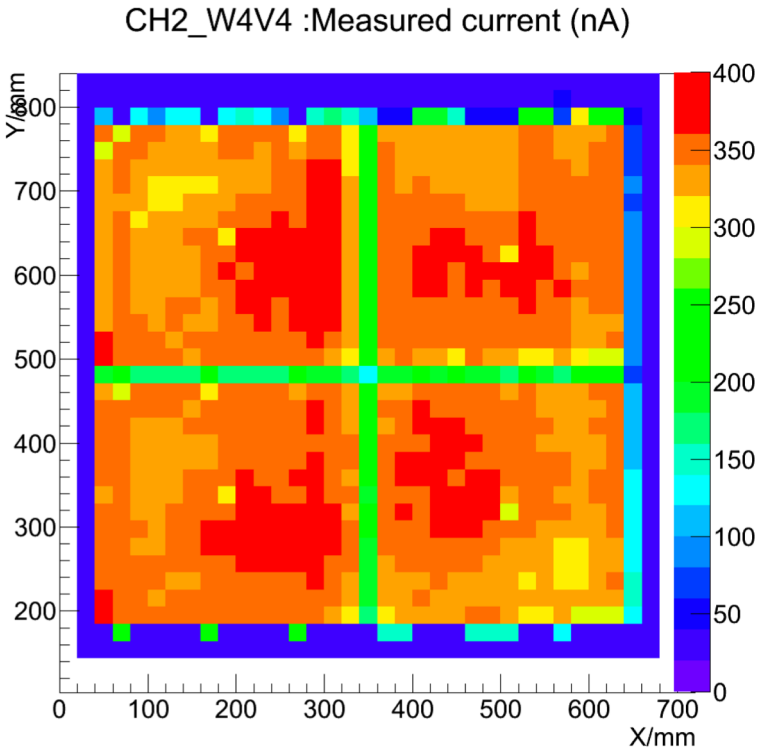


(b)

- The FWHM of leakage current is less than 20%.
- No spark within 24 hours

Prototype X-ray Scan





a) **Out of the chamber.**

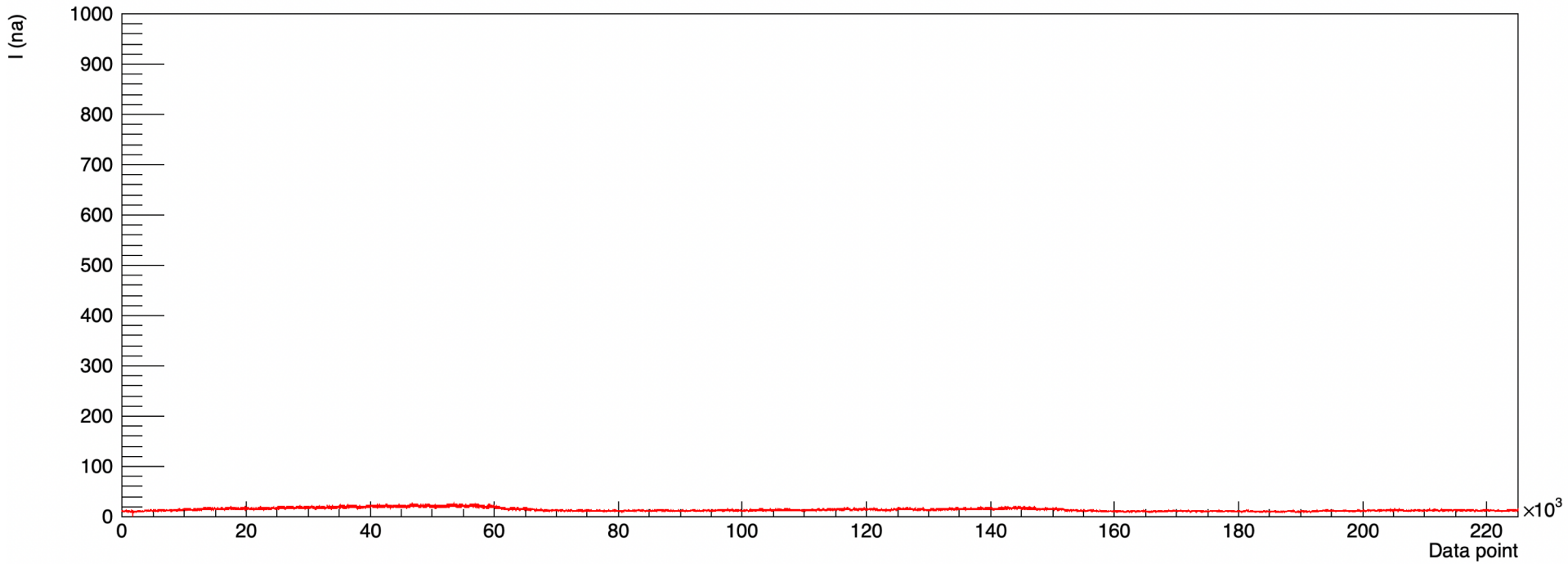
b) **The supporting area.**

c) **Uniformity of the chamber.**

d) **Spark.(LabView current monitoring)**

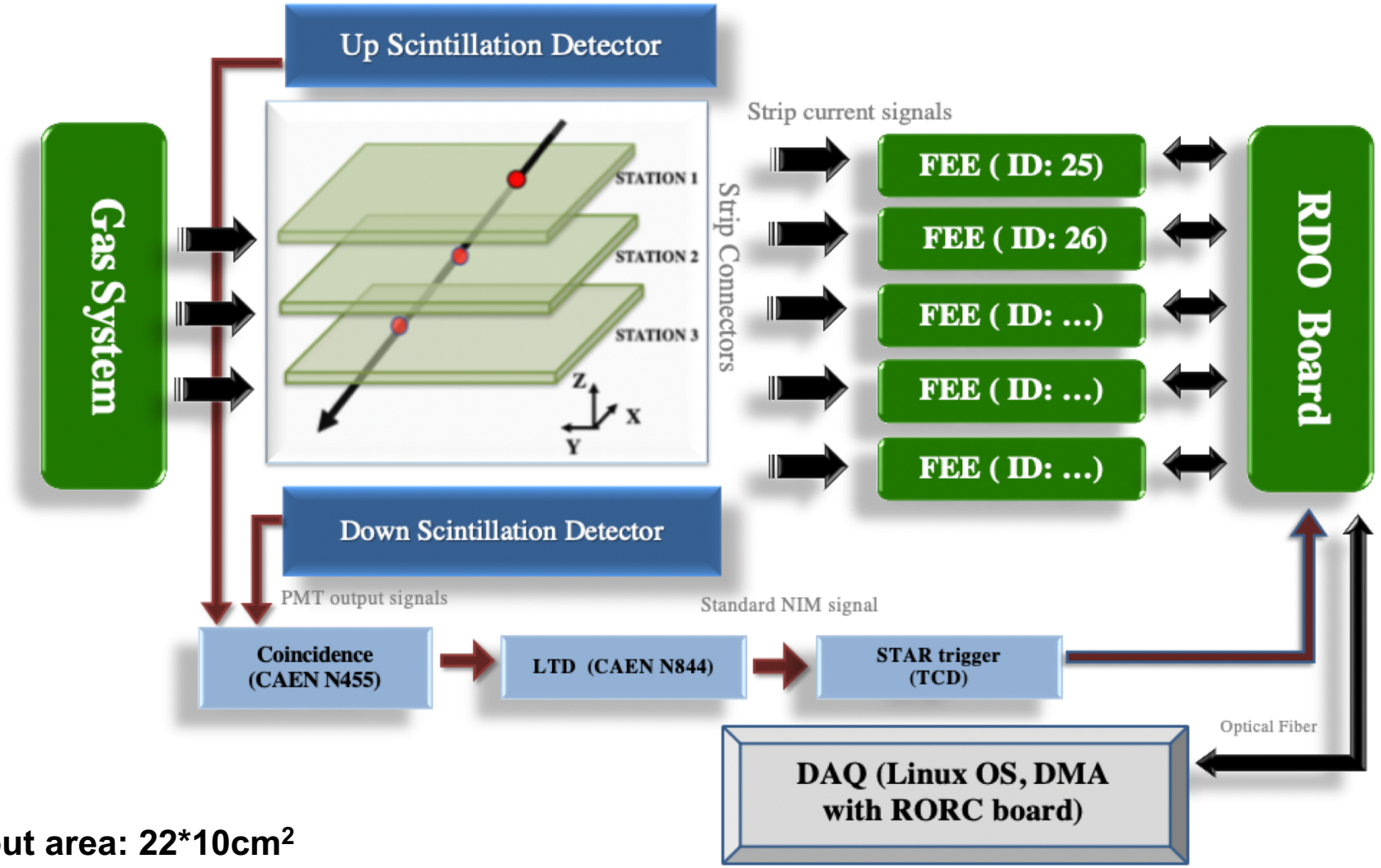
The FWHM we need is less than 20%.
The chamber2 is FWHM=10.2%.

Leakage Current Tracking



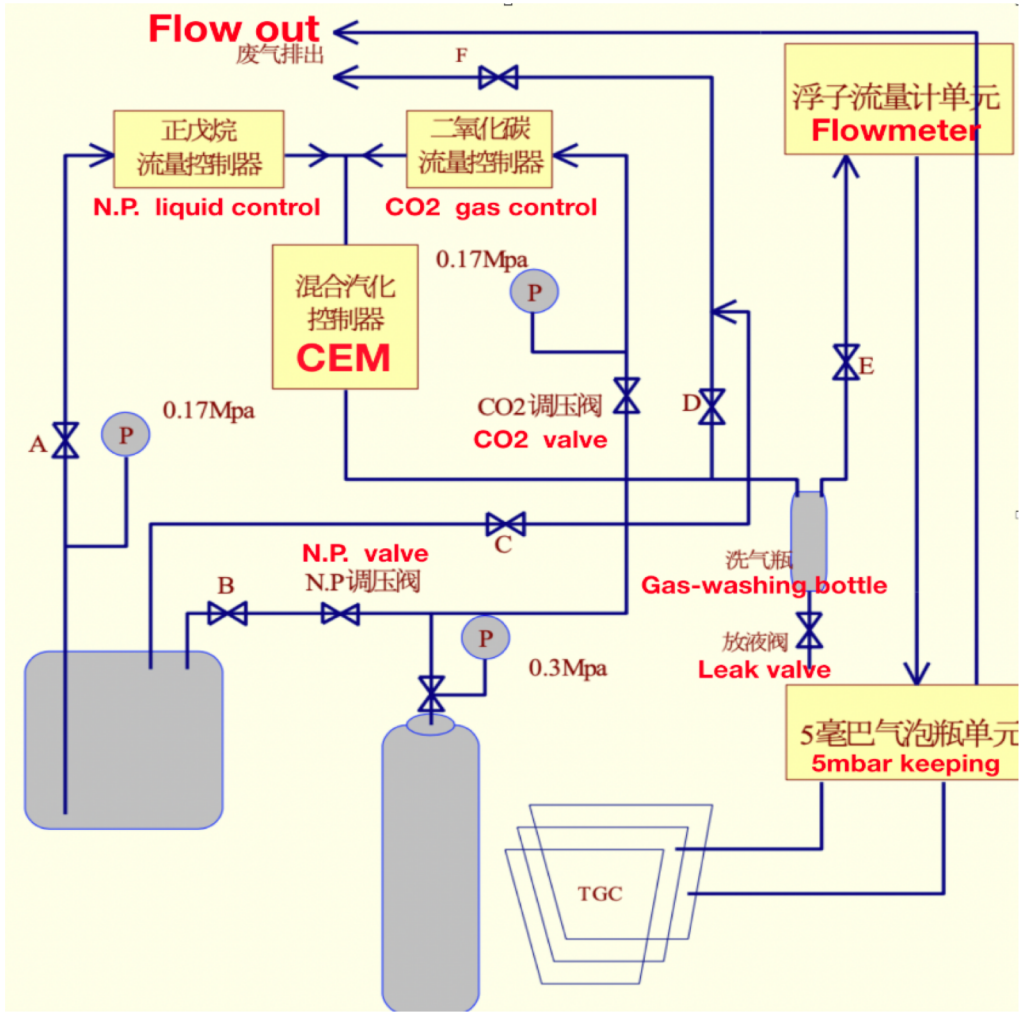
- **CH2-W4H4 leakage current test results meet the requirements.**
- **Monitoring time : 11h**
- **Filling 45%n-pentane+55%co2 gas time: 24h**

Performance Test System



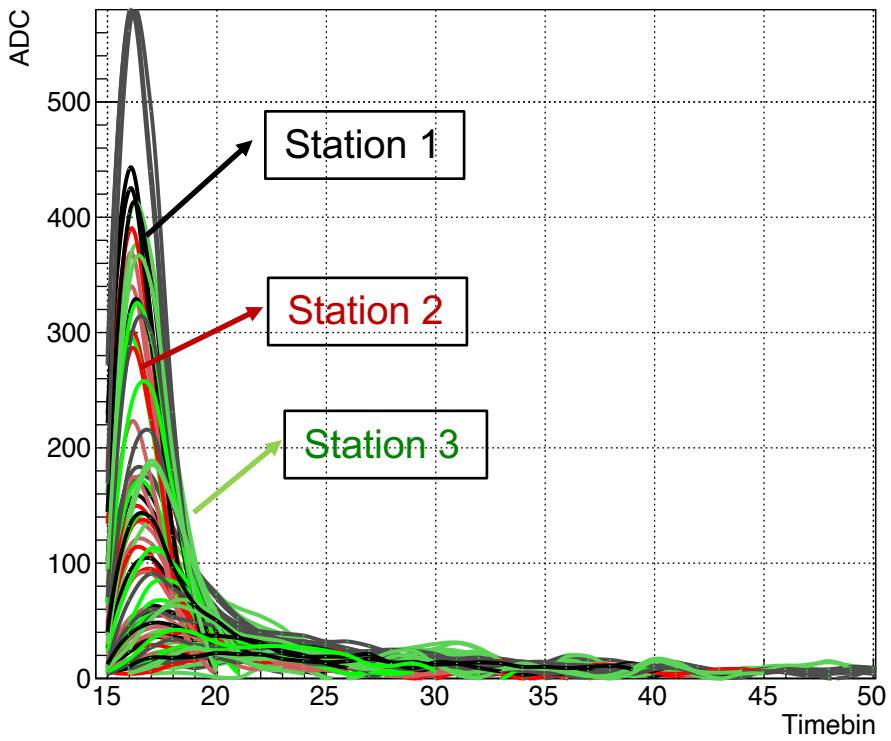
Readout area: 22*10cm^2
Gas: 45%n-Pentane + 55%CO_2
HV: 2700V

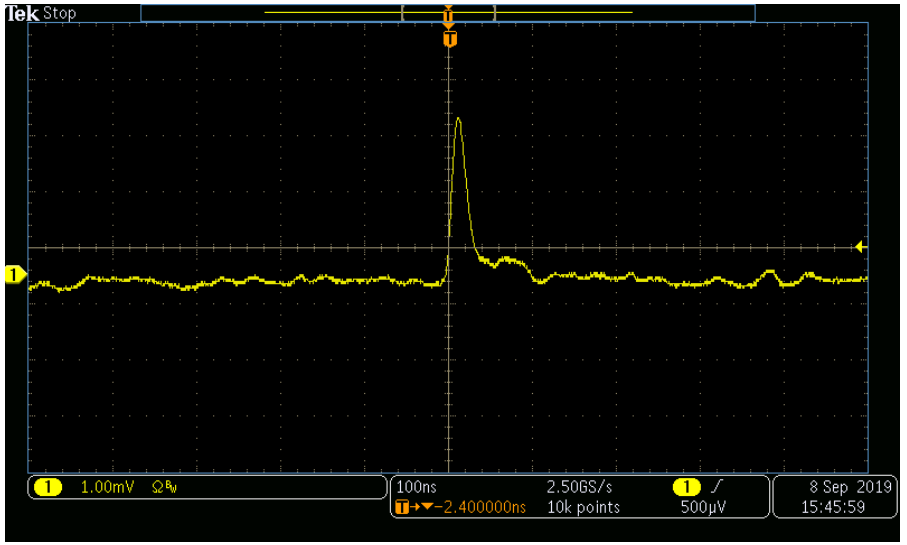
Gas ystem: Control Evaporation Mixing



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

Cosmic Ray Pulses



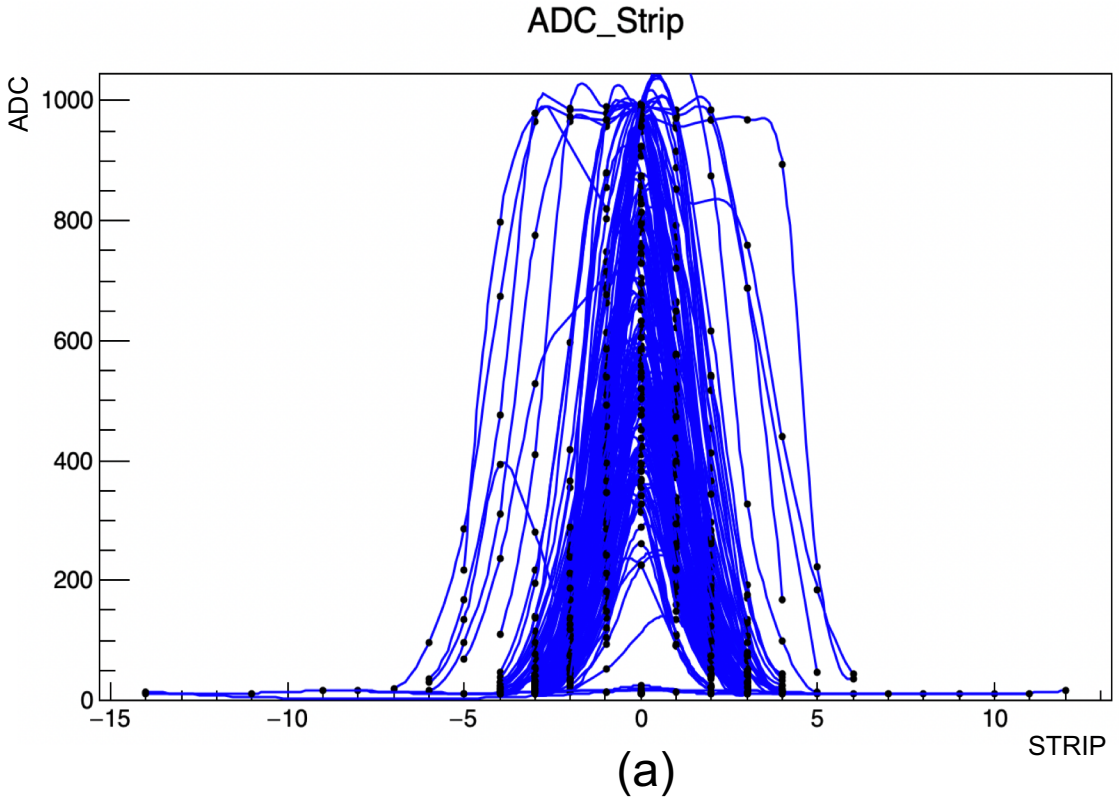


Cosmic ray signal features:

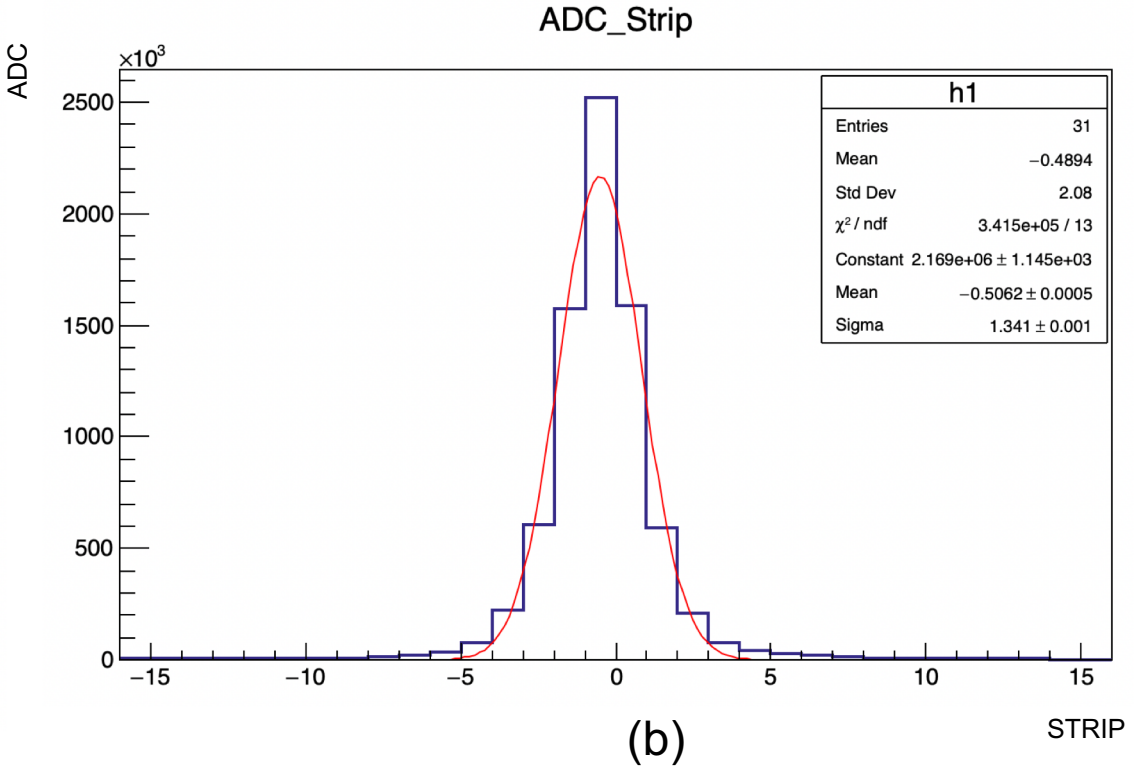
- **Time continuous (>300ns);**
- **The fired strips should be continuous;(>3strips)**
- **The charge of each Timebin (>16ADC);**

Signal Selection: Space Continuous

The signal pulses of cosmic ray are distributed along the strip.



(a)



(b)

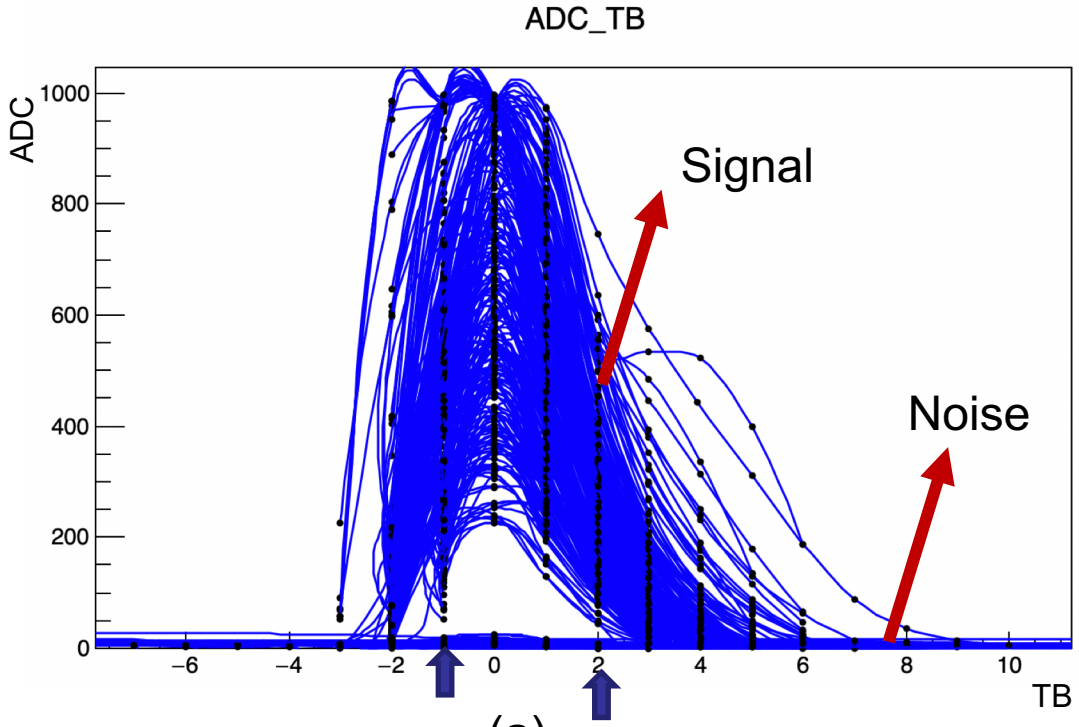
1. For each event, get the TB of MaxADC.
2. At same TB, the ADC distribution varies with the strip.

The sumADC distribution of each event at the same the strip.

STRIP number >3sigma ➔ STRIP>=4

Signal Selection : Time Continuous

The signal pulses of cosmic ray are distributed along the TimeBin.



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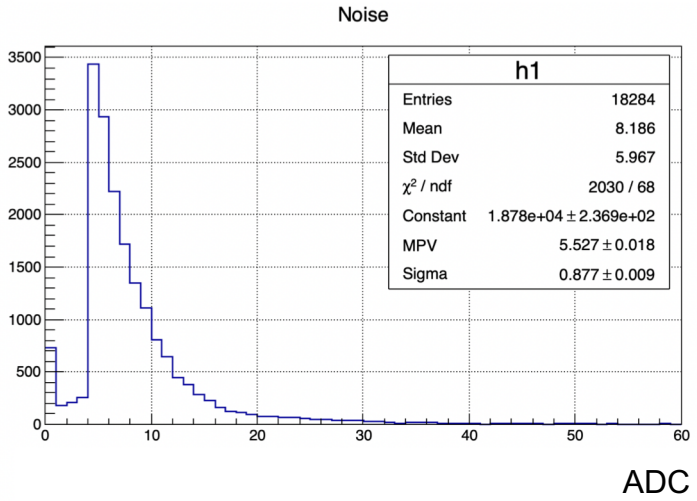
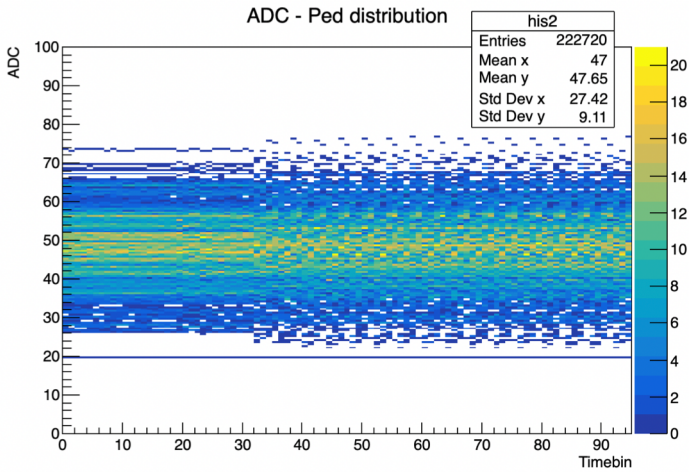


(b) Noise distribution



(c)

Pedestal distribution for each chann

1. For each event, get the strip of the MaxADC.
2. The signal pulses of this strip in every event.
3. -3<=TB<=7; The shortest pulse is 4 timebin and the longest is 11.

➔ADC_cut>16

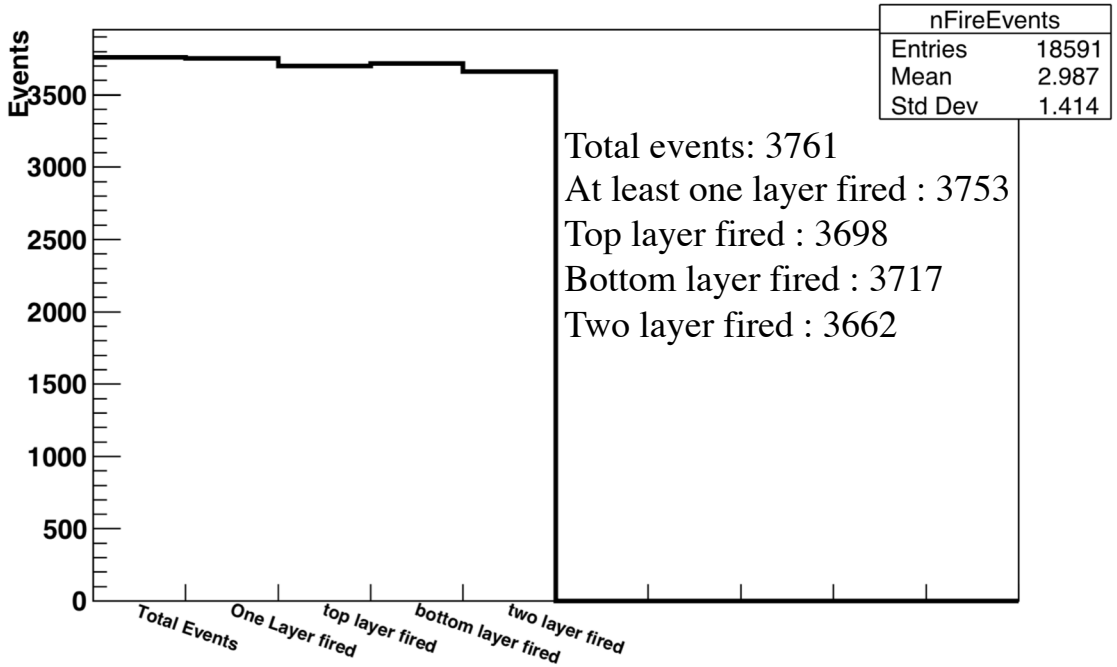
➔TB>=4

30cm*30cm Prototype Detection Efficiency at STAR

Run 01106088

Cut: ADC threshold >= 10 ADC (top & bottom) adjacent Strip fired>= 4 Pulse length >= 400ns

Timing : 0-3μs (cosmic trigger)



Total events: 3761
At least one layer fired : 3753
Top layer fired : 3698
Bottom layer fired : 3717
Two layer fired : 3662

For efficiency:

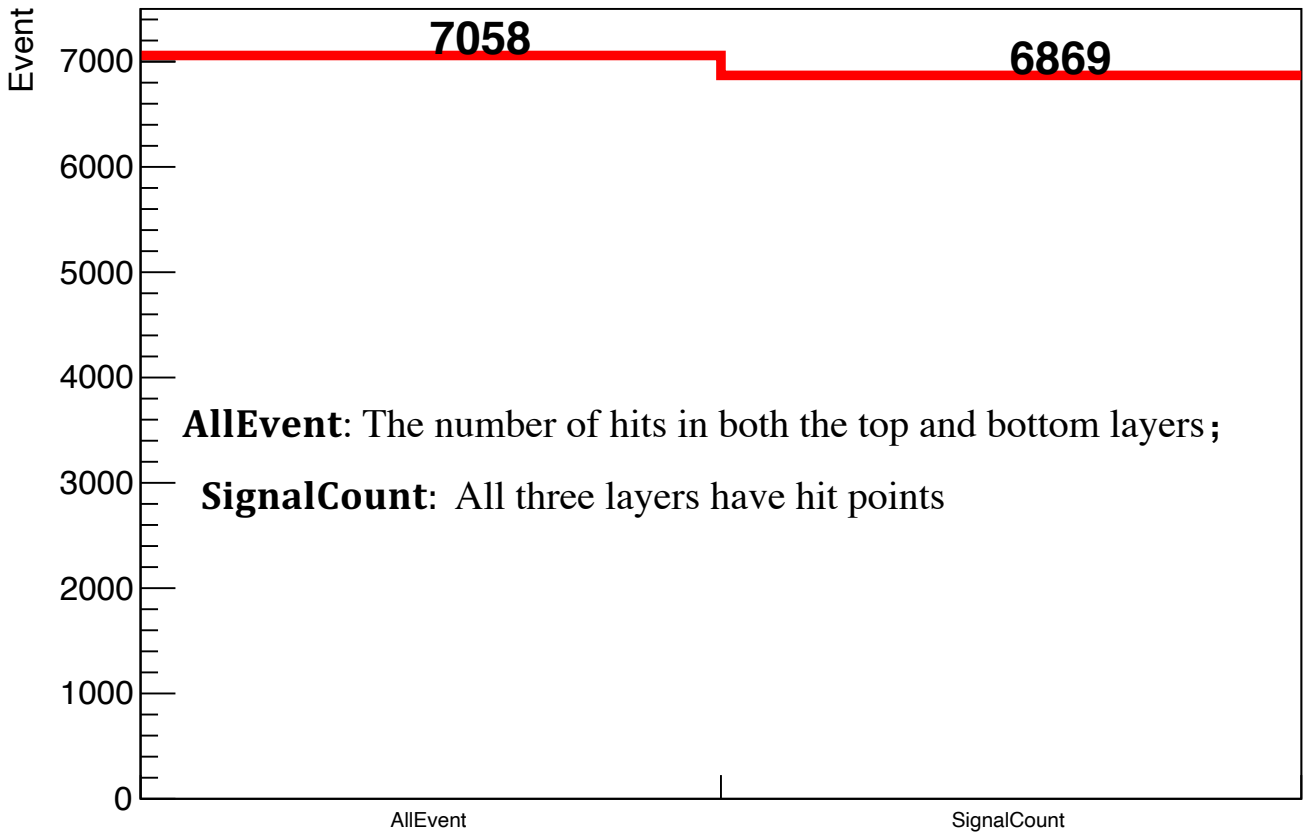
$DEFF_{sTGC\ 1}$= 98.3%

$DEFF_{sTGC\ 2}$= 98.8%

$DEFF_{sTGC\ 1}$ V $DEFF_{sTGC\ 2}$ = 99.8%

At working voltage, the efficiency is more than 98%.

60cm*60cm Prototype Detection Efficiency at SDU

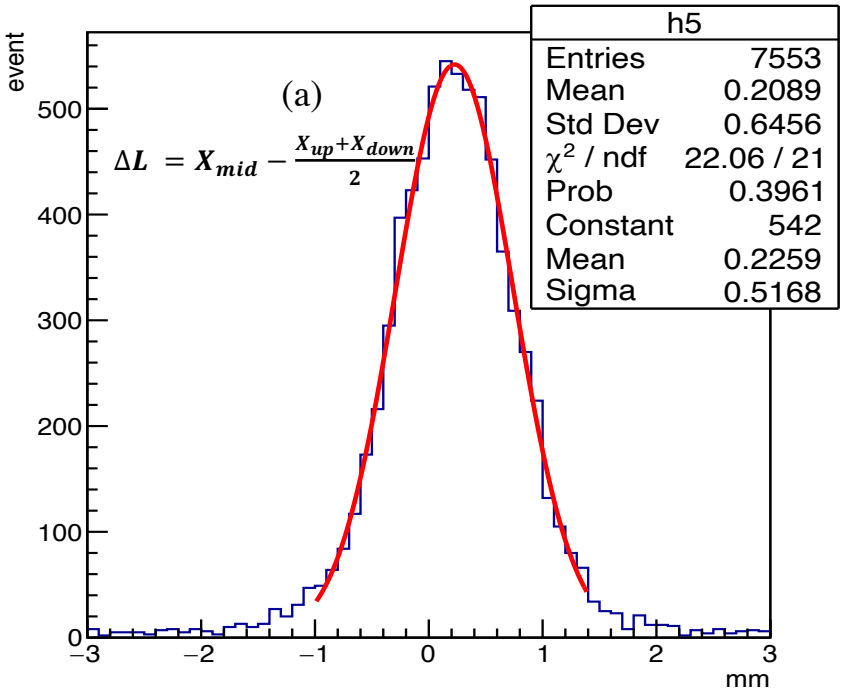


AllEvent: The number of hits in both the top and bottom layers;

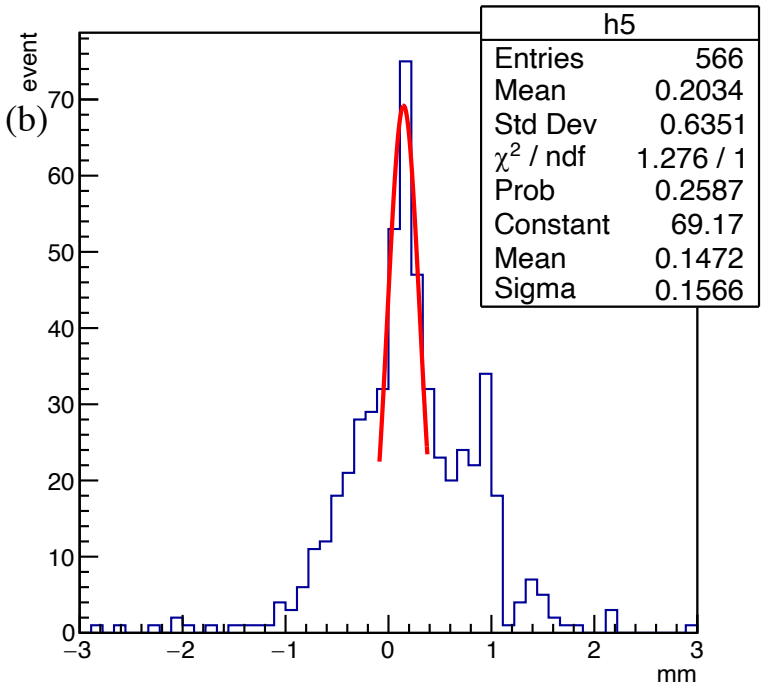
SignalCount: All three layers have hit points

- Cut: $X_{mid} - \frac{X_{up}+X_{down}}{2} < 10$ mm (~3 strips);
- Efficiency= $\frac{SignalCount}{AllEvent} = 98.3\%$
- Detection efficiency of sTGC is more than 98% at 2700V.

60cm*60cm Prototype Position Resolution



Cosmic rays are not selected



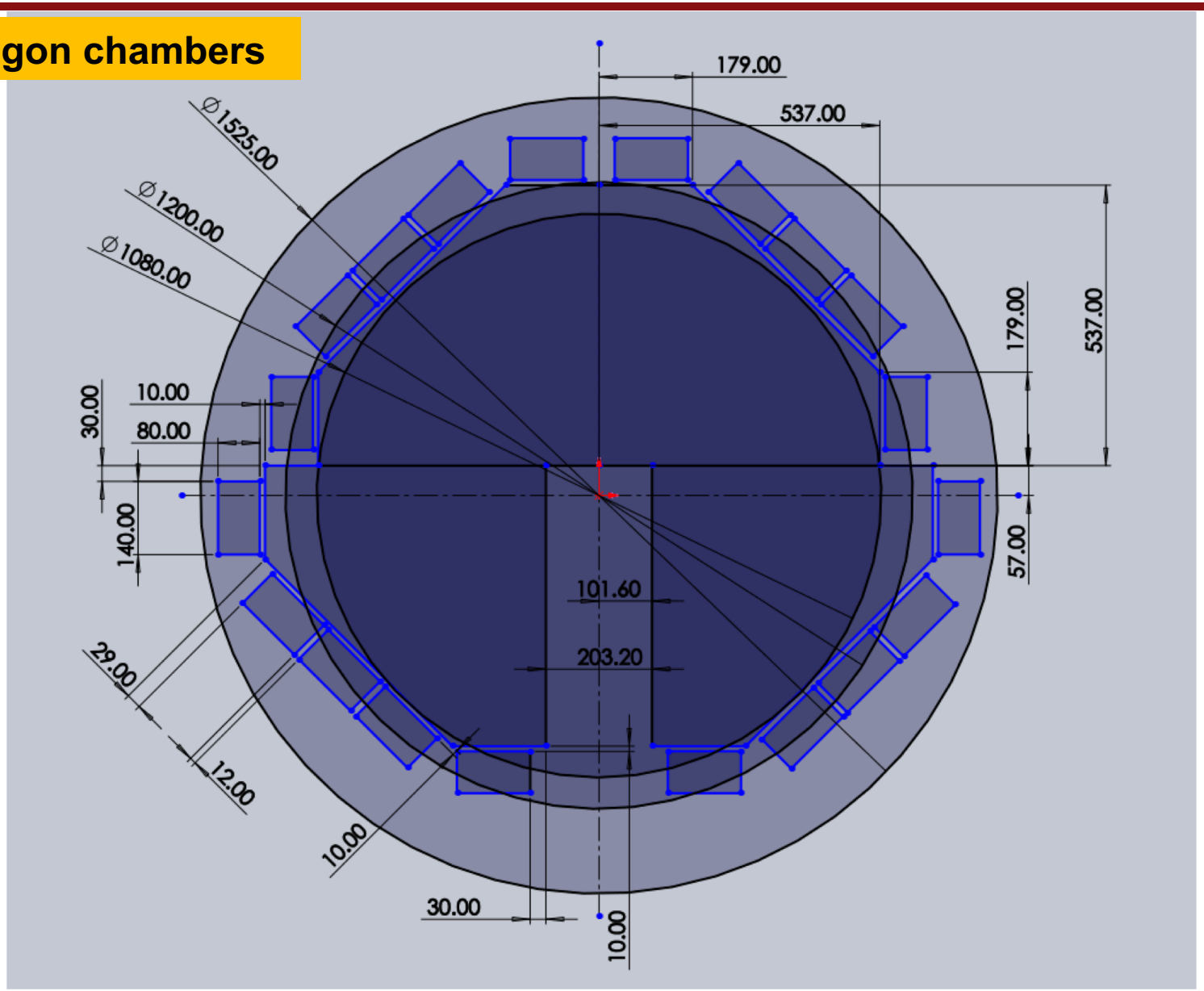
The angle of the cosmic rays in the XZ plane : 89.4° - 90.6°
Background：Without rotation and shift correction

Sigma is about 500um w/o any correction.

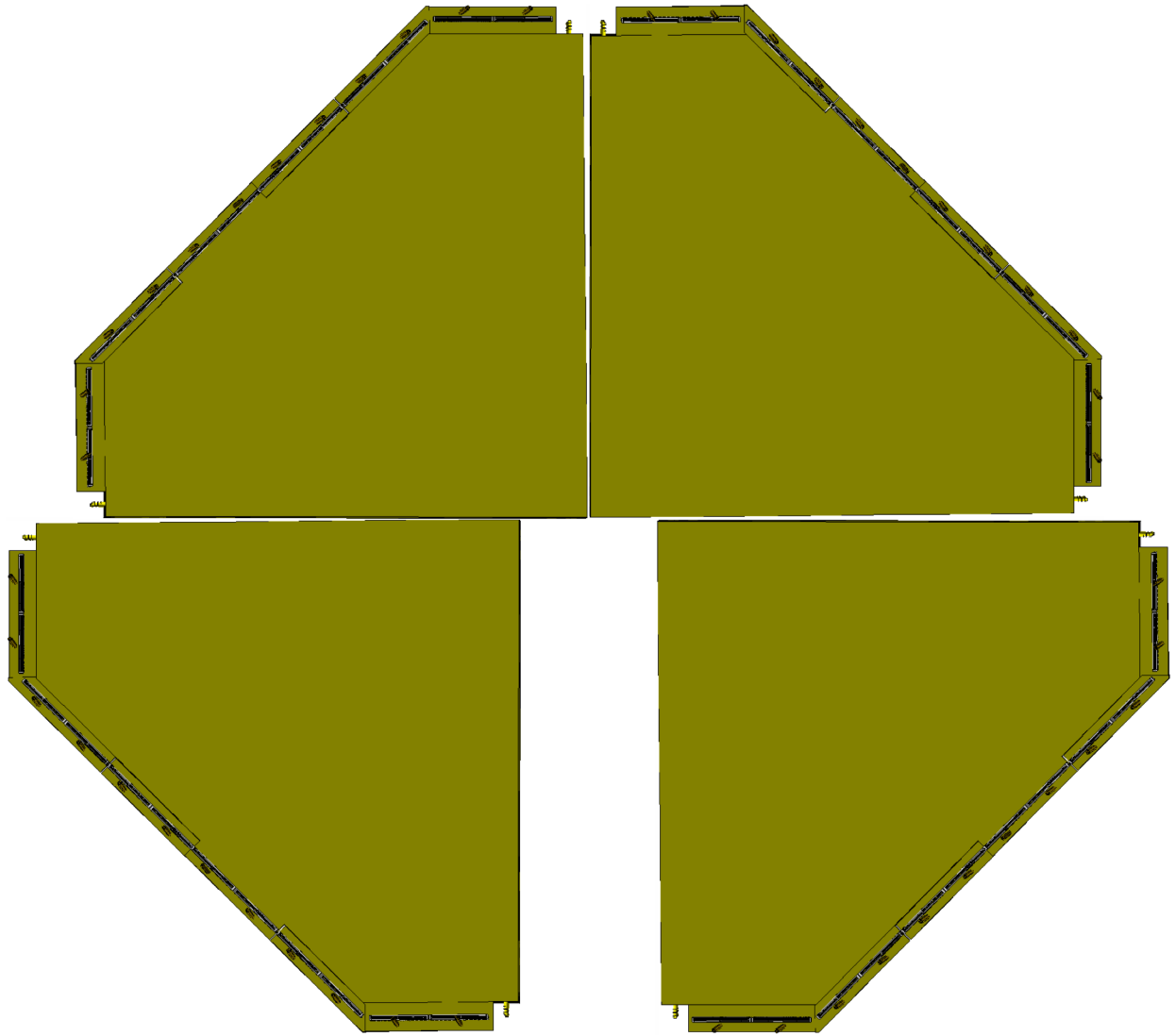
Select events with an angle between 89.4° and 90.6° (in XZ plane for X direction resolution). Sigma is about 150um without rotation and shift correction.

Proposed Symmetric Pentagon Design + VMM

Symmetric pentagon chambers

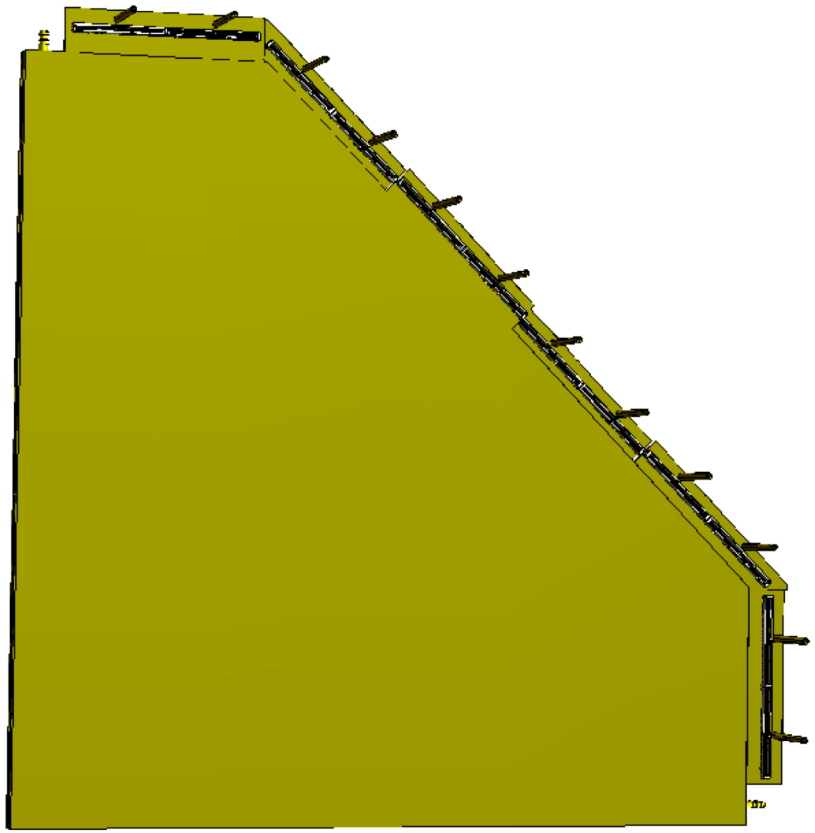


Current Symmetric Pentagon Drawing



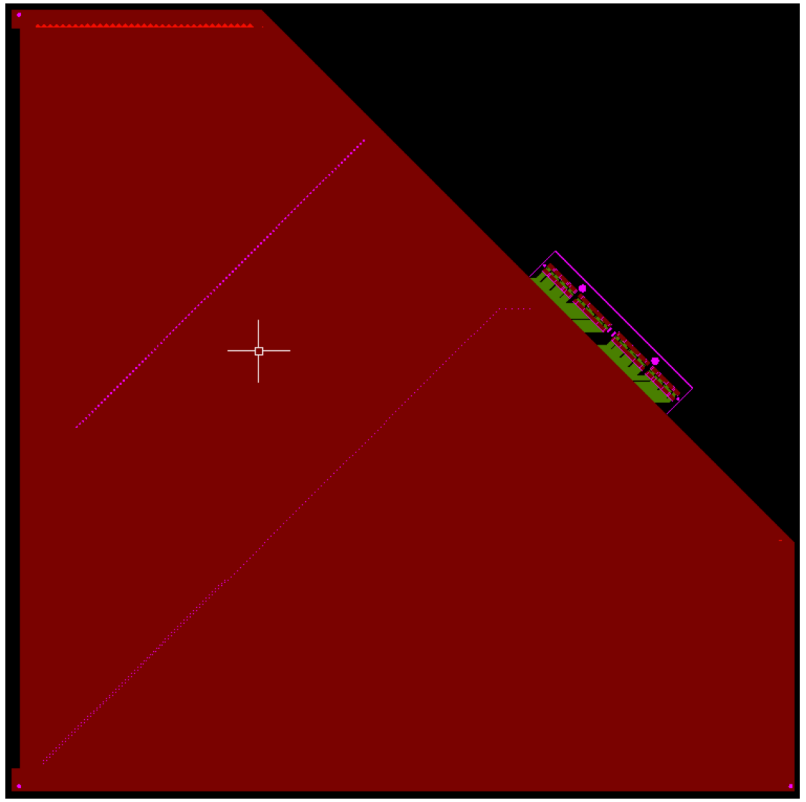
Pentagon Module

- Pentagon prototype has been designed.
- Shape file has been sent to BNL integration group for space check.
- Joint screw points of integration can be added on the edges (supporting PCB sticks + screws)

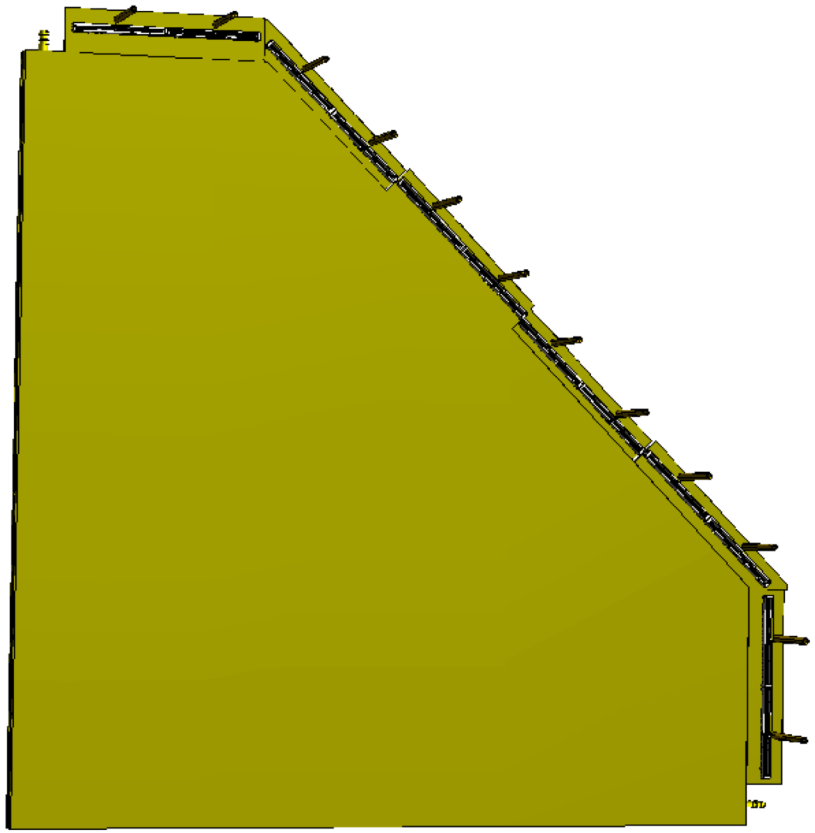


XY layer

Diagonal layer



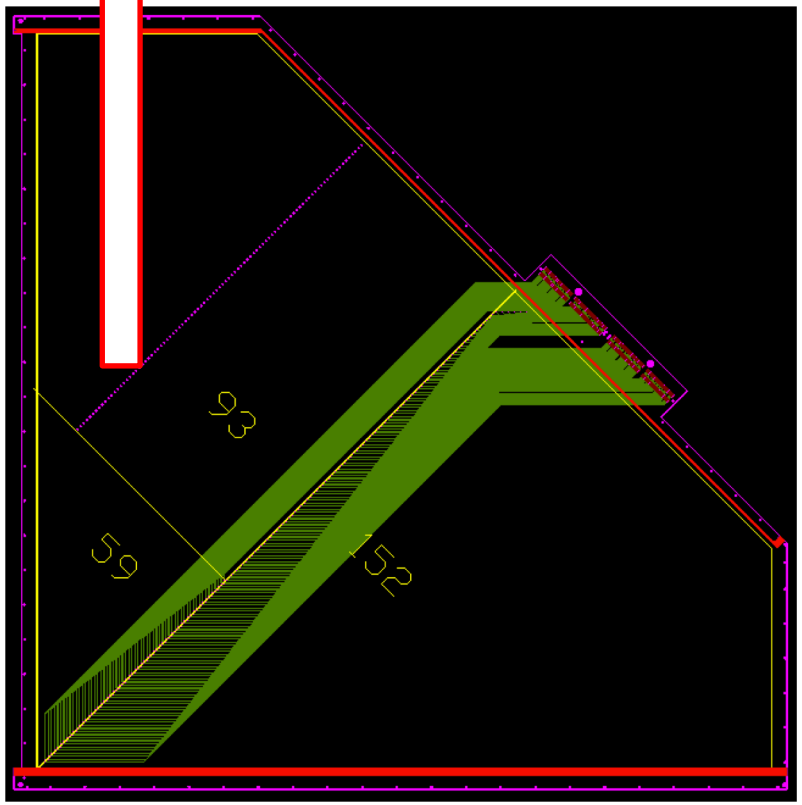
Pentagon Module



This area with 93 pads will be grounded.

XY layer – 3 pad rows

Diagonal layer – 2 pad rows



Summary

- **sTGC production and QA procedures has been designed.**

- **60cm x 60cm prototype finished. Passed all QA and performance tests.**
  -- *HV burn-in, gas tight, X-ray scan*
  -- Detection efficiency > 98% @ 2700V, position resolution ~150um w/o shifting and rotating correction

- **New symmetric pentagon prototype has been designed.**
  -- *3 rows of X/Y strips (2 FEEs) + 2 rows of diagonal strips (1 FEE) for one chamber*
  -- *Same design for all four layers*

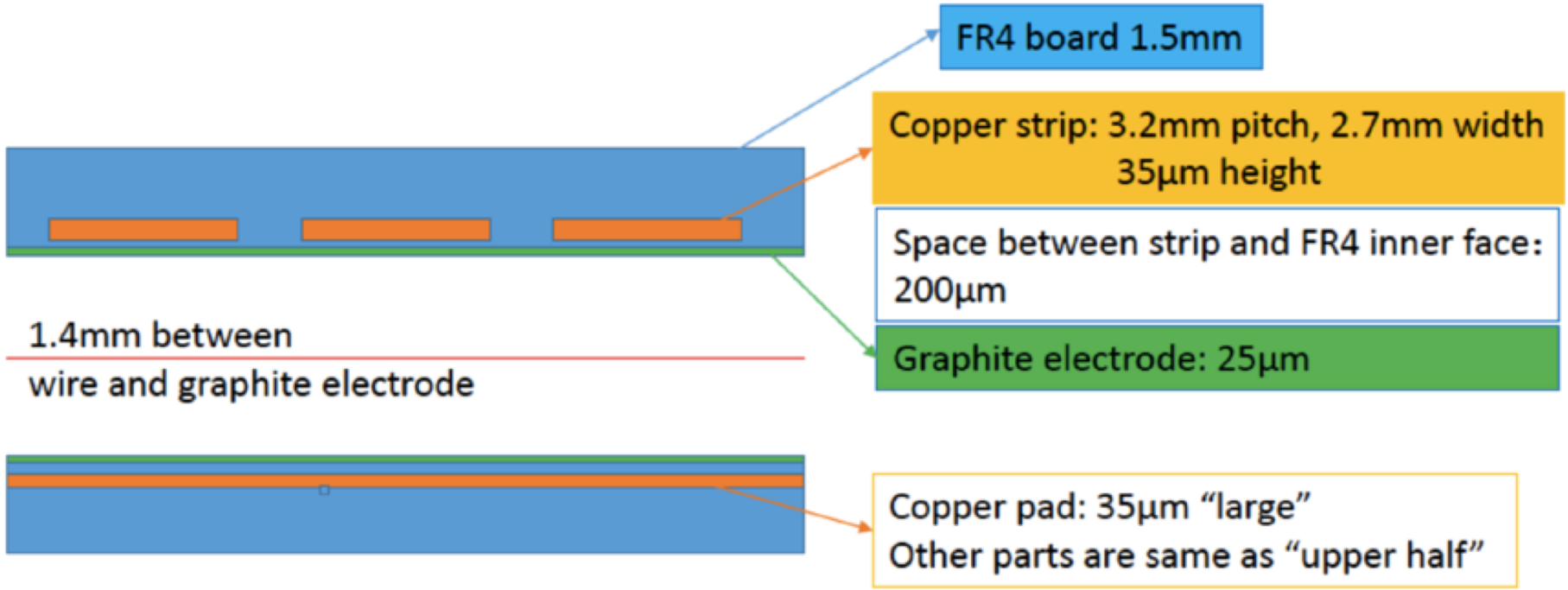
Future plan:

- *Ship the 60cm x 60cm prototype to BNL in early March*
- *Send the drawing to vender for production in March*
- *Design the tooling for pentagon shape*
- *Improve the procedure due to the pentagon shape*

Backup

sTGC Geometry

sTGC layout-side-view



Wire: Φ50μm Au-plate tungsten wire, 1.8mm pitch

Working gas: 45% n-pentane + 55% CO_2

Honeycomb paper for mechanic support outside of the layer or in between two layers