sTGC R&D at SDU for STAR ☆ Forward Upgrade

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To Use sTGC

For forward upgrade, we need:

- Tracking points in STAR x-y plane
- Position sensitive (100-200um)
- Low cost
- Large coverage
- Relative mature technique

-> small strip Thin Gap Chamber

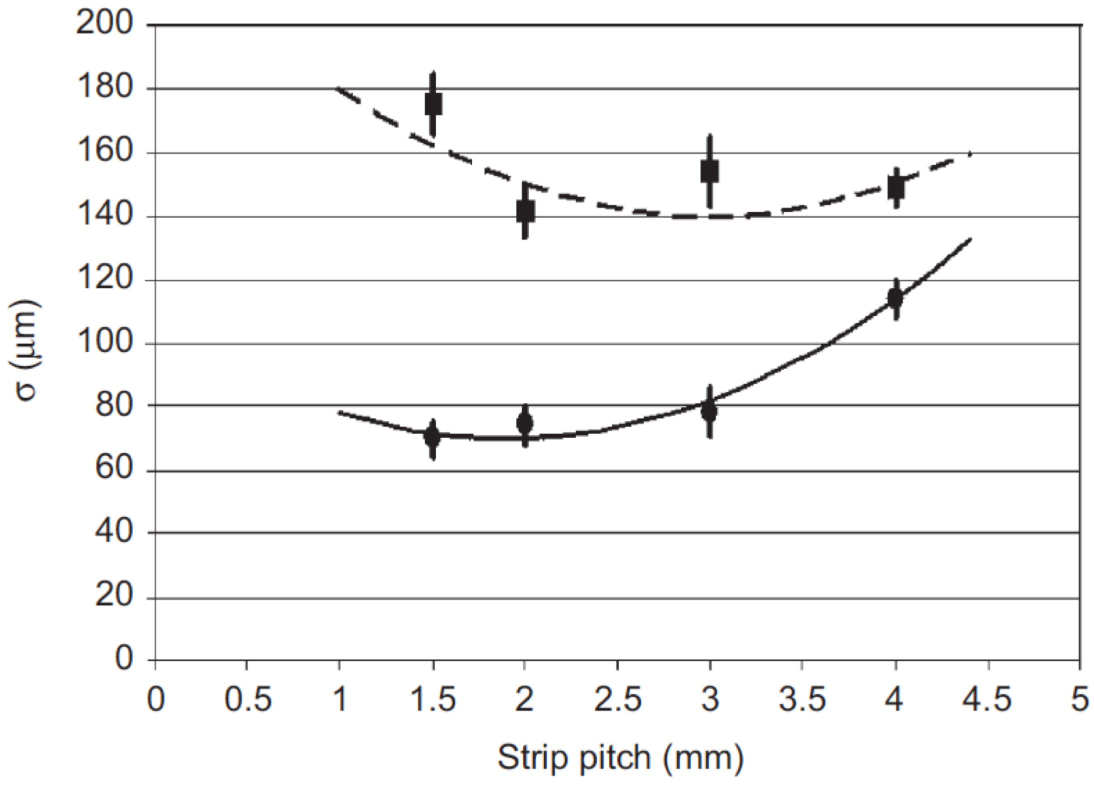
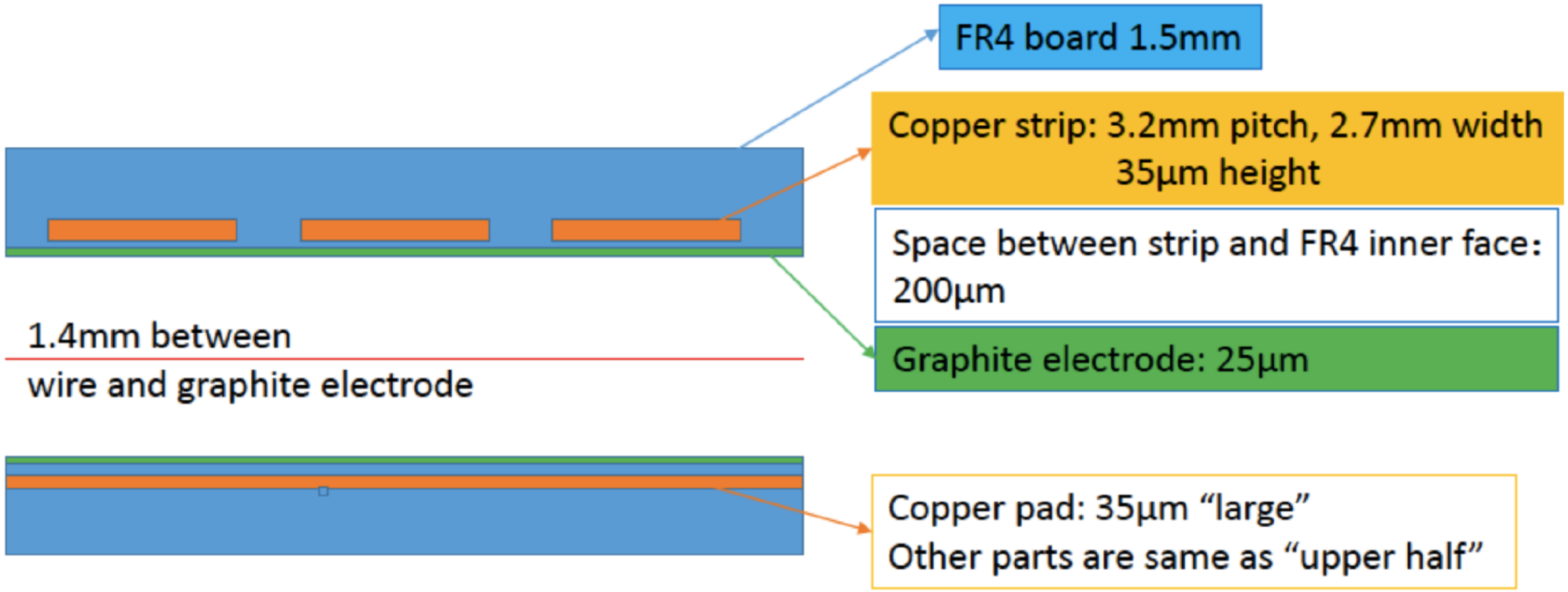


Fig. 6. Average position resolution in HV region 2.9–3.2 kV: for the angle region of 0–10° (points, solid line) and 20–30° (squares, dashed line) as a function of strip pitch. The lines are just to guide the eye.

Developed by ATLAS group: ***V. Smakhtin et al., NIM.A, 598 (2009) 196–200***
A. Abusleme et al., NIM.A, 817(2016) 85–92

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

sTGC Production Procedure

Carbon Coating

↓

Wire Winding

↓

Two Halfs Combination

↓

X-ray Scan

↓

Two Chambers Combination

↓

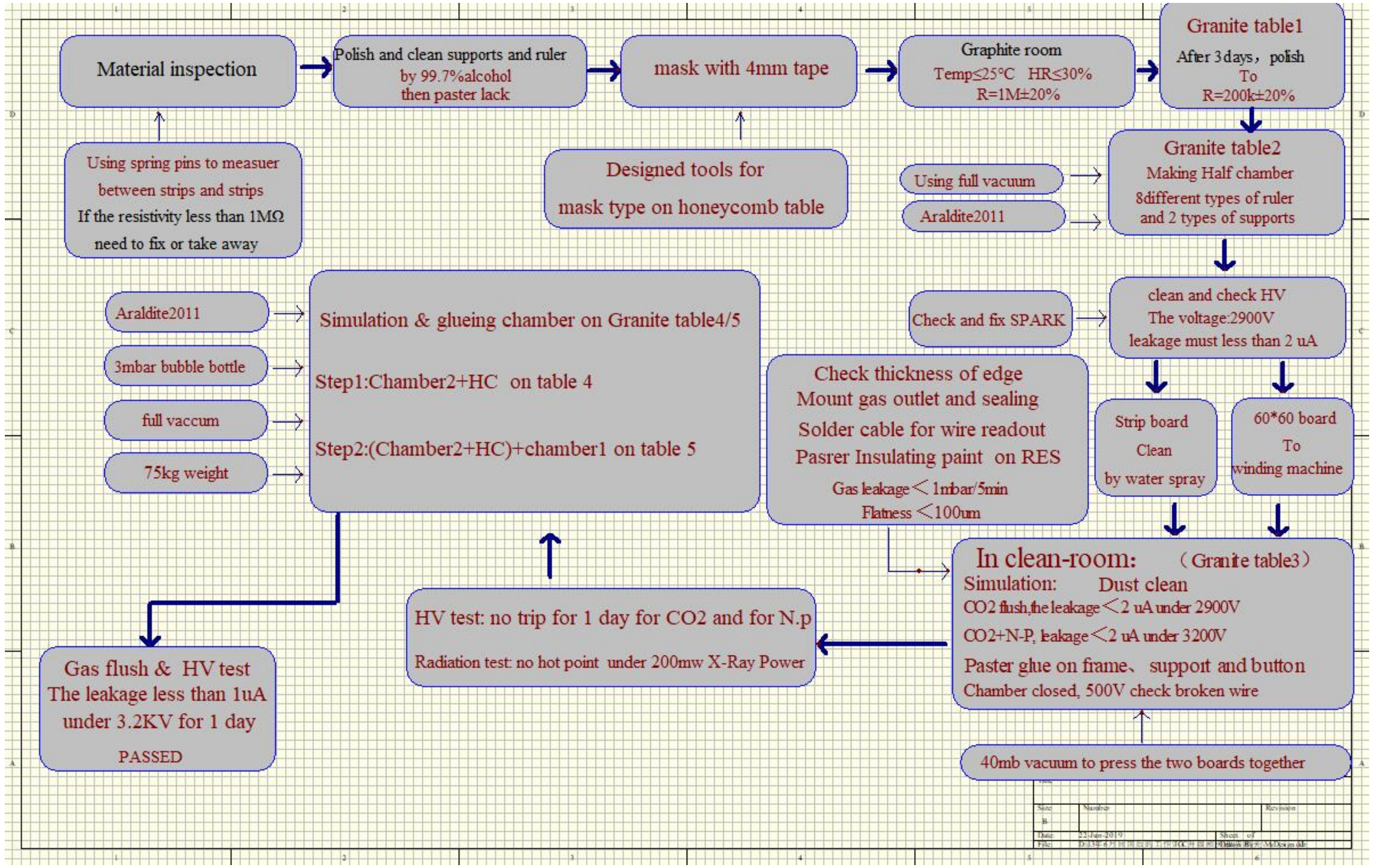
Performance Test

Same clean room as iTPC production

Now shared with ATLAS sTGC group

sTGC Production Procedure

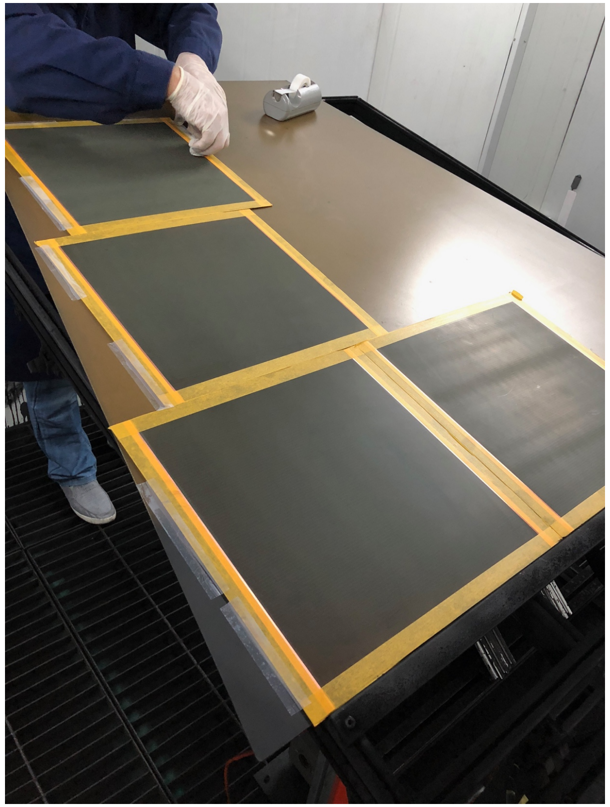
- Carbon Coating
- Wire Winding
- Two Halfs Combination
- X-ray Scan
- Two Chambers Combination
- Performance Test



Graphite Spraying

SDU ALTAS group have a automatic graphite sprayer

Automatic graphite sprayer



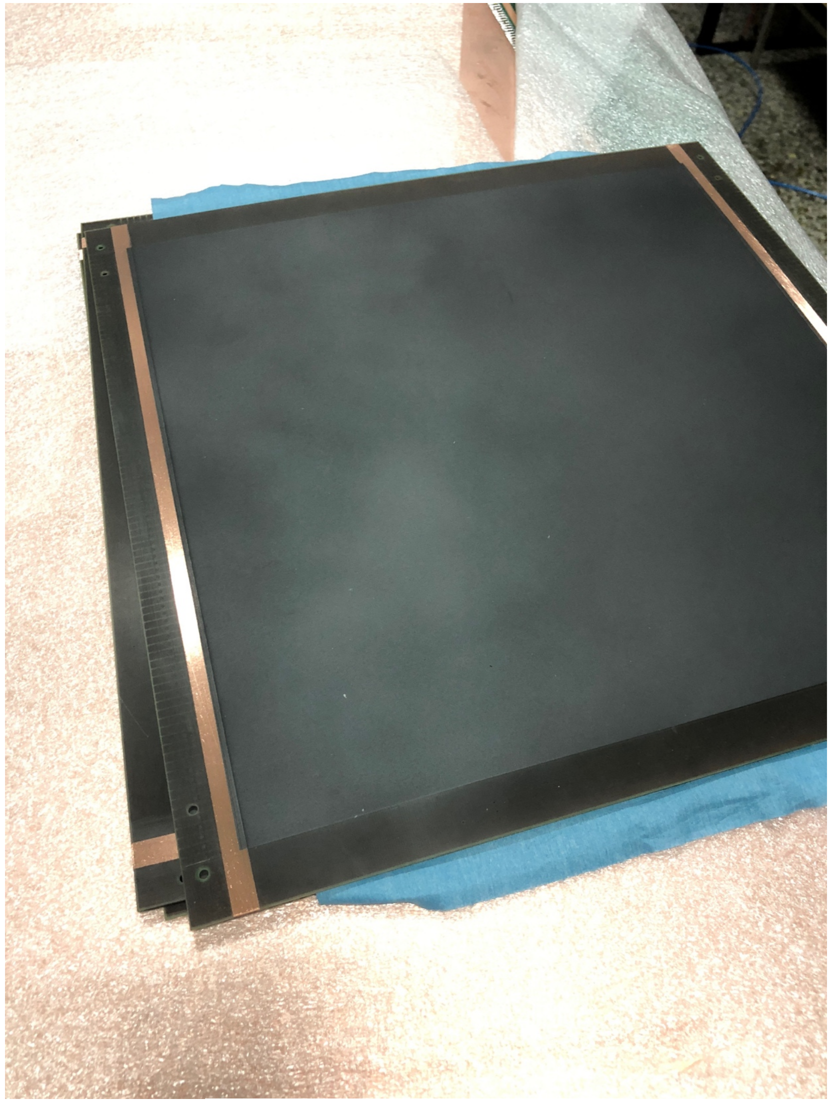
PCBs can be sprayed together

Surface Polishing

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

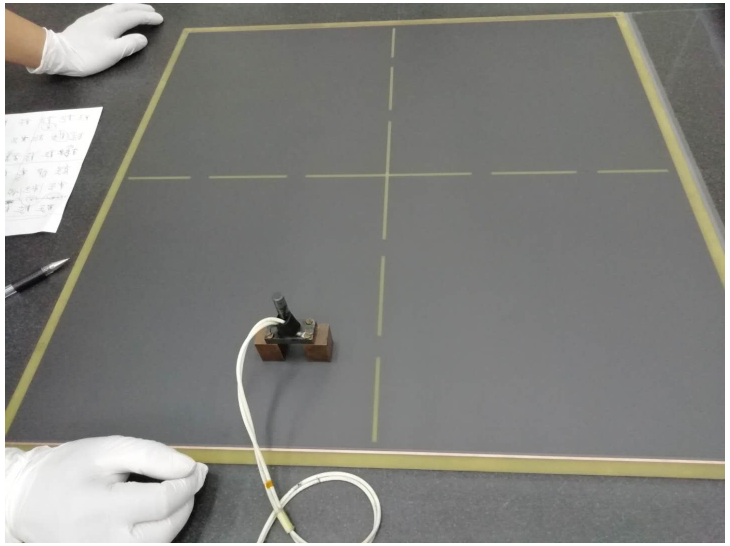
Measure -> Polish -> Measure …….

After spraying



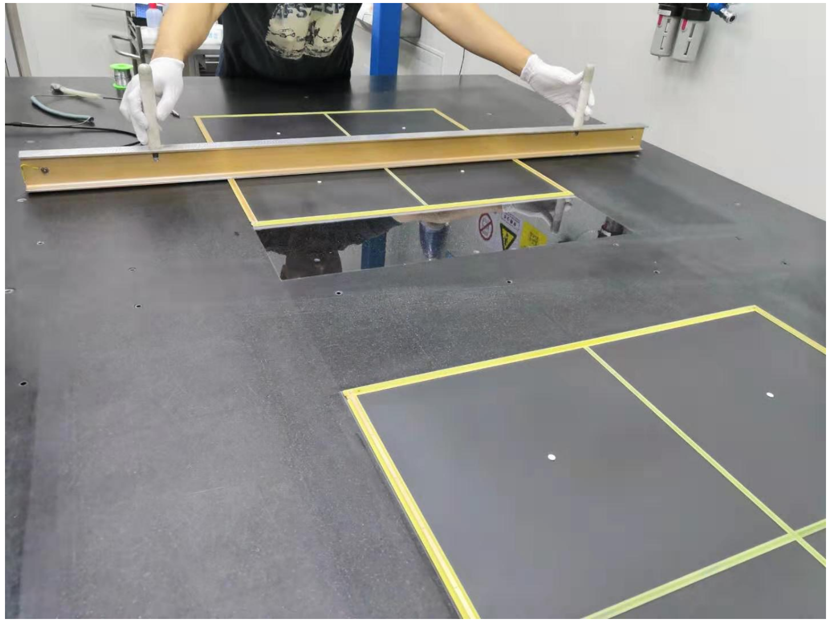
Before polishing

Polishing



Measuring

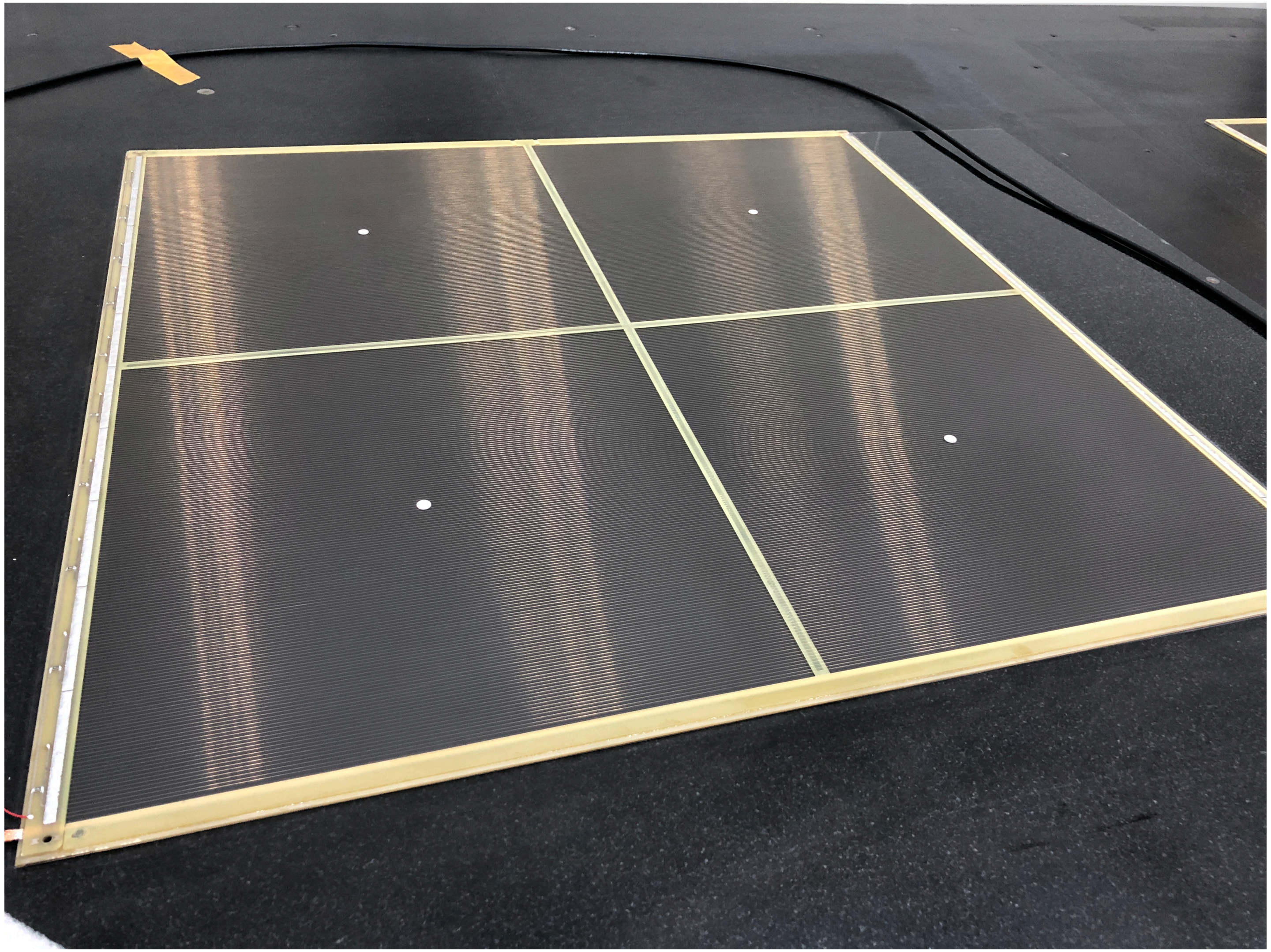
Wire Mounts and Supporting Structure Installation



Quick HV scan

Tooling for supporting structure position constrain

A Wire Plane with Wires

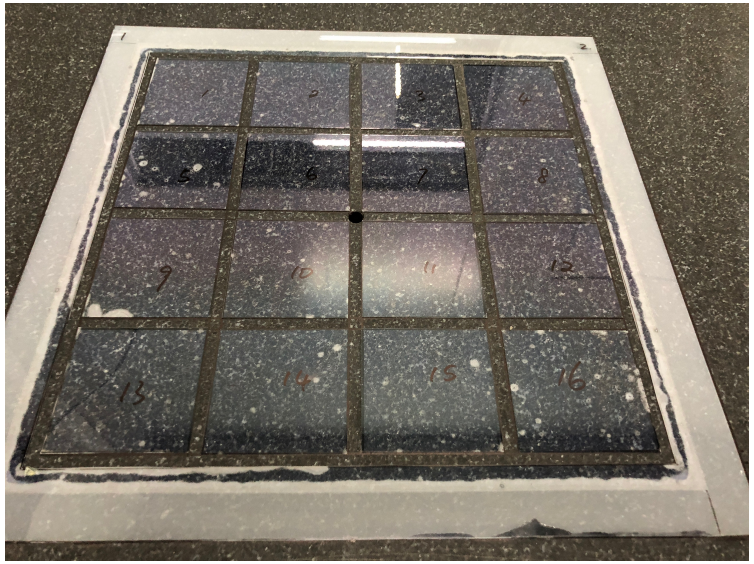


Ready to be bonded to the PPPCB half to build a chamber

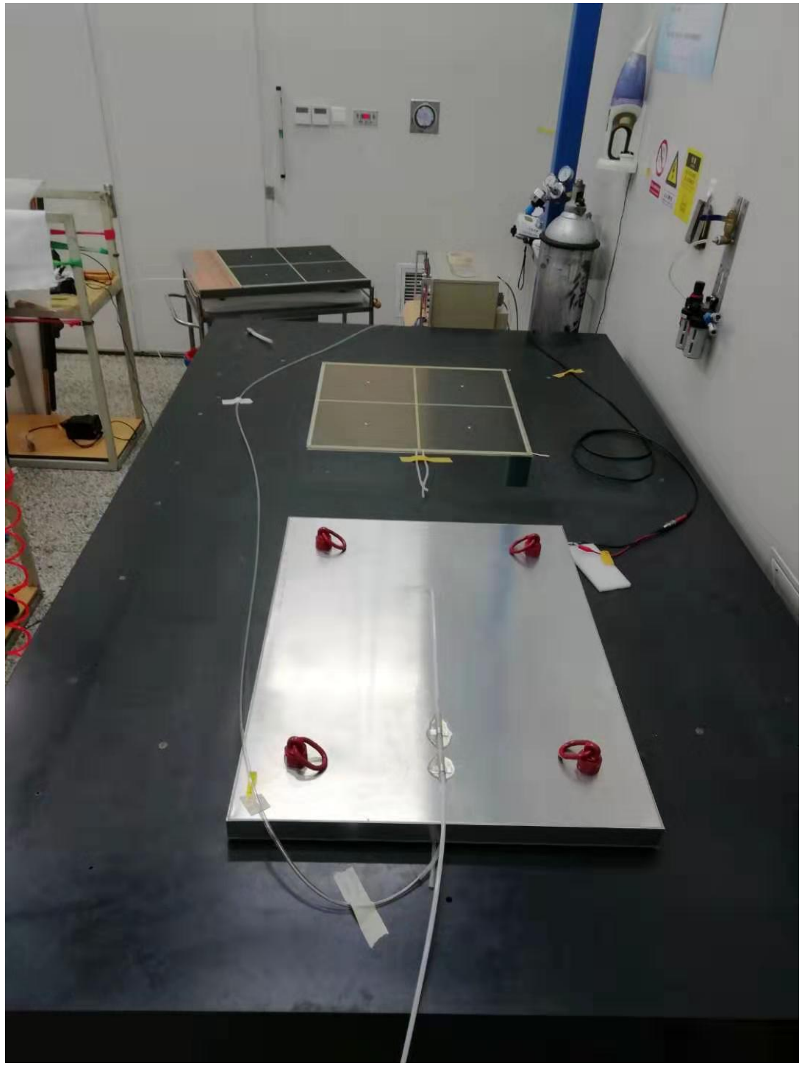
Wire Winding

- ✓ 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 half



Vacuum pumping frame on granite table



Two halfs combining rehearsal

Design of the Small Prototype Module

- ✓ Similar geometry ATLAS sTGC

  ---- side view

- ✓ Use strip layer instead of pad layer

  ---- same upper and lower layers

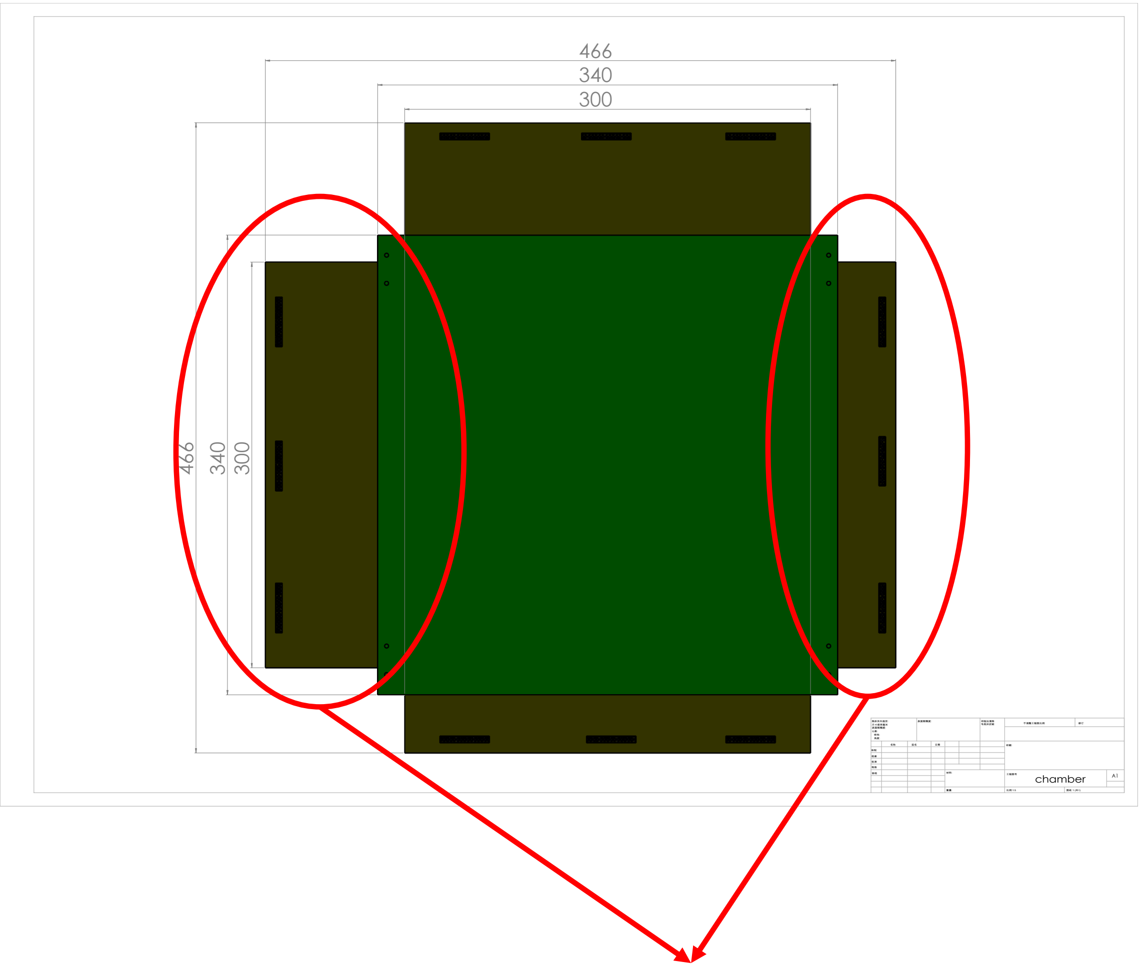
- ✓ Use current ATLAS wire mount and support material

  ---- need machining

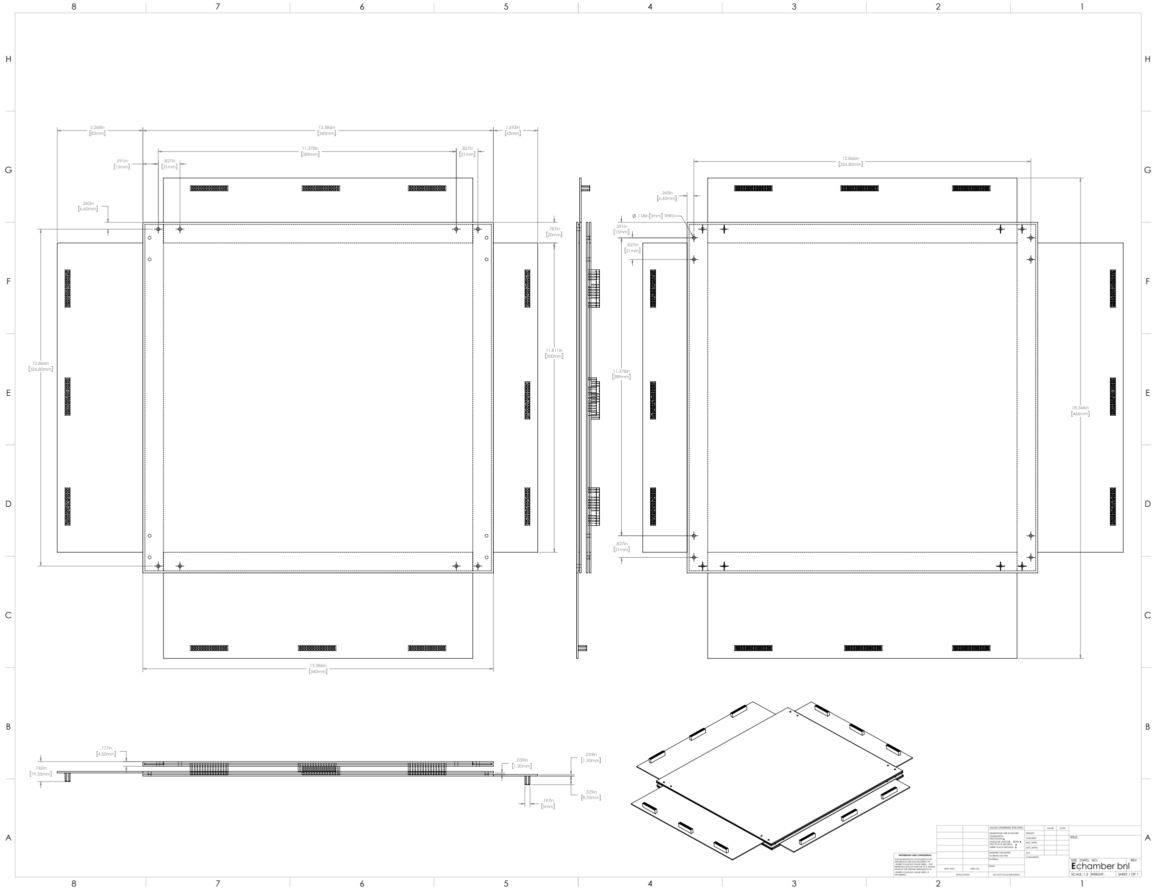
- ✓ Adapters are designed for both upper and lower pad planes

  ---- can read the position perpendicular to wire if needed

Design of the Small Prototype Module



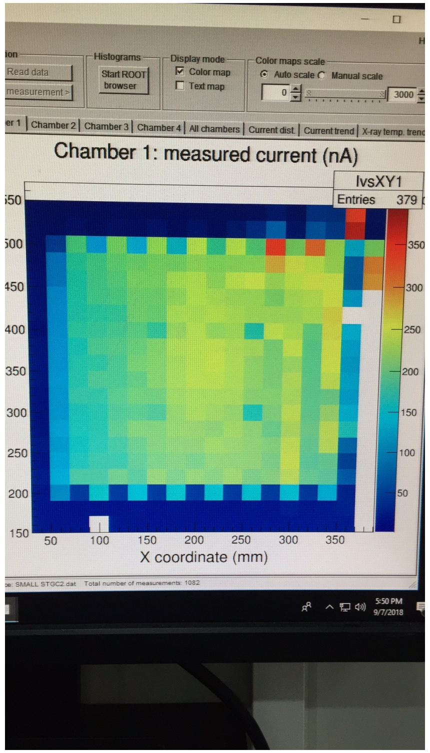
- ✓ The work started from Jan.2018
- ✓ Active area is 30cm X 30cm
- ✓ Designed for STAR TPX electronics



Functionally only need one side adapter
Designed for backup in prototype

HV Burn-in and X-ray radiation test

- ✓ Flowing 45% n-pentane and 55% co_2
- ✓ Ramping up to 3200V
- ✓ Track the leakage current
- ✓ No spark observed



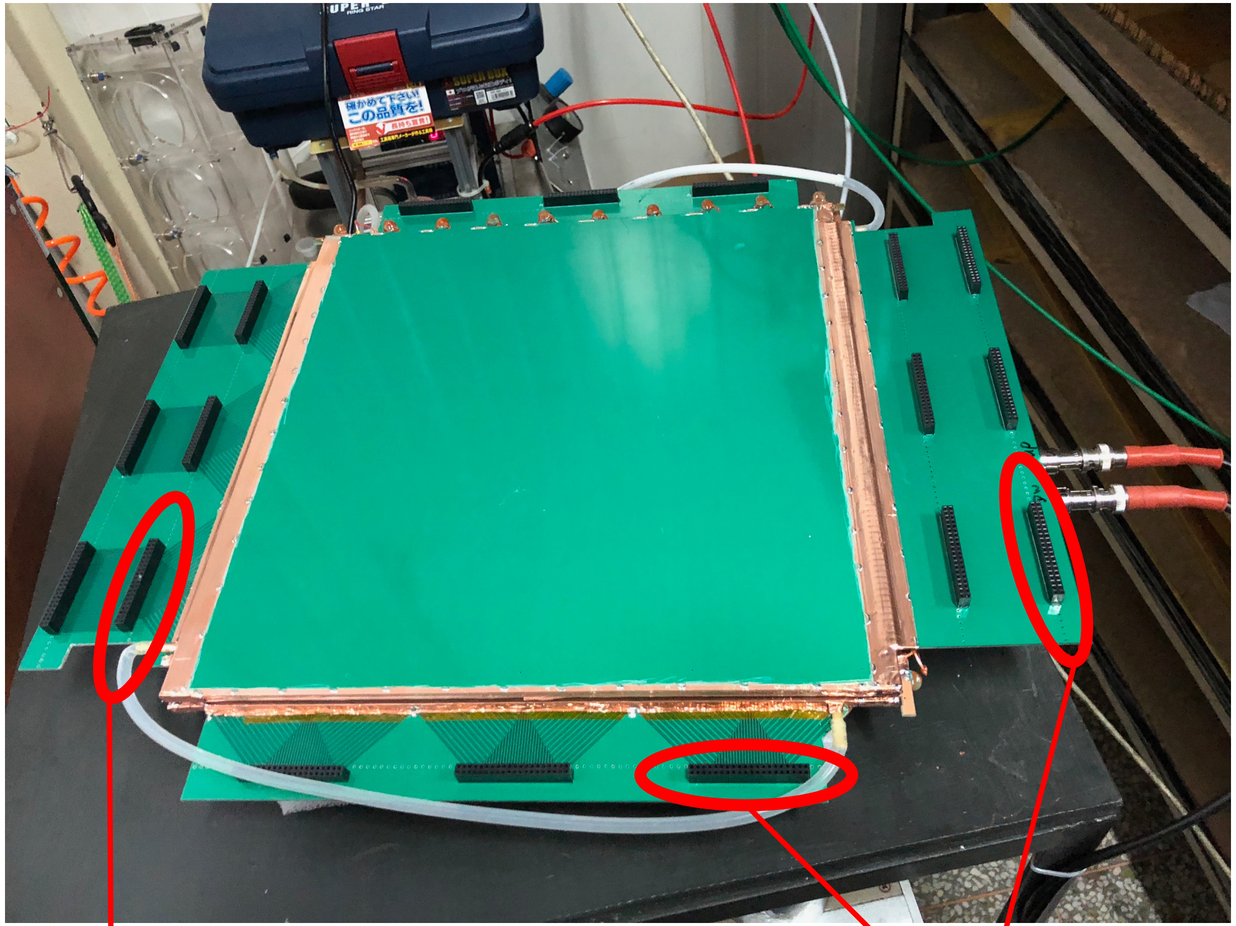
2D X-ray scan platform

Step by step scan (2cm/step)

Track the leakage current

Due to the previous sTGC experience, seen from the leakage current distribution, the flatness is about 50 micros.

Finalized Small Prototype Module



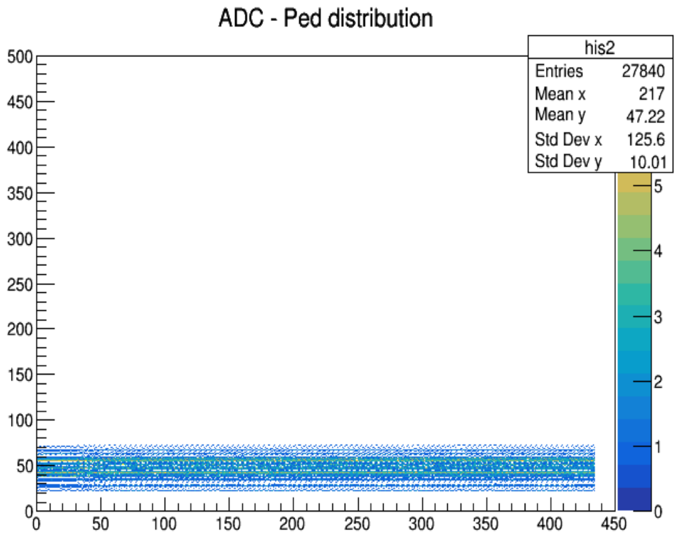
- ✓ 2D readout
- ✓ Have input signal readout port for test
- ✓ Need 3 FEEs for 94 channels per layer

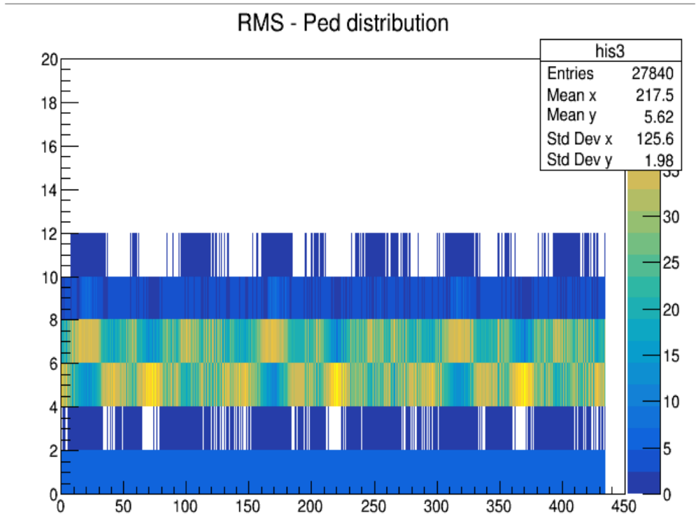
For input signal readout

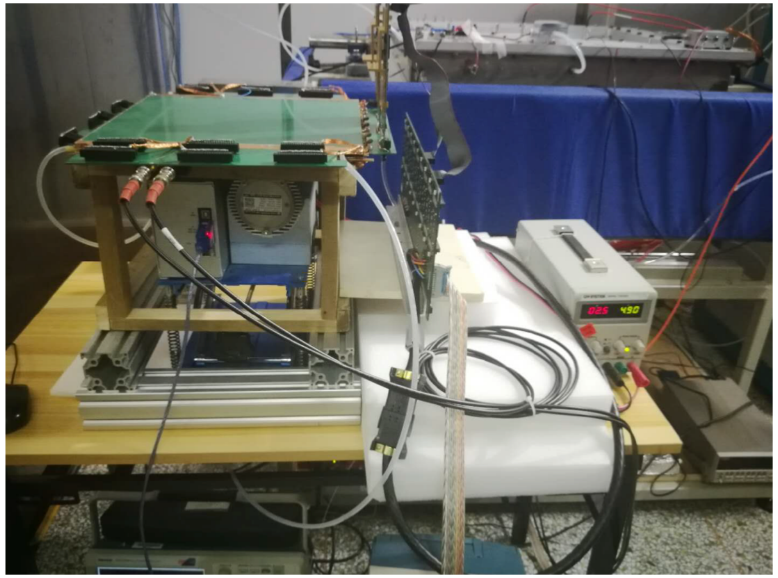
For FEE connection

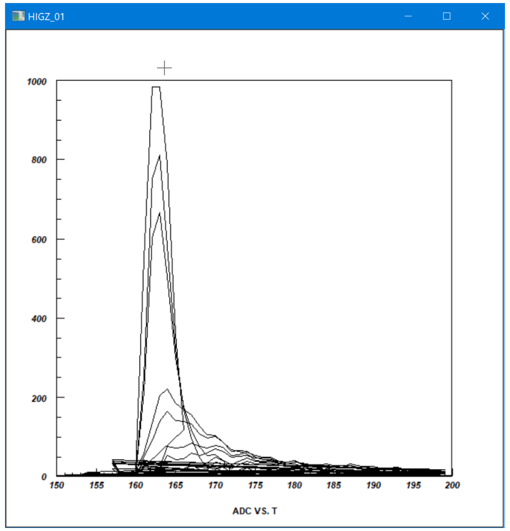
Test Results with TPX Electronics at SDU

- RMS ~ 5 compared to 1-2 intrinsic value, not low but acceptable

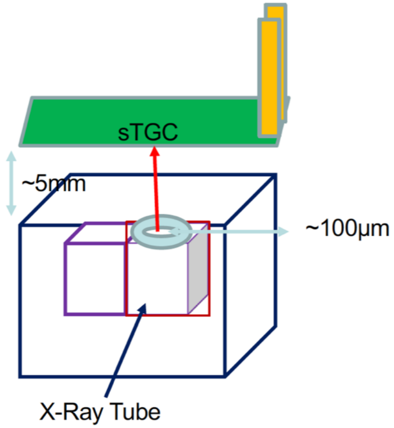








Signal peaks at TPX ADC limit level

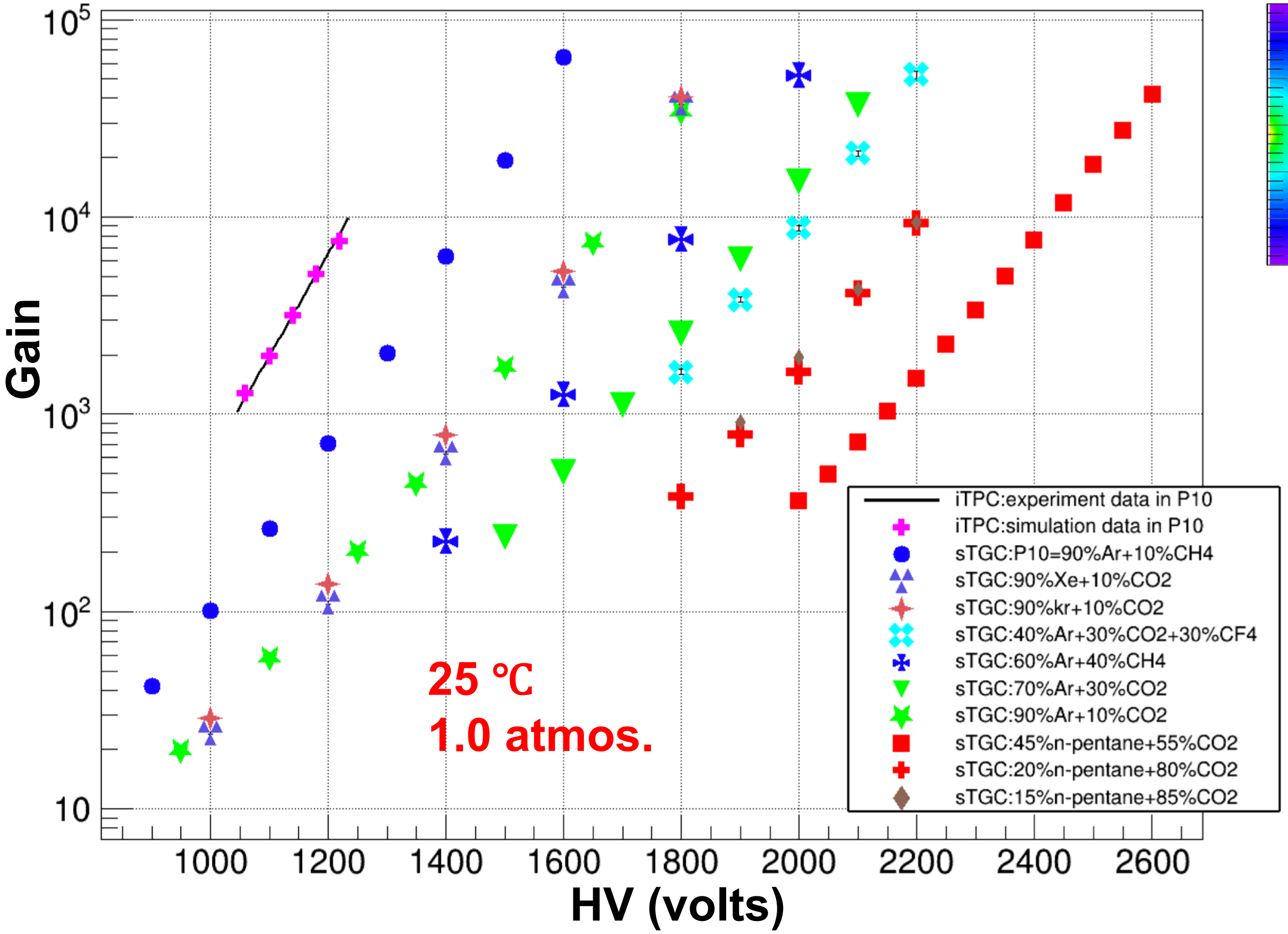


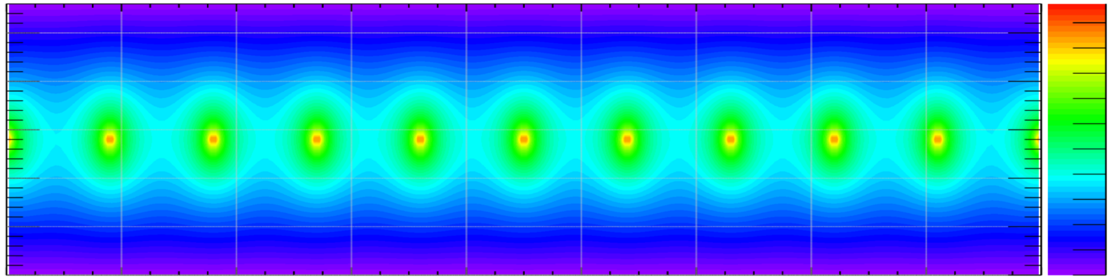
Garfield++ Simulation on sTGC Gain

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





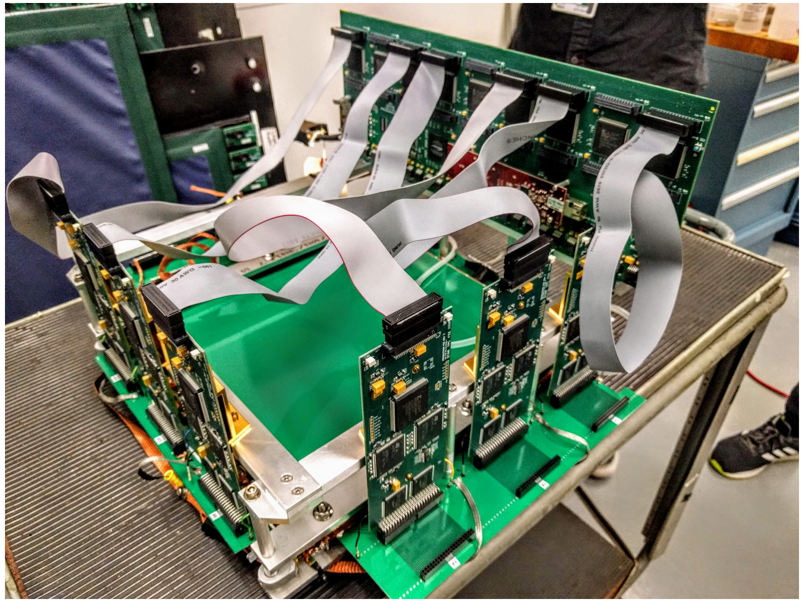
To provide references for different gas options:

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

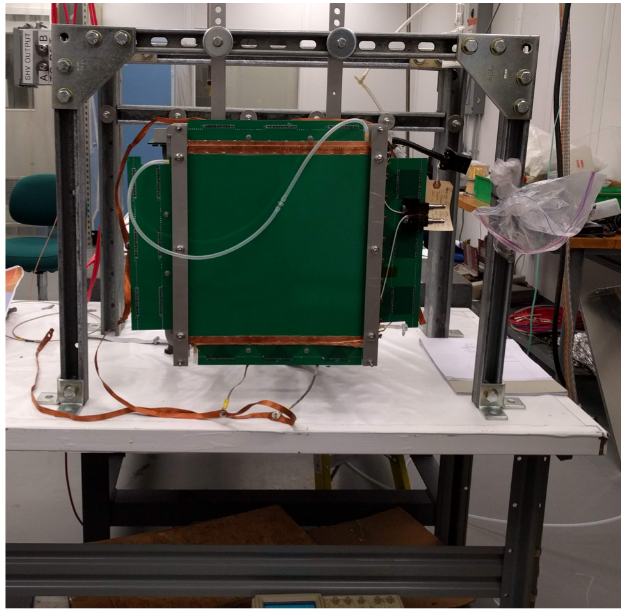
Small Prototype at STAR

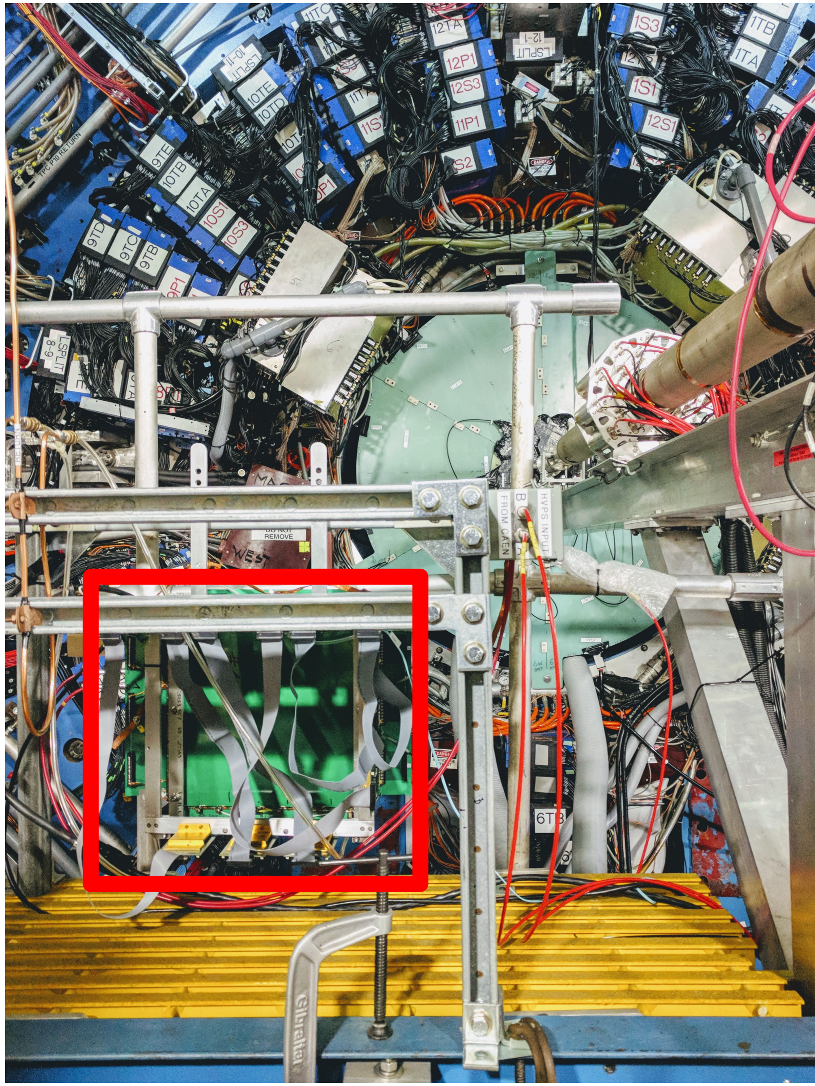
- ✓ 30x30 cm prototype delivered to BNL in January 2019
- ✓ Module tested in test-stand using cosmic rays + scintillator pads for trigger
- ✓ Connected to STAR Data Acquisition system – first test data being analyzed now
- ✓ Installed in STAR on June 5, 2019

Prototype in STAR Clean Room



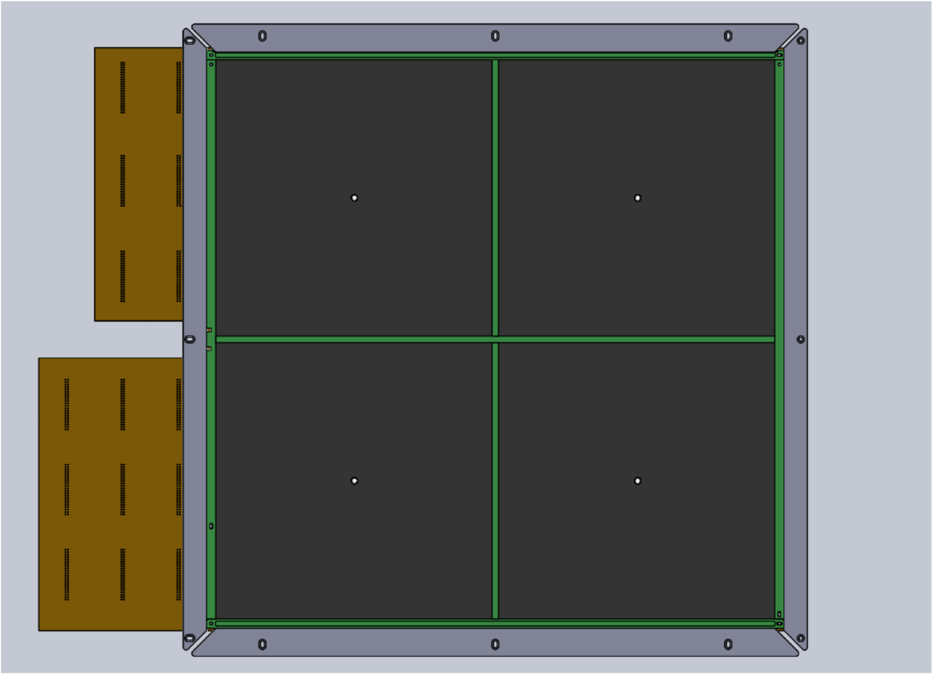
On the Mounting Structure



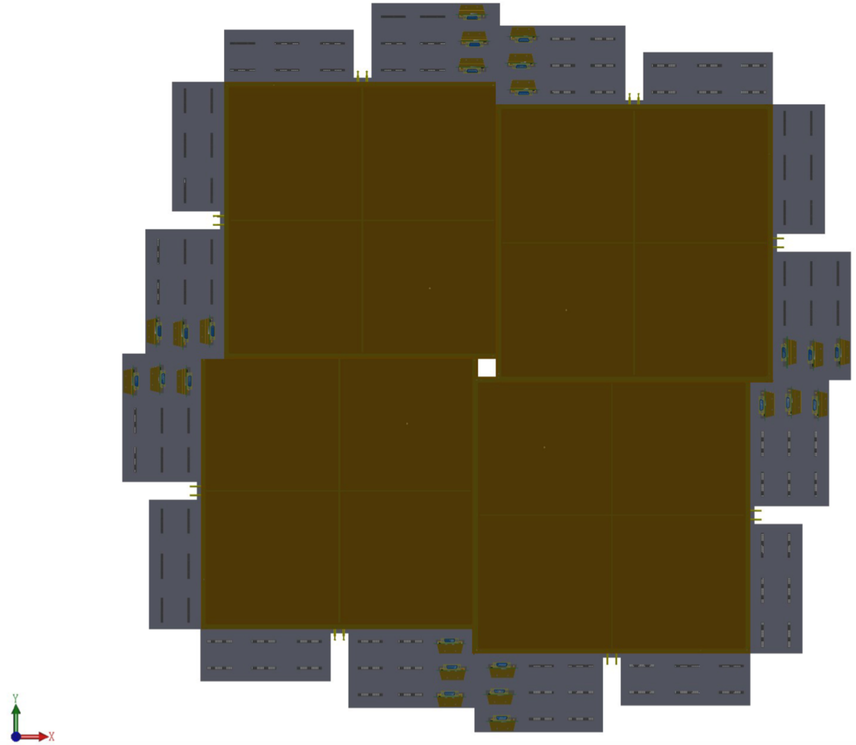


On STAR in Run19

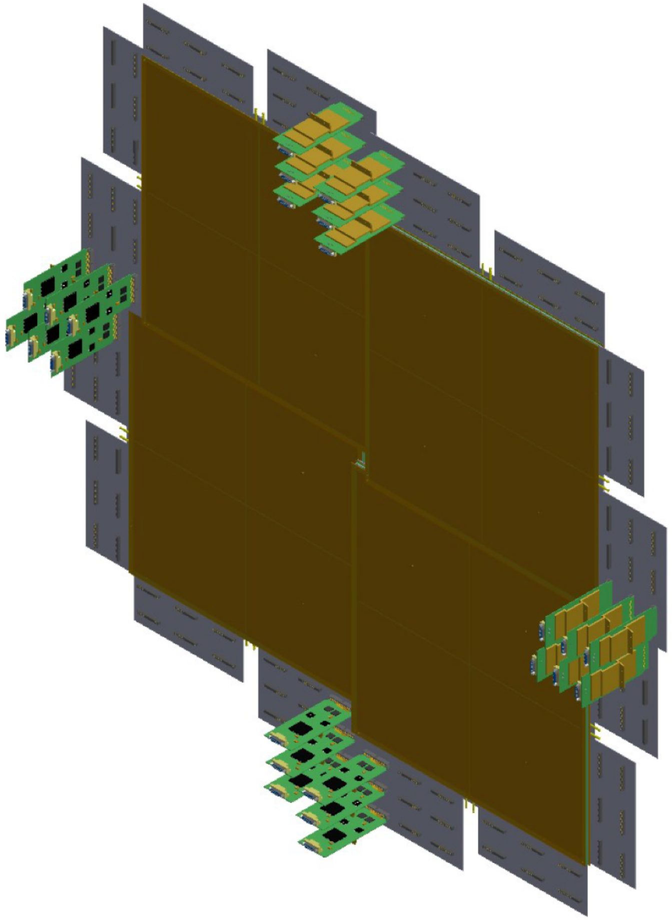
Full Size Prototype



Drawing for strip layer



Endcap view for the whole layer

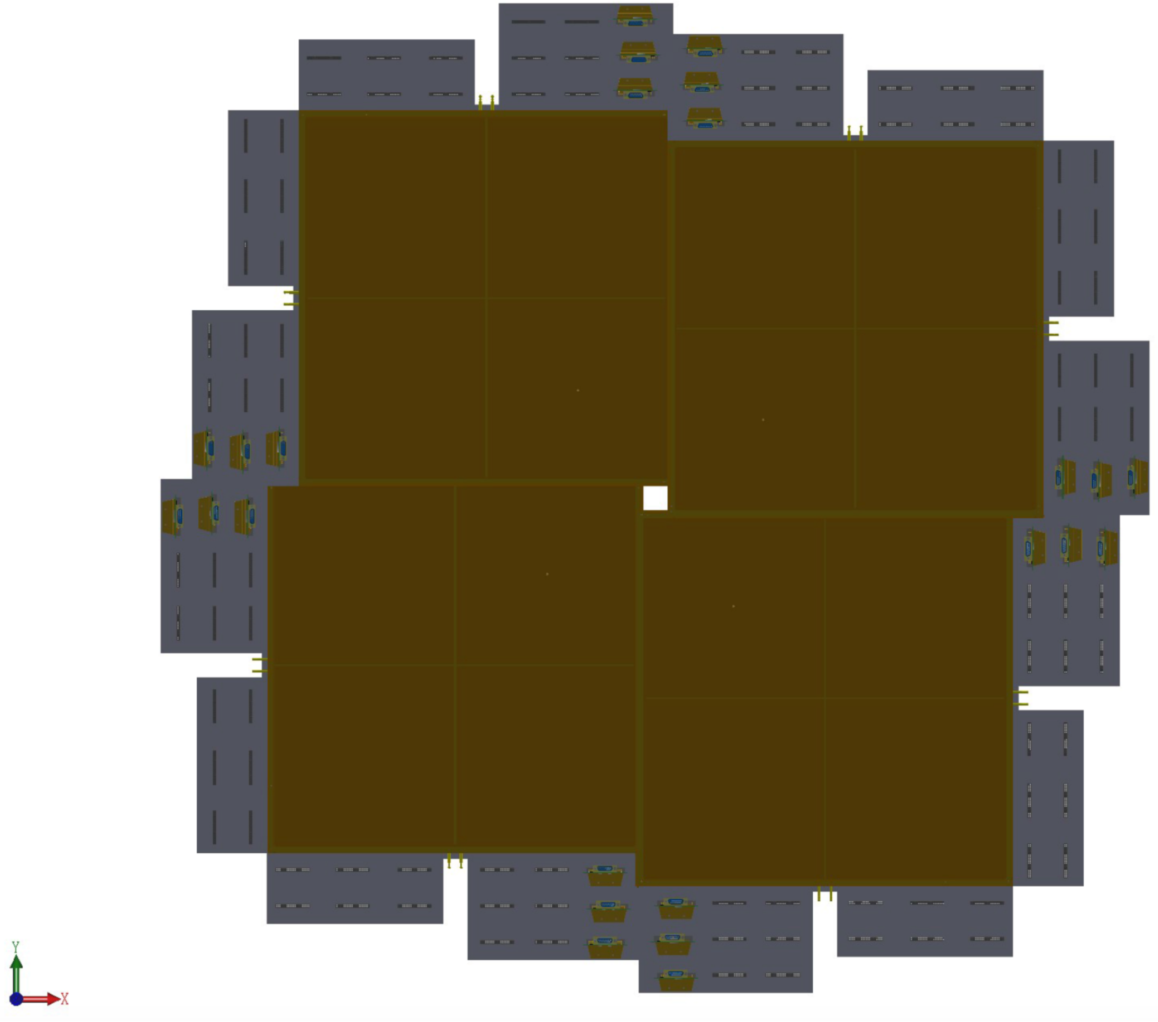


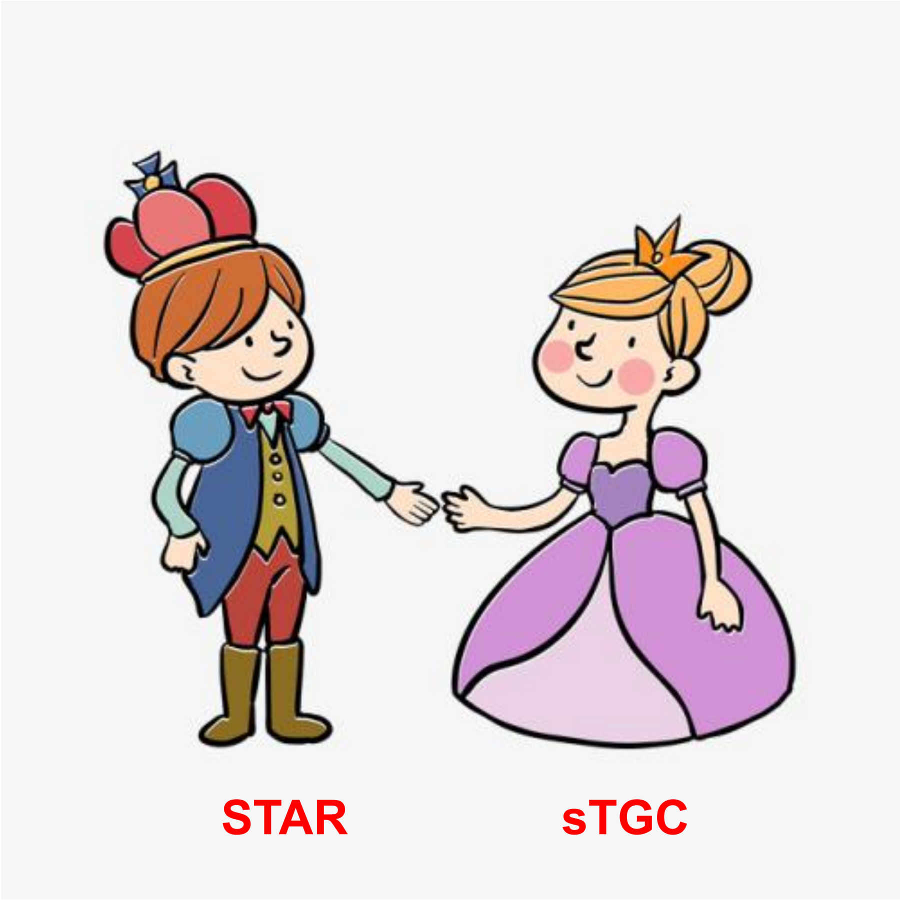
With several FEEs inserted

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

Integration

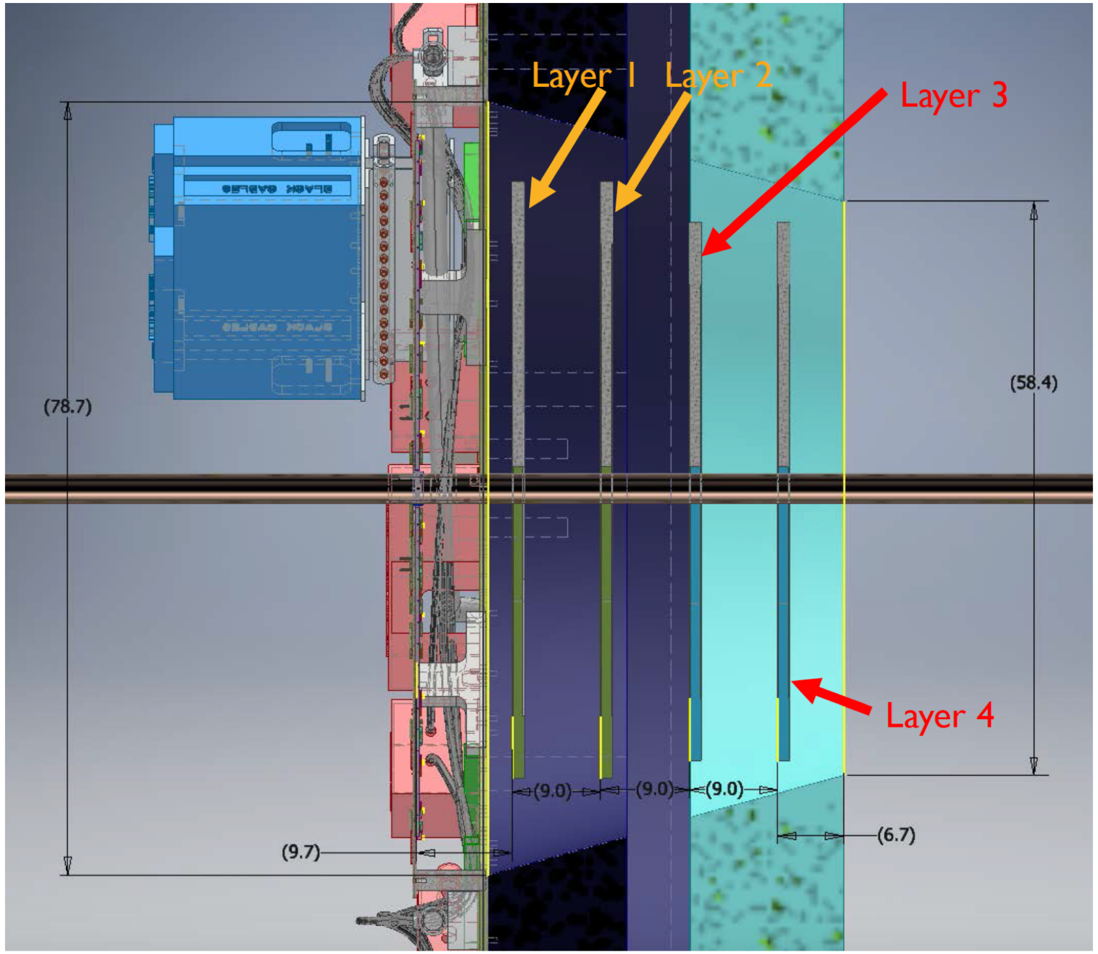
- Used to be a happy story   60cm*60cm active square plus electronics

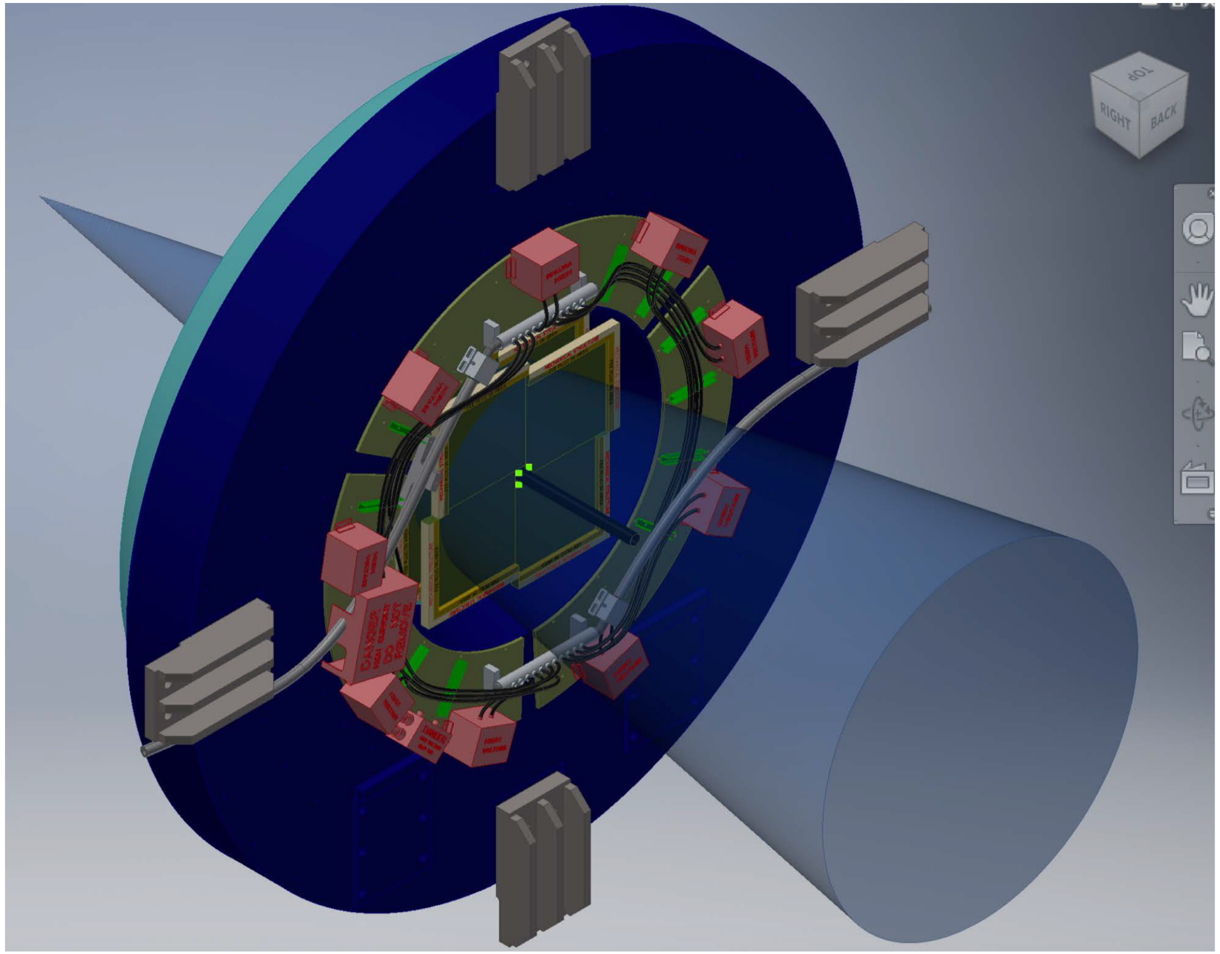




Integration

- The size should be limited by the cone size
- Need at least two different sizes for inner and outer layers





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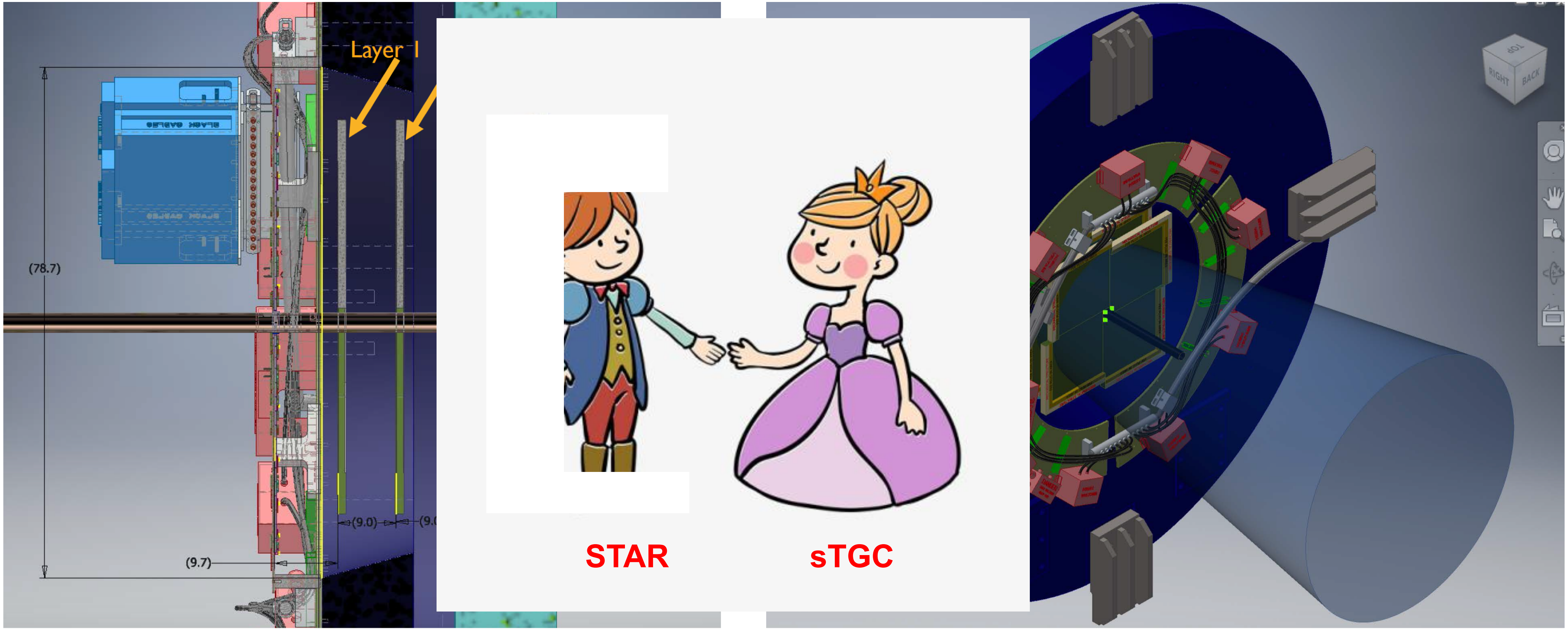
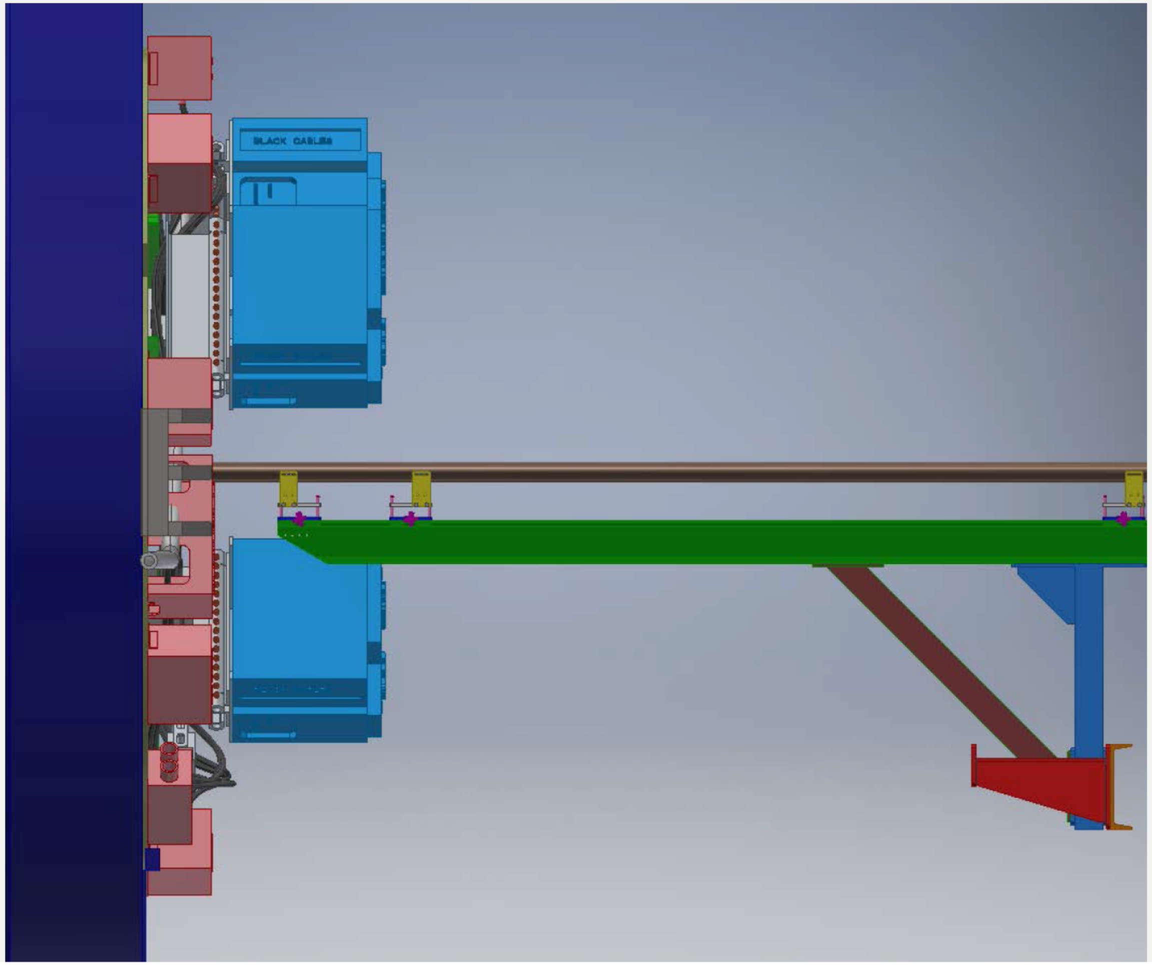
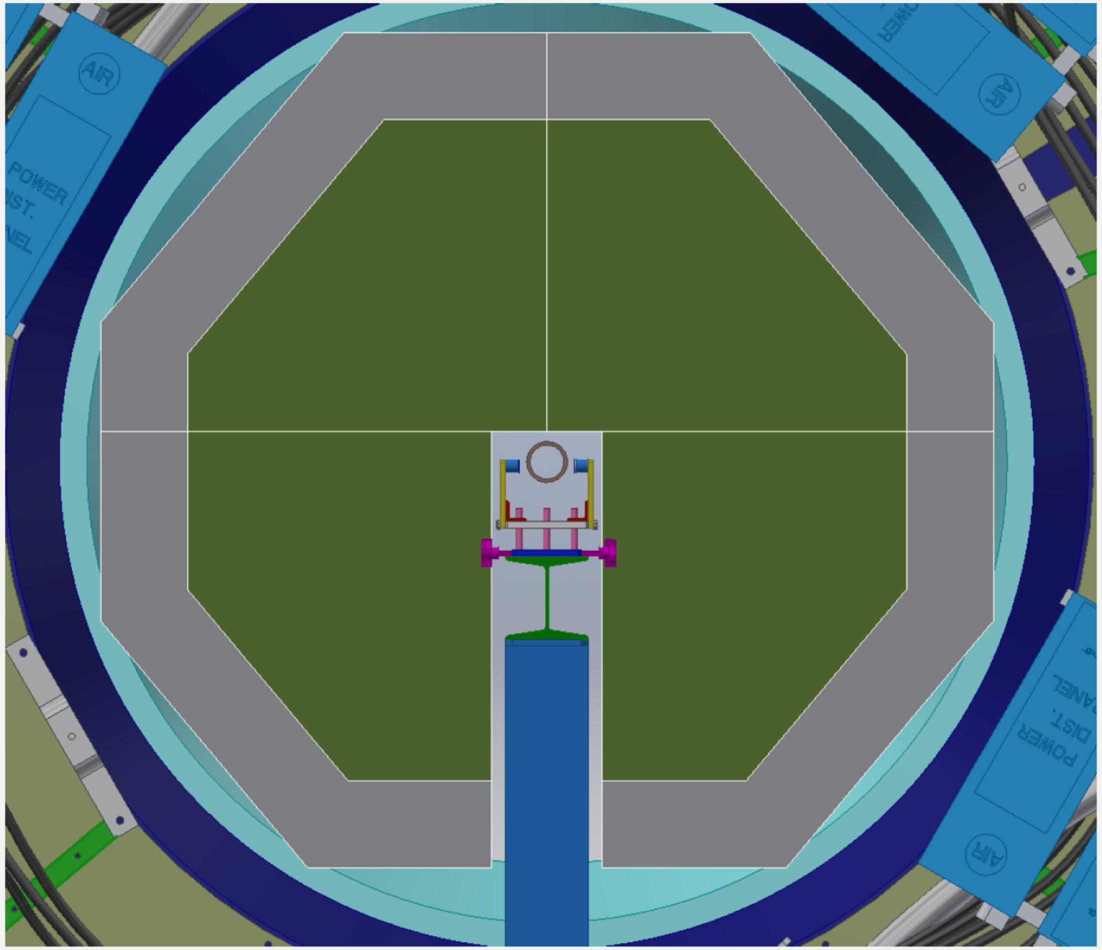


Integration

- There needs to be a gap for lifting if TPC needs to be repaired
- At least need 6 different types of chambers?





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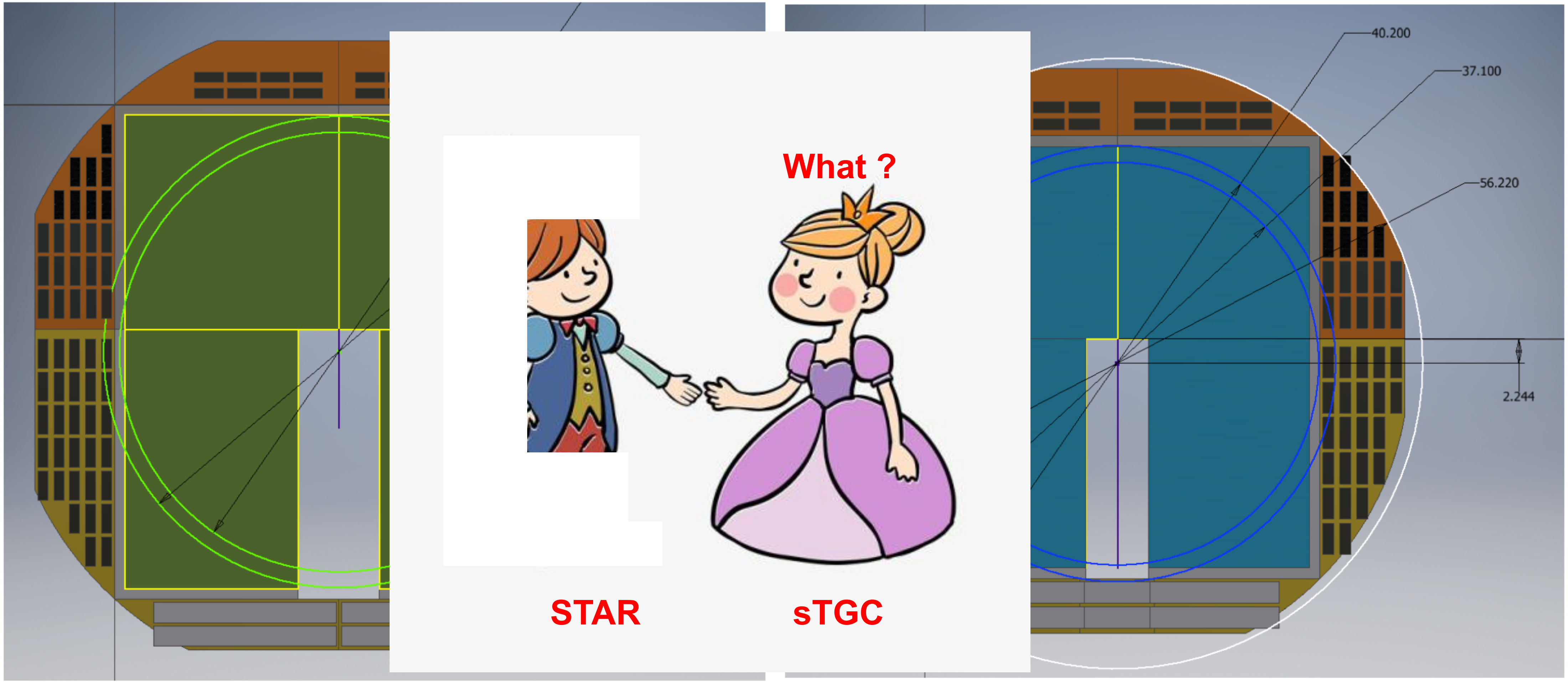


Electronics

Planned to use STAR TPX electronics

iTPC TPX electronics was retired after upgrade

But the spacing usage for TPX electronics is large

Very hard to put in the cone size together with the detector

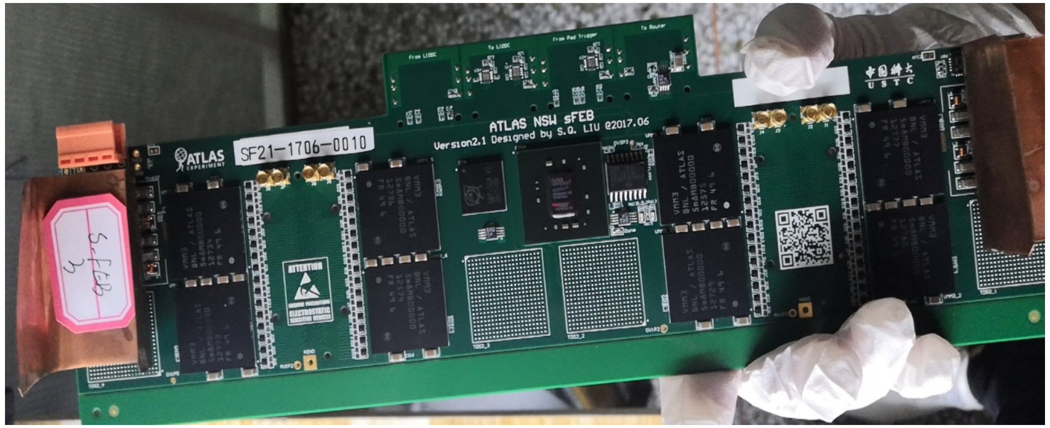
Now considering the ATLAS sTGC electronics using VMM chips

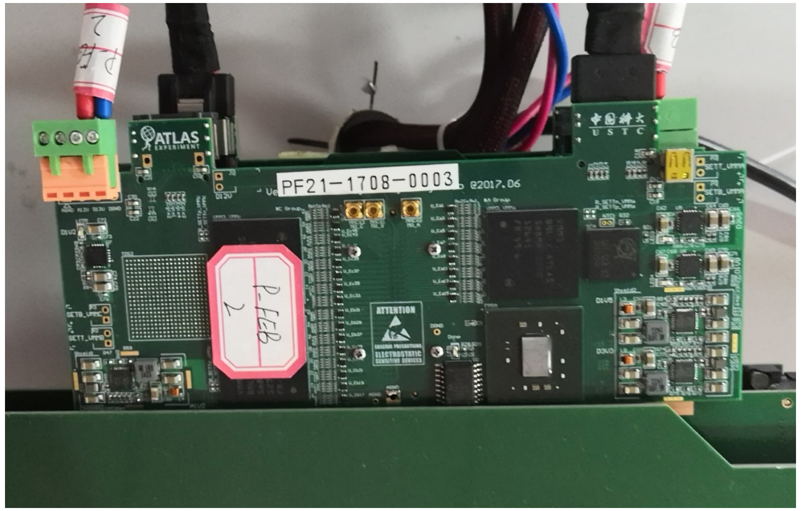
28cmx8cm for 512 channels, including triggering part which is not need for STAR

The boards are designed by USTC group

ALTAS NSW pFEB

ATLAS NSW sFEB

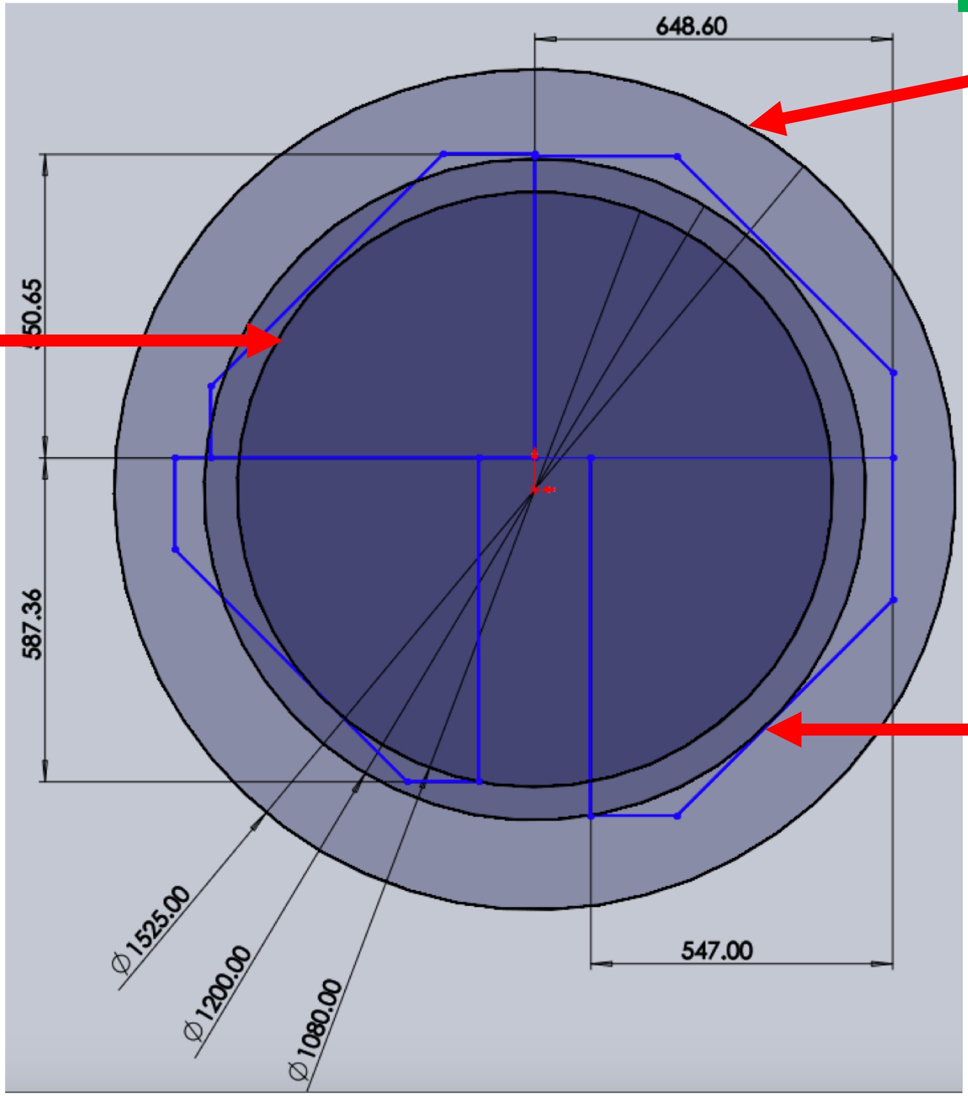




A New Design

Cone size at most inner layer

η = 2.6 at most outer layer



η = 2.5 at most outer layer

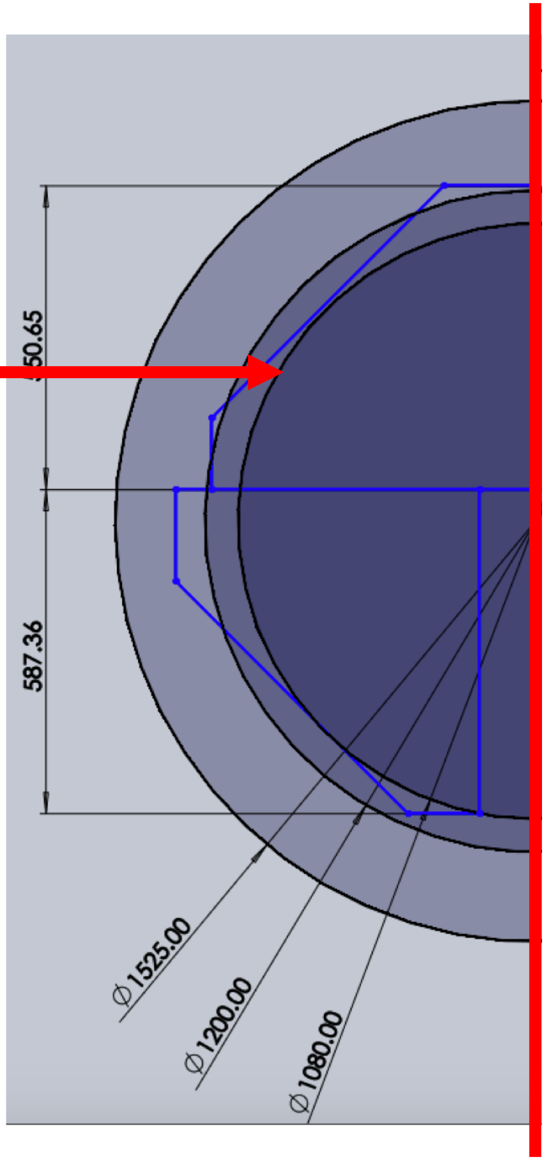
A New Design

Plan A： η = 2.6

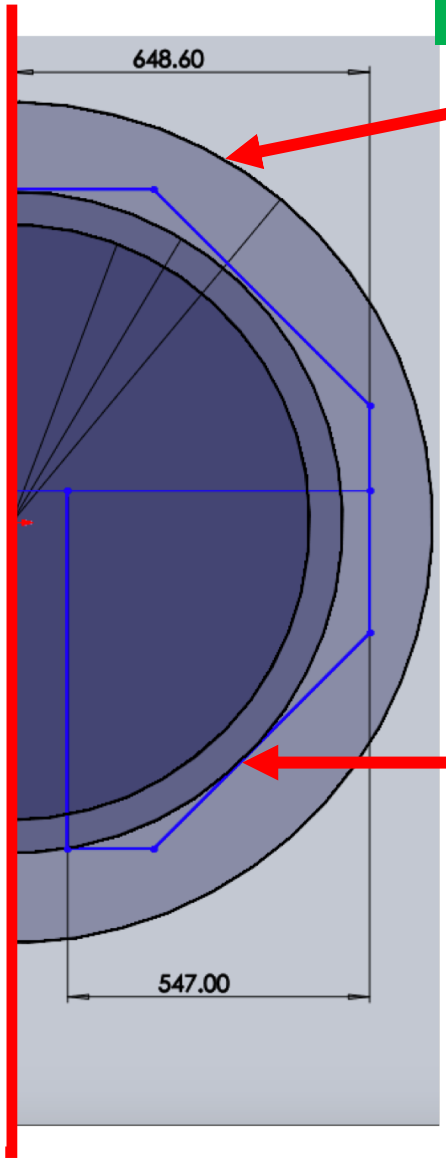
Symmetric pentagon

Only one type of chamer

η = 2.6 at most outer layer



A New Design



Cone size at most inner layer

η = 2.5 at most outer layer

Plan B： η = 2.5

Asymmetric pentagon

Two types of chamber

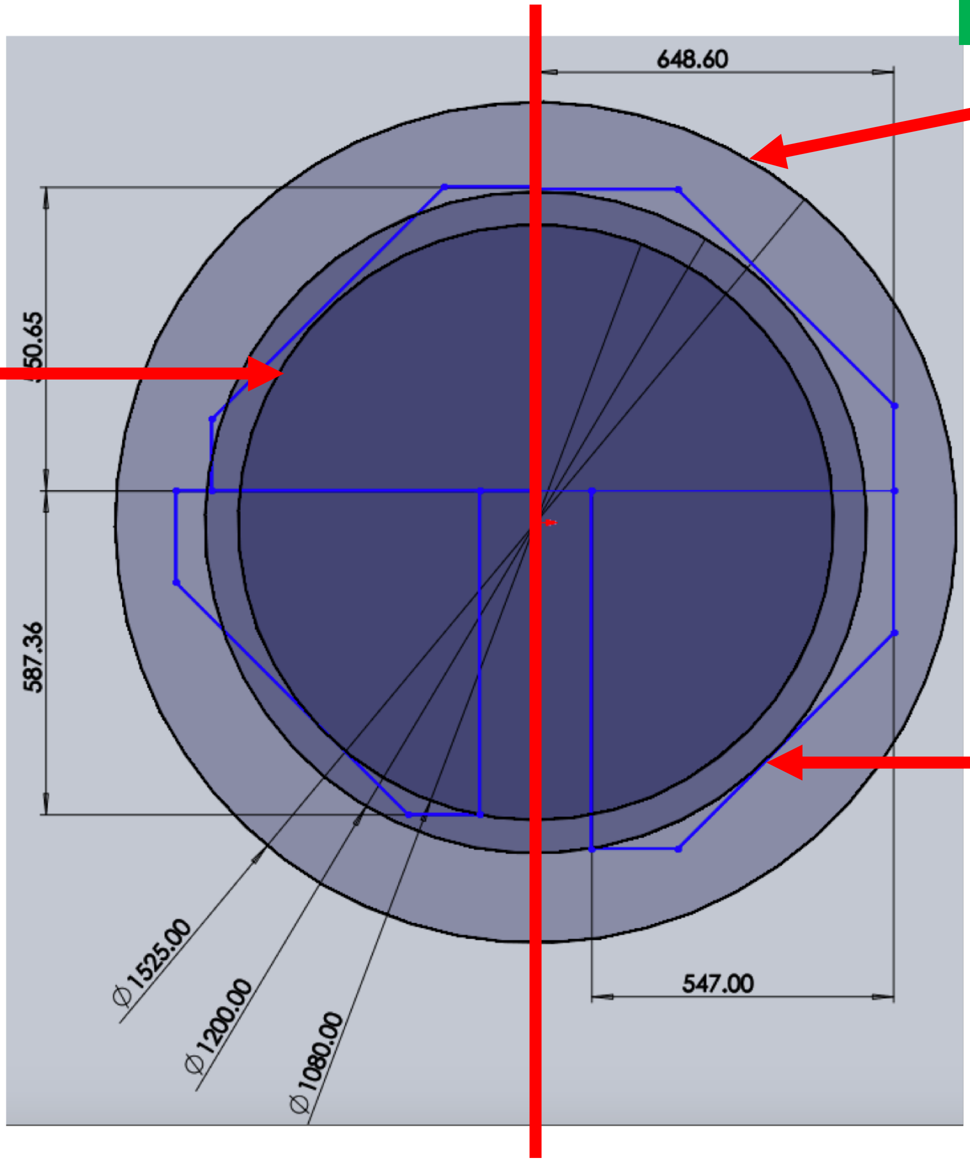
A New Design

Plan A： η = 2.6

Symmetric pentagon

Only one type of chamer

η = 2.6 at most outer layer



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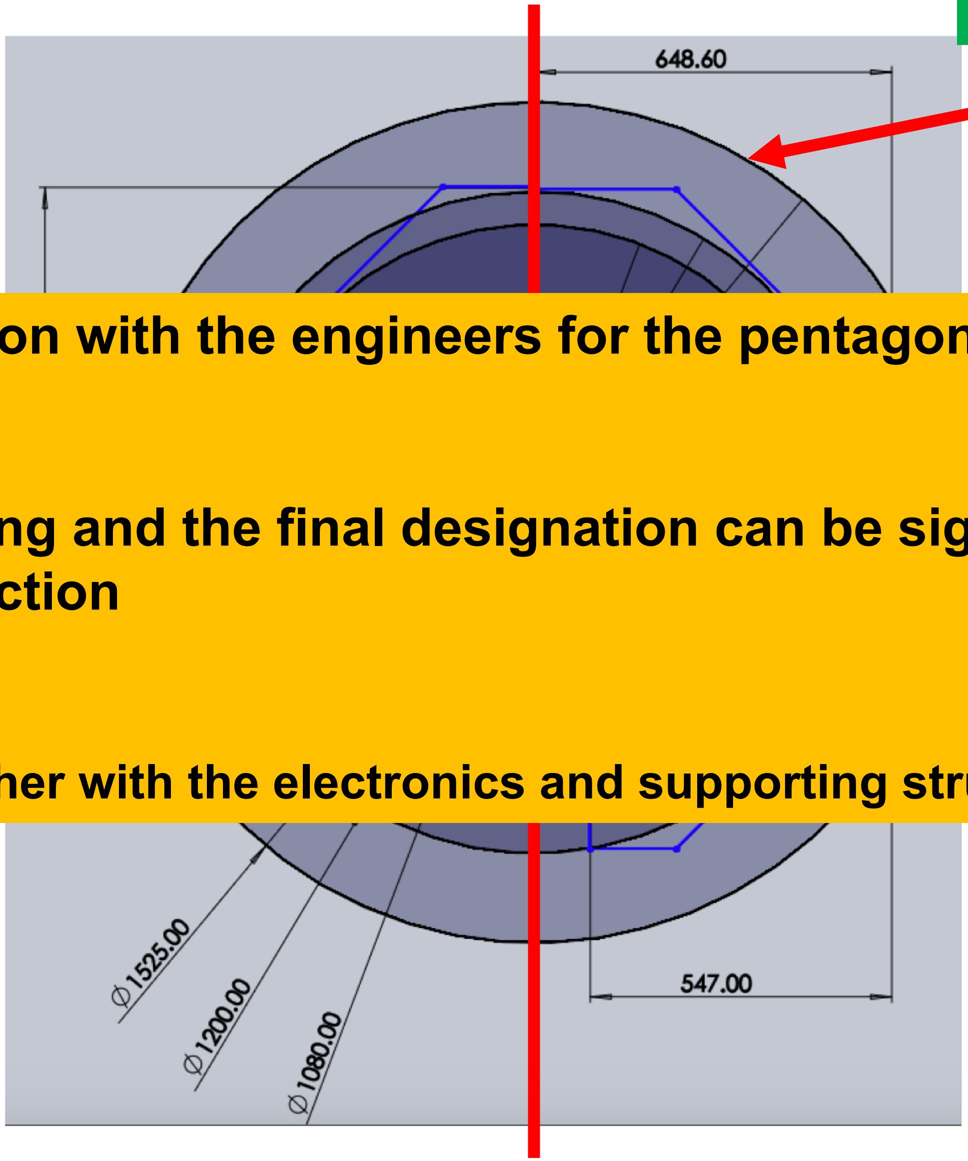

- ✓ **Still need further discussion with the engineers for the pentagon shape feasibility**
- ✓ **With this design, the tooling and the final designation can be significantly simplified which is important for mass production**
- ✓ **Need to be considered together with the electronics and supporting structure**

Plan B： η = 2.5

Asymmetric pentagon

Two types of chamber

Summary

Small sTGC prototype (30cmx30cm) has been designed and **built in SDU**. Preliminary test has been done and results are promising.

The small module was **installed at STAR in Run19**. Data are in studying.

Full size prototype (60cmx60cm) is **in building**.

Mass production procedure is under developing and improving.

New pentagon shape design for mass production is under discussion. Need to use ATLAS VMM chips for readout electronics.

Future plan:

- Detailed performance test for full size prototype (position resolution, efficiency)
- Work together with integration group and electronics group for final design