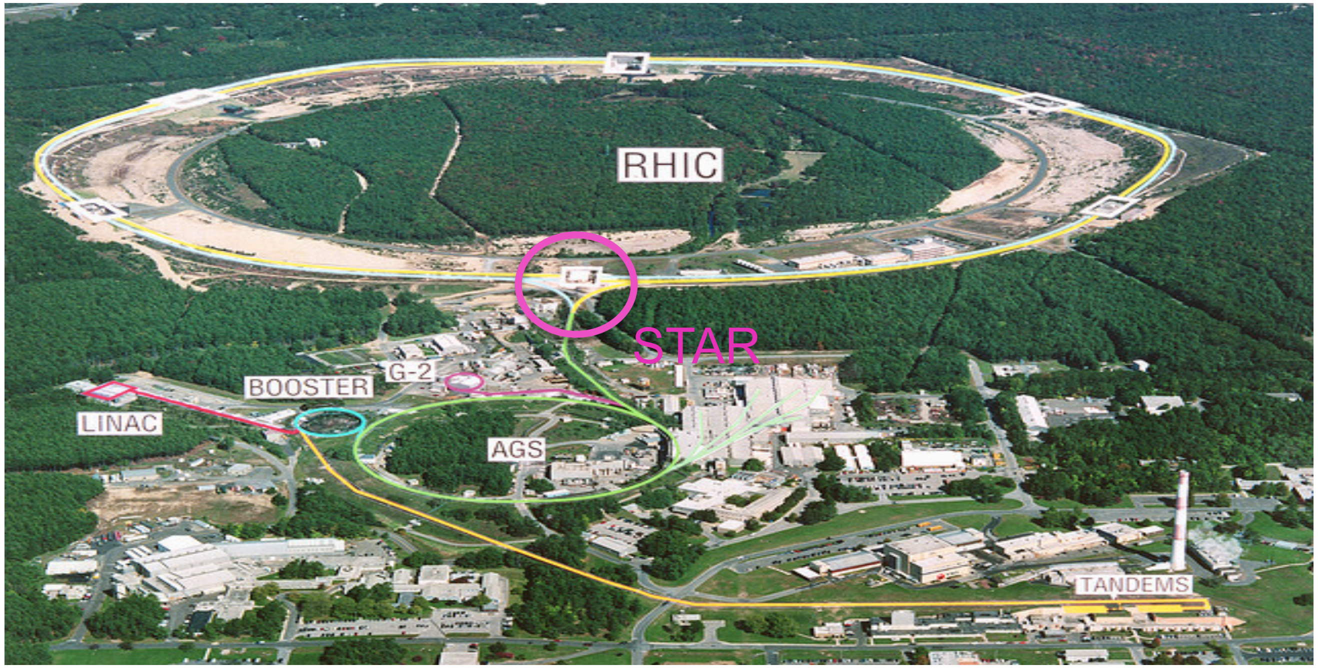
The STAR FGT upgrade program



Xuan Li for the STAR Collaboration

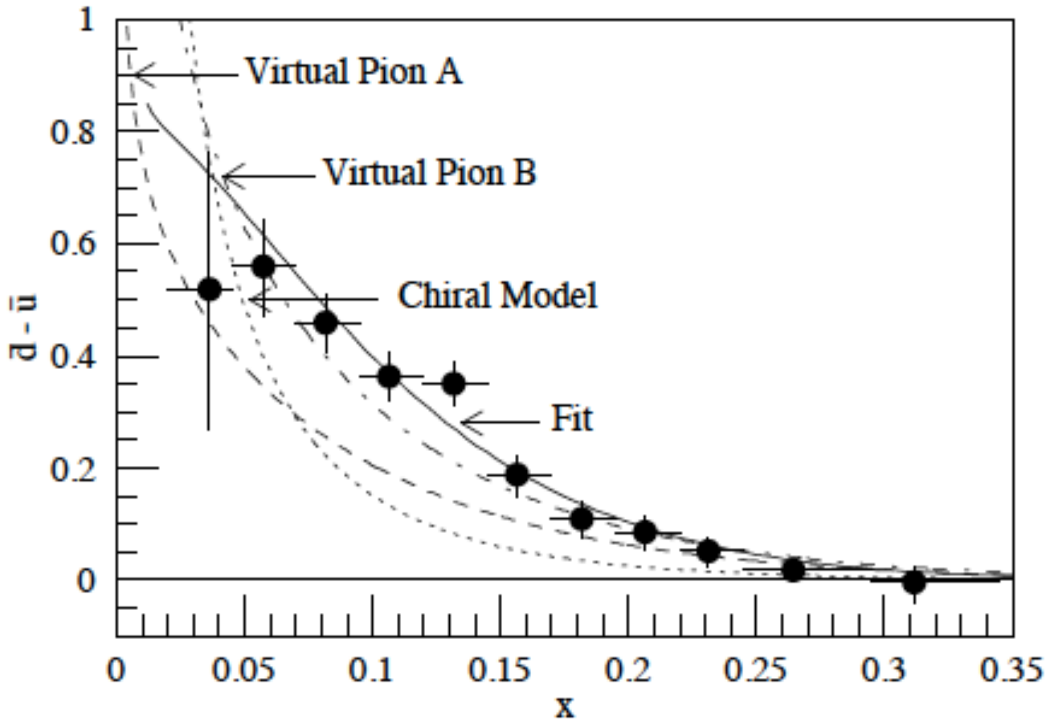
Temple University

Outline

- Motivation
  - Forward GEM Tracker (FGT) physics program
- FGT overview
  - Assembly and installation
  - Cosmic ray results for RHIC Run 13
- FGT upgrade and open discussion for p+A collisions
- Summary

Motivation

- Asymmetry of unpolarized sea quark distribution function had been found in Drell-Yan process ($p+N \longrightarrow \mu^+\mu^-$).

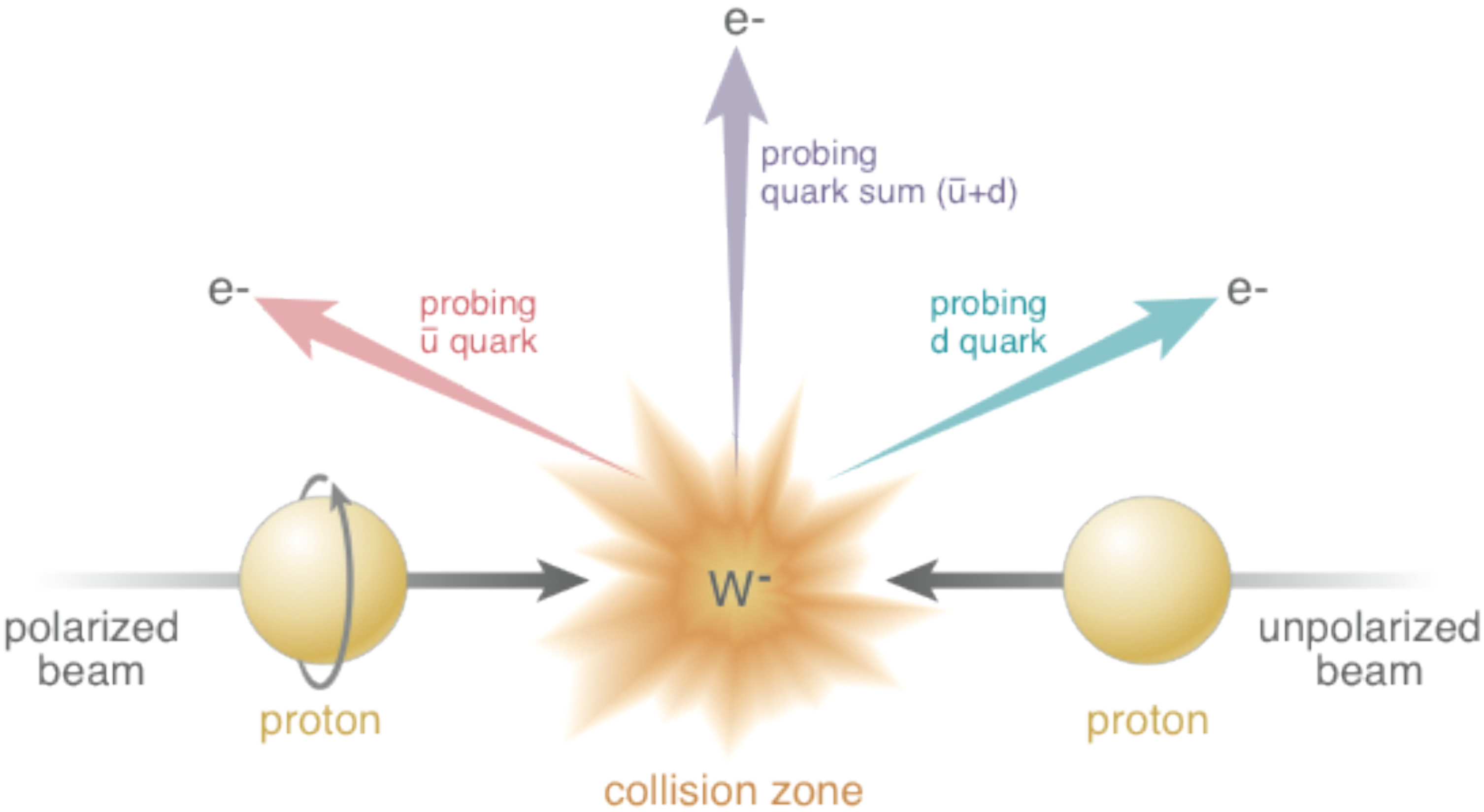


T.C.Awes et al., Phys.Rev.D58:092004,1998

- Other channels?
- How about polarized sea quark distribution?

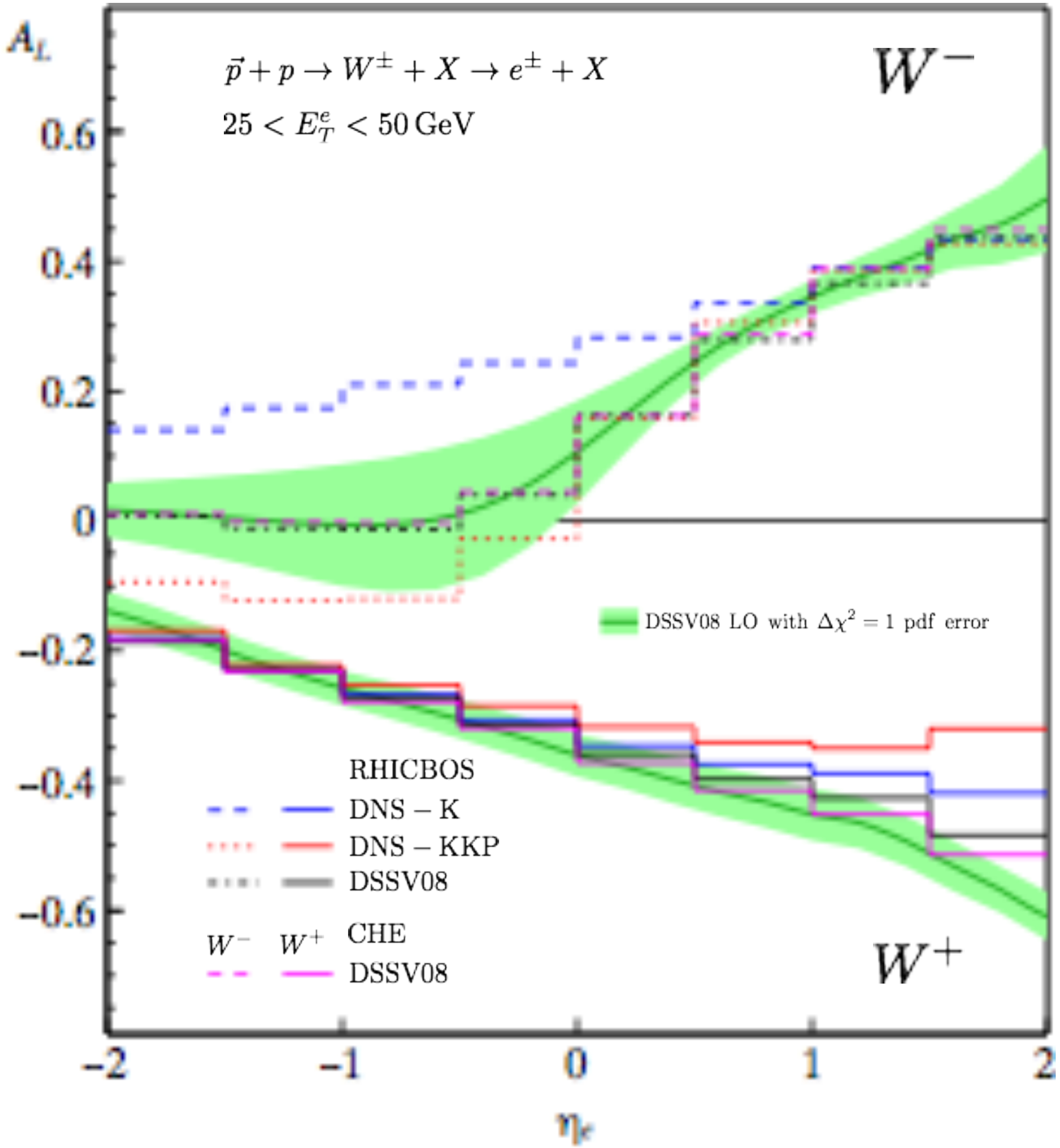
W production – unique new probe to measure quark polarization

- Probing polarized quark distribution via W production.



W measurement at STAR

- STAR A_L results and projection.

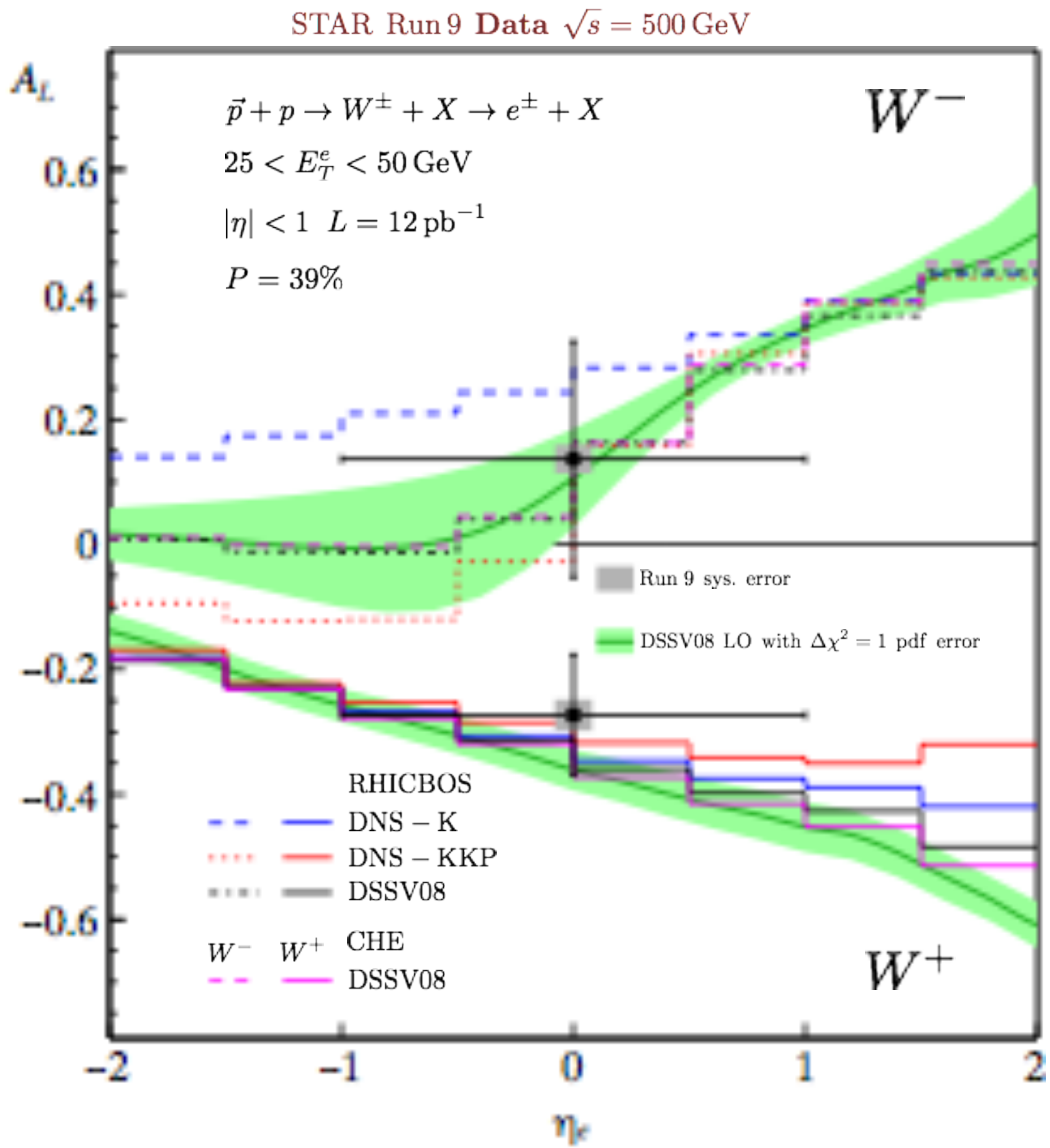


W measurement at STAR

- STAR A_L results and projection.

Measured asymmetries (Run 9) are in agreement with theory evaluations using polarized pdf's (DSSV) constrained by polarized DIS data

⇒ Universality of helicity distr. functions!



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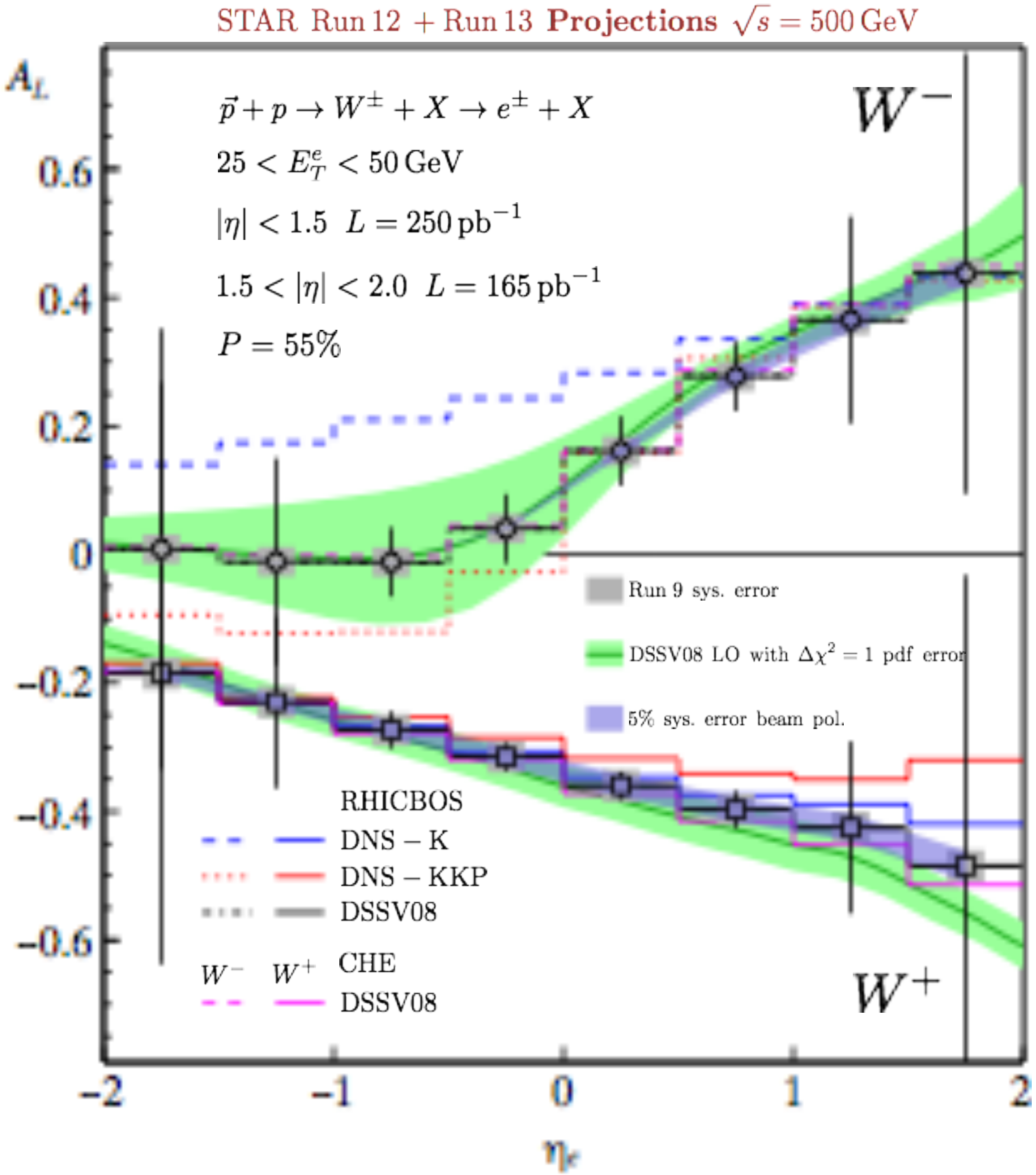
Critical: Measurement of W^+ and W^- asymmetries as a function η_e



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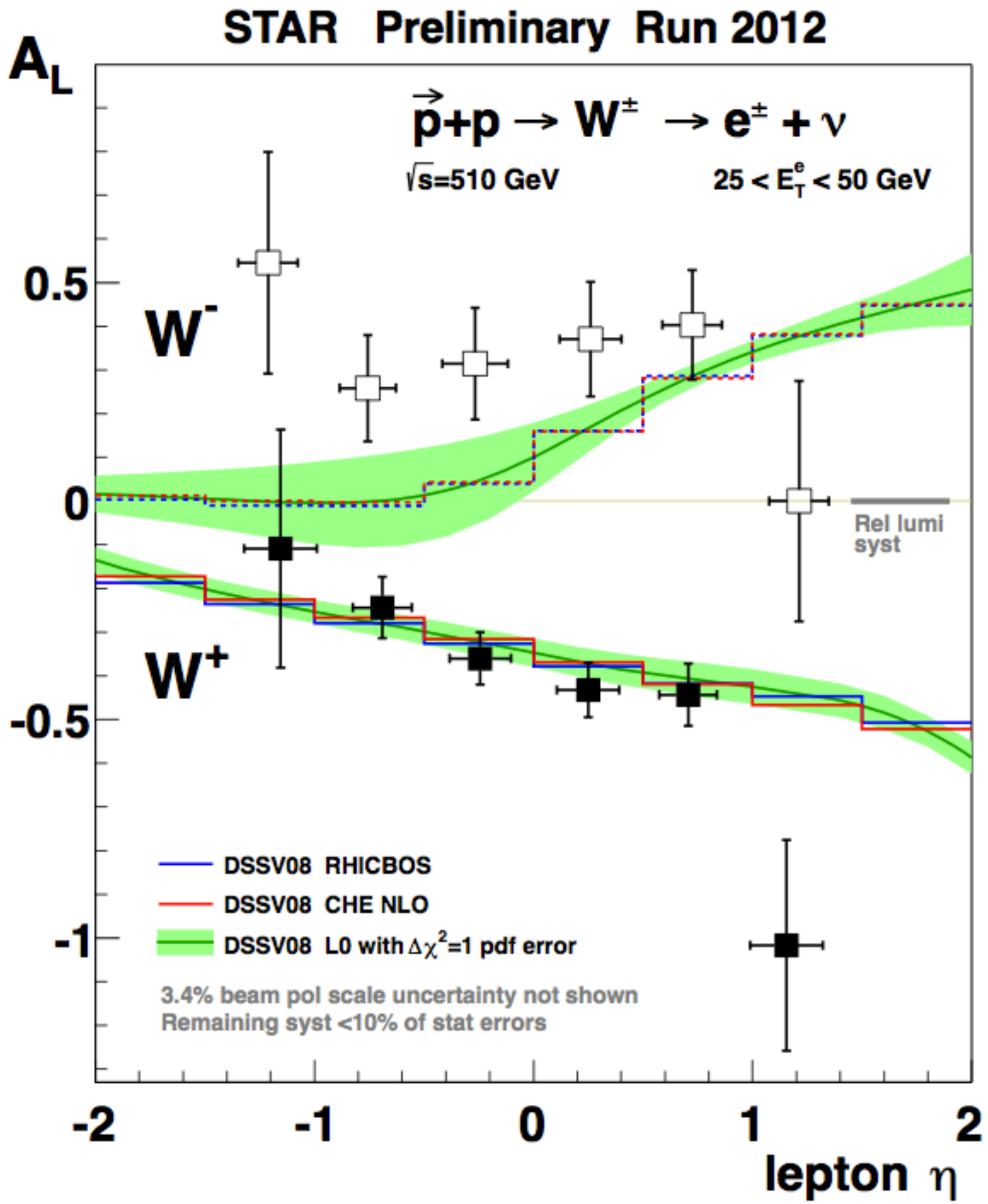
Extension of backward / forward η_e acceptance enhances sensitivity to anti-u / anti-d quark polarization

⇒ STAR Forward GEM Tracker ($1<|\eta_e|<2$)



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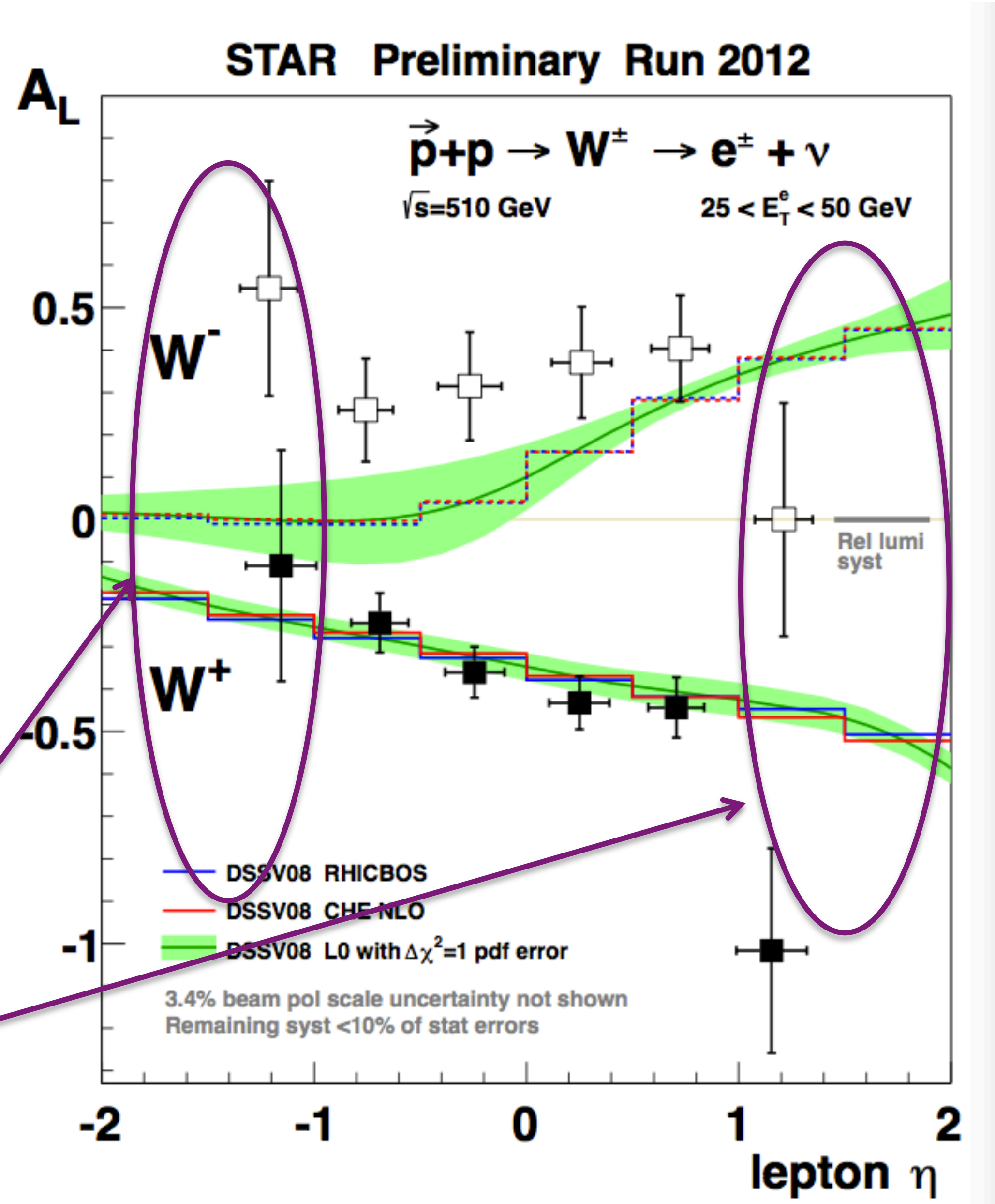
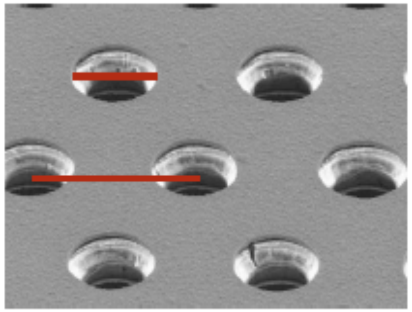


GEM technology

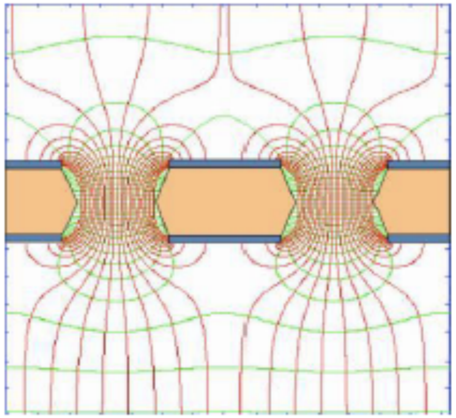
- Gas Electron Multiplier technology used for its high resolution capabilities at a very low mass.

Hole diameter: 70μm

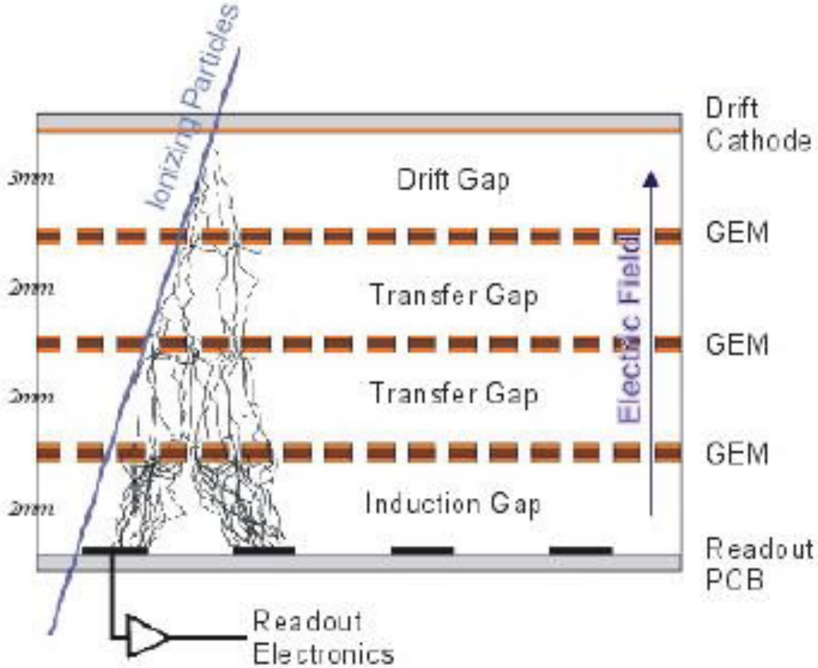
Pitch: 140μm



Single GEM in electic field



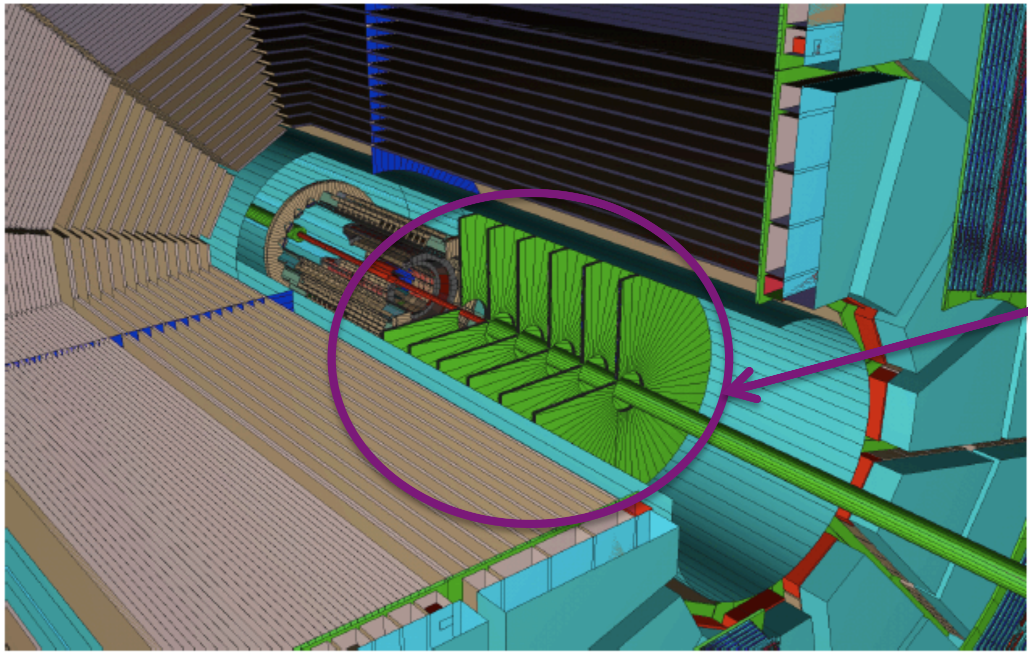
Ionizing particles pass through Triple GEM



- GEMs use a high electric field in the holes of a copper coated foil to amplify very small signals produced by ionizing particles.

FGT overview - design

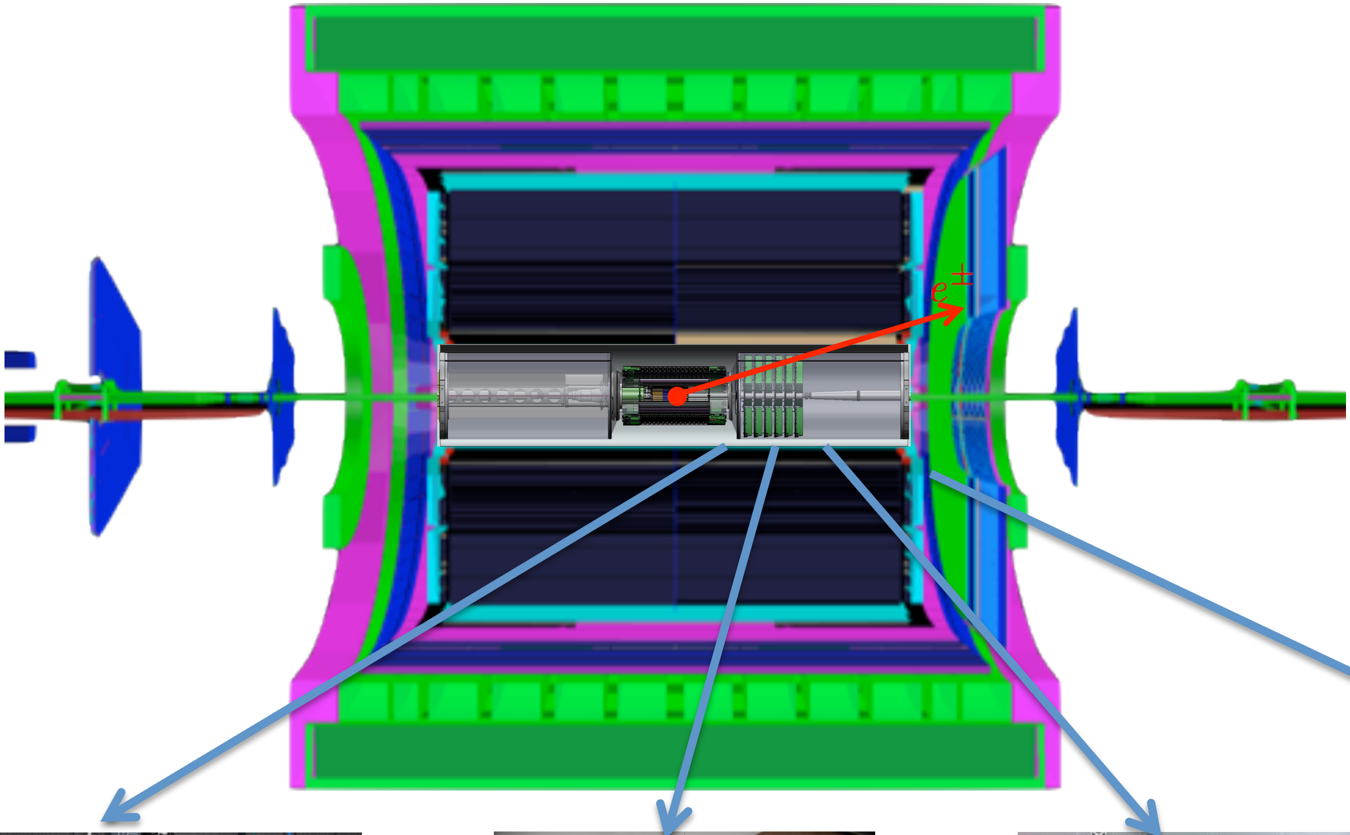
- Design constraints
  - Low mass which is important being close to interaction region.
  - Size limited by GEM foil production technology.
  - High rate – around 0.5MHz/cm^2, very radiation tolerant.



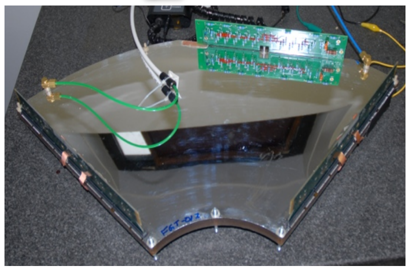
FGT installed inside STAR

FGT overview - construction

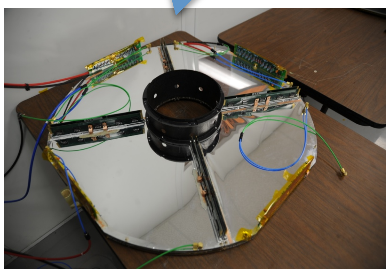
- Forward GEM Tracker - layout



The FGT has been fully installed in STAR for RHIC Run 13.

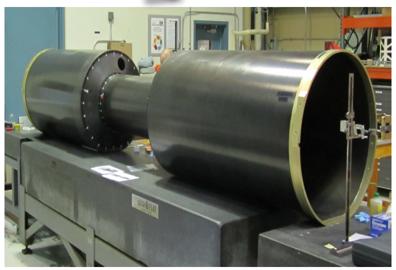


Quarter section



Disk

FGT consists of 6 disks

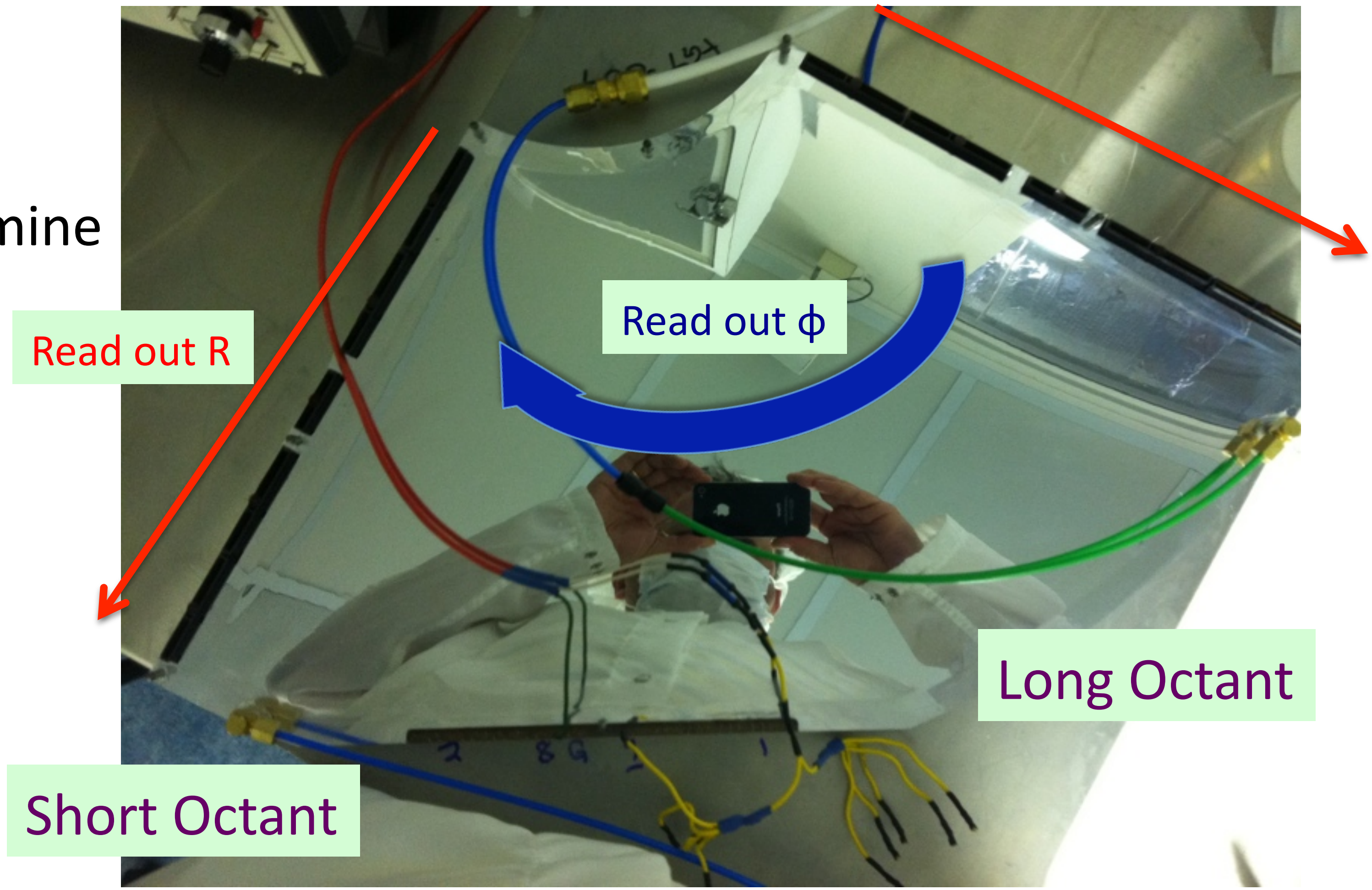


West Support Cylinder (WSC) for FGT

Look inside FGT quadrant

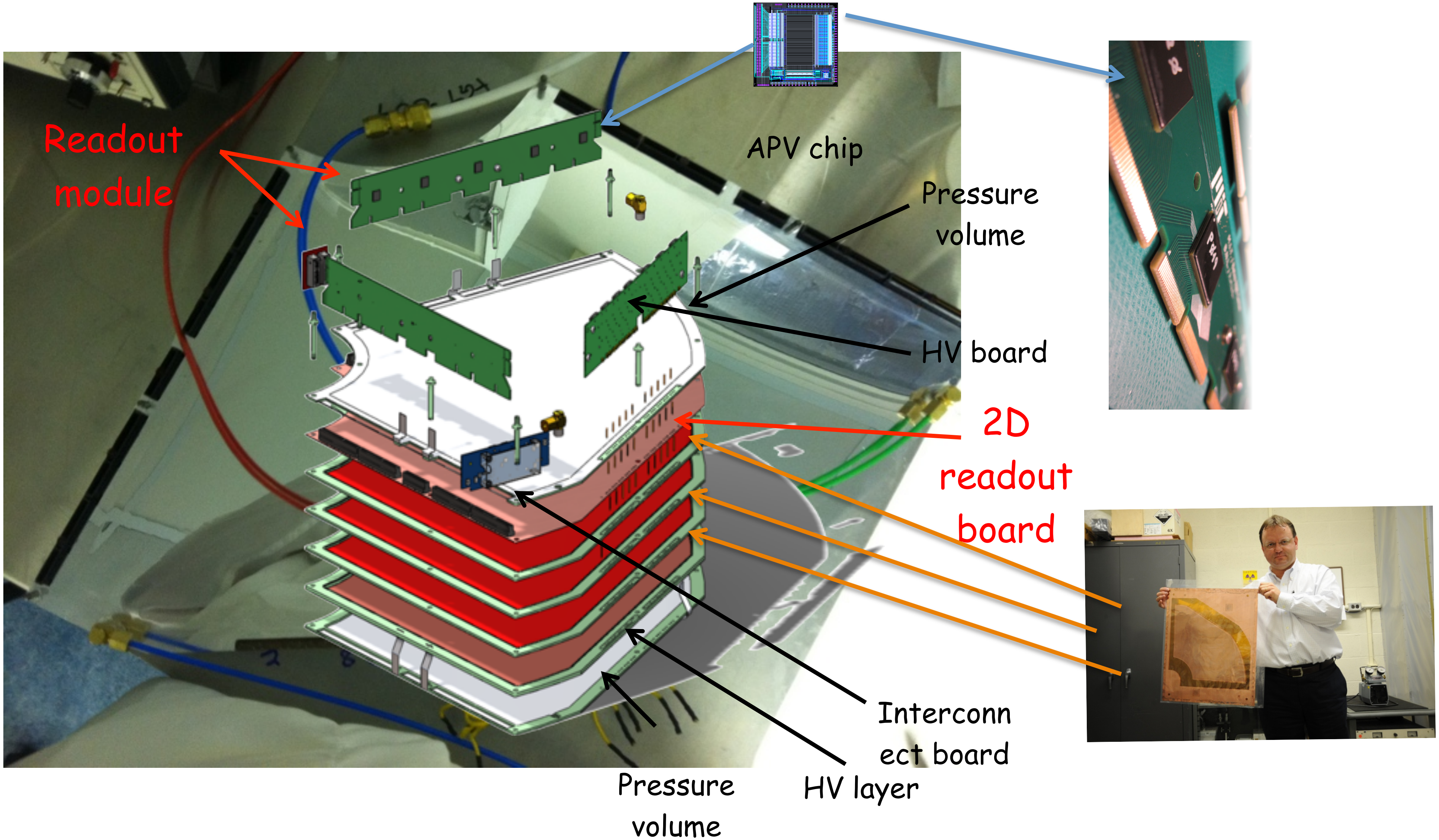
- FGT quarter section - layout

Read out R, ϕ
value to determine
hit position



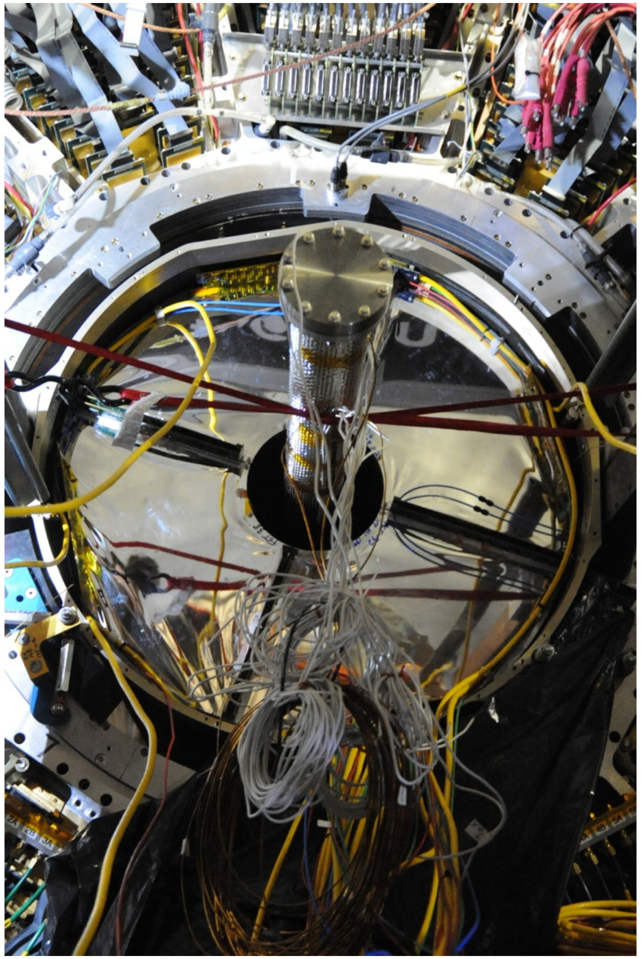
Look inside FGT quadrant

- FGT quarter section - layout

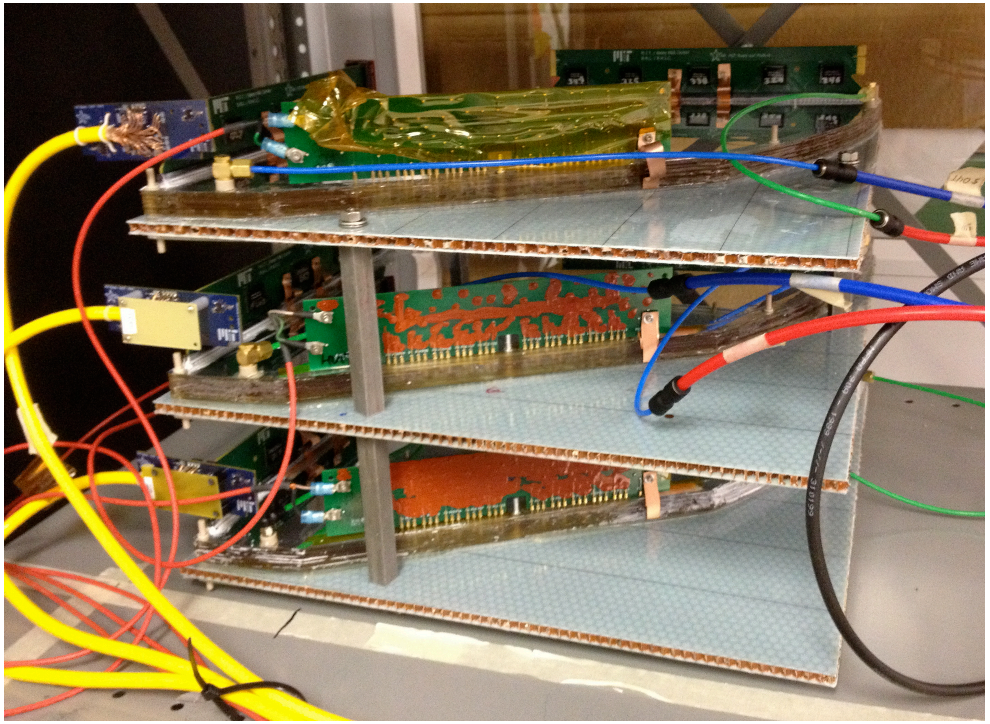


FGT installation and calibration

- FGT has been fully installed in STAR for RHIC run13.



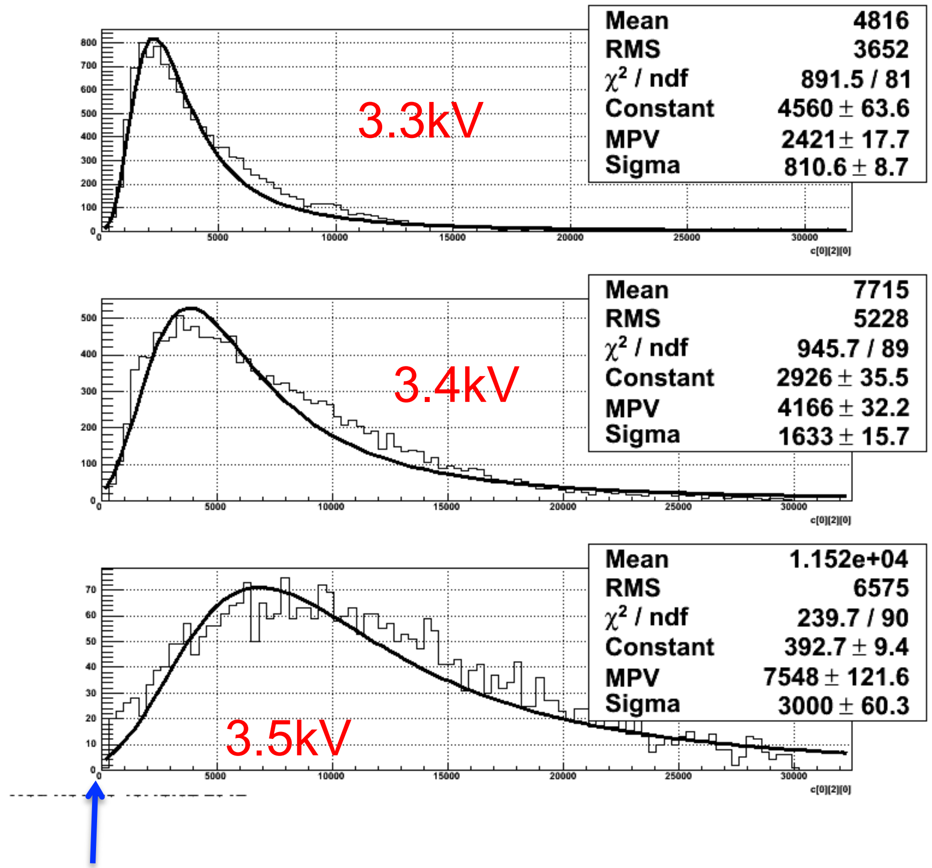
- Tune HV and APV parameters with three layers of FGT quadrants in cosmic ray test.

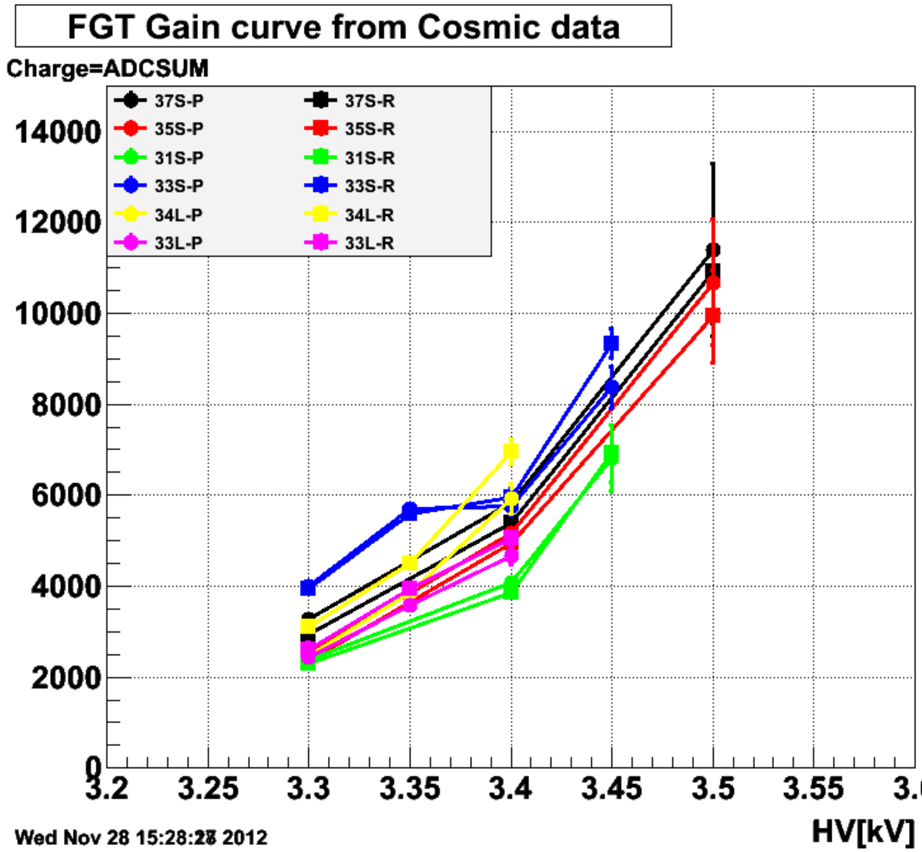


- Trigger scintillating counters not shown in this picture located above and below the FGT cosmic ray setup.

FGT cosmic ray – Gain curve

- Gain VS HV





Cluster threshold = 4*PedRMS(~40)*3timebin ~ 500

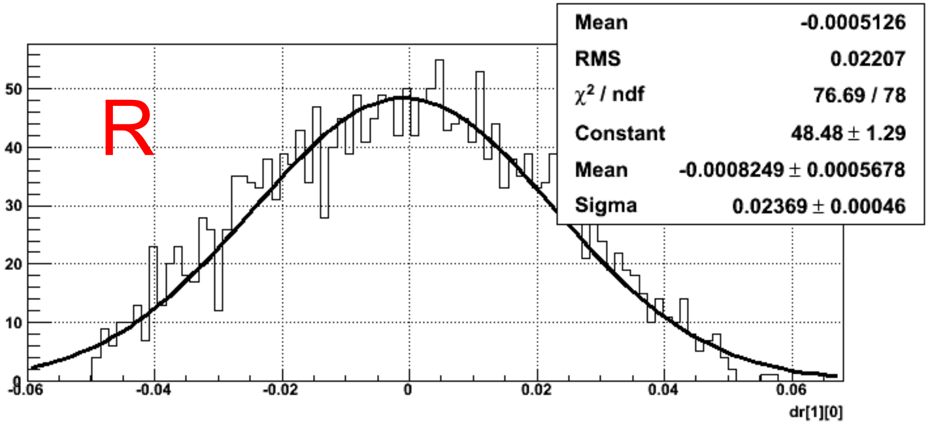
ADC saturate at peak time-bin of peak strip for

~10% of pulses at 3.4kV

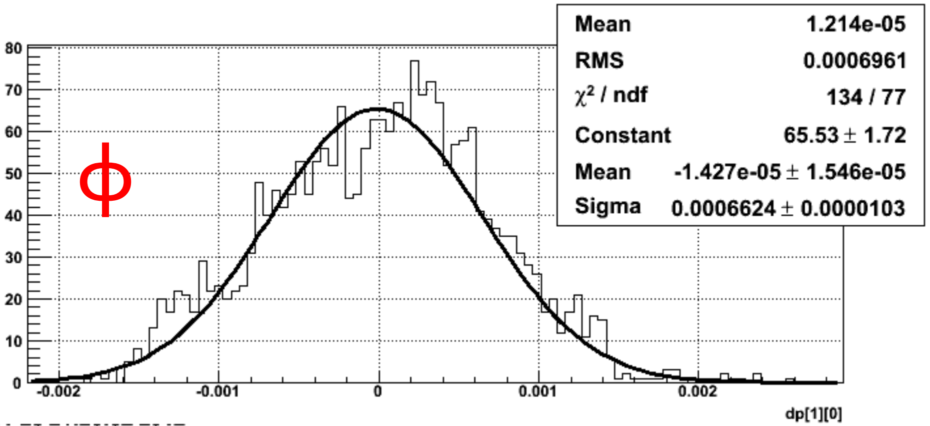
~50% of pulses at 3.5kV (but no visible effect on residual yet)

FGT cosmic ray - residual

- Use the top and bottom quadrants to determine the projected value for the middle quadrant.



Sigma = 240um



Sigma = 0.6mrad
=> 180um @ R=30cm

Assuming all quadrants have same resolution:

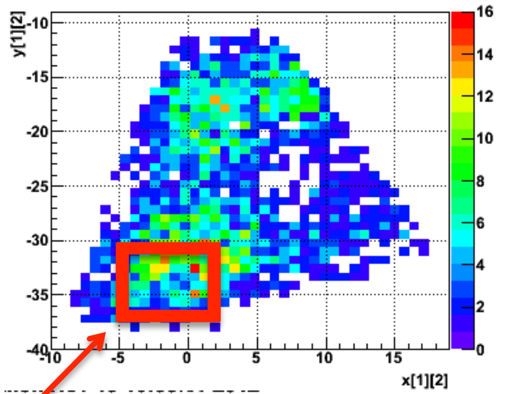
Single detector position resolution = Residual at middle quad/1.22 (from simple geometry)

180um residual @ Middle => 150um resolution at each detector

FGT cosmic ray - efficiency

- "Good event": with clean one cluster in R&ϕ of two quadrants and calculate efficiency for third quadrant within good trigger area.
- Sensitive to noise at higher HV & low Threshold.

Top-Short "Golden event" Hit Map



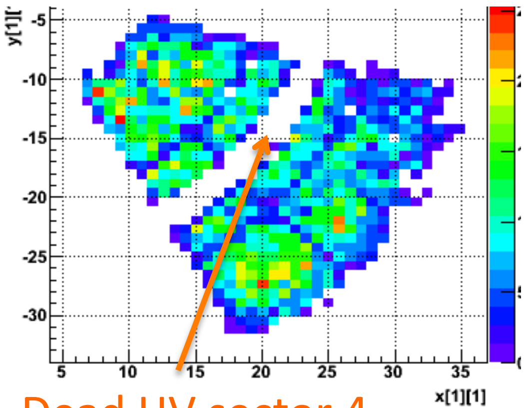
Efficiency calculated in this area only

Reading the short octant

	Top	Middle	Bottom
3.3kV	73%	83%	81% → higher thr 76%
3.4kV	83%	88%	78% → higher thr 86%
3.5kV	87%	95%	61% → higher thr 86%

Default Thr= 4*PedRMS(~40)*3timebin ~ 500
Higher Thr = 7 * PedRMS(~40)*3timebin ~ 850

Middle-Long "Golden event" Hit Map



Dead HV sector 4

	Top	Middle	Bottom
3.4kV	72%	60%	70%

Efficiency calculated in whole octant

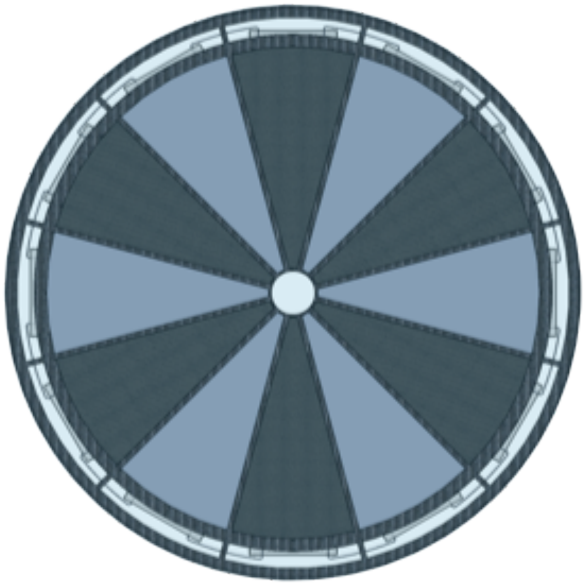
- Use the cosmic ray results to decide which quadrant for final installation.

FGT related measurements

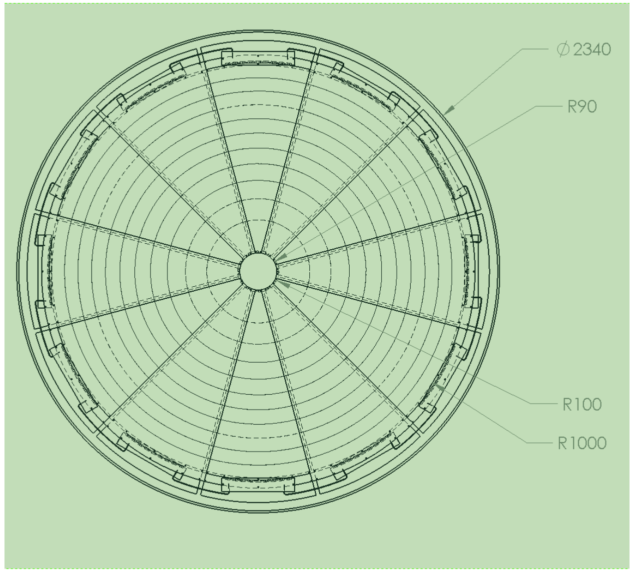
- The FGT will enhance the tracking capability of STAR in pseudorapidity range $1<\eta<2$.
- The primary FGT design is for W measurements in p +p collisions. But, together with other STAR detectors the following measurements may be possible.
  - $J/\psi \longrightarrow e^+e^-$, heavy flavor via electron decay channel.
  - Charged hadron, i.g. $\pi^+\pi^-$.
  - Drell-Yan?
  - Jets?
- Do we need larger GEM detectors?

Forward Large Triple-GEM design at Temple University (I)

- Supported by EIC R&D program.
- The active area of Large Triple-GEM detectors is 10cm<R<100cm.
- Each detector covers 30° azimuthal angle and use separate 2D readout.
- 12 GEM detectors are mounted on light-weight support structure



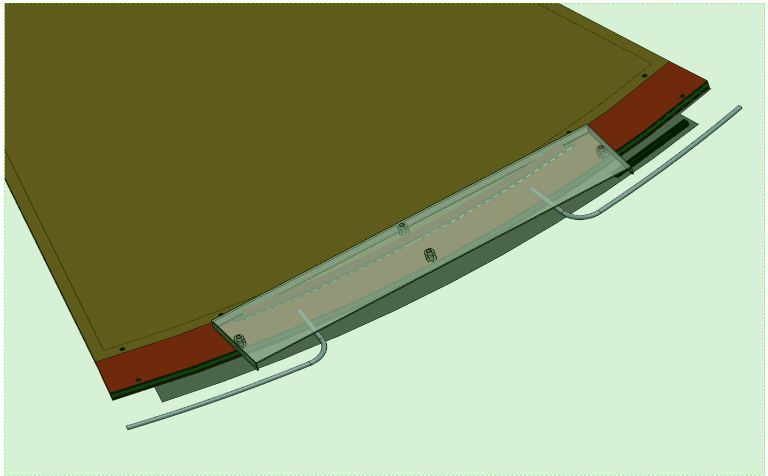
Schematics of the large GEM detector



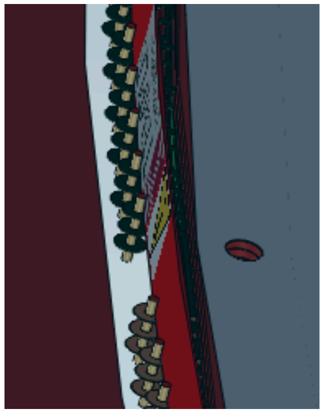
GEM segmented side of the large GEM detector

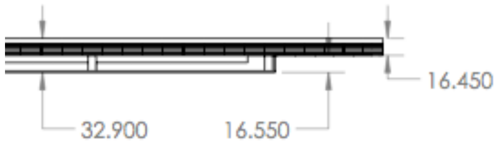
Forward Large Triple-GEM design at Temple University (II)

- Large Triple GEM layout

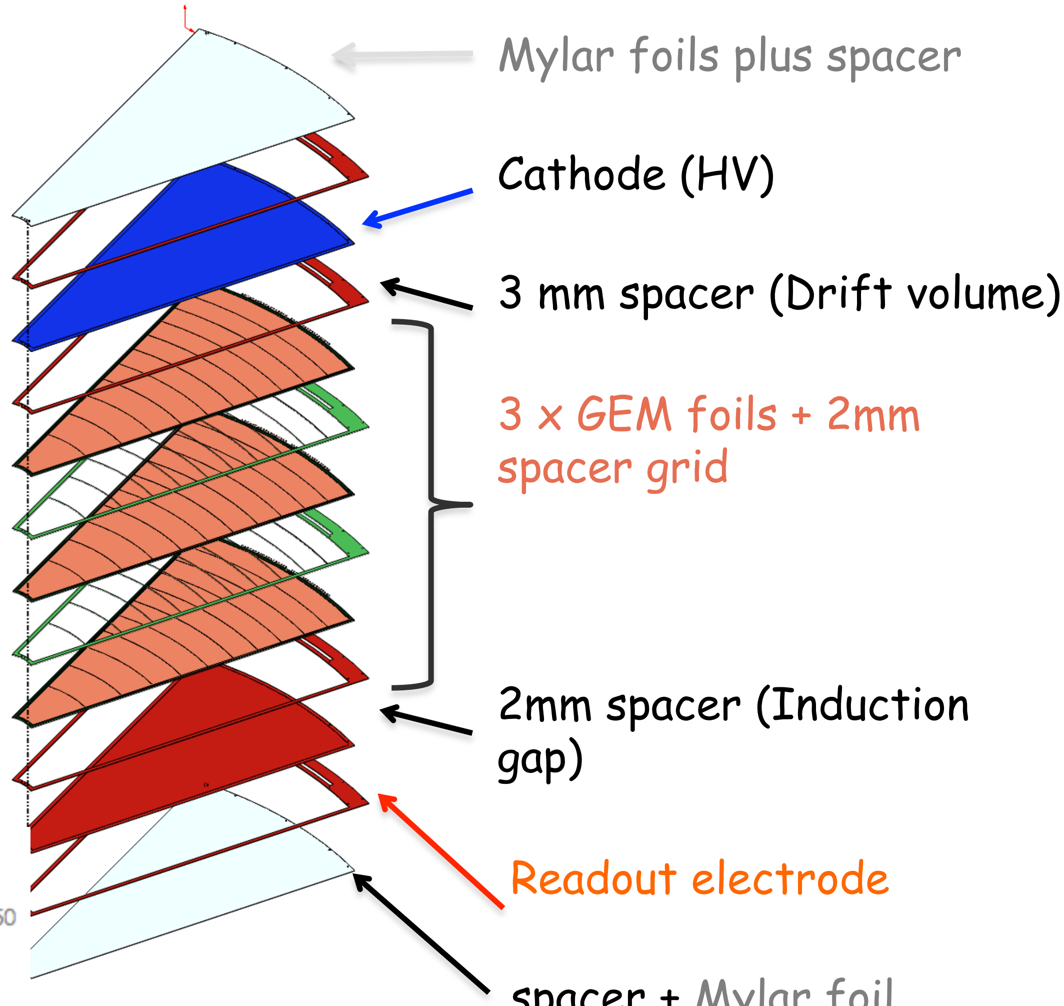


Gas, HV, and readout connections





16.45 mm thick
+ service box

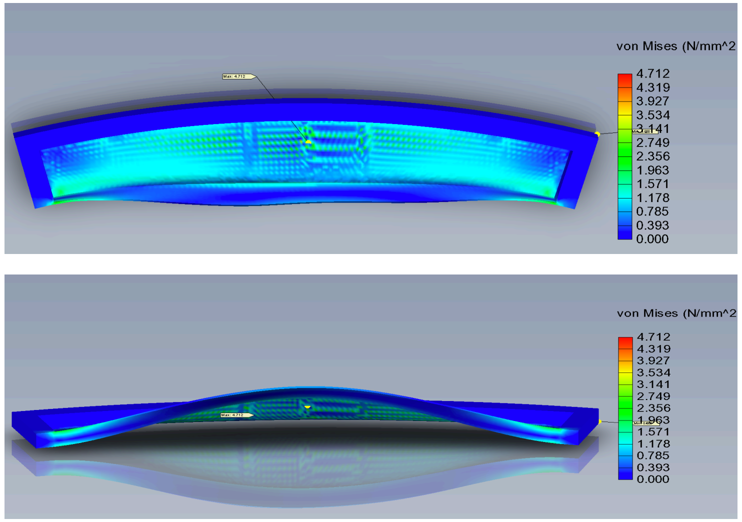


Exploded view of the GEM detector

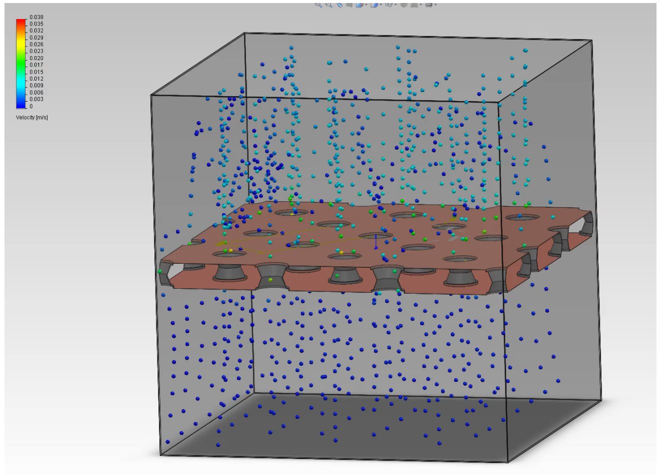
Lightweight (<1% X_0 in active area)

Forward Large Triple-GEM design at Temple University (III)

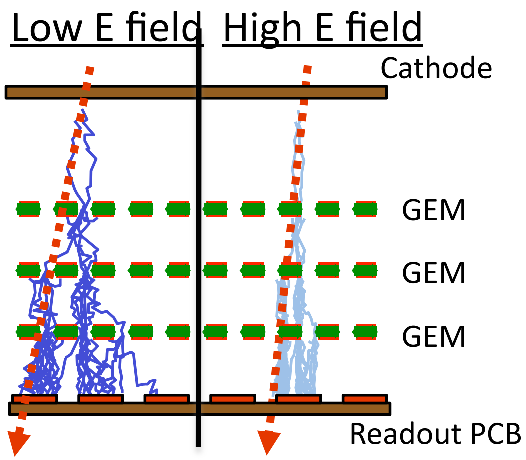
- Study the mechanical deformation.

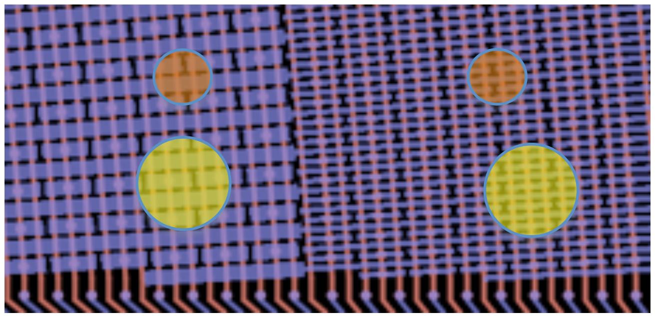


- Study the gas diffusion inside the detector.



Triple GEM amplification with diff HV conf.





Optimization of the signal size vs. electrode pitch

Can GEM detectors be used for p+A collisions?

- Question 1: Which measurements? For example, J/ψ production or di-hadron correlations to study gluon saturation in p+A.
- Question 2: Will the higher multiplicity in p+A collisions (compare to p+p collisions) impact the resolution of GEM detectors?
- Question 3: What kind of design of the GEM 2D readout board for p+A collisions? Strip only, strips plus pads, pad only or others?
- All these questions should be answered by simulations first to study the feasibility.

Summary

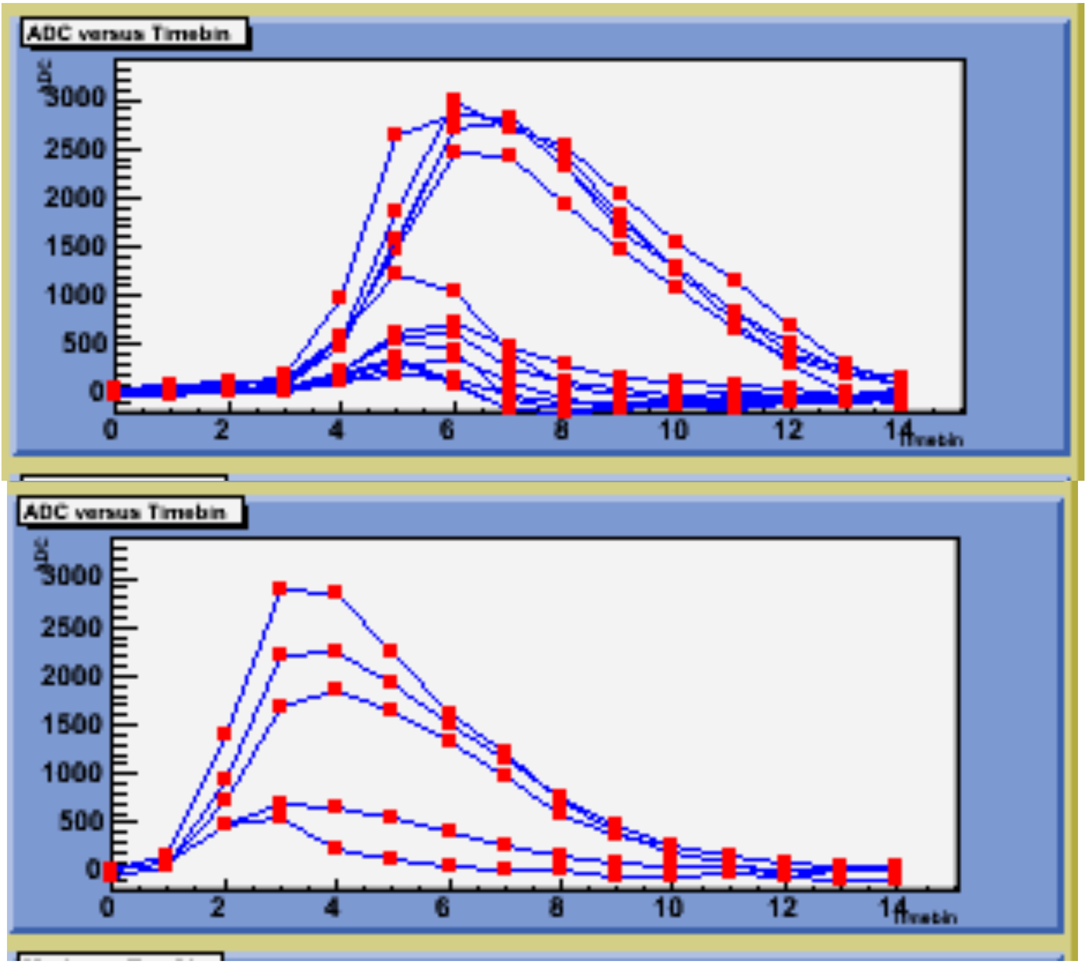
- The STAR FGT has been fully installed for RHIC Run 13. Cosmic ray results provide the first stage calibration for the FGT.
- Large Triple GEM detector R&D at Temple University is ongoing.
- The application of GEM detector in p+A collisions need simulation studies.
- Suggestions or comments on how to use GEM detectors in p+A collisions are very welcome!

Thanks for your attention!

- Thanks for the hard work of the STAR FGT group and Temple large GEM working group.
- Special thanks
  - Bernd Surrow, Maxence Vandenbroucke from Temple University,
  - Akio Ogawa, Ramiro Debbe from BNL.
  - Jason Bessuille, Ross Corliss, Gerrit van Nieuwenhuizen and Ben Buck from MIT.

Backup

- The FGT has 15 time bins.



One time-bin = 107nsec/4 = 27nsec
All strips with ADC sum 3 sigma above ped in a quadrant from 1 event are shown / panel
Timing moves 4 time-bin event by event due to cosmic system trigger only at RHIC clock