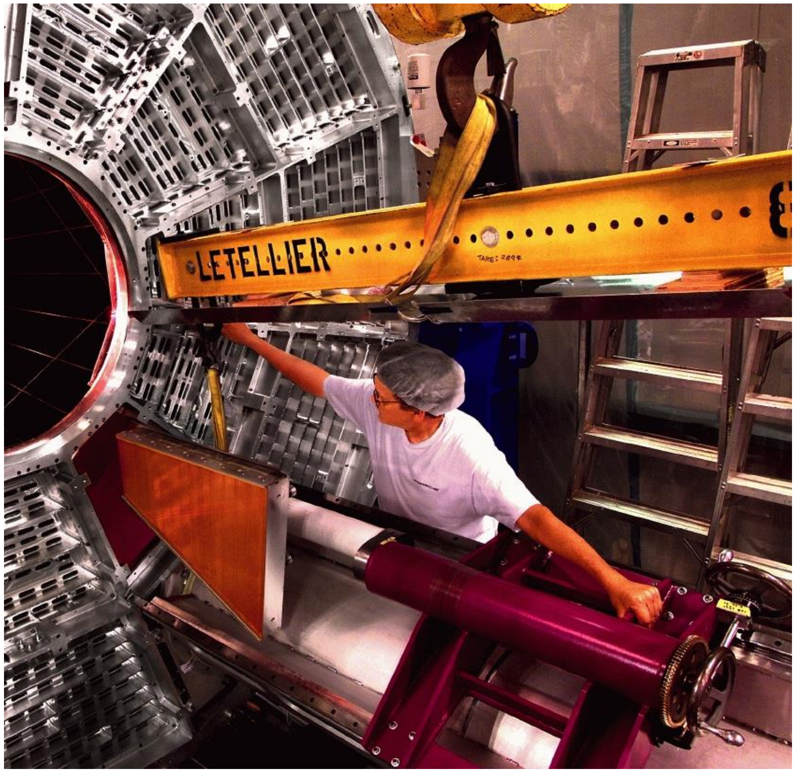
The iTPC upgrade at STAR



Chi Yang

for the STAR collaboration

University of Science and Technology of China

- ***Introduction***
- ***Motivation***
- ***Physics impaction in BES II***
- ***Upgrade details***
- ***Summary***

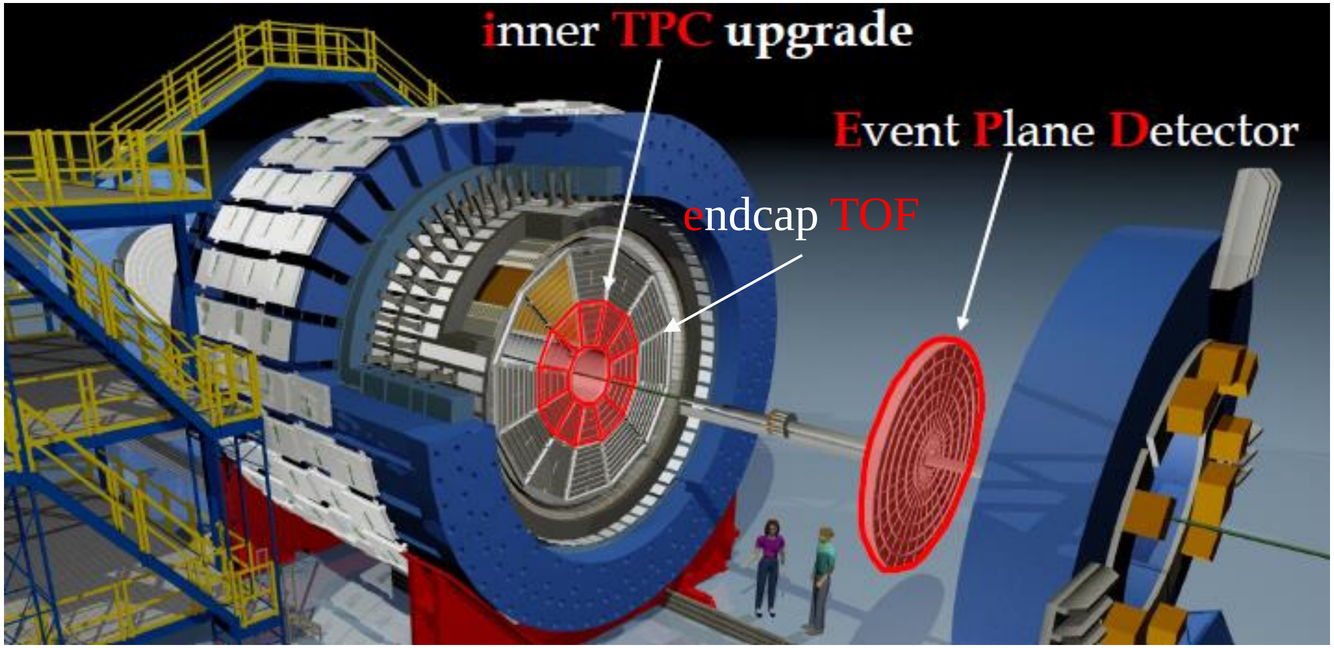
SQM Berkeley 2016

NSFC National Natural Science Foundation of China

Office of Science U.S. Department of Energy

STAR

Upgrade plan for BES II



iTPC upgrade:

TPC	iTPC upgrade
Sparse pad rows	Continuous pad rows
$\|\eta\|<1$	$\|\eta\|<1.5$ (geometric 1.7)
p_T >125 MeV/c	p_T >60 MeV/c
	Better dE/dx resolution

EPD upgrade:

$1.8 < \eta < 4.2$ **J. Zhang, Thu., 11:00**

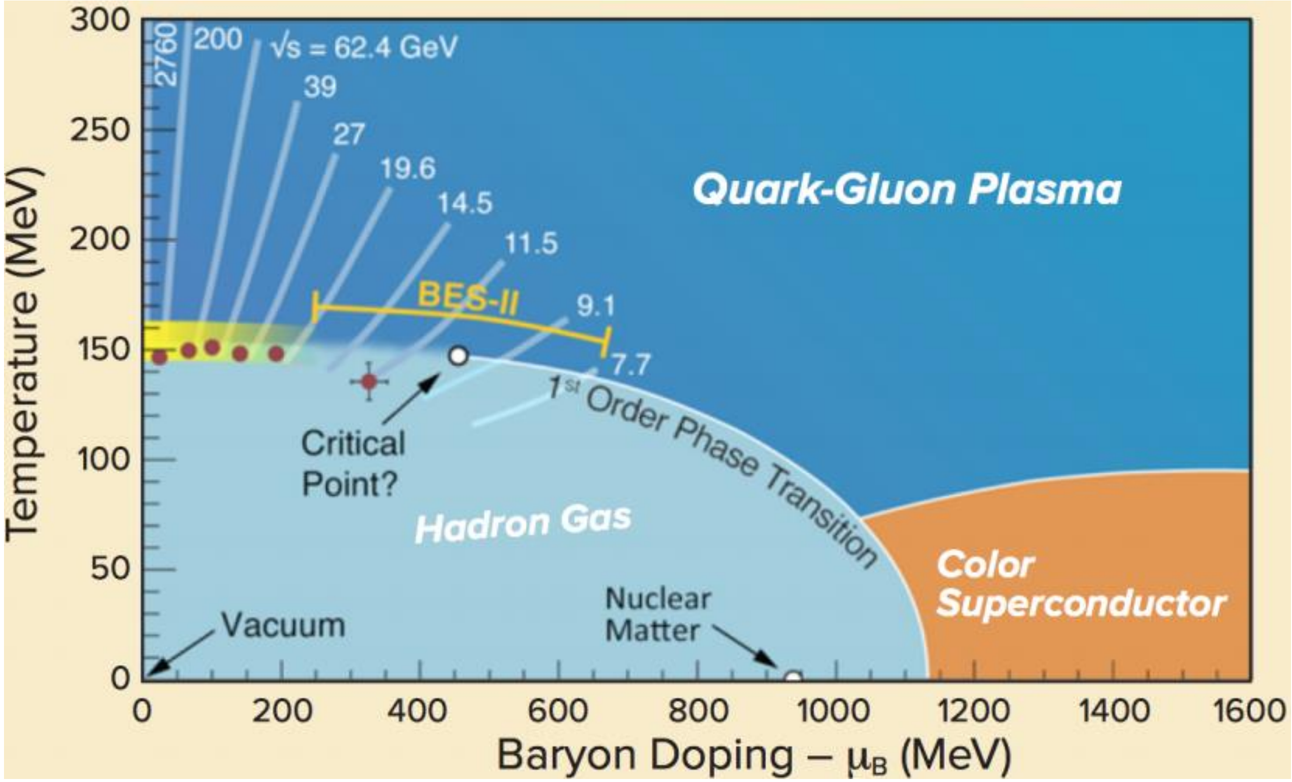
Replaces ageing BBC

Greatly improved Event Plane info (esp. 1st-order EP);
Better trigger & b/g reduction.

eTOF upgrade:

$-1.6 < \eta < -1.1$ **A. Schmah, Fri.,9:30**

Physics motivation



RHIC Beam Energy Scan Phase 1 (BES I)

From 2010 to 2014

7 collision energies 62, 39, 27, 19.6, 11.5 and 7.7 GeV

Vary temperature T and baryon chemical potential μ_B

Search for

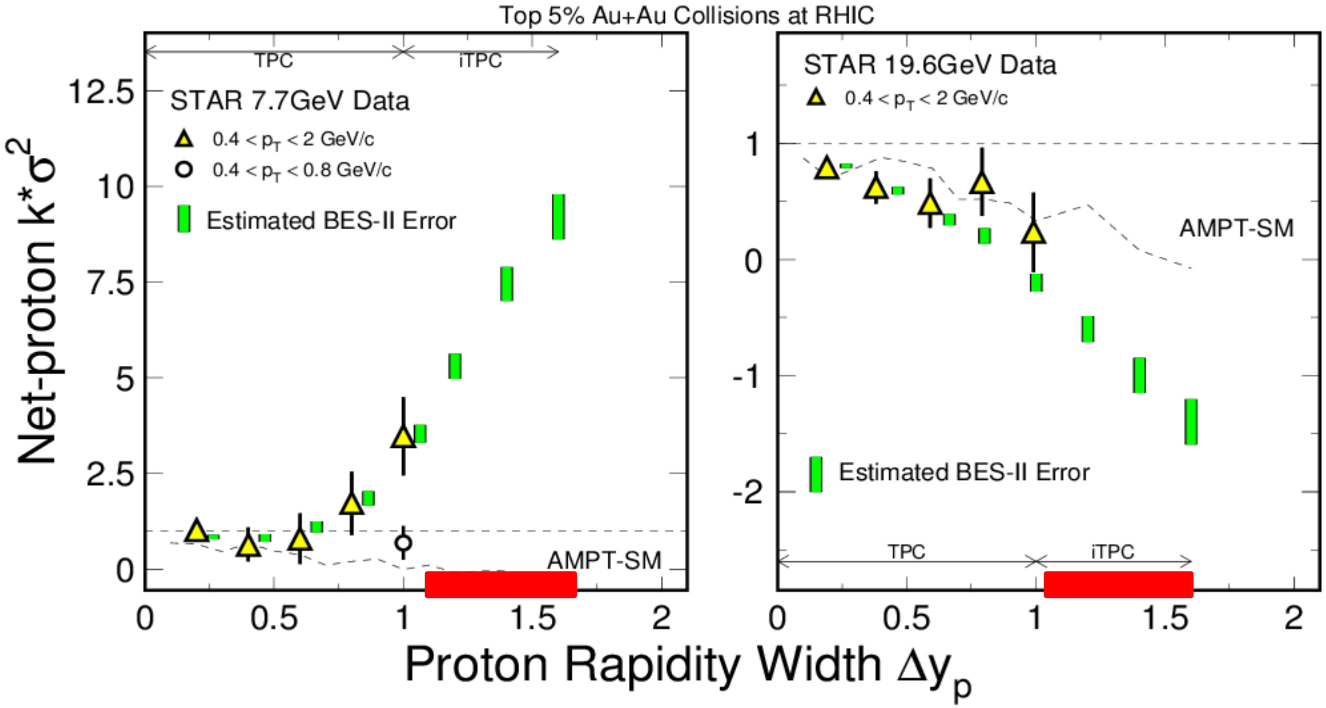
- Turn-off of sQGP signature
- Signs of 1^{st} order phase transition
- The QCD critical point
- Vector meson behavior in QGP

BES II and related analysis

Collision Energies (GeV):	7.7	9.1	11.5	14.5	19.6	
Chemical Potential (MeV):	**420**	**370**	**315**	**260**	**205**	
Observables	Millions of Events Needed					
R_{CP} up to p_T 4.5 GeV	NA	NA	160	92	22	Some Physics Gets Lost
Local Parity Violation (CME)	50	50	50	50	50	
asHBT (proton-proton)	35	40	50	65	80	
Directed Flow studies (v_1)	50	75	100	150	200	
net-proton kurtosis ($\kappa\sigma^2$)	80	100	150	200	300	
Elliptic Flow of ϕ meson (v_2)	100	150	200	300	400	
Dileptons	100	160	230	300	400	
Proposed Event Goals:	**100**	**160**	**230**	**300**	**400**	**Max**
Projected Weeks with LEReC	14	9.5	5.0	2.5	3.0+	

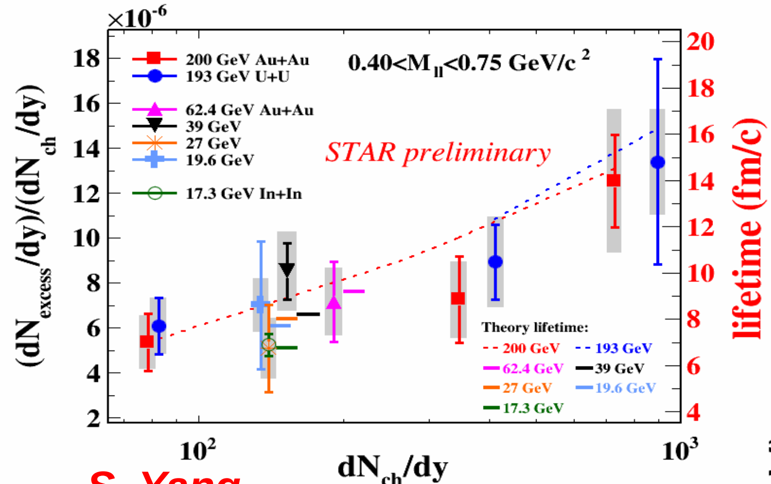
In BES I	***4***	***-***	***12***	***20***	***36***

Net-proton cumulants in BES II

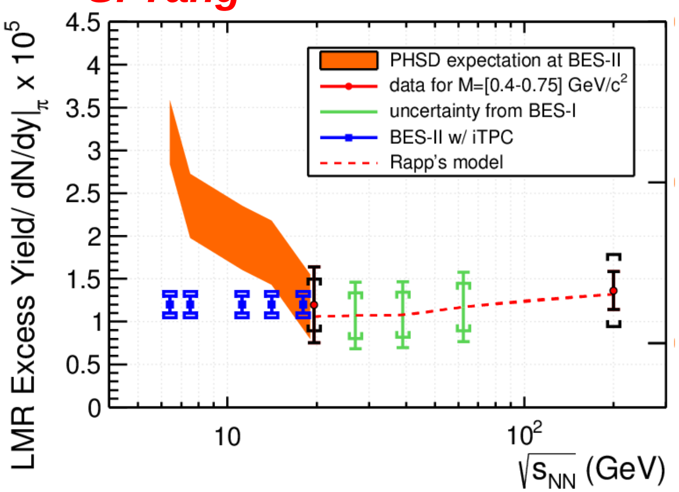


- ✓ BES I has revealed non-trivial energy dependence
- ✓ Rapidity length of correlation is important
- ✓ Measure as fct. of Δy_p in wide range is needed to establish true nature of correlation
- ✓ iTPC upgrade will enable this measurement in wider range

Di-electron measurements in BES II

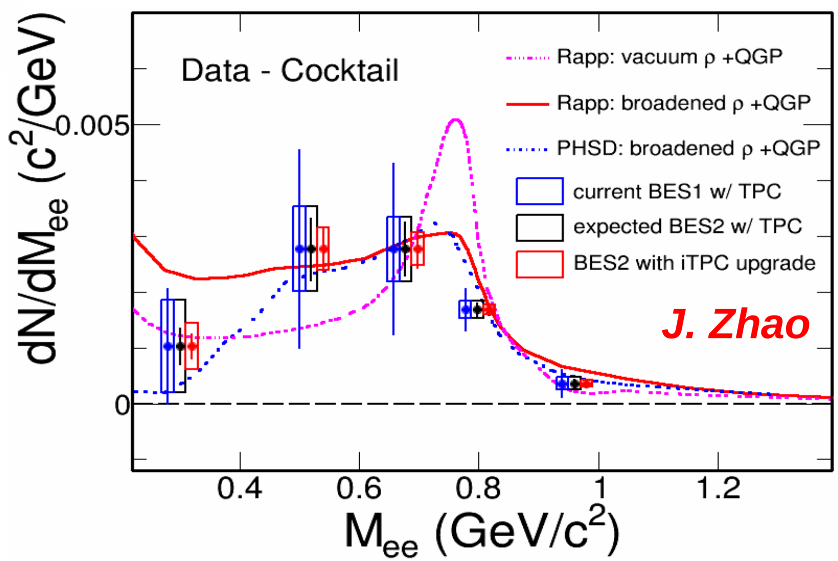


S. Yang



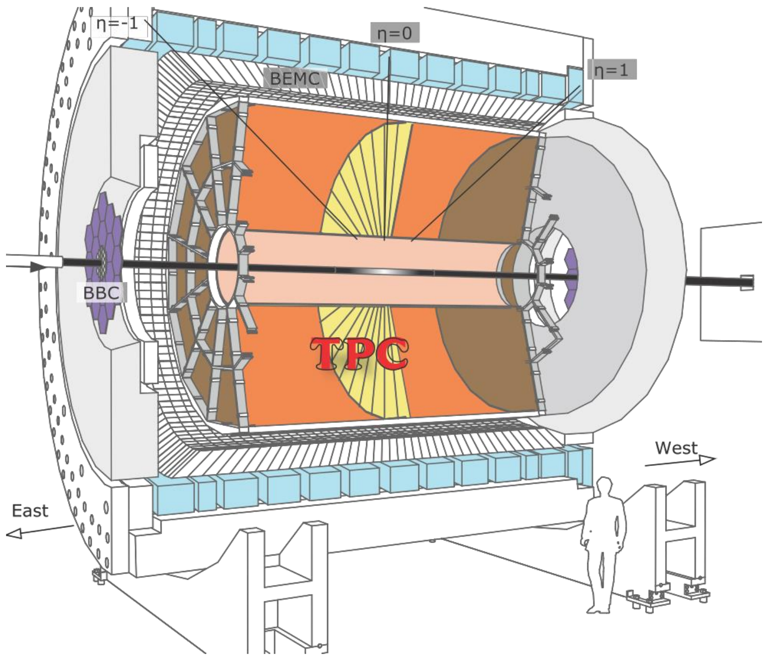
Low-mass di-electron production

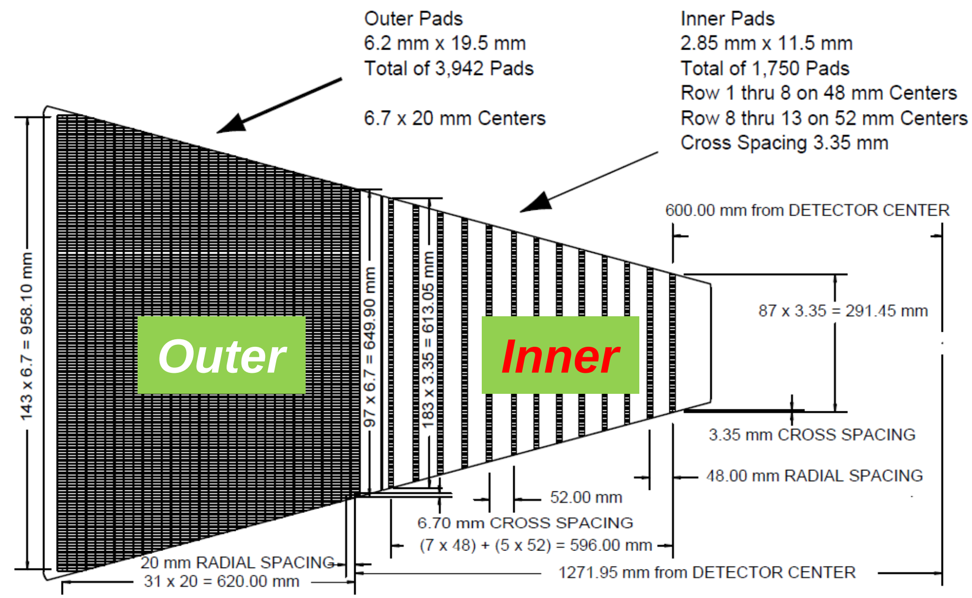
- *Au+Au, U+U, p+p*
- *19.6, 27, 39, 62, 200 GeV*
- *Vector mesons behavior in medium*
- *Production yield probes timescale of collisions*



- ✓ *Improved dE/dx will reduce the dominant systematic error on current data significantly*
- ✓ *Systematically study continuum from 7.7-19.6 GeV*
- ✓ *Distinguish model with different rho-meson broadening*
- ✓ *Study effect of total baryon density on LMR excess*

TPC at STAR





Working gas： P10 90% Ar +10 CH_4 Atmospheric + 2mbar

Readout： ~40us open window for ~2.1m drift length each side

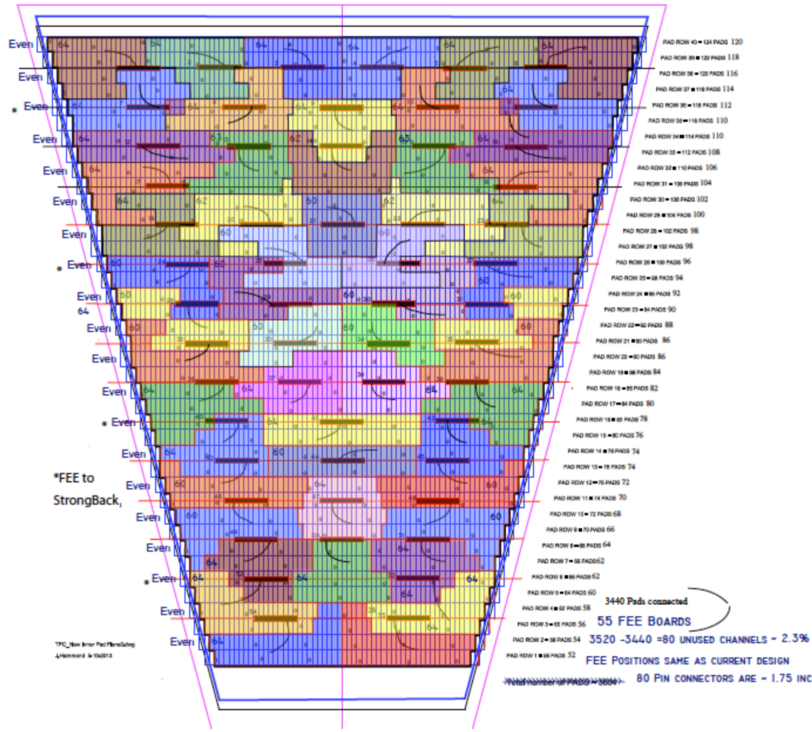
Sector： 12 sectors each side X 2 sides

Gain: ~ 3700 for inner ~1200 for outer

iTPC upgrade content

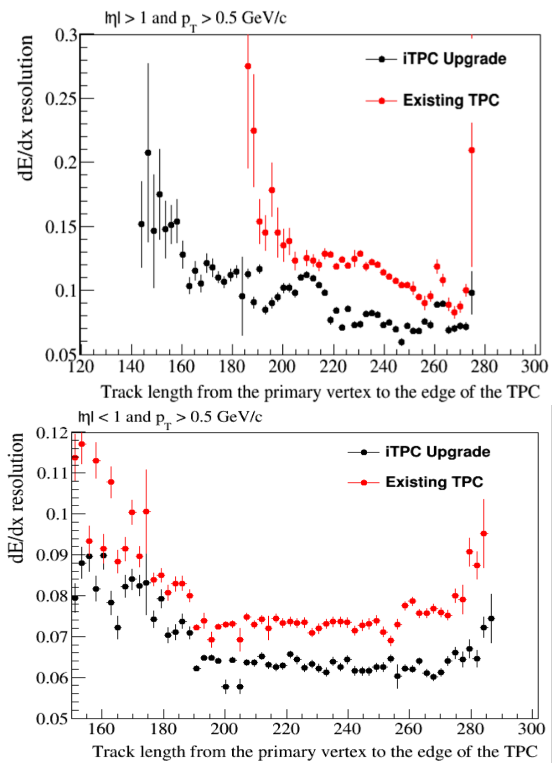
Produce and replace all 24 inner sectors including:

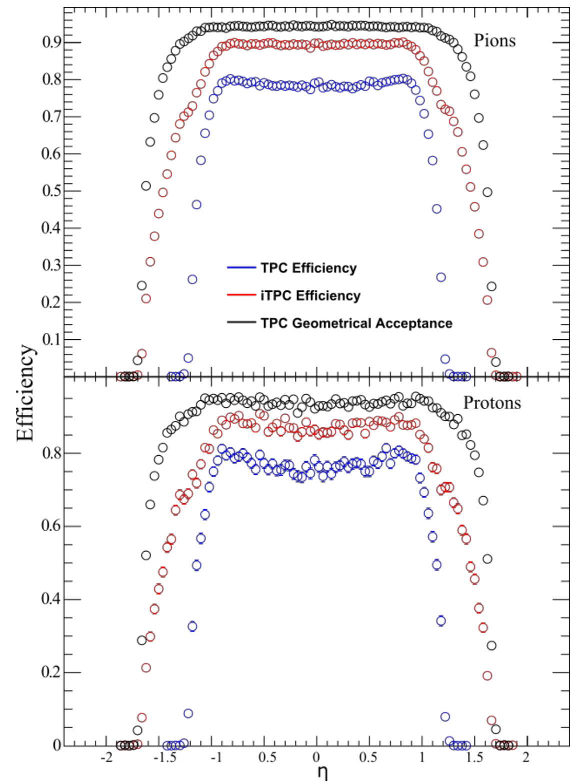
- ✓ Increase readout channels by about a factor of two
  - *-- Provide complete coverage for an inner sector*
- ✓ Renew all three wire frames
  - *-- Replace ageing wires*
- ✓ New electronics for inner sectors
  - *-- Double # of readout channels per FEE*
- ✓ New designed insertion tools
  - *-- Install and replace sectors*
- ✓ New designed strongback
  - *-- Optimize slot position for FEEs*



Pad plane layout for one sector

Simulated improved performance





I. Chakaberia

dE/dx resolution is significantly improved

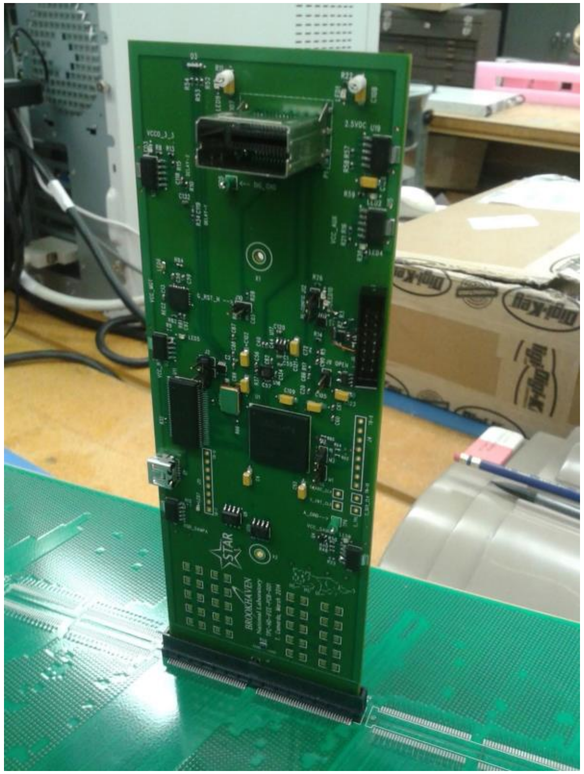
-- increased effective measured track length in TPC

The pseudo-rapidity coverage is nearing the geometrical acceptance limits of the detector

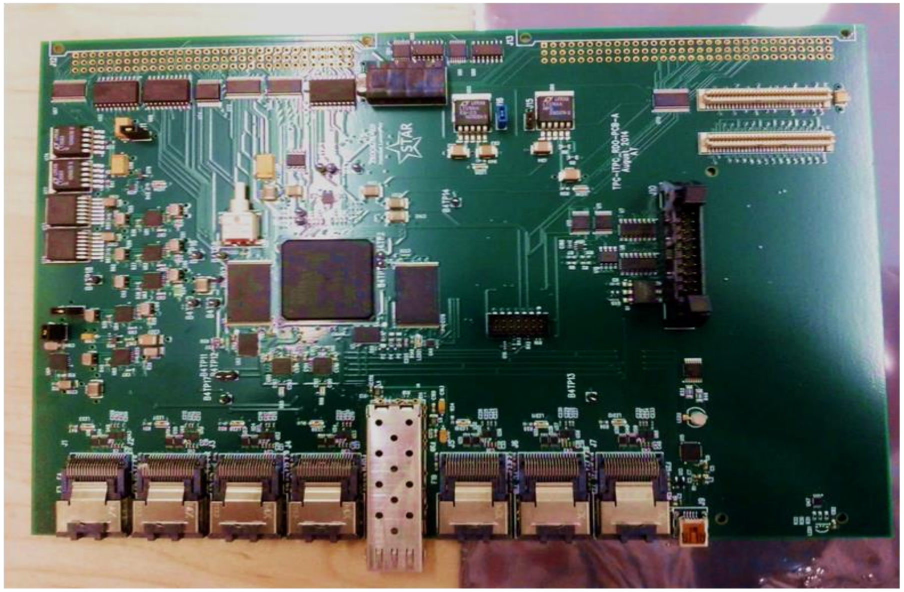
-- enables reconstruction of the low transverse momenta particles

Electronics

- iFEE based on current FEE layout, with ALICE SAMPA chip
- Twice #channels per FEE
- iRDO based upon a commercial daughtercard which houses the FPGA, PROM, SDRAM, clocks etc



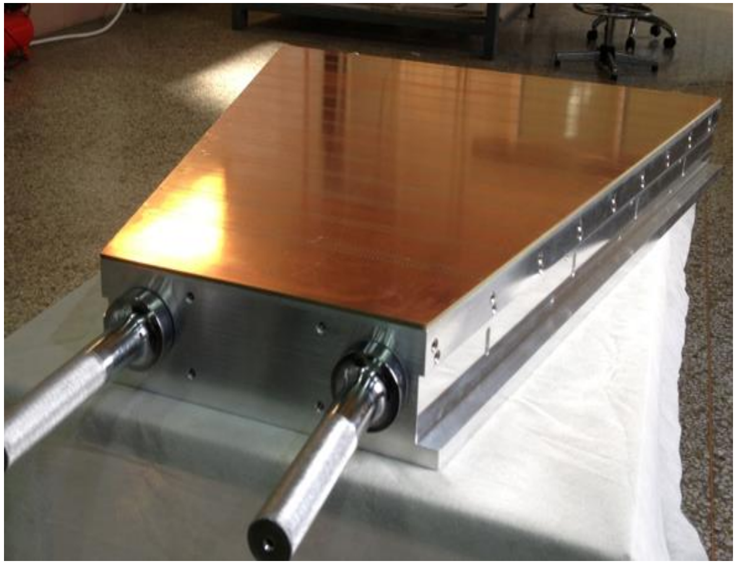
Pre-prototye iFEE electronic card shown plugged into the padplane



RDO prototype

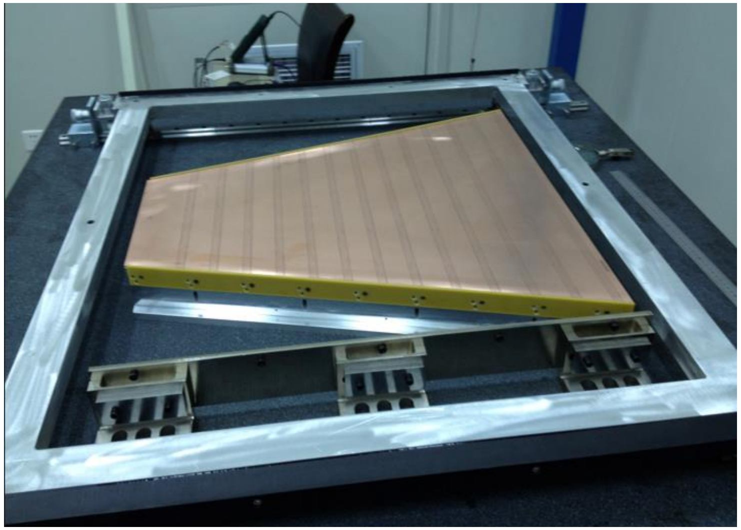
TPC sectors

MWPC production: *SDU, USTC, SINAP*



Padplane glued onto strongback

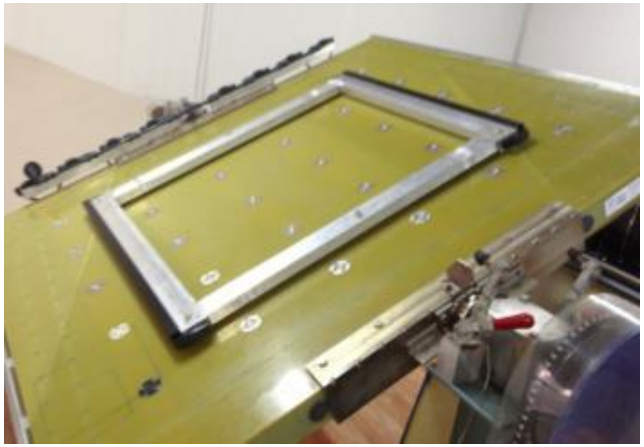
- Pure construction project, little or no engineering and design left
- Reduce ion leaking between inner and outer sector
- First prototype has been made at SDU



Wire mounting prototype

Wire frame

- Wire winding machine



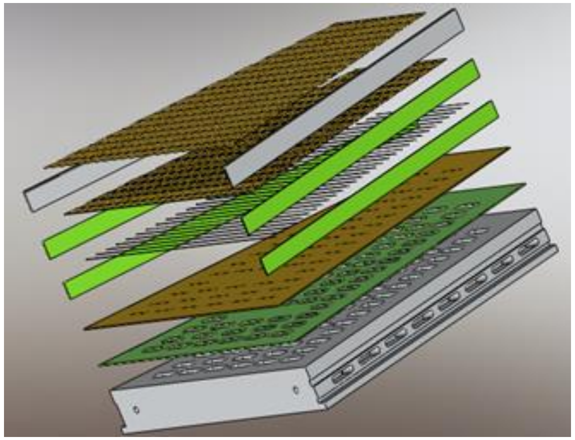
Three wire frames per sector

-- Anode, Ground, Gate

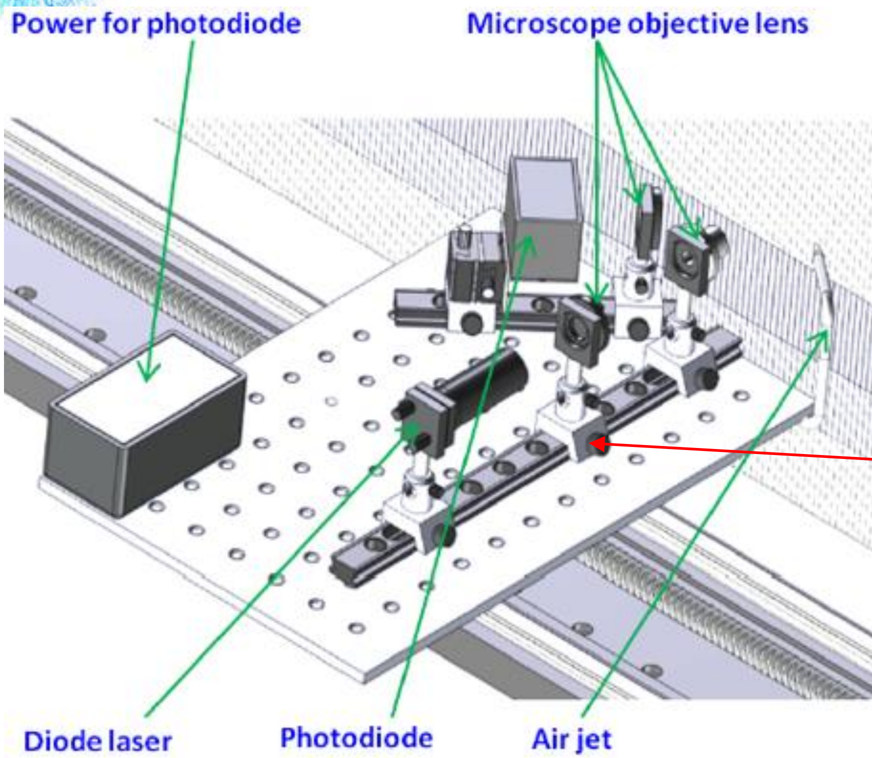
Precise wire tension, pitch and height

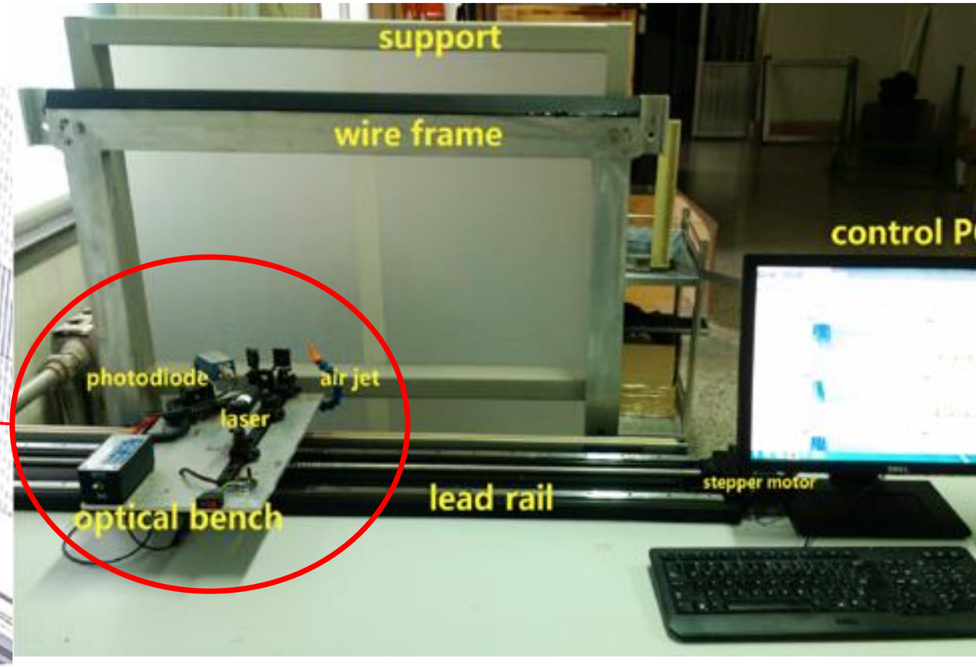
-- Gain uniformity, Active area

	Tension	Tolerance	Composition	Pitch (mm)	Diam.(μm)
Anode wire	0.5N	0.03N	Au-plated W	4	20
Ground plane	1.2N	0.06N	Au-plated Be–Cu	1	75
Gated grid	1.2N	0.06N	Au-plated Be–Cu	1	75



Wire tension, pitch and height





Determine wire tension by optically measuring the vibration frequency:

-> laser scan on each wire

-> synchronized with gas jet

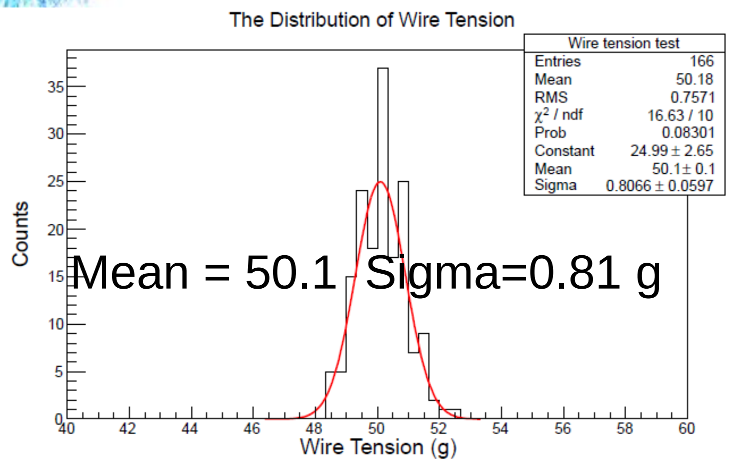
-> get voltage fluctuation transformed of laser absorption via photodiode

-> get fundamental oscillator frequency via FFT algorithm

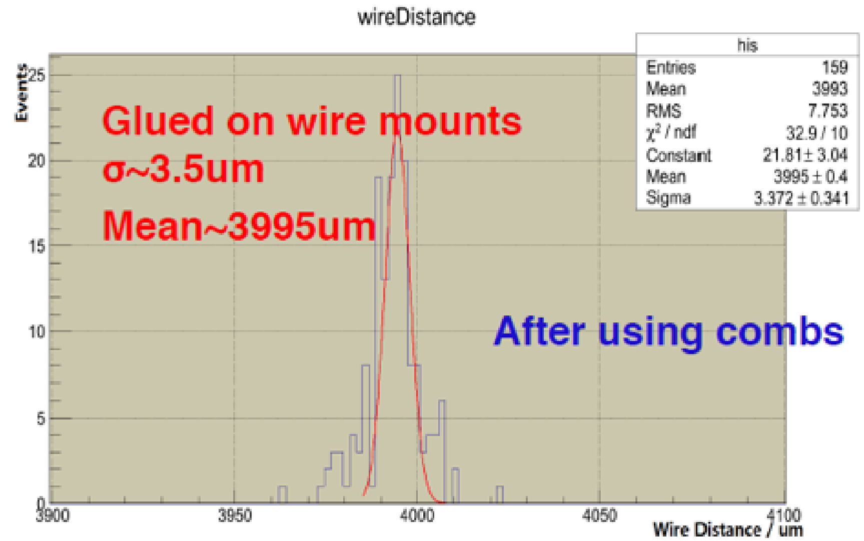
-> calculate tension

Wire pitch is obtained simultaneously.

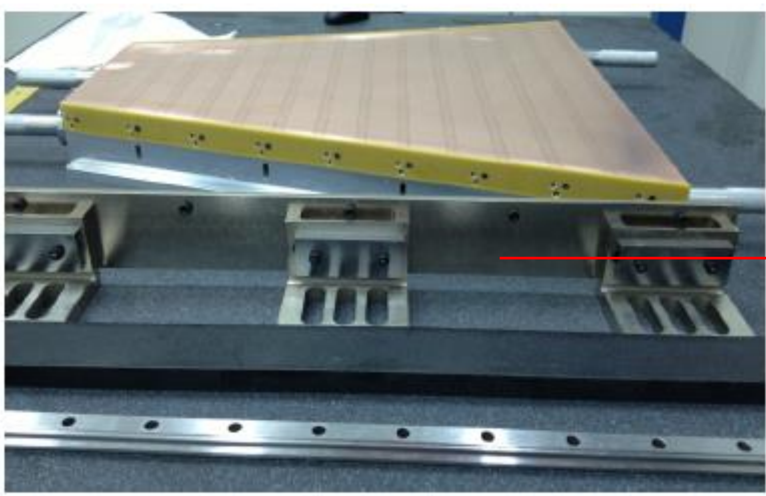
Wire tension, pitch and height



<6% precision request



Wire pitch is at the same level as previous TPC measurement (~7μm)

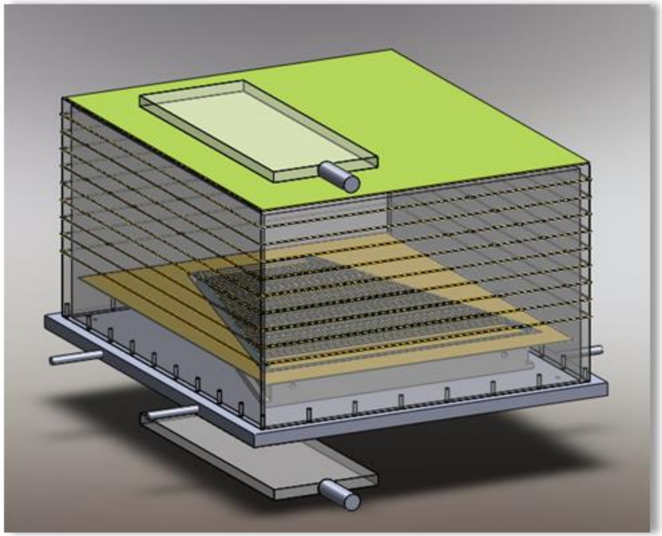


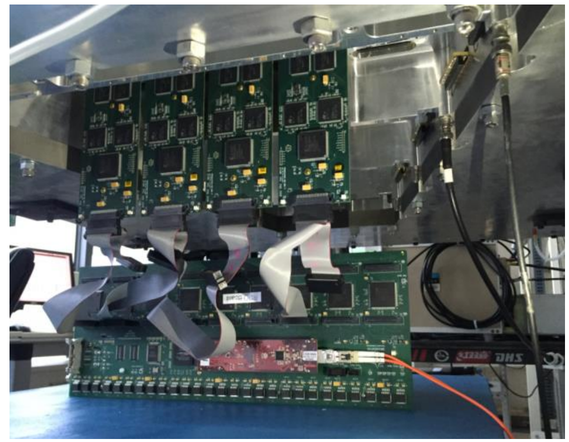
Wire combs:

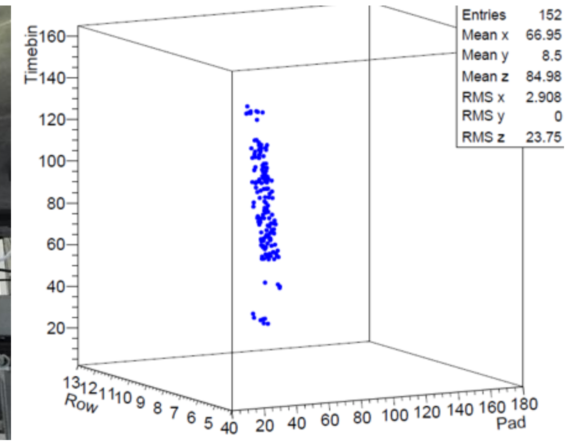
Fix wire pitch, ~3.5μm precision
Fix wire height, ~20μm precision

Prototype testing system

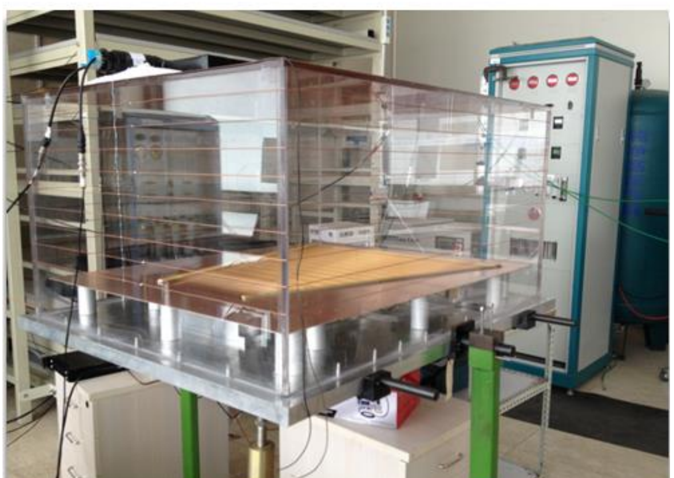
Layout of the test chamber with sector and trigger







- *A testing system has been built*
- *DAQ similar to current STAR TPC DAQ*
- *Cosmic-ray track can be reconstructed*
- *Testing based on ^{55}Fe and X-ray source has been processing for gain scan*
- *More test results coming soon!*

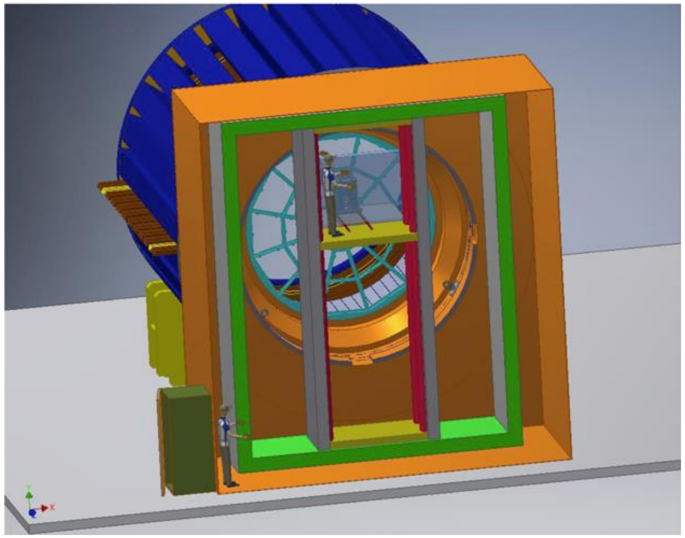


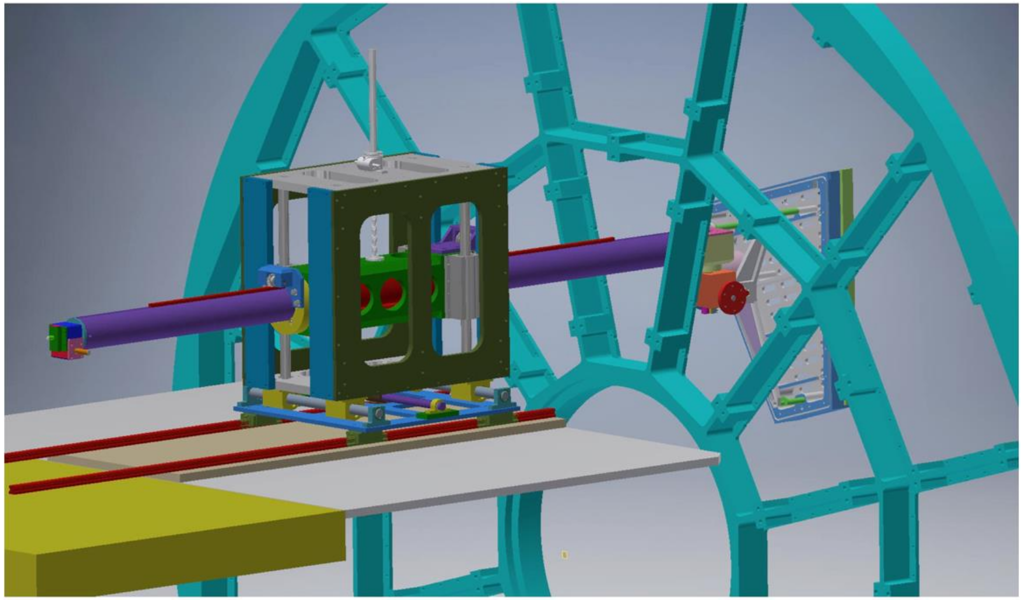
Insertion tooling and installation

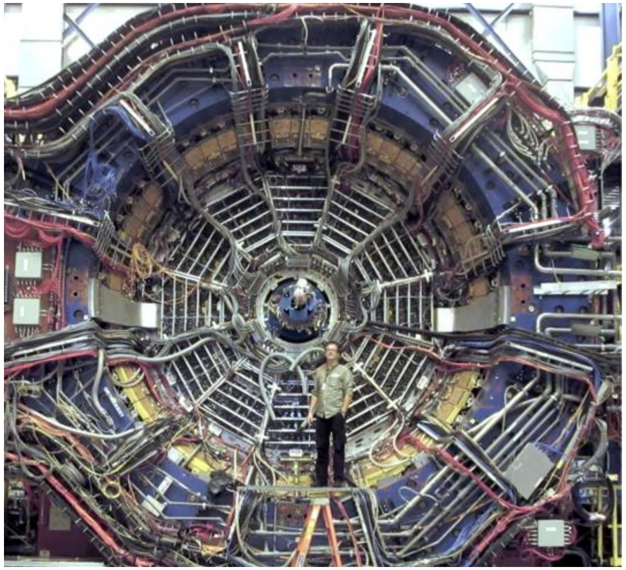
Clean room covers the installation area

Insertion tooling needed for installation and for replacement of two outer bad sectors

Designed by Rahul Sharma, Ralph Brown and much input from LBNL, CERN







Time schedule

Installation schedule

- End Run-17 (6/1/2017)
  - *8 months installation period*
  - *Verify & test installation tooling*
  - *Exchange one outer sector, and possibly one new inner sector module with electronics*

- Run 18 Start 2/1/2018 End 5/31/2018 (13 weeks)
  - *Long installation (shutdown) period needed*
  - *Aim for start of Run-19 in March 2019*

Production schedule

- Start from Jan.2017 to Apr.2018
  - *16 months mass production period*
  - *28 sectors (24+4)*
  - *Mass production procedure determined by 2016*
  - *Two prototypes produced and tested by 2016*

Summary

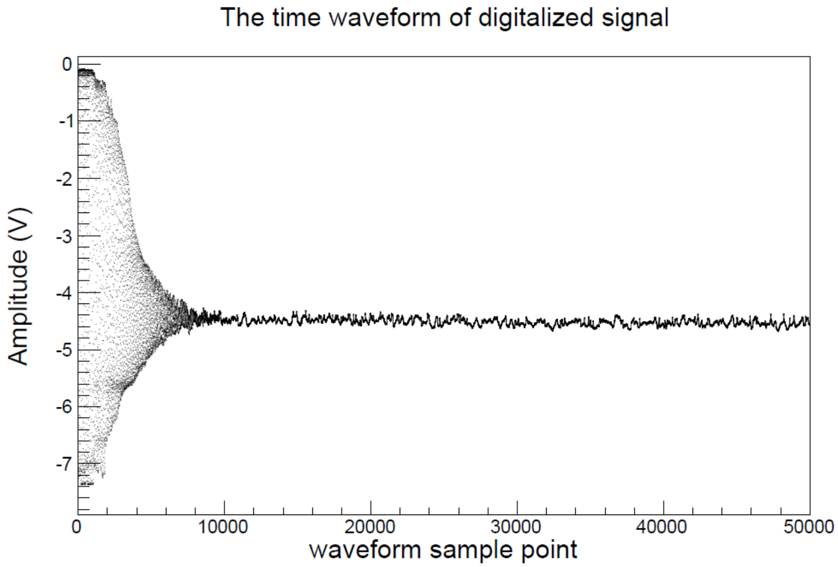
- iTPC upgrade will improve many STAR physics results both in statistics and acceptance coverage
- Improved performance from inner TPC will reduce many physics analysis uncertainties
- A complete construction plan is ready, aiming fully installation before Run-19 in March 2019
- First inner sector prototype has been produced with qualified wire tension, pitch and height
- Detail testing for the first prototype is ongoing

- *Thanks to all iTPC group members*

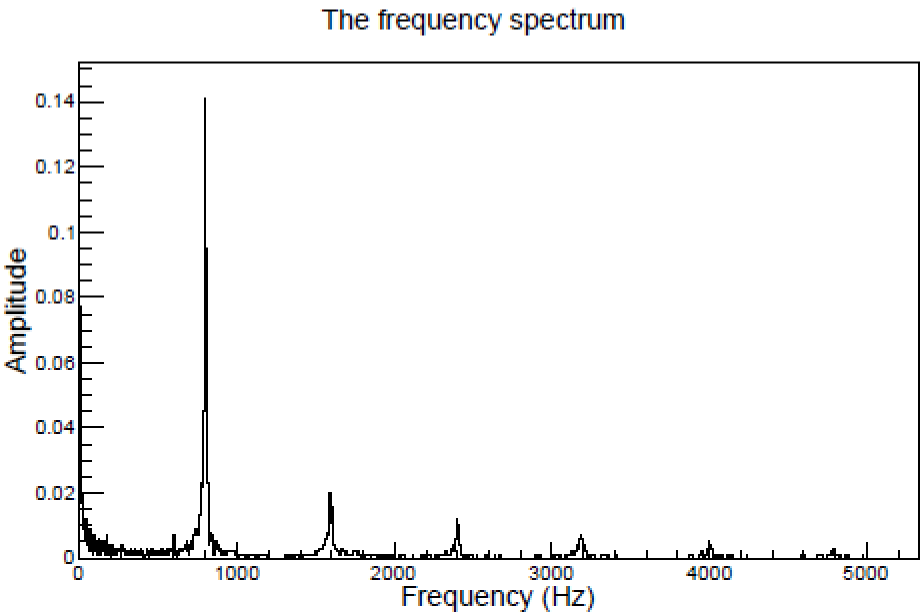
Thank you!

Wire tension measurement detail

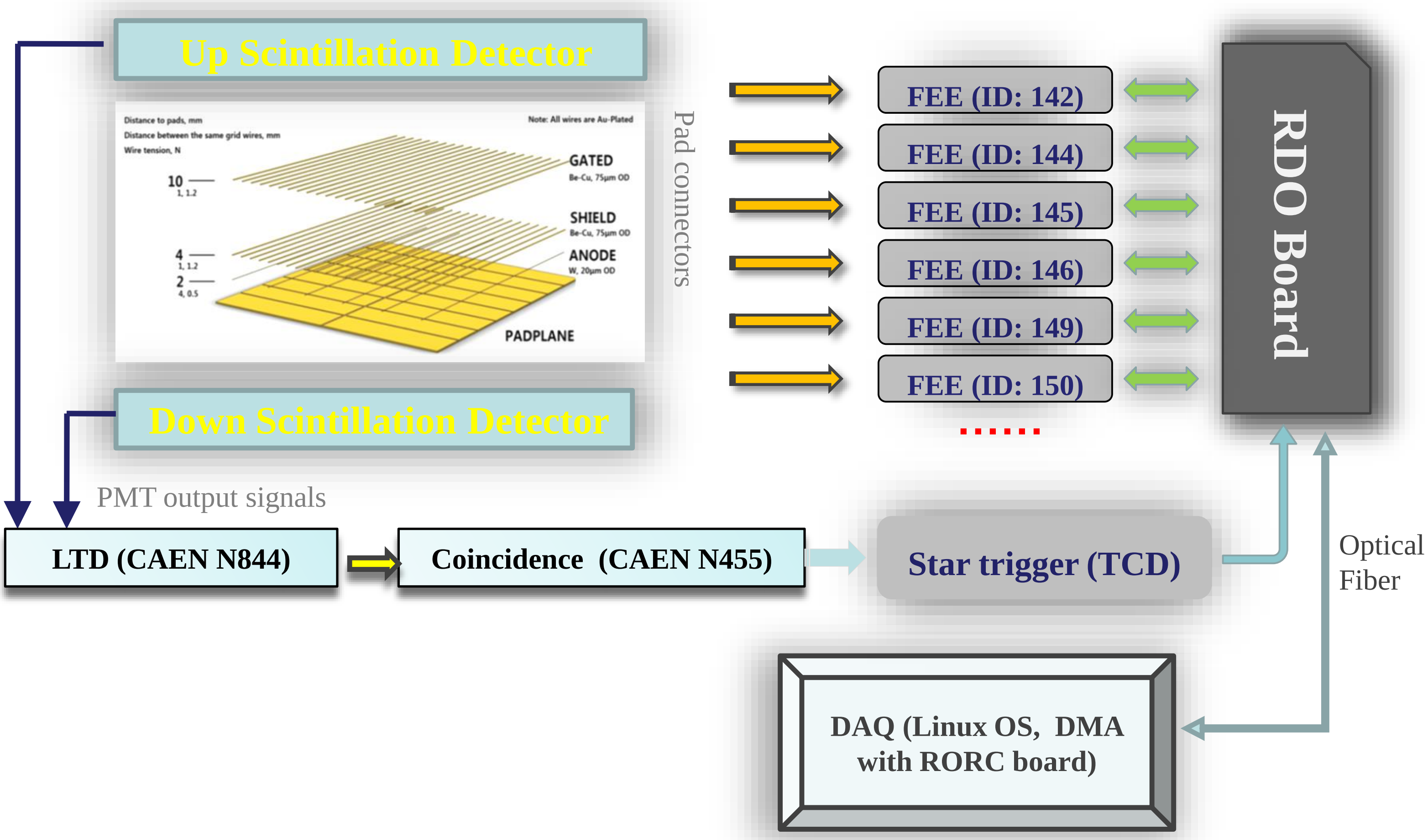
voltage fluctuation transformed of laser absorption via photodiode



fundamental oscillator frequency via FFT algorithm (highest peak)



Testing system layout



TPC parameters

Basic parameters for the STAR TPC and its associated hardware

Item	Dimension	Comment
Length of the TPC	420 cm	Two halves, 210 cm long
Outer diameter of the drift volume	400 cm	200 cm radius
Inner diameter of the drift volume	100 cm	50 cm radius
Distance: cathode to ground plane	209.3 cm	Each side
Cathode	400 cm diameter	At the center of the TPC
Cathode potential	28 kV	Typical
Drift gas	P10	10% methane, 90% argon
Pressure	Atmospheric +2 mbar	Regulated at 2 mbar above atm.
Drift velocity	5.45 cm/μs	Typical
Transverse diffusion (σ)	$230\ \mu m/\sqrt{cm}$	140 V/cm & 0.5 T
Longitudinal diffusion (σ)	$360\ \mu m/\sqrt{cm}$	140 V/cm
Number of anode sectors	24	12 per end
Number of pads	136 608	
Signal to noise ratio	20:1	
Electronics shaping time	180 ns	FWHM
Signal dynamic range	10 bits	
Sampling rate	9.4 MHz	
Sampling depth	512 time buckets	380 time buckets typical
Magnetic field	0, $\pm$0.25 T, $\pm$0.5 T	Solenoidal