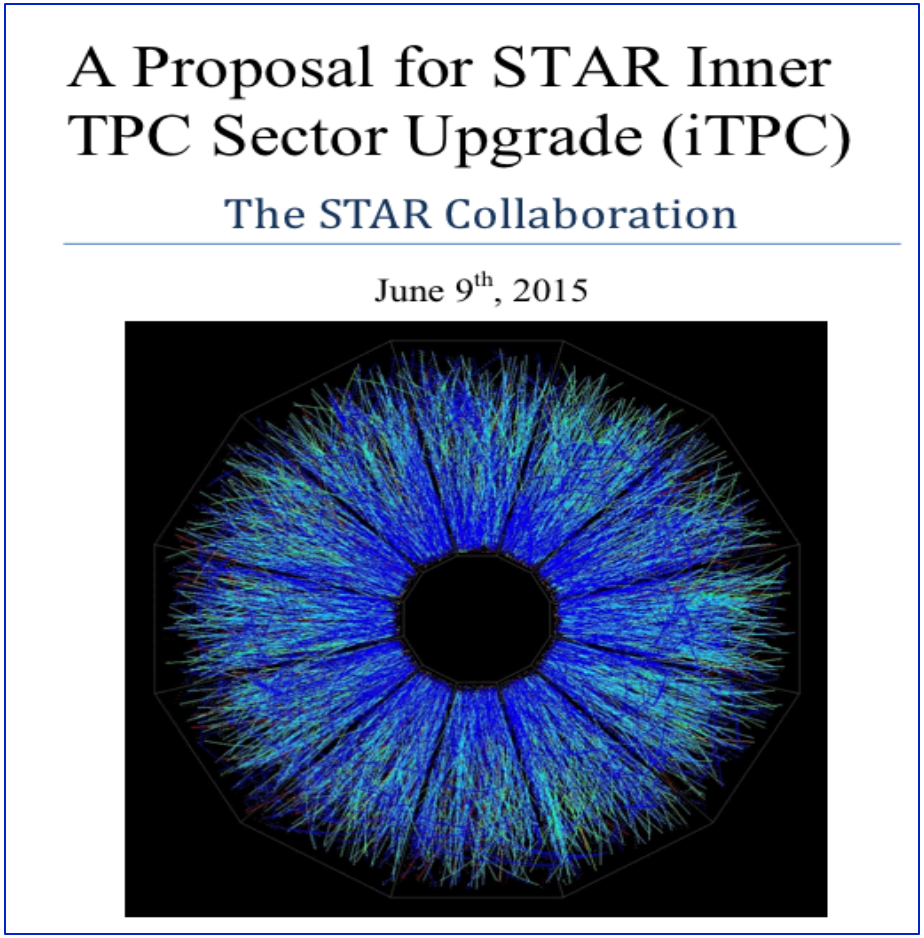
iTPC upgrade at STAR experiment

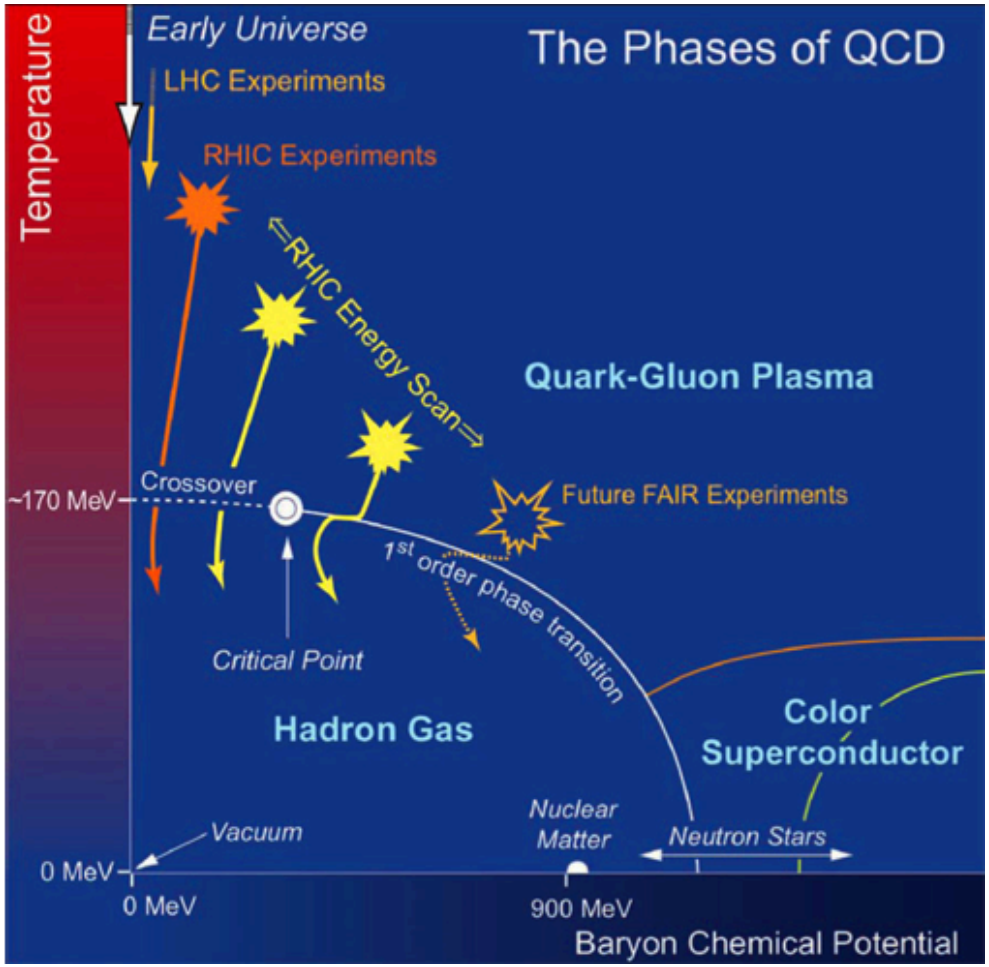
Qinghua Xu (Shandong U.), for the STAR/iTPC group



Hadron 2015, Kunshan，August 2015

The Phase Diagram of QCD Matter

- **Heavy ion collisions allow to explore the QCD phase structure by varying the collision energy.**



Goals of RHIC- BES program:

- ✓ **Turn-off of QGP signatures**
- ✓ **Search critical point**
- ✓ **1st order phase transition**

RHIC Beam Energy Scan II- Physics for iTPC

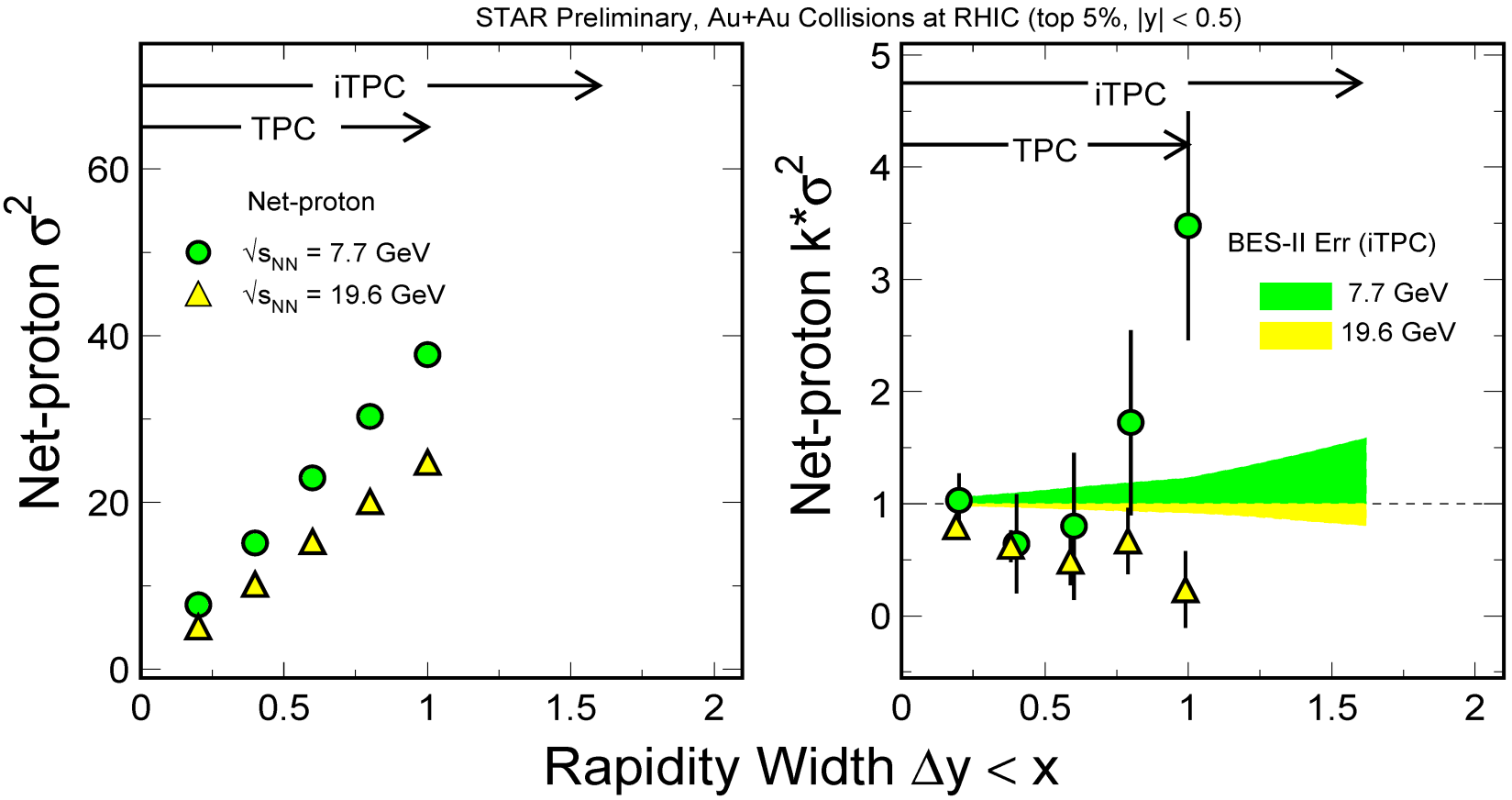
- **Beam Energy Scan – Phase I Results (2010-2014):**
  - ✓ Seen the turn-off of QGP signatures.
  - ✓ Seen suggestions of the first order phase transition.
  - ✓ Seen indication of a critical point, but not conclusive.

- **The most promising region for refining the search is in the lower energies -> 19.6, 15, 11.5, 7.7, and lower.**

- **The iTPC upgrades strengthen the BES II physics program via:**
  - ✓ Rapidity dependence of proton kurtosis
  - ✓ Dilepton program (reduce sys. errors with improved PID)
  - ✓ Enables the internal fixed target program to cover 7.7 to 3 GeV

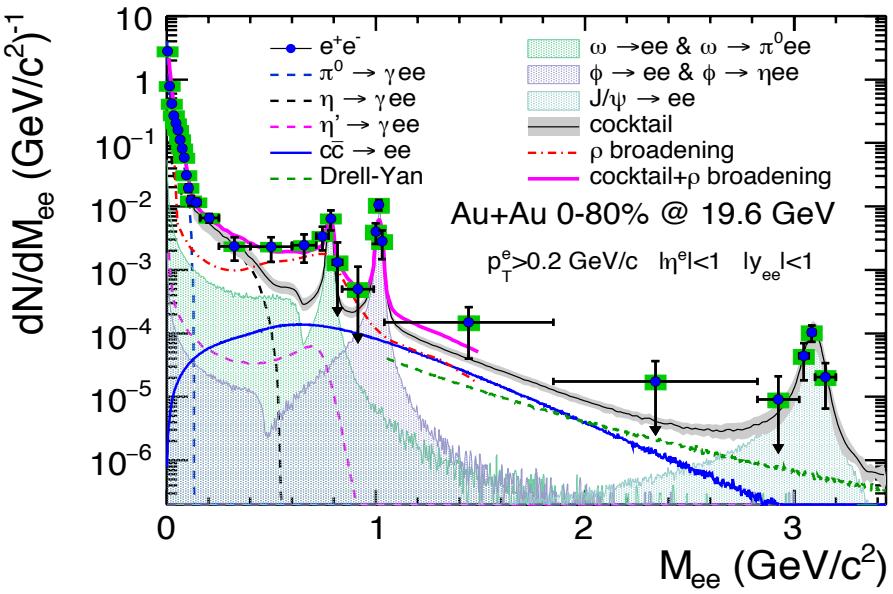
Critical point search- Kurtosis measurement

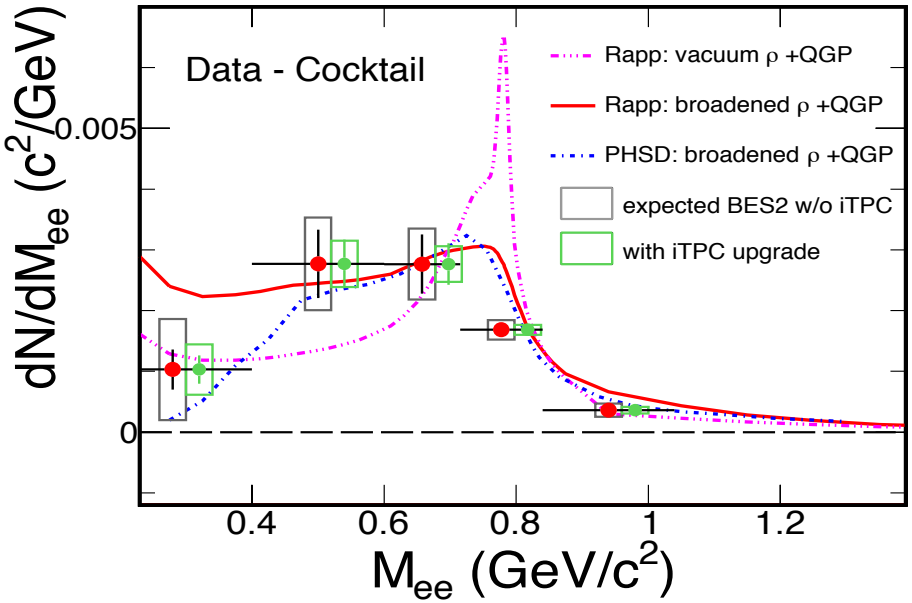
- **Extend the rapidity coverage to enhance the sensitivity with iTPC:**



Di-lepton measurement- Chiral Symmetry Restoration

- **Reduce the systematic uncertainty for di-lepton with iTPC:**

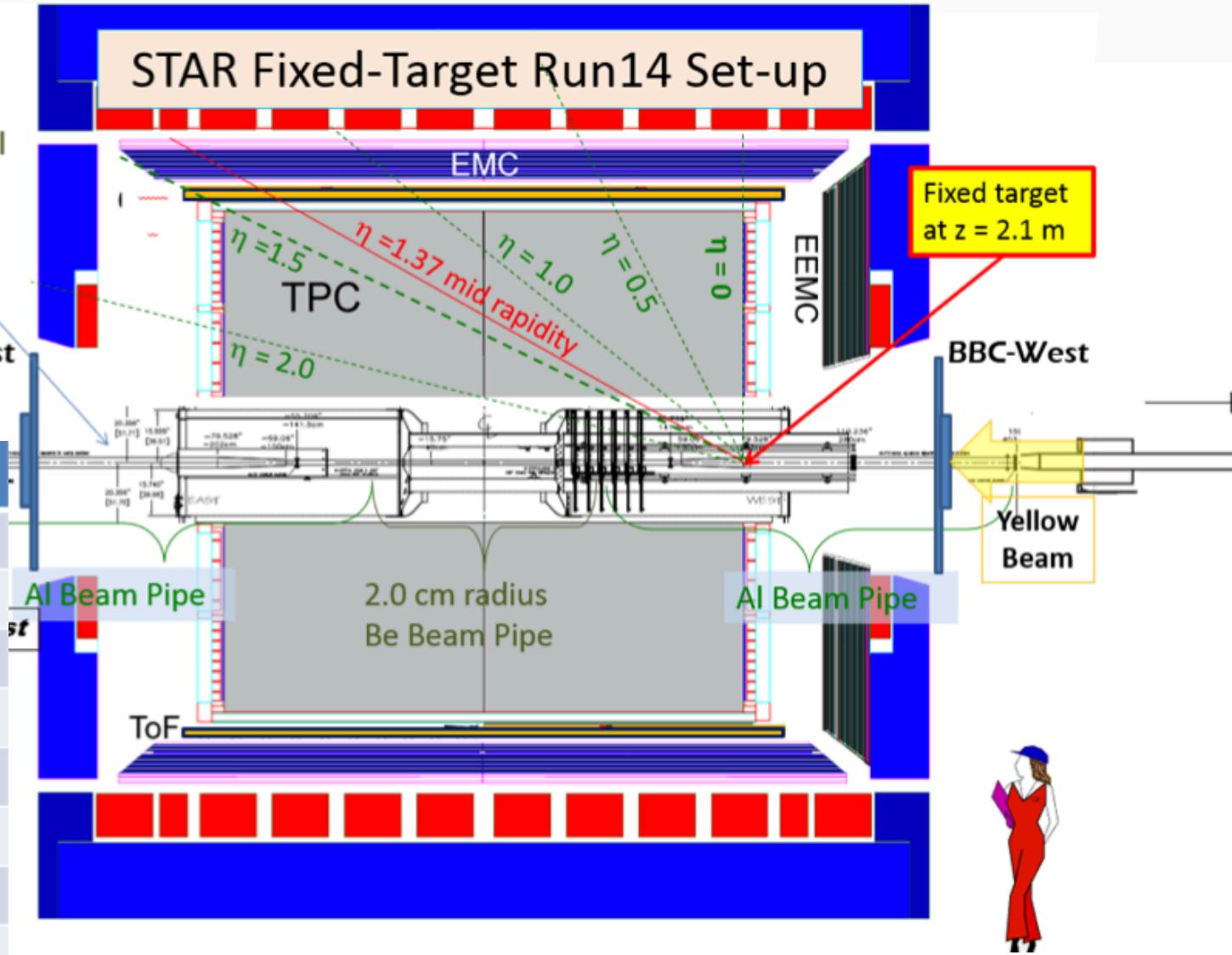




Fixed target program at STAR

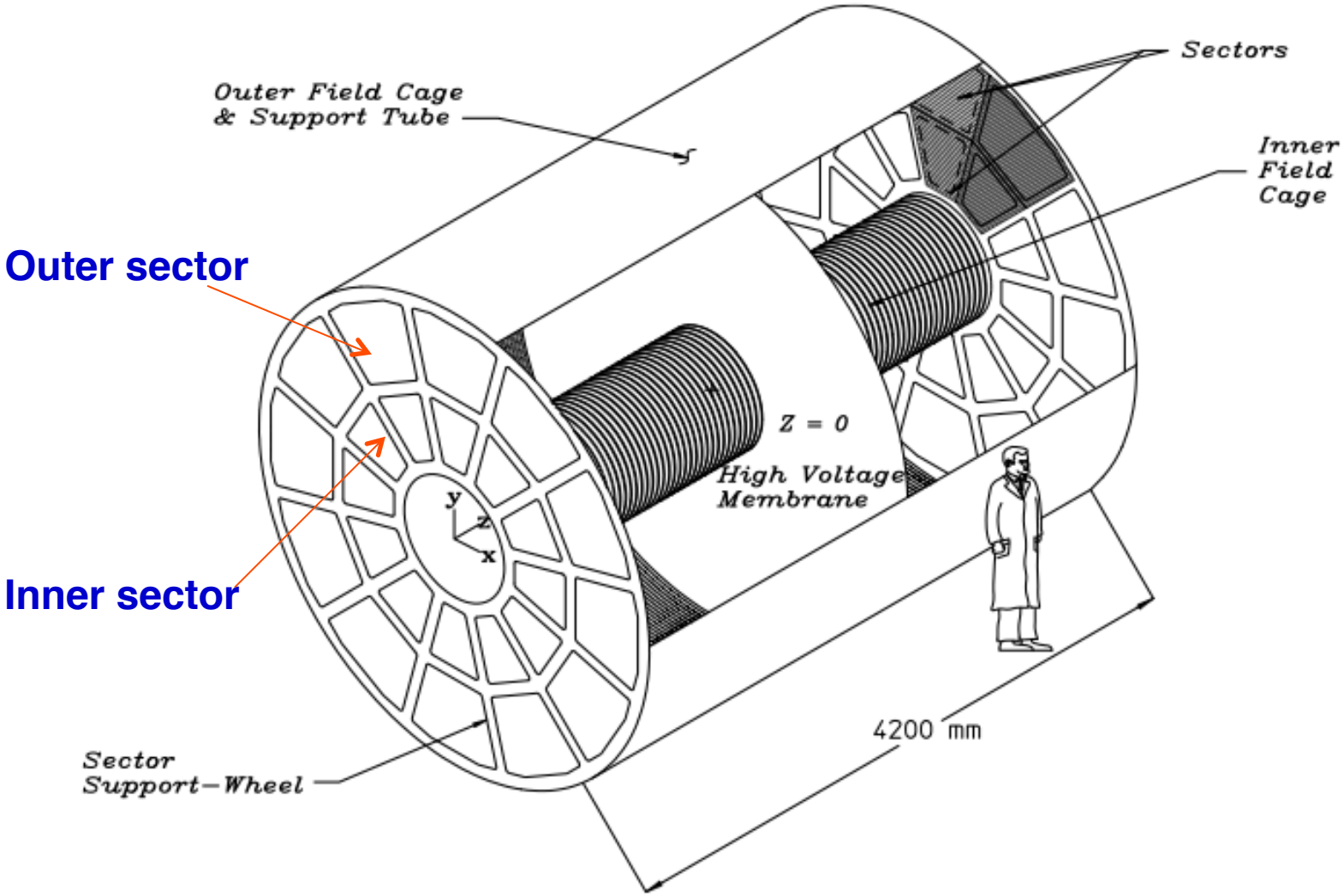
iTPC allows FXT at 7.7, 6.2, and 5.2

Fixed-Target Energy	Center-of-mass Rapidity
7.7	2.10
6.2	1.87
5.2	1.68
4.5	1.52
3.9	1.37
3.5	1.25
3.2	1.13
3.0	1.05



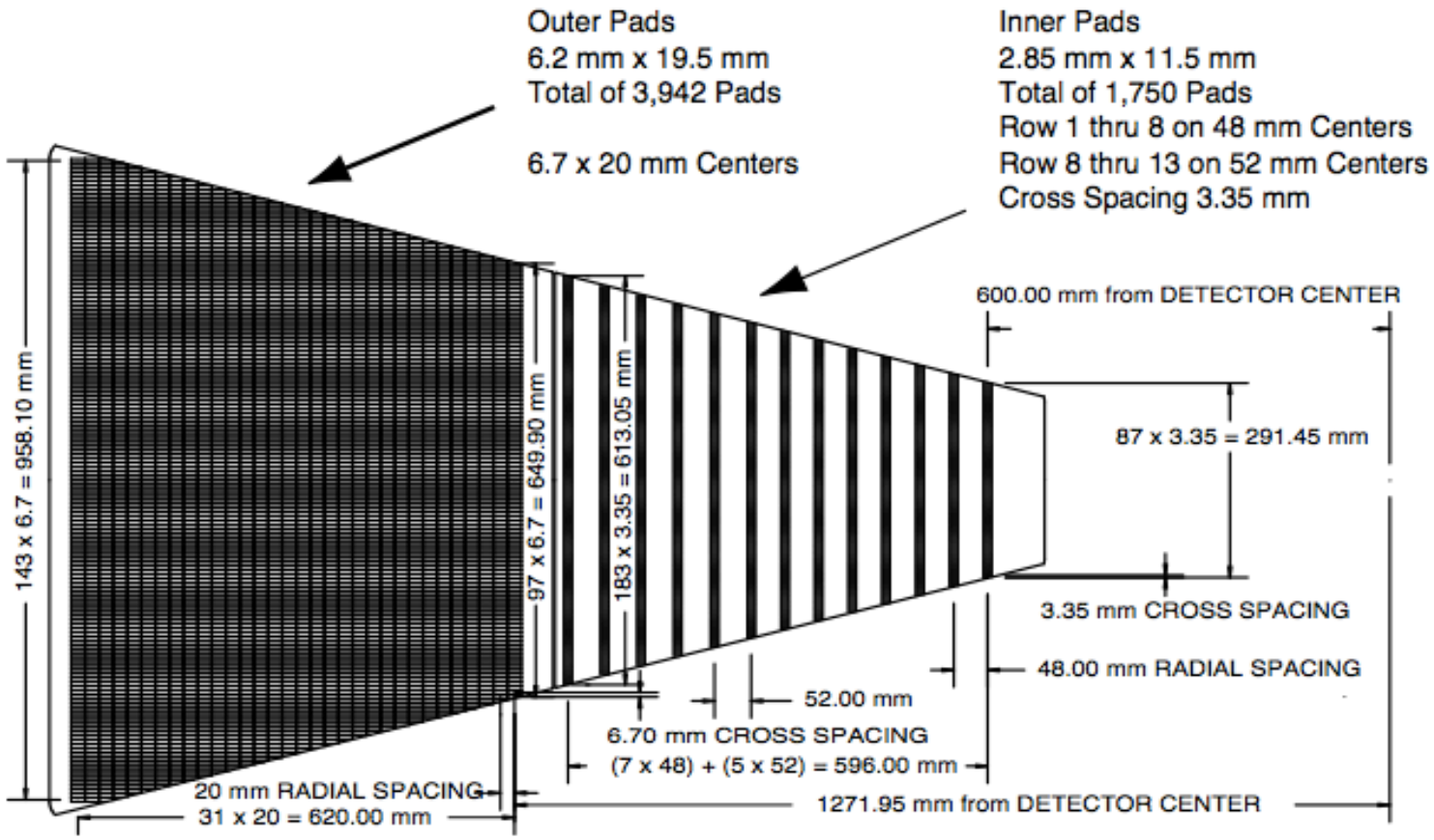
Upgrade of iTPC readout at STAR

- **Upgrade the inner TPC MWPC read out:**



Upgrade of iTPC readout at STAR

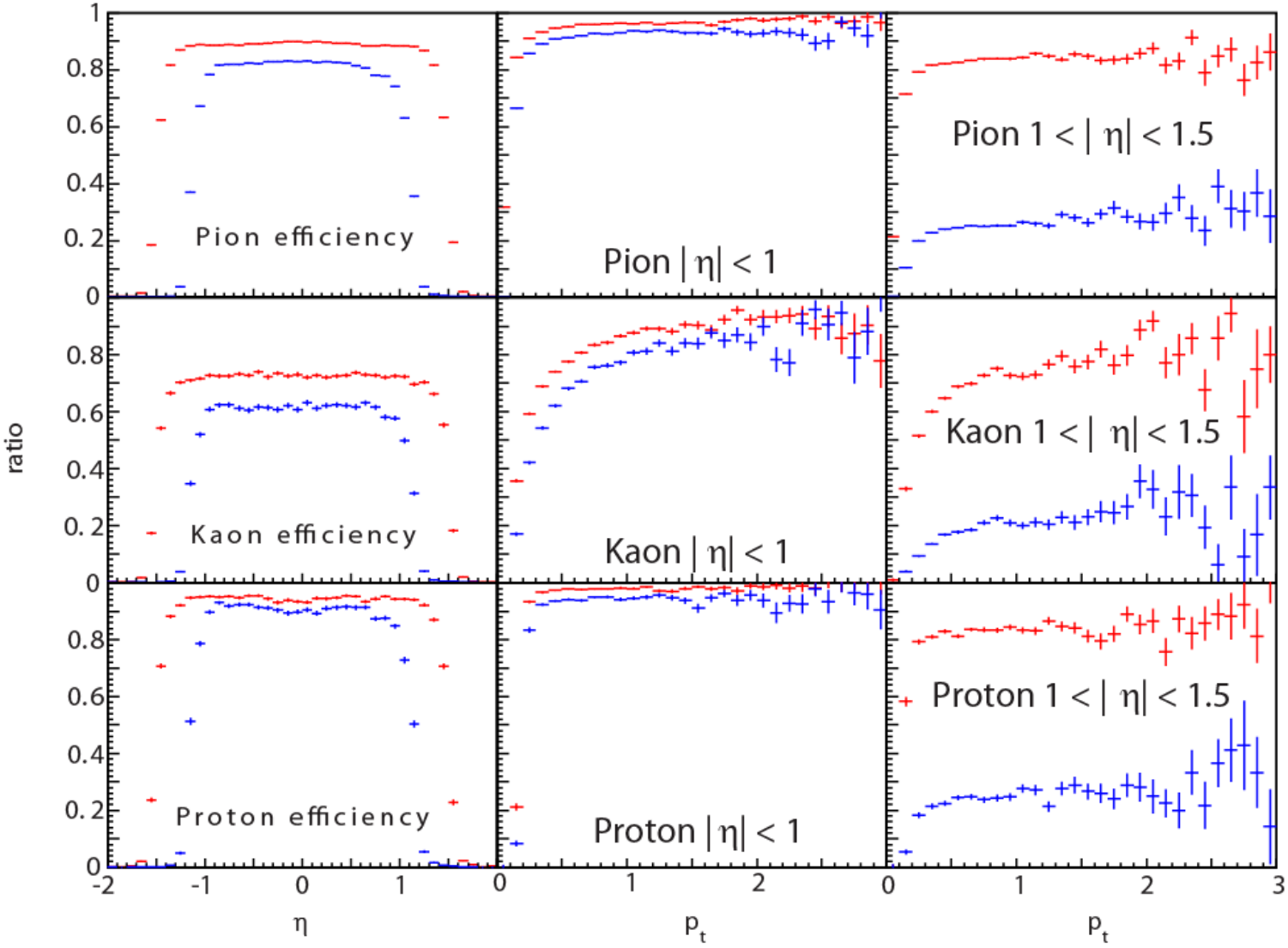
- Increase the segmentation on the inner pad plane, coverage 20%->100%
- Renew the inner sector wires which are showing signs of aging



The upgrade will provide better momentum resolution, better dE/dx resolution, and improved acceptance: $|\eta|<1.0 \rightarrow |\eta|<1.5$

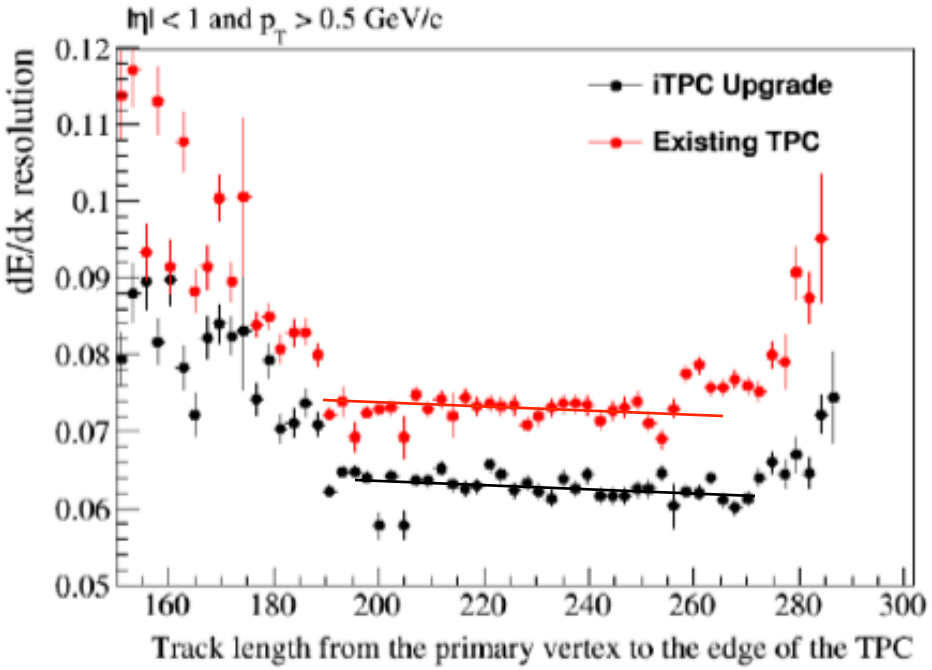
Extending rapidity coverage

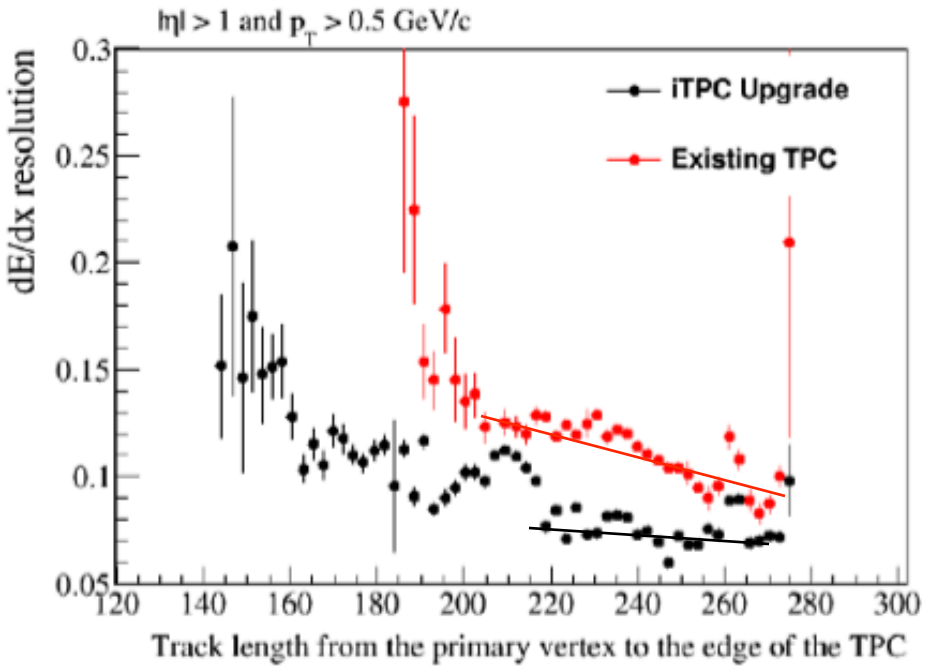
- **Improve acceptance at high eta and low p_T :**



Improvement to dE/dx Resolution

- **Enhance the particle ID with improved dE/dx resolution:**





Proposed run schedule for RHIC-Beam Energy Scan II

Years	Beam Species and	Science Goals	New Systems
2014	Au+Au at 15 GeV Au+Au at 200 GeV ^{3}He+Au at 200 GeV	Heavy flavor flow, energy loss, thermalization, etc. Quarkonium studies QCD critical point search	Electron lenses 56 MHz SRF STAR HFT STAR MTD
2015-16	p↑+p↑ at 200 GeV p↑+Au, p↑+Al at 200 GeV High statistics Au+Au Au+Au at 62 GeV ?	Extract η/s(T) + constrain initial quantum fluctuations Complete heavy flavor studies Sphaleron tests Parton saturation tests	PHENIX MPC-EX STAR FMS preshower Roman Pots Coherent e-cooling test
2017	p↑+p↑ at 510 GeV	Transverse spin physics Sign change in Sivers function	
2018	No Run		Low energy e-cooling install. STAR iTPC upgrade
2019-20	Au+Au at 5-20 GeV (BES-2)	Search for QCD critical point and onset of deconfinement	Low energy e-cooling
2021-22	Au+Au at 200 GeV p↑+p↑, p↑+Au at 200 GeV	Jet, di-jet, γ-jet probes of parton transport and energy loss mechanism Color screening for different quarkonia Forward spin & initial state physics	sPHENIX Forward upgrades ?
≥ 2023 ?	No Runs		Transition to eRHIC

BNL Associate Director, B. Muller, June 2015

Collaboration on iTPC Project within STAR

components	Responsible institutes			Funding source
Electronics	BNL (ALICE Chips)	Ljubicic,	Scheetz + Electronics group	BNL/DOE
Mechanics design	LBL+BNL	Anderssen	+ 1 engineer + Sharma	R&D/STAR/DOE
Strongback	UT Austin	Hoffmann	+ UT Machine shop	UT+DOE
Insertion tool	BNL	Sharma	Scheblein	Capital/STAR/DOE
MWPC	**SDU+USTC**	**Q. Xu**	C.G. Zhu + technicians	**NNSFC,MOST**

Strongback

Prototype – original drawings produced at UT Austin

Only modify position of FEE openings.

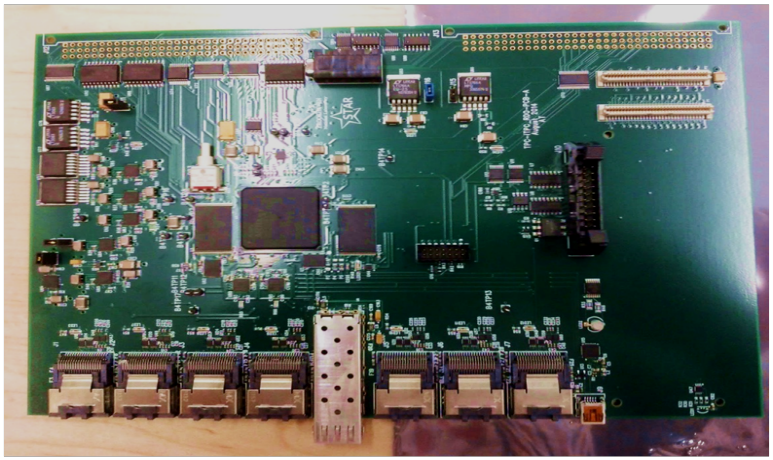
No reduction in thickness

Pure construction project, no engineering and design

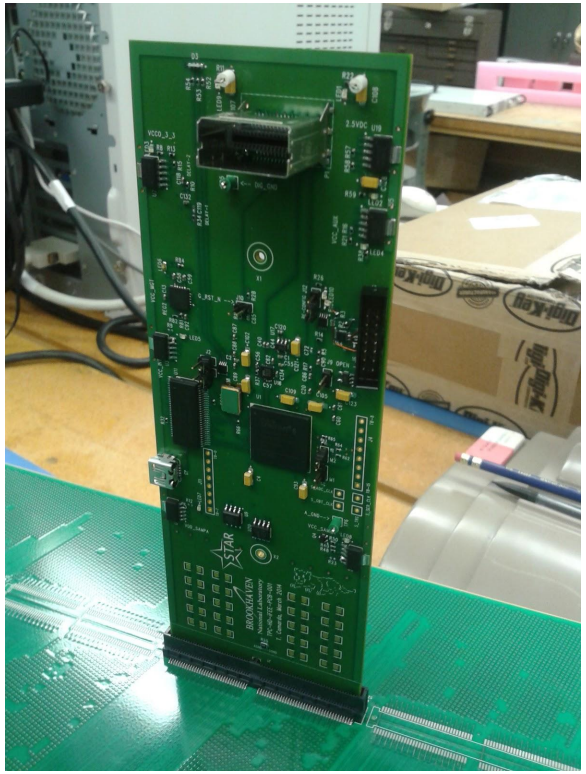
- but lots of retrieving old knowledge.

Electronics

- FEE based on current FEE, but using ALICE SAMPA chip
- Twice channels per FEE
- RDO similar to existing
- Developments over several years by BNL electronics group



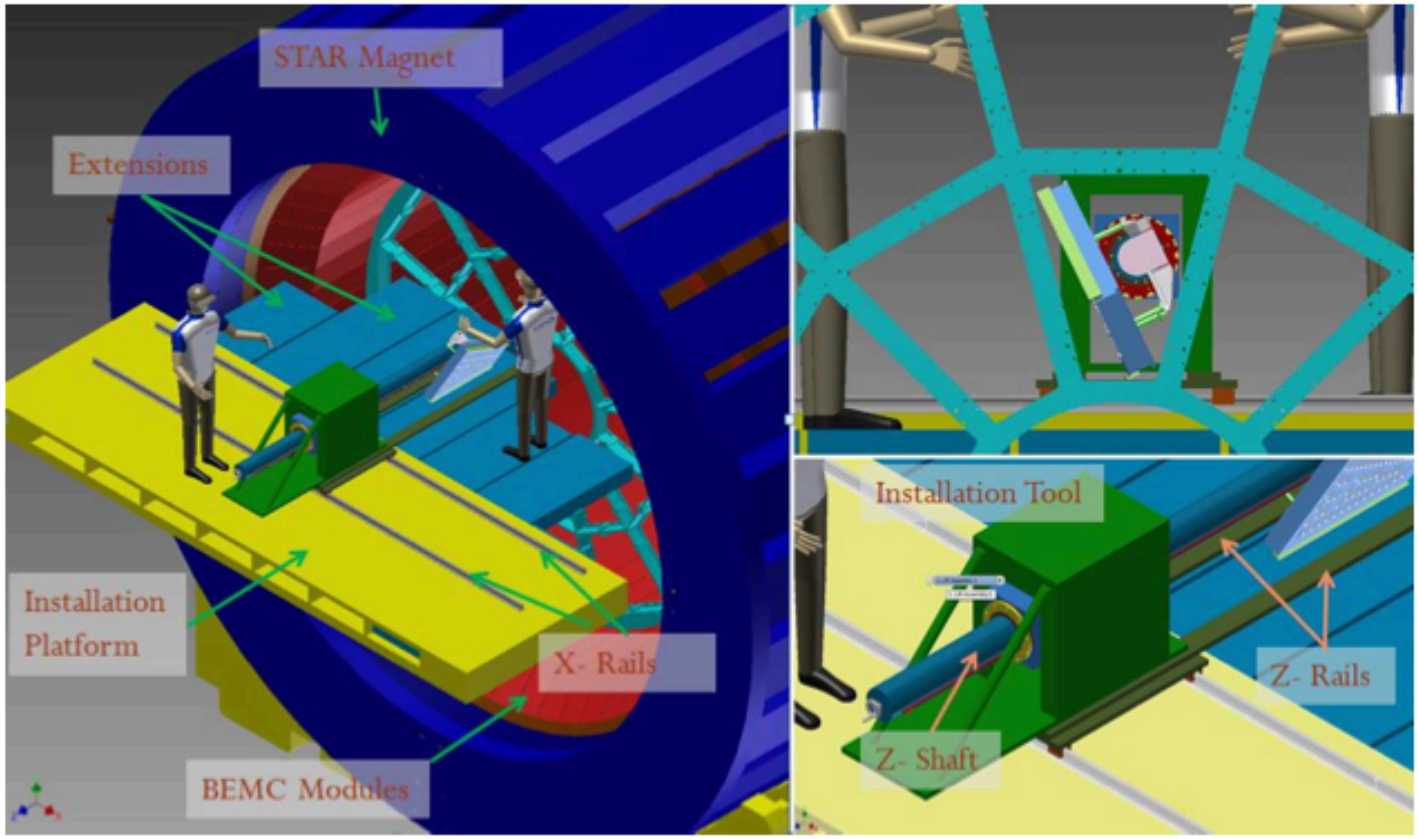
RDO prototype



Pre-prototye iFEE (ppFEE) electronic card shown plugged into the padplane

Sector Insertion Tooling

- Concept based on ALICE design
- Cartesian coordinates, being designed at BNL

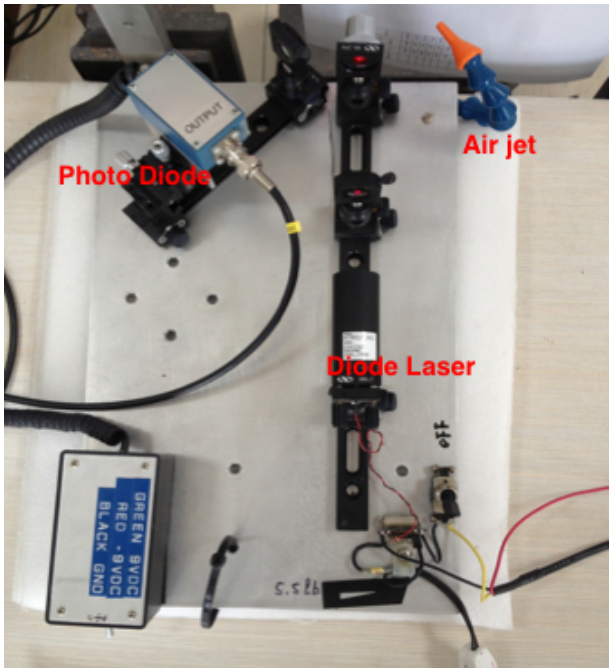


Wire winding for MWPC at SDU

- **Three layers of wire for iTPC MWPC:**

Wire	Diam. (μm)	Pitch (mm)	Composition	Tension (N)
Anodes	20	4	Au-plated W	0.50
Anodes—last wire	125	4	Au-plated Be–Cu	0.50
Ground plane	75	1	Au-plated Be–Cu	1.20
Gating grid	75	1	Au-plated Be–Cu	1.20

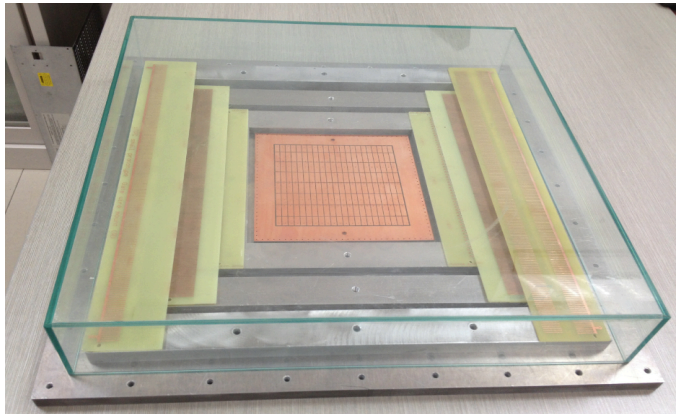
Wire pitch and tension controlled by winding machine (SDU)



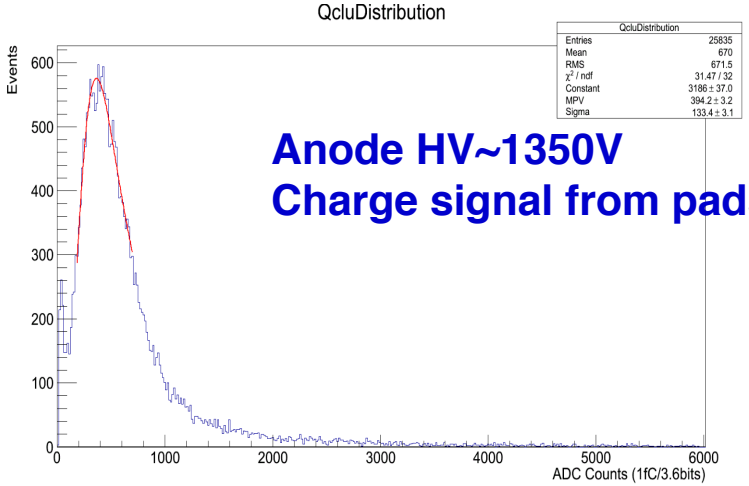
Laser system to check the tension

Progress on prototyping

- **Small MWPC prototype made at SDU July 2014; Tested with cosmic ray system:**



Small TPC prototype

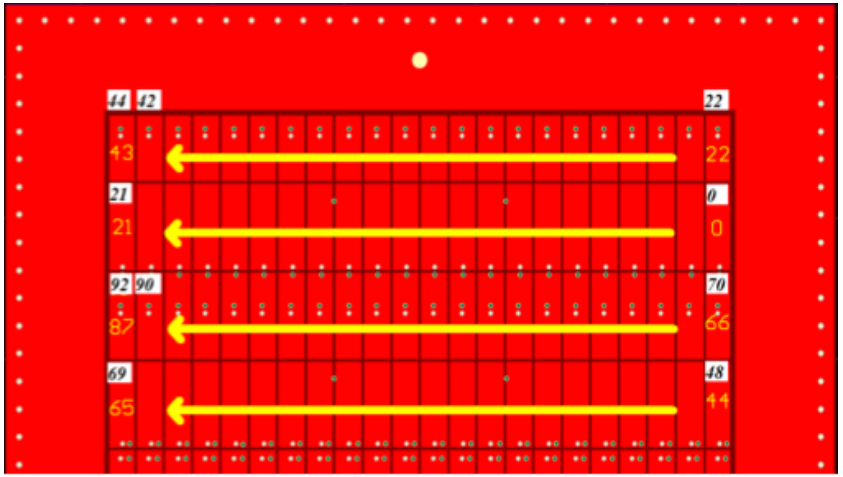


Anode HV~1350V
Charge signal from pads

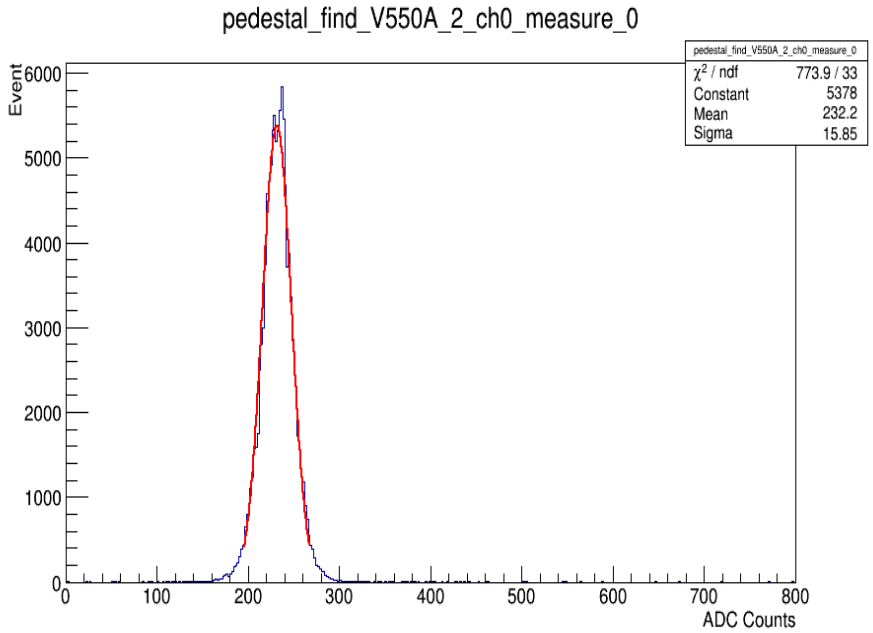
Cosmic ray test system

Test results of small TPC

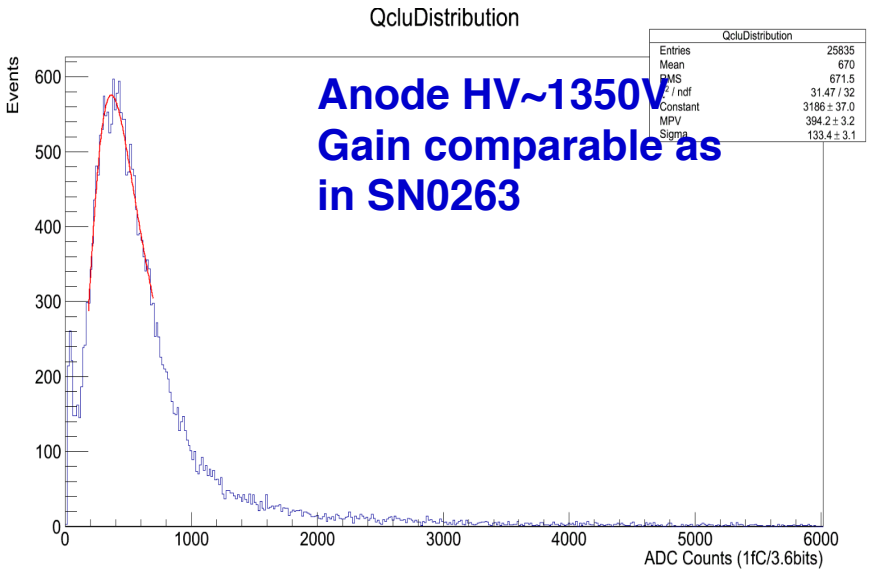
- First reading out the charge of 88 pads of 176 in total with simple electronics (one V550A board).
  Now setting up using STAR DAQ.



- Pedestal seen for the charge of single pad

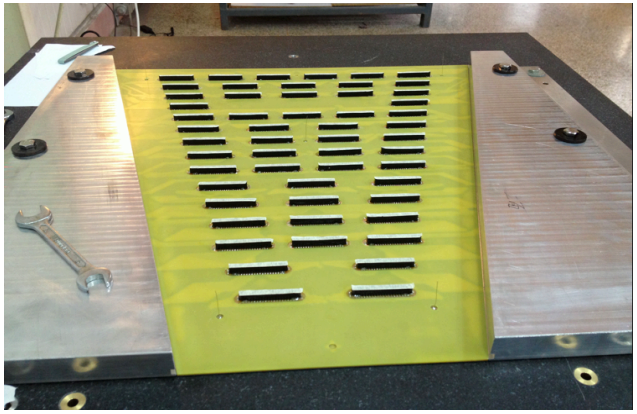


- Signal after subtracting pedestal

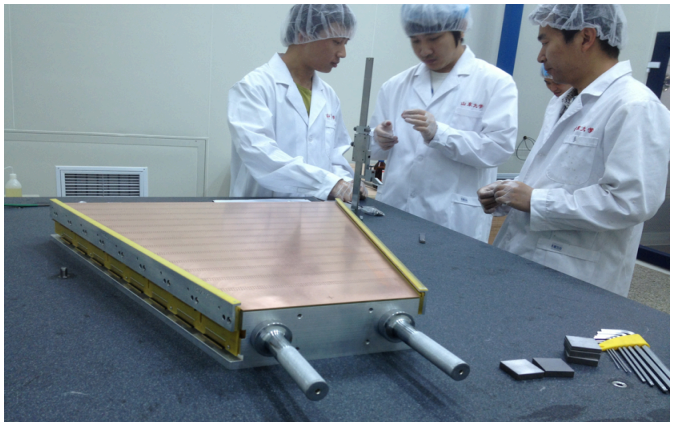


Full size iTPC prototyping

- **Started the full size iTPC prototyping since September 2014. Several tools were made and prototyping is progressing well.**

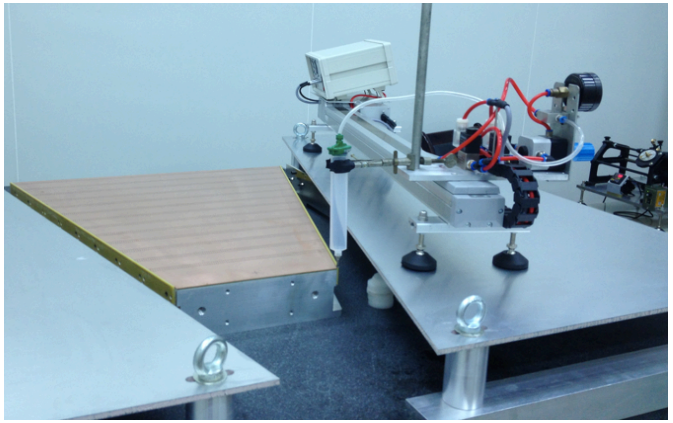


PCB bonding



Side wire mounts

Pining the wire mounts



Gluing machine

Summary

- **RHIC-BES studies the phase diagram of QCD matter:**
  Phase transition, Critical Point, Turn off of QGP signals.

- **iTPC improves the reach of all BES II observables:**
  - ✓ **Rapidity dependence of net-proton kurtosis**
  - ✓ **Di-electron program in the Intermediate mass region**
  - ✓ **Internal fixed target program covering 7.7 to 3.0 GeV**

- **The project has made significant progress.**
  Key involvement by China group (SDU, USTC,SINAP)

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Thanks!