



**DNP 2017**

Fall Meeting of the Division of Nuclear  
Physics of the American Physical Society

# The STAR Beam Energy Scan Phase II and iTPC upgrade



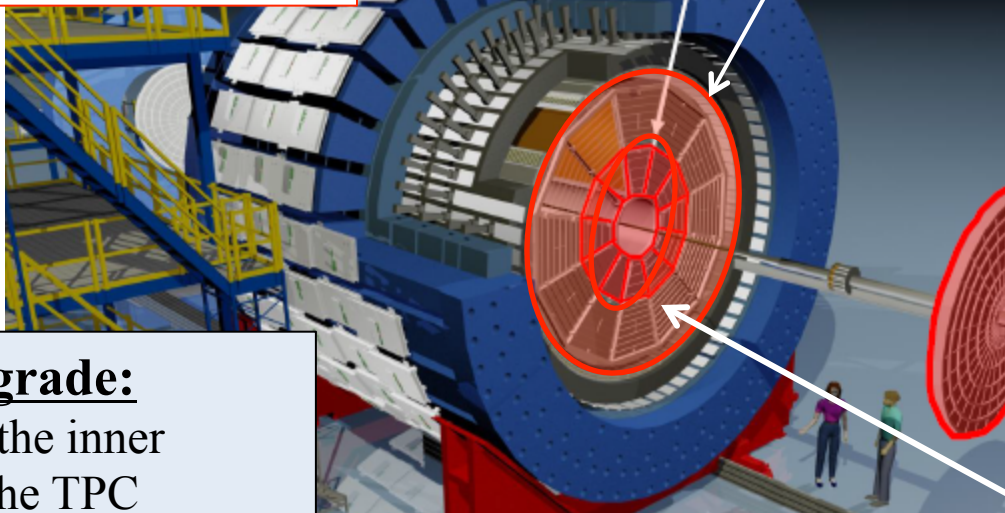
Flemming Videbæk  
for the STAR collaboration  
Brookhaven National Laboratory

# The STAR Upgrades and BES Phase II



Major improvements  
for BES-II

inner TPC upgrade  
Endcap TOF  
Event Plane Detector



## iTPC Upgrade:

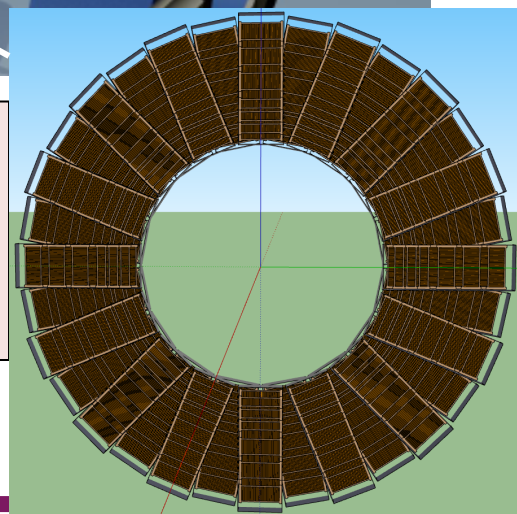
- Rebuilds the inner sectors of the TPC
- Increase #padrows from 13 to 40
- Improves  $dE/dx$
- Extends  $\eta$  coverage from 1.0 to 1.5
- Extends  $p_T$  acceptance from 125 MeV/c to 60 MeV/c

## EndCap TOF Upgrade:

- PID at  $\eta = 1.1$  to 1.5
- Provided by CBM-FAIR Phase-0

## EPD Upgrade:

- Allows a better and independent reaction plane measurement critical to BES physics
- Improves trigger

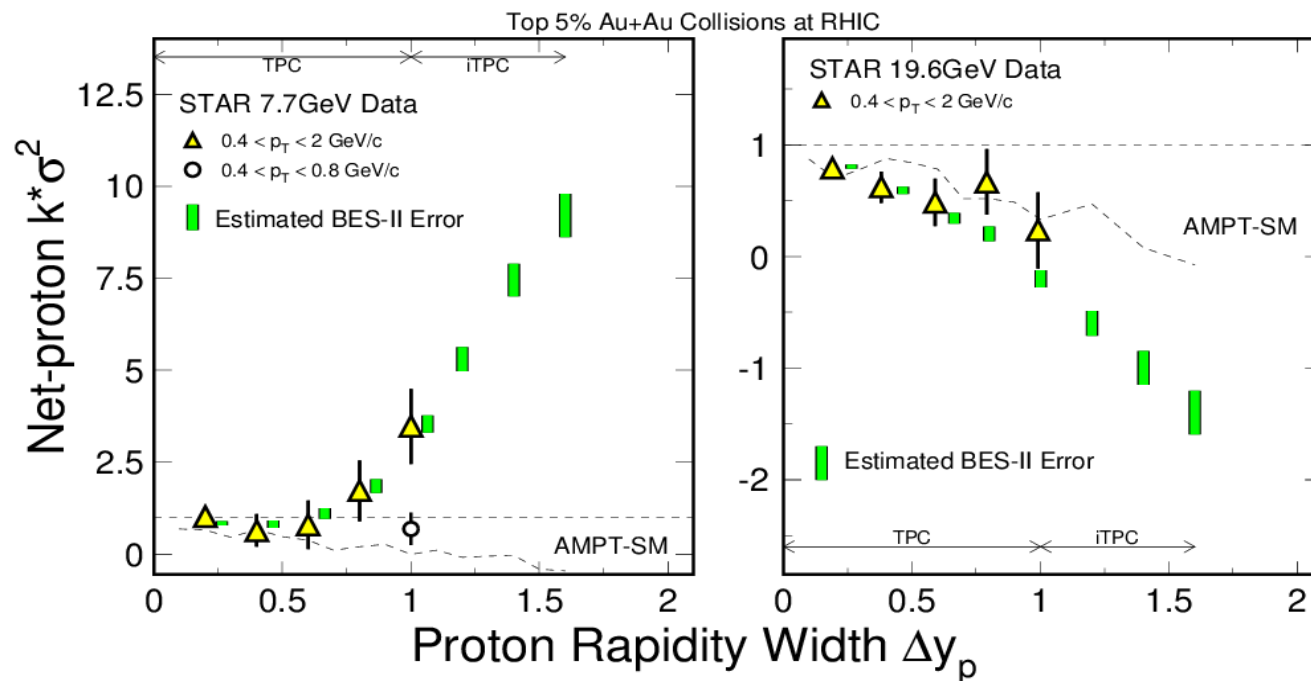


# BES-II Physics highlights (I): net-proton Kurtosis



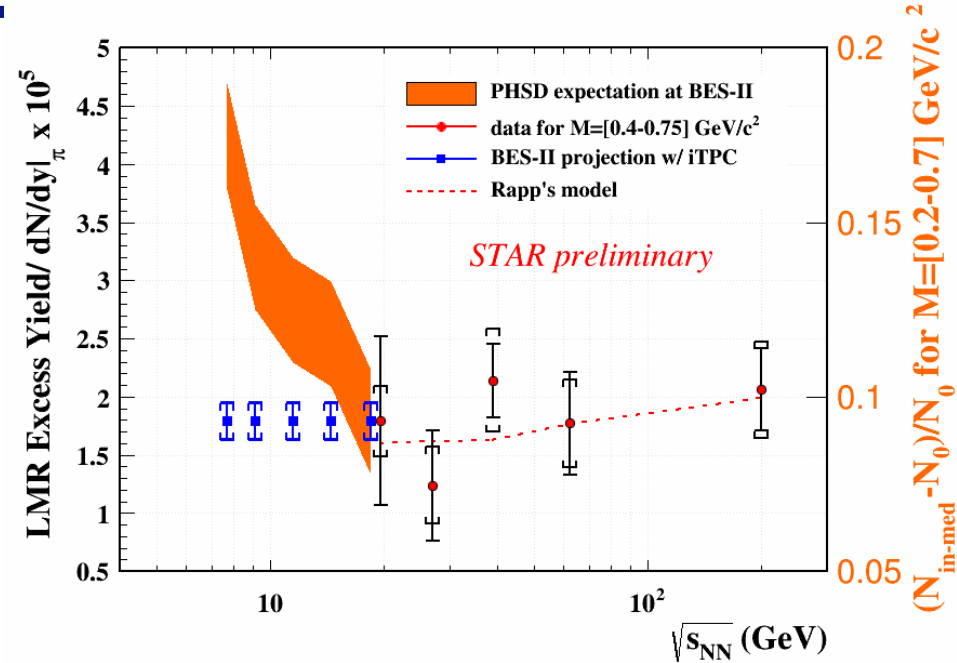
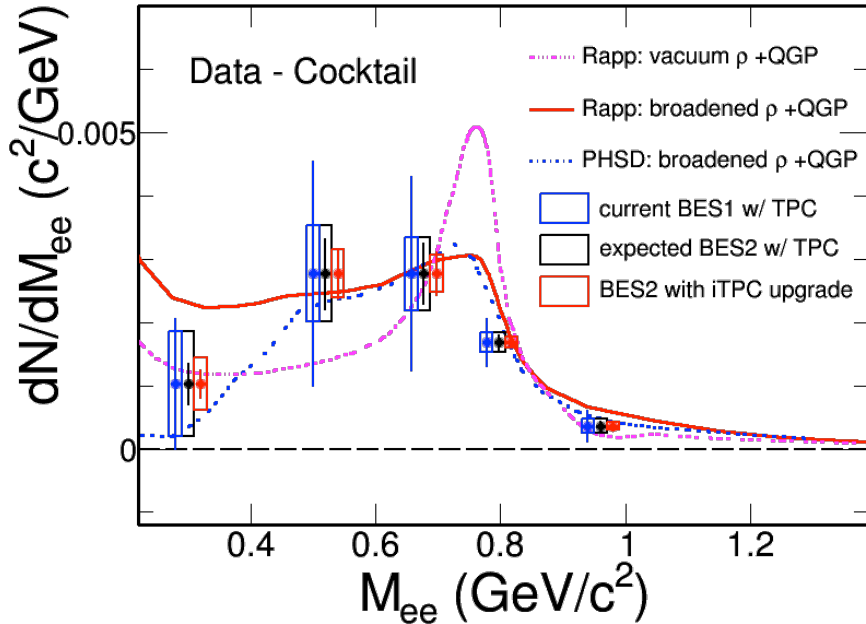
Reach the necessary rapidity width of the correlation/fluctuation ( $\sim 1$ -2 unit)

- Increase in  $\Delta y_p$  from iTPC alone
- Improved statistics from Low Energy RHIC electron Cooling (LEReC)



*A proposal for iTPC upgrade STAR Note 619*  
<https://drupal.star.bnl.gov/STAR/starnotes/public/sn0619>

# BES-II Physics highlights (II): Di-electron measurements



- Systematically study di-electron continuum from  $\sqrt{s_{NN}} = 7.7 - 19.6$  GeV
- Distinguish models with different  $\rho$ -meson broadening mechanism (PHSD vs Rapp's method)
- Study the total baryon density effect on Low Mass Region excess yield in BES-II
- Study low- $p_T$  enhancements
- **Inner Time Projection Chamber upgrade: reduced systematic (improved PID) and statistical uncertainties**

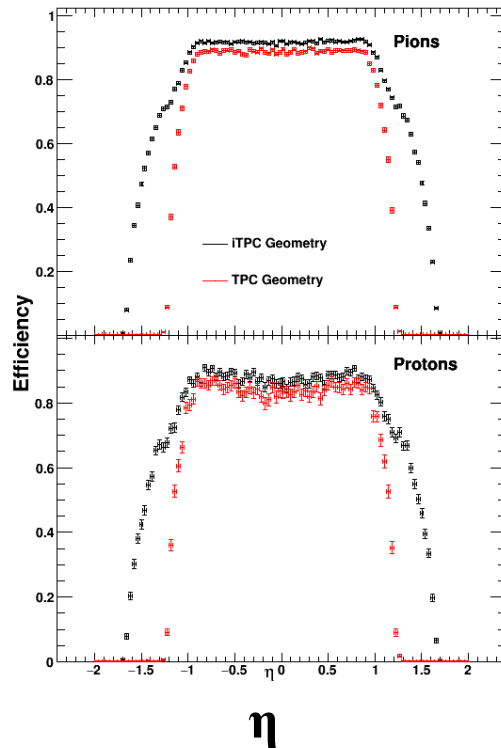


# Improved performance

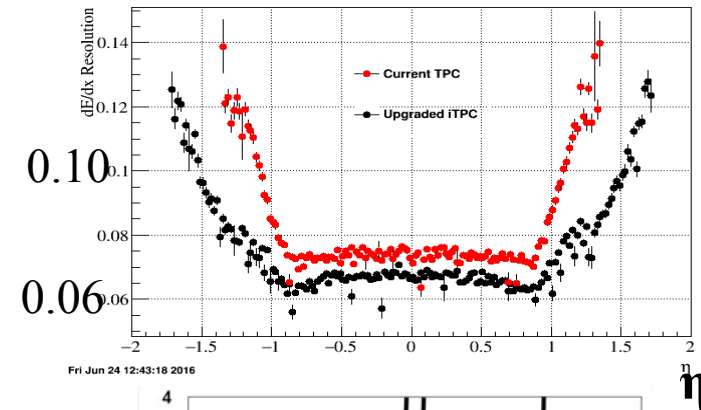


Increase rapidity coverage from  $\eta \sim 1$  to  $\sim 1.5$

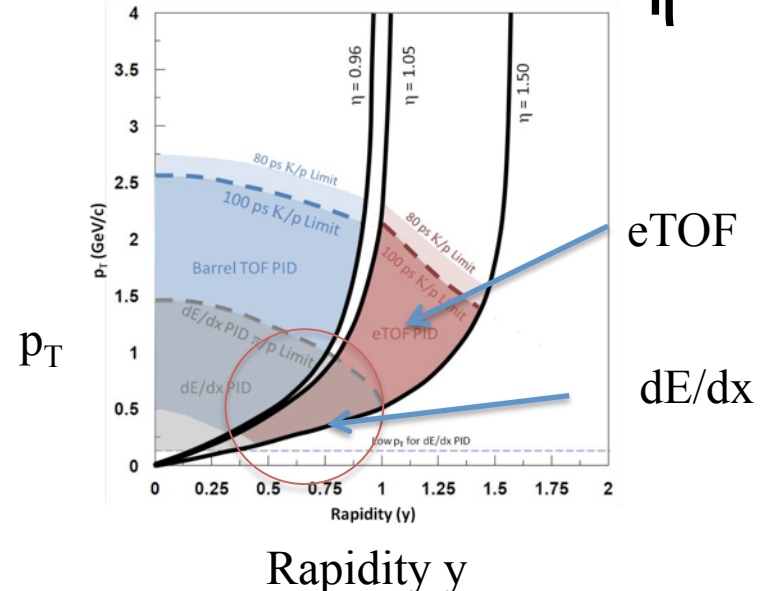
Also Increased efficiency in  $p_T$



## Improved dE/dx



Fri Jun 24 12:43:16 2016



# The inner TPC upgrade

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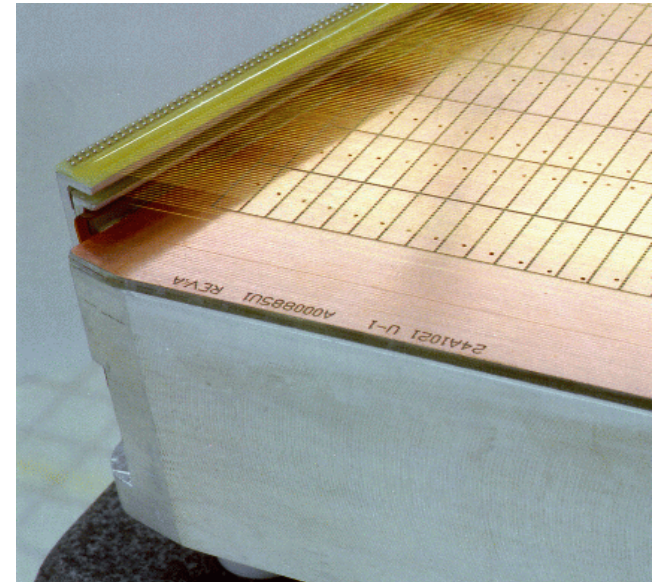
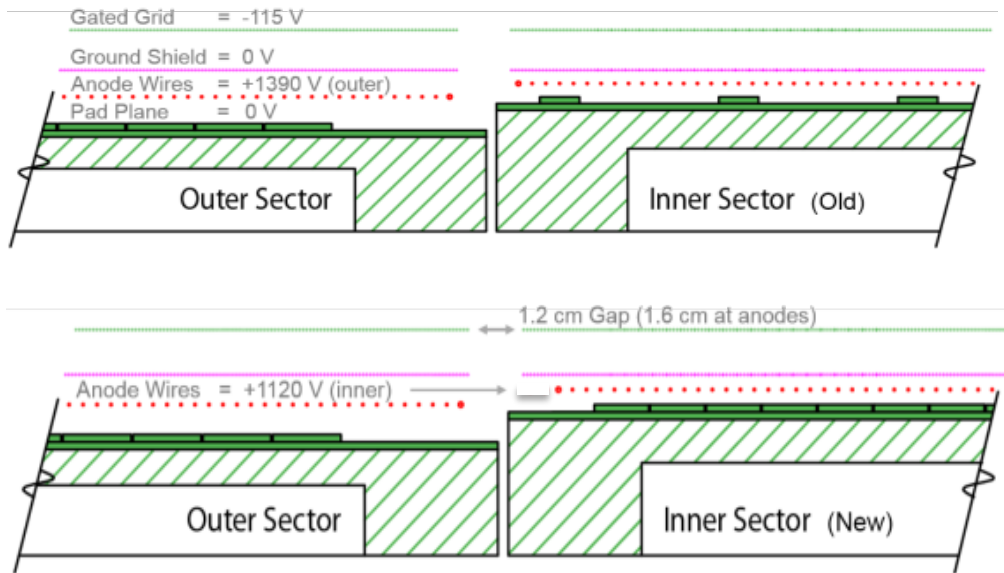
## Replace all 24 inner sectors, with

- ✓ Increase readout pad rows from 13 to 40
  - 20% coverage -> ~100% coverage
- ✓ Strongbacks
  - Nearly identical to existing, small modification for slot positions
- ✓ Wire mounting of 3 planes
  - Replace ageing wires
- ✓ New electronics for inner sectors
  - Double # of readout channels per FEE, use ALICE SAMPA chip
- ✓ New designed insertion tools
  - Install and replace sectors
- Planned to be complete for RHIC run 2019

*Technical Design Report STAR Note 644*

*<https://drupal.star.bnl.gov/STAR/starnotes/public/sn0644>*

# iTPC sector



New arrangement of pads and wire showing improvement in pad coverage

Actual picture of an outer sector

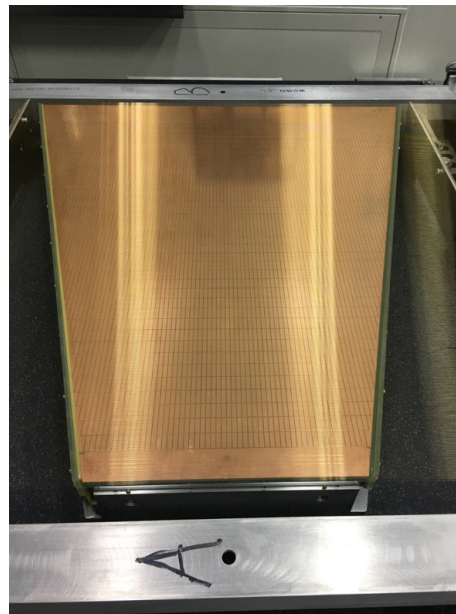
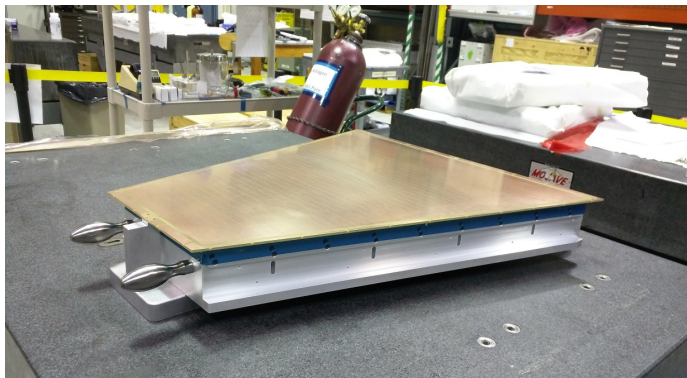
- Pad, side mounts, wire planes

# iTPC upgrade MWPC

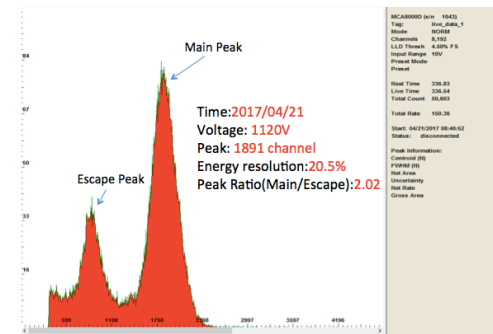


## Sectors (strongback + padplane + MWPC)

- Precision assembly at LBL of padplane to strongbacks and side mounts ongoing
- Sector production started at SDU, (5 completed, testing ongoing) with a first fully tested sector installed in STAR in October 2017



*Sector wire mounting*



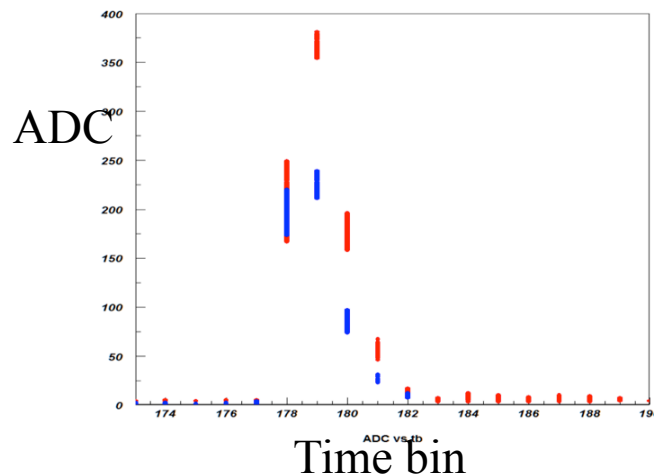
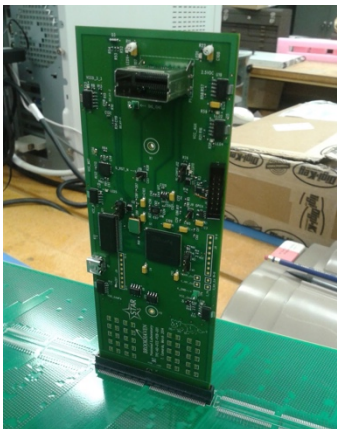
FWHM 20%



# iTPC electronics



- Double #channels per FEE 332 channel -> 64 channels
- Using SAMPA chip
- 2FEEs and RDO installed on one inner row of TPC for 2017
- Running through USB port with beam (pp500)
- Designed and produced pre-production RDO and FEE to instrument one Full sector for tests in Fall and in beam for 2018

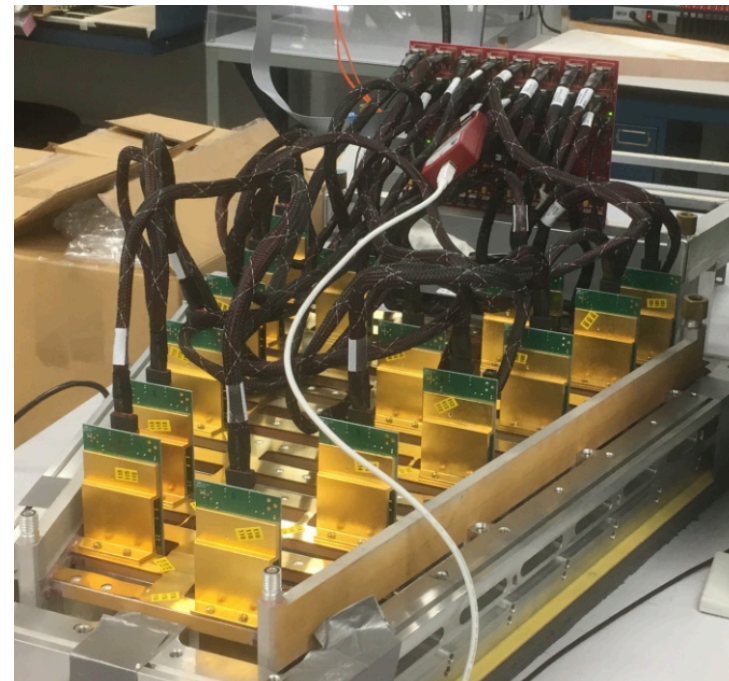


Time Response of signal from iFEE with SAMPA compared with current electronics. Will work well for STAR.

Red – SAMPA

Blue – current electronics

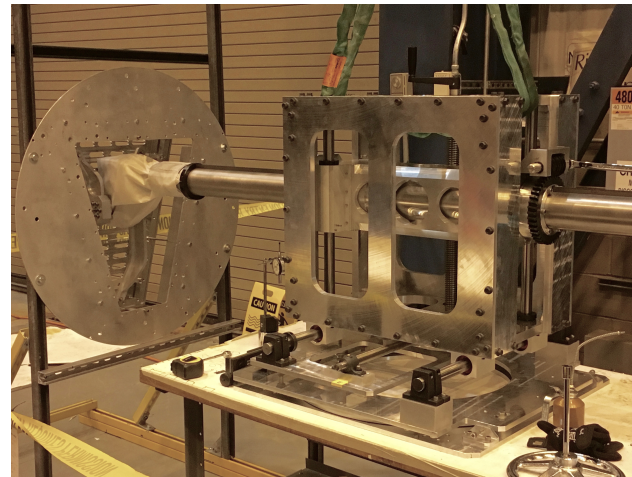
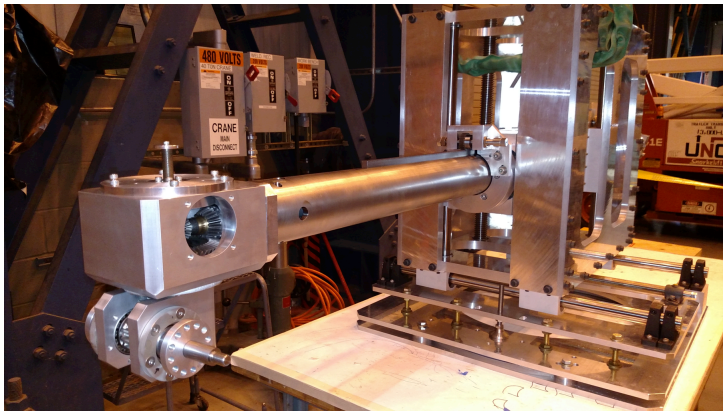
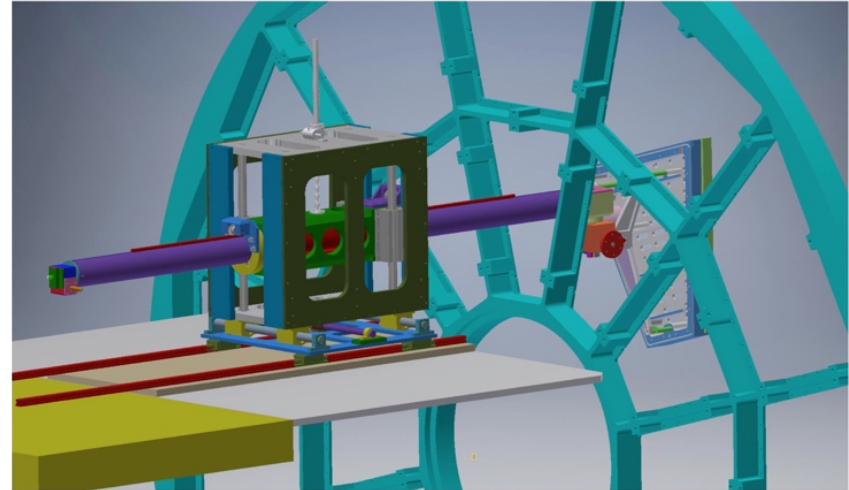
- For run-18 one inner sector will be populated with new electronics
- QA and testing stand for FEEs and RDO connected to pad planes in dummy sector



# iTPC: Installation



- Insertion tool
  - Completed at UIC & BNL; was extensively commissioned and used for sector installation
  - Delicate precision operation

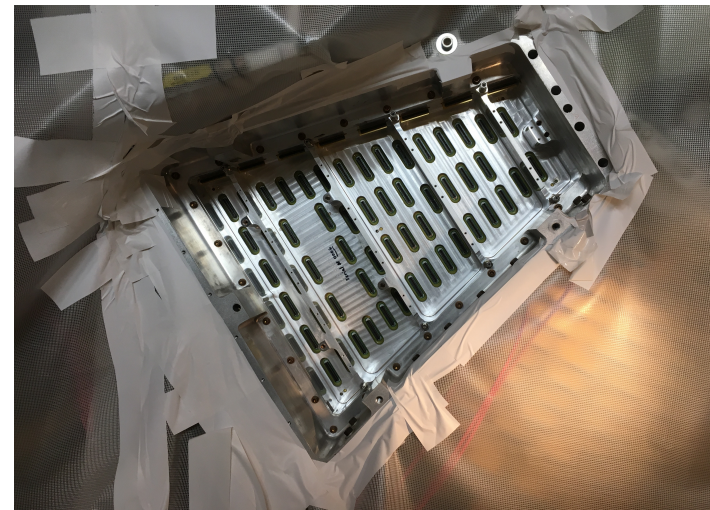




# Sector installation



Installation was done October 5 successfully and took about 1.5 days  
Installation done in clean environment





# Summary

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- STAR continues to have a vigorous upgrade program to utilize the capabilities of RHIC and the existing detector systems
- For BES-II (2018-2020) the **iTPC**, **EPD** and **eTOF** upgrades significantly extend rapidity and  $p_T$  coverage of STAR. The upgrades are well underway
- One sector has been installed for the upcoming run-18, and the full complement will be installed end of 2018 ahead of run-19

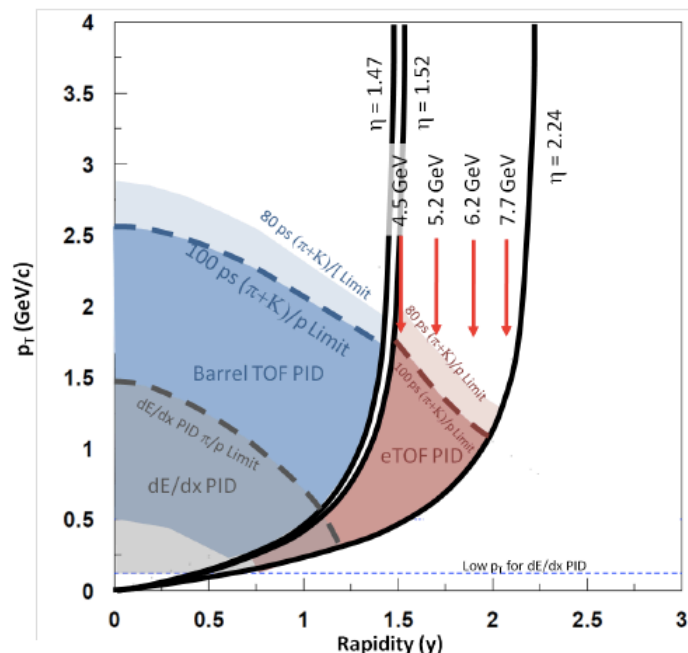
# BACKUPS

# TPC parameters



Item	Inner	Outer	iTPC	Comment
Pad Pitch (center to center)	3.35 x 12	6.70 x 20	5.0 x 16	mm
Isolation gap between pads	0.5	0.5	0.5	mm
Pad Size	2.85 x 11.5	6.20 x 19.5	4.5 x 15.5	mm
Number of Pads	1750	3940	3440	
Anode to padplane spacing	2	4	2	mm
Anode voltage	1170 V	1390 V	~ 1120 V	20:1 S/N
Anode Gas Gain	3770	1230	~ 2000	nominal
Anode Wire diameter	20 $\mu\text{m}$	20 $\mu\text{m}$	20 $\mu\text{m}$	Au plated W
Anode Wire pitch	4	4	4	mm
Anode Wires phase locked to pad location	3 wires, #2 over center	5 wires, #3 over center	4 wires, centered	grp centered over the pad

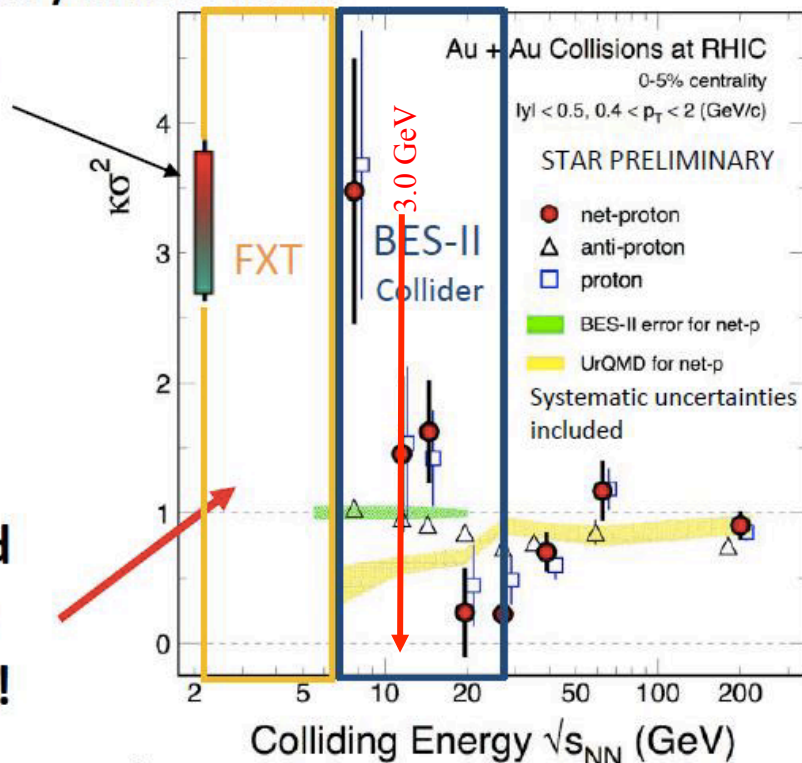
# Net-proton Fluctuation at low energies



## Preliminary HADES result

0-10%  
(QM 2017)

Need  
data  
here!

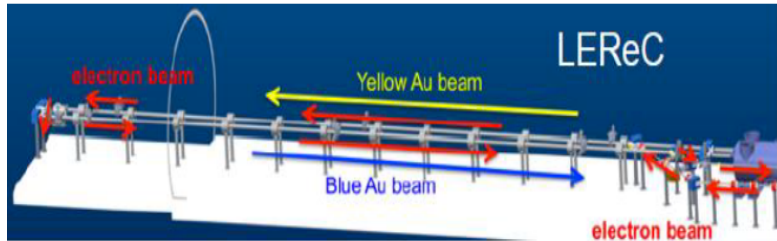


Au+Au at 3 GeV:  
mid-rapidity well within current TPC  
Fixed target program for STAR

With high statistics, establish a bridge between BES and world program at fixed target (HADES/CBM/NICA/JPARC/SHINE)



# Low Energy RHIC electron Cooling (LEReC)



- Many results are statistics limited
- Improve event statistics roughly same real time
- Take advantage of CAD experience gained in BES-I

