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

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

EPD Upgrade:
• Allows a better and independent reaction plane measurement critical to BES physics
• Improves trigger

EndCap TOF Upgrade:
• PID at $\eta = 1.1$ to 1.5
• Provided by CBM-FAIR Phase-0
BES-II Physics highlights (I): net-proton Kurtosis

Reach the necessary rapidity width of the correlation/fluctuation (~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
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

Data - Cocktail

![Graph showing di-electron continuum and model predictions]
Improved performance

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

Also increased efficiency in $p_T$

Improved $dE/dx$
The inner TPC upgrade

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
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
iTPC 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

• 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

<table>
<thead>
<tr>
<th>Item</th>
<th>Inner</th>
<th>Outer</th>
<th>iTPC</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>Pad Pitch (center to center)</td>
<td>3.35 x 12</td>
<td>6.70 x 20</td>
<td>5.0 x 16</td>
<td>mm</td>
</tr>
<tr>
<td>Isolation gap between pads</td>
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<td>0.5</td>
<td>0.5</td>
<td>mm</td>
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<tr>
<td>Pad Size</td>
<td>2.85 x 11.5</td>
<td>6.20 x 19.5</td>
<td>4.5 x 15.5</td>
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<tr>
<td>Number of Pads</td>
<td>1750</td>
<td>3940</td>
<td>3440</td>
<td></td>
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<tr>
<td>Anode to padplane spacing</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>mm</td>
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<tr>
<td>Anode voltage</td>
<td>1170 V</td>
<td>1390 V</td>
<td>~1120 V</td>
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<tr>
<td>Anode Gas Gain</td>
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<tr>
<td>Anode Wire diameter</td>
<td>20 μm</td>
<td>20 μm</td>
<td>20 μm</td>
<td>Au plated W</td>
</tr>
<tr>
<td>Anode Wire pitch</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>mm</td>
</tr>
<tr>
<td>Anode Wires phase locked to pad location</td>
<td>3 wires, #2 over center</td>
<td>5 wires, #3 over center</td>
<td>4 wires, centered</td>
<td>grp centered over the pad</td>
</tr>
</tbody>
</table>
Net-proton Fluctuation at low energies

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

10/28/2017

Videbæk, DNP 2017