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AGS/RHIC Users Meeting
June 6, 2019



Big Picture

- In 2015 NSAC developed the Long Range Plan for Nuclear Science;
- This endorses the second phase of the Beam Energy Scan at RHIC and STAR experiment;

The 2015 LONG RANGE PLAN for NUCLEAR SCIENCE

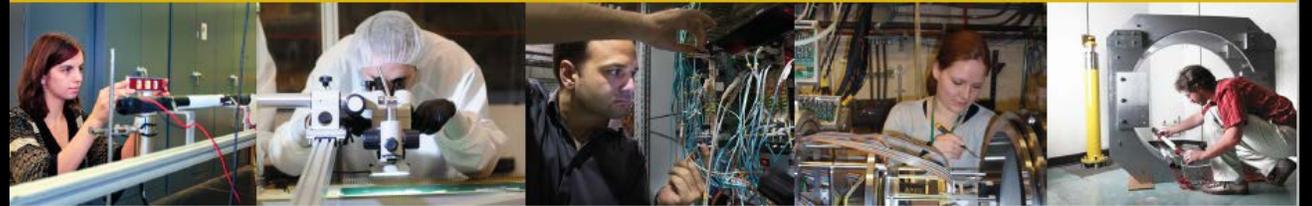


REACHING FOR THE HORIZON

“The upgraded RHIC facility provides unique Capabilities that must be utilized to explore the Properties and phases of quark and gluon matter in The high temperatures of the early universe and to Explore the spin structure of the proton.”

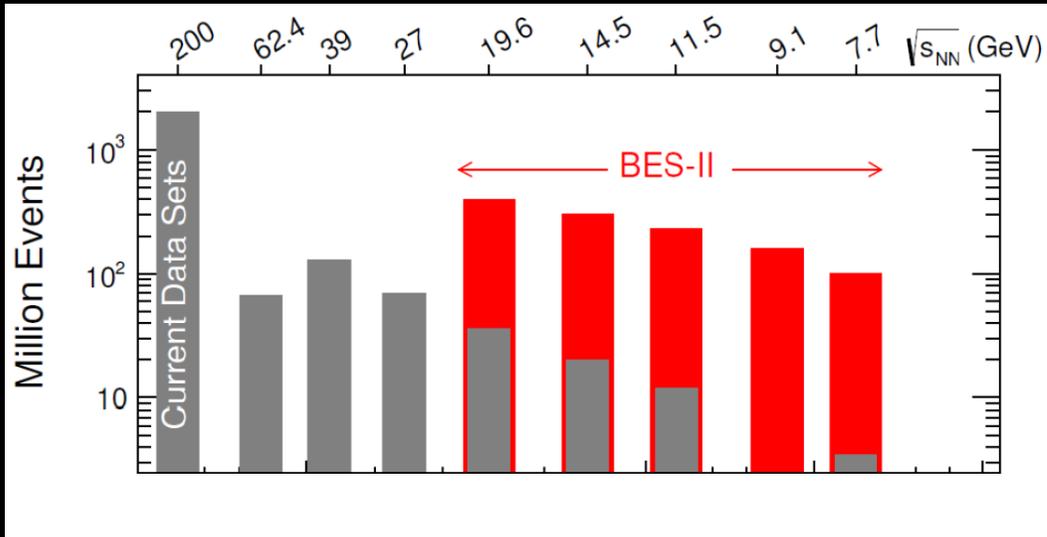


The Site of the Wright Brothers' First Airplane Flight



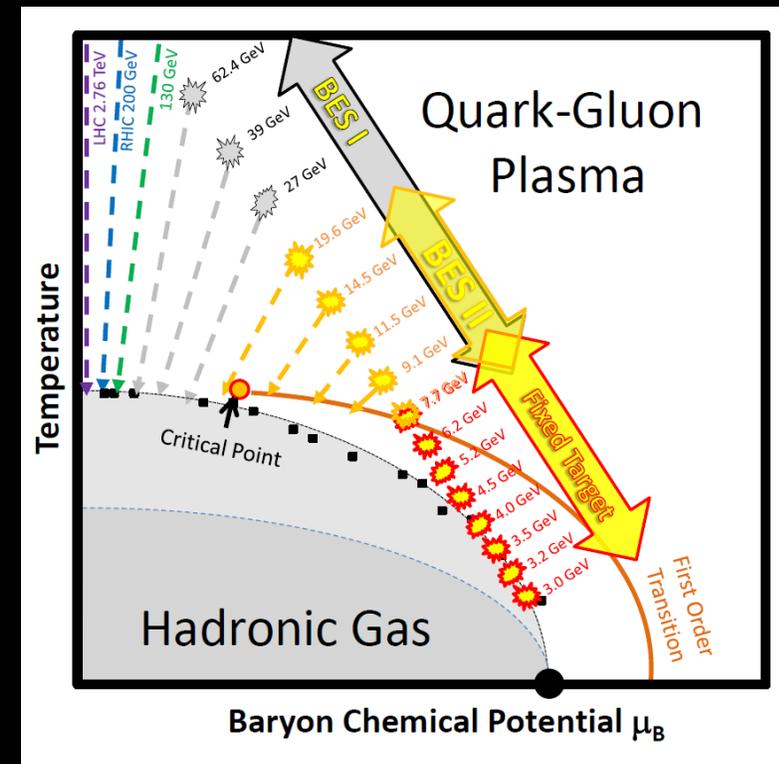


Recommendation for Beam Energy Scan II



Based on the recommendations STAR developed the 2019 beam usage request, planning running conditions for the 2019 and following years to complete BES II.

“The trends and features in BES-I data provide compelling motivation for a strong and concerted theoretical response, as well as for the experimental measurements with higher statistical precision from BES-II. The goal of BES-II is to turn trends and features into definitive conclusions and new understanding.”





BESII & BUR 2019

Beam Energy (GeV/nucleon)	$\sqrt{s_{NN}}$ (GeV)	μ_B (MeV)	Run Time	Number Events
9.8	19.6	205	4.5 weeks	400M
7.3	14.5	260	5.5 weeks	300M
5.75	11.5	315	5 weeks	230M
4.55	9.1	370	9.5 weeks	160M
3.85	7.7	420	12 weeks	100M
31.2	7.7 (FXT)	420	2 days	100M
19.5	6.2 (FXT)	487	2 days	100M
13.5	5.2 (FXT)	541	2 days	100M
9.8	4.5 (FXT)	589	2 days	100M
7.3	3.9 (FXT)	633	2 days	100M
5.75	3.5 (FXT)	666	2 days	100M
4.55	3.2 (FXT)	699	2 days	100M
3.85	3.0 (FXT)	721	2 days	100M

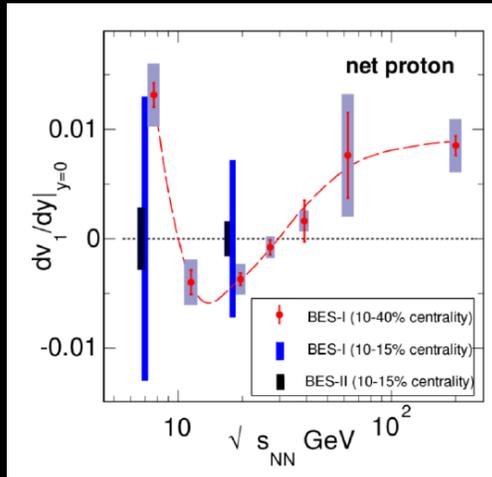
- During Run-19 STAR data taking was interleaved with dedicated development and commissioning of the low energy electron cooling (LEReC) to be ready for the upcoming lower energy runs;
- Fixed target runs further extend/complement the BES-II while staying within the range of RHIC energies.



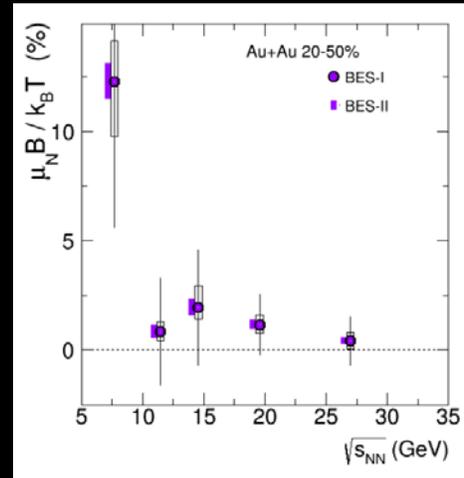
Beam Energy Scan II

- With larger statistics (LReC) and detector STAR upgrades BES-II will enable us to look into the highly sensitive parameters with higher precision;

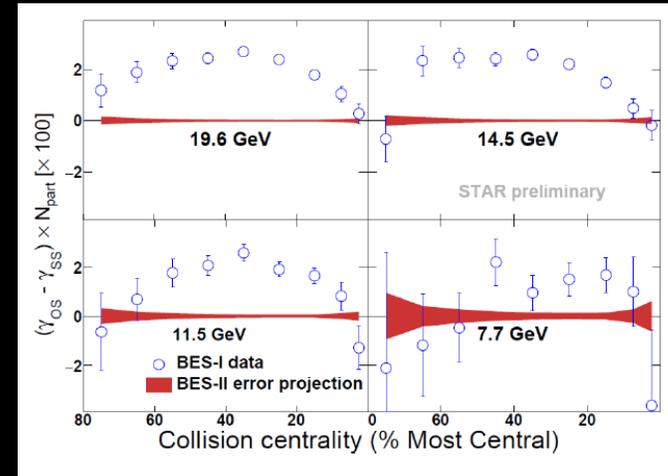
Net proton directed flow



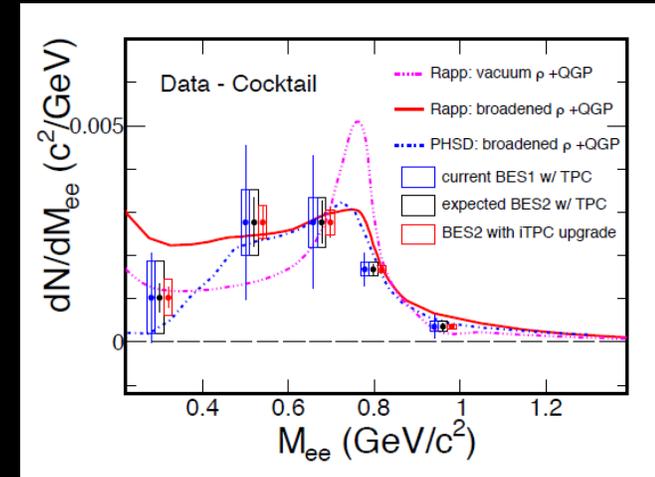
Lambda global polarization difference



Disappearance of the CME signal and low energies

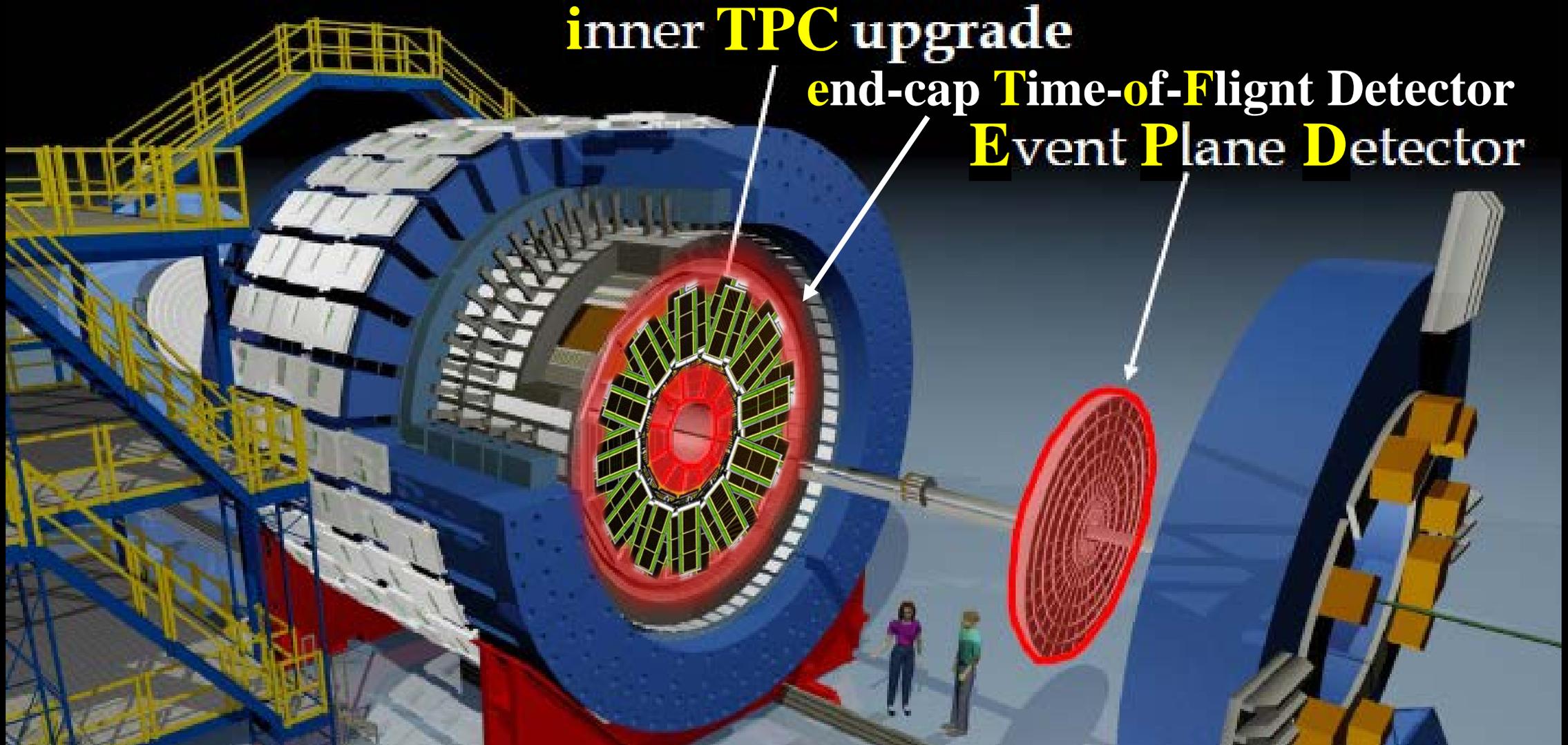


Di-electron invariant mass spectra



etc...

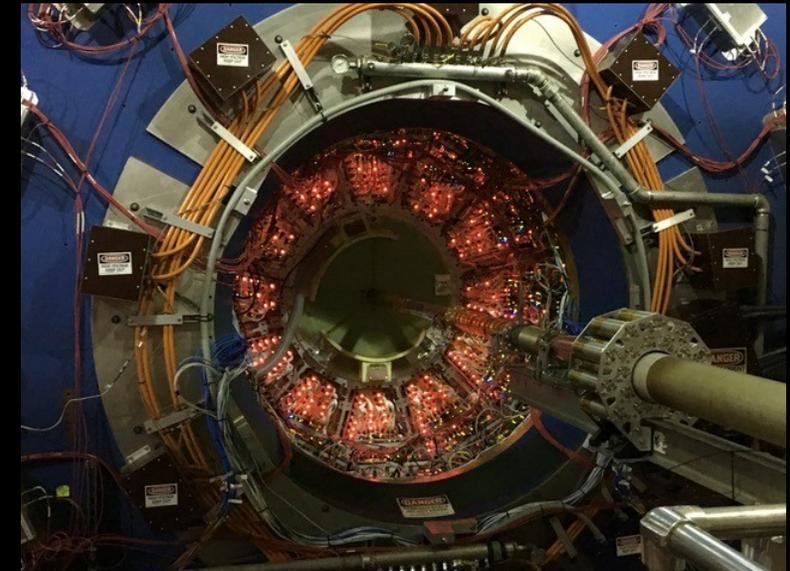
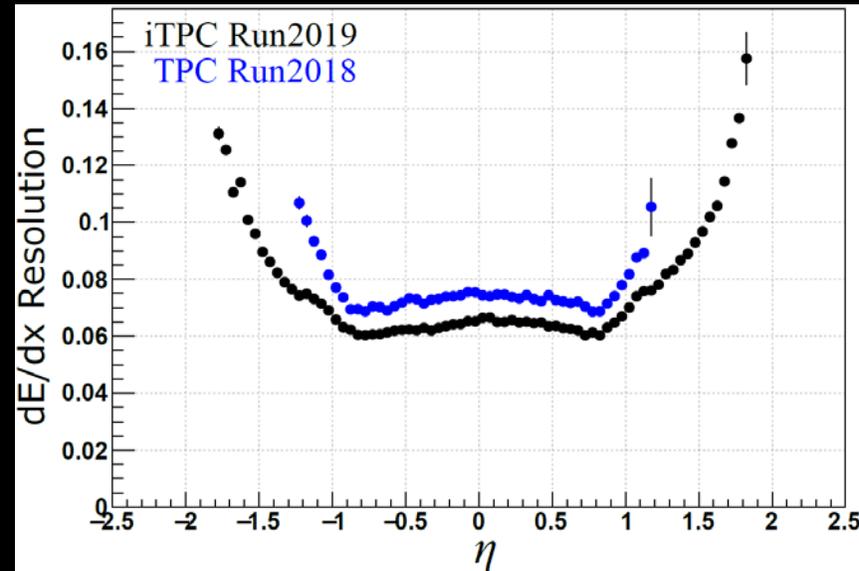
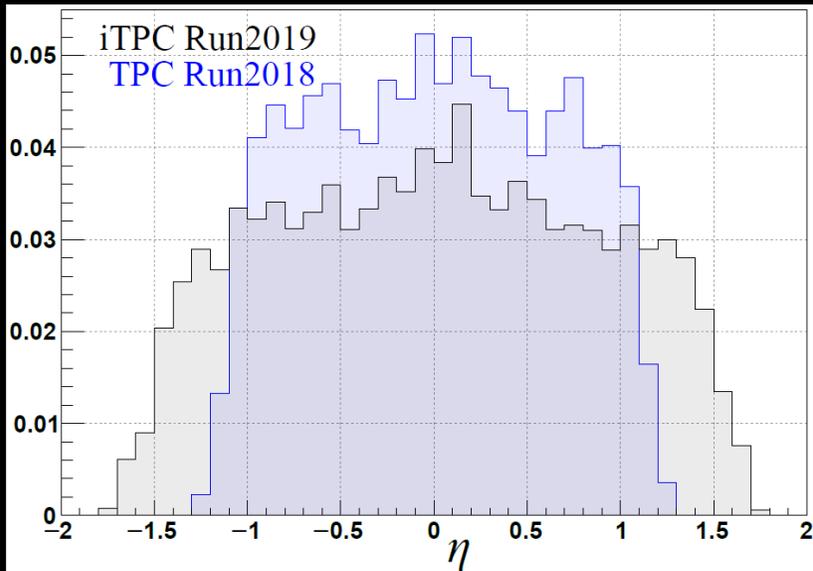
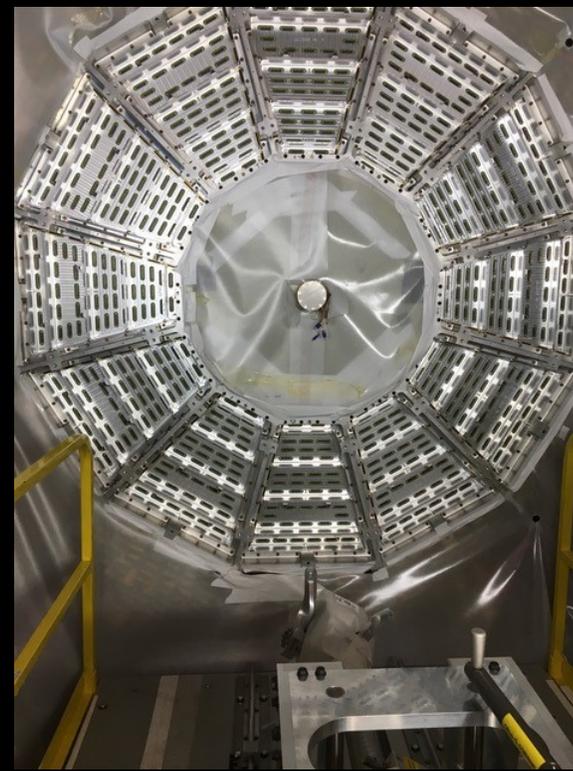
Key Upgrades for Success





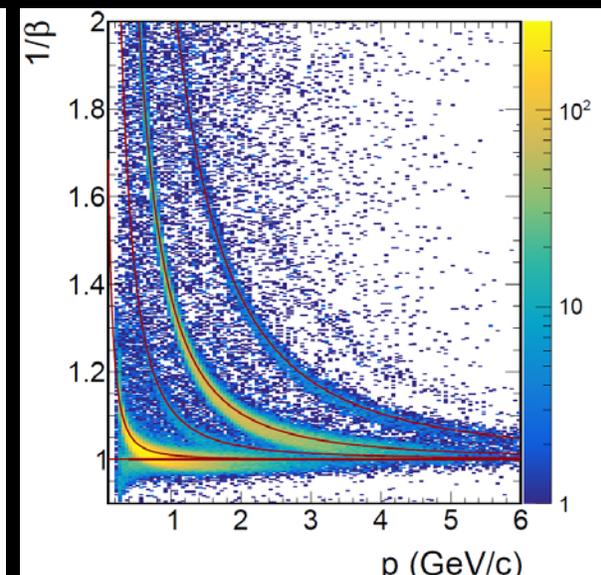
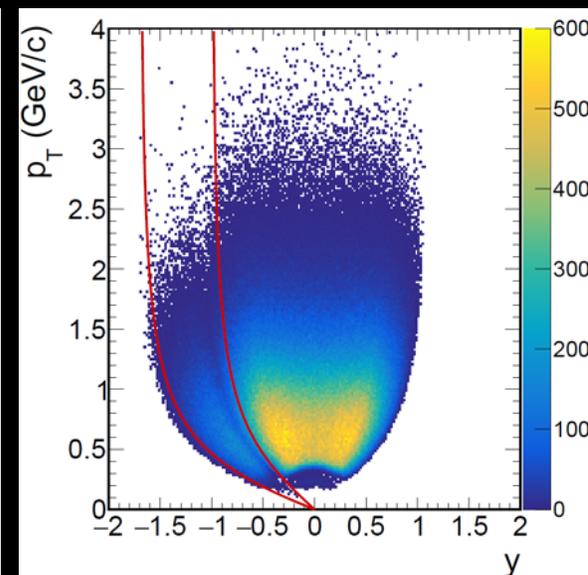
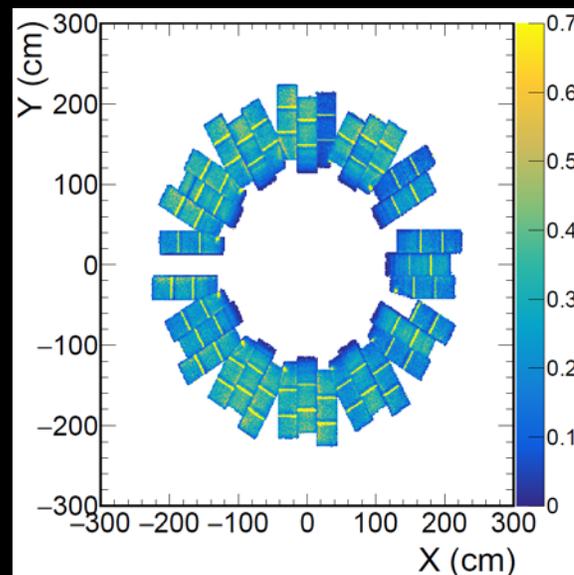
iTPC

- All 24 sectors installed during shutdown FY18/19;
- Successfully integrated into the data-taking since day 1 of the Run-19;
- Demonstrated improvement in pseudorapidity coverage and dE/dx resolution;



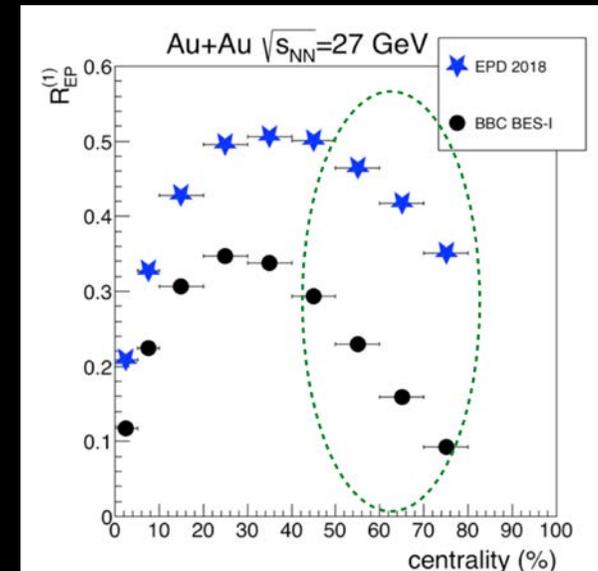
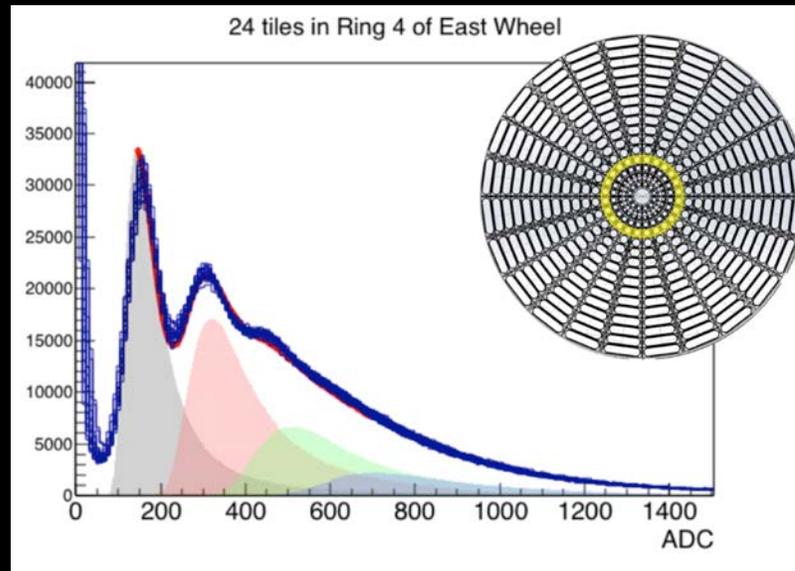
eTOF

- End-cap time-of-flight detector was fully installed;
- Extended pseudorapidity coverage: $-1.1 > \eta > -1.5$;
- Time resolution was measured to be $\tau_{system} = 85$ ps; [Goal < 100 ps]



EPD

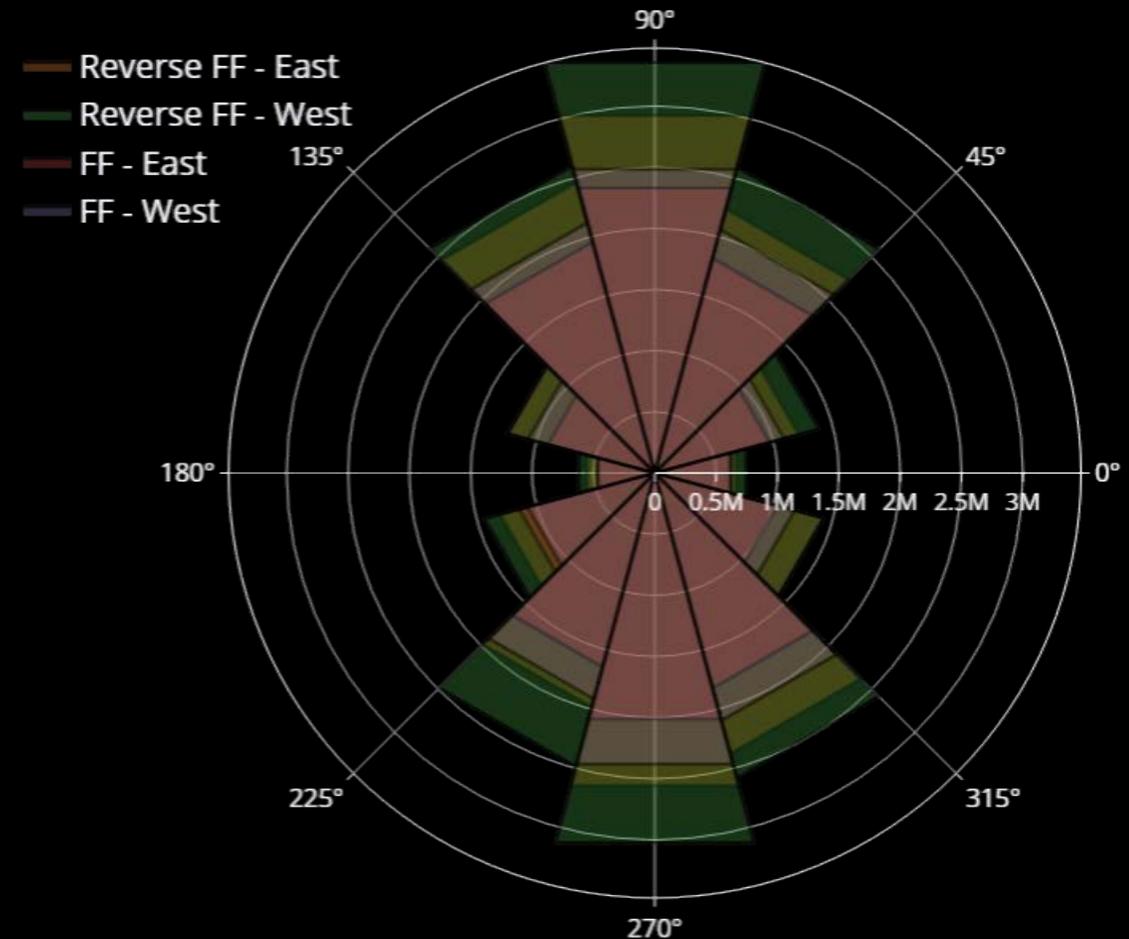
- Fully installed and ready for Run-18;
- Pseudorapidity coverage $2.1 < |\eta| < 5$;
- • Extremely uniform response;
- • Event plane resolution greatly improved especially for peripheral collisions.



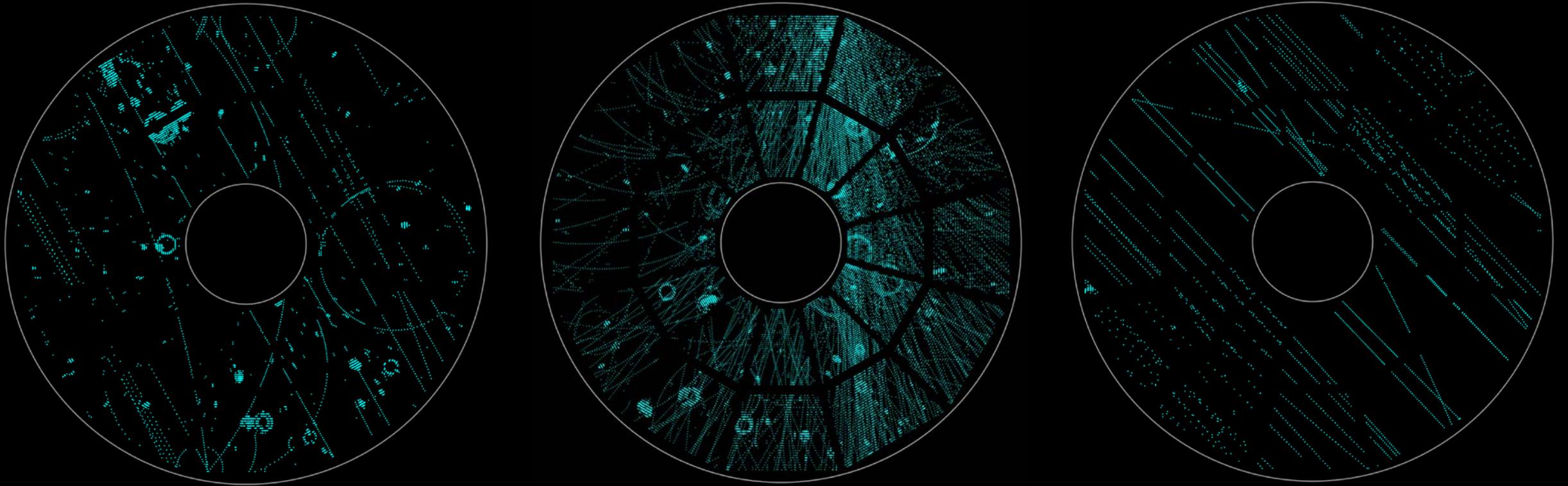


Cosmic Run 2019

- During cosmic run the upgraded system with fully tested, commissioned, and tuned for the datataking;
- Goal: align the TPC with newly installed inner TPC sectors;
- Half a million events in each sector requested to properly do alignment of every (sub)sector;
- Both polarity of magnetic field needed to eliminate field dependent effects;
- During this time all detectors were commissioned and ready for the collisions.

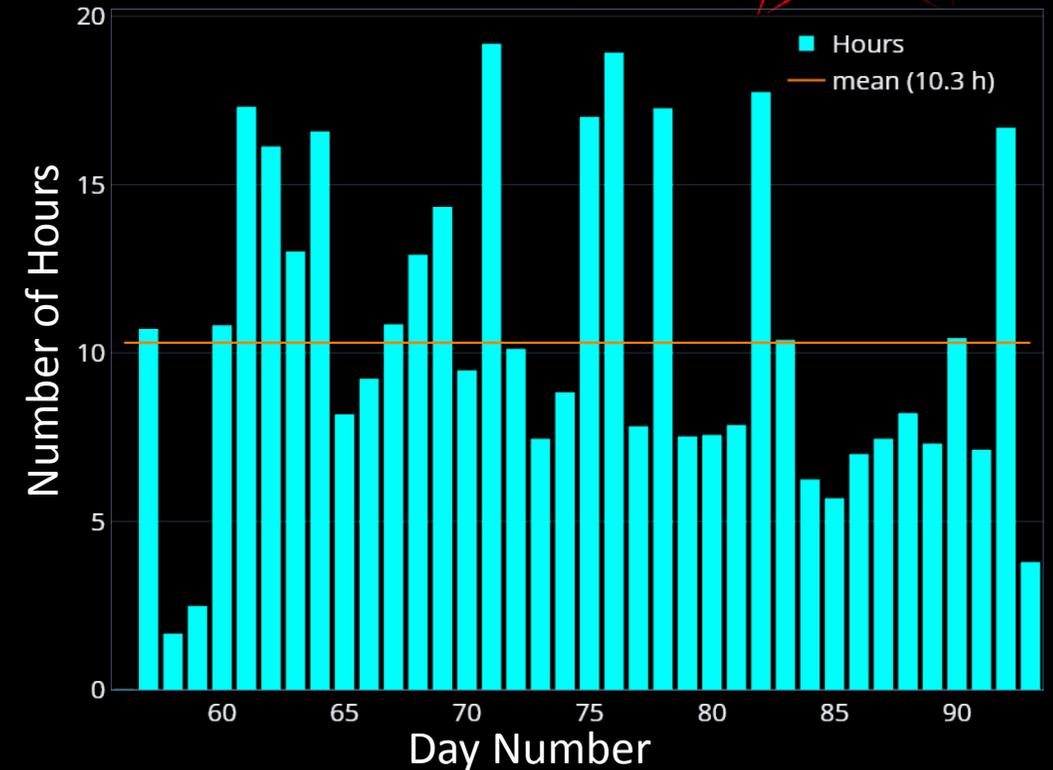
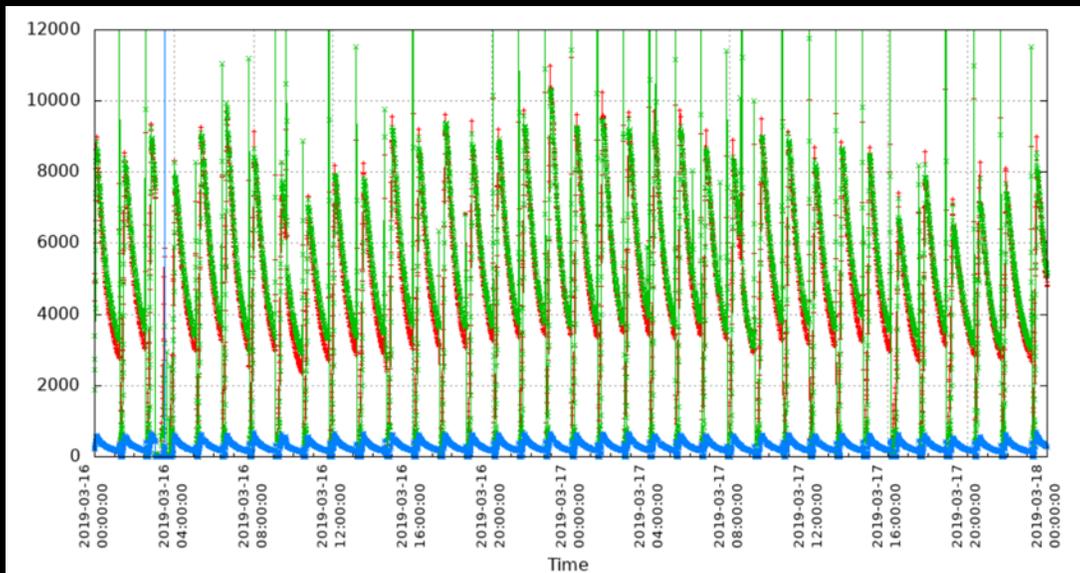


A Few Spectacular Cosmic Events



AuAu 19.6 GeV : Data-taking [I]

- RHIC provided very stable and low background beams;
- Typically 1 hour fills with 20 minutes in between;
- Lessons learned from the past:
 - Gap cleaning moved to the end of the fill;
 - Good communication between STAR and CAD for beam condition optimization is critical.

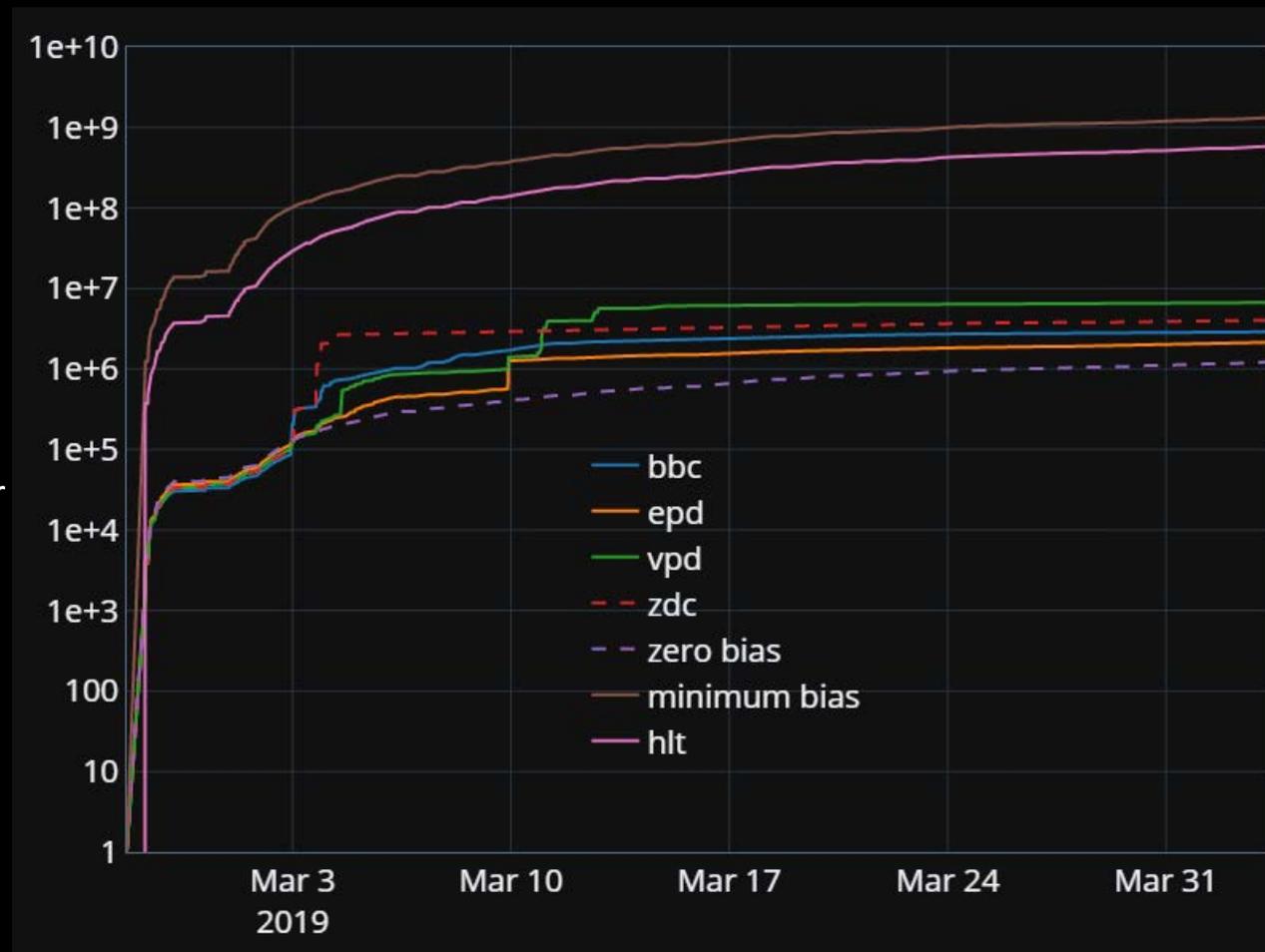


- General running condition was to alternate beam-time between STAR and LEReC;
- Achieved over 10 hours of physics running on average;
- “Good” event fraction 40-45%.



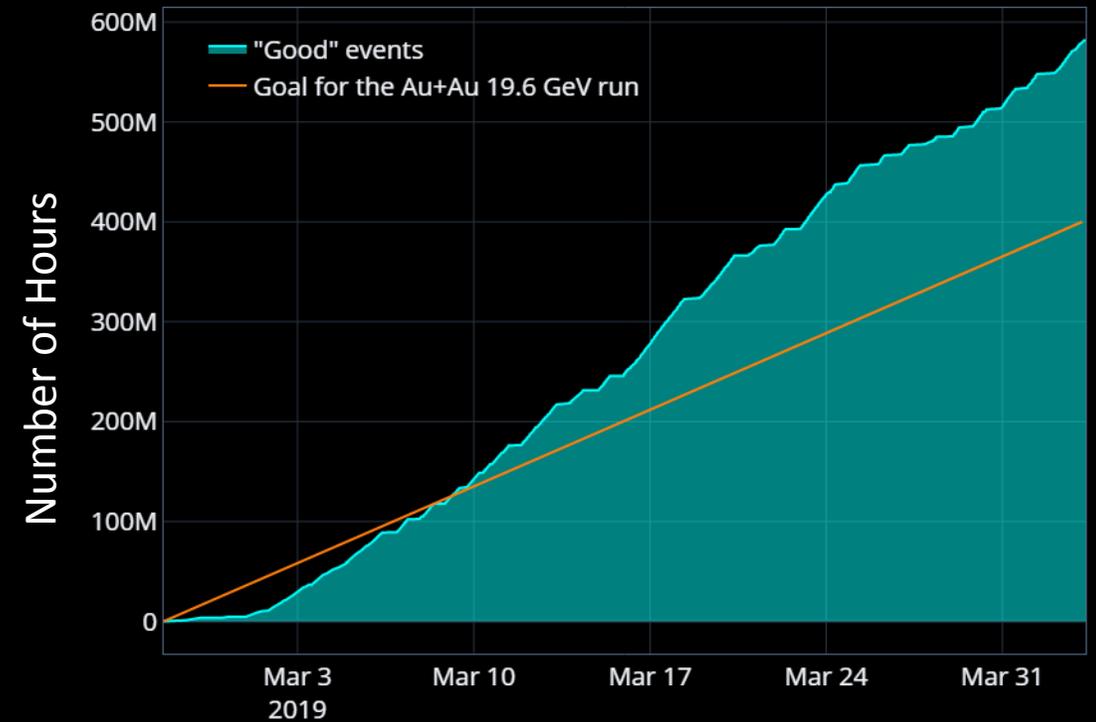
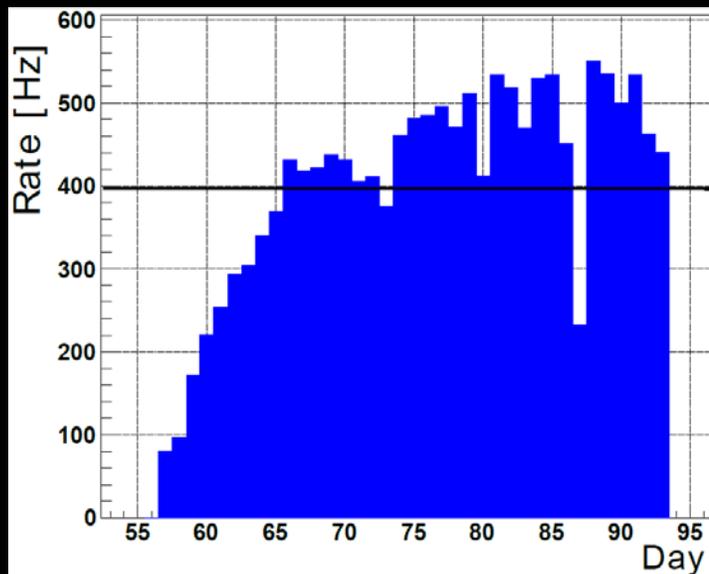
AuAu 19.6 GeV : Data-taking [III]

- STAR collects the data and monitor its quality using suite of physics and monitoring triggers working in parallel;
- This enables us to have minimally biased collision trigger for data-taking, with the monitoring triggers for efficiency measurements and to provide handle on understanding any biases for physics triggers;
- For 19.6 GeV run STAR has collected over 1.3 billion minimum bias events which has very loose event selection optimized for collision signal vs. background;
- Minimum bias selected events are run through the STAR high level trigger (HLT) system in real time, which then selects, marks, and counts the “good” events where the HLT reconstructed vertex is within ± 70 cm along the beam direction and ± 1 cm in radial direction.
- These “good” events is what we measure our goals against.



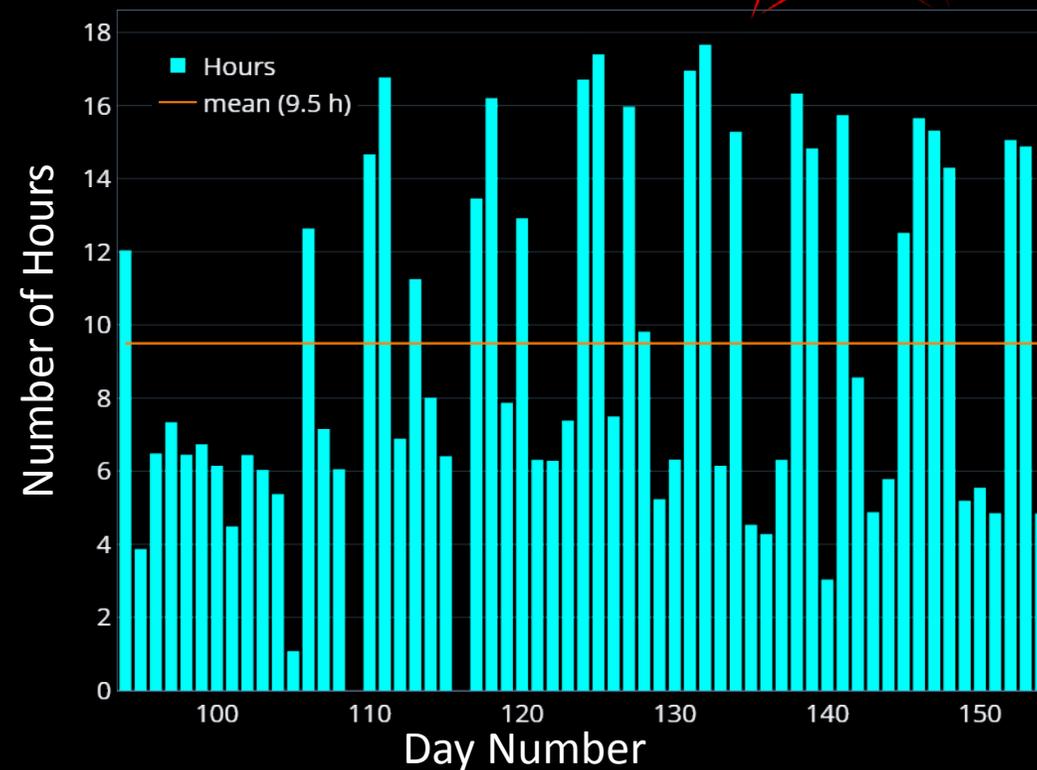
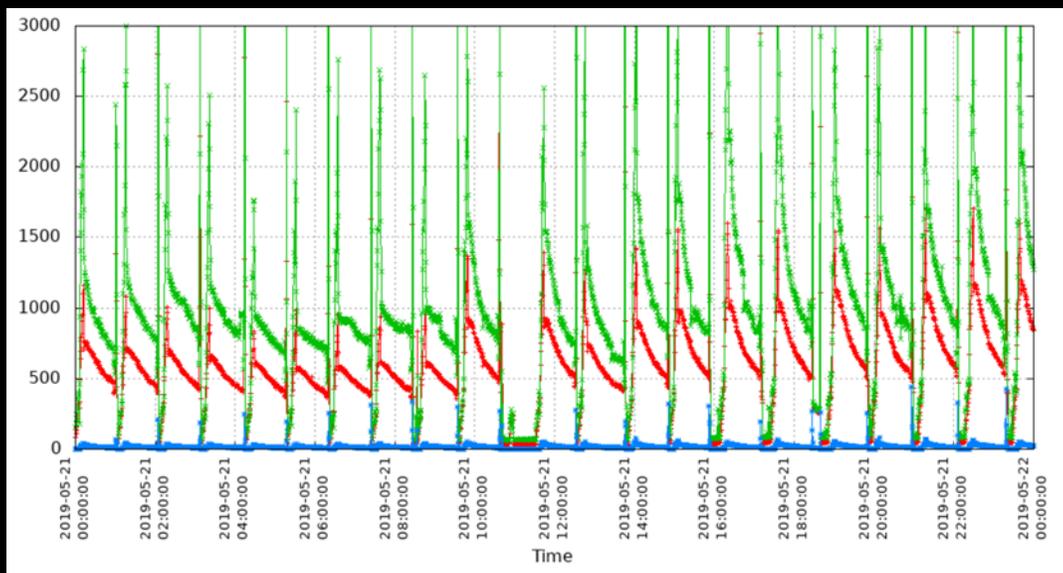
19.6 GeV Au+Au Summary

- Overall very effective data-taking and high quality stable beams;
- During this period eTOF has been commissioned and further tuned to maximize its performance and efficiency;
- On April 4th Au+Au concluded with over 581 M minimum-bias events, (within our "good" event selection criteria).



AuAu 14.6 GeV : Data-taking [I]

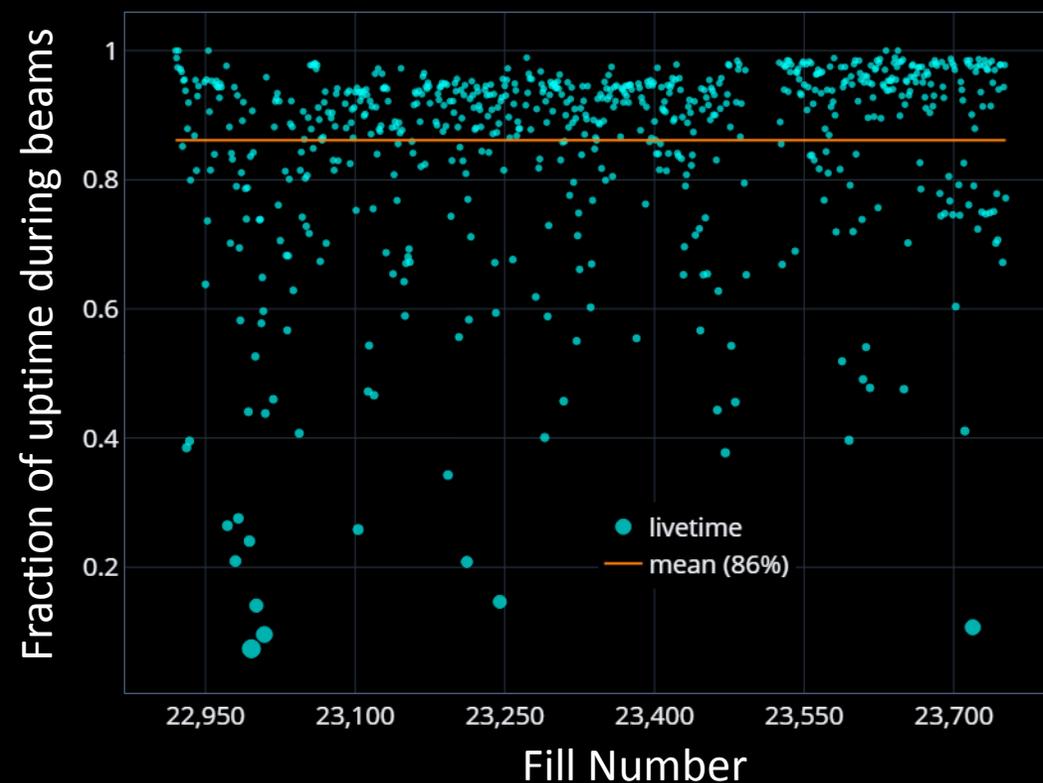
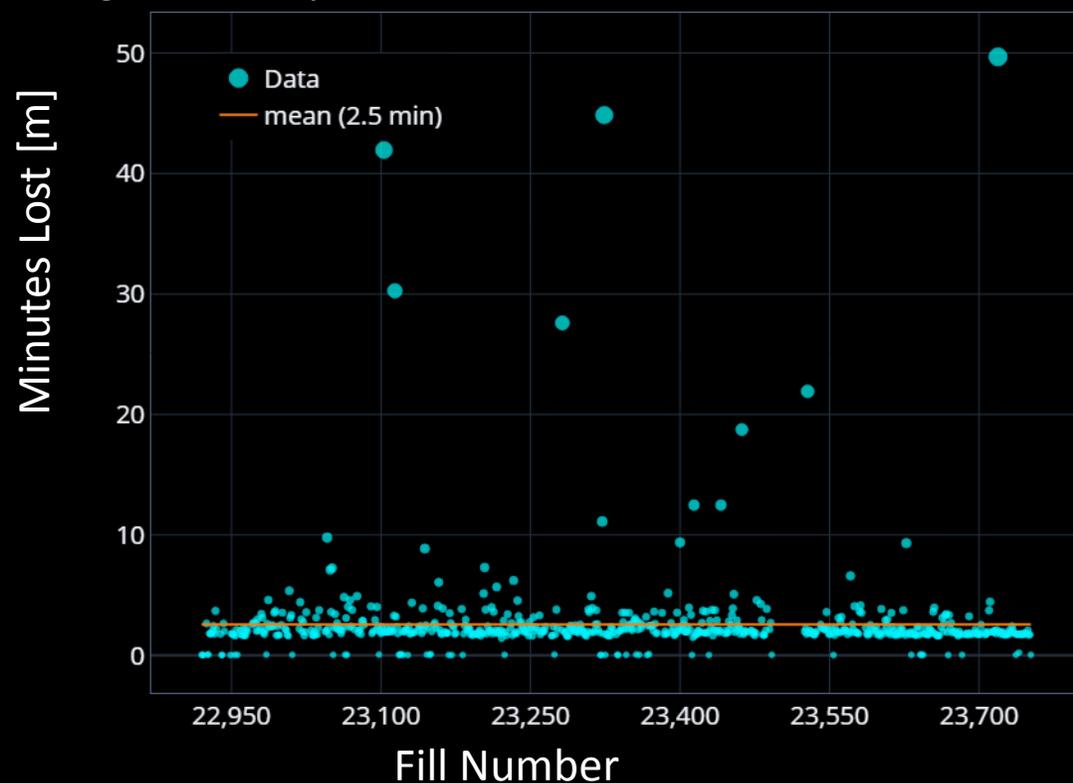
- With lower energy beam quality deteriorates faster;
- This led to 45 minutes fills with a single data-taking run to minimize the loss of the beamtime;
- Turn around time remained short (about 20 minutes).



- General running condition was to alternate beam-time between STAR and LEReC;
- Achieved 9.5 hours of physics running on average.
- Good event fraction 35-40%;

AuAu 14.6 GeV : Data-taking [II]

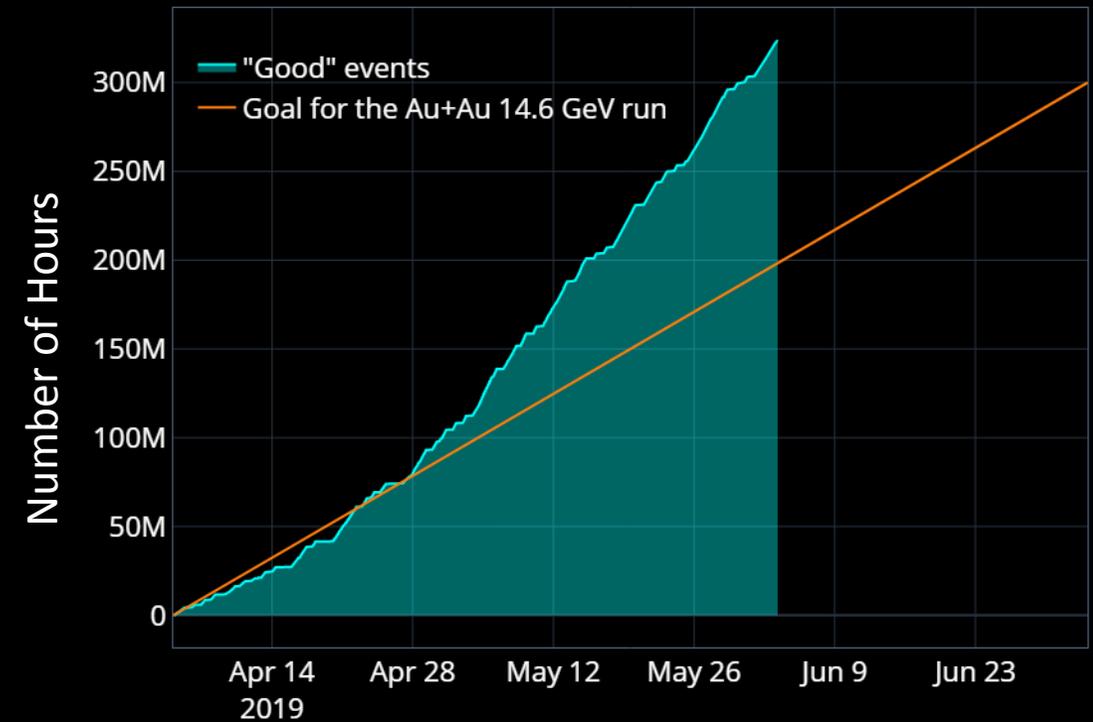
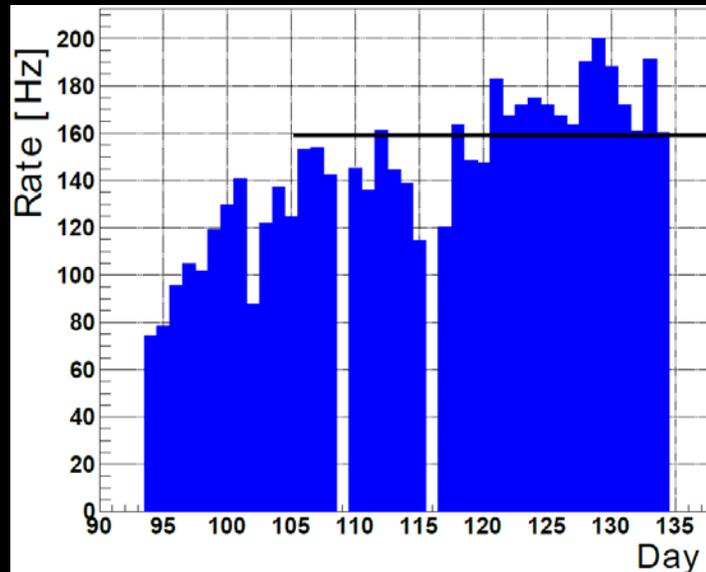
- Very diligent QA efforts set up during the Run-19 showed “injection runs” not usable for data analysis at this energy;
- Therefore the runtime was even more meticulously optimized to eliminate the beam time losses and ensure high efficiency.





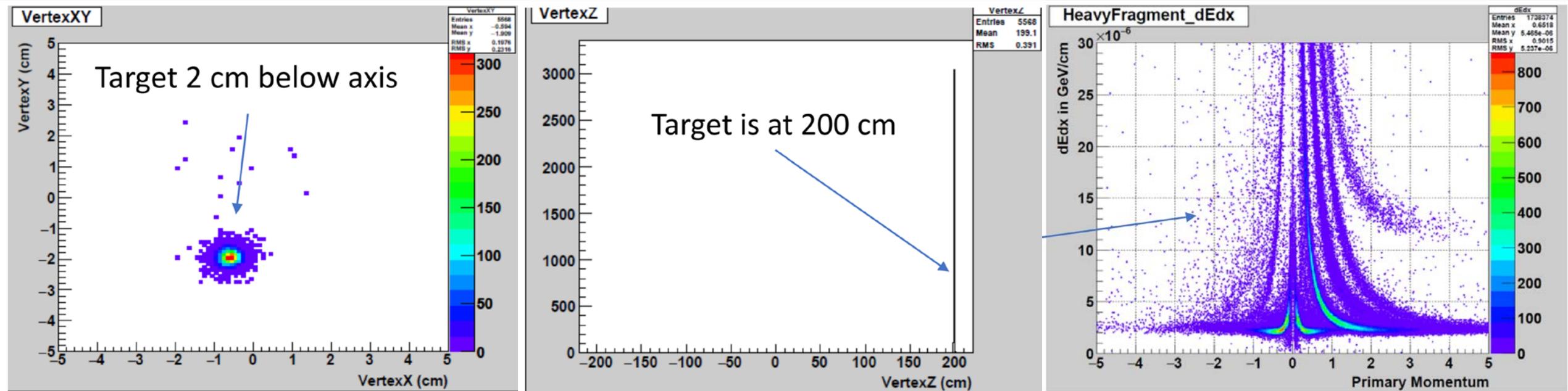
14.6 GeV Au+Au Summary

- C-AD worked during entire run to gradually eliminate every obstacle and provide STAR with ever-increasing collision rates;
- On June 3rd Au+Au concluded with over 324 M minimum-bias events, (within our "good" event selection criteria);
- Finalizing the planned 2019 beam energies earlier than scheduled opens possibility to get a head start on Run-20 $\sqrt{s} = 7.7$ GeV with commissioning of LEReC this year.



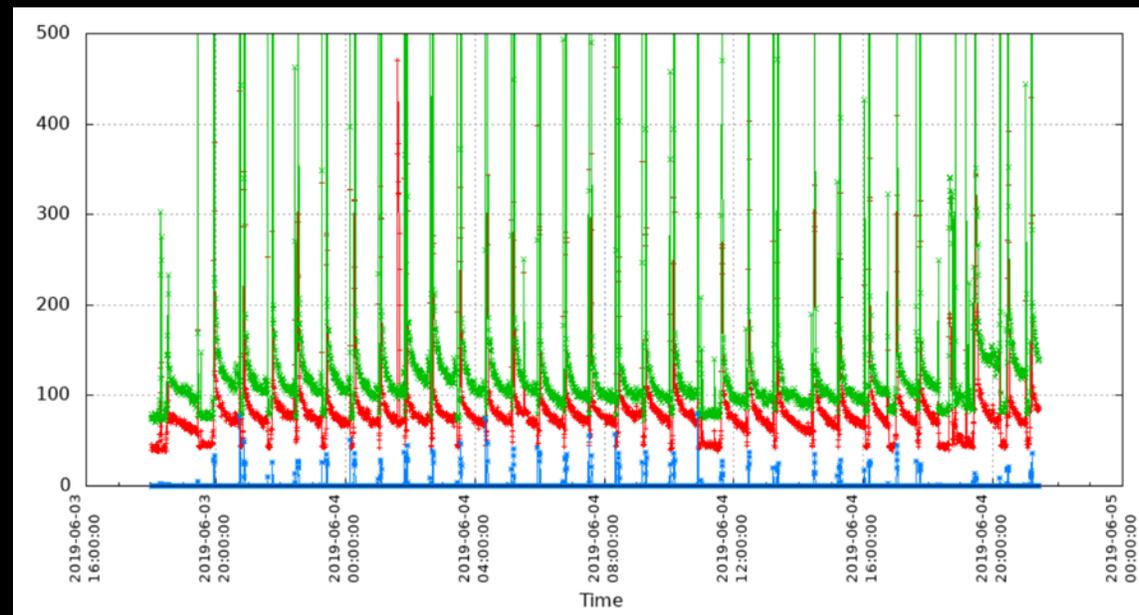
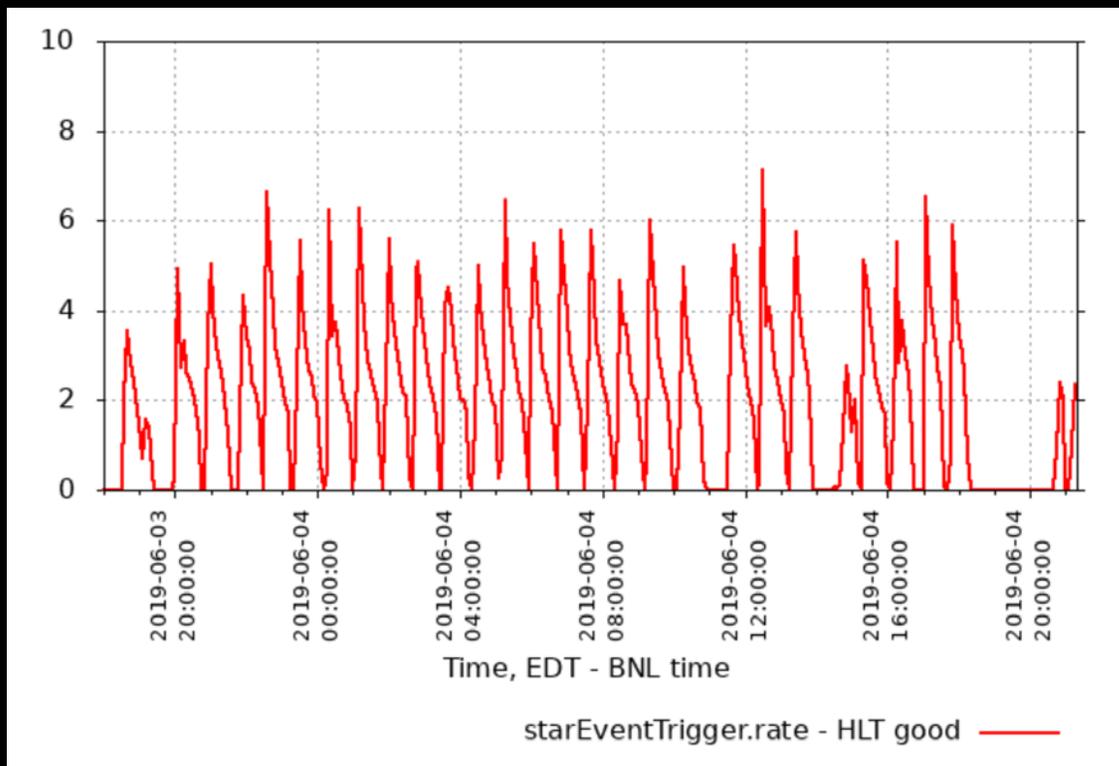
Quick Look at the FXT

- We had a chance of testing FXT during LEReC dedicated time with 3.85 GeV beam;
- First impressions were positive;
- Looking forward to the FXT runs ahead in Run-19.



Plan for the rest of Run-19

- Au+Au 7.7 GeV run has started to have necessary setup and conditions prepared for the run-20;
- LEReC will also attempt to commission its setup on a real physics run.



- C-AD was able, once again, to provide very clean 7.7 GeV collisions;
- Systems still to run for this year:
 - Au+Au 200 GeV collider during RHIC APEX;
 - FXT beam energies ($\sqrt{s_{NN}}$) at 3.85 (3), 4.55 (3.2), 7.3 (3.9), and 31.2 (7.7) GeV.



Summary

- BES II successfully commenced in RHIC Run-19;
- iTPC & ETOF commissioned and integrated into data-taking successfully;
- Goals for both 19.6 and 14.6 GeV beam energy runs completed with surplus;
- Looking forward to the exiting results from these datasets;
- Deep gratitude to the C-AD for spectacular work for the success of the Run-19.