

The logo features a red five-pointed star outline. The word "STAR" is written in bold blue capital letters across the center of the star. To the right of the star, the words "Run24" are written in a dark red, sans-serif font.

(Performance, goals, achievements and challenges)

J.H. Lee / BNL

**BNL NPP 2024 PAC Meeting
November 7-8**

Run24 - timeline

- 8/1/23 : End of Run23 beam operation (Valve box in I004B failure)
- 4/2/24 : Shift (2 person) start, flammable gas flow (shift total ~~27~~ 29 weeks) 2 weeks before cooldown
- 4/6-: Cosmic data taking with magnet on
- **4/15 : RHIC 4k Cooldown start (~~25~~ 27 cryo weeks)**
- 4/16 : Full Shift (4 person) start + period coordinator
- 4/27 : First collisions for trigger/timing setup
- 4/30 : Start physics with p+p (low-luminosity)
- 5/17 : Start STAR high-luminosity/spin physics
- 5/20 : Rotator on for radial polarization
- ~~8/26 : 19 weeks cooldown mark. switching to Au+Au for 6 weeks~~
- **9/30 : 24 weeks cooldown mark. switching to Au+Au for 3 weeks**
- ~~10/7 : End of run~~
- **10/21/24: End of run**
- 3/24/25 : 4k Cooldown for Run25 (to be determined)

Beam Use Request for Run24

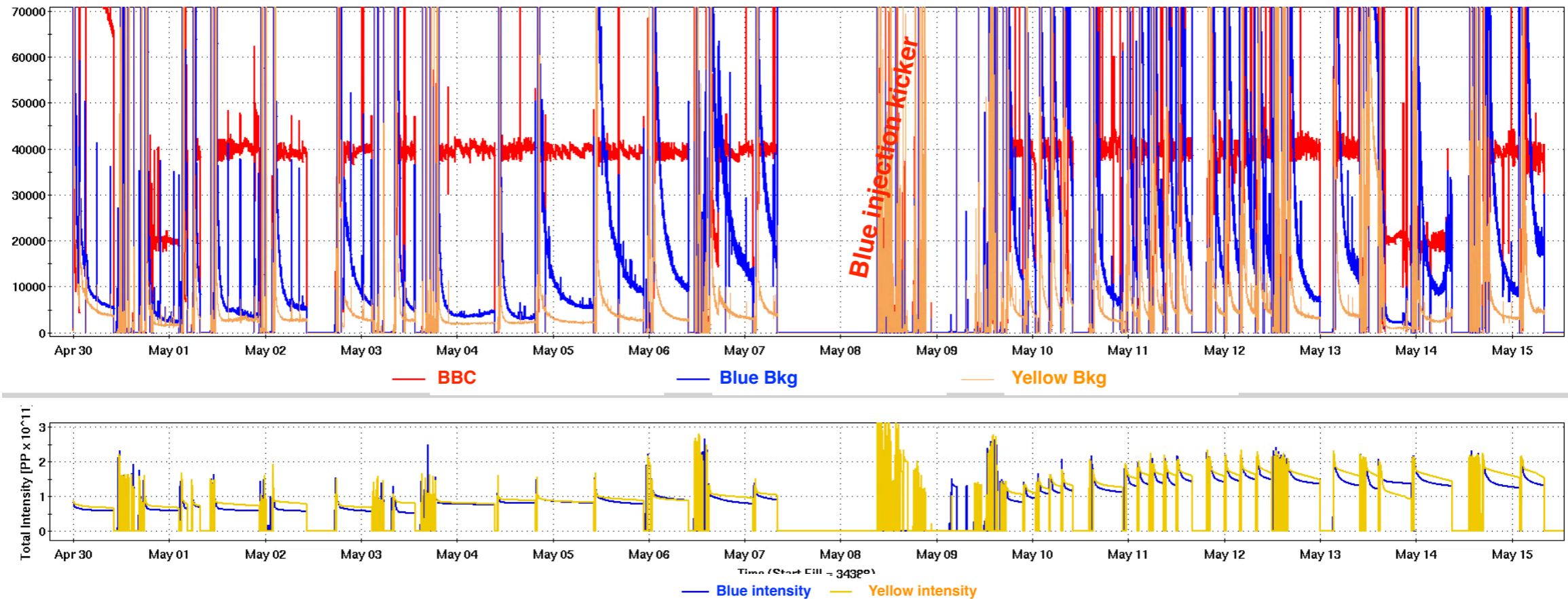
$\sqrt{s_{NN}}$ (GeV)	Species	Number Events/ Sampled Luminosity	Year
200	$p+p$	142 pb ⁻¹ /12w	2024
200	$p+Au$	0.69 pb ⁻¹ /10.5w	2024
200	Au+Au	18B / 32.7 nb ⁻¹ /40w	2023+2025

Assuming 24 physics weeks / year

The PAC recommends that the top priority for Run 24 is to complete the commissioning of sPHENIX and to collect the high statistics pp dataset necessary as a reference for all the sPHENIX hard probes Au+Au measurements in Run 25, and simultaneously allow STAR to make landmark polarized proton measurements using its new forward instrumentation. We recommend p+Au running in Run 24 if, and only if, the top priority above has been completed and a p+Au run of at least 5 weeks can be accomplished.

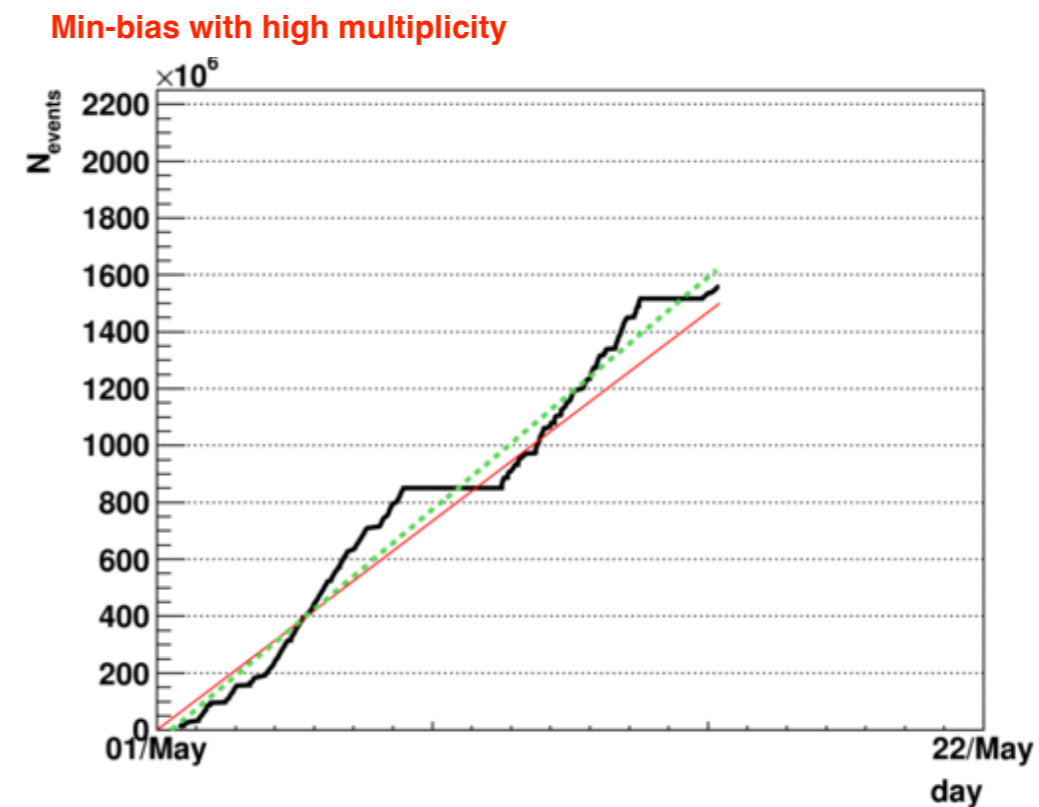
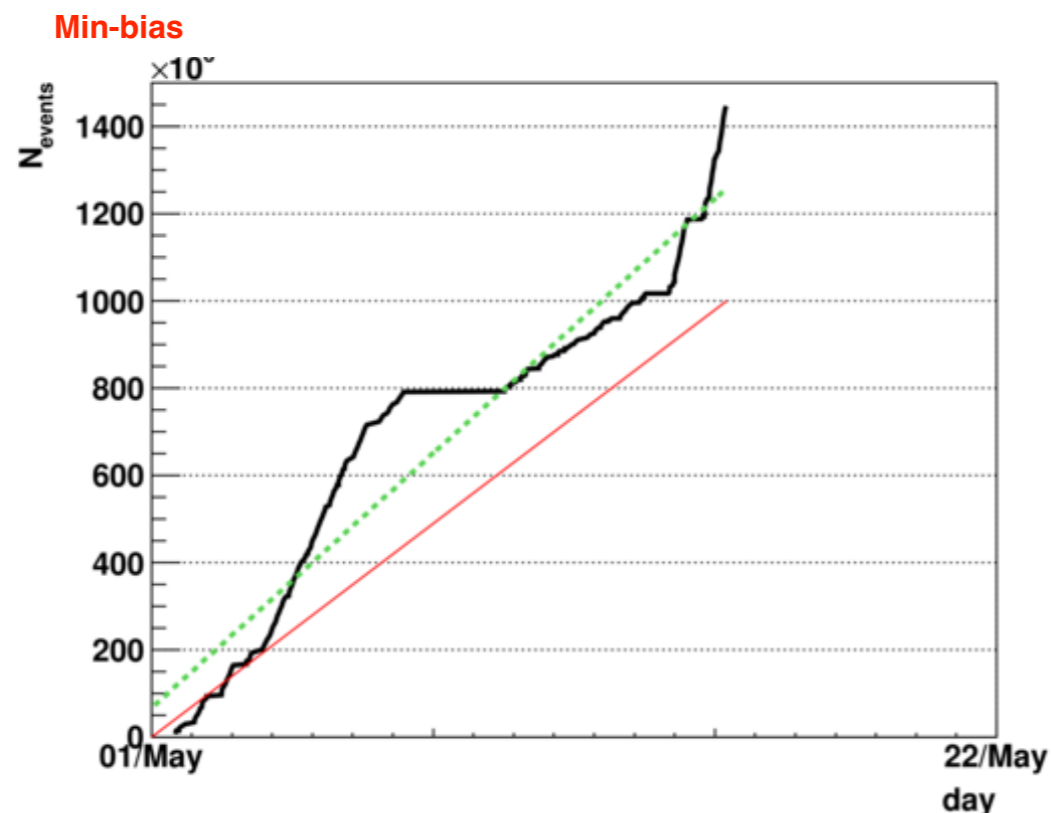
- Luminosity goal for p+p: 142 pb⁻¹ for 12 weeks of running
- Figure of Merit goal: $\mathcal{P}^2L = 0.57^2L = 46.1 \text{ pb}^{-1}$
- **Revised goals:** L=170 pb⁻¹, FoM = 55 pb⁻¹ assuming 14.5 weeks

pp low-luminosity

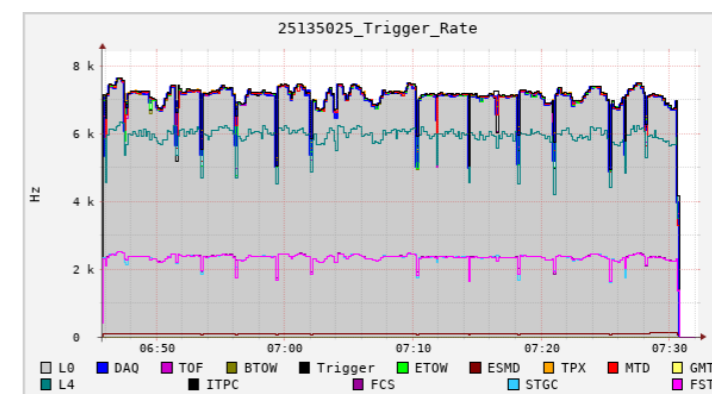


- Opportunistic running (2 weeks) during sPHENIX's commissioning
- To study collectivity in high-multiplicity pp with minimal event pile-up
- 1 mrad crossing angle and luminosity leveling BBC at 20~40k (x100 lower than nominal luminosity)
- Background in Blue dominating at 20k, set BBC leveling at 40k

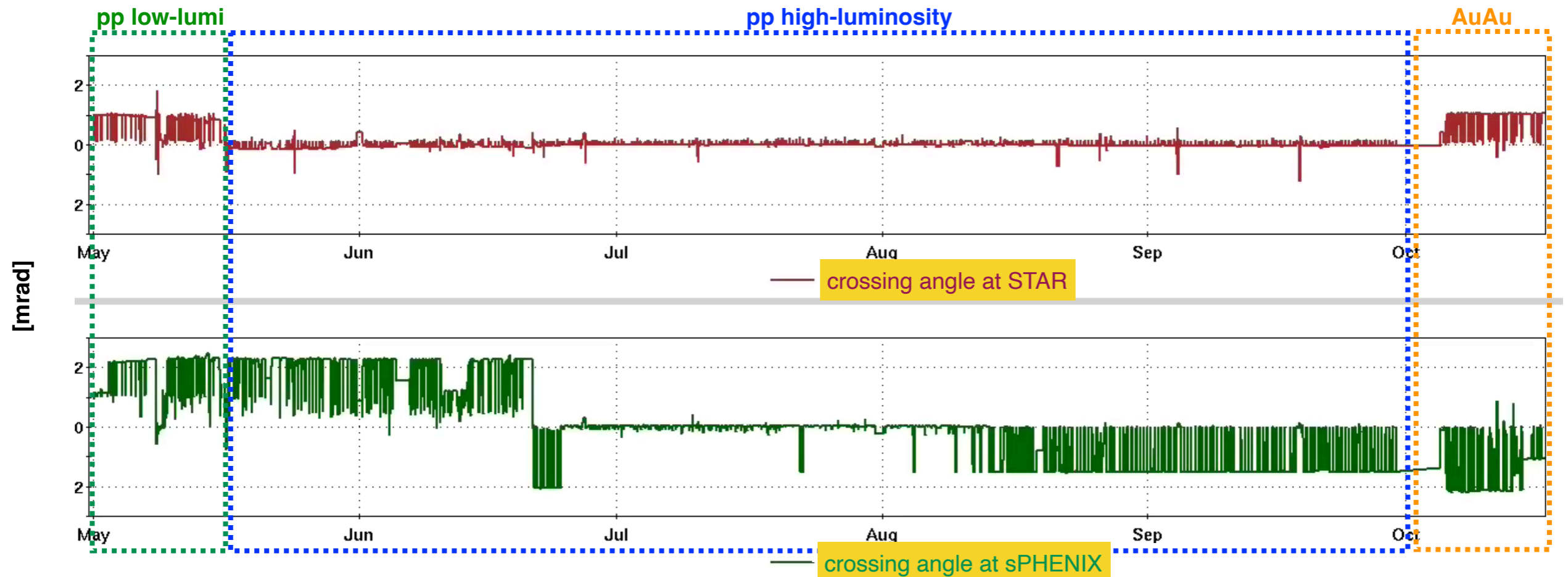
Min-bias with pp low-luminosity



- Successful ~1.5B each Min-bias and Min-bias high-multiplicity events as planned
- Min-bias using EPD (with background reduction cut)
- Min-bias high-multiplicity (~25% “central”) using ToF multiplicity
- Maximum DAQ rate ~ 7 kHz (DAQ5k upgrade in Run23)

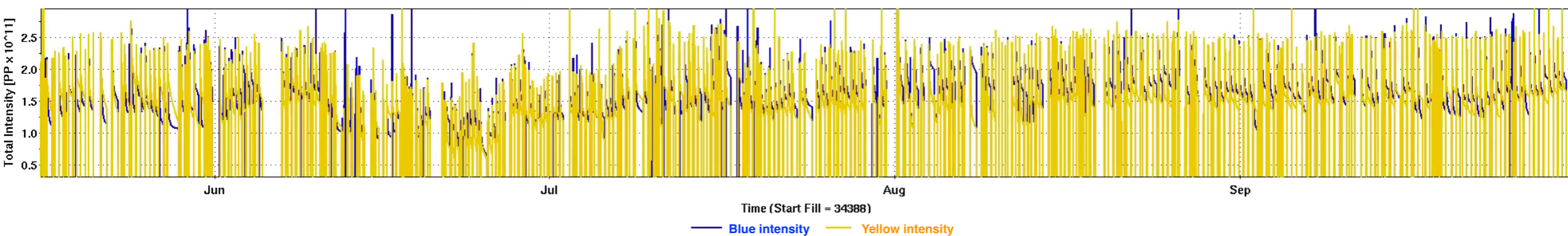
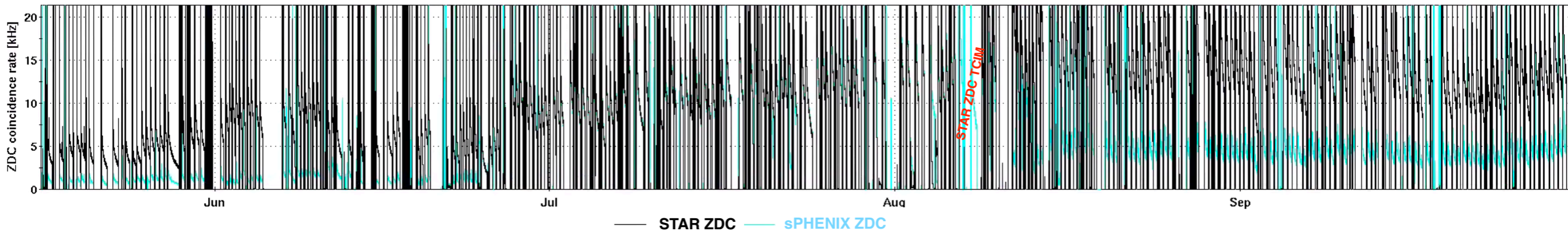


Crossing angle



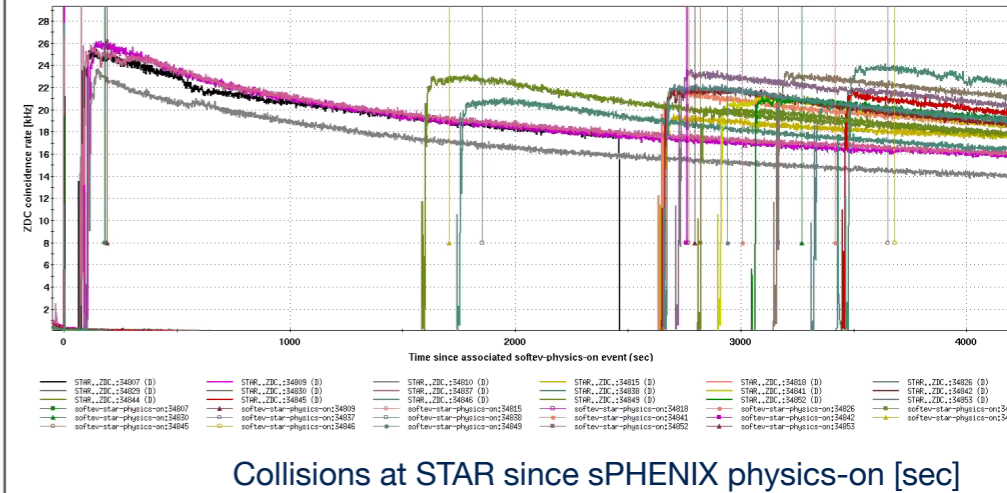
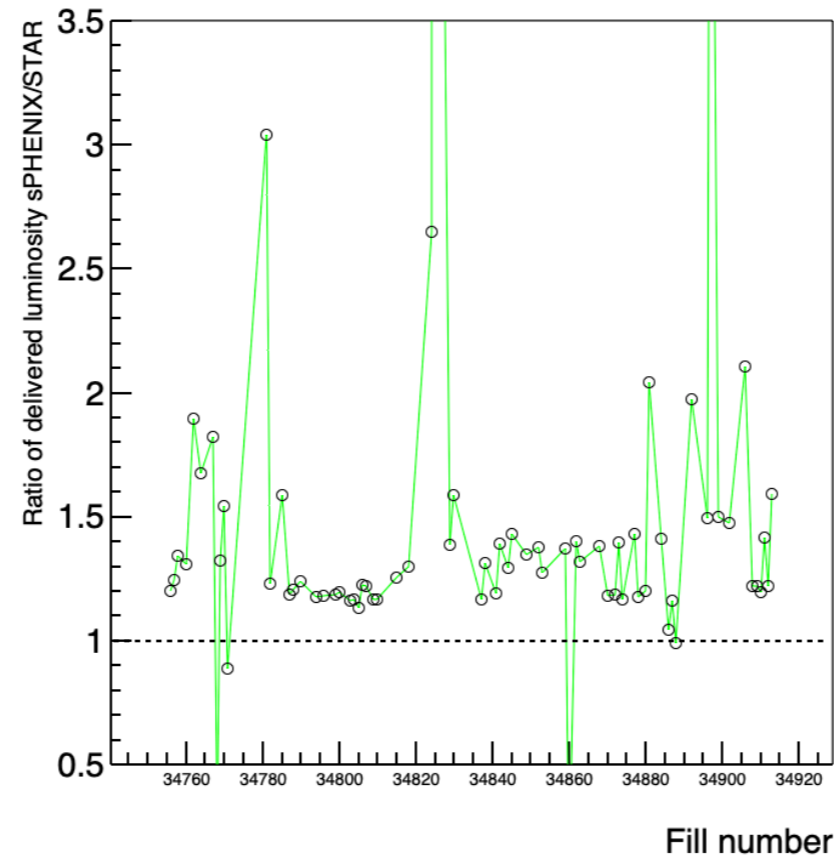
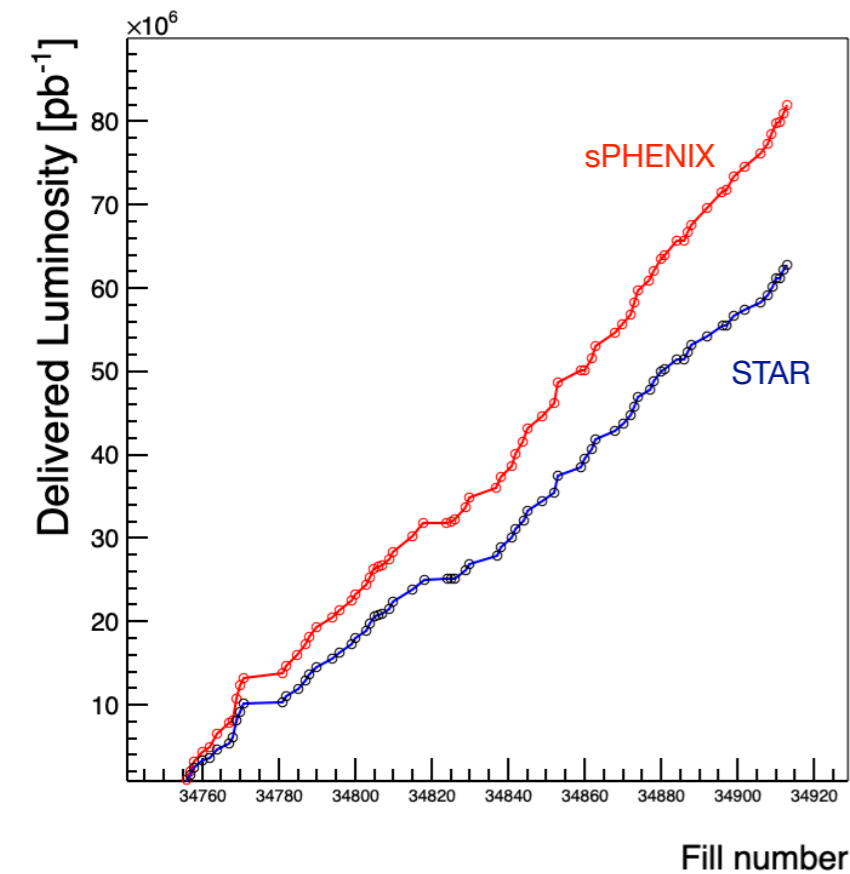
- Crossing angle at STAR: 0 (or 1) mrad, at sPHENIX: 2 (or 1.5, 1, 0) mrad
- Reduce luminosity by x3-4 with 1 mrad
- Beam-beam effect with a crossing angle affects total maximum luminosity available
- Impact on background in AuAu
- Crossing angle/luminosity at sPHENIX changes background at STAR

pp high-luminosity / spin



- 19.5 weeks: Machine uptime 57%, STAR uptime 79% during the period
- Machine issues and improvements:
 - Initial luminosity ramp-up
 - No e-Lens (vs Run 15) to reduce beam-beam effects
 - 56 MHz cavity impact on emittance (not fully damped)
 - Beam-beam effect without a crossing angle (separate physics-on)
 - Machine development fixing chromaticity greatly improved instability and emittance (July 16)
- Multiple low-intensity configurations for sPHENIX TPC commissioning

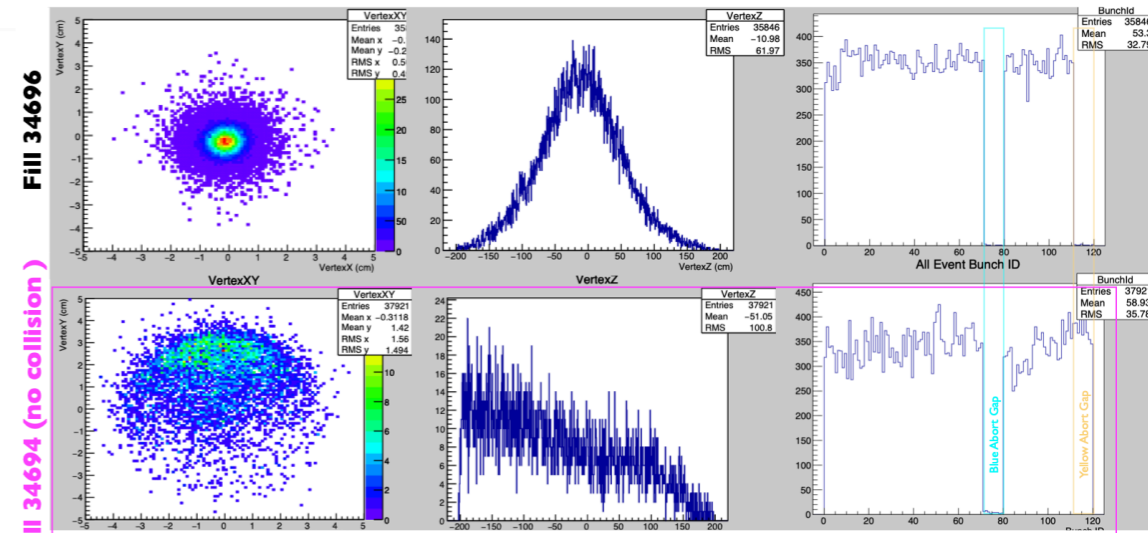
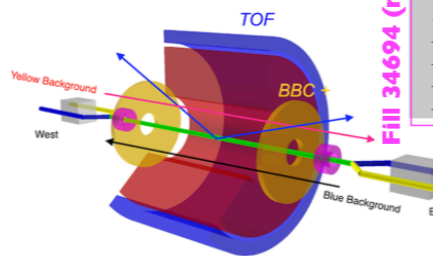
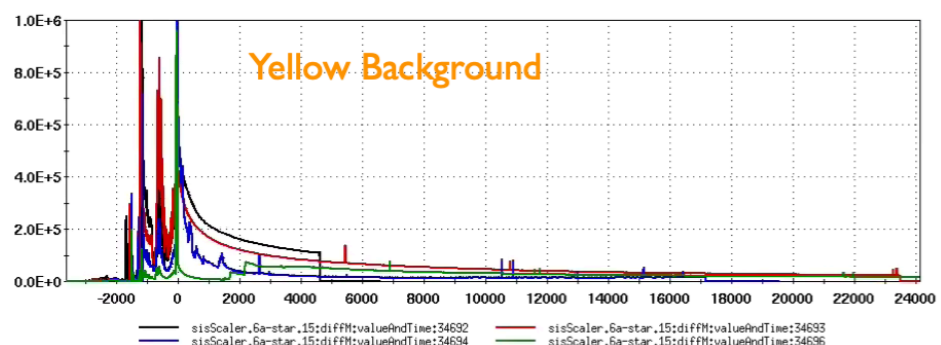
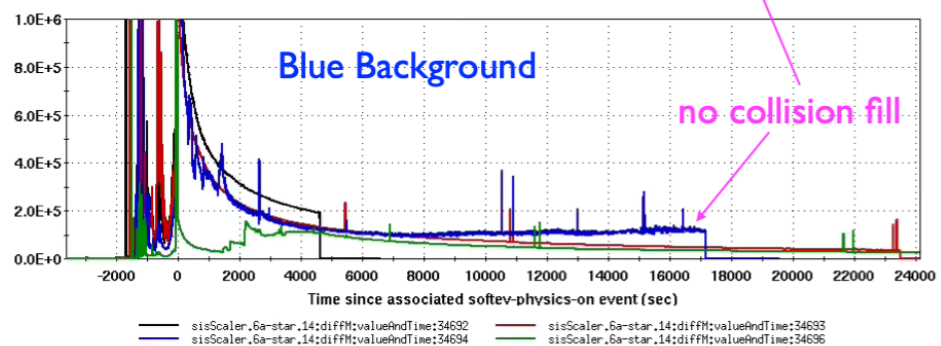
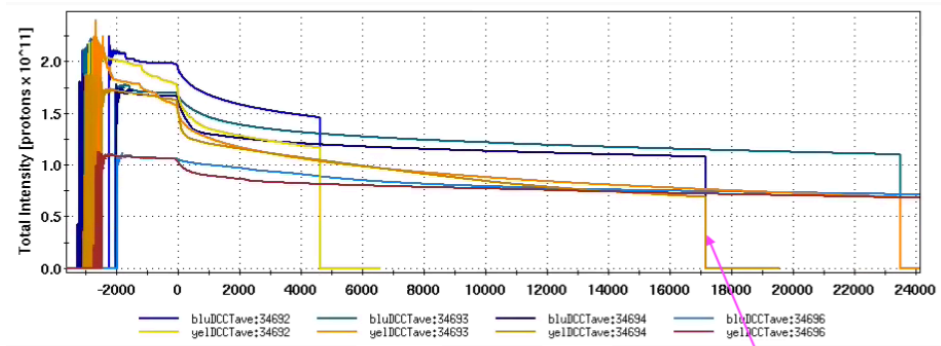
Running with sPHENIX, beam-beam effect



Collisions at STAR since sPHENIX physics-on [sec]

- STAR and sPHENIX collisions at separate times since July 5
- Until sPHENIX adding a crossing angle when sPHENIX TPC was fully operational (~Aug 10)
- Collision at STAR only when beam-beam parameter is $< 10^{-3}$
 - minimum wait time of 40 mins if the beam-beam parameter is above the threshold

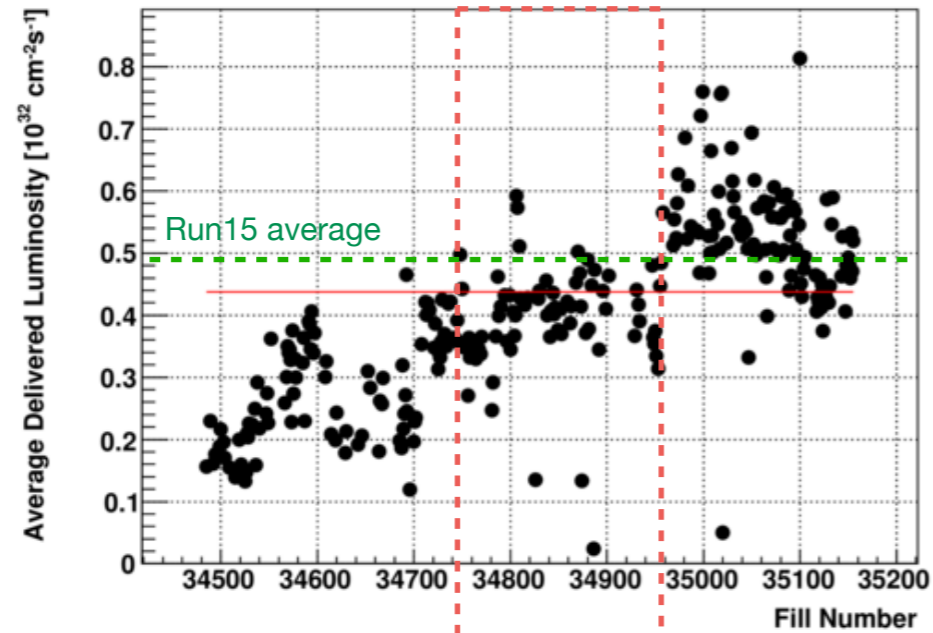
Background in pp



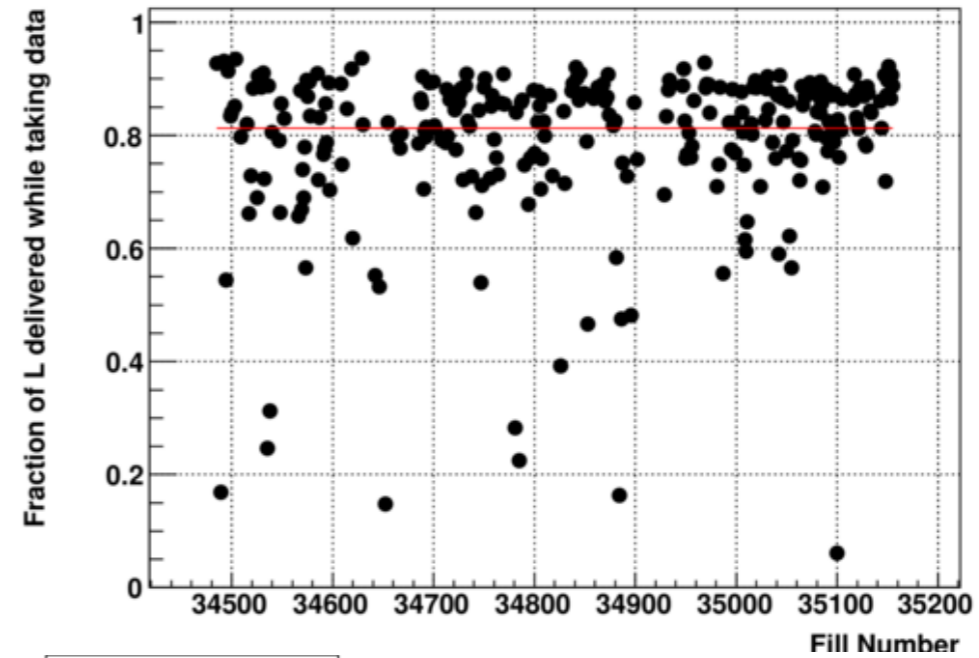
- High background in Blue (significant fraction non-collision related)
- Some reduction/improvement was made by adding “Mask” at 11 o’clock (Jul 12)
- Further reduction required significant beam developments needing new dynamic aperture - not implemented

pp luminosity and efficiency

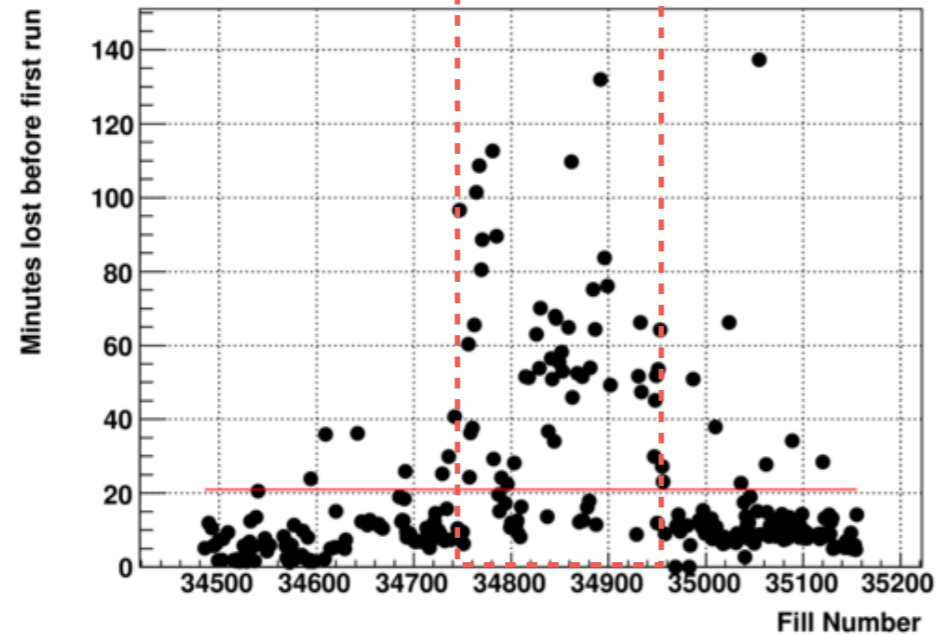
Average Delivered Luminosity [$10^{32} \text{ cm}^{-2}\text{s}^{-1}$]



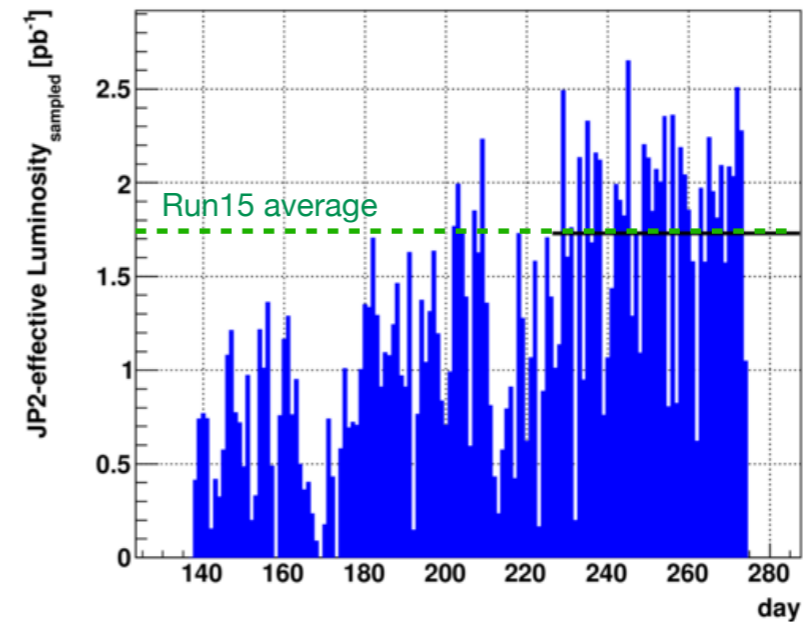
Fraction of L delivered while taking data



Minutes lost before first run

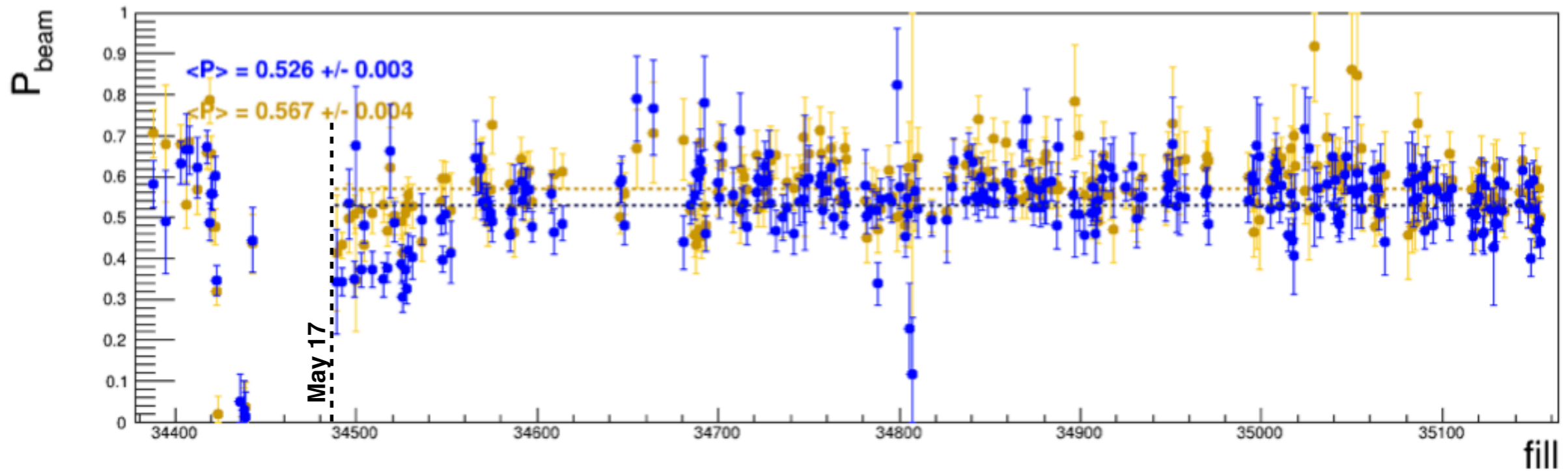


events_perday.txt



- Efficient running: Sampled luminosity fraction $\sim 80\%$
- Average delivered luminosity/Fill: $0.44 * 10^{32} \text{ cm}^{-2}\text{s}^{-1} < \text{Run15}$

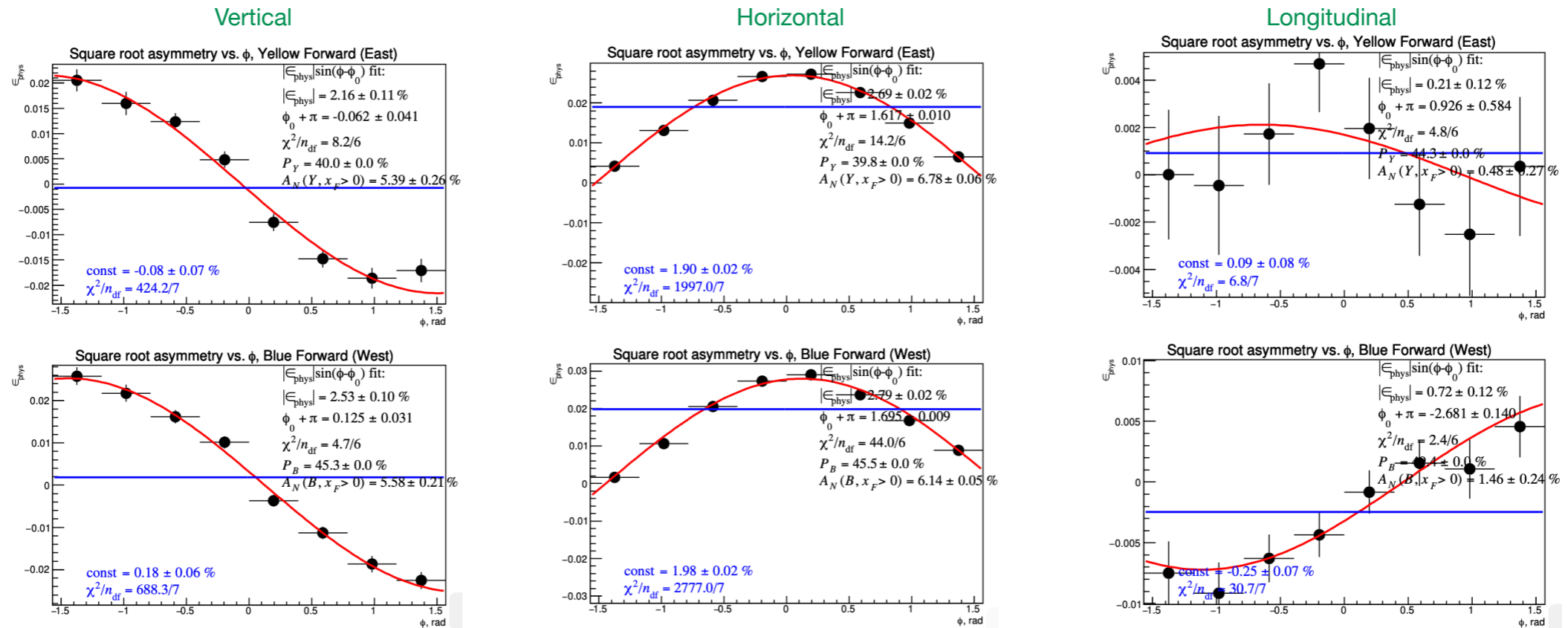
Polarization



<https://wiki.bnl.gov/rhicspin/Polarimetry/H-jet/Run24pp>

- Polarization ~53% Blue, ~57% Yellow (H-Jet measurement)
- Goal assumed 57% for Yellow and Blue polarization

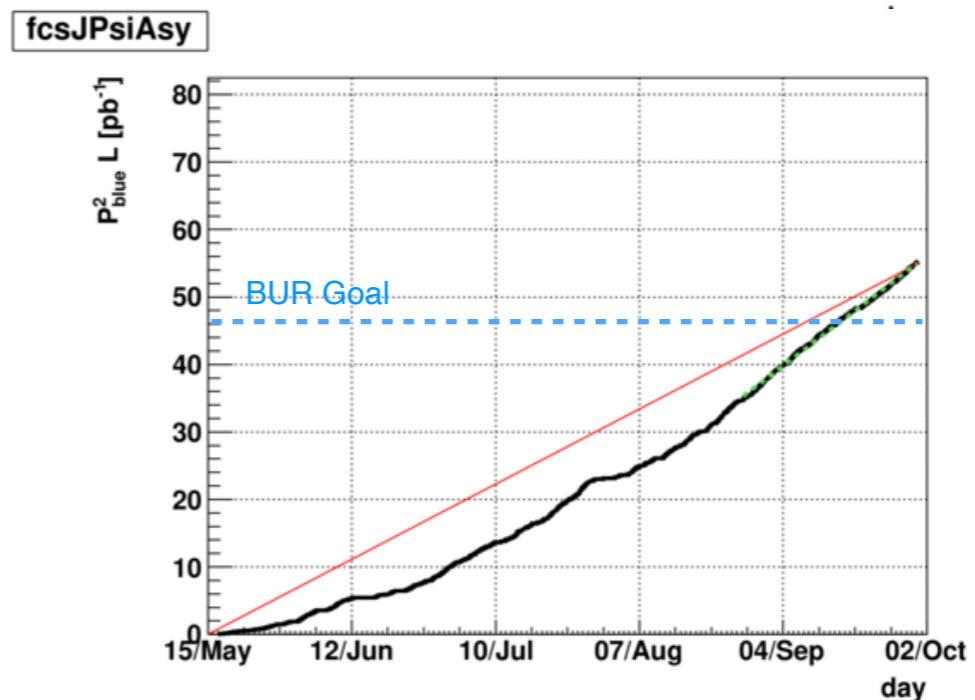
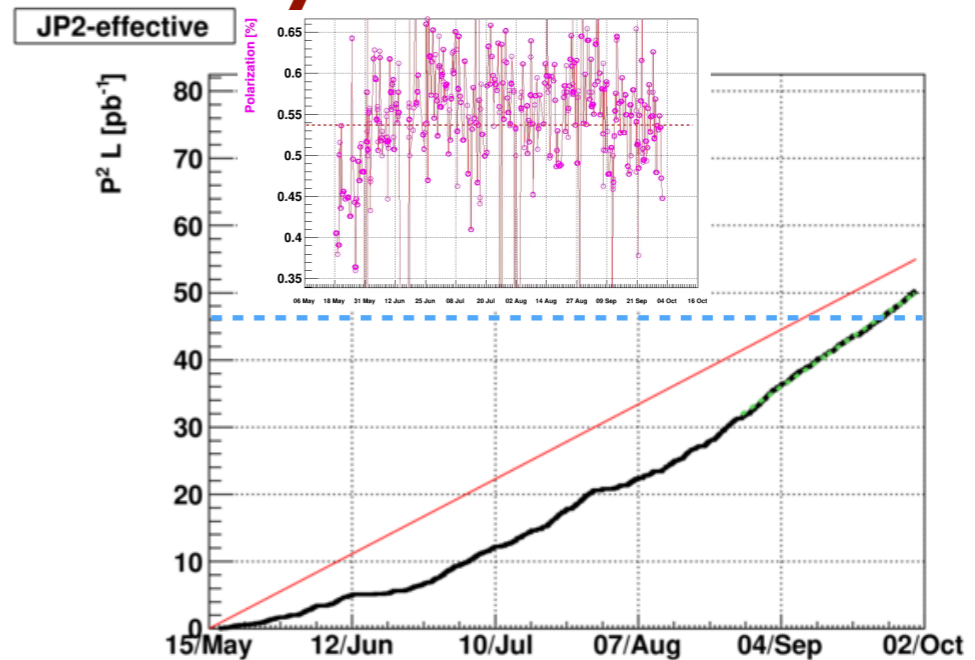
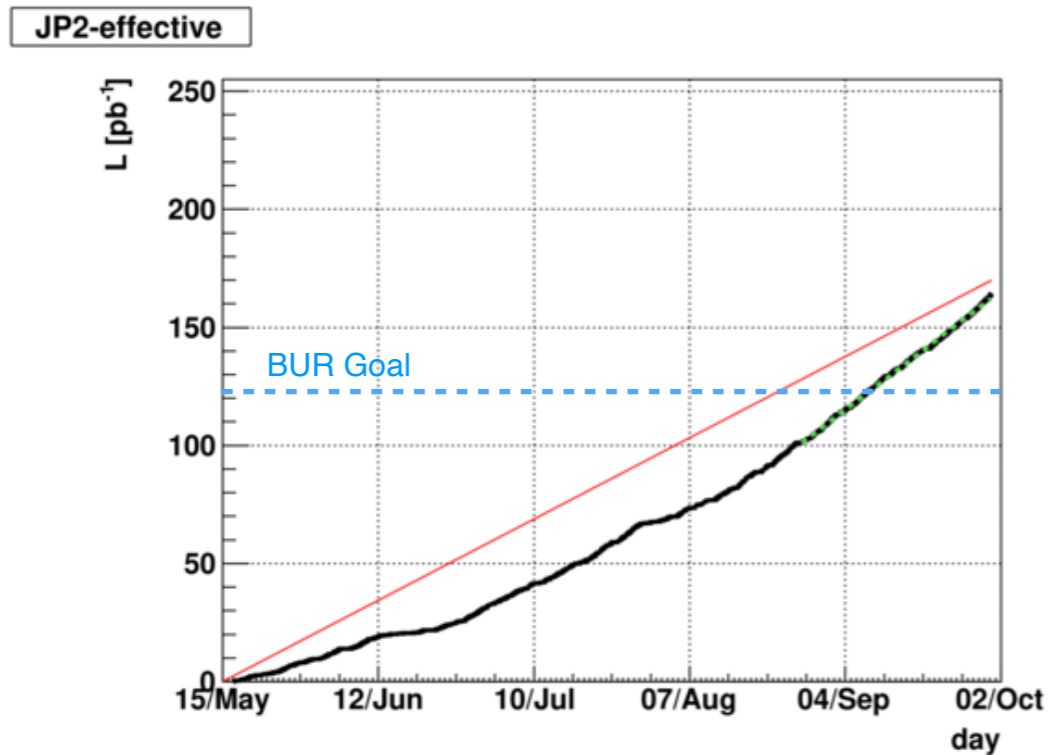
Radial (horizontal) polarization



3d spin direction measurements at STAR (APEX session on Aug. 21)

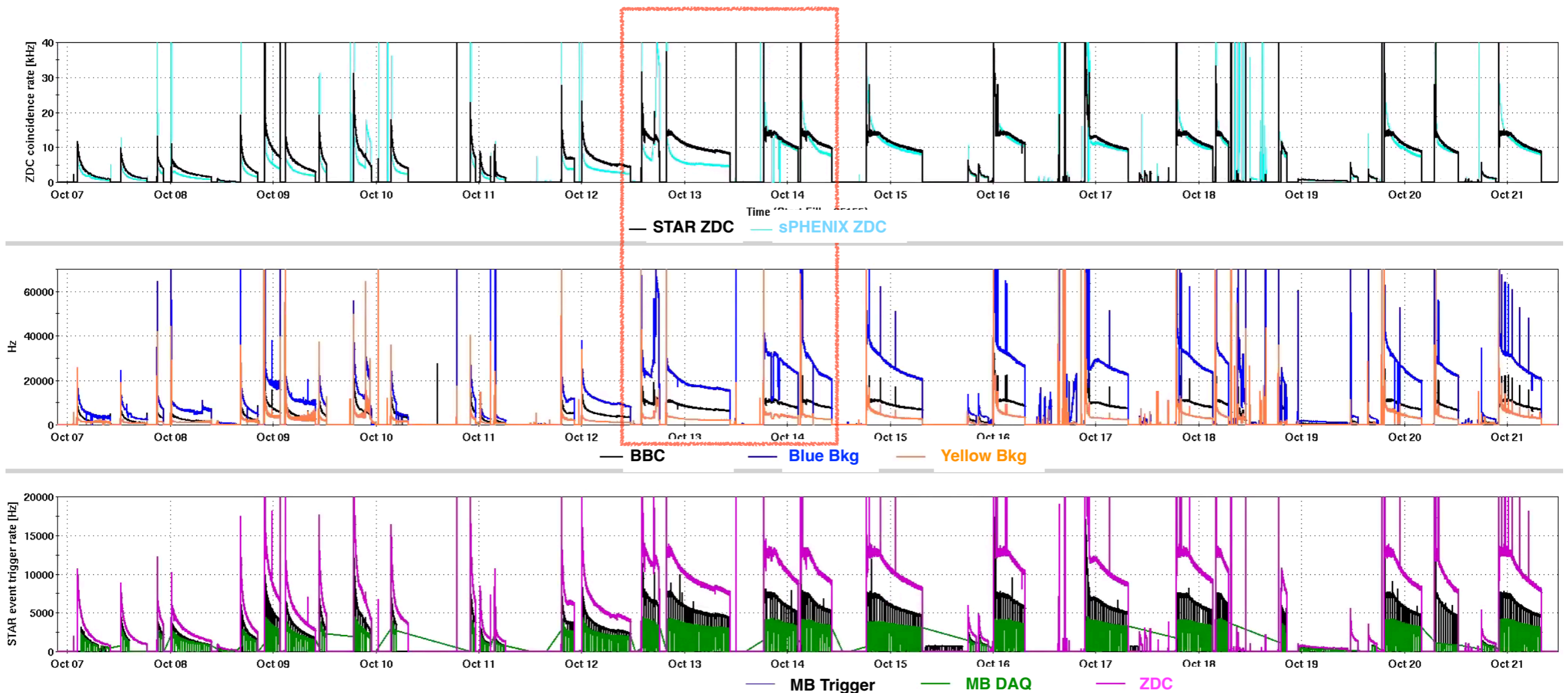
- Requested to maximize figure of merit and minimize systematics for physics measurements with forward detectors
- Run-by-run and fill-by-fill measurements with scaler and dedicated ZDC local polarimeter runs to monitor spin rotation
- Rotation in 90 ± 5 degree
- Residual (longitudinal) polarization to be estimated

pp sampled luminosity and FoM



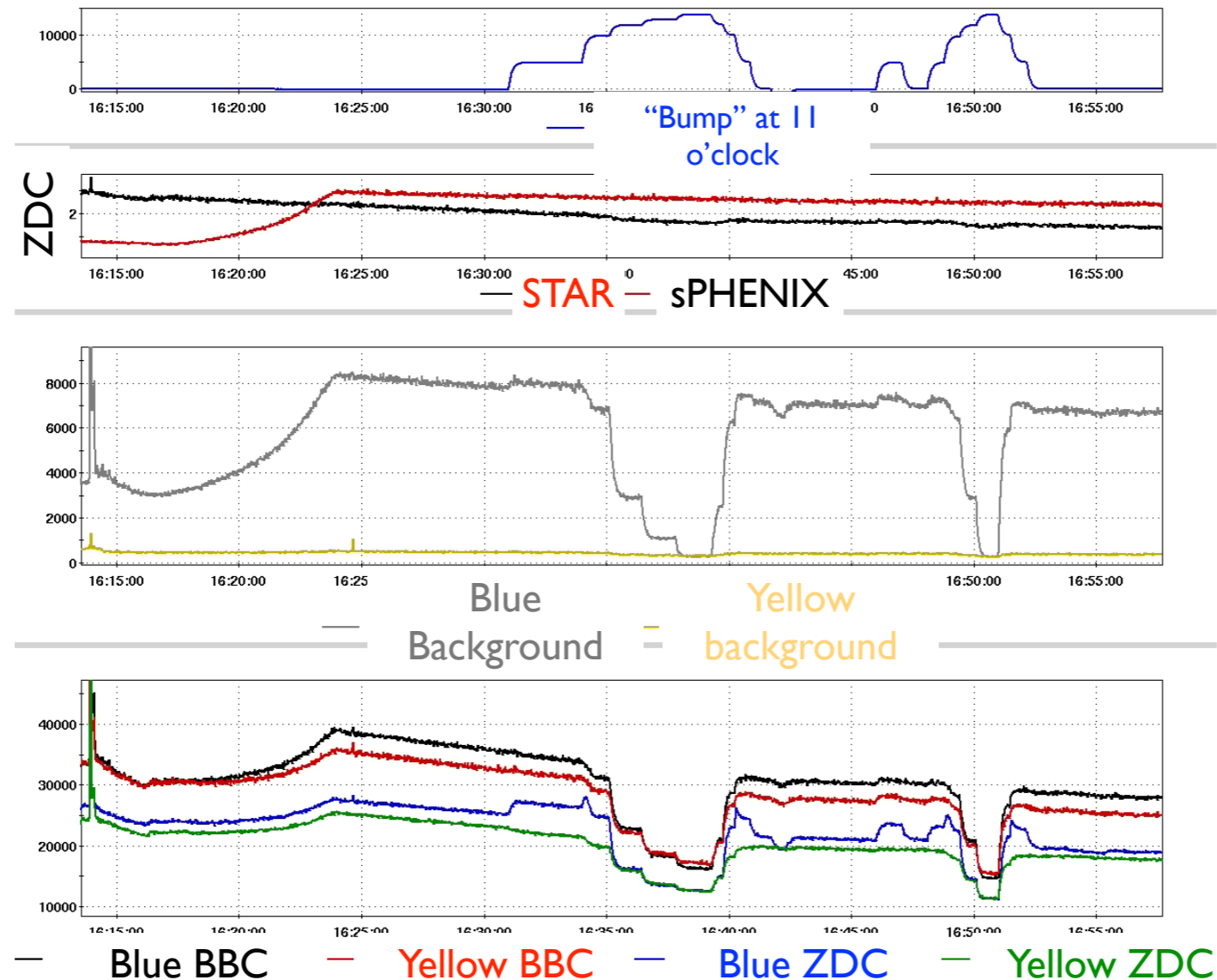
- Sampled Luminosity: JP2, JP2 FoM, fcsJPsi FoM = 164.2 pb⁻¹, 50.3 pb⁻¹, 58.5 pb⁻¹
- Luminosity and FoM, reaching 97%, 91%, 106% of revised goal, and **exceeded the original Goals** in BUR

Au+Au



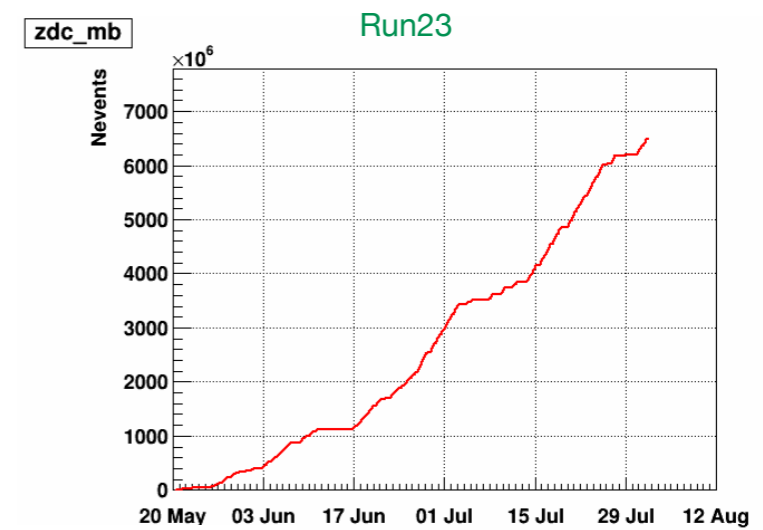
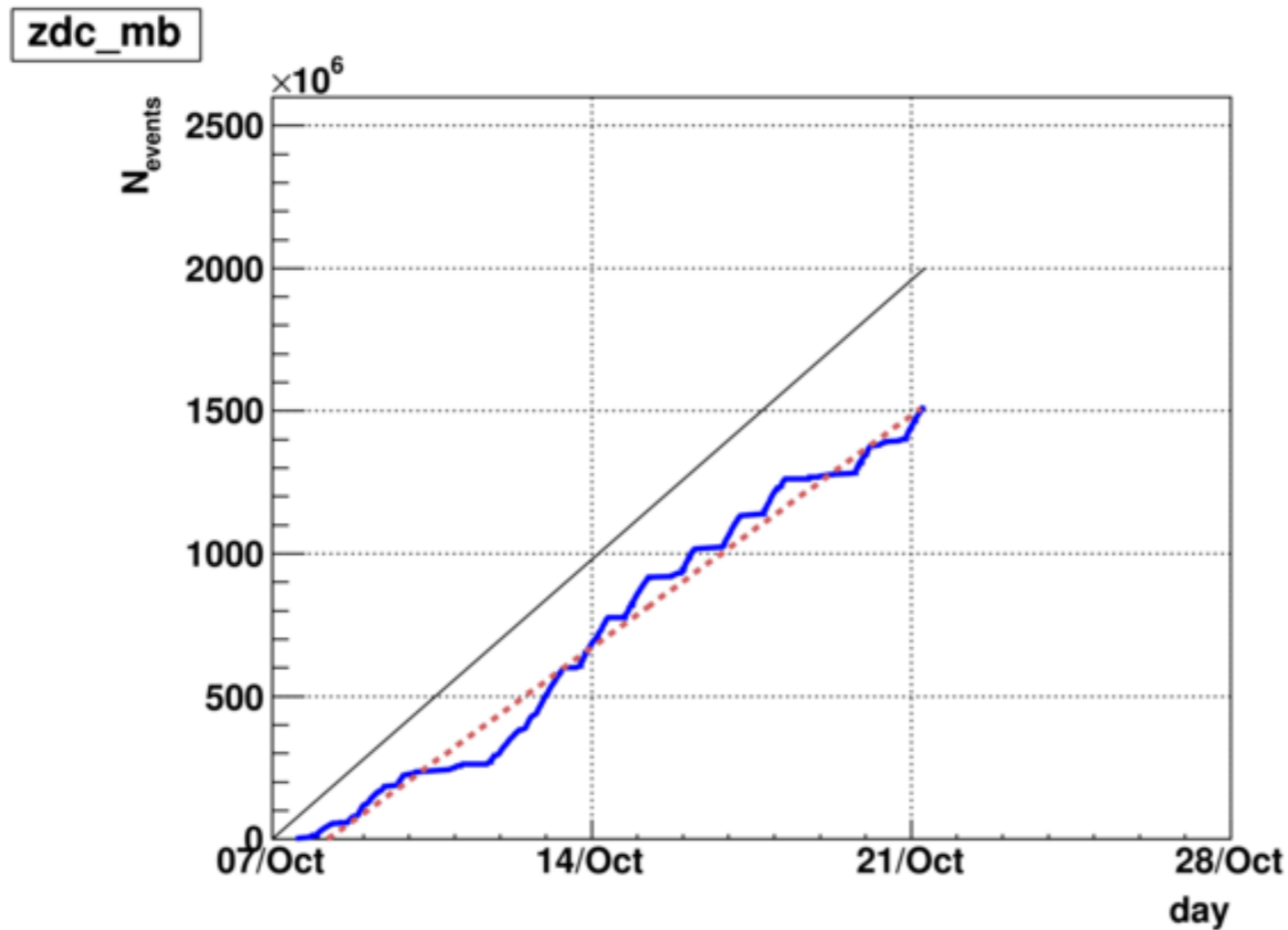
- 3 weeks of running (9/30 - 10/21)
- Machine:
 - Significant time dedicated to understand, reduce background in sPHENIX MVTX
 - 56 MHz cavity commissioning
- Beam: crossing angle 1 mrad, leveling ZDC at 13 kHz
- High background in Blue as in Run23
- Significant fraction produced from the collision in sPHENIX (“Au78”)

Background from Au78



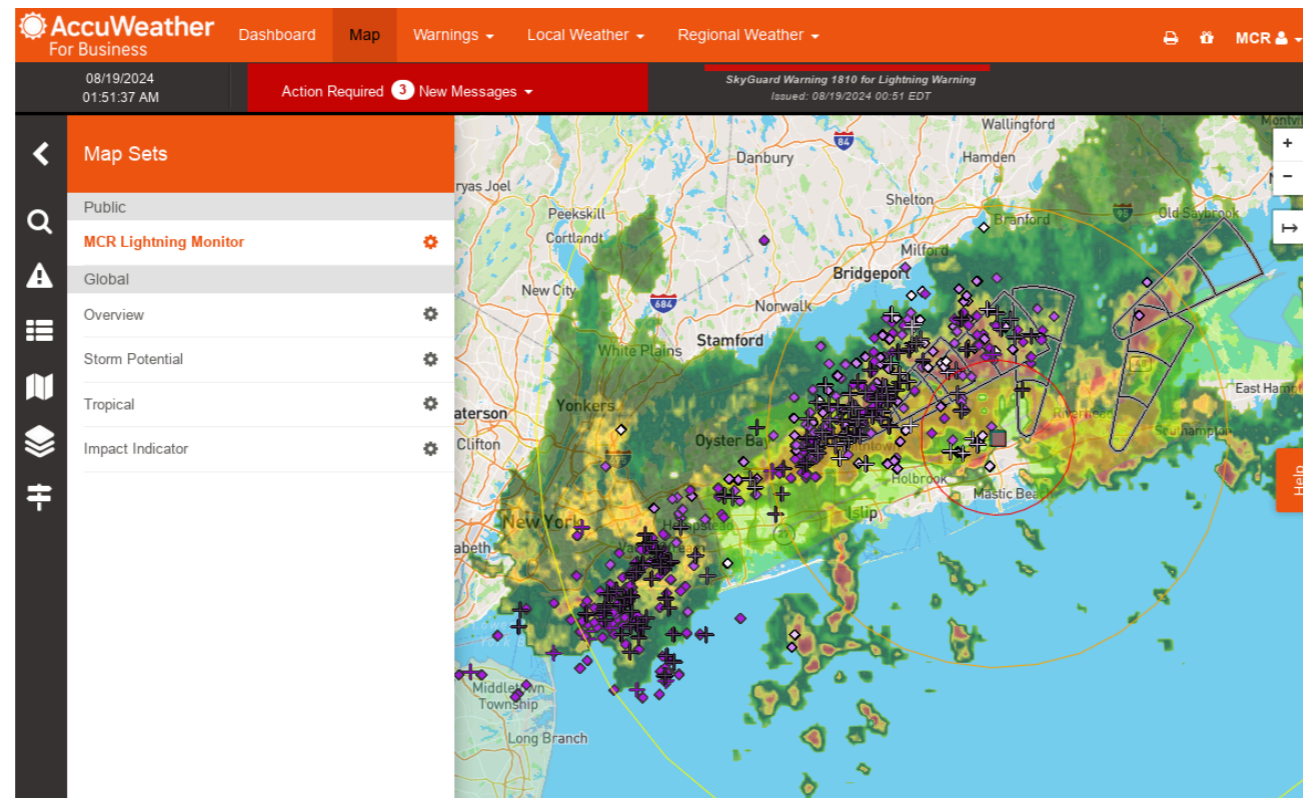
- Blue background understood with “Au78 test” (June 29 2023)
- New lattice needed: data quality expected to be significantly improved

Min-bias in AuAu



- Min-bias 1.52B (Run23 6.5B :Total 8B / Goal 18B)
- +UPC events 230M
- Min-bias maximum DAQ > 4 kHz
- To be continued in Run25 with high-luminosity/ p_T program

Operation challenges - weather



4 am Aug 19

- No major impact from temperature issues on operation
- Magnet cooling, AC,...
- Multiple weather-related stand-downs
- Unusually high number of power dips
- Painful recoveries, lingering issues
 - ex: Recovery of ZDC TCIM (8 days no or incorrect ZDC signals to CAD Aug. 6-14)
- Shutdown due to a flood at STAR (Aug 19)

Summary

- **Successful Run24**, despite challenges - dynamic schedule, beam configurations, weather
 - No major issues with detectors
 - Exceeded original BUR goals for pp
 - Additional data sets acquired with low-luminosity in pp
 - Continued collection of Min-bias data in AuAu
- Shutdown activities are planned for completion on time to ensure readiness for Run25