



STAR Summary and Run25 Plan

J.H. Lee / BNL

**2024 RHIC Retreat
November 15**

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

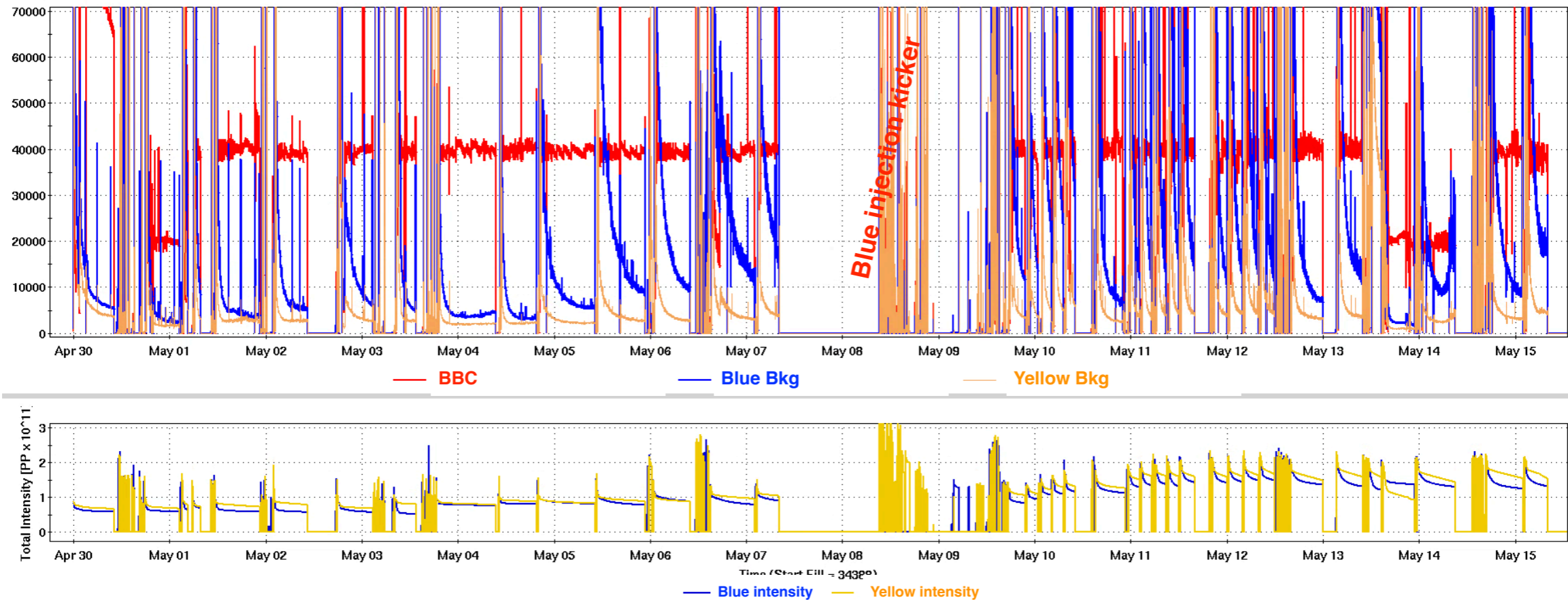
$\sqrt{s_{NN}}$ (GeV)	Species	Number Events/ Sampled Luminosity	Year
200	$p+p$	142 pb ⁻¹ /12w	2024
200	$p+Au$	0.69 pb ⁻¹ /10.5w	2024
200	Au+Au	18B / 32.7 nb ⁻¹ /40w	2023+2025

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.

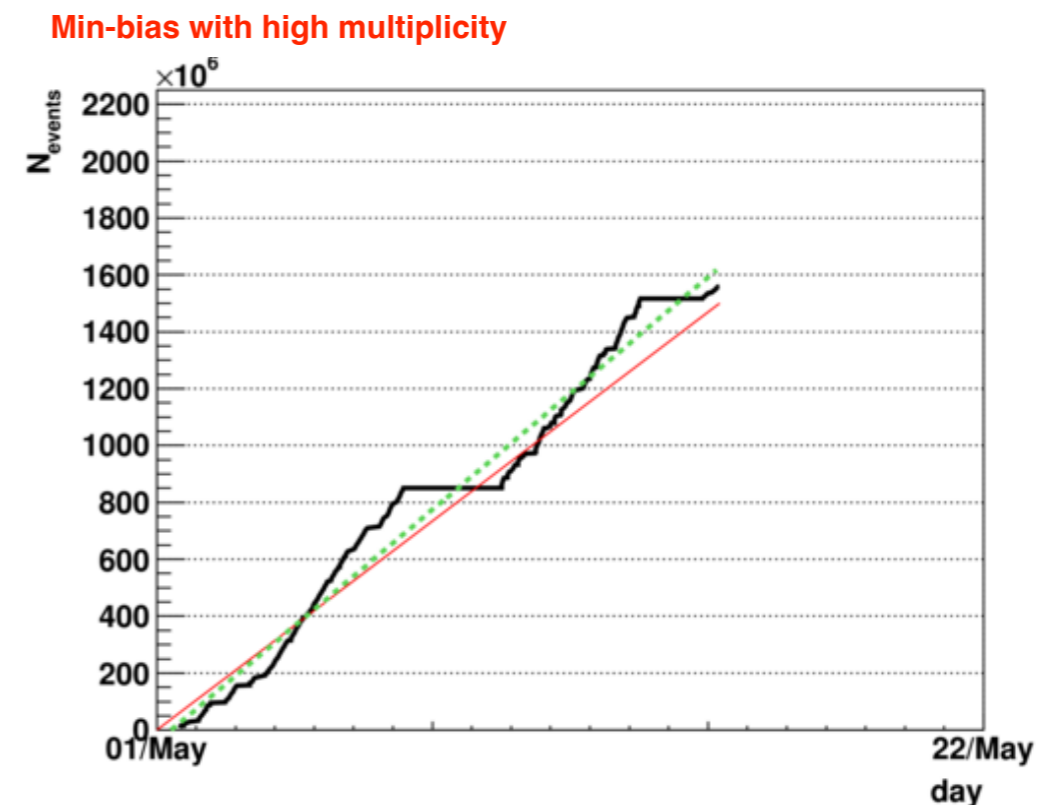
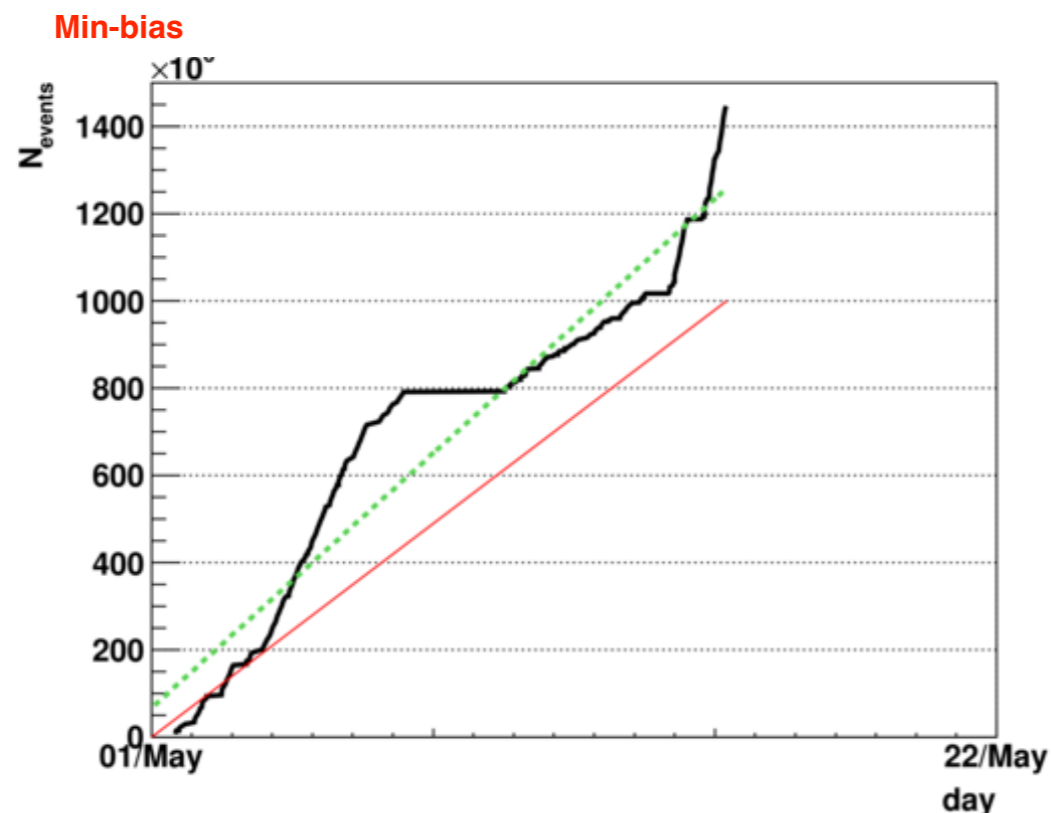
- Luminosity goal for p+p: 142 pb⁻¹ for 12 weeks of running
- Figure of Merit goal: $\mathcal{P}^2L = 0.57^2L = 46.1 \text{ pb}^{-1}$
- **Revised goals:** L=170 pb⁻¹, FoM = 55 pb⁻¹ assuming 14.5 weeks

pp low-luminosity

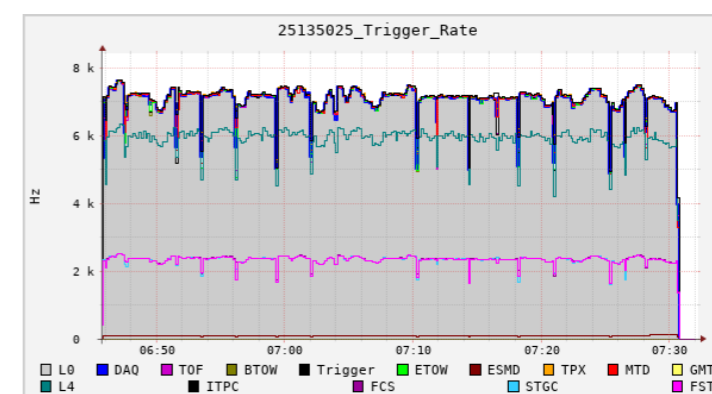


- Opportunistic running (2 weeks) during sPHENIX's commissioning
- To study collectivity in high-multiplicity pp with minimal event pile-up
- 1 mrad crossing angle and luminosity leveling BBC at 20~40k (x100 lower than nominal luminosity)
- Background in Blue dominating at 20k, set BBC leveling at 40k

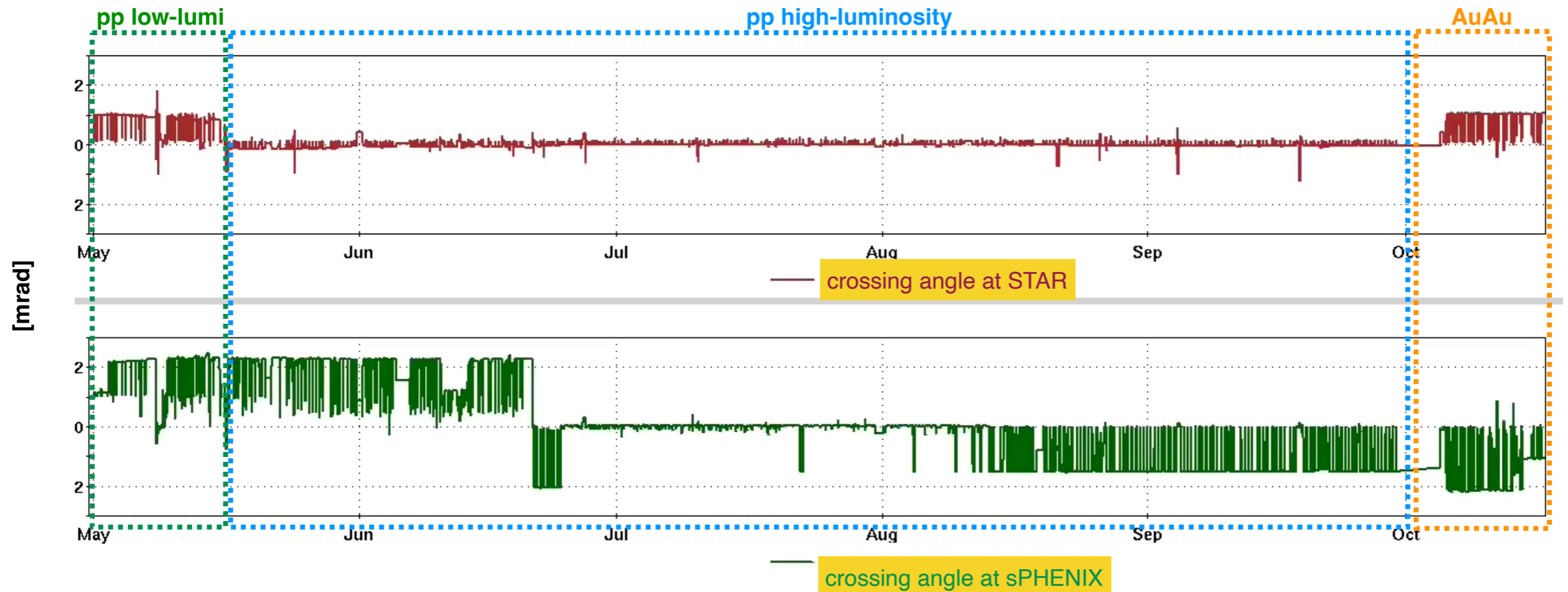
Min-bias with pp low-luminosity



- 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)

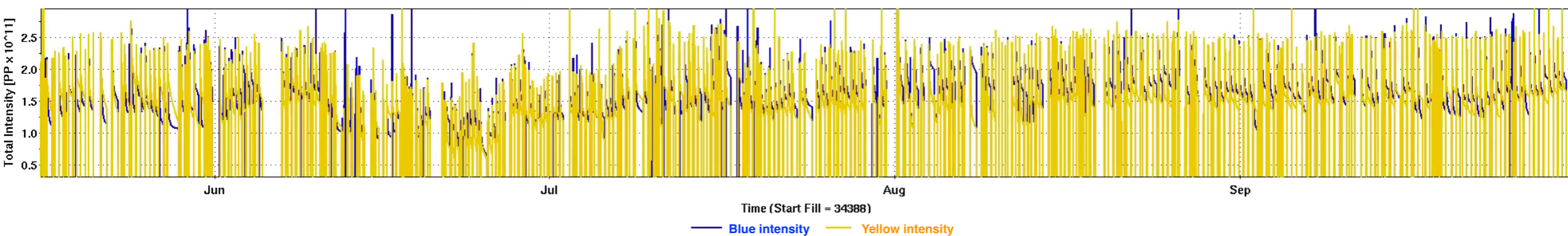
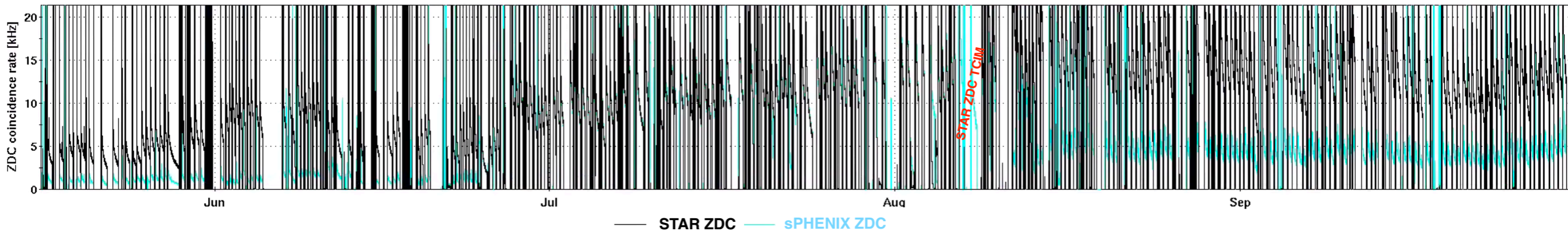


Crossing angle



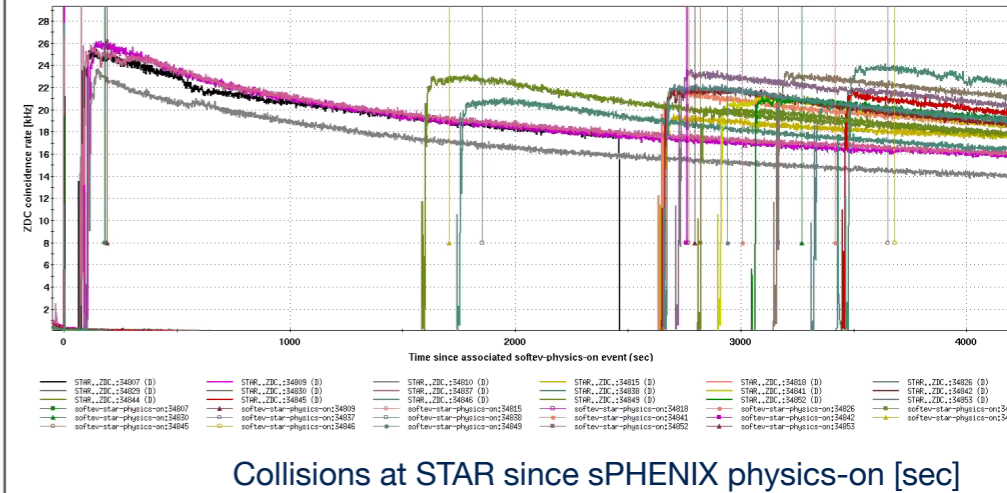
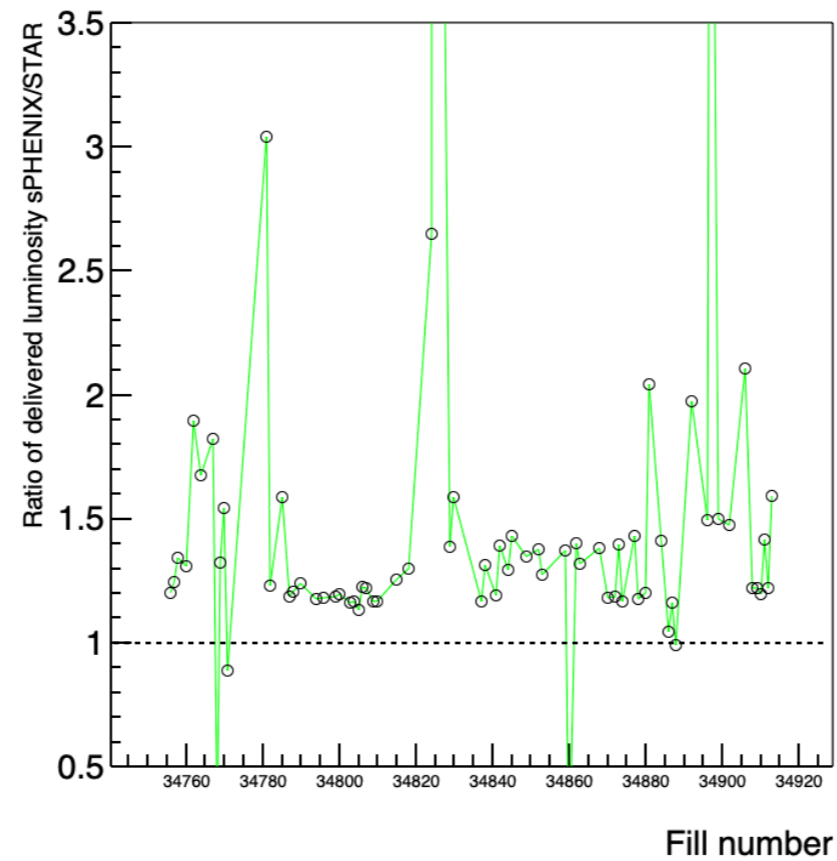
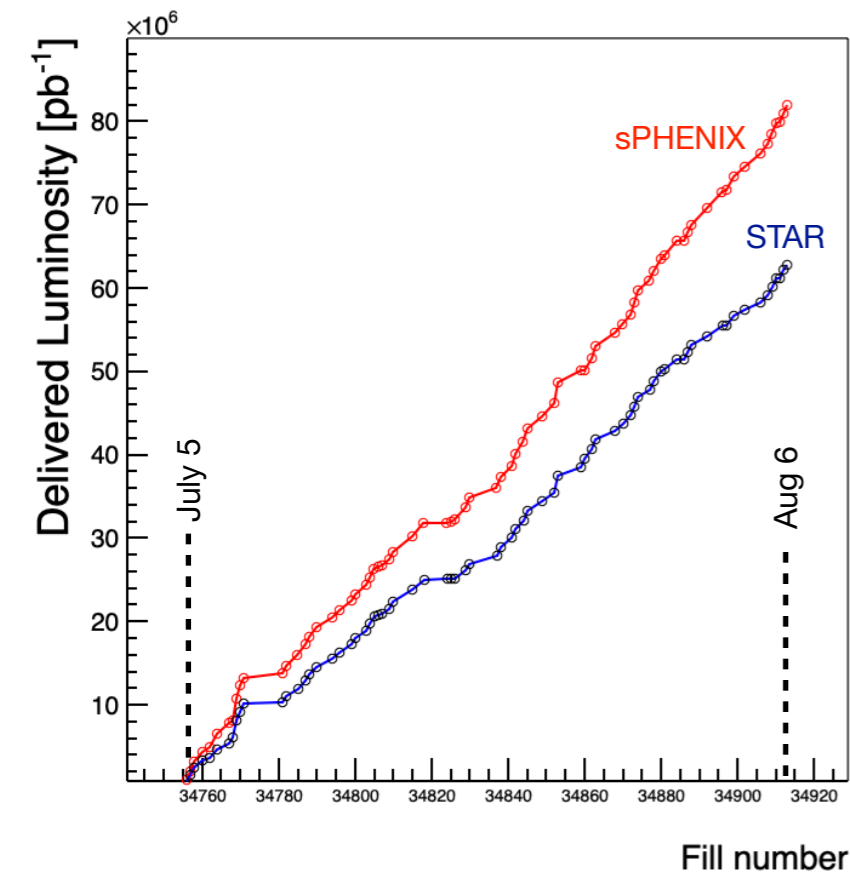
- Crossing angle at STAR: 0 (or 1) mrad, at sPHENIX: 2 (or 1.5, 1, 0) mrad
- Reduce luminosity by x3-4 with 1 mrad
- Beam-beam effect with a crossing angle affects total maximum luminosity available
- Impact on background in AuAu
- Crossing angle/luminosity at sPHENIX changes background at STAR

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

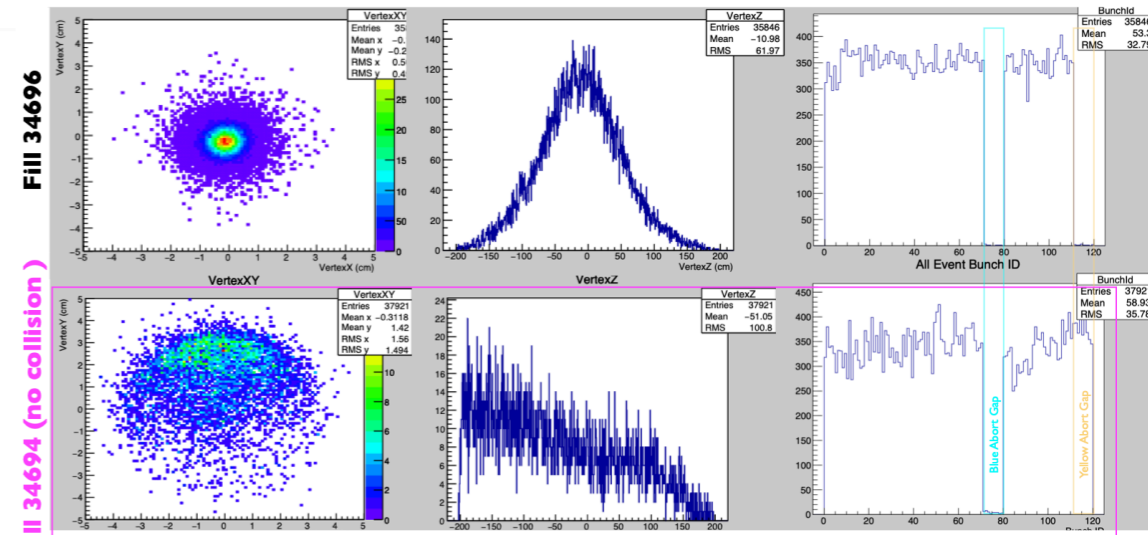
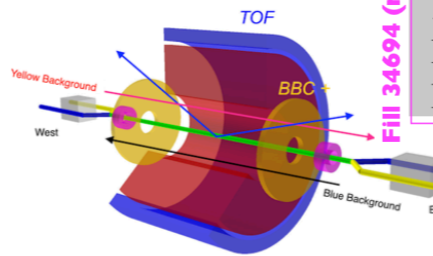
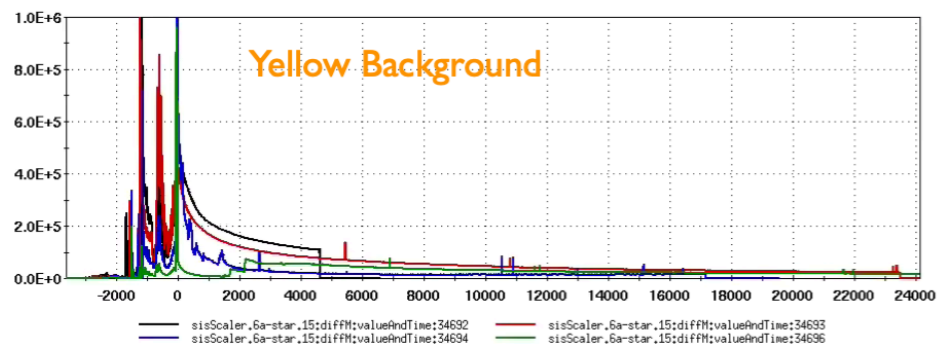
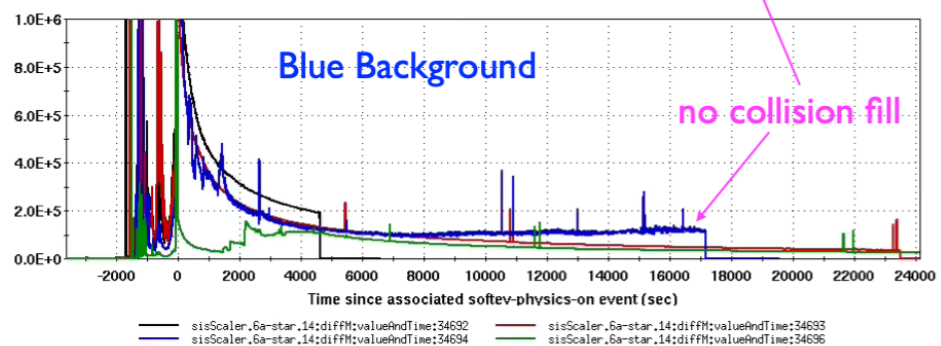
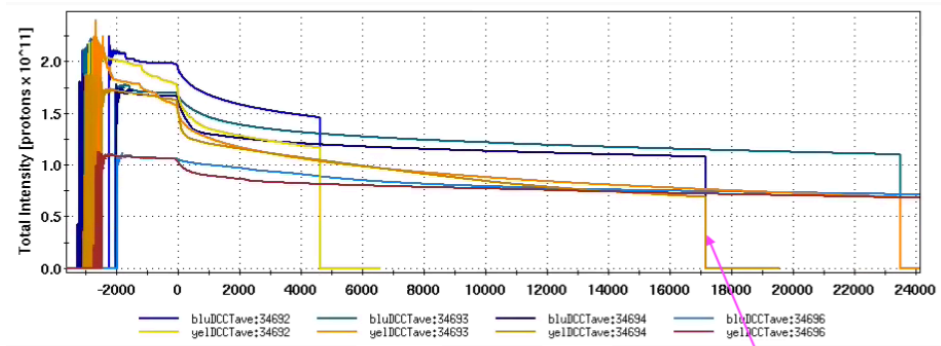
Running with sPHENIX, beam-beam effect



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

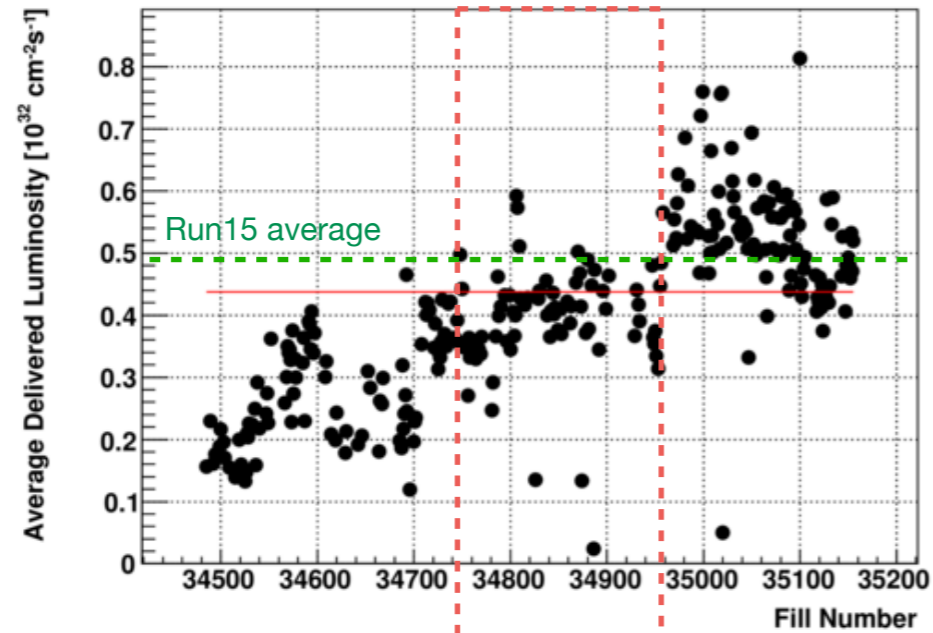
Background in pp



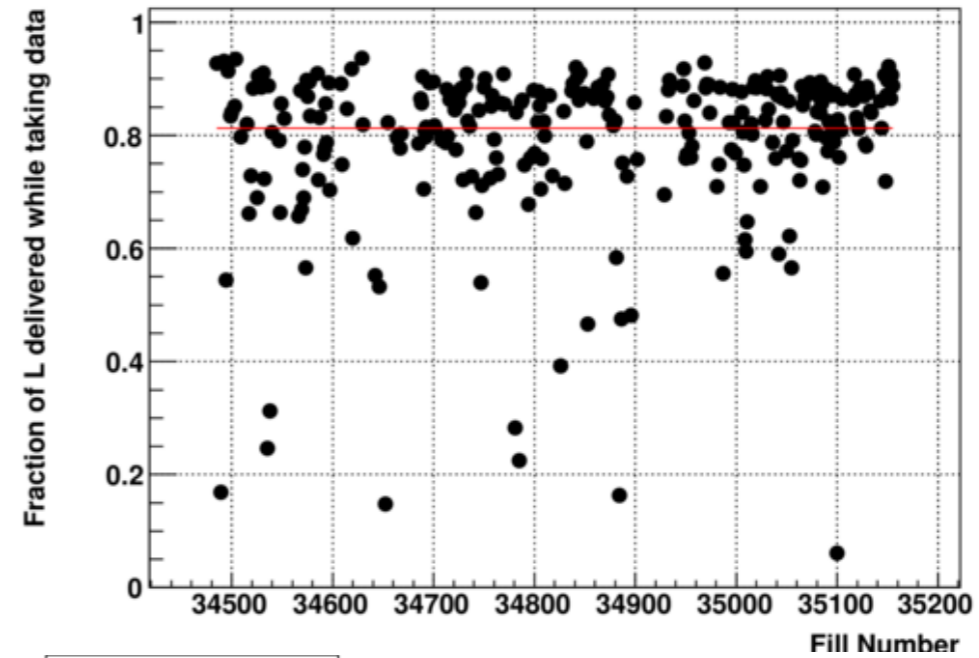
- High background in Blue (significant fraction non-collision related)
- Some reduction/improvement was made by adding “Mask” at 11 o’clock (Jul 12)
- Further reduction required significant beam developments needing new dynamic aperture - not implemented

pp luminosity and efficiency

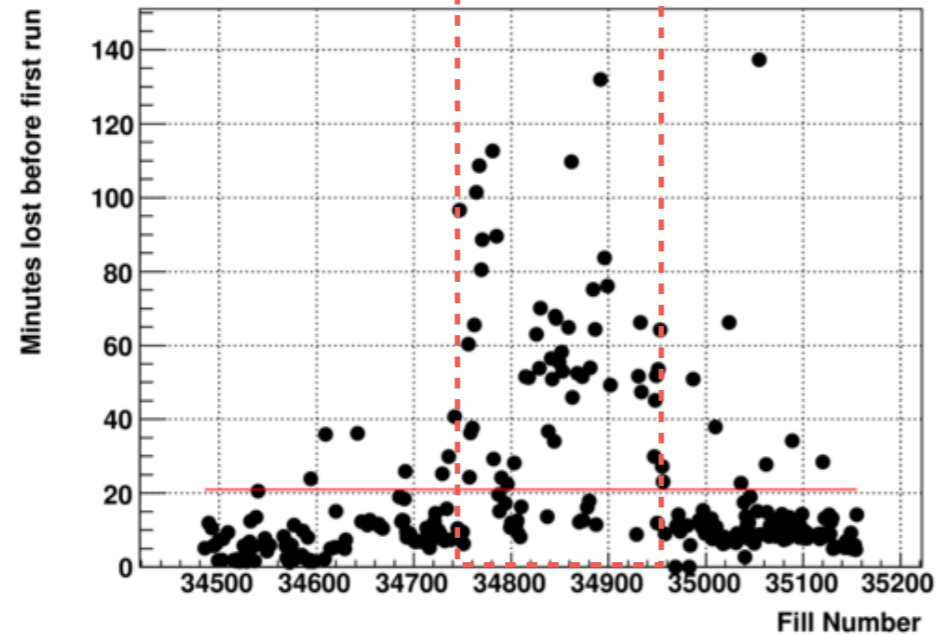
Average Delivered Luminosity [$10^{32} \text{ cm}^{-2}\text{s}^{-1}$]



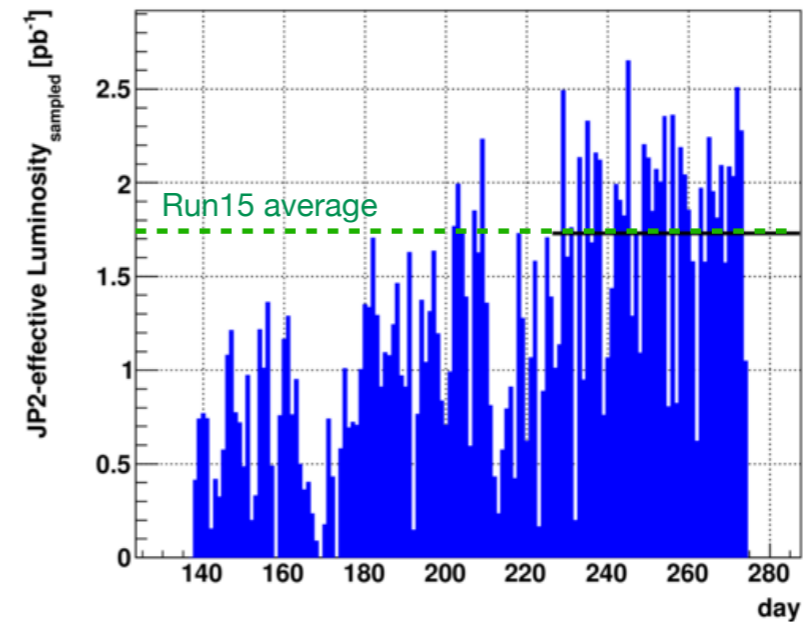
Fraction of L delivered while taking data



Minutes lost before first run

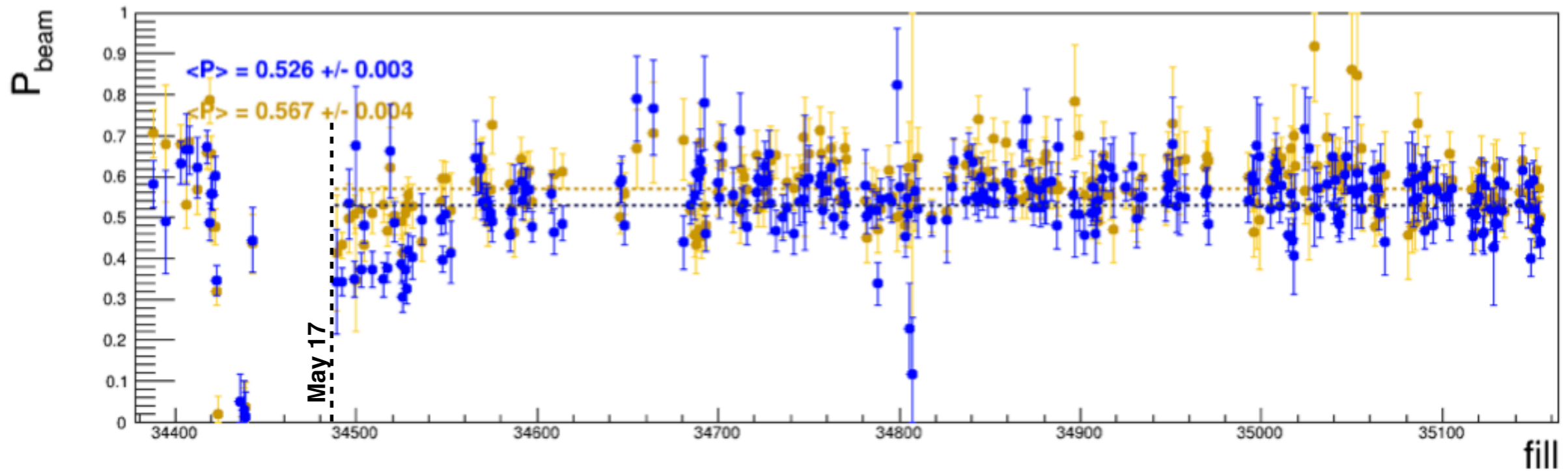


events_perday.txt



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

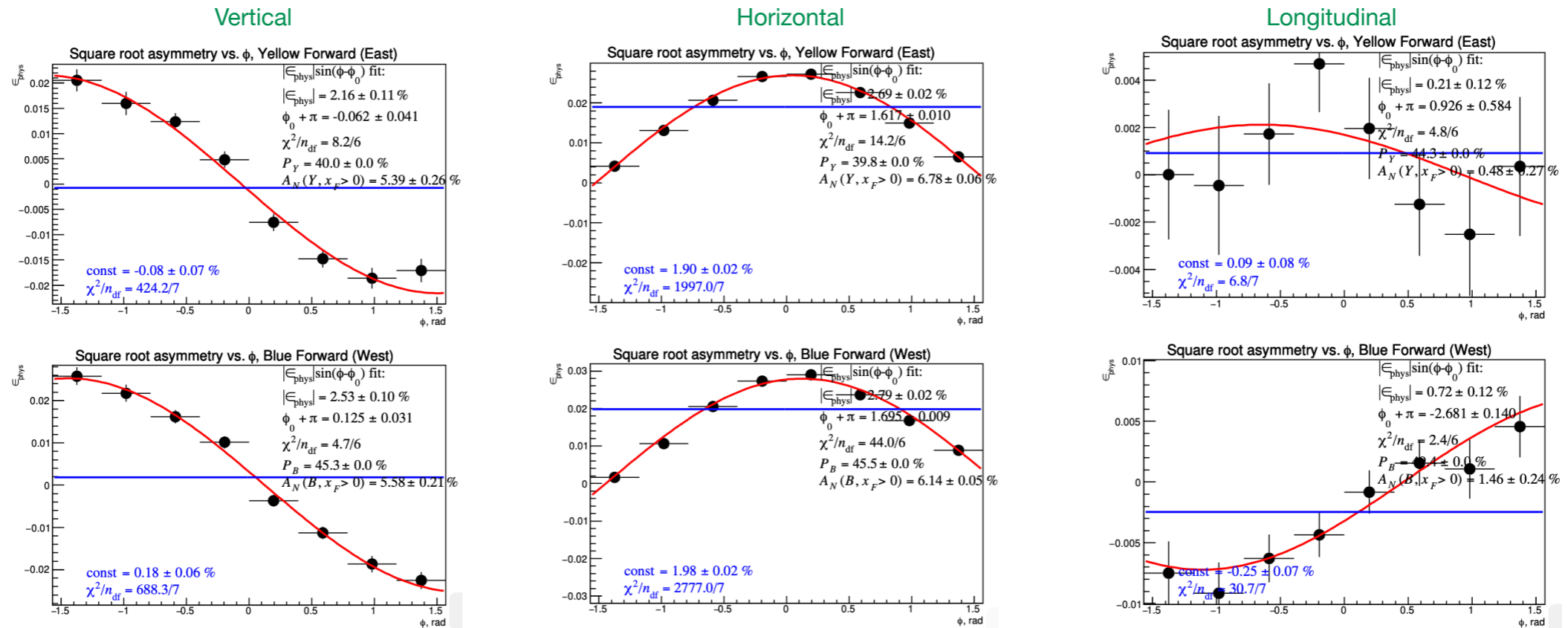
Polarization



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

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

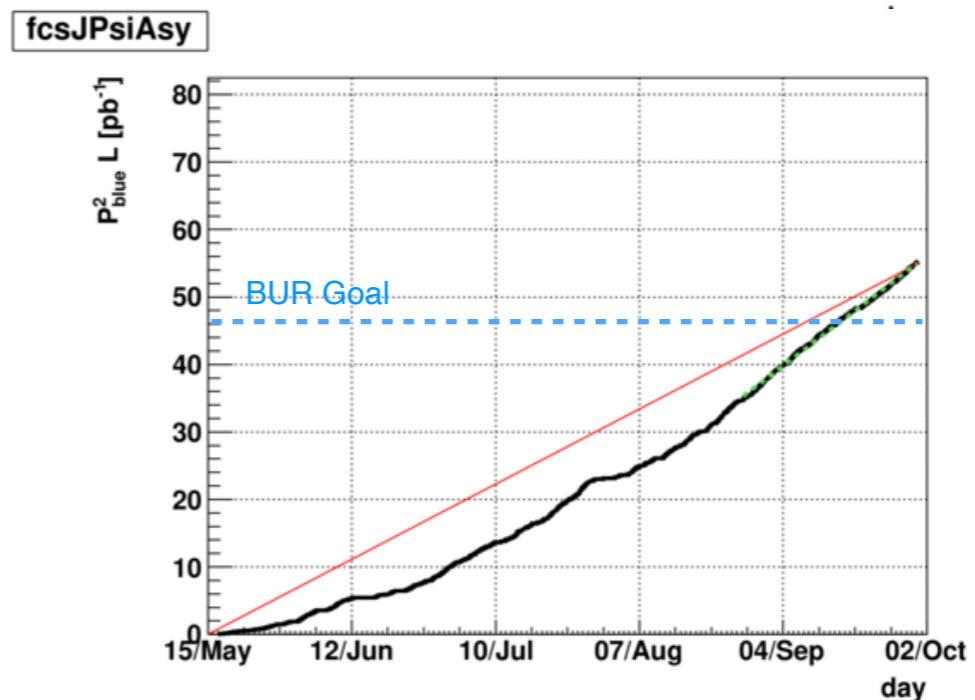
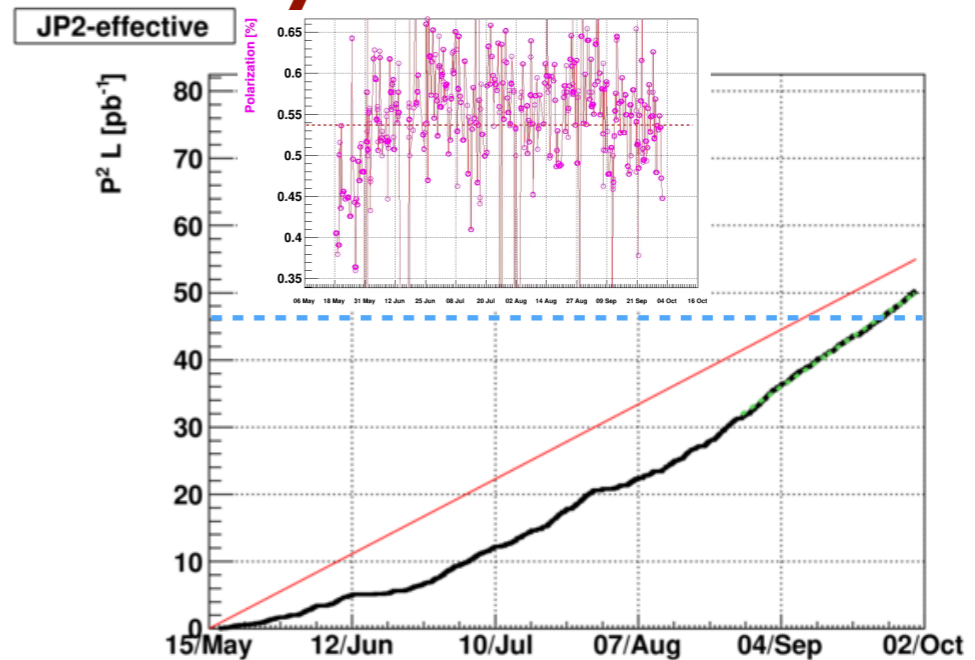
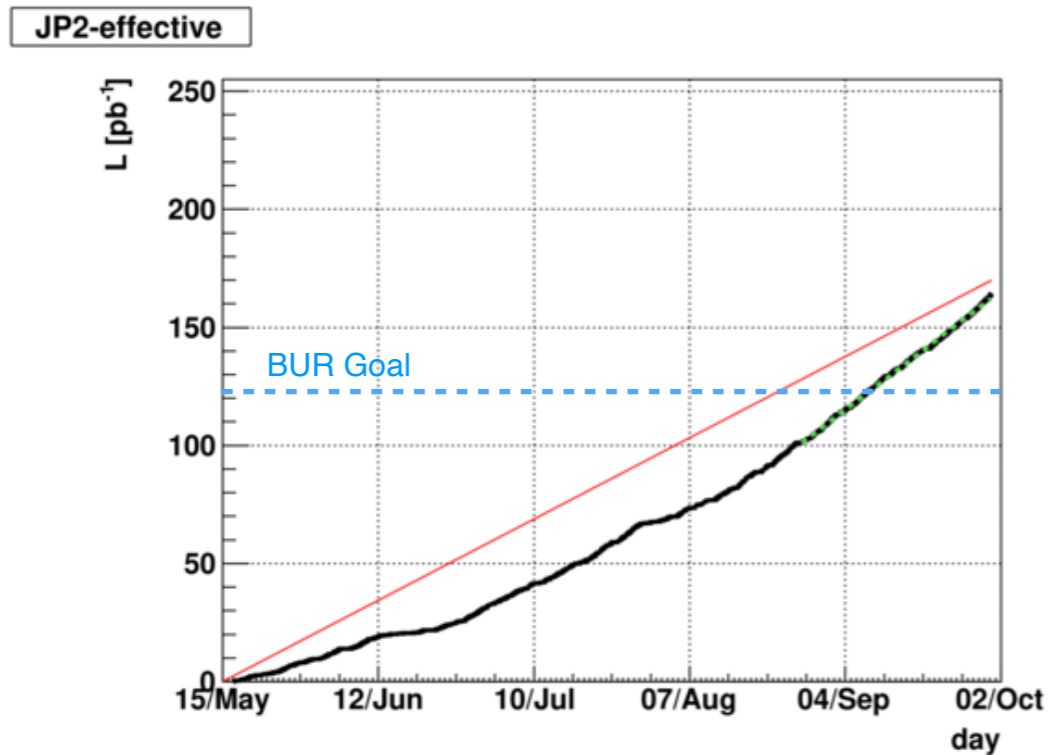
Radial (horizontal) polarization



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

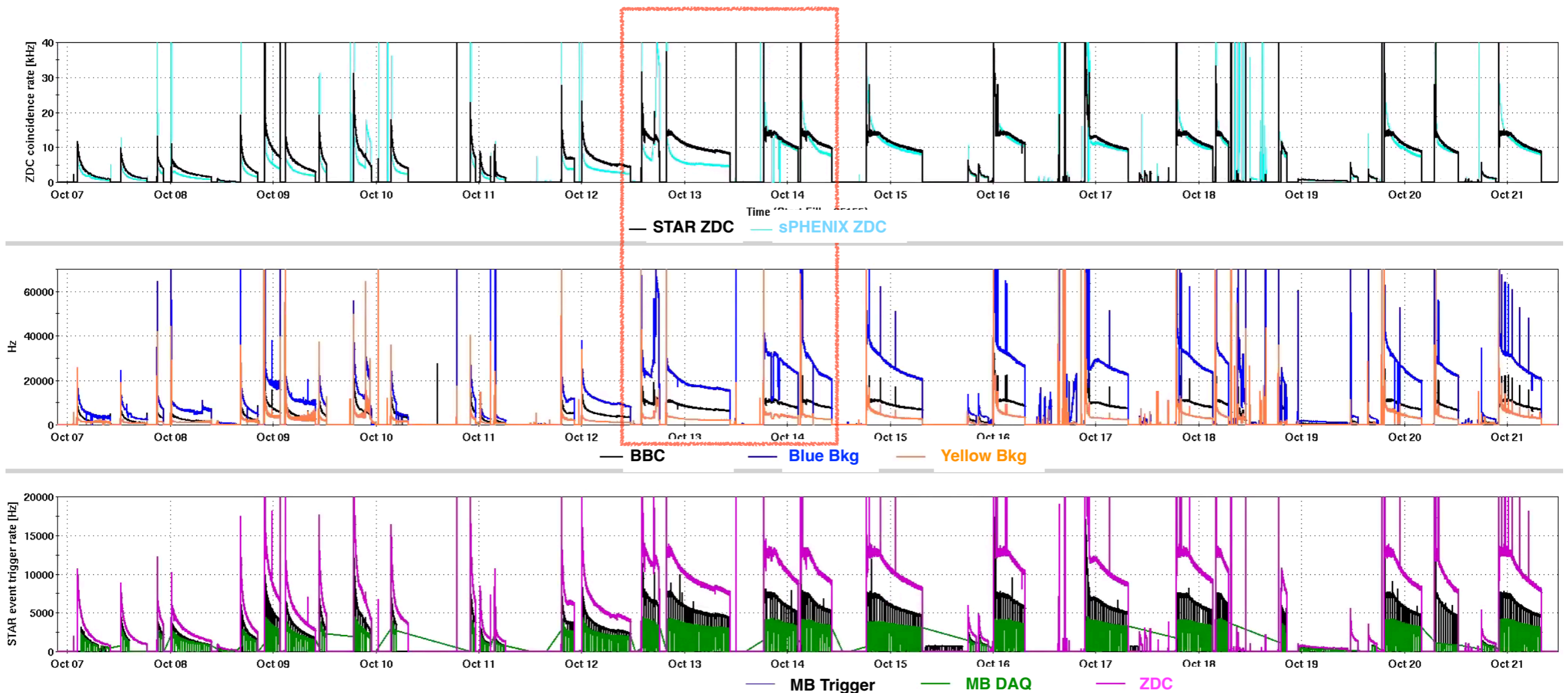
- Requested to maximize figure of merit and minimize systematics for physics measurements with forward detectors
- Run-by-run and fill-by-fill measurements with scaler and dedicated ZDC local polarimeter runs to monitor spin rotation
- Rotation in 90 ± 5 degree
- Residual (longitudinal) polarization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

pp sampled luminosity and FoM



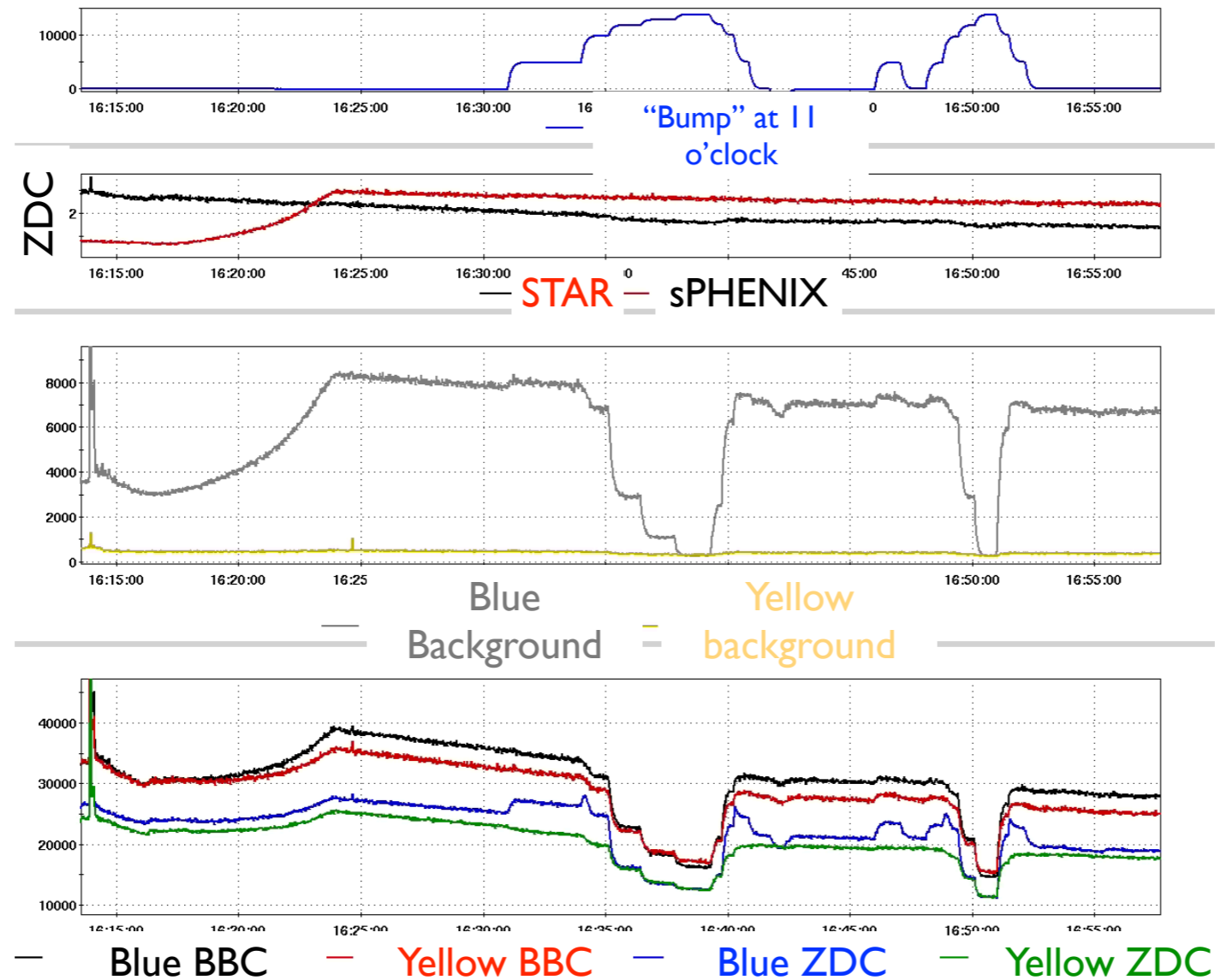
- Sampled Luminosity: JP2, JP2 FoM, fcsJPsi FoM = 164.2 pb⁻¹, 50.3 pb⁻¹, 58.5 pb⁻¹
- Luminosity and FoM, reaching 97%, 91%, 106% of revised goal, and **exceeded the original Goals** in BUR

Au+Au



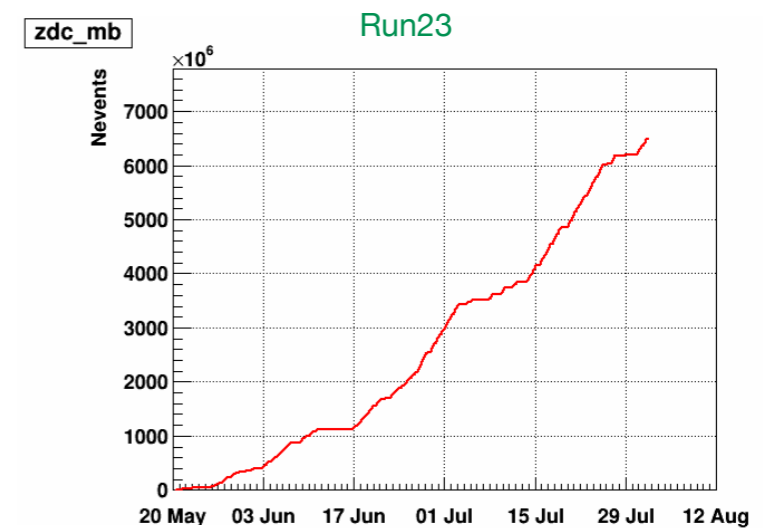
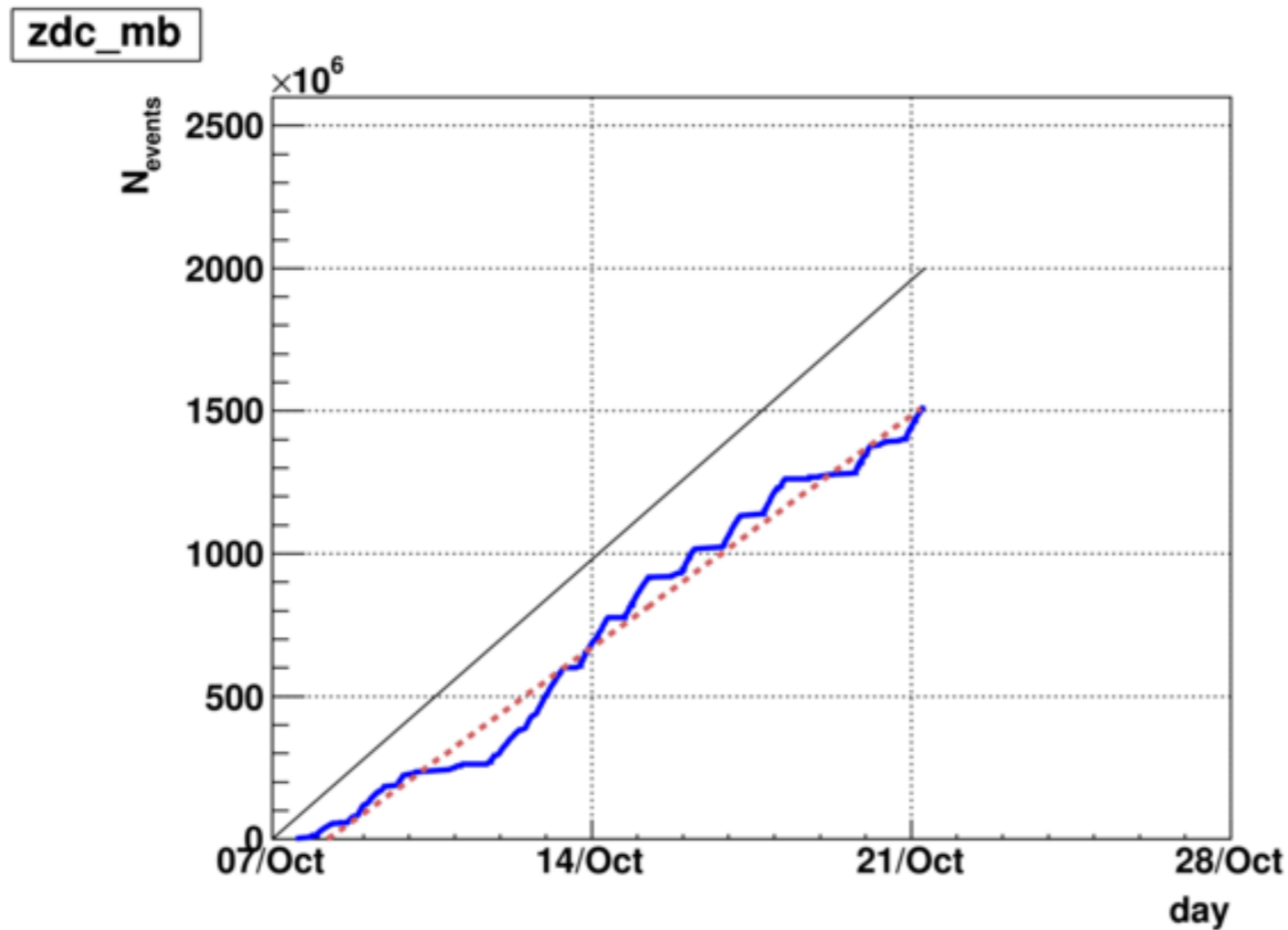
- 3 weeks of running (9/30 - 10/21)
- Machine:
 - Significant time dedicated to understand, reduce background in sPHENIX MVTX
 - 56 MHz cavity commissioning
- Beam: crossing angle 1 mrad, leveling ZDC at 13 kHz
- High background in Blue as in Run23
 - Significant fraction produced from the collision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

Background from Au78



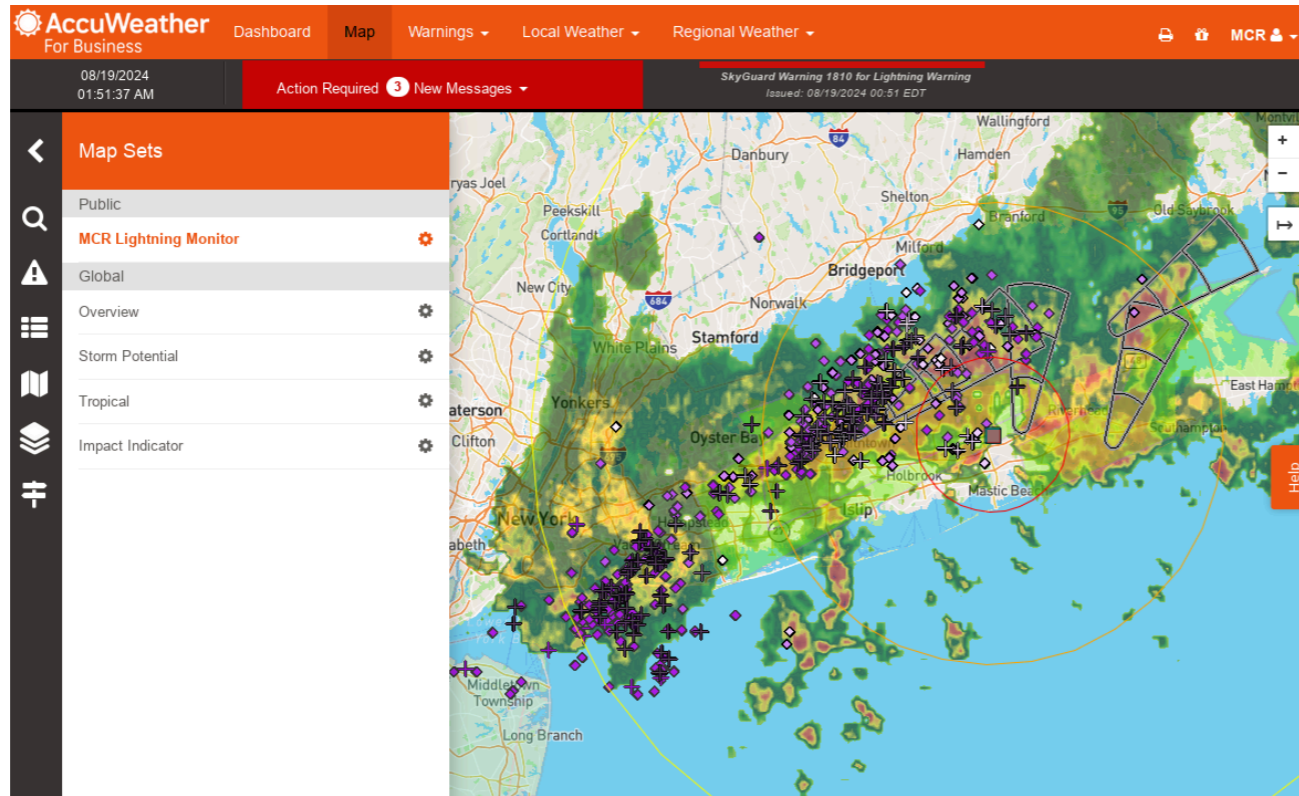
- Blue background understood with “Au78 test” (June 29 2023)
- New lattice needed: data quality expected to be significantly improved

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)

Run25 Request

$\sqrt{s_{NN}}$ (GeV)	Species	Number Events/ Sampled Luminosity	Year
200	Au+Au	8B+ 5B / $1.2 \text{ nb}^{-1} + \mathbf{20.8 \text{ nb}^{-1}}$	2023+2024+ 2025 (20 cryo-weeks)
200	Au+Au	8B+ 9B / $1.2 \text{ nb}^{-1} + \mathbf{28.6 \text{ nb}^{-1}}$	2023+2024+ 2025 (28 cryo-weeks)

- **Completing Au+Au at 200 GeV**
 - **Original Goals: Min-bias 20 B / Sampled luminosity 40 nb⁻¹**
- Requesting an extension of Run25 beyond 28 weeks allowing 5 weeks of pAu, targeting 0.22 pb⁻¹
- **Au+Au running mode: high luminosity for rare probe/high-p_T physics + controlled low luminosity for minimum-bias physics**
 - **High luminosity: 0 crossing angle**
 - **Minimum bias: 1 mrad crossing angle+leveled ZDC rate at 13 kHz**
 - **Mix two data taking modes depending on luminosity/beam condition to achieve the goals**

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
- Thank you CAD for all the collisions and the support throughout the run