

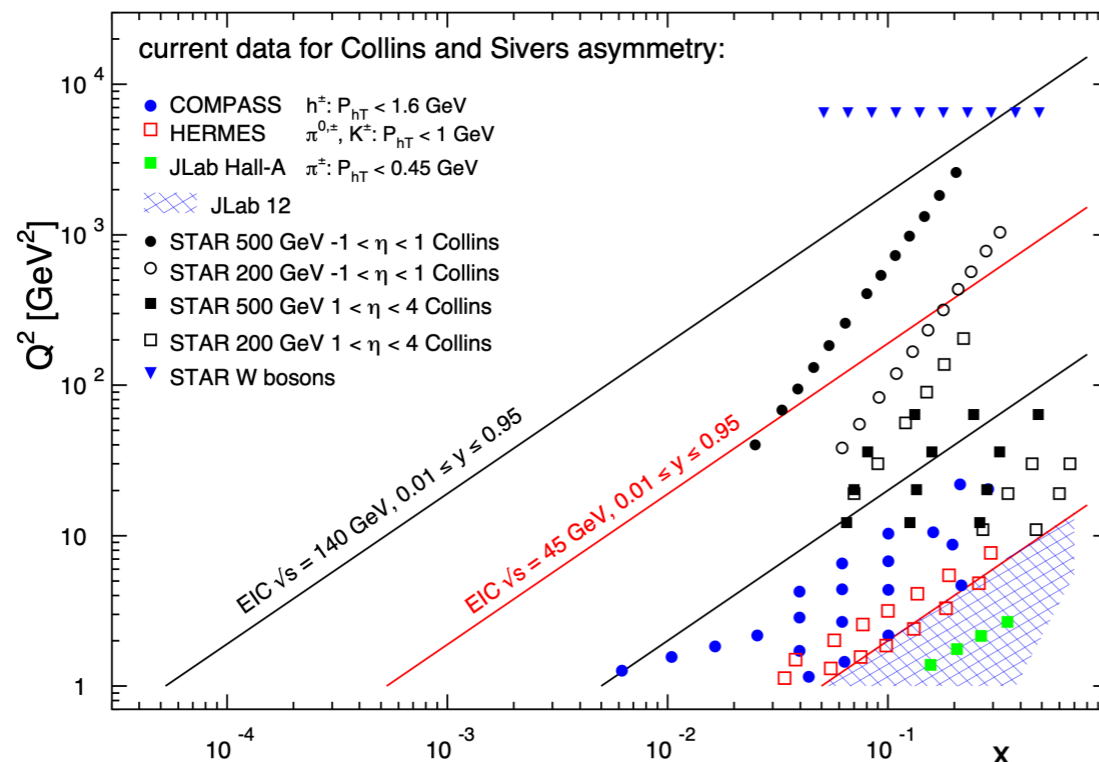


**J.H. Lee**  
**for STAR Collaboration**

**RHIC Retreat 5-24-22**

# STAR Goals and Request for Run22

- p+p at  $\sqrt{s}=510$  GeV with transverse polarization
- **Sampled luminosity 400 pb<sup>-1</sup> with polarization  $\geq 55\%$**
- **Luminosity leveling** for maximum FoM at  $L \sim 1.35 \cdot 10^{32}$  cm<sup>-2</sup>s<sup>-1</sup>
- Commissioning and data taking with new **Forward upgrade** detector systems



Kinematic coverage for Collins and Sivers Asymmetry:  
 STAR covers  $0.005 < x < 0.5$  with Forward Upgrade

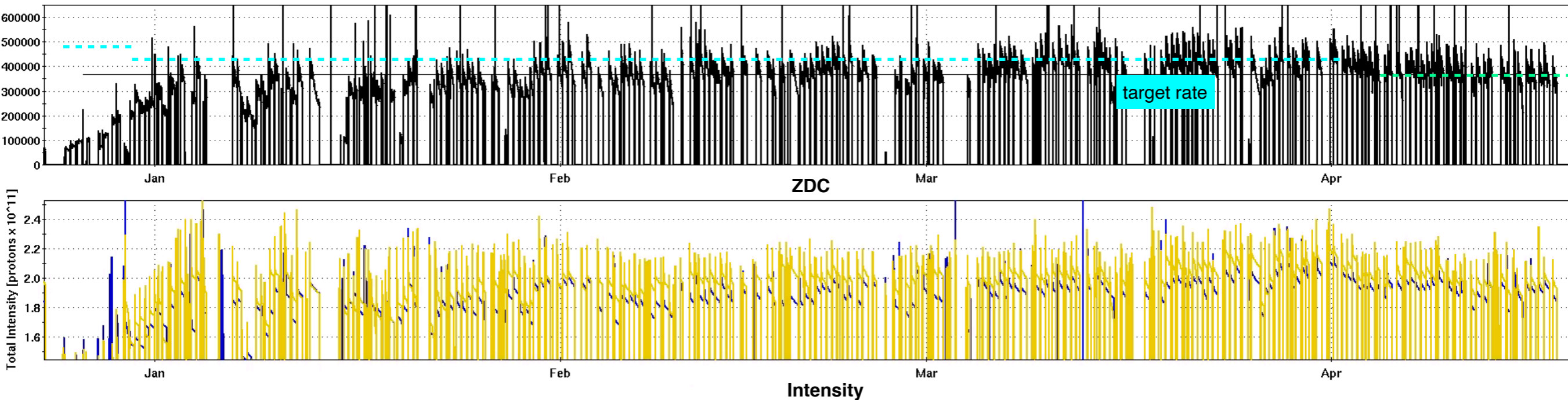
# Run22 objectives

- Luminosity
  - stable and leveled luminosity at  $\sim$ target luminosity
  - minimal background
  - measure/determine cross-section
- Polarization
  - key to physics FoM  $P^2L$
  - high polarization with known components
- Data taking Efficiency
  - high detector / trigger uptime
  - optimal system live time
  - efficient shift operation
- Detector performance
  - no major issues

# Run22 - Schedule

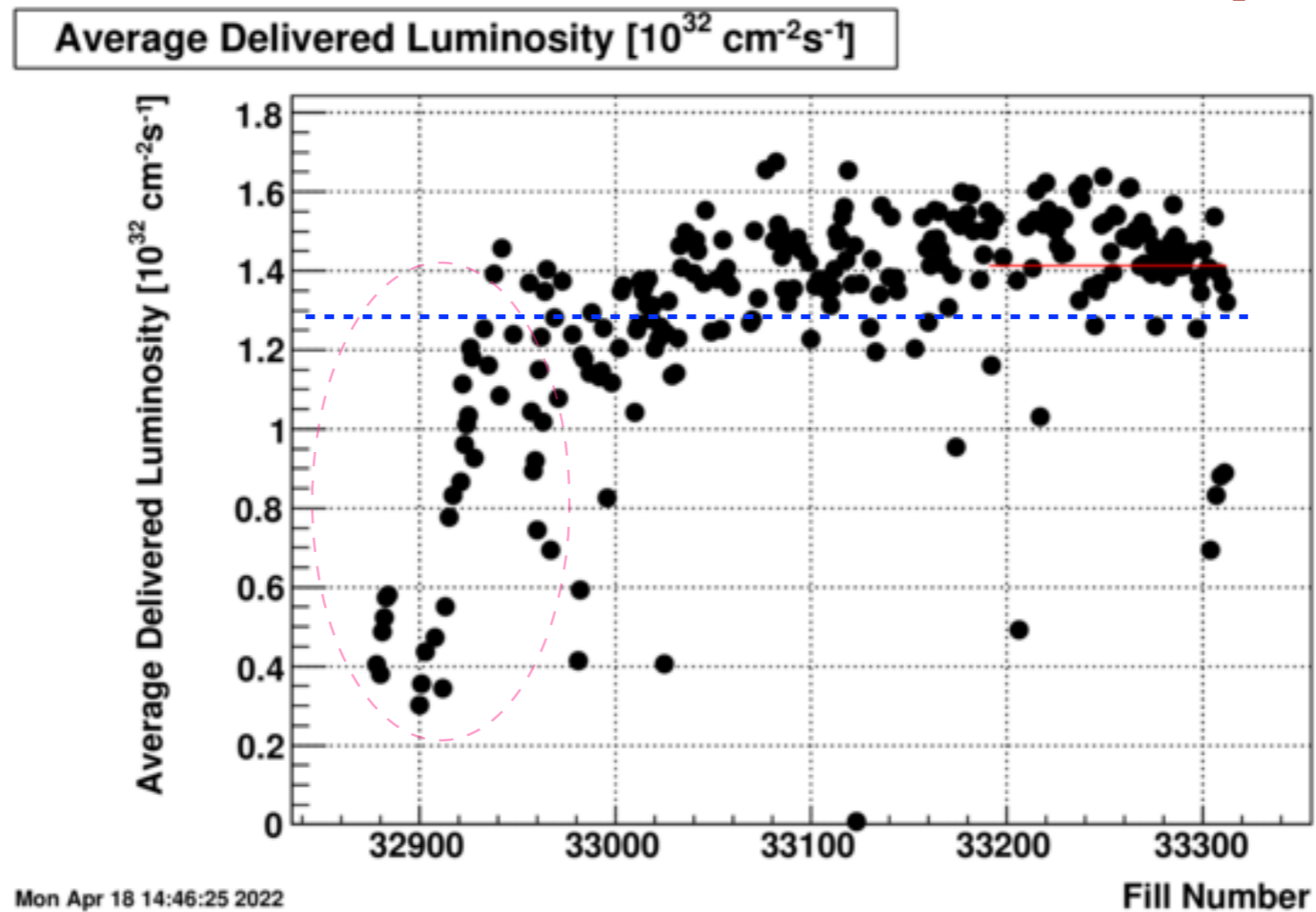
- 11/15/21 : Original cool-down start date. Blue ring cool-down start
- Delay start (13 days) with cryo control upgrade. Yellow cool-down start
- 12/3 : Blue snake Bi9-2 (inner helical dipole) damage from major power outage
  - ran partial Bi9-1,4 at 85% of spin rotation
- 12/13 : Blue snake Bi9-4 (outer) damage; reconfigure to run with Bi9-1,3
- **12/15 : Start physics data taking (Midrapidity program)**
- 12/20 : Physics declaration/CAD (18 days from first injection)
- **12/25 : Start Full physics (Midrapidity + Forward)**
- 1/2 : Change store energy to 254.87 → 254.21 to maximize vertical orientation of spin
- 1/12 : AGS Siemens MG damage, switch to Westinghouse MG
- 3/8 : Switch back to Siemens
- 4/4 : 2-weeks extension
- 4/18 : Run end

# Luminosity



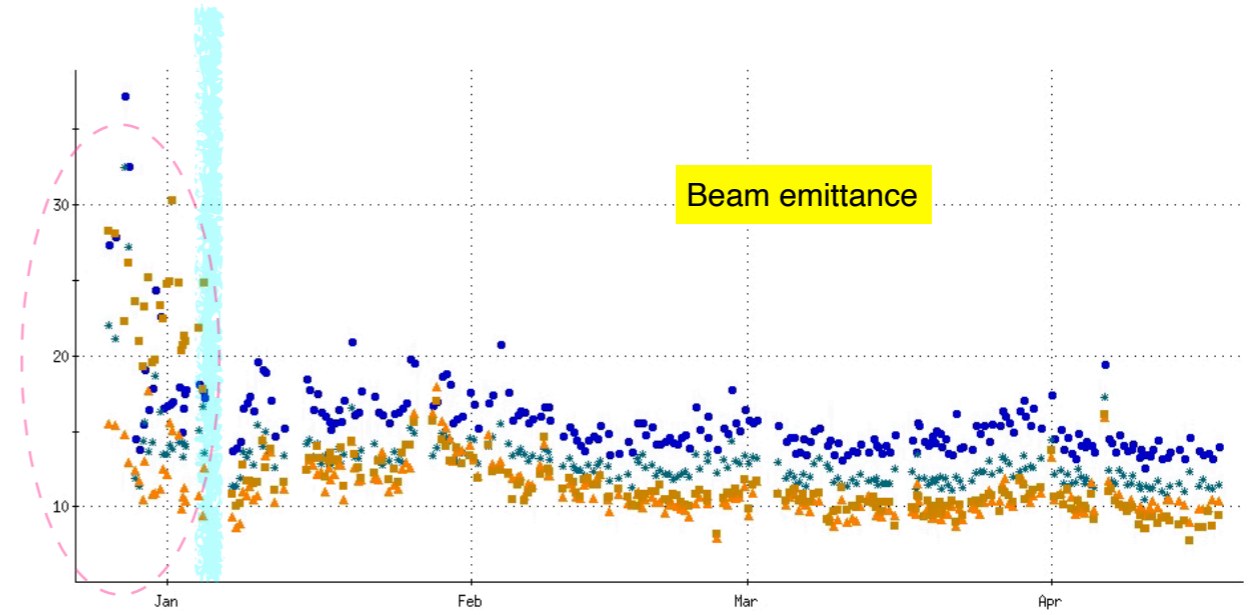
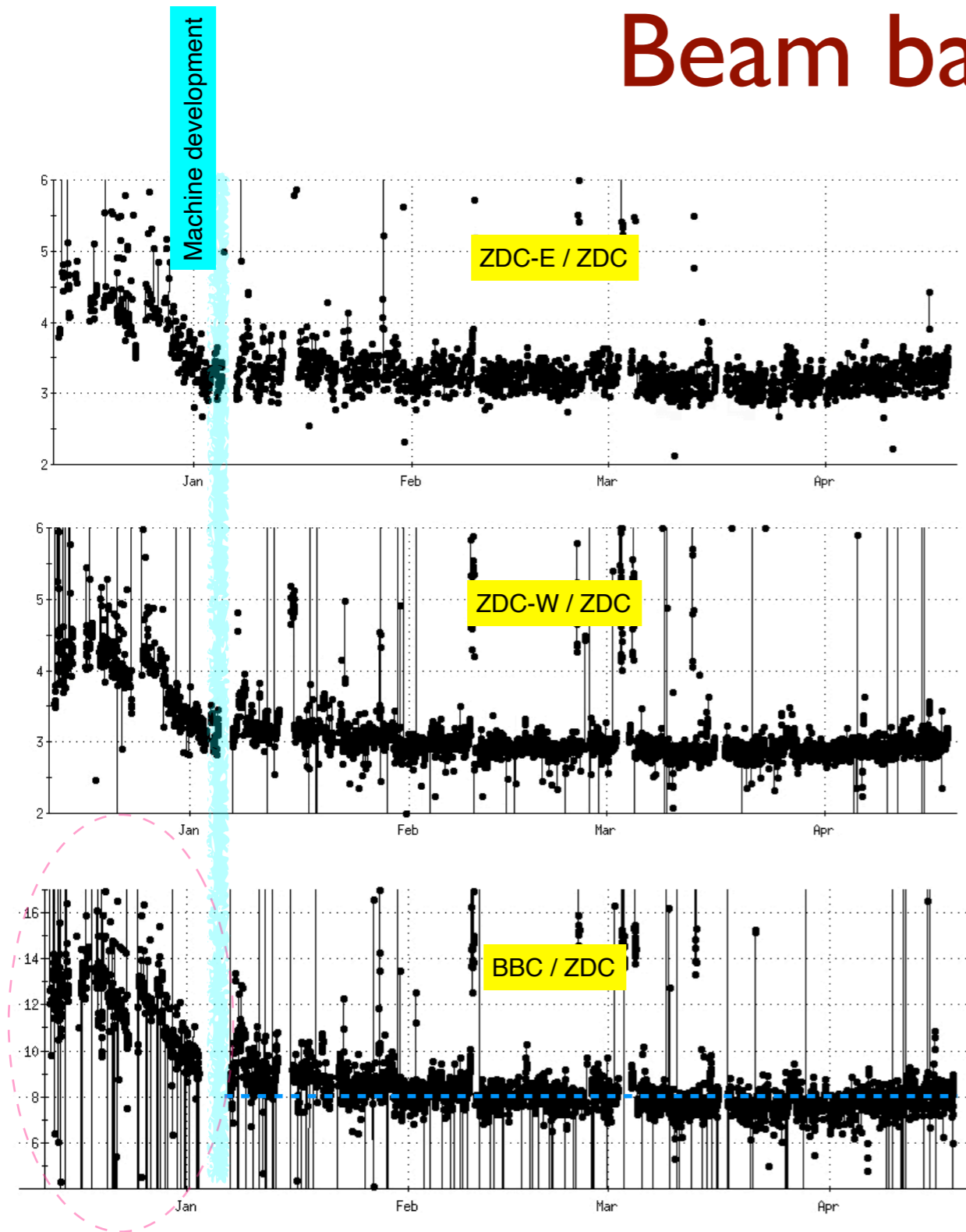
- Target luminosity  $\langle L \rangle \sim 1.35 \cdot 10^{32} \text{ cm}^{-2}\text{s}^{-1}$
- Luminosity adjusted mainly with beam intensity and  $\beta$ -squeeze (1,2 in-store)
- Average luminosity delivered close to the requested (with cross-section 1.86 mb)
- ZDC cross-section value change: 2.68 mb (Run 17)  $\rightarrow$  2.06 mb  $\rightarrow$  1.86 mb (16 Vernier scans throughout the run)

# Delivered luminosity



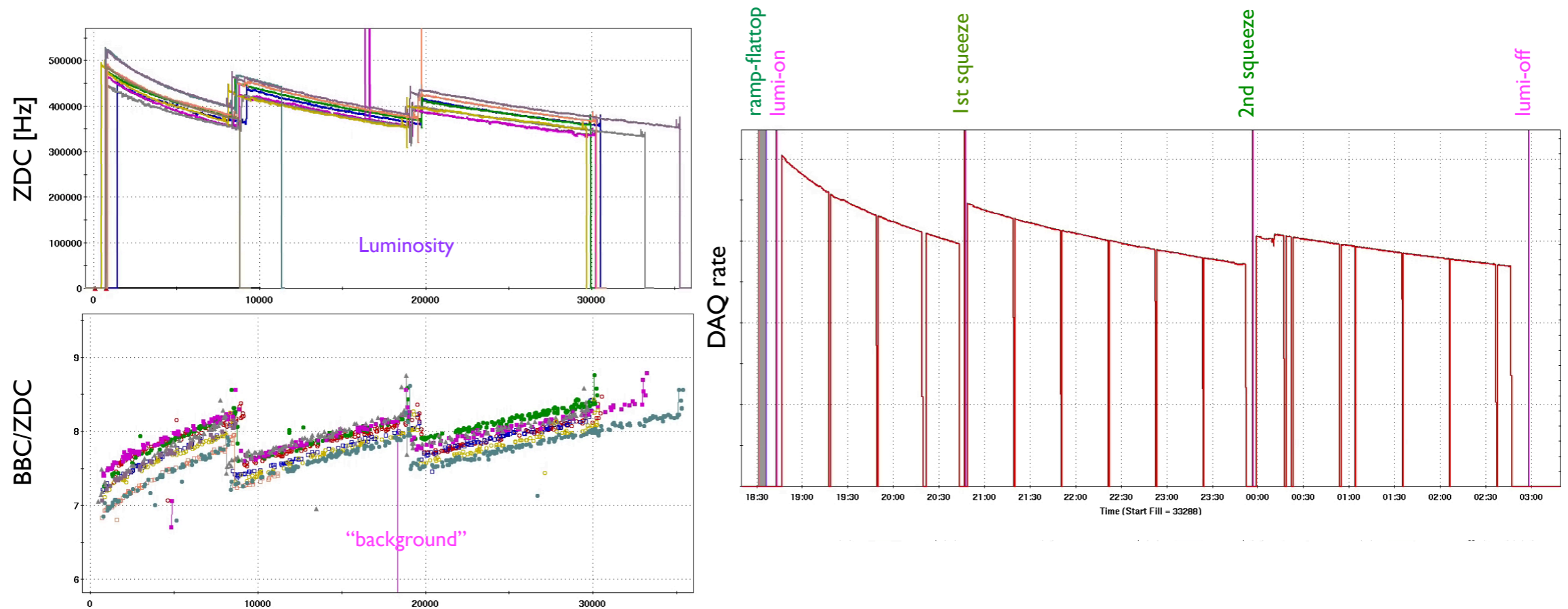
- Average delivered luminosity  $1.3 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
- Run 17 average:  $1.2 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
- Luminosity more stable after machine development

# Beam background



- higher background (with high emittance) earlier in the run
- improved with machine development (tune/chromaticity, injection,..)
- stable and clean: BBC/ZDC  $\sim 8$  (as in run I7)
- No significant background issues identified

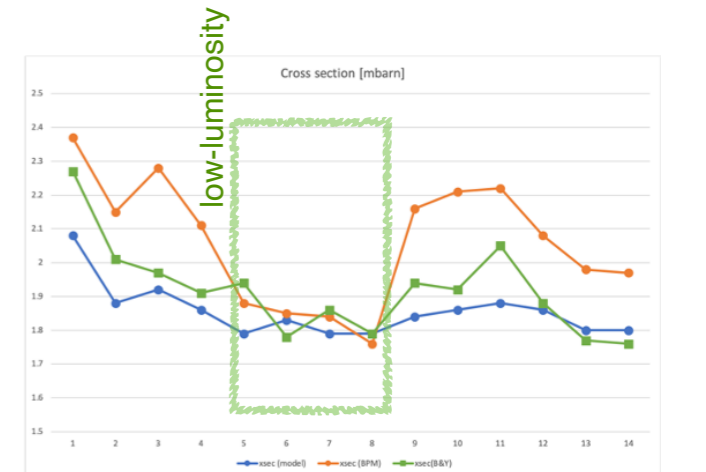
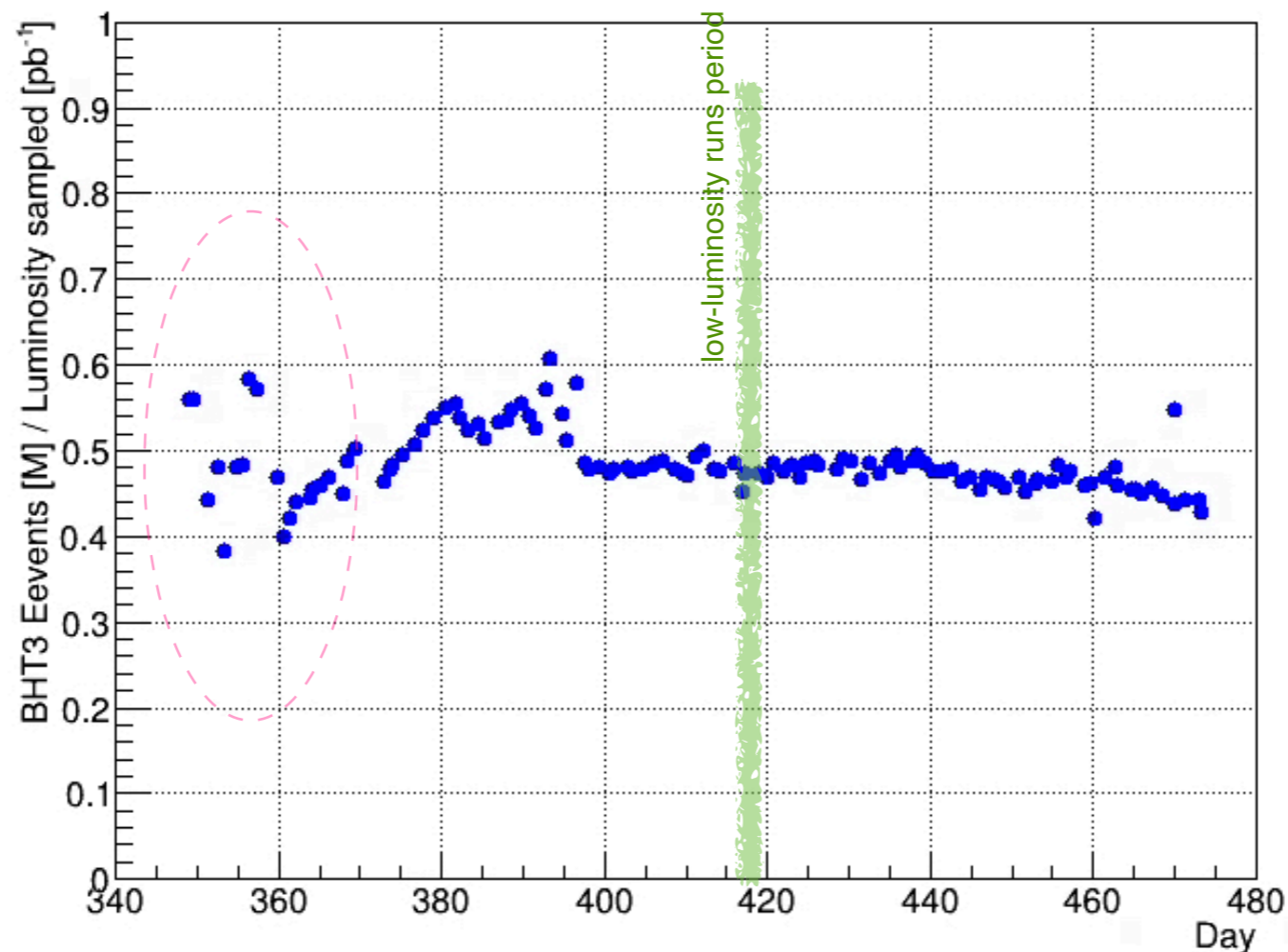
# Luminosity leveling and background



- Well controlled luminosity with (1),2  $\beta$ -squeezes
- No indication of enhanced background with the squeeze
- Squeeze, polarization measurement, DAQ well coordinated



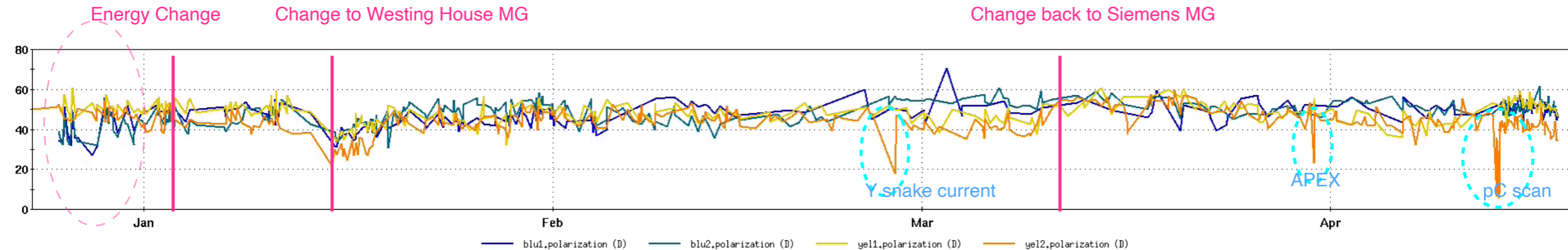
# Physics rates (BHT3) / ZDC



ZDC cross-section from Vernier scans (A. Drees)

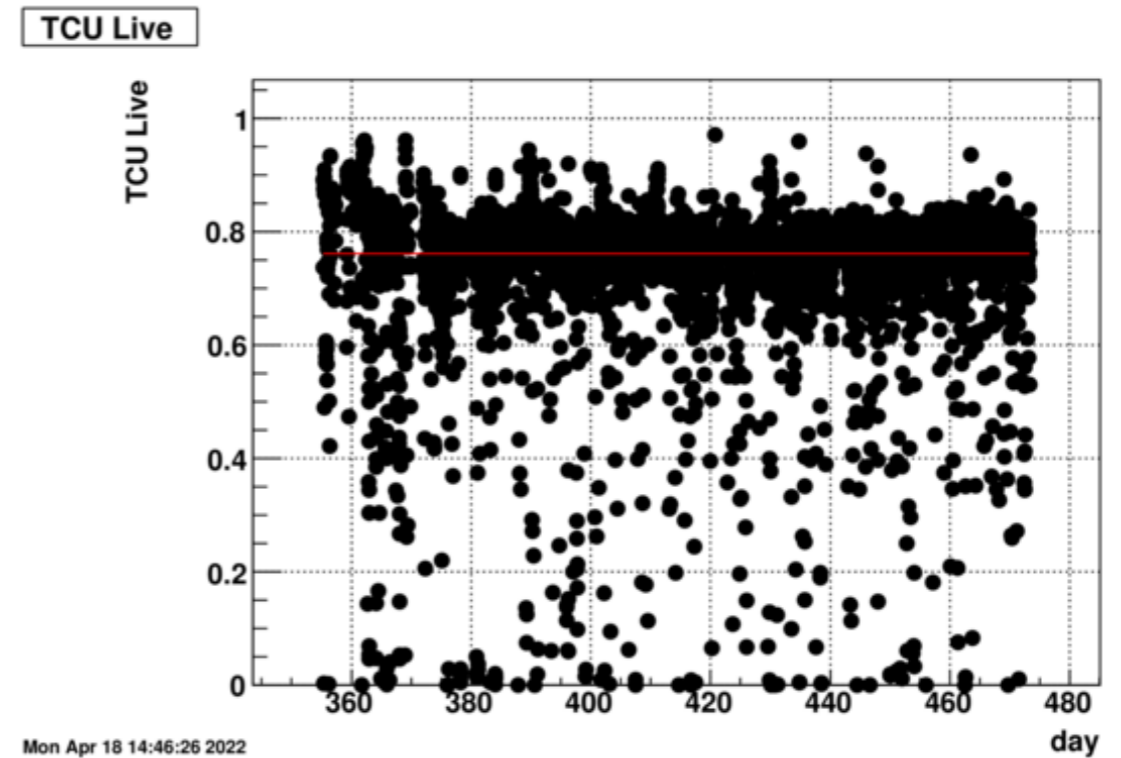
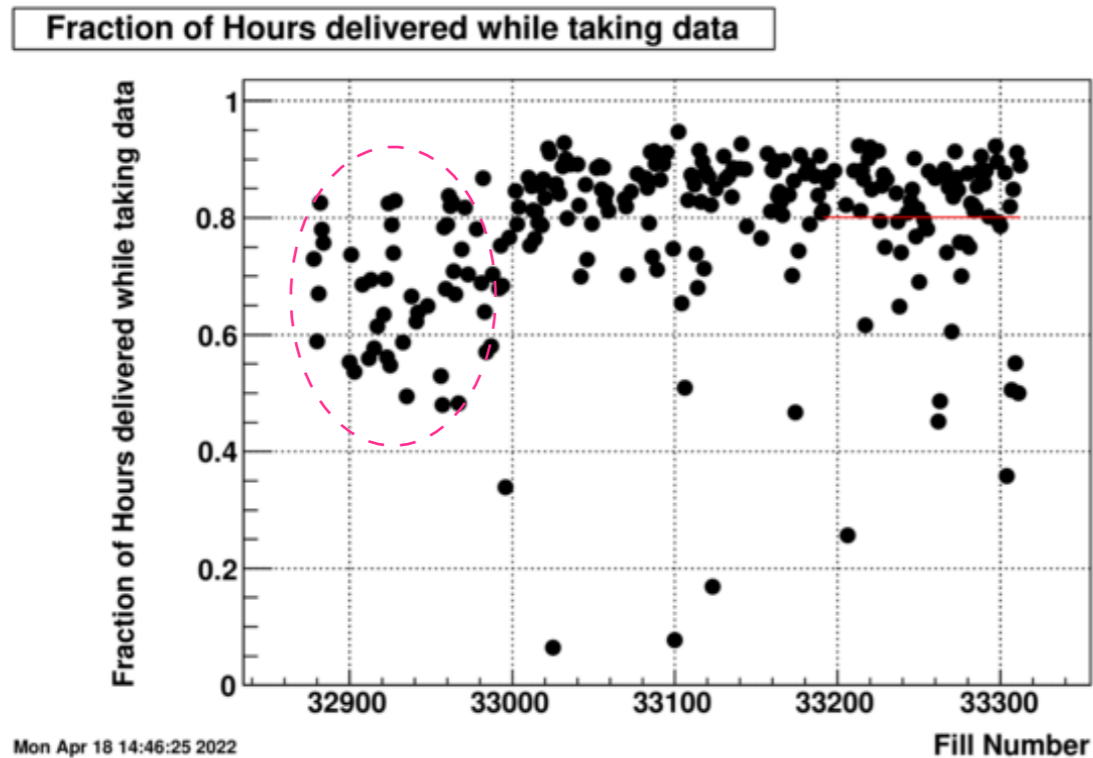
- BHT3 / ZDC ~ “stable” similar as in Run I7
- BHT3: Base W/Z trigger using EM calorimeter energy cut
- No indication of changes of cross-section seen by Vernier scans
- Low luminosity ( $O(10^3)$ ) for precision cross-section measurement and alignment for new Forward detectors

# Polarization



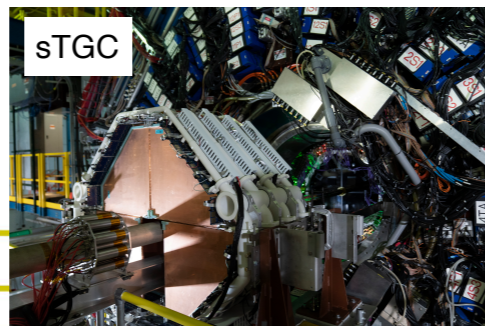
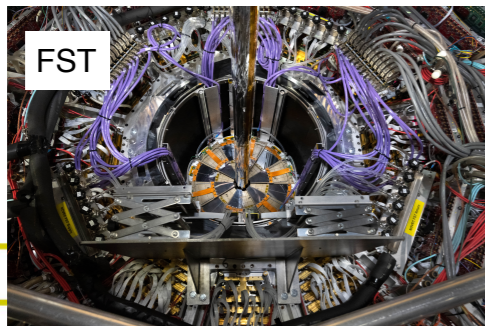
- Yellow and Blue polarization  $\sim 51\%$  (luminosity weighted) (vs 55% in Run I7 as requested)
- Beam energy change to maximize the vertical component
- residual radial tilt angle  $\sim$  few degree
- Longitudinal component estimated to be  $\sim 10\%$  with rotator scan
- Degraded with AGS Westinghouse MG for the middle half of the run

# Data collection efficiency



- Sampled/Delivered  $450\text{pb}^{-1}/767\text{pb}^{-1} \sim 58.7\%$  (Run 17: 63%)
- Uptime 77%, Live time 76% (Run 17: 78%, 80%)
- DAQ Downtime: interruptions for polarization measurements+ $\beta$ -squeeze ( $\sim 4\%$ ), run control ( $\sim 4\%$ ) detector ramping up/down ( $\sim 1\%$ ), detector/shift crew issues ( $\sim 12\%$ ), ..

# Forward upgrade detectors



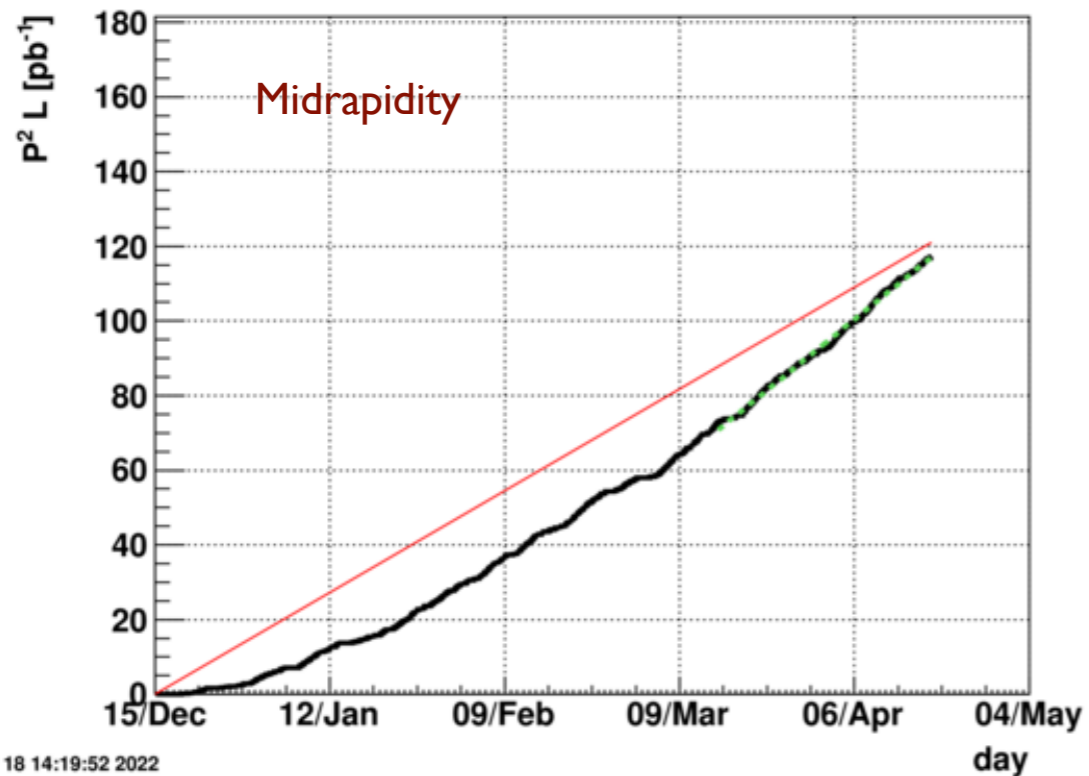
Run: 23099024  
EventId: 1731  
p+p at 510 GeV

- Tracking (**F**orward **S**ilicon **T**racker, **s**mall-strip **T**hin **G**ap **C**hamber) and Calorimeter system (**F**orward **C**alorimeter **S**ystem)
- Installation completed during shutdown 2021 (construction and installation in the pandemic period)
- Successful commissioning and performance - Smooth data taking throughout the run

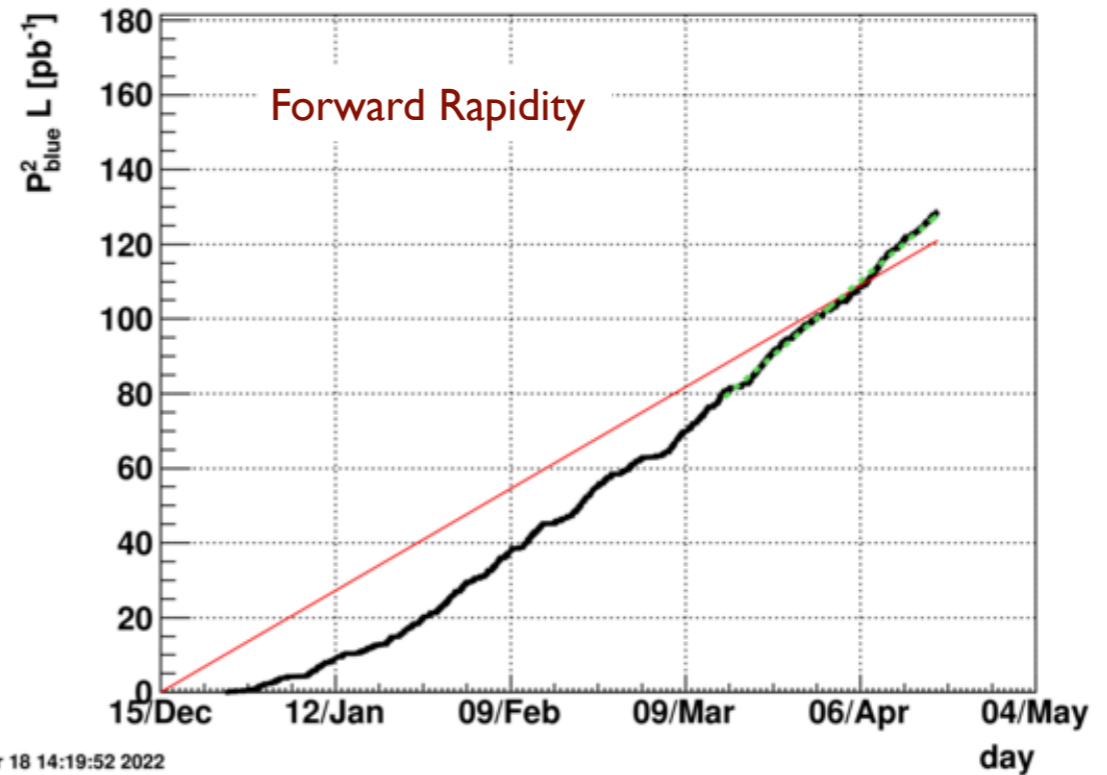


# Physics goals

BHT3



fcsDY



Final score:

- $\int P^2 L$  - Midrapidity BHT3: 117.2 pb<sup>-1</sup> (98% of goal), Forward Rapidity FcsDY: 126.7 pb<sup>-1</sup> (106%)
  - $\int L = 452 \text{ pb}^{-1}$ ,  $P = 51\%(Y), 51\%(B)$
  - physics data taking period of 56.6 days (~16 “physics weeks”)

# Run22 operations

- Continuing the “**hybrid**” **operation mode** with shift crew 2+1: leader, detector operator (separate room) + a remote crew for QA due to restricted manpower and for maximum distancing. On-site period coordinators. All connected through Zoom
  - With the running condition, worked efficiently
    - more and new detectors to control this run
    - higher detector activities with high luminosity
    - Run23 running conditions expected to require similar shift activities
- Communication with MCR / CAD
  - Real time
    - Main two-way channel: phone communication and BERT
    - STAR: Gpm, RHIC status broadcast, e-log
    - MCR: Online QA plots, event rates, vertex info. available through CDEV and a direct web link. Luminosity tracker. Not as much utilized as in BES runs.
    - Zoom connection with MCR as needed, but rarely used (or needed). More active channel might be useful in the future
  - Progress/issue feedback
    - RHIC status meeting, Time meeting, Coordination meeting
    - Special meetings: Spin direction, Vernier scan, ..

# Beam Use Request for Run23+(Run25)

$\sqrt{s_{NN}}$ (GeV)	Species	Number Events/ Sampled Luminosity	Year
200	Au+Au	20B / 40 nb <sup>-1</sup>	2023+2025
200	<i>p+p</i>	235 pb <sup>-1</sup>	2024
200	<i>p+Au</i>	1.3 pb <sup>-1</sup>	2024

Assuming 24 physics weeks / year

year	minimum bias [ $\times 10^9$ events]	high- $p_T$ int. luminosity [nb <sup>-1</sup> ]		
		all vz	vz <70cm	vz <30cm
2014	2	27	19	16
2016				
2023	20	40	36	24
2025				

- Au+Au at 200 GeV
- High luminosity for rare probe/high- $p_T$  physics + controlled low luminosity for minimum bias physics
  - high- $p_T$  : ZDC ~ 100K Hz (29 weeks)
  - minimum bias : leveled ZDC rate at ~10K Hz (19 weeks)
  - Mix two modes depending on beam condition
  - crossing angle (optional)
- No new detectors to commission

# Summary

- **Run22:** Eventful, but achieved the physics goals requested in BUR
- No significant issues with data and detectors in Run22
- New forward detectors: successful commissioning and performance
- Operation with “hybrid” shift mode worked efficiently
- Thanks to CAD for the great performance making Run22 successful