RUN 2022

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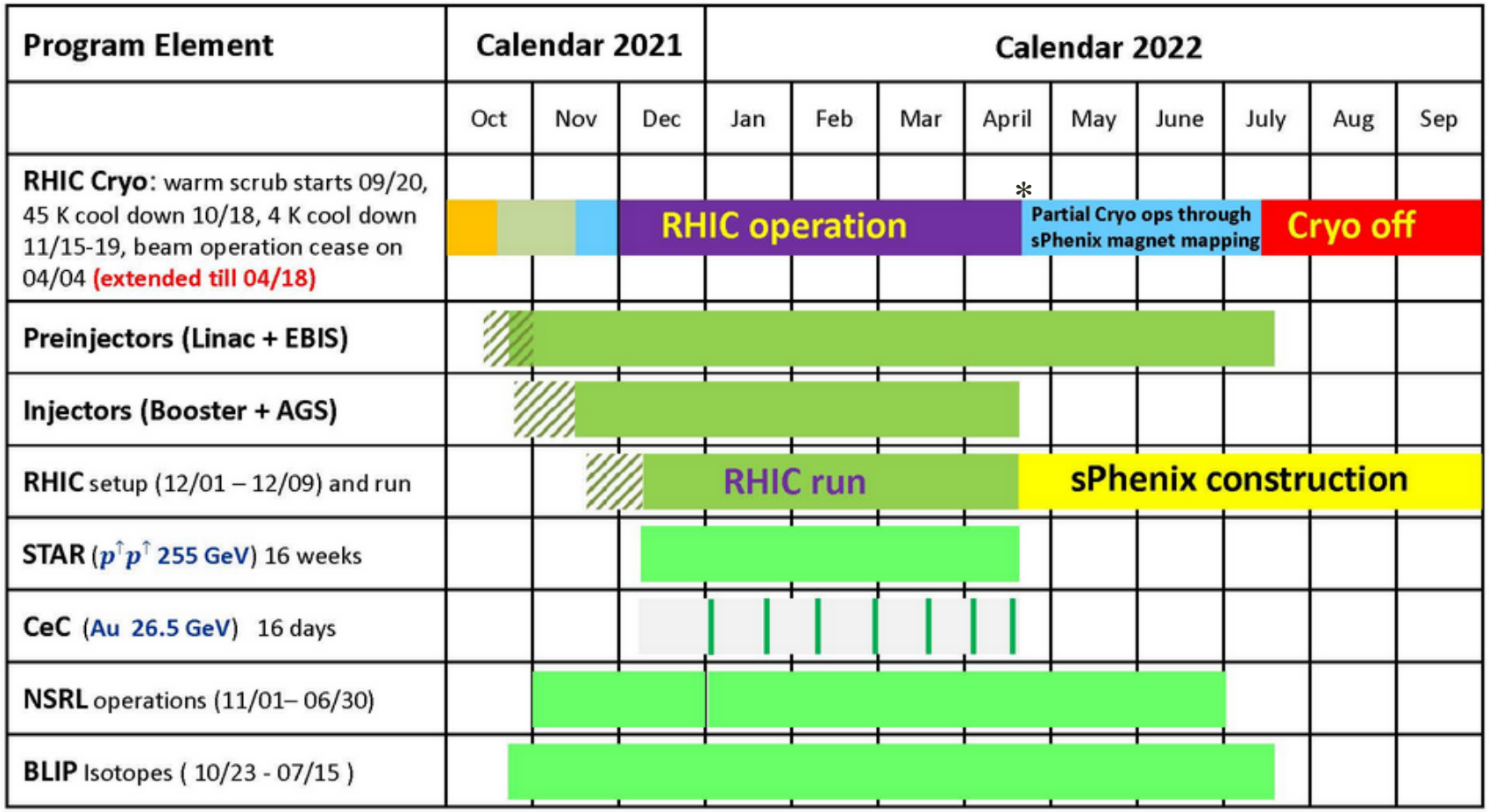
RUN22 SCHEDULE



Note: the RHIC run will last for 20 weeks, and includes the final cooldown, the commissioning, the STAR physics program, and 16 dedicated days of beam use for the CeC program.

*RHIC Operation was granted a 2 week run extension, ending on 4/18 instead of the original end date of 4/4

RUN22 SCHEDULE TIMELINE

Blue cooldown begins: 11/28/2021

Yellow cooldown begins: 11/30/2021

Blue 4K reached: 11/29/2021

First circulating bunch (Au) in Blue: 12/03/2022

Yellow 4K reached: 12/02/2021

First circulating bunch in Yellow (Au): 12/05/2022

CeC PoP Start: 11/24/2021

Physics Start for Polarized Protons: 12/22/2022

End Physics Operations: 04/18/2022

Begin Cryo Warmup: 04/18/2022

RHIC Activities End: 04/18/2022

Cryo Warmup Complete: 05/03/2022

MODE TIMELINE

- **Mode 1A:** polarized p on polarized p at 254.2 GeV particle energy
  - **Beam Operation:** 12/03/2021 - 04/18/2022 [136 days, 128 days for physics]

    (interleaved with Mode 2A)

- **Mode 2A:** $^{197}Au^{79+}$ in Yellow ring for CeC PoP at 26.5 GeV/nucleon particle energy
  - **Beam Operation:** 11/24/2021 - 04/18/2022 [145 days, 8 days for experiment]

    (interleaved with Mode 1A)

RUN COORDINATORS

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Modes of Operation: 1A, 2A

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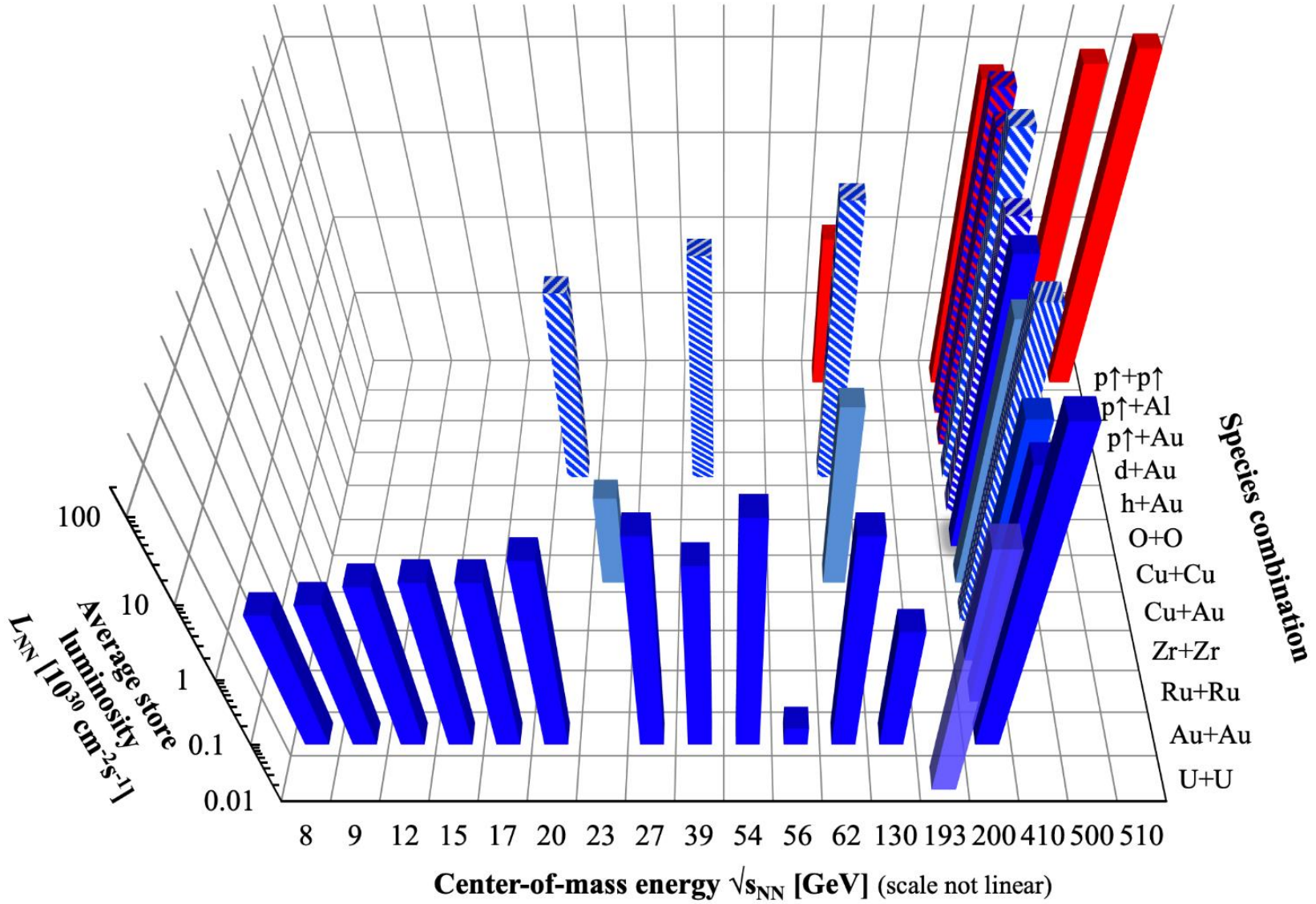
Modes of Operation: 2A

RUN OVERVIEW

MAJOR ACCOMPLISHMENTS AND EVENTS

- OPPIS LEBT modified (Einzel lenses replaced by quadrupoles) for higher transmission
- Multiple start-up issues: AGS cold snake short to ground, Booster vacuum restoration, Siemens rheostat repair, AGS high leakage current during high-pot, AGS cable tray damage in conduit under road, AGS dipole coil replacement, vacuum leak in Yellow IR7 triplet, stuck vacuum valve in BtA - replaced with spool piece, cryo control upgrade completion delayed full 4K cool-down by 13 days (time used to setup CeC electron beam), BNL site-wide power outage of 86 sec on 12/02/2021 - about 1 day recovery (found a helical magnet in Blue snake bi9 damaged after recovery)
- prepared new bunch split and merge scheme to reduce peak current at AGS injection and thereby emittance: additional bunch split on intermediate energy level in Booster and recombination at AGS before extraction (not used with Westinghouse MG)
- 40 Ohm injection kickers (used for low energy runs) inadvertently installed for Run-22 resulting in a kick too weak by 10-15%, switched to nominal 25 Ohm resistors for Blue and Yellow on 4/4/2022
- helical dipole 2 of Blue snake bi9 found to be open (possibly damage in power outage), need to run with configuration like in Run-3 (Yellow snake with same problem): 2 inner helical dipoles turned off, 2 outer helical dipoles a full strength with field reversed - provides a partial snake with 90% spin rotation
- after power dip on 12/13/21 found helical magnet 4 in Blue snake bi9 also damaged, reconfigured again to use helical magnets 1 and 3 for a partial snake (can be done from outside)
- work on 7b-qd1 quench detection system requires 5x longer energy ramp for 3 days (12/25-27/2021)
- changed store energy from $\gamma = 271.635$ ($G\gamma = 487.0$) to $\gamma = 270.938$ ($G\gamma = 485.75$) to have nearly vertical spin direction in all locations with bo9 partial snake - in particular pC polarimeters and STAR, beginning with fill no. 32934 (01/02/2022)
- Siemens MG set damage on 01/12/2021, switch to Westinghouse MG, switched back to Siemens on 03/08/2022 with new brushes and re-surfaced rings
- no abort kicker pre-fires in physics with RHIC abort kicker relays and delayed aborts (first time ever for a high energy run)

RHIC ENERGIES, SPECIES COMBINATIONS, AND LUMINOSITIES (RUN-1 TO RUN-22)

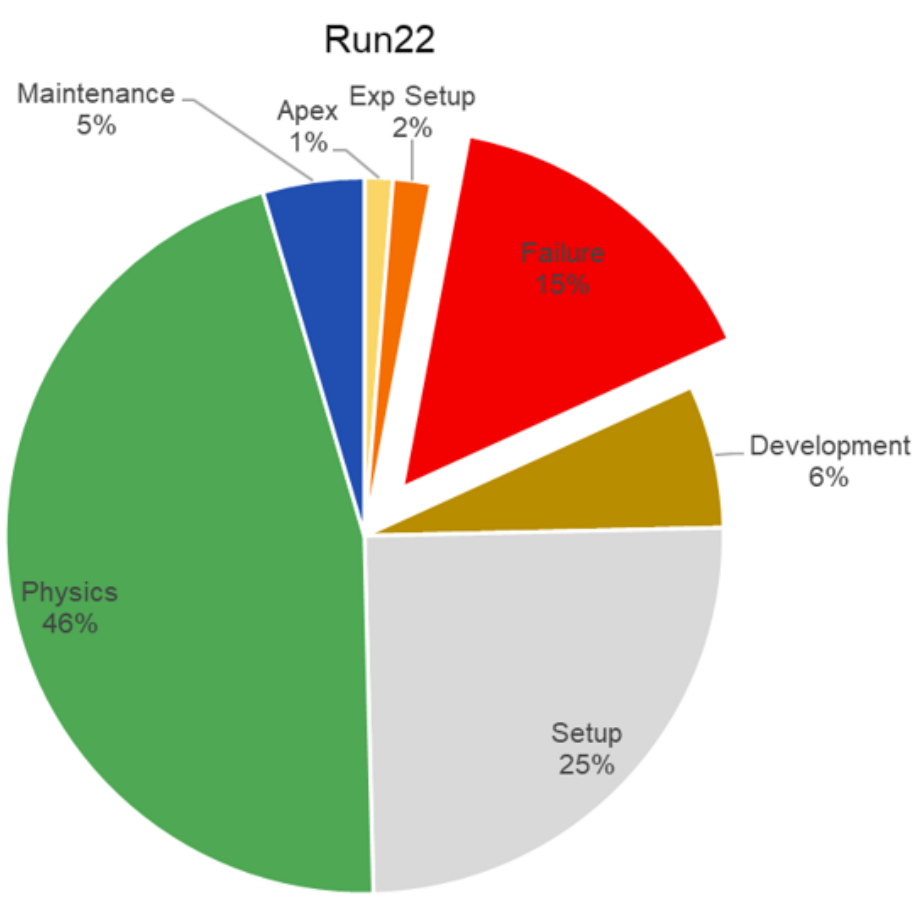


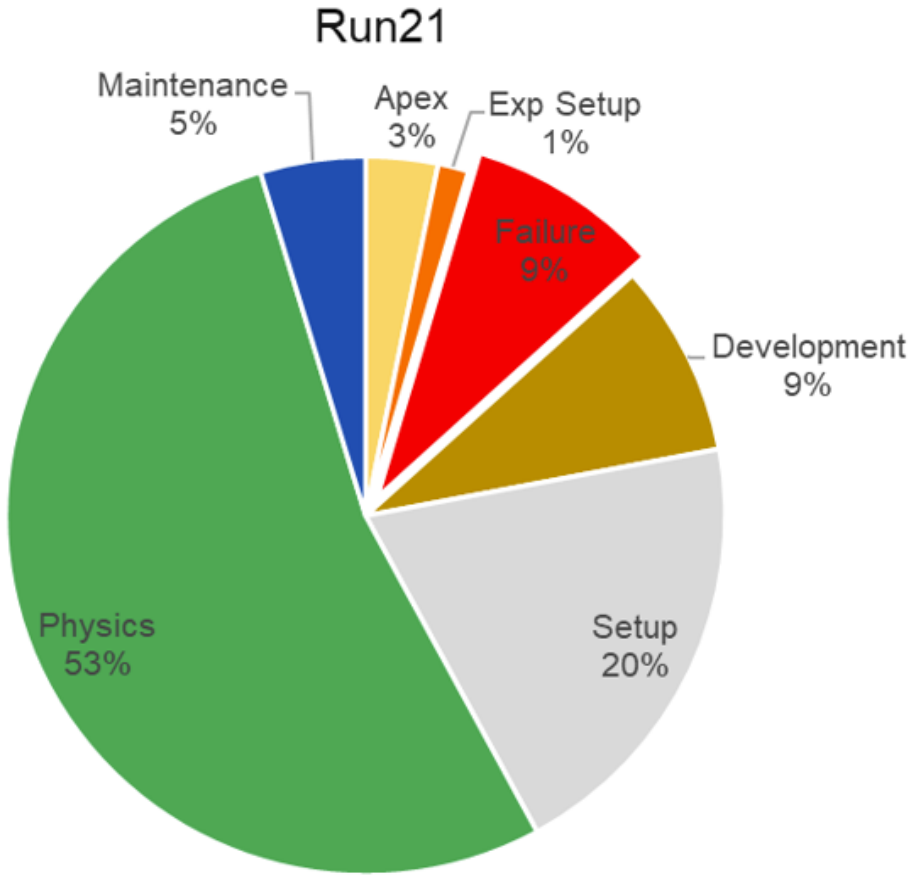
RUN PARAMETERS

Mode Name	Energy/ Nucleon [GeV]	No. Bunches	Ions/ bunch [10^9]	B* [m]	rms emittance [μm]	Run Avg. Store Polarization [%]	STAR Luminosity [pb^{-1}]	STAR Luminosity [rel. to Run-17]
1A	254.2	111	200	1.5→1.2→1.0	2.5→3.6	Blue: 50 Yellow: 49.5	807	1.48x
1B	26.5	12	1	5.0	-	-	-	-

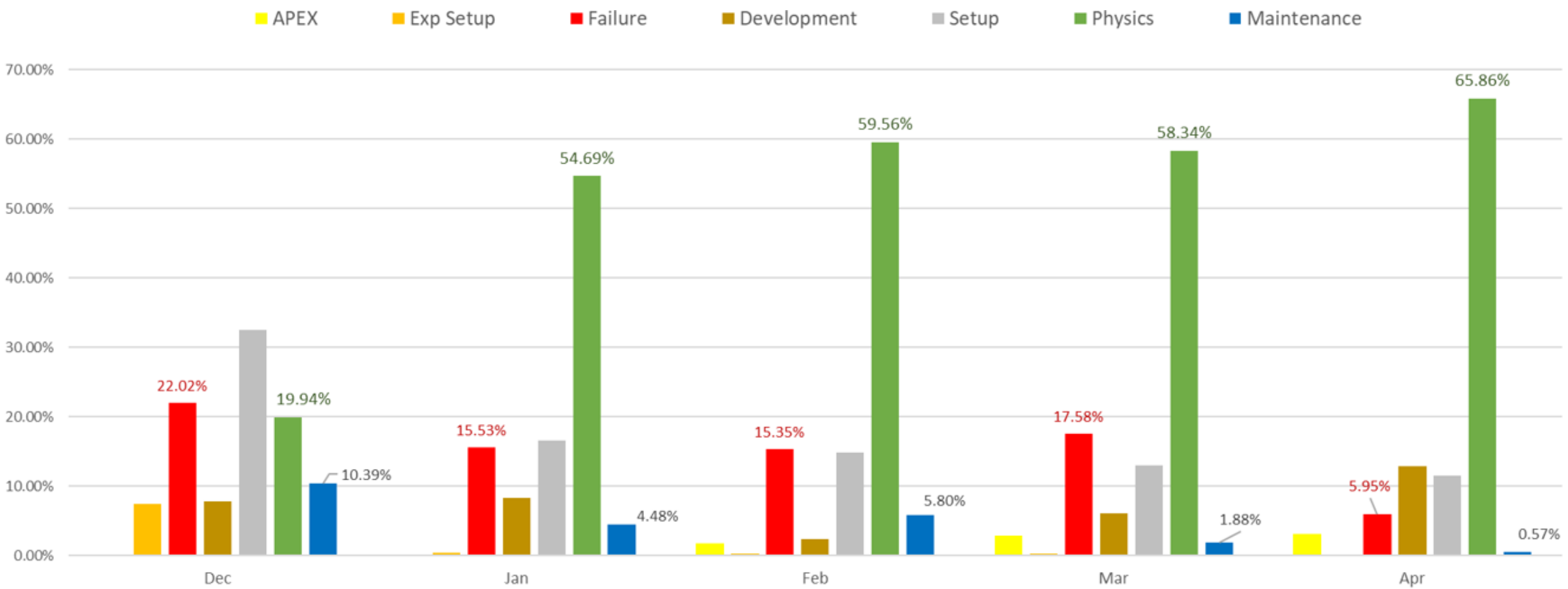
- Total 18 days setup for physics
- Nominal store length of 8 hours
- first β^*-squeeze immediately after energy ramp, second β^*-squeeze after 3h

TIME SPENT PER MODE

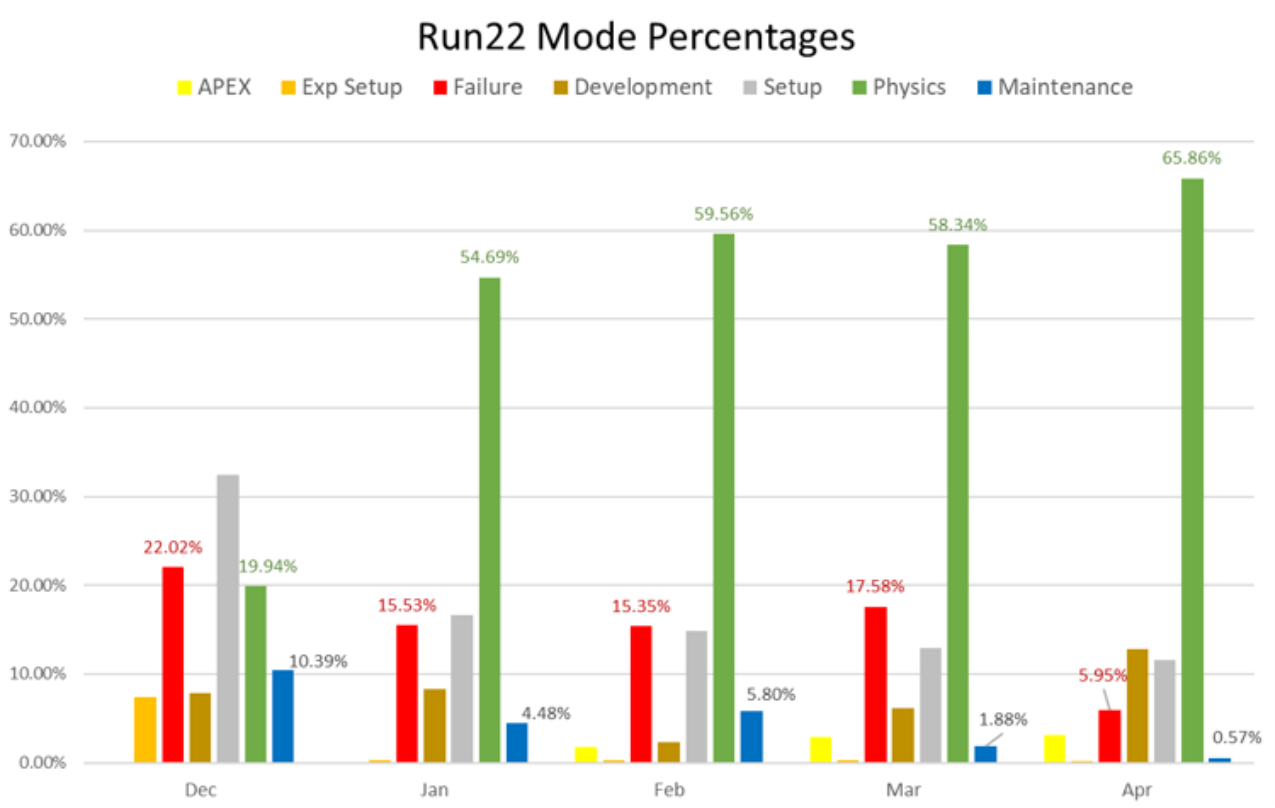


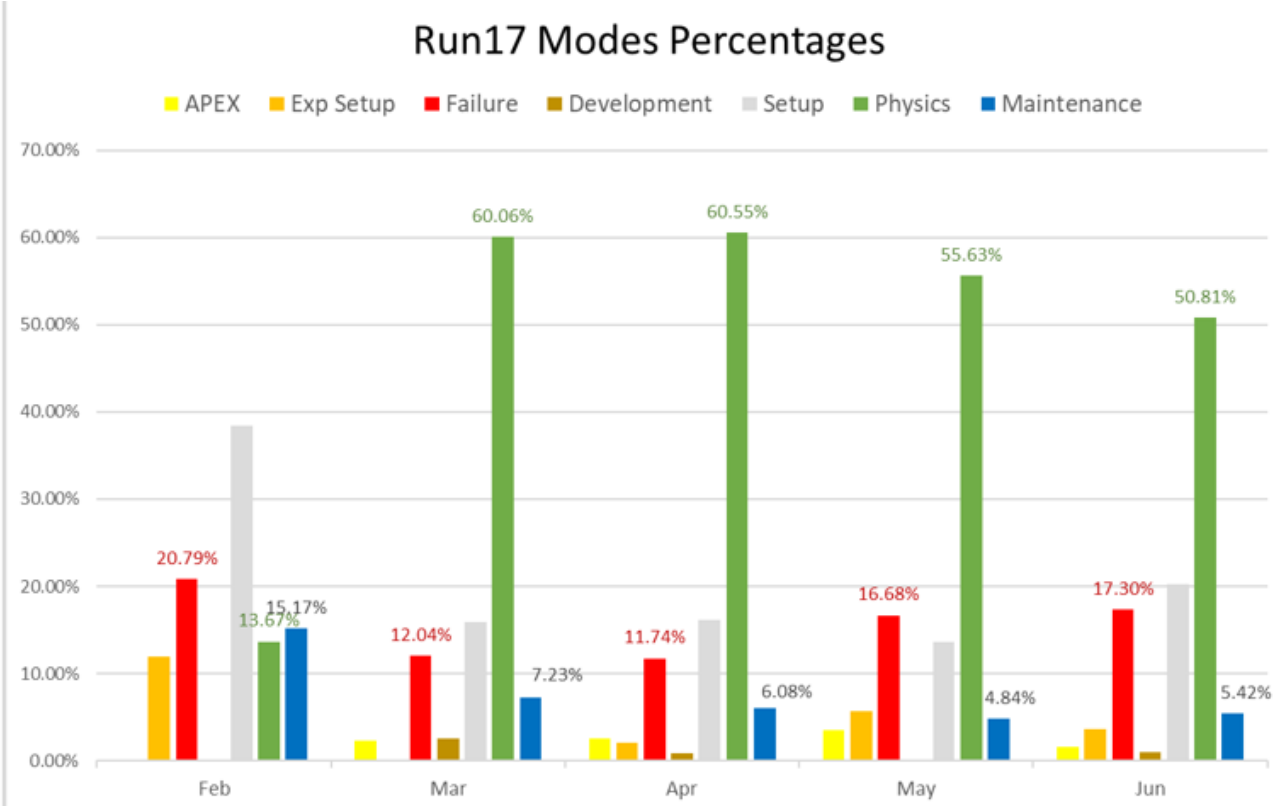


RUN-22 MODE PERCENTAGES

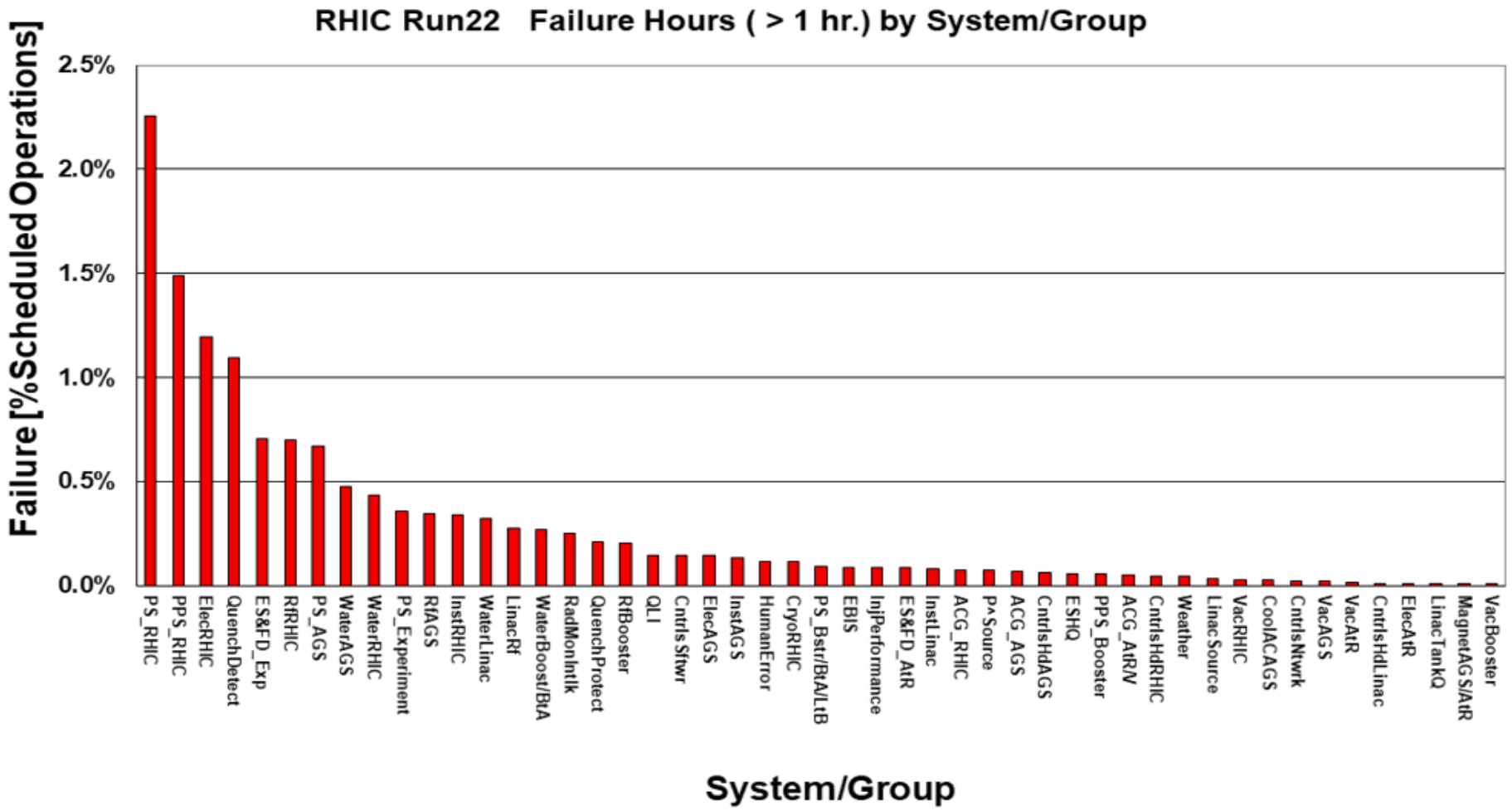


MODE PERCENTAGES COMPARISON





FAILURE HOURS BY SYSTEM/GROUP



CEC OPERATIONS

CEC RESULTS FROM RUN-22

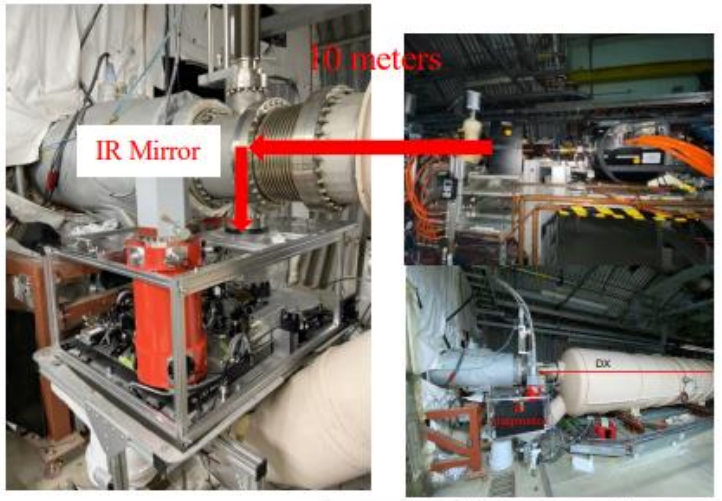
- Run-22 goal of demonstrating Coherent electron Cooling not met, CeC lost ~71% of operational time due to issues with Integrated Current Transformer and damage to the SRF gun during a cathode exchange

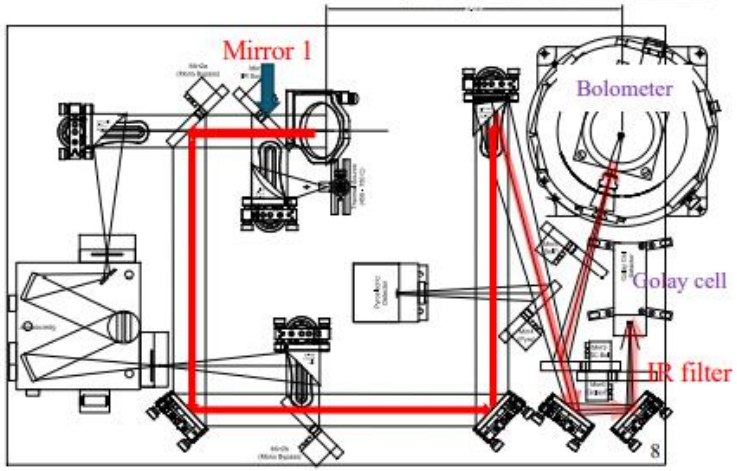
- Primary CeC achievement for Run-22 was verifying high Plasma Cascade Amplification (PCA) gain at frequencies of 6 THz and above thanks to new pieces of IR diagnostics (For long time maximum observed PCA gain was ~ 5 with frequencies under 6 THz).

- PCA Gain is measured by comparing IR radiation from PCA and relaxed lattice configurations. The radiation is delivered to the two most sensitive IR detectors (shown on right):

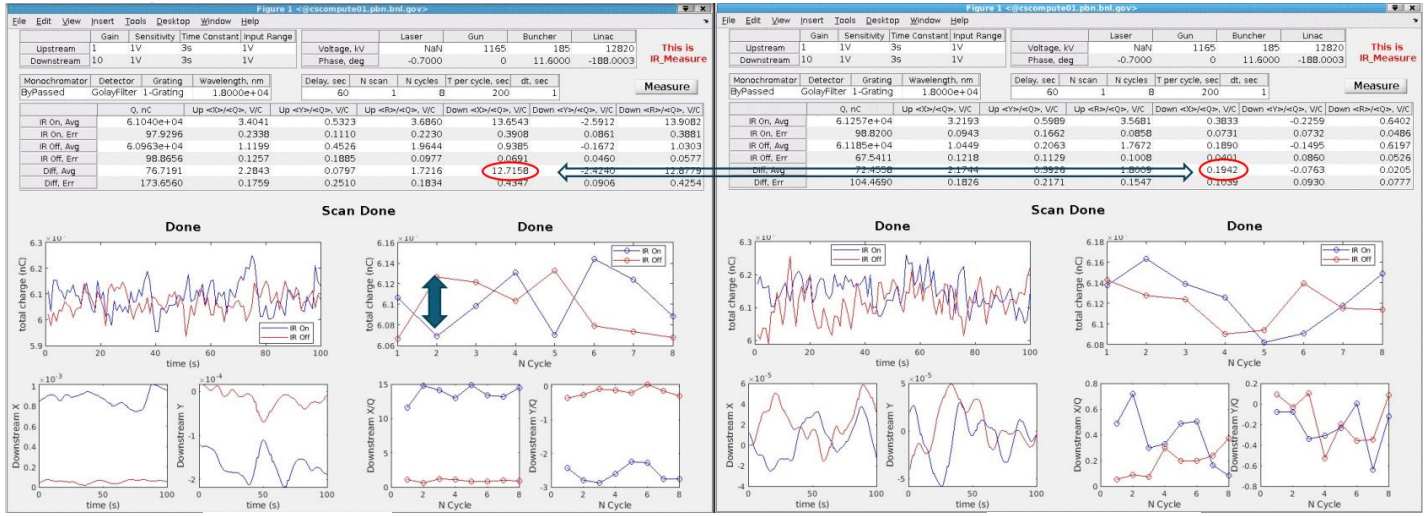
  - **Golay cell:** equipped with new IR filter (passband of 3.5 - 10 THz) improved its sensitivity at high frequencies

  - **Cry-cooled bolometer:** (spec sensitivity range: 6 THz -60 THz) first became operational and played important role





CEC RESULTS FROM RUN-22

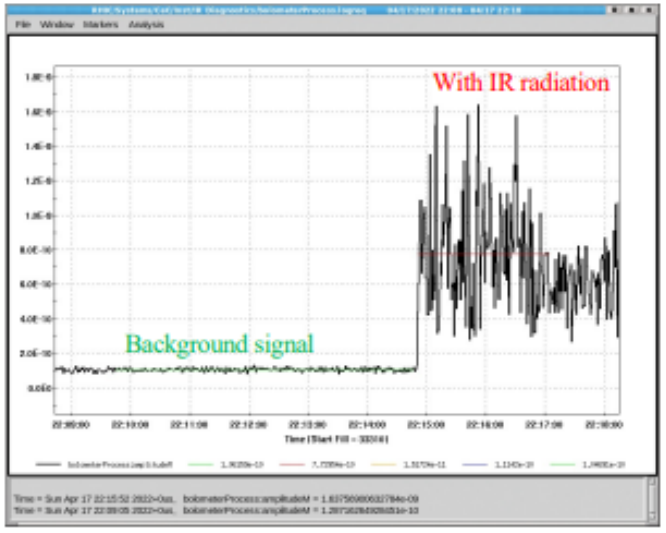


PCA lattice

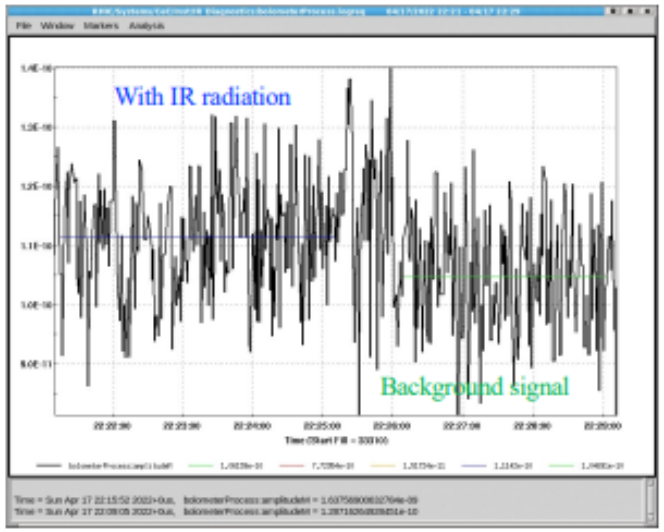
Relaxed lattice

Golay Cell Measurement*:

Gain = PCA /Relaxed = 65



PCA lattice



Relaxed lattice

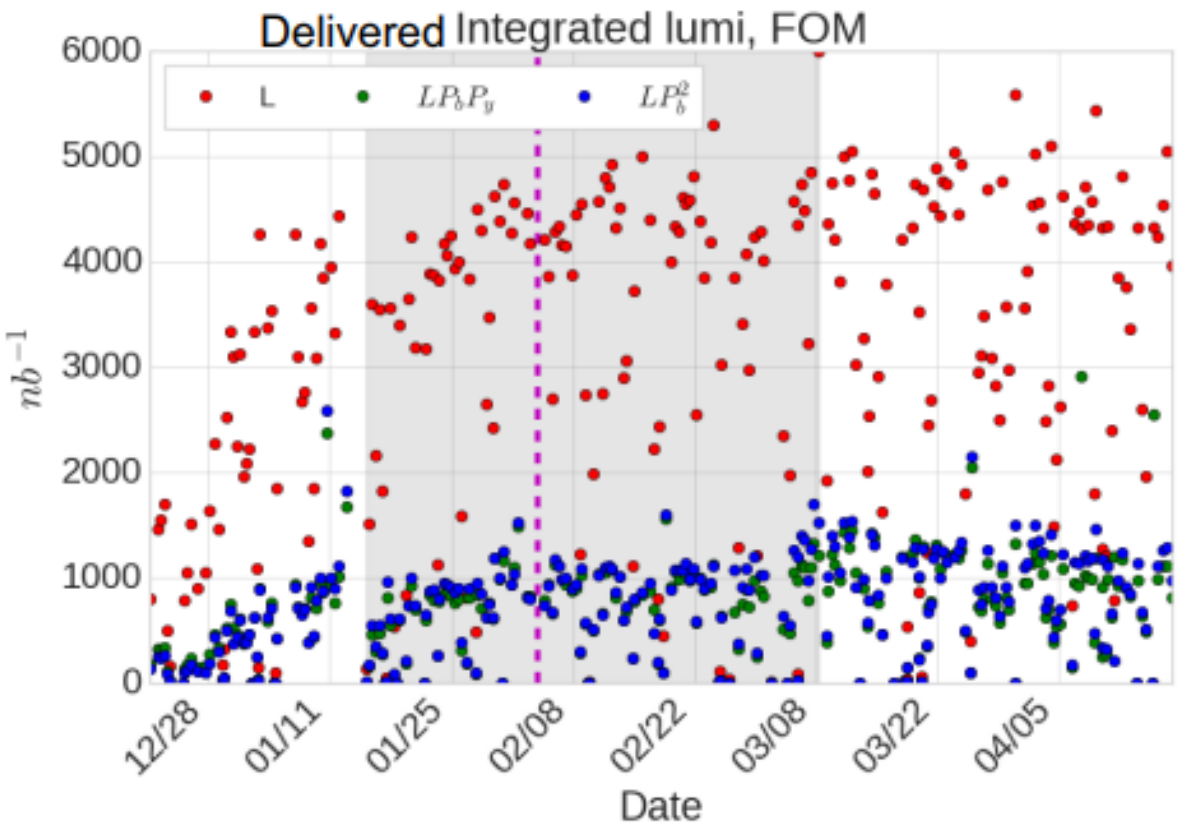
Bolometer Measurement*:

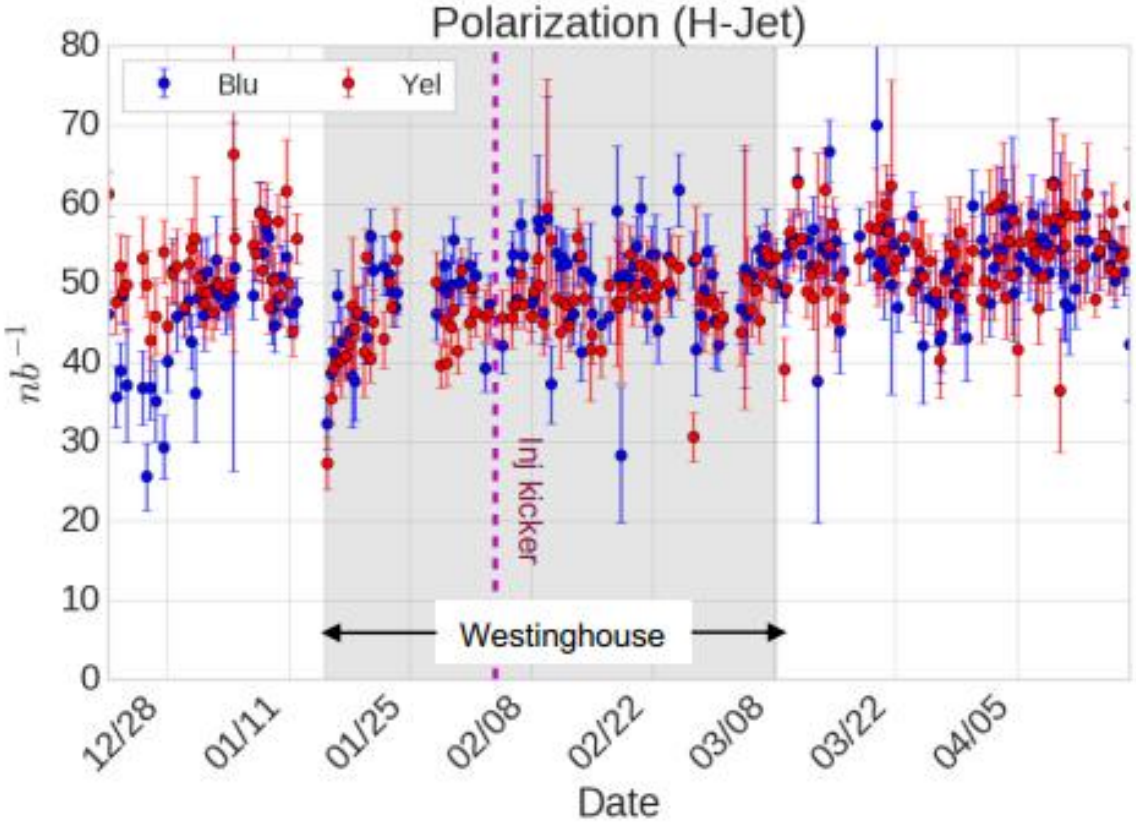
Avg Gain = PCA /Relaxed ~ 100

Peak Gain = PCA /Relaxed ~ 300

*For a more in-depth explanation of these results and measurement methods, see the CeC presentation documented on the RHIC retreat page (linked at the end of presentation in the "Useful Links" section.

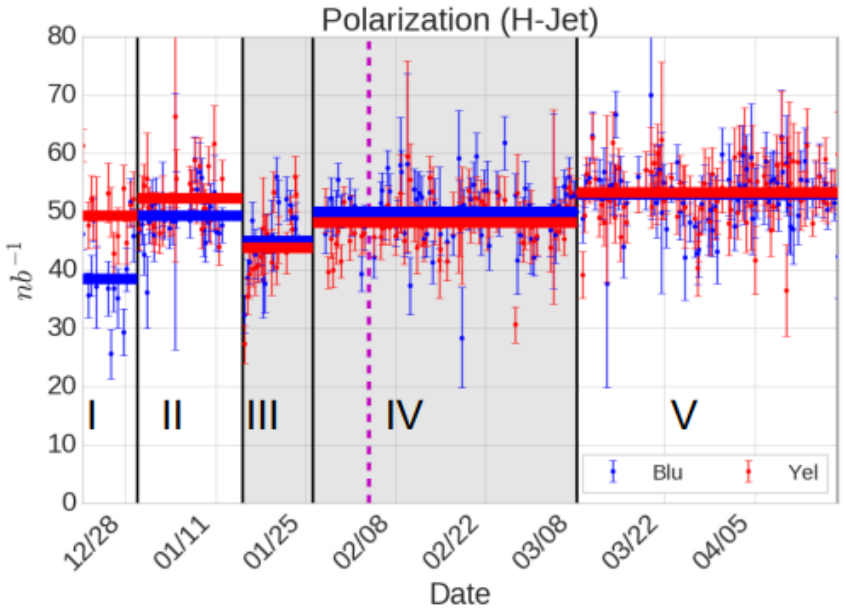
LUMINOSITY FOR POLARIZED PROTON PHYSICS





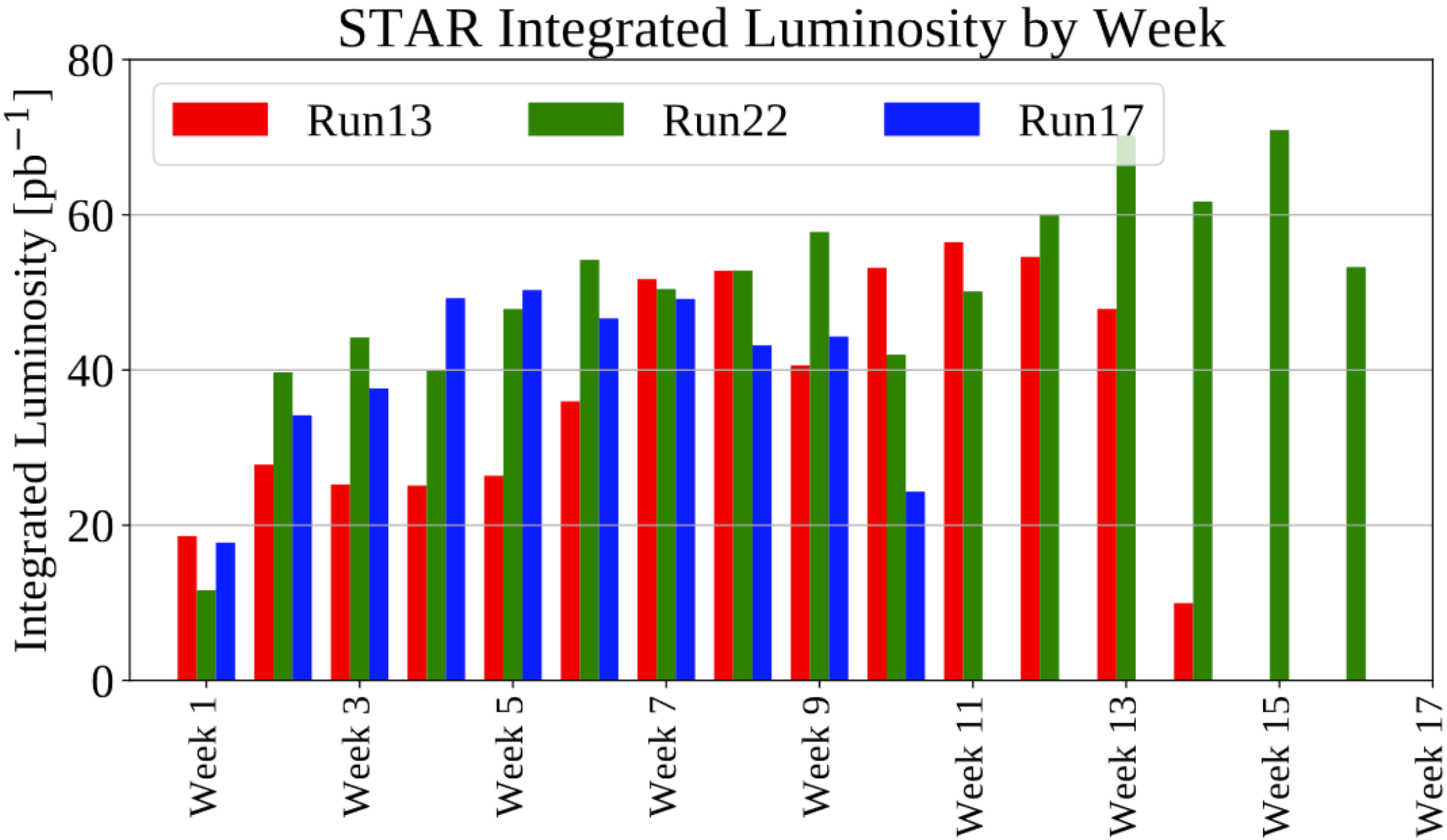
In plots;
GRAY indicates operation with Westinghouse
PINK dashed line indicates injection kicker correction

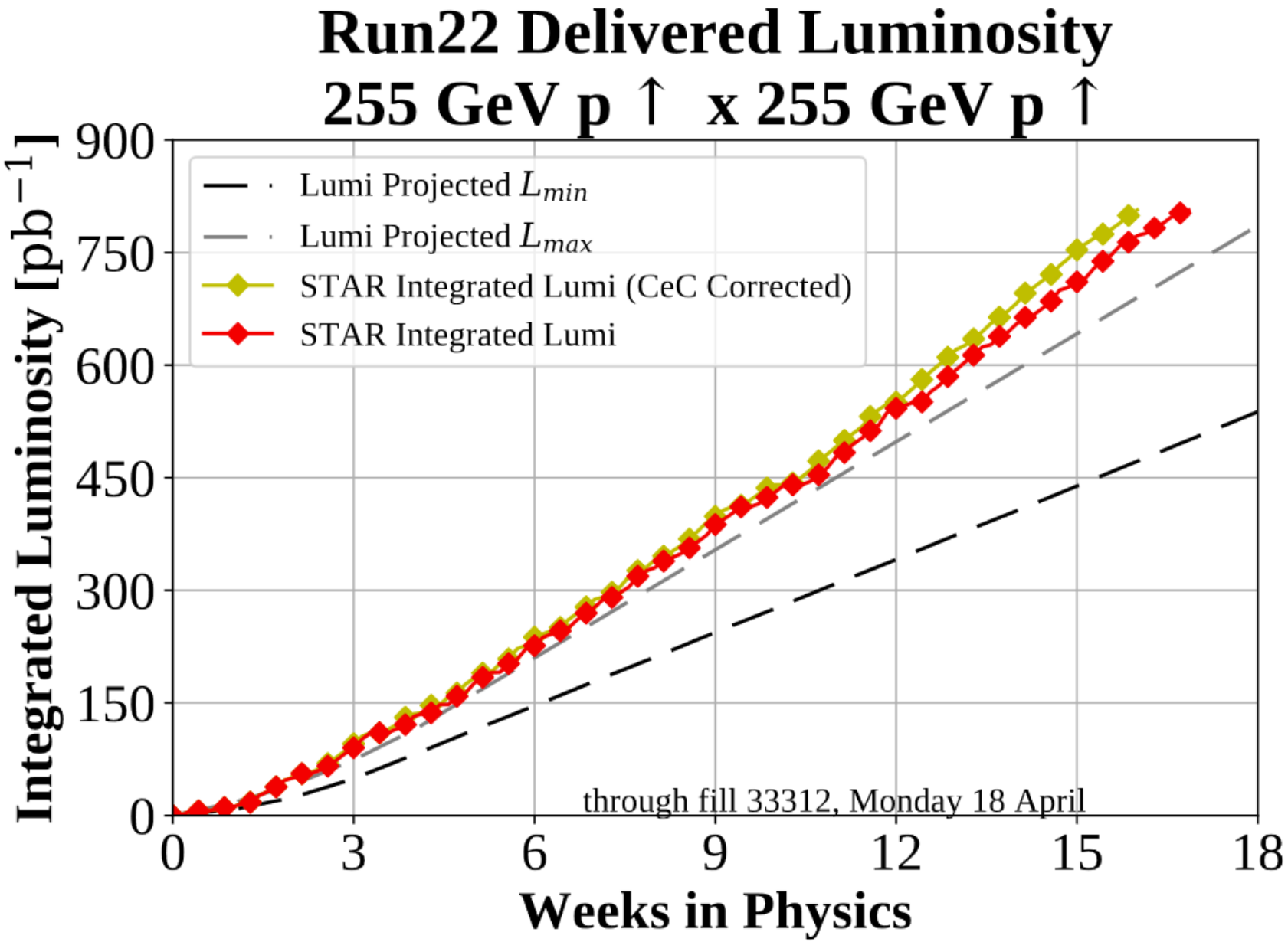
SIEMENS VS WESTINGHOUSE POLARIZATION

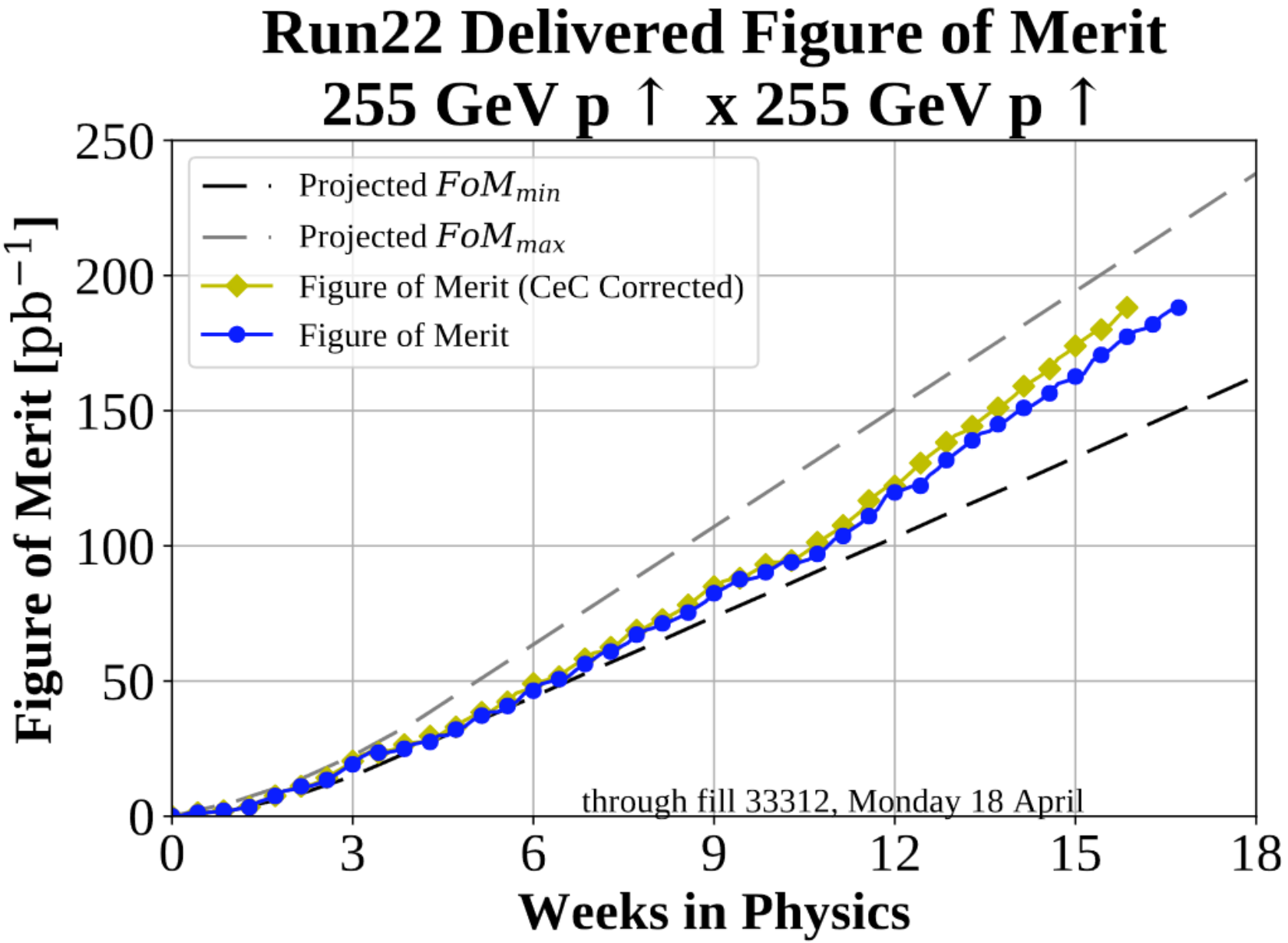


Polarization by period					
	Fill start	Fill end	Note	Blue	Yellow
I	32878	32920	Siemens, non-optimal BI9 snake	**38.5**	**49.4**
II	32921	32981	Siemens, optimal BI8 snake	**49.3**	**52.3**
III	32982	33020	Westinghouse setup	**45.0**	**43.9**
IV	33021	33167	Westinghouse nominal	**50.0**	**48.1**
V	33168	33312	Siemens nominal	**53.0**	**53.4**
Full Run				***50.0***	***50.5***

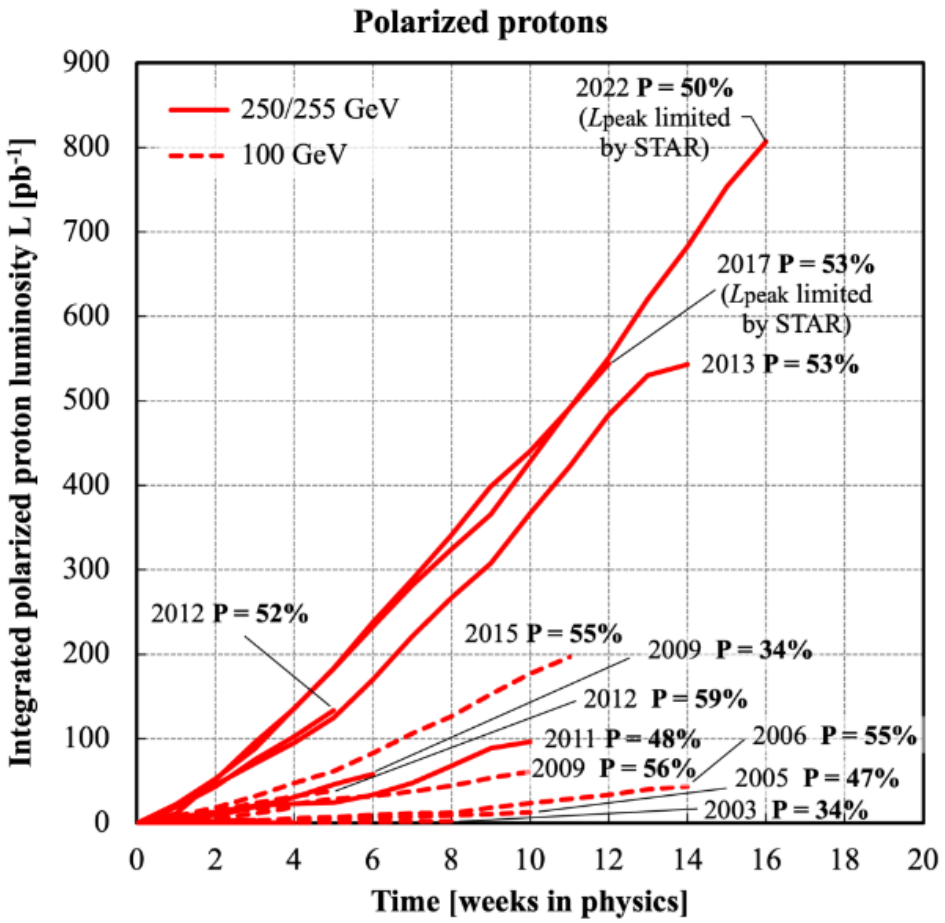
PINK dashed line indicates injection kicker correction


STAR Integrated Luminosity by Week
Integrated Luminosity [pb^{-1}]
Run13
Run22
Run17
0
20
40
60
80
Week 1
Week 3
Week 5
Week 7
Week 9
Week 11
Week 13
Week 15
Week 17


Run22 Delivered Luminosity
255 GeV p ↑ x 255 GeV p ↑
Integrated Luminosity [pb^{-1}]
900
750
600
450
300
150
0
Lumi Projected L_{min}
Lumi Projected L_{max}
STAR Integrated Lumi (CeC Corrected)
STAR Integrated Lumi
through fill 33312, Monday 18 April
0
3
6
9
12
15
18
Weeks in Physics

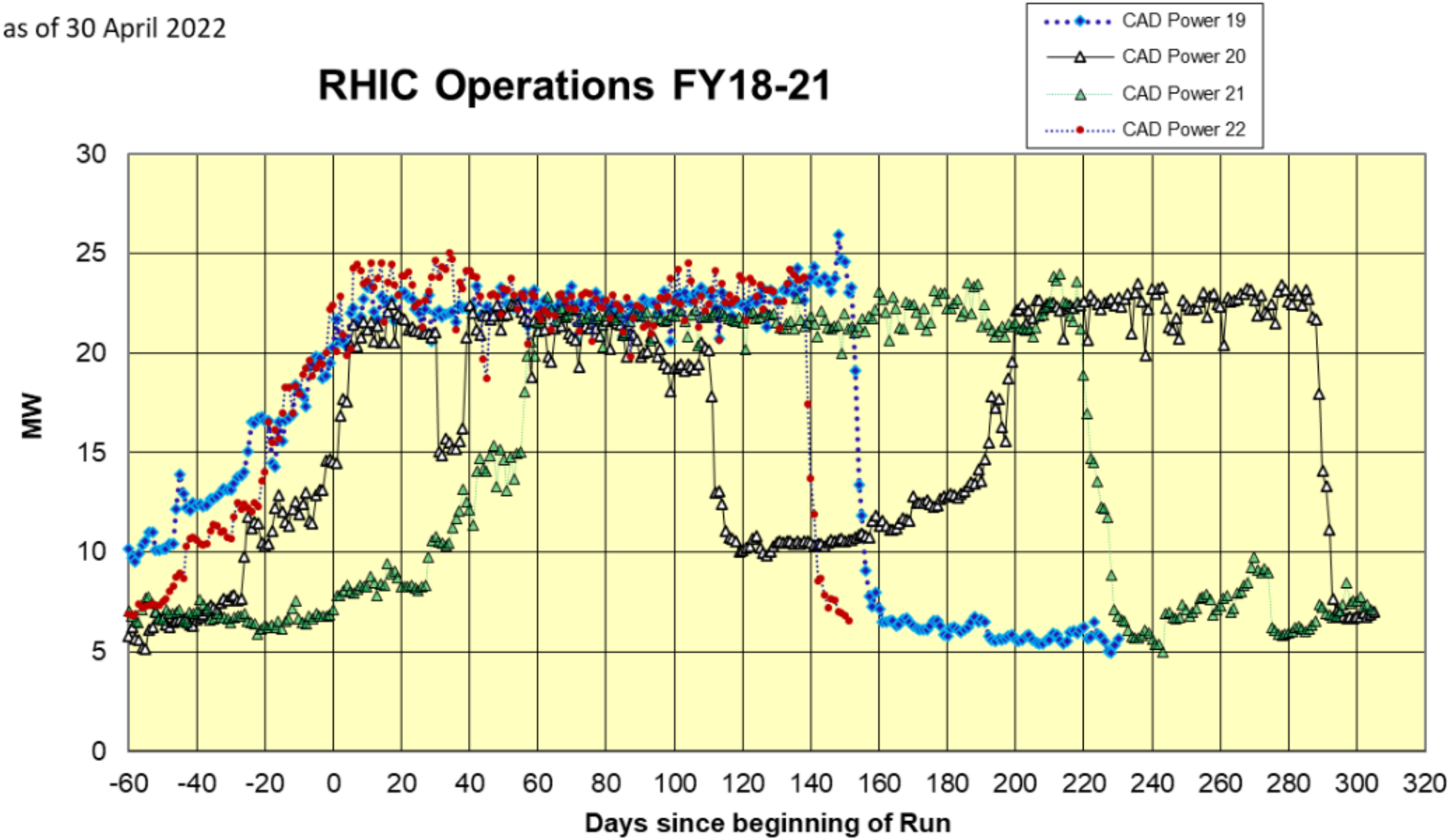

Run22 Delivered Figure of Merit
255 GeV p ↑ x 255 GeV p ↑
Projected FoM_{min}
Projected FoM_{max}
Figure of Merit (CeC Corrected)
Figure of Merit
through fill 33312, Monday 18 April
Figure of Merit [pb^{-1}]
Weeks in Physics
0
50
100
150
200
250
0
3
6
9
12
15
18

COMPARISON WITH OTHER POLARIZED PROTON RUNS

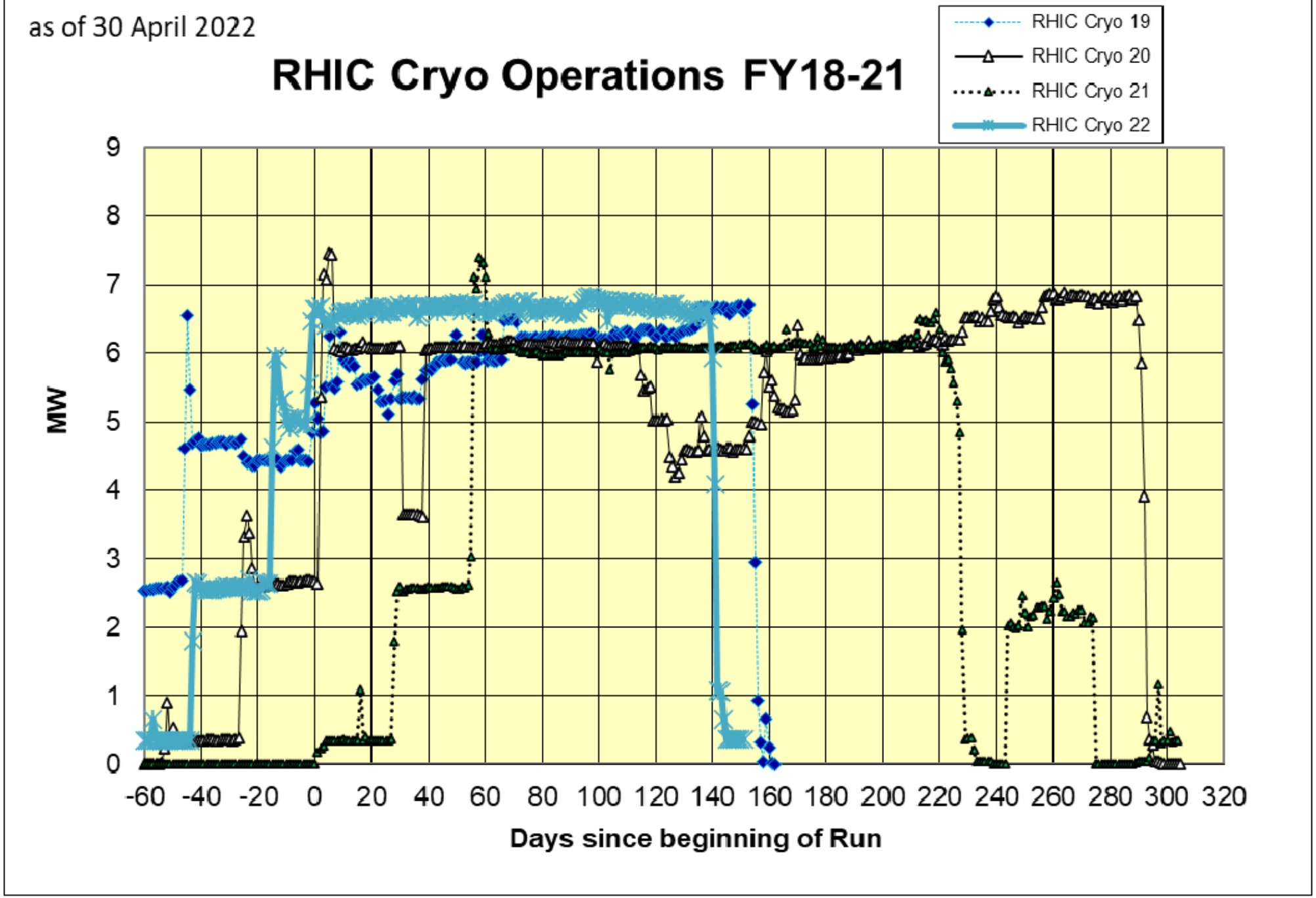


POWER AND CRYO USE

as of 30 April 2022

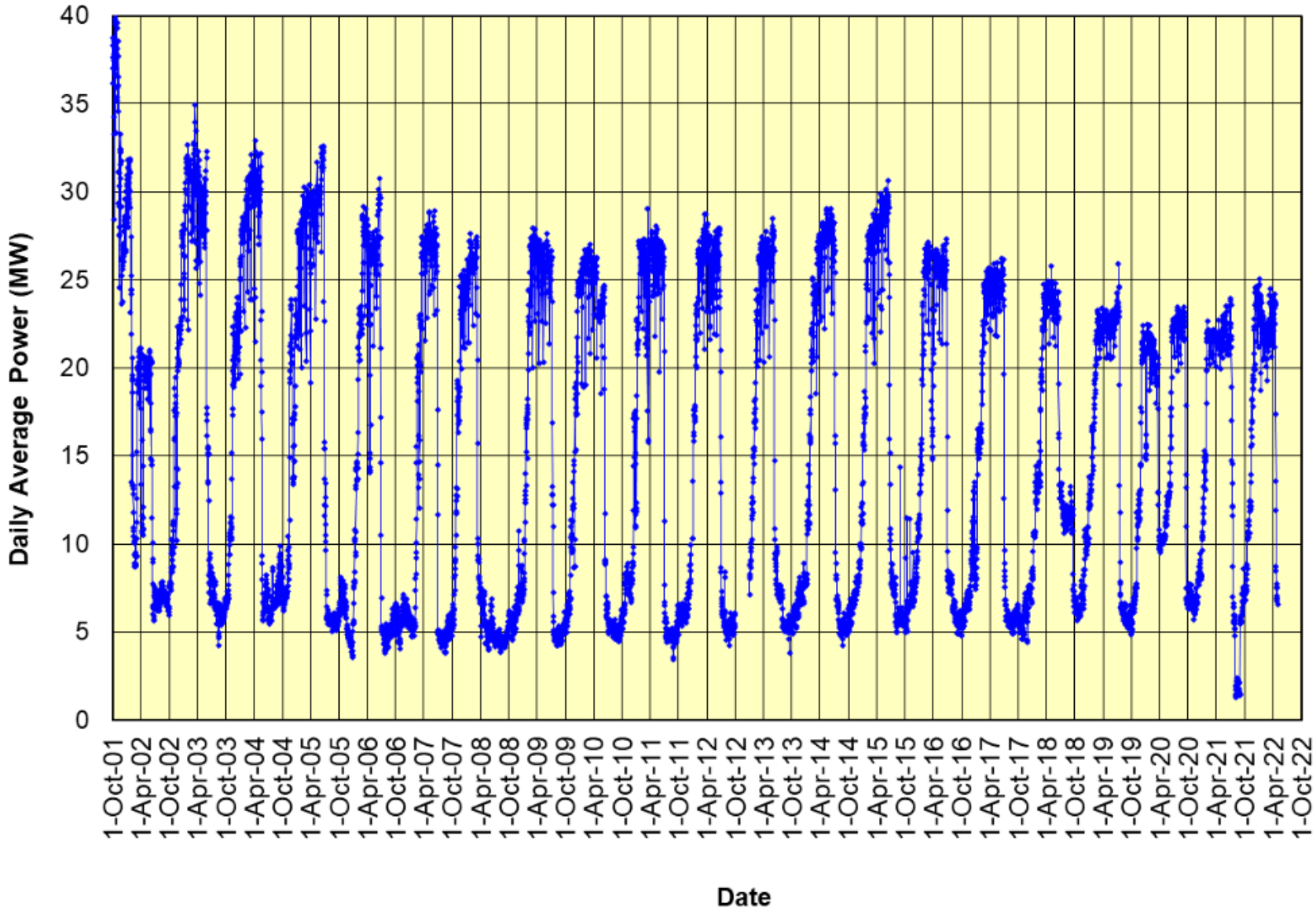


as of 30 April 2022



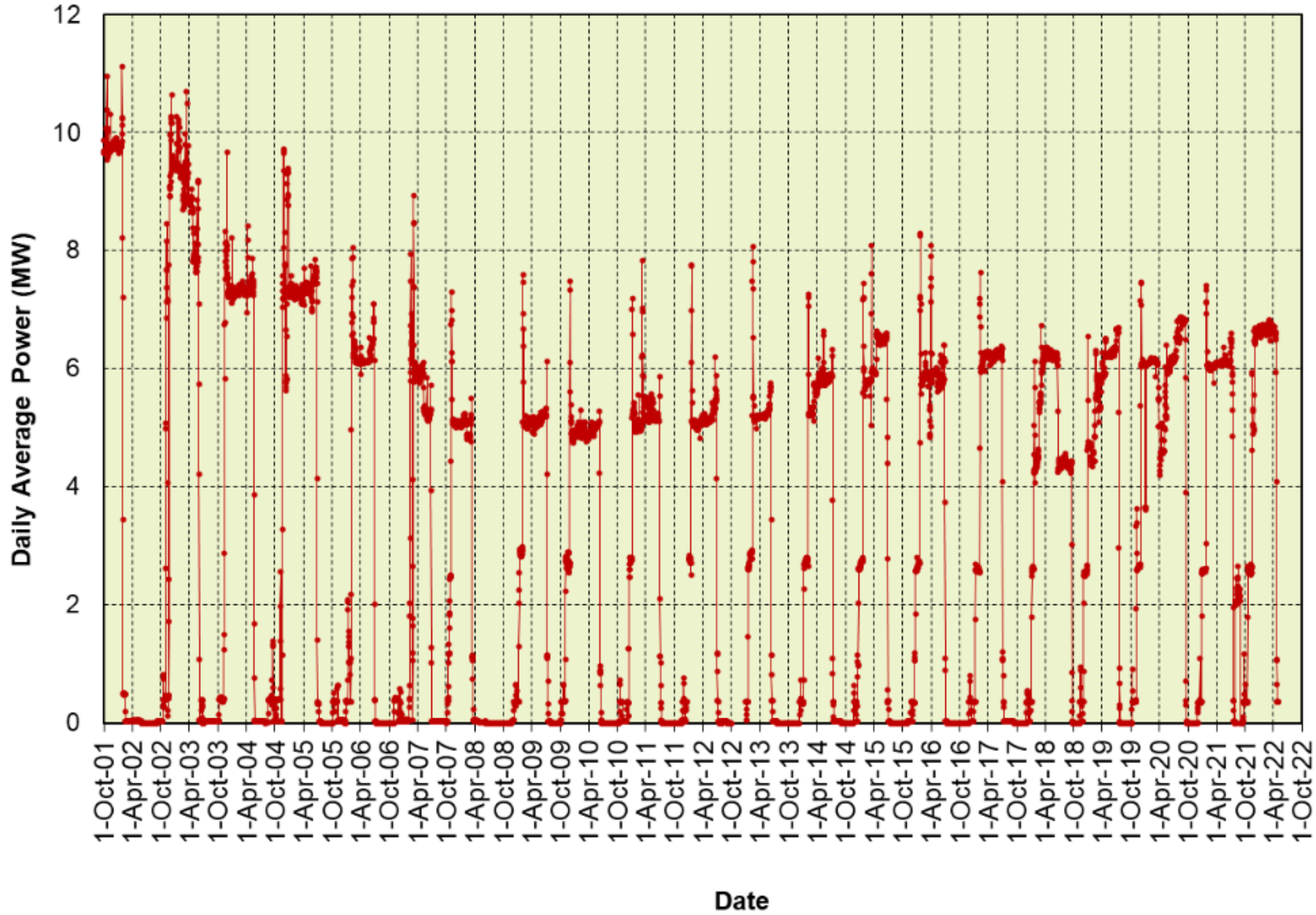
as of 30 April 2022

C-AD Energy Use FY 2002-21



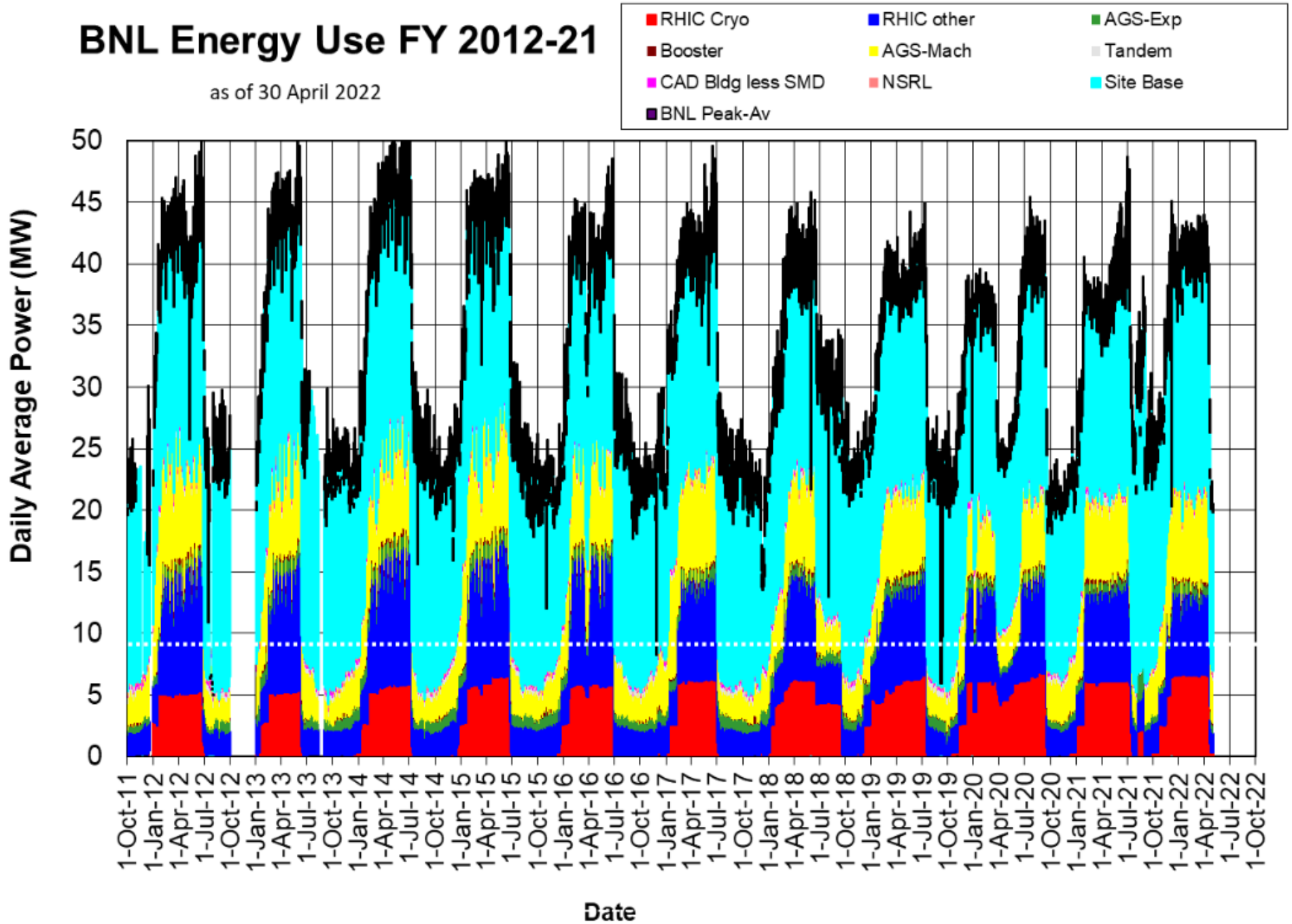
as of 30 April 2022

C-AD Cryo Energy Use FY 2002-21

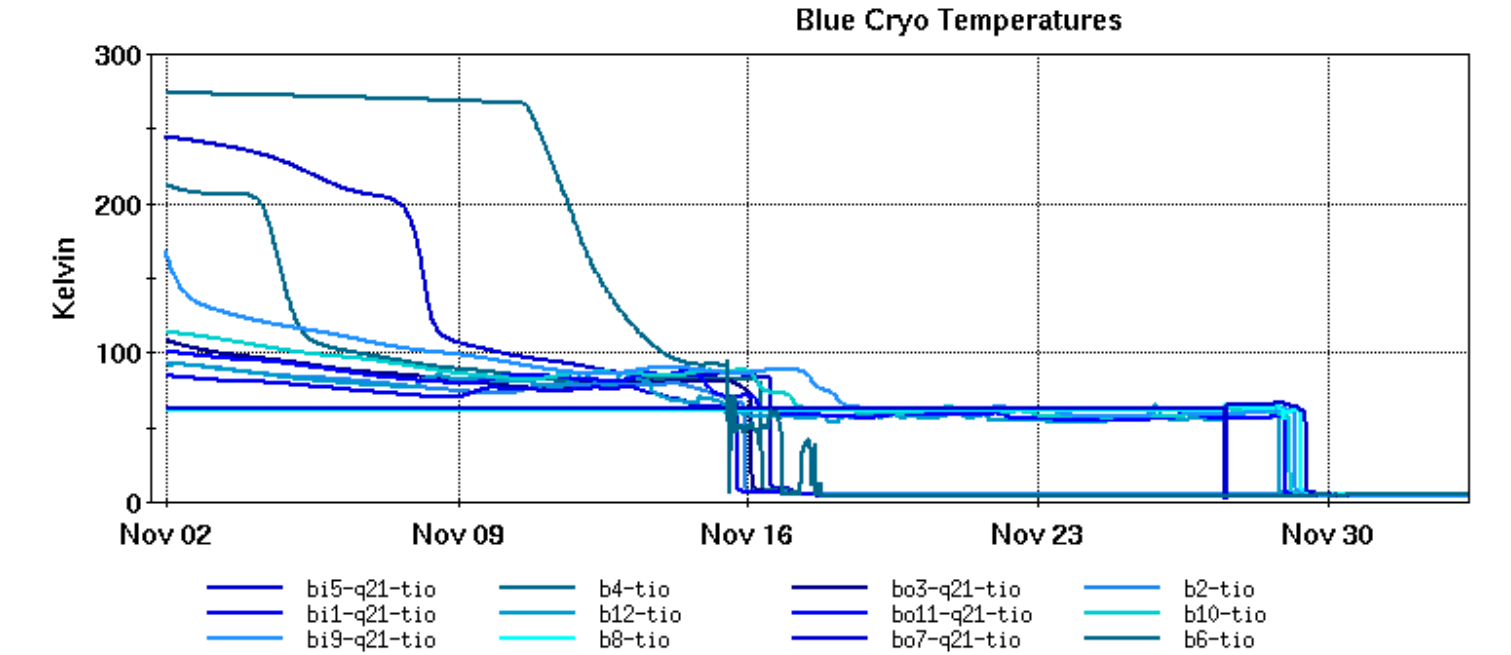


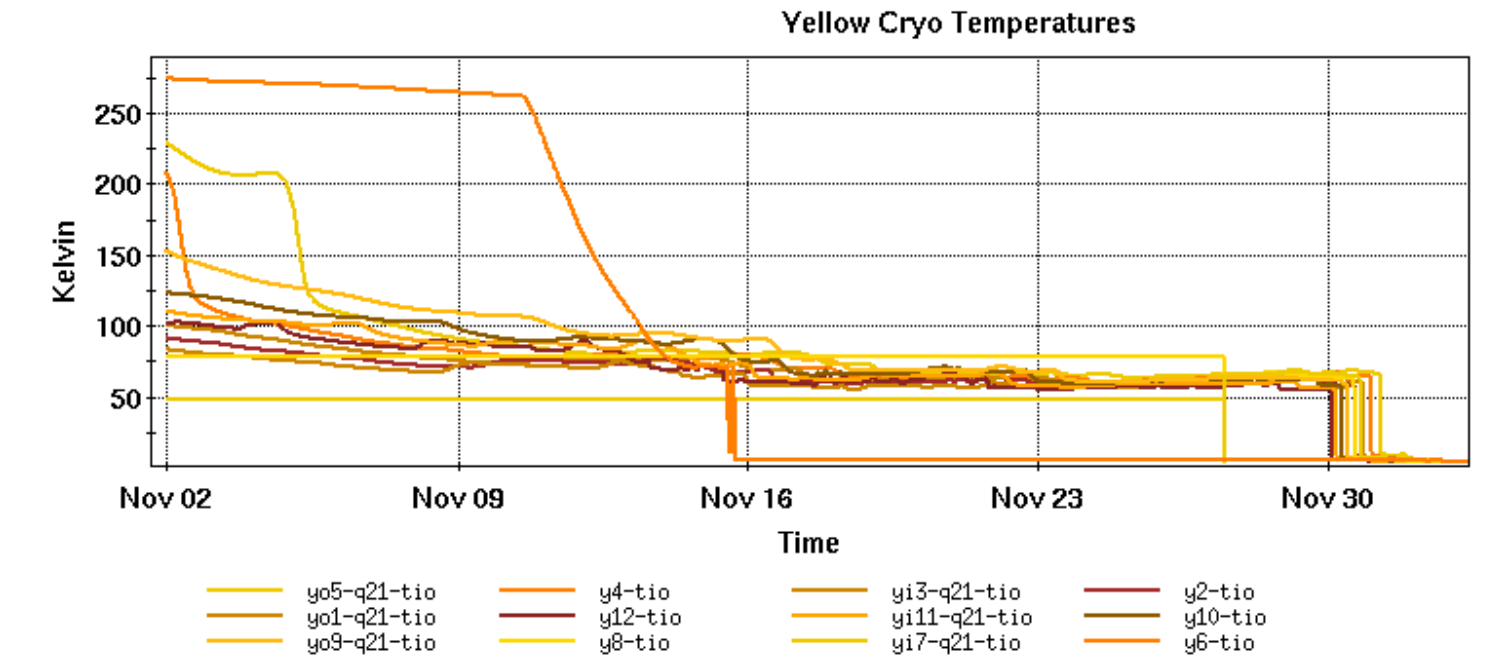
BNL Energy Use FY 2012-21

as of 30 April 2022

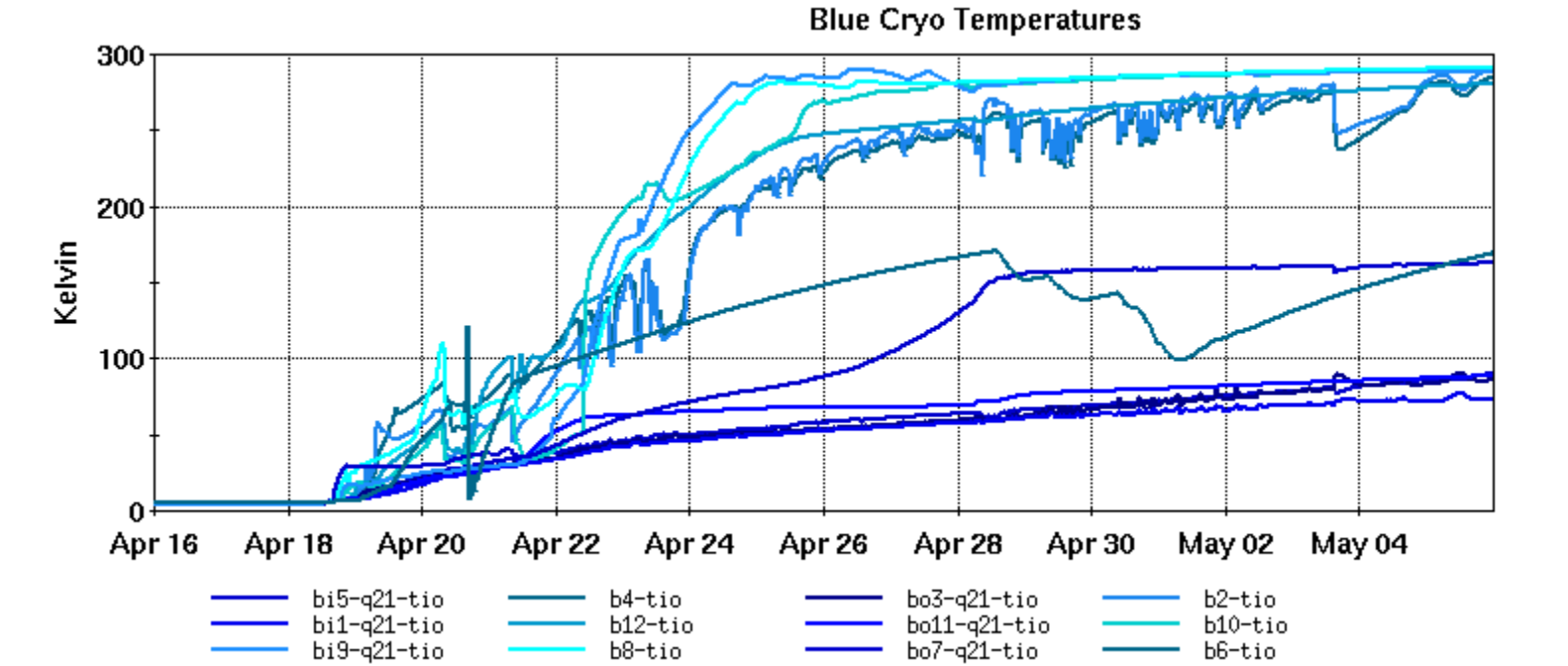


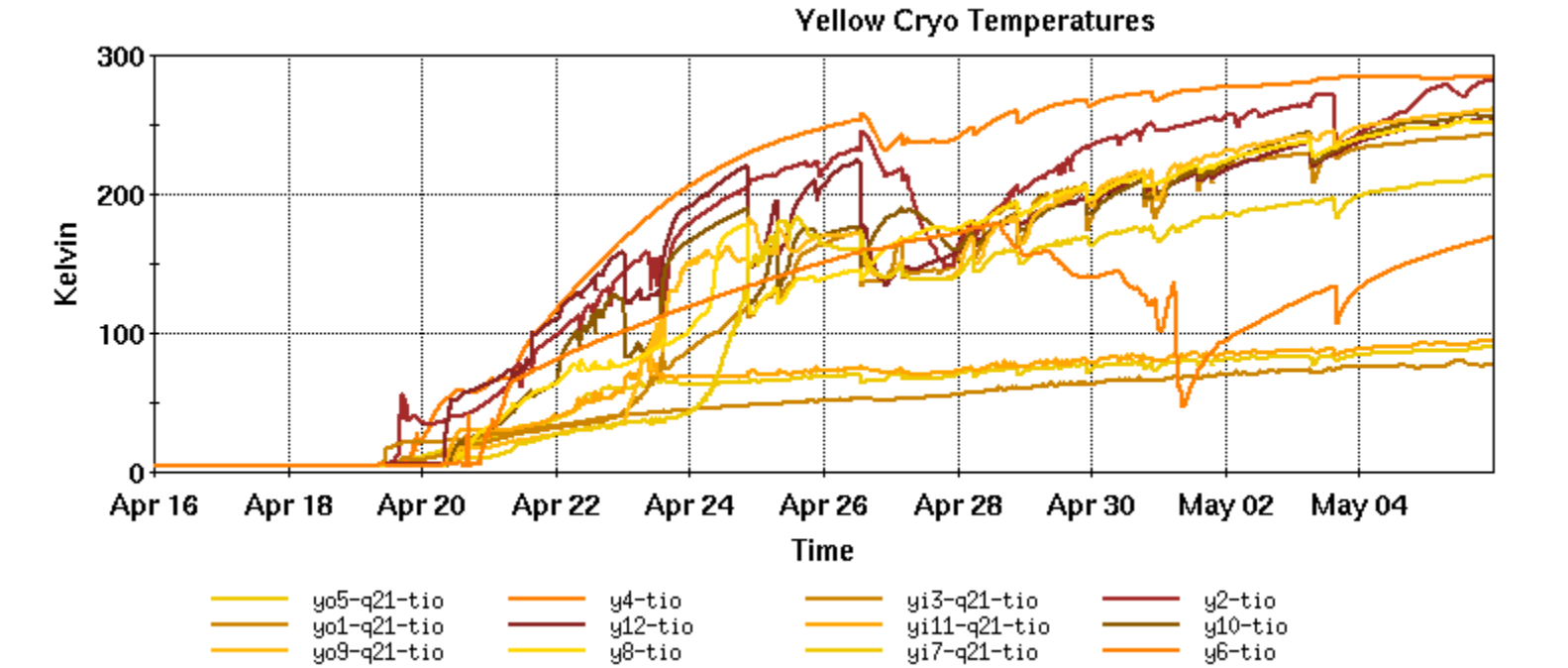
20 CRYO-WEEKS COOLDOWN





20 CRYO-WEEKS WARM UP





USEFUL LINKS

Machine/Detector Planning Page

http://server.c-ad.bnl.gov/esfd/RMEM_22/rhic_planning.htm

RHIC Run Overview (FY01-FY22)

https://www.rhichome.bnl.gov/RHIC/Runs/index.html#Run-22

RHIC Retreat Page (FY22)

https://indico.bnl.gov/event/15353/

Store Statistics

https://www.cadops.bnl.gov/AGS/Operations/Run22/

Scheduling Physicist

https://www.c-ad.bnl.gov/esfd/Scheduling_Physicist/FY22_Collider-Accelerator_Schedule.htm