C-AD through 2025 and beyond

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U.S. DEPARTMENT OF ENERGY

Preparations for Run-25/26

- sPHENIX and STAR BURs and operating scenarios
- other beam time requests

Beyond Run-25/26

- transitioning to the EIC
- mid-term R&D

Michiko Minty

2024 RHIC Retreat
15 November 2024

Preparations for Run-25/26

Major Shutdown Activities Prior to Run – 25/26

See P. Sampson
"Shutdown Activities"

Ion Sources

- EBIS work for RHIC Run-25 with high-intensity Au (see later slides)
- LION source installation

LINAC

- First full LINAC maintenance since 2019
- Refurbish Bldg. 930 backup chiller; air handlers (continuing)
- IRR/ARR preparations

AGS Booster

- Vacuum valve replacement and bake
- Gauge instrumentation replacements
- 911 chiller replacement (supplies Booster RF cavities)
- LLRF upgrades (continuing)
- IRR/ARR preparations

AGS

- IRR/ARR preparations
    - Lighting and legacy cable removals
    - Cable tray / trench remediation (continuing)

RHIC

- No major accelerator upgrades planned
- Address higher He leak rate identified in Run-24
- 56 MHz cavity (commissioning in Run-24)
- "Early removals" for EIC as schedule and staffing allow (less than planned, focus on E-Lenses)

Sitewide

- Possible tower 7 Motor Control Center and Switchgear upgrade
- Main Feeder MPO upgrades to continue
- High tension wire pole replacement
- Alternate feed upgrade
- Temple Place upgrades

Focus on EBIS preparation, IRRs and ARRs, and early removals for the EIC.

Reliability - operation during summer months

Experiment readiness led to accelerator operations during the summer (Run-23 and Run-24).

Concerns and mitigation plans detailed in 2022 RHIC Science & Technology Review:

Concerns	Heat	Many support buildings not equipped to operate with sustained high temperatures Many unique AC systems
	Humidity	Reduced cooling tower efficiency, increased load on AC equipment Condensation issues
	Power	More frequent power dips and/or outages (storm related), possible brown-outs
	Air Conditioning	Aging equipment, some obsolete controls and parts
Mitigation	Maintenance • ensure existing systems are operable at full capacity • verify existing AC spares inventory (9 portable units, 6 portable high-volume fans)	
	AC ductwork modifications	
	New procurements • spare AC systems for RHIC alcoves (5) • portable AC units for RHIC service buildings (6) for power supply quench detection racks	

RHIC Run-23: accelerator availability impacted by air conditioning (AC) availability in building containing RHIC main magnet power supplies.

RHIC Run-24: strengthened mitigation efforts (next slide), AC tech support, availability tracking efforts

RHIC Run-24 operations not held off by AC

RHIC Run-25: margin for error (for AC) will be smaller – need to improve on mean time to repair.

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2024 RHIC Run Air Conditioning Systems

See D. Chan
“Cooling Infrastructure and RHIC R&R”

Completed Repairs during RHIC Run

- 1000P - condenser Fan Replacement
- 1002A - Thermostat Failure
- 1006 - STAR Control Room – System Replaced
- 1008IR - Condenser Fan and Blade Replacement
- 1009A - Refrigerant Leak
- 1002D, 1002F, 1005E, 1007W, 1010A, 1010B - Bard Unit Failures
- sPHENIX – Chiller Coil Replacement, Electrical grounding of IR Split Unit and sPHENIX – Gas Mixing House AC Unit
- 1012 – 50 ton package unit failure, split AC unit
- 1004A – split AC unit
- 1006 – 200 ton chiller
- 1004B – control room and
  high bay AC units
- 1006 – rooftop chiller

Completed Replacements

- E18, A18, B18, 1002 Bard Units
- 1006 Control Room

Upcoming RHIC Maintenance Replacements

- 1007W, 1005E – Bard Units
- 1004A – 75 Ton Package Unit
- 1004B – 50 Ton Package Unit
- L18 – 12.5 Ton Package Unit
- ~ 15 alcove split AC units

RHIC Run 25/26 Preparation

- Check existing spare parts inventory to replenish those used in Run-24
- Procure contract to ensure availability of larger capacity AC systems with portable generators (May – Oct 2025)

1004A Rental AC Unit

1004A Portable AC Unit

1008 AH Portable AC Unit

1004B Replacement AC

1004B 2nd Unit

1012A Rental AC Unit

911 Rental Chiller

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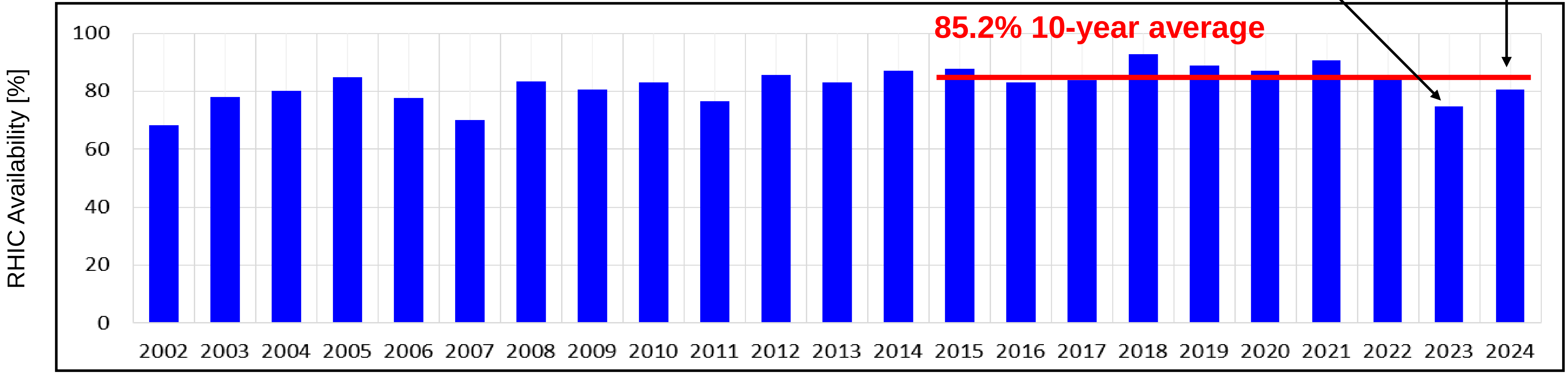
C. Naylor

RHIC Availability

Au+Au
100 GeV
74.4% FY23

p↑+p↑, Au+Au
100 GeV
80.4% FY24



Availability = beam time / scheduled beam time
Availability goals: 82.5% (< FY20) , 85% (FY21-FY22), 82.5% (FY23), 80.0% (FY24)

RHIC Run FY24: **80.4%**
Average over last 10 years: **85.2%**

Availability primarily impacted by environmental factors (heat, humidity, storm-related issues) in Run 2023 and by summer storm-related issues in Run 2024.

Availability goal met in FY24.

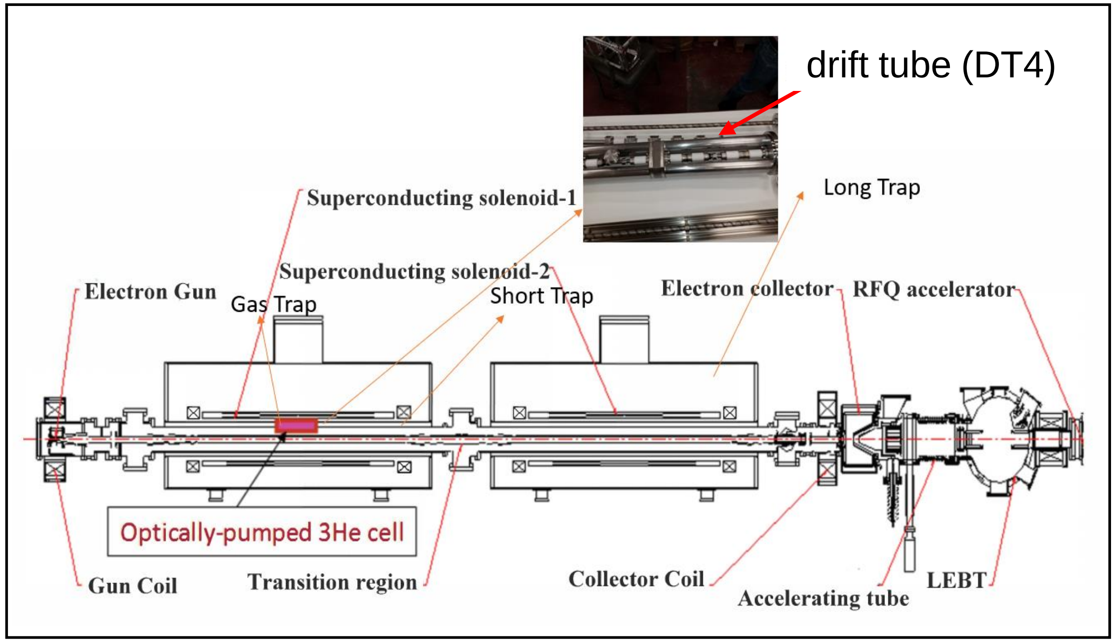
Extended EBIS

See E. Beebe "EBIS Status"

Goals: improvements over EBIS
- ~ 40% more ion intensity
- 2 mA polarized $^{3}He^{++}$
- better performance with noble gases (gas cell)
- provision of ions from H to U

Status:
- operating for NSRL (since Apr 2023)
- demonstrated all ion species (Jun 2023)
- outstanding issues for high rep-rate operation:
  - low cathode lifetime (new manufacturer)
  - voltage breakdown in (smaller diameter) drift tubes (DT4 and DT6)

Parameter	Required for run25	Achieved
Electron current	> 8 A	6.7 A
# Au ion single Pulse @ Xf108	1.2 E9	1. E9
# Au ions 12 Pulse mod @ Xf 108	1.2 E9	8.E8 (stable for 10-20 min only)



Next steps: cathode replacement (Nov 2024), increase DT4 and DT6 diameter (if needed)
Plan B: provision of Au beams from Tandem (as in RHIC Run-23).

56 MHz cavity – effect on bunch distribution

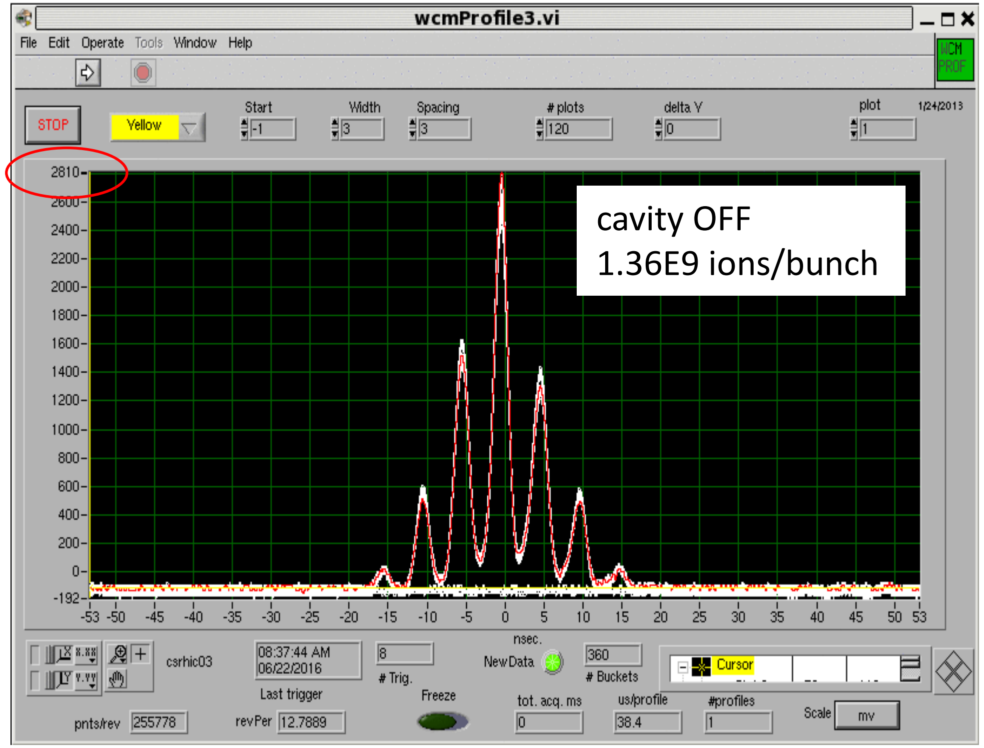
M. Blaskiewicz, K. Smith, K. Mernick, S. Polizzo, F. Severino, Q. Wu, A. Zaltsman

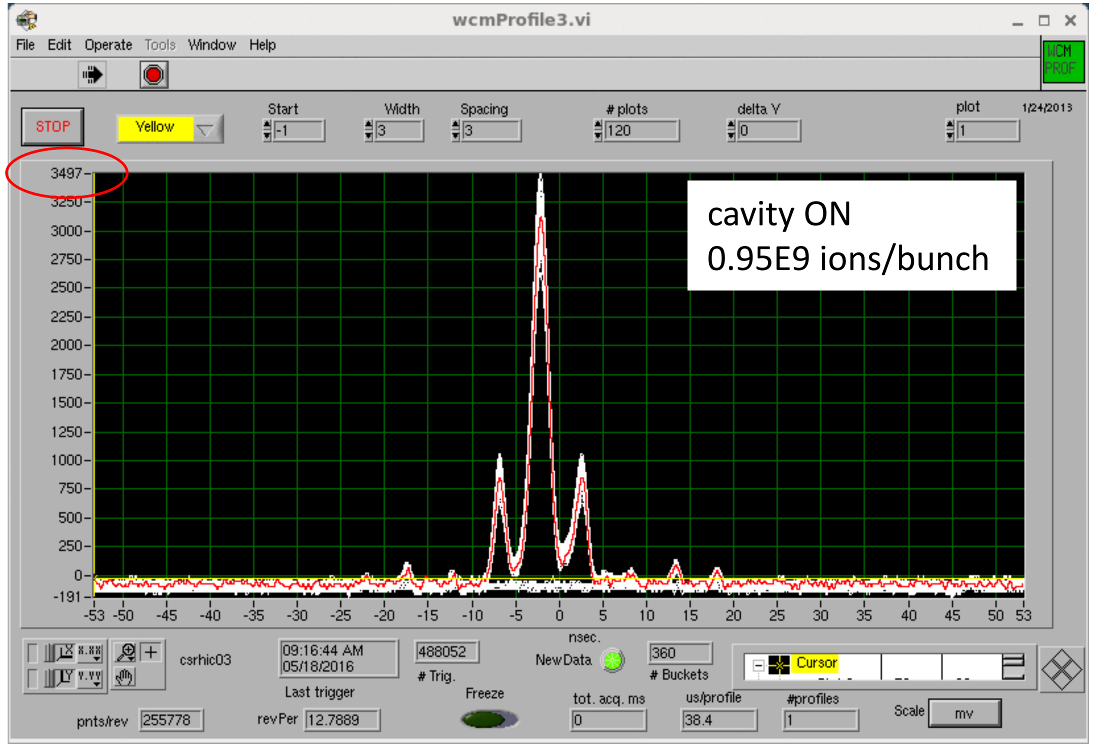
See K. Mernick 56 MHz Commissioning”

Increases luminosity in the detector’s vertex

- increases peak current in primary bunch and reduces current in satellite bunches
- also enables smaller β* at the interaction point due to reduced hourglass effect

Demonstrated improvement in longitudinal focusing during run in 2016 (d-Au) Yellow ring (Au) wall current monitor





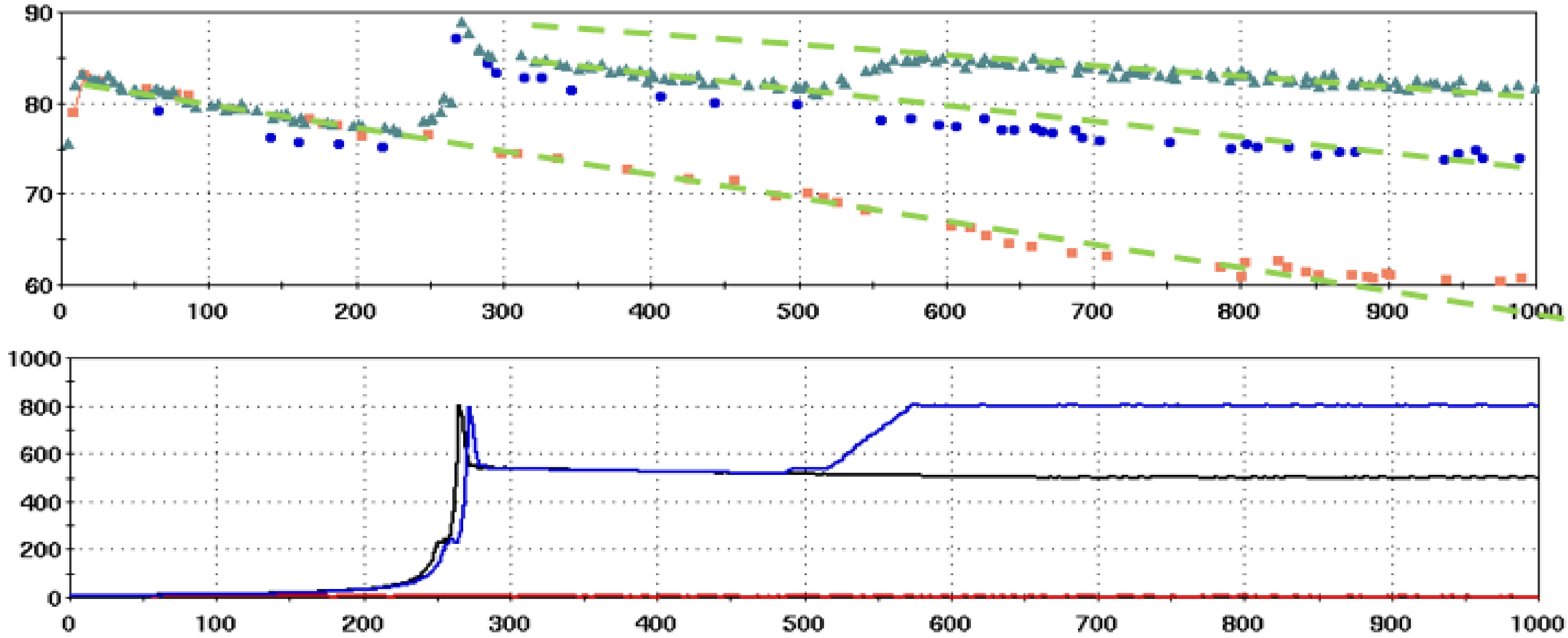
Peak current with 56 MHz SC cavity substantially higher even with lower bunch intensity

56 MHz cavity – effect on luminosity

Qiong Wu et al

Substantial (>15%) increase in luminosity in PHENIX (+/- 10 cm) vertex with the 56 MHz cavity

Run-16 with 56 MHz SC RF cavity OFF and ON
Blue: 1.95 E9 deuterons / bunch, Yellow: 2.09E9 Au ions/bunch



PHENIX 10cm / ZDC

56 MHz Cavity Voltage (kV)

Time (seconds after lumi-event)

56 MHz cavity recommissioned during Run-24 up to 1.5E9 Au ions/bunch (next year aim for 1.8E9)

sPHENIX and STAR BURs (Run 25/26) and operating scenarios

Beam User Requests (BURs)

sPHENIX

see J.Haggerty "sPHENIX Summary and Run 25 Plan"

sPHENIX Physics Target in Run-25: **7 nb^{-1} (50B events)**		
Collision Species	Cryoweeks	Projected luminosity, $\|z\| < 10$ cm
Au+Au 200 GeV	20	2.4 – 4.2 nb^{-1} recorded
Au+Au 200 GeV	28	3.6 – 6.4 nb^{-1} recorded

If Au+Au luminosity target is met, ordered priority list for additional running:		
Collision Species	Physics weeks	Projected luminosity, $\|z\| < 10$ cm
1. p+p 200 GeV	8	13 pb^{-1} sampled + 3.9 pb^{-1} streaming
2. p+Au 200 GeV	5	80 nb^{-1} sampled + 24 nb^{-1} streaming
3. O+O 200 GeV	2	13 nb^{-1} sampled + 3.9 nb^{-1} streaming

STAR

see J.H. Lee "STAR Summary and Run 25 Plan"

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

Start with Au+Au with 100 GeV beams.

Note: NPP PAC met 7–8 Nov, 2024 and suggests the PAC reconvene a few weeks after RHIC Run-25/26 start before making further recommendation on priorities.

Run 25/26 with 20/28 weeks Au+Au at 100 GeV/n

W. Fischer et al

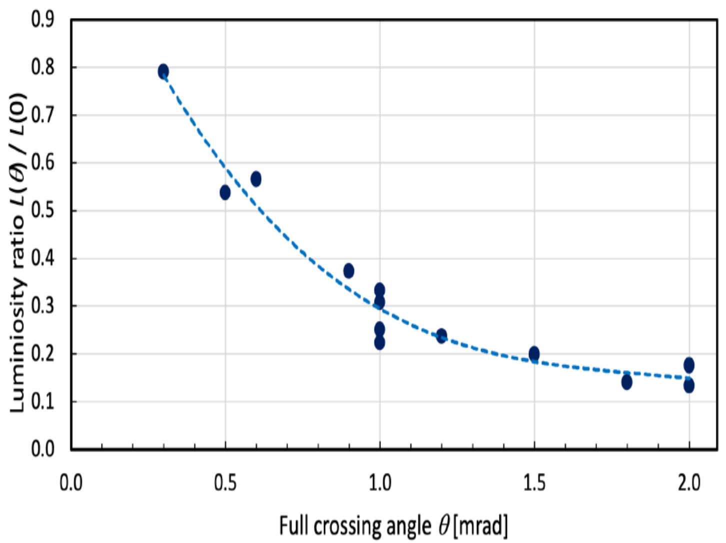
Note: 2 cryo-weeks were already spent to extend Run-24

RHIC Run start	0.5 weeks	Final cooldown to 4K
Set-up mode	2.0 weeks	RHIC re-commissioning and MVTX background studies
Ramp-up mode	0.5 weeks	8 hours/day for experiments
Data taking for physics	14.5 / 22.5 weeks	24/7 operation for sPHENIX and STAR
Controlled turn-off	0.5 weeks	End of run after 18 / 26 weeks

Table 1: Demonstrated and projected luminosities for 100 GeV/nucleon Au+Au runs.

Parameter	Unit	FY2007	2010	2011	2014	2016	2023	2025E
No of bunches k_b	…	103	111	111	111	111	111	111
Ions/bunch, initial N_b	10^9	1.1	1.1	1.3	1.6	2.0	1.65	1.75
Envelope function at IP β^*	m	0.85	0.75	0.75	0.70	0.70	0.70	0.70
Beam-beam parameter ξ/IP	10^{-3}	-1.7	-1.5	-2.1	-2.5	-3.9	-3.2	-3.4
Initial luminosity L_{init}	10^{26} cm^{-2}s^{-1}	**30**	**40**	**50**	**80**	**155**	**101**	**115**
Average/initial luminosity	%	40	50	60	62	56	56	60
Average store luminosity L_{avg}	10^{26} cm^{-2}s^{-1}	**12**	**20**	**30**	**50**	**87**	**44**	**68**
Time in store	%	48	53	59	68	65	44	50
Max. luminosity/week ($\theta = 0$)	μb^{-1}	380	650	1000	2200	3000	1300	2300
Min. luminosity/week ($\theta = 0$)	μb^{-1}							1300

Measured lumi ratio with crossing angle



Planning basis: 22 week shutdown with 4K cooldown starting 24 Mar 2025
Note: NPP PAC recommended considering a shorter shutdown, further coordination with experiments needed.

Other possible operating scenarios: p+p, p+Au

W. Fischer et al

Table 2: Demonstrated and projected luminosities and polarization for p↑+p↑ and p↑+Au runs at 100 GeV.

		p↑+p↑						p↑+Au	
Parameter	Unit	FY2008	2009	2012	2015	2024	2025E	FY2015	2025E
No of colliding bunches k_b	…	109	109	109	111	111	111	111	111
Protons/bunch, initial N_b	10^{11}	1.5	1.3	1.6	2.25	1.95	1.95	2.25/0.0016	1.7/0.0016
Envelope function at IP β^*	m	1.00	0.70	0.85	0.85	0.85	0.85	0.85/0.70	0.85/0.70
Beam-beam parameter ξ/IP	10^{-3}	-5.3	-6.3	-5.8	-9.7	-8.4	-8.4	-5.3/-4.1	-5.3/-3.1
Initial luminosity L_{init}	10^{30} cm^{-2}s^{-1}	**35**	**50**	**46**	**115**	**74**	**74**	**0.88**	**0.66**
Average/initial luminosity	%	65	56	71	55	58	58	51	51
Average store luminosity L_{avg}	10^{30} cm^{-2}s^{-1}	**23**	**28**	**33**	**63**	**43**	**43**	**0.45**	**0.34**
Time in store	%	60	53	59	64	~60	60	65	50
Max. luminosity L/week	pb^{-1}	7.5	8.3	9.3	25	17	17	0.140	0.115
AGS extraction, P_{max}	%	55	65	72	68	~65	65	68	65
RHIC store average, P_{max}	%	**45**	**56**	**59**	**57**	**54**	**54**	**60**	**54**

Projections based on past demonstrated experience.
Projections for 100 GeV O+O to be based on Run-21 experience
(in 14 days, 32 nb^{-1} delivered luminosity with head-on collisions)

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sPHENIX MVTX auto-recovery rates with Au+Au

see K. Hock
“sPHENIX Backgrounds”

Working hypothesis: off-momentum Au ions lost on aperture and fragments reach sPHENIX MVTX

Note: stray particles difficult to detect (MVTX auto-recovery rate upsets not correlated with signals in any RHIC beam loss monitors)

C-AD Task Force established (led by A. Drees) with accelerator and detector physicists

Simulations underway or planned to simulate several approaches:

- particle tracking under various scenarios
- particle tracking with relocated mask serving as momentum collimator
- addition of absorber material close to MVTX (FLUKA simulations)

Realignment of sPHENIX beam pipe not under consideration at this time.

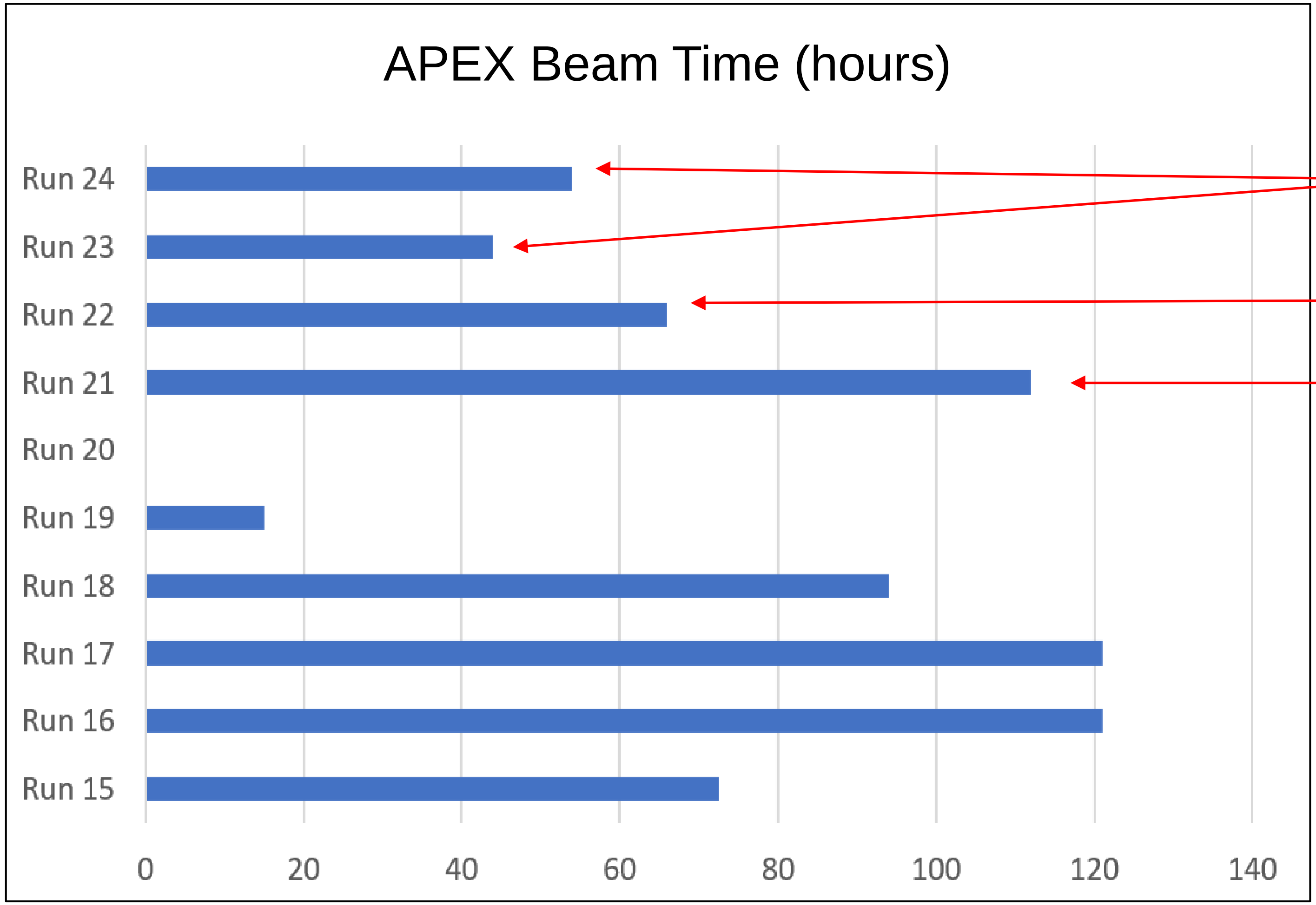
Other Beam Time Requests

Beam Time Requests (not including BURs)

Proposed Activity	Duration	Relevance / Comment
APEX for EIC	up to 2 weeks	needed to inform EIC design
p+Au	5 weeks minimum	high priority per past PACs, cancelled in 2024 due to funding constraints
FXT at STAR	3 weeks	3 energies, 3 species, 3 targets (reference STAR BUR)
CeC	2-3 weeks	advancements in accelerator science

Accelerator Physics Experiments (APEX) - Overview

see Y. Luo "APEX Summary and Plans"



experiments to inform EIC design

experiments to inform EIC design and beam cooling studies

focus: beam cooling studies

(minimal APEX during BES-II and pandemic)

APEX workshop held March 2024 https://indico.bnl.gov/event/22322/. Featured:

- comprehensive list of EIC-related APEX requests for 2024/2025 (next slide)
- detailed plans for experiments

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APEX 2024/2025 Objectives

F. Willeke, BNL – EIC
APEX workshop (Mar 2024)

Topic	#Studies	requested Hours	Relevance for EIC
Collective Effects	2	14	confirm vacuum design
Flat Beam	3	84	Feasibility flat beam
Instrumentation	3	14	Confirm concepts & designs
Dynamic Aperture	2	6	Confirm simulations
Transition Crossing	3	24	Ensure concept
Hadron Polarization	4	46	Confirm simulation and design
Beam* Cooling	9	133	Confirm cooling feasibility, simulation and design
Beam Optics	2	18	Backup simulations
Radial Shift	1	32	Confirm feasibility of large beam radial offset in HSR

*coherent electron cooling, electron cooling, and stochastic cooling

Total of 29 studies, 371 hours @ 46.4 shifts, 15.5 days, 2.2 cryo weeks

APEX 2024/2025

Y. Luo, H. Huang

Run-24 APEX requests: 123 hours (p), 56 hours (Au)
Run-24 APEX experiments performed : 87 hours (p), 0 hours (Au)

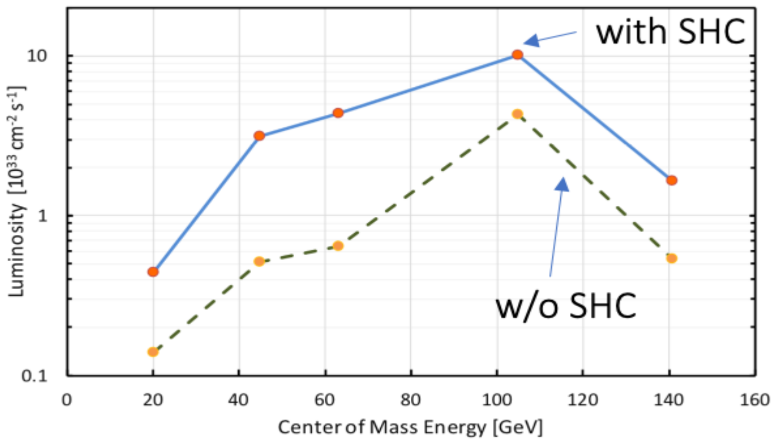
Assumptions Run-25/26 (standard practice reminder)

- no APEX before physics program started (assume 2 weeks for this in Run 25/26)
- one APEX session = 15 hours APEX +1 hour back-to-physics
- APEX takes place every other week
- all experiments reviewed and prioritized by APEX acceptance committee

Personal perspective: advance planning more critical than ever, planning process greatly improved this year (e.g. year-long schedule published in advance)

CeC: Proposal for dedicated time for CeC demonstration after completion of RHIC physics Run 25

V. Litvinenko



NAS Assessment of U.S.-Based EIC Science: *The accelerator challenges are two fold: a high degree of polarization for both beams, and high luminosity.*

- ✓ Demonstration of CeC would provide confidence that EIC cooler could do the job
- ✓ CeC system is fully operational
  - ✓ Necessary beam parameters were demonstrated
  - ✓ High gain Plasma-Cascade Amplification was experimentally demonstrated
  - ✓ Ion imprint in electron beam was experimentally observed
- ✓ Remaining challenge – demonstrate stability

- ✓ Coherent electron Cooling remains the leading candidate for EIC to achieve design average luminosity of 10^{34} cm^{-2}sec^{-1}
- ✓ We propose to have a dedicated 3-weeks RHIC run to ensure experimental demonstration of Coherent electron Cooling technique

- ✓ Two-step program towards successful demonstration of CeC
  - ✓ During RHIC physics run we will bring all CeC systems to full readiness
  - ✓ 3 weeks of RHIC operation with Au ion in Yellow at CeC operational energy to complete following tasks:

1. Develop RHIC ramp to the CeC operations energy – 2 days
2. Adjust CeC systems to new stray fields and restore the e-beam quality – 2 days
3. Propagate e-beam in the CeC section, and align ion and electron beams – 3 days
4. Match relativistic factors of ion and electron beams – 1 day
5. Restore High-Gain Plasma-Cascade amplification with CW e-beam – 3 days
6. Fine system tuning and demonstration of Coherent electron Cooling – 10 days

Important: Previous experience proved that any switching from regular RHIC physics operation to dedicated CeC shift or APEX session resulted in significant loss of time. This is the main reason why we suggest to separate CeC dedicated RHIC operation from RHIC physics run. Still, it is possible to move one week of dedicate (for example as part of APEX) during the physics run and reduce post-physics CeC tun to two weeks.

CeC: Proposed modes of operation

V. Litvinenko

- To maximize chances for success, we will develop two modes of operation during RHIC physics run, below and above RHIC transition energy.
- Lower energy of operation would provide for better quality of ion beam and easier choice of electron beam parameters, but this will new mode to develop
- **Best mode will be selected for the demonstration**

Parameter	Mode 1	Mode 2
γ, relativistic factors of the beams	19.57	28.5
Au ion beam energy, GeV/u	18.2	26.5
Electron beam energy, MeV	10	14.56
Peak current, A (core, 50% of the beam)	≥ 22	≥ 45
Normalized emittance (core, > 50% of the beam), μm rad	≤ 1.5	≤ 1.5
RMS relative energy spread (core, > 50% of the beam), 10^{-4}	≤ 2	≤ 2
Energy flat top (core, > 50% of the beam), $\lvert 10^4\, \delta\gamma/\gamma \rvert$	< 1.5	<1.5

Beyond Run-25/26

Goals for C-AD support of the Hadron Injector Complex

- Maintain accelerators and infrastructure for start of EIC operation; provide hadron beams when needed by the EIC
  - continue the 25-year upgrade plan
  - validate all systems with beam annually
- Continue accelerator operations in support of application programs
  - Tandem self-supported (stand-alone non-designated user facility); backup pre-injector
  - BLIP (funded by DOE Isotope Program) – supports EBIS and LINAC operation
  - NSRL – supports source and AGS Booster operation
- AGS - plan for ~1 month/year development of polarized beams (protons, He3) for the EIC
- Complete Accelerator Readiness Reviews
- Ensure well-trained staff supporting the injector complex

Removal and Refurbishment (R&R) for the EIC

See D. Chan “Cooling Infrastructure and RHIC R&R”

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25-Year Upgrade Plan for the Injector Complex

R. Michnoff, et al

Excerpt of planning document – with input from C-AD group leaders

3	Priority	Machine/Program	Group	Info provided by:	Project Name	Description
5	1	RHIC	RHIC PS	Don Bruno	RHIC Quench Detector Upgrade	RHIC Quench Detector Upgrade
6			RF	Zaltsman, Severino	PLC upgrade	Replace outdated PLC5 system
7			Instrumentation	Rob Michnoff, Lenny DeSanto	Collimator motor controller upgrade to AMP controllers	
8		0	ES&F	M. Albanese	912 SRF Test Facilities	
9					912 Pump Room Upgrade	For Cryo
10		AGS	Power Distribution	PK Feng	912 EEBA Outdoor Cable Trays	Replacement
11					AGS Outdoor Cable Tray	Replacement
12			Injectors	Haixin Huang	AGS transverse damper amplifer	Replace the obsolete amplifier
13		Booster	Instrumentation	Rob Michnoff, Lenny DeSanto	Booster/AGS BPM upgrade	upgrade V to Frequency board to V to Fiber, Fiber receiver board
14			Vacuum	Dan Weiss	Booster Vacuum	Replace aging equipment (& cables) with new. Add redundancy and features to improve service and relia
15			Power Distribution	PK Feng	BOOSTER Outdoor Cable Tray	Replacement
16			Injector PS	Ioannis Marneris, Ed Bajon	New Booster MMPS with new building	Replace the Existing Booster Main Magnet Power supply with a new design.
17		Linac	RF	Zaltsman, Severino	BNL 210 Project	40 yr. Future supply of 210 RF tubes 7835
18			Instrumentation	Rob Michnoff, Lenny DeSanto	LPM Control system upgrade	• improve faraday cup S/N ratio• replace laser fiber, repair laser system/optics• transition Faraday cup me
19		Boster/AGS	RF	Zaltsman, Severino	PLC upgrade	Replace outdated PLC5 system
20		EIC	Cryogenics	Roberto Than, Russ Feder	Leak Reduction Program: Central Plant	Replace valves and flanges, etc. in 1005H Central Plant for helium leakage reduction
21					Leak Reduction Program: Corrector lead flow circuits	Replace compression fittings with welded/VCR fittings.
22			RHIC preparation for EIC	Joe Tuozzolo	IR12 Polarized Gas Jet (2024)	Remove system
23					Reconfigure IR12 IR block tunnel section for EIC space needs (2024)	Increase tunnel width
24					IR10 RHIC Blue spin flipper system (2023 or 2024)	Remove system
25					IR10 RHIC eLens (2024) needed for EIC?	Remove system
26					IR04 RHIC AC dipoles (CAD - 2022)	Remove system
27					IR02 CeC & LEReC External Beam Lines (TBD)	Remove system
28					B09DU7 or B03DU7 SC Snake Magnets and Power Supplies (2024)	Remove for refuribishment
29					Complete fiducialization of the RHIC tunnel for laser trackers	Survey upgrade
30					Survey check of the RHIC superconducting magnet cryostats that will be used	0
31		BLIP	Instrumentation	Rob Michnoff, Lenny DeSanto	BLIP Raster LPM work	repair laser system/optics , return system to an operational state
32		EBIS	Source	M. Okamura	RF amplifier for EBIS injector	Solid state amplifiers (300 kW each) for EBIS RFQ and IH LINAC
33		RHIC, Injectors	Controls Hardware	M. Costanzo	Mux system	New/Replace with other
34		Injectors/ EIC?	Controls Software	John Morris	MADC-II	Software support for new Controls HW design to replace MADC. Use cases at EBIS and in analog mux repl
35		EIC-electrons	Cryogenics	Roberto Than, Russ Feder	Bldg 912 SRF Cryogenic System Upgrade: 900W Helium Plant, Purifier, Vacuum	New system for 4X increase in capacity for SRF test facility
36					Bldg 912 SRF Cryogenic System: CryoDistribution to New SRF Bunkers	New distribution from new cryoplant to 3 new SRF Bunkers
37		RHIC/EIC CRYO	Power Distribution	PK Feng	1005H 4160V MCC	Substation 5F and 5G. Replacement

Prioritization of refurbishments and upgrades underway

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Cryo upgrades for the EIC

R. Than, R. Feder et al

From EIC Accelerator Project Dependencies Review, 19-20 Aug 2024 (R. Michnoff, J. Tuozzolo)

Cryogenic Systems

- 912 Upgrade is most urgent.
- Central Plant Upgrade is needed before EIC startup
- Roberto Than & Russ Feder's Presentation

Project	Sub-project	Estimate ($M)	Basis of estimate	Funding Source
Central Plant end-of-life replacements (materials only)	Cryo C&I Upgrades	**2.0 - 2.5**	Actuals + EJ	Capital Equipment
	Cold End Upgrade	**5 – 6**	Past Projects	Was AIP, need funding
	Rotoflow Skids	**2.5 – 3.0**	Vendor Quotes	Was AIP, need funding
	Intercooler and Aftercooler HXs, and helium leak reduction	**3.0– 3.5**	Vendor Quotes	Was AIP, need funding
	Ambient Vaporizers + Piping	**1.0-1.2**	Past Projects	Was AIP, need funding
	AGS cold snake cryo coolers	**0.6-0.8**	Engineering Judgement	Need funding
Central Plant Total		**14.1-17**		
912 Technical Infrastructure upgrade to support EIC SRF testing (materials only)	New helium liquefier plant and supporting eqpt and piping	7	Vendor Quotes	AIP
	New cryo-distribution to SRF bunkers	3 -3.5	Past Projects	Need funding
	New purifier, relocated sub-atmospheric equip	1.5	Vendor Quotes	?
	Infrastructure improvements	.5	Past Projects	?
912 Upgrade Total		**12 – 14**		

Electron-Ion Collider

Off-project dependencies are being actively reviewed

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Accelerator Safety, Readiness Reviews

Major effort for department

All legacy accelerators must undergo Accelerator Readiness Reviews

ARR Tandem	Nov 2022 – done
ARR AP Hot Cell (IP)	Dec 2022 – done
USI sPHENIX sc magnet (IRR w/ external)	Mar 2023 – done
ASE Change for RHIC (ODH)	Feb 2024 – done
ARR IP Cyclotron (IP)	Feb 2024 – done
USI sPHENIX isobutene use	July 2024 – done
Large Vertical Test Facility (LVTF)	Dec 2024 (Safety Analysis complete, no BHSO approval needed)
ARR ATF (ATRO, C-AD assisting)	Jan 2025
RHIC decommissioning	Aug 2025 (authorization basis docs approved by BHSO)
ARR Linac+Booster	Apr 2026 => effort partially estimated
ARR RF Test Facility 2 (new)	Sep 2026 (needed with DOE O420.2D, electrons >10 MeV)
ARR RF Test Facility 1 (ERL cave)	Mar 2027 (needed with DOE O420.2D, electrons >10 MeV)
ARR AGS	Oct 2027 => effort not yet estimated

… then need to get ready for EIC ARRs.

C-AD Mid-Term R&D (as of 13 Nov 2024)

Summary courtesy M. Wiener

TYPE	PI	Title [slightly adjusted to fit]
FOA	G. Hoffstaetter	AI/ML for higher polarization in the BNL hadron injector complex
FOA	X. Gu	Advanced modeling of beam physics and performance optimization for nuclear physics collider
FOA	E. Wang	Photocathodes with 90% polarization and quantum efficiency >1%
FOA	M. Gaowei	Cathode R&D for high intensity electron sources for the EIC
FOA	M. Okamura	Development of high-current, highly charged Laser Ion Source
FOA	S. Brooks	CEBAF 20 GeV upgrade studies
PD	K. Brown	High Energy Effects Test Facility (HEET)
PD	M. Minty	Accelerator Science and Technology for a Future Higgs Factory
LDRD	M. Okamura	Development of a Lithium Beam Driver for BNCP
LDRD	H. Huang	Storage Ring pEDM at BNL
LDRD	S. Brooks	Ion Trap Test Stand and Laser Cooling Studies of Ultra-Low Emittance Bunches for High Luminosity
LDRD	D. Trbojevic	Fast Cycling Permanent Magnet FFA Synchrotron for SBU Hospital and Other Applications

Acronyms: FOA = Funding Opportunity Announcement (DOE), PD = Program Development (BNL),
LDRD = Laboratory Directed Research and Development (BNL), PI = Principal Investigator

Summary

Summary – C-AD through 2025 and beyond

Preparation for Run-25/26

- focus on EBIS preparation (Tandem as back-up), accelerator reliability (e.g. AC), and EIC "early removals"

Operating Scenarios

- planning basis: 22 week shutdown with start-up on 24 Mar 2025
- planning guidance: Au+Au at 200 GeV c.o.m for 20 or 28 weeks - less 2 weeks expended in Run-24
- task force established to try to better understand and address high sPHENIX auto-recovery rates
- priorities to be revisited after experience gained in Run-25/26

Other Beam Time Requests

- multiple proposals: APEX for the EIC, p+Au, FXT at STAR, and CeC (and more from BURs)

Transitioning to the EIC

- objectives: maintain the injector complex in a ready-state for the EIC (including refurbishments and upgrades), complete ARRs, address off-project dependencies (e.g. cryogenic system upgrades), start EIC R&R

Mid-Term R&D

- many FOAs, PDs, and LDRDs in progress to develop new accelerator-based capabilities and to support research in near- and far-term accelerator science and technology