Evolution of Maintenance for RHIC

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Machine Evolution: Outline

- This talk will review the evolution of operation maintenance practices through the 55 years of operations at the Collider Accelerator Department (CAD) at Brookhaven.
- Discuss various historical states and the relation to the maintenance program.
- Focus on evolution during Relativistic Heavy Ion Collider operation.
- Present detailed description of the present system.
- Show and discuss an example.

Some Background:

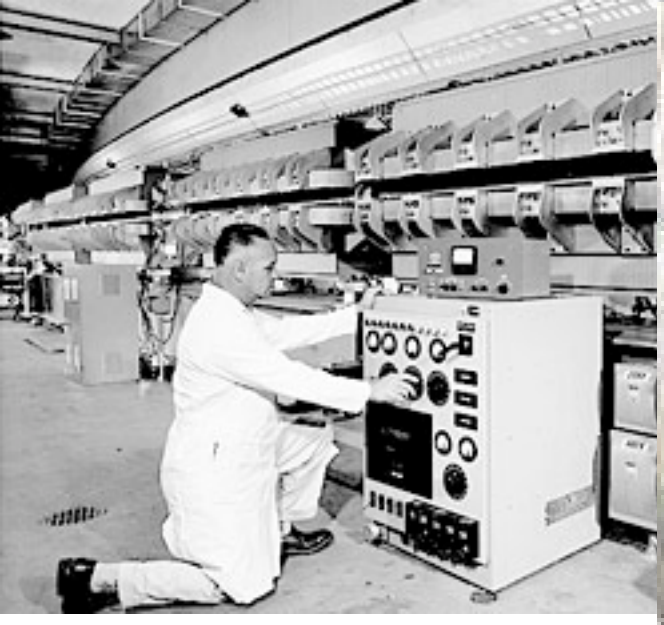
- RHIC- 2 Main Rings comprise 250GeV proton/ion Collider. Relativistic Heavy Ion Collider.
- AGS- Main injector for RHIC
- AGS Booster- AGS injector, Experimental Beams
- LINAC- Proton injector for Booster, provides proton beams for Isotope Production (BLIP)
- ElectronBeamIonSource (EBIS) provides ion species ^{2}He – U for use in Booster, AGS and RHIC.

History: 1950's

- Cosmotron:
  - Weak focusing synchrotron.
  - Established Operations and Support Groups.
  - Basis for initial CAD Operations/Maintenance/Repair practices.

1960's

- AGS Commissioned and first physics runs begin.
- Single use facility,
  - 50MeV Proton DT LINAC injector.
  - 33GeV Main Ring.
  - Internal Fixed Target.
  - External Secondary beam line.
  - Experimental equipment (Bubble Chambers).
- Operations group takes over as systems handed over from SMEs, designers and Accelerator Physicists.
- Migration of personnel and practices from Cosmotron.
- Shiftwork, 24 hour operation.



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Maintenance Practices: Background

- Shift workers:
  - MCR Operators 2-4.
  - LNAC Operators 2.
  - Motor Generator Operators 2.
  - Water Group 2.
  - Vacuum Group 2.
  - Experimental Support 2-3.
  - Facilities 2.
  - Health Physics 2.
  - Experimenters 3-5.
- Total Shift workers 20+
- SMEs for each group “days”.

Failure and Maintenance

- Many failures handled by the on shift personnel.
- Parallel work determined by on shift crew chief.
- Maintenance during failure or long shutdown.

Maintenance: Early Days

- Maintenance items add up awaiting failure.
- Maintenance Coordinator maintains list.
- Nearly all work “worker planned work”.
- Accelerator Management Decides when to go down for maintenance.
- Scheduling Physicist, Head of Operations roles.
  - 1-3 Days advance notice to affected personnel.
  - Machines to be opened.
  - Major work to be performed.
- Groups:
  - Individual plans, small jobs.
  - Emergent jobs immediately addressed.

AGS Maintenance Origins:

- Duration 1-3 days or longer depending on need, failure.
- Long recovery:
  - Systems left in various states, SMEs critical.
    - Systems one of a kind.
    - SME call in very frequent
  - Slow vacuum recovery.
  - Operations “re-commissioning”.
- Many days before full recovery in some cases.
- Records in hand written logs or experts memories…

1970's-80's

- 200 MeV LINAC upgrade:
  - Add 'parasitic' user: Brookhaven Lab Isotope Production.
  - BLIP sets separate schedules.
  - Secondary to the AGS Schedule.
  - LINAC shift personnel remains the same.
  - Added personnel at BLIP.
- Multiple external targets, experiments:
  - Expanded shift personnel Experimental Area Organization, beam separators.
  - Discrete division of equipment.
  - Experimental support.

1970’s and 1980’s

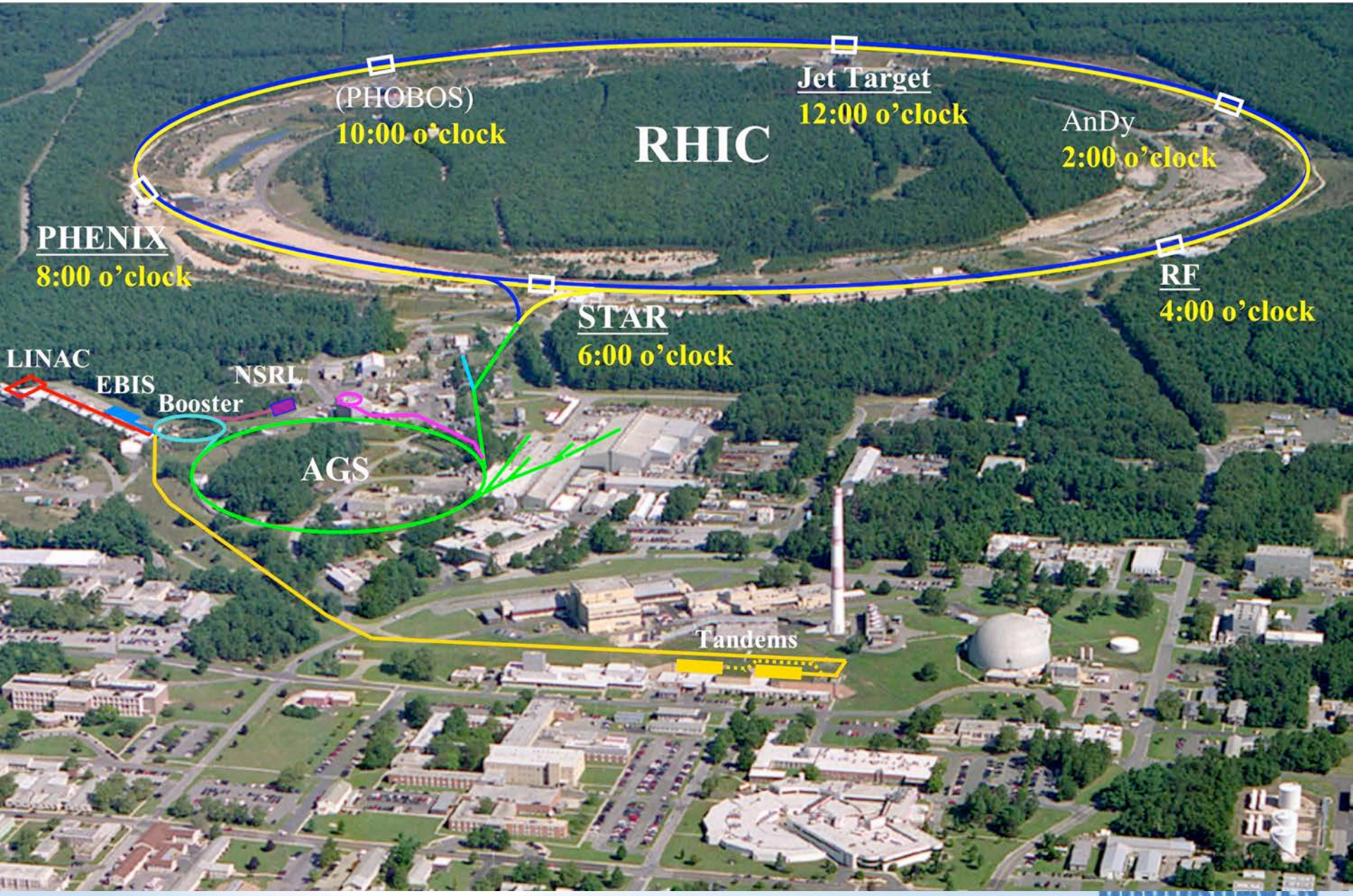
- Machine and experimental maintenance issues segregated.
- Records, coordination left to individual groups.
- Standardization of controls and hardware.
- Standardized procedures.
- Work Planning.
- SAFETY

Late 1980's and 1990's

- Heavy Ions from Tandem.
- AGS Booster.
- G-2 experiment
- Switchyard and external targets.
- HI experiments- primary beam to "secondary areas".
- Multiple extraction mode running.
- RHIC Constriction, commissioning…
- Further reduction in shift personnel…
- Increased/formalized call in procedures…

Its getting too complicated!!

Collider Accelerator Department


(PHOBOS)
10:00 o'clock
RHIC
Jet Target
12:00 o'clock
AnDy
2:00 o'clock
PHENIX
8:00 o'clock
RF
4:00 o'clock
STAR
6:00 o'clock
LINAC
EBIS
Booster
NSRL
AGS
Tandems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2000's

- Standardization.
- Integration to Collider Accelerator Department.
- Integration Operations.
- Collider Accelerator Support (CAS).
- Experimental Support and Facilities.
- Maintenance integration into Operations.
- Further reduction in Shift Personnel
  - 3 MCR
  - 2 CAS
  - 2 Cryo

Staffing

- 3 MCR (2 Operators 1 Operations Coordinator).
- 2 CAS, stationed in the field, area in MCR.
- 2 Cryo, remote CCR and MCR.
- Facilities separate, 1-3 people on shift, remote locations.
- Operations Specialists, Accelerator Physics support, Maintenance Support, Group Support as necessary.

2007-present MSG Role

- Work Planning, Scheduling.
- Scheduled periodic Maintenance.
  - All work on all systems documented, scheduled, tracked.
- Shutdowns treated similar to Maintenance Days.
- Project Management.
- Commissioning Management.
- Major failure, unscheduled maintenance coordination.
- Coordinate job closeout, resolution and return to operation.
- Formalized hand over for Operations.

Example: Yesterday

- Weeks in advance, staff made aware of Scheduled Maintenance/Changeover.
- Weekly Scheduling meeting: Define length, analyze risk, convey plans to experiments, discuss recovery.
- Weekly Supervisors Meeting:
  - Updates, preliminary Schedules, Discussion, preplanning work.
  - Time Meeting: Convey outline of plans to rest of the department.
- Planning, Coordinating Meeting: Detailed Schedule.
- Job Request, Approval, Execution, Closeout/re-commission,

April 2015

Sun	Mon	Tues	Weds	Thu	Fri	Sat
			1 Maintenance 0800-1600	2 Physics	3 Physics	4 Physics
5 Physics	6 Physics	7 Physics	8 APEX Beam to NSRL	9 Physics MD	10 Physics	11 Physics
12 Physics	13 Physics	14 Physics	15 Maintenance 0800-1600	16 Physics	17 Physics	18 Physics
19 Physics	22 Physics	21 Physics	22 APEX	23 Physics MD	24 Physics	25 Physics
26	27 p-Au changeover Maintenance	28 p-Au Setup	29 p-Au-Setup	30 p-Au Setup		

Schedule for p-Au turnover April 27th

Time	Action	Pre-req	Personnel
0430	Siemens off for Bearing work	Last RHIC pp fill completed	PSG/MCR
0500	Begin Siemens Bearing Work NOTE: NO LOTO AT THIS TIME	Siemens Set secured	PSG
0645	Dump RHIC beam, ramp down.	Experimenter's prep for dump completed.	OWL
0700	 Begin RMMPS LOTO LINAC off for cool-down RS LOTO RF at 4 o'clock Tunnel Access begins: Begin setup for moves at 10&12. Open fence at 4 o'clock	Main Magnets at Zero WG Ready for access RF systems off RA all but Sector 4 &10. XA 10, ACS tests in sector 4 NO Beam in RHIC	MCR WG PSG MCR FES MCR/SG/PSG CAS
0800	Access LINAC for Water Sample zone 1 to RA Sector 4&10 RA	HP RA survey zone 1 Surveys, tests complete	HP/CAS/WG MCR
0900	Move DX magnets at 9, 10, 11 and 12. Survey	Systems monitors active	SG/PSG/VG/IG
1100	Moves complete at 10 and 12, prep 6 and 8 begins Begin polarity swap	RMMPs LOTO in place, Hi Pot Disconnected.	SG RPSG
1300	Access complete restore LINAC/BLIP	RF recovery complete	LINAC
1400	Begin moves for 5&7 DX Sweeps Begin	Systems monitors active Polarity swap stops if not complete	VS/PSG/VG/IG CAS/MCR
1600	Begin moves for 6&9 DX Siemens Start Up/AGS Restoration	Systems monitors active Bearing work completed	VS/PSG/VG/IG PSG
1800	All moves complete, remove Hi Pot. Sweep remaining tunnel areas. Complete polarity change as necessary AGS running	All items located and recorded Siemens up and running	SG/VG/CAS/MCR RPSG MCR
1900	Begin test ramps	Tunnel Secured	MCR/RPSG
2100	Sweep experiments	Experiment access complete	CAS/MCR
2200-0900Tuesday	Aperture probe with beam- No RHIC access	Ramp tests complete for night	AP/MCR
4/28 0900-1200	High Current Ramp tests	Beam activity complete- no apertures found*	RPSG
1200	Resume setup with beam – NO ACCESS	Ramps working	AP/MCR

RHIC

Job #	Group	Job Title	Time Required	Status	Ring Access
10	Beam Components & Instrumentation	RHIC CNI Polarimeters - Modify 3 Camera Setups	4-6 hrs	RS	12z1
11	Beam Components & Instrumentation	CEC Instrumentation- Installation and Setup of Instrumentation Equipment	8 hrs	C	2z1, 2z2
12	Beam Components & Instrumentation	Sector 1- Work Planning & Documentation for LEREC	1 hr	C	1z1, 2z1
13	Beam Components & Instrumentation	Sector 2- Work Planning & Documentation for LEREC	1 hr	C	2z2
14	Beam Components & Instrumentation	Sector 12- Work Planning & Documentation for LEREC Equipment Moves	30 min	C	12z1
15	Beam Components & Instrumentation	RHIC BLM System-v9-lm3.5-dmp - Investigate Signal Issues	30 min	C	10z1, 10z2
16	Beam Components & Instrumentation	RHIC Sector 12 Yellow CNI Polarimeter - Setup for Au Running	3 hrs	C	12z1
17	Beam Components & Instrumentation	RHIC Sector 12 Blue CNI Polarimeter - Replace Carbon Targets/Replace B2-4 & B2-5 Silicon Detectors	2 hrs	C	12z1
18	Beam Components & Instrumentation	RHIC BLM System - Sector 7 DX BLM Work for DX Move	1 hr	CAN	7z1
19	Beam Components & Instrumentation	RHIC BLM System - Sector 8 DX BLM Work for DX Move	1 hr	CAN	8z2
20	Beam Components & Instrumentation	9MHz Test Cavity - Complete Installation of Area Monitor Chipmunk	30 min	C	4z1
21	Beam Components & Instrumentation	RHIC Jet Polarimeter- Investigate & Repair Silicon Temperature Diode Issues	2 hrs	N	12z1
38	Beam Components & Instrumentation	yi6-bh7 BPM - Investigate Signal Problems	30 min	C	6z2
39	Beam Components & Instrumentation	RHIC 2 O'Clock Yellow High Frequency Schottky System -Change Attenuators	15 min	C	2z2
47	Beam Components & Instrumentation	bo6-bv11 BPM - Investigate Signal Problems	30 min	C	6z2
53	Beam Components & Instrumentation	RHIC Sector 8 Yellow Mask- Swap Jaw Controls & Test	1 hr	C	8z2
56	Beam Components & Instrumentation	RHIC Sector 11 Yellow Stochastic Cooling Longitudinal Kicker -Inspection/Cleaning of Viewports	20 min	C	12z1
57	Beam Components & Instrumentation	RHIC Sector 11 Yellow Stochastic Cooling Longitudinal Kicker - Cavity Heater Maintenance	15 min	CAN	12z1
58	Beam Components & Instrumentation	RHIC Sector 3 Yellow Vertical Stochastic Cooling Kicker -Chiller & Heater System Maintenance	15 min	C	4z1
59	Beam Components & Instrumentation	RHIC Sector 3 Yellow Horizontal Stochastic Cooling Kicker -Chiller & Heater System Maintenance	15 min	C	4z1
60	Beam Components & Instrumentation	Sector 2 - Stochastic Cooling Longitudinal Pickup - Check System Setup In Tunnel	15 min	C	2z2
61	Beam Components & Instrumentation	Sector 12 Yellow Horizontal Stochastic Cooling Pickup LLRF-Check System Setup In Tunnel	15 min	C	12z1
62	Beam Components & Instrumentation	RHIC Sector 12 Yellow Vertical Stochastic Cooling Pickup - Check System Setup In Tunnel	15 min	C	12z1
68	Beam Components & Instrumentation	Install 6dB attenuators on bo2-bh6	30 min	C	2z1
22	Controls	Install and Terminate Network Cable in 5C Tunnel	1.5 hrs	C	5z1
23	Controls	Shut Down and Remove V201 from CFE-4A-BYSN to Evaluate	1.5 hrs	C	N/A
48	Controls	ups ip address chage	1 min	IP	N/A
49	Facilities and Ops	Installation of the 9Mhz	4 hrs	C	4z1
24	Facilities & Experimental Support	Deliver 9 MHz to RHIC 1004	8 hrs	C	4z1
35	Facilities & Experimental Support	Move DX and other equipment	12 hrs	C	ALL RHIC
54	Facilities & Experimental Support	PHENIX CMI Voltage Taps	4 hrs	IP	8z1
25	RF	56 MHz SRF Cavity Conditioning	6 hrs	N	N/A
41	RF	Install and hook up new 9 MHz cavity	8 hrs	C	4z1
42	RF	Check Air flow switches	1 hr	C	4z1
43	RF	Check servo amps	2-4 hrs	C	4z1
26	Power Supply (RHIC)	test new p-Au ramp	45 min	N	N/A
27	Power Supply (RHIC)	dh0 Link Box Swaps / dhX Magnet Moves	18 hrs	N	N/A
28	Access Controls	Tie in 9MHz to PASS - 4/27/15 Maintenance	1 hr	C	N/A

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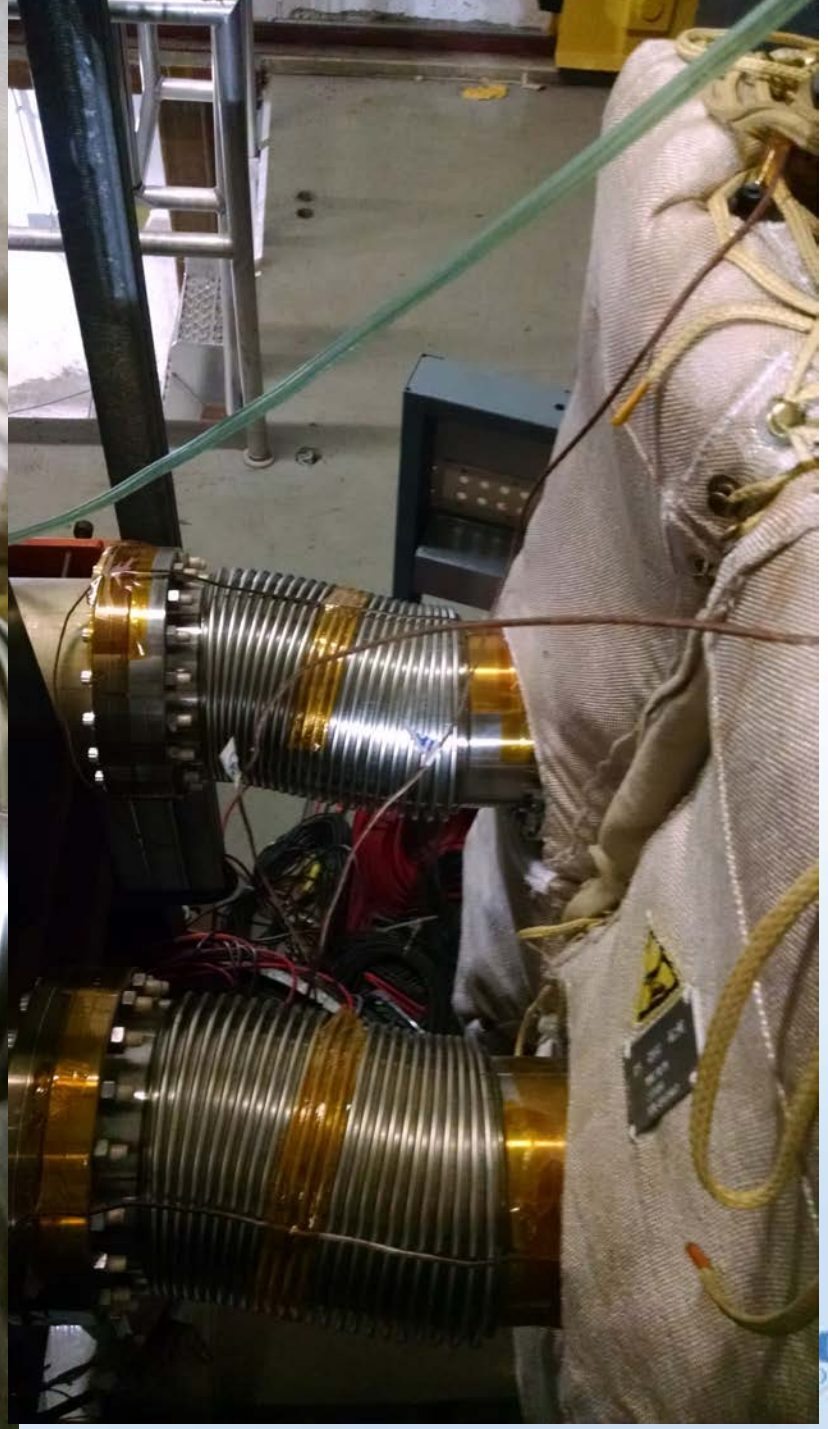
4/28	High Current Ramp tests

✔
✔
✔
✔
✔
✔
← LINAC Start Delay, ACS issue on at 1700hrs
✔
✔
✔
← Ring Hi-Pot longer than expected
← Delay in tests translates to slightly late start (2400hrs)



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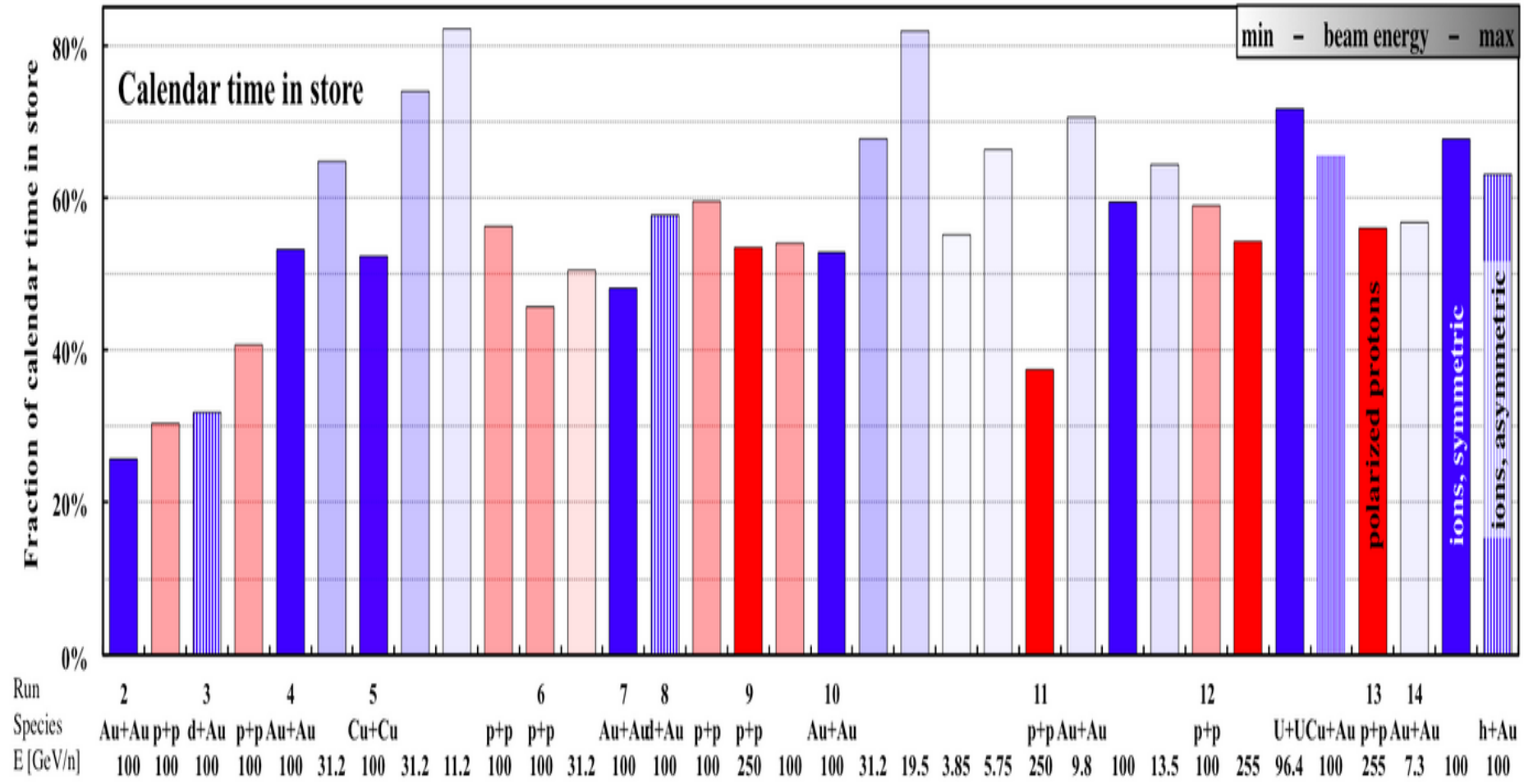
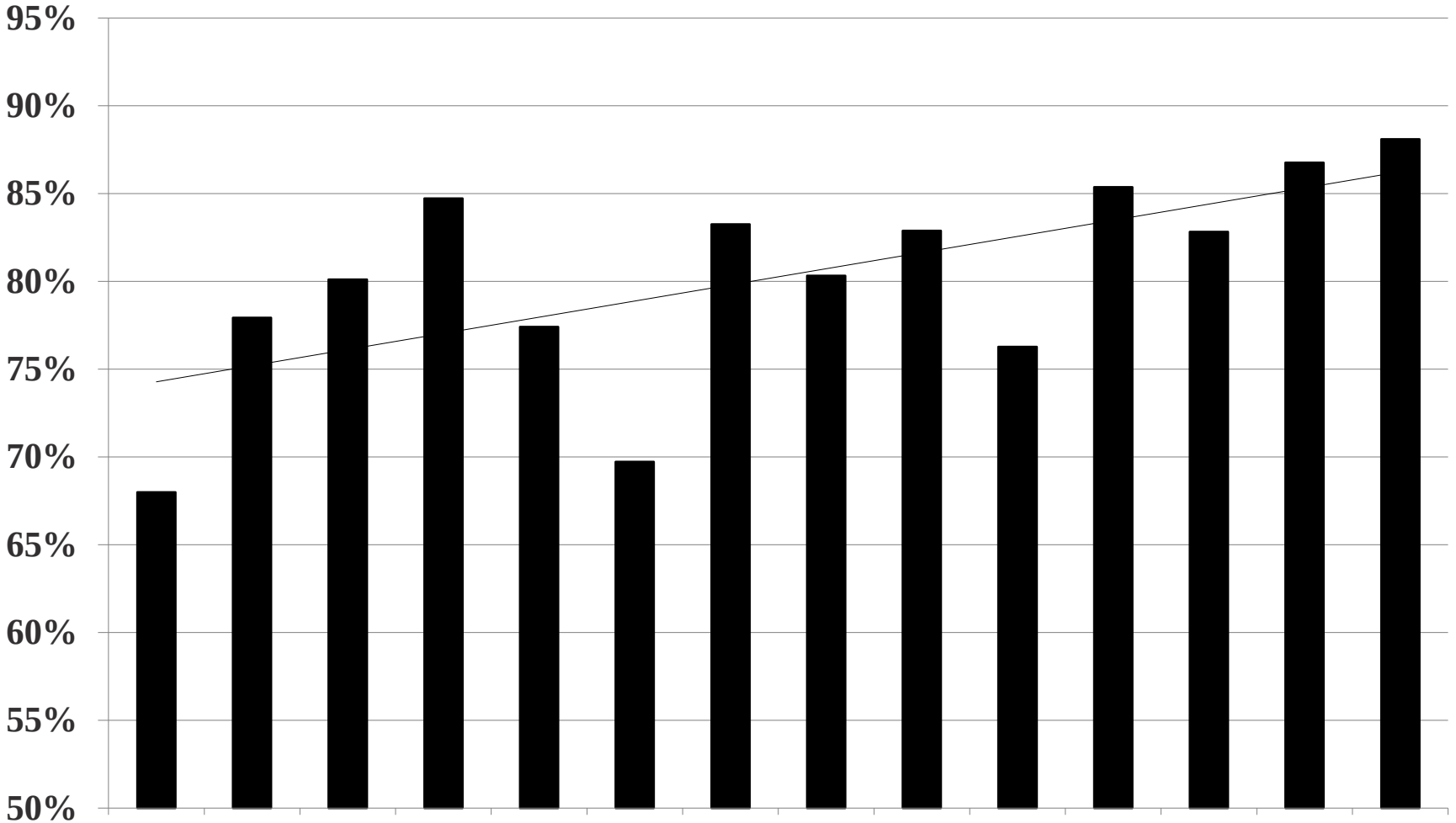
Availability:

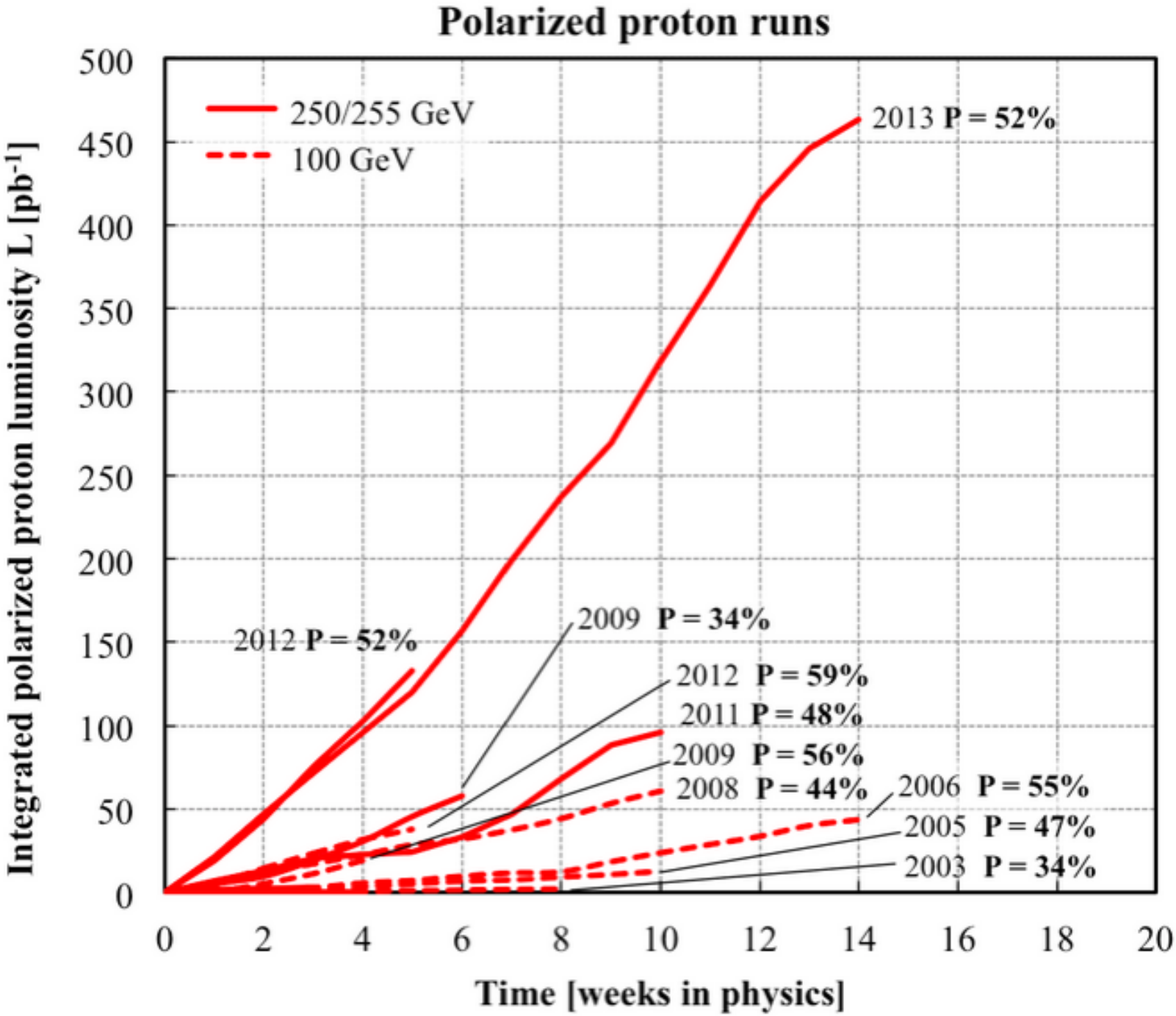


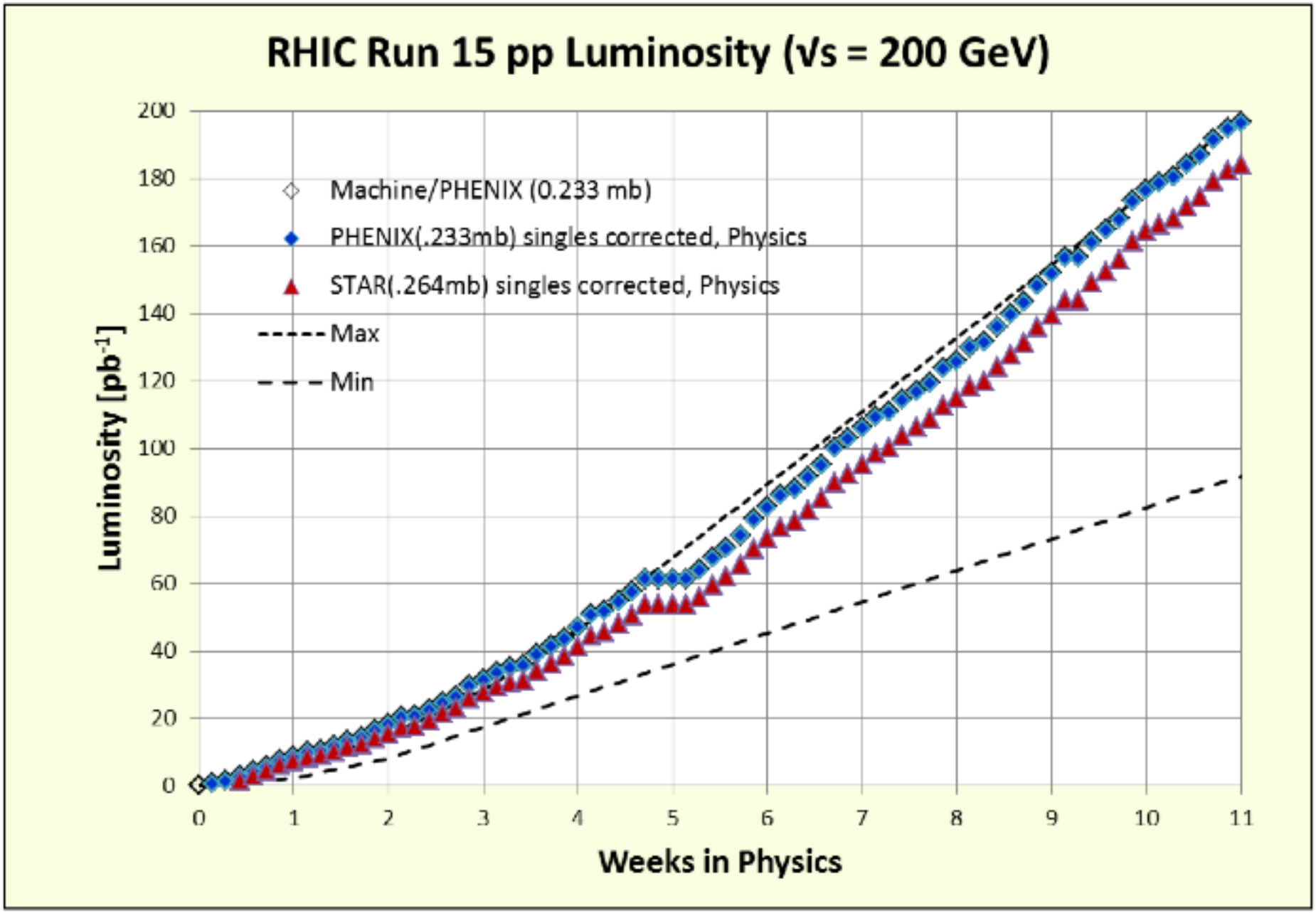
From data Assembled by W. Fischer , BNL

RHIC AVAILABILTY 2002-2015



Graph from data assembled by P. Ingrassia, BNL


Polarized proton runs
Integrated polarized proton luminosity L [pb-1]
Time [weeks in physics]
250/255 GeV
100 GeV
2013 P = 52%
2012 P = 52%
2009 P = 34%
2012 P = 59%
2011 P = 48%
2009 P = 56%
2008 P = 44%
2006 P = 55%
2005 P = 47%
2003 P = 34%
0
50
100
150
200
250
300
350
400
450
500
0
2
4
6
8
10
12
14
16
18
20


RHIC Run 15 pp Luminosity (√s = 200 GeV)
Luminosity [pb-1]
Weeks in Physics
Machine/PHENIX (0.233 mb)
PHENIX(.233mb) singles corrected, Physics
STAR(.264mb) singles corrected, Physics
Max
Min
0
20
40
60
80
100
120
140
160
180
200
0
1
2
3
4
5
6
7
8
9
10
11

Conclusions:

- As facilities grow and needs change, maintenance practices must also evolve.
- Efficient operation must include a cohesive maintenance plan and coordinated execution and closeout.
- Unification and centralization of documentation will reduce preventable delays to recovery of operation.
  - No job to large or small!
- Scheduling in advance will increase probability of a successful shutdown/maintenance period.
- Schedules made with player input, close to the time a execution can produce a more realistic time scale.
- Improvements to Maintenance show direct improvement to the bottom line.

Thank you