Collider-Accelerator Department Overview

Presented to

RHIC Facility Annual Science and Technology Review

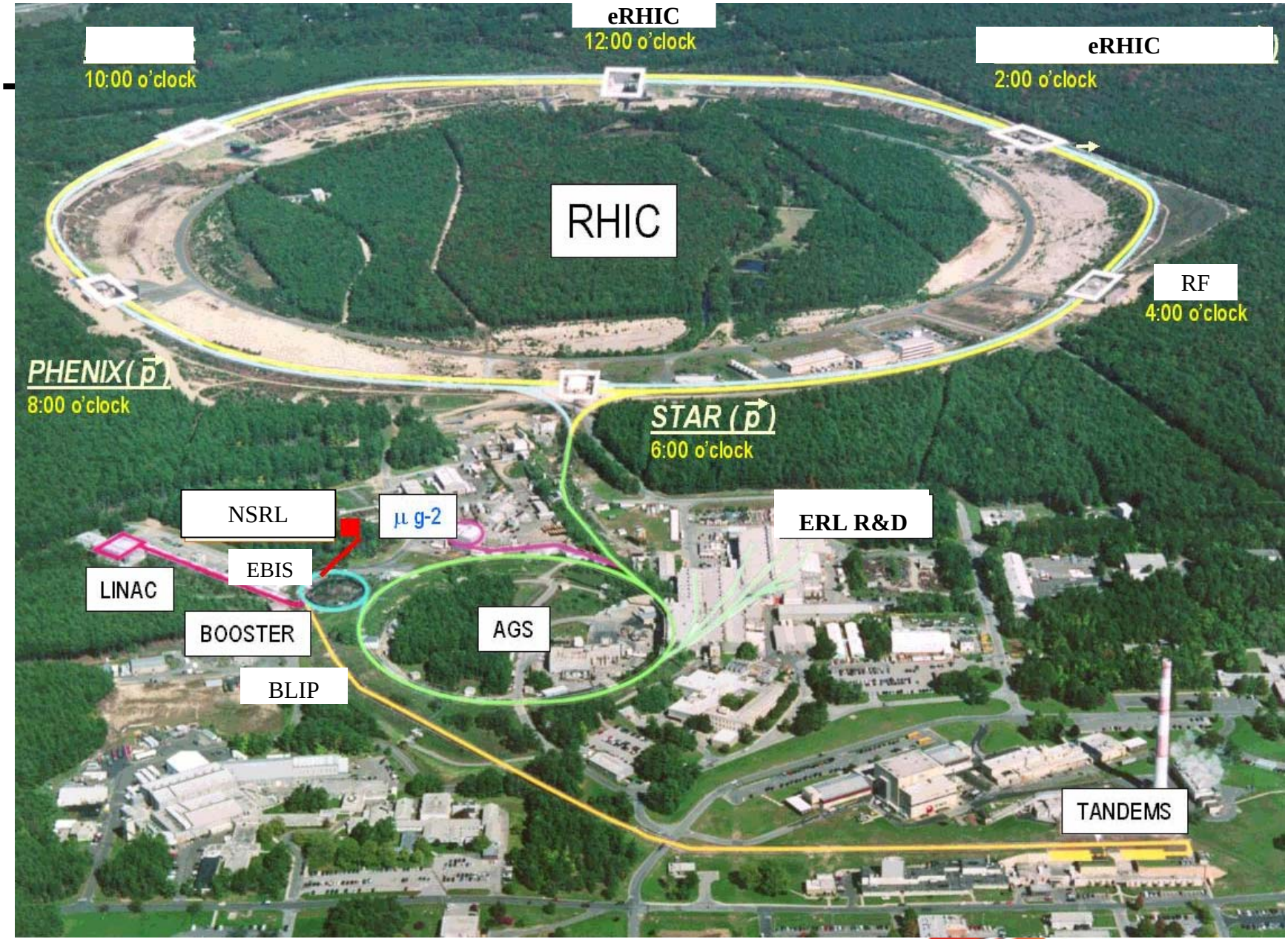
Derek I. Lowenstein
July 7, 2008

FY2007 Nuclear Physics S&T Review Action Items

Recommendations

BNL should develop a plan with an aggressive schedule to demonstrate feasibility of transverse and longitudinal cooling with bunched beams. This plan should be submitted to DOE by December 31, 2007.

Submitted to DOE as requested.


eRHIC
12:00 o'clock
10:00 o'clock
eRHIC
2:00 o'clock
RHIC
RF
4:00 o'clock
PHENIX($\vec{p}$)
8:00 o'clock
STAR ($\vec{p}$)
6:00 o'clock
NSRL
μ g-2
ERL R&D
EBIS
LINAC
BOOSTER
AGS
BLIP
TANDEMS

C-A Department Personnel

COLLIDER-ACCELERATOR DEPARTMENT
Circa July 2008

Mission: "To develop, improve, and operate the suite of particle/heavy ion accelerators used to carry out the program of accelerator-based experiments at BNL; support of the experimental program including design, construction and operation of the beam transports to the experiments, plus support of detector and research needs of the experiments; to design and construct new accelerator facilities in support of the BNL and national missions. The C-A Department supports an international user community of over 1500 scientists. The Department performs all these functions in an environmentally responsible and safe manner under a rigorous conduct of operations approach."

Staff: The Collider-Accelerator Department headcount is:

	Total	NP*	EBIS	NSRL	OTHER
Ph.D. Scientists	52	48	1	2	1
Postdoctoral Fellows	4	4	0	0	0
Engineers/Professional	135	124	4	5	2
Designers/Technicians	171	160	4	6	1
Admin./Clerical	20	19	0	1	0
Totals	382	355	9	14	4

*Does not include - 15 Magnet Division employees charged to NP.
Additional support - 14 FTEs are purchased as Laboratory assigned

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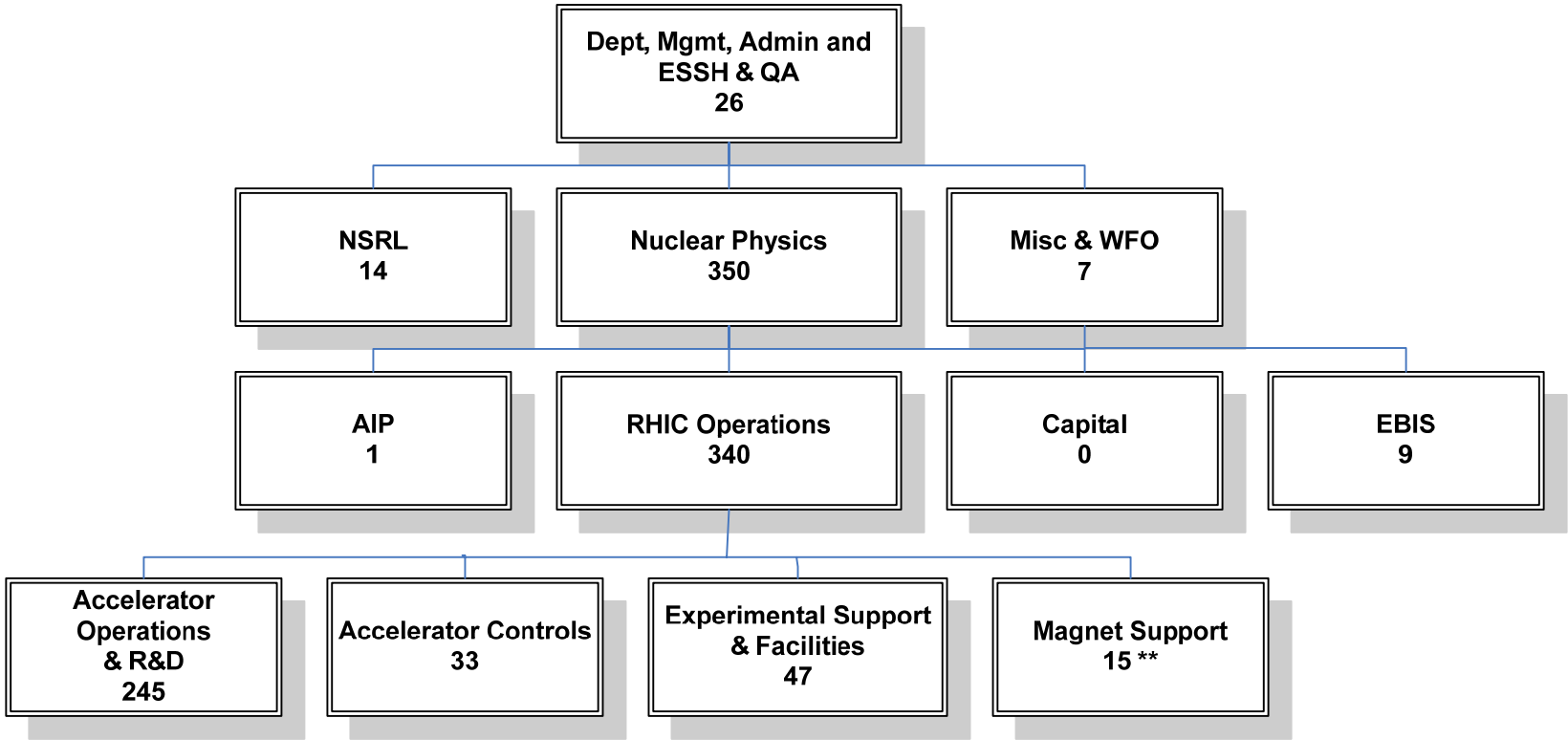
Office of Science U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY

Collider-Accelerator Department

(Programmatic Heads 371)



*Reflects Head data circa May 2008

**Superconducting Magnet Division Personnel

C-AD Accelerator Physics Students (2002-2008)

Student	Mentor	Comments
Lin, Fanglei	Bai	Post Doc at Physics
Chang, Xiangyun	Ben-Zvi	C-AD Staff Member
Calaga, Rama	Ben-Zvi	C-AD Staff Member
Grimes, Jacob	Ben-Zvi	Researcher in Texas
Wang, Gang	Ben-Zvi	Current Ph.D. Student
Wu, Qiong	Ben-Zvi	Current Ph.D. Student
Hammons, Lee	Litvinenko	Current Ph.D. student
Longhi, Emily	Litvinenko	Accelerator Scientist at Diamond light source
Roychowdhury, Samadrita	Litvinenko	Researcher at Xerox Corp.
Chalut, Kevi	Litvinenko	Post Doc at Duke Univ.
Webb, Stephen	Litvinenko	Current Ph.D. Student
D'Imperio, Nicholas	Luccio	BNL Employee
Ranjbar, Vahid	MacKay	Post Doc at TechX Corp.
Kanesue, Takeshi	Okamura	Current Ph.D. Student
Tamura, Jun	Okamura	Current Ph.D. Student
Cardona, Javier	Peggs	Prof. of Physics, Bogota, Colombia
Fliller, Ray	Peggs/Drees	Post Doc at Fermilab
Iriso, Ubaldo	Peggs/Drees	Post Doc at CELLS light source, Barcelona, Spain
Tang, Chunmei	Peggs	Stay-at-home mom
Warner, Arden	Peggs	Physicist, Accelerator Div., Fermilab
Hao, Yue	Ptitsyn	Current Ph.D. Student
Takano, Junpei	Roser	Assistant Professor at KEK

FY 2008 Awards and Publications

FY 2008 Awards (to date)

- **Free Electron Laser Prize – I. Ben-Zvi, August 2007**
- **BNL Engineering Award – S.V. Badea, January 2008**
- **APS Fellows – W. Fischer, A. Hershcovitch, D. Trbojevic, January 2008**
- **AAAS Fellow – I. Ben-Zvi, February 2008**
- **2008 IEEE Nuclear & Plasma Sciences Society Merit Award – I. Ben-Zvi, April 2008**
- **BNL Sitewide Safety Steward Employee Recognition Program for Safety Awareness Honorable Mention – P. Sparrow, April 2008**
- **BNL Tenure Awarded – M. Blaskiewicz, A. Fedotov, June 2008**
- **BNL Spotlight Awards – 14 members of C-AD (to date)**

FY 2008 Publications and invited talks (to date)

- **146 publications**
  - **35 journals, 20 refereed**
  - **111 conference proceedings**
- **Approx. 10 invited talks**

C-AD Accelerator Community Leadership Positions

- Chair, Particle Accelerator S&T, IEEE NPSS: I. Ben-Zvi
- Chair, FEL Prize Com., PAC'09 Scientific Program Sub-Com., PAC'11 Scientific Program Com.; Member, USPAS Program Advisory Com., APS DPB Nominating Com., International Executive FEL Com.: V. Litvinenko
- Chair, US Particle Accelerator School Board of Governors: D. Lowenstein
- Program Leader, US LARP: S. Peggs (to 7/31/08)
- Chair, Fermi Research Alliance Visiting Committee; Member, APS DPB Nominating Committee: F. Pilat
- Member, DOE HSS Safety Directives Review Team: E. Lessard
- Past-Chair, APS Division of Particles & Beams Executive Com.: T. Roser
- Chair, IEEE Nuclear & Plasma Sciences Society (Long Island Chapter); Member, Scientific Program Com., PAC'09: W. Zhang
- Editor, ICFA Beam Dynamics Newsletter and CSNS Project Head: J. Wei
- + others serving on DOE, NNSA, NSF, CERN, RAL, GSI, J-PARC committees and reviews

C-AD Program Areas (2008)

RHIC
- d -Au and p-p operations operations

Tandem
- Commercial Users

Linac
- Isotope production, BLIP (DOE NE)

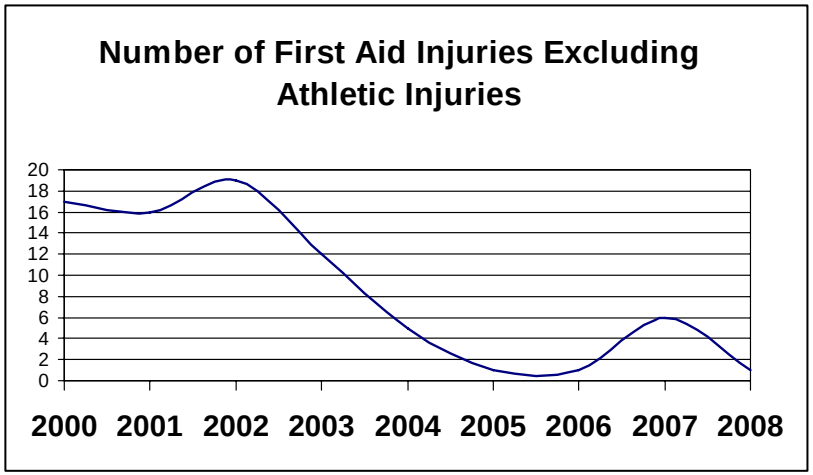
Booster
- NASA Space Radiation Laboratory (NSRL)

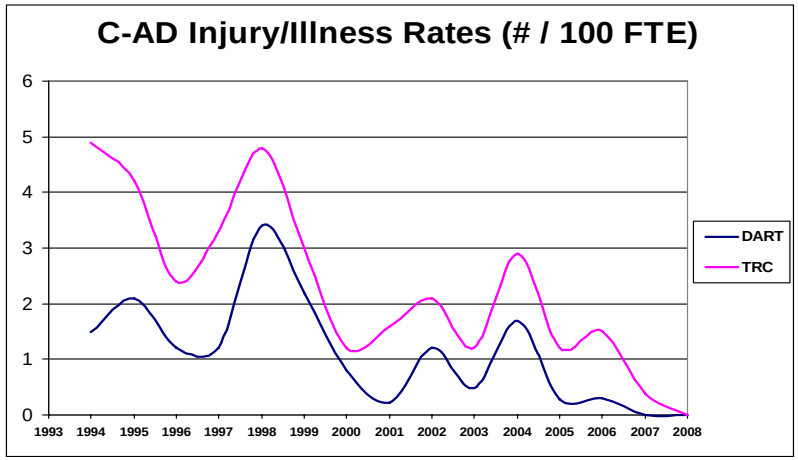
Projects
- EBIS (DOE / NASA)
- Proton interrogation, U line (DTRA)

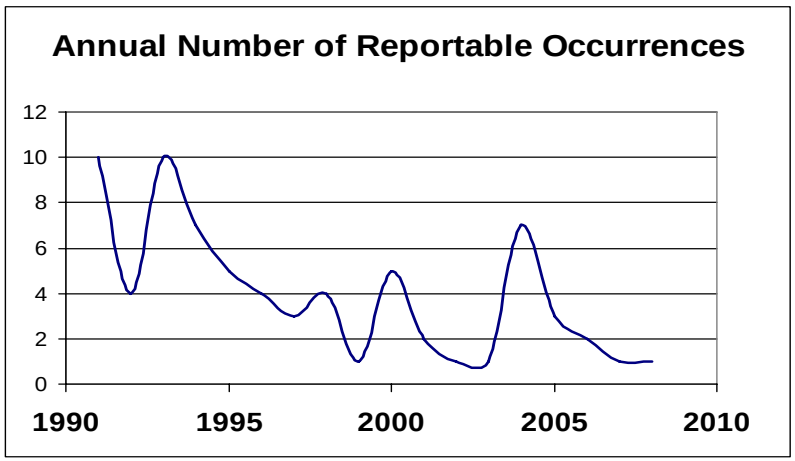
R&D
- Energy Recovery Linac (DOE / US Navy)
- LARP (DOE HEP)
- Joint neutrino source R&D effort with FNAL (DOE HEP) continues

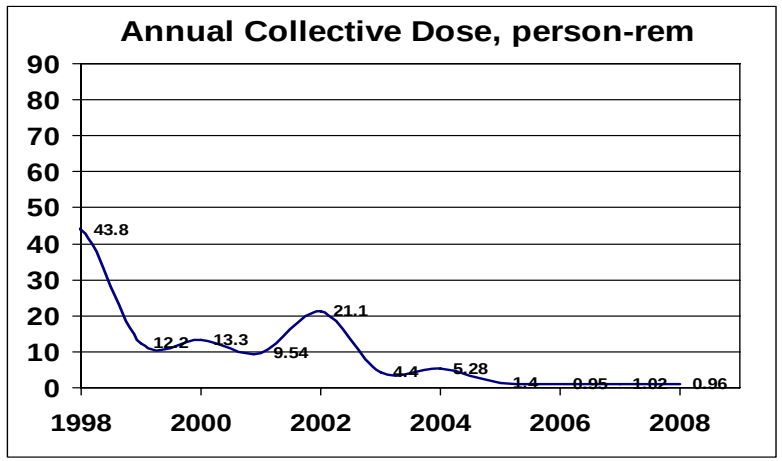
RHIC Performance

ESH Performance at C-AD







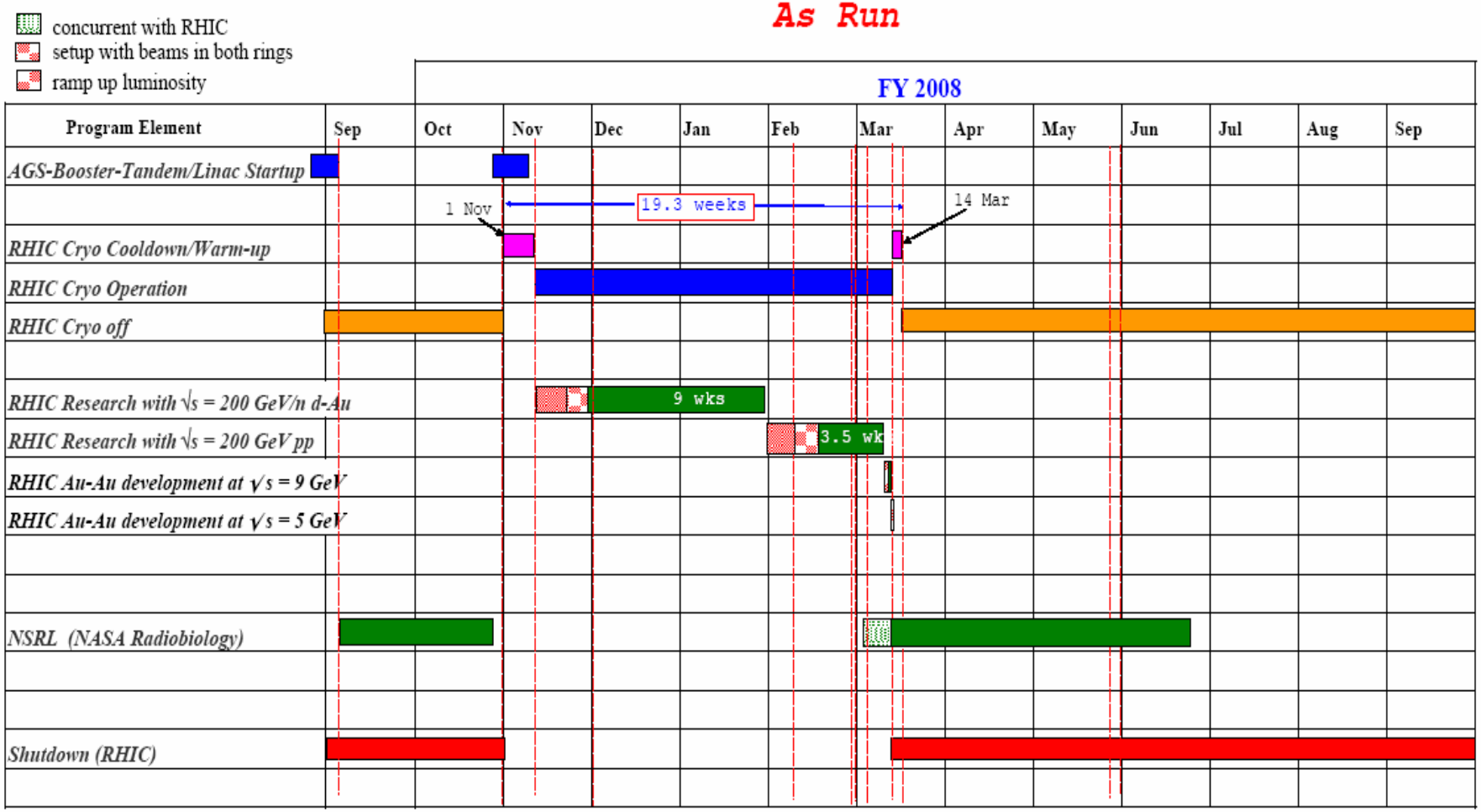


http://www.bnl.gov/cad/esfd

C-A Operations-FY08

13 Mar 08

As Run



RHIC d-Au Highlights

100x100 GeV/nucleon for PHENIX and STAR

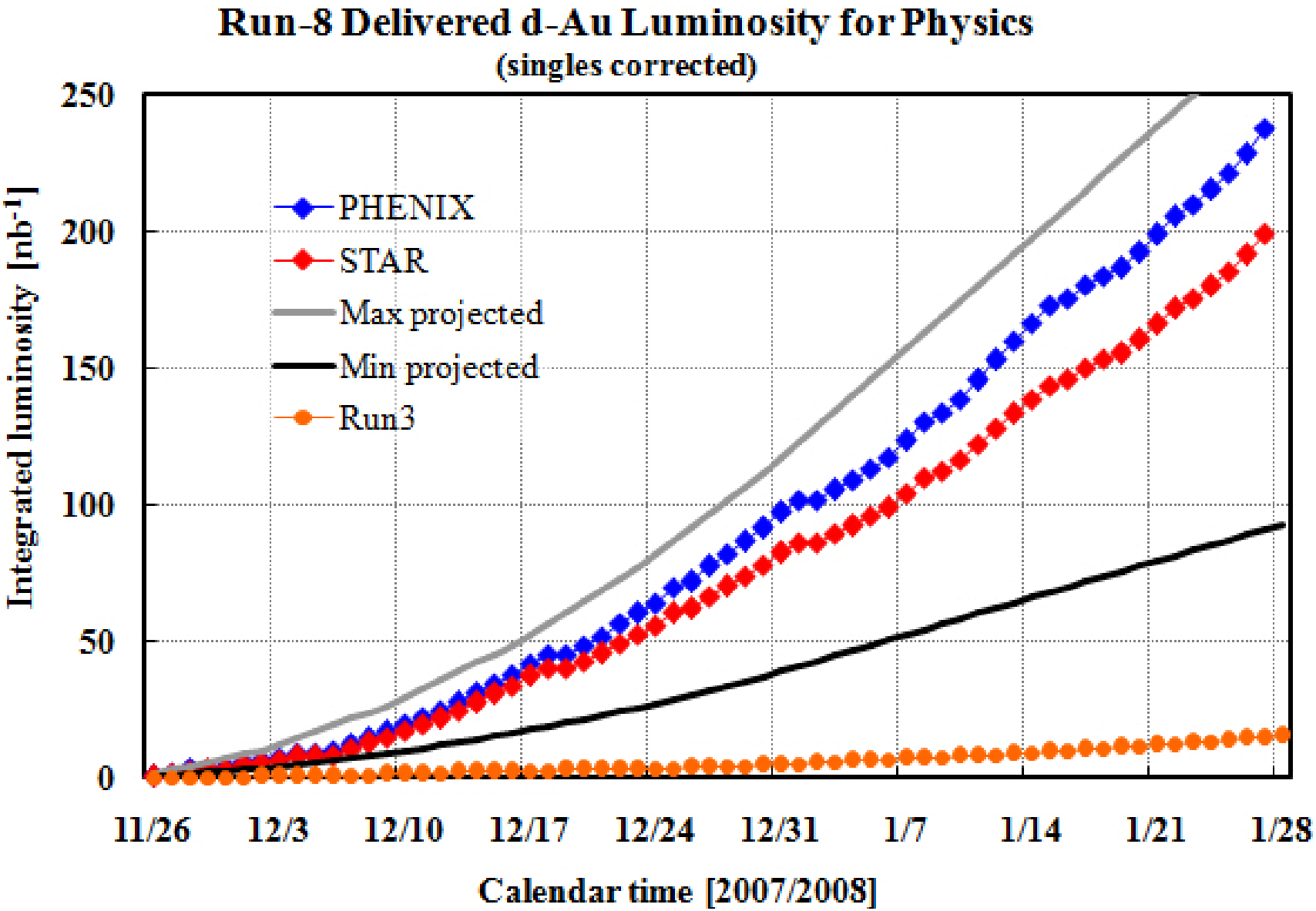
- delivered 10x more integrated d-Au luminosity than in Run-3
  (about a factor 2 from β*, number of bunches, and time in store)

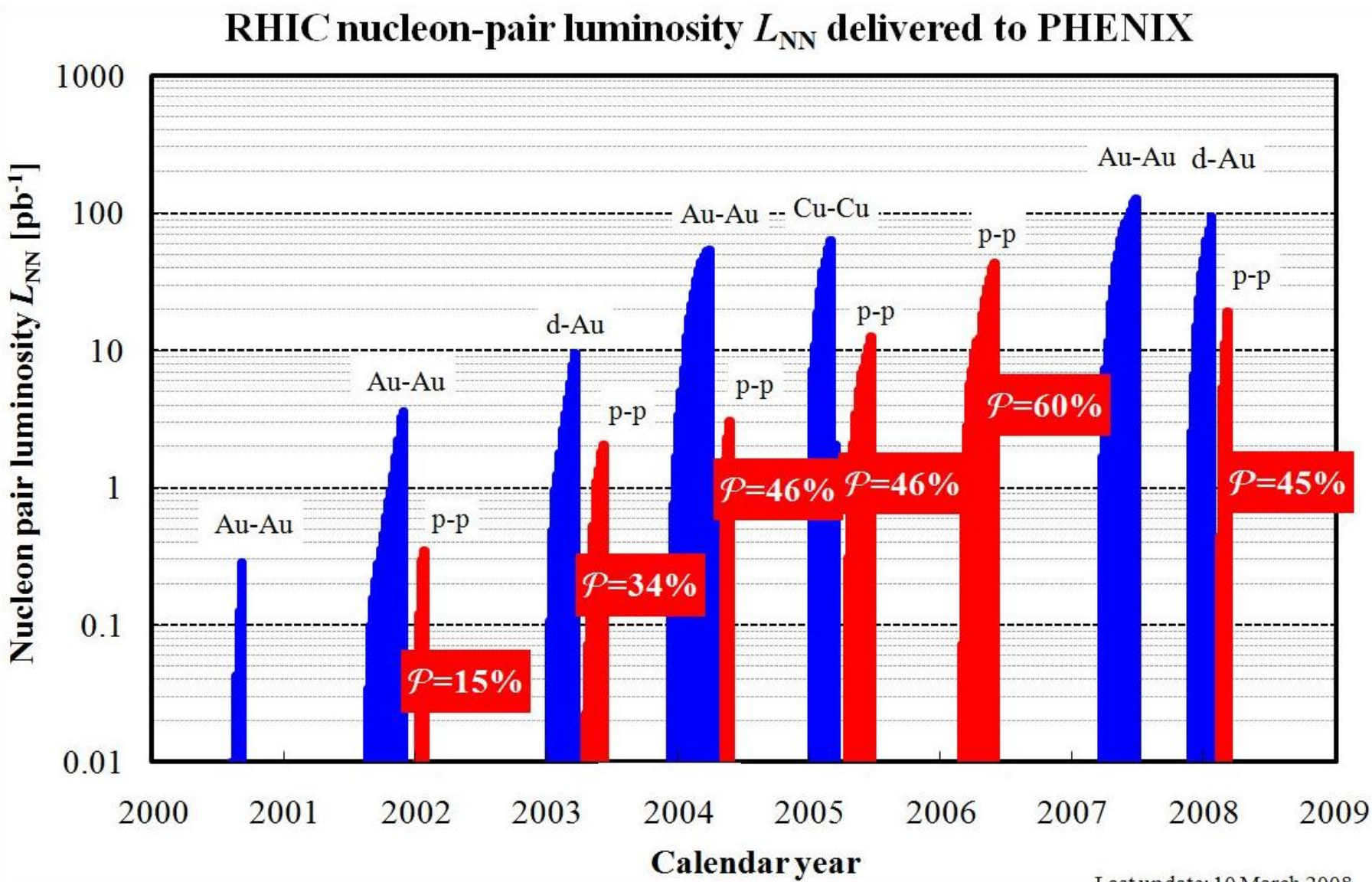
- average store luminosity $12.5 \times 10^{26} cm^{-2} s^{-1}$ vs. $3 \times 10^{26} cm^{-2} s^{-1}$ in Run-3

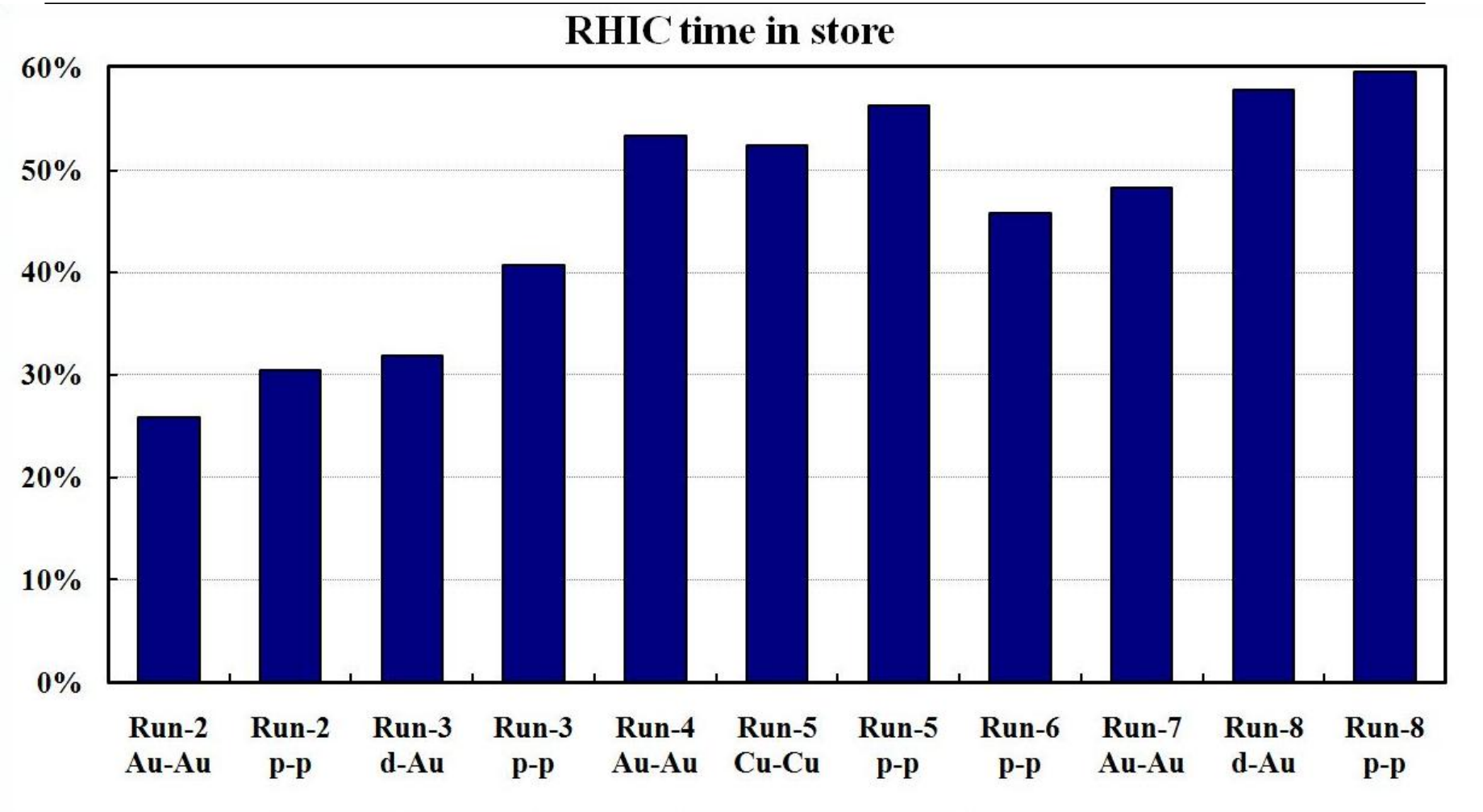
- longitudinal stochastic cooling operational in Yellow ring again
  (d beam in Blue cannot be cooled because 100x more particles
  than in Yellow ring,15-20% luminosity enhancement)

- lattice with reduced IBS growth rates in Yellow ring

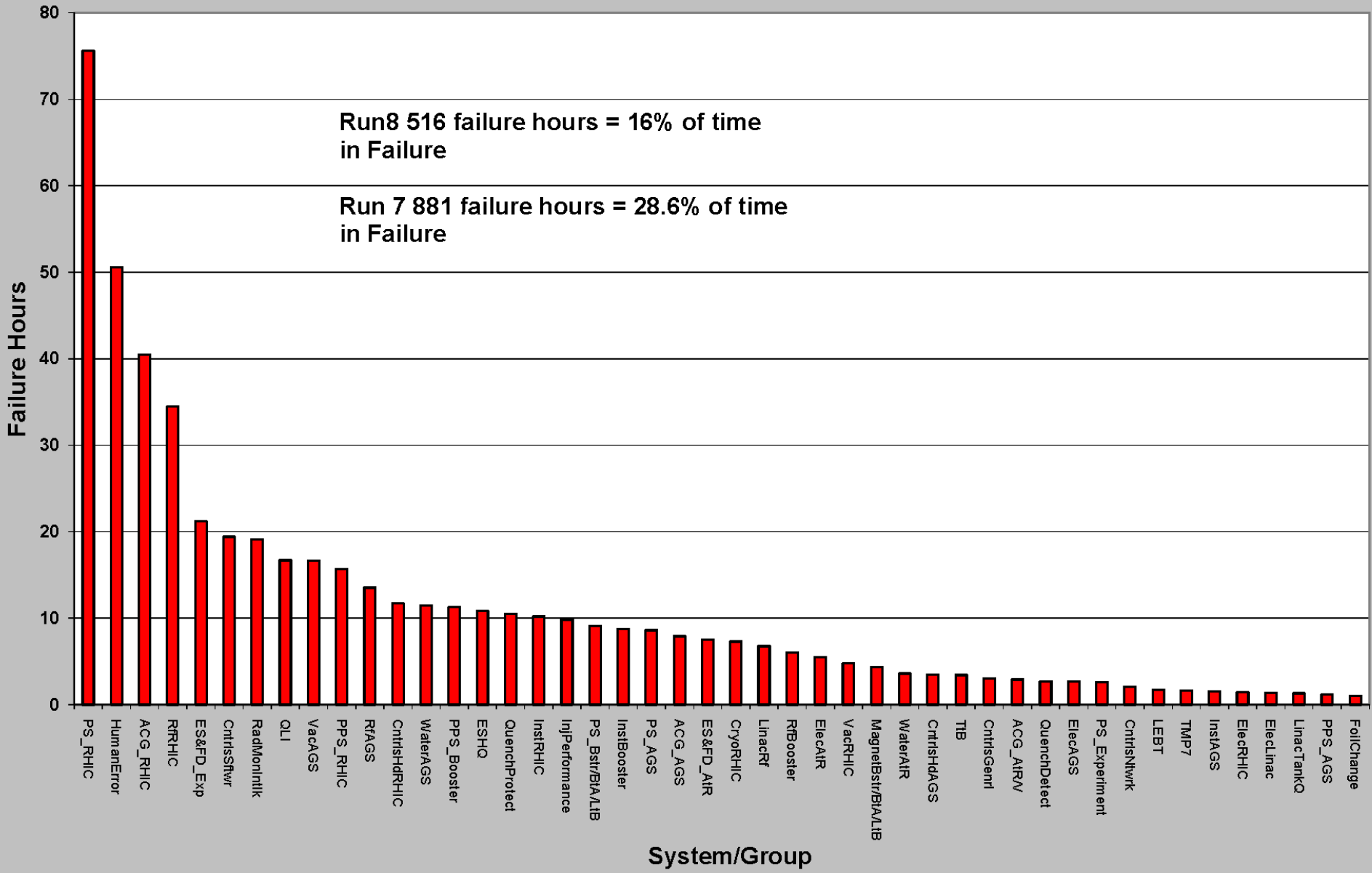
- time in store was 58% of calendar time (48% in Run-7 Au-Au)

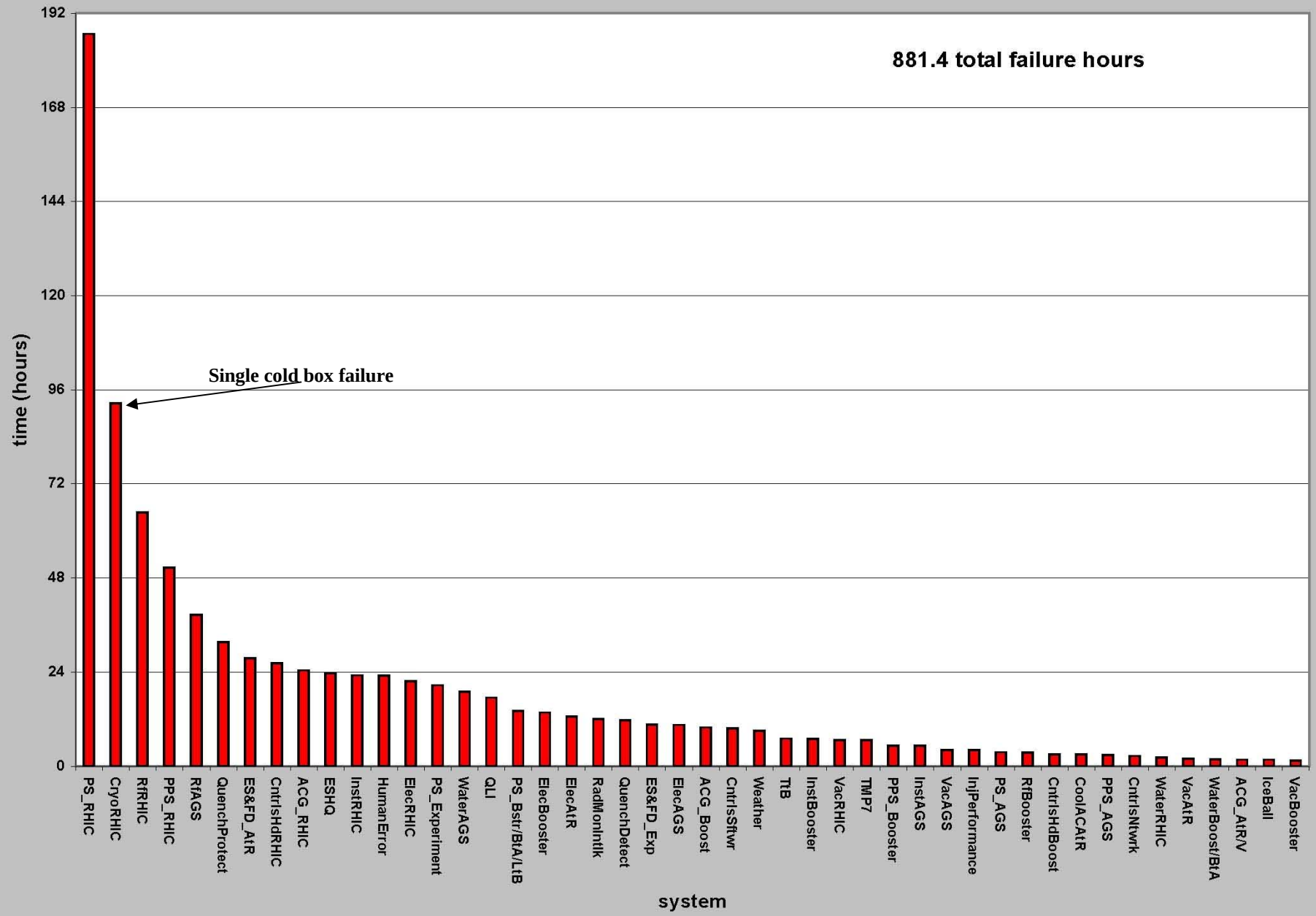

Run-8 Delivered d-Au Luminosity for Physics
(singles corrected)
Integrated luminosity [nb-1]
250
200
150
100
50
0
PHENIX
STAR
Max projected
Min projected
Run3
11/26
12/3
12/10
12/17
12/24
12/31
1/7
1/14
1/21
1/28
Calendar time [2007/2008]


RHIC nucleon-pair luminosity L_{NN} delivered to PHENIX
Nucleon pair luminosity L_{NN} [pb^{-1}]
1000
100
10
1
0.1
0.01
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Calendar year
Au-Au
p-p
Au-Au
p-p
d-Au
p-p
Au-Au
p-p
Cu-Cu
p-p
p-p
Au-Au
d-Au
p-p
$\mathcal{P}$=15%
$\mathcal{P}$=34%
$\mathcal{P}$=46%
$\mathcal{P}$=46%
$\mathcal{P}$=60%
$\mathcal{P}$=45%
Last update: 10 March 2008


RHIC time in store
60%
50%
40%
30%
20%
10%
0%
Run-2 Au-Au
Run-2 p-p
Run-3 d-Au
Run-3 p-p
Run-4 Au-Au
Run-5 Cu-Cu
Run-5 p-p
Run-6 p-p
Run-7 Au-Au
Run-8 d-Au
Run-8 p-p

Run8 Failure Hours (> 1 Hr.) by Group/System




Run 7 Failures by system (to 6/26)
881.4 total failure hours
Single cold box failure
time (hours)
192
168
144
120
96
72
48
24
0
PS_RHIC
CryoRHIC
RfRHIC
PPS_RHIC
RfAGS
QuenchProtect
ES&FD_AtR
CntrlsHdRHIC
ACG_RHIC
ESHQ
InstRHIC
HumanError
ElecRHIC
PS_Experiment
WaterAGS
QLI
PS_Bstr/BtA/LtB
ElecBooster
ElecAtR
RadMonIntlk
QuenchDetect
ES&FD_Exp
ElecAGS
ACG_Boost
CntrlsSftwr
Weather
TtB
InstBooster
VacRHIC
TMP7
PPS_Booster
InstAGS
VacAGS
InjPerformance
PS_AGS
RfBooster
CntrlsHdBoost
CoolACAtR
PPS_AGS
CntrlsNtwrk
WaterRHIC
VacAtR
WaterBoost/BtA
ACG_AtR/V
IceBall
VacBooster
system

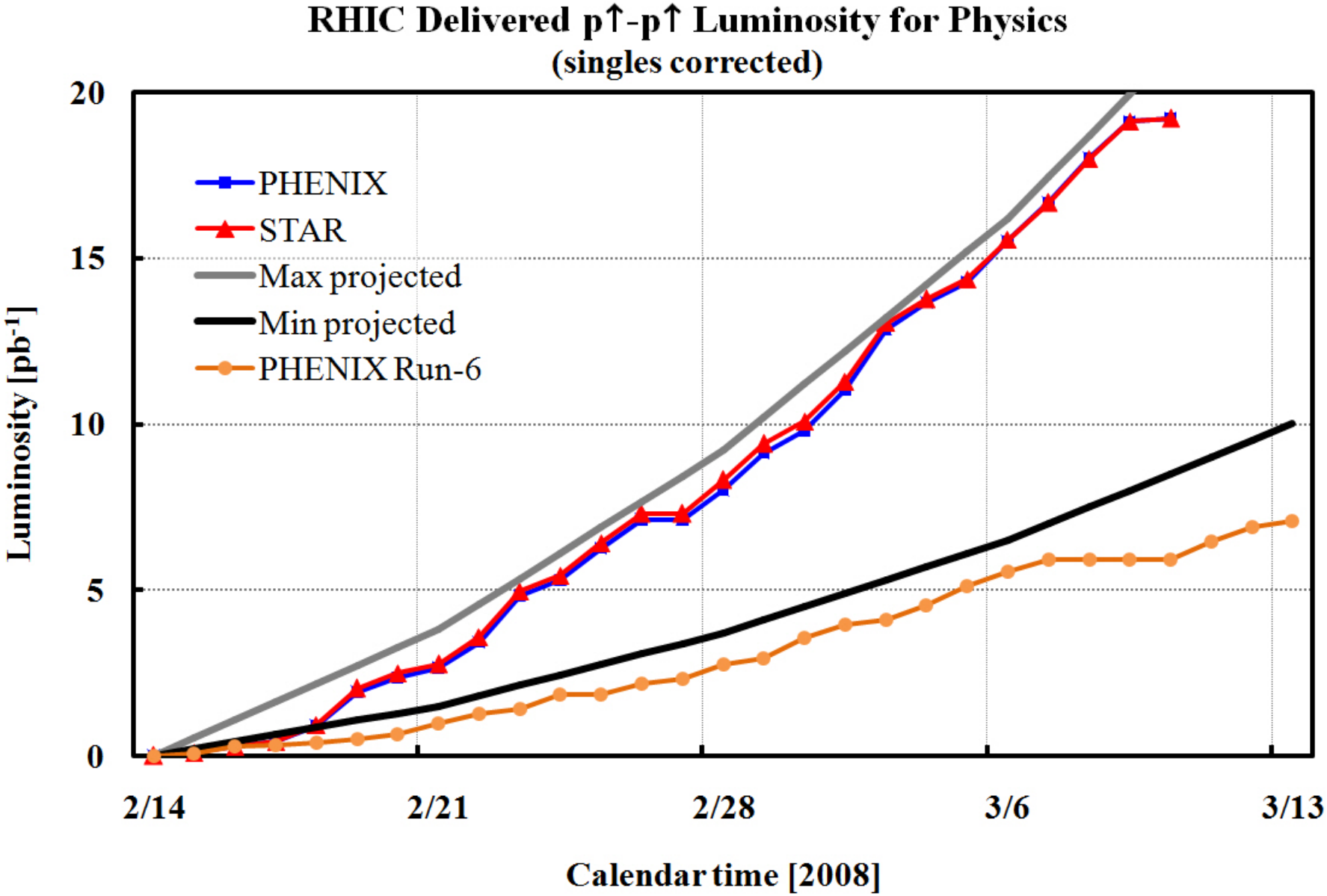
RHIC p-p Highlights

100x100 GeV for PHENIX and STAR

- average store luminosity $23 \times 10^{30} cm^{-2} s^{-1}$, 15% increase over Run-6
- polarization about 10% (absolute) lower than in Run-6
  (50% of difference from source, 50% from short AGS setup)

- tested near-integer working point
  (abandoned because of 10 Hz triplet vibration lead to large and modulated background)
- tested $\beta^* = 65cm$
- tested injection on the fly in AGS (no dwell field)

- time in store was 60% of calendar time (46% in Run-6 p-p)
  (but no rotator ramps for most part of run)



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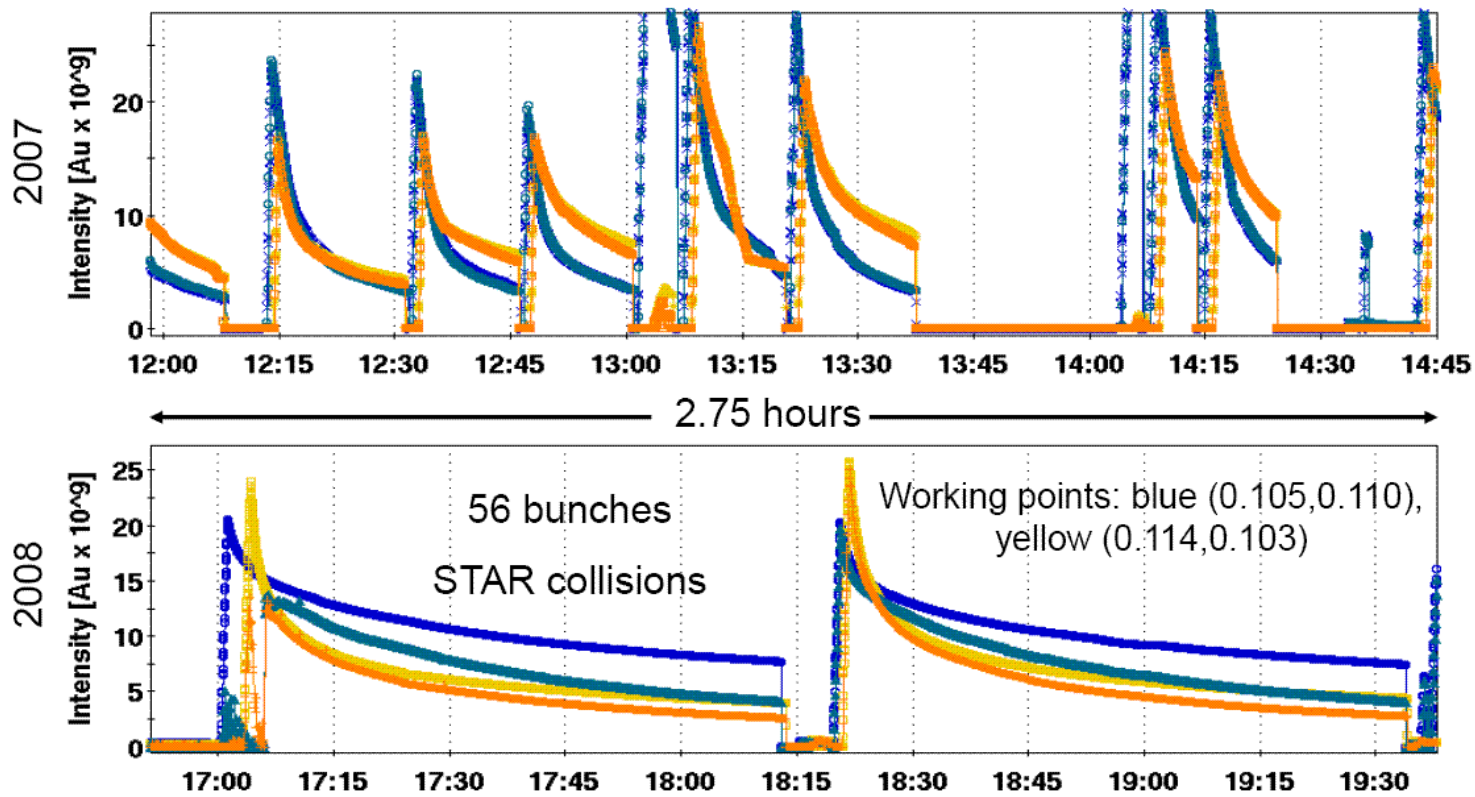
RHIC Au-Au operation at √s = 9 GeV

2007 vs 2008 Low Energy Test: Beam Lifetime



2007

2008

- 2008 blue beam lifetime: 3.5 minutes (fast), 50 minutes (slow)
- Sextupole reversal and elimination of octupoles clearly helped beam lifetime
- Injection efficiency and yellow beam lifetime can clearly benefit from further tuning

Also tested √s = 5 GeV with Yellow beam only – bunched beam lifetime only seconds.

R&D

C-AD R&D

Focus on 2 main areas: RHIC and eRHIC

Luminosity and polarization performance for RHIC

- Heavy ion stochastic cooling (DOE, BNL) - See Brennan presentation
  - Longitudinal yellow system is operational, longitudinal blue system is ready but not yet used under operational conditions (had d beam in Blue ring in Run-8)
  - Transverse systems are under design, 1st plane to be installed for next run
- Polarized protons development (source, AGS, RHIC)
- Electron lenses for head-on beam-beam compensation
- Coherent Electron Cooling for protons – See BenZvi presentation

eRHIC design

- ERL (BNL, US Navy, AES) - See Ben-Zvi presentation
- eRHIC design (MIT-Bates, Novosibirsk, JLab). See Vladimir Litvinenko presentation
  - Focus on linac-ring design. ERL will be required.
  - Magnet prototype (LDRD)
- Polarized He^3 source
- Polarized electron gun (MIT)

WHITHER RHIC II ? (see breakout presentations)

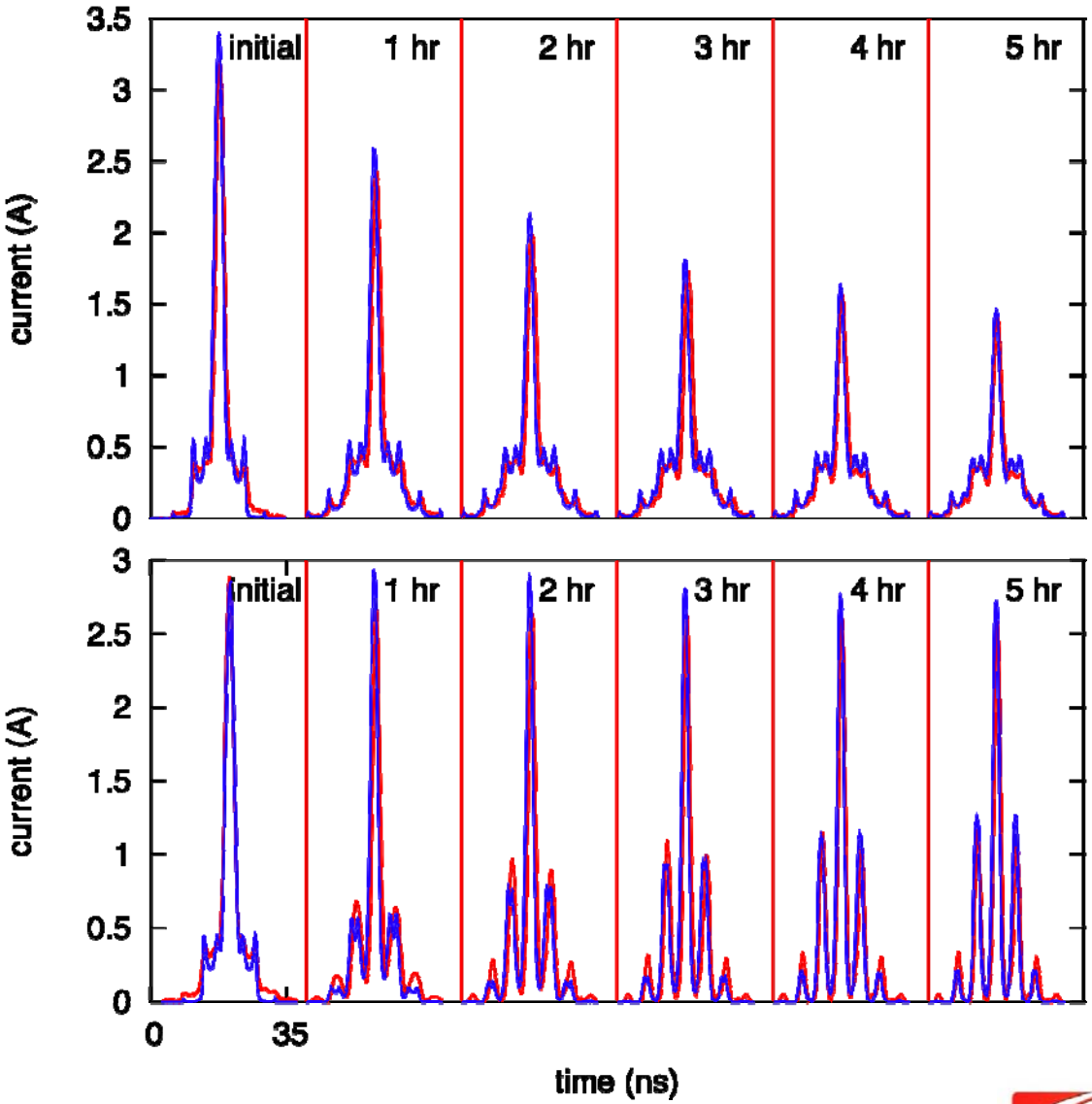
- Stochastic cooling + 56 MHz cavity is estimated to cost ~$10M and provide ~6-8 luminosity increase
  - Additional 56 MHz rf system and harmonic number = 720, migration of beam to neighboring buckets can be greatly reduced and luminosity increased by 30%

- Electron cooling was estimated to cost ~$100M and provide x10 luminosity increase

⇓

~~RHIC II~~

Longitudinal Stochastic Cooling (see Brennan presentation)



No cooling

Cooling

Data = red
Blue = simulation

ERL & Electron cooling R&D (see Ben Zvi presentation)

Progress to date:

- Detailed studies of traditional electron cooing for RHIC has been completed
- Novel scheme of Coherent Electron Cooling (CeC) has been proposed
- Studies of CeC are underway
- ERL R&D was carried our to address the issues for eRHIC - both for 20 GeV electron accelerator and CeC
- Navy added $1.3M direct to the $1M from DOE
- DOE SBIR added $0.15M

Expected progress:

- 5-cell high-current cavity successfully tested vertically, horizontal test at BNL in 2008
- 1 MW klystron installed, undergoing acceptance test
- Photocathode preparation chamber has been delivered
- Laser to be delivered 2008
- Many components fabricated
- Most of magnetic measurements has been completed
- Beam test of gun + cavity in 2009
- Beam in ERL in 2010
- Test of coherent electron cooling at RHIC in 2012

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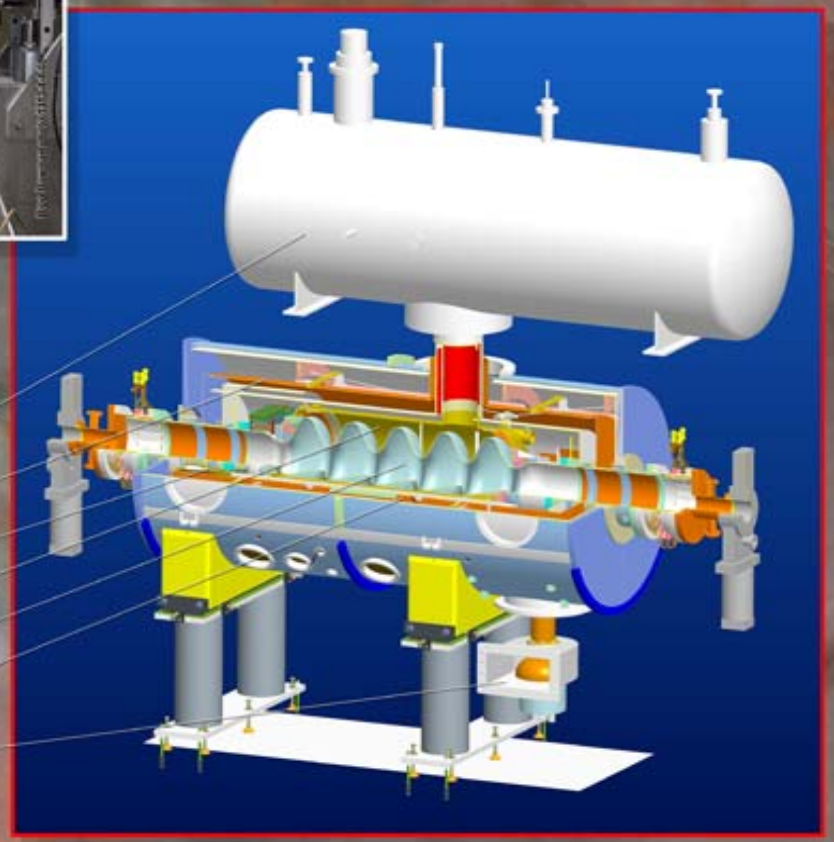
Energy Recovery Linac 5-Cell Super Conducting RF Cavity

5-Cell Cavity in Fabrication Fixture Assembly



Issues

- Yearly CRs wreak havoc on operations. Base funding level is inadequate to start without a modest increase.

- Buildup of GSO to minimize annual congressional budgetary inactions effecting running schedule was accomplished in FY2007, but was spent in FY2008 to allow for an additional 6 weeks, for a total of 19 weeks.

- Increased support for accelerator R&D
  - We are clearly supportive of the ONP FY2009 initiative to broaden an increase accelerator r&d across the university and laboratory community
    - 2-3% of RHIC ops (NP) budget is applied to next generation developments
    - eRHIC focus includes polarized electron source r&d at MIT
      - No funding was available for MIT in FY2008

- Delayed EBIS funding of $2.4M into FY2009 eliminated most of project float, but will still allow to meet CD4 date
- Beam availability almost at maximum projection
  - Power supply failures are diminished by 50% but still the major problem
  - Focus also on human performance

2007 (2008) Summary

- **FY2007 delivered luminosity goals were met, resulting in another excellent year. FY2008 delivered x10 d-AU over previous Run 3**

- **RHIC average store luminosity increased by 2.5 over previous Au run. Now at 1.5 over enhanced design luminosity goal and 6 over design specification. Did not run Au-Au in Run 8. pp focus was to deliver luminosity for STAR.**

- **Challenge #1 is to increase the availability to provide even more luminosity and improved availability in FY2008. Increased availability to 58% (d-Au, 97% of maximum) and 60% (p-p, 100% of maximum)**
- **Challenge #2 is to reach RHICII specifications at minimal cost. RHICII cost reduced by 90%**
- **Challenge #3 is to minimize the technical and fiscal risks for eRHIC. Several possibilities under study, including a phased energy approach.**