BROOKHAVEN NATIONAL LABORATORY

RHIC Run 2016

Xiaofeng Gu

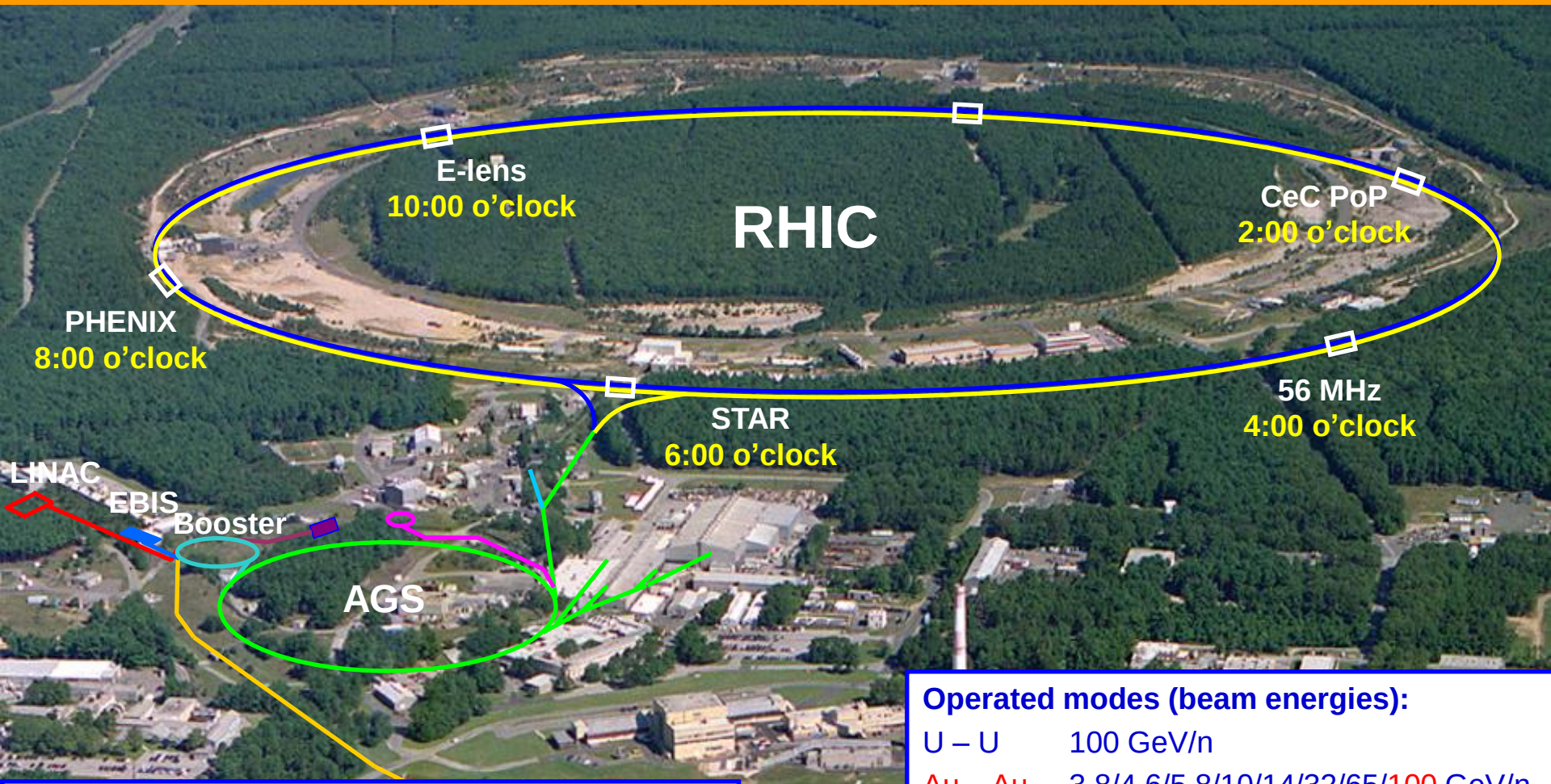
for CAD

June 09, 2016
RHIC & AGS Users' Meeting

Outline

- High Intensity Beam
- Machine Protection
- Parameters and Achievements
- Sub-systems
- Summary

RHIC – a High Luminosity (Polarized) Hadron Collider



Achieved peak luminosities:

Au–Au (100 GeV/n) 155×10^{26} cm^{-2} s^{-1}

p↑–p↑ (250 GeV) 245×10^{30} cm^{-2} s^{-1}

Performance defined by

1. Luminosity L
2. Proton polarization P
3. Versatility (species, E)

Operated modes (beam energies):

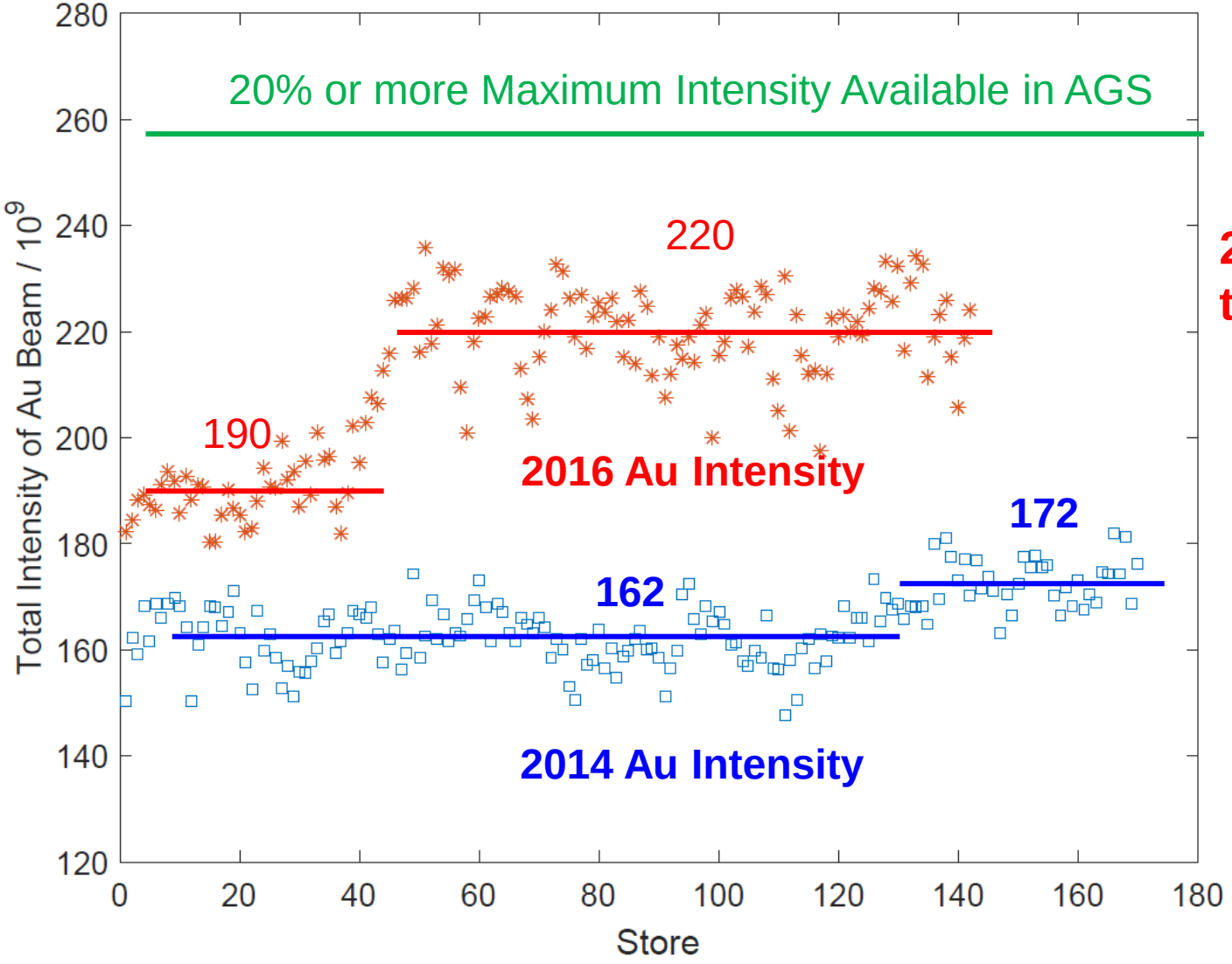
U – U	100 GeV/n
Au – Au	3.8/4.6/5.8/10/14/32/65/100 GeV/n
d – Au	9.8/19.5/31.2/100 GeV/n
Cu – Cu	11/31/100 GeV/n
p↑ – p↑	11/31/100/205/250 GeV
H3 – Au	100 GeV/n
p↑ – Al	100 GeV/n
p↑ – Au	100 GeV/n

2016 Run Schedule

Run-16 (last run for PHENIX, sPHENIX in ≥ 2022)

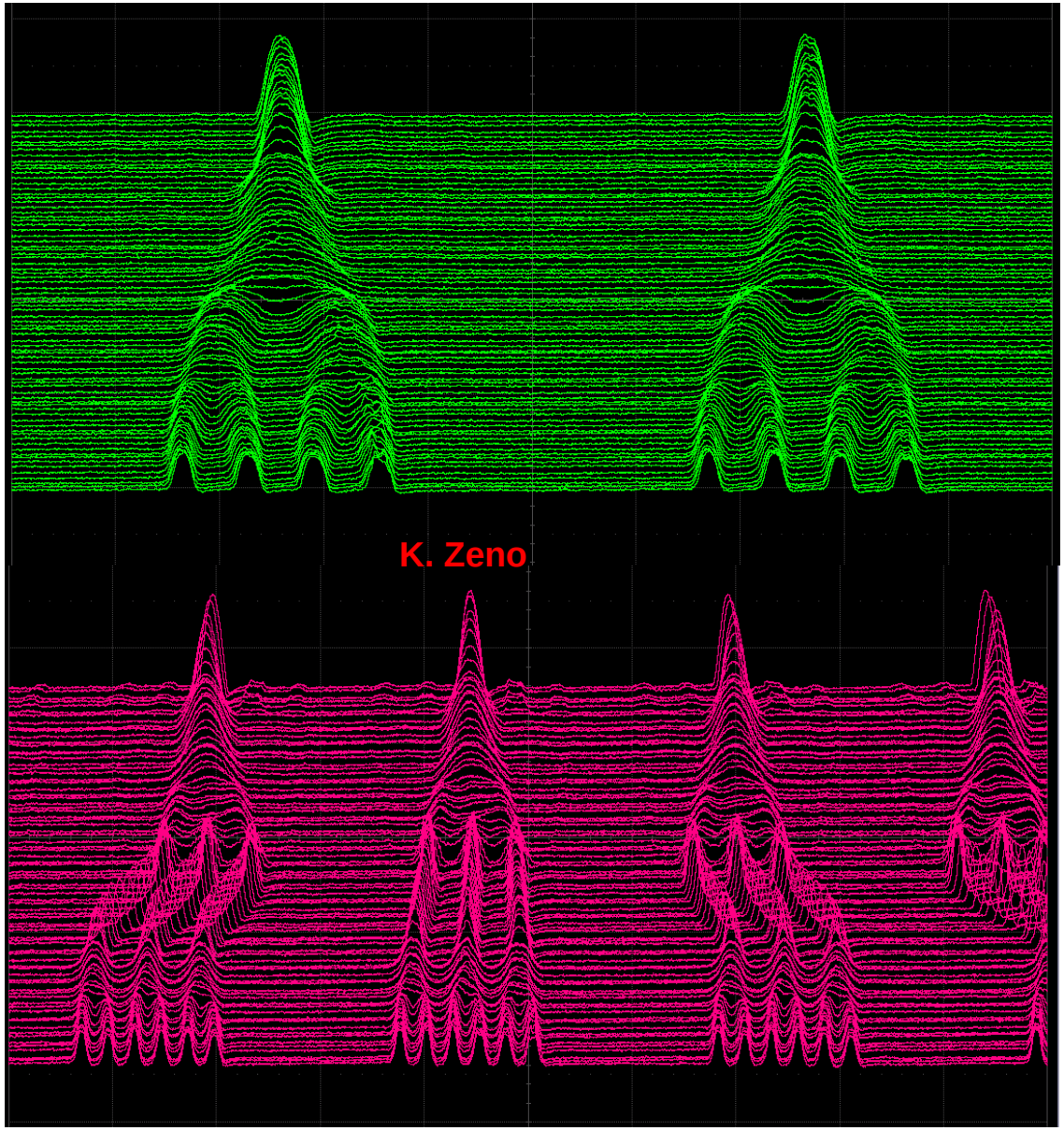
- Au+Au at 100 GeV, **10** weeks physics + 19.5 days diode repair
- d+Au at 9.8/19.5/31.2/100 GeV, **6** weeks
  PHENIX / STAR protection, minimization of setup time
- CeC PoP, **1** week
  Coherent electron Cooling (Proof of Principle) is a novel cooling technique for potential application in eRHIC.

Au Intensity Limits in RHIC



28% more intensity than in Run-14

More Au Intensity from Injectors in 2016



Run14: 8->4->2 merge in AGS

Run16:12->6->2 merge in AGS

Run14: 2.1E9 in AGS

Run16: 3.15E9 in AGS

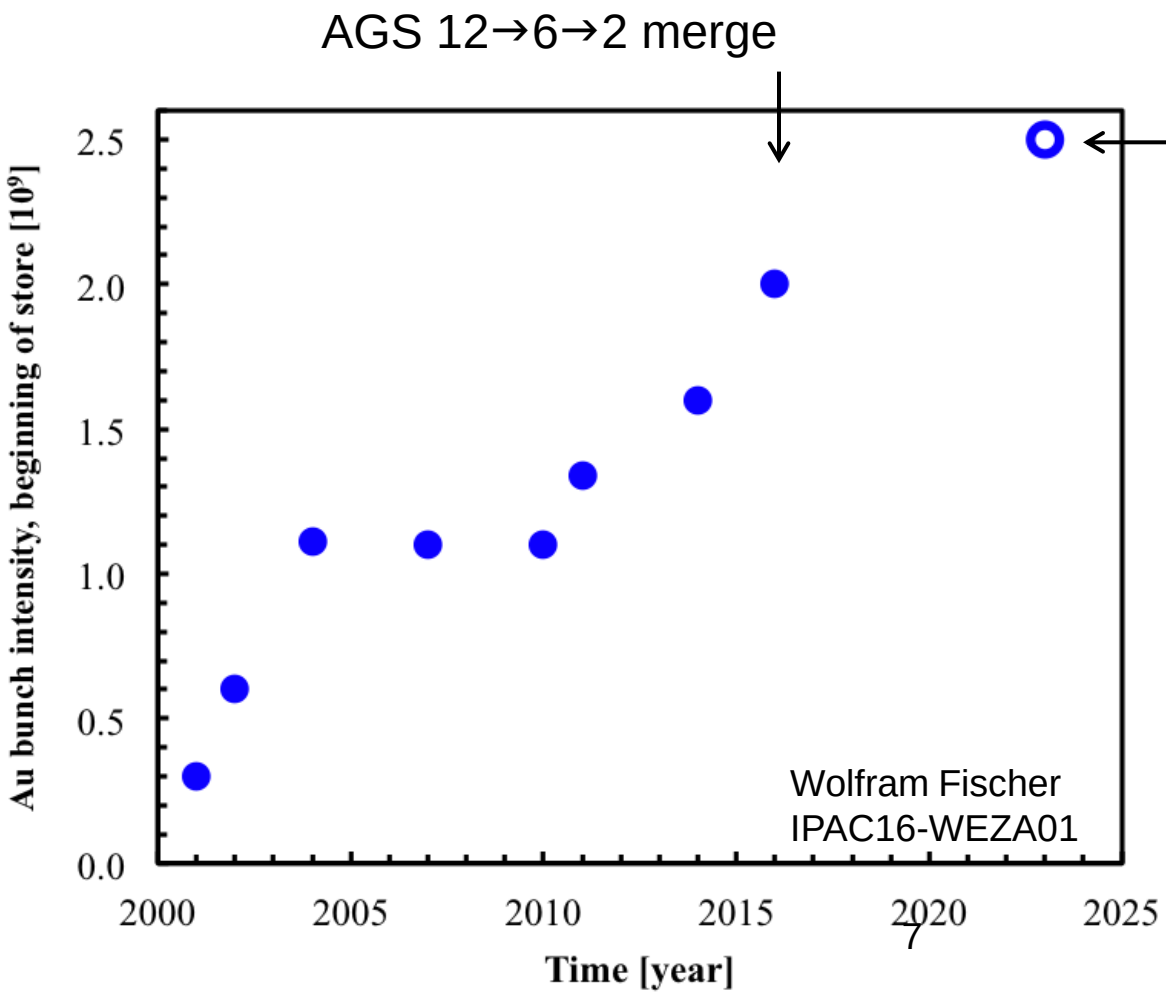
Injection: 2.5E9 from AGS used

~20% more intensity available

Limited by Landau Cavity

Au Bunch Intensity Evolution

$$L(t) = \frac{1}{4p} f_0 N \frac{N_b^2(t)}{e(t)b^*(t)} h(b^*, s_s, q)$$



main limits:
- injectors output
- transition instability in RHIC (e-clouds)
- **presently Landau cavity RF amplifiers**

H. Huang, K. Gardner, K. Zeno, RF, et al.

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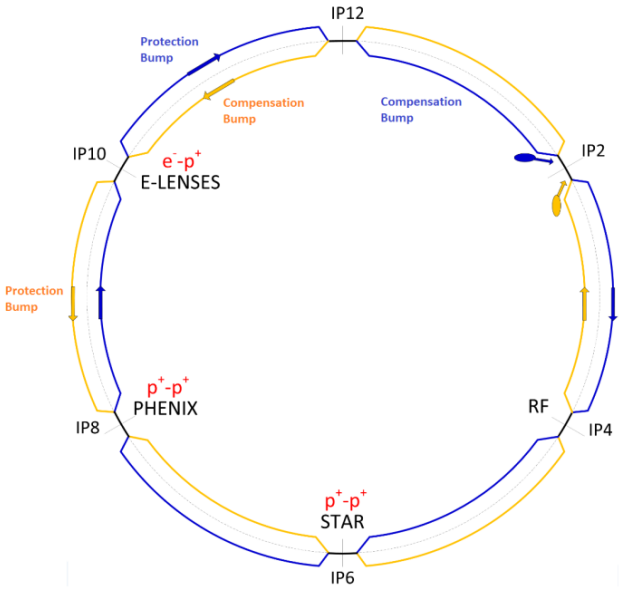
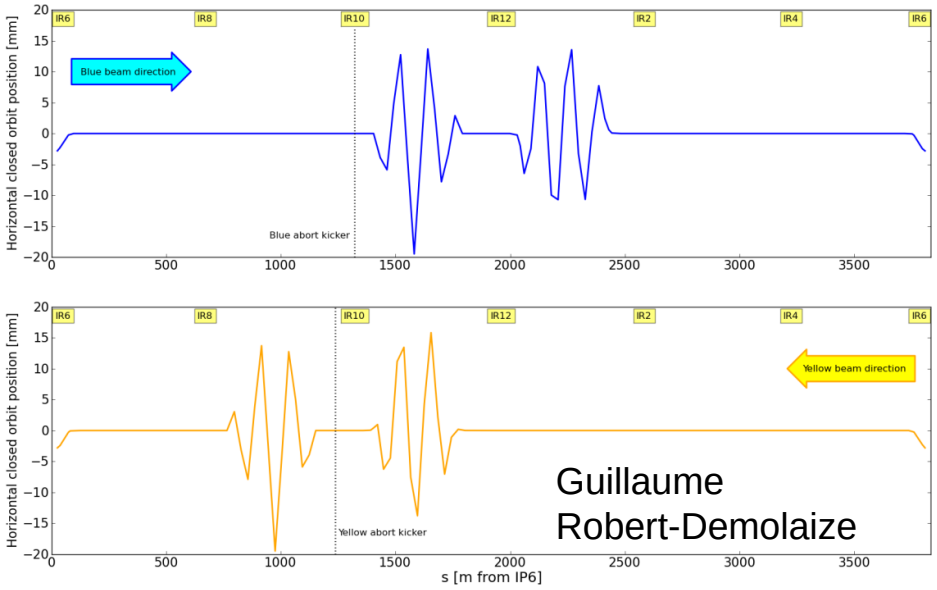
Protection Bump and Beam Loss



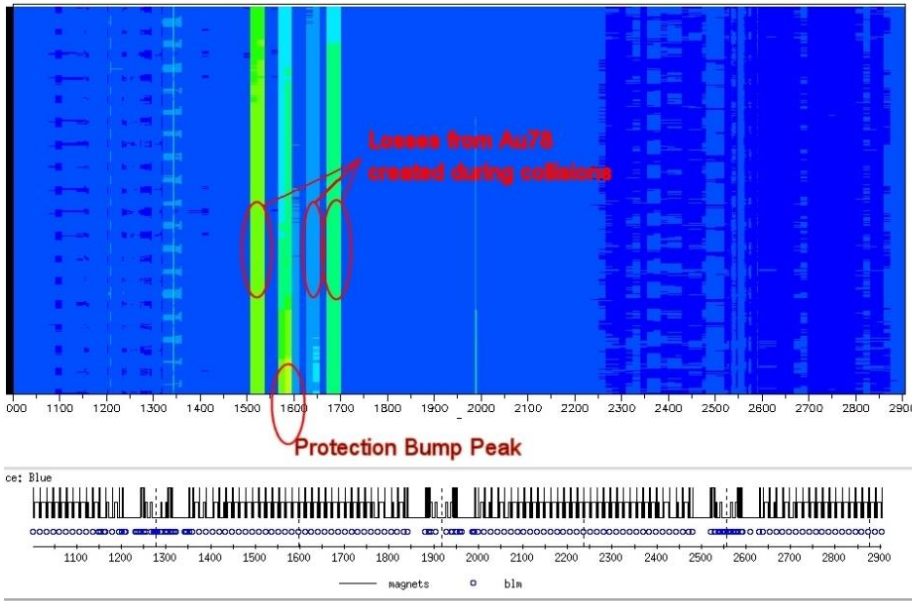
To protect detectors, the protection bumps were installed from Run14.

The chronic beam loss near protection bump comes from luminosity/collision; Pre-fire/de-bunched beam also causes acute beam loss there;

A mechanical switch in series with the thyratron (M. Chiu, A. Drees & CAD) can resolve this problem.



Guillaume Robert-Demolaize



B10D19 Magnet Diode Failure

Beam Loss Caused Quench on 3/17;

QD trip link on 3/18;

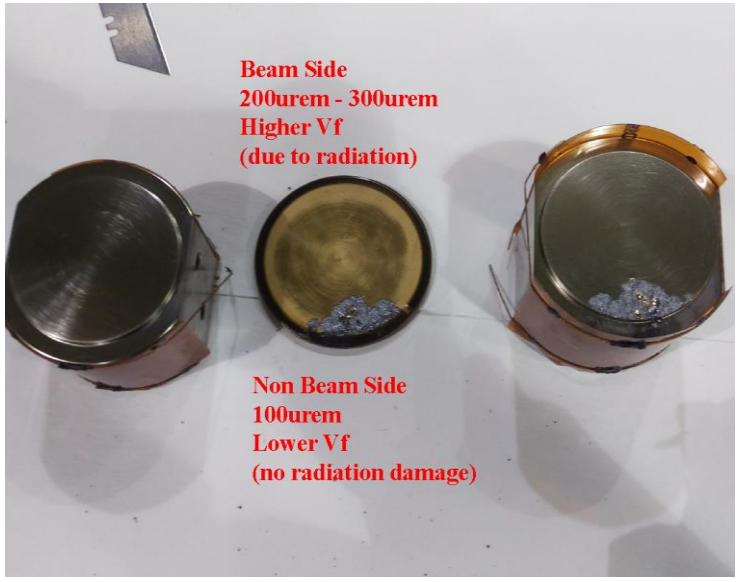
Confirm magnet problem;

Warm up and cut it open;

Replace and test new diode;

Cooling down and hi-pot;

4/6 had physics again.



Appreciate to everyone for the excellent coordination and support from the Collider-Mechanical Group, Radiological Control Division, Collider Electrical Power Supply Group, Vacuum Group, Cryogenic Group, Operations Group, Superconducting Magnet Division and BNL Central Shops that made extraordinary contribution to the repair.

A special thanks to Gary McIntyre, Scott Seberg, Richard Anderson, Harold Dorr, Rob Karl, Mark Lavery who planned and executed the tunnel work together with the BNL welders and outstanding support from Paul Berg and his team; and Don Bruno, George Ganetis (NSLS-II), Gregg Heppner, Theo Samms, Don Gosline, Joe Drozd, Ken Hartmann, John Adessi, Femi Bamgbose, Erik, and Chaofeng Mi and others who diagnosed the problem.

Called into service all hours of the day and night; CMS and weld team worked 12 hour shifts 24 /7; put on shift with minimal heads up

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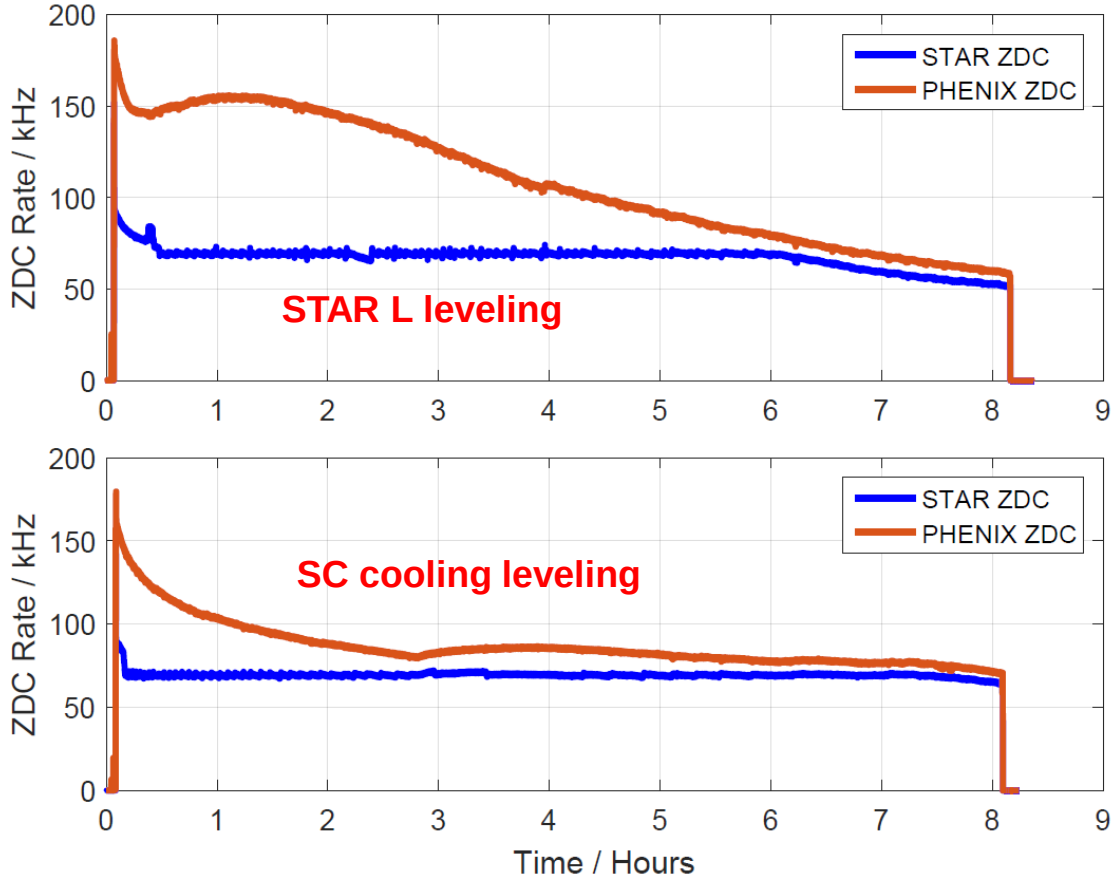
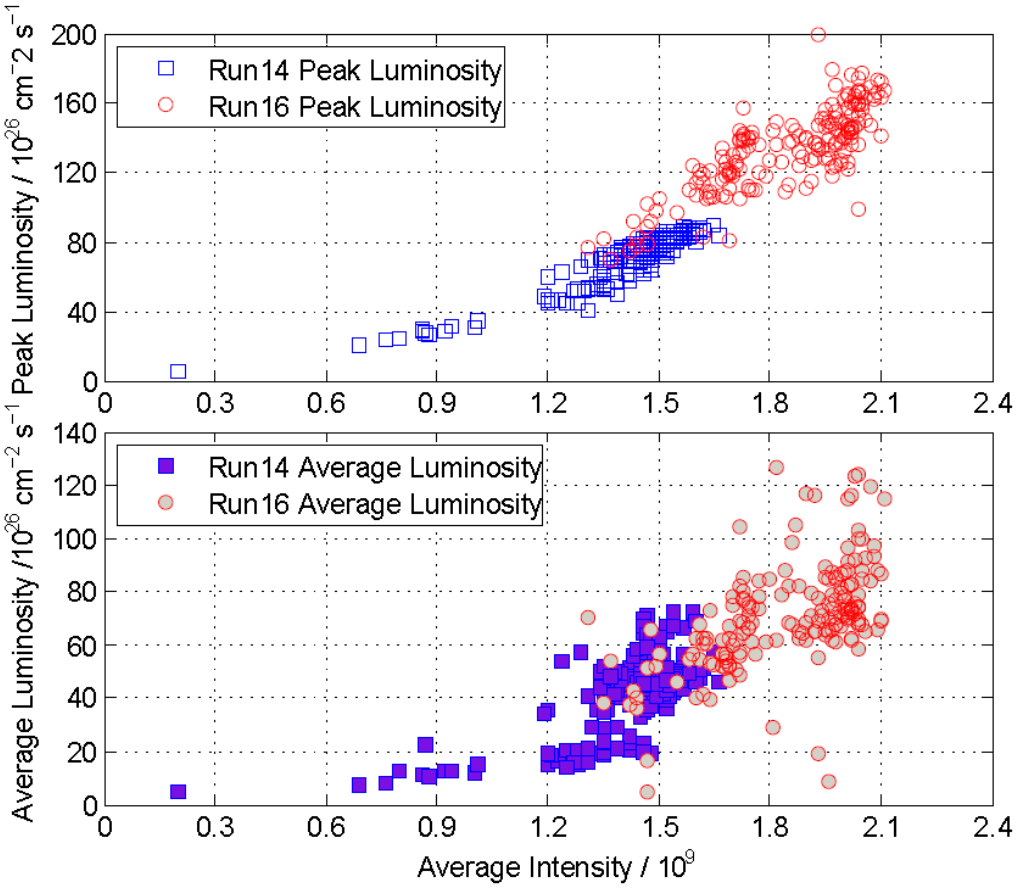
Store with Star Luminosity Leveling



1. Starts leveling from the beginning of store with 70 kHz (60kHz for several stores);
2. Vertical separation was used for leveling;
3. Reduced initial SC cooling to reduces beam loss and L in PHENIX, preserves intensity, and allows for longer leveled stores for STAR (bottom plot)

Peak and Average Luminosity

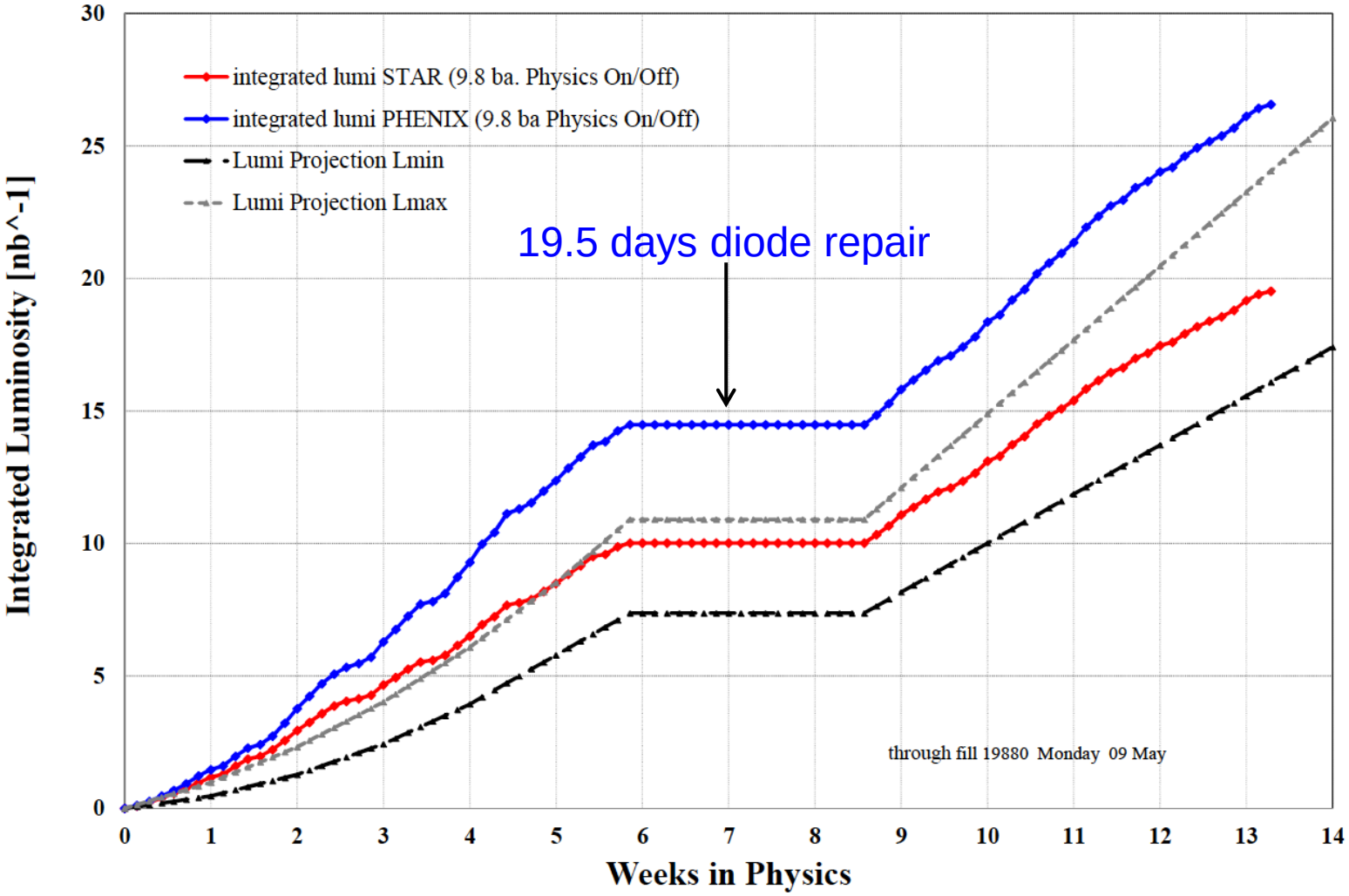


1. L_{peak} +80%

2. L_{avg} +60%

1. Average all peak luminosity: 80% more
2. Average all average luminosity: 60% more
3. Excluded 12 extremely low intensity store for Run14 for luminosity.

Run16 Delivered Luminosity



This plot can't represent the **best RHIC performance** because of leveling.

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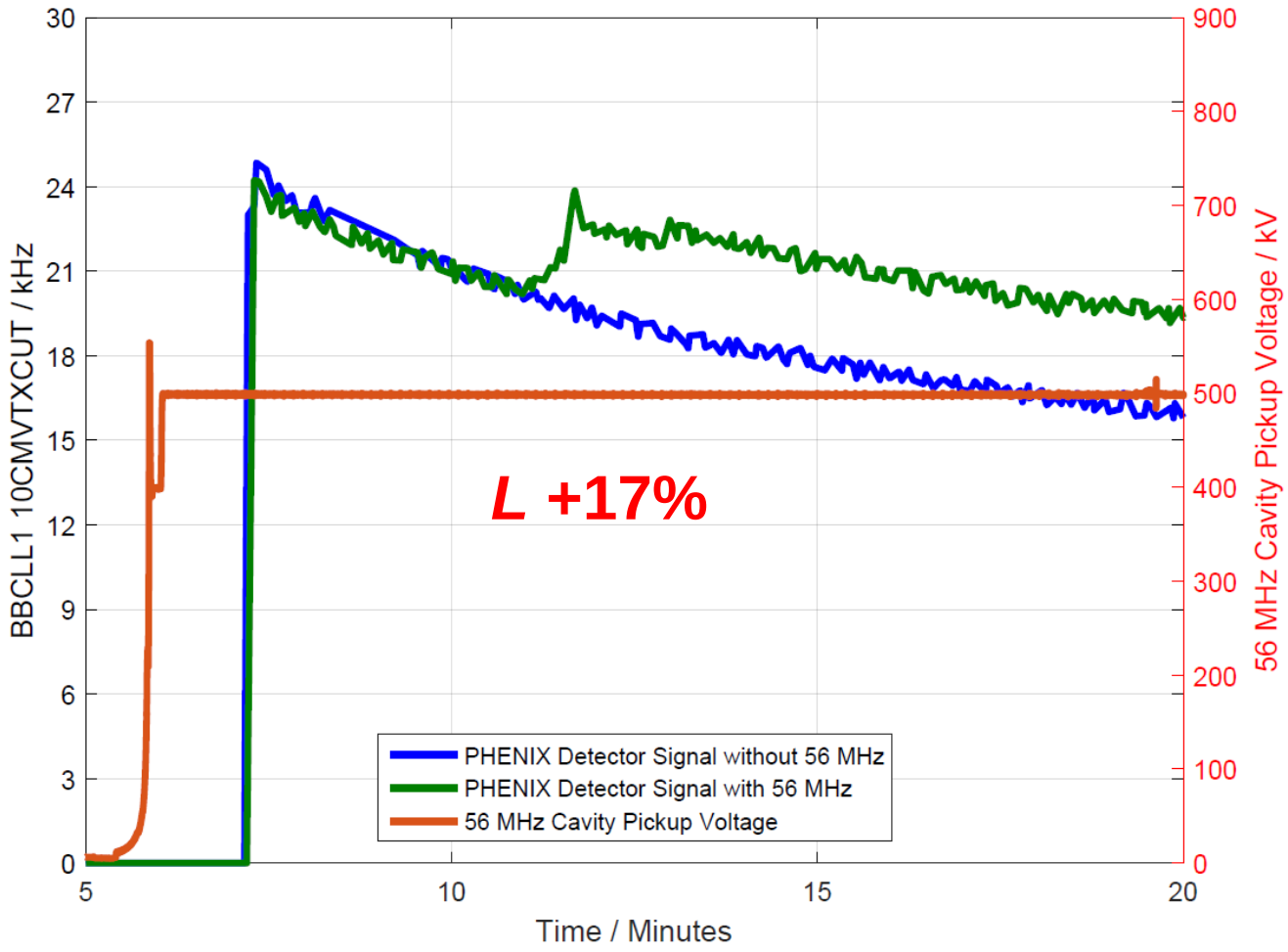
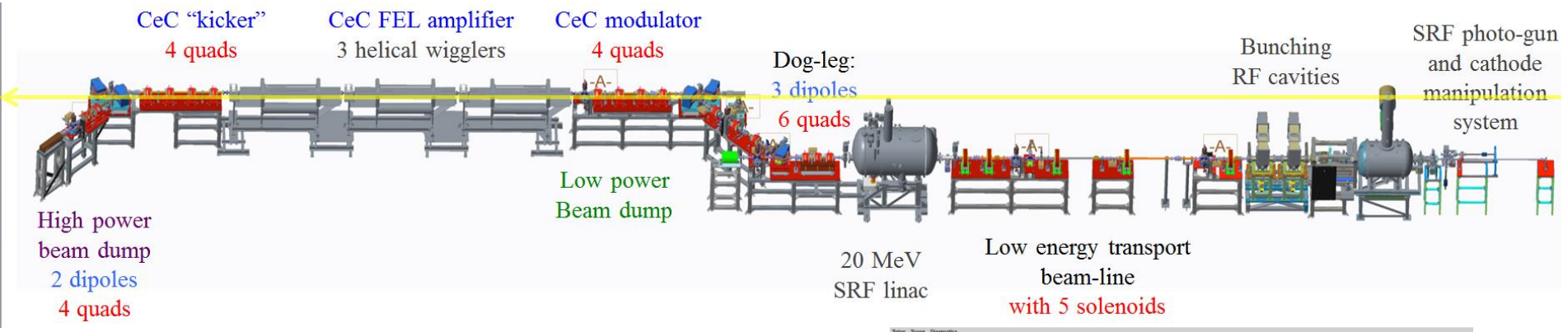
56 MHz Cavity: Commissioning and Operation



Full operational during d-Au run (the first operational superconducting RF cavity in RHIC)

CeC PoP: Commissioning

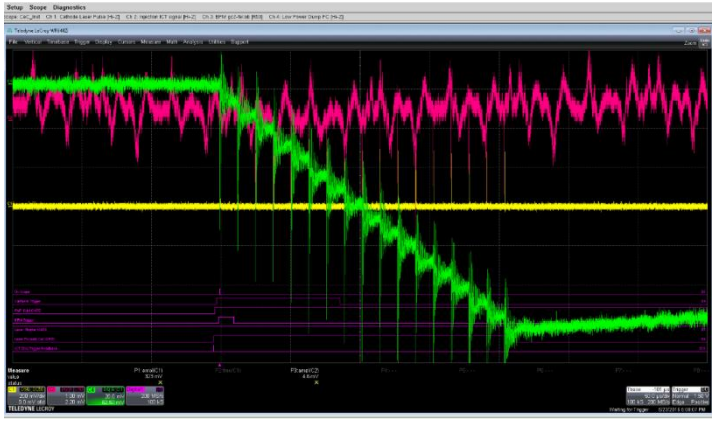


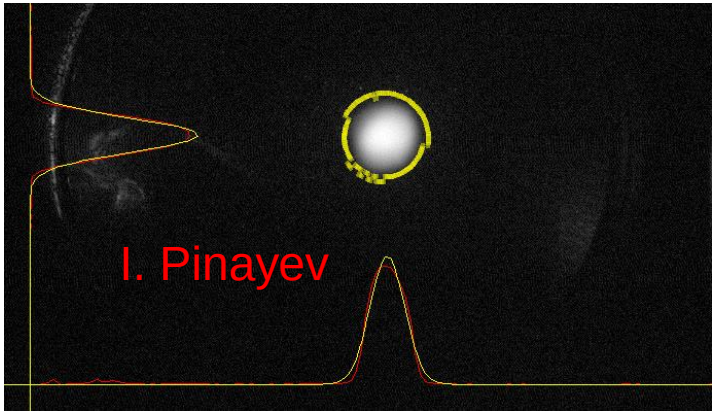
1. Coherent electron Cooling (PoP) is a novel cooling technique for potential application in eRHIC.

2. Installation was completed, the commissioning stage started during 100 GeV run.

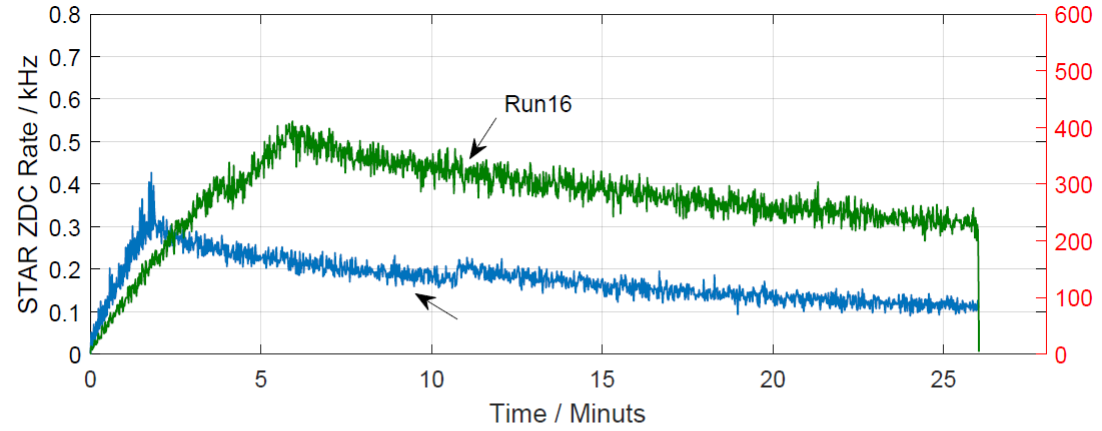
3. Electron beam was propagated to low power beam dump.

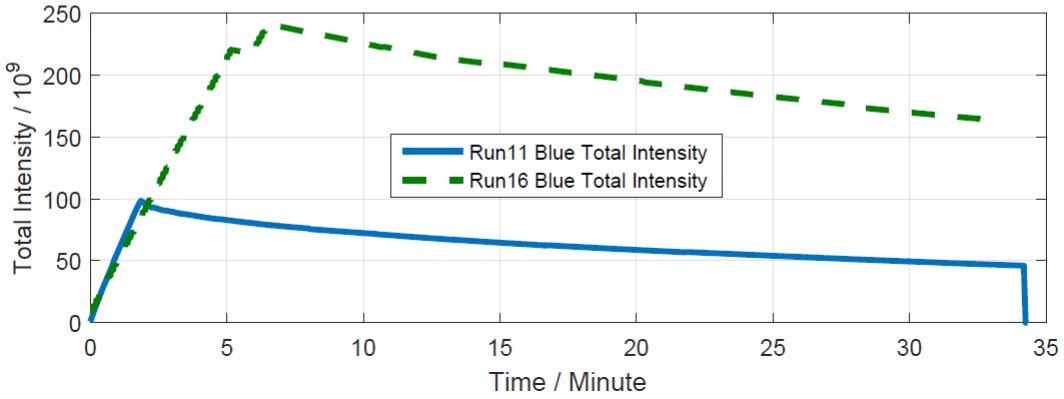
4. 60~100nC charge has achieved with one cathode; beam profile and emittance were measured.





Low Energy Au-Au: Test for Near Future





1. $L_{Integrated}$ +110%

2. $L_{Initial}$ + 70%

1. Run16 Integrated STAR luminosity is **2.1** times of Run11 and 1.7 times for initial luminosity.

2. Energy = **9.8 GeV** (Run11 and Run16), beta* 1.4 time larger;

3. Store15710 (Best store of Run11) and 19659 (Run16)

RHIC 2016 100 GeV AuAu Operation Summary

1. The gold (Au) intensity in the RHIC during the 2016 run exceeded the previously achieved intensity by **28%**. **L_{peak} +80% L_{avg} +60%**

2. There is **20%** (compared with the max. intensity in 2016) more Au intensity available from AGS.

3. With more intensity in the future, the **machine protection** needs to be careful re-evaluated. (Topic of Run16 Retreat)

4. 56MHz is the **first operational** superconducting RF cavity in RHIC machine;

5. Low energy test has **2.1 times** integrated luminosity compared with the best store in Run11.