BROOKHAVEN NATIONAL LABORATORY

RHIC Au-Au Operation at 100 GeV in Run16

Xiaofeng Gu for CAD

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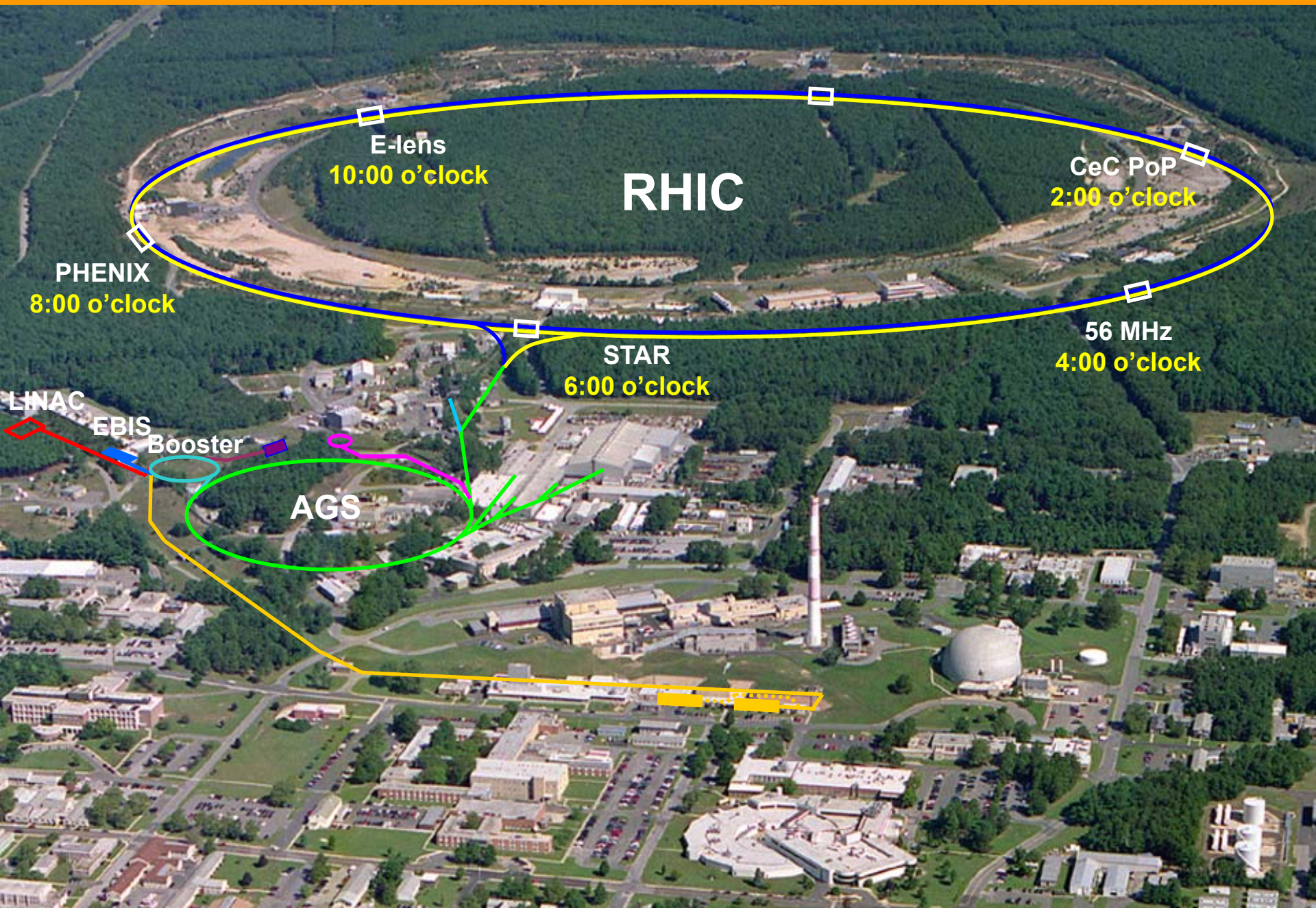
Thanks to the Committee for the invitation!

Outline

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

RHIC – a High Luminosity (Polarized) Hadron Collider



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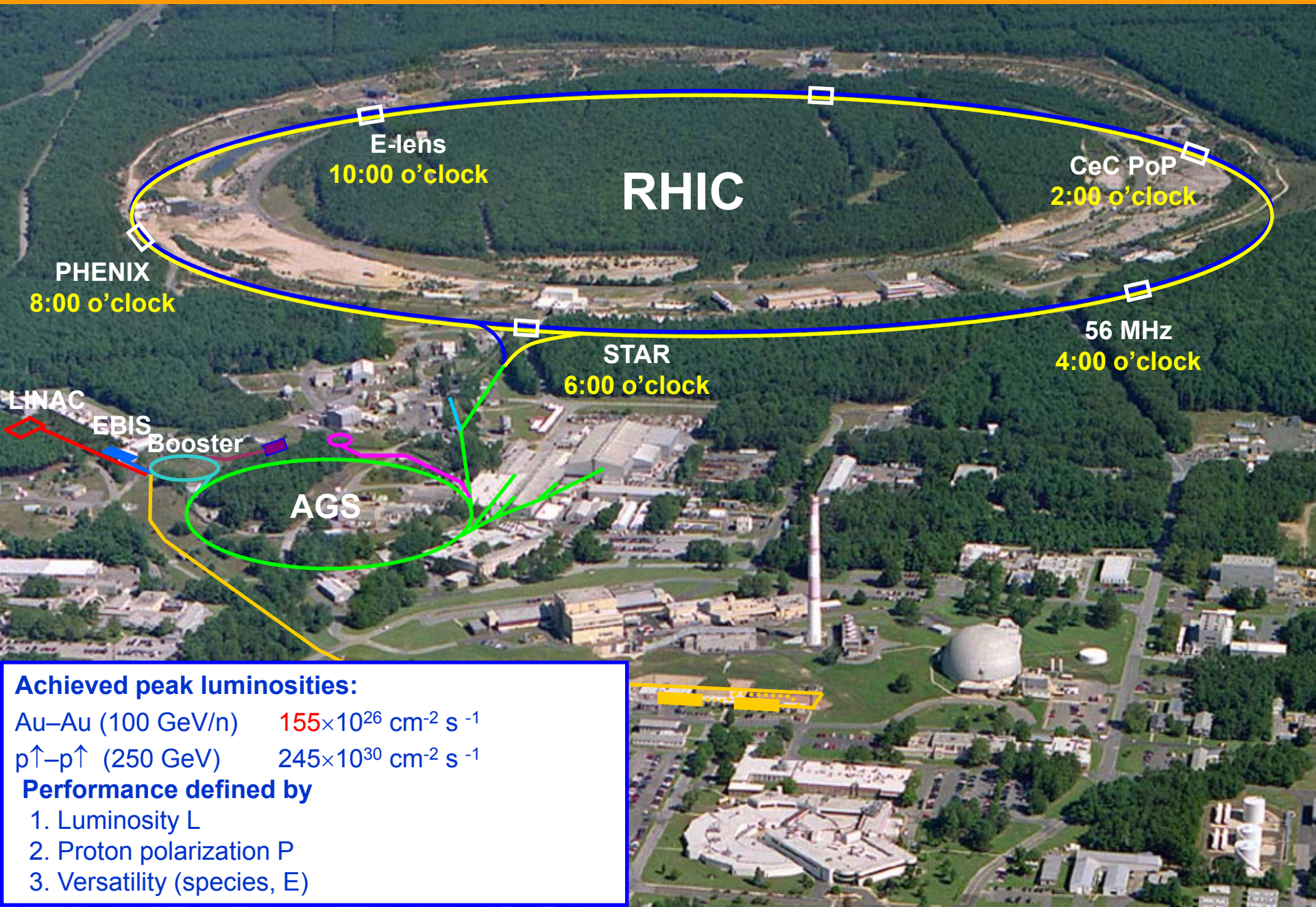

Achieved peak luminosities:

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)

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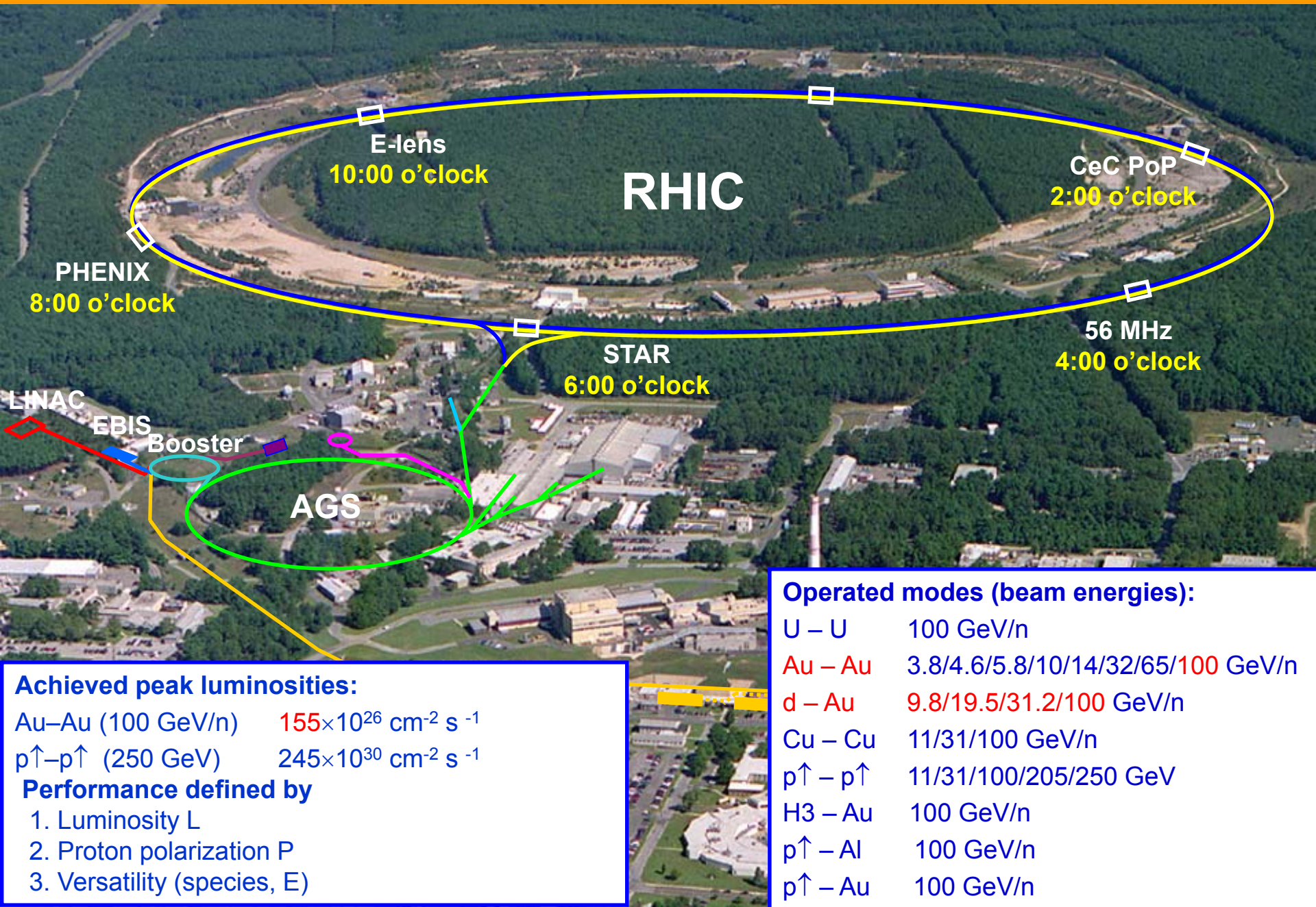

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Operated modes (beam energies):

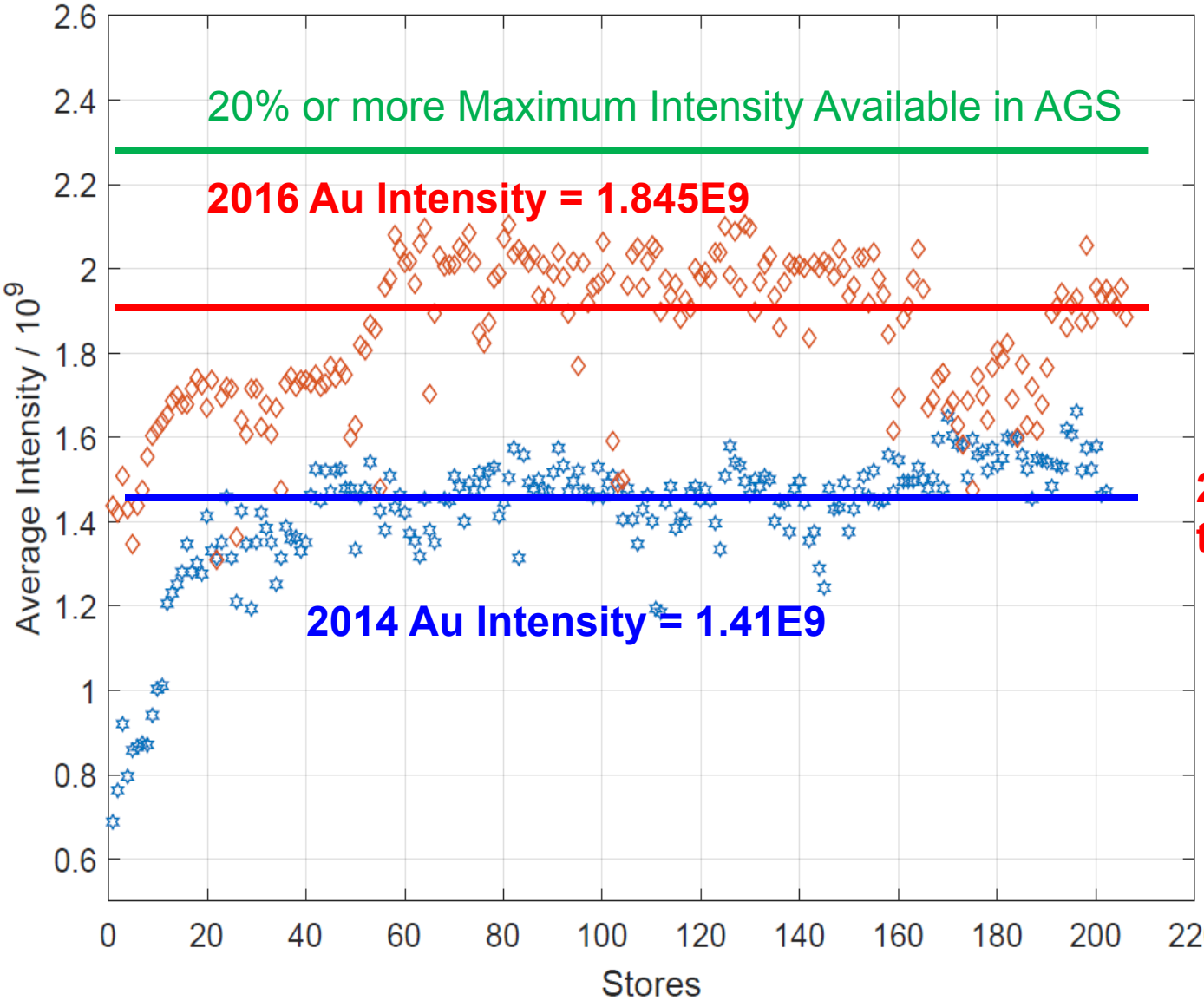
U – U	100 GeV/n
Au – Au	3.8/4.6/5.8/10/14/32/65/100 GeV/n
d – Au	9.8/19.5/31.2/100 GeV/n
Cu – Cu	11/31/100 GeV/n
p↑ – p↑	11/31/100/205/250 GeV
H3 – Au	100 GeV/n
p↑ – Al	100 GeV/n
p↑ – Au	100 GeV/n

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 (re-used for 100 GeV Au-Au run)
  Coherent electron Cooling (Proof of Principle) is a novel cooling technique for potential application in eRHIC.

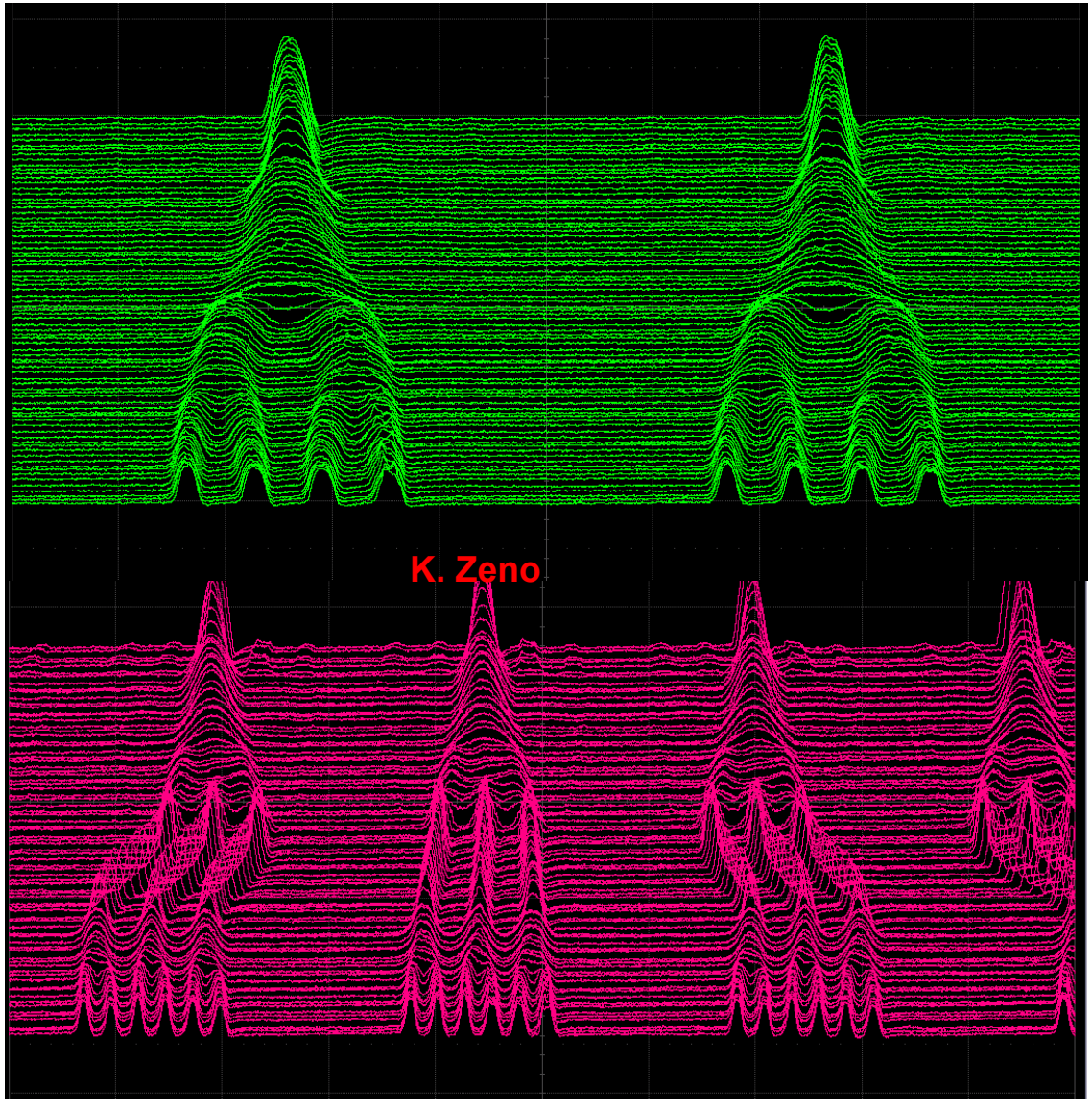
Au Intensity Limits in RHIC



$$L(t) = \frac{1}{4\pi} f_0 N \frac{N_b^2(t)}{\varepsilon(t)\beta^*(t)} h(\beta^*, \sigma_s, \theta)$$

28% more intensity than in Run-14

More Au Intensity from Injectors in 2016



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

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

Max. Intensity in AGS:
Run14: 2.1E9 available in AGS

Run16: 3.15E9 available in AGS

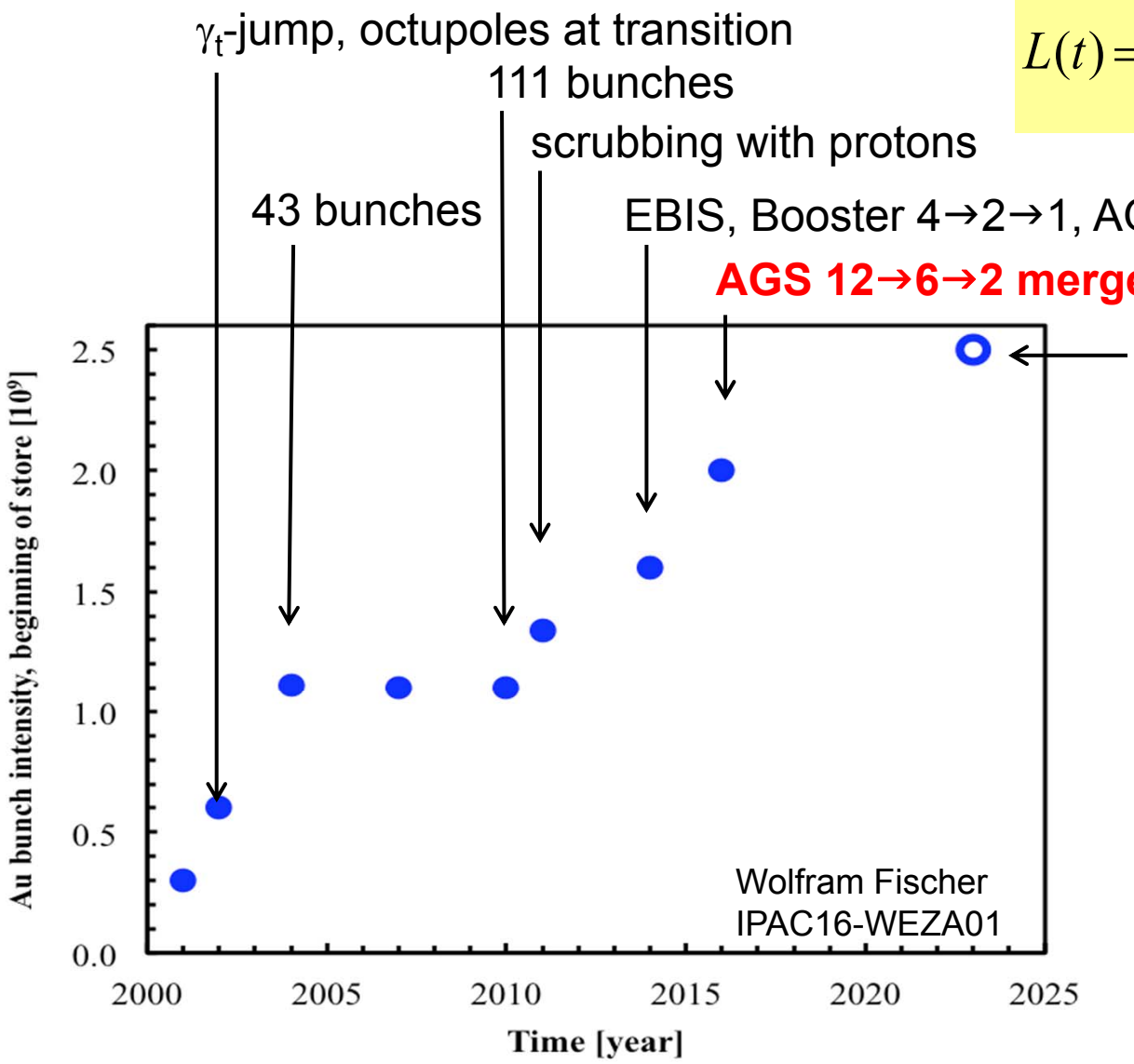
Operation:
Injection: 2.5E9 from AGS used

~20% more intensity available

Limited by Landau Cavity

Au Bunch Intensity Evolution

$$L(t) = \frac{1}{4\pi} f_0 N \frac{N_b^2(t)}{\varepsilon(t)\beta^*(t)} h(\beta^*, \sigma_s, \theta)$$



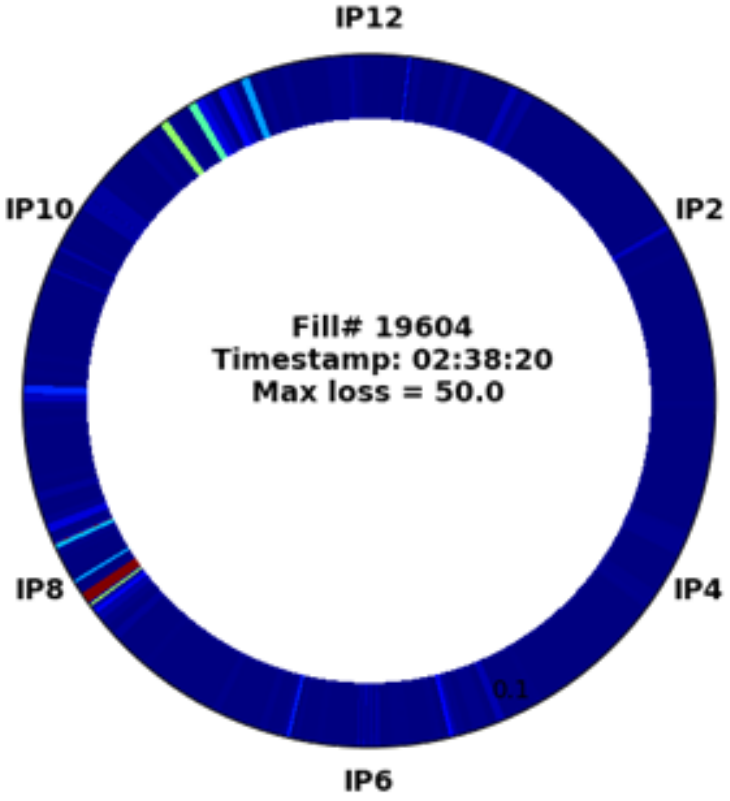
main limits:
- injectors output
- transition instability in RHIC (e-clouds)
- presently Landau cavity RF amplifiers

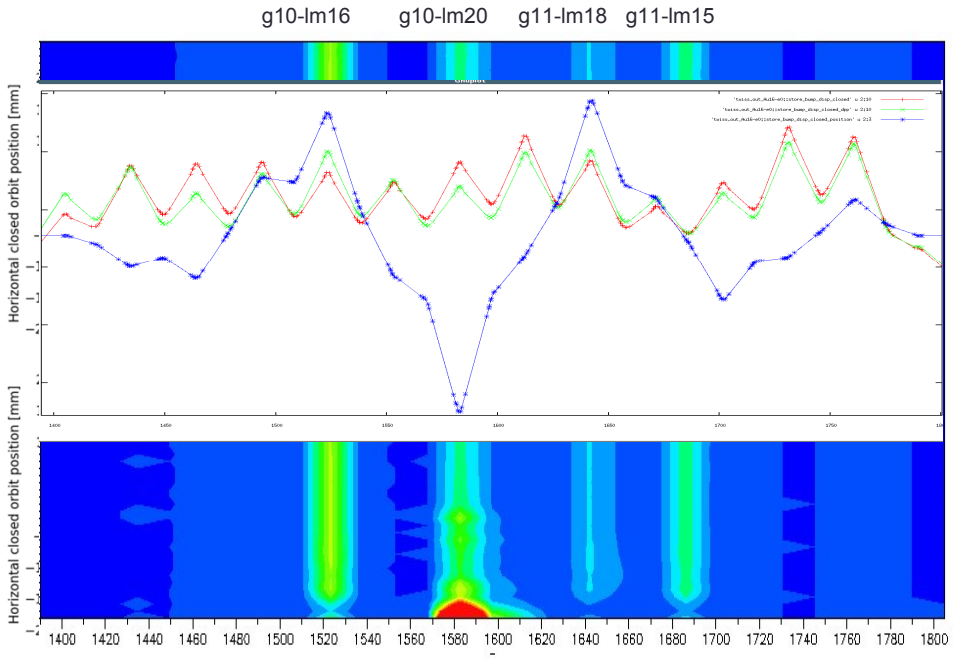
AGS: 20% more
Extended EBIS: 40% more

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

Protection Bump and Beam Loss

1. To protect detectors from pre-fire, the protection bumps were installed from Run14;
2. Pre-fire beam (orbit) can cause acute beam loss there as well as the de-bunched/off momentum (dispersion) beam during experiment;
3. The lattice with protection bump also caused chronic radiation (orbit and dispersion);The chronic beam losses come from luminosity/collision and dominated by blue beam;
4. They cause electronics upset → therefore store abort → associated losses are one reason of diode fail and 2.8 weeks repair.





Courtesy of Guillaume Robert-Demolaize (orbit)

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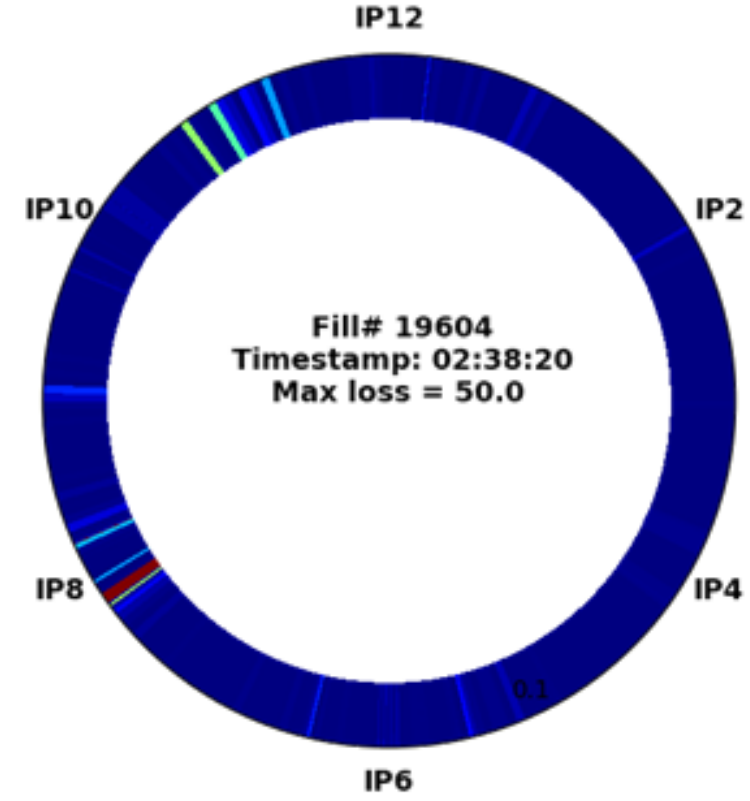

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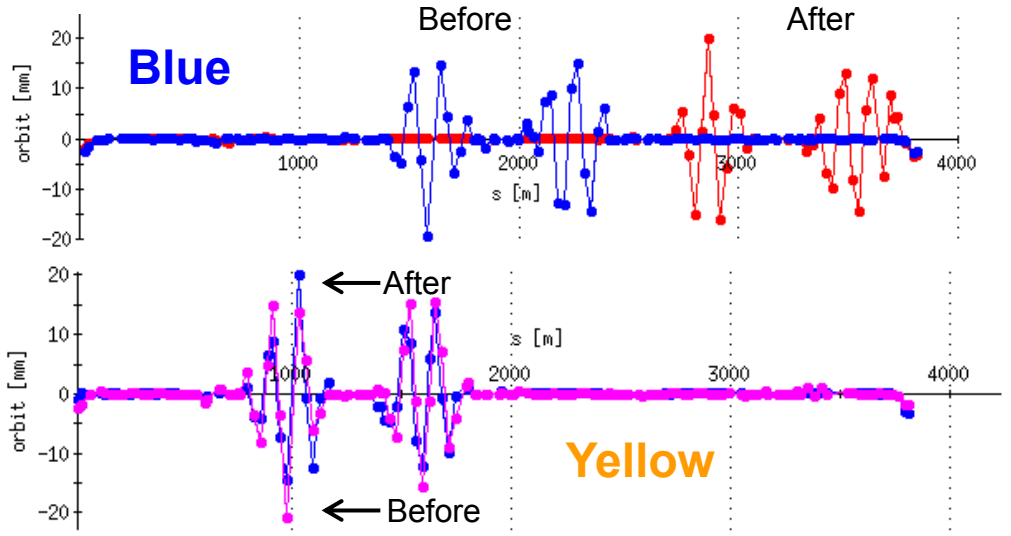
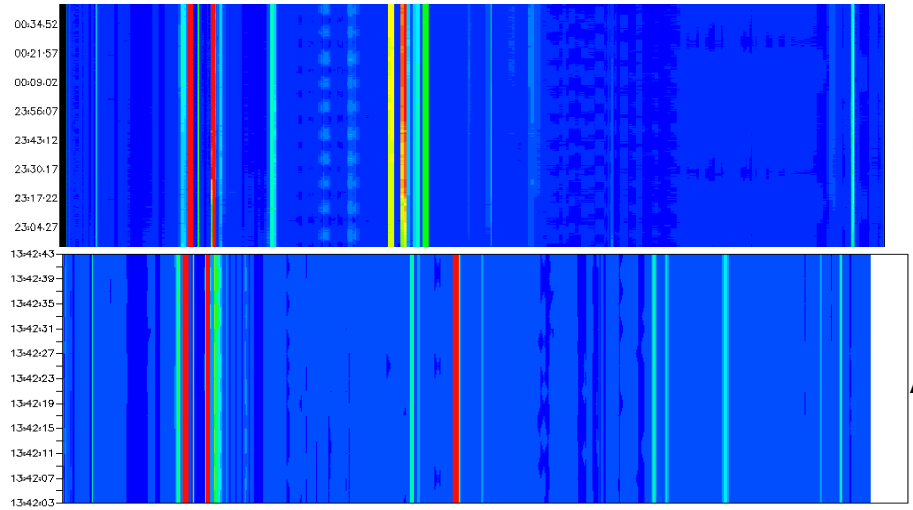
Solution

1. Change blue bumps location
2. Move beam more closer to mask;
3. Flip the max. BPM position pointing to outside of the rings (diode inside)

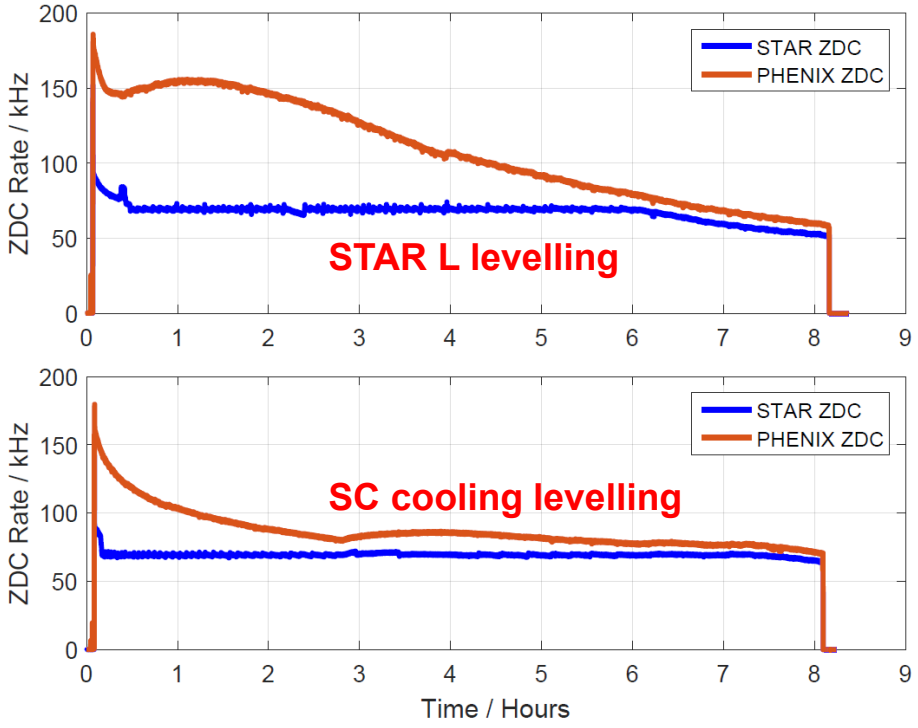


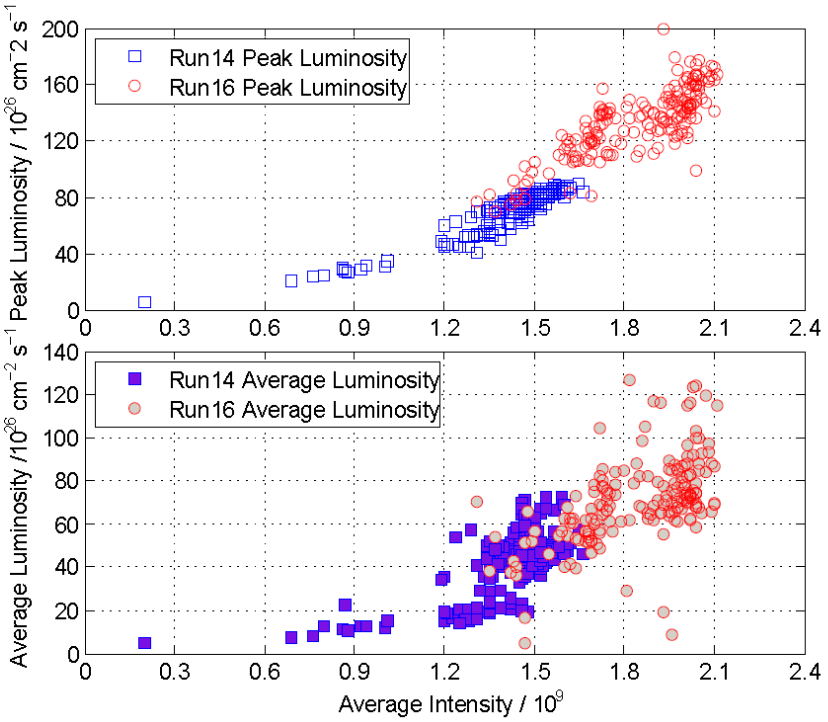
1. Less losses in ARC10~11;
2. More losses mask;
3. No losses at IP2;
4. Fewer communication error;



Many thanks to Mike Blaskiewicz, Guillaume, Vincent, Al, Christoph and others.

Luminosity and Levelling



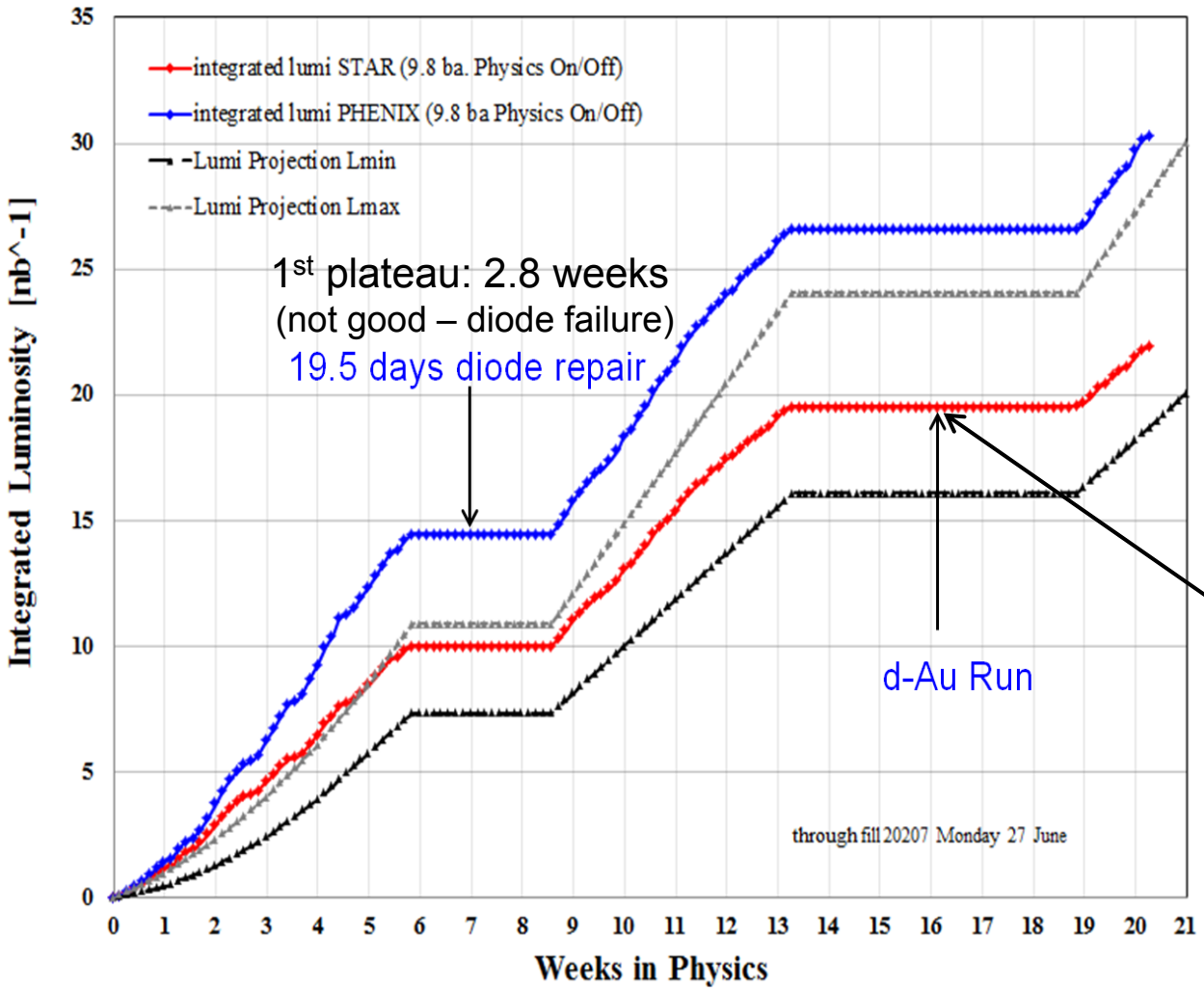


1. Starts levelling from the beginning of store with 70 kHz (60kHz for several stores);
2. Vertical separation was used for levelling;
3. Reduced initial SC cooling to reduces beam loss and L in PHENIX, preserves intensity, and allows for longer levelled stores for STAR (bottom plot)

1. L_{peak} +85%
2. L_{avg} +75%
3. 10 best store.

Run16 Delivered Luminosity

L = 3.0 nb^{-1}/week (+33% vs. 2014)

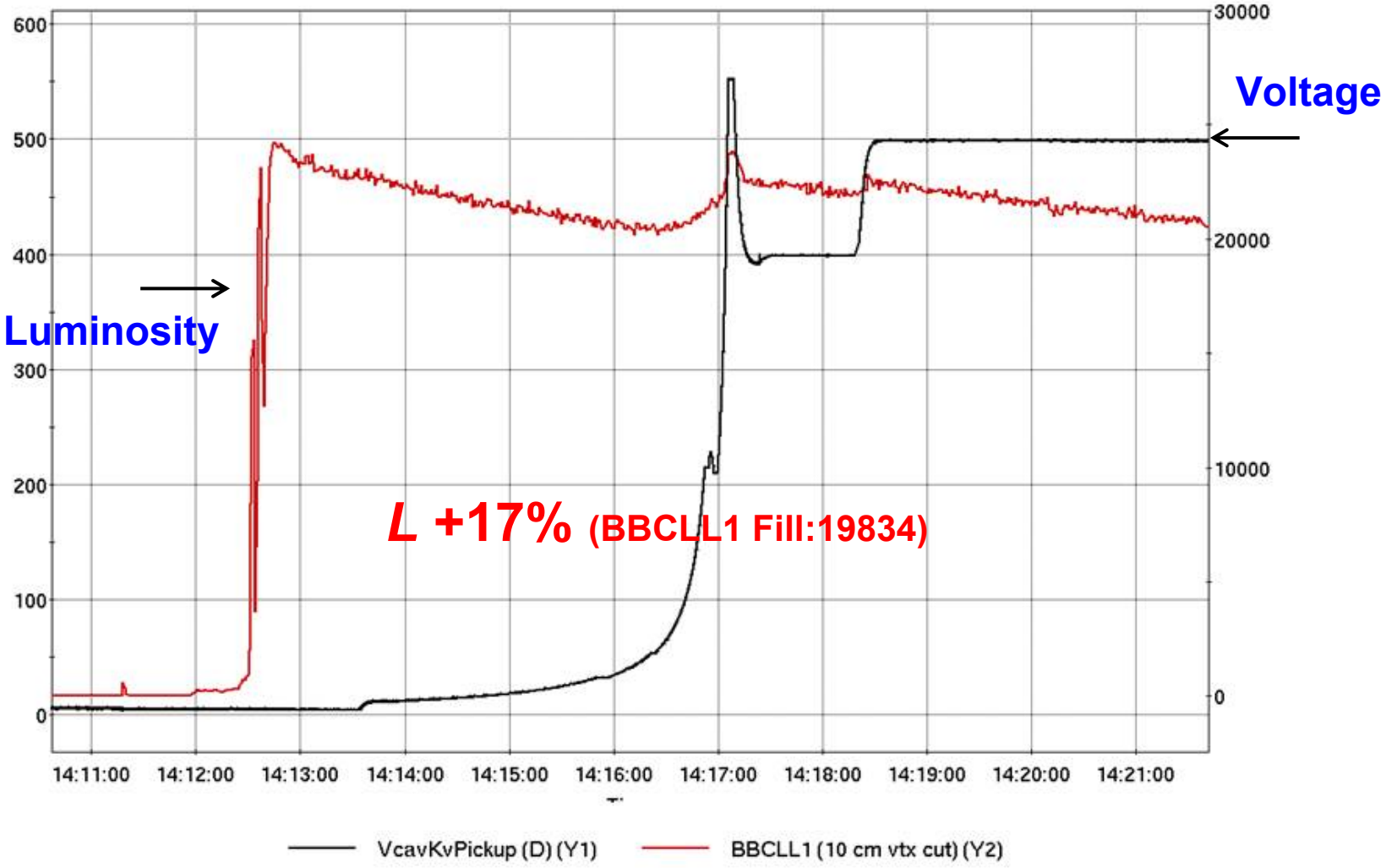


more collisions in 10 min than in the entire 5-week commissioning run in 2001

2nd plateau: 5.6 weeks
(good – switched in and out of d+Au quickly)

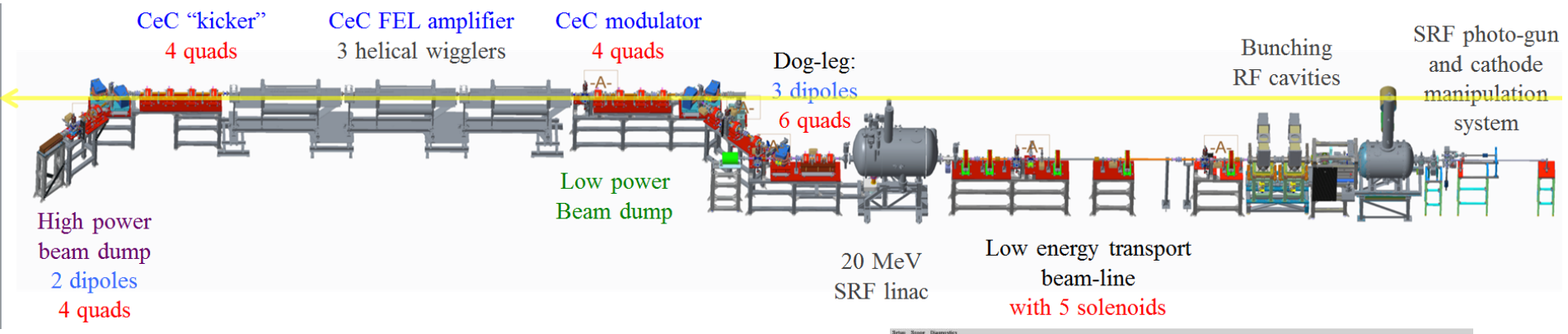
This plot can't represent the **best RHIC performance** because of levelling.

56 MHz Cavity: Commissioning and Operation



Has achieved 1 MV cavity voltage during 100 GeV Au-Au run without HOM damper.

CeC PoP: Commissioning

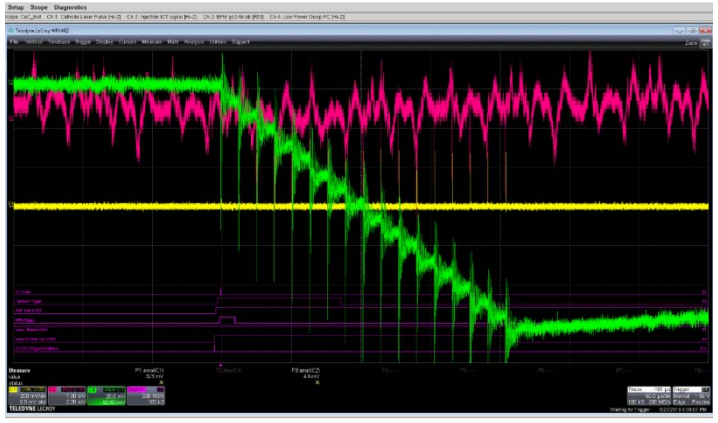


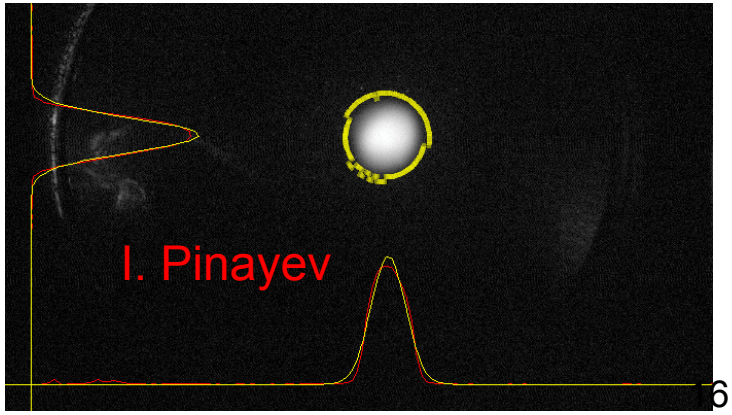
1. Coherent electron Cooling is a novel cooling technique for potential application in eRHIC.

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

3. 8 MeV electron beam was propagated to high power beam dump.

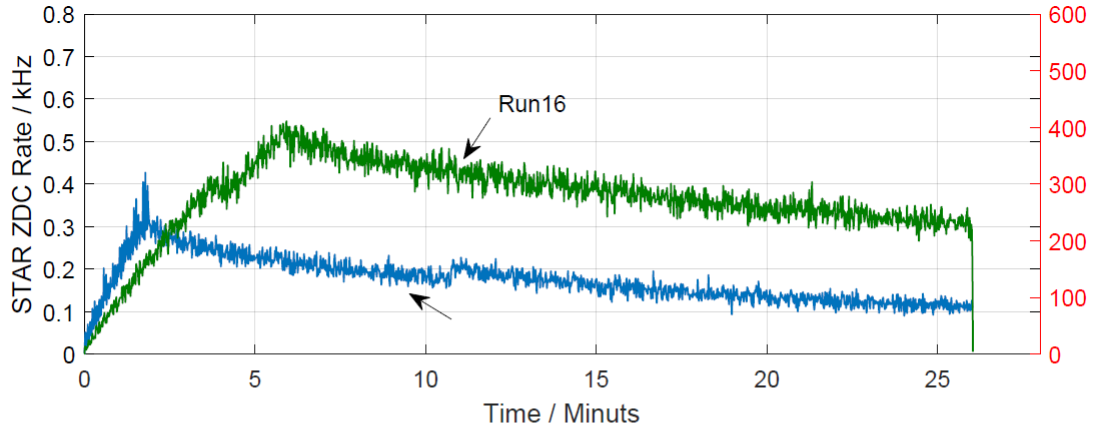
4. 60~100nC charge has achieved with one cathode; beam profile and emittance were measured.

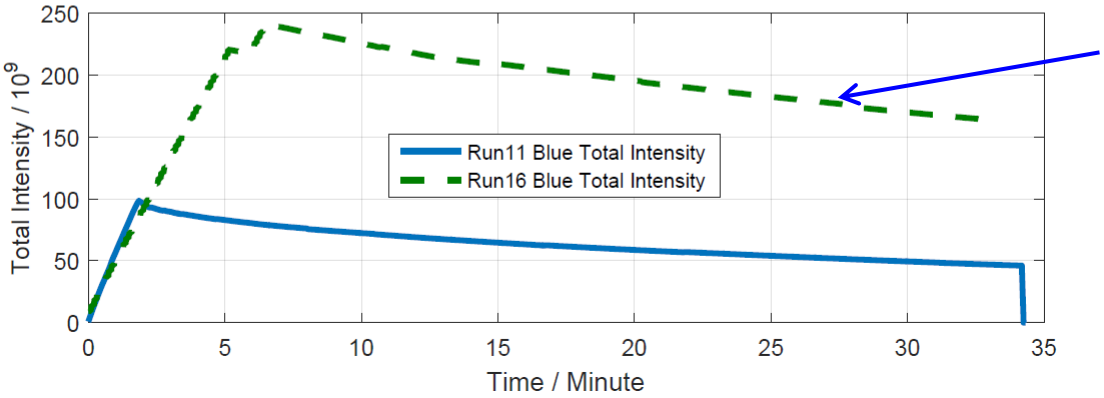




I. Pinayev et al. "Commissioning of CeC PoP Accelerator", WEPOB62, this proceeding.

Low Energy Au-Au: Test for Near Future





1. $L_{Integrated}$ +110%
2. $L_{Initial}$ + 70%
3. L should reach > 5 times
4. Caused by Emittance and beta*

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, emittance also 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} **+85%** L_{avg} **+75%**

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.

4. Low energy (10 GeV/nucleon) test has **2.1 times** integrated luminosity compared with the best store in Run11.

5. 8 MeV CeC beam delivered from the gun to the high energy dump

6. A replacement of a RHIC dipole cold quench protection diode in just 19 days.

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