

# RHIC Run 15 Report

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for C-AD  
RHIC/AGS Users Meeting  
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# Running Modes

- p-p (100 GeV beam energy)
  - ~10 weeks
- p-Au
  - ~5 weeks
- p-Al
  - ~1.5 weeks

# Polarized proton operations

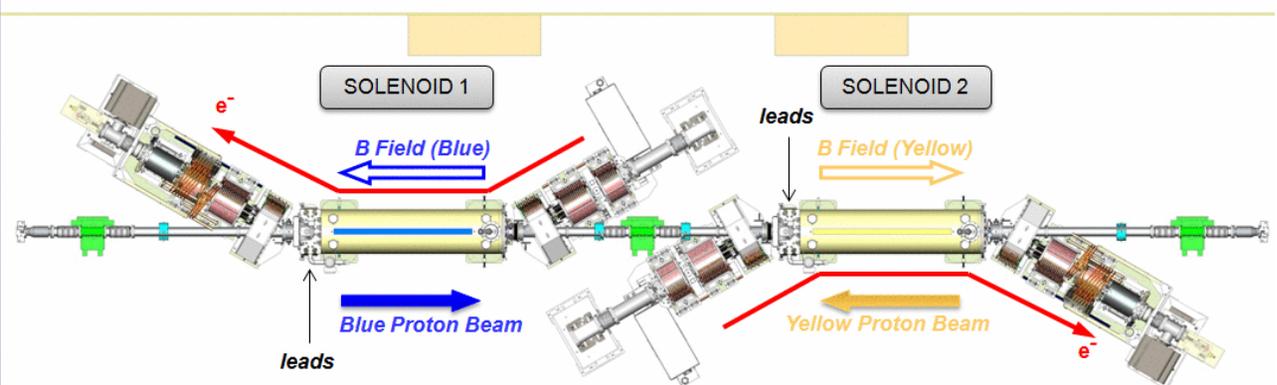
- E-lens
  - Device
  - Lattice
  - Operation (typical store)
- Injector improvements
  - $h=2$  operation in the Booster

# Beam-beam compensation

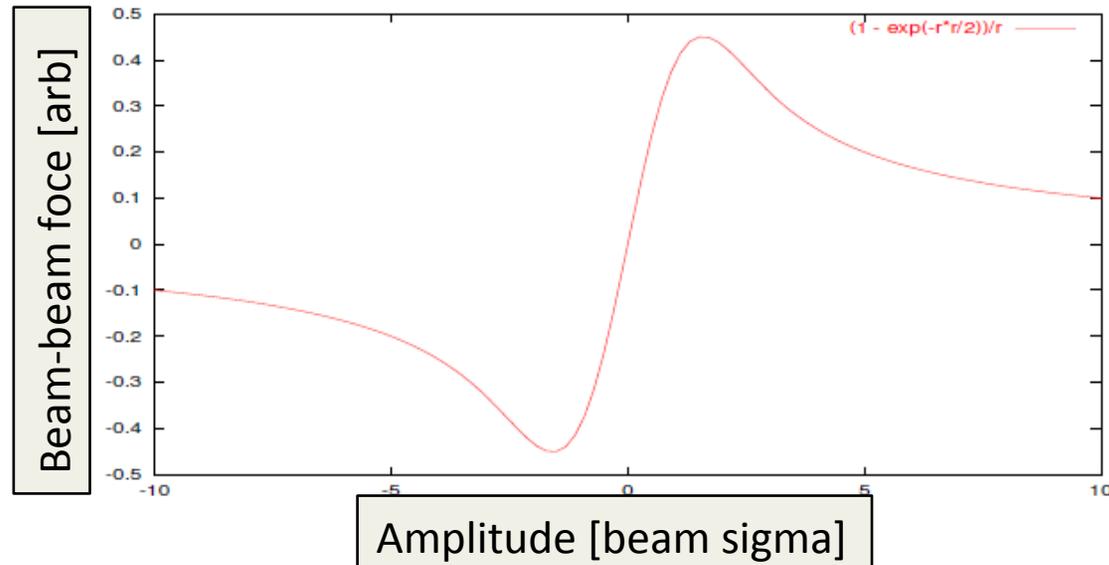
p-p lumi is limited by beam-beam.

Oncoming proton beam acts as a nonlinear defocusing force  
Leads to beam decay, emittance increase

Carefully tailored electron beams provide equal but opposite focusing force



Beam-beam force - round beams

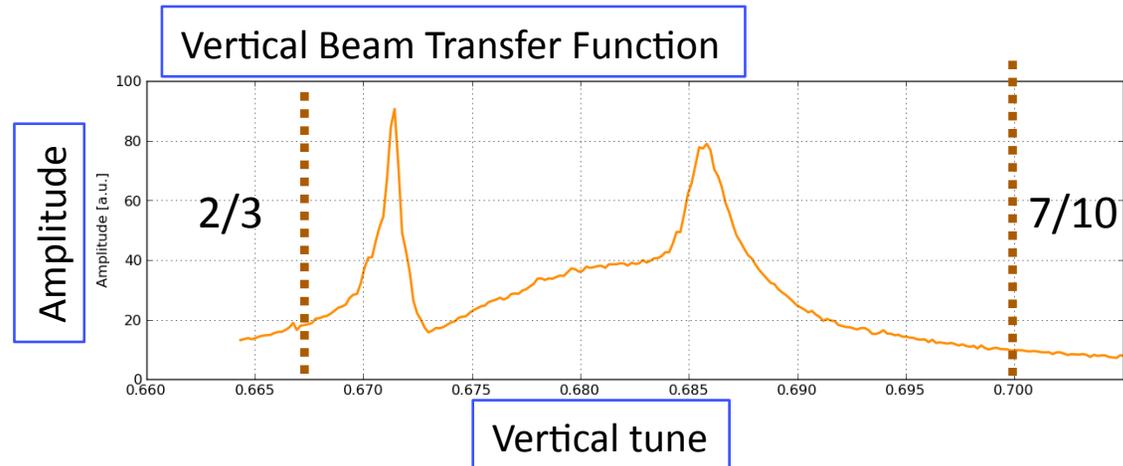
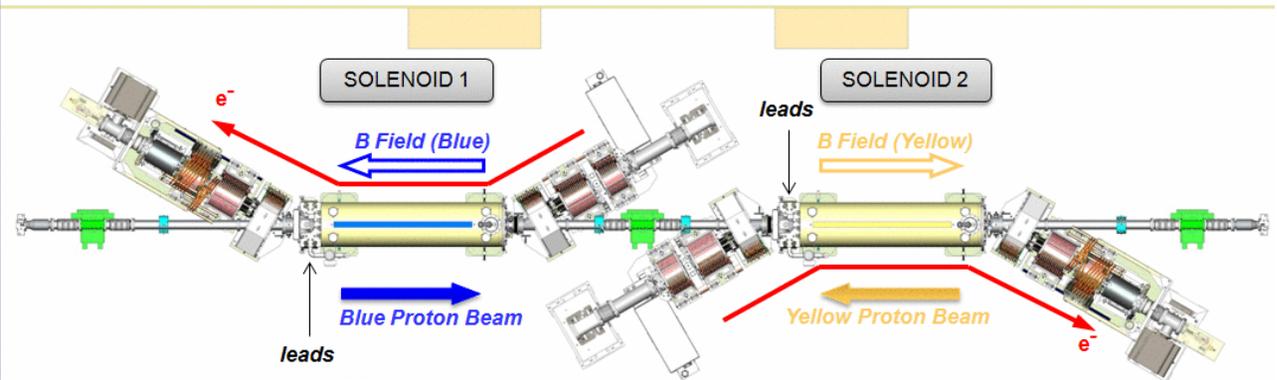


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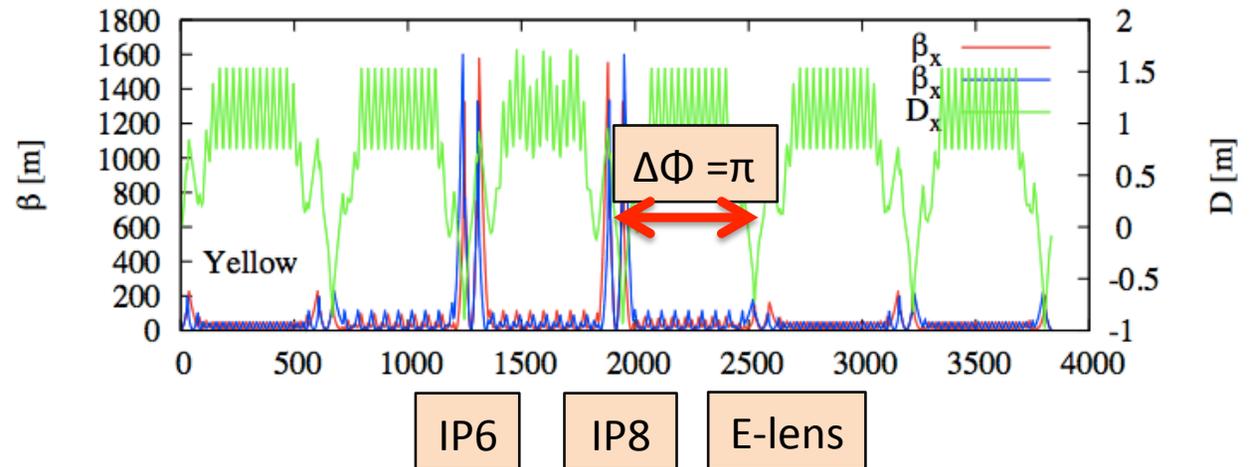
# Beam-beam compensation

## Lattice improvements

E-lens requires  $\pi$  phase advance from lens to one colliding IP

$\pi/2$  phase advance per cell and 'ATS' style beta squeeze allow passive compensation of sextupole driving terms

Increased off momentum DA

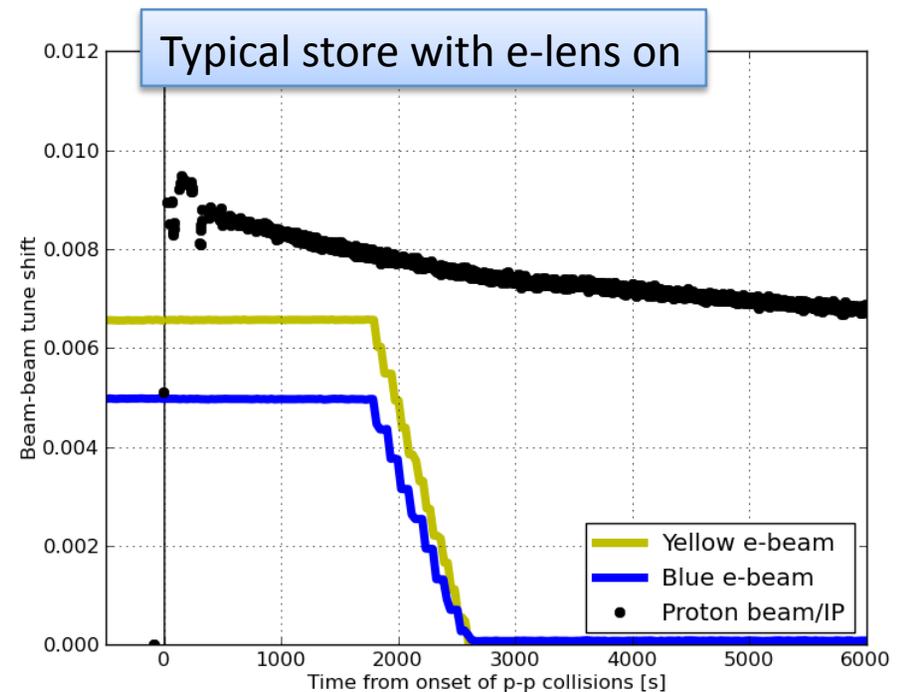


Complete retooling of the ramp/lattice creation software

Optics measured-to-model agreement quite good (10-15% beat beat) without need for additional correction.

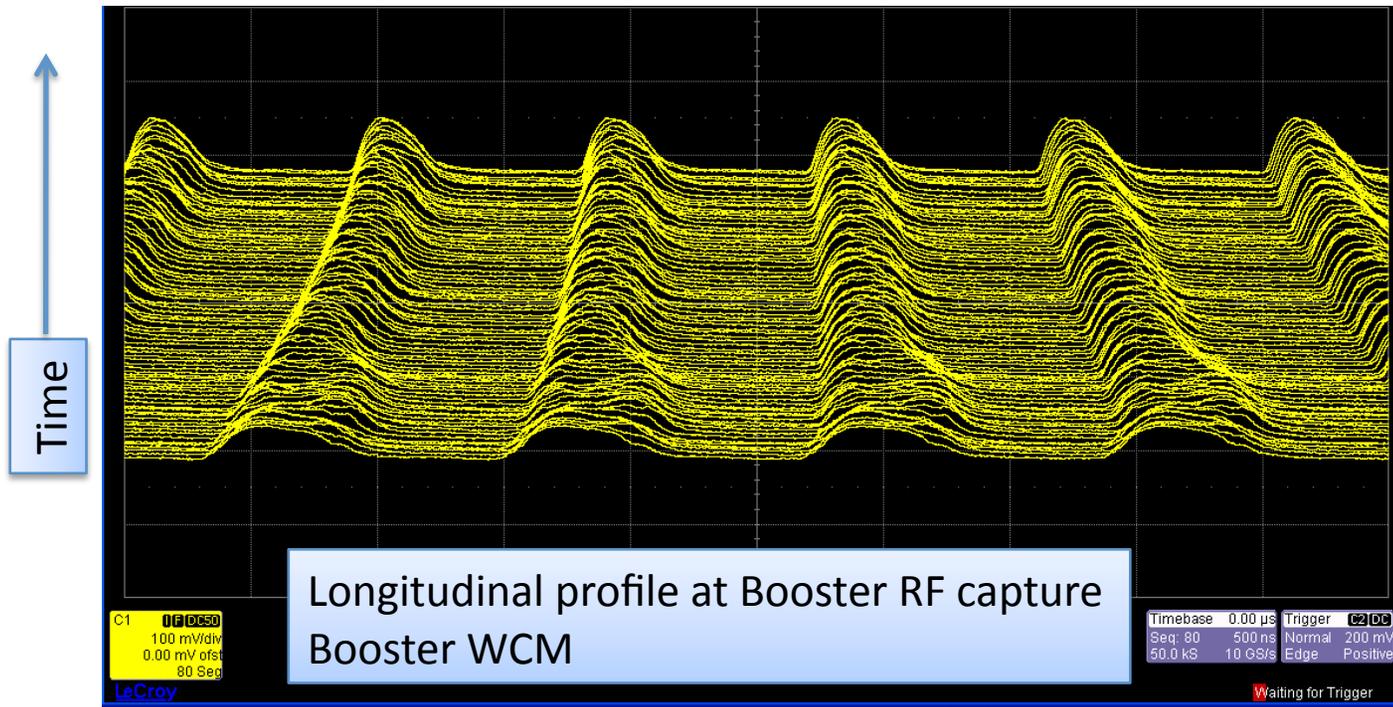
# Beam-beam compensation

Run	Achievable BB tune shift/IP
Run12	0.006
Run 15 (no e-lens)	0.008
Run 15 (w/ e-lens)	0.010



Blue e-lens limited to  $\sim 500$  mA by onset of e-current instability  
Yellow e-lens operating as expected at  $> 1$  A

# Injector emittance



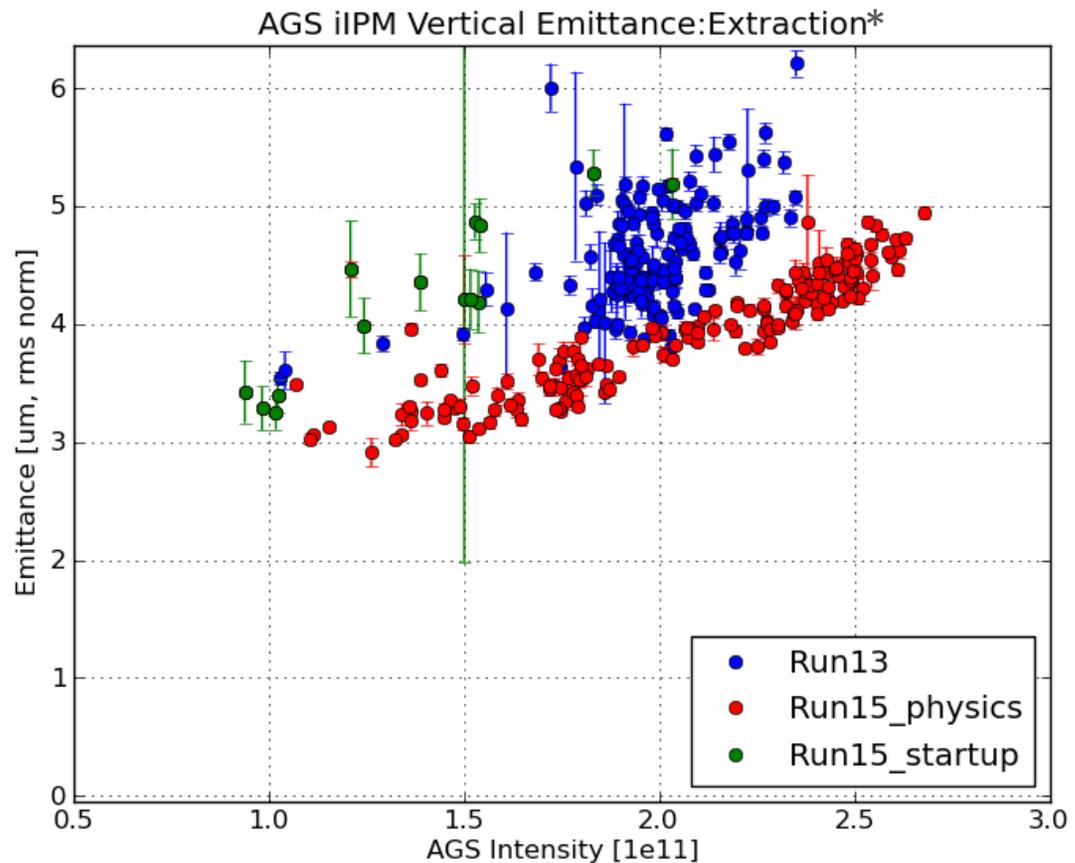
Booster space charge driven emittance growth indicated by Run 14 measurements

Additional RF frequencies added at capture to elongate bunches, reduce current density

# Injector emittance

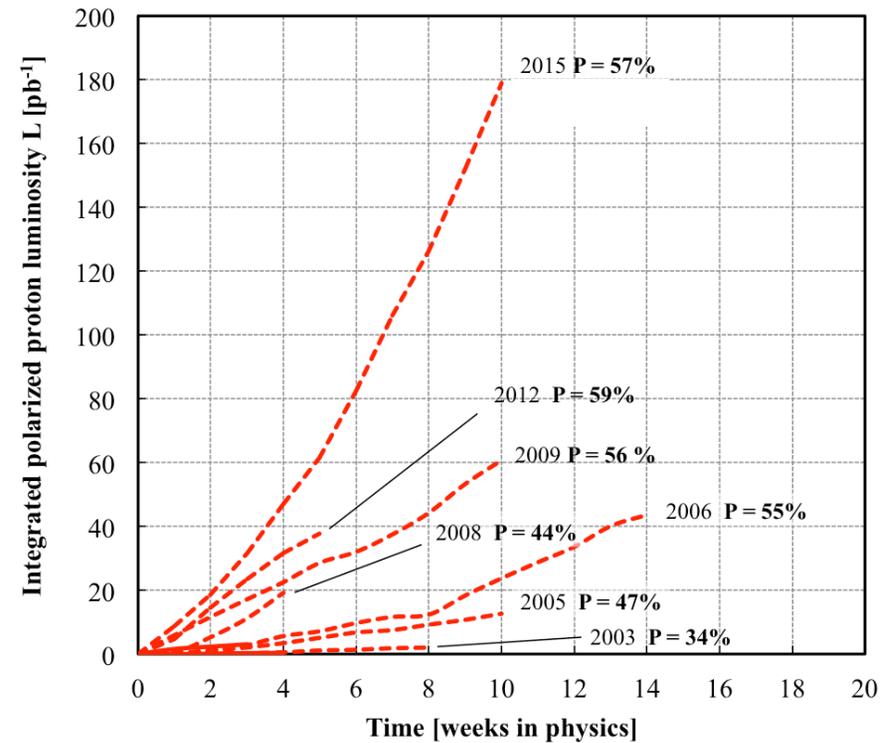
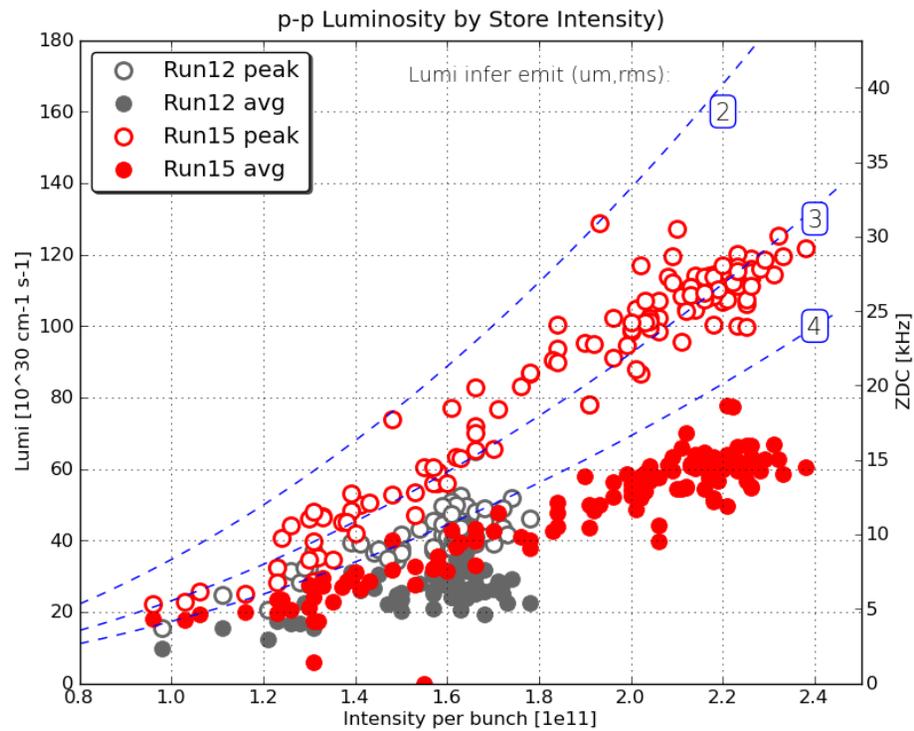
Injector emittance control improved by

- h=2 Booster capture
- Tuning with high intensity from source ( $10^{12}$ /pulse)



\*This IPM has significant intensity-dependent systematics. Good for relative measurements, not absolute

# p-p Luminosity



# Polarization

## Spin Direction

PHENIX

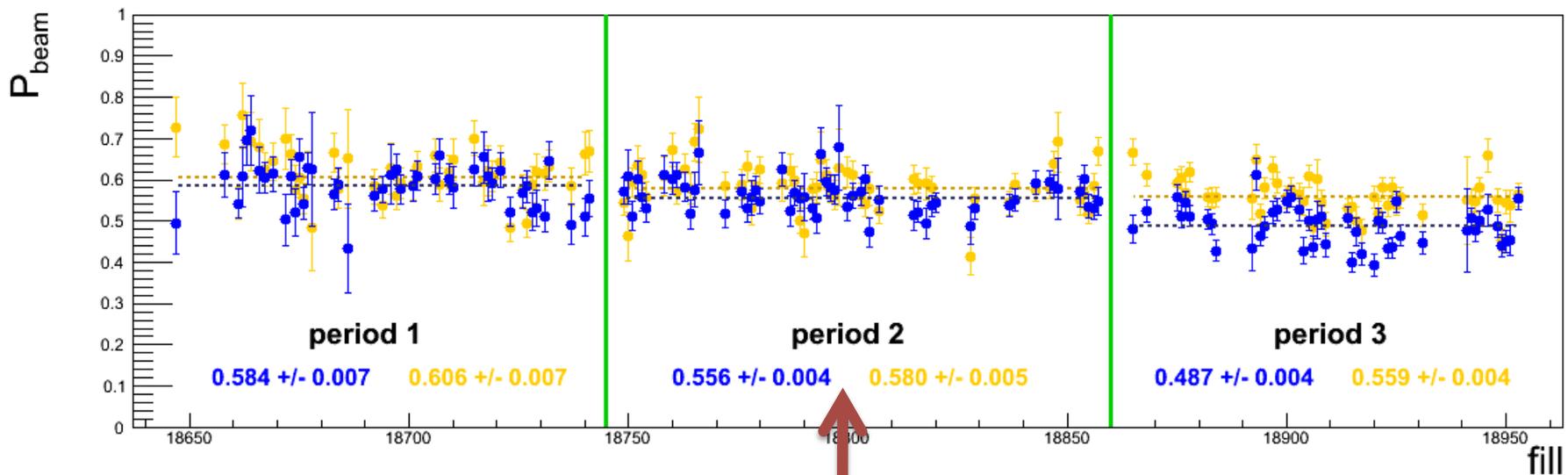
Transverse

STAR

Longitudinal

Transverse

Longitudinal



Successful transverse running

- Blue, yellow difference consistent with AtR transmission
- Polarization decay at store reliably  $\leq 1\%$ /hour
- Allowed revisiting the longitudinal running

# Polarization

## Spin Direction

PHENIX

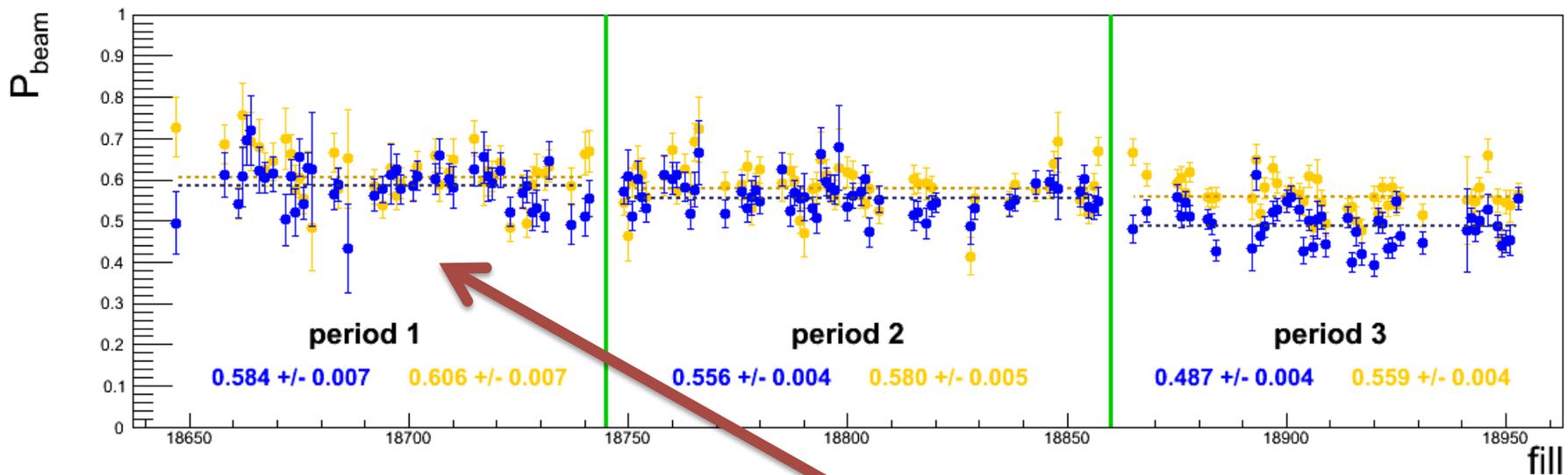
Transverse

STAR

Longitudinal

Transverse

Longitudinal



Substantial radial component at STAR

- Incorrect rotator settings
- Difficulties with local direction measurement

Plot courtesy of K.O. Eyer

# Polarization

## Spin Direction

PHENIX

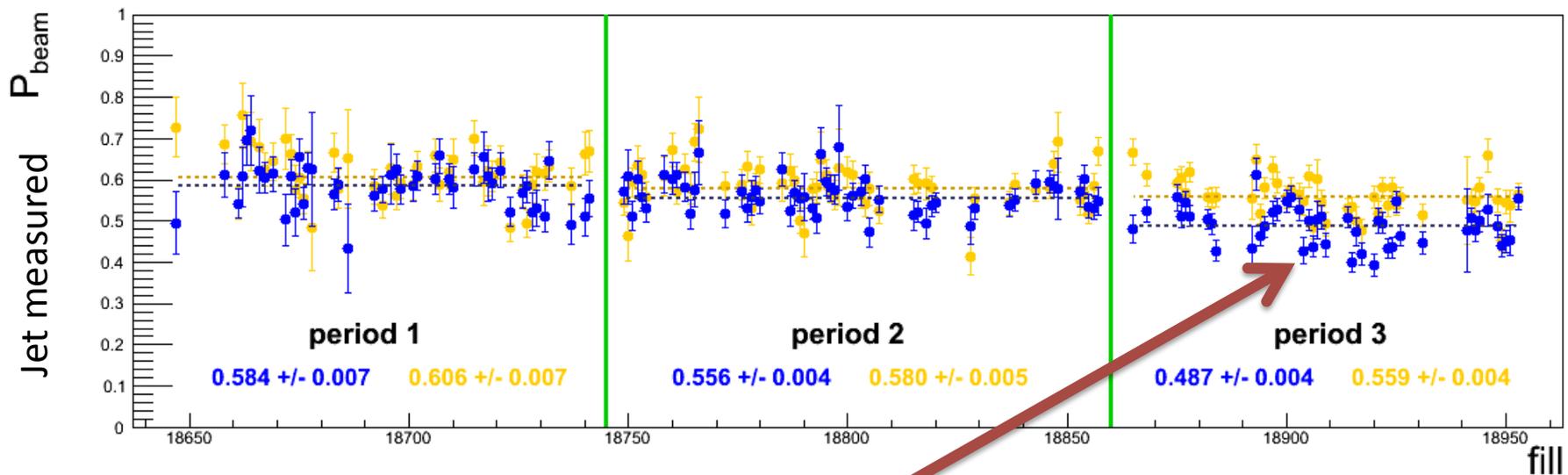
Transverse

STAR

Longitudinal

Transverse

Longitudinal



Revisiting longitudinal operation at STAR

- AGS polarization drops off
- Blue polarization lifetime at store nearly 2%/ hour

Plot courtesy of K.O. Eyer

# Polarization Problems: Possible cures

## AGS Polarization

- Jump quad timing and field stability
- Extensive profile measurements at intermediate energies to localize polarization loss

## RHIC polarization lifetime and rotators

- Similar problems encountered in Run 9 100 GeV run
- Scans of rotator current in Run 15 need careful analysis (ongoing)
- Full simulation of spin dynamics at store with rotators

# Proton-Ion Operations

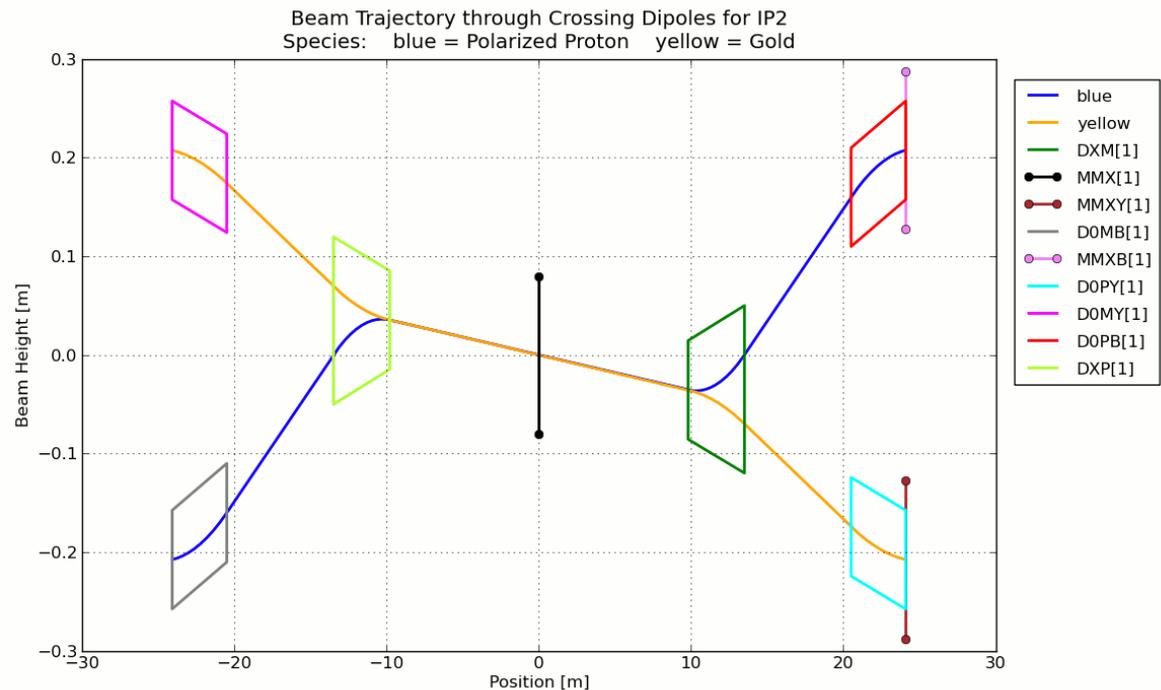
Run Coordinator: Chuyu Liu

p-Au (and p-Al) operation require moving DX magnets to keep beams inside the aperture. A first for RHIC operation.

Several aperture restrictions identified/removed before the switch (ion pumps, STAR pipe)

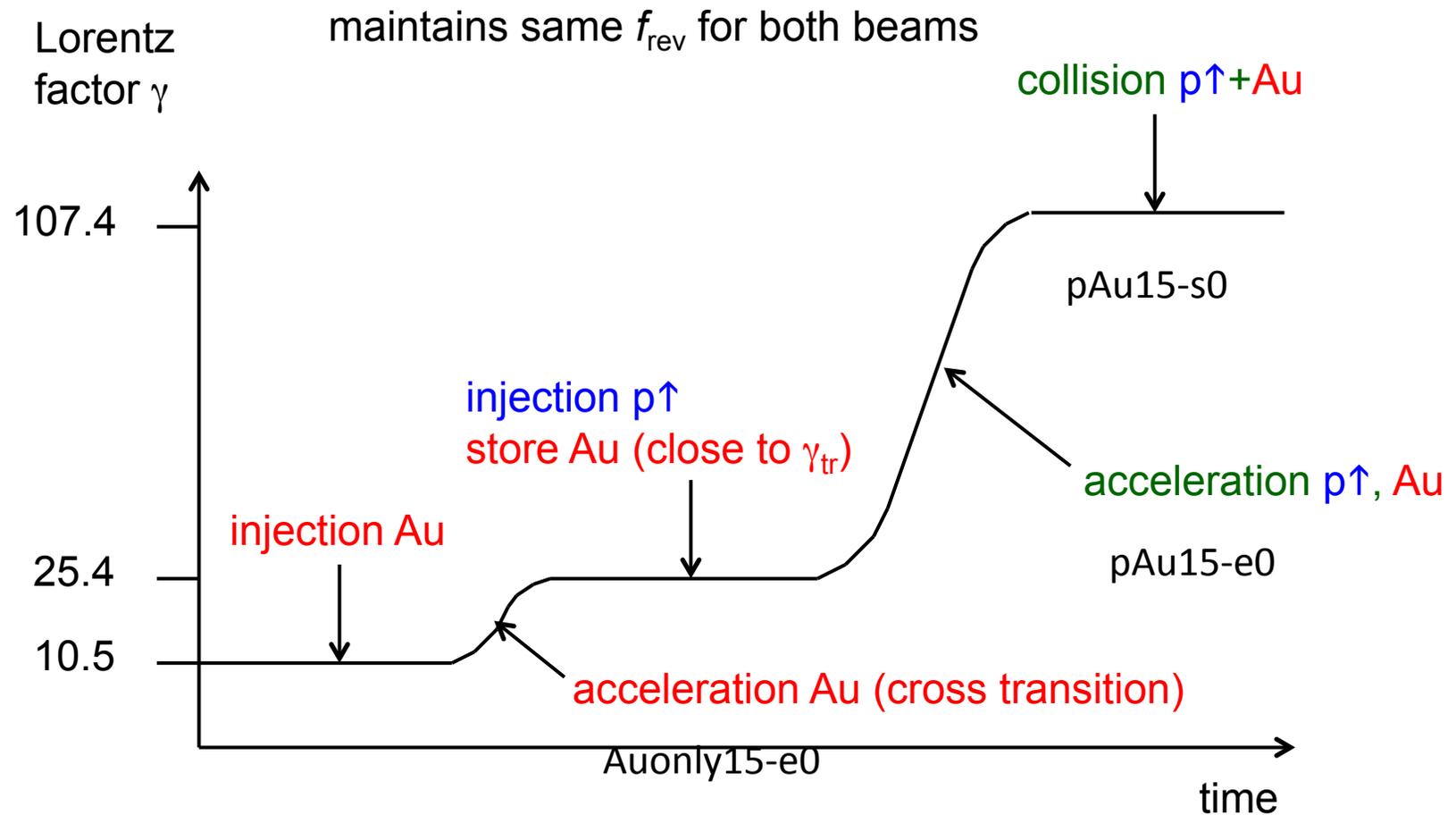
Physical move took ½ day

Established collisions in ~ 1 week.

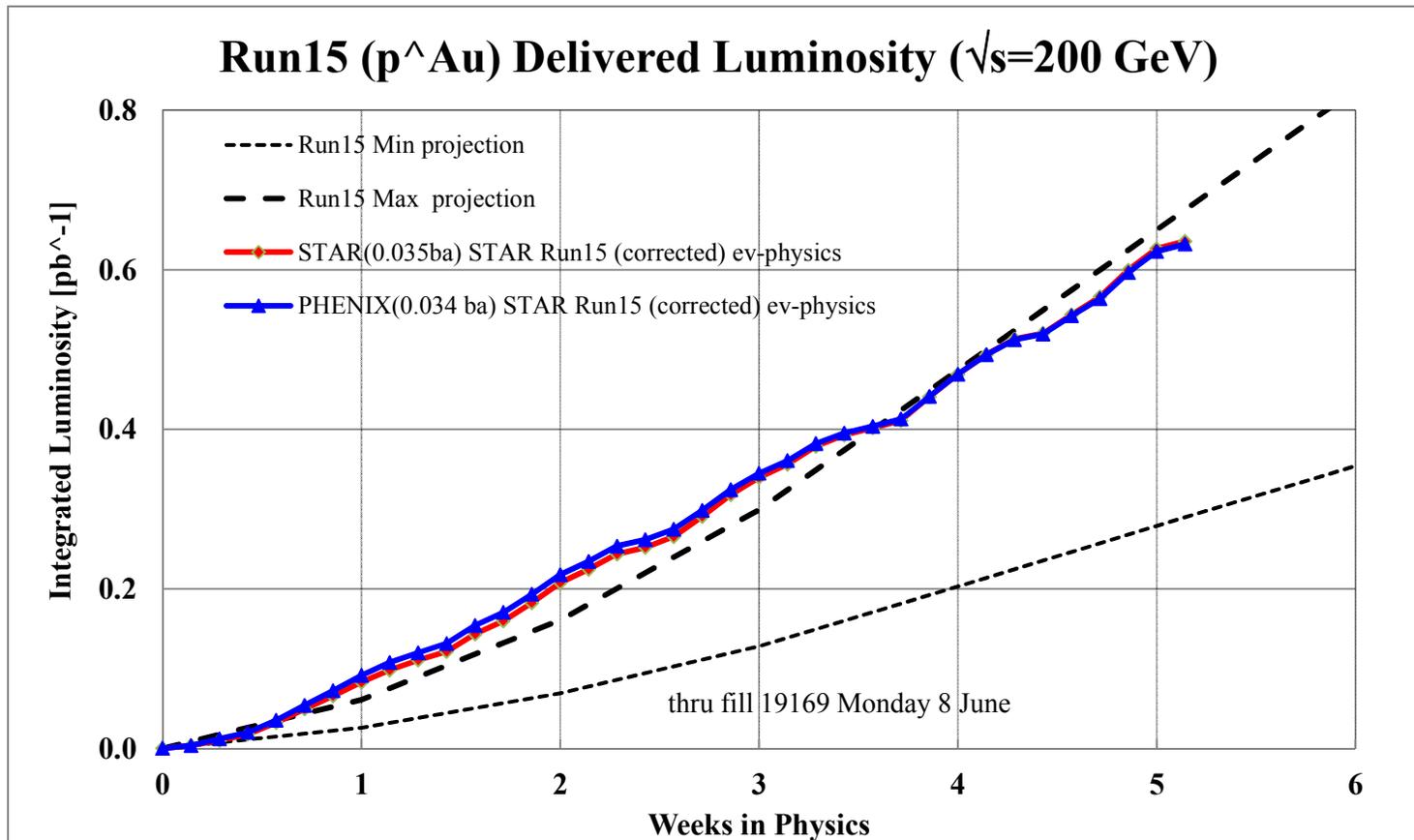


(plot courtesy of C. Liu)

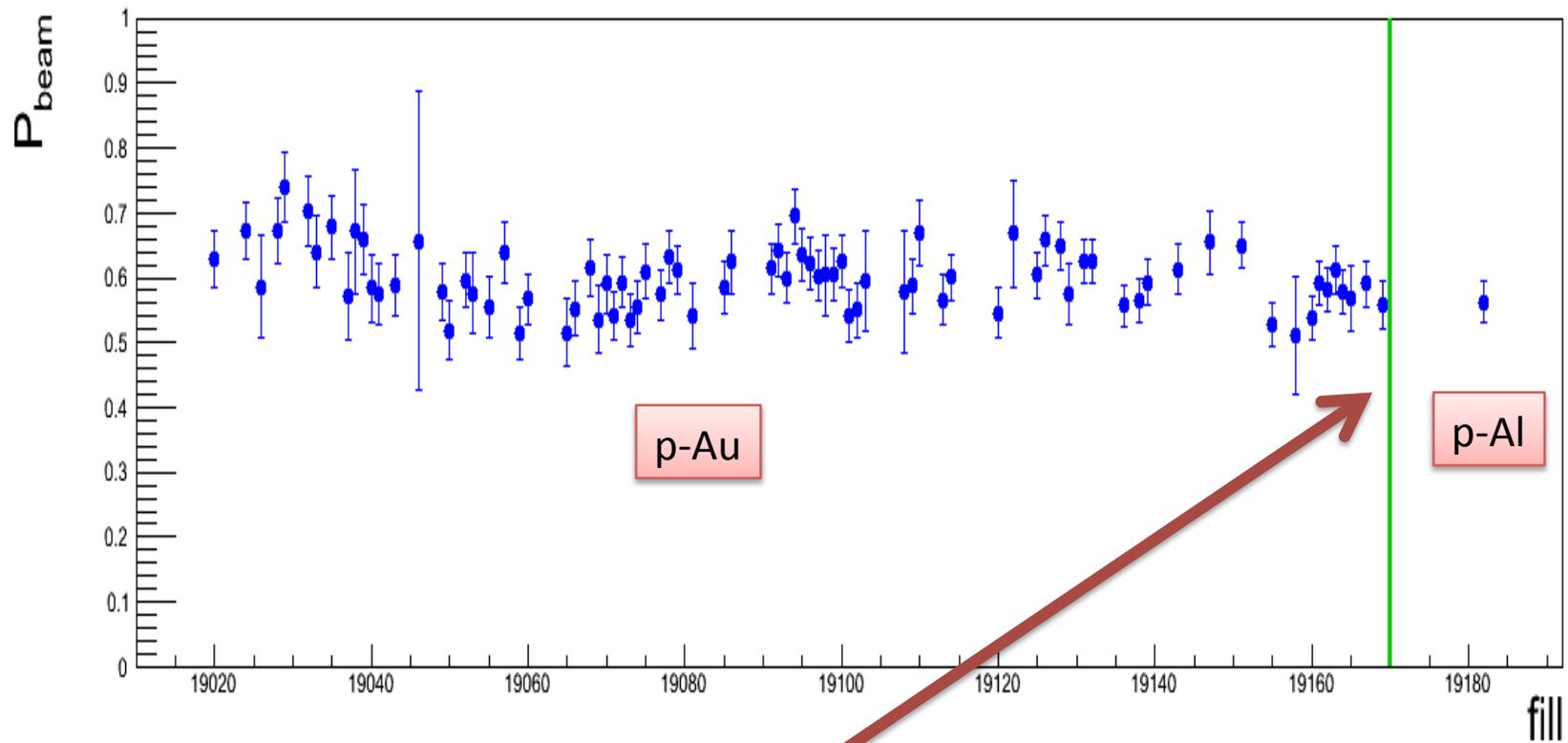
# Proton-Ion Operations: Two Ramp Scheme



# Proton-Au Operations: Integrated Luminosity



# Proton-Ion Operations: Polarization



16 hours between last p-Au store and first p-Al store

(plot courtesy of O. Eyser)

# Accelerator/Experiment Protection

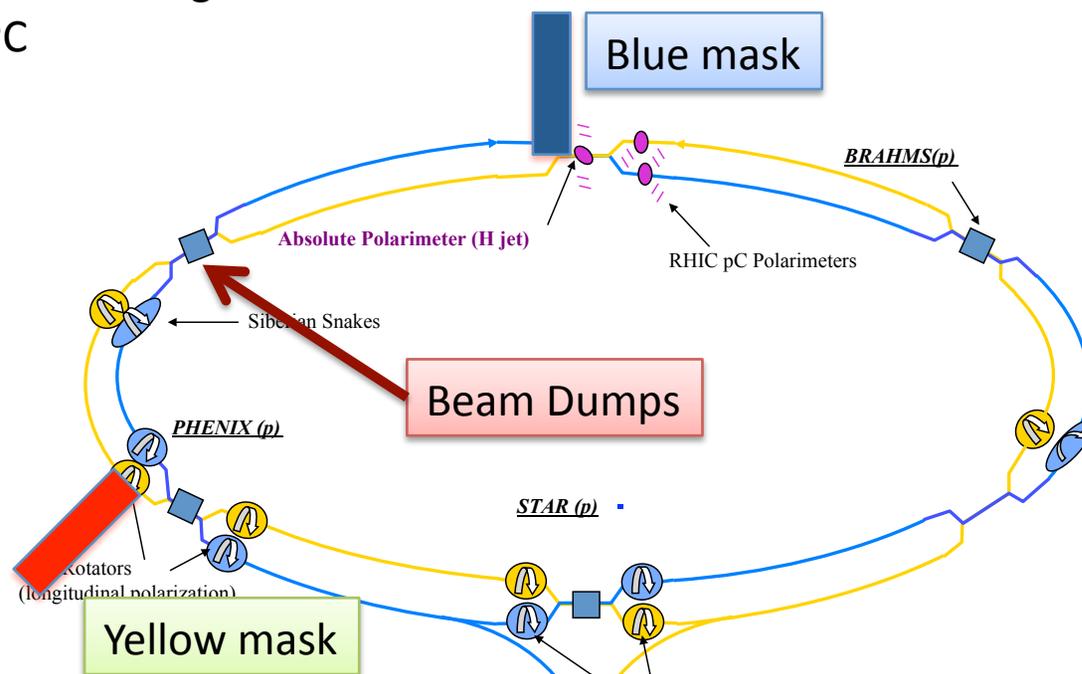
Abort kicker pre-fires causing detector damage  
Particularly YELLOW -> PHENIX MPC

Particularly damaging during  
asymmetric running  
(one event during Cu-Au in Run  
12)

Arc orbit bump worked well for  
Run 14 Au-Au protection

Masks installed for Run 15

- Protection is lattice dependent
- Yellow mask is already at Q4 upstream of IP8. Even well intercepted beam may enough shower to cause damage



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## Possible cures

- Move the abort system (dump and kicker) to IP12
- Insert an intercepting mask into a 'dummy' section of the cryostat downstream of the dump (needs a cryo bypass)

# Summary

- A challenging run, with many highlights, in particular:
  - Successful commissioning and first demonstration anywhere of electron lenses for beam-beam compensation and increased p-p luminosity
  - Successful reconfiguration and operation of highly asymmetric species for p-Au and p-Al
- The challenges have produced 'homework' for C-AD
  - Understanding polarization 'drift' in the AGS
  - Understanding polarization decay with rotators with 100 GeV beams
  - Preventing detector damage, particularly during asymmetric running