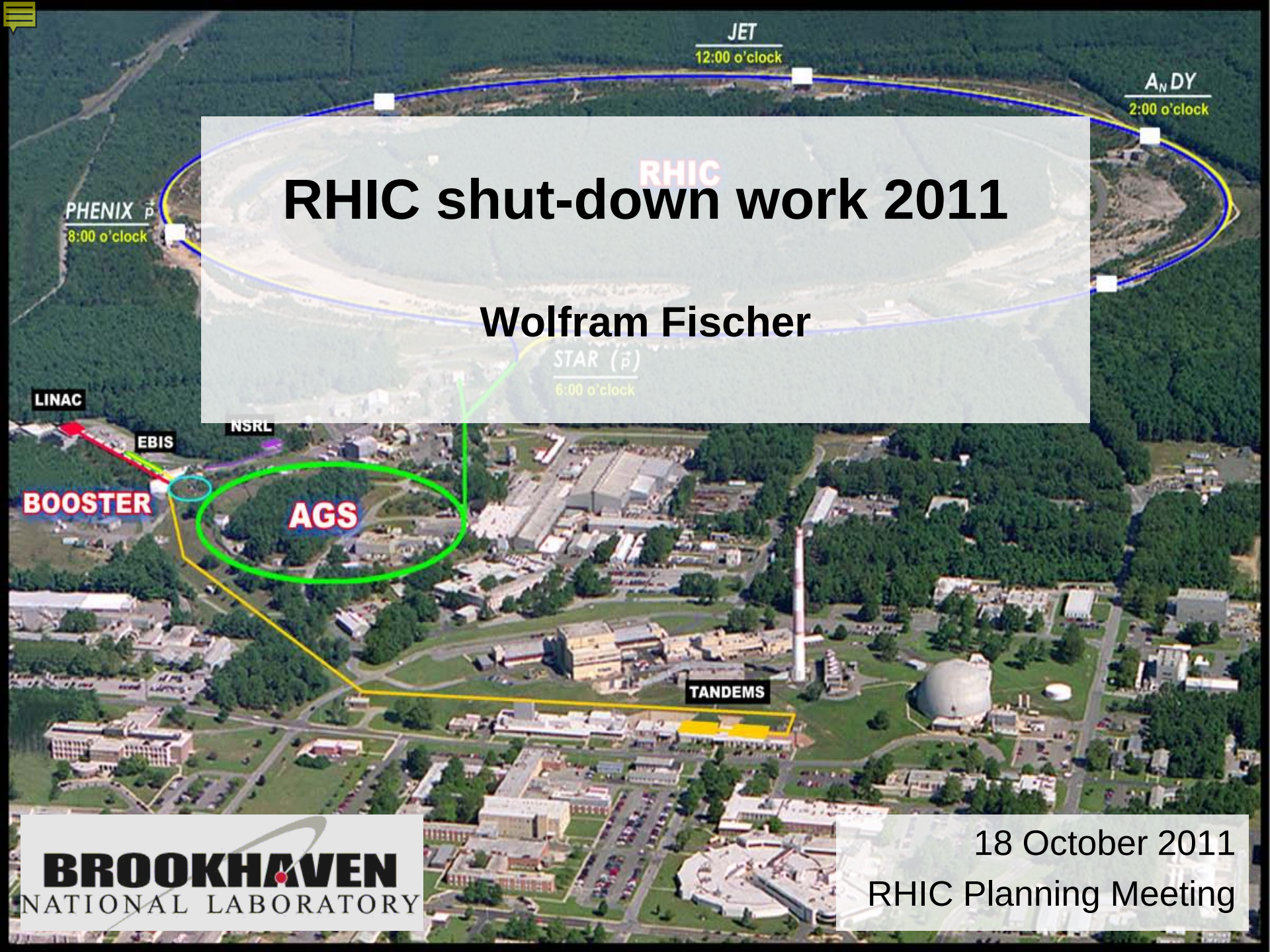


RHIC shut-down work 2011

Wolfram Fischer

BROOKHAVEN NATIONAL LABORATORY

18 October 2011

RHIC Planning Meeting

Plan to start cool-down on 3 January 2012.

So far no delay anticipated.

Finished items

- AGS Sextupole Coil Replacement – 6 magnets/sectors (Badea)
- AGS Siemens maintenance and inspection (Badea, Porqueddu)
- AGS G17 Quadrupole Coil Repair (Lehn, Porqueddu)
- ETB Beam Line Mods (Corrector and Quad)
- RHIC e-lens installation prep: cryogenic DX tap and xfer line, cable tray, water, PS Racks (Hock, Pendzick, Phillips, Lederle, Seberg,)
- RHIC 56 MHz installation prep: cable tray, cryogenic lines/compressor, PS Racks (Lederle, Seberg)
- RHIC RF π wave length Acc Cavity – Tuner Travel inspection, Damper Loop Inspection (Weiss)
- RHIC RF Stochastic Cooling – Yellow Long Kicker rebuild (Lehn)
- RHIC Collimators Inspect for Beam Induced Damage (Lehn)
- RHIC Tank Farm Piping/Bellow Repair (Lederle)
- RHIC 2:00 CeC cryogenic tap installation at DX Magnet (Lederle, Seberg)

Items to be finished before 16 December

- BLIP New Window Assembly (waiting for HP technicians)
- ETB Inflector modification (if needed) (will be done by 1st week of December)
- AGS Siemens Power Supply Bearing Oil System Maintenance (Porqueddu) (awaiting parts, will be done by 1st week of December)
- AGS I5 Vacuum Chamber Replacement / I5&J5 Beam Absorber (Liaw) (parts due in beginning of November)
- RHIC ODH install relief detector test system (Theisen, Sandberg, Tallerico) (complete middle of November and then testing, ODH zero will be delayed by testing and approval).
- RHIC RF 9 MHz Cavity Upgrade (Liaw) new capacitor tuner drive (Mahler) (Will be ready for RF testing November 1, baked out by December 15).
- RHIC RF Stochastic Cooling – horizontal kickers and PU's installation (Liaw) (First of 4 kickers shipped to the tunnel yesterday – blue #1, Mike promises the blue #2 by next Friday, Yellow #1 and #2 are assembled but await RF testing they should both be in RHIC by the end of November)
- RHIC RF Stochastic Cooling – Blue Long Kicker rebuild (Liaw) (Still have leaking feedthrough problems – we sprayed them before and we will spray them again if necessary – new motor drive mounting being designed and installed) should be back in the tunnel before the end of November.

RHIC Collider Projections (FY 2012 – FY 2016)

W. Fischer, J. Alessi, M. Bai, M. Blaskiewicz, H. Huang, Y. Luo, C. Montag, V. Schoefer,

Last update: 14 October 2011

This note discusses in Part I the running modes for the RHIC Run-12 (FY 2012) operating period including constraints from cryogenic cool-down, machine set-up and beam commissioning. In Part II a 5-year outlook is given. This latest update is based on the experience gained during the Run-11 operation, the planned luminosity upgrades in RHIC, the shutdown work in 2011, and the physics plans for Run-12.

In the following all quoted luminosities are delivered luminosities. Recorded luminosities are smaller due to vertex cuts, detector uptime, and other considerations. An estimate of how much of the delivered luminosity can be recorded must be made by every experiment individually. Quoted beam polarization numbers are intensity-averaged as measured by the hydrogen jet. The luminosity-weighted polarization functions and figures of merit can be calculated from the center polarization and polarization profile parameters.

Part I – Run-12 Projections

Cryogenic operation – After the shutdown the two RHIC rings will be at room temperature. After bringing the rings to 50 K, 1 week will be required to cool them down from 50 K to 4 K. At the end of the run, ½ a week of refrigerator operation is required for the controlled warm-up to liquid nitrogen or room temperature.

Running modes – [illegible] polarized protons at 100 GeV and 250 [illegible] on, and copper-gold operation at 100 GeV/nucleon.

http://www.rhichome.bnl.gov/RHIC/Runs/

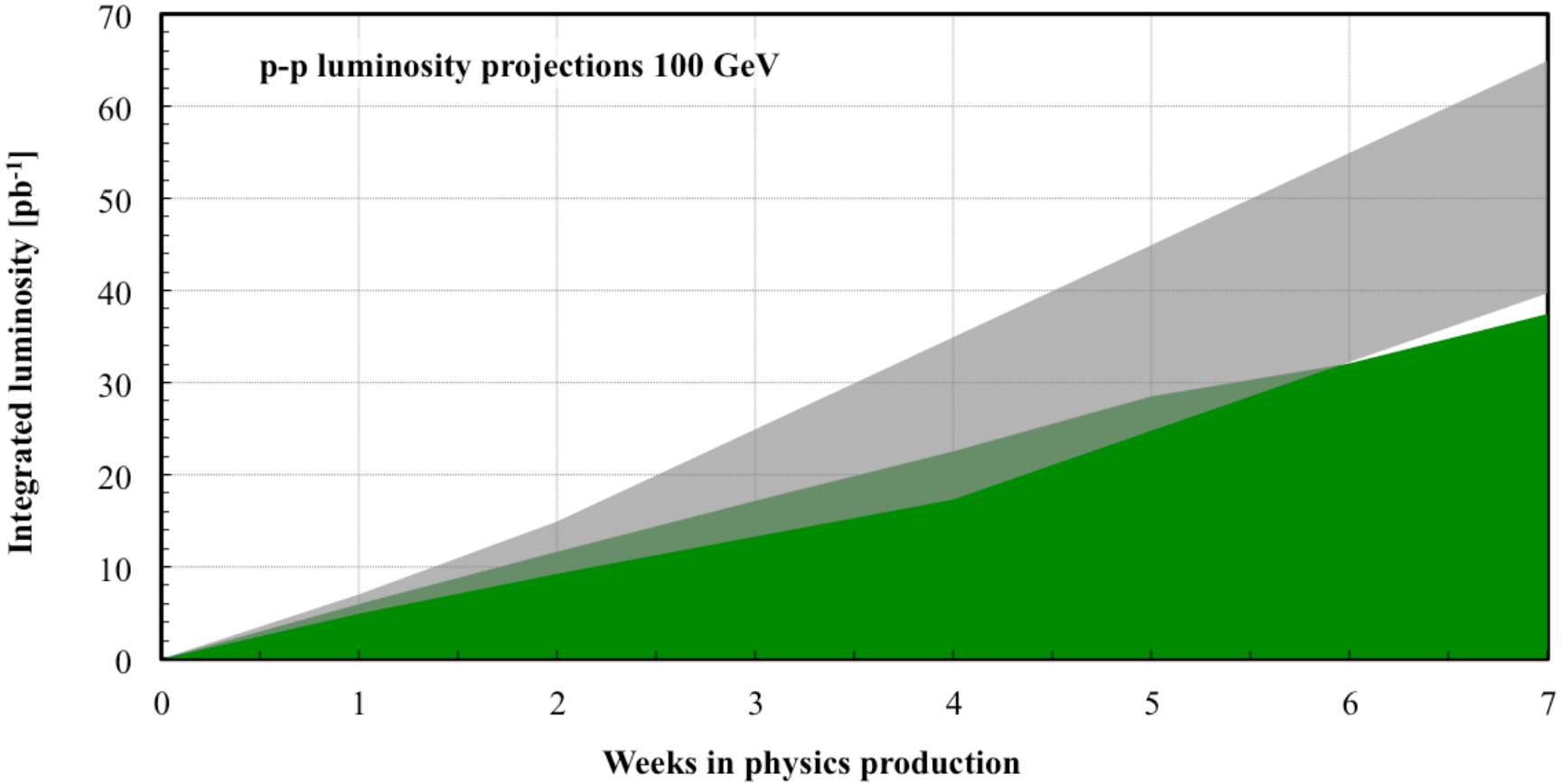
Run-12 projections p⇝-p⇝ at 100 GeV

- p⇝-p⇝ at 100 GeV last done in Run-9
  - higher L_{peak} (compared to Run-8) did not increase L_{avg}, limited by beam-beam and other nonlinear effects
- Expect only few improvements compared to Run-9
  - orbit/Q/ΔQ_{min}/Q' control, periodic orbit correction and 10 Hz orbit feedback in store, 9 MHz + bouncers, collimation on ramp
- Polarization as least as good as in Run-9

		Run-9 achieved	Max Run-12 projections
Polarization P	%	57★	**55-60★**
Peak luminosity L_{peak}	$10^{30}\,cm^{-2}s^{-1}$	50	**52**
Avg. store luminosty L_{avg}	$10^{30}\,cm^{-2}s^{-1}$	28	**30**
Luminosity per week L_{week}	pb^{-1}	8	**10**
Time-in-store	%	53	**55**

★ H-jet measurement (intensity-average over transverse and longitudinal profiles)

Run-12 projections p↑-p↑ at 100 GeV



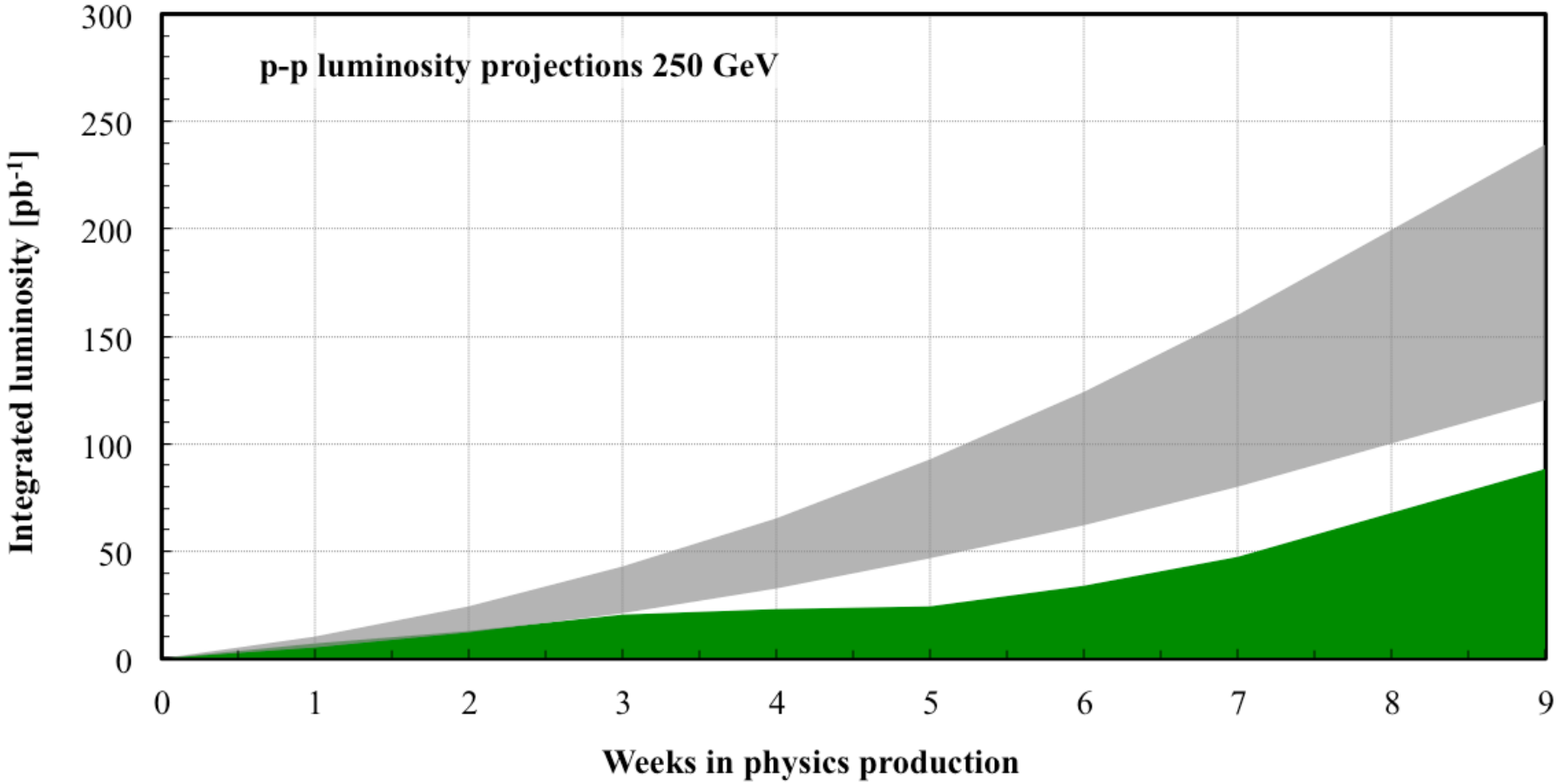
Run-12 projections p⇝-p⇝ at 250 GeV

- p⇝-p⇝ at 250 GeV demonstrated full luminosity potential
  commissioned AGS tune jumps, 9 MHz rf, orbit/Q/ΔQ_{min}/Q' control, periodic orbit correction and 10 Hz orbit feedback in store, collimation on ramp, dump upgrade, CNI upgrade, …
- Fast ramp up to peak performance (i.e. faster than in Run-11)
  + better polarization
  + smaller emittances (in all dimension)

		Run-11 achieved	Max Run-12 projections
Polarization P	%	48★	**50-55★**
Peak luminosity L_{peak}	10^{30} cm^{-2}s^{-1}	145*	**200**
Avg. store luminosty L_{avg}	10^{30} cm^{-2}s^{-1}	90*	**125**
Luminosity per week L_{week}	pb^{-1}	25	**40**
Time-in-store	%	37	**55**

★ H-jet measurement (intensity-average over transverse and longitudinal profiles)

Run-12 projections p⇝-p⇝ at 250 GeV



Polarization in Run-11 and Run-12

Run-11 store polarization as measured by H-jet (measures <P>): 48% in Run-10 vs. 35% in Run-9

(polarization has a profile $R_x \approx R_y \approx 0.2$, $R = \sigma^2/\sigma_p^2$, P_0 in center up to 65%)

- AGS horizontal tune jump system operational
  P +8% with high intensity, tested in Run-9,
- Acceleration near $Q_v = 2/3$ in RHIC
  P +25%, measured *P* transmission as function of Q_v in Run-9, tested ramp with Au in Run-10, simulated differences between Au and p ramp last summer
- Vertical orbit control on ramp
  20 μm measured orbit rms late in ramp – real rms depends on BPM offsets
- Smaller momentum spread on ramp

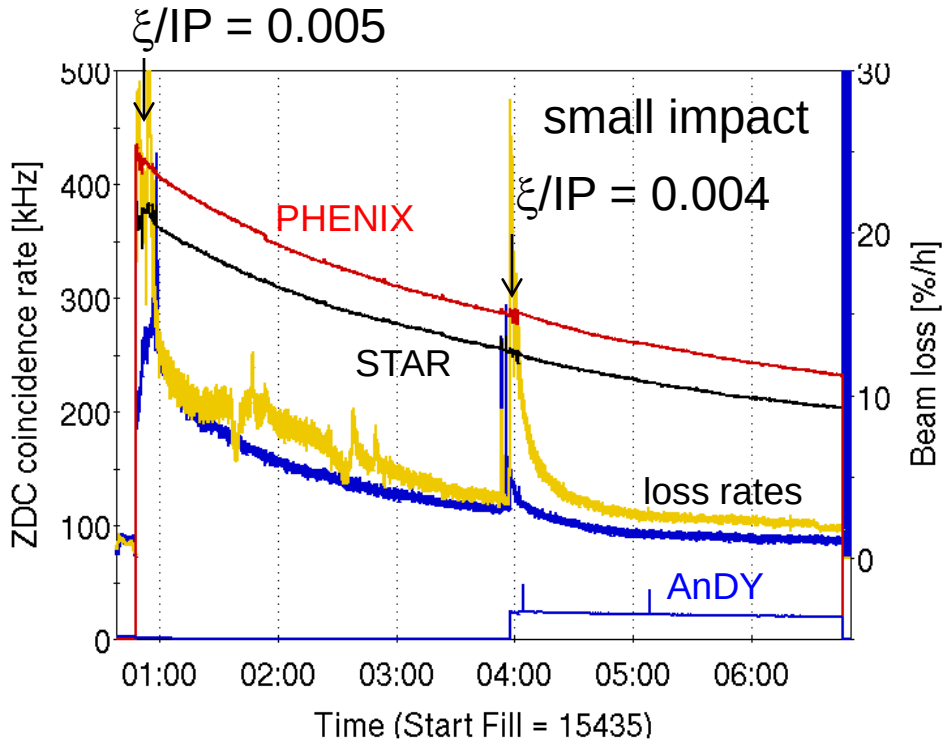
Run-12 incremental improvements:

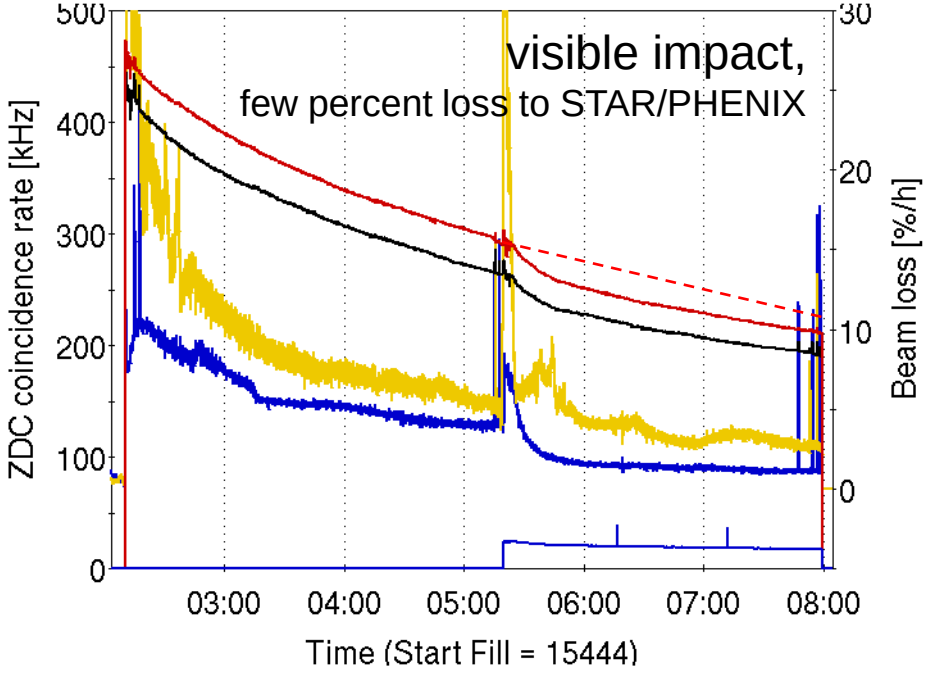
- Changes in source/LEBT/MEBT ♑ *P* +6%
- Smaller emittances, 24♑18 mm.mrad (less *P* profiles in AGS and RHIC) ♑ *P* +8%
- Small change in store energy in RHIC (*P* lifetime reduction) ♑ *P* +5%

Also need to prepare for further improvements in Run-13

A_nDY in Run-11 (250 GeV pp)

- Beam envelope function β^* = 3.0 m at IP2
- Reduced IP2 crossing angle from initially 2.0 mrad to zero
- Added 3rd collision with following criteria (last instruction):
  1. $N_b \leq 1.5 \times 10^{11}$
  2. Beam loss rate <15%/h in both beams
  3. Not before first polarization measurement 3h into store





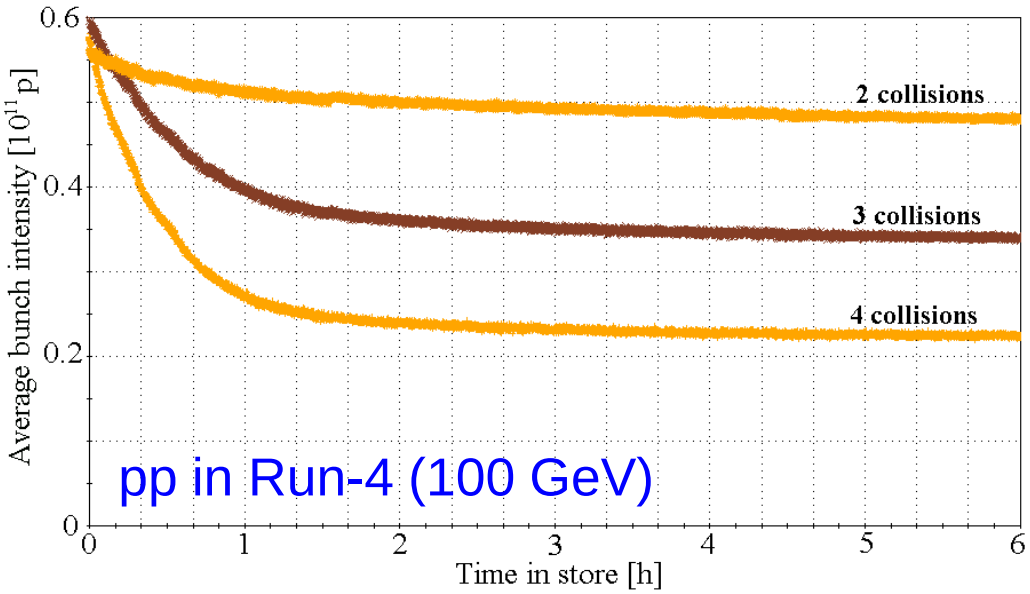
Future operation of A_nDY

- Can reduce β^* at IP2
  - have run with β^* = 2.0 m previously for BRAHMS
  - β^* = 1.5 m probably ok, needs to be tested
- Longer stores
  - 10h instead of 8h in Run-11 (depends on luminosity lifetime and store-to-store time)
- Collide earlier in store when conditions are met
  - needs coordination with polarization measurement, PHENIX and STAR
- Electron lenses (see later) if A_nDY runs beyond Run-13
  - increases max beam-beam tune spread, currently $\Delta Q_{max,bb} \approx 0.015$
  - can be used for to increase $\xi \sim N_b/\varepsilon$ and/or number of collisions

Run-11 luminosity at A_nDY:
max ~0.5 pb^{-1}/store

With improvements:
~3x increase,
~10 pb^{-1}/week

(A_nDY sees stronger impact of prematurely aborted stores than STAR and PHENIX)

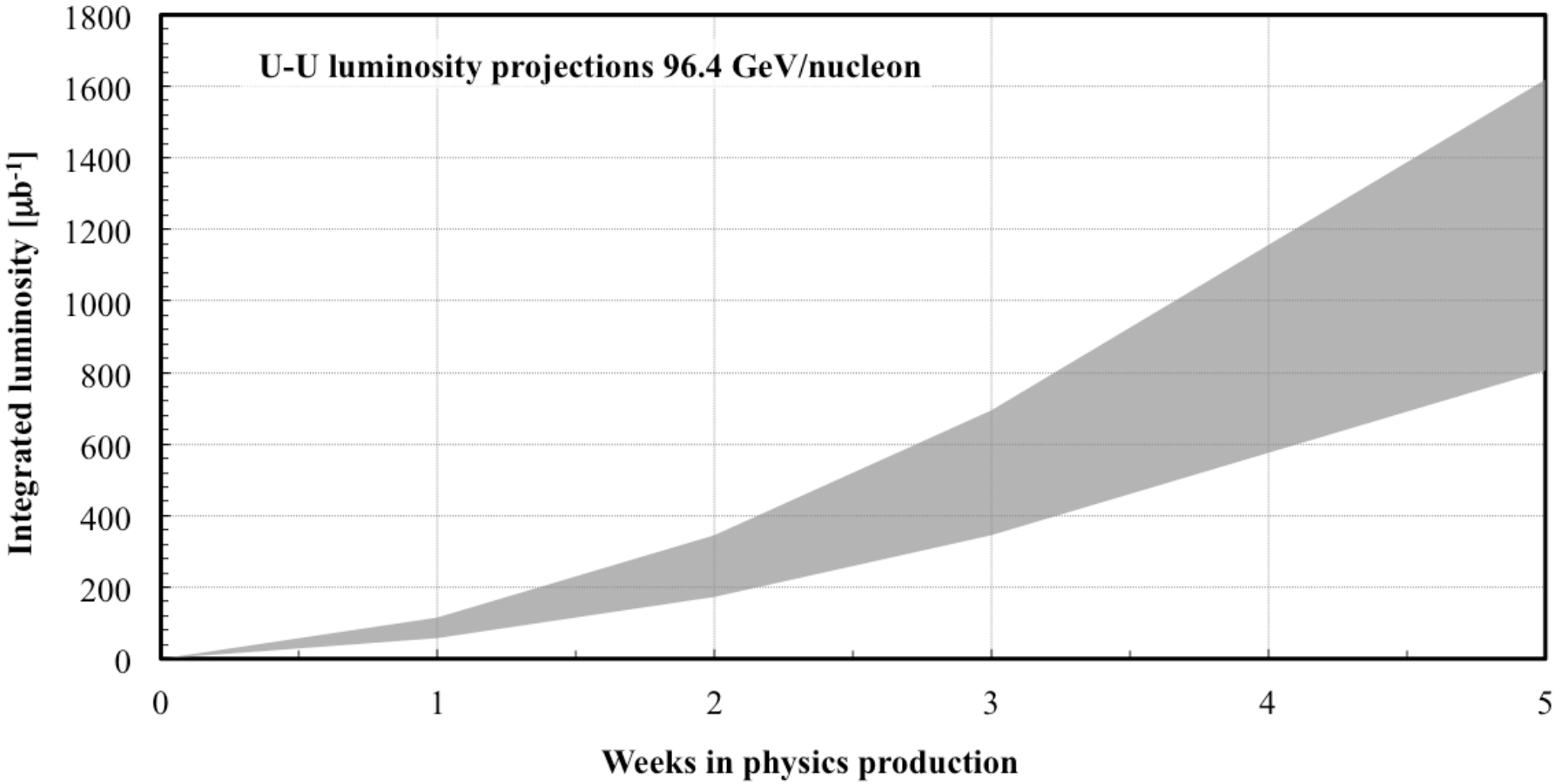


Run-12 projections U-U at 96.4 GeV/nucleon

- First RHIC U run, exploration for STAR/PHENIX
  - need EBIS
  - charge state ~40, Booster injection efficiency may be different, Booster bunch merge needed
- RHIC luminosity largely determined bunch intensity and cooling
  - same rigidity as 100 GeV/nucleon (no training)
  - 3D stochastic cooling, increase in off-momentum DA

		Run-11 Au-Au	Run-12 projections
Number of bunches N	…	111	**111**
Bunch intensity N_b	10^9	1.3	**0.6 – 0.85**
β^*	m	0.75	**0.75**
Peak luminosity L_{peak}	$10^{26}\,cm^{-2}s^{-1}$	50	**11 – 21**
Avg. store luminosty L_{avg}	$10^{26}\,cm^{-2}s^{-1}$	30	**7 – 14**
Luminosity per week L_{week}	nb^{-1}	1.0	**0.2 – 0.45**
Time-in-store	%	37	**55**

Run-12 projections U-U at 96.4 GeV/nucleon



Run-12 projections Cu-Au at 100 GeV/nucleon

- First ion run with EBIS
  - need both Cu and Au sources (only gases for NSRL), Booster bunch merge needed (no margin for longitudinal emittance increase in RHIC)
- RHIC luminosity largely determined by bunch intensity and cooling
  - Cu in Blue and Au in Yellow (like d-Au), ≈ same charge for Cu and Au
  - horizontal stochastic cooling new (3D sc for Au and Cu)
  - increase in off-momentum DA

		Run-5 Cu-Cu	Run-11 Au-Au	Max Run-12 projections
Number of bunches N	…	37	111	**111**
Bunch intensity N_b	10^9	4.5	1.3	**4.0 / 1.3**
β^*	m	0.9	0.75	**0.85**
Peak luminosity L_{peak}	$10^{26}\,cm^{-2}s^{-1}$	200	50	**170**
Avg. store luminosty L_{avg}	$10^{26}\,cm^{-2}s^{-1}$	80	30	**100**
Luminosity per week L_{week}	nb^{-1}	2.4	1.0	**3.1**
Time-in-store	%	52	59	**55**

Run-12 projections Cu-Au at 100 GeV/nucleon