Polarized RHIC in the past and in Run-9

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Run-8 Time-Line

- January 28: End of d-Au run, switch-over to polarized protons.
- February 14: Start of polarized protons physics run.
- March 10: End of polarized protons run, switch-over to low-energy Au-Au.
- March 11: End of Run-8, start warm-up.

Polarized Proton Goals (in a nutshell)

- STAR:
  1. Unpolarized comparison data for d-Au.
  2. Transverse (vertical) spin running.

- PHENIX:
  1. 250 GeV (did not happen).
  2. Transverse (radial) spin running.
  3. Machine development towards higher luminosity.

Goals (cont.)

- RHIC:

  1. Satisfy all customers in terms of physics running.

  2. Machine development towards higher luminosity in Run-9 and beyond.

$\Rightarrow$ High expectations, conflicting goals – and only six weeks of running!

The short, sad life of the near-integer working point

Motivation:

- In Run-6, performance was beam-beam limited. With working points on opposite sides of the diagonal, the beam above the diagonal inevitably suffered.

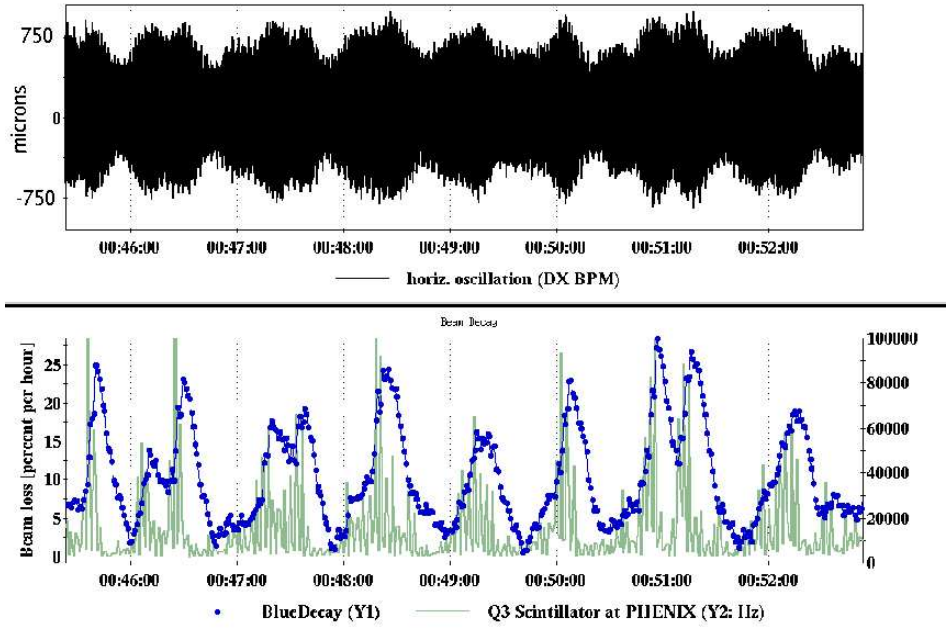
- To overcome this, a new (better) working point was necessary.

- Best candidate: near-integer (.96/.95).

Known challenges:

- β-beat scales as $1/\sin(2\pi Q)$.
- Orbit distortion scales as $1/\sin(\pi Q)$.
- 10 Hz beam-beam offset (= modulated orbit distortion) increases – but we have a dedicated feedback for that.

Blue beam decay and orbit jitter – perfect correlation!



High beam decay causes background – too much for experiments. Abandoned after one week.

Back to Run-6 configuration

- Reloaded pp28 as pp83.
- Two-person shifts for shorter start-up time.
- Colliding beams within 24 hours!
- Increased injected bunch intensity up to 1.84e11 (Blue)/ 1.76e11 (Yellow).
- No hard beam-beam limit observed. Both beams are below the diagonal.

Polarization

- Polarization was significantly lower than in Run-6.
- AGS performance lower than in Run-6. Initially injection on-the-fly, later returned to Run-6 configuration to improve performance.
- Poor Yellow polarization transmission (≈ 75 percent).
- Two days before the end of the run, horizontal snake orbit angle was identified as possible cause of Yellow polarization loss.

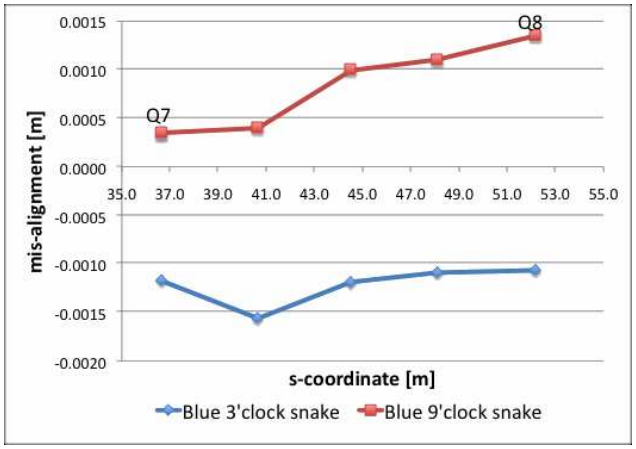
- Broken BPM in Yellow snake region prevented otherwise straightforward orbit correction.

- Unsuccessfully attempted orbit angle scan; not enough ramps.

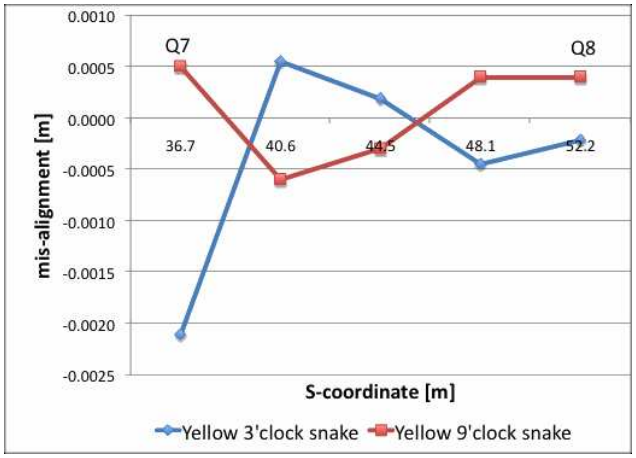
- Careful analysis of survey data during the shutdown revealed that horizontal snake orbit is likely cause of polarization loss.

Horizontal snake angle from survey data

BLUE



YELLOW



$\Delta\Theta = -0.03\,\mathrm{mrad}$ $\Delta\Theta = -0.11\,\mathrm{mrad}$

Resulting spin tune error due to snake orbit angle:

$$\Delta Q_s = G\gamma\frac{\Delta\Theta}{\pi}$$

Consistent with spin tune measurements

β^*-squeeze

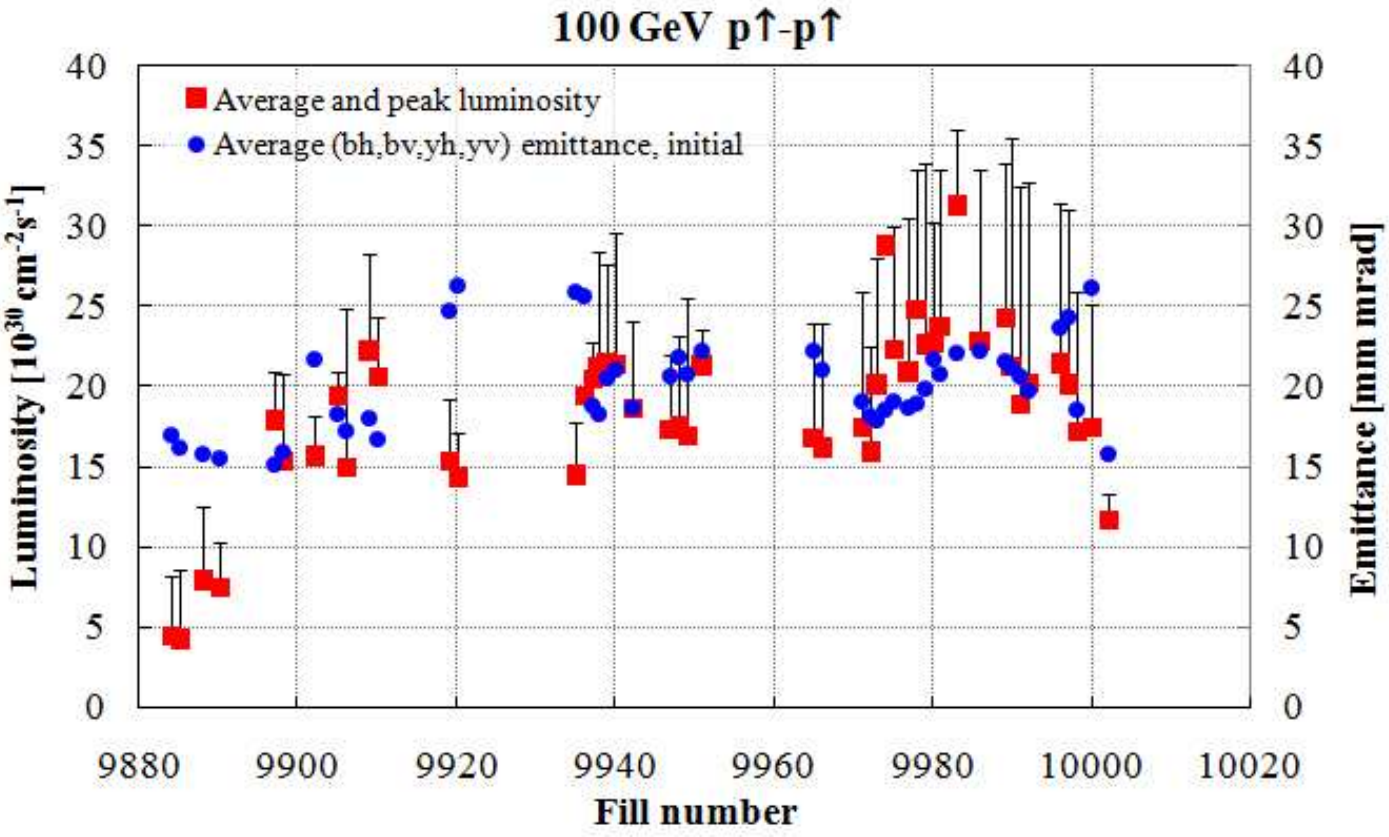
- Several attempts during APEX and Machine Development to squeeze to $\beta^* = 0.7\,\mathrm{m}$.

- Each and every time, we almost made it operational – but not quite. Reasons: Lack of time, human error,...

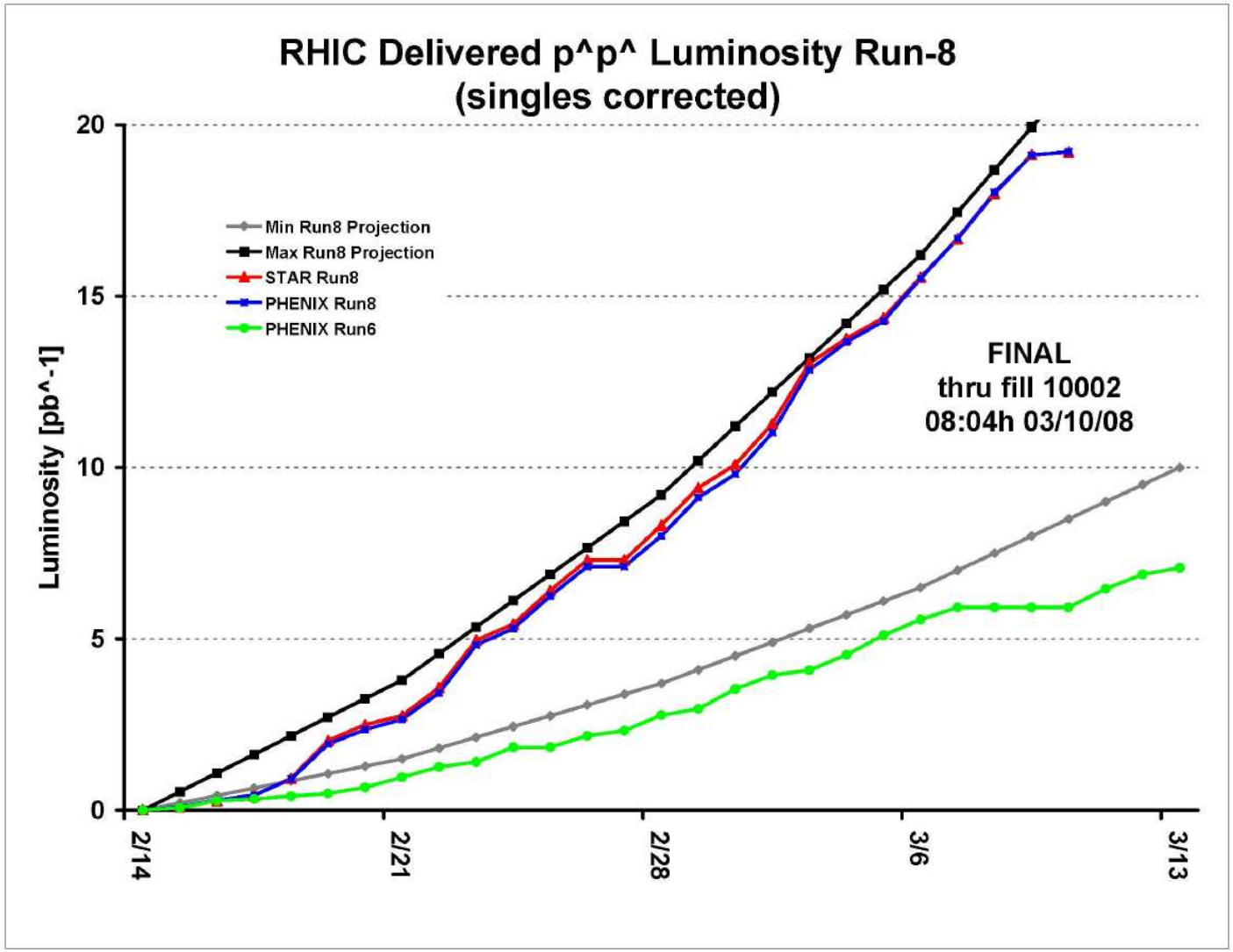
- Achieved so far: 56 bunches at store.

- Backgrounds are as low as for $\beta^* = 1.0\,\mathrm{m}$.

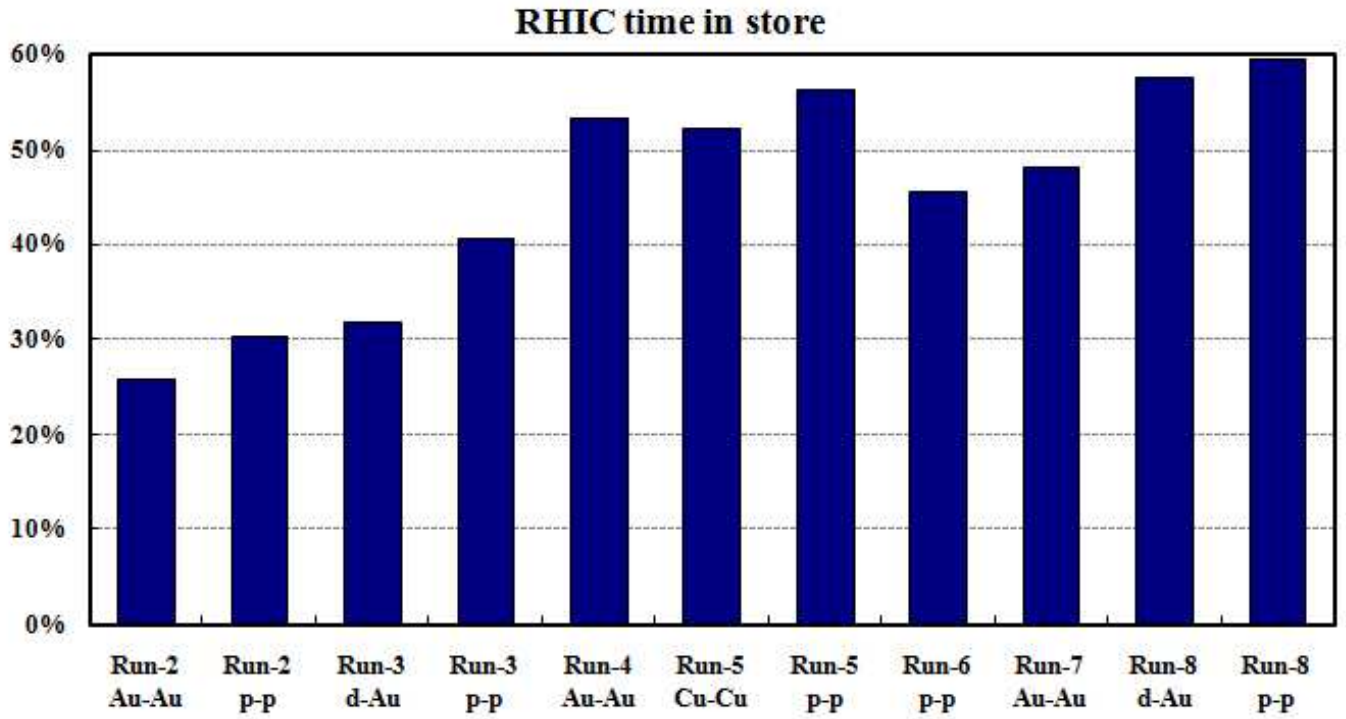
- Lifetime at store requires nonlinear chromaticity correction.



Courtesy Wolfram Fischer



Courtesy Peter Ingrassia



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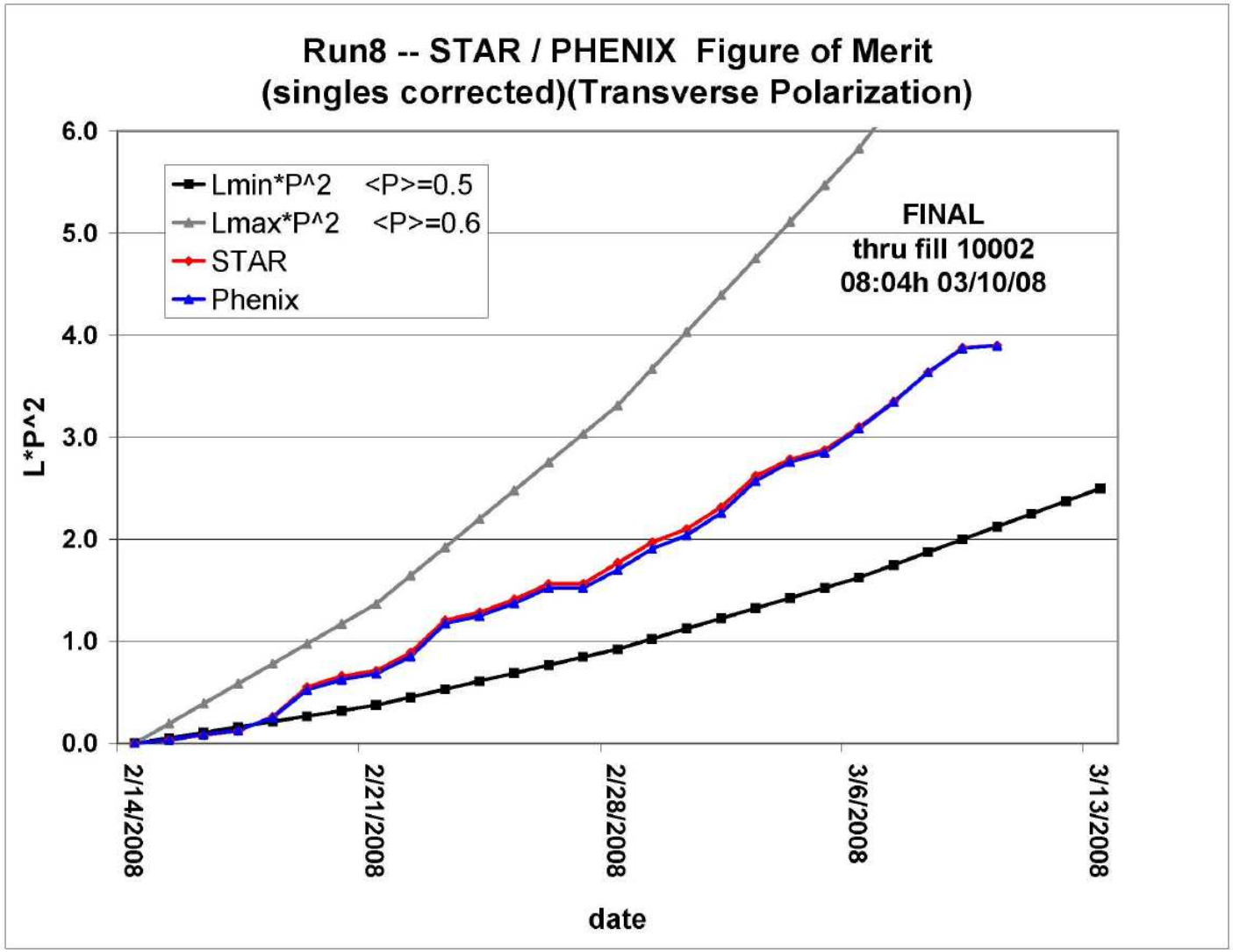

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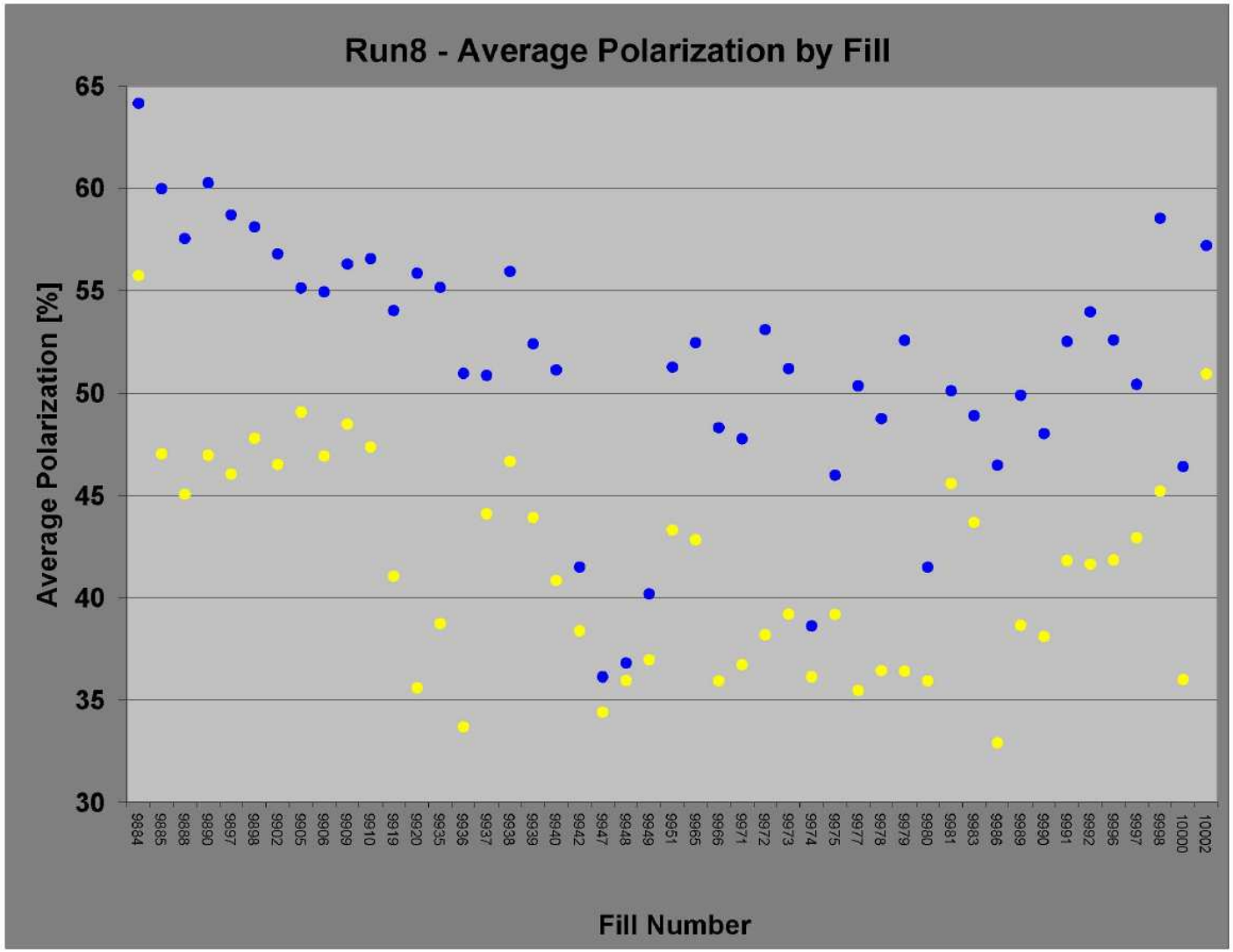

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Improvements and plans for Run-9

- Run-9 will start with 250 GeV (Mei).
- Ramps will be identical up to 100 GeV.
- Continuous AGS tuning during 250 GeV run.
- Repair BPMs and re-align RHIC snake regions.

$\rightarrow$ start-up at 100 GeV should be extremely fast; RF capture, instrumentation timing identical to 250 GeV.

Tighter β^*-squeeze

- $\beta^* = 70\,\mathrm{cm}$ was tested during Run-8.
- Luminosity lifetime/beam lifetime at store are uncertain.
- Tracking studies underway to determine initial β^* value for Run-9; most likely 70 cm.
- $30 - 40$ percent luminosity increase seems realistic.

Nonlinear chromaticity correction

- Eliminate tune spread from nonlinear chromaticity, then fill up this space by beam-beam.

- Experience with $\beta^* = 70\,\mathrm{cm}$ in Run-8 showed that this is required for good lifetime.

- 20 – 30 percent luminosity increase (?)

9 MHz cavity

- Reduces bunchlength by factor $\sqrt{2}$.
- Shorter bunches improve hourglass factor.
- Longer bunches on the ramp also reduce transverse emittance blow-up due to lower density/peak current.
- Common cavity will lock bunches on the ramp - avoids long-range beam-beam.
- To be commissioned during 250 GeV set-up (?)
- 20 – 30 percent luminosity increase (at $\beta^* = 1.0\,\mathrm{m}$).

Conclusion

- Goals on delivered polarized protons luminosity and FOM were met according to projections.
- Time in store reached a new record: $(60 - \epsilon)$ percent for polarized protons.
- However, six weeks were too short to make real progress in Run-8.
- β^*-squeeze was an important development towards higher proton luminosity in Run-9.
- Expect to reach enhanced luminosity goals in Run-9.