2022 RADIAL SHIFT APEX RESULTS

G. Robert-Demolaize for the RS Team

I – Context

- EIC hadron lattice design studies focus on the implementation of a transverse orbit displacement, or *radial shift*, to generate the required circumference change to match the length of the electron lattice independently of the energy of the circulating hadron beam (100 or 275 GeV).

E_{tot} GeV	γ	$1-\beta$ 10^{-3}	ΔC mm	$\langle \Delta R \rangle$ mm
41	43.70	0.2619	-908.5	–
100	106.58	0.0440	-73.2	-11.7
133	141.75	0.0249	0.1	0.0
275	293.09	0.0058	73.2	11.7

- Run21 APEX demonstrated the feasibility of radially shifted closed orbits using 100 GeV/u Au beams and a relative dipole field shift δB = ±1%. Two configurations were tested, Short IR (orbit “flat” between D5’s) and Long IR (between Q10’s). Peak orbit excursions are in the ±18.5-20 mm range depending on the configuration. Chromaticity control was an issue for the δB = -1% setups, both Short and Long IR.

- The time requested for Run22 APEX was intended for the first proof-of-principle setups with 255 GeV polarized protons with δB = ±1%. However, lattice design was made difficult due to hitting multiple RHIC-specific limitations, mainly the power supply limits of IR quadrupoles and horizontal orbit correctors. As such, as of this writing, our team has only been able to test the Short IR configuration for δB = ±0.5%.

- Similar to Run21, dedicated ramp files were created to ramp the Yellow ring from its 254 GeV flattop setpoint at the end of the energy ramp (pp22-255GeV-e1) into the new magnet settings for each Radial Shift (RS) attempt.

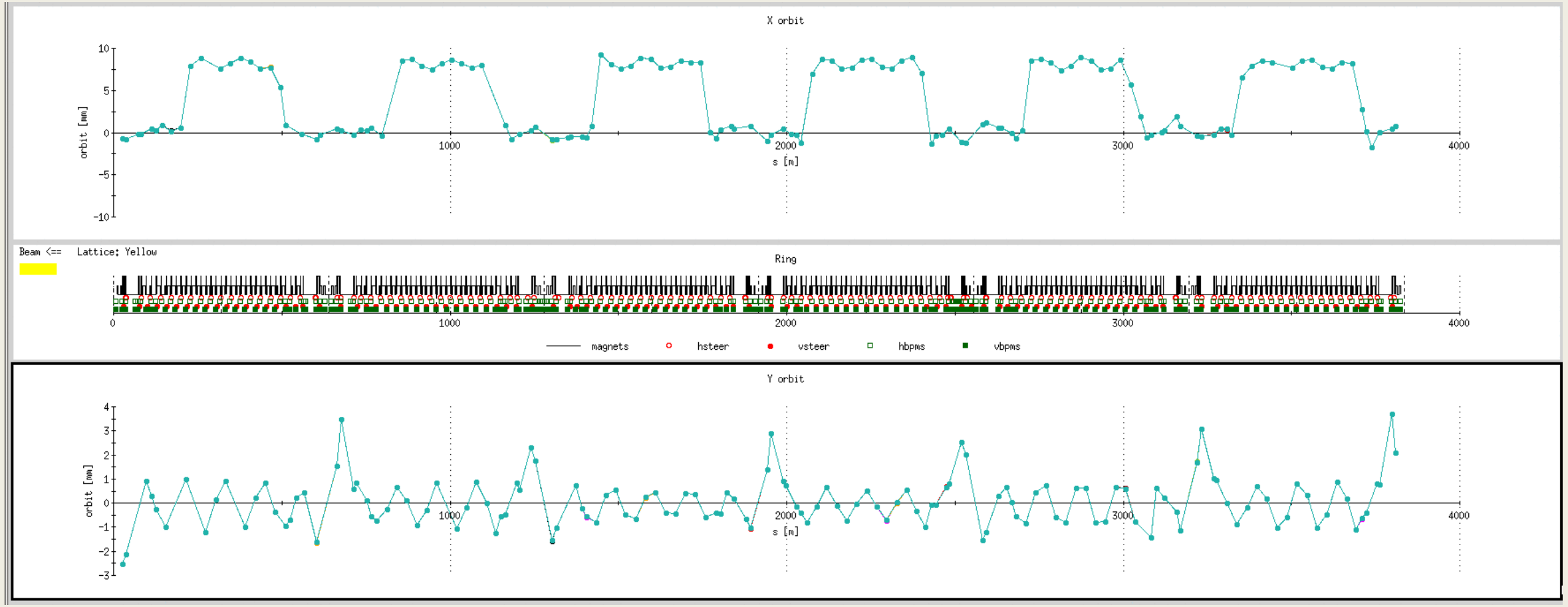
- The first 25 seconds of each ramp is used to remove the vertical separation bumps. Tune/coupling feedback is used for the entire duration of the RS ramps, while orbit feedback is turned off after 25 seconds.

- Preparations for this APEX was delayed due to personnel change: namely, we had to re-figure out the recipe for proper RF control during the RS ramp attempts – in order to make sure that the frequency would follow the radius change and the beam would stay on-momentum.

- Initial setup was longer than Run21 since we had to “mode-switch” RHIC to make it possible to ramp the Yellow beam only. Many thanks to all system experts and OPS team that made themselves available for both parts of the experiment throughout the day.

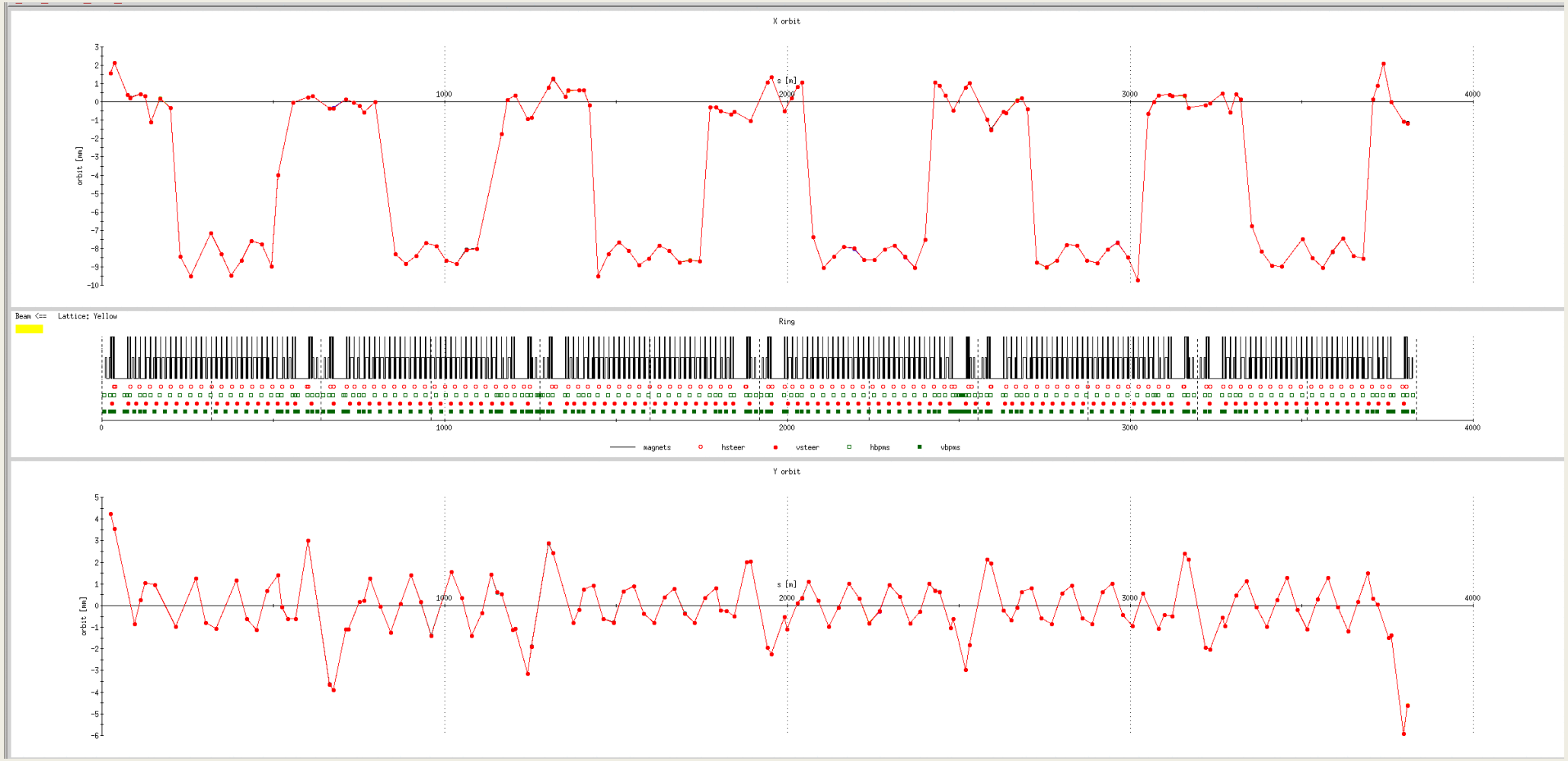
- Procedure for each attempt: ramp 12 bunches (1.4e11 pp/bunch) to flattop; program the new RF function; measure polarization and chromaticity; run the RS ramp, optimize the beam lifetime as needed; repeat the polarization and chromaticity measurements.

- pp22-255GeV-RSmP5 – δB = -0.5%



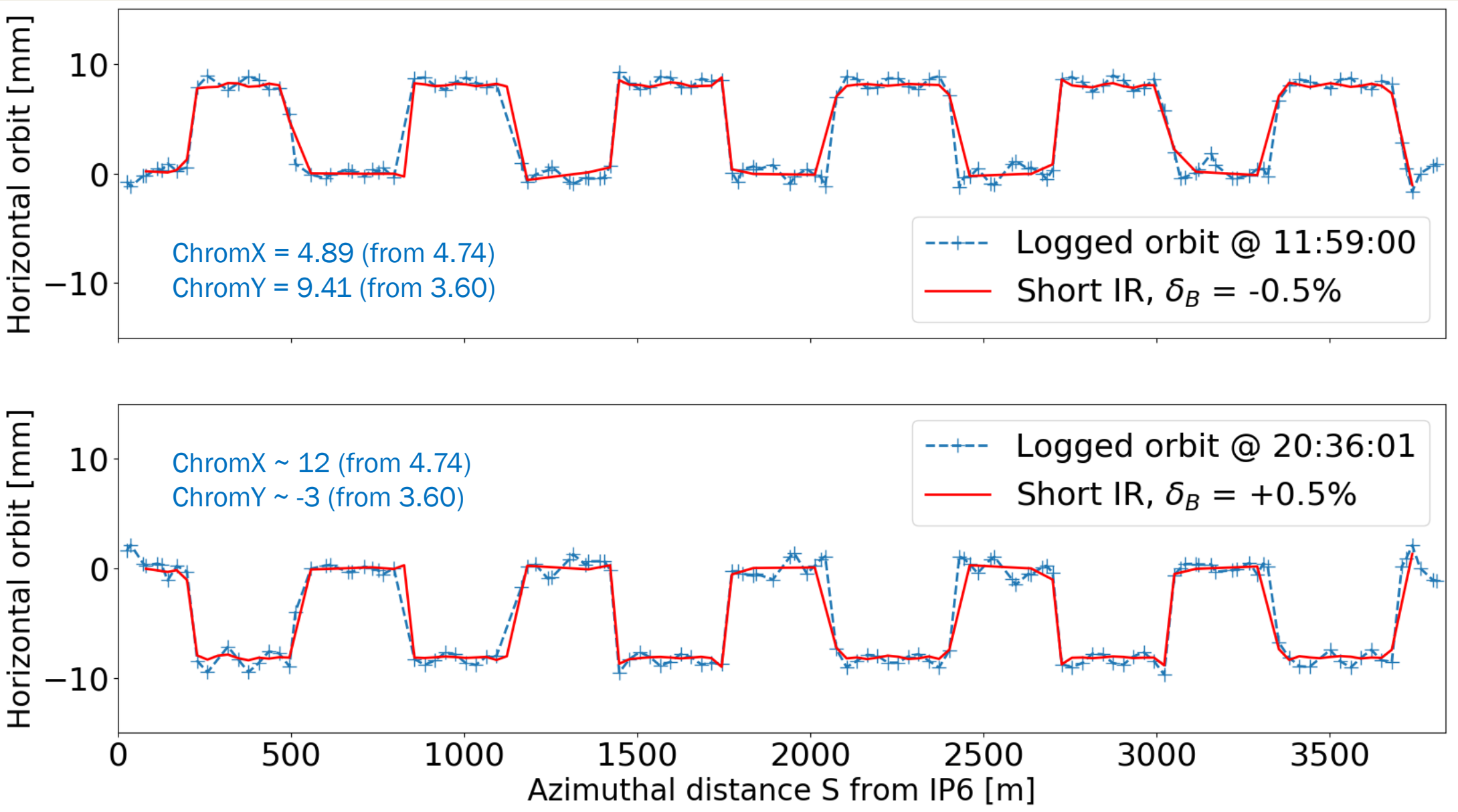
- Rather large vertical orbit distortion: this is likely the effect of every RHIC imperfection (roll, etc…).
- X_{mean} feedback issue on the first try, which blew the beam up longitudinally. We had similar results after the fix.
- No significant change in polarization was measured!

- pp22-255GeV-RSpP5 – δB = +0.5%

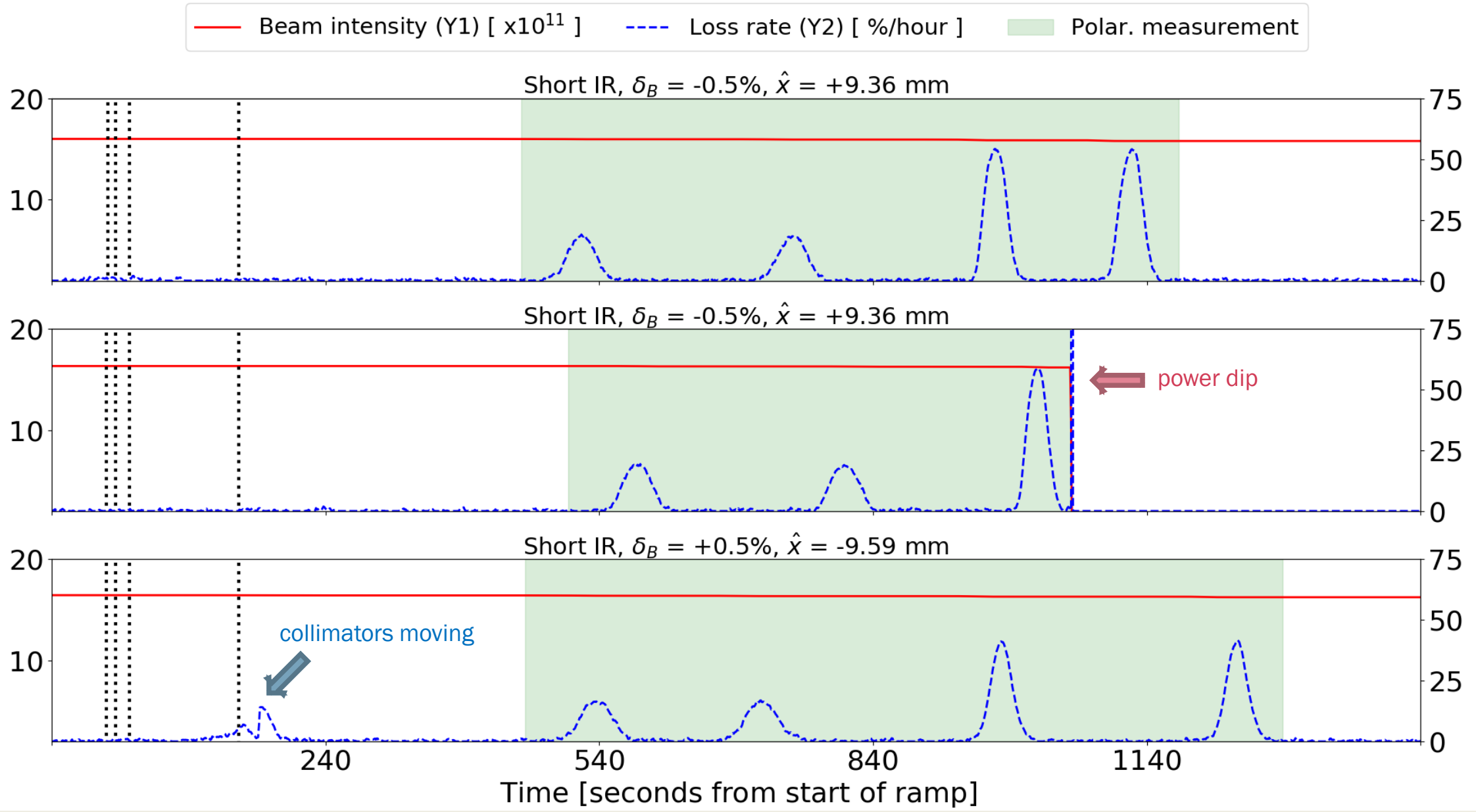


- Chromaticity application did not report any data post-RS ramp; K. Mernick posted a fit from logged data.
- Again, no significant change in polarization was measured!

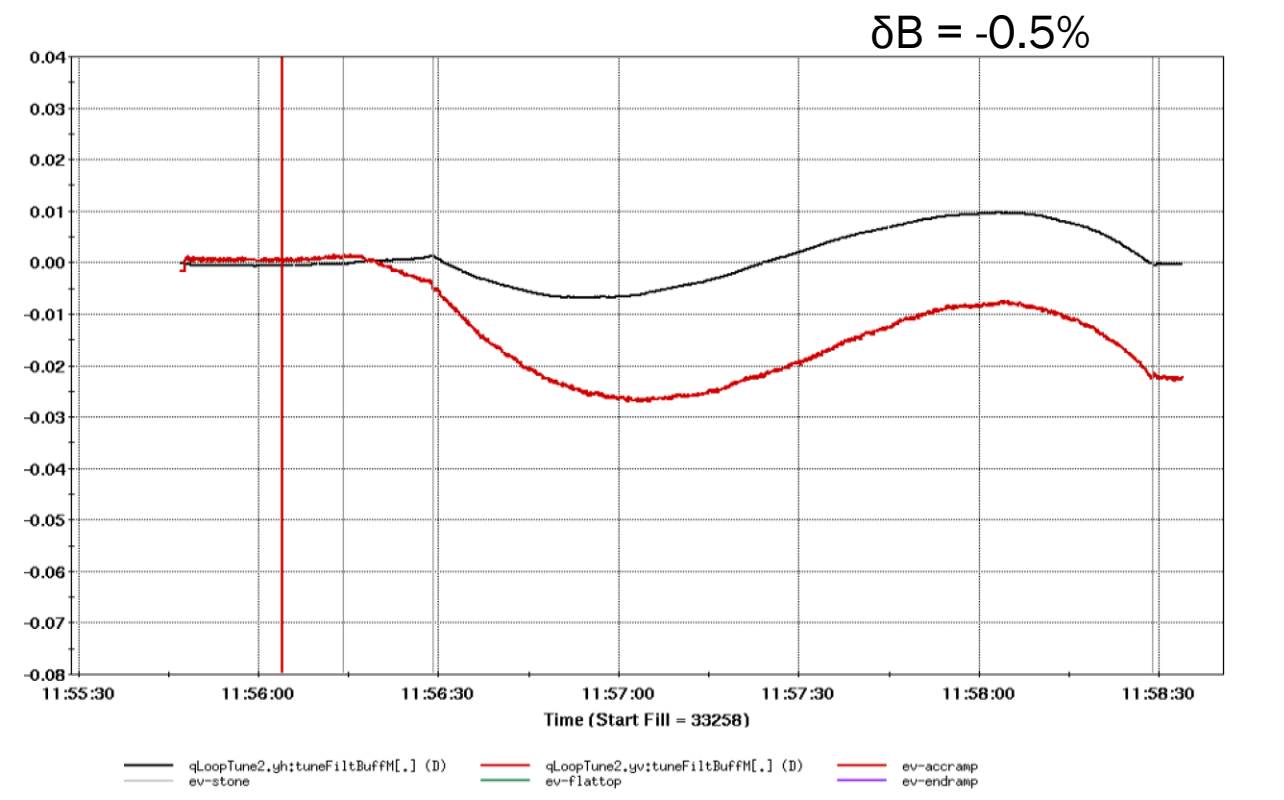
- Comparing model and measurement:

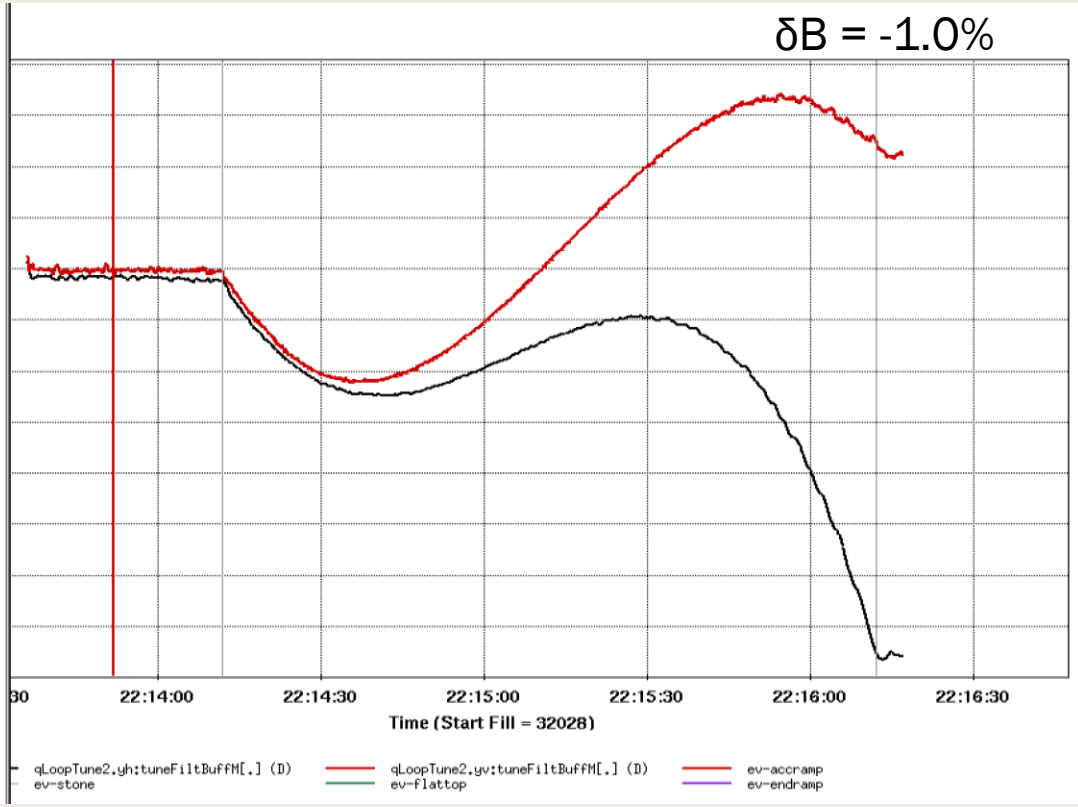


- Beam losses for each attempt:



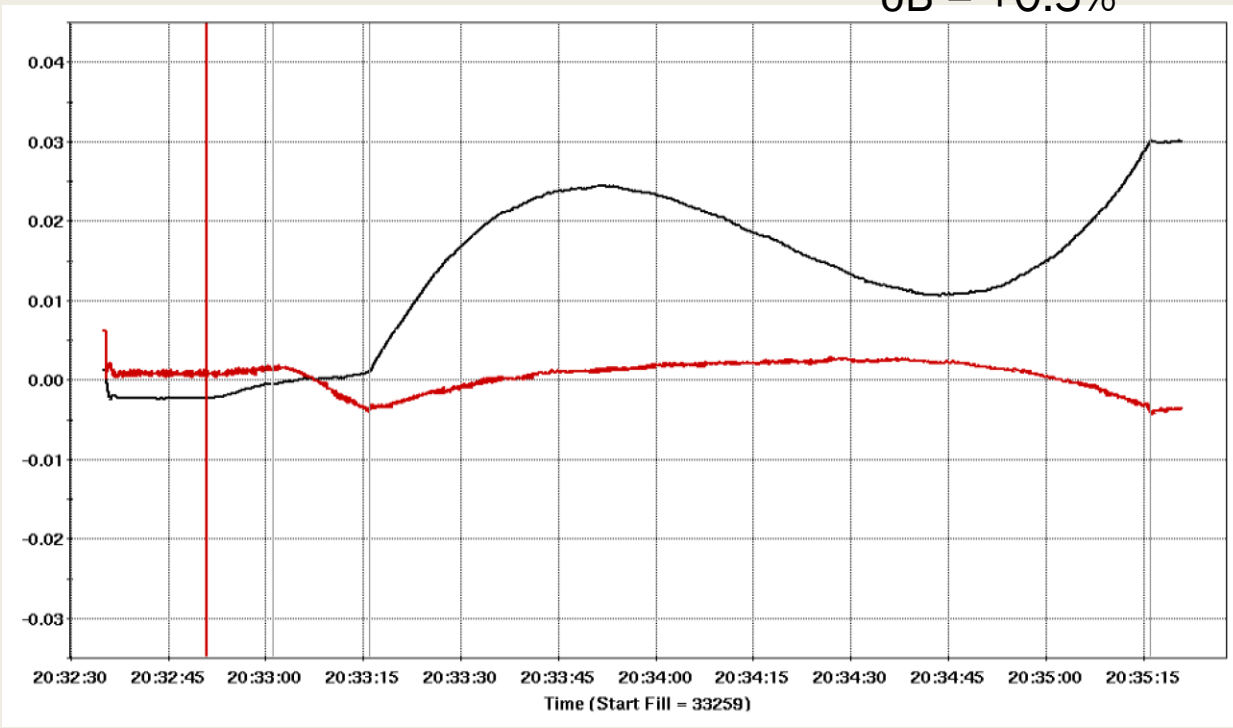
- Comparing tune feedback efforts Run21/Run22:



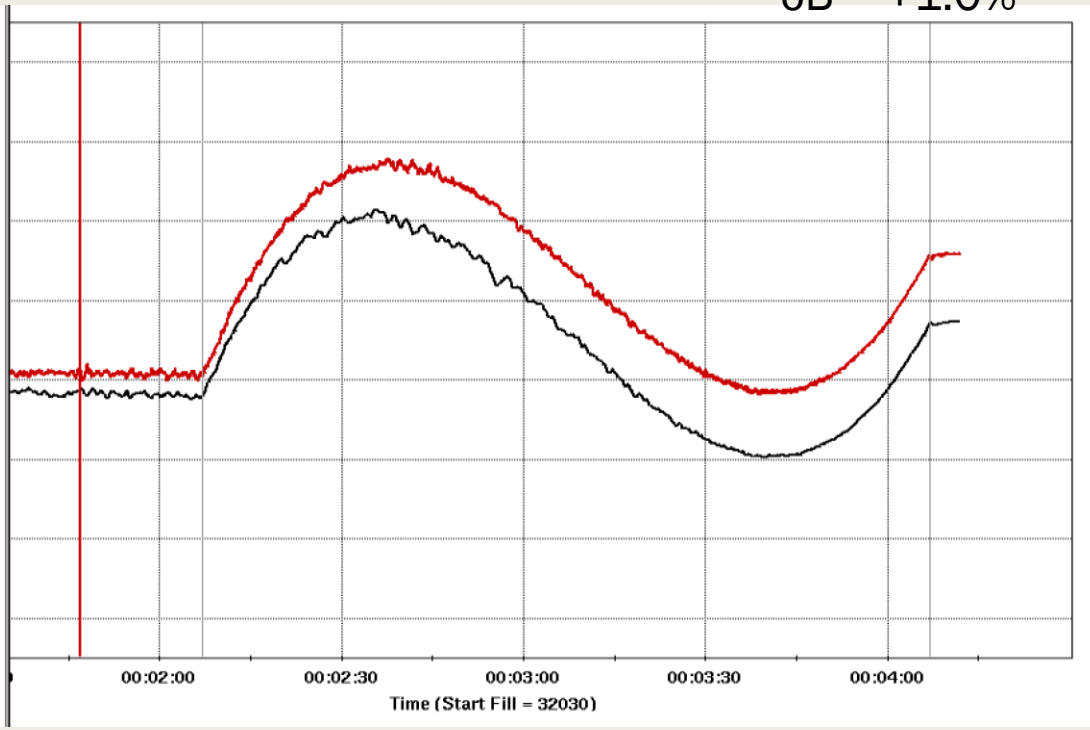


- Comparing tune feedback efforts Run21/Run22:

δB = +0.5%



δB = +1.0%



- Consistent with chromaticity measurements.

- Raises even more question on the modeling of chromaticity…

- Successfully established circulating beam with large circumference change (about ±30 mm) for 254 GeV polarized protons, with no change in beam lifetime and no significant polarization loss.

- Limited in the amplitude of excursion available for testing given the present RHIC pp configuration: this emphasizes once again the need for drastic changes for future HSR design and operations.

- With current set of tools, controlling/correcting the vertical orbit is not straightforward; it can be done but it requires significant changes.

- Regarding chromaticity at large orbit excursions, the plot thickens: preliminary results seem to diverge from the observations from Run21 => we clearly need to look deeper into this particular issue.

- Remainder of Run22 APEX: still looking to test more configurations, in particular the Long IR ones. Pressed with time and personnel availability…