

Demonstrate Large Emittance Ratio in RHIC for EIC

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General Remarks

- Started at 7am and ended at 6pm. Extended 2 hours due to Tandem To Booster (TTB) issues.
- First Fill 33912: we checked coupling angle settings at injection. No changes needed to the machine settings. Then we ramped to store, checked coupling angle settings are store, angles found with beams are very different from the machine settings. No explanation yet. We lost beams during trying to use tune/coupling feedback to correct coupling.
- Second Fill 33913: quick verified coupling angles found in last fill. Then we brought beams to collision, tune changes and emittance exchange observed. After with cooling and collision for 1 hour, then we separated the beams. Until we had emittance ratios 12:1 in Blue and 9:1 in Yellow, we collided beams again. This time, the tune and emittance did not change much.

Coupling Angles from Beams

Blue - F2/F13

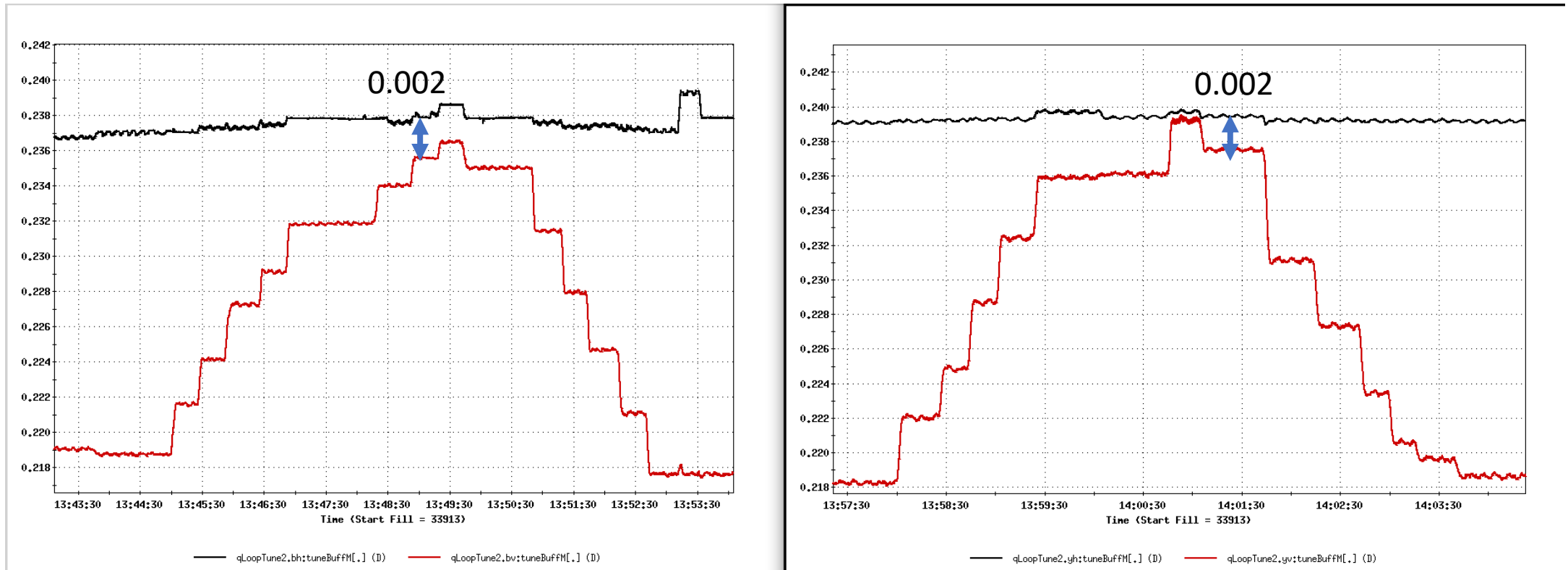
Yellow- F2 /F13

In machines:	(5 / 0.3) rad	(-0.6/4.1) rad
Run 12-14 :	(5.2/0.3) rad	(0.9/5.3) rad
Found at inj.:	(5.1/0.4) rad	(-0.5/4.1) rad
Found at store:	(5.9/1) rad	(0.1/4.8) rad

Coupling angles are used for coupling correction in feedback. So far no clue why they changed so far at store, 30-50 degrees. I got store lattice from Guillaume and will check it.

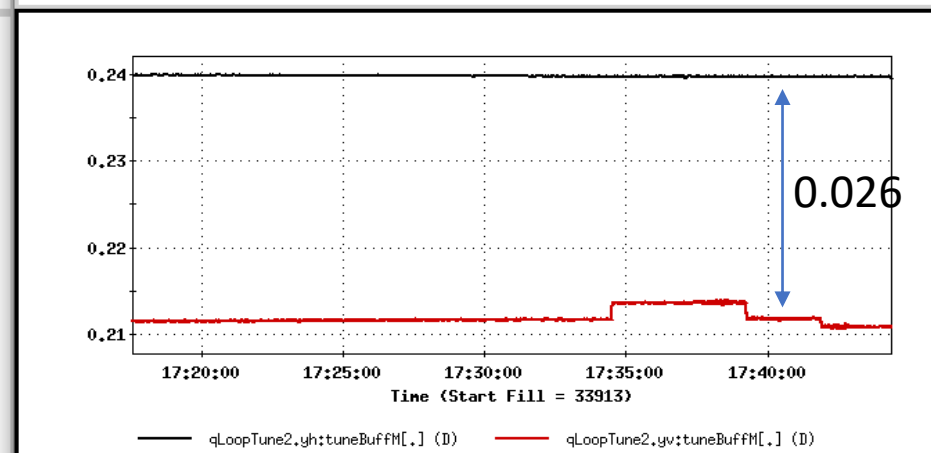
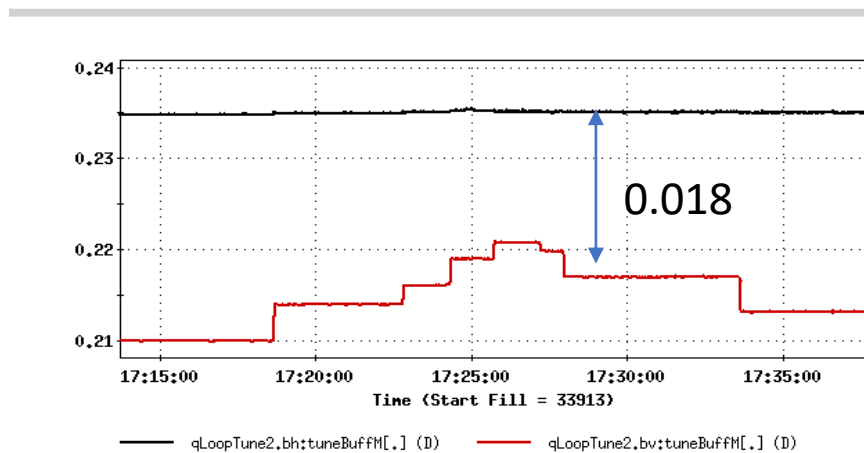
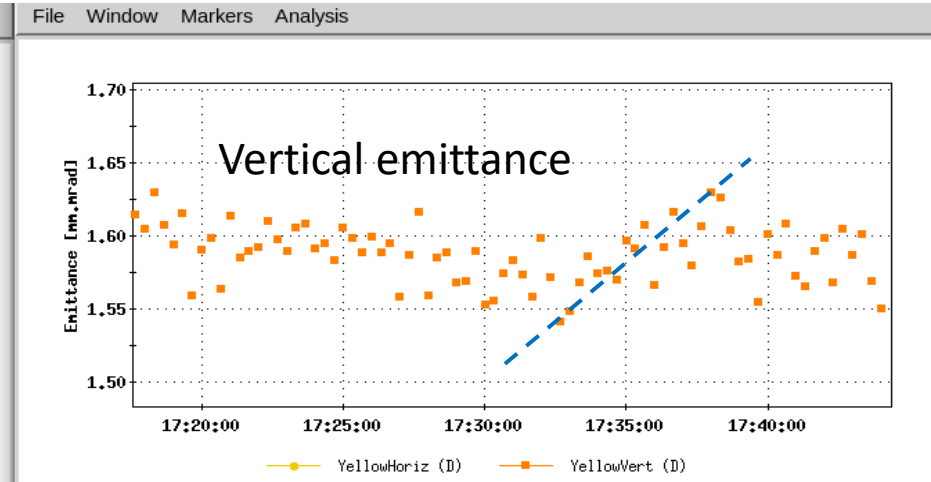
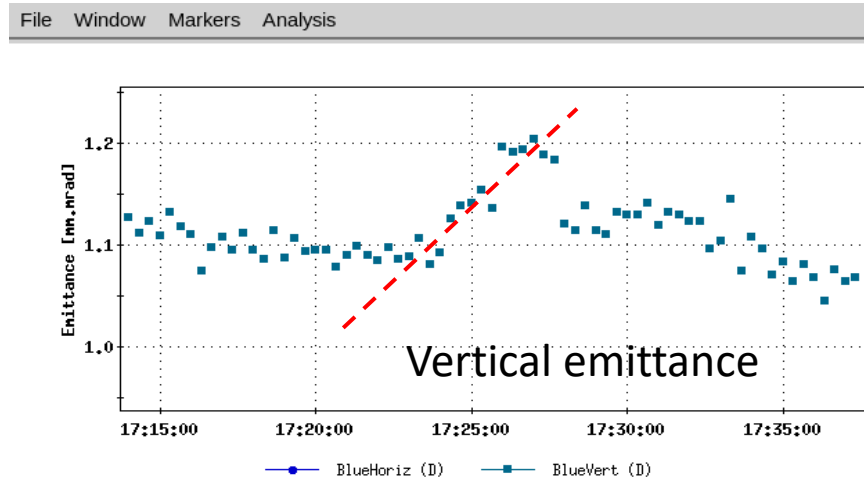
Need to revisit with 12 bunches in the next experiment.

The minimum tune split with 28 bunches



In both rings, we were able to transverse tunes closed to 0.002 before a very large beam decay. Need revisit with 12 bunches. (FYI: In 2018, we measured $dQ_{min} \sim 0.001-0.0015$ at store. In 2021, we measured $dQ_{min} \sim 0.0003$ at injection.)

Pushing Tunes Closer



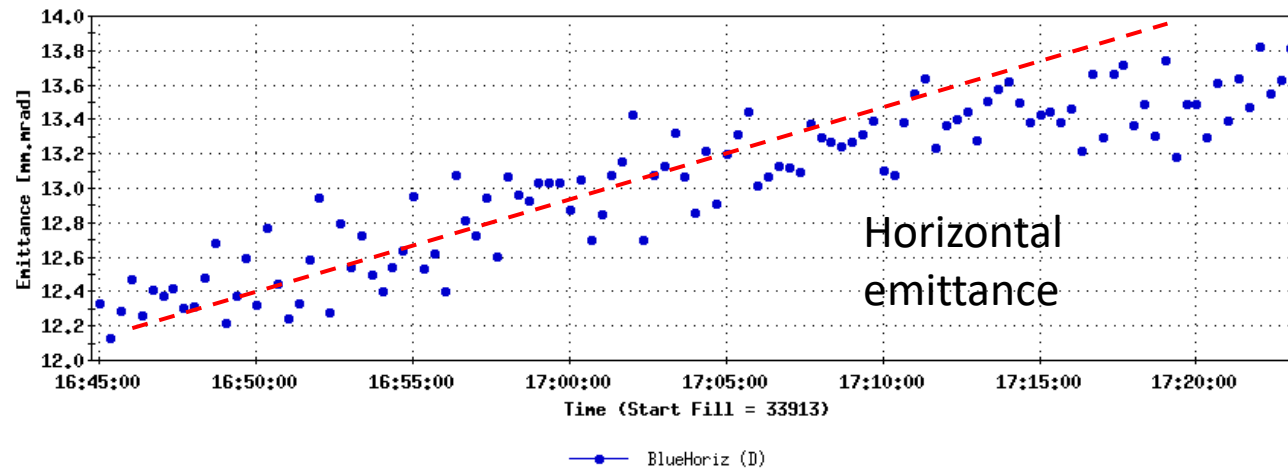
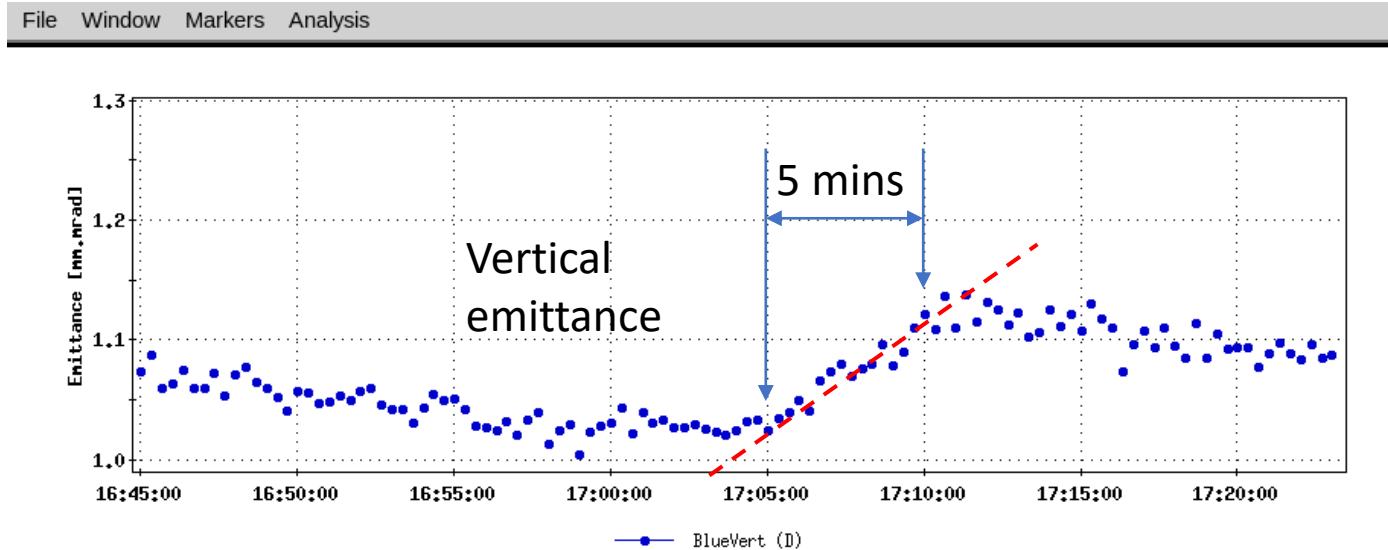
0.234991580247879
Time = Wed Jun 28 17:29:24 2023+660264us, qLoopTune2,bv:tuneBuffM[.] =
0.216952785849571

Time = Wed Jun 28 17:27:04 2023+590334us, qLoopTune2,yh:tuneBuffM[.] =
0.239899575710297
Time = Wed Jun 28 17:28:24 2023+22673us, qLoopTune2,yv:tuneBuffM[.] = 0.211723193526268

Blue ring

Yellow ring

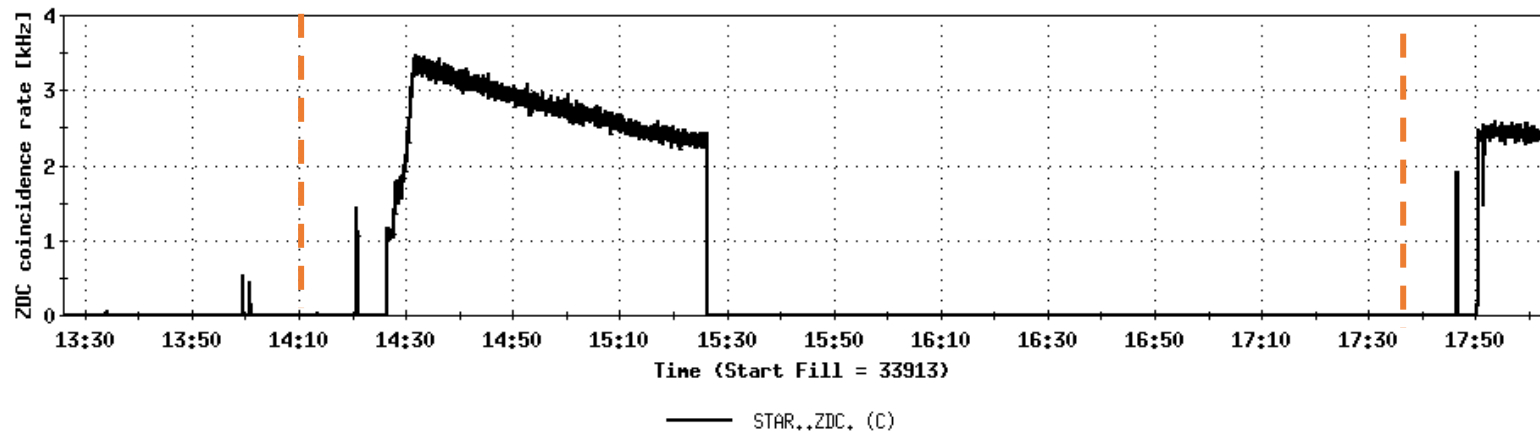
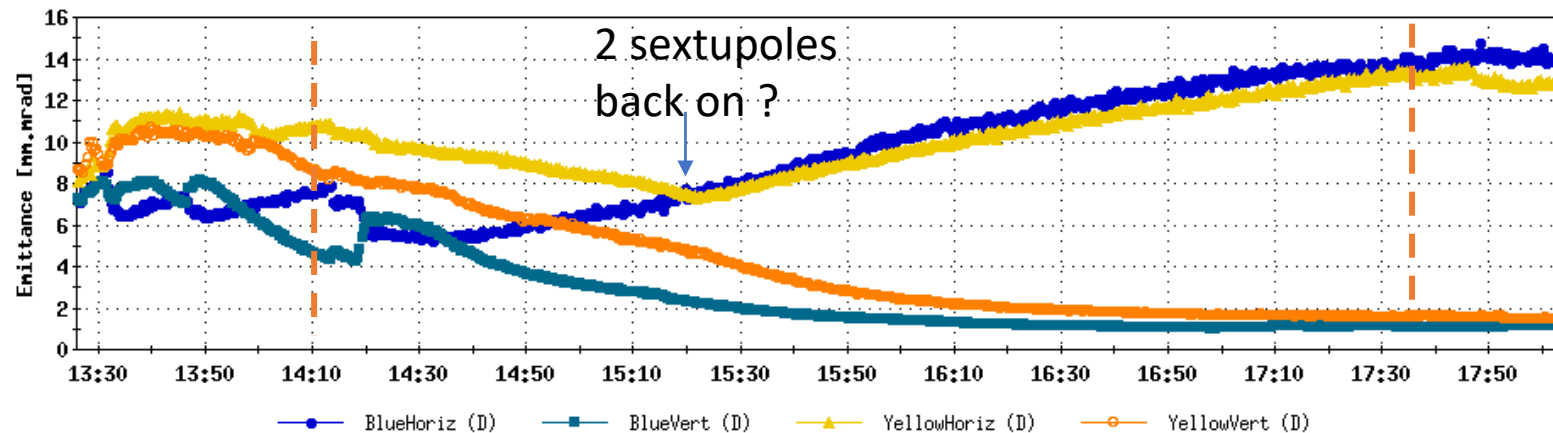
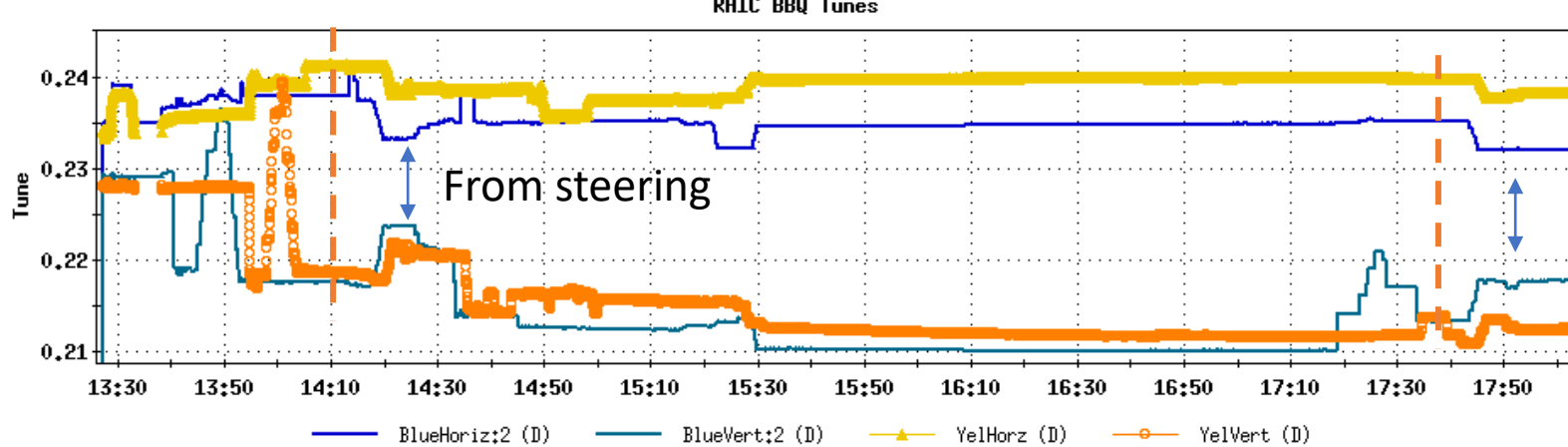
Switching Cooling To A Flat Beam



Here we temporarily switched off vertical cooling for 5 minutes for Blue ring when the emittance ratio is 12:1.

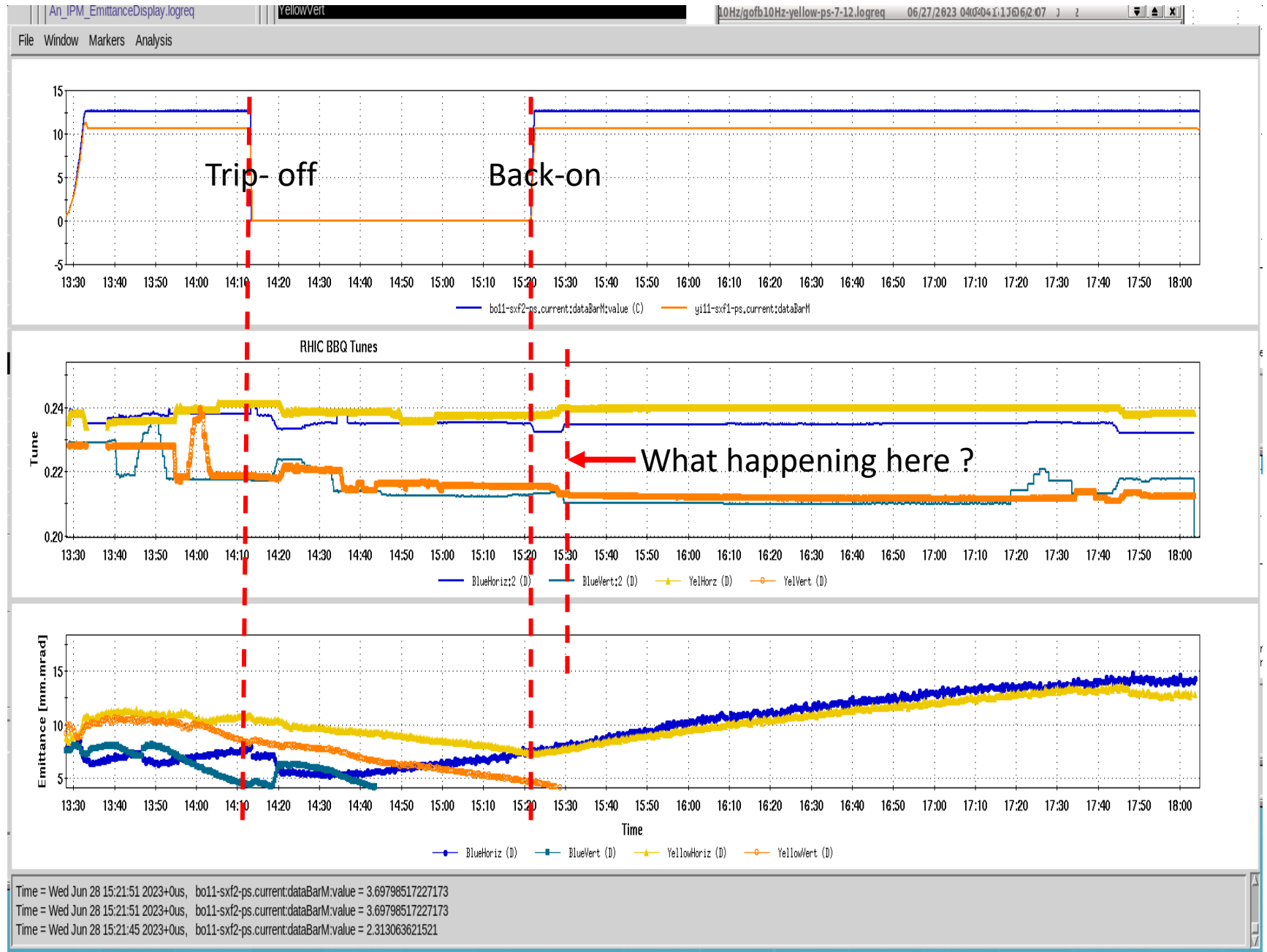
Two Collision Attempts

- 1) For the first test: blue split decreased, beam go round.
- 2) For second test: blue tune split decreased but not so narrow like first test. Yellow also kept a large tune split.
- 3) At 14:14 two sextupoles tripped off, one in each ring. Brought back at ~15:30?

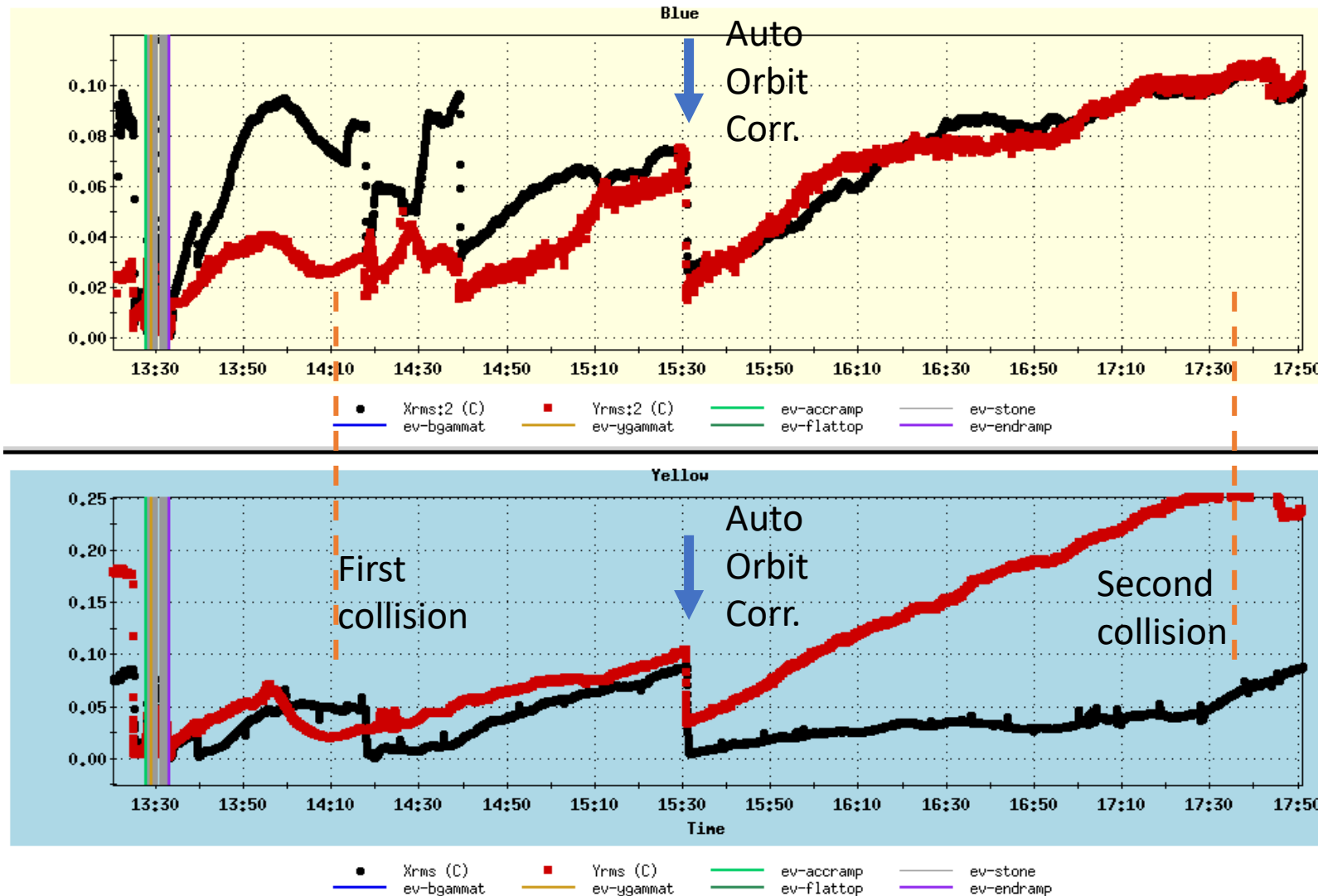


Sextupole Trip-Off and Back-on

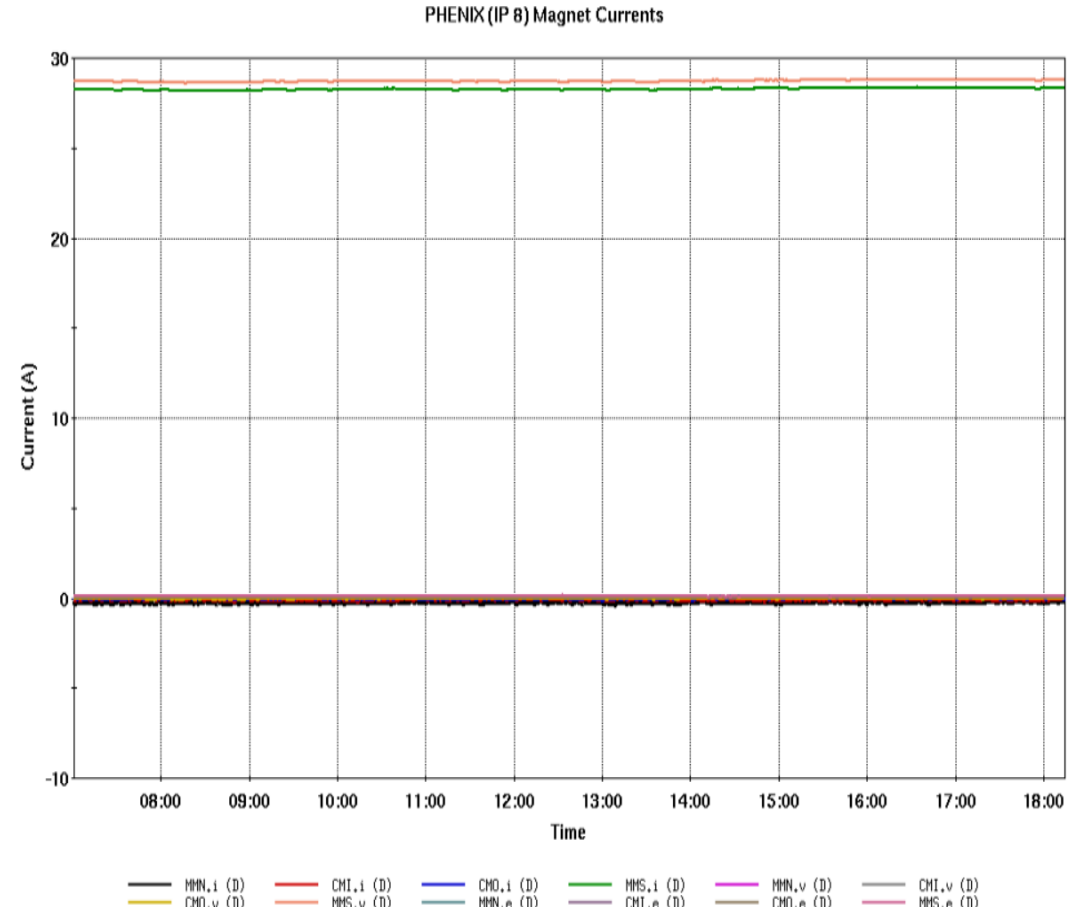
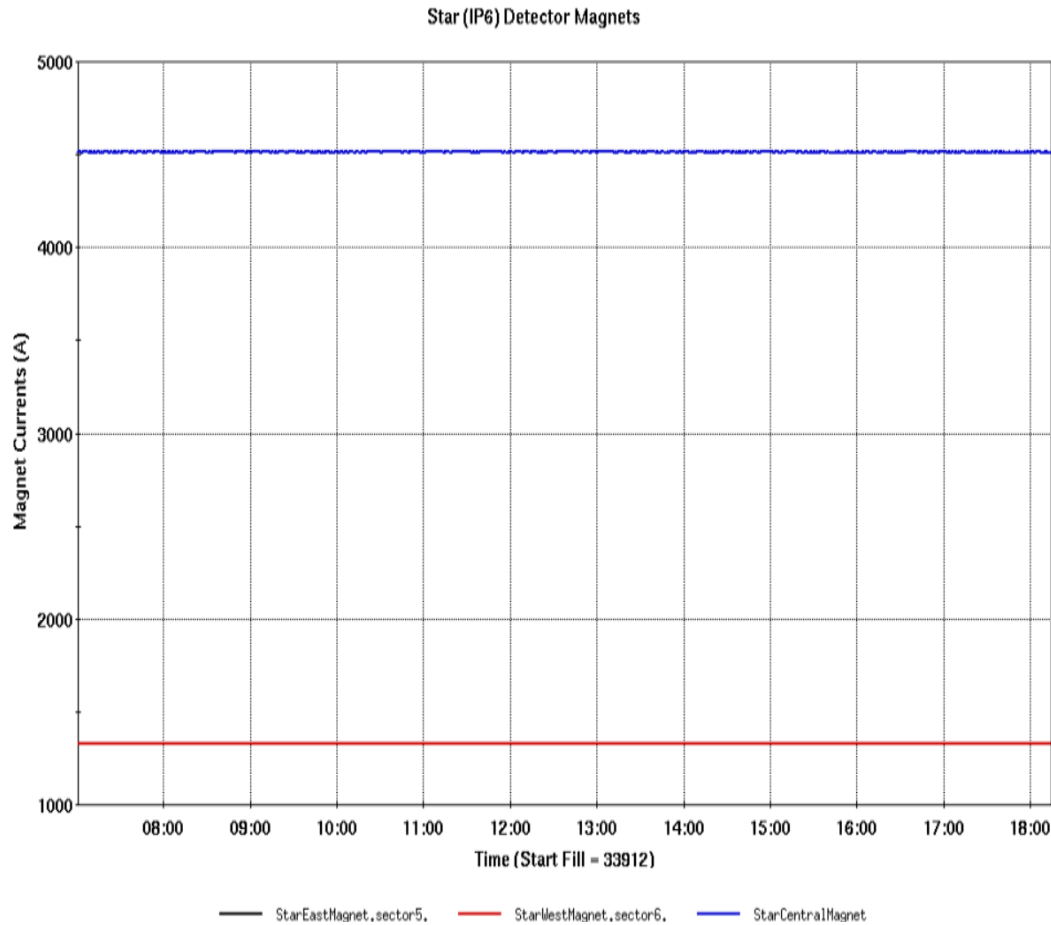
Sextupole back-on
coincided with Yellow
horizontal emittance
starting to grow.



Orbit During this Experiment

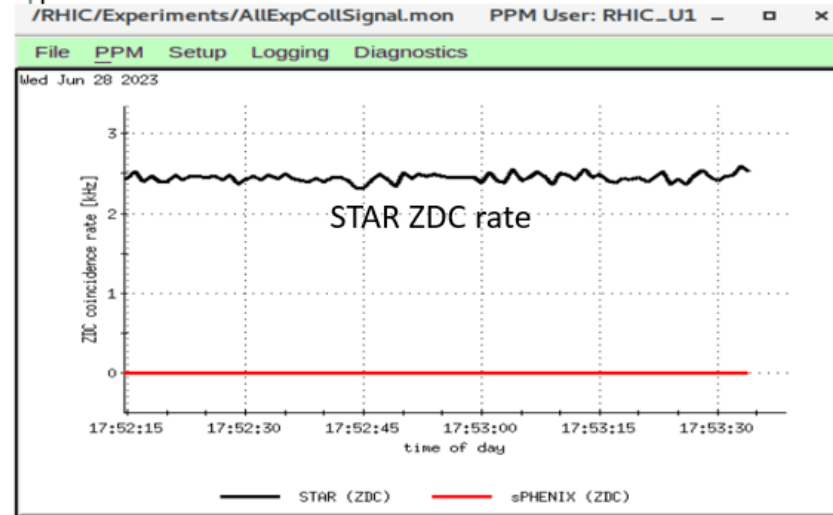
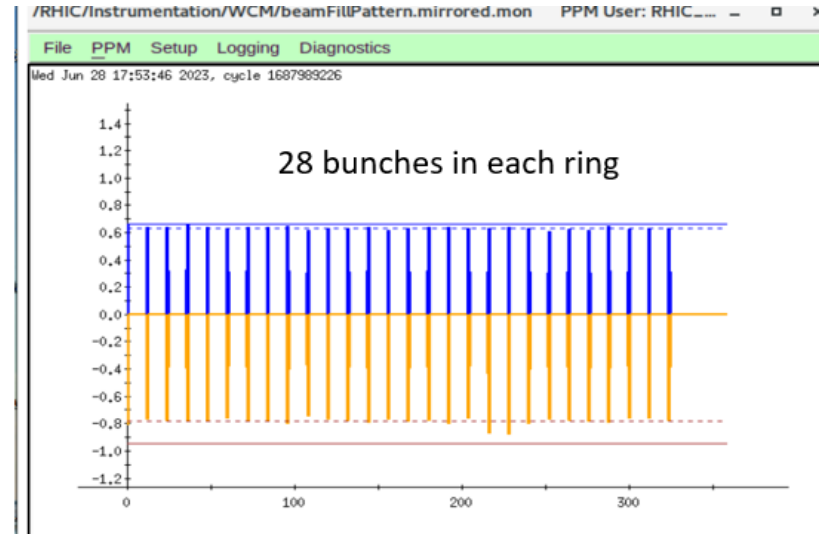
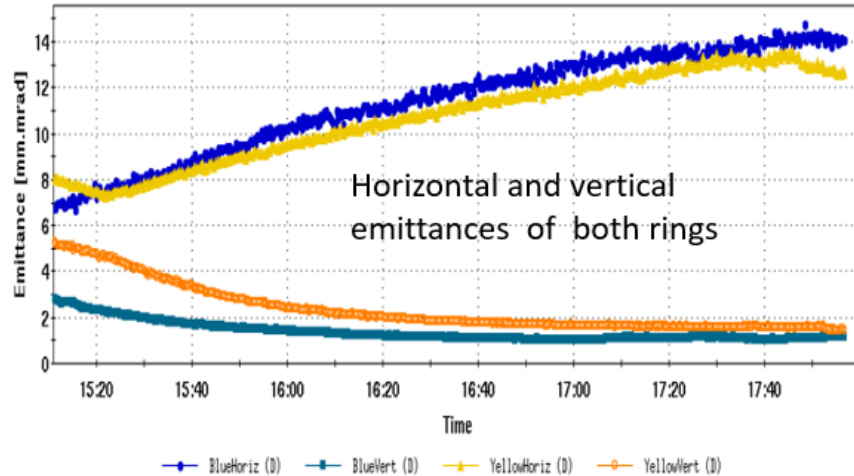
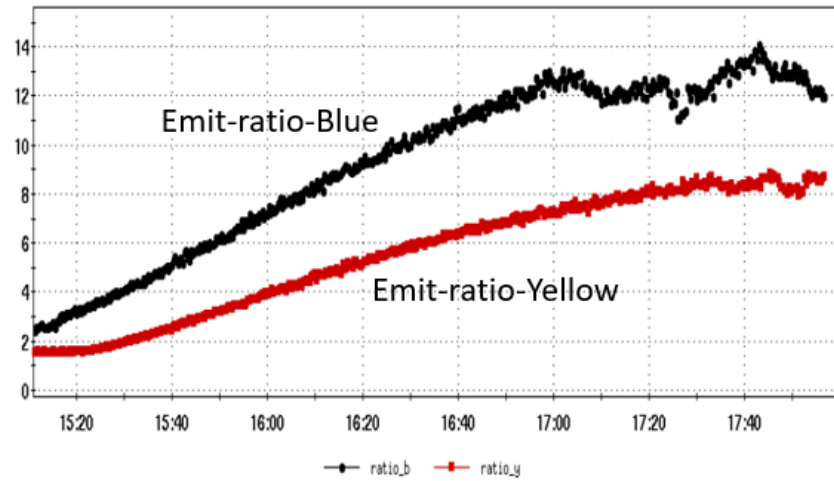


STAR and sPHENIX Magnets



Star and Phenix magnet currents remained unchanged during APEX time.

Collide With Flat Beams



Summary and Plan

- 1) During this experiment, measured coupling angles at injection and store. The store values are quite off. Need revisit.
- 2) Demonstrate flat beams with cooling and decoupling: Blue emittance ratio reached 14:1 in Blue and 9:1 in Yellow.
- 3) Tested collision with flat beams. There was no much emittance exchanges between horizontal and vertical planes with collision. The beam-beam parameter with one collision at IP6 is probably 0.005.
- 4) For next experiment, we will revisit coupling correction at store and study large emittance ratio dependence.