Dynamic aperture measurements

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Outline

- Motivation
- Measurements at RHIC Run-3, Run-4, Run-5
- Proposed experiment(s) for Run-6

Motivation

Project historical perspective

(probably common, certainly true at RHIC…):

1. Extensive DA simulations and tracking during the design and construction phase
2. Commissioning, operations→ typically end of 1
3. DA measurements during experiments/MD time, rather time consuming

Motivation for continued DA measurements:

1. Model benchmarking (UAL)
2. Accelerator physics (apex "class 1.5")
3. If DA measurement fast→ operational figure of merit for corrections, complementing beam lifetime (for working points, resonance correction at injection, beam-beam, IR correction, etc.)

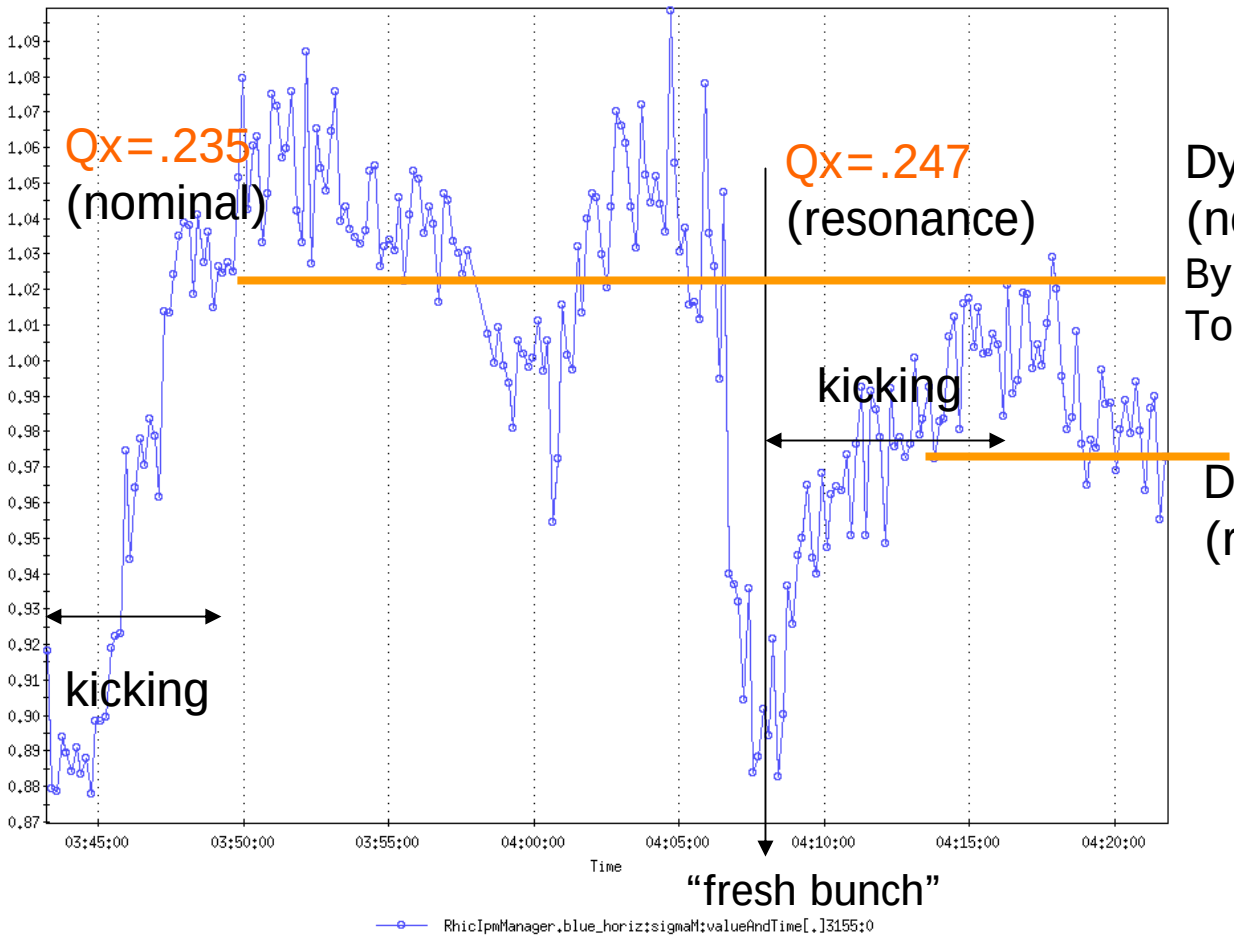
DA measurement – method (Run-3)

Method used:

- ramp 6 bunches (avoid possible emittance blow-up), **nominal tunes**
- use **scrapers** to confirm halo beam size (PIN diodes) and core beam size (DCCT and WCM, beam intensity)
- increase H emittance of bunches selectively via **tune meter kicks (1 Hz)**
- measure continuously emittance with **IPM** and **Schottky**
- emittance '**saturation**' defines **aperture**
- use scrapers to confirm beam size
- check **loss** pattern and use **orbit** to discriminate **physical from dynamic aperture** (physical typically at the abort, and triplets)
- repeat procedure for vertical emittance
- repeat procedure for horizontal **tune close to the 0.25 resonance**

DA measurement blue, β*=2m (Run-3)

Blue ring - **β*=2m** in IP6 and IP8



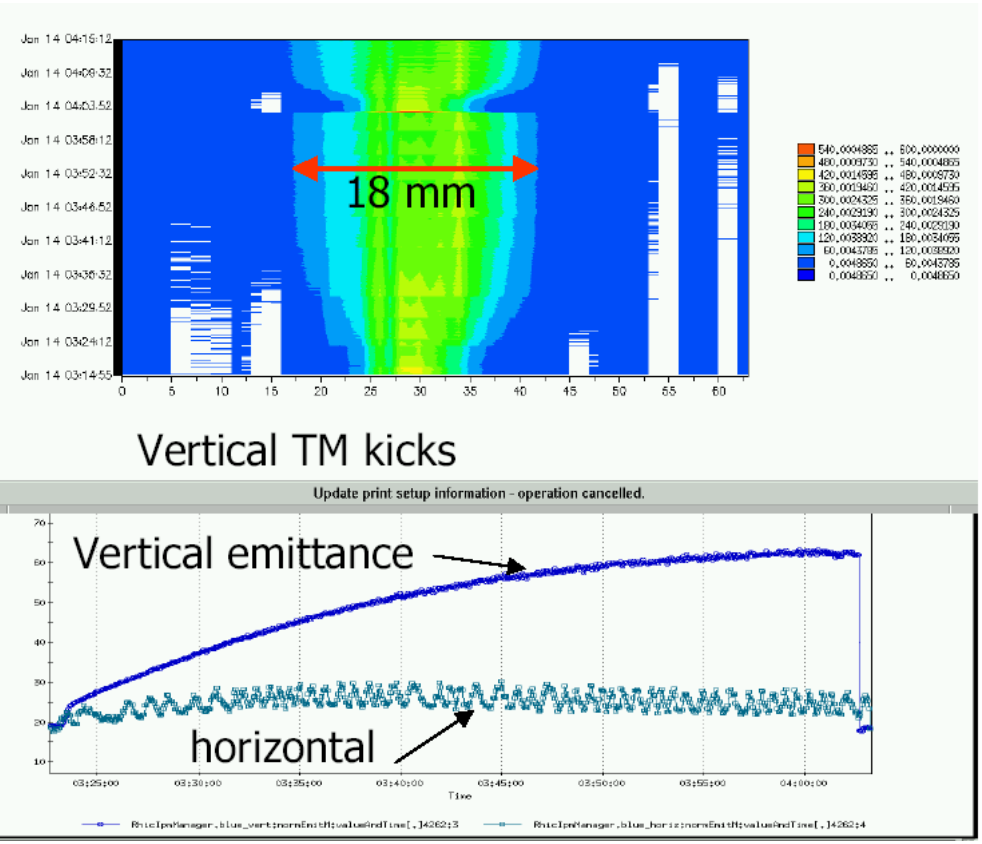
Dynamic aperture (nominal tune) ~**4.5 sigma**
By rescaling the emittance
To the initial one

Dynamic aperture (resonant tune) ~**3.6 sigma**

DA measurements (Run-4)

Fulvia, Nikolay, Steve T, Vadim

IPM measurements

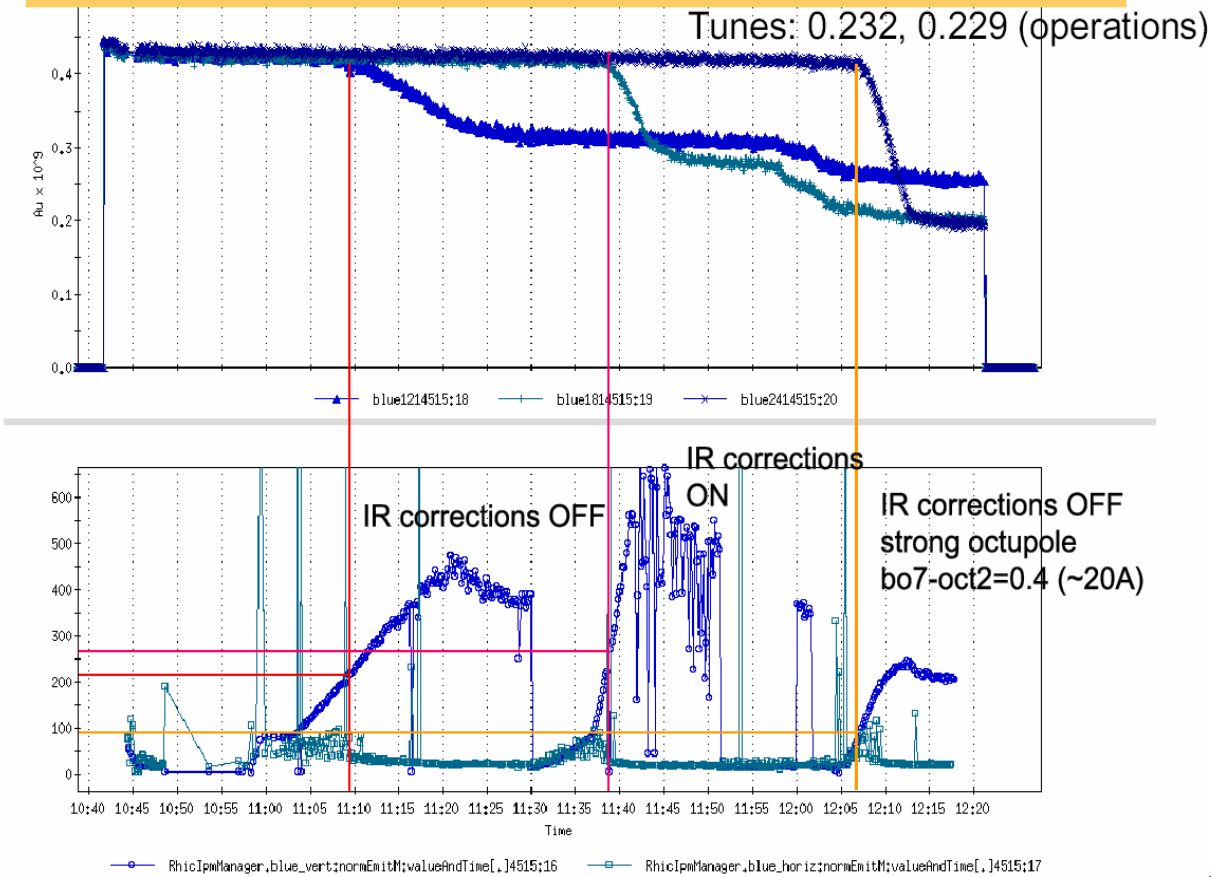


- Gradually increase beam size with tune-meter kicker to reach dynamic aperture limits
- Signature:
  - IPM emittance saturation
  - reaching limit of transverse distribution width
  - beam losses
- Beam loss location was at 6 and/or 8 o'clock triplets

DA measurement (Run-4)

Noting emittance when losses starts
Measurement uses different bunches each time

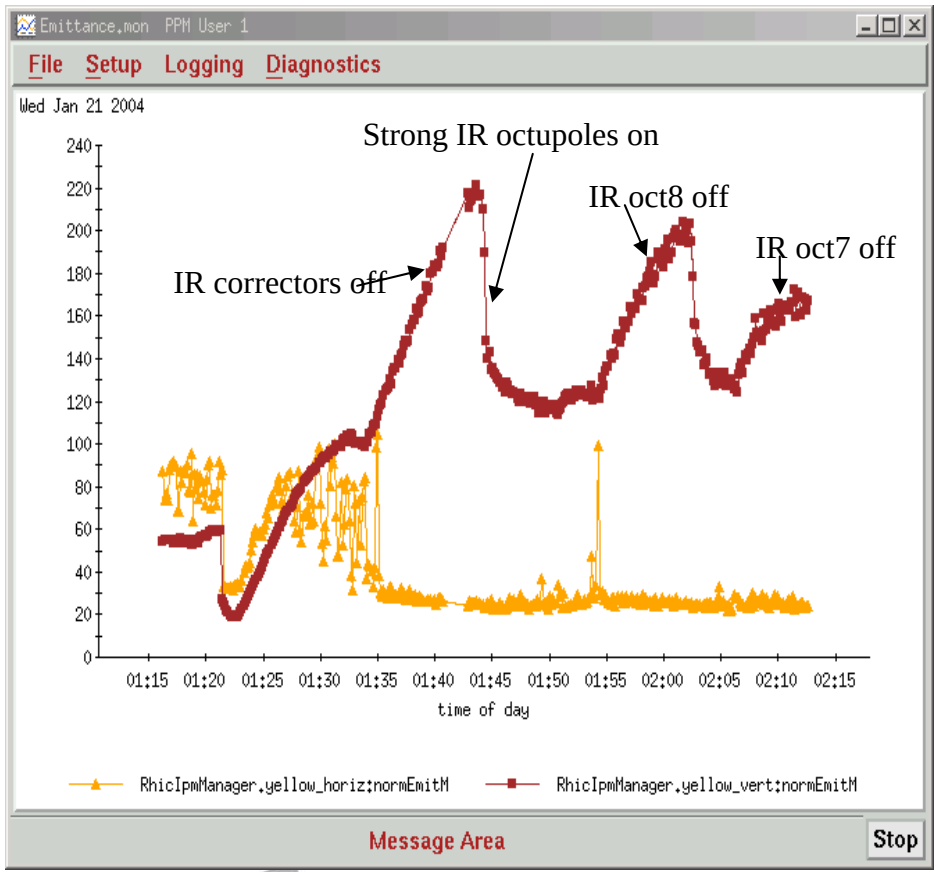
Dynamic aperture – blue (february 11)



- Measurement precision is limited to +-30π
- Measurements have been done with different IR corrector settings, with and without beam-beam and for different working points
- VER aperture > HOR
- Blue – Yellow consistent
- Dynamic aperture is tune dependent (no surprise)
- IR correction help (~30% hor - ~15% vert.)
- Best measured aperture (good working point, no beam-beam, IR correctors On) is about 11 σ (for 10π initial emittance)

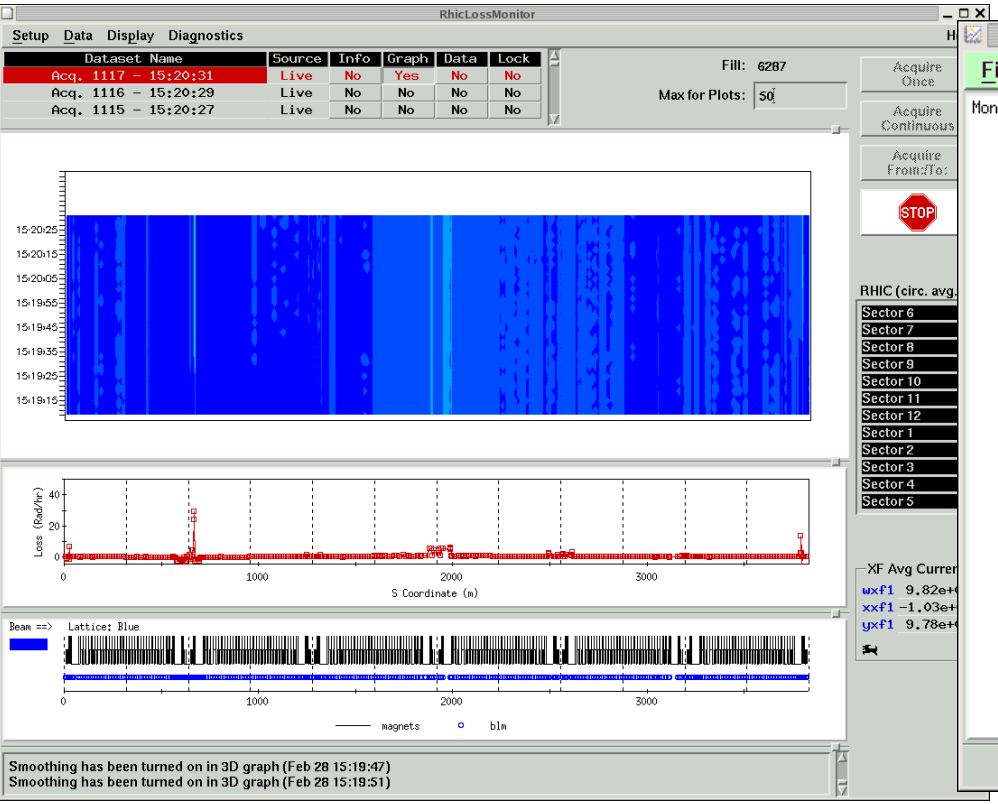
DA measurement (Run-4)

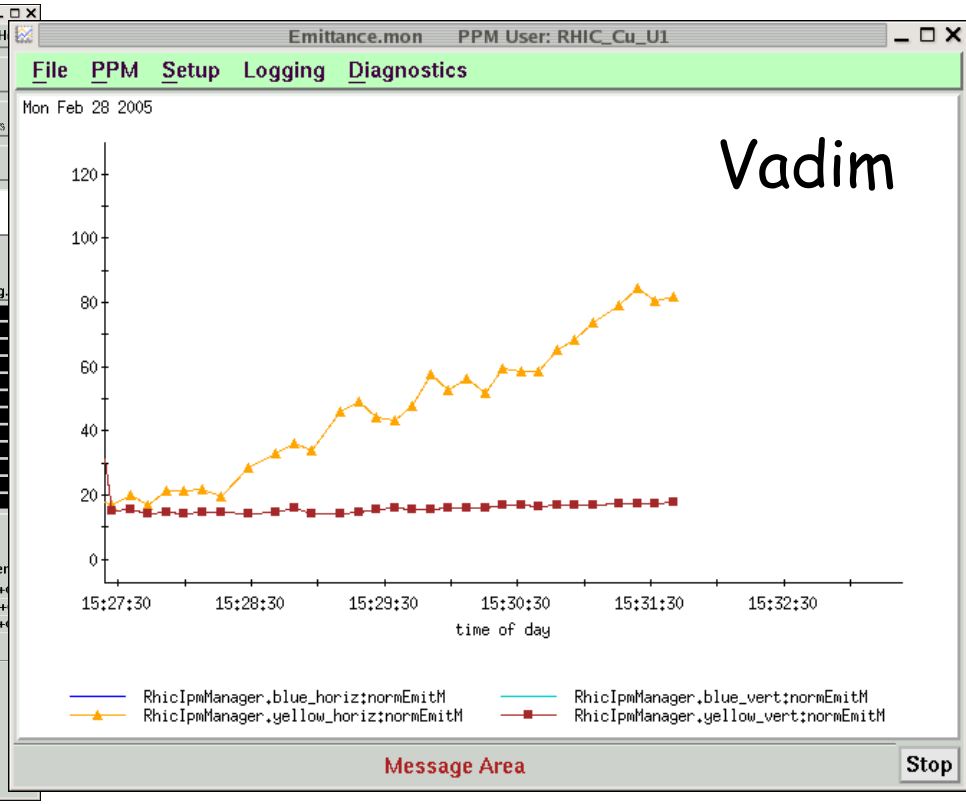
Dynamic aperture shrinking from strong octupoles
Measurement with one bunch



- The DA measurement have been used to calibrate the model using predetermined nonlinear sextupoles/octupoles
- Comparison of the measured results with the model has been done (Nikolay)
- The DA measurement have been used to verify quality of IR nonlinear correction (and, thanks to this, the problem was identified and fixed on the initial stage of IR correction at IR8)

Physics Aperture (Run-5)





Yellow horizontal -> 8 o'clock triplet
Yellow vertical -> the anti-grazing ridge (6 o'clock)
Blue horizontal -> the anti-grazing ridge
Blue vertical -> either 7 o'clock triplet or the anti-grazing ridge

Proposal for Run-6 DA measurement

TEAM: Bai, Bengtsson, Pilat, Ptitsyn, Satogata

Goal:

- Demonstration of method
- Calibration with existing DA measurements

Method:

- Drive beam with AC dipole (injection first) with controlled drive (first fixed frequency, increase amplitude)
- Measure amplitude of beam oscillations (M-turn BPM), spectrum and beam losses