Spin Experiment

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Outline

- Summary of spin beam experiment during Run05
  - What did we do?
  - What have we learned?
  - Status of each experiment
- Proposal for spin beam experiment during Run06

Run 05 Spin Beam Experiment List

- Snake resonance spectrum
  - Team: M. Bai, F. Lin, S. Y. Lee, V. Pittsyn, T. Roser, H. Huang
    G. Hoffstaetter, W. W. MacKay, S. Tepikian
  - Goal:
    - Measure snake resonance spectrum in RHIC
    - Provide a quantitative description on the snake resonance strength dependence on the orbit distortion
  - Benefit:
    - Help us to quantitatively define the available tune space as well as how well one should correct the RHIC orbit

Run 05 Spin Beam Experiment List

- Spin tune measurement
  - Team: M. Bai, G. Bunce, Itaru, Osamu, T. Roser, Sandro
  - Goal:
    - Measure the spin tune by measuring the coherent spin precession driven by the spin flipper. The key of this experiment is to use the carbon polarimeter to measure the turn by turn precession of the spin vector's vertical component and radial component
  - Benefit:
    - It is very critical to keep the spin tune at $\frac{1}{2}$ in RHIC to avoid polarization loss at snake resonances. This technique eventually allows us to measure the spin tune at RHIC store energy to check whether the snake is set properly

Run 05 Spin Beam Experiment List

- CNI polarimeter study
  - Team: A. Bravar, Haixin, Itaru
  - Goal:
    - Study pC scattering at lower and higher t values compared to regular polarimeter measurements
  - Benefit:
    - Provide an improvement of RHIC Carbon polarimeter

Run 05 Spin Beam Experiment Status

-- Snake resonance spectrum

- The experiment took a total of 4 sessions with a total of 7 hours including one 1-hour session dedicated to the development of mini ramp of gg63
- Explore the 7/10 resonance
  - Very difficult to observe at injection because the intrinsic spin resonance at injection is very weak.
    - Tune scan in Blue at injection
    - Polarization lifetime in Yellow at injection with an 80π mm-mrad beam
  - Successfully observed at $G\gamma$ = 63 in Blue
    - Detailed tune scan in Blue
    - Yellow polarization as a function of time with Qy=0.7
- Explore the ¾ resonance
  - $\frac{3}{4}$ resonance was observed in Yellow at injection. No significant impact of orbit distortion on the $\frac{3}{4}$ resonance
  - Tried to measure the $\frac{3}{4}$ resonance strength in Yellow at $G\gamma$ = 63 with different orbit distortion. But failed due to heavy beam losses and time constraints

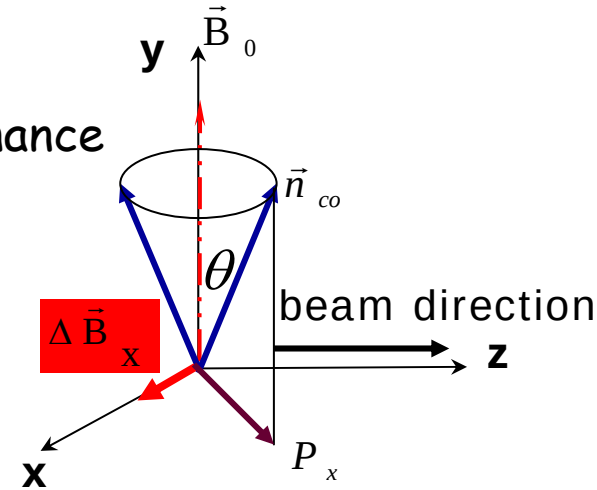
Run 05 Spin Beam Experiment Status

-- Spin tune measurement

- How to use spin flipper to measure spin tune?
  - Spin motion nearby a spin depolarization resonance

$$P_y = \frac{K - G\gamma}{\sqrt{|\varepsilon|^2 + (K - G\gamma)^2}} \qquad P_x = \frac{\varepsilon}{\sqrt{|\varepsilon|^2 + (K - G\gamma)^2}}$$

$$\text{Spin tune} = K = G\gamma + \varepsilon \tan\theta$$



  - Induce a coherent spin precession with spin flipper. Measure the turn by turn spin precession. Calculate the precession amplitude of the vertical and radial component.

- The experiment took a total of 1 sessions, and 2 hours at injection. However, the time was spent on fighting with the spin flipper frequent tripping problem and were not able to get useful data

- Currently, we are focusing on analyzing the RHIC pp 2004 spin flipping data
  - Ron Gill and M. Bai

Run 05 Spin Beam Experiment Status

-- carbon polarimeter study

- This study took a total of two sessions, each with 2 hours at store.
- Preliminary results
  - Clearly see diffractive dip at -t = 0.08 (GeV / c)^2
  - don't see a second zero crossing of A_N at high t
  - lowest energy of recoil carbon ion detected > 200 keV
  - Detailed data analysis is still in process

Run 06 Spin Beam Experiment List

- Snake resonance spectrum
  - motivation
    - Why didn't we see $\frac{3}{4}$ resonance in Blue at injection?
    - Quantitatively measure the sensitivity of even order snake resonance strength on the orbit distortion
    - Complete the 7/10 resonance spectrum
  - Description:
    - Detailed tune scan in Blue and Yellow around 0.75 at injection with similar orbit distortions
      - Estimate: 2 hours
    - At $G\gamma$=63
      - Tune scan around 0.75 in Yellow with three different orbit distortions
        - Estimate: a total of 3 hours
      - Complete the tune scan around 0.7 in Blue
        - Estimate: a total of 2 hours
  - Total estimated Time: 8 hours (data taking plus contingency)

Run 06 Spin Beam Experiment List

- Spin tune measurement / spin flipping
  - Goal:
    - Commission the technique of measuring spin tune using spin flipper at injection
    - Take data at store
    - If successful, test spin flipping
  - Description:
    - At injection
      - Scan the spin flipper tune from 0.45 to 0.5 until significant radial component is measured
      - Set the spin flipper with this tune. Measure the amplitude of the radial component and vertical component of the spin vector. Calculate the angle and the spin tune
      - Place the spin flipper at the measured spin tune and check whether the angle is 90°
    - If success is achieved at injection, we would like to take the same measurement at store
  - Estimated time: 8 hours

Run 06 Spin Beam Experiment List

- Polarimeter study
  - perform these studies also at 24 GeV (injection) and 200 GeV
  - complete the 100 GeV measurements
  - Estimated time: 3-6 hours

Run 06 Spin Beam Experiment List

- Energy calibration:
  - Team: W. W. MacKay
  - Goal:
    - Provide a precision of 0.5% energy measurement for physics experiments by scanning the radial component of the spin vector as a function of energy. The key of this technique is to use a STAR spin rotator to tilt the spin vector away from vertical
  - Description:
    - At injection
      - Turn on one of the STAR rotators to a current which corresponds to θ=0 and μ=90^o . This should be done in steps with orbit corrections in between the steps
      - Measure the vertical and radial component of the spin vector as a function of θ with μ fixed at 90^o. The constraint of the current is to keep spin tune fixed at $\frac{1}{2}$.

Run 06 Spin Beam Experiment List

- Energy calibration:
  - Description:
    - Energy scan near injection
      - Measure the vertical and radial component of the spin vector with different energy at a step size of $\Delta G\gamma = 0.2$. Prefer to do the scan from $G\gamma = 46.5$ (injection) to $G\gamma = 49$. Expect zero crossing at $G\gamma = 47.5$. If one can extend the measurement to $G\gamma = 51$, the accuracy will be improved.
    - Energy scan at store energy
      - Ramp with all the rotators off
      - Turn on one of the STAR rotators. This requires to turn it on at steps with orbit corrections in between
      - Follow similar steps for energy calibration as at injection. And the preferred energy step size is also $\Delta G\gamma = 0.2$

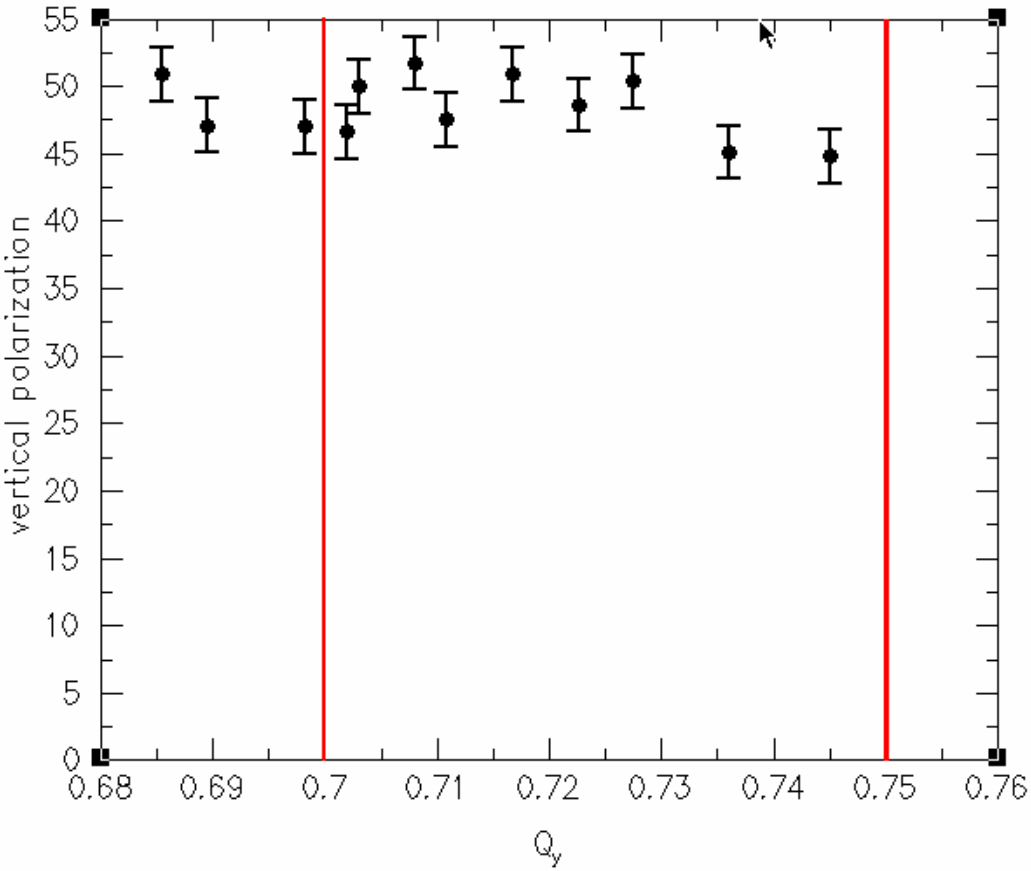
Run 06 Spin Beam Experiment List

- Establish RHIC Injection with Spin Rotator on
  - Goal:
    - To test feasibility of injection with rotators set for Storage energy values -- particularly for longitudinal polarization at 100 and 250 GeV.
  - Benefit:
    - Save the dedicated time for rotator-ramp at store and speed up the turn-around time between collisions
    - However, this may introduce additional depolarization mechanisms due to the fact that the stable spin direction is in the horizontal plane in part of the ring
  - Team:
    - W. MacKay, V. Ptitsyn, T. Satogata, A. Luccio

Run 06 Spin Beam Experiment List

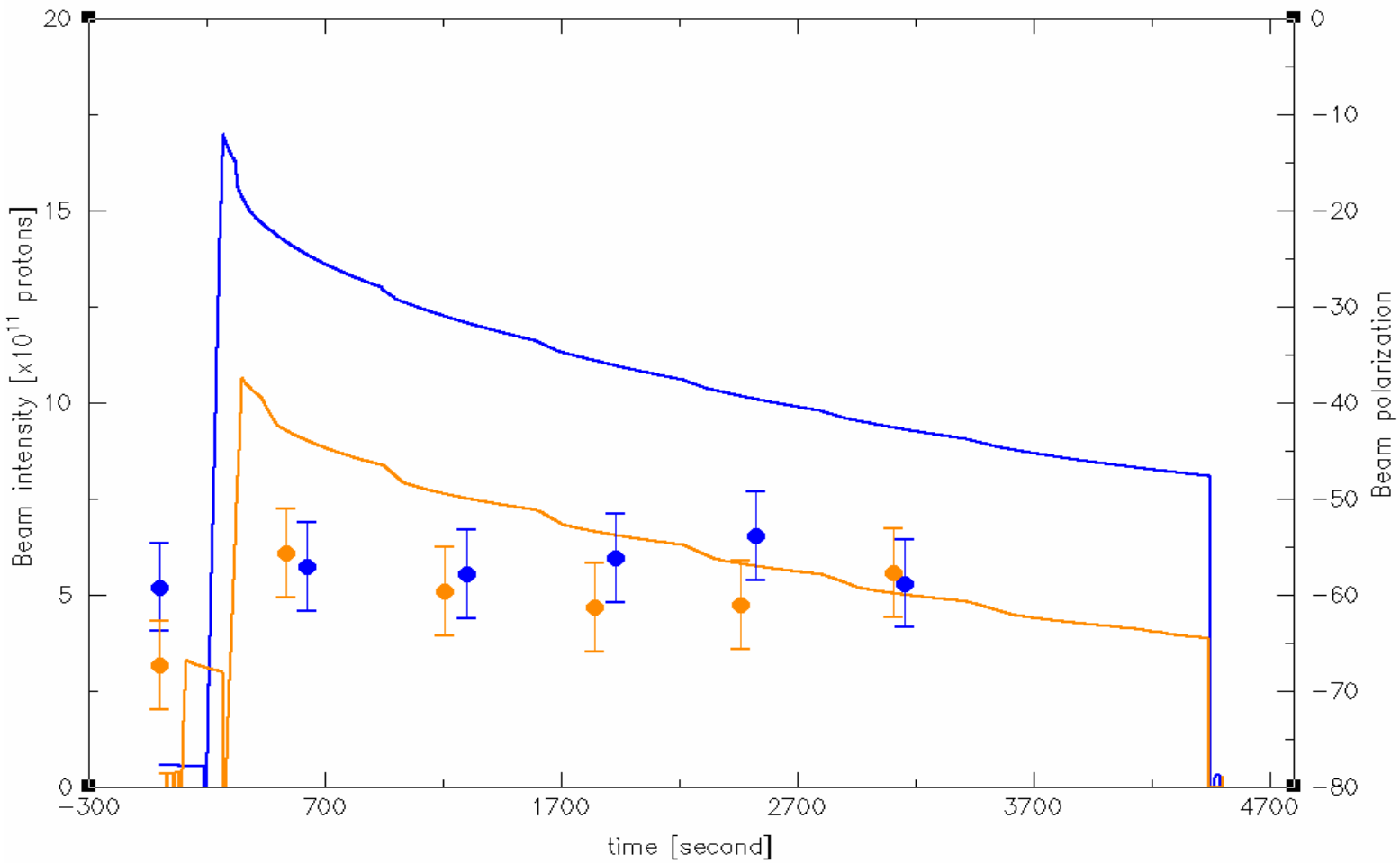
- Establish RHIC Injection with Spin Rotator on
  - Description:
    - Set up injection in Blue or Yellow with a pair of rotators on at settings for longitudinal polarization at 100GeV.
      - With circulating beam, ramp the two rotators around either STAR or PHENIX (or perhaps the pairs around both experiments) together, stopping at several steps to re-correct the orbit and tunes for good survival. Care must be taken to deal with the large transverse offsets in the rotators at injection; a horizontal bump at injection very well may be necessary.
    - After reaching the desired settings with beam surviving, optimize the orbit, tunes, chromaticities, and coupling
    - Measure the polarization with the rotators on
    - Repeat the above steps for the other ring.
    - If successful, then a later follow-up experiment or possibly commissioning time could be used to tune up acceleration for real running. Of course we would have to verify that polarization survived up the ramp with the rotators turned on.

Tune scan in Blue at injection



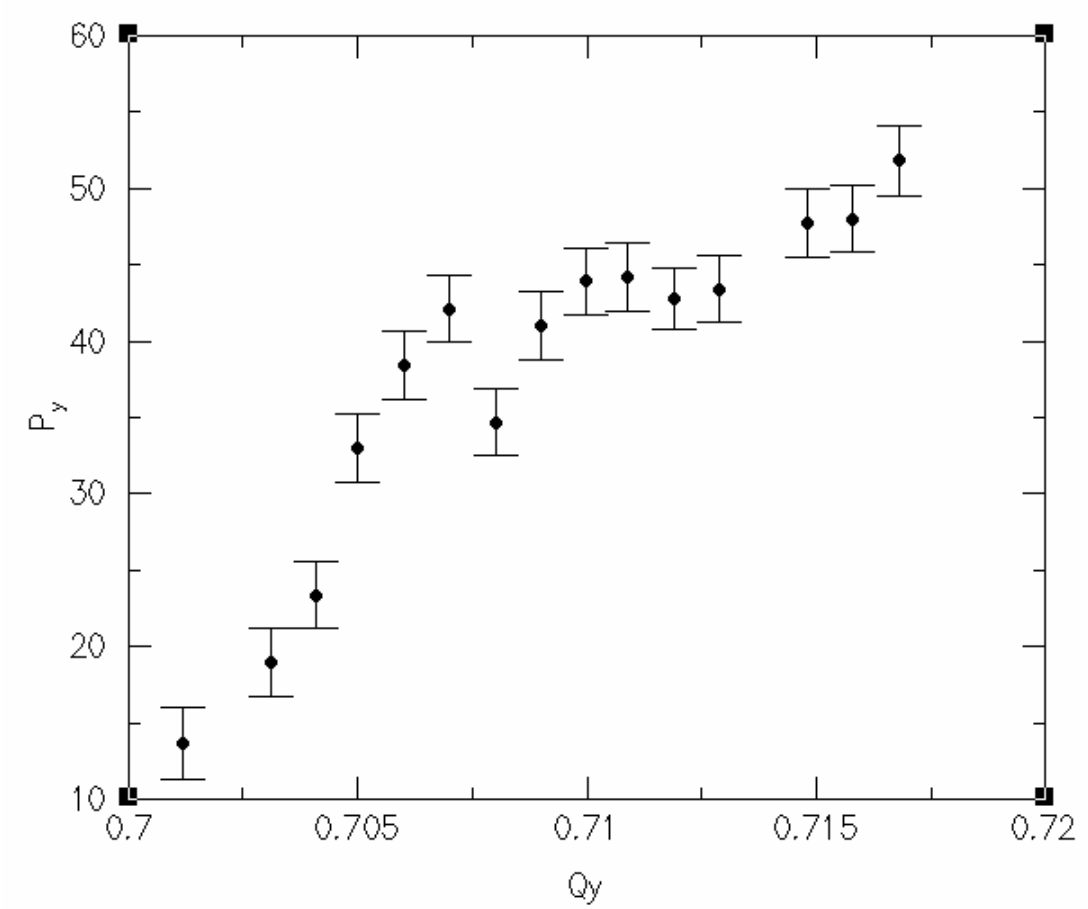
- Blue tune was scanned at injection. No significant depolarization was observed either at snake resonance 7/10 or ¾
- This is consistant with the expectation that the intrinsic spin resonance at injection is very weak

Yellow emittance scan at injection



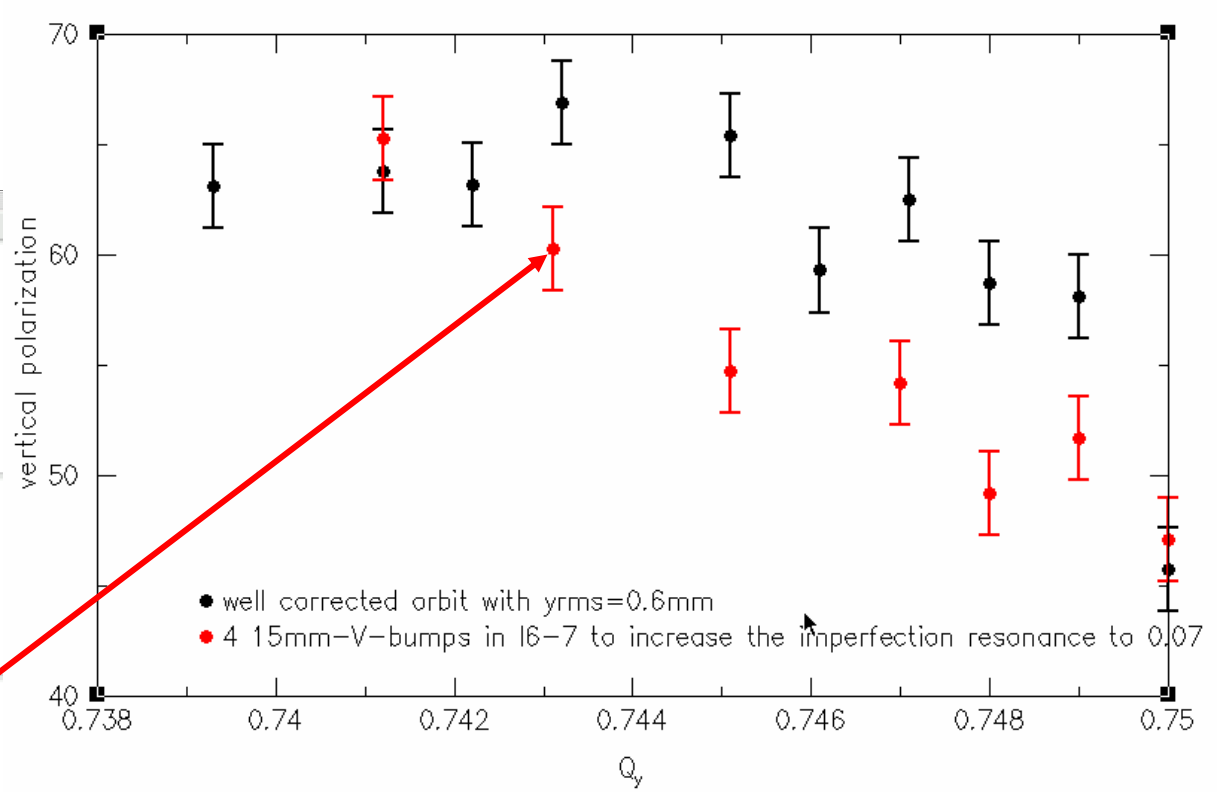
- Both beams were stored at injection. The Yellow vertical tune was set to 0.7
- Yellow beam emittance was deliberately blown up using tunemeter kicker to probe the 7/10 resonance.

Blue Tune scan at Gγ=63

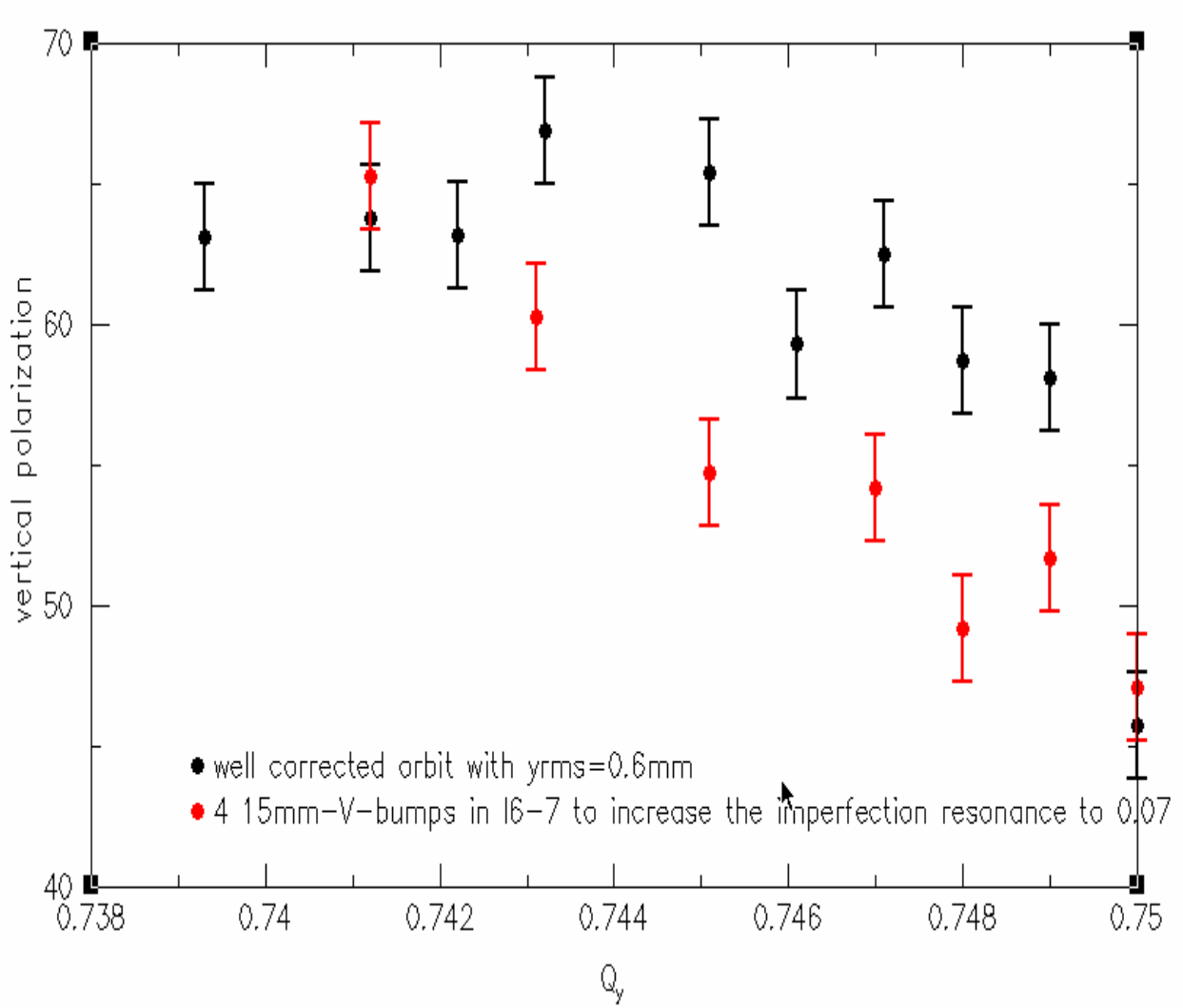


- Both beams were stored at Gγ=63 which is very close to one of the major intrinsic spin resonances
- The Blue vertical tune was scanned from 0.718 to 0.70
- Burned the target during the scan

Yellow ¾ resonance vs. orbit distortion at injection



Yellow ¾ resonance vs. orbit distortion at injection



No significant enhancement on the ¾ snake resonance from orbit distortion

Yellow 7/10th resonance at Gγ=63