RHIC Polarization Beam Experiments

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Outline

- Polarization related beam experiment
  - RHIC polarimeter studies – Huang
    - Beam polarization profile studies
  - Spin tune measurement
    - Turn by turn spin precession measurement
  - *Spin flipping commissioning*
    - Allows one to reverse the spin collision pattern to reduce the systematics for experiments
  - *Acceleration pp beyond 100 GeV towards 250 GeV*
  - Establish injection with both snake and spin rotator on at their full field
  - Others…
- conclusion

RHIC Spin Tune Measurement

- Objective
  - Measure the spin precession tune in RHIC. The benefit of this experiment is the following
    - Check/Set the snake current
    - Guide the setting of the optics: betatron tunes, chromaticities, coupling.
    - Crucial for the spin flipping commissioning
- Principle of the Experiment
  - Use the ac dipole to title the spin vector into the horizontal plane
  - Measure the turn by turn spin precession
  - The spin precession tune is obtained from the Fourier spectrum of the turn-by-turn data.

RHIC Spin Tune Measurement

- Time needed
  - 4 hours dedicated time
    - Injection
    - Store: for spin flipping commissioning
- Resources
  - Instrument
    - RHIC polarimeter
    - ac dipole

RHIC Spin Flipping

- Objective
  - reverse the spin collision pattern to reducing the systematic errors
- Principle of the experiment
  - In the presence of two full Siberian Snakes apart from each other by 180 degrees, the spin precession tune in RHIC becomes ½

$$\nu_s = \frac{1}{\pi}\left|\mu_1 - \mu_2\right|$$

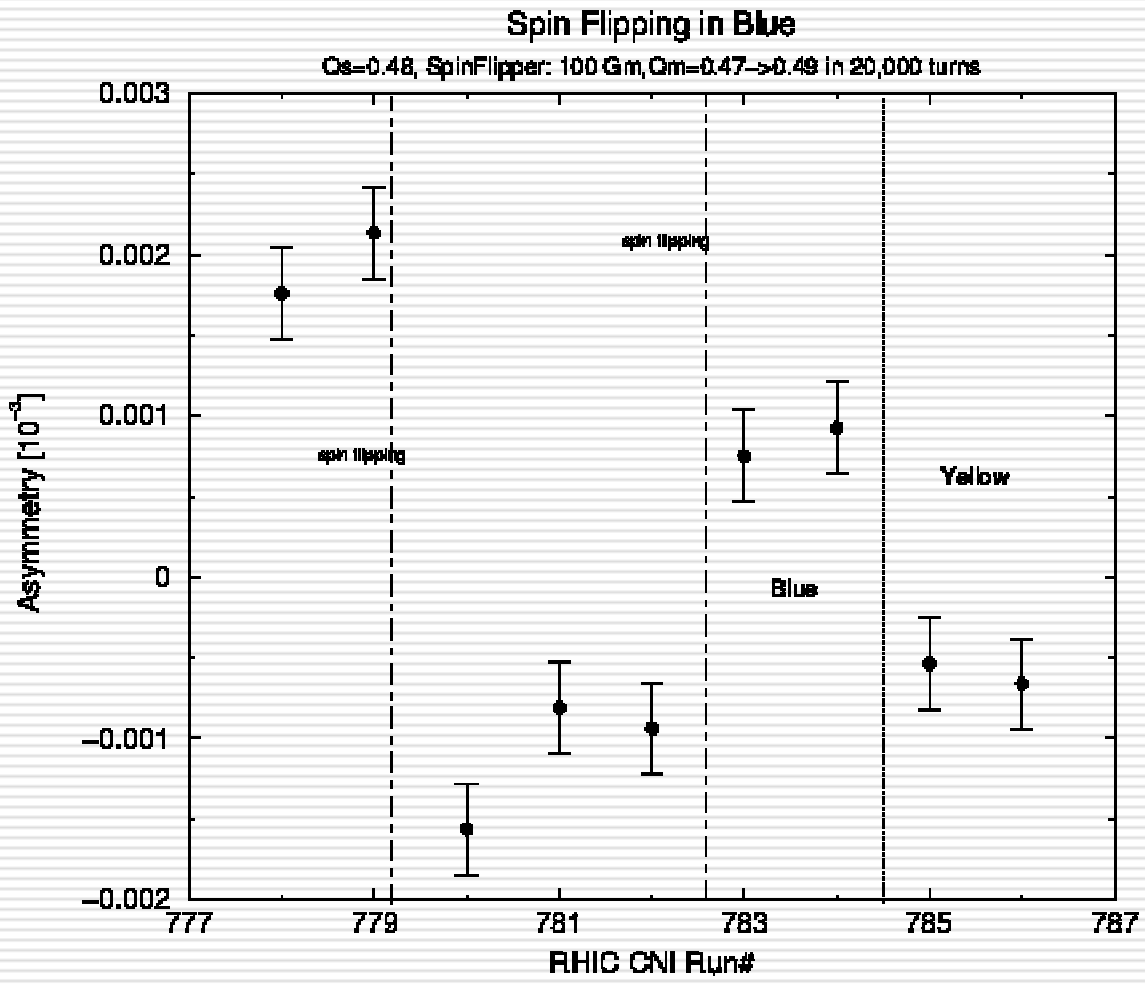
$\mu_{1,2}$ is the angle between the snake axis and the beam direction

  - The vertical ac dipole will be energized to oscillate nearby the spin precession frequency

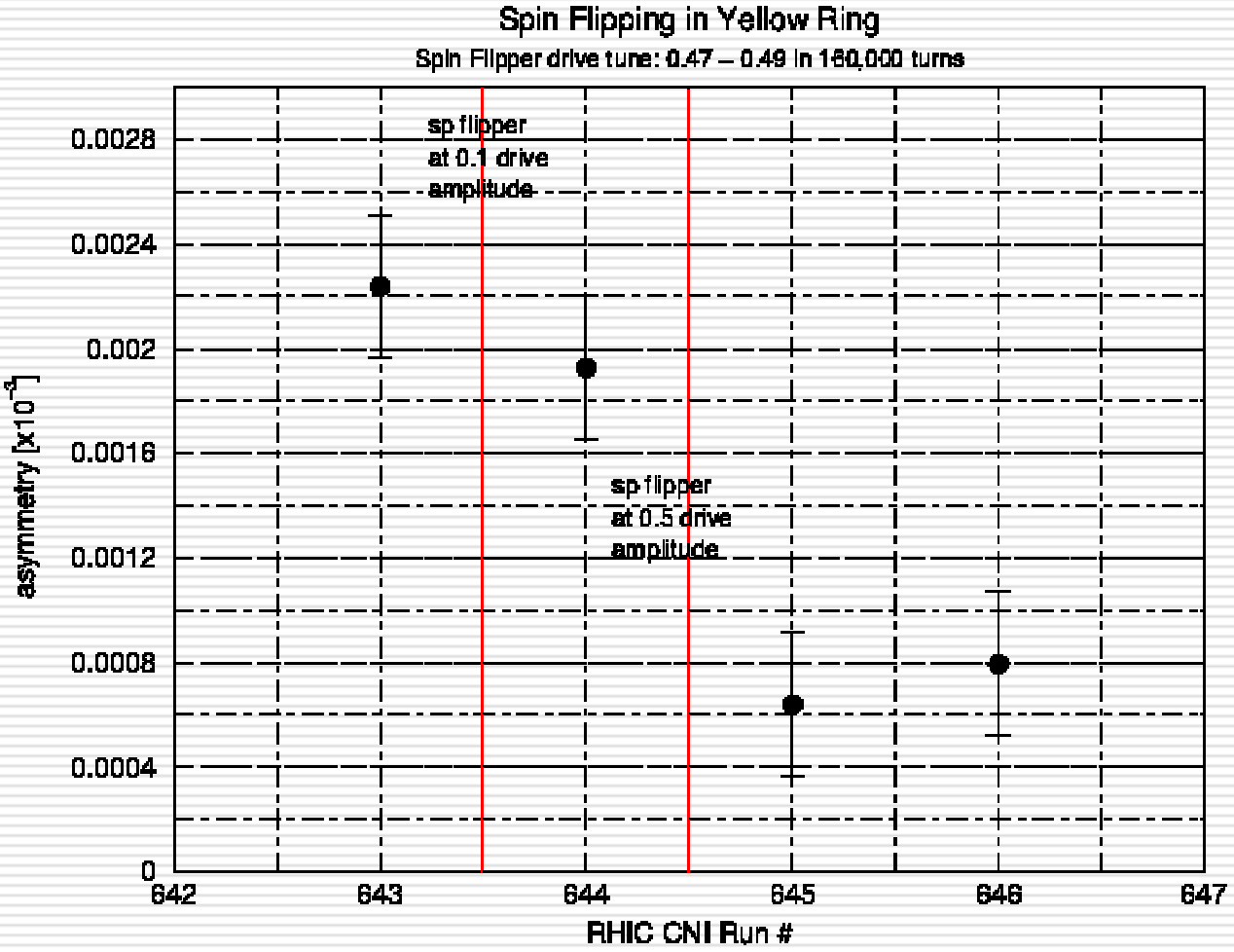
RHIC Spin Flipping

- Principle of the experiment
  - By slowly ramping the vertical ac dipole oscillating frequency across the spin precession frequency
  - Results from previous runs
  - The critical key point to achieve full spin flip is to know where the spin precession tune is.
- status
  - So far, no dedicated beam time
  - Had a total of couple of hours beam time at the end of store
  - However, difficult to do at the end of store due to the limitation of the aperture

RHIC Spin Flipping



RHIC Spin Flipping



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RHIC Spin Flipping

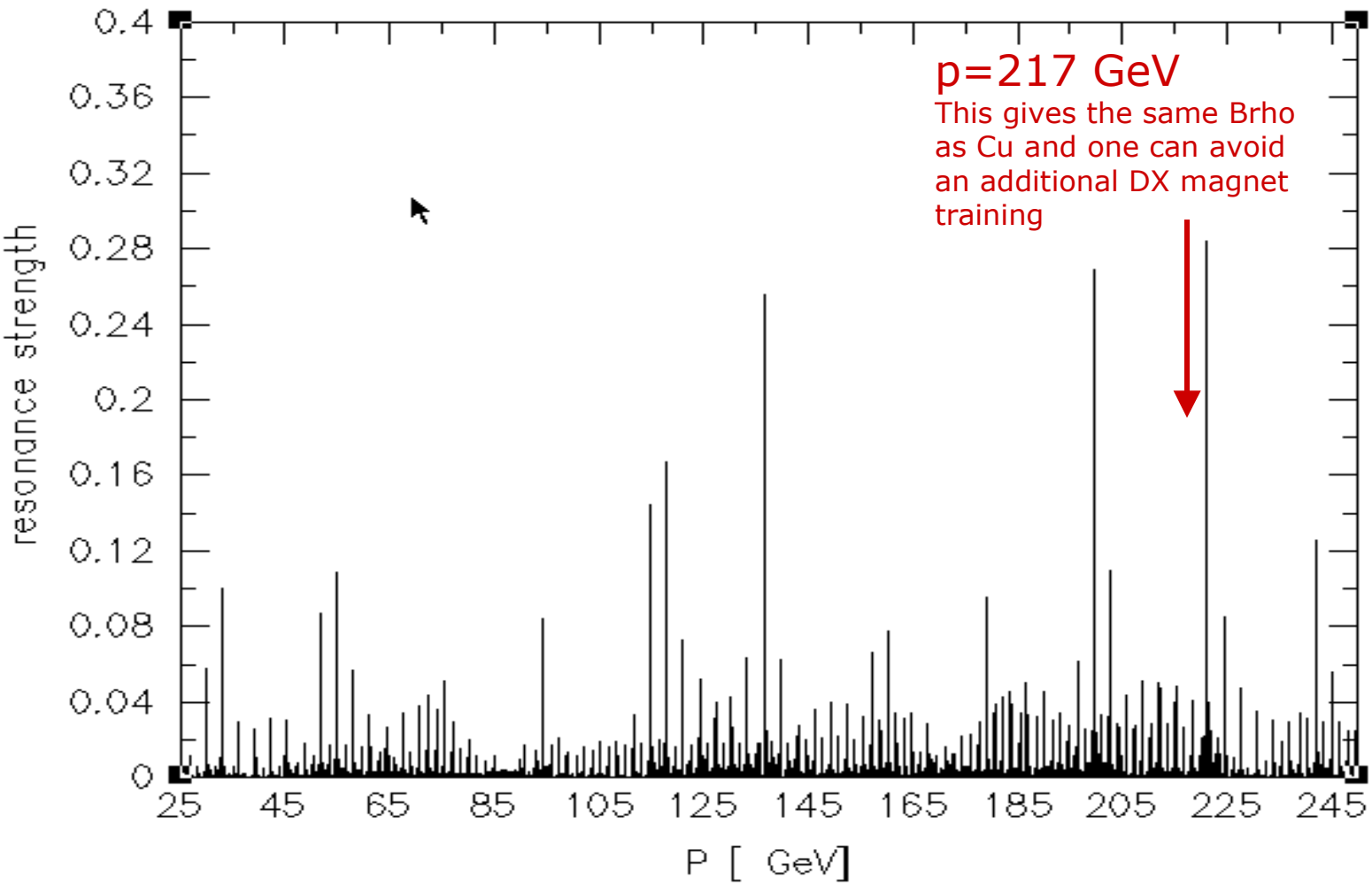
- experiments
  - Measure the spin flipping efficiency vs. spin flipper efficiency. Both the flipper frequency sweep range and the snake setting remain constant
  - Measure the spin flipping efficiency vs. spin flipper frequency sweep range. Both the flipper strength and the snake setting remain constant
  - Measure the spin flipping efficiency vs. spin tune frequency sweep range. The flipper setting stays constant
- Resources
  - Ac dipole, RHIC polarimeter and BPMs
- Time needed
  - A total of 16 hours dedicated time

RHIC pp acceleration to higher energies

- RHIC final goal
  - Collision at $\sqrt{s}$ = 500 GeV
  - Polarization > 70%
  - Luminosity
    - 150×10^{30} $cm^{-2}s^{-1}$ at 250 GeV
    - 60×10^{30} $cm^{-2}s^{-1}$ at 100 GeV
- Objective
  - Find out how much depolarization we will get and identify the location of the depolarization along the ramp with our current orbit correction/control capability

Challenge of going beyond 100 GeV

Intrinsic spin resonance
Qx=28.73, Qy=29.72, emit= 10



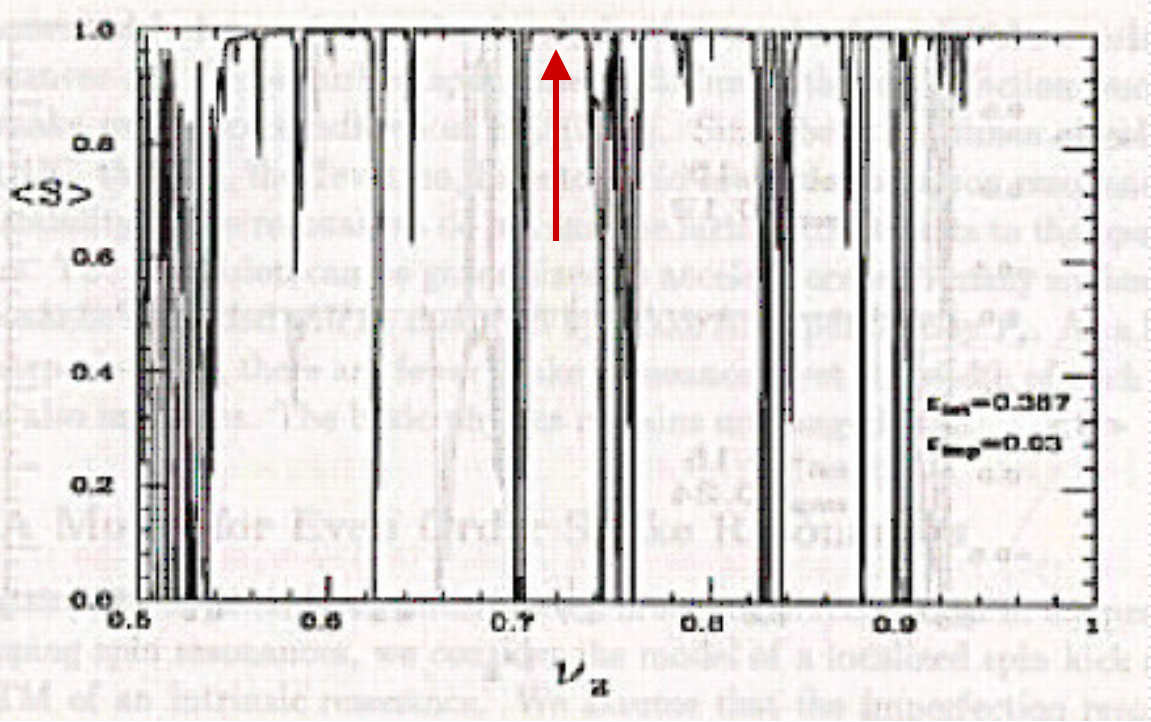
Snake resonance

- resonance condition

$$\nu_y = \frac{\nu_s \pm k}{n}$$

- each resonance is proportional to the imperfection spin resonance.
- even order snake resonance is more sensitive to the intrinsic resonance

Rhic pp nomial working point



RHIC pp acceleration to higher energies

- key point
  - Flat orbit
    - Require rms orbit distortion under 0.5um
    - Highly rely on the quality of BPMs
  - Tune control
    - tune feedback demonstrated during FY04 Run
  - Decoupling along the ramp

Establish injection with Spin rotators on at full field

- Objective
  - Allow one to injection beam with both snake and spin rotator on at their full field. This will eventually save us about 7 minutes per fill.
- History
  - This was tried during the FY04 Run. The efforts was abandoned after we were not able to establish circulating beam in about 1.5 shift.
- Experiment
  - Based on the lesson we learned, the experiment should be carried out in a progressive way, namely, gradually ramp up the rotator current and correct the orbit along the rotator ramp-up steps

conclusion

- The proposed polarization experiments are essential for helping us to better understand the spin dynamics in RHIC as well as in general. This will certainly greatly benefit the RHIC spin program