Machine Goals of the RHIC SPIN program

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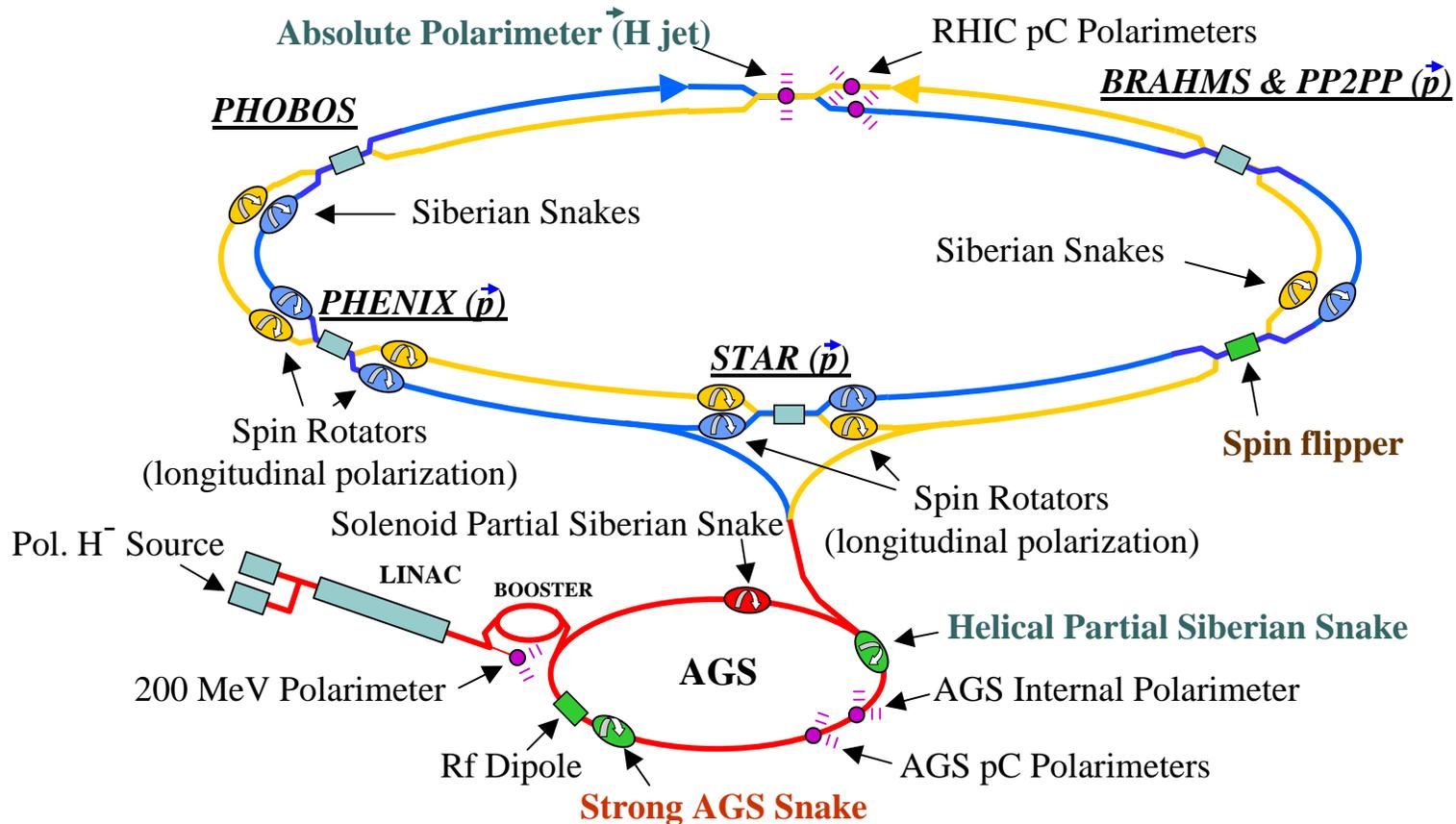
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Outline

- What has been accomplished so far in the development of the RHIC spin capability
  - Polarization capability
  - Luminosity capability
- What are the machine goals for the RHIC spin program over the next 4 years
- Summary

RHIC pp accelerator complex

Absolute Polarimeter (H jet)

RHIC pC Polarimeters

BRAHMS & PP2PP ($\vec{p}$)

PHOBOS

Siberian Snakes

Siberian Snakes

PHENIX ($\vec{p}$)

STAR ($\vec{p}$)

Spin flipper

Spin Rotators
(longitudinal polarization)

Spin Rotators
(longitudinal polarization)

Solenoid Partial Siberian Snake

Pol. H$^-$ Source

LINAC

BOOSTER

Helical Partial Siberian Snake

AGS

200 MeV Polarimeter

AGS Internal Polarimeter

Rf Dipole

AGS pC Polarimeters

Strong AGS Snake

■ Installed and commissioned during FY04 run
■ Plan to be commissioned during FY05 run
■ Plan to be installed and commissioned during FY05 run

Milestones of RHIC Spin Program

	Milestone
FY00	New polarized proton source(OPPIS) commissioned One snake was installed in the sector 9 in Blue ring By slowly turning on this snake after the pp was injected, a radial polarization was measured and demonstrated that the snake was working as expected CNI polarimeter in Blue installed and commissioned
FY02	All snakes for both rings installed and commissioned CNI polarimeter in Yellow installed and commissioned
FY03	Spin rotators installed and commissioned provided longitudinal polarizations at STAR and PHENIX for physics data taking
FY04	RHIC absolute polarimeter using Hydrogen Jet target installed and commissioned AGS 5% helical warm snake installed and commissioned

What has been achieved in the AGS

- Successfully commissioned the warm helical partial snake which is provided by RIKEN, Japan. This new snake greatly reduced the polarization loss due to the linear coupling between the horizontal and vertical betatron oscillations.

- Routinely provide 0.7×10^{11} protons per bunch with 45% - 50% polarization and 1.0×10^{11} protons per bunch with 40% polarization at AGS extraction energy

- Capable of providing more than 1.0×10^{11} protons per bunch with 45% at the end of the run
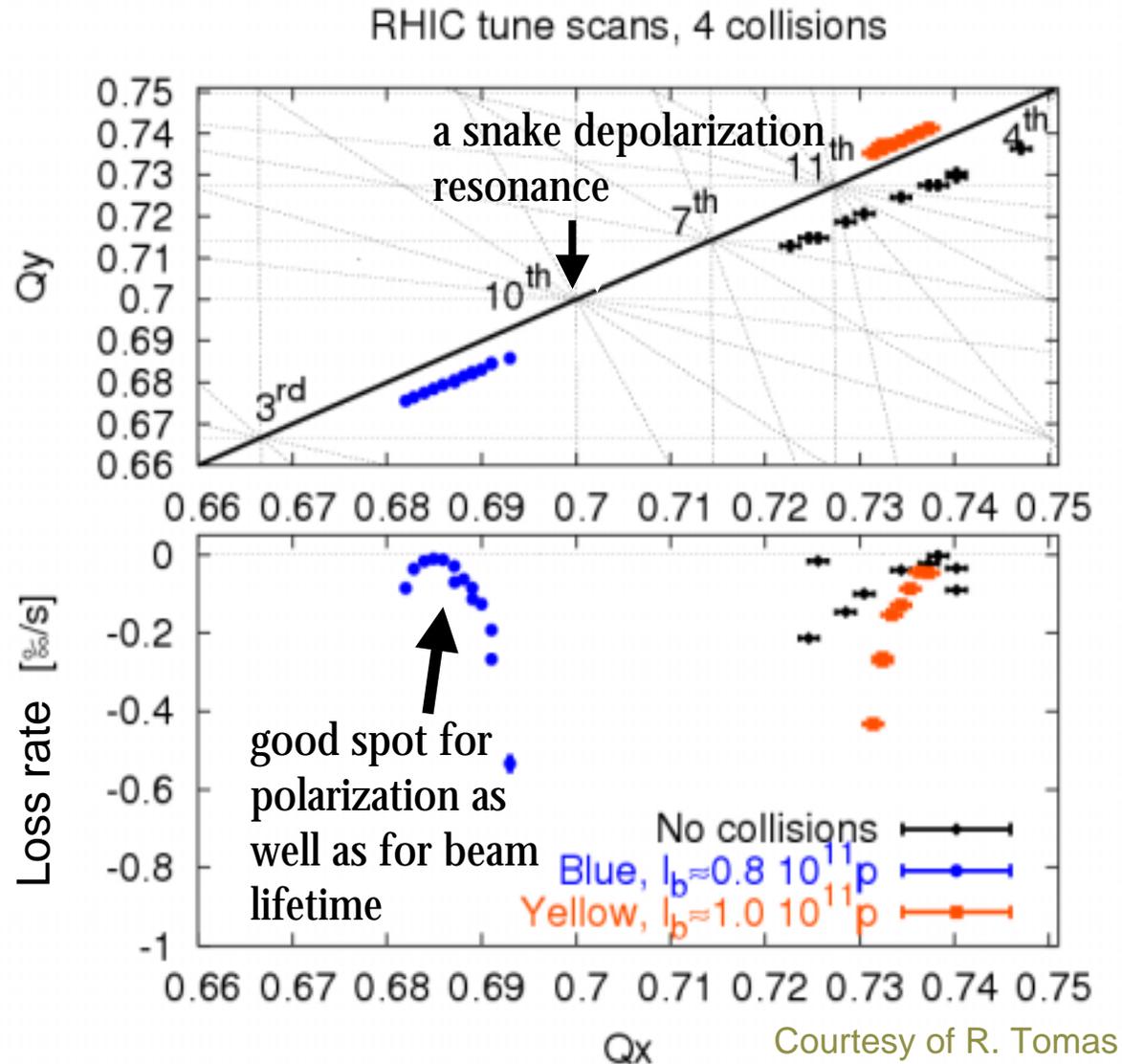
What has been achieved in RHIC

- New working point development. The working point is where the betatron tunes are located. The new working point of *(0.68, 0.69)* demonstrated they are benign to both beam lifetime and beam polarization

- Absolute polarization was measured at RHIC injection energy as well as store energy with the newly installed H target.

- Routinely provided stores with *average store luminosity $4x10^{30}cm^{-2}s^{-1}$*, average *blue polarization 45%* and average *yellow polarization 40%.*

- High luminosity development with un-polarized proton source yielded *$1x10^{31}$ $cm^{-2}s^{-1}$ average store luminosity* with 2 collisions at STAR and Phenix.

- Explored the total beam intensity limit due to vacuum pressure. A total of 45 bunches per ring with $1.5-2.0x10^{11}$ protons per bunch yielded an vacuum pressure of $3x10^{-7}$ Torr at both IP10 and IP12.
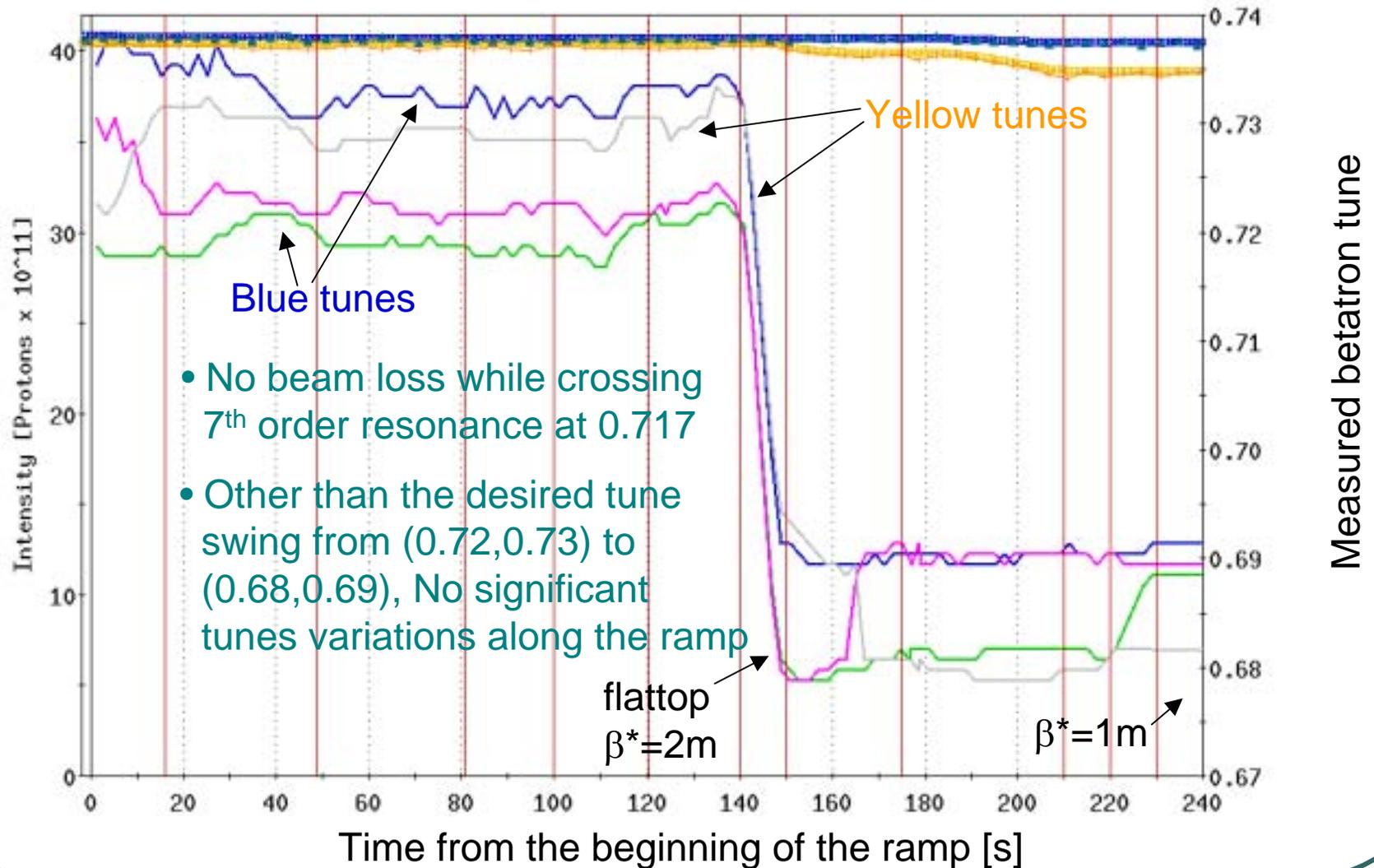
RHIC New Working Point

Motivation for new working point development:
- good for polarization transmission efficiency
- good beam lifetime under collisions
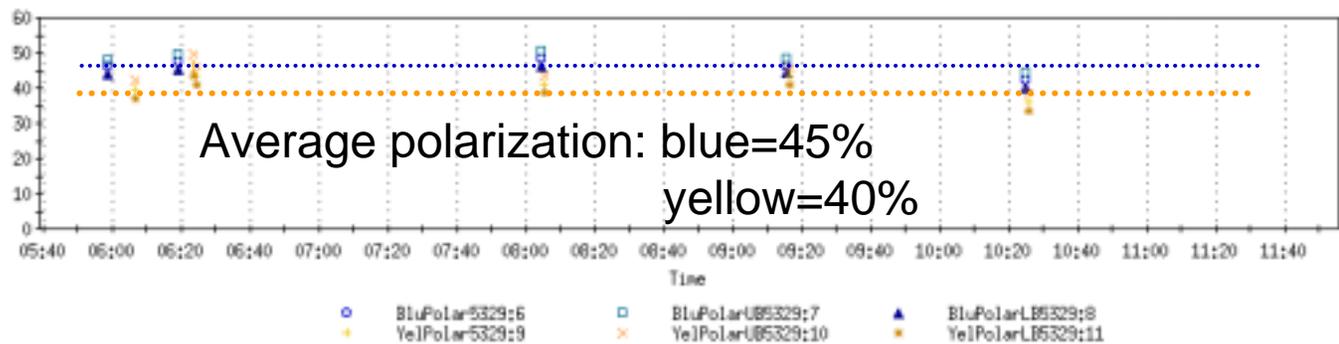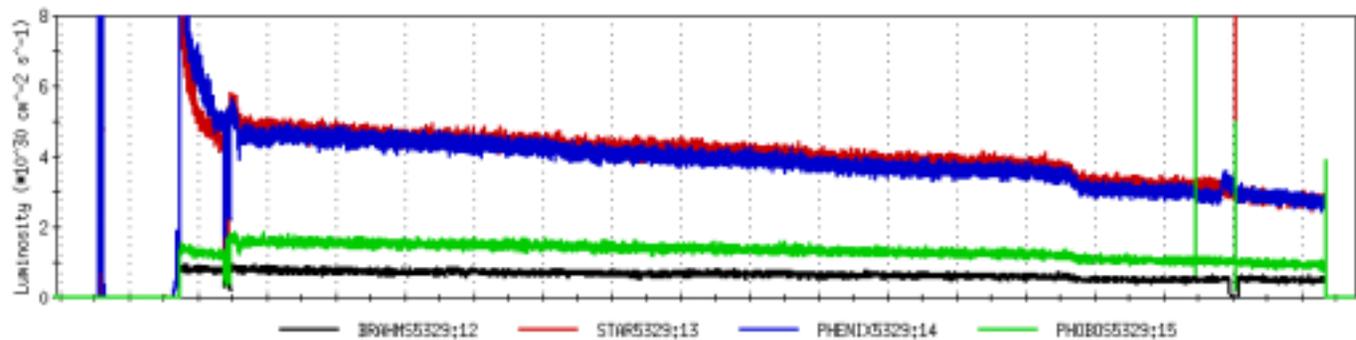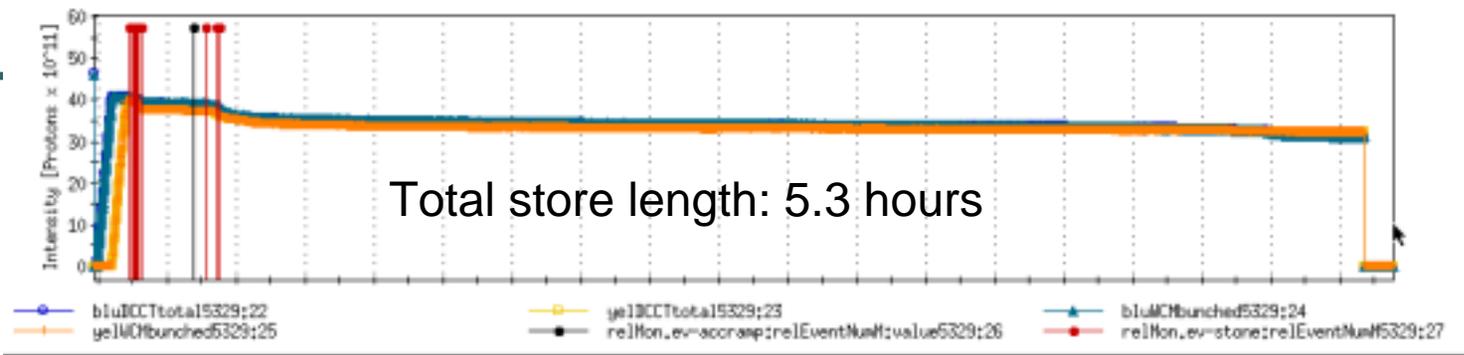- good polarization lifetime

RHIC tune scans, 4 collisions

a snake depolarization resonance

good spot for polarization as well as for beam lifetime

No collisions
Blue, $I_b \approx 0.8 \cdot 10^{11}$ p
Yellow, $I_b \approx 1.0 \cdot 10^{11}$ p

Courtesy of R. Tomas

A typical ramp (combine two plots)

Yellow tunes

Blue tunes

- No beam loss while crossing 7th order resonance at 0.717

- Other than the desired tune swing from (0.72,0.73) to (0.68,0.69), No significant tunes variations along the ramp

flattop
β*=2m

β*=1m

Intensity [Protons x 10^11]

Measured betatron tune

Time from the beginning of the ramp [s]

A typical store

Total store length: 5.3 hours

Average polarization: blue=45%
yellow=40%

Machine Goals for the Next 4 years

- Achieved

	bunch intensity $[10^{11}]$	# of bunch	$£_{peak}$ $[10^{30}]$ $cm^{-2}s^{-1}$	$£_{store\ average}$ $[10^{30}]$ $cm^{-2}s^{-1}$	$£_{per\ week}$ $[pb^{-1}]$	polarization at store
FY04	0.7	56	5.4	4.0	1.0	40%

- Future goals
  - Polarization
   - 70% or more beam polarization at RHIC injection
    - 70% beam polarization at RHIC store energy 250GeV/c
  - Luminosity
    - bunch intensity: 2×10^{11} protons per bunch
    - 112 bunch per ring
    - with a normalized beam emittance of 20π mm-mrad, a luminosity of
      - 60×10^{30} $cm^{-2}s^{-1}$ is expected at 100 GeV/c
      - 150×10^{30} $cm^{-2}s^{-1}$ is expected at 250 GeV/c
  - For RHIC machine goals beyond 4 years, please see T. Roser's talk on the RHIC Luminosity Upgrade.

How to Achieve the Polarization Goals

• AGS strong cold snake, funded by DOE, is expected to yield 100% polarization transmission efficiency from RHIC injection energy to extraction energy. The expected absolute polarization is 70%.

• The warm snake will be used for spin matching at AGS injection&extraction in the presence of the strong cold snake.

Gγ=36+ν, ε=0.011
64 ptrs w. 10 π mm–mrad emittance

partial snake resonance
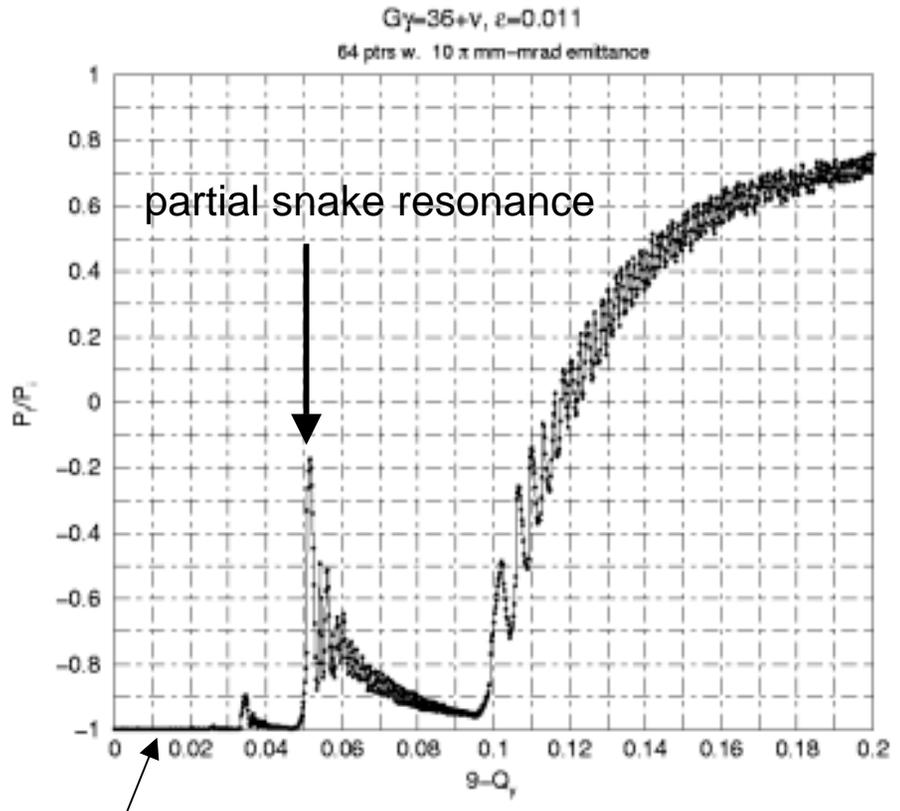
desired vertical betatron tune to avoid depolarization

How to Achieve the Polarization Goals

• fine tuning of snake rotation angle and precession axis direction
- • the rotation angle: 180°
- • precession axis direction: $\pm45^o$

• polarization ramp measurement allows one to identify the depolarization location along the ramp

• a new solenoid for the polarized proton source
- • double the beam intensity
- • 5% increase of polarization

• high polarization at 250 GeV/c
- • planned upgrade of RHIC orbit control

How to Achieve the Polarization Goals

• Polarization:

  • A survey and alignment of the whole machine are expected to reduce the effect of the depolarization resonance strength in RHIC
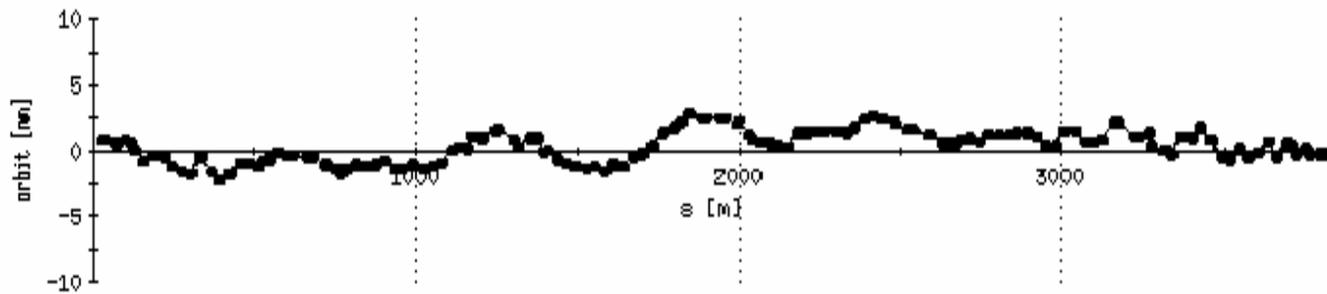
Flat orbit:
  Sum of kicks on the spin vector from quads as well as the dipole correctors = 0
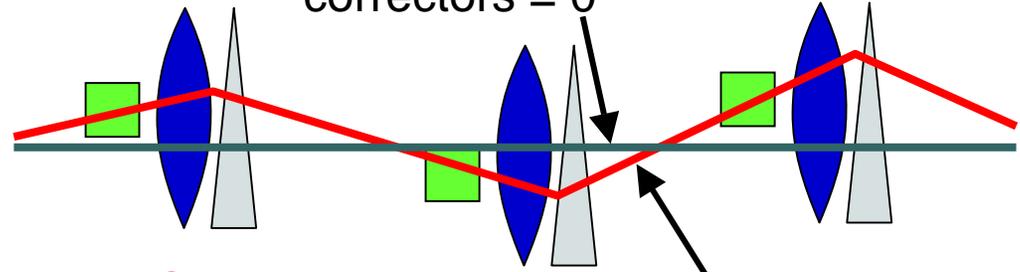
Orbit through the center of bpms

golden orbit using the latest survey

Achieve the Luminosity Goal

• Luminosity:

> • The AGS cold snake is also expected to deliver high polarization beam with high bunch intensity

> • by NEG coating all the beam pipes in the warm sections, the total beam intensity is also expected to be raised significantly

Summary

- Things achieved in FY04
  - commissioned the new working point which is benign to both the beam lifetime as well as the beam polarization
  - demonstrated providing stores with an average luminosity of $4x10^{30}cm^{-2}s^{-2}$ and beam polarization of 45% in blue ring and 40% in yellow ring.
  - Measured absolute polarization with H Jet target at RHIC injection and store energy
- Machine goals for the next 4 years
  - provide collisions of 112 bunches per ring with $2x10^{11}$ protons per bunch and beam polarization of 70%.
- Approaches for achieving the goal
  - AGS cold snake
  - NEG coating the beam pipes in all the warm sectors to eliminate the electron multi-pactoring induced vacuum pressure rise