

# ***RHIC Polarized Protons, Operations and Plans***

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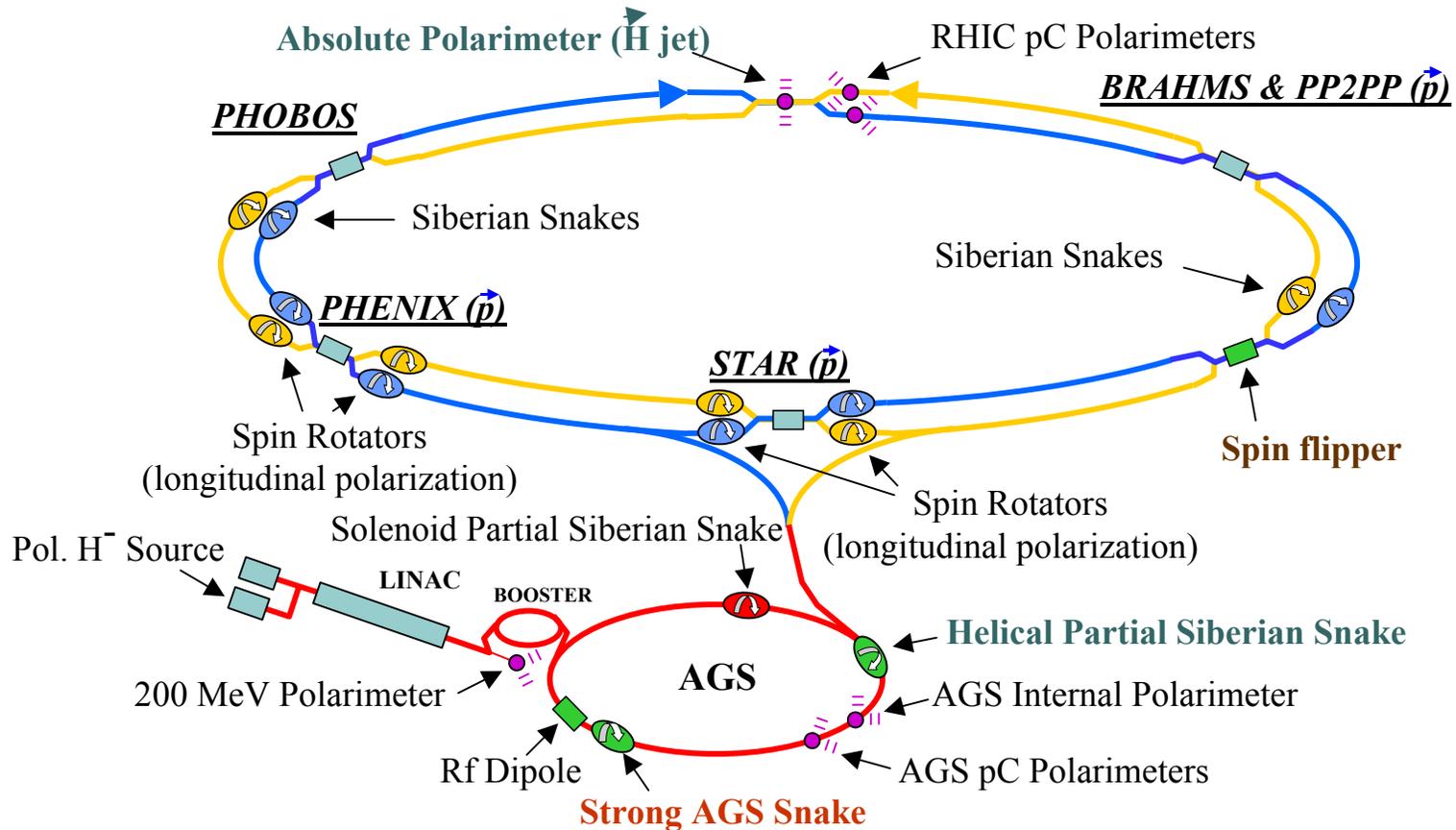
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# Outline

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- 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
- Plans for the RHIC spin program
- Summary

# RHIC pp accelerator complex



- 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	<p>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</p> <p>CNI polarimeter in Blue installed and commissioned</p>
FY02	<p>All snakes for both rings installed and commissioned CNI polarimeter in Yellow installed and commissioned</p>
FY03	<p>Spin rotators installed and commissioned provided longitudinal polarizations at STAR and PHENIX for physics data taking</p>
FY04	<p>RHIC absolute polarimeter using Hydrogen Jet target installed and commissioned AGS 5% helical warm snake installed and commissioned</p>

# Polarized proton status in AGS

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- 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  $0.7 \times 10^{11}$  protons per bunch with 45% - 50% polarization and  $1.0 \times 10^{11}$  protons per bunch with 40% polarization at AGS extraction energy
- Capable of providing more than  $1.0 \times 10^{11}$  protons per bunch with 45% at the end of the run



# Polarized proton status in RHIC

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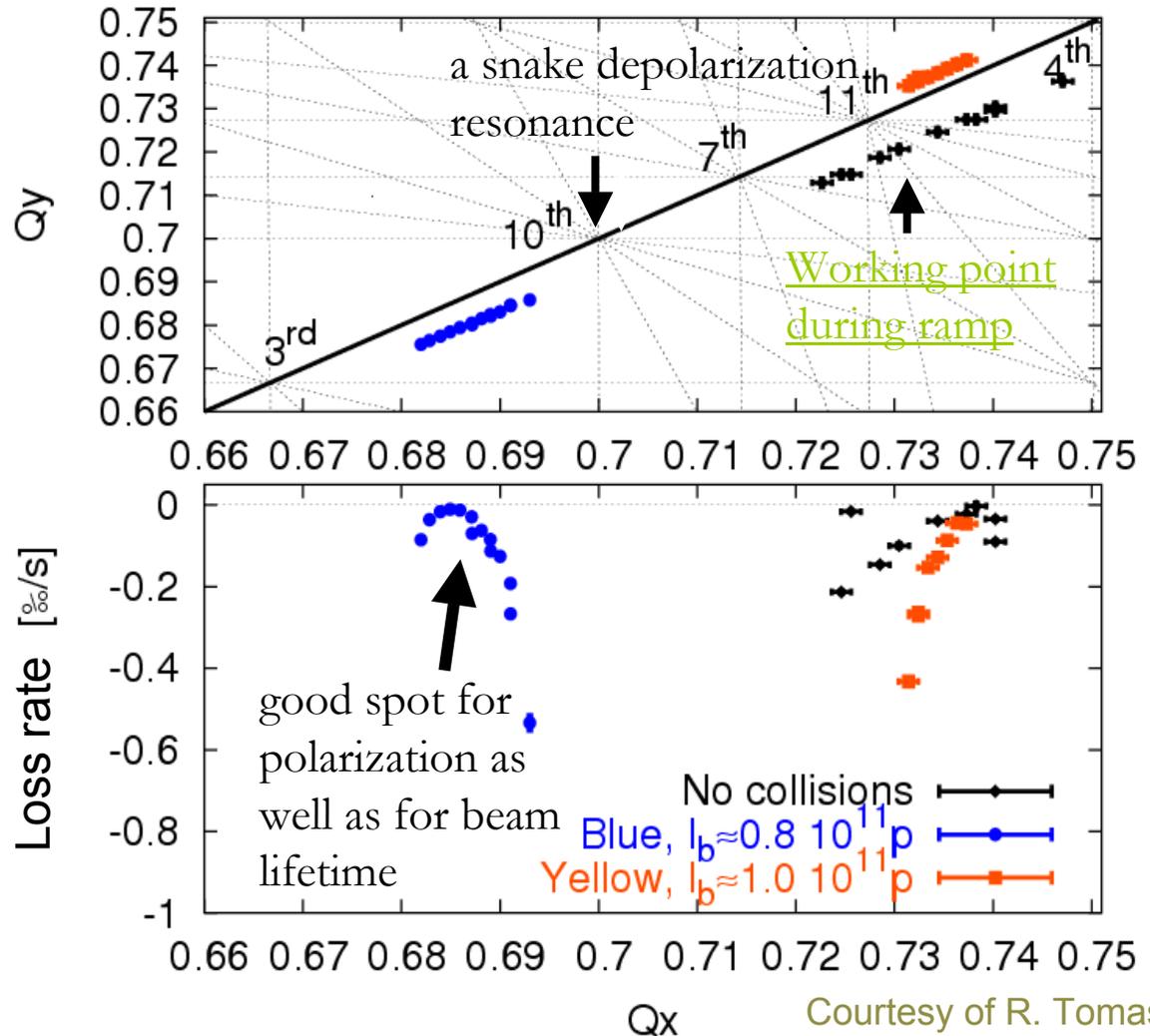
- New working points which are benign to both beam lifetime and beam polarization were commissioned
- Capable of routinely providing stores with *average store luminosity*  $4 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$ , average *blue polarization* 45% and average *yellow polarization* 40%.
- Achieved collisions at 100 GeV/c of 28 bunches per ring with  $1.7 \times 10^{11}$  un-polarized protons per bunch. The average store luminosity with 2 collisions at STAR and PHENIX is  $1 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$
- The total beam intensity is limited by the vacuum pressure in the warm sections. Expect to be improved by the installation of NEG coating the warm beam pipes.

# 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



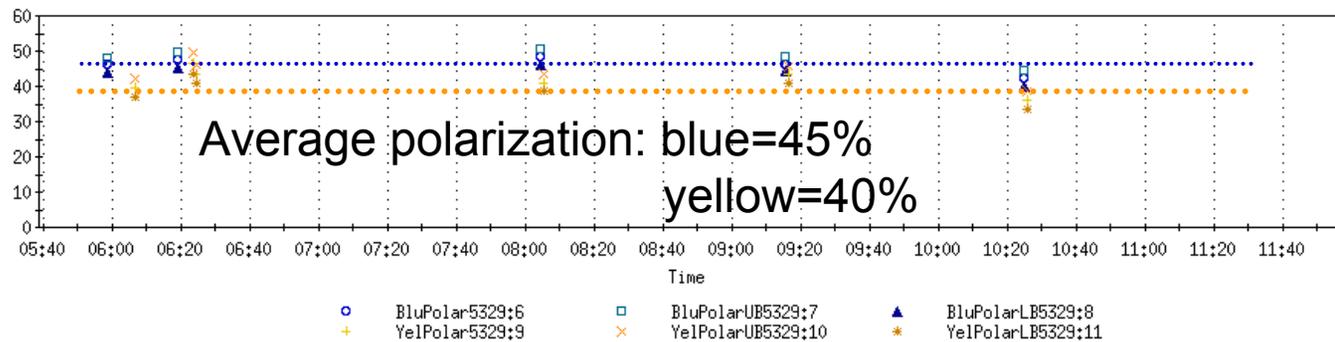
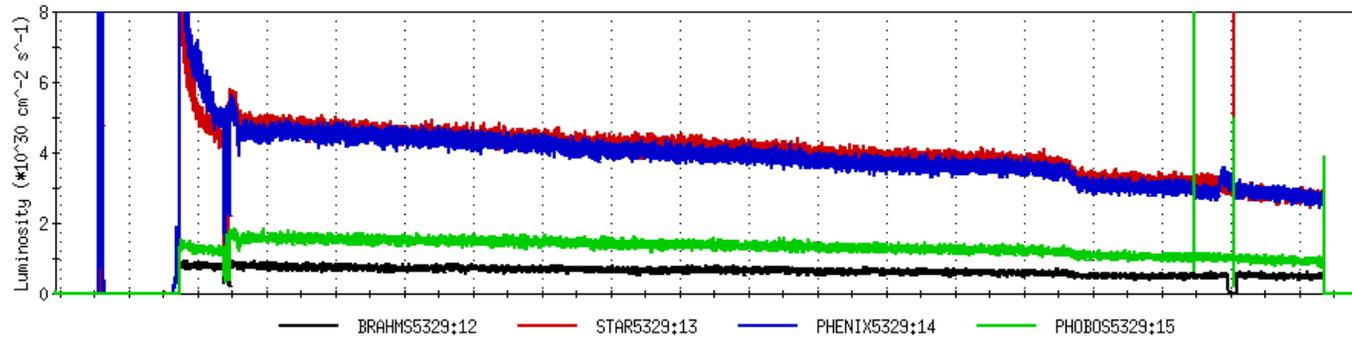
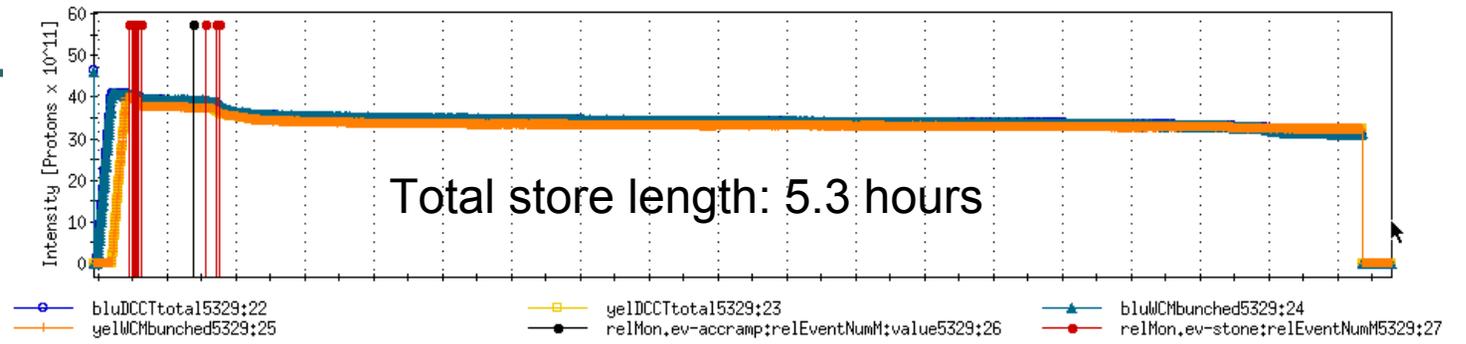
Courtesy of R. Tomas

# Polarized proton status in RHIC

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# A typical store



# Polarized proton status in RHIC

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# Machine Goals for the Next 4 years

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

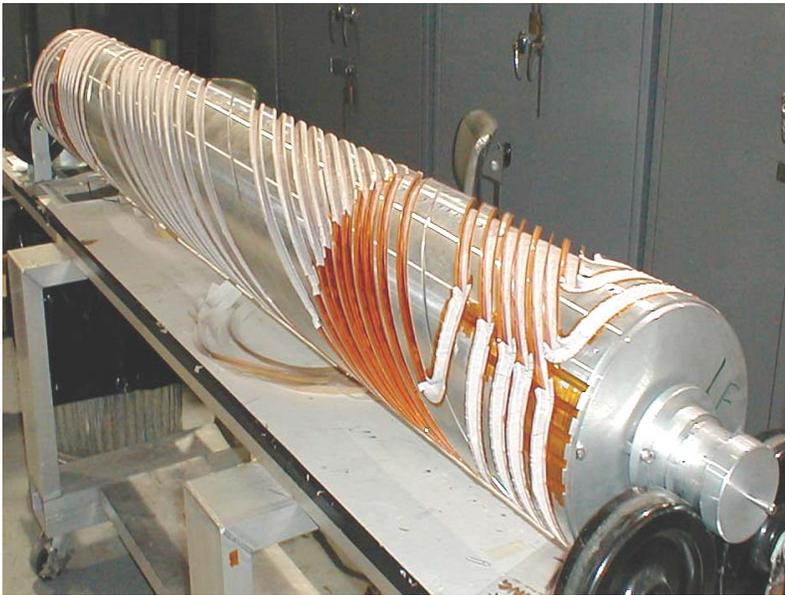
# How to Achieve the Polarization Goals

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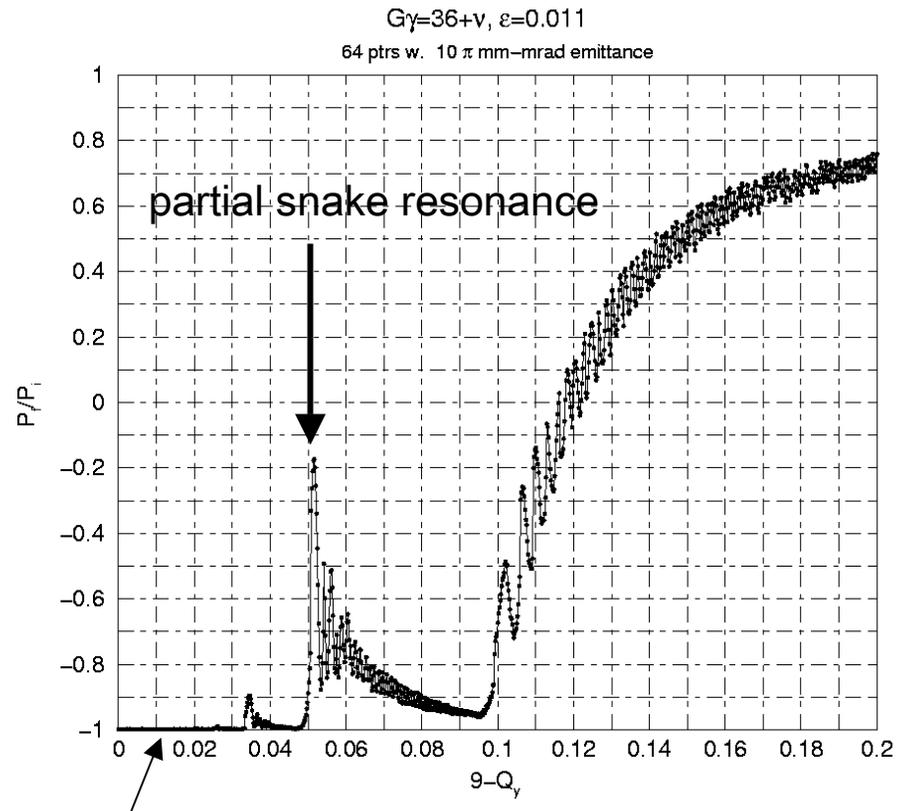
- AGS cold snake (AIP)
- fine tuning of snake rotation angle and precession axis direction
  - the rotation angle:  $180^\circ$
  - precession axis direction:  $\pm 45^\circ$
- polarization ramp measurement allows one to identify the depolarization location along the ramp
- a new solenoid for the polarized proton source (AIP)
  - double the beam intensity
  - 5% increase of polarization
- high polarization at 250 GeV/c
  - improved survey and absolute position monitoring
  - beam-based orbit flattening

# AGS cold snake

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

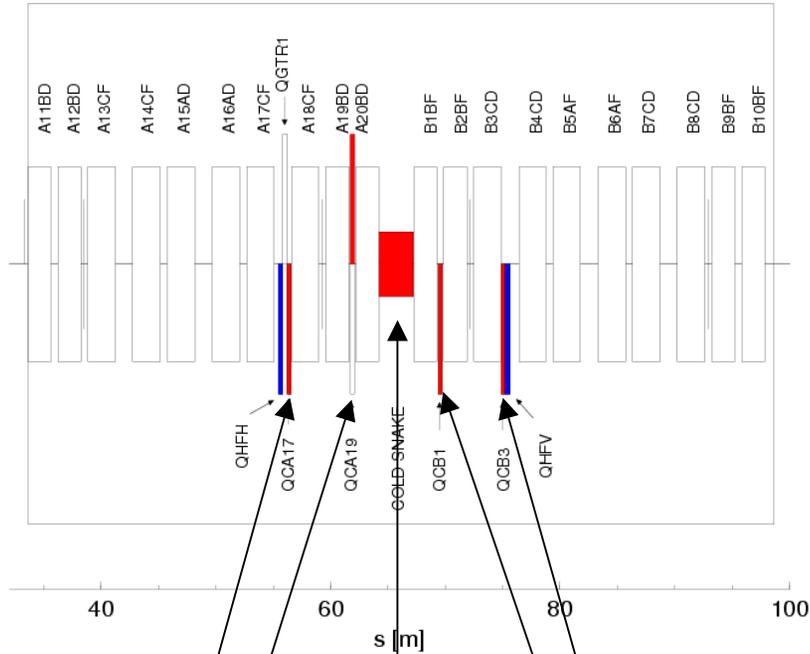


30% s.c. helical snake build at SMD (AIP)  
Installation: Dec. 2005



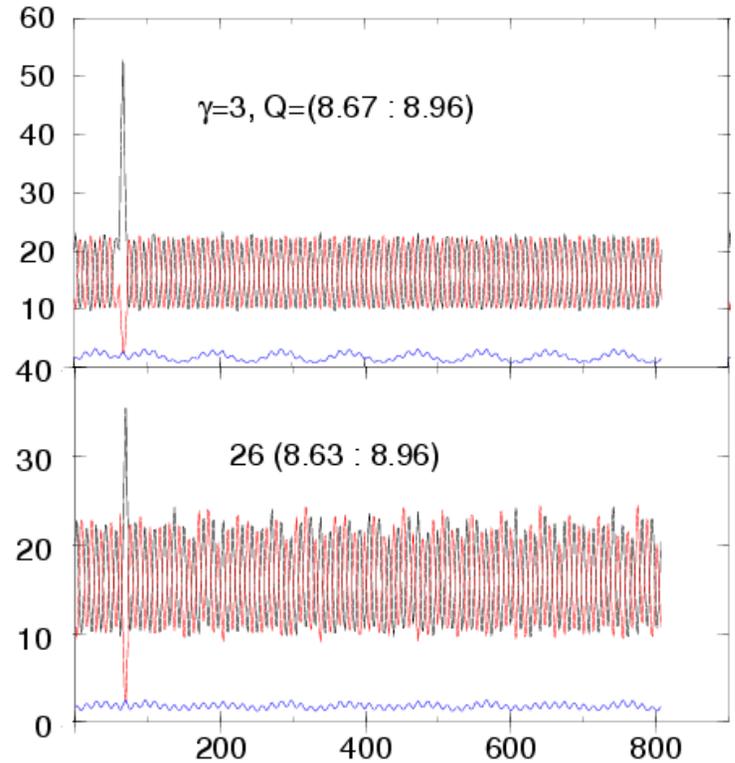
desired vertical  
betatron tune to  
avoid depolarization

# AGS cold snake – optics matching

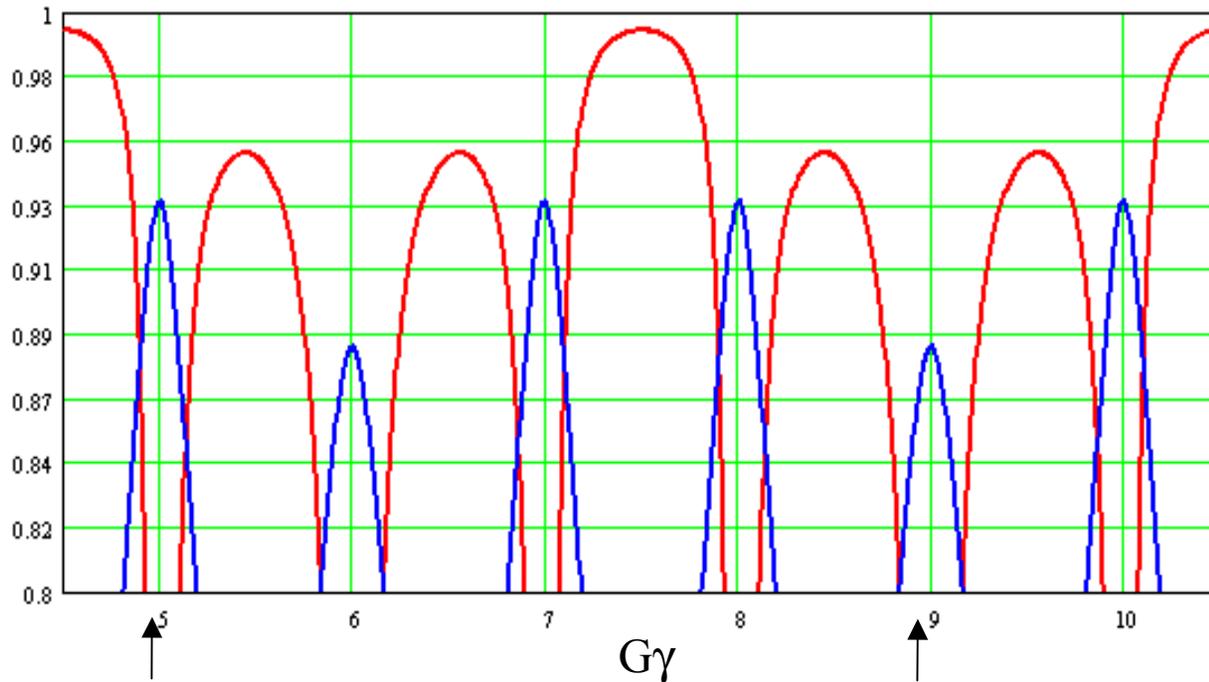


Cold snake

4 quadrupoles for optics matching



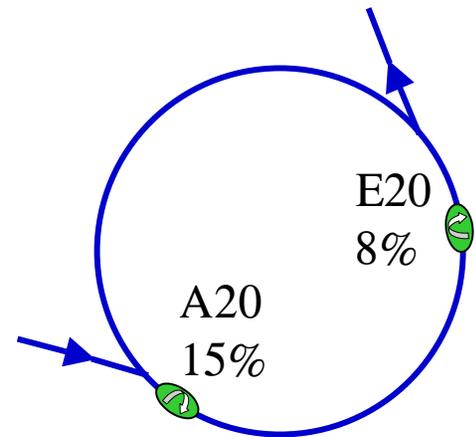
# Two partial snake scenario



Injection

First intrinsic resonance ( $0+\nu$ )

- Vertical component of stable spin
- Spin tune



# How to Achieve the Polarization Goals

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- AGS cold snake (AIP)
- fine tuning of snake rotation angle and precession axis direction
  - the rotation angle:  $180^\circ$
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- polarization ramp measurement allows one to identify the depolarization location along the ramp
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## **How to Achieve the Luminosity Goal**

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- 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

# Projections

	bunch intensity [ $10^{11}$ ]	# of bunch	$\mathcal{L}_{\text{peak}}$ [ $10^{30}$ ] $\text{cm}^{-2}\text{s}^{-1}$	$\mathcal{L}_{\text{store average}}$ [ $10^{30}$ ] $\text{cm}^{-2}\text{s}^{-1}$	$\mathcal{L}_{\text{per week}}$ [ $\text{pb}^{-1}$ ]	polarization at store[%]
FY04	0.7	56	6	4	0.9	40
FY05	1.0	79	16	9	2.8	45
FY06	1.4	79	31	22	7.1	65
FY07	2.0	112	80	64	21.6	70
FY08	2.0	112	89	72	26	70

# Plans

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FY05

- survey and realignment
  - AGS cold snake commissioning
  - NEG coating 100m warm beam pipes
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FY06

- AGS cold snake operational
  - more NEG coating
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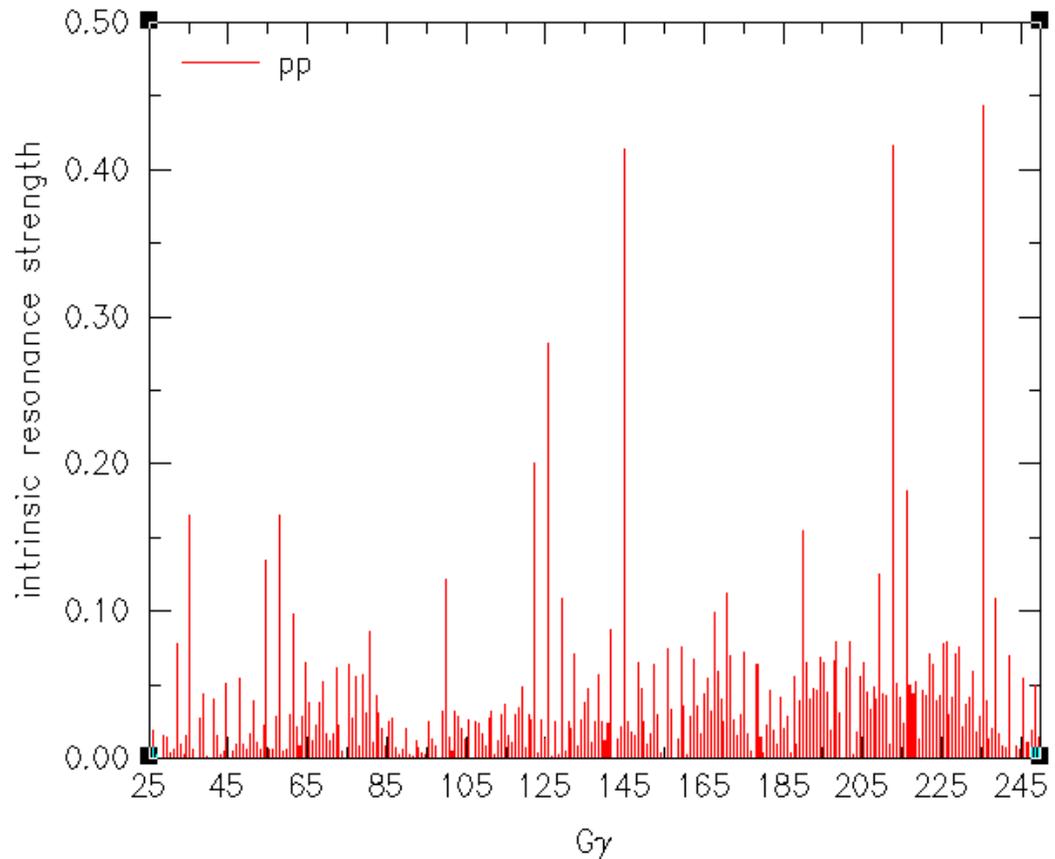
FY07

- new solenoid for the polarized proton source OPPIS

# Issues

how to get to 250GeV with high polarization

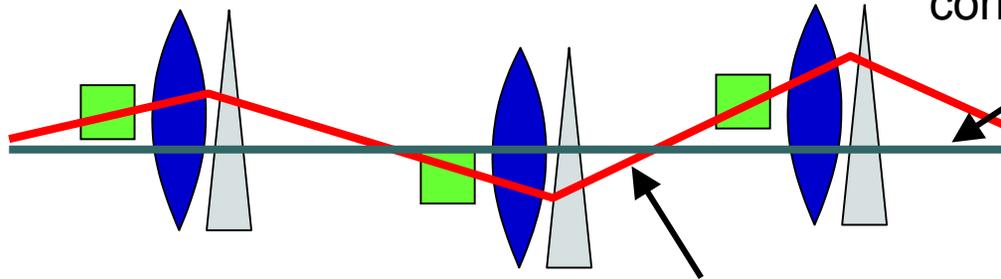
- spin depolarizing resonances get stronger as energy goes up, and so do the snake depolarizing resonances
- need very good orbit control to minimize the polarization losses due to the snake depolarizing resonances



# RHIC ideal orbit for polarized protons

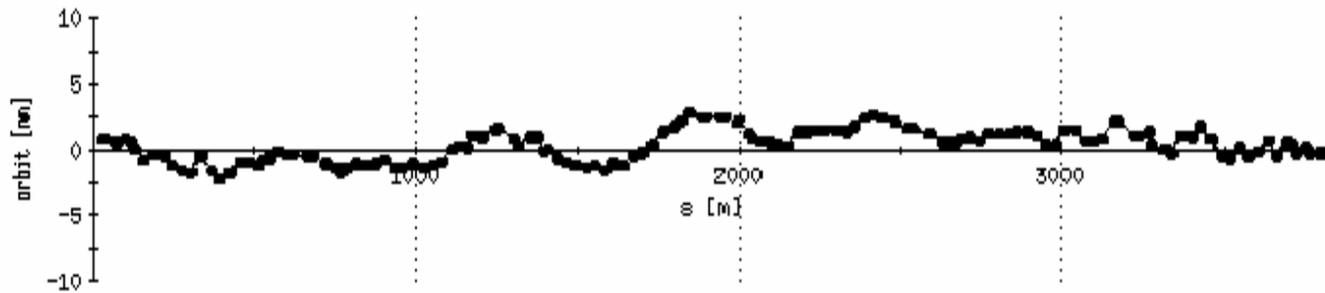
Flat orbit:

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



# Summary

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- Polarized proton status
  - Capable of providing  $1.0 \times 10^{11}$  protons per bunch with 45% with the warm Helical snake
  - Capable of providing stores with an average luminosity of  $4 \times 10^{30} \text{cm}^{-2} \text{s}^{-2}$  and beam polarization of 45% in blue ring and 40% in yellow ring.
- Machine goals for the next 4 years
  - provide collisions of 112 bunches per ring with  $2 \times 10^{11}$  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