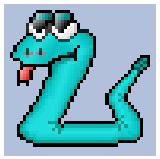
Polarized Protons in RHIC with SPIN Rotators

Waldo MacKay



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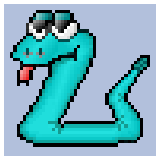
Goals for FY02 Polarized Proton Run

- 2 pC-CNI polarimeters (1 per ring)✓
- 4 snakes (2 per ring) installed.✓
- 8 power supplies (2 per snake).✓
- Source: $> 70\%$ polarization, several $\times 10^{11}$/pulse.✓

- Provide 100 GeV $\times$ 100 GeV collisions with long. pol. at all IR's. ✓✗
  - Instantaneous Luminosity $\gtrsim 1 \times 10^{30}\mathrm{cm}^{-2}\mathrm{s}^{-1}$✓
  - Hope to achieve at least 50% polarization per beam.✗(AGS)
  - $2 \Rightarrow 1$ snake ramps for longitudinal polarization.✗

- Decelerate beam to calibrate CNI polarimeters.✗
- Commission PLL: partially successful.
- Accelerate polarized protons to 250 GeV.✗
- Commission Spin Flipper.✓



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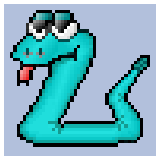
More details

- Flattened orbit vertically to surveyed coordinates.✓
- Rebucketing.✗
- PLL not routine for up ramps.✗
- $\beta^* = 10$ m at IP2.✓
- AGS problems:
  - AGS polarization too low ($P \lesssim 30\%$).✗
  - AGS emittances large (trans, long).
  - No Siemens: slower ramp rate.
  - J10 bump power supply problem.
  - Polarization dependence vs intensity?
- RHIC polarization transmission varied:
  - Vertical tune control.
    - Snake resonances.
  - Vertical orbit control: sometimes walked away.



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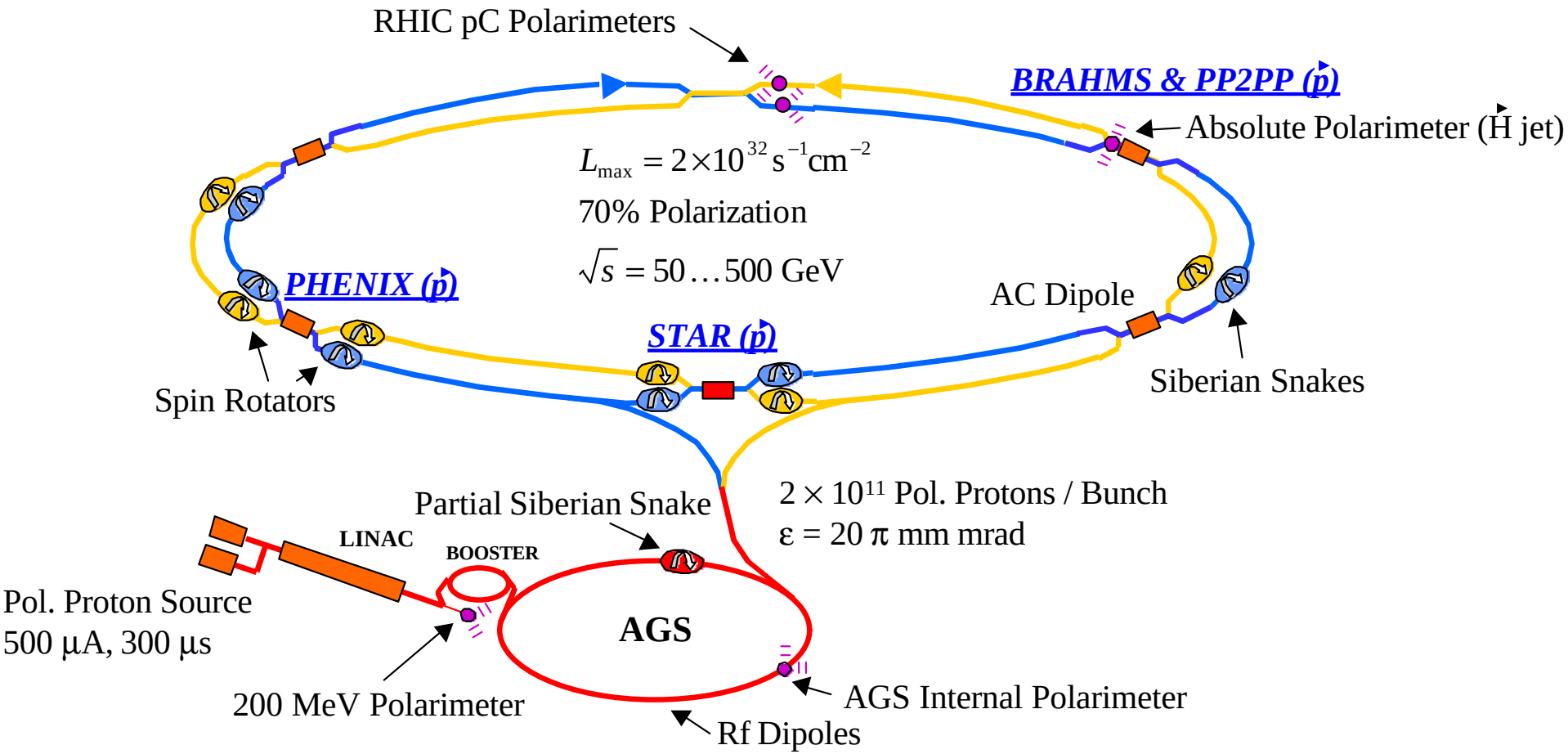
Polarized Protons in RHIC



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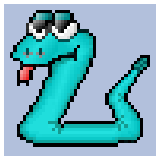
Things in AGS for Next Time

- Siemens.
- J10 bump supplies not oscillating.
- Updated apps:
  - Snake control.
  - AC dipole control.
  - Coherence monitor.
  - Betatron tunes.
- Upgraded hardware:
  - AC dipole control.
  - Coherence monitor.
  - Betatron tunes.
- New p+C CNI polarimeter for AGS. (Measure during ramp.)
- Improved logging of AGS data and readbacks.
  - including polarizations of bunches injected into RHIC.
- Multiple bunches in AGS?
  - with different polarizations? What is required?



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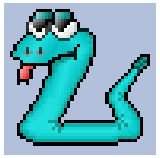
Things in RHIC for Next Time

- Energy ramp: (symmetric lattice?,) fixed $\beta^* = 5?, 10?$ m.
  - to what energy: 100, 250 GeV? (other?)
  - Make PLL operational for up ramp.
- Develop ramps at flattop:
  - Ramps for STAR, PHENIX, and PHOBOS magnets.
  - β-squeeze to 2-3 m at IP2&10, to 1 m at IP6&8
  - to turn on rotators.
- Calibrate snakes with spin flipper.
- Scan tunes for new working point.
- Commission rotators.
- Improve emittances: long. and trans.
- More intensity/bunch: at least 1×10^{11}.
  - 110 bunches?
- Deceleration ramp again. (from what energy?)
- Rebucketing? or other reduction of long. emitt.?
  - Lock rf in both rings up ramp?
- Improve efficiency (of the whole enchilada).



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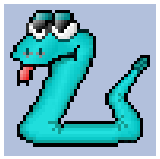
Considerations for Deceleration Ramp

- Measure transfer functions (TF) for typical magnets before next fall:
  - Short dipole (D9) down ramp from 100 GeV, other energies?
  - Sextupole TF's: hysteresis, persistent current decay effects.
- Tune up down ramp to get beam to bottom without PLL.
- Then use PLL to hold tunes constant.
- Develop magnet ramp for counteracting persistent current decay back at injection energy, if necessary.
- Dedicated time (several days) should be set aside for the down ramp.



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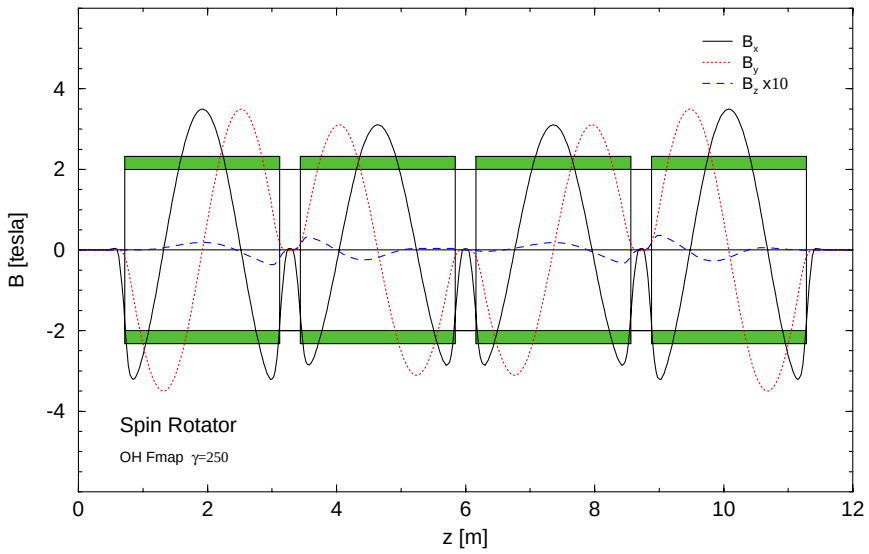
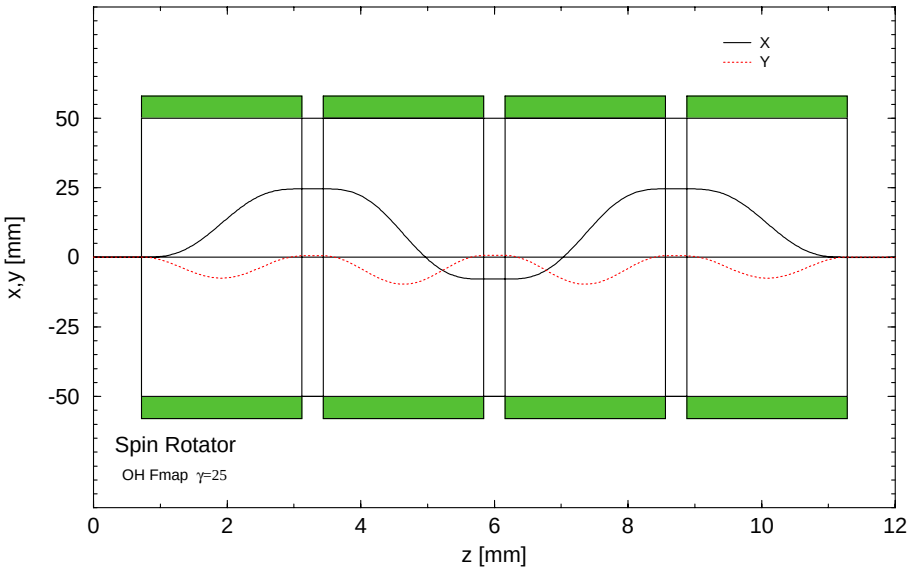
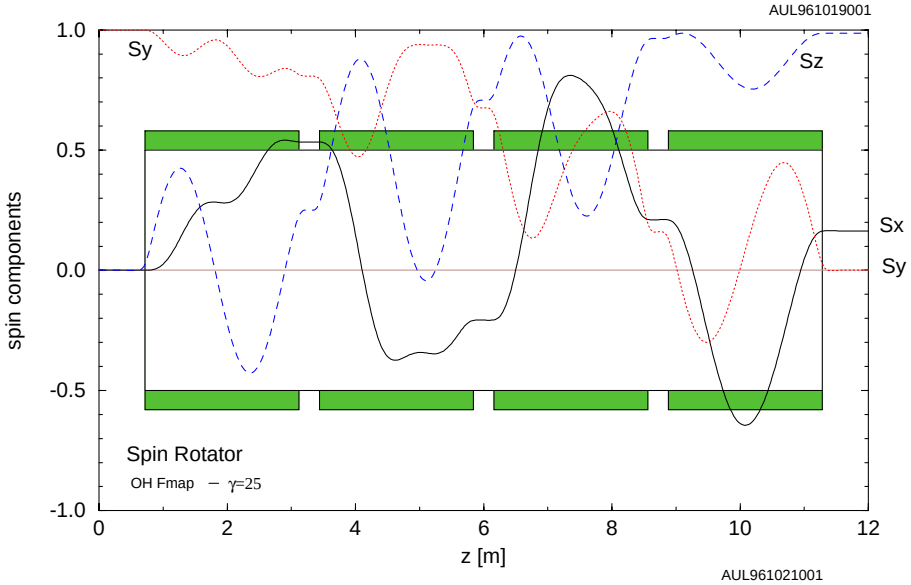
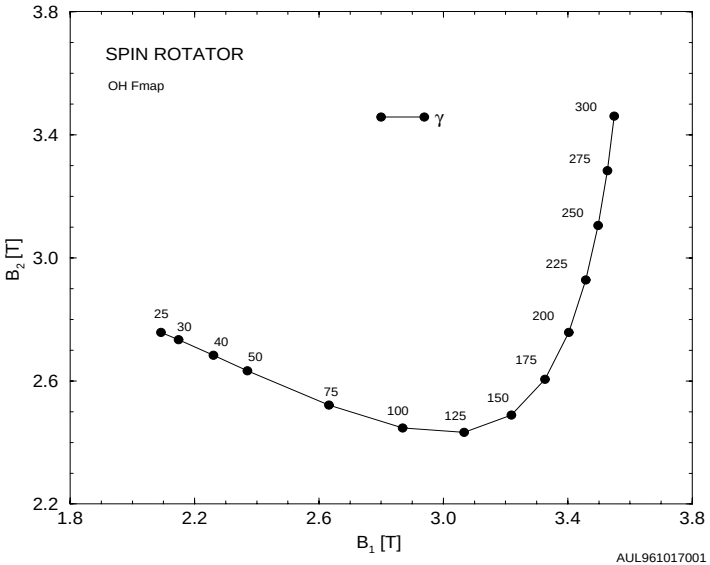
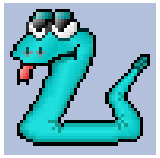
Operation of Rotator











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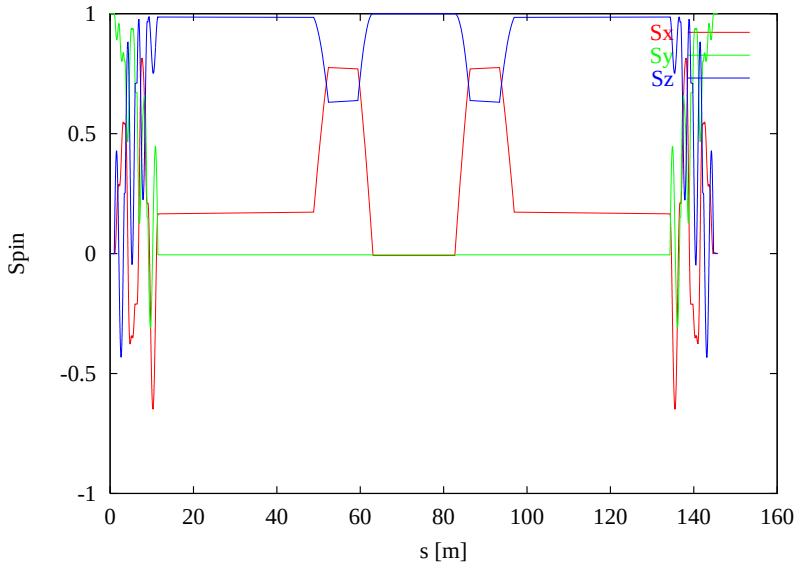
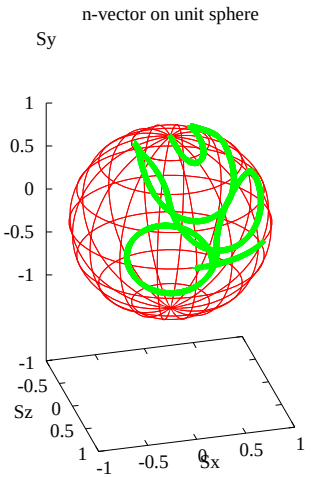
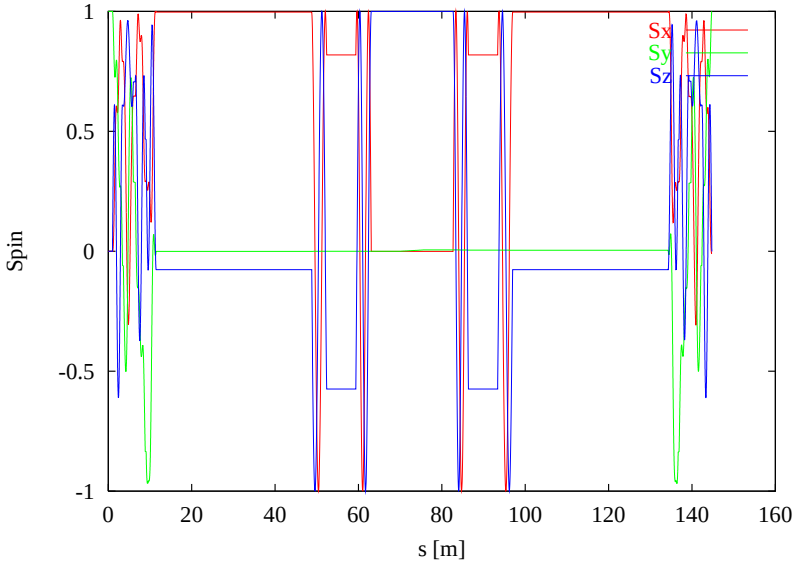
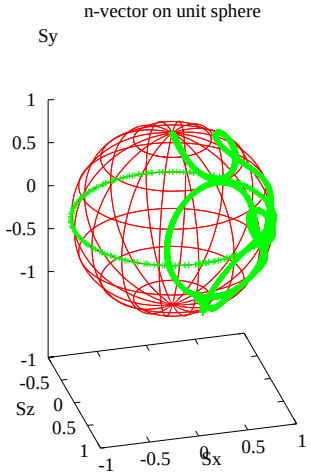
STAR at injection

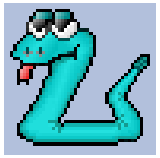




STAR at 250 GeV







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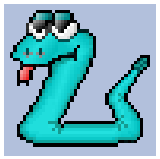
Status of Rotators

- Rotators 1-4 waiting for installation.
- Rotator 5 completed but waiting for final survey.
- Rotator 6 in final wiring of turrets, awaiting survey.
- Rotator 7 cold mass almost completed.
- Rotator 8 helices completed, awaiting fixture.
- Warm-to-cold transitions are being opened.

- Racks in alcoves being prepared for power supplies.
- 10 of 16 Quench Protection Assemblies (QPA) have been modified.



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Calibration of Snakes/Rotators

Two snakes:

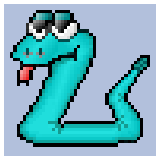
- Set two snakes in one ring for best guess at $\mu_{1,2} = 180°$ and $\phi_{1,2} = \pm 45°$.
- Detune currents by predicted amounts for $\nu_{\rm sp} = 0.5 - \epsilon$.
- Verify shift of spin tune with ac dipole.
- Remeasure with a few different settings to calculate sensitivity matrix.
- Calculate and apply correct currents.

Energy calibration with $2 \Rightarrow 1$ snake ramp (injection and/or store):

- Ramp down one snake and measure horizontal polarization.
- Do energy scan through at least one full unit of $\Delta(G\gamma)$.
  This should give a calibration of energy vs current.

Rotator calibration:

- This needs work to develop a workable scheme.
  Perhaps measure shift of spin tune with a single rotator on. We could also measure radial and vertical components for different settings.



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Comments on Luminosity

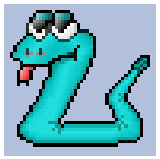
Last time:

$$L_{\text{peak}} = f_{\text{rev}} \frac{N_1 N_2 N_b}{4\pi\sigma_x\sigma_y} = f_{\text{rev}} \frac{N_1 N_2 N_b}{4\pi \frac{\epsilon^N_{95\%}}{6\beta\gamma}\beta^*}$$

$$\simeq 78 \text{ kHz} \times \frac{\left(7\times 10^{10}\right)^2 \times 55}{2 \times \frac{2\times 10^{-5} \text{ m}}{107} \times 3 \text{ m}}$$

$$\simeq 1.8 \times 10^{30} \text{ cm}^{-2}\text{s}^{-1}$$

- For the energy ramps we, want equal and constant β^* at all IR's.
  - Ramp with $\beta^* = 5 \rightarrow 10$ m?
  - Squeeze at storage: $\beta_{\text{IP6,8}} = 1$ m? $\beta_{\text{IP2}} \sim 2$ m? $\beta_{\text{IP10}} \sim 3$ m?
- Can we accelerate 55×10^{11} protons per ring?
- 110 bunches.
- Energy: 100 or 250 GeV?



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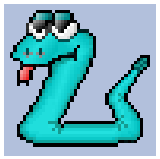
Predicted peak luminosity at PHENIX for next run with 250 GeV protons:

$$L_{\text{peak}} \simeq 78 \text{ kHz} \times \frac{\left(1 \times 10^{11}\right)^2 \times 55}{2 \times \frac{2 \times 10^{-5} \text{ m}}{266} \times 1 \text{ m}} \sim 2.7 \times 10^{31} \text{cm}^{-2} \text{s}^{-1}.$$

- Perhaps higher if we can get more current in the rings.
  - We should try some 110 bunch running at least to shake the bugs out of the systems.



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