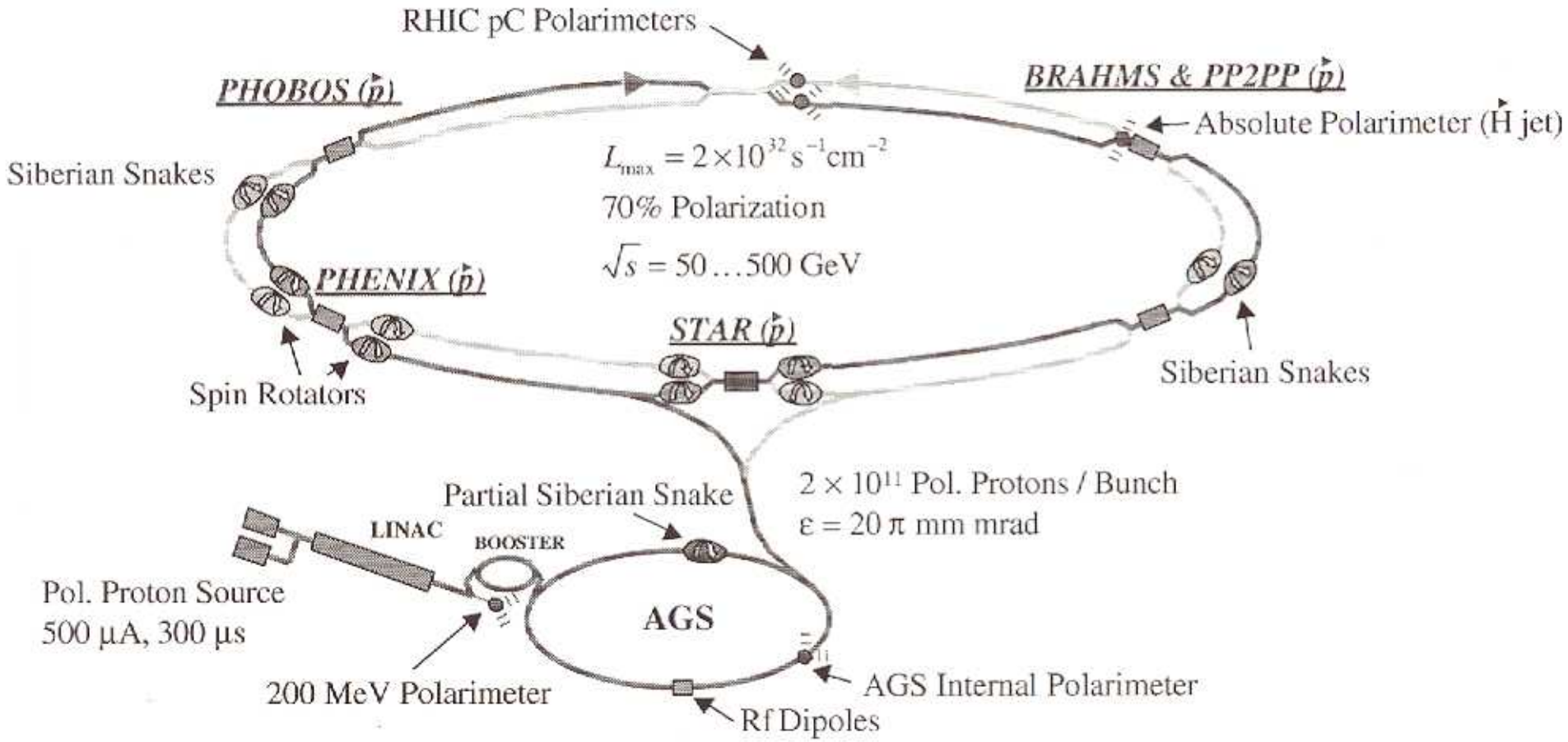
Machine Issues for RHIC Spin



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Goals

This run:

- Trans. pol. protons colliding at $\sim$100 GeV per beam ($P > 50\%$).
- Long. pol. protons colliding at $\sim$100 GeV per beam ($P > 50\%$).
- Commission acceleration of pol. protons to 250 GeV per beam.

Next Run:

- Long. Pol. at STAR and PHENIX with 250 GeV per beam.

Schedule of Current Run

- 8 Nov: 1 shift shutdown to install AGS polarimeter.
- 9 →26 Nov: Au in RHIC; pol protons in AGS.
- 26 →29 Nov: Shutdown to change RHIC to pol. protons.
  Run pol. protons in AGS.
- 30 Nov.→21 Dec.: Commission pol. protons in RHIC.
- 22 Dec.→∼25 Jan.: Physics with pol. protons.

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Commissioning Progress

- Power supplies connected to all four snakes.
  - Not yet tested to full field.
  - Not yet tested with beam.
- Polarized beam in AGS ($G\gamma = 7.5$ as of yesterday).
- $\beta^* = 3$ m injection test scheduled for this afternoon.
  - Vertical flattening to surveyed positions yet to be done.
- Spin flipper installed.
  - System previously tested outside ring.
  - Requires ring access when we first power it.

Status of Future Additions

- 4 rotators completed and awaiting installation in RHIC.
- 5th rotator cold mass being assembled.
- 6th rotator all four helices cold tested.
- 7th rotator: 4th helix being cold tested.
- 8th rotator:
  - 3 of 4 helices stacked and in various stages of wiring the ends
  - last helix remains to be stacked and wired.
- All helices to be finished by Dec., 2001.
- Last rotator to be finished by April., 2002.
- All 8 rotators to be installed in RHIC by Oct., 2002.

- New AGS Partial snake: Helical
  - requires more study: warm or supercond.
  - no definite plan yet.

- Polarized Jet Target: see following talks

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Other links

- AGS commissioning plan:
  http://www.rhichome.bnl.gov/People/huang/pp02/FY02plan.htm
- Previous talks:
  http://www.rhichome.bnl.gov/RHIC/Spin/spinfigs/figslist.html
  http://www.rhichome.bnl.gov/RHIC/Spin/spinfigs/wwm-rsc1oct01.pdf
- Polarization angles at IR's and polarimeters for different energies:
  http://www.rhichome.bnl.gov/RHIC/Spin/spinfigs/100GeV-1snake.html
- Other ideas for upgrades:
  http://www.rhichome.bnl.gov/RHIC/luminosity/

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Possible RHIC Upgrades

- Luminosity increase RHIC II: electron cooling
  - cool protons at injection (double luminosity over RDM+)
  - spin cooling with polarized electrons?
- eRHIC: polarized electrons and proton collisions
- Energy increase: (20–30%)

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Parameters for Proton Collisions

Scheme		RDM	RDM+	RHIC II
Emittance (95%), ϵ	$[\pi\mu\mathrm{m}]$	20	20	12*
IP beta function, β^*	[m]	2.0	1.0	1.0
Number of bunches, M		60	120	120
Bunch population, N	$[10^{11}]$	1.0	2.0	2.0
Beam-beam parameter per IR, ξ		.0037	.0073†	.012‡
Angular beam size, σ'^*	$[\mu\mathrm{rad}]$	79	112	86
RMS beam size, σ^*	$[\mu\mathrm{m}]$	158	112	86
Peak Luminosity, L_0	$[10^{31}\mathrm{cm}^{-2}\mathrm{s}^{-1}]$	1.5	24	40

* For RHIC II assumes electron cooling at injection to reduce emittance.

† For RDM+ assumes only collisions at 3 IR's.

‡ For RHIC II assumes only collisions at 2 IR's.

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Increasing Energy

We have considered the possibility of increasing the energy of beams in RHIC by as much as 30% with a modest trade-off in luminosity. The arc dipoles and quadrupoles were designed with considerable margin. For higher energies ($>$ 100 GeV/nucleon) the minimum β^* may be required to increase as the interaction region triplets saturate. The separator magnets (DX) have the least margin for increased field, so we consider three scenarios: allowing for a small crossing angle with the present DX magnets, upgrading the DX magnets to higher strength, and permitting a crossing angle of $\sim 1^\circ$ by removing the DX magnets altogether.

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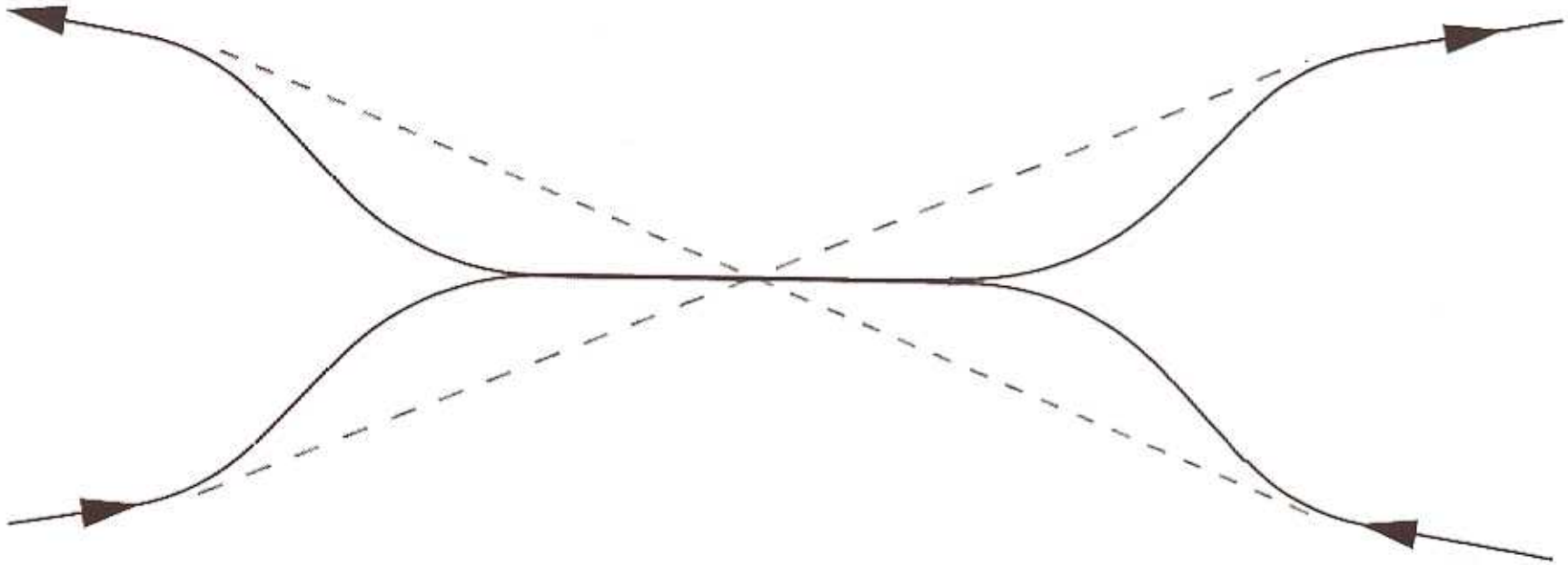
Trajectories of Both Beams Through IR



The dashed lines indicate trajectories without DX magnets.
The crossing angle without DX's is $\alpha = 0.18$ mrad.

Conclusions for an energy upgrade

- 25 → 30% increase in energy looks possible.
- 0° crossing angle requires new D0 & DX magnets.
  - Higher energies require all new dipoles.
- 2.5 mrad crossing angle perhaps possible with existing magnets.
  - DX magnets may only make 10–15% more energy.
- 18 mrad crossing angle
  - DX magnet not needed.
  - D0 magnet runs at low field ($B \sim 1.6$ T).
- Snakes work in all scenarios.
- Spin rotators should work.
  - For 18 mrad crossing angle: reverse power supplies.

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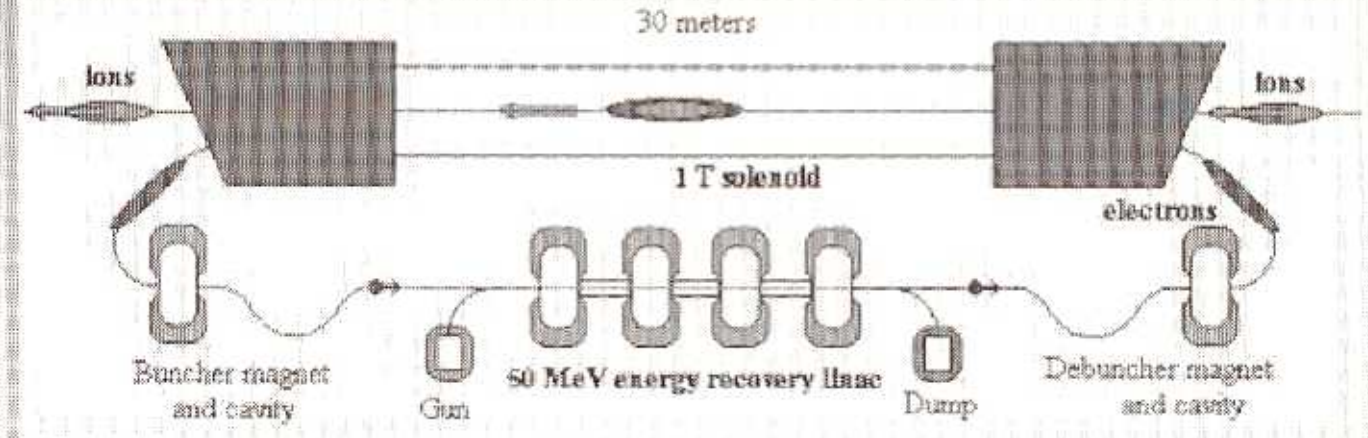
Schematic of the RHIC Cooler

- Energy Recovery Linac
- Buncher - debuncher



> x10 increase in the integrated luminosity of RHIC, as well as better accumulation of rare species.

Ilan Ben-Zvi
Beam Cooling and Related Topics
Bad Honnef, May 14-18, 2001

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eRHIC – a Polarized Electron on Ion or Polarized Proton in RHIC

The Electron-Ion Collider is proposed as an essential tool for research into the fundamental structure of matter:

- What is the *structure* of hadrons in terms of their quark and gluon constituents?
- How do quarks and gluons *evolve* into hadrons via the dynamics of confinement?
- How do the quarks and gluons *reveal* themselves in the structure of atomic nuclei?

Ilan Ben-Zvi

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