Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

Acceleratiion of polarized helions at the EIC

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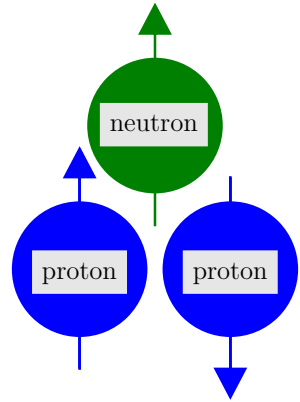
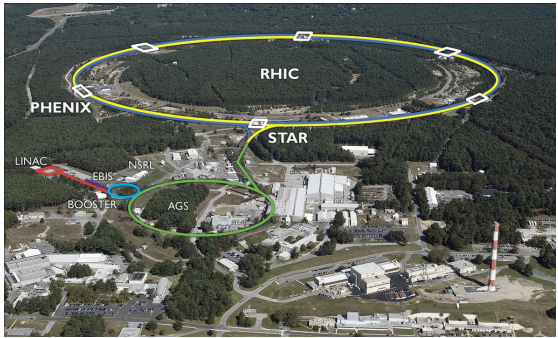
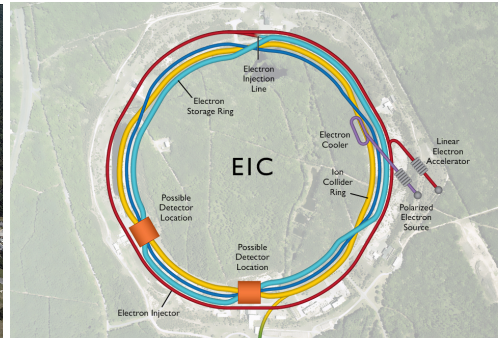
Why helions?

- Polarized neutron collisions are part of the EIC physics program (q=0).
- Polarized neutrons will give an asymmetry due to valence quark composition differing from protons.
- Polarized neutron collisions will be facilitated with collisions of polarized helions where up to 86% of the polarization is accounted for by the neutron.
- Polarization scheme of helions provides polarized neutrons paired with two unpolarized protons, q=2.
- The highest energy polarized helions have been accelerated is in the low MeV range. The EIC will have collisions at 183 GeV/u.



The RHIC and EIC Accelerator Complex



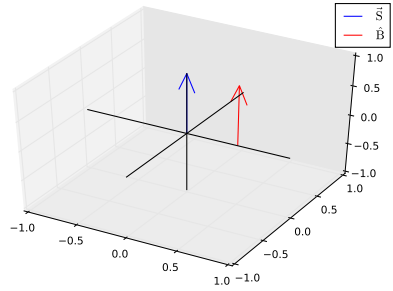


- RHIC scheduled to run until 2025.
- 2025 through 2032 is construction of EIC.
  - Installation of electron collider ring inside RHIC tunnel.
- EIC commissioning and physics program to follow.

Spin Dynamics

Torque on the magnetic moment from a magnetic field: $\vec{\Gamma} \propto \vec{S} \times \vec{B}$

- No torque if the two are parallel
- Maximum if the two are orthogonal



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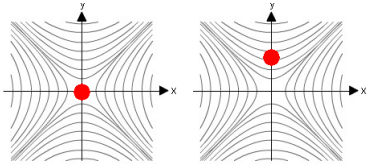
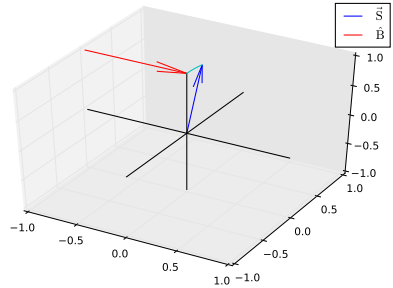
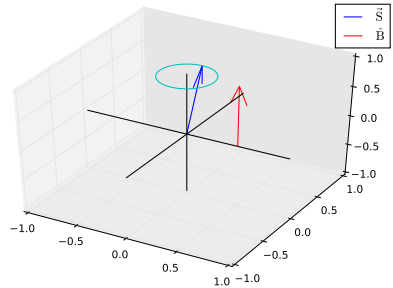




Spin Dynamics

Torque on the magnetic moment from a magnetic field: $\vec{\Gamma} \propto \vec{S} \times \vec{B}$

- No torque if the two are parallel
- Maximum if the two are orthogonal
- Beam now rotates in dipole field since they are no longer parallel.



Number of rotations the spin rotates in one turn is known as the spin tune: $\nu_s = G\gamma$, with G being the anomalous magnetic moment ($G_{helions}$=-4.1842, $G_{protons}$=1.7928) and γ being the Lorentz factor.

Depolarizing Resonances

There are two types of depolarizing resonances which occur when the spin rotations are in phase with the particle motion.
These are intrinsic resonances at

$$\nu_s = nP \pm \nu_y$$

These are imperfection resonances at

$$\nu_s = n$$

	Booster		AGS		HSR	
species	p	h	p	h	p	h
Energy (injection) (GeV/u)	0.2	0.002	1.4	1.4	22.9	10.1
Energy (maximum) (GeV/u)	1.4	1.4	22.9	10.1	274.0	182.1
Strong intrinsic Resonances	0	2	5	5	12	19
Imperfection Resonances	2	6	40	38	480	767

Resonance Mitigation Techniques

The HSR

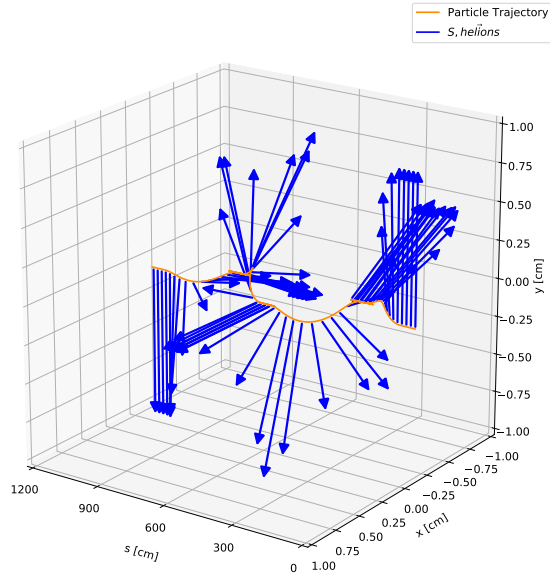
- will have 6 full helical dipoles (snakes) to rotate the spin 180 degrees
- this will mitigate polarization for nearly the full energy range.

The AGS

- will rely on the existing partial snake to avoid all intrinsic and imperfection resonances

The Booster

- will use existing harmonic corrector magnets for correction of imperfection resonances,
- and an AC dipole (installed 2021) for several intrinsic resonances.



Polarized Helions from 2 MeV/u to 183 GeV/u

There is very little margin for beam loss or polarization loss.

- EIC requirements are 0.8×10^{11} helions/bunch at 70% polarization at top energy.
- The expectations from the source (in development) are 2.0×10^{11} helions/pulse at 80% polarization.
- Acceleration from 2 MeV/u up to 183 GeV/u can only afford to lose 40% of the intensity, and 12% of the polarization.

Numerical simulations from 2 MeV/u up to 183 GeV/u are coupled with beam studies in the injectors to determine the optimum configuration.

Thank you

Thank you and questions.