RHIC Accelerator Physics EXperiment (APEX) Program – FY 2024

Verification of RHIC Octupoles Limitations

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January 26, 2024

Proposal: RHIC Octupoles Limitations

Goal

Scan RHIC octupoles to the maximum allowable by power supplies to find the maximum operational octupole current before practical dynamic aperture reduction.

Benefits

The Landau damping offered by octupole magnets is a passive mechanism to mitigate collective effects from impedance and electron cloud and unstable head-tail modes.

Understanding of the RHIC octupoles performance limitations will inform the decisions on proper mitigation mechanisms for collective effects in the EIC HSR.

Results

Report in APEX weekly meeting and the EIC Design Report.

Description

Machine and beam setup

Proton beam in store with about 6 nominal charge bunches

- Landau damping is single-bunch effect → no need for fully populated beam
- DA measurement involves controlled beam loss
- Reduced beam current → reduced beam loss

Beam energies: 24 and 255 GeV

- DA limitations by octupoles are more severe for 24 GeV beam

Several tune pairs, including Qx, Qy = (0.28, 0.21) [BBQ]

- EIC HSR fractional tunes at injection

Method

Scan octupole current to max. available from power supplies while monitoring beam loss [BLM; IPM; DCCT, WCM]

- Octupole designed to operate at 25-33% of their quench limit (198 A), wire layers bench tested to +/-100 A.
- Operating current is +/-50.6 A. Power supplies are bipolar. Sets of octupoles are powered in series. [RHIC Configuration Manual, pp. 58-59; EIC-ADD-TN-077] Current leads might be a limitation. [F. Micolon]

Further studies

Repeat at different radial shifts

- RHIC APEX Radial Shift, POC: G. Robert-Demolaize

Resources

Team	M. Blaskiewicz, V. Ptitsyn, S. Verdu-Andres, MCR crew
Spokesperson(s)	S. Verdu-Andres
Time	4 hours, a second try might be needed
Data analysis	In-situ and offline
Applications	Regular control room applications
Instrumentation	BBQ
	IPM
	BLM
	DCCT, WCM

Detuning coefficient ranges

S. Peggs et al., EIC-ADD-TN-077 (2023): https://www.osti.gov/servlets/purl/2205642

Tune Q varies with particle amplitude a:

$$Q_x(J_x, J_y) = Q_{x0} + \kappa_{xx} J_x + \kappa_{xy} J_y$$
$$Q_y(J_x, J_y) = Q_{y0} + \kappa_{xy} J_x + \kappa_{yy} J_y$$

$x=(2J\beta)^{1/2}\cos(\psi)$

Accel.	Energy & optics	Octupole count	Octupole sums $\sum \beta_x^2$ $10^6\mathrm{m}^2$	$\sum \beta_x \beta_y$ $10^6\mathrm{m}^2$	$\sum \beta_y^2$ $10^6\mathrm{m}^2$	Detuning coefficient ranges κ_{xx} $10^3\mathrm{m}^{-1}$	$-\kappa_{xy}$ $10^3\mathrm{m}^{-1}$	κ_{yy} $10^3\mathrm{m}^{-1}$
RHIC	injection	90	0.106	0.047	0.103	±94.9	±84.2	±92.3
	storage		0.115	0.050	0.108	±9.3	±8.1	±8.8
HSR	injection	137	0.200	0.116	0.321	±179.1	±207.8	±287.5
	storage		0.243	0.148	0.362	±19.7	±24.0	±29.4

Table 3: RHIC and HSR detuning coefficient ranges. The HSR injection and storage optics are hi-n-inj-101723-proton.bmad and hi-n/275-10-collision/hsr.bmad, with the layout git#17e7f5e69c010f93d5be9cf027e71bec2495beed. The RHIC optics are derived from the Au23-100GeV-e0 lattices.

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