

ERL parameters for strong hadron cooling in an Electron-Ion Collider

In September 2018 the National Academy of Sciences reported “*An Assessment of U.S.-Based Electron-Ion Collider Science*” in answer to a commission by the Department of Energy [1]. Page 54 states that: “*To attain the highest luminosities demanded by the science, cooling of the hadron beam is essential. Energy recovery linacs (ERLs), a special type of recirculating linac, presently offer the only credible concept for electron cooling of high-energy, colliding beams.*”

Nominal ERL parameters necessary for strong hadron cooling in eRHIC and JLEIC are listed in Table 1, along with design parameters of contemporary test facilities.

Parameter	Units	eRHIC		JLEIC		CBETA	cERL	ER@	
		MBEC	PCA	ERL	CCR			CEBAF	LERF
		[2]		[3]		[4]	[5]	[6]	[7]
Number of passes		3		1	11	4	1	5	1
Top energy	MeV	149.8		110		150	20	7,000	135
Average current, 1 beam	mA	110		140	1,520	40	100	0.1	8.5
Total current, all beams	mA	660		140	–	320	200	1	17
RMS bunch length	mm	4 – 20	1.2	20		1.0	0.6	0.15	1
RMS energy spread	10 ⁻⁴	1	3	< 3					5
RF frequency	MHz	563		476	–	1300	1300	1497	1497
Bunch frequency	MHz	112.6		43.3	476	41.9	1300	249.5	75
Electron bunch charge	pC	1,000		3,200		123	77	0.2	135
Normalized emittance	μm	1 – 2	4	36		2	>1.3		15

Table 1: Nominal high level parameters of an ERL required for strong hadron cooling in an Electron-Ion Collider, compared with the design parameters of contemporary test facilities.

References

- [1] *An Assessment of U.S.-Based Electron-Ion Collider Science*, National Academy of Sciences report NAS-25171, (2018), <https://www.nap.edu/download/25171#> .
- [2] *eRHIC Pre-Conceptual Design Report*, e.g. Tables 3.57 and 3.60, (2018), unpublished. PCA : Plasma Cascade Amplification. MBEC: Microbunch Electron Cooling.
- [3] S. Benson & C. Tennant, private communication (2018). Total length of the JLEIC top hat is 20 mm. The drift and Larmor emittances are 36 μm and < 19 μm. CCR: Circulating Cooling Ring.
- [4] *CBETA Design Report*, (2017), https://www.classe.cornell.edu/CBETA_PM/notes/CBETA_Design_Report-2017-06-08_large.pdf .
- [5] T. Miyajima, private communication, (2018).
- [6] S.A. Bogacz et al., *ER@CEBAF: A Test of 5-Pass Energy Recovery at CEBAF*, (2016), <http://www.toddsatogata.net/Papers/2016-ErPacProposal.pdf> .
- [7] S. Benson, *An Overview of the Low Energy Recirculation Facility*, (2018), unpublished.