Brookhaven National Laboratory

Epilog: from RHIC to eRHIC

Steve Peggs

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peggs@bnl.gov

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Accelerator physics issues in eRHIC

I. Ben-Zvi, J. Kewisch, J. Murphy, S. Peggs*

Brookhaven National Laboratory, Upton, NY 11973, USA

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In 2000 Peter Paul (Director for Science & Technology) asked for paper discussing an electron-RHIC collider

The 2001 NIM paper that followed named it "eRHIC"

Abstract

The accelerator physics issues associated with adding electron-gold & polarized electron-proton collisions to the RHIC repertoire are discussed.

Two scenarios are considered: “ring-ring” & “linac-ring” …

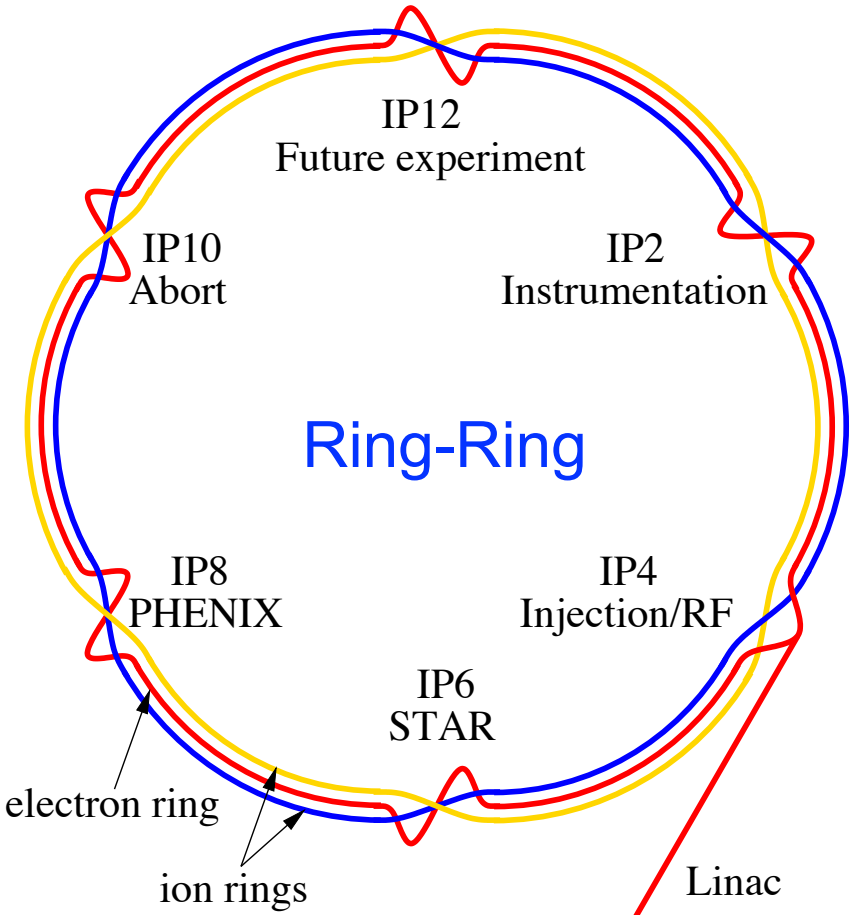
In the first scenario a third electron ring, possibly made from permanent magnets, is added to the RHIC tunnel.

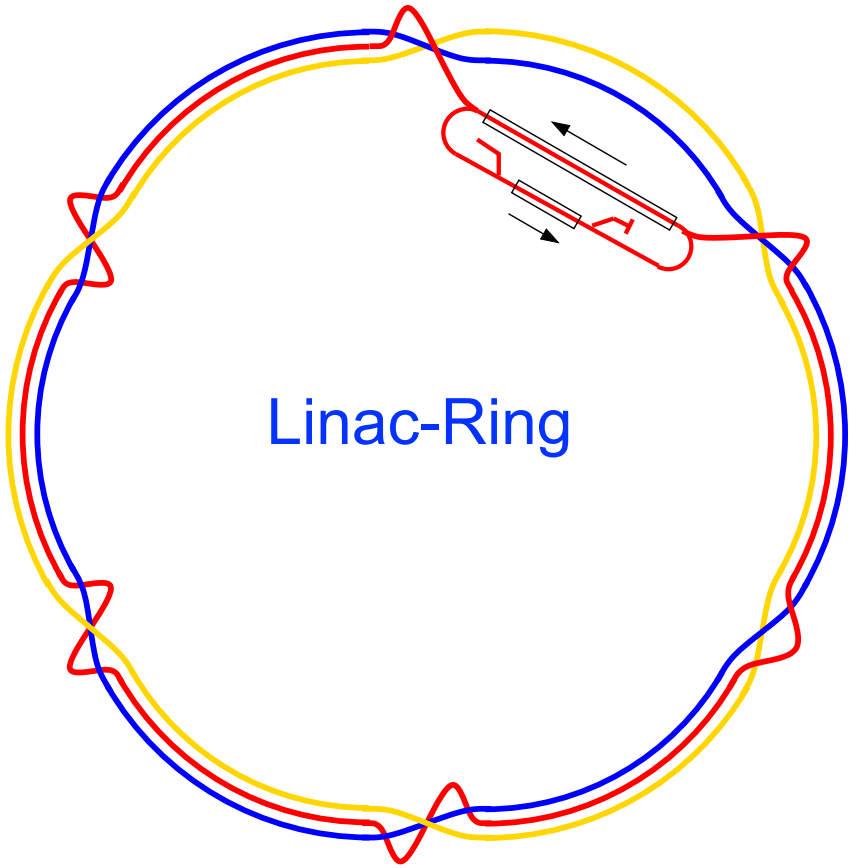
In the second scenario … beam power is recuperated by recycling the beam through the full energy linac injector.

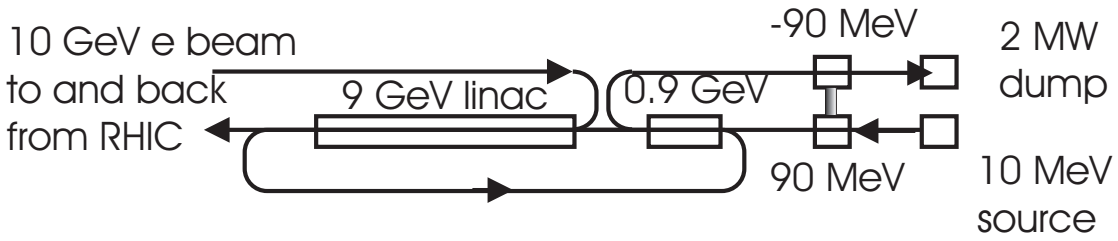
Straw man ring optics are presented, … intensity limitations … with as many as 2520 bunches.

Synchrotron radiation, beam-beam, electron cloud, & cryogenic heat load limits are examined [along with] implications for new & upgraded … systems …

Two scenarios





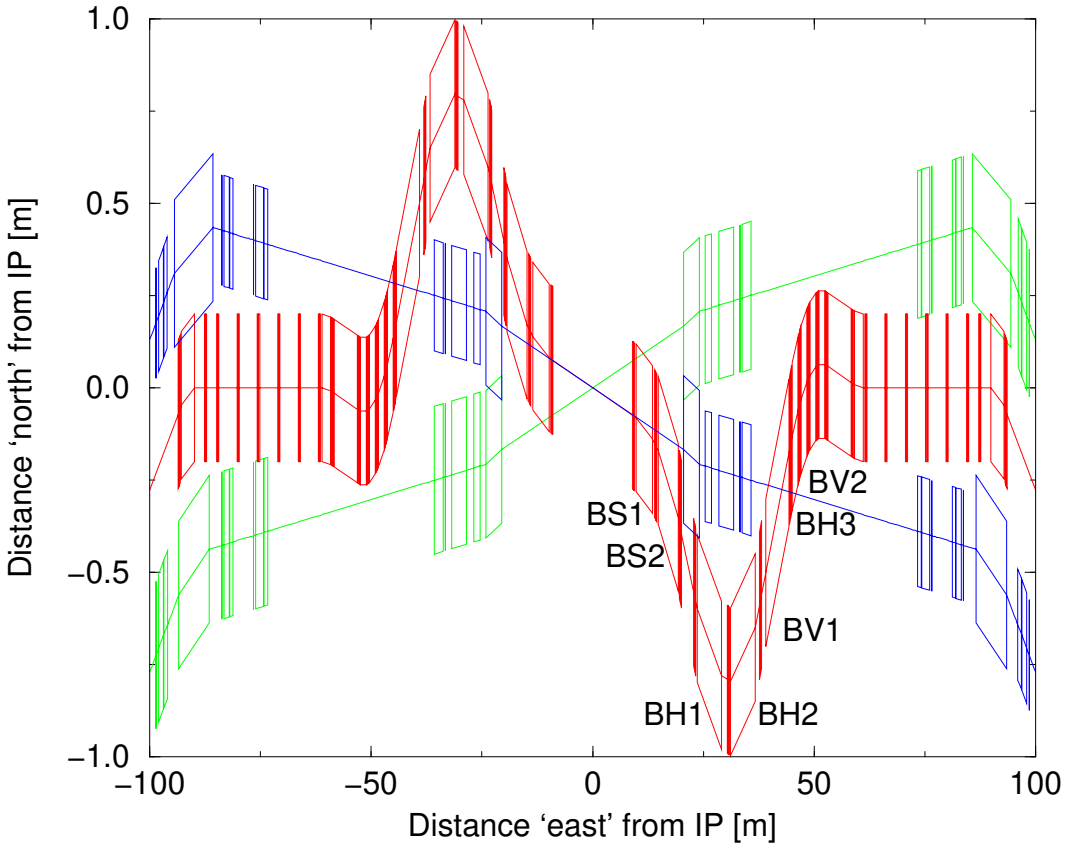


Jorg Kewisch's IR design

… design trajectories still collide head-on in the modified eRHIC straw man interaction region geometry [10].

… a common angle of 8.3 mrad with respect to the center line axis … minimizes the … synchrotron radiation close to the IP).

Beam separation is performed by … the … BS1 magnet [which] deflects the electron beam by 15.0 mrad … shielding the IP from the synchrotron radiation of the stronger BS2 septum magnet.



Compare with SLAC B-factory

"An electron ring in the RHIC tunnel has an energy and a circumference similar to … the [HER] ring in the SLAC or KEK B-factory — it has been tellingly observed that `eRHIC is half a B-factory' [9]."

Ring		SLAC HER	eRHIC
Energy, E_e	(GeV)	9	10
Circumference, C	(m)	2200	3833
Bend radius, ρ	(m)	165	242.8
Energy loss per turn, U_0	(MeV)	3.52	3.64
Emittance, ε_e	(nm)	50	40
Number of bunches, N_b		415/831/1658	360/2520
Bunch spacing, τ	(ns)	16.8/8.4/4.2	35.5/5.1
Compaction factor, α		2.4×10^{-3}	0.61×10^{-3}
RF frequency, f_{rf}	(MHz)	476	394
Harmonic number, h		3492	5040
Bunch length, σ_l	(mm)	11	9
Energy spread, σ_E		6×10^{-4}	5.5×10^{-4}
Beam current, I	(A)	3	3
Total synchrotron power, P	(MW)	10.56	10.92
Linear power load, P_{lin}	(kW/m)	10.2	7.2

Half a B-factory?

"… even with 360 bunches, the RHIC bunch spacing of 35.5 ns is modest by comparison with existing B-factories, and by comparison with the projected parameters of the LHC. …

It is … natural to consider a much larger number of bunches"

No. of bunches, M		360	2520
Electron–gold			
Luminosity, L	(cm^{-2} s^{-1})	6.4×10^{30}	45.0×10^{30}
Electron bunch population, N_e		2.43×10^{11}	2.43×10^{11}
Gold bunch population, N_i		1.19×10^{9}	1.19×10^{9}
Electron beam current, I_e	(A)	1.1	7.7
Electron stored energy, U_e	(kJ)	140	981
Total radiated power, P_{rad}	(MW)	4.0	27.9
Linear power load, P_{lin}	(kW/m)	2.6	18.3
Gold beam current, I_i	(A)	0.42	2.97
Gold stored energy, U_i	(kJ)	1352	9464
Electron–proton			
Luminosity, L	(cm^{-2} s^{-1})	2.1×10^{32}	15.0×10^{32}
Electron bunch population, N_e		1.00×10^{11}	1.00×10^{11}
Proton bunch population, N_i		0.93×10^{11}	0.93×10^{11}
Electron beam current, I_e	(A)	0.45	3.16
Electron stored energy, U_e	(kJ)	58	404
Total radiated power, P_{rad}	(MW)	1.6	11.5
Linear power load, P_{lin}	(kW/m)	1.1	7.5
Proton beam current, I_i	(A)	0.42	2.92
Proton stored energy, U_i	(kJ)	1335	9346

Half a Bee?

[9] M. Python song, “Eric the Half a Bee”

Is this wretched demi-bee,
half asleep upon my knee,
some freak from a menagerie?
No! It's Eric the half a bee.

or

No! It’s [eRHIC] the half a [B-factory]

Contrary to rumor, Monty Python members did NOT study Philosophy at Cambridge University.

Nonetheless this song is inspired by the “Ship of Thesus” problem in Philosophy …

Claude, on the “Ship of Thesus”

If you remove parts of something, at what point does it cease to be the thing it was? A bee missing a wing is still a bee. But half a bee?

Heidegger spent an entire career on asking “what does it mean to be?” What constitutes existence itself?

Aristotle says half a bee is not a bee — it has lost its essential nature.

Buddhism questions the entire premise entirely — the whole bee was never a fixed, essential thing to begin with.

Philosophers of biology today lean on functional organization. No — half a bee is not a bee.

This is NOT why eRHIC was renamed EIC.

Epilog

RHIC is dead

Long live RHIC

All hail EIC !