

Epilog: from RHIC to eRHIC

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Accelerator physics issues in eRHIC

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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”



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” ...

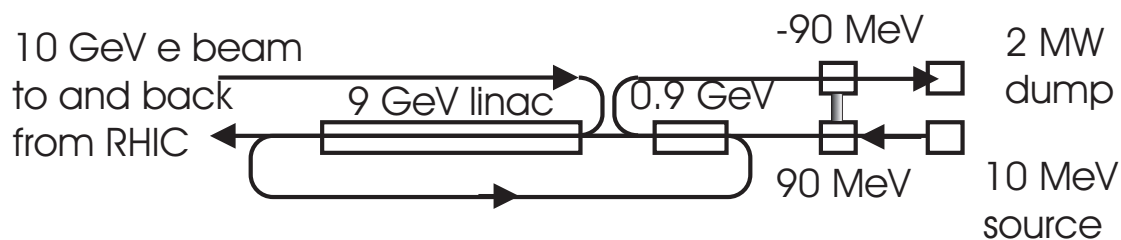
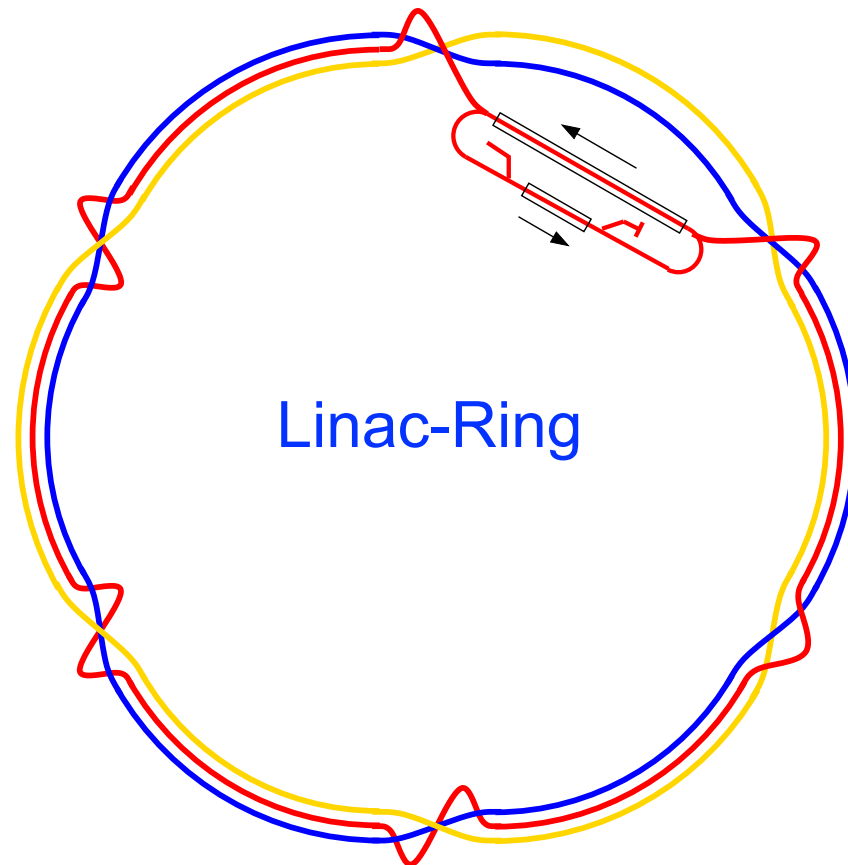
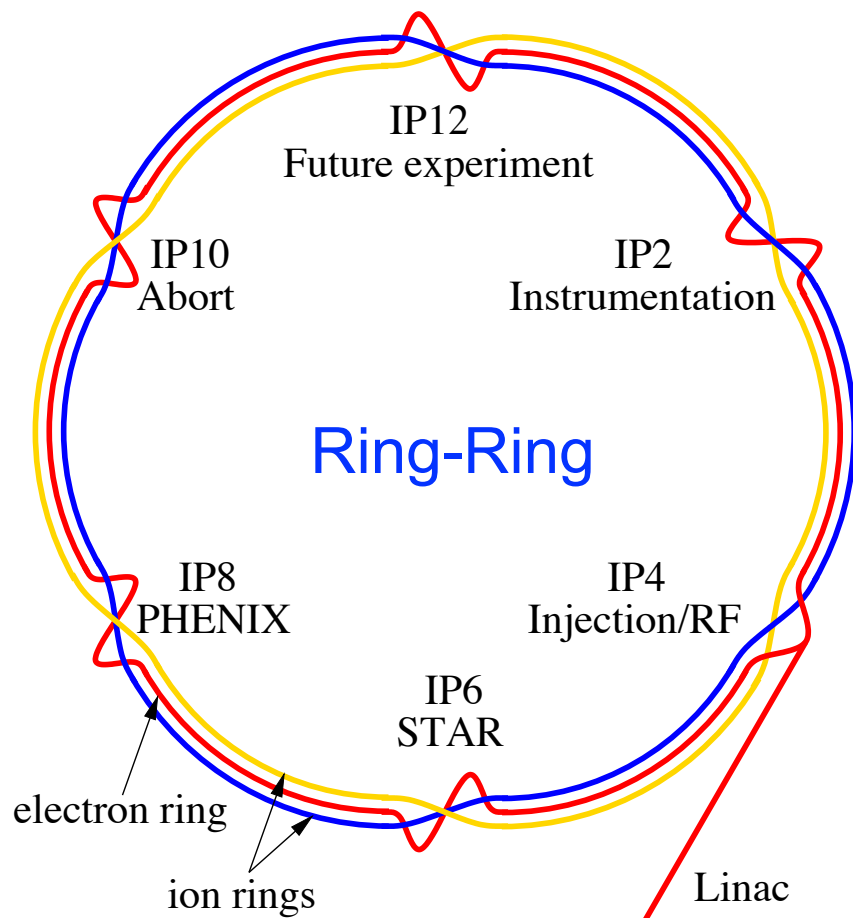
In the first scenario a third electron ring, possibly made from permanent magnets, is added to the RHIC tunnel.

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 ... new & upgraded ... systems ...

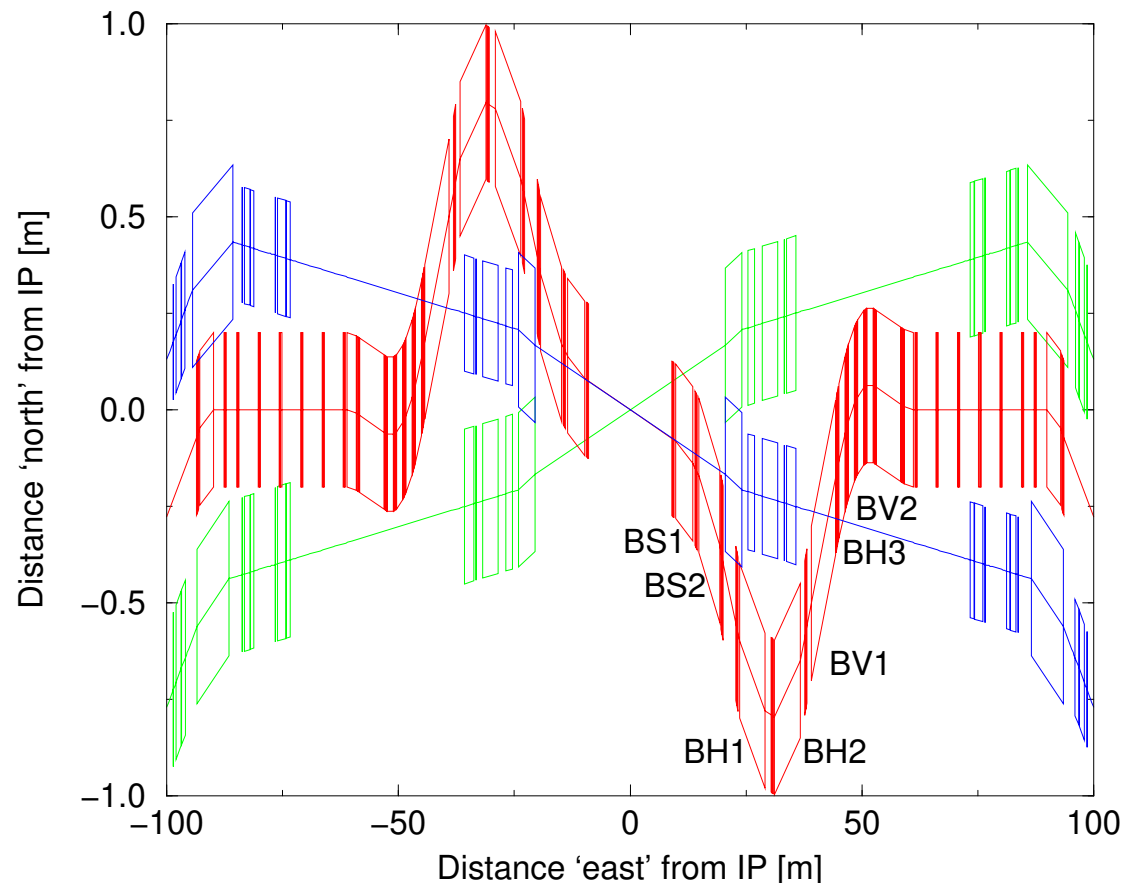
Two scenarios



... 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 ... by ... the ... BS1 magnet 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_0	(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?



“... the RHIC bunch spacing of 35.5 ns is modest by comparison with ... B-factories, and ... the LHC. ...

It is ... natural to consider a much larger number of bunches”

No. of bunches, M		360	2520
<i>Electron-gold</i>			
Luminosity, L	($\text{cm}^{-2} \text{ s}^{-1}$)	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
<i>Electron-proton</i>			
Luminosity, L	($\text{cm}^{-2} \text{ s}^{-1}$)	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



[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 ...

The “Ship of Thesus”



If you remove parts of something, when 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.



RHIC is dead
Long live RHIC
All hail EIC !