

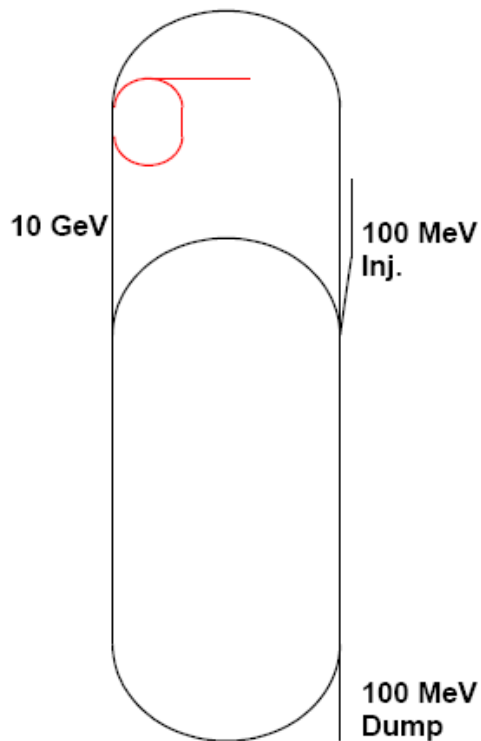
Polarized Low Energy Electron-Ion Collider

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ERL-Ring Collider

(Hyde, Krafft, Weiss)

Machine concept



- CEBAF 10 GeV linac w. energy recirculation
2-3 GeV proton/ion storage ring w. current ~ 1 A
 - Could fit into large hall, upgrade possible
- Baseline luminosity $\sim 10^{32} \text{cm}^{-2} \text{s}^{-1}$
Upgrade (shorter β^*) $\sim 10^{33}$

Parameter	Unit	electron	proton
Beam Momentum	(GeV/c)	10	2.4
Beam Current	(A)	0.008	1.0
Geom. Emittance (x/y)	(nm)	5/1	10/10
β_x^*/β_y^*	(mm)	20/100	10/10
$\sigma_x \otimes \sigma_y$	(μm)	$10 \otimes 10$	$10 \otimes 10$
Luminosity	($\text{cm}^{-2} \text{s}^{-1}$)	10^{32}	

Ring-Ring Low Energy EIC

Design features

- A generic high polarization ring-ring design
- High luminosity, up to $3 \cdot 10^{33} \text{ s}^{-1} \text{ cm}^{-2}$
- Can be basically low energy part of high energy ELIC design
(0.2 – 0.4 GeV SRF Linac, 3 GeV proton ring, 2 MeV e-cooler)
- COSY components may be used in ion complex
(50 MeV Linac, 0.3 GeV cyclotron, 3.7 GeV synchrotron)

Required upgrade or new systems

- New RF system for ions
- 50~300 MeV SRF ion linac
- 2 MeV electron cooler
- Electron storage ring

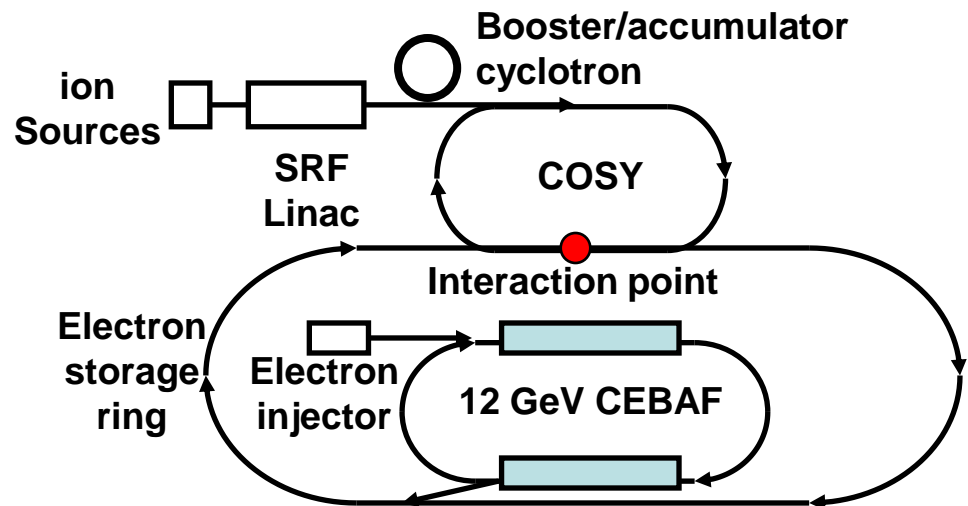
(Derbenev, Krafft, Zhang)

Interaction region design

- Crab crossing colliding beams
- Traveling focusing

Major R&Ds

- Forming high intensity ion bunches and space charge effects
- Electron cooling
- Traveling focusing for ion beams



PELICAN



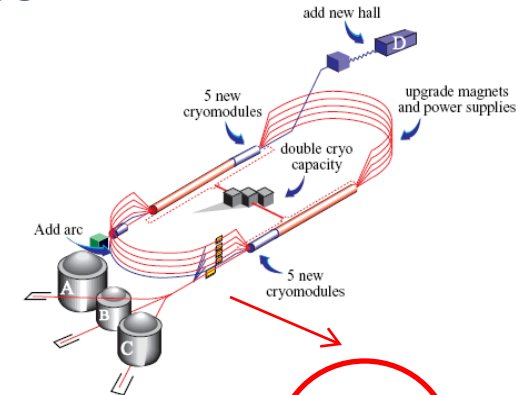
Symmetric e-p collisions over full range of CEBAF energies

(Bogacz, Horn, Klein, Nadel-Turonski)

- optimal resolution, particle identification, and acceptance
- s up to 300 GeV² (9 on 9) or 600 GeV² (12 on 12)
- luminosities approaching 10³⁴ s⁻¹cm⁻² with 9 GeV/c ions

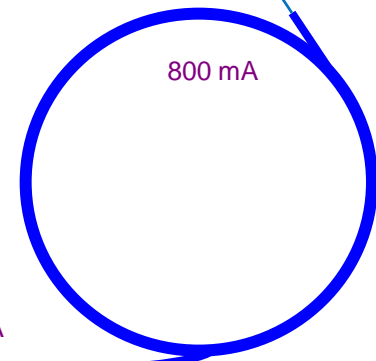
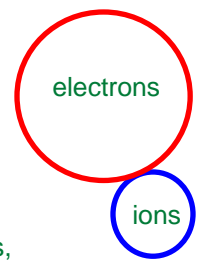
Project X-like strategy

- build a state-of-the-art **ion injector** (\$100 M) that
 - can be used by (shared with) ELIC
 - will do all accumulation, cooling, bunching, and acceleration
 - simplifies and reduces cost of ion storage ring
 - provides very good emittance and beam current
 - can itself be staged
- injector **linac** can also be used for
 - applications
 - creation of hadronic beams
 - fixed target experiments



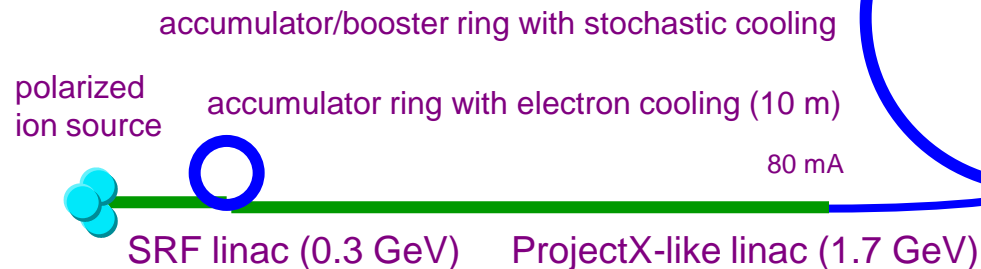
Storage rings:
geometry compatible
with previous option.

CEBAF, storage rings,
and ion injector are not
to scale!



*Compatible with all
ELIC staging options*

TN-08-070
<http://tnweb.jlab.org/tn/2008/08-070.pdf>



Beam Parameters

		ERL-Ring	Ring-Ring	MANUEL
Beam Energy	GeV	10/2.4	4/4	3/15
Circumference	m	150/300	300/300	580/580
Beam Current	A	0.008/1	3.6/0.61	2/0.25
Repetition Rate	GHz	0.25	1.5	0.052
Particles per Bunch	10^{10}	0.02/2.5	1.5/0.254	3/0.3
Bunch Length	cm		0.25/5	10/10
Normalized Emittance	mm mrad		23.5/0.37	2/2
β^*	cm	2/1	5/0.25	10/10
Beam Size at IP	μm	10/10	12.3/12.3	110/110
Beam-Beam Tune Shift		NA/small	0.024/0.007	0.01/0.015
Laslett Tune Shift		NA/small	0.001/0.15	?/0.083
Luminosity	$10^{32} \text{ s}^{-1}\text{cm}^{-2}$	1	30	2

Electron parameters are red;

Ring-Ring parameters common to both ring-ring designs

Additional Hardware

- Electron Complex
 - Recirculation ARCs and line to dump (ERL-RING)
 - Electron Storage Ring (Ring-Ring Designs)
- Ion Complex
 - Ion Source
 - Collider Ring (not need if housed in a Hall, <2.4 GeV/c)
 - New Tunnels
 - 50~300 MeV SRF Linac, booster, cyclotron, 2 MeV e-cooler (CEBAF-COSY, ERL-Ring)
 - Two accumulator rings and 2 GeV SRF Accelerator (PELICAN)

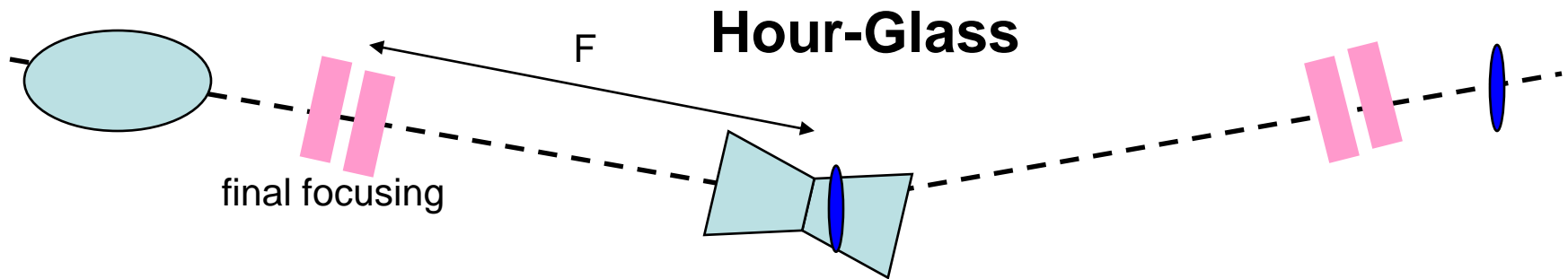
Conclusions

- Highly interesting low energy ion colliders may be designed with luminosities above $10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$
- In principle, luminosity will increase if the proton energy increases, but there are other issues which may also affect the final achievable value of the luminosity
- All of the ideas will require a new ion complex for Jefferson Lab.
- Parts of the COSY ring can be reused no matter which approach is taken

Backup Slides

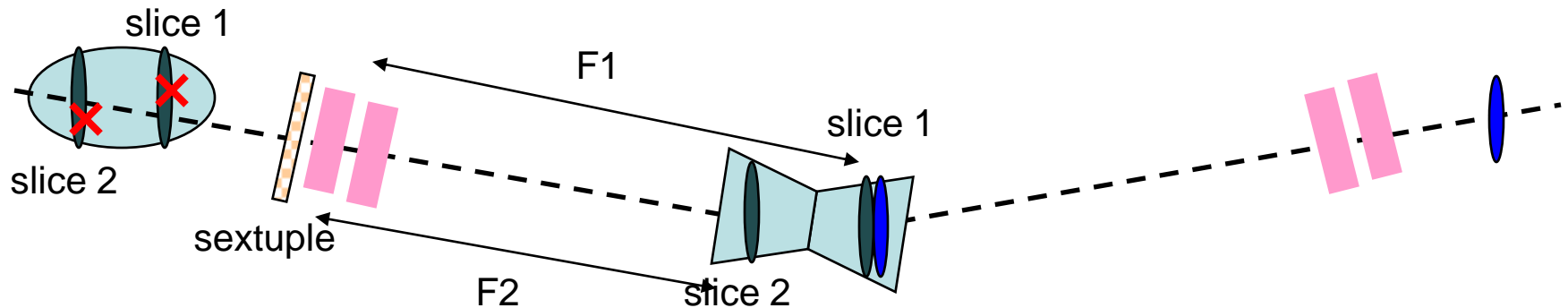
Backup slides

Traveling Focusing Scheme



Linear final focusing block produce uniform focus length for every slices

Ya. Derbenev, Proc. EPAC 2002



Nonlinear sextupole working with linear final focusing block produce non-uniform focus length for different slices of a long bunch