Outline

- Introduction
- An EIC@JLab: $100<s<2600$ with high luminosity
- An EIC@JLab at High Energy: Design Update & Staging
- More details on EIC@JLab Design
- EIC@JLab R&D
- Summary
Great Opportunities Ahead of Us

• 12 GeV CEBAF Upgrade
  ➢ CD3 for upgrade approved,
  ➢ Construction already started
  ➢ Exciting fixed target program beyond 2020

• What CEBAF will provide
  ➢ Up to 12 GeV CW electron beam
  ➢ High repetition rate (3x499 MHz)
  ➢ High polarization (>80%)
  ➢ Very good beam quality
  ➢ World first multi-pass recirculated SRF linac above GeV energy

Opportunity: **Electron-Ion Collider** on CEBAF
  ➢ Add a *modern* ion complex with a *Green Field* design
  ➢ Expand science program beyond 12 GeV CEBAF fixed target physics
  ➢ Open up new science domain with higher CM energy
Science Motivation and Detector Requirements

• Key issues in nucleon structure & nuclear physics
  ➢ Sea quark and gluon imaging of nucleon with GPDs ($x \gtrsim 0.01$)
  ➢ Orbital angular momentum, transverse spin, and TMDs
  ➢ QCD vacuum in hadron structure and fragmentation
  ➢ Nuclei in QCD: Binding from EMC effect, quark/gluon radii from coherent processes, transparency

• Machine/detector requirements
  ➢ High luminosity $> 10^{34}$: Low rates, differential measurements
  ➢ CM energy: $s \sim 1000 \text{ GeV}^2$: Reach in $Q^2, x$
  ➢ Detactability: Angular coverage, particle ID, energy resolution
  
  ➦ favors lower, more symmetric energies!
ELIC Design Goals

- **Energy**
  - Wide CM energy range between 10 GeV and 100 GeV
  - Low energy: 3 to 10 GeV e on 3 to 12 GeV/c p (and ion)
  - Medium energy: up to 11 GeV e on 60 GeV p or 30 GeV/n ion
  - High energy: up to 10 GeV e on 250 GeV p or 100 GeV/n ion

- **Luminosity**
  - $10^{33}$ up to $10^{35}$ cm$^{-2}$ s$^{-1}$ per interaction point
  - Multiple interaction points

- **Ion Species**
  - Polarized H, D, $^3$He, possibly Li
  - Up to heavy ion A = 208, all striped

- **Polarization**
  - Longitudinal at the IP for both beams, transverse of ions
  - Spin-flip of both beams
  - All polarizations $>70\%$ desirable

- **Positron Beam** desirable
Design Challenges & Opportunities

Design an Electron-Ion Collider that

- Covers a wide CM energy range (10 to 100 GeV) in a unified & coherent way for highest science productivity
  - Medium energy EIC is our immediate goal so it should be given first priority for maximum design optimization
  - High energy EIC is a future goal so it should be left with greatest flexibility and upgrade potential
- Deliver best collider quality in terms of high luminosity, high polarization, multiple interaction points, maximum flexibility and reliability
- Takes maximum advantages of existing CEBAF
- Offers a good path for staging and future upgrade
- Requires minimum R&D and realizes in a most cost effective way

- Ion complex is a green field design so we have freedom to be innovative
- We can take benefit of knowledge learnt in the last several decades and incorporate many proofed great ideas/schemes in the design
- We have an opportunity to design a brand new class of hadron collider just as we had done in CEBAF near twenty years ago.
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EIC@JLab at Low to Medium Energy

Three compact rings:
- 3 to 11 GeV electron
- Up to 12 GeV/c proton (worm)
- Up to 60 GeV/c proton (cold)
EIC@JLAB at Low to Medium Energy
ELIC Figure-8 Collider Ring Footprint

- Ring design is optimized with
  - Synchrotron radiation power of e-beam
    → prefers large ring (arc) length
  - Space charge effect of i-beam
    → prefers small ring circumference

- Multi IPs require long straight sections
- Straight sections also hold required components (e-cooling, injection and ejections, etc.)
## EIC@JLab Parameters at Low-to-Medium Energy Beam Energy

<table>
<thead>
<tr>
<th></th>
<th>GeV</th>
<th>60/5</th>
<th>60/3</th>
<th>12/3</th>
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<tbody>
<tr>
<td>Collision freq.</td>
<td>MHz</td>
<td>499</td>
<td></td>
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<tr>
<td>Particles/bunch</td>
<td>$10^{10}$</td>
<td>0.74/2.9</td>
<td>1.1/6</td>
<td>0.47/2.3</td>
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<tr>
<td>Beam current</td>
<td>A</td>
<td>0.59/2.3</td>
<td>0.86/4.8</td>
<td>0.37/2.7</td>
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<tr>
<td>Energy spread</td>
<td>$10^{-4}$</td>
<td>~ 3</td>
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<tr>
<td>RMS bunch length</td>
<td>mm</td>
<td>5</td>
<td>5</td>
<td>50</td>
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<tr>
<td>Horz. emit., norm.</td>
<td>μm</td>
<td>0.56/85</td>
<td>0.8/75</td>
<td>0.18/80</td>
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<tr>
<td>Vert. emit. Norm.</td>
<td>μm</td>
<td>0.11/17</td>
<td>0.8/75</td>
<td>0.18/80</td>
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<tr>
<td>Horizontal beta-star</td>
<td>mm</td>
<td>25</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Vertical beta-star</td>
<td>mm</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vert. beam-beam tune shift / IP</td>
<td></td>
<td>0.01/0.03</td>
<td>0.015/0.08</td>
<td>0.015/0.013</td>
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<tr>
<td>Laslett tune shift (p-beam)</td>
<td></td>
<td>0.1</td>
<td>0.054</td>
<td>0.1</td>
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<tr>
<td>Peak Luminosity/IP, $10^{34}$</td>
<td>cm$^{-2}$s$^{-1}$</td>
<td>1.9</td>
<td>4.0</td>
<td>0.59</td>
</tr>
</tbody>
</table>
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ELIC at High Energy & Staging

<table>
<thead>
<tr>
<th>Stage</th>
<th>Max. Energy (GeV/c)</th>
<th>Ring Size (M)</th>
<th>Ring Type</th>
<th>IP #</th>
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<tbody>
<tr>
<td>1</td>
<td>Low</td>
<td>12 5 (11)</td>
<td>Warm</td>
<td>5 (11)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>630 630</td>
<td>Warm</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Medium</td>
<td>60 5 (11)</td>
<td>Cold</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>600 600</td>
<td>Warm</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
<td>250 10</td>
<td>Cold</td>
<td>1800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1800 1800</td>
<td>Warm</td>
<td>4</td>
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<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Large</th>
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<tr>
<td>Circumference</td>
<td>m</td>
<td>1800</td>
</tr>
<tr>
<td>Radius</td>
<td>m</td>
<td>140</td>
</tr>
<tr>
<td>Width</td>
<td>m</td>
<td>280</td>
</tr>
<tr>
<td>Length</td>
<td>m</td>
<td>695</td>
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<tr>
<td>Straight</td>
<td>m</td>
<td>306</td>
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## EIC@JLab Parameters: High Energy

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
<th>Value</th>
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<tbody>
<tr>
<td>Beam Energy</td>
<td>GeV</td>
<td>250/10</td>
<td>150/7</td>
</tr>
<tr>
<td>Collision freq.</td>
<td>MHz</td>
<td>499</td>
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</tr>
<tr>
<td>Particles/bunch</td>
<td></td>
<td>1.1/3.1</td>
<td>0.5/3.25</td>
</tr>
<tr>
<td>Beam current</td>
<td>A</td>
<td>0.91/2.5</td>
<td>0.4/2.6</td>
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<tr>
<td>Energy spread</td>
<td></td>
<td>10⁻⁴</td>
<td>3</td>
</tr>
<tr>
<td>RMS bunch length</td>
<td>mm</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Horz. beta-star</td>
<td>mm</td>
<td>125</td>
<td>75</td>
</tr>
<tr>
<td>Vert. beta-star</td>
<td>mm</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Horz. emit., norm.</td>
<td>μm</td>
<td>0.7/51</td>
<td>0.5/43</td>
</tr>
<tr>
<td>Vert. emit. Norm.</td>
<td>μm</td>
<td>0.03/2</td>
<td>0.03/2.87</td>
</tr>
<tr>
<td>B-B tune shift per IP</td>
<td></td>
<td>0.01/0.1</td>
<td>0.015/0.05</td>
</tr>
<tr>
<td>Laslett tune shift (p-beam)</td>
<td></td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Lumi. per IP, 10⁻³⁴</td>
<td>cm⁻²s⁻¹</td>
<td>11</td>
<td>4.1</td>
</tr>
</tbody>
</table>

**Major design change: symmetric IR ➔ asymmetric IR**
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ELIC Baseline Design Choice

- Energy Recovery Linac-Storage-Ring (ERL-R)
- ERL with Circulator Ring – Storage Ring (CR-R)
- Back to Ring-Ring (R-R) by taking CEBAF advantage as full energy polarized injector

Reason of design change:
High current polarized electron/positron source R&D too challenging
- ERL-Ring: 2.5 A
- Circulator ring: 20 mA
- State-of-art: 0.1 mA

→ Note we don’t have to have ERL in order to delivering high luminosity
→ Key for high luminosity is high repetition, small beta* & short bunch

- 12 GeV CEBAF Upgrade polarized source/injector already meets beam requirement of ring-ring design
- CEBAF-based R-R design still preserves high luminosity, high polarization (+polarized positrons…)
Achieving High Luminosity

ELIC design luminosity

\[ L \approx 4 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1} \] for medium energy (60 GeV x 3 GeV)

\[ L \approx 1 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1} \] for high energy (250 GeV x 10 GeV)

ELIC luminosity Concepts

- High bunch collision frequency (0.5 GHz, can be up to 1.5 GHz)
- Short ion bunches \((\sigma_z \approx 5 \text{ mm})\) \((\text{also much smaller bunch charge})\)
- Relative long bunch (comparing to \(\beta^*\)) for very low ion energy
- Strong final focusing \((\beta_y^* \approx 5 \text{ mm})\)
- Large beam-beam parameters \((\sim 0.01/0.1 \text{ per IP, } 0.025/0.1 \text{ largest achieved})\)
- Need electron cooling of ion beams
- Need crab crossing colliding beams
- Large synchrotron tunes to suppress synchrotron-betatron resonances
- Equal (fractional) betatron phase advance between IPs
ELIC Ring-Ring Design Features

- Unprecedented high luminosity
- Electron cooling is an essential part of ELIC
- Up to four IPs (detectors) for high science productivity
- “Figure-8” ion and lepton storage rings
  - Ensure spin preservation and ease of spin manipulation
  - No spin sensitivity to energy for all species.
- Present CEBAF injector meets storage-ring requirements
- 12 GeV CEBAF can serve as a full energy injector to electron ring
- *Simultaneous* operation of collider & CEBAF fixed target program.
- Experiments with polarized positron beam are possible.
Figure-8 Straight Sections & Interaction Regions

Minimizing crossing angle reduces crab cavity challenges & required R&D

Interaction Region

Optional 2\textsuperscript{nd} detector
Interaction Regions and Detectors

- 8 meters (for scale)
- Offset IP
- 140 degrees
- ID ~ length solenoid
- Add'l dipole field needed on ion side!

<table>
<thead>
<tr>
<th>IP</th>
<th>Energy</th>
<th>Type</th>
<th>Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medium</td>
<td>General purpose</td>
<td>9+9 m</td>
</tr>
<tr>
<td>2</td>
<td>Medium</td>
<td>Diffraction/low $Q^2$</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Low</td>
<td>DVCS-type</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>(polarimetry)</td>
<td></td>
</tr>
</tbody>
</table>

Ent’s talk on ELIC detector design in this Workshop

Magnetic Field in cold yoke around electron pass.

Leant from LHeC

Electron FF quads

Proton 1st SC FF quad for ion

(P. Brindza, ME)

8 meters (for scale)

ID ~ length solenoid

No need for add’l dipole! $\theta > 10^\circ$

$Q > 10^o$ $\rightarrow$ ID ~ length solenoid
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EIC@JLab Accelerator R&D

We have identified the following critical R&D for ELIC

- Electron cooling
- Crab crossing and crab cavity
- Forming high intensity low energy ion beam
- Beam-beam effect
- Traveling focusing for very low energy ion beam

Will discuss issues/requirements/state-of-art/challenges/activities

<table>
<thead>
<tr>
<th>Level of R&amp;D</th>
<th>Low-to-Medium Energy (12x3 GeV/c) &amp; (60x5 GeV/c)</th>
<th>High Energy (up to 250x10 GeV)</th>
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<tr>
<td>Challenging</td>
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<td>Electron cooling</td>
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<tr>
<td>Semi Challenging</td>
<td>Electron cooling</td>
<td>Crab crossing/crab cavity</td>
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<td></td>
<td>Traveling focusing (for very low i energy)</td>
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</tr>
<tr>
<td>Likely</td>
<td>Crab crossing/crab cavity</td>
<td>High intensity low energy i beam</td>
</tr>
<tr>
<td></td>
<td>High intensity low energy i beam</td>
<td>Beam-beam</td>
</tr>
<tr>
<td></td>
<td>Beam-beam</td>
<td></td>
</tr>
<tr>
<td>Know-how</td>
<td>Spin tracking</td>
<td>Spin tracking</td>
</tr>
<tr>
<td></td>
<td>IP design/chromaticity</td>
<td>IP design/chromaticity</td>
</tr>
</tbody>
</table>
Electron Cooling: ERL Circulator Cooler

**Issues**
- Essential for delivering ion bunches with small emittances and short length.
- Cooling electron energy
  - up to 6.5 MeV for low energy ELIC
  - up to 33 MeV for medium energy ELIC
  - up to 136 MeV for high energy
- Up to 3 A CW un-polarized beam (~nC bunch charge)

**ERL Based Circulator Cooler**
- SRF ERL able to provide high average current CW beam with minimum RF power
- Circulator ring for reducing average current from source/ERL

**ERL Key technologies**
- High intensity un-polarized electron source/injector
- Energy Recovery Linac (ERL)
- Fast kicker

**Beam Dynamics R&D (staged cooling)**
EC Enabling Technologies

High intensity e source/injector
- 30 mA, up to 136 MeV, 1 nC bunch charge
- Cathode lifetime is ok with circulator ring
- Conceptual design adopts light source (FEL) photo-injector
- Beam qualities should be OK

Fast kicker
- RF deflecting cavity
- High power ultra-short pulse (sub-ns, 20kW)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
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<tbody>
<tr>
<td>Beam energy</td>
<td>MeV</td>
<td>125</td>
</tr>
<tr>
<td>Kick angle</td>
<td></td>
<td>10^{-4}</td>
</tr>
<tr>
<td>Integrated BdL</td>
<td>GM</td>
<td>1.25</td>
</tr>
<tr>
<td>Frequency BW</td>
<td>GHz</td>
<td>2</td>
</tr>
<tr>
<td>Kicker Aperture</td>
<td>Cm</td>
<td>2</td>
</tr>
<tr>
<td>Peak kicker field</td>
<td>G</td>
<td>3</td>
</tr>
<tr>
<td>Kicker Repetition Rate</td>
<td>MHz</td>
<td>15</td>
</tr>
<tr>
<td>Peak power/cell</td>
<td>KW</td>
<td>10</td>
</tr>
<tr>
<td>Average power/cell</td>
<td>W</td>
<td>15</td>
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<tr>
<td>Number of cells</td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

**JLab FEL Gun R&D**

(J. Musson JLab, EE)
EC Enabling Technology: ERL

JLab FEL Program

- ERL based FEL
- High average power up to 14 kW (world record)
- Mid-infrared region, extension to UV is planned
- Photocathode DC injector, 10 mA class CW beam, sub-nC bunch charge
- Beam energy up to 200 MeV, energy recovery
- Next step/proposal: 100kW average power, 100 mA CW beam with ERL, nC-class bunch charge

<table>
<thead>
<tr>
<th>Energy</th>
<th>MeV</th>
<th>80-200</th>
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<tbody>
<tr>
<td>Charge/bunch</td>
<td>pC</td>
<td>135</td>
</tr>
<tr>
<td>Average current</td>
<td>mA</td>
<td>10</td>
</tr>
<tr>
<td>Peak current</td>
<td>A</td>
<td>270</td>
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<tr>
<td>Beam power</td>
<td>MW</td>
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<td>Energy spread</td>
<td>%</td>
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<tr>
<td>Normalized emittance</td>
<td>µm-rad</td>
<td>&lt;30</td>
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</table>

JLab is world leader in ERL technology!

We are considering using this facility to test ERL based circulator cooler ring and for beam dynamics studies.
**Crab Crossing & Crab Cavity**

**Issues**

- High bunch repetition requires crab crossing colliding beams to avoid parasitic beam-beam
- Crab cavities are needed to restore head-on collision and avoid luminosity reduction
- ELIC crossing angle: ~ 2\(\times\)12 mrad (9+9 m IR)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Beam Energy (GeV/c)</th>
<th>Integrated Kicking Voltage (MV)</th>
<th>R&amp;D</th>
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<tr>
<td>electron</td>
<td>10</td>
<td>~ 1</td>
<td>State-of-art</td>
</tr>
<tr>
<td>Proton</td>
<td>12</td>
<td>~ 1</td>
<td>State-of-art</td>
</tr>
<tr>
<td>Proton</td>
<td>60</td>
<td>5</td>
<td>Not too far away</td>
</tr>
<tr>
<td>Proton</td>
<td>250</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

- Crab cavity development & gradient limits
- Phase & amplitude stability requirements
- Beam dynamics/luminosity dependence of crab crossing

**State-of-art:**

KEKB Squashed cell@TM110 Mode
Crossing angle = 2 \(\times\) 11 mrad
\(V_{kick}=1.4 \text{ MV}, \ E_{sp}= 21 \text{ MV/m}\)
New (Innovative) Program

- Compact TEM-type, parallel-bar
- Deflecting $\Rightarrow$ 12 GeV CEBAF
- Crabbing $\Rightarrow$ ELIC
- Providing high transverse kinking

Single cell: 37x50cm, 4 MV@500MHz
Multi-cell: $\sim n \times (37 \text{ cm}), n \times (4 \text{ MV})$
Great News From KEK

KEK Press Release (05/11/09)
“Using Crab Cavities, KEKB Breaks Luminosity World Record”

Symmetry Breaking (05/11/09)
“Record luminosity collisions due to “crab” crossing,

Trick: 28 skew sextupoles
Forming High Intensity Ion Beam

Stacking/accumulation process
- Multi-turn (~20) pulse injection from SRF linac into an accumulator-cooler ring
- Damping/cooling of injected beam
- Accumulation of 1 A coated beam at space charge limited emittance
- Fill prebooster/large booster, then acceleration
- Switch to collider ring for energy booster, RF bunching and initial/continuous cooling

In addition to simulation study, we are considering team up with ORNL to study space charge effect at SNS
Beam-Beam Interactions

Simulation Model
• Single/multiple IP, head-on collisions
• Ideal rings for e & p, a linear one-turn map
• Radiation damping & quantum excitations

Simulation Code
• BeamBeam3D by LBNL

Simulation Scope & Limitations
• 10k ~ 30k turns for a typical simulation run (multi-days of NERSC supercomputer)
• 0.15 s of storing time (12 damping times)
• reveals short-time dynamics with accuracy
• can’t predict long term (>min) dynamics

Low-to-medium energy b-b problem
• Non-relativistic, space charge dominated
• Ring transport can’t be treated as a one-turn map, coupling everywhere
• Long ion bunch (up to 20 x β*), longitudinal dynamics important
• Traveling focusing scheme introduces non-linear optics

70% of peak luminosity
Coherent instability

Simulation Model
Simulation Scope & Limitations
Low-to-medium energy b-b problem

Simulation Code
Simulation Scope & Limitations
Boosting luminosity at low ion energy: Traveling Final Focusing/Crab Waist

Traveling Final Focusing
- Laslett tune-shift limits bunch charge for very low energy ions (space charge dominated)
- Long bunch length enables more bunch charges, therefore high luminosity
- Hour glass effect could kill luminosity if bunch length is much larger than beta-star
- “Traveling Focusing” (Brinkmann/Dohlus), can mitigate hour-glass effect
- New realization: crab crossing beam with sextuples

Crab Waist
- Proposed by P. Raimondi for Super-B factory for luminosity enhancement
- It deals with large Piwinski angle and low vertical beat-star
- Current Super-B design calls 0.2 mm beta-star while bunch length is 6 mm
- Recent proof-of-principle experiment done at DAΦNE very positive

Crabbed waist can be realized with a sextupole in with IP in x and at $\pi/2$ in y.
Summary

- EIC@JLab promises to accelerate and store a wide variety of polarized light ions and un-polarized heavy ions to collider with polarized electron or positron beam enabling a unique physics program.

- The ELIC covers a wide CM energy range (10 to 100 GeV) in a coherent way. However, the low-to-medium energy one (CM energy 10 to 50 GeV) is our immediate goal & R&D focus.

- EIC@JLab luminosity for e-p collisions should exceed $1 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ at high energy end ($250 \times 10 \text{ GeV}^2$), reach $4 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ at medium energy ($60 \times 3 \sim 5 \text{ GeV}^2$), and $6 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$ at low energy end ($12 \times 3 \text{ GeV}^2$)

- Positron beam can also be used for additional positron-ion and electron-positron collision programs. Both electron & positron beam possess high (>80%) polarization.

- We have identified the critical R&D topics for EIC@JLab. In general, R&D for the medium energy EIC is much easy than for high energy one, which also provides a nice staging approach for accelerator R&D. We are aggressively pushing R&D programs to validity and optimize ELIC design

**ELIC is the primary future of JLab!**
ELIC Study Group

W. Fischer, C. Montag - Brookhaven National Laboratory
D. Barber - DESY
V. Danilov - Oak Ridge National Laboratory
V. Dudnikov - Brookhaven Technology Group
P. Ostroumov - Argonne National Laboratory
V. Derenchuk - Indiana University Cyclotron Facility
A. Belov - Institute of Nuclear Research, Moscow, Russia
V. Shemelin - Cornell University
Backup Slides
ELIC Conceptual Design

Green-field design of ion complex directly aimed at full exploitation of science program.

30-250 GeV protons
15-100 GeV/n ions

Electron Cooling

Accumulator -cooler ring & prebooster

Snake

3-10 GeV electrons
3-10 GeV positrons

12 GeV CEBAF Upgrade
Electron Polarization

Producing/matching
- Polarized electron source of CEBAF
- Preserved in recirculated CEBAF
- Injected into Figure-8 ring with vertical polarization
- Turn to longitudinal polarization at IP using vertical crossing bends and solenoid spin rotators

Maintaining in the ring
- electron self-polarization
- SC solenoids at IRs removes spin resonances & energy sensitivity.
Positrons in CEBAF/ELIC

International Workshop on Positrons at Jefferson Lab
March 25-27, 2009

- Non-polarized positron bunches generated from modified electron injector through a converter
- Polarization realized through self-polarization at ring arcs

“CEPBAF”, S. Golge (Ph. D thesis) / A. Freyberger
Polarized Positron Source, J. Dumas (Ph.D thesis) / J. Grames
Joint JLab/Idaho Univ. Position Program

Proof of Principle Experiment: extendible to higher energy (& yield)

CEBAF Electron Source
- High-P (~85%), High-QE (~3mA/500 mW)
- e- bunch: 3mA @ 1497 MHz demonstrated
- Thesis: duty factor => low power, high peak

MeV-Accelerator
- Cryounit tested to ~8 MeV
- GO setup => 1.9mA @ 1497 MHz

Precision Electron Mott Polarimeter (~1%)
Precision Electron Spectrometer (~3%)

During positron production:
- Polarized source is off
- Dipoles are turned on

Polarized source
Unpolarized source

15 MeV
115 MeV
e-
e+

10 MeV
5 MeV
e+
e-

15 MeV
dipole

Longitudinal emitt. filter
Transverse emitt. filter
Converter

Conversion Target (Tilted/Normal Tungsten Foils)

Electrons: 8 MeV, 1 mA | W target: 100 μm

ΔE = ±250 keV, Δθ = ±2°

Δθ = ±10°
Δθ = ±5°

Δθ = ±10°

Collimators
Geant4 simulation
Sweep Dipole
Spec. Dipole#1
Spec. Dipole#2
Geant4 simulation
Analyzer magnet

Transmission Polarimeter (MIT loan)

(M. Polker)
Other R&D