WG-2 Organization

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WG-2 Charge

➢ The number of existing and future ERL based accelerator projects are steadily increasing in North America, Europe, and Asia. Working Group 2 (WG2) will survey the optics designs of nearly all of these machines, and will include operational experiences at existing machines.

➢ WG2 will also address the critical issues of injector optimization, error tolerances, halo formation and collimation, start to end simulation, beam instabilities, and collective effects in order to realize the excellent performance qualities of ERLs, such as ultra-low emittance, high current, high stability, and high reliability.

# Understanding of WG-2 Issues from Previous ERL Workshops

(These are our opinions and not everyone may agree.)

Lattice and Optics

- Emittance preservation
  - Design for suppressing CSR effects
  - Design for suppressing ISR effects
- Bunch compression/stretch scheme
- High HOM-BBU threshold current
  - Optics optimization including coupling
- Large energy acceptance
  - Energy spread induced by FEL/scatterings
  - Energy spread amplified by deceleration
- Path length control
- …
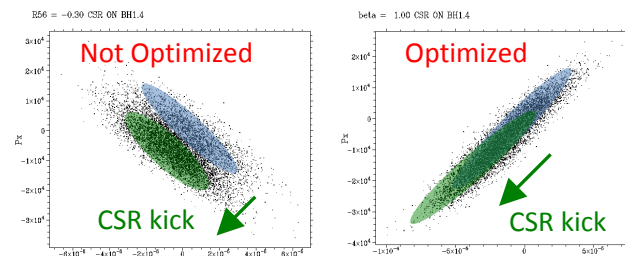
Optimization of CSR kick
for suppressing CSR effect
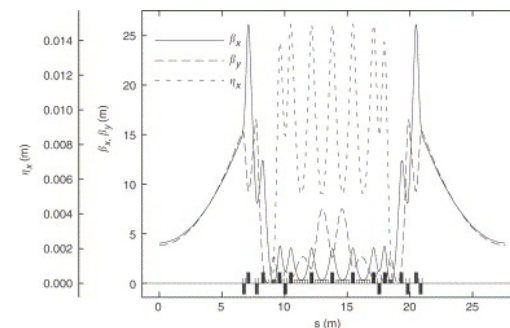
Low dispersion lattice
for suppressing ISR effect

Modular pass corrector

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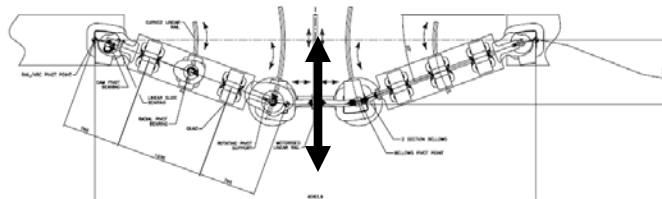
CSR Wake

- There are many CSR wake calculation codes in different formalisms and approximations.
- Further work on more accurate and powerful computational tools is still needed.
- CSR can be suppressed by vacuum chamber shielding.
  - Confirmed by analytic formalism and numerical simulation
  - More experimental verification needed
   (V. Yakimenko et al., WEP107, PAC11)
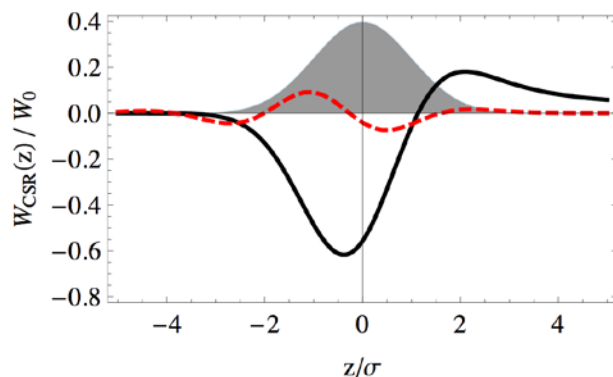
CSR Wakefield in **Free Space** and with **Shielding**

N particle Power spectrum
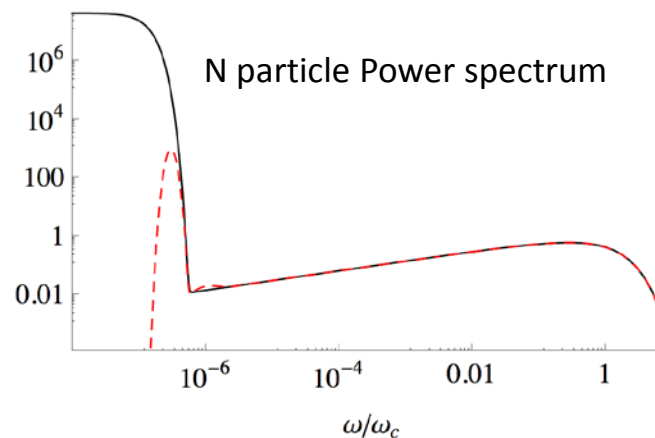
HOM-BBU

- Simulations agree with measurements at JLAB ERL.
- BBU threshold current can be increased by optics optimization including X-Y coupling, polarized cavities and HOM randomization.
- Developments of ERL-oriented cavities for high current beams encourage multi-turn ERLs.
- BBU studies on multi-turn ERLs may be insufficient.
- HOM heating also limits beam current and bunch length.

BBU simulations for Cornell ERL

KEK-ERL cavity
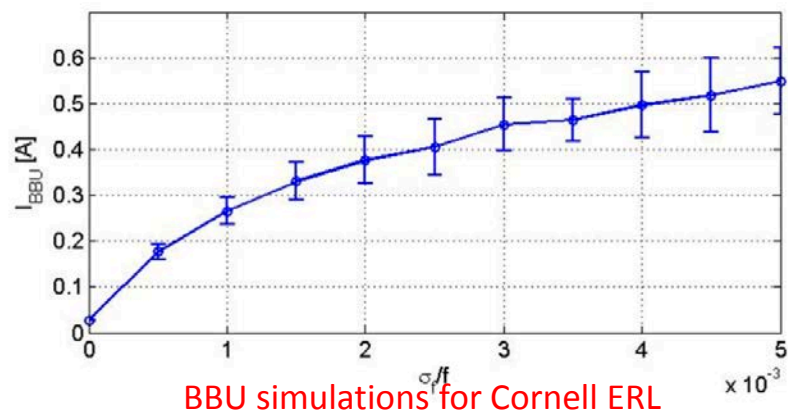
Resistive-Wall Wake

- Transverse RW wake can cause multi-bunch BBU.
- Exact wake calculation and BBU simulation show the beam position displacement due to the RW wake is saturated and may be manageable.
- Heating due to longitudinal RW wake can be serious because of short-bunch and high-current ERL beams.
- Such heating was observed at the JLAB wiggler chamber and managed by adding cooling.
- Copper plating can be effective in suppressing RW heating of an ID chamber.

Beam position displacement due to transverse RW wake
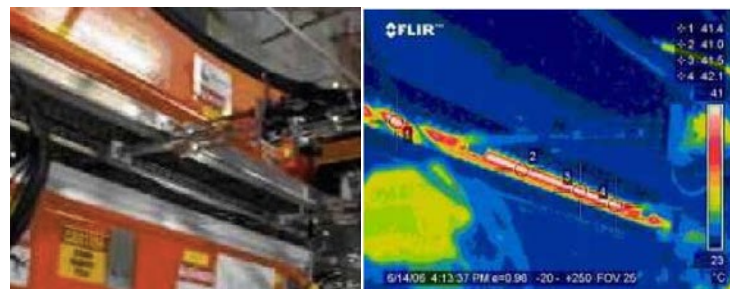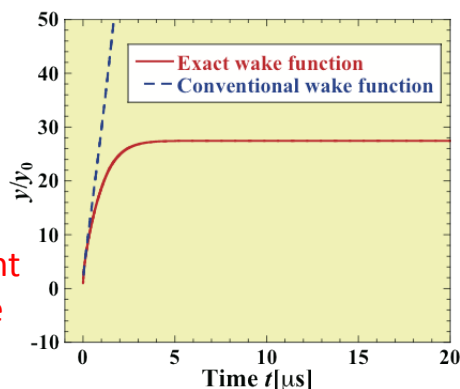
RW heating at JLAB wiggler

Ion Trapping

- Trapped ions induce fast ion instability.
- Two approaches are proposed for eliminating ion trapping:
    1) Ion clearing electrode
        - Installing an electrode every 10 m at Cornell ERL
        - Electrode induced wake fields taken into account
    2) Gap in bunch train
        - Widely employed in storage rings
        - Variation of beam loading in gun and cavities
- No ion effect has never been observed at 4 JLAB-ERLs.
- Experimental studies on ion trapping should be done in existing and future test facilities.

Ion clearing electrode

T_p T_g
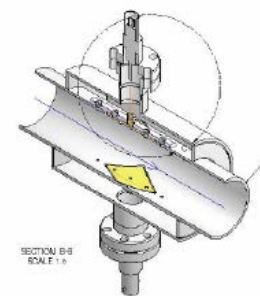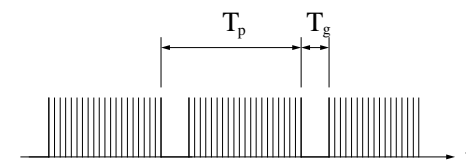
Gap in bunch train

Beam Loss

- Beam loss can be a huge operational problem for ERLs.
- Many potential sources:

  1) Touschek/IBS scattering
  2) Residual gas scattering
  3) Space charge and CSR effects
  4) Strayed light from a drive laser
  5) Bunch tail at photocathode
  6) RF fields and field emission of cavities

Trajectories of Touschek-scattered electrons at Cornell ERL

- Simulation codes are being implemented for some sources such as Touschek/IBS scattering.
- Further studies of beam halo formation and beam loss are needed.

Injector Design & Optimization

- Injector design issues:
  - Emittance compensation scheme
  - Merger optics
  - Envelope matching to main linac

Injector design for KEK cERL

- Multi-objective optimization is powerful tool.
  - Giving a better result than manual optimization
  - Quite efficient with genetic algorithm
- Analytical approaches have been encouraged.
  - Study on beam physics behind
  - New concept and new scheme
  - Comparison with multi-objective optimization
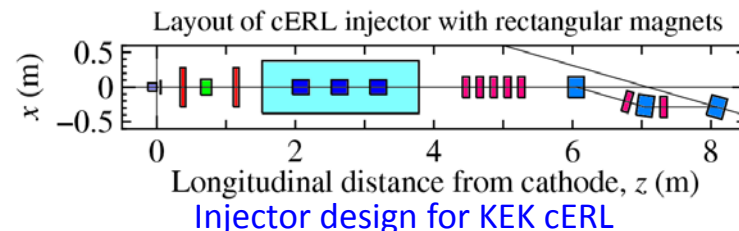
Multi-turn ERL

- Advantages
  - Cost savings for SRF system and accelerator tunnel
- Risks and challenges
  - Lower HOM-BBU threshold current
    (4-fold drop@JLAB & 6-fold drop@Cornell for 2 turns)
  - Tighter orbit and return time tolerances
  - Effects of higher bunch current at reduced repetition rate of injector beams avoiding superimposed 2-color beams
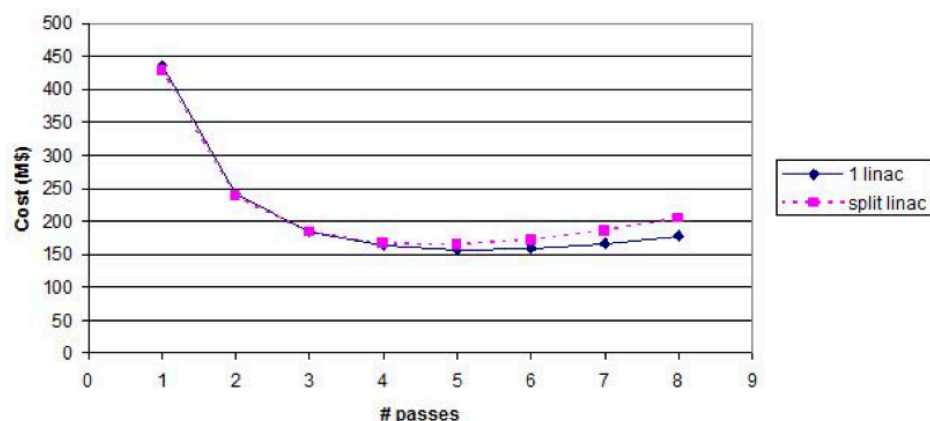
Cost analysis at JLAB
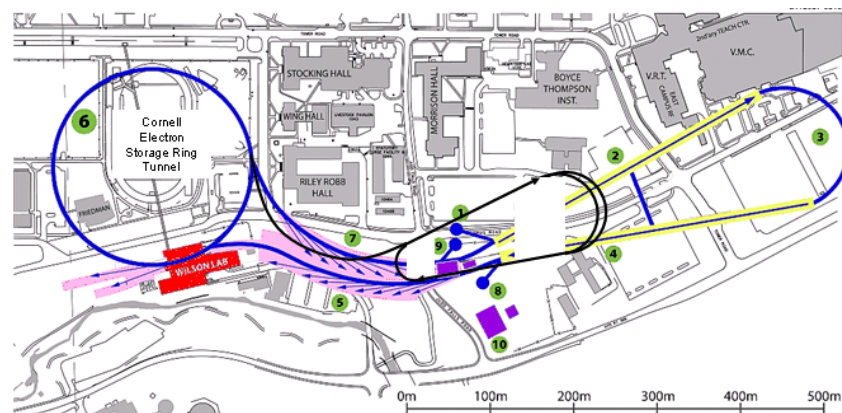
Single- and Multi-turn ERLs at Cornell

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Other Issues

- Error tolerances
- Orbit stability
- Simulation codes (elegant, BMAD, GPT, IMPACT-T, ….)
- Start-to-End(S2E) simulation
- Energy spread due to wakes
- Longitudinal space charge effects
- Light source performance
- Roles of test facilities and collaboration work

ALICE test facility

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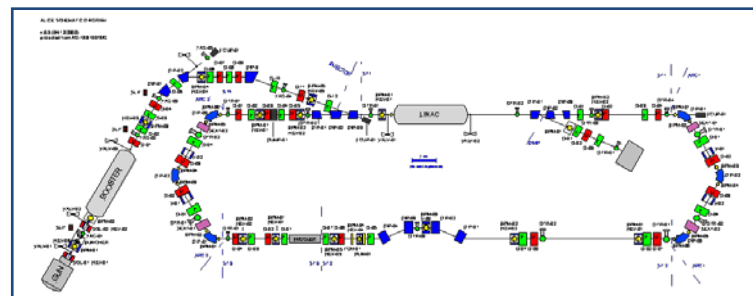
WG-2 Agenda

WG-2 Presentations

■ **26 talks** (incl. 1 talk of WG-5 in the joint session)
  – North America   9
     (USA 9)
  – Europe   9
     (UK 3, Germany 3, Russia 2, Switzerland 2)
  – Asia   8
     (Japan 5, China 2, Korea 1)

■ **5 Posters**
  – Europe   2
  – Asia   3

WG-2 Sessions

Monday afternoon : **Existing ERLs** **(3 talks)**

Tuesday morning : **Nuclear & High-Energy Physics ERL Design** **(3 talks)**

Tuesday afternoon : **Light Source ERL Design** **(5 talks)**

Wednesday morning : **Beam Dynamics** **(4 talks)**

Thursday morning : **Simulation Codes and Techniques** **(3 talks)**

Thursday afternoon 1 : **Beam Loss** **(3 talks)**
Joint session WG2/WG5

Thursday afternoon 2 : **Injector & Emittance Control** **(5 talks)**
Joint session WG1/WG2

Program (1)
Existing ERLs

Monday 15:30 – 17:00
Accelerator Transport Lattice Design Issues for High Performance ERLs Stephen Benson (JLAB)   25 min
Lattice of the Novosibirsk ERL Oleg Shevchenko (BINP)   25 min
Investigation of beam dynamics with not-ideal electron beam on ALICE ERL Yuri Saveliev (STFC/DL/ASTeC)   25 min

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Program (2)

Nuclear and High-Energy Physics ERL Design

Tuesday 11:00 – 12:15
The Mainz Energy Recovering Superconducting Accelerator (MESA)   **-a versatile experimental arrangement based on a compact accelerator.**   Kurt Aulenbacher (IKP)   20 min
Lattice Designs for the Future ERL-based Electron Hadron Colliders eRHIC and LHeC   Vadim Ptitsyn (BNL)   20 min
Layout, optics and beam dynamics for the LHeC ERL   Frank Zimmermann (CERN)   20 min

Program (3)
Light Source ERL Design

Tuesday 13:30 – 15:30
Optics Layout for the ERL Test Facility at Peking University   Senlin Huang (Peking U.)   20 min
Status of the Optics for BERLinPro   Bettina Kuske (HZB)   20 min
Design Studies on the ERL Test Facility at IHEP-Beijing   Jiuqing Wang (IHEP)   20 min
Strategy of the Lattice and Optics Design of 2 loop Compact ERL and Multi-GeV ERL   Miho Shimada (KEK)   20 min
Cornell ERL Lattice and Simulations   Christopher Mayes (Cornell U.)   20 min

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Program (4)
Beam Dynamics

Wednesday 11:00 – 12:30
Beam dynamics issues in ERL-LCS gamma-ray sources Ryoichi Hajima (JAEA)   20 min
The Multiturn ERL X-ray Source (MARS) Feasibility Study Gennady Kulipanov (BINP)   20 min
Wakefields and Energy Spread for the eRHIC ERL Alexei Fedotov (BNL)   20 min
Transverse BBU Studies for eRHIC at Different Top Energy Settings Dmitry Kayran (BNL)   20 min

Program (5)

Simulation Codes and Techniques

Thursday 11:00 – 12:15
OPAL a versatile Parallel Tool for Precise 3D Beam Dynamics Studies including Collective Effects Andreas Adelmann (PSI)   20 min
Calculation of CSR impedance using mesh method Demin Zhou (KEK)   20 min
What is a beam line in the silicon brain of the computer? Etienne Forest (KEK)   20 min

Program (6)
Beam Loss

Thursday 13:30 – 15:30: Joint Session with WG-5
Beam-Beam Effects in an ERL-based Electron-Ion Collider Vadim Ptitsyn (BNL)   20 min
Intra-beam Scattering and its Application to ERL Alexei Fedotov (BNL)   20 min
Beam dynamics for ERLs Georg Hoffstaetter (Cornell U.)   20 min

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Program (7)
Injector and Emittance Control

Thursday 16:00 – 18:30 : Joint Session with WG-1
Emittance Partitioning Through Controlling Eigen-Emittances Bruce Carlsten (LANL)   20 min
Envelope Matching from Injector to Main Linac for ERL Tsukasa Miyajima (KEK)   20 min
Longitudinal dynamics in the ALICE injection line Julian McKenzie (STFC/DL/ASTeC)   20 min
Optics Design of High Current and Low Emittance Injector for BERLinPro Alexander Matveenko (HZB)   20 min
Investigation of the effect of space charge in the compact-Energy Recovery Linac Ji-Gwang Hwang (Kyungpook National U.)   20 min

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Poster Session

Tuesday 16:00 – 18:30
Lattice Design and Beam Dynamics of ERL-TF in IHEP,China Xiaohao Cui (IHEP)   20 min
Longitudinal Stability of ERL with Two Accelerating RF Structures Yaroslav Getmanov (BINP)   20 min
Research on BBU for the PKU-ERL Test Facility Si Chen (Peking U.)   20 min
Effects caused by high-current in BERLinPro recirculator Alexey Bondarenko (HZB)   20 min
Injector performance for XFEL-O operation in ERL light source Tsukasa Miyajima (KEK)   20 min

Plenary Talks

Tuesday 9:30 – 10:00

Three-Dimensional Coherent Synchrotron Radiation Calculations
Bruce Carlsten (LANL)   30 min

Thursday 9:00 – 9:30

Beam Halo Management
Christopher Mayes (Cornell U.)   30 min

Friday 9:30 – 10:00

WG-2 Report
Christopher Mayes (Cornell U.) Norio Nakamura (KEK)   30 min

Thank you for your attention !