Working Group 2:

ERL Beam Dynamics and Optics:
Collective Effects, Multi-Pass Effects, Halo Simulations

Michael Abo-Bakr (HZB), Vadim Ptitsyn (BNL)

Workshop on Energy Recovery Linacs (ERL2015)

June 7-12, 2013, Stony Brook University, Stony Brook, New York

ERL: beam dynamics and optics working group charge

Dr. Michael Abo-Bakr, HZB

Dr. Vadim Ptitsyn, BNL

WG2 will address the optics and beam dynamics challenges in ERLs. It will include lessons learnt from past and present ERL operation as well as issues arising during the design work on future ERL facilities. The group scope includes design approaches for one-pass and multi-pass ERL lattices, error tolerances, preserving longitudinal and transverse beam emittances during beam transport, simulation tools suitable for ERL modelling. We also will look at beam instabilities and collective effects as well as at mechanisms defining halo formation and beam losses.

WG2 Presentations on ERL 2015

Monday, Plenary Sessions: WG2 Presentations
Location: Universe (Theatre)

11:00 **A FFAG-ERL at Cornell, a BNL/Cornell Collaboration**
                        Speaker: Georg Hoffstaetter (Cornell University)

16:45 **Microbunching Instability in ERLs - a Blessing or a Curse?**
                        Speaker: Atoosa Meseck (HZB)

17:10 **Status and Commissioning Results of the R&D ERL at BNL**
                        Speaker: Dr. Dmitry Kayran (Brookhaven National Lab)

<u>WG2 Presentations on ERL 2015</u>

Tuesday morning, Session 1: WG2 Presentations
Location: Wang Center (Lecture Hall 2)

10:45 **eRHIC: an Efficient Multi-Pass ERL based on FFAG Return Arcs**
$\qquad\qquad\qquad\qquad$ Speaker: Dr. Stephen Brooks (BNL)

11:10 **Correction Methods for Multi-Pass eRHIC Lattice with Large Chromaticity**
$\qquad\qquad\qquad\qquad$ Speaker: Dr. Chuyu Liu (CAD)

11:35 **LHeC ERL Design and Beam-Dynamics Issues**
$\qquad\qquad\qquad\qquad$ Speaker: Alex Bogacz (Jefferson Lab)

12:00 **Beam and Polarization Dynamics in Electron FFAG Lattices**
$\qquad\qquad\qquad\qquad$ Speaker: Francois Meot (BNL)

WG2 Presentations on ERL 2015

Tuesday afternoon, Session 2: WG2 + WG4 (SRF) Joint Session Presentations

Location: Wang Center (Lecture Hall 2)

14:00 **Investigations on Transverse Beam Break Up Using a Recirculated Electron Beam**

>> Speaker: Thorsten Kuerzeder (TU Darmstadt)

14:25 **HOM-BBU Simulation for KEK ERL Light Source**

>> Speaker: Si Chen (KEK)

14:50 **Linear Microbunching Gain Estimation Including CSR And LSC Impedances in Recirculation Machines**

>> Speaker: Cheng-Ying Tsai (Virginia Polytechnic Institute and
>> State University)

15:15 **Study of CSR Impact on Electron Beam in the JLab ERL**

>> Speaker: Christopher Hall (Colorado State University)

WG2 Presentations on ERL 2015

Tuesday afternoon, Session 2: WG2 Presentations

Location: Wang Center (Lecture Hall 2)

16:00 **Transverse Emittance Preserving Arc Compressor: Sensitivity to Beam Optics, Charge and Energy**

Speaker: Simone Di Mitri (Elettra - Sincrotrone Trieste)

16:25 **Aspects of eRHIC Longitudinal Dynamics**

Speaker: Dr. Yue Hao (Brookhaven National Laboratory)

Discussion

WG2 Presentations on ERL 2015

Wednesday afternoon, Session 3: WG2 Presentations

Location: Lecture Hall 1

15:55 **The Optics of the eRHIC Low Energy FFAG Cell with Realistic Field Maps**

Speaker: Dr. Nicholaos Tsoupas (BNL)

16:20 **Optics Considerations for the Cornell-BNL FFAG-ERL Test Accelerator**

Speaker: Christopher Mayes (Cornell University)

Discussion

WG2 Presentations on ERL 2015

Thursday morning Poster Session: WG2 Presentations

Location: Lecture Hall 1

Jiang Gui Wang (ANSTO):
A Modelling Study of IBA Injection Beamline on SIRIUS at ANSTO

Jorg Kewisch (BNL):
Space charge Calculations for Low Energy RHIC Electron Cooler (LEReC)

Stephen Brooks(BNL):
eRHIC: An Efficient Multi-Pass ERL Based on FFAG Return Arcs (3-D eRICH DISPLAY)

Hans-Walter Glock (HZB/Compaec):
bERLinPro: Impedance Calculations for the Vacuum System

Hot Topics:

ERLs & FFAG
- Cβ (Cornell/BNL): Hoffstätter, Mayes
- eRHIC (BNL): Brooks, Tsoupas, Liu
- LHeC (CERN): Bogacz
- Beam Transport Simulation: Meot. Hao

Microbunching Instability
- μB in ERLs: Meseck
- μB with LSC & CSR: Tsai

Beam Break Up
- Transv. BBU: Kuerzeder
- HOM BBU (KEK ERL): Chen

FFAG Recirculation:

Basic Principle:
Strongly focusing lattice, using quadrupoles, which centers are offset
Should be able to transport beams in wide energy range (factor 4)

Used at:
- Sub-GeV range proton accelerators
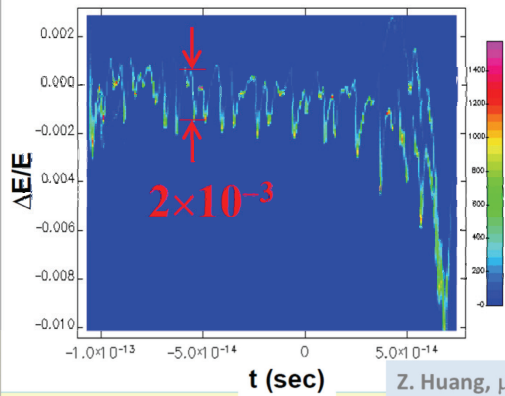- NS-FFAG electron accelerator EMMA

Future applications:
- eRHIC
- Cornel-BNL ERL-FFAG Test Facility
- Other future multiturn recirculators ?

eRHIC orbits in Detector bypass section
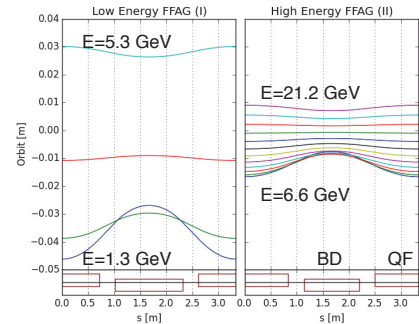
Orbits in eRHIC Transition section

Z. Huang, μB @ LCLS (2004)

2×10^{-3}

1×10^{-4}

ΔE/E

Sp

t (sec)

t (sec)
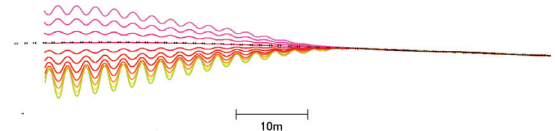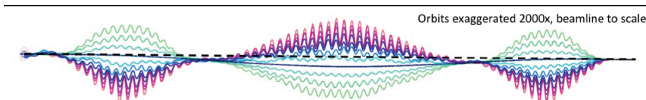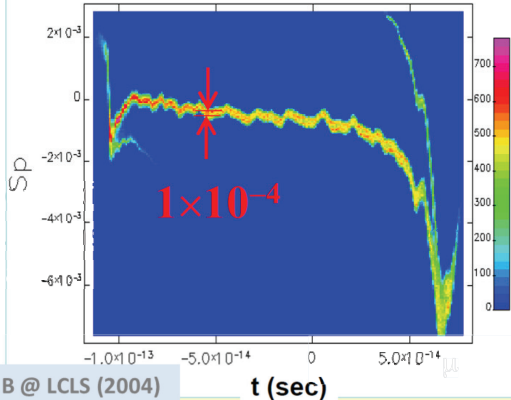
No Laser-Heater

Matched Laser-Heater

Impedance

Energy

λ

R_{56}
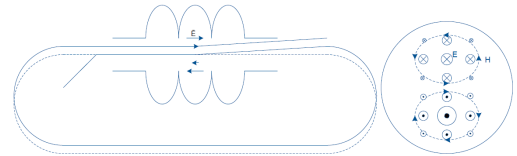
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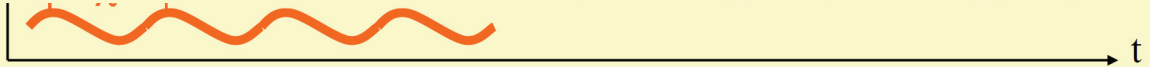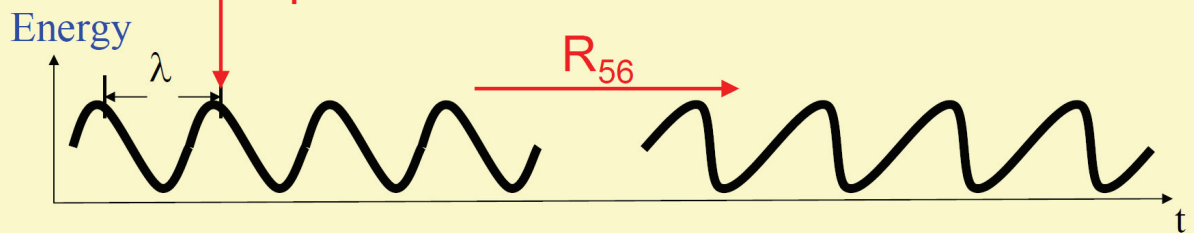
Multipass Beam-Break Up:

Basic Principle:

resonant interaction of bunch with High-Order cavity modes

→ pumps up HOM energy → destroys beam quality, leads to beam loss

Cures:

- Minimizing HOM power by cavity design and proper damping
- Cavity frequency spread
- Beam optics: proper phase advance, Twiss parameter, transverse beam rotation

Multipass beam-breakup thresholds
for 16 pass operation (simulation results)

$\Delta f/f$ (rms)	Current Threshold (mA)
0	53
5e-4	95
1e-3	137
3e-2	225
1e-2	329

Y. Petenev
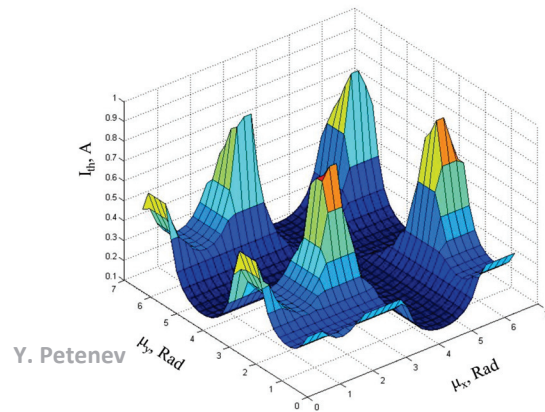
Hot Topics Questions:

ERLs & FFAG
- momentum range: what are acceptance limits?
- multi beam sections: beam diagnostic, orbit and optics correction
- polarized beams: transport in the presence of errors/misalignments
- beam transport simulation tools

Microbunching Instability
- Blessing or Cure?
  - Cure: occurrence depending on beam parameters, compression, …: what when unwanted?
  - Blessing: how to breed?

Beam Break Up
- threshold current scaling with the number of turns?

More questions are welcome to rise up in the WG2 sessions.