Low Energy RHIC electron Cooling

Layout, Infrastructure, and Engineering
- Baseline design updates
- IP 1:00 location - available.
- Estimate schedule.
- 84.5 MHz SRF gun max. energy of 2.5 MV – **2K**.
- 84.5 MHz 2.5 MV SRF accelerating cavity in the same cryostat – **2K**.
- SC solenoid inside the cryostat between the gun and cavity.
- 507 MHz energy correction warm cavity (6th harmonic).
- Electron beam transport with beam instrumentation and magnets from SCRF cryostat to the blue cooling section
- **Cooling section in Yellow ring** – 20 m long between Q3 & Q4.
- 10cm correction solenoids w/BPM/correctors located every 2m.
- **Free space between the solenoids** is mu metal triple shielded.
- **U-turn between cooling section** in Blue & Yellow Rings – special dipoles.
- **Cooling section in Blue Ring** – 20 m long between Q3 & Q4.
- Dump for the electron beam (CTI - 250 kW) + shielding + 45° bend.
- **9.0 MHz RHIC HI RF Cavity**
The electron accelerator (a short linac) will consist of a two-cavity superconducting RF (SRF) cryomodule producing beam with energy up to 5 MeV and normal conducting cavity for energy spread correction.

The cryomodule will house:

- A photoemission SRF gun of a quarter wave resonator (QWR) type, operating at 84.5 MHz;
- A 84.5 MHz QWR SRF booster cavity;
- There will be a superconducting solenoid (with magnetic field up to 1 kG) between two SRF cavities.

507 MHz normal conducting cavity will correct energy spread due to RF curvature of the SRF cavities.
SCRF Cavity Issues

Decision to operate cavities at 2K instead of 4.5K.

- ANL provides 2 SCRF cavities with helium vessels and SC solenoid.
- TBD will they be provided as a completed string? Or in sections?
- BNL provides: Cryostat, Internal support frame, magnetic shielding, cryogenic supply and 2K heat exchanger, cryogenic heat shield, FPC (purchased window assembly + cryostat interface).
- Mechanical Engineering support team: G. McIntyre, J.C. Brutus, Y.R. Than, T. Tallerico, C. Pai

Decision on RF Amplifier Designs (A. Zaltsmen and S. Belomestmykh)
Design Issues

SCRF gun and cavity performance/RF system. ERL Test
RF Amp/power supplies – solid state
Building power and AC requirements.
Cryogenic system design 01:00, new cryogenic tap, internal heat exchanger.
CeC PoP equipment available – cryogenic vacuum pump system
Beam dump design – 250kW
Beam line elements: ebeam instrumentation, injection/extraction ebending, 180° turn configuration, e-focusing solenoid/corrector magnets & power supplies, quadrupoles??
Cooling Beamline magnetic shielding: triple mu metal

Low Energy RHIC electron Cooling
Notes From LE eCooling Timing meeting 10/31, K. Brown


Agenda: A. Fedotov presentation, overview of eCooling and Timing requirements,  B. Sheehy presentation, laser timing

Fedotov presentation:
Kevin S. – For SC each ring needs different cooling rates. eCool consideration? Cooling rates for both Blue/Yellow will be same (same electron beam).

Discussion of bunch 7% specification Bunch to bunch variations cannot exceed 7% (rms) in electron bunch amplitude, but variations within a single bunch are not an issue.

Some discussion of recombination monitor.

100 ps lock will be set by the synchronization of the RF with the laser system.

For RF, works on a revolution harmonic, not a bunch harmonic. So electron bunches will shift in phase over RHIC bunches in a single turn (electron bunches will not land in the same phase for each ion bunch). However, from turn to turn they must remained locked to within 100 psec (rms).

Sheehy presentation:
Reviewed timing as needed by the laser system.

Discussion of laser macropulse pattern. LLRF can provide what is needed (K. Smith).
Need the gated pulses in order to keep beam power dumped minimized.

LLRF will provide the rev tick, rf clock, and gate timing for Laser.

Discussion of laser diagnostics timing requirements. Looks straight forward, but details need to be worked out offline.
24m to larger tunnel
RHIC Program Timeline

• Run 14 CeC PoP Gun (and cryogenic system) commissioning.
  FY 14 ERL Gun High Current Testing

• Run 15 CeC PoP Beamline commissioning.
  Summer 2015 01:00 or 02:00 Q3/Q4 equipment move.
  Building/tunnel infrastructure improvements.

• Run 16 CeC PoP Experiment
  Summer 2016 Cavity and beamline installation.

• FY 17 LEReC Component and ebeam Commissioning
  RHIC will not run fy17. Cryostat cold testing.

• FY 18 Run 17&18 LEReC Operations

Low Energy RHIC electron *Cooling*
Estimate and Review Schedule

October 21: *Freeze design parameters: 14 M or 20 M, (final white paper).*

01:00 Side, 2K cryogenics, passive magnetic shielding, 20 M

**November 4:** Provide conventional facilities estimated needs: AC power, water and air-conditioning, floor and rack space, heavy equipment, beamline components, cables and cable tray, . . .

November 18: round 1 - Cost estimate spreadsheets, milestone schedules, system operating/design parameters.

December 6: round 2 - Cost estimate spreadsheets, milestone schedules, system risk list and risk mitigation.

December 20: Project Execution Plan first draft (w/Risk List).

January 3: Project Execution Plan distributed internally for review.

January 7: DOE Presentation Dry Run

January 13: Project Execution Plan sent to DOE.

January 27 (Monday): DOE Review 2 ½ days.
November 4: Provide conventional facilities estimated needs: AC power, water and air-conditioning, floor and rack space, heavy equipment, beamline components, cables and cable tray, . . .

Need feedback on this spreadsheet
DOE Review Preliminary Schedule

**Day 1**

08:30  Executive Session  (30 min)
09:00  Welcome  T. Roser (10 min)
09:10  LEReC overview – goals and cooling approach  A. Fedotov (40+10 min)
10:00  Electron beam transport and system specifications  D. Kayran (25+5 min)
10:30  **Coffee Break - Small Conference Room**
10:50  System design overview  J. Tuozzolo (30+10 min)
11:30  Project management, cost, schedule, risk  K. Mirabella (25+5 min)
12:00  **Lunch - Small Conference Room**
13:00  **Tour – RHIC 01:00 (location for LEReC)**
14:00  SRF gun and cavity design and fabrication  P. Ostroumov (30+10 min)
14:40  SRF cryostat design and assembly  S. Belomestnykh (30+10 min)
15:20  Cryogenic system  R. Than (25+5 min)
15:50  **Coffee Break - Small Conference Room**
16:10  Photo cathode and laser  B. Sheehy/J. Skaritka (25+5 min)
16:40  Magnets, power supplies, and vacuum system  G. Mahler (25+5 min)
19:00  **Dinner (committee members and presenters)**
DOE Review Preliminary Schedule

Day 2

08:30 Executive Session (30 min)
09:00 9 MHz ion beam RF systems
09:25 507 MHz RF, power amplifiers, and low-level for all systems
09:50 Instrumentation
10:15 Controls and communications

10:40 Coffee Break - Small Conference Room

11:00 Beam dump
11:25 Buildings, AC, electrical and cooling water infrastructure
11:50 Systems and beam commissioning

12:15 Lunch - Small Conference Room

13:15 Executive Session (135 min)
15:30 Answers to questions / discussion (90 min)

Day 3

08:30 Executive Session (30 min)
09:00 Answers to questions / discussion (60 min)

10:00 Coffee Break - Small Conference Room

10:30 Executive Session (90 min)

12:00 Lunch - Small Conference Room

13:00 Close-out (60 min)
14:00 Adjourn
Funding and Immediate Planning

• The LEReC will be funded as an AIP
• Because the funding target is $8M, DOE wants a preliminary design with a cost estimate and
• DOE wants to review the preliminary design with a cost estimate and schedule by January 27, 2014 before releasing funds.
• The cost estimate will be done using spreadsheets provided by K. Mirabella similar to eRHIC and the BLIP raster upgrade.
• Estimate will include (CAD and BNL Trades) labor and material.
  (CAD labor will be “free” but manhour estimates are needed)
• Estimate most include equipment moves, building modifications, installation costs, and equipment testing/commissioning.
• Labor for pre-estimate is to be charged to your group’s RHIC operating account.
Funding and Immediate Planning

AIP Project Management
(K. Mirabella/R. VanWormer, based on recent BLIP raster AIP project experience)

• The schedule needs to be resource loaded so “at year” funding can be presented to and requested from the DOE.
• Schedule milestones must be presented.
• A risk list with mitigation plans must be presented.
• System operating parameters at project completion (CD-4) must be presented as well as longer term optimal parameters.

All of the above must be in an Execution Plan given to the DOE review team 2 weeks before the review.

Cost estimate spreadsheets will be distributed later today.
Extra Slides
Location, Location, Location

RHIC 1:00 IP, BRAHMS and AnDY out, CeC to be completed 2016

- Control Room/Instrumentation w/AC
- Laser Room w/AC (New)
- Power Supply Building w/AC
- Tunnel w/crane
- Utility Building – Water/Cryogenics
- Cryogenic Recovery System (New)
- Site Power – 1002 Transformer Yard

Low Energy RHIC electron Cooling
CeC PoP Equipment Sharing

Building preparation completed for CeC:

• Share Cooling water tower/water pumps.
• Laser building ordered, delivery 11/15/2013.
• Cryogenic system 2K or 4.5K for SCRF cavities.
• Helium return system being completed in 1002A.
• ODH system being installed in 1002A.
• More cable tray being installed.
Systems Engineers

Project Lead: A. Fedotov (RD)
Project Engineer: J. Tuozzolo (AD)
Project Management: K. Mirabella (Admin)
CeC layout – B. Martin
SRF – S. Belomestnykh (RD)
SCRF Cavity – Argonne NL /(BNL interface - AD) TBD
Cathode Insertion Fixture – C. Brutus (AD)
Cavity Tuners, Power Coupler, Laser Port – C. Brutus/TBD (AD)
RF Systems PS and LLRF – A. Zaltsman (AD)
Cryogenics – R. Than, T. Tallerico, P. Orfin, J. Haung (AD)
Beamline (Magnets and Power Supplies) – G. Mahler, R. Lambiase (CeC, AD)
Diagnostics – M. Minty, D. Gassner, T. Miller, L. DeSanto (CeC, AD)
Drive Laser & Photocathode Development – B. Sheehy (CeC, RD)
Conventional Facilities – A. Pendzick, J. Scaduto, P. Feng (ESF)
Beam Line and Insulating Vacuum Systems – M. Mapes (AD)
RF 6th Harmonic Cavity – Zaltsman (AD)
Beam Dump – L. Snydstrup (AD)
Summary

- Physics design is near complete – **14 m or 20 m cooling?** (Finalize 1:00 or 2:00 location)
- Preliminary beam line design is underway.
- Site has been chosen/infrastructure.
- LEReC lattice needs to be frozen:
  - SCRF system specifications
  - Vacuum chamber/magnet specifications
  - e beam instrumentation
  - HI beam instrumentation
- Engineering team to be finalized and assigned.
# Tunnel Location Details

## Sector 2

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### Yellow Inner

- Start of warm sector
- 10 Hz GOF Magnet
- Moveable BPM (LF Schottky)
- 0.25m BPM BTF Pick-up
- Beam Loss Monitor
- Hybrid Kicker
- ARTUS Kicker V (or B-by-B longit damper)
- Electron Det V
- ARTUS Kicker V (or B-by-B longit damper)
- ARTUS Kicker Horizontal (start)
- ARTUS Kicker Horizontal (end)
- Future ARTUS Kicker V
- Future ARTUS Kicker V
- Future ARTUS Kicker H
- Future ARTUS Kicker H
- Future B-Ionization PM Vertical
- SC Long Pick-up (start)
- SC Long Pick-up (middle)
- SC Long Pick-up (end)
- Button BPM
- WCM
- DCCT
- HF Schottky PU
- Pin diodes (2)
- New Long SC pickup
- End of warm sector

### Blue Outer

- Start of warm sector
- 10 Hz GOF Magnet
- BBQ Kicker
- 1M Pick-up
- 0.25MBPM
- PLL BBQ PU (Moveable)
- ARTUS Kicker Horizontal (start)
- ARTUS Kicker Horizontal (end)
- Lumi-Mon (6-way cross only)
- Beam Loss Monitor
- Traveling Wave Cavity
- Future ARTUS Kicker H
- Future B-Ionization PM Vertical
- Button BPM
- WCM
- DCCT
- HF Schottky PU
- End of warm sector

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Low Energy RHIC electron Cooling
Low Energy RHIC electron Cooling

Left 1:00 Sector
Yellow

Low Energy RHIC electron Cooling
Move Equipment Blue

Low Energy RHIC electron Cooling
Timeline

FY2013 Physics approach/preliminary design approved.
FY2013 Design Safety Review Questionnaire completed.
FY2013 Initial 2:00 Layout and LEReC Lattice.
FY2013 SCRF Cavities physics design and performance specifications.
FY2014 Engineering “kick-off” meeting/assignments/start bi-weekly engineering meetings
FY2014 DOE review and approval
FY2014 CeC gun cavity cryogenics commissioned, performance benchmark for quiet helium source.
FY2014 LECeC Lattice “frozen”, energy, intensity, location, component specifications.
FY2014 Engineering systems PDR, systems specifications, building requirements/system loads.
FY2014 Order SCRF Cavities/cryostat, SC solenoid, RF amplifiers, buncher system.
FY2014 Support building layout/equipment locations, cable tray, electrical service, AC & water loads.
FY2015 Detailed cryogenic component design BNL PCSSR – long lead procurements.
FY2015 Detailed beamline design, ASSRC/FDR – long lead component procurements.
FY2015 Support building modification design/contracts (2015 shutdown modifications)
FY2015 Move RHIC beamline components (2015 shutdown modifications)
FY2016 Receive and test LEReC beamline and cryogenic components
FY2016 2016 Shutdown installation LEReC beamline and cryogenic components
FY2017 Engineering commissioning for LEReC beamline and cryogenic components using RHIC refrigerator without RHIC.
FY2018 Operations (Run 17)