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Brookhaven National Laboratory*

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STATUS OF R&D ENERGY RECOVERY LINAC AT BROOKHAVEN NATIONAL LABORATORY *

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Abstract

In this paper we present status and plans for the 20-MeV R&D energy recovery linac (ERL), which is under construction at Collider Accelerator Department at BNL. The facility is based on high current (up to 0.5 A of average current) super-conducting 2.5 MeV RF gun,

single-mode super-conducting 5-cell RF linac and about 20-m long return loop with very flexible lattice. The R&D ERL, which is planned for commissioning in early 2009, aims to address many outstanding questions relevant for high current, high brightness energy-recovery linacs.

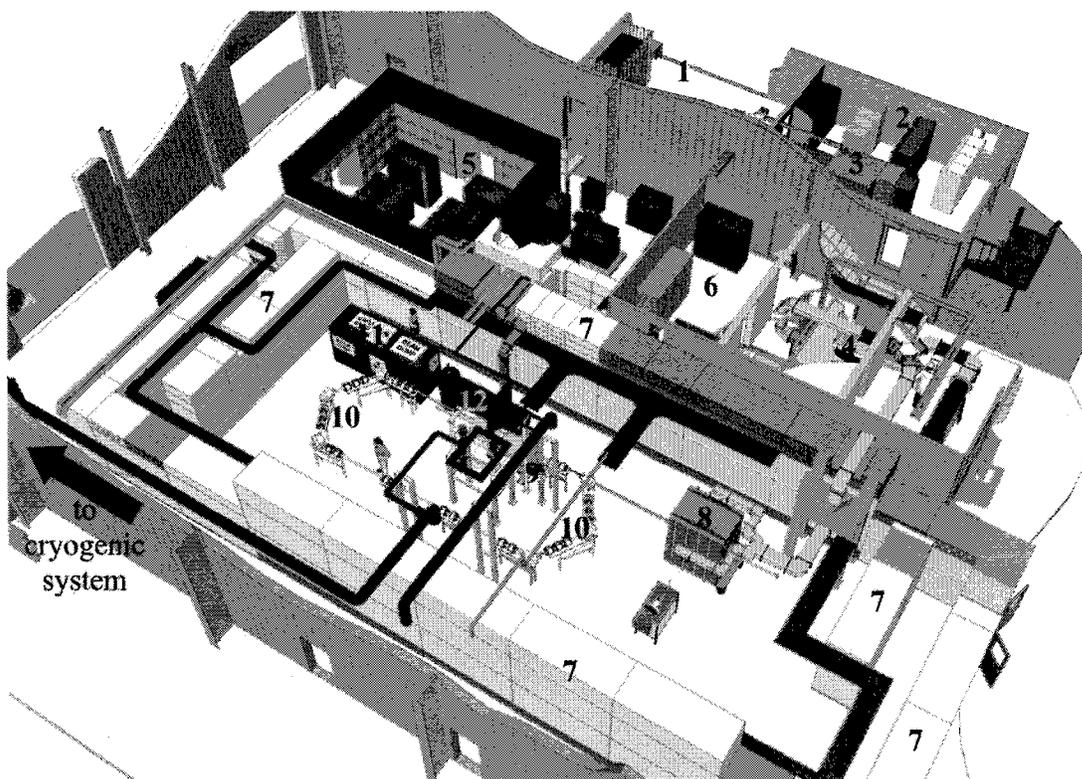


Figure 1. Layout of R&D ERL in Bldg. 912 at Collider-Accelerator Department, BNL: 1 – R&D ERL control room; 2 – diagnostic and control racks; 3 – 703.75 MHz, 50 kW CW RF transmitter; 4 - 703.75 MHz, 1 MW CW klystron; 5- 2 MW CW HV power supply for the klystron; 6 – power supplies and other electronics; 7 – shielded R&D ERL vault with removed roof beams; 8 – 2 MeV, 703.75 MHz SRF photo-injector; 9 – 20 MeV, 703.75 MHz 5-cell SRF linac; 10 – return loop; 11 – beam dump; 12- part of the 1.8 K° cryogenic system (most of the system is outside the picture).

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ERL R&D PROGRAM AT BNL

R&D ERL, shown in Fig.1, will serve as a test-bed for future RHIC projects – RHIC II with ERL-based electron cooling [1, 2] and 10-to-20 GeV ERL for lepton-ion collider eRHIC [3,4]. It will also address more general issues expanding capabilities of ERLs: from novel SRF injectors [5], high current and high brightness beam ERL operation [6] and highly flexibility lattice [7,8] to enable covering a vast operational parameter space from non-achromatic lattice to achromatic large range tunability of of R_{12} , R_{34} and R_{56} parameters. Some parameters we plan to attack with this ERL are listed in Table 1.

Table 1. Parameters for the R&D ERL

Mode:	High charge/current
Injection energy, MeV	2.5 / 2.5
Maximum beam energy, MeV	20 / 20
Average beam current, A, up to	0.05/ 0.5
Bunch rep-rate, MHz	9.4 / 704
Charge per bunch, nC	5 / 0.7
Normalized emittance, mm*mrad	<10/ ~2

Future RHIC upgrades define the goals for the R&D ERL development to test:

- ❖ Key components of the RHIC II electron cooler
- ❖ High Current ERL based solely on SRF technology
 - 703.75 MHz SRF gun test with 500 mA CW
 - high current 5-cell SRF linac test with HOM absorbers (one turn - 500 mA, two turns - 1 A)
 - stability criteria for CW beam currents ~ 1 A
- ❖ Scalability for future linac-ring collider eRHIC with
 - 10-25 GeV SRF ERL for eRHIC
 - possible SRF ERL based an FEL-driver for high current polarized electron gun
 - attainable ranges of electron beam parameters in SRF ERL

While few remaining elements of the R&D ERL are in advanced stage of design, majority of its elements are in the process of procurement, manufacturing, testing, measurements or installation. Present plan is to start the commissioning of complete R&D ERL in early 2009. The commission of multiple ERL subsystem (1 MW klystron, 5-cell cavity, cryogenics, power supplies and magnets, diagnostics, SRF gun) will expand from summer 2007 till the end of 2008.

STATUS

Many of the ERL subsystem and most of its infrastructure had been installed in the Bldg. 912 ff the C-AD complex. Some photographs are shown below.

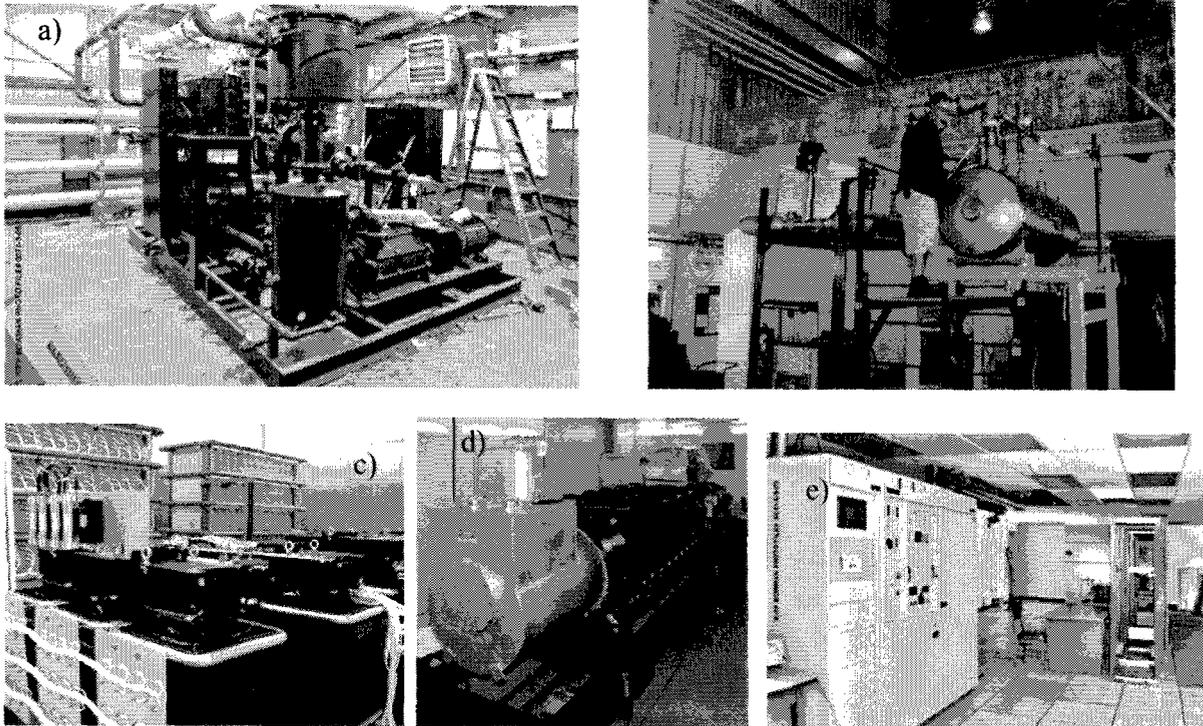


Figure 2. Some of R&D ERL subsystems: a) cryogenic pump for 1.8 K^o operation; b) installation of ballast-tank for liquid He in the ERL shielded vault; c) 2 MW CW high voltage IGBT power supply installed in a dedicated air-conditioned room; d) 1 MW CW 703 MHz klystron installed into 2" steel garage; e) future diagnostics & control room with 50 KW 703.75 MHz transmitter and some racks

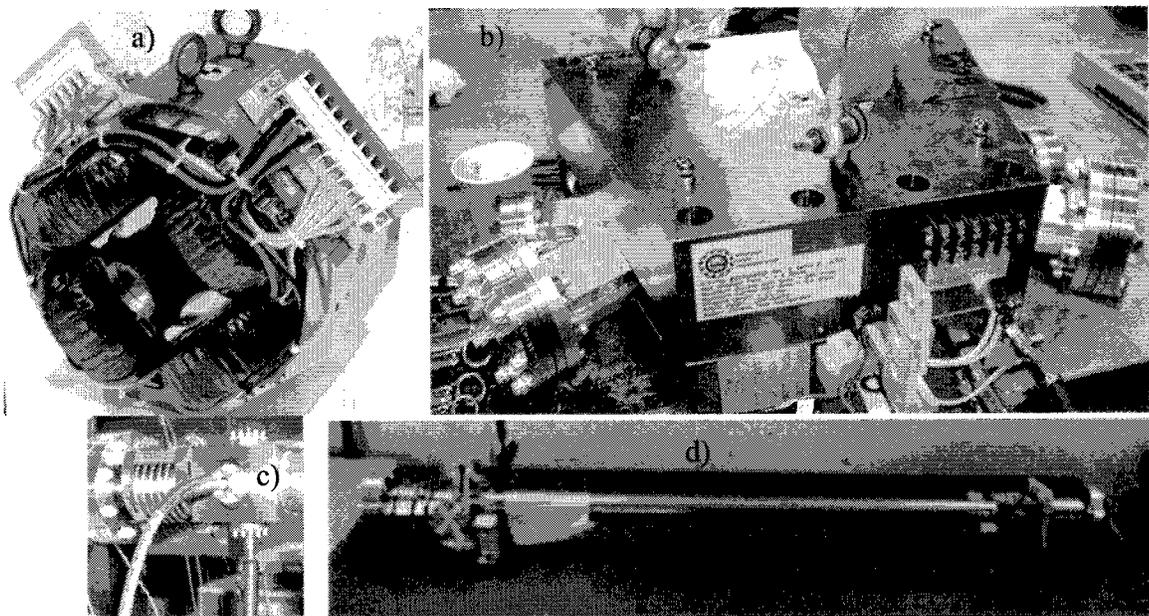


Figure 3. Some of R&D ERL components: a) ERL-loop quadrupole; b) ERL-loop 60° dipole magnet with its Al vacuum chamber; c) BMP unit with BMP-buttons as part of d) ERL vacuum chamber for straight sections.

Among system in place are both 1MW (for SRF gun) and 50 kW (for 5 cell 20 MeV SRF linac) including circulators and dummy loads, cryogenic pump and ballast tank for the 5-cell cryostat, water-cooling system, shielded vault with PPS system, buildings for laser room, powers supplies and control room. ERL-loop vacuum chambers (including dipole, quadrupole and BPM units) as well as all vacuum system controls and electronics are on hand. ERL-loop quadrupole and dipole magnets are in production (by Everson-Tesla, PA), tests and under magnetic measurements [7]. All loop magnets and their supports will be in hands by the end of year 2007.

The 5-cell SRF linac successfully went through vertical test at Jlab [9] demonstrating accelerating voltage in excess of 20 MeV/m. Horizontal test of this linac is planned in R&D ERL vault for January 2008.

All remaining orders for electronics, diagnostics [10] and power supplies for R&D ERL will be placed before October, 2007 with expected delivery in mid-2008.

The order for the laser system (needed for 5 nC, 9 MHz mode of operation) had been placed and system will be delivered to BNL in December of this year. The preparation chamber for SRF gun photo-cathodes is in the final stage of production and will be at BNL in July 2007.

The SRF gun is the stages of the final design and initial manufacturing at AES, Medford, NY. It should be delivered to BNL by the end of 2008. Injection beam-line (ZigZag), some common elements and ejection beam-line are also in the final stages of design. All critical design issues for the injection magnets had been resolved [7] and the remaining components will be manufactured in year 2008.

Overall, the R&D ERL at BNL makes steady progress toward its commissioning in early 2009.

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