CONTROLS SYSTEM DEVELOPMENTS FOR THE ERL FACILITY*

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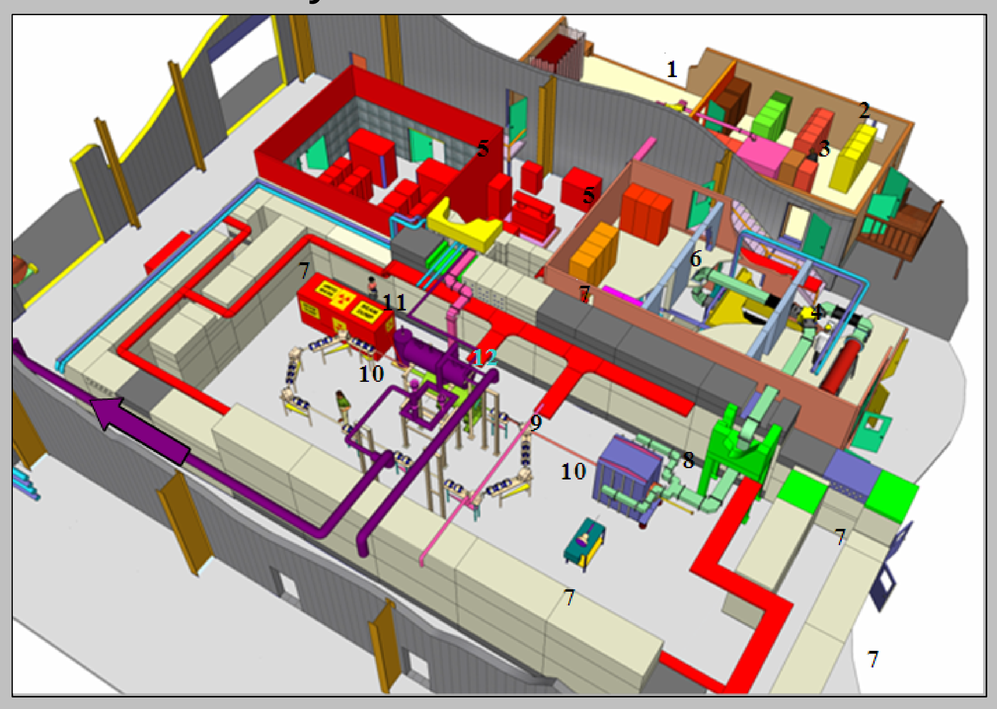
Purpose of the Energy Recovery LINAC

The ERL R&D project will serve as a testbed for the technologies needed to build a future electron-ion collider as an upgrade of the Relatavistic Heavy-Ion Collider (RHIC) at the BNL, called eRHIC. Goals include the verification of efficient energy recovery and generation of average beam currents of 500 mA while running in CW mode. Critical elements of the machine are listed in the diagram below, followed by a list of major past and future milestones.

Machine Layout



Layout of the R&D Energy Recovery LINAC in the shielded vault:
1 - Control Room; **2** - diagnostic and control racks; **3** - 703 MHz 50 kW CW RF transmitter; **4** - 703 MHz 1MW CW klystron; **5** - 2MW CW HV power supply for the klystron; **6** - magnets power supplies and other controls;
7 - shielded ERL vault with removable beams; **8** - 2 MeV 703 MHz SRF photo-injector; **9** - 15-20 MeV 703MHz 5-cell SRF linac; **10** - return loop;
11 - beam dump

Timeline

April 2009	First Cold Emissions Test (CET) of the 5-cell RF cavity
July 2011	Completed conditioning of the Fundamental Power Couplers (FPCs) for the electron gun
Early 2012	First Gun-to-5-cell (G5) test with ~1 μA beam
2013	Estimated start of full ERL operations

Components of the ERL Controls System

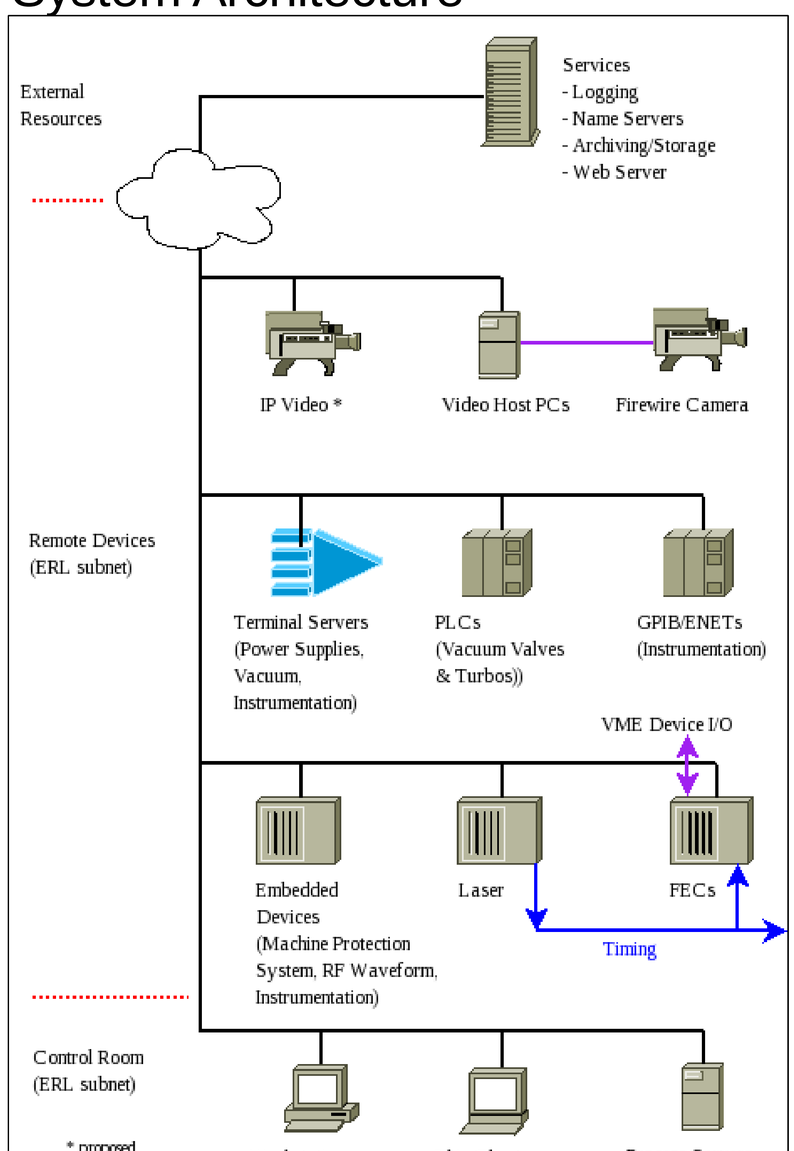
An Ethernet network serves as the primary controls conduit for the distributed devices around the ERL. Selected devices are bridged to the network through serial terminal servers or using GPIB/ENET-100 modules as shown in the architecture diagram below.

Our existing image acquisition system uses IEEE1394 cameras connected to host PCs running Red Hat LINUX, though we will evaluate Gigabit Ethernet cameras as an alternative platform.

Timing signals will be distributed to equipment via an event link, and trigger delays will be controlled remotely using a Stanford Research Systems DG645. Cyber Security concerns may require a shift from using the network to access the laser PC (running Windows XP) to using serial communications through a terminal server.

The Machine Protection System (MPS) uses the National Instruments CompactRIO platform, which is an embedded device running custom LabView programs for detection and reporting of interlocks from digital and analog inputs from critical systems.

System Architecture



Software

- C++
- Java
- LabView

Hardware

- Workstation & Server PCs running Red Hat Enterprise LINUX
- VME Front End Computers (FECs) running VxWorks
  - Processors
    - MV2100
    - POWER3E
    - MV3100
    - XILINX Virtex II
  - Boards (examples)
    - SIS3803 scaler
    - VMIC3122 ADC
    - VMIC3123 ADC
    - VMIC4140 DAC
    - OMS VX2 motion controller
    - Custom delay generator

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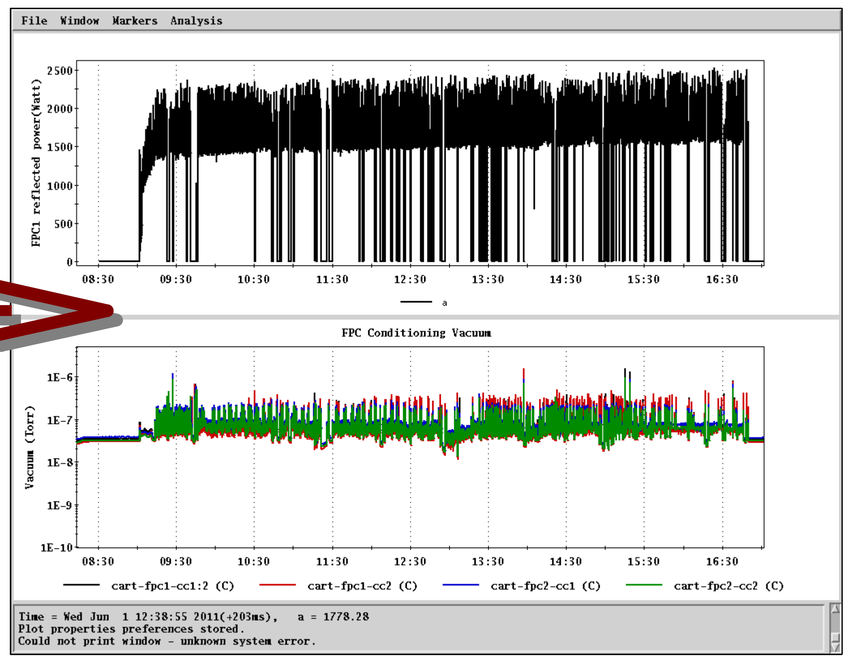
Controls in Action

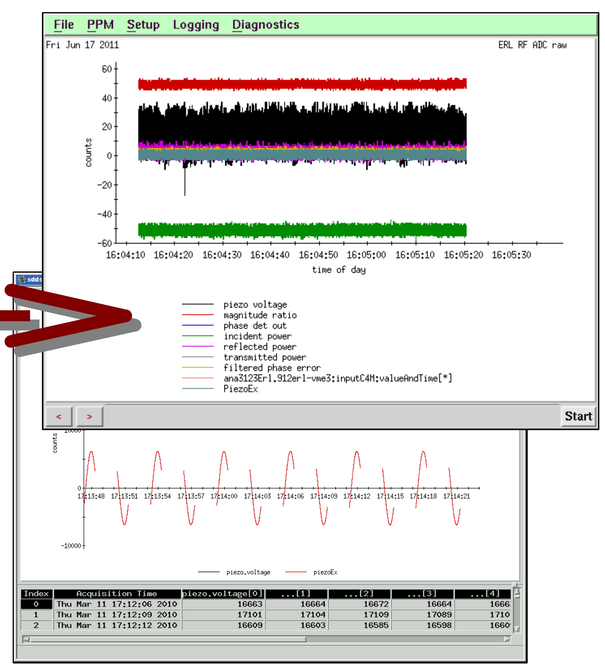
This is an example of data plotted from the logging system using the LogView application showing FPC reflected RF power during conditioning work, along with vacuum readings from the conditioning cart.

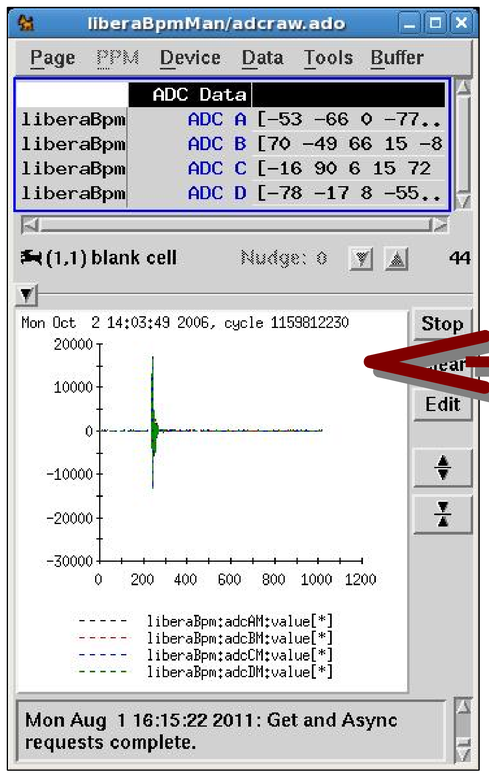
The readings from a peak RF power meter and vacuum gauge controller were acquired by separate C++ programs running on the ERL process server.



A fast VMIC3123 ADC VME board is used to digitize LLRF and RF power signals.

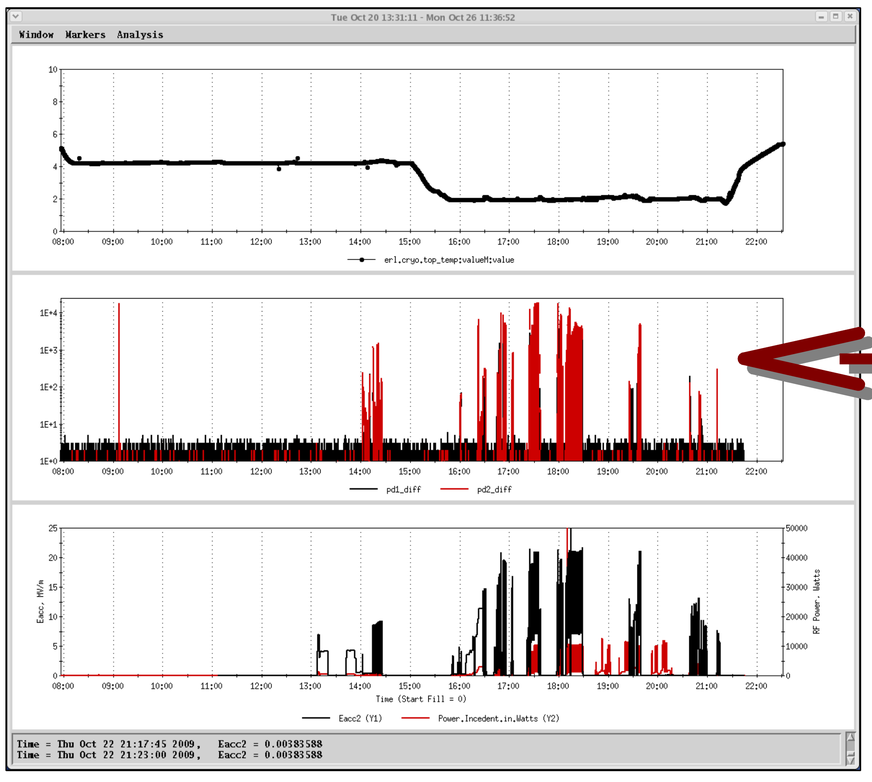
The data shown in the top picture demonstrates the elimination of client load issues when the sampling rate is reduced by 4x and a data reflection server (FEC to PC) is used.





Shown here is a live set of Beam Position Monitor (BPM) test data acquired from a Libera Brilliance Single Pass module displayed through the Parameter Editing Tool (PET) application.

The Libera platform includes an ARM processor running LINUX, on which we have built a copy of our existing code base using the cross development library provided by the vendor, Instrumentation Technologies.



Correlation of data from three separate platforms is demonstrated in the logged data from 5-cell RF cavity testing (temperature in Kelvin, scaler counts from PIN diode loss monitors, and RF gradient/power).

Network Time Protocol (NTP) is currently used in order to synchronize timing on each LINUX server and FEC.

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