Design and Status for the Electron Lens Project at the Relativistic Heavy Ion Collider

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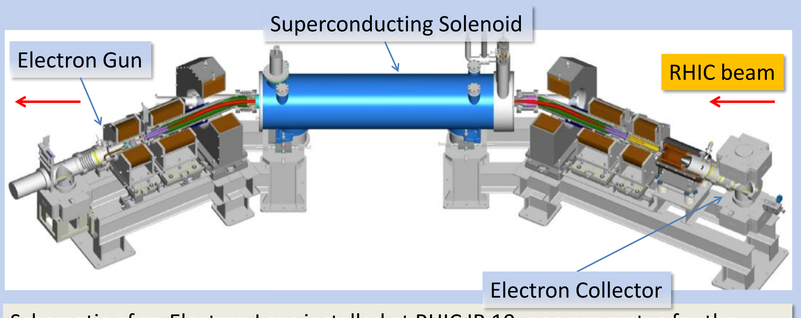
e-Lens Goals & Design



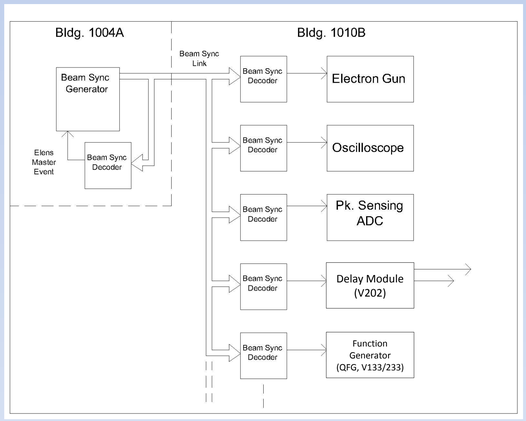
Schematic of an Electron Lens installed at RHIC IR 10: one apparatus for the Blue Ring, and one for the Yellow Ring.

The Blue and Yellow e-Lenses are installed in the RHIC Ring at Interaction Region 10, in order to partially counteract the head-on beam-beam tune shift effect on the colliding RHIC beams, and thus permit RHIC proton beam operations at higher beam intensities, and therefore higher colliding beam luminosities for the RHIC experiments. First commissioned during the FY2014 run, both electron lenses were successfully operated on a routine basis in a DC mode during the FY2015 RHIC 100 GeV polarized proton run.

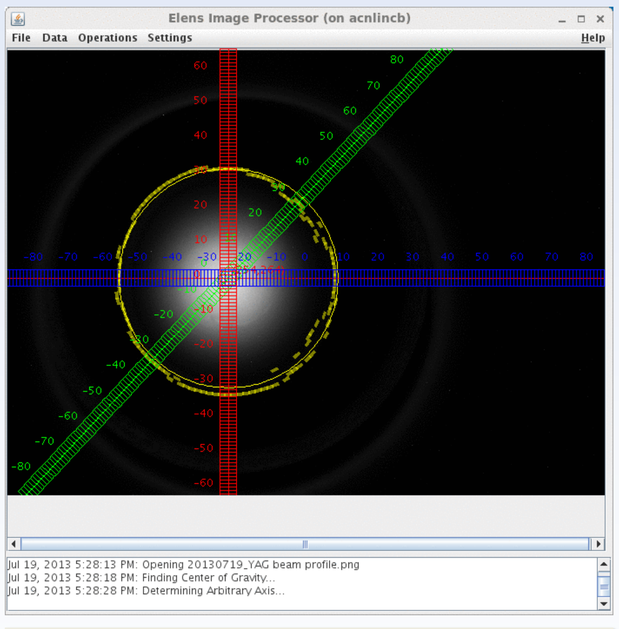
The main components of each e-Lens are the electron gun, electron collector, and superconducting solenoid magnet, though a set of additional systems are required for their routine operation. Beam transport magnets of both superconducting and non-superconducting varieties are controlled through two separate sets of standard VME hardware and software: warm magnets use equipment (PSC, QFG, and PSI) developed for the Injector machines within the Collider-Accelerator Department, and the cold magnets utilize the RHIC equipment (WFG, MADC) for reference control and readbacks. Another system of note is beam instrumentation, which is primarily comprised of BPMs, current transformers, YAG crystal-based beam profile monitors, pinhole raster scan beam profilers, as well as new electron backscatter detectors (described below, right).

Key Controls Infrastructure

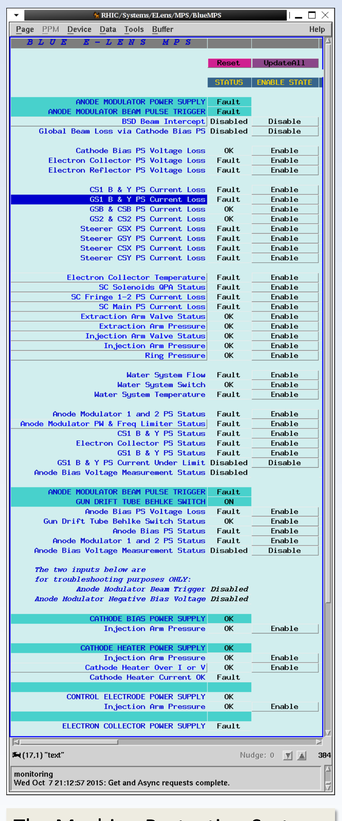
- Timing System
  - VME hardware based (VxWorks)
  - RHIC Event Link core
  - RHIC Beam Sync Link
  - Server-based remote interface for e-Lens mode control
- Machine Protection System
  - National Instruments CRiO
- Beam Instrumentation
  - Gigabit Ethernet Cameras (Aravis library)
  - SiS VME scalers
  - CAEN VME ADCs
  - OMS VME stepper motor controllers
  - VMIC 3122 ADCs



Schematic of the e-Lens timing system, including RHIC components (bldg. 1004A) and e-Lens-specific components (1010B).

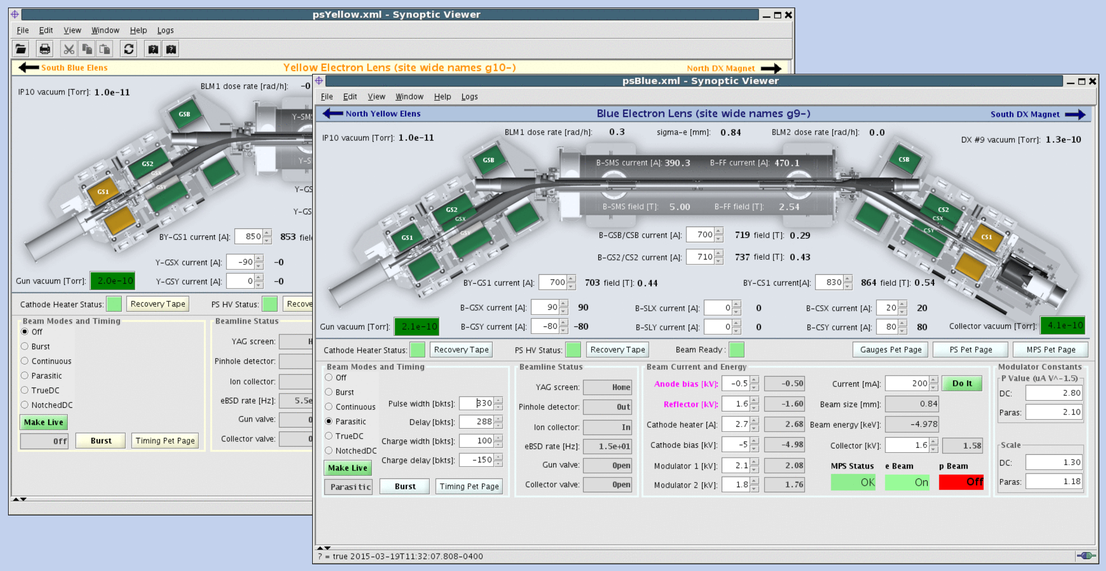


Electron beam profile data provided by the e-Lens Image Analysis application using GigE camera data obtained by inserting YAG crystal instrumentation into the beam path.



The Machine Protection System interface for the Blue e-Lens, showing a sampling of the current logic inputs and outputs.

Synoptic User Interface



Synoptic-type user interfaces for the Blue and Yellow e-lenses, developed using the Syndi application.

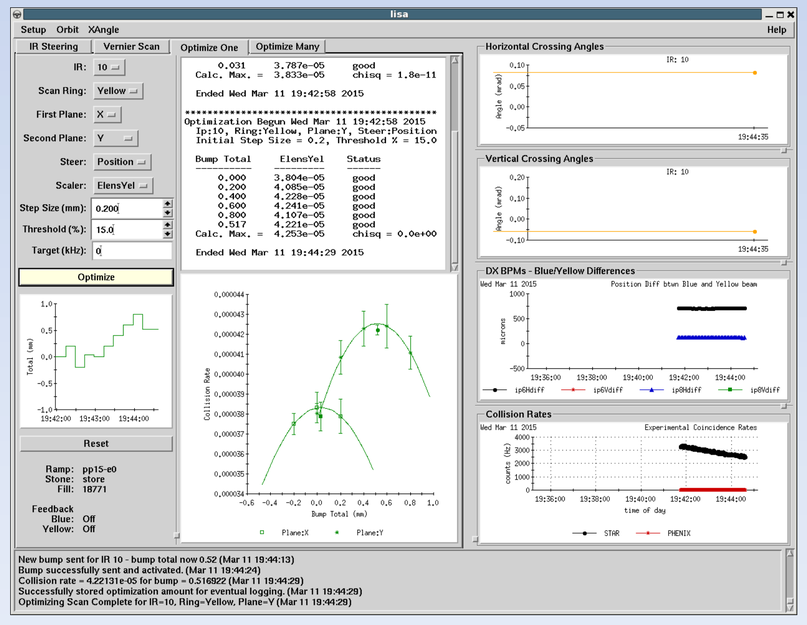
In addition to the more commonly used user interfaces within the Controls System at the Collider-Accelerator Department at Brookhaven National Laboratory, the Syndi editor and display application has been adapted from the original version developed at FermiLab. Due to the compact and complex nature of the electron lenses, these synoptic displays have evolved to serve an important role in the operation of the equipment.

Development of the control pages themselves has migrated since their inception from the Syndi software developer, to the project physicist, and ultimately to a member of the RHIC Operations group. While capable of embedding complex business logic within each page, we have elected to minimize the amount of such logic implemented within the page in favor of server-based software that leverages critical functionality, such as parameter caching.

New Run, New Tools

For RHIC Run FY2015, a new type of beam instrumentation called an electron backscatter detector (eBSD) was commissioned in both e-Lenses. Positioned on the gun side of the apparatus, it provides a scaler signal representing the count of backscattered electrons from the fraction of successful interactions between the electron beam and RHIC beam. Since this signal is alignment dependent, it can be used for automated tuning feedback within the standard Interaction Region steering application for RHIC, called LISA.

At right, you can see the application output after one pass of optimization on the eBSD scaler data for the Yellow e-Lens.



LISA application plot showing X and Y transverse beam steering optimization in RHIC IR 10 based on eBSD measurements.

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