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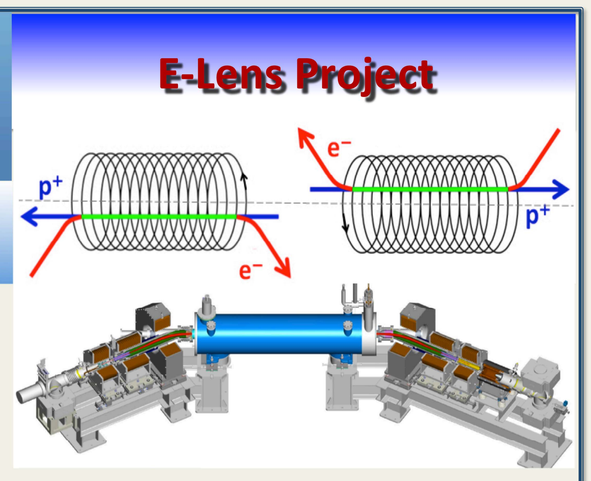
SLAC
BROOKHAVEN NATIONAL LABORATORY
Collider-Accelerator Department
RHIC Relativistic Heavy Ion Collider
Accelerator Research & Development Division



MOPF08

Beam Profile Measurements in the RHIC Electron Lens using a Pinhole Detector and YAG Screen

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Abstract

The Coherent Electron Cooling Proof-of-Principle experiment, based on an FEL, is currently under construction in the RHIC tunnel at BNL. Diagnostics for the experimental machine are currently being designed, built and installed. This presentation focuses on the design of the infrared diagnostics instrumentation downstream of three tandem 2.8m long helical wiggler sections that will ultimately act on a 22MeV 68uA electron beam co-propagating with the RHIC ion beam at 40GeV/u. The 14 um FEL radiation will be extracted from RHIC via a viewport in a downstream DX magnet and analysed by instrumentation on a nearby optics bench. Instruments concentrating on three parameters, namely intensity, spectral content, and transverse profile, will extract information from the wiggler radiation in an attempt to quantify the overlap of the electron and ion beams as well as the degree of coherent cooling.

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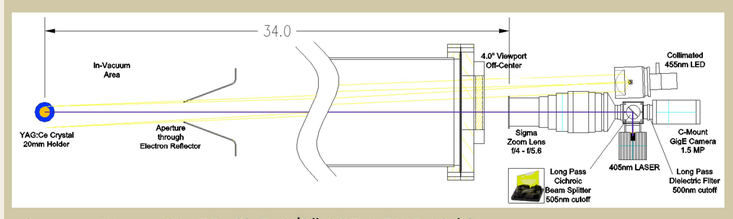
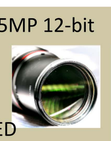
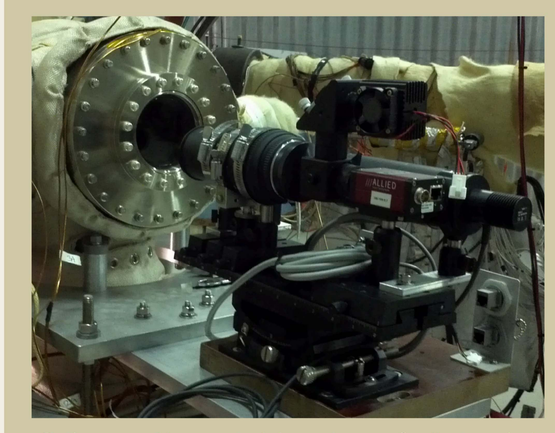
Optics Assembly



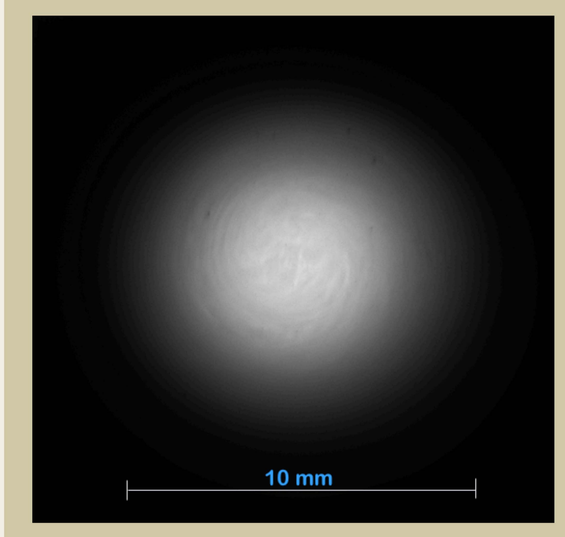
Camera: Manta G145B, GigE, 2/3" CCD 1.5MP 12-bit
Zoom Lens: manual
Target: YAG:Ce crystal (0.1mm) d=1.3m
Illumination:

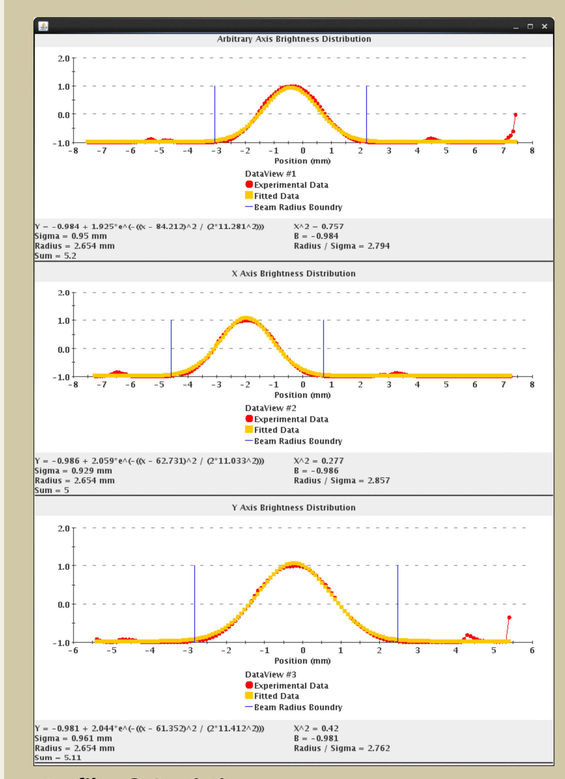
- Adjacent mounted White projection LED
- Adjacent mounted 455nm (blue) projection LED
- On Axis 405nm (violet) Laser via dichroic beam splitter





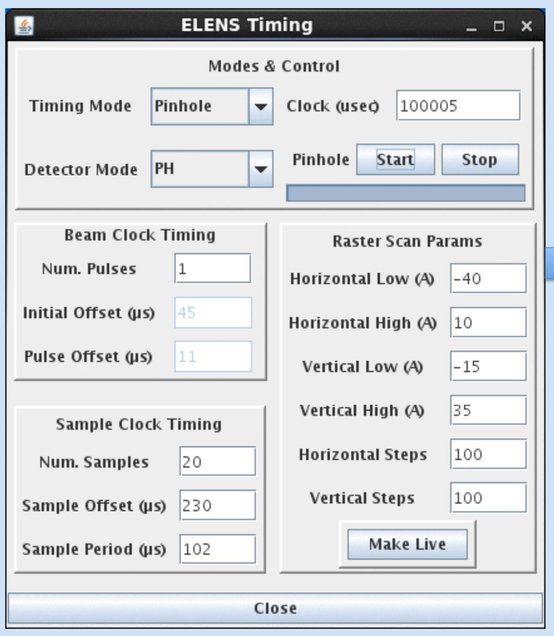
Optics assembly mounted downstream of collector window.

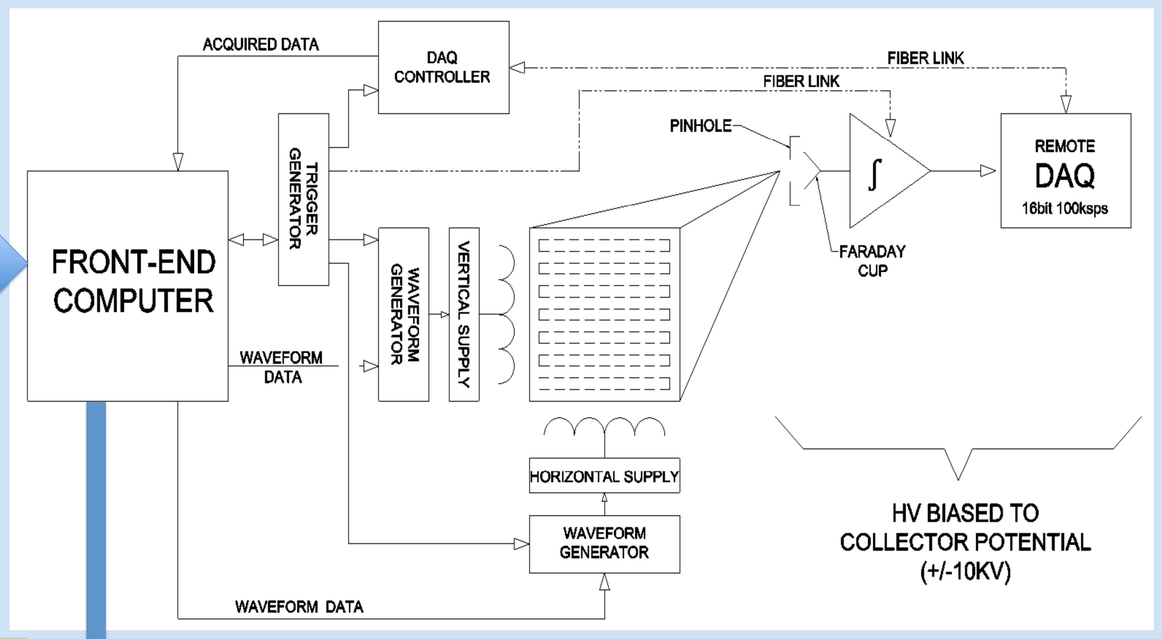




Profiles & Statistics
The plots generated include the averaged intensity points with a fitted curve overlaid. The blue lines show the beam radius boundary. Calculated data include the trend line formula, Sigma, radius and X^2.

PinHole Scan Parameters





PinHole Scan Profile 210mA, 6keV

Pinhole scanning system is comprised of a scanned electron beam by controlled steering coils. Beam is raster scanned over a fixed faraday cup covered with a 0.1mm pinhole mask. The magor hardware components are:

Waveform Generators – controller with waveform table coupled via fiber to a remote module with an analog output to generate arbitrary waveforms as well as 4 analog inputs for power supply readbacks. Timing inputs synchronize stepping through the waveform table.

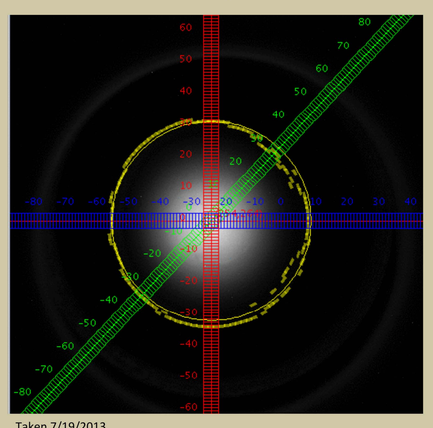
Data Acquisition Module – module with 4 Analog inputs and is isolated from its controller by a bidirectional fiber optic link. The controller contains a readback buffer for the data as well as external timing sync inputs.

Trigger Generator - multi-channel module utilizing a widely-distributed master clock and event link to generate output pulses with programmable delays and widths with deterministic timing.

Front End Computer – (FEC) a VME-based controller running the VxWorks Operating system used to control the other three components above and to bridge their parameters and data with the rest of the controls system infrastructure over an Ethernet network.

YAG Profile 70mA, 6keV

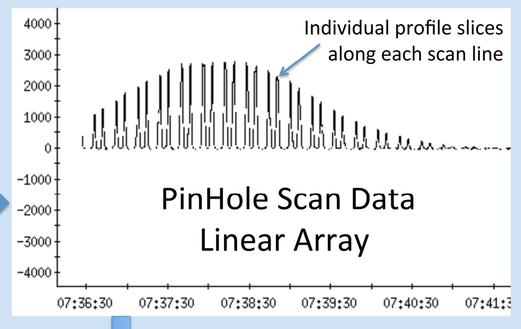
Axis Definition for Profile Plots
Controls are provided in the software to define an arbitrary axis, in addition to the X & Y axes, along which to compute average values within defined boxes, and plot the intensity profile for the three axes, as shown on the right. A boundary definition circle is automatically defined at 2.5% intensity.



Taken 7/19/2013

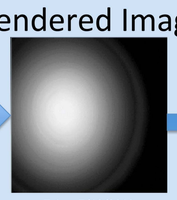
Machine Measurement Parameters

Parameter	YAG	PinHole
Beam Energy	6 KeV	6 keV
Beam Current	70 mA	210 mA
Pulse Width	1 µs	12.5 µs
Rep Rate	1 Hz	10 Hz
Resolution	~40 pixels/mm	~8.5pts/mm



Raster -> Array
Scaling mm/A
Skew Comp.
Rendering
Smoothing

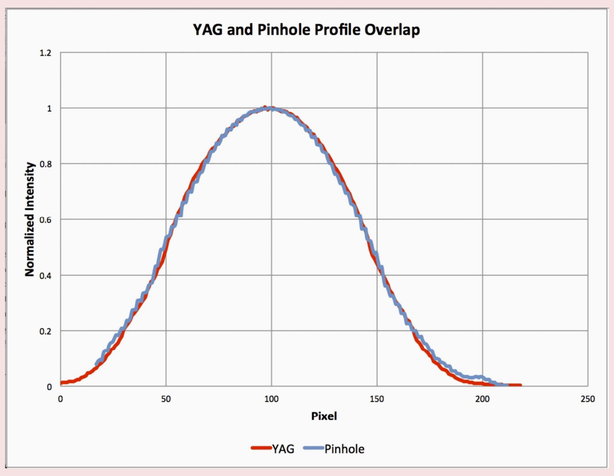
PinHole Scan Rendered Image



Taken 7/19/2013

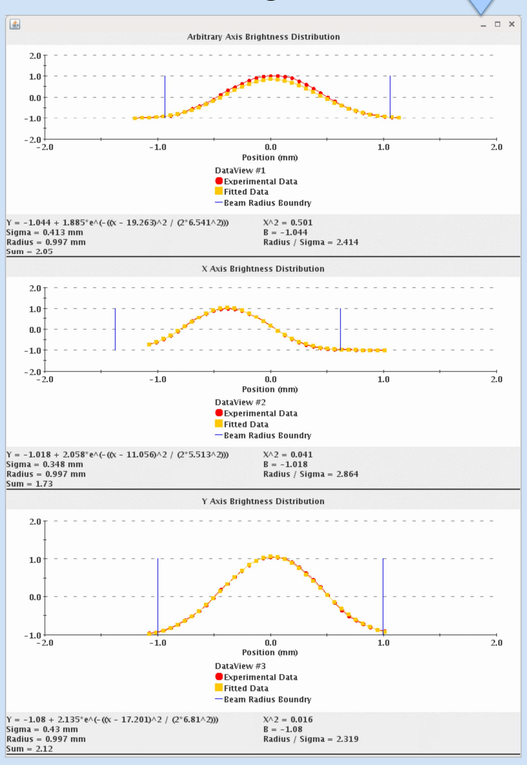
Comparison of YAG vs PinHole Scan Beam Image Profiles

Excellent agreement of the two profiling methods. YAG screen shall be the preferred method with the PinHole scan retained as a back-up measuring system.



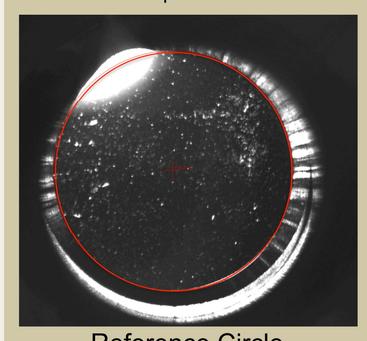
PinHole Scan 210mA, 6keV

PinHole Scan Image Profiles



CALIBRATION FUNCTIONS

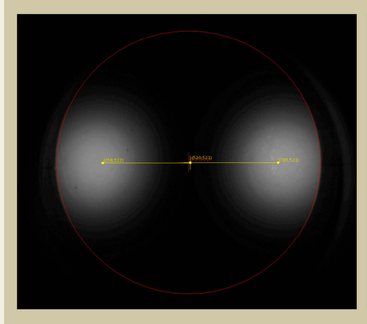
Procedures are provided in the software to calibrate the YAG image.



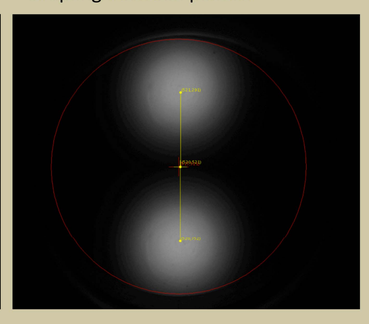
Reference Circle
On illuminated YAG screen

Reference Circle - the red reference circle is drawn on the 20mm crystal holder bezel. This allows the software to compute the pixel/mm scaling coefficient.

Deflection Coefficients – YAG screen images are taken at max horizontal & vertical steerer deflections. The software plots lines between the max deflected image pairs. The length and skew angle of the lines gives the steerer calibration coefficient (A/mm) and the skew angle error due to coupling between planes.

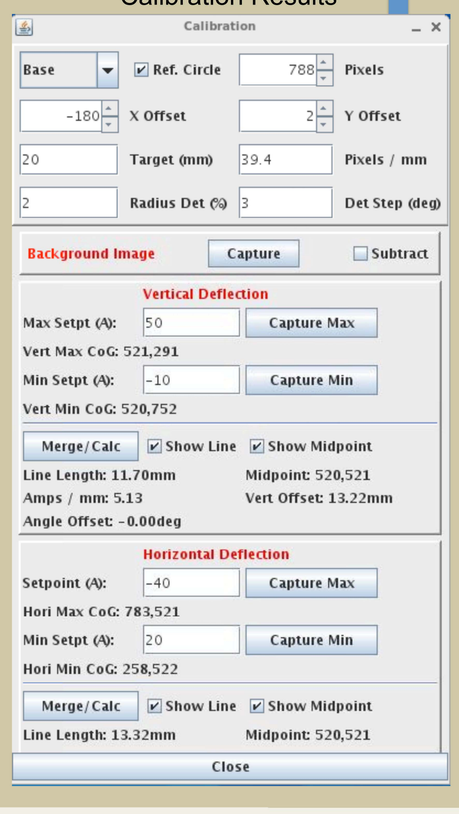


Horizontal Deflection



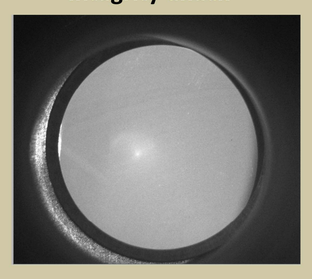
Vertical Deflection

Calibration Results



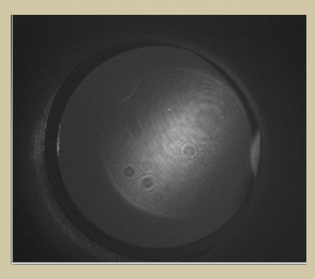
YAG Diagnostics

Integrity Check



YAG crystal flooded with 455nm light from focused LED

Focus Assistance



YAG crystal illuminated with 405nm expanded laser beam