Record Performance of CeC SRF Gun

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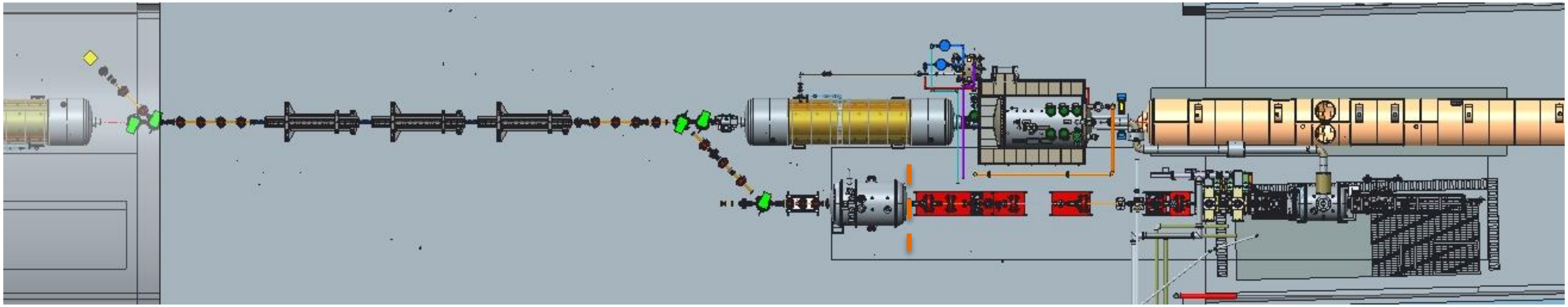
Record Beam Generated by SRF Gun Operating in CW Mode

- Bunch charge exceeds 3 nC
- Beam energy 1.6-1.7 MeV (CW), >2 MeV (pulse)
- We have demonstrated electrical field at time of emission exceeding 21 MV/m

	FZD	HZD	NPS	Wisconsin	CeC
Charge, pC	300	6	78	100	3000
E, MV/m	5	5-7	6.5	12	21
Frequency	1.3 GHz	1.3 GHz	500 MHz	200 MHz	113 MHz
Cathode	Cs_2Te	Pb	Nb	Cu	CsK_2Sb

Coherent Electron Cooling Project



Electron beam is generated by 113 MHz SRF gun with photocathode driven by a green laser. Two 500 MHz copper cavities provide energy chirp and beam is compressed to desired peak current. After compression beam is accelerated by 704 MHz SRF cavity and merged into CeC PoP structure having three helical undulators.

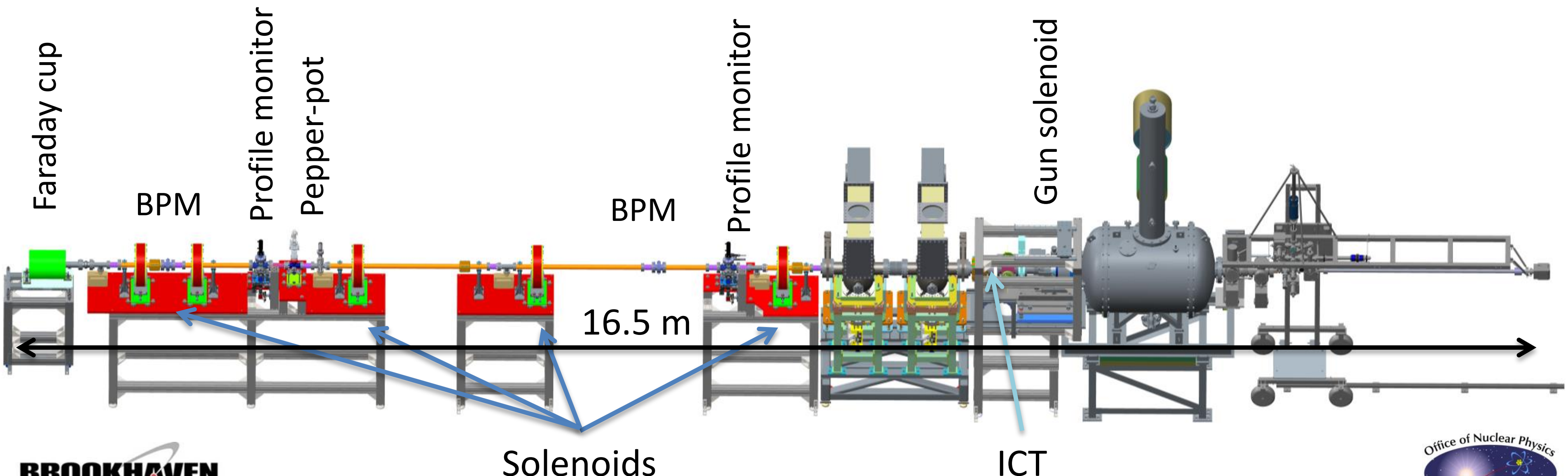
Presently equipment is installed up to location of 704 MHz cavity.

Electron Beam Parameters for CeC

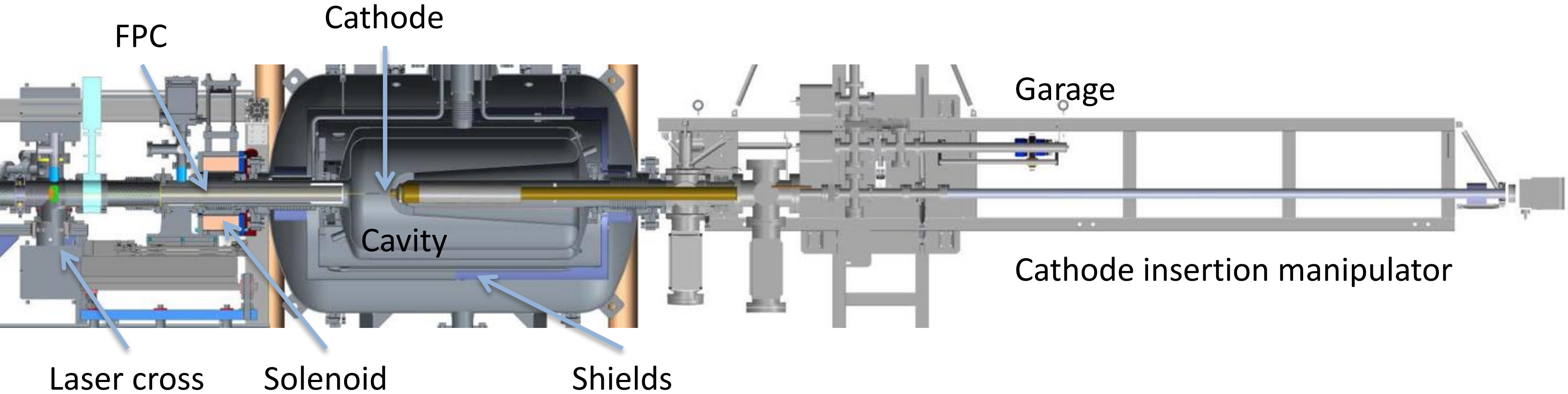
- Gun energy 1.5-2 MeV
- Beam charge 1-5 nC
- Final beam energy 22 MeV
- Normalized emittance < 5 mm mrad
- Energy spread 10^{-3}
- Pulse repetition rate 78 kHz

Diagnostics for Low Energy Beam

- Integrating current transformer (1.25 nV s/nC)
- Two beam profile monitors with 1.3 megapixel cameras
- Pepper-pot in front of the second profile monitor
- Two BPMs
- Low power beam dump with Faraday cup was temporarily installed at the end (place for 704 MHz accelerating cavity)



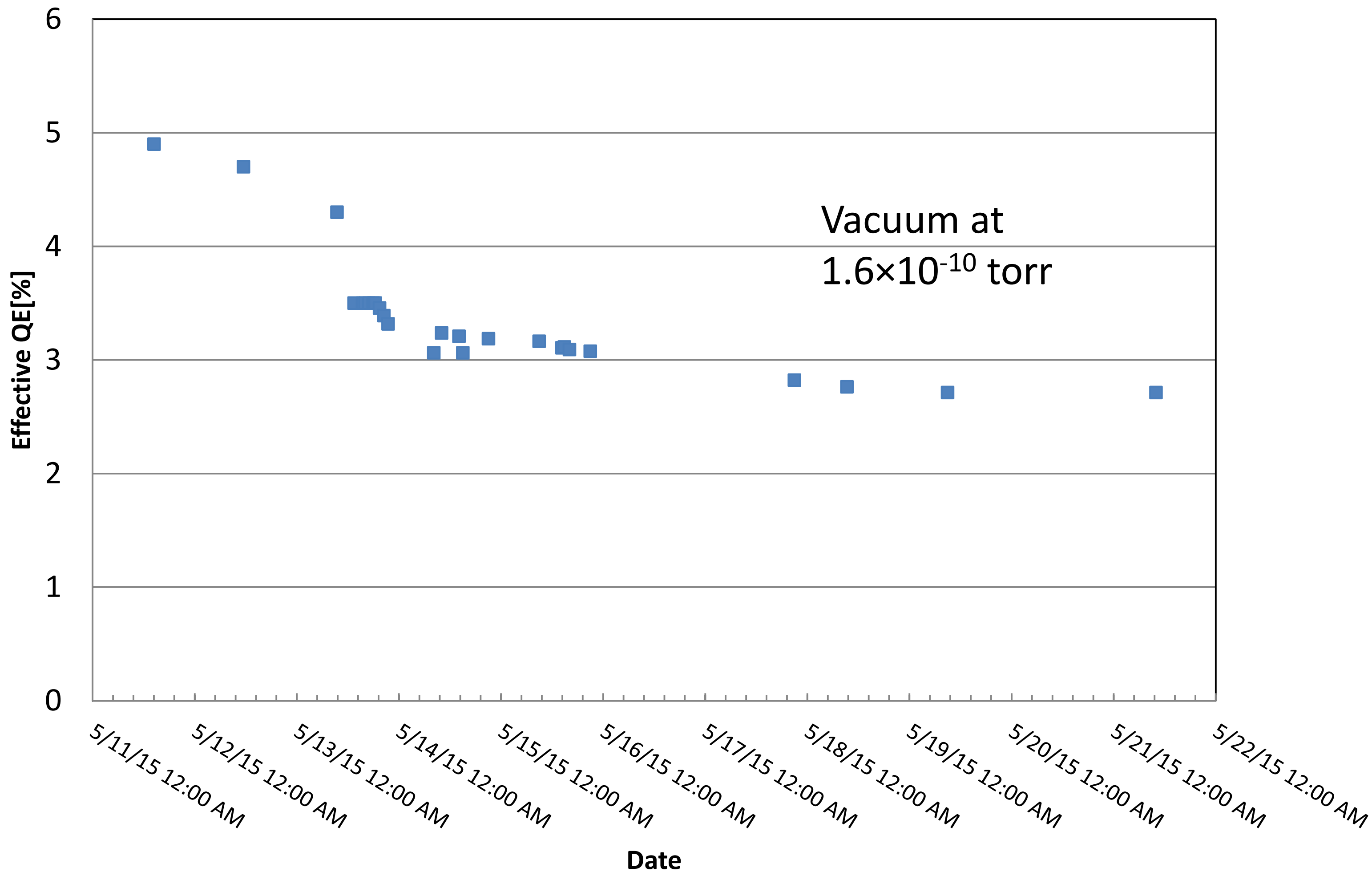
CeC SRF Gun



- Quarter-wave cavity
- 4 K operating temperature
- Manual coarse tuner
- Fine tuning is performed with FPC
- 2 kW CW solid state power amplifier
- CsK_2Sb Cathode is at room temperature
- Cavity field pick-up is done with cathode stalk (1/2 wavelength with capacitive pick-up)
- Up to three cathodes can be stored in garage for quick change-out
- Design gradient 22.5 MV/m

Cathode QE Evolution

Initial QE is 8-10%, the evolution after transfer is shown below.



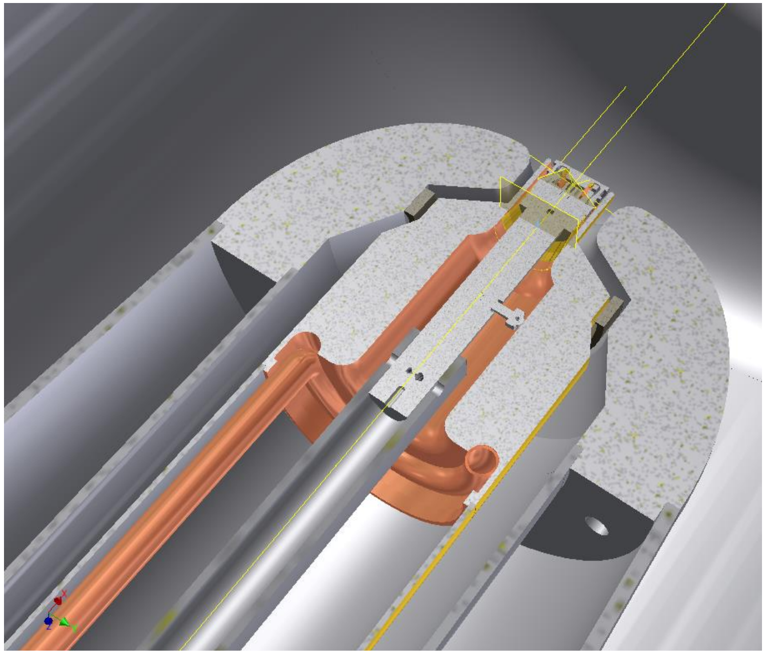
Drive Laser

Picolo AOT-1 by Innolas

Rep-rate	up to 5 kHz
Wavelength	532 nm
Pulse energy	up to 6 μJ
Pulse duration	0.7 ps
Spot size on the cathode	1.5 mm

We will replace laser with a new one. Wavelength will be the same, repetition rate 78 kHz, peak power 1 kW, tunable pulse length up to 550 ps

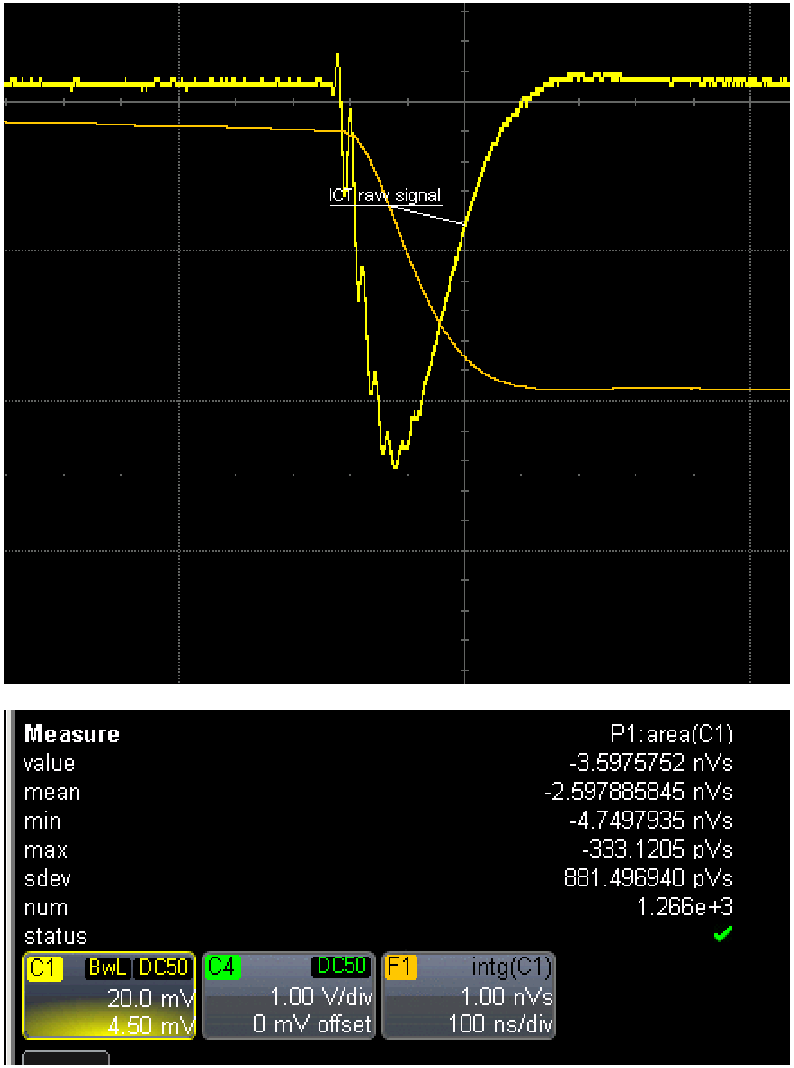
Problems Encountered



Photocathode end assembly

- Multipacting in the FPC area – long conditioning cycle with molybdenum puck
- Excessive dark current – helium discharge cleaning
- Photocathodes found dead prior insertion into the gun – added port for QE monitoring inside the garage
- Substantial spikes in the residual pressure during insertion into the gun – added NEG getters
- Multipacting inside the cathode stalk – laser cleaned the cathode sides, developing mask for the cathode deposition system

First Beam Observation



First beam was observed with integrating current transformer during phase scan. The charge was 0.5 nC.

Emission was observed over 100 degrees span.

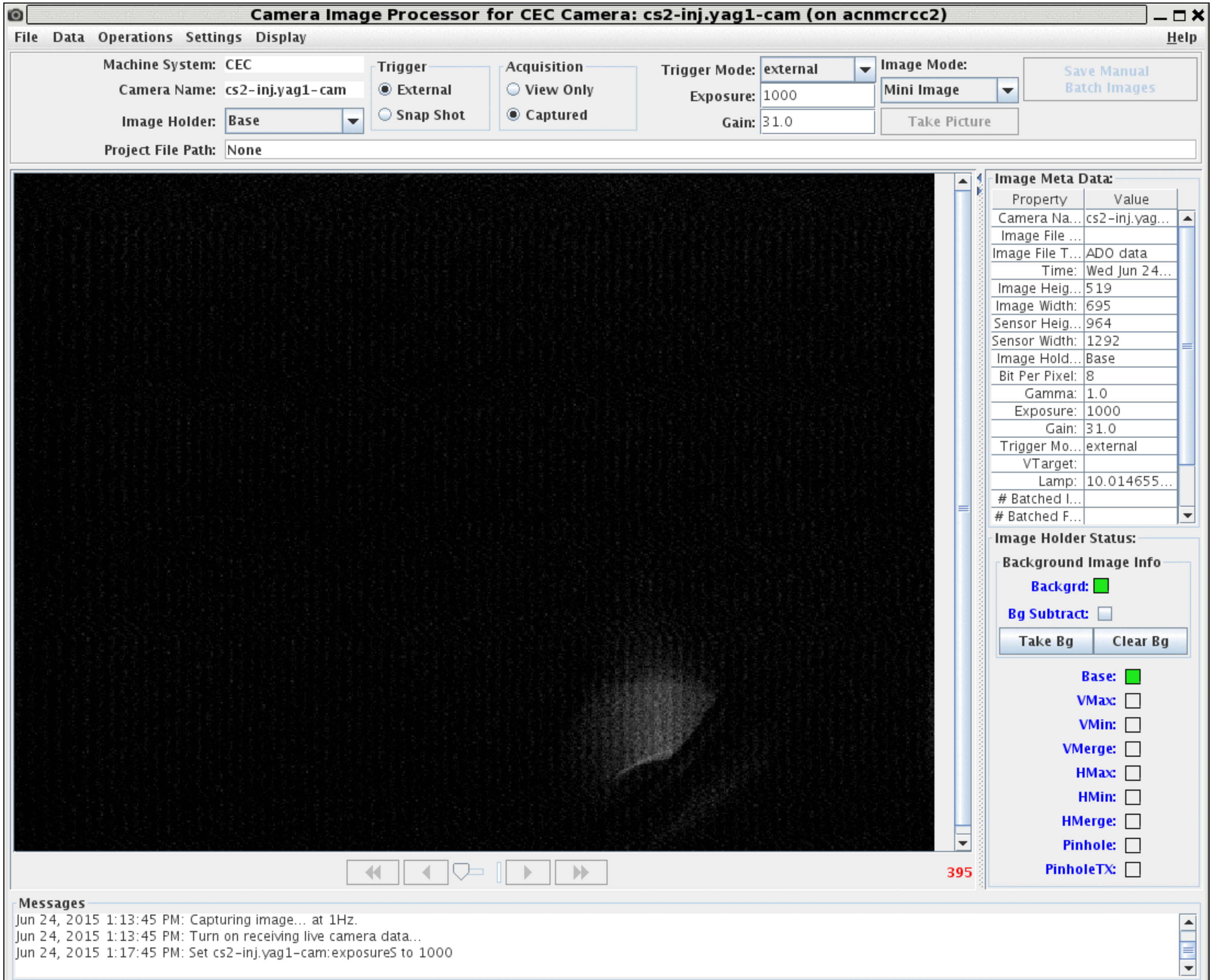
We have found that beam charge is limited by space charge forces

E_{laser}	Q	QE
375 nJ	0.5 nC	0.3%
1 µJ	0.66 nC	0.15%
6 µJ	1.24 nC	0.05%

After 50% laser spot size increase we were able to observe 3 nC charge.

We have increased pulse repetition rate from few Hz to 5 kHz (laser max) and observed 15 µA current.

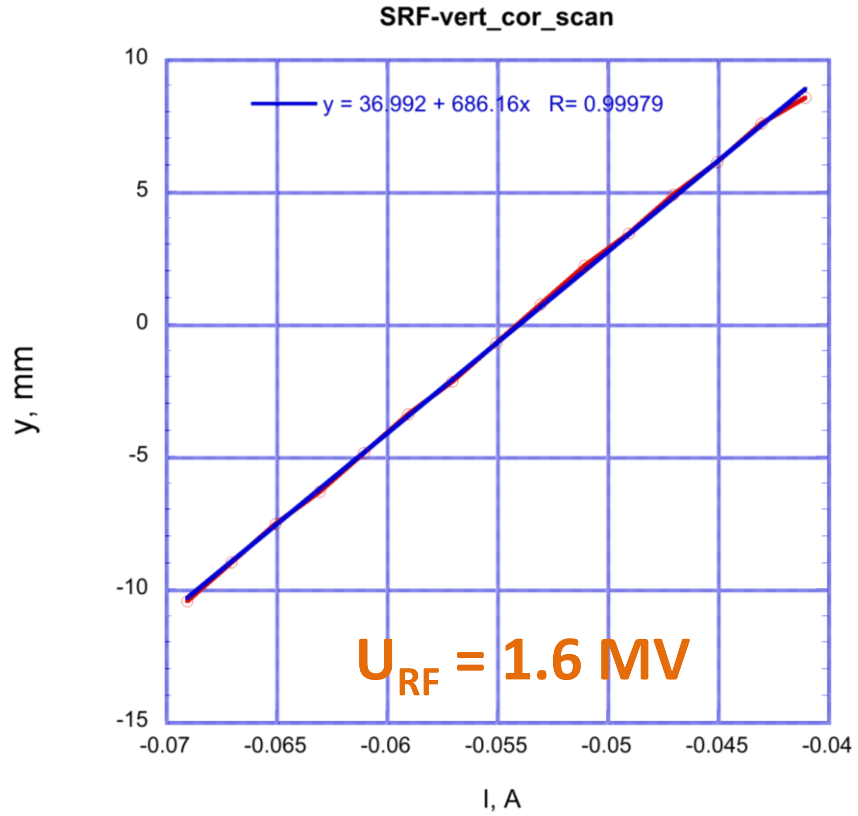
First Beam Image



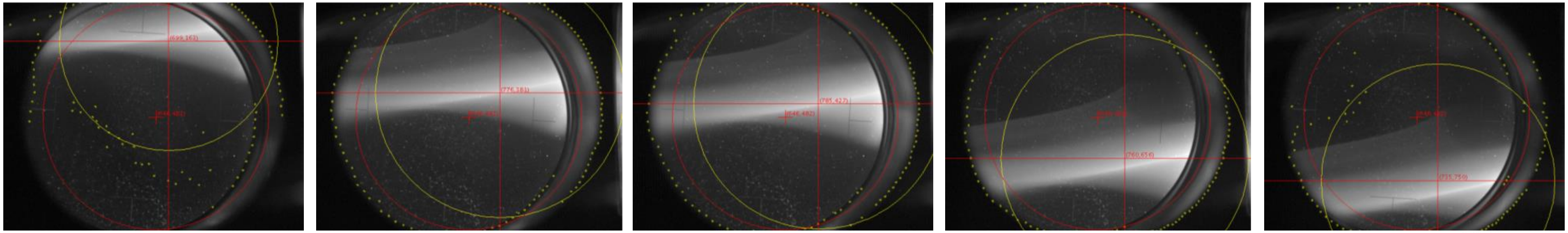
Beam Energy Measurement

We have found the cause why we were not able to observe full beam – stray magnetic field from an ion pump. The yoke was taken away but by this time the cathode had zero QE. Therefore, we used the dark current to measure beam energy.

We were able to see beam on the first profile monitor 2.77 m downstream. Beam was steered with calibrated vertical trim and beam position was observed on the profile monitor. No focusing elements in between.

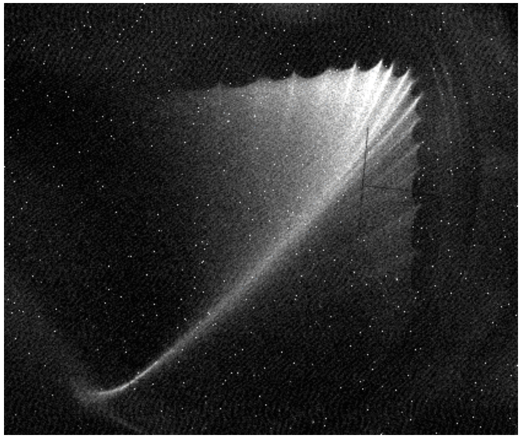


U_{RF} = 1.6 MV



Conclusions

- We have demonstrated the record parameters for the SRF gun
  - Warm cathode contributes to high QE and high beam charge
  - Low frequency of the gun allows to generate electron beam close to conditions in a DC gun and fully utilize available field gradient
- The implemented modifications and thorough conditioning of the system allowed us to observe the beam from the "first" try
- We are installing the remaining equipment and will resume tests in January-February



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