Presentation on Ghost Beam Measurements

Joshua Yoskowitz

November 12, 2018

Summary of past results

- 8/16 11pm (3588142/3588146): Mamun ended a 1mA electron beam that ran for 9 hours. Gun HV: 200kV, Gun solenoid at 200A, Anode bias at 1kV. After discontinuing the laser, the ghost beam was visible on all three viewers and had a very high intensity. Mamun lowered the gun solenoid current to zero and then back. Ghost beam disappeared with a brief rise in vacuum pressure on the gun IP.
- 8/17 1pm (3588392): With the gun HV at 200kV, gun solenoid at 200A, and anode bias at 1kV, all three viewers were inserted and then lifted sequentially. No ghost beam was observed.
- 8/19 7:40pm to 8/20 12am (3589175, 3589182, 3589222): After running 30uA electron beam for 10 minutes with gun HV at 200kV and gun solenoid at 200A, a high intensity ghost beam was observed and steered on all three viewers. The ghost beam kept its intensity for nearly 4 hours. The ghost beam was steered into the beampipe and then returned to its original position. No drop in intensity was observed. The gun HV was stepped down in increments of 10kV and then brought back to 200kV. Each time the ghost beam decreased in intensity, but restored its intensity once the HV was brought back to 200kV.

Summary of past results cont'd

- 8/20 (3589229) 12:42am: Mamun lowered the gun solenoid incrementally and brought it back to 200A. After each increment, the ghost beam moved further and further to the edge of the viewer and then finally went off screen at 40A. When the gun solenoid current returned to 200A from above 40A, the ghost beam returned to its original position with its original intensity. When the gun solenoid current returned to 200A from 40A, the ghost beam did not reappear.
- 8/20 (3589240) 1:45am: Mamun ran 30uA for 5 minutes and 30minutes with the anode at 0kV. In neither case was a ghost beam observed.
- 8/28 (3592355/3592382) 5:19pm: After running 2uA for 5 minutes with similar conditions as previous runs, the anode bias was lowered from 1kV to 600V, 500V, 400V, and 300V and brought back to 1kV each time. In the 600V and 500V measurements, the ghost beam intensity was reduced and then slowly restored to its original intensity when the anode bias was returned to 1kV. When the anode bias was lowered to 400V and 300V and returned to 1kV, the ghost beam disappeared and did not restore its intensity.

Summary of past results cont'd

- 8/28 (3592400/3592418) 6pm: Ran 2uA e-beam for 5 minutes with similar conditions, but with anode bias at 400V. No ghost beam appeared. Repeated experiment, but with anode bias at 500V. No ghost beam appeared. The anode bias was raised to 1kV, but no ghost beam appeared. Ran 3uA e-beam with anode bias at 600V. Ghost beam appeared and increased in intensity once the anode bias was raised to 1kV.

Ghost Beam Tests

- Test 1a: Run 100uA electron beam for 5, 10, 15, and 20 minutes, then measure ghost beam intensity as a function of time. Does lifetime and/or intensity of ghost beam scale with duration of prior electron beam?
- Test 1b: Repeat test 1a, but with 250uA. Does lifetime and/or intensity of ghost beam scale with prior electron beam current?
- Test 2: Threshold tests: What is the threshold anode bias, gun solenoid current, and solenoid lens currents (first two after gun solenoid) below which the ghost beam cannot survive (i.e. intensity of ghost beam is not restored to original intensity).
- Lifetime of high intensity ghost beam test
- Future tests?

Test 1a

- See logbook entries here: https://logbooks.jlab.org/book/gtslog
- Ran 100uA for 5, 10, 15, and 20 minutes and recorded ghost beam intensity profile after 0, 2, 4, and 6 minutes.
- Had to center the ghost beam on viewer 2 each time, as the ghost beam is not in the same place as the electron beam at viewer 2.
- Gun HV at 100kV, gun solenoid at 150A, anode bias at +1kV

Test 1a Intensity vs. Time

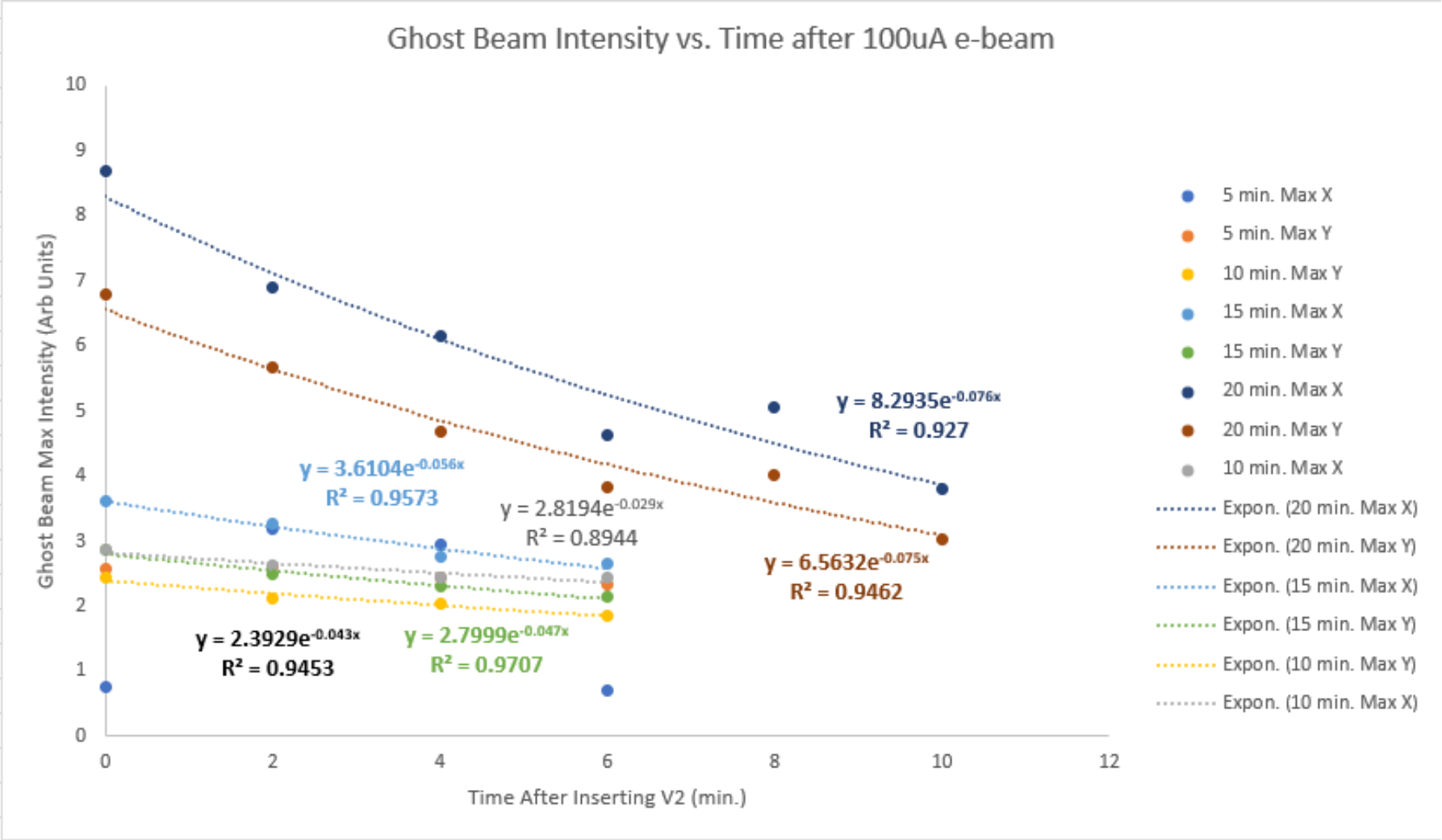

Figure: Ghost Beam Intensity vs. Time after 100uA e-beam

Test 1a Size vs. Time

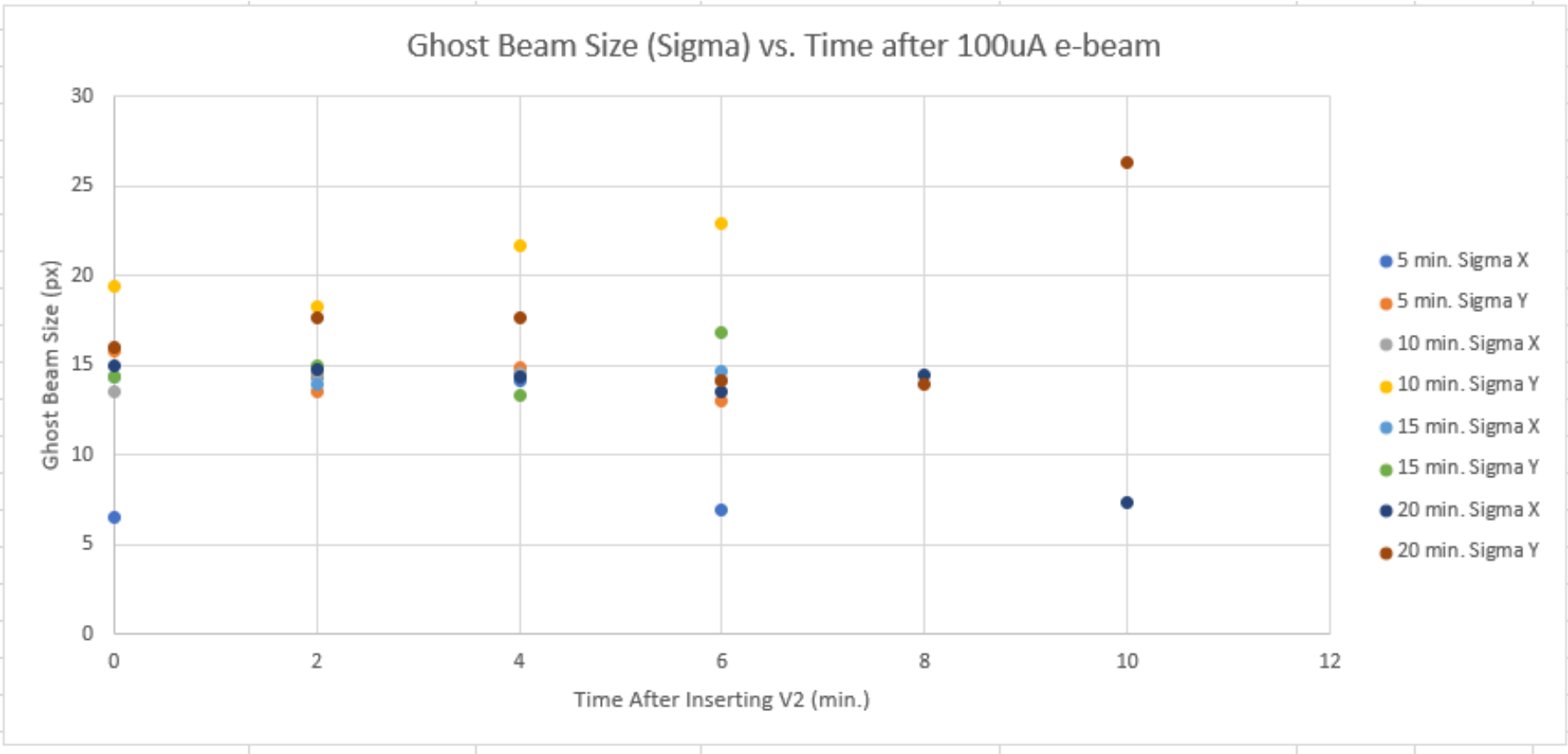

Figure: Ghost Beam Size (Sigma) vs. Time after 100uA e-beam

Test 1b

- See logbook entries here: https://logbooks.jlab.org/book/gtslog
- Repeated test 1a for 250uA. Had to center the ghost beam on viewer 2 as before.
- Gun HV at 100kV, gun solenoid at 150A, anode bias at +1kV

Test 1b Intensity vs. Time

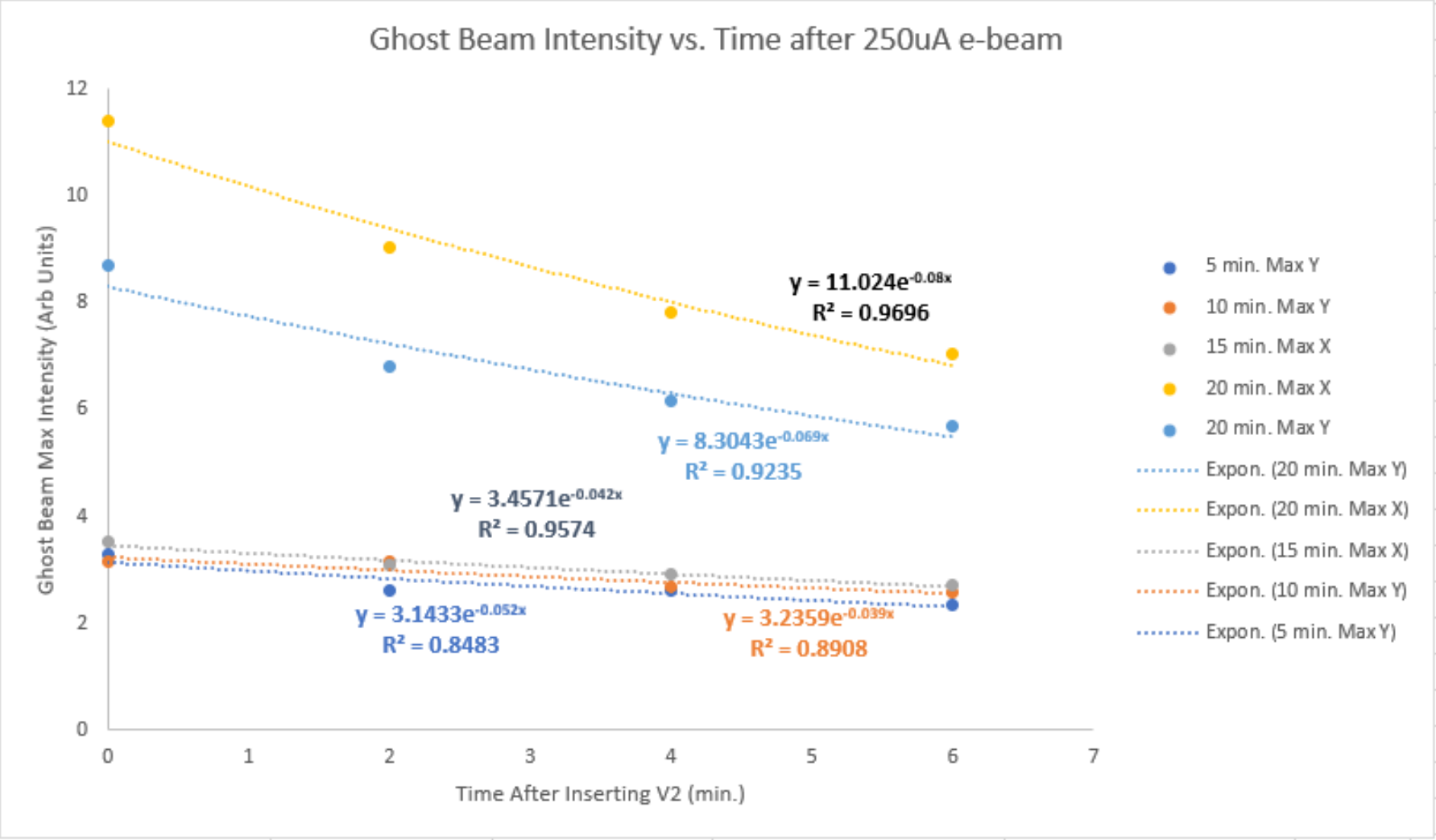

Figure: Ghost Beam Intensity vs. Time after 250uA e-beam

Test 1b Size vs. Time

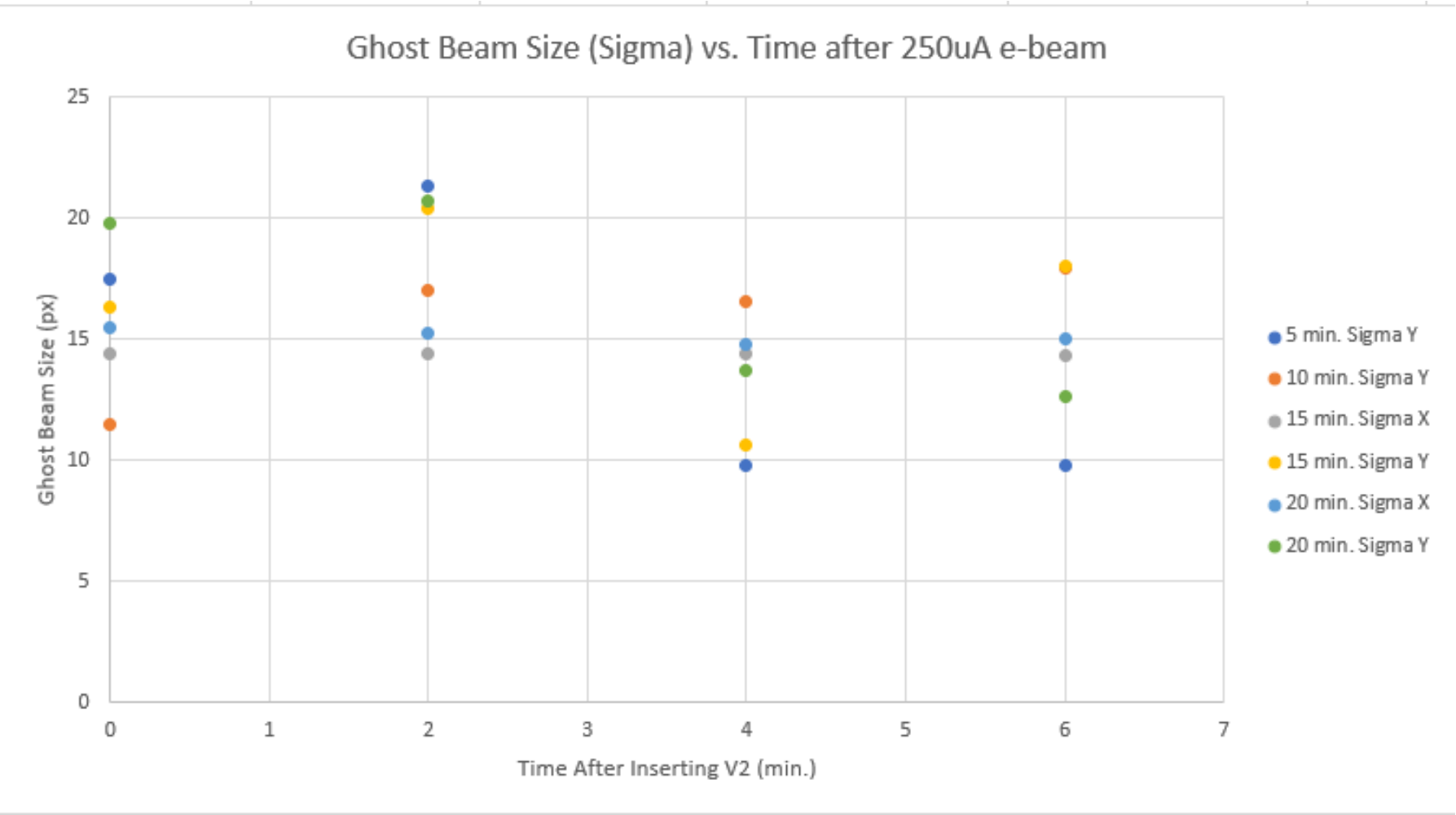

Figure: Ghost Beam Size (Sigma) vs. Time after 250uA e-beam

Anode bias threshold test

- See logbook entries 3623086 and 3623092.
- Ran 100uA for 10 minutes.
- Gun HV at 100kV, gun solenoid at 150A, initial anode bias at +1kV
- Slowly lowered anode bias until ghost beam disappeared. This occured at anode bias dial index 3, corresponding to 410V.
- Returned anode bias to 1kV. Ghost beam initially had a lower intensity, but slowly returned to its original intensity.
- Ran 100uA for 10 minutes with anode bias at 410V. No ghost beam observed. Raised anode bias to 1kV. No ghost beam observed, indicating that 410V is the threshold voltage. Vacuum levels still show characteristic decay.

Gun solenoid threshold test

- See logbook entries 3623136 and 3623599.
- Ran 100uA for 10 minutes with gun HV at 100kV, gun solenoid initially at 150A, and anode bias at +1kV.
- Lowered gun solenoid current in steps of 25A until reaching 75A at which point the ghost beam was deflected off screen. Recording ghost beam intensity profile at each step.
- Returned gun solenoid to 100A. Ghost beam slowly returned to its intensity and position as when the gun solenoid current was previously at 100A.
- Lowered gun solenoid current to 50A and then returned it to 100A. Ghost beam slowly returned to its original intensity and position, but took a longer time to do so compared to 75A measurement.
- Repeated for 45A, 40A, 35A It took an increasingly longer time for the ghost beam to return to its original intensity.
- Repeated for 30A. Ghost beam did not return.
- After 100uA for 20min. run, gun solenoid current was lowered directly to 30A from 150A and then returned to 150A. Ghost beam did not reappear, indicating that 30A is the threshold current.

Lifetime of high intensity ghost beam

- See logbook entries 3623547 and 3623657.
- After clearing the ghost beam by lowering the gun solenoid current to 30A and returning it to 150A, I ran 250uA e-beam for 10 seconds using magnet settings for the ghost beam, not the electron beam. Electron beam scraped part of beamline pipe (or some beamline apparatus), causing vacuum levels to briefly rise to ˜4e-8 torr at the gun IP.
- I then recorded the ghost beam intensity profile every minute for 10 minutes on viewer 2.

Intensity vs. Time for high intensity ghost beam

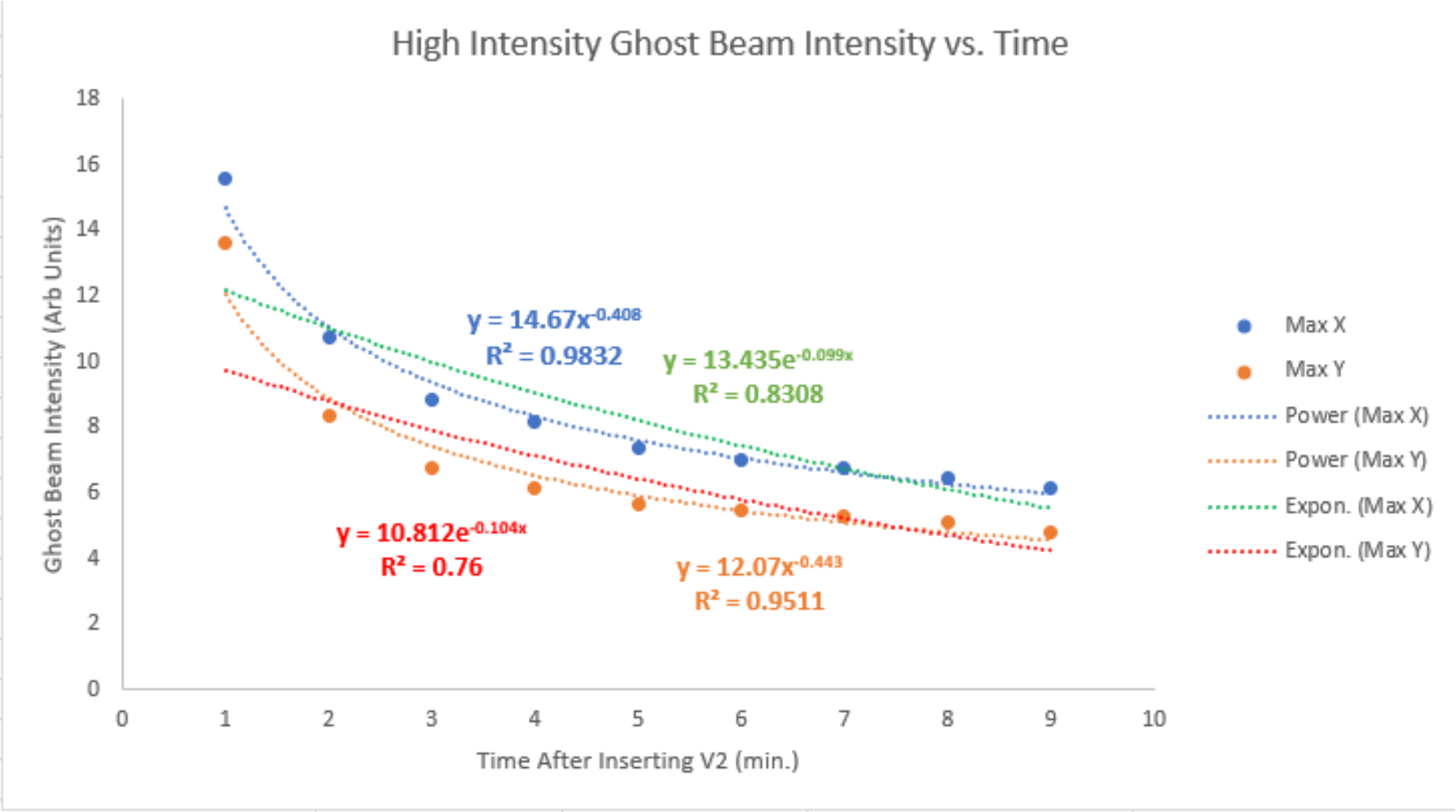

Figure: Intensity vs. Time of high intensity ghost beam

List of conclusions from ghost beam testing

- Ghost beam is made up of negatively charged particles due to how it moves with the corrector magnets. Uncertain as to whether or not they are electrons due to the large difference in magnet settings for the electron and ghost beams.
- Ghost beam appears below the electron beam by several millimeters...maybe centimeters.
- For an electron beam with gun HV at 100kV, gun solenoid at 150A, and anode bias at 1kV, the threshold anode bias is 410V and the threshold gun solenoid current is 30A. Above these values, when the anode bias or gun solenoid current is returned to its original value, the ghost beam intensity will return to its original intensity. It takes longer to do so the closer the anode bias or gun solenoid current is to their threshold values.
- Ghost beam is NOT stable under these conditions. It has a definite lifetime that apparently scales inversely with the maximum vacuum level during the prior electron beam run. The ghost beam intensity exponentially decays.
- First two solenoid lenses have no effect on ghost beam intensity, as the ghost beam appears even when these solenoids are off.

Future tests?

- Perform "mass spectroscopy" on ghost beam to determine the identity of the ghost particles by steering the ghost beam a certain amount using corrector magnets, observing the movement of the ghost beam on the viewers, and determining their charge to mass ratio.
- Using some sort of spectrometer to measure the light emitted due to ionization of gas molecules. A gas molecule is ionized by a high-energy, incident electron. An electron in the gas molecule reaches an excited state, and then returns to its original state and in doing so, emits a characteristic frequency of light depending on the difference in energy levels.
- Using a BPM to measure characteristic ion frequencies from ions that are trapped within the electron beam.