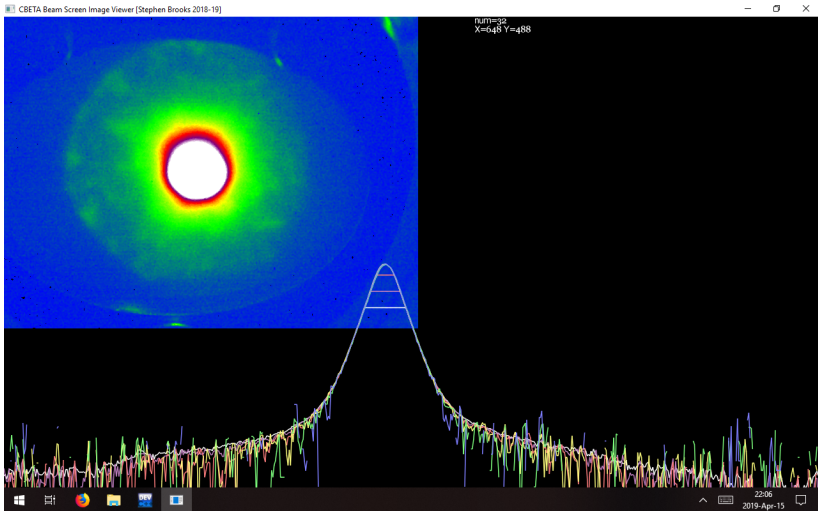# Observation of Beam Halo in the CBETA Injection Line
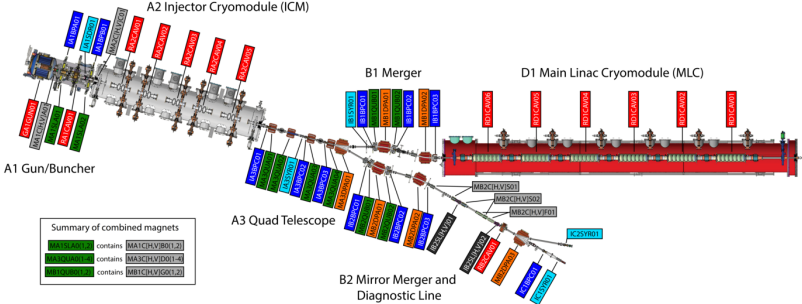
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CBETA meeting

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This is taken at IA3SYR01, just downstream of the ICM. Took exposures from 1,2,4,8,16,32 bunch trains. Longest ones saturate to some extent. Rescaled them by 1/trains and they agree well in the good data region.
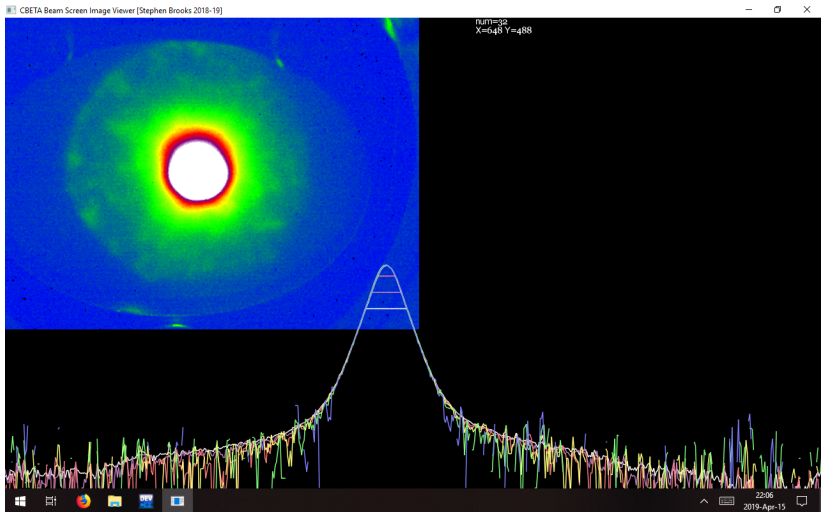
Injector layout

FAT Injector, Diagnostic Line, and Linac Layout

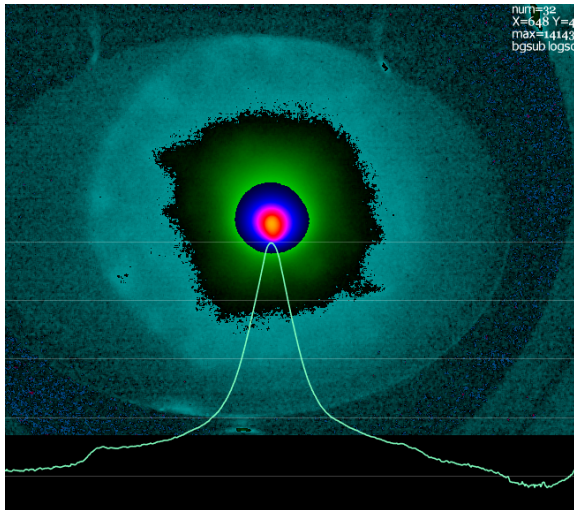Beam was 400Hz, 42 bunches per train, camera exposure 0.0025, 0.005, 0.01, 0.02, 0.04, 0.08 seconds. Background frame was subtracted (helps a lot - 10x). Median filter on the camera was on, 10 frames were averaged (also helps a lot). Something that looks like halo is visible.

Combined brightest, non-saturated part of each image for each pixel. Makes a larger dynamic range. Halo is at 3e-4 area intensity. However, it covers 100x the area as the core so actually contains ~3% of the "charge".

Other stuff that could cause halo-looking signal

- ▶ Camera effects
  - ▶ Lens flare
  - ▶ Bloom
- ▶ Reflections within the vacuum chamber and back on the screen (can see this)
- ▶ Direct light from cathode laser bouncing off screen (no bend between cathode and this screen)
- ▶ Sensitivity variations in BeO crystal

Real halo could be from:

- ▶ Ambient light on photocathode
- ▶ Ivan: maybe halo is junk laser pulses not fully extinguished

How to eliminate spurious halo-looking things?

Steered a dipole corrector upstream of screen. Definitely see lens flares from camera lens travelling in the opposite direction as beam. Halo appears to move with beam, however can't yet distinguish this from a camera system effect so...

Changed a quad just upstream of the screen. Halo **changes shape** like a beam, camera/lens/bloom effect would not.
Conclusion: this is halo is real electrons.

Other stuff causing light signal

> YES   Camera effects
>> YES   Lens flare
>> YES   Bloom

> SOME   Reflections within the vacuum chamber and back on the screen (can see this)

> NO?   Direct light from cathode laser bouncing off screen (no bend between cathode and this screen)

> NO?   Sensitivity variations in BeO crystal

A1 screen. Changing the steering right after the gun (thru a solenoid so diagonal). Before the ICM. No visible halo at this stage. We do see camera bloom (brightness beyond the screen).
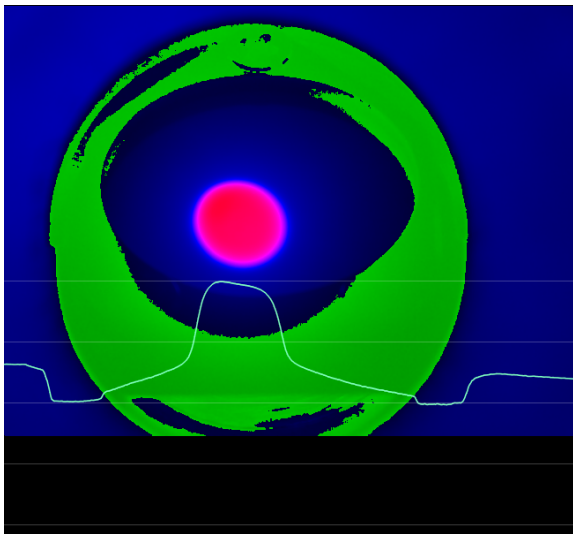
Attempted high dynamic range stack of A1 screen but dominated by scattered light, bloom etc. No halo visible.
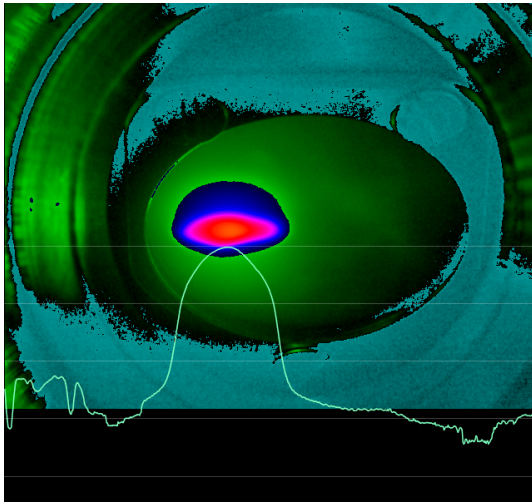
B1 screen. Going further downstream, past first dipole bending towards MLC. Ambiguous - maybe halo here? Would have to scan quad to verify.

Managed to get a quad scan at 9:30pm between MLC stuff. The
halo is at B1 and made of electrons, as can be seen from the GIF.

How to get rid of halo — options

- ▶ If it's from the cathode, there's already a plan to use a selectively-activated cathode that only produces beam from a small spot for high-current running
- ▶ An early collimator would also work if halo is from the cathode
- ▶ If it's the laser ghost pulses, the planned pocl cell upgrade should improve things

Optional stuff we could put in the beam pipe that would help

- Collimators e.g. from Japan or just some cheap graphite annulus
- Screens with holes in them, or adjustable insertion edge screens for better halo pics
- Joseph Wolfenden (Cockroft Inst., UK) has a clever fancy halo diagnostic with micro-mirrors
- Alignment/survey stuff for getting absolute beam axis reference
  - Grids/lines on screens, survey fiducials on screens, accurate positioning
  - Laser pointer that goes down middle of pipe onto target at far end, shows (0,0) for screens