The Center for BRIGHTBEAMS
A National Science Foundation Science & Technology Center

Pulsed Electron Beams for Radiation Effects Testing

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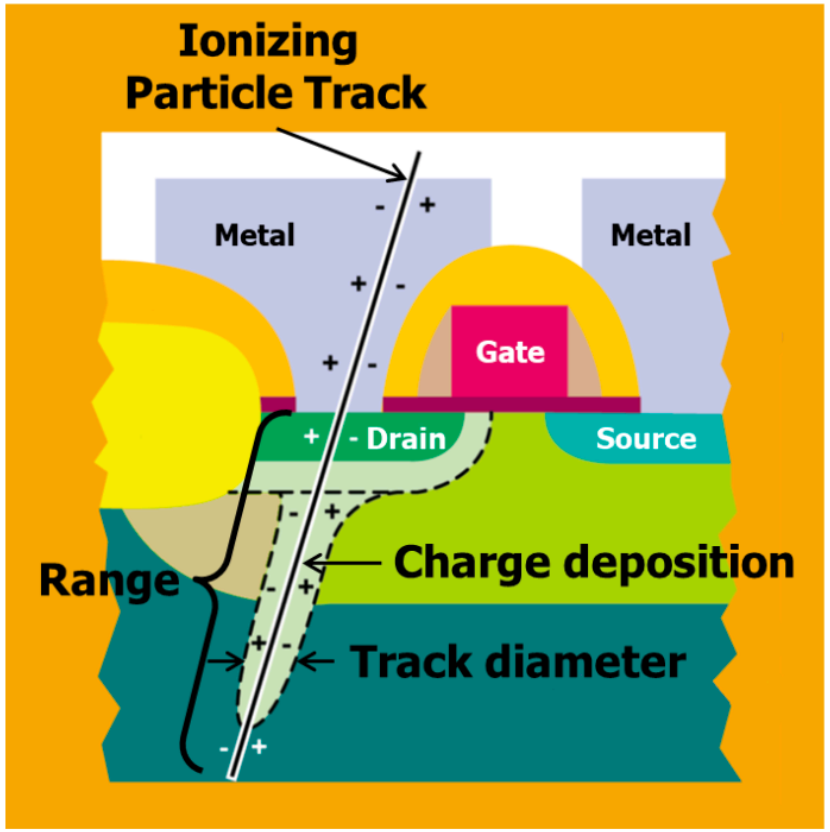
Radiation Effects

- The radiation hardness of an electronic component is critical to mission success
- Single Event Effects (SEE) are caused by single ions hitting spacecraft
- SEE can cause bits to flip, memory losses, or latch-up
- Imperative to have adequate testing infrastructure to characterize SEE resistance

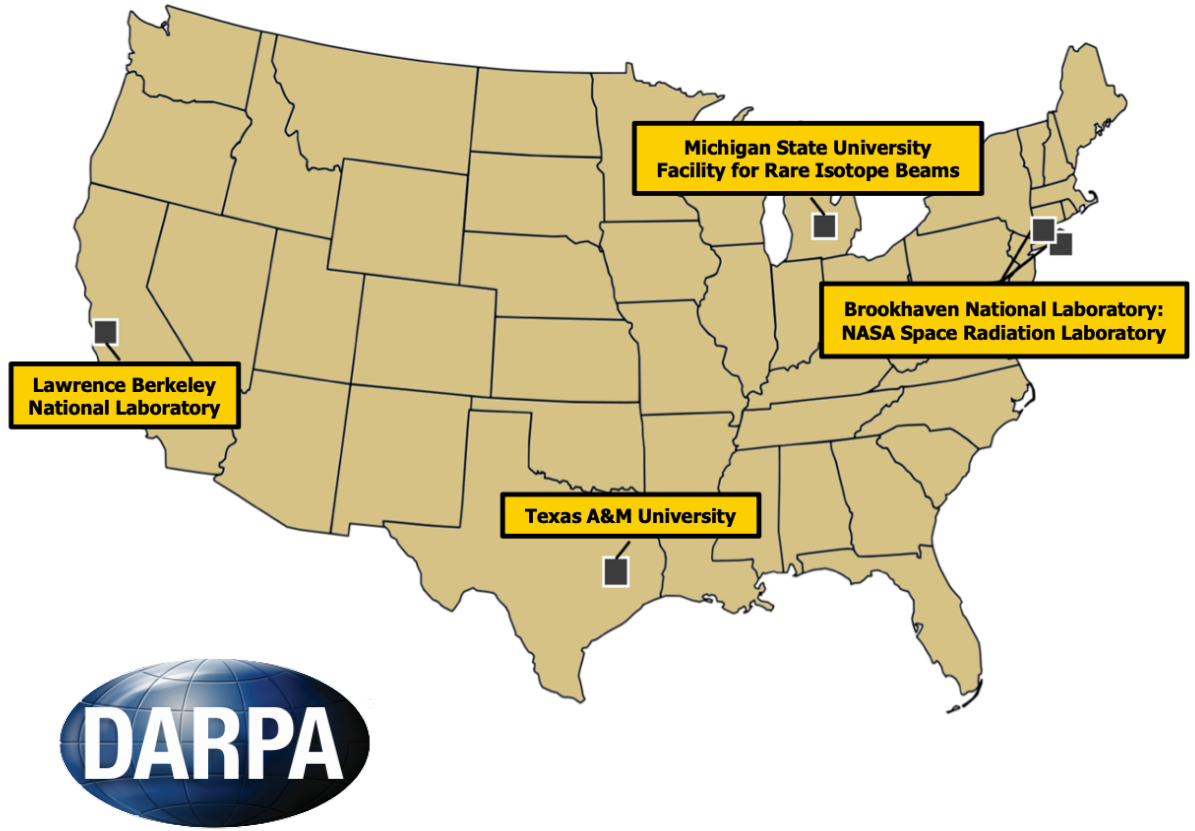
Single-event Effects (SEE)



Testing at the Speed of Light, National Academies of Sciences, Engineering and Medicine, 2018

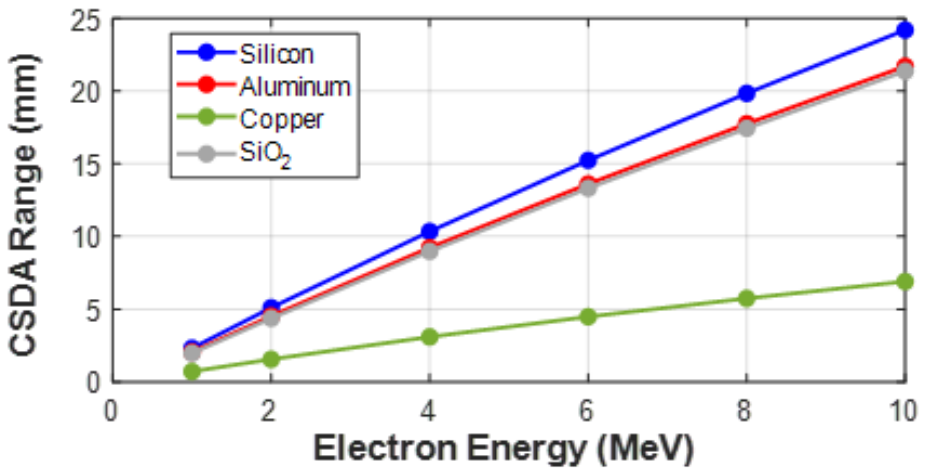
Current Testing Infrastructure

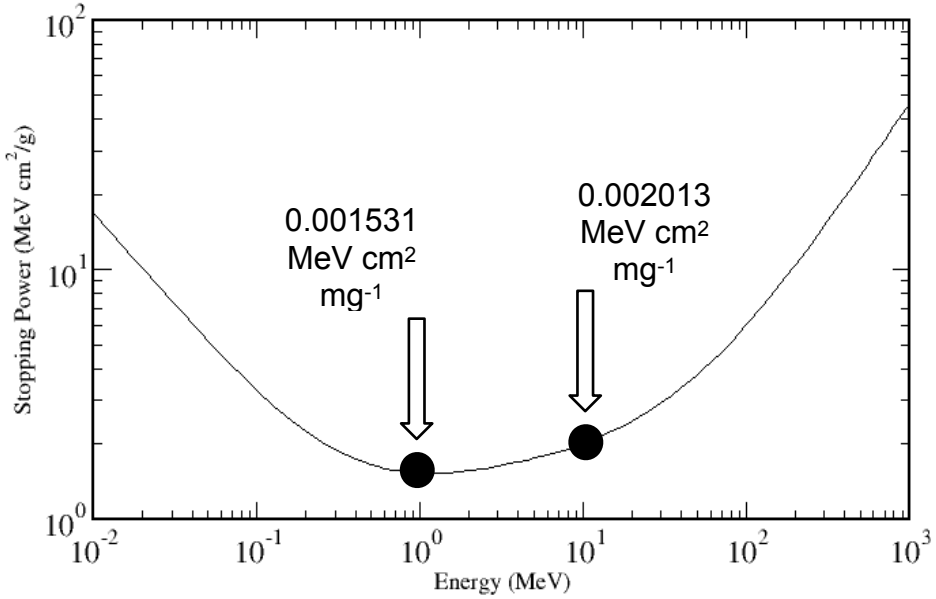
- SEE testing takes place in heavy-ion facilities
- Current facilities are extremely oversubscribed
- Current heavy-ion sources don't have variable Linear Energy Transfer (LETs), high penetration depth, and beam localization
- Alternatives to heavy-ion testing are required for the space missions of the future



Pulsed Electrons | An Alternative

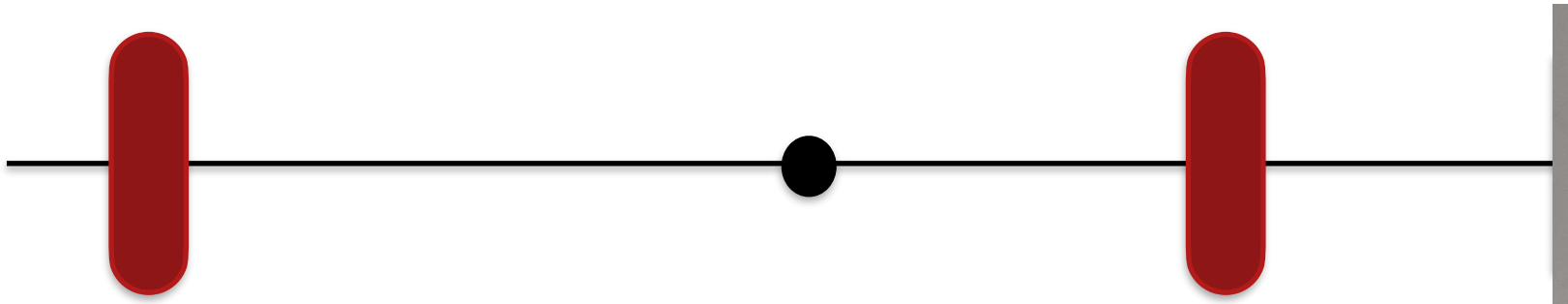
- Ultrafast high-energy electron beams are a good candidate
- Electrons have deep penetration depths
- Short bunches can mimic ion tracks
- Bunch control allows for beam localization and variable LETs





Testing at PEGASUS

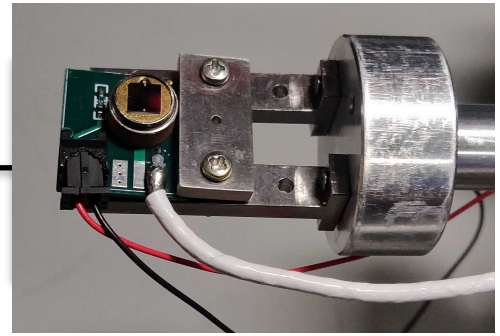
- Sought to correlate photodiode responses between existing heavy-ion data and pulsed electrons



Solenoid
z = 0.2895 m

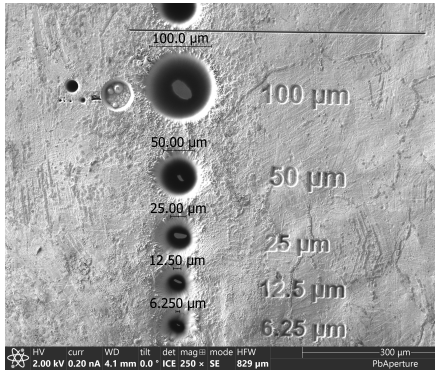
Aperture
z = 3.191 m

Solenoid
z = 4.5618 m

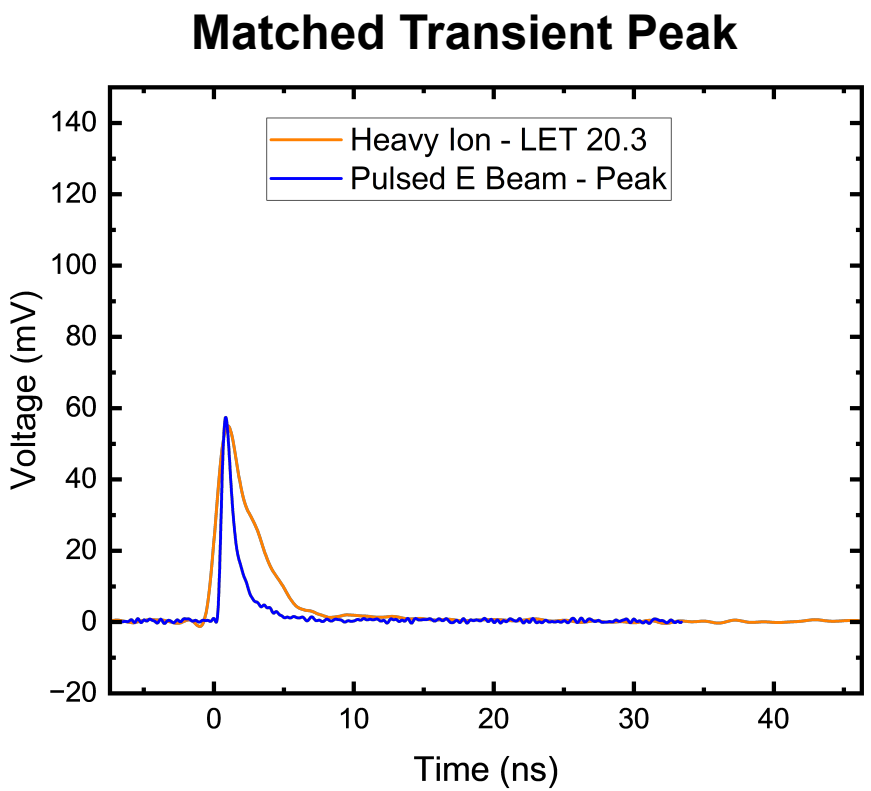


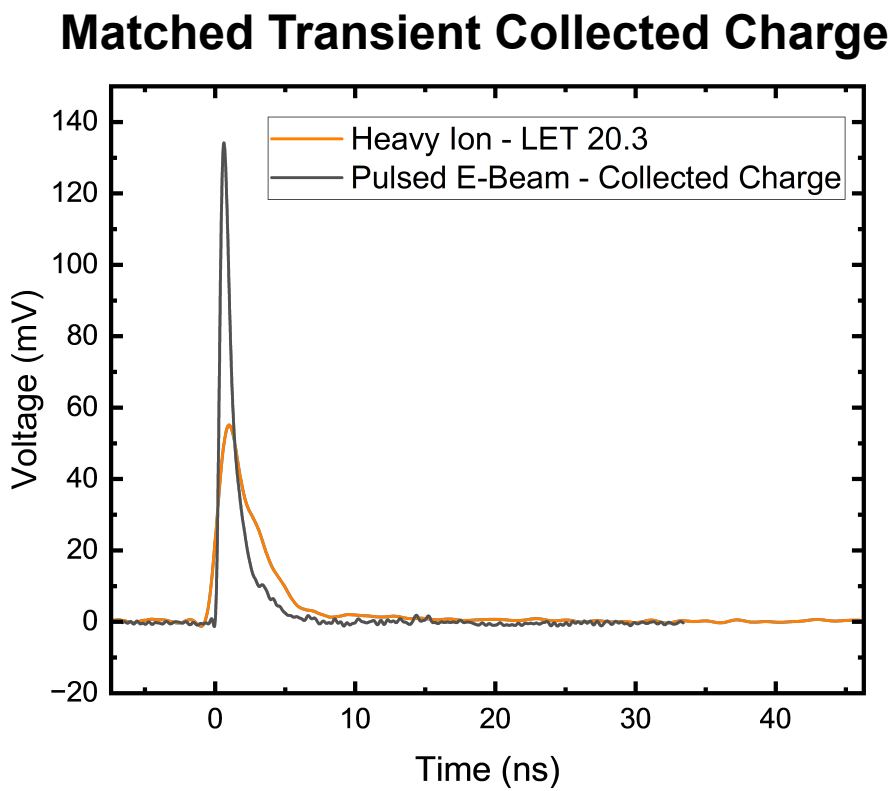
Sample
z = 5.1317 m

Beam Parameters:
- 6 MeV
- < 100 um spot size (unclear due to jitter)



First Tests at PEGASUS

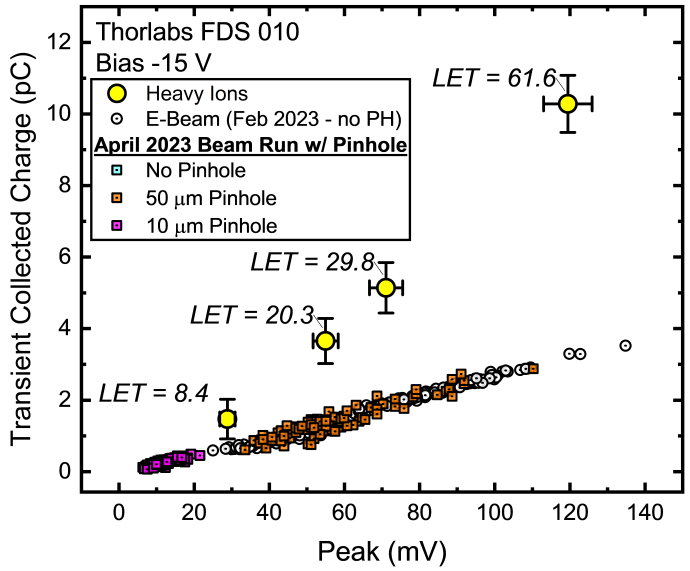


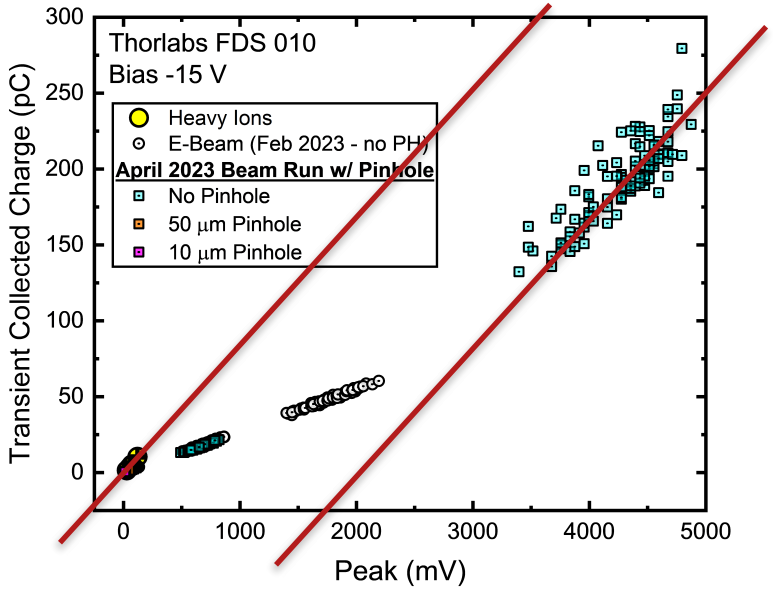


Electron transients are faster and shorter

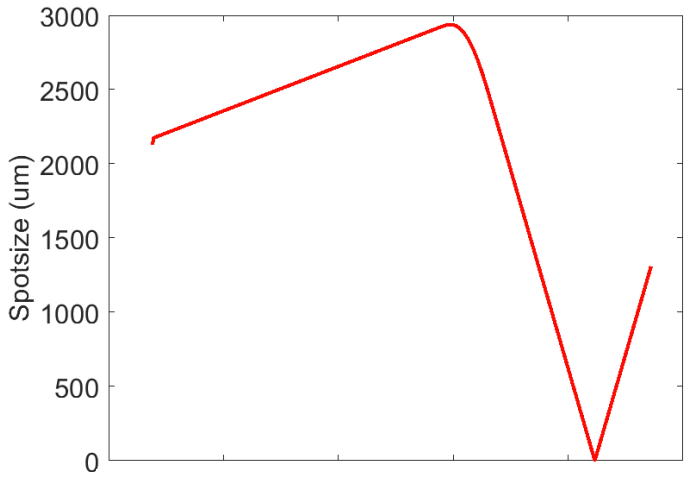
First Tests at PEGASUS

- Strong correlation was not achieved
- Saturating the sample with charge yielded better correlation at similar spot size
- Same deposited charge over larger area collects more efficiently (than heavy ion)
- Looking towards generating high fidelity smaller spots to better mimic charge collection physics



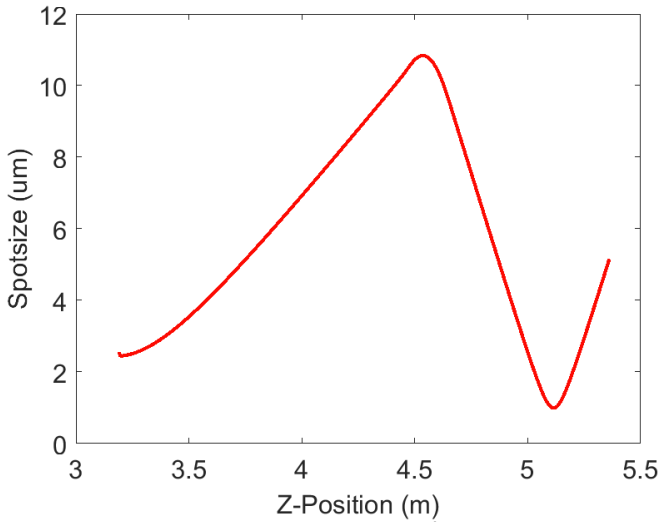


Achieving Small Spot Sizes



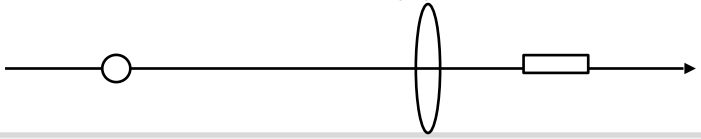
No pinhole

20 um at sample with 500 fC



10 um pinhole

940 nm at sample with 500 fC

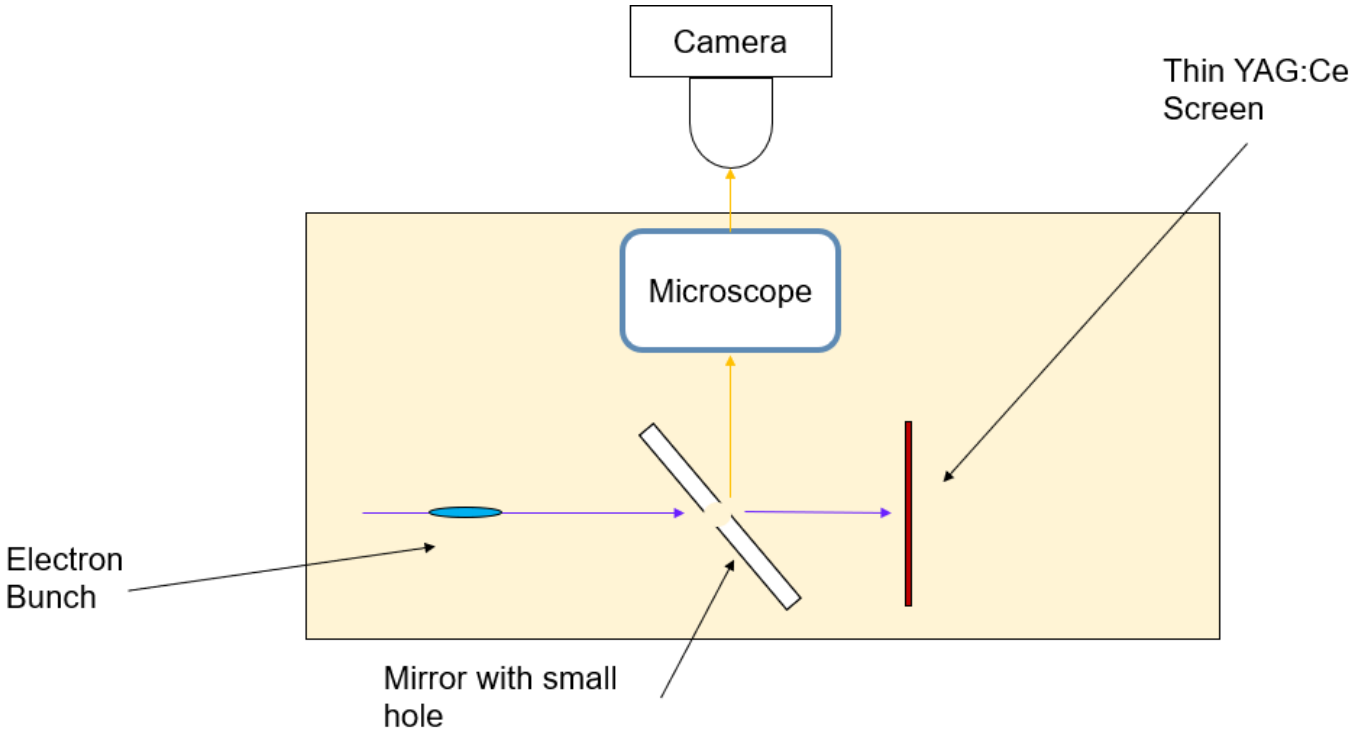


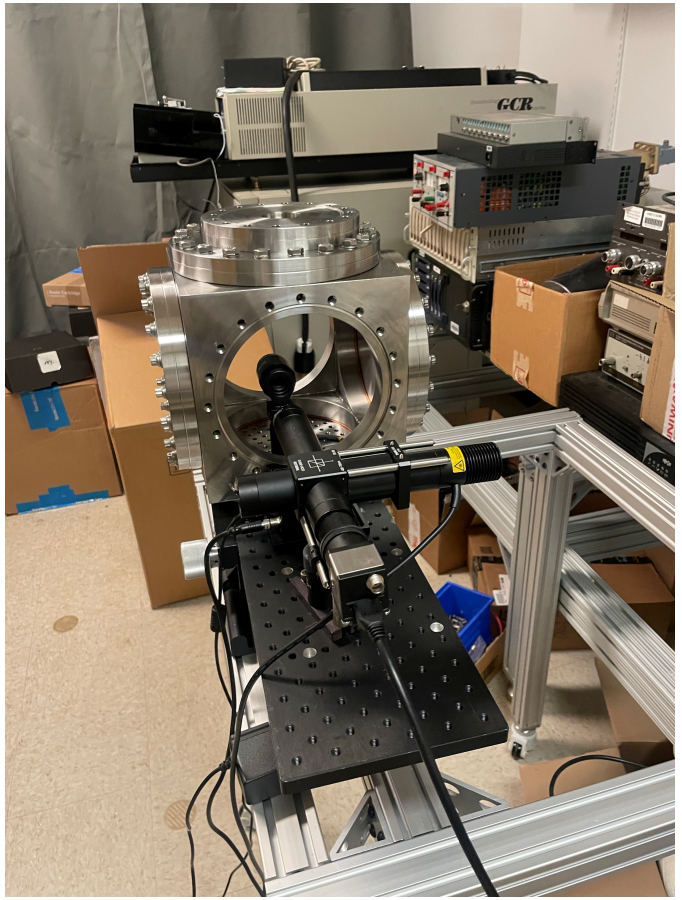
- Simulations in GPT
- Pinhole to sample simulations shown

Parameter	Value
σ_x	200 um
σ_t	150 fs
γ	7.28
MTE	0.5 eV

Current Work

- Building a single-shot spot size diagnostic





Moving Forward

- Moving towards DARPA objectives for ASSERT - higher energies, thicker targets
- Work with Yttrium photocathodes is underway to reduce emittance at photoemission
- Planning to run experiments in the next few months with smaller spot sizes
- Looking to test out the single-shot spot size diagnostic
- Making sample chamber upgrades for better in-vacuum alignment
- Presenting further research results at IPAC ‘24