Northern Illinois University

Design and Analysis of a Halo-Measurement Diagnostics

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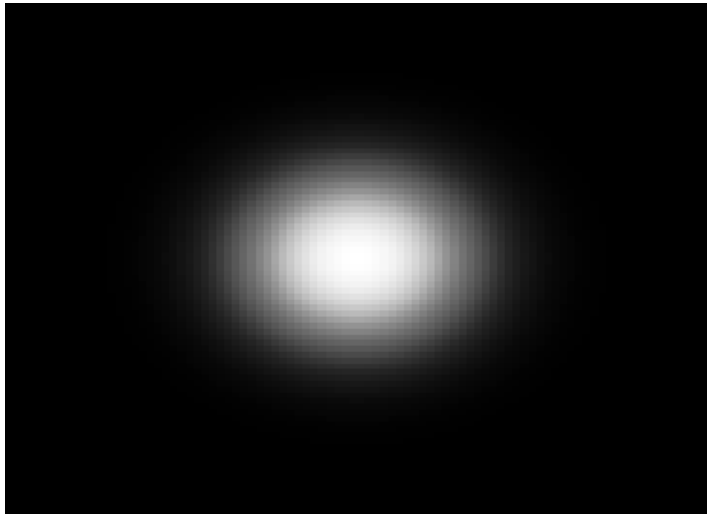
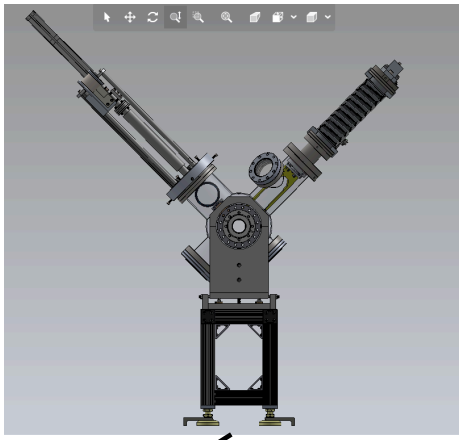
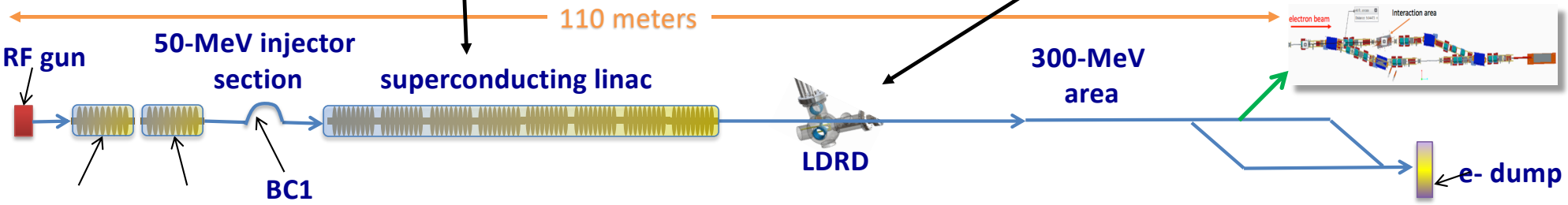
What is a Beam Halo?

- The low intensity of particles surrounding the main core of the beam[1]
- This halo can cause beam loss, which could cause issues with experiments
  - Limit the average current of the ERL cooler

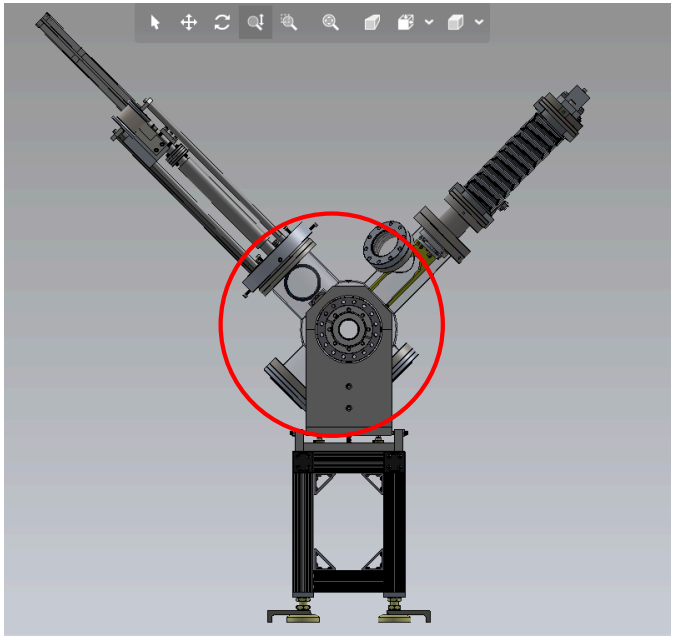


FAST Project^2





Large-dynamical-range diagnostics



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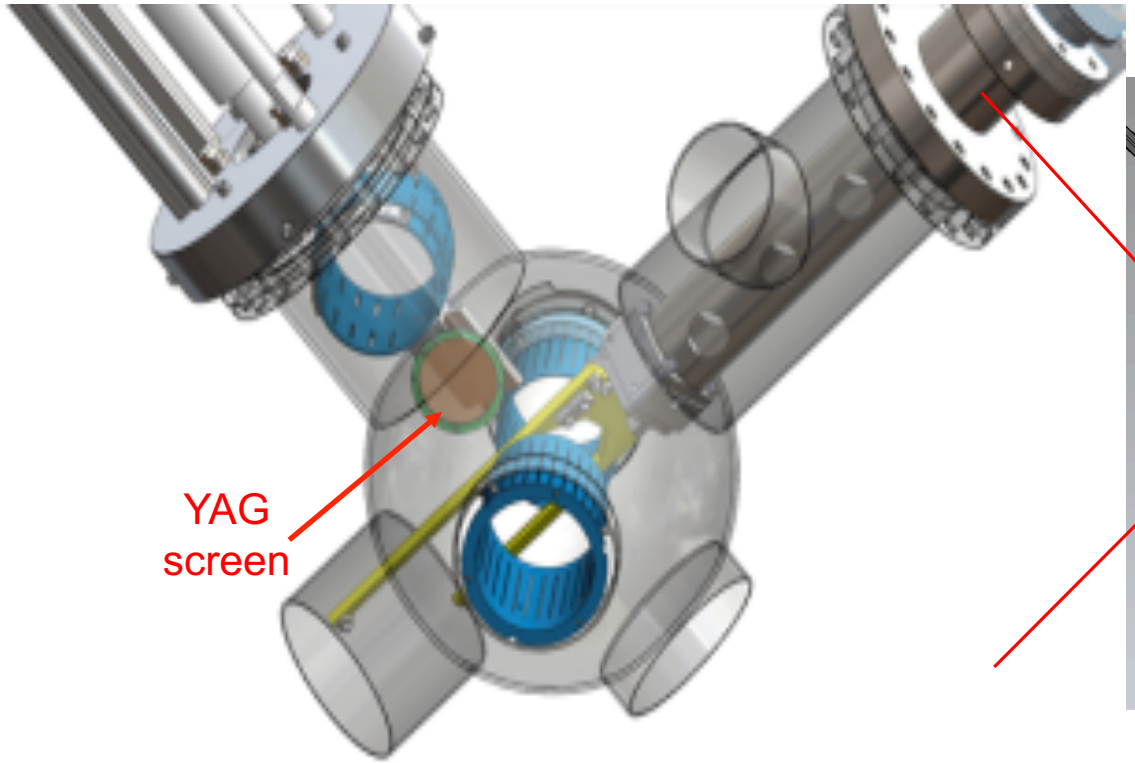
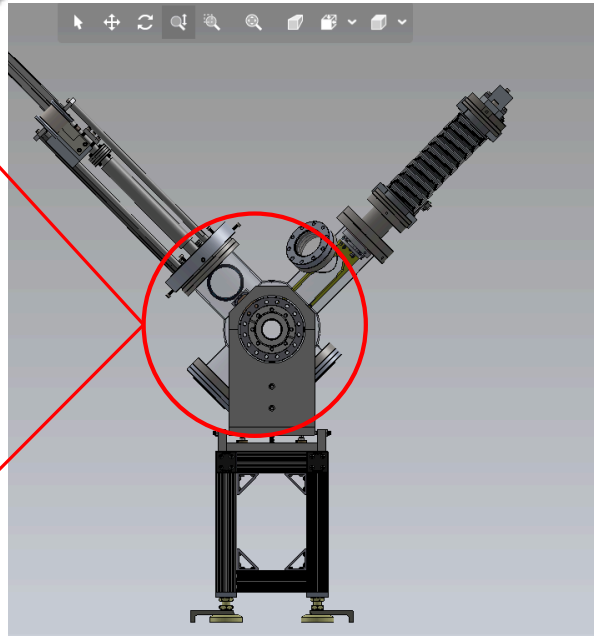
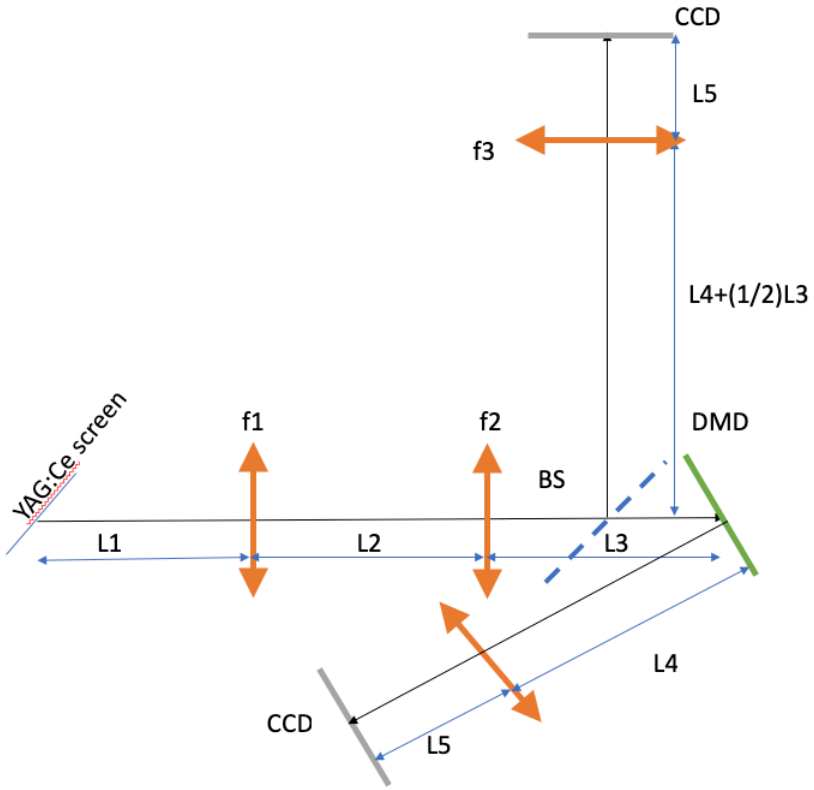




Optics Setup



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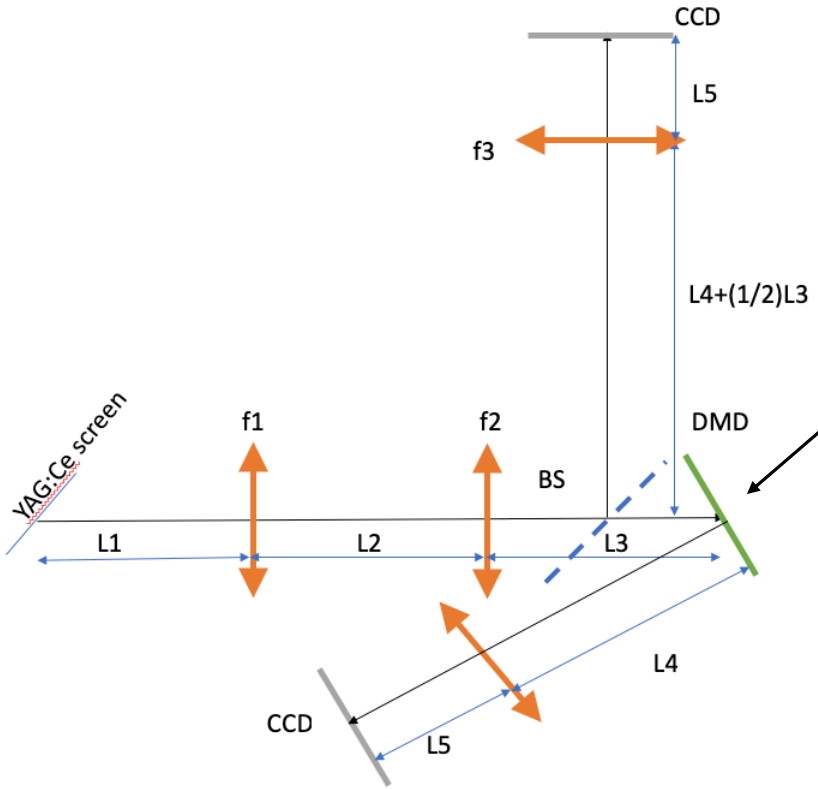
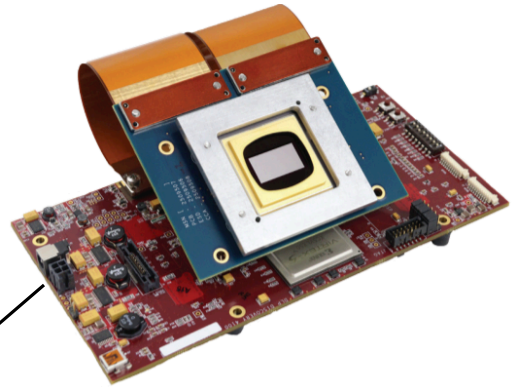
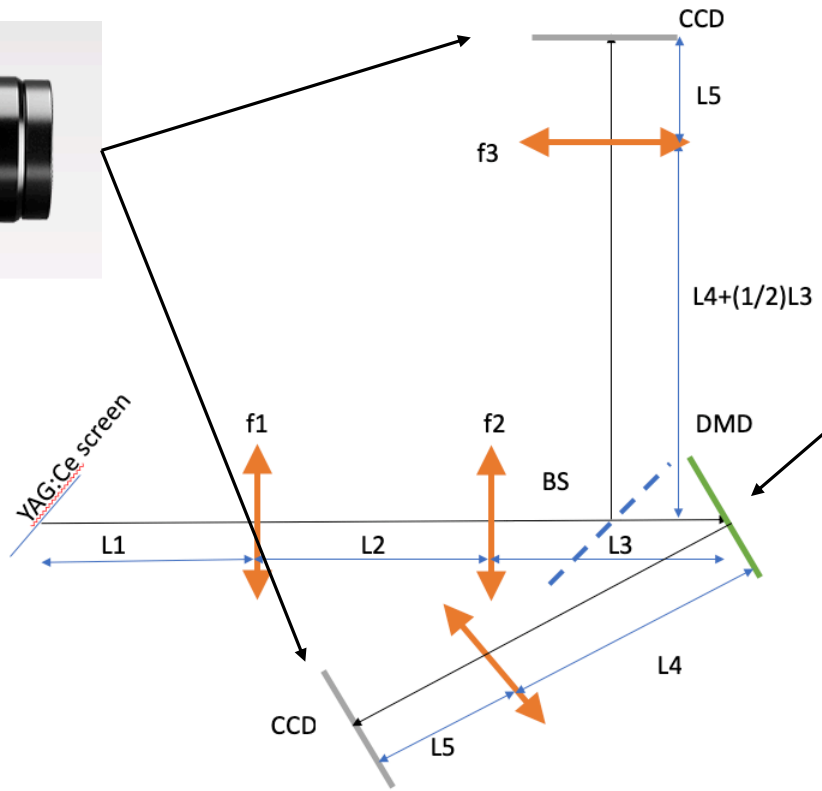


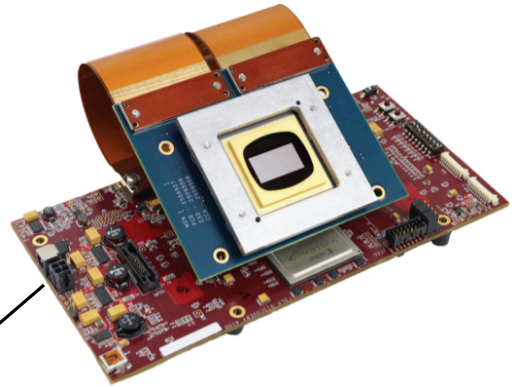


DLP6500 Type-S
Digital-Micromirror Device
(DMD) Board

Optics Setup

Prosilica GC 2450
CCD Camera





DLP6500 Type-S
Digital-Micromirror Device
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Ray Transfer Matrix

- Want to focus beam on DMD
- Completed with the sympy Python package

$$\begin{bmatrix} r_F \\ \theta_F \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} * \begin{bmatrix} r_i \\ \theta_i \end{bmatrix}$$

Ray Transfer Matrix

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$$\begin{bmatrix} r_F \\ \theta_F \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} * \begin{bmatrix} r_i \\ \theta_i \end{bmatrix}$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \left(-\frac{1-\frac{l_2}{f_2}}{f_2} - \frac{1}{f_1} \right) l_3 - \frac{l_2}{f_1} + 1 & \left(-\frac{(1-\frac{l_1}{f_1})l_2 + l_1}{f_2} - \frac{l_1}{f_1} + 1 \right) l_3 + \left(1 - \frac{l_1}{f_1}\right) \\ -\frac{1-\frac{l_2}{f_1}}{f_2} - \frac{1}{f_1} & -\frac{(1-\frac{l_2}{f_2})l_2 + l_1}{f_2} - \frac{l_1}{f_1} + 1 \end{bmatrix}$$

Optical Values

Component	Value
f_1	Constant, can be chosen
f_2	Constant, can be chosen
l_1	Constant based off of LDRD
l_2	$l_2 = \frac{f_1(7f_2 + 13l_1) + 13f_2l_1}{13(-f_1 + l_1)}$
l_3	$l_3 = \frac{f_2(7f_1 - 20l_2)}{20(f_1 + f_2 - l_2)}$

Everything from the YAG screen to the DMD is in terms of known constants.

Optical Values

Component	Value
f_1	0.025 m
f_2	0.030 m
l_1	0.314 m
l_2	0.061 m
l_3	0.255 m

Everything from the YAG screen to the DMD is in terms of known constants.

Summary

- Outlined need for halo-measurement
- Designed an optical layout
- Calculated the ray transfer matrix
- Solved for distances using focal lengths of lenses
  - Entry point to DMD

Future Plans

- Finish optical calculations for remaining variables
- Simulate optical setup with SRW Python program
- Confirm optical setup, purchase apparatus
- Build/test optical setup
- Attach setup to LDRD, take measurements

Acknowledgements

- This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear physics under contract DE-AC05-06OR23177 and DE-AC02-07CH11359.

- [1]Morris, A., & Peggs, S. (2018). A review of various methods of detecting and measuring beam halos. doi:10.2172/1475159
- [2]Piot, P., et al. (2019) High-charged magnetized beams at FAST-IOTA. 2019 JLEIC collaboration meeting, Jlab.