Arthur B. McDonald
Canadian Astroparticle Physics Research Institute

Measuring the Refractive Index of Aerogel Tiles using OCT for the HELIX Experiment

Avani Bhardwaj

27th May 2024

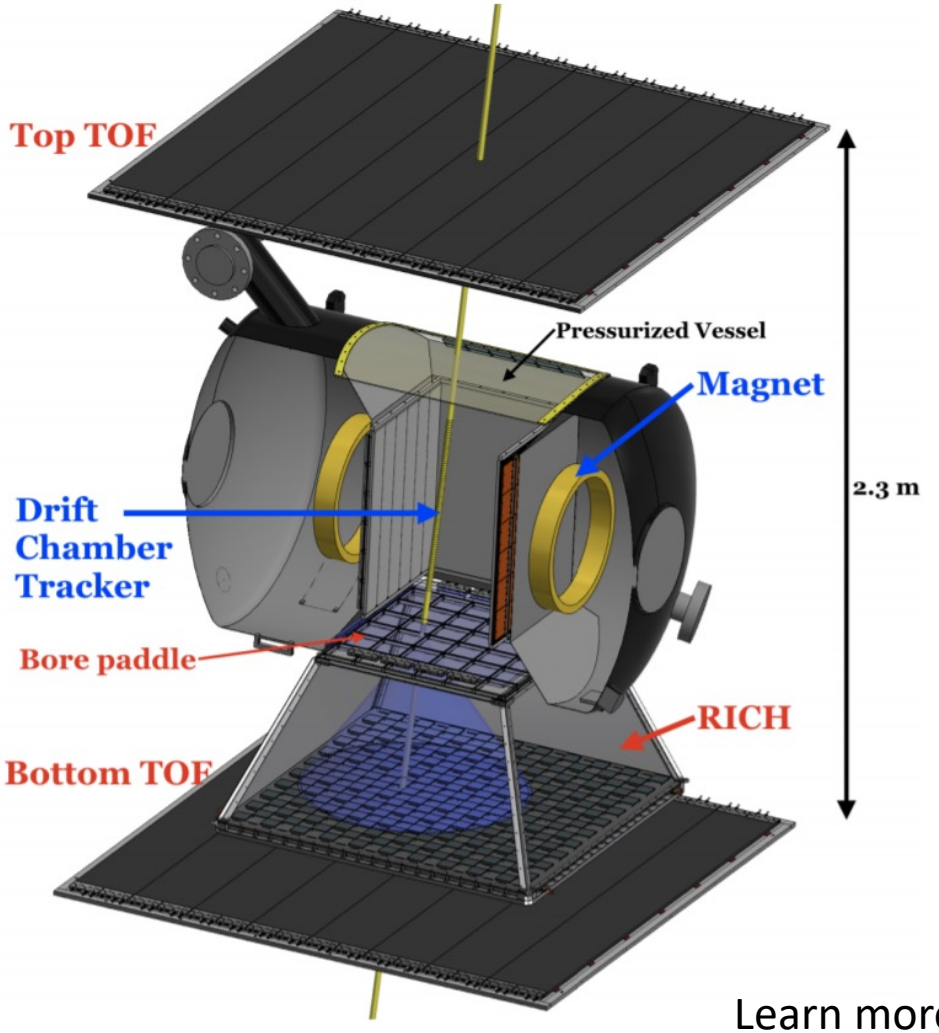
CAP student talk competition

Queen's Ultrafast Laser Lab

HELIX

HELIX

High Energy Light Isotope eXperiment



HELIX is launching sometime this week!

Learn more about this at Melissa's Talk

Why are we measuring Cosmic Rays ?

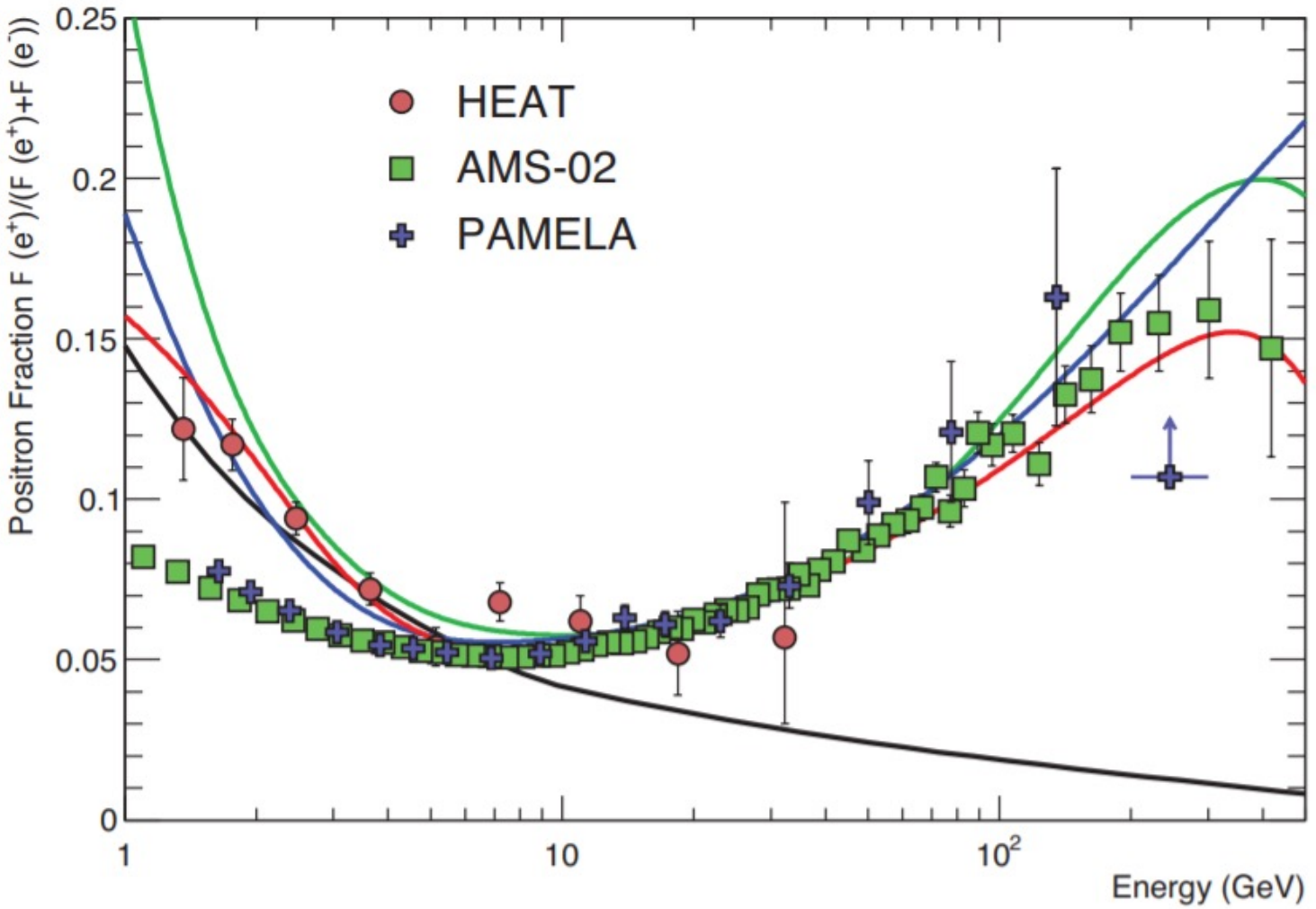
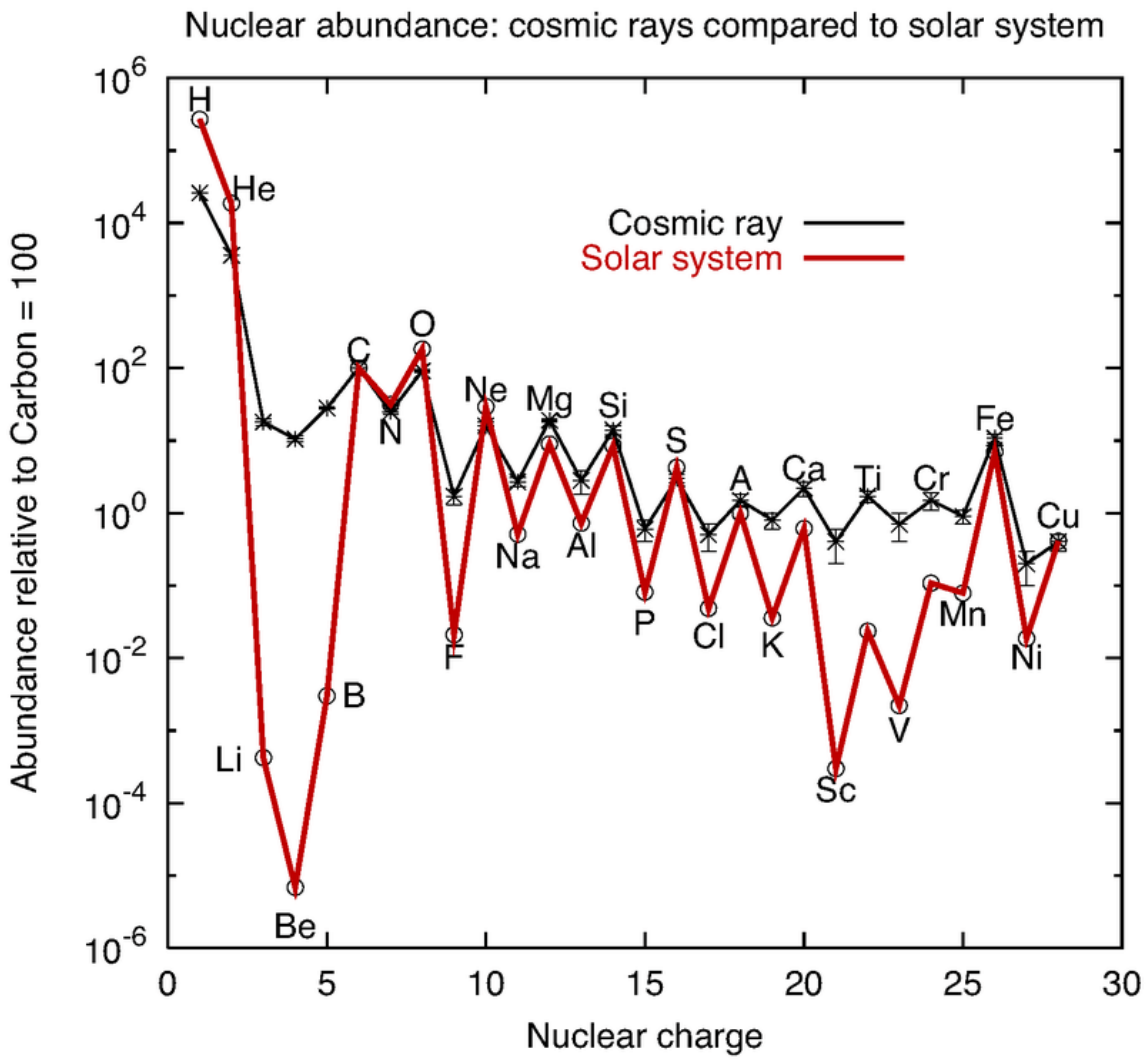
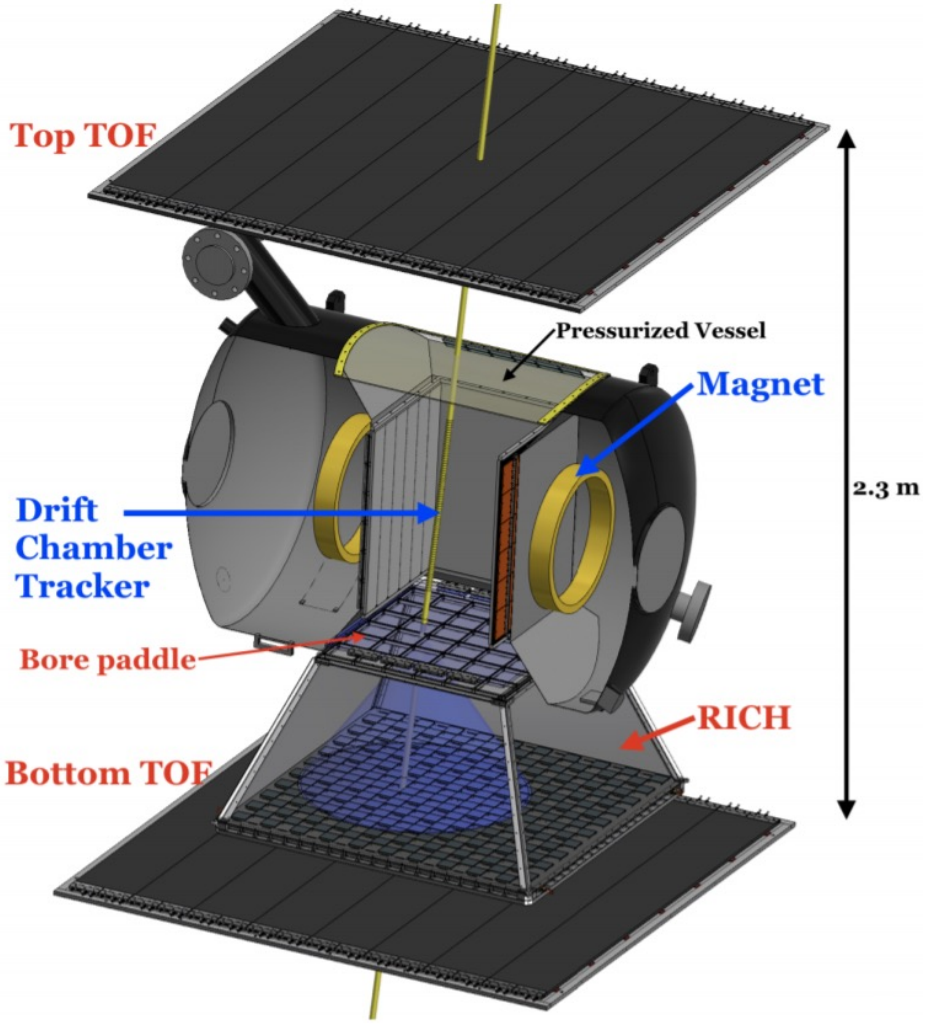


Figure from Particle Data Group (link)

Why are we measuring Beryllium ?



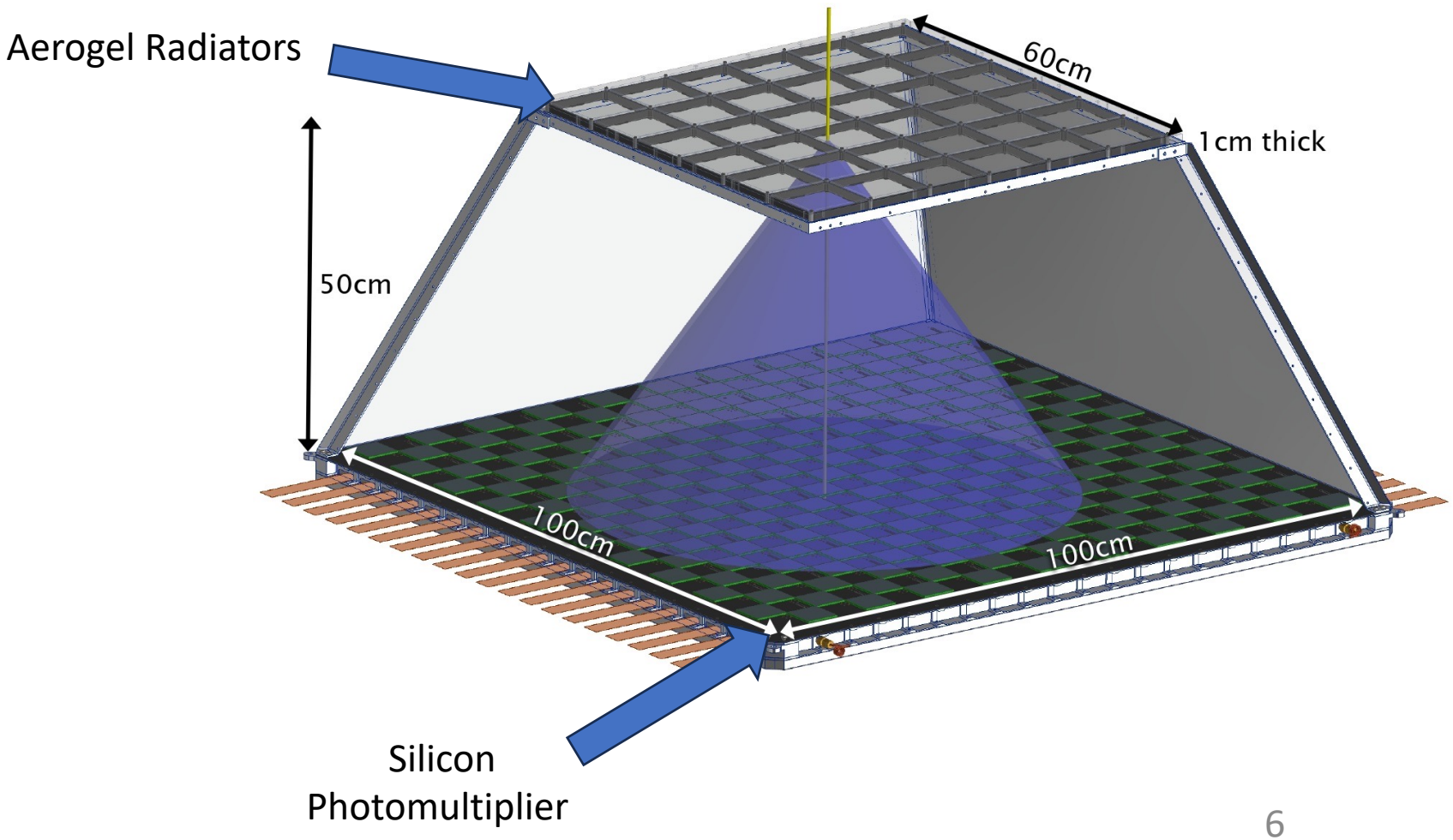
How do we measure ^{10}Be and ^{9}Be?



Measuring velocity for particles with E > 1GeV/n

$$cos\theta = \frac{1}{n\beta}$$

n = 1.155



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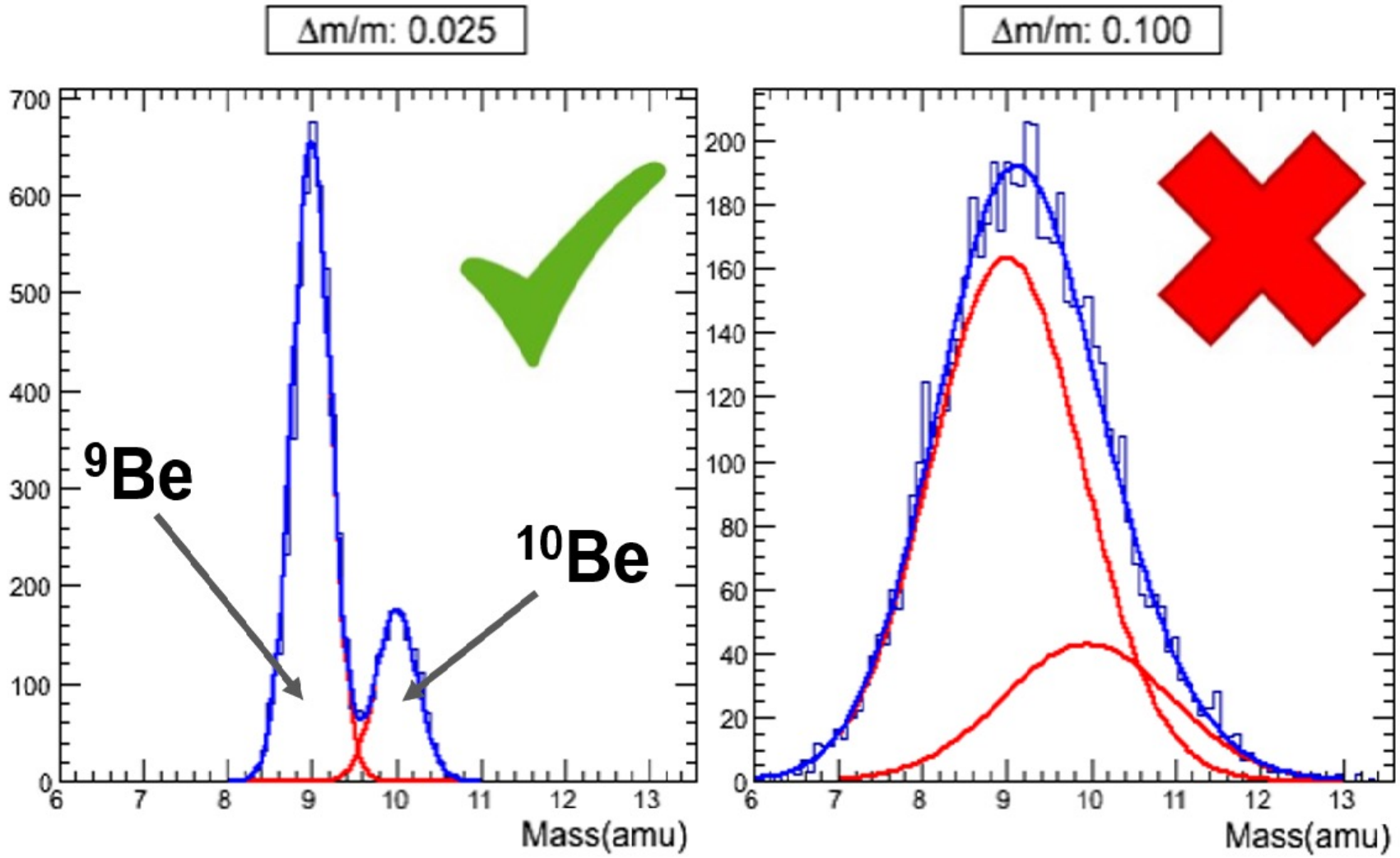


^{9} Be = 9.01 amu

^{10} Be = 10.01 amu

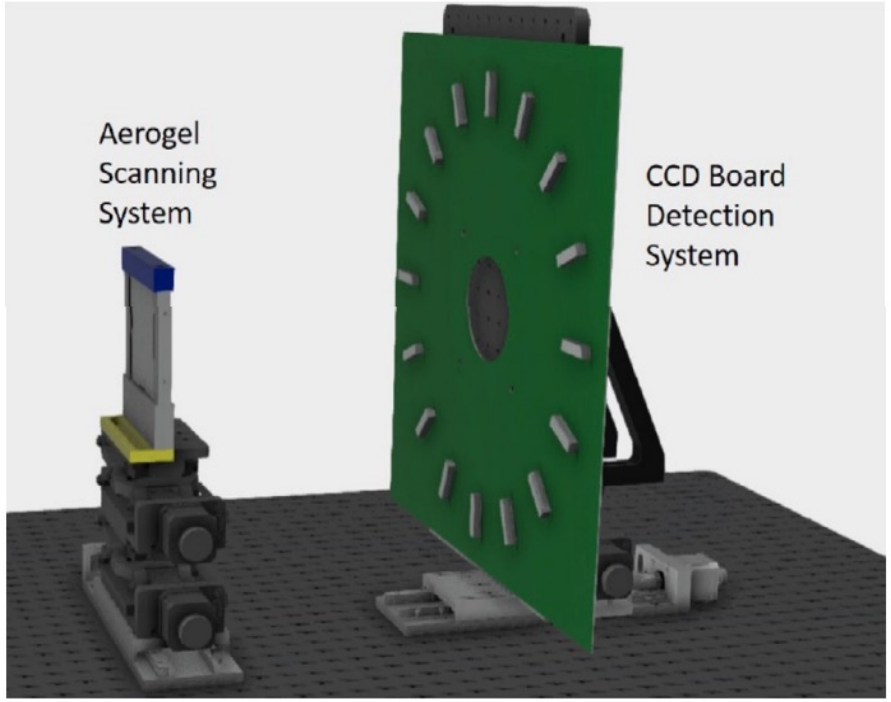
How do we get a 2.5% mass resolution?

Variations across the tile affect the velocity resolution.

We need to account for them. By knowing the refractive index as a function of position.

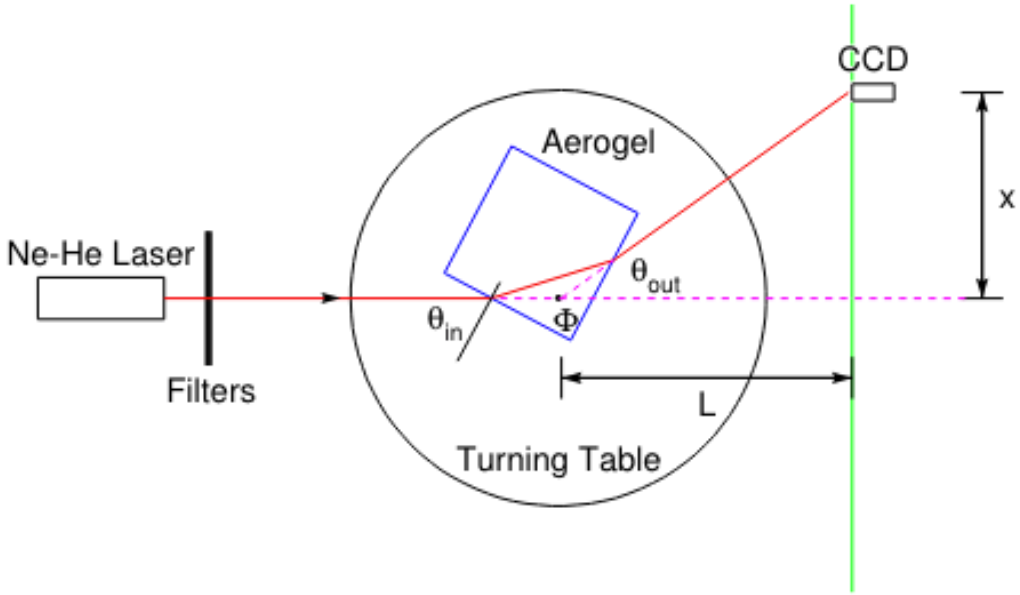
Need to measure refractive index better than 0.1%

Current Methods:



Electron Beam Method

Image from: arXiv:2307.09689v1



Prism Method

Image from: doi:10.1016/j.nima.2005.08.072

Optical Coherence Tomography

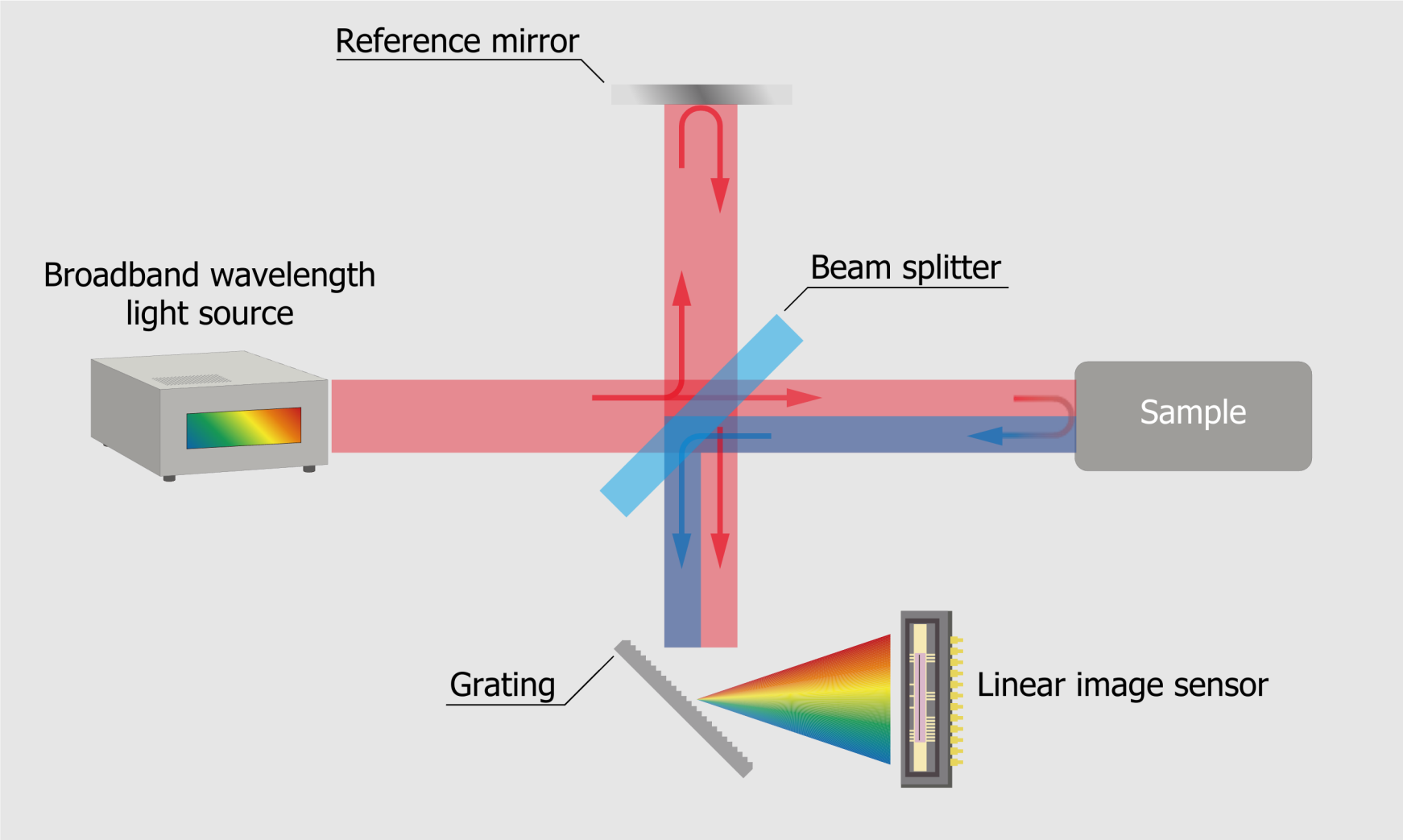
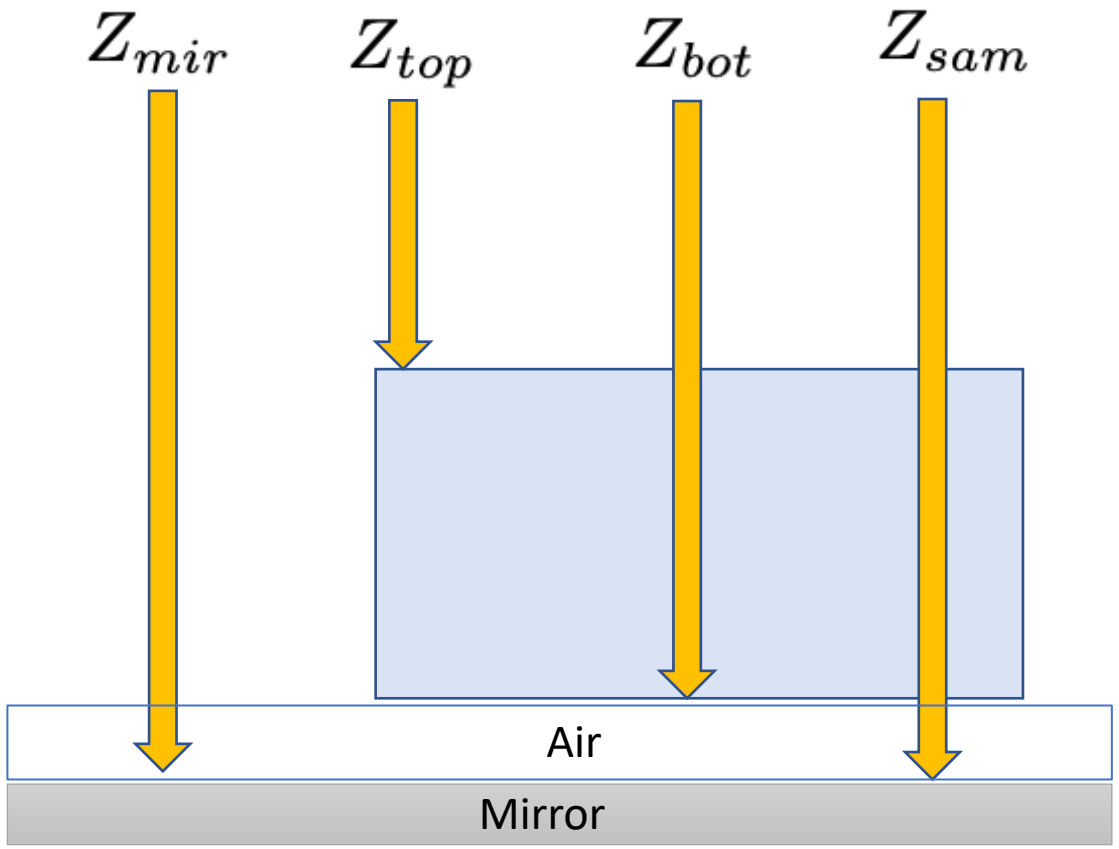


Image from Link

How to get refractive index as a function of position ?

Experimental Set up:

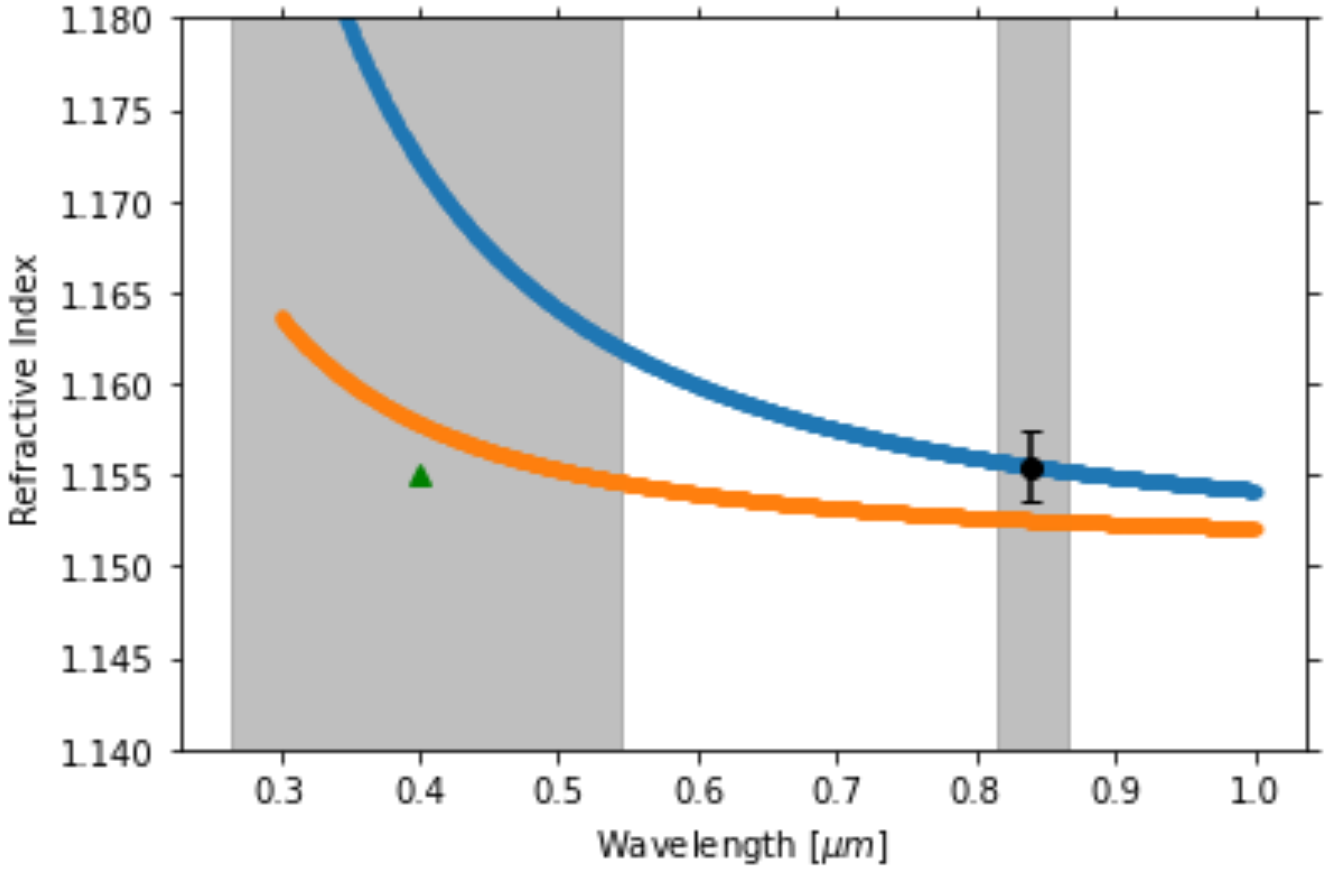


$$thickness = (Z_{top} - Z_{bot}) - (Z_{mir} - Z_{sam})$$

$$n_g = \frac{Z_{bot} - Z_{top}}{(Z_{top} - Z_{bot}) - (Z_{mir} - Z_{sam})}$$

Cameron Romanet MSc Thesis

How to get phase refractive index from group ?

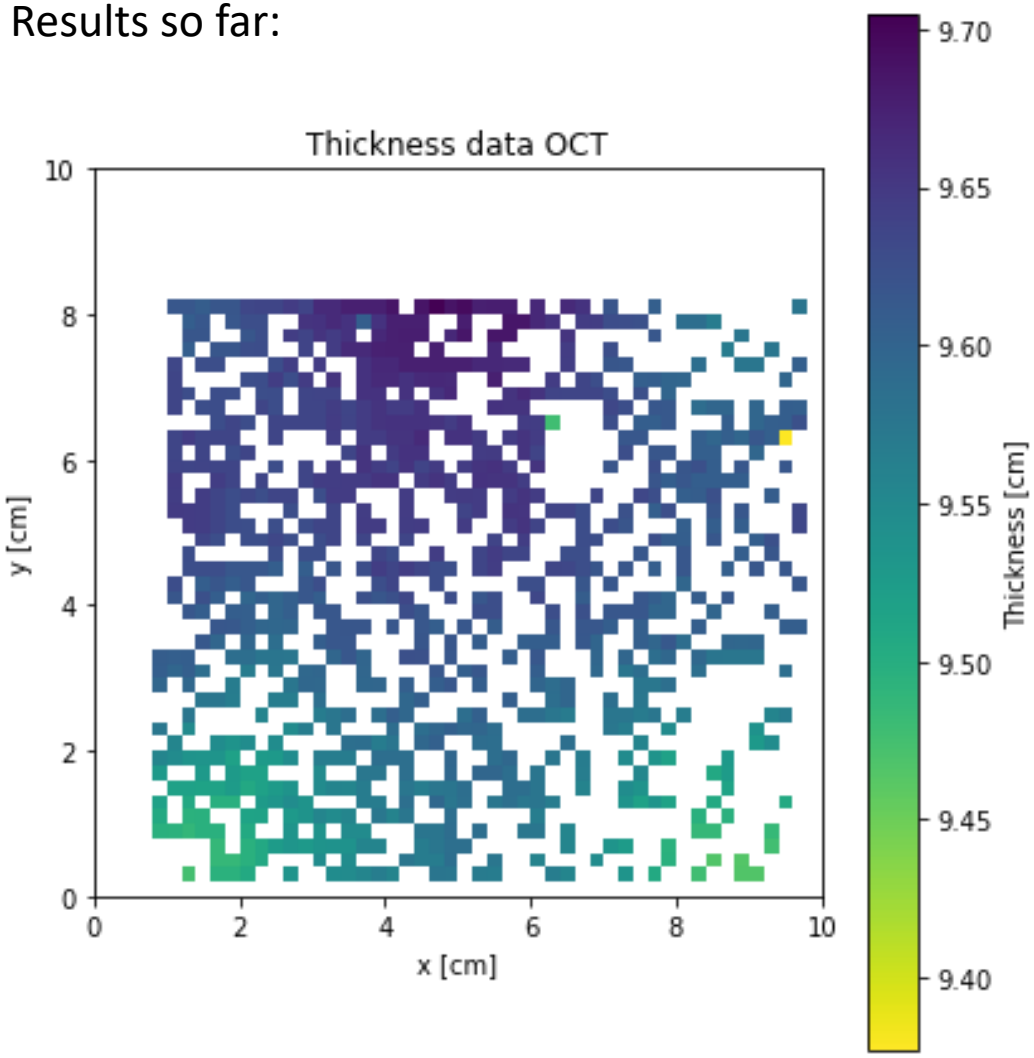


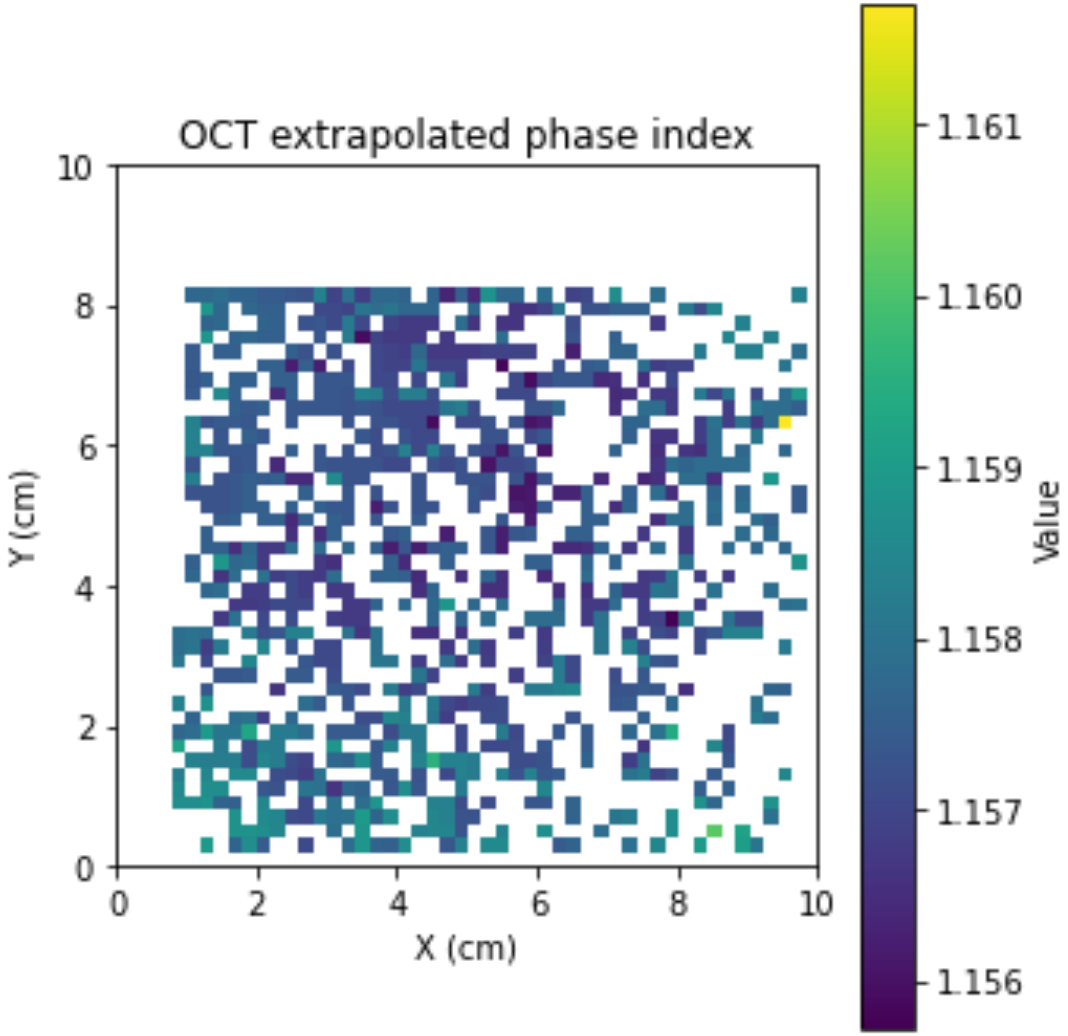
$$n^2(\lambda) = 1 + \sum_i \frac{B_i \lambda^2}{\lambda^2 - C_i}$$

$$n_g = n(\lambda) - \frac{dn}{d\lambda}$$

Thickness and Refractive Index

Results so far:





Next steps:

HELIX Collaboration

University of Chicago

Scott P. Wakely, Rostom Mbarek, Hyebin Jeon, Z. Siegel, Keith McBride

Indiana University

James Musser, Gerard Visser, Brandon Kunkler, Mark Gebharb, Mike Lang

McGill University

David Hanna, Stephan O'Brien

Northern Kentucky University

Scott Nutter

Ohio State University

Patrick Allison, James J. Beatty, Lucas Beaufore, Dennis Calderone

Pennsylvania State University

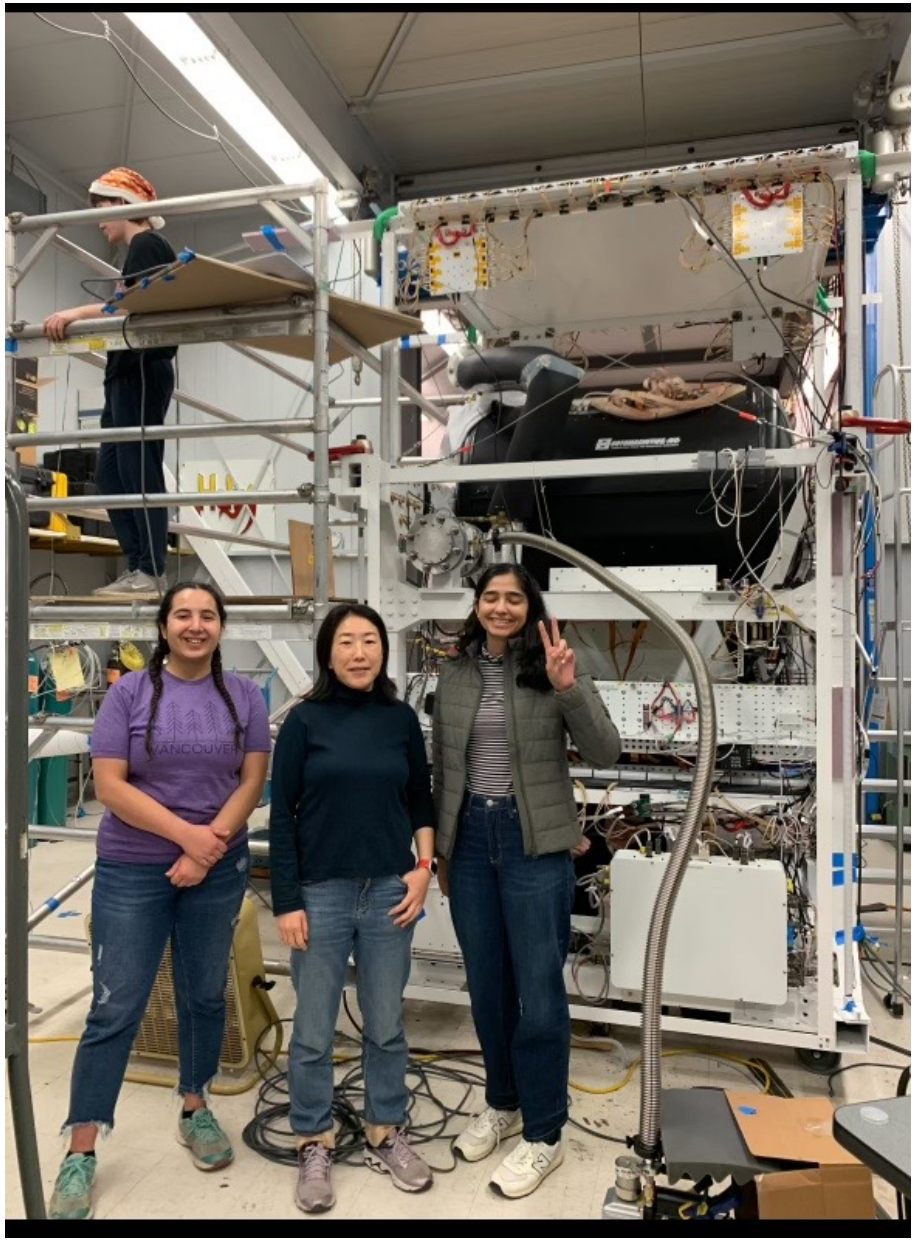
Yu Chen, Stephane Coutu, Samuel I. Mognet, Monong Yu

Queen's University

Nahee Park, Melissa Baiocchi, Avani Bhardwaj, Conor McGrath

University of Michigan

Gregory Tarle, Noah Green



Queen's Ultrafast Laser Lab

Thanks

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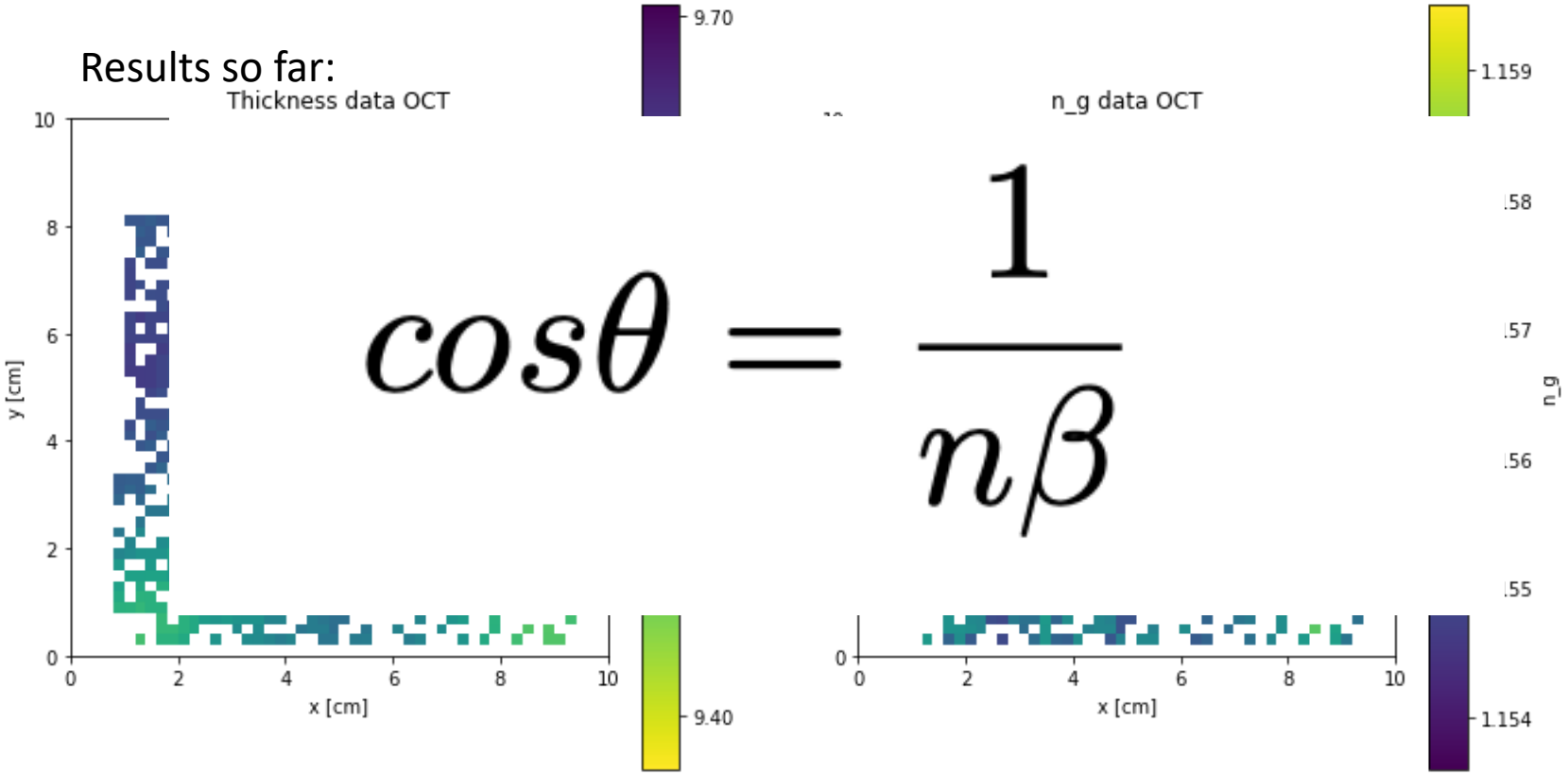
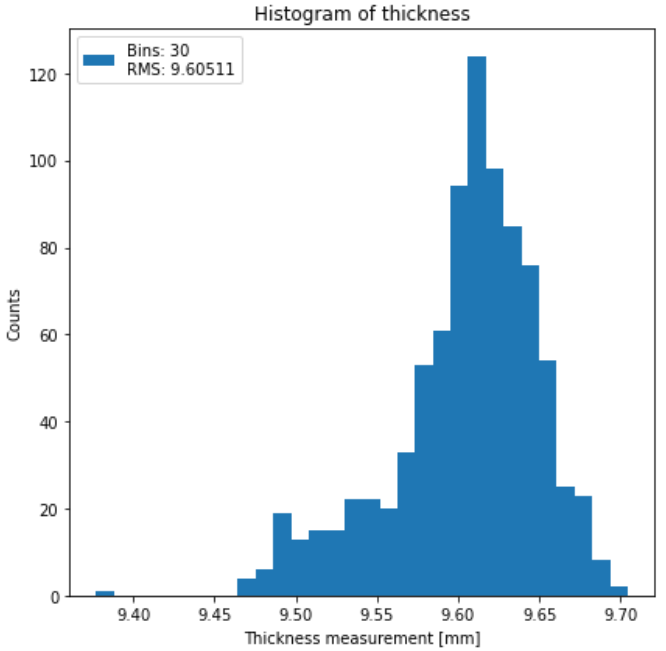
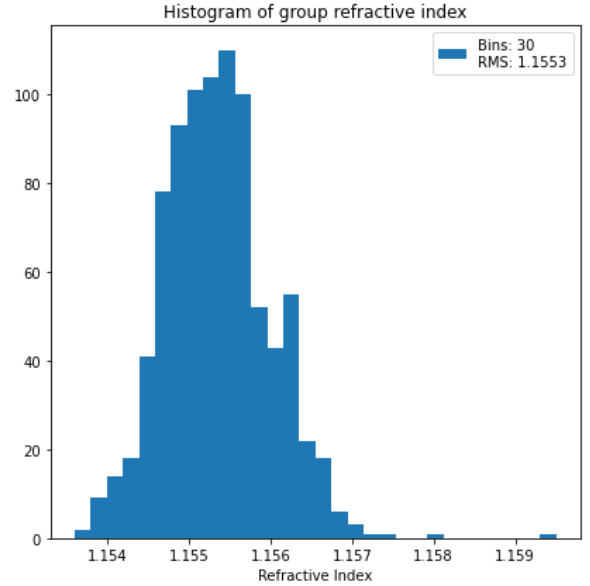
Thickness and Refractive Index

Results so far:



$$cos\theta = \frac{1}{n\beta}$$

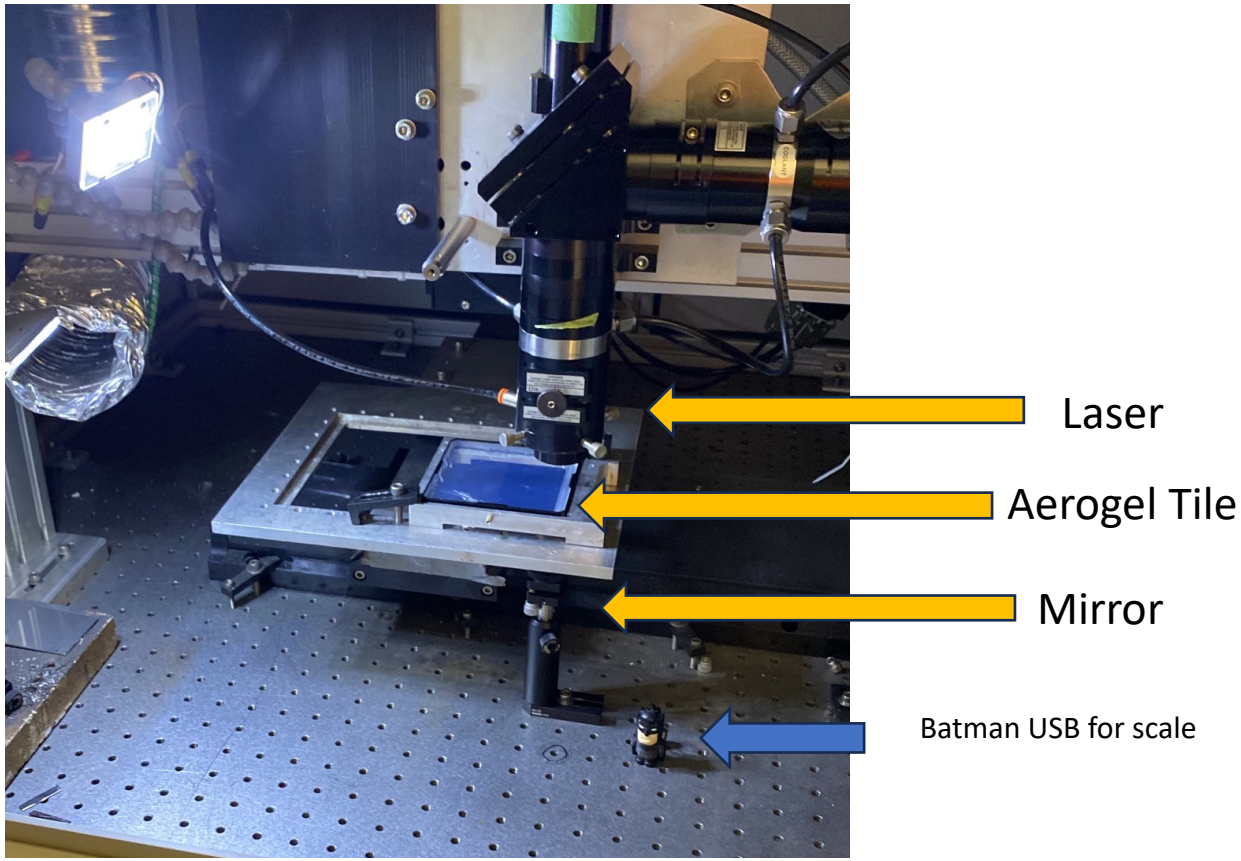




Mean thickness:
9.56 cm

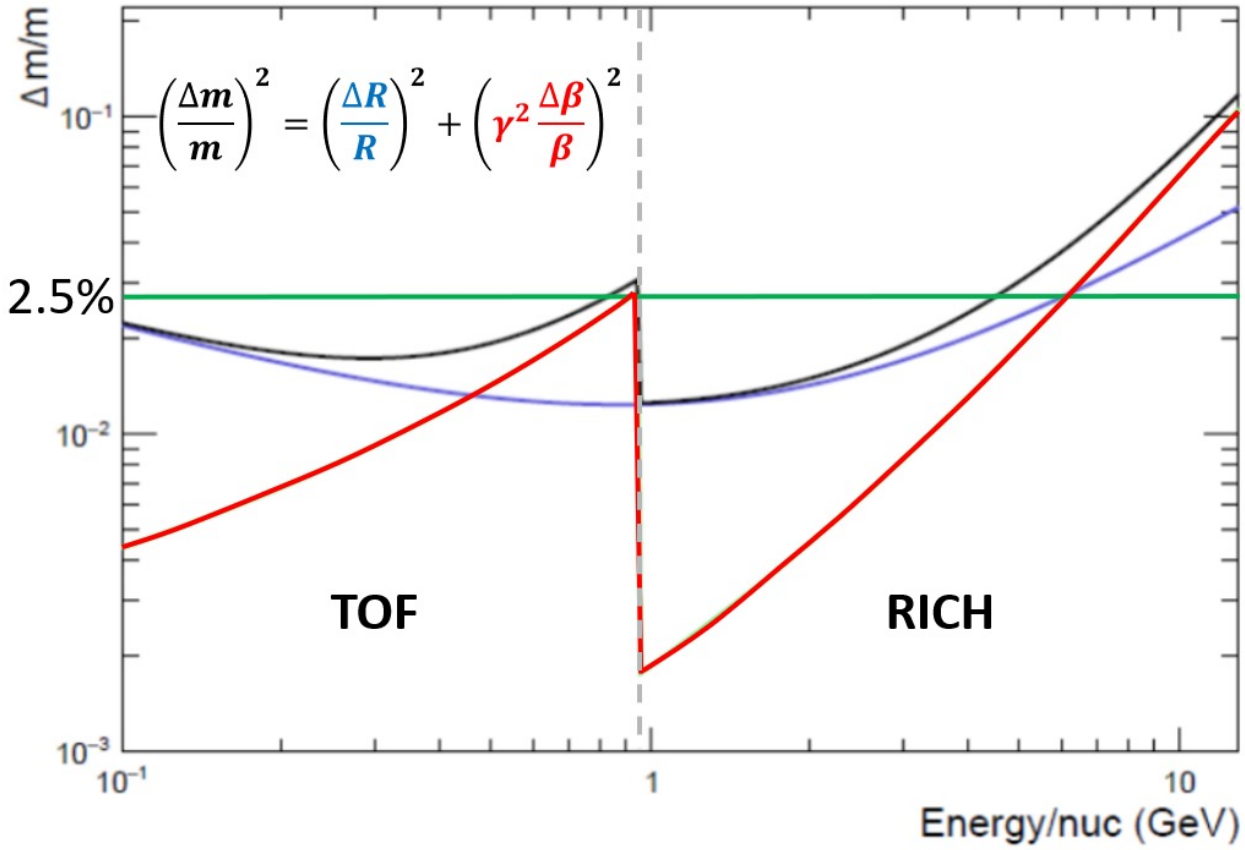
Mean group refractive index: 1.1553

How to get refractive index as a function of position ?



OCT method

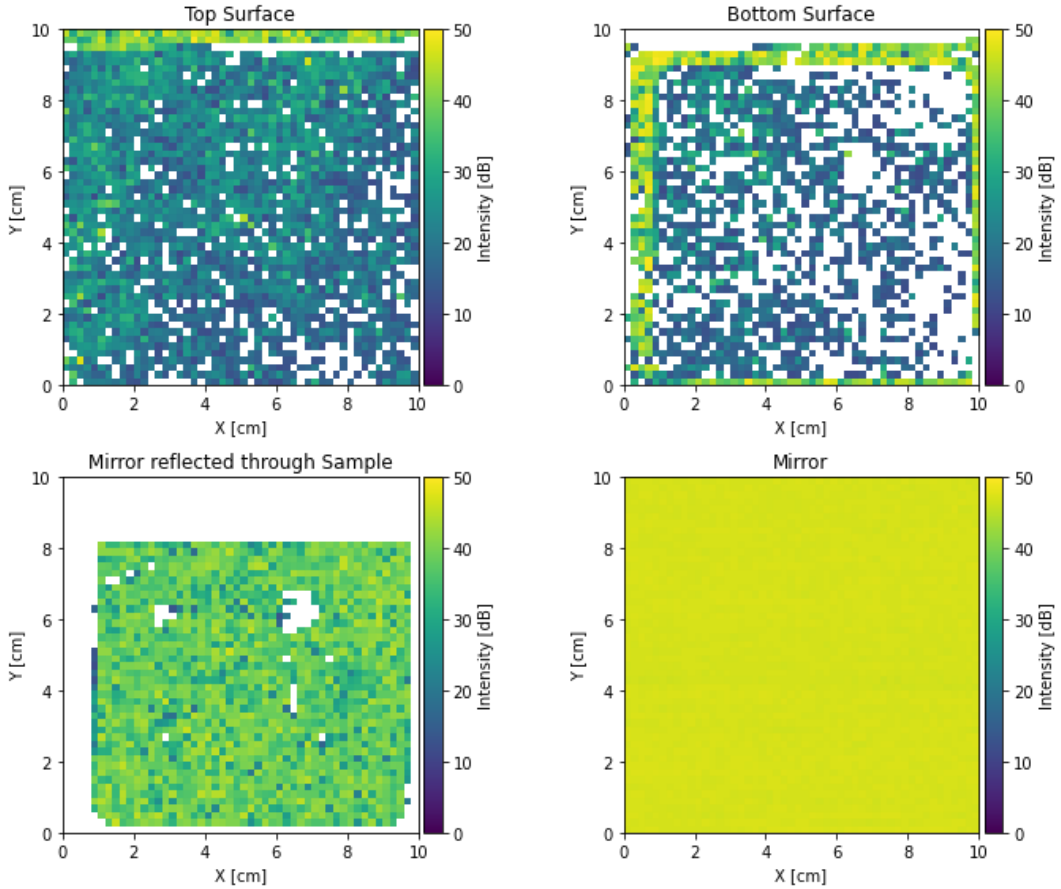
How do we measure Be_10 and Be_9?



How to get refractive index as a function of position ?

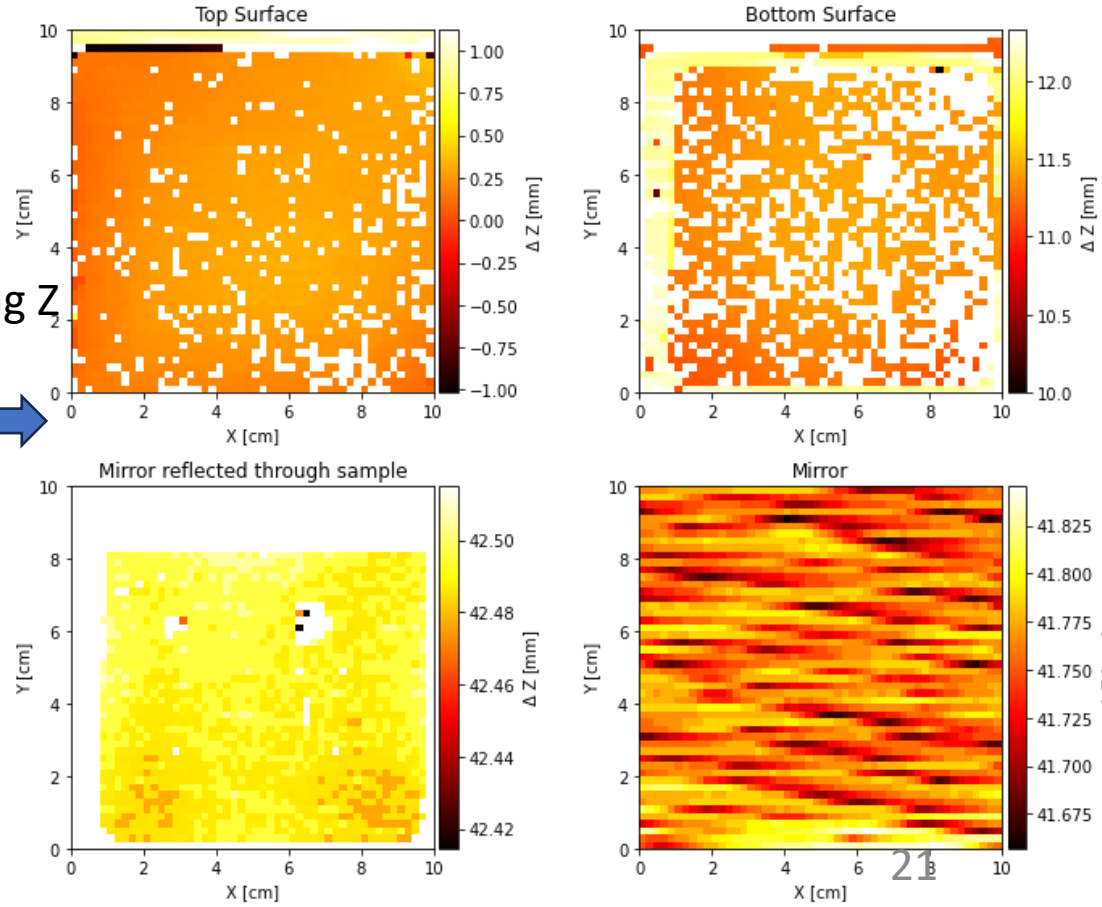
Results so far:

Intensity

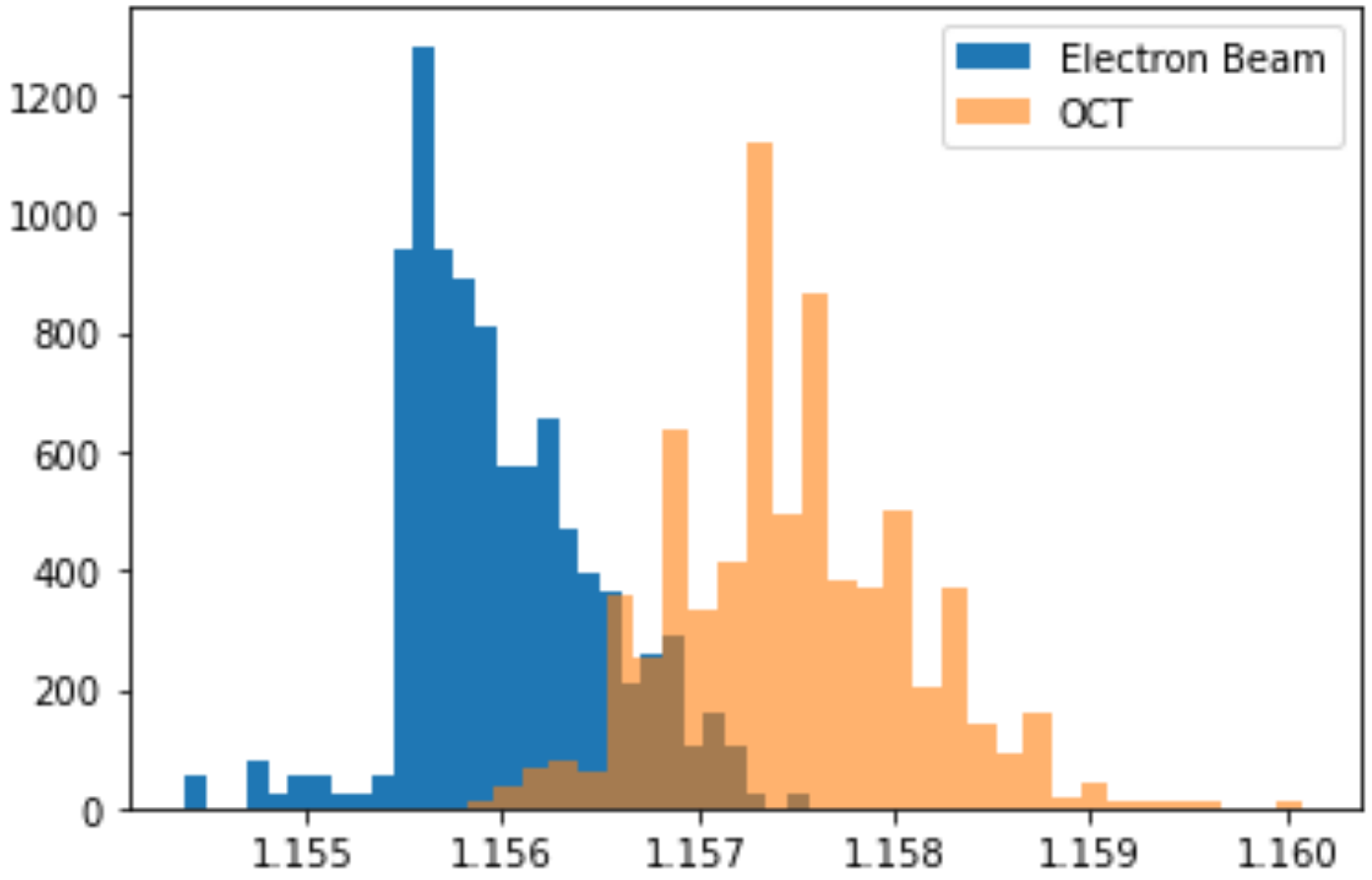


Corresponding Z position

Depth



How to get phase refractive index from group ?



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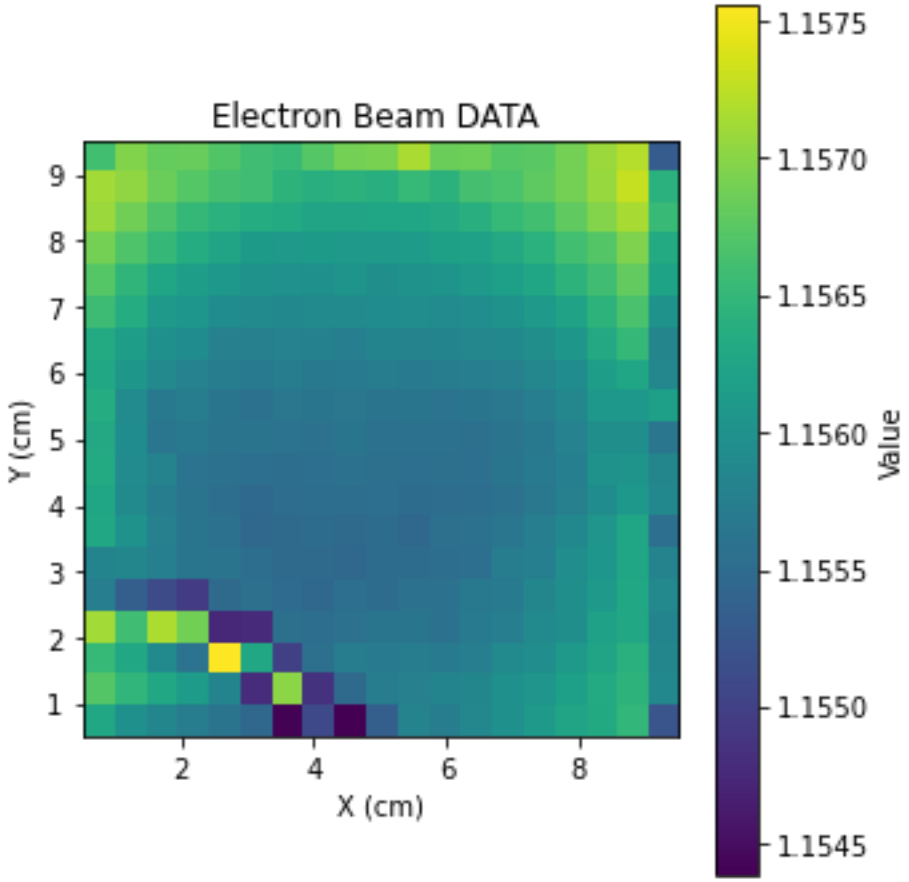

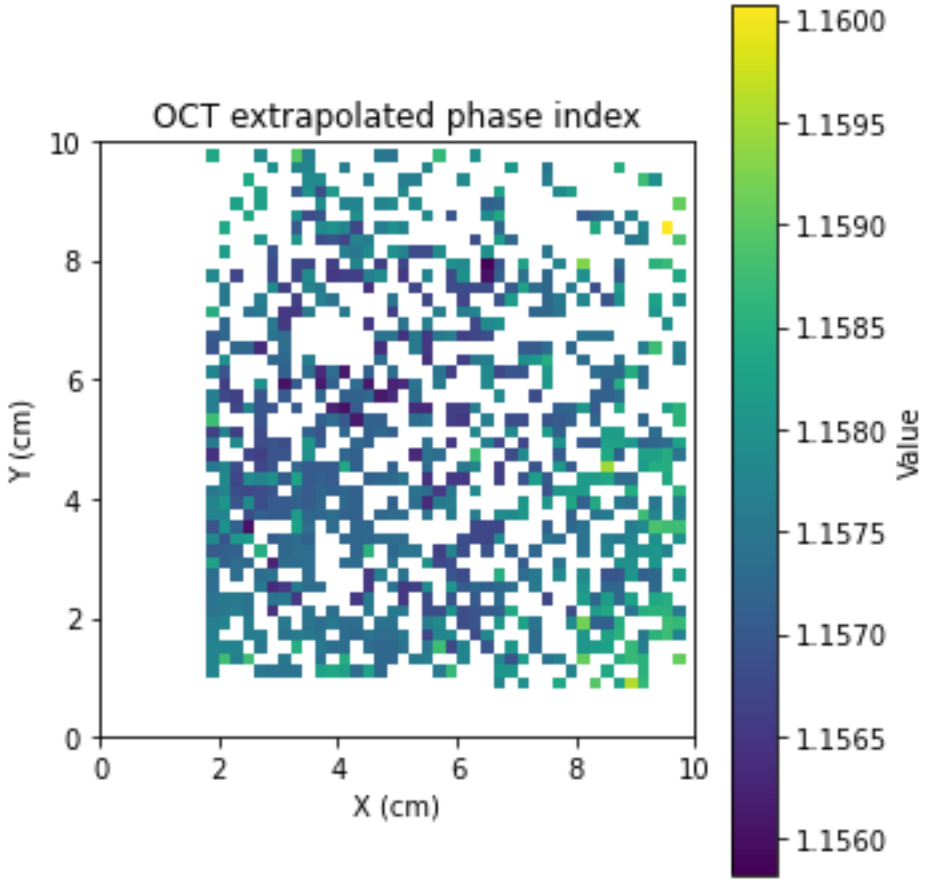

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