Monte-Carlo Exploration of Focused Neutron Guide Geometries

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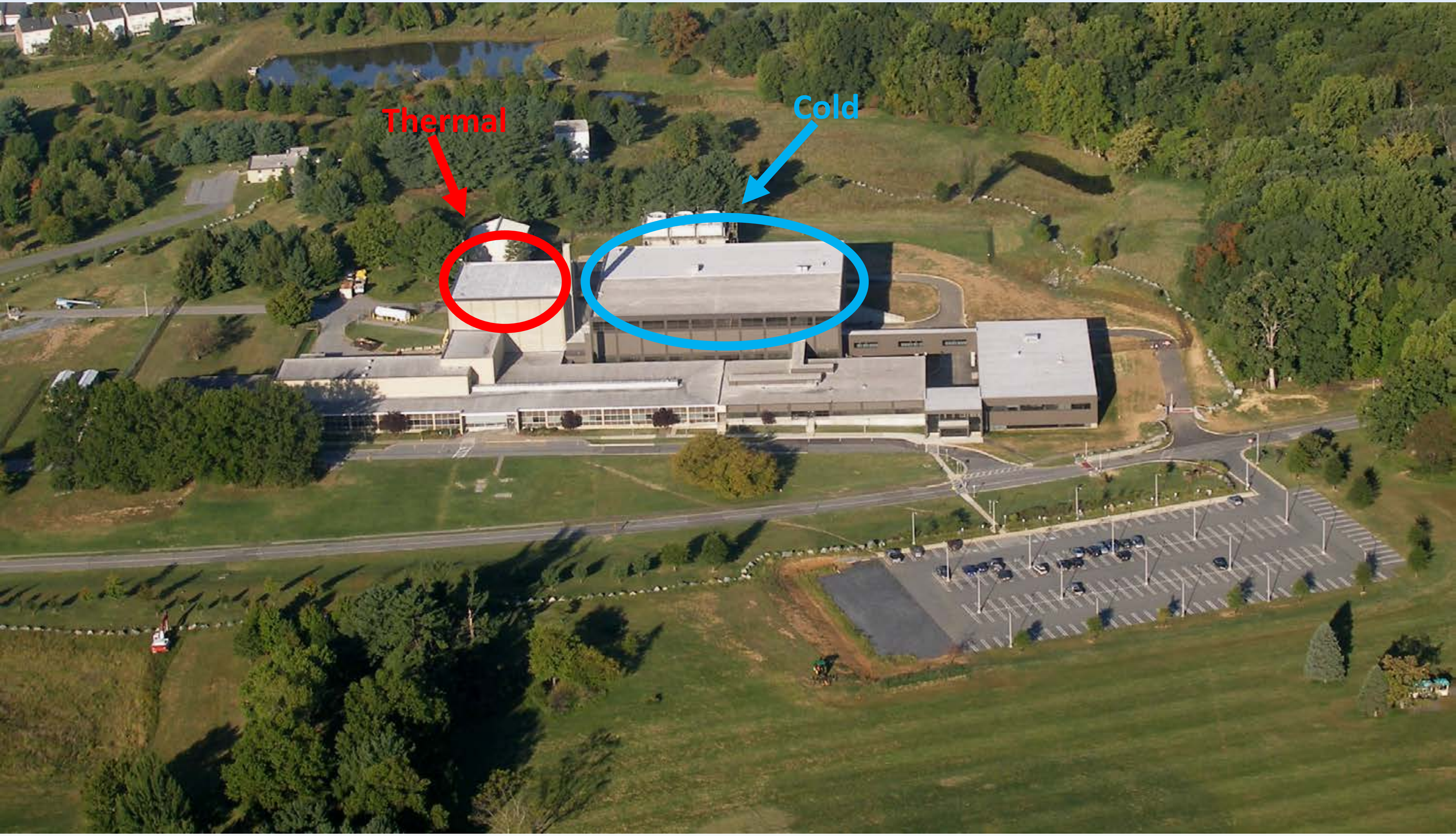
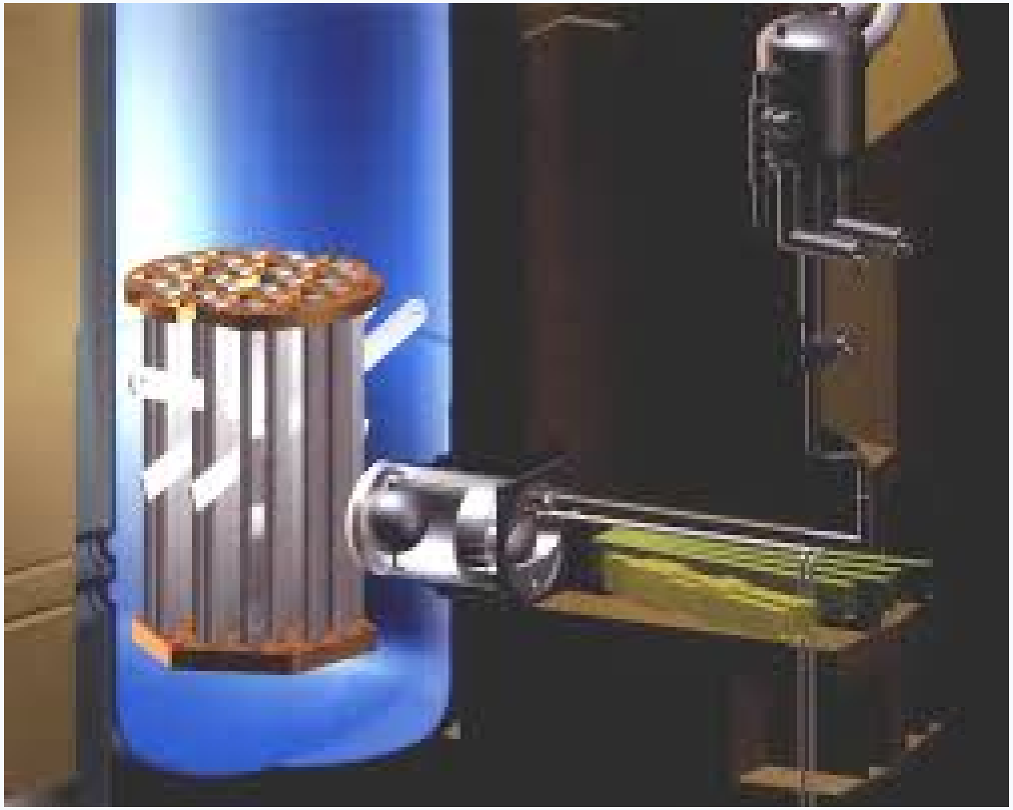
Mentor: Leland Harriger

NIST Center for Neutron Research



https://commons.wikimedia.org/wiki/File:NCNR_in_2010_from_the_air.jpg

New Cold Source



- A new cold source will be replacing the current cold source
- This produces most of the cold neutrons used at the NCNR

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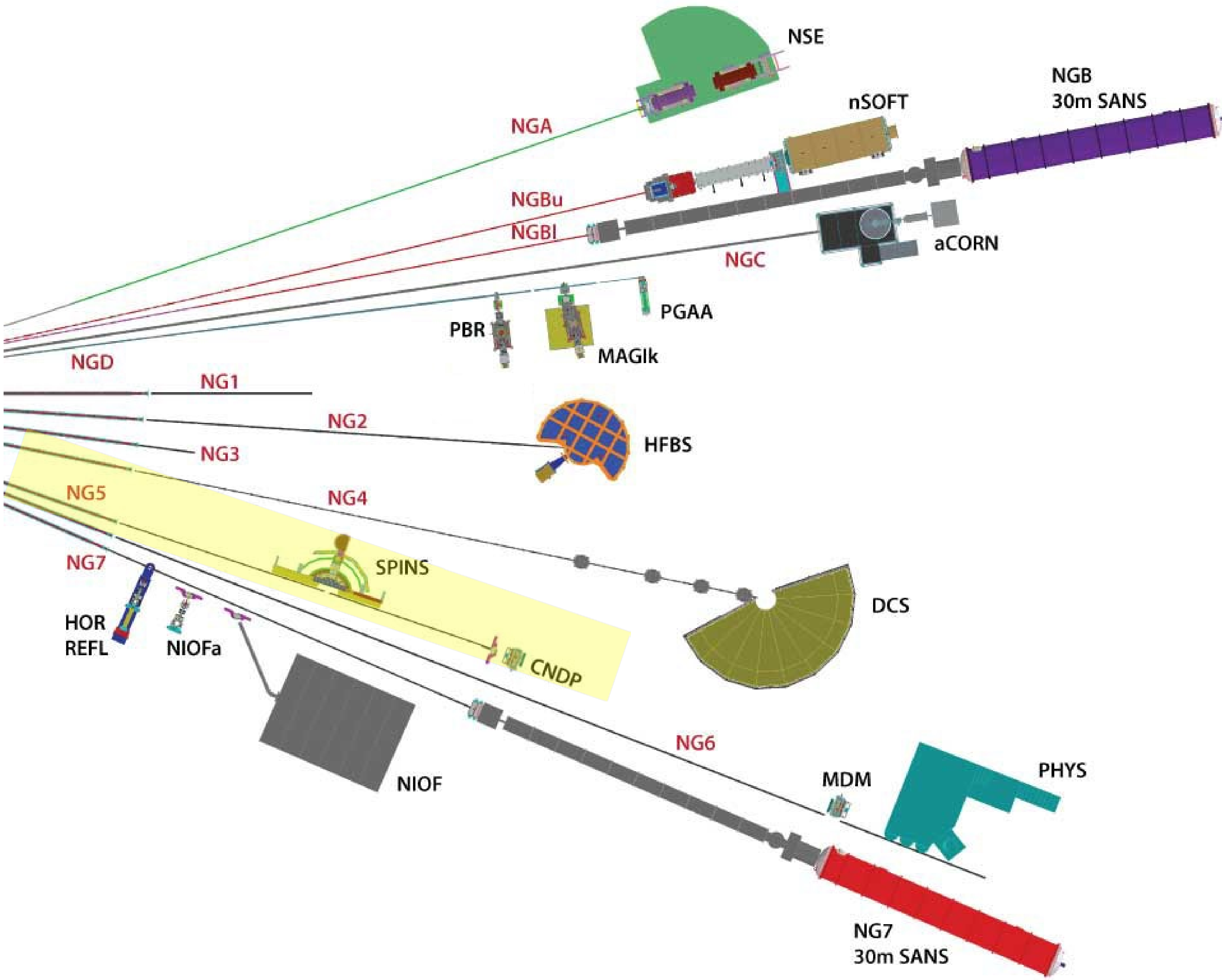
Replacing NG5 and SPINS



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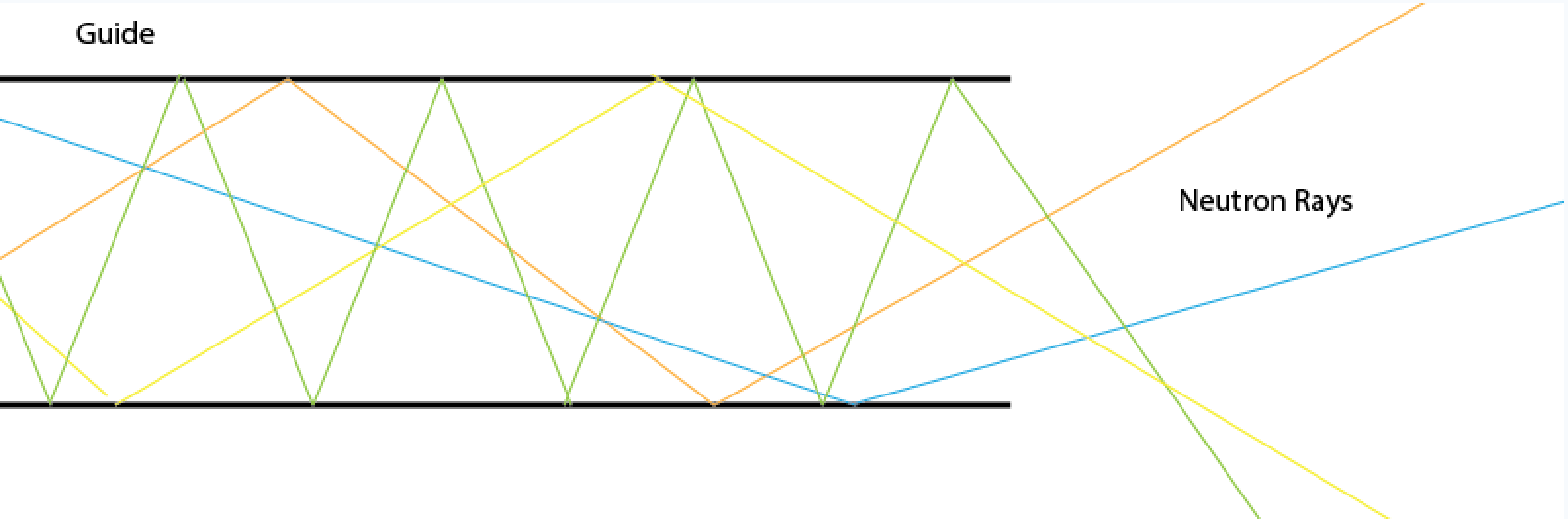
Software used

- Mcstas
  - http://www.mcstas.org/
- Guide_bot_distribution
  - Courtesy of Mads Bertelsen
- iFit
- NCNR Rocks Cluster

1st Generation Guide: NG5

- Neutron guides contain coatings that line the inner walls that allow the neutrons to bounce down the guide
- NG5 is a 41 meter long straight rectangular guide
- Coated in Ni58



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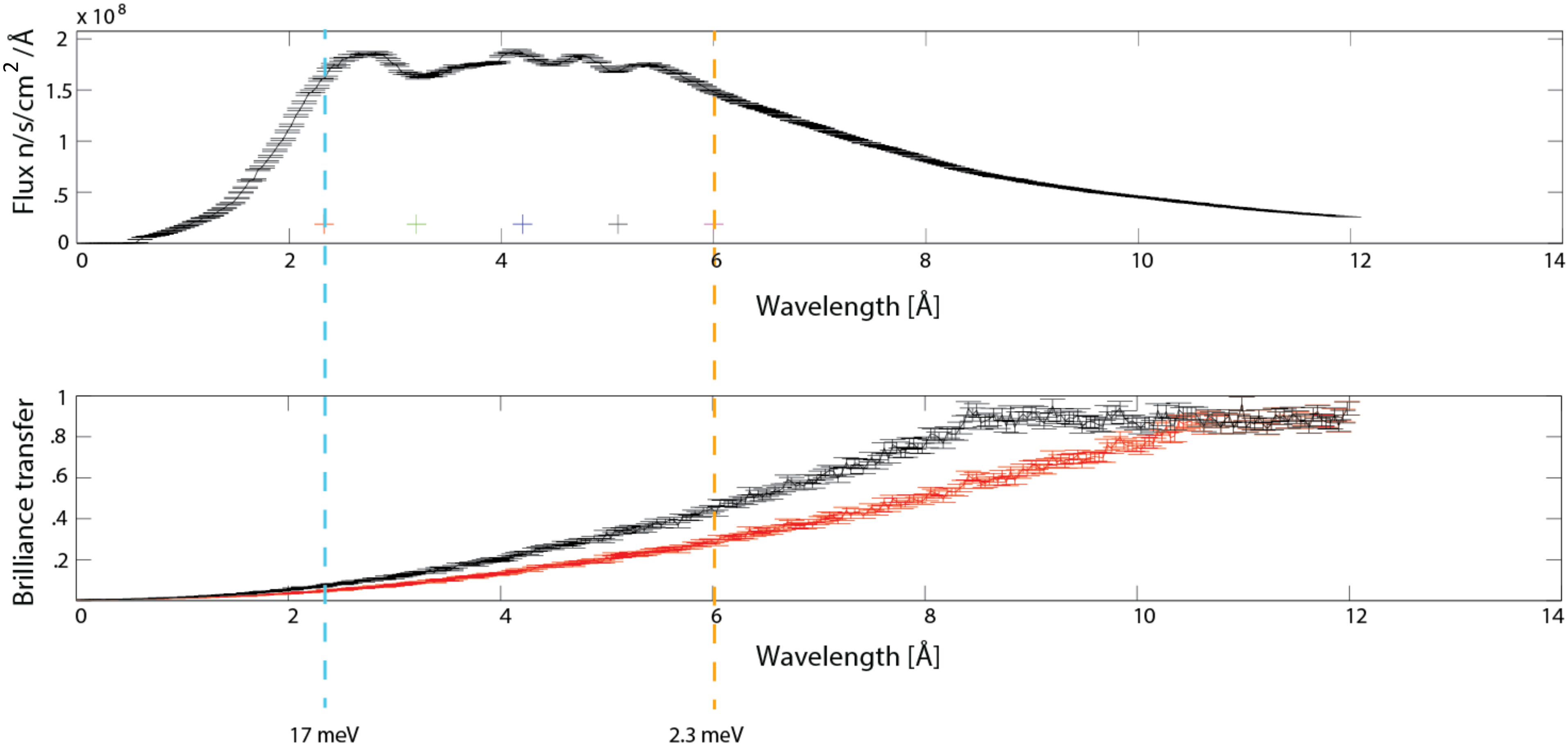
NG5 Baseline



2.3 meV: 1.5e8 Flux , 30% brilliance transfer

17 meV: 1.6e8 Flux , 6% brilliance transfer

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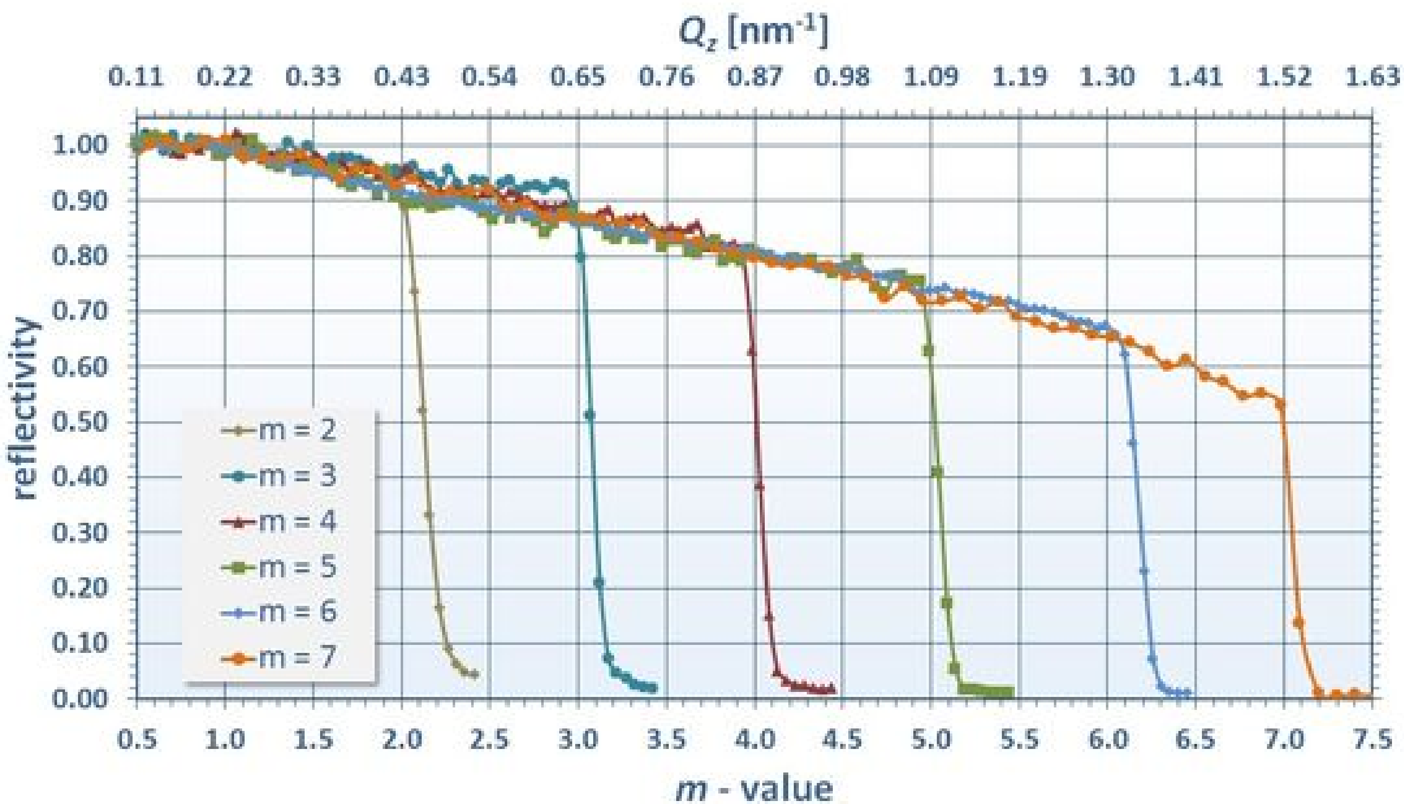
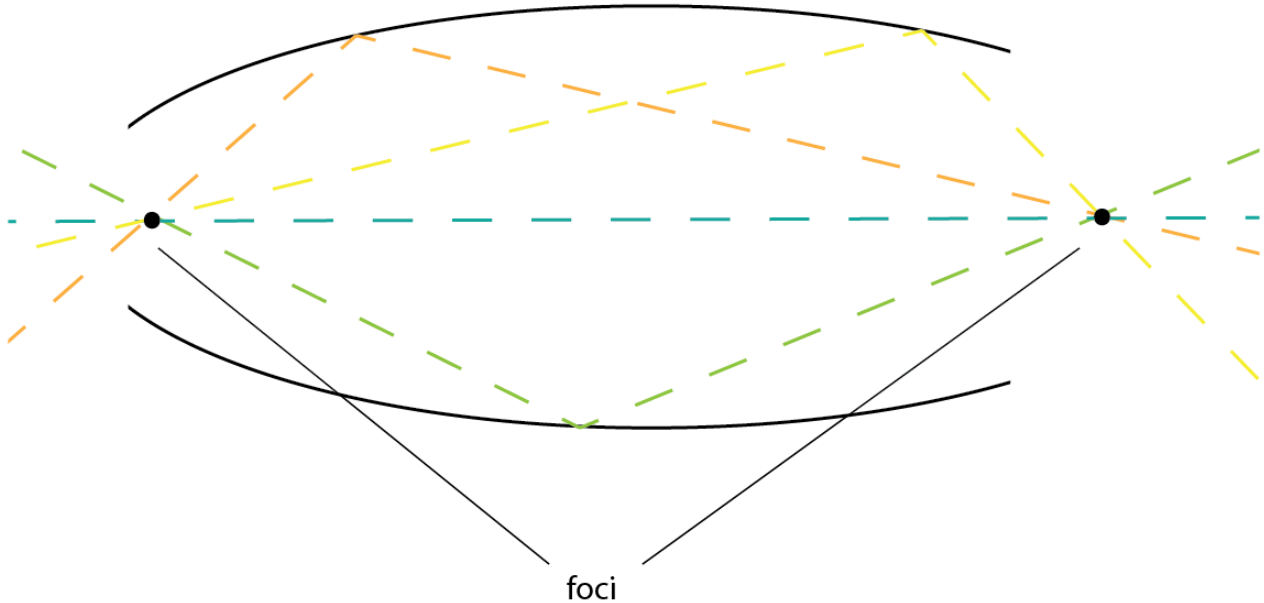
2nd Generation Guides

- Fairly recent
- Supermirror coatings
- Ballistic elliptical shape

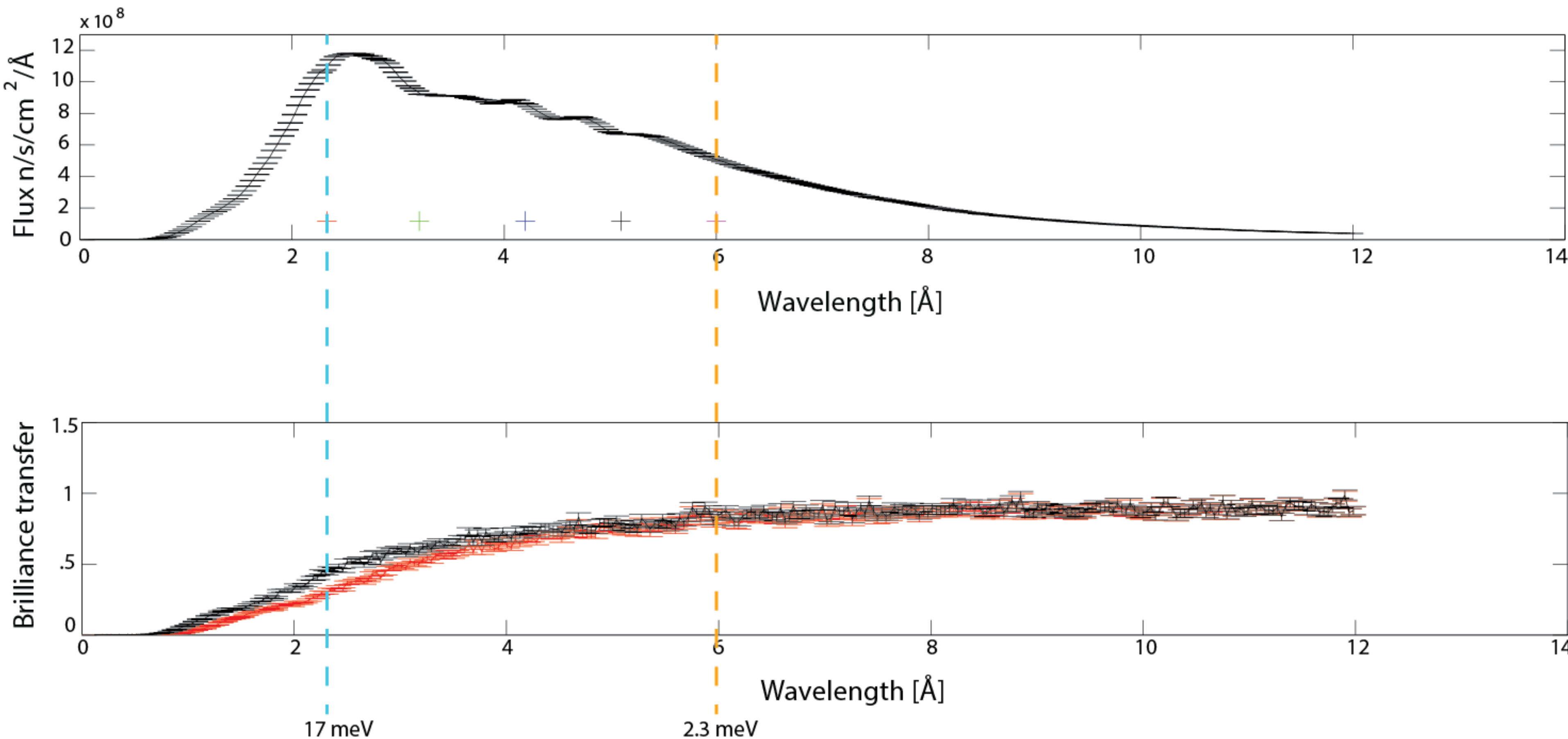


Ballistic Ellipse

- Use a ballistic elliptical geometry
- Each neutron should ideally only bounce once down the guide



Ballistic Ellipse



2.3 meV: 5e8 Flux , 80% brilliance transfer

17 meV: 11e8 Flux , 45% brilliance transfer

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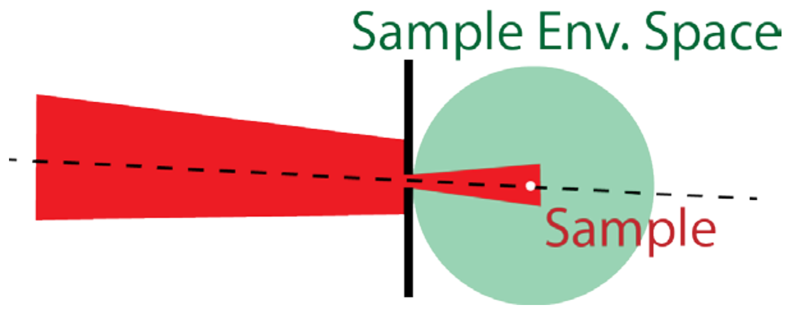
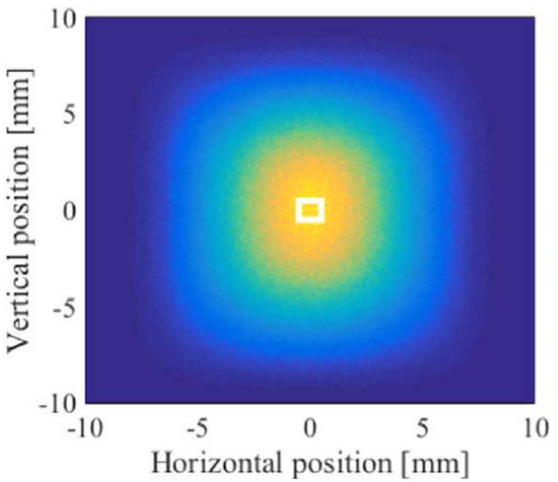
Improvements to 2nd Generation Guides

- Things to look forward to:
  - Perfect sample masking
  - A focused beam
  - No fast neutrons

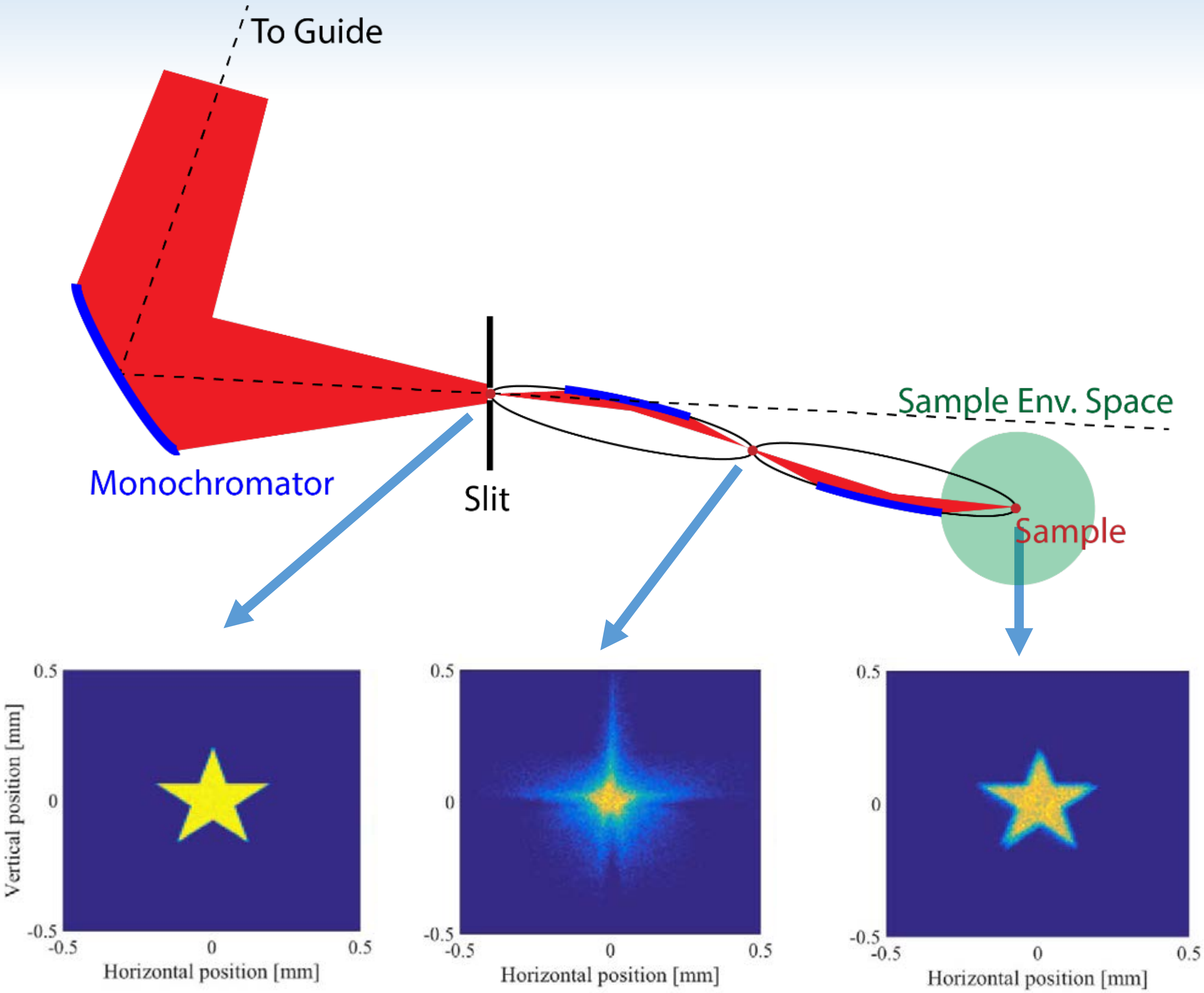
Sample Masking

- With larger beam intensities, we can look at smaller sample sizes
- Previously sample sizes were ok with current masking techniques
- Mask can only be placed at the edge of sample environment, allowing beam to widen again by the time it reaches the sample





Selene Tip



- Place a slit at monochromator focal point & focus beam via Selene Tip
- Can include a slit that provides exact selection of divergence
- Breaks line of sight so fast neutrons do not hit sample

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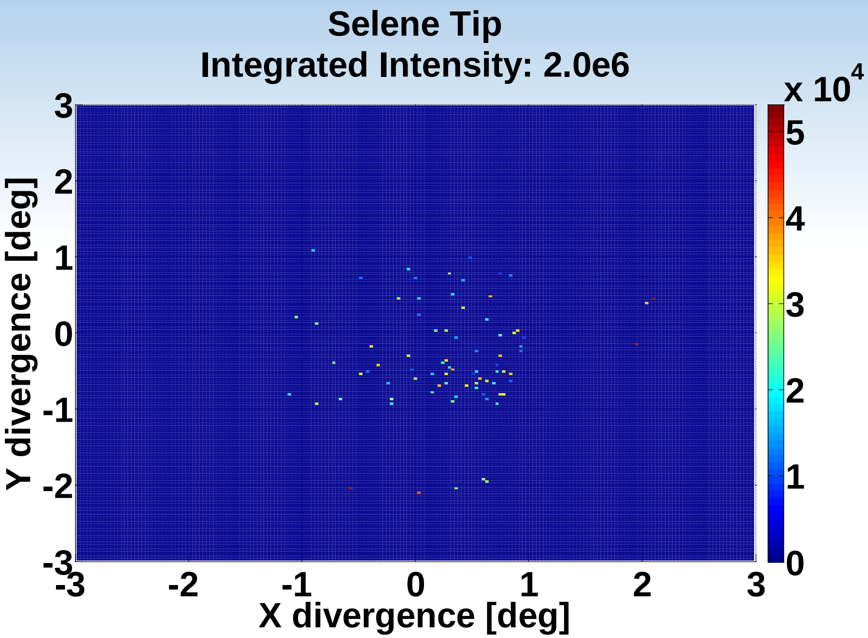
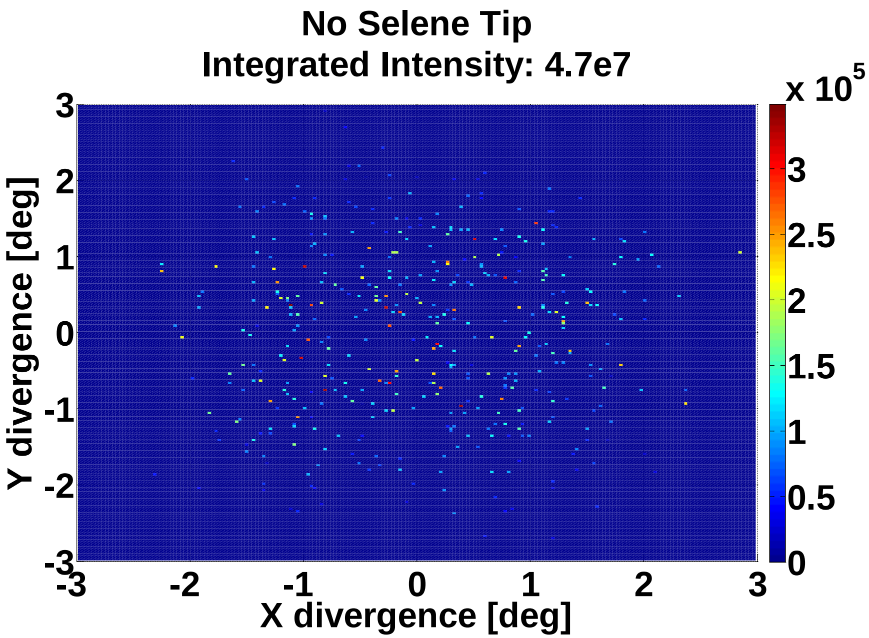
Selene Tip





- Over 1 order of magnitude reduction in flux at the sample position for a 5mm sample
- First attempt (ever) at optimizing this type of instrument configuration

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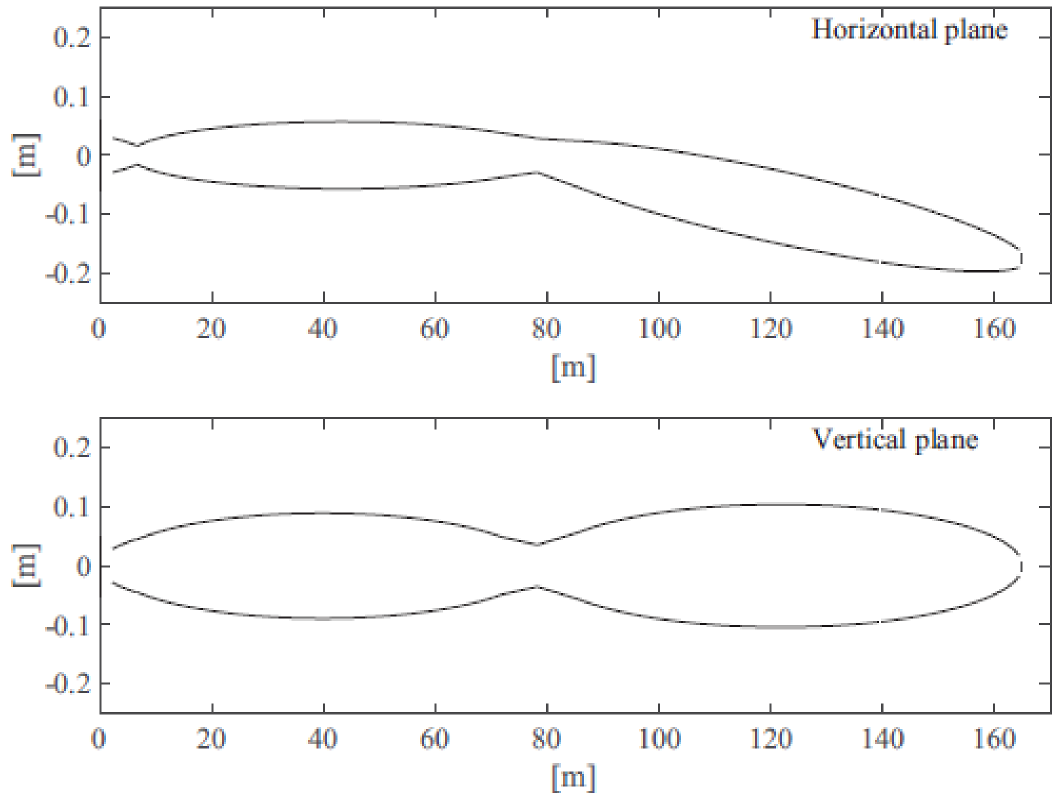
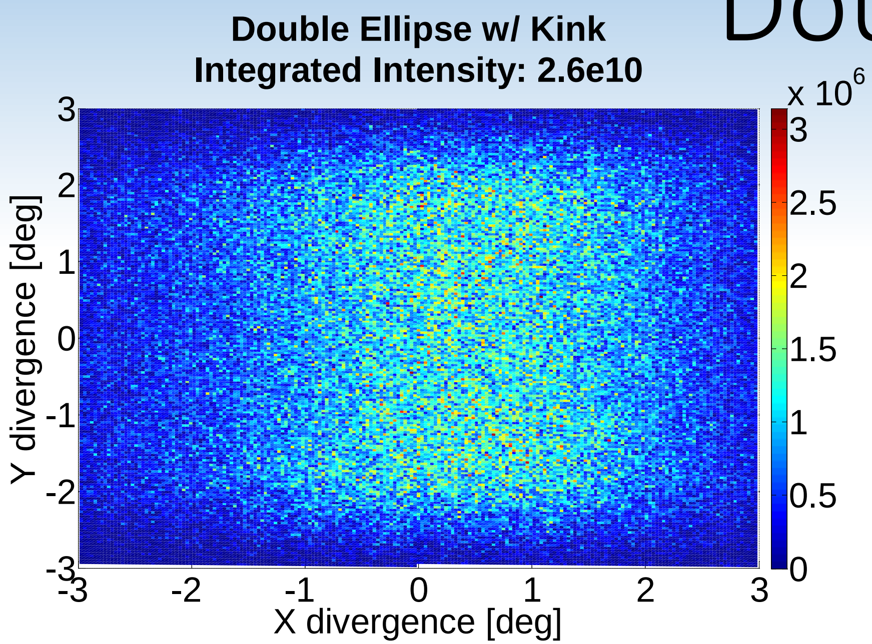
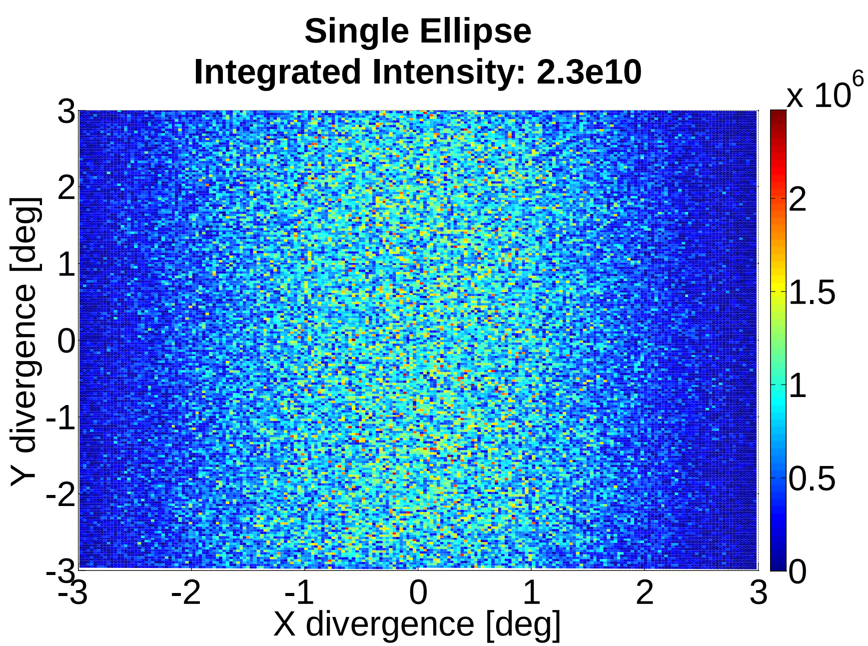
Double Ellipse with Kink

- Considered on the BIFROST spectrometer at ESS.
- Breaks line of sight



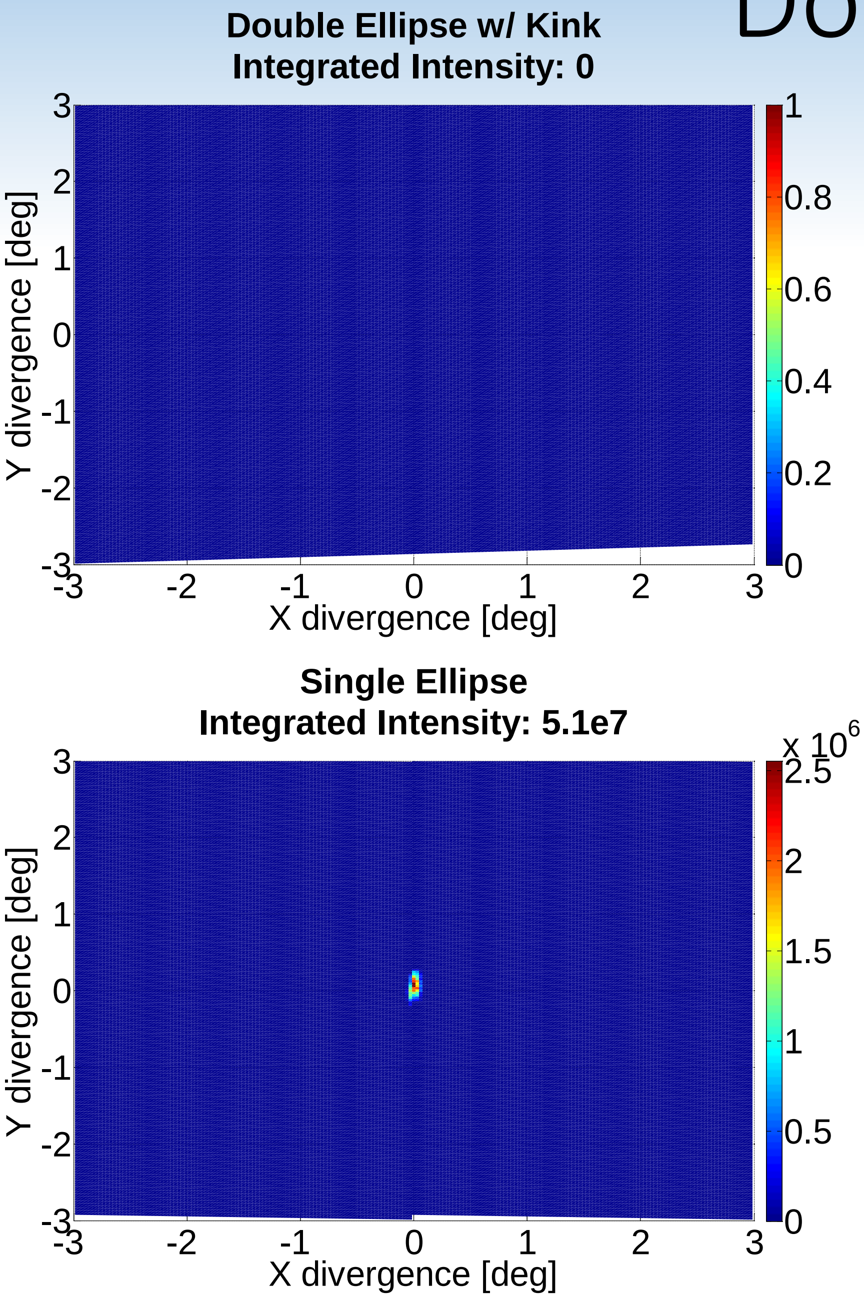
Double Ellipse with Kink





- 20cm x 30cm Sample
- Increase in neutron flux (~1.2x more neutrons)
- ~8.5x more neutrons than NG5

Double Ellipse with Kink



- All fast neutrons are eliminated at the sample position

Future Work

- Perform a careful study of energy resolution & the beam profile at the sample position of the double ellipse with a kink
  - Inhomogeneous phase space typical for a bended guide
- Put in an order for guide parts ASAP since ESS will be buying up all of the guides very soon!

Acknowledgments

- Leland Harriger
- Mads Bertelson
- Jeff Lynn
- Julie Borchers, Joe Dura, and all SURF Directors
- NSF and CHRNS

Monte Carlo

- Many systems cannot be perfectly modeled
- Monte Carlo randomly samples a distribution function to determine the probability of a neutron reflecting or transmitting

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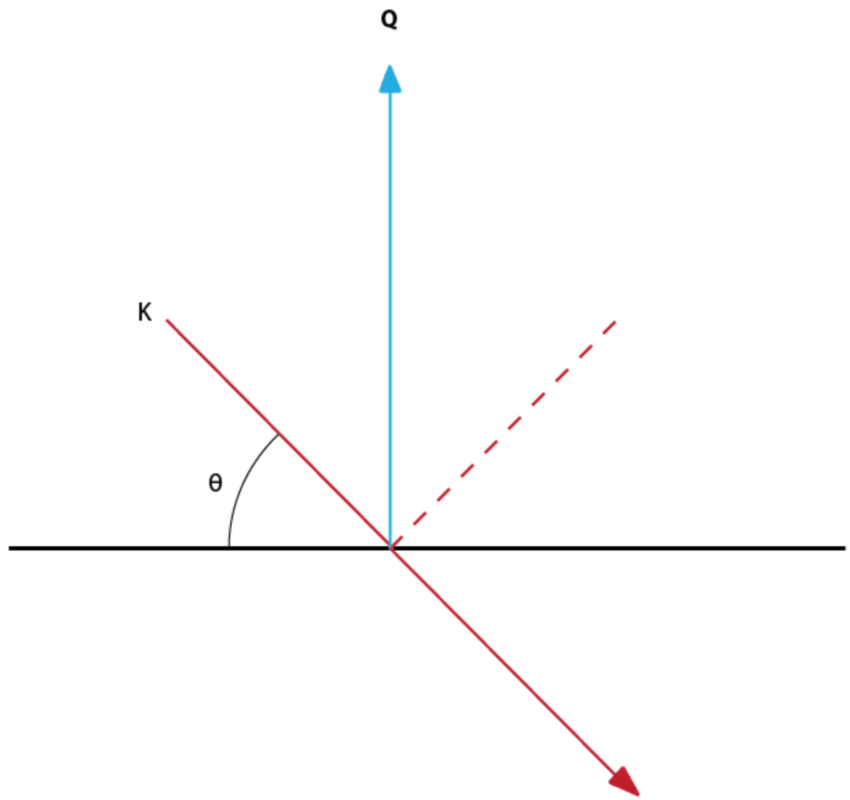
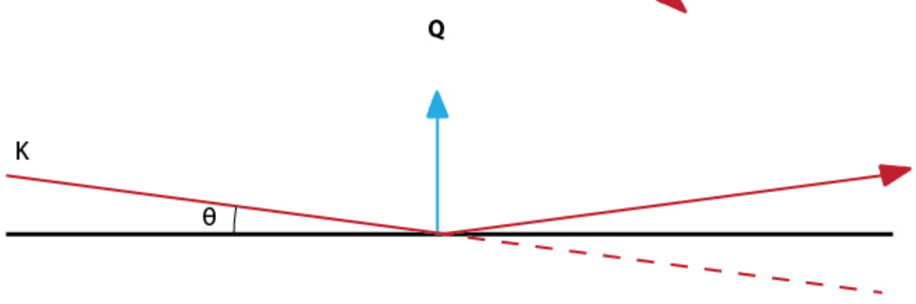
Momentum Transfer





- The momentum and collision angle determine the momentum transfer (Q)

$$Q = 2K sin\theta$$

$$sin\theta \approx \theta$$