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SDRD SITE-DIRECTED RESEARCH & DEVELOPMENT

High-fidelity dynamic neutron imaging and radiography for subcritical experiments and other applications
LO-005-19, Year 3 of 3

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Acknowledgments: Others from LAO, NLV, STL, and LLNL

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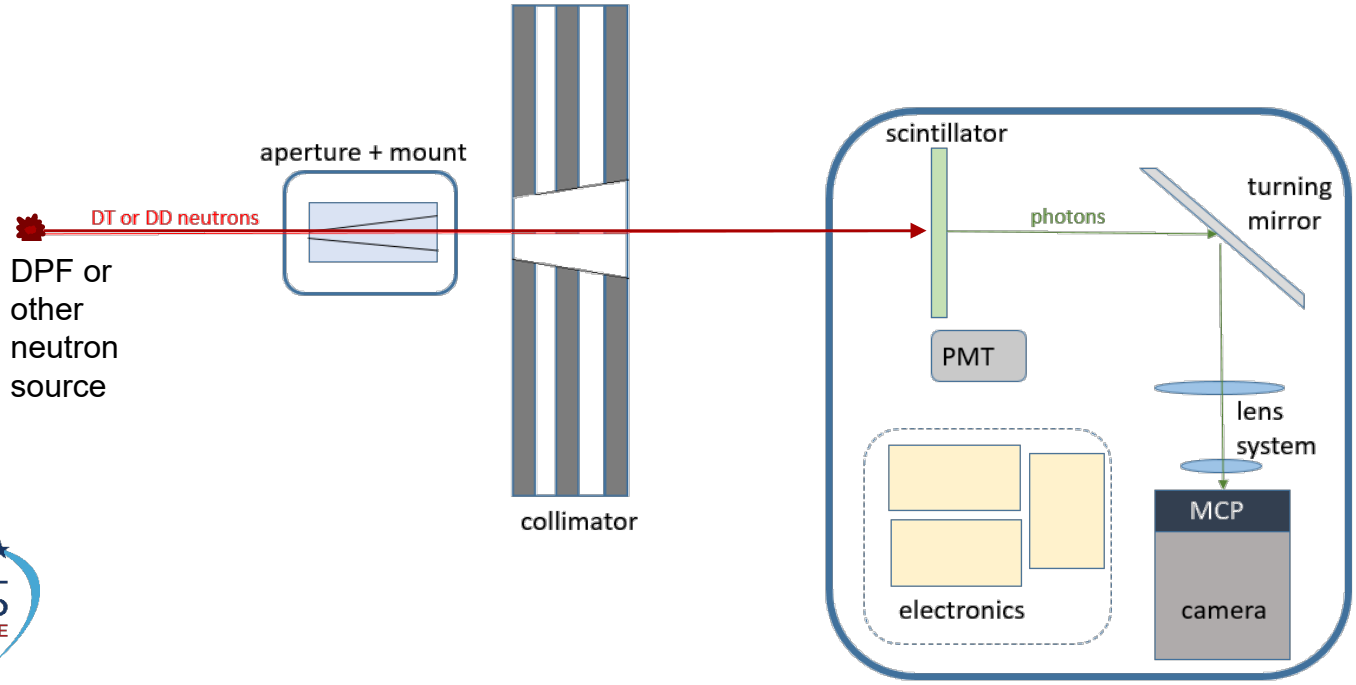
Challenge/Need for Diagnostic Development

- There is a need for neutron radiography to characterize down-hole experiments
  - Neutrons can be used to detect light elements that might be buried within heavier elements, offering more information compared to just using x-rays for radiography

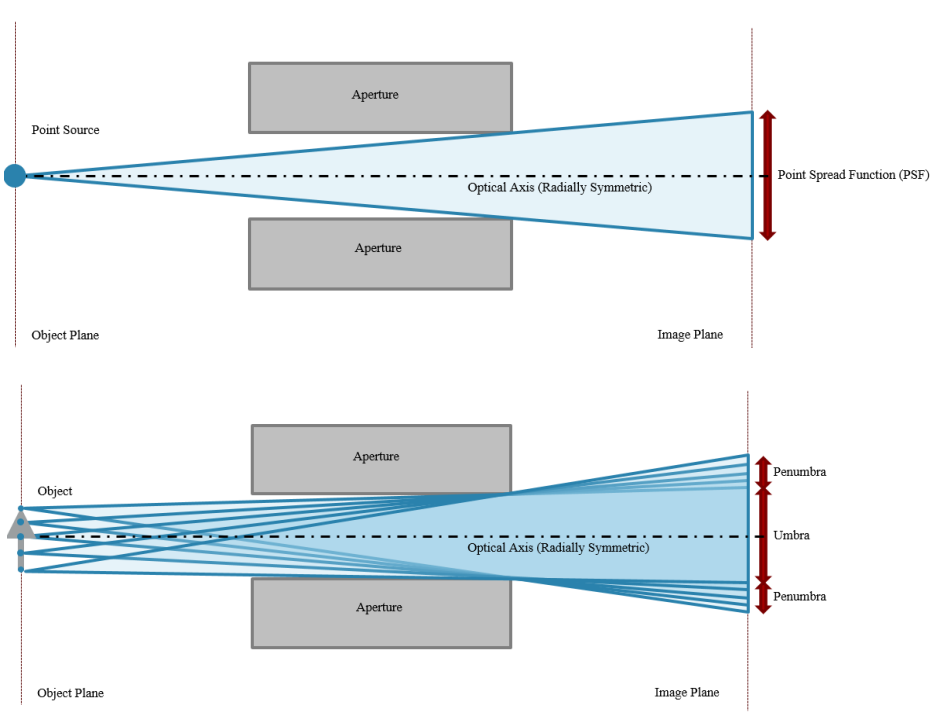
Challenge/Need for Diagnostic Development

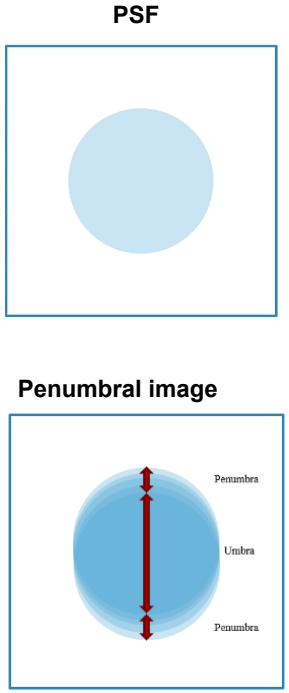
- There is a need for neutron radiography to characterize down-hole experiments
- For radiography, we need to know the size and shape of the neutron spot generated by the probing neutron source
- Need for a portable, short-range neutron imaging detector to characterize potential neutron sources
  - One candidate: dense plasma focus (DPF), another is laser ablation z-pinch source



Technical Approach/Penumbra Imaging

- In the case of low intensity sources where pinhole imaging will not work but penumbral apertures can be used
- Point spread function used to deconvolve the recorded penumbra images to give the “true” source shape and size
- Penumbral imaging is already an established technique for measuring source size and shape, but had yet to be done on DPF





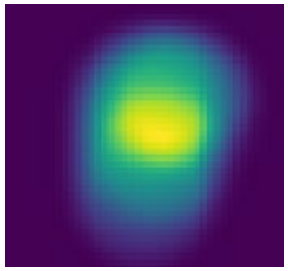
Images courtesy of Damyn Chipman

Technical Approach/Penumbra Imaging

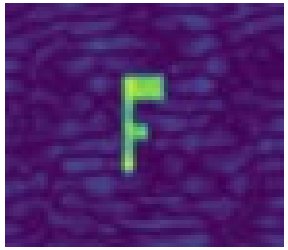
- Validation of our measurement and analysis technique

Example of simulated F-shaped source

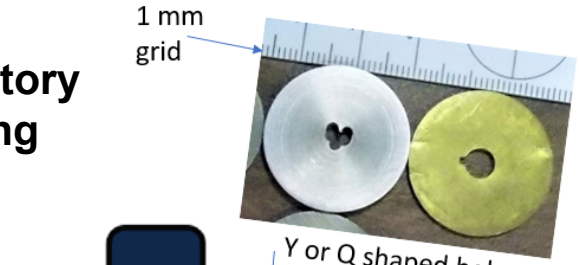
Raw image



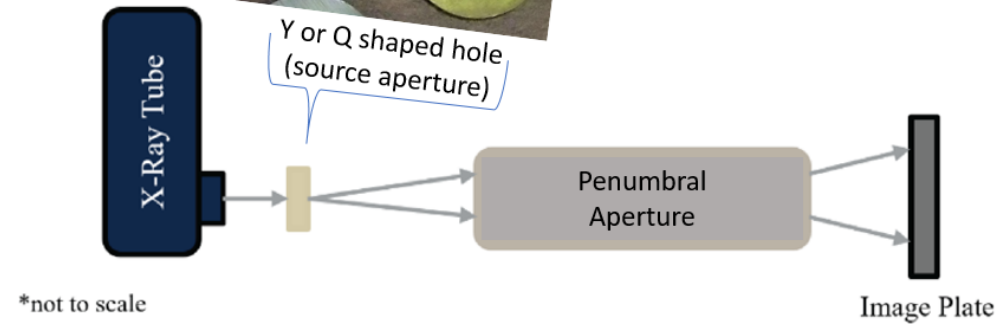
Resulting image

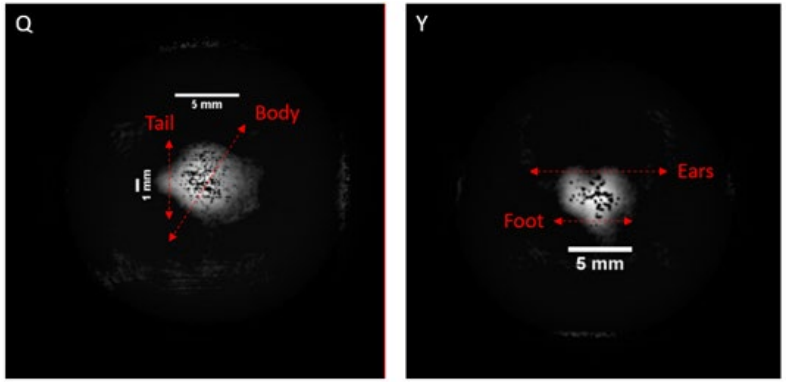


Laboratory testing



HEX lab penumbral aperture setup





- Could reconstruct Q and Y shape lab sources, determining the source size and resolving features of about 1 mm

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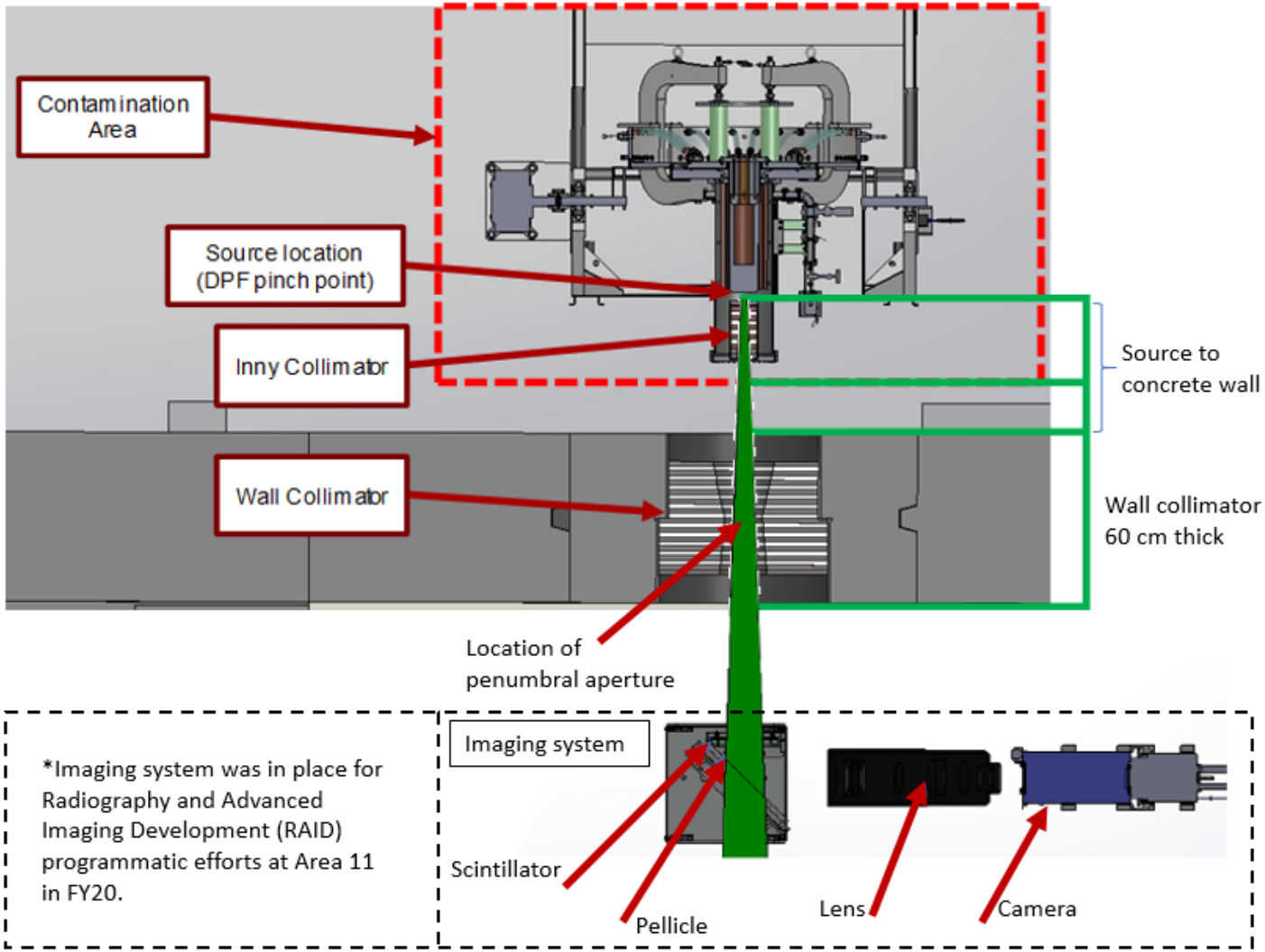
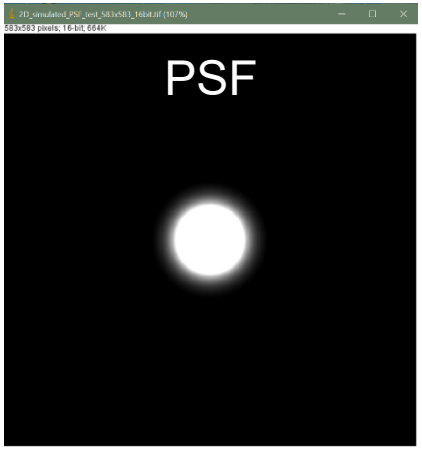
Results: Measurements on neutron source

- Using neutron imager developed at LAO, the LO conical penumbral aperture was fielded to record several images of the DPF source of high energy radiation **Area 11**
- Other candidates:
  - MJOLNIR
    - LLNL
  - LAZE
    - UNR

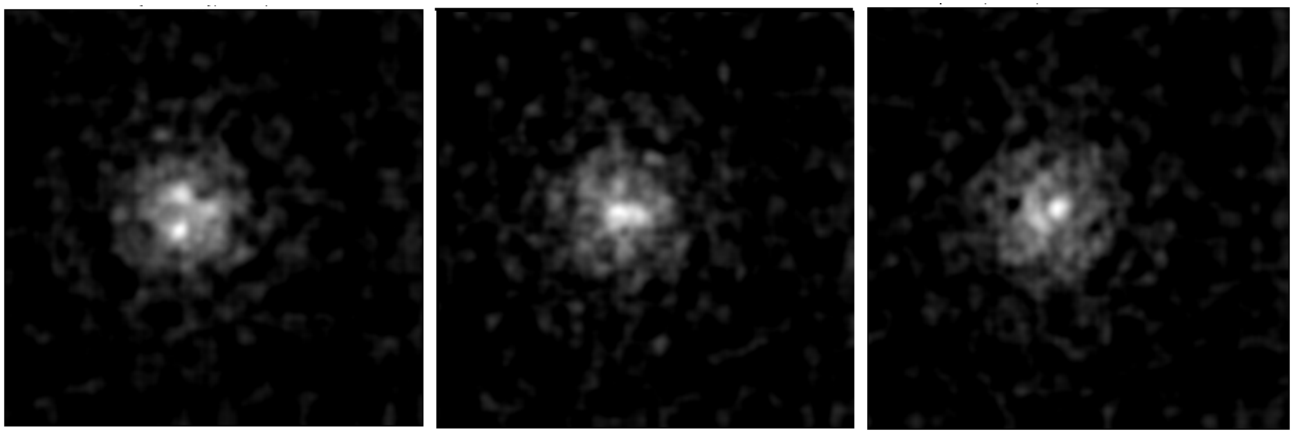


Results: Deconvoluted images

- Using neutron imager developed at LAO, the LO conical penumbral aperture was fielded to record several images of the DPF source of high energy radiation



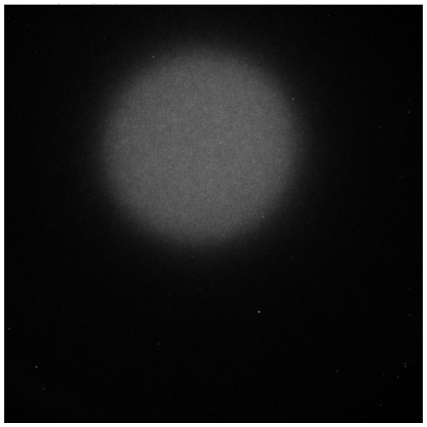
Deconvolved images



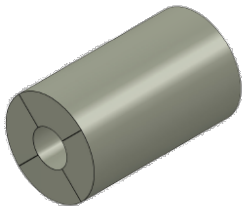
Excited by first set of penumbral images of the neutron source, needed comparison with other aperture and spot size measurements

Rollin' hole aperture vs. conical penumbral aperture

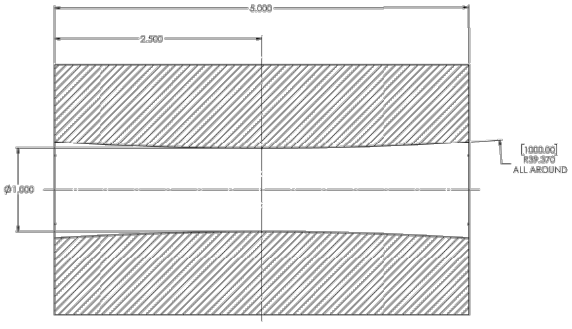
Previously unanalyzed rollin' hole data from Area 11

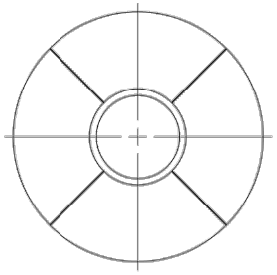


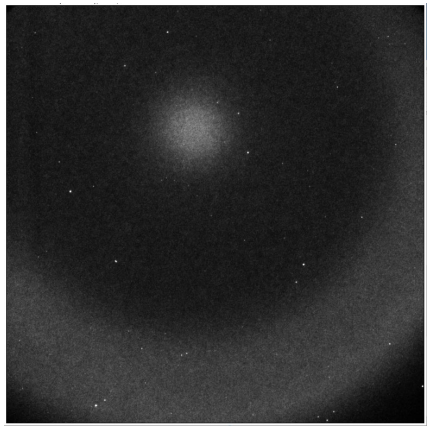
Needed PSF and de-convolution with previously tested image reconstruction techniques



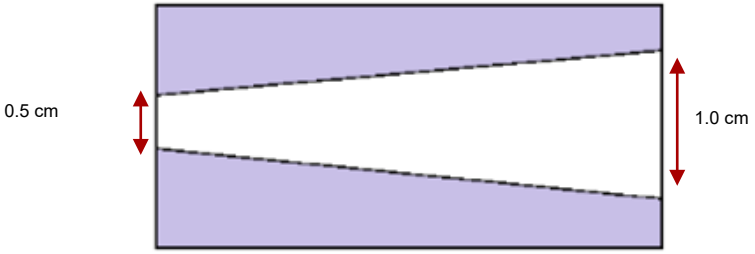
Rollin' hole







Conical



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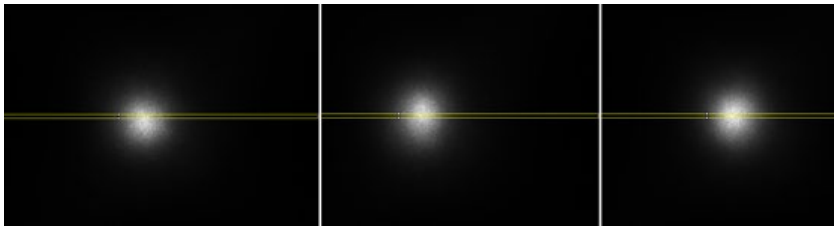
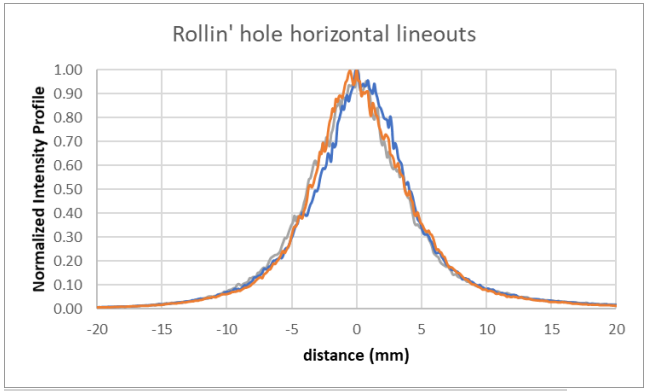
Rollin’ hole aperture vs. conical penumbral aperture results



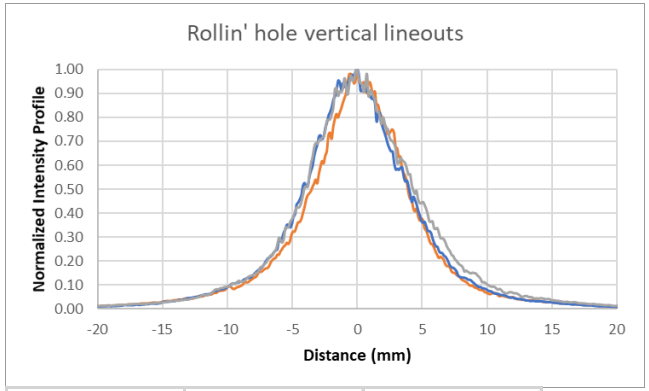
Rollin’ hole



FWHM 11:57	FWHM 12:27	FWHM 12:57
7.6415	7.0253	7.5183

Horizontal profile

units (mm)

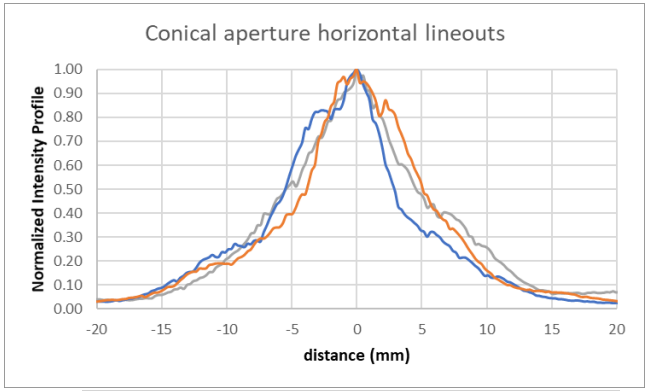


FWHM 11:57	FWHM 12:27	FWHM 12:57
7.395	8.381	8.2578

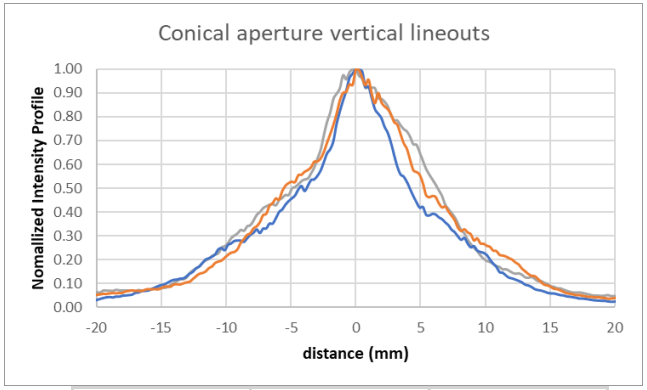
Vertical profile

units (mm)

Conical



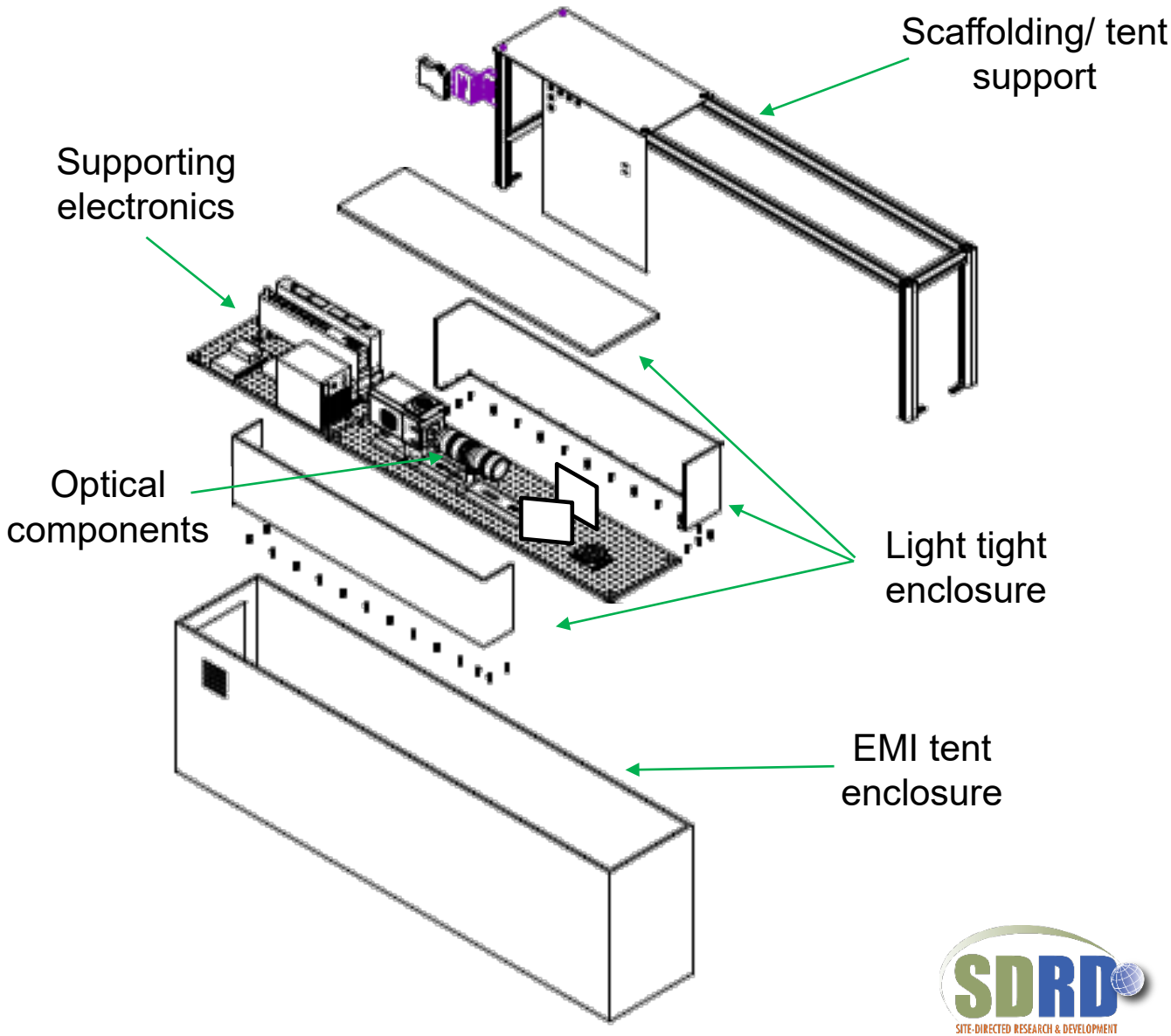
FWHM 12	FWHM 44	FWHM 59
10.1065	8.874	8.381



FWHM 12	FWHM 44	FWHM 59
11.0925	8.381	10.846

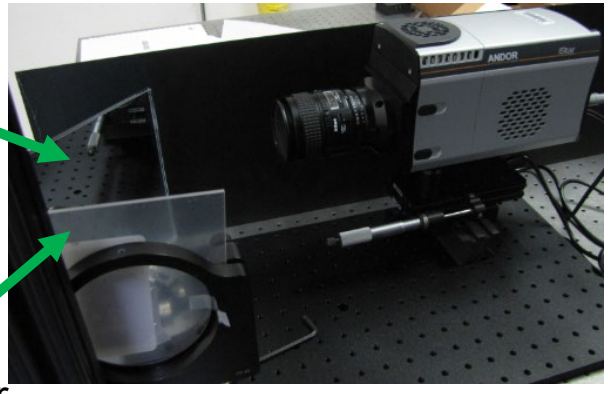
Result: Neutron imager design

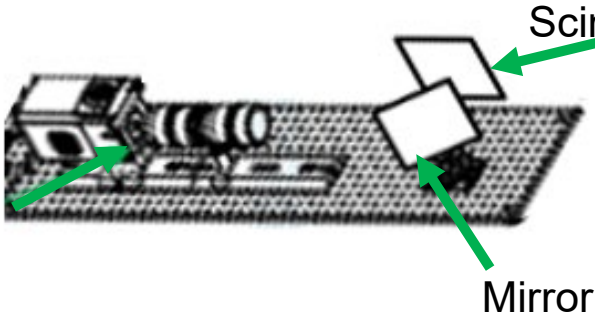
- Original project goals planned for a portable imager that could easily go to DPF at either NLV, Area 11, LLNL, or other neutron sources.
- Designed and planned for experimentation but not yet fielded

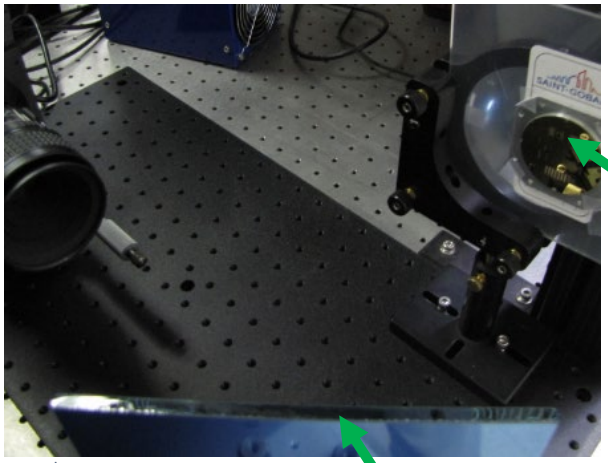


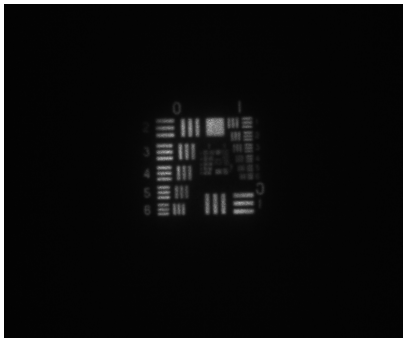
Result: Portable neutron imager

- Testing ongoing at LO



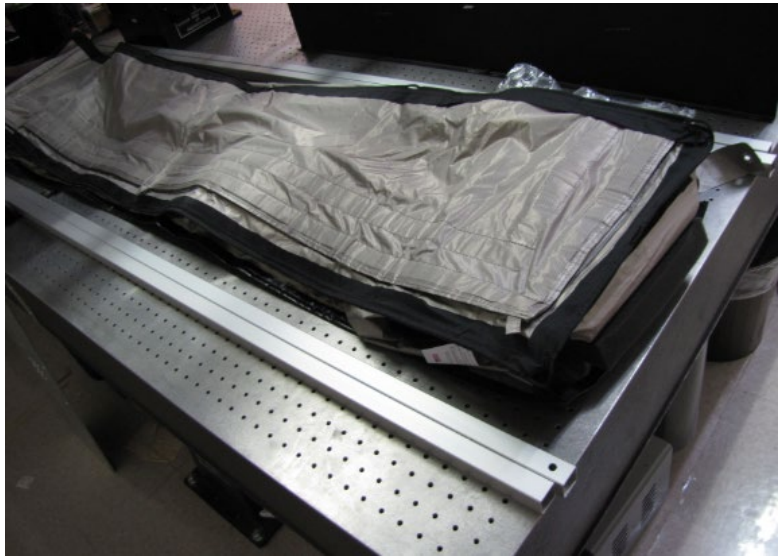




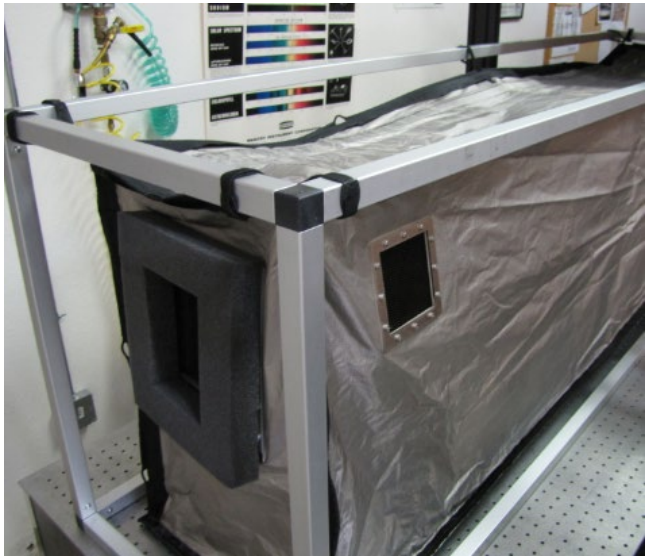


Result: Portable neutron imager

- Lightweight portable EMI shielding using tent-like material makes for easy travelling between experimental sites (LLNL, UNR).



Broken down



Erect enclosure

Summary of Results, Path Forward

- Penumbral aperture fielding and image analysis a success for this project
  - Multiple good shots with conical aperture at Area 11 DPF FY20
  - Analyzed images from penumbral rollin' hole aperture, comparable results
    - Working now on manuscript to compare the penumbral technique with RAID programmatic efforts using rolled edge
- Great if imager is fielded on future neutron source shots (not just DPF)
  - MJOLNIR shot schedule has been rough (constant state of damage, redesign and rebuilding)
    - At end of Q1 and Q3: We reported damage to the system and lengthy downtime with no new shots obtainable for this year
  - Area 11 experienced some downtime after high yield testing
  - LAZE experiments at UNR/NTF with Zebra shots resuming this month – Chance to measure on LO-001-21 (Wiewior - SDRD)
    - Offers unique chance for non-DPF source
- Hopefully these results and other future measurements motivate a continuation of efforts like these

Acknowledgments

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MSTS – STL

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