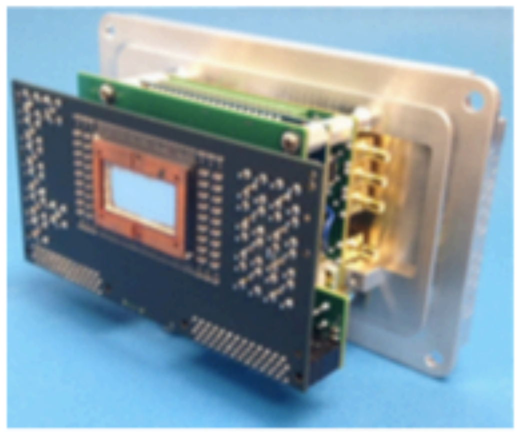
X-Ray Imaging Session 1 Outbrief

October 8th, 2015

October 6, 2015

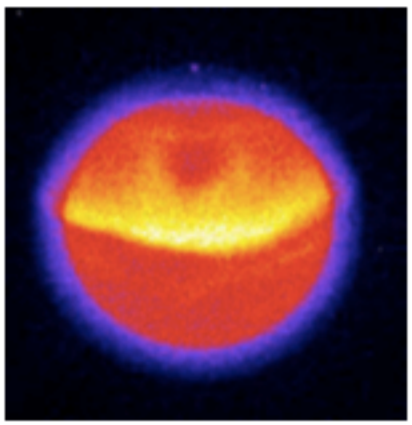
First Use of Hybrid CMOS Cameras on Z and NIF



John Porter on behalf of the UXI project team
Sandia National Laboratories, jlporte@sandia.gov

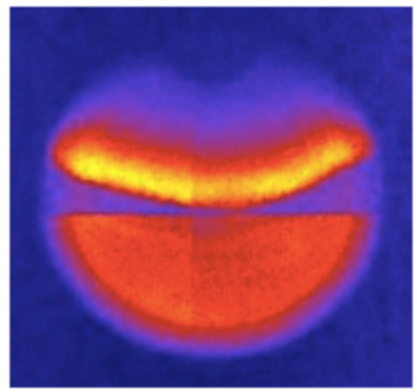
Comparison of Furi and CCD images on NIF shot N150901-002-999

CCD

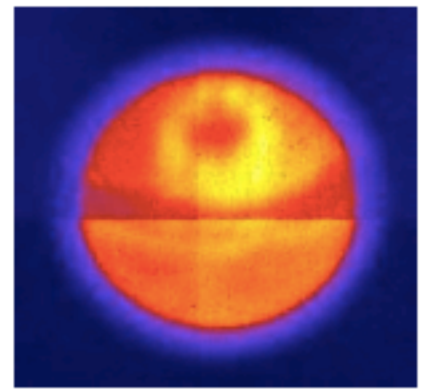


Furi operated in 2ns-on/2ns-off timing mode

Frame 1



Frame 2



Data courtesy H. Chen and N. Palmer (LLNL)

Next Steps

- **Characterize & begin fielding next-generation cameras**
  - Hippogriff
  - Icarus
  - Small Outline Package
- **Integrate cameras into new diagnostics**
  - Multi-frame x-ray backlighting
  - Pulse-dilation framing camera
  - X-ray spectrometers
  - Visible shadowgraphy
  - Neutron detection
- **Correct limitations in present Furi/Hippogriff design**
  - Improve exposure uniformity
  - Reduce integration time
  - Option for using diodes optimized for higher- or lower-energy detection
  - Option for “tiling” to increase effective sensor size

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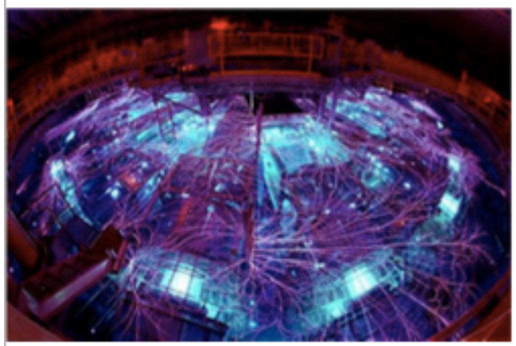
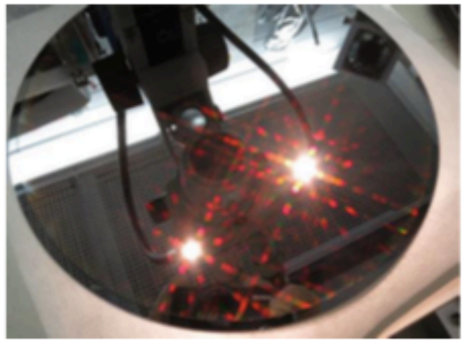

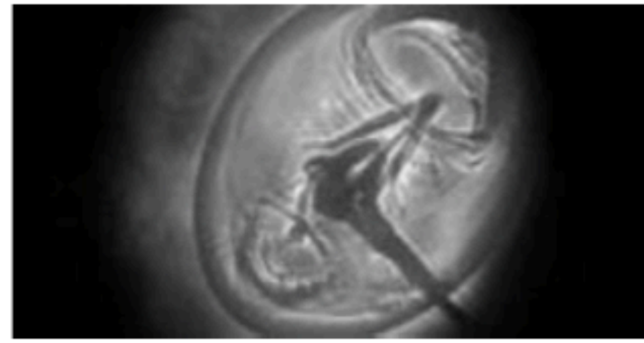

Low-Energy Sensitive Diodes for hCMOS Sensors

Q. Looker, R. Kay, J. Long, G. Robertson, M. Sanchez, D. Trotter, J. Porter

10/6/2015

U.S. DEPARTMENT OF ENERGY NNSA

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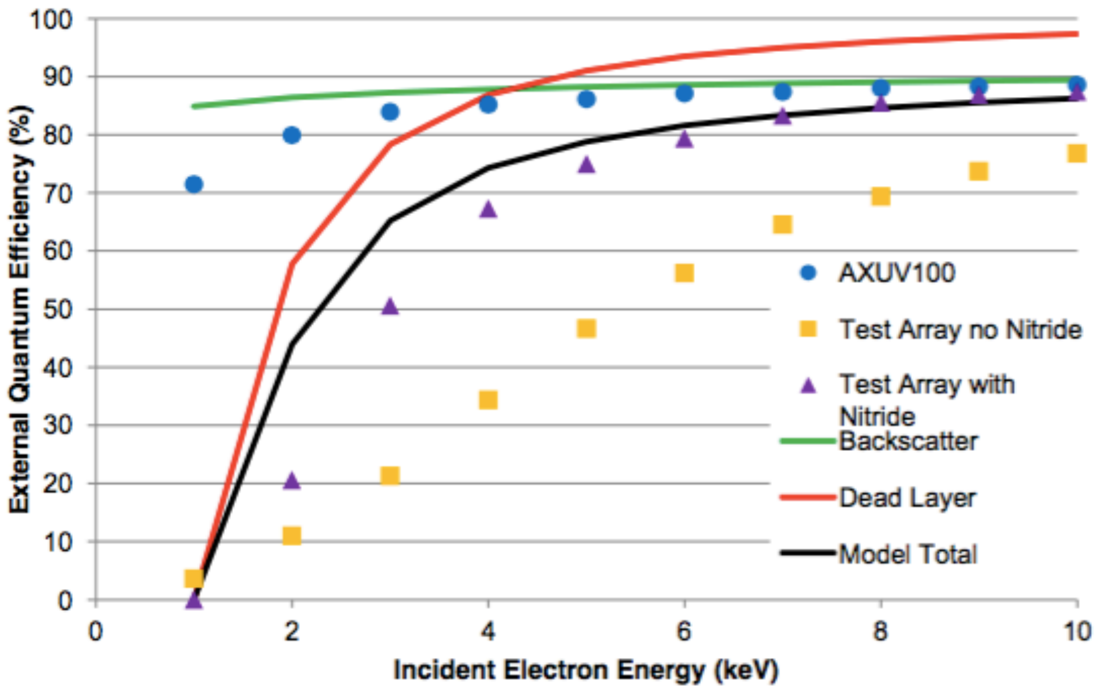
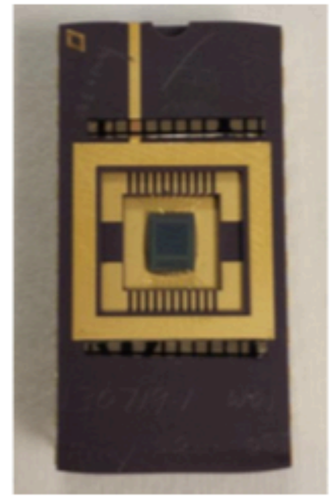
Current Generation Diode Array Sensitivity Tested

- Surface passivation adds more dead layer absorption, but apparently reduces surface recombination



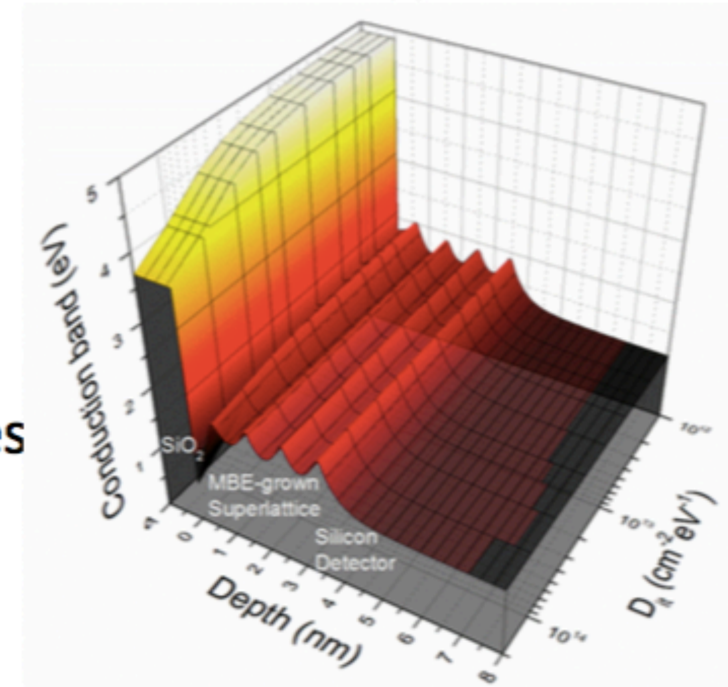


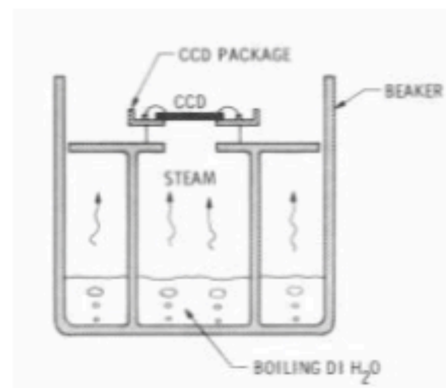
Dead Layer based on Si_3N_4 stopping power from [1] and SiO_2 stopping power values from [2]

[1] NIST Estar, http://physics.nist.gov/PhysRefData/Star/Text/ESTAR.html
[2] J. Ashley & V. Anderson, JES Vol. 24, pp. 127-148 (1981)

Path Forward

- hCMOS cameras will incorporate nitride passivation layer
- New discrete diodes will provide test bed for alternative technologies
  - JPL Delta Dope, successfully demonstrated to increase CCD UV sensitivity [1]
  - Univ. of Arizona flash oxide, also demonstrated for UV rays on CCDs [2]
- hCMOS diode arrays will incorporate new findings





[1] Hoenk et al., APL Vol. 61, pp. 1084-1086 (1992)
[2] Janesick et al., Opt. Eng. Vol. 26, pp. 852-863 (1987)

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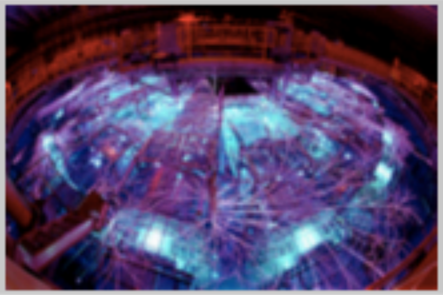

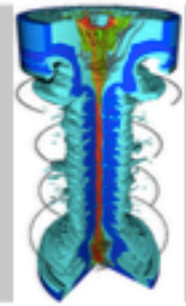

Self-emission crystal imaging and spectroscopy for MagLIF.

E.C. Harding, M.R. Gomez, S. A. Slutz, A.B. Sefkow, M. Geissel, A.J. Harvey-Thompson, M. Schollmeier, K.J. Peterson, T.J. Awe, S.B. Hansen, K.D. Hahn, P.F. Knapp, P.F. Schmit, C.L. Ruiz, D.B. Sinars, C.A. Jennings, I.C. Smith, D.C. Rovang, G.A. Chandler, M.R. Martin, R.D. McBride, J.L. Porter, and G.A. Rochau

Sandia National Laboratories, Albuquerque, NM

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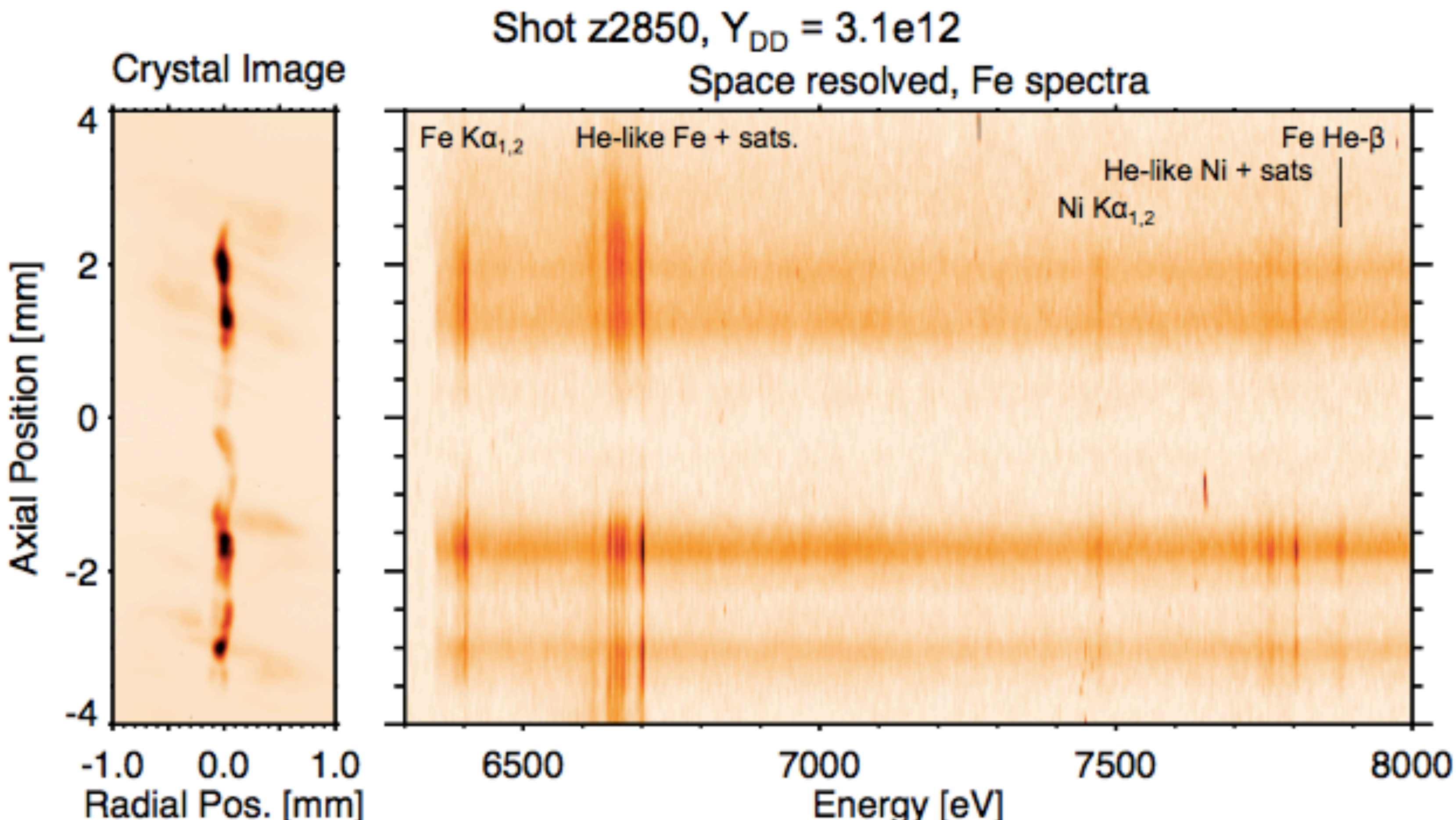
We believe we are observing He-like Fe emission from stagnation. The crystal image and spectra can be aligned using the spatial fiducials attached to the target.



The Fe He-like emission can be fit with synthetic spectra from PrismSPECT to estimate T_e and n_e.

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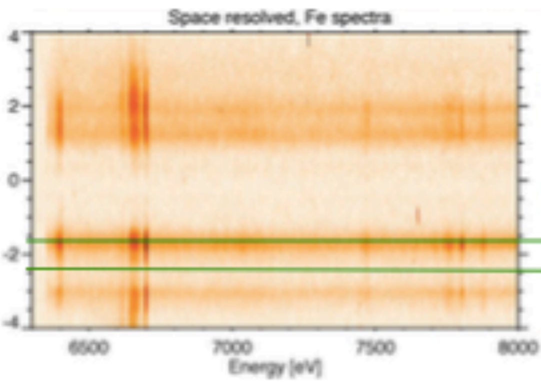
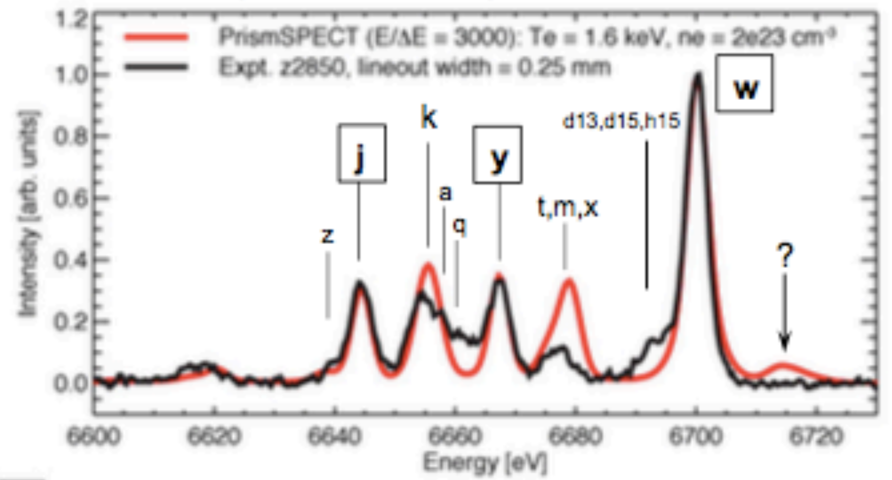
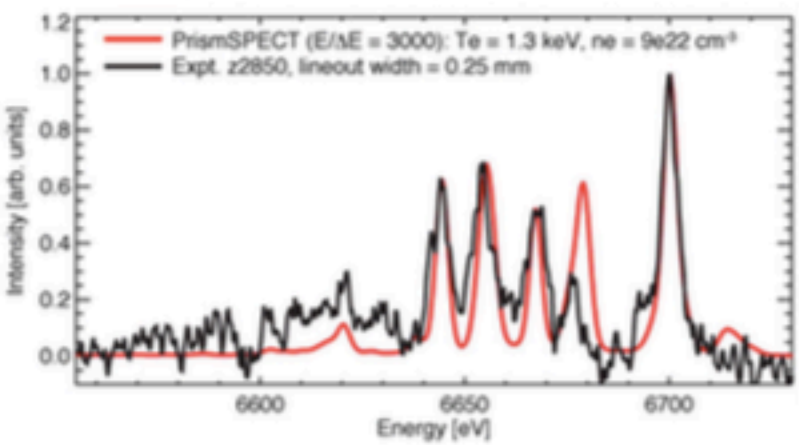


T_e = 1.6 keV, n_e = 2e23 cm^{-3}



T_e = 1.3 keV, n_e = 9e22 cm^{-3}



Note: Prism calculations are 1D, nLTE, steady-state, and assume 10% Be mix with .001% Fe. Optical depth of Fe w-line ~ 0.1 to 0.2 ODs.

Kirkpatrick-Baez Microscope for NIF

Diagnostic Workshop, Los Alamos 2015

L. A. Pickworth & the KBO team

LLNL-PRES-XXXXXX
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Lawrence Livermore National Laboratory

We have taken the first alignment shots on NIF which show good resolution and illumination at 10.2keV

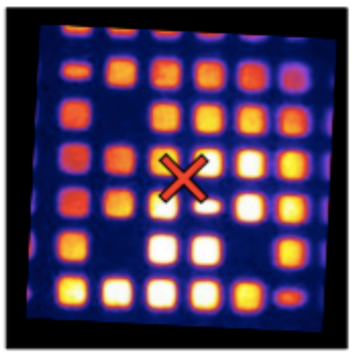


Image at 1.5keV
Manson Source

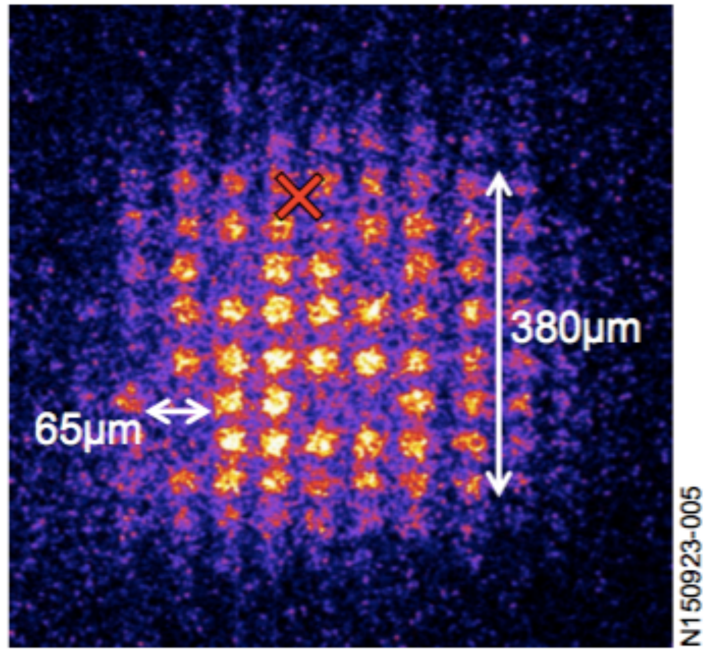


Image at 10.2keV
Ge back light

Full field of view is ~380μm diameter with <8μm resolution

We have designed built and fielded a modular KBO system for NIF

- The NIF KBO has <8um resolution across a ~300μm field of view
- The first mirror pack operates at 10.2keV with plans for two more operating at different enegies
- We have developed an alignment scheme for the diagnostic to achieve better pointing to TCC
- First images have been obtained from NIF at 10.2 keV

High-resolution Penumbral Imaging on the NIF

October 6, 2015

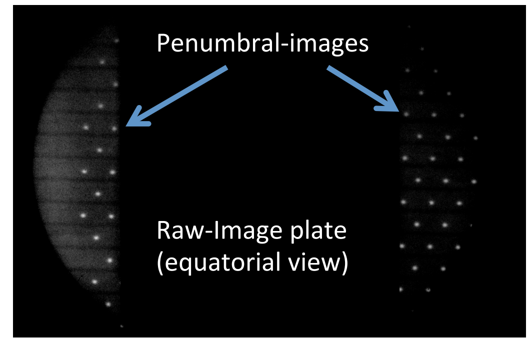
Benjamin Bachmann
T. Hilsabeck (GA), J. Field, A. MacPhee, N. Masters, C. Reed (GA), T. Pardini, B. Spears, L. Benedetti, S. Nagel, N. Izumi, V. Smalyuk, D. Bradley, J. Kilkenny

Lawrence Livermore National Laboratory

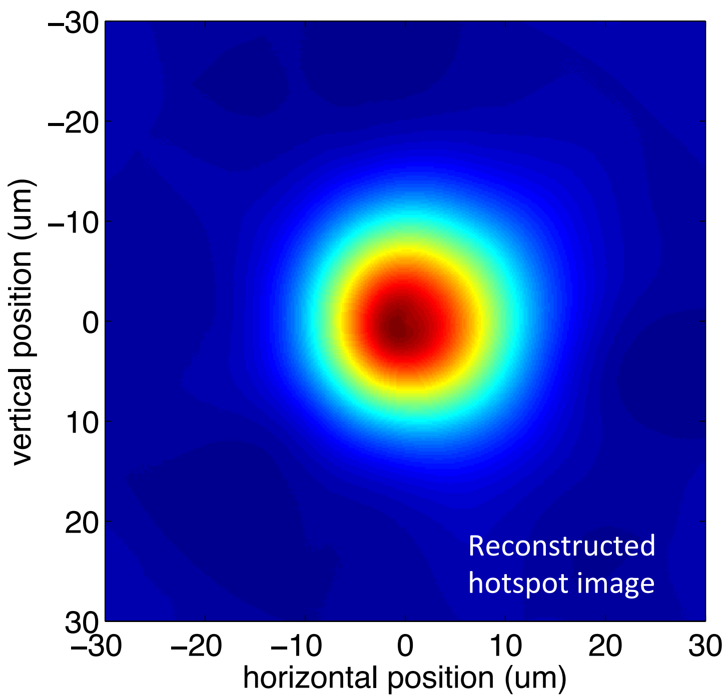
LLNL-PRES-XXXXXX
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

We successfully fielded Penumbral Imaging on the NIF – on IP (58x Magnification)

Gbar solid sphere target, on Image Plate of DIXI LoS:



Reconstruction



10 μm radius (1/e)

Highest resolution hotspot image on the NIF to date:
<u>1.5μm resolution (limited by IP resolution)</u>

Summary

- 1.5μm resolution Penumbral Imaging has been successfully fielded on the NIF

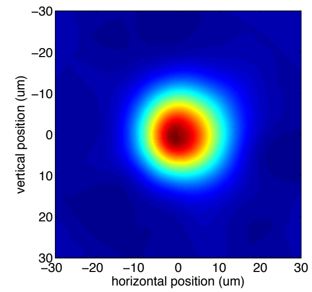
- Penumbral imaging has potential of significantly improving hotspot imaging in ICF implosions

- Manufacturing challenges of quality apertures have been overcome

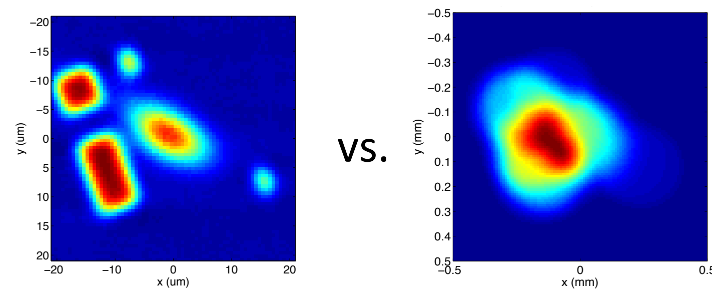
- Many possible applications

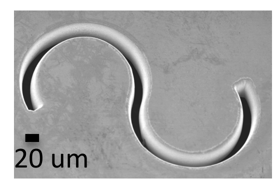
“we just scratched the surface”

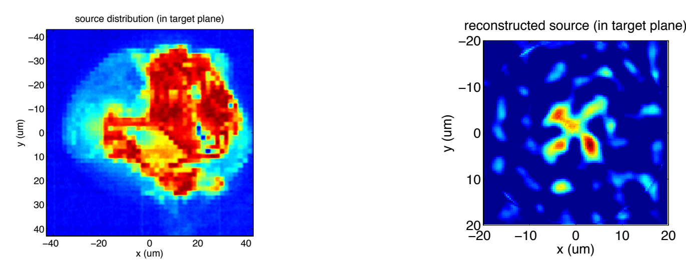
Reconstructed Penumbral Image
N140928-004



Penumbral Imaging | Pinhole Imaging







Opportunities, Questions, and Summary

- Opportunities
  - H-CMOS cameras becoming available for more applications; new models imminent
  - Multilayer coating capabilities synergy (Wolter, KB) at NIF and Z.
  - Opportunity for collaboration: penumbral imaging on Z? What kind of aperture would you use for a Z pinch?
  - In-chamber D-SLOS on Z could be transformational; both for imaging and spectroscopy
    - Moving to high-yield on all HED facilities means that developing and integrating capabilities for extreme environments will be transformational

- Questions:
  - What impact does time-integration have on Te measurements from Fe?
  - Possible resolution from processing of pinhole imaging vs. penumbral imaging
  - What are the performance impacts for H-CMOS imagers and diodes from radiation damage? What about X-Ray absorption in the ROIC?

- Summary:
  - Early successes for H-CMOS at NIF and Z
  - Low-energy X-Ray/electron detection diode developed and characterized
  - X-Ray I&S capabilities coming online at Z for diagnosing MAGLIF
  - KB microscope coming online; 8 micron resolution demonstrated. Development needed for higher-energy crystals
  - 1.5-micron penumbral x-ray imaging demonstrated