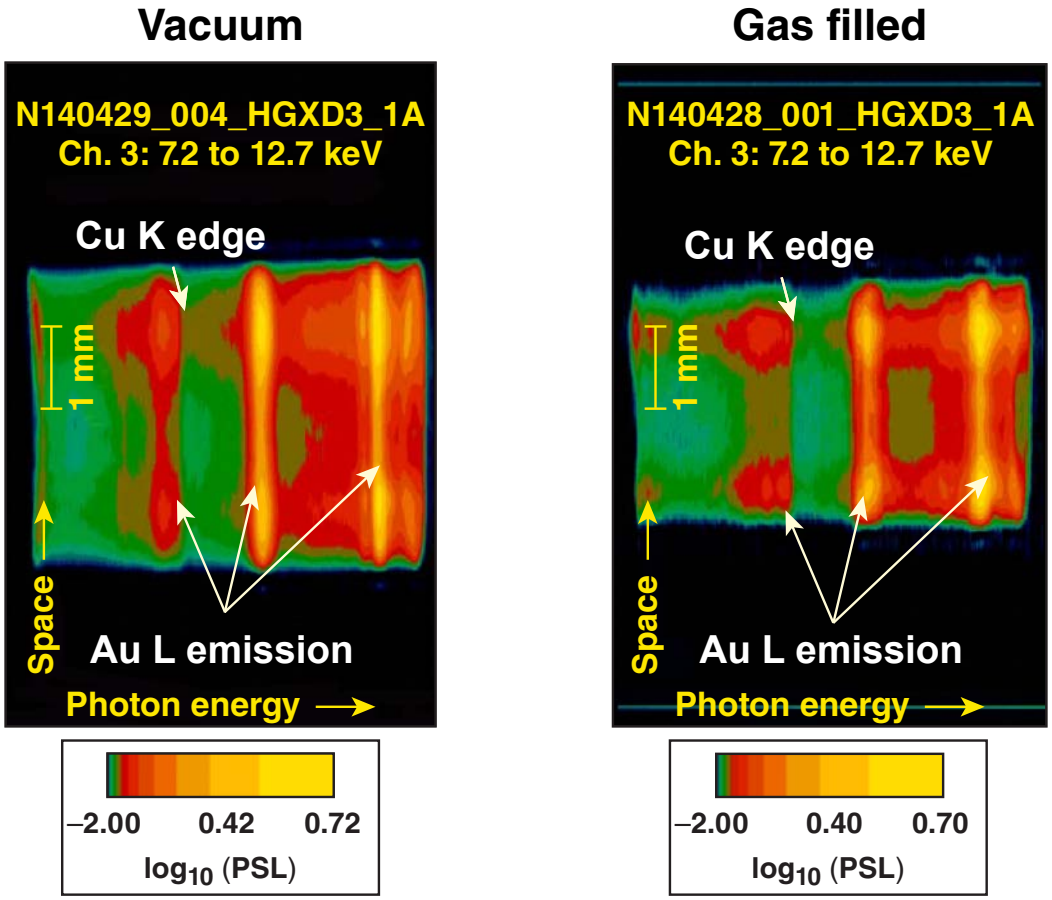
Hohlraum T_e Inferred from Au L-shell Emission



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Summary

The plasma at the laser entrance hole of a National Ignition Facility (NIF) hohlraum is diagnosed using Au L-shell spectroscopy

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- Laser-ablated plasmas created at the inner wall of the hohlraum (Au bubble) and at the laser entrance hole (LEH) radiate L-shell emission from Ne-like to Co-like charge states of Au
- The Au L-shell spectrum of the ($3d_{5/2}$ to $2p_{3/2}$ transitions) are analyzed to infer the T_e of the radiating plasma
- The simulated LEH T_e is lower than the measured LEH T_e

This technique will be used to diagnose T_e of the Au bubble.

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Collaborators

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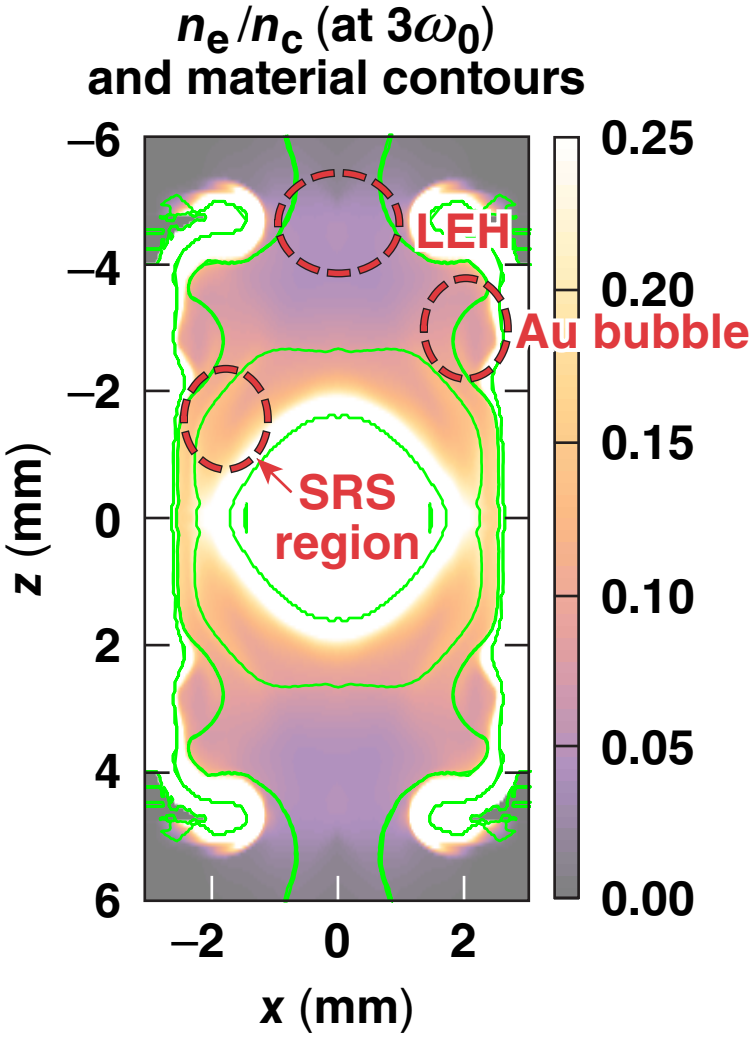
Motivation

There is an unexplained drive deficit of 10% to 25% in gas-filled, ignition-scale hohlraums*



- Plasma conditions must be diagnosed in three regions: LEH, Au bubble, stimulated Raman scattering (SRS) region
- Plasma-diagnostic techniques
  - Au L-shell emission spectroscopy
  - μdot x-ray spectroscopy**
  - optical Thomson scattering

NIF shots scheduled in FY15

The amount of energy stored in the hohlraum plasma will be studied.

*J. D. Moody *et al.*, Phys. Plasmas 21, 056317 (2014).
**M. A. Barrios, NO7.00005, this conference.

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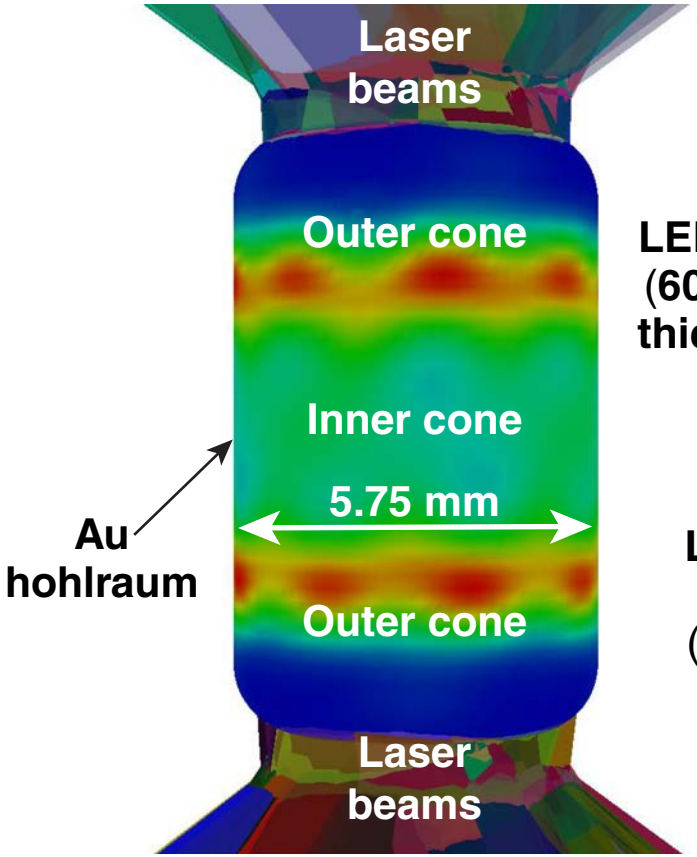
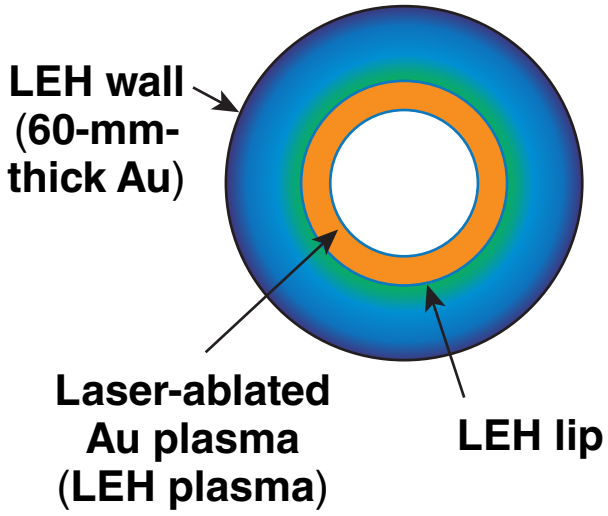
Laser-ablated plasmas created at the inner wall of the hohlraum (Au bubble) and at the LEH radiate Au L-shell emission

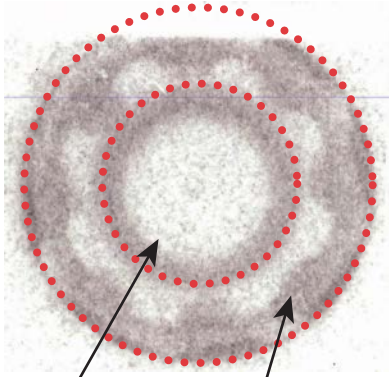
Model of laser-irradiated hohlraum



Model LEH view



Measured, gated 4-keV image of Au bubble in view-factor hohlraum



The LEH plasma can be observed, but the LEH wall blocks the view of the Au bubble.

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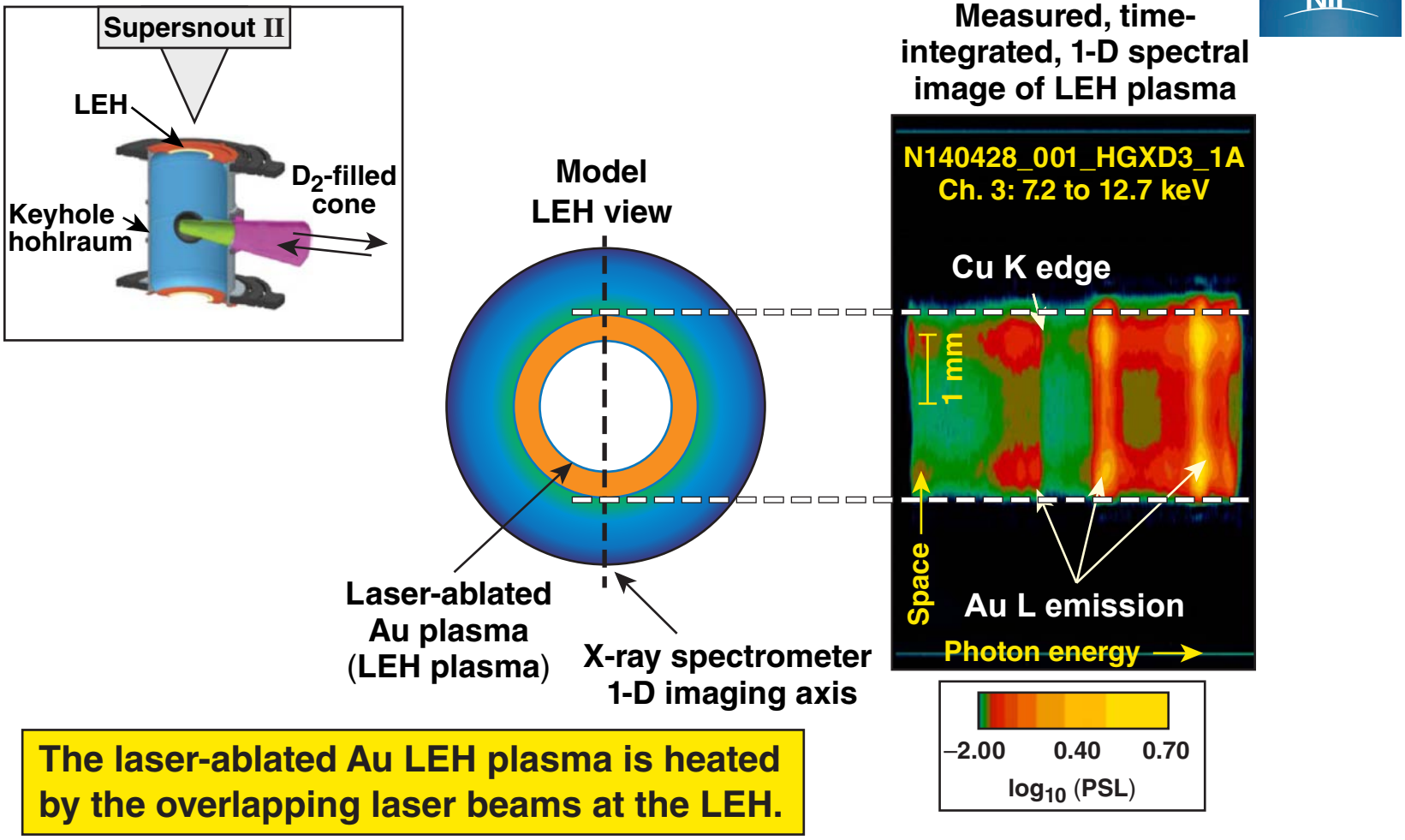
One-dimensional spectral images (6 to 16 keV) and broadband x-ray images are recorded along the hohlraum axis



The laser-ablated Au LEH plasma is heated by the overlapping laser beams at the LEH.

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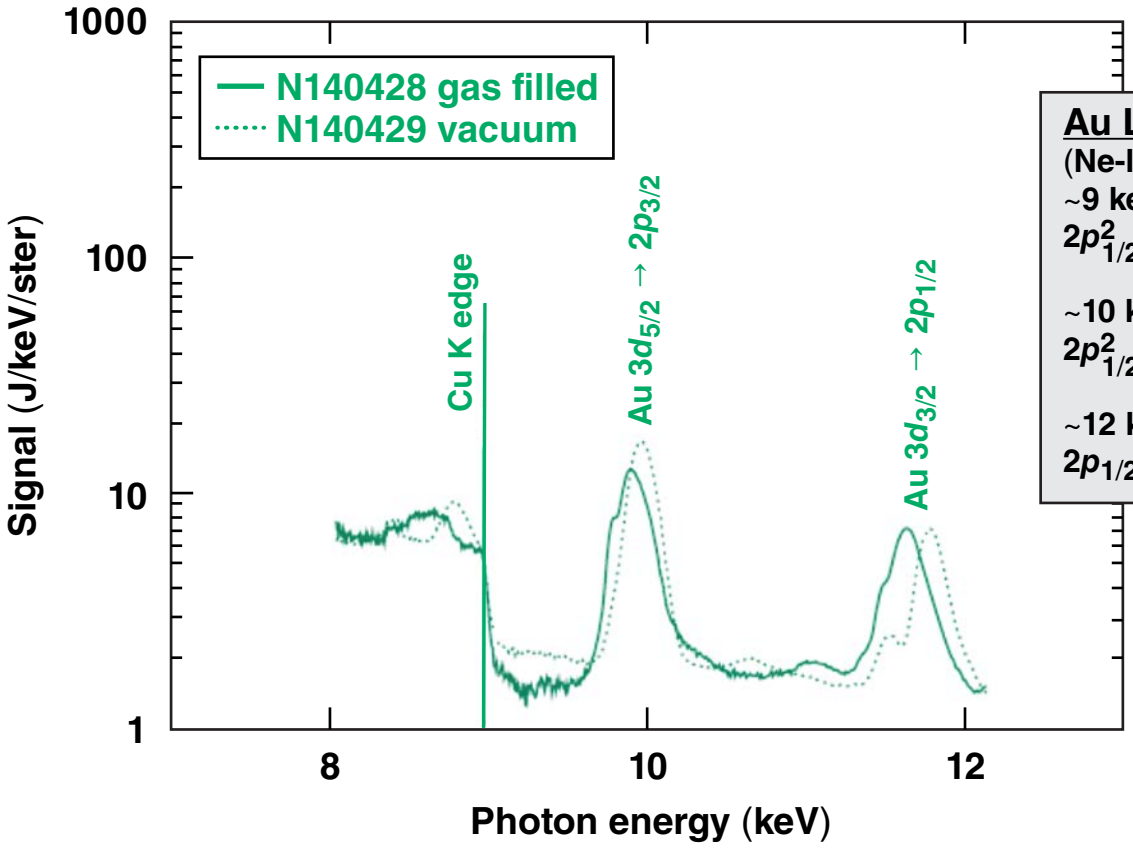
Different line shifts are observed in the Au L-shell emission for vacuum and gas-filled hohlraums



Au L-shell transitions*
(Ne-like to Co-like Au)

~9 keV:
$2p^2_{1/2}2p^3_{3/2}\,3s^23p^k3d \rightarrow 2p^63s3p^k3d^{k'}$

~10 keV:
$2p^2_{1/2}2p^3_{3/2}\,3s^k3p^{k'}3d^{k''}3d \rightarrow 2p^63s^k3p^{k'}3d^{k''}$

~12 keV:
$2p_{1/2}2p^4_{3/2}\,3s^k3p^{k'}3d^{k''}3d \rightarrow 2p^63s^k3p^{k'}3d^{k''}$

Au $L_{\alpha 1}$ = 9.713 keV
Au $L_{\alpha 2}$ = 9.628 keV
Au $L_{\beta 1}$ = 11.442 keV
Au $L_{\beta 2}$ = 11.585 keV

The Cu K edge provides a photon-energy fiducial.

*M. J. May *et al.*, High Energy Density Phys. 4, 78 (2008).

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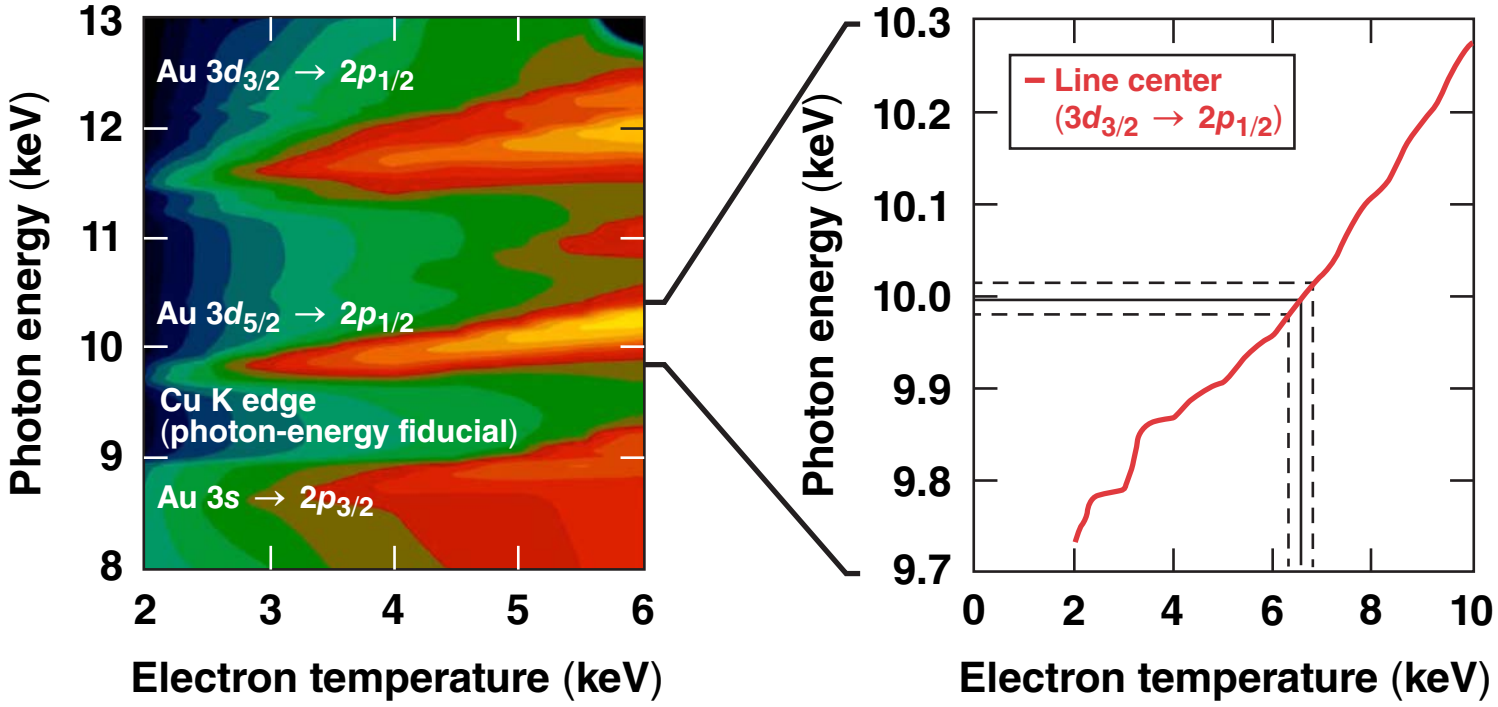
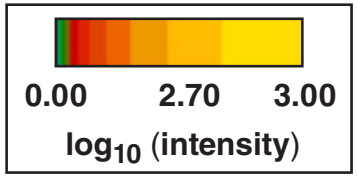
The Au L-shell emission is predicted to shift to higher photon energies as T_e increases

Calculations from *SCRAM atomic physics code for Au L-shell emission**



$T_r = 0$
$n_e = 10^{20}$ cm^{-3}
Optically thin



T_e increases → Au is ionized → Au L-shell transition shifts to higher photon energy.

*S. B. Hansen *et al.*, High Energy Density Phys. 3, 109 (2007).

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The LEH T_e is inferred from the Au $3d_{5/2} \rightarrow 2p_{3/2}$ transitions assuming uniform plasma conditions

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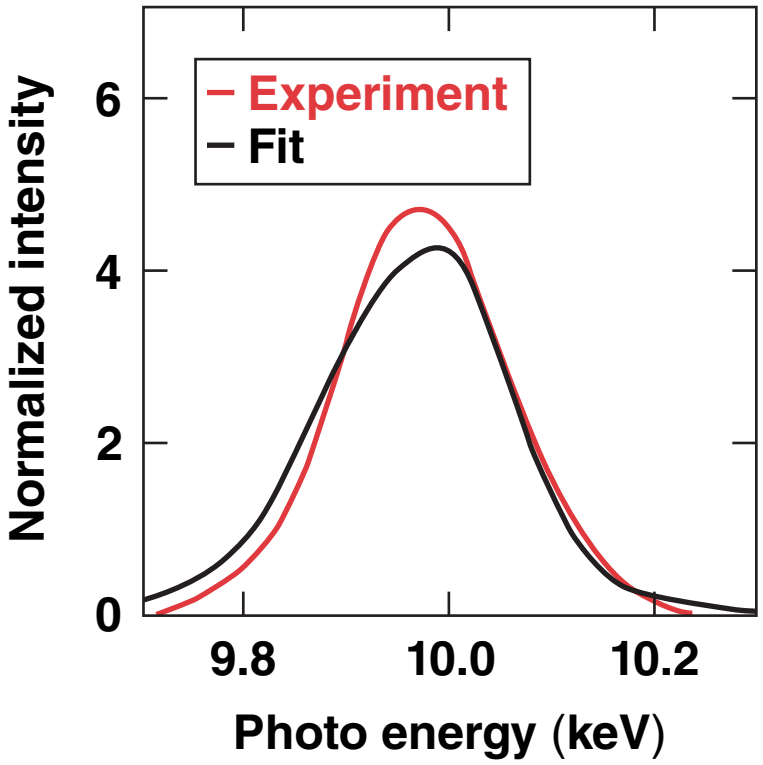
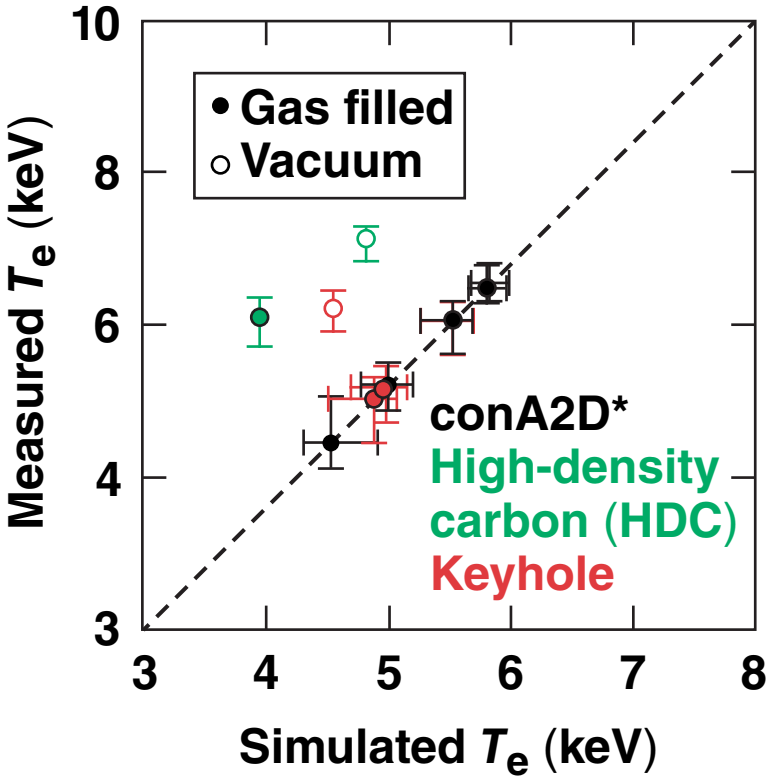
Measurement versus spectral fit



LEH T_e measured versus simulated



The simulated LEH T_e is lower than the measured LEH T_e.

*Convergent ablator campaign on the NIF

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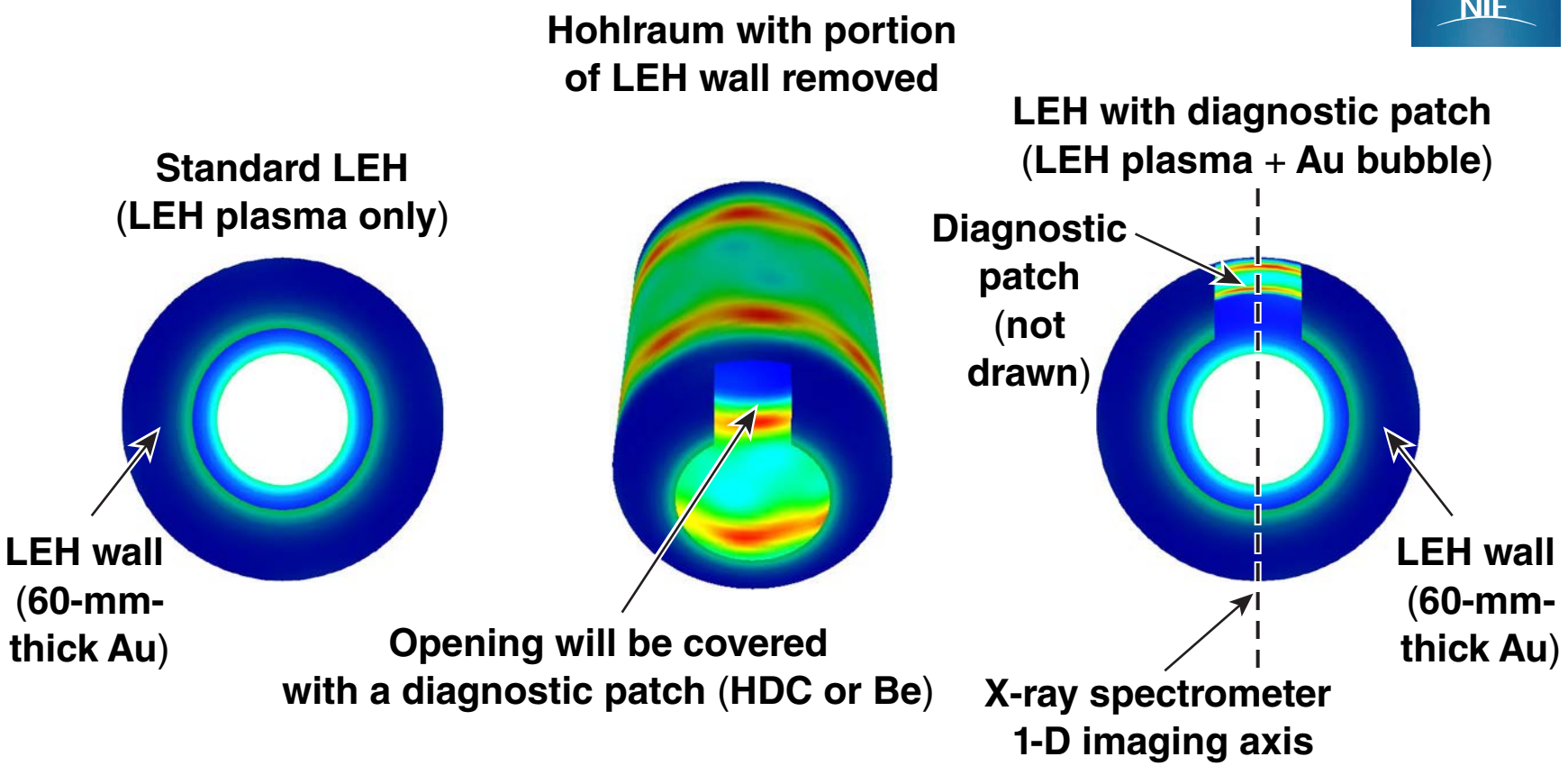
A diagnostic patch in the LEH wall provides a line of sight to the Au bubble



The diagnostic patch will confine the hohlraum plasma and transmit the Au L-shell emission from the Au bubble.

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Summary/Conclusions

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This technique will be used to diagnose T_e of the Au bubble.

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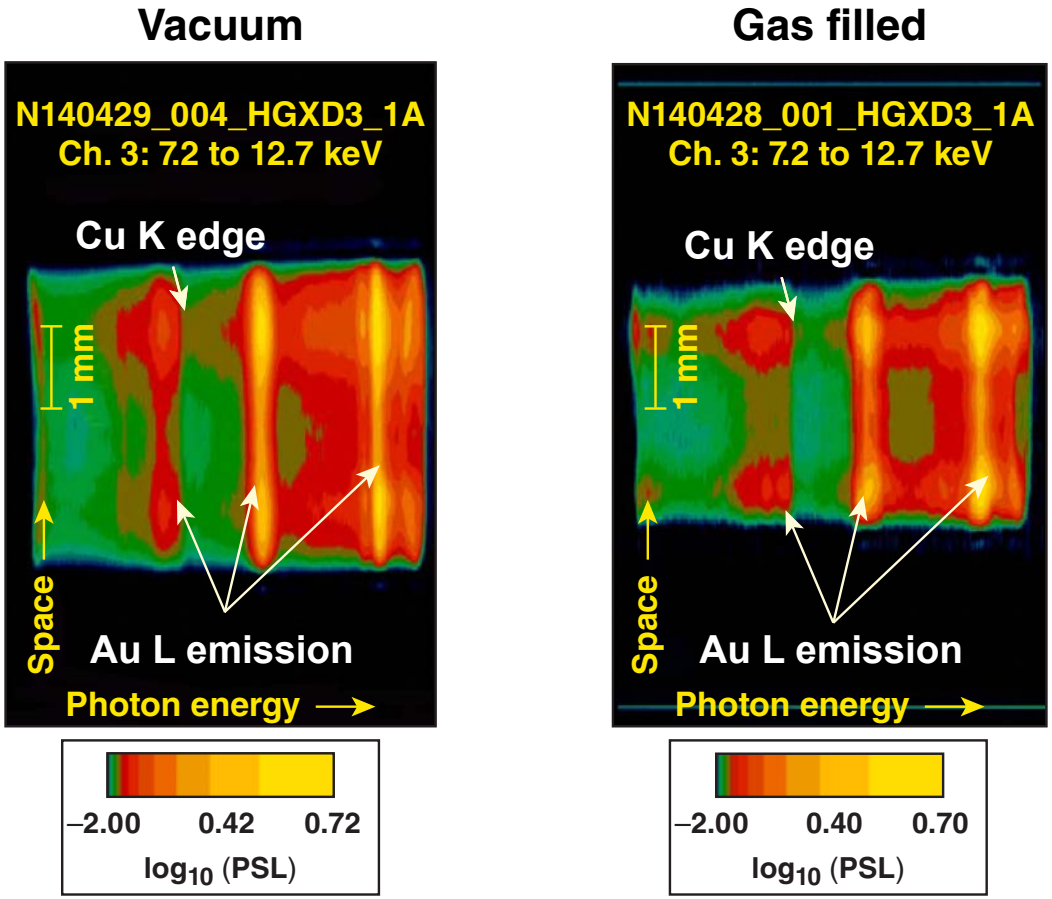
A Cu K-edge filter is used as a fiducial for the photon energy scale



As the plasma T_e increases, peaks of the Au L-shell emission shift to higher photon energies.

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