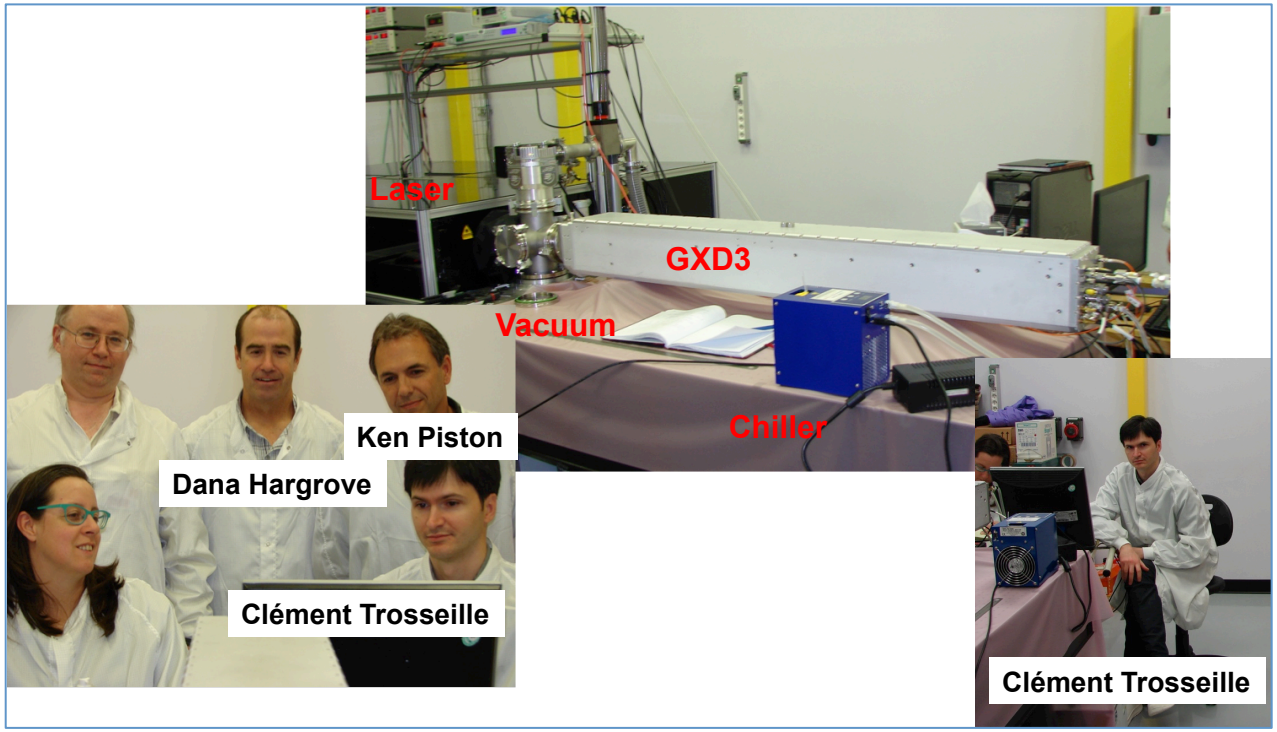
National Diagnostic Plan-overlap with CEA

Flat fielding NIF gated imager at Limeil- October 2015



3rd CEA_NNSA Diagnostic Meeting
LLE
6/29/16

S. Batha, J. Kilkenny
G. Rochau, C. Sangster

Key to the National Diagnostic Plan is the subject matter experts who have met ten times since 2009

Next Meeting November 8-10, at LLNL- CEA

welcome

The FY17 President's Budget substantially increased the na Diagnostic budget for FY17 by $10M compared to FY16

(Dollars in Thousands)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Inertial Confinement Fusion Ignition and High Yield					
Ignition	77,994	77,994	76,334	75,432	-902
Support of Other Stockpile Programs	23,598	23,598	22,843	23,363	+520
Diagnostics, Cryogenics and Experimental Support	61,297	61,297	58,587	68,696	+10,109
Pulsed Power Inertial Confinement Fusion	5,024	5,024	4,963	5,616	+653
Joint Program in High Energy Density Laboratory Plasmas	9,100	9,100	8,900	9,492	+592
Facility Operations and Target Production	335,882	335,882	339,423	340,360	+937
Total, Inertial Confinement Fusion Ignition and High Yield	**512,895**	**512,895**	**511,050**	**522,959**	**+11,909**

Explanation of Changes
FY 2017 vs FY 2016

Diagnostics, Cryogenics and Experimental Support +$10,109,000

- The increase supports the progressive execution of the National Diagnostics Strategy with primary focus on efforts to develop, advance, and implement transformation diagnostics at ICF/HED facilities.

"Transformative diagnostics" – Major national efforts with the potential to transform experimental capability for the most critical science needs across the complex

Transformational diagnostic	Institutions	Description
Single LOS imaging (h-CMOS, dilation)	SNL, LLNL, GA	X-ray gating along a single line of sight for all missions and all three facilities at time resolutions from 20-2000 ps.
Optical Thompson Scattering (OTS)	LLNL, LLE	UV Thompson scattering on NIF and OMEGA for hohlraum conditions, radiation channel flow, and discovery science
3D n/gamma imaging (NIS)	LANL, LLNL	Pinhole imaging along 3 lines-of-sight for 3D measurements of the burn in ICF capsules
Gamma spectroscopy (GCD)	LANL, LLNL, GA	Detailed determination of the burn history and shell rho-r in ICF capsules
Time resolved n spectrum (MRS-t)	MIT, LLNL, GA	Determination of the rho-r and ion temperature evolution during the burn in ICF capsules
Hi Res. X-ray spect. (HiRes)	LLNL, PPPL, LLE	Electron density and temperature in HED experiments and ICF implosions
Hard x-ray imaging (Wolter)	SNL, LLNL	High spatial resolution, large field-of-view, narrow-band imaging of high energy x-ray emission and backlighting
Time resolved diffraction	LLNL, SNL	Time-resolved phase determination of materials at very high pressure

Also broad and local class of diagnostics

The transformational diagnostics are planned for all facilities

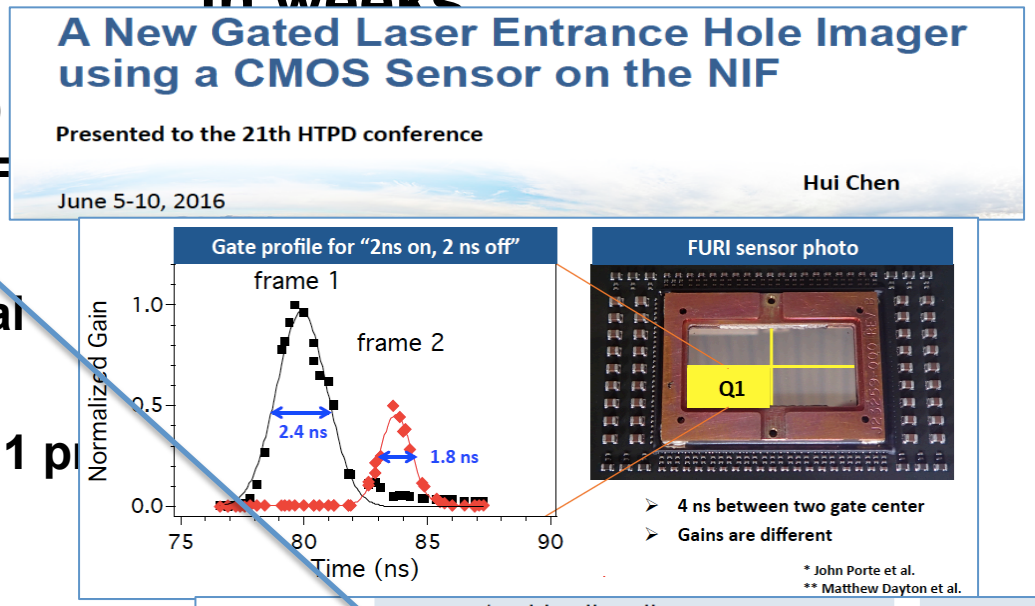
Transformational Diagnostic	NIF	OMEGA	Z
h-CMOS	SXI, SLOS	SLOS	Imager & Spect. 4 frame red.
Optical Thomson Scattering	5w, 3w	4w, 5w	Preheat FY19 Use NIF & OOMEGA
3D n imaging	polar, 2nd equator		
Gamma Cerenkov Detector	GCD, super GCD	(NTD)	GRH-tritium?
Time resolved n spect.	MRS-t		MRS-tritium?
Hi Res spectroscopy	3 xtal	hi res	XRS3
Hard x-ray imaging	3x Wolther	SLOS-2	Wolter
Diffraction(time)	FY19?		FY18- one frame FY20 vs time

A two frame gated CMOS- FURI is in use at NIF. Some issues but expect a delivery of 4 frame device-ICARUS in weeks

- 2 frame device(FURI)
  On 100 shots on NIF

- Flat fielding is essential
  (A Carpenter- 11am
  C Troiselle, R Benedetti 1 pl

- SNL will deliver the four frame device-ICARUS- in weeks
  (L Klaus- 11 am)



	'High' Full Well Sensors			'Low' Full Well Sensors	
	In Use		New Design	In Testing	
	Furi	Hippogriff	Daedalus	Icarus	Acca (test chip)
Year	FY14	FY15	FY17	FY16	FY18
Min. Gate	1.5 ns	~2 ns	~1.0 ns	~1.5 ns	~1 ns
Frames	2	2 (full resolution) 4 or 8 (Row interlaced)	3 (full resolution) 6+ (Row interlaced)	4 (full resolution) 8 (L/R interlaced)	8
Tiling Option	No	No	One Side	No	Linear Tiling
CMOS Process	350 nm (SNL)		350 nm (SNL)	350 nm (SNL)	130 nm (G.F.)
Pixels	448 x 1024		512 x 1024	512 x 1024	512 x 512
Pixel Size	25 µm x 25 µm		25 µm x 25 µm	25 µm x 25 µm	
Capacitor Full Well	1.5 million e⁻		1.5 million e⁻	0.5 million e⁻	

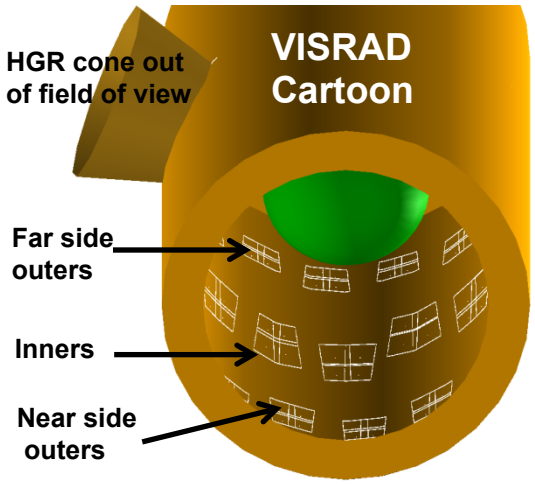
SNL thinks that exporting a system to France is "allowable"

The NIF gated LEH imager from SNL shows a time dependent inner / outer power balance during the low foot main drive

0.96g/cc ^{4}He Lowfoot hohlraum

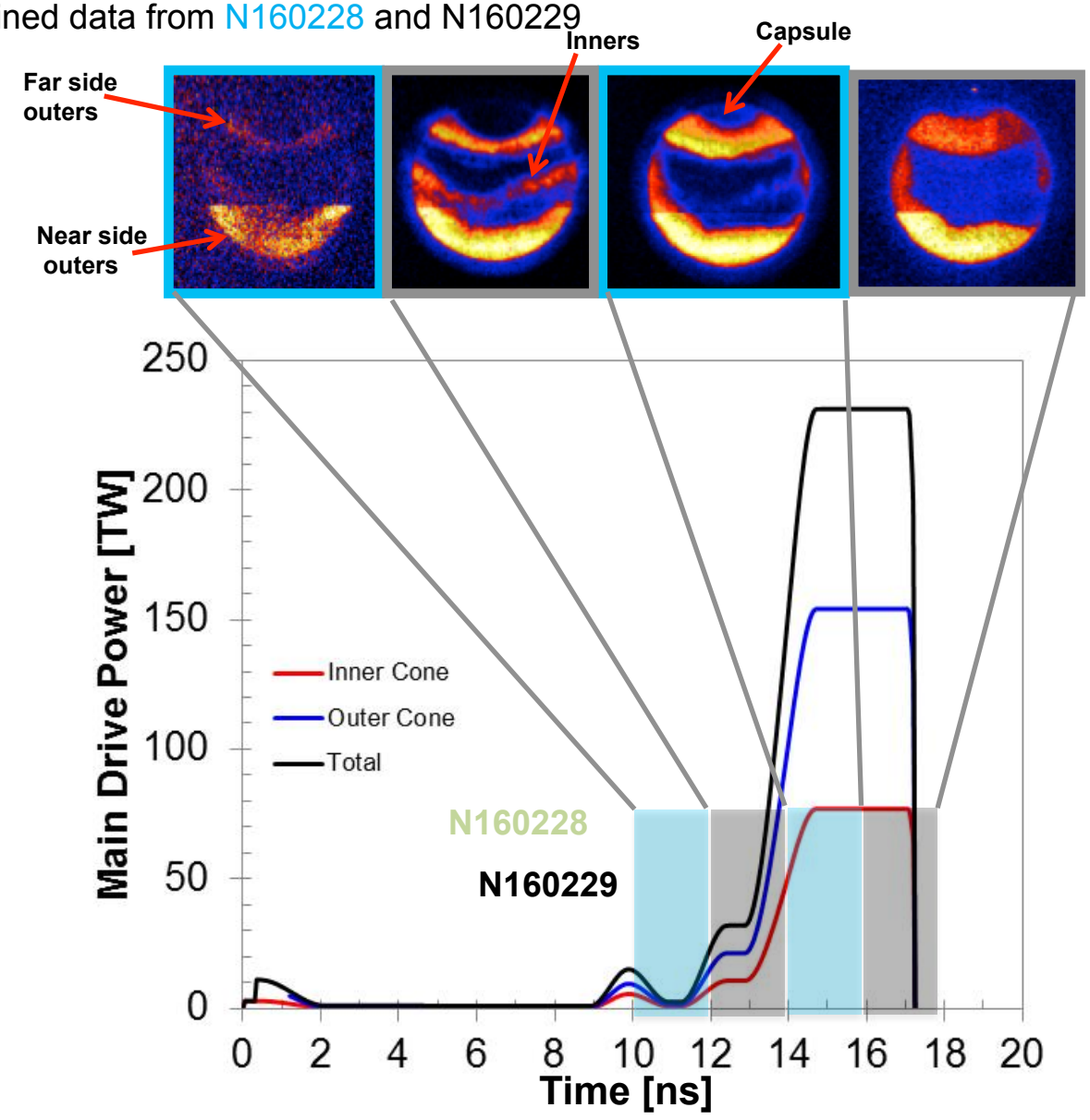
$\delta\lambda$ = 4.7 (23), 3.5 (30),1.2

SXI-L view



VISRAD img assumes emission is ~300um inside initial hohlraum radius

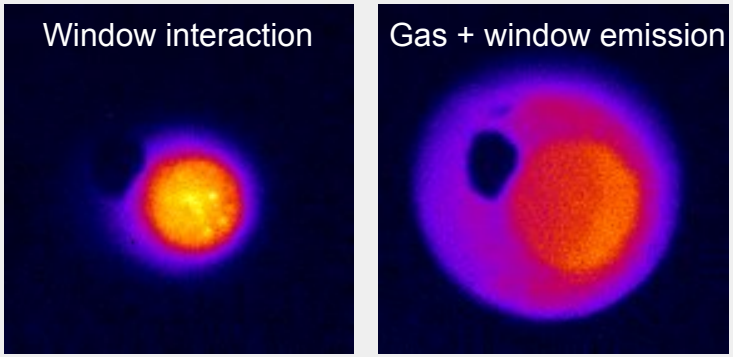
Combined data from N160228 and N160229

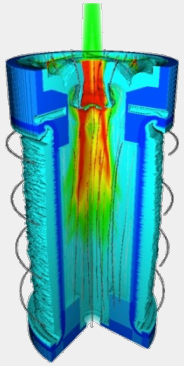


hCMOS imagers have been used on Z for laser preheat shots, and testing is underway for gated opacity measurements

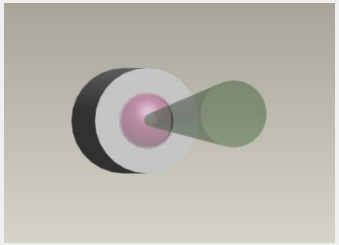
MagLIF laser preheat on Z*

9 ns gate separated by 10 ns





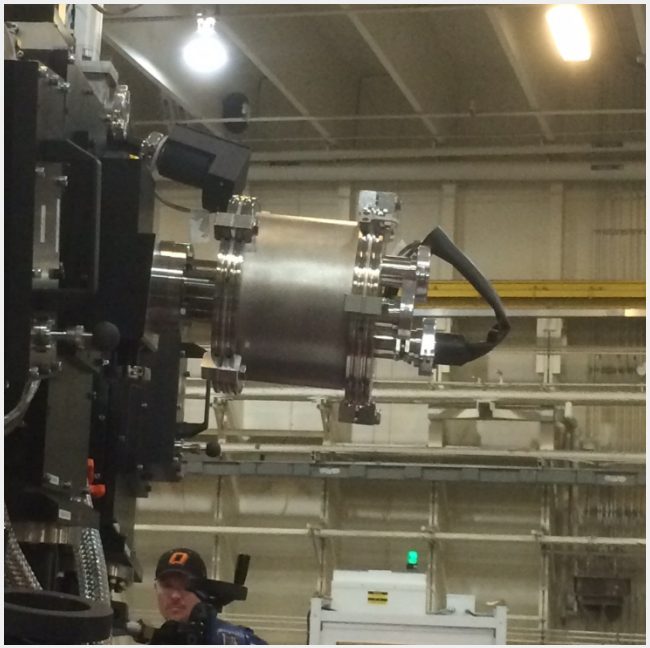
Camera View of LEH



Use during integrated MagLIF shots planned for early FY17

hCMOS testing for gated opacity

hCMOS assembly on an axial elliptical crystal spectrometer



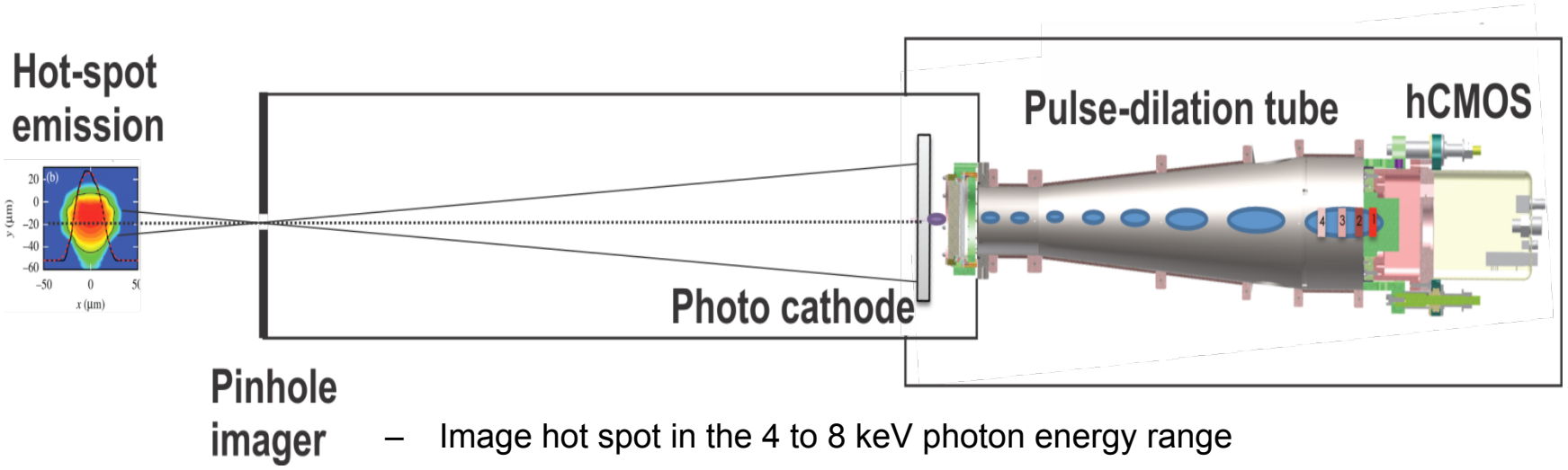
Initial measurements planned this summer

*Porter (SNL) et al.

Phase 1 of SLOS diagnostic on OMEGA comprises a pinhole imager, pulse-dilation tube, and hCMOS detector- Theobald 9:30

Phase 1 of Single Line-of-Sight gated x-ray imager (SLOS1)

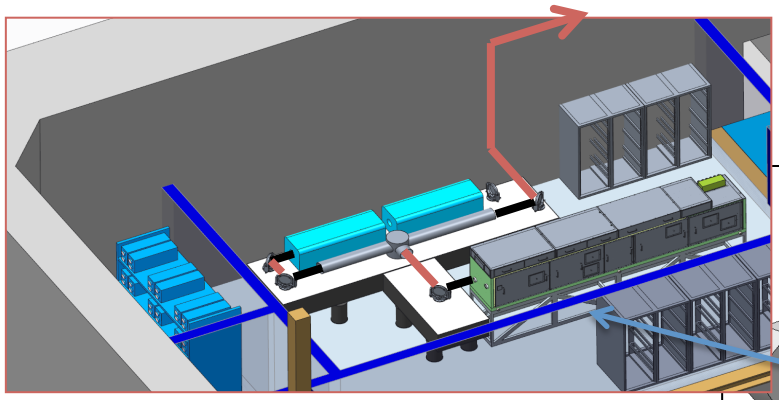
LLNL
SNL
General Atomics
Kentech

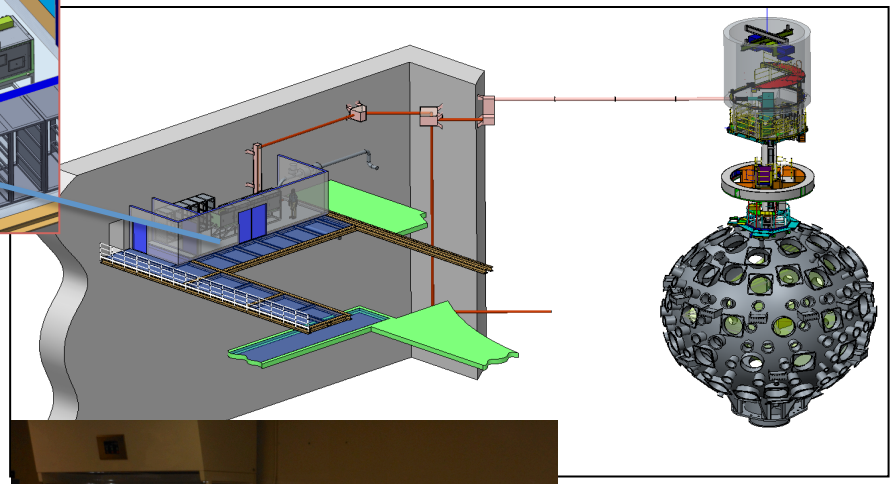


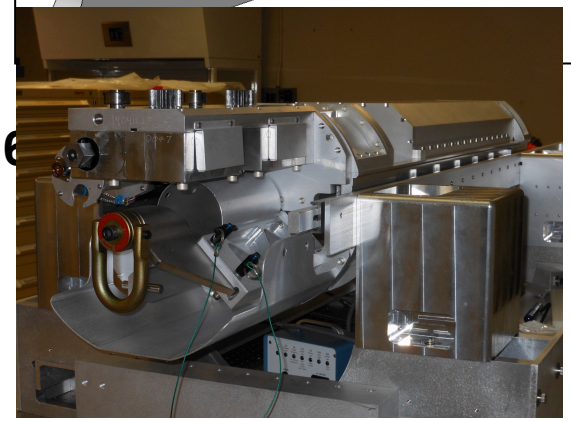
- Image hot spot in the 4 to 8 keV photon energy range
- Temporal resolution < 30 ps
- 4 frames to sample ~100 ps neutron burn width from DT cryogenic implosions
- Pinhole imager provides ~7 μm spatial resolution for ~20 μm hot-spot radius

Optical Thomson Scattering

- 5 ω conversion efficiency ~ 20%, prize paper at CLEO- Begishev- tomorr
- NIF PAM + multi-pass simplified design- Ross tomorrow 8:30

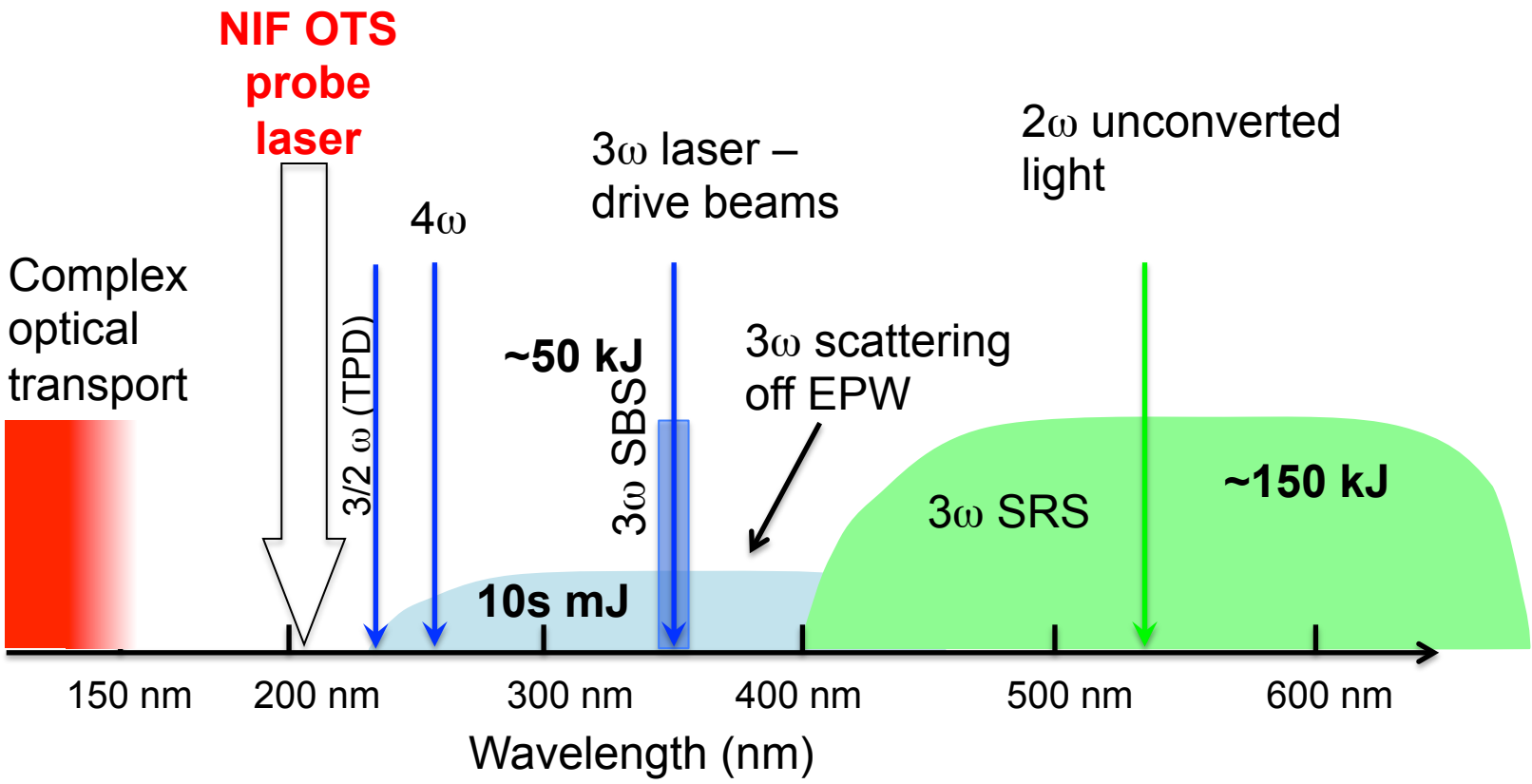






- 3w scattering on NIF Q4 FY16

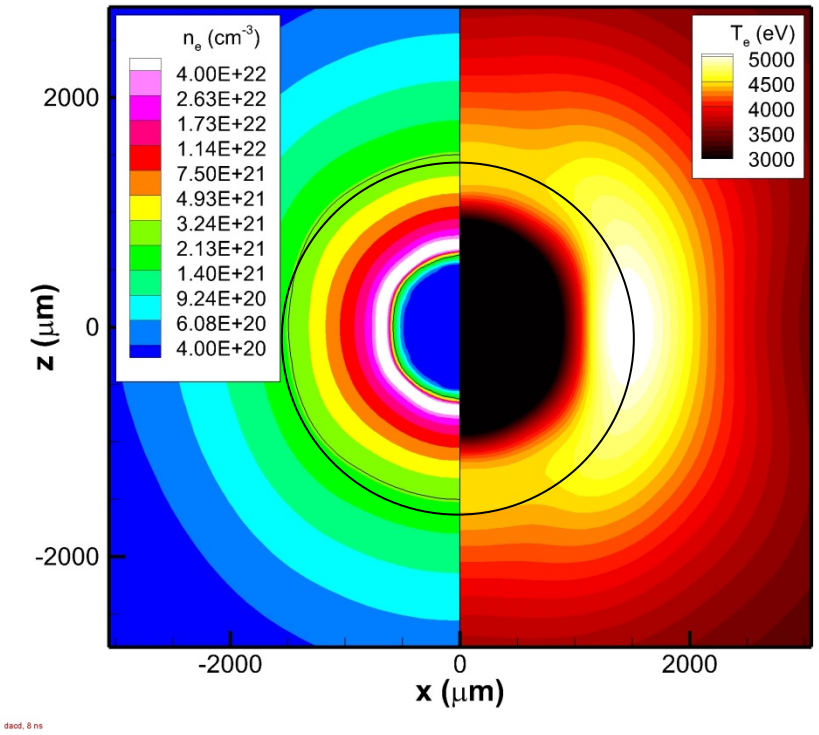
Thomson scattering from a deep-UV probe beam will overcome the harsh environment that challenges optical measurements in a hohlraum

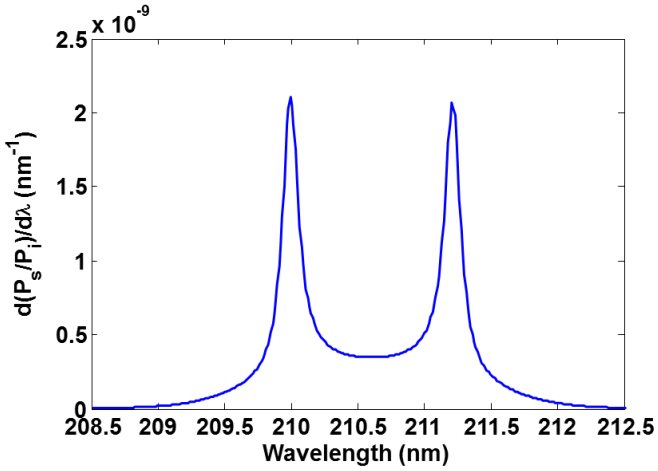


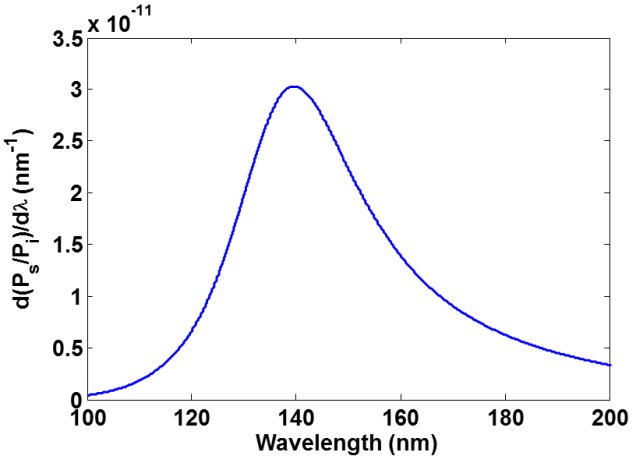
Expected TS signal is a few μJ

The deep-UV NIF OTS will be a pioneering diagnostic in Thomson scattering research

5ω Thomson scattering will provide access to quarter critical plasma conditions in polar direct drive experiments







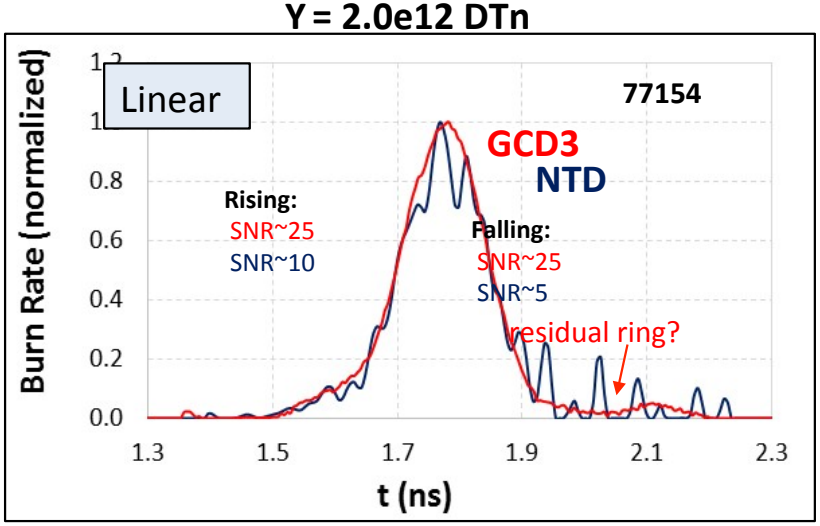
Thomson scattering will characterize the significant angular temperature gradients predicted by hydrodynamic simulations

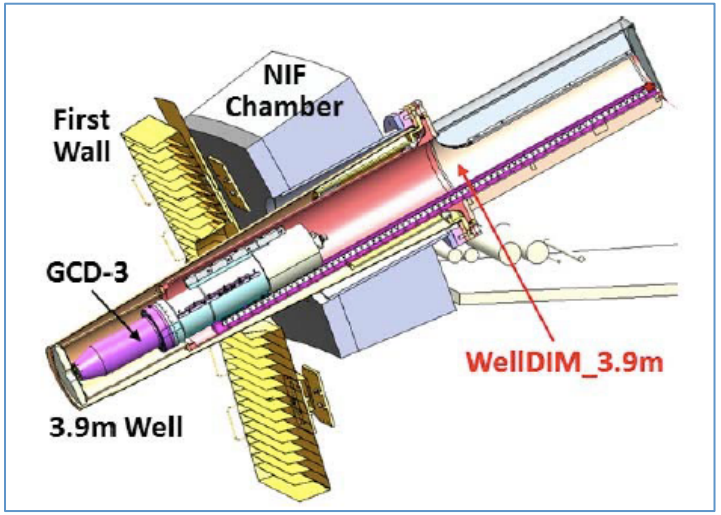
A new optical Thomson scattering probe beam on OMEGA will provide access to quarter-critical plasma conditions

- A sister Dynamic Compression Sector laser is being built to support Thomson scattering operations on both OMEGA and EP
- The new laser will decouple the probe beam from the main system allowing Thomson scattering on 60 beam experiments and provide a more flexible pulse shape/timing for all experiments
- The new system will provide 2ω, 4ω, and 5ω probe light
- Current 4ω operations is limited to thermal scattering at $12\%N_{cr}$ due to refraction
- The new
- 5ω operations will enable:
  - Access to $n_{cr}/4$ plasma conditions (T_e, T_i, N_e, V_{flow})
  - The direct measurement of the amplitude of ion-acoustic waves driven by cross-beam energy transfer

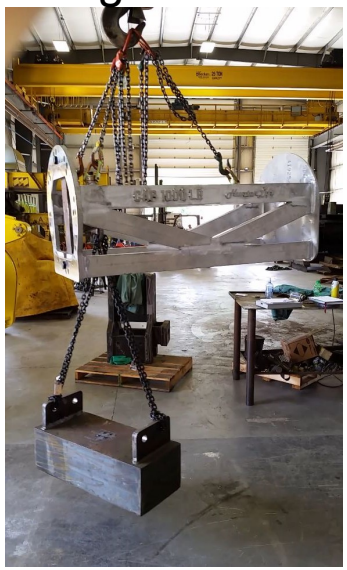
The new Thomson-scattering system will open a new regime of LPI physics on the Omega Systems

Neutron Temporal Diagnostic on OMEGA crucial truncated burn- NIF's Gamma-Cerenkov Detector (GCD) will be more sensitive and ultimately faster





Testing GCD loader



10 psec PMT being tested in July

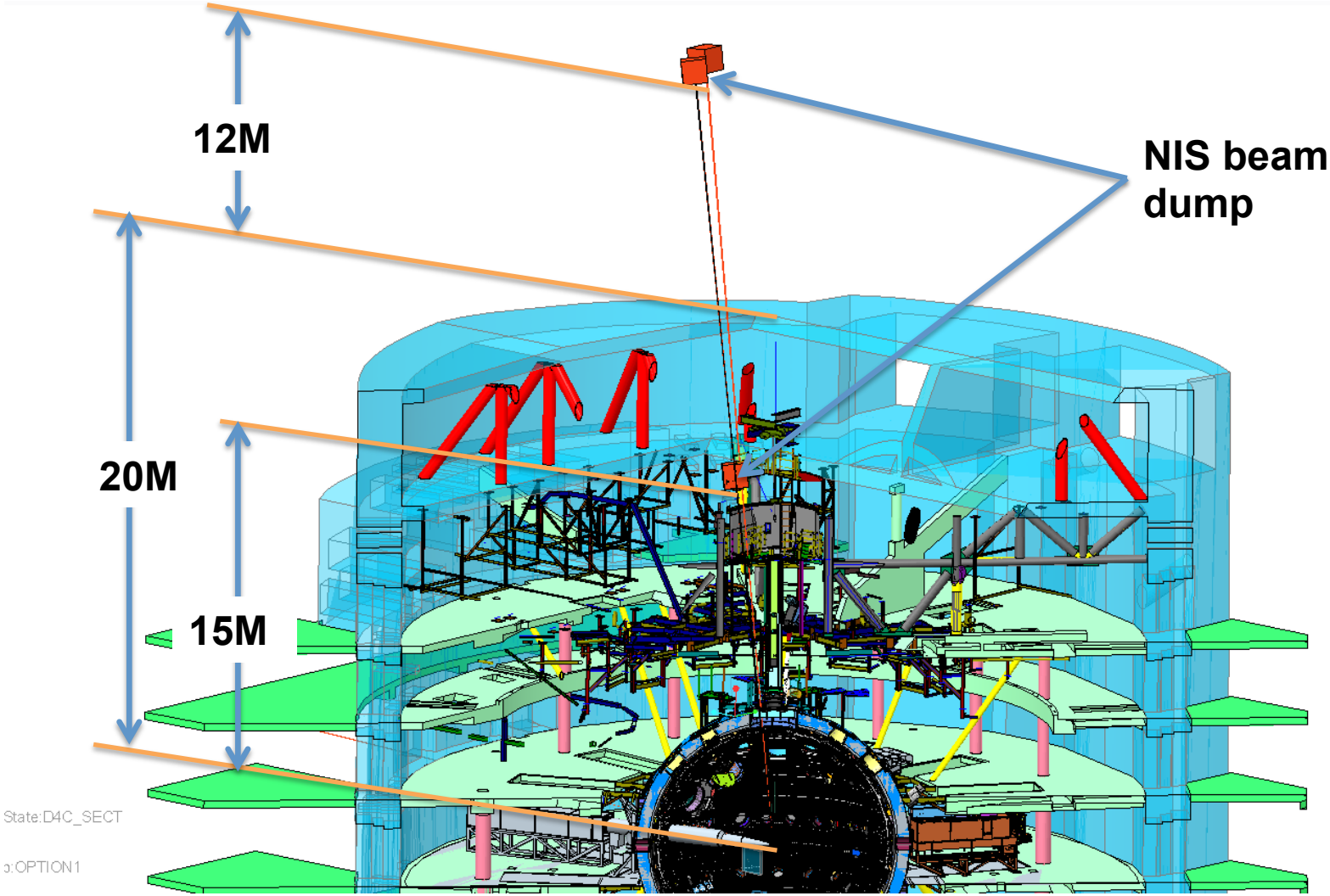
SYDOR INSTRUMENTS, LLC

291 Millstead
Phone: +1 585
Fax: +1 585-27
E-mail: sales@

Name:	Hans Herrmann	**Date:**	
Account:	**LANL**	**Quote #:**	
Phone:	**(505) 665-5075**	**Contact Person:**	
E-mail:	herrmann@lanl.gov	**Quote valid for:**	

Qty.	Description
1	• **Phase 1 - Proof of Concept Drift Time Dilation PMT (POC TD-PMT)** A POC TD-PMT will be designed, modeled and built. Proof of concept drive electronics will be constructed and the tube will be packaged together with a compact solenoid such that the front section of the detector will fit into a 64mm diameter mount. The temporal recording window at the photo-cathode will be set at approximately 500ps with a target resolution of better than 10psecs. See notes below for more details.

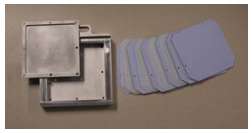
18 months ago we thought NIS had to be above the Target Bay on the roof costing $nM like north pole nToF

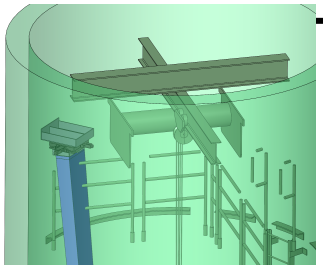


A simplified detector design allows a near polar neutron image on NIF (un-scattered) in early FY17 – Hibbard -tomorrow

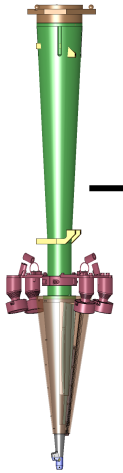
New Design

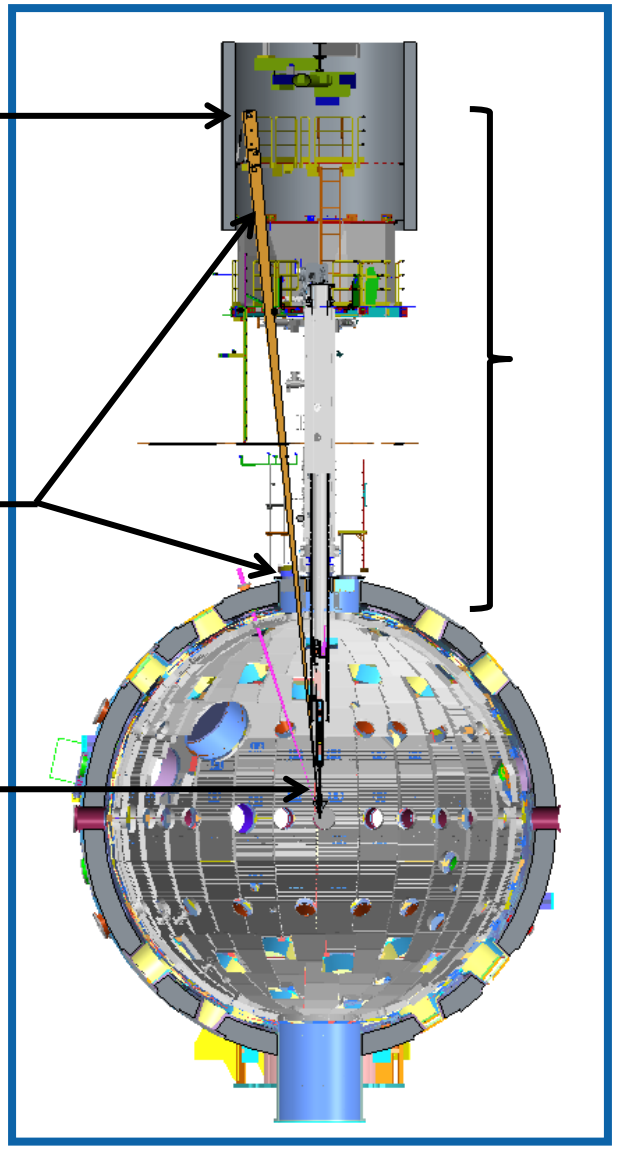
Stacked Image Plate on X/Y stage





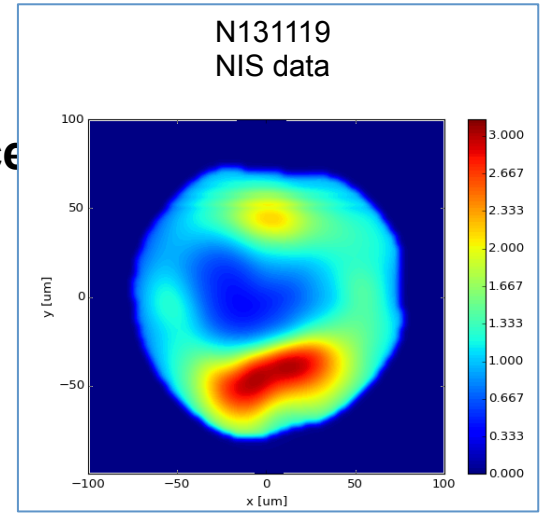
Neutron collimators (if required)



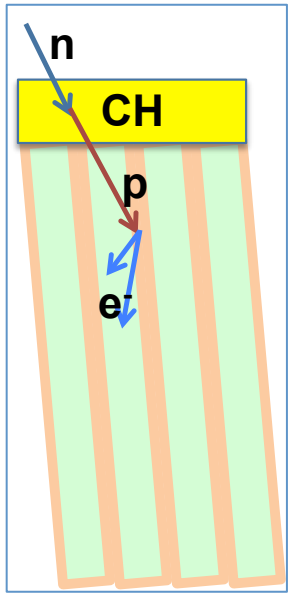


Neutron and gamma imaging

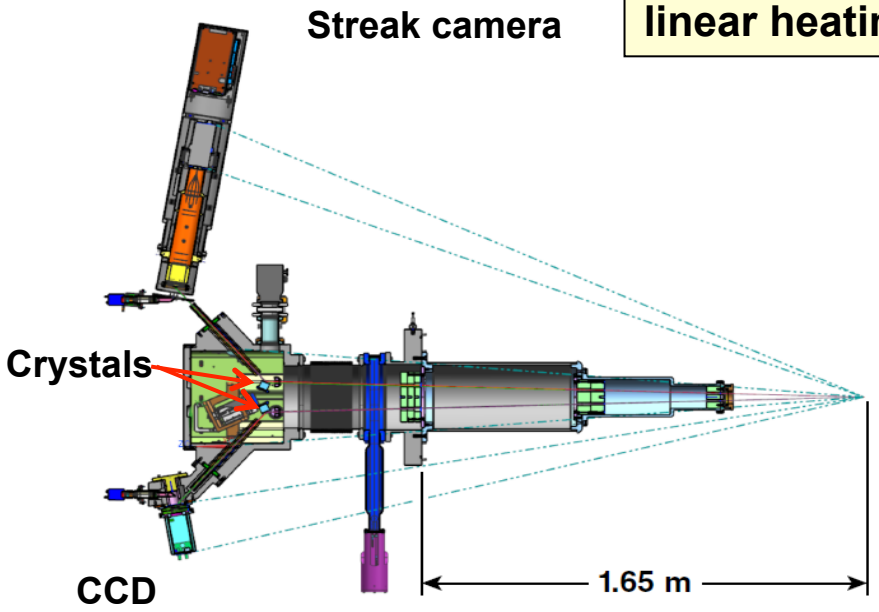
- Down-scatter(DS) n imaging detects polar ice



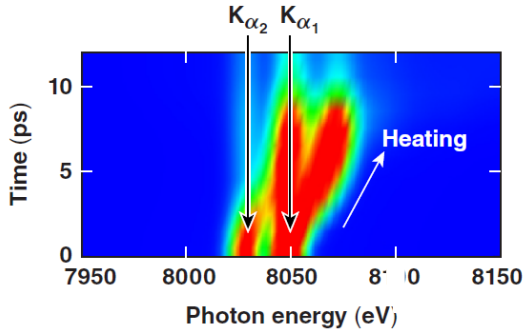
- More than 1 view is needed (Volegov)
- Polar view of un scattered image (Hibbard)
- Detector spatial resolution drives system cost (Grim)
- Direct MCP 14 MeV detection?
  - new ideas for DS imaging better dx ?
- Gamma imaging demonstrated (Grim, Vologov)

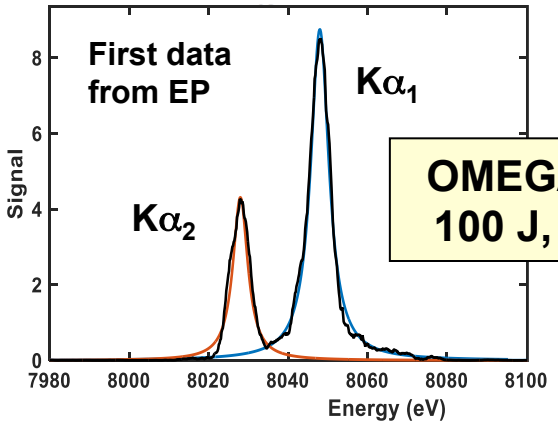


HiRes, developed with PPPL, is an ultrafast, high-resolving power spectrometer for temperature-relaxation studies*



PrismSPECT prediction for solid density Cu, a linear heating gradient of 350ev and E/ΔE ~ 1000





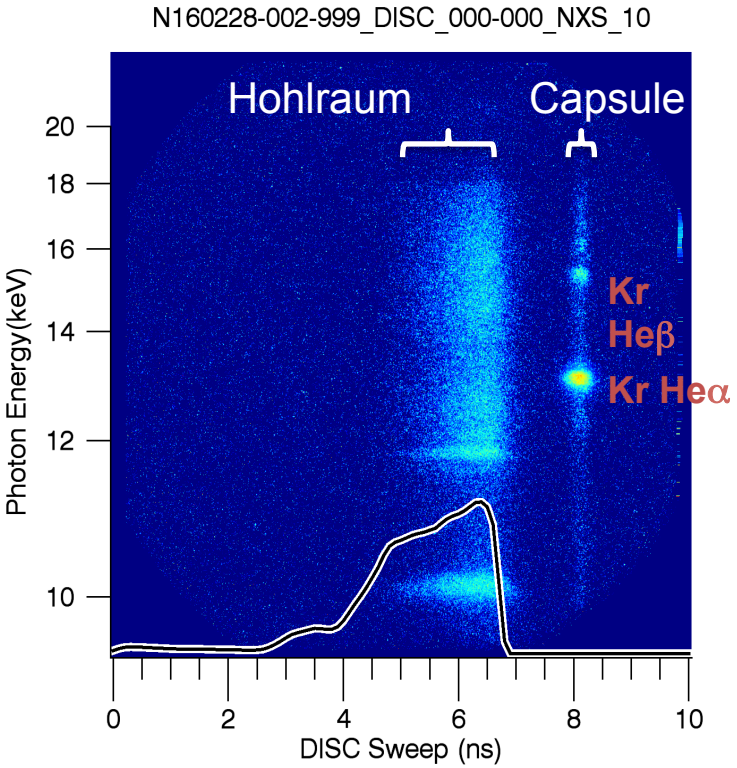
OMEGA EP 100 J, 1 ps

The streak camera will be deployed for time-resolved emission spectroscopy experiments in Q2FY17… then HiResΩ

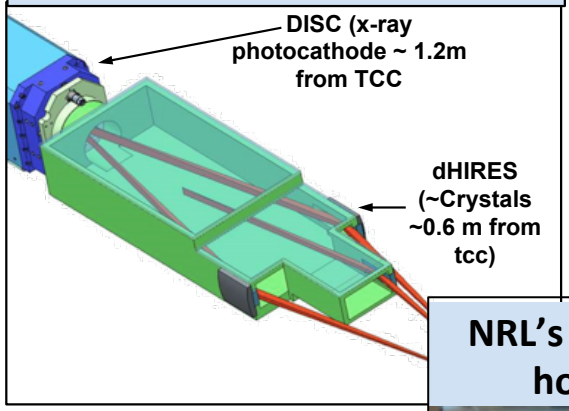
Nilson- 2:15 PM

*P. M. Nilson *et al.*, NIF Diagnostic Workshop (2014)

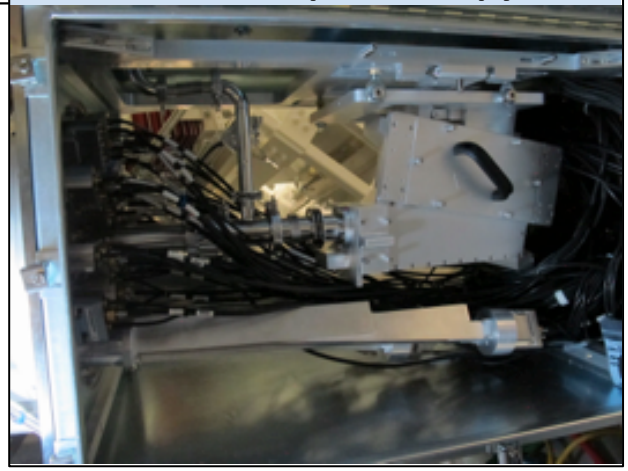
X-ray spectroscopy on NIF implosions



PPPL designed, LLE built spect, upgraded x-ray streak camera



NRL's VIRGIL on NIF, recording holhraum spectroscopy



The Magnetic Recoil Spectrometer (MRSt) for time-resolved measurements of the neutron spectrum at the National Ignition Facility (NIF)

J.A. Frenje[1], T.J. Hilsabeck[2], C. Wink[1], P. Bell[3], R. Bionta[3], C. Cerjan[3], M. Gatu Johnson[1], J.D. Kilkenny[2], C.K. Li[1], F. H. Séguin[1] and R.D. Petrasso[1]

[1]*Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA*

[2]*General Atomics, San Diego, CA 92186, USA*

[3]*Lawrence Livermore National Laboratory, Livermore, CA 94550, USA*

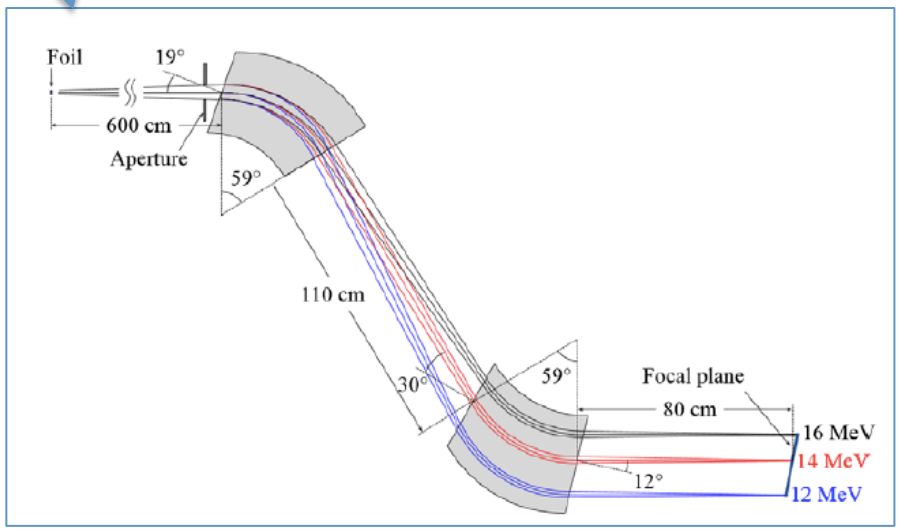
A stretch / compress scheme for a high temporal resolution detector for the Magnetic Recoil Spectrometer time (MRSt)

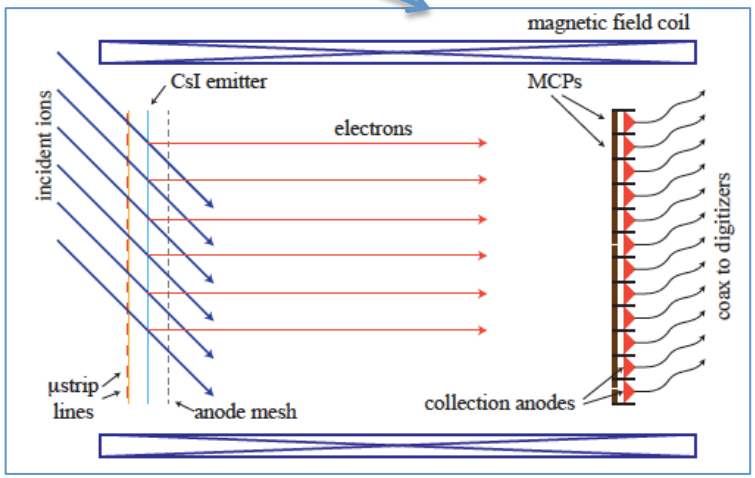
T. J. Hilsabeck,[1, a)] J. A. Frenje,[2] J. D. Hares,[3] and C. Wink[2]

[1)] *General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA*

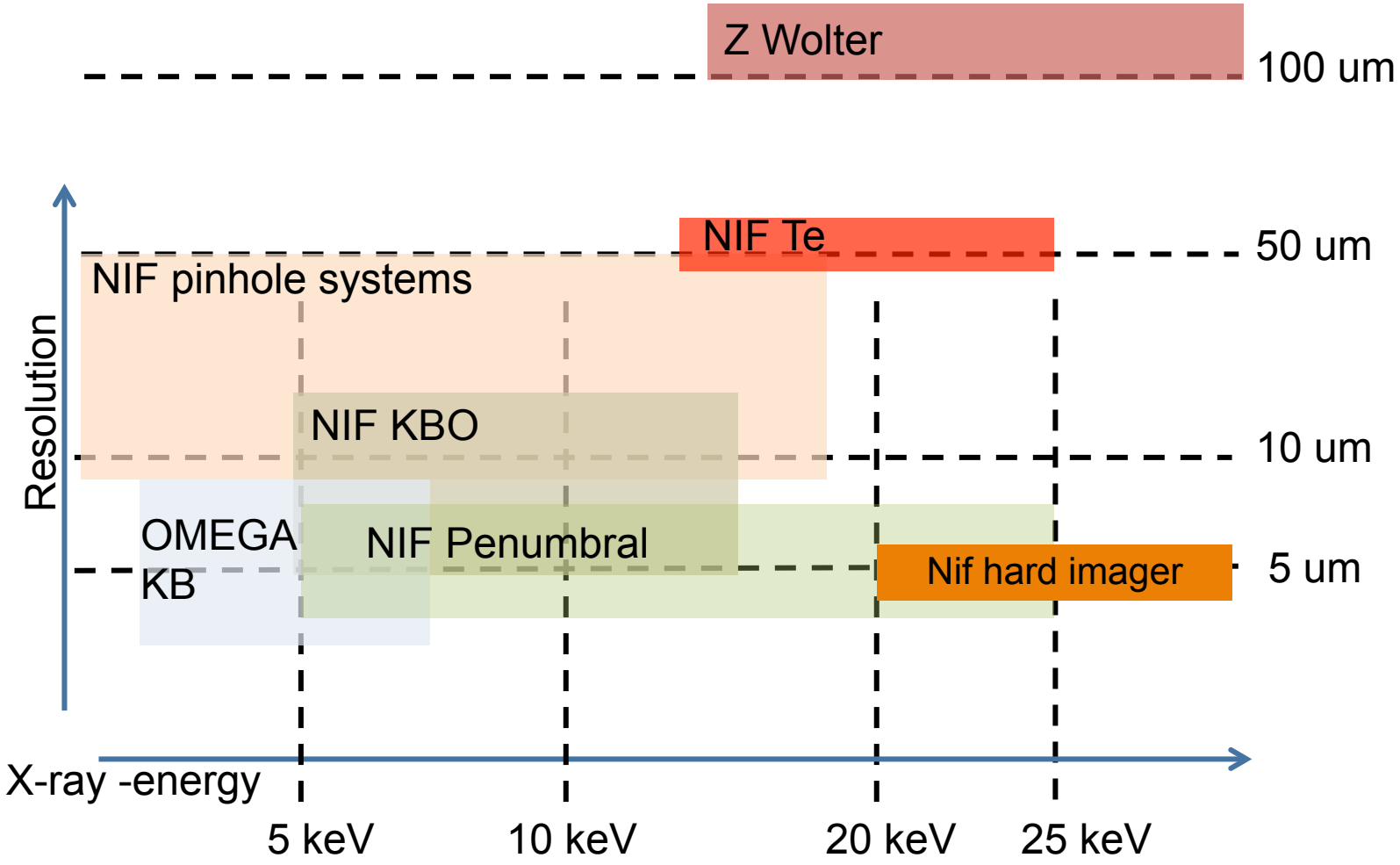
[2)] *Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA*

[3)] *Kentech Instruments Ltd., Wallingford, Oxfordshire OX10 8BD, United Kingdom*





To image ICF plasmas above 20 keV with suitable resolution requires large solid angles Troussel, Pickworth, Bourdon



Wolter for Z ready 17, NIF Wolter needs further development in replica optics research or..

Dante Upgrades- electrical & x-ray

Clipper circuits, in situ calibration and more……

CEA-NNSA Joint Diagnostic Meeting

Bart Beeman

June 29-30, 2016

Ongoing action item list 1 of 3

Subject	Conclusions @ the workshop	Next actions	Status- 6/28/16
SNL/ h-CMOS for LEH X-ray Imagers and DMX central imager	CEA is very interested to get such a framing camera for its LEH imagers and DMX central imager (LEH closure)	Request for US export to France authorization due to the present control export of such a camera	Ruling that export is allowable. SNL personnel could bring ICARUS to CEA . Flat field? and leave. Discuss purpose of first use.
	Too large Magnification Ratio for DMX LEH imaging due to the available camera active surface area	Find a solution to reduce this MR	
Au M-band flat & sharp spectral channel for DANTE	LLNL is interested to get such a channel for Dante	Next VTCs (1st ASAP) to define - the requirement (broad band or few spectral channels) - spectral contrast - LLNL / CEA - the best fixture (old Phebus or new LMJ) - LLNL/CEA - alignment accuracy of the Dante flange (LLNL)	NIF waiting to implement Need Multilayer mirror and housing that was designed and ready to fied on LLE DANTE Need to develop an alignment procedure
Digital recording improvement for NIF			
Clippers	LLNL is interested to get more clippers	New order request from LLNL	Done- Bart Beeman to report
Macaque/Souris remote calibration racks	LLNL seems interested to get such a system	First test needed on NIF?	Done- Bart Beeman to report
GXD #3 flat field tests @ CEA/DIF on 5w laser	A preliminary measurement analysis was realized. The results are promising but a more deeply analysis is necessary	A new period of test could be necessary to obtain more results	Report out in LLE- Recommend LLNL adopt optical + study optical vs x-ray Can we colaborate on Spatial resolution improvememnts

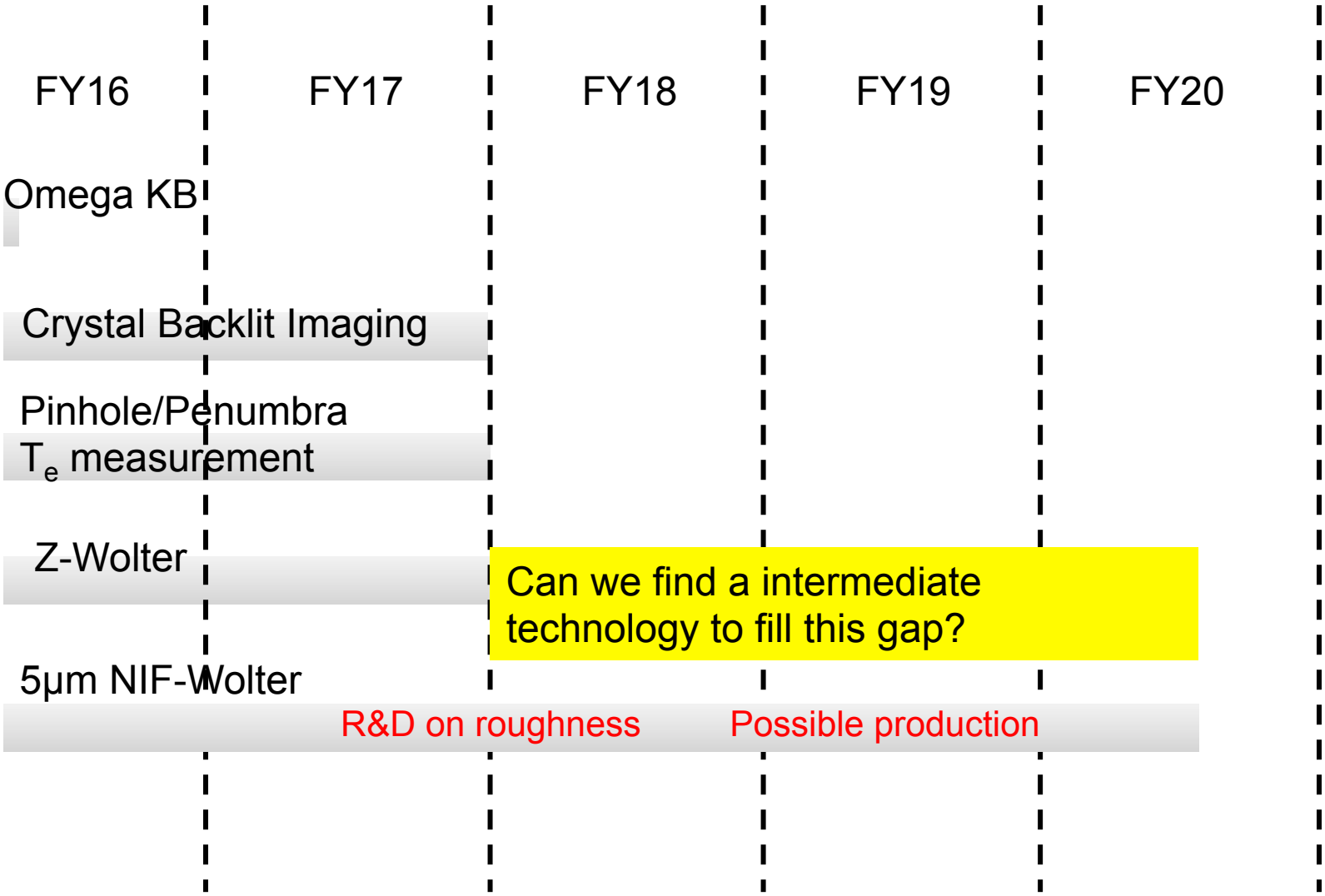
Ongoing action item list 2 of 3

Subject	Conclusions @ the workshop	Next actions	Status- 6/28/16
Toroidal mirrors imaging	LLNL is proposing to test such a system on NIF. FODI LoS/ inserter envisaged.	- Short term: requirements definitions (spectral range, distances and spatial resolutions number of images needed). - medium term: one image on NIF if interested to get one. - longer term: multiple LoS imager well adapted to LLNL requirements.	Active discussion by Pickworth/ P Troussel. Is toroidal optic resolution sharp enough?
APS-CCD-CMOS w/ global reset	CEA is developing hardened CMOS APS readout. By coupling it to a long decay scintillator and using the global reset feature, neutron induced bkgd is almost totally eliminated. LLNL is interested to test it on NIF high neutrons shots on its dedicated neutron irradiation location (close to its wall or inside the TC)	LLNL will provide ASAP to CEA the drawings of this tests areas and the distance for the recording hardware (cables & FO links).	Visit 7/18/16 for test CEA rdump and readPHILIPPE PAILLET – CEA VINCENT GOIFFON – CEA SYLVAIN GIRARD – Univ. of XXXXX
Neutron Imaging			LANL has drawings of the deuterated scintillator array. Measurements will be with WNR beam at LANL
Cadillac capillary array filling	LANL is interesting to be helped to fill a capillary array (dia. 80 mm for Cadillac)	CEA has an unused capillary cell already filled w/ deuterated scintillator (100 x 100 mm x 5 cm). Can be it used for that LANL first test on Cadillac?	
Multiview on Omega	Both LANL and CEA agree to this possibility on Omega for preparing multiview on NIF and 3D reconstructions.	TIM#6/P7 port (well protected against BKGD) is unique and quite jammed. LLE is proposing to use another TIM (#3?)	
Back alignment	In case of the new ATLAS alignment system on NIF cannot use for the NIS alignment. LANL wish to use the CEA expertise into that area.	Wait for LANL needs.	NIF can use ATLAS

Ongoing action item list 3 of 3

Subject	Conclusions @ the workshop	Next actions	Status 6-28-16
Fast hard x-ray scintillator	CEA have developed it (doped Bi into CH scintillators) for hard x-ray detection. Moreover it can be included by polymerization into any shapes as the FO faceplate or MCP.	Is LLNL interested to test one sample in comparison w/ the new LBL scintillator? (decay time for ex.).	LLNL SNL still looking at options. Common test facility for scintillators?
CEA- CVD diamond results w/ data mining Tests of CVD diamond	CEA have the most complete set of CVD diamond detectors data on Omega (dixit J. Knauer). This data base can be used to determine if the dose effect response modification is true or not.	J. Knauer proposes to use a graduate student to help CEA for this data mining (dose dependence). CEA will try to organize the available results into a more detailed data base ready for this dose effect analysis. J. Knauer must determine when his student can work on that data base.	
Spatially resolved Tion	CEA & LANL solutions are quite different but mutual information are welcome		
Streak camera, photocathodes and calibration	LLNL is not particularly interested in CEA's photocathodes and calibration studies in soft X-ray domain	Information exchange about : 1 - production, design, simulation of structured photocathodes 2 – simulation of streak tubes with CST	LLNL is interested in structured Photocathode- NStech progress
French PhD students or postdocs on NIF for enhancing CEA/LMJ & LLNL/ NIF collaboration on ICF diagnostics	Can CEA find some postdocs or student ready to work on this collaborations subject on NIF? LLNL will pay them?	CEA agree for that proposal and will start immediately the research of such candidate interested to fill such a position @ LLNL/NIF	

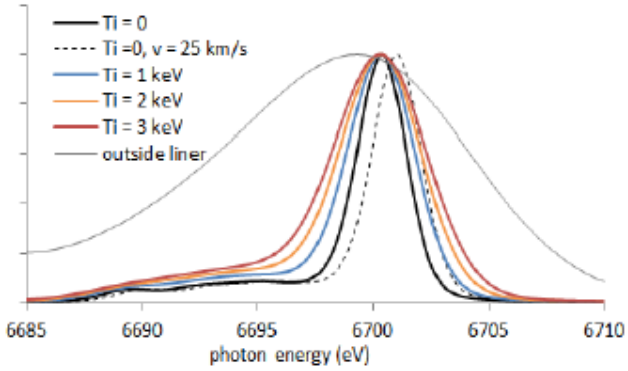
Time line to achieve a high energy imaging system for HED /ICF



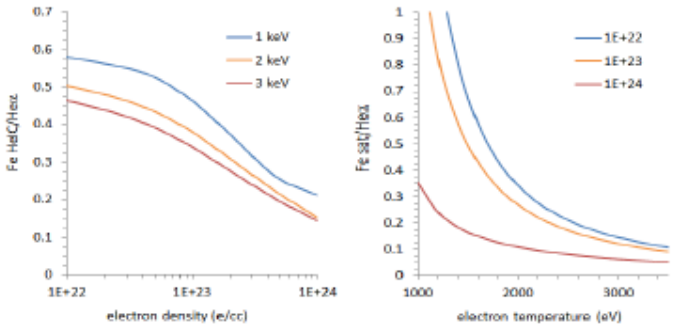
Details about stagnation from high-res, axially resolving XRS3* spectrometer

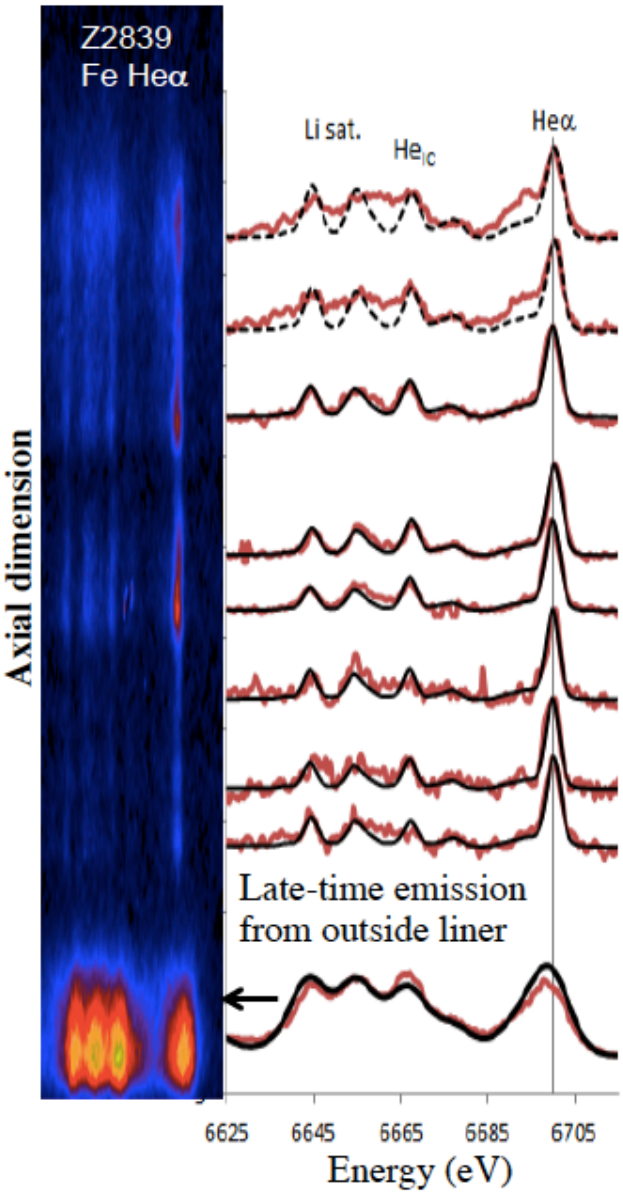
Sandia National Laboratories

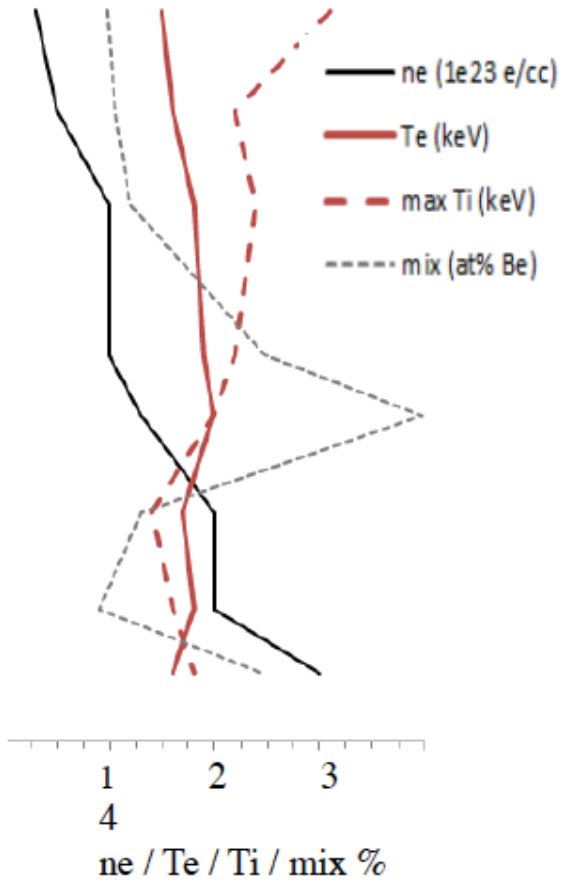
Line shapes →T_{ion}, v_{bulk}, & r_{source}



Line ratios →T_e, n_e, & mix







Line shifts indicate v_{bulk} < ~15 km/s
Consistent with GORGON

*E.C. Harding et al., Rev. Sci. Inst. 86, 043504 (2015)

Material provided by Stephanie Hansen and Eric Harding

The Diagnostic Steering Group will plan FY17 program in consultation with the site managers

MTE 10.3 by site

Site	FY17	FY17-FY16
	$M	$M
HQ	4.2	3.1
LANL	5.6	0.2
LLNL	47.4	3.3
NNSA		
ABQ	0	-2.8
SNL	7	3.7
LLE	4.5	2.5
Total	68.7	10

1 Late summer – after workshops – re-evaluate transformational diagnostics (progress & mission)

2 Late summer after markups work w site managers to plan a FY 17 work scope that is consistent with revised budget expectations to sites

NDP management group, with input from the SSP and HED programs, binned activities into three categories: Transformational, Broad, and Local

Transformational: Major national efforts with the potential to transform experimental capability for the most critical science needs across the complex

Broad: Significant national efforts that will enable new or more precise measurements across the complex

Local: Important efforts involving implementation of known technology for a local need

Transformational	Broad	Local
16-frame high time-res gating	Neutron Temporal Diagnostic	KB microscope
UV Thomson Scattering	Precision nToF	High energy spectroscopy
Fusion Gamma(t,hν)	B-fields on NIF	Various NIF/Omega snouts
3-D fusion burn imaging	Pulsed x-ray cal source	Crystal imaging & backlighting
Fusion Neutron(t,hν)	Photon Doppler Velocimetry	Radchem
X-ray(t,hν) $\lambda/\delta\lambda \sim 10000$	High-res x-ray streak cameras	…many more…
20-50keV image,10 ps, <10μm	High energy detectors	
Diffraction(t)	Radiation hardening	

FY16 slightly less than 50% of diagnostic budget spent on transformational diagnosti

Progress in FY 16 on transformative diagnostics- key issues only

Gated x-ray imager h-CMOS	Two frame imaging on NIF- 150 shots- epiphanous two frame used on Z for laser preheat shots First SLOS detector to go on OMEGA Q1FY17
Optical Thomson Scattering OTS	OTS: 5w conversion OK- 2nd highest rank paper at CLEO Laser using NIF PAM + multi-passes lay out NIF detector commissioned with 3w scattering Q4 FY16
3D n imaging NIS	Detector for un-scattered neutrons simplified Polar imaging un-scattered n Q2 FY17
Gamma Cerenkov Detector GCD	GCD will measure burn truncation as well as nTD NIF GCD in 3.9m well Q4 FY16.
Time resolved n spectrometer MRS-time	Detector concept developed
Hi Res x-ray spectroscopy	OMEGA, resolved K_α splitting R ~8000 Z- Fe spectra from MagLIF NIF-Kr He like spectra doped gas implosion PPPL/LLE/LLNL spectrometer commissioned 1FY17
Hard x-ray imaging	Z Wolther CDR, commission late FY17
Diffraction(time)	Laser optics procurement for Z delayed