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LLNL-CONF-490848

MULTI-KEV X-RAY YIELDS FROM HIGH-Z GAS TARGETS FIELDED AT OMEGA

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July 17, 2011

APS Division of Plasma Physics 2010
Chicago, CA, United States
November 7, 2010 through November 12, 2010

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Summary

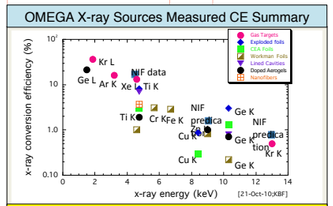
We report on modeling of X-ray yield from gas-filled targets shot at the OMEGA laser facility. The OMEGA targets were 1.8 mm long, 1.95 mm in diameter Be cans filled with either a 50:50 Ar:Xe mixture, pure Ar, pure Kr or pure Xe at ~ 1 atm. The OMEGA experiments heated the gas with 20 kJ of 3ω (~350 nm) laser energy delivered in a 1 ns square pulse. The emitted X-ray flux was monitored with the X-ray diode based DANTE instruments in the sub-keV range. Two-dimensional X-ray images (for energies 3-5 keV) of the targets were recorded with gated X-ray detectors. The X-ray spectra were recorded with the HENWAY crystal spectrometer at OMEGA.

Predictions are 2D *r-z* cylindrical with DCA NLTE atomic physics. Models generally

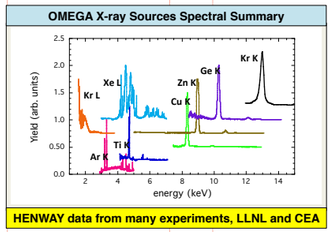
- Underpredict the Xe L-shell yields.
- Overpredict the Ar K-shell yields.
- Correctly predict the Xe thermal yields.
- Greatly underpredict the Ar thermal yields.

However, there are spreads within the data, *e.g.* the DMX Ar K-shell yields are correctly predicted. The predicted thermal yields show strong angular dependence.

High-efficiency cold X-ray sources have been validated experimentally

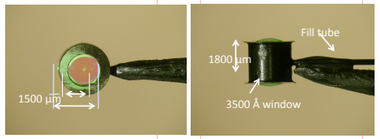


HENWAY, DMX, SNL PCD, DANTE data from many experiments



HENWAY data from many experiments, LLNL and CEA

Targets are 1.8 x 1.8 mm Be cylinders with 75 micron thick walls

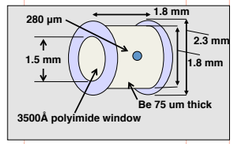


1.0 atm Ar - n_e = 4.4% n_{cr} 1.5 atm Ar - n_e = 6.6% n_{cr}
1.2 atm Xe - n_e = 14.1% n_{cr} 1.2 atm Ar:Xe - n_e = 9.7% n_{cr}

Configurations

- 40 Beams
- Pulse shape: 1 ns square in all legs, SG1018
- All Beams @ t= 0
- All Drive beams - Max 500 J/beam in UV

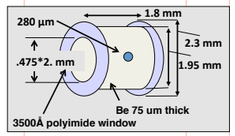
April 2010: Shots 57690-57694, P6-P7 axis



- DPPs EIDI-300 in cone 2 & 3 beams
- DPRs in cone 1 beams

Cone #: angle from axis	Distance from LEH (μm)	Towards port	Focus (mm)
1: 21.4°	2700	P6	-0.4
2: 42.0°	1800	P6	0.0
3: 58.9°	1800	P6	0.0

June 2010: shots 58415-58419, P5-P8 axis

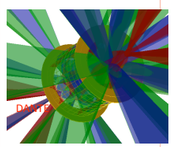


- DPPs EIDI-300

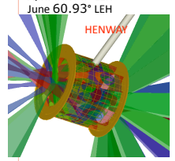
Cone #: angle from axis	Distance from LEH (μm)	Towards port	Focus (mm)
1: 21.4°	1200	P7	-0.0
2: 42.0°	900	P7	0.0
3: 58.9°	900	P7	0.0

Detector views

DANTE 37.38° LEH

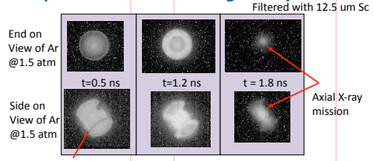


HENWAY
April 68.78° LEH
June 60.93° LEH



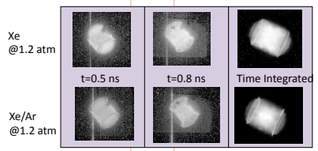
DMX 37.38° LEH (not shown)

Temporal Evolution of Ar Target X-ray Emission



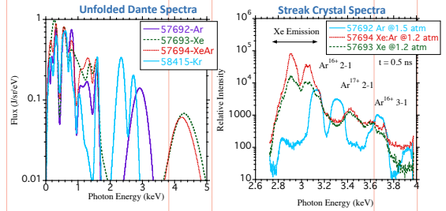
Early uniform Ar X-ray emission evolves into axial emission

Temporal Evolution of Xe and Xe:Ar Emission

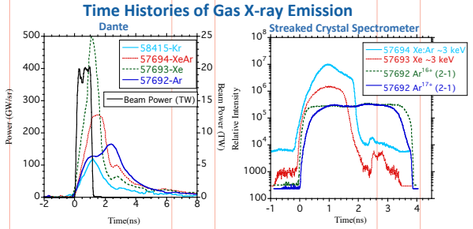


Xe and Xe:Ar emission is fairly uniform throughout the experiment

Spectra for Ar, Xe, and Ar:Xe gas targets

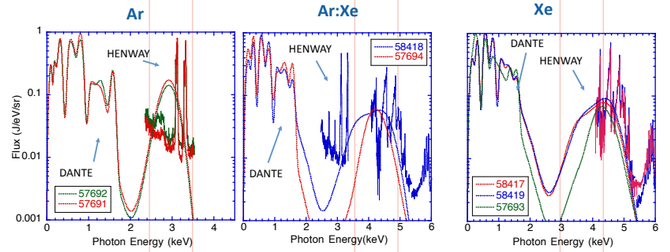


Time Histories of Gas X-ray Emission

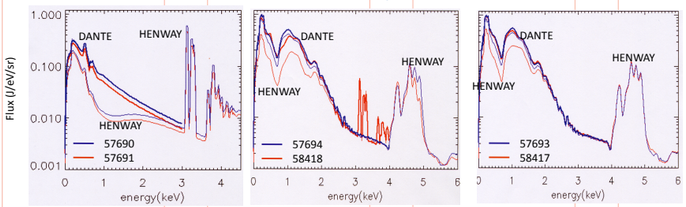


Lower Z (Ar) gas targets have a different time evolution than higher Z (Xe) targets

Measured Spectra



Simulated Spectra



Strong angular dependence in thermal spectrum is predicted

Conversion Efficiency Summary

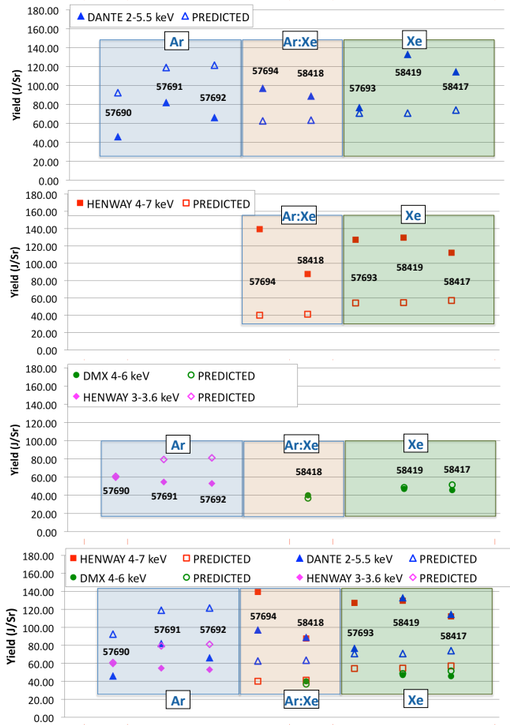
Shot	Gas	Gas pressure (atm)	Laser Energy (kJ)	Dante Yield (J/sr)	Conv. Efficiency %
57690	Ar	1.04	19.238	511.8	33.4
57691	Ar	1.44	19.674	539.6	34.5
57692	Ar	1.49	19.611	501.8	32.2
57693	Xe	1.17	19.443	608.0	39.3
57694	Xe:Ar (50:50)	1.19	19.500	580.5	37.4
58417	Xe	1.41	19.378	617.0	40.0
58418	Xe/Ar(50:50)	1.32	19.262	510.8	33.3
58419	Xe	1.18	18.654	625.2	42.1

FABS Calorimetry shows that LPI beam-energy losses are small (< 10%), yielding good coupling

Shot	Gas	Gas Pressure (atm)	Laser energy (kJ)	B25 Energy (J)	B25 SRS (J)	B25 SBS (J)	% total backscatter
57690	Ar	1.04	19.238	457.2	3.9	30.1	7.4
57691	Ar	1.44	19.674	468.9	6.5	35.8	9.0
57692	Ar	1.49	19.611	465.9	9.2	33.2	9.1
57693	Xe	1.17	19.443	459.5	5.3	23.2	6.2
57694	Xe:Ar (50:50)	1.19	19.500	460.9	6.1	32.2	8.3
58417	Xe	1.41	19.378	436.1	4.0	21.3	5.8
58418	Xe/Ar(50:50)	1.32	19.262	429.9	3.7	22.4	6.1
58419	Xe	1.18	18.654	420.9	3.3	14.5	4.2

The SBS channel dominates these OMEGA LPI yields

Yields



Yield (J/Sr)	Ar			Ar:Xe		Xe		
Shot	57690	57691	57692	57694	58418	57693	58419	58417
Gas (atm)	1.04	1.44	1.49	1.19	1.32	1.19	1.18	1.36
Dante 0-2 keV	465.9	457.6	435.7	483.4	512.8	526.2	625.2	617.0
prediction	148.8	173.4	175.8	453.8	464.8	545.5	547.2	579.6
Dante 2-5.5 keV	45.92	82.01	66.16	97.10	88.86	76.74	132.9	114.5
prediction	92.4	119.0	121.5	62.57	63.41	70.83	70.83	74.04
Henway 4-7 keV				139.4*	87.62	127.2*	129.6	112.2
prediction				40.08	41.25	54.23	54.63	57.09
Henway 3-3.6 keV	59.34	54.59	52.99					
prediction	60.79	79.32	81.13					

*film saturated

Lawrence Livermore National Laboratory

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This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.
This work was also supported by the Defense Threat Reduction Agency under the IACRO 09-45501 "Evaluation of Lasers for X-Ray Production on NIF."

NIF

LLNL-POST-XXXXXX