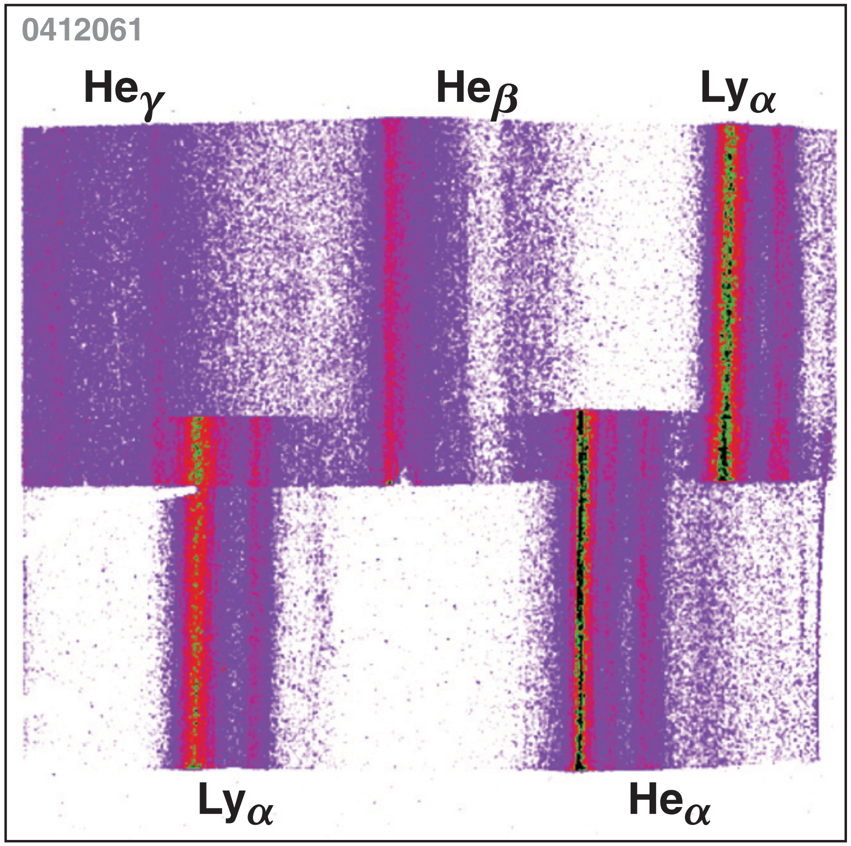
High-Brightness ~2-keV Source Development for Backlighting of Cryogenic Implosions



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Summary

Backlighting of cryogenic-implosion targets requires ultrashort x-ray flashes with a high spectral brightness

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- A spectral brightness of ~60 μJ/eV/ps/Sr of the backlighter at ~2 keV is required to overcome the target self-emission in cryogenic implosions.
- High-energy beams (up to 2.6 kJ) from OMEGA EP will be used at high intensity (>10^{18} W/cm^2) for backlighting.
- Short-pulse experiments with up to 500 J of energy show promising results, with measured spectral emissions up to 1.8 mJ/ev/Sr.
- Time resolved spectroscopy is required to measure the spectral brightness without relying on assumptions of the emission time.

Collaborators

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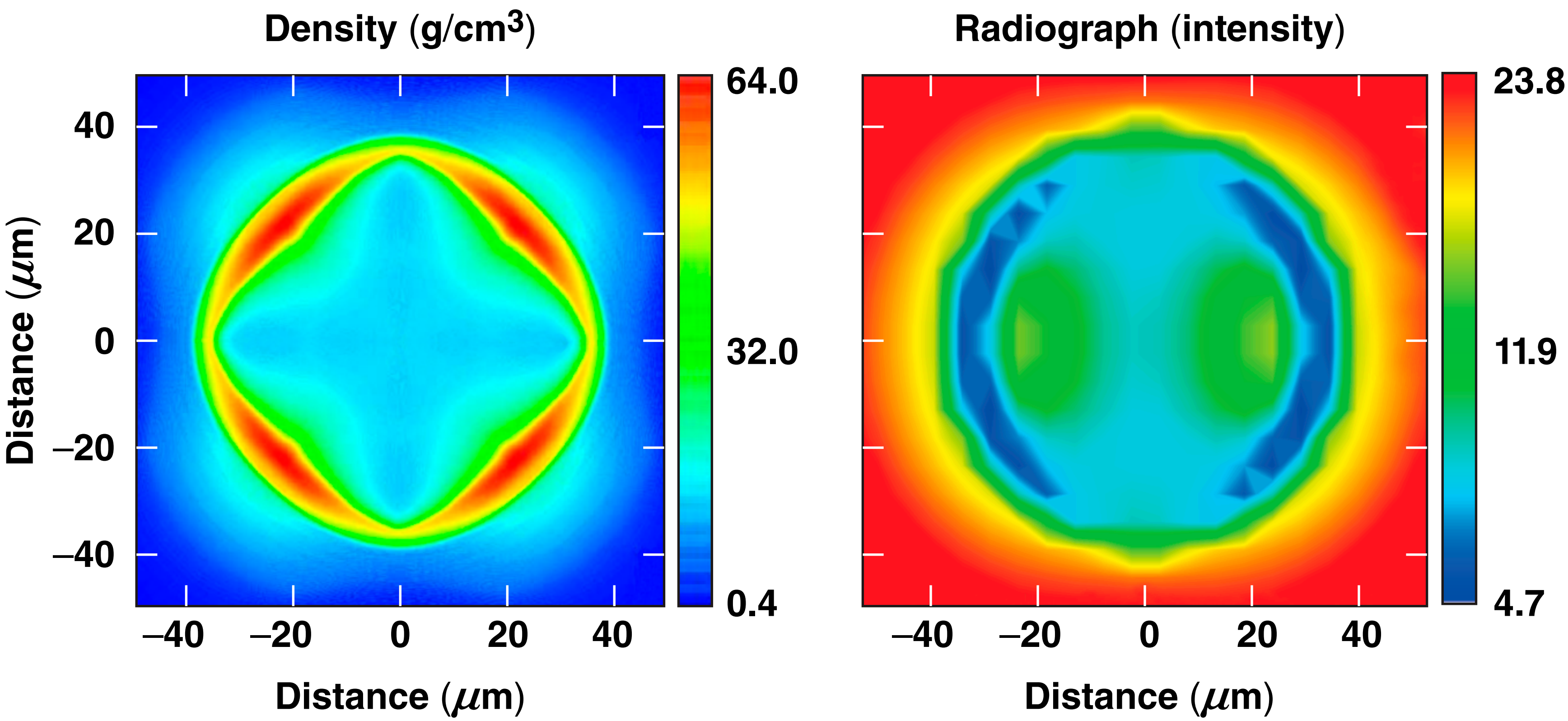
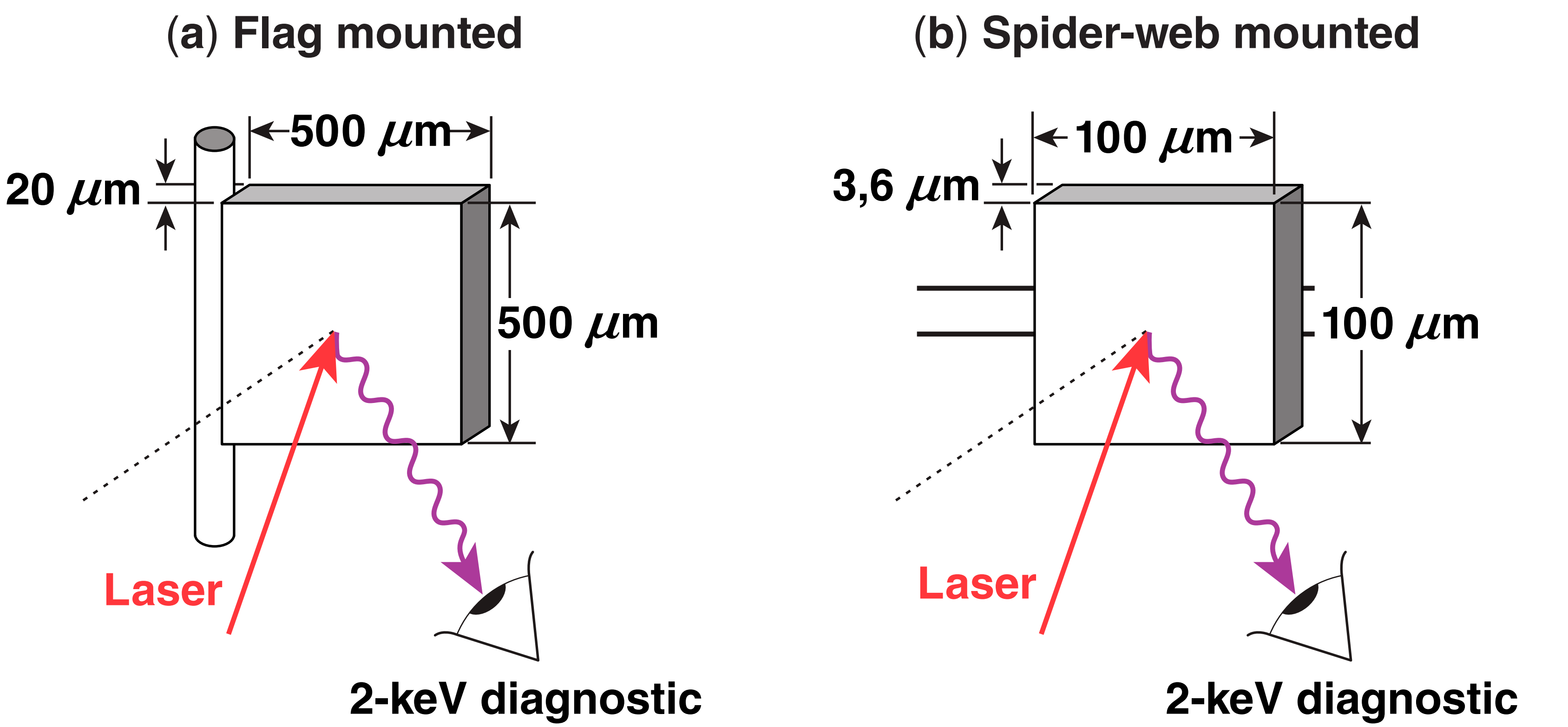
A backlighter spectral brightness of ~60 μJ/eV/ps/Sr in the 2-keV spectral range is required for imaging



- Simulations predict a self-emission of 8 μJ/eV/ps/Sr in the 2-keV range.
- Current cryogenic experiments show a self-emission of ~2 μJ/eV/ps/Sr.
- The simulation assumes, for the backlighter, a 3-keV Planckian spectrum filtered in the 2- to 2.2-keV spectral range.

E11559b

Both flag-mounted and spider-web-mounted mass-limited targets were used in the experiments



- **Electron refluxing* in mass-limited targets could improve the conversion efficiency**

*P. M. Nilson (YI2.00001)

Experiments were performed at three different laser facilites with energies up to 500 J

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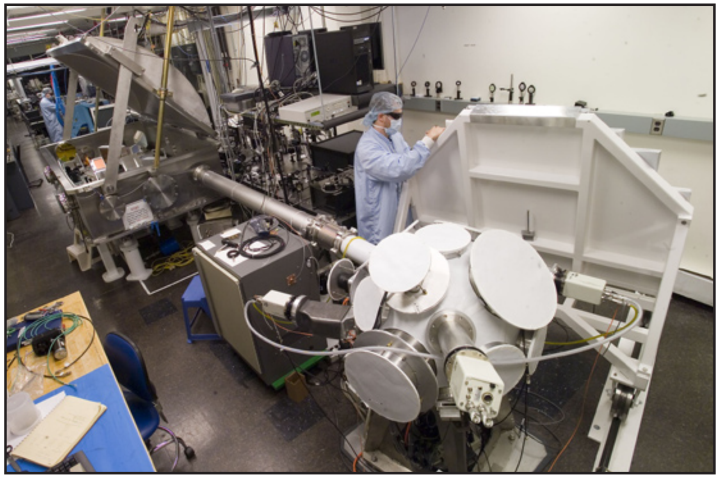
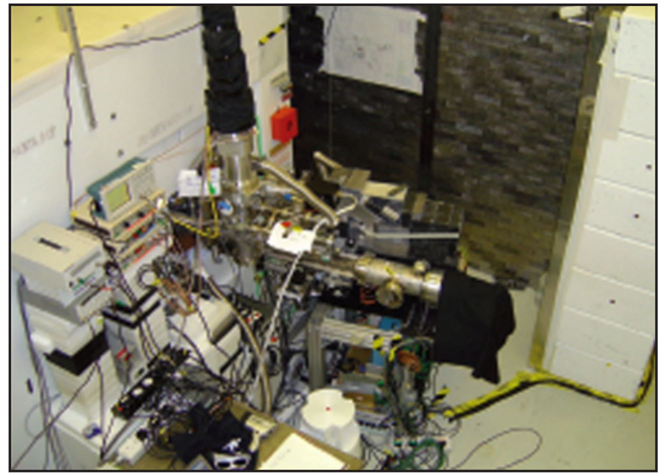
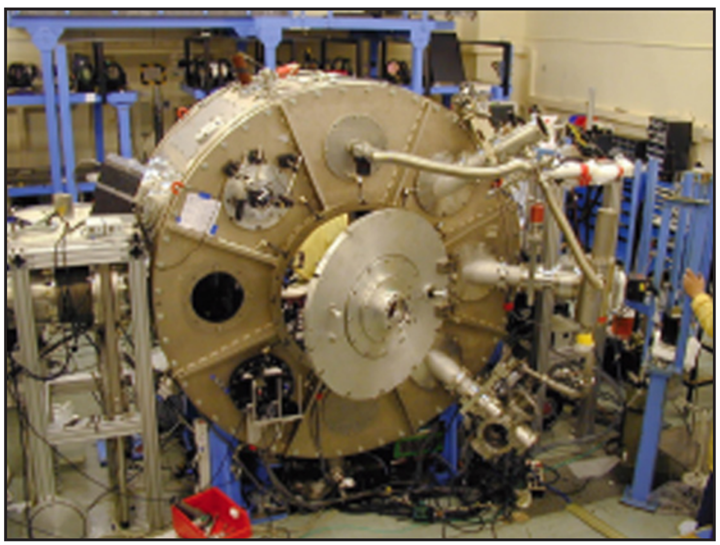
MTW laser at LLE



PW laser at RAL



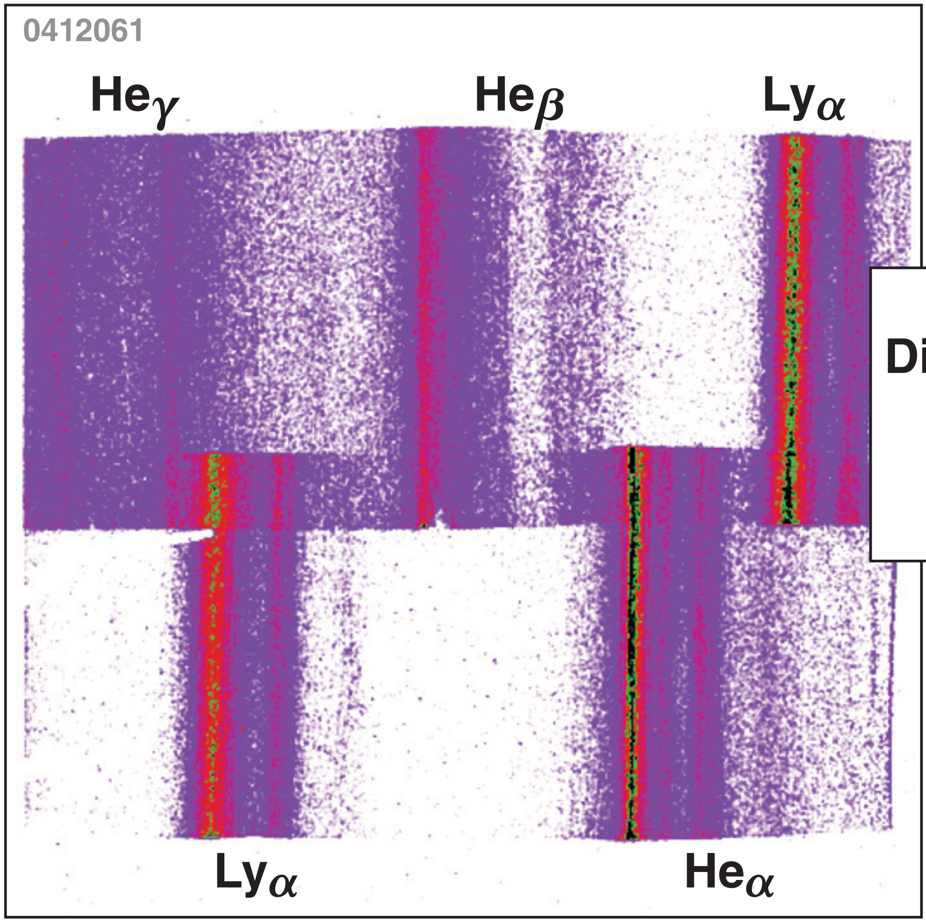
100 TW laser at RAL



Facility	MTW	100 TW	PW
Energy	<10 J	<100 J	<500 J
Pulse	1 ps	10 ps	1 to 10 ps
Intensity (W/cm^2)	$<10^{19}$	10^{19}	$>10^{20}$

E16290

Al *K*-shell emission is observed between 6.2 Å and 8.2 Å on an x-ray CCD array



Target:	Al foil in spider web
Dimensions:	6 μm × 100 μm × 100 μm
Energy:	~400 J
Pulse:	10 ps
Intensity:	~1.6 × 10^{19} W/cm^2

The radiated spectral energy density has been calculated from the measurements

- Deposited radiation energy in one CCD pixel:

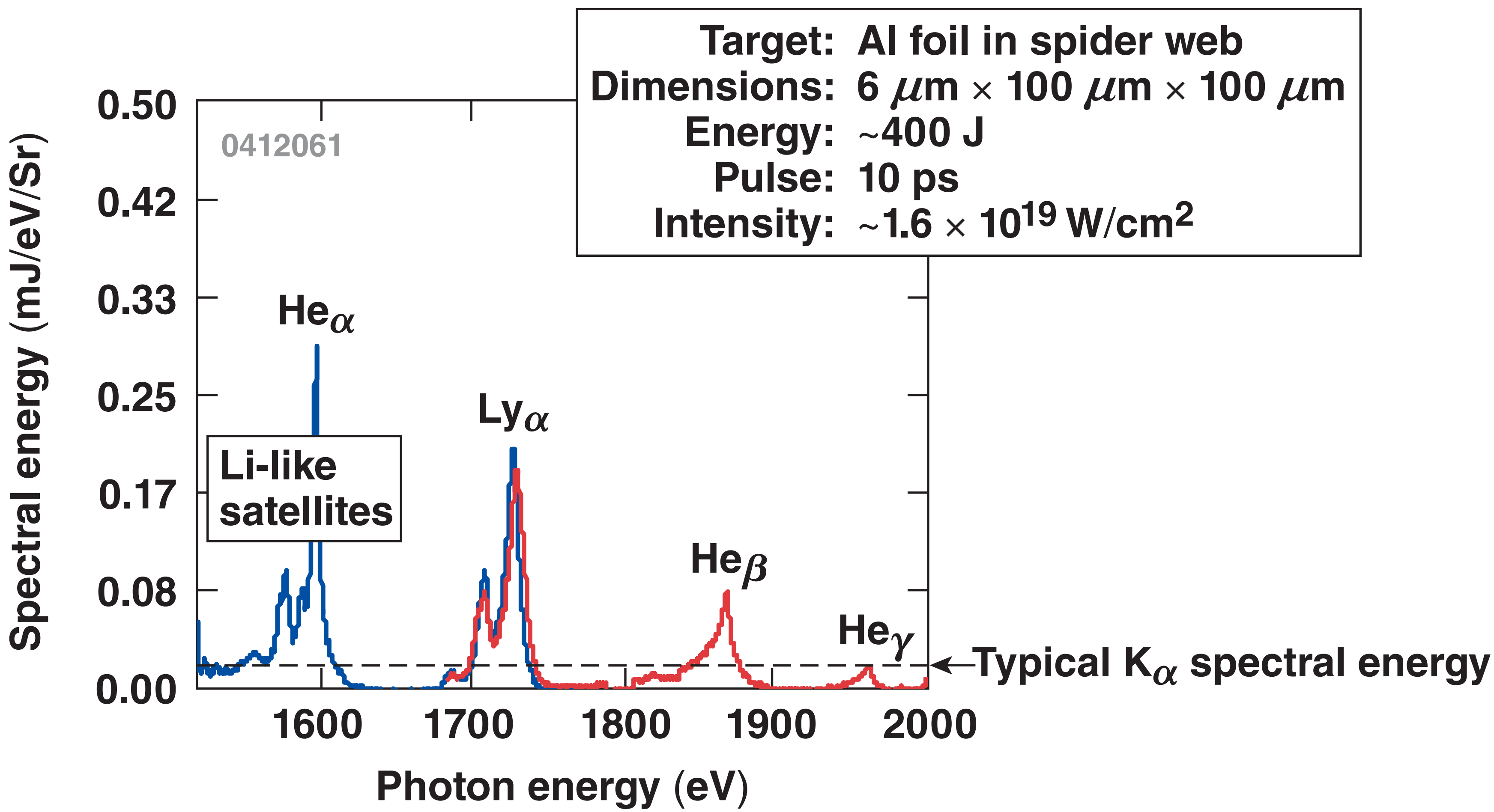
$$E_{pix}(\mathrm{J}) = \mathrm{Signal}(\mathrm{ADU}) \times \alpha(\mathrm{eV/ADU}) \times (1.6 \times 10^{-19})$$

- The CCD was calibrated with K_α emission: $\alpha = (4.56 \pm 0.01)$ eV/ADU.

$$\tilde{E}_{source}(\mathrm{J/eV}) = \frac{E_{pix}(\mathrm{J})\left[1 + (\Delta\lambda_{res}/\Delta\lambda_{line})^2\right]^{1/2}}{\mathrm{QE} \times T_{filt} \times \eta_{cryst} \times \eta_{\Delta\Omega} \times \Delta(\hbar\omega)_{pix}(\mathrm{eV})}$$

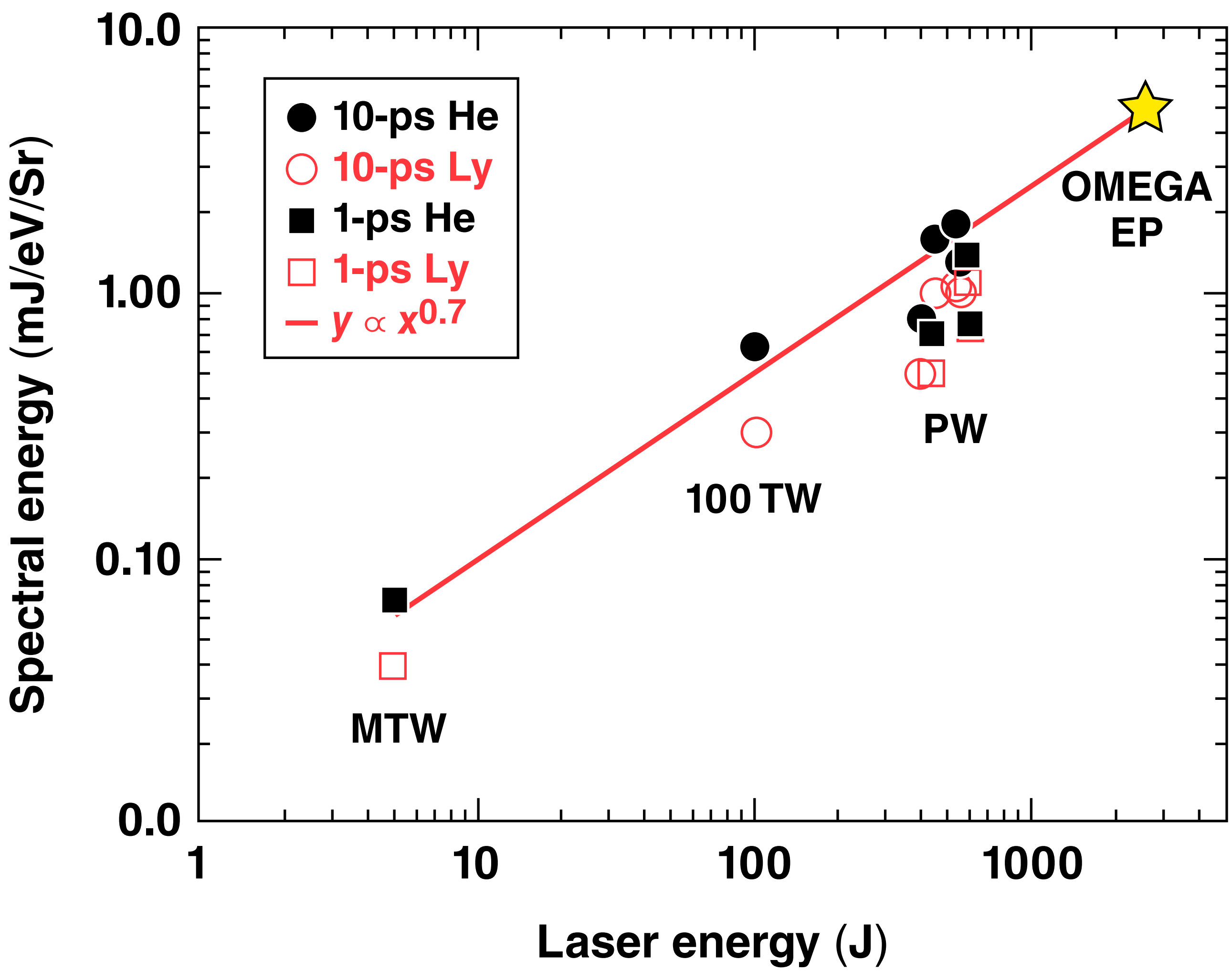
- The quantum efficiency (QE) of a CCD is assumed to be 100%.
- The filter transmission, T_{filt}, and the crystal diffraction efficiency η_{cryst} were taken into account.
- The solid angle $\eta_{\Delta\Omega}$ was obtained from the rocking curve width.
- The spectral range per pixel is given by $\Delta(\hbar\omega)_{pix}(\mathrm{eV})$

The He$_\alpha$ line is much brighter than the K$_\alpha$ line at these photon energies



E13594a

The emitted spectral energy (mJ/eV/Sr) is a function of the laser energy



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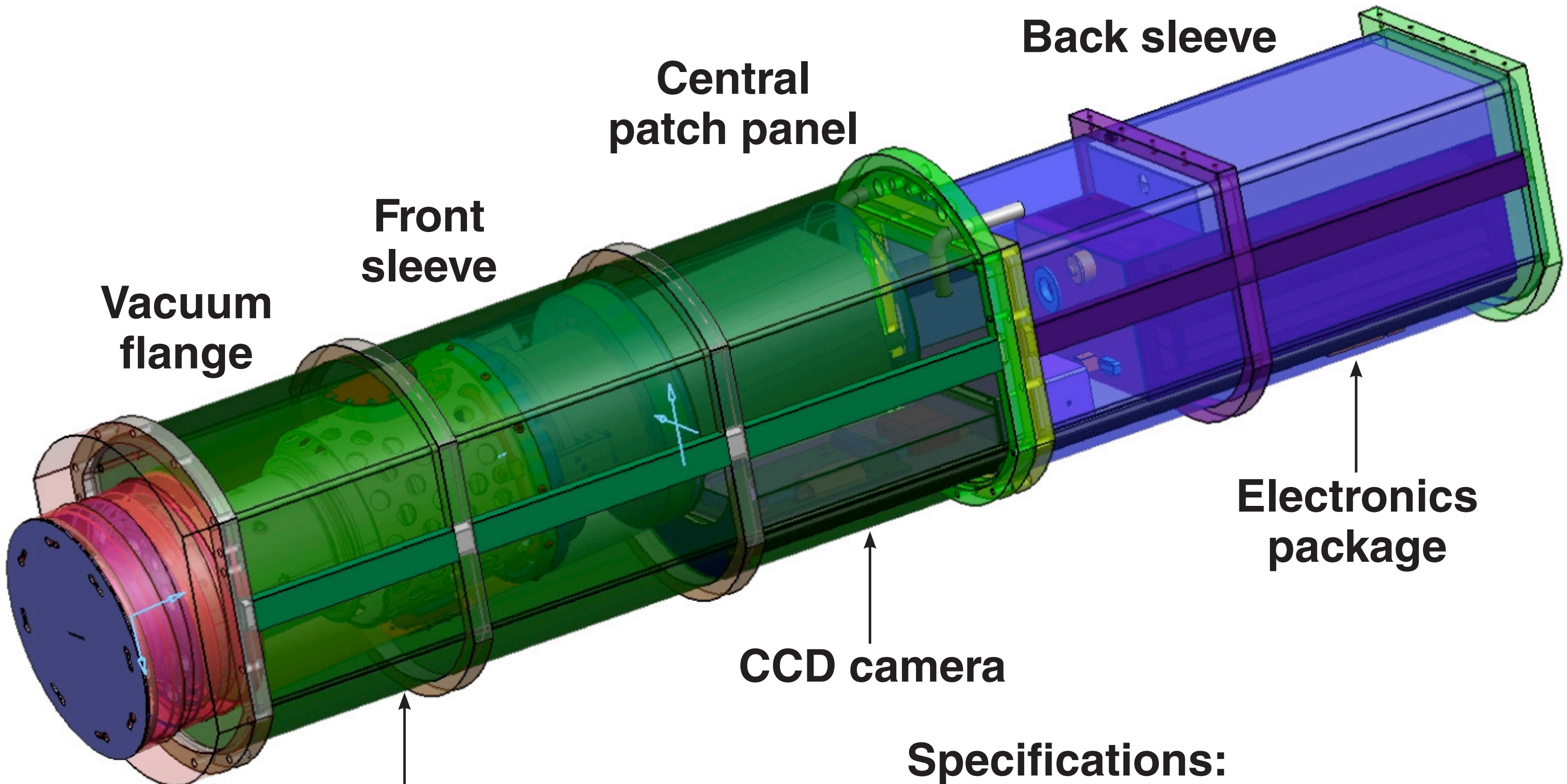
A 2-ps time-resolution, ultrafast x-ray streak has been developed and is being tested



Specifications:

- 10 lp/mm spatial resolution
- 2-ps temporal resolution
- 0.5-ns and 2-ns streak window
- 10-ps rms trigger jitter

E15853

Summary/Conclusions

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