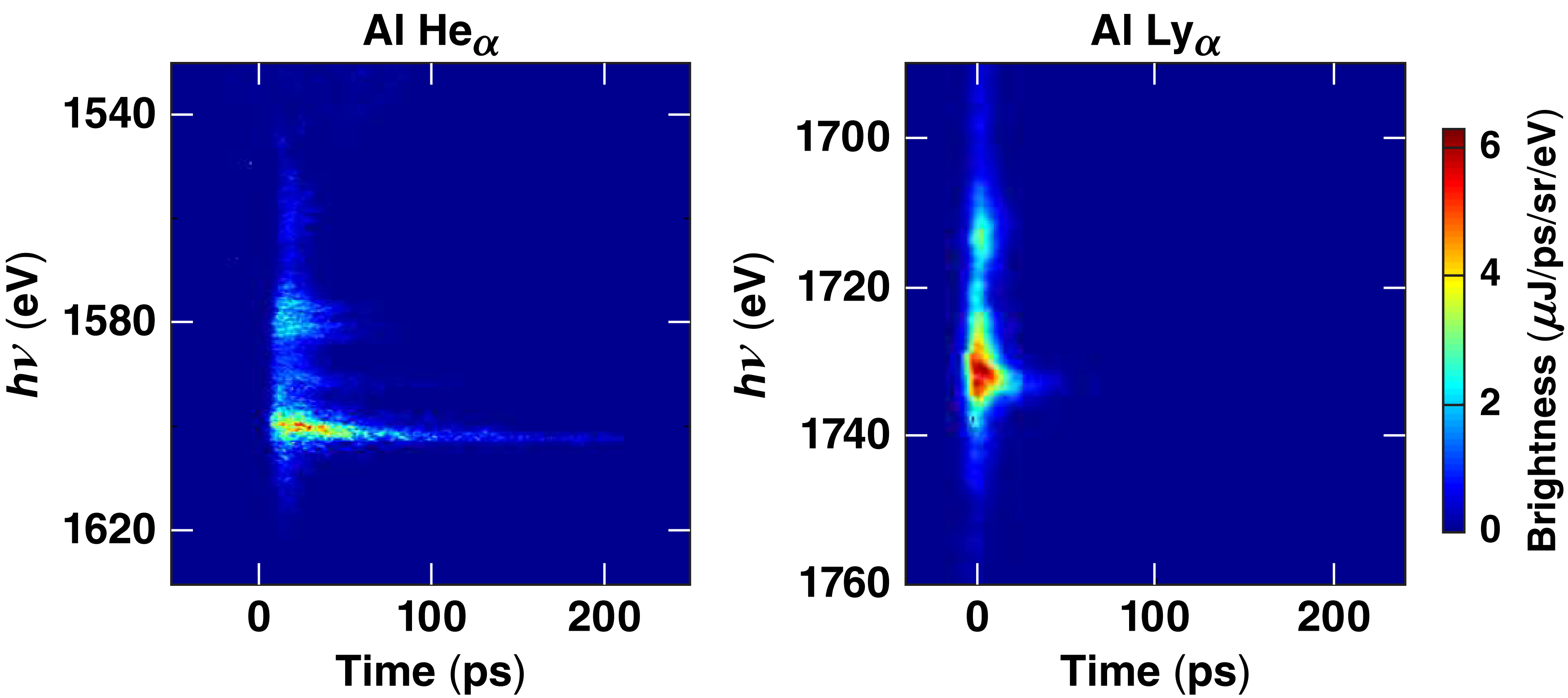
Time-Resolved X-Ray Brightness Measurements from Short-Pulse Laser-Irradiated Thin Foils



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Summary

The spectral brightness of high-intensity short-pulse laser–foil interactions has been measured near 2 keV

- 2-keV backlighting sources for cryogenic targets on OMEGA need high spectral brightness values to overcome the 400 mJ/ps/sr/eV/cm^2 self-emission
- Peak brightness and decay time measurements have been made of both Aluminum He$_\alpha$ and Ly$_\alpha$ for foils irradiated with laser energies up to 10 J, and intensities $>10^{19}$ W/cm^2
- The emission was also imaged allowing us to estimate a lower limit of the peak spectral brilliance (~17 mJ/ps/sr/eV/cm^2 for He$_\alpha$, ~35 mJ/ps/sr/eV/cm^2 for Ly$_\alpha$)
- Data indicates that peak brightness will increase with laser energy and target dimensions can be optimized for longer decay times

Collaborators

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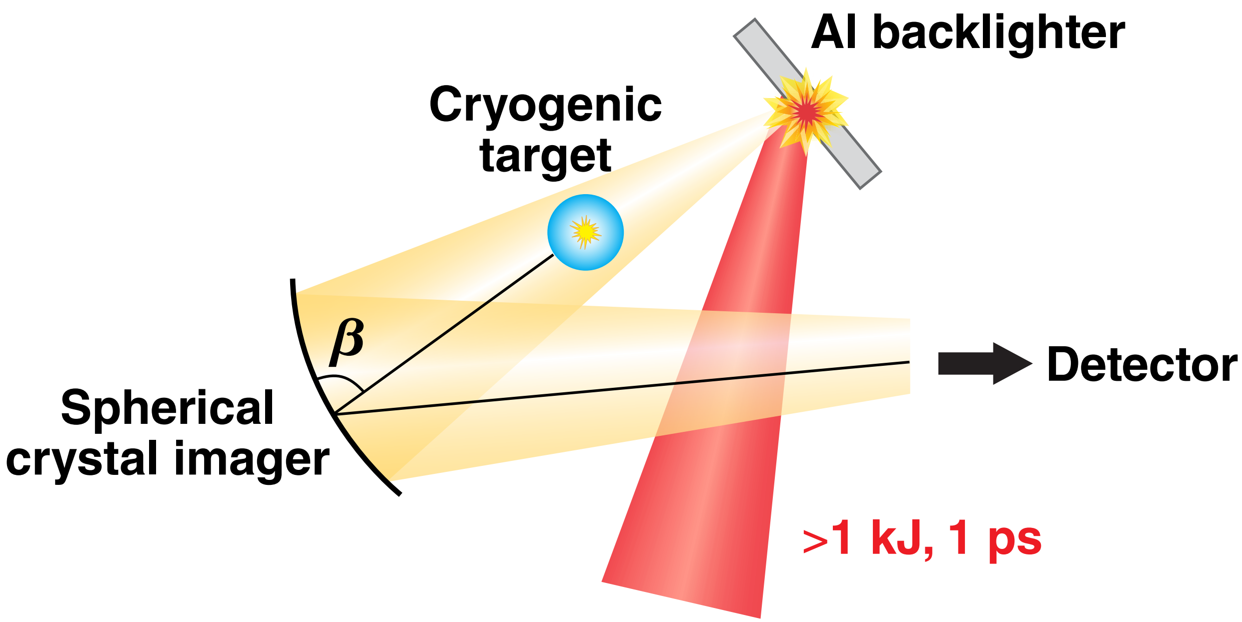
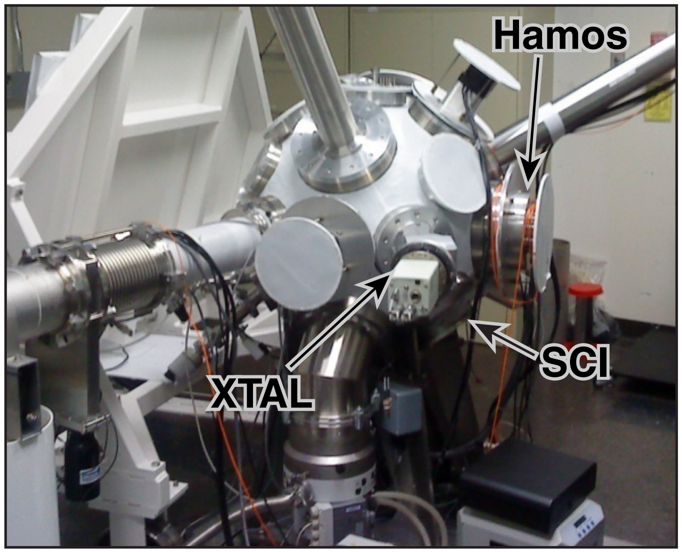
Bright ~2-keV sources are required for backlighting imploding cryogenic shells on OMEGA

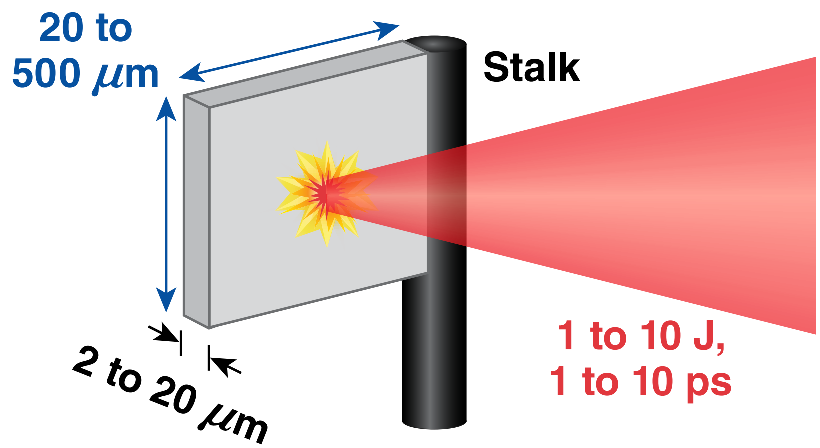


- *DRACO*/Spect3D simulations predict a self-emission of ~400 mJ/ps/sr/eV/cm^2 near 2 keV at peak compression
- To overcome the self-emission, high spectral brilliance required for good imaging contrast
- The backlighter source area must be comparable to shell size

Flag-mounted aluminum foil targets were used on the LLE Multi-Terawatt (MTW) system at intensities up to 4×10^{19} W/cm^2

MTW laser target chamber





- High-contrast laser (~10^{10})
- L_E = 1 to 10 J
- τ_L = 0.7 to 10 ps
- Spot diameter ~5 μm (50% L_E)
- Intensity ~ low 10^{18} to 4×10^{19} W/cm^2

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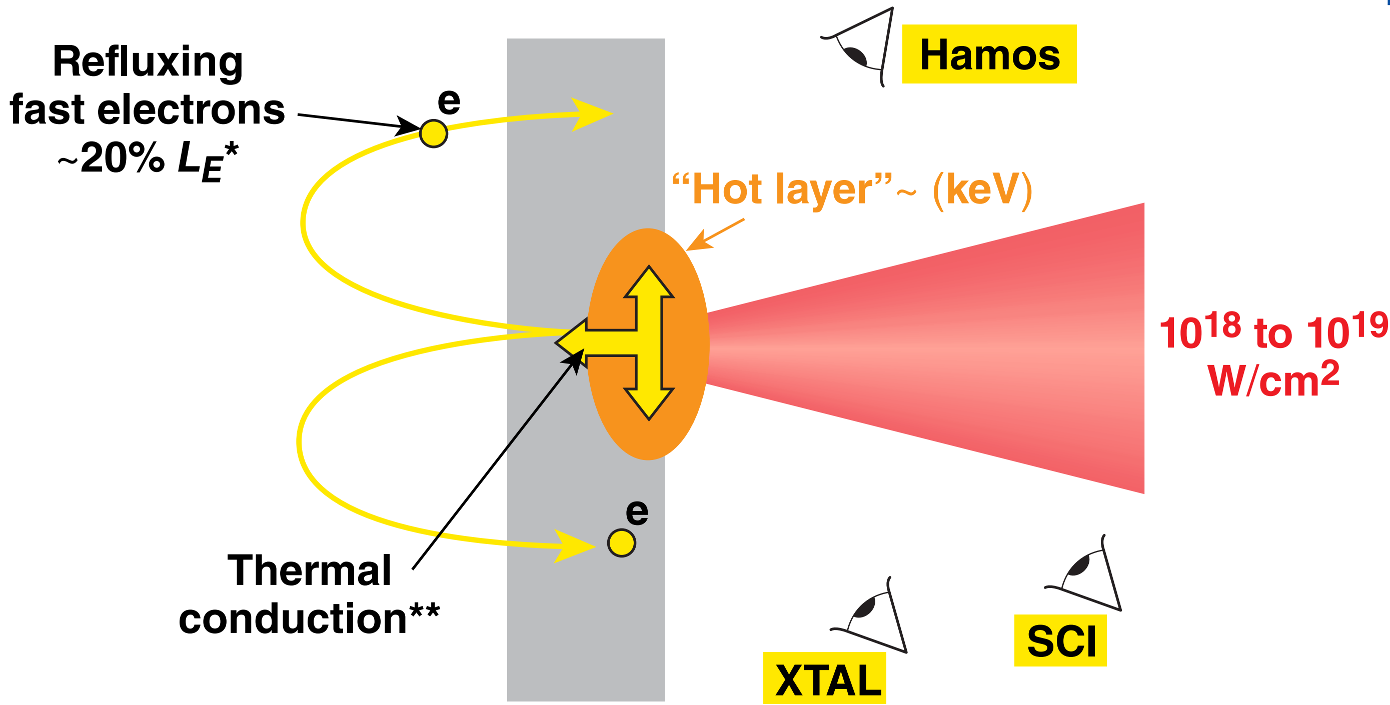
A short-pulse, high-intensity laser interaction creates an expanding hot layer, thermal conduction, and bulk heating by refluxing fast electrons



- XTAL – calibrated time-integrated spectrum
- Hamos – time-resolved spectrum
- SCI – spatial image of emitting area

} Estimate of spectral brilliance (μJ/ps/sr/eV/cm^2)

*P. M. Nilson *et al*., Phys. Plasmas 18, 056703 (2011).
**B. T. V. Vu, A. Szoke, and O. L. Landen, Phys. Rev. Lett. 72, 3823 (1994); Ditmere *et al*., Phys. Rev. Lett. 77, 498 (1996).

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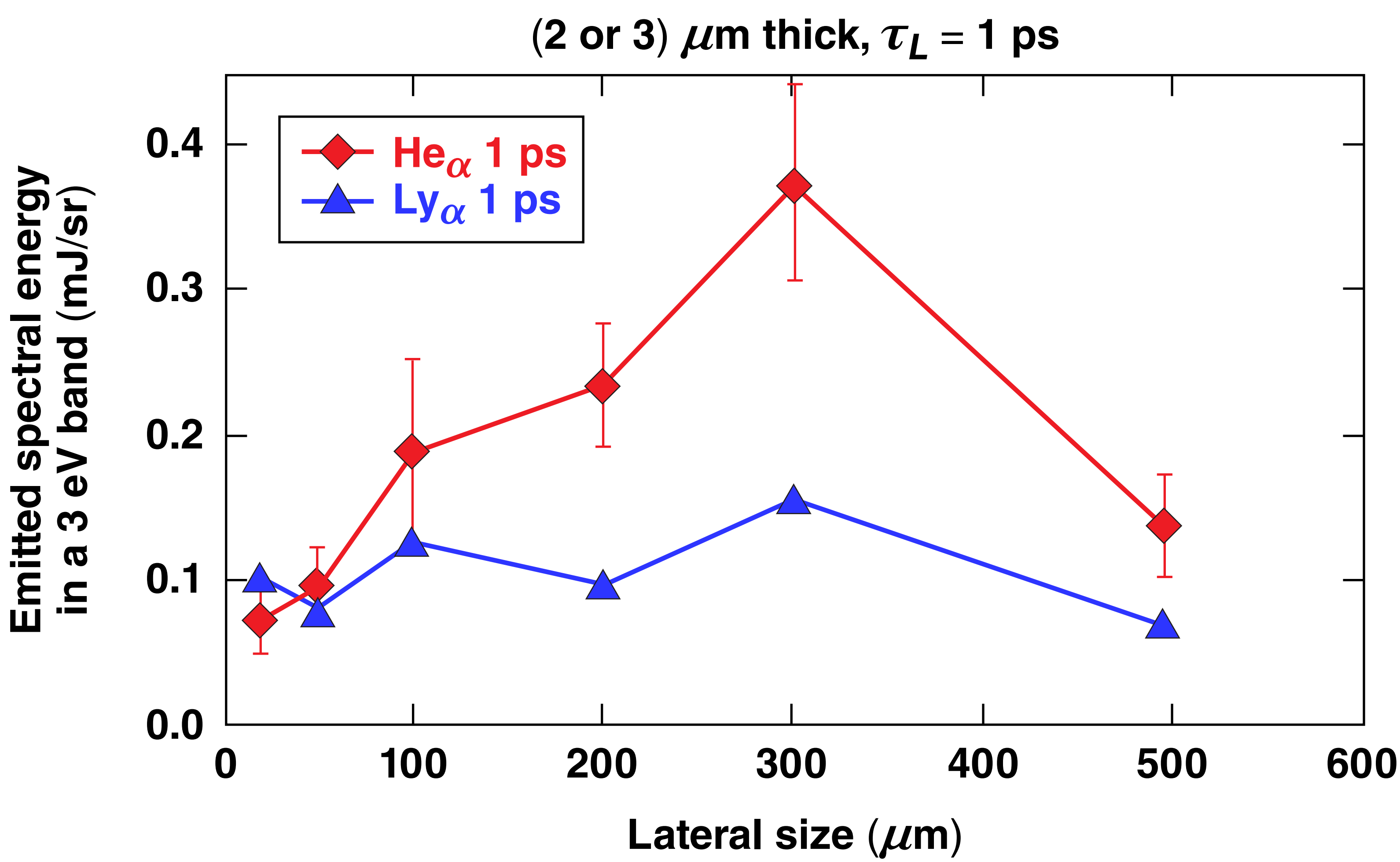
The time-integrated He$_\alpha$ emission is maximized for a specific lateral dimension



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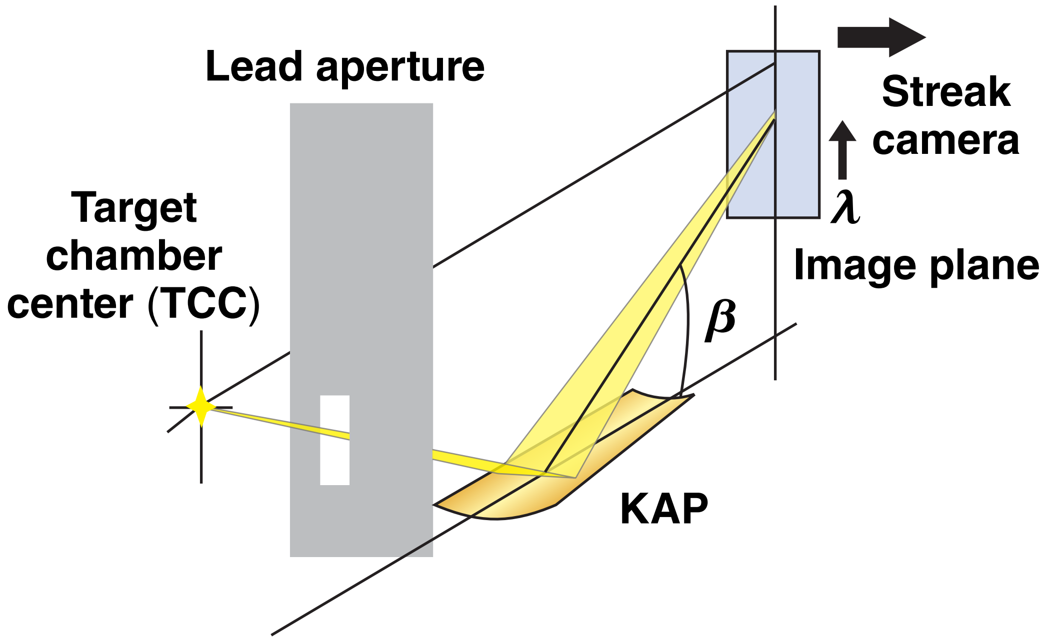
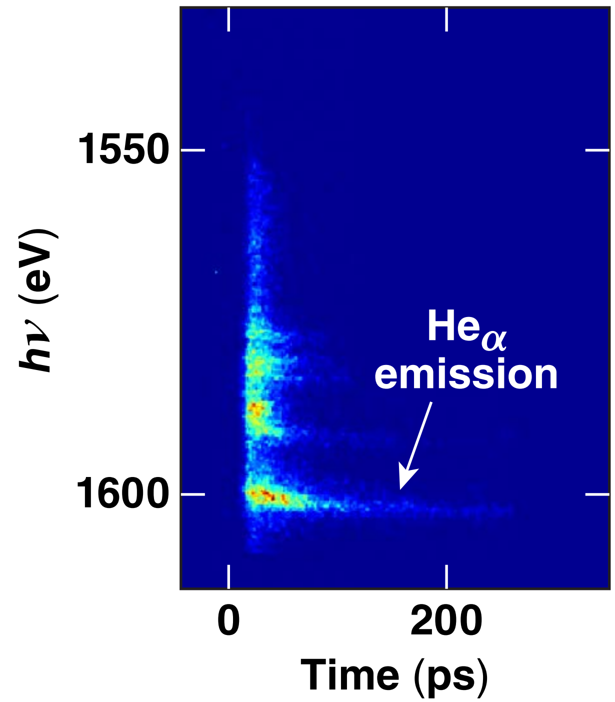
The x-ray emission was temporally and spectrally resolved





- Conically curved focusing* KAP crystal
- Spectral range (~ ± 0.4 Å around He_{α} or Ly_{α})
- Spectral resolution $E/\Delta E$ ~ 750
- Temporal resolution ~ 2 ps

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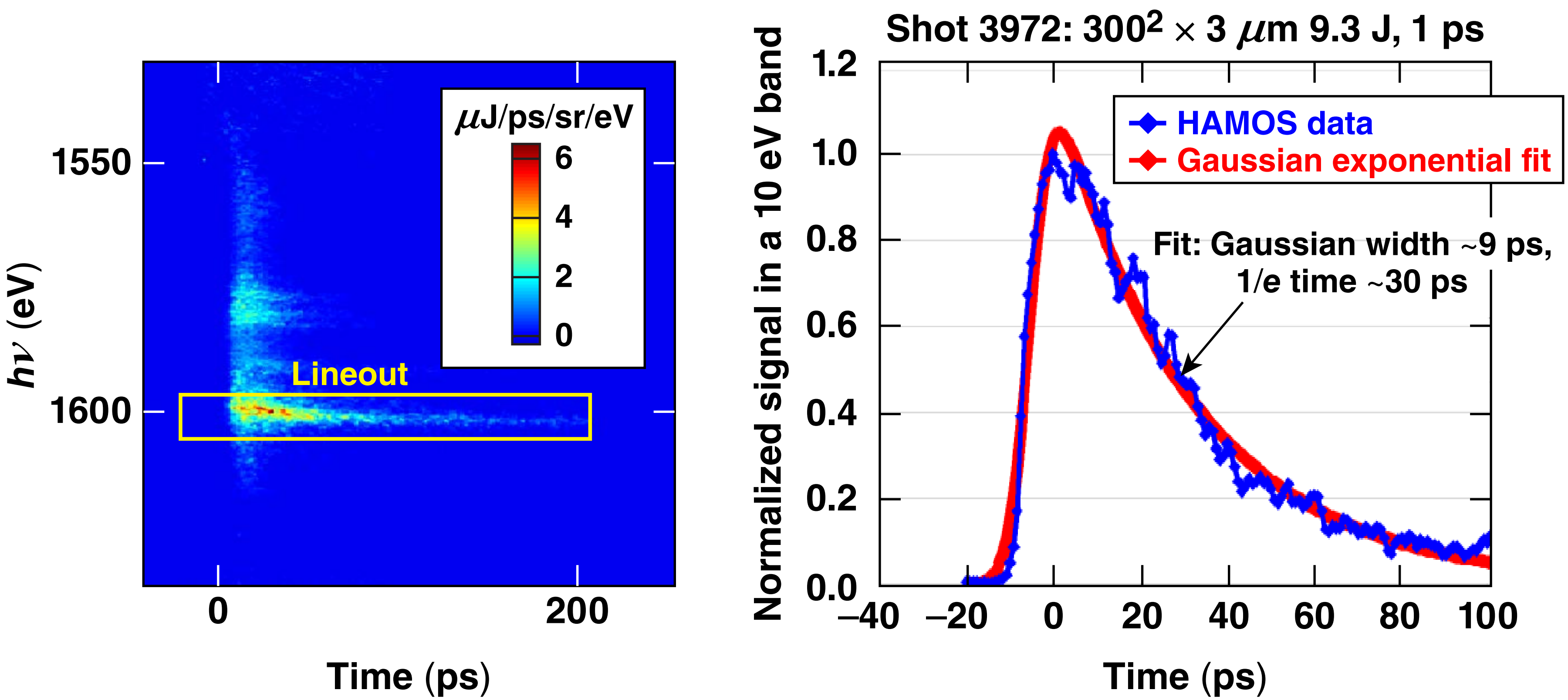
*T. A. Hall, J. Phys. E, Sci. Instrum. 17, 110 (1984).

Emission streaks were fitted to the convolution of a Gaussian and exponential decay



- Simultaneously recorded time-integrated data was used to calibrate HAMOS and determine spectral brightness

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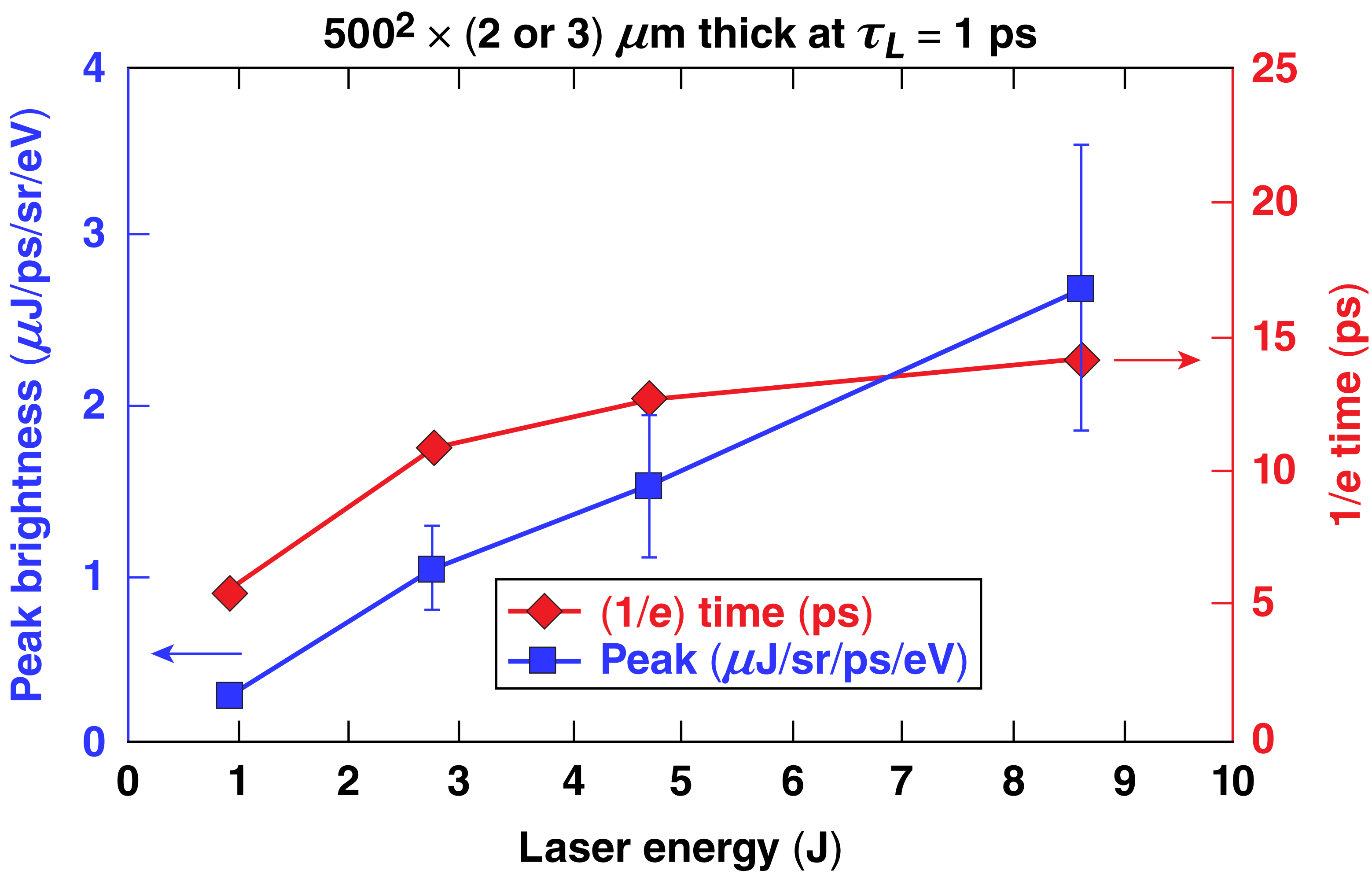
The He_α peak brightness increases with laser energy



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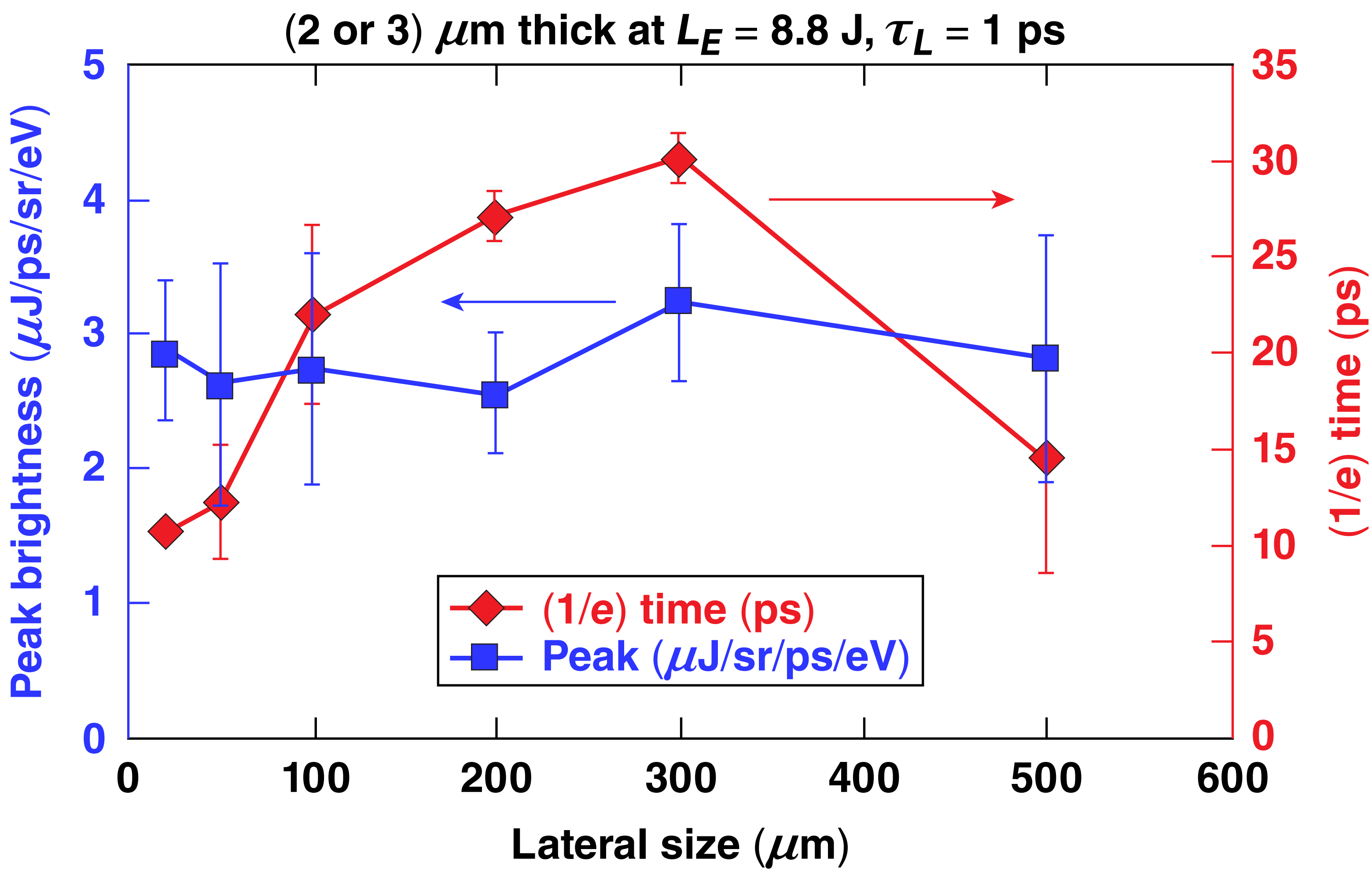
Target dimensions can be chosen to optimize decay time while maintaining peak brightness



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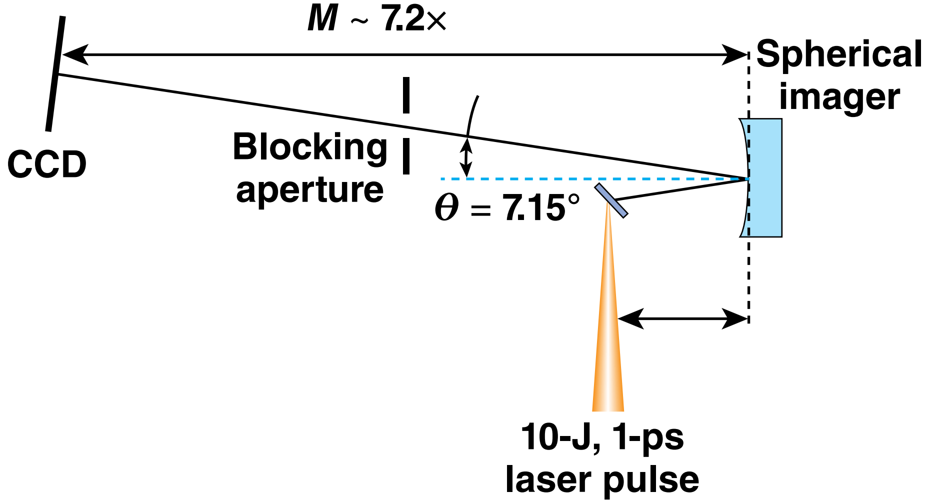
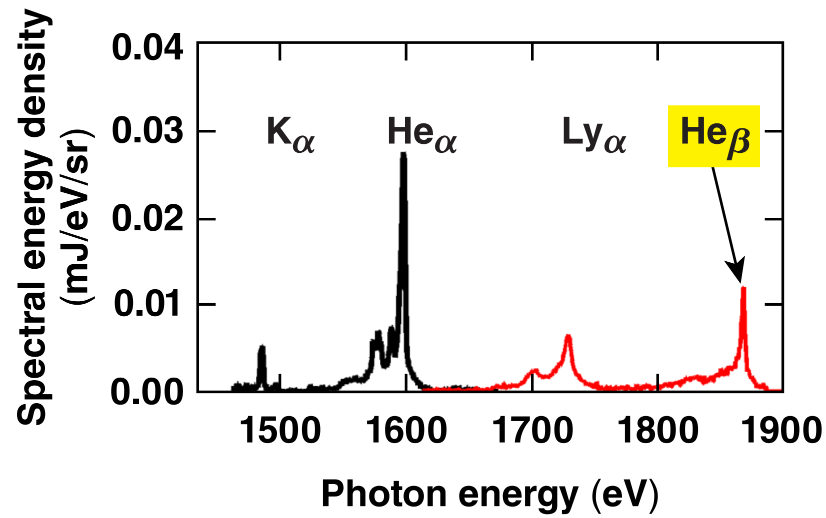
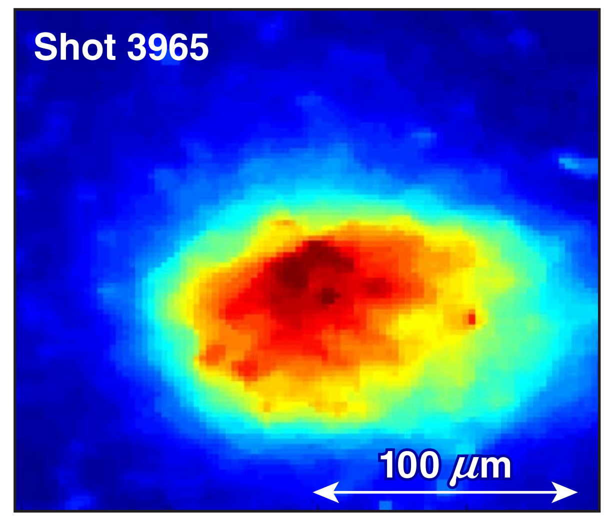
Spatially resolved He_β emission was measured







- The estimated lower limits for the peak spectral brilliance are ~17 mJ/ps/sr/eV/cm^2 for He_α, and ~35 mJ/ps/sr/eV/cm^2 for Ly_α

*C. Stoeckl *et al.*, Rev. Sci. Instrum. 83, 033107 (2012).

Summary/Conclusions

The spectral brightness of high-intensity short-pulse laser–foil interactions has been measured near 2 keV

- 2-keV backlighting sources for cryogenic targets on OMEGA need high spectral brightness values to overcome the 400 mJ/ps/sr/eV/cm^2 self-emission
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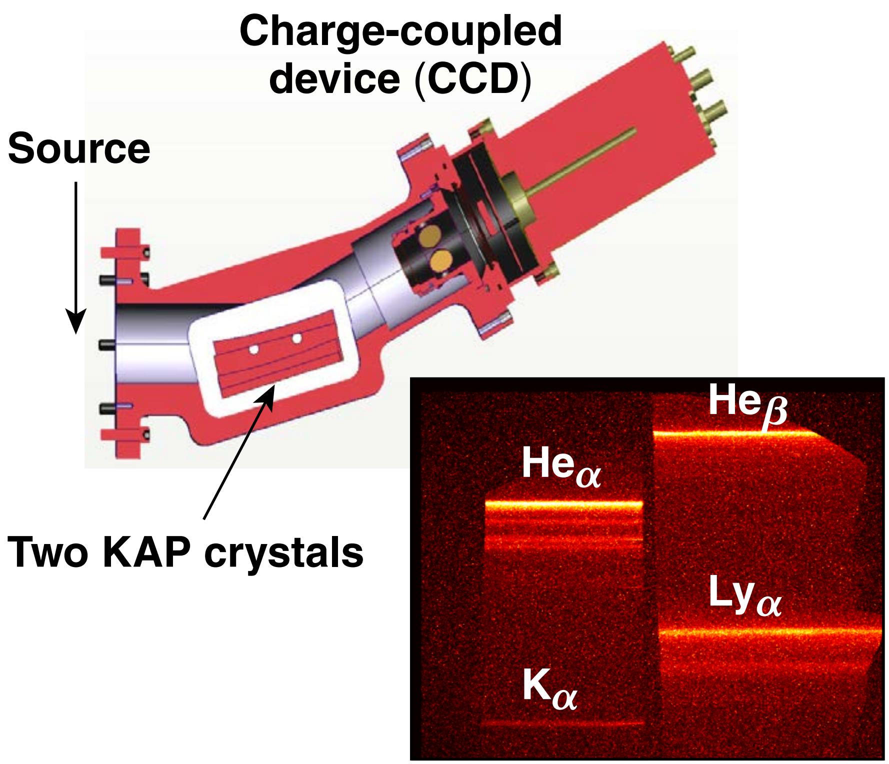
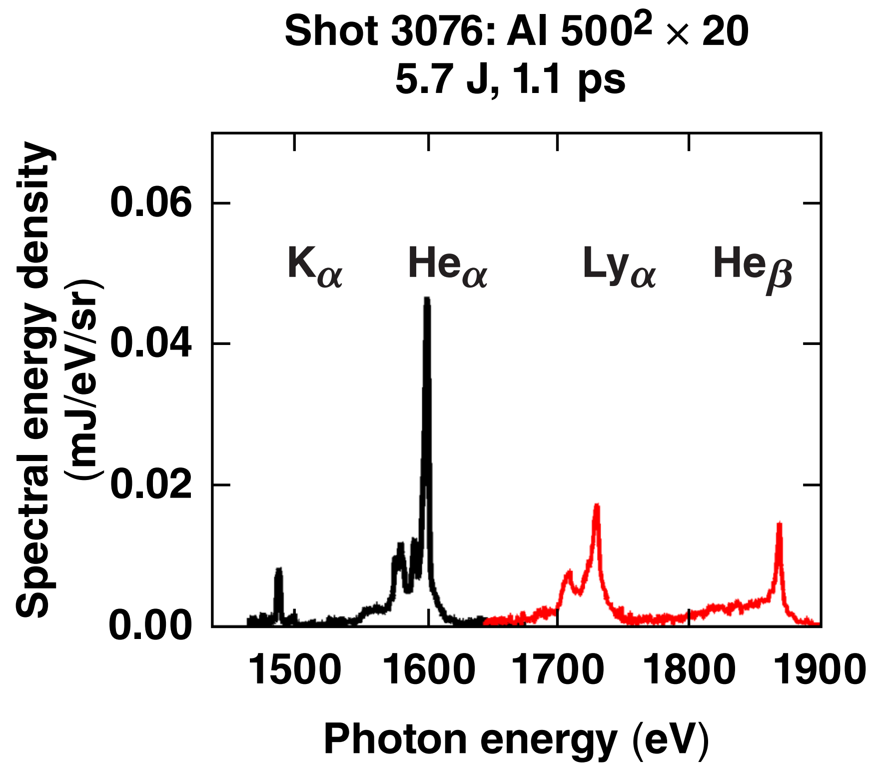
XTAL diagnostic measures time-integrated spectrally resolved emission

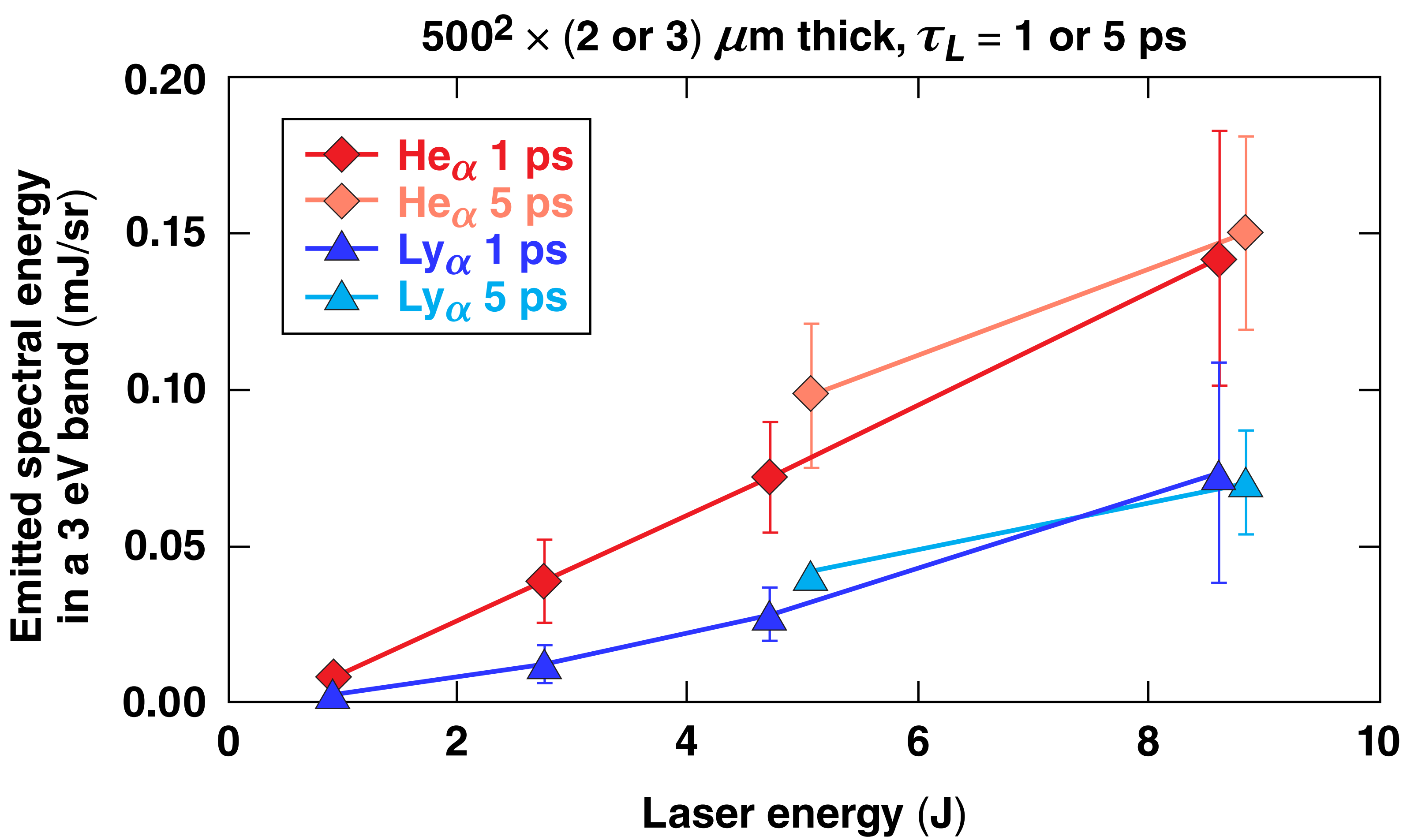




- Dual channel ~ 2 keV KAP crystal spectrograph
- Spectral range ~1.5 to 1.9 keV (~6.6 to 8.4 Å)
- Spectral resolution $E/\Delta E$ ~ 750

W. Theobald *et al.*, Rev. Sci. Instrum. 80, 083501 (2009).

Emitted spectral energy increases with laser energy



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