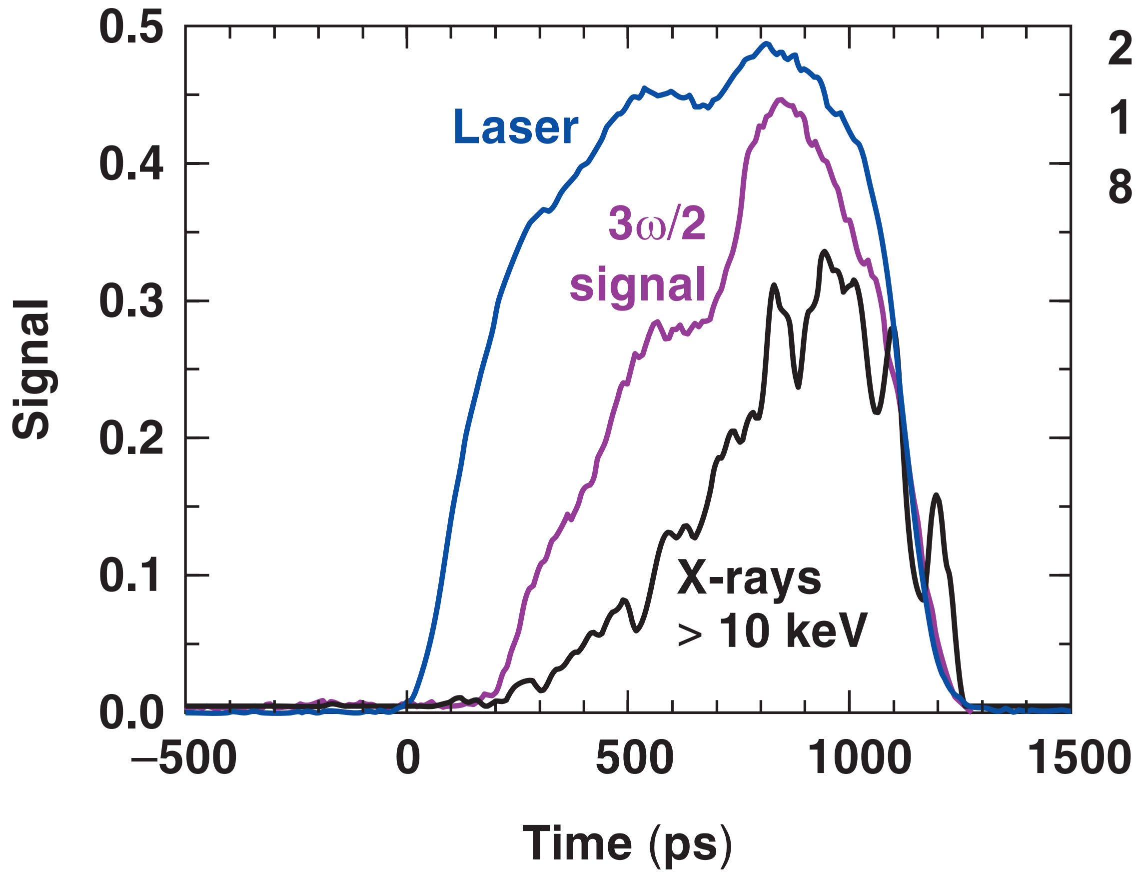
Optical and X-Ray Signatures from the Two-Plasmon-Decay Instability on OMEGA



20-μm CH shell,
1-mm dia,
8×10^{14} W/cm^2

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Summary

Hard x rays correlate with two-plasmon-decay instability

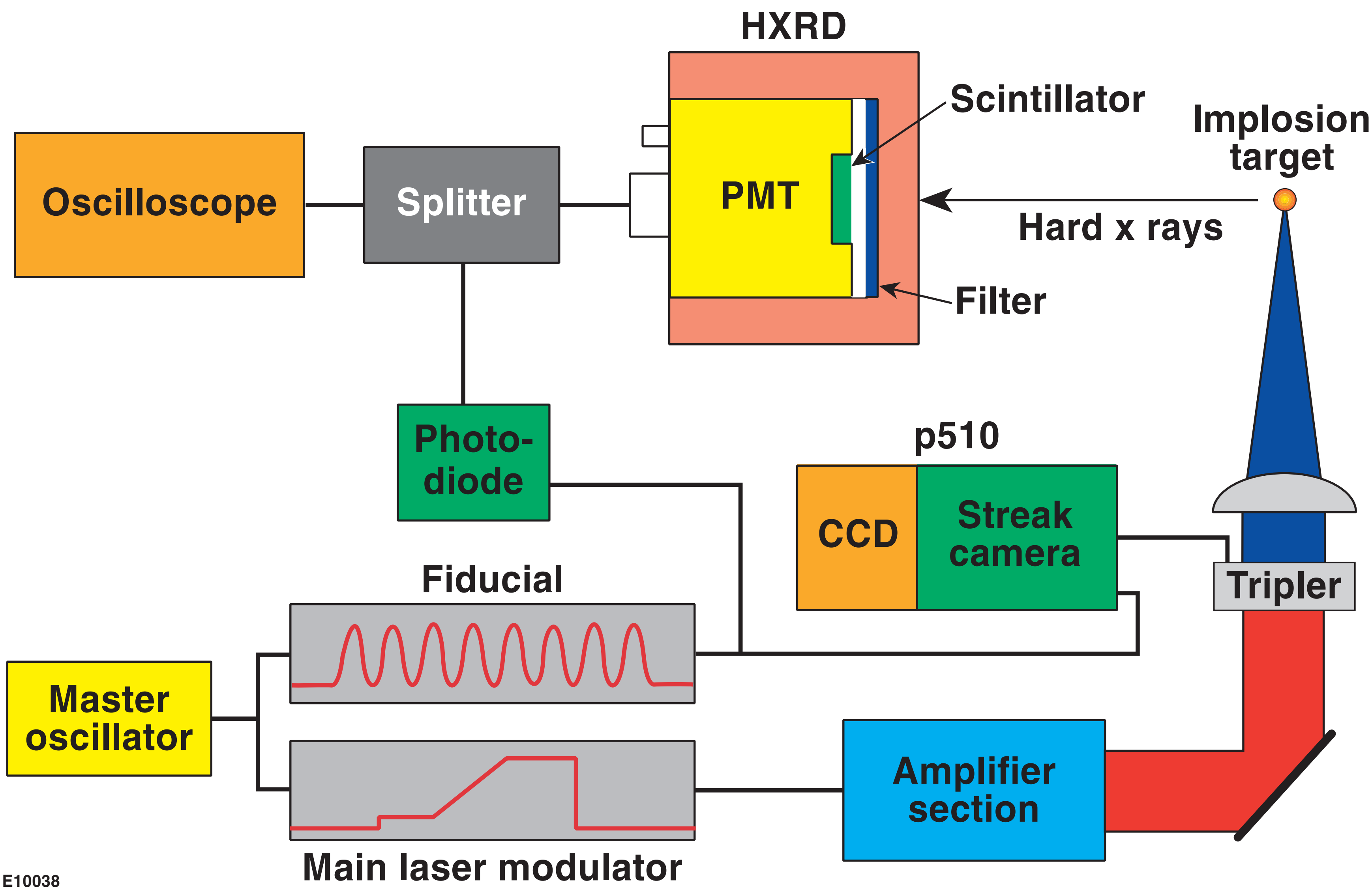
- Hard x rays were recorded time resolved in a wide energy range from 10 keV to 200^{+} keV.
- The $3\omega/2$ light associated with the two-plasmon-decay instability correlates with the hard x-ray emission.
- No optical signature of the SRS instability was observed.
- The radiated energy in hard x rays (> 30 keV) is $\leq$ 100 mJ.
- The hot-electron temperature was found to be 100 to 200 keV.
- An energy content in hot electrons of $\approx$ 0.1% of the laser energy is inferred using scaling laws from previous experiments.

E10443

Five detectors measure x-ray timing, energy, and spectrum

- The Neutron Temporal Diagnostic (NTD)—a detector designed for neutronics applications—can be used to measure soft > 10 keV with 20-ps time resolution.
- A dedicated set of four x-ray detectors was set up using a fast scintillator (800-ps decay time) combined with a fast microchannel-plate photomultiplier (70-ps rise time) for x-ray energies of 20 to 200^+ keV.
- The energy band of the x rays is determined by a single-edge-type filter.
- Two 3-GHz digital oscilloscopes (120-ps rise time) record the signals.
- An optical fiducial establishes absolute timing.
- The four detectors are calibrated relative to each other.
- The high dynamic range of the detectors (> 10,000) enables their use on 1- to 60-beam shots.

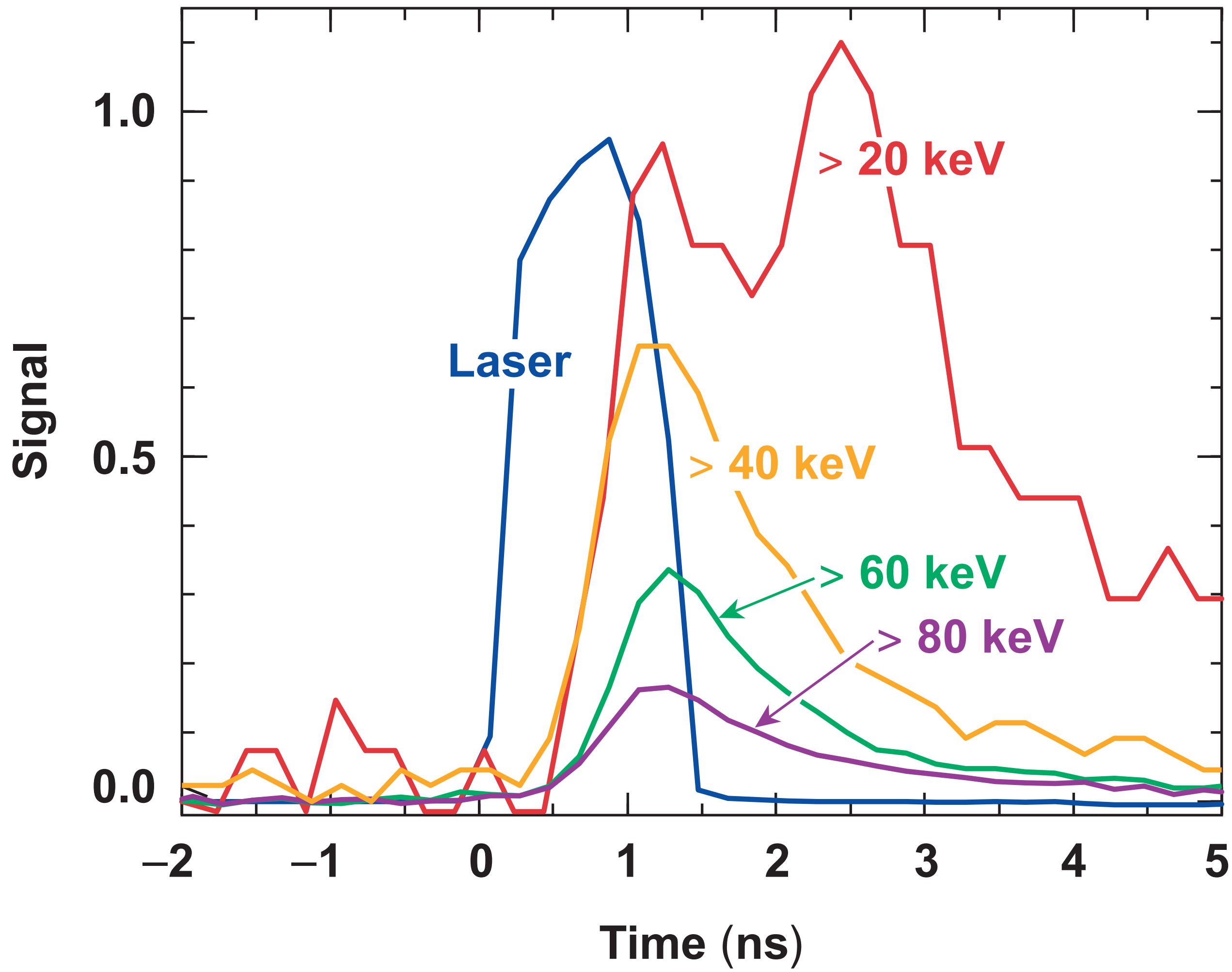
A simple design was used for the HXRD's



E10038

HXRD's show x-ray emission between 20 keV and 200 keV

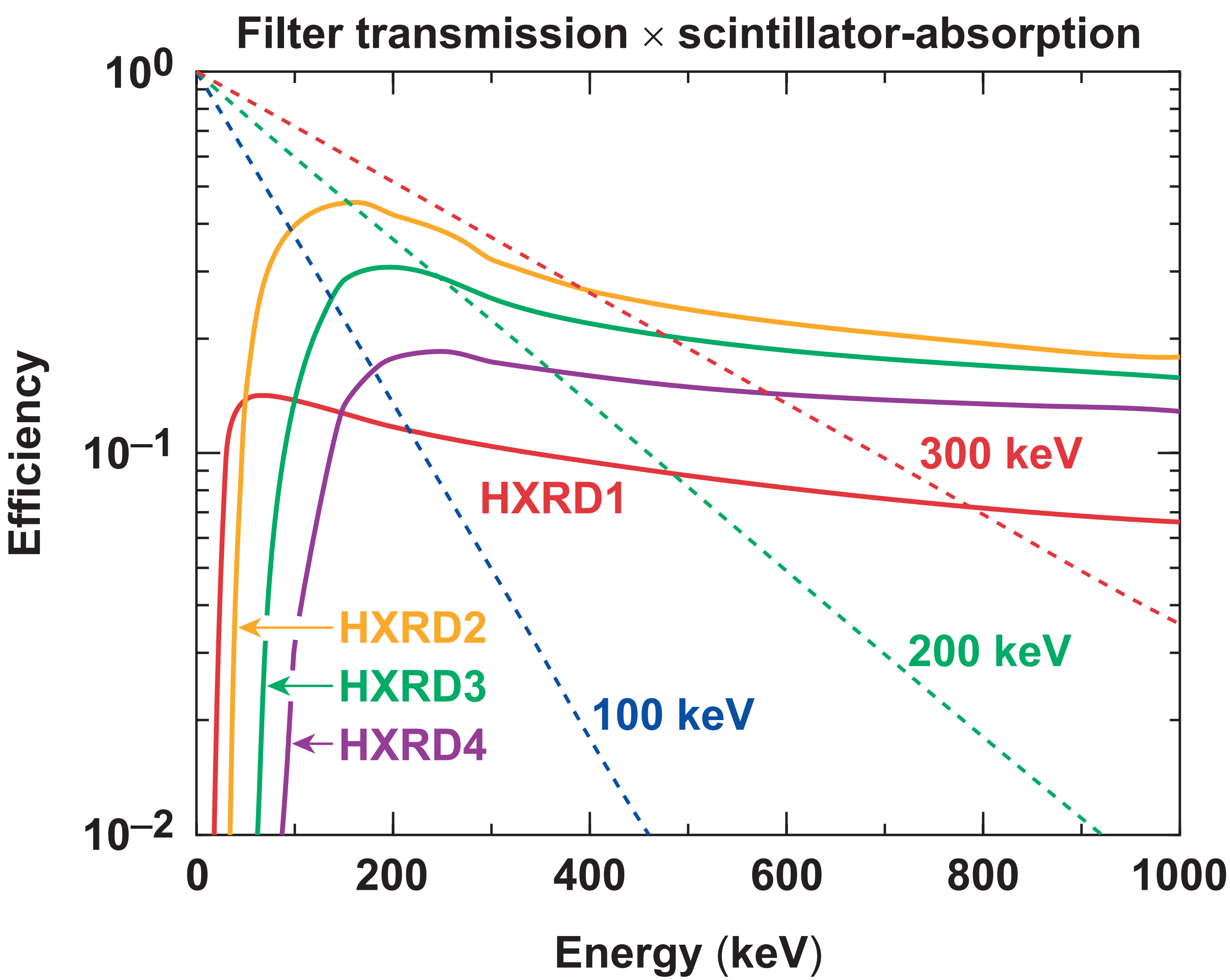
- 20-μm CH shell, 1-mm diam., 8 × 10^{14} W/cm^2, 1-ns square



E10111

The electron temperature can be estimated by assuming an exponentially decaying spectrum

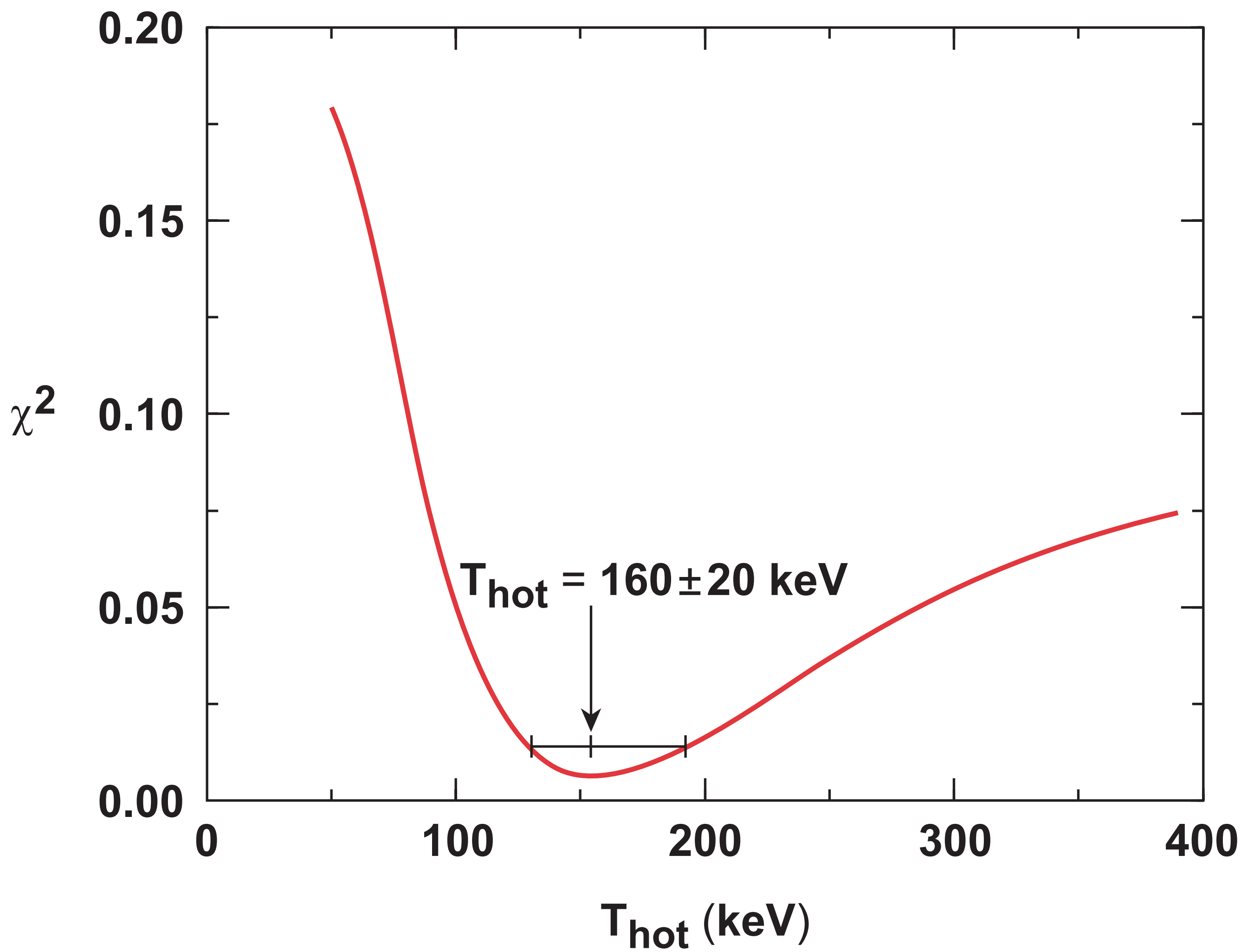
UR LLE



E10404

χ^2 analysis shows a distinct minimum

- 20-μm-CH-shell, 1-mm-diam, 8×10^{14} W/cm^2, 1-ns square

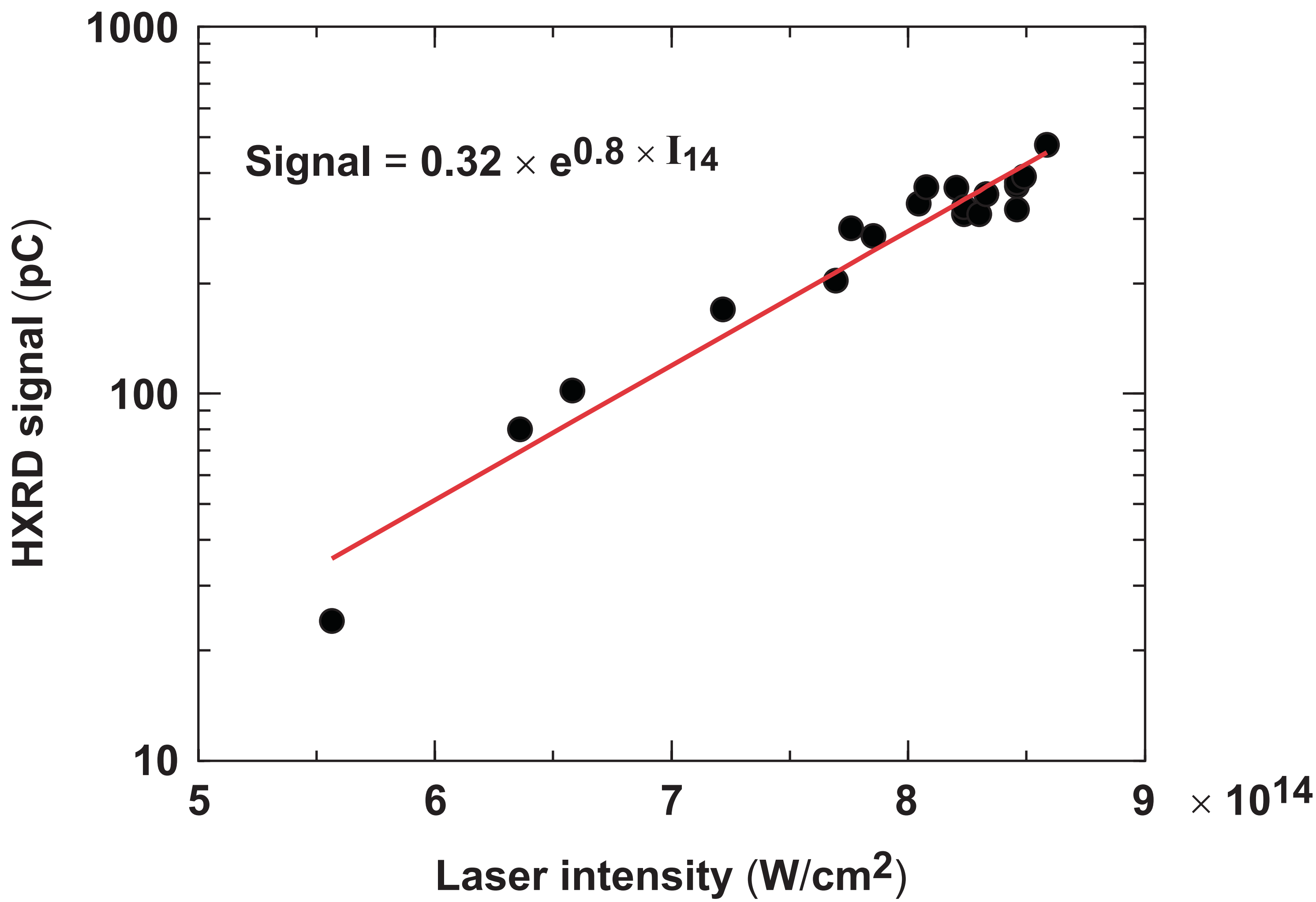


E10405

The x-ray signal rises exponentially with laser intensity

UR LLE

- 20-μm shell, 1-mm-diam, 1-ns square



E10403

Estimating the hard x-ray energy radiated from the target

- The number of photons emitted by the scintillator is obtained using the published sensitivity of the MCP-PMT in S (C/J):

$$N_{phot} = \text{charge}(C)/(S \times h\nu)$$

- The hard x-ray energy incident on the scintillator is calculated using the yield of the scintillator Y (phot/keV x ray):

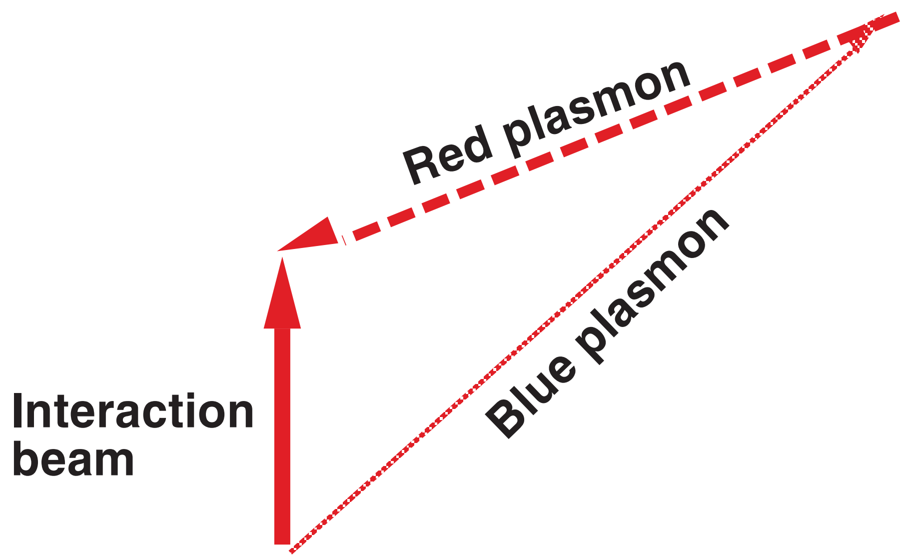
$$E_{reg} = N_{phot}/Y$$

- Assuming an exponential x-ray spectrum, the registered x-ray energy is calculated using the filter transmission F(ν):

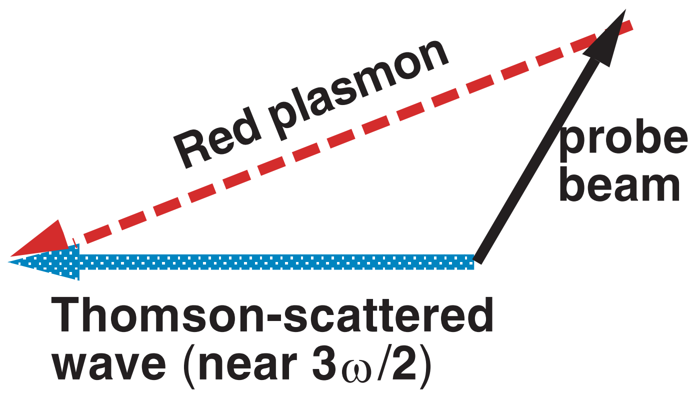
$$E_{reg} = E_0 \int_0^\infty \left[\exp(-h\nu/kT) F(\nu) d\nu\right]$$

- Combining the above expressions with the solid angle of the detector yields an estimate of radiated energy from the target.

The two-plasmon decay instability near the Landau cutoff can be probed by Thomson scattering



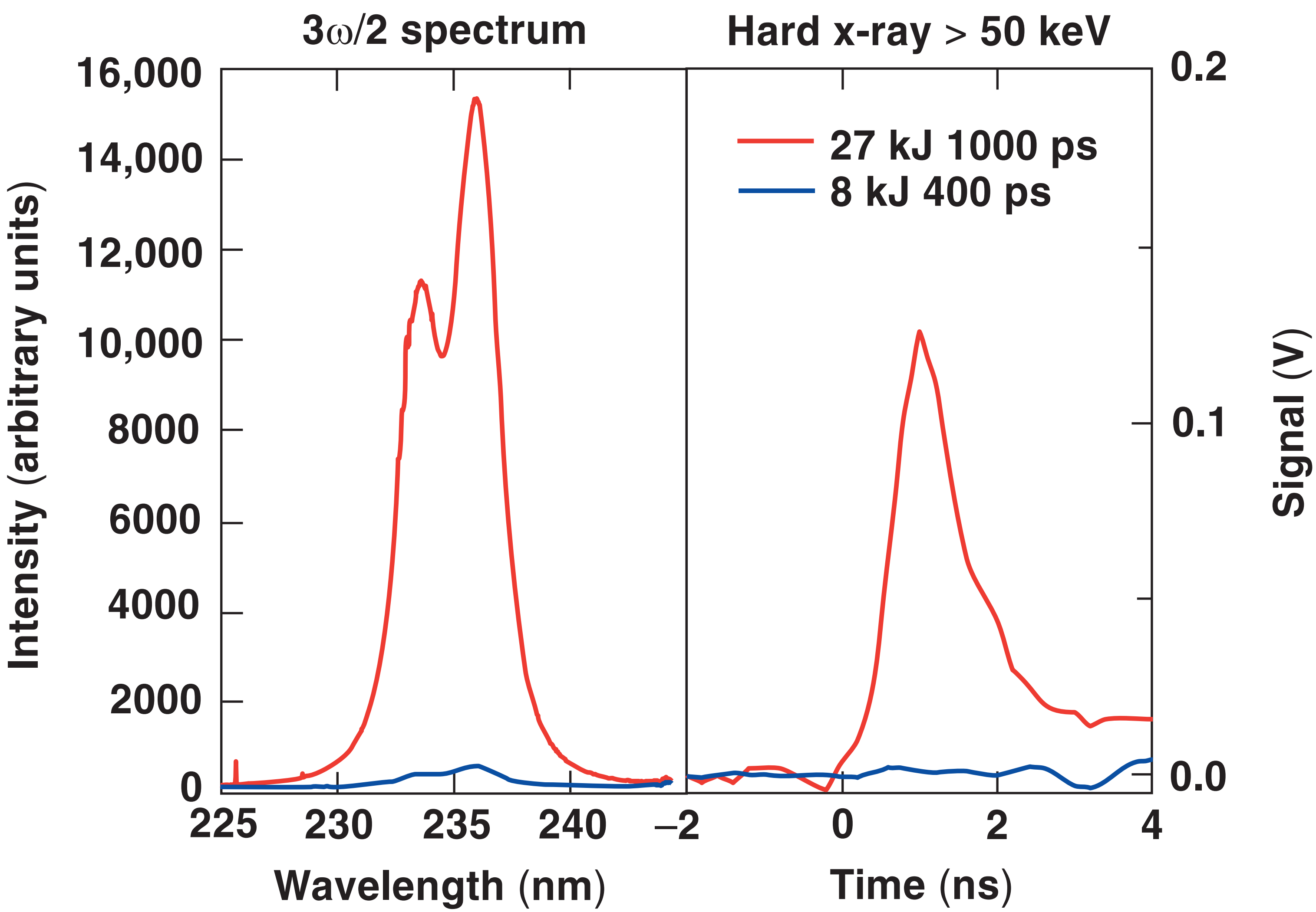
Two-plasmon decay
(primary decay process)



Thomson scattering
(secondary scattering
process)

E6414

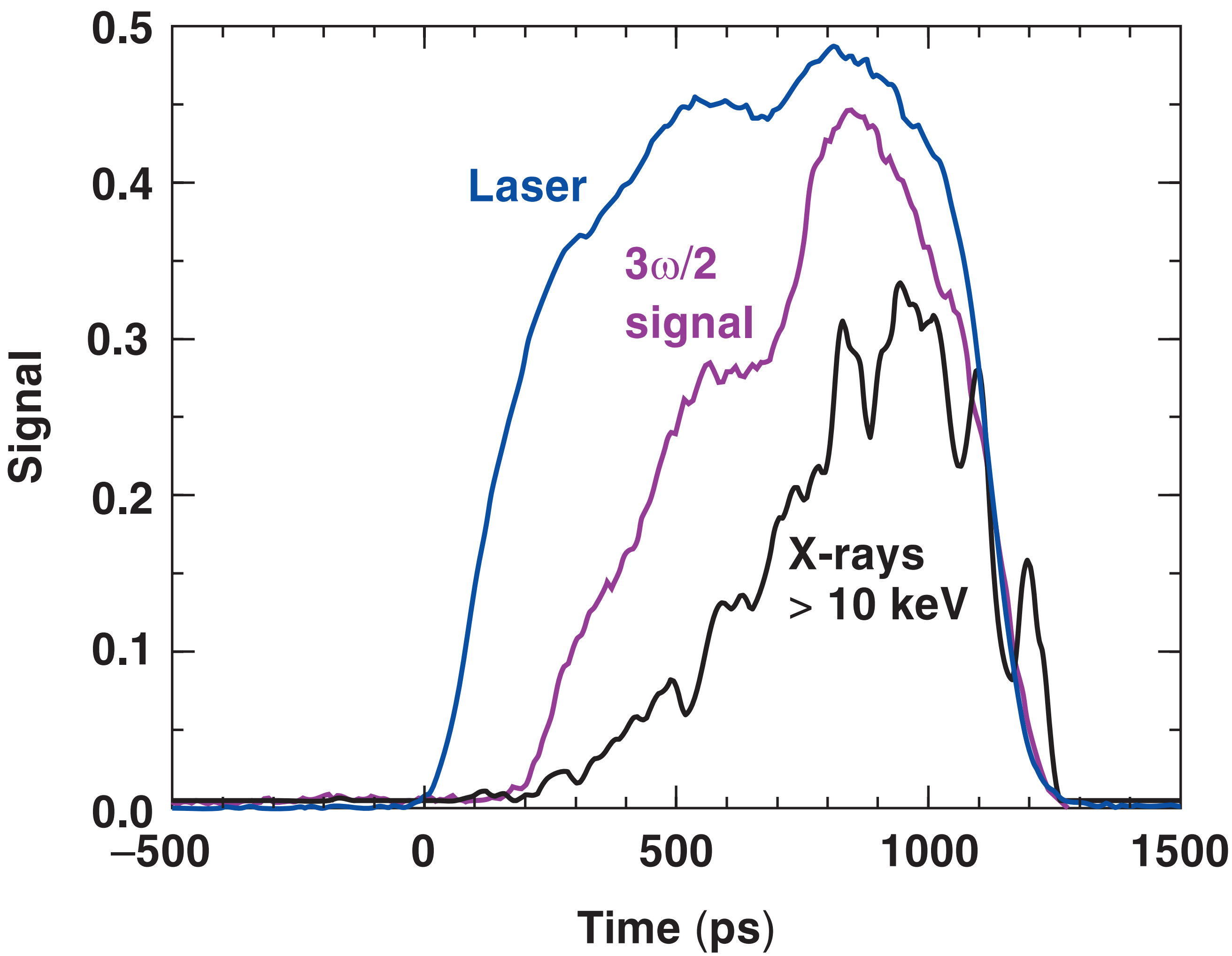
3ω/2 light correlates with hard x-ray energy



E9767

3ω/2 light correlates with hard x rays for square pulse

- 20-μm-CH-shell, 1-mm diam. , 8×10^{14} W/cm^2, 1-ns square

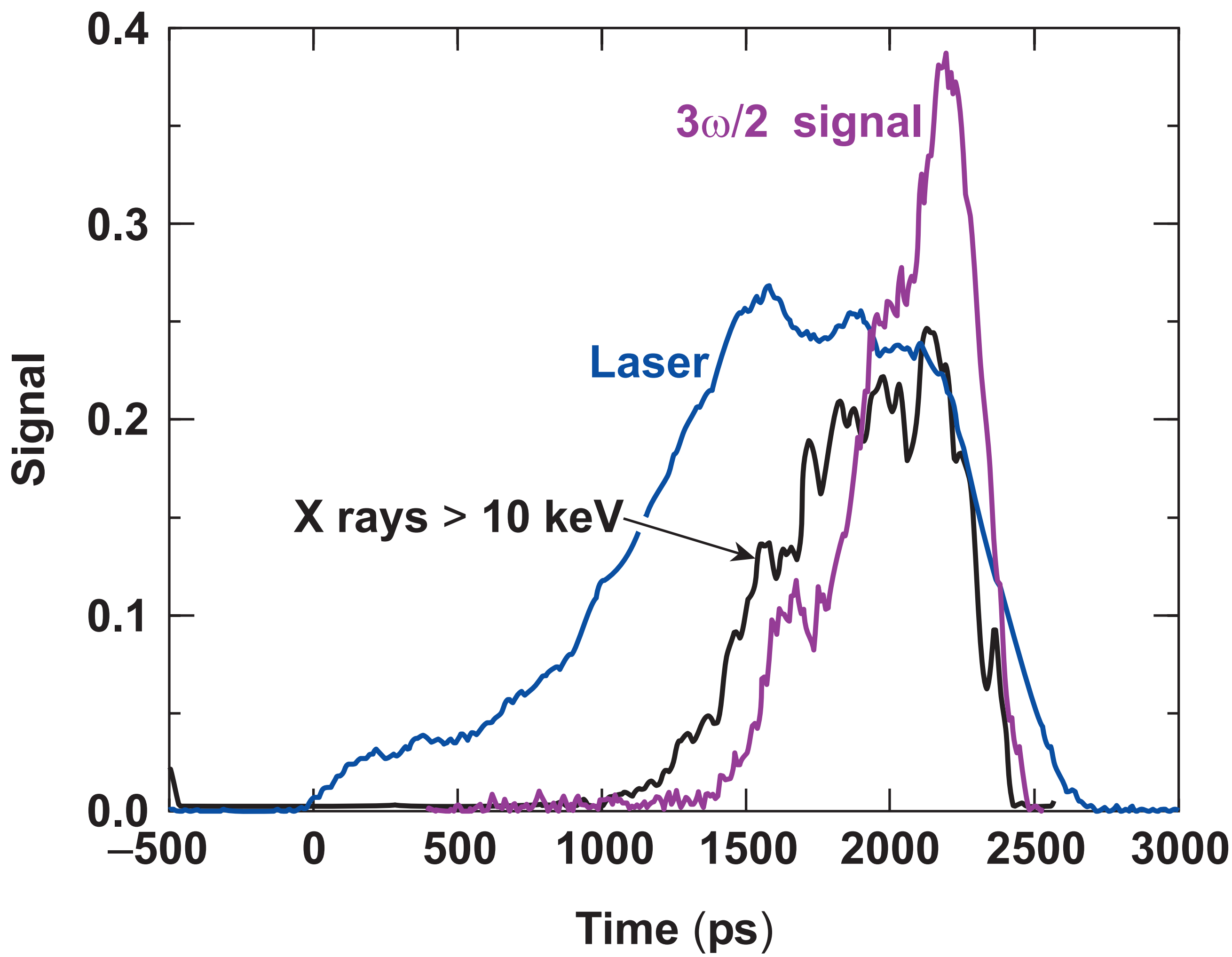


E10109

$3\omega/2$ light correlates with hard x rays for shaped pulse

UR LLE

- 20-μm-CH-shell, 1-mm diam. , 5×10^{14} W/cm^2, 2.4-ns shaped

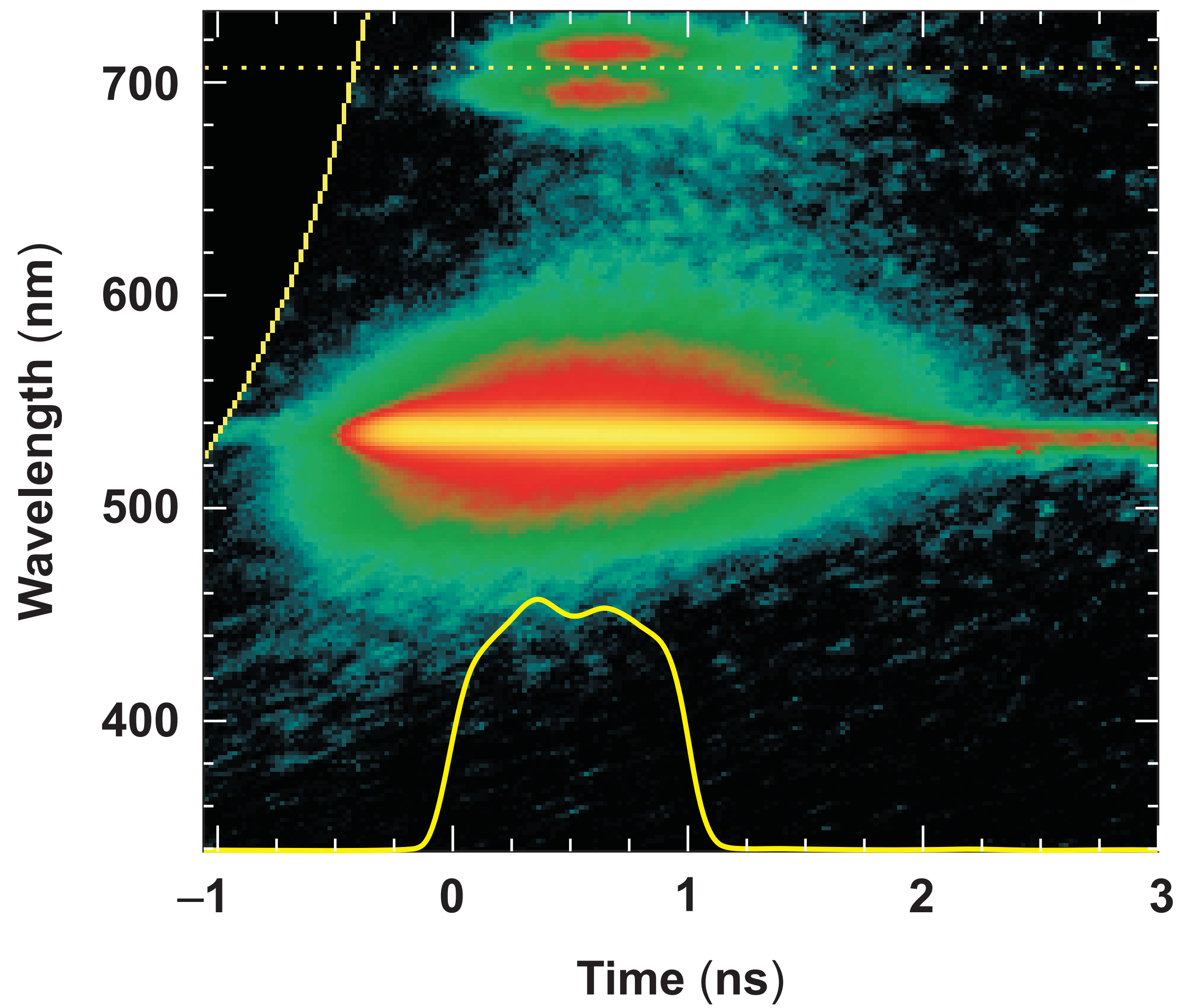


E10110

SRS spectrum shows no detectable Raman instability

UR LLE

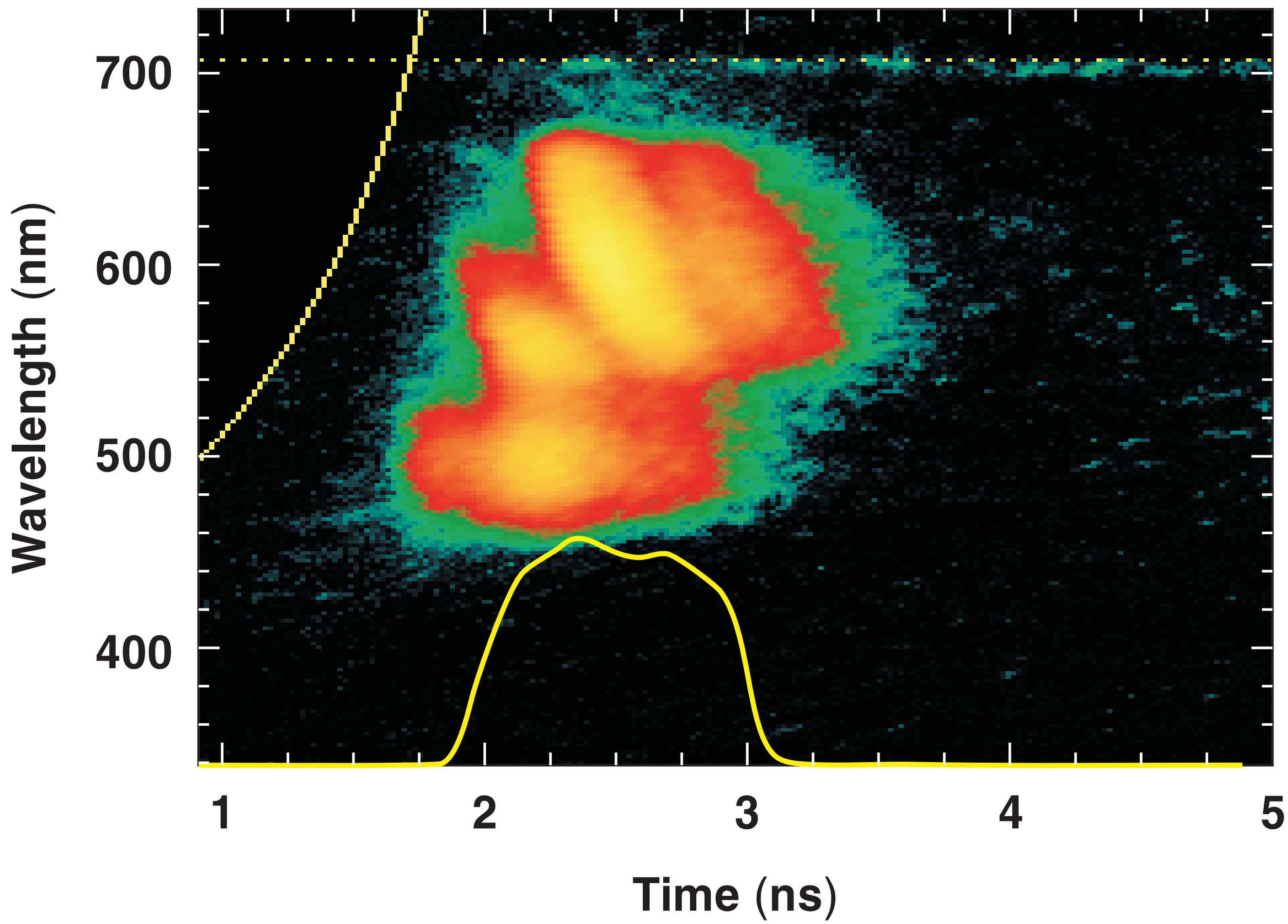
- 20-μm-CH-shell, 1-mm-diam, 8 × 10^{14} W/cm^2, 1-ns square



E10118a

Experiment in planar geometry shows evidence of SRS

SRS spectrum for shot 17318



E10119

Summary/Conclusions

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