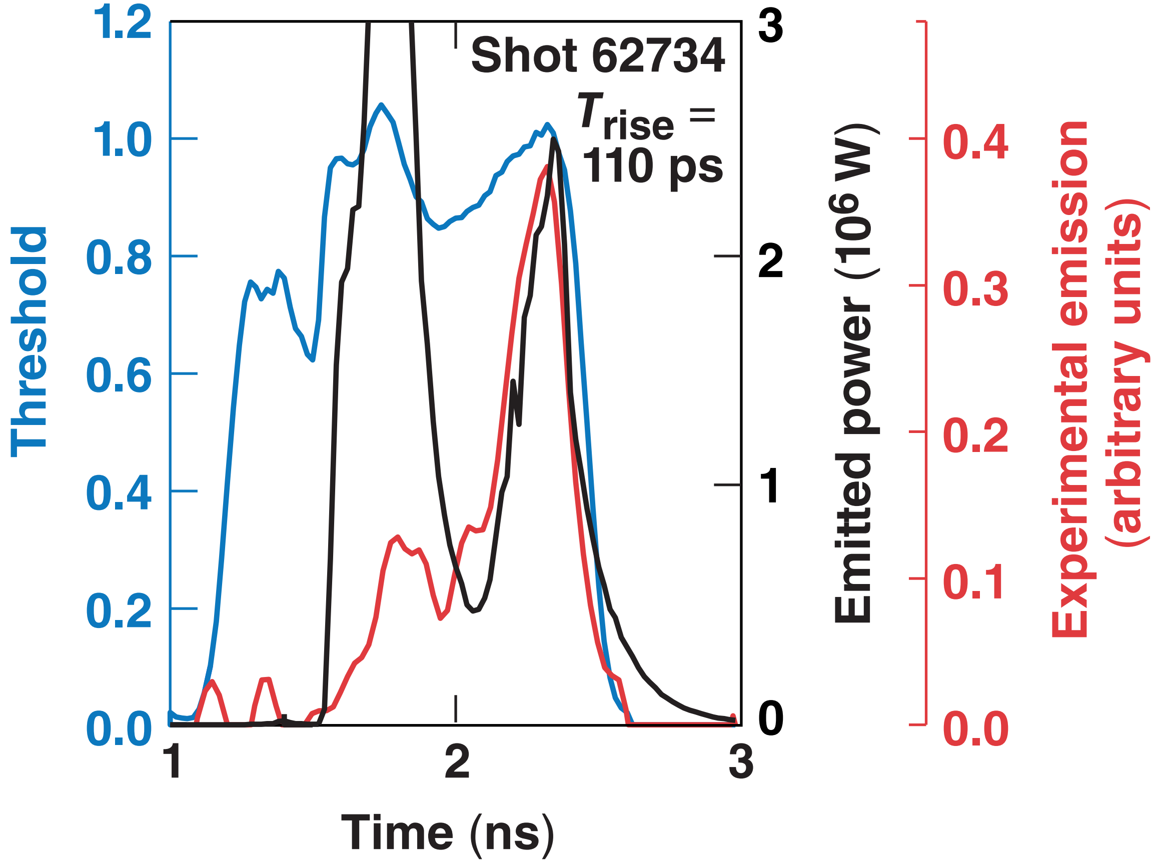
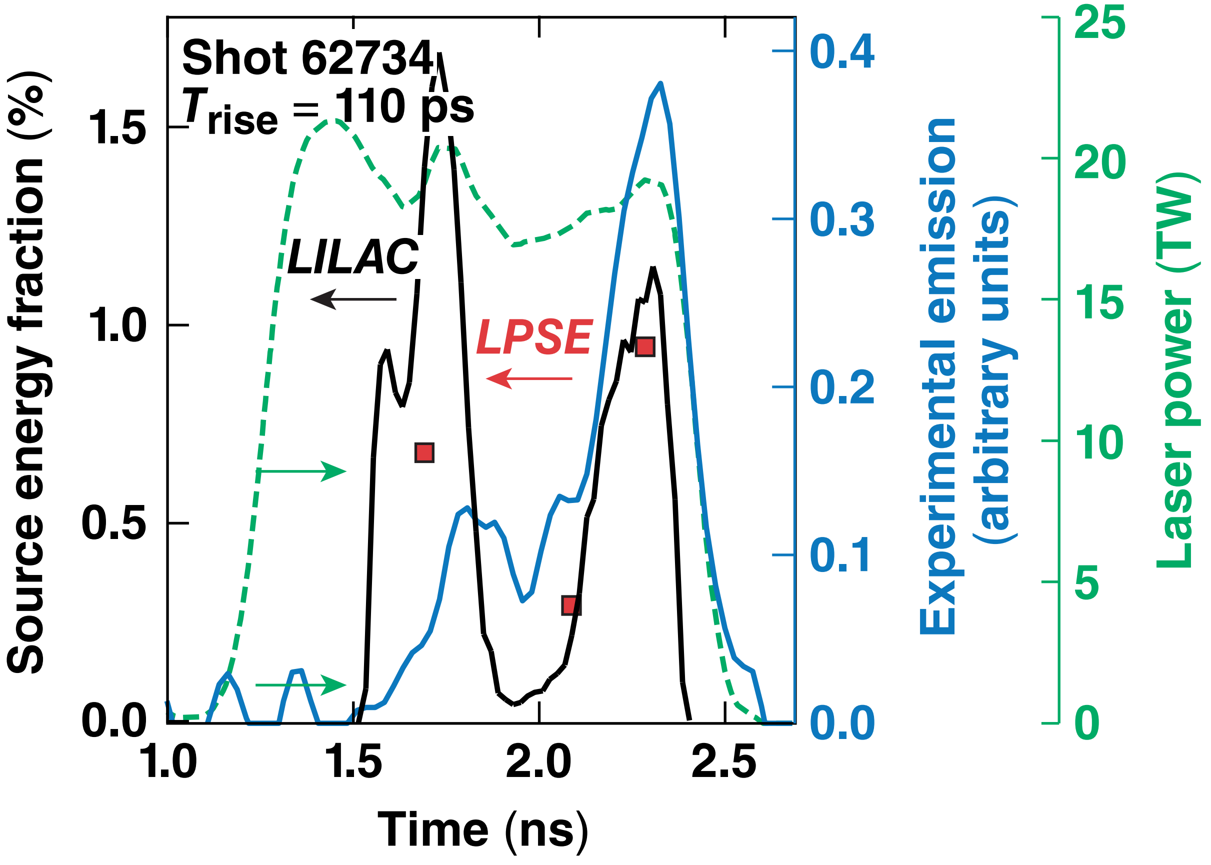
Understanding Hard X-Ray Emission in Direct-Drive Implosions





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59th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Milwaukee, WI
23–27 October 2017

Summary

The fast-electron production from two-plasmon decay (TPD) depends on the gain and on the thermal electron distribution above 10 keV

- Simulations of hard x-ray (HXR) emission from TPD electrons in the hydrocode *LILAC* and in *LPSE** show earlier emission than in experiments, which depends on the rise time of the drive pulse
- *LPSE* simulations show that low thermal-electron temperatures can reduce the fast-electron production
- Simulations with the Fokker–Planck–Vlasov code, *FPI*,** confirm that the population of ~10-keV thermal electrons fills up more slowly than the fastest drive-pulse rise times

*J. F. Myatt *et al.*, Phys. Plasmas 24, 056308 (2017).
**J. P. Matte *et al.*, Phys. Rev. Lett. 53, 1461 (1984).

Collaborators

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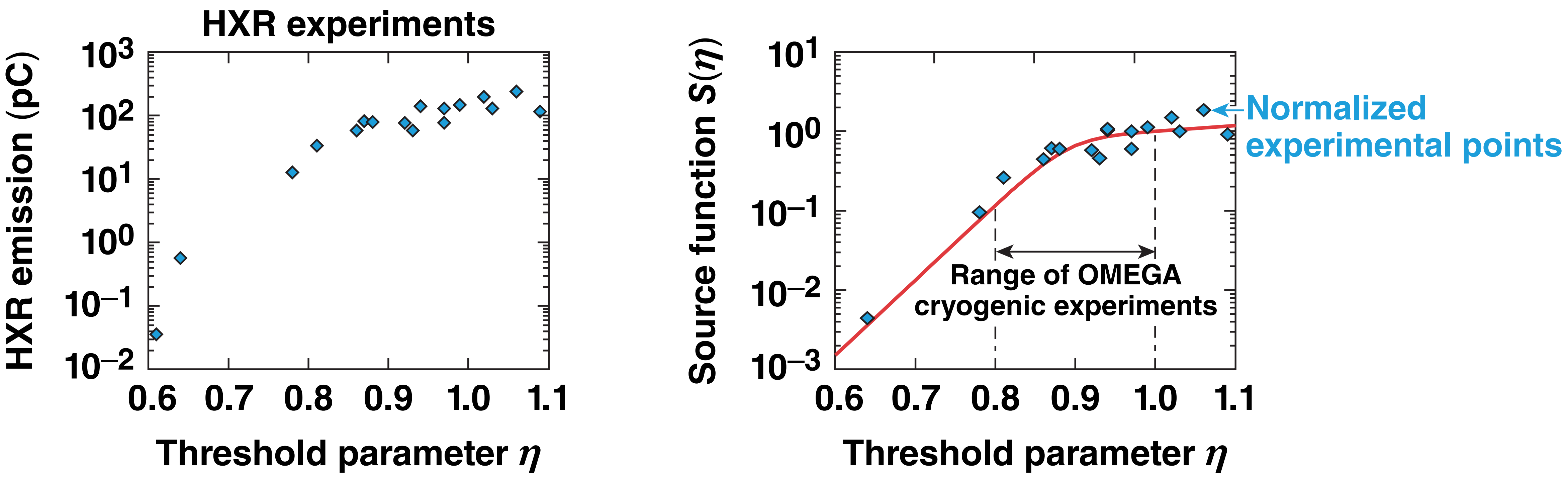
The source of fast electrons is based on the measured HXR emission from intensity-sweep experiments

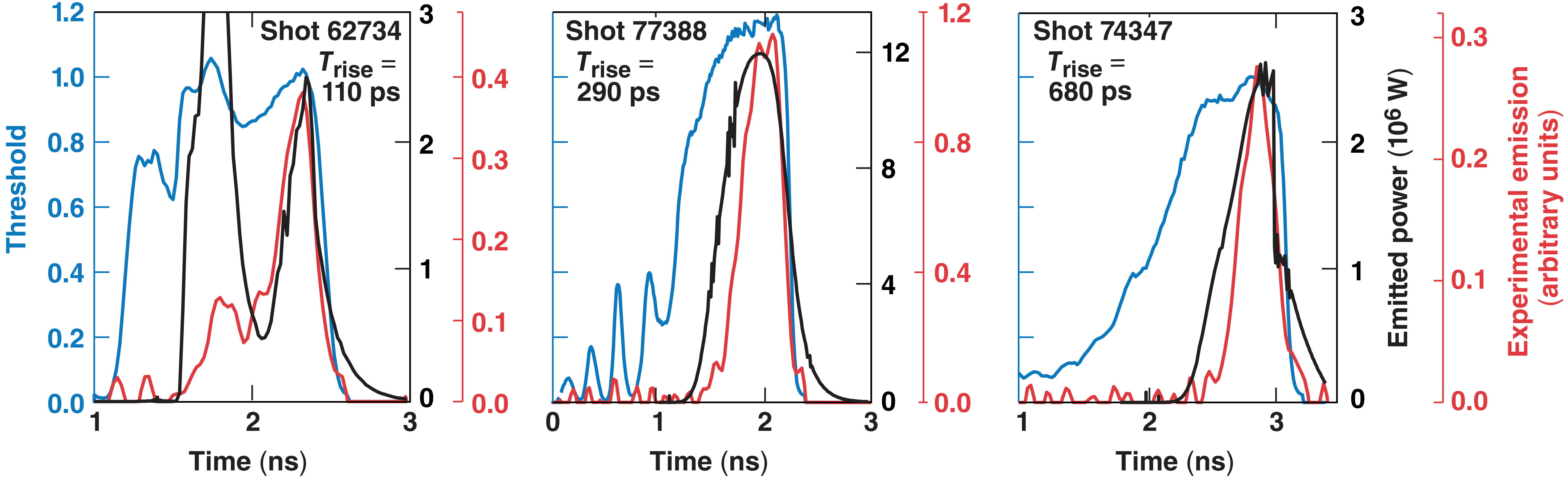


- The HXR emission depends on the threshold parameter: $\eta = I_{14}$ (at $n_c/4$)*$L(\mu m)/[233 * T$ (keV)]†
- The source function was designed to follow the same dependence as the HXR emission
- The source energy is given by $E_s = F_s * S(\eta)$, where F_s is adjusted to give the measured HXR total emission energy

TC12479b

†A. Simon *et al*., Phys. Fluids 26, 3107 (1983).

The amount of early computed HXR emission depends on the drive pulse rise time

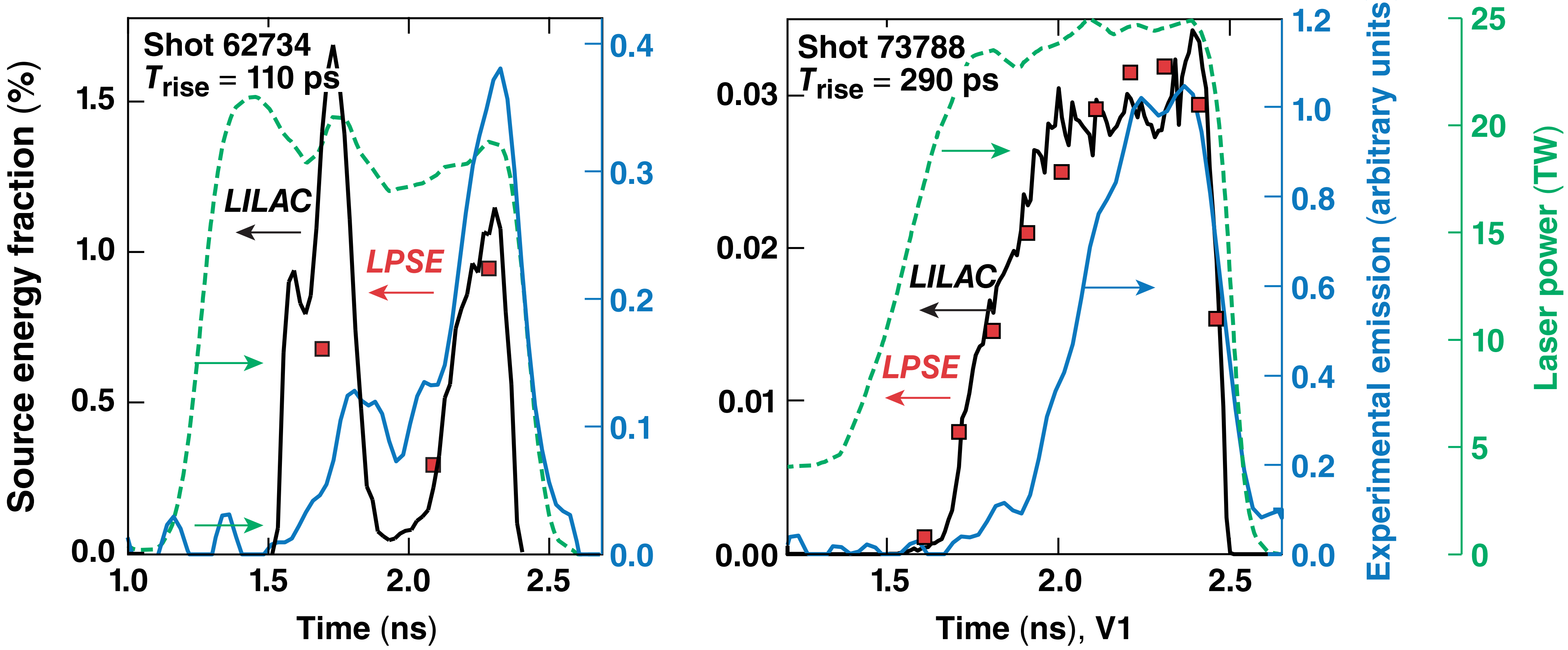


- The differences in early measured emission could come from hydrodynamic uncertainty (<20% lower threshold parameter)
- That the differences slowly vanish during the drive pulse suggests some time-dependent relaxation effect, such as the Maxwellization of high-energy electrons

TC13880

The early emission from *LILAC* is supported by *LPSE** simulations for the energy fraction into electrons >50 keV

- *LPSE* (laser-plasma simulation environment) is a 3-D laser–plasma interaction code
- The *LPSE* simulations were carried out with a Maxwellian thermal-electron distribution function



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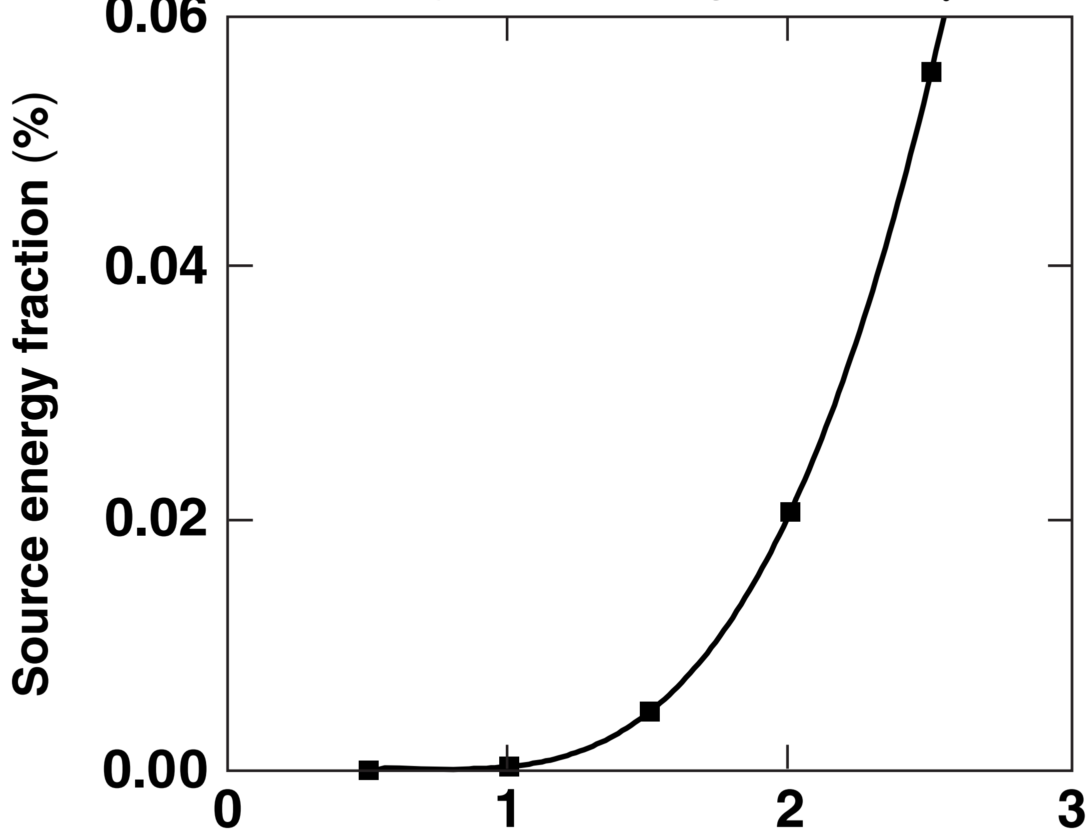
*J. F. Myatt *et al.*, Physics of Plasmas 24, 056308 (2017).

Simulations with *LPSE** imply that electrons with energy >10 keV are needed to generate TPD fast electrons

Threshold parameter = 1.81
Density scale length = 211 μm



- *LPSE* simulations were carried out with a Maxwellian distribution
- The threshold parameter
- $\eta = I_{14}$ (at $n_c/4$)*$L(\mu m)/[233 * T$ (keV)]

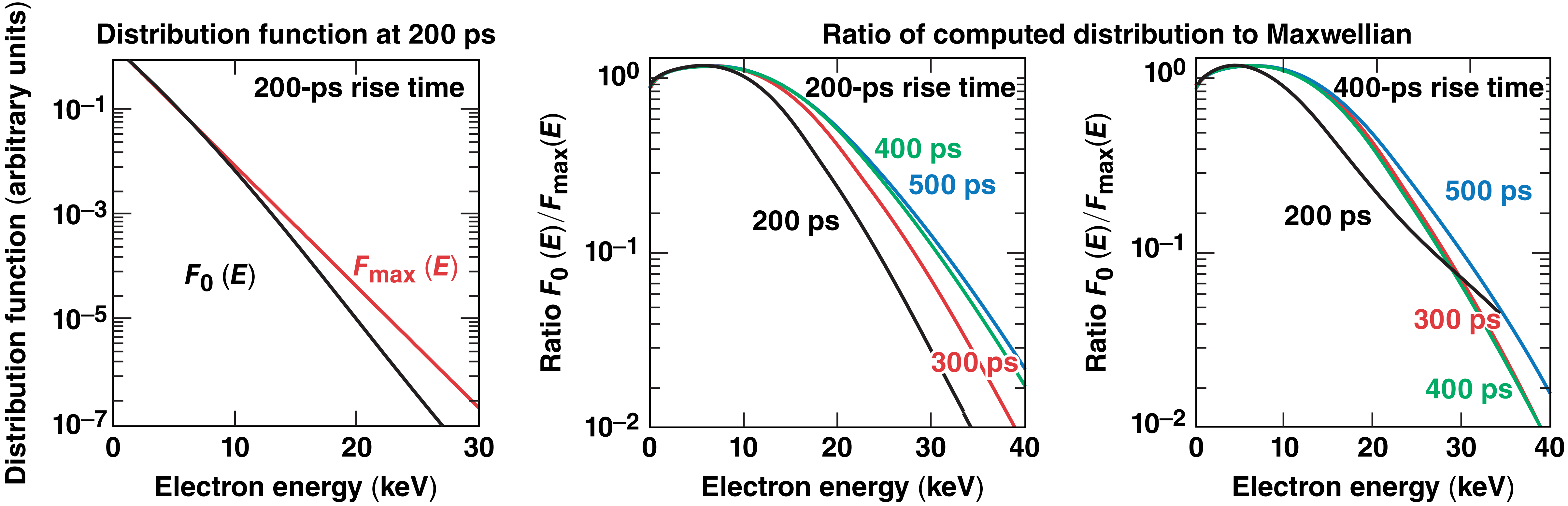
  is kept constant by varying the laser intensity from 1×10^{14} to 5×10^{14} W/cm^2

TC13882

*J. F. Myatt *et al.*, Physics of Plasmas 24, 056308 (2017).

*FPI** simulations show that, for the fast-rising pulse, the distribution function needs 400 ps to equilibrate

- *FPI* is a Fokker–Planck code that simulates laser absorption and nonlocal thermal electron transport
- The simulations used linearly rising laser pulses of 200 ps and 400 ps followed by a constant pulse at the peak intensity of 9×10^{14} W/cm^2



The decrease in the electron population >10 keV may not be the only cause for the lack of early emission in the fast-rising pulse cases.

TC13924

*J. P. Matte *et al.*, Phys. Rev. Lett. 53, 1461 (1984).

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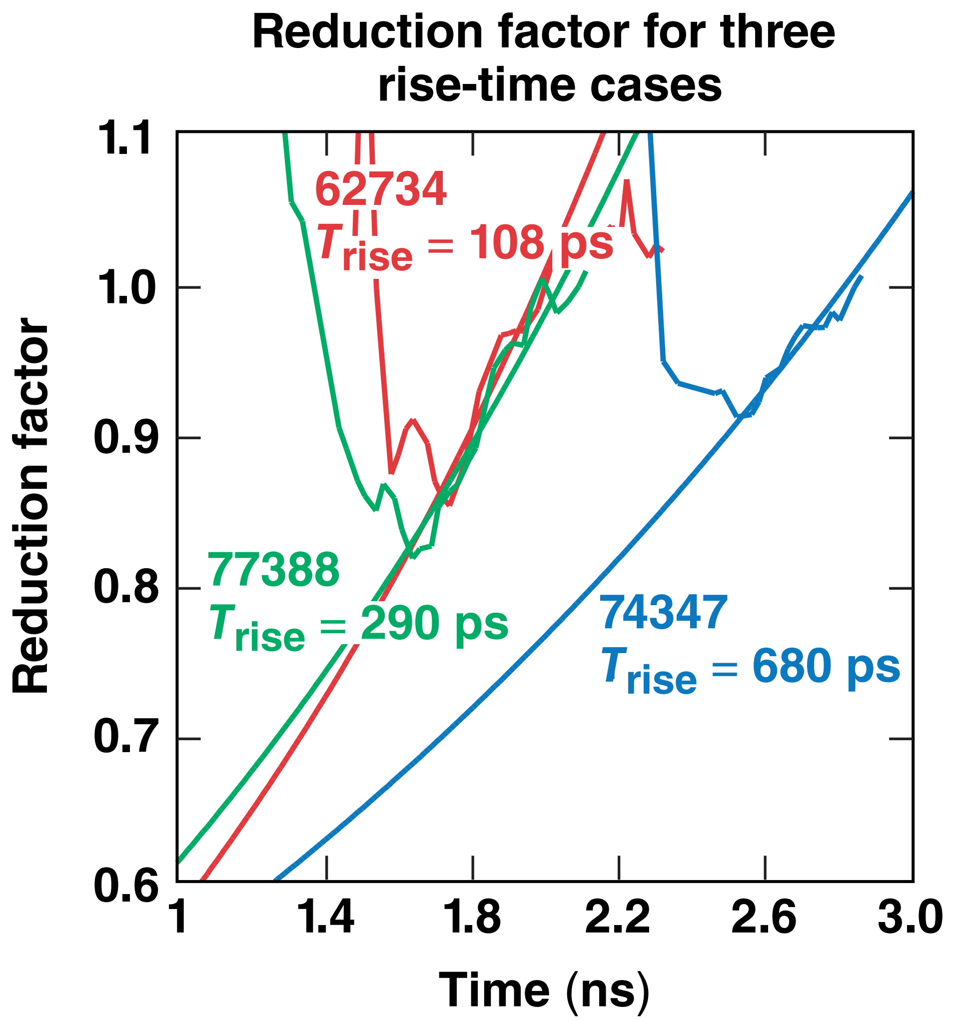
A threshold reduction factor was obtained from the ratio of the measured to the computed HXR emissions

- This factor is obtained such that the value of the computed threshold parameter gives the same HXR emission level as that measured
- The correction factor can be expressed as an exponential in time

$$R_F = \exp[t/2 \times 10^{-9} - 1.0]$$

- The exponential fit is done from the start of the HXR emission to the peak



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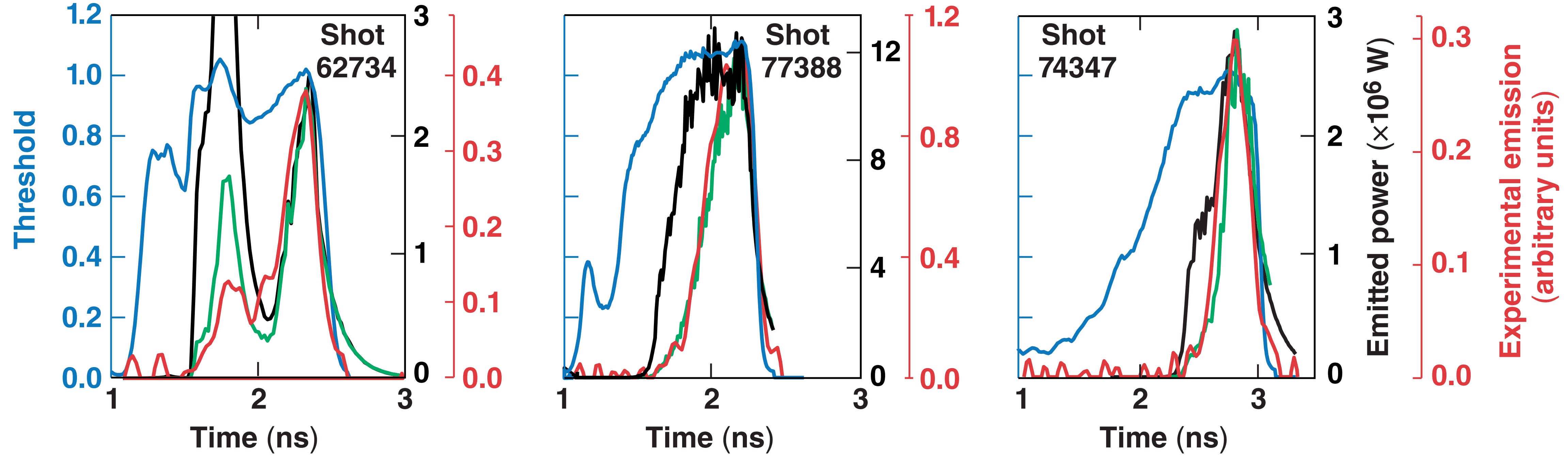
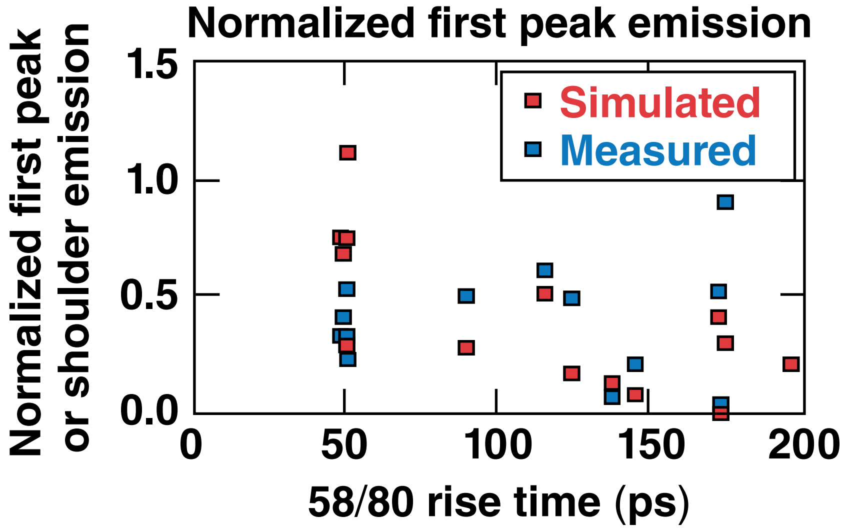
Applying the reduction factor resulted in closer agreement between simulated and measured HXR emission





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