Two-Plasmon-Decay Hot-Electron Distributions from Anisotropic Thick-Target Bremsstrahlung Measurements

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Bremsstrahlung from thick planar targets shows a dramatic anisotropy

- The direction of fast electrons must also be anisotropic.
- The electron source is assumed to be TPD.
- Directionality of TPD electrons is important for the calculation of fuel preheat*.
- The bremsstrahlung spectral distribution is well-modeled with a hot-electron temperature of $120 \pm 20$ keV.
- Bremsstrahlung angular distribution is consistent with $\Theta = 10^\circ \pm 5^\circ$, but requires the assumption of 15% backscatter.

*J. A. Delettrez, this conference
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The experiments used six OMEGA interaction beams incident on a preformed CH plasma at an intensity of \( I = 4 \times 10^{14} \text{ W/cm}^2 \)

- The target was irradiated by six symmetrically arranged interaction beams
The theoretical bremsstrahlung angular distributions are based on cross sections obtained by partial-wave calculations in a relativistic self-consistent potential†

• This is the thick-target bremsstrahlung problem.

• The bremsstrahlung distribution is then constructed with the following assumptions:
  – the electrons are assumed to propagate in a straight line and run down in energy according to the csda stopping power*
  – the electrons are exponentially distributed in energy and characterized by the temperature $T_{\text{hot}}$

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*ICRU Report #37.
Bremsstrahlung angular distributions depend upon the initial hot-electron temperature and the photon energy that is observed.

- The electron is assumed to travel in a straight line, and angles are relative to the momentum $p_0$.

Intensity/keV sr (arbitrary units)

[Diagram showing angular distributions with $T_{hot} = 140$ keV and $T_{hot} = 70$ keV, along with photons above 20 keV.]
The hardest photons are peaked into lobes, with little emission directly forward.

- The angular divergence of the hot electrons has not been taken into account.

Intensity/keV sr (arbitrary units)
The effect of angular divergence of the hot electrons on the bremsstrahlung emission is estimated in a simple way

- The electron momenta are assumed to be uniformly distributed into “beamlets” within a cone half angle $\Theta$.

- The bremsstrahlung angular spectrum, differential in photon energy, is summed over each beamlet.

- In reality, one can imagine a more complicated angular dependence.
The model directly computes the signal expected in each channel of the HXRD, i.e., the HXRD response functions\(^1\) are taken directly into account.

An isotropic angular electron distribution, in the forward half-space, is not able to reproduce the bremsstrahlung distribution for small angles $0^\circ < \theta < 60^\circ$.

- The “bump” at $\theta = 40^\circ$ is not reproduced.
- Agreement doesn’t look too bad for large angles.
- Here $T_{\text{hot}} = 120$ keV.

![Graph showing HXRD signal vs. Observation angle](image-url)
The failure to reproduce the bremsstrahlung distribution for small angles $0^\circ < \theta < 60^\circ$ is more apparent in a polar plot.

![Diagram of HXRD signal (arbitrary units)]
Reasonable agreement with the observed bremsstrahlung angular distribution is achieved with a narrow beam of hot electrons, $\Theta = 10^\circ \pm 5^\circ$

- Here, a 15% backscatter has been assumed
Reasonable agreement with the observed bremsstrahlung angular distribution is achieved with a narrow beam of hot electrons, $\Theta = 10^\circ \pm 5^\circ$ (polar plot)
Multiple scattering needs to be taken into account when predicting the signal in channel #2; this will require Monte Carlo modeling.
Measurements of bremsstrahlung from thick planar targets show a dramatic anisotropy in emission

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