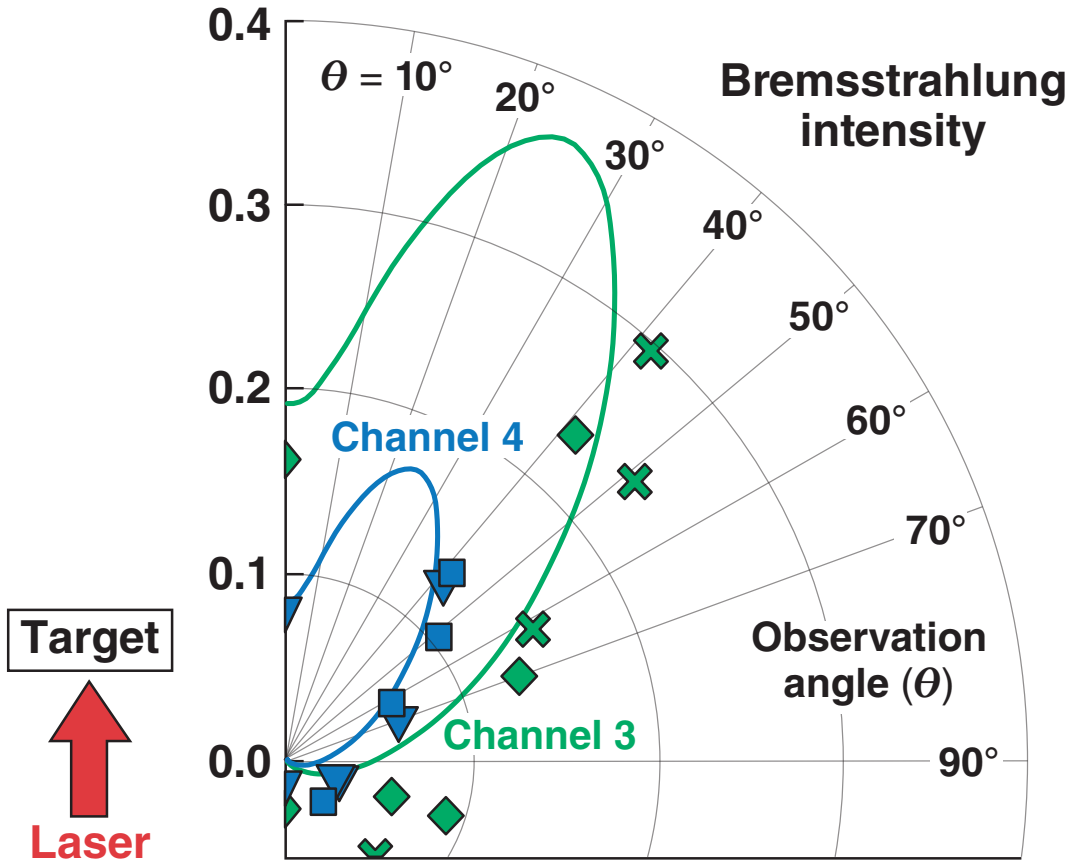
Two-Plasmon-Decay Hot-Electron Distributions from Anisotropic Thick-Target Bremsstrahlung Measurements



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Summary

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±20 keV.
- Bremsstrahlung angular distribution is consistent with $\Theta = 10° \pm 5°$, but requires the assumption of 15% backscatter.

TC8104

*J. A. Delettrez, this conference

Collaborators

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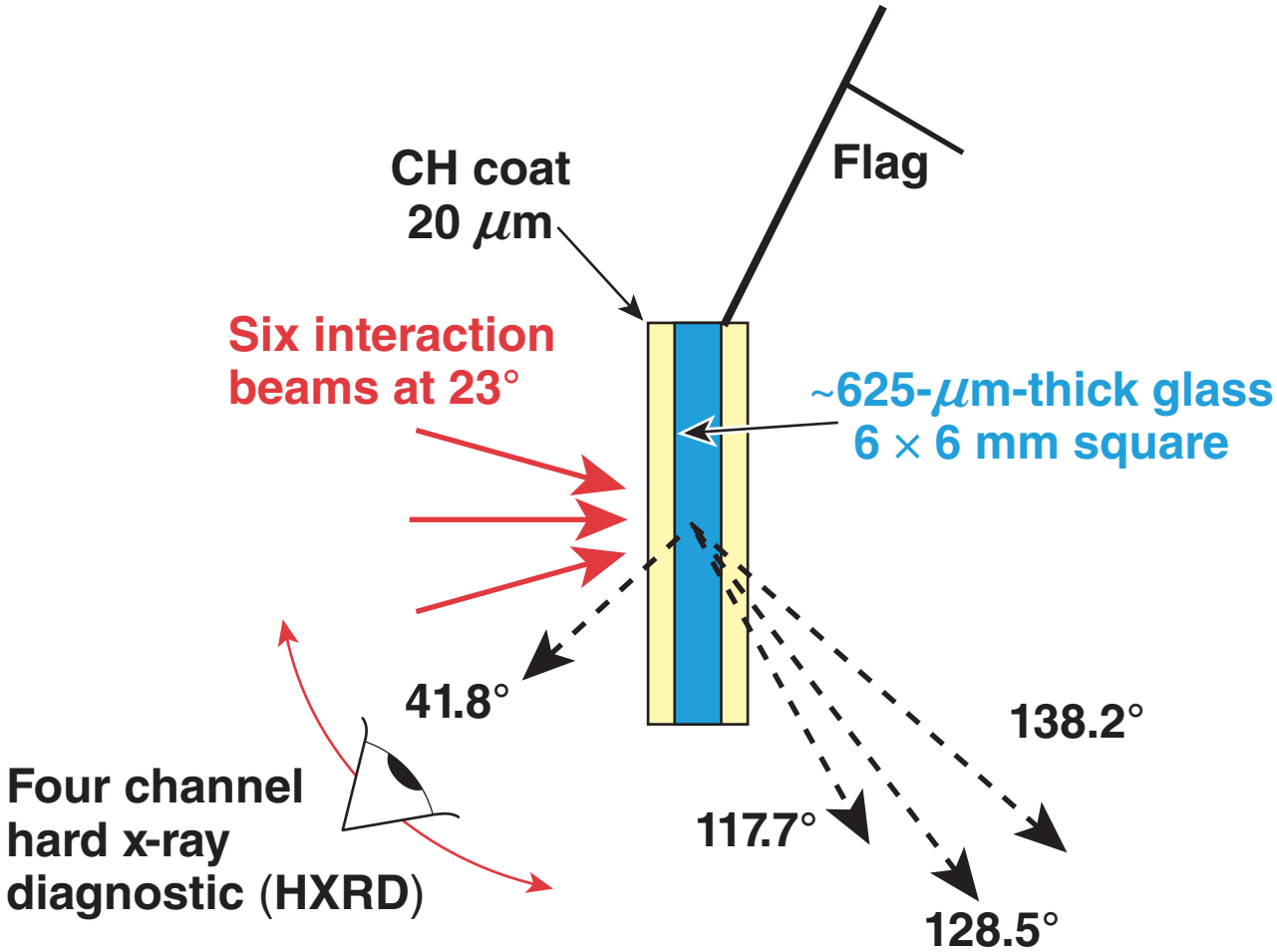
The experiments used six OMEGA interaction beams incident on a preformed CH plasma at an intensity of $I = 4 \times 10^{14}$ W/cm^2

- The target was irradiated by six symmetrically arranged interaction beams



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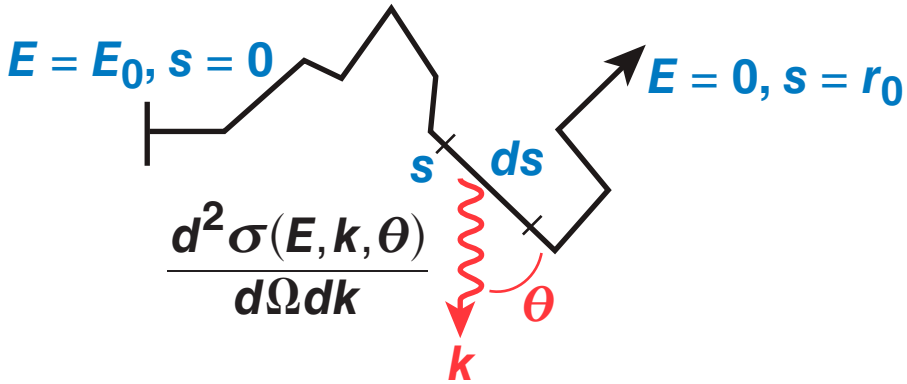
The theoretical bremsstrahlung angular distributions are based on cross sections obtained by partial-wave calculations in a relativistic self-consistent potential†

- 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_{hot}



†H. K. Tseng, R. H. Pratt, and C. M. Lee, Phys. Rev. A 19, 187 (1979).
*ICRU Report #37.

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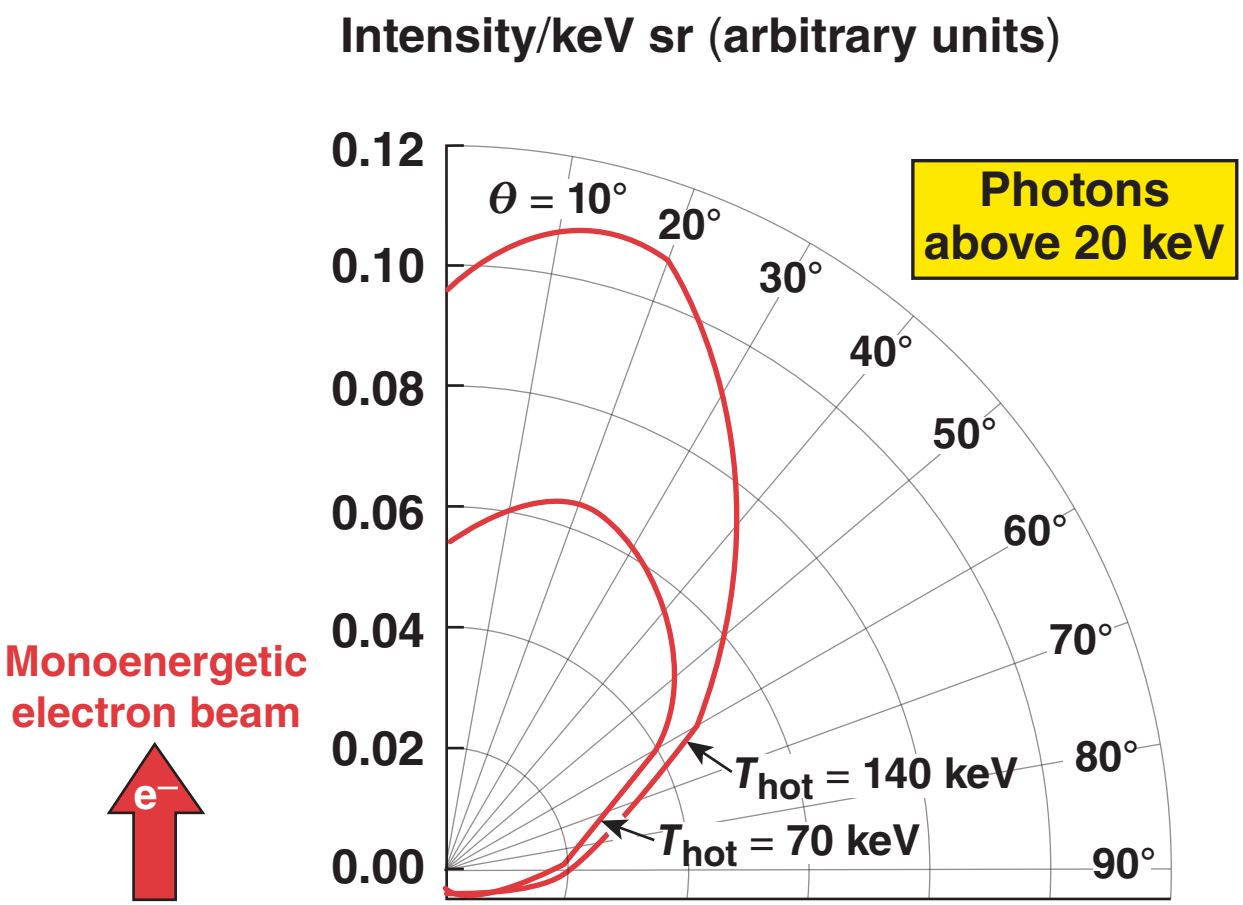
Bremsstrahlung angular distributions depend upon the initial hot-electron temperature and the photon energy that is observed

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



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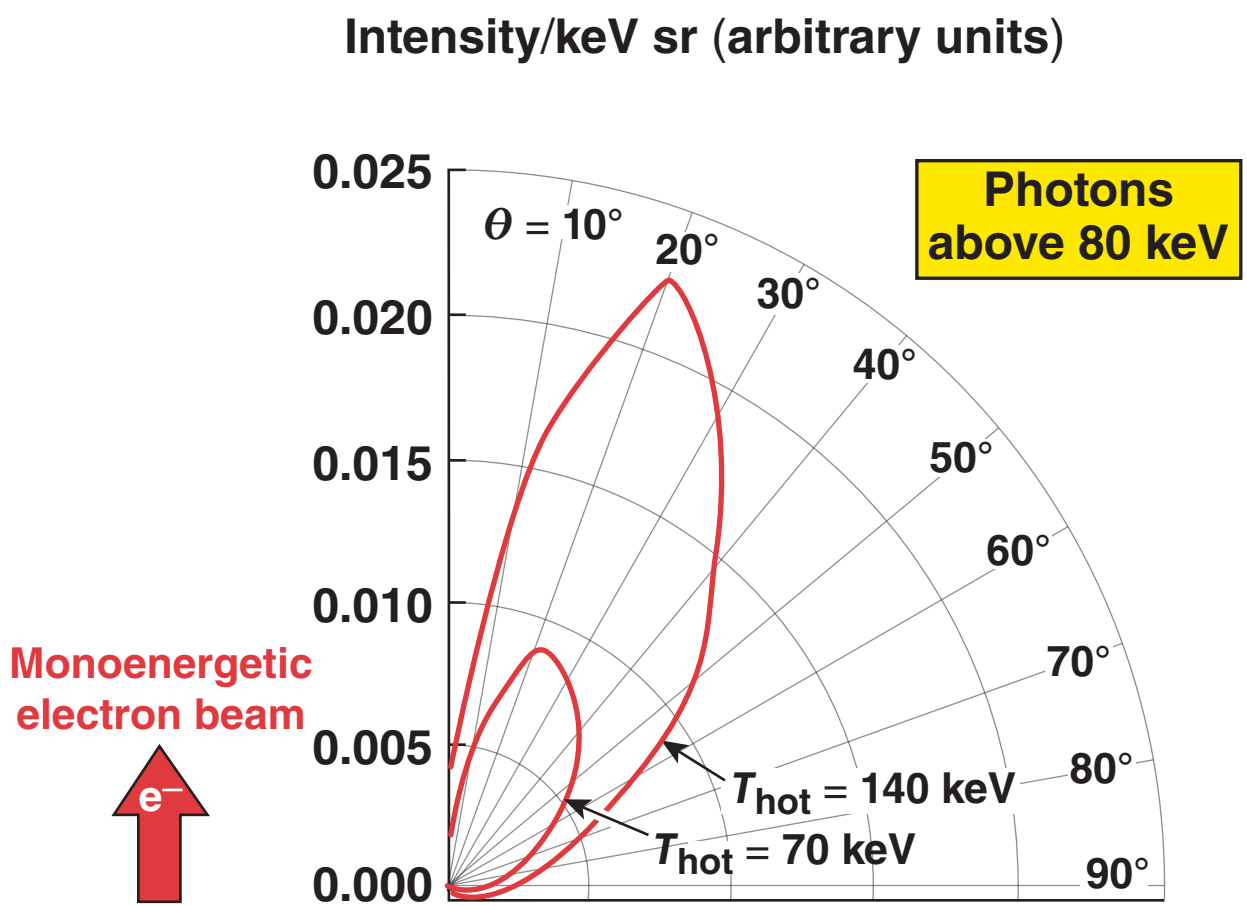
The hardest photons are peaked into lobes, with little emission directly forward

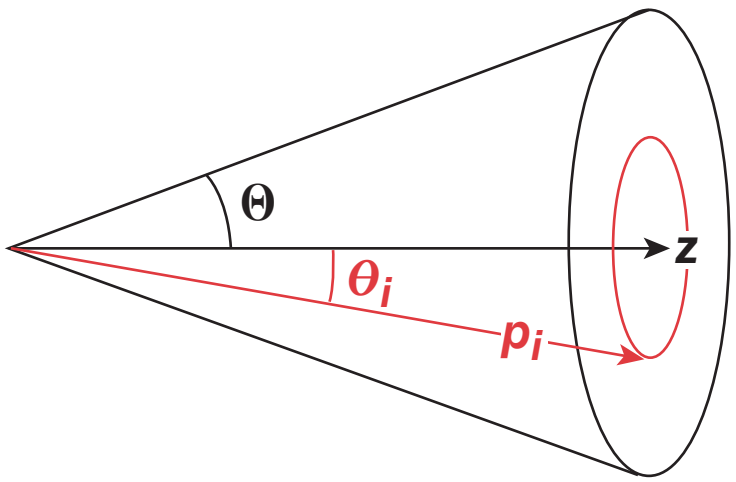
- The angular divergence of the hot electrons has not been taken into account



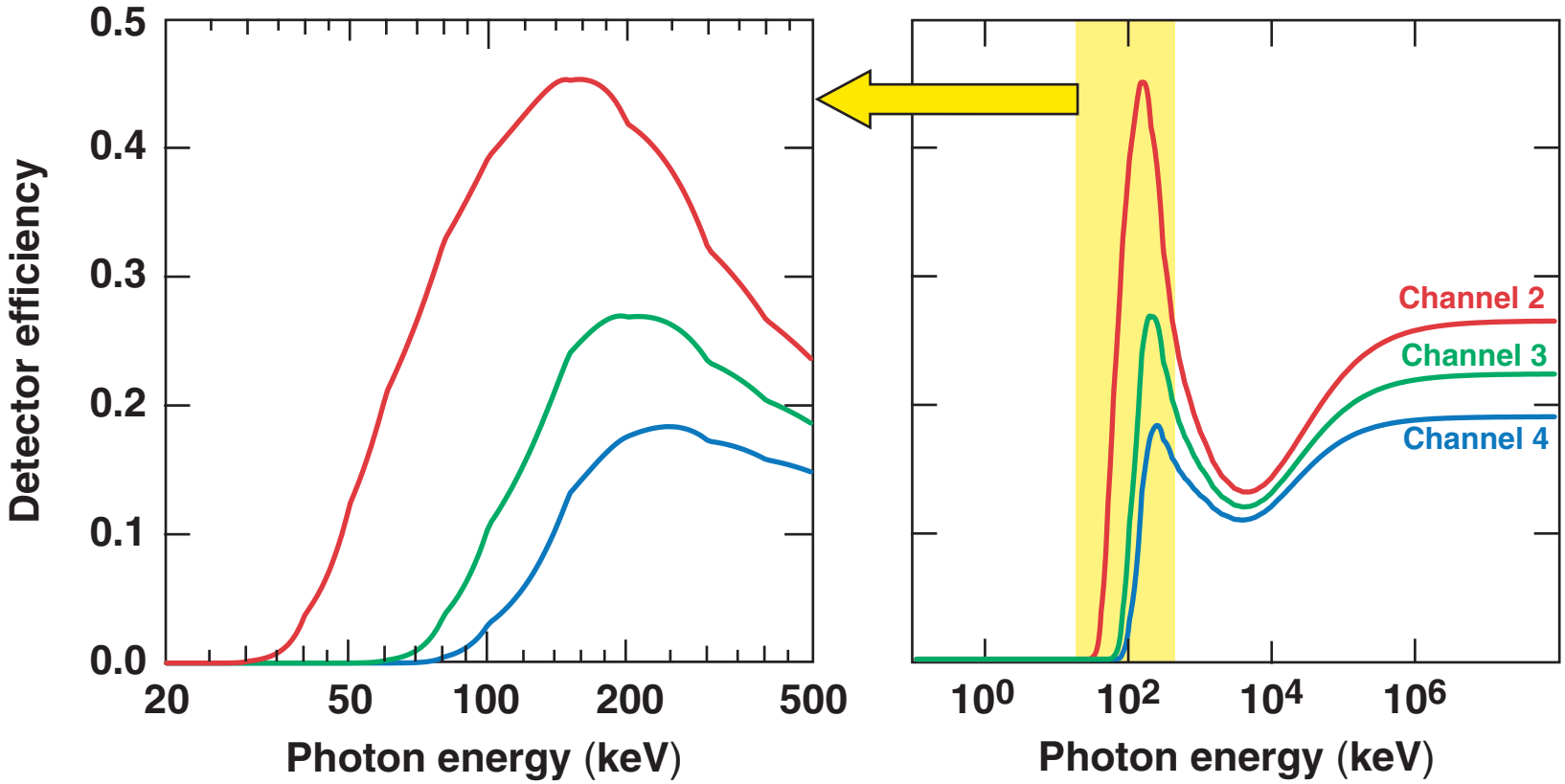
TC8108

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 Θ.
- 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

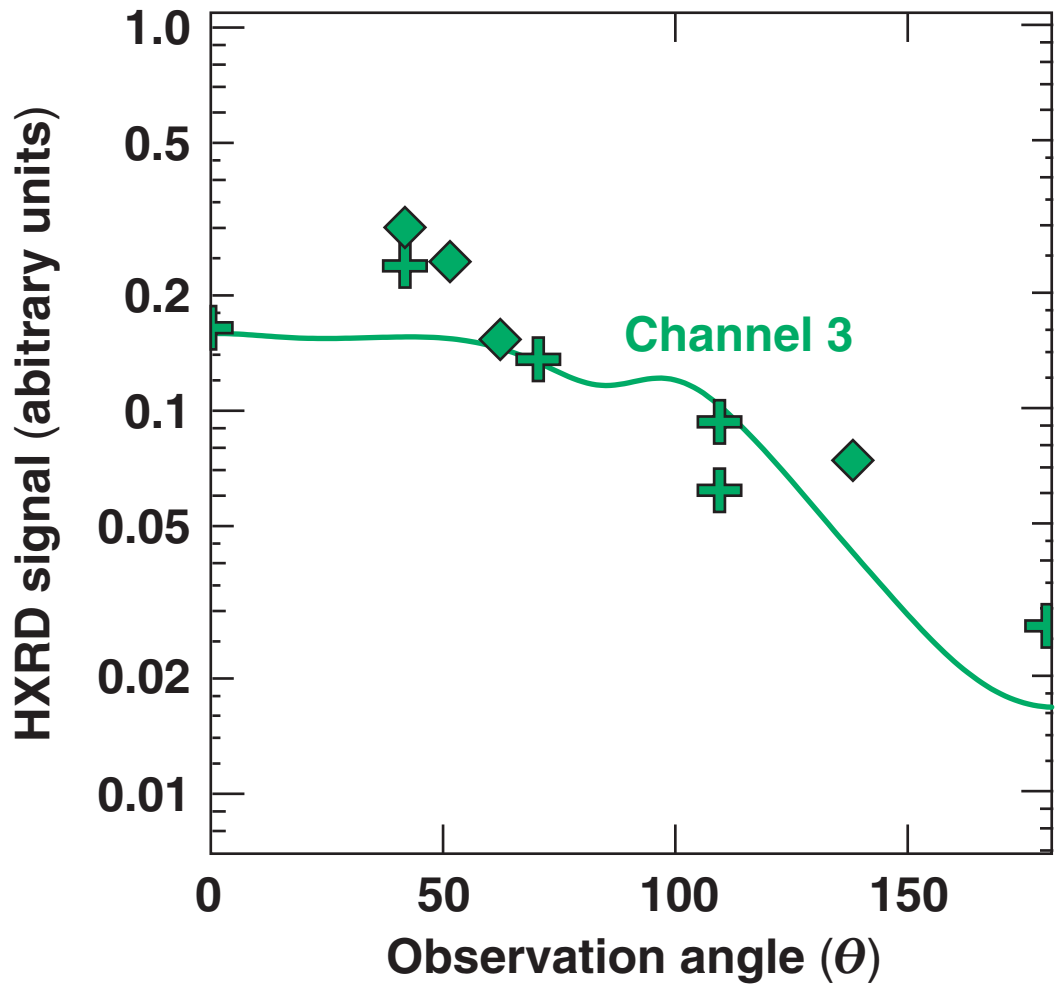


TC8110

[1]C. Stoeckl *et al.*, Rev. Sci. Instrum. 72, 1197 (2001).

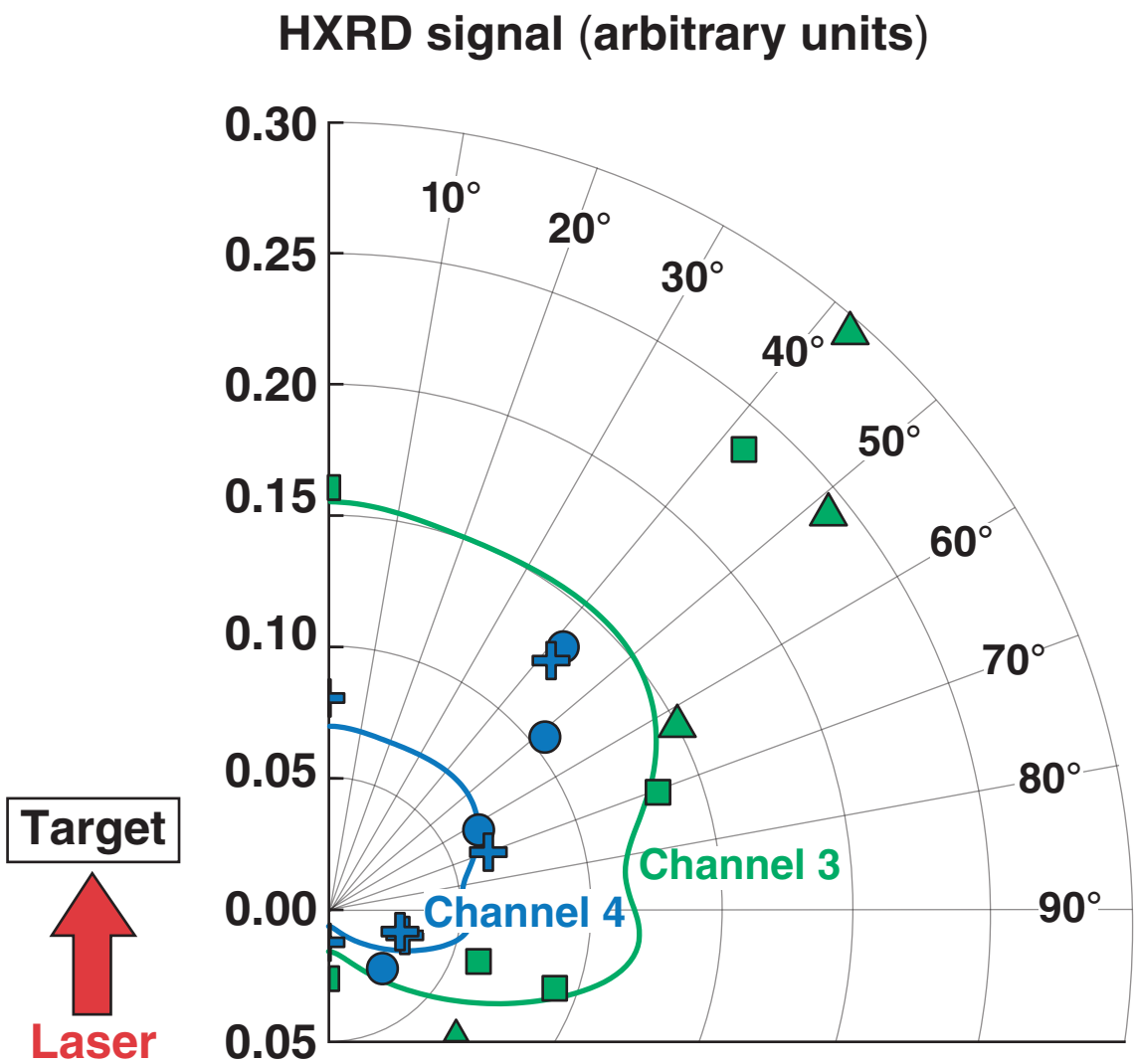
An isotropic angular electron distribution, in the forward half-space, is not able to reproduce the bremsstrahlung distribution for small angles $0° < \theta < 60°$

- The "bump" at $\theta = 40°$ is not reproduced
- Agreement doesn't look too bad for large angles
- Here $T_{hot} = 120$ keV



TC8111

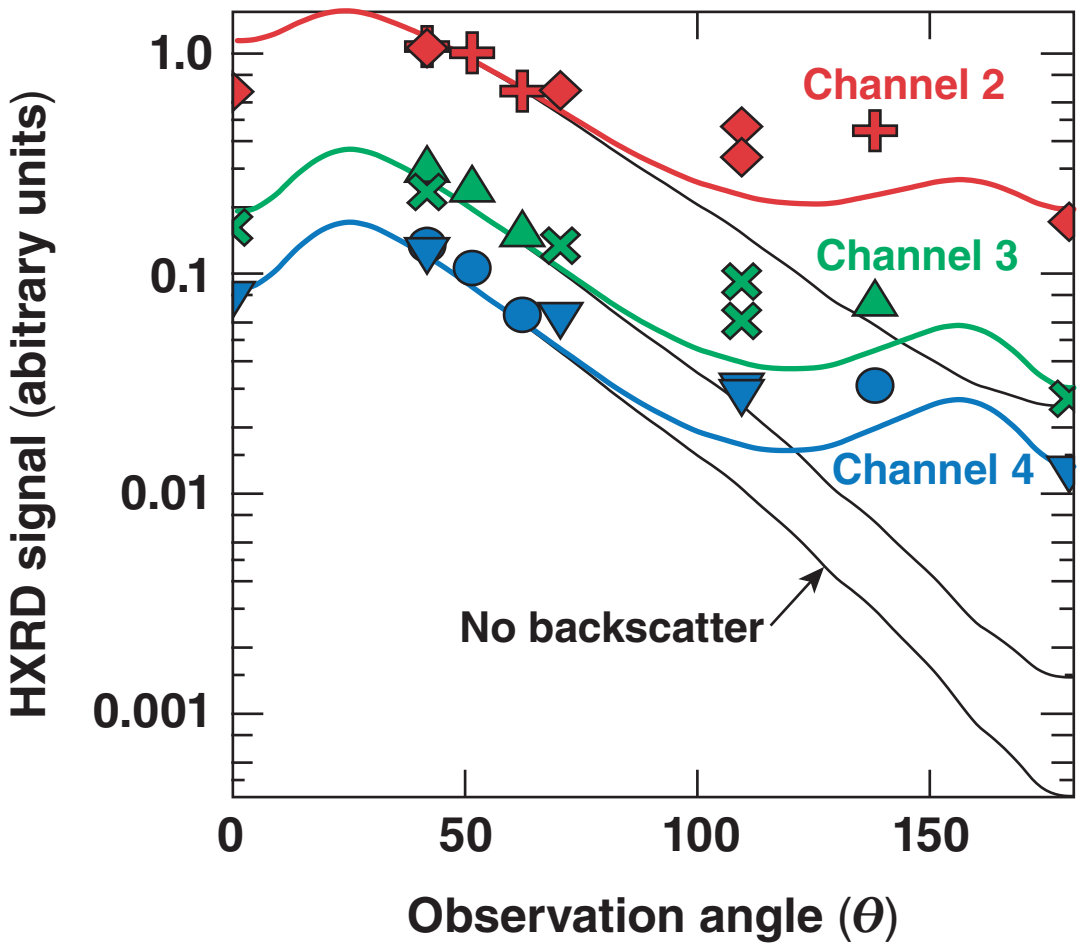
The failure to reproduce the bremsstrahlung distribution for small angles $0° < \theta < 60°$ is more apparent in a polar plot



TC8112

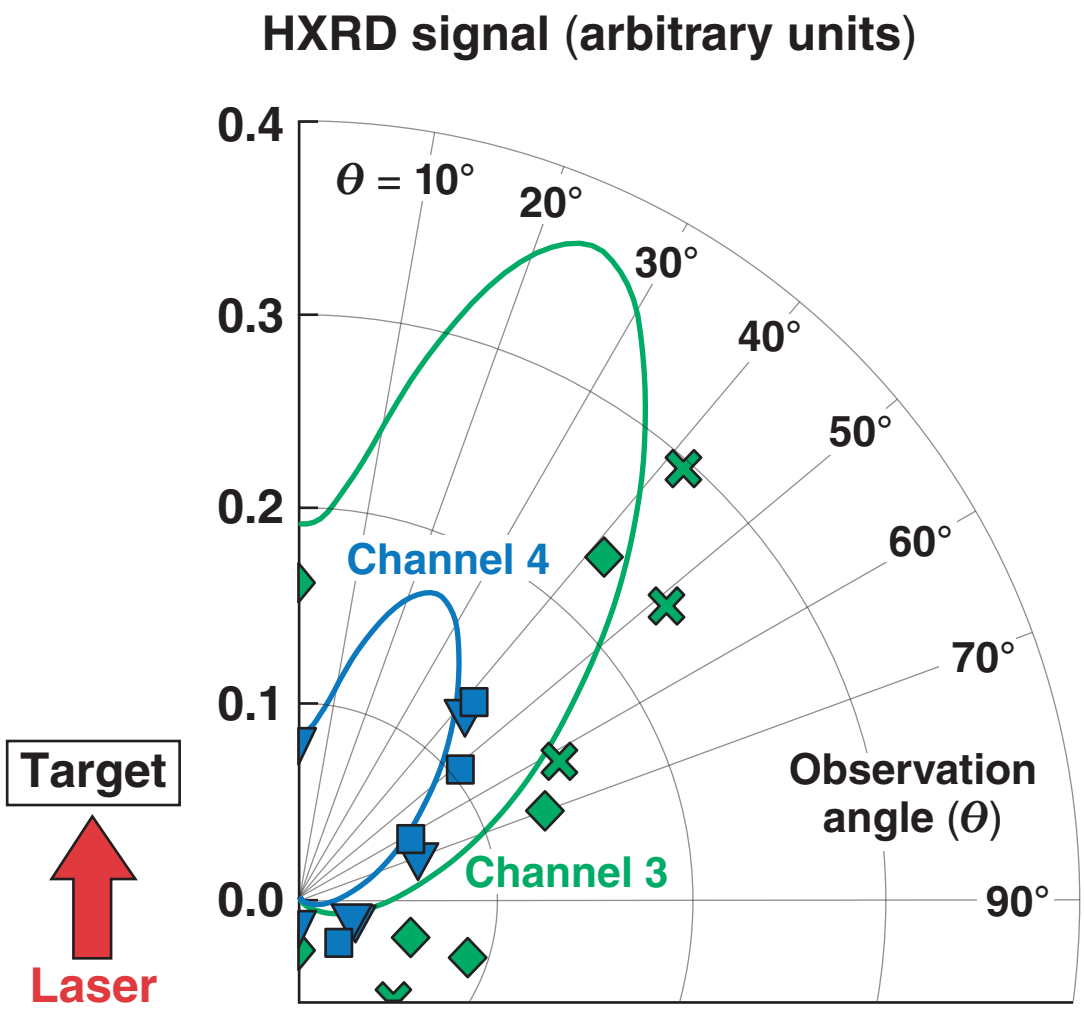
Reasonable agreement with the observed bremsstrahlung angular distribution is achieved with a narrow beam of hot electrons, $\Theta = 10° \pm 5°$

- Here, a 15% backscatter has been assumed



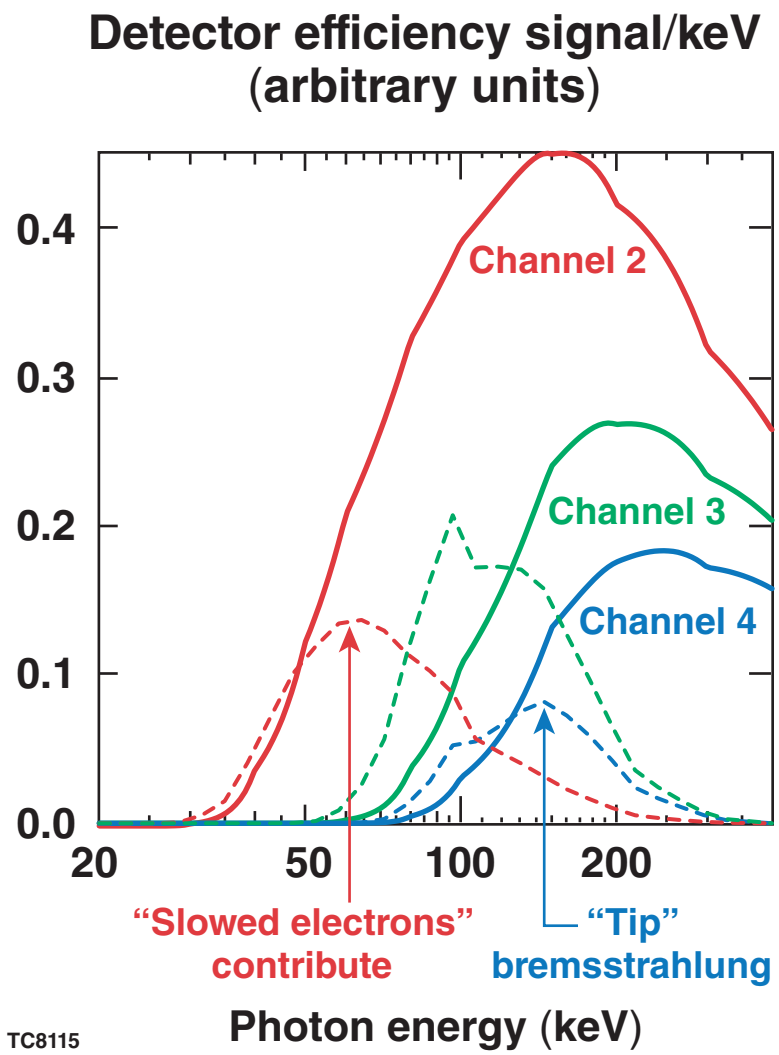
TC8113

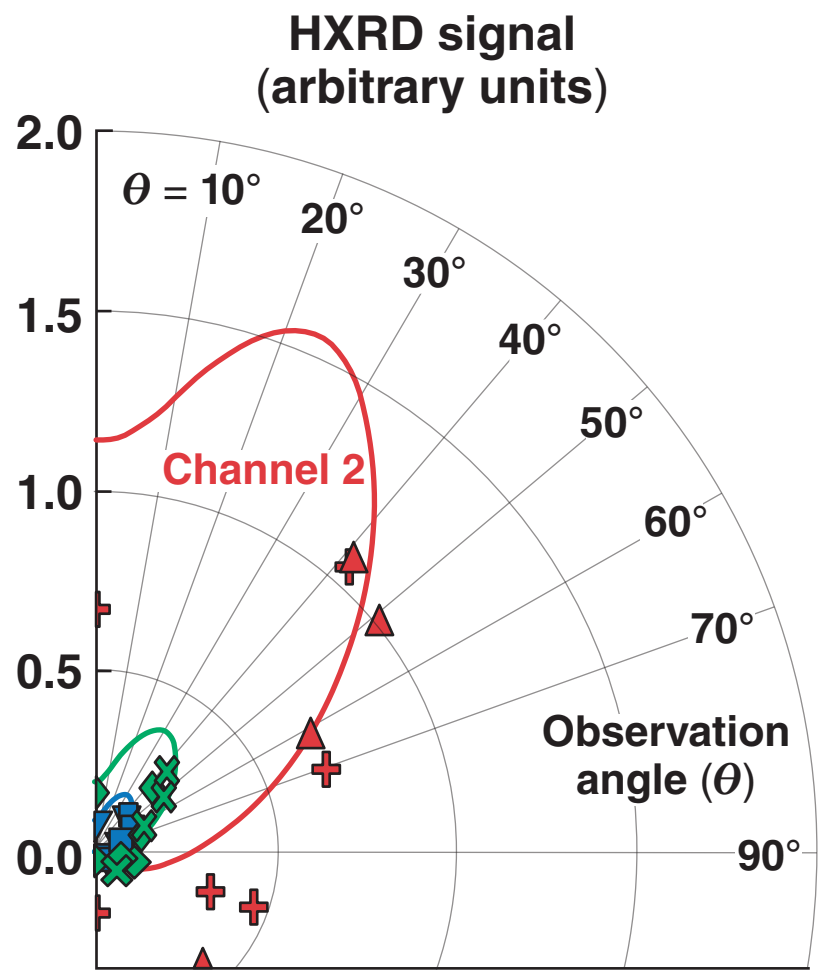
Reasonable agreement with the observed bremsstrahlung angular distribution is achieved with a narrow beam of hot electrons, $\Theta = 10° \pm 5°$ (polar plot)



TC8114

Multiple scattering needs to be taken into account when predicting the signal in channel #2; this will require Monte Carlo modeling





TC8115

Summary/Conclusions

Measurements of bremsstrahlung from thick planar targets show a dramatic anisotropy in emission

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- The electron source is assumed to be TPD.
- Directionality of TPD electrons is important for the calculation of fuel preheat*.
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