Characterization of The Laser-Induced Fast Electron Scattering

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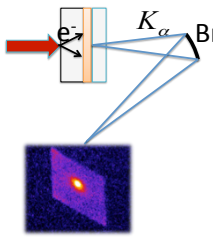
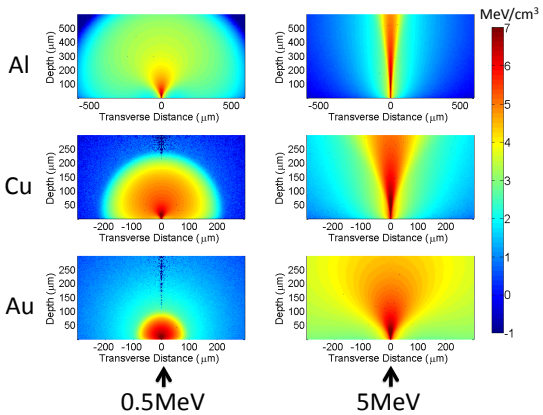
Motivation



- Fast electron scattering may enlarge the measured electron divergence
- Studied using MCNP

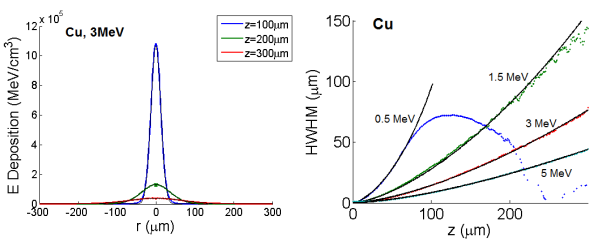
General Results

Energy Deposition (Point Source)



- **Divergence is larger for lower energy and higher Z.**

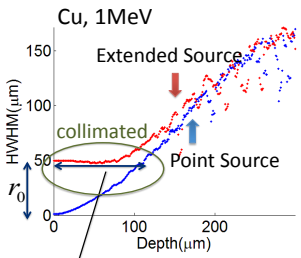
Divergence



Lineouts at various depths — HWHM - depth

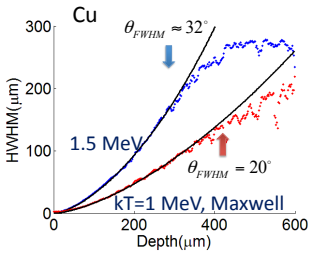
Source Dependence

Source Size

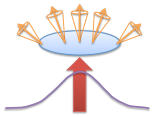


$$z_0 \propto \frac{r_0^{2/3} E^{2/3} A^{1/3}}{Z^{2/3} \rho^{1/3}}$$

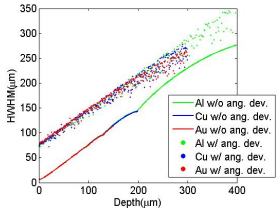
Energy Distribution

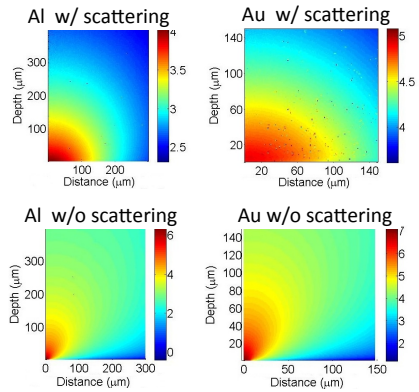


Realistic Source



A. Debayle, J. J. Honrubia, etc. Phys. Rev. E 82, 036405 (2010)

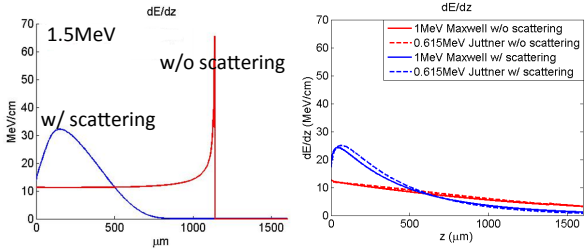




- **Energy deposition changes with and without scattering, however, divergence does not.**

Energy Deposition vs. Depth

Medium: Cu



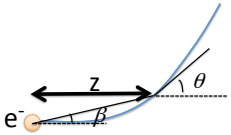
- **Both scattering and initial energy distribution can hide the Bragg peak.**
- **Peak energy deposition appears at much smaller depth due to scattering.**

Simple Fitting

From small angle scattering[1], $\langle \cos\theta \rangle = \exp(-k_1 \Delta s)$

k_1^{-1} is the 1st order transport mean free path

For HWHM, assume $k \propto k_1$



For $kz << 1$

$$HWHM = \frac{1}{3}\sqrt{2k}\, z^{3/2},$$

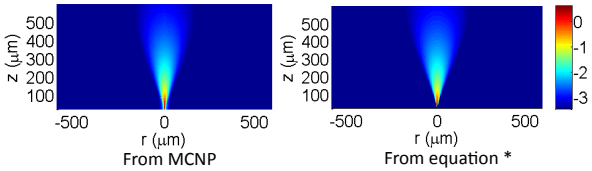
$$k \approx (0.11\, cm^2 MeV^2 / mol) \frac{Z^2 \rho}{A E_0^2}$$

β ~ Gaussian distribution (central limit theorem)

Energy deposition: $D(z)\, z^2 \exp(-\frac{r^2}{4\alpha^2 z^2}) / (z^2 + r^2)$ *

$\alpha^2 \approx 0.059\, cm^2 MeV^2 / mol \frac{\rho}{A} \frac{Z^2}{E_0^2} z$ Assume $D(z) \propto 1/z^3$

Eg. Al, 1.5MeV, Error ~ 10%



From MCNP — From equation *

1. H. W. Lewis, *Phys. Rev.* **78**, 526 (1950), S. Goudsmit and J. L. Saunderson, *Phys, Rev.* **57**, 24 (1940)