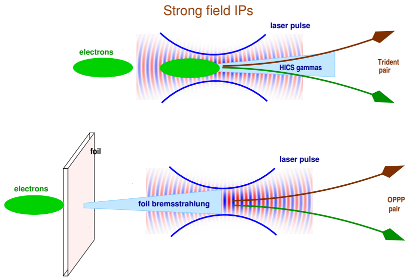
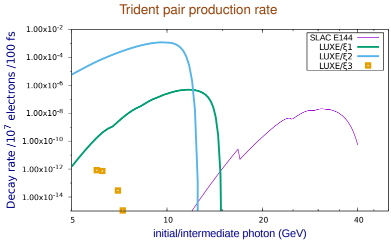
Isolating the main processes at LUXE

[Hartin, Ringwald, Tapia]

- Three main processes at LUXE - HICS gamma production, One photon pair production (OPPP), Trident process (HICS gammas + strong field) pair production
- There are compelling reasons to study the three processes separately
- HICS shows mass shift - strong field leads to increase in electron rest mass
- Trident leads to rare resonance processes, related to dispersive vacuum
- OPPP pair production at ultra high intensity - non-perturbative physics
- PROBLEM: Trident process pair production limited by laser intensity (suppressed already at $\xi \sim 3$)
- SOLUTION: Use foil to convert electrons to gammas upsteam of the strong field IP with high intensity laser further upstream

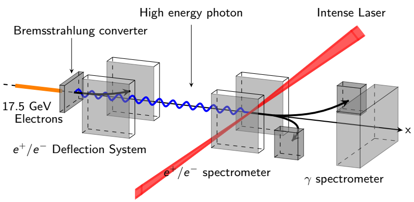




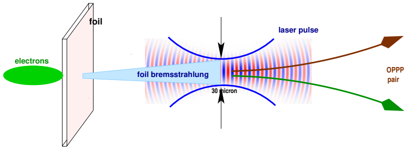
High energy gamma rate via foil bremsstrahlung

- For pure OPPP process we need foil upstream of strong field IP. This produces significant spray of e+e- as well as gammas
- Foil e+e- spray mixes with strong field pair prod. So either rely on detector discrimination, OR bend away with deflection system before second IP.
- Foil will interfere with HICS/Trident so it should be removable. Experiment operates in two modes.
- Distance of foil from strong field IP limited by beamstrahlung divergence. We need a good overlap of gammas and strong field laser at focus.
- Needs to be studied fully in mixed Geant/IPstrong simulation
- Radiation safety, Detector issues, Transition rates etc.

Strong field + foil, experimental setup



Bremsstrahlung divergence and strong field IP



Bremsstrahlung from foil - Geant vs parametrisation

- Initial LUXE Geant model set up. Studied bremsstrahlung from thin foil of various thicknesses

- Foil produces higher energy gammas at rate orders of magnitude above HICS rate

- Thin foils produce more high energy gammas. (wear and tear on the foil?)

- Analytic fits of bremsstrahlung rates studied for foil thickness above and below radiation length

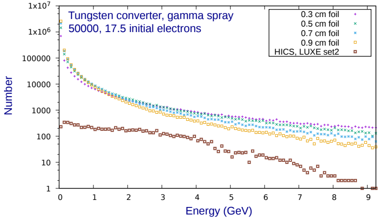
- Approximation formula quoted in arxiv:1802.06612 - not very satisfactory. Need full monte carlo

$$\frac{dN}{df} \approx \frac{(1-f)^{4l/3} - e^{-7l/9}}{f(7/9 + 4/3\ln(1-f))}$$

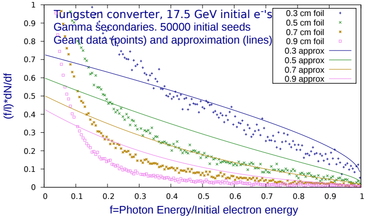
$$f = \frac{\omega_{\text{brem}}}{17.5\ \text{GeV}}, \quad l = \frac{\text{foil thickness}}{\text{radiation length}}$$

- Find suitable analytic fit function. Fold with OPPP rate, to get overall pair production rate

Foil bremsstrahlung rate vs HICS



Foil bremsstrahlung rate fit



Bremsstrahlung + OPPP rates

- Find suitable analytic fit function for bremsstrahlung from coverter

- V2 parametrisation works at X_0 and mid to high energies

$$\frac{dN}{df} \approx \frac{l\left[\frac{4}{3}(1\text{-}f) + f^2\right]}{f^2}\,\frac{(1\text{-}f)^{\frac{4l}{3}} - e^{-\frac{7l}{9}}}{\frac{7}{9} + \frac{4}{3}\ln(1-f)}$$

$$f = \frac{\omega_{\text{brem}}}{17.5\ \text{GeV}}, \quad l = \frac{\text{foil thickness}}{\text{radiation length}}$$

- Calculate rates for one photon pair production with initial bremsstrahlung photons

- Assume all electrons are converted and all photons interact with 20 fs strong laser - about two pairs per bunch

- Assume, $\xi, \chi_{\text{g}} = \frac{2\xi k\cdot k_i}{m^2}$ and bremsstrahlung rate are known for each pair

- Plot of scaled rate vs ξ at constant χ_{g} asymptotes for measurable range at LUXE