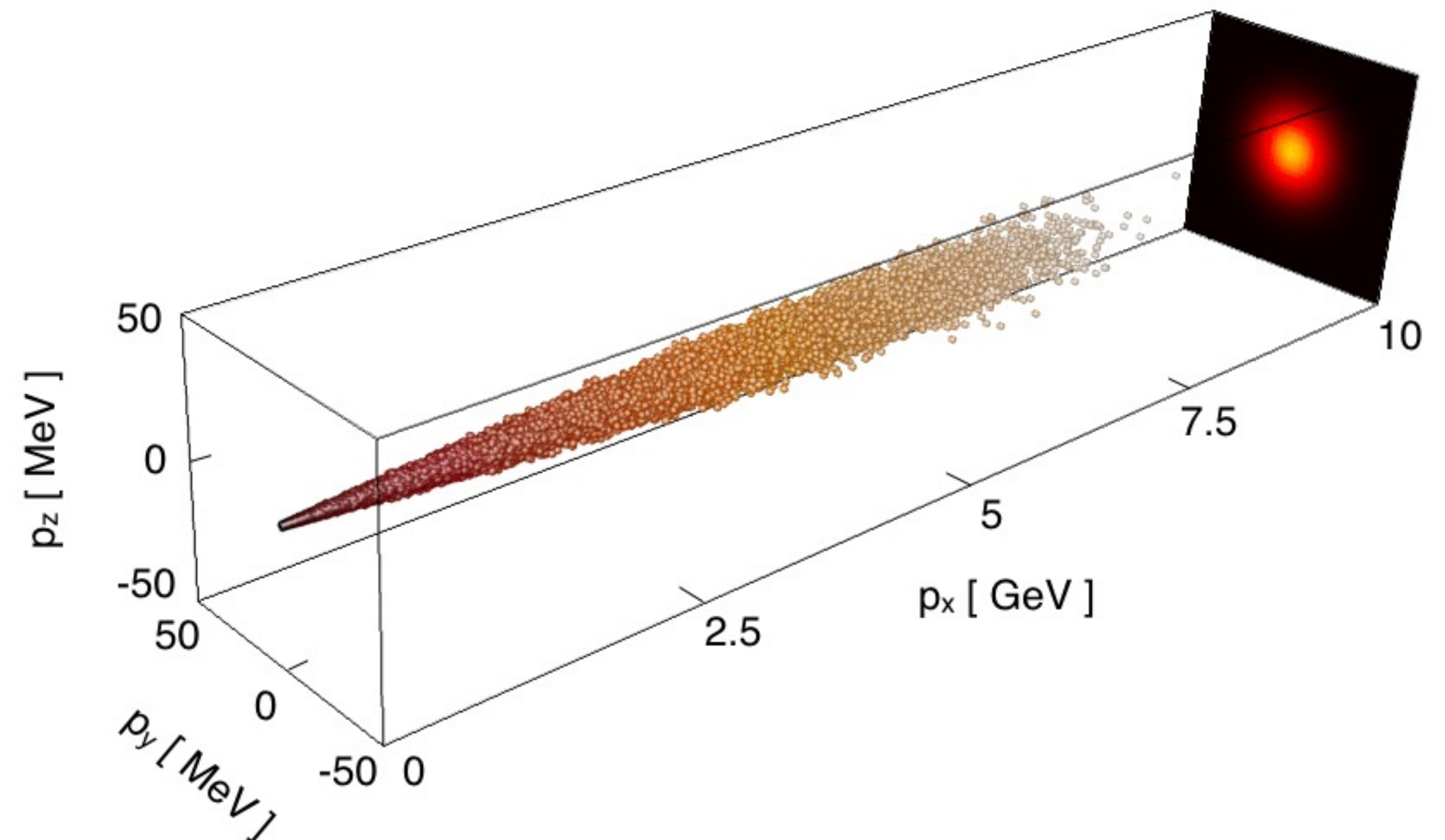# Kick-off discussion for QED experiments@LUXE

Marija Vranic
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Luis O. Silva
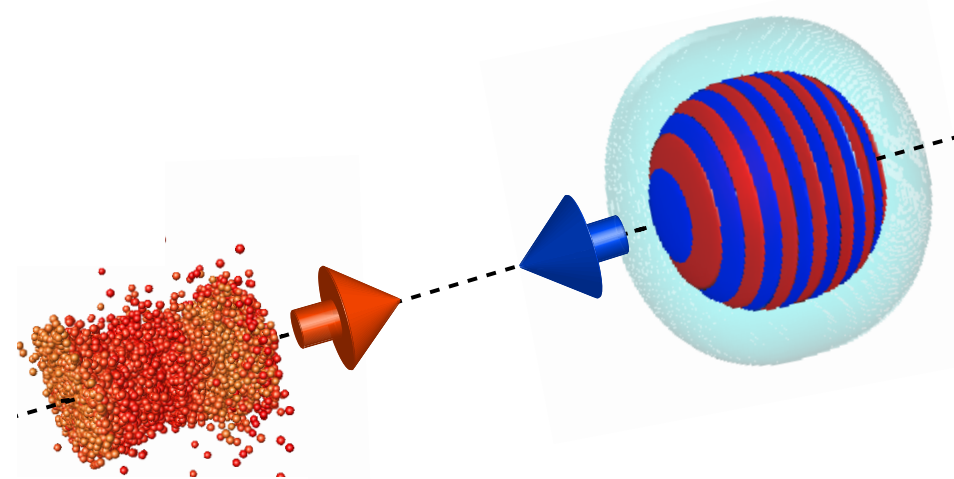
GoLP / Instituto de Plasmas e Fusão Nuclear
Instituto Superior Técnico, Lisbon, Portugal

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Highest value of χ is obtained for relativistic particles counter-propagating with a laser

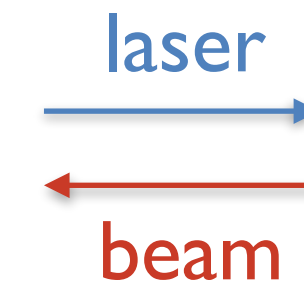## Unity is achieved when particle feels E=Es in its own rest frame

$$E_s = \frac{m^2 c^3}{e\hbar} \qquad \chi = \frac{\sqrt{(p_\mu F^{\mu\nu})^2}}{E_s\, mc}$$

$$\chi_e = \frac{1}{E_s}\sqrt{\left(\gamma\vec{E} + \frac{\vec{p}}{mc}\times\vec{B}\right)^2 - \left(\frac{\vec{p}}{mc}\cdot\vec{E}\right)^2}$$

Classical: $\chi \ll 1$

QED: $\chi \simeq 1$
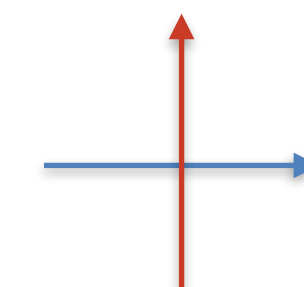
Counter-propagation

laser

beam

$$\chi \approx 2\,\gamma_0 a_0 \times 2 \times 10^{-6}$$

Co-propagation

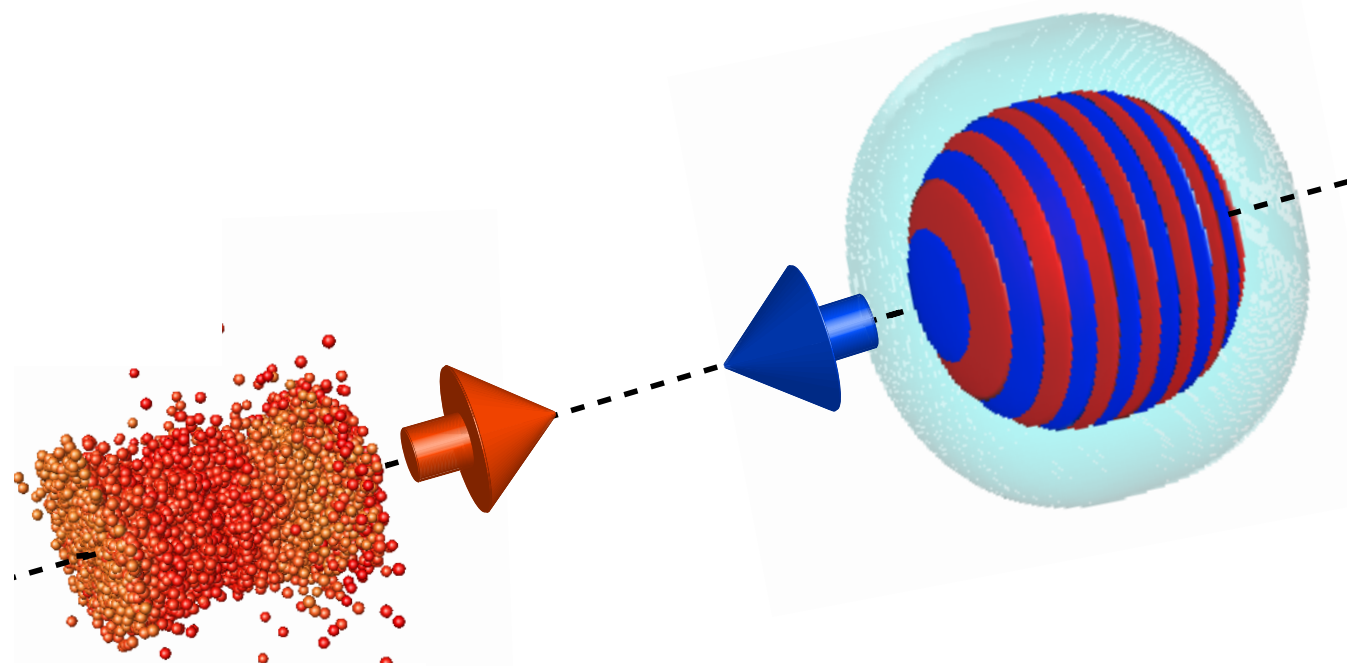$$\chi \approx \frac{a_0}{2\gamma_0} \times 2 \times 10^{-6}$$

Interaction at 90 deg.

$$\chi \approx \gamma_0 a_0 \times 2 \times 10^{-6}$$

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How much energy can be converted from e- to photons in a laser - electron beam scattering?

LUXE could achieve up to 70% conversion efficiency to gamma-rays, and potentially reach a chi~2

$$\chi \sim \xi_e \, [\text{GeV}] \times \frac{a_0}{100}$$

Relative energy loss as a function of electron initial energy and the laser intensity (30 fs lasers, one micron wavelength)*

- $E_0 = 0.5$ GeV
- $E_0 = 1$ GeV
- $E_0 = 1.5$ GeV
- $E_0 = 3$ GeV *
- $E_0 = 13$ GeV *
- $E_0 = 53$ GeV
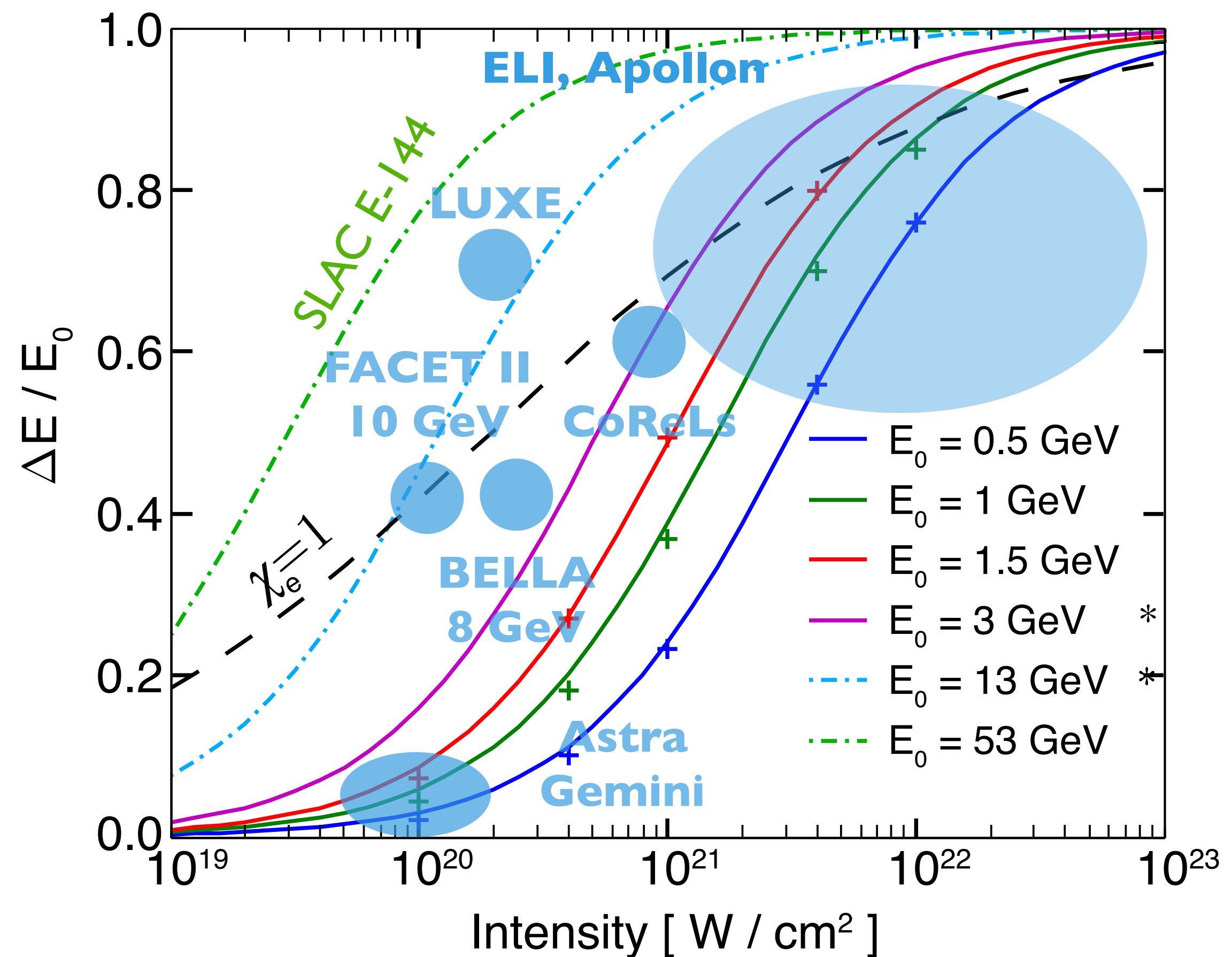
* M. Vranic et al., PRL 113, 134801 (2014)

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A fraction of radiated photons decays into electron-positron pairs

Example for FACET-II parameters
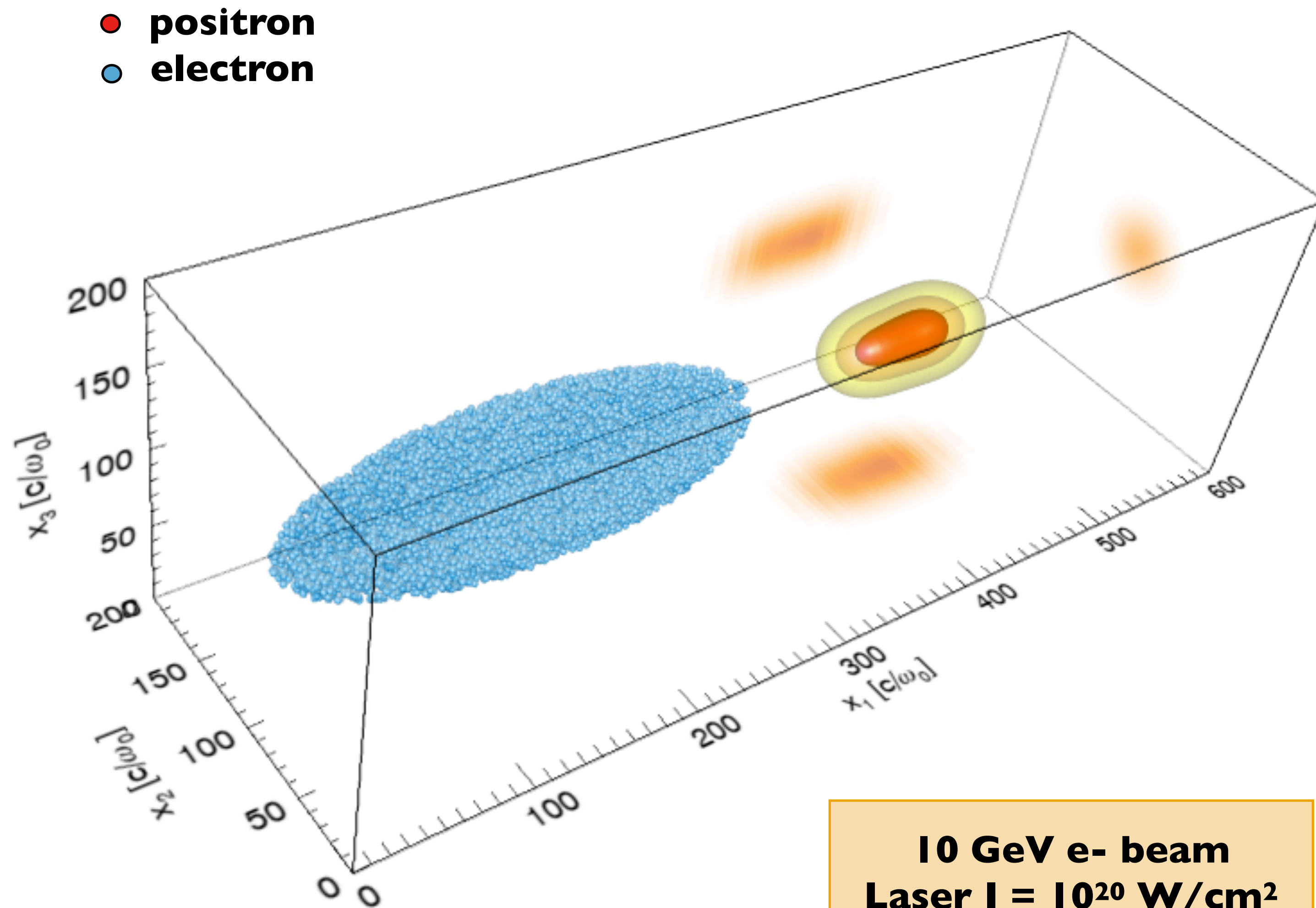
● positron
● electron

10 GeV e- beam
Laser I = 10^{20} W/cm^2

Positrons: energy vs angle

$a_0 = 10$
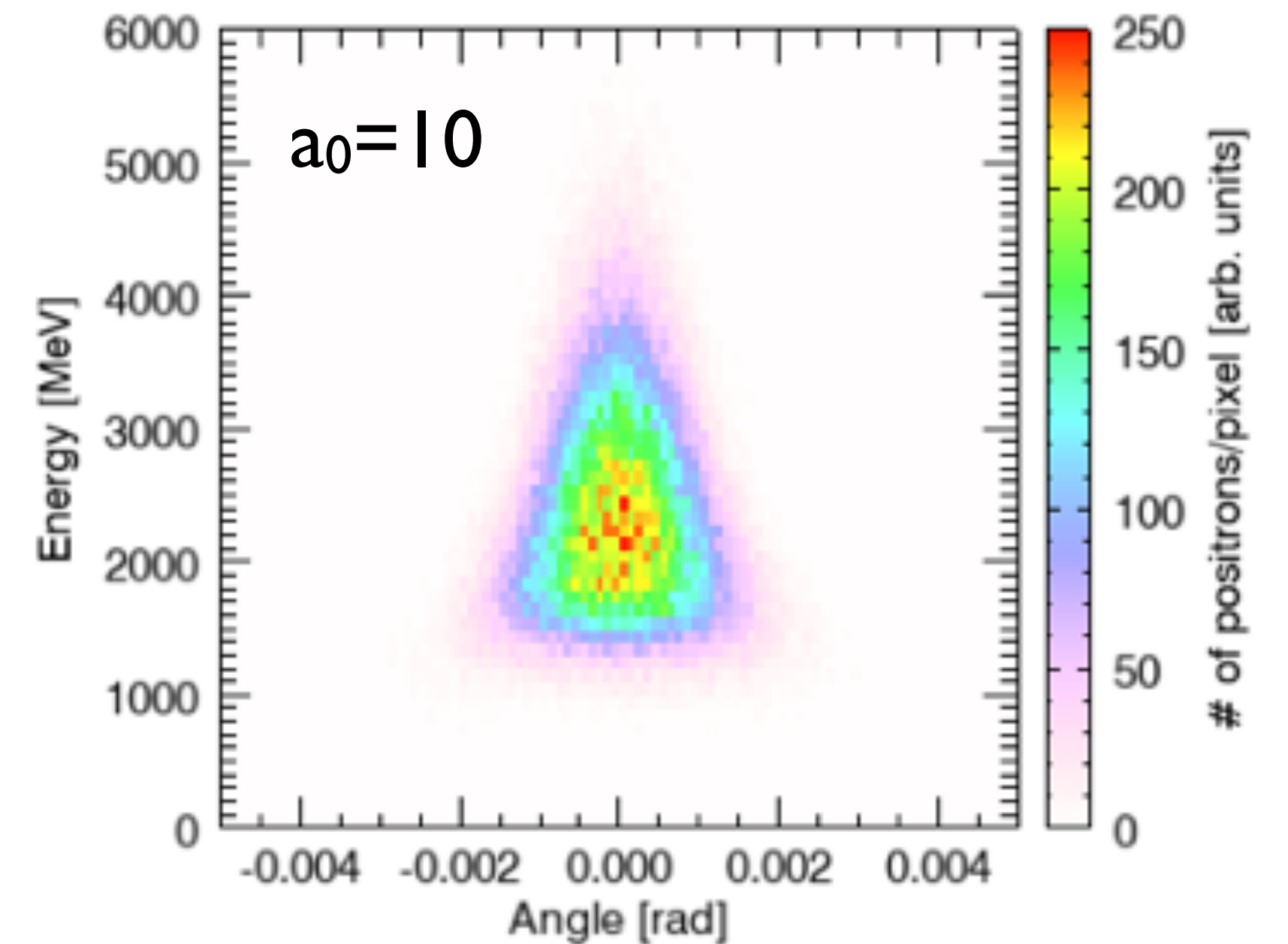
I nC electron beam gives
~ 0.2 pC of positrons

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How many BW pairs to expect in LUXE?

Estimate based on a published scaling for a 30 fs pulse

Assuming laser intensity $I \sim 10^{20}$ W/cm^2

 # positrons ~ (0.001 - 0.01) # electrons

T. Blackburn et al., PRA **96**, 022128 (2017)

Our modeling capabilities

- **Full-scale QED-PIC simulations for the laser-electron beam scattering configuration.**

- **Modeling of the photon-laser collision for the bremsstrahlung configuration.**