LUXE.

A NEW EXPERIMENT TO STUDY NON-PERTURBATIVE QED AND SEARCH FOR NEW PARTICLES IN ELECTRON-LASER AND PHOTON-LASER COLLISIONS

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Strong-field QED?

Quantum electrodynamics (QED) is the world's most precisely known (and tested) theory

Vacuum polarisation increases α_{EM} with energy

- At high energies, perturbative expansions fail
- The Schwinger limit $\varepsilon_{cr} = 1.32 \cdot 10^{18}$ V/m defines the strong-field regime of QED

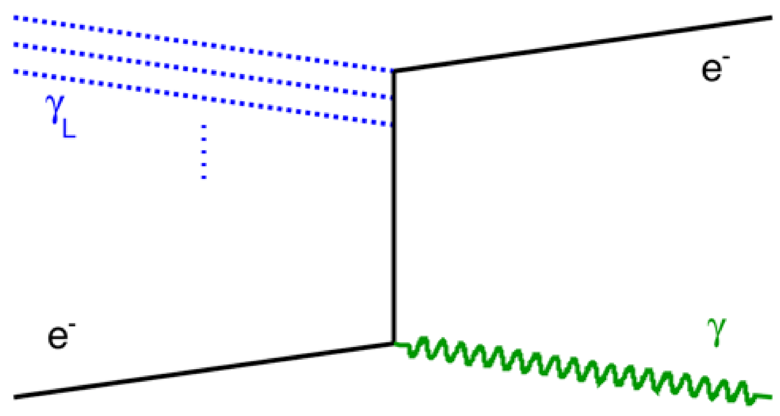
LUXE (Laser Und XFEL Experiment) will investigate the transition into the non-perturbative regime of QED for the first time

Key questions and quantities.

How do e^+, e^- or γ behave when propagating in a very strong field?

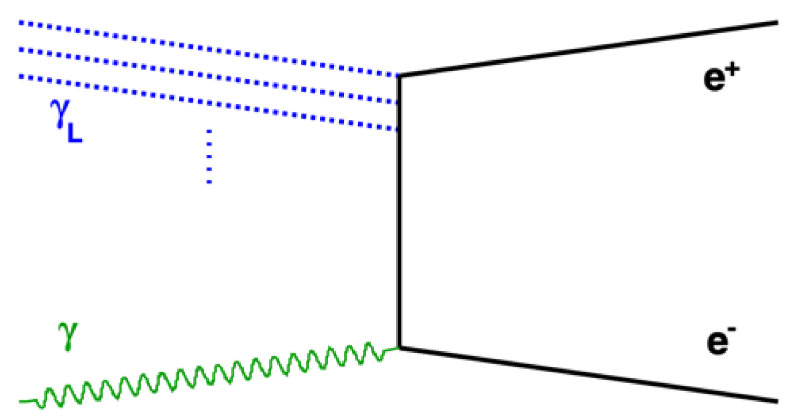
Could new particles be produced in rare photon interactions with matter?

Highly-boosted electrons ($\gamma_e \sim 10^4$) and high-intensity laser pulses (of frequency ω_L) allow us to study ε_{cr}



Compton scattering

$$e^- + n\gamma_L \to e^- + \gamma_C$$



Breit-Wheeler pair production

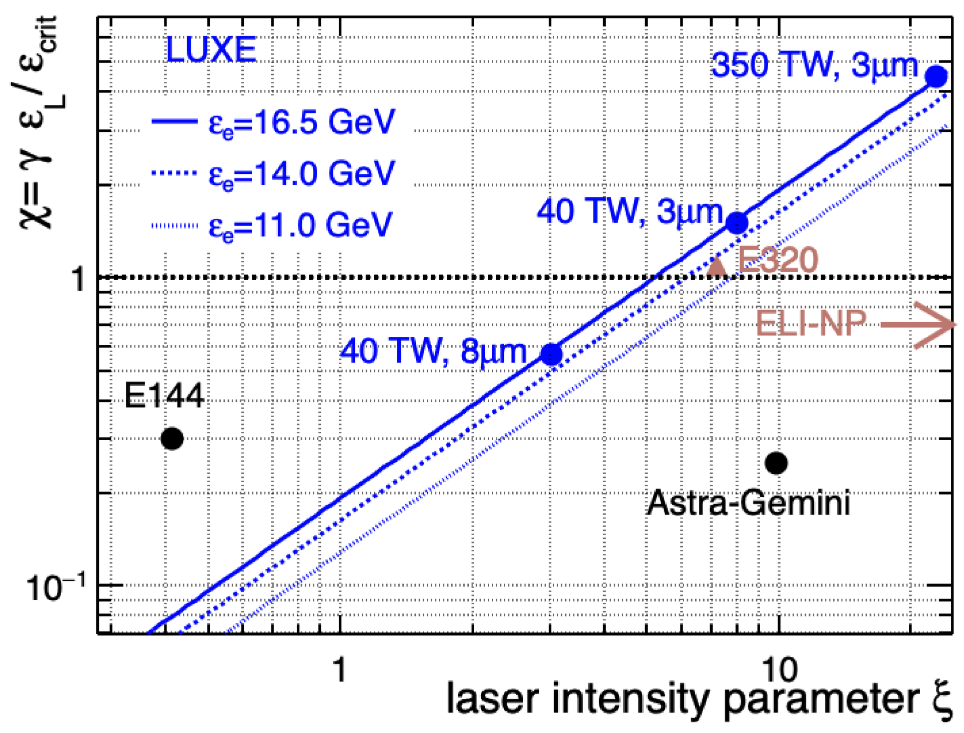
$$\gamma_C + n\gamma_L \to e^- + e^+$$

Quantum parameter

$$\chi_\gamma = (1 + \cos\theta)\frac{E_\gamma}{m_e}\frac{\varepsilon_L}{\varepsilon_{cr}}$$

Field intensity parameter

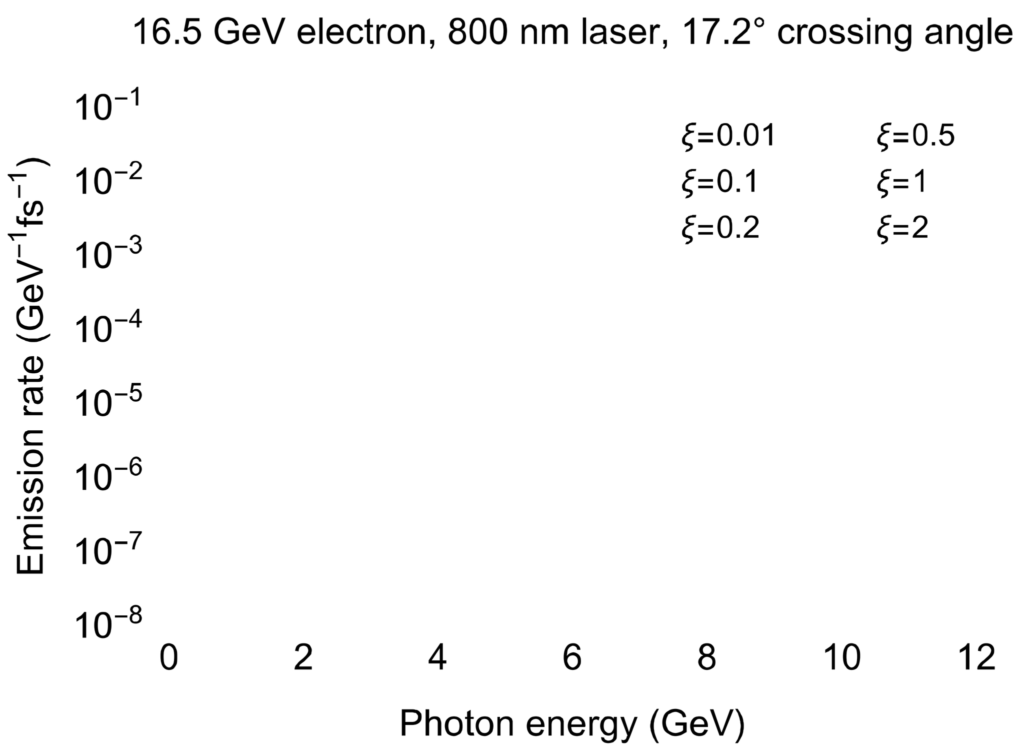
$$\xi = \sqrt{4\pi\alpha}\left(\frac{\varepsilon_L}{\omega_L m_e}\right) = \frac{m_e \varepsilon_L}{\omega_L \varepsilon_{cr}}$$



Goals.

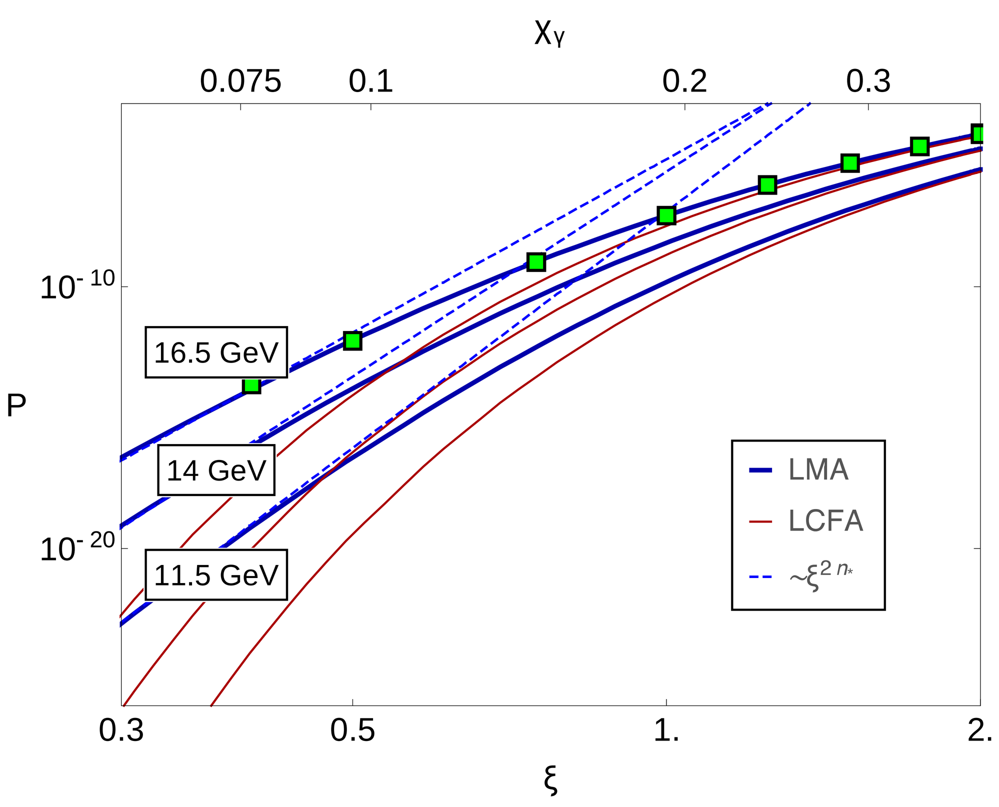
Nonlinear Compton scattering

Reconstruct Compton edge in electron or photon spectrum



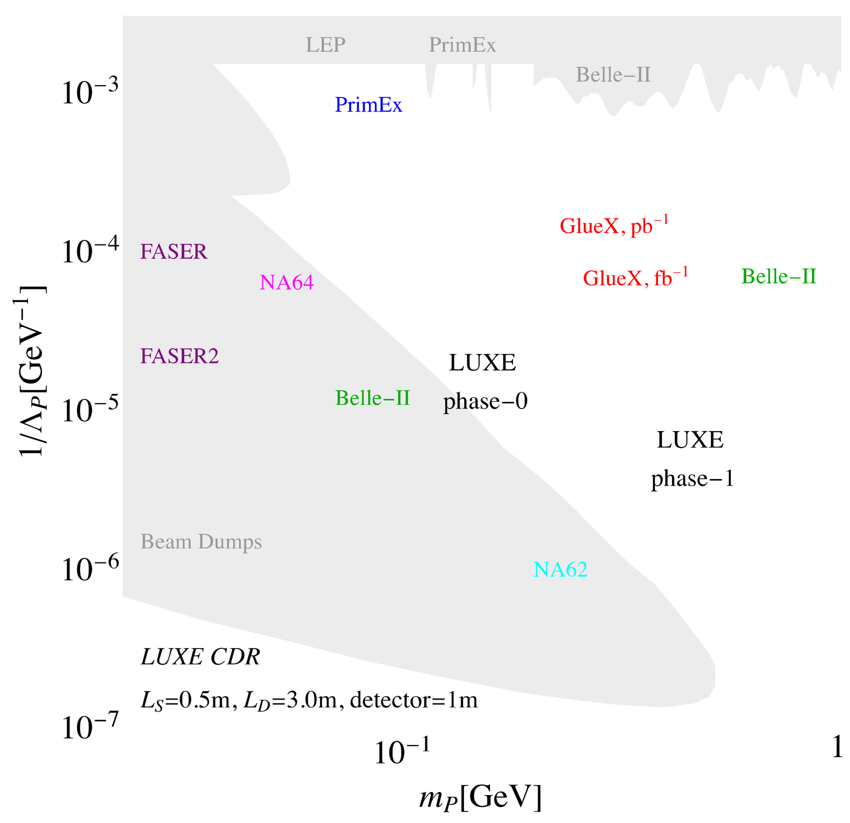
Nonlinear Breit-Wheeler

Measure positron rate



Search for BSM physics

Use Compton-photon beam in a beam-dump experiment



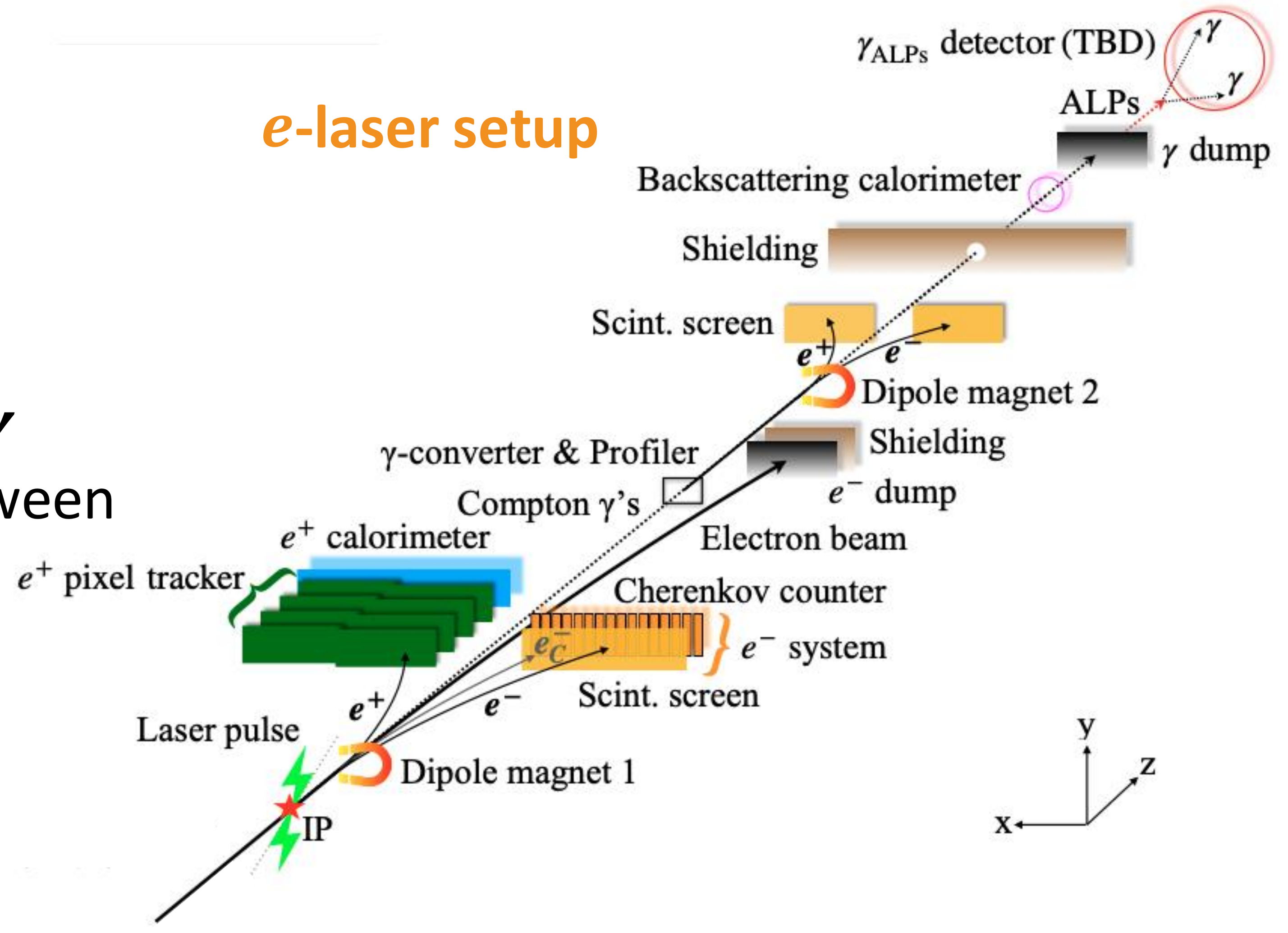
Detectors and lasers.

Measure fluxes and spectra of e^+ ,e^- and γ

Particle fluxes vary between ~0.01 (e^+) and 10^9 (e^-,γ) per laser shot

LUXE basic LASER parameters	
active medium	Ti:Sa
wavelength (energy)	800nm (1.55eV)
crossing angle	17.2°
pulse length	30fs
spot size	≥3μm
power	40TW / 350TW
peak intensity [10¹⁹ W/cm²]	13.3 / 120

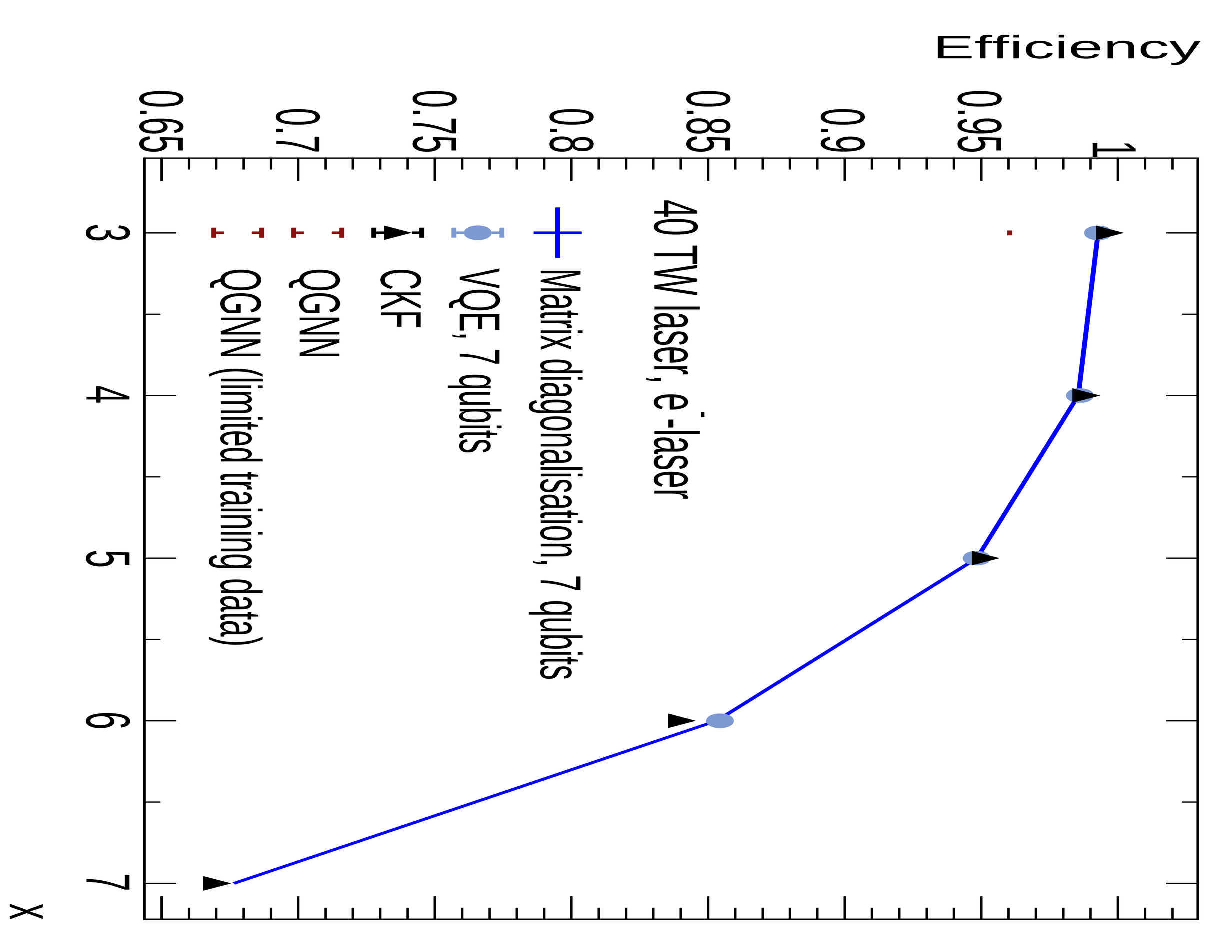
***e*-laser setup**



BSM detectors need ~zero background $\gamma\gamma$ events

Quantum computing.

Studied performance of hybrid classical-quantum algorithms for track reconstruction



References.

- Eur. Phys. J. ST 230 (2021) 11
- arXiv: 2304.01690

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