Strong-Field Quantum Electro-Dynamics at LUXE

At DESY in Hamburg, we have access to a high-quality, high-energy electron beam in the EuXFEL – up to 17.5 GeV, with bunch population of around 1.5 x 10^9.

Strong-field electric fields in the lab come from extremely powerful & short ‘chirped’ LASER pulses.

LUXE will collide LASER pulses in two modes with both high-energy electron bunches (e-laser) and photons (γ-laser). The photons are produced via the electrons radiating via bremsstrahlung or Inverse Compton Scattering, with the combination of the focused high-power LASER pulse and high-energy electric field, LUXE is expected to reach and exceed the Critical Field and so achieve χ > 1, as yet unexplored parameter space.

With χ exceeding 1, the collision is expected to transition into a tunneling regime. This shape is crucial as it informs us immediately the quality of the particle-LASER interaction from bunch-to-bunch. This can allow for an instantaneous testing of the vacuum (right) or Non-Linear Breit-Wheeler Process, with considerable background.

ELECTRON DETECTION

ELECTRON DETECTION

Photon Detection

Three independent detectors are used to measure various characteristics of the gamma beam envelope.

The low rates expected for the Breit-Wheeler process motivates the use of Silicon pixel-trackers and Silicon/GaAs calorimeter(s) to resolve individual positrons above this reasonable background.

The high flux gives high light levels, allowing remote optical cameras to detect signal at high position resolution.

High flux means Cherenkov medium with low refractive index (e.g. Ar) can be used, which provides few signal photons but excludes low energy (background) charged particles E < 20 MeV.

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Cherenkov light which is detected by a Thin Tungsten target to convert a proportion (~1%) of the gamma beam to e+ e− pairs, and using a Bethe-Heitler deconvolution algorithm and the summed energy of the e+ e− pair, the gamma beam is reconstructed by absolute energy distribution.

The energy profile of the e+ e− are reconstructed with another Scint. Screen & Camera system.

Track multiplicity reconstruction (left) for simulation of the Tracker.

Finally, in front of the gamma beam dump, a Backscattering Calorimeter measures the total photon flux using photon backscatters from the Copper dump.

A screen of scintillating material is used in this region in conjunction with a segmented Cherenkov detector.

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Further Reading:
- The DESY-II Testbeam Facility; Ralf Diener et al., https://arxiv.org/abs/1807.09328

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