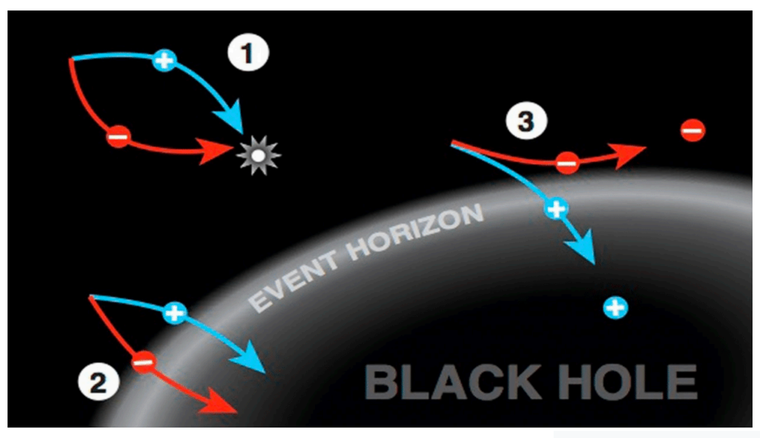
# The LUXE Experiment.

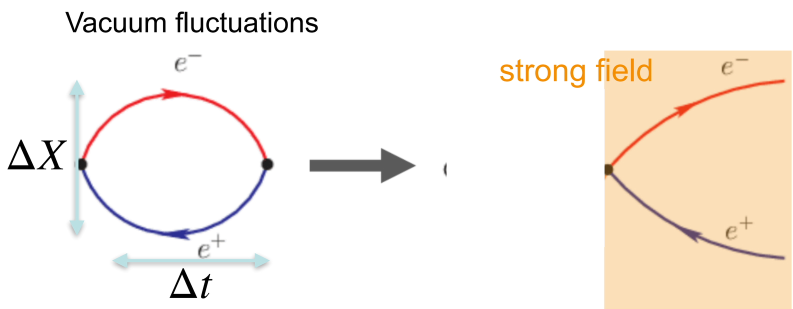
## Probing Non-perturbative Quantum-Electrodynamics

## Strong fields

Hawking Radiation:
strong gravitational field




Vacuum Pair Production:
strong electromagnetic field




Analogous Mechanism:
energy needed to separate an electron-positron pair

$$E_{separate} = Fd_{min}$$

heisenberg yields minimum distance for separation

$$\Delta t \geq \frac{h}{\Delta E} \rightarrow \Delta t_{min} = \frac{\hbar}{2mc^2} \rightarrow d_{min} = 2c\Delta t_{min} = \frac{\hbar}{mc} = \lambda_c$$

gravitational force
near event horizon

$$F_G = \frac{G_N M m}{r_s^2} = \frac{mc^4}{4G_N M}$$

schwarzschild radius: $r_s = \frac{2G_N M}{c^2}$

energy to separate pair:

$$E_{separate} = Fd_{min} = \frac{mc^4}{4G_N M} \times \frac{\hbar}{mc} = \frac{\hbar c^3}{4G_N M}$$

Real Pair: $\frac{\hbar c^3}{hG_N M} > 2m_e c^2$

$$E_{e^+e^-pair} = 2m_e c^2$$

electromagnetic force

$$F_{elm} = e\epsilon$$

energy to separate pair:

$$E_{separate} = Fd_{min} = e\epsilon \times \frac{\hbar}{mc} = \frac{\hbar e\epsilon}{mc}$$

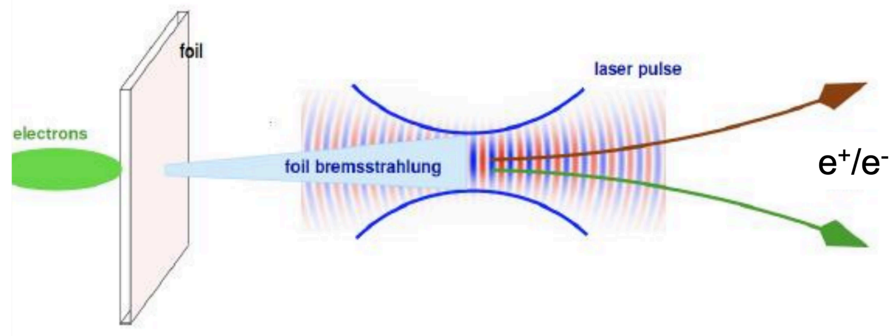
Real Pair: $\frac{\hbar e\epsilon}{mc} > 2m_e c^2 = 2.6 \times 10^{18}\frac{V}{m}$

## The Experimental Idea

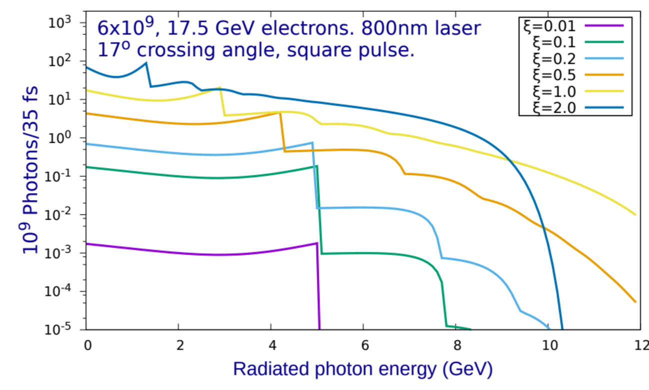
Strong field not achievable non-relativisticly ($10^{18}\frac{V}{m}$)

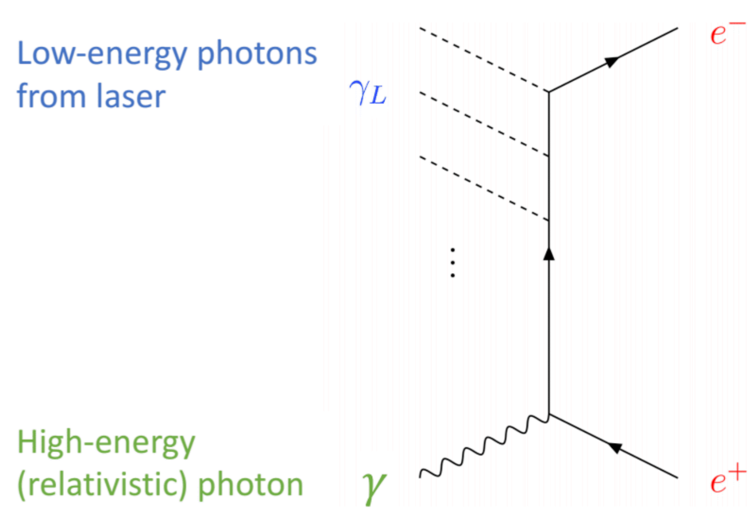
**Idea: Use relativistic electrons and a strong laser
to measure strong field effects**

Photon decay in presence of strong fields



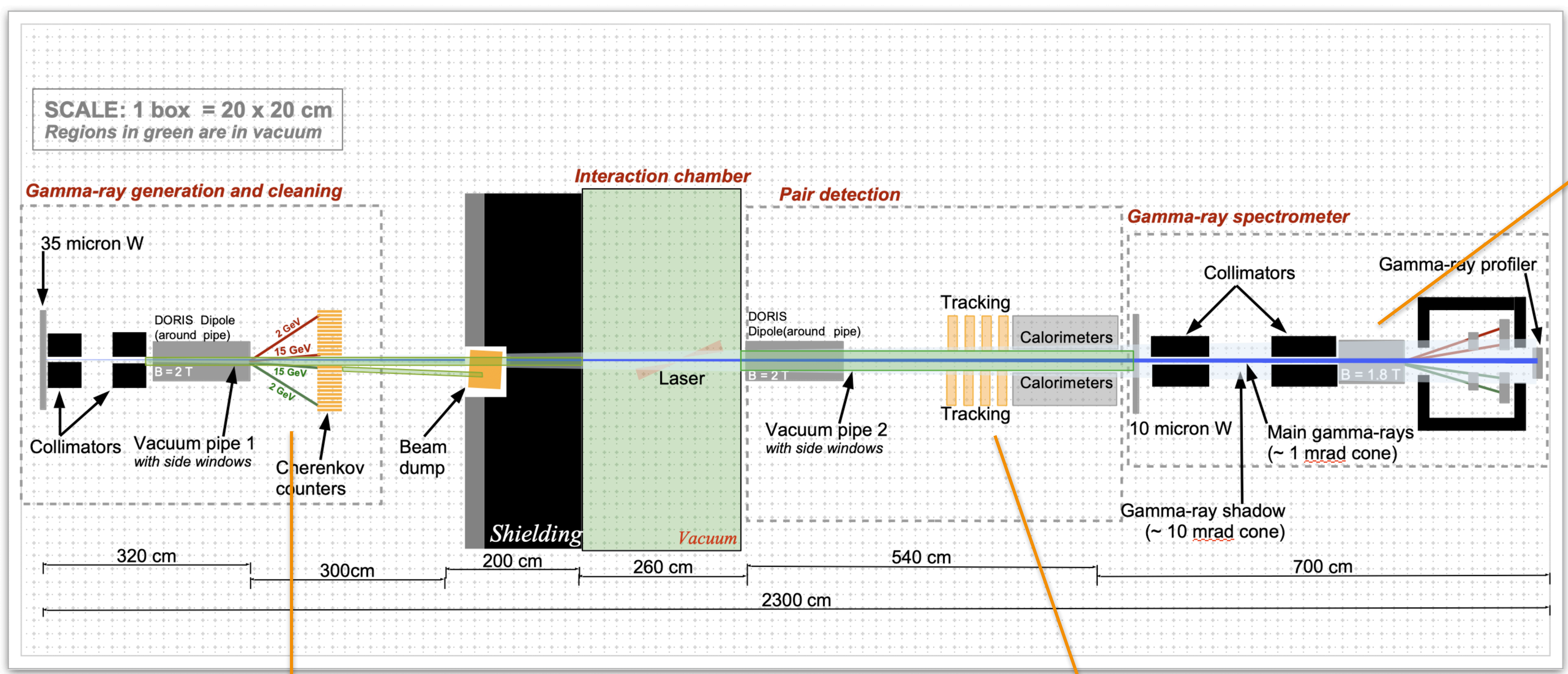

Shift of compton edges
in presence of strong fields




## Experimental Setup for $\gamma_{Laser} - \gamma_{beam}$ interaction

**Challenges for particle physicists: What we want to measure**




Analyse leftover photon spectra and rates after laser-photon interaction

**Challenge: high rate of photons with different energies**

**technical approach: use wire or foil to produce bremsstrahlung $e^+e^-$ pairs which are analyzed in a spectrometer.
Reconstruct total photon number from backscattering**

Measure the produced pairs from conversion
to calculate number of photons in beam

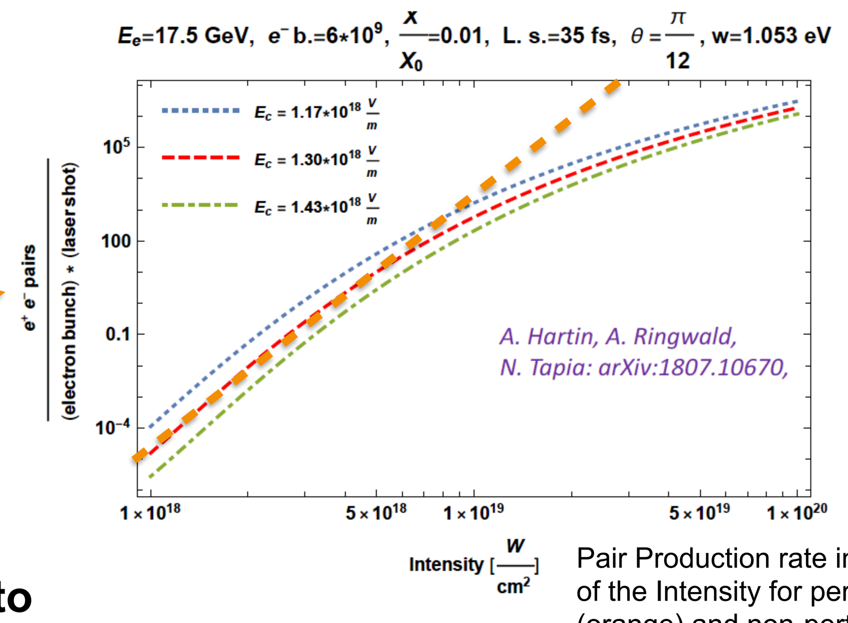
**Challenge: Very high rate of pairs**

**Technical approach: Magnetic spectrometer
with cherenkov counters**

Track and count the number of pairs produced
by photon decay and separate background and signal

**Challenge: Signal and background originating
from same pipe but different positions**

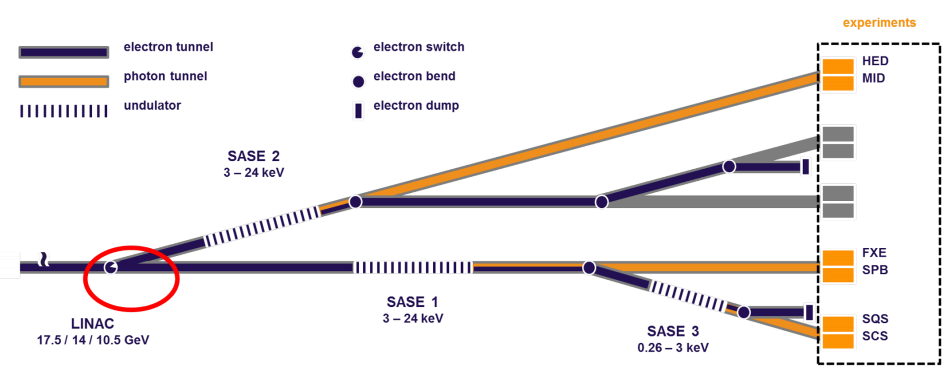
**Technical approach: Use precision tracking detectors to
reconstruct origin and energy of particles**



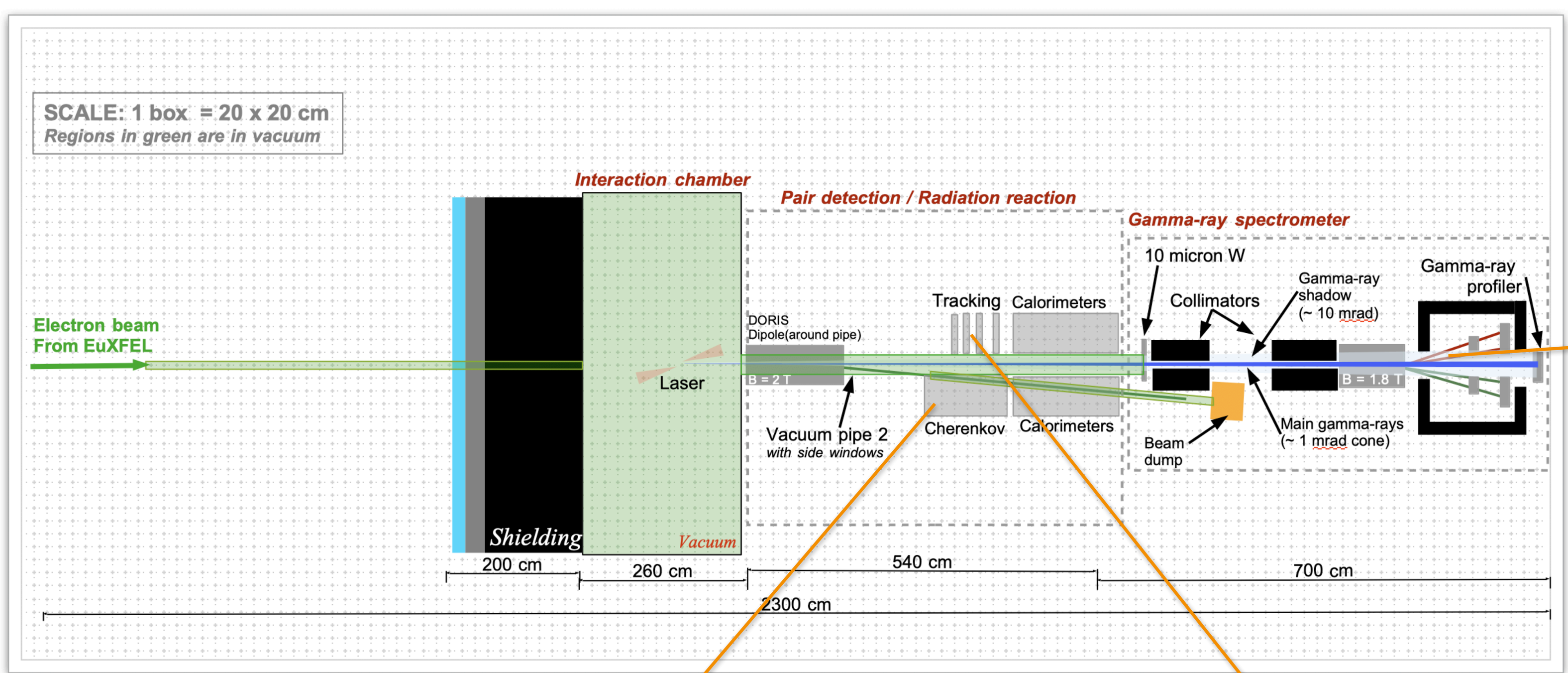

Pair Production rate in dependence
of the Intensity for perturbative
(orange) and non-perturbative QED

## Experimental Setup for $\gamma_{Laser} - e_{beam}$ interaction

**Different Experiment, New Challenges**




European XFEL branch and foreseen location




Analyse photon energy spectra from compton scattering
and find compton edges

**Challenge: huge number of incoming photons**

**Technical approach: Use wire to convert small amount of
photons to bremsstrahlung $e^+e^-$ pairs which are analyzed
in a spectrometer. Reconstruct total photon number from
backscattering in a dump.**

Measure electron energies and rates from
conversion in $\gamma_{Laser} - e_{beam}$ interaction

**Challenge: Has to be measured in presence
of the primary beam**

**Technical approach: Use cherenkov counters and
magnetic spectrometer**

Measure precise positron energies and rates
from conversion in $\gamma_{Laser} - e_{beam}$ interaction

**Challenge: high number of background particles
from primary beam conversions**

**Technical approach: Use precision tracking detectors to
reconstruct origin and energy of particles**

More Information: Letter of Intent for the LUXE Experiment; arXiv:1909.00860