

# Long-lived particles at the LUXE experiment

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10<sup>th</sup> workshop of the LLP Community  
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# The LUXE experiment

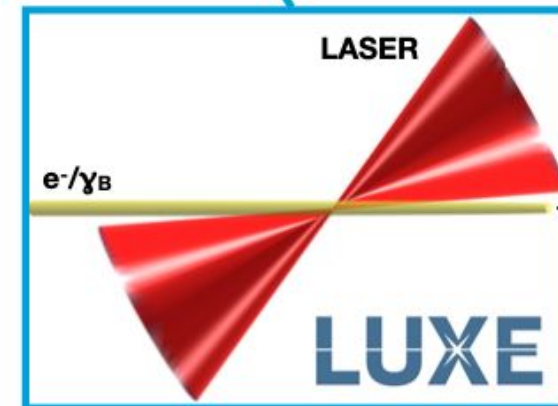


LUXE is a new experiment at DESY and Eu.XFEL

- Collisions of electron beam and a high-power laser
- **Study for the first time non-perturbative QED**

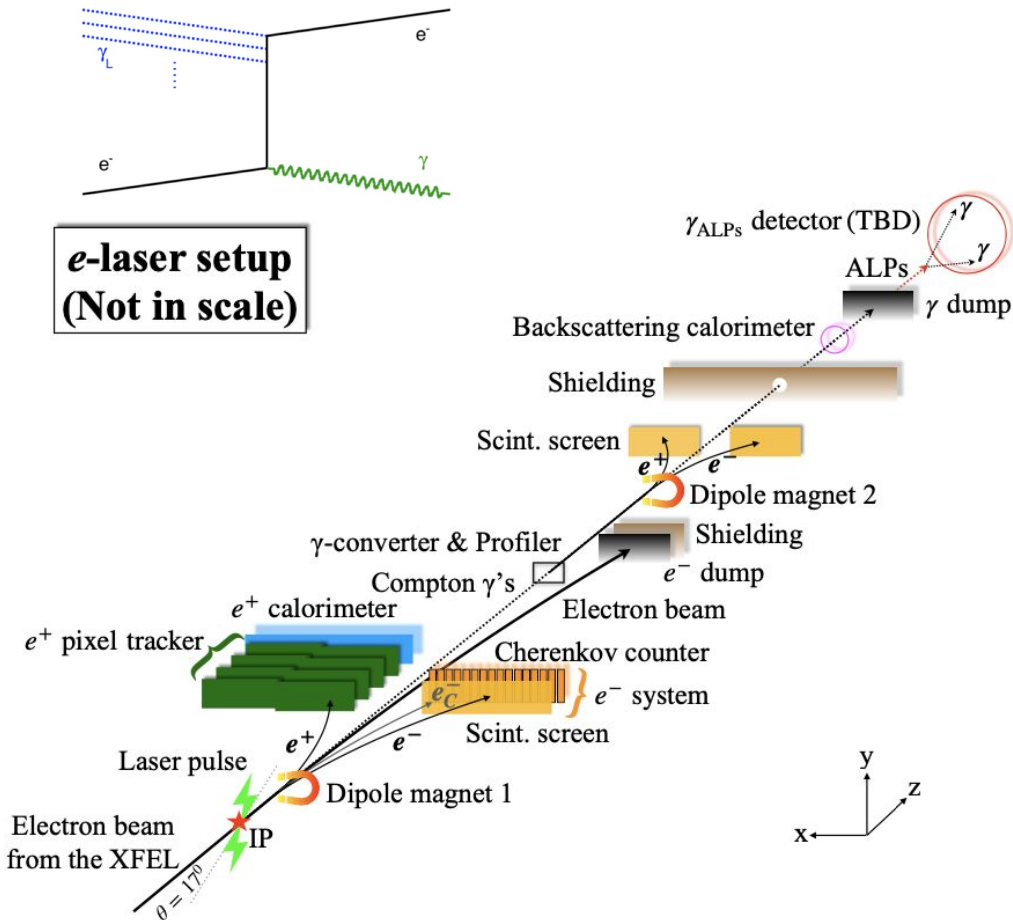
More Information at:

- CDR arXiv: [2102.02032](https://arxiv.org/abs/2102.02032)
- Website <https://luxede.desy.de>



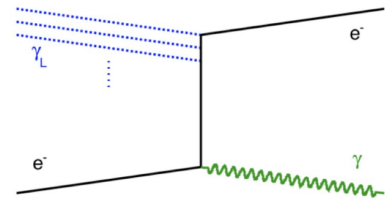
# A novel type of beam dump experiment

## And a reminder of the experimental setup

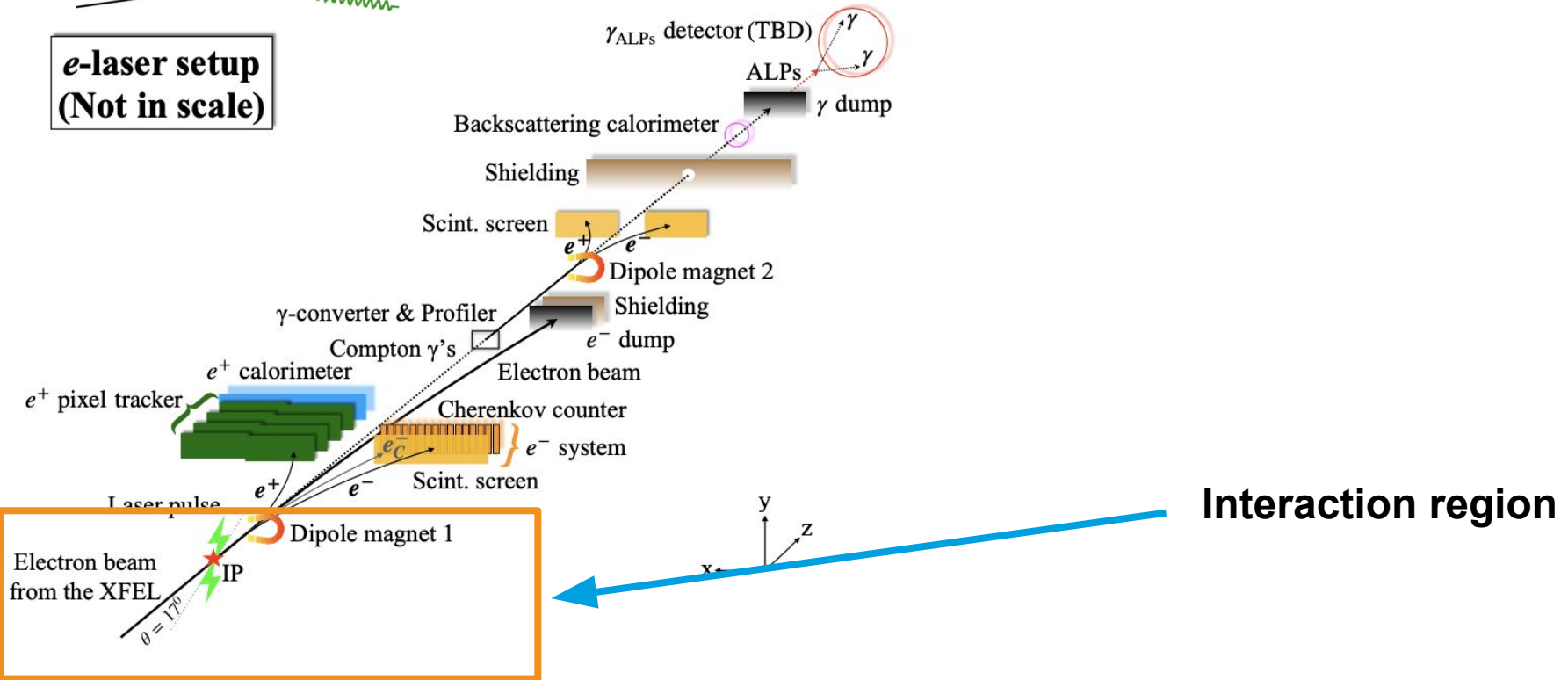


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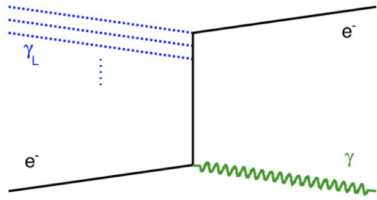


**e-laser setup  
(Not in scale)**

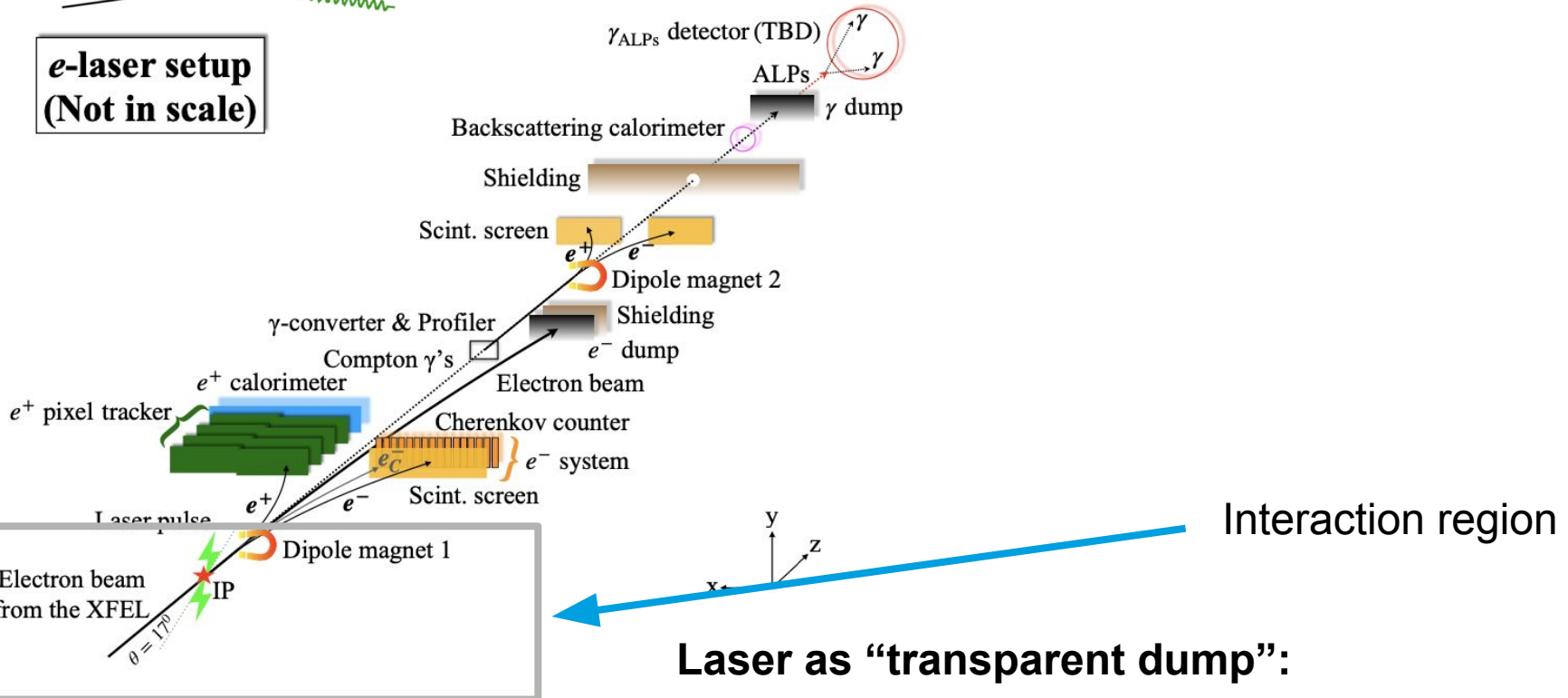


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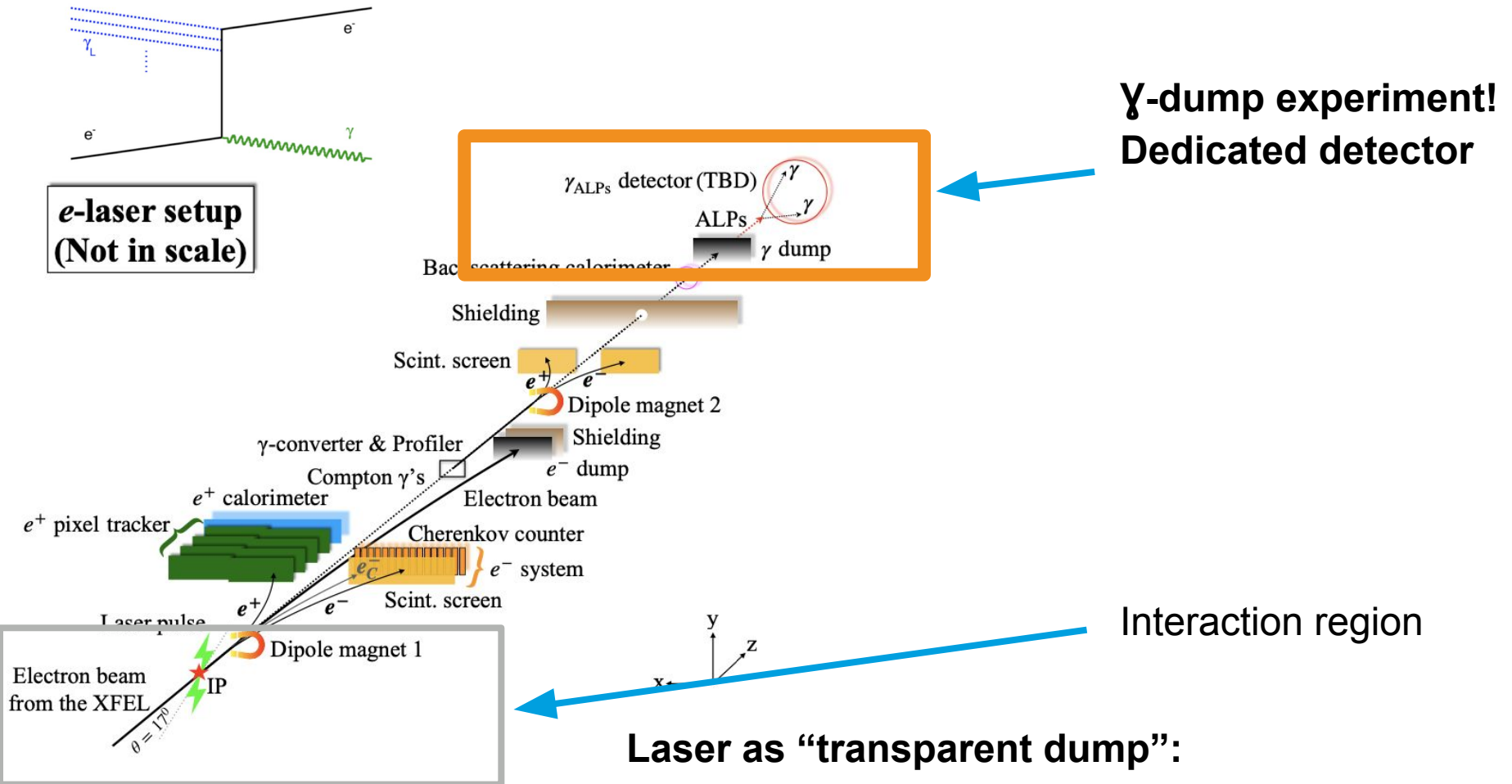


**Laser as “transparent dump”:**

- effective way of producing an intense GeV photon beam

# A novel type of beam dump experiment

## And a reminder of the experimental setup

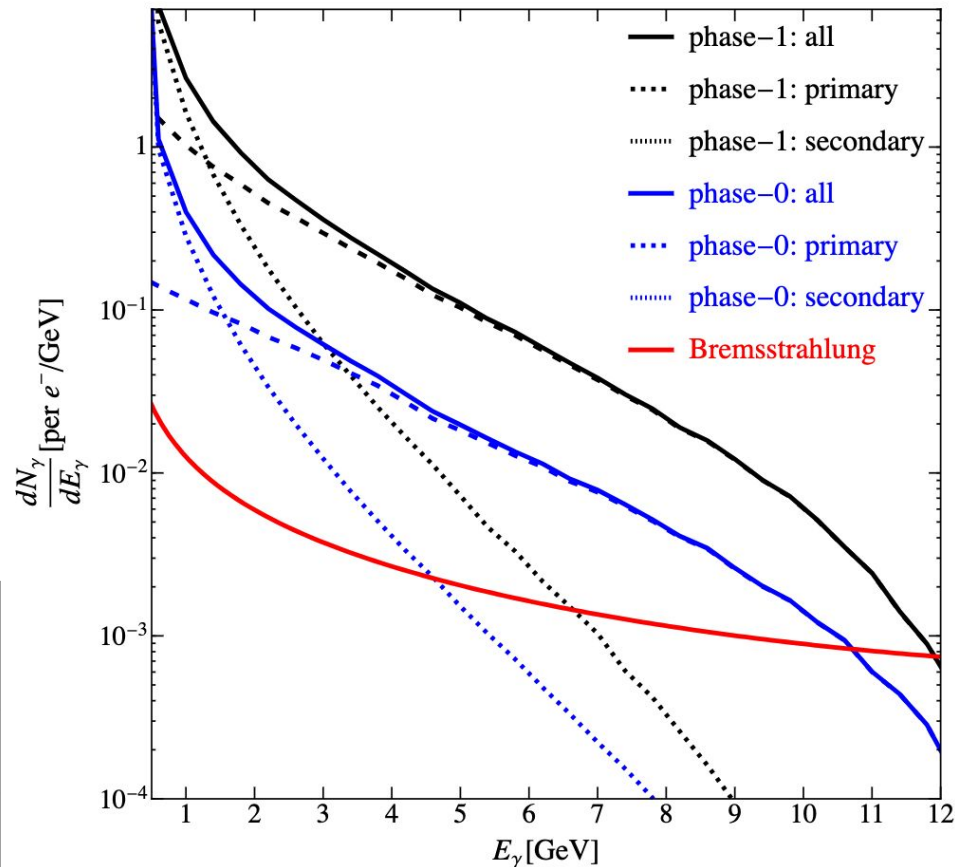


# The advantages of a “transparent dump”

A long laser pulse can transfer  $O(1)$  of the initial electron energy to the photons.

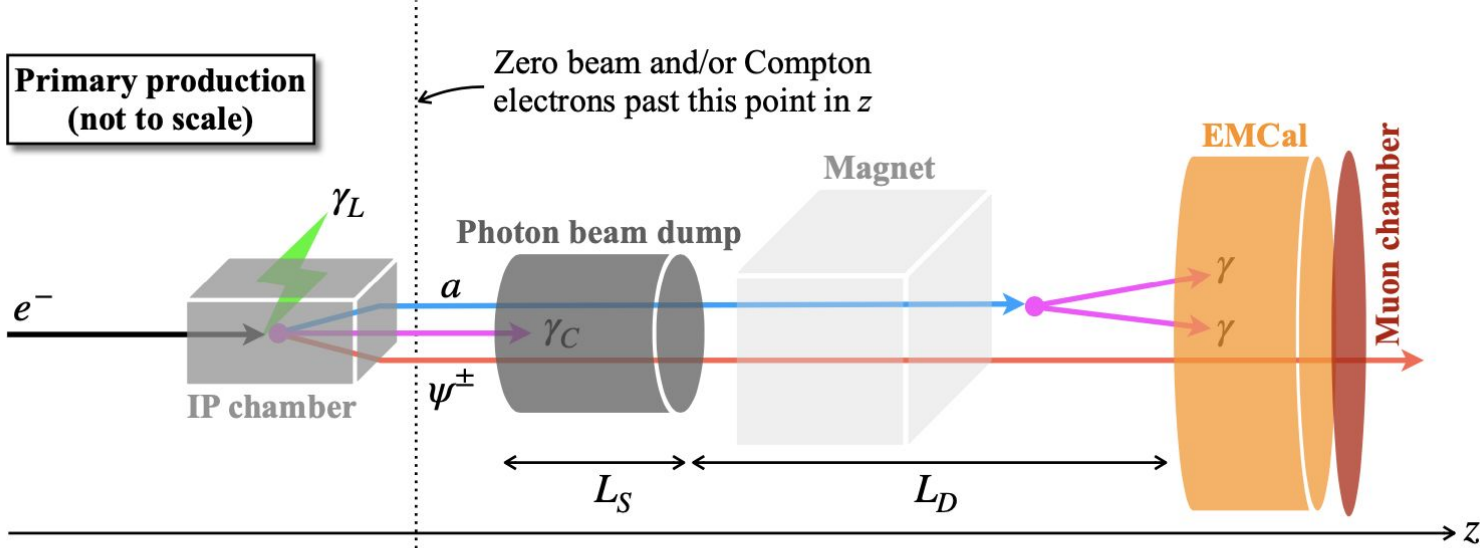
- Multiple GeV photons can be produced for every initial electron.
- Competitive with photon production from thin targets

$E_\gamma > 1$ GeV	#Photons (per $e^-$ )	Background (per $e^-$ )
<b>LUXE</b>	0.12 / 2.5	$\sim 0$
<b>Thin e-dump</b>	0.03	$\sim 0$
<b>Thick e-dump</b>	6.7	$\times 100$



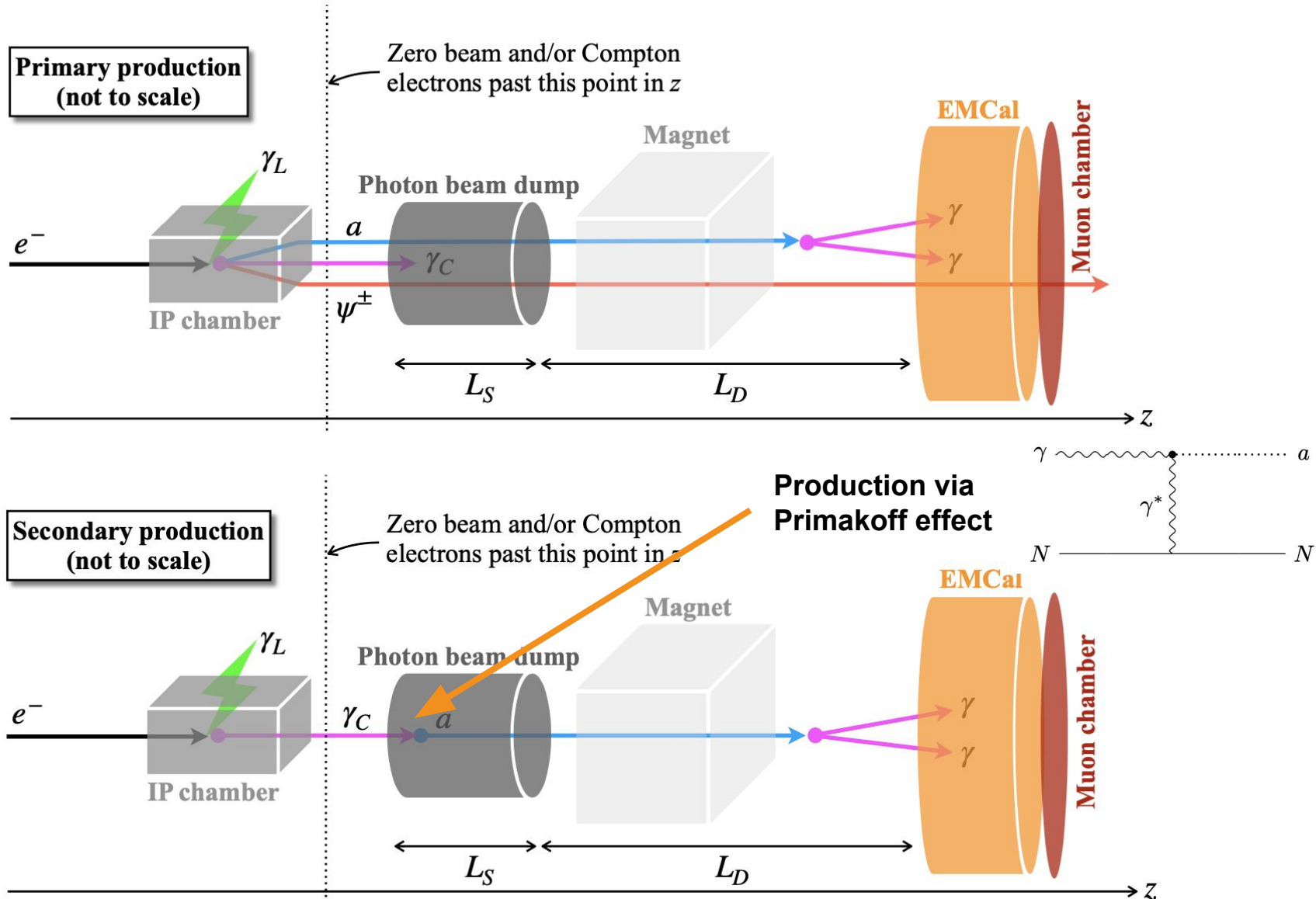
Bai, Blackburn, Borysov, Davidi,  
Hartin, Heinemann, Ma, Perez,  
Santra, Soreq, Tal Hod, [2107.13554](https://arxiv.org/abs/2107.13554)

# BSM production modes at LUXE





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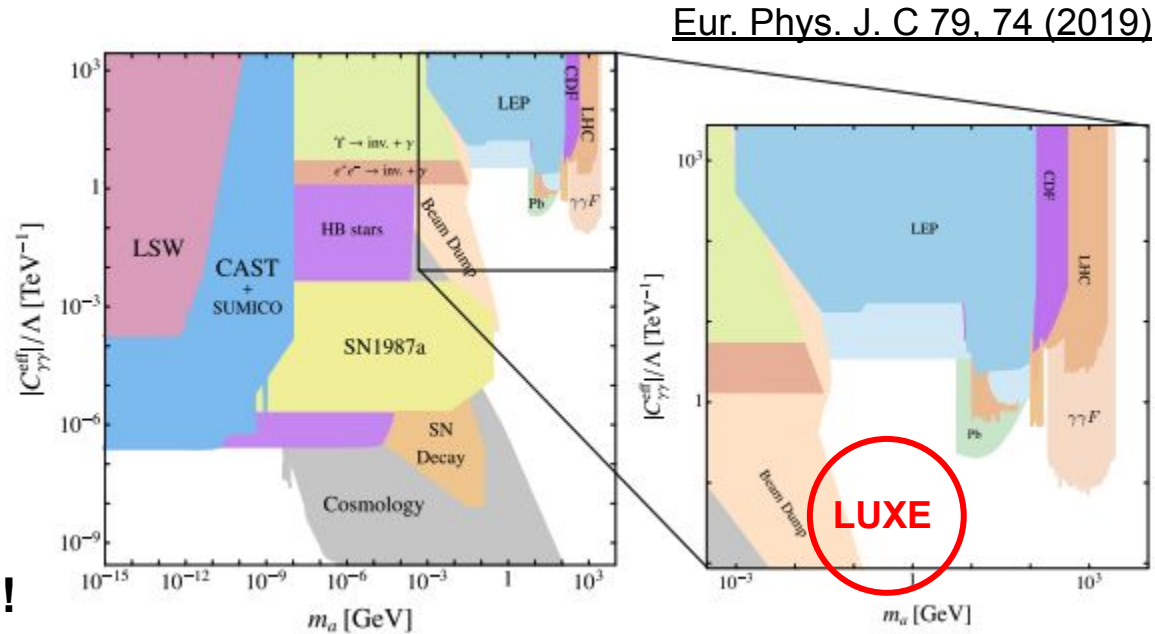
# A notable target, but not the only one

## Axion-like particles or new scalars

The Axion is part of a solution to the strong CP problem

- portal to dark matter and/or dark sector
- if very light, it is a dark matter candidate

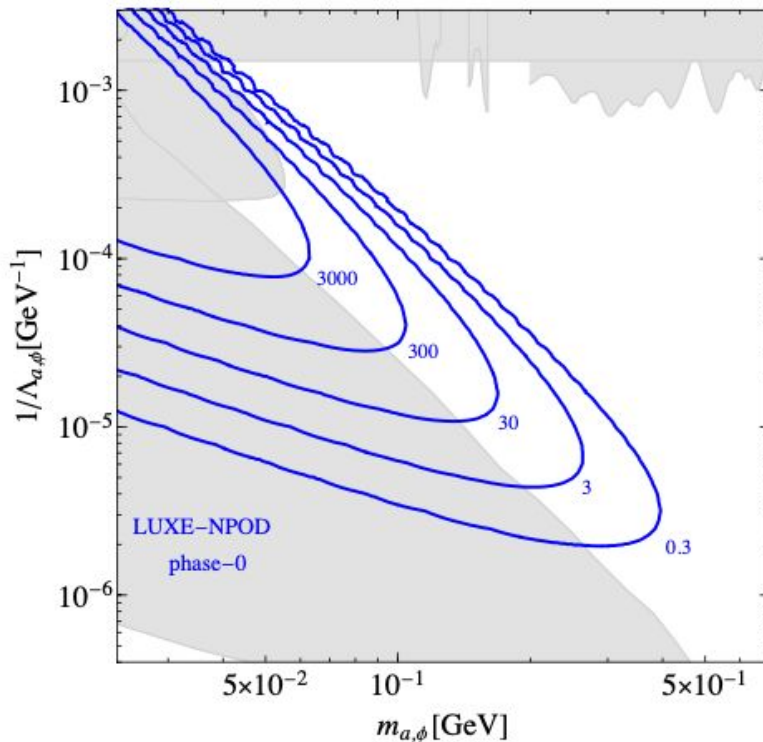
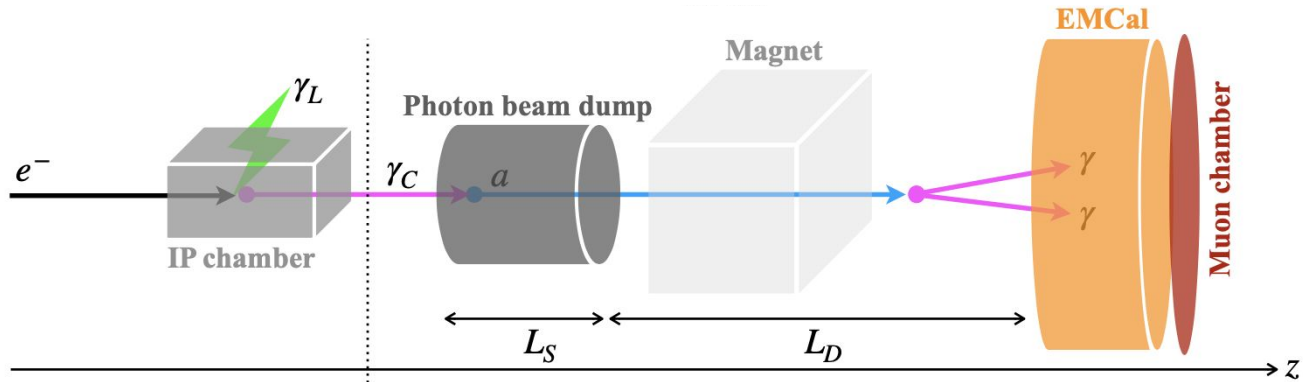
**Well motivated BSM scenario!**



However the experimental setup bears no prejudice against other model sharing the same signature:

- Look for generic (pseudo-)scalars as a function of mass and lifetime

# Expected signal yields



$$N_a \approx \mathcal{L}_{\text{eff}} \int dE_\gamma \frac{dN_\gamma}{dE_\gamma} \sigma_a \left( e^{-\frac{L_S}{L_a}} - e^{-\frac{L_D + L_S}{L_a}} \right) \mathcal{A}$$

$$E_e = 16.5 \text{ GeV}$$

$$N_e = 1.5 \times 10^9$$

$$N_{\text{BX}} = 10^7$$

EuXFEL parameters

$$\text{Dump depth } L_S = 1.0 \text{ m}$$

$$\text{Decay path } L_D = 2.5 \text{ m}$$

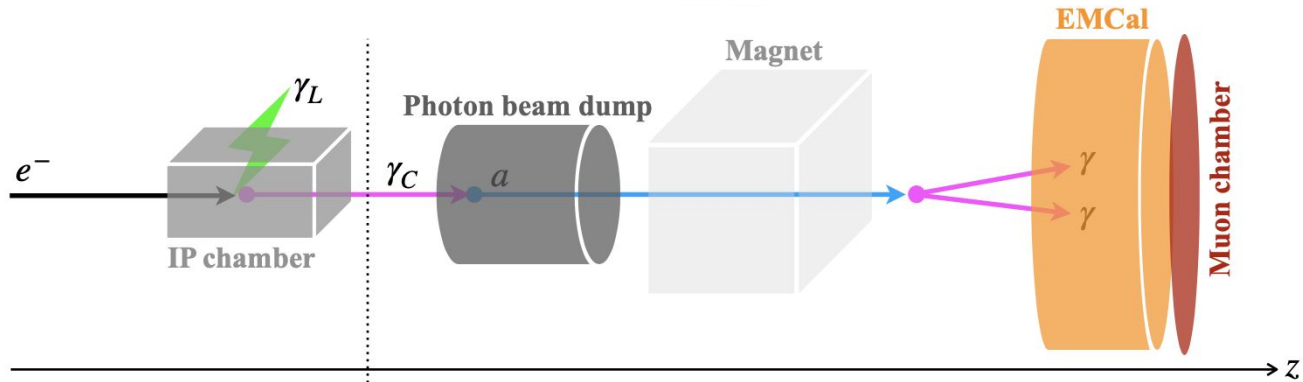
$$R_D = 1.0 \text{ m}$$

Experimental design

Absolute rate depends on:

- Geometrical acceptance
- Number of incoming photons

# Detection and measurement



**Assume (pseudo-) scalar to decay back into pairs of photons**

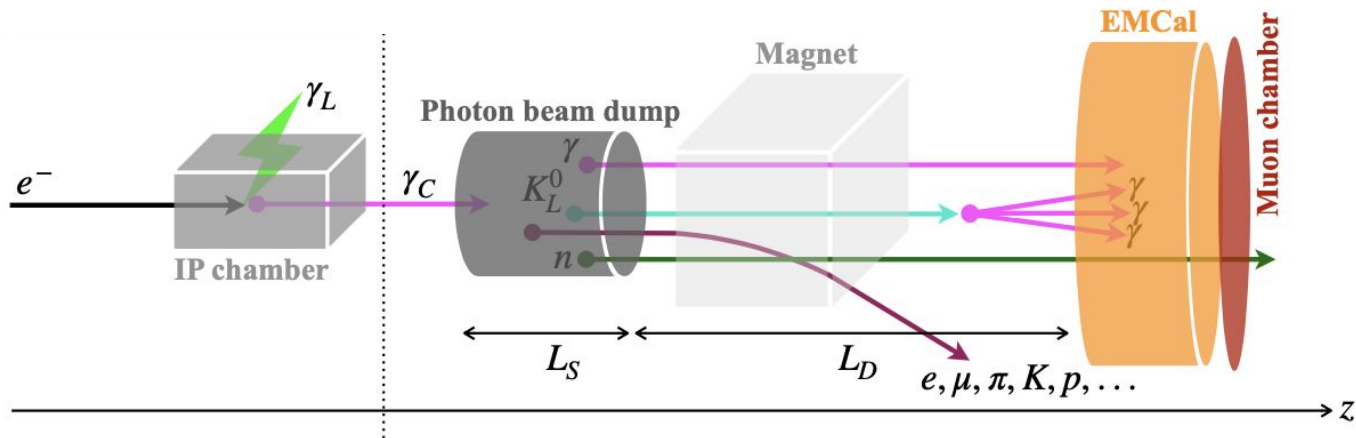
Plan to measure:

- Decay position
- Mass ( $m = \sqrt{[2 E_1 E_2 (1 - \cos \alpha)]}$ )

**Plan to use a calorimeter system with good pointing capabilities (intertwined tracking layers).**

- Need to optimise lever arm, tracking technology, and comply with available space in experimental area!

# Backgrounds



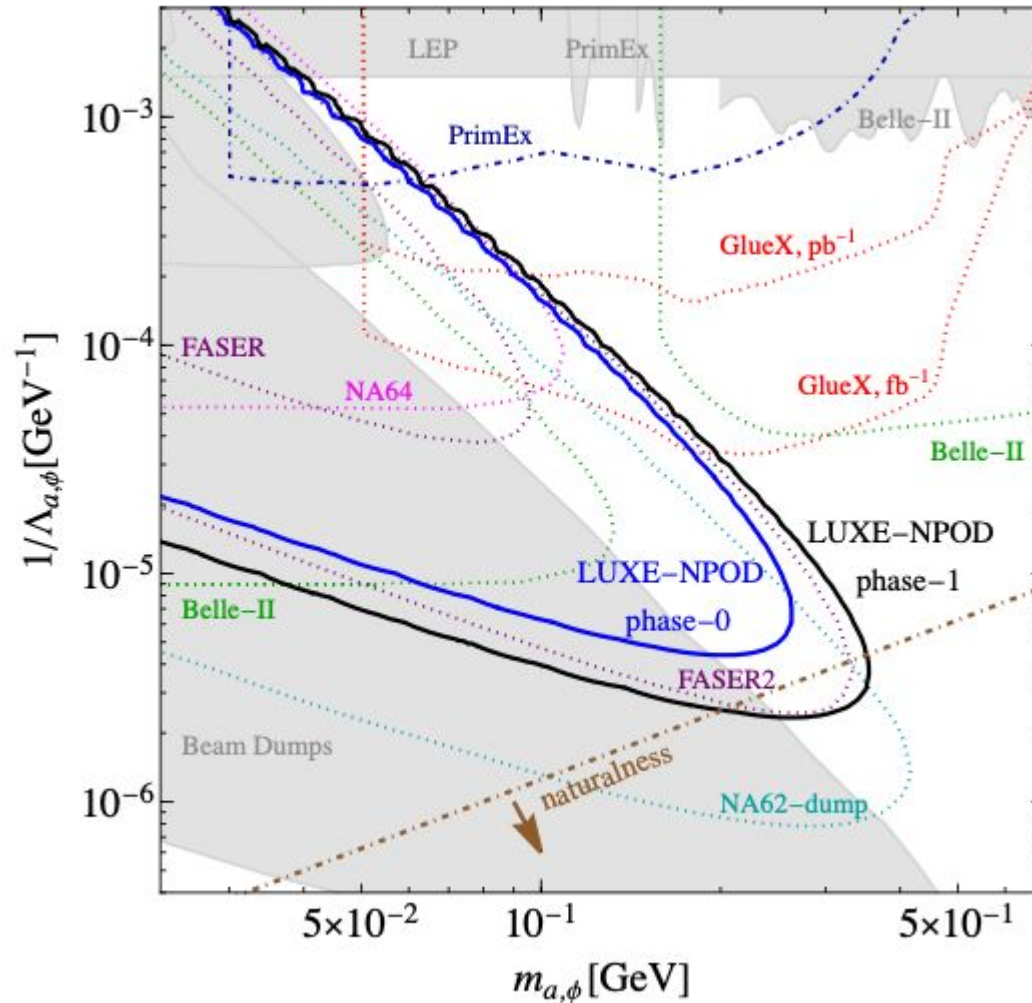
Initial estimation of the backgrounds emerging from the dump with GEANT4:

- charged particles - bent by a magnetic field (1.5 T of 1 m)
- fake photons
  - $N_{2n \rightarrow 2\gamma} \approx 5 \times 10^8 \times P_{2n \rightarrow 2\gamma}(f_{n \rightarrow \gamma}) \times R_{\text{sel}}$
  - $N_{n\gamma \rightarrow 2\gamma} \approx 1 \times 10^6 \times P_{n\gamma \rightarrow 2\gamma}(f_{n \rightarrow \gamma}) \times R_{\text{sel}}$
- real photons -  $N_{2\gamma} \approx 8 \times 10^2 \times R_{\text{sel}}$

Targets for the BSM detector to have  $O(1)$  background events

$$f_{n \rightarrow \gamma} \sim 10^{-3} \text{ and } R_{\text{sel}} \sim 10^{-3}$$

# Comparison with other experiments



# Summary

LUXE's main aim is to test QED in its non perturbative regime.

- Start data-taking in 2025

However, LUXE can function as a **novel photon source** to create an intense GeV-scale photon beam to look for new physics in a **beam dump experiment**.

New ALP parameter space can be explored: masses up to  $O(350)$  MeV and decay constant of  $O(10^5 - 10^6)$  GeV, competitive with other experiments.

The detector requirements are known, and the development has just started.

- Plenty of space to experiment with new ideas!

**Thank you!**