

Probing New Physics at the LUXE Experiment

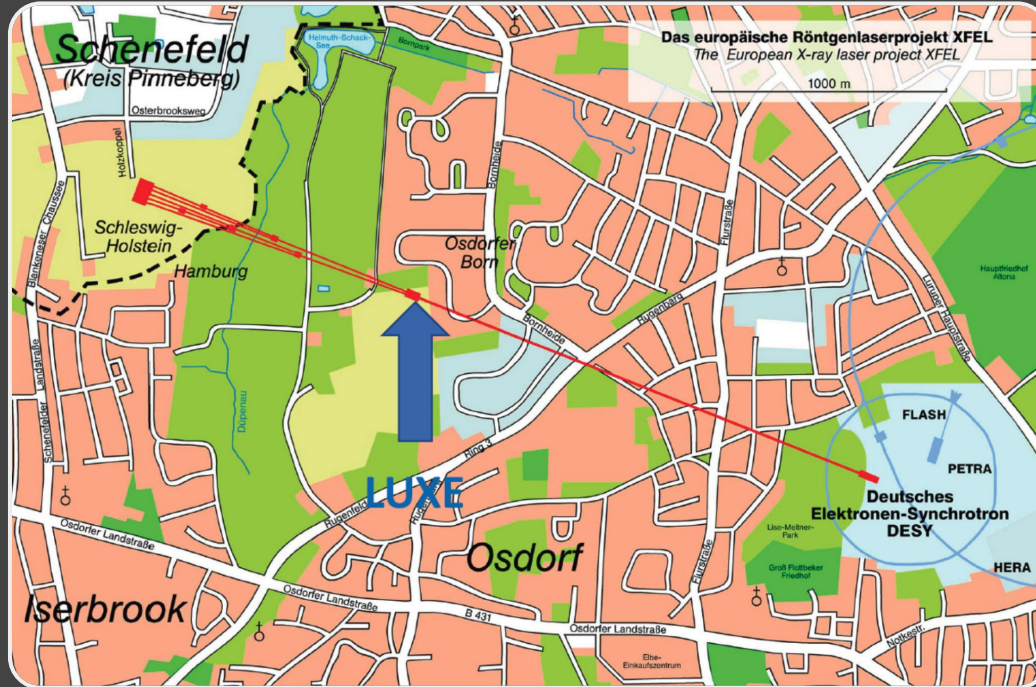


LUXE

Ivo Schulthess on behalf of the LUXE collaboration
21. June 2023 - LLP 13 Workshop
Deutsches Elektronen-Synchrotron DESY

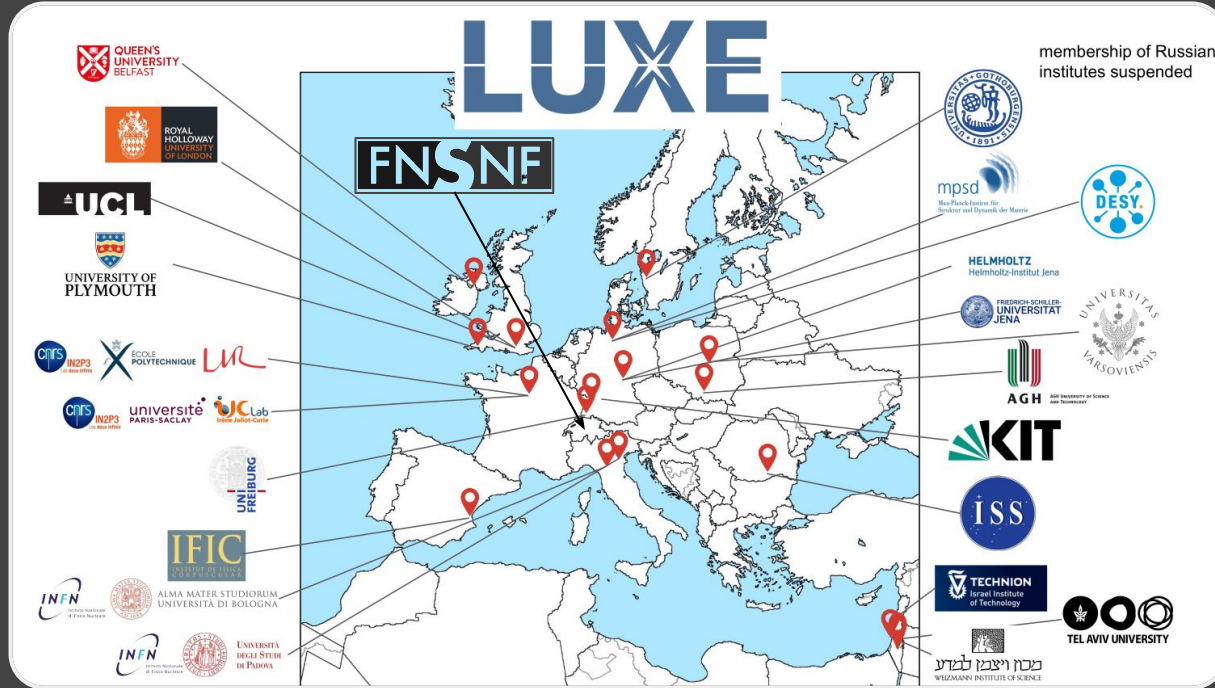
DESY Site

The European XFEL and the *Laser Und XFEL Experiment* LUXE



LUXE

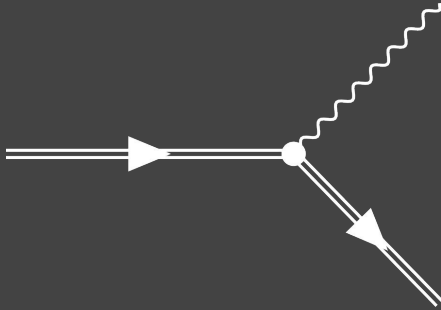
The Collaboration



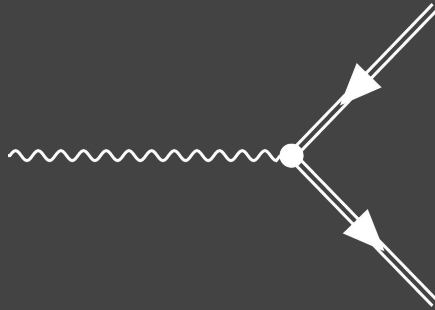
LUXE

Testing QED in the Strong-Field Regime

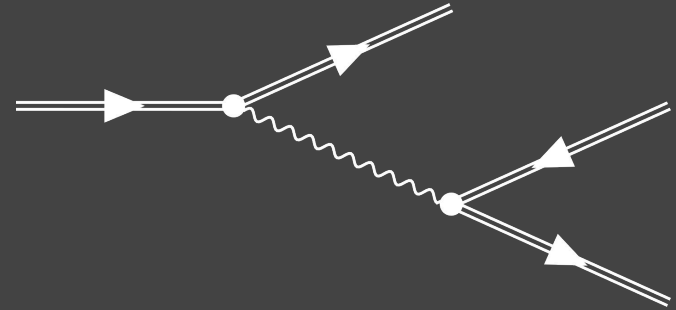
non-linear Compton
 $e^\pm \rightarrow e^\pm + \gamma$



non-linear Breit-Wheeler
 $\gamma \rightarrow e^+e^-$

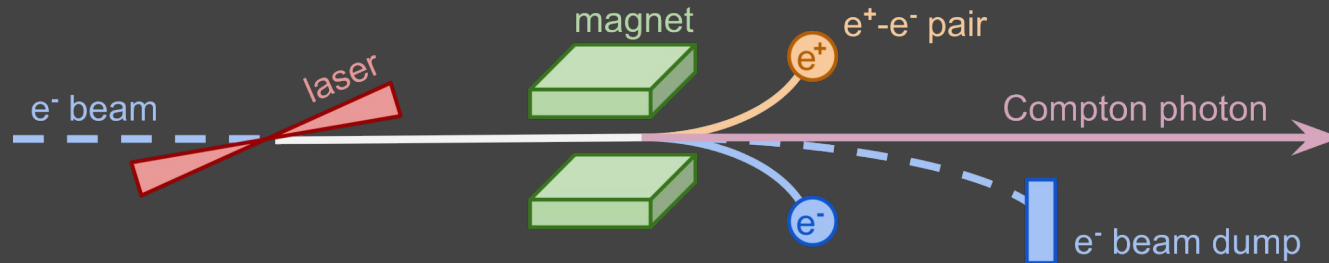


non-linear trident
 $e^\pm \rightarrow e^\pm + e^+e^-$



LUXE

Experimental Schematic: Electron-Laser Mode



electrons

- 10 Hz bunches
- up to 17.5 GeV
- 10^9 e^- /bunch

laser

- 1 Hz
- 40 TW (phase-0)
- 350 TW (phase-1)

photons

- 3.5 γ/e^-
- 1.7 γ/e^- (>1 GeV)

LUXE-NPOD

Photon Garbage Collector → New Physics

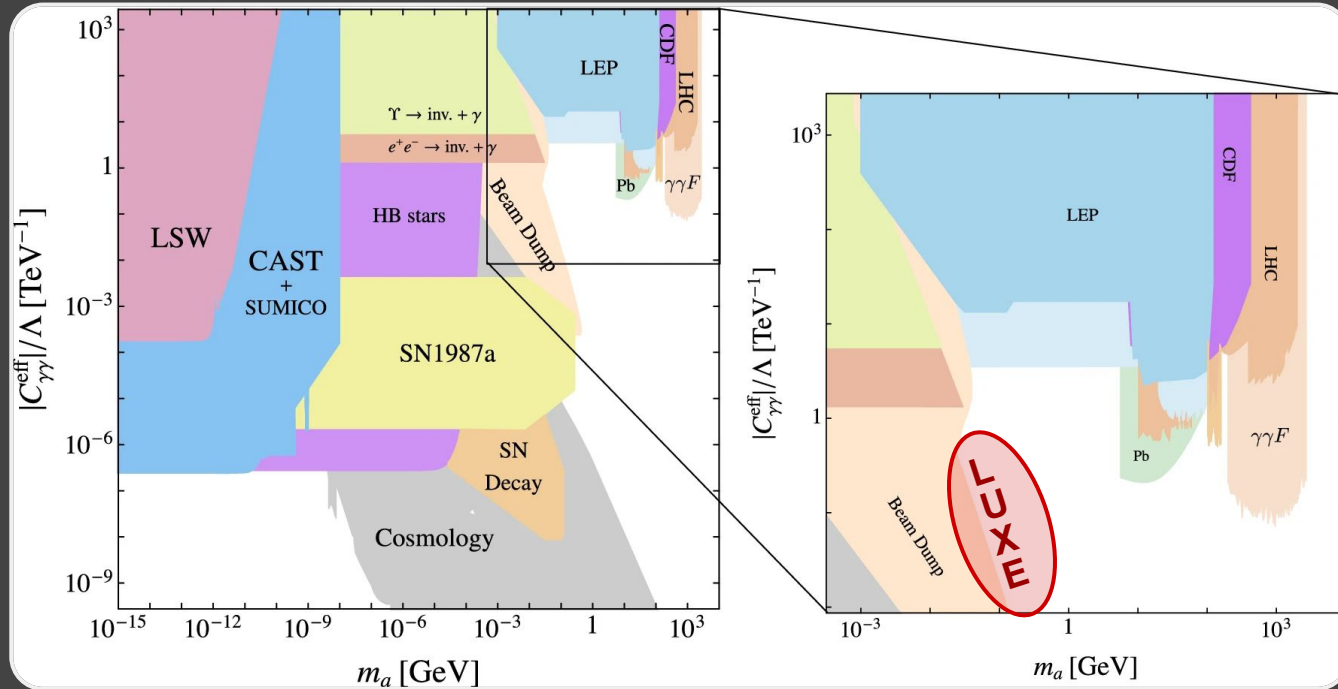
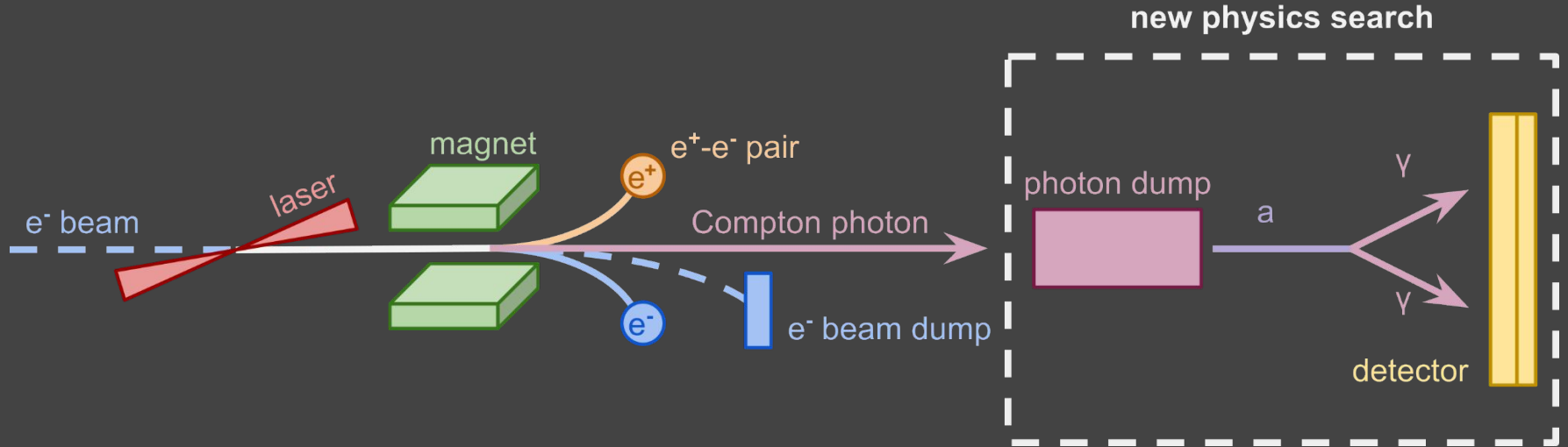


figure adapted from Bauer, M. et al. *Axion-like particles at future colliders*. Eur. Phys. J. C 79, 74 (2019).

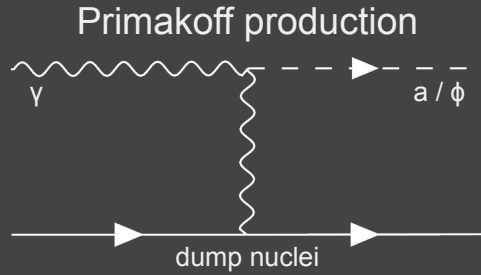
LUXE-NPOD

New Physics at Optical Dump NPOD

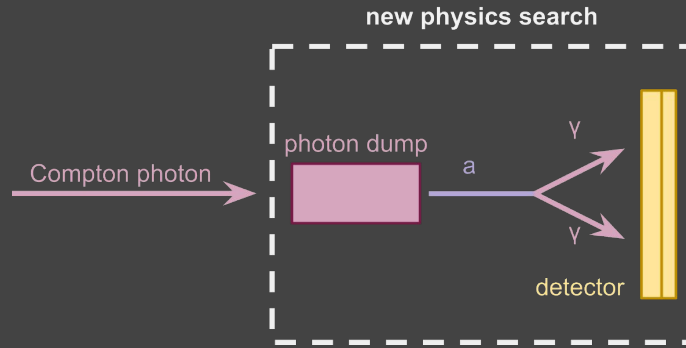


LUXE-NPOD

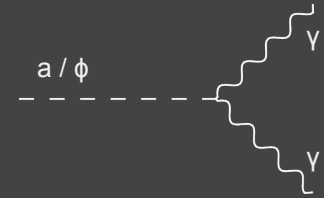
Production and Decay Mechanisms



$$\mathcal{L}_a = \frac{a}{4\Lambda_a} F_{\mu\nu} \tilde{F}^{\mu\nu}$$



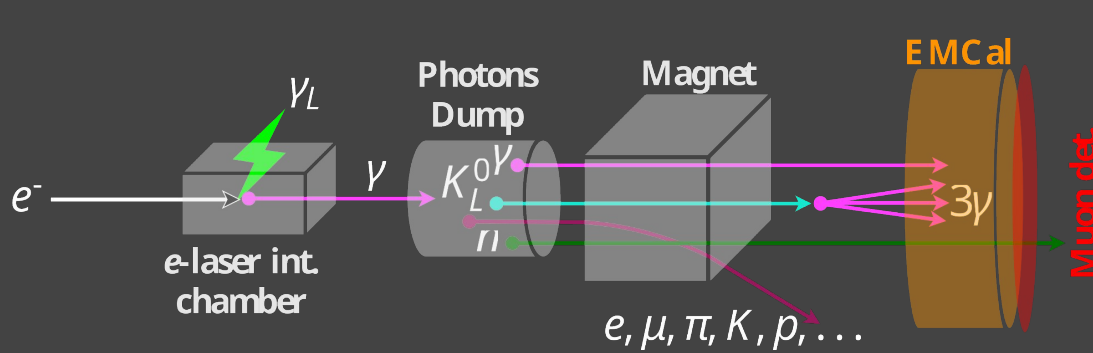
photon decay channel



$$\Gamma_{a \rightarrow 2\gamma} = \frac{m_a^3}{64\pi\Lambda_a^2}$$

LUXE-NPOD

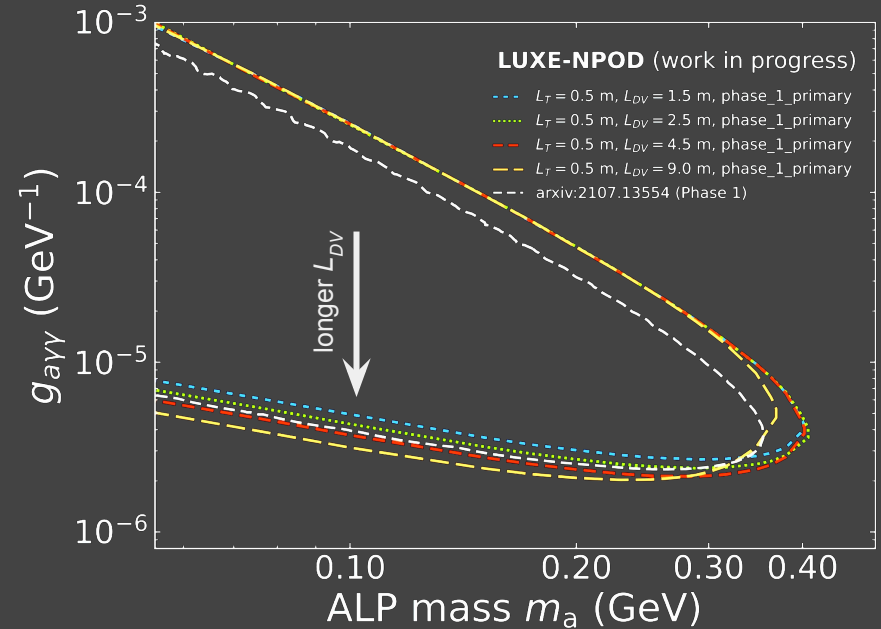
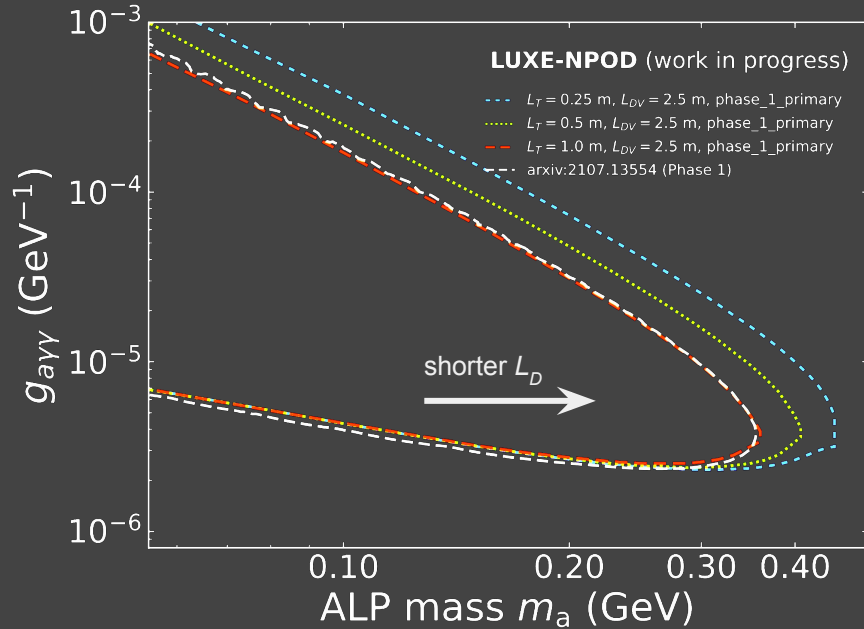
Background Estimation



	LUXE NPOD	LUXE e^- on dump
N_a	4	16.5
N_{BG}	0.8	156.1
SNR	5	0.1

LUXE-NPOD

Photon Dump and Decay Volume Optimization



LUXE-NPOD

Expected Phase-Space Coverage

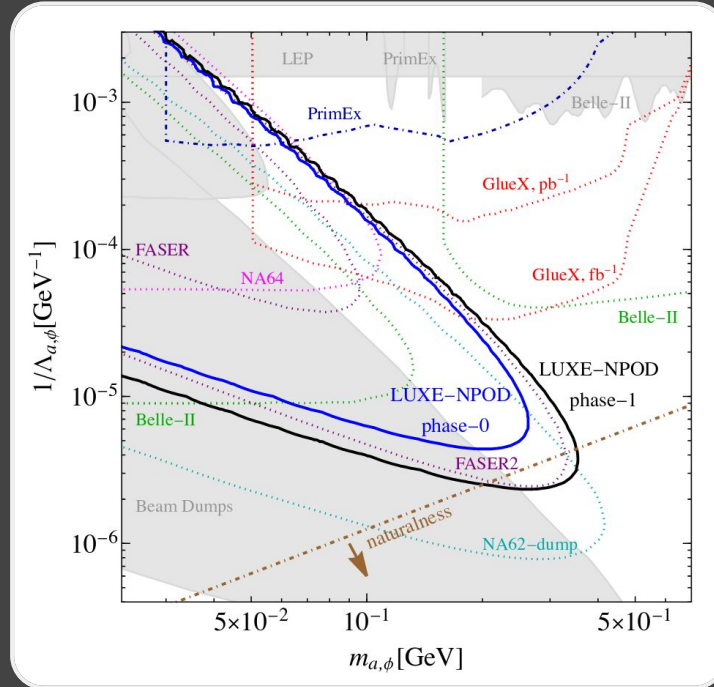
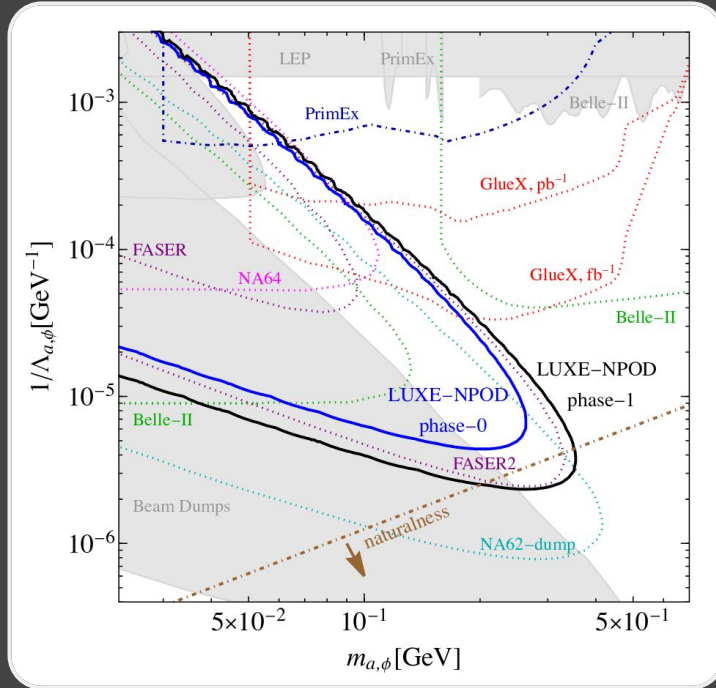


figure from: 10.1103/PhysRevD.106.115034

LUXE-NPOD

Conclusion

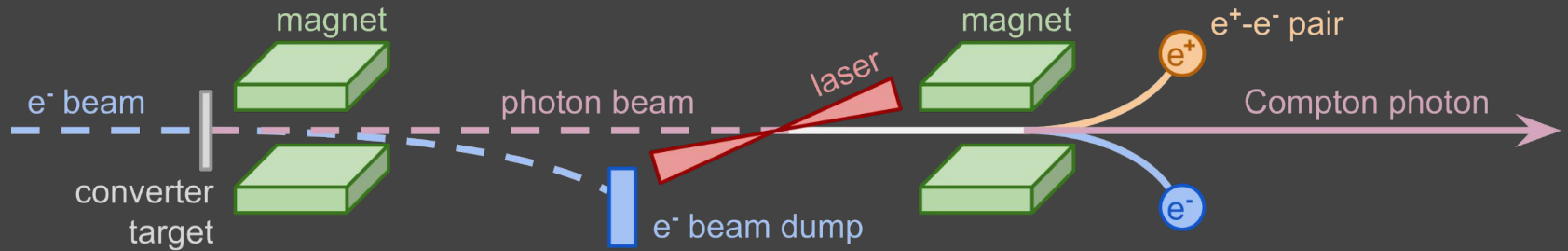


- LUXE can test strong-field QED
- LUXE-NPOD can cover new phase space of a/ϕ
- only 1 year of data taking in parasitic mode
- NPOD concept applicable to other experiments

Backup

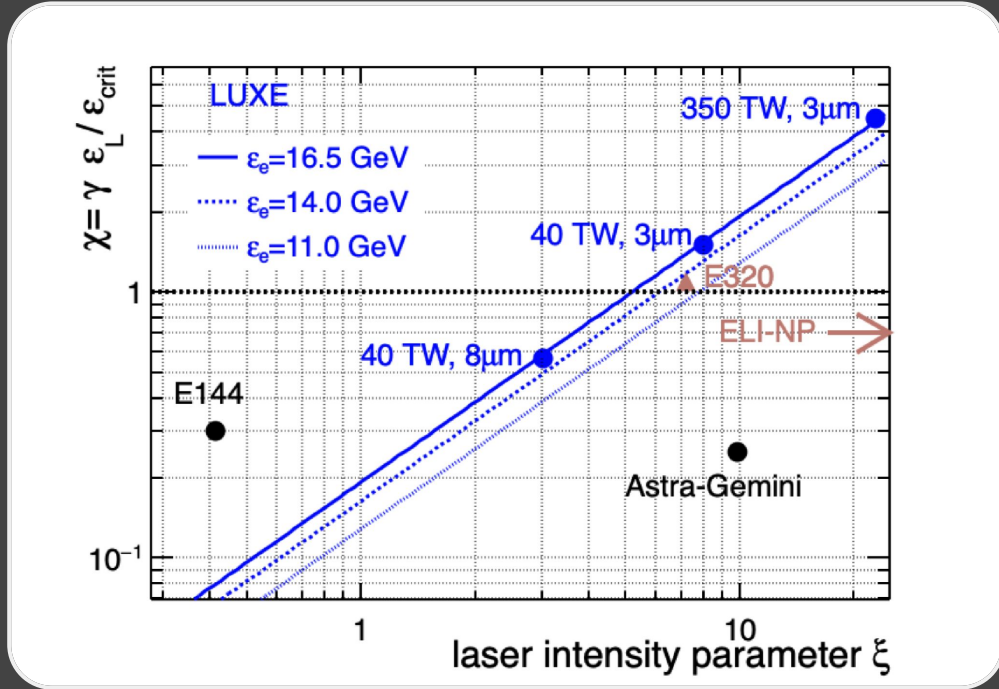
LUXE

Experimental Schematic: Photon-Laser Mode



LUXE

Strong-Field QED Goals



quantum parameter

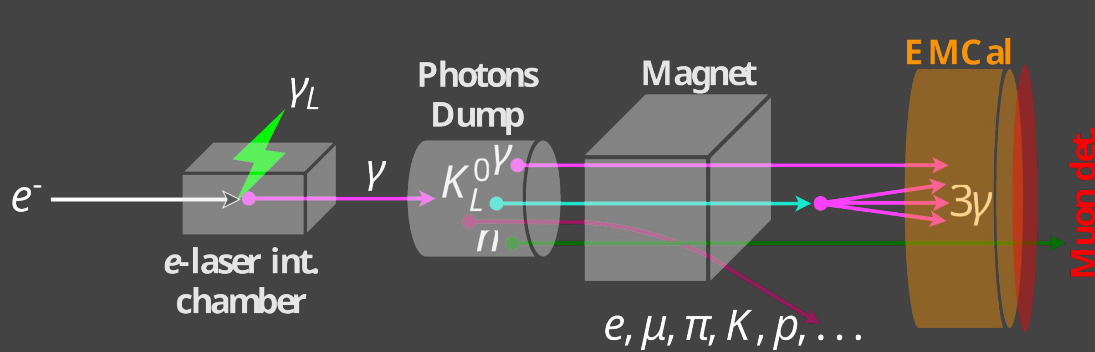
$$\chi_\gamma = (1 + \cos \theta) \frac{E_\gamma \epsilon_L}{m_e \epsilon_c}$$

field intensity parameter

$$\xi = \sqrt{4\pi\alpha} \left(\frac{\epsilon_L}{\omega_L m_e} \right) = \frac{m_e \epsilon_L}{\omega_L \epsilon_c}$$

LUXE-NPOD

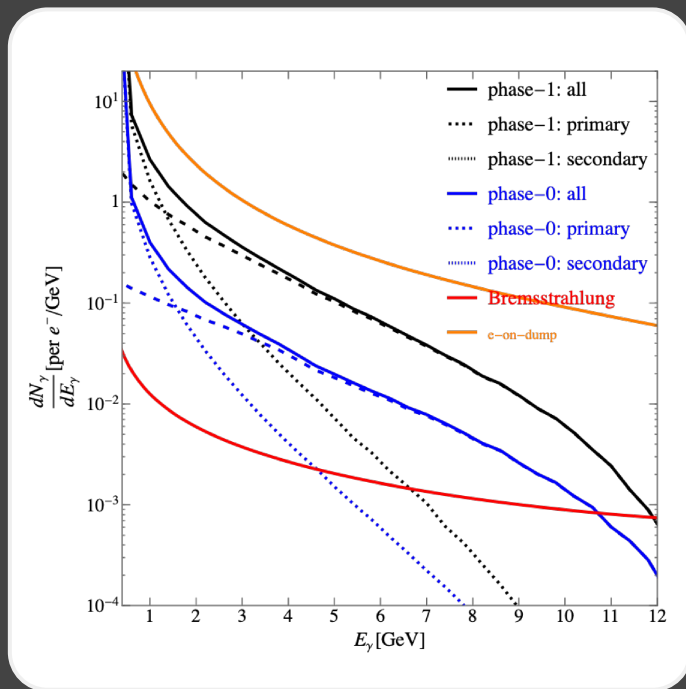
Background Estimation



	LUXE NPOD	LUXE e^- on dump
$N_{2\gamma}$	0.4	133.9
$N_{2n \rightarrow 2\gamma}$	0.1	1.1
$N_{\gamma+n \rightarrow 2\gamma}$	0.3	21.1

LUXE-NPOD

Photon Number Estimation



Prospects

Prospects of an NPOD at the *International Linear Collider* ILC

