Massive pseudoscalar production at LUXE

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LUXE Workshop, DESY

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Ljubljana

A. Hartin, A. Ringwald and N. Tapia
DESY
Hamburg

Outline

Why massive pseudoscalars?

Why massive pseudoscalars? strong CP problem

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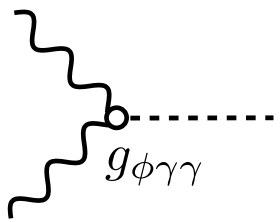

$$g_{\phi\gamma\gamma}\,\phi\,\mathrm{tr}\, F \cdot \widetilde{F}$$

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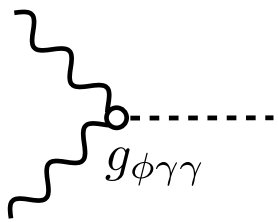

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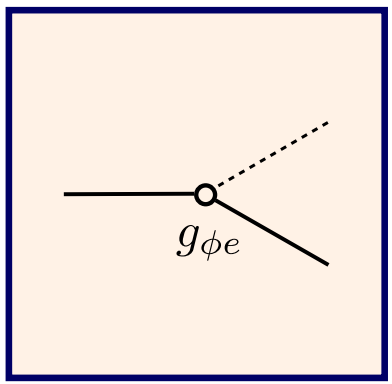
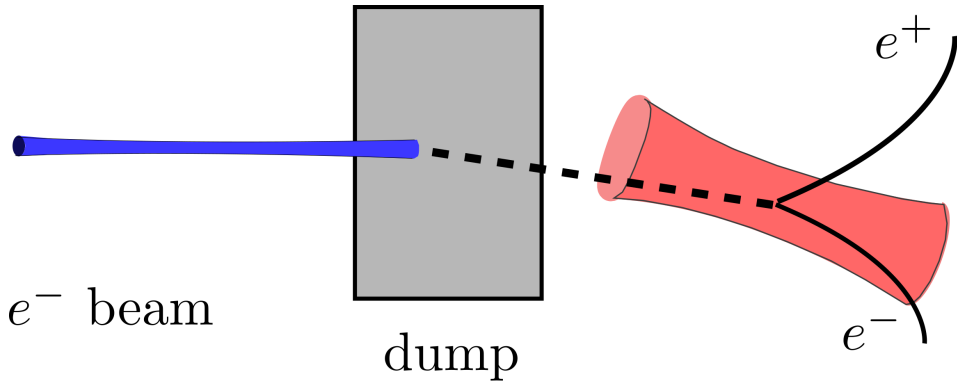


$g_{\phi e}\,\phi\,\overline{\psi}\gamma_5\psi$

Possible experimental set-up: #1



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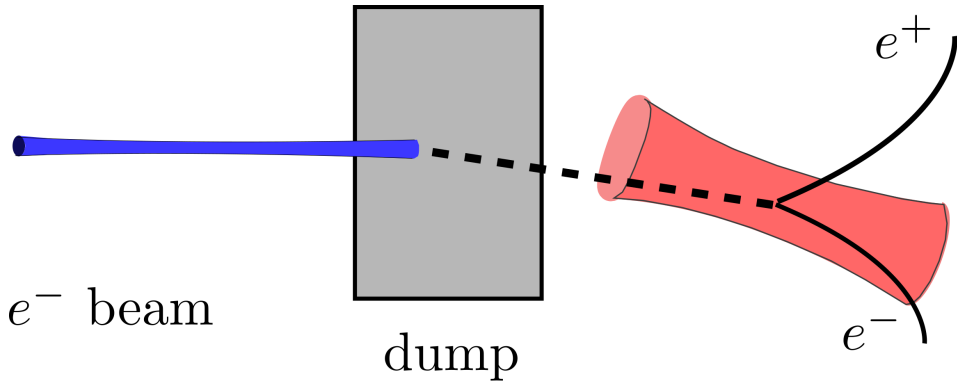

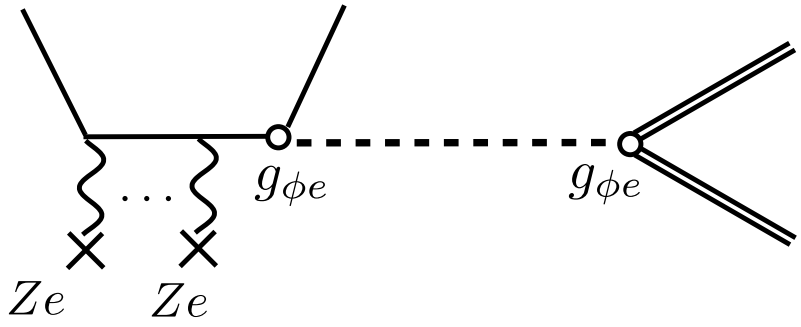

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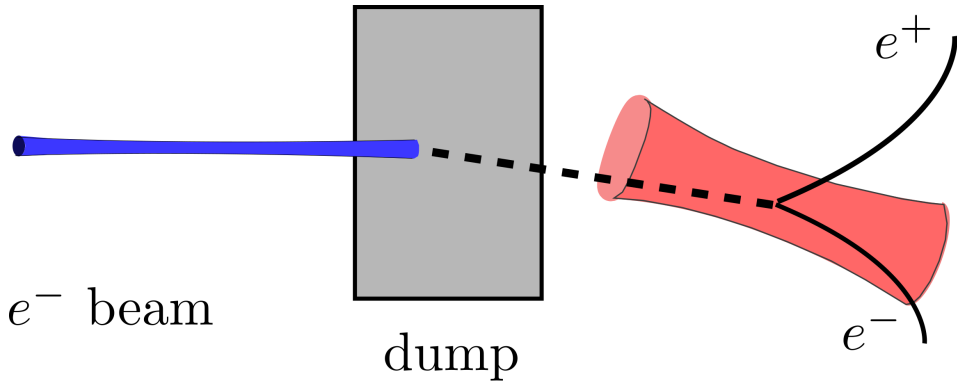

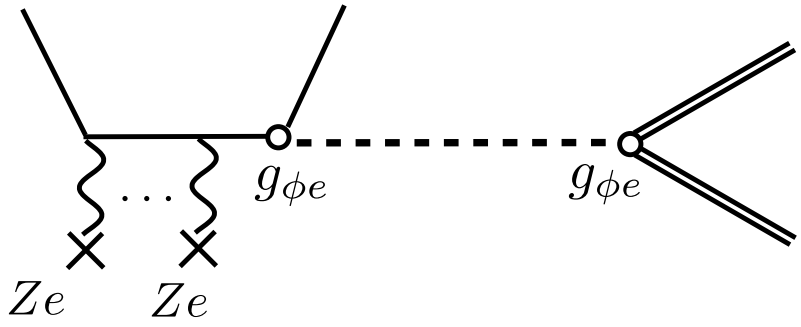

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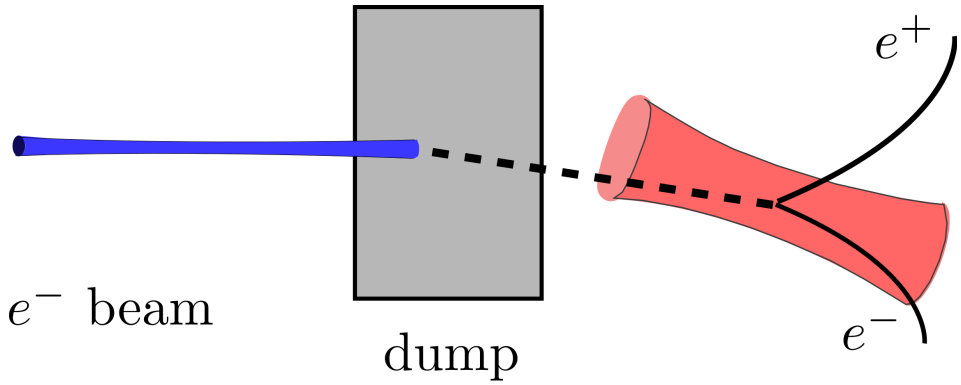

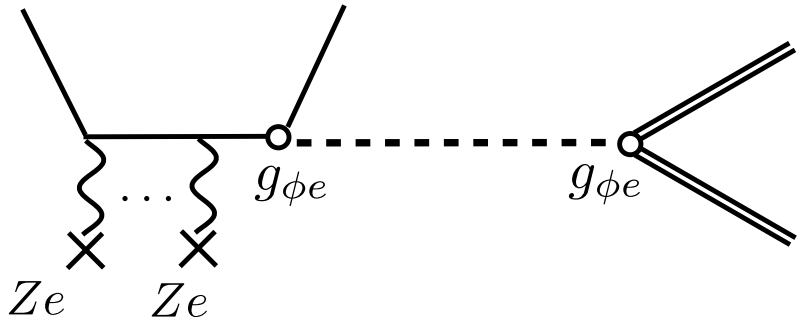

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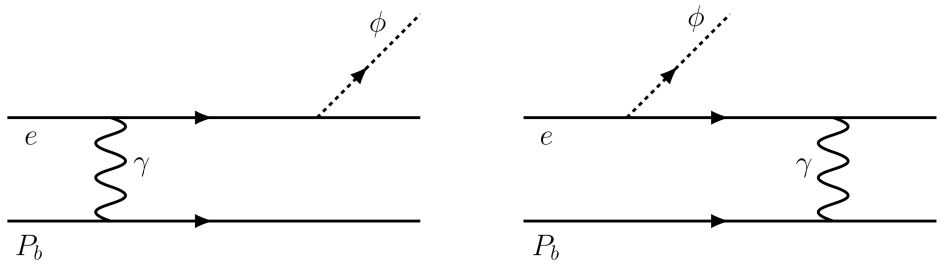
ξ (or: a_0), $\qquad \chi = \xi \dfrac{\varkappa \cdot p}{m^2} \approx 2\,\xi \omega_1 \gamma_e$

Beam dump probe



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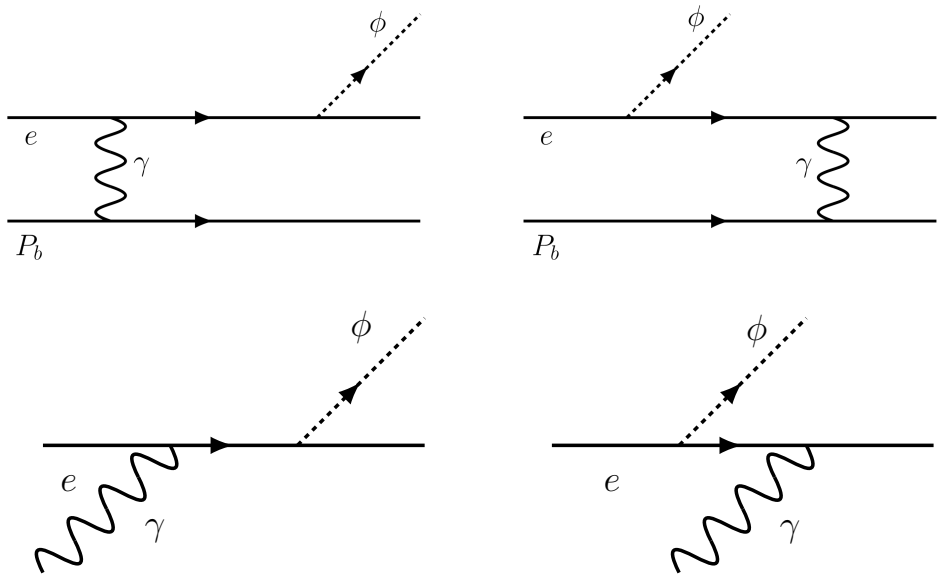

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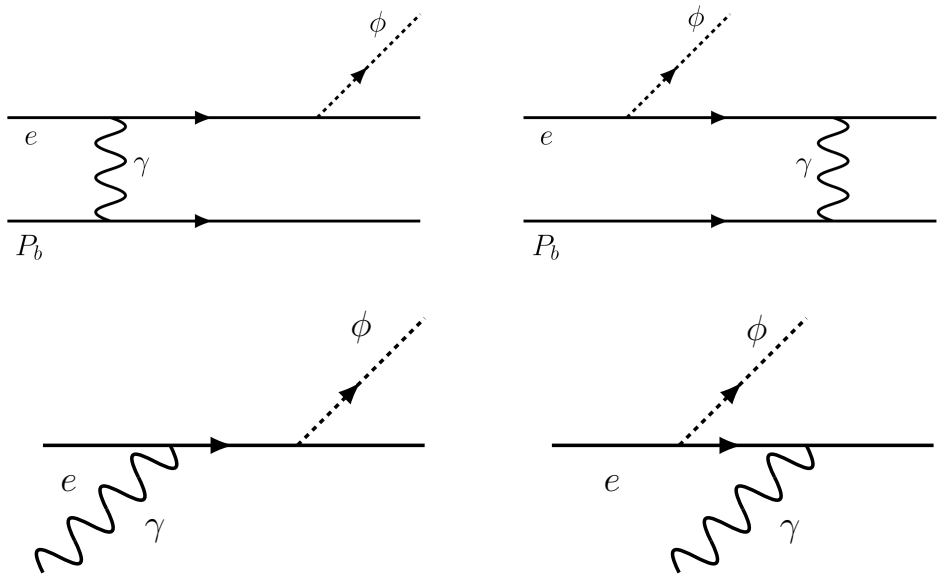
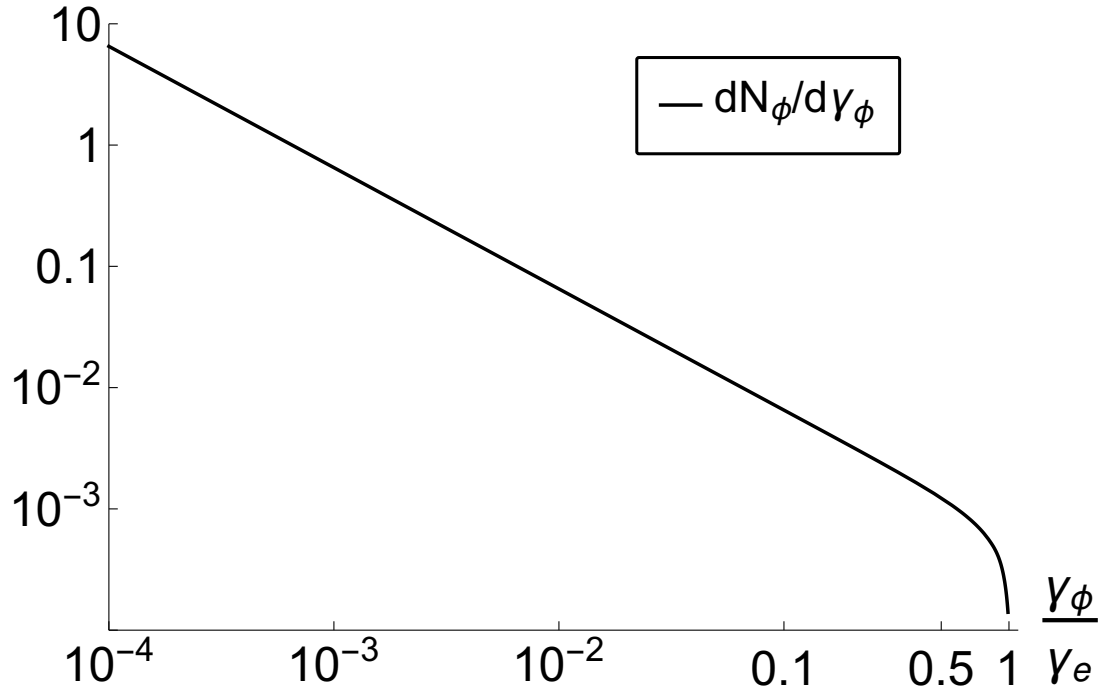


$$\frac{d\sigma}{d\gamma_\phi d\Omega_\phi} = \frac{\alpha^2 g_{\phi e}^2}{\pi} \frac{\gamma_e}{U^2} \left[x^3 - 2\delta^2 \frac{m_e^2}{U} x^2(1-x) + 2\delta^2 \frac{m_e^4}{U^2} \left(x^3(1-x) + \delta^2 x(1-x) \right) \right]$$

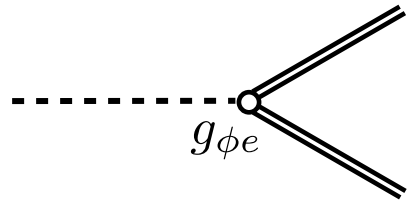
$$U = x E_e^2 \theta_\phi^2 + m_e^2 \left(x + \delta^2 \frac{1-x}{x} \right); \quad x = \frac{\gamma_\phi}{\gamma_e}; \quad \delta = \frac{m_\phi}{m_e}$$

Y.-S. Tsai, *Axion Bremsstrahlung by an electron beam*, Phys. Rev. D **34**, 1326 (1986)

Beam dump probe spectrum



Axionic pair creation



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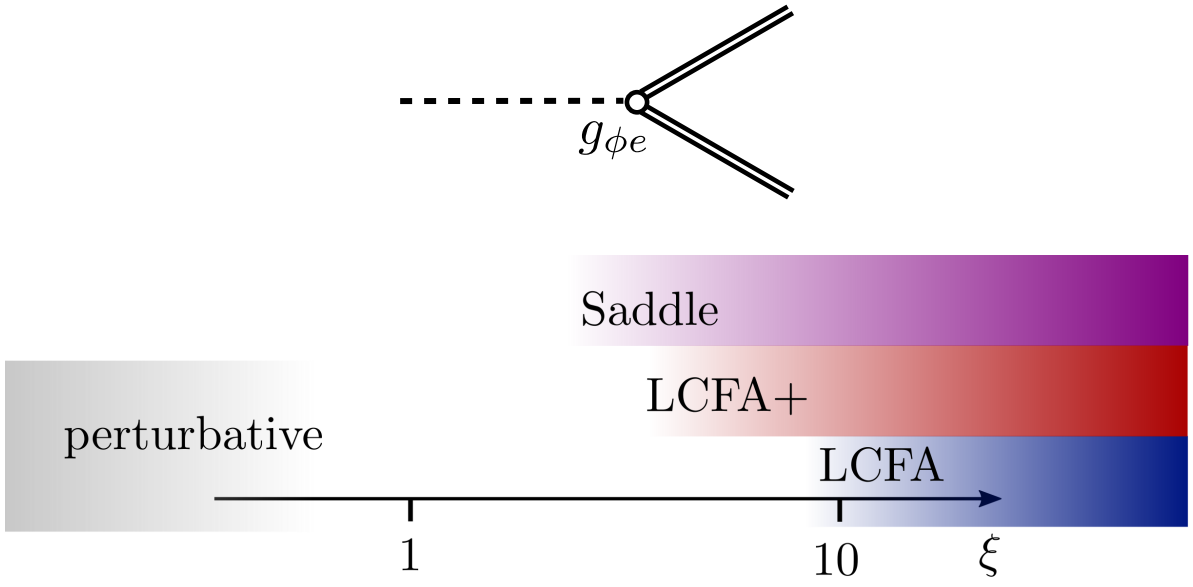

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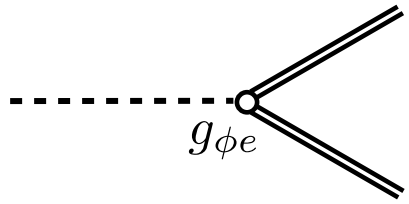

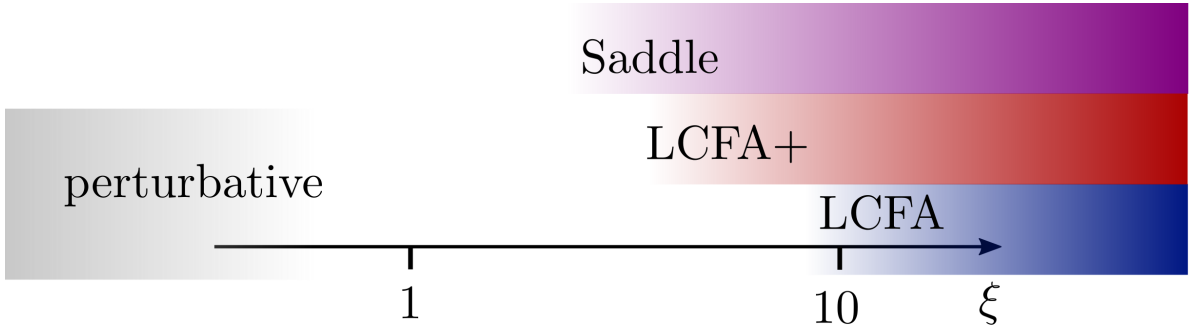

$$2n\frac{\omega_l}{m}\gamma_\phi \approx \delta^2 + (1+\xi^2)\frac{\gamma_\phi^2}{\gamma_e(\gamma_\phi - \gamma_e)}$$

$$0.4\, n\, \omega_l[1.55\,\mathrm{eV}]\ \gamma_\phi[17.5\,\mathrm{GeV}] \approx \delta^2 + (1+\xi^2)\underbrace{\frac{\gamma_\phi^2}{\gamma_e(\gamma_\phi - \gamma_e)}}_{\geq 0.5}$$

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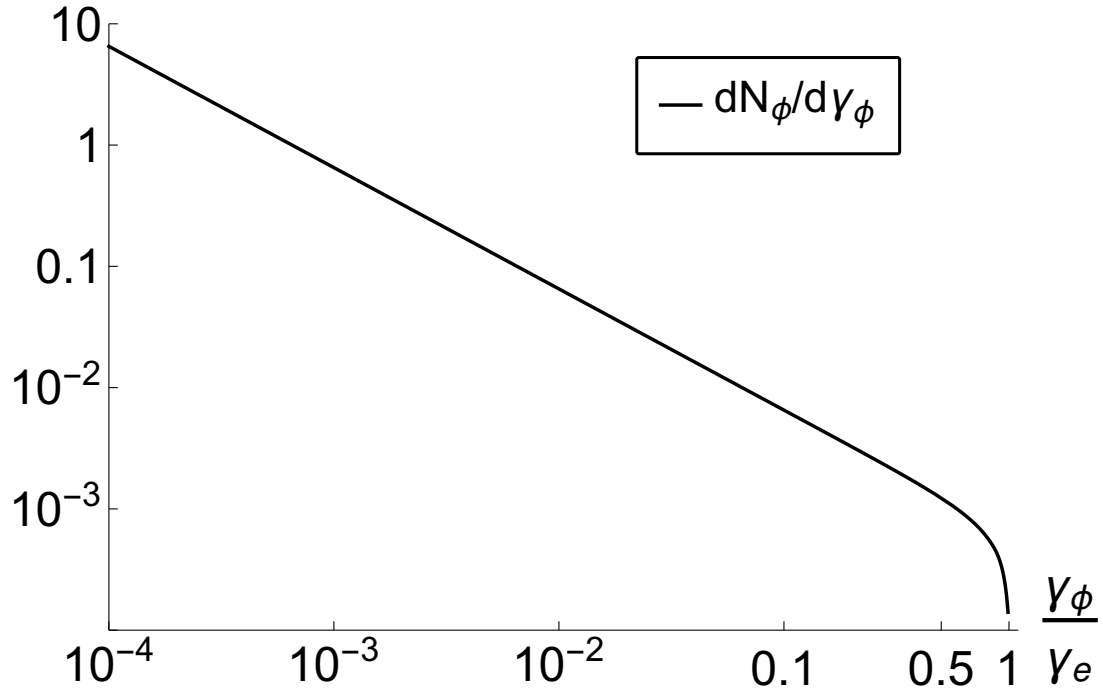
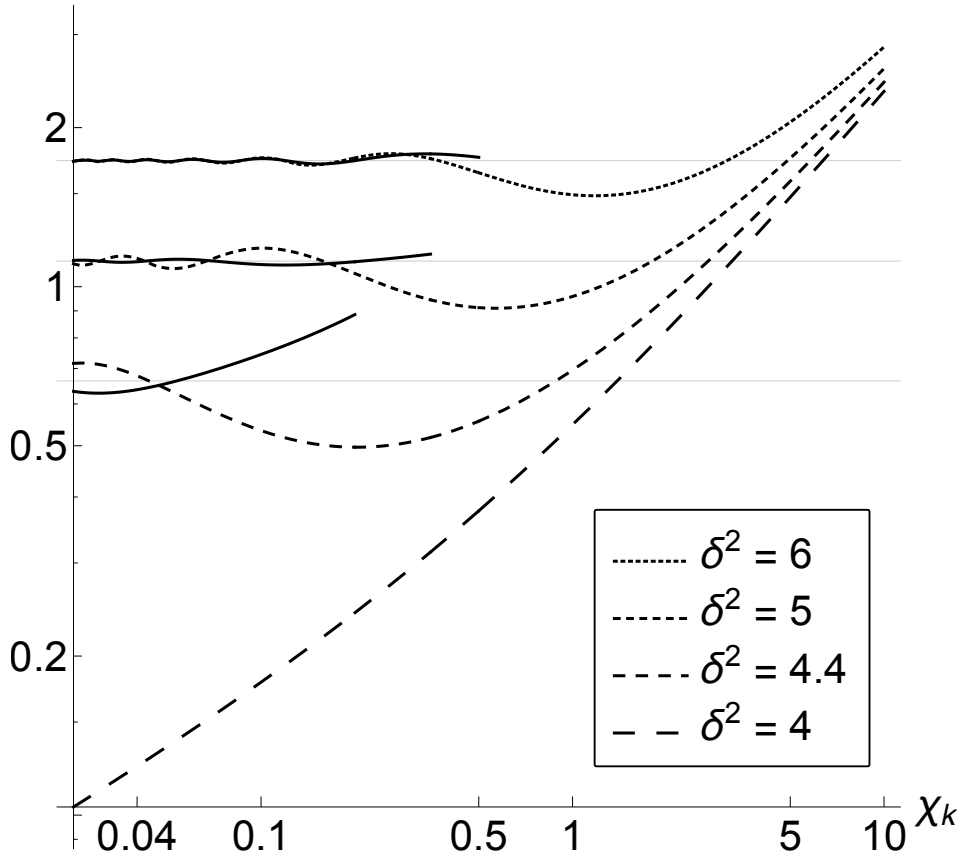


Axionic pair creation: Const Crossed Field local rates



B. King, B. Dillon, K. Beyer and G. Gregori (in preparation) (2019)

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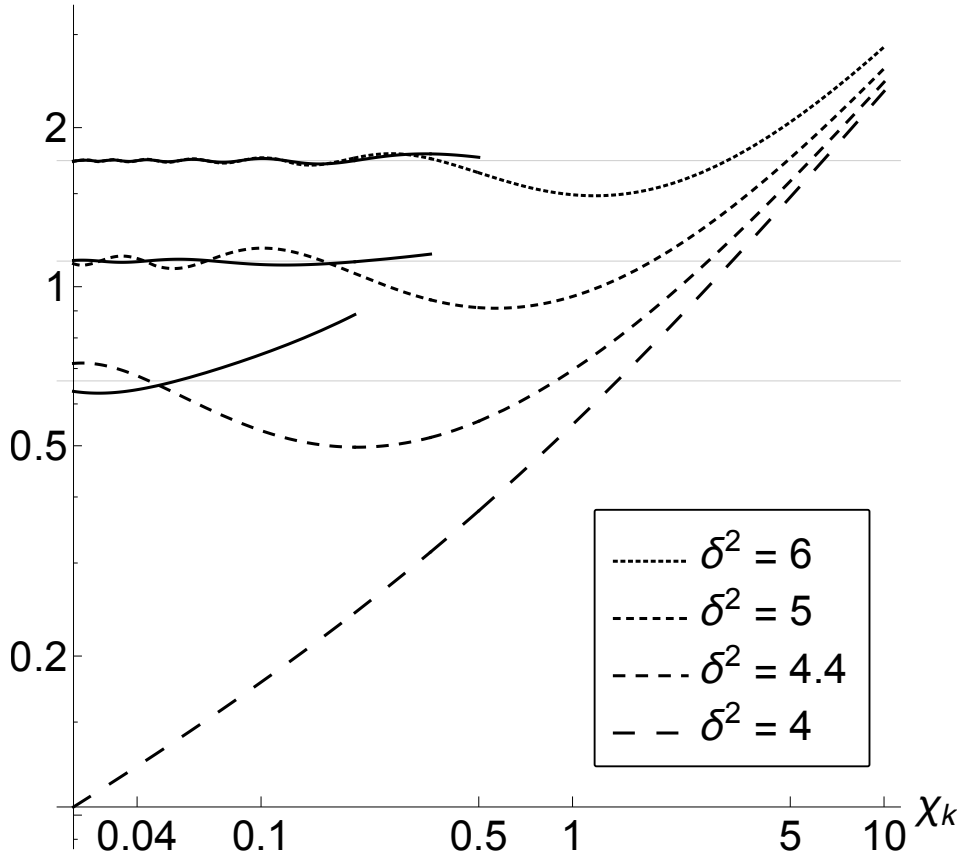

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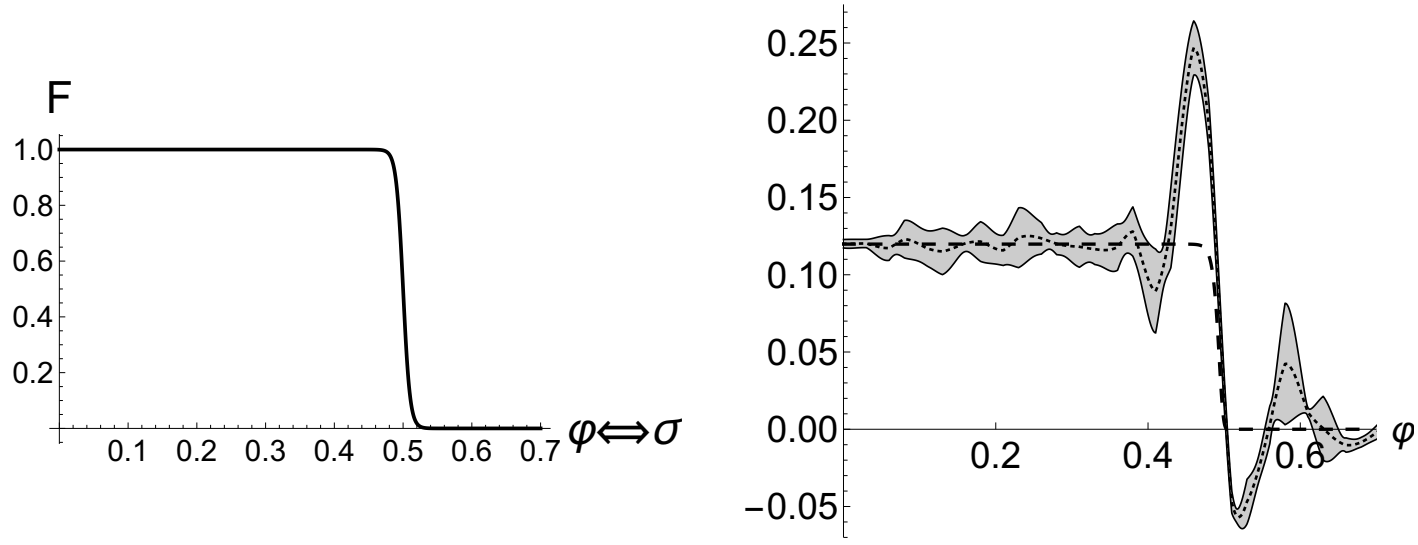
$$\mathrm{R} \sim \exp\left[-\frac{8}{3\chi_k}\left(1-\frac{\delta^2}{4}\right)^{3/2}\right]$$

LCFA comparison



(Nonlinear) pair creation in a "finite" quasi-constant field

$$a_0 = 10; \quad \chi = 1$$

BK, B. Dillon, K. Beyer, G. Gregori, (in preparation) (2019)

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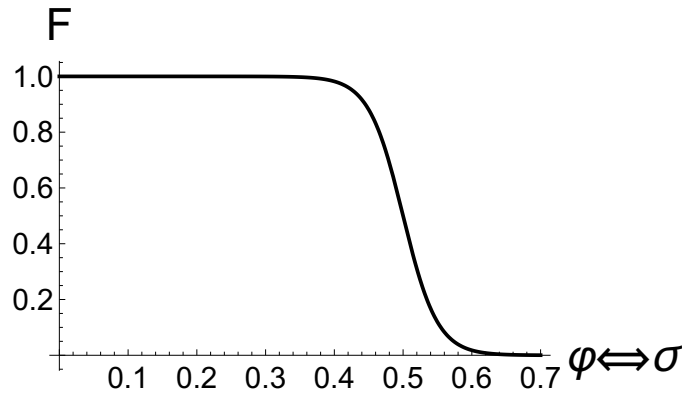

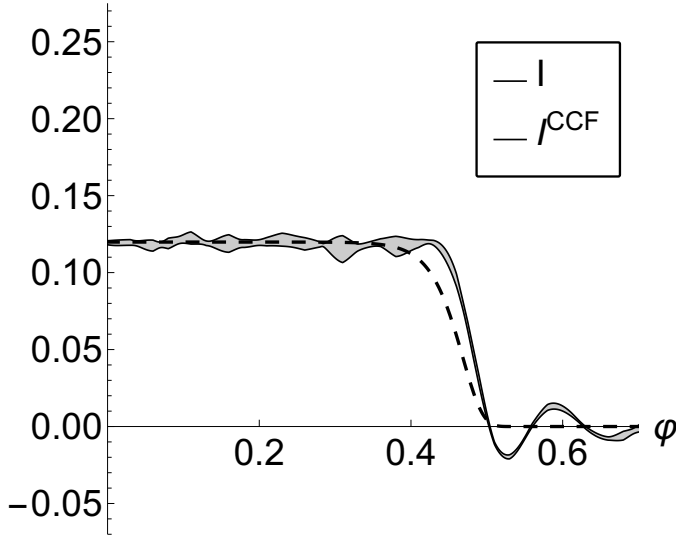

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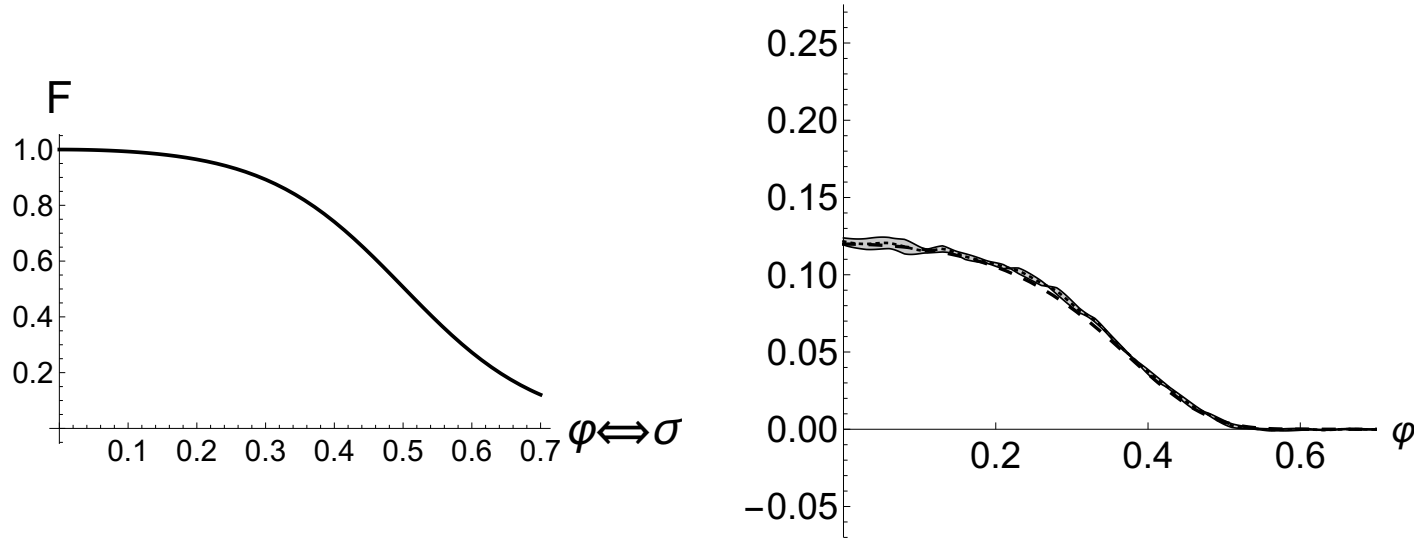

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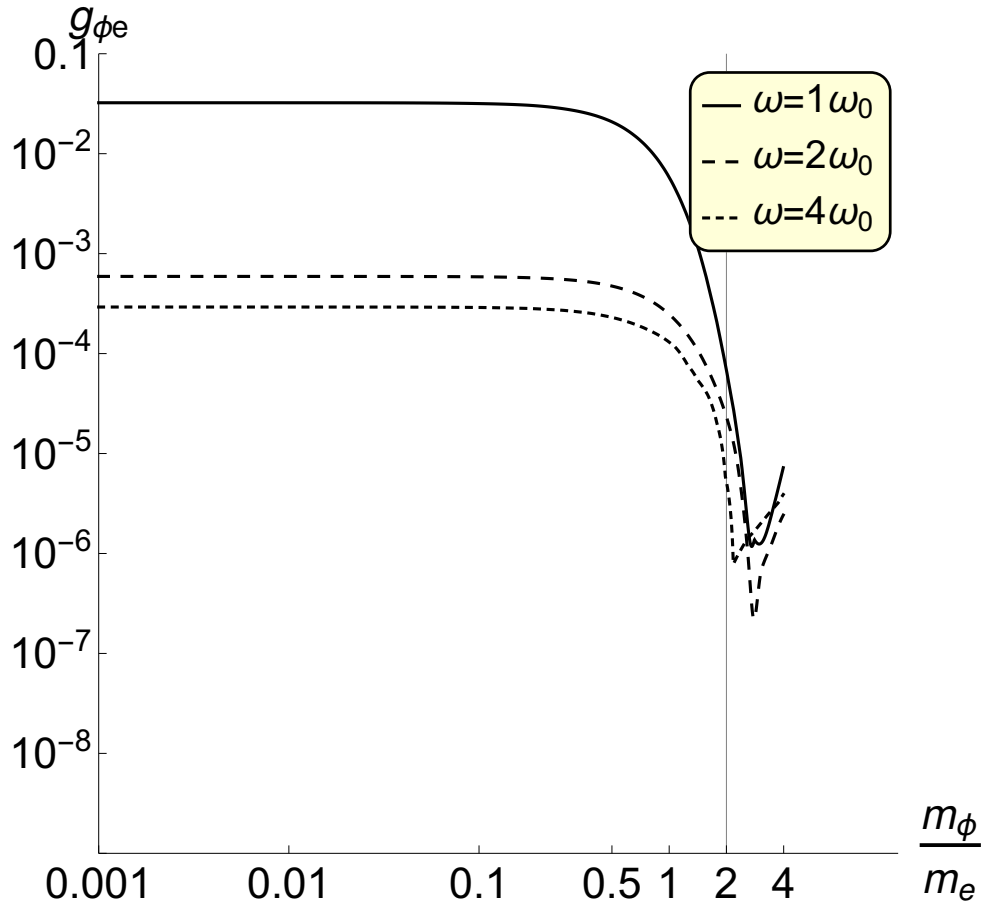

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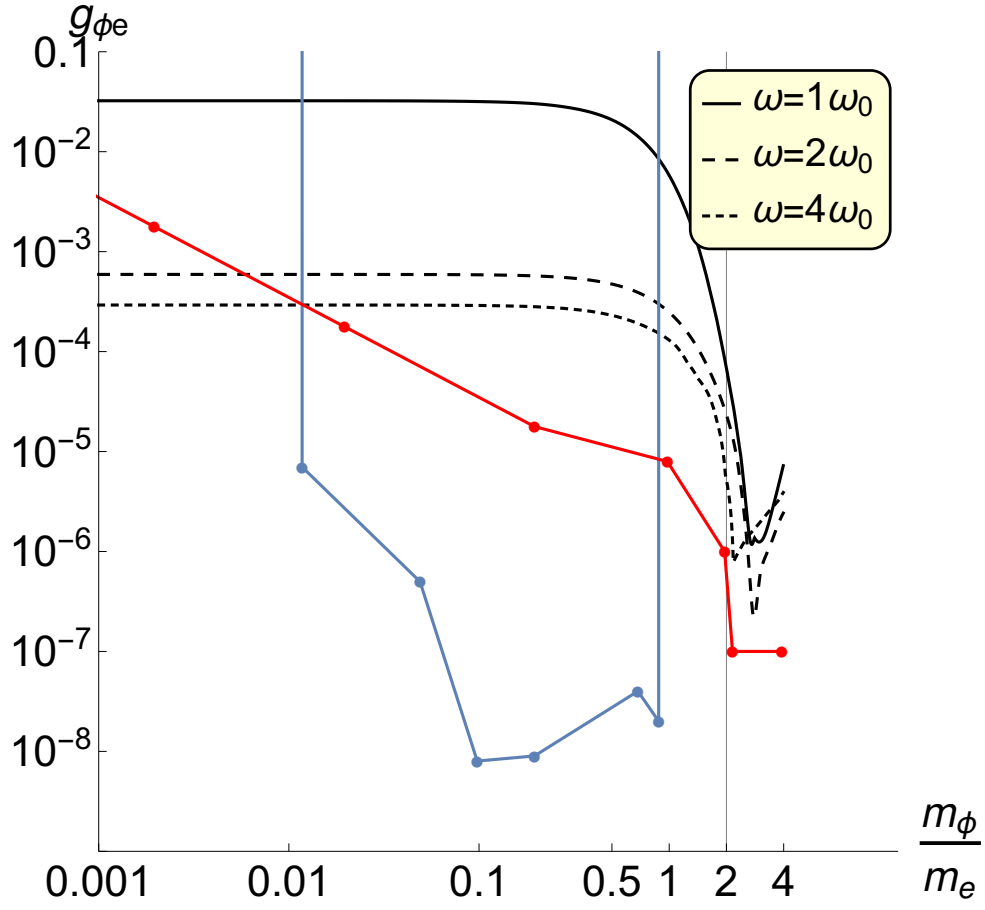


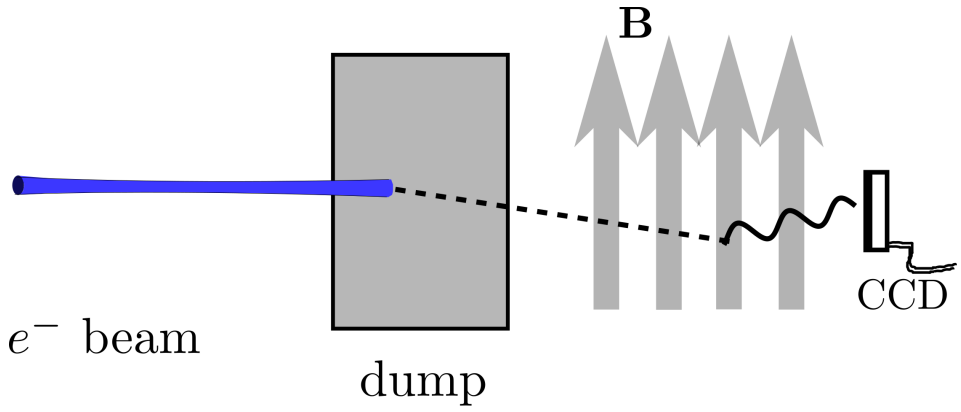
- Blue line = Compton Conversion in Borexino

  G. Bellini et al. Eur. Phys. J. C **54**, 61-72 (2008)

- Red line = Corrected E137 beam dump

  Y-S. Liu and G. A. Miller, PRD **96**, 016004 (2017)

Possible experimental set-up: #2



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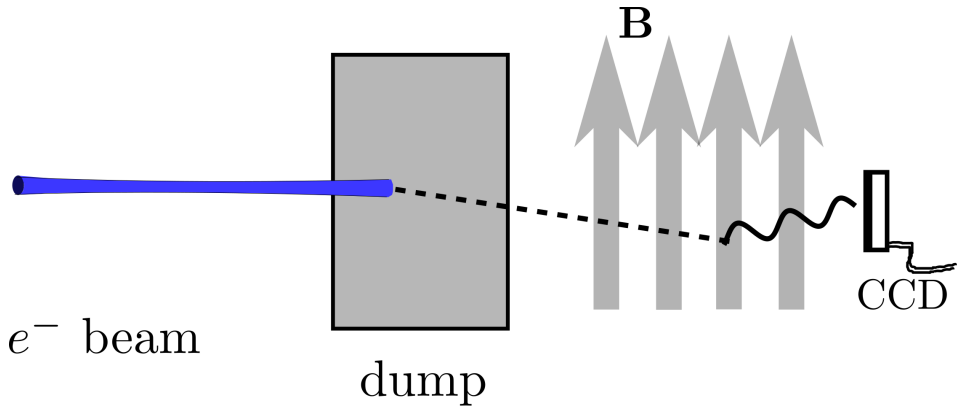

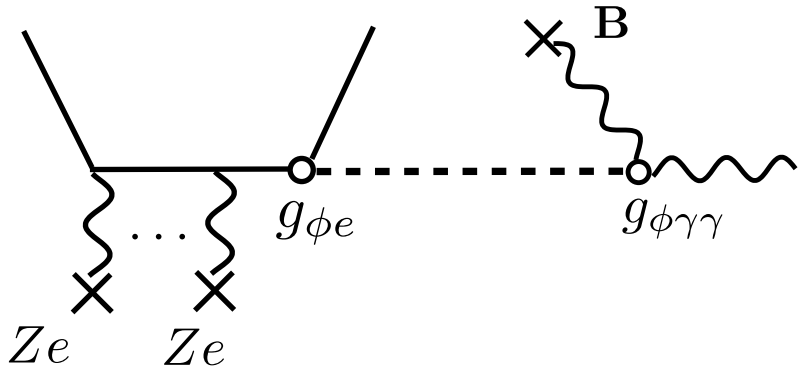

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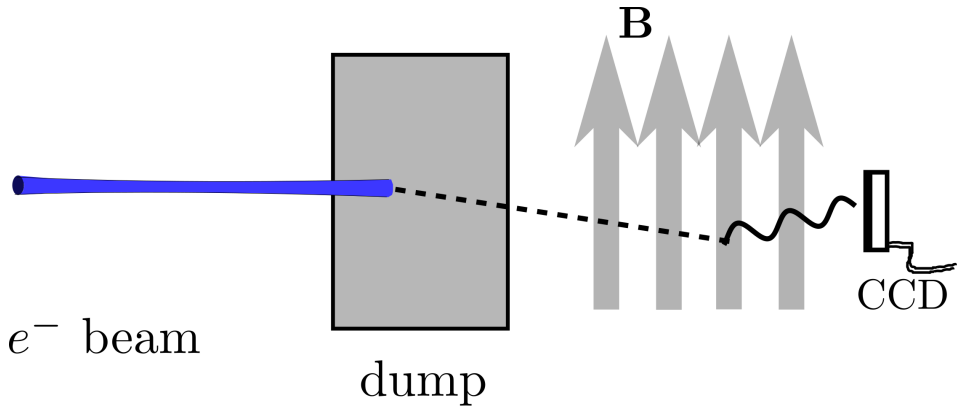

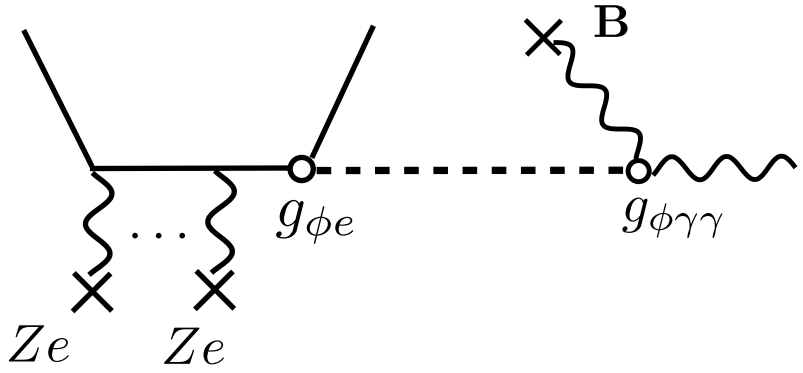

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Axionic photo reconversion

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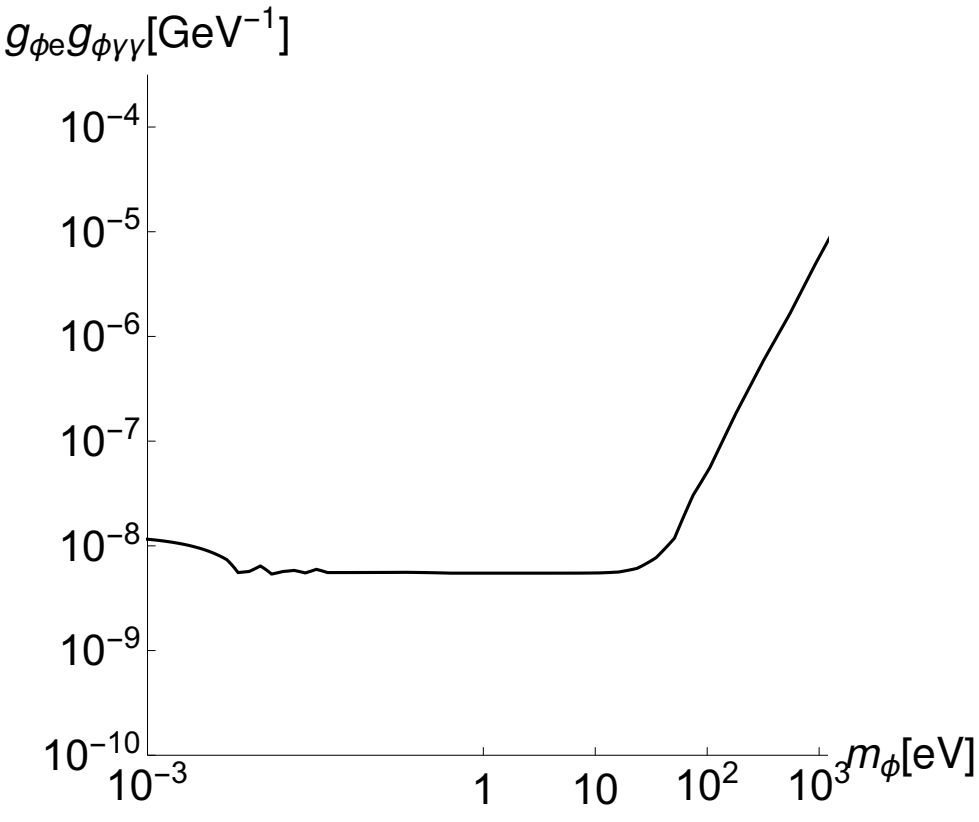

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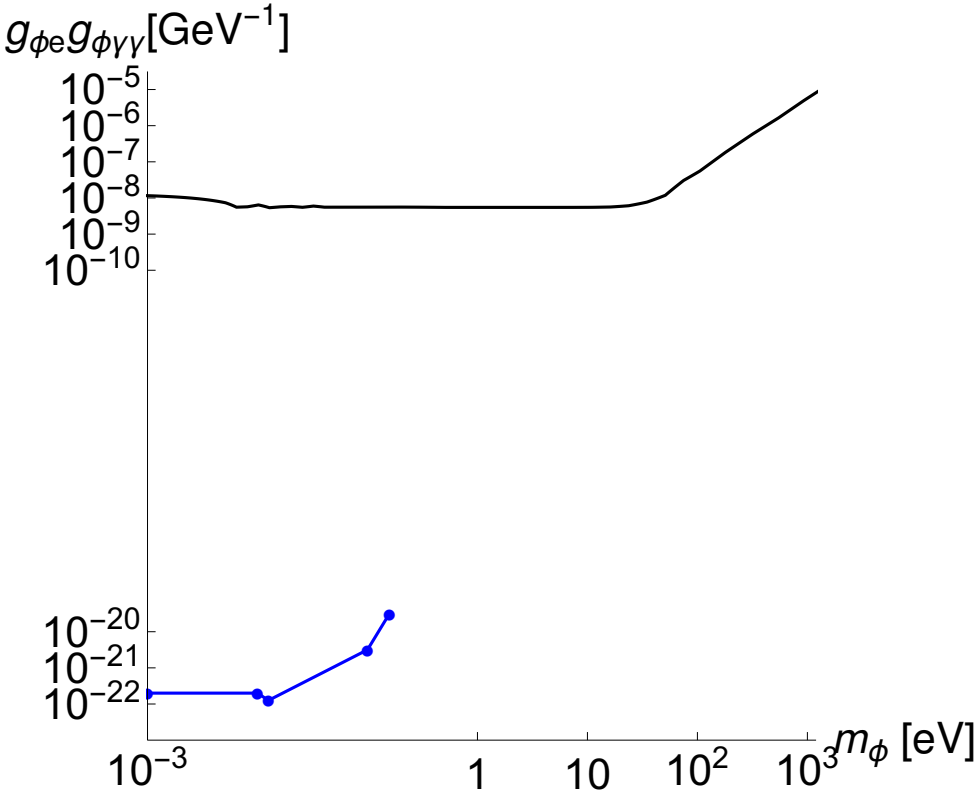

- Blue line = CAST (2013) results

Barth et al. JCAP **010**, 1305 (2013)

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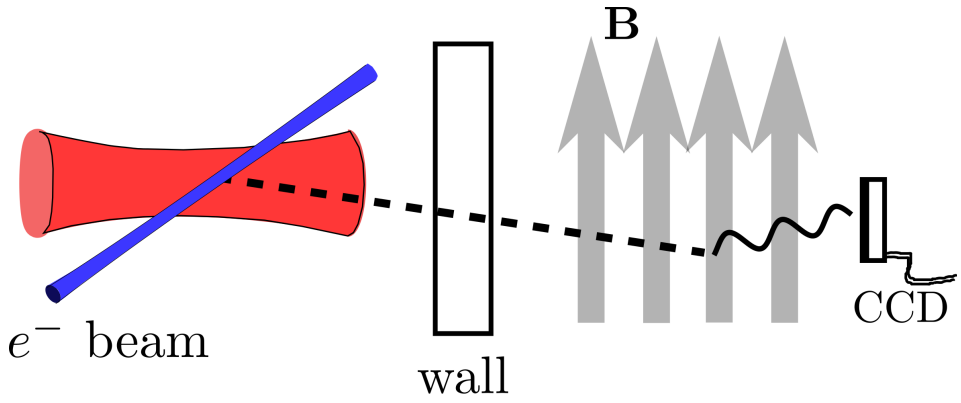

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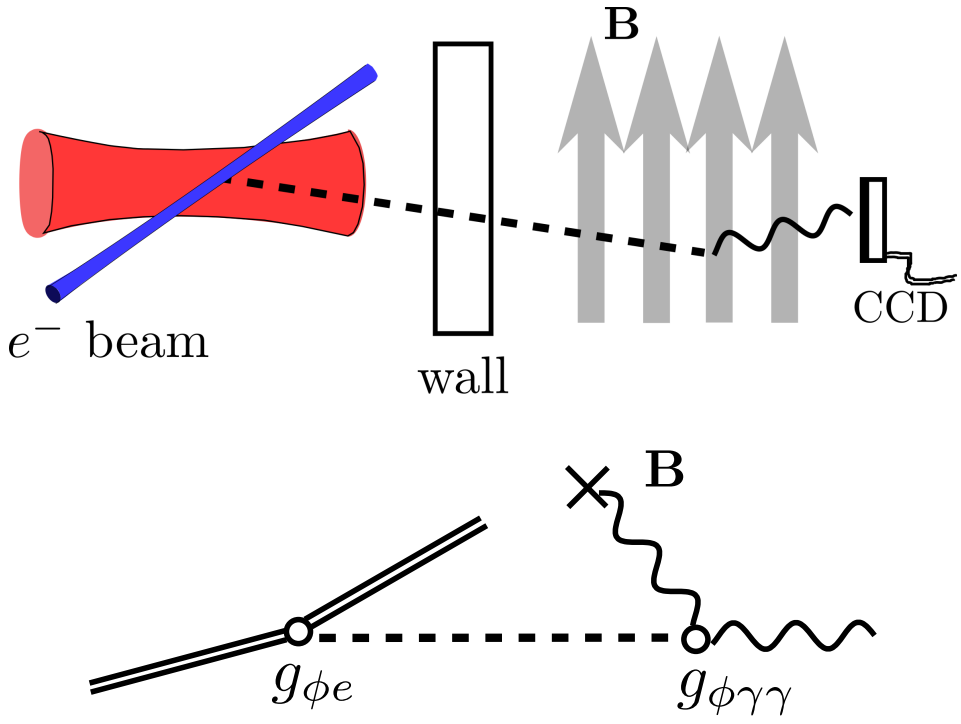

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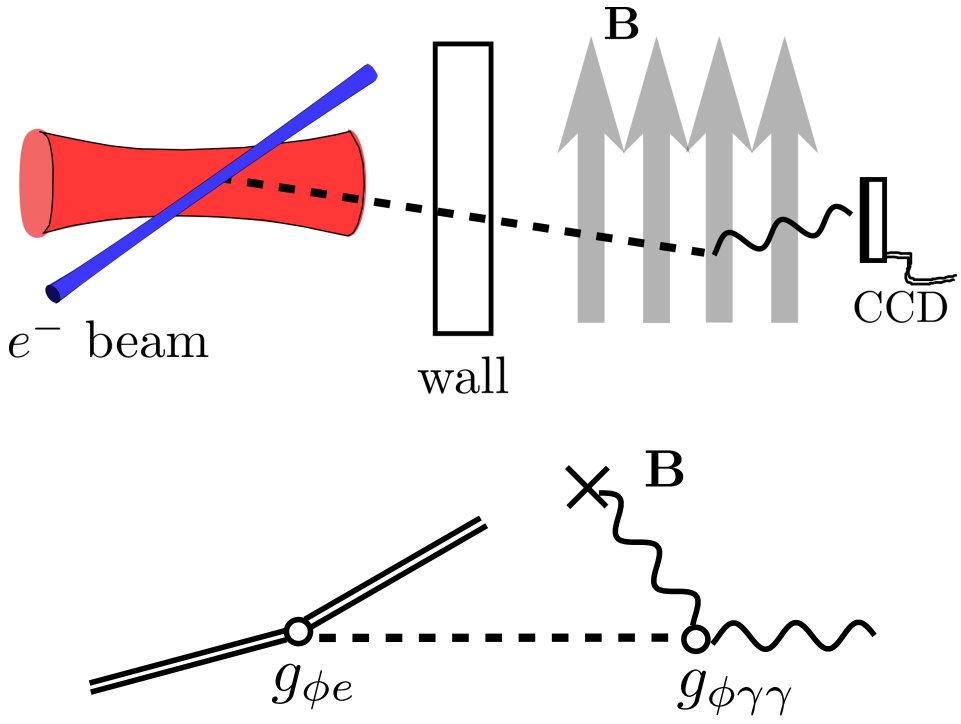

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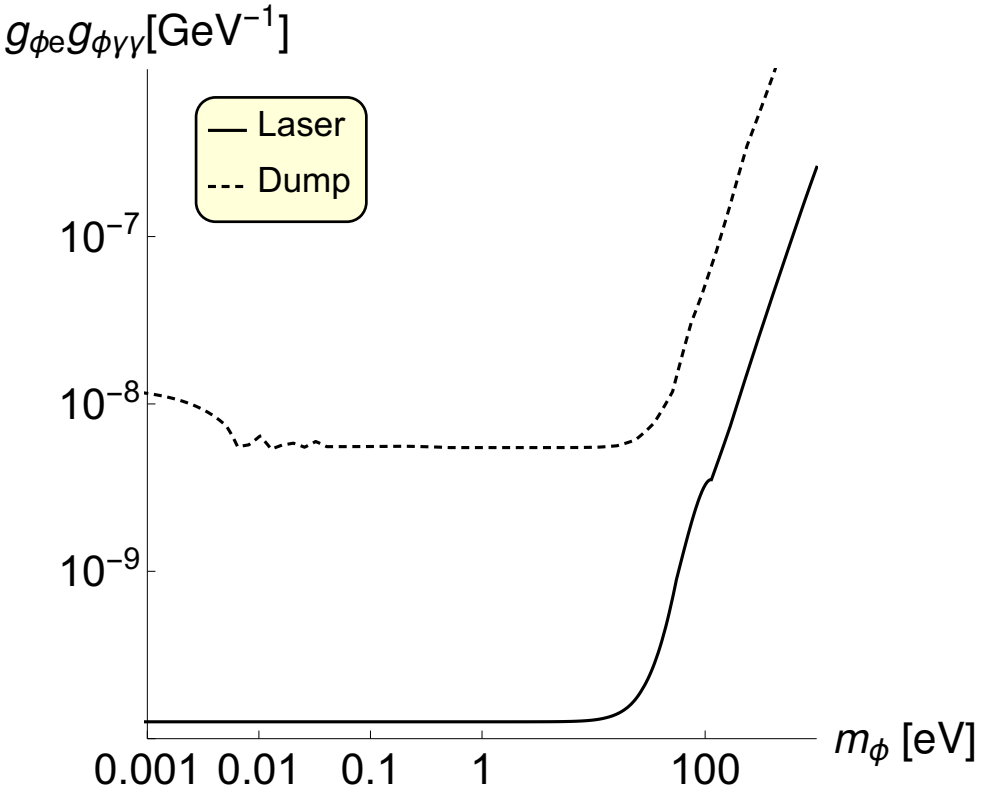
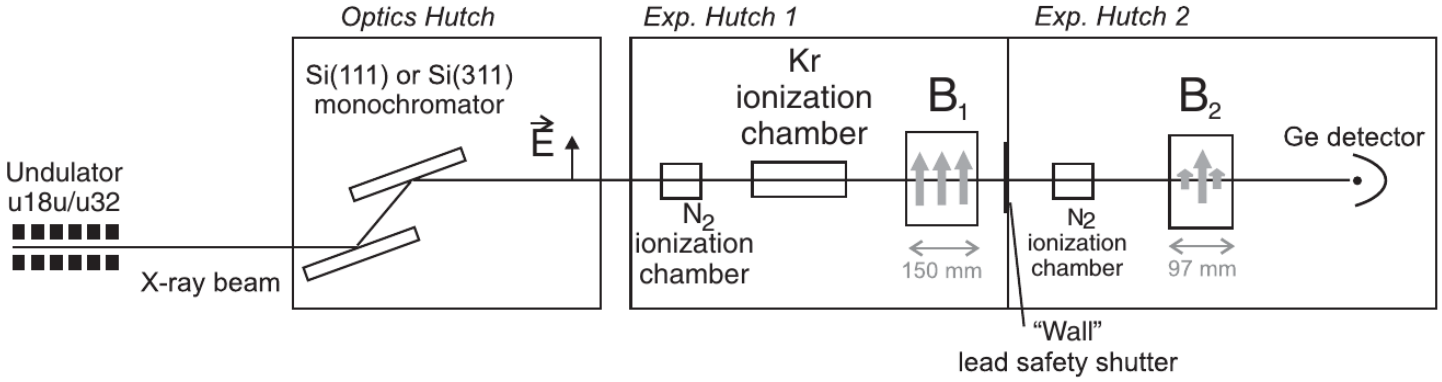


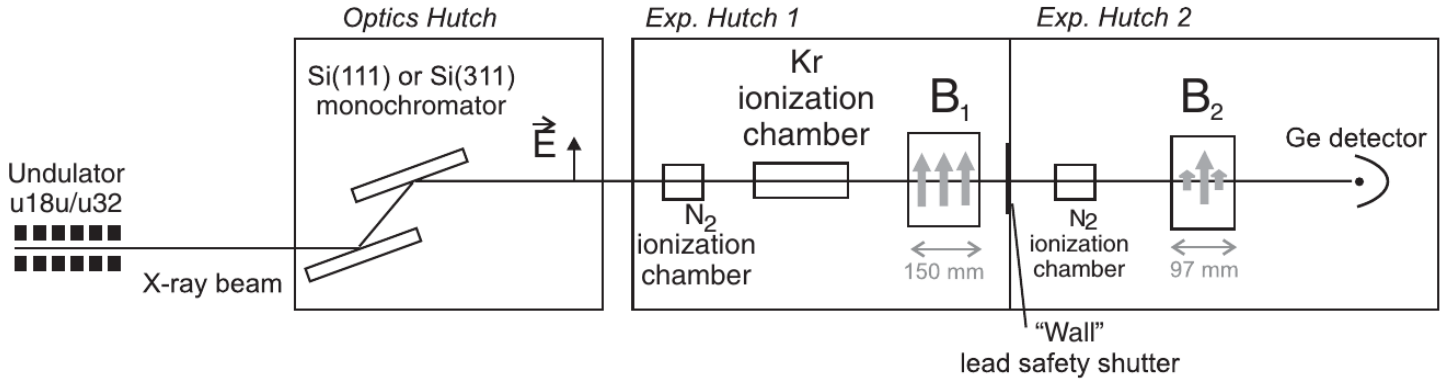
Previous studies

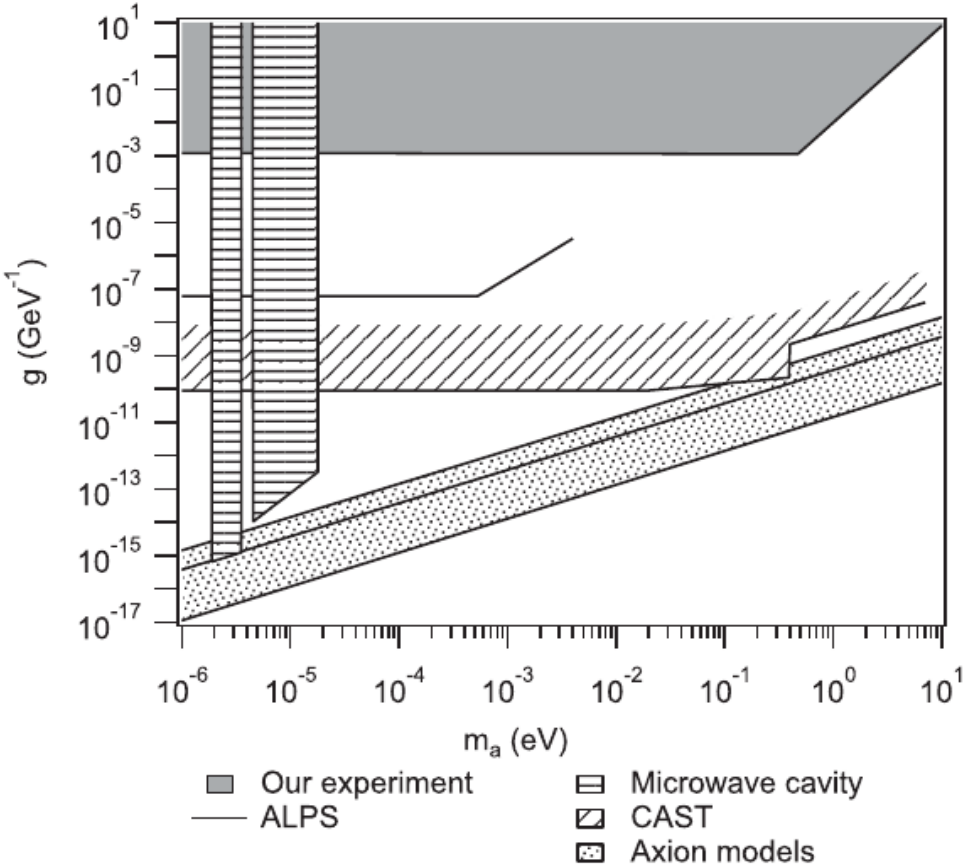
R. Battesti et al., PRL **105**, 250405 (2010)



Previous studies

R. Battesti et al., PRL **105**, 250405 (2010)





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- Laser-particle BSM searches relatively new idea
- Not currently competitive, but some suggestions can be run parasitically and there's room for improvement...

BK, B. Dillon, PRD **99**, 035048 (2019)

BK, PLB **782**, 737-743 (2018)

BK, B. Dillon, EPJC **78**, 775 (2018)