Two-photon physics & backgrounds at FCC-ee

SNS students for FCC-ee

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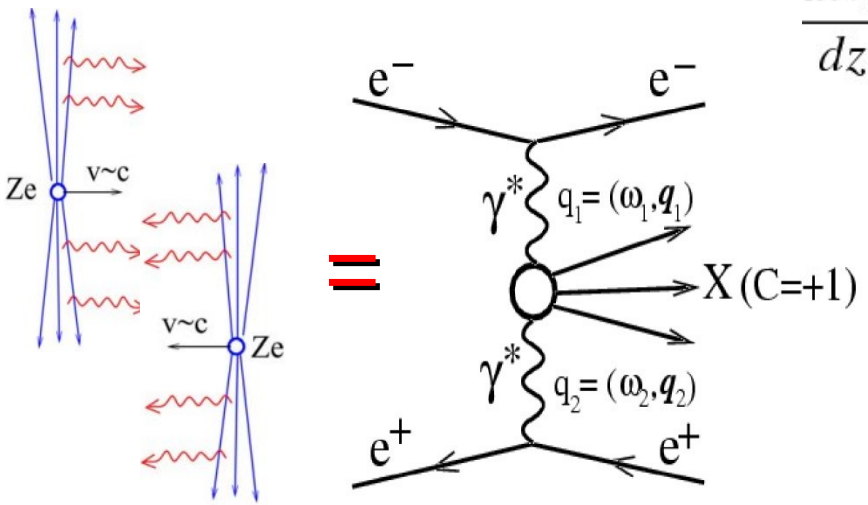
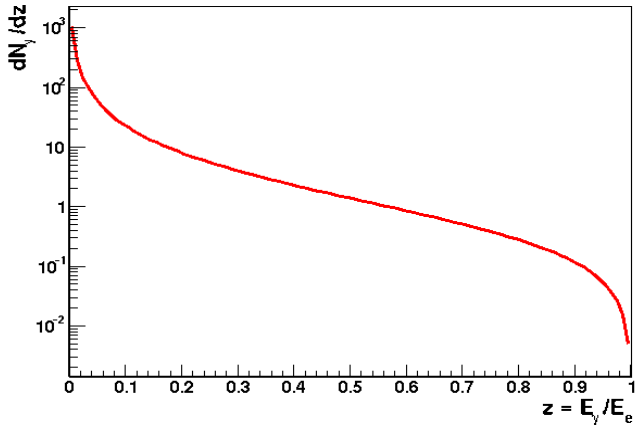
Photon-photon collisions at FCC-e^+e^-

- Electromagnetic field of high-energy charge = equivalent photon flux. Weizsäcker-Williams (EPA) spectrum for $e^{\pm}$ beam:



$$\frac{dN_\gamma}{dz} \approx \frac{\alpha_{em}}{2\pi}\frac{1}{z}\left[1+(1-z)^2\right]\ln\frac{Q^2_{max}}{Q^2_{min}}\,, \quad z=\omega/E_e$$

Soft bremsstrahlung γ spectrum

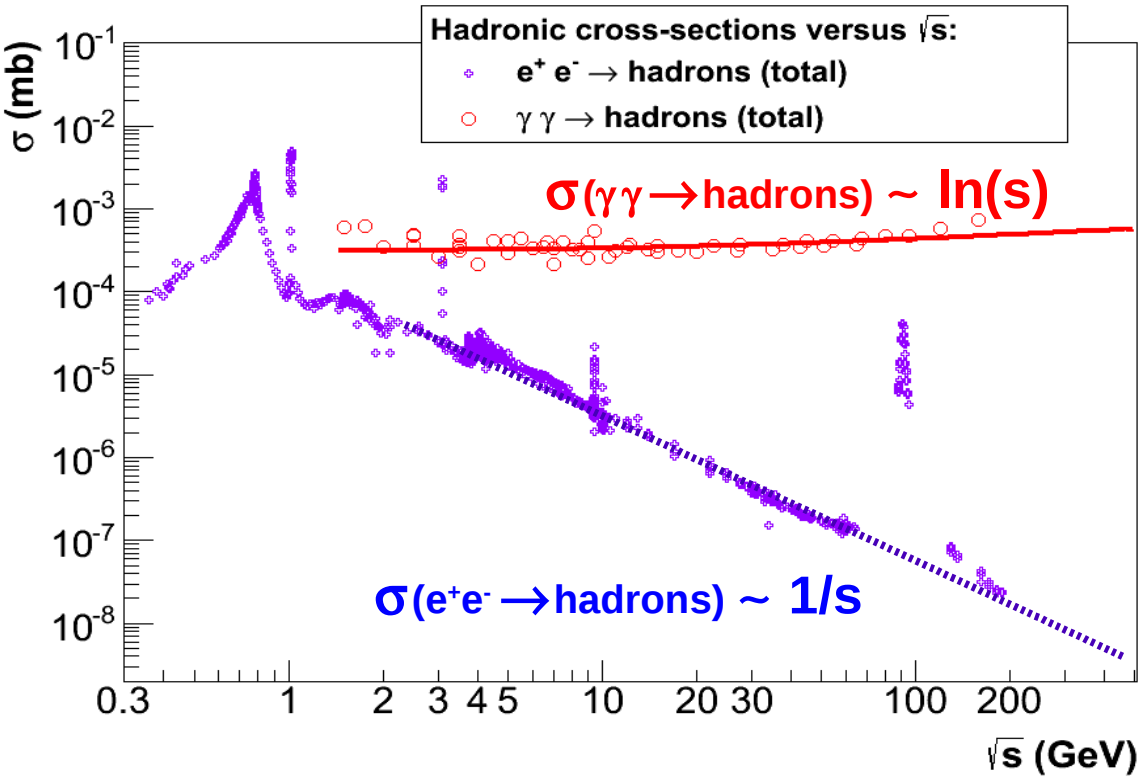


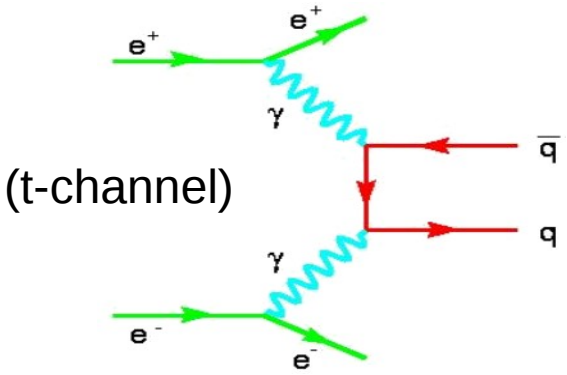
- Two-photon collisions provide complementary QCD, EW, Higgs, BSM physics opportunities, although with reduced lumis & energies:
  - $\mathscr{L}_{\gamma\gamma}(W_{\gamma\gamma}>0.1\cdot E_e) \sim 10^{-2}\,\mathscr{L}_{e+e-}$
  - $\mathscr{L}_{\gamma\gamma}(W_{\gamma\gamma}>0.5\cdot E_e) \sim 0.4\cdot 10^{-3}\,\mathscr{L}_{e+e-}$

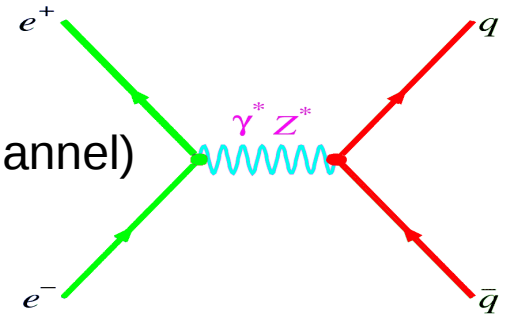
(Main reason for Compton-backscattered laser-photons at PLC: $E_\gamma \sim E_e$, $\mathscr{L}_{\gamma\gamma} \sim 0.8\cdot\mathscr{L}_{e+e-}$)

QCD in γ-γ collisions at FCC-e^+e^- (I)

- Hadron production cross section versus sqrt(s):







- At √s~300 GeV, γγ x-secions are ~$5 \cdot 10^4$ times higher:

  σ(γγ→hadrons)~ 5 μb

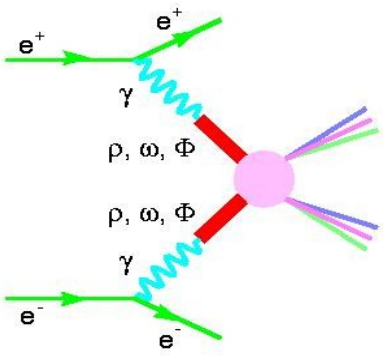
  σ(ee→hadrons)~ 0.1 nb

  Hadron yields "just" ~2 orders of magnitude higher, taking into account $\mathscr{L}_{eff}$ ~ $10^{-(2\text{-}3)}$ reduction penalty

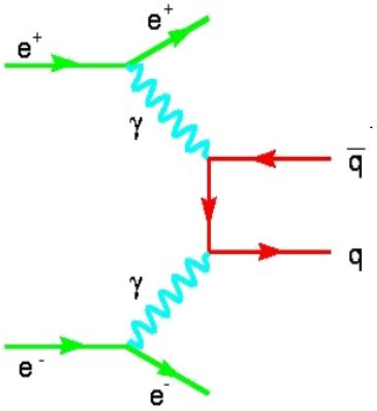
- Hadronic backgrounds for all other FCC physics studies

QCD in γ-γ collisions at FCC-e^+e^- (II)

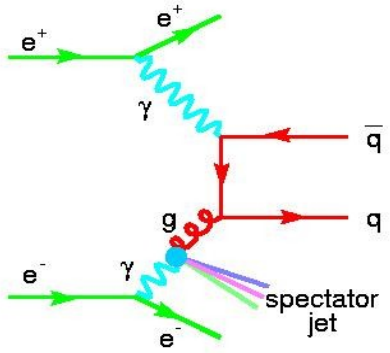
- Leading QCD contributions in γ γ collisions:



Soft (VMD)

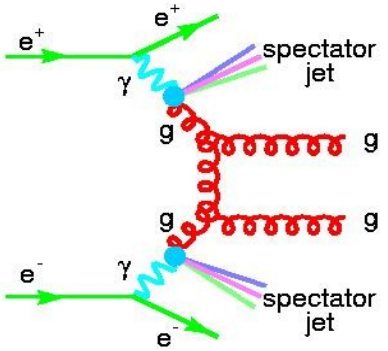


Direct



(single resolved)

γ-"hadron"



(double resolved)

"hadron"-"hadron"

- $\sigma_{tot}(\gamma\gamma)$, (di)jets, resonances, incl.hadrons, heavy-Q,... via untagged $e^{\pm}$
- Photon QED & QCD structure functions:

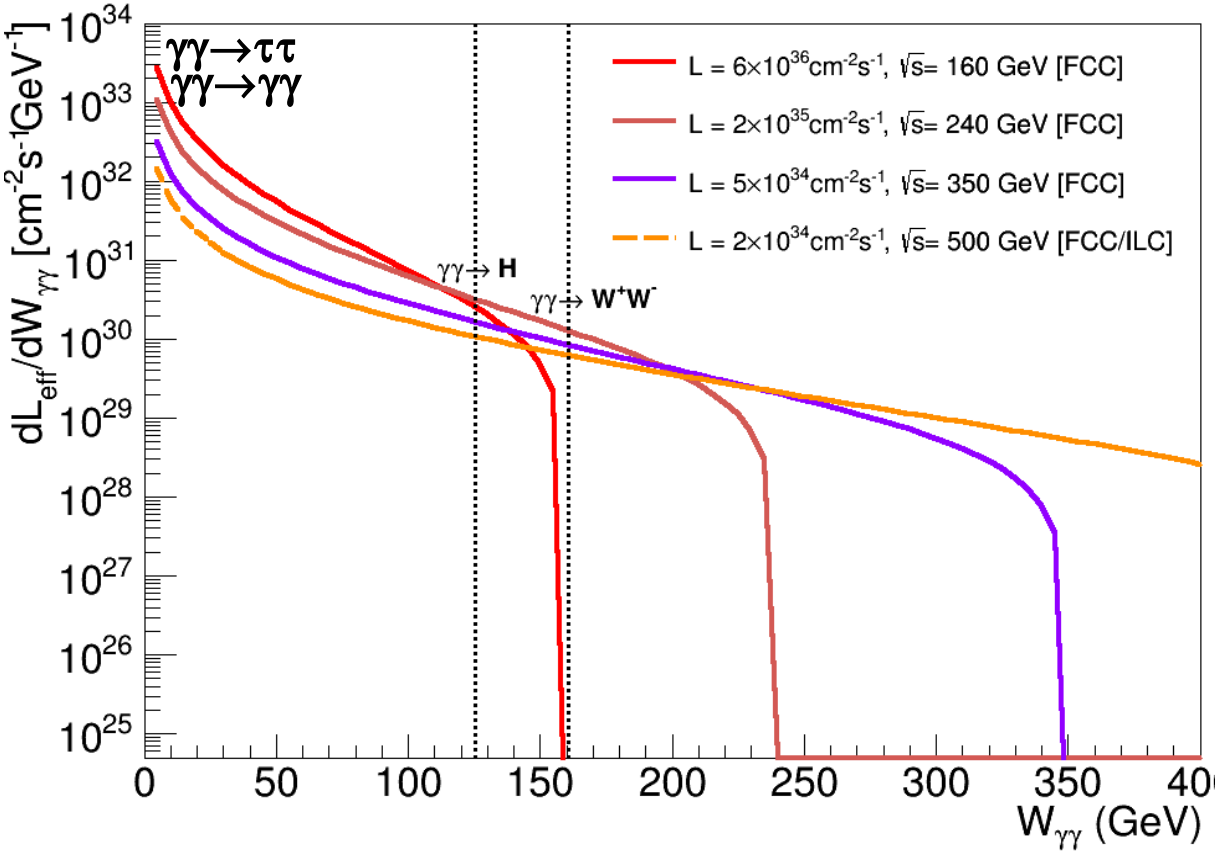
  $F^{\gamma}_{2,QCD/QED}$ over wide (x,Q^2), gluon content of γ

  Quasireal/virtual γ via single/double tags

- Implemented in PYTHIA6+ROOT. Code ready: Crossc-check with LEP2 results needed, and ready to play with ...

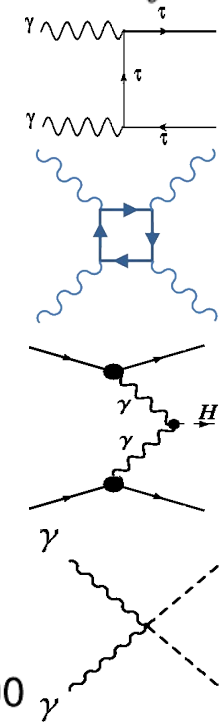
Non-QCD γ-γ physics at FCC-e^+e^-

- Convolve e^+e^- EPA spectra, scale by beam $\mathscr{L}_{ee}$



Examples:

$$N_X = \int dW_{\gamma\gamma} \frac{dL_{\gamma\gamma}}{dW_{\gamma\gamma}} \sigma_X^{\gamma\gamma}(W_{\gamma\gamma})$$



~10^8 di-τ/year

~10^3 LbyL/year

($m_{\gamma\gamma}$>5GeV)

~10^3 Higgs/year

~10^4 WW/year

- Thanks to large FCC lumi: $\mathscr{L}_{eff}(\gamma\gamma)$~20 times higher than p-p($\gamma\gamma$) at LHC without huge LHC p-p pileup.
- Double tagging outgoing e^+e^-: Forward detectors (~mrad) needed

Anomalous e.m. τ moments via $\gamma\gamma \to \tau\tau$

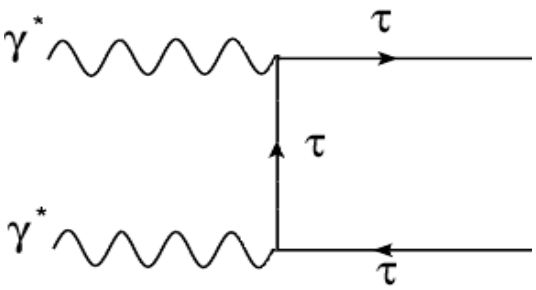
- Magnetic moment of tau-lepton: a_τ = 1.17734(2)e-4 (QED)

  Current LEP bounds: $-0.052 < a_\tau < 0.013$

- Electric dipole-moment of tau-lepton: $|d_\tau| < 10^{-34}$ e cm

  Current LEP (also BELLE) limit: $|d_\tau| < 3.1 \cdot 10^{-16}$ e cm

- Anomalous moments via $\gamma\gamma \to \tau\tau$ (x-section=270 pb at FCC-Z):



$$\Gamma^\nu = F_1(q^2)\gamma^\nu + \frac{i}{2m_\tau}F_2(q^2)\sigma^{\nu\mu}q_\mu + \frac{1}{2m_\tau}F_3(q^2)\sigma^{\nu\mu}q_\mu\gamma^5$$

$$F_1(0) = 1,\ F_2(0) = a_\tau,\ F_3(0) = \frac{2m_\tau d_\tau}{e}.$$

- Two-photon di-tau at CLIC (or FCC-ee) at 0.5 TeV, $2 \cdot 10^{34}$ cm^{-2}s^{-1}: