WG5 "QCD & γ-γ physics"

γγ-2 plans: EWK in γγ collisions

FCC-ee QCD & γγ PWG5 meeting

CERN, 3th June 2014

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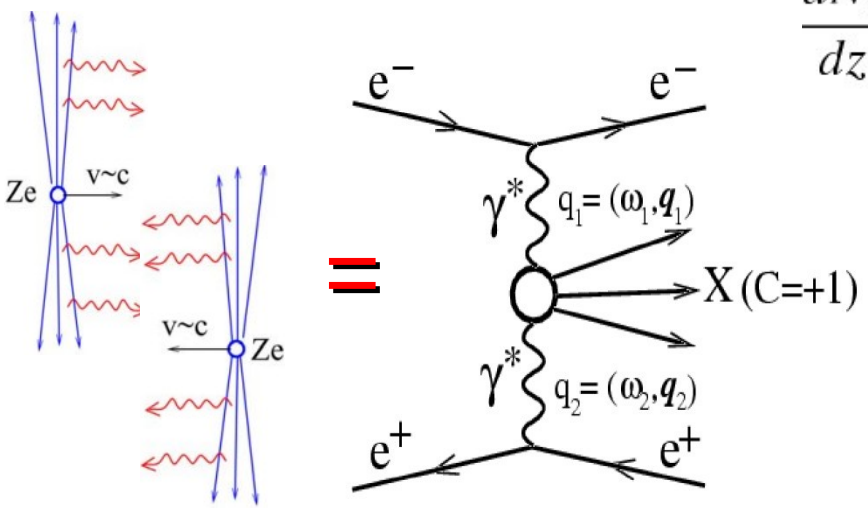
CERN

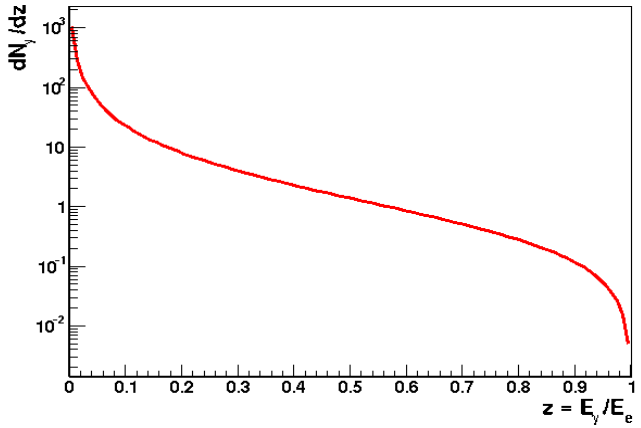
Photon-photon physics at FCC-e^+e^-

- 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

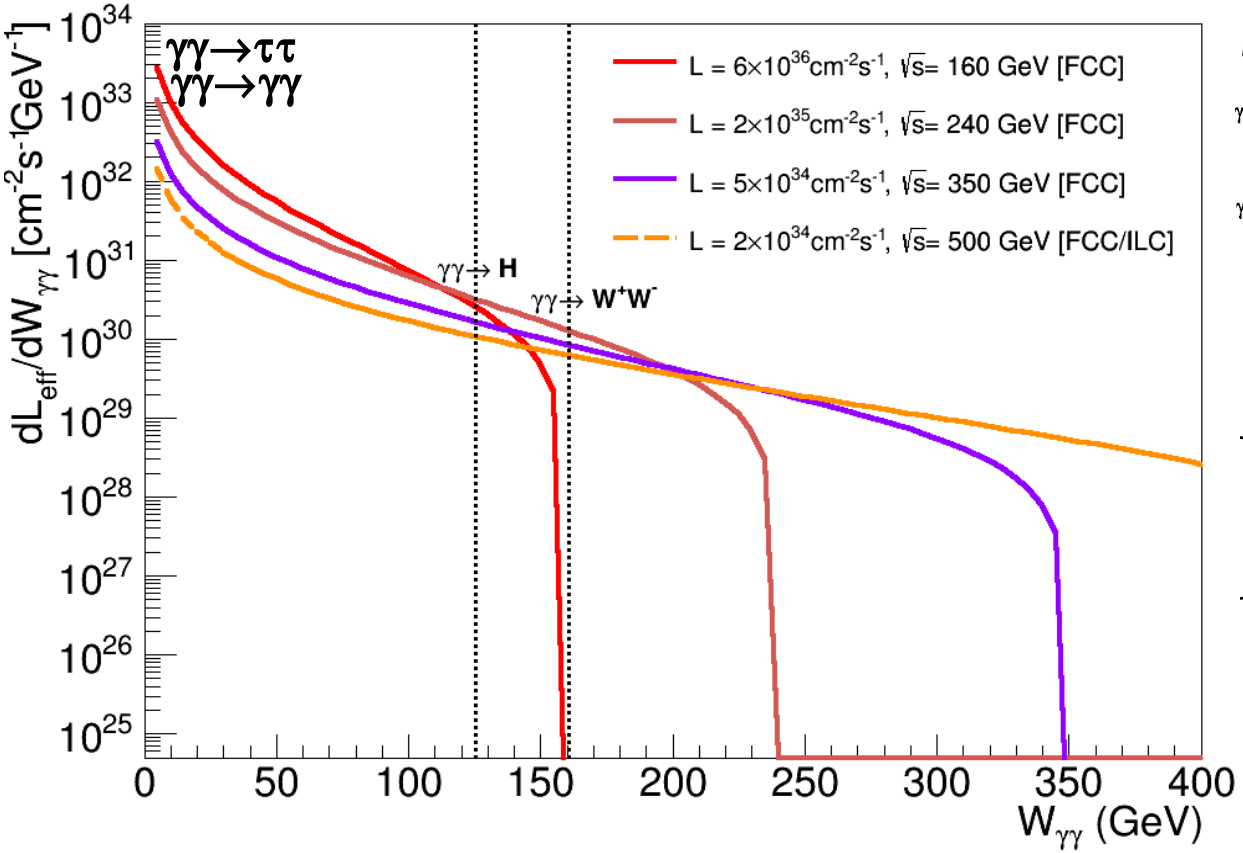


- Two-photon collisions provide complementary QCD, EW, Higgs, BSM physics opportunities, although with reduced lumis & energies:
  - $\mathscr{L}_{\gamma\gamma}(W_{\gamma\gamma}>0.1\cdot E_e) \sim 10^{-2}\,\mathscr{L}_{e+e-}$
  - $\mathscr{L}_{\gamma\gamma}(W_{\gamma\gamma}>0.5\cdot E_e) \sim 0.4\cdot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

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

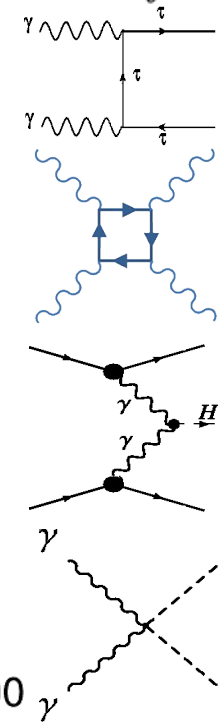
EWK & Higgs γ-γ physics at FCC-e⁺e⁻

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



Examples:

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



~10^7 di-τ/ab^{-1}

~10^3 LbyL/ab^{-1}

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

~10^2 Higgs/ab^{-1}

~10^4 WW/ab^{-1}

- 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

EWK & Higgs γ-γ physics at FCC-e^+e^-

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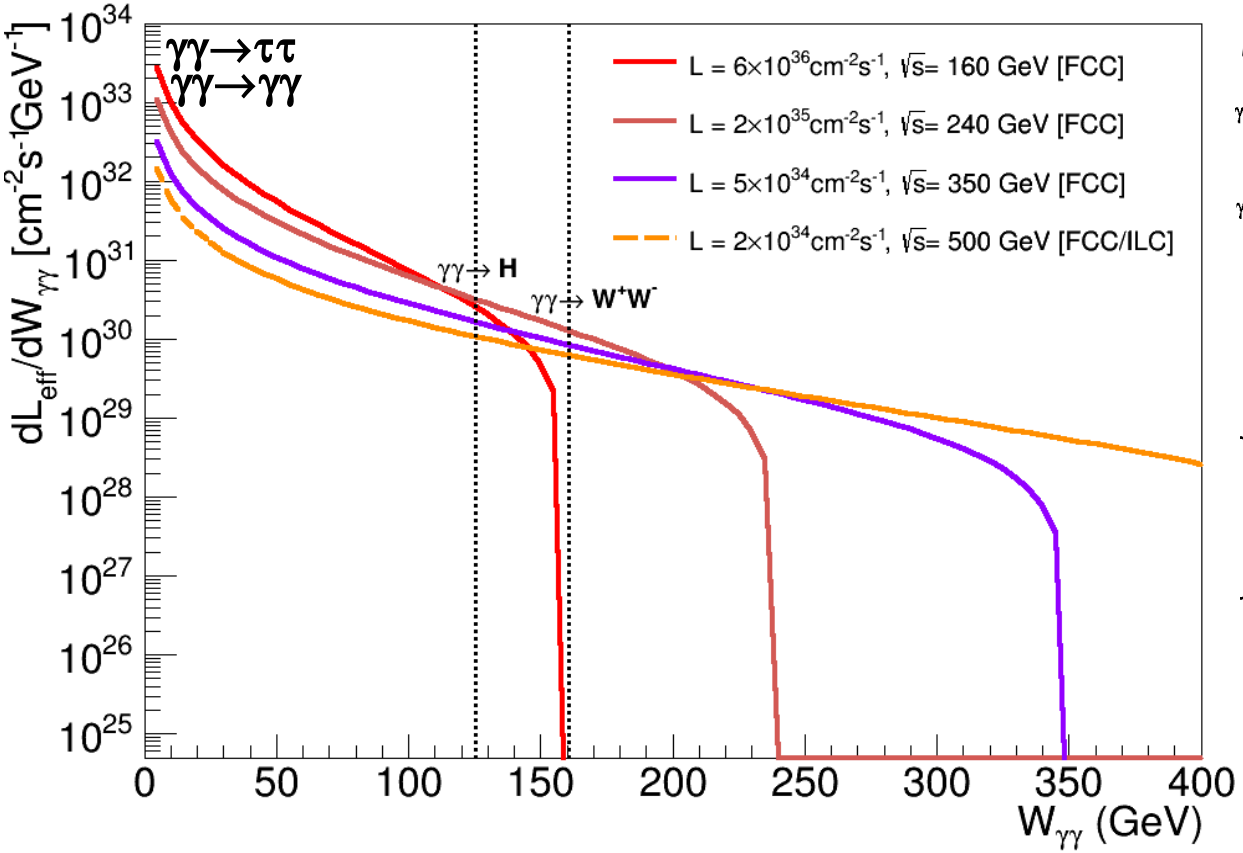

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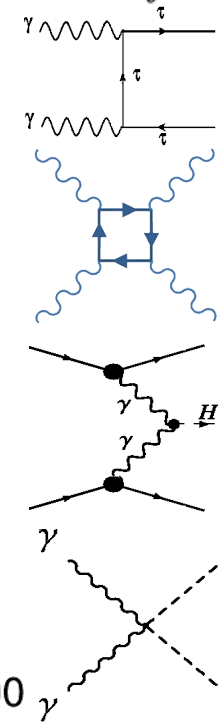

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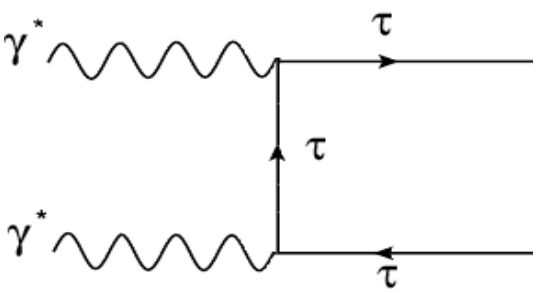
- See next talk by Patricia Rebello

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

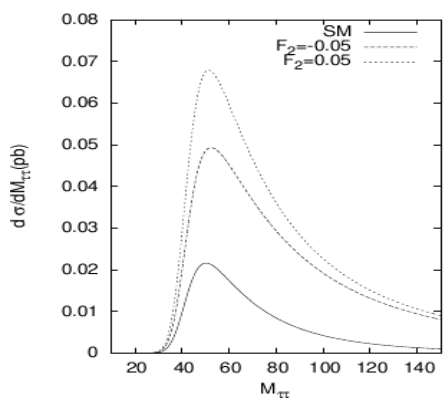
  Current LEP (also BELLE) limit: $|d_\tau| < 3.1 \cdot 10^{-16}$ e cm
- Anomalous moments via $\gamma\gamma \to \tau\tau$ (x-section=270 pb at FCC-Z):

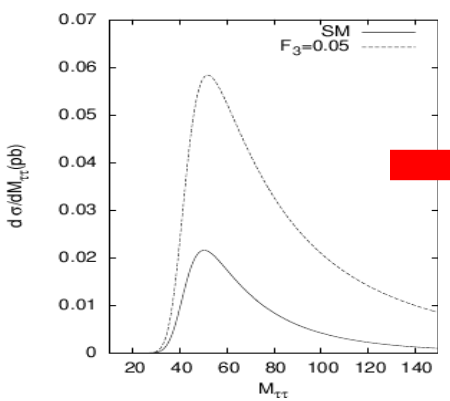


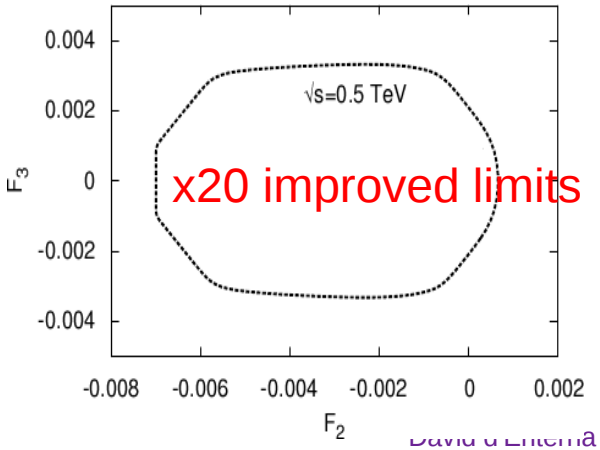
$$\Gamma^\nu = F_1(q^2)\gamma^\nu + \frac{i}{2m_\tau}F_2(q^2)\sigma^{\nu\mu}q_\mu + \frac{1}{2m_\tau}F_3(q^2)\sigma^{\nu\mu}q_\mu\gamma^5$$

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

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







Backup slides

WG5 mandate: Physics objectives

- Determine best achievable EXP & TH precision on α_s measurement via: Z,W,τ hadronic decays widths, jet rates, event shapes, ...
- Explore other competitive QCD physics opportunities opened in e+e-.
- Evaluate photon-photon physics possibilities via EPA fluxes: Higgs, anomalous quartic gauge couplings, anomalous top,τ e.m. moments,...

- Set goals for sub-detector performance (including forward $e^{\pm}$ taggers for $\gamma\gamma$ physics) and experimental-conditions so that syst.~stat. Uncertainties for the measurements
- Define experimental/phenomenological software needs to make possible these measurements and their interpretation with the required precision.
- Help evaluating the QCD impact on rest of FCC measurements. Provide design study for "background" event generators for QCD and $\gamma\gamma$ processes.

WG5 mandate: Managerial objectives

- Joint experiment-phenomenology group with 2 (bi-annual) conveners:
  2014-2016: D. d'Enterria (dde@cern.ch), P.Skands (Peter.Skands@cern.ch)
- Build international collaboration with synergies with similar e^+e^- (linear or circular) collider studies.
- Attract people for the studies relevant to the group.
- Maintain high level of contacts with the other WGs.
- Create sub-groups (with sub-conveners) matching the scientific objectives.
- Appoint editors towards the production of intermediate reviews and a contributions to final Yellow Report.
- Report progress to the physics coordination at monthly FCC-ee physics meetings.

WG5 mandate: Timescales & deliverables

- "Exploration" phase (Feb'14 – March'15): Identify all possible options and potential studies, including requirements and constraints.
  - ☛ Deliverable: Interim written report for review milestone workshop

- "Analysis" phase (March'15 – Sept'16): Detailed studies of the identified baselines.
  - ☛ Deliverable: Interim written report for review milestone workshop

- "Elaboration" phase (Sept'16 – Dec'17): Delivery of all information required for the final Conceptual Design Report (CDR) of the study.

☛ Final Yellow Report (early 2018) to be included into the FCC CDR.

JOIN THE QCD & PHOTON-PHOTON WG5 ACTIVITIES !