

WG5 “QCD & γ - γ physics”

$\gamma\gamma$ -1 plans: QCD in $\gamma\gamma$ collisions

FCC-ee QCD & $\gamma\gamma$ PWG5 meeting

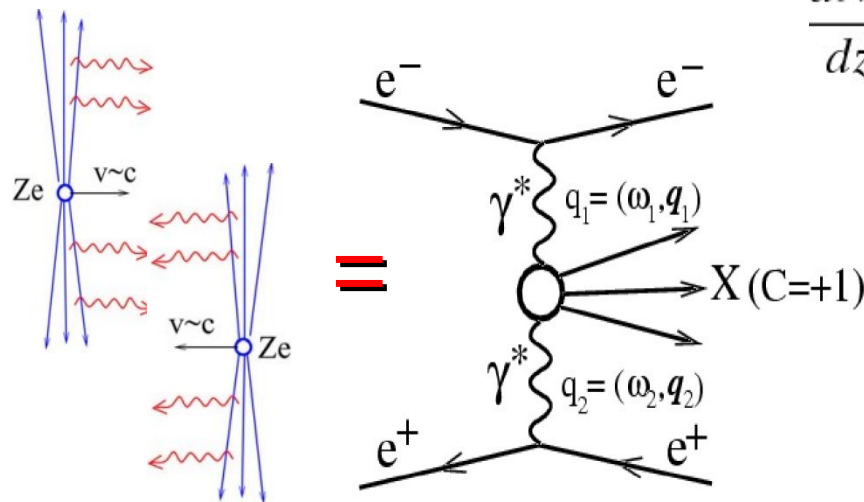
CERN, 3th June 2014

David d'Enterria, Peter Skands

CERN

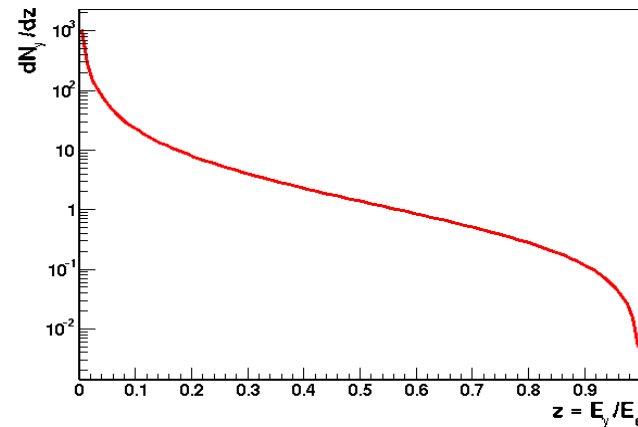
Photon-photon physics at FCC- e^+e^-

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



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

Soft bremsstrahlung γ spectrum



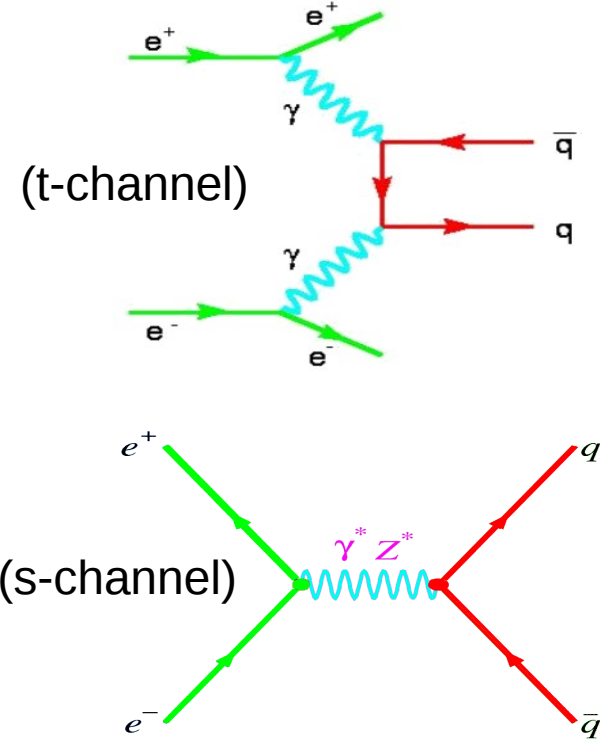
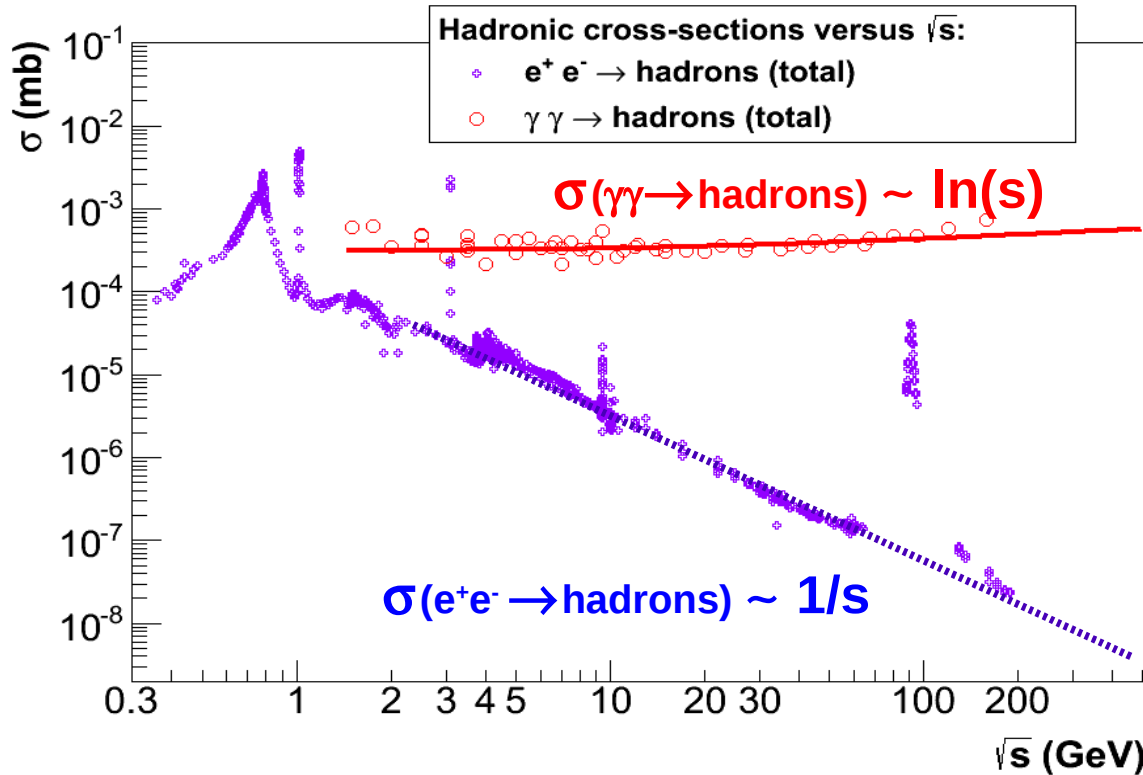
- Two-photon collisions provide **complementary QCD, EW, Higgs, BSM physics** opportunities, although with **reduced lumis & energies**:

- $\mathcal{L}_\gamma(W_\gamma > 0.1 \cdot E_e) \sim 10^{-2} \mathcal{L}_{e^+e^-}$
- $\mathcal{L}_\gamma(W_\gamma > 0.5 \cdot E_e) \sim 0.4 \cdot 10^{-3} \mathcal{L}_{e^+e^-}$

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

QCD in $\gamma\text{-}\gamma$ collisions at FCC- e^+e^- (I)

- Hadron production cross section versus \sqrt{s} :



- At $\sqrt{s} \sim 300$ GeV, $\gamma\gamma$ x-sections are $\sim 5 \cdot 10^4$ times higher:

$$\sigma(\gamma\gamma \rightarrow \text{hadrons}) \sim 5 \mu\text{b}$$

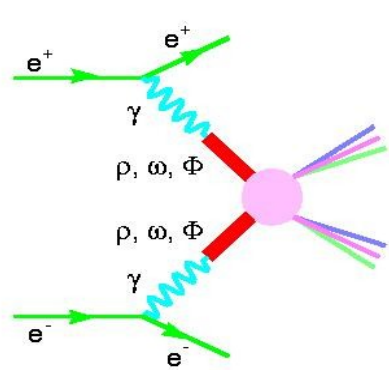
$$\sigma(ee \rightarrow \text{hadrons}) \sim 0.1 \text{ nb}$$

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

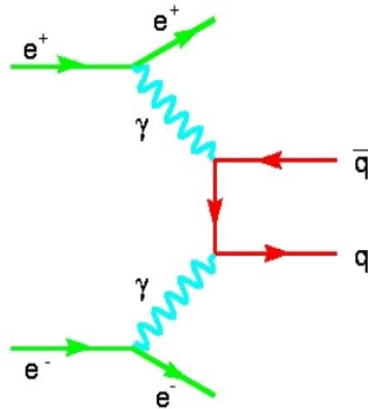
- Hadronic backgrounds for all other FCC physics studies

QCD in $\gamma\text{-}\gamma$ collisions at FCC- e^+e^- (II)

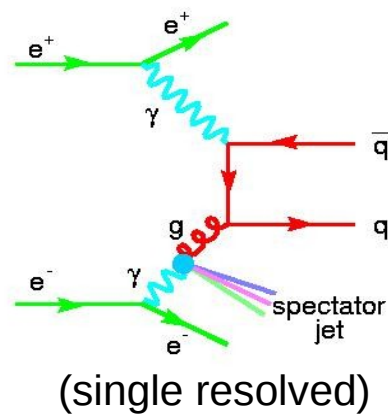
- Leading QCD contributions in $\gamma\gamma$ collisions:



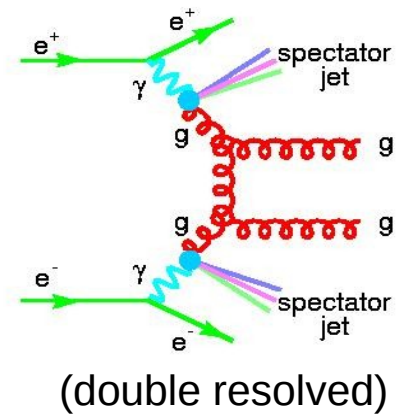
Soft (VMD)



Direct



γ -"hadron"



"hadron"- "hadron"

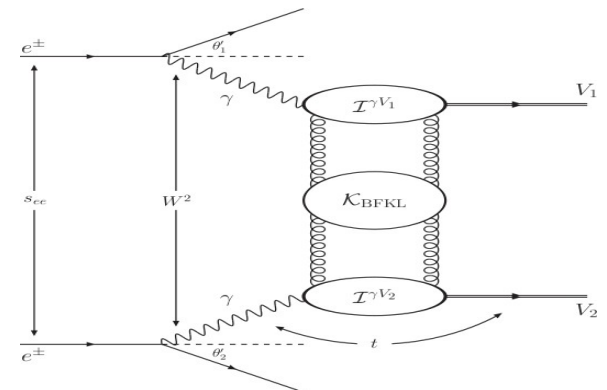
- $\sigma_{\text{tot}}(\gamma\gamma)$, (di)jets, resonances, incl.hadrons, heavy- Q ,... via untagged e^\pm

- Photon QED & QCD structure functions:

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

Quasireal/virtual γ via single/double tags

- BFKL dynamics via $\gamma\gamma \rightarrow \rho\rho, J/\psi, J/\psi, YY$:



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 !