Photon structure functions at the ILC/CLIC energy range

On behalf of the FCAL Collaboration

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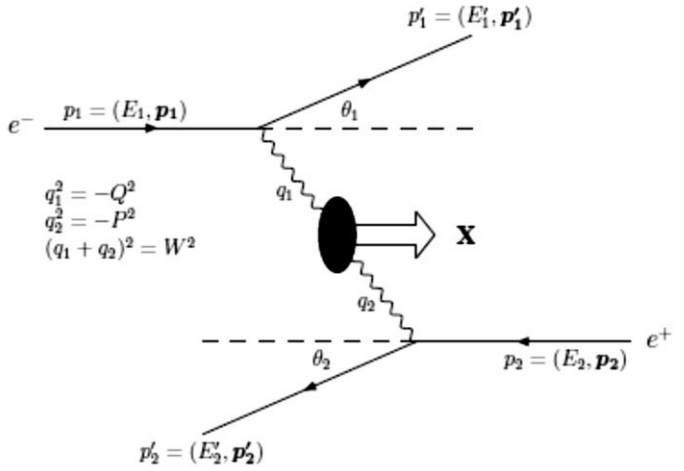
Is the study of photon structure important?

In spite of many studies of the photon structure, still it is needed to bring our understanding of the photon to the same level as HERA has achieved for the proton. This will offer new insights in QCD.

- It is expected that at the ILC/CLIC it will be possible to measure the evolution of the photon structure function in a wider kinematical range.
- The contributions from Z^0 exchange in eγ DIS and the charged-current process $e\gamma \rightarrow \nu X$ become accessible, allowing to study the weak photon structure.
- The interaction of two virtual photons is a 'golden' process to study the parton dynamics – DGLAP and/or BFKL.
- The possibility of tagging both electrons would allow to measure W^2 independently of the hadronic final state.



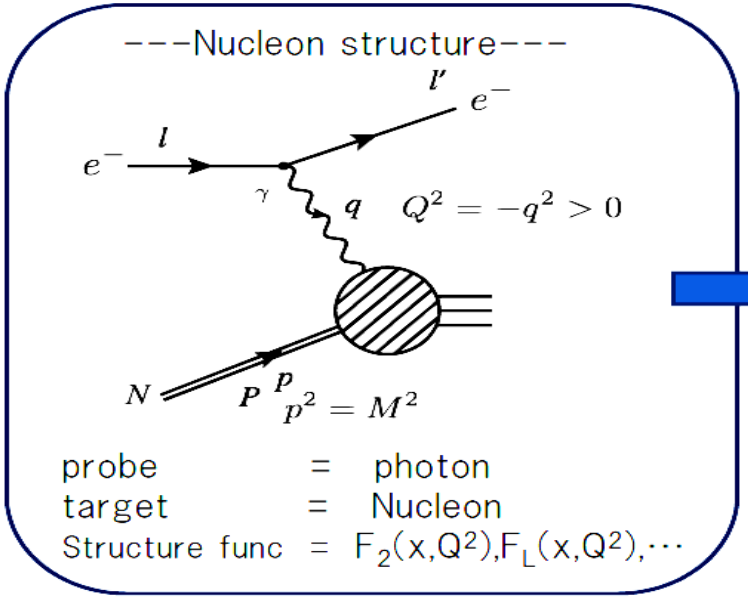
- A new light on the photon structure could be shed by spin-dependent structure functions, which have not been measured so far – this would be possible in the polarized e^+e^- collisions in the future linear collider.
- Two-photon processes are a background for physical analyses in which New Physics signals are being searched for, therefore their evaluation will be important to obtain reliable results.

Photon structure function

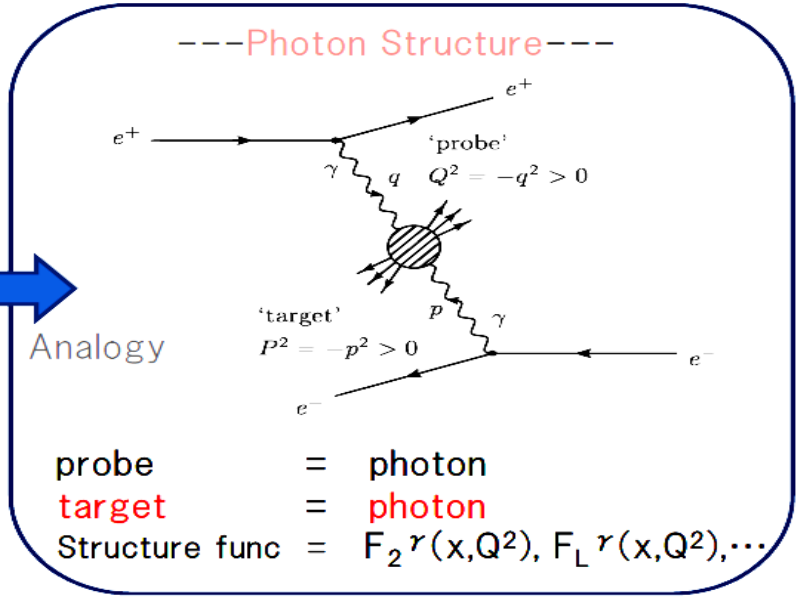
Deep inelastic eγ scattering

Analogy with studies of the proton structure functions at HERA

HERA



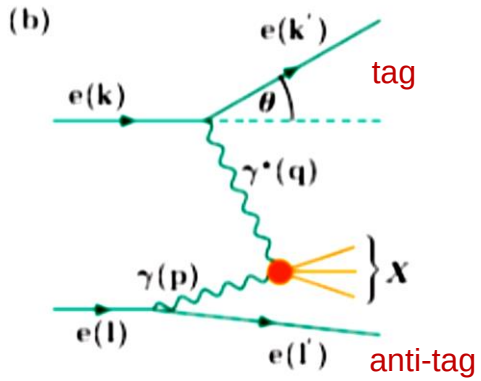
LC



Possible synergy with HERA studies

Photon structure function & its measurement

The single-tag process $e^+e^- \rightarrow e^+e^- \gamma\gamma \rightarrow e^+e^- X$



$$\frac{d\sigma(e\gamma \rightarrow eX)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4} \cdot \left[\{1+(1-y)^2\}F_2^\gamma(x,Q^2) - y^2 F_L^\gamma(x,Q^2)\right]$$

$$Q^2 = 4E_b E' sin^2(\theta/2)$$

$$y = 1 - \frac{E'}{E_b} cos^2\left(\frac{\theta}{2}\right)$$

$$x = \frac{Q^2}{Q^2 + W^2 + P^2}$$

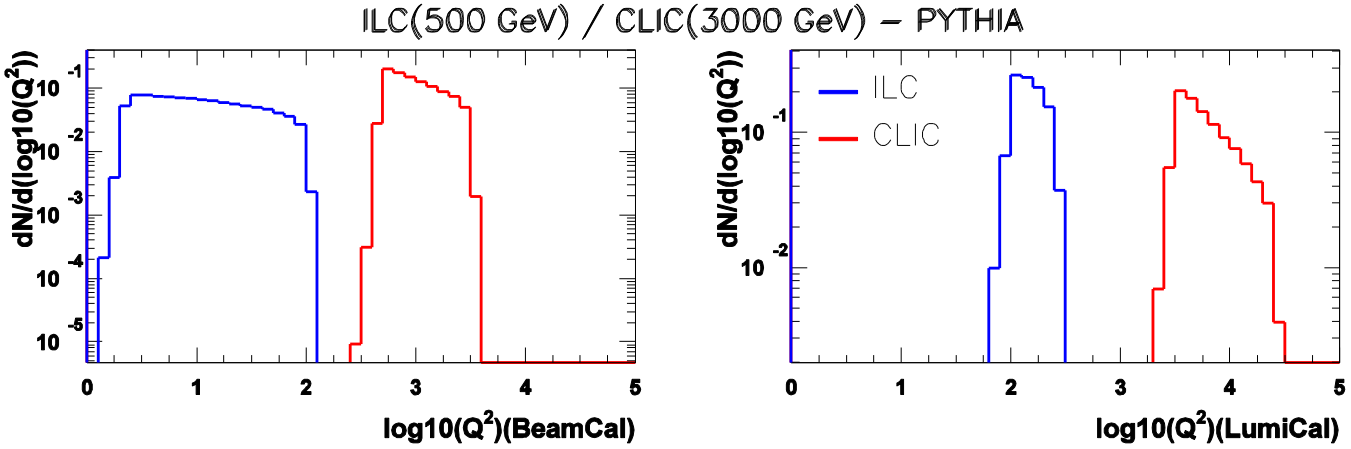
$$W^2 = \left(\sum E_h\right)^2 - \left(\sum \vec{p}_h\right)^2$$

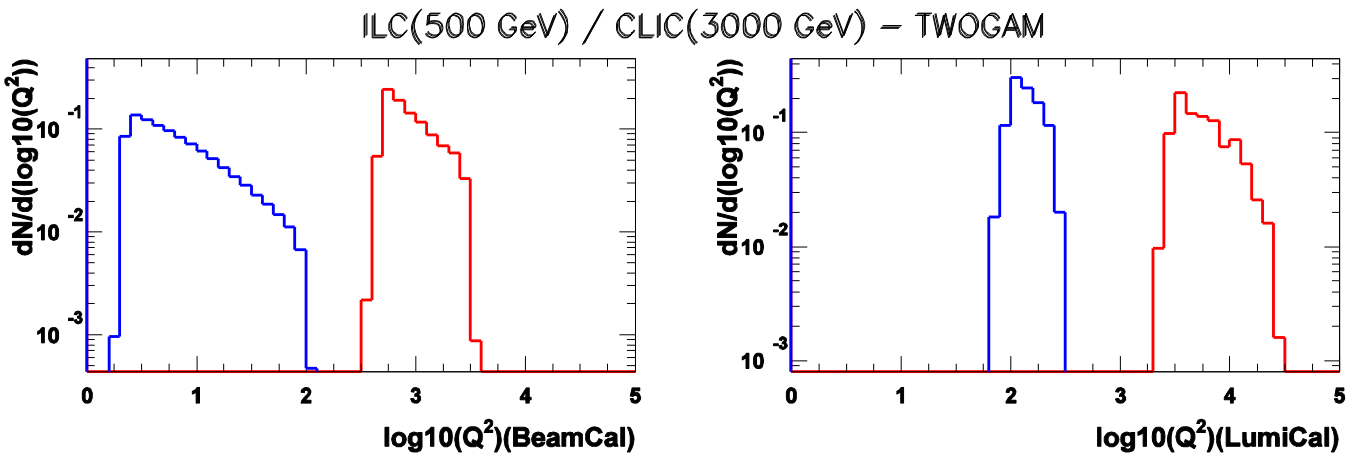
x – fraction of parton momentum with respect to the target photon

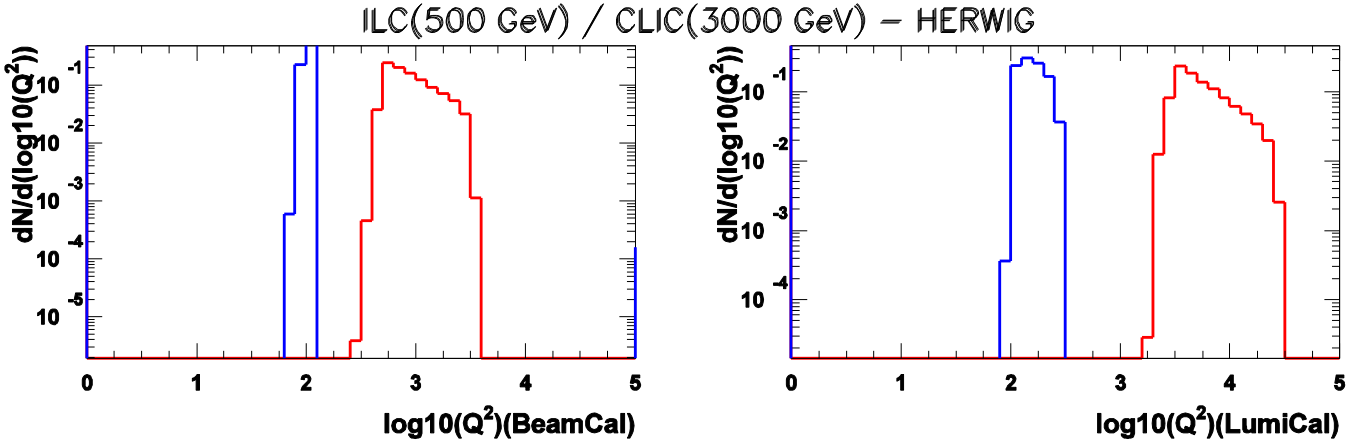
y – energy lost by the inelastically scattered electrons

E_b (E') – energy of the beam electrons (the scattered electrons)

E_h $(\vec{p}_h)$ – energies (momenta) of final state particles







Expected values of kinematic variables – generation level

ILC

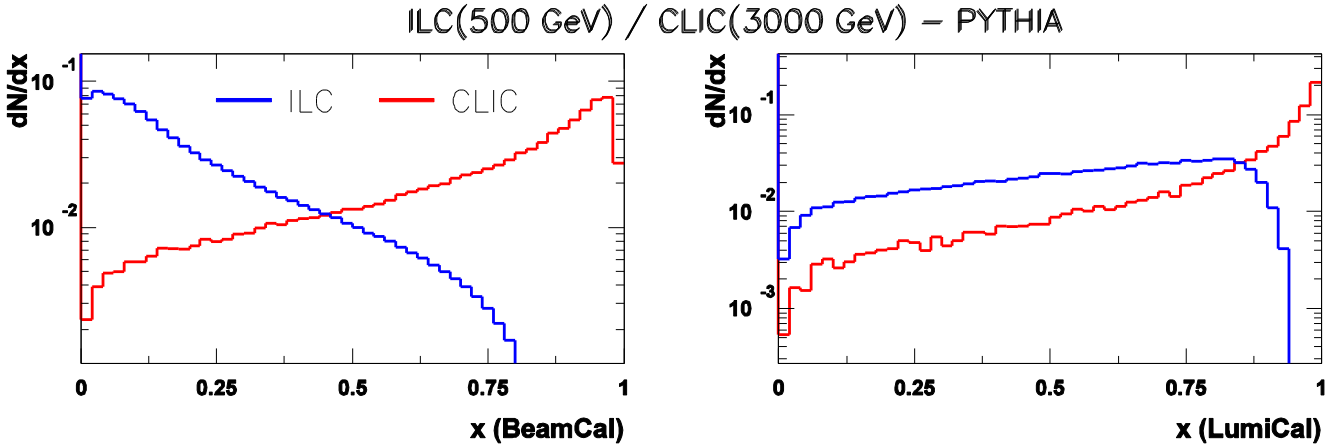
LumiCal
31 – 78 mrad

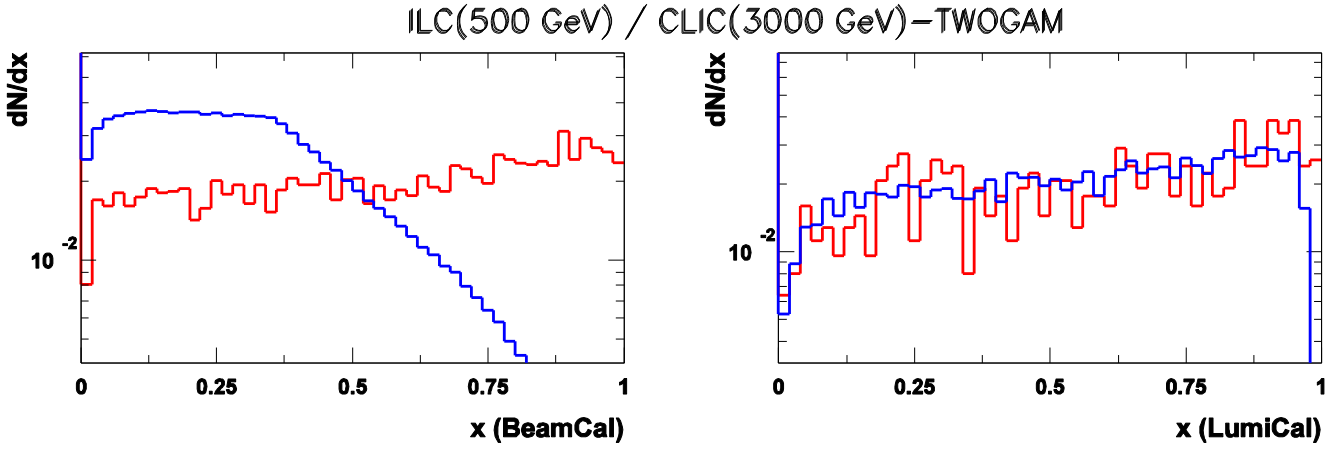
BeamCal
5.8 – 43.5 mrad

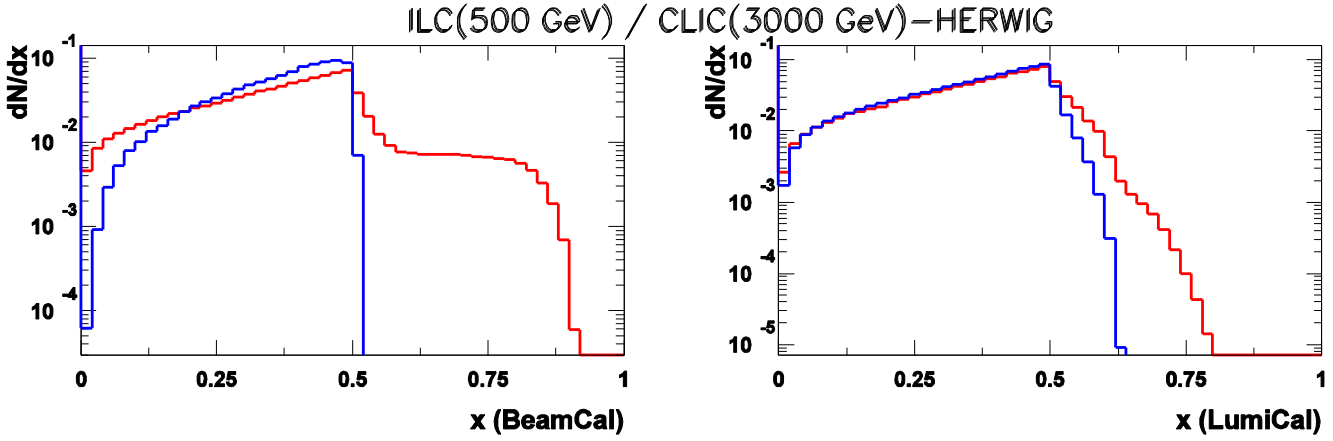
CLIC

LumiCal
38 – 110 mrad

BeamCal
10 – 40 mrad







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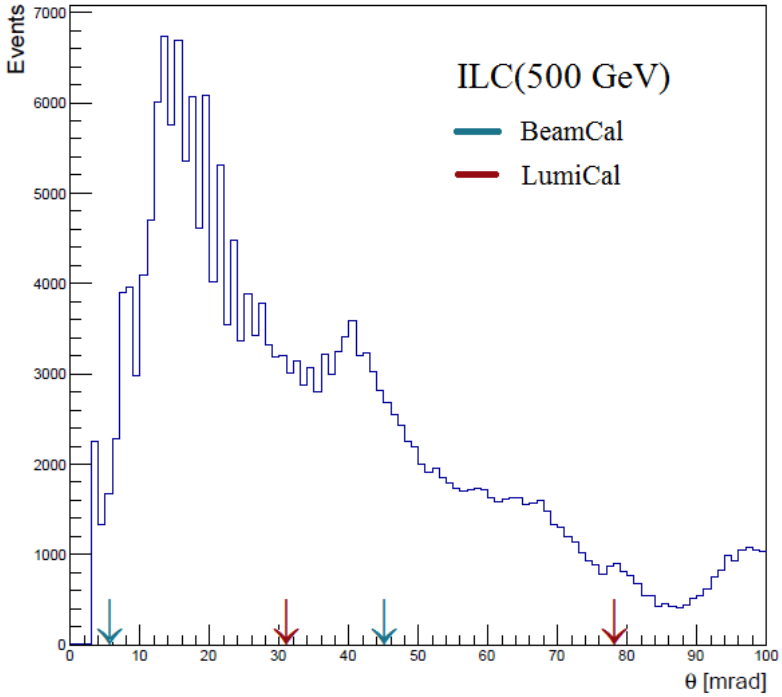
Polar angles of scattered electrons



For higher beam energy electrons are scattered in smaller angles → more events are lost

ILC

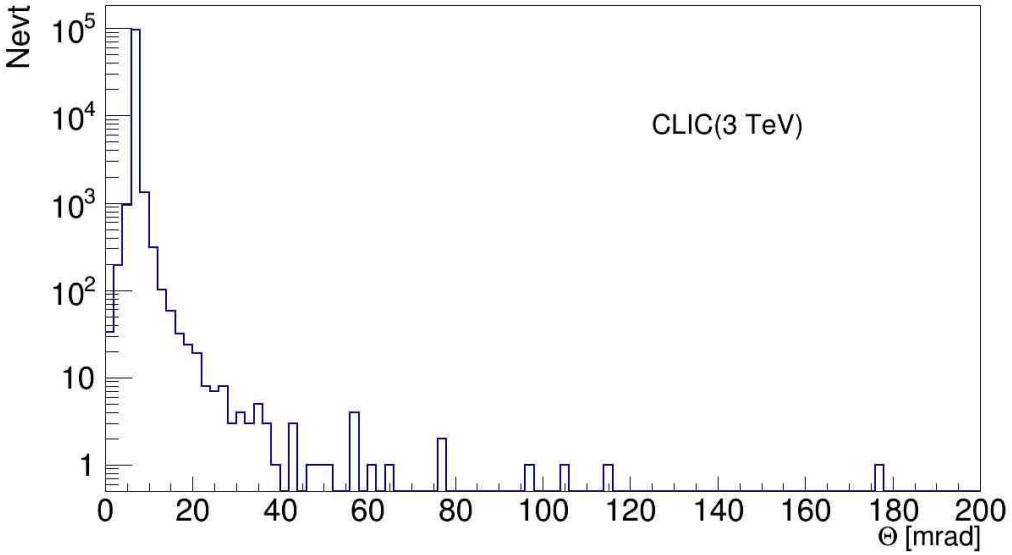
LumiCal 31 – 78 mrad

BeamCal 5.8 – 43.5 mrad

CLIC

LumiCal 38 – 110 mrad

BeamCal 10 – 40 mrad

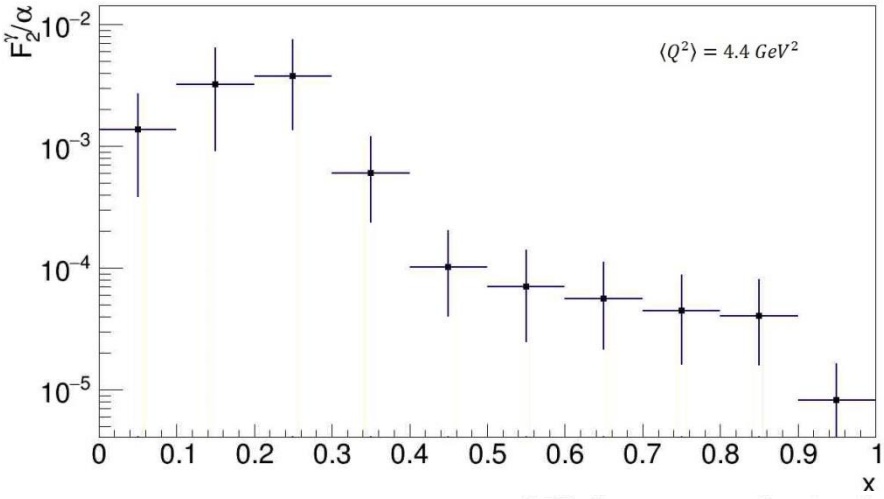


Photon structure function

PYTHIA Monte Carlo studies

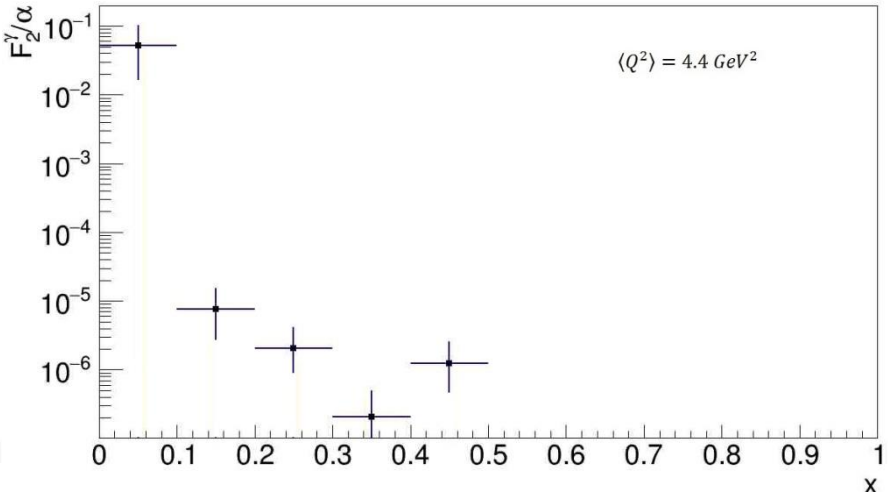
$e^+e^- \rightarrow e^+e^- \gamma^*\gamma \rightarrow \mu^+\mu^-$

QED photon structure function, BeamCal, ILC(500)

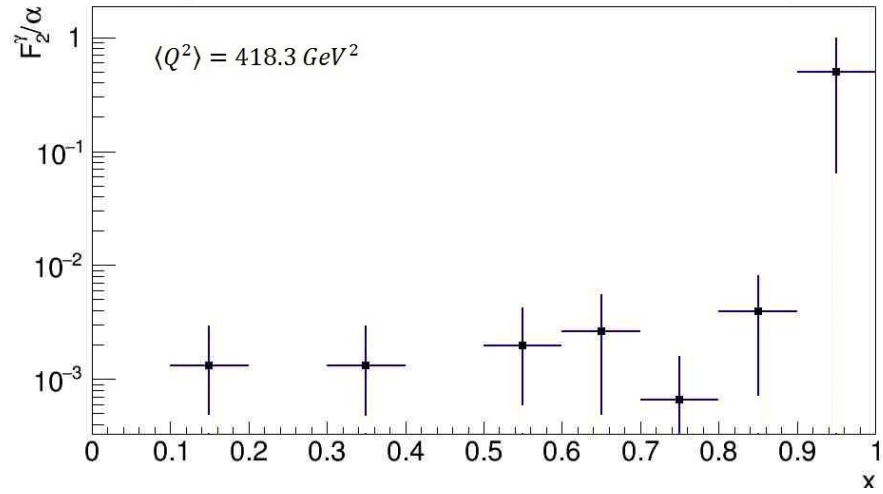


$e^+e^- \rightarrow e^+e^- \gamma^*\gamma \rightarrow$ hadrons

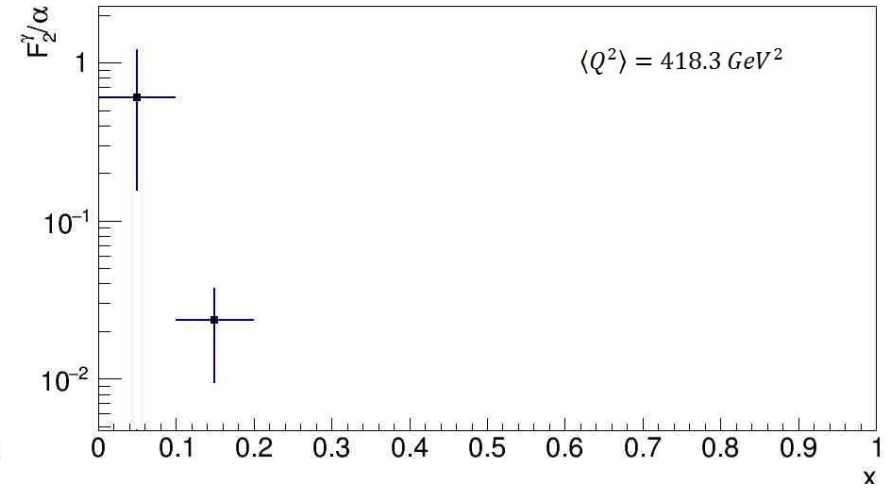
QCD photon structure function, BeamCal, ILC(500)



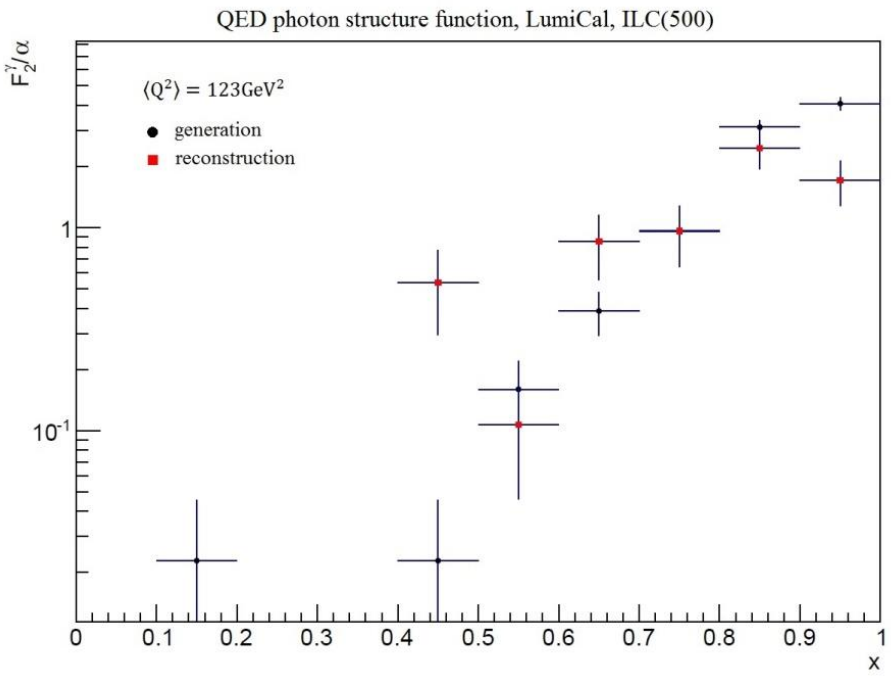
QED photon structure function, BeamCal, CLIC (3000)

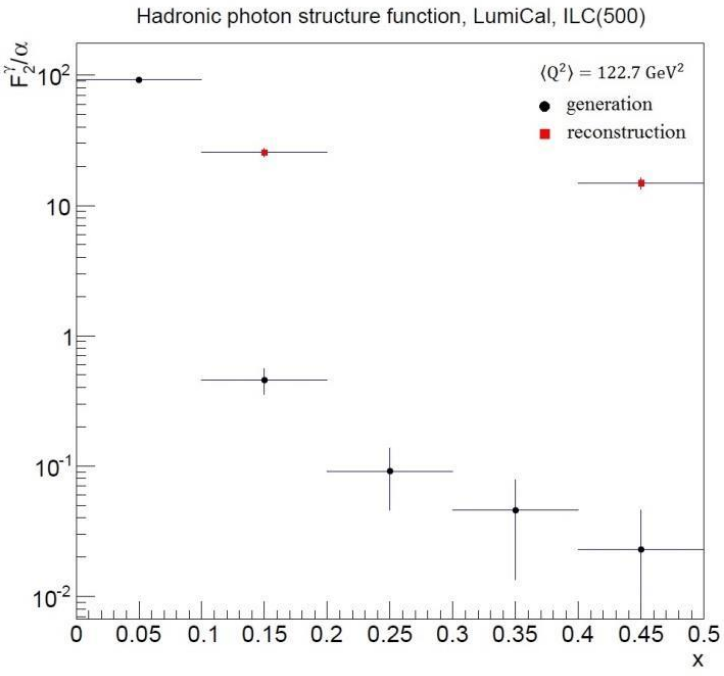


QCD photon structure function, BeamCal, CLIC (3000)



Photon structure function





Examples of results for generation and reconstruction level – ILC (500 GeV)

Scattered electrons tagged at the LumiCal

Only statistical uncertainties

Summary and Outlook

- At ILC/CLIC it will be possible to extend the available kinematical range for the measurement of the photon structure functions.

- Information from forward detectors can be used to study the photon structure functions. However, at higher energies tagging of the scattered electrons is difficult.

- The comparison of the PYTHIA generator level results with predictions of other Monte Carlo generators (HERWIG, TWOGAM) has been made. Because of differences further study is necessary.

- The next steps include the estimation of systematic effects, including background (beamstrahlung, annihilation, etc.) and the use of the reconstructed variables in the analysis for CLIC.

- The determined kinematical variables should be corrected due to the detector effects (the so-called unfolding method).