# Fast evaluation of $p[\gamma]p[\gamma] \to \ell^+\ell^- + X$ cross-section with APPLGRID

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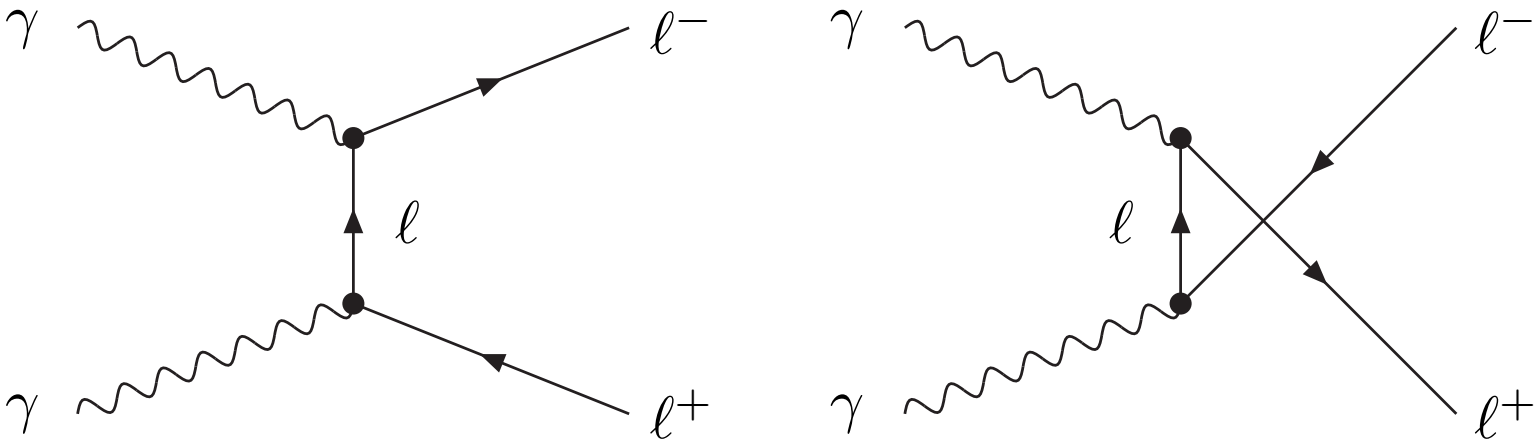
# Motivation




Photon-induced $\gamma\gamma \to \ell^-\ell^+$ process is an irreducable background to neutral current Drell-Yan-like process $q\bar{q} \to \gamma/Z \to \ell^-\ell^+$ and should be considered as part of NLO EW contribution to the production of charged lepton pair.

# Cross-section

3-differential cross-section of the process $p[\gamma]p[\gamma] \to \ell^+\ell^- + X$ at LO:

$$\frac{d\sigma_{\gamma\gamma}}{dx\,dy\,dz} =$$
$$= \frac{4\pi\alpha^2}{s_0} f_\gamma\left(\frac{M_{min}}{\sqrt{s_0}}e^{x+y}, \mu_F^2\right) f_\gamma\left(\frac{M_{min}}{\sqrt{s_0}}e^{x-y}, \mu_F^2\right)\left(1+\tanh^2 z\right),$$

where $x = \ln\frac{M_{\ell^+\ell^-}}{M_{min}}$, $y = Y_{\ell^+\ell^-}$, $z = -\ln\tan\frac{\hat{\theta}}{2}$.

$f_\gamma$ — photon PDF (photon is considered as parton within proton).

# Correction factors at LHC ($\sqrt{s_0} = 14$ TeV)

| $M_{\ell^+\ell^-} >$, GeV | $\sigma_{\gamma\gamma}$ (SANC), pb | $\sigma_{\gamma\gamma}$ DH, pb arXiv:0911.2329v2 | $\delta_{\gamma\gamma}$, % |
|---|---|---|---|
| 50 | 1.29(1) | 1.26(5) | 0.17 |
| 100 | 0.378(1) | 0.376(1) | 1.15 |
| 200 | $6.39(1) \times 10^{-2}$ | $6.39(1) \times 10^{-2}$ | 4.30 |
| 500 | $3.98(1) \times 10^{-3}$ | $3.98(1) \times 10^{-3}$ | 4.92 |
| 1000 | $3.54(1) \times 10^{-4}$ | $3.54(1) \times 10^{-4}$ | 5.21 |
| 2000 | $1.88(1) \times 10^{-5}$ | $1.87(1) \times 10^{-5}$ | 6.19 |

$\delta_{\gamma\gamma} = \frac{\sigma_{\gamma\gamma}}{\sigma_0}$, where $\sigma_0$ — cross-section of single Z production at LO.

# Some features of implementation

- SANC generator produces unweighted events which are saved to file. Each event $i$ is assigned a weight

$$w_i = \frac{\sigma_{tot}}{N} \cdot \frac{1}{f_\gamma(x_{1_i}, Q_i^2) f_\gamma(x_{2_i}, Q_i^2)},$$

  where $\sigma_{tot} = \int d\sigma$, $N$ - total number of events. We use MRST2004qed pdf set to evaluate photon pdf.
- These events are used to fill grids for different observables with help of APPLGRID interface.
- These grids can be used for fast convolution with arbitrary photon PDF to get the cross-section (for the moment we use MRST2004qed pdfs for convolution)
- The standard APPLGRID package was modified so one can handle one extra pdf (photon) in addition to 13 standard pdfs (gluon and quarks).

# Test grid

The interface was tested with the following grid parameters

$$
\begin{aligned}
&nXbins = 50 \\
&xLow = 10^{-8}, \quad xUp = 1 \\
&xorder = 6 \\
&nQ2bins = 1 \\
&q2Low = 8315.17, \quad q2Up = 8315.19
\end{aligned}
$$

We get an agreement with the result of `SANC` Monte Carlo when using `MRST2004qed` pdfs.

# Summary

- The stand-alone `APPLGRID` interface to `SANC` Monte Carlo generator for gamma-induced process was created. It has been tested with `MRST2004qed` pdfs.
- Next step: to implement it into `HERAFitter` package.