Forward Physics Monte Carlo Update

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Forward Physics Monte Carlo

The main purpose of the Forward Physics Monte Carlo (FPMC) is to simulate diffractive and photo-induced processes in hadron-hadron collisions.
FPMC is based on HERWIG 6.5. The original code for two-photon exchanges in e^+e^- collisions is adapted to pomeron/gluon exchanges. Hadronization is included via HERWIG.
We can distinguish exclusive processes (QED and QCD) and inclusive processes.

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Production mechanisms in FPMC

NFLUX	Description (Color singlet exchanges)
9	QCD factorized model, Pomeron flux
10	QCD factorized model, Reggeon flux
12	QED flux from Cahn, Jackson; $R \sim 1.2A^{1/3}$
13	QED flux from Drees et al., valid for heavy ions
14	QED flux in pp collisions, from Papageorgiou
15	QED flux in pp collisions, from Budnev et al
16	QCD KMR exclusive model
17	QCD CHIDe exclusive model
19	$\mathbb{P} - \mathbb{R}$ exchange
20	$\gamma - \mathbb{P}$ exchange in pp collisions.
21/22	$\mathbb{P} - \mathbb{R}$ exchange in pp collisions.
23	$\gamma - \gamma$ in pA collisions.
25/26	$\mathbb{P} - \gamma$ in pA collisions.

Inclusive hard diffraction

Hard diffractive processes follow the Ingelman-Schlein model of diffraction. The pomeron structure is described by PDFs measured at events with rapidity gap at HERA. For single diffractive events with single pomeron exchange

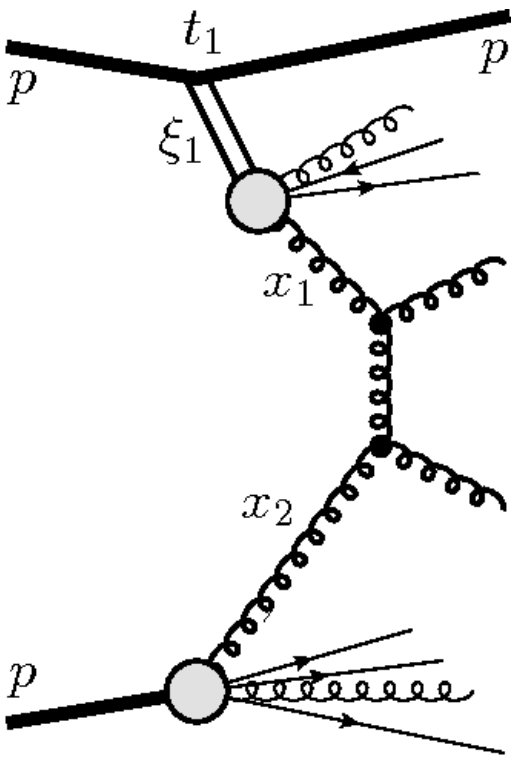
$$\mathrm{d}\sigma^{pp\to pX} = \sum_i \int f_i^D(x_i, \mu^2, \xi, t) f_j(x_j, \mu^2) d\sigma^{i,j\to X}(x_i, x_j, \mu^2)\, \mathrm{d}x_i\, \mathrm{d}x_j\, \mathrm{d}\xi\, \mathrm{d}t \tag{1}$$

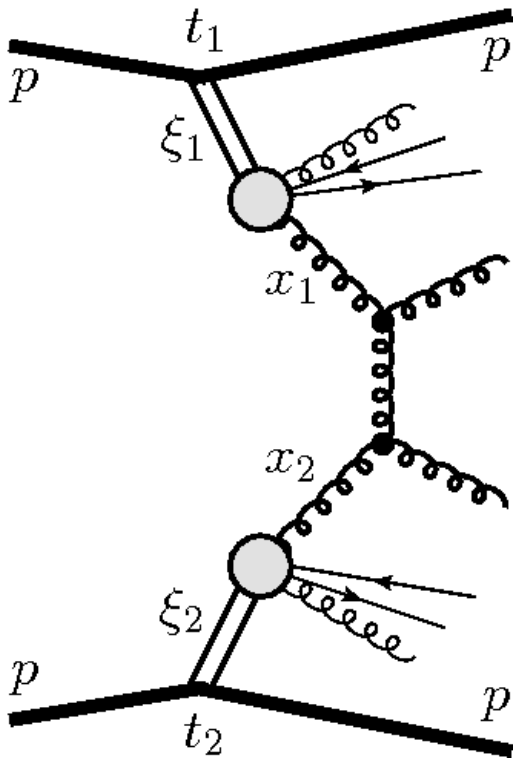
And double pomeron exchange

$$d\sigma^{\mathrm{pp}\to\mathrm{ppX}} = \sum_{i,j} \int dx_i dx_j\, d\xi_i d\xi_j\, F_{\mathbb{P}/p}(\xi_i) F_{\mathbb{P}/p}(\xi_j) \times f_{i/\mathbb{P}}(x_i, \mu^2) f_{j/\mathbb{P}}(x_j, \mu^2)\, d\hat{\sigma}(ij \to X) \tag{2}$$

Single and double diffractive processes

One can use the parton-level amplitudes available in HERWIG 6.5 and couple this with the exchanged object. For example, DPE + $gg \to gg$ and SD $gg \to gg$.





Photon-induced processes (Exclusive)

In case of the photon induced processes, the Equivalent Photon Approximation (EPA) is used to describe the coupling of the photon to the proton considering its electromagnetic structure. A constant survival probability of 0.9 is used for these processes.

$$\frac{d\sigma}{d\Omega} = \int d\omega_1 d\omega_2 \frac{d\sigma_{\gamma\gamma\to X}(W = \sqrt{(4\omega_1\omega_2)})}{d\Omega} f(\omega_1) f(\omega_2). \quad (3)$$

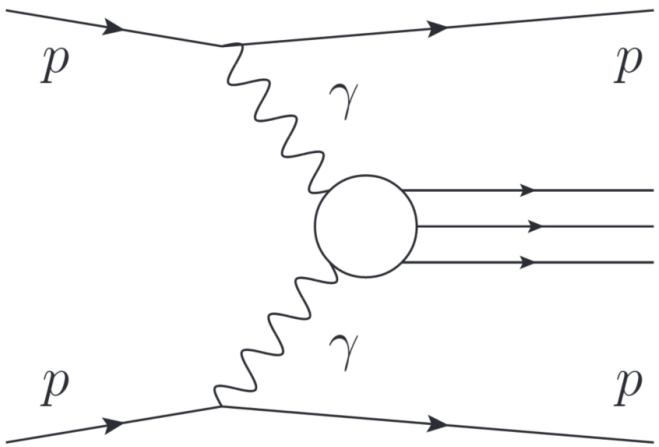


Photo-induced processes (Exclusive)

Process	Parameters
$\gamma\gamma \to W^+W^-$ (QED)	SM parameters.
$\gamma\gamma \to \gamma\gamma$ (QED)	m and Q of particle in the loop.
$\gamma\gamma \to \gamma\gamma$ (aQGC)	ζ_1, ζ_2
$\gamma\gamma \to W^+W^-$ (aQGC)	a_W^0/Λ, a_W^0/Λ
$\gamma\gamma \to ZZ$ (aQGC)	a_Z^0/Λ, a_Z^0/Λ
$\gamma\gamma \to Z\gamma$ (aQGC)	ζ, $\tilde{\zeta}$
$\gamma\gamma \to \phi^0/\phi^2 \to \gamma\gamma$	m, $f_{\gamma\gamma}$, Γ
$\gamma\gamma \to \phi \to Z\gamma$	m, $f_{\gamma\gamma}$, $f_{Z\gamma}$ Γ
$\gamma\gamma \to \phi \to ZZ$	m, $f_{\gamma\gamma}$, f_{ZZ}, Γ
$\gamma\gamma \to \phi \to W^+W^-$	m, $f_{\gamma\gamma}$, $f_{W^+W^-}$ Γ
$\gamma\gamma \to \phi \to HH$	m, $f_{\gamma\gamma}$, f_{HH} Γ
$\gamma\gamma \to \phi \to gg$	m, $f_{\gamma\gamma}$, Γ

The vertices are induced by the general coupling $\phi F^{\mu\nu}F_{\mu\nu}$, $\phi V^{\alpha\beta}V_{\alpha\beta}$. f are the couplings of the resonance to the diboson.

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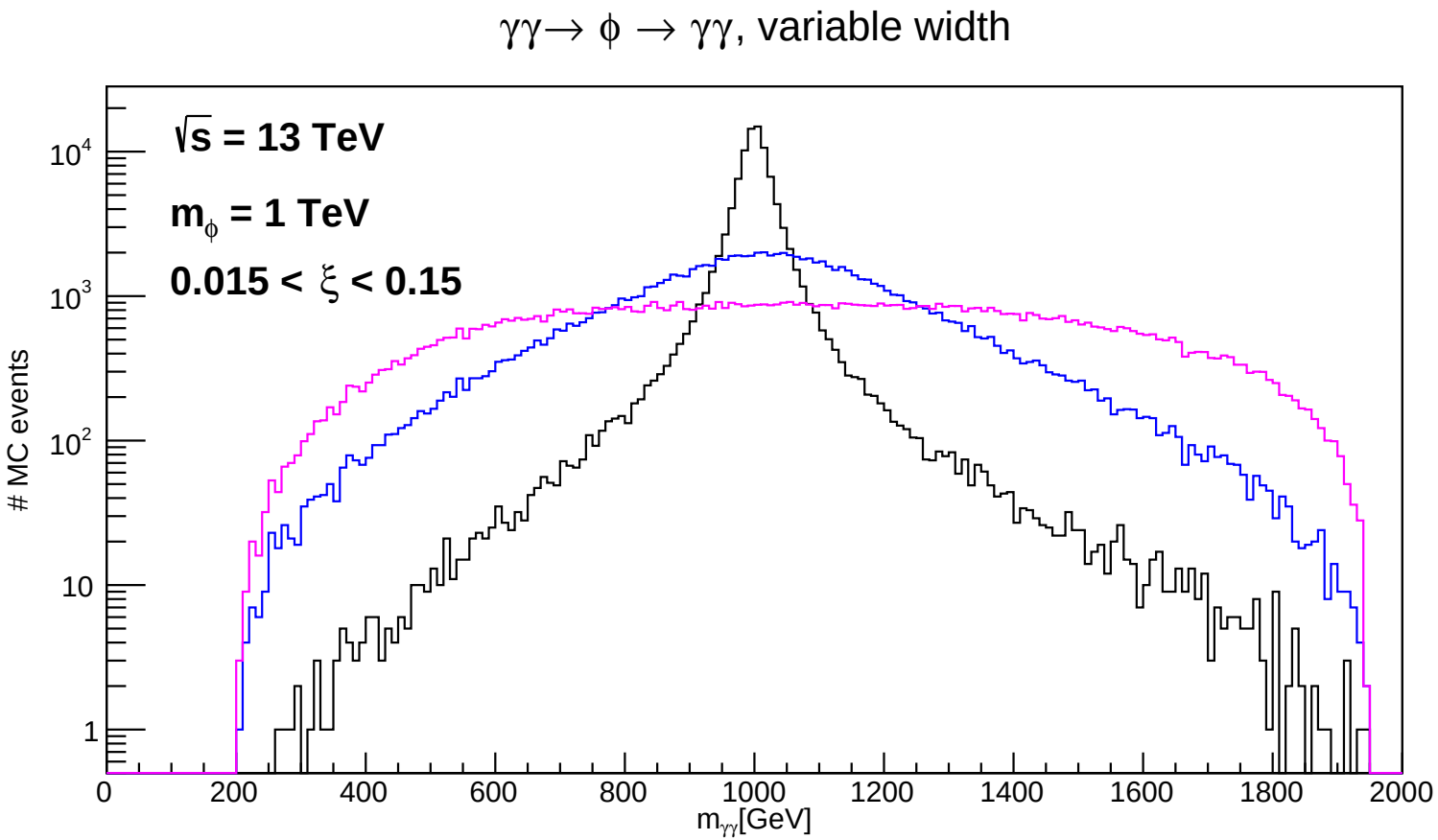
Example, ϕ resonance in $\gamma\gamma$



Photon-induced processes

Provided the amplitudes $\mathcal{M}^{i}_{\lambda_1\lambda_2\lambda_3\lambda_4}$ for a given $\gamma\gamma \to AB$ process, we can implement it on the FPMC (Modularity in photo-induced processes) for the corresponding $pp \to pABp$ process. (See talk later for $\gamma\gamma \to Z\gamma$ instance)

Conclusion/Outlook

- Improvement on the survival probability $\mathcal{S}$ (Dependence on p_T of incoming and outgoing protons).
- A second version of the FPMC manual is on the way.
- The FPMC includes QCD-CEP (Durham model, CHIDe model). However we refer to ExHuMe or SuperChic2 generators for the QCD central exclusive production, which has a better treatment for this flux.