# JetPhox/DiPhox programs

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LAPTH
CNRS/Université de Savoie

Workshop on Photon Physics and Simulation at Hadron Colliders – March 2012

# Outline

- Phox Family
- JetPhox
- Isolation criteria
- DiPhox

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A set of programs to compute, at NLO, cross-section for reactions involving photon, hadron and jet.
`http://lapth.in2p3.fr/PHOX_FAMILY/main.html`

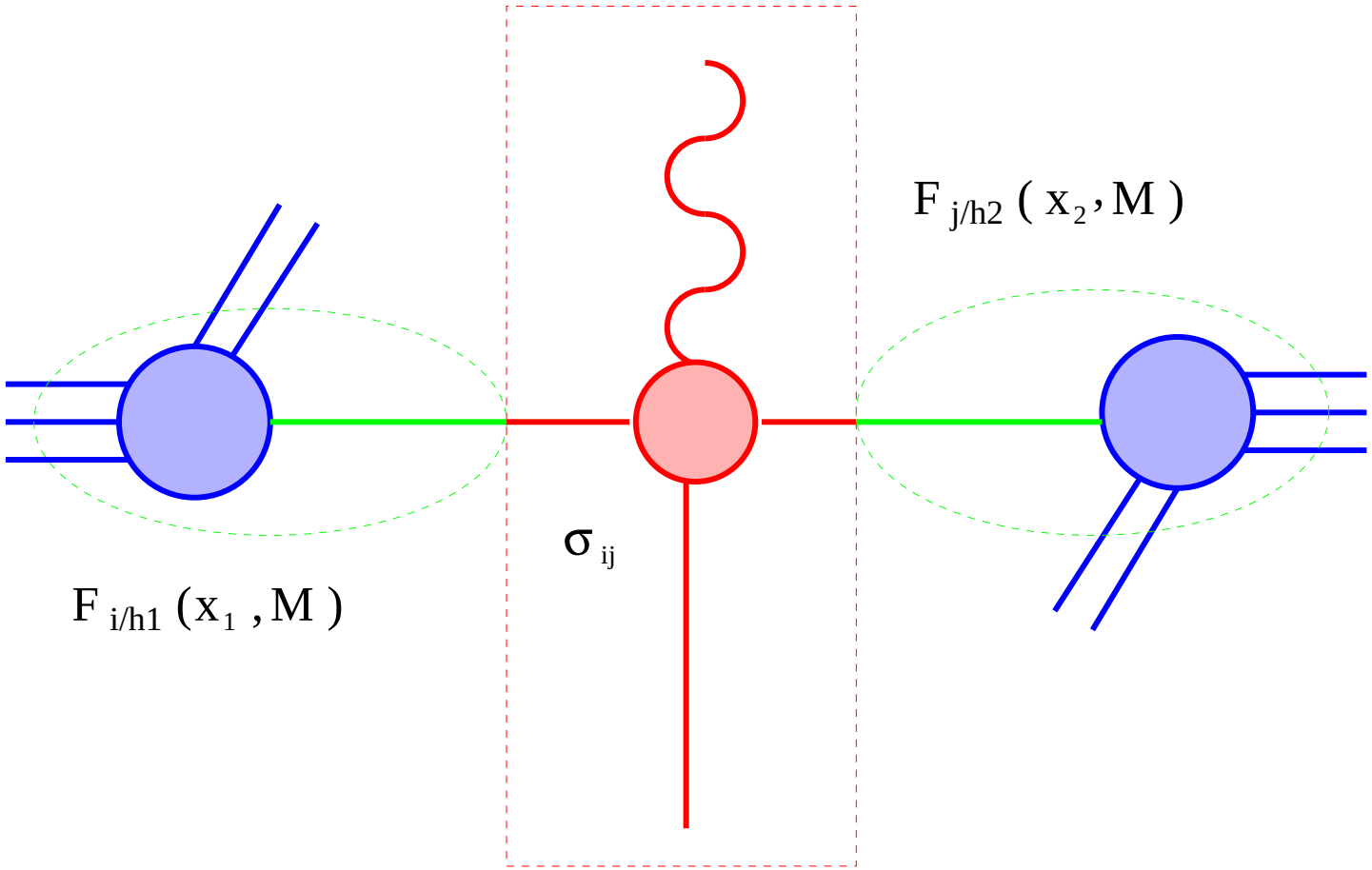
F. Arleo, T. Binoth, M. Fontannaz, J. P. Guillet, G. Heinrich, E. Pilon, M.Werlen

JETPHOX is a Fortran program to calculate the reactions hadron $+$ hadron $\rightarrow \gamma/$hadron $+$ jet $+$ X (latest version 1.3.1_1).

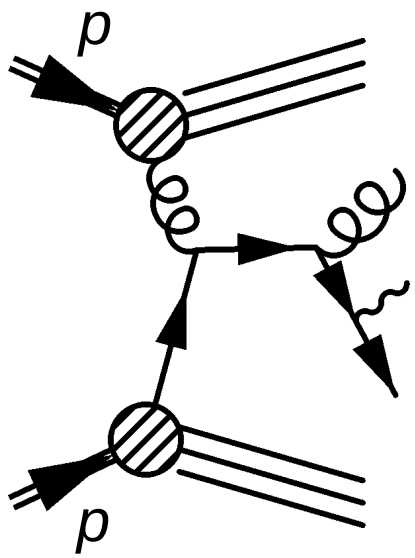
- output : root ntuples/histograms
- can handle different isolation criteria
- can give the pdf error band in one run

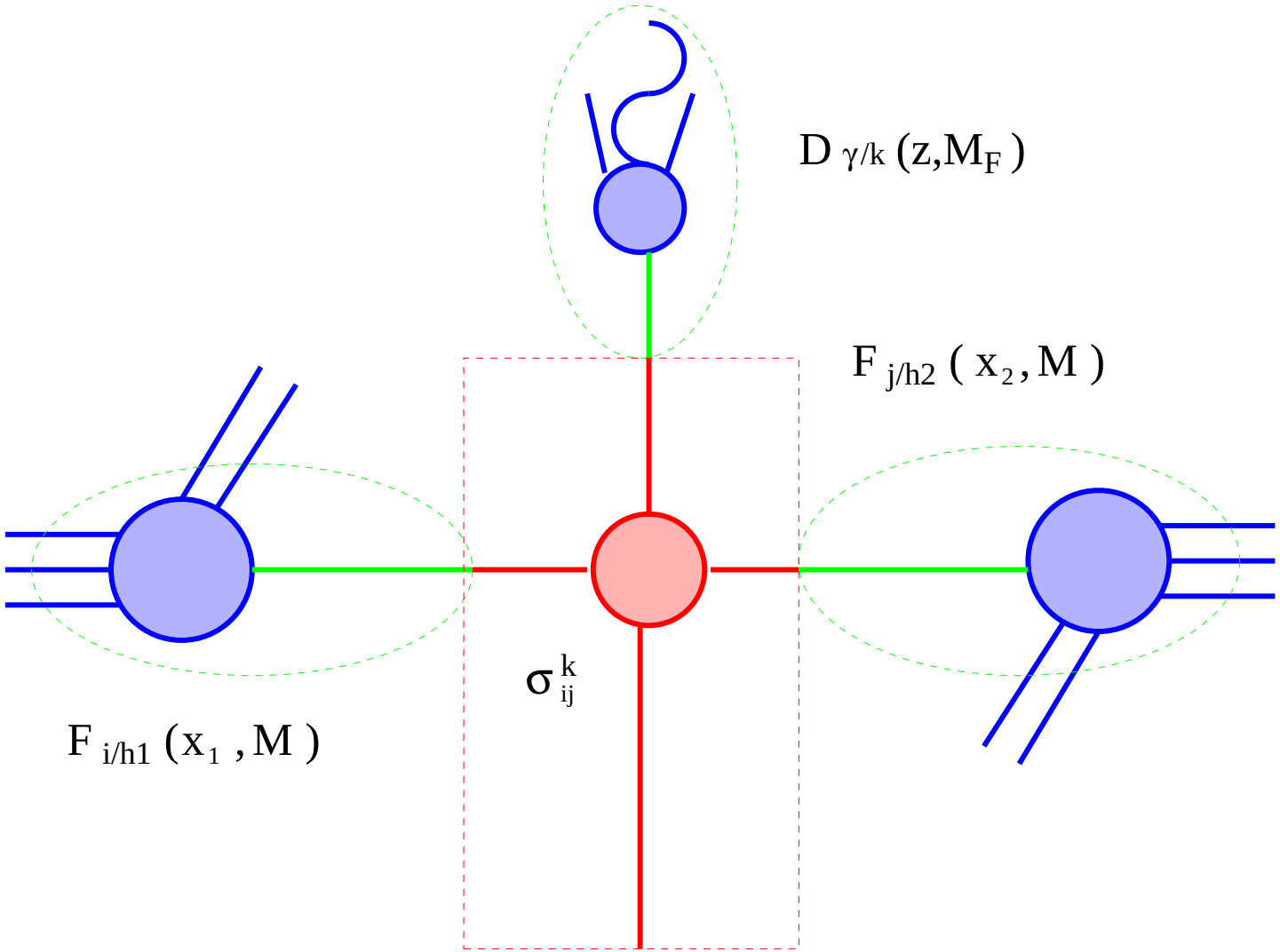
DIPHOX is a program to calculate the hadroproduction of two photons (or one hadron plus one photon, or two hadrons) at NLO (latest version 1.3.3)

- output : root ntuples/histograms
- can handle different isolation criteria
- can give the pdf error band in one run


F j/h2 ( x2 , M )
σ ij
F i/h1 (x1 , M )

$O(\alpha_s)$ :




D γ/k (z,M_F )
F j/h2 ( x_2 , M )
σ k ij
F i/h1 (x_1 , M )

- Only the sum $\sigma^D + \sigma^F$ is a physical observable
- When $M_F \gg$ hadronic scale $D_{\gamma/k}(z, M_F)$ behaves like $\alpha/\alpha_s(M_F)$

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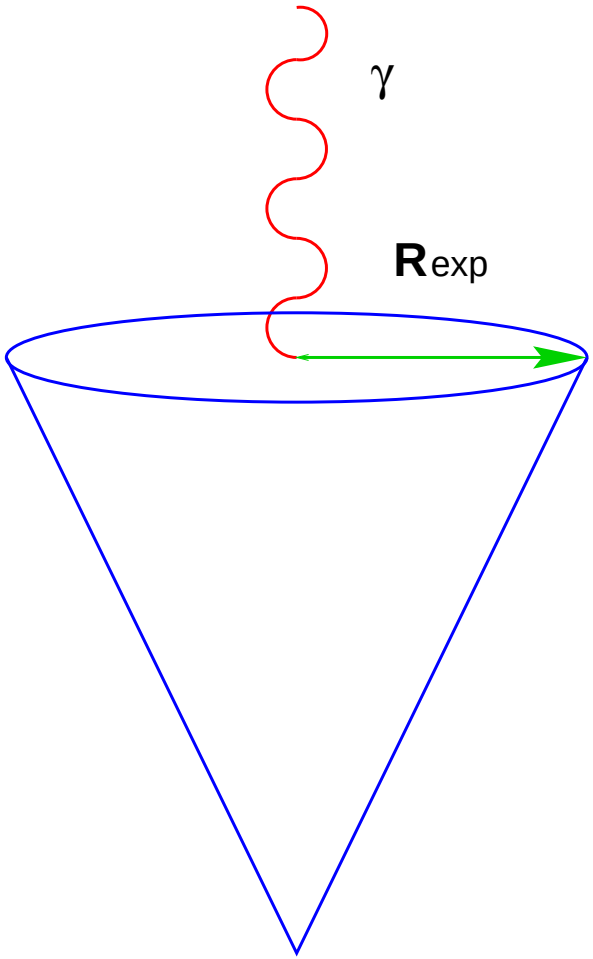
# Isolation criteria
## Standard criterion




$E_T^{had} \leq E_{T\,max}$ inside
$(y - y_\gamma)^2 + (\phi - \phi_\gamma)^2 \leq R_{exp}^2$

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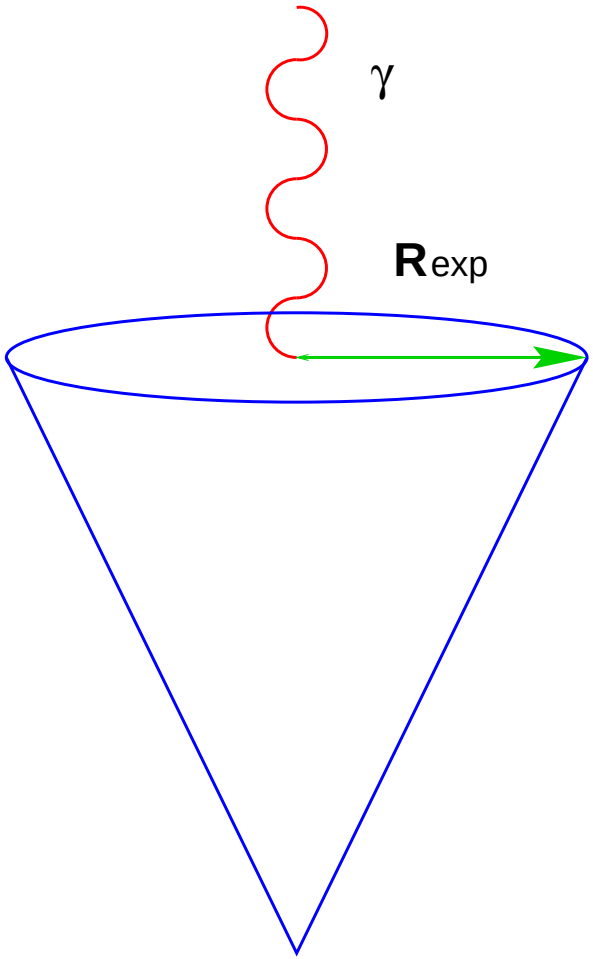
## Standard criterion

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Large Log. when $R_{exp} \rightarrow 0$ and $E_{T\,max} \rightarrow 0$

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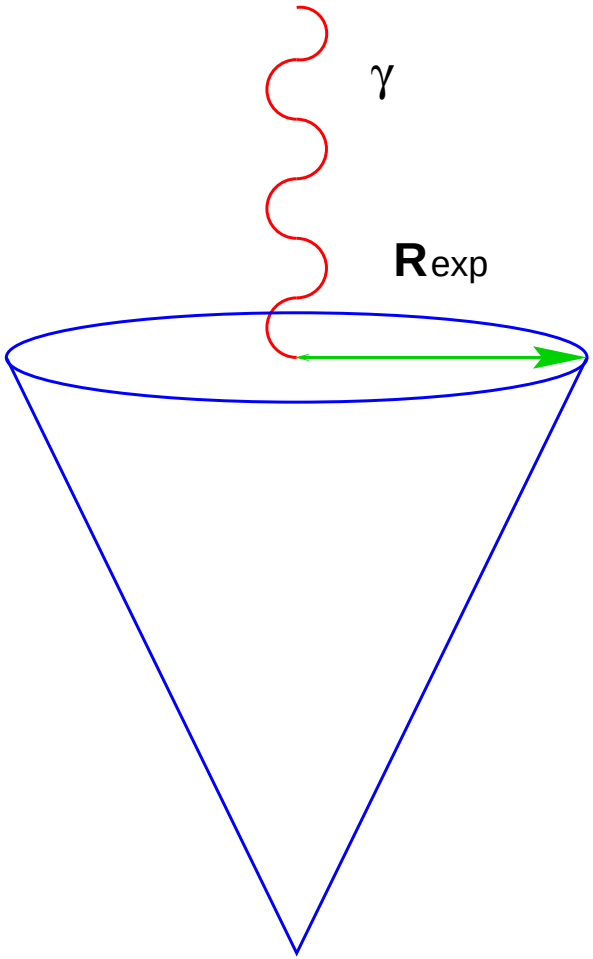


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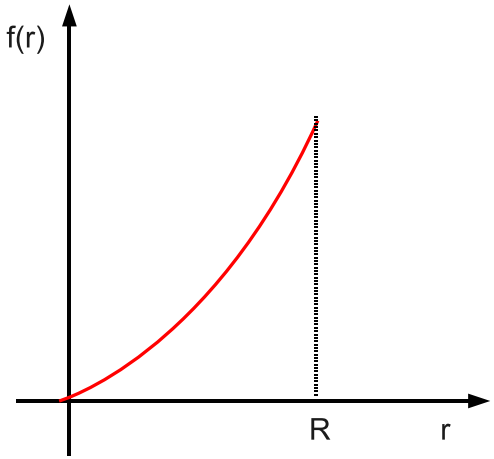
Large Log. when $R_{exp} \rightarrow 0$ and $E_{T\,max} \rightarrow 0$

Underlying events, pile up, ....

# Isolation criteria
## Criterion a la Frixione

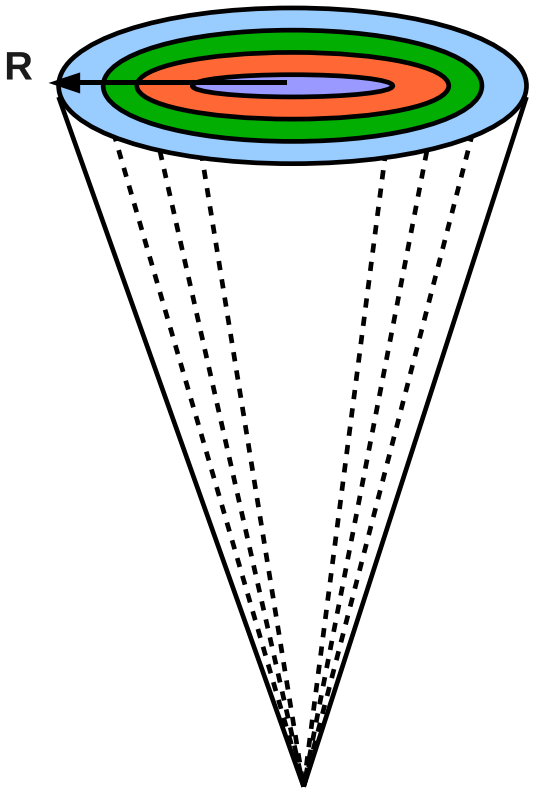


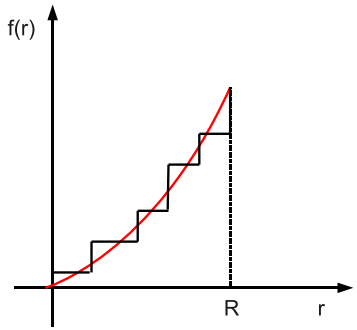

Other isolation criterion ( S. Frixione )
where $E_{T\,had} < f(r)$

$f(r) \rightarrow 0$ when $r \rightarrow 0$ like $r^{2n}$

kill the fragmentation contribution

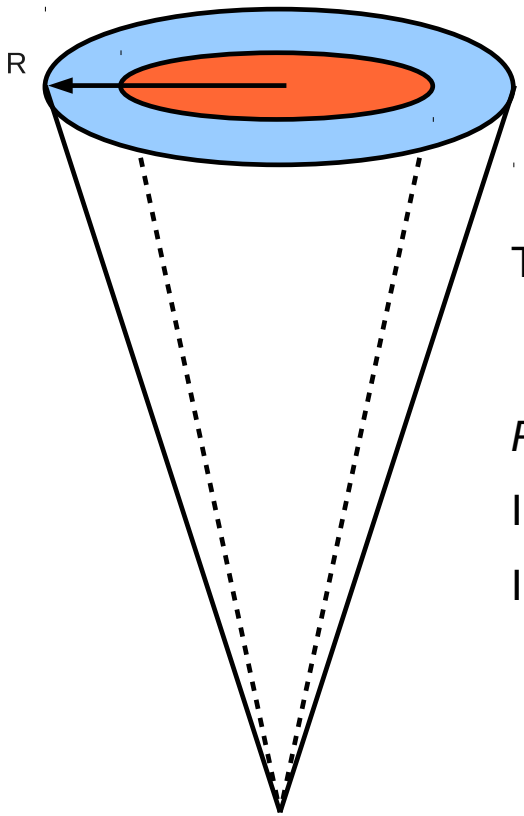
# Isolation criteria
## Discrete version




$$E^{j}_{T\,max} = \epsilon\, P_{T\,\gamma} \left( \frac{1-\cos(r_j)}{1-cos(R)} \right)^{n}$$

# Isolation criteria
## Hollow cone

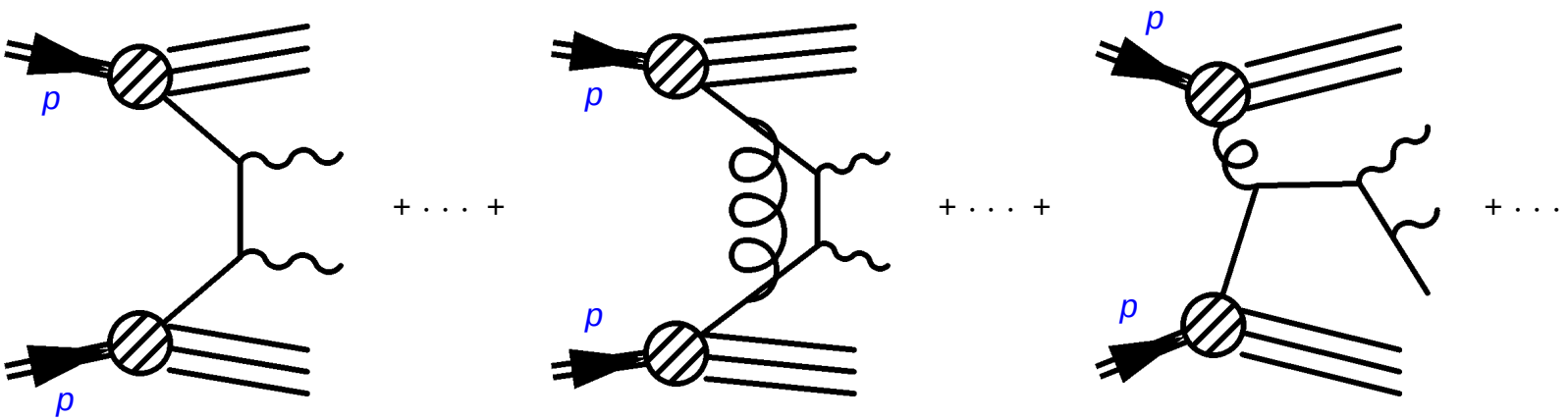



To mimic the photon shadow in the central cone

$R_2 = 0.4$ $R_1 = 0.1$

In the inner cone $R_1$, $E_{T\ max} < 15$ GeV

In the crown $R_2 - R_1$, $E_{T\ max} < 2$ GeV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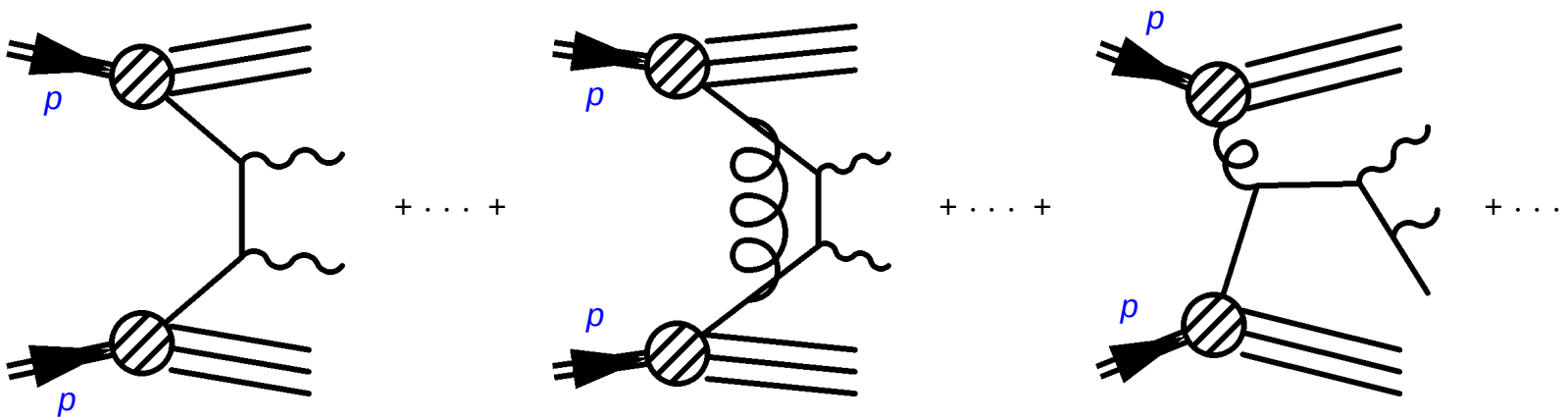
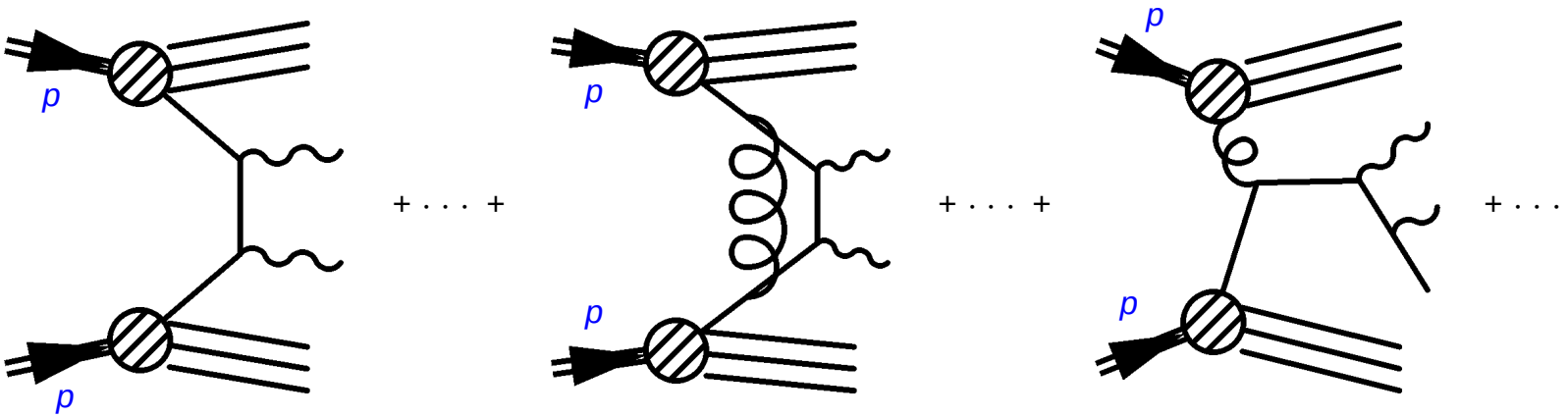



$O(\alpha^2) + O(\alpha^2\ \alpha_s)$

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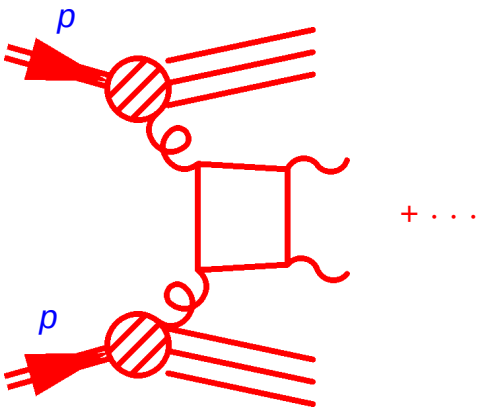

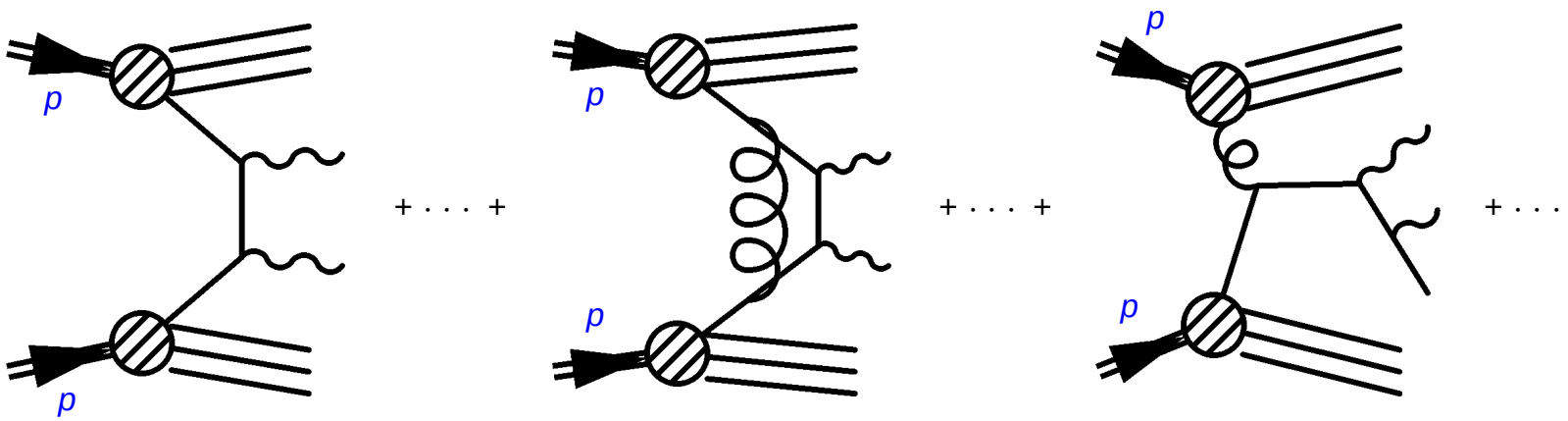


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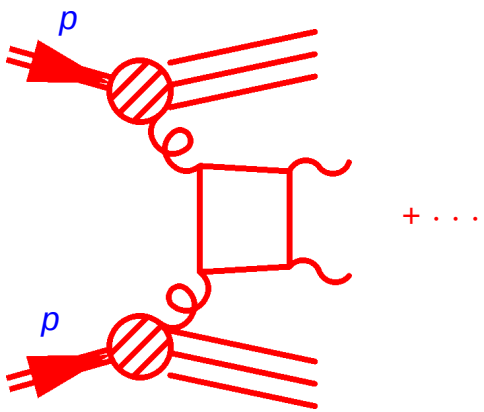
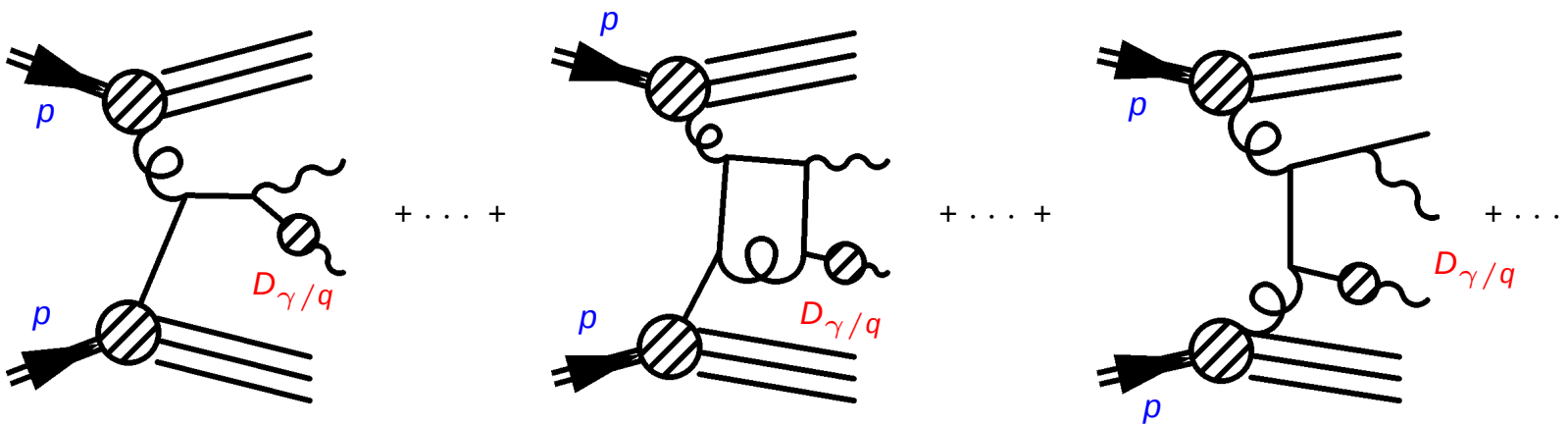



$O(\alpha^2\ \alpha_s^2)$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$D_{\gamma/q}$
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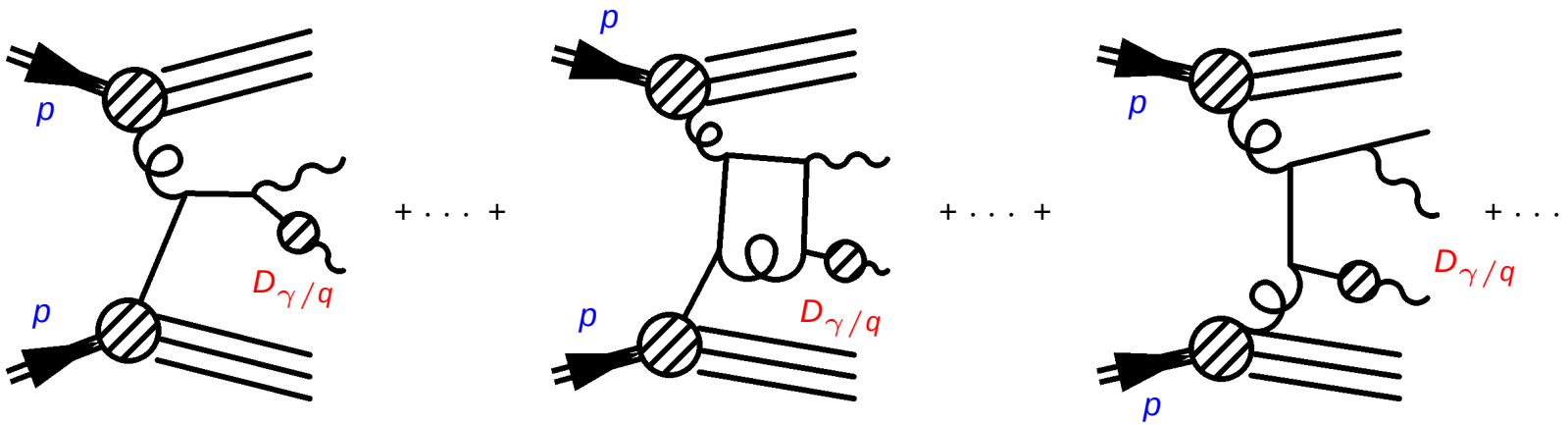
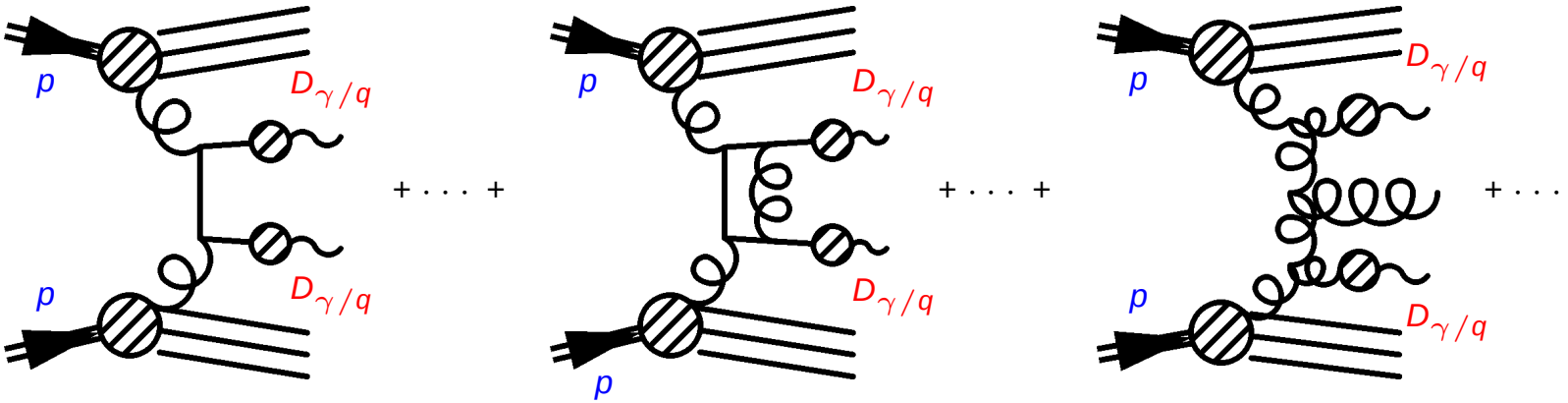
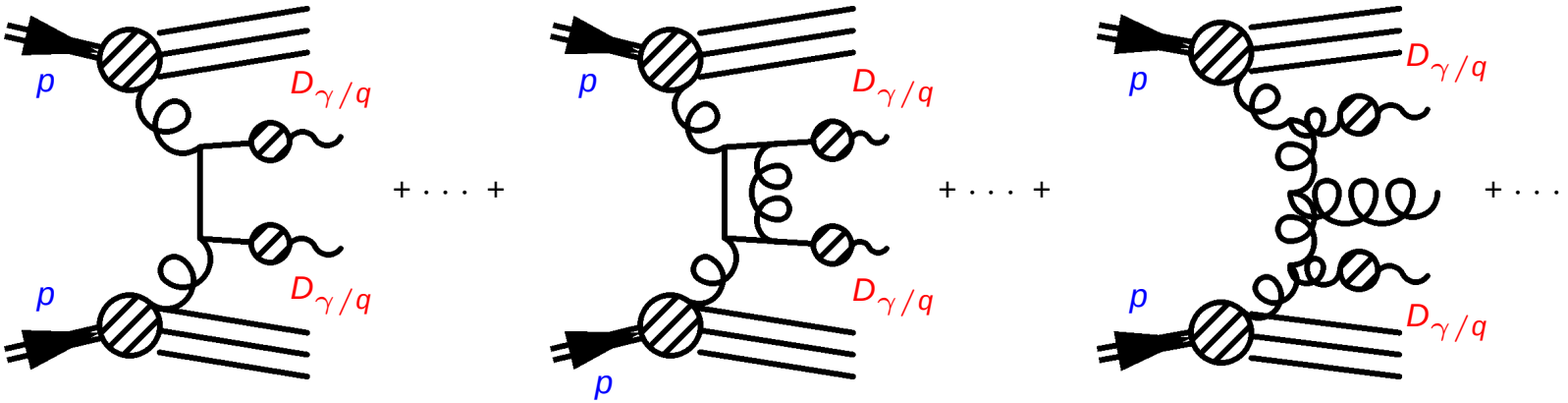



$O(\alpha^2\ \alpha_s) + O(\alpha^2\ \alpha_s^2)$ but $D_{\gamma/q}(z, M_f^2) \simeq 1/\alpha_s(M_f^2)$

# DiPhox

## Two Fragmentation






$O(\alpha^2\ \alpha_s^2) + O(\alpha^2\ \alpha_s^3)$

- infrared sensitive observables :
  - $P_{T\,\gamma\gamma}$ low; $P_{T\,\gamma\gamma} \simeq E^{h}_{T\,max}$
  - $\Delta\phi \rightarrow \pi$
  - symmetric $P_T$ cuts
- inclusive treatement of the fragmentation
- knowledge of the fragmentation functions ?

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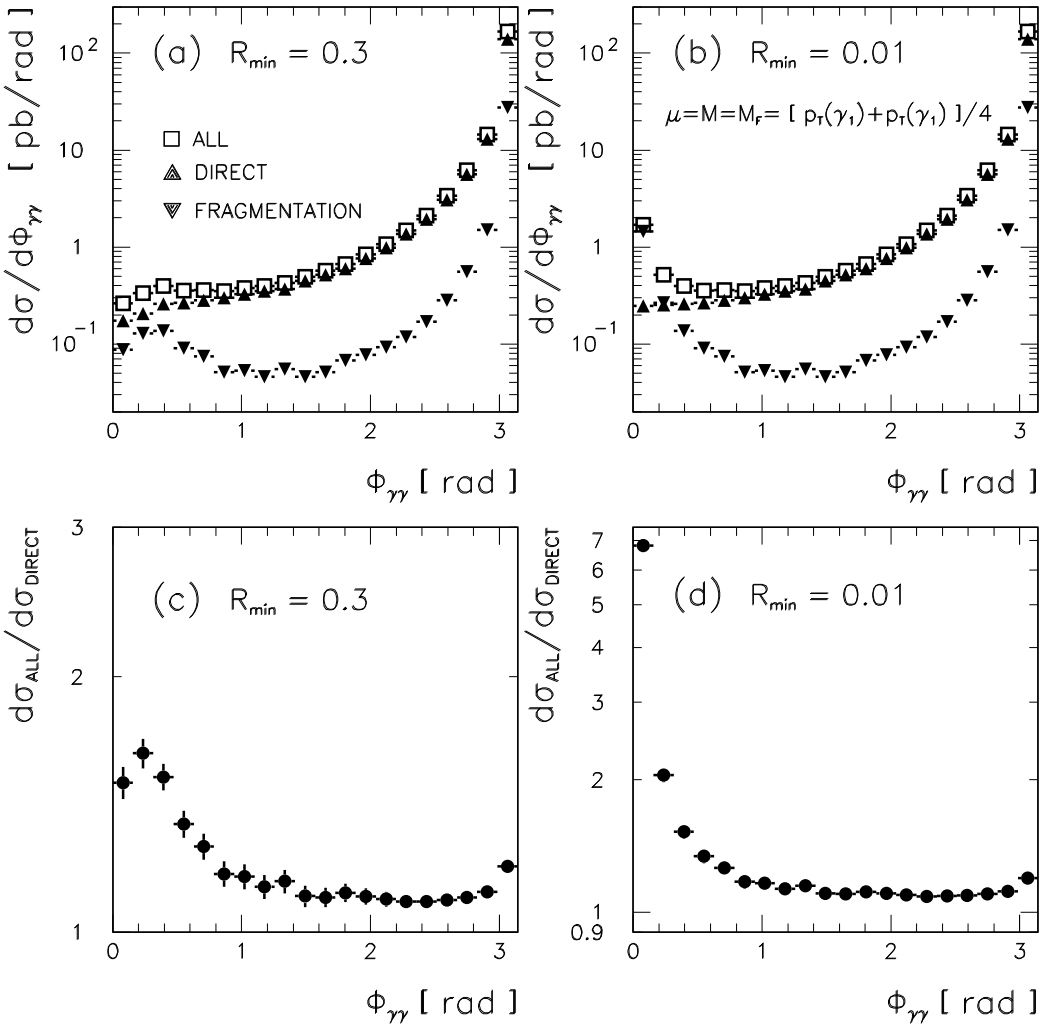
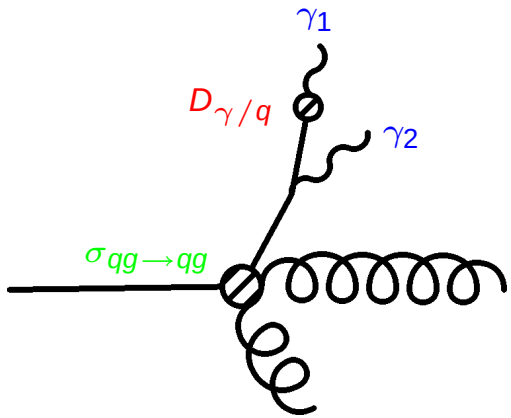
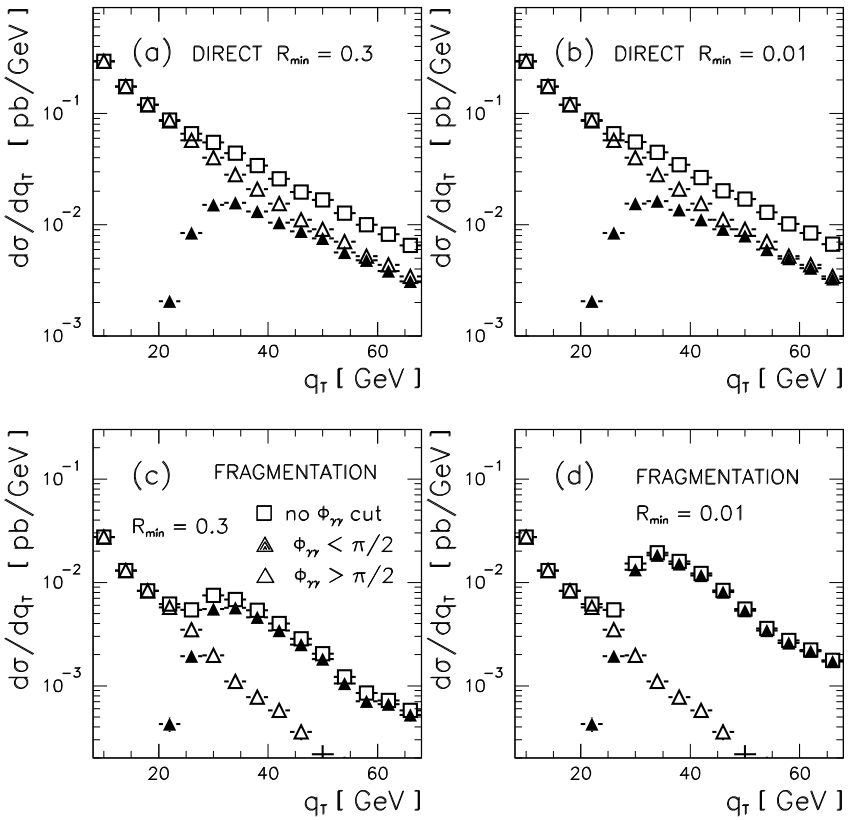
# DiPhox

## Enhancement at $\phi_{\gamma\gamma} = 0$



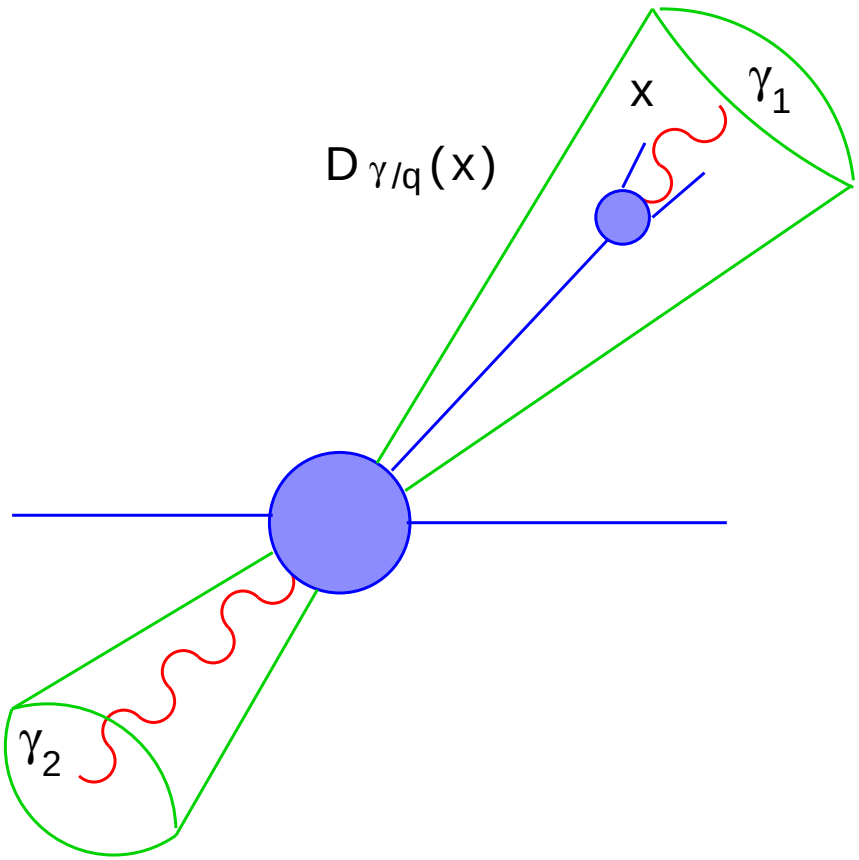
# DiPhox
## $q_T$ shoulder




$$q_T^2 = |\vec{P}_{T\,\gamma_1} + \vec{P}_{T\,\gamma_2}|^2$$
$$= P^2_{T\,\gamma_1} + P^2_{T\,\gamma_2} + 2\,P_{T\,\gamma_1}\,P_{T\,\gamma_2}\,\cos\Phi_{\gamma\gamma}$$

$$q_{T\,min} = \sqrt{P^2_{T\,\gamma_1\,min} + P^2_{T\,\gamma_2\,min}} \simeq 20.34\,\text{GeV}$$

$$q_{T\,lim} = P_{T\,\gamma_1\,min} + P_{T\,\gamma_2\,min} \simeq 28.75\,\text{GeV}$$




For one fragmentation, at LO:

$$\begin{aligned} q_T &= |\vec{P}_{T\gamma_1} + \vec{P}_{T\gamma_2}| \\ &= (1-x)\, P_{T\gamma_2} \\ &= E_T^{had} \end{aligned}$$

Because of isolation criterion:

$$\frac{d\sigma^{LO}}{dq_T} \simeq \Theta(E_{T\,max} - q_T)\,\sigma$$