Higgs production in the high-energy limit of pQCD

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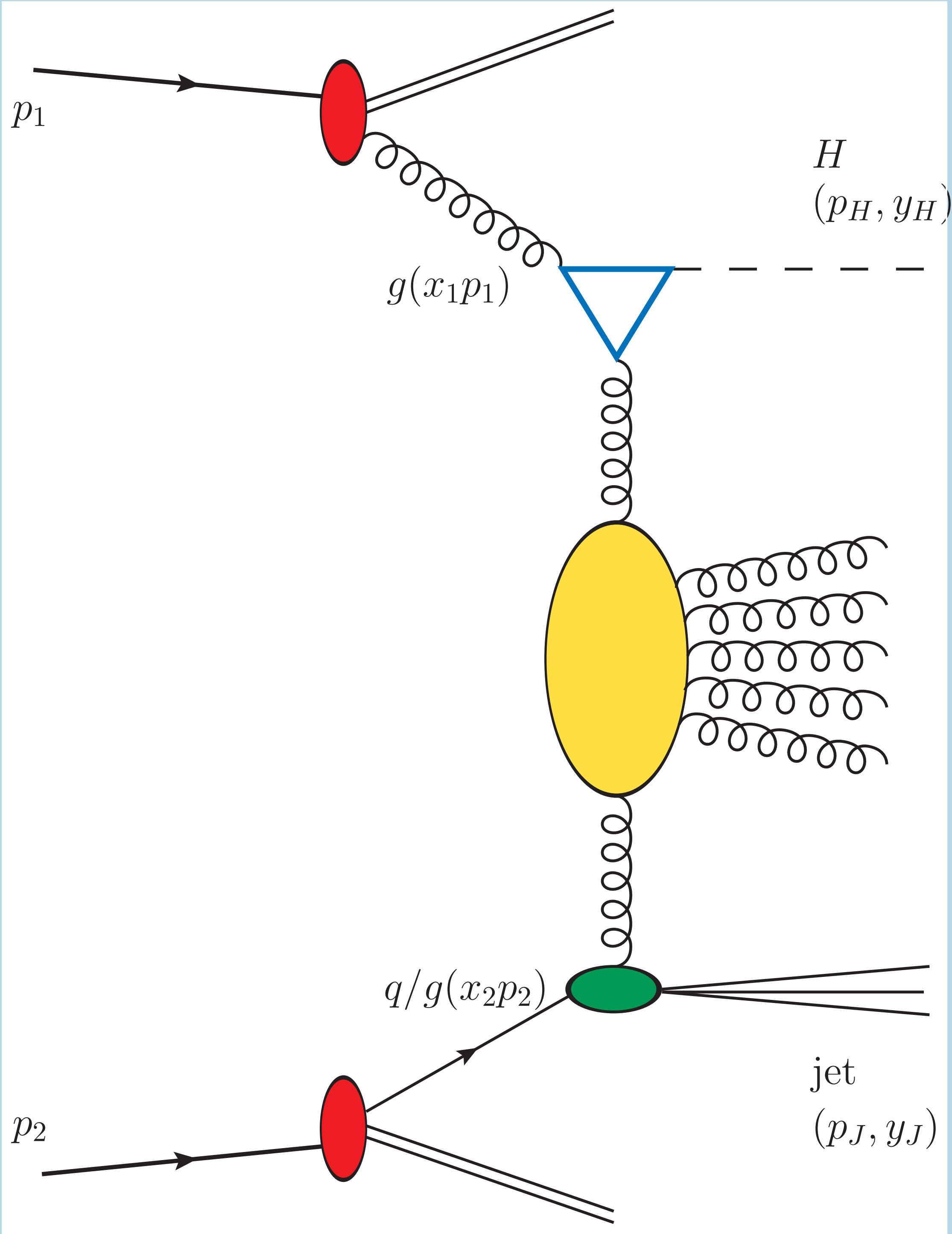
Higgs-jet hadroproduction

The inclusive hadroproduction of a Higgs boson in association with a jet, featuring a large separation in rapidity, is proposed as a novel probe channel of the Balitsky-Fadin-Kuraev-Lipatov (BFKL) approach. In a general hybrid collinear/high-energy factorization the hadronic cross section can be built as a convolution of two collinear PDFs (parton distribution functions) and a BFKL resummed partonic cross section. The latter is obtained as a convolution between two impact factors (one for the production of the Higgs and one for the production of the jet) and the BFKL Green's function



Motivation

The definition and the study of observables sensitive to high-energy dynamics in Higgs production has the double advantage of

- allowing us to clearly disentangle the high-energy dynamics from the fixed-order one.
- providing us with an auxiliary tool to extend Higgs studies in wider kinematical regimes.

From the point of view of phenomenology, considering the production of the Higgs gives us the chance to obtain a natural "stabilizing" effect under higher order corrections and under scale variations. This feature, absent in the production of two jets strongly separated in rapidity (Muller-Navelet channel), allows us to carry out studies around **natural scales**, avoiding the implementation of optimization procedures of the series such as Brodsky-Lepage-Mackenzie one.

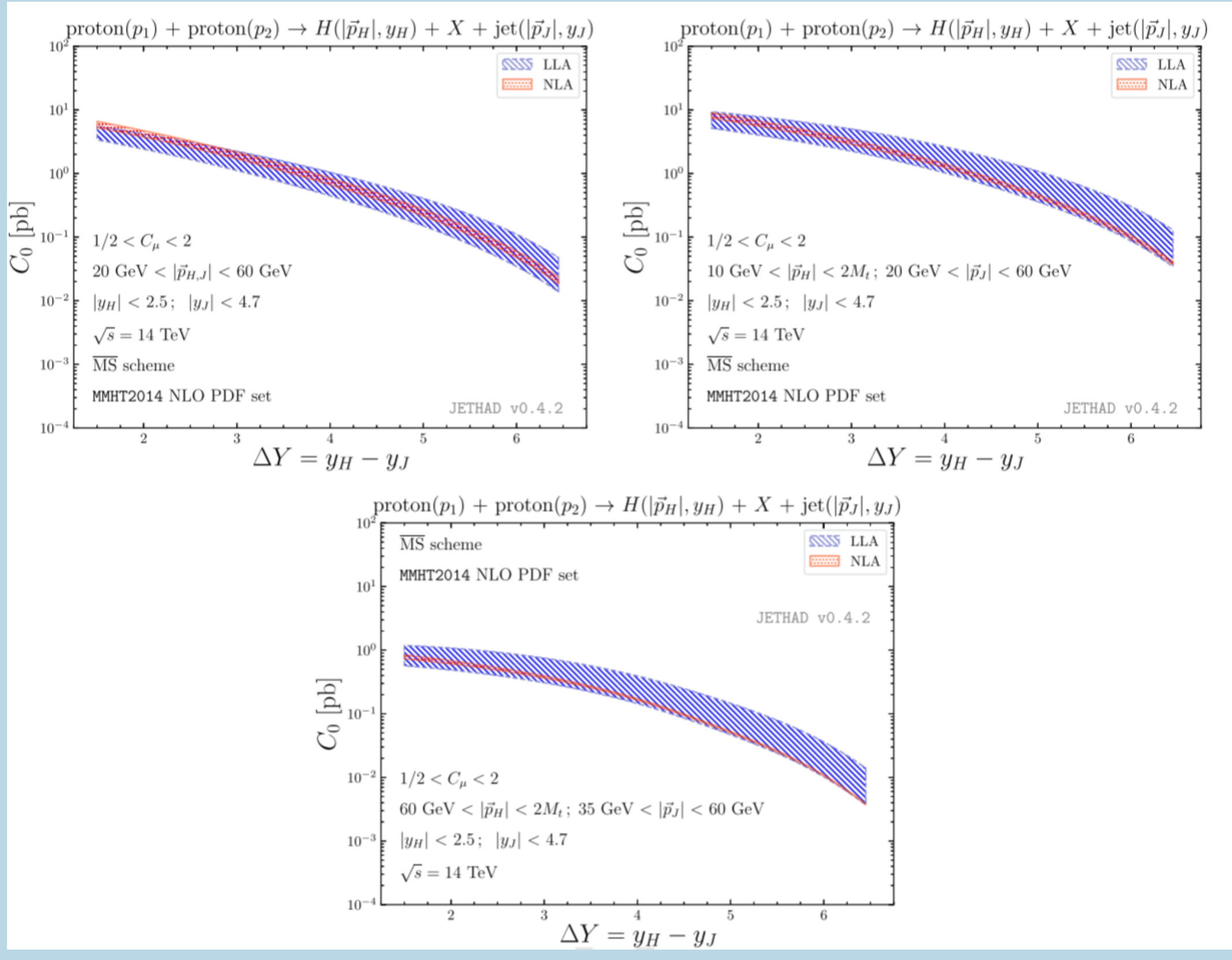
Conclusions

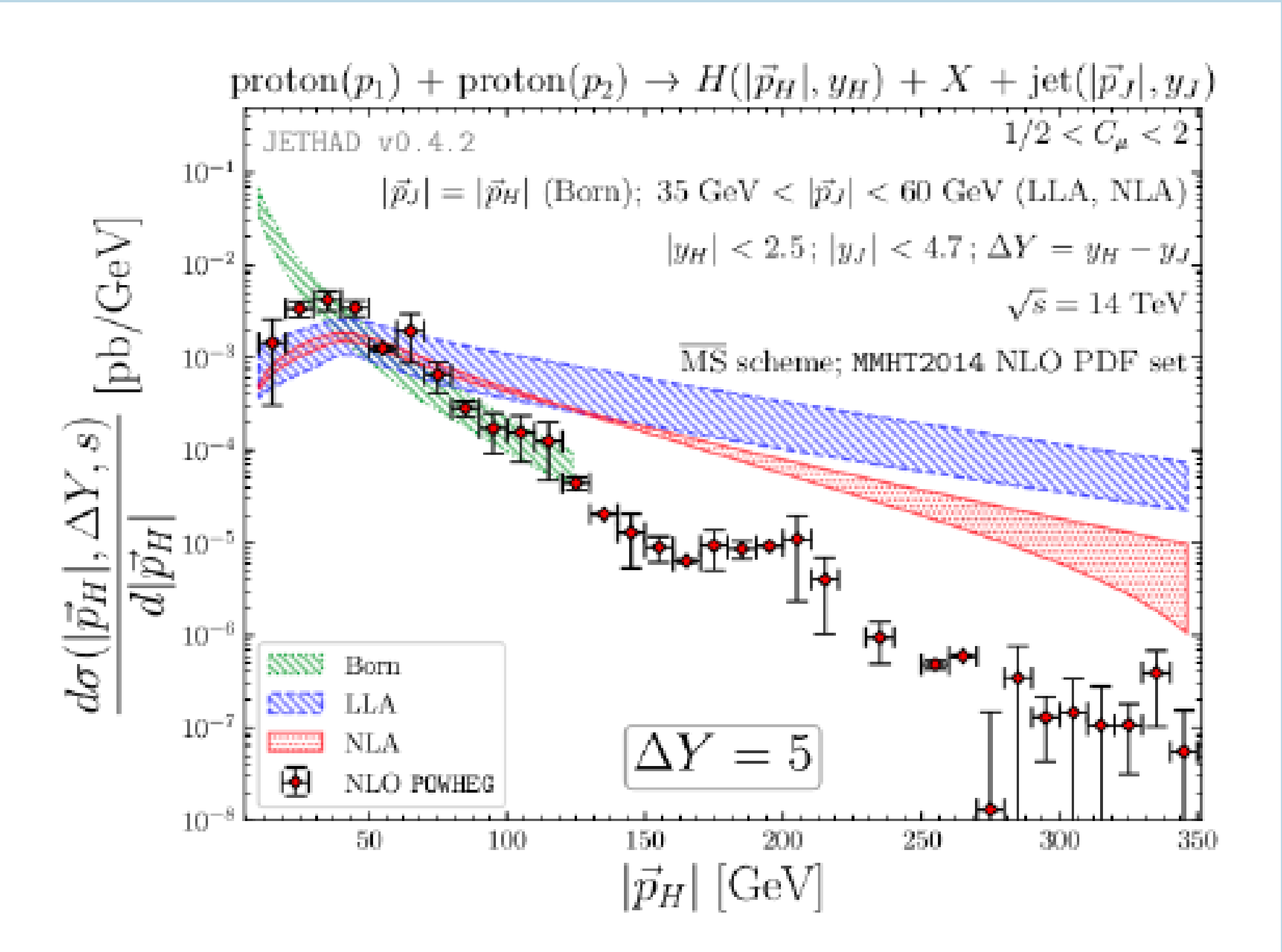
- Higgs + jet exhibits quite a *fair stability* under higher-order corrections.
- A high-energy treatment is *valid* and can be afforded in the region where $\vec{p_H} \sim \vec{p_J}$, and the study can be upgraded to next-to-leading order in the limit $M_t \to \infty$.

Partial NLA accuracy: Stabilization effects and p_T-distribution

In the lower left figure, we present predictions for the cross section summed over azimuthal angles, C_0, in three distinct kinematical configurations. Notable, partial NLA predictions (red) show a milder discrepancy with respect to pure LLA (blue) ones. This represents a novel feature in the context of semi-hard reactions, thus demonstrate the underlying assumption that the large energy scales provided by the emission of a Higgs boson stabilize the BFKL series.

We present also (right Figure) a comparison between the p_H-distribution at $\Delta Y = 5$ obtained by a fixed-order NLO calculation (through POWHEG method) and the same distribution evaluated in our hybrid collinear/ high-energy framework. It is interesting to observe that the NLO fixed-order prediction is systematically lower than the LLA-and partial NLA-BFKL ones. This observation provides with an interesting window for discrimination between fixed-order and high-energy-resummed approaches.



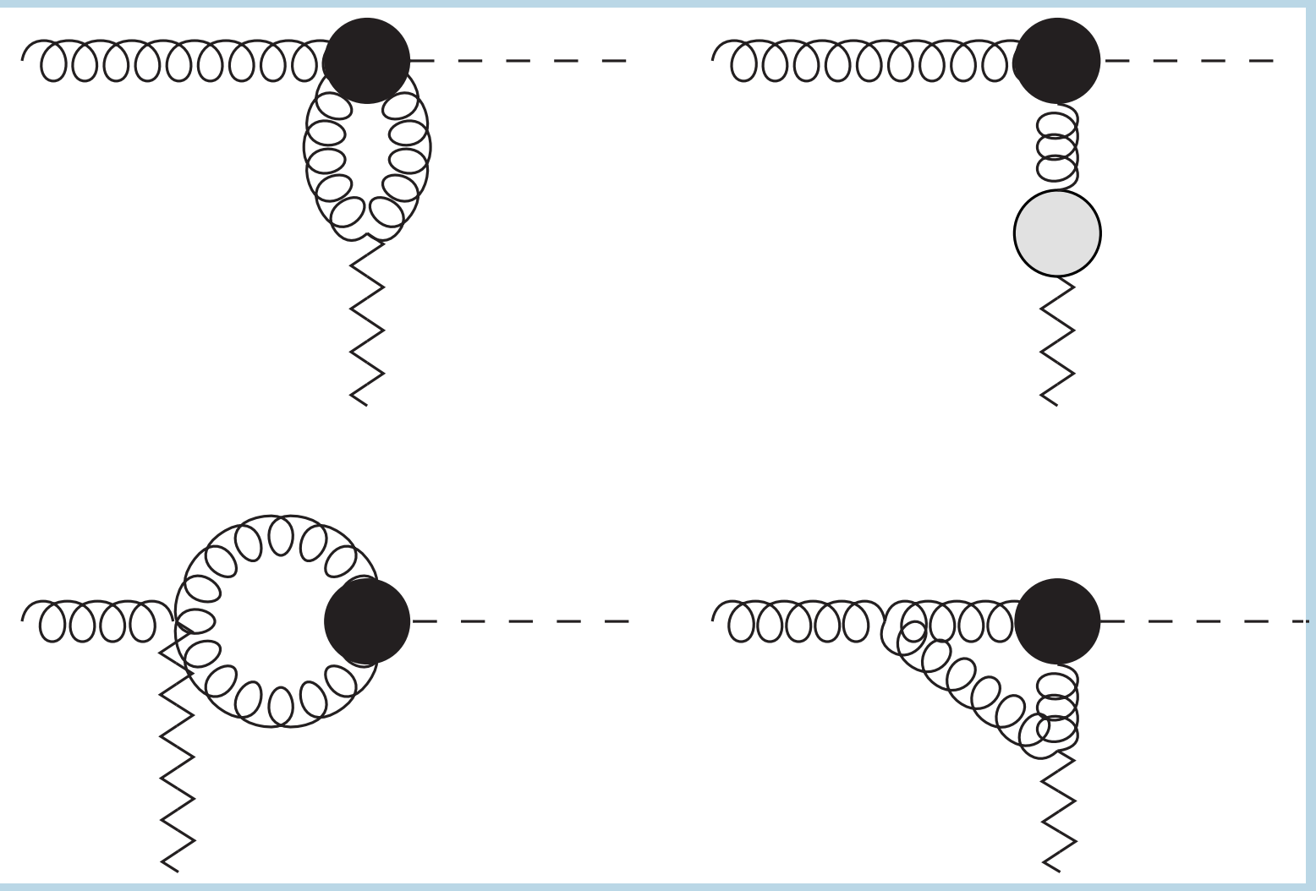


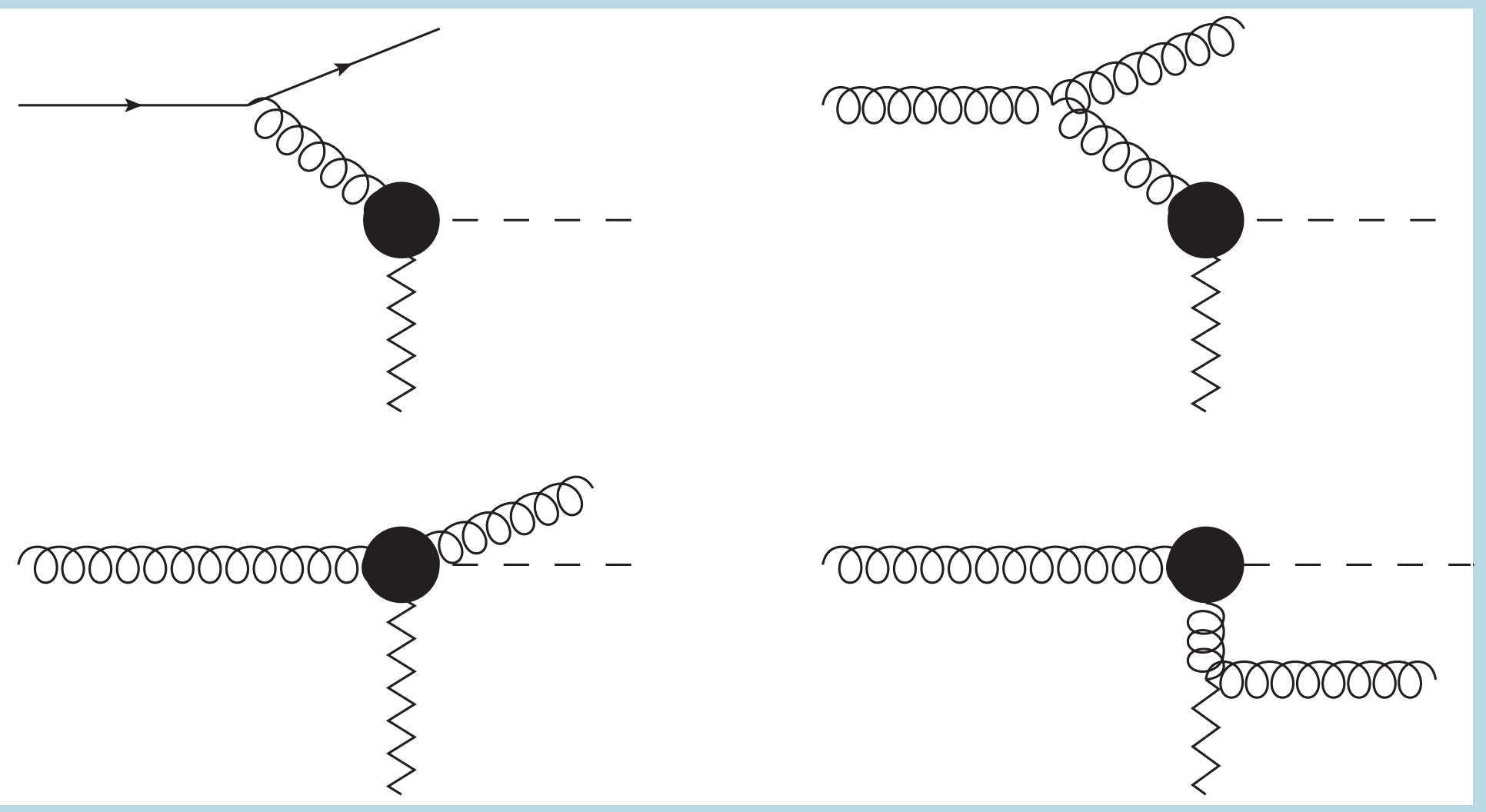
Full NLA accuracy: Higgs impact factor at NLO in a nutshell

Our current goal is the inclusion of subleading effects due to next-to-leading order corrections to the Higgs impact factor. We consider the next-to-leading order impact factor in the infinite top-mass limit through the effective Lagrangian:

$$\mathcal{L} = \frac{1}{4} g_H F^a_{\mu\nu} F^{\mu\nu,a} H \tag{1}$$

In the left Figure, we show all single gluon in the t-channel diagrams contributing to the virtual part of the impact factor (there are also contributions coming from two gluons in the t-channel exchange) while, in the right one, some diagrams contributing to the real part. The zigzag line is a Reggeized gluon while, the black circle is the effective two/three gluon-Higgs coupling, generated by the lagrangian (1), and representing the infinite top-mass (M_t) limit of the usual top triangle.





In this limit, the LO order impact factor is

$$\frac{d\Phi^H_{gg}(z_H, \vec{p}_H, \vec{q})}{dx_H d^2\vec{p}_H} = \frac{g_H^2}{8\sqrt{N_c^2 - 1}} \vec{q}^{\,2} \delta(1 - z_H) \delta^{(2)}(\vec{q} - \vec{p}_H) \,,$$

where z_H is the fraction of momenta of the initial gluon carried by the Higgs, $\vec{p}_H$ its transverse momenta and $\vec{q}$ is the Reggeon transverse momenta. The basic ingrediants to build the NLO impact factor are given by

$$\frac{d\Phi^{\{Hq\}}_{qq}(z_H, \vec{p}_H, \vec{q})}{dz_H d^2\vec{p}_H} \,, \quad \frac{d\Phi^{\{Hg\}}_{gg}(z_H, \vec{p}_H, \vec{q})}{dz_H d^2\vec{p}_H} \,, \quad \frac{d\Phi^{H(\text{NLO})}_{gg}(z_H, \vec{p}_H, \vec{q})}{dx_H d^2\vec{p}_H} \,,$$

which represent: the real contribution associated with the emission of an additional quark ($d\Phi^{\{Hq\}}_{qq}$), the real contribution associated with the emission of an additional gluon ($d\Phi^{\{Hg\}}_{gg}$), the virtual contribution ($d\Phi^{H(\text{NLO})}_{gg}$). These contributions are combined with a suitable "BFKL" counter term to remove *rapidity divergences* and then convoluted with corresponding PDFs to reabsorb *infrared singularities* affecting partonic impact factors. The remaining *soft singularities* cancel out when we combine real and virtual corrections, as guaranteed by the Kinoshita-Lee-Nauenberg theorem. At this point, we are left with only *ultraviolet divergences* which are removed by the renormalization procedure.