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Photon-induced contributions and AFB predictions

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in collaboration with S. Bondarenko and L. Kalinovskaya

Discussion items

Photon-induced processes are a natural ingredient of EW processes at hadron colliders
(cancellation of QED IS mass singularities, contribution of photon density in the proton)

The NNPDF31_as_0118_nlo_luxqed PDF set induces a very large distortion of the AFB distribution, compared to its pure QCD counterpart

This feature is not visible with other PDF sets that include QED DGLAP evolution

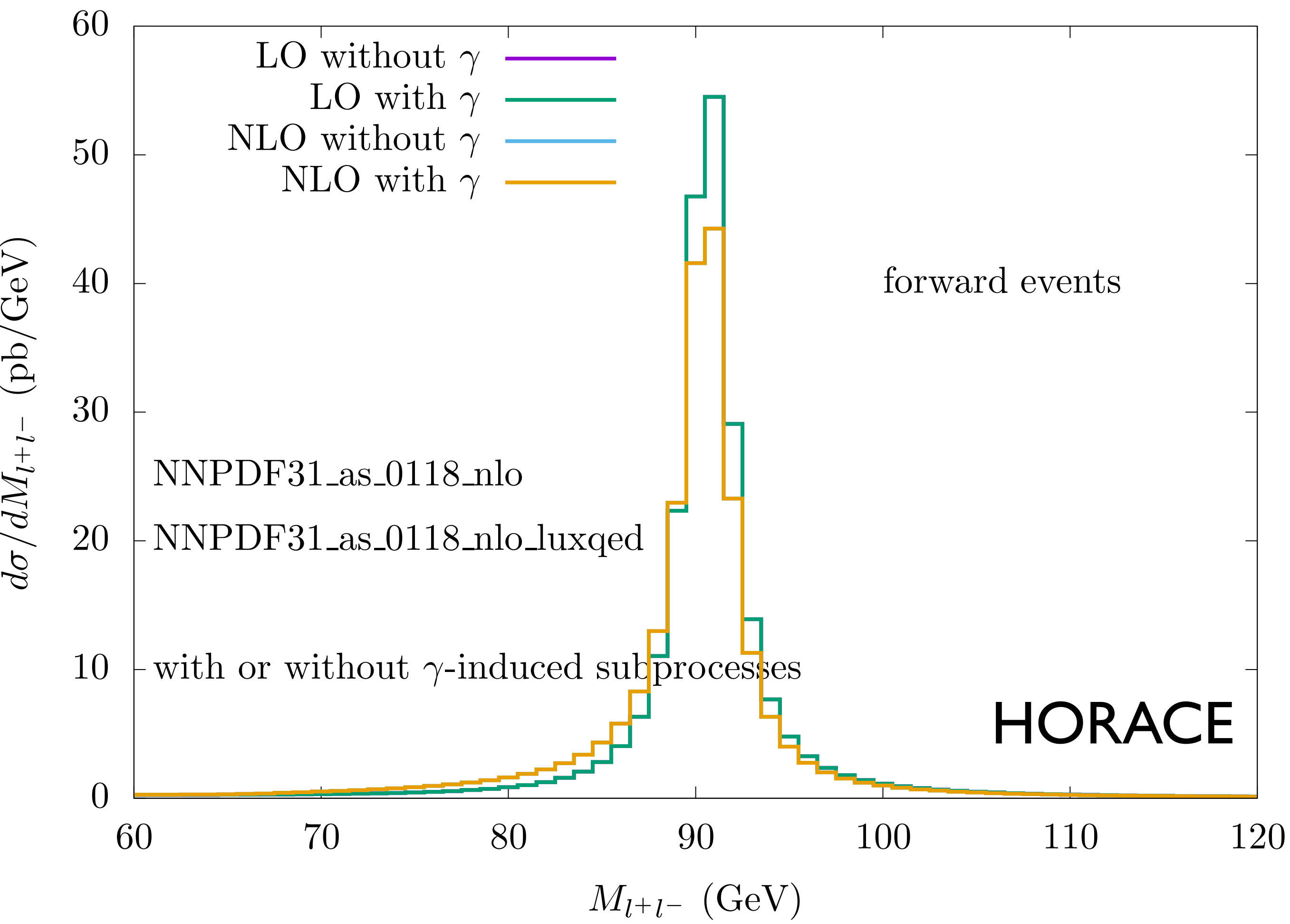
1) The prediction of AFB is a “stress test” for modern PDF sets.
How can we make quantitative assessments?

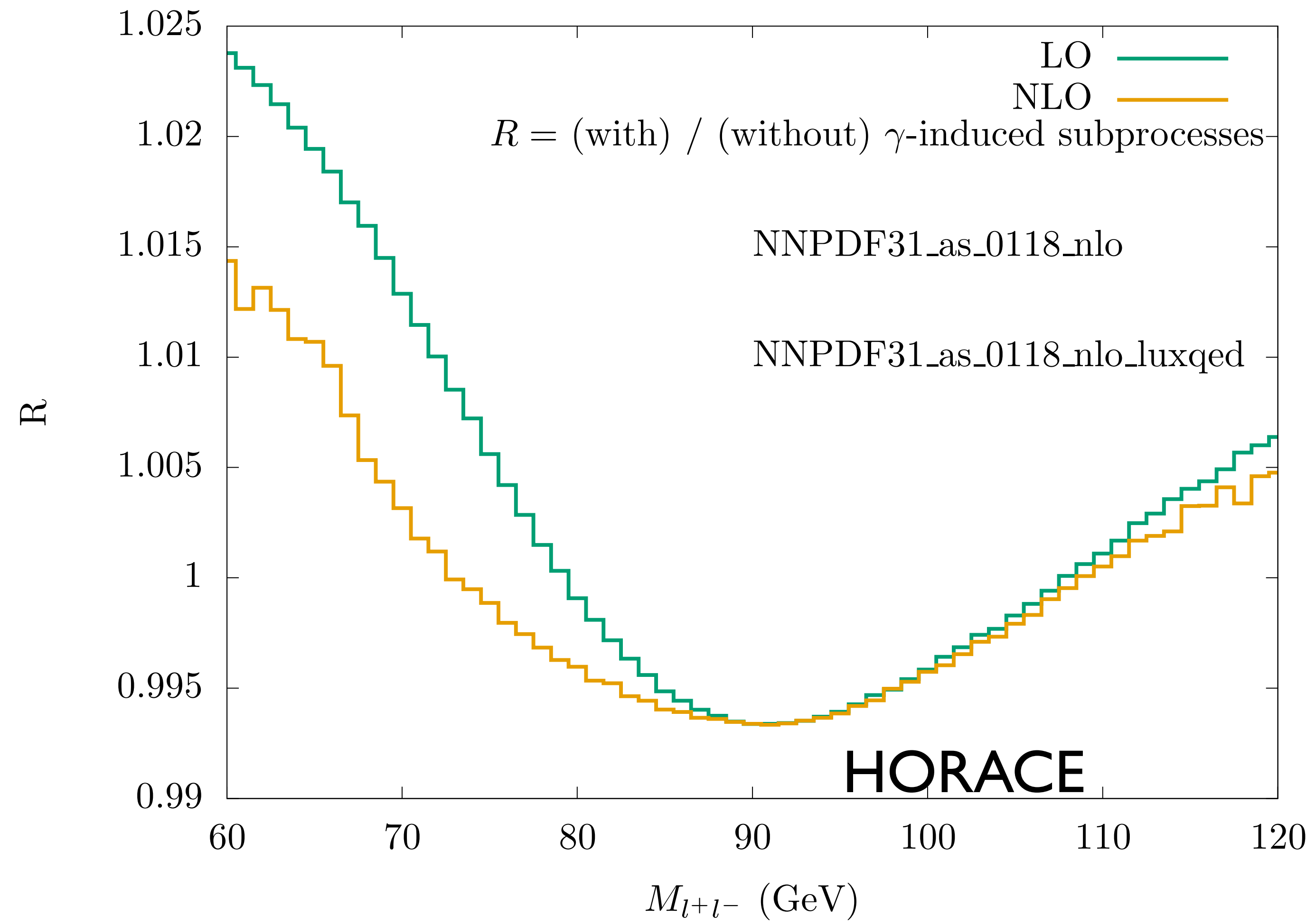
2) Assuming that the predicted effect is sound,
which fraction of it is reabsorbed in the calibration phase of the measurement ?

M_{ll} distribution: photon-induced contributions

simulation with γ-induced: NNPDF31_nlo_as_0118_luxqed and γ-induced subprocesses

simulation without γ-induced: NNPDF31_nlo_as_0118 and NO γ-induced subprocesses





the simulation with γ-induced slightly depletes the Z peak

A_{FB} distribution: photon-induced contributions

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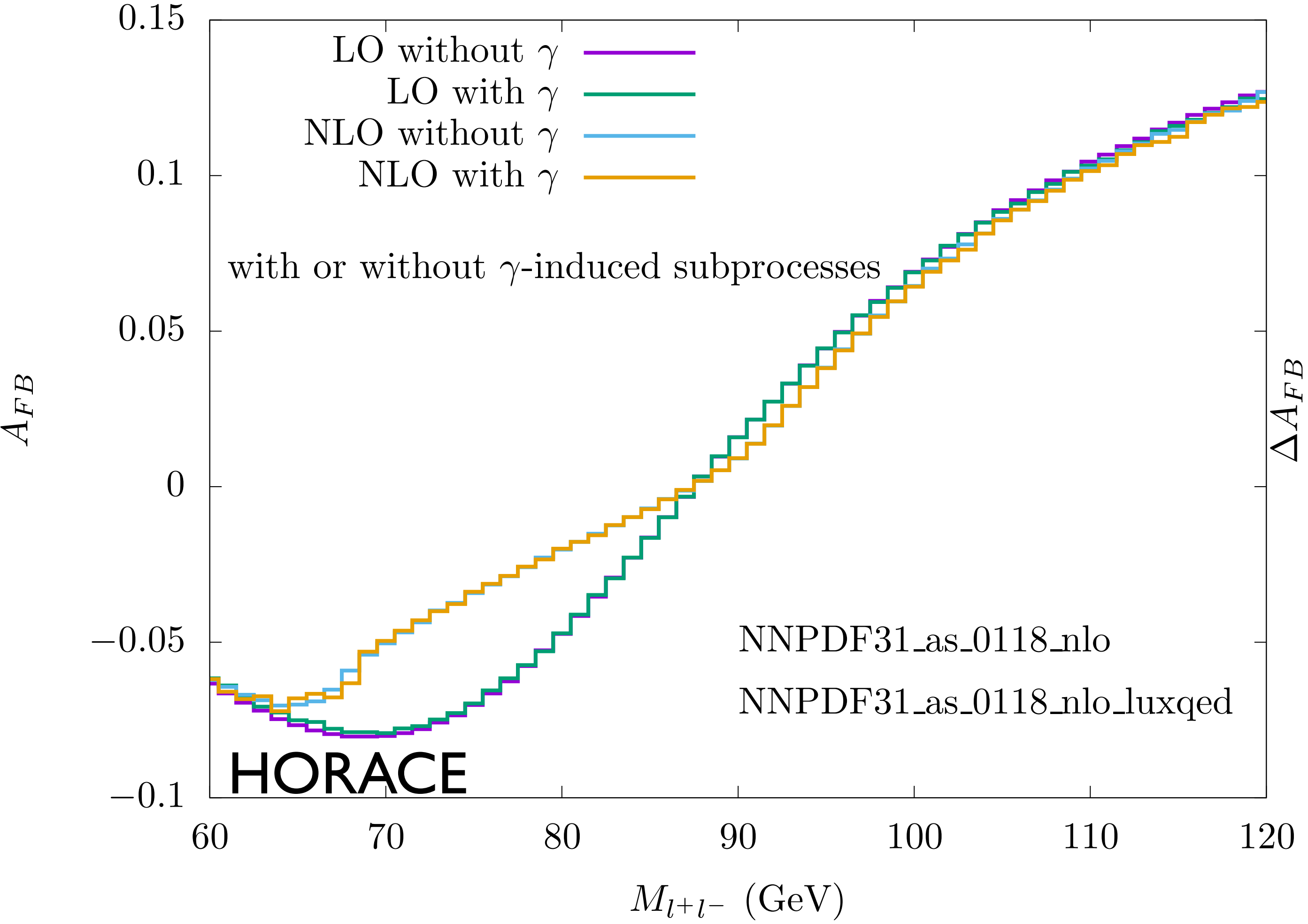

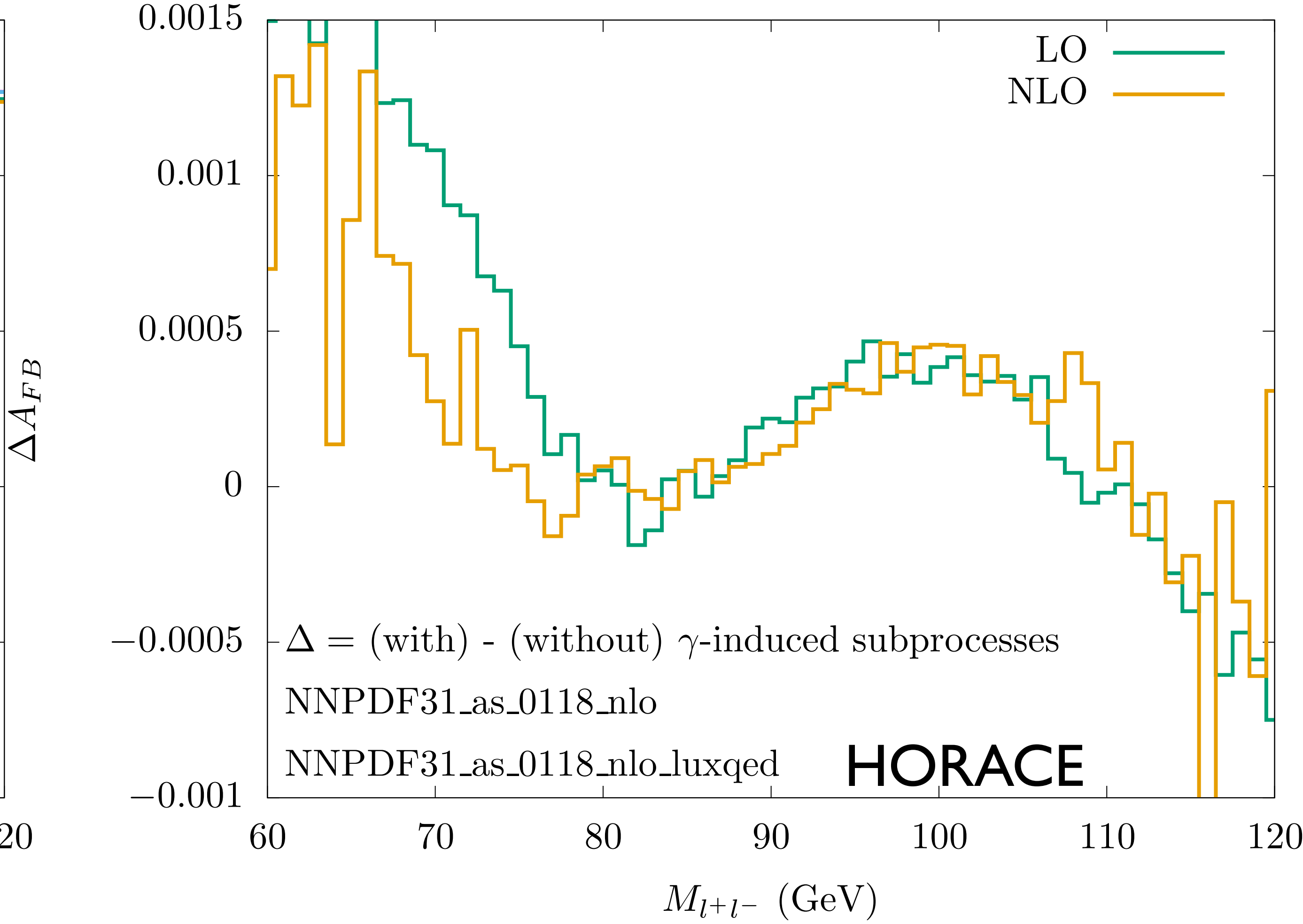

Physically consistent approximations

simulation with γ-induced: NNPDF31_nlo_as_0118_luxqed and γ-induced subprocesses

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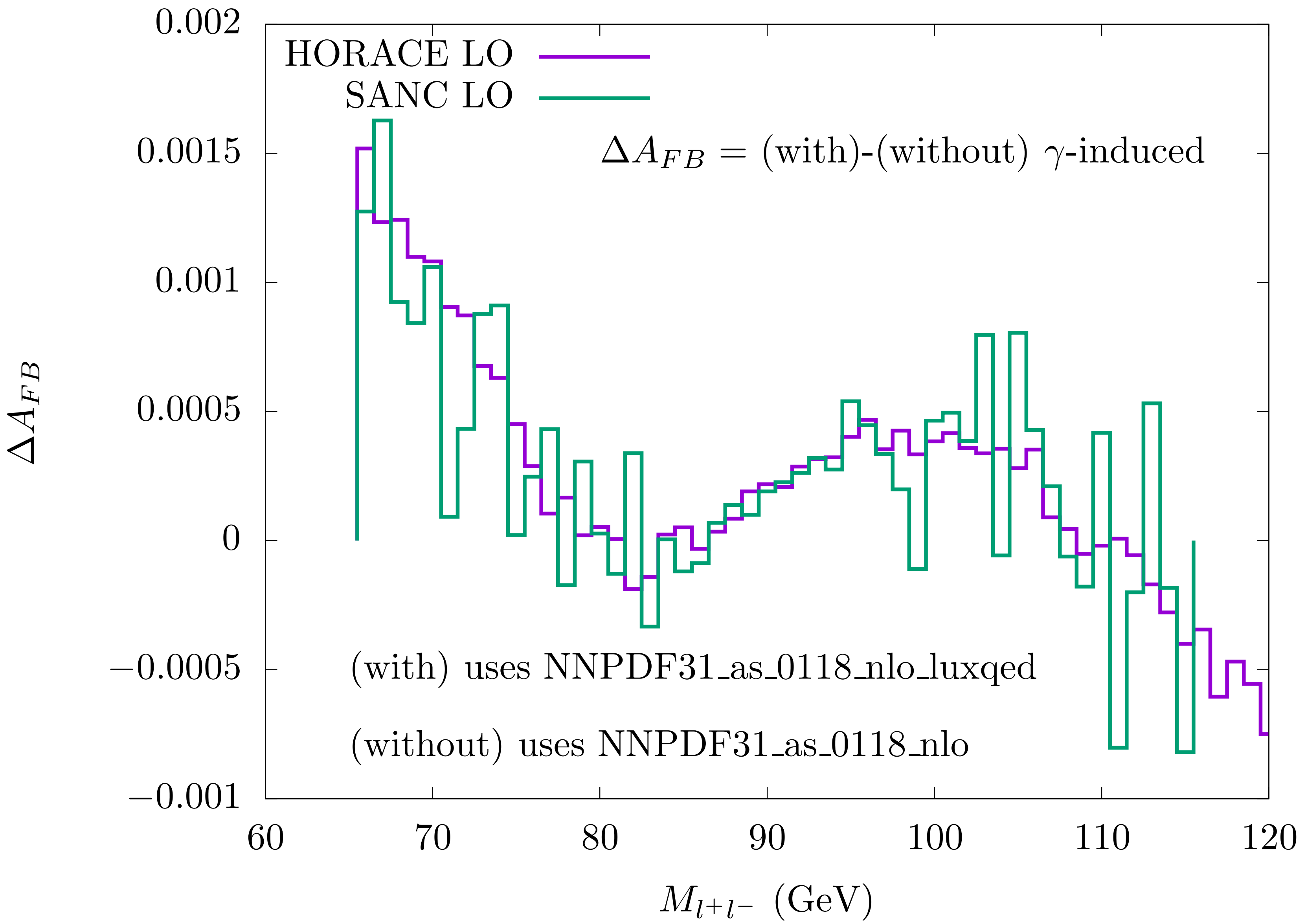
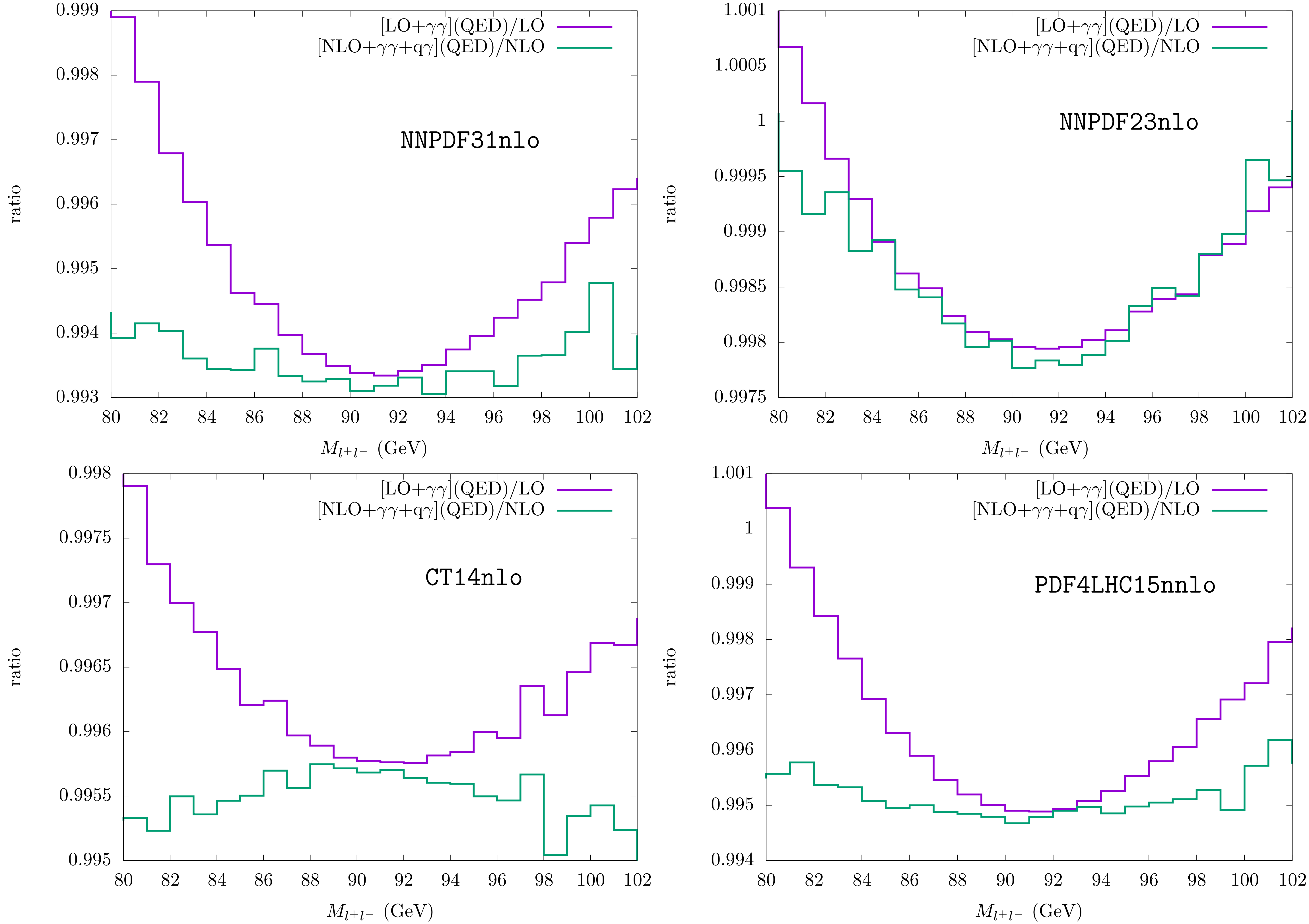
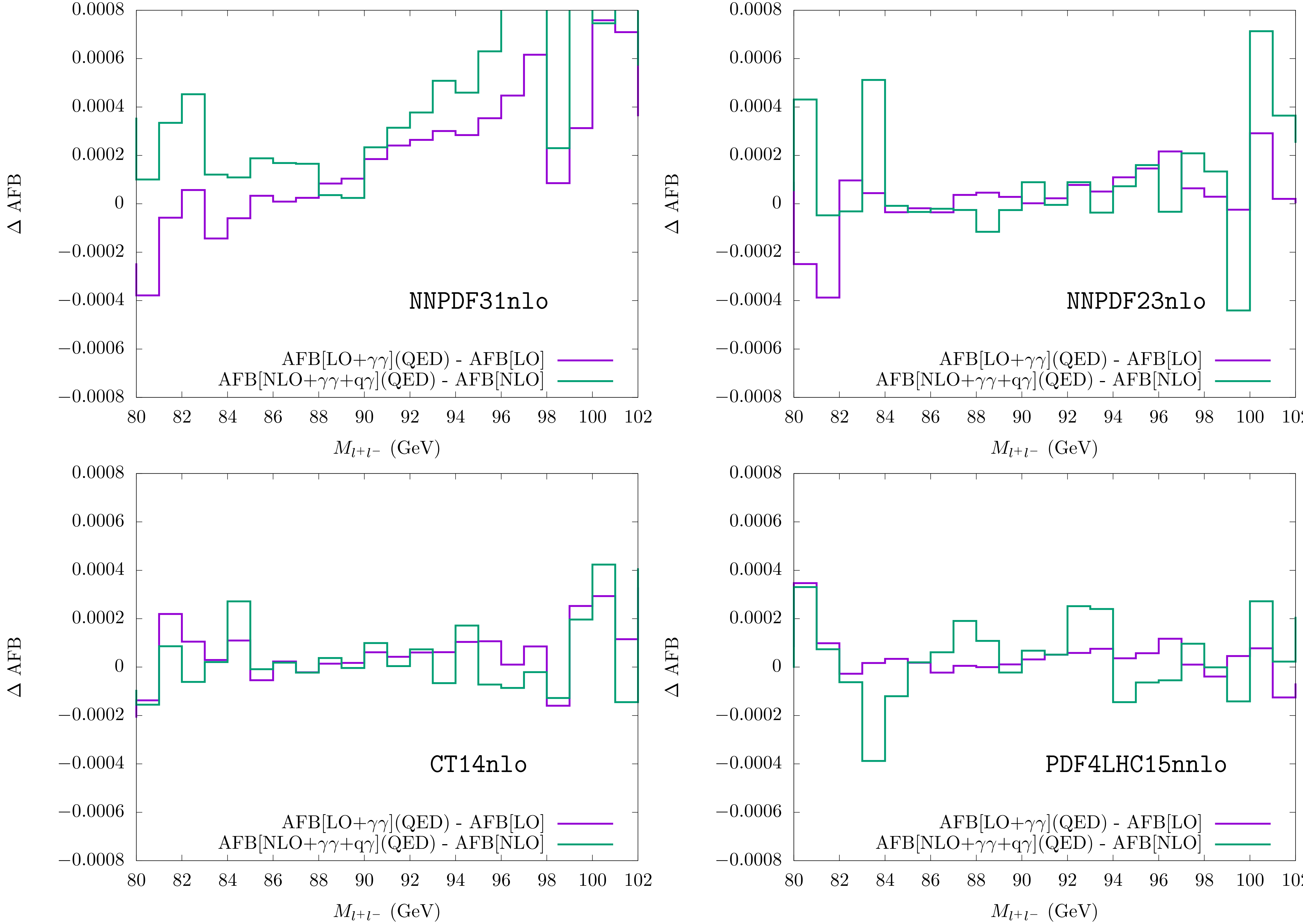


Ratio @LO and @NLO



Δ A_{FB} @LO and @NLO



QED PDFs : QED models for the DGLAP input and evolution

The parameterisation of the photon density (in analogy to all other partons) represents a feature of the PDF set

DGLAP evolution equations require a boundary condition (e.g. measured at low scales) for all parton densities, including the photon one; if not available, an *Ansatz* must be provided

The photon density

was generated dynamically (MRST2004, NNPDF23, CT14) or

satisfies the LUX-QED relation (LUX-QED_PDF4LHC15, NNPDF31)

At LO the invariant mass distribution is directly proportional to the parton-parton luminosity

$$\frac{d\sigma}{dM_{\ell\ell}} \propto \sum_{i,j} \mathscr{L}_{ij}(\tau)\,|\,\mathscr{M}(ij \to \ell^+\ell^-)\,|^2 \Big|_{q^2=M^2_{\ell\ell}}$$

the parton-parton luminosity can be defined as $\mathscr{L}_{ij}(\tau) = \int_\tau^1 dx\, f_i(x)\, f_j(\frac{\tau}{x})$ $\tau = \frac{M^2_{\ell\ell}}{S}$

We can separately analyse $\mathscr{L}_{\gamma\gamma}$, $|\,\mathscr{M}(\gamma\gamma \to \ell^+\ell^-)\,|^2$, $\mathscr{L}_{q\bar{q}}$, $|\,\mathscr{M}(q\bar{q} \to \ell^+\ell^-)\,|^2$,

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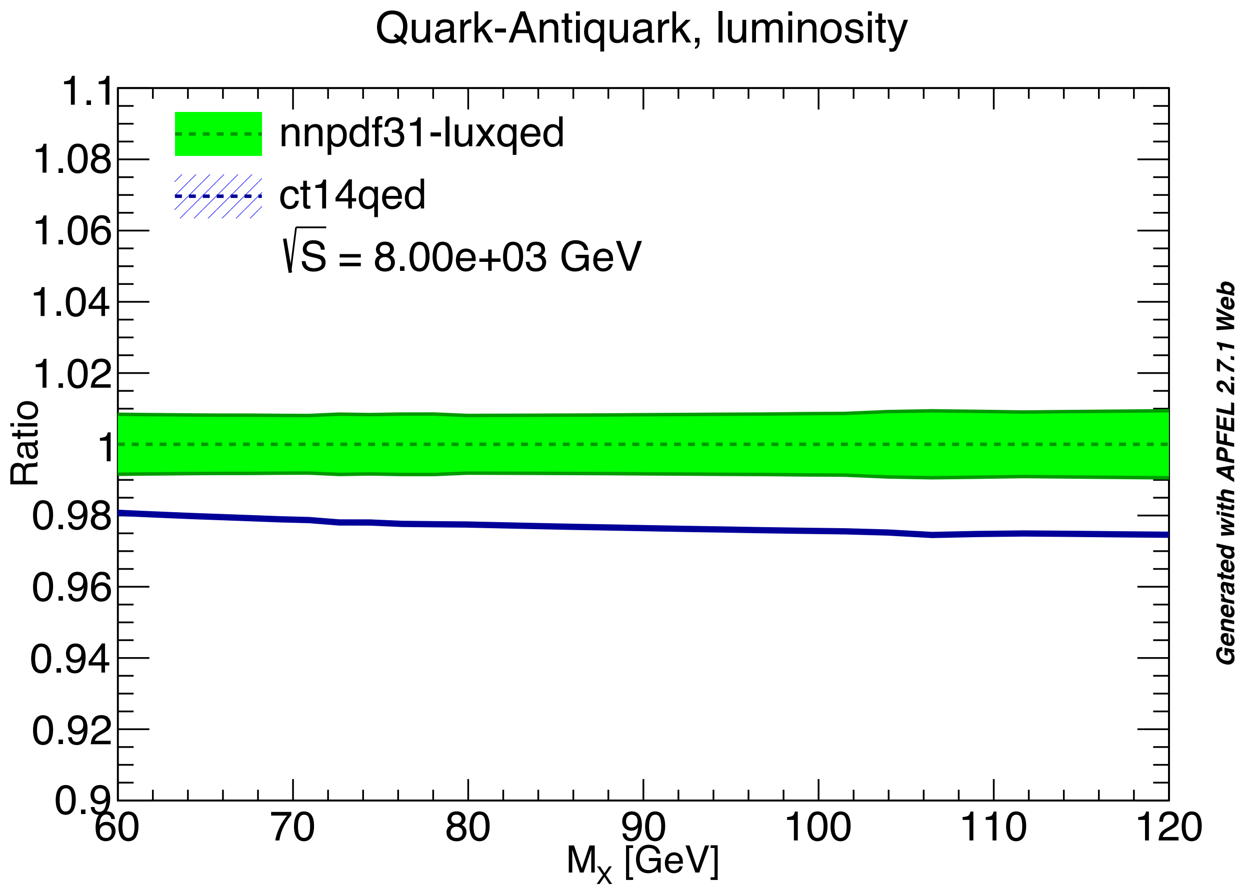
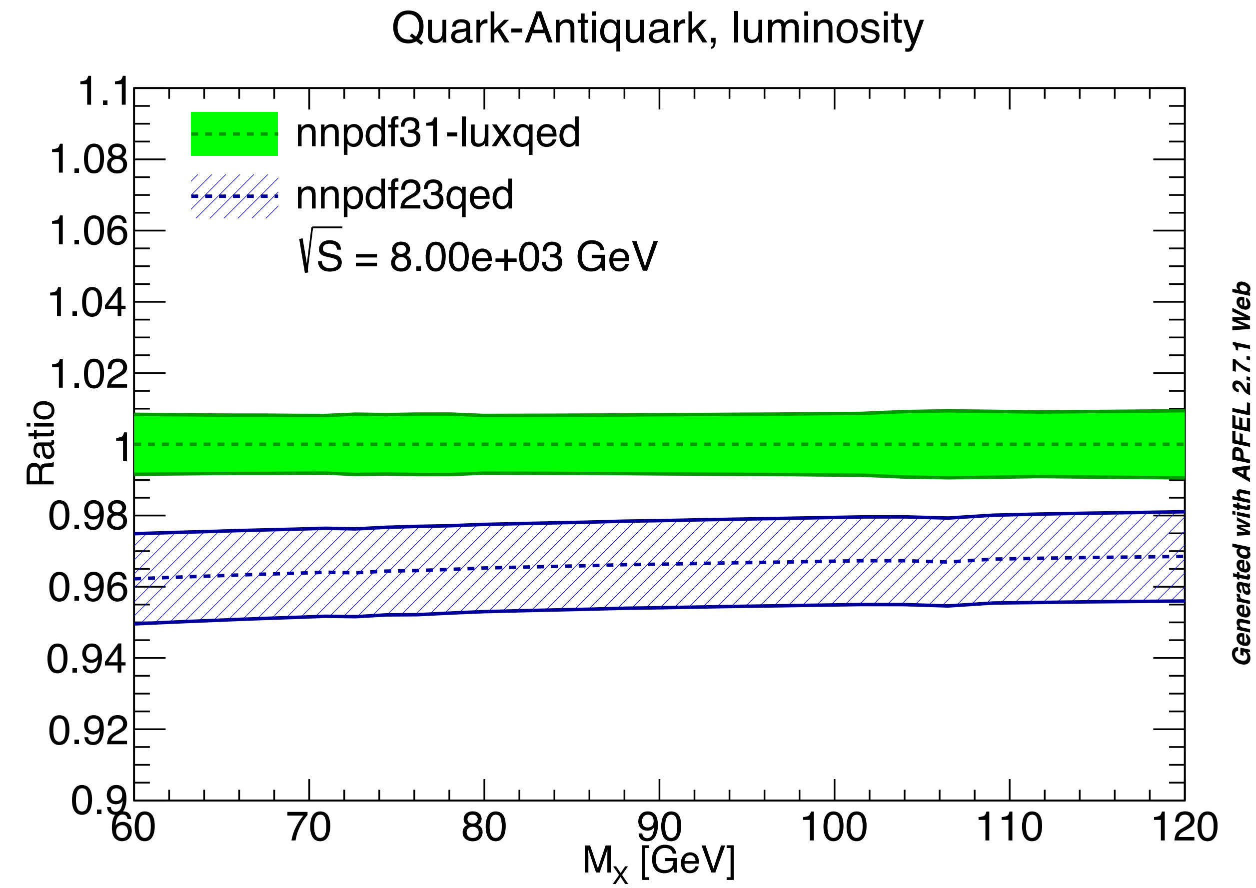
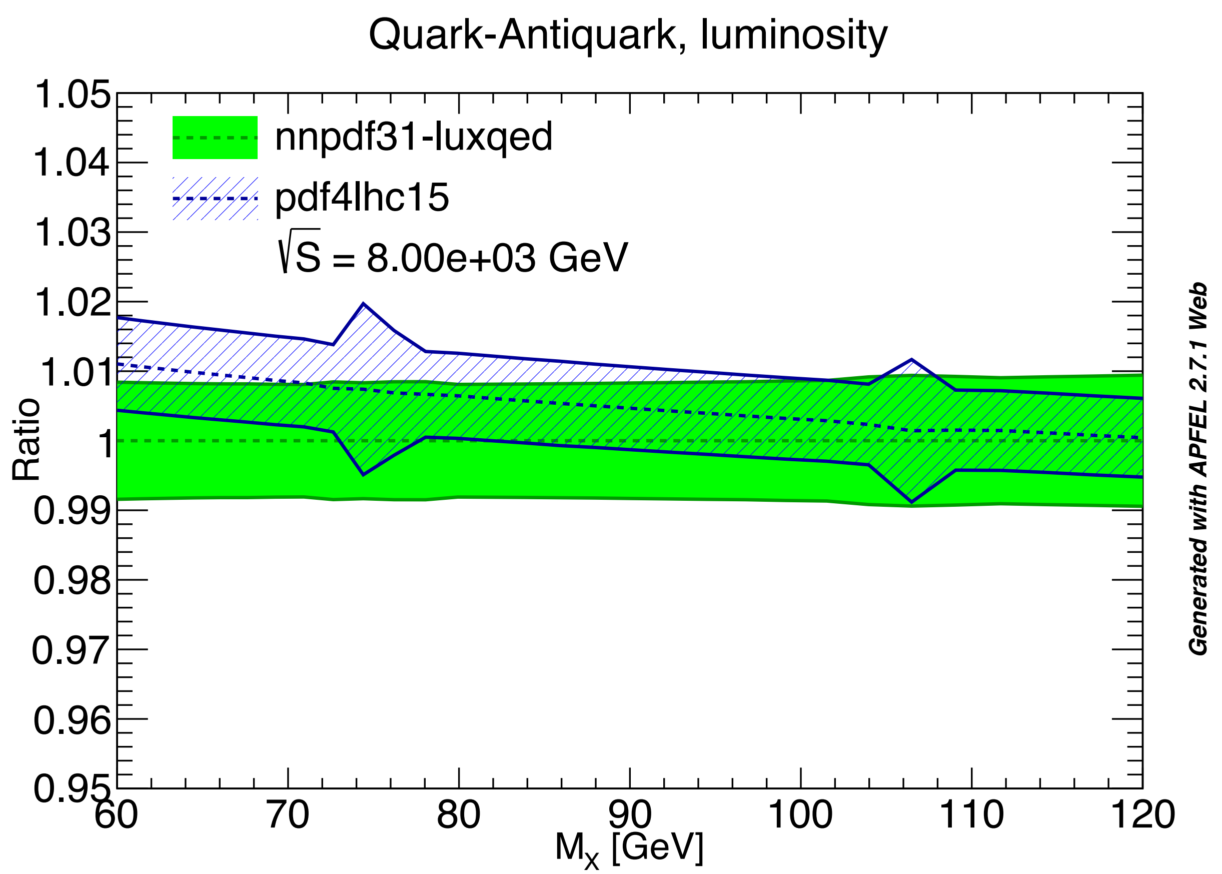
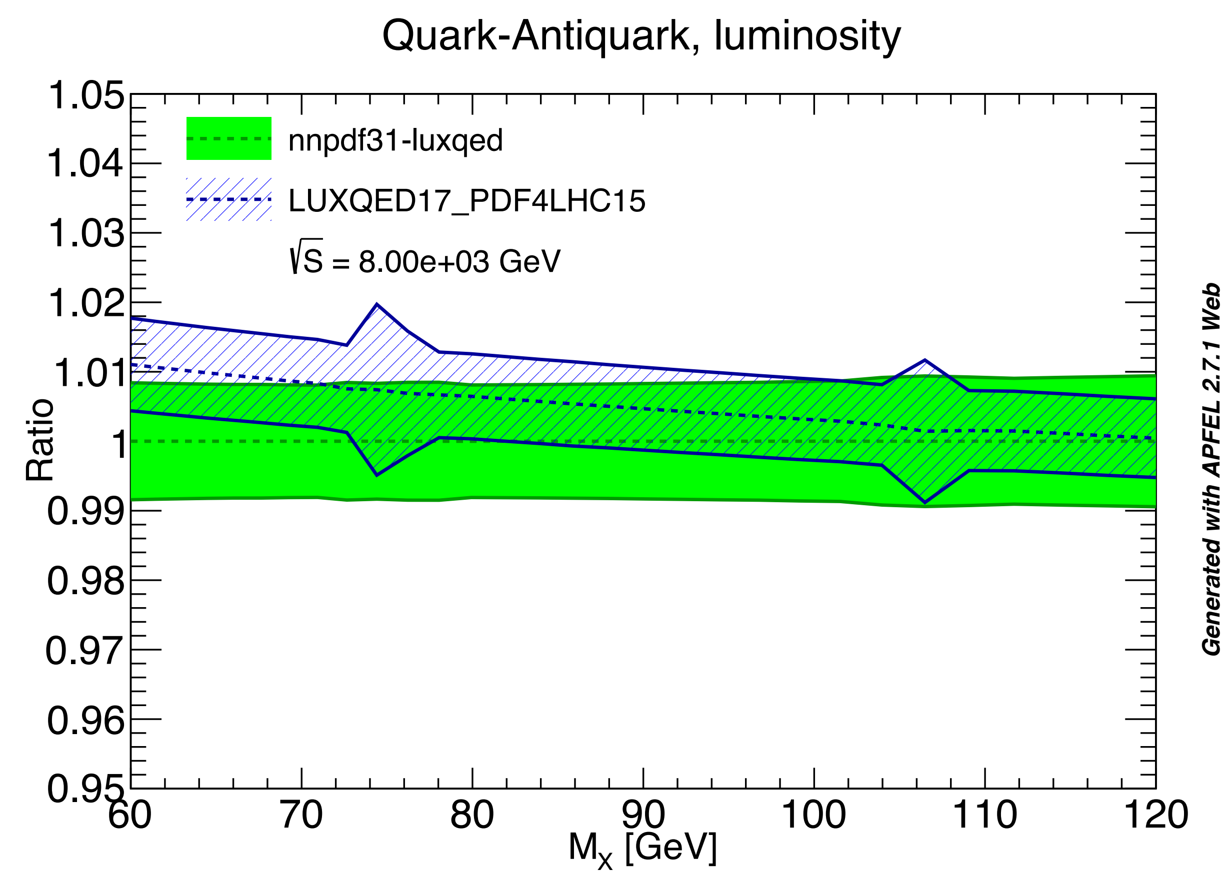
and eventually consider the prediction for AFB

QED PDFs : quark-antiquark luminosities

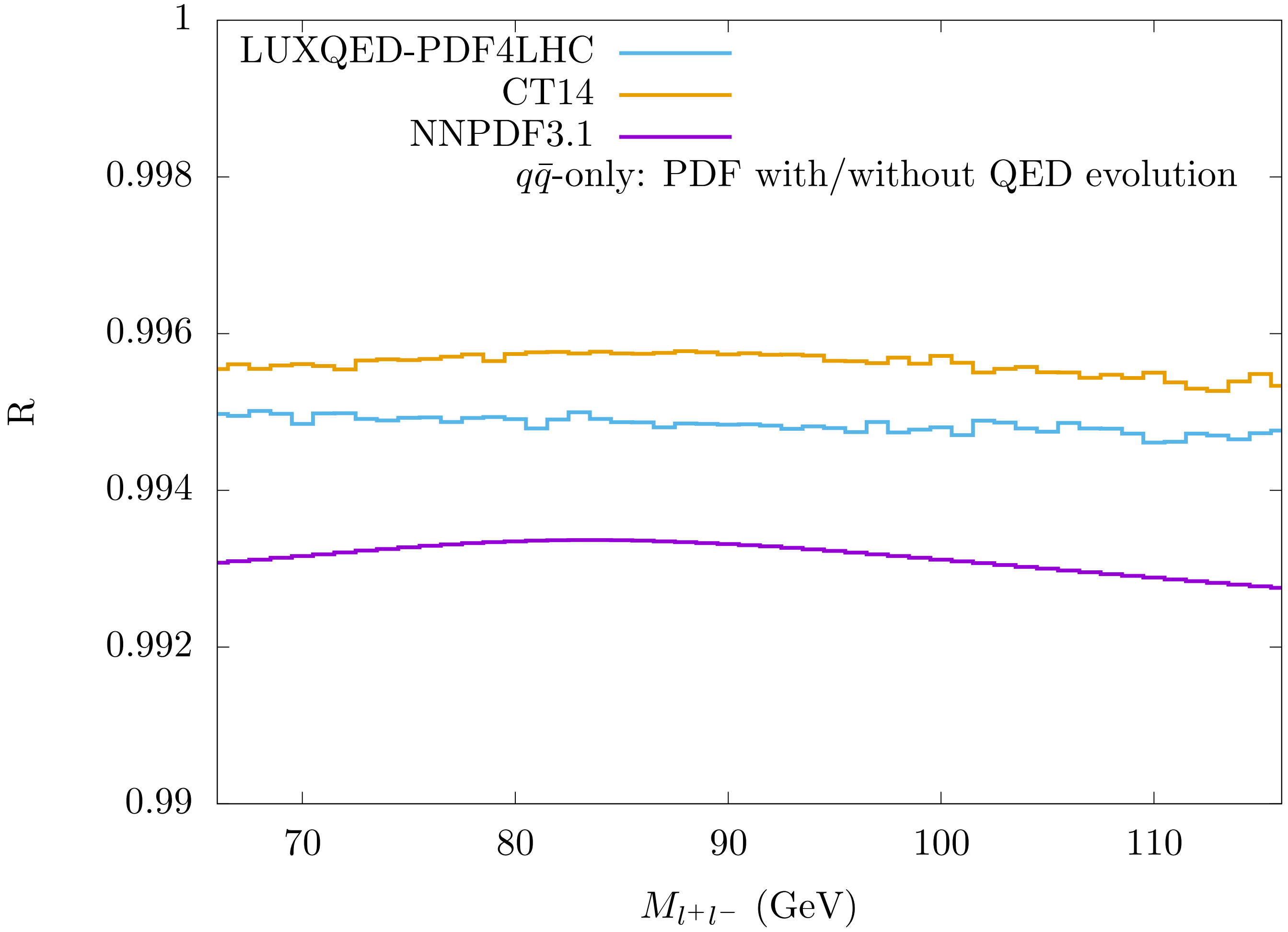


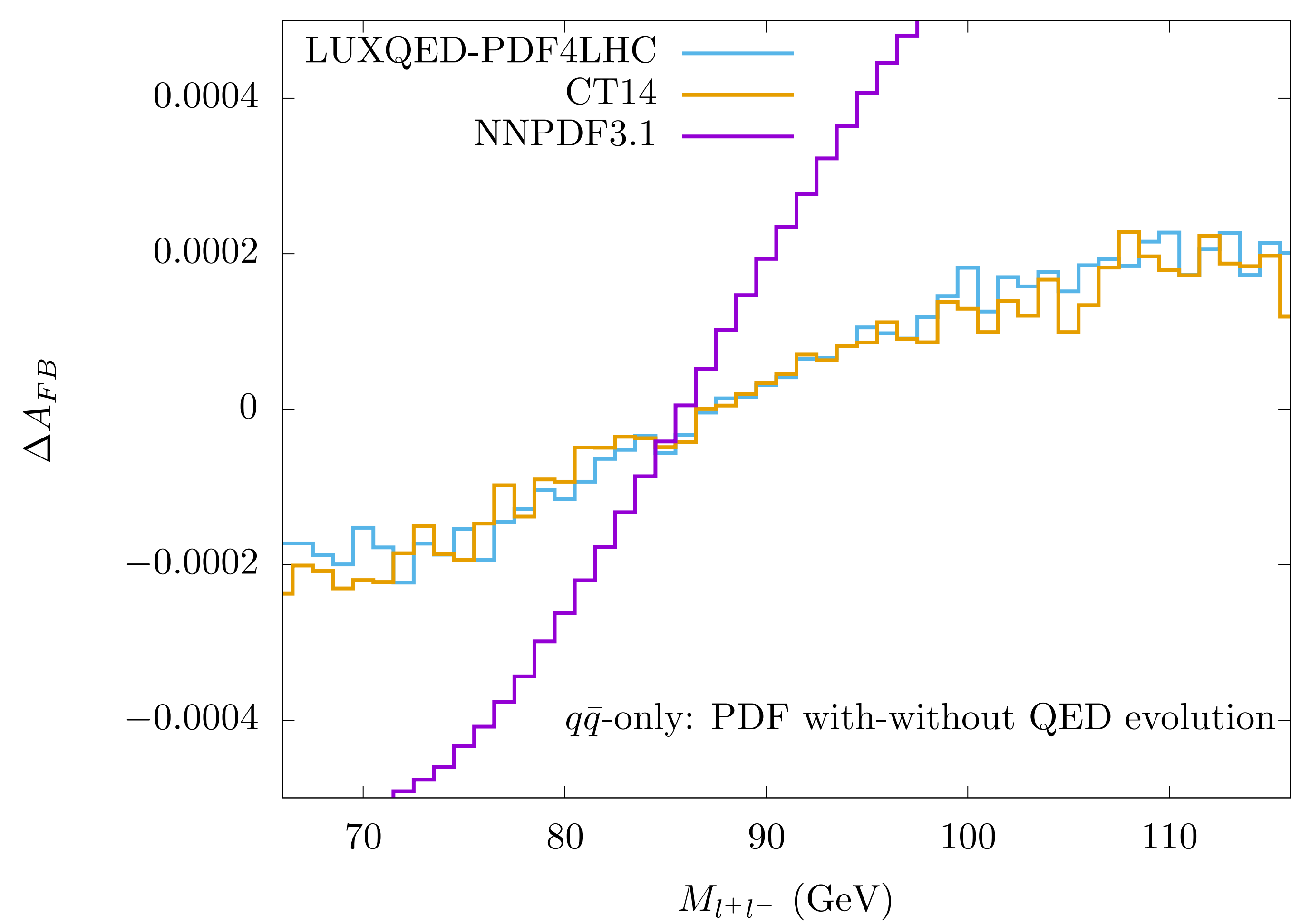






QED PDFs : impact of quark-antiquark luminosities

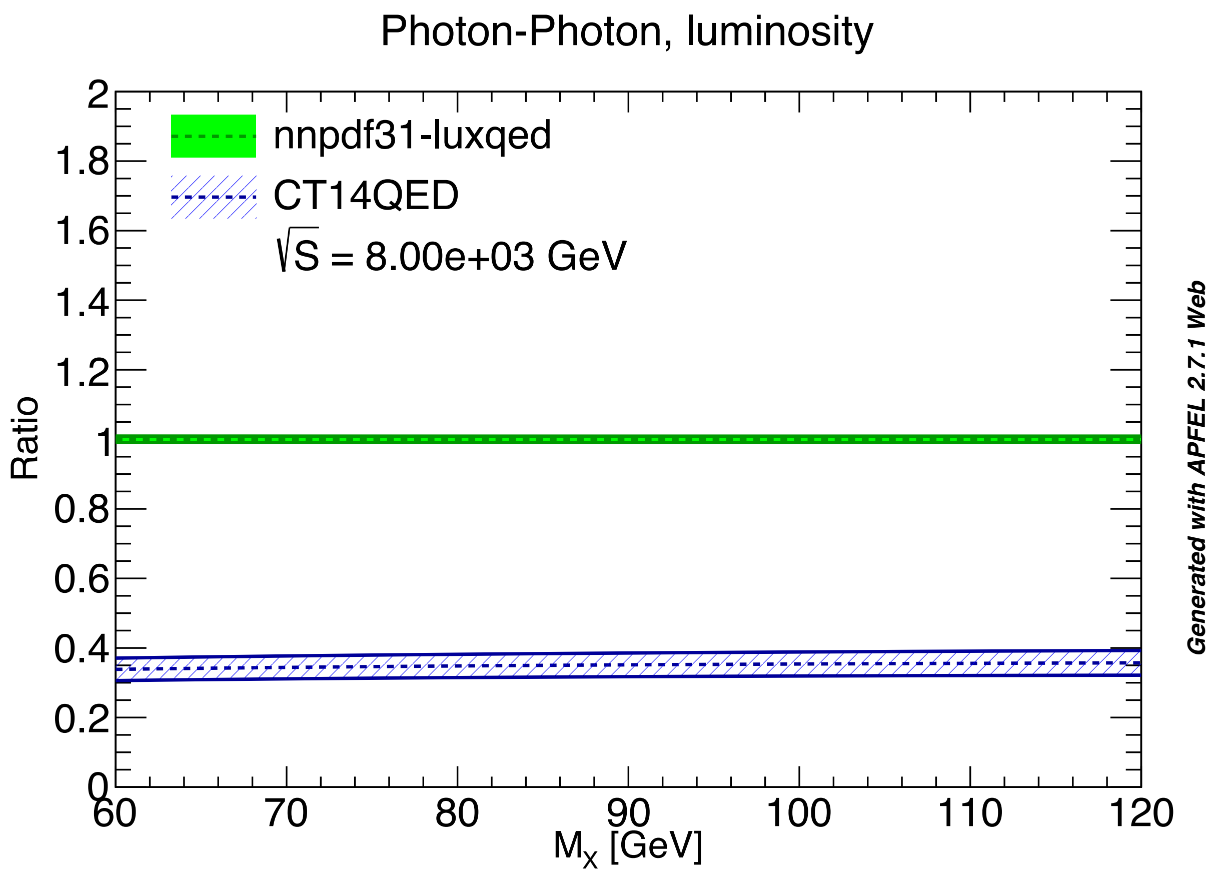


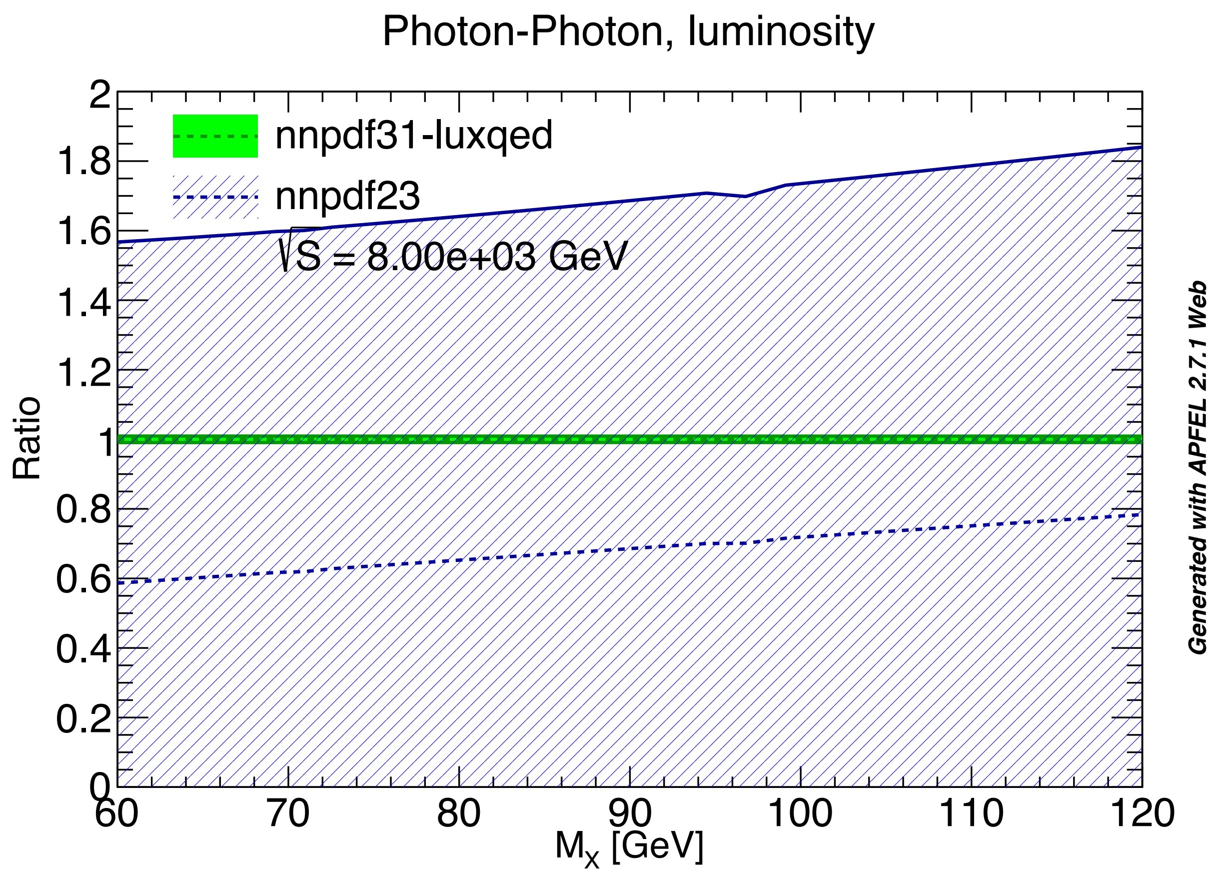


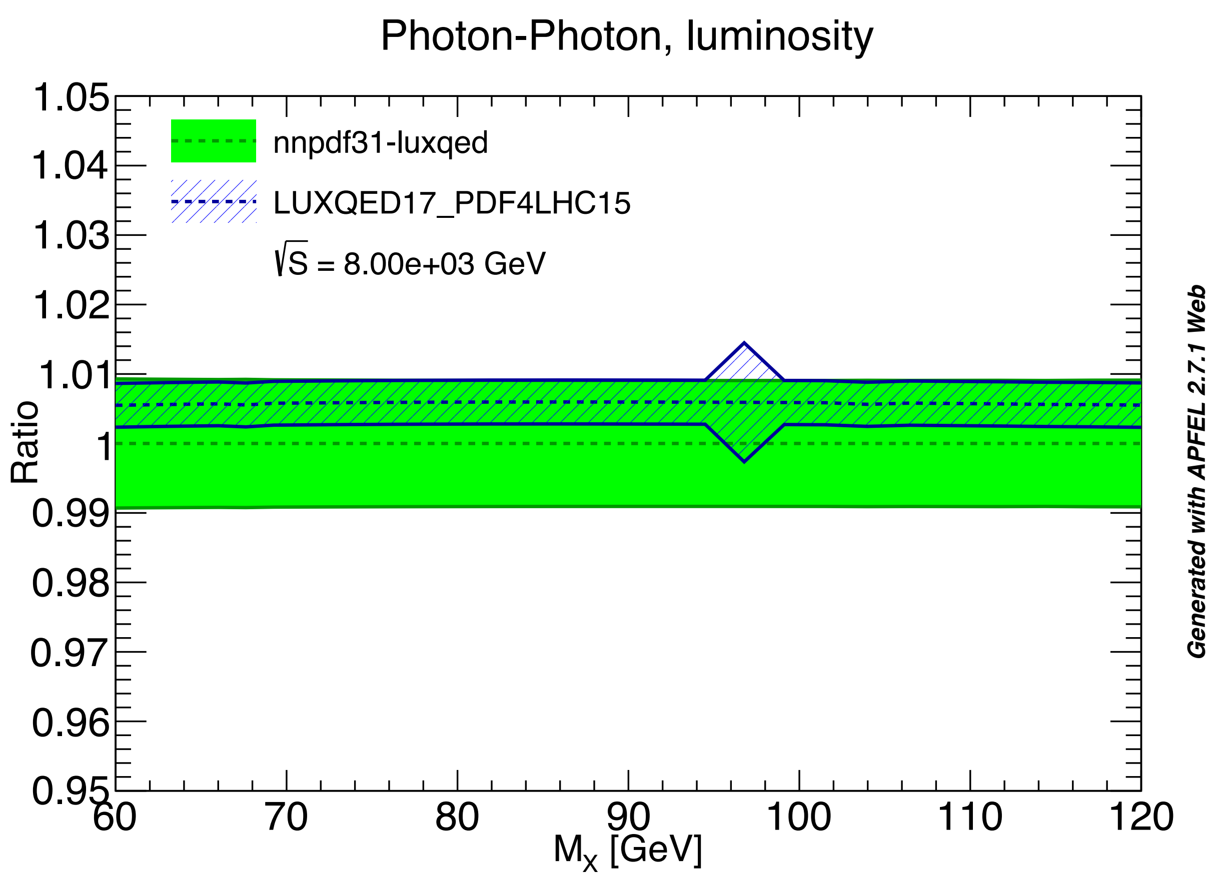
The consistency between the value of the parton-parton luminosities and the invariant mass distribution is expected

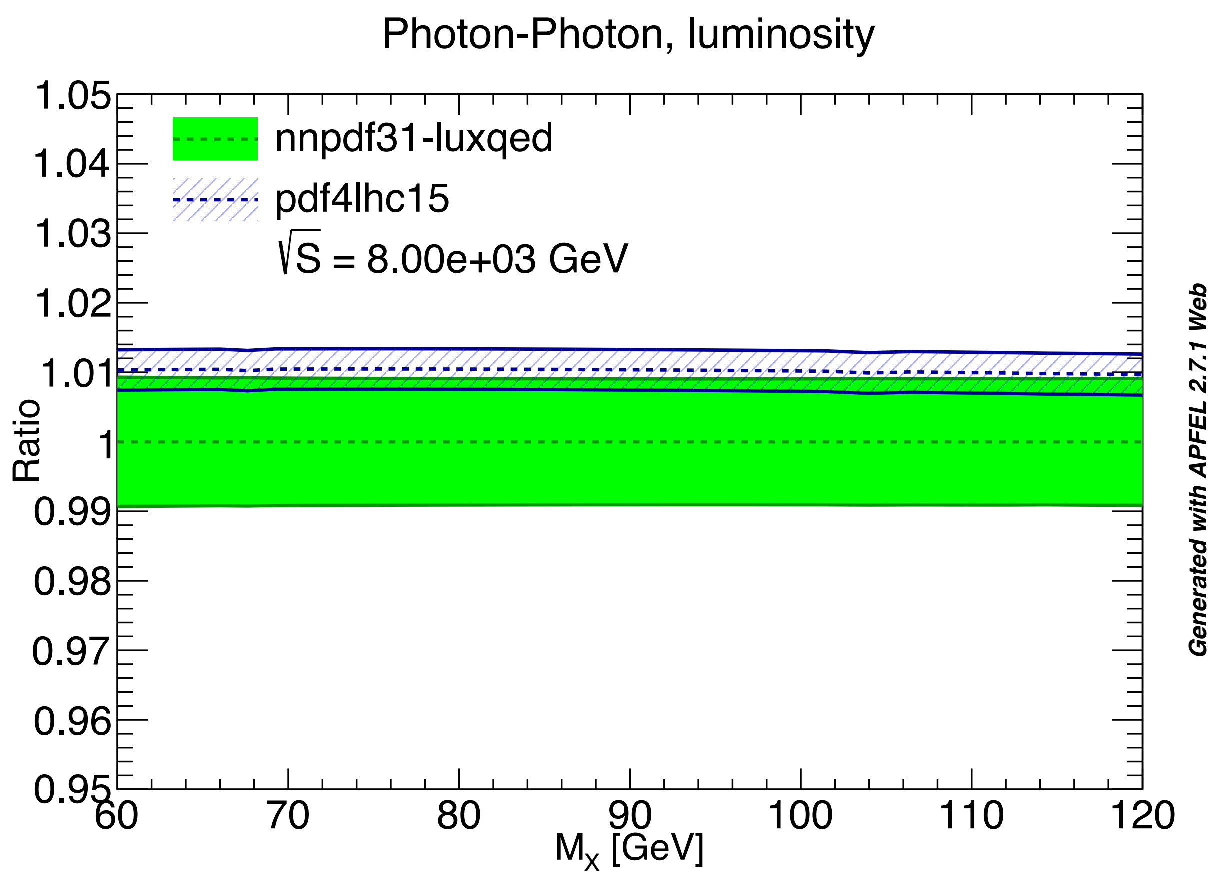
Small differences in the implementation e.g. of QED-DGLAP evolution (affecting e.g. quark densities) may have a pronounced impact on AFB

QED PDFs : photon-photon luminosities









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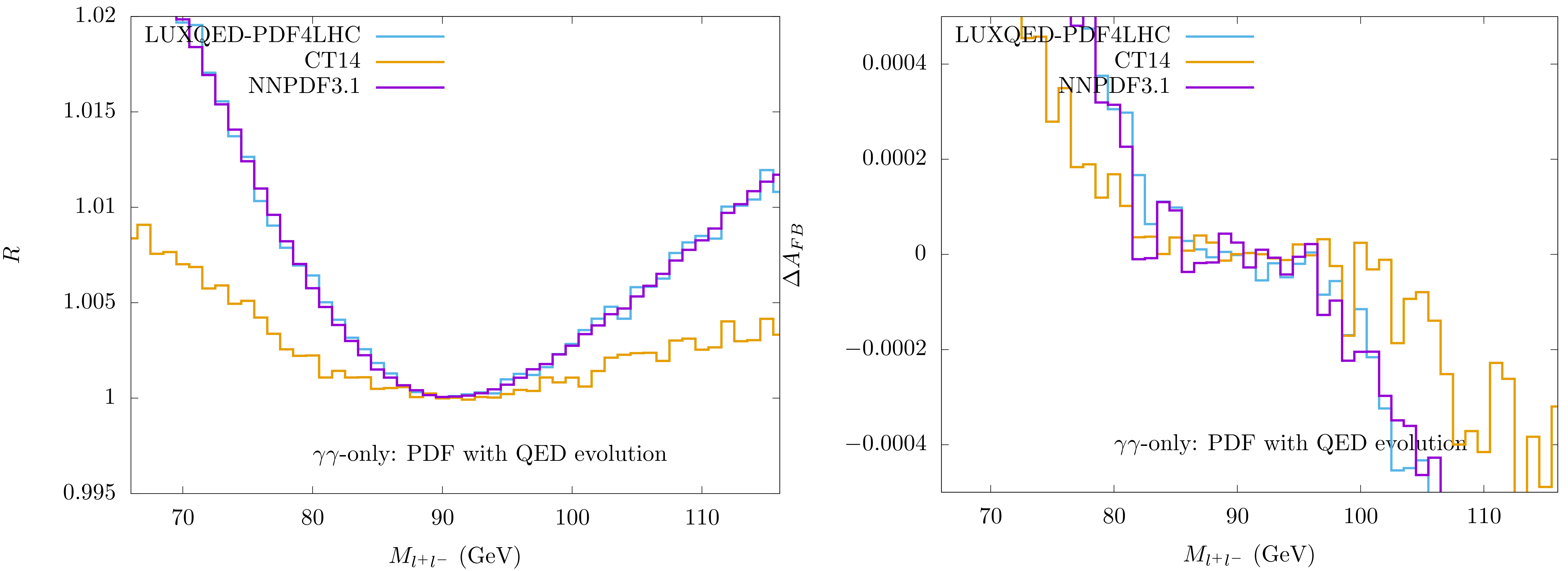

The consistency between the value of the parton-parton luminosities and the invariant mass distribution is expected

The LUXQED photon densities in the model are very similar in different PDF sets
In progress high-statistics runs to confirm the statement

The physically-motivated approximations are the outcome of a cancellation

Comments and conclusions

AFB offers the possibility of a "stress test" of modern PDFs

The consistency between the value of the parton-parton luminosities and the invariant mass distribution is expected

Small differences in the implementation e.g. of QED-DGLAP evolution (affecting e.g. quark densities) may have a pronounced impact on AFB

The physically-motivated approximations are the outcome of a cancellation

We need a careful study of the PDF uncertainty affecting AFB in the Z-peak region to establish the significance of the observed distortion