

## MCSANC update for $pp(\gamma\gamma, q\gamma) \rightarrow \mu^+\mu^-$ @ 8 TeV

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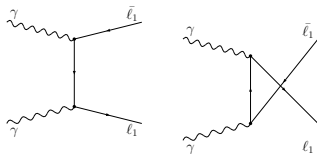
in collaboration with A. Vicini

LHC EW Precision sub-group meeting, CERN, May 07, 2019

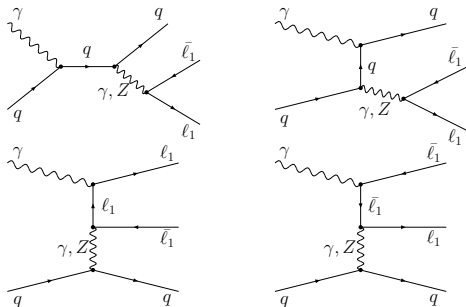
## SETUP:

- Photon-induced processes with initial photons in protons ( $\gamma\gamma$  and  $q\gamma$ ) at tree (LO) level
- LO QCD – no QCD corrections
- NLO QED – no pure weak corrections (another story, see next talk)
- $G_\mu$  EW-scheme: Born  $\sim \alpha^2(G_\mu)$ , Virt, Subt (DIS), Soft-, Hard-Brem  $\sim \alpha_0\alpha^2(G_\mu)$   
( $\alpha_0=1/137.0360, \alpha(G_\mu)=1/132.2332$ )
- Fixed-width scheme:  $\text{prop}(s, M_Z) = 1/(s - [M_Z^2 - iM_Z w_Z])$
- Physical parameters are from the hep-ph:1606.02330

$\gamma\gamma$  partonic subprocesses  $\sim \alpha_0^2$



$q\gamma$  partonic subprocesses  $\sim \alpha_0\alpha^2(G_\mu)$



## CUTS and OBSERVABLES:

- cuts options:
  - **FV - the fiducial volume:**  $80 \text{ GeV} < m_{\mu^+\mu^-} < 102 \text{ GeV}$  and  $p_t > 25 \text{ GeV}$  and  $|\eta_l| < 2.5$ ;
- observables:
  - $\sigma(\text{LO})$  – LO cross-section (pb),  
ratio =  $\sigma(\text{QED})/\sigma(\text{LO})$  – relative contribution;
  - $A_{\text{FB}}(\text{LO})$  – asymmetry,  
 $\Delta A_{\text{FB}} = [A_{\text{FB}}(\text{QED}) - A_{\text{FB}}(\text{noQED})]$  – difference of asymmetries,  
where  

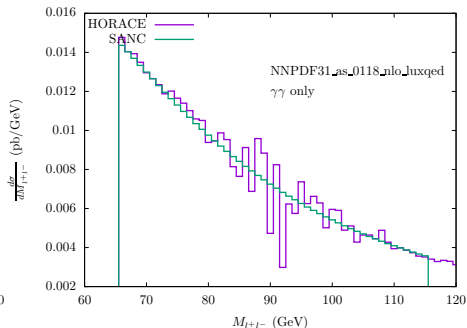
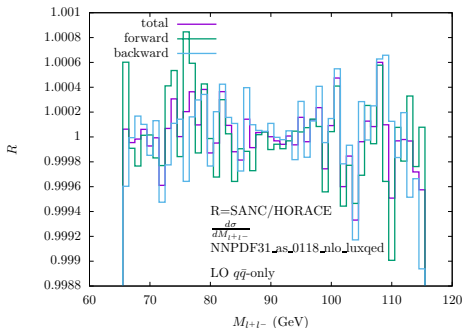
$$A_{\text{FB}} = (F-B)/(F+B),$$

$$F = \int_{\cos\theta' > 0} \sigma(\text{LO} + \text{QED}) d\cos\theta',$$

$$B = \int_{\cos\theta' < 0} \sigma(\text{LO} + \text{QED}) d\cos\theta',$$
 $\theta'$  – the lepton polar angle in the Collins-Soper reference frame (see, e.g. <https://arxiv.org/abs/1606.00689>)

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## $M_{ll}$ distribution: comparison of HORACE and SANC results

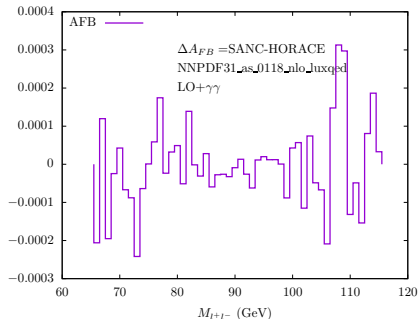
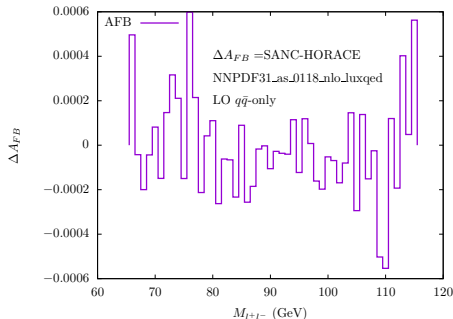


no significant trend emerges

a different normalisation of the  $\gamma\gamma$  contribution fixed in the HORACE data

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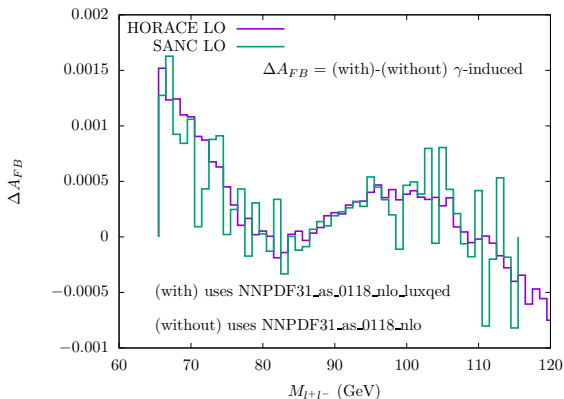
## AFB distribution: comparison of HORACE and SANC results



no significant trend emerges  
 more statistics is needed

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## Physically consistent approximations

simulation with  $\gamma$ -induced: NNPDF31\_nlo\_as\_0118\_luxqed and  $\gamma$ -induced subprocessessimulation without  $\gamma$ -induced: NNPDF31\_nlo\_as\_0118 and NO  $\gamma$ -induced subprocesses

**Two approximations:**

- [LO+ $\gamma\gamma$ ](QED) vs. LO(noQED)
- [NLO+ $\gamma\gamma+q\gamma$ ](QED) vs. NLO(noQED)

for the following pairs of PDF-functions:

NNPDF31\_nlo\_as\_0118\_luxqed vs. NNPDF31\_nlo\_as\_0118

NNPDF23\_nlo\_as\_0118\_qed vs. NNPDF23\_nlo\_as\_0118

CT14qed\_proton vs. CT14nlo

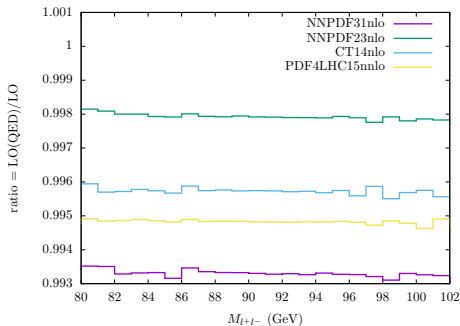
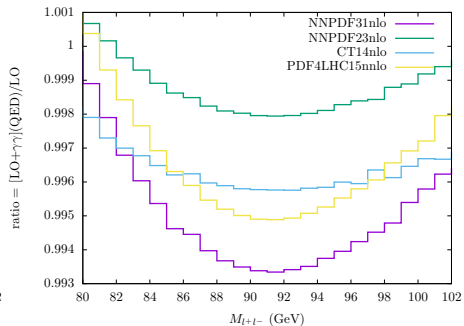
LUXqed\_plus\_PDF4LHC15\_nnlo\_100 vs. PDF4LHC15\_nnlo\_100

observables:

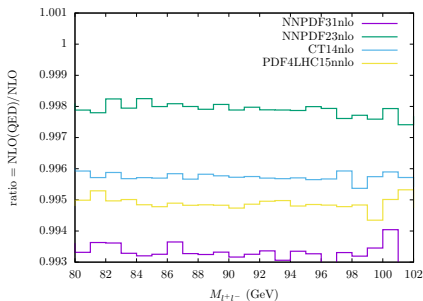
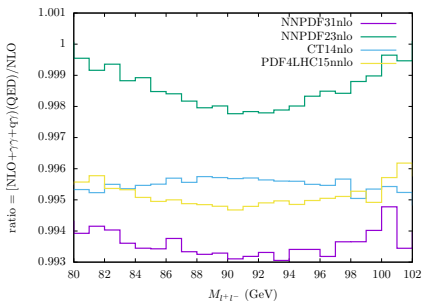
- ratio =  $\sigma(\text{QED})/\sigma(\text{noQED})$
- $\Delta A_{\text{FB}} = [A_{\text{FB}}(\text{QED}) - A_{\text{FB}}(\text{noQED})]$



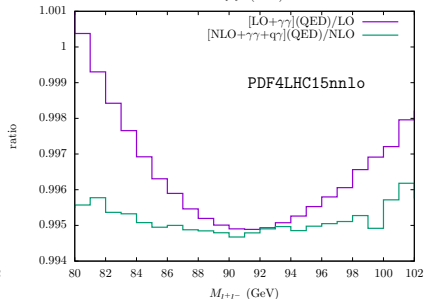
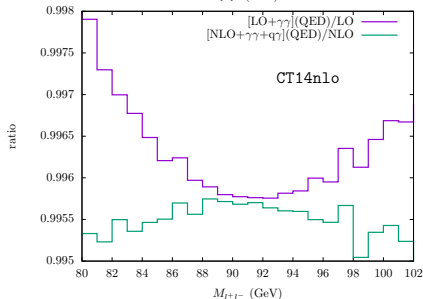
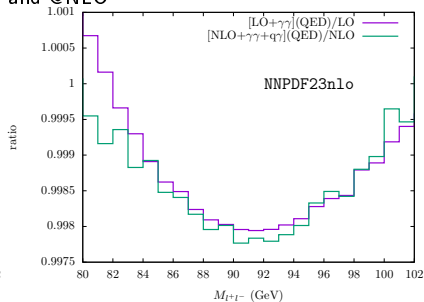
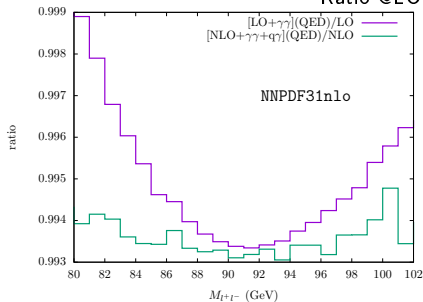
[LO](QED)/LO

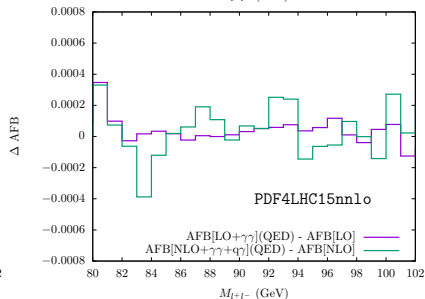
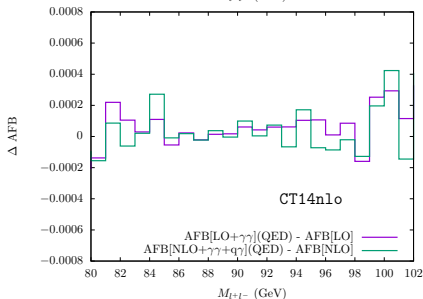
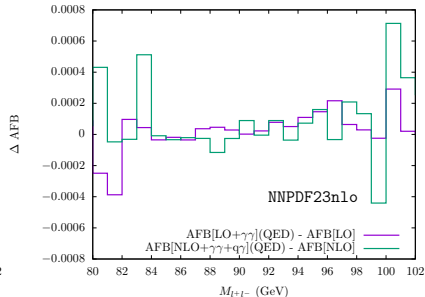
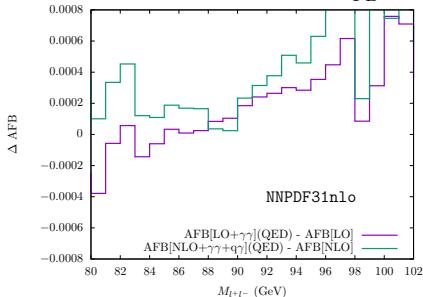
[LO+ $\gamma\gamma$ ](QED)/LO

[NLO](QED)/NLO

[NLO+ $\gamma\gamma$ + $q\gamma$ ](QED)/NLO

## Ratio @LO and @NLO



$\Delta A_{FB}$  @LO and @NLO

## SUMMARY:

near the Z-pole – in the central lepton invariant-mass region [66-116] GeV

- comparison between MCSANC and HORACE gives good agreement for LO and LO+ $\gamma\gamma$  cross-sections
- the  $\Delta A_{FB}$  at LO shows a shift (about  $2 \cdot 10^{-4}$ ) of  $A_{FB}$  at the Z peak for NNP31\_nlo\_as\_0118\_luxqed vs. NNP31\_nlo\_as\_0118 function (MCSANC and HORACE); no shift for other functions (MCSANC) (why?)
- apparently the same results are valid at NLO (MCSANC, preliminary), but to be precise one needs higher statistic calculations
- the subtraction scheme should be checked
- all results should be independently checked