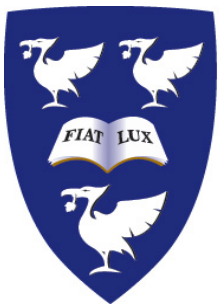


**HO QCD and HO EW calculations for
NC Drell-Yan production
- follow up from LPCC 9.10.12 -**



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NNLO QCD and HO EW corrections

Proposal for theory comparisons – and unified approaches for experiments

❖ **New baseline: FEWZ 3.1 (3.1.a3 and 3.1.b2) :**

“Combining QCD and electroweak corrections to dilepton production in FEWZ”,
Ye Li, Frank Petriello, arXiv:1208.5967 (August 2012)

❖ **use Gmu schema as default, and $\alpha(M_Z)$ as cross check**

$$\frac{1}{\alpha_G} = \frac{\sqrt{2}G_\mu M_W^2}{\pi} \left(1 - \frac{M_W^2}{M_Z^2} \right); \quad \sin^2 \theta_W = 1 - \frac{M_W^2}{M_Z^2}$$

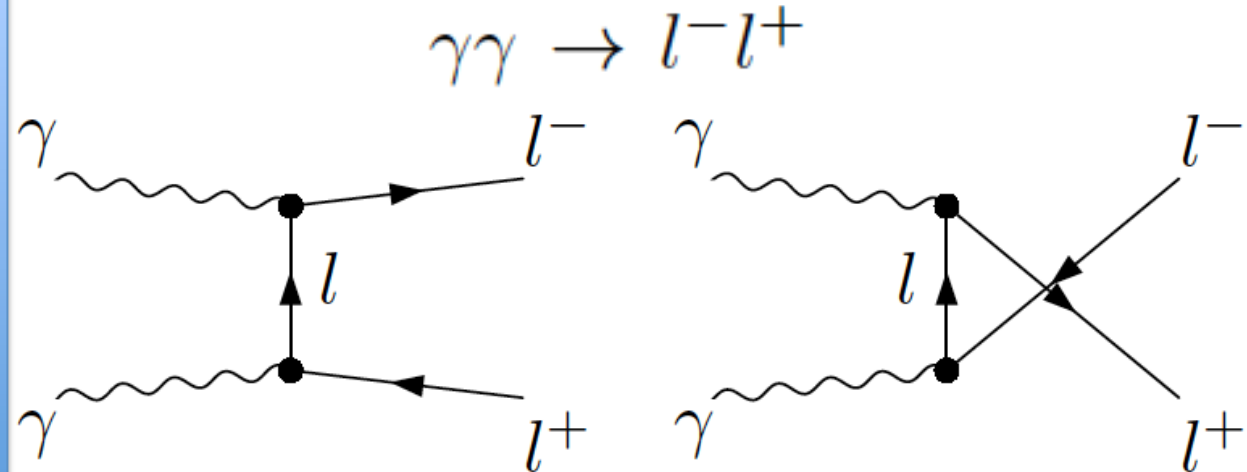
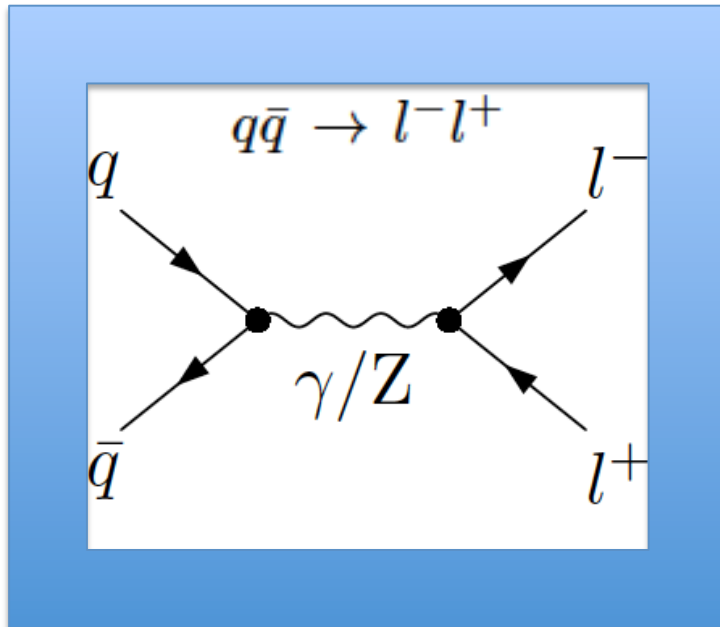
❖ **agreement on PDG input parameters? masses and widths**

❖ **use external programs like HORACE and SANC for cross checks**

Questions:

- **How to assign determine remaining HO EW uncertainties?**
- **Which uncertainties we didn't address so far? Real W and Z radiation e.g. is now included in MCFM v6 and new Powheg, but what with other diboson generators? How to estimate those missing corrections reliably?**
- **Which precision we may achieve for theory calculations? NNLO QCD and EW? What is here the best strategy? How to estimate remaining scale uncertainties?**
- **How to treat best photon-induced processes? Simulate and subtract from data? - or - Do not subtract from data at all?**

Lowest order partonic cross section



Neutral Current Drell Yan processes

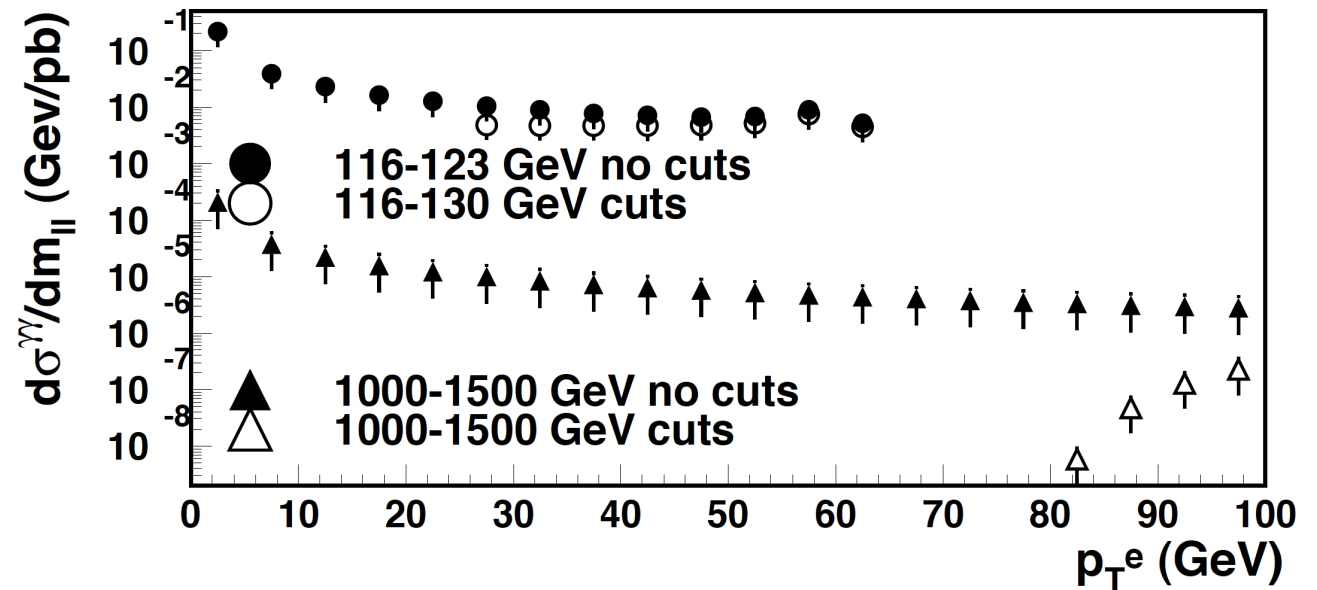
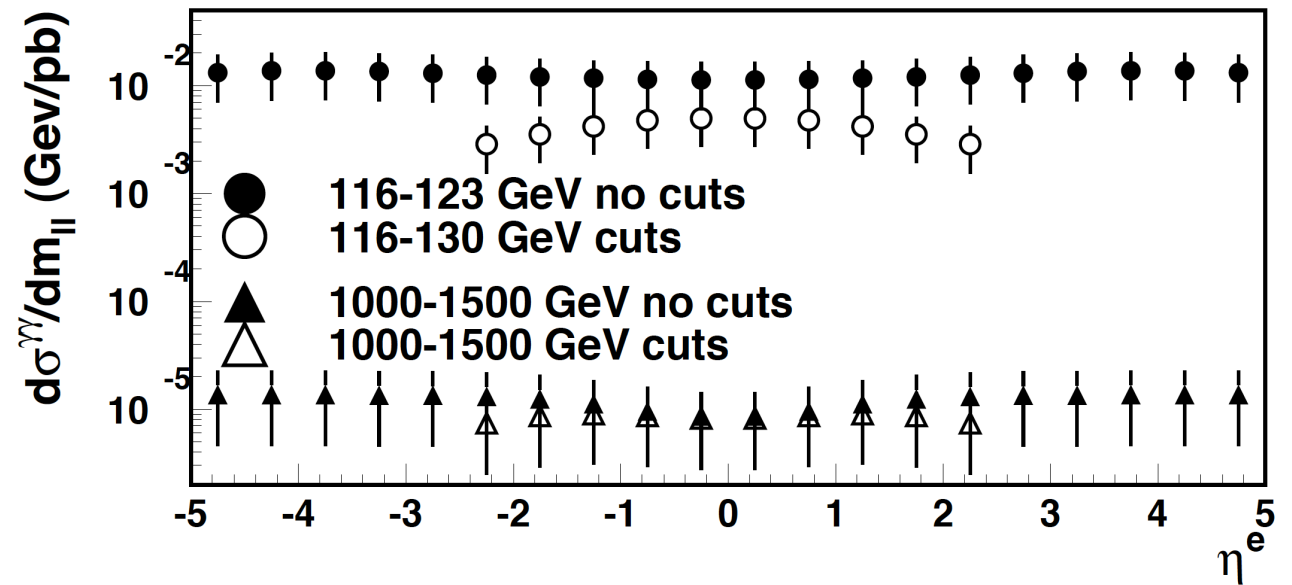
- $q\bar{q}$ induced processes : sensitive to structure of the **proton**

Irreducible background

- $\gamma\gamma$ (γq) induced processes : sensitive to QED and structure of the **photon**
- ➔ *non-resonant; suppressed due to the smallness of the photon PDF*
- ➔ MRST 2004qed fit (NLO QCD): " Parton distributions incorporating QED contributions", A.Martin, R.Thorne, hep-ph/0411040

LO Photon induced Processes

- photon-induced background is flat versus eta of produced lepton
- pt dependence slightly different than DY
- STRONG dependence on fiducial cuts
- MRST2004qed
- FEWZ 3.1.b2 dynamic scale
- separate calculations per bin



Results

- MRST2004qed
- NLO QCD
- fiducial cuts : $\eta < 2.4$ (2.5)
- ✓ ALL PI results confirmed by SANC

δ calculation:

denominator: NLO QCD

w/o photon

numerator:

MISS=triangles (green)

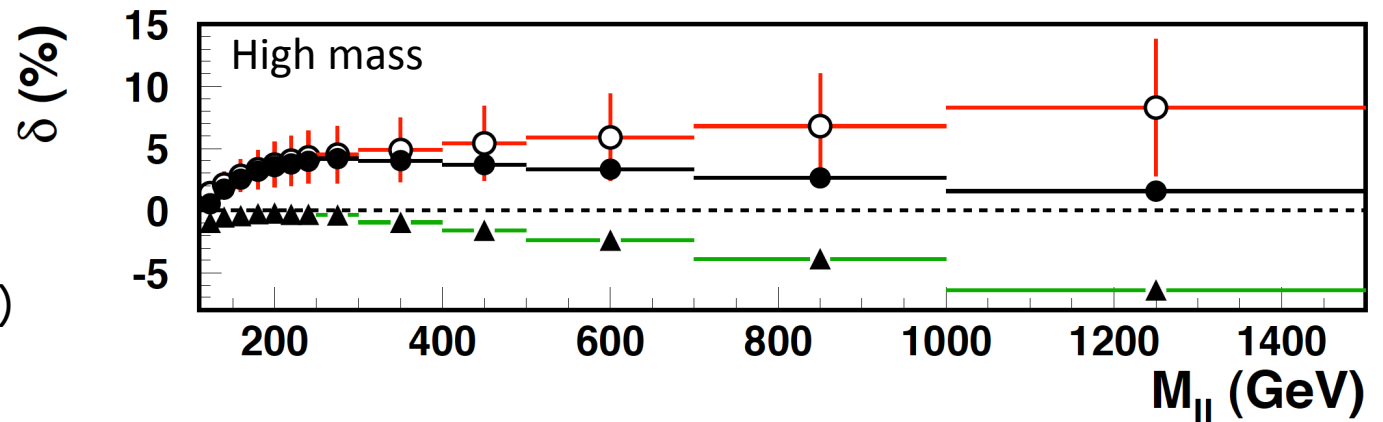
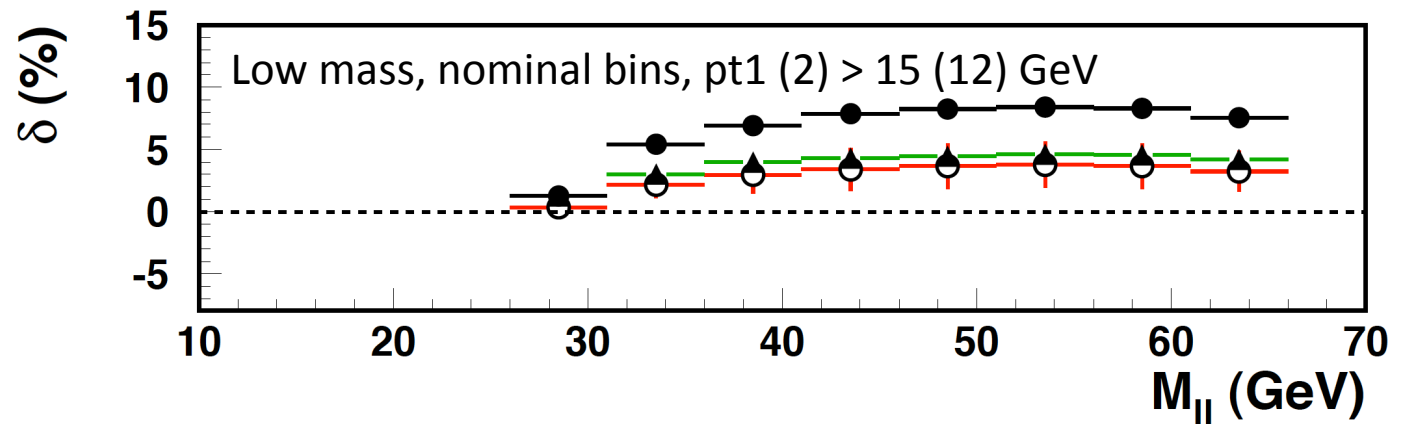
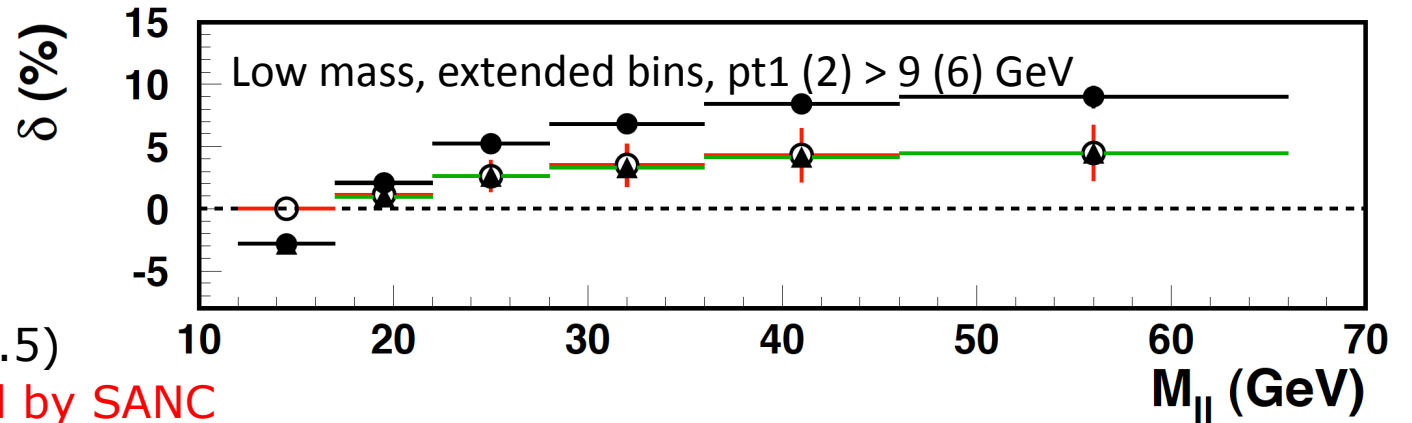
LO γ induced=open (red)

with $\sim 50\%$ error bar

MISS including γ induced

=full (black)

→ LO photon-photon induced contributions are as sizeable as the PW+ISR+IFI effects (MISS) and the PDF uncertainties



A working list for cross checks & benchmarks

- ✧ Assign uncertainty for applying HO EW corrections (cut dependence, non-convergence between EW schemata etc.), see my slide 2
- ✧ Issue 1 : LO photon induced contributions should be calculated with MRST2004qed, and ADDED to modern PDF NNLO QCD+ HO EW predictions (use Durham workshop prescription, stay tuned for updates of QED in proton part)
- ✧ Issue 2 : NLO photon induced contributions have to be added as well → those are not included in FEWZ 3.1 and need external calculations, which may be renormalisation and factorisation scale dependent
- ✧ Issue 3 : Estimate remaining NNLO QCD scale uncertainties (CPU time, alternatives?) → we should agree on a basic prescription
- ✧ Issue 4 : Do we miss further EW corrections?
 - ➔ EW corrections have to be matched with experimental procedures, e.g. we correct for QED FSR, we subtract diboson background with MC ...
 - ➔ MC modelling of photon induced contributions would be highly welcome (e.g. now an option in newest Madgraph5)
 - ➔ **Extra follow-up : EW parameter settings in Monte Carlo's**
- ✧ **issue 5 : Add photon-induced into our extrapolation factors? ... depending on our data corrections strategy...**