LHC final states, potential experimental and theoretical accuracies

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"A review on potential LHC reactions and their accuracies"

Abstract: Cross section calculations for a large number of Standard Model LHC reactions have been performed during the last 20 years. Many experimental simulations demonstrate how various final states might eventually be selected. These studies indicate how large the potential signals and backgrounds might be and the results can be found at various places in the literature.

We attempt to give a comprehensive summary for these different cross sections and their potential statistical errors.

Furthermore, we try to provide some consistent estimates for potential systematic errors of these future LHC measurements. Obviously, many experimental and theoretical uncertainties can only be estimated or guessed today. Nevertheless, such a list might not only become useful during the coming years, but will eventually be proven to be too pessimistic or optimistic once real measurements can be performed at the LHC.

preparing a theoretical/experimental review?

- identify relevant LHC (Standard Model) Reactions

- summarize theoretical cross sections (inclusive)
  and using simple experimental cuts (limited η and p_t)

- how large are PDF uncertainties?

- a few examples ..

- How to collect/combine the material?
  (round table meeting Tuesday 12.10 14:30)

Usefulness of such a document?

provide “known” numbers in one review document

to know what can be done experimentally

to know what can be done theoretically

to confront todays wisdom with tomorrows reality
thus start LHC physics with “adequate” precision!

Experimental limitations for LHC precision reactions:

- counting statistics $\pm 1\%$ $\rightarrow$ with 10^4 events ($\Delta N/N = 1/\sqrt{N}$)

- backgrounds: the cleaner $\rightarrow$ the better!
  (reduced/controlled by cuts)

- efficiency and geometrical acceptance?

a simple detector model?

using roughly the CMS/ATLAS potential

"Isolated" electrons, muons and photons:

$\Delta E/E_{e,\mu,\gamma} =$ few % excellent angular resolution, "high" efficiency
and "small/negligible" backgrounds
geometrical acceptance: $p_t \geq$ 10 GeV and $|\eta| \leq$ 2.5

"Isolated(??)" jets:

High efficiency for $p_t \geq$ 30 GeV (??) and $|\eta| \leq$ 4.5(??)

Energy resolution? $\Delta E_t/E_t \approx 100 - 200\%/\sqrt{E} + 5\%$ (??)

Missing transverse momentum: depends on final state!
in general a mixture between lepton and jet accuracies

a list of well defined final states

- Drell–Yan type lepton pair final states. This includes on– and off–shell W and Z decays.

- γ–jet final states

- Diboson events of the type WW, WZ, ZZ, $W\gamma \rightarrow$ leptons (SM Higgs production might perhaps be included here).

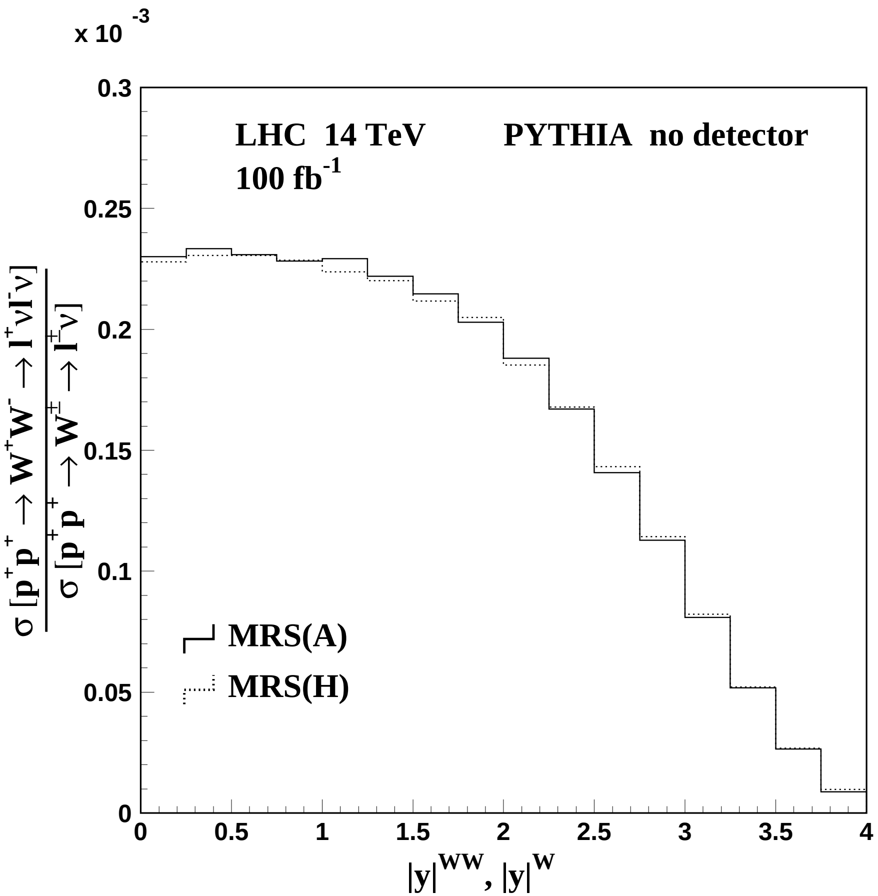
- Events with top quarks in the final state, identified with at least one isolated lepton.

- Hadronic final states with up to n(=2,3 ..) Jets and different p_t and mass.

define useful cross section ratios!

an example:

precise ratio prediction (at LO) ($\leq 1\%$) for
$\sigma(q\bar{q} \to W^+W^-)/\sigma(q\bar{q} \to W^\pm)$



uncertainties from different HO QCD calculations:

ELECTROWEAK GAUGE BOSON RAPIDITY DISTRIBUTIONS AT NNLO

C. Anastasiou, L. Dixon, K. Melnikov and F. Petriello Dec 2003, hep-ph/0312266

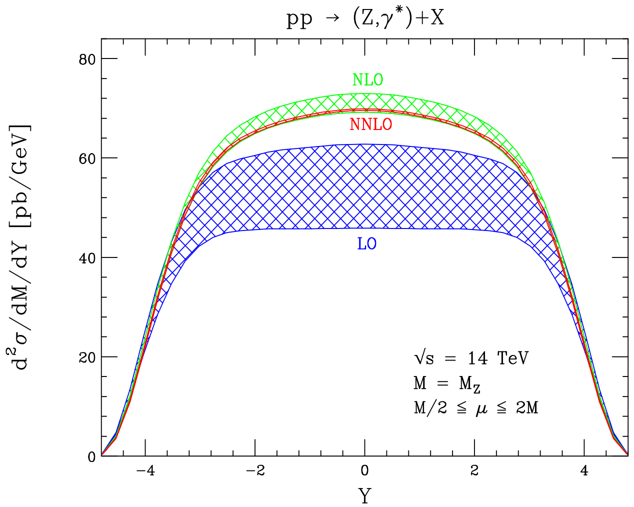


Figure 3: The CMS rapidity distribution of an on-shell Z boson at the LHC. The LO, NLO, and NNLO results have been included. The bands indicate the variation of the renormalization and factorization scales in the range $M_Z/2 \leq \mu \leq 2M_Z$.

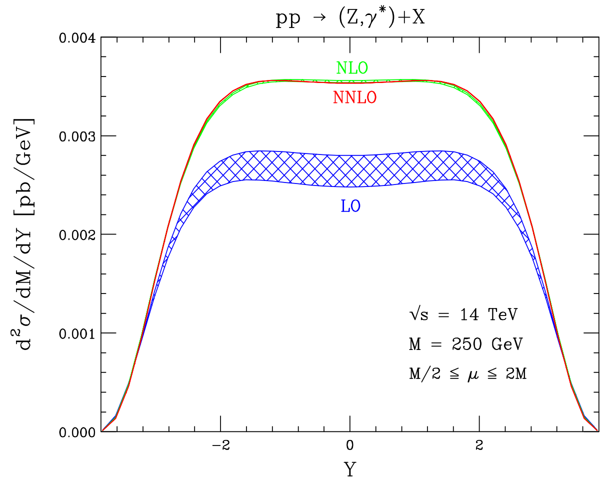
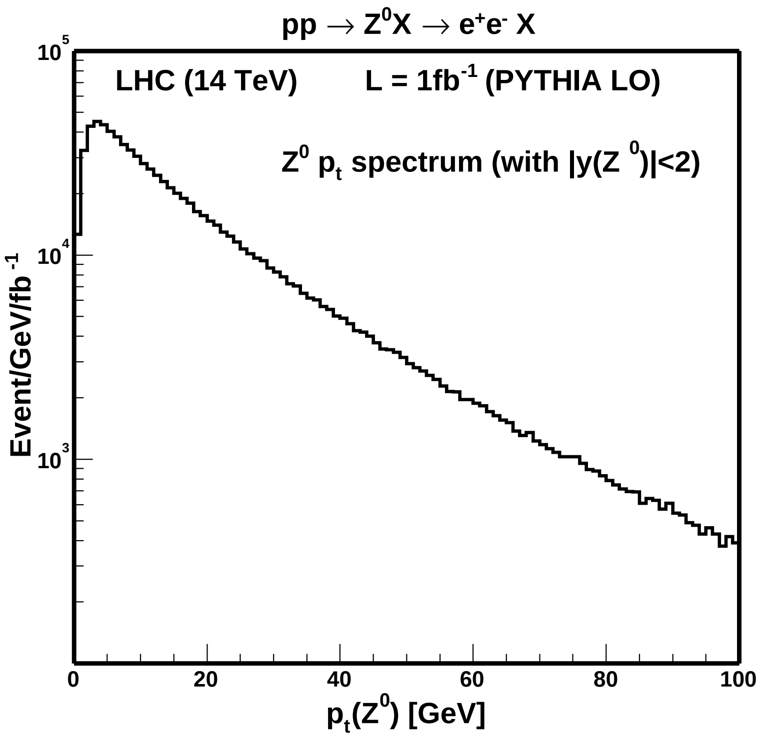
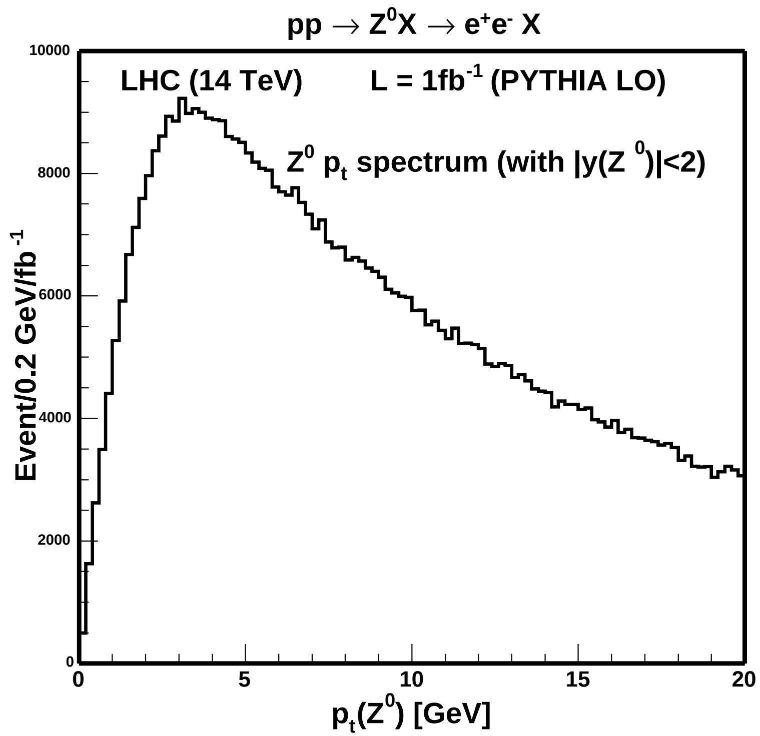


Figure 14: The rapidity distribution for (Z, γ^*) production at the LHC for an invariant mass $M = 250$ GeV. The LO, NLO, and NNLO results have been included. The bands indicate the residual scale dependences.

high(est) precision QCD test at the LHC? the p_t spectrum of the Z boson!

Huge cross section, "no" background and precision measurement $pp \to ZX \to e^+e^-X$





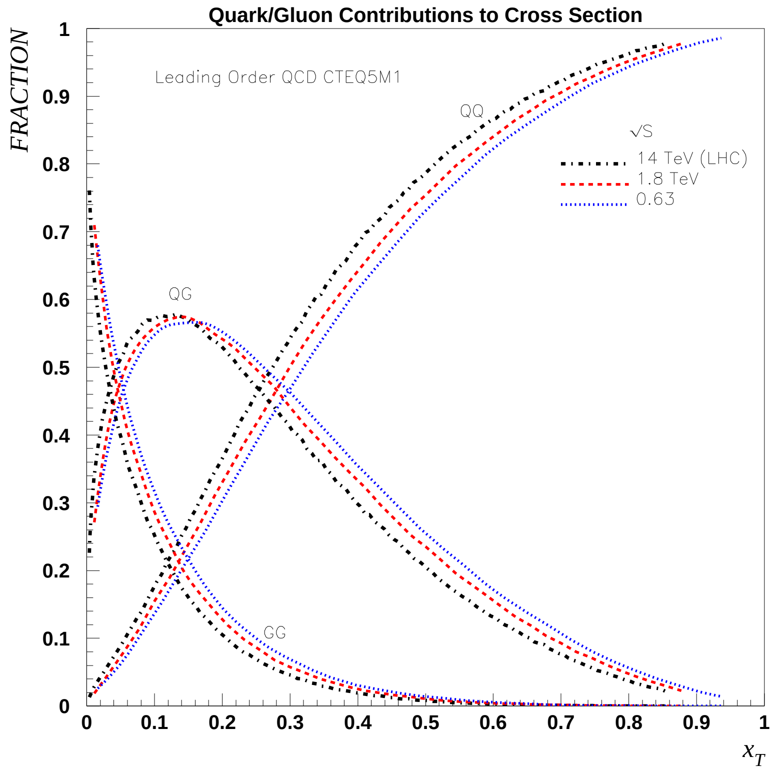
who will predict p_t spectrum in all its beauty?

including (multi)jet activity and rapidity distribution!

use result to invent (iterative?) a method to predict p_t spectrum of other final states!

QCD×QCD reactions?

measure rapidity and p_t $\longrightarrow$ PDF consistency measurements!



plot made by Manjit Kaur (Panjab University/CMS)

Round table discussion:
Tuesday 12.10 at 14:30!

How to fill the tables?

Reaction	PYTHIA	HERWIG	LO	NLO (NNLO)
$q\bar{q} \rightarrow W^+ \rightarrow \mu^+\nu$				
$q\bar{q} \rightarrow W^- \rightarrow \mu^-\nu$				
$q\bar{q} \rightarrow Z^0 \rightarrow \mu^+\mu^-$				
$\sigma(W^+)/\sigma(W^-)$ $\sigma(W^\pm)/\sigma(Z)$				
"accepted" $\sigma(W^+)$				
"accepted" $\sigma(W^-)$				
"accepted" $\sigma(Z)$				
accepted $\sigma(W^+)/\sigma(W^-)$ accepted $\sigma(W^\pm)/\sigma(Z)$				