Early EWK/top measurements at the LHC

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Introduction

- LHC was built for discoveries: SUSY, Higgs, etc.
- What is the role of EWK/top measurements in the LHC program?
- Several themes
    1. High PT analysis commissioning
    2. In passing: “bread and butter” measurements to be made
    3. EWK/top are backgrounds for many new physics sources. Tails!
    4. New physics with W, Z, top
- Will try to cover these points with some examples

Warning

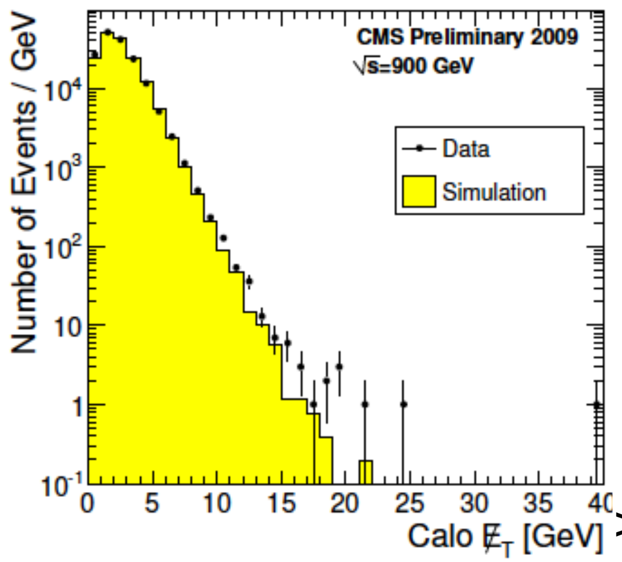
- I am on CMS
- So most of the examples are from CMS studies
- Not because they are better than Atlas
- But because I know them best

- Also: most results are for 10 TeV. The story at 7 TeV is not that different. Lower cross-section is main difference

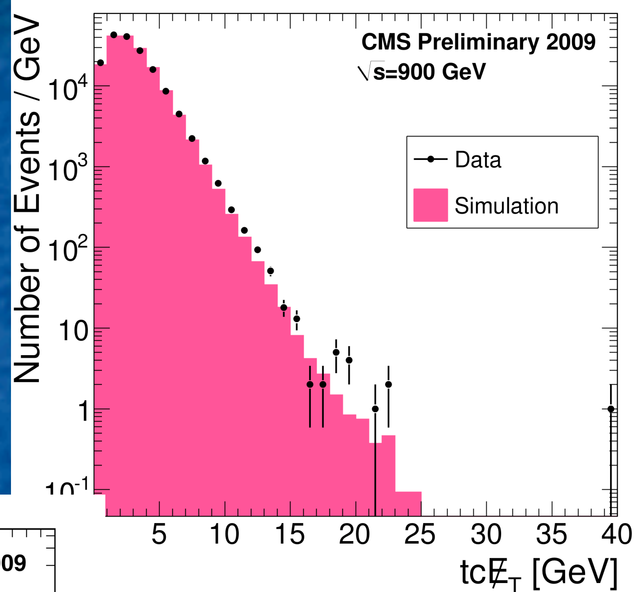
Aside

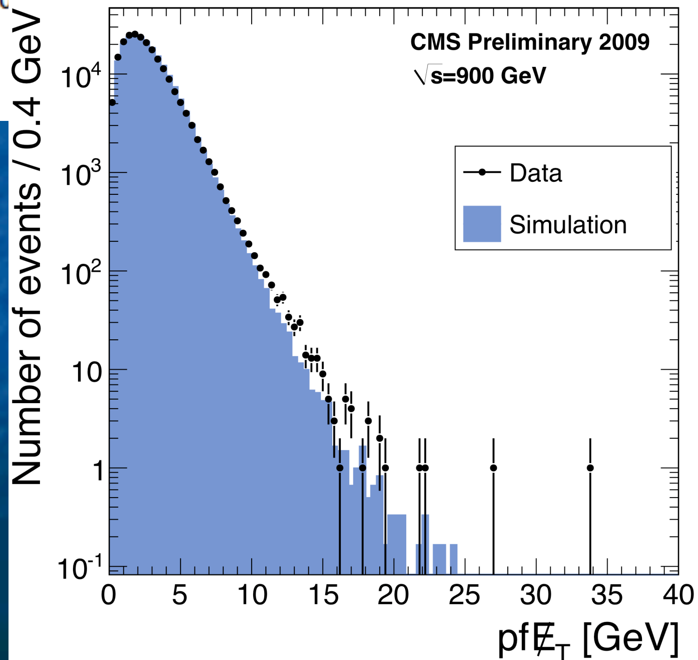
- Lesson from low energy Dec 2009 CMS run is that CMS is looking pretty good.
- I am quite optimistic that we will be able to produce physics results quite quickly (LHC willing)

An example: Missing E_T in 900 GeV min-bias at CMS



(a) Calo$\not{E}_T$ distribution



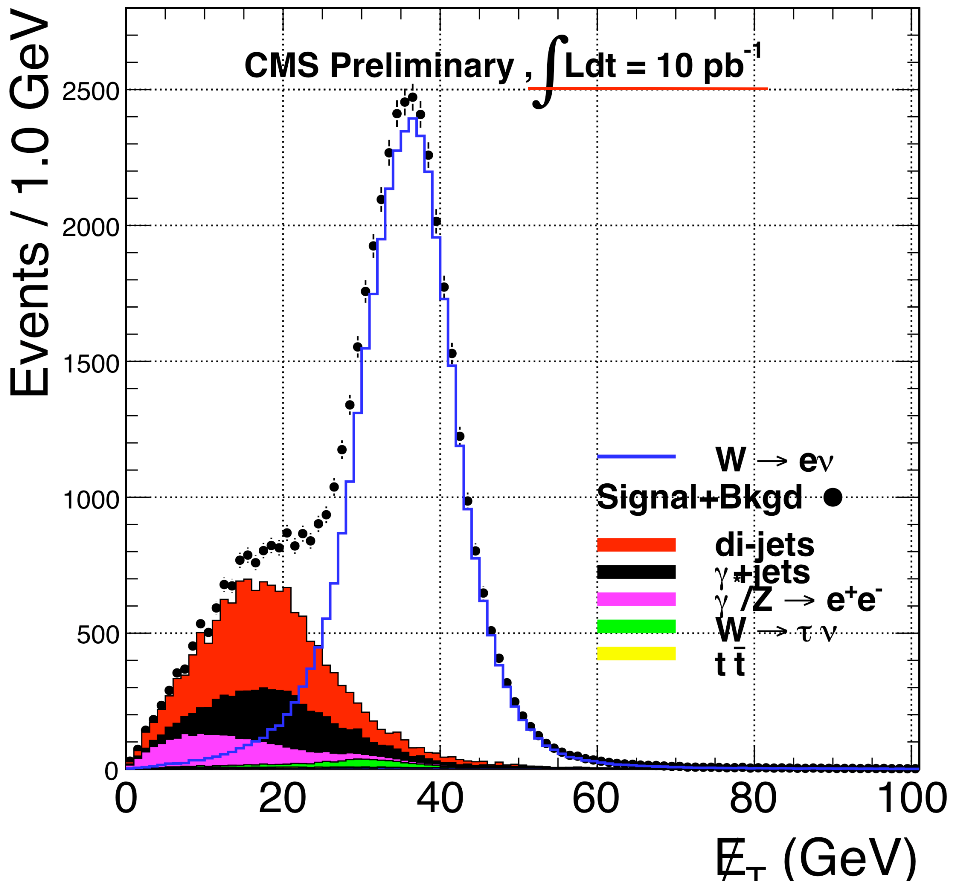


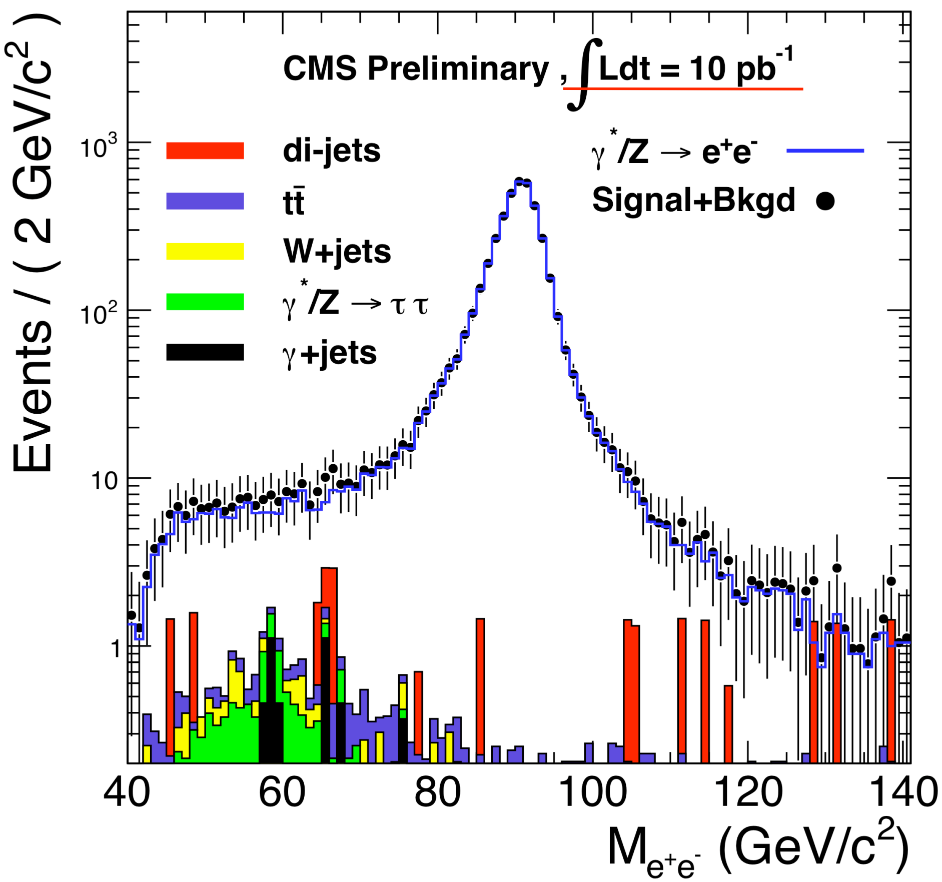
Agreement over 4 orders of magnitude

W/Z/top cross-sections

- These are the 1st measurements
- **It is the 1st necessary step in preparation for the program of searches in high P_T physics**
- High rate processes (esp W/Z)
- Will have results for ICHEP this summer
  - LHC willing
- Techniques are ready

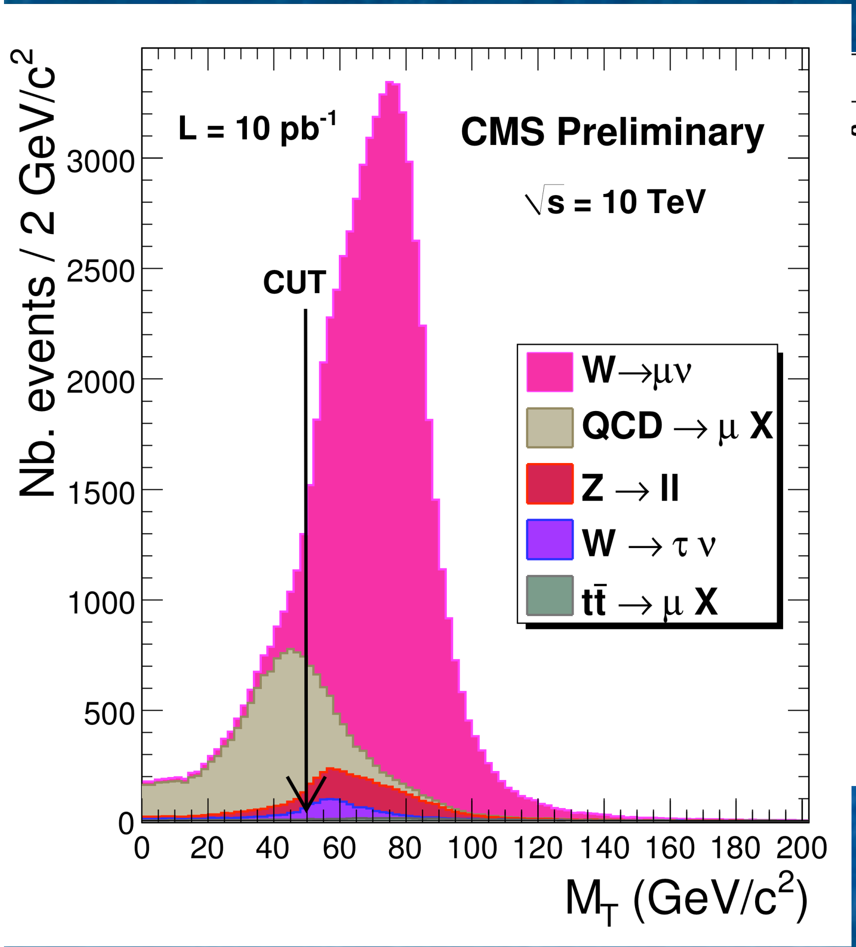
W/Z in electrons

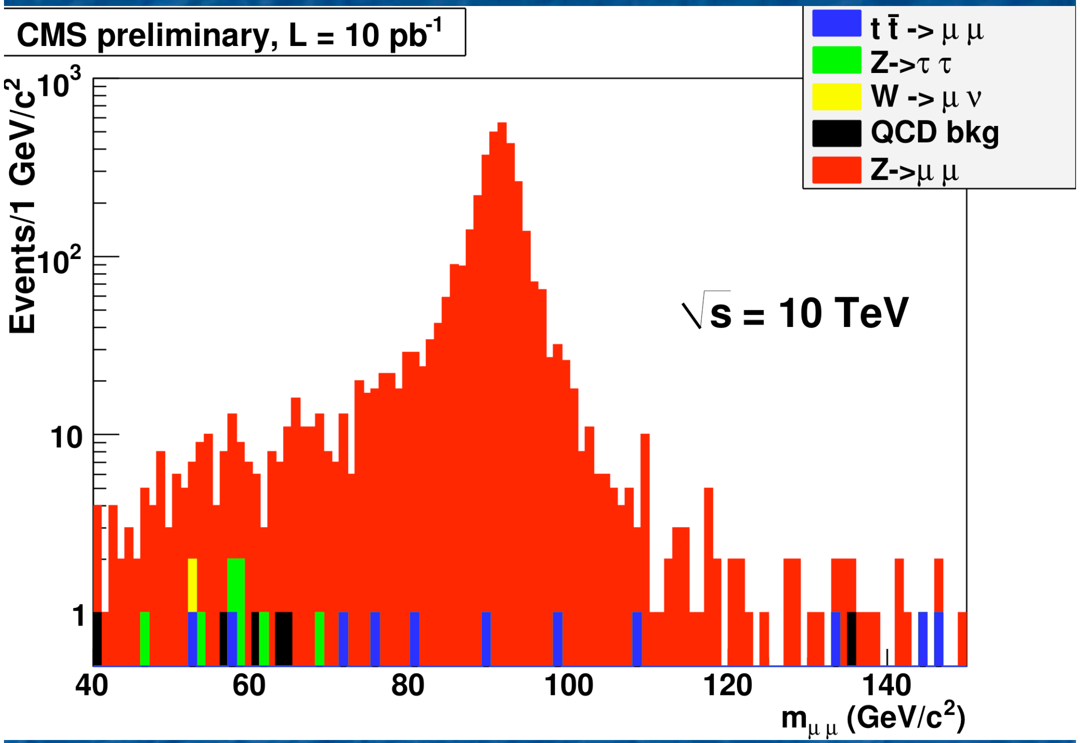




37K W→eν with ~ 4% syst
4K Z→ee with ~ 2.5% syst

W/Z in muons



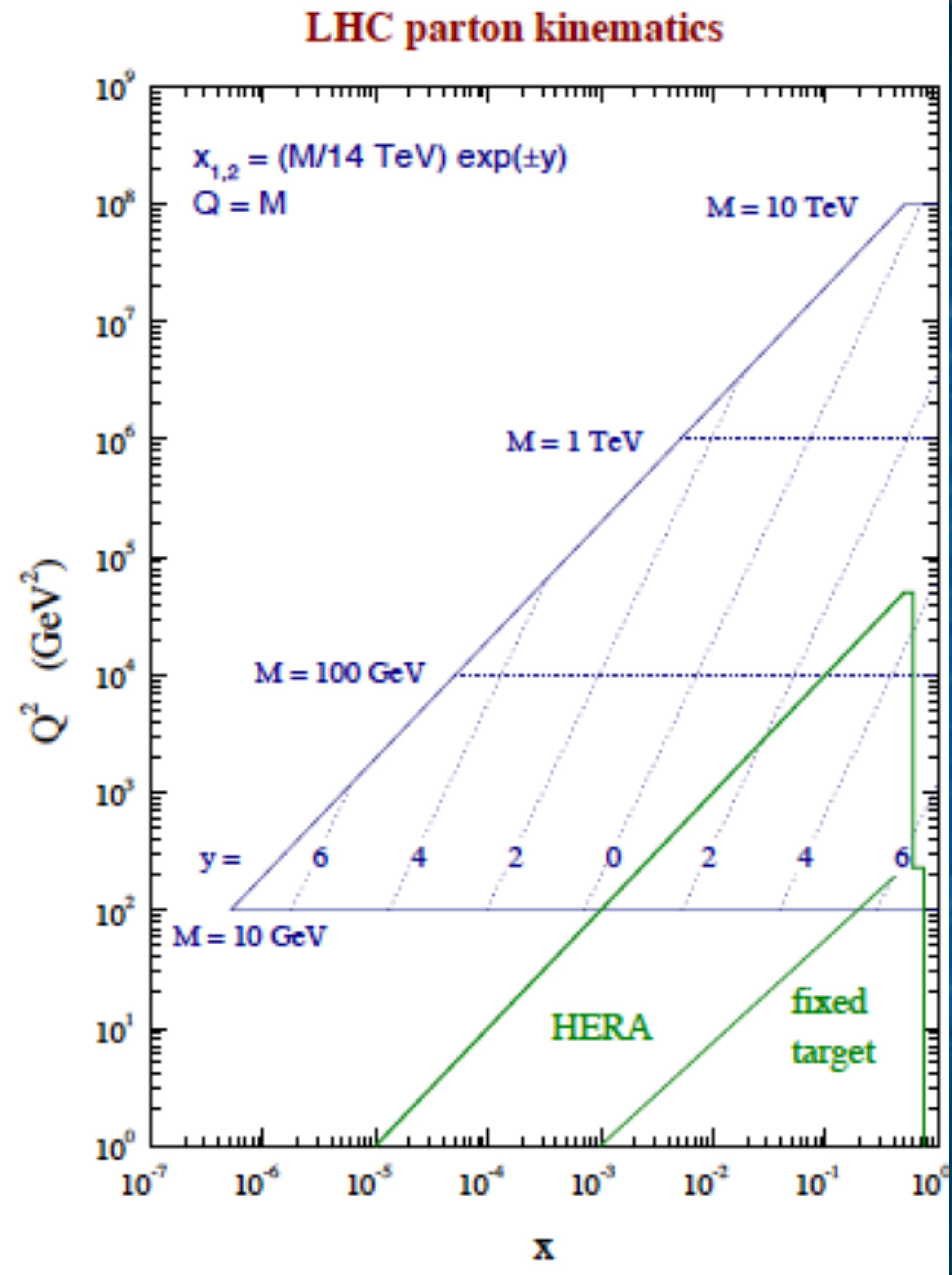


Transverse Mass

47K W→μν
5K Z→μμ

W/Z cross-sections

- **We should have clean signals in a few pb^{-1}.**
- 1^{st} step towards high P_T physics commissioning
- The measurements of the cross-section will be limited by the luminosity uncertainty (10%?)
- What Physics do these measurements teach us?
  - Verify our understanding of higher order QCD corrections to the Drell-Yan process
    - But with 10% luminosity uncertainty not very useful
  - Information on PDF
    - Again with 10% lumi uncertainty not very useful

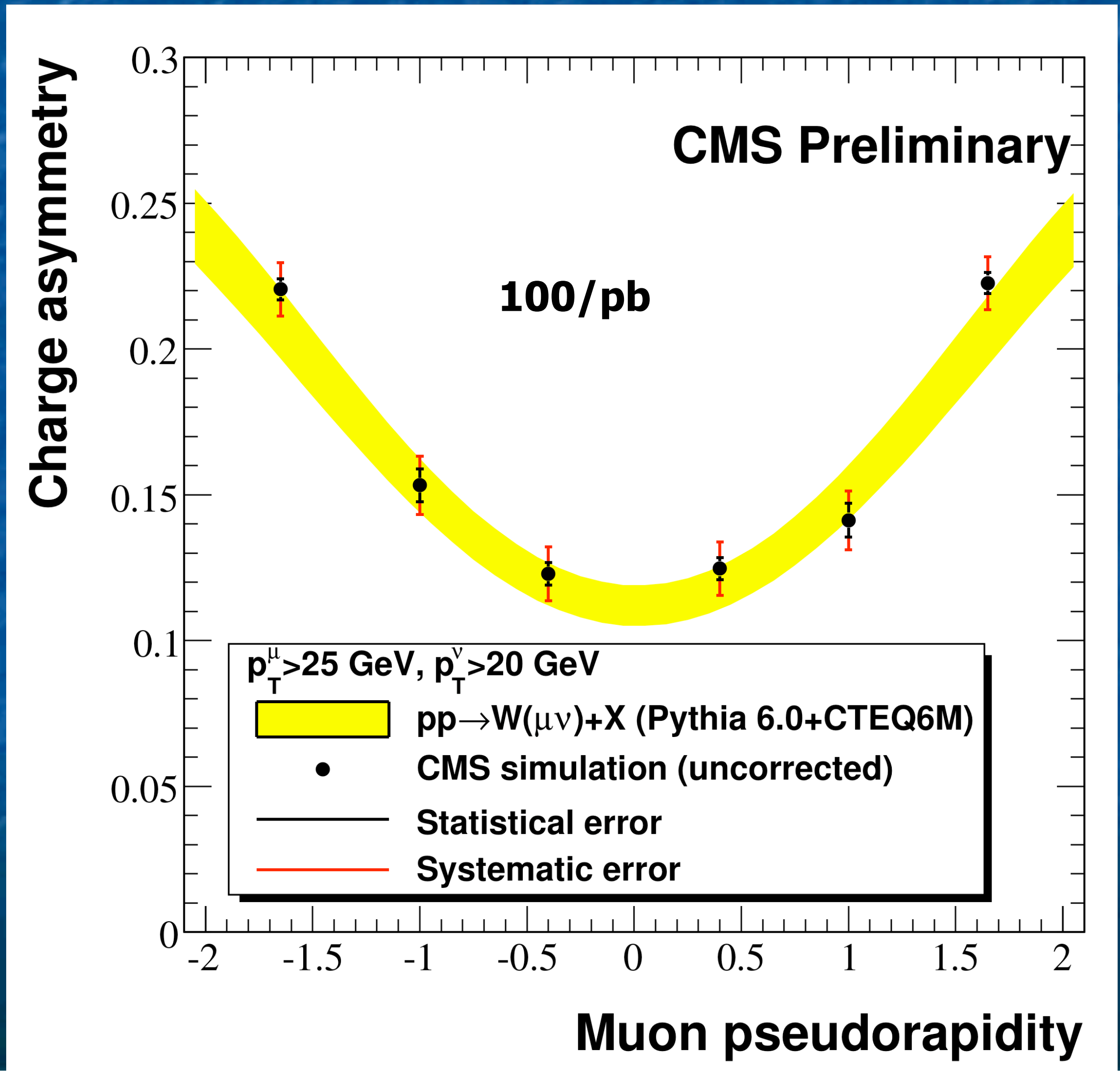


At LHC probe different kinematical region

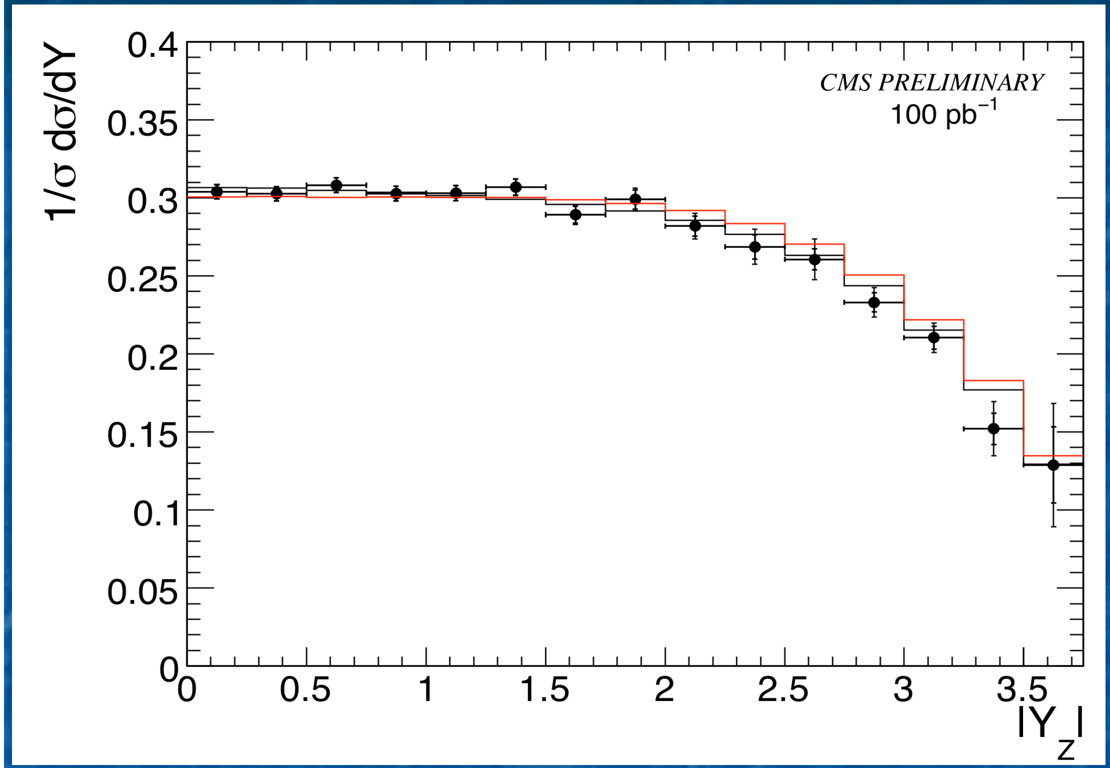
Differential distributions, asymmetries are more useful than absolute x-section

W^+ vs W^-

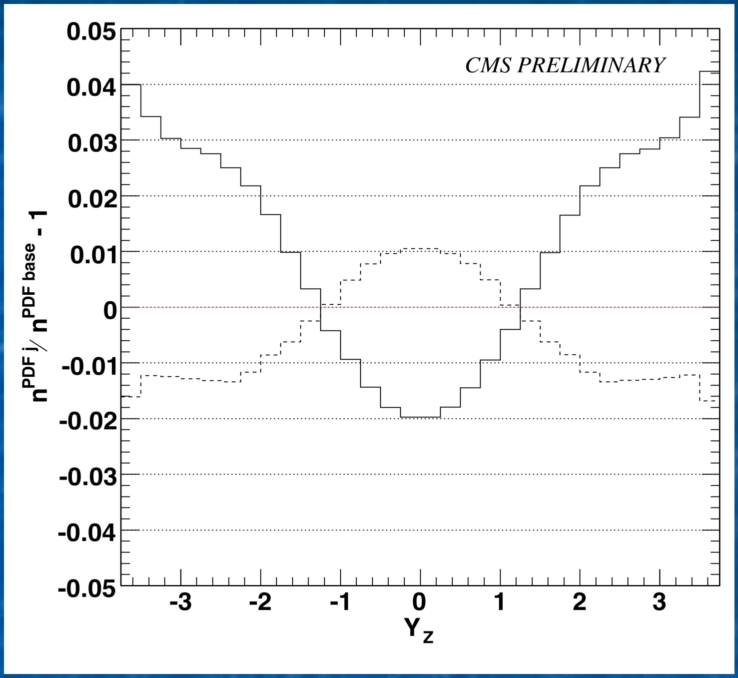
$$\frac{\sigma(pp \to W^+)}{\sigma(pp \to W^-)} \sim \frac{u\bar{d}}{d\bar{u}} = \frac{u}{d}\,\frac{\bar{d}}{\bar{u}}$$



Z-rapidity



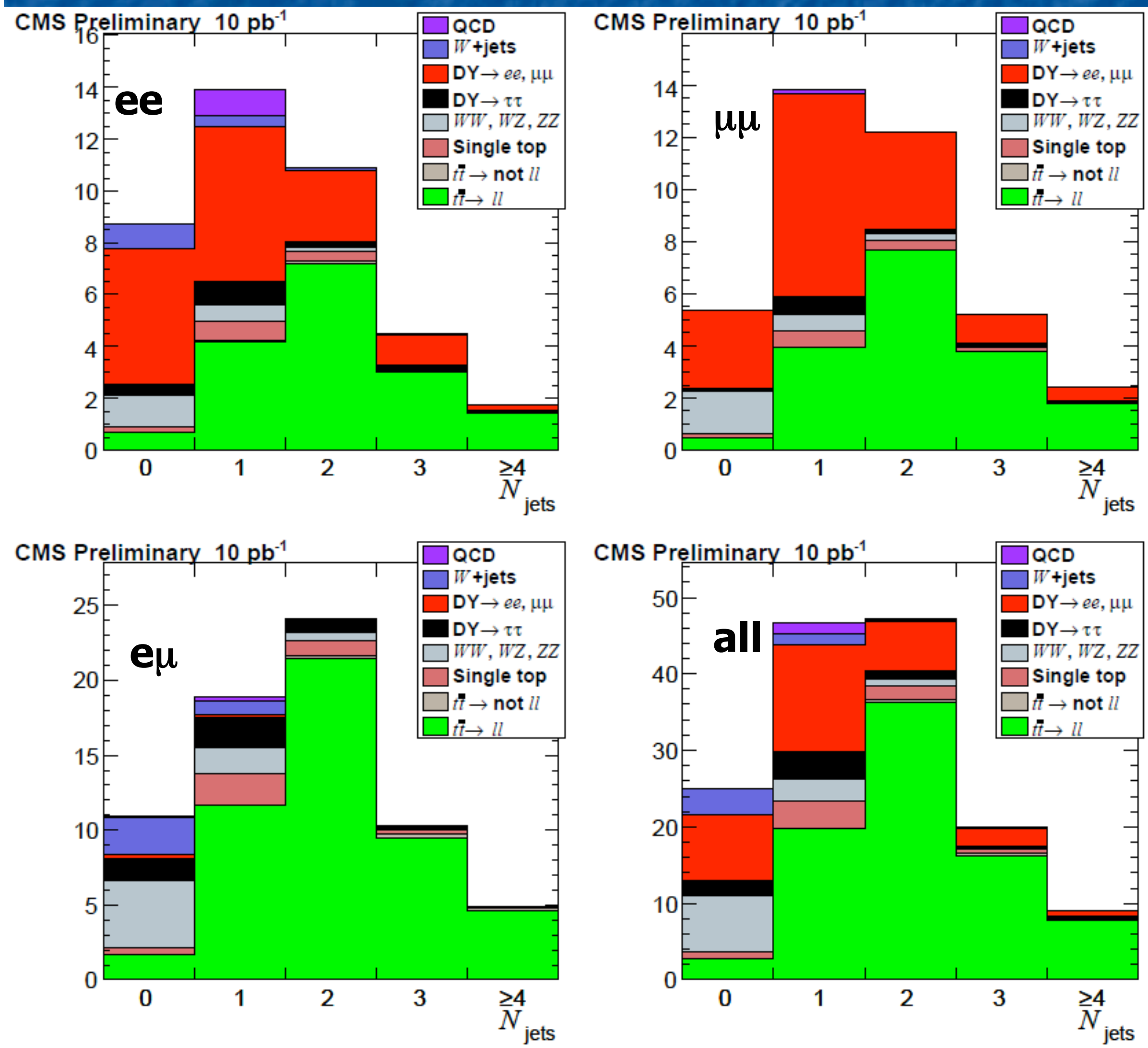
The prediction for the positive variation of one of the CTEQ basis vectors (#13) is shown in red



CTEQ6.5 PDF vector number 13 (positive and negative variation)

The low-x PDF sensitivity is at high rapidity

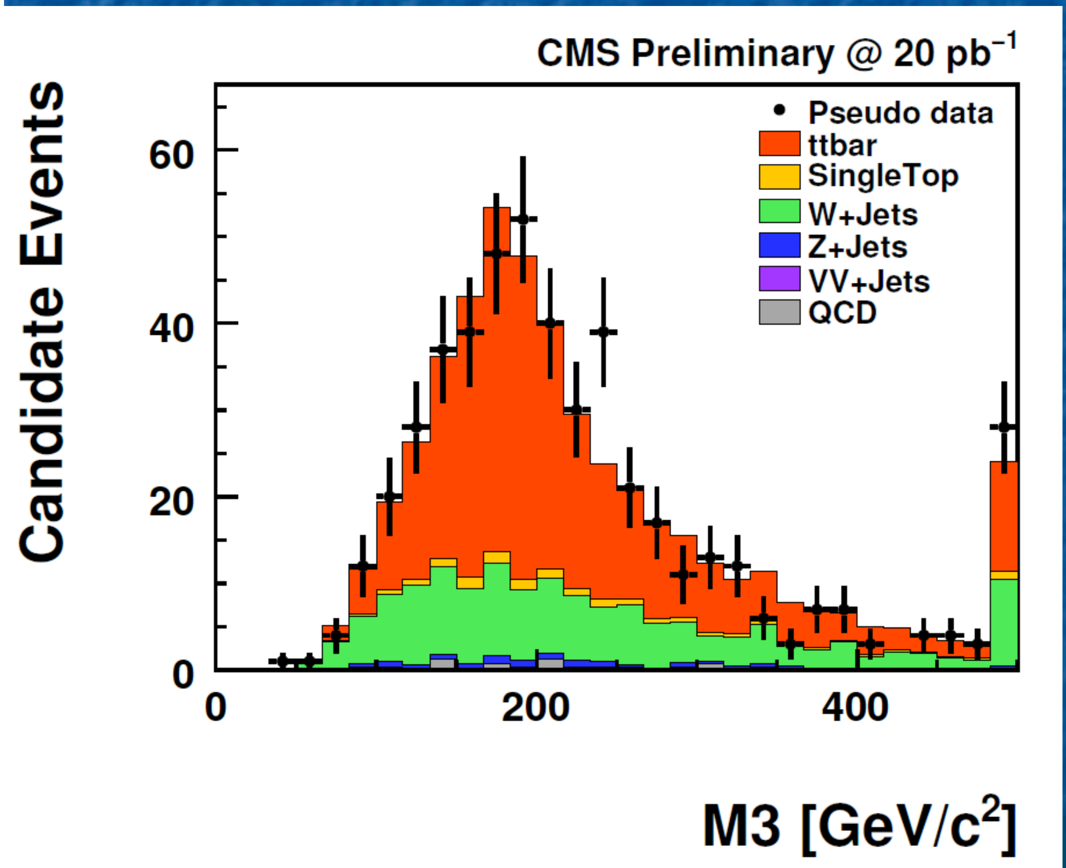
Top cross-section (dilepton)



- Select 2 leptons, MET
- Look at jet multiplicity
- Events with 2 or more jets are top

~ 60 clean events in 10/pb at 10 TeV

Top cross-section l+jets

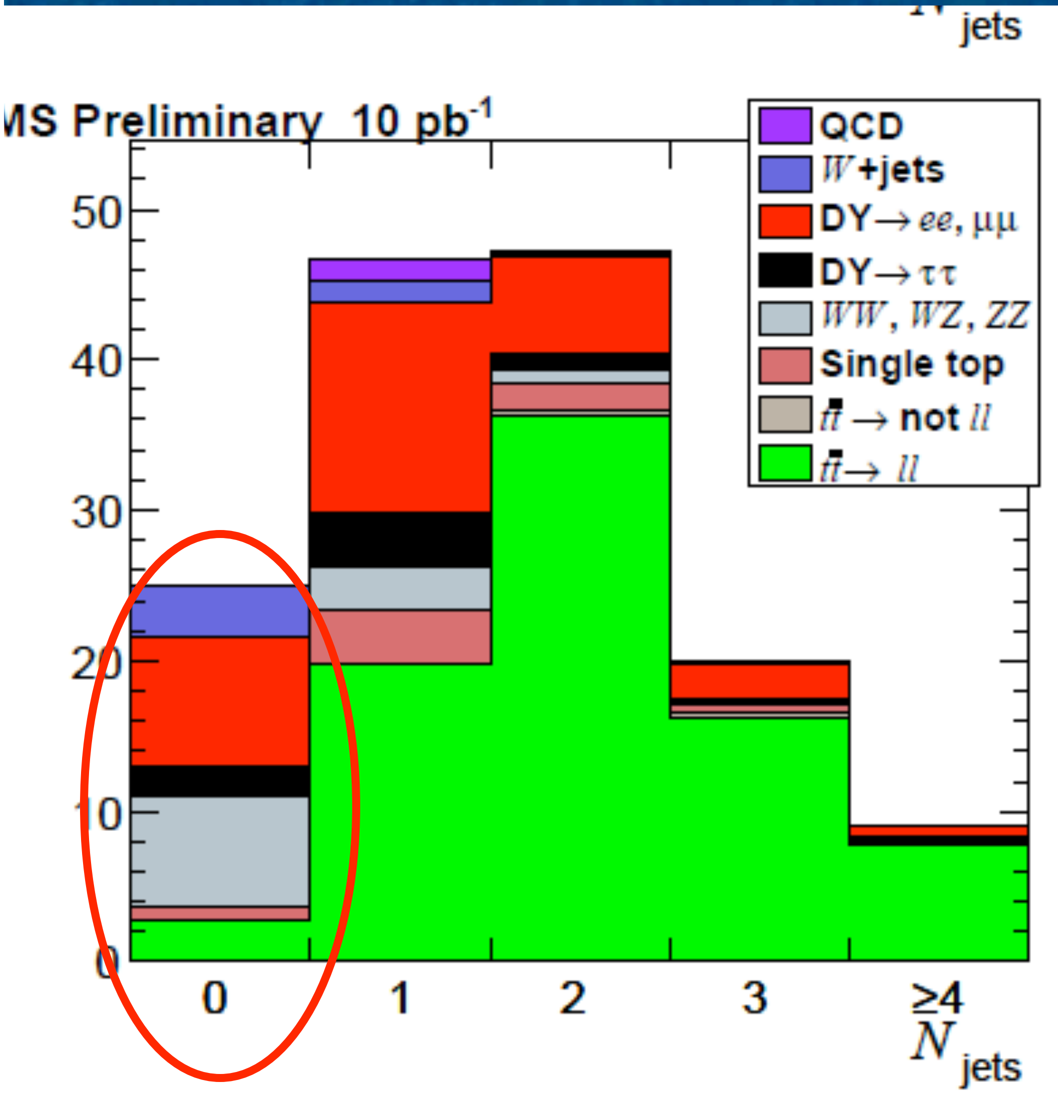


- **Several techniques even without b-tagging.**
- **This example: μ+4jets, mass of 3 jets with highest vector-sum-Pt**

The top x-section measurements will provide 1st demonstration of ability to do complex multi-object analyses

Will provide 1st checks of b-tagging

With more lumi: WW x-section



- Take top dilepton analysis
- Go to 0-jet bin
- Tighten ele-ID to get rid of W+fake
- Tighten MET/add topological cuts to get rid of Drell-Yan
- Add some data
- Voila: WW!

- 38 signal, 13 BG events in 100/pb

- First step towards H→WW search

Table 23: 95% C.L. interval of the anomalous coupling sensitivities from W^+W^-, $W^\pm Z$, $W^\pm\gamma$ final states with 10.0 fb^{-1} of integrated luminosity and the cutoff $\Lambda = 2$TeV. The table also indicates the variables used in the fit to set the AC sensitivity interval. For reference, some recently published limits from Tevatron and LEP are also listed. These limits caculation assumptions are given in the table as well.

Diboson, (fit spectra)	λ_Z	$\Delta\kappa_Z$	Δg_1^Z	$\Delta\kappa_\gamma$	λ_γ
WZ, (M_T)	[-0.015, 0.013]	[-0.095, 0.222]	[-0.011, 0.034]		
$W\gamma$, (p_T^γ)				[-0.26, 0.07]	[-0.05, 0.02]
WW, (M_T)	[-0.040, 0.038]	[-0.035, 0.073]	[-0.149, 0.309]	[-0.088, 0.089]	[-0.074, 0.165]
WZ, (D0) (1.0 fb^{-1})	[-0.17, 0.21]	[-0.12, 0.29] ($\Delta g_1^Z = \Delta\kappa_Z$)			
$W^\pm\gamma$ (D0), (0.16 fb^{-1})				[-0.88,0.96]	[-0.2,0.2]
WW, (LEP) ($\lambda_\gamma = \lambda_Z, \Delta\kappa_Z = \Delta g_1^Z - \Delta\kappa_\gamma \tan^2\theta_W$)			[-0.051,0.034]	[-0.105,0.069]	[-0.059,0.026]

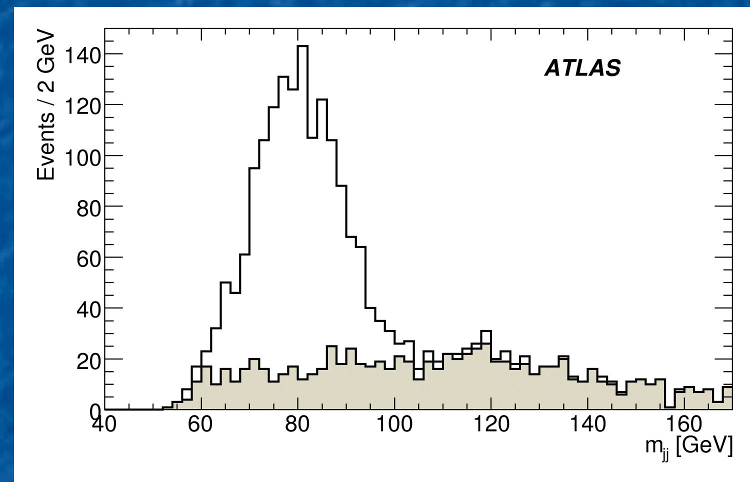
ATLAS: Anomalous couplings

Top as a calibration tool

Jet energy scale (JES) (14 TeV) using ttbar→ lepton + 4 jet events

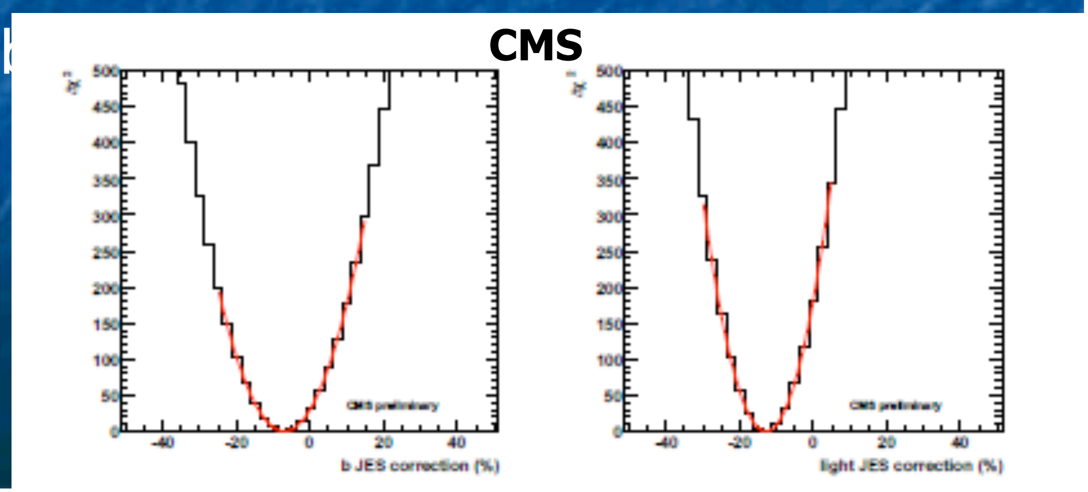
Atlas:

- Look at W-mass peak for events with 2 btags
- JES to ± 2% with 50 pb^{-1}.



CMS:

- kinematical fits with top and W mass constraint with JES floating
- JES to ± 1% with 100 pb



NB: These are overall scale uncertainties
For PT and η dependence, need more stat

$R = BR(t \rightarrow Wb) / BR(t \rightarrow Wq)$

- Take the dilepton eμ + 2 jets sample which is a very clean ttbar sample
- Knowing the btag efficiency, from the number of btag jets can extract R
- Alternatively: assume R=1 (SM value) and measure the btag efficiency (ie: use as calibration)

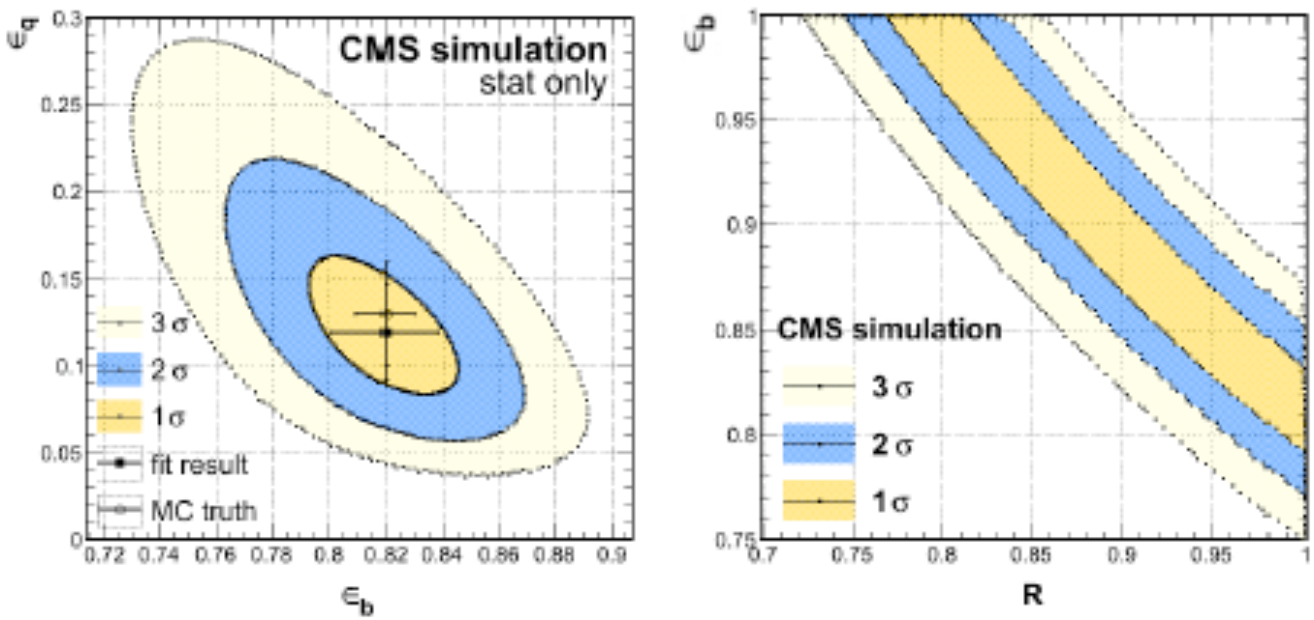


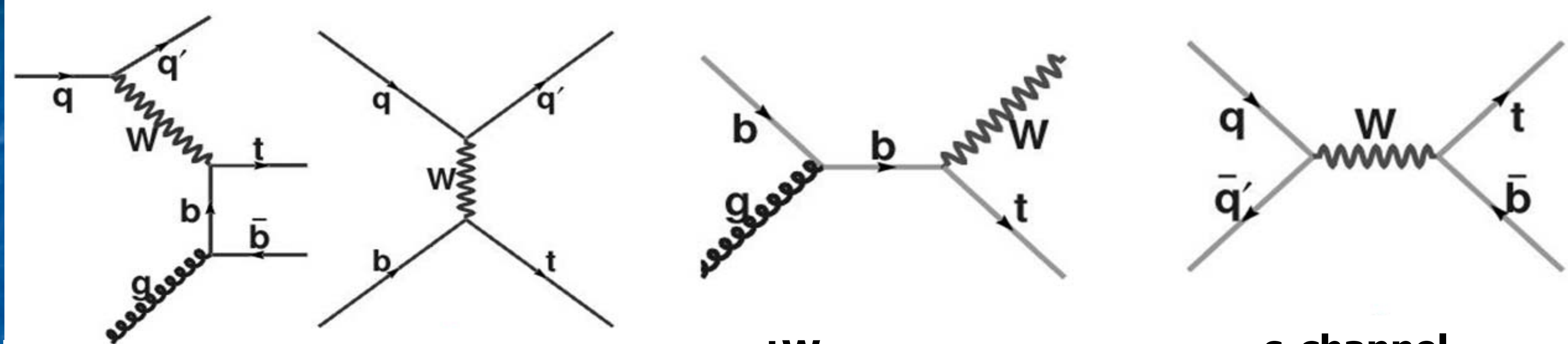
Figure 5: (*Left*) Jet Probability algorithm with the loose working point is used to fit both b-tagging (ε_b) and mistagging (ε_q) efficiencies, assuming $R = 1$. The contour plot for the simultaneous fit is shown with MC truth superimposed. (*Right*) Contour plots (1σ, 2σ and 3σ) for the likelihood obtained by floating R and ε_b.

In 250 pb^{-1}: gives R within 2% (stat) ± 9% (syst ε_b) ± 3% (other syst)

OR

taking R=1, gives ε_b within 2% (stat) ± 4% (syst)

Single top cross-section



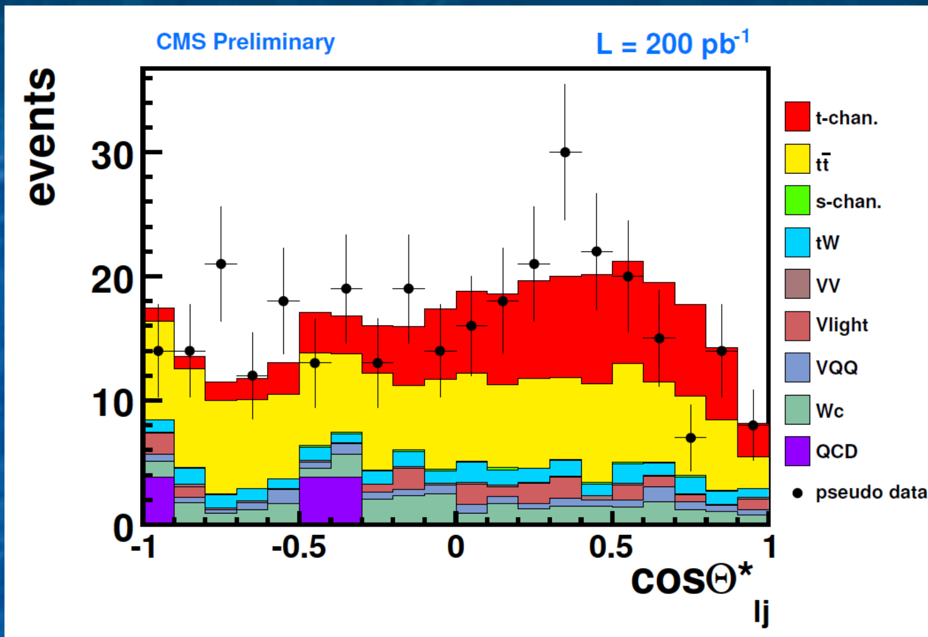
t-channel
σ(LHC) ~ 130 pb
σ(TeV) ~ 1.1 pb

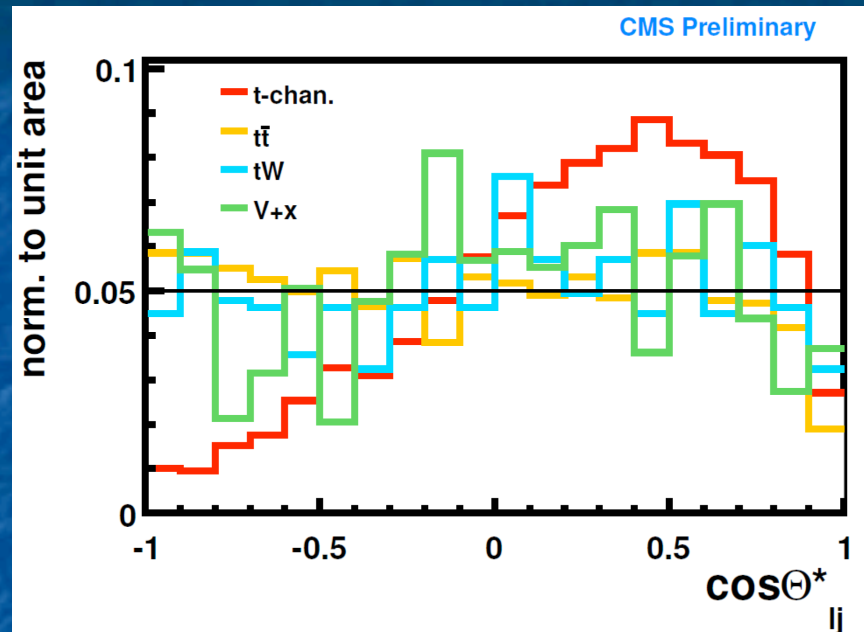
tW
σ(LHC) ~ 29 pb
σ(TeV) ~ 0.1 pb

s-channel
σ(LHC) ~ 5 pb
σ(TeV) ~ 0.6 pb

- A lot easier at the LHC than at the Tevatron.
- CMS plans a 1st measurement of the t-channel based on a fit to a single variable
  - Due to V-A, events are distributed as ~ 1+ $\cos\theta^*_{lj}$, where θ^*_{lj} is the angle between the lepton and the light quark jet in the reconstructed top rest frame
  - All backgrounds are flat in $\cos\theta^*_{lj}$.

*** 1 isolated muon, MET, 1 b-tagged jet, 1 non-b jet**

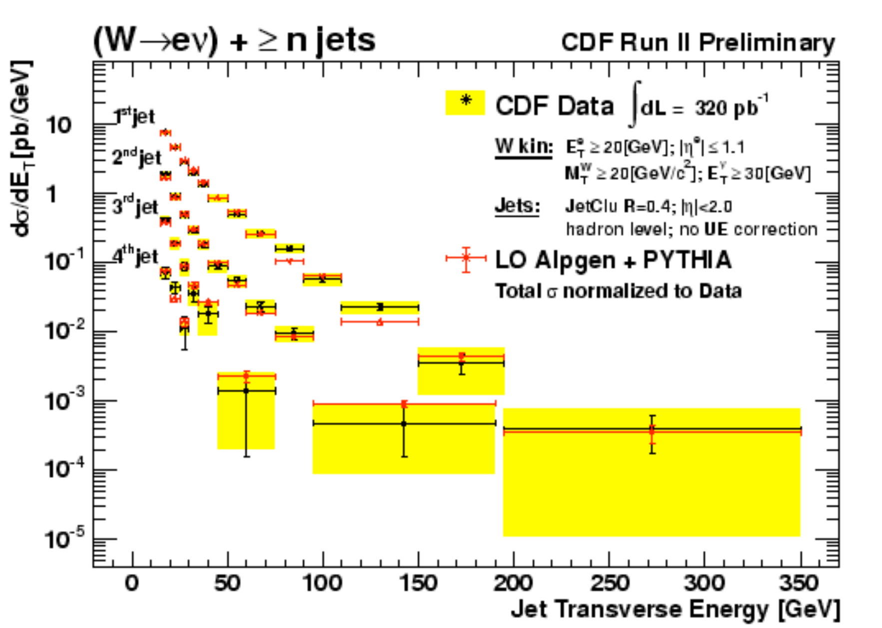


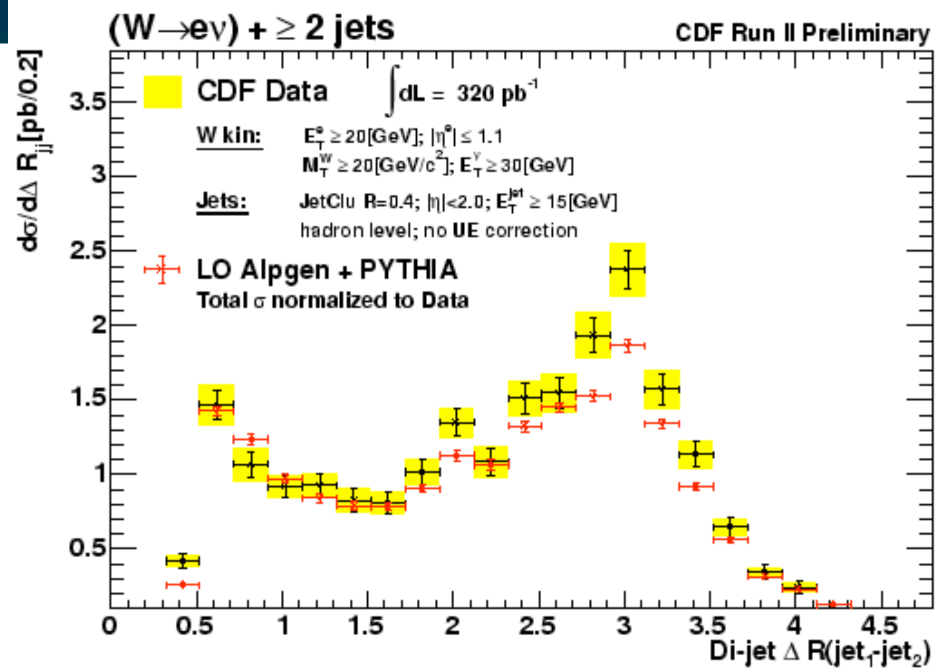


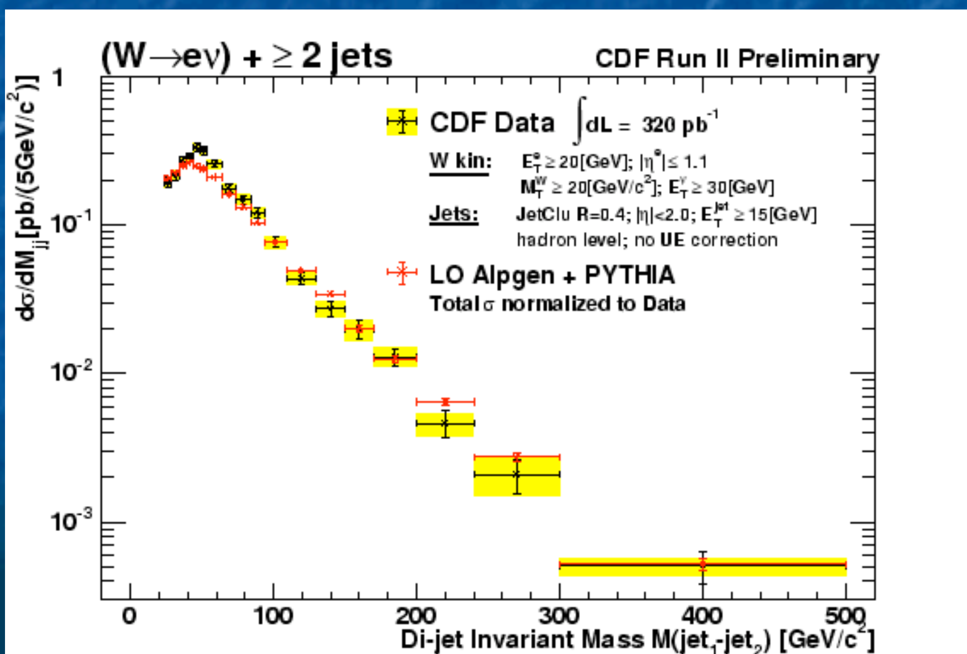
± 35% stat ± 15% syst in 200 pb^{-1} (2.7 σ)

Towards the searches

- EWK and top are BG too many of the searches
- Need to understand them







CDF W+jets Monte Carlo tuning

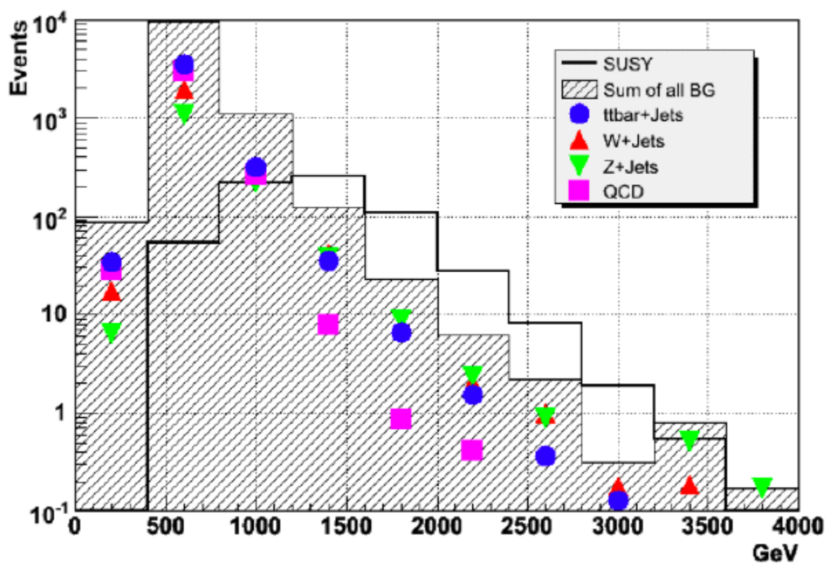
Will have to go through this process

This is very important……

……but……..

energies. The signal corresponds to production of squarks and gluinos with a mass of the order of 1 TeV. While the signal has certainly a statistical significance sufficient to claim a deviation from the SM, it is unsettling that its shape is so similar to that of the sum of the backgrounds. The theoretical estimates of these backgrounds have also increased significantly over the last few years, as a result of more accurate tools to describe multijet final states. There is no question, therefore, that unless each of the background components can be separately tested and validated, it will not be possible to draw conclusions from the mere comparison of data against the theory predictions.

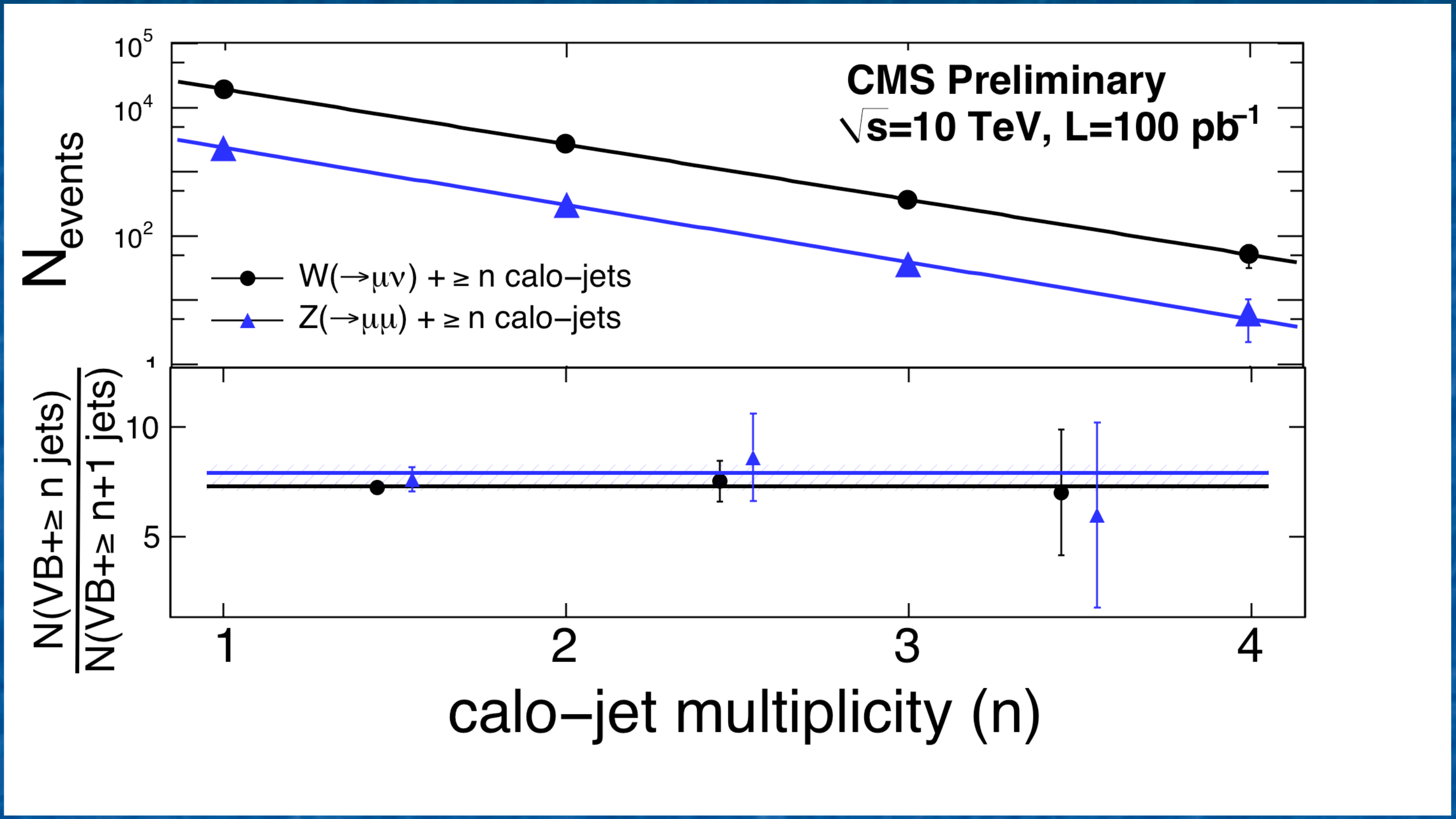
I am not saying this because I do not believe in the goodness of our predictions. But because claiming that supersymmetry exists is far too important a conclusion to make it follow from the straight comparison against a Monte Carlo. One should



M. Mangano
IJMPA 23 p3833 (2008)

→ Exploit ratios, use tricks to get data-driven predictions to complement MC approaches

Example of a ratio

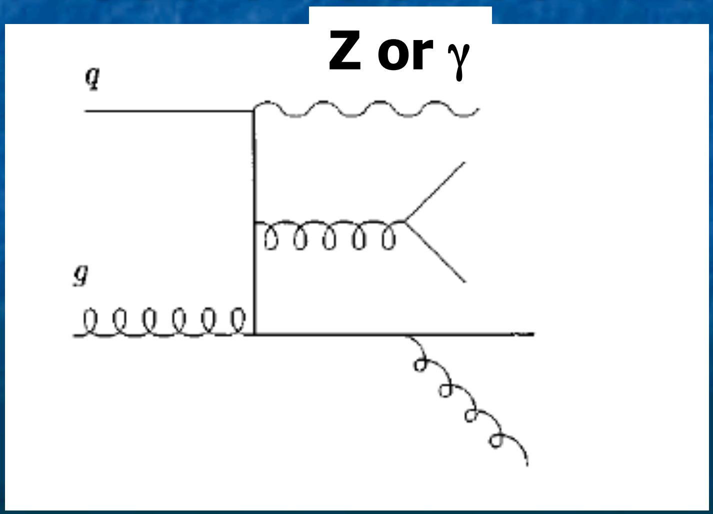


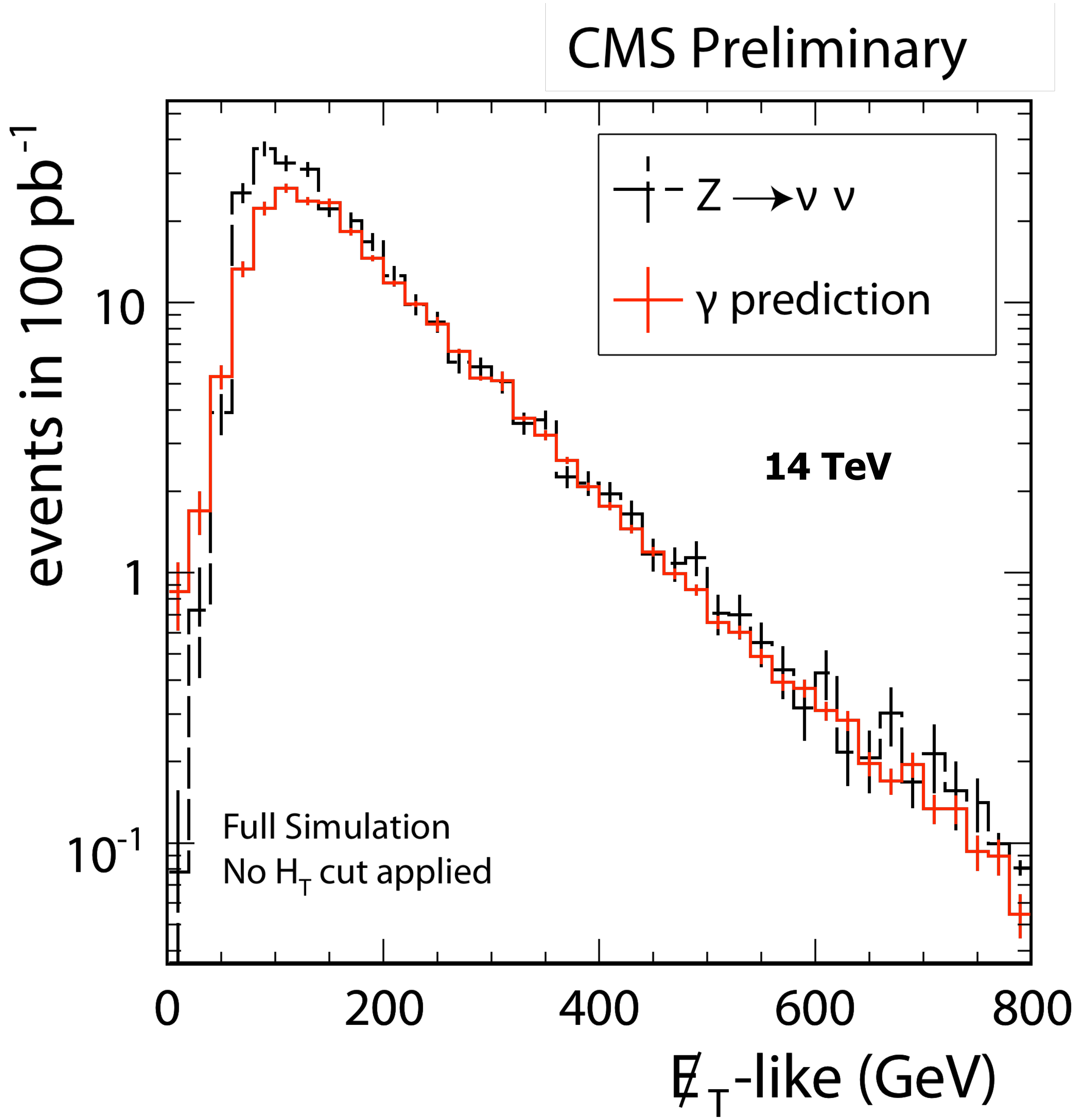
$$C_W / C_Z \equiv \frac{W + n \text{ jets}/W + (n+1) \text{ jets}}{Z + n \text{ jets}/Z + (n+1) \text{ jets}}$$

Sensitive to new physics in W (or W-like) or Z that is not in both

Example of a trick

- $Z \rightarrow \nu\nu$ + jets is a significant problem in multijet + MET searches
- Trick: use γ+jets to estimate it
- Same basic diagrams, with differences that are more or less under control





CMS Preliminary
events in 100 pb-1
10
1
10-1
Z → ν ν
γ prediction
14 TeV
Full Simulation
No HT cut applied
0
200
400
600
800
E̸T-like (GeV)

Conclusions

- The LHC Physics program is finally starting
- By the summer conference we should have the first measurements of W and Z.
- Also, the 1st hint of ttbar, maybe even a 20-30% cross-section measurement if the lumi is high enough (say ~ 10/pb)
- This will be the 1st step in commissioning the high P_T physics program