First V+jets results with CMS

Vitaliano Ciulli (Univ. & INFN Firenze)

V+jets workshop, 8-10 Sep 2010, Durham

Outline

Jet and missing energy reconstruction

W and Z selections and cross-section measurement

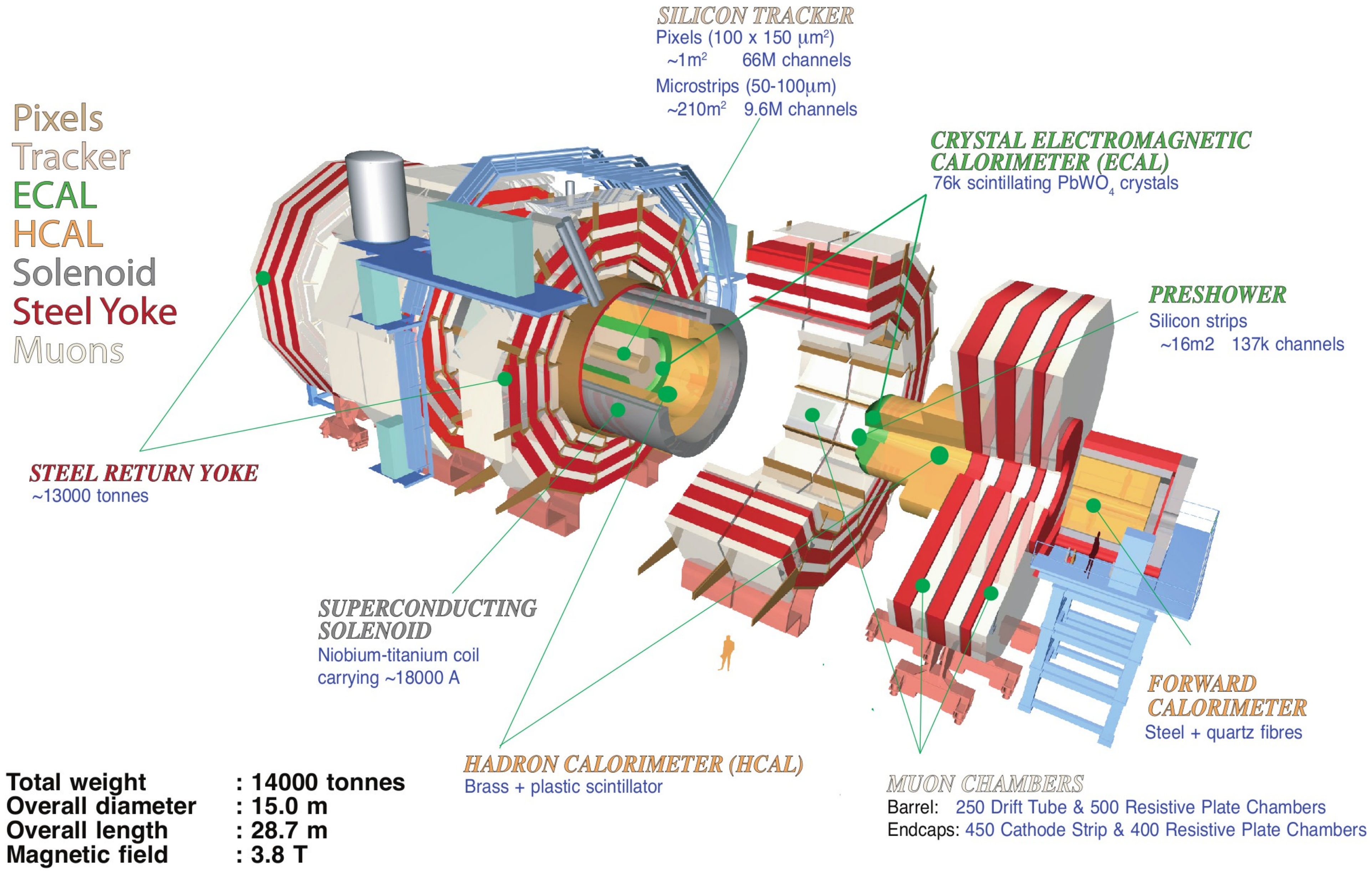
First results on W+jets

Systematic uncertainty from Jet Energy Corrections

First look at 1.1 pb^{-1}

P. Lenzi in the next talk will discuss the prospects for measurements of W/Z + jets with full 2010/2011 LHC data

CMS detector



Acceptance:

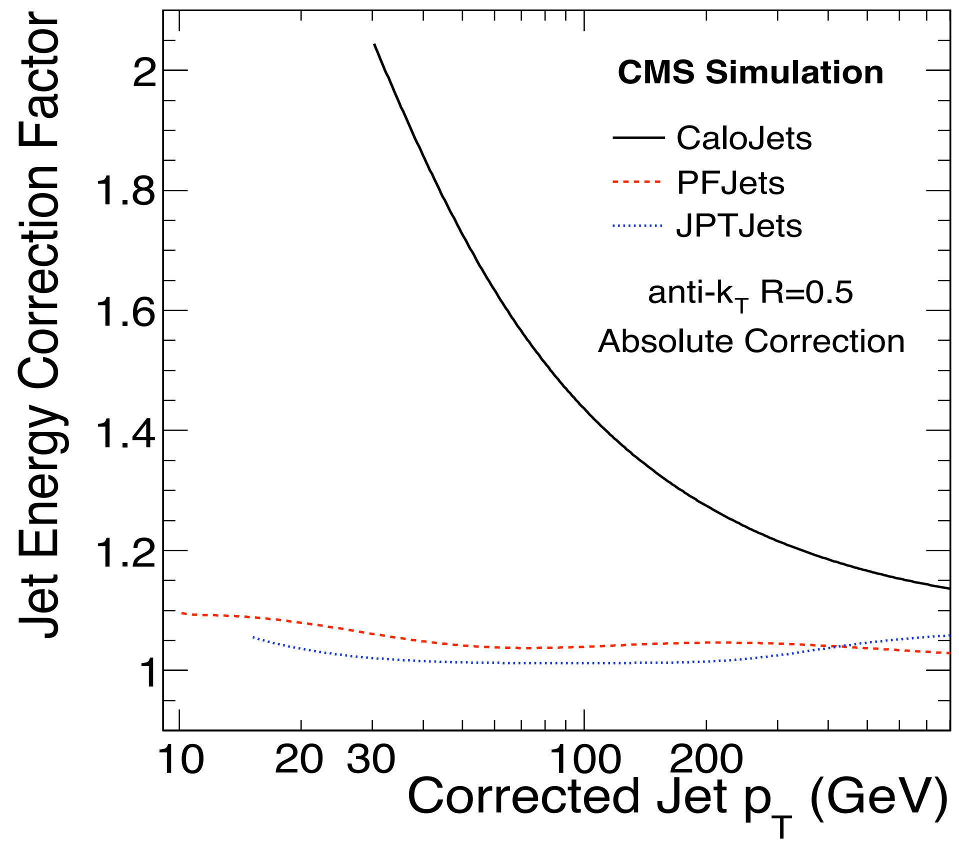
- Tracker: $|\eta| < 2.5$
- Electromagnetic Calorimeter: $|\eta| < 3$
- Forward Calorimeter: $|\eta| < 5.2$

Jet reconstruction

Standard jet reconstruction: anti-KT algorithm with $\Delta R = 0.5$

Four different jet types:

- Calo Jets: based on calorimetric towers only
- Jet Plus Tracks (JPT): Calo jets complemented with track informations
- Particle Flow (PF): jet clustering start from a list of "identified particles"; more similar to generator level jets
- Track jets: use only tracks

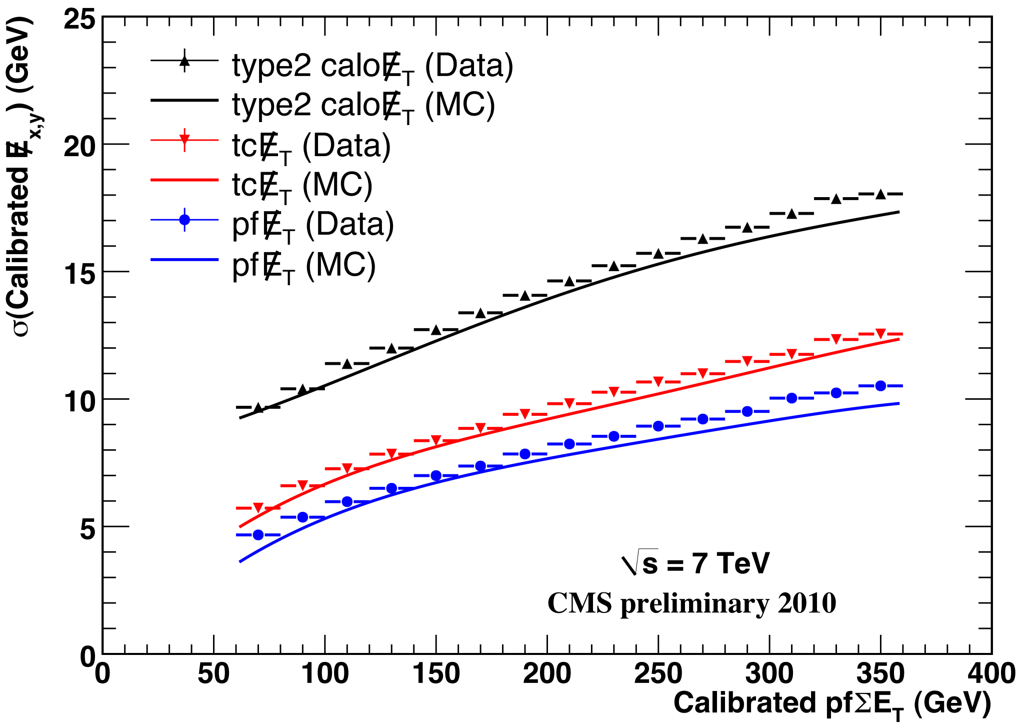


Using different inputs allows for systematic cross-checks

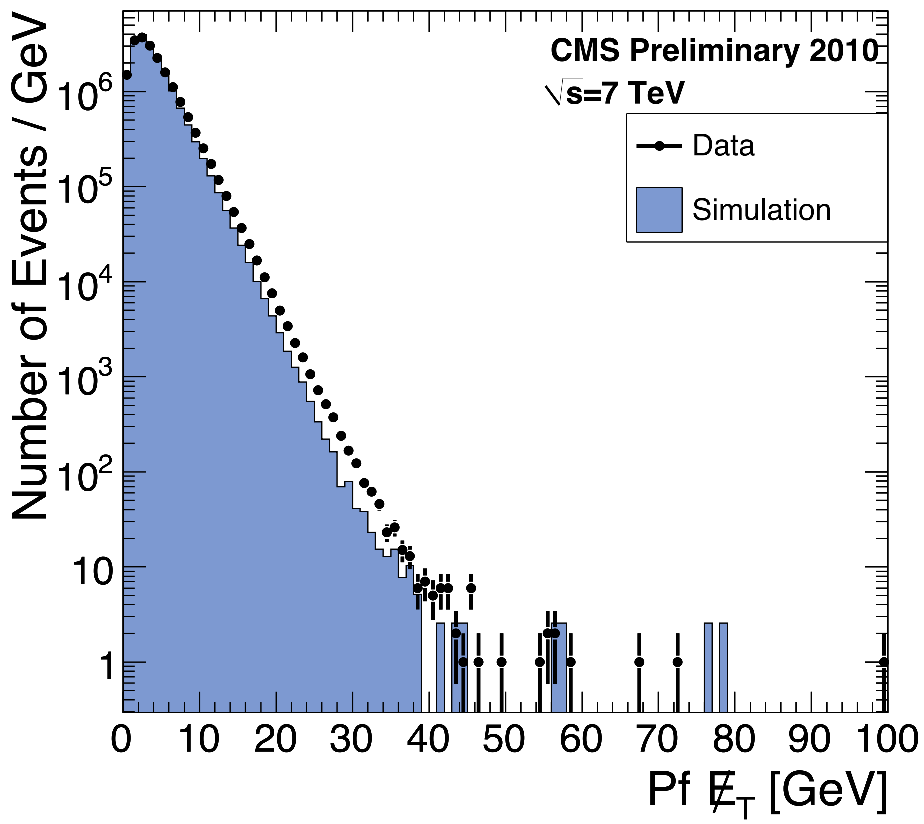
Results based on PF jets: smaller jet energy corrections in the tracker acceptance, $|\eta| < 2.5$

Missing transverse energy

Missing transverse energy also reconstructed using “Particle Flow” objects which provide the highest resolution

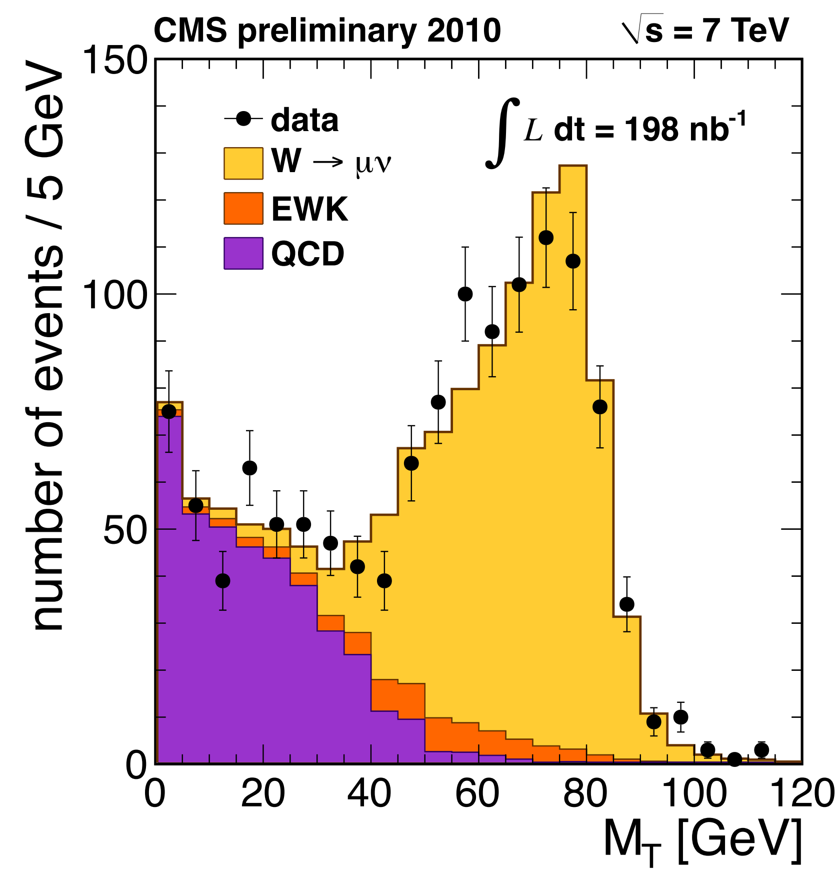


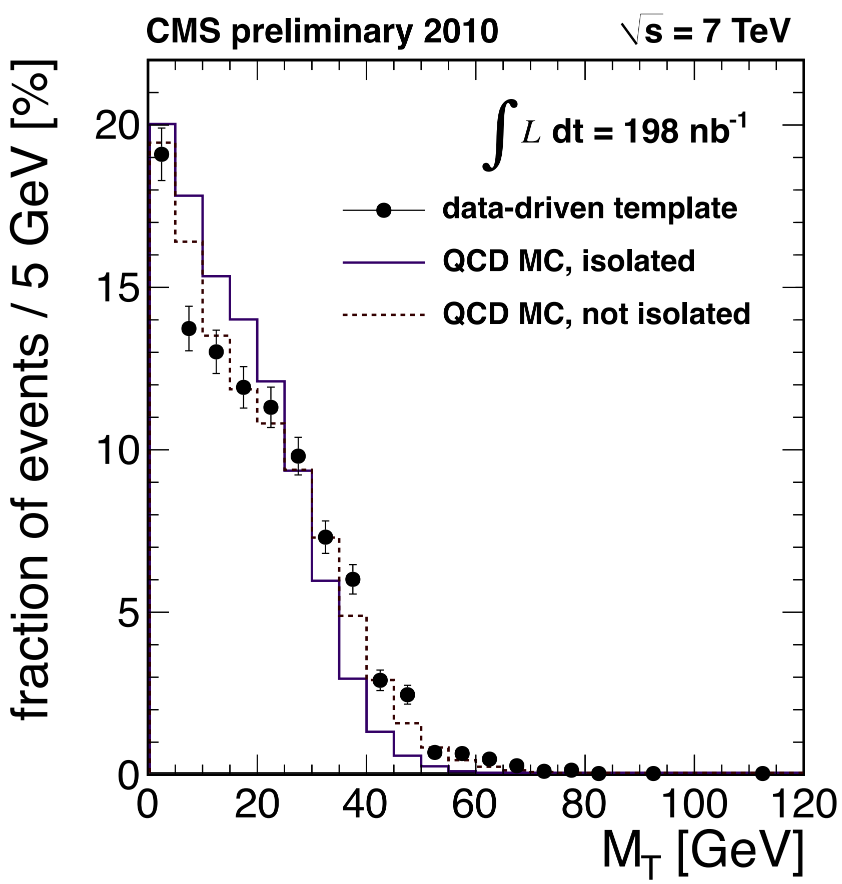
Good agreement between MC and data in minimum bias events



W → μν events

- Event triggered with $p_T > 9$ GeV
- Muon $p_T > 20$ GeV, $|\eta| < 2.1$
- Isolation $(\Sigma p_T\,(tk) + \Sigma E_T\,(had+em))/p_T < 15\%$
- ME_T reconstructed using PF technique
- Drell Yan rejection (veto on events with a second muon of $p_T > 10$ GeV)

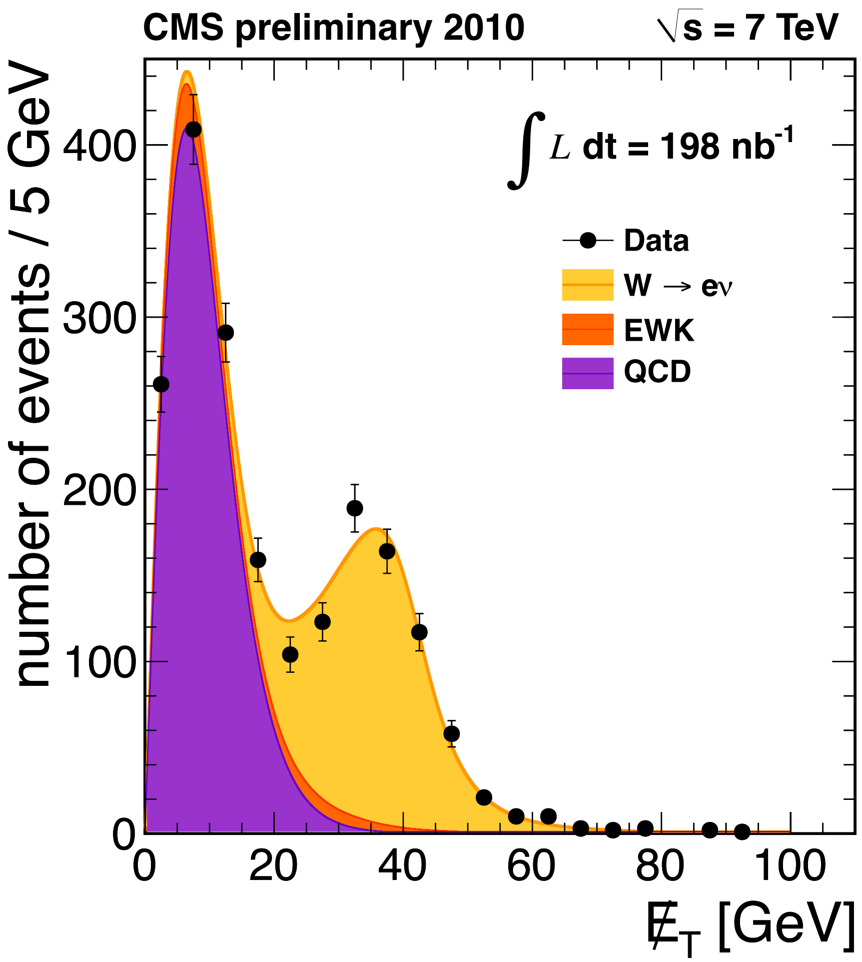


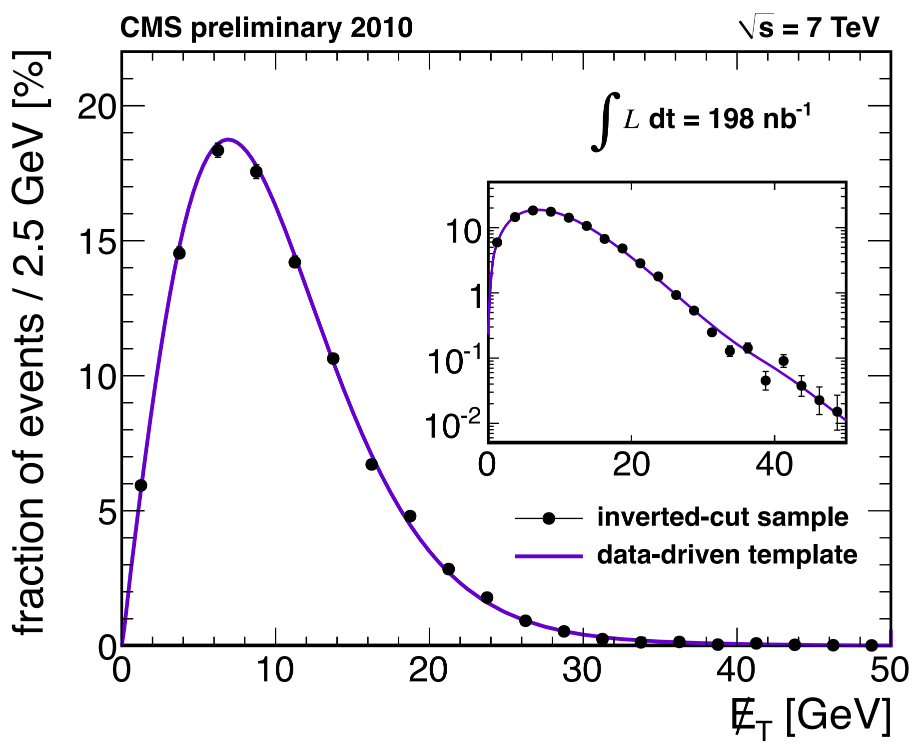


- Main source of BG: QCD (b hadron decays)
- W Signal yield extracted through a Binned Likelihood fit to the M_T distribution (Signal + QCD & EWK BGs)
- W Signal and EWK MT shapes modeled from MC
- QCD M_T shape extracted from data (isolation inversion)

W → eν events

- Events triggered with $E_T > 15$ GeV
- Electron $E_T > 20$ GeV
- $|\eta| < 1.4442$ (Barrel), $1.566 < |\eta| < 2.5$ (Endcap)
- Isolation (independent cuts on track, em, had)
- Drell Yan rejection (veto on events with a second electron of ET>20 GeV)

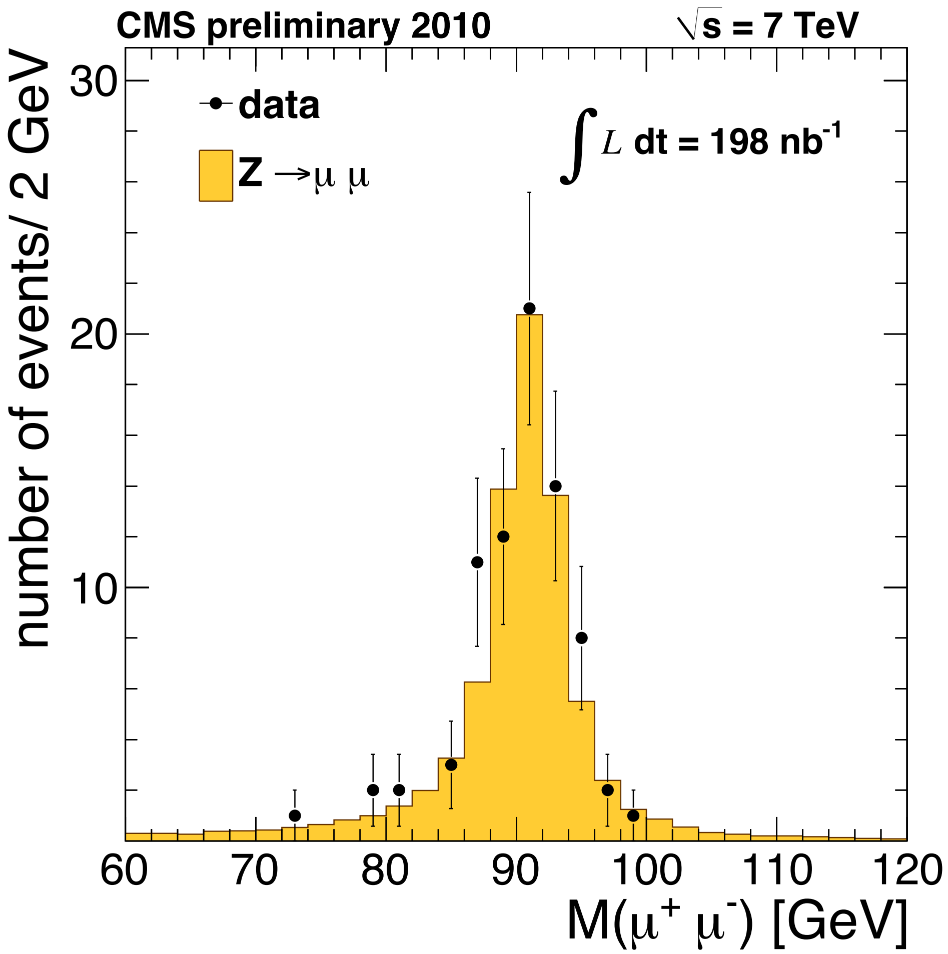


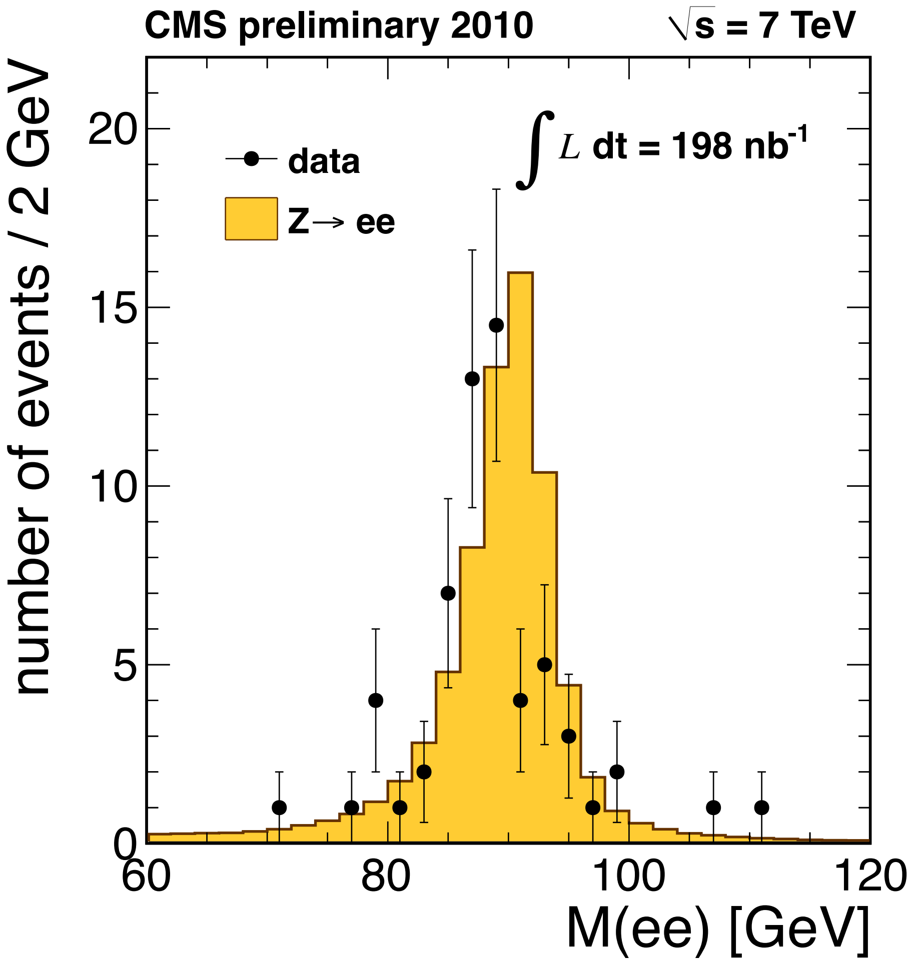


- QCD BG dominated by fake electrons
- Unbinned Likelihood fit to the MET distribution
- W Signal and Electroweak MET shape modeled from Monte Carlo
- QCD background is parameterized and fixed using an inverted isolation cut sample

$Z \rightarrow \mu\mu$ and $Z \rightarrow ee$

Z decays selected with same p_T cut on the leptons and looser isolation and identification criteria

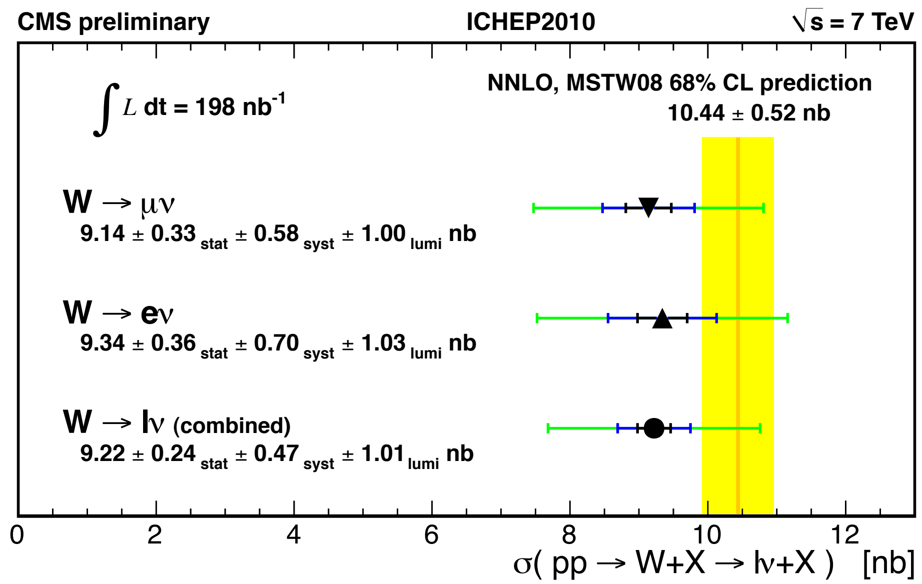


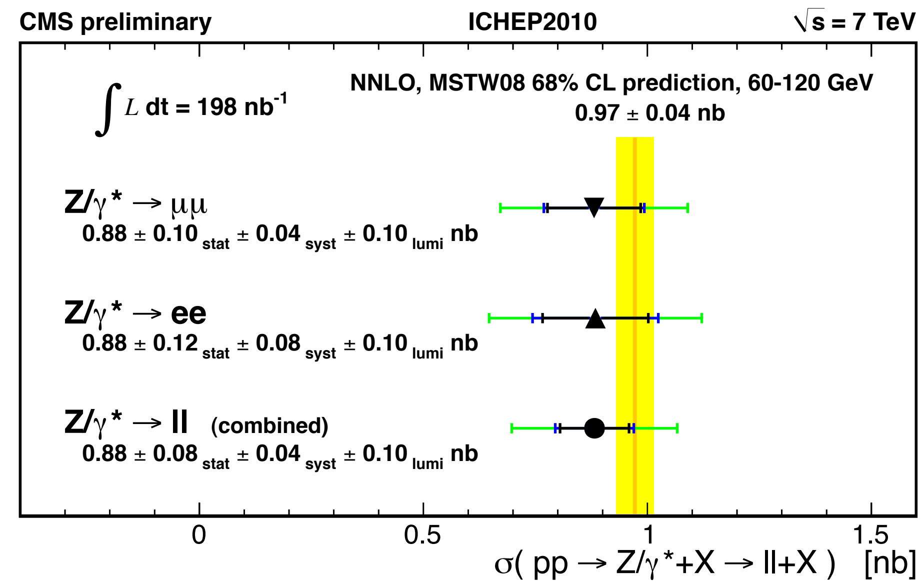


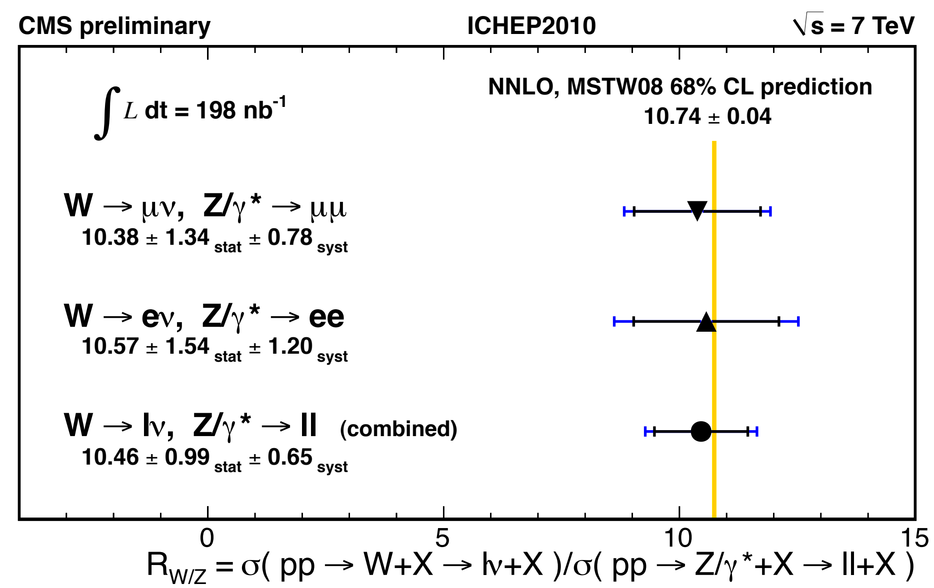
77 candidates selected the invariant mass range $60 < m_{\mu\mu} < 120$ GeV

61 candidates selected in the invariant mass range $60 < m_{ee} < 120$ GeV

Cross-section results



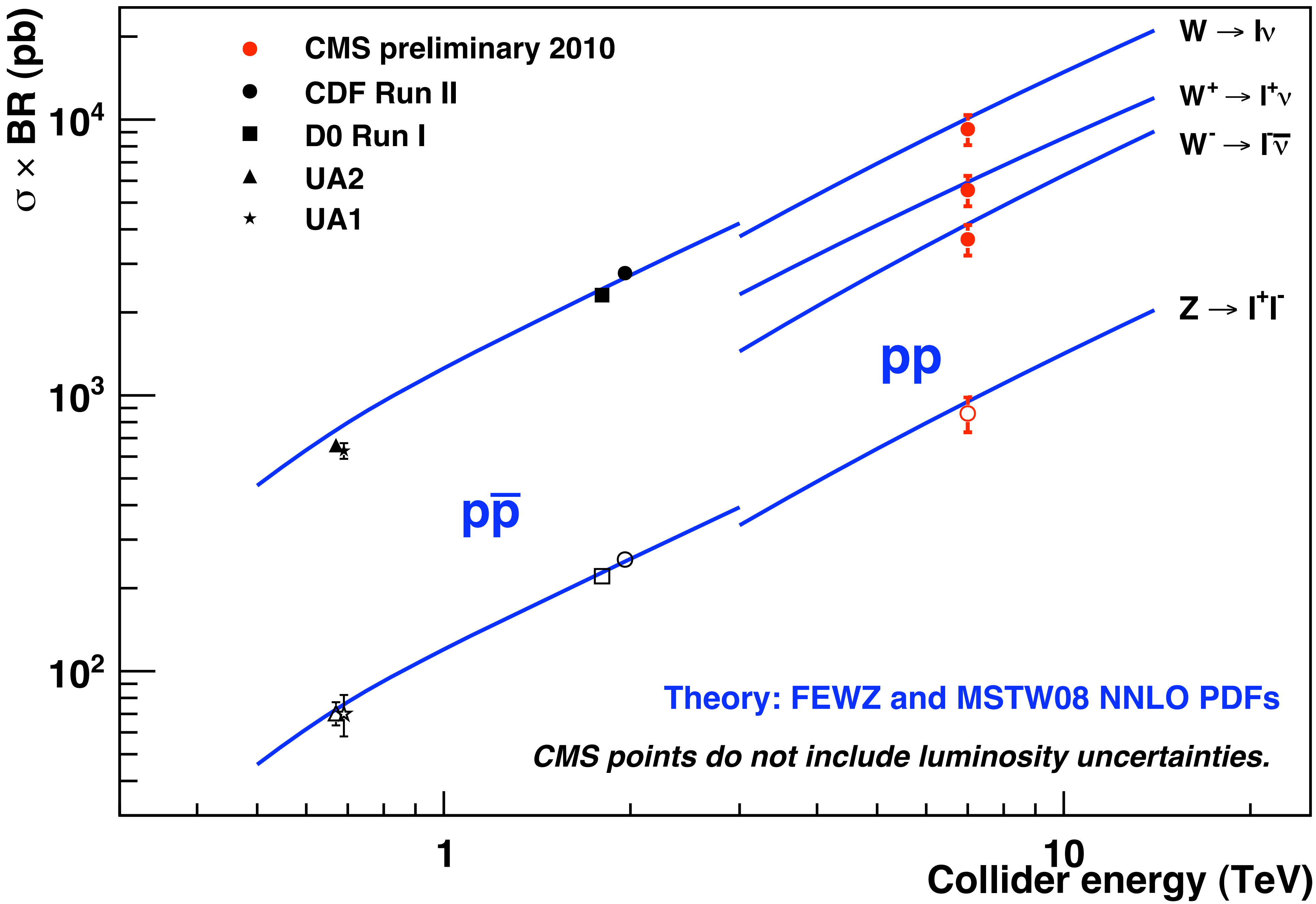




Results are on the lower side, but consistent with SM within the **uncertainty on luminosity**

Ratio W/Z is also consistent with the SM expectations

Cross-section results



Jets in events with W candidates

W selection as for the inclusive analysis

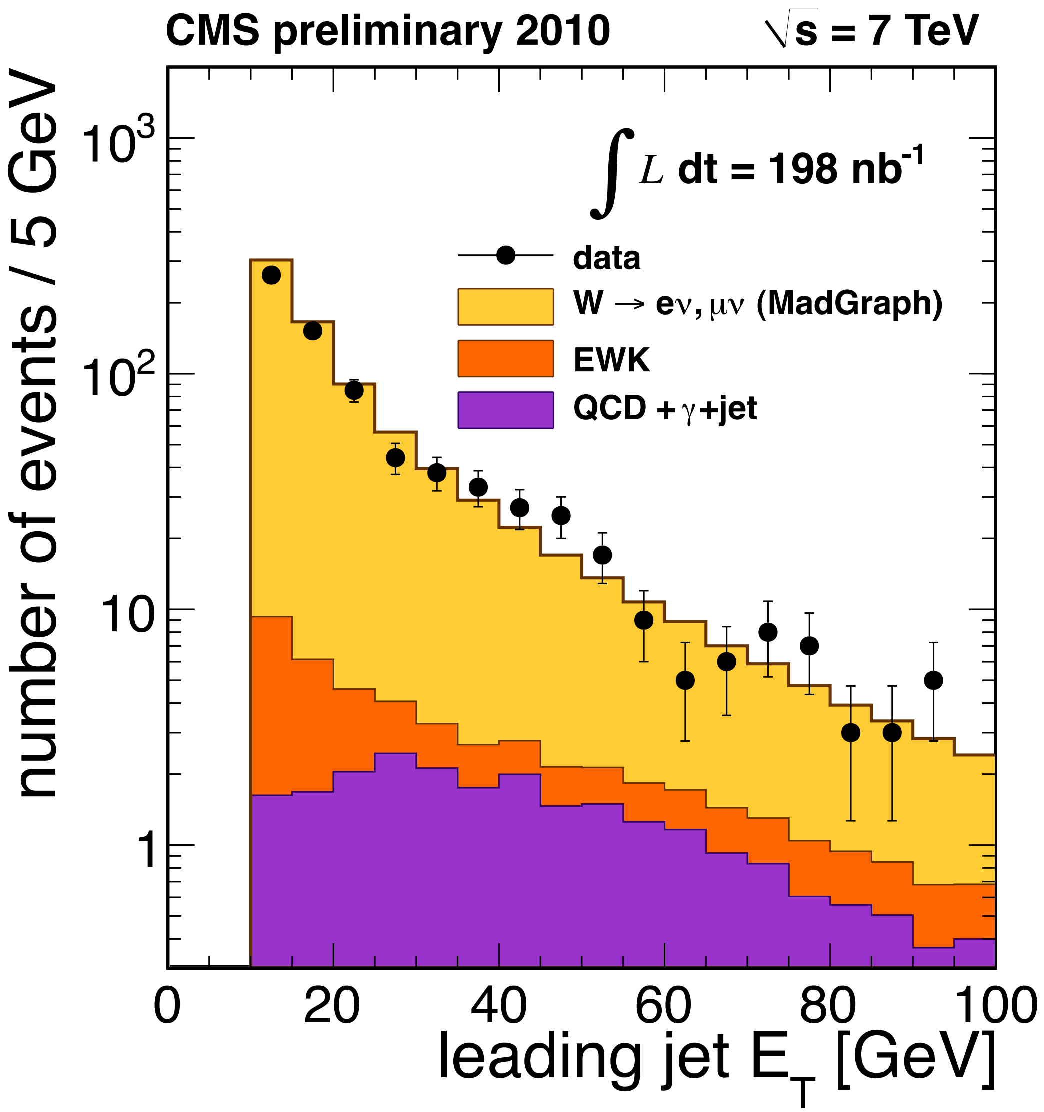
Jets reconstructed using Particle Flow objects in $|\eta| < 2.5$

Jets must be separated from the lepton by $\Delta R > 0.5$

- avoids counting the lepton as a jet
- no effects on jet counting as leptons are required to be isolated

Signal and EWK background are normalized to NLO cross-section calculated with MCFM

Leading jet E_T distribution in W events



Jet rates

Yields shown for events with ≥ *n* jets

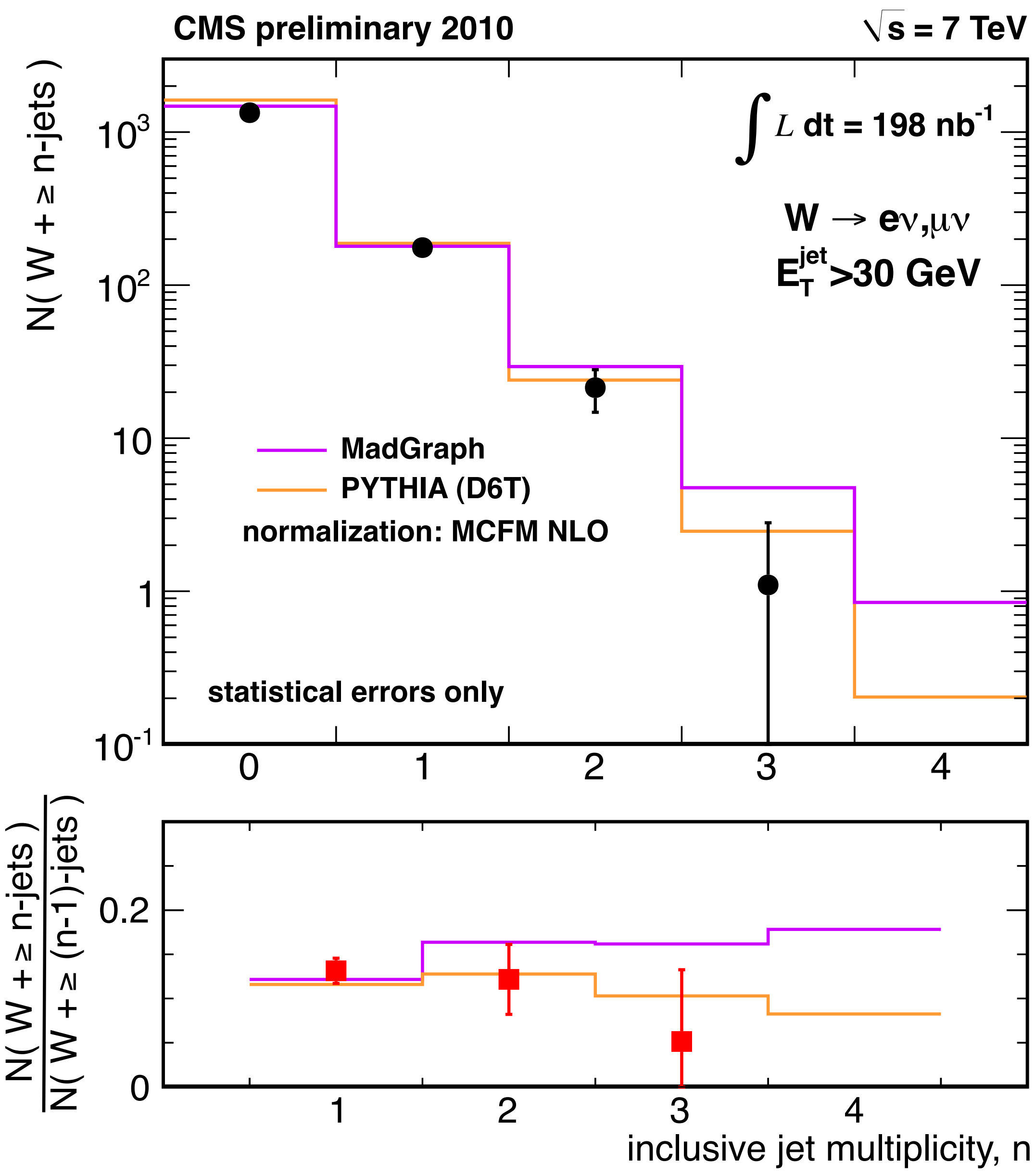
- *inclusive rates*

Two ET thresholds considered:

- E_T>15 GeV
- E_T>30 GeV (shown here)

W signal extracted with a fit to the MT distribution in each sample

- statistical errors only are shown
- tt background sizeable for $n \geq 3$

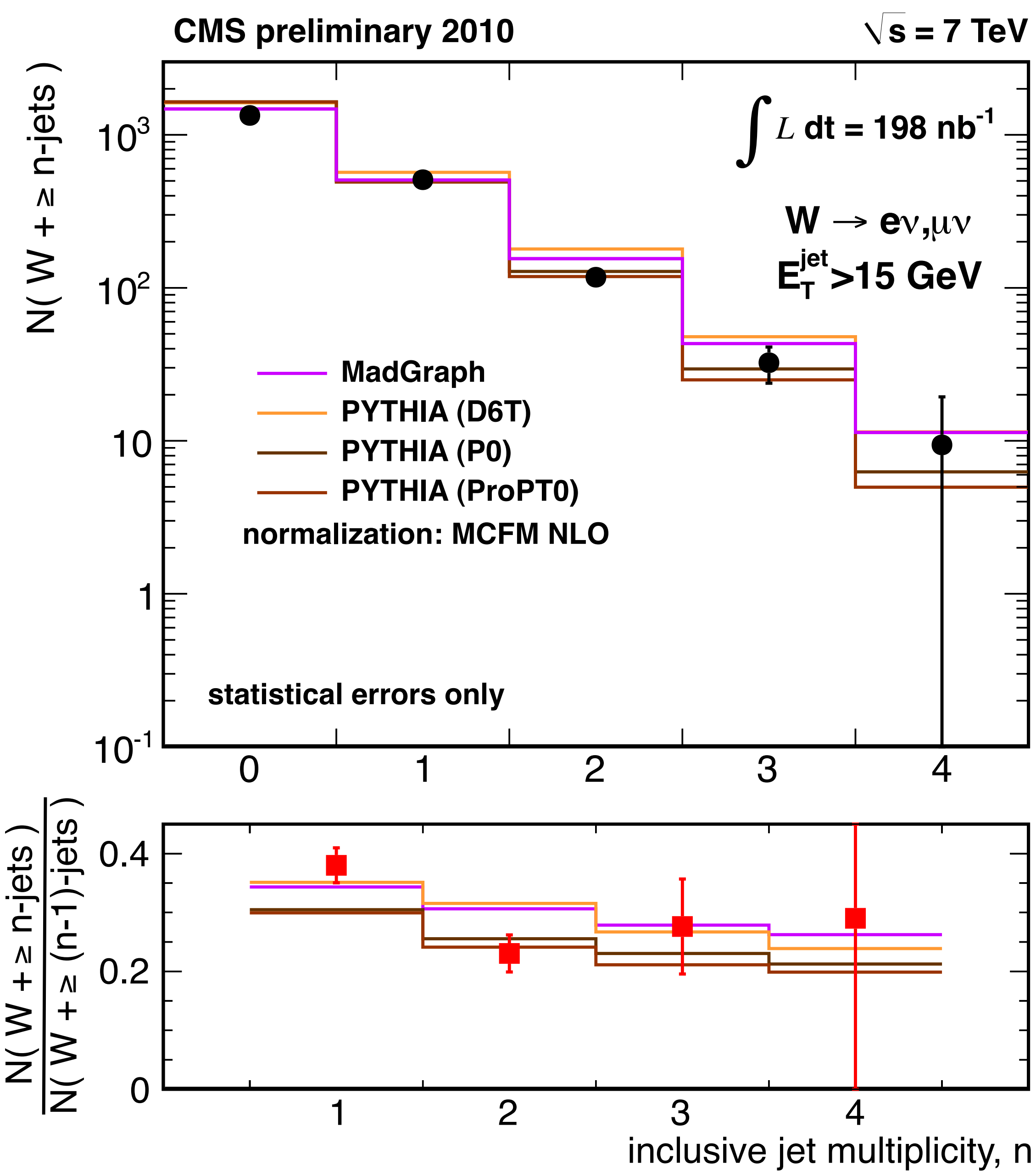


Jet multiplicity

The use of Particle Flow jets allows to lower the jet E_T threshold to $E_T > 15$ GeV

No big differences within PS (PYTHIA) and ME+PS (MadGraph)

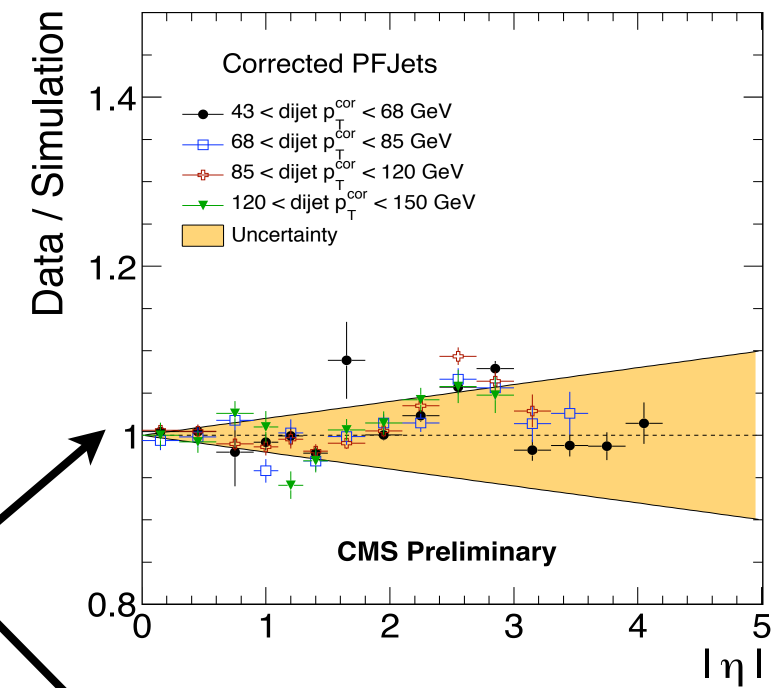
But strong dependence on the MC tune (more in next talk)

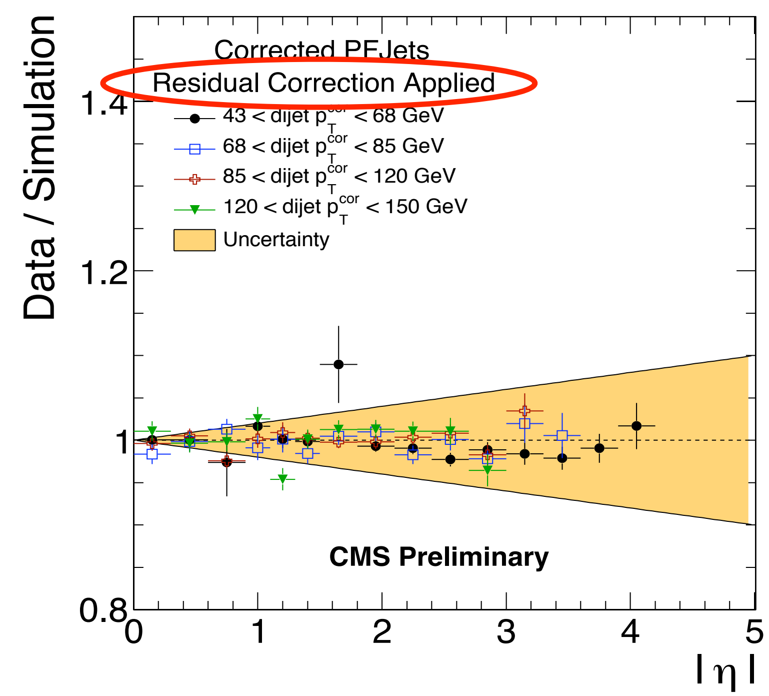


Jet energy corrections

Systematic uncertainty estimated from MC:

- $5\% + 2\% \times |\eta|$
- absolute scale will be obtained from γ+jet events: first look gives indications that this error is quite conservative
- relative uncertainty can be cross-checked with di-jets events: residual miscalibration is within the error band and can be further corrected



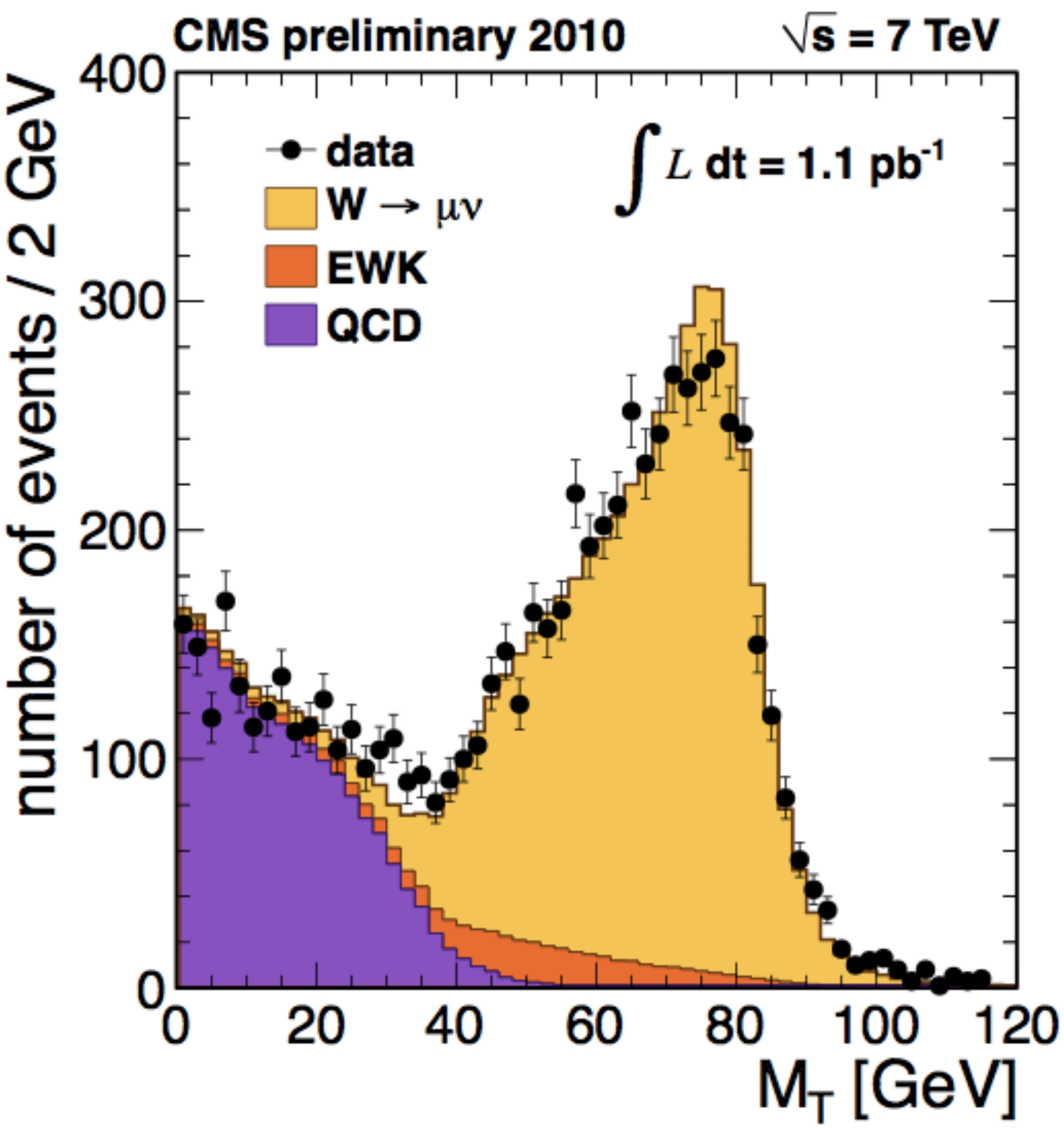


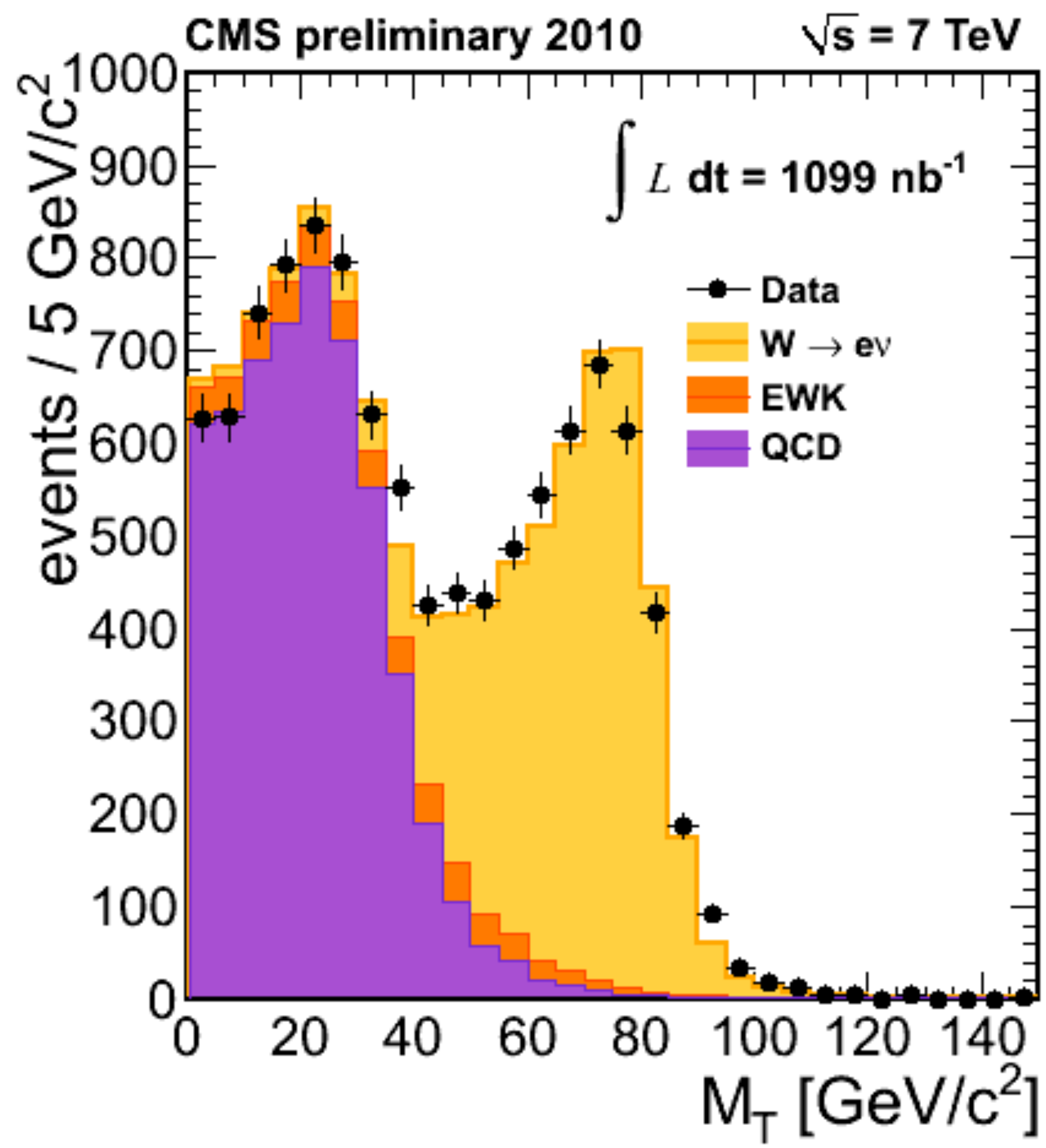
The uncertainty on the jet rate in W events is

- 10%-40% for 1-4 jets with E_T>15 GeV
- 10%-20% for 1-4 jets with E_T>30 GeV

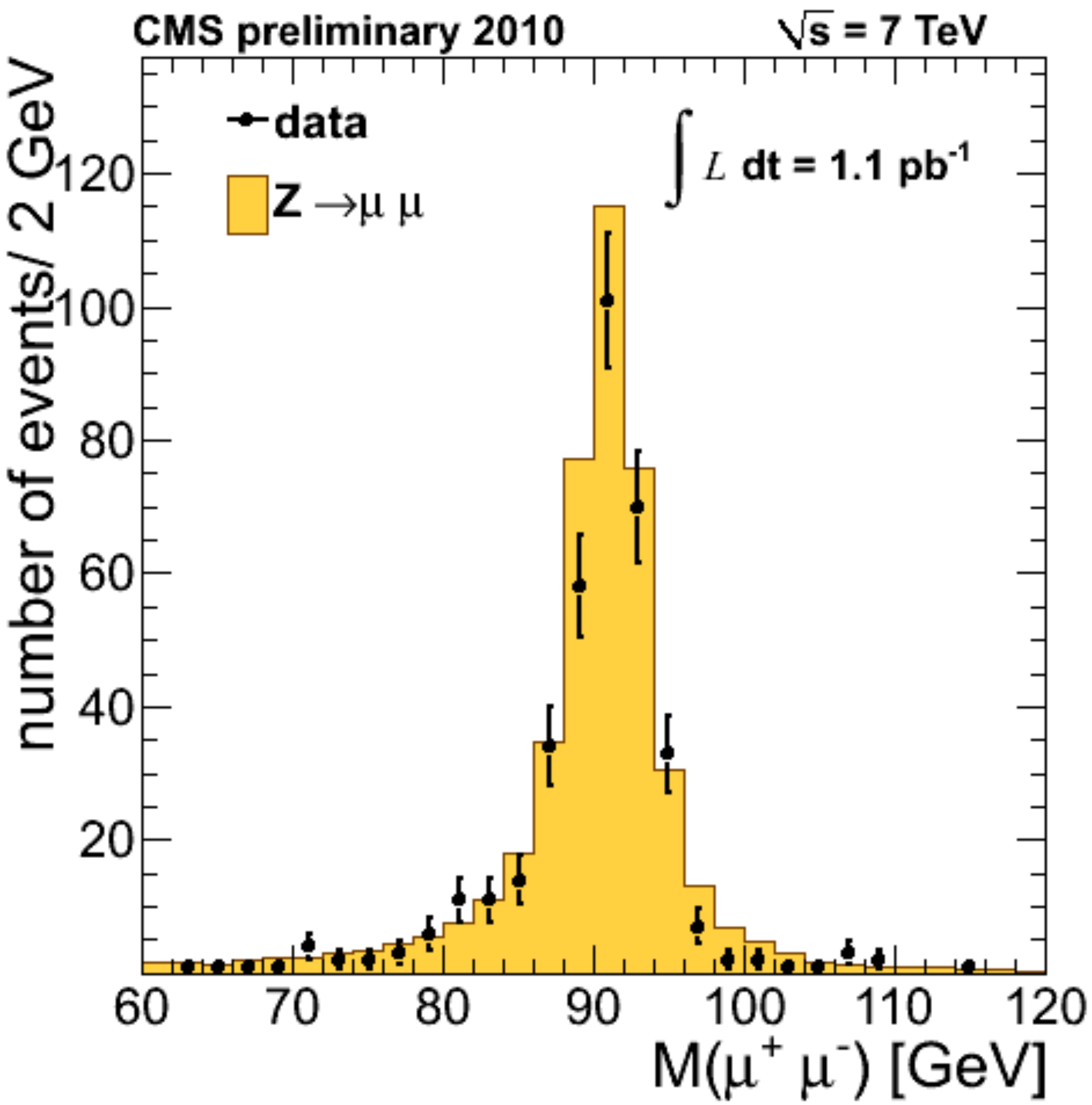
The uncertainty is even smaller and rather constant for the *n+1/n* ratio

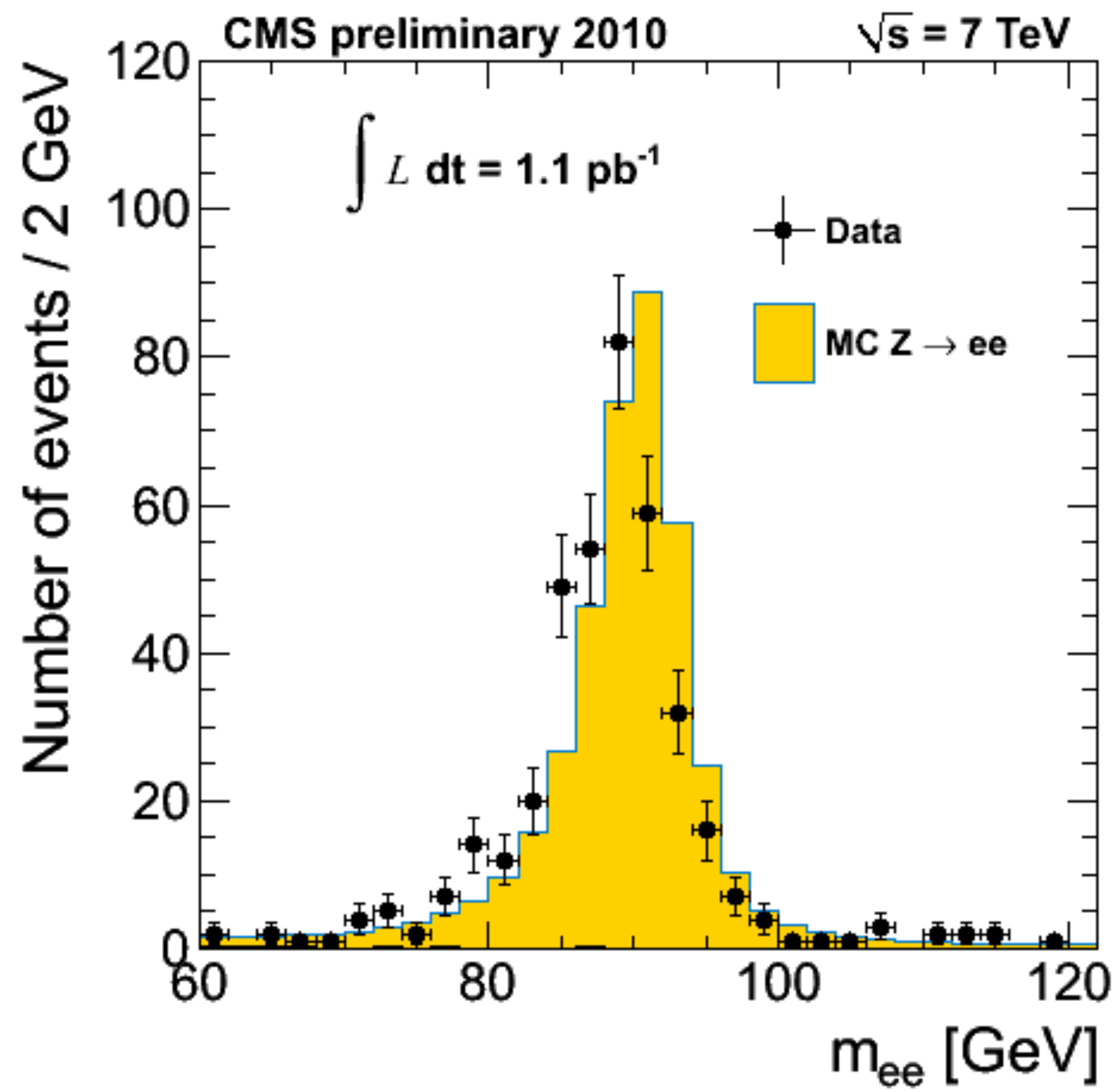
W plots with 1.1 pb^{-1}





Z plots with 1.1 pb^{-1}





Summary

With few hundreds nb^{-1} we have shown that our detector is well suited to perform nice physics studies with vector bosons and jets

- basic kinematic variables and measurements are in good agreement with expectations from Monte Carlo
- the jet E_T spectrum in particular can be studied down to very low momentum

The LHC is expected to deliver about 30 pb^{-1} by the end of 2010

More (and better) to come...

Backup slides

Systematics errors for W x-sec

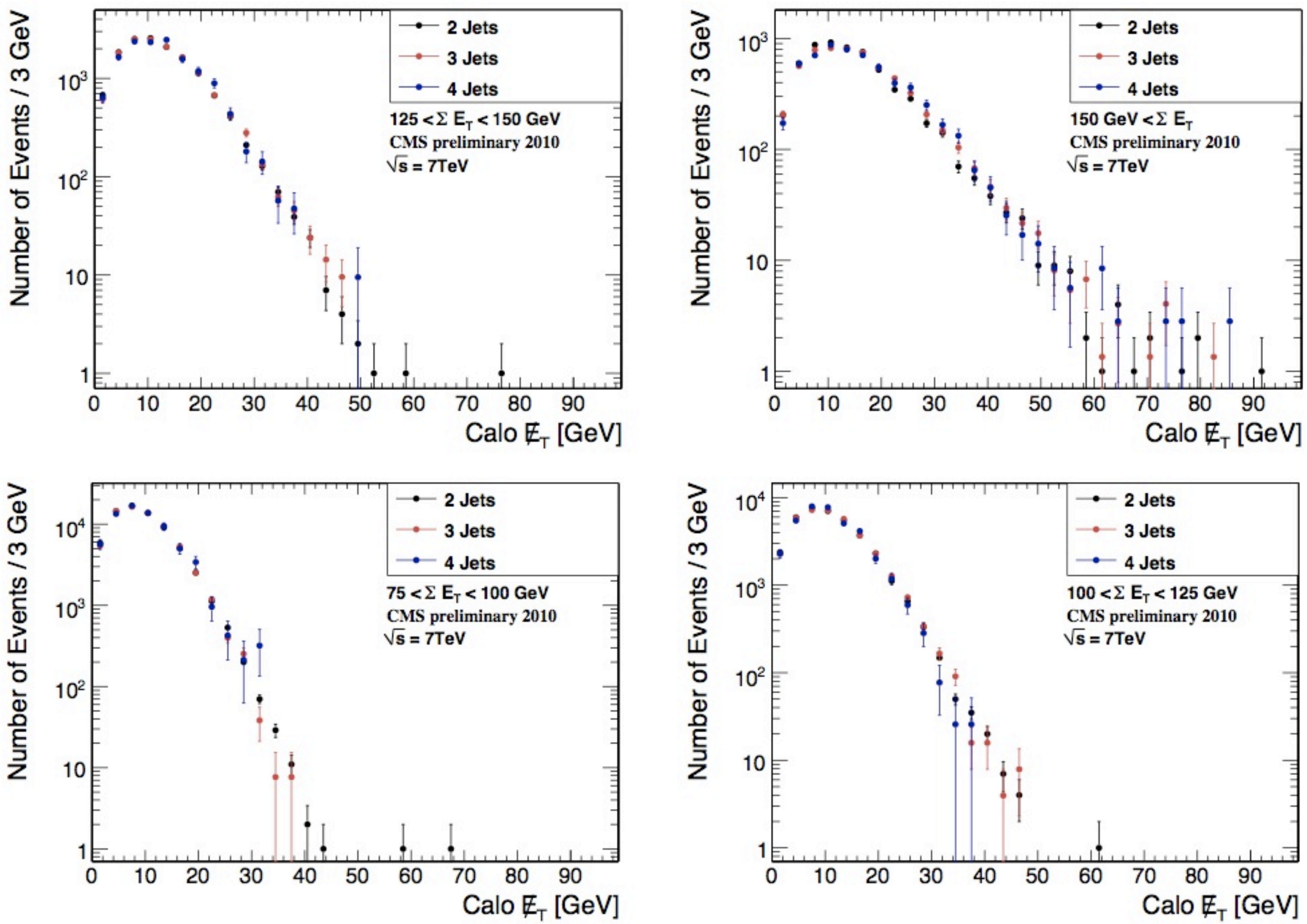
- Efficiencies and scales studied in Z events and recoil studies
- Background uncertainties from cut inversion studies and control samples
- PDF uncertainties evaluated via CTEQ66, MSTW08NLO, NNPDF2.0 sets

Source	$W \to \mu\nu$ (%)	$W \to e\nu$ (%)
Lepton reconstruction	3.0	6.1
Trigger Efficiency	3.2	0.6
Isolation Efficiency	0.5	1.1
Momentum/energy scale	1.0	2.7
MET scale and resolution	1.0	1.4
Background subtraction	3.5	2.2
PDF uncertainty in acceptance	2.0	2.0
Other theoretical uncertainties	1.4	1.3
Total systematic error	6.3	7.7
Luminosity uncertainty	11.0	11.0

Systematic errors for Z x-sec

Source	$Z \rightarrow \mu\mu$ (%)	$Z \rightarrow ee$ (%)
Lepton reconstruction	2.5	7.2
Trigger Efficiency	0.7	-
Isolation Efficiency	1.0	1.2
Momentum/energy scale	0.5	-
PDF uncertainty in acceptance	2.0	2.0
Other theoretical uncertainties	1.6	1.3
Total systematic error	3.8	7.7
Luminosity uncertainty	11.0	11.0

MET vs jet multiplicity



- Uncorrected Calo MET in jet events for different $SumE_T$ ranges
- Different jet multiplicity bins (jets w/p_T>20 GeV, |η|<3)

=> MET distribution "primarily" controlled by $SumE_T$, and not jet multiplicities