Dijet invariant mass distribution in $pp \rightarrow W(\rightarrow l\nu)+jj$ final states at $\sqrt{s} = 7$ TeV

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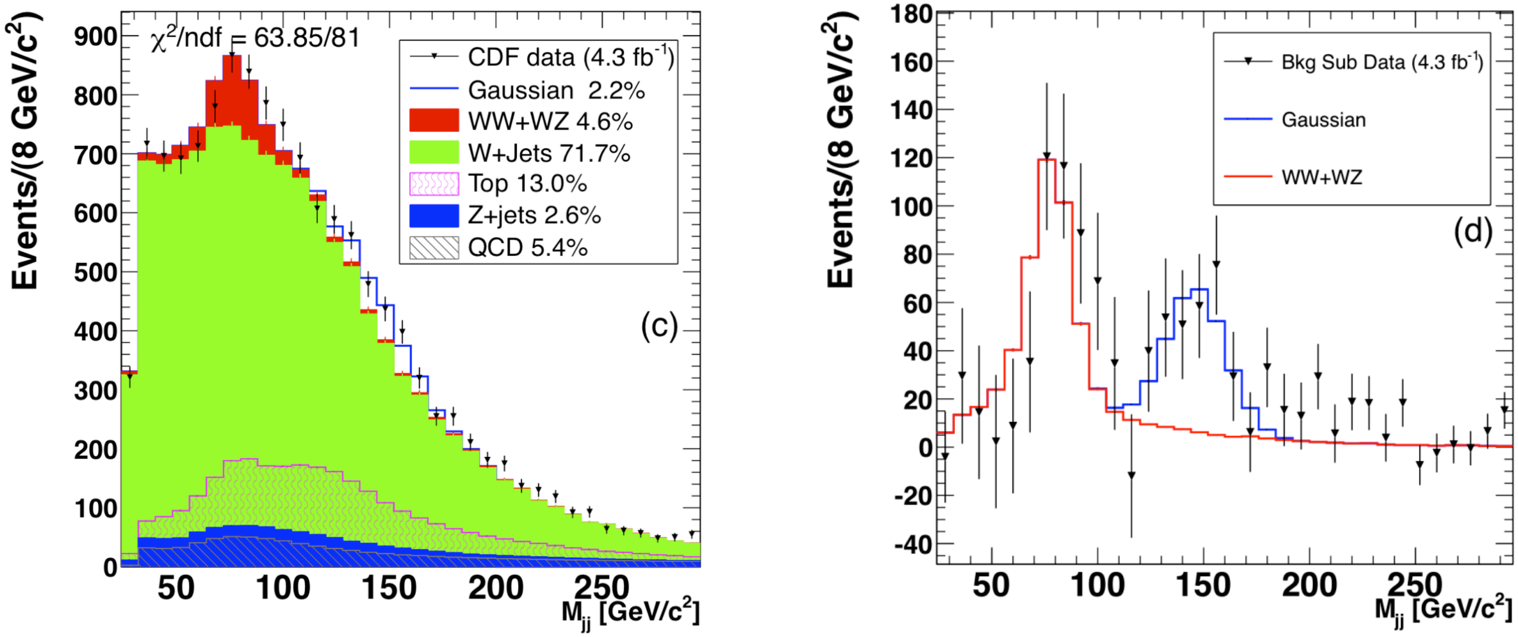
[8] Universidade do Estado do Rio de Janeiro (UERJ), Brazil

https://cdsweb.cern.ch/record/1431015 *EWK-11-017*
https://twiki.cern.ch/twiki/bin/viewauth/CMS/EWK11017TWiki

CDF : Anomaly

➢ arXiv: 1101.6079, Phys. Rev. Lett. 106:171801 (2011)



❖ An excess of 253 events at 145 GeV, width = 15 GeV

❖ Significance of 3.2σ at 4.3fb^{-1} and 4.1σ at 7.3fb^{-1}

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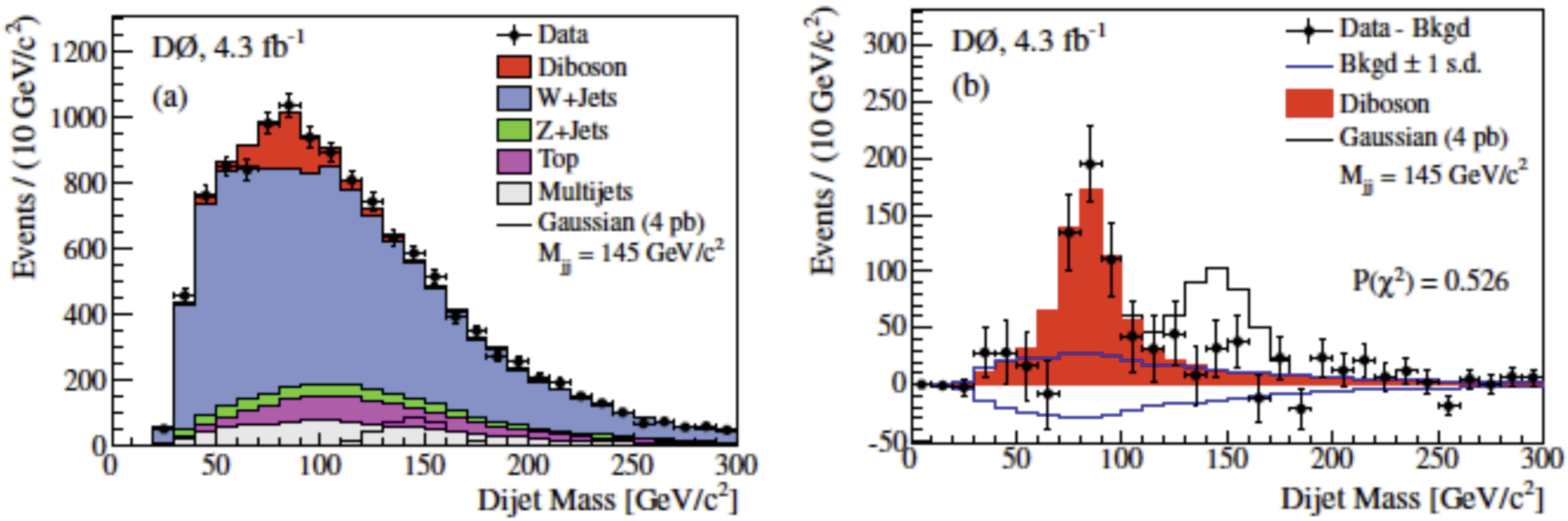
➢ **arXiv: 1106.1921, Phys. Rev. Lett. 107:011804 (2011)**

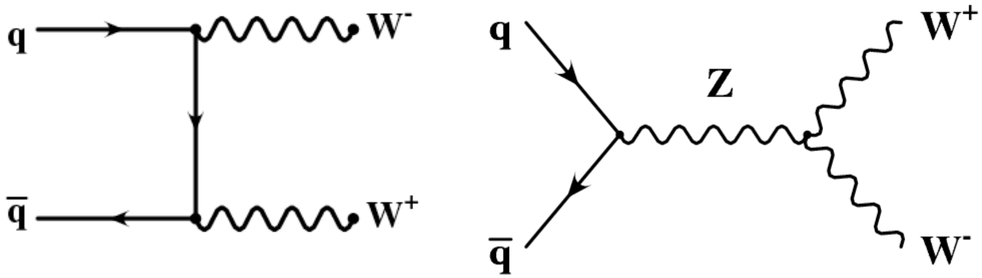


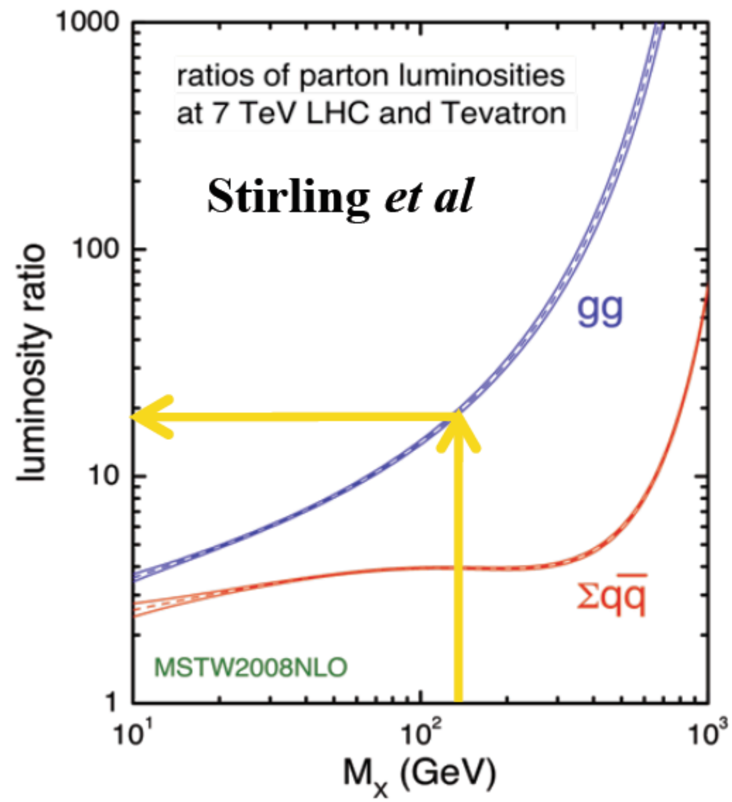
❖ **Smooth falling spectrum beyond 110GeV**

❖ **The CDF cross section (4pb) is excluded at 99.9999% CL**

❖ **Consistent with the Standard Model**

LHC Environment



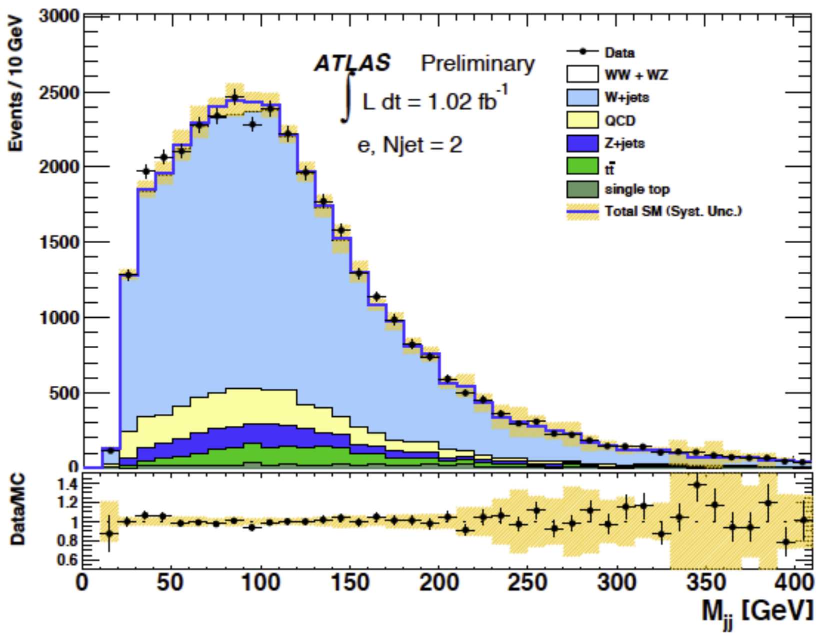


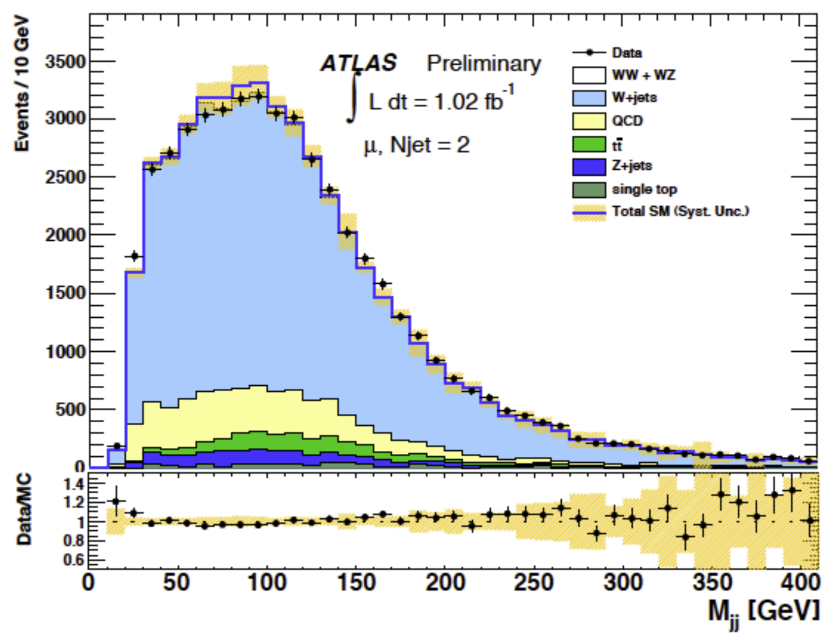
- **The WW+WZ Signal is dominated by qqbar diagrams and the luminosity ~3x higher at 7TeV (vs. 2TeV)**
- **The dominant background (W+Jets) increases 20x due to qg and gg processes**

- **The S/B is much worse and stronger cuts need to be applied in order to extract the signal**
- **It is very hard to generate as large background MC sample as data**

Out Of The Box Analysis : ATLAS

➢ **Presented at EPS : ATLAS-CONF-2011-097 (1.02fb^{-1})**





❖ **Excessive Wjj background**

❖ **2Jet Events Only / No Visible Diboson Peak**

❖ **Large Systematic Uncertainties**

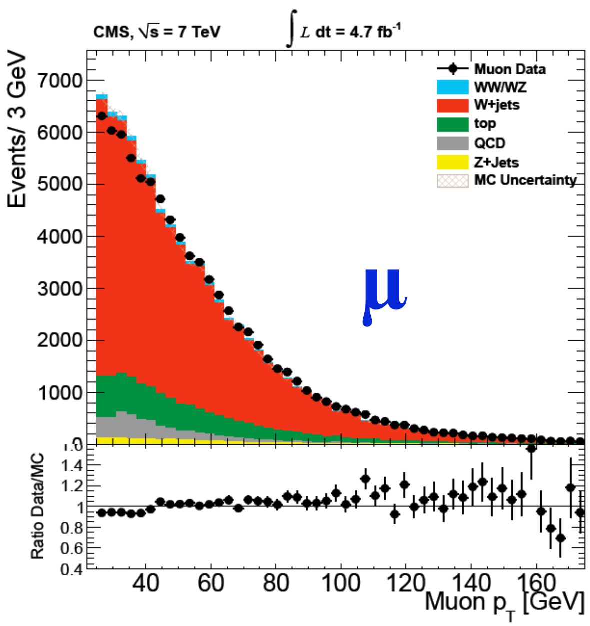
Event Selection

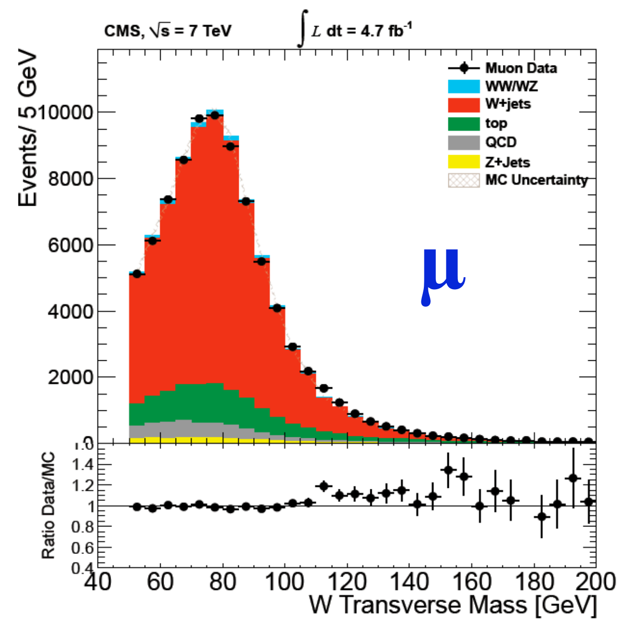
Event Selection & Quality Cuts

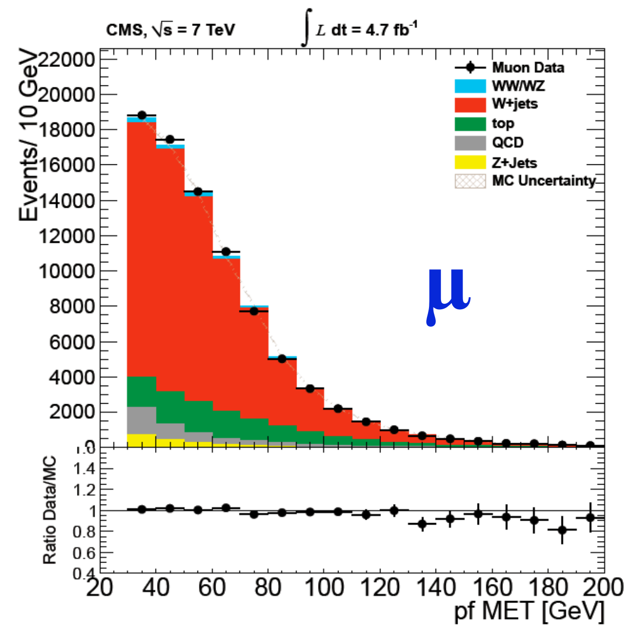
$W \to \ell\nu$ selection	Jet selection
Single lepton trigger	$p_T^{\text{lead jet}} > 40$ GeV
High-quality lepton ID and isolation	$p_T^{\text{2nd jet}} > 30$ GeV
Muon (electron) $p_T > 25(35)$ GeV	dijet $p_T > 45$ GeV
$\not\!\!E_T > 25(30)$ GeV for muon (electron) samples	$\Delta\eta_{jj} \leq 1.2$
W transverse mass > 50 GeV	$\Delta\phi(\not\!\!E_T, \text{lead jet}) > 0.4$
Second lepton veto	$0.3 < p_T^{\text{2nd jet}}/m_{jj} < 0.7$

- **Studied in detail**
- **Motivated by recommendations of Estia Eichten, Kenneth Lane and Adam Martin (ELM) - arXiv:1107.4075v1**
- **Do not remove the potential new physics**

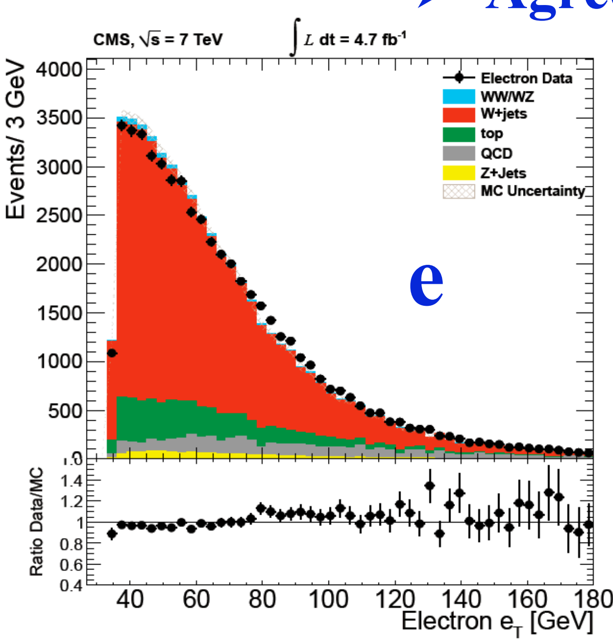
❖ **Improve the signal to background ratio and reduce the systematic uncertainty**

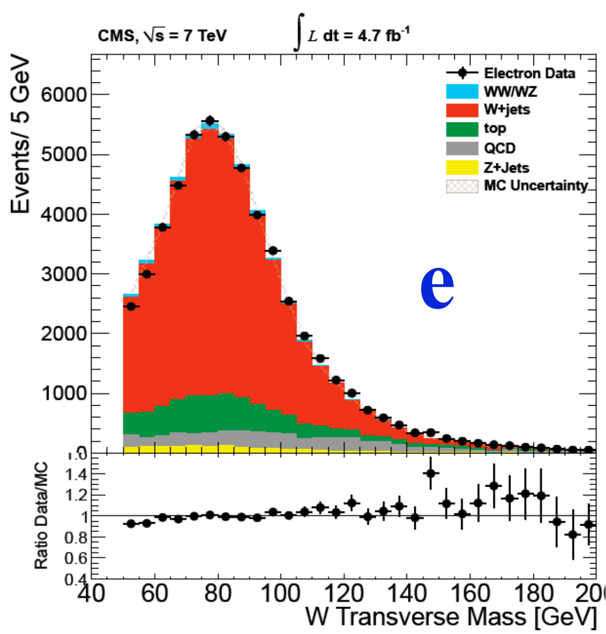


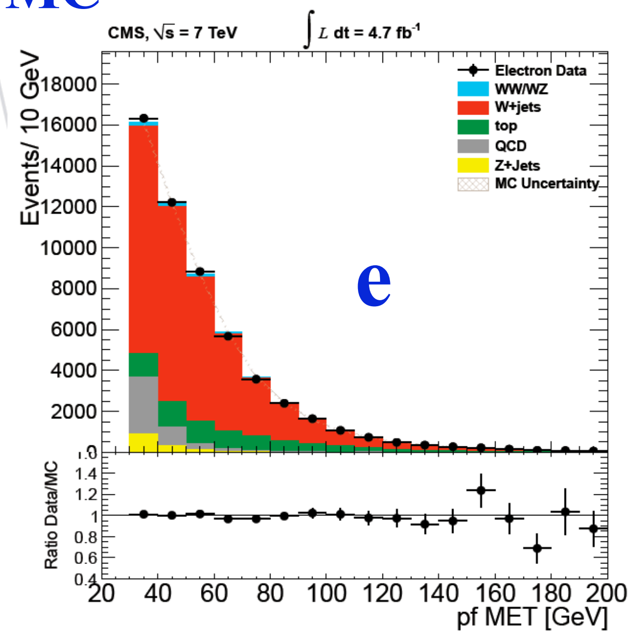




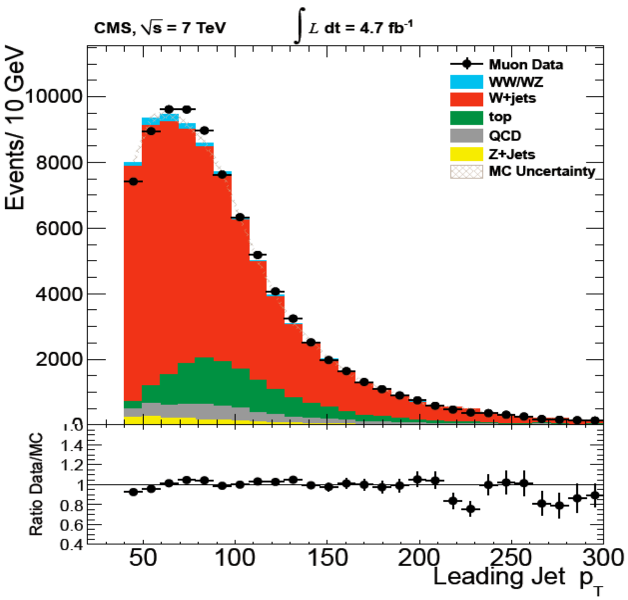
➢ **Agreement between Data and MC**

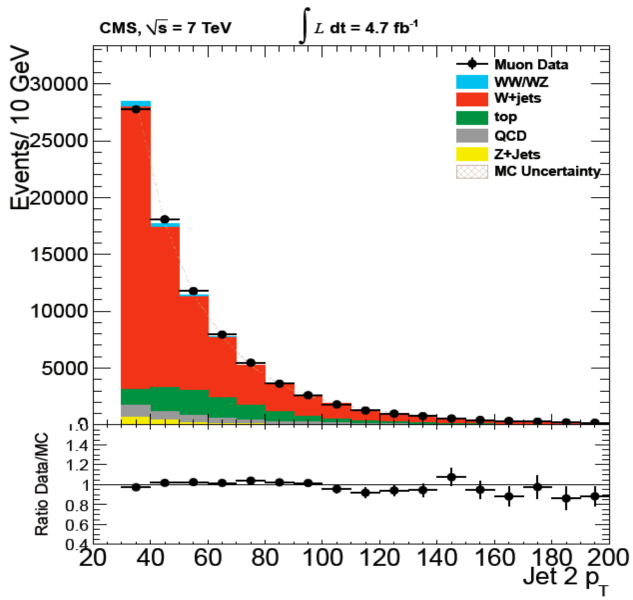


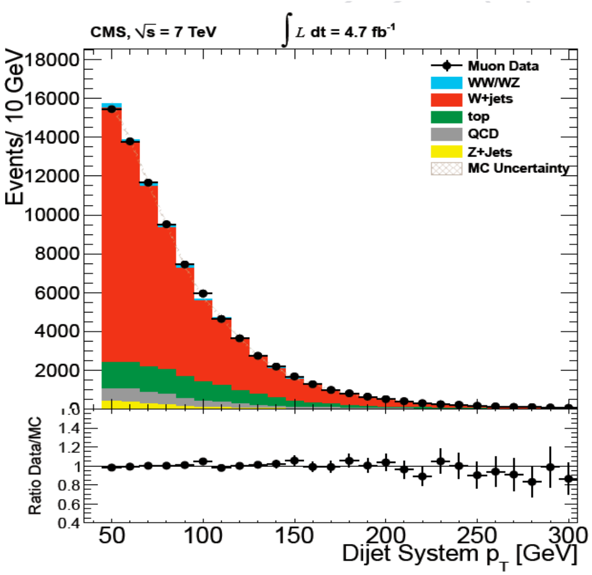


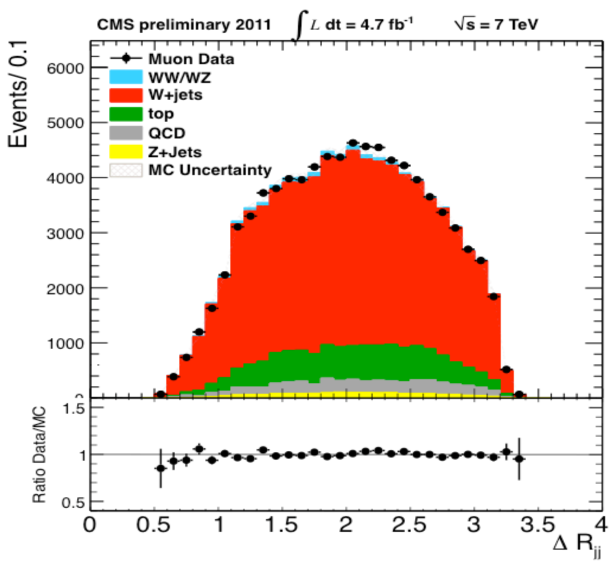


μ


CMS, √s = 7 TeV
∫L dt = 4.7 fb⁻¹
Muon Data
WW/WZ
W+jets
top
QCD
Z+Jets
MC Uncertainty
Events/ 10 GeV
Ratio Data/MC
Leading Jet p_T

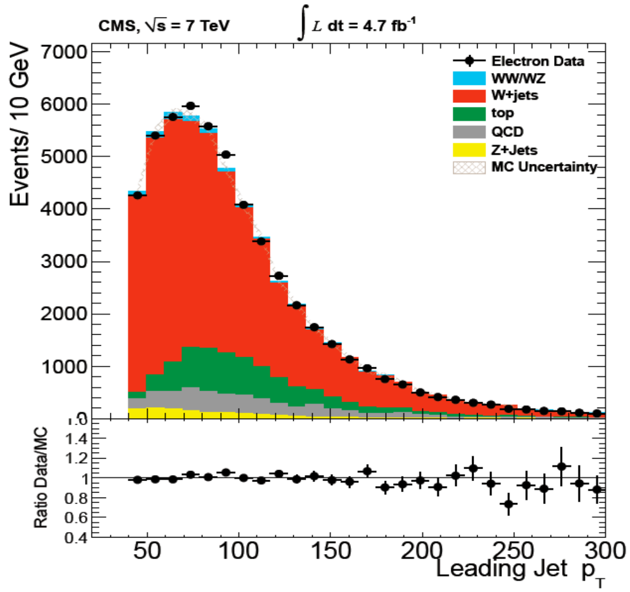

CMS, √s = 7 TeV
∫L dt = 4.7 fb⁻¹
Muon Data
WW/WZ
W+jets
top
QCD
Z+Jets
MC Uncertainty
Events/ 10 GeV
Ratio Data/MC
Jet 2 p_T

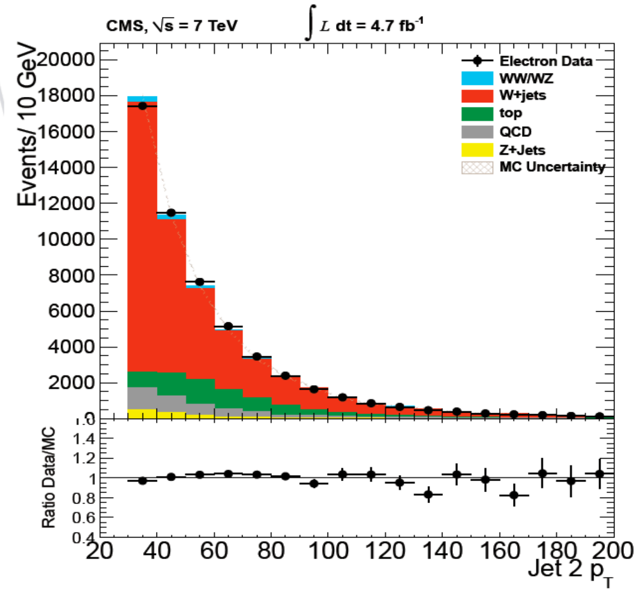

CMS, √s = 7 TeV
∫L dt = 4.7 fb⁻¹
Muon Data
WW/WZ
W+jets
top
QCD
Z+Jets
MC Uncertainty
Events/ 10 GeV
Ratio Data/MC
Dijet System p_T [GeV]

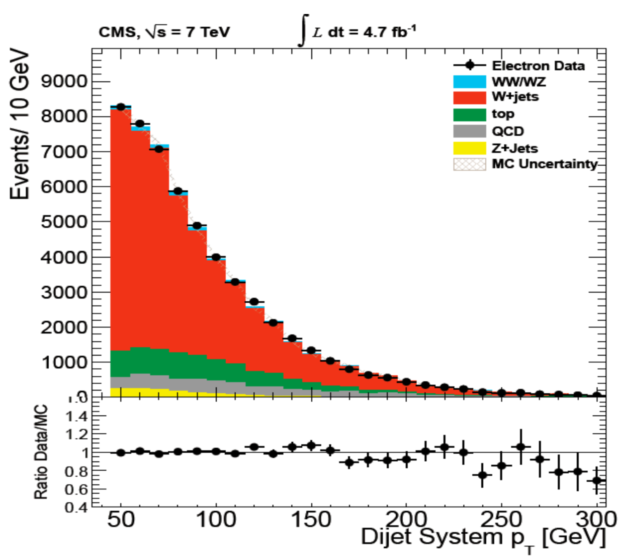

CMS preliminary 2011
∫L dt = 4.7 fb⁻¹
√s = 7 TeV
Muon Data
WW/WZ
W+jets
top
QCD
Z+Jets
MC Uncertainty
Events/ 0.1
Ratio Data/MC
Δ R_jj

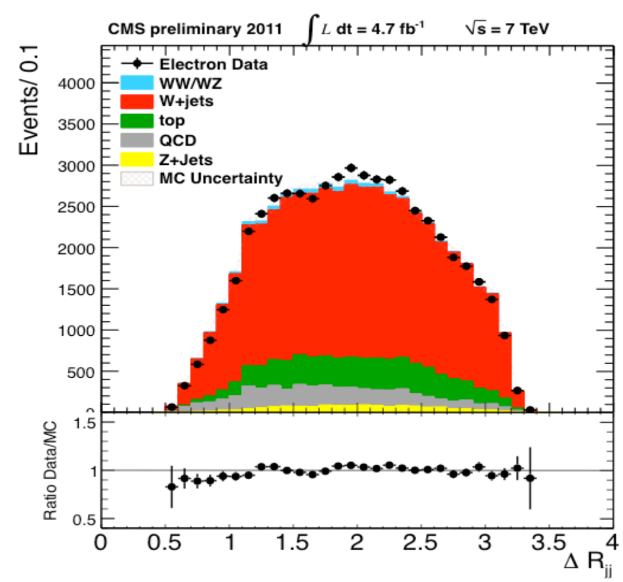
Mjj Distribution

e









Template Fit

Maximum Likelihood Fit

❖ Unbinned maximum likelihood fit within $30 < M_{jj} < 400$ GeV

❖ Exclude the potential signal region ($123 < M_{jj} < 186$ GeV)

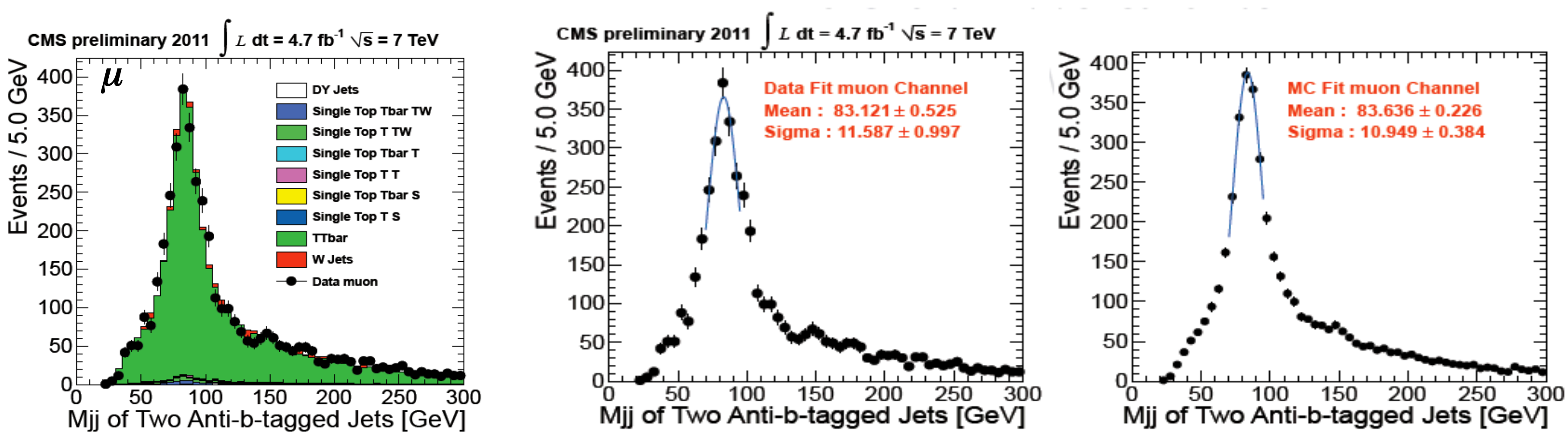
❖ Four Separate Fits: μ-2Jet Bin, μ-3Jet Bin, el-2Jet Bin, el-3Jet Bin (combine the results when setting exclusion limits)

➢ **Templates:**

- **W+Jets - Dominant Background : Morphing of multiple MC templates; yield and error are free to vary in the fit.**
- **WW+WZ (Diboson) : MC; expected yields from NLO prediction, errors are Gaussian-constrained (σ =0.10*mean).**
- **TTbar, Single Top, Z+Jets : MC; expected yields from NLO with Gaussian-constrained errors (σ =0.07*mean, 0.05*mean, 0.043*mean).**
- **QCD : Data, by inverting the isolation cut; expected yields and errors from MET fit of the Data.**
- **Data: 4.7fb^{-1}**

JES from Top Events

- **Compare to the (almost) pure ttbar control sample:**
  - **Exactly four jets - two b-tagged and two anti-btagged**
  - **Use the anti-btagged jets to reconstruct the hadronic W**
  - **Compare the fits of data vs MC**
  - **Similar approach and conclusions as TOP-11-015 (top mass measurement)**

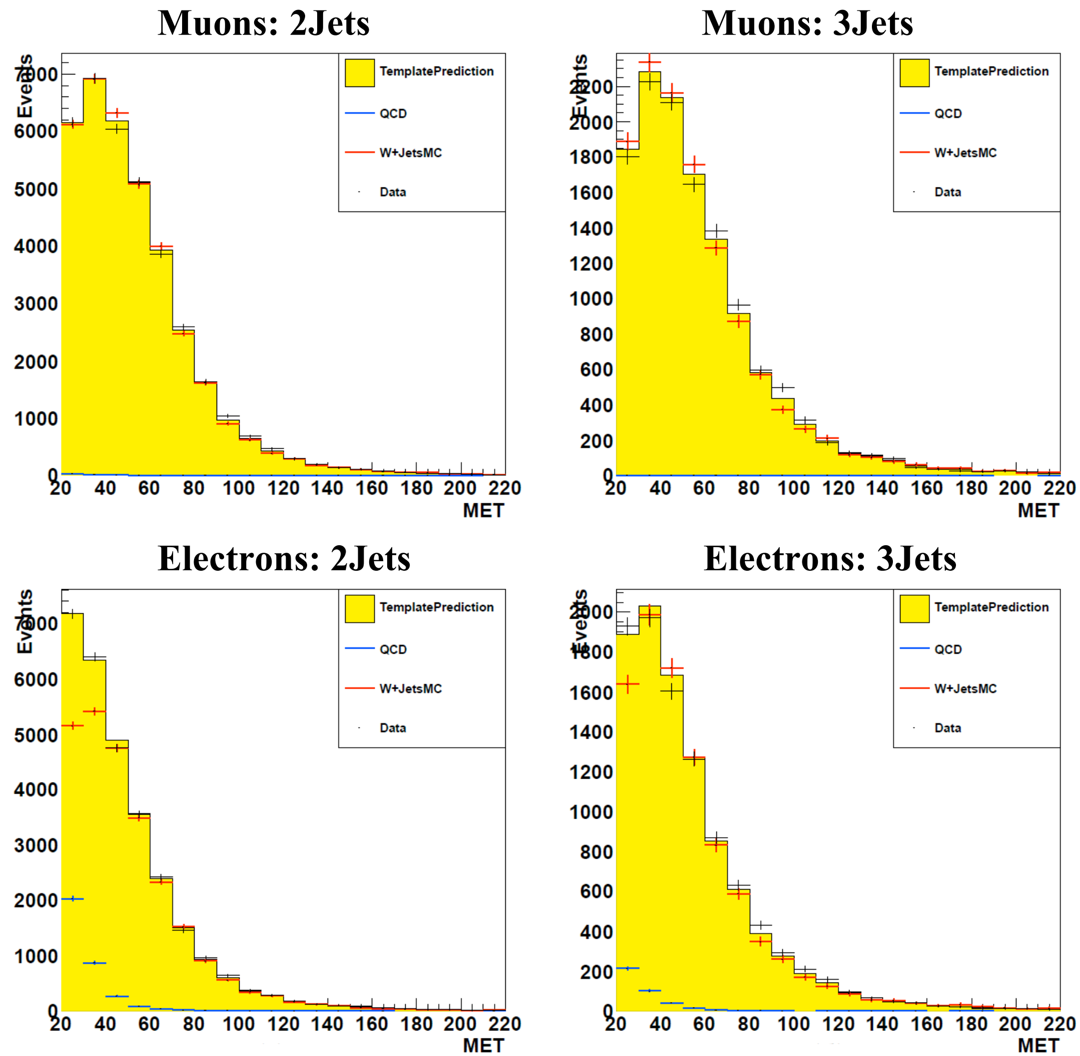


❖ **The difference in JES is propagated to our templates and makes a negligible impact**

QCD Template And Normalization

❖**Invert the lepton Isolation**

❖**Fit MET distribution**



- **Relative Fractions (accounting for acceptances):**
  - **μ 2J : 0.001625 ± 0.004214**
  - **el 2J : 0.0617 ± 0.00384**
  - **μ 3J : 0.0 ± 0.0040797**
  - **el 3J : 0.0213 ± 0.00678**

- **QCD Errors in the global template fit:**
  - **μ : fractions listed above (i.e., >100%)**
  - **el : 50% of the QCD event yield**

W+Jets

❖ **The simulation needs to describe the matrix elements for the hard processes as well as the subsequent development of the hard partons into jets of hadrons.**

❖ Standard Approach:

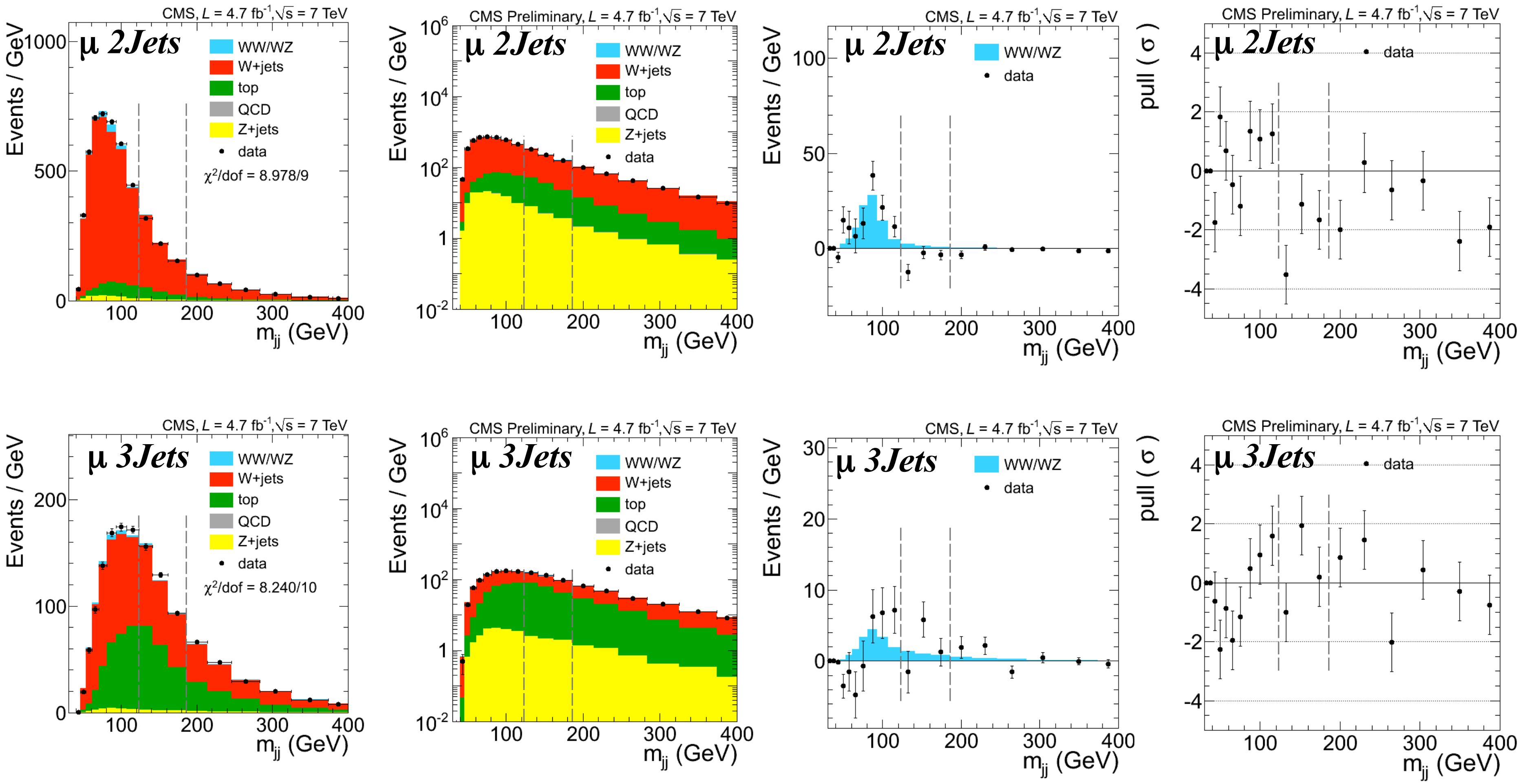
- **Fit with the default NLO MC: Matrix Element – Parton Shower matching threshold = 20GeV, Factorization Scale = 20 GeV**
- **Repeat the fit with alternate ME-PS matching (Factorization) samples where threshold and scale vary by a factor 2, and compute the systematics**
- **Overcovers the errors and can get into the non-perturbative regime**

❖ Template Morphing:

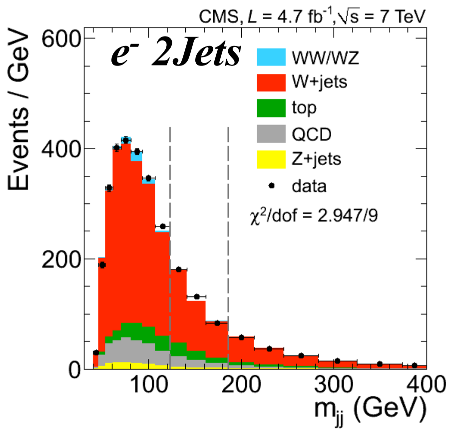
- **Fit with the combination of Default MC, either Matching Up or Matching Down MC, and either Scale Up or Scale Down MC**
- **The relative fractions are free to vary in the fit**
- **Accounts for Matching and Factorization errors**
- **Accounts for W+Jets shape uncertainty**

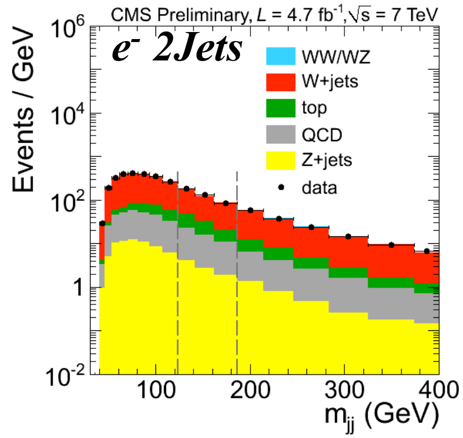
$$\mathcal{F}_{\mathrm{W+jets}} = \alpha \cdot \mathcal{F}_{\mathrm{W+jets}}(\mu_0^2, q'^2) + \beta \cdot \mathcal{F}_{\mathrm{W+jets}}(\mu'^2, q_0^2) + (1-\alpha-\beta) \cdot \mathcal{F}_{\mathrm{W+jets}}(\mu_0^2, q_0^2),$$

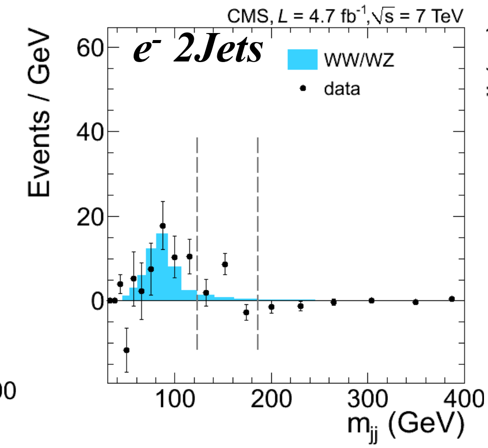
Fit Output - Muons

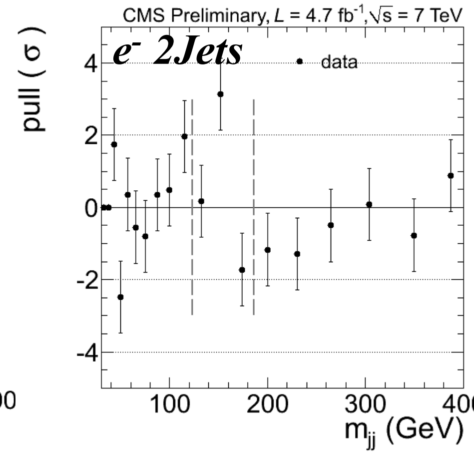


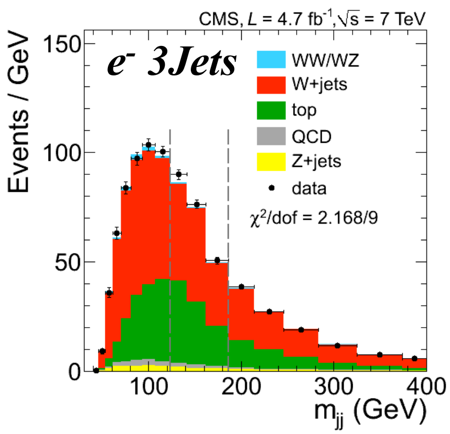
Fit Output - Electrons

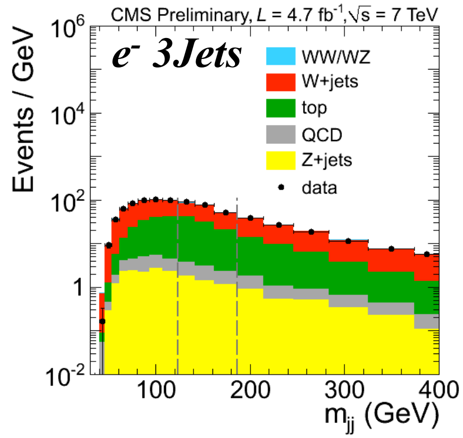


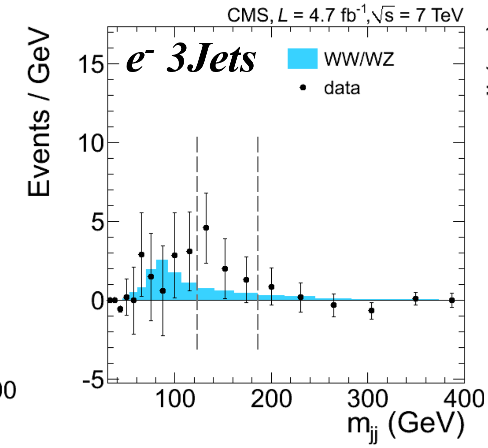


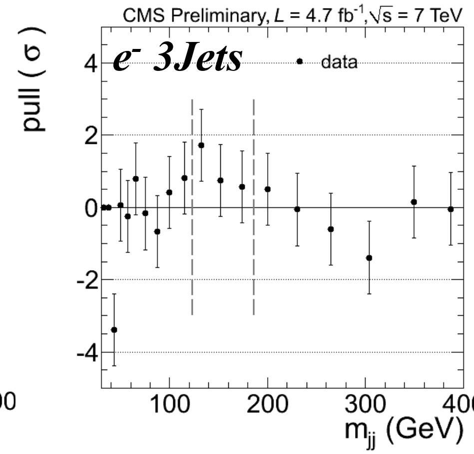












Results:

❖ We are able to model the Data, obtain reasonable pull distributions and extract the Yields.

Event Yields

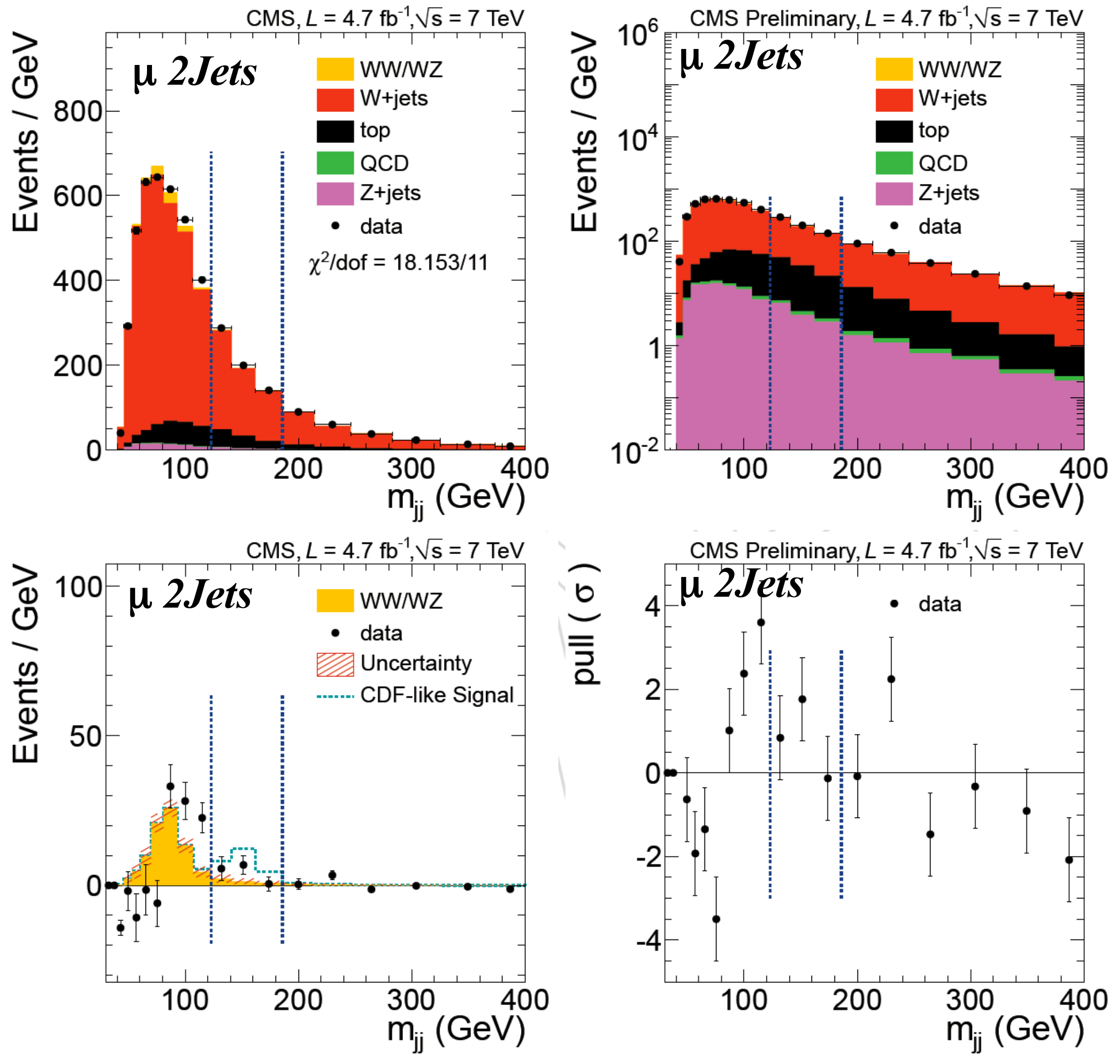
Bin	2 Jets	μ	3 Jets	
	Predicted	Extracted	Predicted	Extracted
W+jets	56918	59430±519	15210	13419±360
Dibosons	1110	1167±108	307	314±31
$t\bar{t}$	4211	4258±290	7285	8753±371
Single top	1646	1663±82	939	945±47
Drell-Yan+jets	1728	1731±74	528	528±23
Multijet	110	28±284	0	0.0
Data/Total Yield	67900	68277±307	24046	23960±192
Corrected Total	—	68218±417	—	23995±284
in region ($123\,\text{GeV} < m_{jj} < 186\,\text{GeV}$)				
Data/Total Yield	14050	14494±125	7751	7693±95

Bin	2 Jets	e	3 Jets	
	Predicted	Extracted	Predicted	Extracted
W+jets	30329	29989±1202	8025	8600±287
Dibosons	620	646±61	173	174±17
$t\bar{t}$	2384	2413±164	3989	4085±242
Single top	870	864±43	494	492±25
Drell-Yan+jets	999	1000±43	343	343±15
Multijet	2584	4024±1181	324	330±160
Total	38973	38935±228	14145	14024±142
Corrected Total	—	38902±309	—	14045±210
in region ($123\,\text{GeV} < m_{jj} < 186\,\text{GeV}$)				
Data/Total Yield	8023	7925±92	4438	4319±70

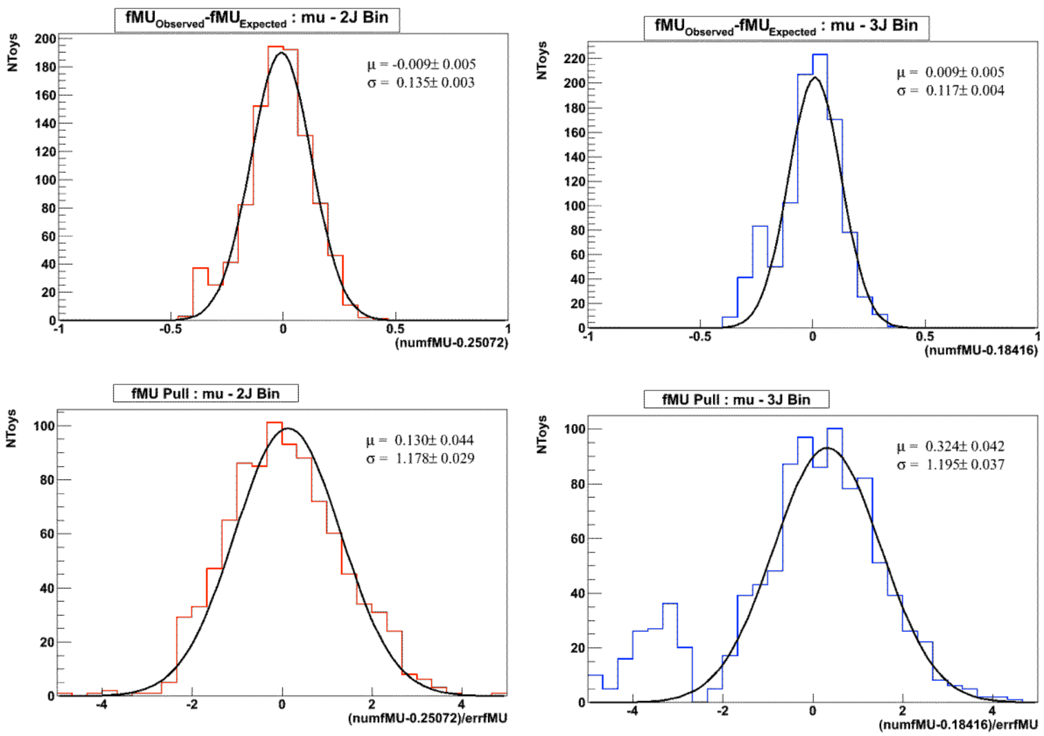
Crosschecks And Validation

Example: Fit Without "Morphing"

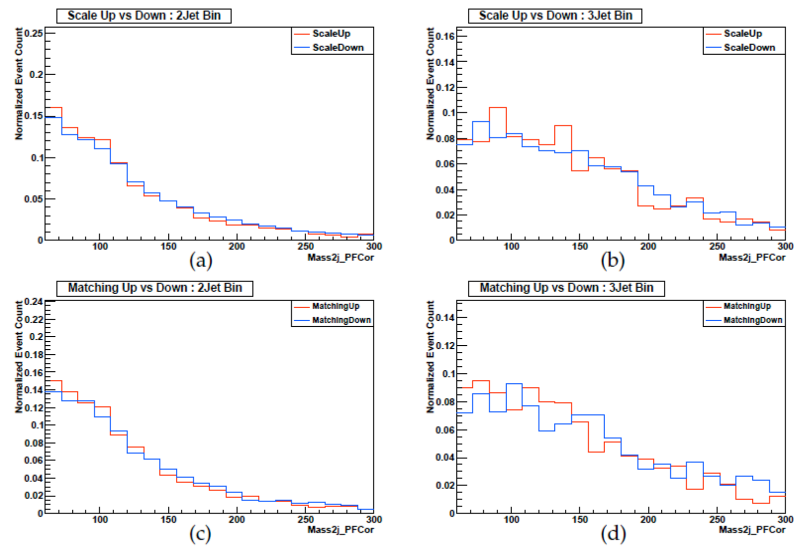
- We repeat the fit using only the default MadGraph shape for W+jets (i.e., templates for alternative renormalization/factorization scale and ME-PS matching scale are not included)
- The default MadGraph sample does not adequately describe the data



Example: ME-PS Matching Variations



Scale and Matching Up vs. Down Shapes

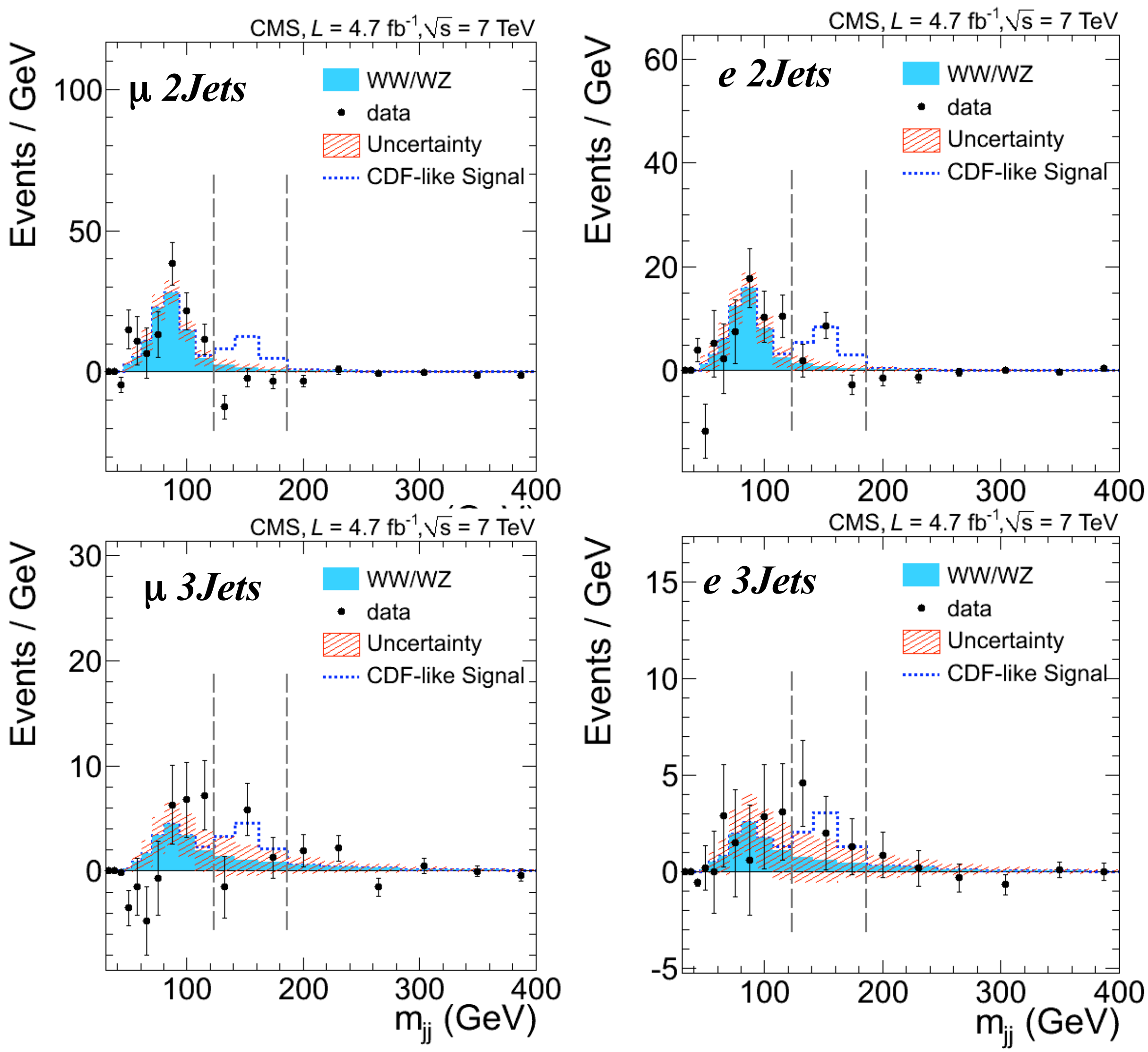


- **By convention fMU<0 (fSU<0) refers to the fraction of the Matching Down (Scale Down) sample**
- **Low discriminating ability between up and down shapes**
  - **Some structural anomalies and overestimated uncertainties observed**

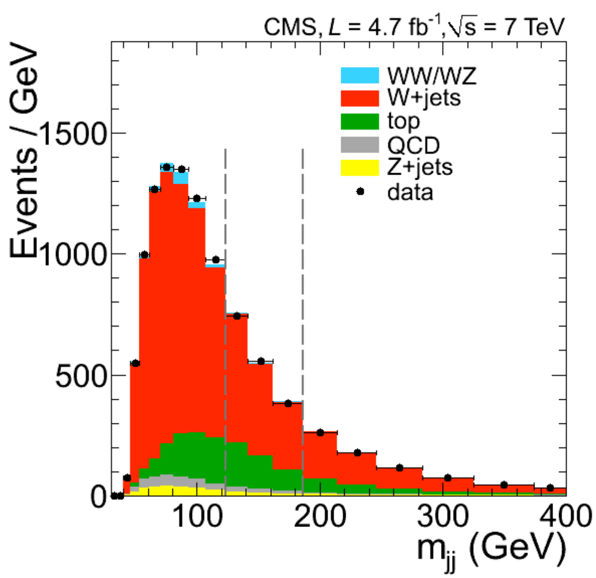
Systematics

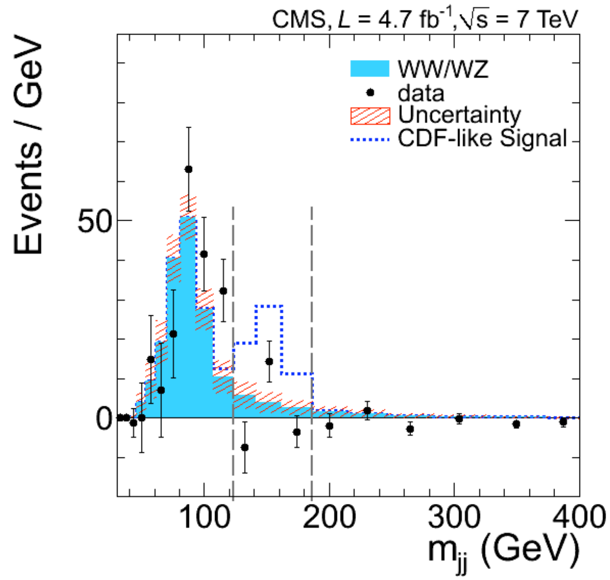
- Jet Energy Scale (JES): estimated using the TTbar control sample. Data and simulation agree within 0.6%, i.e. at the same level as the data measurement.
- W+Jets shape uncertainty: accounted for via the morphing procedure.
- ME-PS Matching and Factorization Scale: included in the W+Jets fit error.
- Fit Bias and limited amount of MC events: corrected for after performing the 1000 toy experiments.
- Additional uncertainties: MET resolution difference between data and MC (0.5%), trigger efficiency (1%), lepton reconstruction and selection efficiency (2%), luminosity (4.5%).

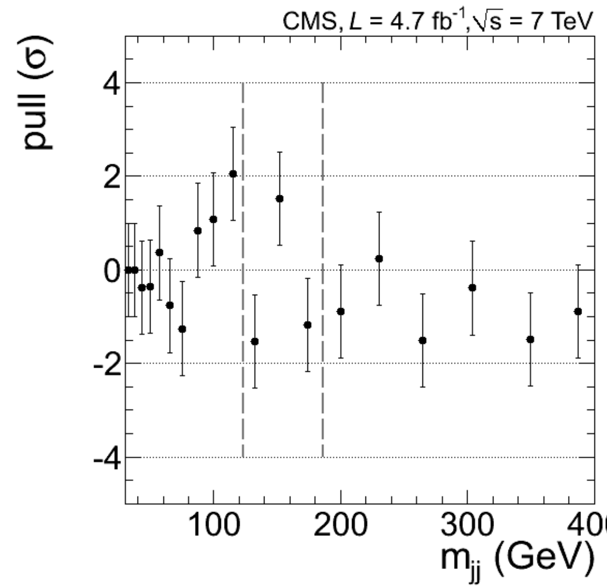
Subtracted Plots With Syst Errors



Combined Result







- **Effective modeling of the data**
- **Systematic uncertainty has been included**
- **No peak observed in the signal region**

Exclusion Limits

CDF-Like Gaussian

- **Gaussian Resonance at 150GeV with a width of 15 GeV.**
- **Estimate the CDF vs CMS production cross-section ratio (and $\varepsilon \times A$) from the WH(M_H=150) process.**
- **This choice gives a conservative limit. WH production is quark-antiquark dominated, which has the smallest increase in luminosity when going from the Tevatron to LHC.**
- **Expected event count is given by:**

$$\sigma_{\mathrm{LHC}}^{dijet-resonance} = \sigma_{\mathrm{Tevatron}}^{dijet-resonance} \times \frac{\sigma_{\mathrm{LHC}}^{WH}}{\sigma_{\mathrm{Tevatron}}^{WH}},$$

$$N^{Signal} = \sigma_{\mathrm{LHC}}^{dijet-resonance} \times BF(W \to \ell\nu) \times (\epsilon \times \mathcal{A}) \times \int \mathcal{L}\mathrm{dt},$$

3.4pb

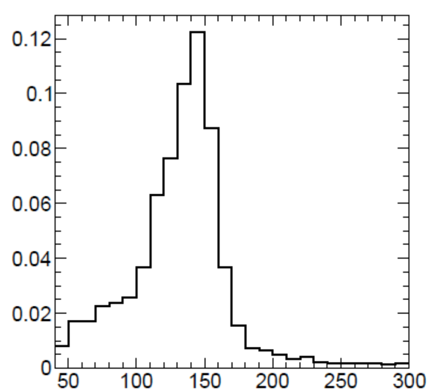
~1-6 %

Potential New Physics

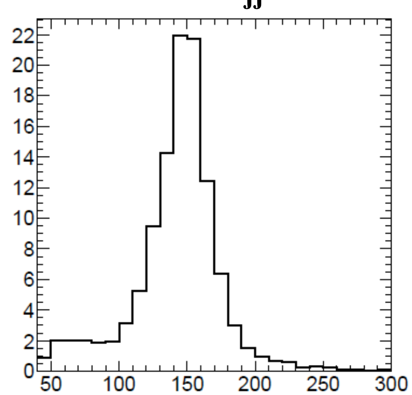
- Technicolor $\rho_T \rightarrow W\pi_T$
- Leptophobic $Z' \rightarrow jj$
- Standard Model Higgs (MH=150GeV) produced in association with a W or Z

Signal Mode	$\sigma \times$BR (pb)	$A \times \varepsilon\,(ejj)$	$A \times \varepsilon\,(ejjj)$	$A \times \varepsilon\,(\mu jj)$	$A \times \varepsilon\,(\mu jjj)$
WH/ZH	0.0145	0.0380	0.0132	0.0599	0.0192
Z'	1.72	0.0421	0.0138	0.0700	0.0234
Technicolor	1.58	0.0387	0.0111	0.0648	0.0200

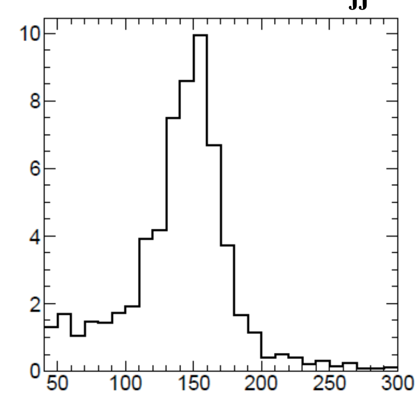
WH/ZH M_{jj}



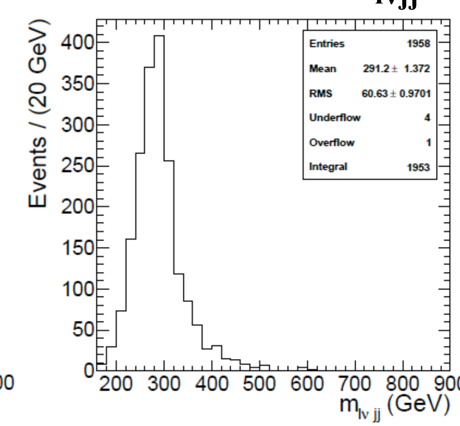
Z' M_{jj}



Technicolor M_{jj}



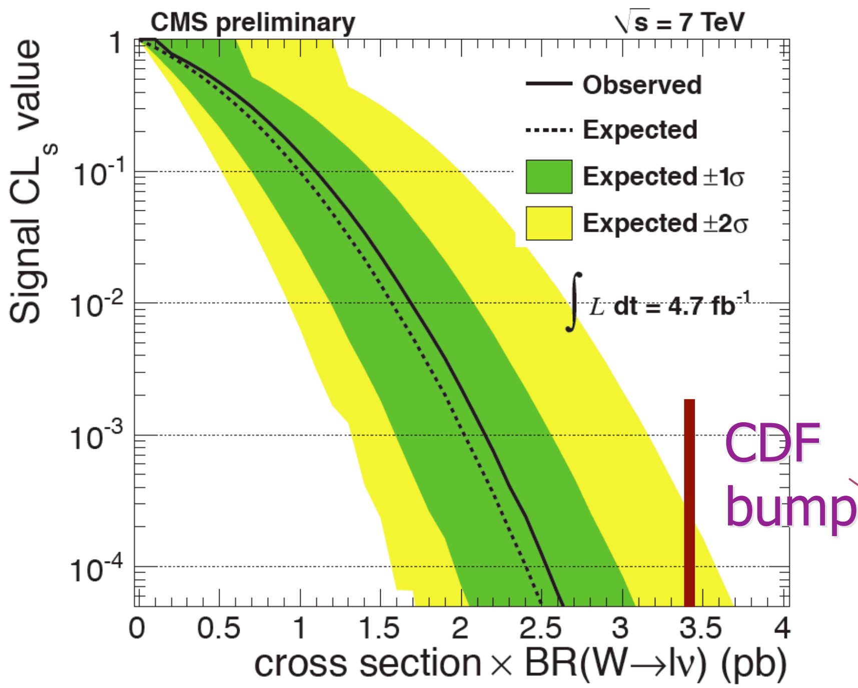
Technicolor $m_{l\nu jj}$

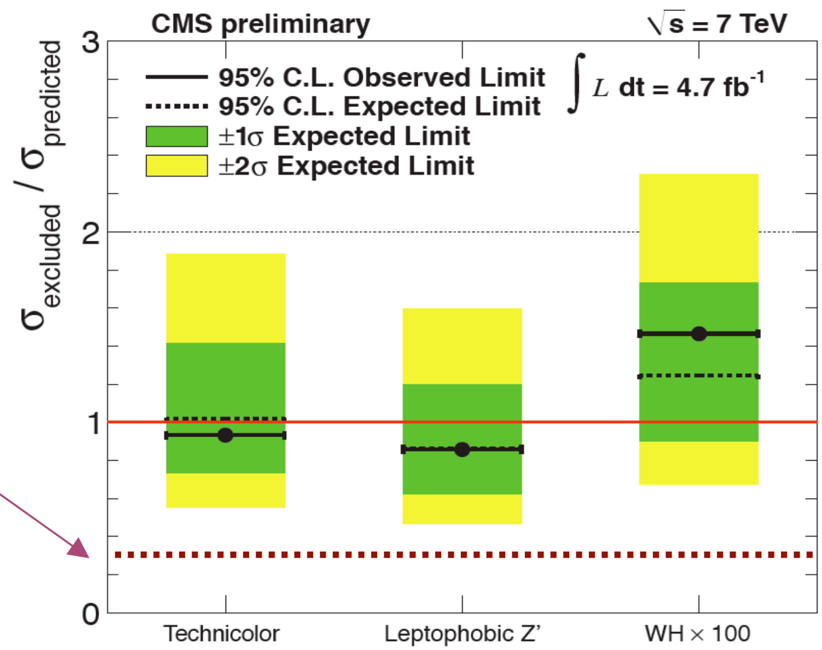


❖ Concrete models on which we can place exclusion limits

Limits & Conclusion

➢ The limit is set using CL_s method, LHC test statistic with profile likelihood





❖Exclusion for the CDF-Like excess and several New Physics Models

❖Successfully model mjj spectrum, observe electroweak diboson signal

❖Smoothly falling mjj spectrum, no apparent peak in the region120-180 GeV

Backup

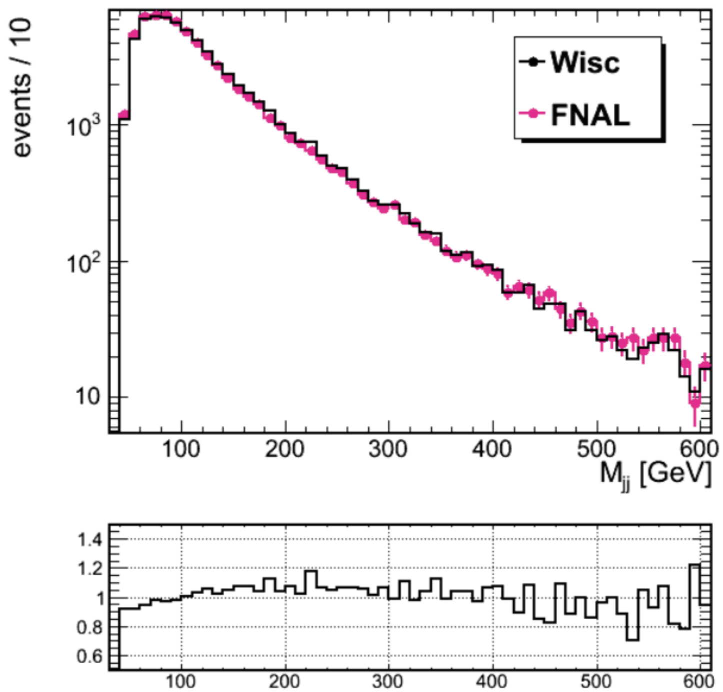
Outline

- **Prior Analyses**
  - **Tevatron**
  - **LHC**
- **Event Selection**
  - **Basic Object Selection**
  - **Pileup**
  - **Quality Cuts**
  - **Control Plots**
- **Likelihood Fit to Estimate Yields of Various Components**
  - **QCD Shape**
  - **W+jets Shape**
  - **Results**
- **Validation**
  - **Cross-Checks**
  - **Validation and Systematics**
- **Exclusion Limits on anomalous dijet production**
  - **New Physics Models**
  - **Results**
- **Conclusions**

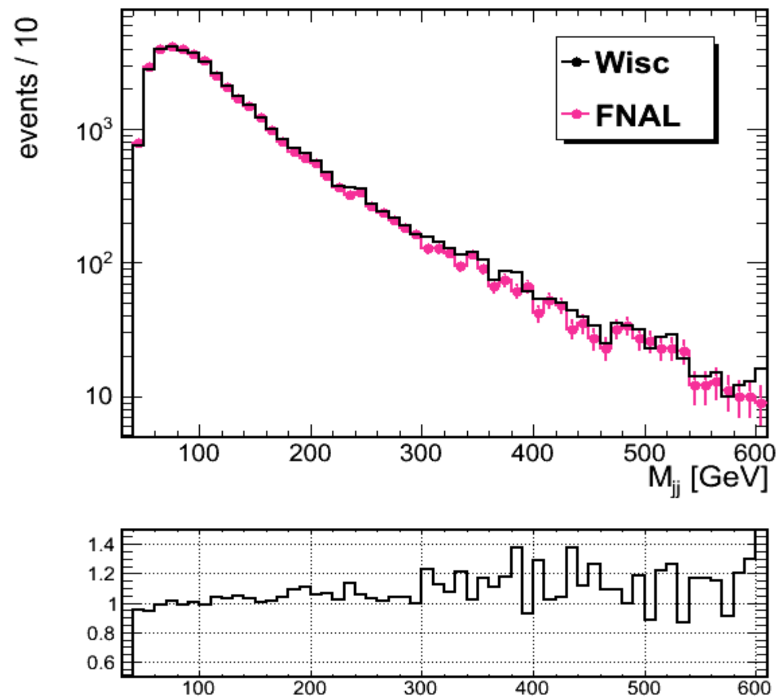
Comparison Of Independent Results

- Ensure that the two sets of data are synchronized

Synchronization : Muons



Synchronization : Electrons



- Fits performed independently yield consistent results
- Consistent with the fit performed using a more relaxed (i.e. CDF-Like) selection

MC And Data Samples

- SingleElectron and SingleMuon Data
- Fall11 MC
- Process in CMSSW_4_2_X

/WJetsToLNu_TuneZ2_7TeV-madgraph-tauola/Fall11-PU_S6_START42_V14B-v1/AODSIM
/WW_TuneZ2_7TeV_pythia6_tauola/Fall11-PU_S6_START42_V14B-v1/AODSIM
/WZ_TuneZ2_7TeV_pythia6_tauola/Fall11-PU_S6_START42_V14B-v1/AODSIM
/TTJets_TuneZ2_7TeV-madgraph-tauola/Fall11-PU_S6_START42_V14B-v2/AODSIM
/QCD_Pt-20_MuEnrichedPt-15_TuneZ2_7TeV-pythia6/Fall11-PU_S6_START42_V14B-v2/AODSIM
/DYJetsToLL_TuneZ2_M-50_7TeV-madgraph-tauola/Fall11-PU_S6_START42_V14B-v1/AODSIM
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/Tbar_TuneZ2_tW-channel-DS_7TeV-powheg-tauola/Fall11-PU_S6_START42_V14B-v1/AODSIM
/T_TuneZ2_s-channel_7TeV-powheg-tauola/Fall11-PU_S6_START42_V14B-v1/AODSIM
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/Technicolor_Wjj_4_2_3_SIM/andersj-Technicolor_Wjj_4_2_3_RAW-ca6deeacdf15095bc2c1568bed374b31/USER
/Technicolor_Wjj_4_2_3_SIM/andersj-Technicolor_Wjj_4_2_3_AODSIM-f71d043e41acd38c60e3392468355a0e/USER

Dataset name	Run range
/EG/Run2010A-Apr21ReReco-v1/AOD /Mu/Run2010A-Apr21ReReco-v1/AOD	136033 - 144114
/Electron/Run2010B-Apr21ReReco-v1/AOD /Mu/Run2010B-Apr21ReReco-v1/AOD	144919 - 149442
/SingleElectron/Run2011A-May10ReReco-v1/AOD /SingleMu/Run2011A-May10ReReco-v1/AOD	160431 - 163869
/ElectronHad/Run2011A-PromptReco-v4/AOD /SingleMu/Run2011A-PromptReco-v4/AOD	165088 - 167913
/SingleElectron/Run2011A-05Aug2011-v1/AOD /SingleMu/Run2011A-05Aug2011-v1/AOD	170826 - 172619
/SingleElectron/Run2011A-PromptReco-v6/AOD /SingleMu/Run2011A-PromptReco-v6/AOD	172620 - 173692
/SingleElectron/Run2011B-PromptReco-v1/AOD /SingleMu/Run2011B-PromptReco-v1/AOD	175832 - 180252

Muons

- Trigger: 2010 Triggers, IsoMu17, IsoMu20, IsoMu24, IsoMu30, Mu40.
- Reconstructed as both global & tracker muon
- $p_T > 25$ GeV, $|\eta| < 2.1$
- Quality Requirements: Standard VBTF Selection
  - Reconstructed as a Global and Tracker Muon
  - ≥10 tracker hits, ≥1 pixel hits (Tracker track)
  - ≥2 muon hits of the Global track
  - $\chi 2/ndf < 10$ global fit
  - Impact parameter $|dxy| < 0.02$ cm (w.r.t. the beam spot)
- Combined Relative Isolation (R=0.3, PU density corrected) < 0.1
- $W_{mT} > 50$GeV (PF MET > 25 GeV)

Electrons

- Trigger: 2010Triggers, Ele25, Ele27, Ele32 (with cut on W transverse mass).
- ECAL seeded gsf electrons
- E_T > 35 GeV, $|\eta|$ <2.5 (excluding 1.44 < $|\eta|$ <1.57)
- WP70 + Isolation Requirements: Standard VBTF Selection
  - https://twiki.cern.ch/twiki/bin/view/CMS/SimpleCutBasedEleID

Conversion Rejection	
missing hits $\leq$	0
Dist	0.02
$\Delta cot\theta$	0.02

Combined Isolation	0.05	
Electron ID	EB	EE
$\sigma_{i\eta i\eta}$	0.01	0.03
$\Delta\phi$	0.03	0.02
$\Delta\eta$	0.004	0.005

- W_{mT}>50GeV (PF MET > 30 GeV)

Jets/MET

- Two or three anti-KT 0.5 PFJets after PfNoPU in each event
- Corrected p_T >30 GeV and $|\eta|$ <2.4
- $|\Delta R(\text{lepton},j)| > 0.3$
- Standard CMS L2, L3, and residual corrections.
- JetMET official Loose Jet Id criteria:
  - fraction of energy due to neutral hadrons < 0.99;
  - fraction of energy due to neutral EM deposits < 0.99;
  - number of constituents > 1;
  - number of charged hadrons candidates > 0;
  - fraction of energy due to charged hadrons candidates > 0;
  - fraction of energy due to charged EM deposits < 0.99.
- PF MET > 25 (μ), 30 GeV (e)

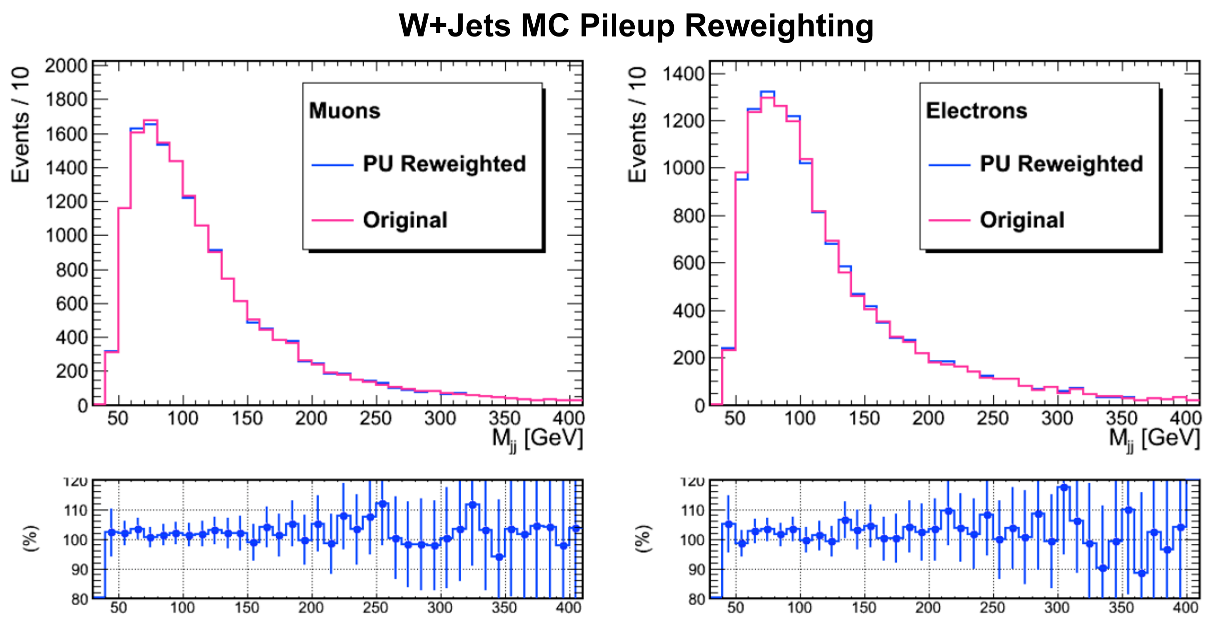
Pileup Effects

- Energy deposits added to the jets
- Low pT jets added to the event
- Tracks and calorimetric towers added to the isolation energy sum of the lepton

❖ Account For Via:

- Default JetMET POG recommended Offset and FastJet PU subtraction
- Explicit corrections to the lepton isolation

❖ Subsequent effect of pileup on the dijet mass distributions is statistically insignificant



QCD Template And Normalization

❖ **Select QCD multijet events with all of the cuts except Isolation:**

- **Invert the Isolation: [Iso_{μ}<0.1, Iso_{el}<0.05] → Iso>0.1**

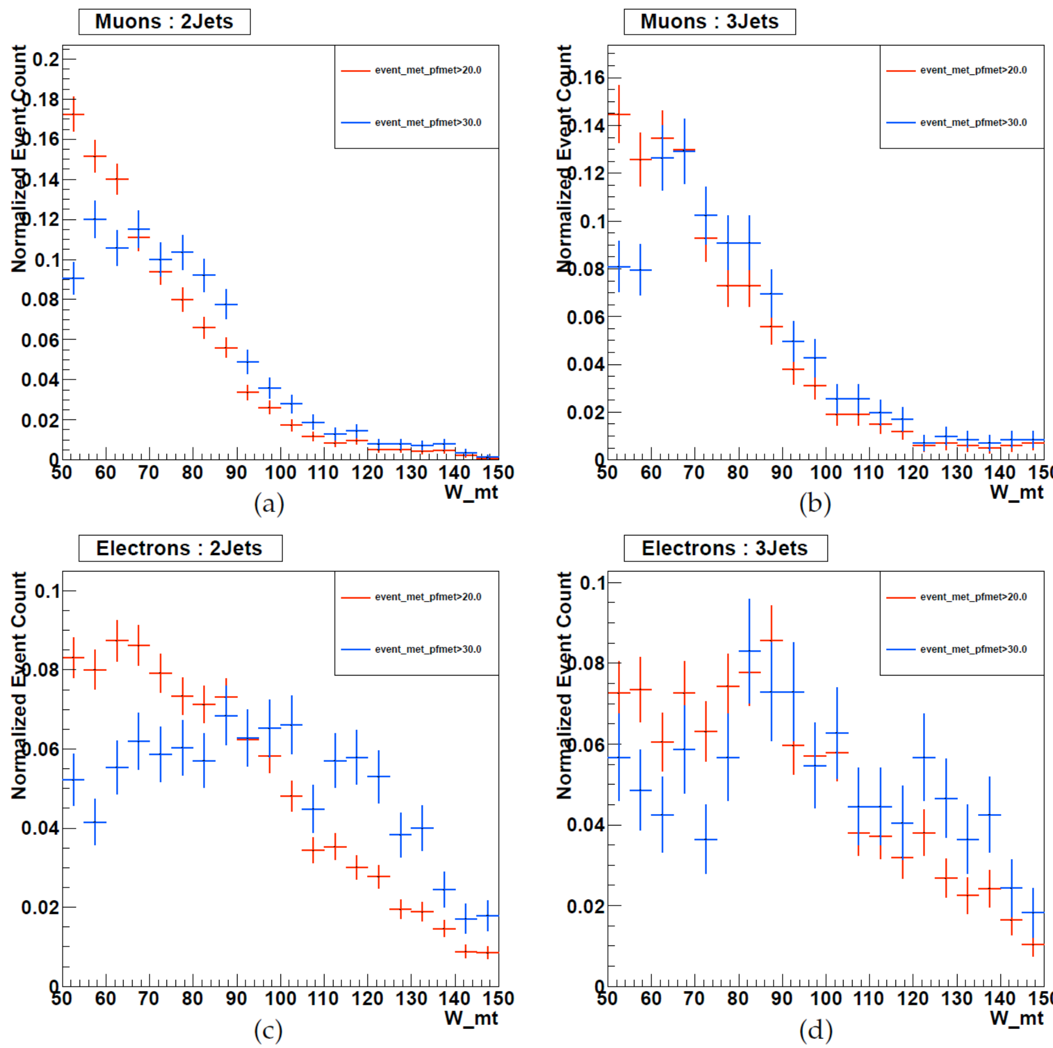
❖ **MET :**

- **QCD – MET is ’fake’ (i.e. originates from badly measured jets), has an exponentially falling spectrum**
- **Other Backgrounds – a wide peak near 35GeV from a real neutrino (with an exception of the highly suppressed Z+Jets)**
- **Loosen the MET Cut: MET>30GeV → MET>20GeV**

❖ **Fit the MET distribution with QCD and W+Jets templates to obtain the relative fractions.**

QCD Cross-check II : W_{mT} Comparison

- **Compare the QCD shapes with MET>20GeV vs. MET>30GeV**

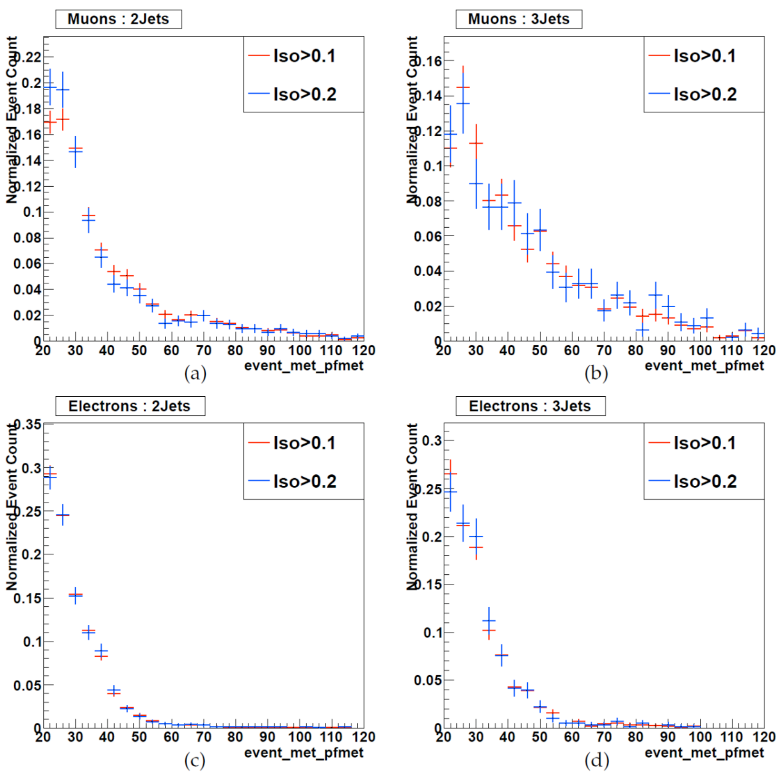


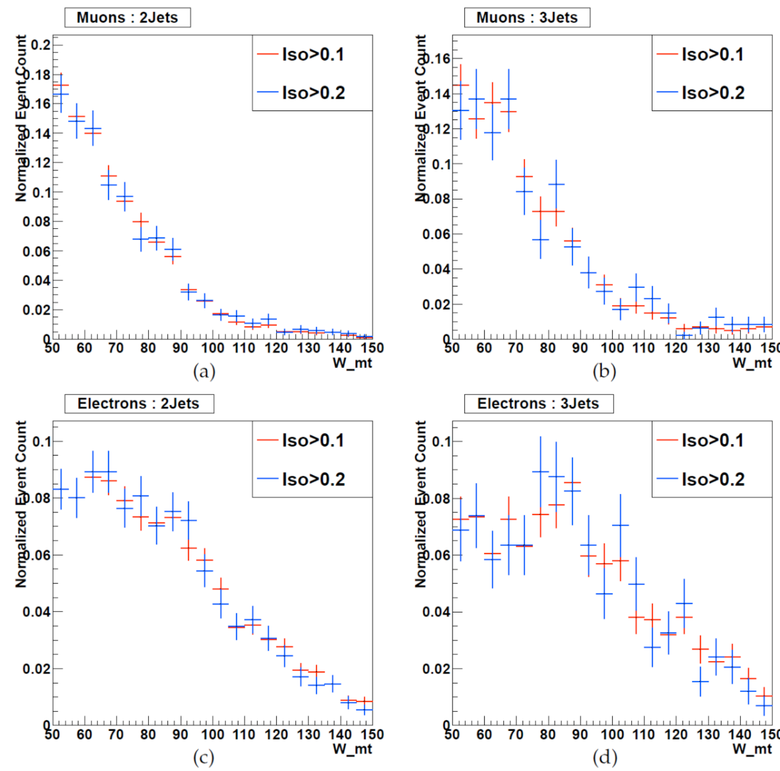
- **Events with MET > 30GeV do not have the same exponential falloff as they contain a higher percentage of W's**
- **Events with MET>20 GeV have a much smaller signal contamination**

QCD Cross-check III : Isolation Inversion

❖ Iso>0.2 vs. Iso>0.1

MET: **W_{mT}:**



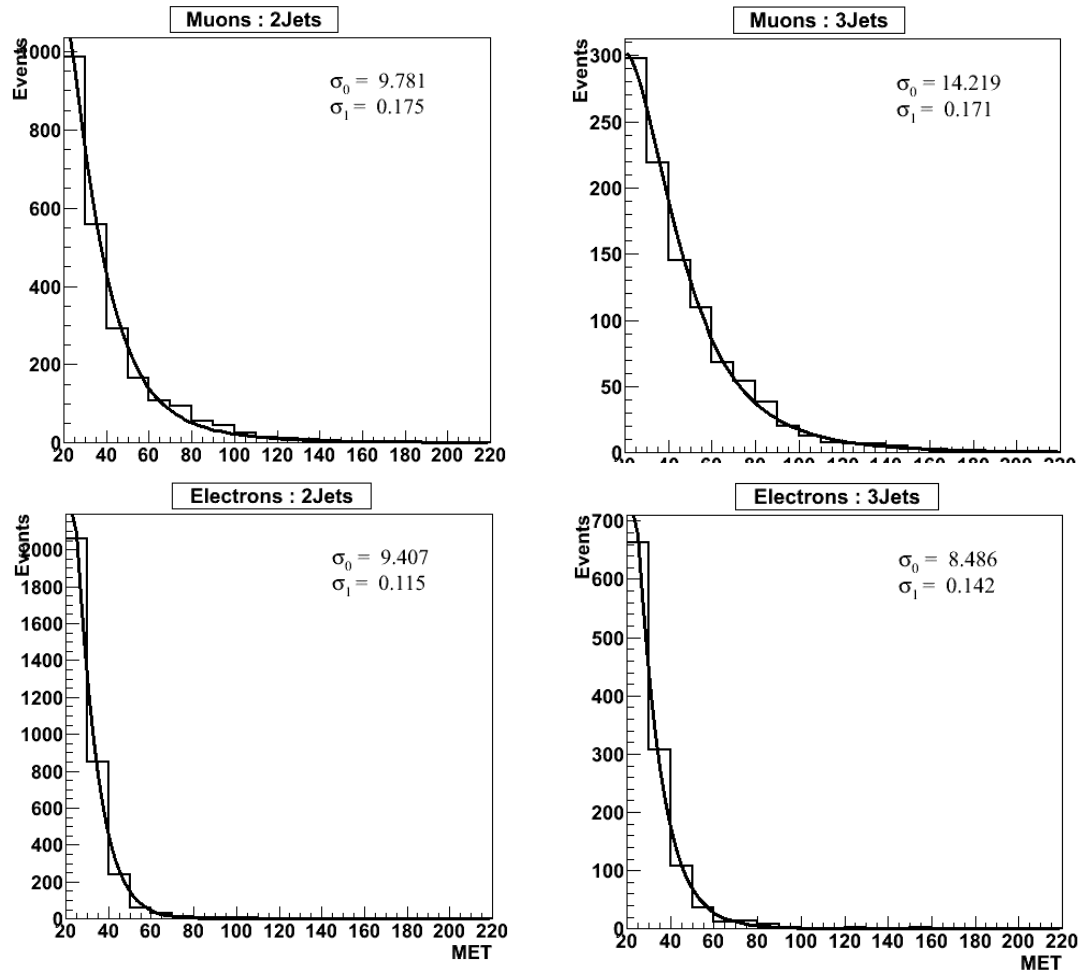


❖ **All cross-checks give consistent results.**

QCD Cross-check I : Rayleigh Function Fit

❖ **Fit the QCD with $xe\text{\^{}}(x^2/2(\sigma_0+x\sigma_1)^2)$**

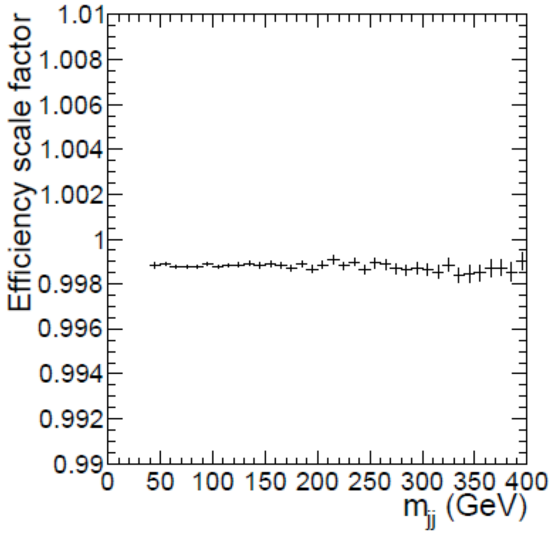
- **Used for the inclusive cross section measurements (arXiv:1012.2466)**



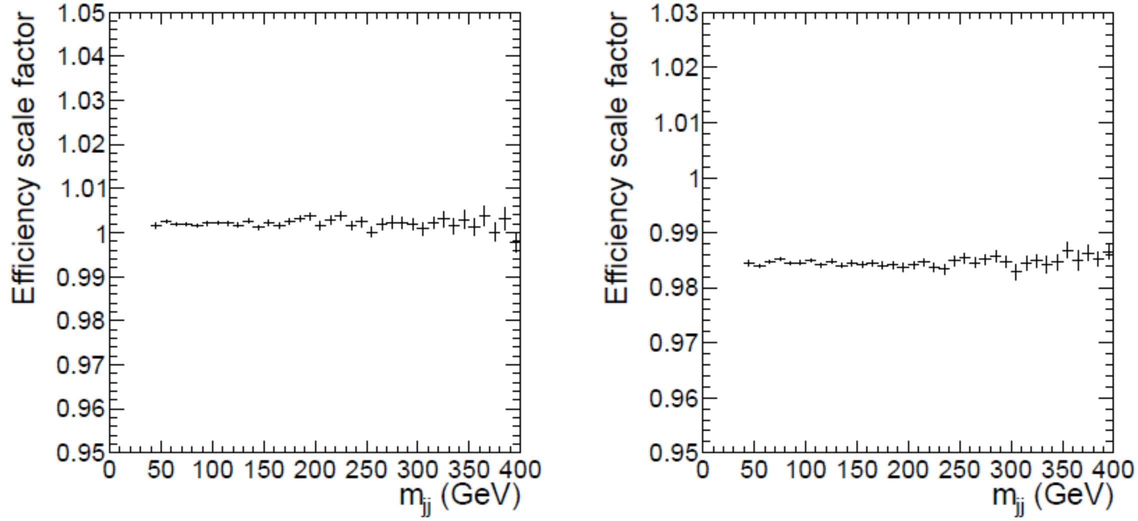
- **Accurately fits the overall shape.**
- **Extracts the intrinsic MET resolution ($\sigma_0 \approx$10GeV).**

Trigger Efficiency Effects I

Luminosity weighted average efficiency scale factors (data/MC) for muon isolation

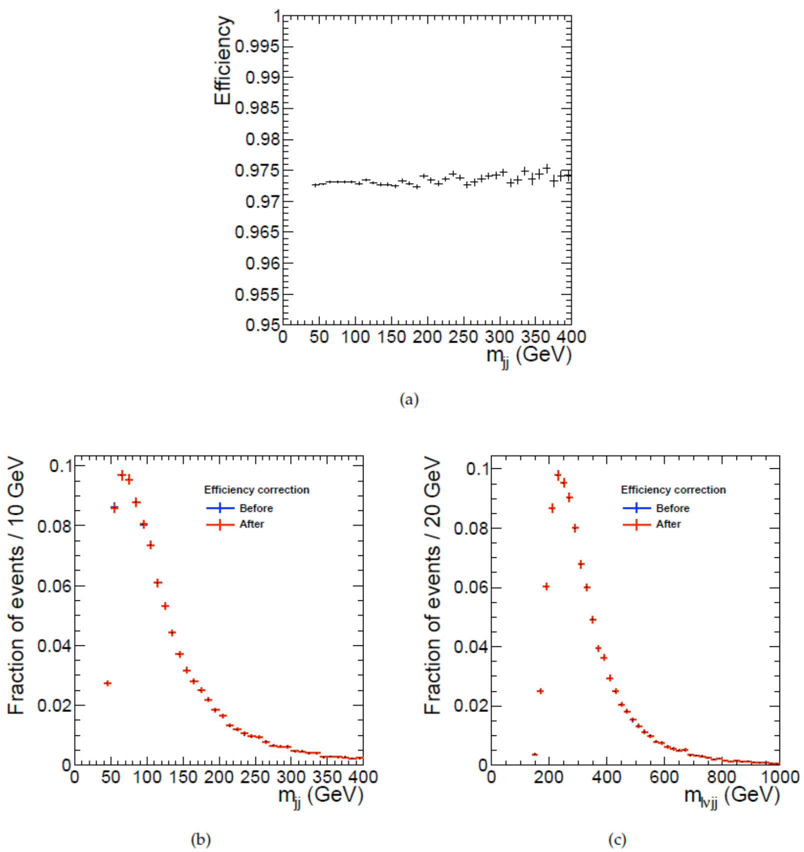


Luminosity weighted average efficiency scale factors (data/MC) for electron reconstruction, i.e., super cluster →GSF electron (a) and electron ID (b).

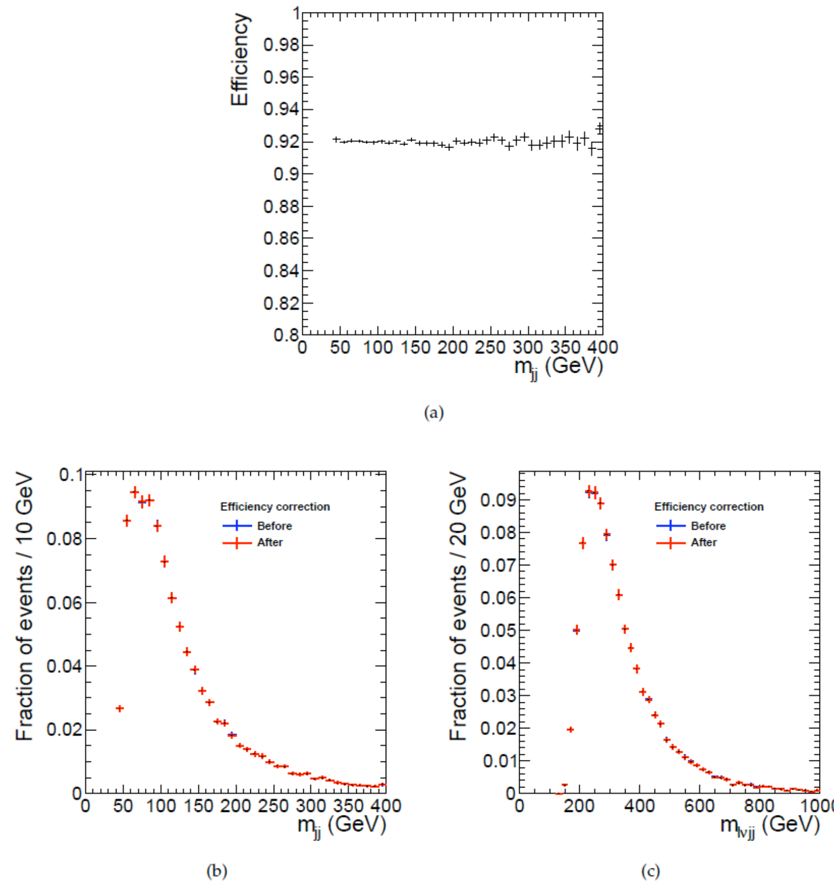


(a) (b)

Trigger Efficiency Effects II



Luminosity weighted average trigger efficiency in the muon data as a function of m_{jj} (a). The effect of this efficiency correction on W+Jets shape is shown for m_{jj} (b) and $m_{l\nu jj}$ (c) templates.



Luminosity weighted average trigger efficiency in the electron data as a function of m_{jj} (a). The effect of this efficiency correction on W+Jets shape is shown for m_{jj} (b) and $m_{l\nu jj}$ (c) templates.

Ele+2Jet+MHT Trigger

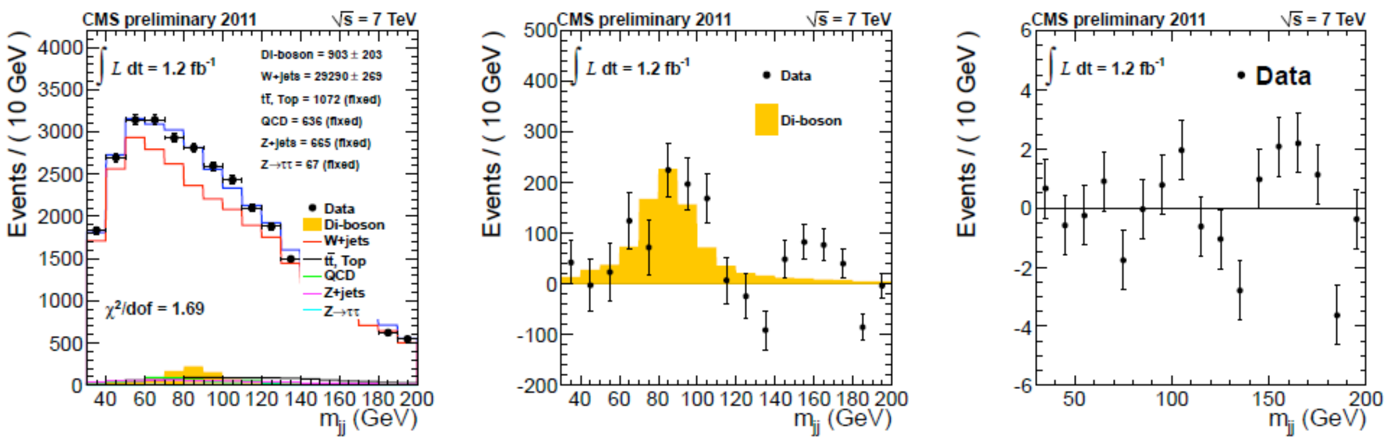
- **Appendix H: Jet p_T threshold studies.**
  - **We examine the impact that changing the cuts would have on the fit results. p_T>50GeV for both jets is needed to remove the problems associated with the kinematic turn-on (<40% of the data is left).**
- **Appendix I (with references to Sections 8 and 9): Trigger Epoch Comparison in The Electron Channel.**
  - **The Ele+2Jet+MHT trigger is described.**
  - **Subsection I.9: A separate fit is performed to the epochs using & not using the two jet calorimeter trigger. Only the fit to the one without the calorimeter (880pb^{-1}) gives a reasonable result.**

❖ **Since either of the approaches would remove most of the electron data we decided to use the Single Electron Trigger instead, where the loss is ~15% versus the Electron+2Jet.**

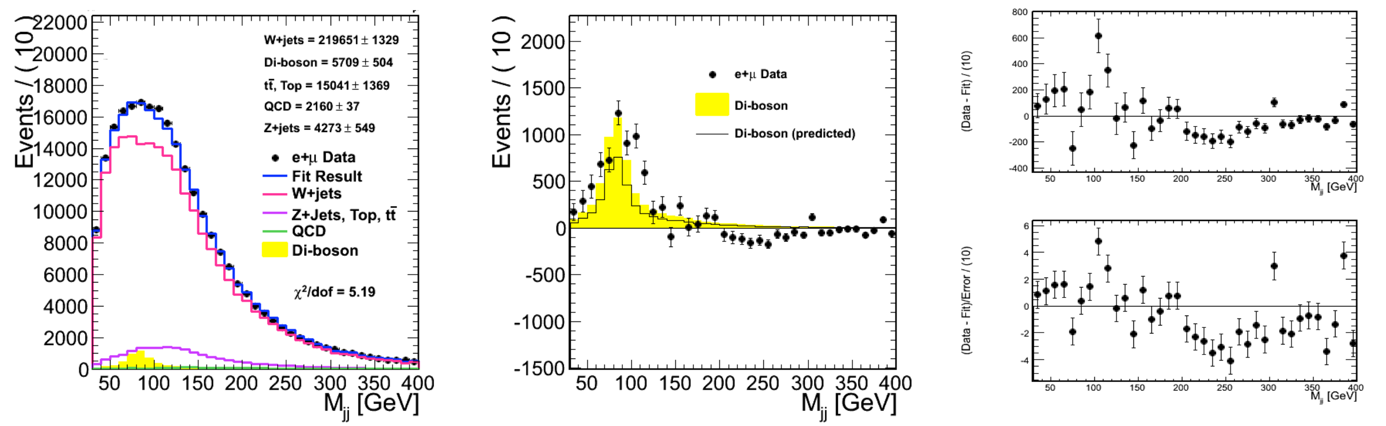
CDF-Like Fitter

❖ Looked at independently by two groups.

Preliminary 1.2fb^{-1}



4.7fb^{-1}



❖ Lower quality fit

❖ Higher systematic uncertainties

Event Generation

❖ Correlations must be taken into account when smearing the Expected Values.

➢ Perform the smearing by first transforming to a 'coordinate system' where the Yields are uncorrelated:

1). Diagonalize the Covariance Matrix (Σ). I.e. find M such that $M\Sigma M^{-1}$ is diagonal (Rows of M are the eigenvectors of Σ).

2). Generate the errors z_i: throw the random events with $\sigma_i^2=(M\Sigma M^{-1})_{ii}$ and mean=0.

3). Transform back: $x_i=\mu_i+(M^{-1}Z)_i$ (μ is the expected value from the default fit).

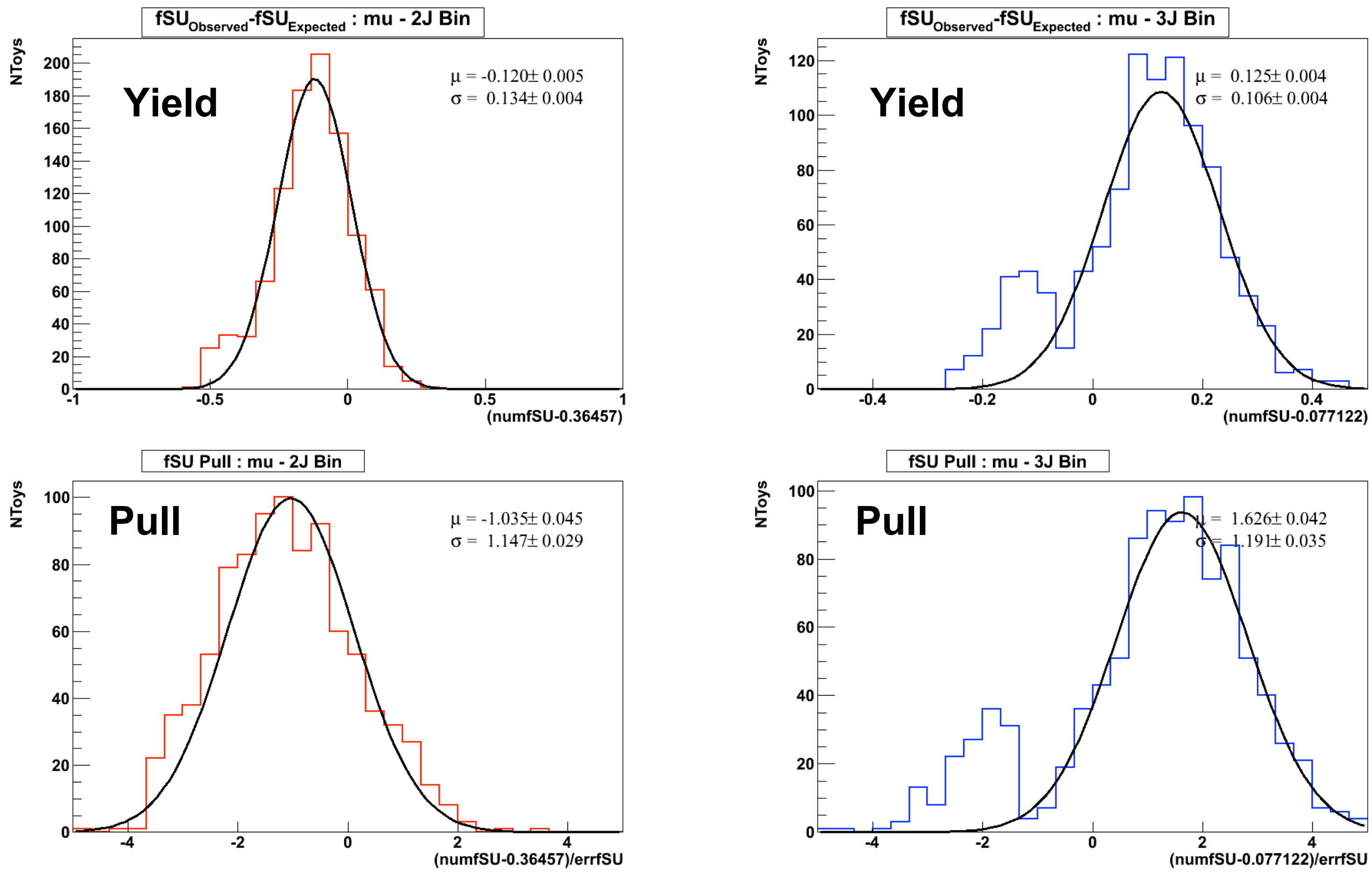
4). Poisson-smear x_i & generate.

➢ Fit the datasets

Validation Procedure

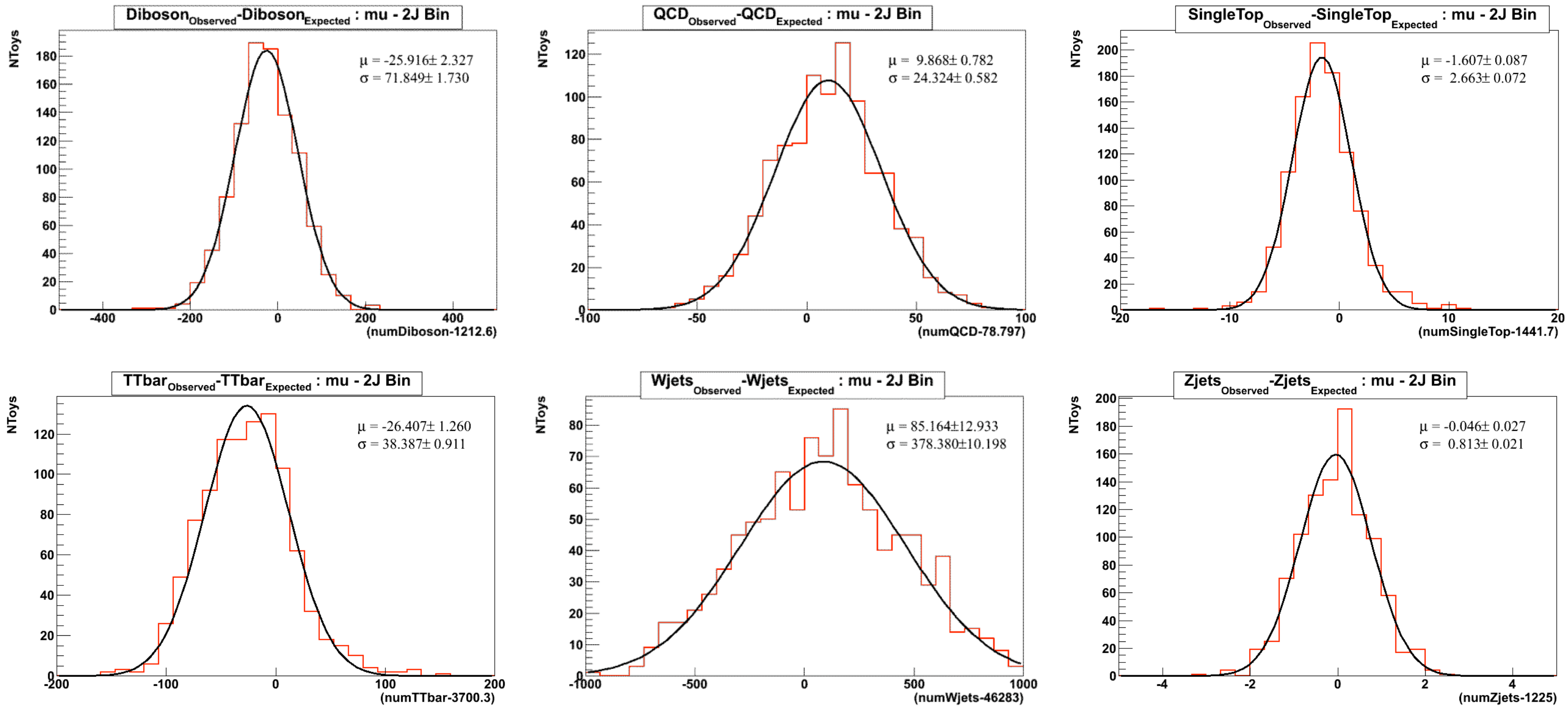
- **Perform the fit to obtain the expected yields.**
- **Generate Toy Monte Carlo for each process from the corresponding MC.**
- **Construct 1000 Sample Datasets.**
  - **Take correlations (between expected yields) into account.**
  - **Implement smearing by Fit and Poisson errors**
- **Perform the fit for each sample dataset.**
- **Examine the resultant Yields and Pulls.**

Factorization Scale Variations



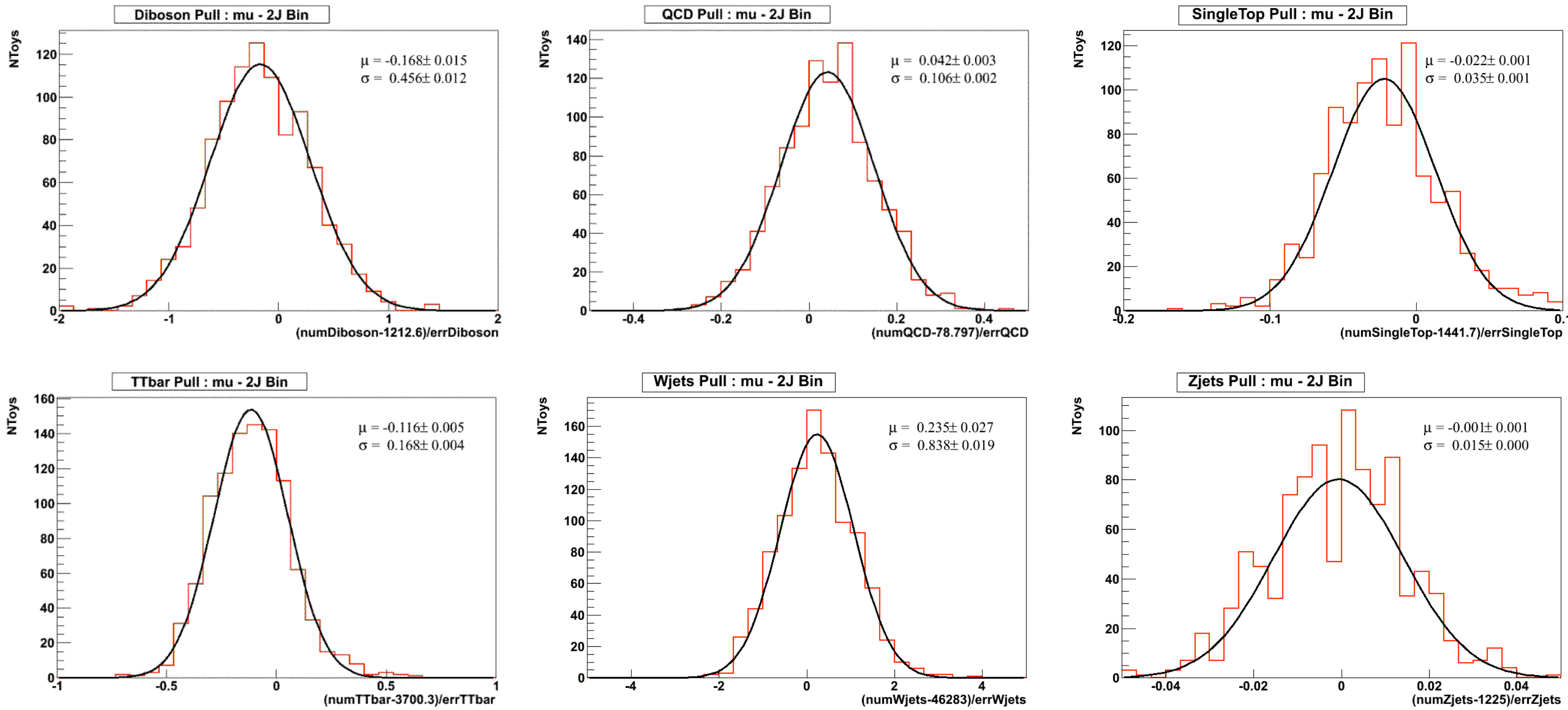
❖ **Structural anomalies and overestimated uncertainties observed**

Yields: 2J Bin



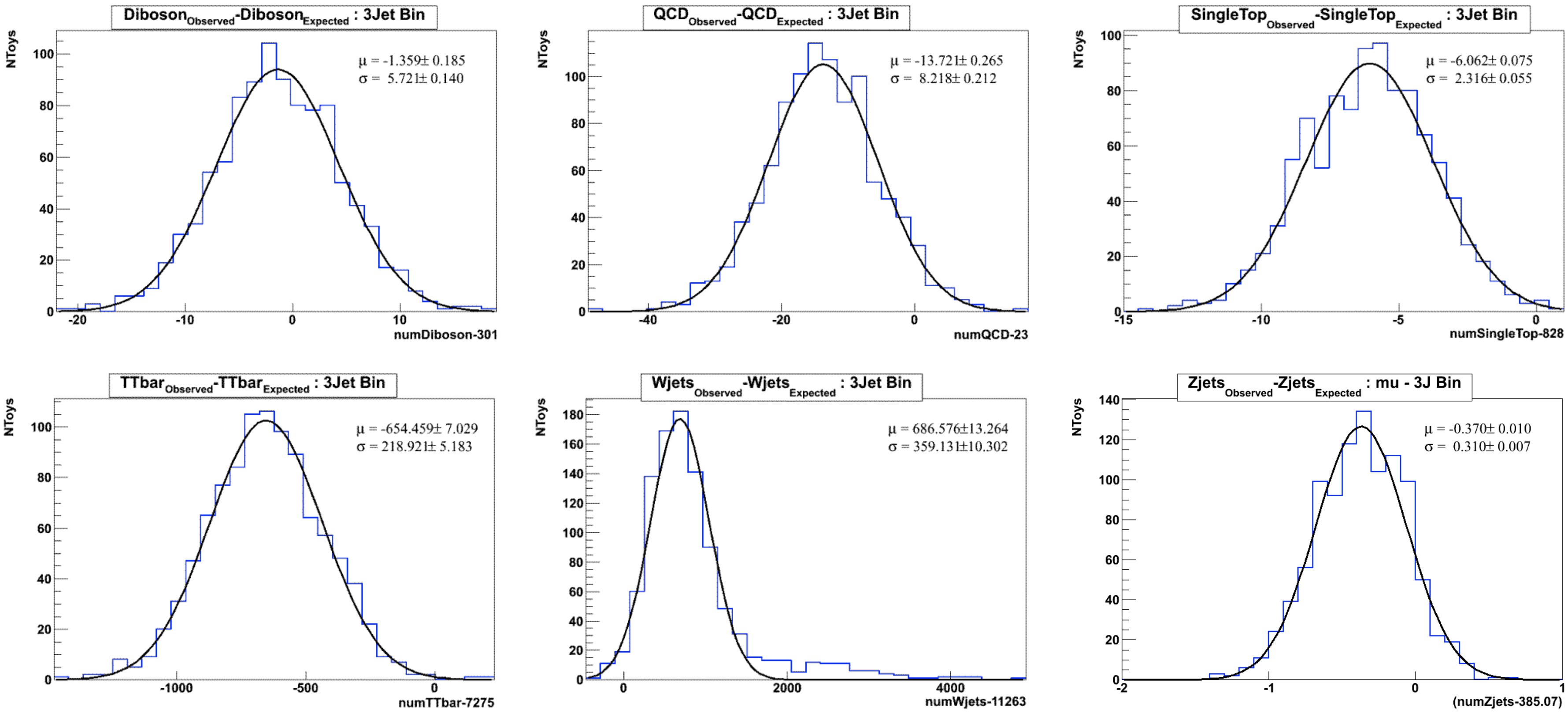
- **Variation in sharpness of the peaks is due to differing constraints imposed when fitting**
- **Small Biases Observed**

Pulls: 2J Bin



- $\sigma_{Pull}<1$
- The spread is underestimated due to lack of sensitivity to the distribution

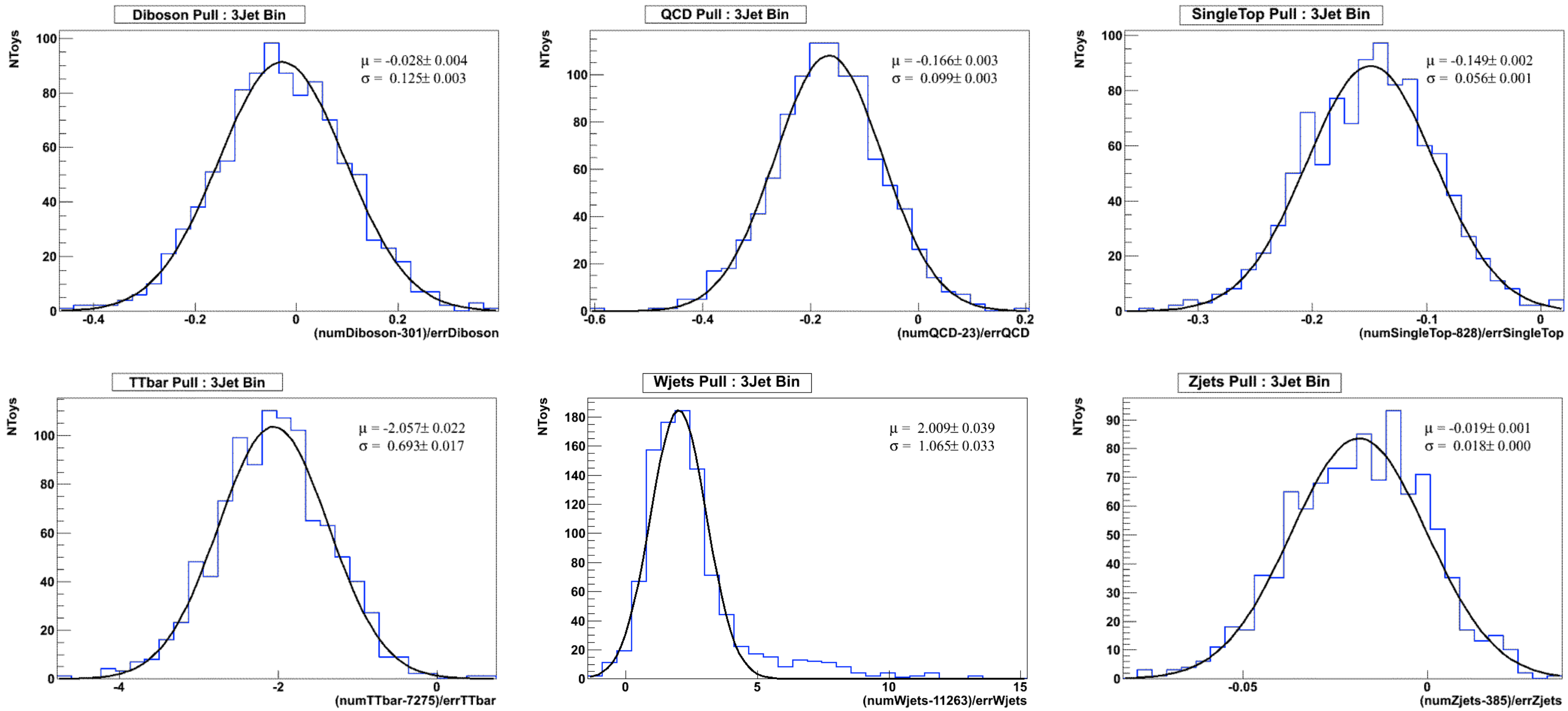
Yields: 3J Bin



✓ **Consistent with the 2J Bin Results:**

- **Variation in sharpness of the peaks is due to differing constraints imposed when fitting**
- **Small Biases Observed**

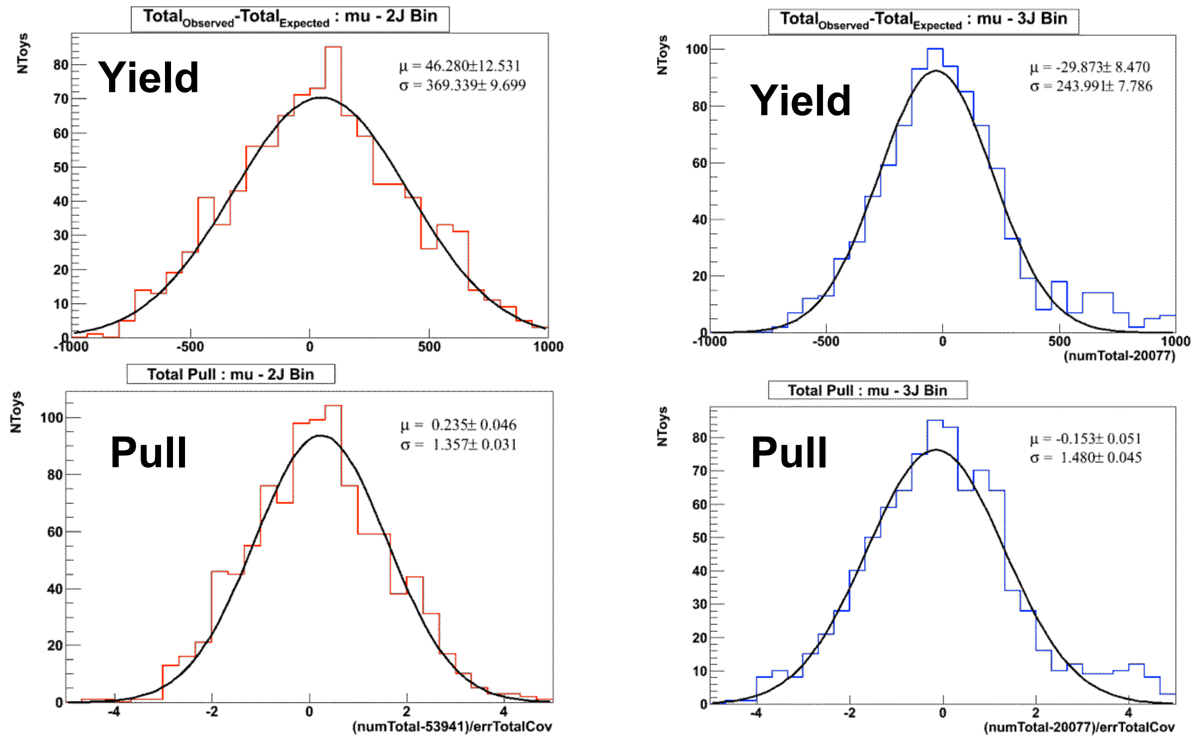
Pulls: 3J Bin



✓ **Consistent with the 2J Bin Results:**

- σ_{Pull}<1
- **The spread is underestimated due to lack of sensitivity to the distribution**

Total Yield & Pull



- Gaussian Distributions for Yields and Pulls centered near 0.
- Pull σ is somewhat overestimated due to lack of sensitivity in the fitter (e.g. difficulties fitting for fMU, fSU).
- Increase the error on the Total Yield by 1.357 (1.48) for the 2-Jet (3-Jet) Bin result.

Validation Results

Parameter Fit Summary

Parameter (Fitted-Expected)	2-Jet Mean	2-Jet σ	3-Jet Mean	3-Jet σ
Diboson	-25.9 ± 2.4	71.8 ± 1.7	-1.4 ± 0.2	5.7 ± 0.1
W+jets	85.2 ± 12.9	378.4 ± 10.2	686.6 ± 13.3	359.1 ± 10.3
Z+jets	0.05 ± 0.03	0.81 ± 0.02	-0.37 ± 0.01	0.31 ± 0.01
QCD	9.9 ± 0.8	24.3 ± 0.6	-13.7 ± 0.3	8.2 ± 0.2
$t\bar{t}$	-26.4 ± 1.3	38.4 ± 0.9	-654.5 ± 7.0	218.9 ± 5.2
SingleTop	-1.6 ± 0.1	2.7 ± 0.1	-6.1 ± 0.1	2.3 ± 0.1
fMU	-0.01 ± 0.00	0.13 ± 0.00	0.01 ± 0.00	0.12 ± 0.00
fSU	-0.12 ± 0.00	0.12 ± 0.00	0.12 ± 0.00	0.11 ± 0.00

Pull Fit Summary

Parameter	2-Jet Pull	2-Jet σ_{Pull}	3-Jet Pull	3-Jet σ_{Pull}
Diboson	-0.17 ± 0.01	0.46 ± 0.01	-0.03 ± 0.00	0.12 ± 0.00
W+jets	0.23 ± 0.03	0.084 ± 0.02	2.01 ± 0.04	1.06 ± 0.03
Z+jets	-0.001 ± 0.001	0.015 ± 0.000	-0.019 ± 0.001	0.018 ± 0.000
QCD	0.04 ± 0.00	0.11 ± 0.00	-0.17 ± 0.00	0.10 ± 0.00
$t\bar{t}$	-0.12 ± 0.00	0.17 ± 0.00	-2.06 ± 0.02	0.69 ± 0.02
SingleTop	-0.02 ± 0.00	0.03 ± 0.00	-0.15 ± 0.00	0.06 ± 0.00
fMU	0.13 ± 0.04	1.18 ± 0.03	0.32 ± 0.04	1.19 ± 0.04
fSU	-1.0 ± 0.04	1.15 ± 0.03	1.63 ± 0.04	1.19 ± 0.04

- ❖ **Small bias is corrected for**
- ❖ **Fitter has been verified to be robust and consistent**

Conclusions

- **Successful modeling of dijet mass spectrum in W+jets events**
- **Observe the diboson peak**
- **Smoothly falling spectrum at higher mjj values**
- **No apparent peak in the signal region 123-186 GeV**
- **Exclude several New Physics Models (technicolor and leptophobic Z')**

- **A CDF-Like excess (≈3.4 pb) is excluded at the 99.9999%CL and we set a 95% CL upper limit of 1.3pb on the production cross-section x BR($W \rightarrow l\nu$) for such resonances.**