EWK WG to investigate CDF anomaly

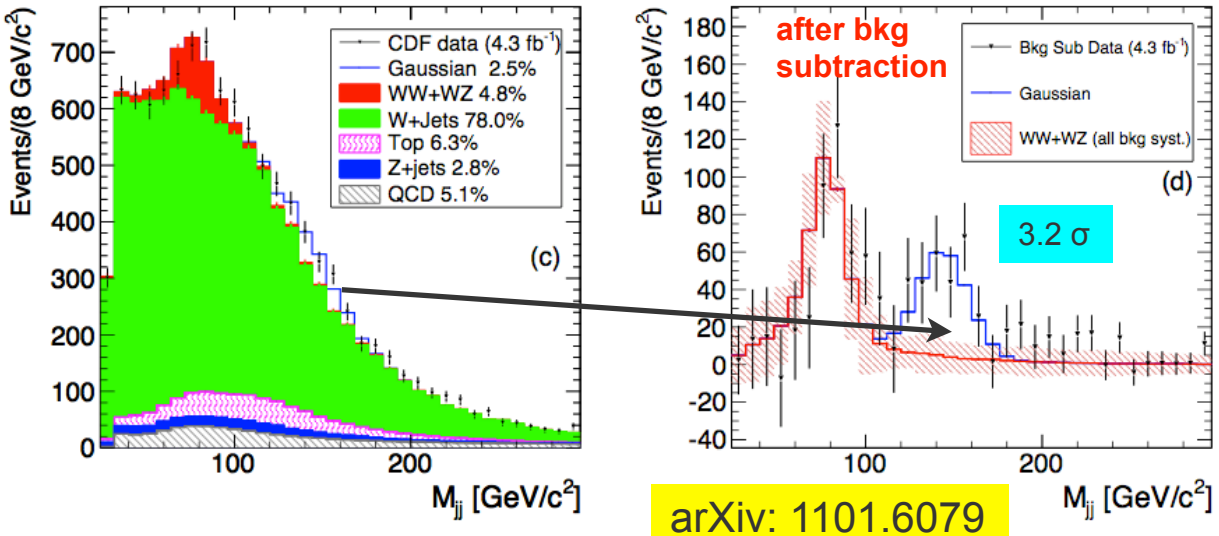
Monika Grothe, Kalanand Mishra

- Introduction to this working group
- Ground rules for operation: organization, meeting, ...
- Planning, logistics: important deadlines, status reports
- Analysis scope: steps, task lists

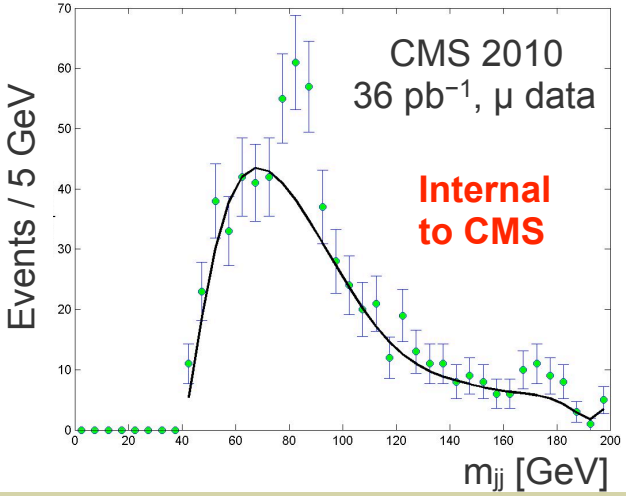
Kickoff Meeting, May 27, 2011

Introduction, purpose of this working group

CDF finds anomaly in W(→lν)+jj events



arXiv: 1101.6079



- ✦W+jj data doesn't have the featureless falloff of dijet mass spectrum
- ✦CDF finds an excess of 253 events, peaked at 150 GeV, width = 15 GeV
- ✦Significance 3.2σ, prod cross section 4 pb

With ~1 fb^{-1} data expected for summer analysis CMS will either exclude the bump with 95% CL or − if it exists − will measure its production rate at LHC

This WG is charged with the immediate goal to produce a result on the time scale of EPS, *i.e.*, by end of July.

Ground rules: how will we operate ?

- We have only 6 weeks to produce result and document it
  - ✓ everyone delivers a well-defined task, not a full analysis
  - ✓ AN and PAS/conf note/ paper: every active WG member contributes
  - ✓ so need to work as a disciplined, focused group
    - -short succinct executive summary from each team member
    - -set weekly goals, assessment of progress made each week
    - -team members remain in contact via AIM, skype, evo on daily basis
    - -new ideas & intellectual input are most welcome

- Some ground rules for today's and subsequent meetings
  - •speak up if you have questions, do not hold until the end of the talk
    - -but be respectful of the time limit
  - •also speak up if need more resources: disk space, permission, ... etc.
    - -let us know ASAP if you are running behind in your task and need enforcement / help

Monika and Kalanand will be accessible via phone, AIM, skype, evo.
Do not hesitate to contact us. We'll set up twiki and instructions soon.

Broad outlines of this analysis

At the end of the day we will find one of the two scenarios:

Case (1) There is no bump around 150 GeV. In this case we will need to exclude just ONE model with 95% confidence: a generic resonance of M≈150 GeV, width ≈ 15 GeV, cross section ≈ 4pb × partonic luminosity ratio of LHC and Tevatron. So, this will be a simple exclusion limit and we will be done.

The last part involves considering at least one new physics model which can reproduce CDF bump, and predict its cross section at LHC. Need to know the efficiency × acceptance for such signal. We have started talking to theorists.

Case (2) There is some excess near 150 GeV. In this case we will measure significance, mass, width, and cross section of the bump − a la CDF. Since the lvjj mass is fully reconstructable (because one can solve quadratic equation for the p_z of neutrino), if the W and dijet bump come from the decay of a massive particle it should be also visible as a bump in the 4-body lvjj invariant mass.

In both cases the analysis will be mostly data-driven with little MC input

What we need to establish along the way ?

Three things:

✦Establish Standard Model electroweak WW+WZ(→lvjj) production
- with both 0 and 1 extra jet − if feasible
  - this will help constrain the JES and nuisance parameters
  - and will establish confidence in our analysis

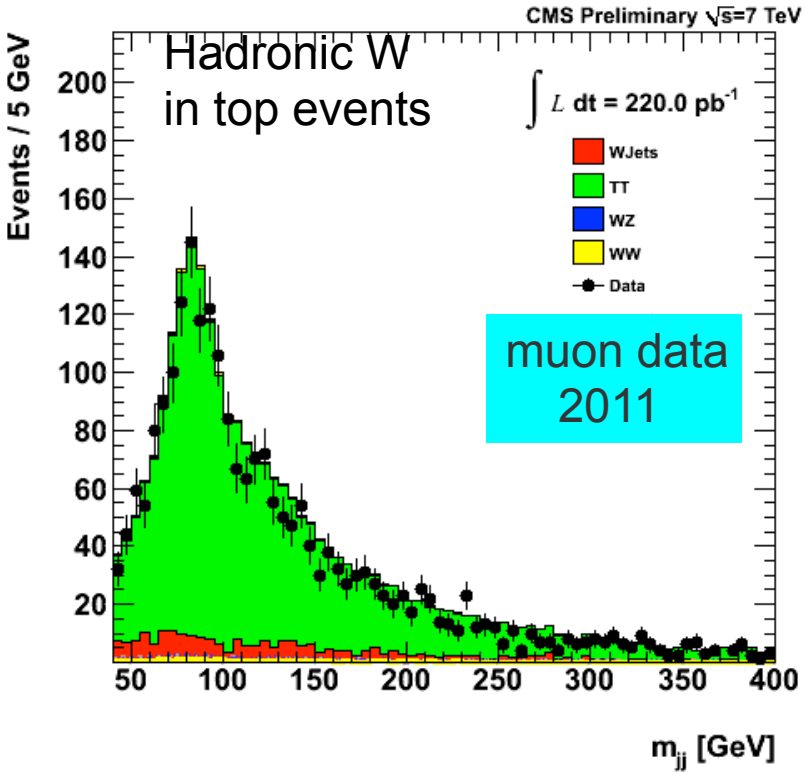
✦Extract both shape and normalization of the W+jets background directly from data
- in other words, thoroughly understand the W+jets background
- otherwise, people will always be skeptical of our result ....

✦Establish a firm understanding of the resolution and shape of W peak in m_{jj} distribution directly from data
- can use to events for this purpose (see next slide)

Some of this work has direct overlap with di-boson subgroup.

Calibrating hadronic W from top events in data

In top events reconstruct clear W peak "out-of-box" with good resolution



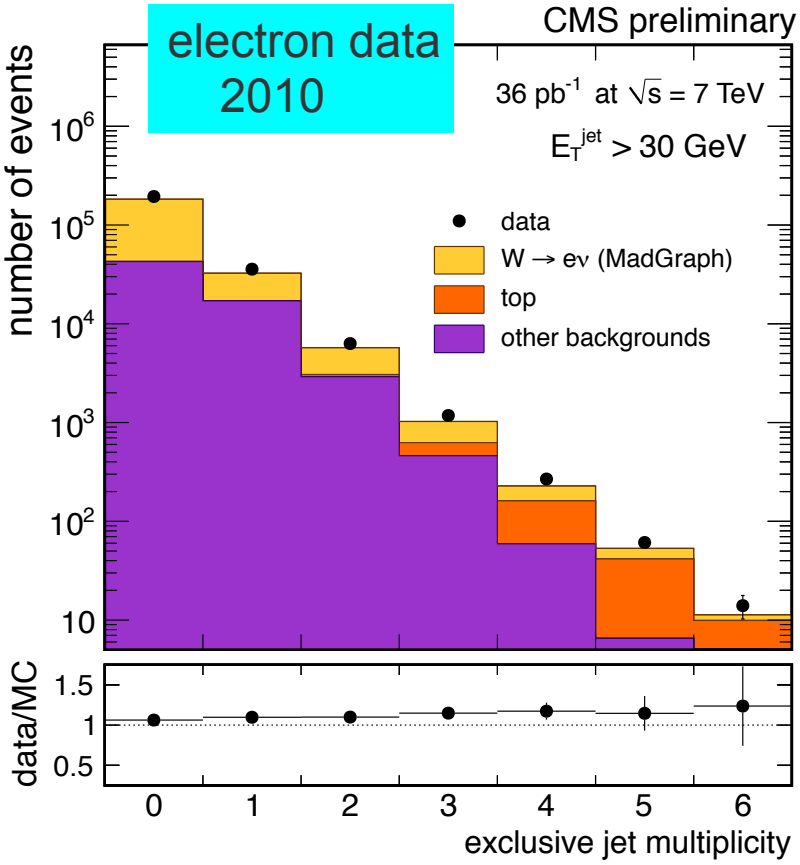
Just require

- ≥4 jets above p_T 25 GeV
- 2 b-tags and
- one leptonic W in the event
  - -mu p_T > 25 GeV OR ele E_T > 25 GeV
  - -MET > 20 GeV

Plot m_{jj} of those two jets which are not b-tagged. This is a pure W→jj sample.

Resolution in hadronic W shape is dominated by jet resolution

And need to monitor basic V+jets distributions



- Key background for us
- Standard strategy:
  a) LO matrix element calculations for each jet multiplicity,
  b) interface with parton shower MC using specific matching recipe (AlpGen, MadGraph, Sherpa)

- Despite difficulty some NLO calculations appeared recently

Build on the excellent work done by EWK V+jets sub-group. Also get in contact with theorists to use NLO cross sections/ shapes wherever possible.

Needless to say, we need to make monitoring plots of jet and boson kinematic differential distributions (e.g., in p_T, rapidity) to make sure we understand the data.

Are we triggering on the events we need ?

Yes, but life is a little complicated ....

✦For 2010 data (36 pb^{-1}) use single lepton triggers with p_T > 17 GeV (or lower)

✦For 2011A data before technical stop (~200 pb^{-1}) still rely on single lepton triggers: Mu_24 (non isolated) and Ele_27 (CaloId, TightIso)

- So, have to go to offline cuts: mu p_T > 25 GeV, electron E_T > 30 GeV

✦For 2011 data after technical stop (~ 100 pb^{-1} so far) there is dedicated "Ele17_CentralJet30_CentralJet25_MHT20" trigger. For muon still rely on Mu_24

- go to following offline cuts to be minimally tighter than trigger:

pfMET>20 GeV, W transverse mass > 50 GeV
leading pf jet pt > 30 GeV, second jet pt > 25 GeV.

✦ Now also have an "inclusive" W trigger in the next menu for electron: keeps electron E_T > 25 GeV (or 30 if needed), pf MET > 25 GeV, W m_T > 40 GeV.

✦Need similar W trigger for muon and also Mu+MHT+jj trigger

For electron may use: (Ele+MHT+jj) || (W_inclusive). For muons: Mu_24 for now.

Data samples

Already have about 350 pb^{-1} on tape

We will analyze both muon and electron data. We already have a significant fraction of integrated luminosity to be used for summer analysis on tape.

Data 2010: Apr21 re−Reco with 4_2_X

/Mu/Run2010A-Apr21ReReco-v1/AOD
/Mu/Run2010B-Apr21ReReco-v1/AOD
/EG/Run2010A-Apr21ReReco-v1/AOD
/Electron/Run2010B-Apr21ReReco-v1/AOD

Use Apr21 re-Reco JSON
Integrated luminosity ≈ 40 pb^{-1}

Data 2011 before May technical stop: May10 re−Reco with 4_2_X

/SingleMu/Run2011A-May10ReReco-v1/AOD
/SingleElectron/Run2011A-May10ReReco-v1/AOD

Use May20 prompt JSON
Integrated luminosity ≈ 200 pb^{-1}

Data 2011 after May technical stop: prompt Reco with 4_2_X

/SingleMu/Run2011A-PromptReco-v4/AOD
/SingleElectron/Run2011A-PromptReco-v4/AOD
/ElectronHad/Run2011A-PromptReco-v4/AOD

Use latest prompt JSON
Integrated luminosity ≈ 100 pb^{-1}

MC samples

Need to re-weight the MC to match PU in data

4.2.X Summer11 samples needed for this analysis are not produced yet. Physics management recommends using 4.1.X Spring11 samples for summer analysis.

W+ jets (MadGraph)

/WJetsToLNu_TuneZ2_7TeV-madgraph-tauola/Spring11-PU_S1_START311_V1G1-v1/AODSIM

WW, WZ (Pythia6)

/WWtoAnything_TuneZ2_7TeV-pythia6-tauola/Spring11-PU_S1_START311_V1G1-v1/AODSIM
/WZtoAnything_TuneZ2_7TeV-pythia6-tauola/Spring11-PU_S1_START311_V1G1-v1/AODSIM

Top (Powheg, MadGraph)

/TTToLNu2Q2B_7TeV-powheg-pythia6/Spring11-PU_S1_START311_V1G1-v1/AODSIM
/TTJets_TuneZ2_7TeV-madgraph-tauola/Spring11-PU_S1_START311_V1G1-v1/AODSIM
/TToBLNu_TuneZ2_s-channel_7TeV-madgraph/Spring11-PU_S1_START311_V1G1-v1/AODSIM
/TToBLNu_TuneZ2_t-channel_7TeV-madgraph/Spring11-PU_S1_START311_V1G1-v1/AODSIM
/TToBLNu_TuneZ2_tW-channel_7TeV-madgraph/Spring11-PU_S1_START311_V1G1-v1/AODSIM

QCD multi-jets (Pythia6)

/QCD_Pt-20to30_EMEnriched_TuneZ2_7TeV-pythia6/Spring11-PU_S1_START311_V1G1-v1/AODSIM
/QCD_Pt-80to170_EMEnriched_TuneZ2_7TeV-pythia6/Spring11-PU_S1_START311_V1G1-v1/AODSIM
/QCD_Pt-20_MuEnrichedPt-15_TuneZ2_7TeV-pythia6/Spring11-PU_S1_START311_V1G1-v1/AODSIM
/QCD_Pt-20to30_BCtoE_TuneZ2_7TeV-pythia6/Spring11-PU_S1_START311_V1G1-v1/AODSIM
/QCD_Pt-30to80_BCtoE_TuneZ2_7TeV-pythia6/Spring11-PU_S1_START311_V1G1-v1/AODSIM

Analysis steps: task list

step 0: Use baseline W,Z selection using recipe from EWK/top PAG

step 1: Use pfJet and pfMET as recommended by JetMET POG
- charge hadron subtraction: get rid of jets generated from PU
- fastJet area subtraction: remove contribution to jet energy from PU
- default “relative”, “absolute”, and “residual” jet corrections
- may need flavor-dependent corrections for light-flavor and b- jets
- switch to fully corrected MET when it becomes available

step 3: Examine basic V+jets differential distributions: pT, eta
step 4: select W+2j and Z+2j events using exactly two jets, plot mjj

step 5: Establish di-boson production using appropriate selection criteria
step 6: Data-driven shape for W+jets and QCD multi-jet
step 7: Data-driven shape/resolution for hadronic W using top data sample
step 8: use some new physics model to optimize cuts for “CDF bump”

step 9: perform signal extraction
step10: set limits

Signal extraction procedure

✦Extract W+jets + QCD multi-jet background shape from data-driven technique: either by inverting the selection criteria or by relaxing them. We need to try both. Float the absolute normalization in data fit.

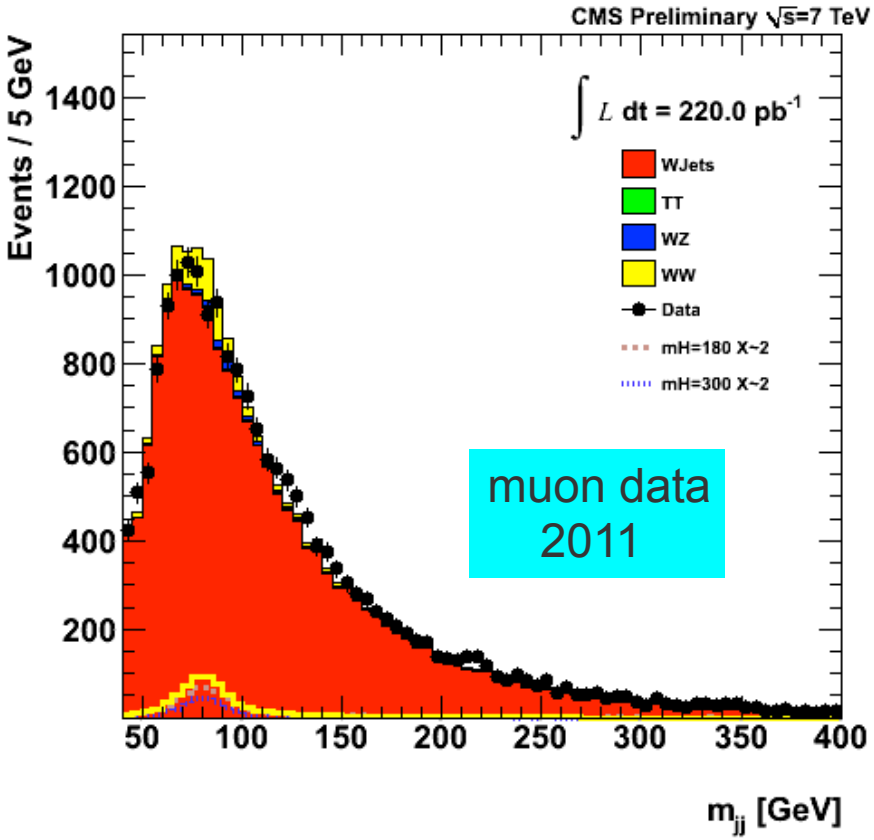
✦Calibrate hadronic W shape using top events. Can even use some limited MC input if needed. WW production cross section is computed up to NLO and also measured by CMS in leptonic channel (although with large uncertainty). We can constrain the absolute normalization of WW and WZ to one of these value or let it completely float.

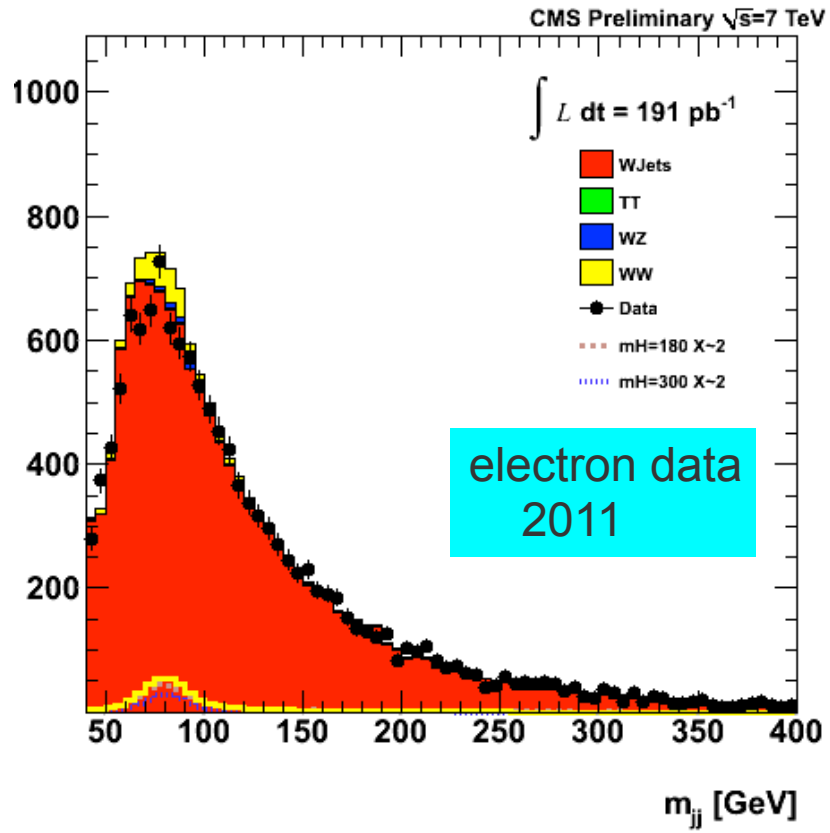
✦Shape of the CDF bump can be taken as a Gaussian. The absolute normalization will come from fit to data, which will set limit on its production rate. We can do this as function of mass and/or width.

Will fine tune the technique as we go along

First look at 2011 data (I)

Dijet invariant mass in W+jj events out-of-box. Just require a tight lepton (μ or e passing top tight isolation / WP80), pf MET > 20 GeV, exactly 2 pf jets > 25 GeV.

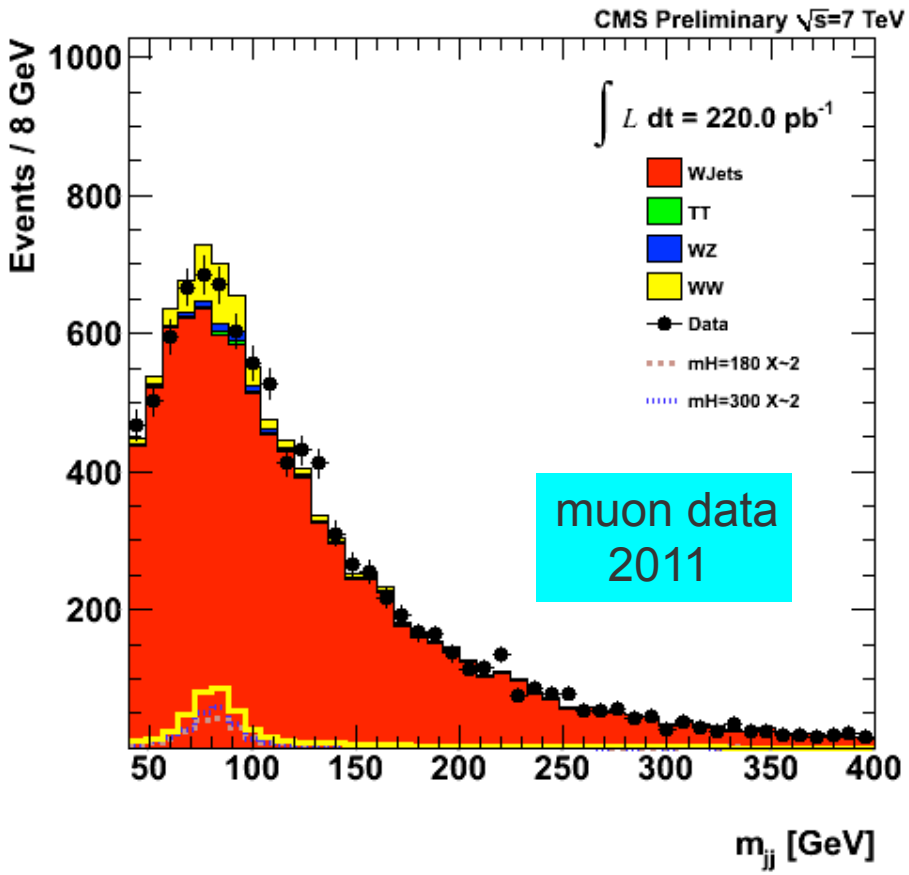


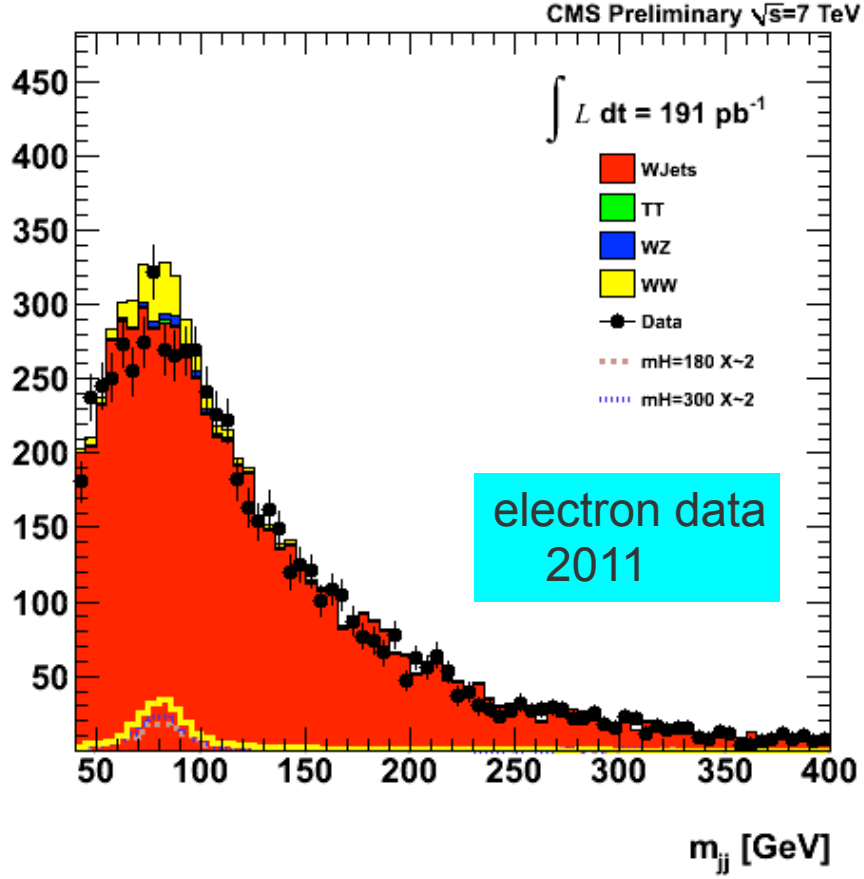


First look at 2011 data (II)

Dijet invariant mass in W+jj events after a simple $|\Delta\phi\ (W_{l\nu}, W_{jj}) - \pi| < 0.2$ cut

Start seeing the emergence of hadronic W peak from the W+jets bkg.





Summary

- The WG has formally started investigating the m_{jj} in W+jj events
  - a basic plan in place
  - will work closely with di-boson sub-group, build on V+jets foundation
  - pay close attention to trigger and will help validate the ones we use
  - 2010 data was well-understood, first look at 2011 data is promising
- Today's kickoff meeting aimed at getting started with right foot
  - get interested people on board
  - involve broader CMS community
- Some introductory presentations today
  - few people on vacation/ traveling but have pledged effort
  - or have volunteered graduate student

BACKUP SLIDES