Study of diboson WW,WZ production in W(→lν)+jj Events

Andrea Benaglia, Pietro Govoni, Leonardo Di Matteo (Milano-Bicocca)
Sarah Boutle, Joey Goodell, Chris Neu, John Wood (Virginia)
Kevin Lannon, Wuming Luo, Jason Slaunwhite (Notre Dame)
Jeffrey Berryhill, Pushpa Bhat, Dan Green,
Kalanand Mishra, Fan Yang, Francisco Yumiceva (Fermilab)
Andre Sznajder (UERJ, Brazil & Fermilab LPC)
Pratima Jindal (Nebraska)

Disclaimer: Plots shown here are very preliminary, NOT approved for showing outside CMS.

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Why we are interested in W(→lν)+jj ?

- W(→lν)+jj is important for variety of reasons
  - ✓Establish electroweak WW diboson production at CMS using W→jj
  - ✓BR for WW→lνjj is 6 times larger than WW→lνlν yielding more events
  - ✓Search mode for SM Higgs with mass above 160 GeV
  - ✓Search for resonances/bumps from new physics

- WW (and WZ)→lνjj is fully reconstructible: can look for WW "bumps"
  - •W pair with μ/e+MET + exactly 2 jets. Solve for kinematics
  - •Most events have solutions with 2 real roots for p_z of ν
  - •Main backgrounds are W+jj, top, and QCD multi-jet
    - -Top background can be reduced by asking for no b tags and for exactly 2 jets ("top veto").
    - -W+jj and QCD multi-jet backgrounds can be reduced by requiring a W mass for the jet pair and other kinematic cuts

For details please see ➡

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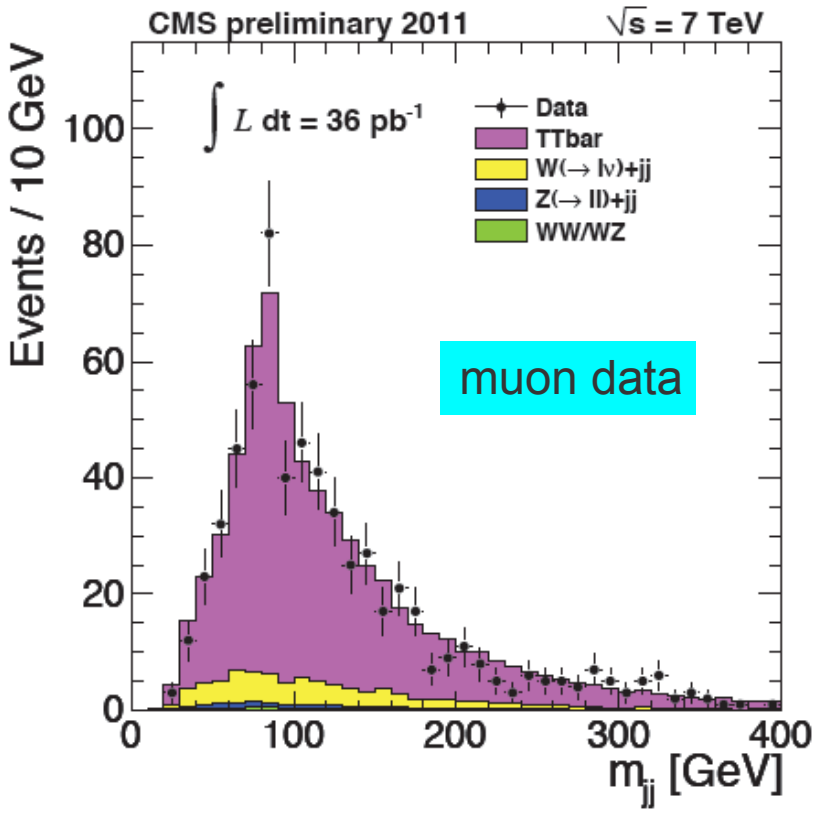
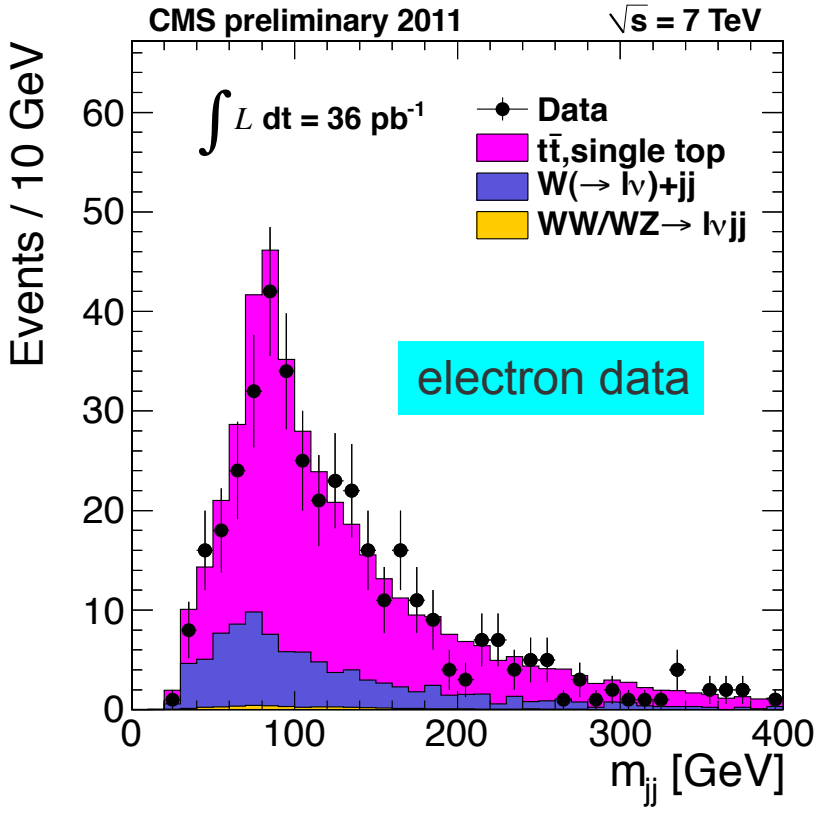
Can we reconstruct hadronic W in CMS ? Yes

In top events reconstruct clear W peak almost “out-of-box” with good resolution

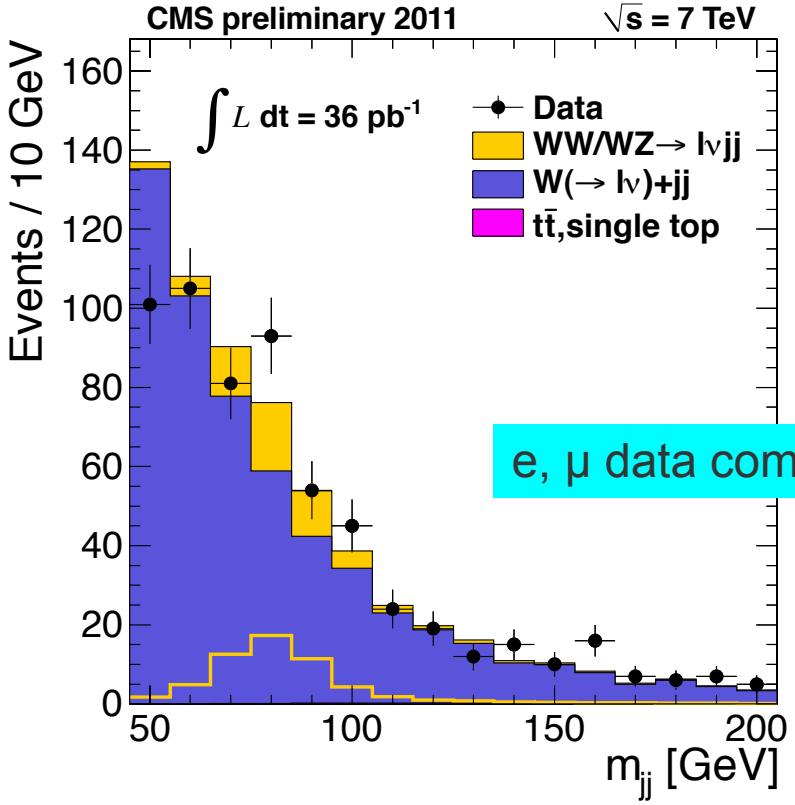




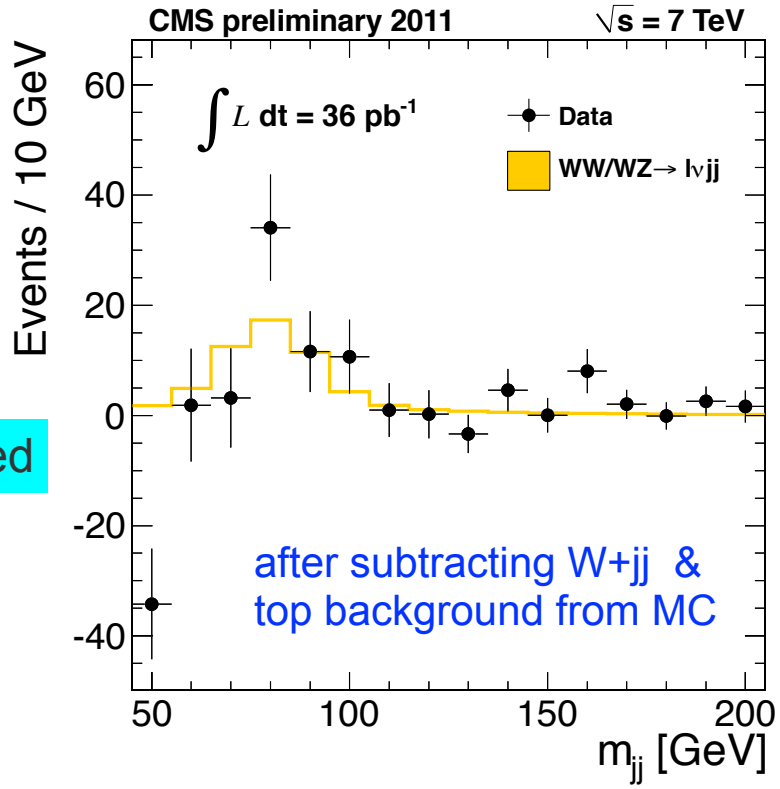
Just require ≥4 jets above p_T 25 GeV, ≥1 b tag and leptonic W (muon: p_T>20 GeV, MET>20 GeV; electron: E_T>25 GeV, MET>25 GeV). Then plot m_{jj} of the two jets which are not b-tagged. Keep all combinations.

Do we see hadronic W/Z peak in W+jj events?

Yes



e, μ data combined

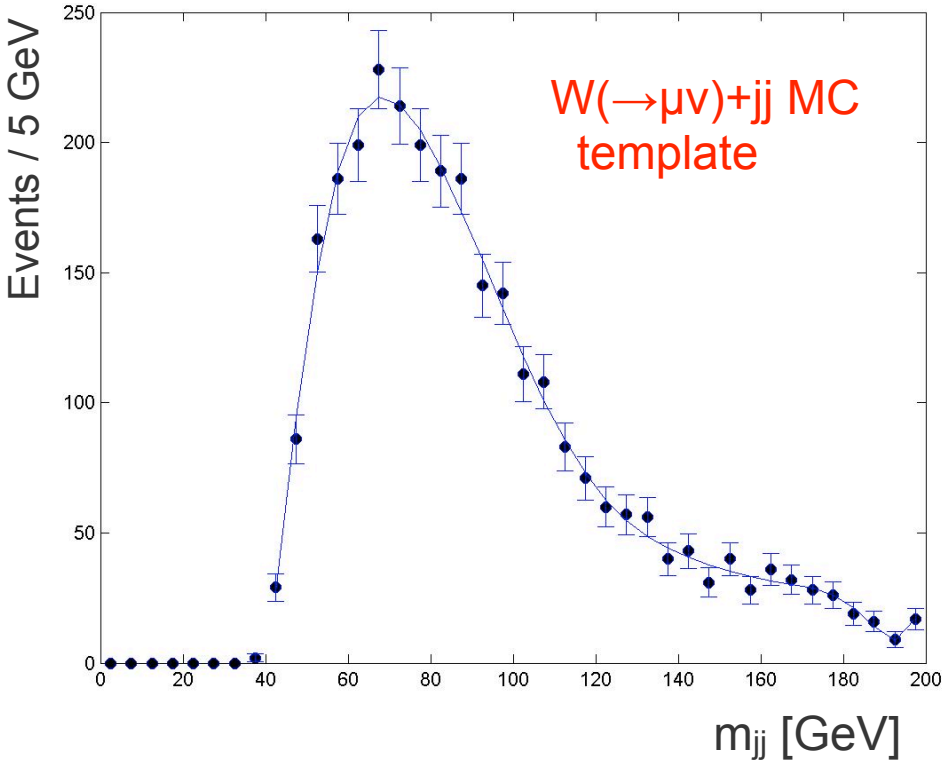


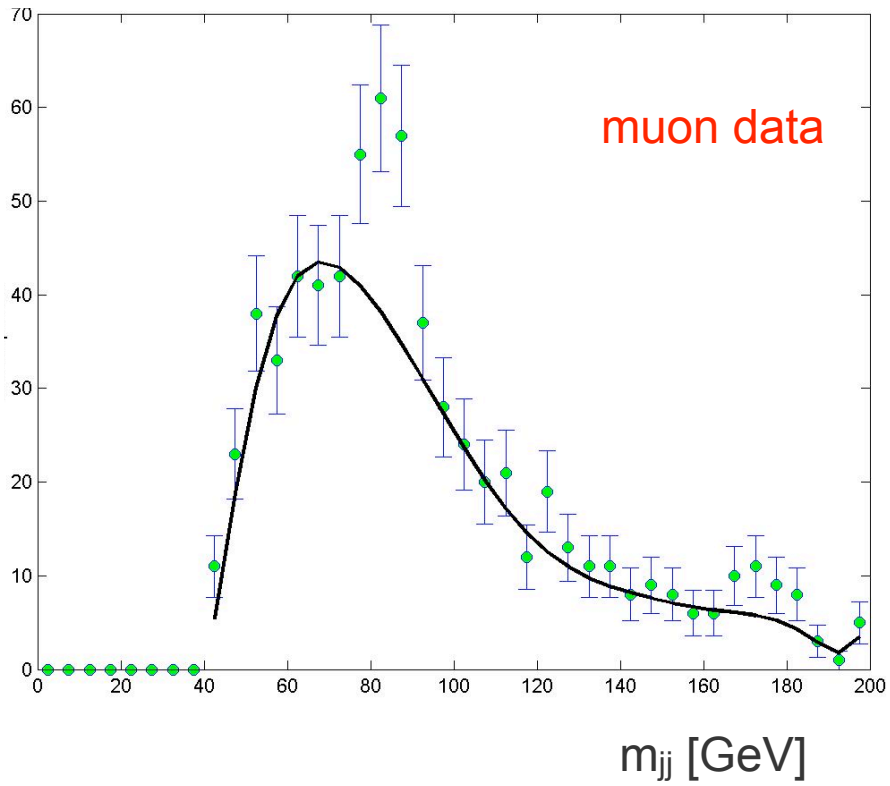
After applying top veto and few simple kinematic cuts see clear peak from hadronic W and Z. Cannot resolve between the two.

observed events in data = 600, MC predicts:
W+jj = 554, Ttbar + single top = 2, WW + WZ = 58

Can improve S/B by optimizing selection

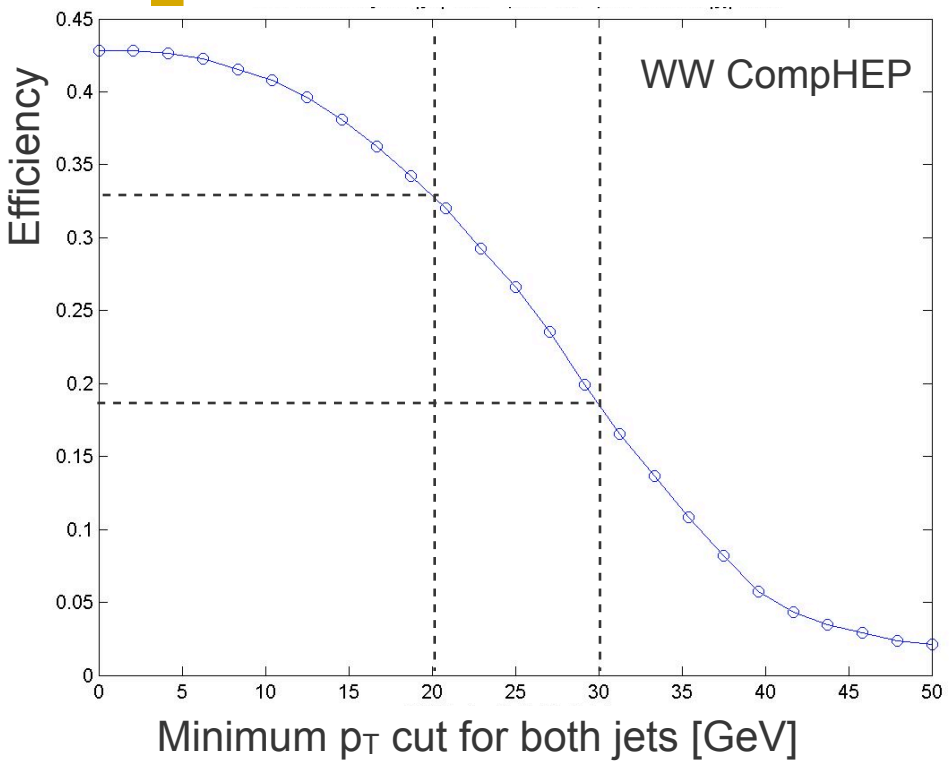
Exploit the angular variables (*e.g.*, angle between the decay planes, and cosθ* for each of the two boson system, Jackson angle etc.) to suppress W+jets bkg.





The fit after all cuts is to the Wjj MC shape. The evidence remains for a W signal in the μ data with ~ 60 ± 20 events above a smooth background.

Keeping W+jj events: big trigger challenge



- WW reconstruction efficiency is a strong function of the cut on jet p_T.
  - We lose ~1.5% of efficiency for each 1 GeV increase in jet p_T cut
- Similar effect from lepton p_T threshold
- Triggering on evjj already challenging if want reasonable threshold to keep most diboson events
  - muons in similar situation with 2x higher instantaneous lumi

Need to make strong case for more BW **now !**

MET >25 GeV will reduce rate by another factor ➜ viable for 2E33 with ele E_T>22 GeV. But MET is uncertain in high PU/ OOP. Jet threshold still too high.

HLT trigger rate (Hz)

Rate projections from run 161311

HLT path	Single Rate @ 5E32	Exclusive Rate @ 5E32	Prescale
Ele17 +	3.8 +- 0.2	1.4	1
CenJet30_CenJet25_PFMHT15	2.8 +- 0.2	1	1
CenJet30_CenJet25_PFMHT20	15.3 +- 0.2	-	20
CenJet30_CenJet25			

Next steps for CMS regarding lvjj analysis

We see three natural phases in the evolution of lvjj analysis:

- Study/measure/understand electroweak WW+WZ(→lvjj) production
  - With both 0 and 1 extra jet − if feasible
    - This will help constrain the JES and nuisance parameters
  - Thoroughly understand the shape of the W+jets background

- Examine the 2011 data as the integrated luminosity increases
  - Trigger is the most critical element in high lumi high pileup scenario
  - Jets and MET with PU are likely to be crucial to optimize.

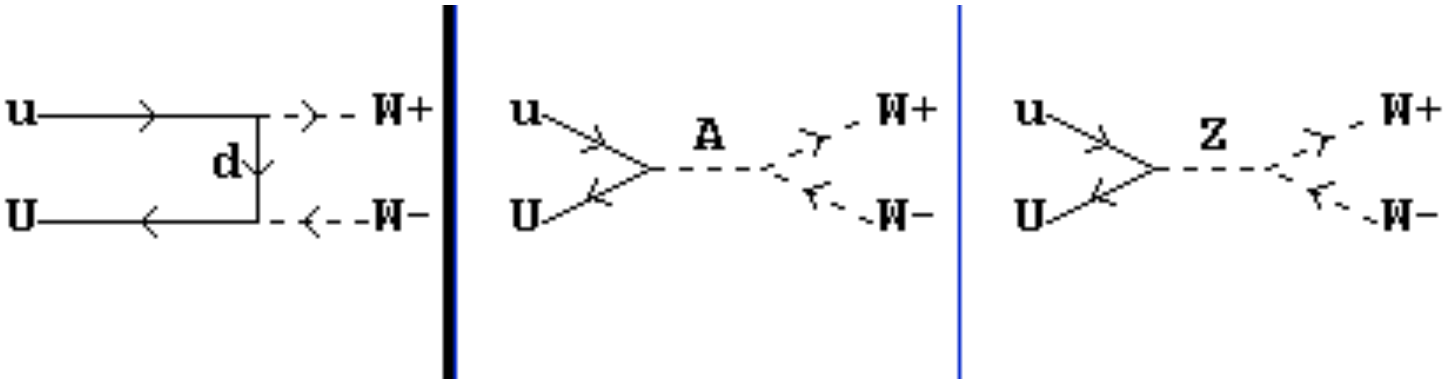
- With a firm understanding of the WW production
  - Will be well positioned to search for resonances (a la CDF bump) and Higgs boson(s)

We plan to contribute to all three phases working with relevant PAGs and POGs.

BACKUP SLIDES

WW production mechanism: LO vs NLO

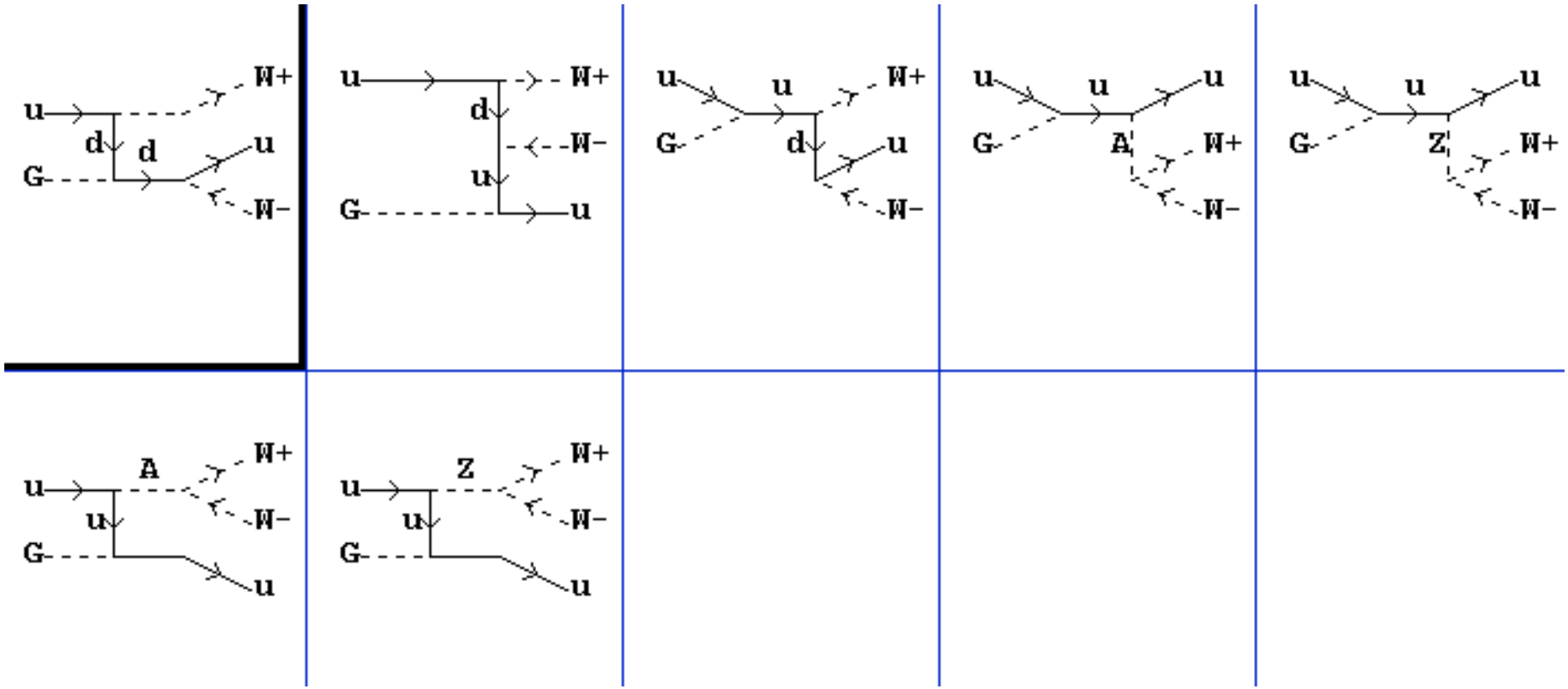
- Use COMPHEP as a quick estimate of the yields.
- The LO tree cross section is 35 pb.
- NLO cross section is 43 pb (WW) and 18 pb (WZ) = 61 pb. In 36 pb^{-1} 2196 WW +WZ are produced. The μ+ν+j+j BR is 2*(1/9)*(2/3), or 325 events each in e, μ.



- NLO processes involve FSR photons and ISR gluons leading to the 43 pb estimate we have assumed.

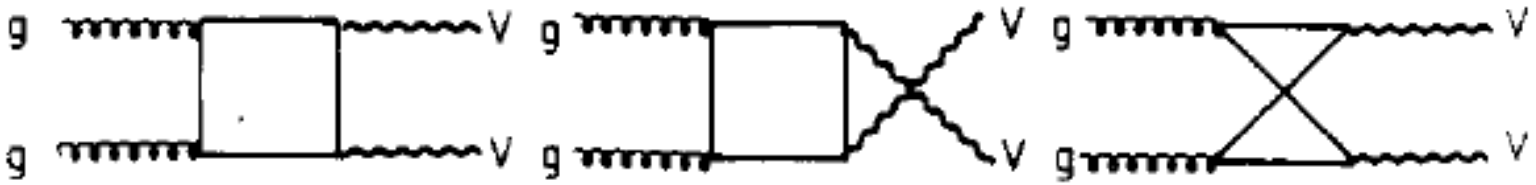
WW production mechanism: NLO

- There are NLO processes like u + g -> W+ + W- + u.
- The COMPHEP cross section for these processes is ~ 13 pb. That is a 36% increase over the LO process.



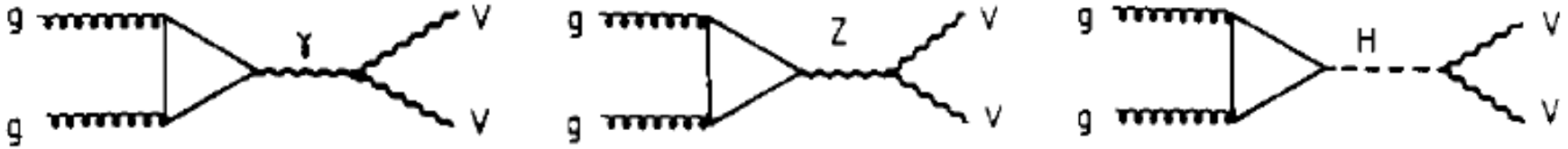
WW production mechanism: more NLO

- There are also g + g processes. The “box” diagram cannot be evaluated in COMPHEP.



- The process g + g -> W+ + W- + q + q is too slow to compute.
- However, it seems clear that there may be W pair processes that moderate the discrepancy between the Monte Carlo prediction and our observed yield.

Other gluon−gluon diagrams



Quick analysis of CMS W(→lν)+jj data

✦W→lν reconstruction
- E_T > 25 GeV, |η| <2.5 (2.1) for electron (muon)
- Passing Top PAG recommended isolation/Id criteria
-W transverse mass: m_T > 50 GeV, PF MET > 25 GeV
-Z veto

✦Require <u>two</u> PF jets in the event
-each jet with corrected p_T >20 GeV and |η| <2.4
-|cosθ*|< 0.4, |Δφ(jet1, jet2)| > 1.5
-|Δφ(jet1, MET)| > 0.6
-|Δφ(W, W) − π| < 0.2
-No b-tagged jets

Apply standard "L2 L3" correction and "residual correction" in data

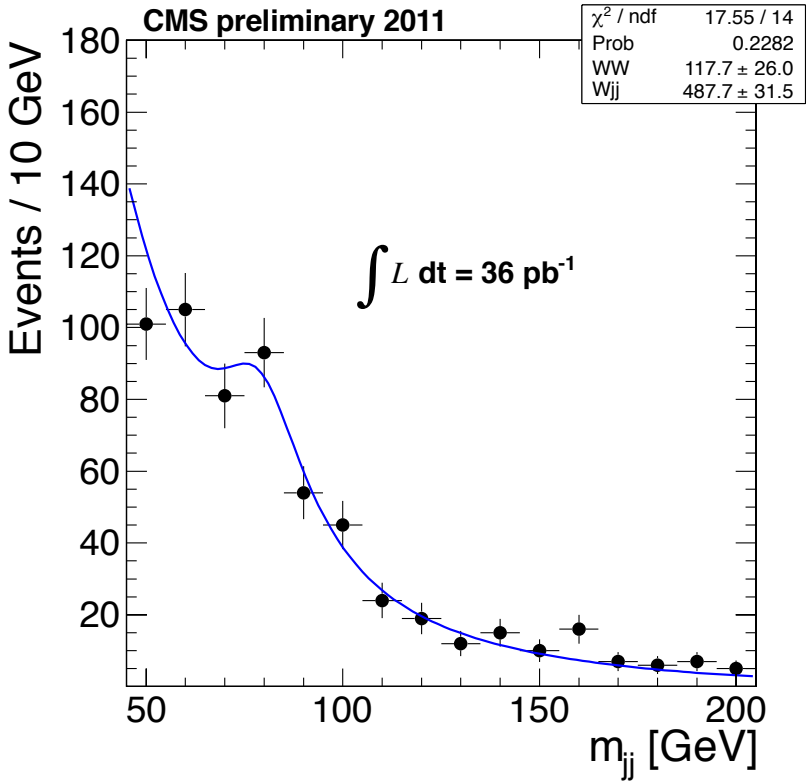
Using 36 pb^{-1} data from 2010 run

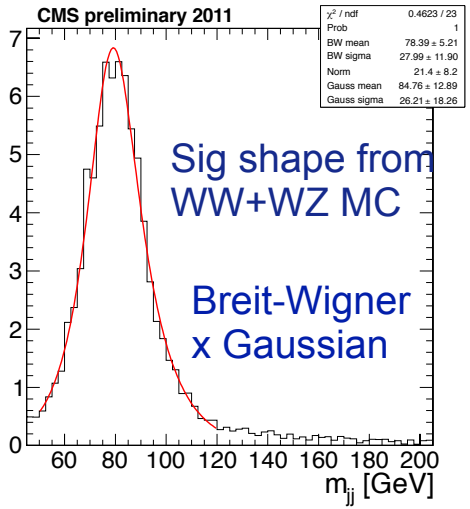
MC: W+jets: Madgraph, Top: Powheg, WW+WZ: Pythia (all with pileup conditions observed in 2010 data)

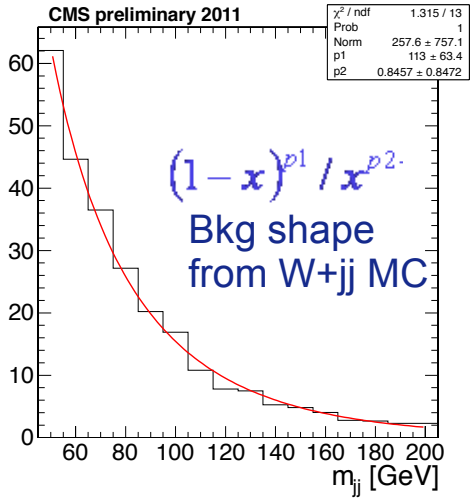
CMS data: WW+WZ signal estimation

(e,μ data combined)

Shape derived from MC.
Fit for the normalization.







WW + WZ yield = 118 ± 26 (stat)
W+jets yield = 488 ± 32 (stat)

Clear evidence of diboson production in lνjj final state in CMS

Any excess between 120−160 GeV is not significant, but is consistent with CDF result.