Status of WW/WZ in lepton-neutrino + jets final state

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Outline

- Analysis blessed:
  1. Event selection
  2. Background Estimate
  3. Fit to data
- Status of the analysis
- Future improvement

Data and MC sample: 3.9 fb^{-1}

DATA

- We use the high P_T lepton data sample for a total statistic of 3.9 fb^{-1} up to period 21
- Electron trigger: ELECTRON_CENTRAL_18
- Muon trigger:
  1. CMUP: run $\leq$ 229763: MUON_CMUP_18_V || MUON_CMUP_18_L2_PT15V
  2. 229763 $<$ run: MUON_CMUP18_V
  3. CMX: run $\leq$ 200272: MUON_CMX18_V || MUON_CMX18_L2_PT15_V
  4. 200272 $<$ run $\leq$ 226194: MUON_CMX18_L2_PT15_V || MUON_CMX18_L2_PT15_LUMI_200_V
  5. 226194 $<$ run $\leq$ 257201: MUON_CMX18_&_JET10_V || MUON_CMX18_&_JET10_LUMI_270_V || MUON_CMX18_&_JET10_DPS_V
  6. 257201 $<$ run: MUON_CMX18_V
- Good run list v28

MC

- PYTHIA is used for signal and top: WW, WZ and $t\bar{t}$
- ALPGEN used for primary backgrounds:
  1. $W \rightarrow l(e, \mu, \tau), \nu$ + partons
  2. $Z \rightarrow ll(e, \mu, \tau),$ + partons
- Trigger efficiency and Lepton reconstruction efficiency by MC, with correction from data
- QCD background extracted from data

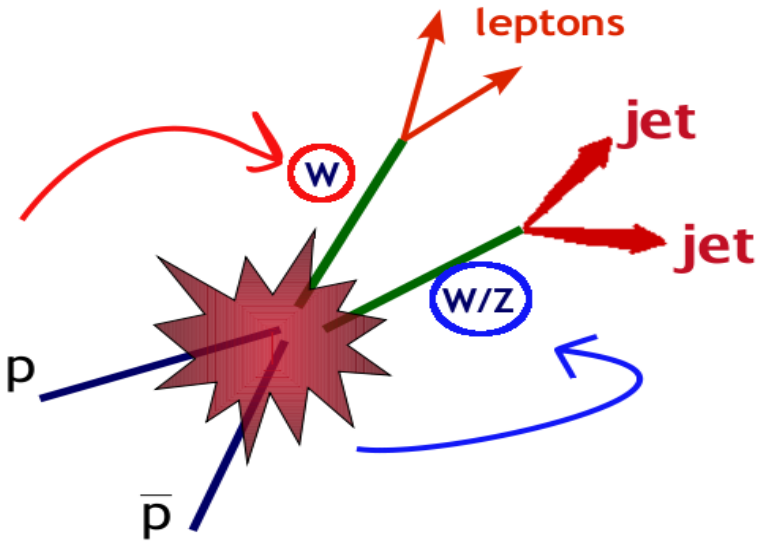
Event selection

Leptonic W candidate:

- one tight lepton (electron or muon) with $E_T > 20$ GeV, $\eta < 1.2$ and $\not\!\!E_T > 25$ GeV
- $M_T(W) > 30$ GeV/c^2 to get rid of large part of the QCD background

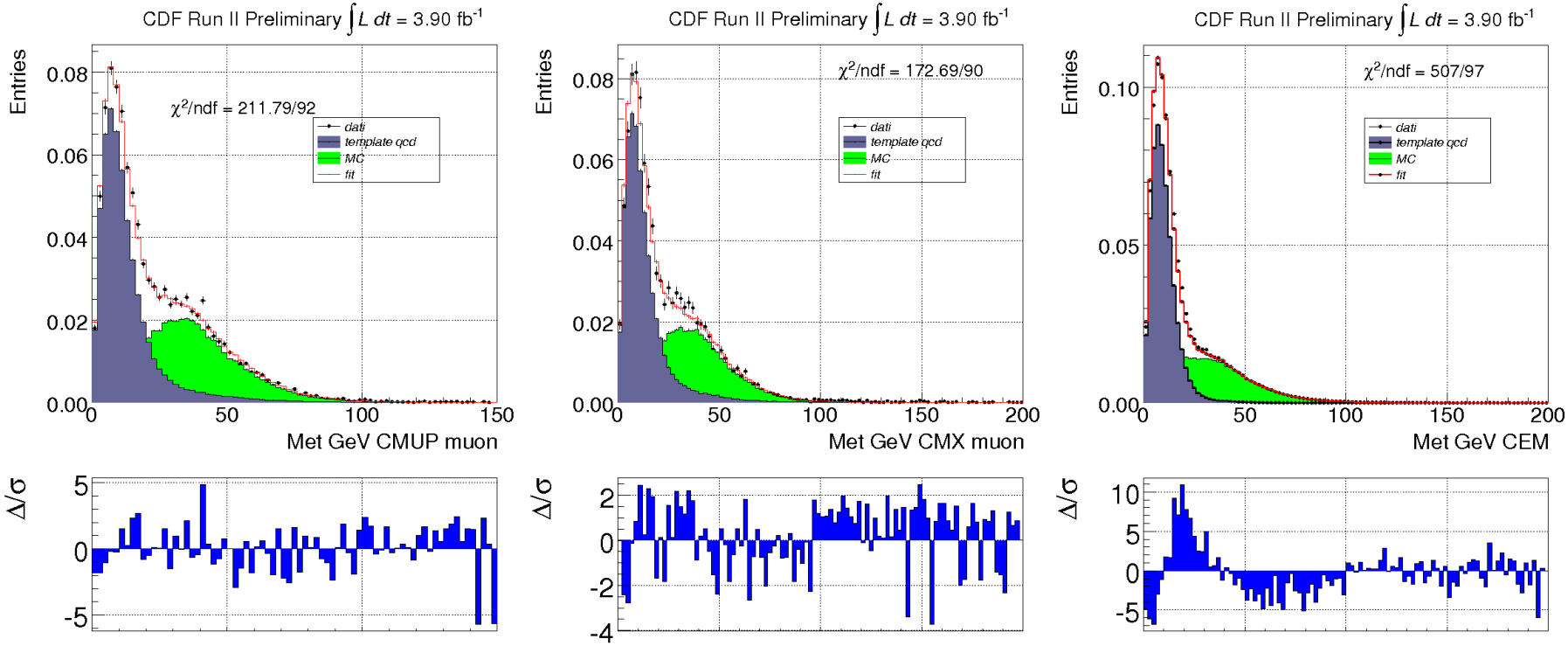
Hadronic W candidate:

- At least 2 jets (reconstructed using JETCLU,R $= 0.4$) with:
  1. $E_T > 20GeV$ corrected at L7.
  2. $|\eta| < 2.4$
  3. $\Delta\eta < 2.5$
  4. Electron removal

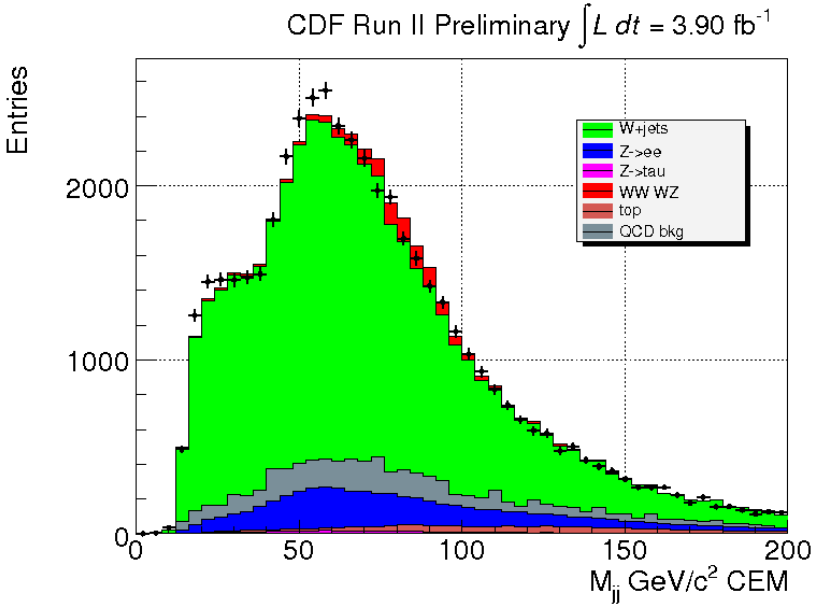


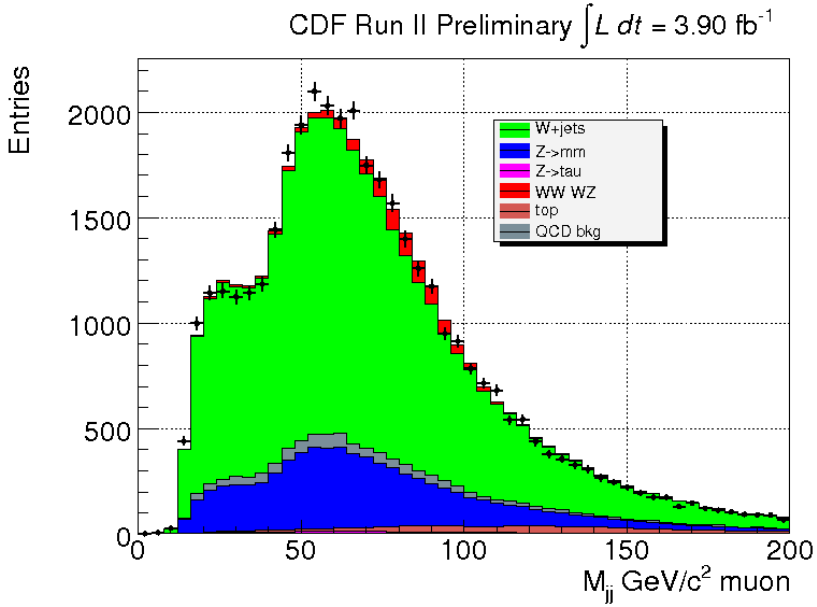
QCD normalization I

- We extract the non W background from data fitting the $\not\!\!E_T$ distribution.
- For the non-W template
  1. In CEM the $\not\!\!E_T$ distribution of isolated (iso < 0.1) antielectrons are used.
  2. For CMUP and CMX we use $\not\!\!E_T$ of non-isolated data (Iso > 0.2) .
- Then knowing the theoretical cross section of the other processes we obtain the W+jets normalization.



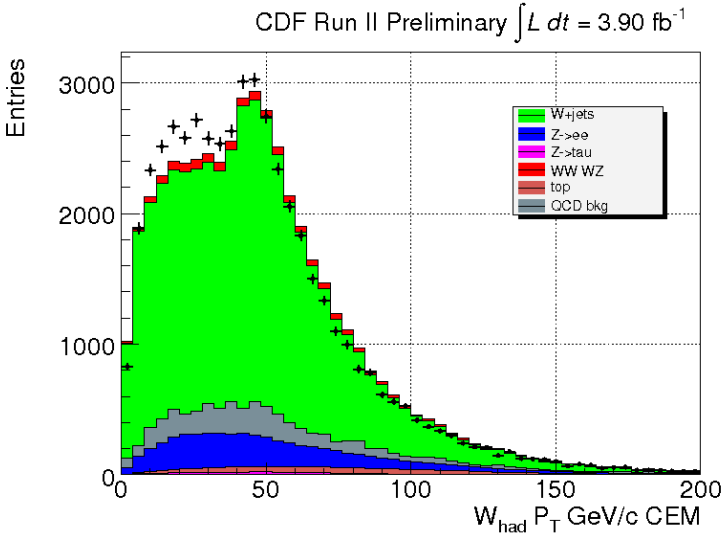
Dijet events

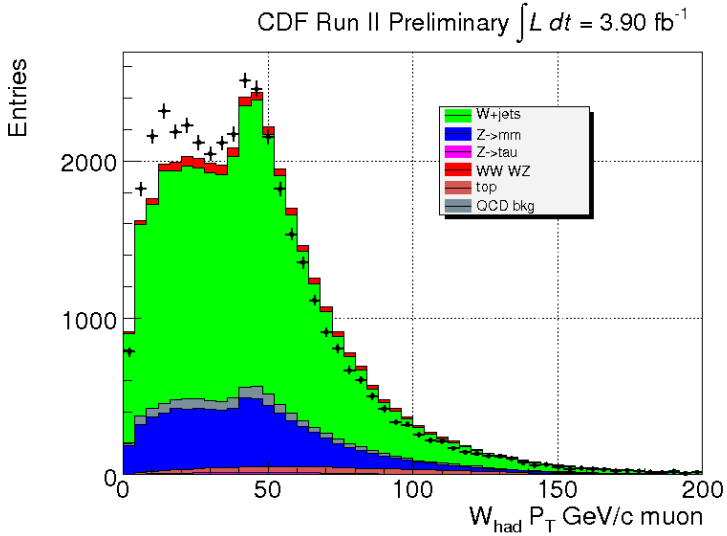




- Poor modeling around 50 GeV/c^2.
- Signal peaks very close to background's shoulder.

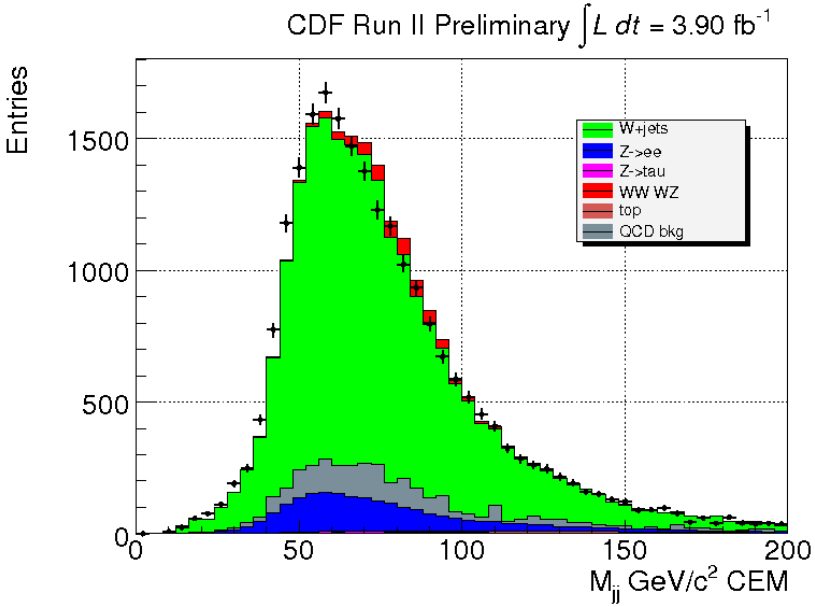
p_T of the W

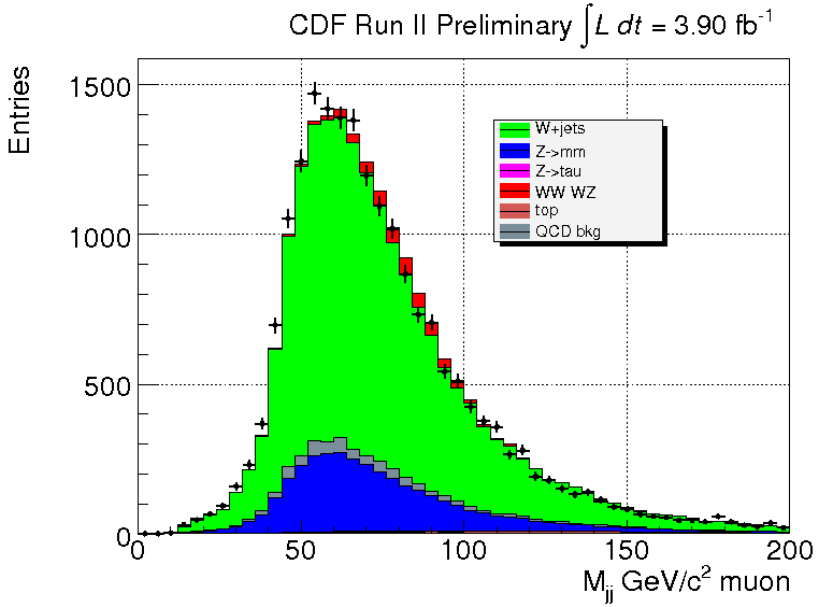




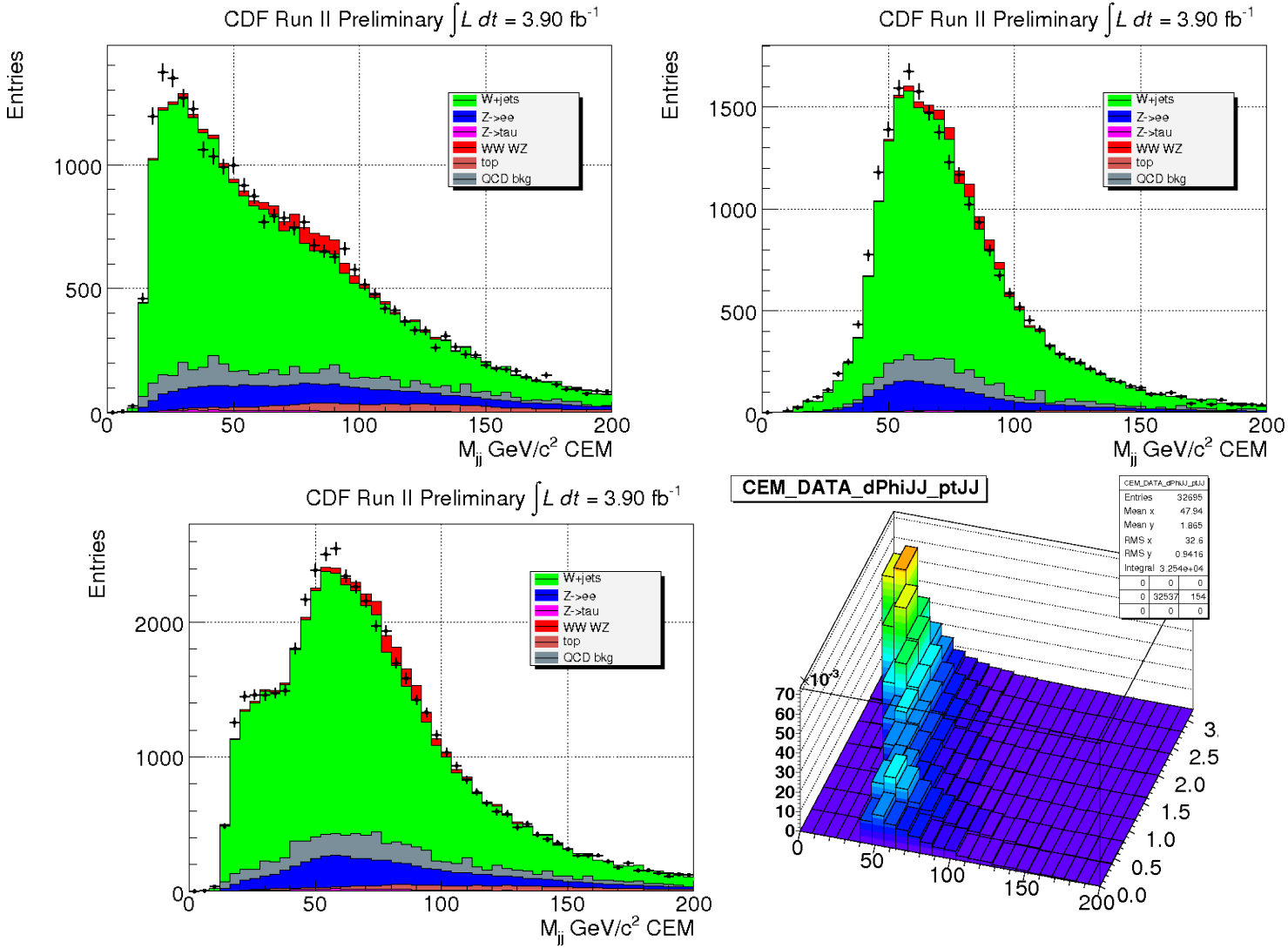
- W Pt distribution not well modelled
- Apply cut: $p_T > 40 GeV/c$ to smooth the distribution of M_{jj}
- Throw away almost 40% of signal...

M_{jj} with W p_T <40 GeV/c



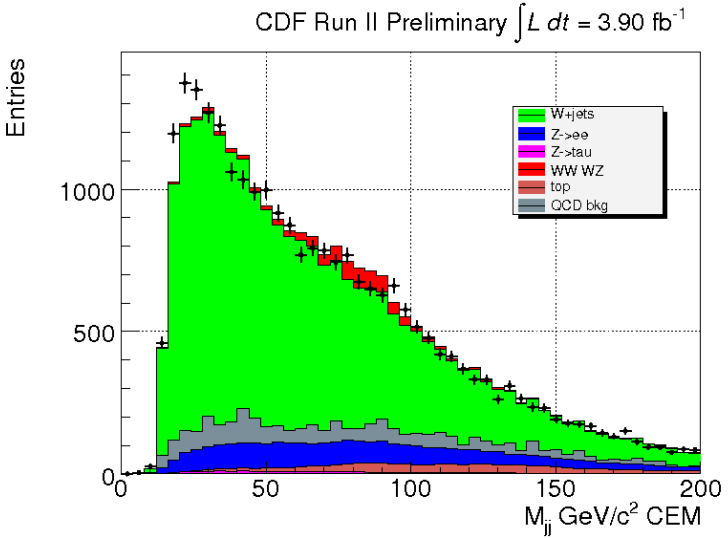


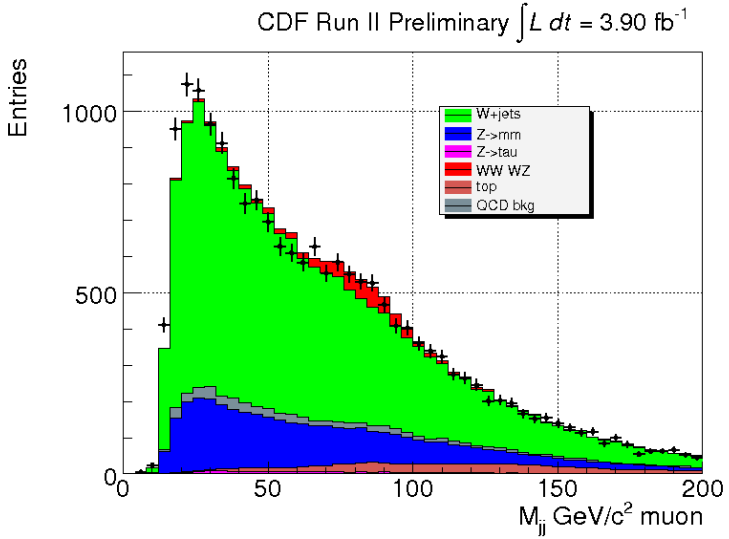
- Signal peaks very close to background: nearly impossible to separate.
- Need more careful study to fully understand this sub-sample.



1. There's clearly a cut in the kinematic acceptance
2. the two mjj have very different shapes
3. the combined mjj hides important information on what component has problems and problems can cancel out.

M_{jj} with W p_T >40 GeV/c



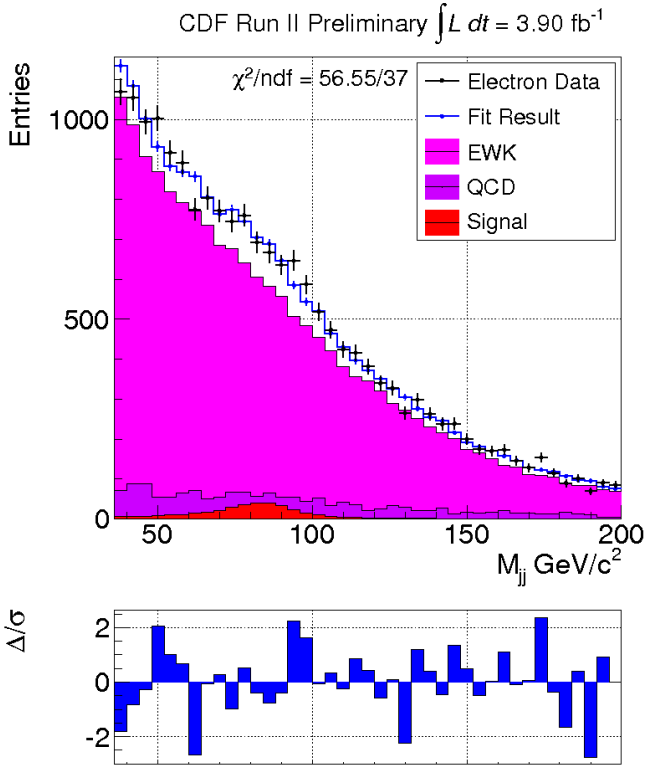


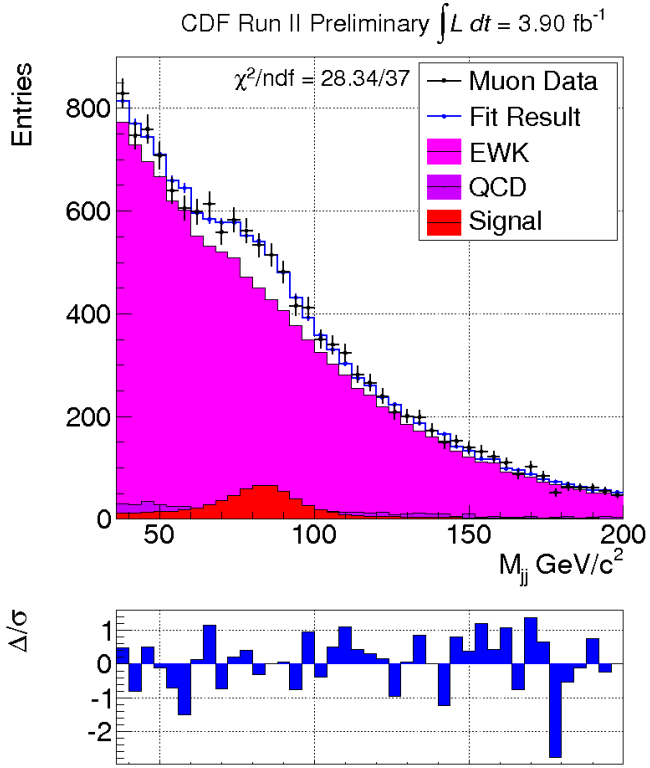
- Binned fit to the mjj shape taking as templates the histograms:
  1. EWK (sum of W+jet, Z+jet and top) $\longrightarrow$ completely free in the fit
  2. SIGNAL (WW and WZ)
  3. QCD $\longrightarrow$ gaussian constraint to the value found in the $\not\!\!E_T$ fit with 20% width (twice the error).
- Fit to the whole shape with $M_{jj} > 36 GeV/c^2$
- Fit electrons and muons separately
- Template statistics uncertainty included in the fit.
- Normalization floating in the fit.
- Fit: Norm , f_{sig} and f_{qcd}

Systematic summary

	Source	e %	μ %	e # of Ev.	μ# of Ev.
Signal Extraction	QCD shape	6.4%	4.8 %	28	31
	EWK shape	9.8%	6.6%	42	43
	JES up	5.1%	5.7%	22	37
	JES down	2.8%	1.6%	12	10
	JER	1.4%	1.1 %	6	7
TOTAL		13.1 %	10.1 %	56	65
Cross section	Luminosity	6%	6%	26	39
	Lepton Acceptance	2%	2%	9	13
	ISR more	1.9%	1.4%	8	9
	ISR less	-1.9%	-1.4%	8	9
	FSR more	0.5%	3%	2	19
	FSR less	-0.5%	-3%	2	19
	PDF	2.0%	2.0 %	9	13
TOTAL		14.8 %	12.8%	63	83

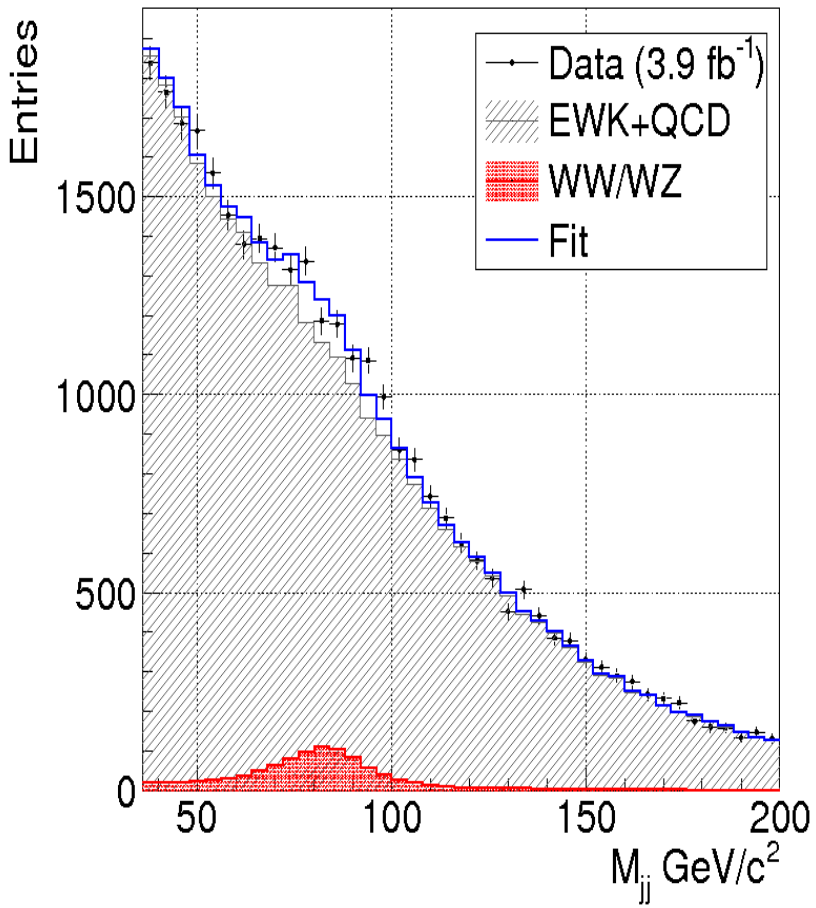
Fit to data and results





	Electron	**Muon**
f_{sig}	0.0227± 0.0094	0.048± 0.011
f_{qcd}	0.083 ± 0.016	0.0428 ± 0.0083
Total#Events	18866 ± 148	13549 ± 122
Observed Total # Events	18905	13573

Fit to data and results



- In a data sample corresponding to 3.9 fb^{-1} using a fit to the invariant mass distribution M_{jj} we estimate combining the two decays: 1070 $\pm$ 232 (stat.) $\pm$ 86 (syst) $WW/WZ \to l\nu jj$ events. Combining in quadrature the significance in the two channels we have 4.61 σ.
- Finally, we measure:

$$\sigma_{WW/WZ} = 14.4 \pm 3.1(\mathrm{stat.}) \pm 2.2(\mathrm{syst.})\mathrm{pb}$$

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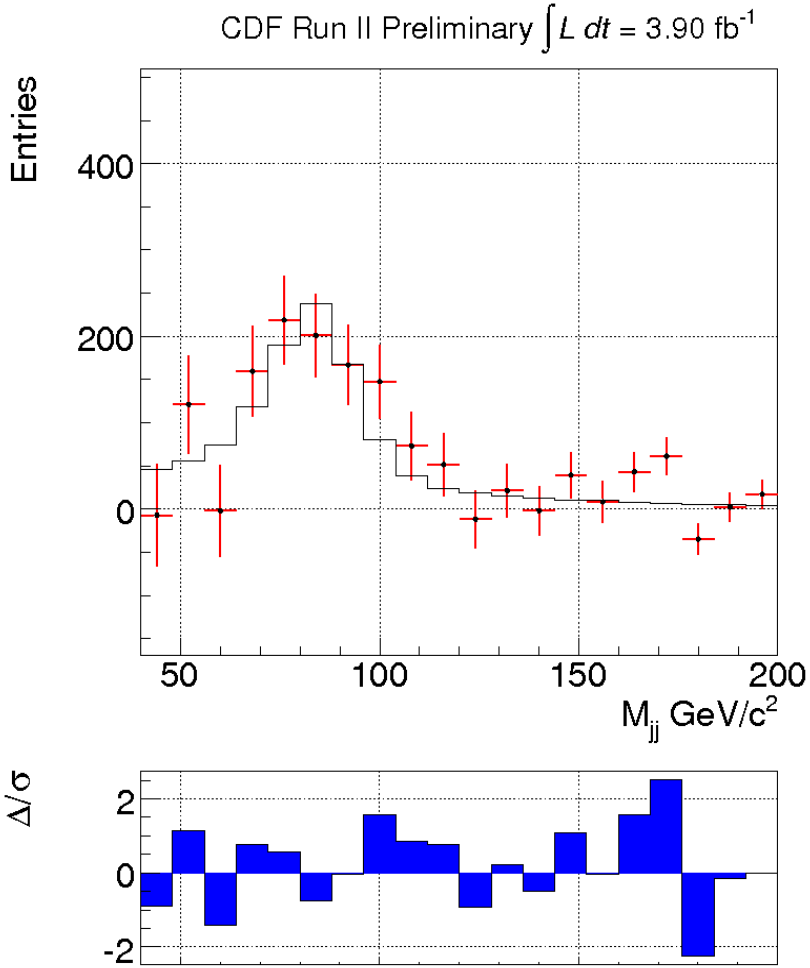

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Status of the analysis

- Writing the PRL togheter with the EPD group
- Extending the data sample to 4.3 fb^{-1}
- Exploring the new MC high lumi sample
- Rebless within september with some changes to the fit.
- Write a PRD.

Future improvement

- Januscia Duchini is working on the multivariate extensions of the analysis:
  1. Right now learned how to use TMVA and found some problems with it.
  2. The idea is to keep it simple: use few variables that we have under control
- Then move on $WZ \rightarrow l\nu + b\bar{b}$: intrduce b-tagging into the analysis.

Backup

Electron selection

Official Tight Electron cuts

Variable	Cut
Region	central
Track	yes
Iso/E_T	≤ 0.1
E_T	> 20 GeV
P_T	> 10 GeV
Track $\lvert Z_0 \rvert$	≤ 60cm
E/P	≤ 2 (unless $p_t \geq 50$ GeV/c)
Had/Em	$\leq 0.055 + 0.00043 \cdot E$
Signed CES ΔX	$3.0 \leq q\Delta X \leq 1.5$
CES ΔX	< 3cm
Lshr	< 0.2
CES Strip χ^2	≤ 10
Fiducial	yes

Muon selection

Official muon CMUP and CMX cuts

Variable	Cut
Iso/P_T	≤ 0.1
P_T	> 20 GeV
Track $\lvert Z_0 \rvert$	≤ 60cm
CMU Fid	$x - fid < 0$cm, $z - fid < 0$cm
CMP Fid	$x - fid < 0$cm, $z - fid < -3$cm
CMX Fid	$x - fid < 0$cm, $z - fid < -3$cm
E_{em}	$\leq 2 + max(0, (p - 100) \cdot 0.0115)$
E_{had}	$\leq 6 + max(0, (p - 100) \cdot 0.028)$
COT Ax hits / Ax Seg	$\geq 5/ \geq 3$
COT Ax hits / Ax Seg	$\geq 5/ \geq 3$
Track no si hits $\lvert d_0 \rvert$	< 0.2cm
Track si hits $\lvert d_0 \rvert$	< 0.02cm
ρ_{exit}	> 140 if CMX
$\lvert \Delta X_{CMU} \rvert$	≤ 7cm
$\lvert \Delta X_{CMP} \rvert$	≤ 5cm
$\lvert \Delta X_{CMX} \rvert$	≤ 6cm
No muons in bluebeam	run $<$154449
No muons in keystone	run $<$186598
No muons in miniskirt	run $<$186598
Larry corrections	data only

MC sample

1. Signal Diboson: itopww, itopwz
2. Background : W(e, μ)+np (ALPGEN), Z(ee,$\mu\mu$,$\tau\tau$)+np, top
   - while waiting for new samples plan to reweight N_vertices in MC to N_vertices in data event by event
3. QCD Background: done using Iso vs $\not\!\!E_T$
   - corrected for MC!

MC sample

sample	σ_{gen}	Ngen
Diboson		
itopww	12.40	2284862
itopwz	3.70	2306591
itopzz	3.80	2323812
W (e^+e^-)+jets		
ptopw0	1800	4928812
ptopw1	225	4909767
ptop2w	35.30	1003193
ptop3w	5.59	1003040
ptop4w	1.03	989607
W $(\mu^+\mu^-)$+jets		
ptopw5	1800	5017218
ptopw6	225	5003166
ptop7w	35.3	1002804
ptop8w	5.59	1013373
ptop9w	1.03	988545
W $(\tau^+\tau^-)$+jets		
utopw0	1800	4885557
utopw1	225	4987134
utop2w	35.3	923989
utop3w	5.59	1008221
utop4w	1.03	186494

sample	σ_{gen}	Ngen
W+HF		
btop0w	2.98	1542539
btop1w	0.888	1545970
btop2w	0.287	1498550
btop5w	2.98	1524880
btop6w	0.888	1508029
btop7w	0.287	1506613
ctop0w	5.	2008023
ctop1w	1.79	1987389
ctop2w	0.628	1926322
ctop5w	5.	1985033
ctop6w	1.79	1979810
ctop7w	0.628	1970504
top		
ttkt75	6.7000	5445003

MC sample

sample	σ_{gen}	Ngen
Z($e^+ e^-$)+jets		
ztopp0	158.	2639520
ztopp1	21.60	2630345
ztop2p	3.47	536159
ztopzb	3.46	4641816
ztop3p	0.55	528491
ztop4p	0.0992	525065
Z($\mu^+ \mu^-$)+jets		
ztopp5	158	2665104
ztopp6	21.60	2664729
ztop7p	3.47	530843
ztopzt	3.46	4710842
ztop8p	0.548	536159
ztop9p	0.0992	536159

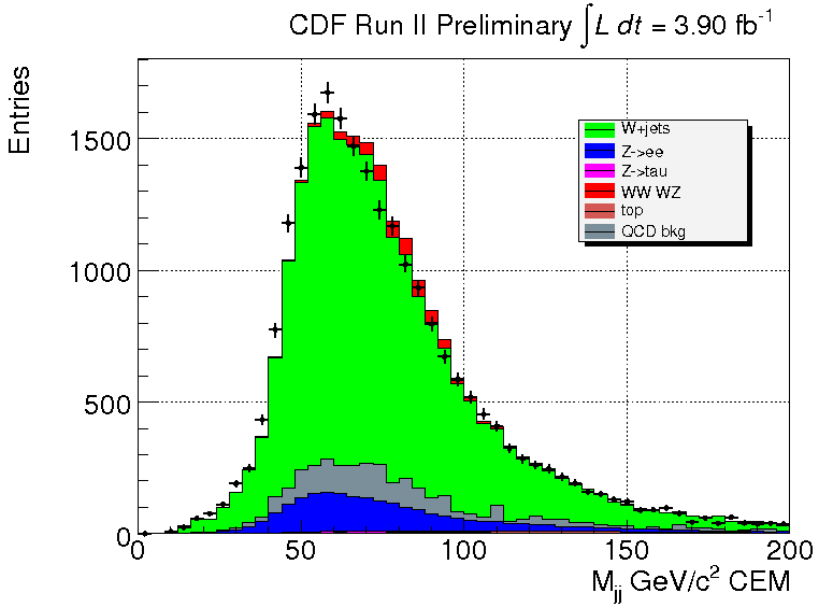
sample	σ_{gen}	Ngen
Z+HF		
ztopb0	0.511	516239
ztopb1	0.134	493381
ztopb2	0.0385	498736
ztopb5	0.511	437329
ztopb6	0.134	494480
ztopb7	0.0385	478485
ztopc0	1.08	662939
ztopc1	0.331	695289
ztopc2	0.107	658211
ztopc5	1.08	671375
ztopc6	0.331	663431
ztopc7	0.107	705108

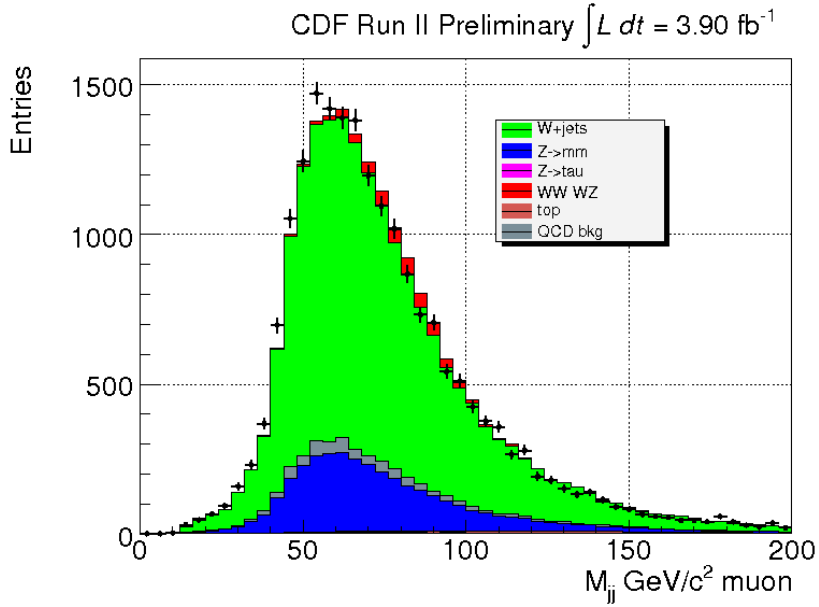
MC sample

sample	σ_{gen}	Ngen
DY		
xtop0p	160.0000	536159
xtop1p	8.3900	515515
xtop2p	1.6100	536159
xtoppb	1.6000	4610071
xtop3p	0.2330	525670
xtop4p	0.0398	520758
xtop5p	160.0000	524357
xtop6p	8.3900	530696
xtop7p	1.6100	525769
xtoppc	1.6000	4644940
xtop8p	0.2330	524697
xtop9p	0.0398	529635

Sample	σ_{gen}	Ngen
DY		
ytop0p	4.0700	519104
ytop1p	0.7060	524895
ytop2p	0.1170	513428
ytop3p	0.0185	531075
ytop4p	0.0033	527280
ytop5p	4.0700	536159
ytop6p	0.7060	529581
ytop7p	0.1170	531006
ytop8p	0.0185	520531
ytop9p	0.0033	527838

M_{jj} with W p_T <40 GeV/c





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