SM W^+W^- and $H \rightarrow W^+W^-$ analysis

X.RUAN, co-Ph.D in IHEP-LAL

Supervisors Shan JIN(IHEP), Zhiqing ZHANG(LAL)

Shu Li, co-Ph.D, USTC and CPPM

co-supervised by Zhengguo Zhao(USTC), Yanwen Liu(USTC), Emmanuel Monnier(CPPM)

CPPM: Centre de Physique des Particules de Marseille

IHEP: Institute of High Energy Physics

LAL: Laboratoire de l’Accélérateur Linéaire

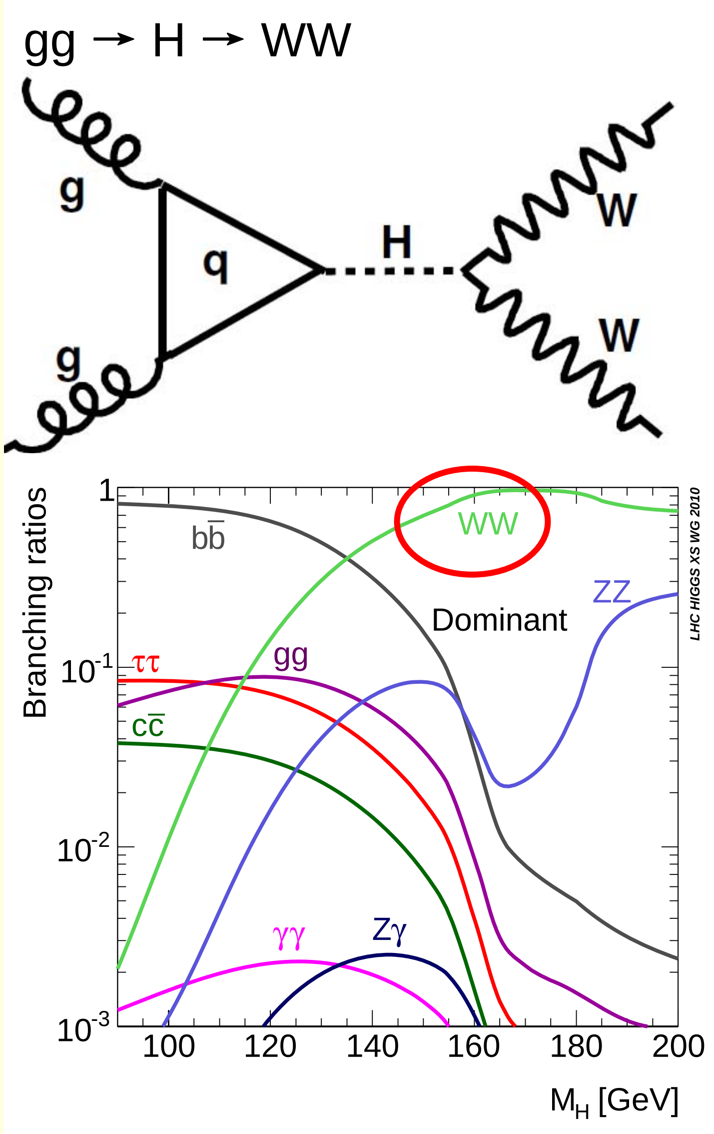
USTC: University of Science and Technology of China

Content

- Introduction
- Standard Model W^+W^- analysis
  - First Standard Model W^+W^- cross section measurement
  - W+jet background estimation
- $H \to W^+W^-$ analysis
  - $H \to W^+W^-$ analysis
  - Top background estimation
  - Exclusion limit
  - Further improvement: multivariate analysis (MVA)

Introduction

- $W^+W^- \to l\nu l\nu$, l=e, μ two leptons final state is observed in 2010 7TeV collision data.
- $W^+W^- \to 2l$ final state: one of the most promising search modes for Higgs discovery for Higgs mass > 135GeV
- As the most important background channel, standard model W^+W^- production cross section is measured with 7TeV collision data in 2010.
- $H \to W^+W^-$ exclusion limit is calculated.



Branching ratio of Higgs decay

SM WW analysis with 2010 7TeV pp collision data

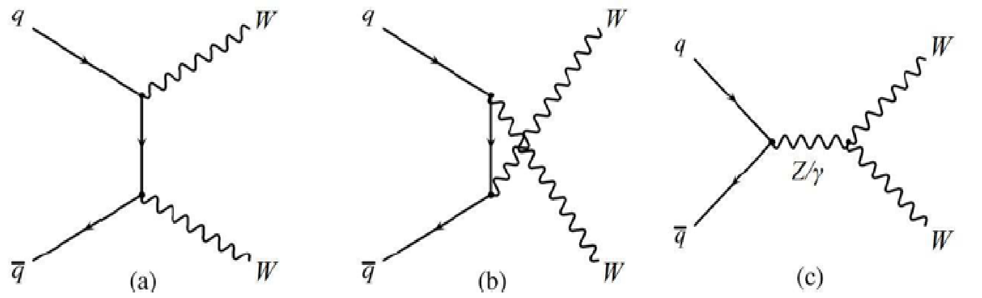
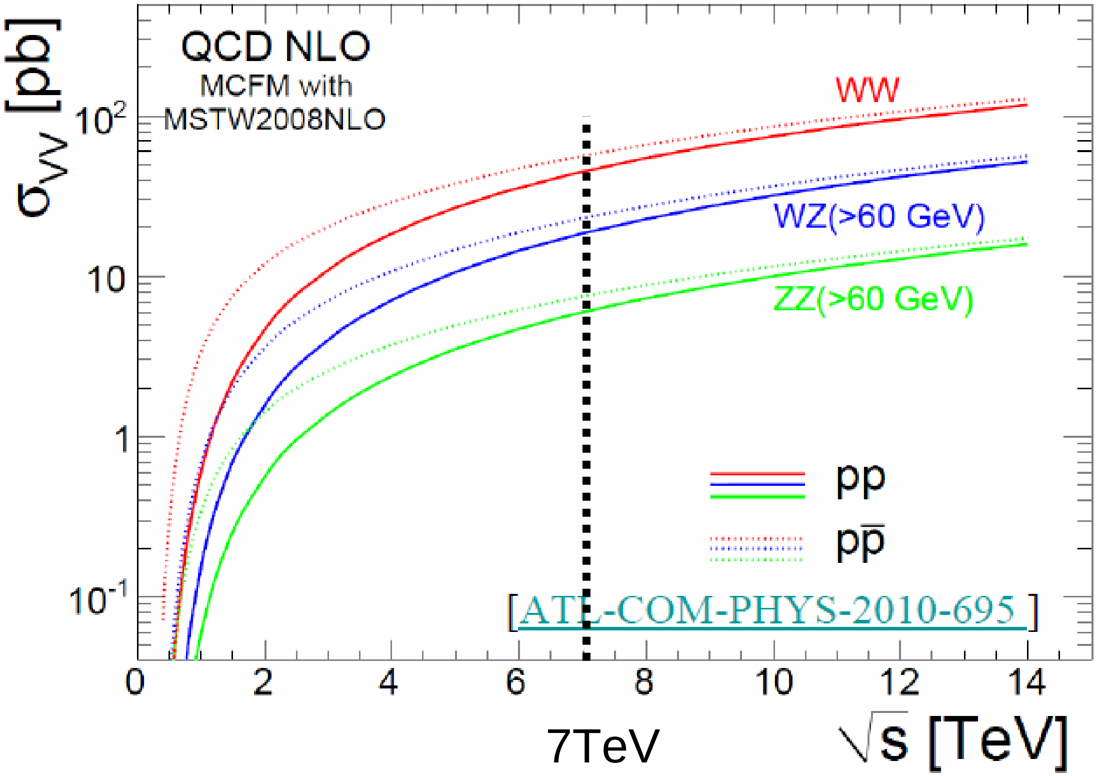
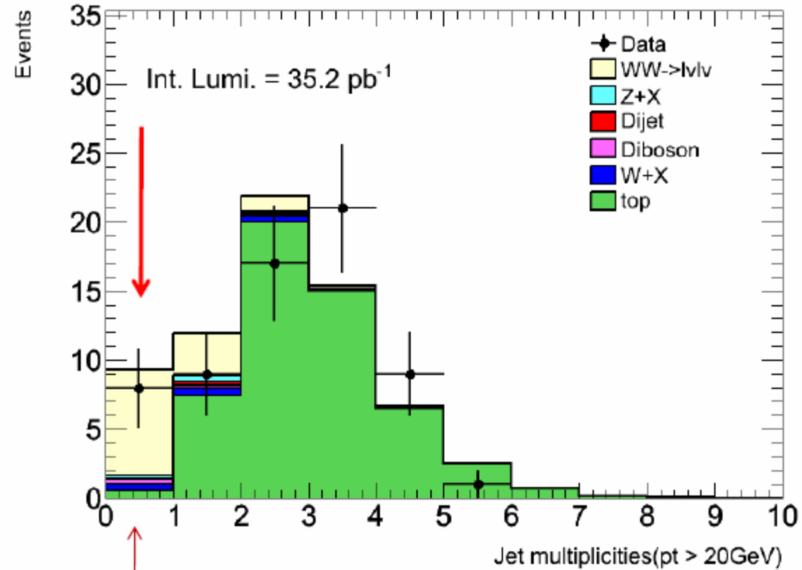


Figure 1: The Standard Model leading order Feynman diagrams for WW production through quark-antiquark initial state.





WW signal dominates 0 jet bin!

WW production cross-section measured from 2010 35.2pb^{-1} pp collision data: (Conf. Note ATL-CONF-2011-015).

$$39.5^{+19.8}_{-15.6}(stat) \pm 6.5(syst)\, pb$$

significance of 3.0 σ

Wjets data-driven background estimation with 2010 data in Rel.15

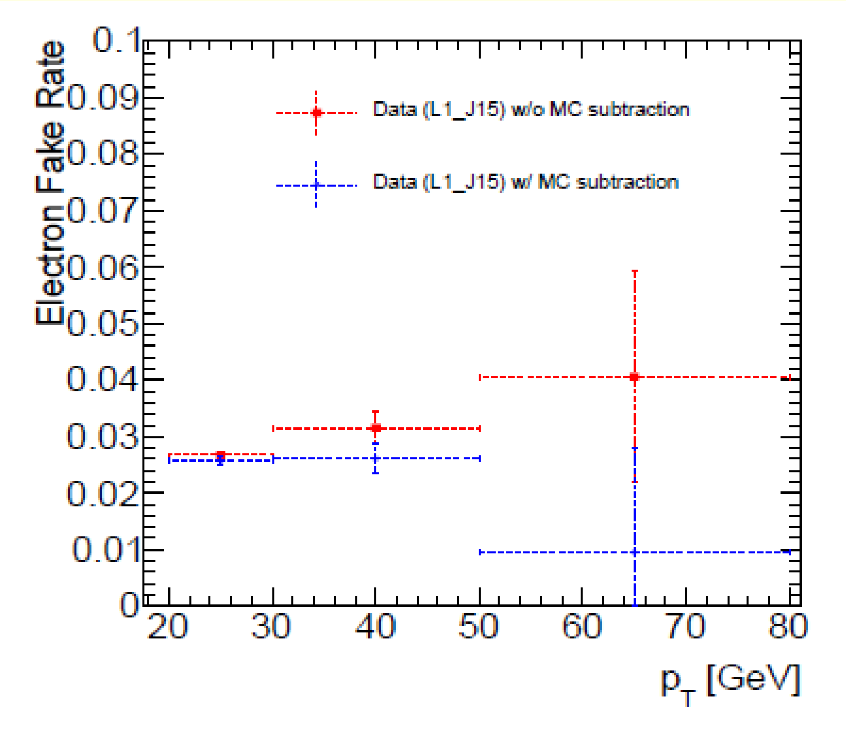
Data-driven strategy:

- Use W+jets enriched control sample to measure the fake rate in data
- Finding events with 1 tight and 1 loose lepton ID
- Fake rate: how many looser ("jet-rich") leptons pass full ID (use jet-triggered data)?

$$f_l = \frac{N_{lepID}}{N_{jet-enrichID}}$$

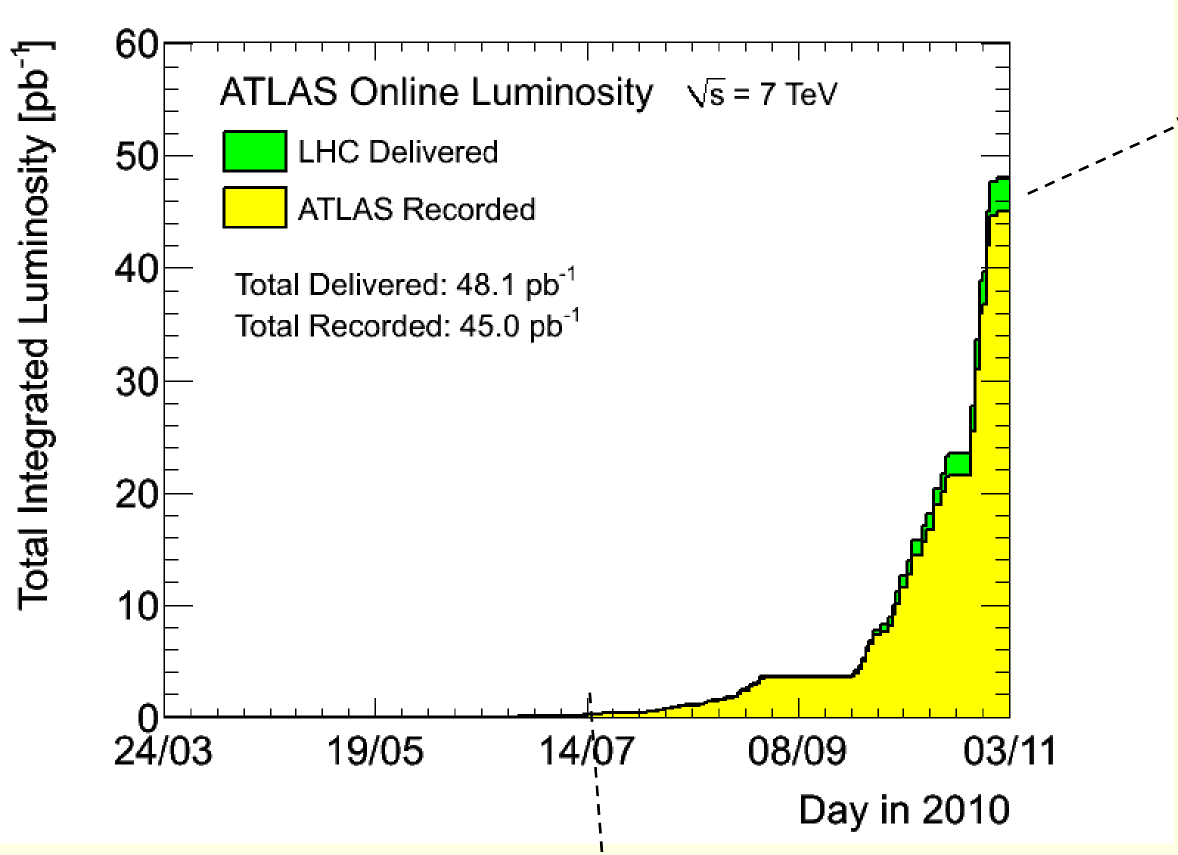
$$N_{W+jet\,Bkg} = f_l \times N_{1lepID+1\,jet-enrichID}$$

The total W+ jets contribution to the final selected WW candidate events is estimated to be 0.54±0.32(stat)±0.21(syst).



Electron fake rate as a function of pT w/ and w/o EW subtraction

$H \rightarrow W^+W^-$ analysis



- With all 2010 data (35pb^{-1}), cut based analysis result for the winter (Moriond) conference (ATL-CONF-2011-005)

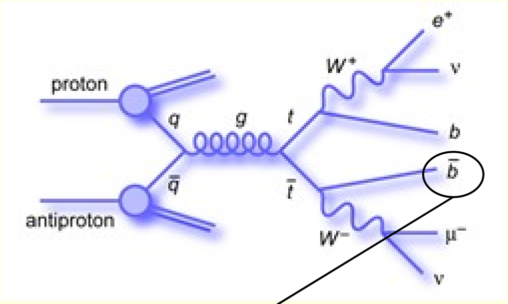
For now:

- Improvements, multivariate analysis
- Combined exclusion limits
- Own code development for deriving exclusion limits for both SM3 and SM4.

- With the first data (311nb^{-1}), background study W+jet.(ATL-CONF-2010-092).

Top background estimation in H → W$^+$W$^-$ analysis in winter 2011

- 35.2pb^{-1} collision data has been analyzed
- A data driven method was used to extract top (ttbar + single top) background in 0 jet analysis, based on H → W$^+$W$^-$ cut flows.
- A b-tagged jet is used to select control sample.
- Jet veto survival probability, calculated in control sample, gives the scale factor from MC to data.



If not observed

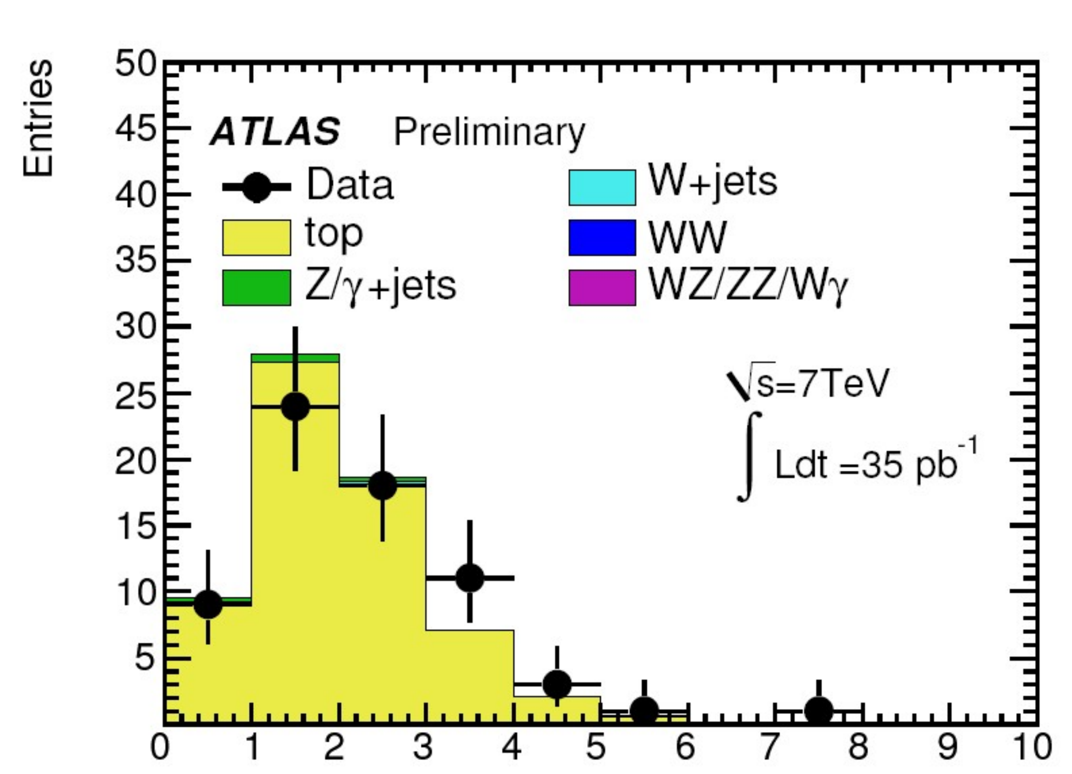
--Jet veto survival probability $P_1^{\mathrm{Btag,Exp/MC}}$

$$N^{\mathrm{Exp}}(ll + E_T^{\mathrm{miss}}, 0j) = \frac{N_{\mathrm{Top}}^{\mathrm{Exp,control}}}{N_{\mathrm{Top}}^{\mathrm{MC,control}}} N_{\mathrm{Top}}^{\mathrm{MC}}(ll + E_T^{\mathrm{miss}}, 0j)$$

$$N_{\mathrm{Top}}^{\mathrm{Exp/MC,control}} = N_{\mathrm{Top}}^{\mathrm{Exp/MC}}(ll + E_T^{\mathrm{miss}}) \left(P_1^{\mathrm{Btag,Exp/MC}}\right)^2$$

B.Mellado, X. Ruan, Z. Zhang, arXiv:1101.1383, submitted to PRD

Top background estimation in H → W^+W^- analysis in winter 2011



N probing jet in control sample

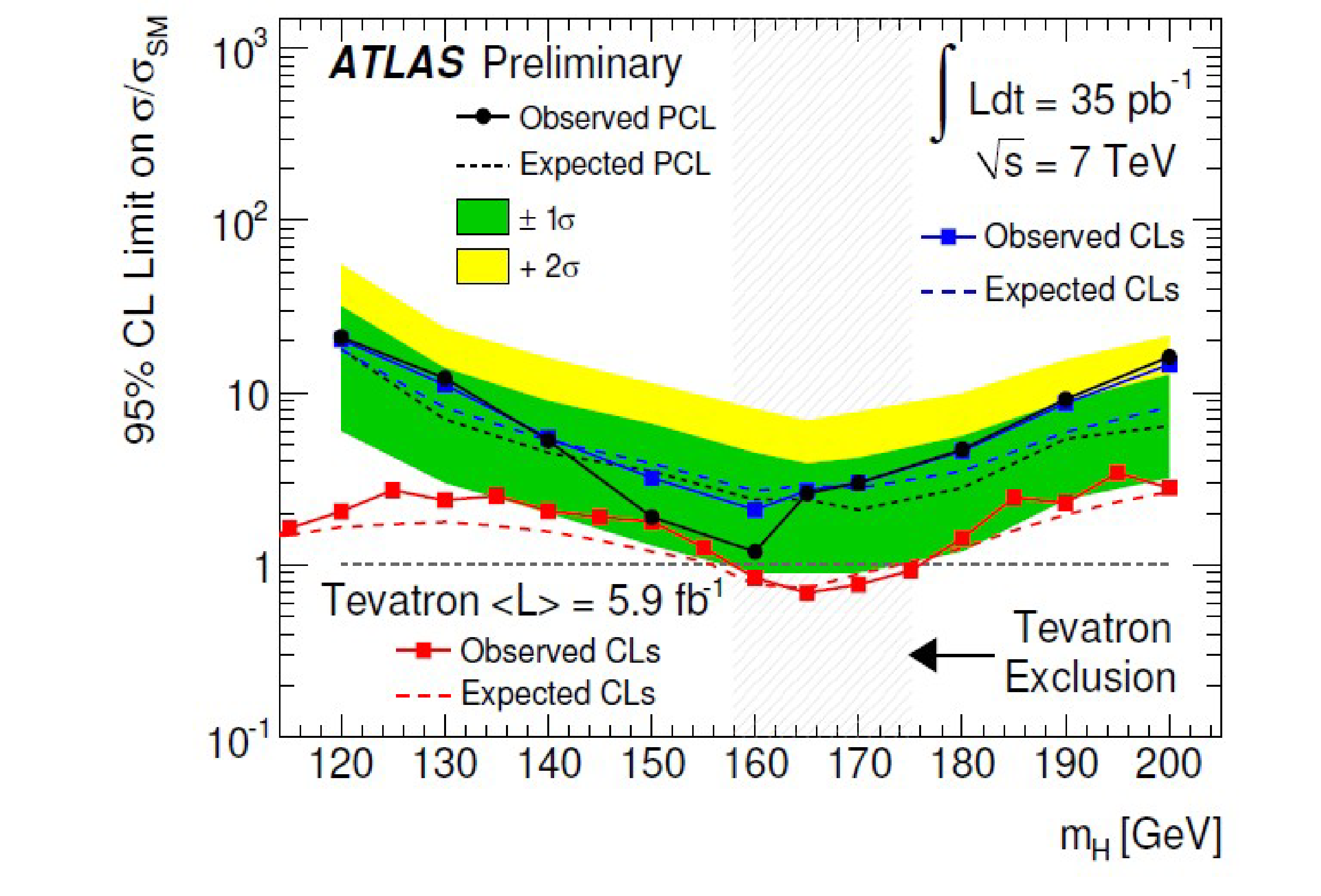
Probing jet: jets excluding the b tagged jet which is used to select control sample

Number of probing jet in control sample gives jet veto survival probability (0 jet bin/all events)

Predicted top with MC after full jet veto: 1.5 events
Predicted top with data-driven method: 1.4(+1.3-1.1) events

- Statistical error dominant
- This method is also used in WW study.

Exclusion limits



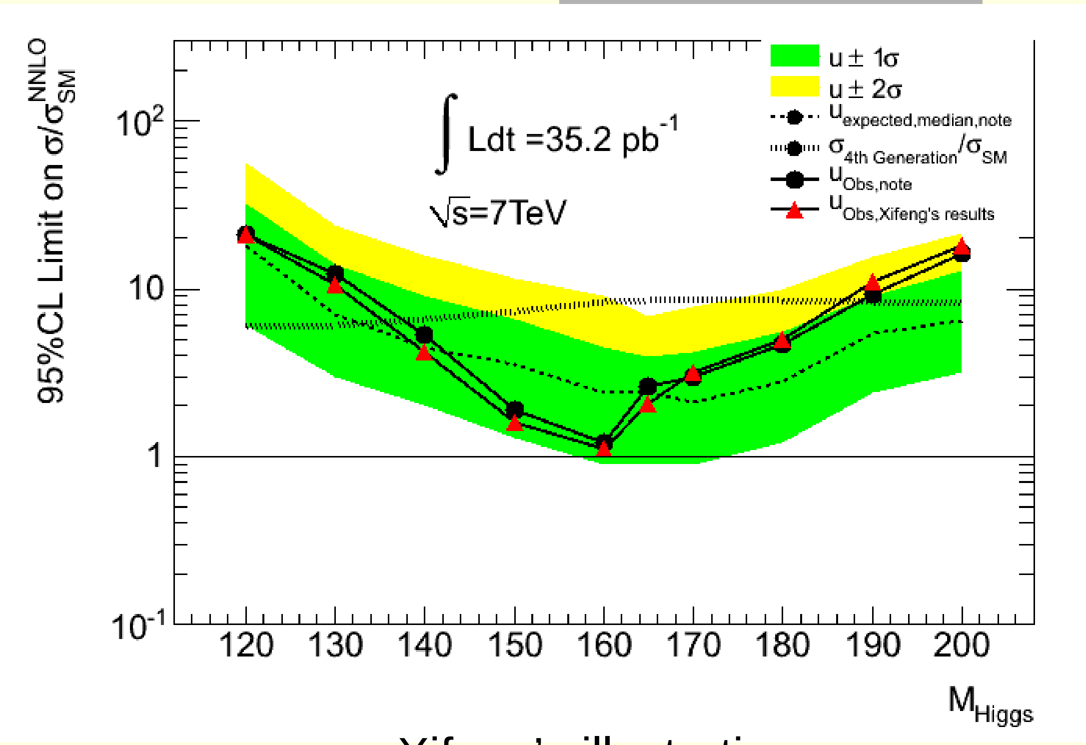
$H \rightarrow W^+W^-$ exclusion limits is calculated and compared with Tevatron result. (right plot)

The method of Power Constrained Profile Likelihood and CLs are compared.

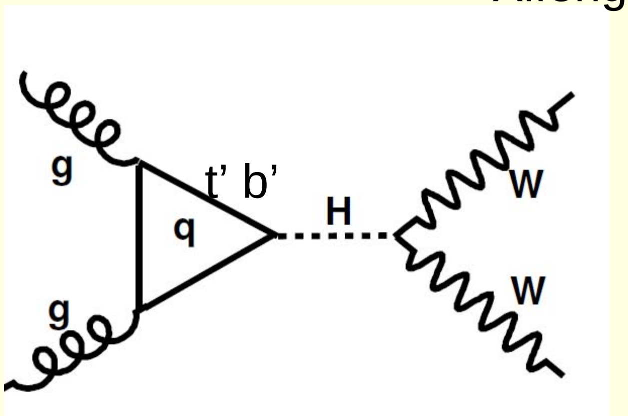
Exclusion limits

An exercise is done by Xifeng to reproduce the exclusion limits, in comparison with the official result.

Within the 4th generation, the mass range (140~190GeV) is excluded at 95%CL.



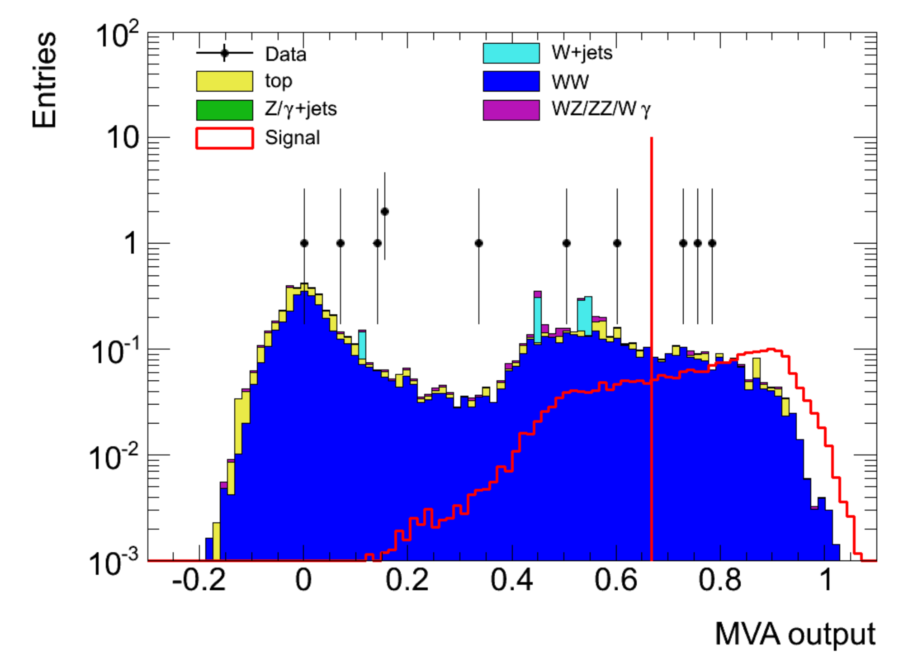
Xifeng’s illustration

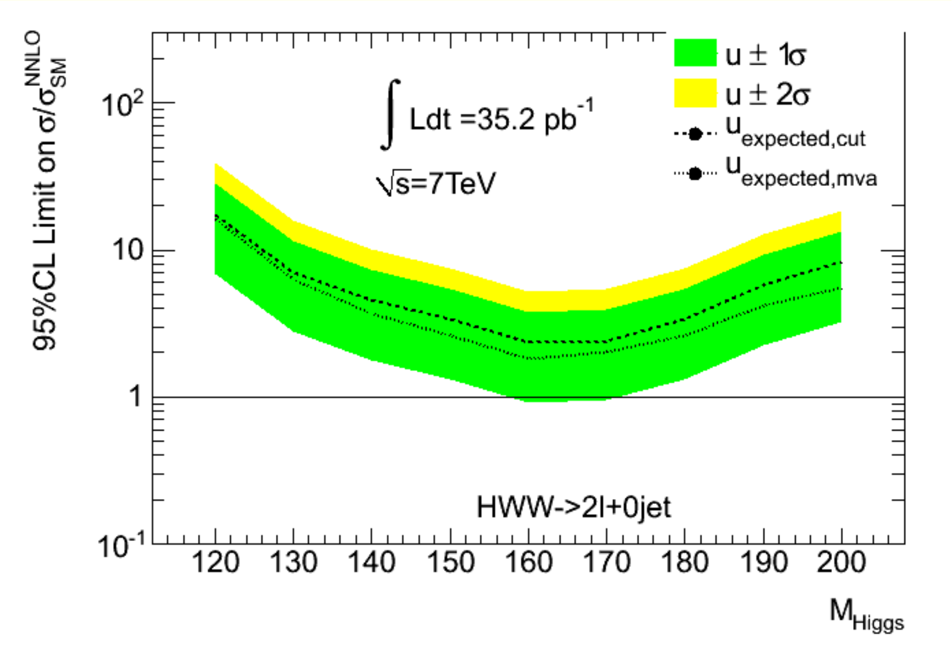


Enhancement from heavy quarks in 4th generation

$H \rightarrow W^+W^-$ multivariate analysis

- MVA analysis is performed to improve the results.
- An artificial neural net output of Higgs mass at 160GeV in 0 jet analysis. (right plot)





Xifeng's illustration

- In 0 jet analysis the result (significance) are improved by 10~20%, in comparison with cut based analysis.

Summary and Perspective

- **Based on 35pb^{-1} in 7TeV 2010 data**
- First significance (3 σ) SM WW cross section measurement
- Higgs exclusion limit approaching SM expectation and Tevatron limits.
- Discovery or large mass range exclusion expected with 2011 and 2012 data

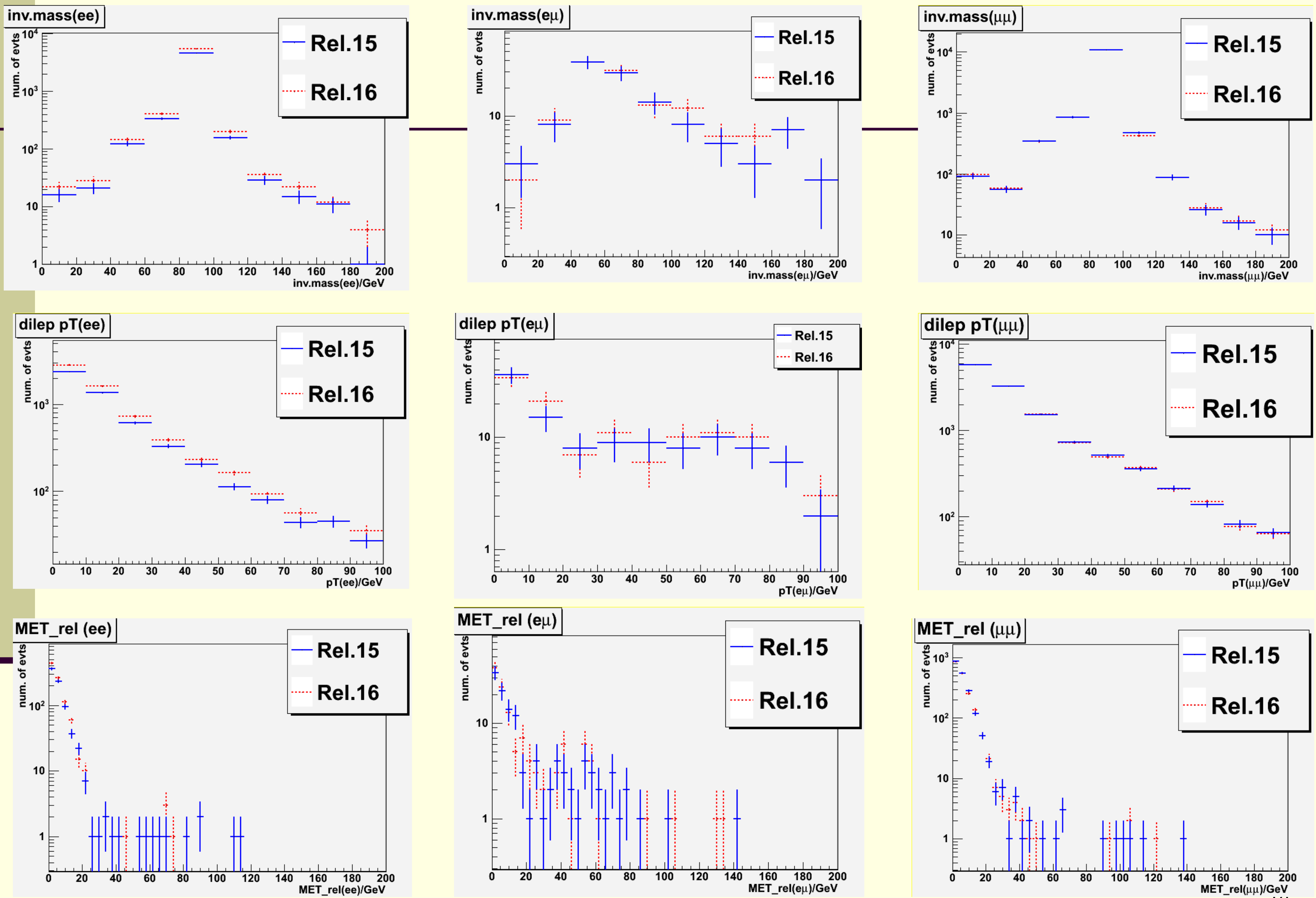
Back up:

Shu Li’s other work for SM WW

Xifeng’s other work:

MVA input variables for HWW

WW Analysis Rel.16 excersice w.r.t. Rel.15



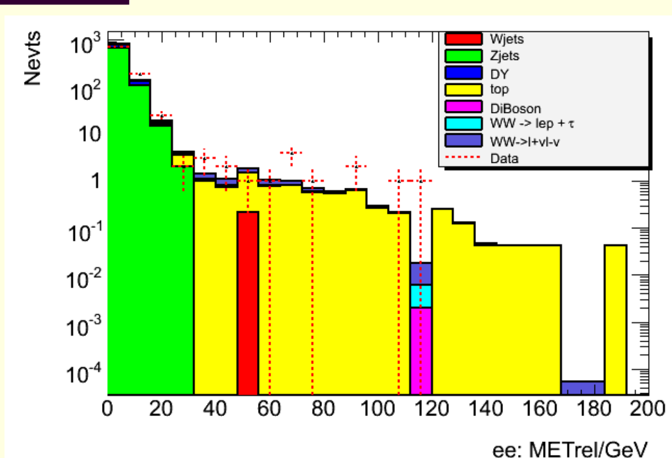
No dramatic issue spotted, slightly benefit after recovering some int. lumi from 2010 reprocessing.

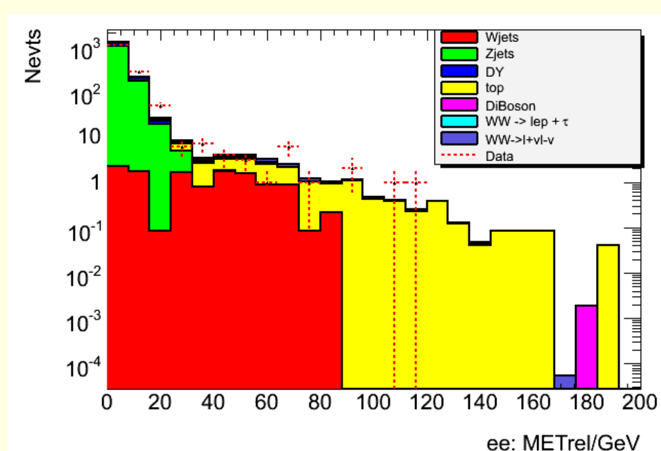
New Electron ID study with 2010 Rel.16 reprocessed data and mc10

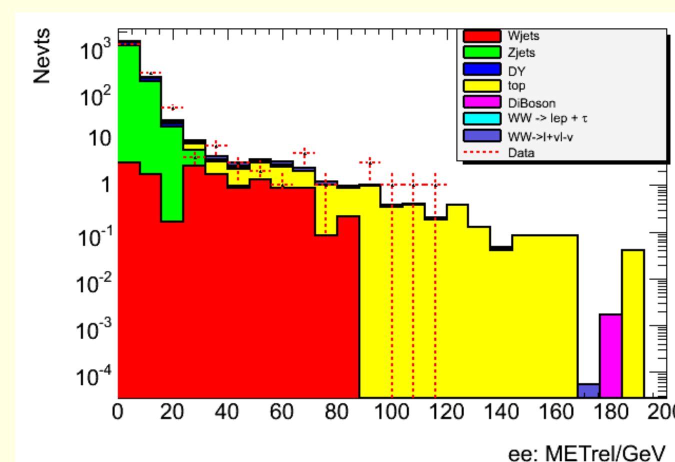
	Data	WW→ll	DiBoson	Top	Wjets	Zjets	DrellYan	WW→l +tau	JF17
Tight ID	8±2.83	7.80±0.10	0.72±0.08	0.90±0.17	0.88±0.88	0.	0.	0.65±0.03	0.
Medium +caloIso 1* +Blayer	15±3.87	9.26±0.11	3.28±0.32	1.26±0.20	13.42±3.79	2.26±1.42	0.	0.81±0.03	0.
Medium +caloIso 2* +Blayer	13±3.6	9.22±0.11	3.31±0.32	1.23±0.20	11.67±3.58	2.26±1.42	0.	0.82±0.03	0.

*caloIso 1: etcone20 with pt correction
*caloIso 2: caloIso98 tuned with MVA(eta and Et dependent)

New Electron ID impact in WWee channel for instance:







MVA input variables. (DeltaPhi between the two lepton line 1 column 1, Pt of leading lepton L1C2, Invariant Mass and transverse mass L1C3. MetProjection L2C1, Pt of subleading lepton L2C2, DeltaEta of the two leptons L2C3.