

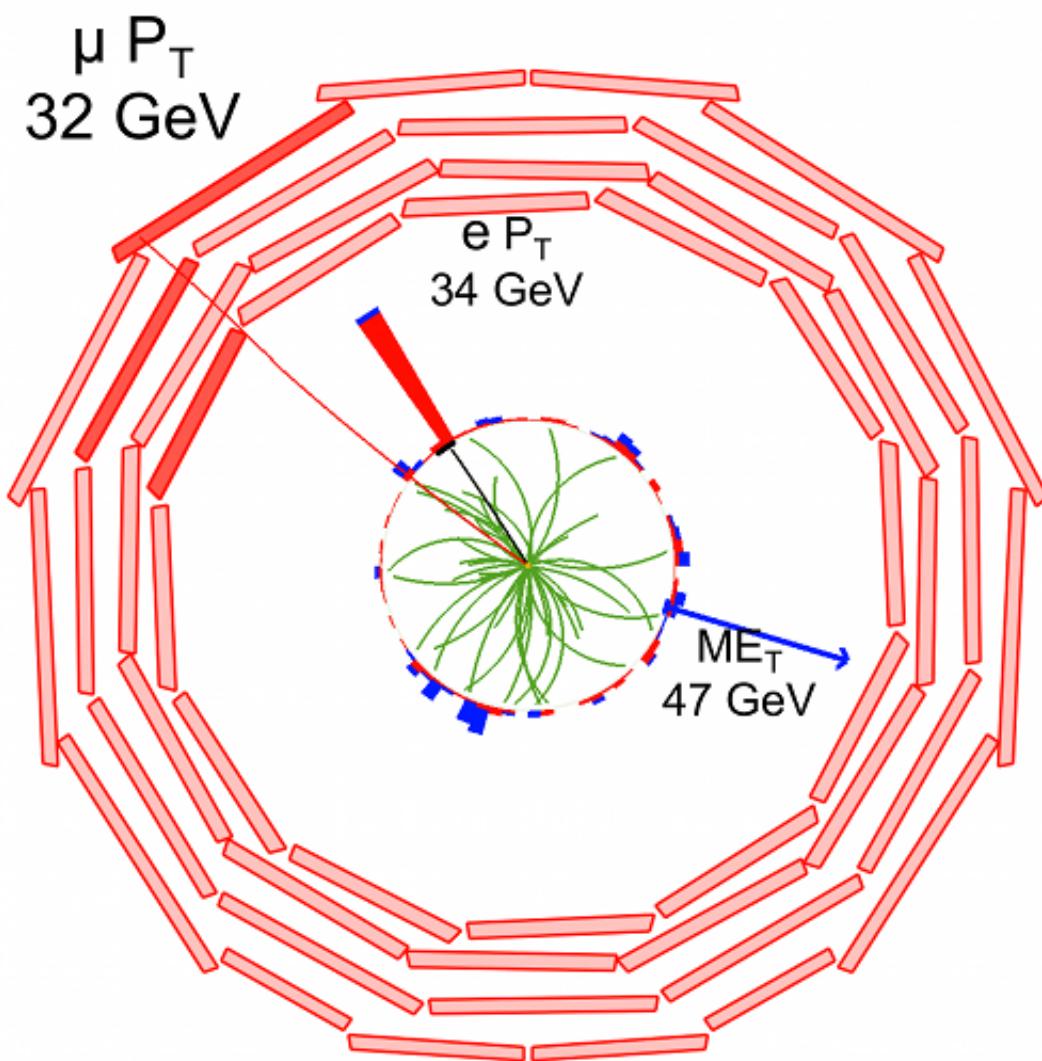
H → WW → 2l2ν and WW cross section estimation in CMS

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CHANNEL SIGNATURE AND MAIN BACKGROUNDS

Event Signature:

- 2 isolated, high p_T leptons (e or μ only in this analysis) with small opening angle
- High Missing E_T from undetected ν's
- Analysis performed on exclusive jet multiplicities (0, 1, 2-jet bins)
- WW : irreducible background



Signal Extraction:

- Optimized Cut Based selection for each Higgs mass hypothesis:
 - $p_T(l)$, m_{ll} , m_T and $\Delta\phi(l)$ as discriminating variables in 0/1 jet bins
 - Dedicated VBF selection for 2-jet bin
- Multivariate Analysis for 0/1 jet bins (2011 results)

Main backgrounds:

- Physical backgrounds: Background with leptons and real MET (WW, ttbar, tW, WZ, ZZ)
- Instrumental backgrounds: No 2 leptons or no real MET (QCD, Z+jets, W+jets)

→ Top, W+jets and DY are estimated with data driven methods

TOP BACKGROUND ESTIMATION

Jet Veto is not enough to reject top background

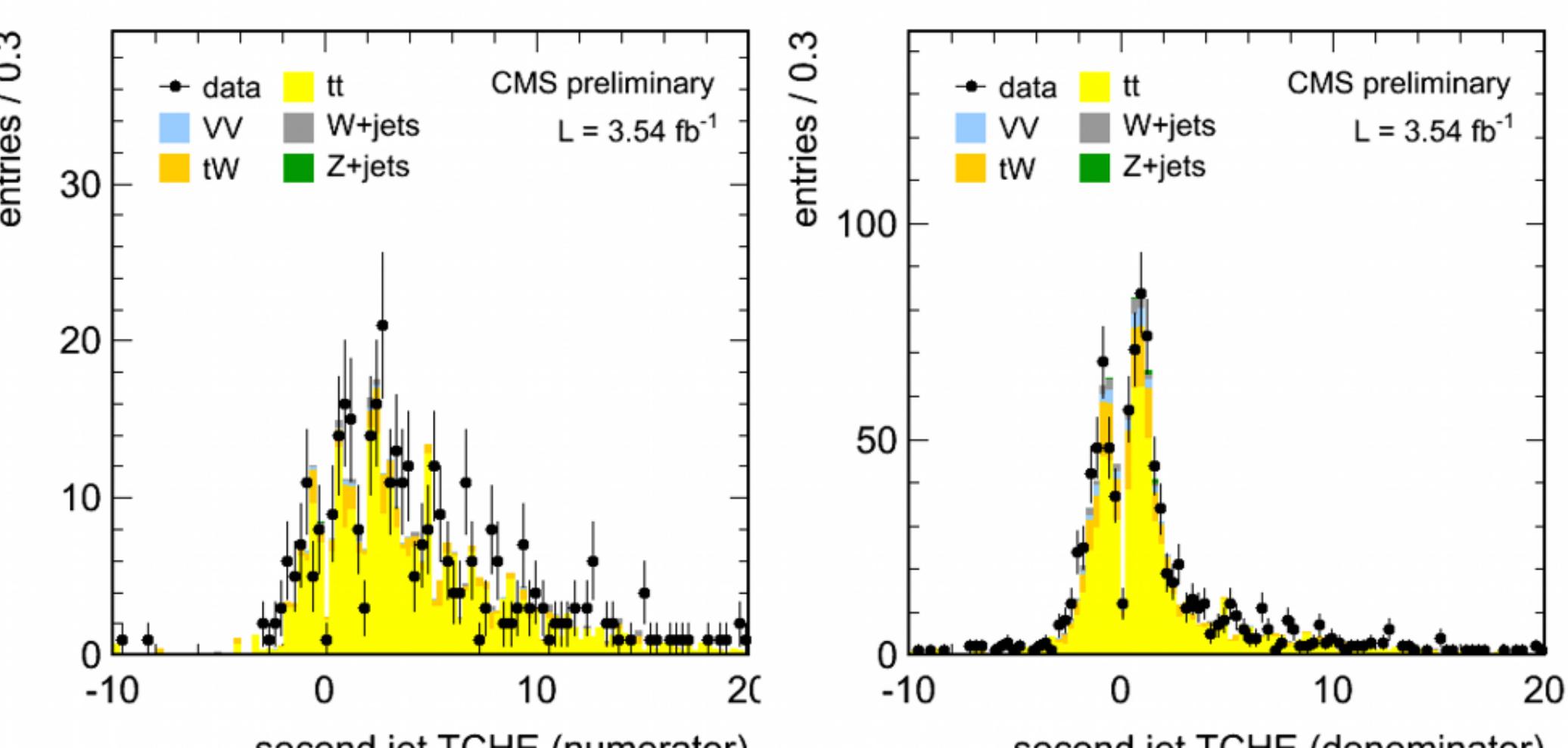
→ Remaining background to be reduced using b-quark properties

Further requirements are imposed to the event

- Soft Muon veto
- Low p_T jet b-tagging

Normalization procedure relies on the measurement on data of the "top-tagging" efficiency

- Efficiency is measured in a top-enriched sample
- Extrapolation to the signal region from the data yields obtained by inverting the top tag veto



Top tagging efficiency numerator and denominator in the top enriched sample

DY BACKGROUND ESTIMATION

- Estimate DY contribution from a signal – free region
- We use the $R_{out/in}$ method based on the Z mass window region

→ Estimate the ratio of DY events outside/inside the Z mass region:

$$R_{MC}^{out/in} \equiv \frac{N_{DY}^{control,MC}}{N_{DY}^{signal,MC}}$$

→ Count the number of events on Data inside that region corrected for:

- ZZ/WZ diboson – MC predicted
- Non-peaking backgrounds as N_{ep} data events
- Extrapolate to the signal region with $R_{out/in}$

$$N_{DY}^{signal,data} = \left(N_{\ell\ell}^{control,data} - k \cdot N_{ep}^{control,data} - N_{ZV}^{control,MC} \right) \cdot R_{MC}^{out/in}$$

Where:

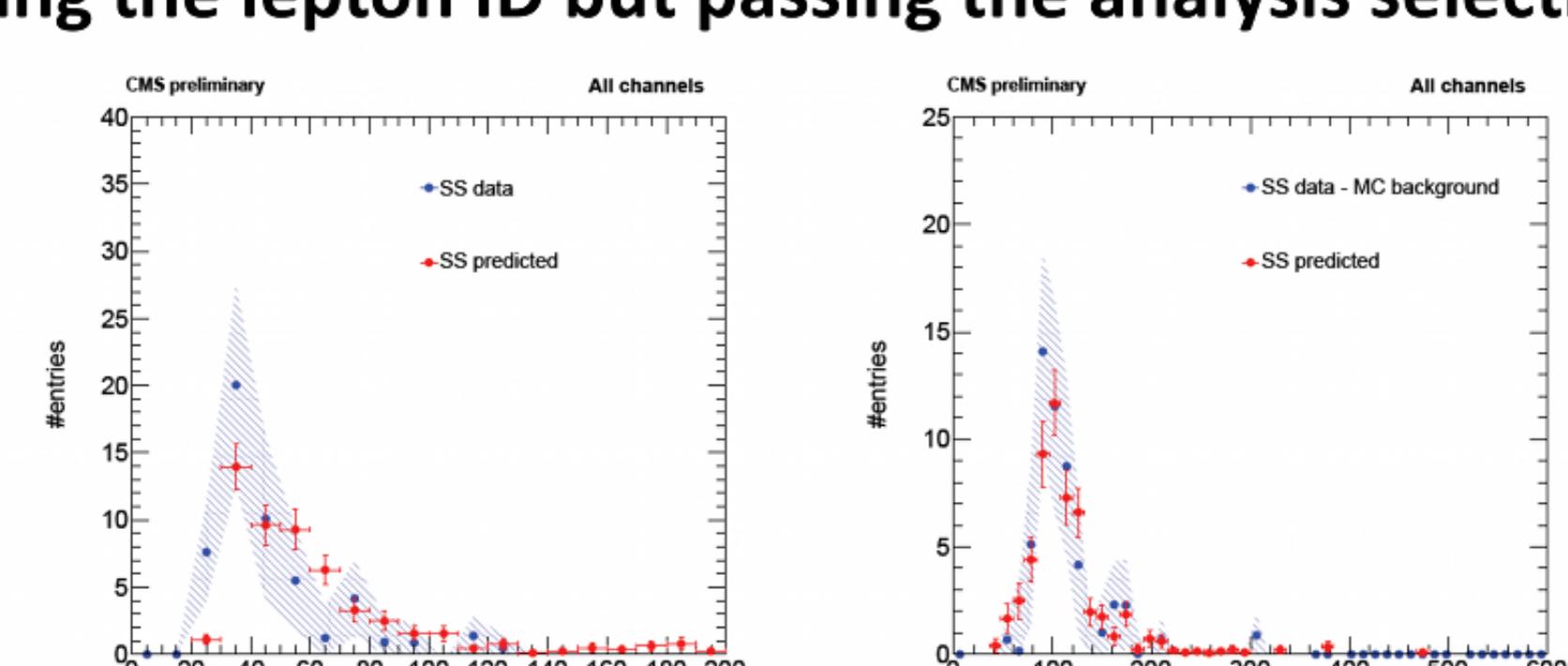
$$k_{SF} = \frac{1}{2} \cdot \left(\sqrt{\frac{N_{ee}^{control}}{N_{pp}^{control}}} + \sqrt{\frac{N_{\mu\mu}^{control}}{N_{ee}^{control}}} \right)$$

Error in the method coming mainly from:

- Systematic error on R estimation
 - R estimated in different MET bins. Error as maximum difference between nominal value and most deviated one
- Error in the counted number of events inside the Z mass

W+JETS BACKGROUND ESTIMATION

- The efficiency for a fakeable object to pass lepton selections (fake rate) is measured in bins of ($p_T \eta$) a QCD enriched data sample
- The fake rate is applied as a weight for the events failing the lepton ID but passing the analysis selections



WW BACKGROUND ESTIMATION

For $m_H < 200$ GeV, 0/1-jet bins: WW yields computed in data from sideband defined as:

- $m_{ll} > 100$ GeV
- m_H dependent cuts on lepton p_T
- Subtract first other background according to their data driven estimates
- WW data driven yields propagated by MC to the Cut Based and MVA Higgs selection

For $m_H > 200$ GeV and 2-jets bin: Use MC prediction

WW CROSS SECTION RESULTS

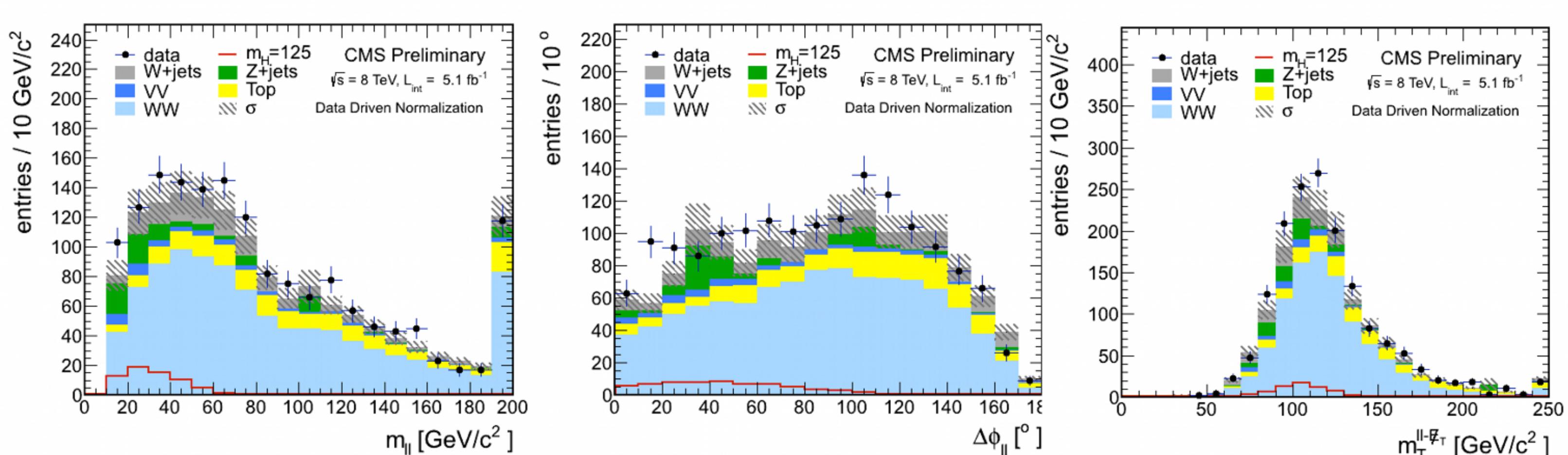
$$\sigma_{WW} = \frac{N_{Data} - N_{bkg}}{L_{int} \cdot \epsilon \cdot BR(WW \rightarrow \ell\nu\ell'\nu')}$$

Increase purity of data sample:

- $\rightarrow p_T > 20$ GeV on both leptons
- No jets with $p_T > 30$ GeV
- WW acceptance x efficiency
- Estimated using MC
- $\rightarrow A \times \epsilon (gg+qq \rightarrow WW) = 3.22 \pm 0.22\%$

$$\sigma_{WW} = 69.86 \pm 2.8 \text{ (stat)} \pm 5.6 \text{ (syst)} \pm 3.07 \text{ (lumi)} \text{ pb}$$

sample	yield \pm stat. \pm syst.
gg → WW	$43.3 \pm 1.0 \pm 13.4$
qq → WW	$640.3 \pm 4.9 \pm 47.4$
t̄t + tW	$130.5 \pm 12.7 \pm 19.3$
W + jets	$60.0 \pm 4.3 \pm 21.6$
WZ + ZZ	$27.4 \pm 0.5 \pm 2.9$
Z/γ*	$42.5 \pm 6.0 \pm 9.9$
Wγ + Wγ*	$25.9 \pm 3.1 \pm 8.2$
total background	$286.4 \pm 15.0 \pm 31.8$
signal + background	$970.0 \pm 15.8 \pm 58.7$
data	1111 ± 33



PLOTS AT WW LEVEL

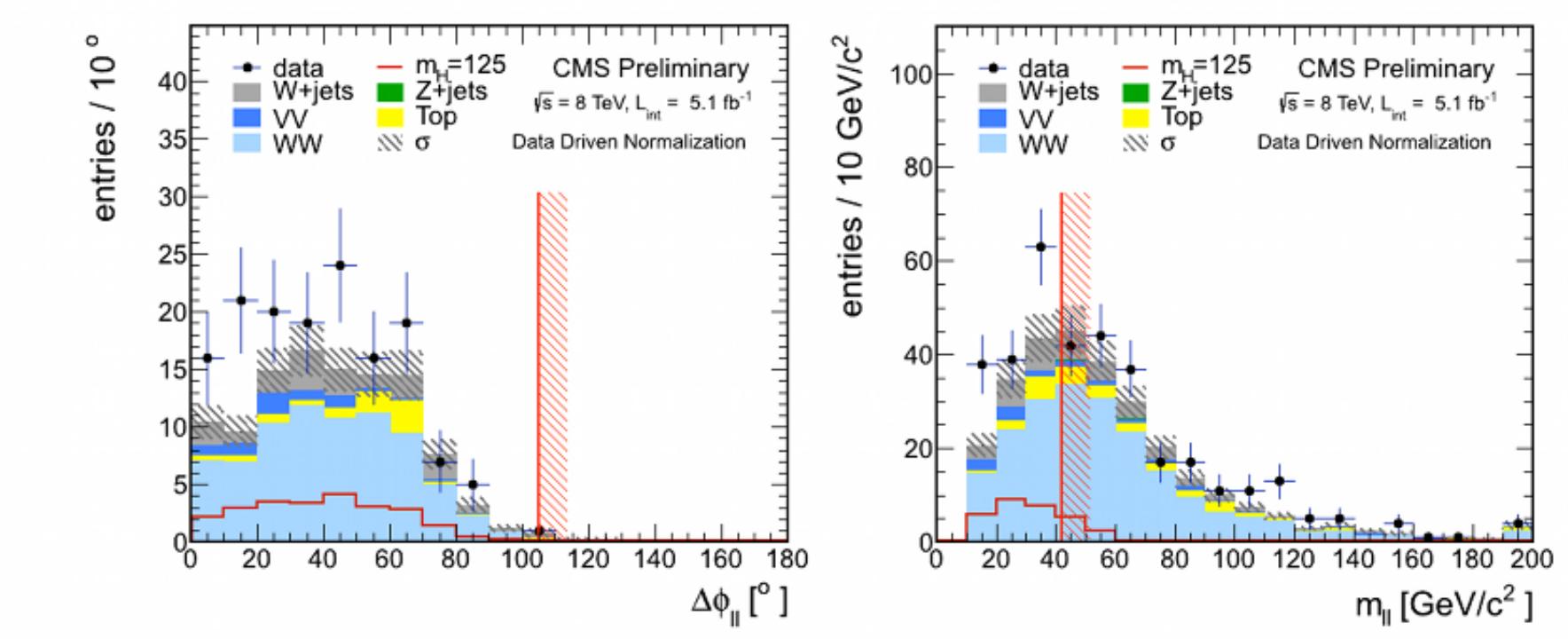
ANALYSIS FLOW

- MET selection**
 - Increase the significance of the signal (genuine MET), versus the $Z \rightarrow ll + jets$ background (fake MET)
- Jet Categorization (0,1 or 2 jets)**
- Veto events with a third lepton** to reduce diboson backgrounds (WZ and ZZ)
 - Lepton with tight ID and isolation requirements, but with $p_T > 10$ GeV
 - Near 100 % signal efficiency while removes 32 % WZ and 3 % ZZ
- Same flavour final states: ee and μμ**
 - Drell Yan events: Z can recoil against jets in the event
 - Take advantage of the azimuthal angle Φ between the leading p_T jet and the Z boson direction
- Reject events with $\Delta\Phi(l, j) > 165^\circ$**
 - j : leading jet with $15 < p_T < 30$ GeV (0 jet bin)
 - ll : dilepton system → Z boson direction
- Kinematical cut $p_T(l) > 45$ GeV**
 - Further remove DY/Z backgrounds and fakes

Till here: WW level → WW xs is calculated

Higgs mass dependent cuts to get rid mainly of WW background

m_H [GeV]	$p_T^{\ell,\max}$ [GeV]	$p_T^{\ell,\min}$ [GeV]	$m_{\ell\ell}$ [GeV]	$\Delta\phi_{\ell\ell}$ [°]	m_T [GeV]
>	>	<	<	[. .]	[. .]
120	20	10	40	115	[80,120]
130	25	10	45	90	[80,125]
160	30	25	50	60	[90,160]
200	40	25	90	100	[120,200]
250	55	25	150	140	[120,250]
300	70	25	200	175	[120,300]
400	90	25	300	175	[120,400]



2012 exclusion limit:

5.1 fb⁻¹ (8 TeV) → Cut based

Observed exclusion range:

135-198 GeV

Expected exclusion range:

127-250 GeV.

2011 + 2012 comb. exclusion limit:

4.9 fb⁻¹ (7 TeV) → Shape BDT

5.1 fb⁻¹ (8 TeV) → Cut based

