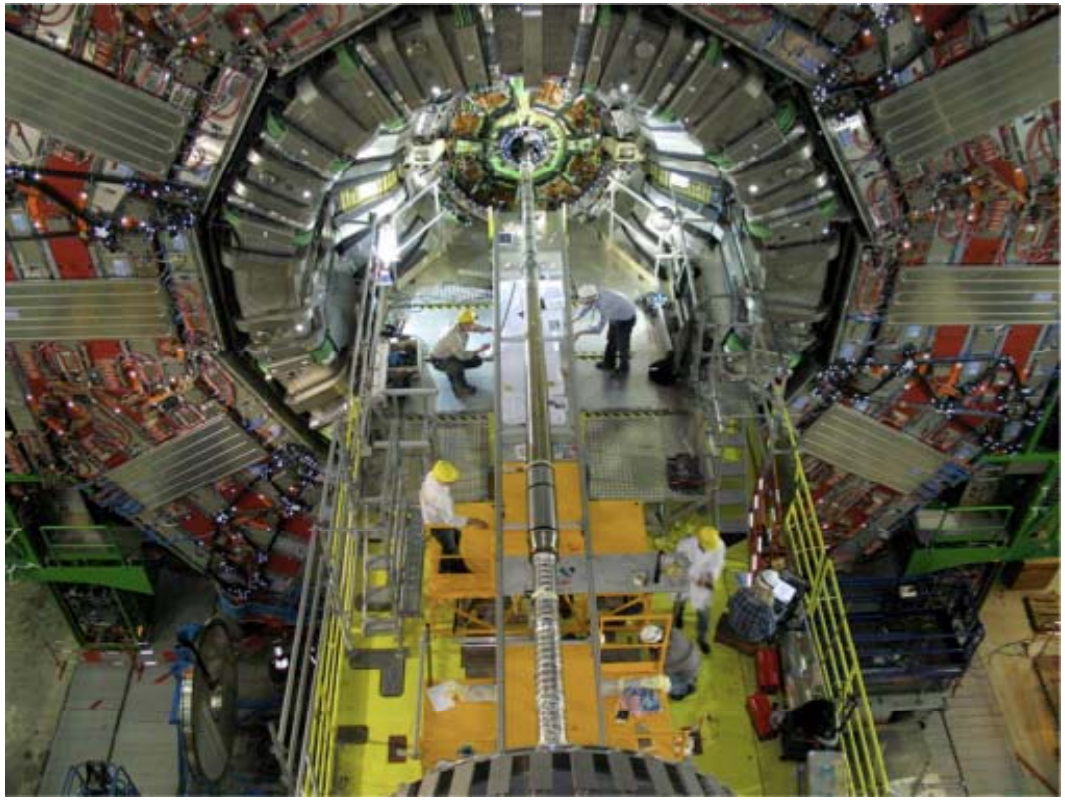
Inclusive W & Z production at the LHC startup



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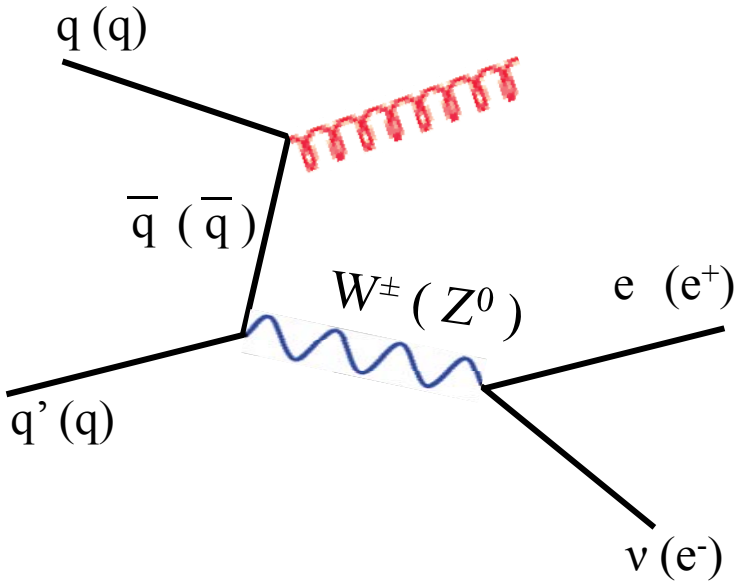
SPLIT08: 4th Conference On Physics at LHC-2008

Overview

<u>W/Z boson production</u>

clean processes with large cross sections

- detector understanding & MC tuning
- calibration & alignment
- setting PDF constraints
- luminosity measurement



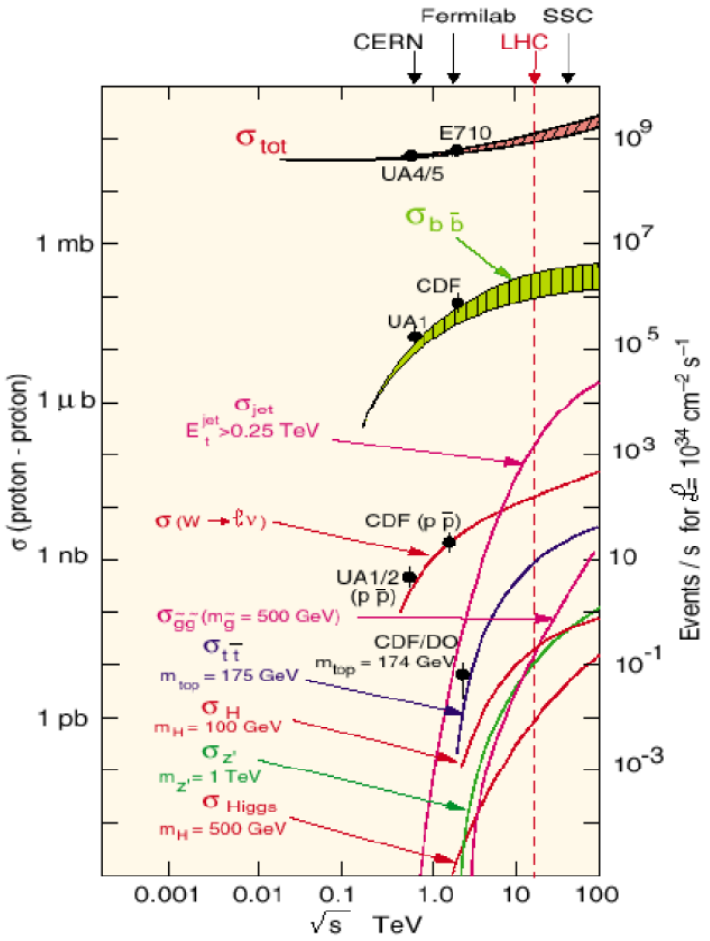
$$\sigma_W \times BR(W \to e\nu) = \frac{N_W^{pass} - N_W^{bkgd}}{A_W \times \epsilon_W \times \int Ldt}$$

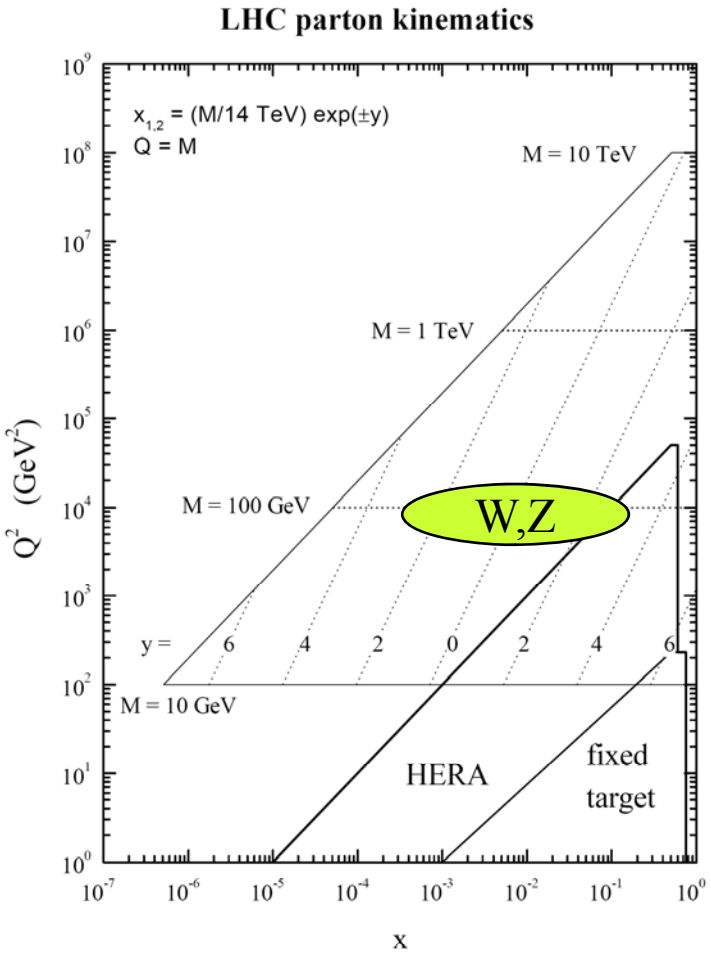
From DATA & Simulation

From Simulation

From DATA
T&P using γ*/Z→ee

W & Z production





low x, sea quarks

10 TeV , $\sigma_{W\to(e,\mu)\nu} = 2\times 11.8$ nb , $\sigma_{Z\to ee,\mu\mu} = 2\times 1.2$ nb

14 TeV , $\sigma_{W\to(e,\mu)\nu} = 2\times 17.2$ nb , $\sigma_{Z\to ee,\mu\mu} = 2\times 1.8$ nb

Selections for $\gamma^*/Z \rightarrow ee, \mu\mu$

$\gamma^*/Z \rightarrow ee$

- Single Isolated electron HLT
- 2 high E_T electrons (E_T>20.0 GeV)
- In ECAL fiducial : $|\eta|<2.5$, excluding Barrel-Endcap transition region
- Track Isolated: $\Sigma(P_T/P_T^e)^2<0.02$, P_T>1.5 GeV, $\Delta R<0.6$
- Electron Id (loose) : H/E, $\Delta\eta$, $\Delta\varphi$, $\sigma_{\eta\eta}$
- 70 GeV $< M_{e,e} <$ 110 GeV

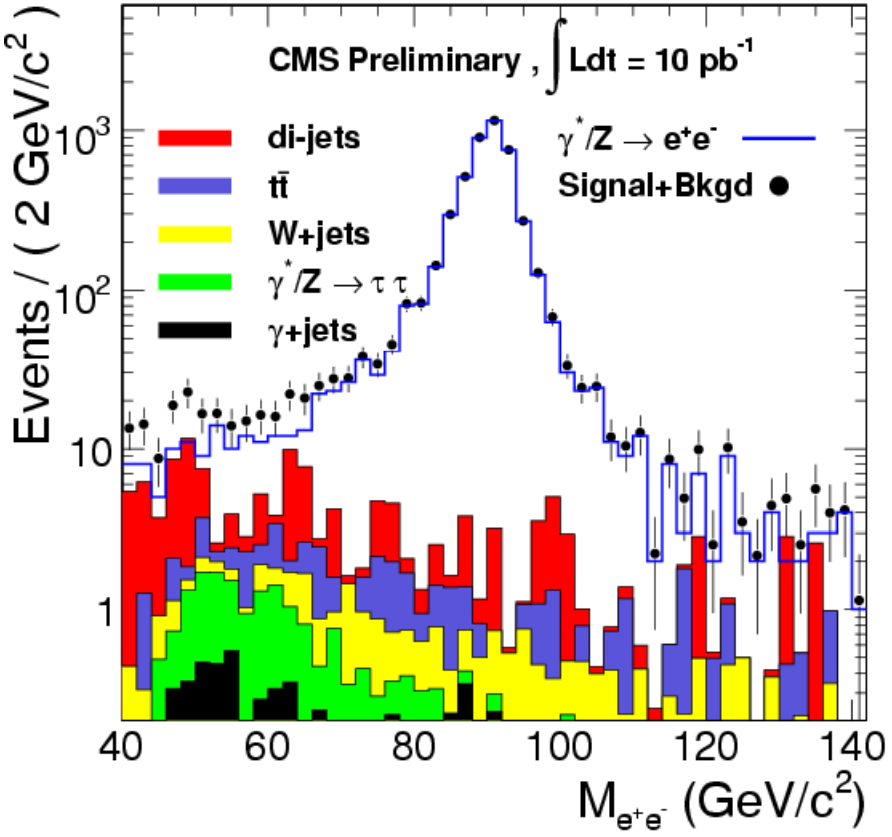
$\gamma^*/Z \rightarrow \mu\mu$

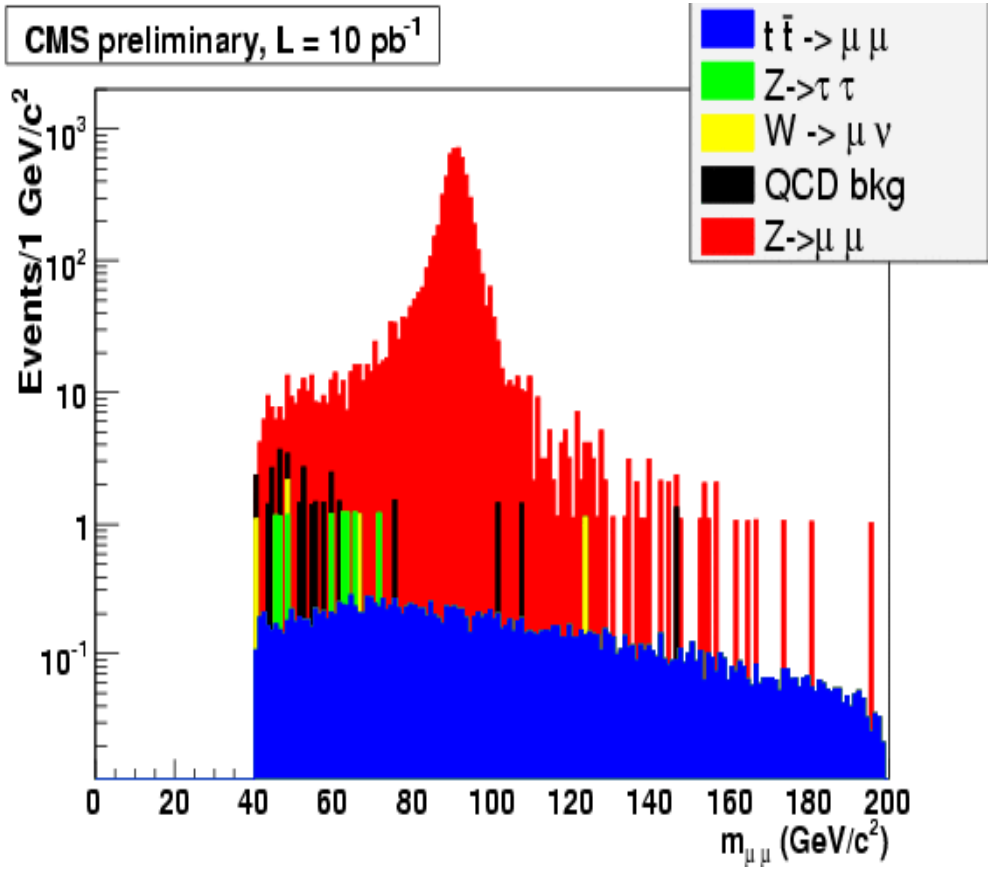
- Relaxed Single Muon HLT
- 2 high P_T muons (P_T>20.0 GeV, $|\eta|<2.0$)
- Hits from Tracker + Muon Chambers
- Opposite charge sign
- Track Isolated: $\Sigma P_T<3$ GeV, $\Delta R<0.3$
- $M_{\mu,\mu} > 40$ GeV

Omitted: Opposite Charge Sign ($\gamma^*/Z \rightarrow ee$) , common vertex, Impact parameter cut.

Background estimation from sidebands and/or simultaneous fit to signal & background.

Selections for $\gamma^*/Z \rightarrow ee,\mu\mu$





Current selections provide a pure sample of $\gamma^*/Z \rightarrow e^+e^-,\mu^+\mu^-$ events.

Assuming NLO cross sections at 14 TeV and 10pb^{-1} of $\int Ldt$ we expect:
~4.6K e^+e^- pairs in the $70<M_{e,e}<110$ mass region
~5.5K $\mu^+\mu^-$ pairs in the $70<M_{\mu,\mu}<140$ mass region.

Selection efficiencies with T&P

- Relies upon $\gamma^*/Z \rightarrow e^+e^-$ decays to provide an unbiased, high-purity electron sample with which to measure the efficiency of a particular cut or trigger.

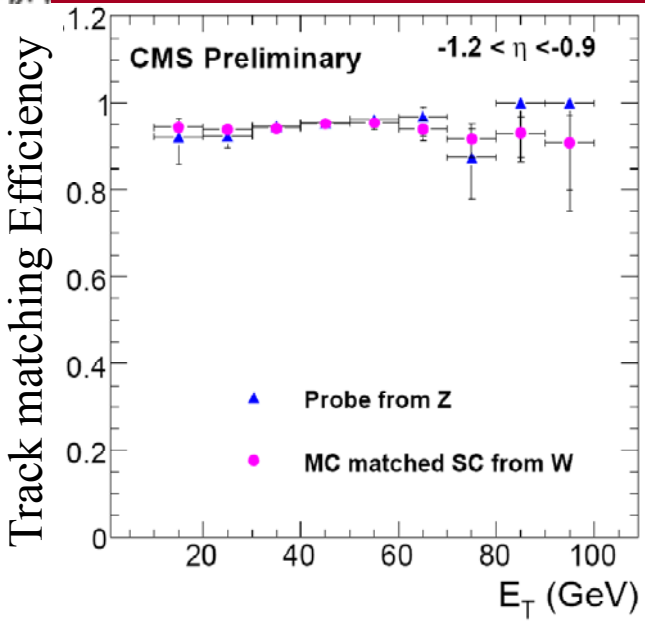
The "tag"	**The "probe"**
Passes stringent electron identification criteria	Passes a set of identification criteria depending on the efficiency under study

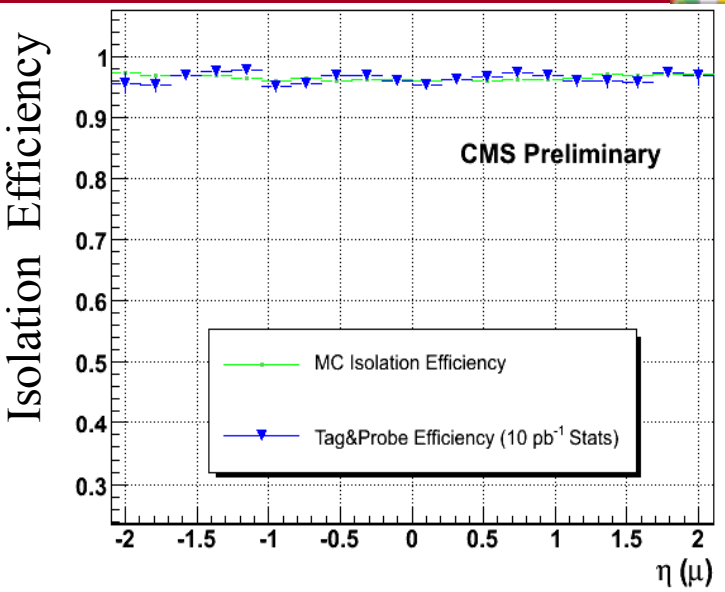
- The invariant mass of the tag & probe, M_{TP}, is required to be within a window around M_Z.

- Tight criteria on the "tag" + M_{TP} requirement is sufficient to ensure high electron purity.

- Contamination might come from jets faking electrons like in the W+jets or di-jets events.

Selection efficiencies with T&P

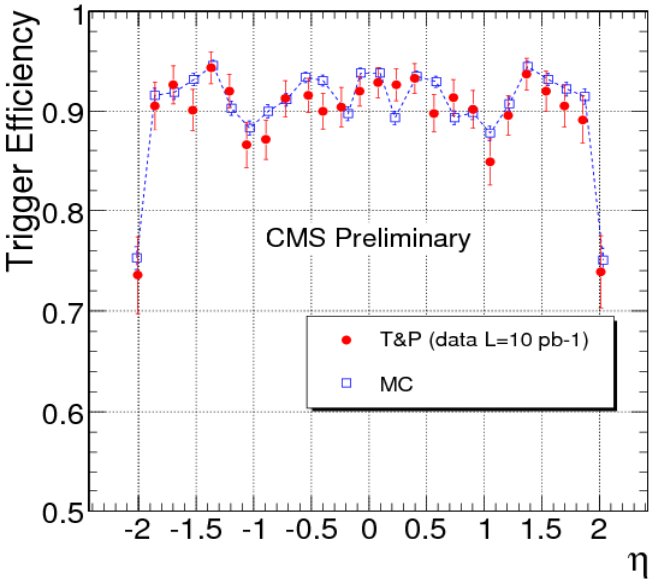




- Background subtraction methods have been developed.

- Correlations between various efficiencies are taken into account by measuring efficiencies in a specific order.

- T&P efficiencies agree well with MC for both electrons & muons.



W Selection

$W \rightarrow e\nu$

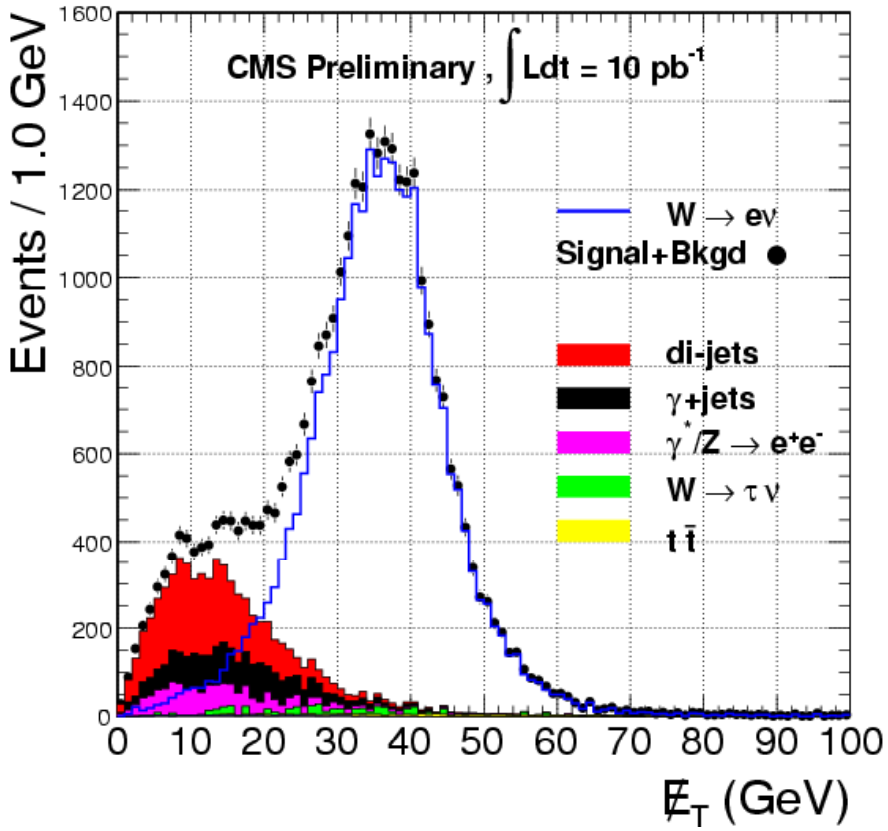
- Single Isolated electron HLT
- A high E_T electron (E_T>30.0 GeV)
- In ECAL fiducial : $|\eta|<2.5$, excluding Barrel-Endcap transition region
- Track Isolated: no tracks with P_T>1.5 GeV in a cone of $\Delta R<0.6$ around the electron.
- ECAL isolation: $\Sigma E_T/E_T^e < 0.02$, $\Delta R<0.3$
- HCAL isolation: $\Sigma E_T/E_T^e < 0.10$ (0.075), $0.15<\Delta R<0.3$
- Electron Id (tight): H/E, $\Delta\eta$, $\Delta\varphi$, $\sigma_{\eta\eta}$
- Reject events with a 2nd electron having E_T>20.0 GeV.

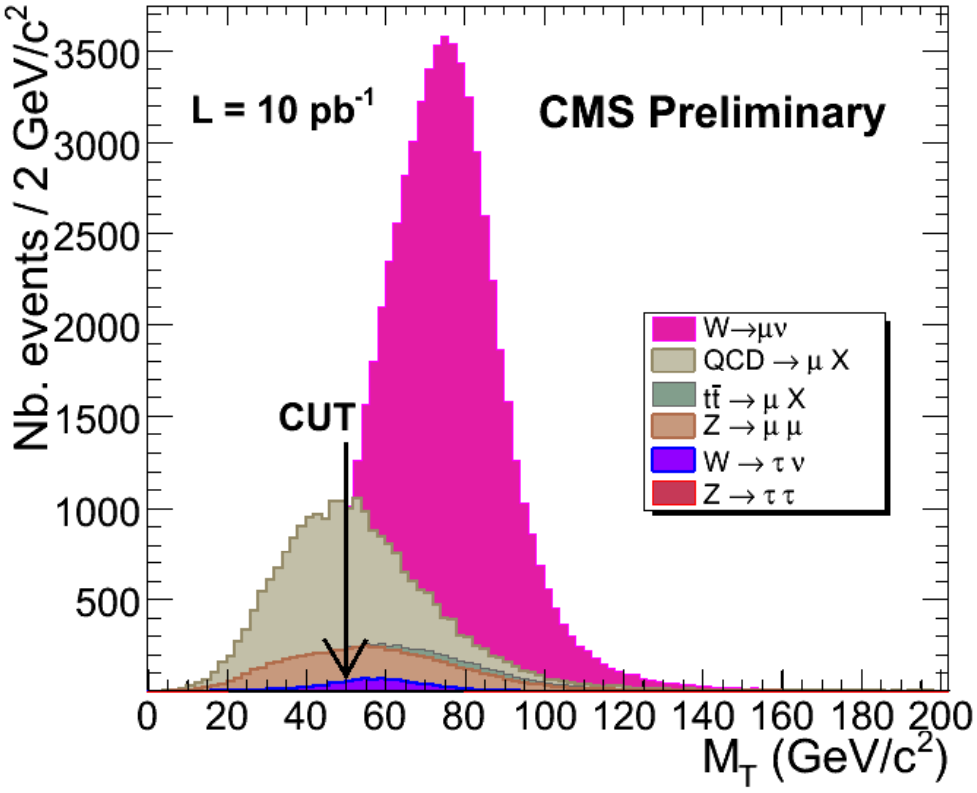
$W \rightarrow \mu\nu$

- Relaxed Single muon HLT
- A high P_T muon (P_T>25.0 GeV, $|\eta|<2.0$)
- Hits from Tracker + Muon Chambers
- Track Isolated: $\Sigma P_T/P_T^{\mu} < 0.09$, $\Delta R<0.3$
- $M_T > 50$ GeV
- Reject events with more than 3 jets with $E_T > 40$ GeV
- Reject events with acoplanarity $\zeta < 1$rad ($\zeta = 180 - \Delta\varphi$) defined between μ & $\not{E}_T$.
- Reject events with 2 P_T>20 GeV muons.

Omitted: Primary vertex requirement, Impact parameter cut.

W Selection

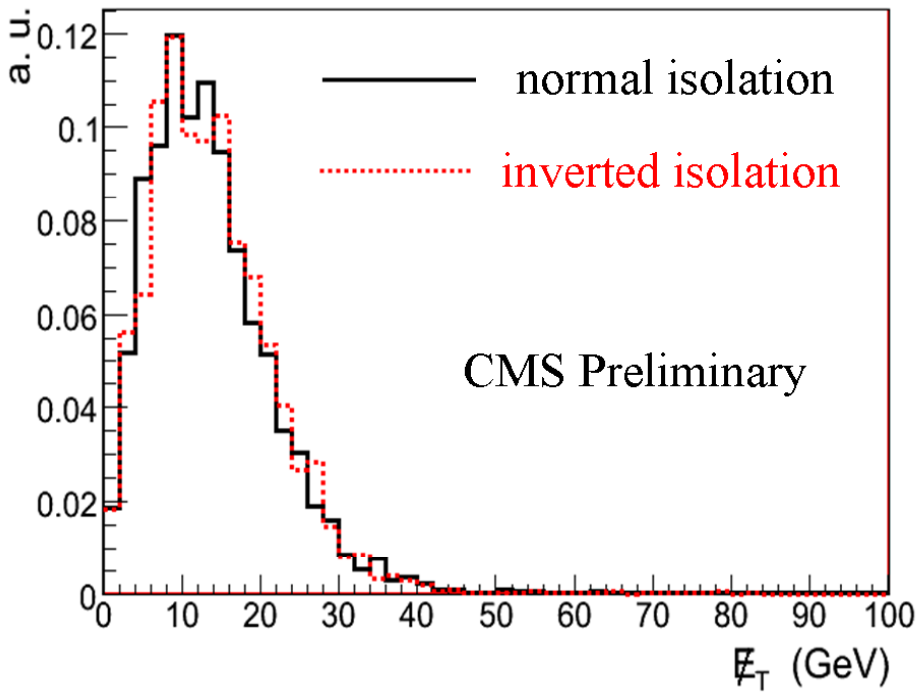


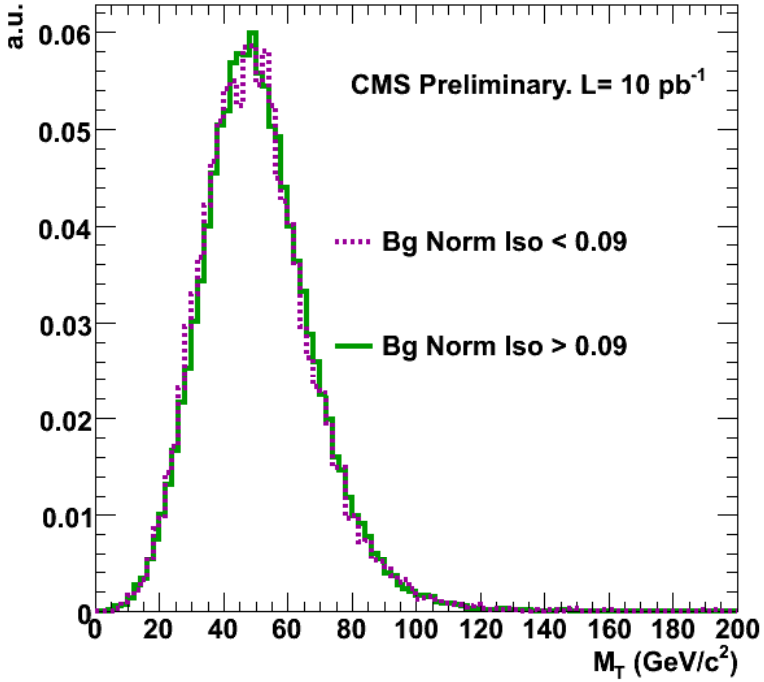


QCD is the major background in both final states.

Assuming NLO signal cross sections at 14 TeV and 10pb^{-1} of $\int Ldt$ we expect:
~28K W→eν events and ~ 6K QCD events
~64K W→μν events and ~16K QCD events

QCD Background Shape from DATA

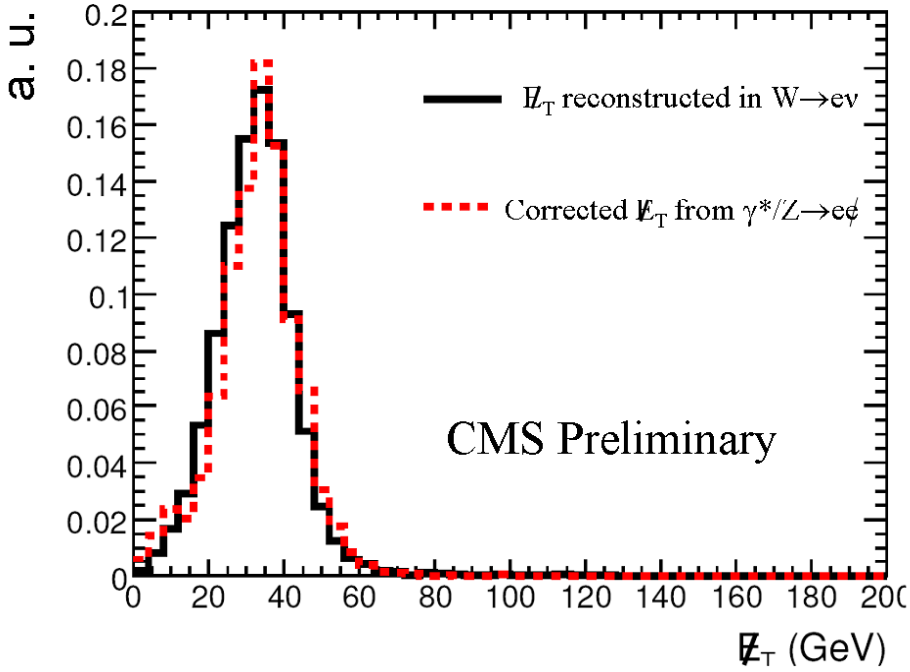


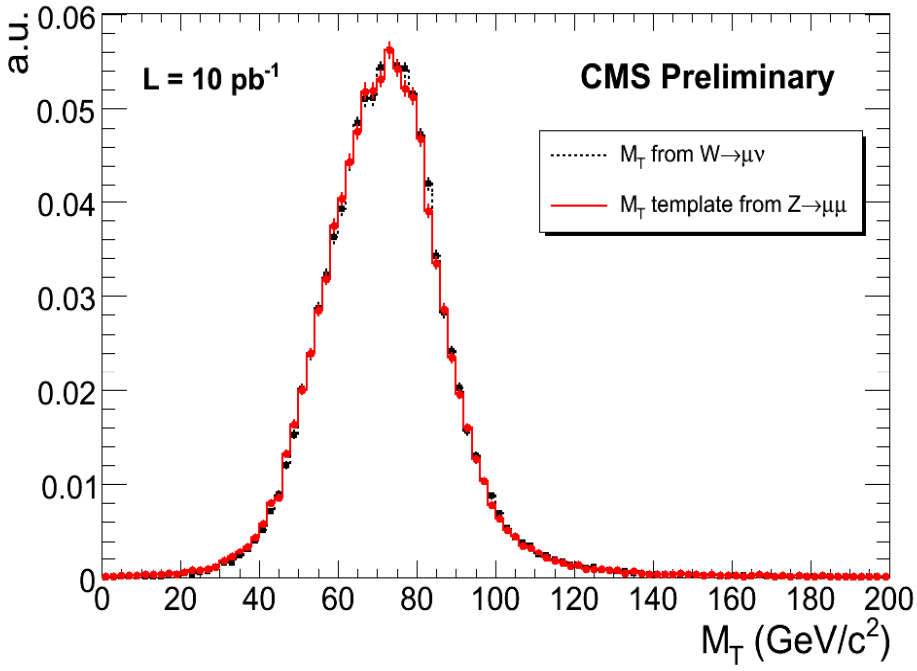


QCD background shape can be predicted by inverting one of the selection cuts (i.e. isolation)

For EWK backgrounds we will be based to MC prediction.

Ersatz W $\not{E}_T$ & M_T from γ*/Z

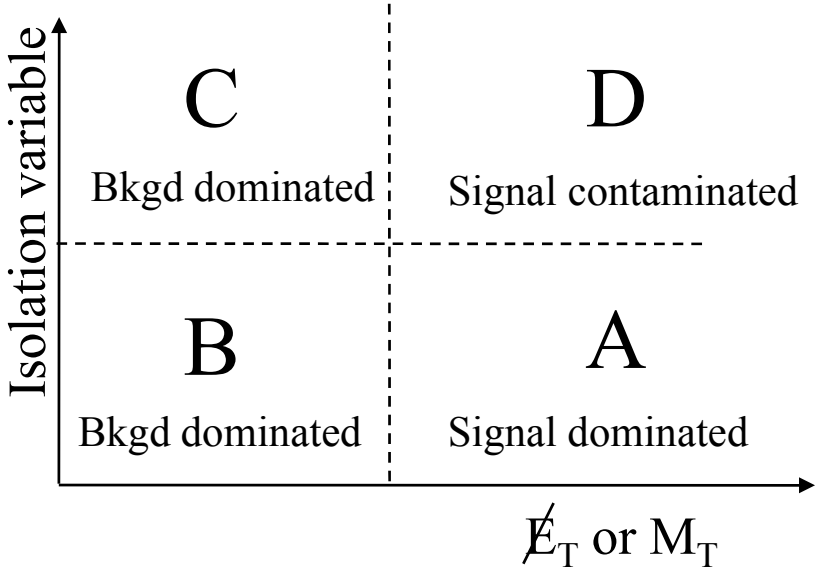


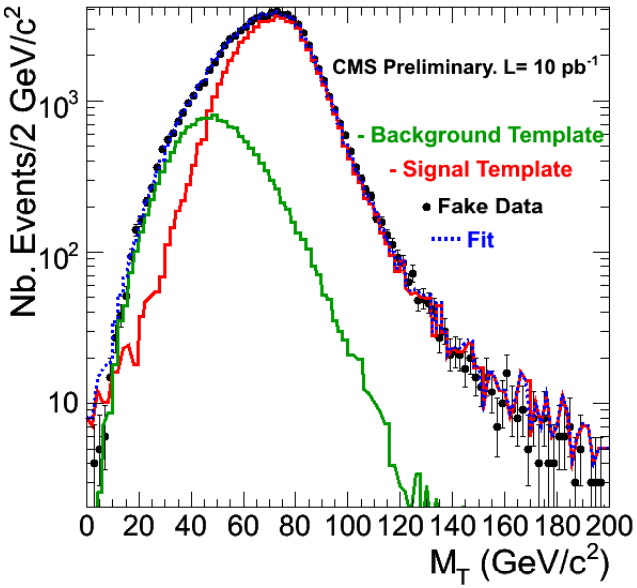


- Use γ*/Z→ee events
- Ensure that one leg will pass the W→eν selection
- Measure $\not{E}_T$ excluding the 2nd lepton.
- Account for M_W, M_Z difference and the neutrino acceptance.

- Use γ*/Z→μμ events
- Ensure that one leg will pass the W→μν selection.
- Parameterize $\not{E}_T$ versus the Z P_T
- Parameterize resolution of the $\not{E}_T$ direction by expressing it as $\not{E}_{T||}$ & $\not{E}_{T\perp}$ to the Z direction.

Methods to extract the signal





$N_i = S_i + B_i + EWK_i$, $i = A,B,C,D$

Assuming that $B_A/B_B = B_D/B_C \Rightarrow$

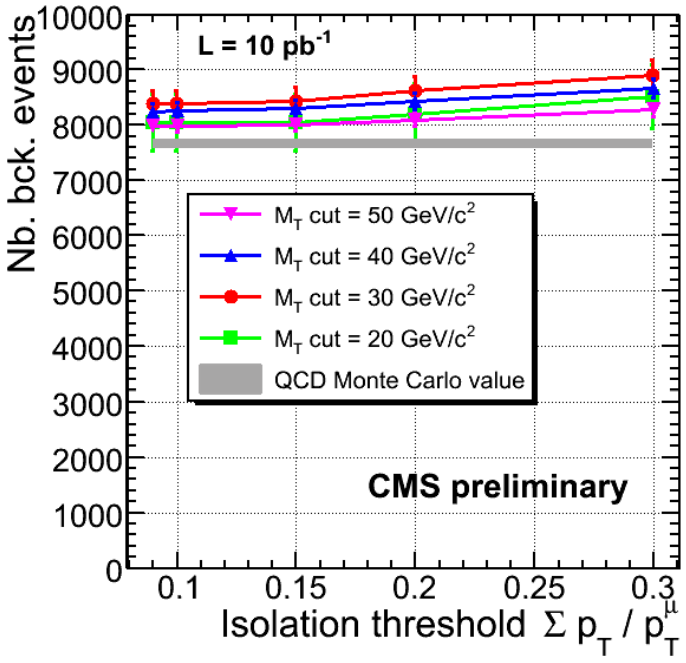
$S_{A+B} = f\ (\ S_{ratios}\ ,\ N_i\ ,\ EWK_i\ )$

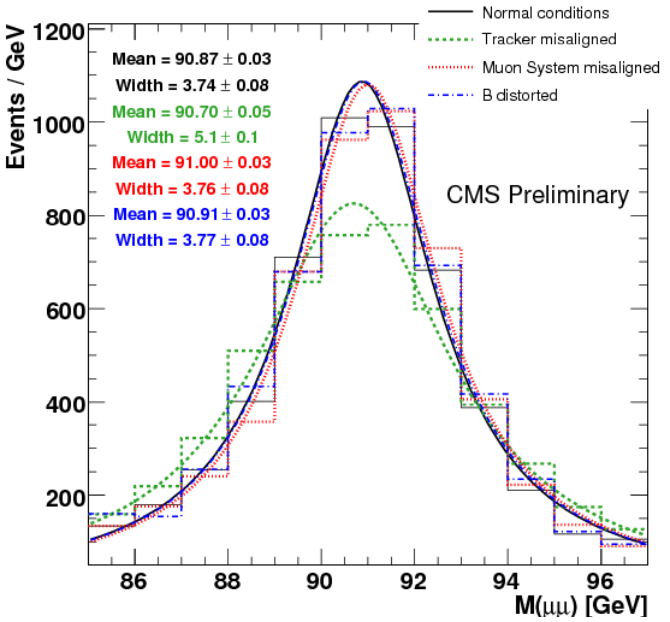
T&P , γ^*/Z MC

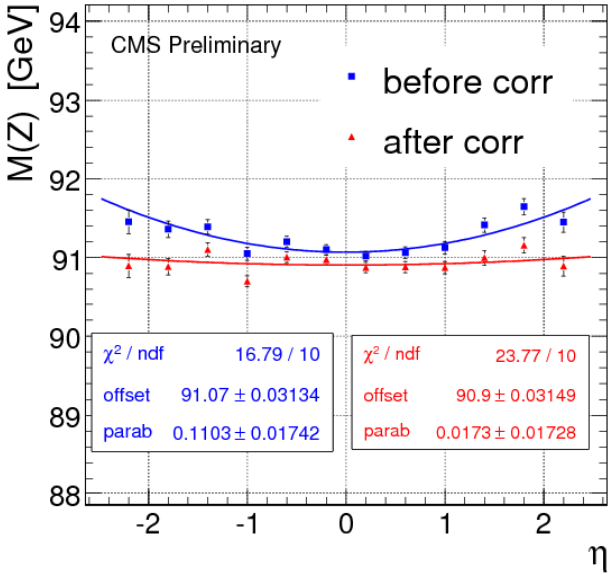
Use the Signal & Background templates and perform a simultaneous fit to the data.

Pair of variables should be uncorrelated for both signal & bkgd

Stability tests & Systematics





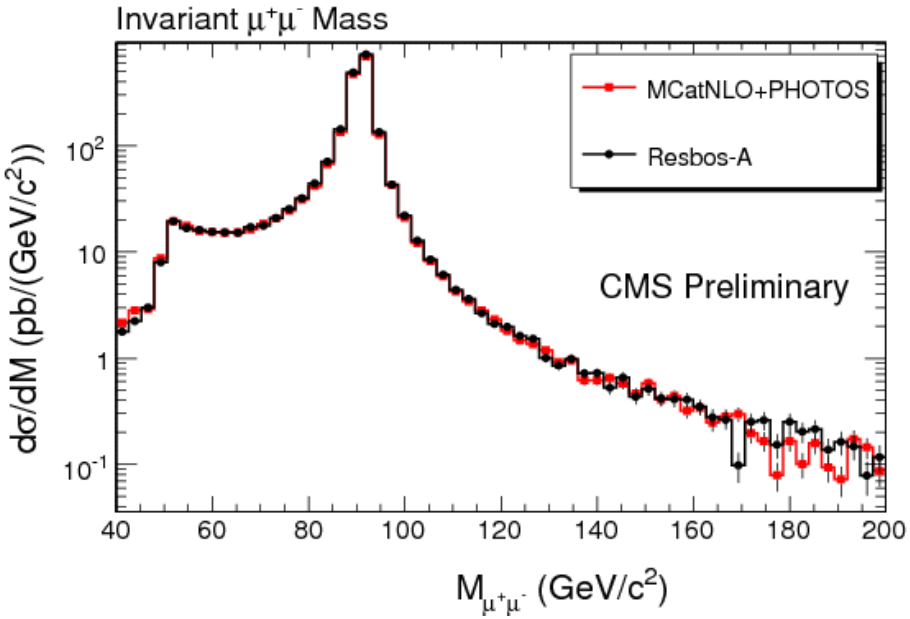


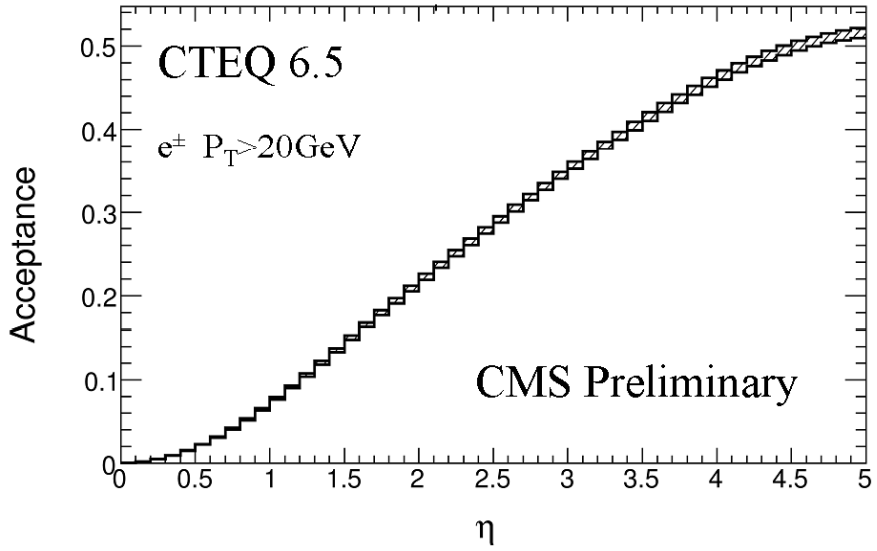
- Various tests have been performed in order to check for possible biases.
- Misalignment & miscalibration at 10pb^{-1} has been taken into account.

Theoretical Studies on Z acceptance

- MC@NLO+PHOTOS seems adequate to guarantee a theoretical uncertainty at percent level on the Z acceptance. (ResBos-A : NLO QED + NNLO QCD)

- Systematic uncertainty on Z acceptance from higher order effects, PDF uncertainties, scale uncertainties and showering effects ~ 1%





Conclusions

- A strategy for the early measurement of the inclusive W & Z production cross section have been developed for the first 10pb^{-1} of pp collision data.

- Simple & Robust selections were applied to both electrons & muons to cope with the imperfections in calibration and alignment of the CMS detector during the initial data taking.

- Tag & Probe (applied on γ^*/Z events) will provide the selection, reconstruction & trigger efficiencies from data.

- Methods to estimate QCD background from data were developed.

- Theoretical uncertainties on the acceptance were estimated to be ~ 1%

- The dominant systematic in the cross section measurements will come from the measurement of the integrated luminosity (10%).