0.1 Higgs

0.1.1 Search for Higgs Boson decays to two W bosons at the LHC

The Standard Model of particle physics (SM) has been highly successful in explaining a large amount of high energy experimental collider data. One of the remaining open questions is the origin of the masses of the W and Z bosons, the electro-weak symmetry breaking mechanism. In the SM the solution to this problem is the Higgs mechanism leading to one additional scalar field, the Higgs field, whose quantum, Higgs boson, should be experimentally observable. The W^+W channel is particularly sensitive for the Higgs boson searches in the intermediate mass range (120 - 200 GeV/c^2).

In 2007-2008 E. Di Marco performed the setup of the analysis strategy in the scenario of 14 TeV pp collisions at LHC [?] [?], and in 2009 did the consolidation of it in 10 TeV scenario [?]. In particular, he used his experience on the electromagnetic calorimeter and on the electron reconstruction to optimize the rejection of fake electrons in the di-electron channel and in the $e\mu$ channel to reject the background coming from W+jets.

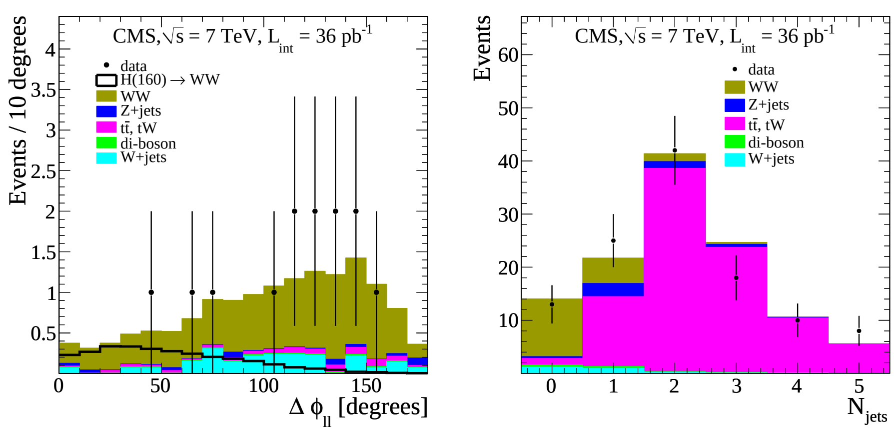
With the CMS dataset of pp collisions at $\sqrt{s} = 7$ TeV we focused on the first measurment of the irreducible electroweak background, the non-resonant production of W^+W^- bosons in the fully leptonic final state. Data driven methods were established to estimate the main backgrounds for this final state, in particular the W+jets, from the measurement of the lepton fake rate from QCD dominated samples and $t\bar{t}$, from an anti-top tagged sample.

In 2010 analysis of the first 36 pb^{-1} data of CMS, 13 W^+W^- events in the fully leptonic final states have been selected. From this yield and the $W \to \ell\nu$ branching fraction, the W^+W^- production cross section in pp collisions at $\sqrt{s} = 7$ TeV is found to be:

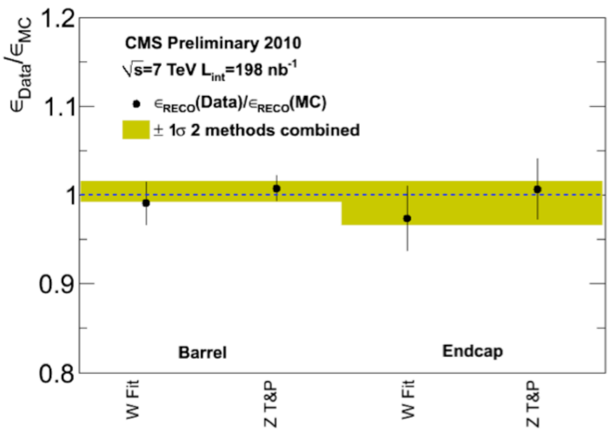
$$\sigma_{W^+W} = 41.1 \pm 15.3\ (stat) \pm 5.8\ (syst) \pm 4.5\ (lumi)\ pb$$

This measurement is consistent with the SM expectation of 43.0 ± 2.0 pb at NLO [?].

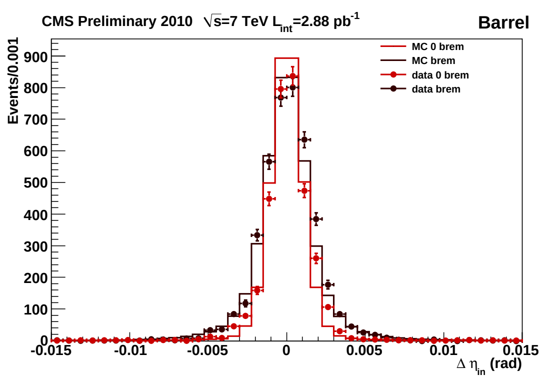
With the same dataset, the search of the Higgs boson in W^+W^- final state has been performed. We used two techniques, both starting from common W^+W^- event selection, one with sequential cuts and the other with a more sophisticated technique (boosted decision tree). Both of them cover a large Higgs boson mass (m_H) range, and each is separately optimized for different m_H hypotheses. In the sequential cut analysis we use the angular correlation existing between the two leptons due to spin of the Higgs boson to discriminate against the non resonant W^+W^- production and the number of jets against the $t\bar{t}$ production 0.1.1.

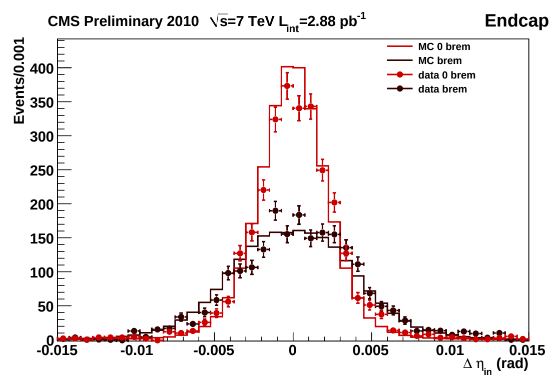


A fundamental ingredient for this first data analysis has been the commissioning of electrons with W decays, performed by us, together with the measurement of the reconstruction and identification efficiency using electrons from $W \to e\nu$ decays, before than the Z could play a role. A technique based on the maximum likelihood fit of the W transverse mass allowed the first measurement of the electron efficiency already with the first 198 nb^{-1} of CMS data 0.1.1 [?].



An innovative technique developed in the *BaBar* collaboration, the $_sPlot$ background subtraction, has been used to validate the electron identification using electrons from W decays with the first data. This allowed us to promptly spot the misalignment conditions between the electromagnetic calorimeter and the tracker, allowing a recovery of the efficiency, above all in the endcap regions, eg. affecting $\Delta\eta$ between the track and the cluster0.1.1.





With the optimized electron selection a first check of the sensitivity of CMS to $H \to W^+W^-$ was done, resulting in an observed upper limit about 3 times the Standard Model prediction around 160 GeV/c^2 Higgs mass. When compared with recent theoretical calculations performed in the context of a SM extension by a sequential fourth family of fermions with very 4 high masses [**?**], the results of the analyses exclude at 95% C.L. a Higgs boson with mass in the range from 144 to 207 GeV/c^2, where the mean expected exclusion at 95% C.L. is in the range from 147 to 193 GeV/c^2 for both the cut-based and the multivariate analysis 0.1.1.

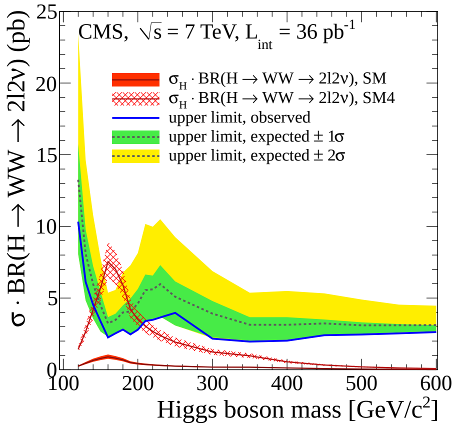
These results have been publised in [**?**].

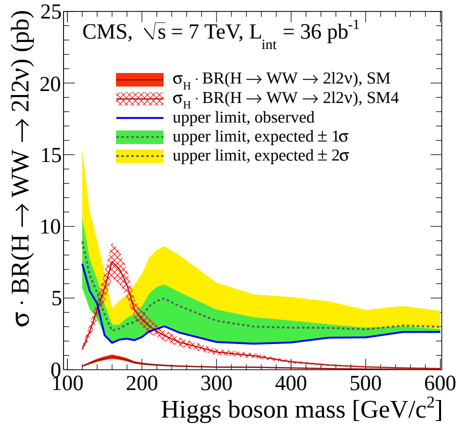
0.2 Electroweak

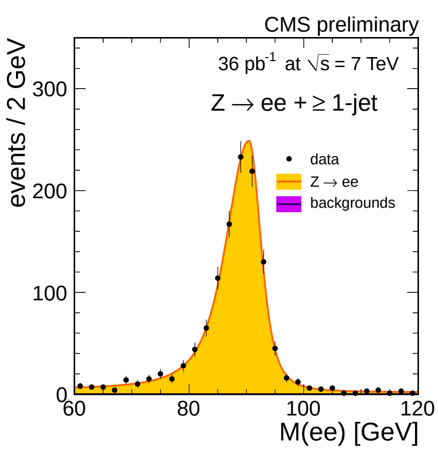
0.2.1 Measurement of W and Z boson in association with jets at the LHC

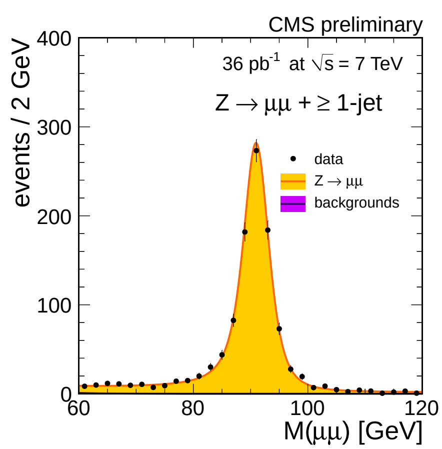
here I put only the updates respect Section 4.2.4 The Z + jets analysis has been performed on the first 36 pb^{-1} of data in a completely data-driven ways as was foreseen by the group in the preliminary studies on Monte Carlo at 14 TeV and 10 TeV. The Z+jet signal has been extracted, using $E_T > 30$ GeV/c *Particle Flow* jet reconstruction, with calibration for energy response variations in η and p_T applied. Unbinned maximum likelihood fits to the di-electron and di-muon invariant masses for Z+1 jet allowed to extract the signal yields in data0.2.1.

The results were unfolded up to the acceptance level to account for detector smearing of the jets and then compared with a Matrix Element generator (Madgraph) interfaced with a parton shower (PYTHIA) and

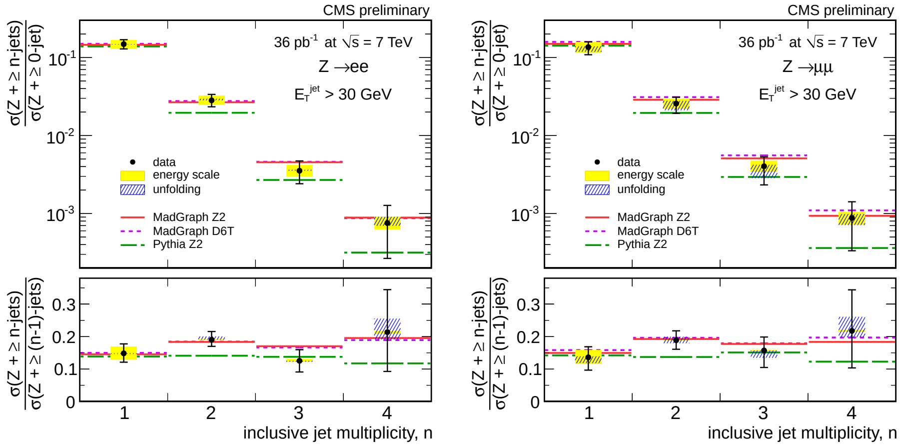

CMS, √s = 7 TeV, L_int = 36 pb^-1
σ_H · BR(H → WW → 2l2ν), SM
σ_H · BR(H → WW → 2l2ν), SM4
upper limit, observed
upper limit, expected ± 1σ
upper limit, expected ± 2σ
σ · BR(H → WW → 2l2ν) (pb)
Higgs boson mass [GeV/c^2]


CMS, √s = 7 TeV, L_int = 36 pb^-1
σ_H · BR(H → WW → 2l2ν), SM
σ_H · BR(H → WW → 2l2ν), SM4
upper limit, observed
upper limit, expected ± 1σ
upper limit, expected ± 2σ
σ · BR(H → WW → 2l2ν) (pb)
Higgs boson mass [GeV/c^2]

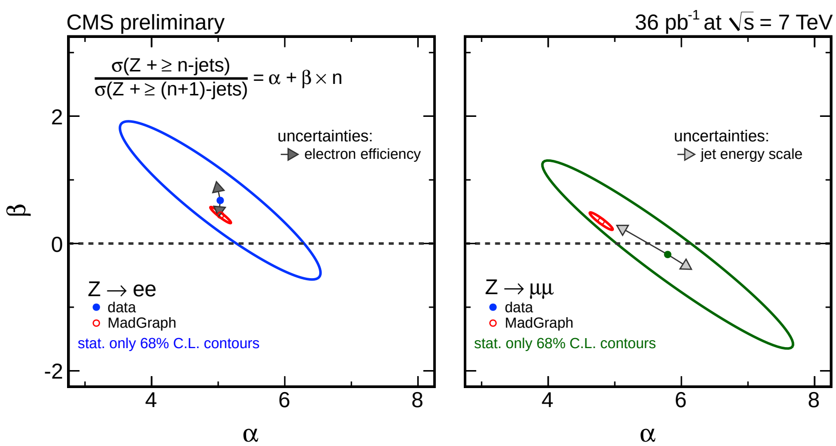

CMS preliminary
36 pb^-1 at √s = 7 TeV
Z → ee + ≥ 1-jet
data
Z → ee
backgrounds
events / 2 GeV
M(ee) [GeV]


CMS preliminary
36 pb^-1 at √s = 7 TeV
Z → μμ + ≥ 1-jet
data
Z → μμ
backgrounds
events / 2 GeV
M(μμ) [GeV]

with a parton-shower Monte Carlo only (PYTHIA). The former clearly describe better the jet multiplicity in data0.2.1.



We also measured the Berends Giele scaling in Z+jets, in a quantitative way, fitting for the inclusive Z+jets sample and the scaling rule (α), allowing a breaking of the rule through a free parameter (β). The unfolding up to the acceptance is performed consistently in the fitting procedure allowing for a correct propagation of the statistical uncertainties. The result on data is consistent with the expected scaling from matrix element MC, and no breaking of this rule is observed so far 0.2.1.



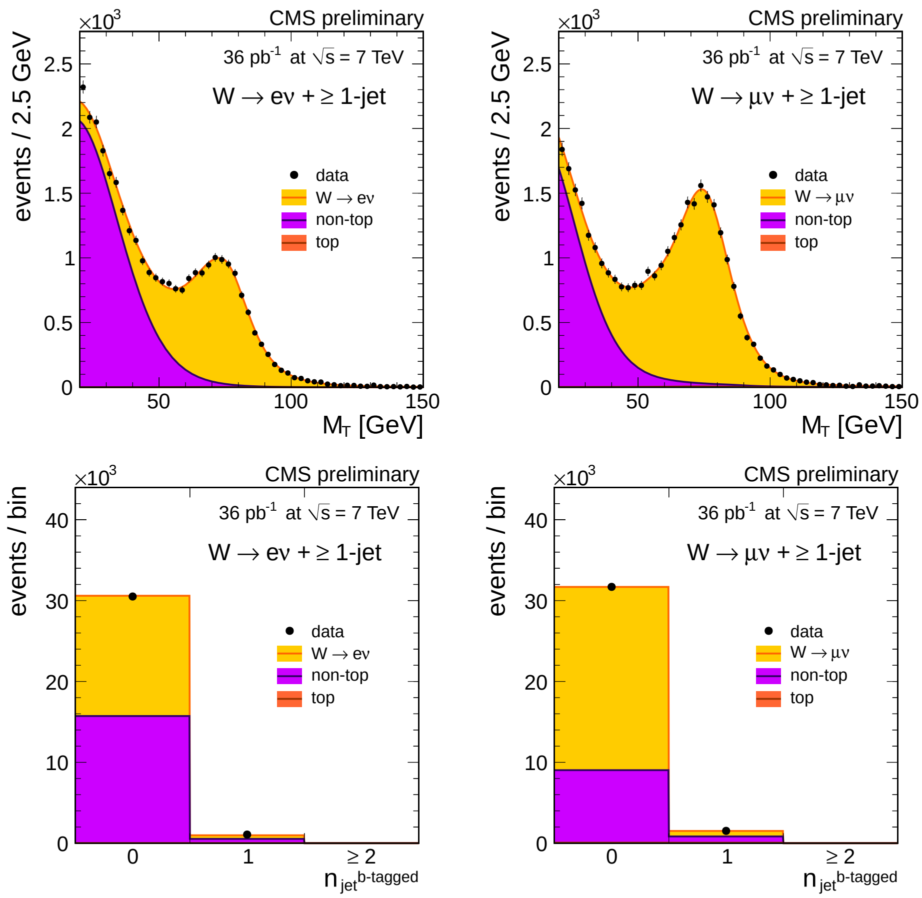
The same measurements of rates and Berends Giele scaling have been performed on the same dataset for W+jets production. Also in this case, the signal extraction and the bacground estimation is done in a completely data-driven way making use of the W transverse mass and of the multiplicity of b-tagged jets in the event and the efficiency of b-tagging one real b-falvored jet plus the mistag rate of light-flavored jets0.2.1. Those have been measured on data control sample (fully leptoninc $t\bar{t}$ sample and QCD, respectively).

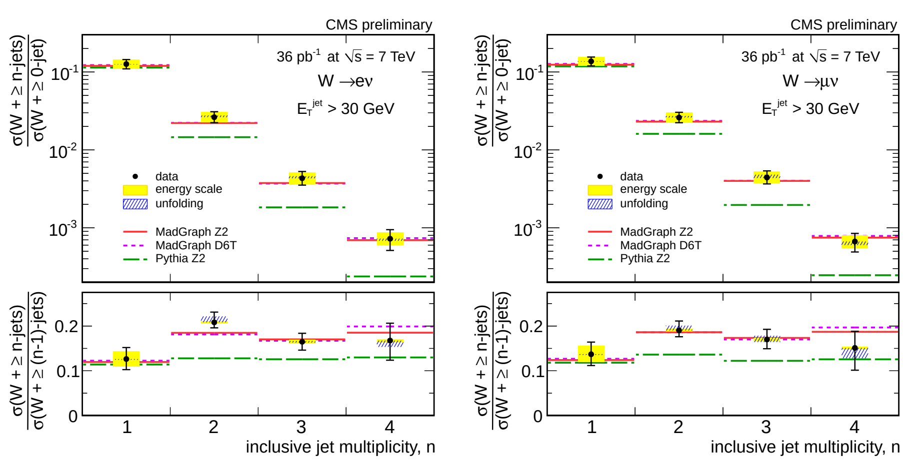
The W+jets rates have been measured consistent with the matrix element calculations 0.2.1.

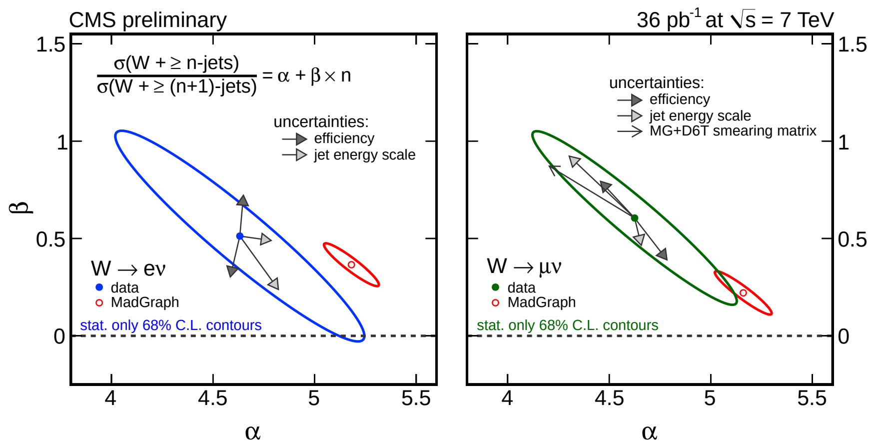
Also in this case, the Berends Giele scaling is consistent with the theory expectation from Madgraph 0.2.1.

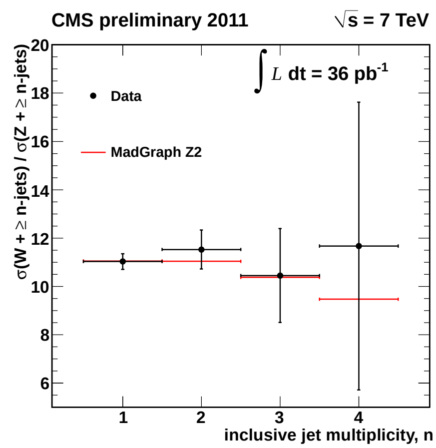
The W/Z measurement, as a function of the jet multiplicity, which is one of the more robust observables with the startup data of CMS, being less sensitive to lepton efficiencies, jet energy scale and other systematics, have been measured. The resulting value is found to be constant with the jet multiplicity, in agreement with Madgrah expectation 0.2.1.

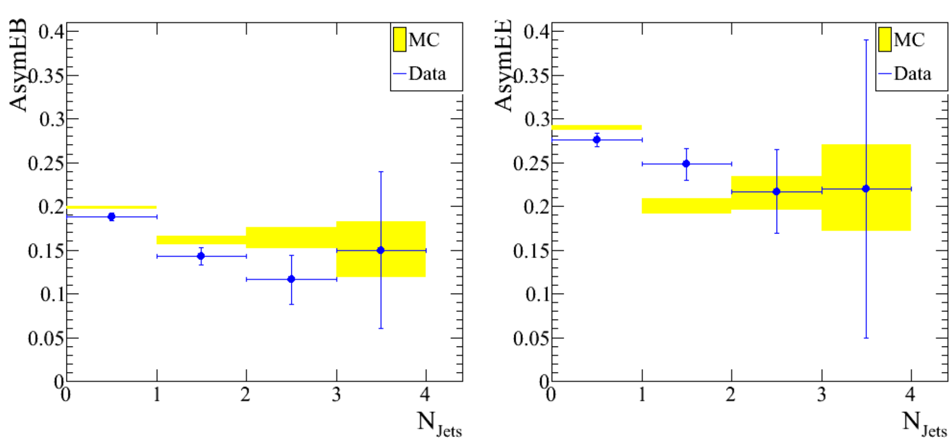
We finally measure also the W^+/W^- asymmetry, as a function of the jet multiplicity, in two $|\eta|$ regions, which have different sensitivity to the charge asymmetry, in the electron final state, up to 3 jets multiplicity 0.2.1.


CMS preliminary
36 pb-1 at √s = 7 TeV
W → eν + ≥ 1-jet
W → μν + ≥ 1-jet
data
W → eν
W → μν
non-top
top
events / 2.5 GeV
M_T [GeV]
events / bin
n_jet^b-tagged


CMS preliminary
36 pb-1 at √s = 7 TeV
W →eν
W →μν
E_T^jet > 30 GeV
data
energy scale
unfolding
MadGraph Z2
MadGraph D6T
Pythia Z2
σ(W + ≥ n-jets) / σ(W + ≥ 0-jet)
σ(W + ≥ n-jets) / σ(W + ≥ (n-1)-jets)
inclusive jet multiplicity, n


CMS preliminary
36 pb^{-1} at $\sqrt{s}$ = 7 TeV
$\frac{\sigma(W + \geq \text{n-jets})}{\sigma(W + \geq \text{(n+1)-jets})} = \alpha + \beta \times n$
uncertainties:
efficiency
jet energy scale
MG+D6T smearing matrix
W → eν
W → μν
data
MadGraph
stat. only 68% C.L. contours
β
α


CMS preliminary 2011
$\sqrt{s}$ = 7 TeV
$\int L$ dt = 36 pb^{-1}
Data
MadGraph Z2
σ(W + ≥ n-jets) / σ(Z + ≥ n-jets)
inclusive jet multiplicity, n

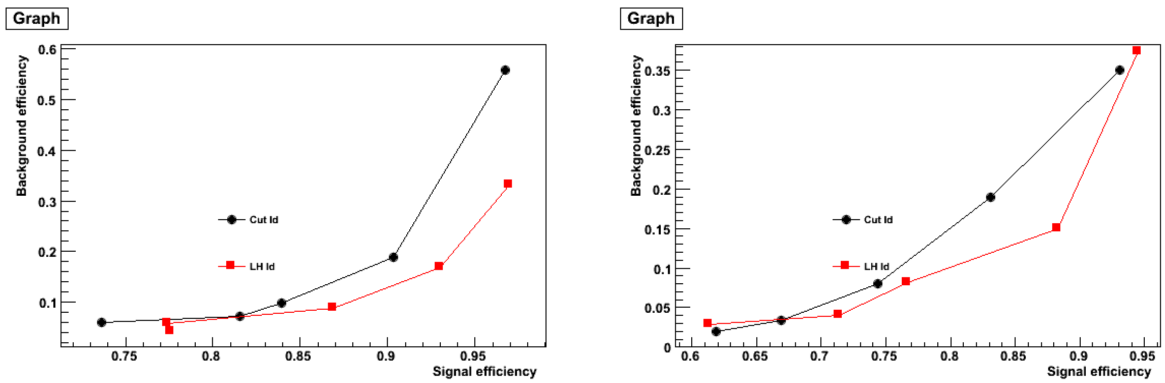

AsymEB
AsymEE
MC
Data
N_{Jets}

0.3 Egamma

0.3.1 Improved electron identification

In the years 2008-2010 we have prepared an algorithm for electron identification based on the a likelihood ratio using a minimal set of low-correlated variables. An optimal classification of electrons has been found based on the properties (material budget in front of the ECAL, fraction of radiated energy) of the identification variables used as probability density functions (PDFs) **??**. A new definition of the electron identification variables used in a cut-based approach and in this likelihood has been deployed soon by us for the 2011 data-taking where the much increased LHC luminosity respect 2010 data introduced large pileup contribution.

We devoted the first part of 2011 data taking to improve the algorithm and to validate it in the new running conditions. The efficiency has been measured on data with $Z \to e^+e^-$ decays, while the misidentification of jets have been measured from data control samples dominated by QCD jets. The ROC curves measured on data show a net improvement respect the simple cut based electron identification in the working points at higher efficiency 0.3.1.



In the optimization of this algorithm the electron isolation has been considered as well, even if kept separate because addressing different backgrounds, and an innovative technique meant for pileup subtraction for jets have been used to mitigate the pileup effect on lepton isolation too. The efficiency for the combination of the new identification and isolation has been found to be constant as a function of reconstructed vertices, as well well behaved in the whole electron acceptance region [**?**], resulting much promising for the forthcoming LHC collisions with 50 ns bunch spacing.