# Search for supersymmetry in single-lepton + jets events using the Lepton-Projection variable with the CMS experiment

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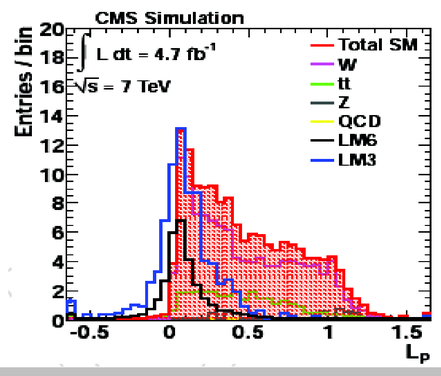
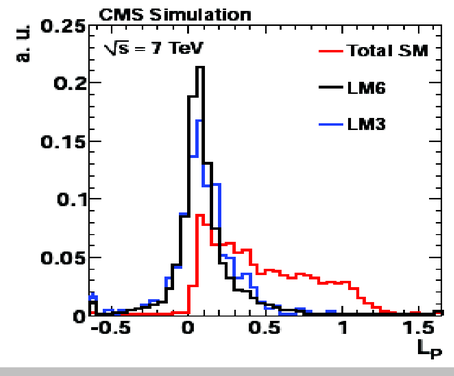
## Introduction

The polarization of high momentum W-bosons is very specific to the Standard Model and can be used to separate the W-boson processes from new physics. The Lepton Projection method uses the difference in the correlation between the lepton and missing transverse energy in events which originate from SM processes and from events originating from sparticle decays. The measurement of the polarization is done by the "Lepton Projection" variable, $L_p$, defined as:

$$L_P = \frac{\vec{P}_T(\ell)\cdot\vec{P}_T(W)}{|\vec{P}_T(W)|^2} = \frac{P_T(\ell)}{P_T(W)}\cos(W,\ell)$$

The $L_p$ distribution for SUSY decays tends to peak near zero, whereas W and top decays (EWK processes) occupy a broad range of $L_p$ values.




## Selection

The analysis requires a single, isolated, high $p_T$ lepton (muon or electron), energetic jets and large missing transverse energy:

- One lepton (muon / electron): $p_T > 20$ GeV , $|\eta| < 2.1/2.4$
- Veto 2nd lepton
- At least 3 jets: $p_T > 40$ GeV , $|\eta| < 2.4$

In addition, large energy in the leptonic and hadronic sector of the event is required by selecting events with large values of the following quantities:

- **Leptonic sector:** $S_T^{lep} = p_T(\ell) + \not{E}_T$
- **Hadronic sector:** $H_T = \sum_j p_T^j$

- $H_T > 500$ GeV (search is performed in different thresholds and bins of $H_T$)
- $S_T^{lep} > 150$ GeV (search is performed in different bins of $S_T^{lep}$)

## Search strategy / Background estimate

The analysis uses two regions of $L_P$. A **"control region"** is defined with events with **$L_P$>0.3** which is depleted in expected signal and is instead dominated by SM events, and a **"signal region"** with events with **$L_P$<0.15**, which is expected to be enriched in the potential SUSY signal.

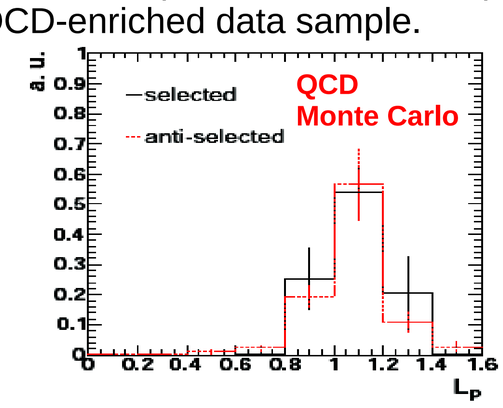
The analysis uses the number of events observed in the **control region**, to predict the SM events in the signal region by the translation factor $R_{CS}$:

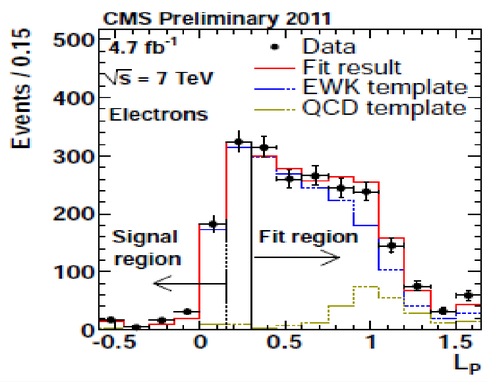
$$N_{SM}^{pred}(L_P < 0.15) = R_{CS} N_{data}(L_P > 0.3)$$

$R_{CS}$ is defined as:

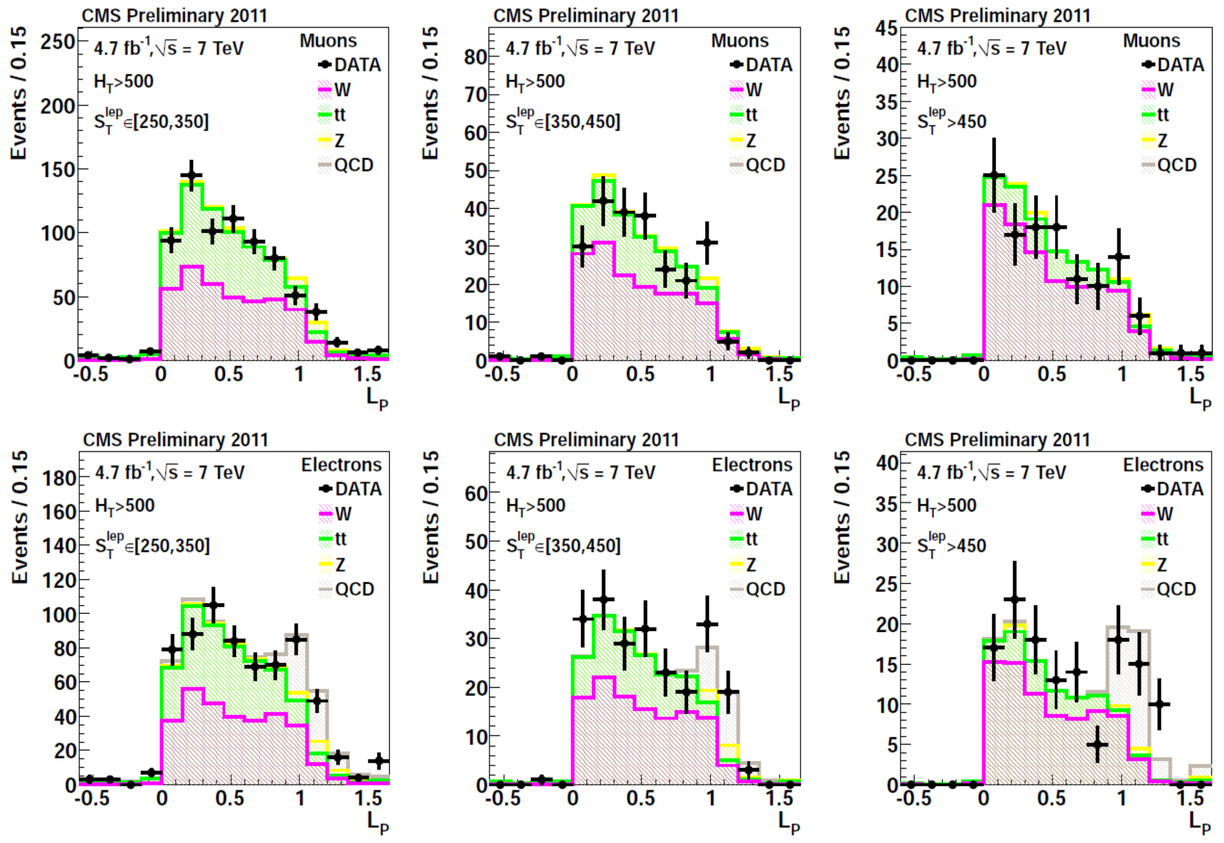
$$R_{CS} = \frac{\text{Number of events with } L_P < 0.15}{\text{Number of events with } L_P > 0.3}$$

For EWK processes, $R_{CS}$ is obtained from MC. The contribution from QCD multijets is negligible for muons. For electrons, a binned maximum likelihood fit of the $L_P$ distribution in the control region is employed. The fit uses two templates: an EWK template from MC and a QCD template from a QCD-enriched data sample.



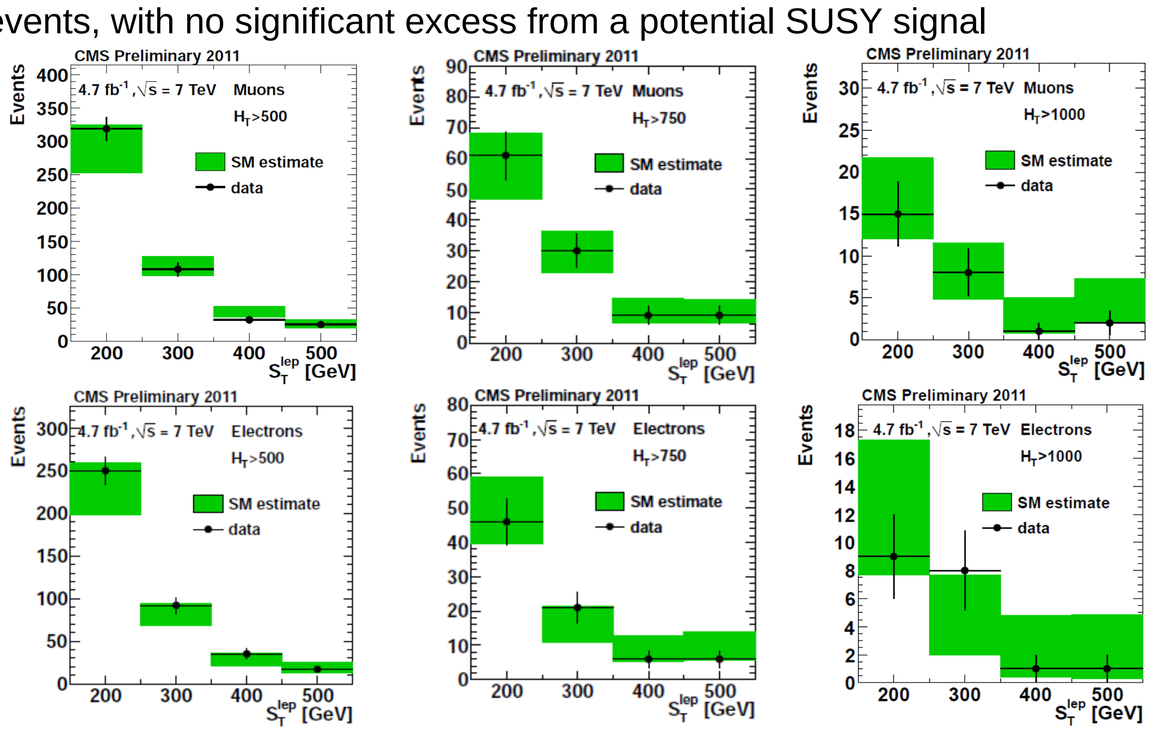




The search is performed in three ranges in $S_T^{lep}$ and three thresholds in $H_T$, in order to make it less dependent on the unknown energy scale of a new physics signal. The figures below show the $L_P$ distribution for $H_T$>500 GeV in three bins of $S_T^{lep}$ (250-350, 350-450, and >450 GeV)



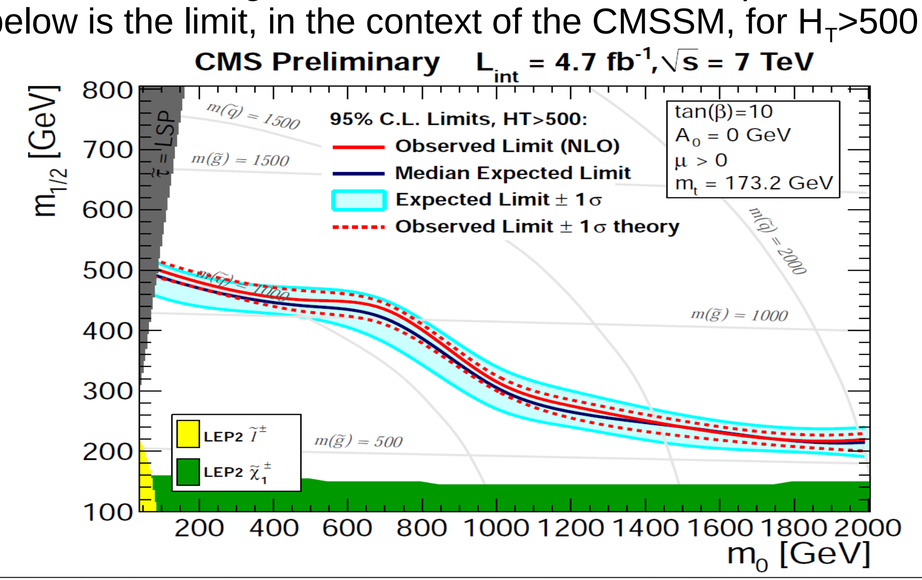

## Results

All estimates of the total contribution expected from SM processes in all $S_T^{lep}$ bins and $H_T$ thresholds are consistent with the number of observed events, with no significant excess from a potential SUSY signal




## Interpretation in CMSSM

Given the absence of signal, lower limits on the SUSY parameters are set. Shown below is the limit, in the context of the CMSSM, for $H_T$>500 GeV.




**References:**
1. CMS Collaboration, "Measurement of the Polarization of W Bosons with Large Transverse Momenta in W+jets Events at the LHC", *Phys. Rev. Lett.* **107** (2011) 021802.
2. CMS Collaboration, "Search for supersymmetry in pp collisions at $\sqrt{s}$ = 7 TeV in events with a single lepton, jets, and missing transverse momentum", *CMS Physics Analysis Summary* **CMS-PAS-SUS-11-015**
3. CMS Collaboration, "Search for supersymmetry in pp collisions at $\sqrt{s}$ = 7 TeV in events with a single lepton, jets, and missing transverse momentum", *CMS Physics Analysis Summary* **CMS-PAS-SUS-12-010**