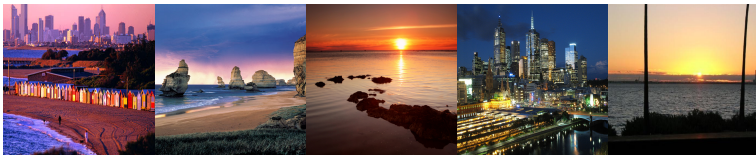


Searches for SUSY in events with two or more leptons in CMS

Pablo Martínez Ruiz del Árbol (ETH Zurich)



International Conference in High Energy Physics 2012, Melbourne, Australia



ETH Institute for
Particle Physics

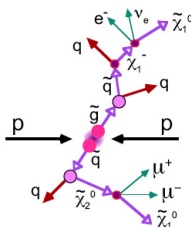


ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

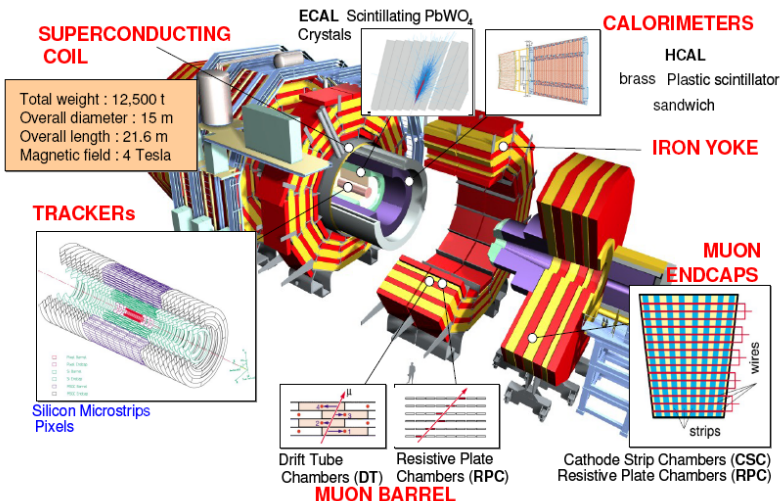
General SUSY searches

- Usually **strong production** expected although weak is also a possibility
- High mass s-particles lead to **long decay chains**
- R-parity conserving SUSY implies **invisible s-particles** in final states
- As a result **large hadronic activity** and **MET** (missing energy) are expected



Selection of CMS analysis from 2011 (5 fb^{-1}) and 2012 (4 fb^{-1}) data taking

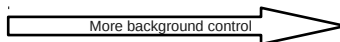
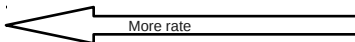
The Compact Muon Solenoid



SUSY searches with leptons in CMS

- Include selection cuts on **hadronic activity** (H_T , jet multiplicity) and **MET**
- Asking for leptons significantly **reduces the background** $H_t = \sum_j P_t(jet)$
- **More controllable** backgrounds due to cleaner **kinematical methods**
- Background estimation at CMS: mainly using **control regions** from **data**
- All analysis provide additional information for **model confrontation**

Pure Hadronic	Single Lepton	Two OS leptons	Two SS leptons	Multileptons
<ul style="list-style-type: none"> • QCD • $Z \rightarrow \nu\nu$ • W+jets • ttbar 	<ul style="list-style-type: none"> • W+jets • ttbar 	<ul style="list-style-type: none"> • Z+jets • ttbar 	<ul style="list-style-type: none"> • ZZ/ZW/WW • ttZ/W • Rare SM • ttbar 	<ul style="list-style-type: none"> • ZZ/ZW/WW • ttbar • Rare SM

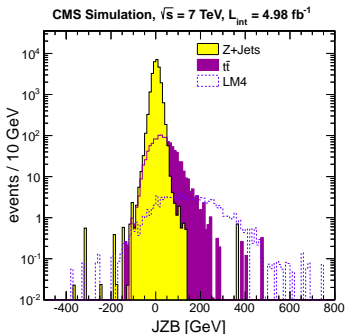


See Seema Sharma's talk for an overview of pure hadronic

See Kajari Mazumdar's talk for an overview of single lepton

On-peak search using the Jet-Z balance method at 7 TeV

- A search in the **Z + jets + MET** final state
- Select events with dilepton mass **compatible** with **Z** mass peak
- Based on the **JZB** variable (p_T balance of hadronic recoil and Z candidate)
- **JZB: correlation** between **MET** and **Z. positive for signal**
- Aim to catch cascade decays $\tilde{g} \rightarrow \text{jets} + \tilde{\chi}_2^0 \rightarrow \text{Z} + \tilde{\chi}_1^0$



$$JZB = |\sum_j \vec{P}_t(\text{jets})| - |\vec{P}_t(Z)|$$

Signal region → Positive values of JZB

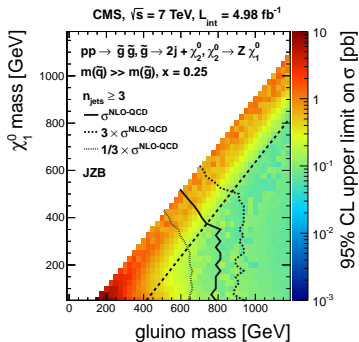
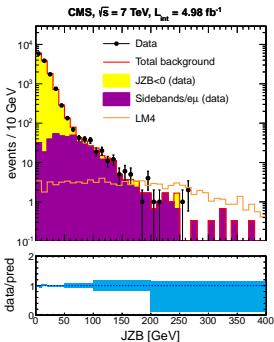
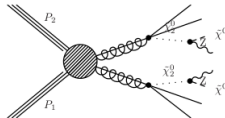
Z+jets → Negative side of JZB

ttbar → Different flavor leptons

Submitted to PLB:
arXiv:1204.3774

On-peak search using the Jet-Z balance method at 7 TeV

- **Good agreement observation-prediction**
- Limits are set in the context of **simplified models**: Single cascade decays



See poster by M.-A. Buchmann

On-peak search using the MET templates method at 7 TeV

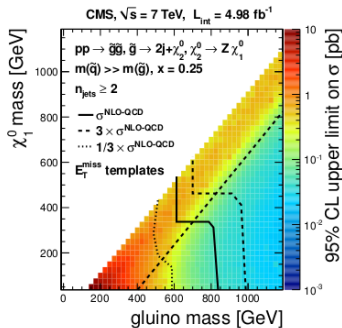
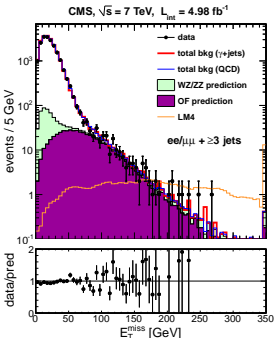
- Complementary search on the **Z + jets + MET** final state
- Agreement observation-prediction:** limits on **simplified models**

Submitted to PLB: arXiv:1204.3774

Signal → High values of MET

Z+jets → Templates from γ +Jets & QCD

ttbar → Different Flavor leptons



Off-peak search using the Edge Method at 7 TeV

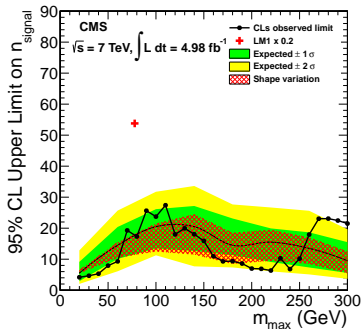
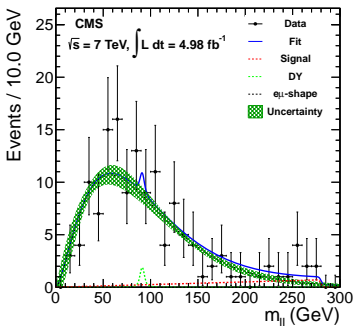
- Search on the $l^+l^- + \text{jets} + \text{MET}$
- Processes $\tilde{\chi}_2^0 \rightarrow \tilde{l}l \rightarrow \tilde{\chi}_1^0 l^+l^-$
- **No significant excess found**

Submitted to PLB:
arXiv:1206.3949

Signal → Fitted to edge shape

Z+jets → Fitted to Z-peak model

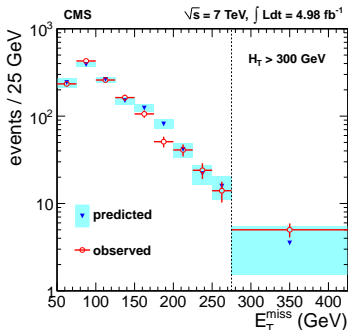
ttbar → Fitted Different Flavor leptons



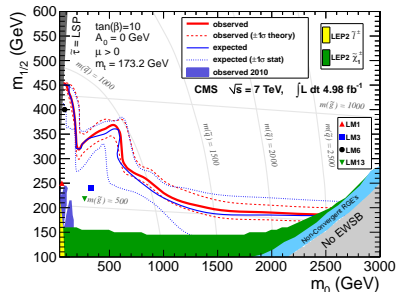
Generic off-peak search at 7 TeV

- Generic search on the $l^+l^- + \text{jets} + \text{MET}$ final state
- Sensitive to topologies without edges
- **No significant excess observed:** exclusion curve in **CMSSM** plane

Signal \rightarrow High values of MET
Z+jets \rightarrow Reduced: high MET, Z veto
ttbar \rightarrow Pt(l) method (Pt(l) \sim Pt($\nu\nu$))



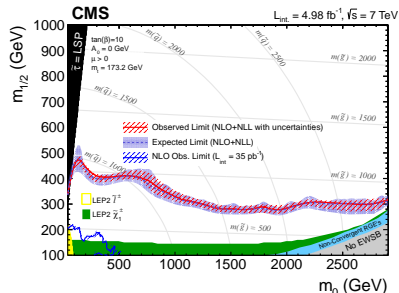
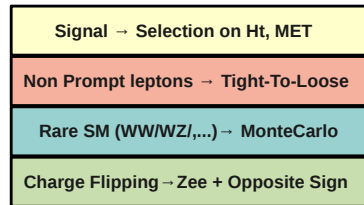
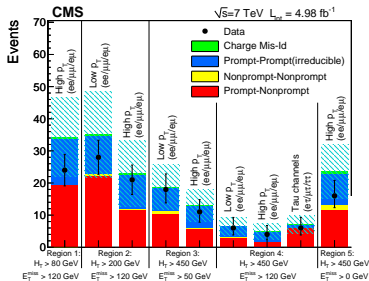
Submitted to PLB: arXiv:1206.3949



Two Same Sign leptons search at 7 TeV

- Search on the **Same Sign** final state
- **Non prompt** leptons in **W+Jets, $t\bar{t}$**
- **Exclusion** curve in **CMSSM** plane

Submitted to PRL: arXiv:1205.6615



Two Same Sign leptons and b-jets search at 7 TeV

- Search on the **Same Sign** leptonic final state with at least **2 b jets**
- Processes with **two or more tops**
- **No significant excess observed**

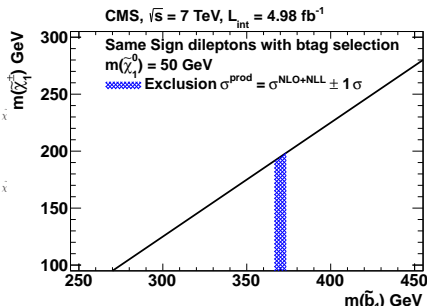
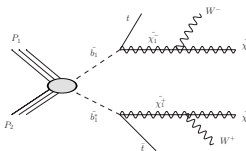
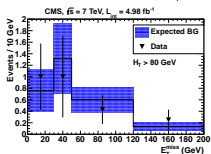
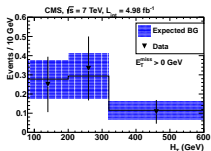
Submitted to JHEP: arXiv:1205.3933

Signal → Selection on Ht, MET, > 2 b jet

Non Prompt leptons → Tight-To-Loose

Rare SM (ttW/ttZ/...) → MonteCarlo

Charge Flipping → Zee + Opposite Sign

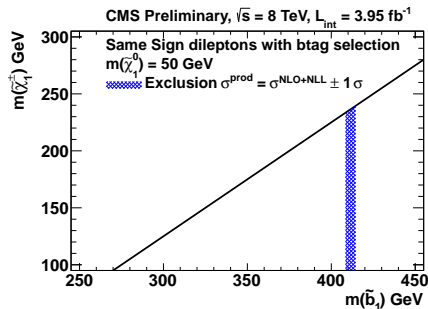
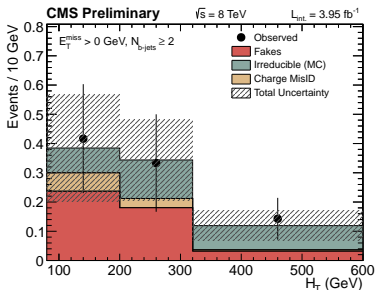


Two Same Sign leptons and b-jets search at 8 TeV **NEW!**

- **Same background** composition as in 7 TeV collisions
- Analysis strategy similar to the 7 TeV analysis
- **Updated selection** to adapt to new conditions (pileup, trigger,...)
- **Good agreement observation-prediction**

PAS-SUS-12-017

See talk by Altan Cakir for more details

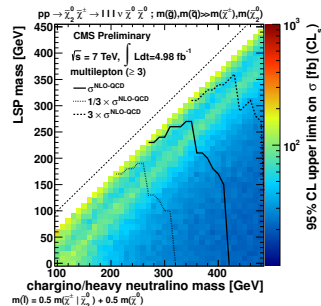
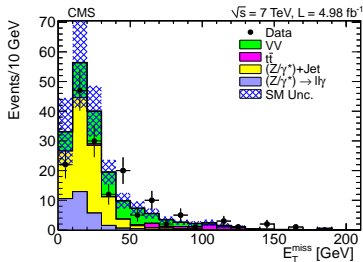


Search with more than two leptons at 7 TeV

- Search on **3 leptons** final state
- **Chargino-neutralino production** with sleptons or $W+Z$
- **No significant excess observed:** constraint several BSM models

Accepted by JHEP: arXiv:1204.5341

Signal → More than 2 leptons
Z+jets → Non prompt lepton rates
WZ/ZZ/ttbar → MonteCarlo
Z γ + assymetric conversions → 3 body mass near Z peak



Conclusions

- Many searches involving **two or more leptons** are performed at CMS
- Developed sophisticated **data-driven methods** for **background estimation**
- **All analysis** provide additional information to allow model **confrontation**
- **No excess** observed in the 2011 data set at 7 TeV
- **Presented the first analysis using 8 TeV data.** More to come ...

More information at:

<https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS>