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# **SEARCHES FOR SUSY IN EVENTS WITH TWO OPPOSITE-SIGN SAME-FLAVOUR LEPTONS IN CMS**

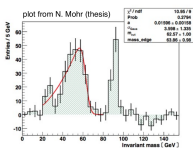
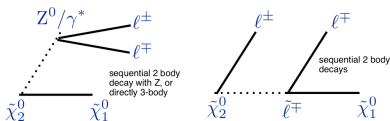
# INTRODUCTION

## This presentation covers

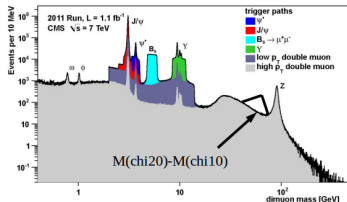
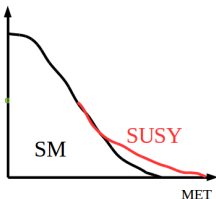
- ▶ Motivation of the search
- ▶ SUSY models we will be sensitive to
- ▶ Short review of the **history** and **state-of-the-art** of the analysis
- ▶ Presenting results almost **hot of the press**
- ▶ Dataset:  $\sqrt{s} = 13$  TeV, **12.9 fb<sup>-1</sup>** presented in **early August** in ICHEP
- ▶ Analysis fully documented in CMS-SUS-16-021

# WHY TWO OPPOSITE-SIGN SAME-FLAVOUR LEPTONS?

- ▶ Two opposite-sign same-flavour leptons can appear in decay of SUSY particles
- ▶ Decays involving an on-shell Z boson will produce an **excess on the Z invariant mass peak**
- ▶ Off-shell Z boson or slepton decays will lead to a **characteristic “edge” shape**

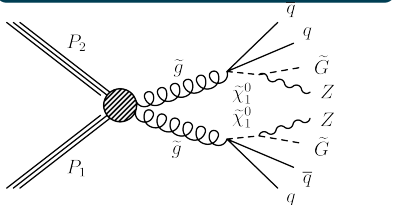


All possible mass endpoints calculated in CMS IN 2006/012, L.Pape, e.g. for a 3-body:  $M_{\tilde{H}^{\pm}}^{\text{max}} = M_X - M_0$



# SUSY MODELS CONSIDERED

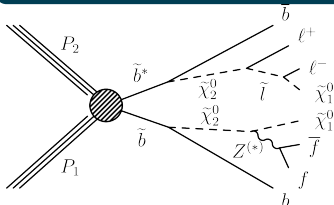
## GMSB scenario



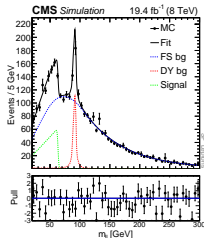
Would be observed as an excess in events

- ▶ compatible with a Z boson
- ▶ additional jets
- ▶  $E_T^{\text{miss}}$

## Slepton-edge scenario



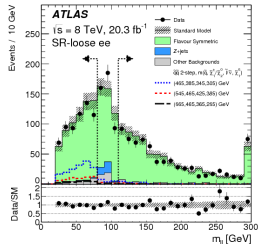
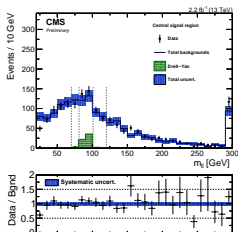
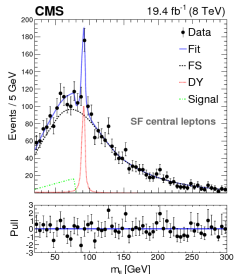
- ▶ Would be observed as an **kinematic edge** in the  $M_{ll}$  distribution



CMS-PAS-SUS-12-019

# AN ANALYSIS WITH QUITE OF A HISTORY

## SEARCH FOR AN EDGE

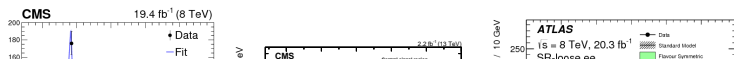


- ▶ Edge-like excess ( $2.6 \sigma$ ) reported by CMS in Run I
- ▶ Compatible with SM predictions by ATLAS

arXiv:1502.06031, CMS-PAS-SUS-15-011, ATLAS-CONF-2015-082, arXiv:1503.03290

# AN ANALYSIS WITH QUITE OF A HISTORY

## SEARCH FOR AN EDGE

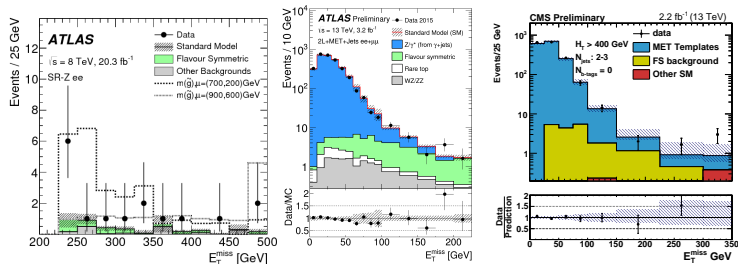


- ▶ Analysis under **careful scrutiny** in the CMS Collaboration
- ▶ Very **precise background estimation** performed

- ▶ “Interpreting a CMS  $l\bar{l}j/p_T$  Excess with the Golden Cascade of the MSSM”, B. Allanach et al. (arXiv:1409:3532v2)
- ▶ “CMS kinematic edge from s-bottoms”, Peisi Huang and Carlos E.M. Wagner (arXiv:1410.4998v3)
- ▶ “A closer look at a hint of SUSY at the 8 TeV LHC”, P. Grothaus, S. P. Liew, K. Sakurai (arXiv:1502.0571v1)
- ▶ Interpreting a CMS  $l\bar{l}j/p_T$  excess with a Leptoquark Model”, B. Allanach et al.

# AN ANALYSIS WITH QUITE OF A HISTORY

## ON-Z SEARCH



- ▶ Excess in ATLAS in runs I ( $3 \sigma$ ) and II ( $2.2 \sigma$ )
- ▶ CMS reported results compatible with SM expectations

arXiv:1502.06031, CMS-PAS-SUS-15-011, ATLAS-CONF-2015-082, arXiv:1503.03290

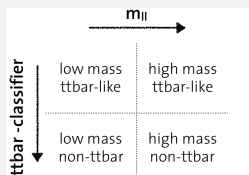
# ANALYSIS STRATEGY

- ▶ Keep regions in which excess was observed
- ▶ Add additional regions to improve sensitivity

## Baseline selection

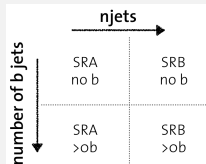
- ▶ 2 OSSF leptons ( $p_T > 25(20)$  GeV)
- ▶  $E_T^{\text{miss}} > 150$  GeV
- ▶ at least two jets ( $p_T > 35$  GeV)

## Search for a kinematic edge



+ 1 region 8 TeV CMS excess

## On-Z search



+ 1 ATLAS excess region

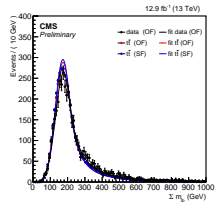
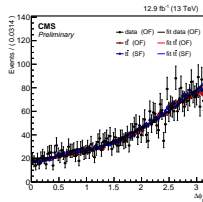
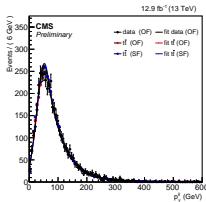
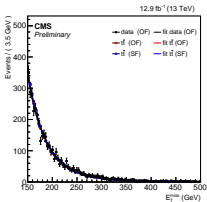
SRA: 2-3 jets,  $H_T > 400$  GeV

SRB: 4+ jets



# BACKGROUND CLASSIFIER - NLL

- ▶  $t\bar{t}$  is the dominant SM background in off-Z searches
- ▶ A likelihood discriminator is built out of four variables
  - ▶  $\Delta\phi_{ll}$
  - ▶  $\sum \min m_{lb} (m_{lj} \text{ if } n_{bjets} < 2)$
  - ▶ Independence of the variables is assumed
- ▶ 95%  $t\bar{t}$  rejection working point is chosen



# STANDARD MODEL BACKGROUNDS

## FLAVOUR SYMMETRIC

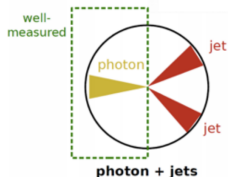
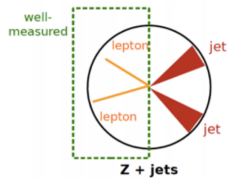
- ▶ Main background in many of the signal regions
  - ▶ Mainly  $t\bar{t}$  ( 98%). Additional contribution from  $Z \rightarrow \tau\tau, WW, \dots$
- 
- ▶ Estimated from **data-driven** methods
  - ▶ **Assumption:** flavour symmetric backgrounds produce OF as frequently as SF
  - ▶ OF channel is used as a control region
  - ▶ Corrected by different object identification and trigger efficiencies

# STANDARD MODEL BACKGROUNDS

DRELL-YAN.  $E_T^{\text{MISS}}$  TEMPLATES

- ▶ Data-driven approach is followed to estimate Z + jets contribution
- ▶ **Assumption:**  $E_T^{\text{miss}}$  in photon + jets is the same as in Z + jets

- ▶  $E_T^{\text{miss}}$  distribution is taken from  $\gamma$ +jets data sample
- ▶ Distribution normalized in low  $E_T^{\text{miss}}$  ( $< 50$  GeV) region

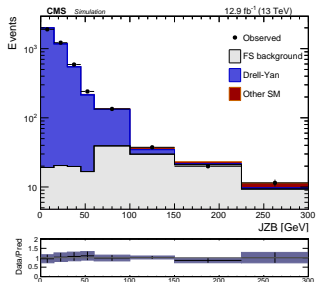
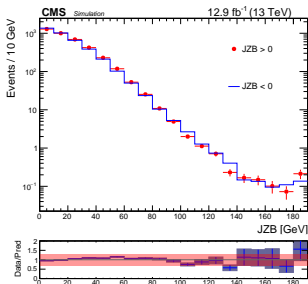
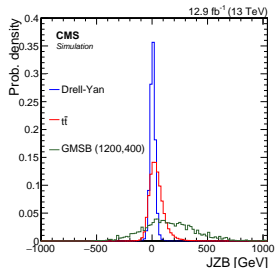


# STANDARD MODEL BACKGROUNDS

## DRELL-YAN. JZB METHOD

- ▶ JZB method is used as a cross-check in the ATLAS search region
- ▶ JZB is a measure of the **momentum unbalance**, defined as

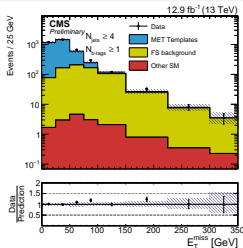
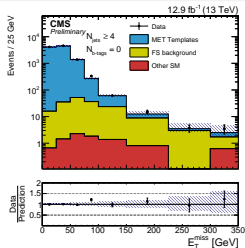
$$JZB = \left| p_T^{\parallel} \right| - \left| \sum p_T^{\text{jets}} \right|$$



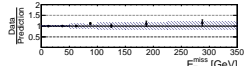
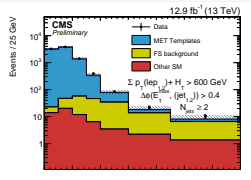
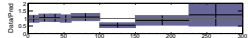
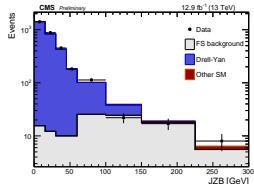
# RESULTS - ON Z SEARCH

- ▶ Results on in the on Z region
- ▶ Overall good agreement
- ▶ No sign of new physics in the ATLAS region

## CMS-specific regions

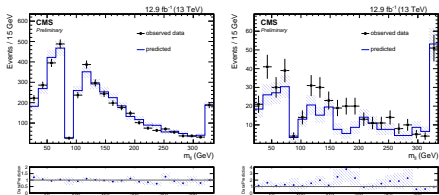
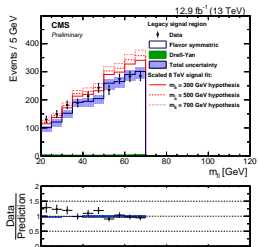


## ATLAS excess region



# RESULTS - SEARCH FOR AN EDGE

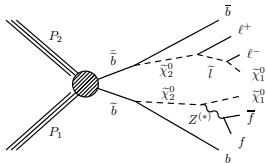
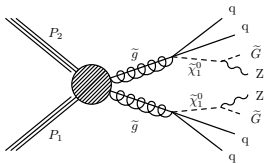
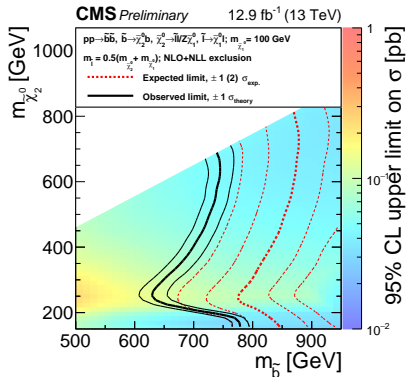
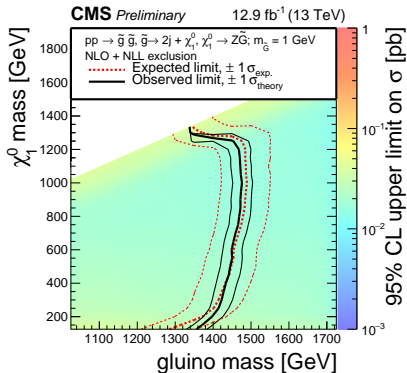
- ▶ Good agreement with SM expectations
- ▶ No sign of the excess observed in Run II data



		ttbar-like	non-ttbar-like
m <sub>ll</sub> < 81 GeV	pred. total	1387.9 ± 48.3	113.1 ± 11.2
	obs	1417	135
m <sub>ll</sub> > 101 GeV	pred. total	2443.4 ± 72.3	212.4 ± 15.7
	obs	2347	285

- ▶ Excess observed in non-ttbar-like, high m<sub>ll</sub> class
- ▶ 3.1 σ local significance

# INTERPRETATION OF THE RESULTS



# SUMMARY

- ▶ Shown results of the search for SUSY with two opposite-sign same-flavour leptons
- ▶ Targeted two kind of topologies
  - ▶ Z bosons produced in sparticle decays
  - ▶ Search for a kinematic edge  $\Rightarrow$  exploit the  $m_{ll}$  resolution
- ▶ New search regions + ATLAS and CMS excess regions
- ▶ No significant **sign of new physics** observed
- ▶ Data taking continues (so far  $27 \text{ fb}^{-1}$  recorded by CMS).

**Stay tuned** for more results at the end of the year



**Thanks for your attention!**  
**Questions?**