searches for SUSY with two or more leptons at 13 TeV with CMS

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introduction

spectacular performance of the LHC has been keeping us (very) busy
collected 12.9 fb$^{-1}$ of good data in two months!
CMS has been working exceptionally as well!

a lot of work done by many people to get results out for ICHEP
some ‘reloads’, many new things

many CMS analyses on 2016 leptonic SUSY searches

this talk: 2 or more leptons looking for strong production
Santi’s talk later: analyses looking for electroweak SUSY
Nadja’s talk later: targeting direct squark production
why leptonic SUSY?

theoretical motivation

‘natural’ SUSY models feature light stops
  -> if flavor is conserved these lead to top quarks and thus leptons

electroweak SUSY models have the weakest mass limits
  -> virtually impossible to look for those in hadronic final states

a lot of experimental motivation as well

measuring leptons is ‘easy’
  -> especially true for muons and electrons

backgrounds from QCD processes become irrelevant
  -> reduced to a handful of well understood processes

our analyses target different lepton flavor/charge/multiplicities
opposite sign, same-flavor dileptons

extensive re-design of parts of the analysis with respect 8 TeV / 2015
introduced new background likelihood discriminator

on-Z and off-Z (‘Zedge’) results hot off the press - PAS SUS 16-021
the two parts are now exclusive

baseline selection of 2 OSSF leptons (25/20), ME_T > 150, at least two jets
all analysis parts on top of this selection

**on-Z**
- m_\parallel in 81-101 GeV
- binning in n_jets and n_{b-jets}
- SRs in ME_T bins
- + ATLAS excess region

**off-Z counting**
- low and high m_\parallel
- binning in mass and new likelihood discriminator
- + CMS 8 TeV region

**inclusive m_\parallel**
- model backgrounds and signal with shapes
- fit signal and backgrounds
methods for OSSF dileptons

two main backgrounds:
  \(Z+\text{jets}\), mainly in on-Z and lower \(\text{MET}\)
  \(t\bar{t}\)bar, in more extreme regions of phase-space

\(Z+\text{jets}\) estimated from photon+jets sample
  correct that sample for residual prompt contamination
  and different \(p_T\) spectrum

check out poster by Sergio Cruz on alternative method!
  JZB method

\(t\bar{t}\)bar (and others) flavor-symmetric, estimated from OF control sample
  correct for different trigger, object, and reconstruction efficiencies
ttbar likelihood discriminator

in off-Z counting, ttbar is ~the only background
   ttbar has very distinct features

we construct a likelihood out of four variables
   di-lepton-\(p_T\)
   sum of \(m_{lb}\)’s (\(m_{lj}\) if \(n_{b\text{jets}} < 2\))
   ME_T
   delta phi_{ll}

allows us to bin in arbitrary ttbar eff.

we chose 95%/5% for our analysis

end up with four signal regions:
   high-low in mass
   high-low in discriminator (NLL)

public code
to use this!
results

perform a fit on baseline selection
simultaneous fit OF+SF for ttbar
best fit @ 132 GeV (148 ± 80 ev.)

on-Z results show good agreement
in all signal regions
ATLAS region: 44 ± 8 vs. 51 obs.

off-Z counting shows disagreement
in one SR: high mass, non-ttbar
3.1 sigma local
interpreting these results

on-Z search
in GMSB gluino production model

off-Z search
in direct sbottom production
same-sign dileptons

very interesting signature to look for new physics
many models predict same sign abundance
very small SM backgrounds

PAS SUS-16-020

same-sign leptons can show up in many ways
highly optimized analysis binned in:
lepton-$p_T$, $H_T$, $M_{E_T}$, $n_{jets}$, $n_{bjets}$, min($m_T$)

three main backgrounds from SM:
1) non-prompt leptons
   -> estimated from data via fake-rate method
   -> optimized object definitions to mitigate flavor dependences
2) rare SM processes
   -> $ttW$, $ttZ$, $WZ$, from MC simulation with validation
3) charge-mis-identification of electrons
   -> very small contribution, measured in data
signal regions and results

in total 68 signal regions
all on top of:
\( m_\| > 8 \text{ GeV} \), Z-veto on 3rd lepton
at least two jets

divide in HH, HL, LL
in lepton-p_T with cuts 10 and 25 GeV

no significant discrepancies observed
proceed to set limits instead
interpretations for same-sign

**T1tttt**

exclusions up to 1400 GeV in gluino mass

**T5qqqqWW**

up to 1500 GeV depending on mass splitting
three or more leptons

requiring a third lepton reduces SM backgrounds even further
T1tttt for instance has up to 4 leptons

main backgrounds:
1) non-prompt leptons
2) rare SM MC
   -> can validate WZ and ZZ relatively well by now
   -> others taken straight from MC

baseline selection
3 leptons, m_\parallel > 12 GeV, 2+ jets, ME_T > 50 GeV

divide analysis into on-Z and off-Z events
OSSF lepton pair compatible with the Z
results for three or more leptons

optimized analysis to be sensitive to many models
bin in $H_T$, $MET$, $n_{b\text{jets}}$
15 off-Z regions
17 on-Z regions

no deviations from predictions observed
proceed to set limits

probe gluino masses up to 1.2 TeV for $T_{1\text{ttt}}$
roughly 1 TeV for light squarks
summary

a lot of work as been done in updating and extending leptonic SUSY searches
  preliminary results are now public as PAS’s

no smoking guns found in the first large CMS data set at 13 TeV
  with the LHC’s performance expect to have a
  substantially increased data set for end of year

many analyses are also still to come in leptonic SUSY
  combinations of multiple analyses are also
  still pending

we’re excited about what’s to come!
the end - questions?

marc
extras