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

ICHEP 2016, chicago

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for the CMS collaboration

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**

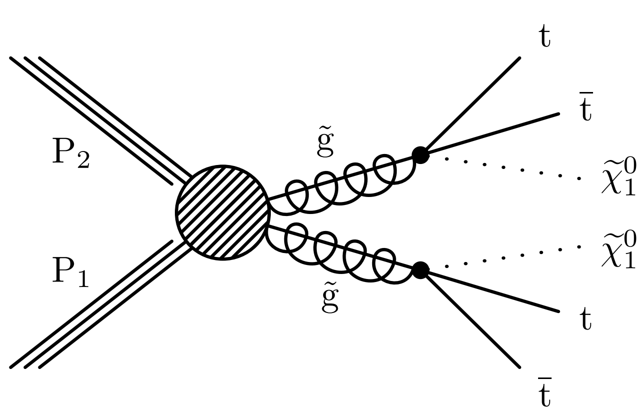
many CMS analyses on 2016 leptonic SUSY searches

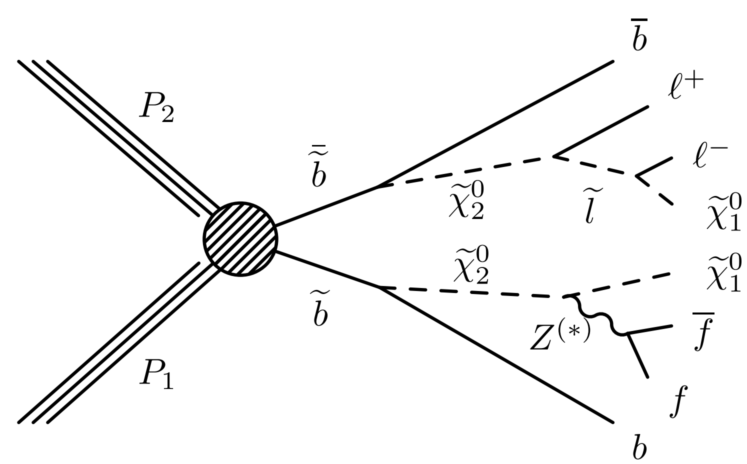
- **this talk:** 2 or more leptons looking for strong production
- **Santi's talk later:** analyses looking for electroweak SUSY
- **Nadja's talk later:** targeting direct squark production

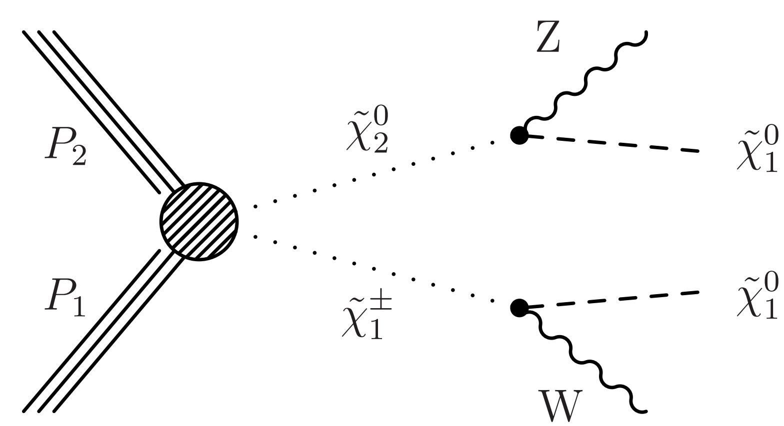
why leptonic SUSY?

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_{ll} in 81-101 GeV
- binning in n_{jets} and $n_{b\text{-}jets}$
- SRs in ME_T bins

+ ATLAS excess region

off-Z counting

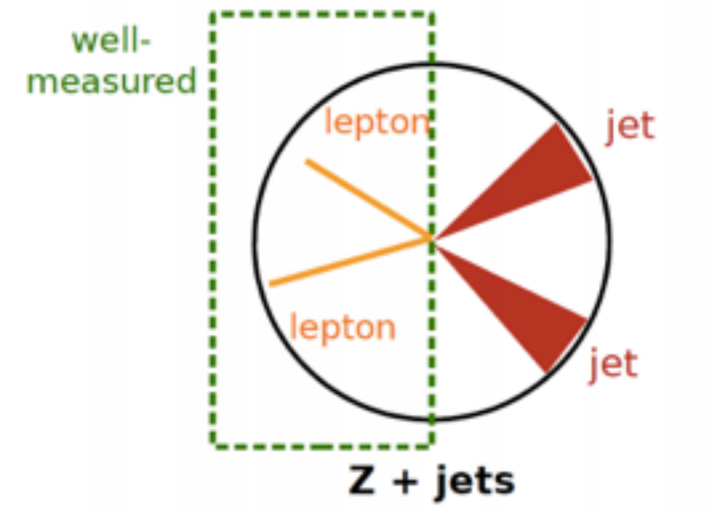
- low and high m_{ll}
- binning in mass and new likelihood discriminator

+ CMS 8 TeV region

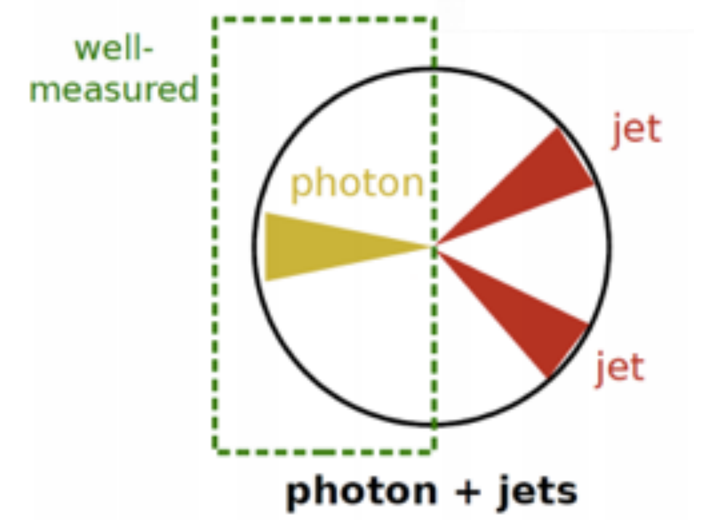
inclusive m_{ll}

- model backgrounds and signal with shapes
- fit signal and backgrounds

methods for OSSF dileptons



two main backgrounds:
- Z+jets, mainly in on-Z and lower ME_T
- ttbar, in more extreme regions of phase-space



Z+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

ttbar (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 $n_{bjets} < 2$)

ME_T

delta phi_{ll}

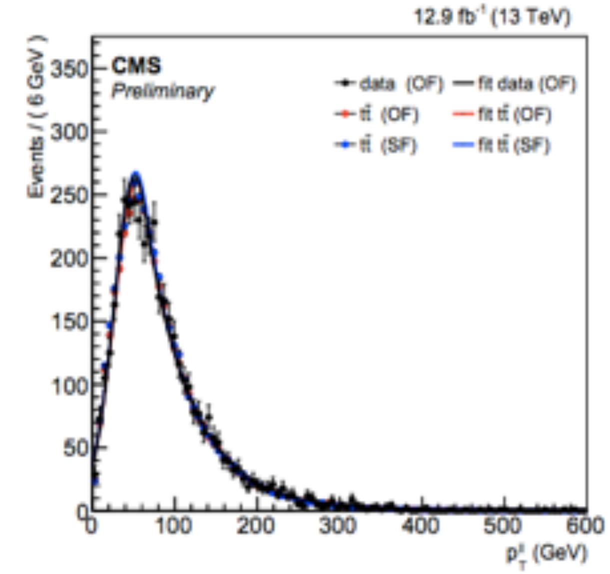
allows us to bin in arbitrary ttbar eff.

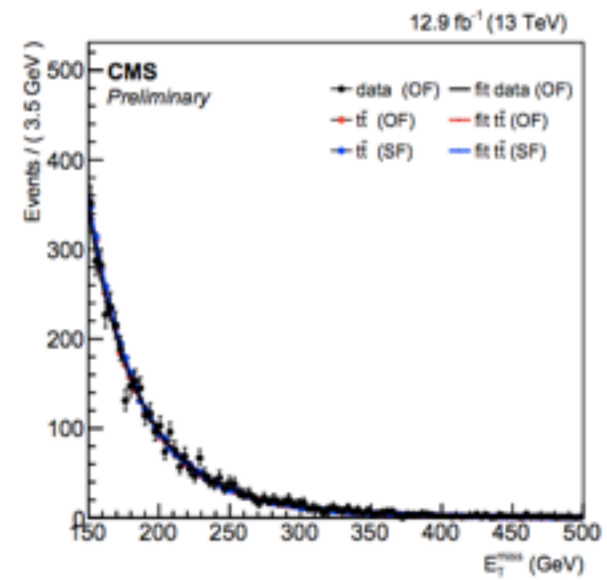
we chose 95%/5% for our analysis

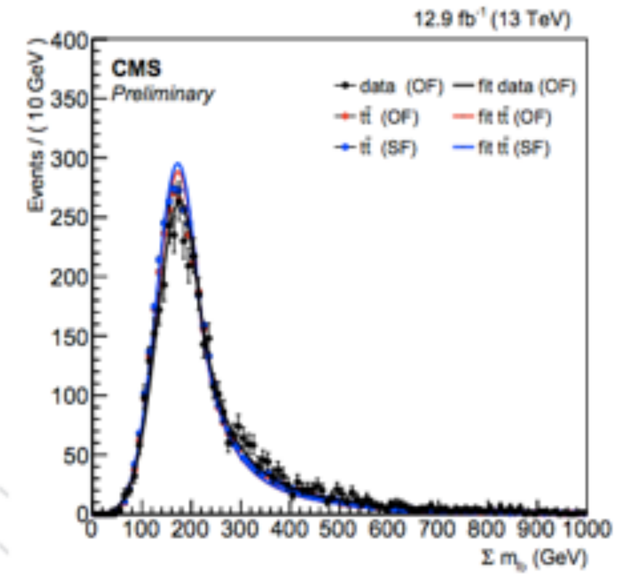
end up with four signal regions:

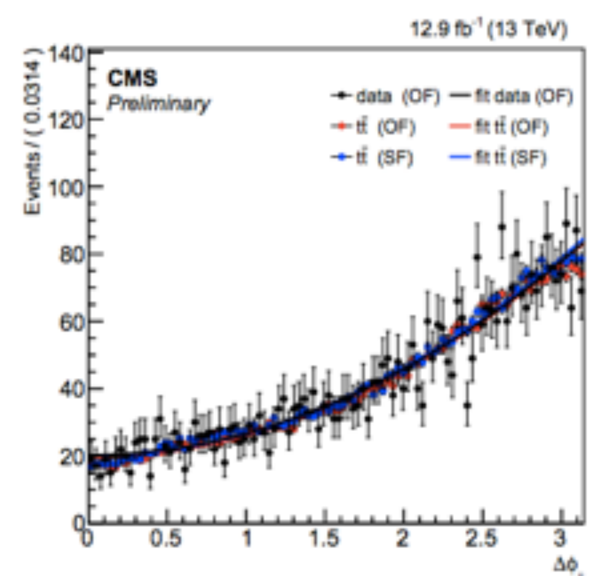
high-low in mass

high-low in discriminator (NLL)









public code to use this!

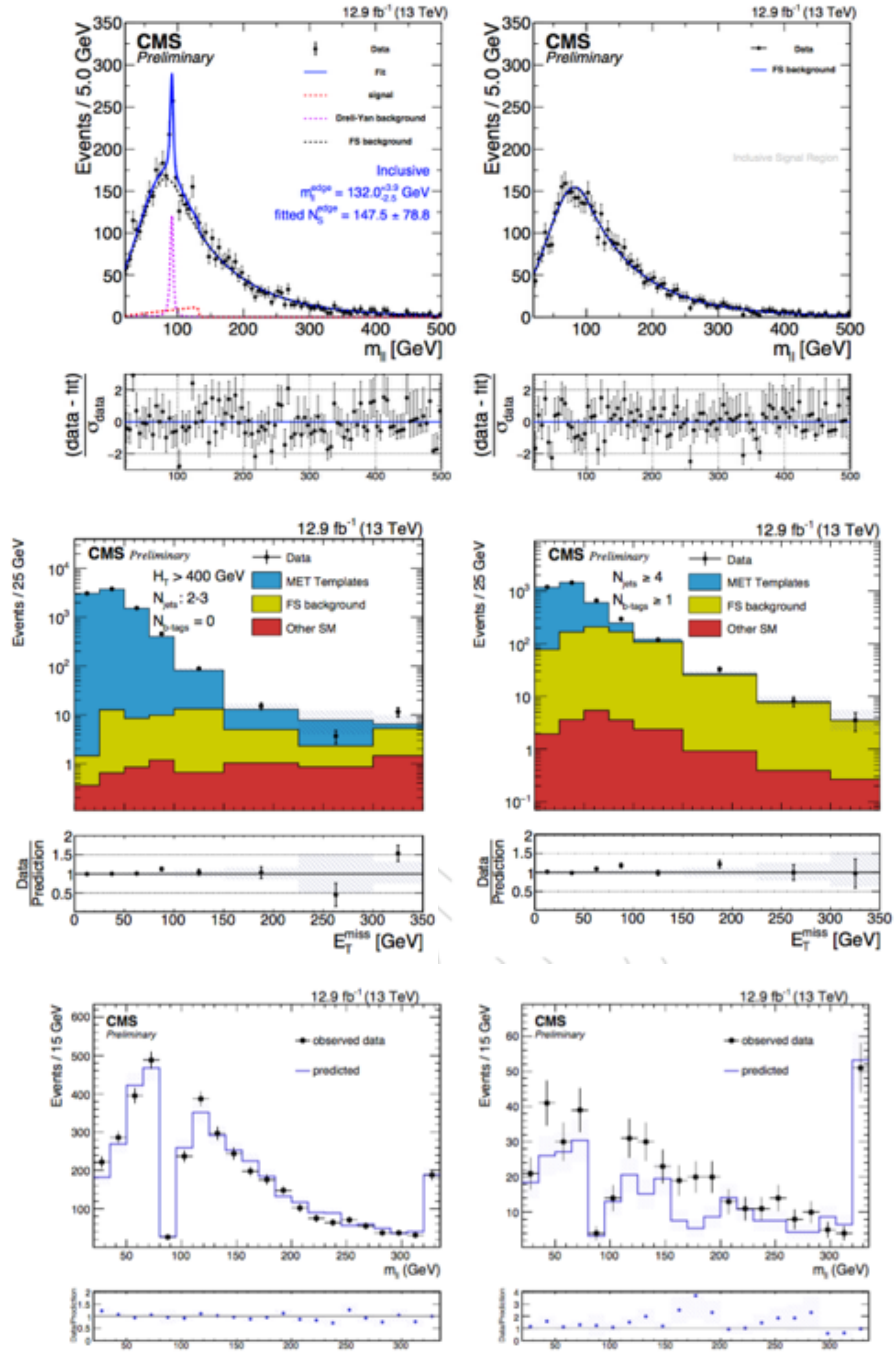
results

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.

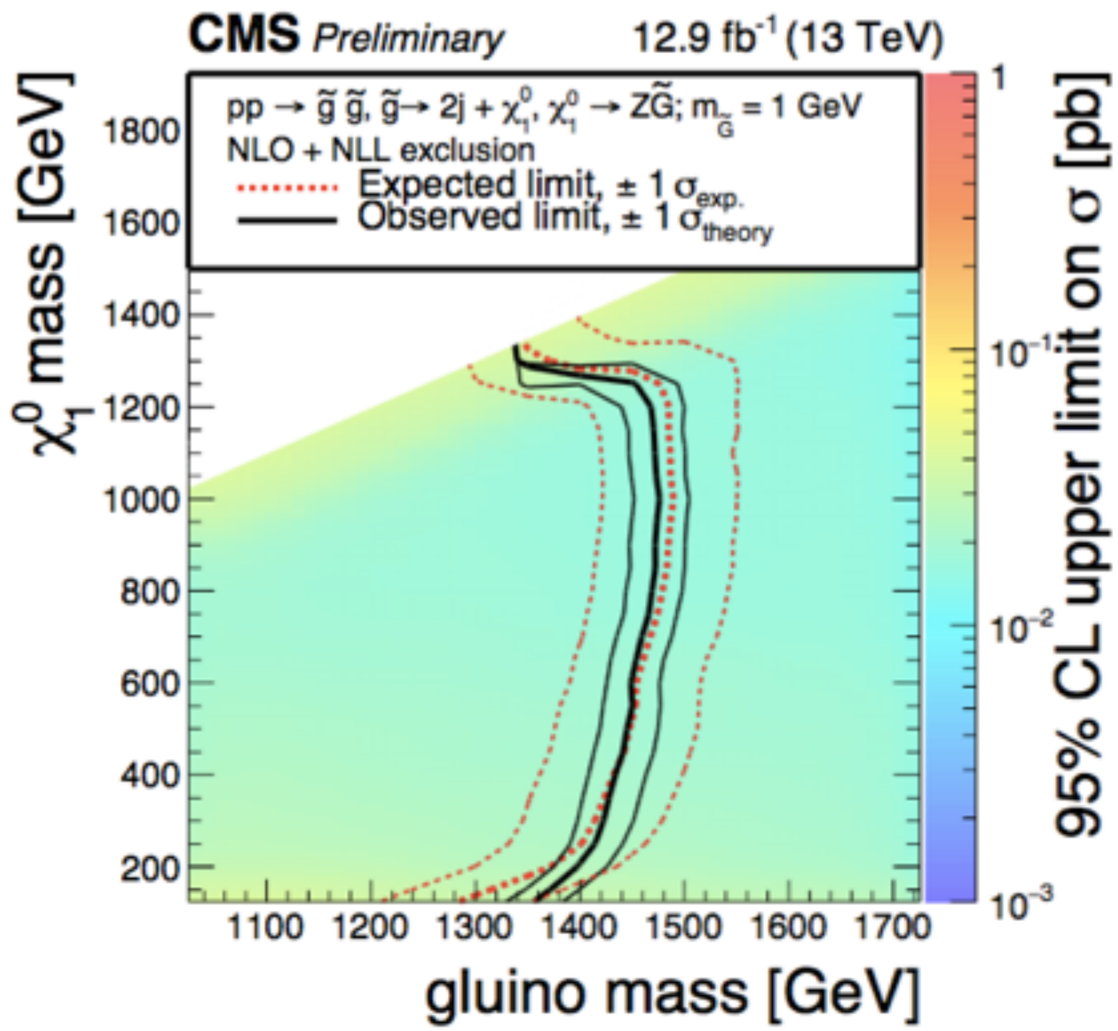
off-Z counting shows disagreement
- in one SR: high mass, non-ttbar
- 3.1 sigma local

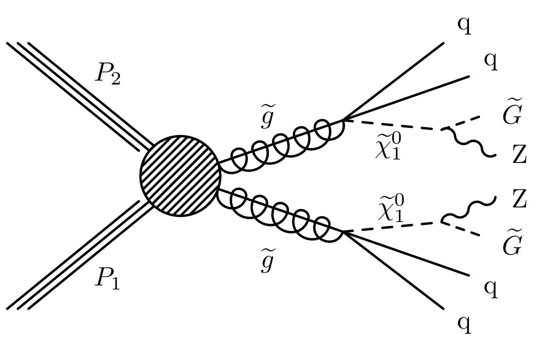
		ttbar-like	non-ttbar-like
mll < 81 GeV	pred. FS	1374.4 ± 48.1	105.8 ± 10.9
	pred. DY	13.5 ± 4.6	7.3 ± 2.5
	pred. total	1387.9 ± 48.3	113.1 ± 11.2
	obs	1417	135
mll > 101 GeV	pred. FS	2435.8 ± 72.2	208.3 ± 15.7
	pred. DY	7.6 ± 2.6	4.1 ± 1.4
	pred. total	2443.4 ± 72.3	212.4 ± 15.7
	obs	2347	285



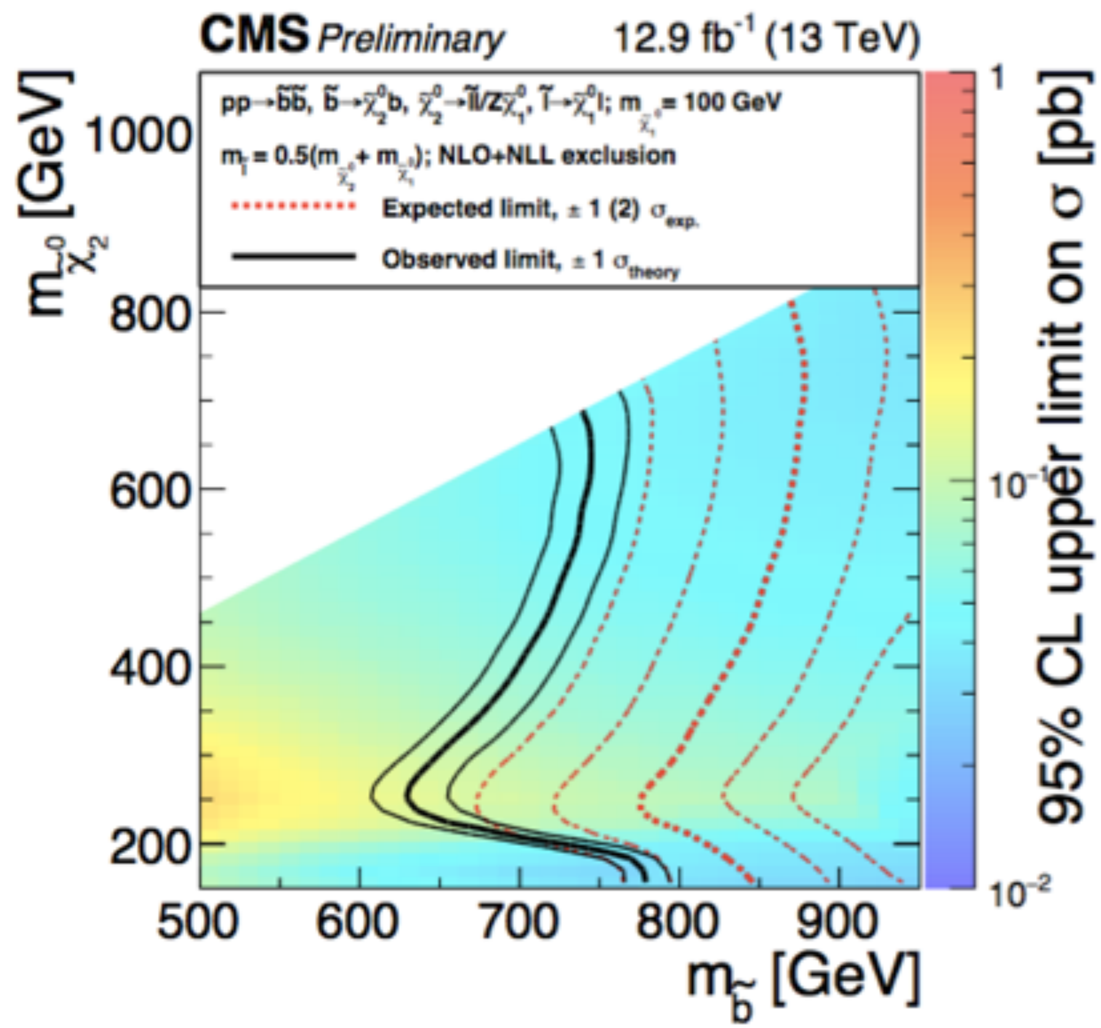
interpreting these results

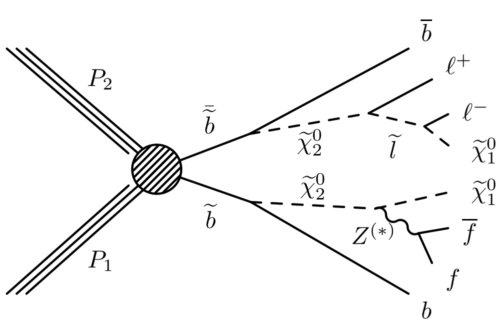
on-Z search
 in GMSB gluino production model



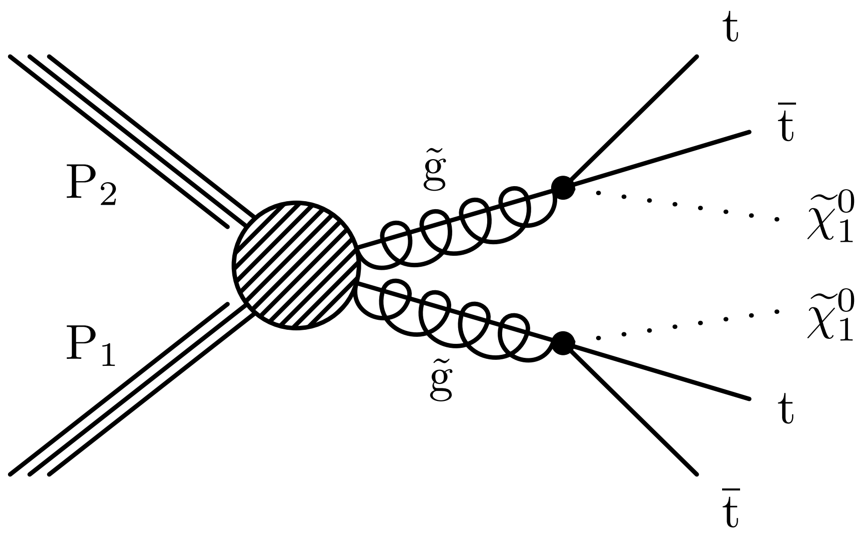


off-Z search
 in direct sbottom production



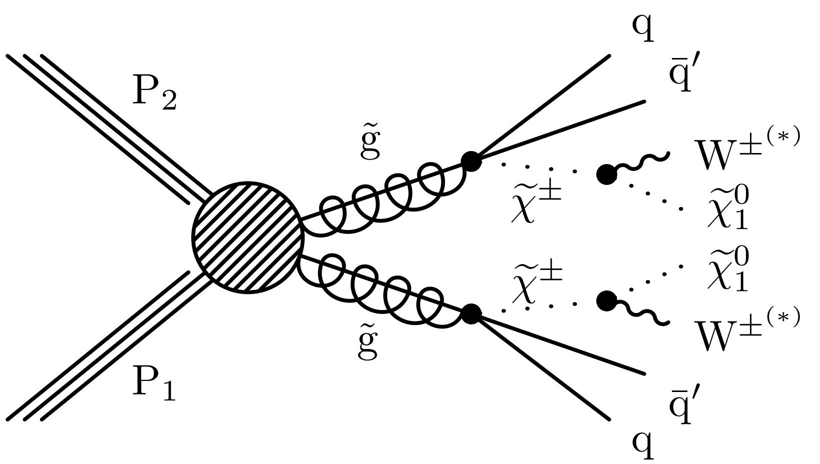


same-sign dileptons



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, ME_T, n_{jets}, n_{bjets}, $\min(m_T)$

three main backgrounds from SM:

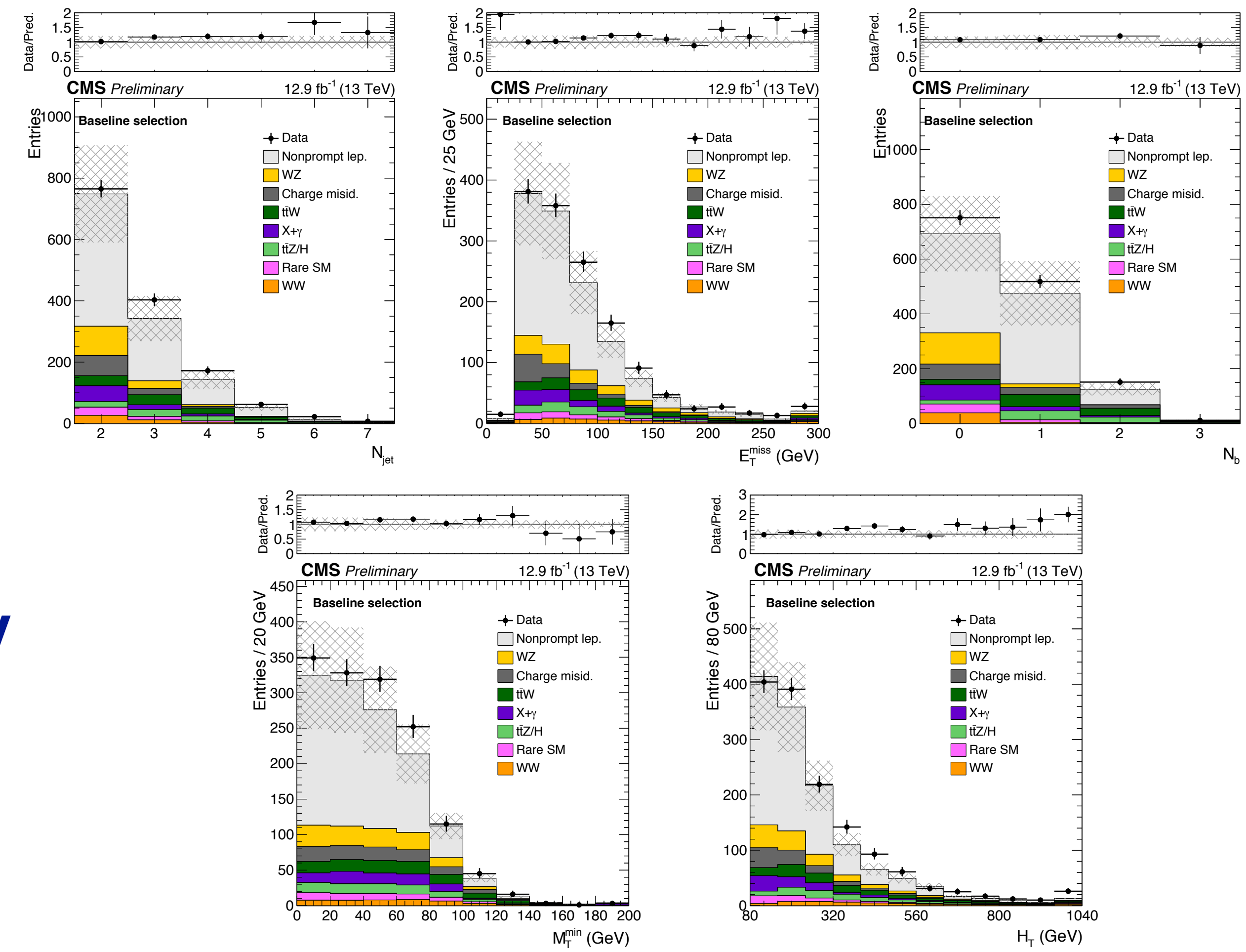
1) non-prompt leptons
   - -> estimated from data via fake-rate method
   - -> optimized object definitions to mitigate flavor dependences
2) rare SM processes
   - -> ttW, ttZ, WZ, from MC simulation with validation
3) charge-mis-identification of electrons
   - -> very small contribution, measured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

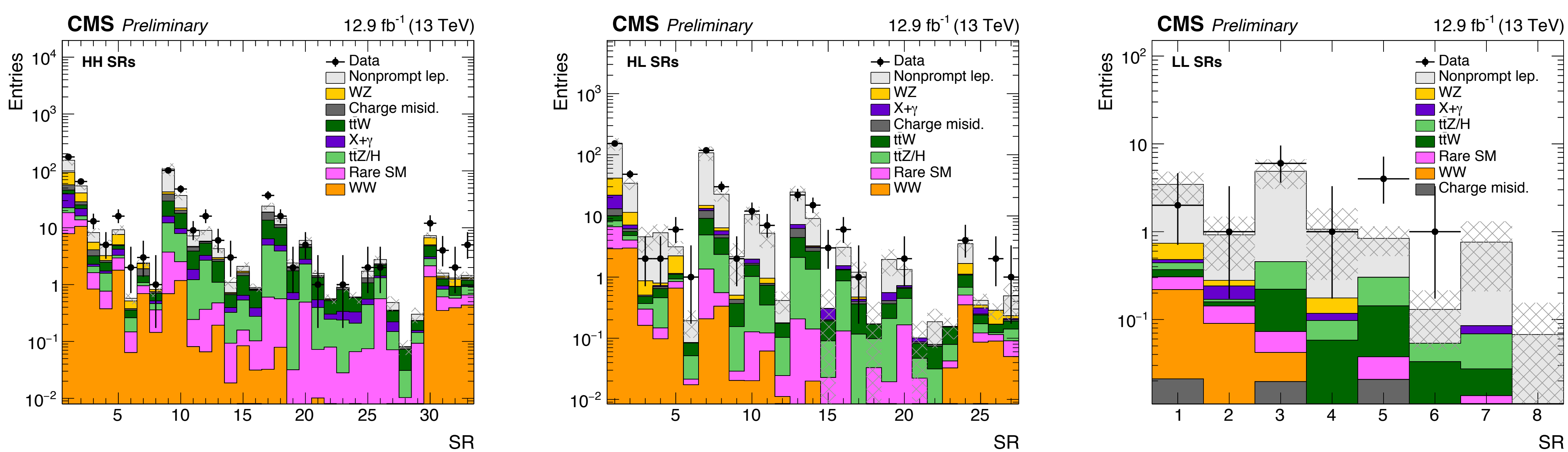
signal regions and results

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

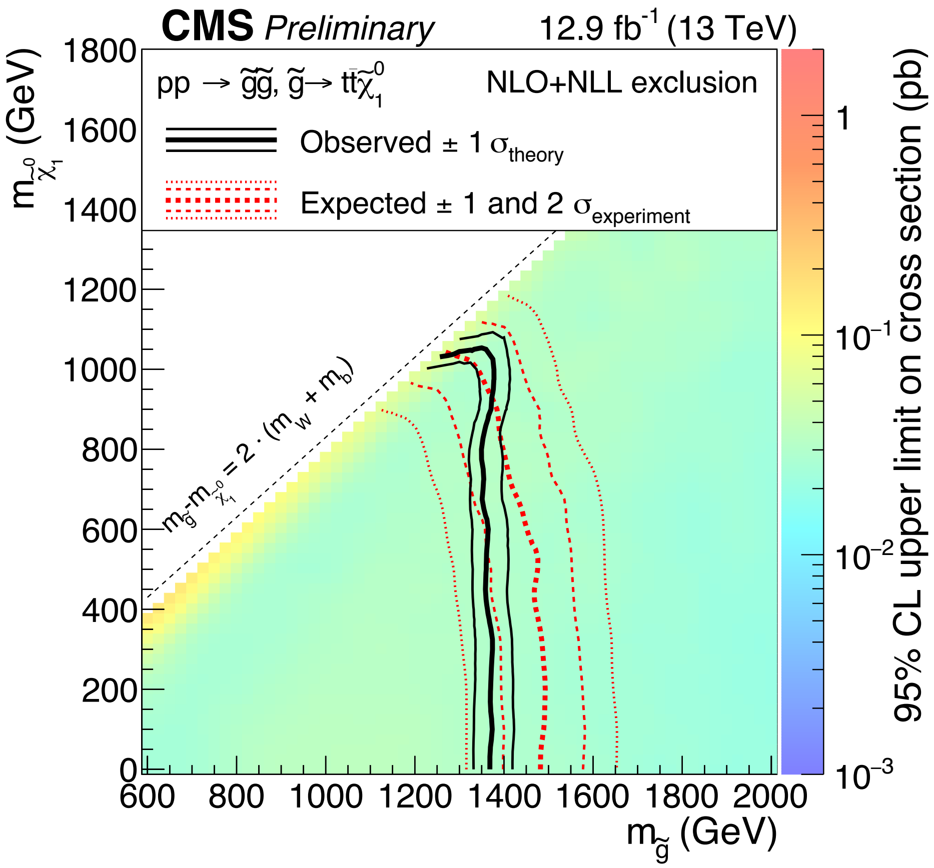
divide in HH, HL, LL
- in lepton-p_T with cuts 10 and 25 GeV

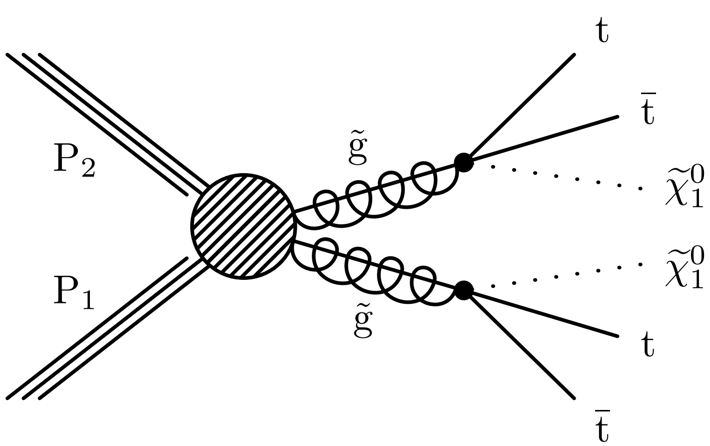
no significant discrepancies observed
- proceed to set limits instead

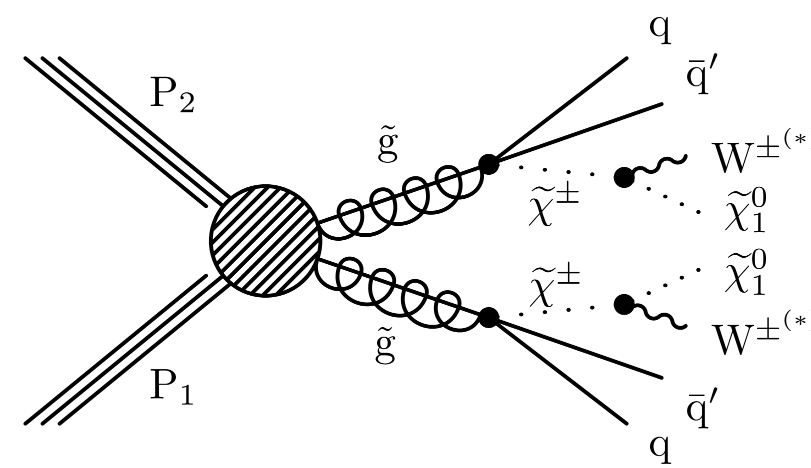


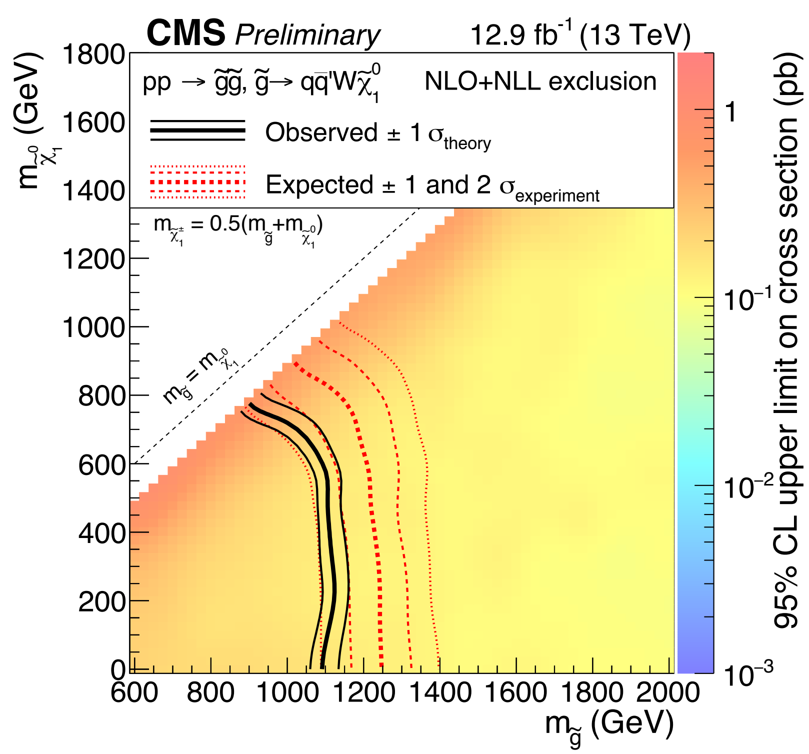


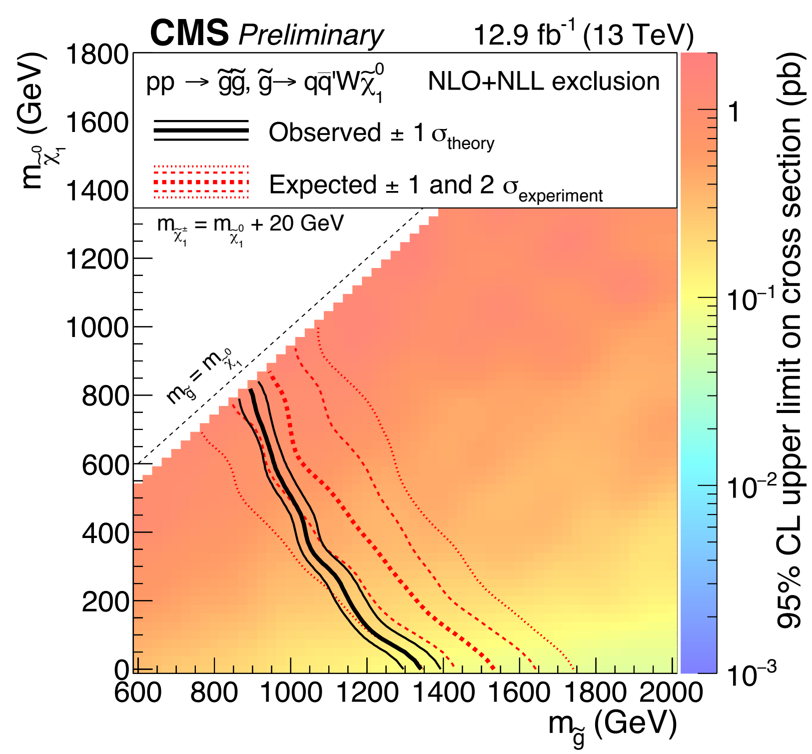
interpretations for same-sign











T1tttt

exclusions up to 1400 GeV
in gluino mass

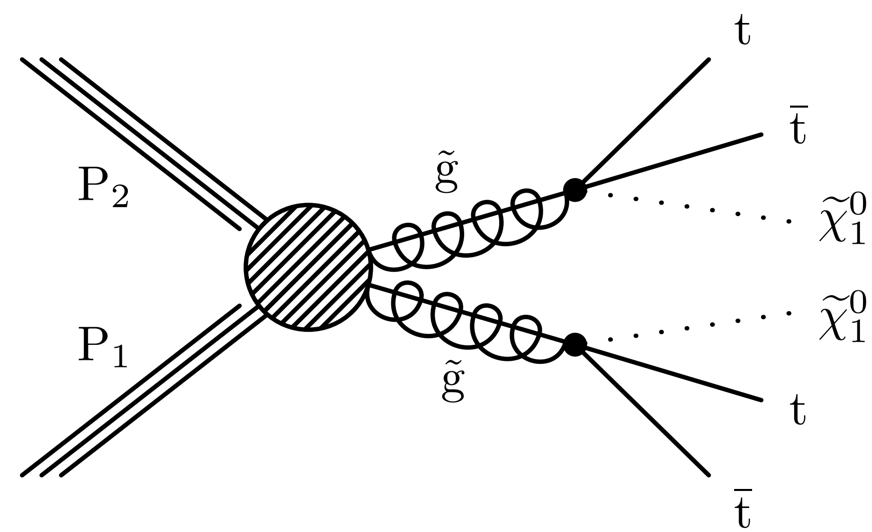
T5qqqqWW

up to 1500 GeV
depending on mass splitting

three or more leptons

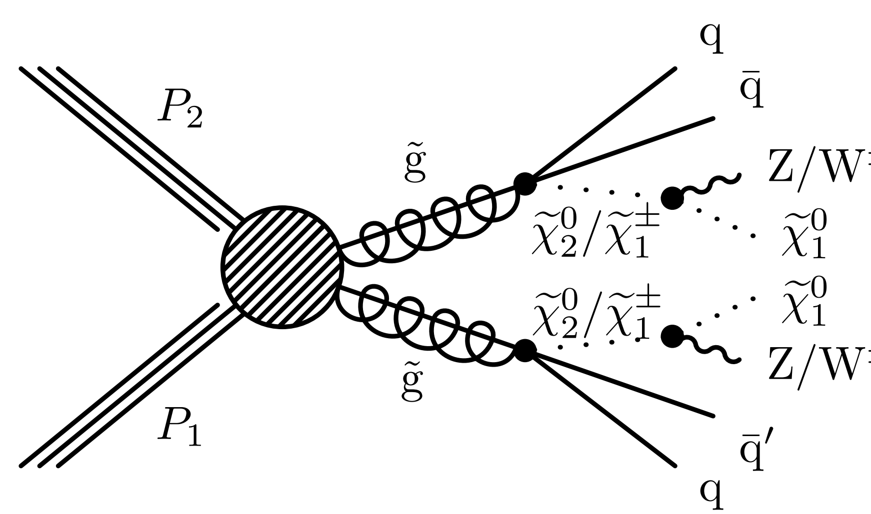
requiring a third lepton reduces SM backgrounds even further

- T1tttt for instance has up to 4 leptons
- PAS SUS-16-022



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_{ll} > 12 GeV, 2+ jets, ME_T > 50 GeV

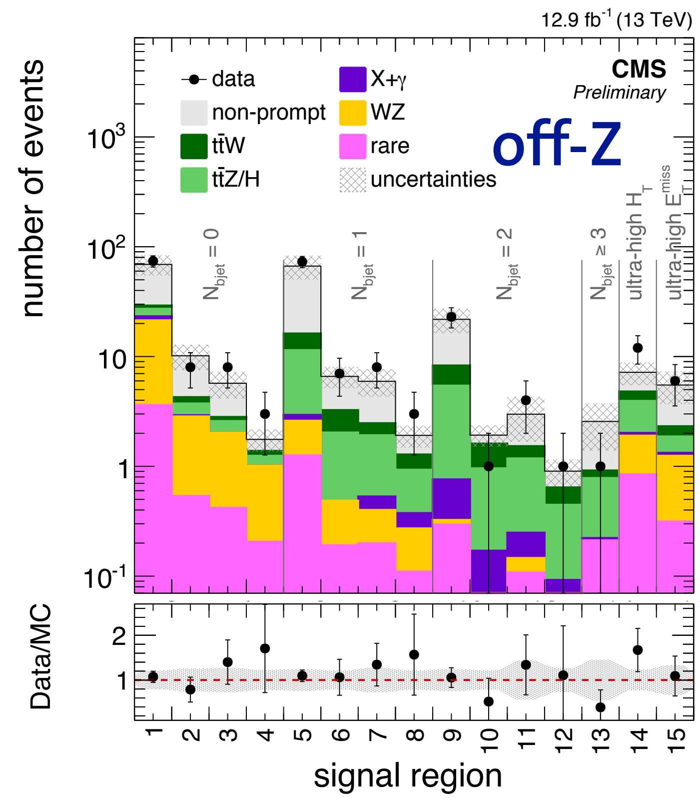
divide analysis into on-Z and off-Z events

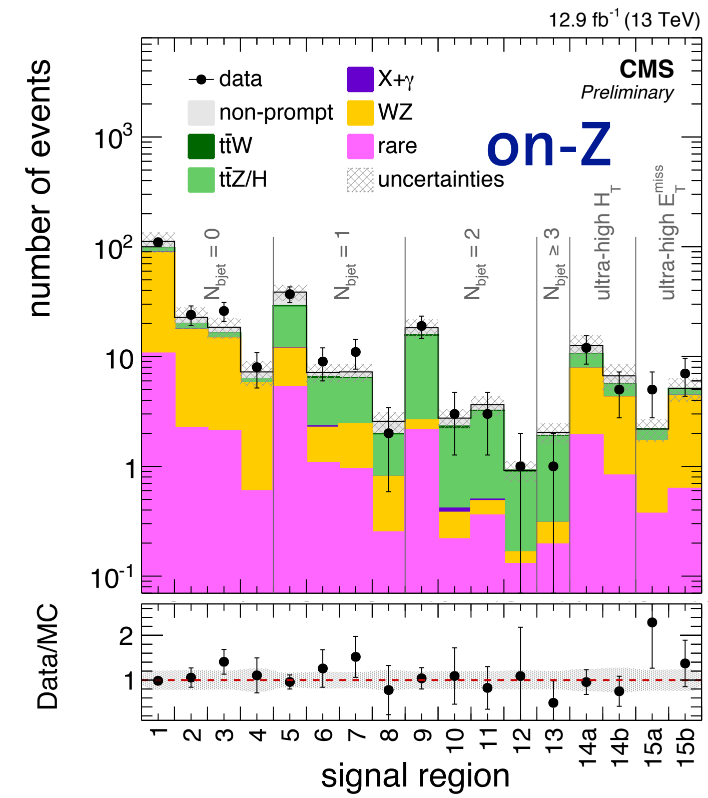
- OSSF lepton pair compatible with the Z

results for three or more leptons

optimized analysis to be sensitive to many models

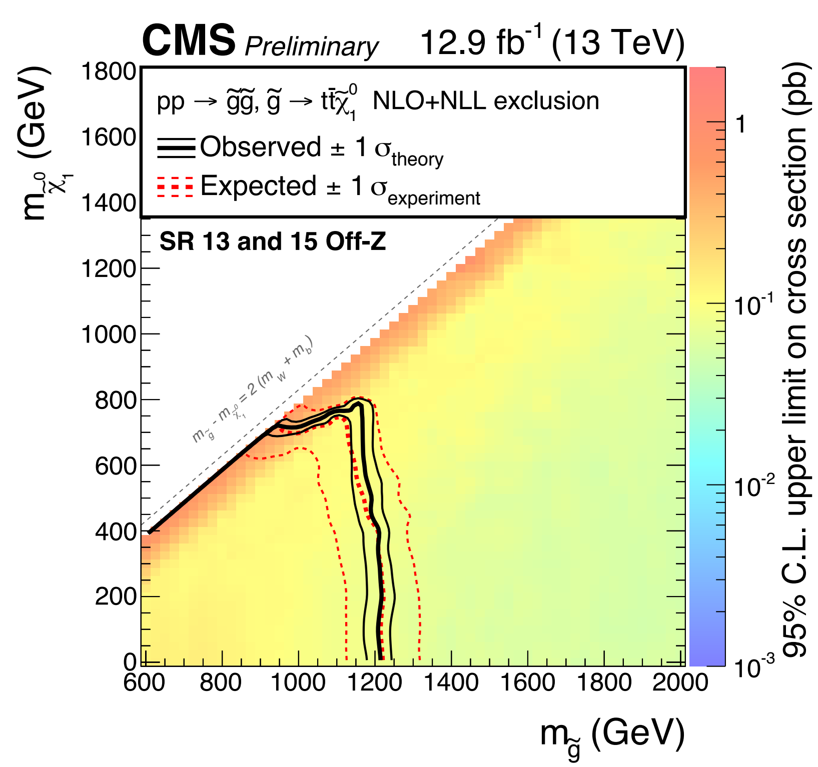
- bin in H_T, ME_T, n_{bjets}
- 15 off-Z regions
- 17 on-Z regions

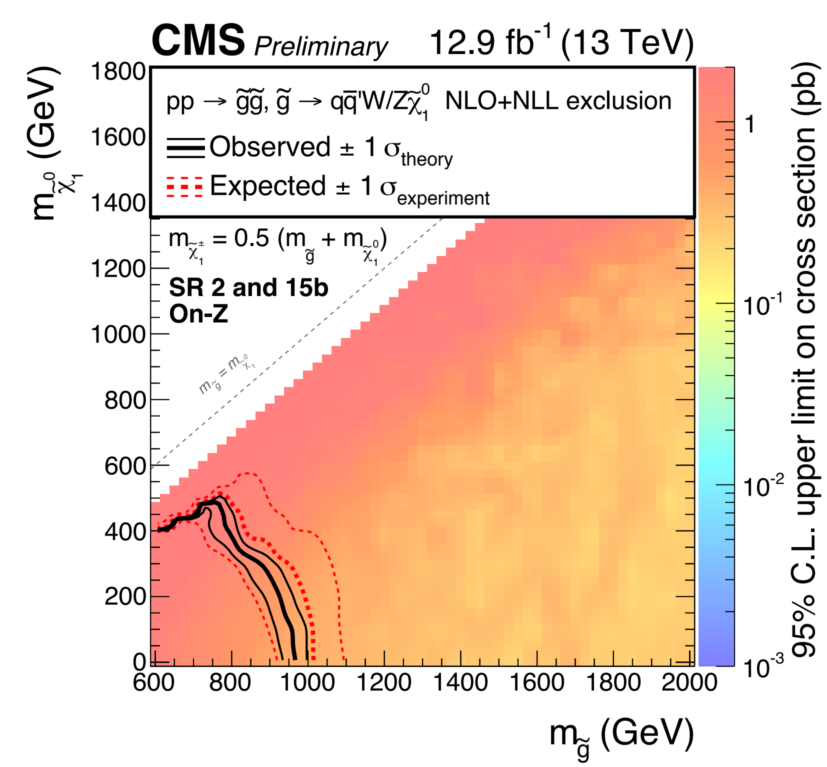




no deviations from predictions observed

- proceed to set limits





probe gluino masses up to 1.2 TeV for T1tttt

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