Supersymmetry discovery potential in future LHC and HL-LHC running with the CMS detector

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Outline

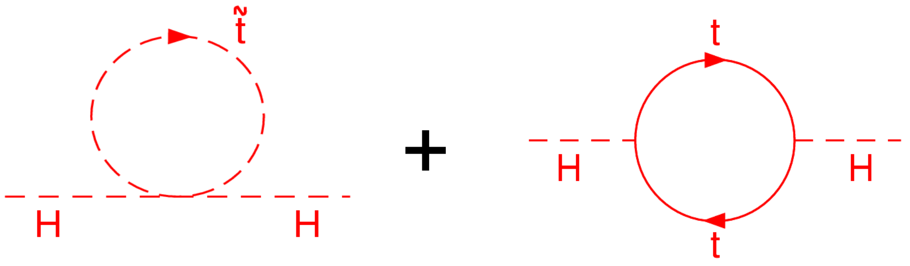
- Part I
  - Introduction
  - Susy motivation
  - Radiation damage
  - Phase II upgrade
  - Susy Models
  - Overview of all 9 analyses
  - Analyses strategies
- Part II
  - STOC model
  - Monojet search
    - Signal and background
    - Event selection
    - Results
  - HT-MHT search
    - Signal and background
    - Event selection
    - Results

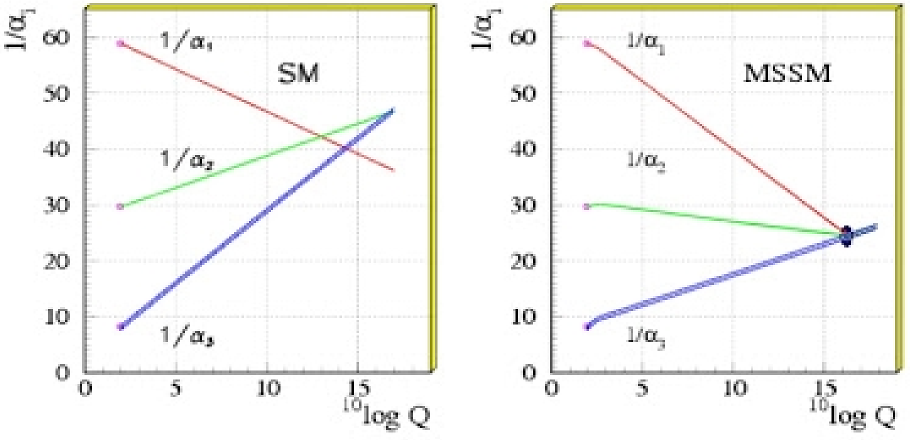
Introduction

- LHC is going to run at the highest energy ever reached, 13 and 14 TeV.
- Does the Standard Model work well at this scale?
- Many theories are waiting for evaluation.
- One of the best motivated theories is SUSY.
- However, SUSY has many free parameters and, as a result, different scenarios are possible.
- We study a few SUSY models to illustrate some example discovery stories describing possible measurements in case of discovery.

Why SUSY?

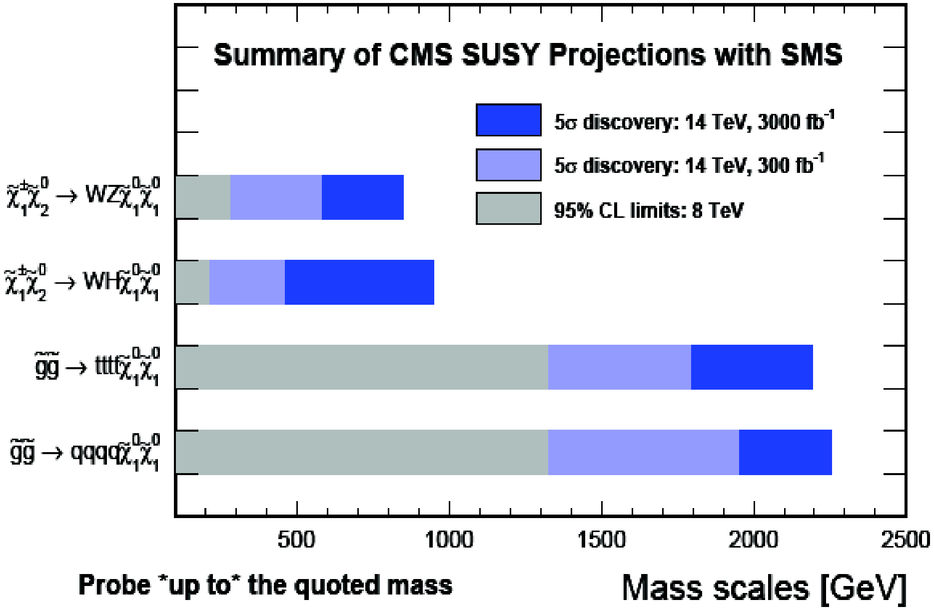
- Mathematically consistent + falsifiable in near future.
- Hierarchy problem:
- Dark matter
- Unification of gauge coupling constants.



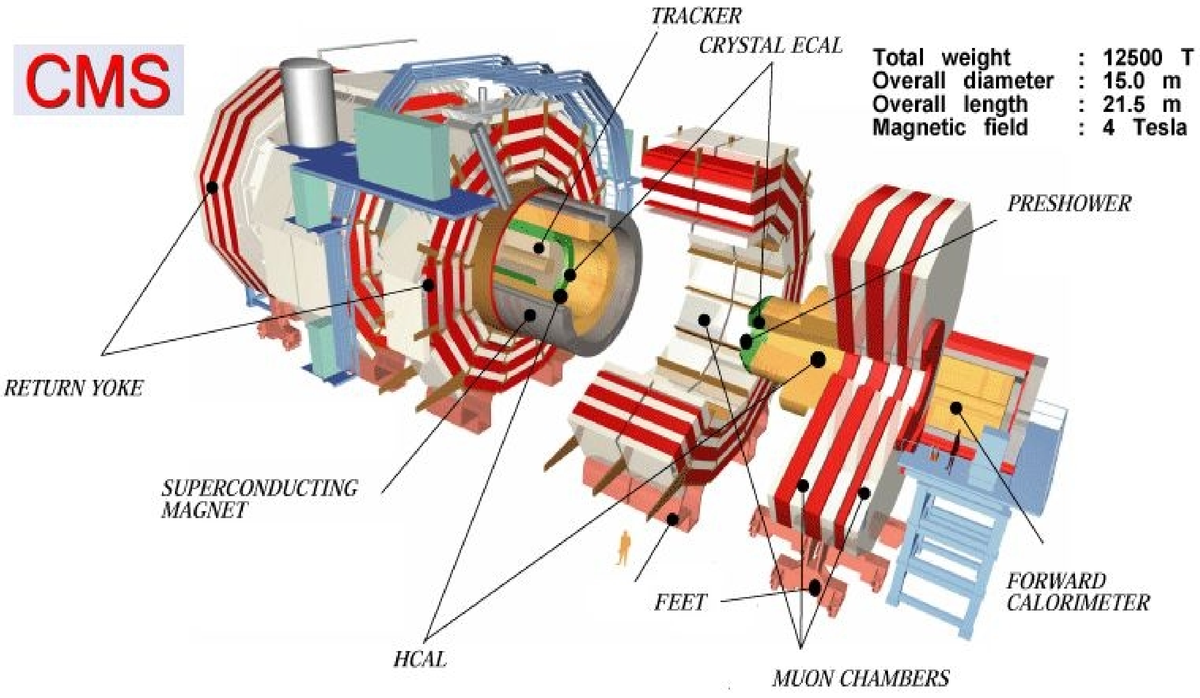


Status Of SUSY Searches

- So far SUSY parameter space has been tested in various ways.
- This is done by analysis of 20/fb of data recorded at 8TeV.
- Future discovery sensitivities with 300/fb (Run 2+3) and 3000/fb (HL-LHC) are presented using simplified models.
- Performed by Hongxuan Liu, Ben Wu, and Nate Chaverin.
- HL-LHC increases mass reach for pair produced SUSY particles by up to 500 GeV.
- Largest relative gains in weak production processes.



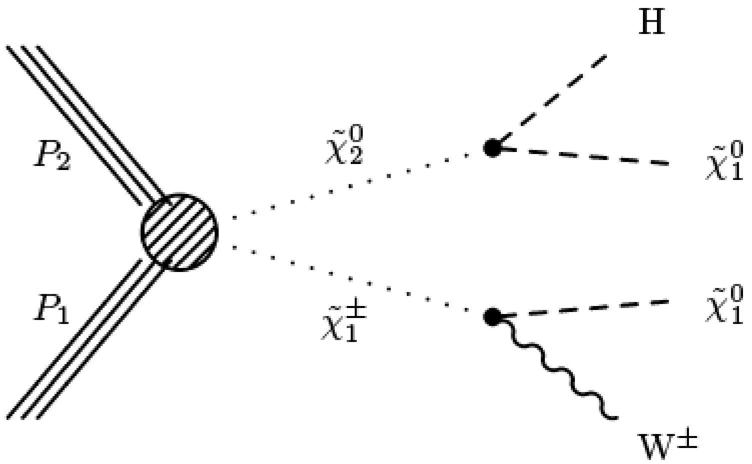
Radiation Damage



All the major
parts of the
detector such as
the tracker
the ECAL
the HCAL
lose their efficiency due to radiation.

Radiation Damage

- SUSY searches need almost all the aspects of the detector performance.
- Damage to any of the detector capabilities will affect the accuracy of the searches.
- As an example we have evaluated the effects of the radiation damage on the following chargino-neutralino signal.



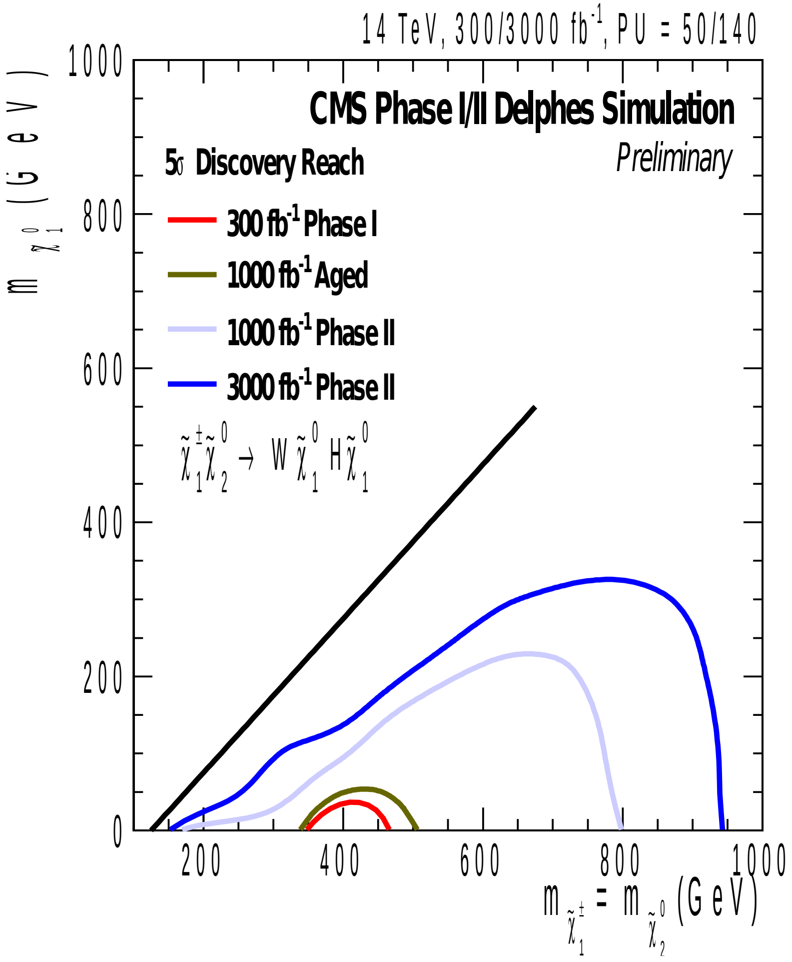
Radiation Damage

The existing detector is expected to achieve a discovery reach of 450 GeV with 300/fb data.

Without upgrade,

however, no additional discovery reach is obtained even with 3000/fb.

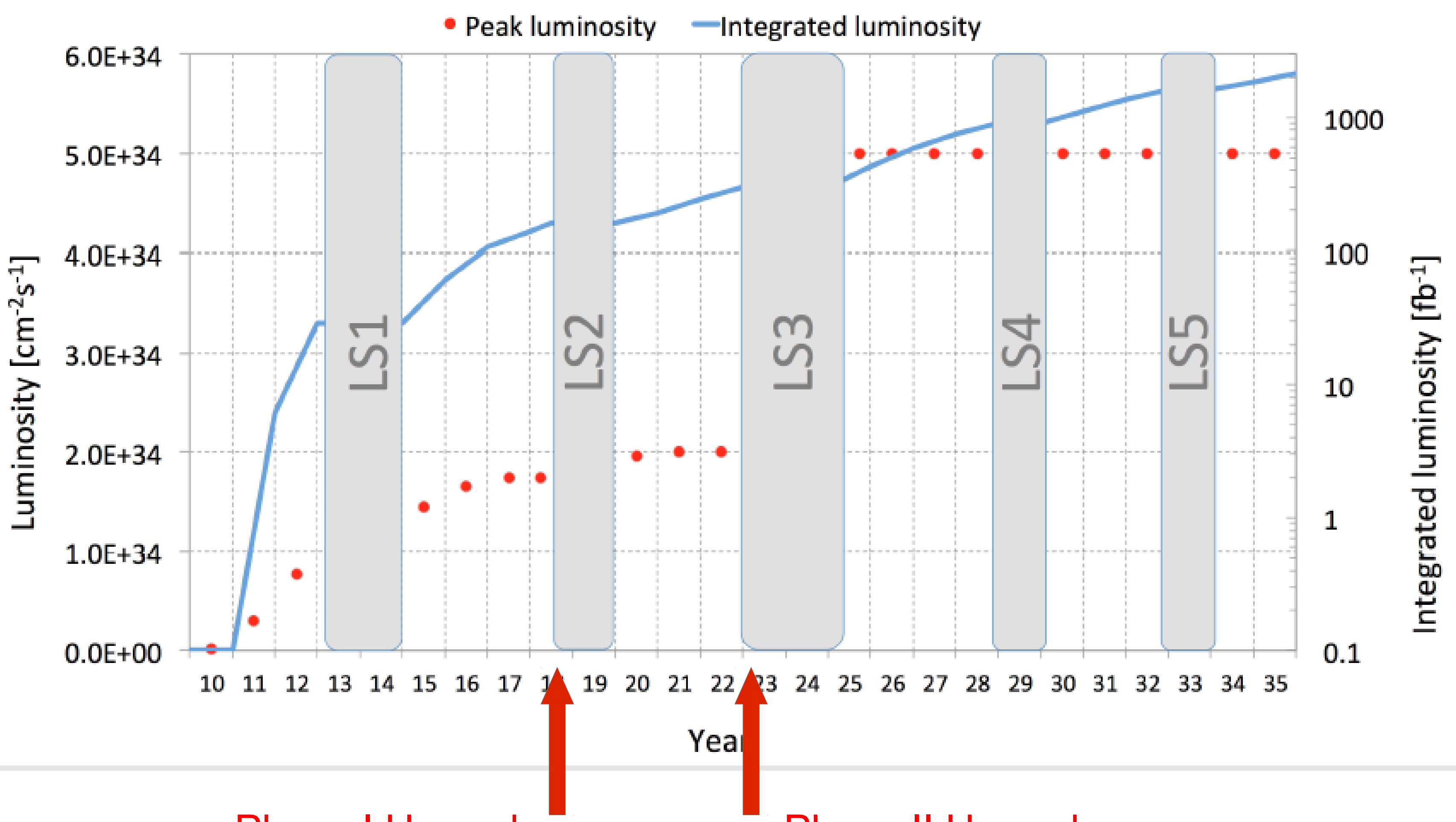
On the other hand an upgraded detector can achieve something around 1000 GeV discovery reach.



Phase II Upgrade

- High-Luminosity(HL) LHC is expected to run at five to ten times higher instantaneous luminosity than baseline LHC.
- The primary goal of the Phase II upgrade program is to maintain the excellent performance of the Phase I detector.
- Tracker and endcap calorimeter will suffer from a significant radiation damage after 300-500/fb and need to be replaced in Phase II upgrade.
- In some scenarios the tracker detector will be extended from psudorapidity of 2.4 to 4.
- Triggers also need to be modified in order to maintain its efficiency.

LHC/HL-LHC TIMELINE

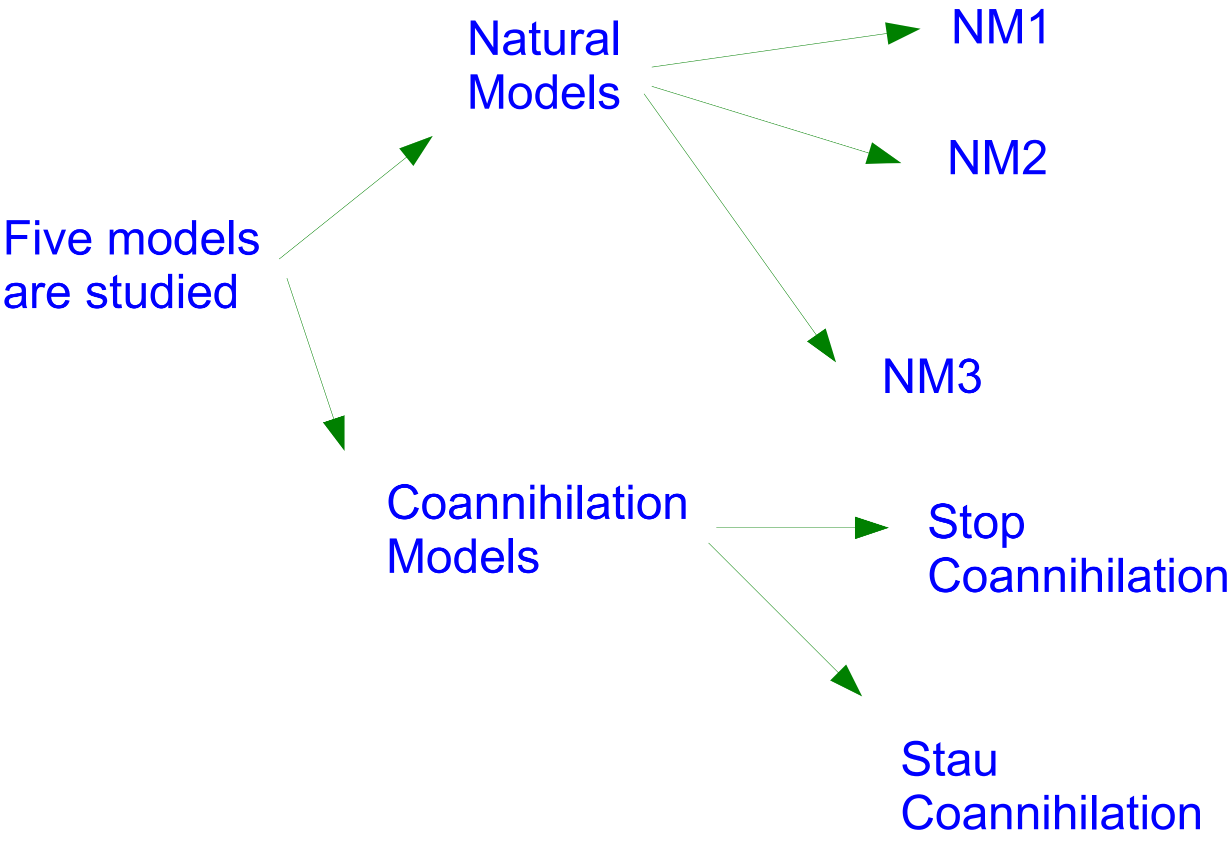


Phase I Upgrade

Phase II Upgrade

Assuming full capability of LHC and HL-LHC, we would like to see the discovery potential for Supersymmetry.

SUSY Models



Five models are studied

Natural Models

NM1

NM2

NM3

Coannihilation Models

Stop Coannihilation

Stau Coannihilation

Three Natural Models

- All motivated by naturalness where free parameters should of the unity order.
- Differ mainly by the particle content of the chargino and neutralino and also mass of the sleptons.
- All have relic density smaller than the WMAP+Planck measurement of 0.1199 ± 0.0027.
- The models are calculated with “SUSPECT”, “SOFTSUSY”, and “SUSY-HIT” softwares.

NM1

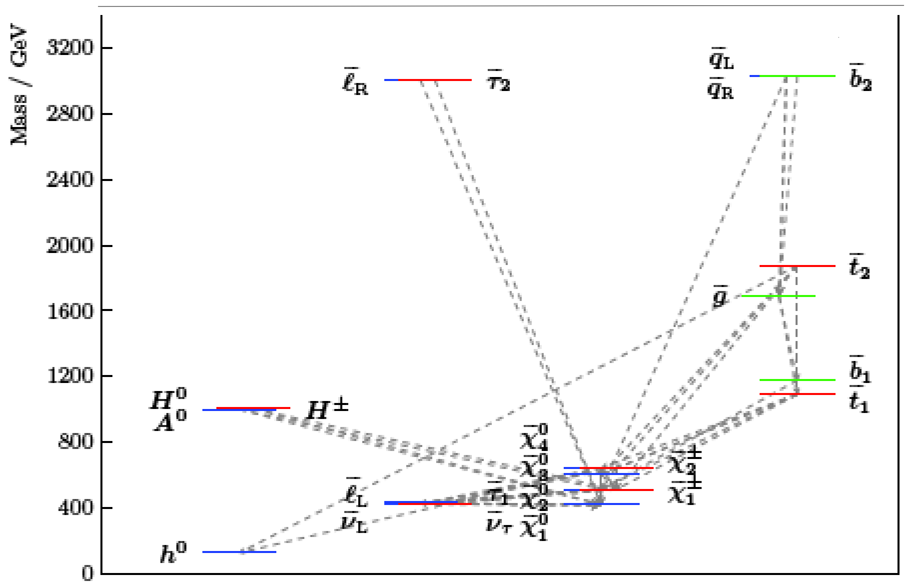
- $\tilde{\chi}_1^0$ is bino like. → $(\mu > M_2 > M_1)$

$(M_2 > M_1 > \mu)$

- $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_2^0$ are wino like.

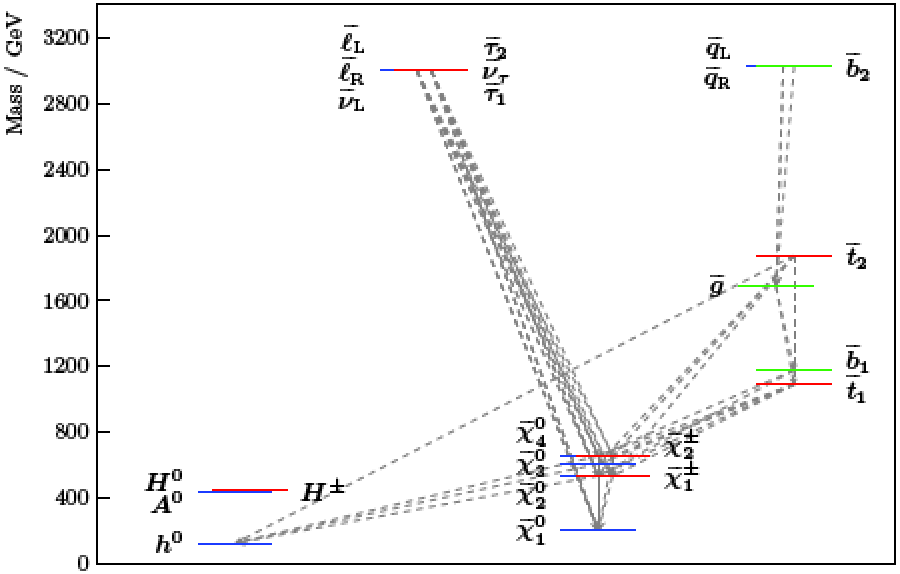
- $\tilde{\chi}_2^\pm$, $\tilde{\chi}_3^0$ and $\tilde{\chi}_4^0$ are higsino like.

$(\mu > M_1 > M_2)$



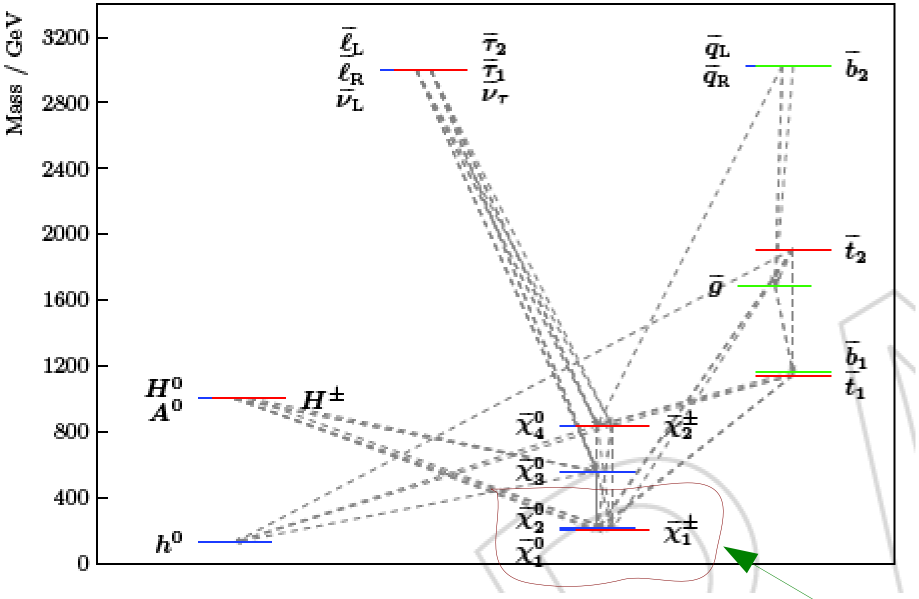
NM2

- The main difference between this model and the previously NM1 model is in the slepton masses which are much higher in here.



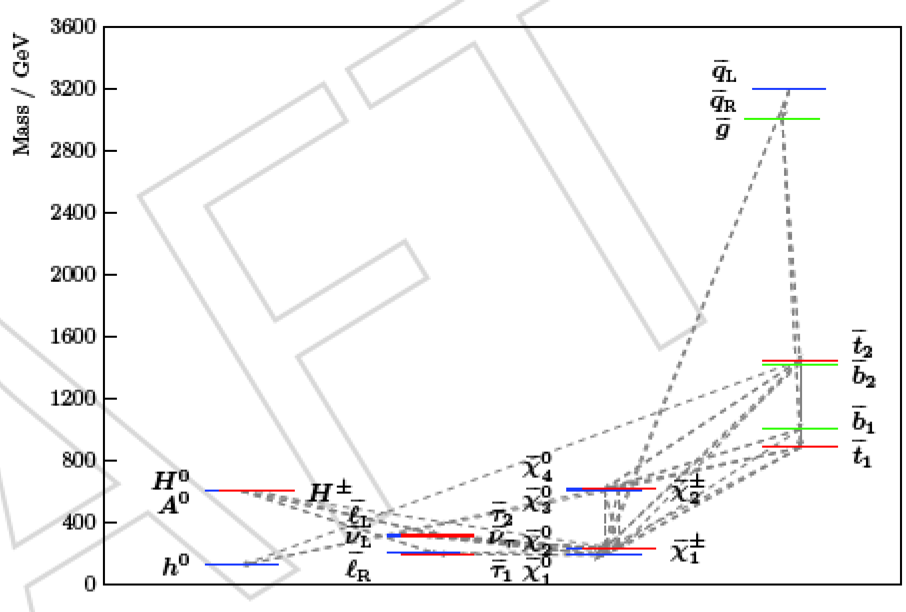
NM3

- This third natural model is very similar to the NM2 model with one key difference.
- The LSP is higgsino like and is accompanied by $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$. All three have very close masses.



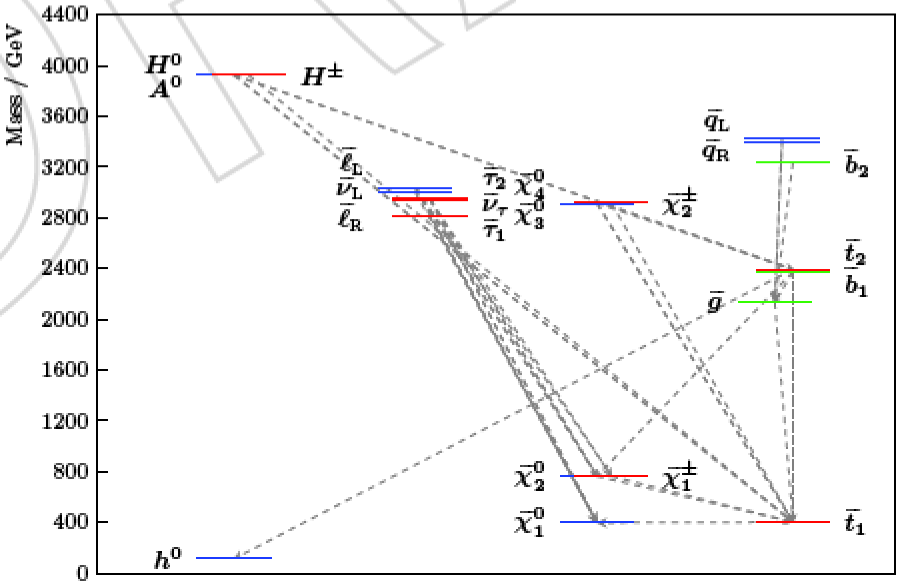
Stau Coannihilation Model

- All the sleptons and sneutrinos are light.
- As is clear from the name, stau and LSP have degenerate masses.



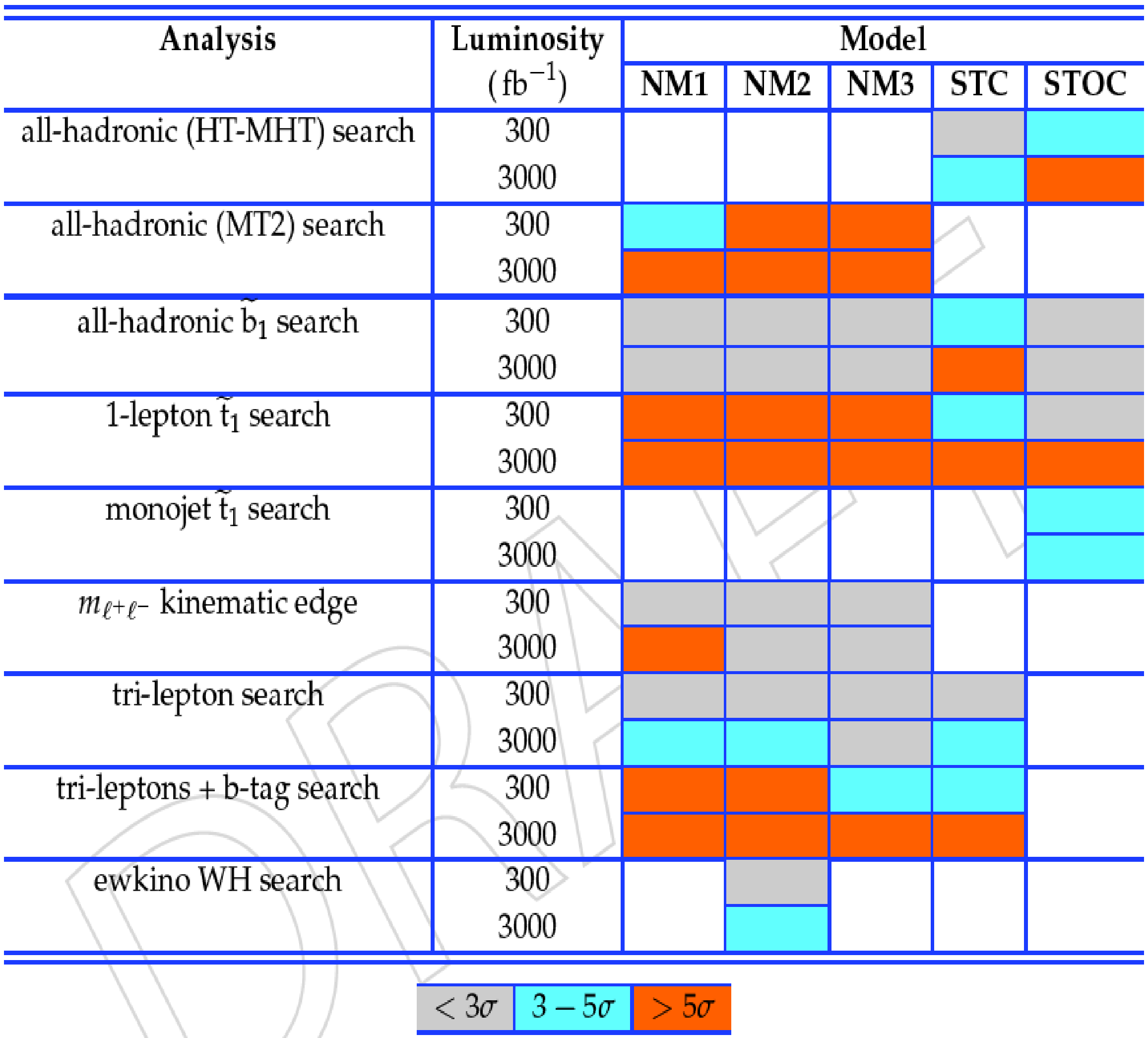
Stop Coannihilation Model

- In this model stop and LSP have degenerate masses.
- LSP is bino like.
- Unlike many other scenarios, here stop never never decay to a top quark.



Analysis Overview

- 9 different analysis are performed.
- This shows the richness of physics that can be studied in HL-LHC if SUSY signal is discovered.



Analysis	Luminosity (fb^{-1})	Model				
		NM1	NM2	NM3	STC	STOC
all-hadronic (HT-MHT) search	300				▨	🟦
	3000				🟦	🟧
all-hadronic (MT2) search	300	🟦	🟧	🟧		
	3000	🟧	🟧	🟧		
all-hadronic $\tilde{b}_1$ search	300	▨	▨	▨	🟦	▨
	3000	▨	▨	▨	🟧	▨
1-lepton $\tilde{t}_1$ search	300	🟧	🟧	🟧	🟦	▨
	3000	🟧	🟧	🟧	🟧	🟧
monojet $\tilde{t}_1$ search	300					🟦
	3000					🟦
$m_{\ell^+\ell^-}$ kinematic edge	300	▨	▨	▨		
	3000	🟧	▨	▨		
tri-lepton search	300	▨	▨	▨	▨	
	3000	🟦	🟦	▨	🟦	
tri-leptons + b-tag search	300	🟧	🟧	🟦	🟦	
	3000	🟧	🟧	🟧	🟧	
ewkino WH search	300		▨			
	3000		🟦			

▨	🟦	🟧
$< 3\sigma$	$3 - 5\sigma$	$> 5\sigma$

Analysis Strategy
Monte Carlo Simulation

- About 1 million events for a given signal and 10 to 100 million events per background are produced with MadGraph (A Monte Carlo event generator).
- These are passed to Pythia for hadronization.
- The cross sections are normalized to next-to-leading order.
- The results are passed to Delphes for detector simulation. Here there are two different configurations. Phase I detector with 50 pileup interactions is used for 300/fb data. Phase II detector with 140 pileup is used for the case of 3000/fb.

Analysis Strategy Uncertainties

- Systematic uncertainties of 8 TeV analyses are used as the starting point.
- The uncertainties are adjusted based on their origin and the way the origin evolves in high energy and luminosity case.
- If the origin of the uncertainty is not a function of energy or luminosity we'll keep the same uncertainty.
- Some uncertainties depend on the number of events that are different at higher luminosity and they are accordingly adjusted.

Summary I

- SUSY is a well motivated theory.
- Search for SUSY needs all the capabilities of the LHC and HL-LHC.
- Radiation damge can badly affect these capabilities and therefore our sensitivity in search.
- Assuming full capability of LHC and HL-LHC, we would like to see the discovery potential for Supersymmetry.
- Five different models from different regions of the phase space are considered.
- Nine different analyses are performed on these models.
- The results show that, when a SUSY signal is discovered in Run 2+3, how HL-LHC will unveil the underlying SUSY spectrum further.

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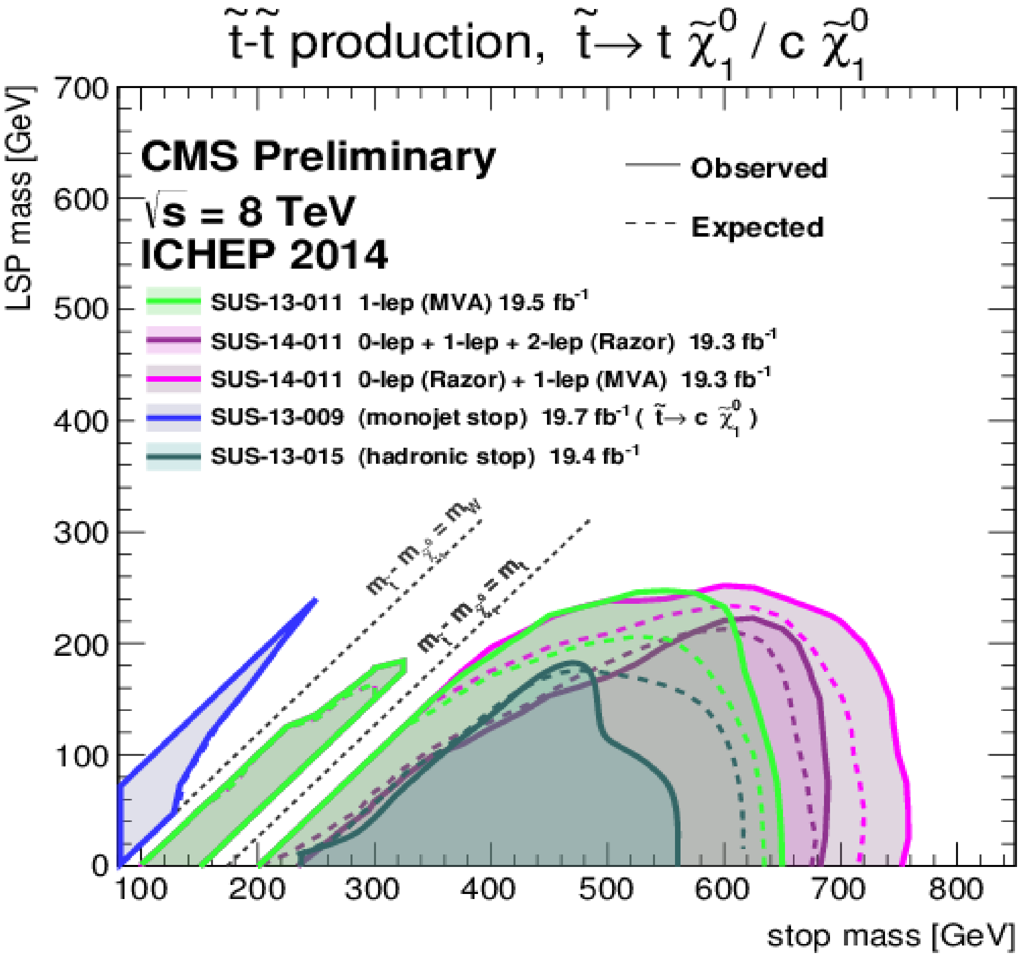
Why Stop Co-Annihilation?

The area around M(stop)~M(LSP) is a difficult region to assess, because the decay products of stop tend to have low p_T.

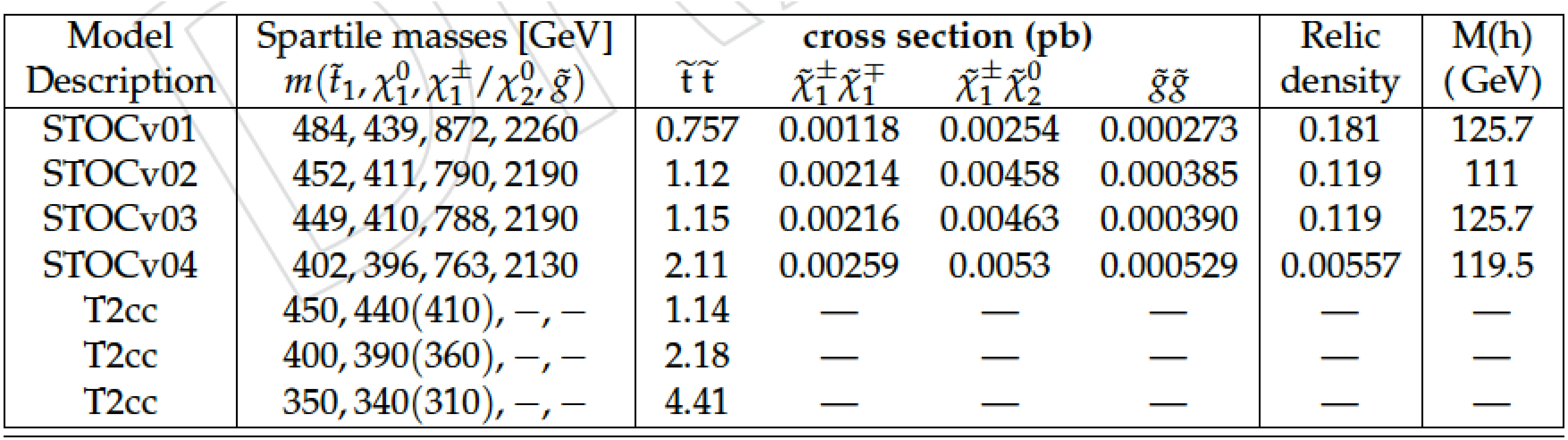
The top squark may be hiding in that region.



One of the ways to do a search sensitive to that region is to require events to have an energetic ISR jet.

The SLHA Information

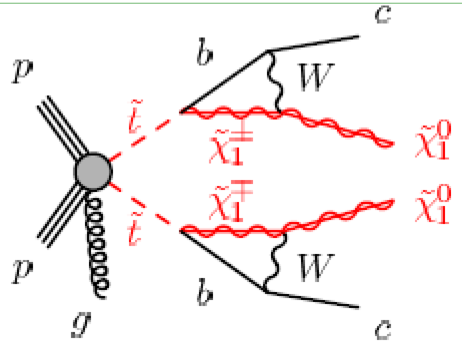
We have investigated a few stop coannhilation models and simplified model T2cc with lower stop masses to investigate the search sensitivity vs stop and LSP masses.



Model Description	Spartile masses [GeV] $m(\tilde{t}_1, \chi_1^0, \chi_1^\pm/\chi_2^0, \tilde{g})$	cross section (pb)				Relic density	M(h) (GeV)
		$\tilde{t}\tilde{t}$	$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp$	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0$	$\tilde{g}\tilde{g}$		
STOCv01	484, 439, 872, 2260	0.757	0.00118	0.00254	0.000273	0.181	125.7
STOCv02	452, 411, 790, 2190	1.12	0.00214	0.00458	0.000385	0.119	111
STOCv03	449, 410, 788, 2190	1.15	0.00216	0.00463	0.000390	0.119	125.7
STOCv04	402, 396, 763, 2130	2.11	0.00259	0.0053	0.000529	0.00557	119.5
T2cc	450, 440(410), –, –	1.14	—	—	—	—	—
T2cc	400, 390(360), –, –	2.18	—	—	—	—	—
T2cc	350, 340(310), –, –	4.41	—	—	—	—	—

Search for compressed supersymmetry spectra in the mono jet signature

Signal & Background



- We are searching for

  ~t → c + $\tilde{\chi}_1^0$

  with one initial energetic jet (ISR jet)
- The Backgrounds are mainly

  Wlv & Zvv & Ttbar
- The background Delphes samples were developed by Alexis Kalogeropoulos, Markus Klute, Seth Zenz, and many others.

Preliminary Event Selection

These are taken from CMS-PAS-SUS-13-009.

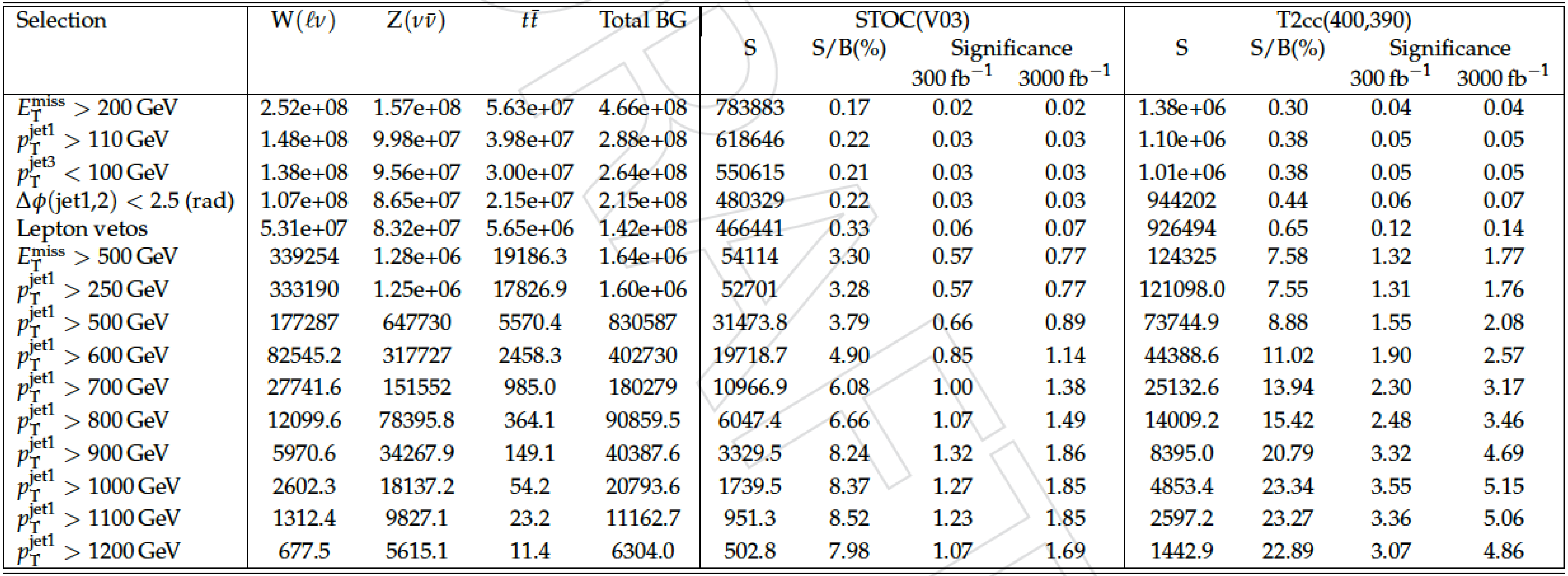
- Events are required to have MET > 250 GeV.
- We have also probed MET > 500 GeV.
- The first jet need to have p_T>110 GeV and |eta|<2.4
- A second jet with p_T > 60 GeV and $|\eta|$<4.5 is allowed.
- $\Delta\varphi$(J1,J2) < 2.5
- Third jet with p_T > 60 GeV and |eta|<4.5 is discarded. We also have probed p_T > 100 GeV.
- Leptons are vetoed.
- The analysis is performed in p_T> 250, ..., 1500 GeV.

Preliminary Uncertainties

Here are the assumed uncertainties based on results in CMS-PAS-SUS-13-009.

- Total of 8% on Wlv events.
- Total of 5% on Zvv events.
- Total of 50% on any other background.
- Significance is calculated using: $\frac{S}{\sqrt{B+\delta B^2}}$

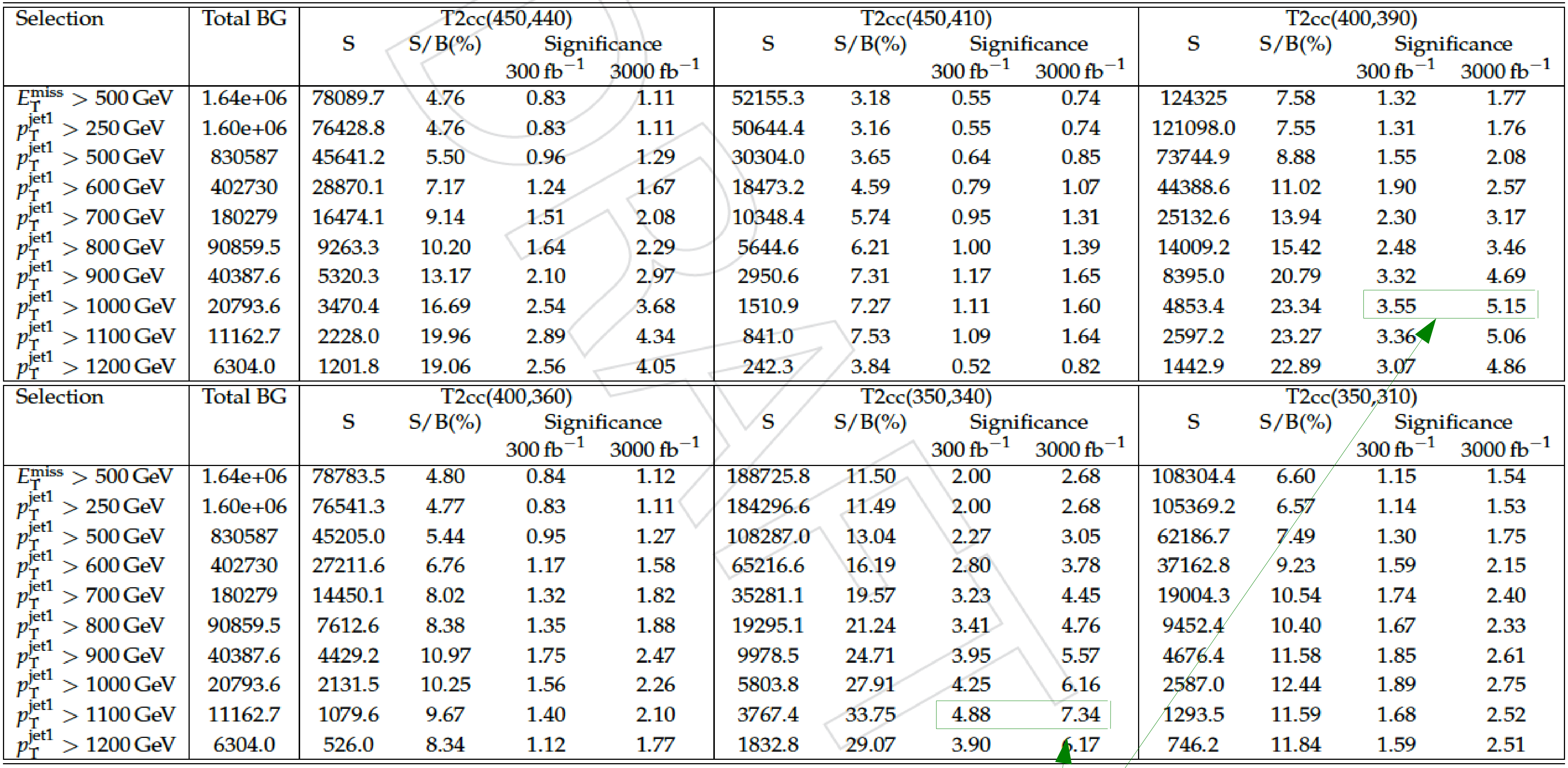
Signal and Background Yields



Selection	$W(\ell\nu)$	$Z(\nu\bar{\nu})$	$t\bar{t}$	Total BG	STOC(V03)				T2cc(400,390)			
					S	S/B(%)	Significance		S	S/B(%)	Significance	
							300 fb^{-1}	3000 fb^{-1}			300 fb^{-1}	3000 fb^{-1}
$E_T^{\text{miss}} > 200$ GeV	2.52e+08	1.57e+08	5.63e+07	4.66e+08	783883	0.17	0.02	0.02	1.38e+06	0.30	0.04	0.04
$p_T^{\text{jet1}} > 110$ GeV	1.48e+08	9.98e+07	3.98e+07	2.88e+08	618646	0.22	0.03	0.03	1.10e+06	0.38	0.05	0.05
$p_T^{\text{jet3}} < 100$ GeV	1.38e+08	9.56e+07	3.00e+07	2.64e+08	550615	0.21	0.03	0.03	1.01e+06	0.38	0.05	0.05
$\Delta\phi(\text{jet1,2}) < 2.5$ (rad)	1.07e+08	8.65e+07	2.15e+07	2.15e+08	480329	0.22	0.03	0.03	944202	0.44	0.06	0.07
Lepton vetos	5.31e+07	8.32e+07	5.65e+06	1.42e+08	466441	0.33	0.06	0.07	926494	0.65	0.12	0.14
$E_T^{\text{miss}} > 500$ GeV	339254	1.28e+06	19186.3	1.64e+06	54114	3.30	0.57	0.77	124325	7.58	1.32	1.77
$p_T^{\text{jet1}} > 250$ GeV	333190	1.25e+06	17826.9	1.60e+06	52701	3.28	0.57	0.77	121098.0	7.55	1.31	1.76
$p_T^{\text{jet1}} > 500$ GeV	177287	647730	5570.4	830587	31473.8	3.79	0.66	0.89	73744.9	8.88	1.55	2.08
$p_T^{\text{jet1}} > 600$ GeV	82545.2	317727	2458.3	402730	19718.7	4.90	0.85	1.14	44388.6	11.02	1.90	2.57
$p_T^{\text{jet1}} > 700$ GeV	27741.6	151552	985.0	180279	10966.9	6.08	1.00	1.38	25132.6	13.94	2.30	3.17
$p_T^{\text{jet1}} > 800$ GeV	12099.6	78395.8	364.1	90859.5	6047.4	6.66	1.07	1.49	14009.2	15.42	2.48	3.46
$p_T^{\text{jet1}} > 900$ GeV	5970.6	34267.9	149.1	40387.6	3329.5	8.24	1.32	1.86	8395.0	20.79	3.32	4.69
$p_T^{\text{jet1}} > 1000$ GeV	2602.3	18137.2	54.2	20793.6	1739.5	8.37	1.27	1.85	4853.4	23.34	3.55	5.15
$p_T^{\text{jet1}} > 1100$ GeV	1312.4	9827.1	23.2	11162.7	951.3	8.52	1.23	1.85	2597.2	23.27	3.36	5.06
$p_T^{\text{jet1}} > 1200$ GeV	677.5	5615.1	11.4	6304.0	502.8	7.98	1.07	1.69	1442.9	22.89	3.07	4.86

- When $\Delta m(\tilde{t},\tilde{\chi}_1^0)$ ~ 10 GeV, sensitivity is high.
- Because final jets are softer.

Signal and Background Yields

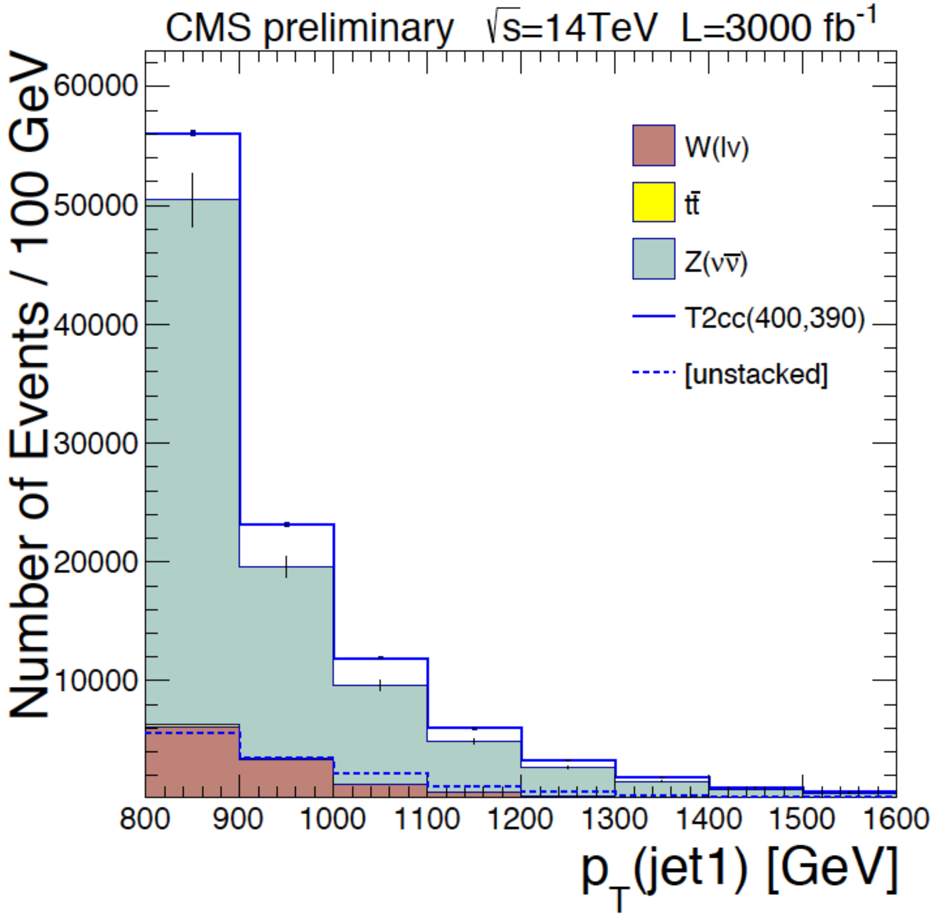


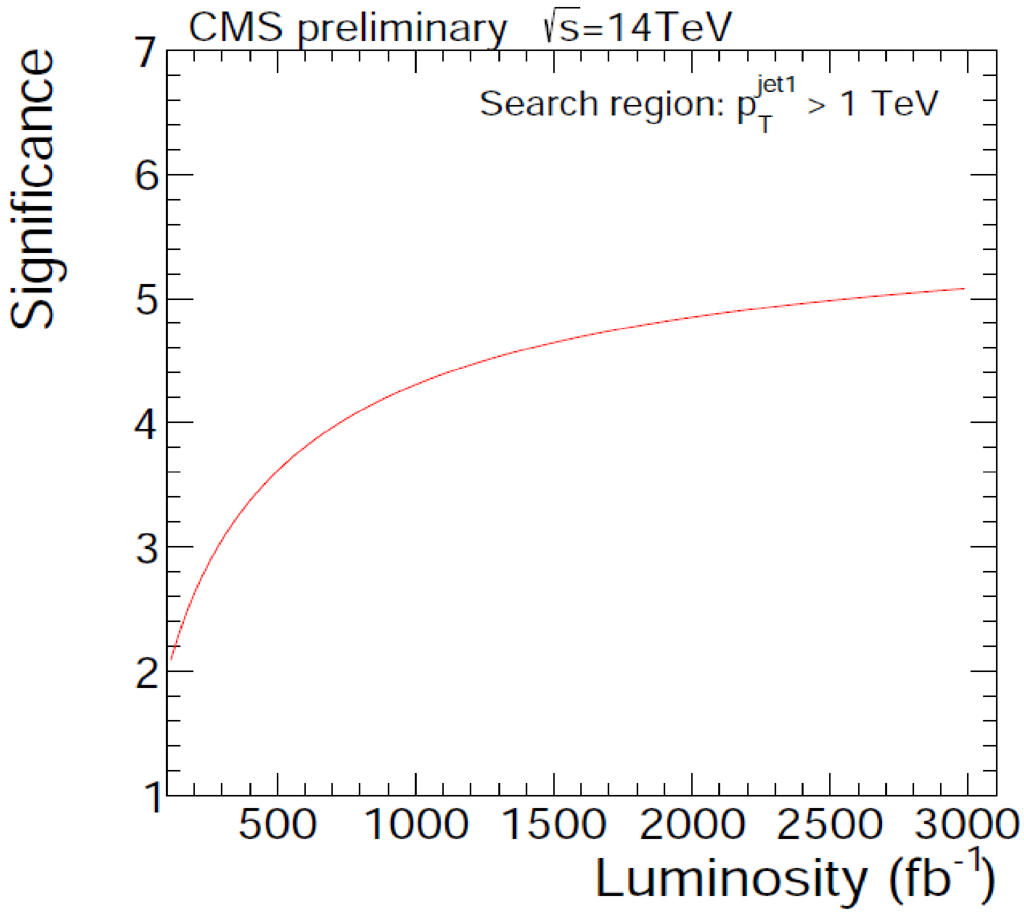
Selection	Total BG	T2cc(450,440)				T2cc(450,410)				T2cc(400,390)			
		S	S/B(%)	Significance		S	S/B(%)	Significance		S	S/B(%)	Significance	
				300 fb^{-1}	3000 fb^{-1}			300 fb^{-1}	3000 fb^{-1}			300 fb^{-1}	3000 fb^{-1}
$E_T^{\text{miss}} > 500$ GeV	1.64e+06	78089.7	4.76	0.83	1.11	52155.3	3.18	0.55	0.74	124325	7.58	1.32	1.77
$p_T^{\text{jet1}} > 250$ GeV	1.60e+06	76428.8	4.76	0.83	1.11	50644.4	3.16	0.55	0.74	121098.0	7.55	1.31	1.76
$p_T^{\text{jet1}} > 500$ GeV	830587	45641.2	5.50	0.96	1.29	30304.0	3.65	0.64	0.85	73744.9	8.88	1.55	2.08
$p_T^{\text{jet1}} > 600$ GeV	402730	28870.1	7.17	1.24	1.67	18473.2	4.59	0.79	1.07	44388.6	11.02	1.90	2.57
$p_T^{\text{jet1}} > 700$ GeV	180279	16474.1	9.14	1.51	2.08	10348.4	5.74	0.95	1.31	25132.6	13.94	2.30	3.17
$p_T^{\text{jet1}} > 800$ GeV	90859.5	9263.3	10.20	1.64	2.29	5644.6	6.21	1.00	1.39	14009.2	15.42	2.48	3.46
$p_T^{\text{jet1}} > 900$ GeV	40387.6	5320.3	13.17	2.10	2.97	2950.6	7.31	1.17	1.65	8395.0	20.79	3.32	4.69
$p_T^{\text{jet1}} > 1000$ GeV	20793.6	3470.4	16.69	2.54	3.68	1510.9	7.27	1.11	1.60	4853.4	23.34	3.55	5.15
$p_T^{\text{jet1}} > 1100$ GeV	11162.7	2228.0	19.96	2.89	4.34	841.0	7.53	1.09	1.64	2597.2	23.27	3.36	5.06
$p_T^{\text{jet1}} > 1200$ GeV	6304.0	1201.8	19.06	2.56	4.05	242.3	3.84	0.52	0.82	1442.9	22.89	3.07	4.86

Selection	Total BG	T2cc(400,360)				T2cc(350,340)				T2cc(350,310)			
		S	S/B(%)	Significance		S	S/B(%)	Significance		S	S/B(%)	Significance	
				300 fb^{-1}	3000 fb^{-1}			300 fb^{-1}	3000 fb^{-1}			300 fb^{-1}	3000 fb^{-1}
$E_T^{\text{miss}} > 500$ GeV	1.64e+06	78783.5	4.80	0.84	1.12	188725.8	11.50	2.00	2.68	108304.4	6.60	1.15	1.54
$p_T^{\text{jet1}} > 250$ GeV	1.60e+06	76541.3	4.77	0.83	1.11	184296.6	11.49	2.00	2.68	105369.2	6.57	1.14	1.53
$p_T^{\text{jet1}} > 500$ GeV	830587	45205.0	5.44	0.95	1.27	108287.0	13.04	2.27	3.05	62186.7	7.49	1.30	1.75
$p_T^{\text{jet1}} > 600$ GeV	402730	27211.6	6.76	1.17	1.58	65216.6	16.19	2.80	3.78	37162.8	9.23	1.59	2.15
$p_T^{\text{jet1}} > 700$ GeV	180279	14450.1	8.02	1.32	1.82	35281.1	19.57	3.23	4.45	19004.3	10.54	1.74	2.40
$p_T^{\text{jet1}} > 800$ GeV	90859.5	7612.6	8.38	1.35	1.88	19295.1	21.24	3.41	4.76	9452.4	10.40	1.67	2.33
$p_T^{\text{jet1}} > 900$ GeV	40387.6	4429.2	10.97	1.75	2.47	9978.5	24.71	3.95	5.57	4676.4	11.58	1.85	2.61
$p_T^{\text{jet1}} > 1000$ GeV	20793.6	2131.5	10.25	1.56	2.26	5803.8	27.91	4.25	6.16	2587.0	12.44	1.89	2.75
$p_T^{\text{jet1}} > 1100$ GeV	11162.7	1079.6	9.67	1.40	2.10	3767.4	33.75	4.88	7.34	1293.5	11.59	1.68	2.52
$p_T^{\text{jet1}} > 1200$ GeV	6304.0	526.0	8.34	1.12	1.77	1832.8	29.07	3.90	6.17	746.2	11.84	1.59	2.51

The Highest significances

Some Plots





3sigma excess with 300/fb becomes 5sigma discovery with 3000/fb.

All The Backgrounds

- In addition to the three main backgrounds considered in the early evaluations, 10 other less important backgrounds are considered.

Selection	BJ Rest	BJJ Rest	B	BBB	H	LL	LLB	TB	TJ	TTB	All Wlv	All Zvv	Ttbar
pt(Jet1)> 900	24	1	0	74	7	867	63	35	27	18	5341	25818	199

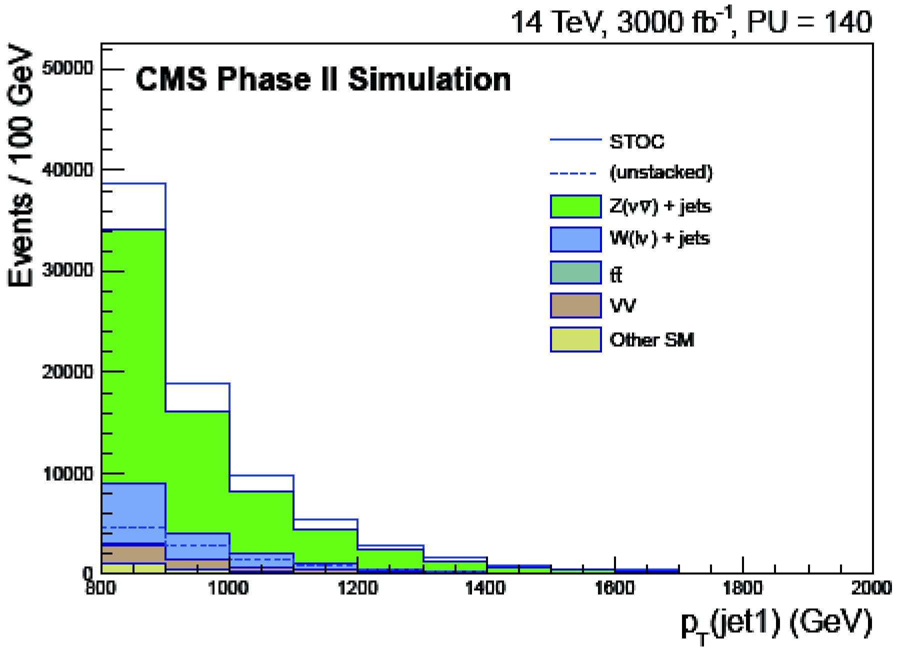
- This table validates our early assumption that Wlv, Zvv, and Ttbar are the main contributors.
- For better accuracy we considered all the backgrounds in our final results.

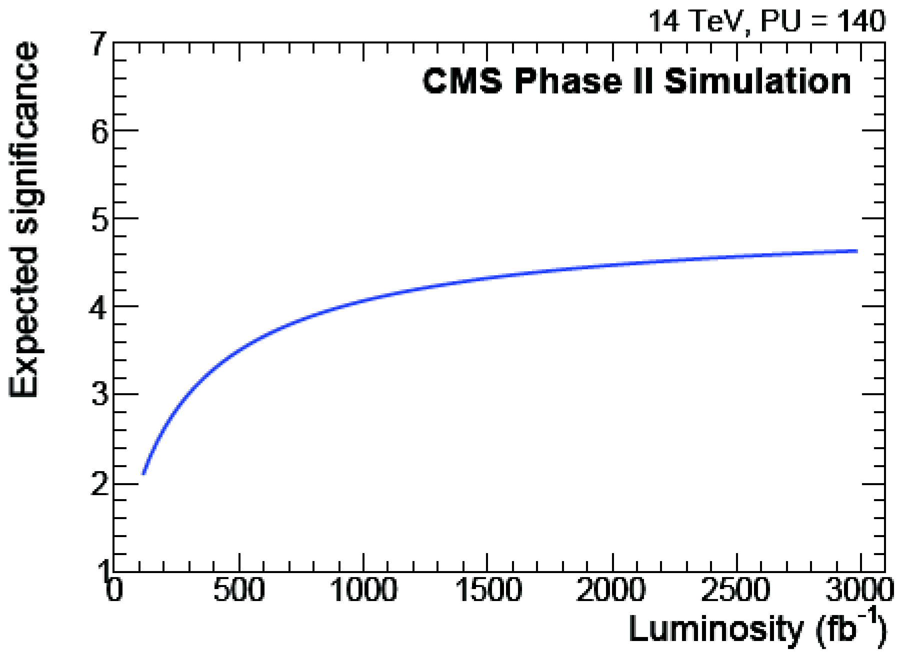
Event Selection Optimization

- I developed a code to further optimize the event selection requirements.
- Events are required to have MET > 600 GeV.

  (original value: 500 GeV)
- $\Delta\varphi$(J1,J2) < 1.8 (original value: 2.5)
- Third jet with p_T > 100 GeV and $|\eta|$<4.5 is discarded. (original value: 60 GeV)
- The rest are the same as those used in the initial study.

Final Results



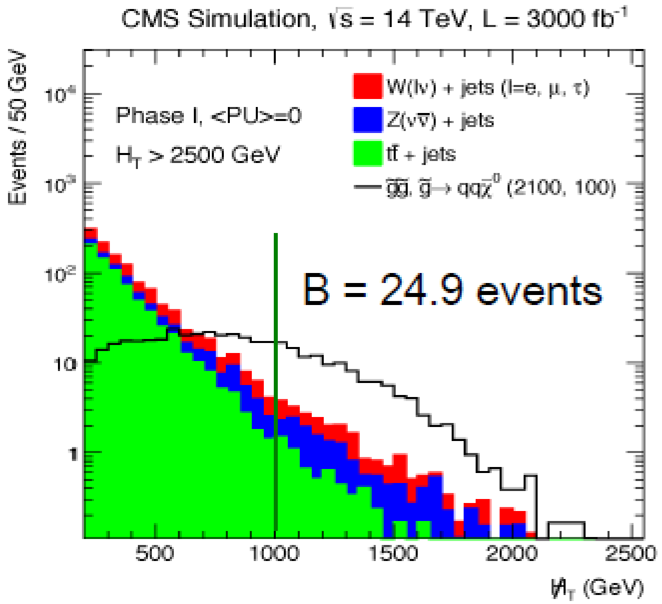


	$Z(\nu\bar{\nu})$ + jets	$W(\ell\nu)$ + jets	$t\bar{t}$	VV	Other	Total SM	STOC
Preselection	$7.1 \cdot 10^7$	$5.0 \cdot 10^7$	$6.3 \cdot 10^6$	$2.5 \cdot 10^6$	$1.2 \cdot 10^7$	$14.2 \cdot 10^7$	811,569
$E_T^{\text{miss}} > 60\,\text{GeV}$	429,615	101,673	6,440	27,565	40,697	605,990	55,668
$p_T^{\text{jet1}} > 900\,\text{GeV}$	25,818	5,341	199	1,948	1,115	34,421	6,526

Inclusive search in the all-hadronic final state with HT & MHT variables

Preliminary HT-MHT Studies

- WE also performed RA2 multijet studies of the last year's ECFA (CMS-PAS-FTR-13-014) on the STOC(V4).
- The analysis used several signal regions.
- A typical one: Njets>=6, HT>=2.5 TeV, MHT>=1.0 TeV.
- The preliminary significance of 8 sigma (signal:74, background:25, uncertainty 30% of background) was reached.



Signal & Background

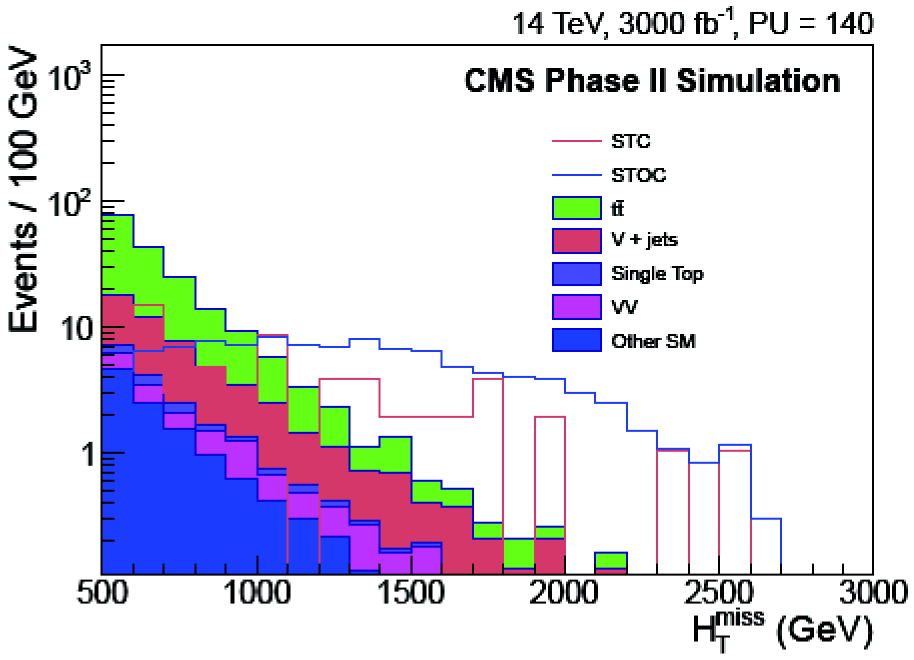
- Heavy colored SUSY particles are produced and after a long decay chain give rise to multiple jets and a large amount of missing energy.
- The Backgrounds are mainly Wlv & Zvv & Ttbar. Ttbar has the highest contribution after the b-tagging requirements.

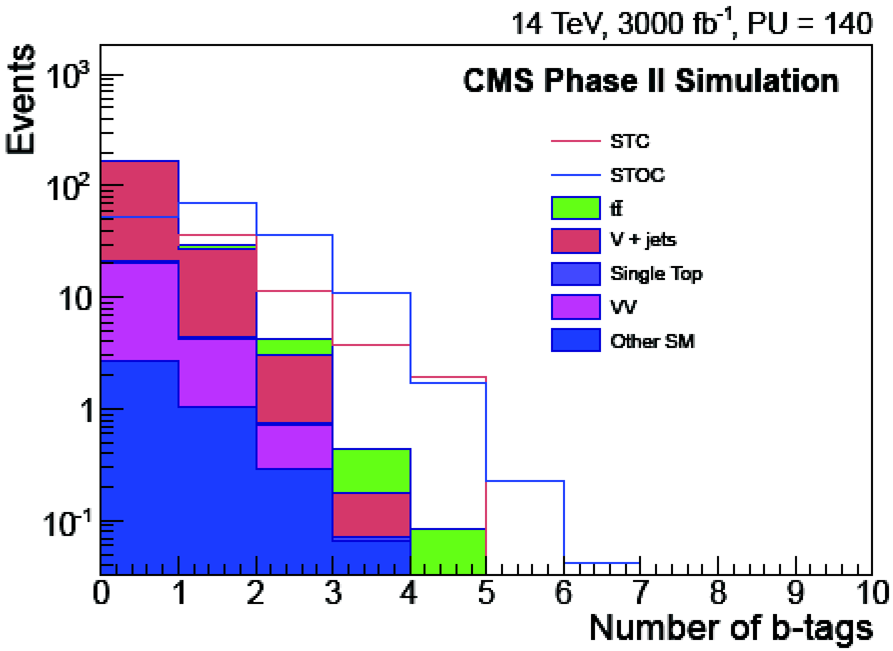
Most Optimized Event Selection

- There should be at least three jets with p_T>50 GeV and |η|<2.5.
- $|\Delta\phi(j_n, \vec{H}_{\mathrm{T}}^{\mathrm{miss}})| > 0.5$ for the first two jets and $|\Delta\phi(j_3, \vec{H}_{\mathrm{T}}^{\mathrm{miss}})| > 0.3$
- Leptons and photons are vetoed.
- There must be at least two b-tag jets.
- HT>2500 GeV.
- MHT>1300 GeV.

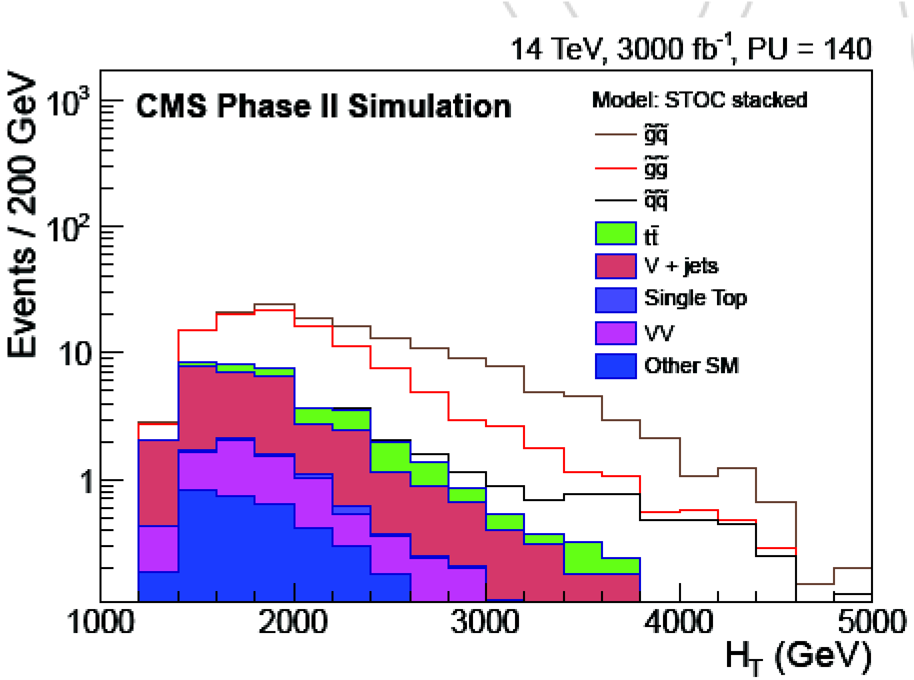
Final Results

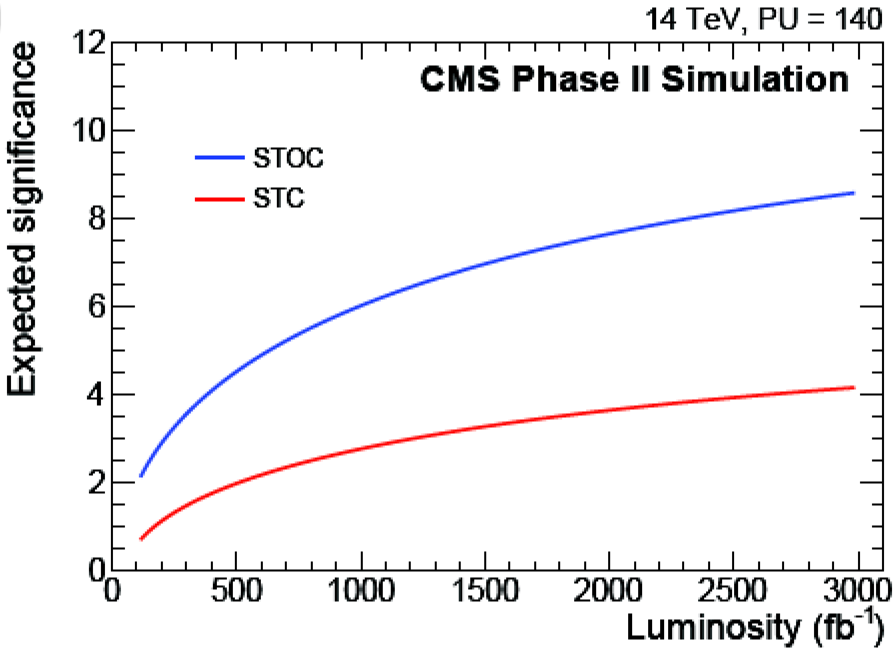
	$t\bar{t}$	V + jets	VV	Single top	Other	Total SM	STC	STOC
$n_{\text{jets}} \geq 3$	18619	505194	11576	661	3913	539964	7067	1383
$H_{\text{T}} > 2500\,\text{GeV}$	396	2102	220	9.5	61	2789	208	388
$n_{\text{b-tags}} \geq 2$	132	35	5.3	2.4	12	186	62	104
$H_{\text{T}}^{\text{miss}} > 1300\,\text{GeV}$	1.6	2.4	0.4	0.1	0.4	4.9	17	49





Final Results





For STC, 1sigma excess with 300/fb becomes 4sigma discovery with 3000/fb. For STOC, 3sigma excess with 300/fb becomes 8sigma discovery with 3000/fb.

Summary II

- The area in the parameter space in which stop and LSP masses are close is a difficult region.
- A sensitive search in this area is to require existence of an initial energetic jet. (Monojet Search)
- After searching different STOC versions we realized that sensitivity is higher for lighter stop masses as well as when stop and LSP have closer masses.
- Rather than stop there are other particles in the STOC model that make the HT-MHT search sensitive.
- Monojet search on STOC reaches 4.7 sigma significance at 3000/fb.
- HT-MHT search on STOC reaches 8 sigma significance at 3000/fb.
- HT-MHT search on STC reaches 4 sigma significance at 3000/fb.

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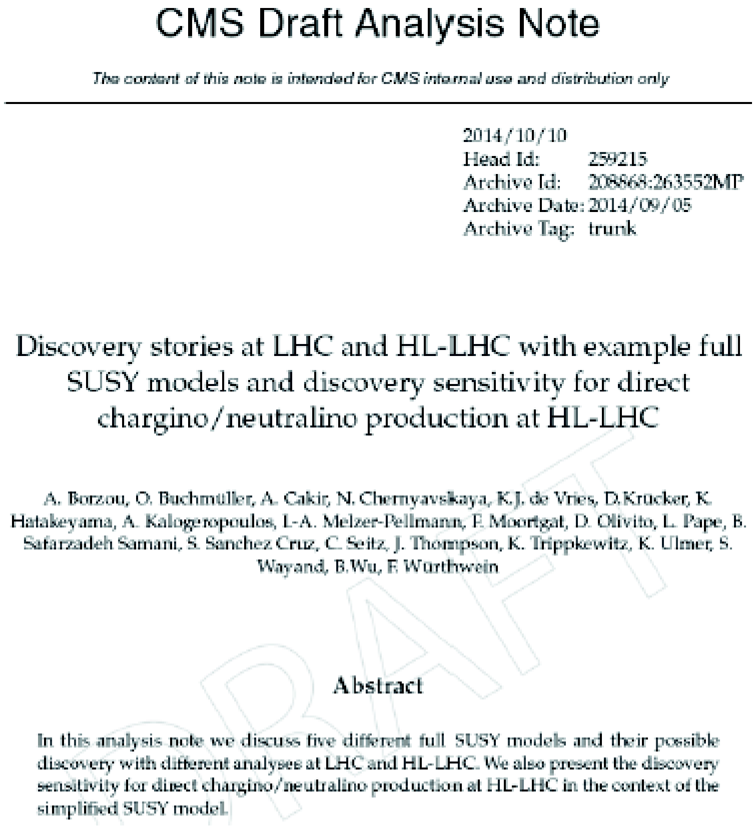


CMS Draft Analysis Note

2014/10/10
Head Id: 259215
Archive Id: 208868:263552MP
Archive Date: 2014/09/05
Archive Tag: trunk

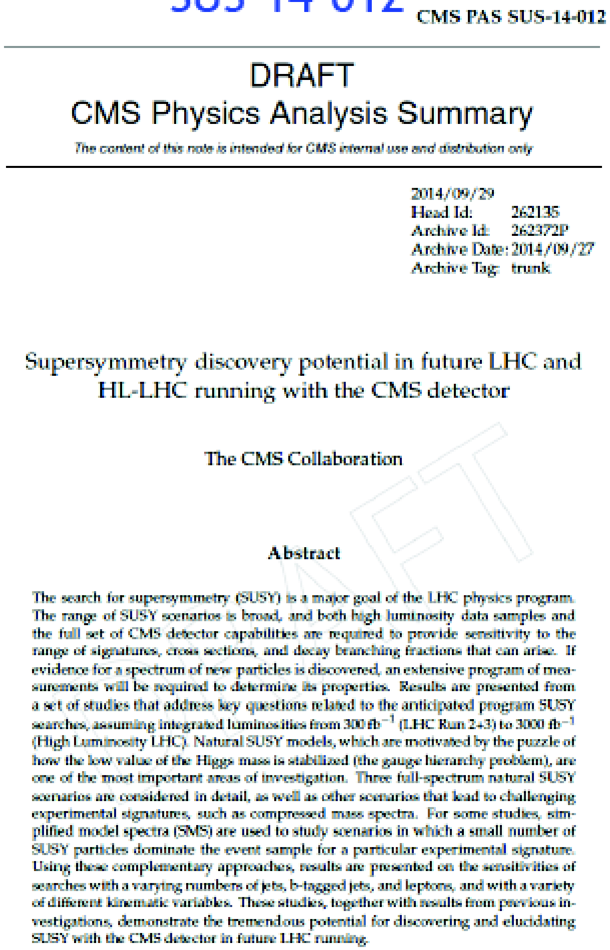
Discovery stories at LHC and HL-LHC with example full SUSY models and discovery sensitivity for direct chargino/neutralino production at HL-LHC

A. Borzou, O. Buchmüller, A. Cakir, N. Chernyavskaya, K.J. de Vries, D.Krücker, K. Hatakeyama, A. Kalogeropoulos, I.-A. Melzer-Pellmann, F. Moortgat, D. Olivito, L. Pape, B. Safarzadeh Samani, S. Sanchez Cruz, C. Seitz, J. Thompson, K. Trippkewitz, K. Ulmer, S. Wayand, B.Wu, F. Würthwein

Abstract

In this analysis note we discuss five different full SUSY models and their possible discovery with different analyses at LHC and HL-LHC. We also present the discovery sensitivity for direct chargino/neutralino production at HL-LHC in the context of the simplified SUSY model.

SUS-14-012



CMS PAS SUS-14-012

DRAFT
CMS Physics Analysis Summary

2014/09/29
Head Id: 262135
Archive Id: 262372P
Archive Date: 2014/09/27
Archive Tag: trunk

Supersymmetry discovery potential in future LHC and HL-LHC running with the CMS detector

The CMS Collaboration

Abstract

The search for supersymmetry (SUSY) is a major goal of the LHC physics program. The range of SUSY scenarios is broad, and both high luminosity data samples and the full set of CMS detector capabilities are required to provide sensitivity to the range of signatures, cross sections, and decay branching fractions that can arise. If evidence for a spectrum of new particles is discovered, an extensive program of measurements will be required to determine its properties. Results are presented from a set of studies that address key questions related to the anticipated program SUSY searches, assuming integrated luminosities from 300 fb^{-1} (LHC Run 2+3) to 3000 fb^{-1} (High Luminosity LHC). Natural SUSY models, which are motivated by the puzzle of how the low value of the Higgs mass is stabilized (the gauge hierarchy problem), are one of the most important areas of investigation. Three full-spectrum natural SUSY scenarios are considered in detail, as well as other scenarios that lead to challenging experimental signatures, such as compressed mass spectra. For some studies, simplified model spectra (SMS) are used to study scenarios in which a small number of SUSY particles dominate the event sample for a particular experimental signature. Using these complementary approaches, results are presented on the sensitivities of searches with a varying numbers of jets, b-tagged jets, and leptons, and with a variety of different kinematic variables. These studies, together with results from previous investigations, demonstrate the tremendous potential for discovering and elucidating SUSY with the CMS detector in future LHC running.

Thanks!!

BackUp

Pseudorapidity

$$\eta = -\ln[\tan(\theta/2)]$$