Search for Supersymmetry at ATLAS

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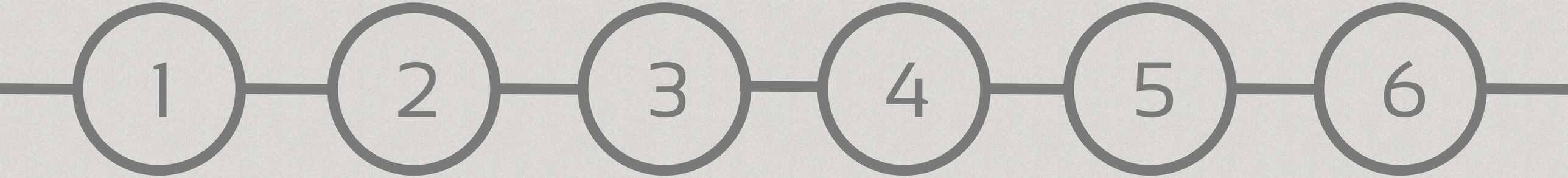
Carsten Hensel

Georg-August-Universität Göttingen

On behalf of the ATLAS Colaboration.

Outline



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INTRO	SETUP	SEARCHES 1	SEARCHES 2	SEARCHES 3	SUMMARY
SUSY, ATLAS	What are we looking for?	Strong Production	EWK Production	What if...?	Where do we go from here?

Outline

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INTRO

SUSY, ATLAS

SUPERSYMMETRY INTRODUCTION

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- SUSY is a concept that adds additional symmetry to SM
- SUSY is key element in many Standard Model extensions
- If SUSY realized around 1 TeV scale:
  - stabilize Higgs mass
  - gauge unification
  - Dark Matter candidate
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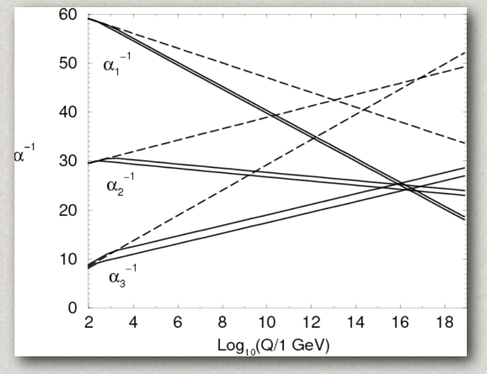

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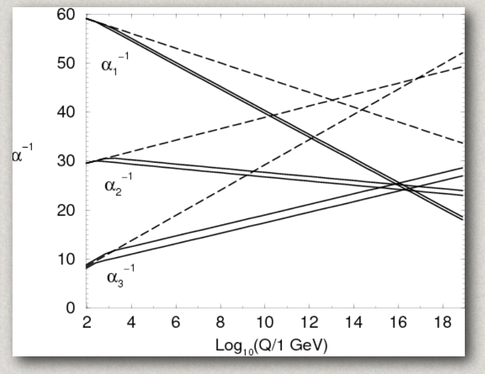

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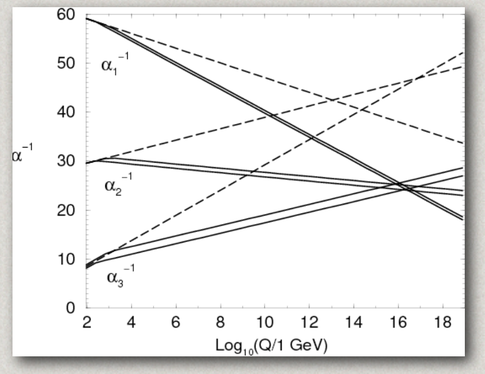

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- SUSY has to be a broken symmetry — parametrize SUSY breaking: 124 parameters

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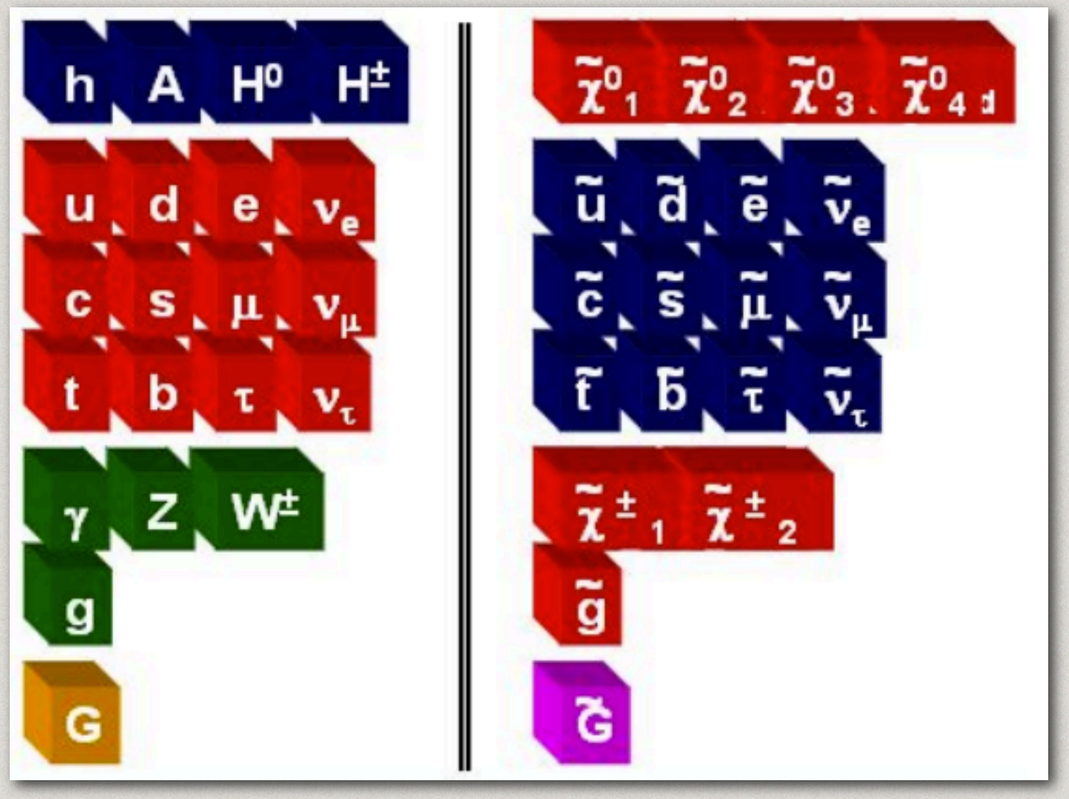

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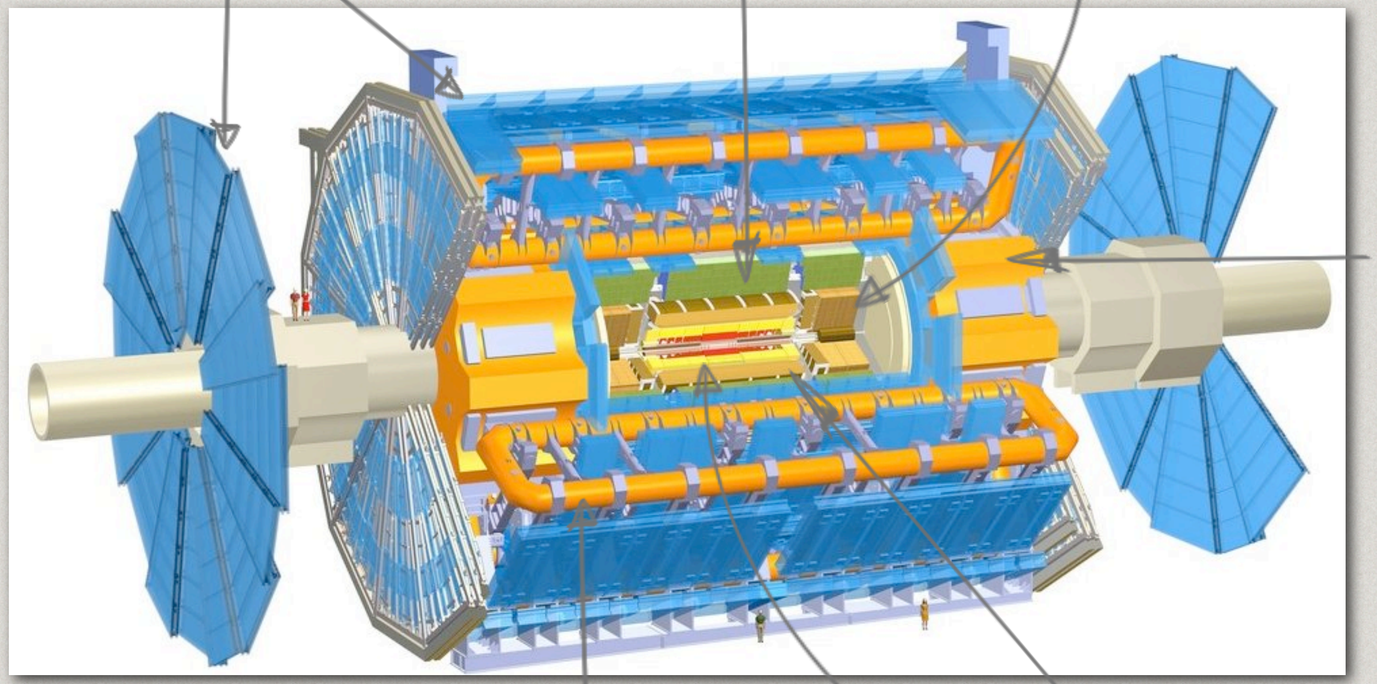

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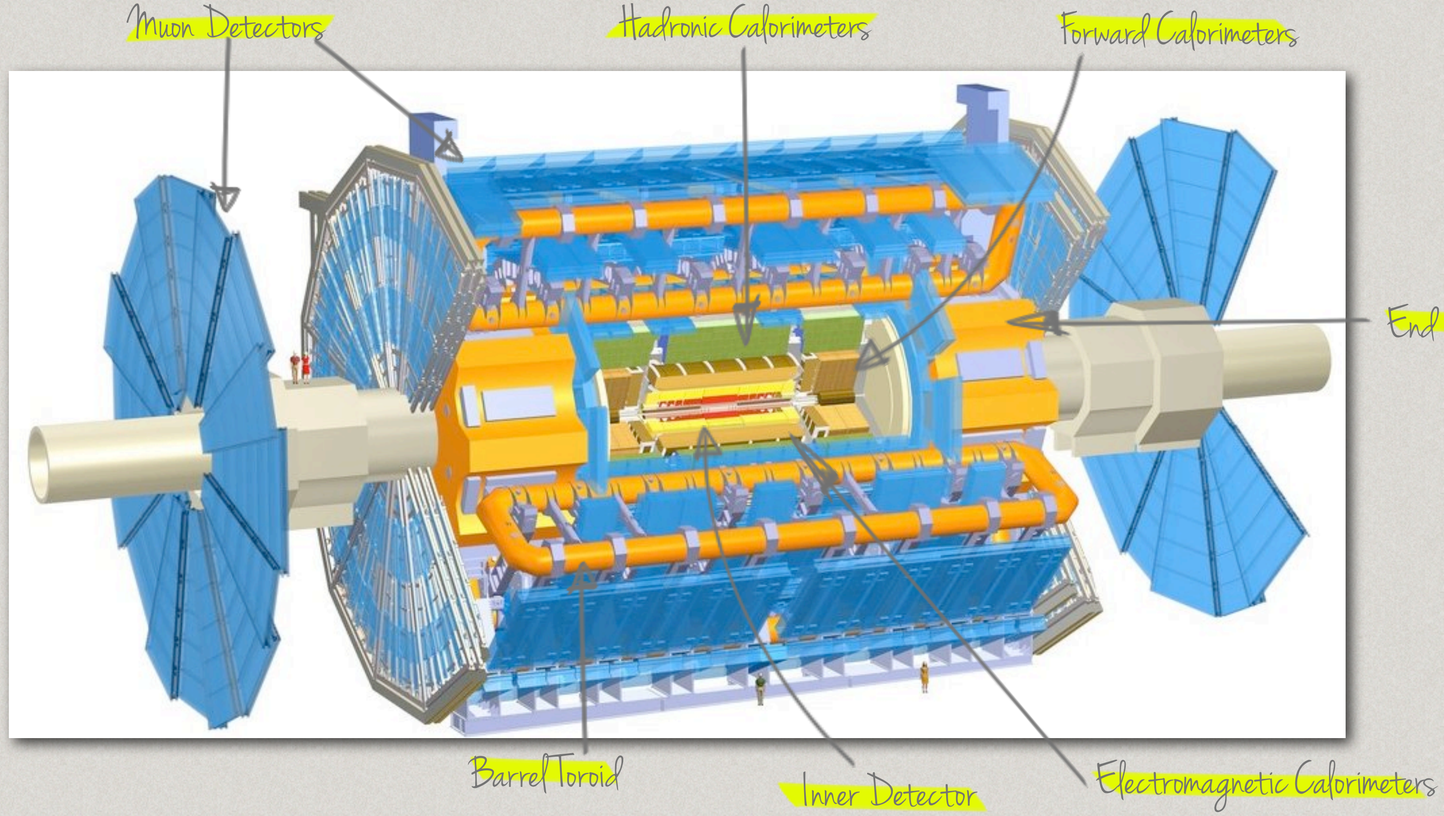
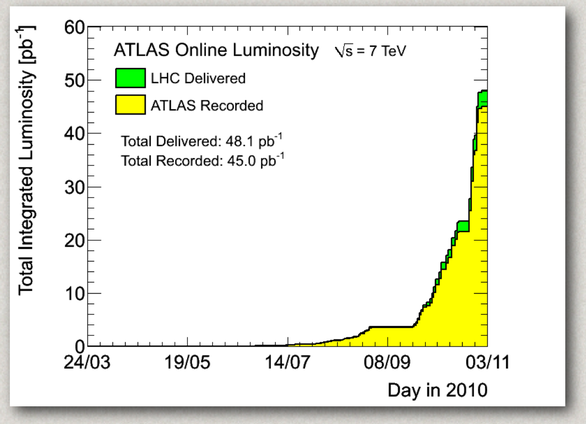
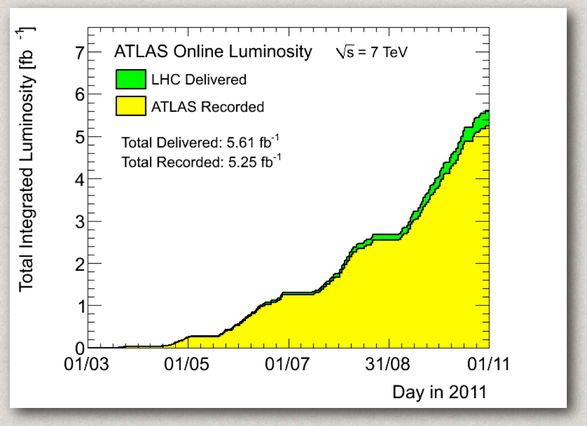


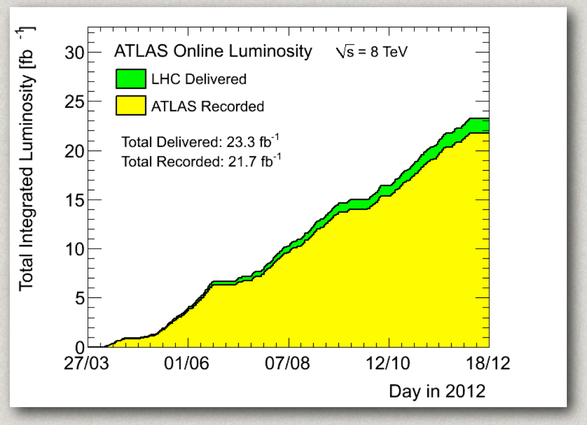
2010, 7 TeV, 45 pb^{-1}



2011, 7 TeV, 5.25 fb^{-1}



2012, 8 TeV, 21.7 fb^{-1}



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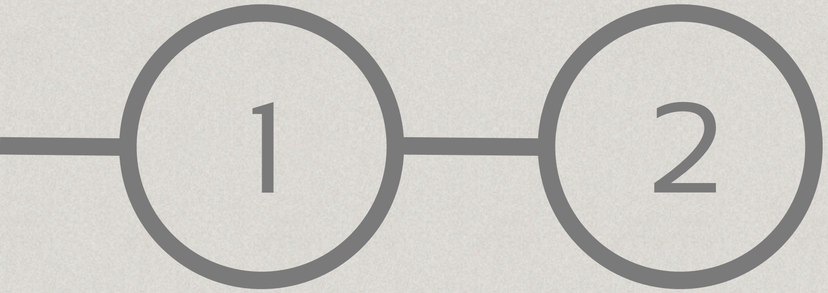

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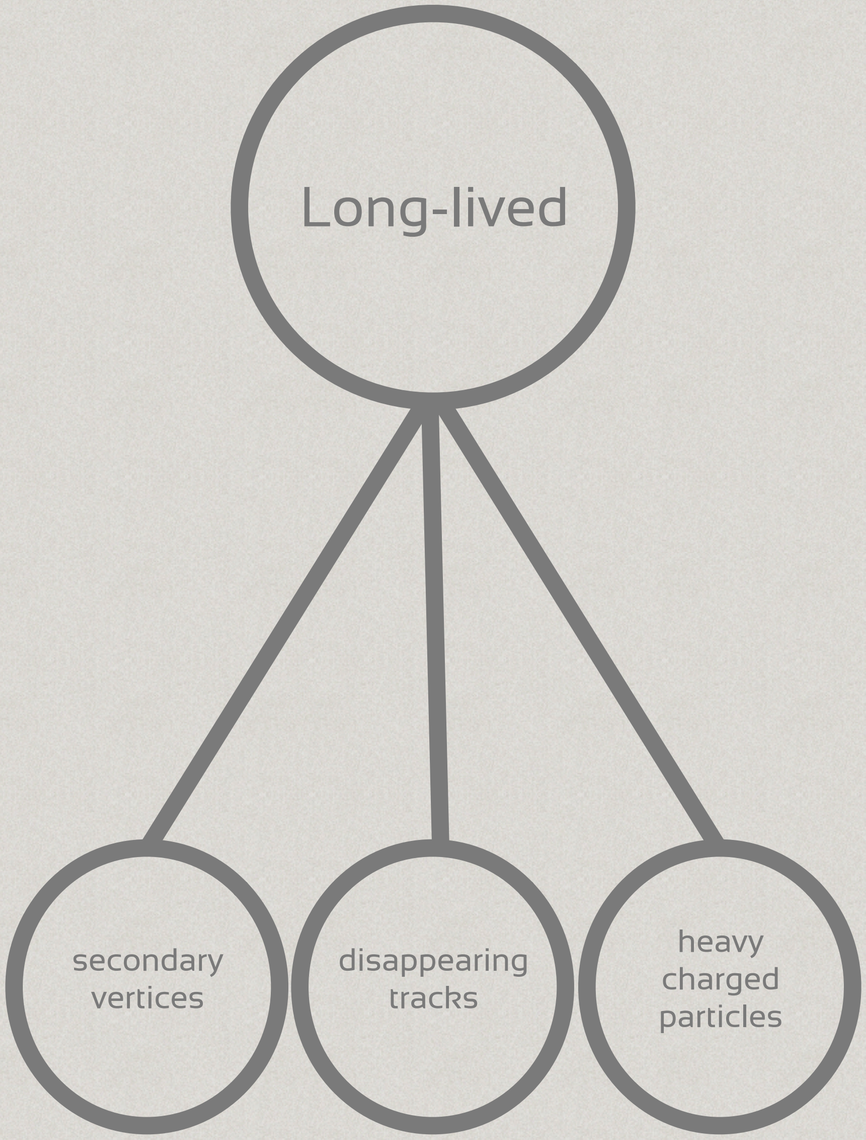

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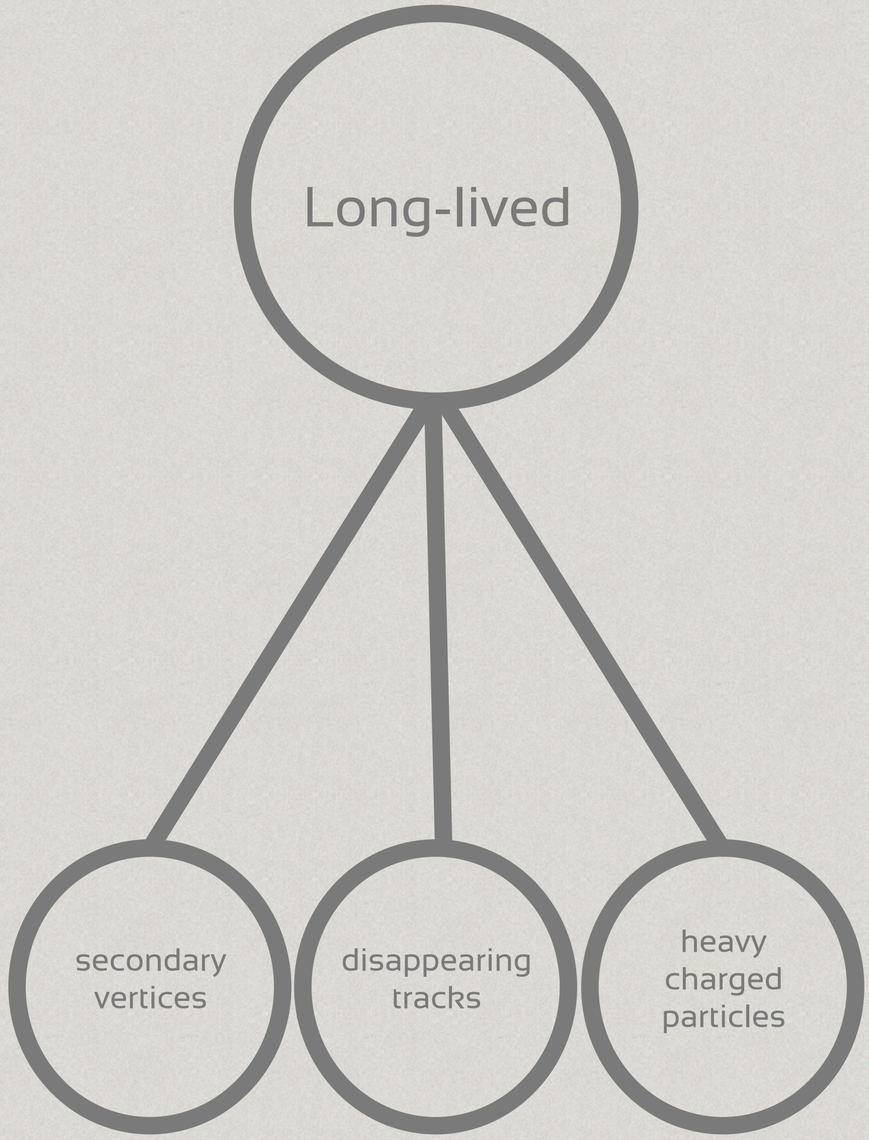
$R = -1^{3(B-L)+2s}$



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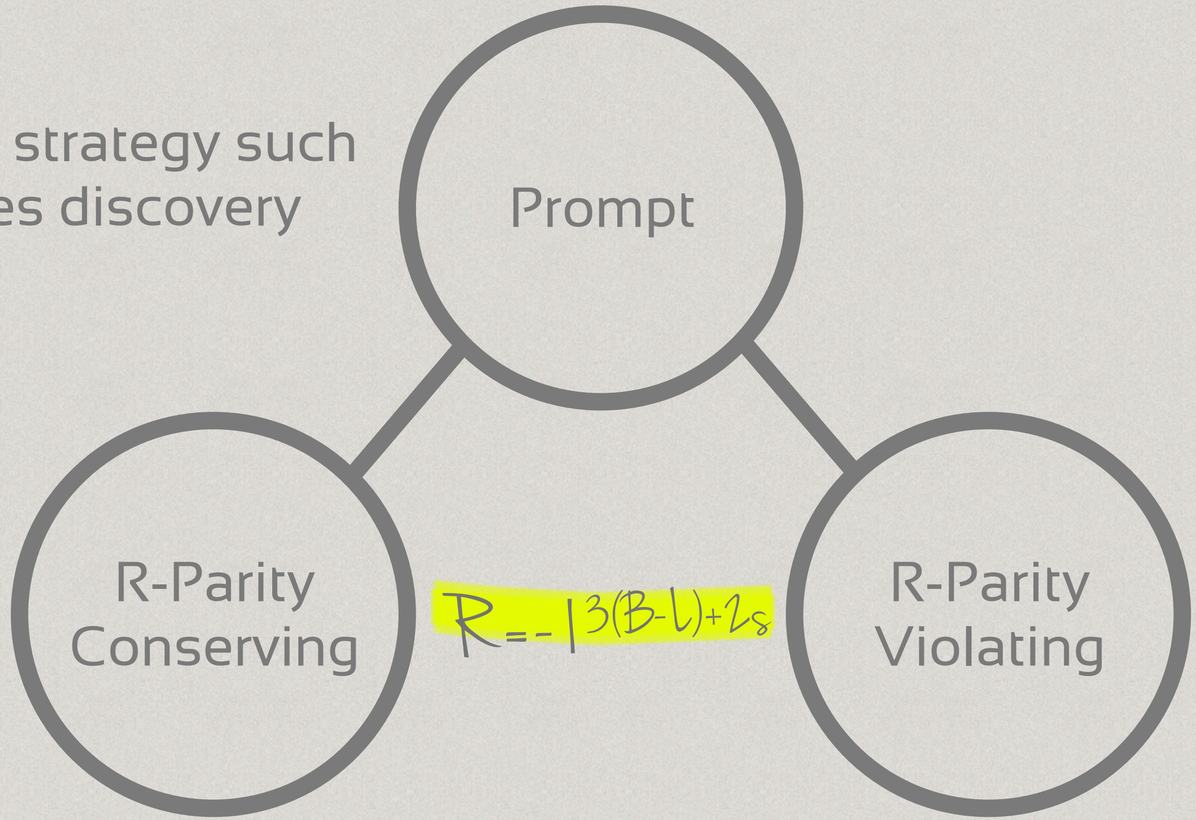

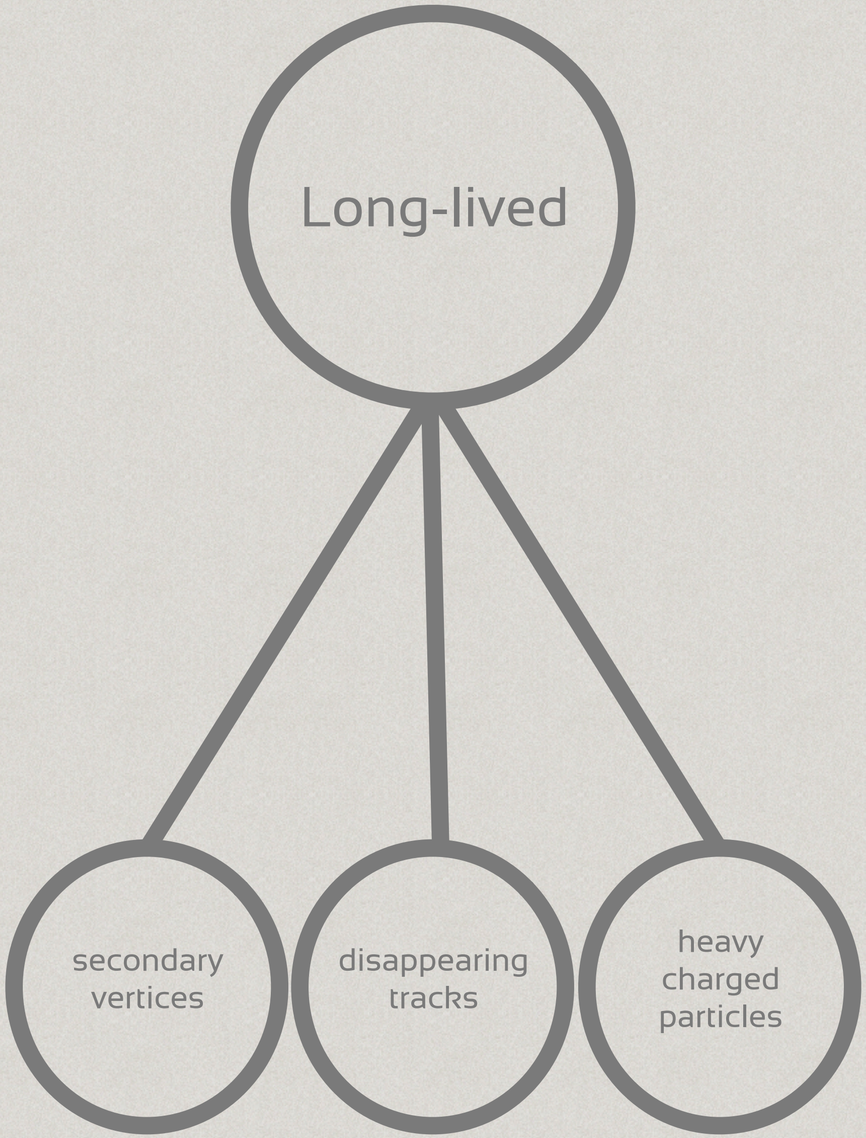

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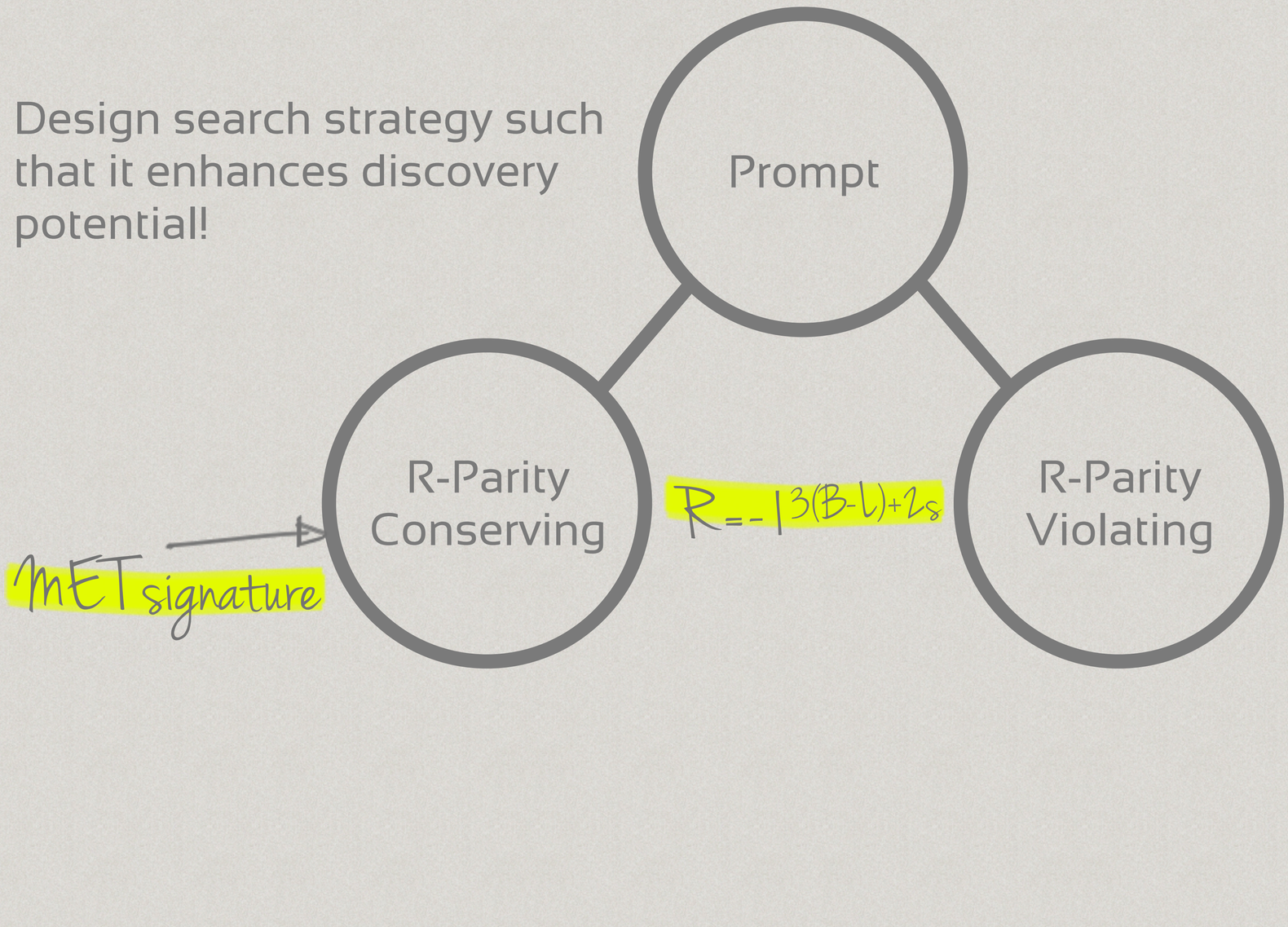

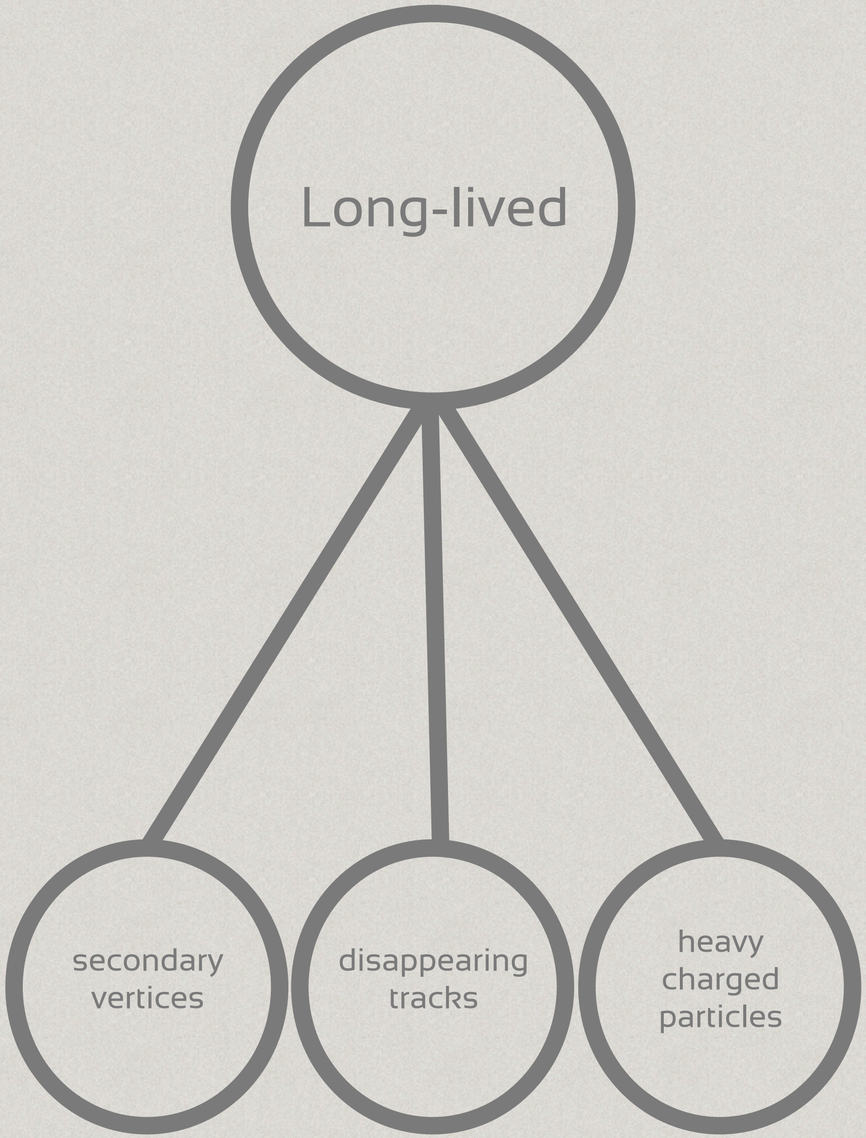

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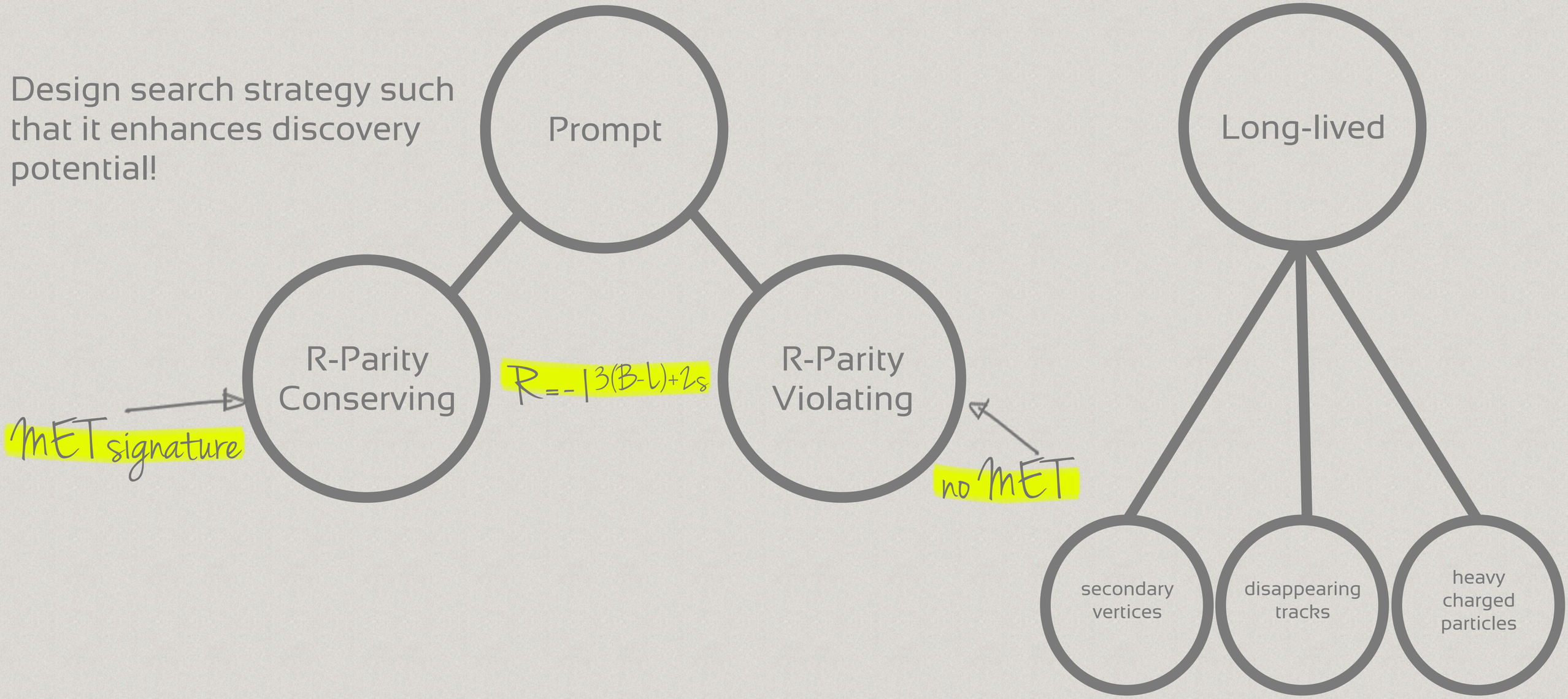

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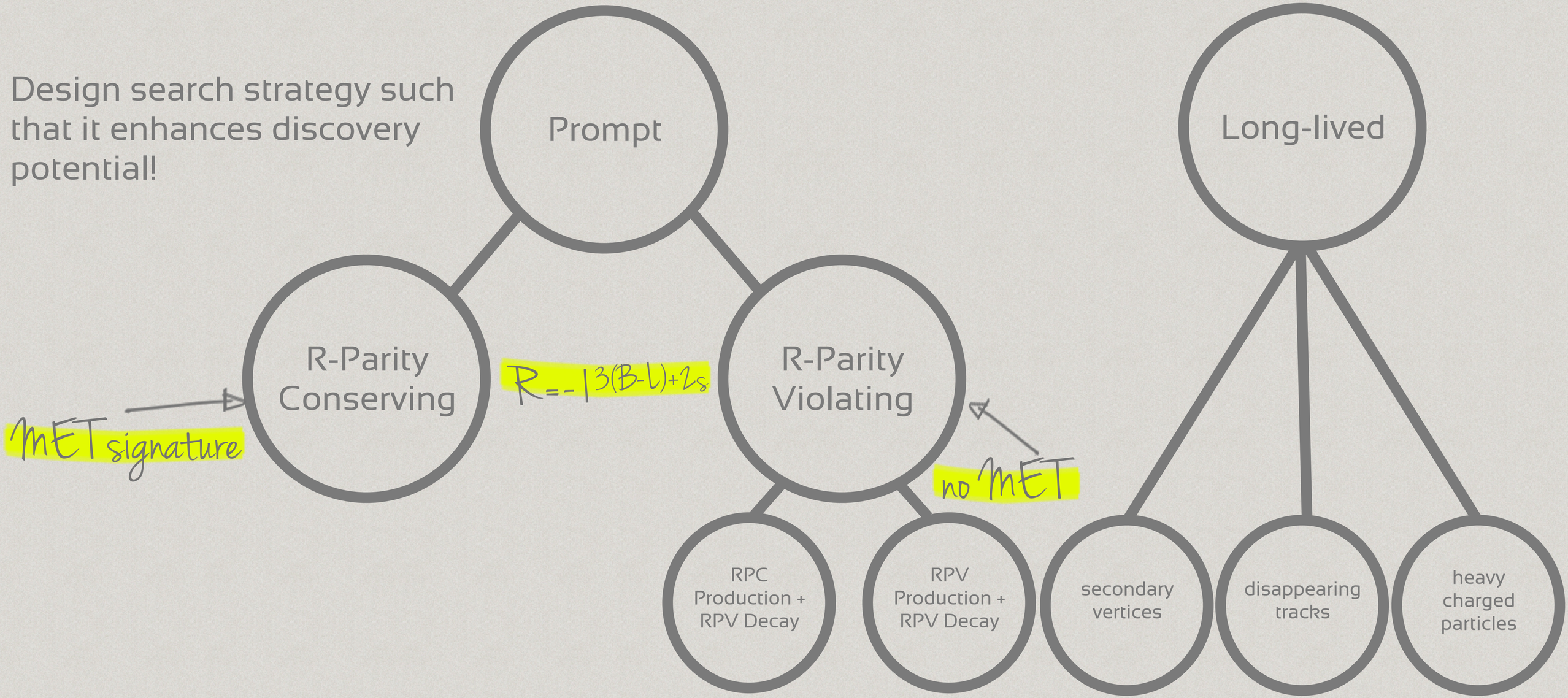

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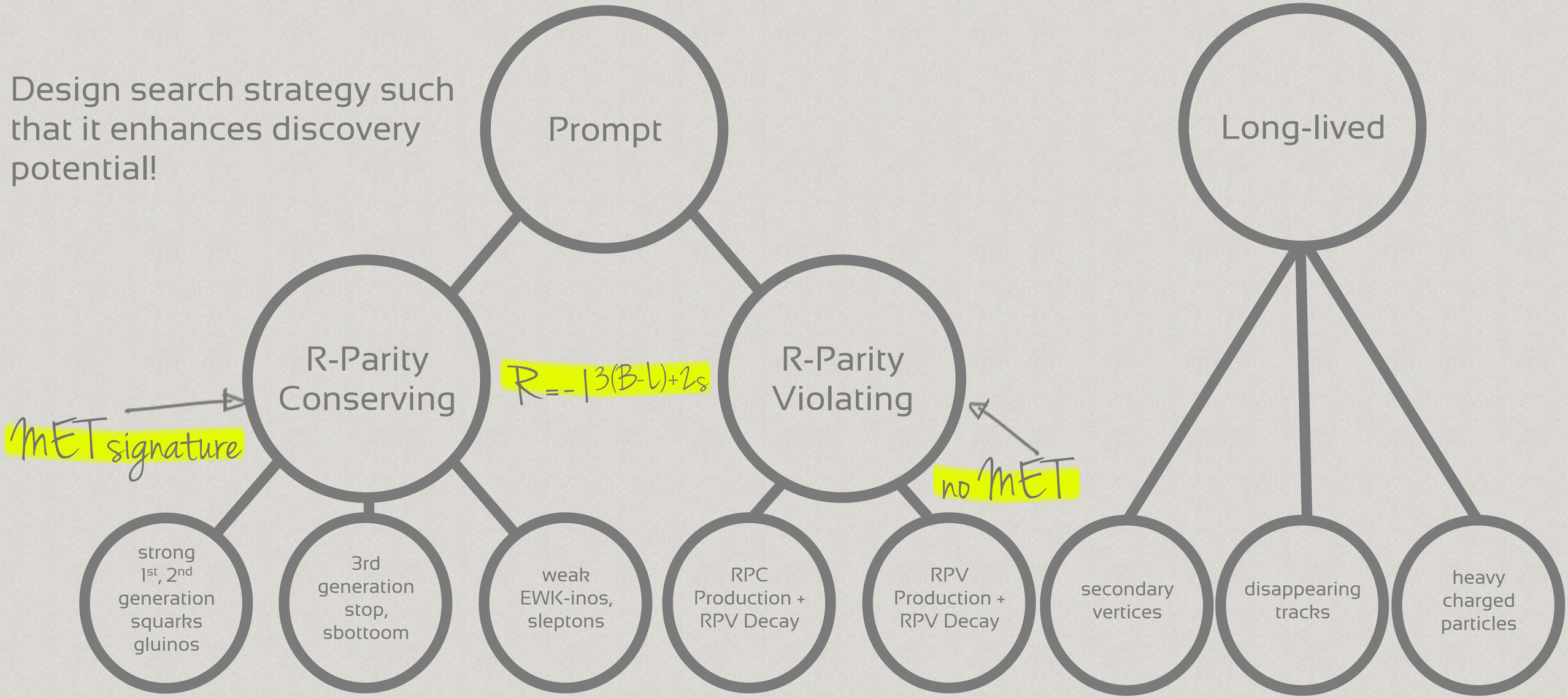

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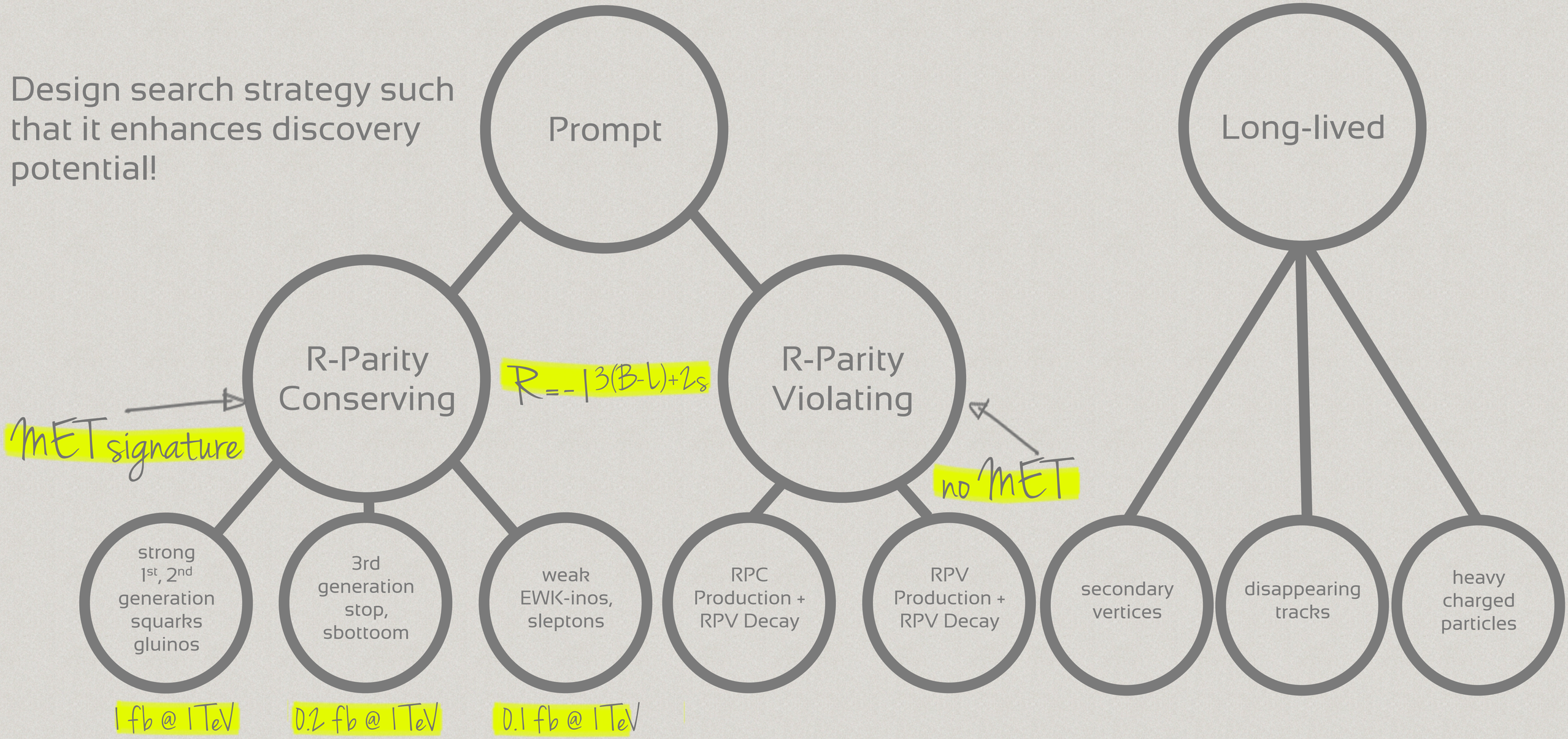

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  - universal scalar masses
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- simplified MSSM
  - effective models with minimal particle content
  - parametrized directly in terms of sparticle masses
  - complementary to pMSSM

GENERAL FEATURES OF ATLAS SUSY ANALYSES

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- Electrons and muons are well-reconstructed and isolated wrt surrounding tracks ($\Delta R \leq 0.2$).
- Electrons within $0.2 \leq \Delta R \leq 0.4$ of jets and muons within $\Delta R \leq 0.4$ are considered jets.
- MET: negative vector sum of all objects (jets, electrons, muons, soft energy deposits)
- jet reconstruction
  - topological clusters
  - jet definition via anti-k_T, corrected for pileup

seed: >4sigma above noise level

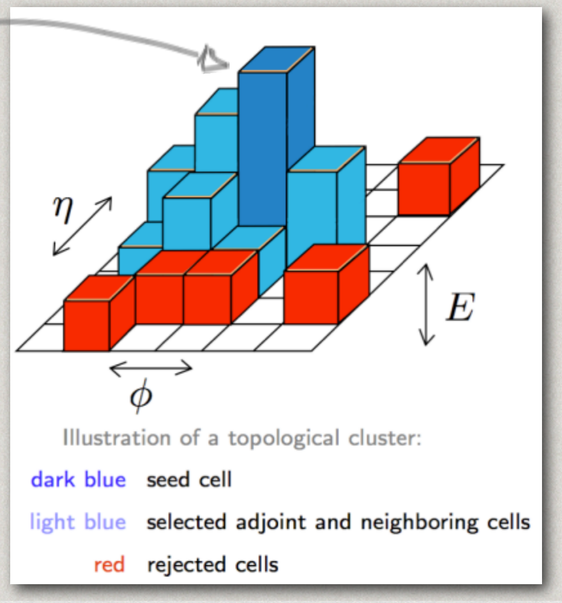
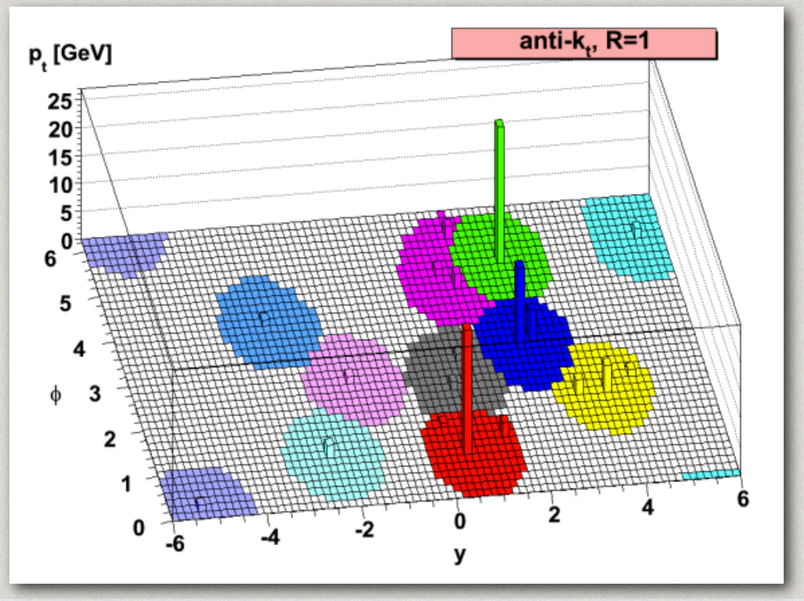


Illustration of a topological cluster:

dark blue seed cell

light blue selected adjoint and neighboring cells

red rejected cells



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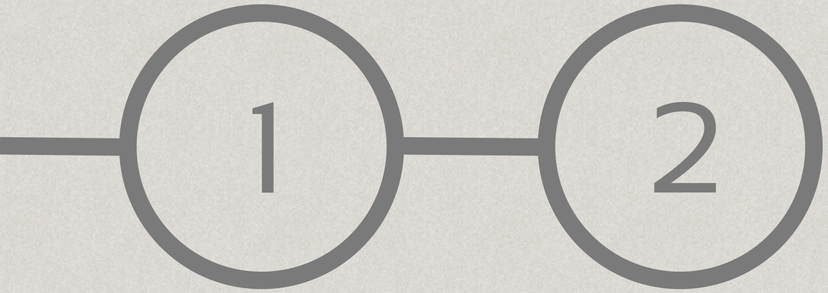

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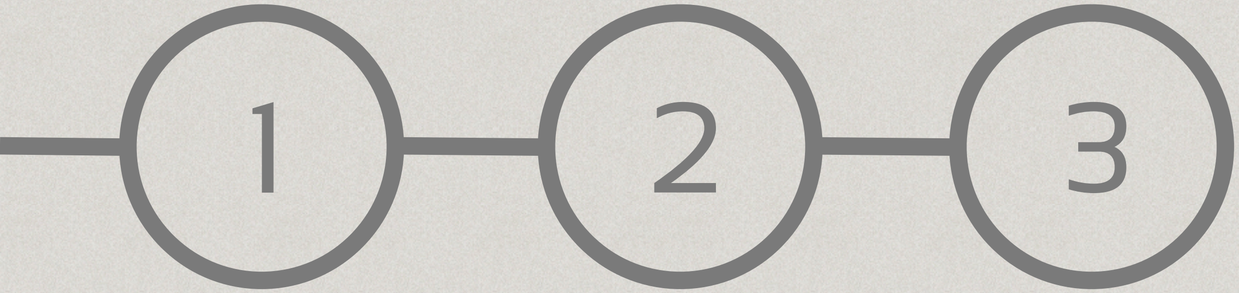

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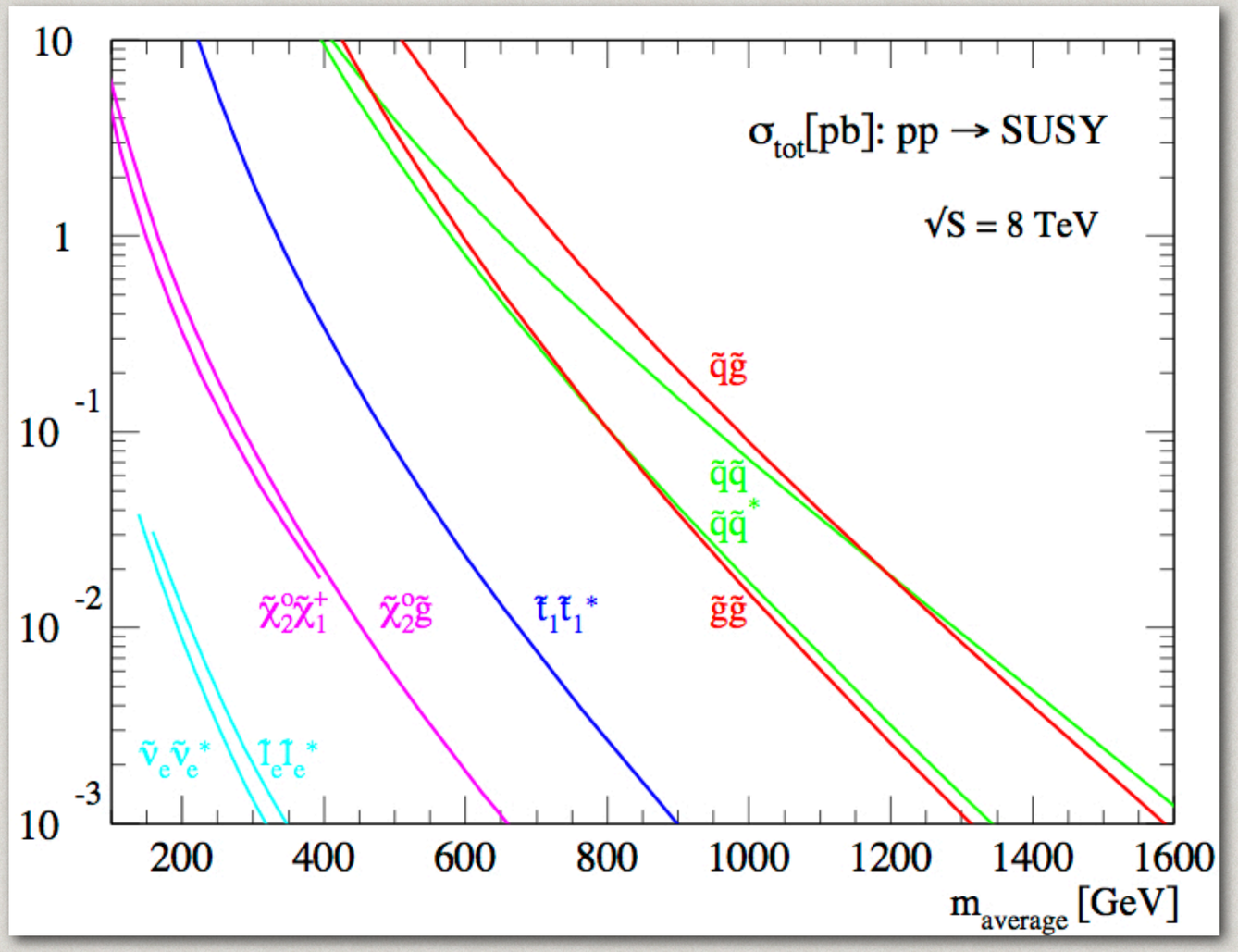

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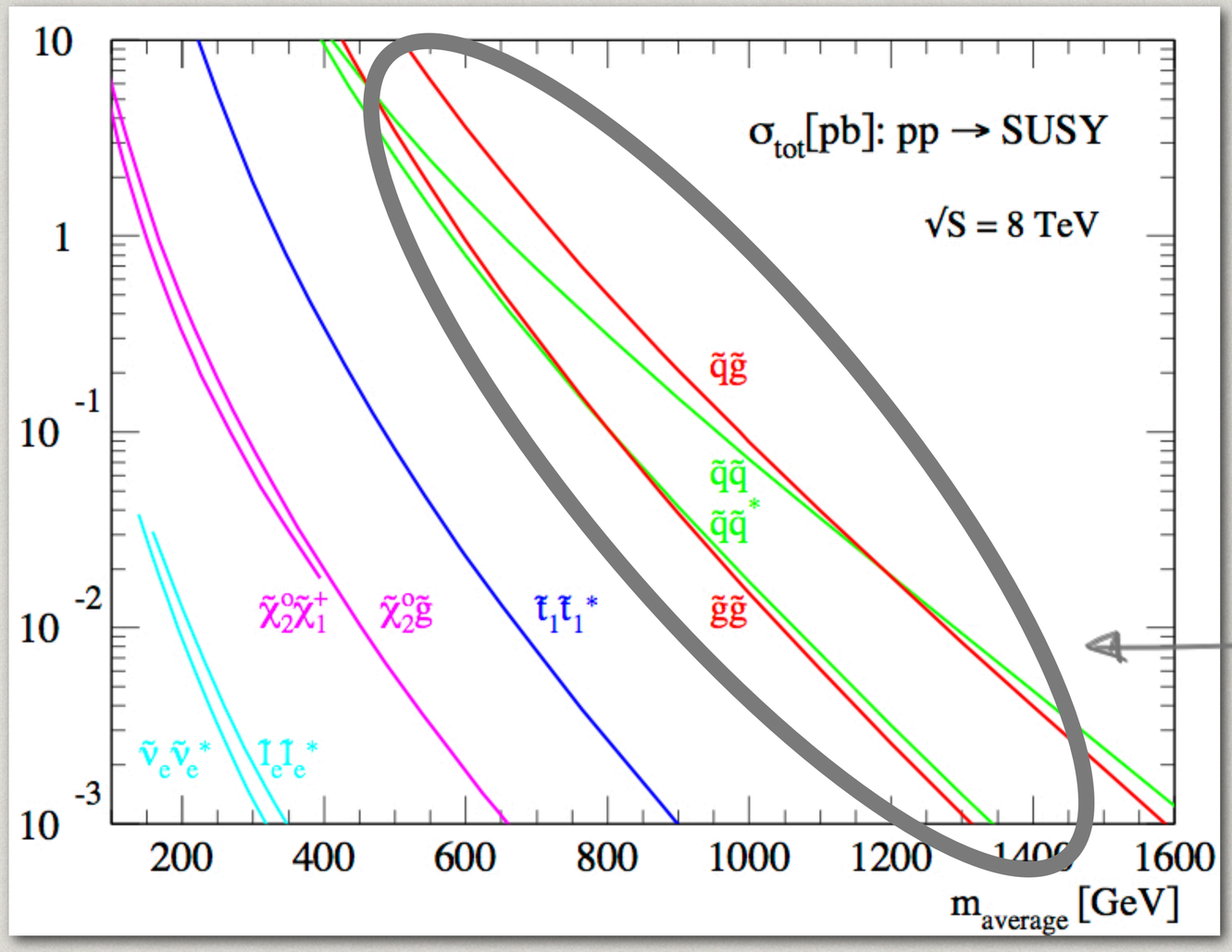

squark/gluiono production

SEARCH FOR GLUINOS AND SCALAR-QUARKS

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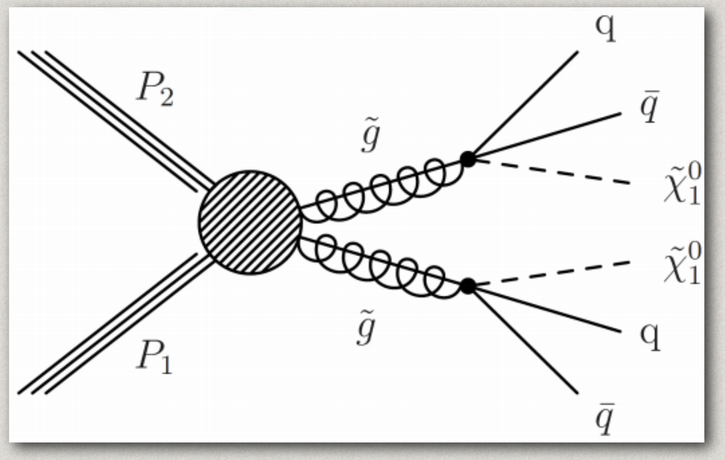

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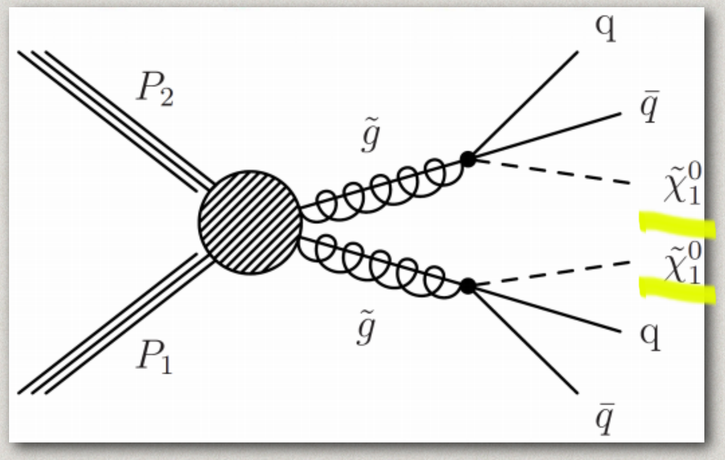

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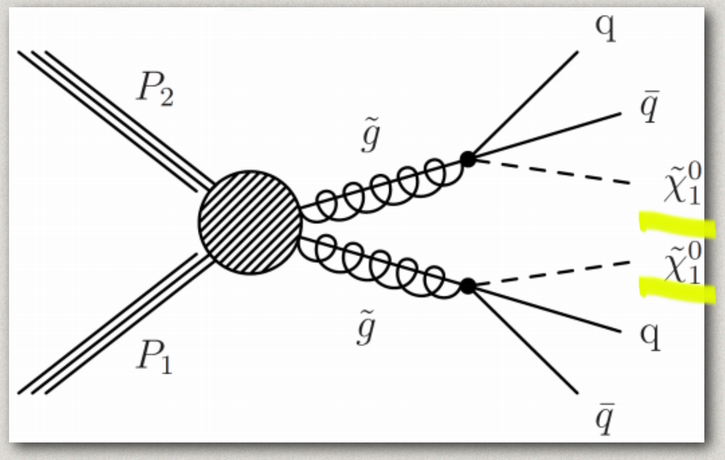
- consider full hadronic final states only ← veto events with reconstructed electron/muons



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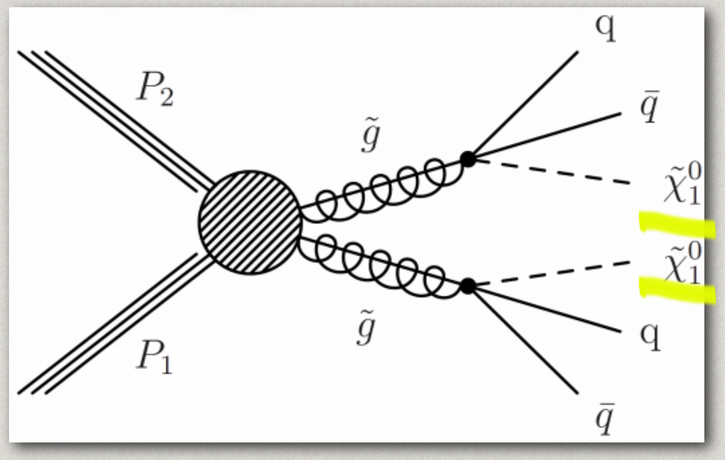

← definition of signal regions

Requirement	Channel				
	A 2-jets	B 3-jets	C 4-jets	D 5-jets	E 6-jets
$E_{\mathrm{T}}^{\mathrm{miss}}$[GeV] >	160				
$p_{\mathrm{T}}(j_1)$ [GeV] >	130				
$p_{\mathrm{T}}(j_2)$ [GeV] >	60				
$p_{\mathrm{T}}(j_3)$ [GeV] >	–	60	60	60	60
$p_{\mathrm{T}}(j_4)$ [GeV] >	–	–	60	60	60
$p_{\mathrm{T}}(j_5)$ [GeV] >	–	–	–	60	60
$p_{\mathrm{T}}(j_6)$ [GeV] >	–	–	–	–	60
$\Delta\phi(\mathrm{jet}, \mathbf{E}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$ [rad] >	0.4 ($i = \{1, 2, (3)\}$)		0.4 ($i = \{1, 2, 3\}$), 0.2 ($p_{\mathrm{T}} > 40$ GeV jets)		
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(N\,j)$ >	0.3/0.4/0.4 (2j)	0.25/0.3/– (3j)	0.25/0.3/0.3 (4j)	0.15 (5j)	0.15/0.25/0.3 (6j)
m_{eff}(incl.) [GeV] >	1900/1300/1000	1900/1300/–	1900/1300/1000	1700/–/–	1400/1300/1000

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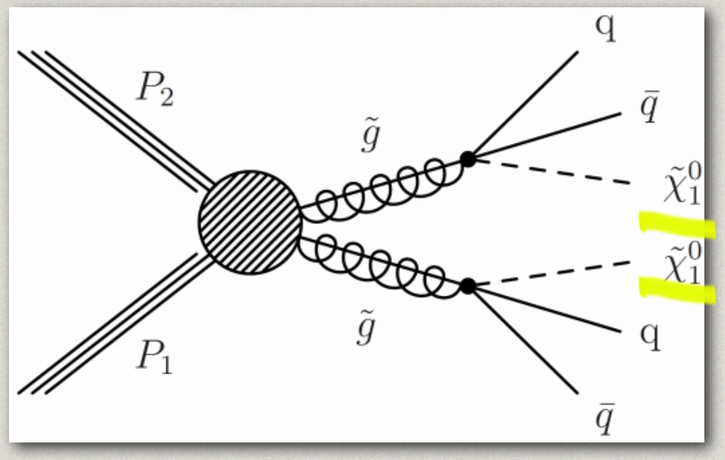
veto events with reconstructed electron/muons



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$p_{\mathrm{T}}(j_4)$ [GeV] >	–	–	60	60	60
$p_{\mathrm{T}}(j_5)$ [GeV] >	–	–	–	60	60
$p_{\mathrm{T}}(j_6)$ [GeV] >	–	–	–	–	60
$\Delta\phi(\mathrm{jet}, \mathbf{E}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$ [rad] >	0.4 ($i = \{1, 2, (3)\}$)		0.4 ($i = \{1, 2, 3\}$), 0.2 ($p_{\mathrm{T}} > 40$ GeV jets)		
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(N\,j)$ >	0.3/0.4/0.4 (2j)	0.25/0.3/– (3j)	0.25/0.3/0.3 (4j)	0.15 (5j)	0.15/0.25/0.3 (6j)
m_{eff}(incl.) [GeV] >	1900/1300/1000	1900/1300/–	1900/1300/1000	1700/–/–	1400/1300/1000

effective mass

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- assume R-parity conservation ← MET
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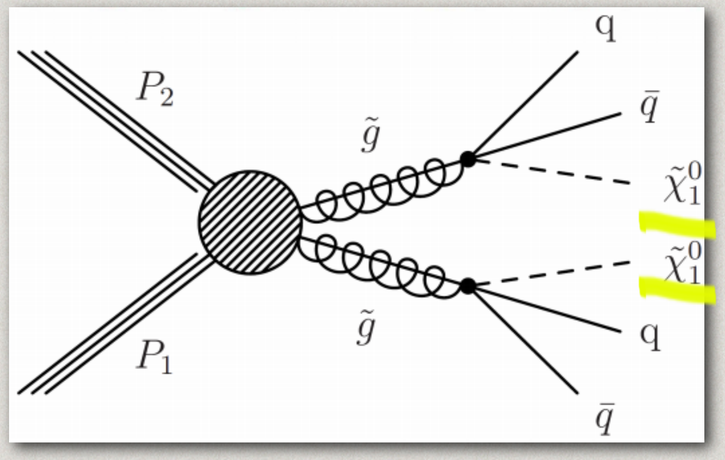


definition of signal regions

Requirement	Channel				
	A 2-jets	B 3-jets	C 4-jets	D 5-jets	E 6-jets
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV] >	160				
$p_{\mathrm{T}}(j_1)$ [GeV] >	130				
$p_{\mathrm{T}}(j_2)$ [GeV] >	60				
$p_{\mathrm{T}}(j_3)$ [GeV] >	–	60	60	60	60
$p_{\mathrm{T}}(j_4)$ [GeV] >	–	–	60	60	60
$p_{\mathrm{T}}(j_5)$ [GeV] >	–	–	–	60	60
$p_{\mathrm{T}}(j_6)$ [GeV] >	–	–	–	–	60
$\Delta\phi(\mathrm{jet}, \mathbf{E}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$ [rad] >	0.4 ($i = \{1, 2, (3)\}$)		0.4 ($i = \{1, 2, 3\}$), 0.2 ($p_{\mathrm{T}} > 40$ GeV jets)		
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(Nj)$ >	0.3/0.4/0.4 (2j)	0.25/0.3/– (3j)	0.25/0.3/0.3 (4j)	0.15 (5j)	0.15/0.25/0.3 (6j)
m_{eff}(incl.) [GeV] >	1900/1300/1000	1900/1300/–	1900/1300/1000	1700/–/–	1400/1300/1000

effective mass

definition of background control regions

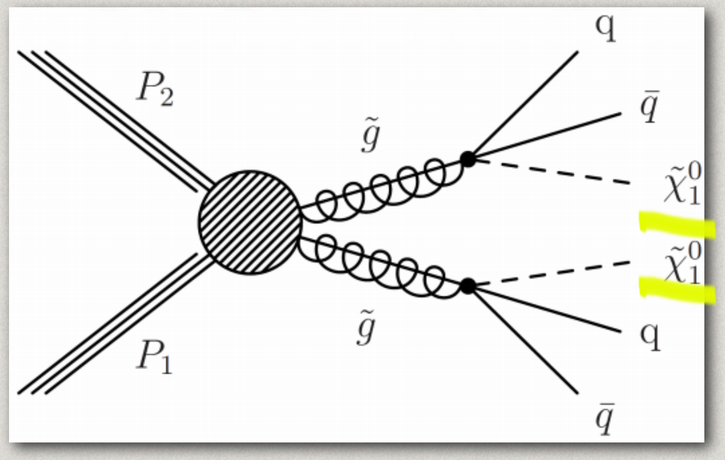
CR	SR background	CR process	CR selection
CRY	$Z(\rightarrow \nu\nu)$+jets	γ+jets	Isolated photon
CRQ	QCD jets	QCD jets	Reversed $\Delta\phi(\mathrm{jet}, \mathbf{E}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$ and $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(Nj)$ cuts
CRW	$W(\rightarrow \ell\nu)$+jets	$W(\rightarrow \ell\nu)$+jets	30 GeV < $m_T(\ell, E_{\mathrm{T}}^{\mathrm{miss}})$ < 100 GeV, b-veto
CRT	$t\bar{t}$ and single-t	$t\bar{t} \rightarrow bbqq'\ell\nu$	30 GeV < $m_T(\ell, E_{\mathrm{T}}^{\mathrm{miss}})$ < 100 GeV, b-tag

SEARCH FOR GLUINOS AND SCALAR-QUARKS

- scenario:
  - direct production of gluinos/scalar-quarks
- assume R-parity conservation
- consider full hadronic final states only

MET

veto events with reconstructed electron/muons



definition of signal regions

use likelihood fit to estimate bkg in SR

definition of background control regions

effective mass

Requirement	Channel				
	A 2-jets	B 3-jets	C 4-jets	D 5-jets	E 6-jets
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV] >	160				
$p_{\mathrm{T}}(j_1)$ [GeV] >	130				
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$p_{\mathrm{T}}(j_3)$ [GeV] >	–	60	60	60	60
$p_{\mathrm{T}}(j_4)$ [GeV] >	–	–	60	60	60
$p_{\mathrm{T}}(j_5)$ [GeV] >	–	–	–	60	60
$p_{\mathrm{T}}(j_6)$ [GeV] >	–	–	–	–	60
$\Delta\phi(\mathrm{jet}, \mathbf{E}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$ [rad] >	0.4 ($i = \{1, 2, (3)\}$)		0.4 ($i = \{1, 2, 3\}$), 0.2 ($p_{\mathrm{T}} > 40$ GeV jets)		
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(Nj)$ >	0.3/0.4/0.4 (2j)	0.25/0.3/– (3j)	0.25/0.3/0.3 (4j)	0.15 (5j)	0.15/0.25/0.3 (6j)
m_{eff}(incl.) [GeV] >	1900/1300/1000	1900/1300/–	1900/1300/1000	1700/–/–	1400/1300/1000

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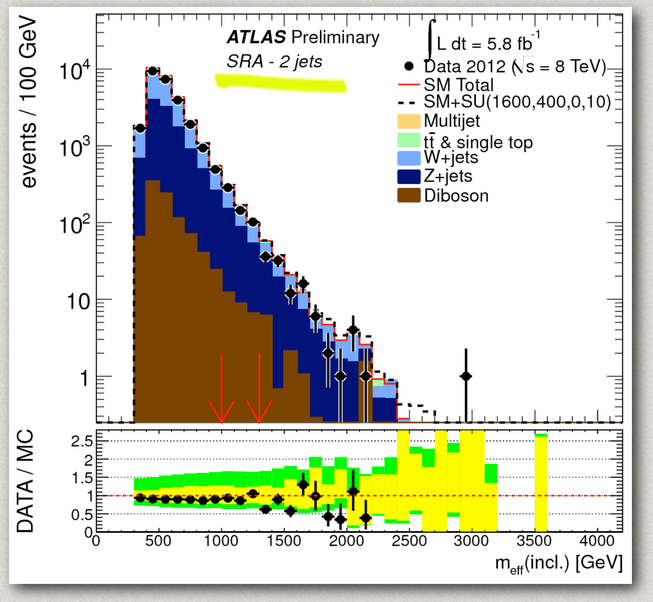
SEARCH FOR GLUINOS AND SQUARKS: DATA vs MC

SEARCH FOR GLUINOS AND SQUARKS: DATA vs MC

loose/medium selection

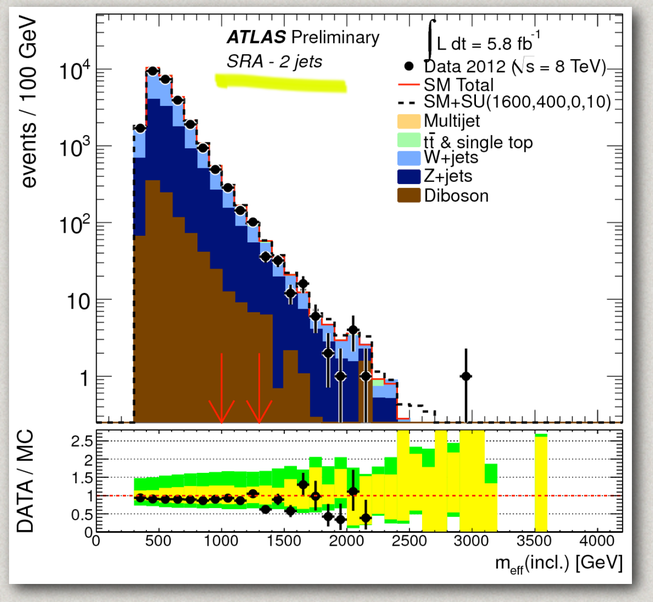
SEARCH FOR GLUINOS AND SQUARKS: DATA vs MC

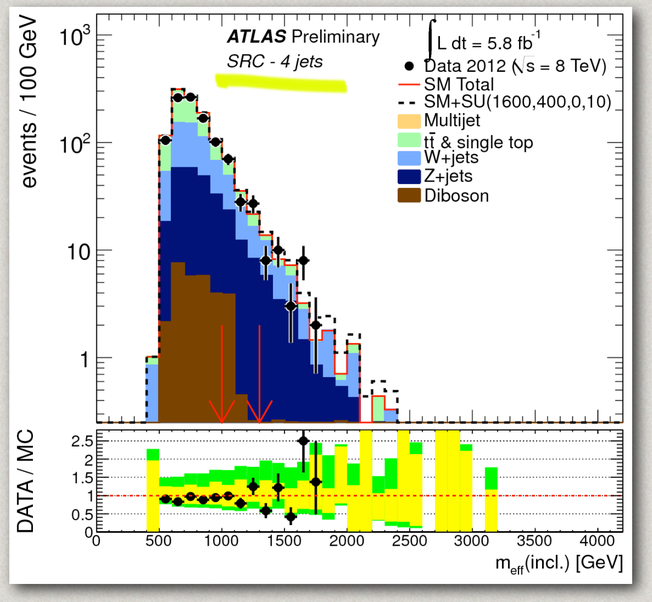
loose/medium selection



SEARCH FOR GLUINOS AND SQUARKS: DATA vs MC

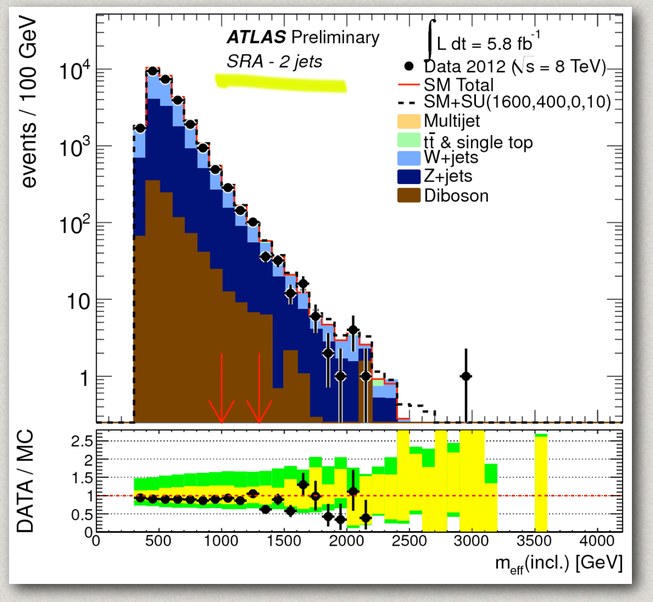
loose/medium selection

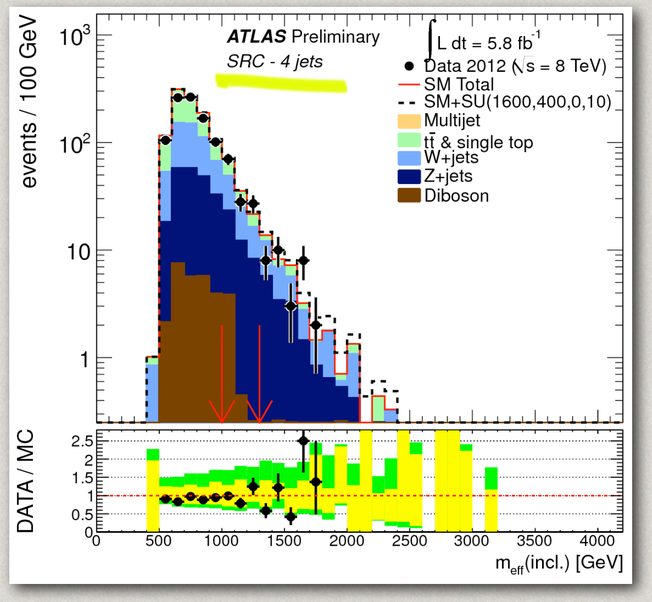


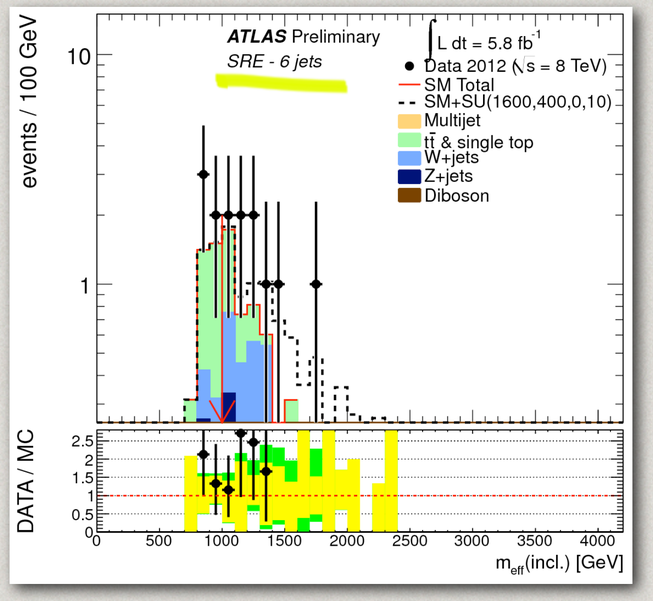


SEARCH FOR GLUINOS AND SQUARKS: DATA vs MC

loose/medium selection



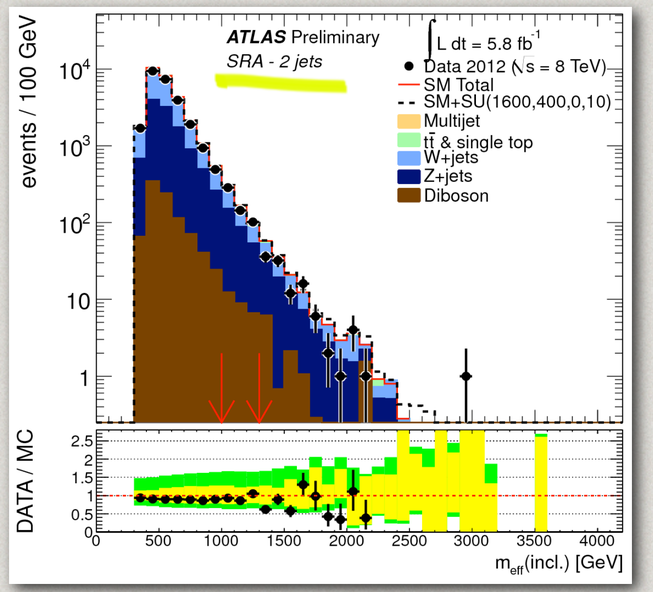


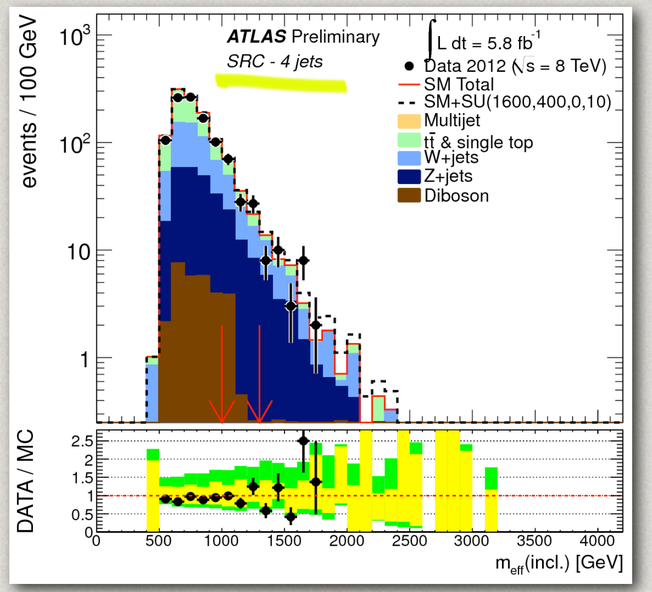


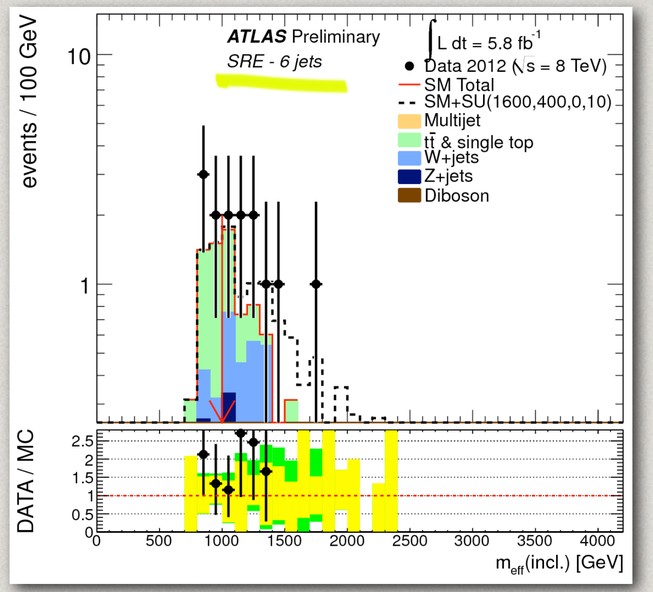
SEARCH FOR GLUINOS AND SQUARKS: DATA vs MC

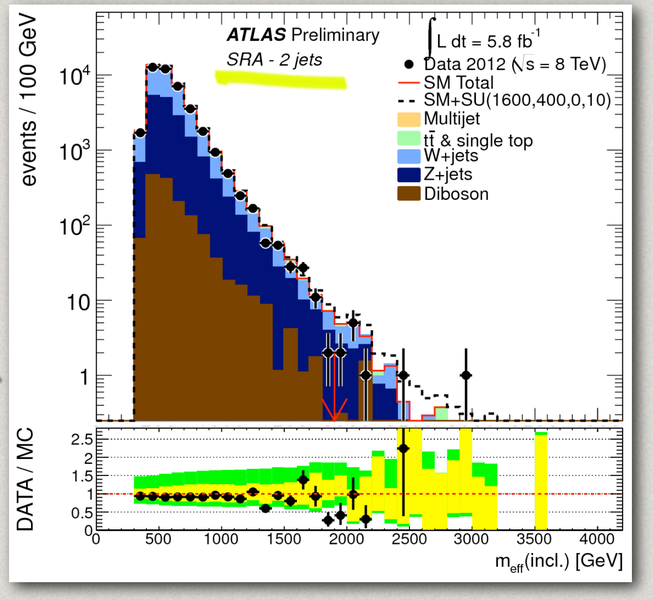
loose/medium selection

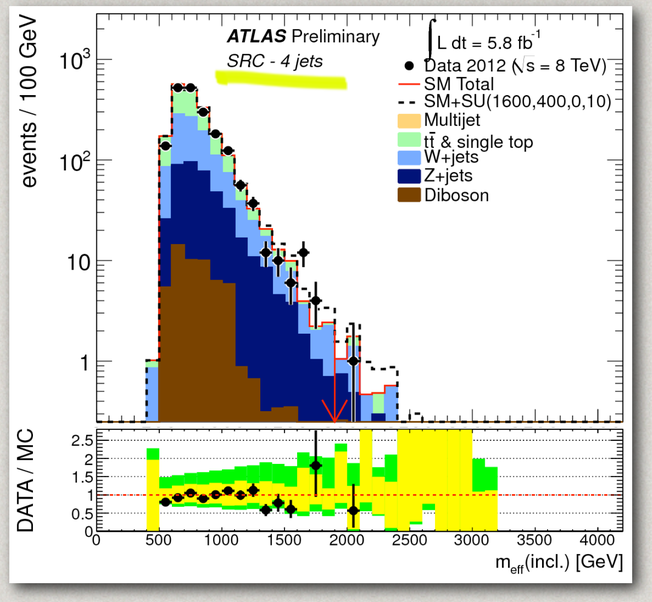
tight selection

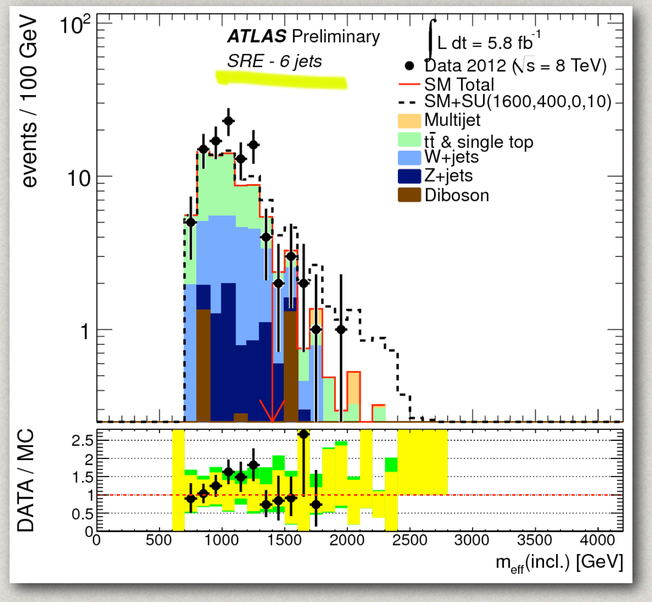






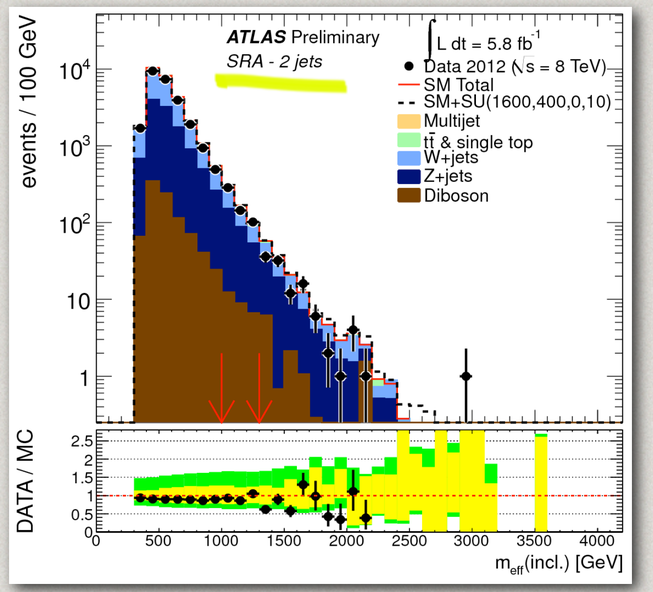


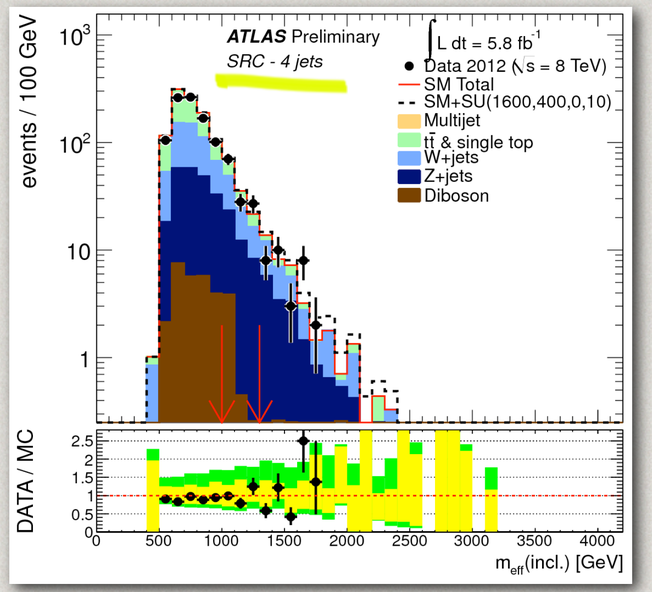


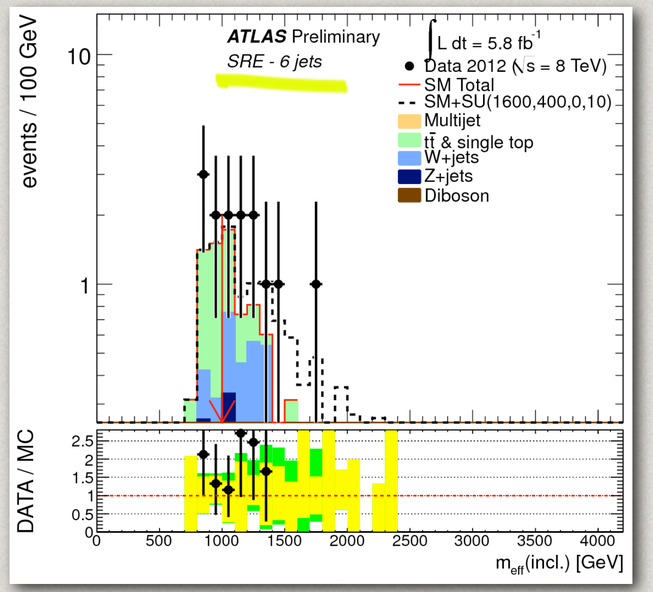


SEARCH FOR GLUINOS AND SQUARKS: DATA vs MC

loose/medium selection



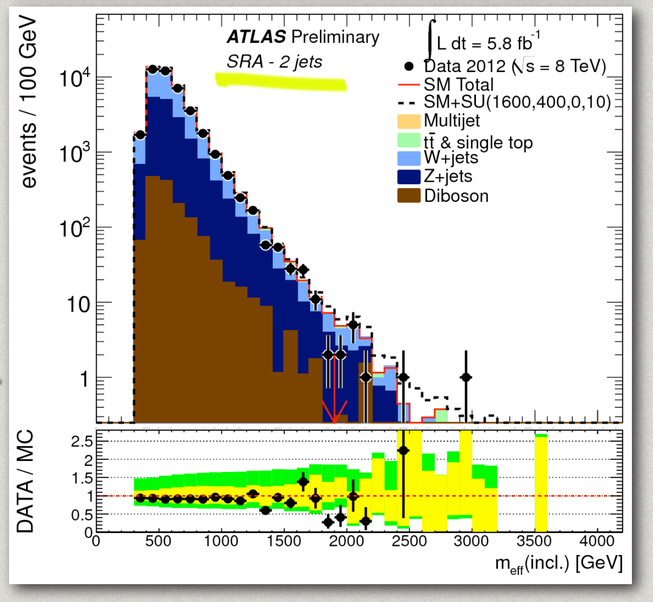


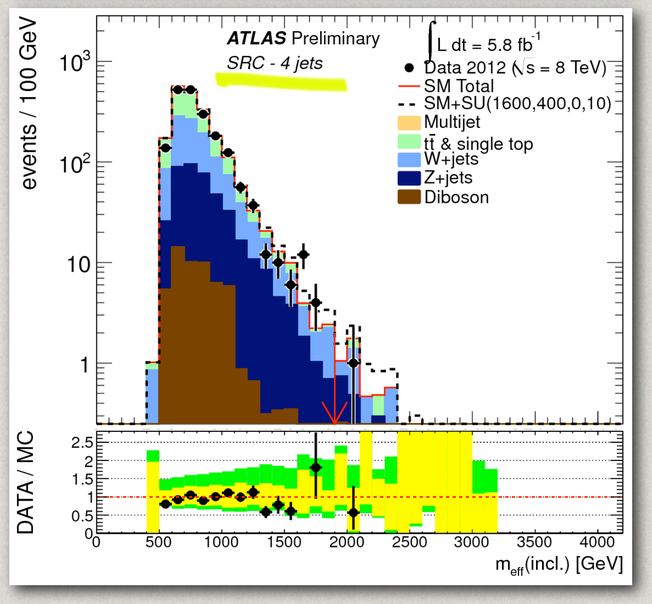


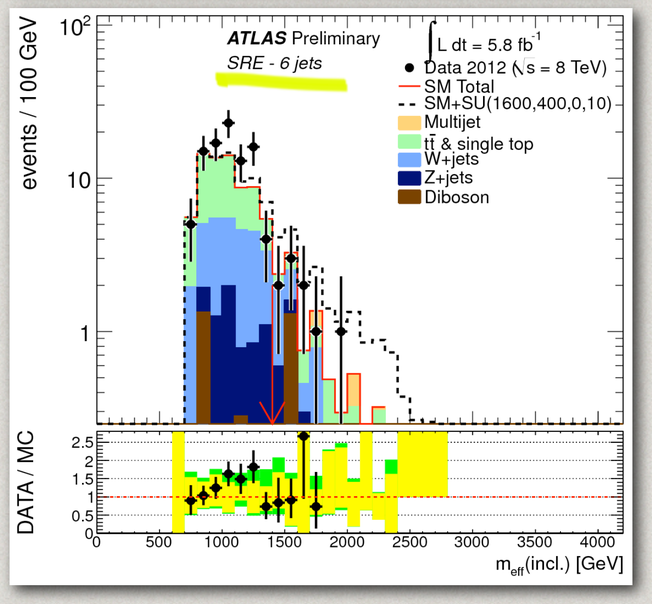
no excess observed

set limits

tight selection







SEARCH FOR GLUINOS AND SQUARKS: LIMITS

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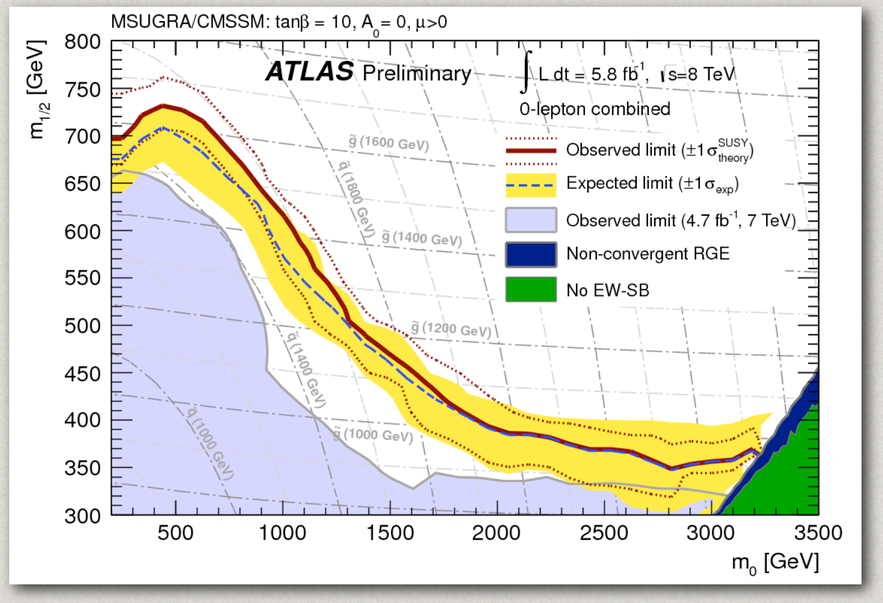
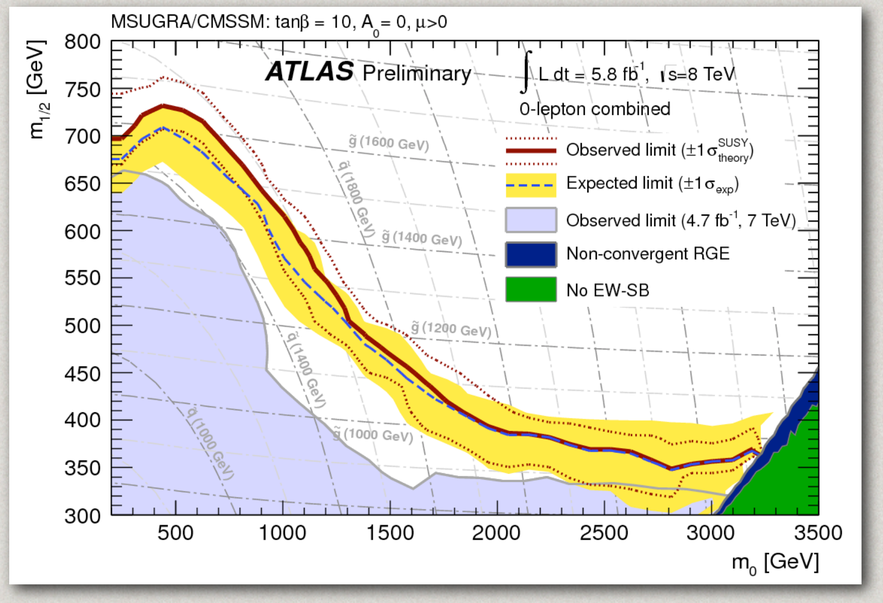
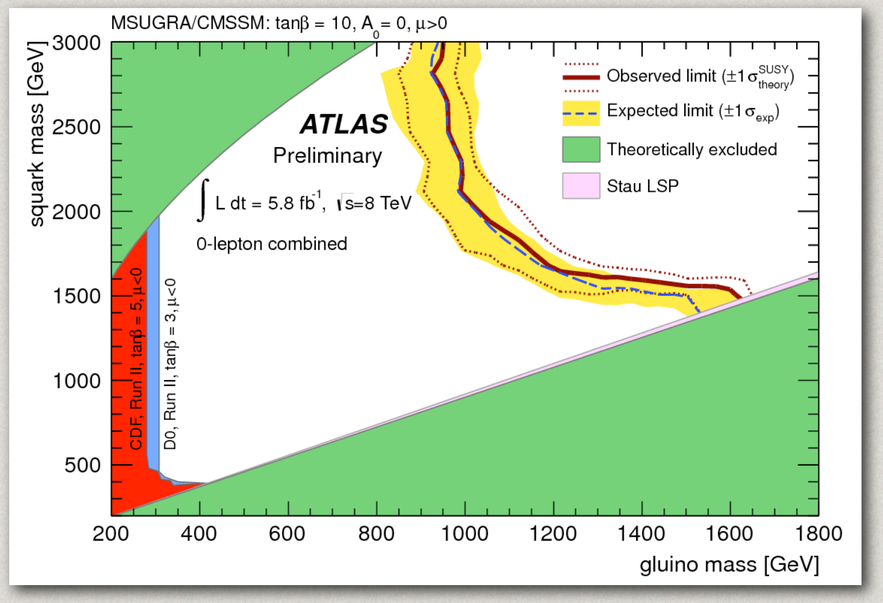


mSUGRA/CMSSM

SEARCH FOR GLUINOS AND SQUARKS: LIMITS

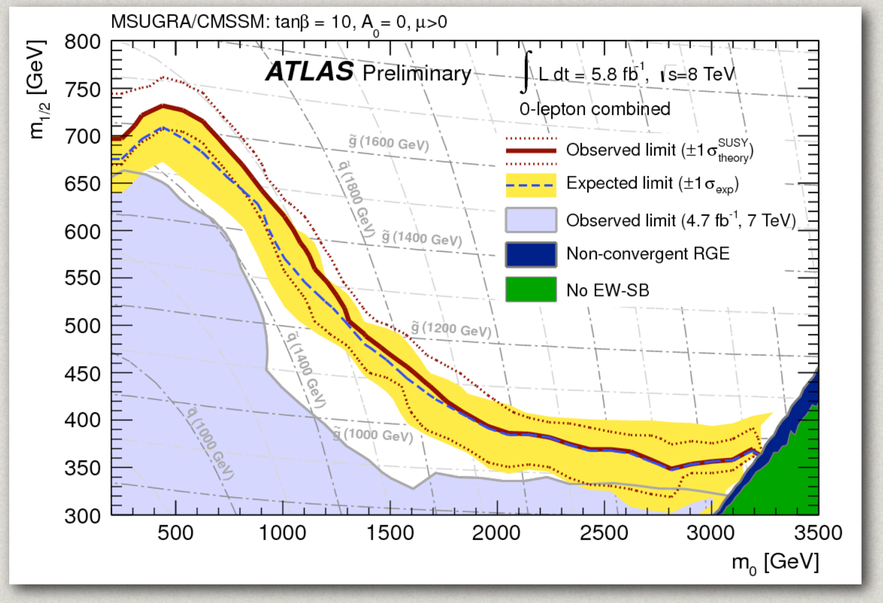
mSUGRA/cMSSM

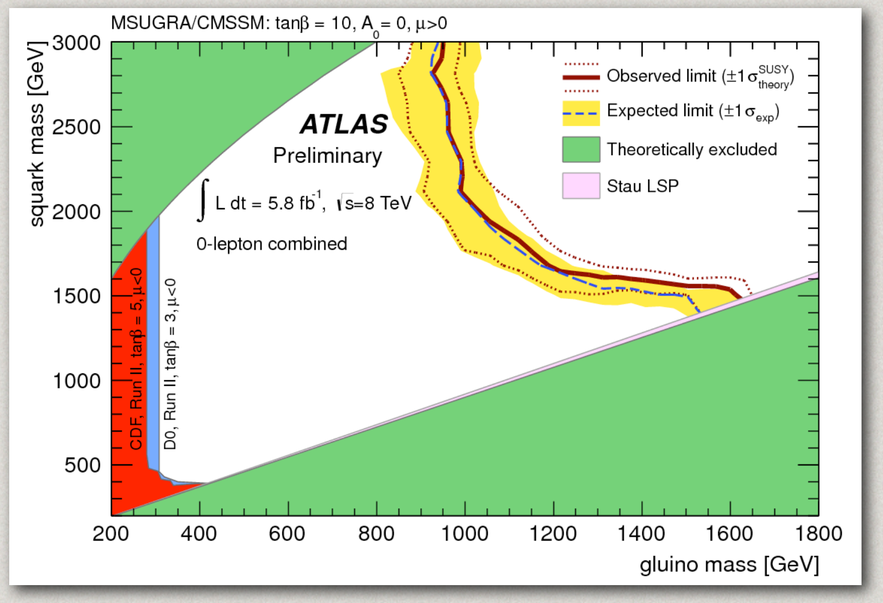




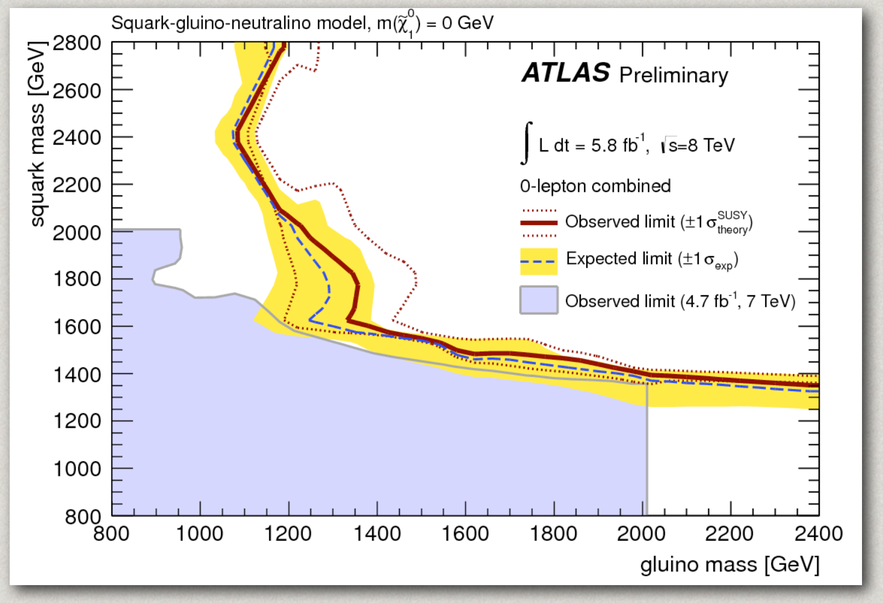
SEARCH FOR GLUINOS AND SQUARKS: LIMITS

mSUGRA/cMSSM



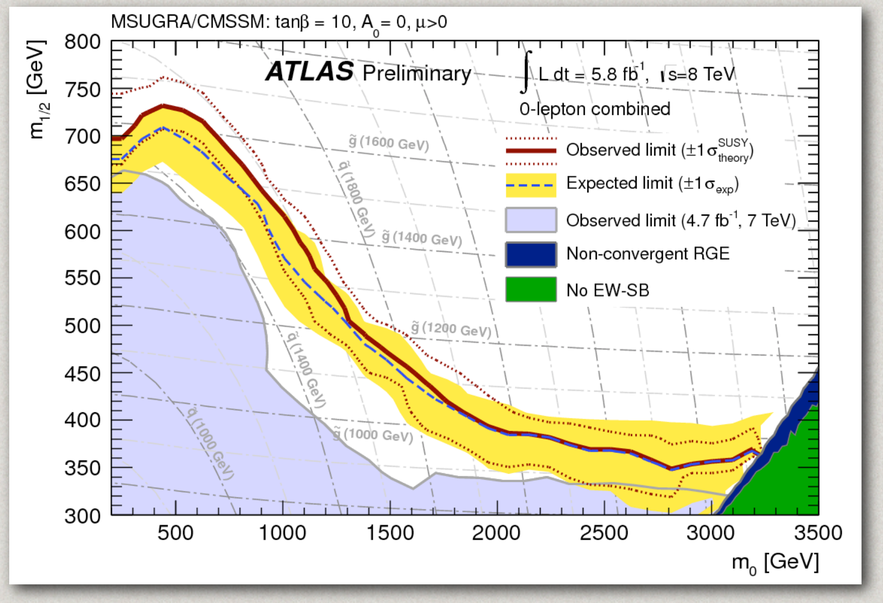


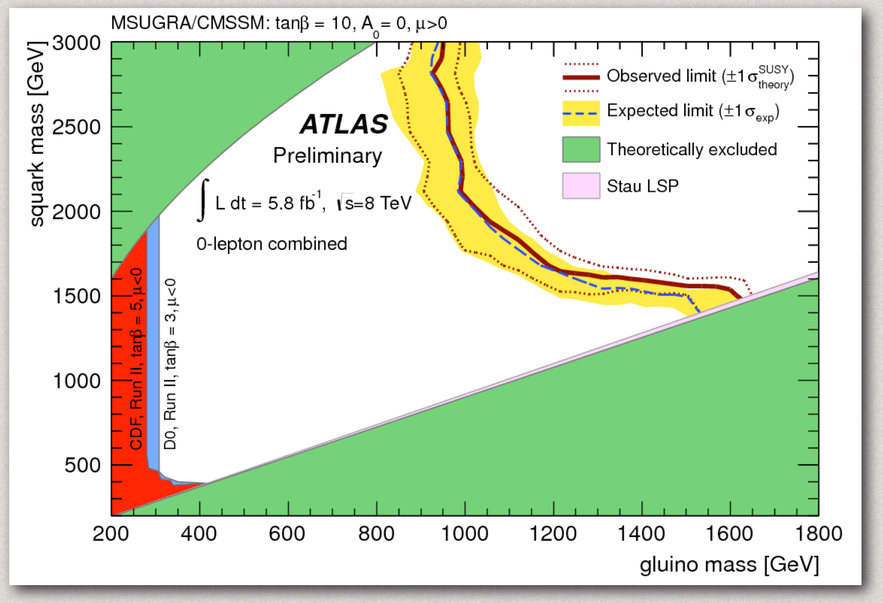
simplified model



SEARCH FOR GLUINOS AND SQUARKS: LIMITS

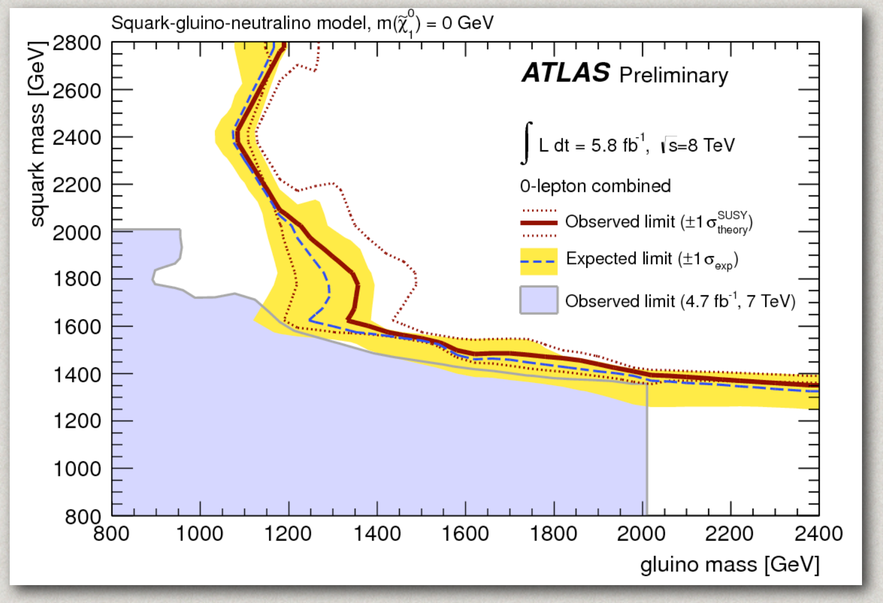
mSUGRA/CMSSM





squark masses excluded below 1500 GeV

simplified model



SEARCH FOR SAME SIGN DILEPTON PAIRS

SEARCH FOR SAME SIGN DILEPTON PAIRS

- scenario:
  - strong production of squarks and gluinos
  - final state products: quarks, leptons, neutralinos
- signature: MET + jets + 2 leptons with same charge sign
  - very low background contamination
- rich spectrum of considered models
  - model independent limits
  - mSUGRA/cMSSM
  - simplified SUSY models

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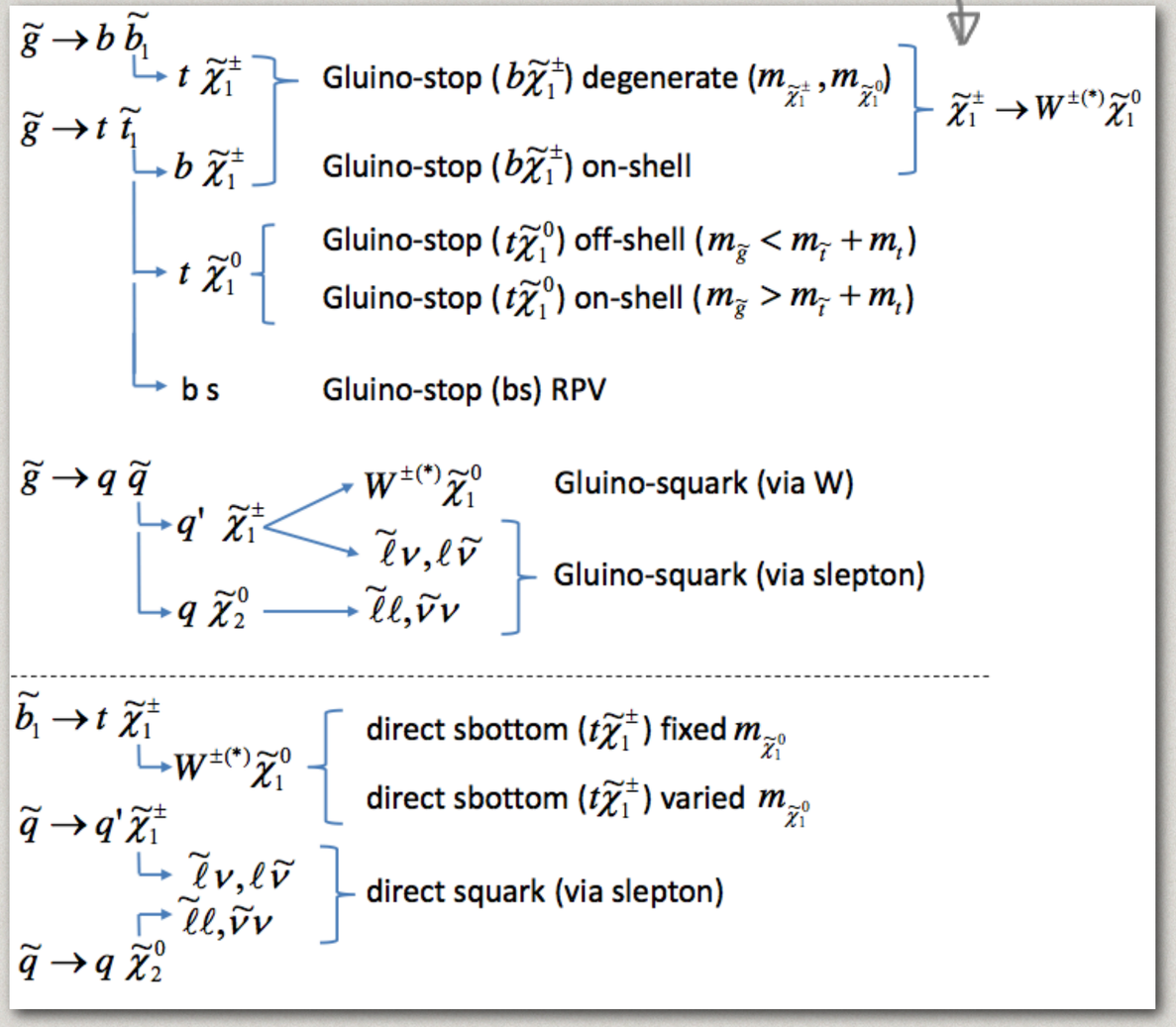
simplified models considered



SEARCH FOR SAME SIGN DILEPTON PAIRS: DATA vs BKG

SEARCH FOR SAME SIGN DILEPTON PAIRS: DATA vs BKG

definition of signal regions

Signal region	N_{b-jets}	Signal cuts (discovery case)	Signal cuts (exclusion case)
SR0b	0	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV,
		$m_T > 100$ GeV, $m_{eff} > 400$ GeV	binned shape fit in m_{eff}
SR1b	≥ 1	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV,
		$m_T > 100$ GeV, $m_{eff} > 700$ GeV	binned shape fit in m_{eff}
SR3b	≥ 3	$N_{jets} \geq 4$	$N_{jets} \geq 5$,
		-	($E_T^{miss} < 150$ GeV or $m_T < 100$ GeV)

SEARCH FOR SAME SIGN DILEPTON PAIRS: DATA vs BKG

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transverse mass (MET + leading lepton)

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SR1b	≥ 1	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV $m_T > 100$ GeV, $m_{eff} > 700$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV, binned shape fit in m_{eff}
SR3b	≥ 3	$N_{jets} \geq 4$ -	$N_{jets} \geq 5$, ($E_T^{miss} < 150$ GeV or $m_T < 100$ GeV)

transverse mass (MET + leading lepton)

effective mass (2 leading leptons)

SEARCH FOR SAME SIGN DILEPTON PAIRS: DATA vs BKG

definition of signal regions

Signal region	N_{b-jets}	Signal cuts (discovery case)	Signal cuts (exclusion case)
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SR1b	≥1	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV $m_T > 100$ GeV, $m_{eff} > 700$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV, binned shape fit in m_{eff}
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transverse mass (MET + leading lepton)

effective mass (2 leading leptons)

- same sign leptons: low backgrounds
  - prompt same sign lepton pairs
  - charge mis-measurement
  - fake leptons

SEARCH FOR SAME SIGN DILEPTON PAIRS: DATA vs BKG

definition of signal regions

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effective mass (2 leading leptons)

- same sign leptons: low backgrounds
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  - fake leptons

W/Z + ttbar, diboson + jets estimated via MC

SEARCH FOR SAME SIGN DILEPTON PAIRS: DATA vs BKG

definition of signal regions

Signal region	N_{b-jets}	Signal cuts (discovery case)	Signal cuts (exclusion case)
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SR1b	≥ 1	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV $m_T > 100$ GeV, $m_{eff} > 700$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV, binned shape fit in m_{eff}
SR3b	≥ 3	$N_{jets} \geq 4$ -	$N_{jets} \geq 5$, ($E_T^{miss} < 150$ GeV or $m_T < 100$ GeV)

transverse mass (MET + leading lepton)

effective mass (2 leading leptons)

- same sign leptons: low backgrounds
  - prompt same sign lepton pairs ← W/Z + ttbar, diboson + jets, estimated via MC
  - charge mis-measurement ← dominated by dilepton ttbar, data-driven estimation
  - fake leptons

SEARCH FOR SAME SIGN DILEPTON PAIRS: DATA vs BKG

definition of signal regions

Signal region	N_{b-jets}	Signal cuts (discovery case)	Signal cuts (exclusion case)
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effective mass (2 leading leptons)

- same sign leptons: low backgrounds
  - prompt same sign lepton pairs ← W/Z + ttbar, diboson + jets; estimated via MC
  - charge mis-measurement ← dominated by dilepton ttbar; data-driven estimation
  - fake leptons ← dominated by ttbar; data-driven estimation

SEARCH FOR SAME SIGN DILEPTON PAIRS: DATA vs BKG

definition of signal regions

Signal region	N_{b-jets}	Signal cuts (discovery case)	Signal cuts (exclusion case)
SR0b	0	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV,
		$m_T > 100$ GeV, $m_{eff} > 400$ GeV	binned shape fit in m_{eff}
SR1b	≥ 1	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV	$N_{jets} \geq 3$, $E_T^{miss} > 150$ GeV, $m_T > 100$ GeV,
		$m_T > 100$ GeV, $m_{eff} > 700$ GeV	binned shape fit in m_{eff}
SR3b	≥ 3	$N_{jets} \geq 4$	$N_{jets} \geq 5$,
		-	($E_T^{miss} < 150$ GeV or $m_T < 100$ GeV)

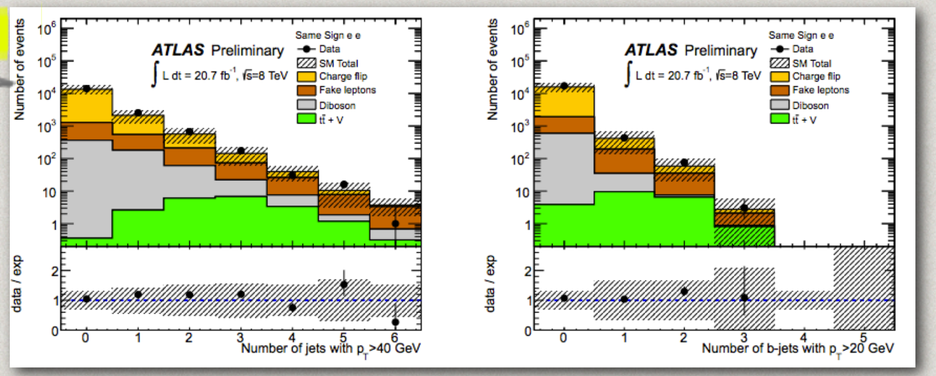
transverse mass (MET + leading lepton)

effective mass (2 leading leptons)

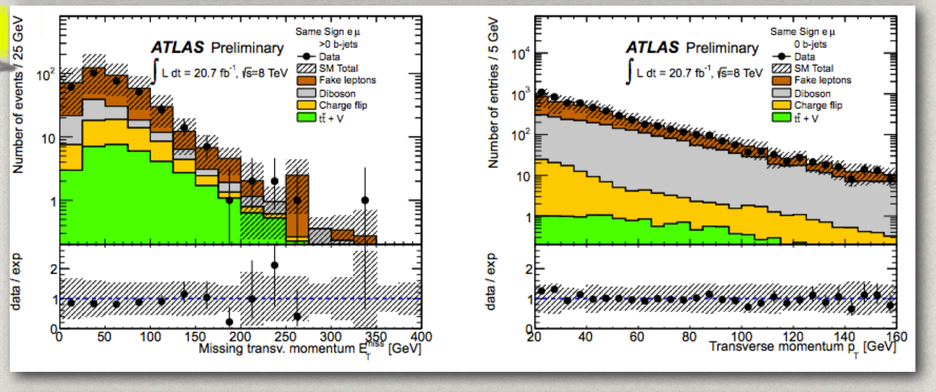
- same sign leptons: low backgrounds
  - prompt same sign lepton pairs — W/Z + ttbar, diboson + jets, estimated via MC
  - charge mis-measurement — dominated by dilepton ttbar, data-driven estimation
  - fake leptons — dominated by ttbar, data-driven estimation

control plots

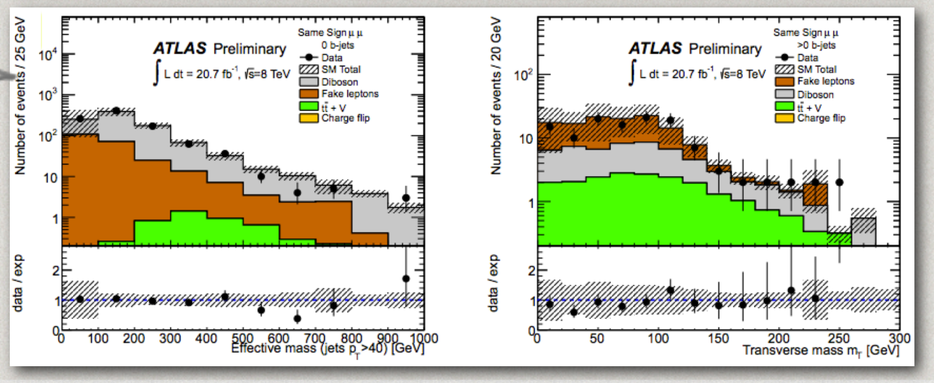
ee



emu



mumu



SEARCH FOR SAME SIGN DILEPTON PAIRS: RESULTS

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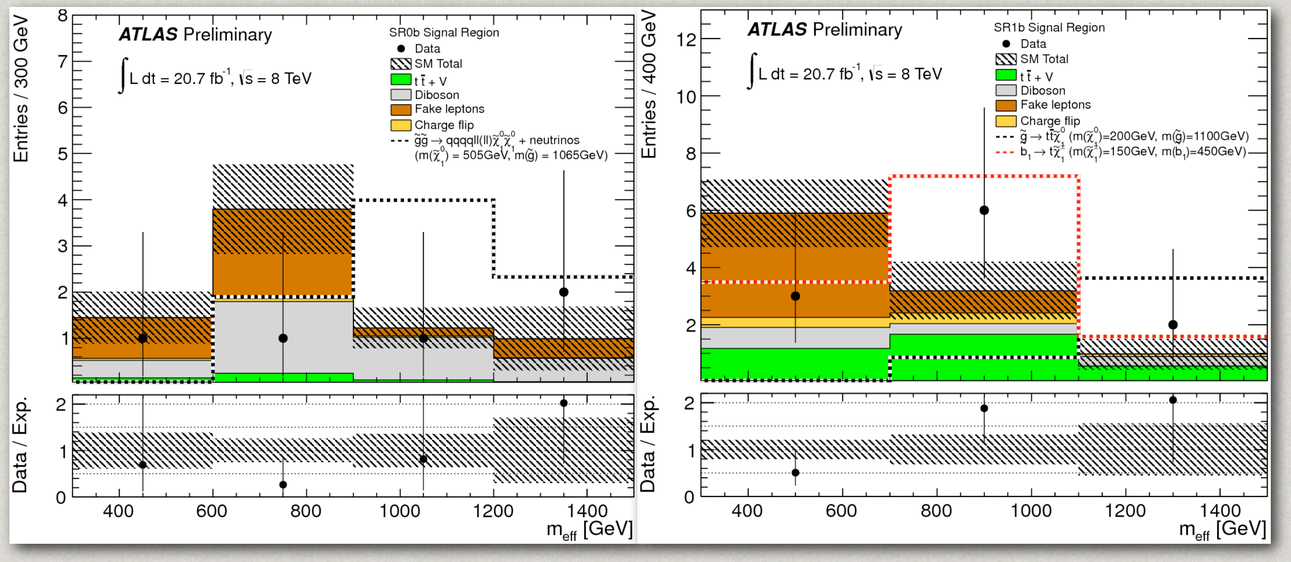

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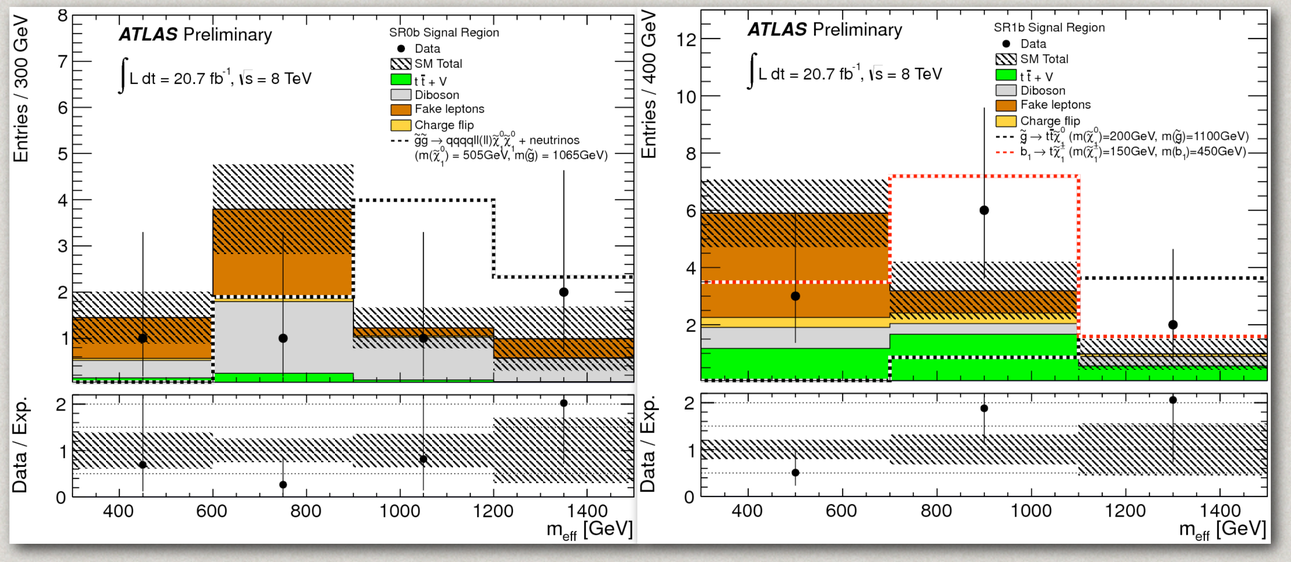

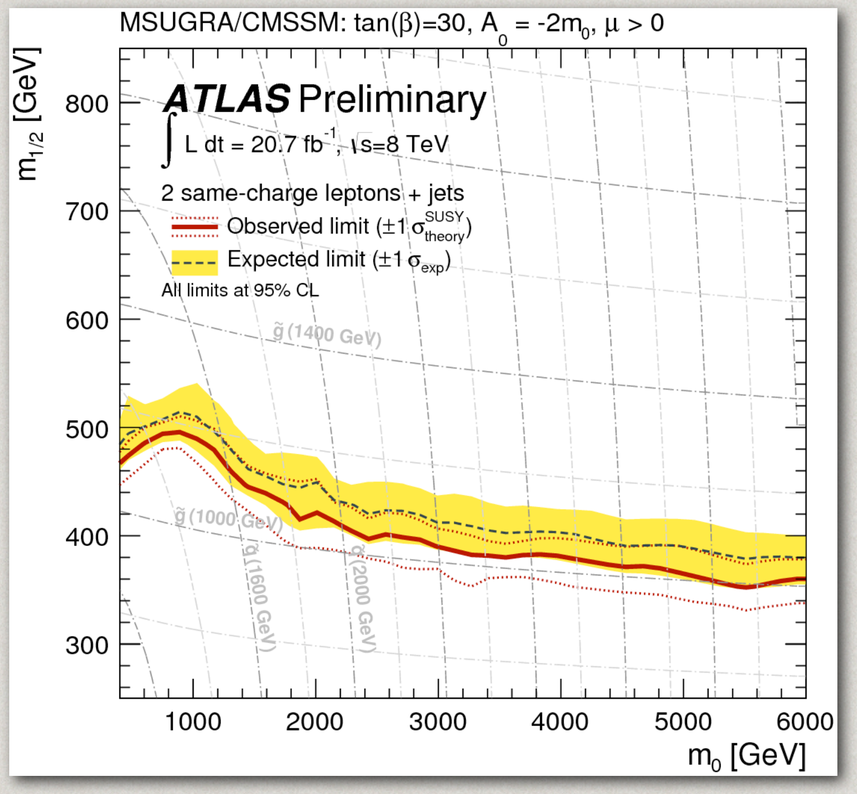

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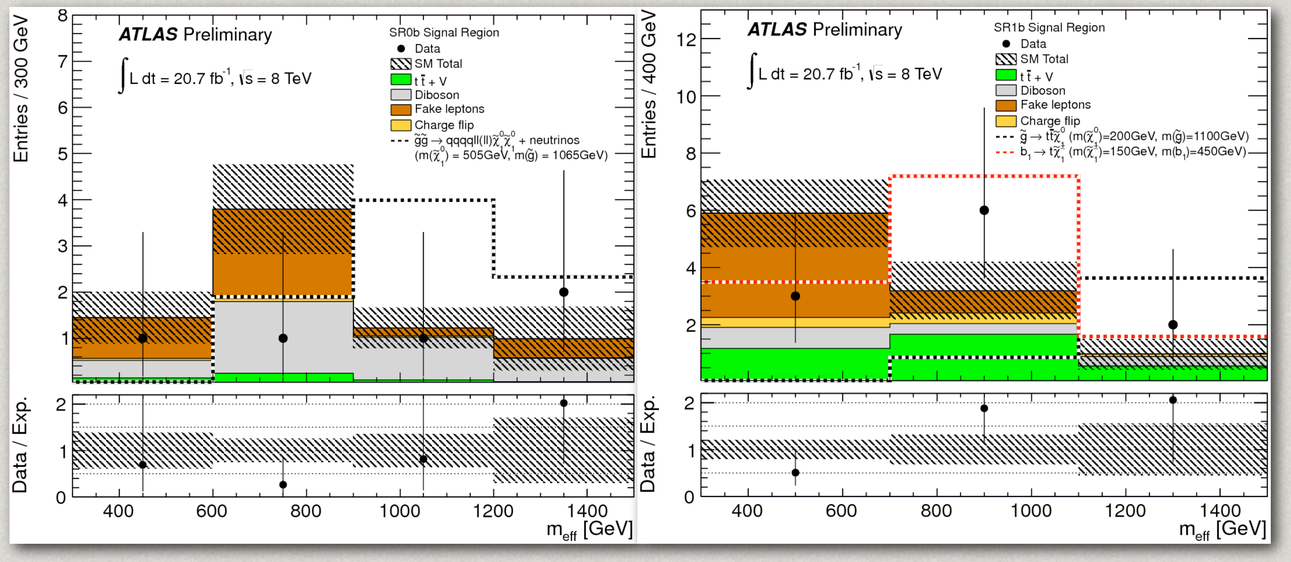
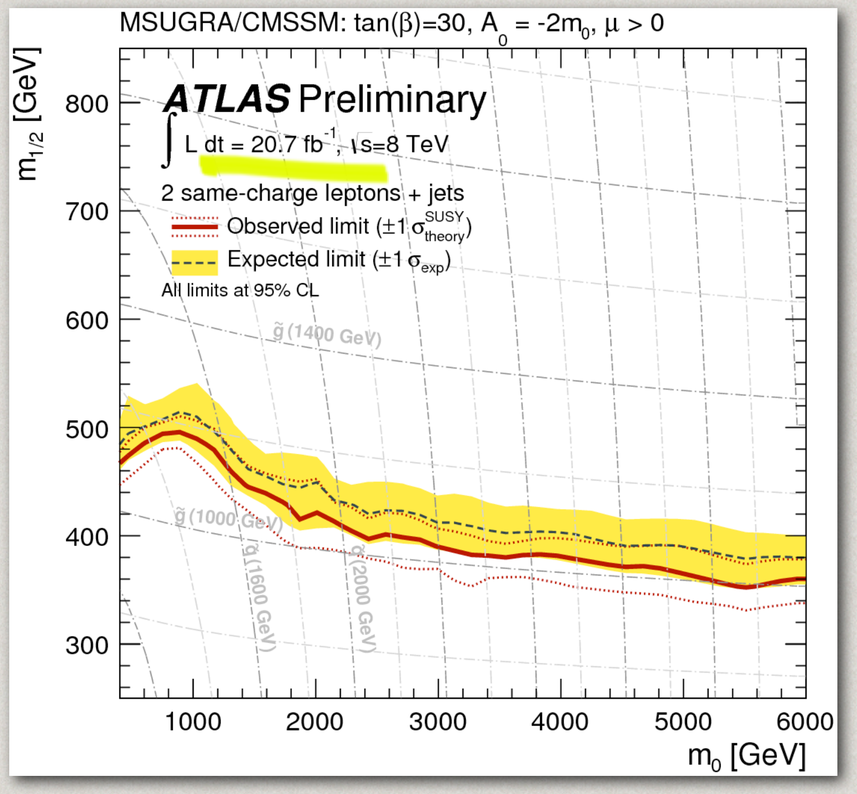


complete 2012 data set



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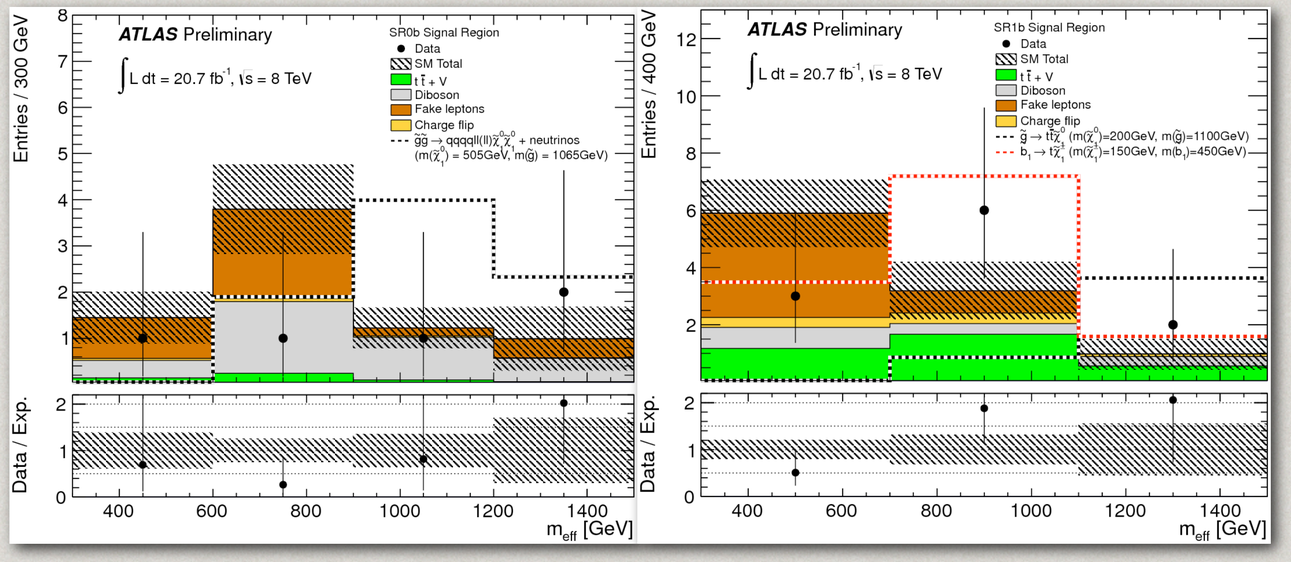

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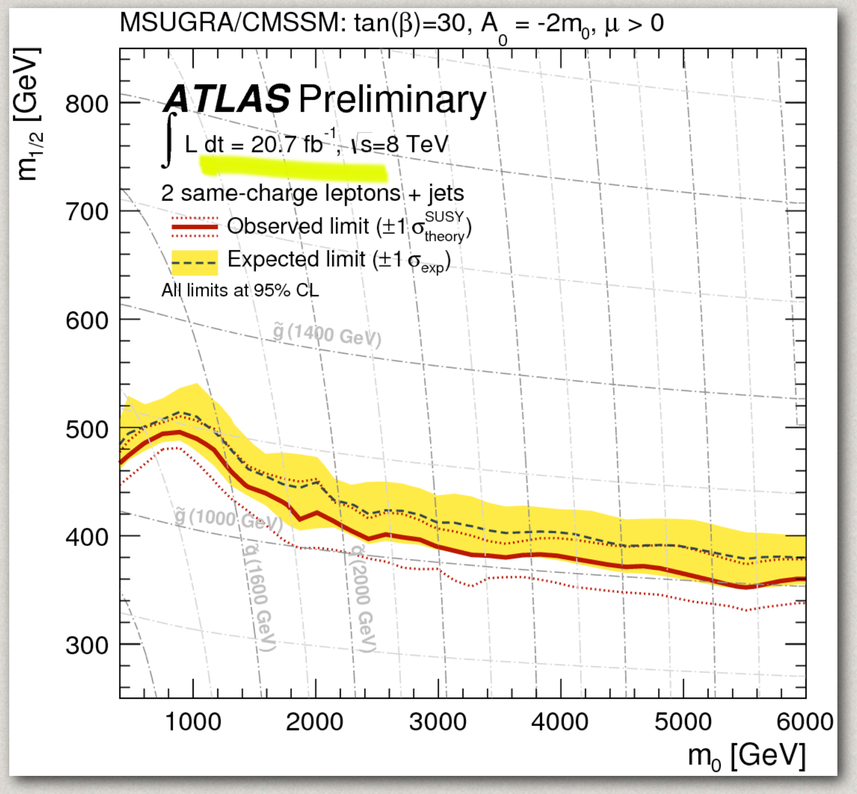

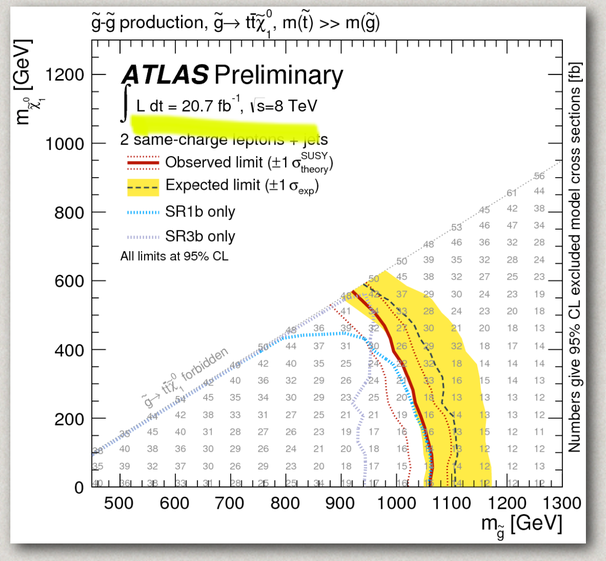

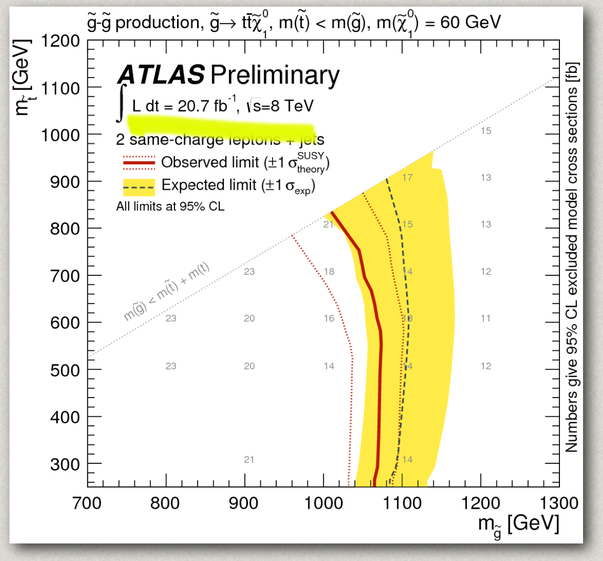

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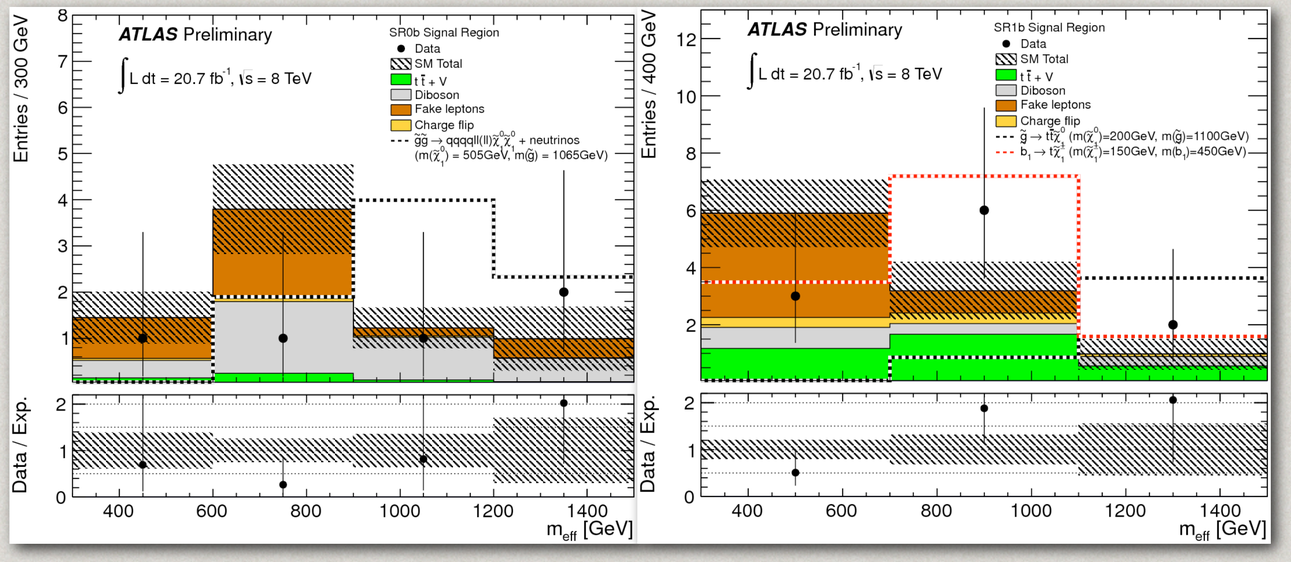

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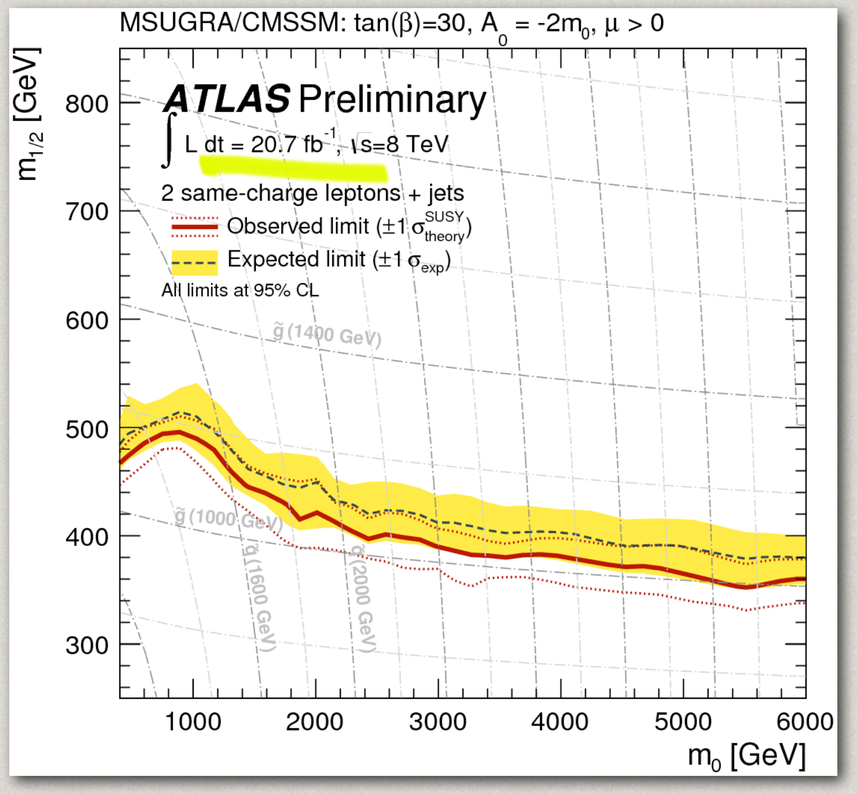

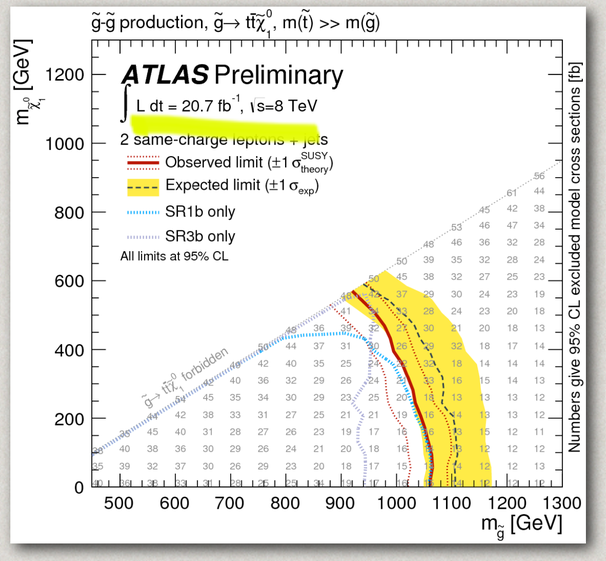

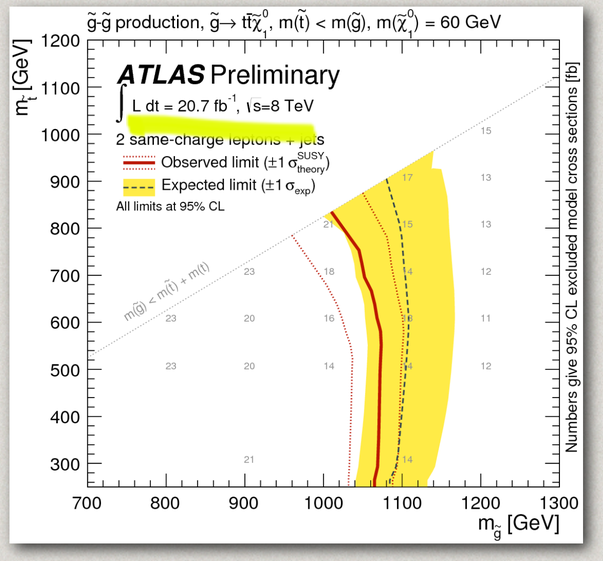

+...

more limits in other models

SUSY CROSS-SECTIONS

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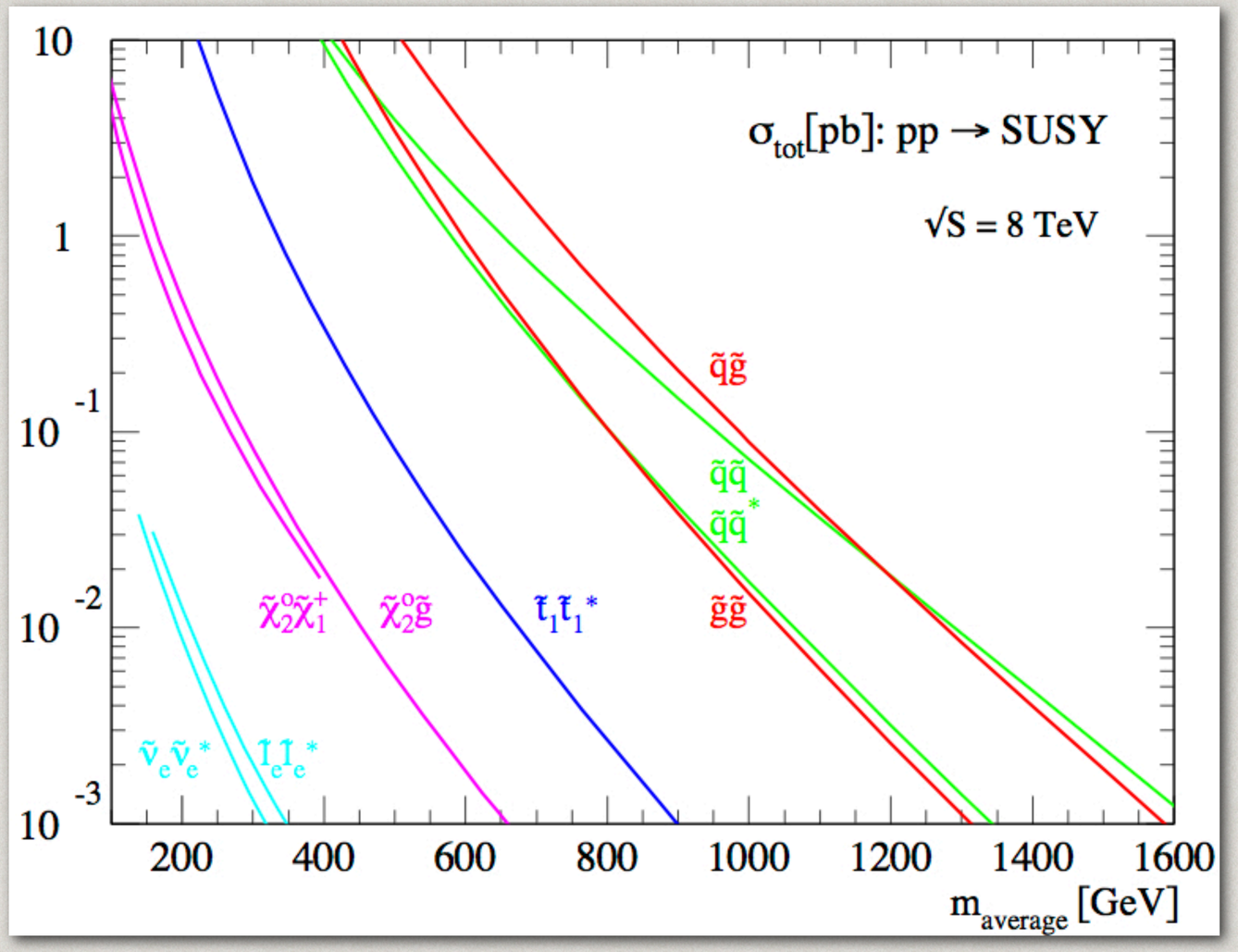

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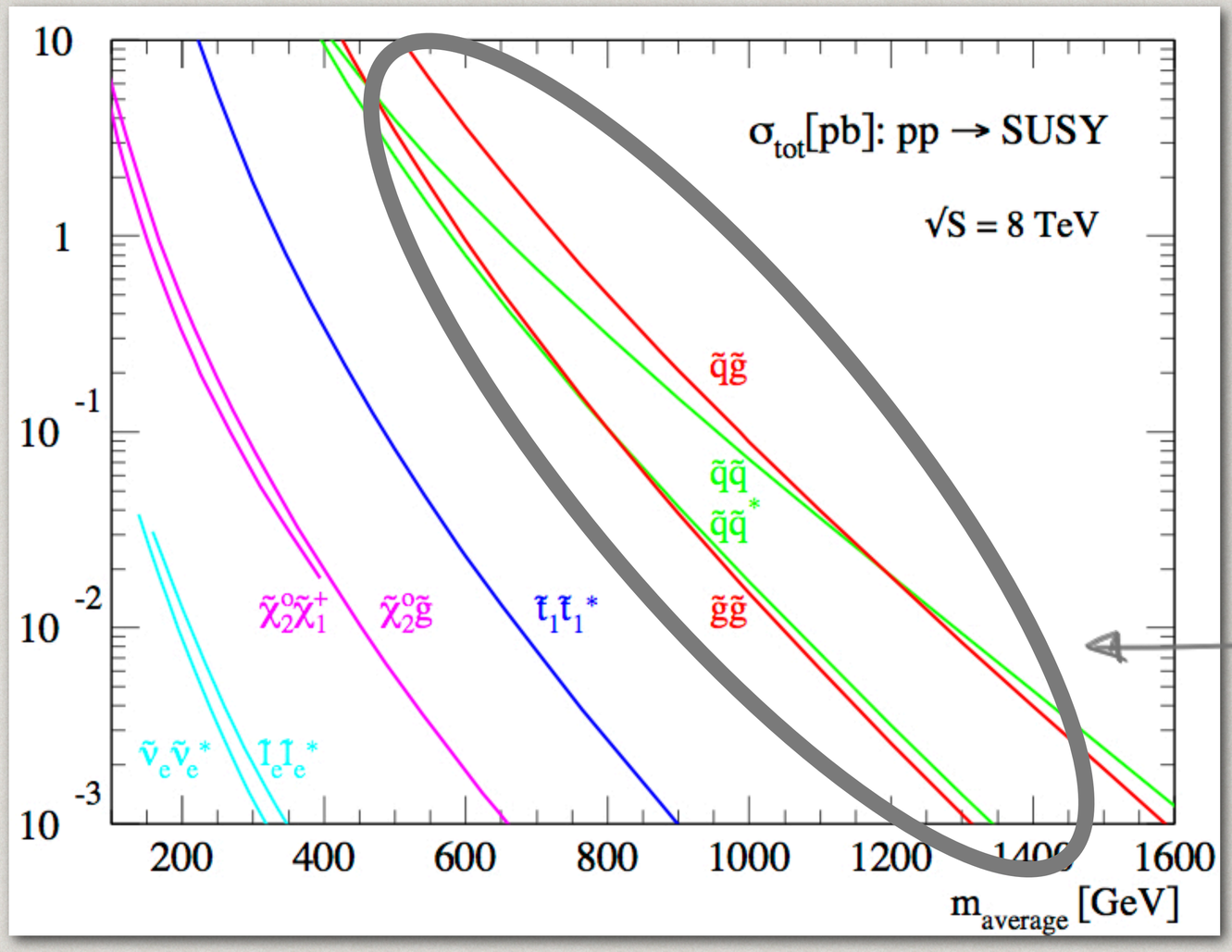

squark/gluiono production

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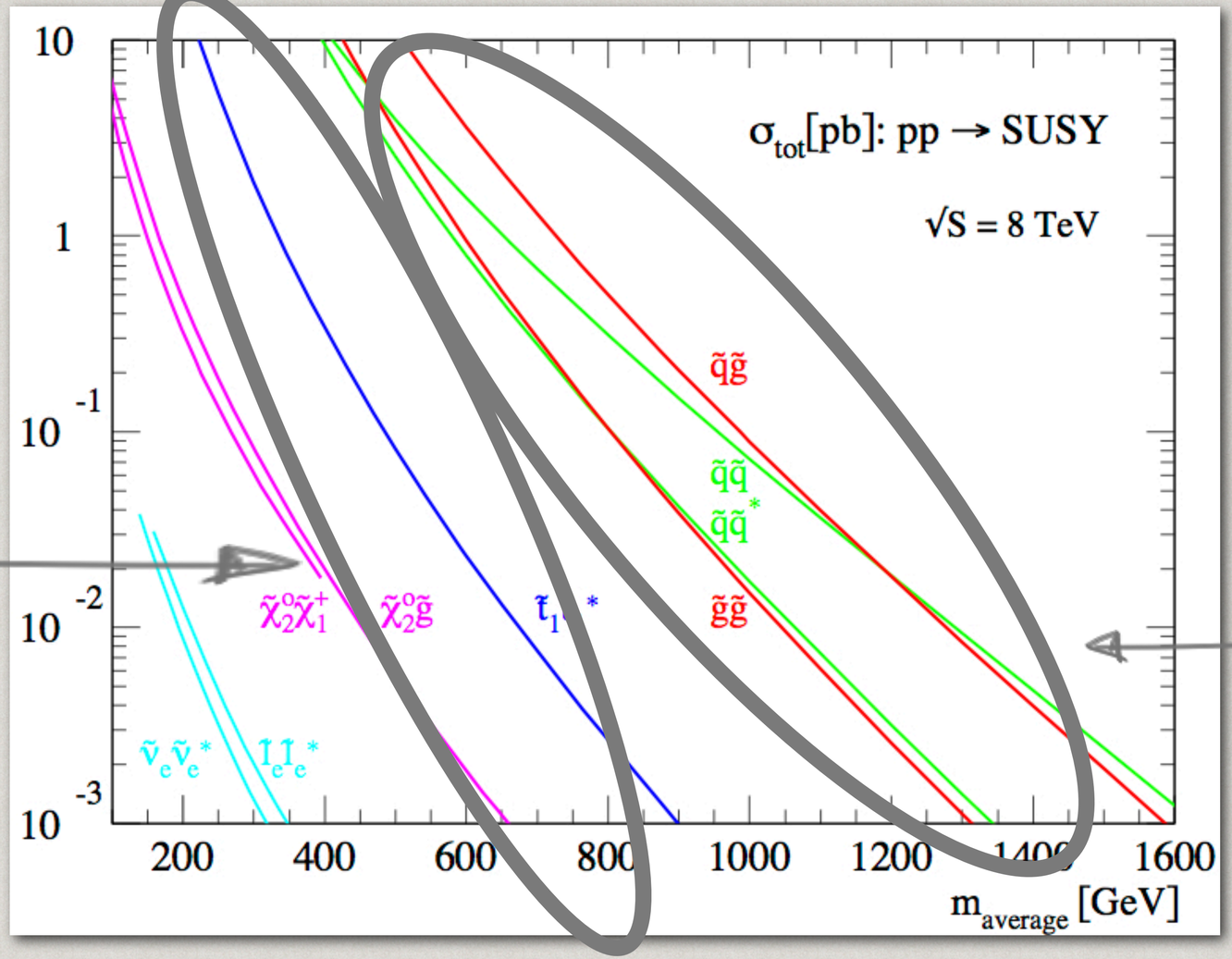

direct stop production

squark/gluiono production

SEARCH FOR SCALAR TOP (0 LEPTON CASE)

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- scenario:
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- signal: MET + ≥ 6 jets
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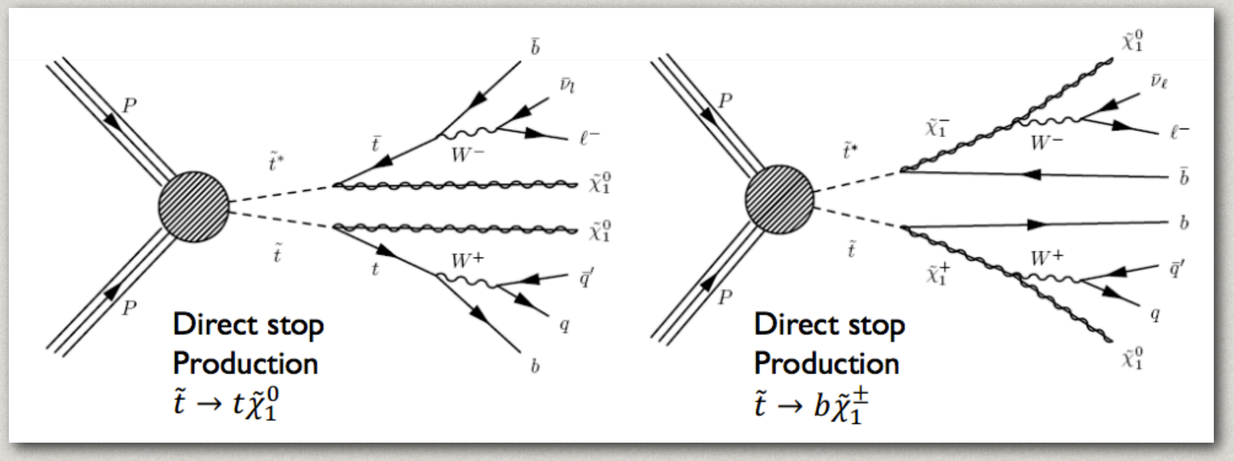

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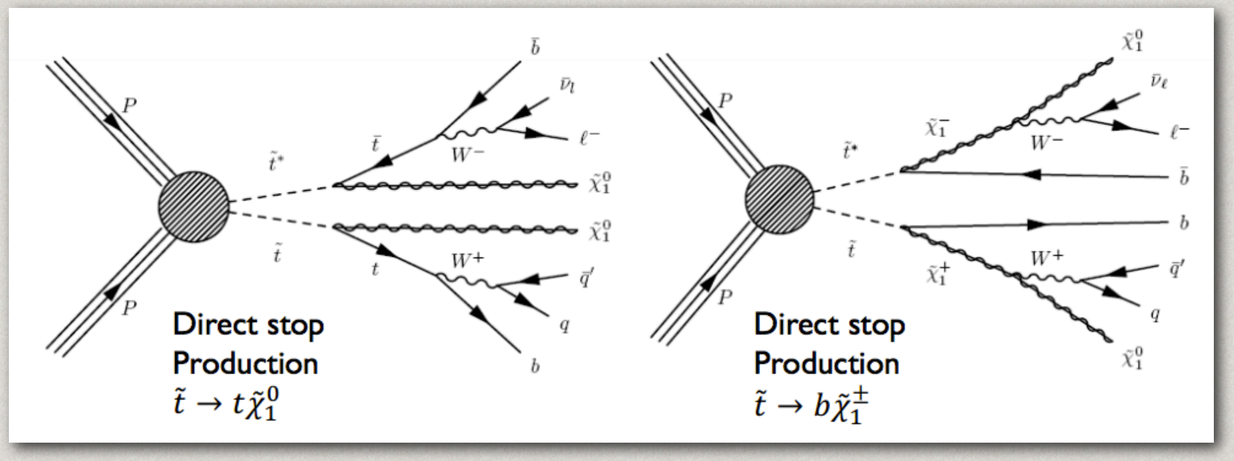
insensitive to top quark polarization



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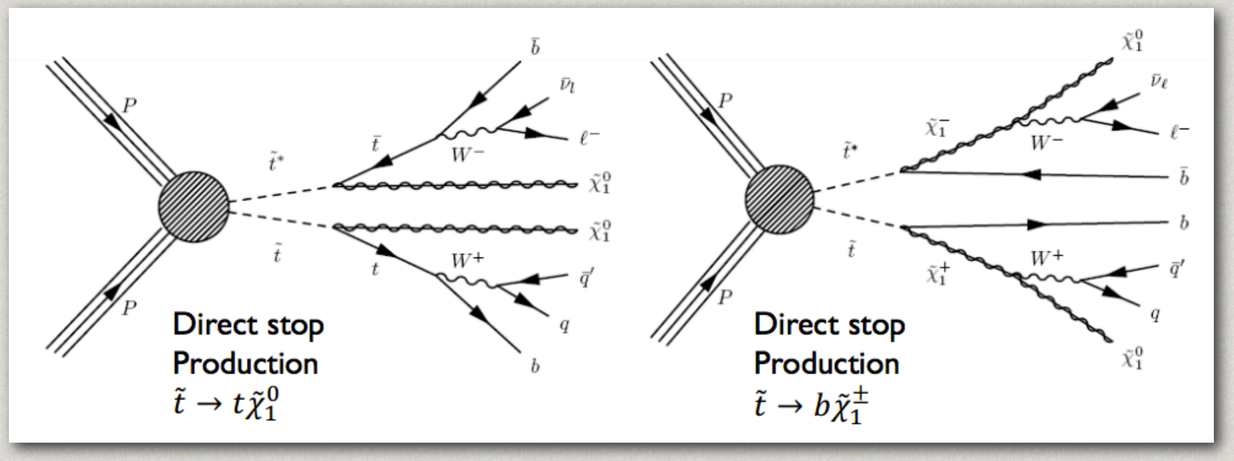

	Signal	$t\bar{t}$ CR	Z+jets CR	Multijet CR
Trigger	E_T^{miss}	single electron (muon)	two electron (muon)	E_T^{miss}
N_{lep}	0	1	2	0
p_T^{ℓ}	< 10 (10)	> 35 (35)	> 20 (20)	< 10 (10)
$p_T^{\ell_2}$	—	< 10 (10)	> 20 (10)	—
$m_{\ell\ell}$	—	—	81 to 101	—
N_{jet}	≥ 6	≥ 6	≥ 6	≥ 6
p_T^{jet}	> 80,80,35,...35	> 80,80,35,...35	> 80,80,35,...35	> 80,80,35,...35
N_{b-jet}	≥ 2	≥ 2	≥ 2	≥ 2
m_{jjj}	80 to 270	0 to 600	80 to 270	80 to 270
E_T^{miss}	> 200, 300, 350	> 200, 300, 350	> 70	> 160
$E_T^{miss,track}$	> 30	> 30	> 30	> 30
$\Delta\phi(E_T^{miss}, E_T^{miss,track})$	< π/3	< π/3	< π/3	> π/3
$m_T(\ell, E_T^{miss})$	—	40 to 120	—	—
$\Delta\phi(\text{jet}, E_T^{miss})$	> π/5	> π/10	> π/5	< π/5
$m_T(b\text{-jet}, E_T^{miss})$	> 175	—	> 175	> 175
Tau veto	yes	no	yes	no

SEARCH FOR SCALAR TOP (0 LEPTON CASE)

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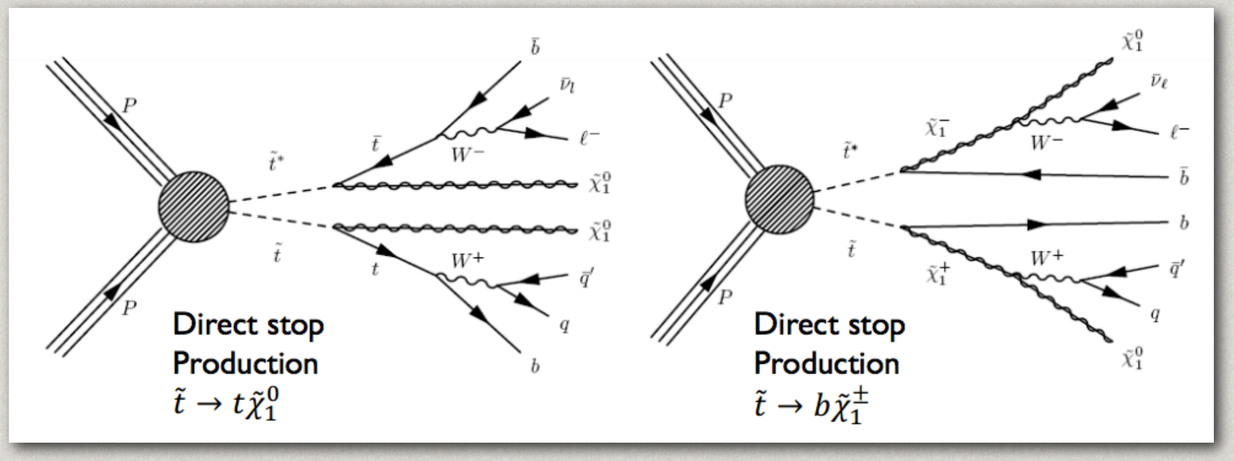

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$m_{\ell\ell}$	—	—	81 to 101	—
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E_T^{miss}	> 200, 300, 350	> 200, 300, 350	> 70	> 160
$E_T^{miss,track}$	> 30	> 30	> 30	> 30
$\Delta\phi(E_T^{miss}, E_T^{miss,track})$	< π/3	< π/3	< π/3	> π/3
$m_T(\ell, E_T^{miss})$	—	40 to 120	—	—
$\Delta\phi(\text{jet}, E_T^{miss})$	> π/5	> π/10	> π/5	< π/5
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Tau veto	yes	no	yes	no

SEARCH FOR SCALAR TOP (0 LEPTON CASE)

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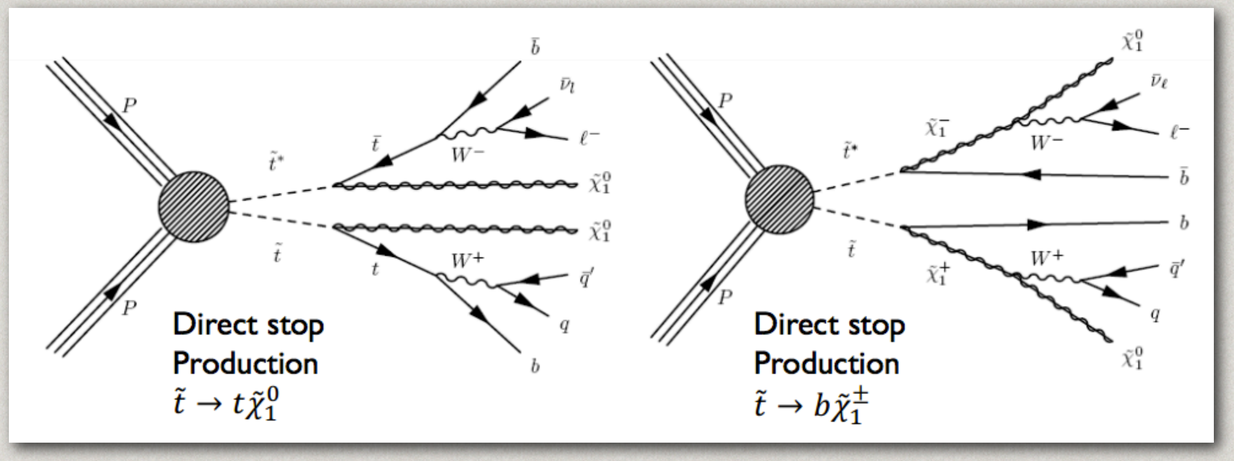
insensitive to top quark polarization



Number of events	SR1	SR2	SR3
Observed	15	2	1
Expected background	17.5 ± 3.2	4.7 ± 1.5	2.7 ± 1.2
Expected $t\bar{t}$	9.8 ± 2.6	1.9 ± 1.3	0.9 ± 0.7
Expected $t\bar{t}$ + W/Z	1.7 ± 1.0	0.7 ± 0.4	0.51 ± 0.30
Expected Z+jets	2.1 ± 0.7	1.2 ± 0.4	0.77 ± 0.29
Expected W+jets	1.2 ± 0.8	0.32 ± 0.29	0.2 ± 0.2
Expected single-top	1.5 ± 0.9	0.5 ± 0.4	$0.3^{+0.5}_{-0.3}$
Expected multijet	0.12 ± 0.12	0.01 ± 0.01	< 0.01
Expected diboson	1.2 ± 1.2	< 0.22	< 0.22
Fit input expectation $t\bar{t}$	9.9	1.7	0.6

	Signal	$t\bar{t}$ CR	Z+jets CR	Multijet CR
Trigger	$E_{\mathrm{T}}^{\mathrm{miss}}$	single electron (muon)	two electron (muon)	$E_{\mathrm{T}}^{\mathrm{miss}}$
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N_{jet}	≥ 6	≥ 6	≥ 6	≥ 6
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$\Delta\phi(E_{\mathrm{T}}^{\mathrm{miss}}, E_{\mathrm{T}}^{\mathrm{miss,track}})$	$< \pi/3$	$< \pi/3$	$< \pi/3$	$> \pi/3$
$m_{\mathrm{T}}(\ell, E_{\mathrm{T}}^{\mathrm{miss}})$	—	40 to 120	—	—
$\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})$	$> \pi/5$	$> \pi/10$	$> \pi/5$	$< \pi/5$
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Tau veto	yes	no	yes	no

SEARCH FOR SCALAR TOP (0 LEPTON CASE)

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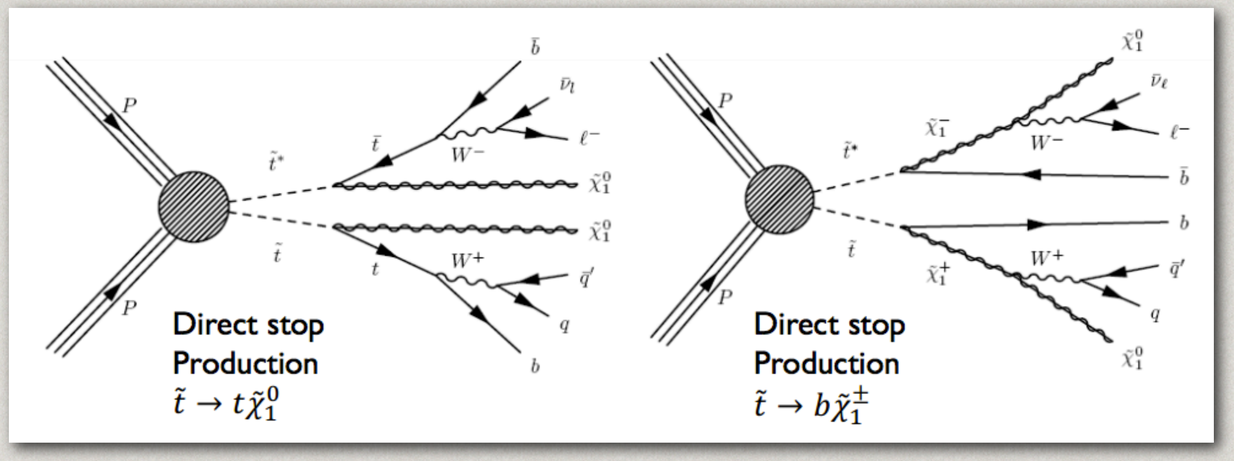

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Expected multijet	0.12 ± 0.12	0.01 ± 0.01	< 0.01
Expected diboson	1.2 ± 1.2	< 0.22	< 0.22
Fit input expectation $t\bar{t}$	9.9	1.7	0.6

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$m_T(\ell, E_T^{miss})$	—	40 to 120	—	—
$\Delta\phi(\text{jet}, E_T^{miss})$	$> \pi/5$	$> \pi/10$	$> \pi/5$	$< \pi/5$
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Tau veto	yes	no	yes	no

SEARCH FOR SCALAR TOP (0 LEPTON CASE): SELECTION

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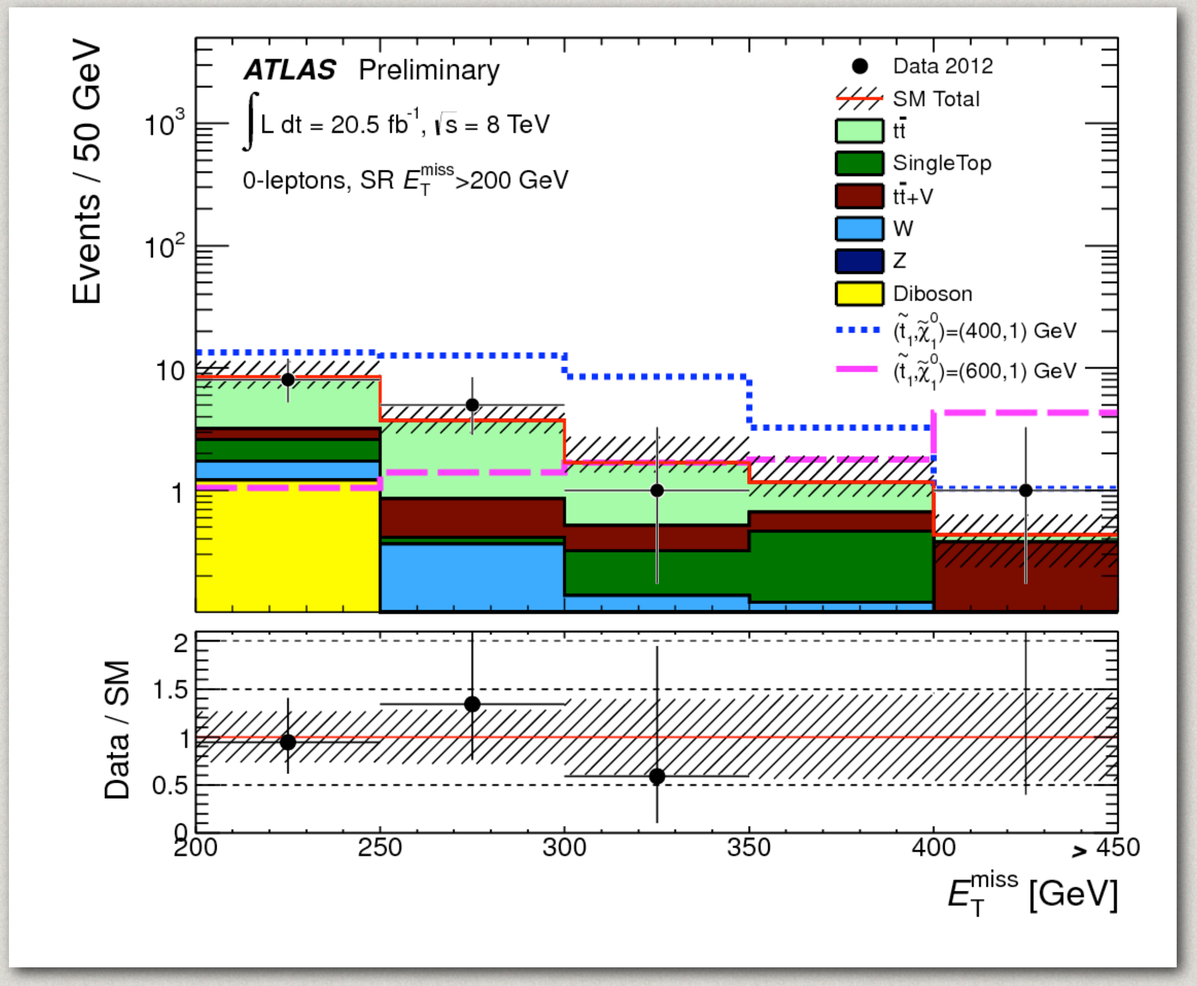
MET



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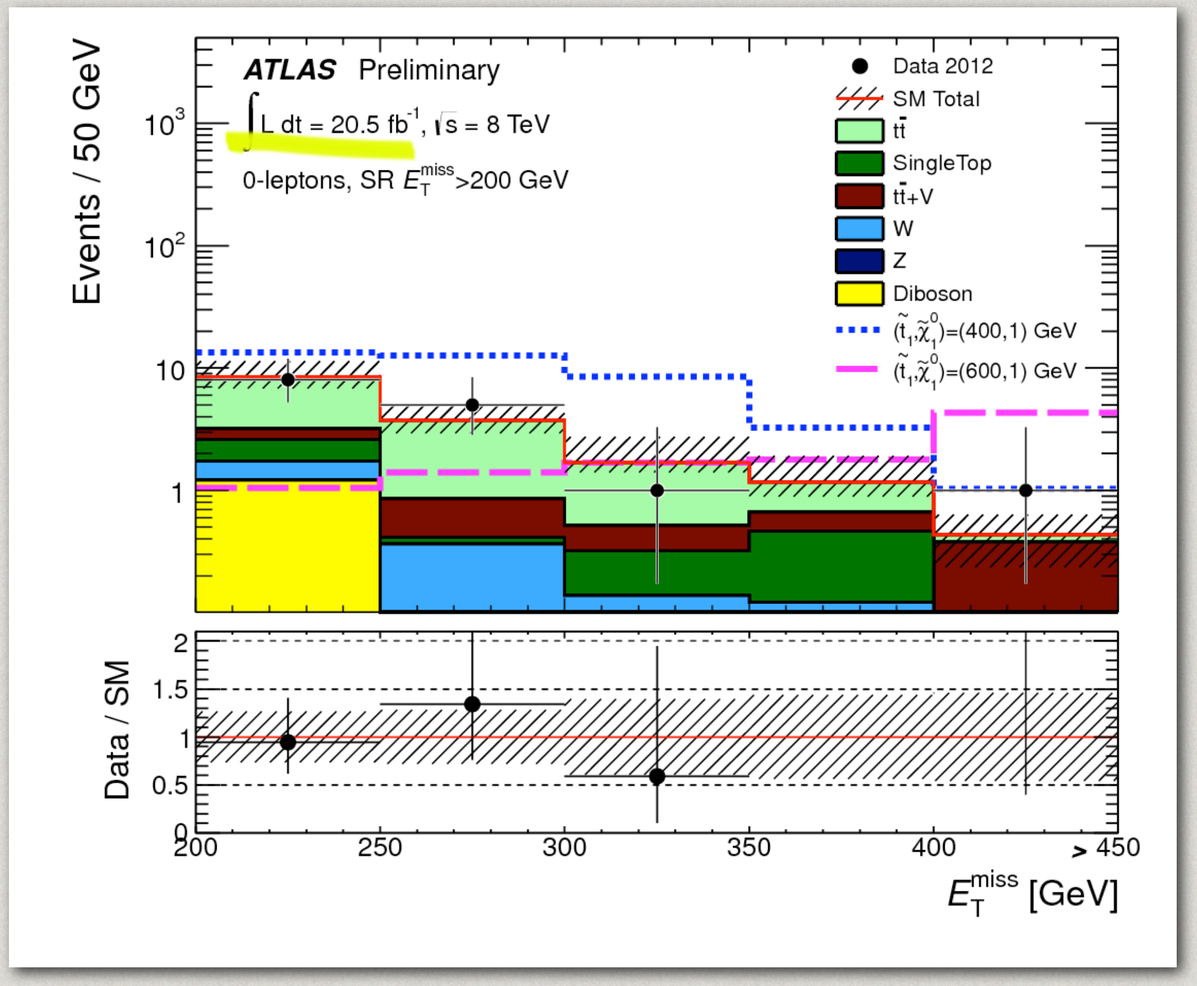

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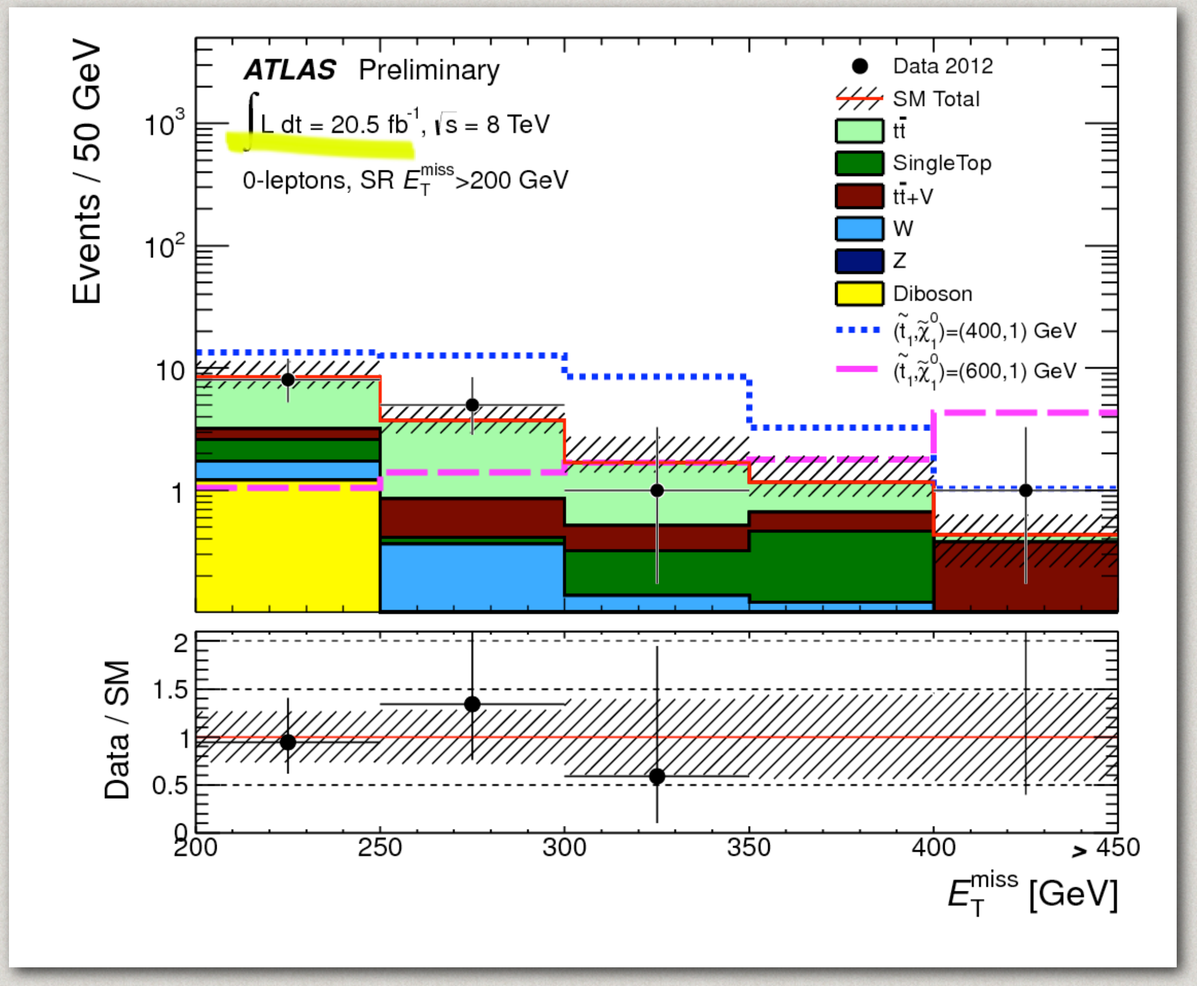
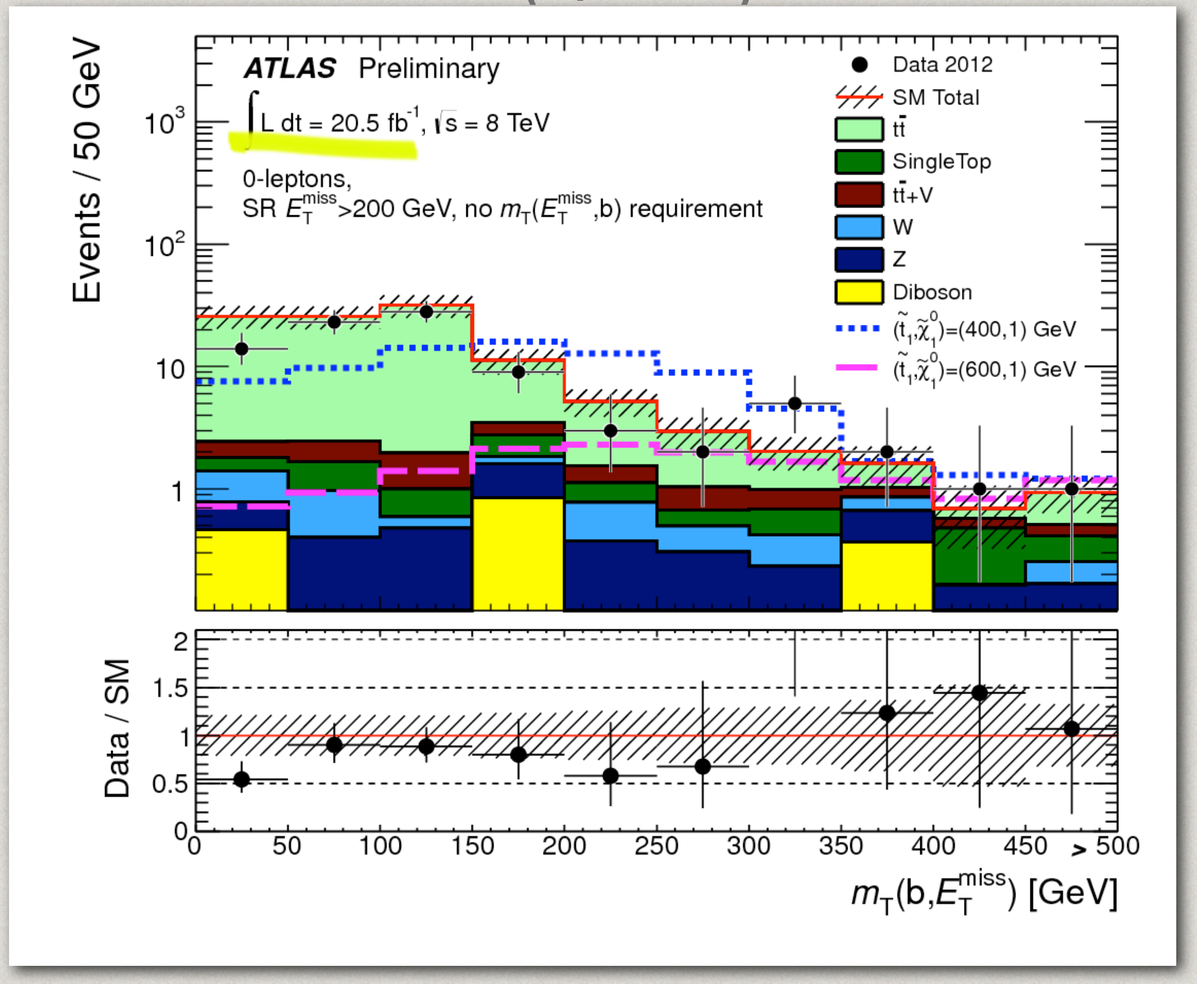


m_T(b, MET)



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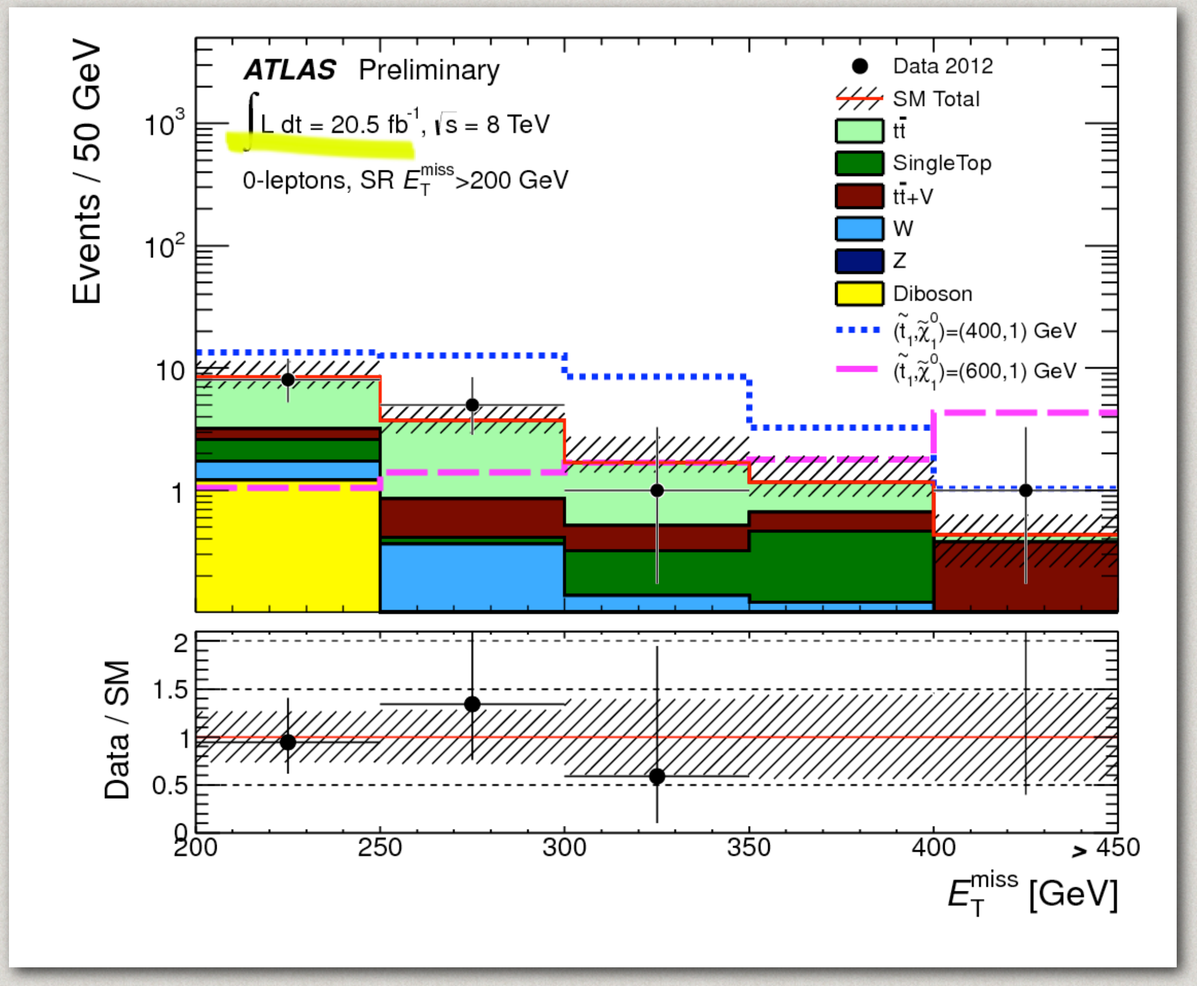

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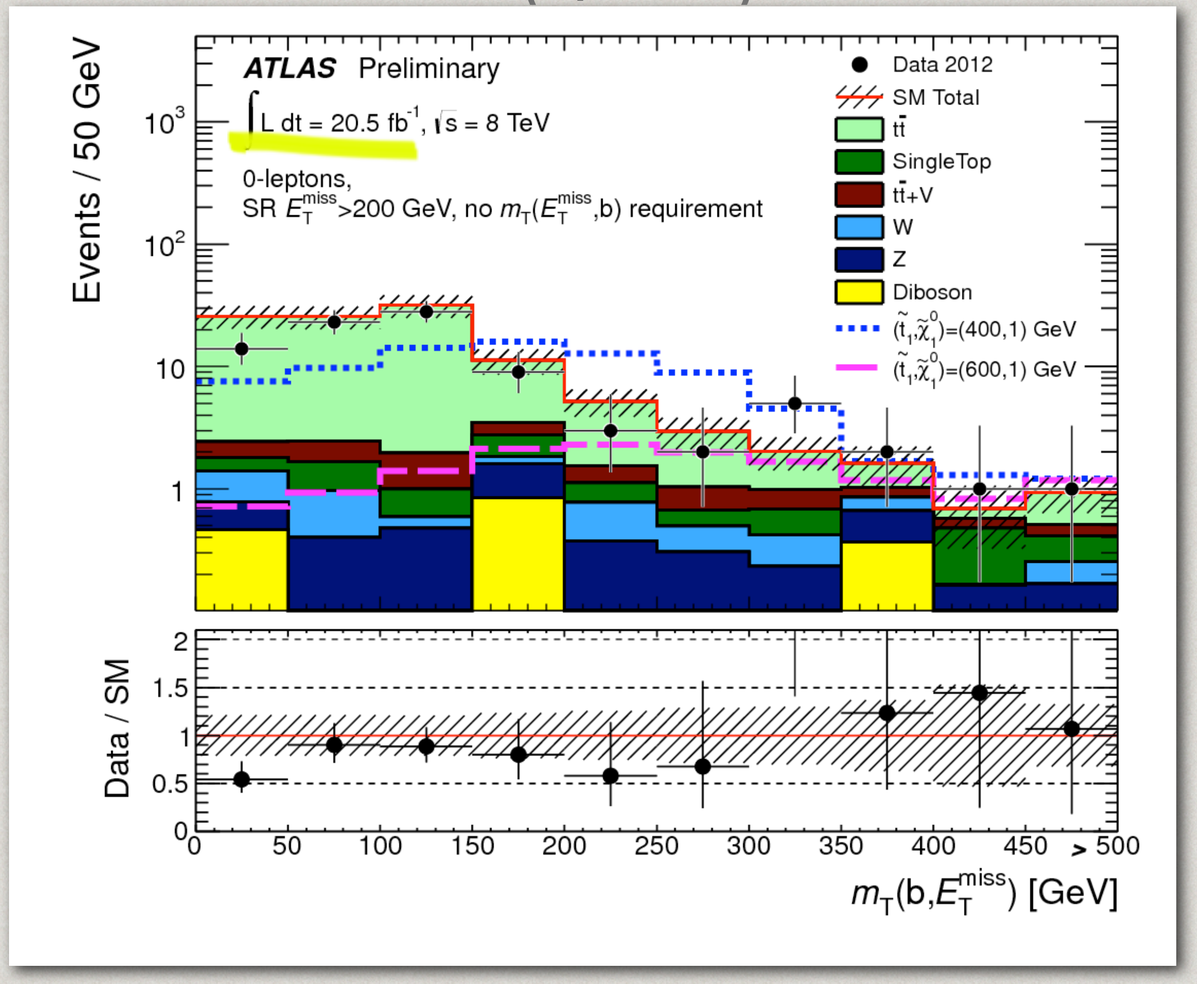
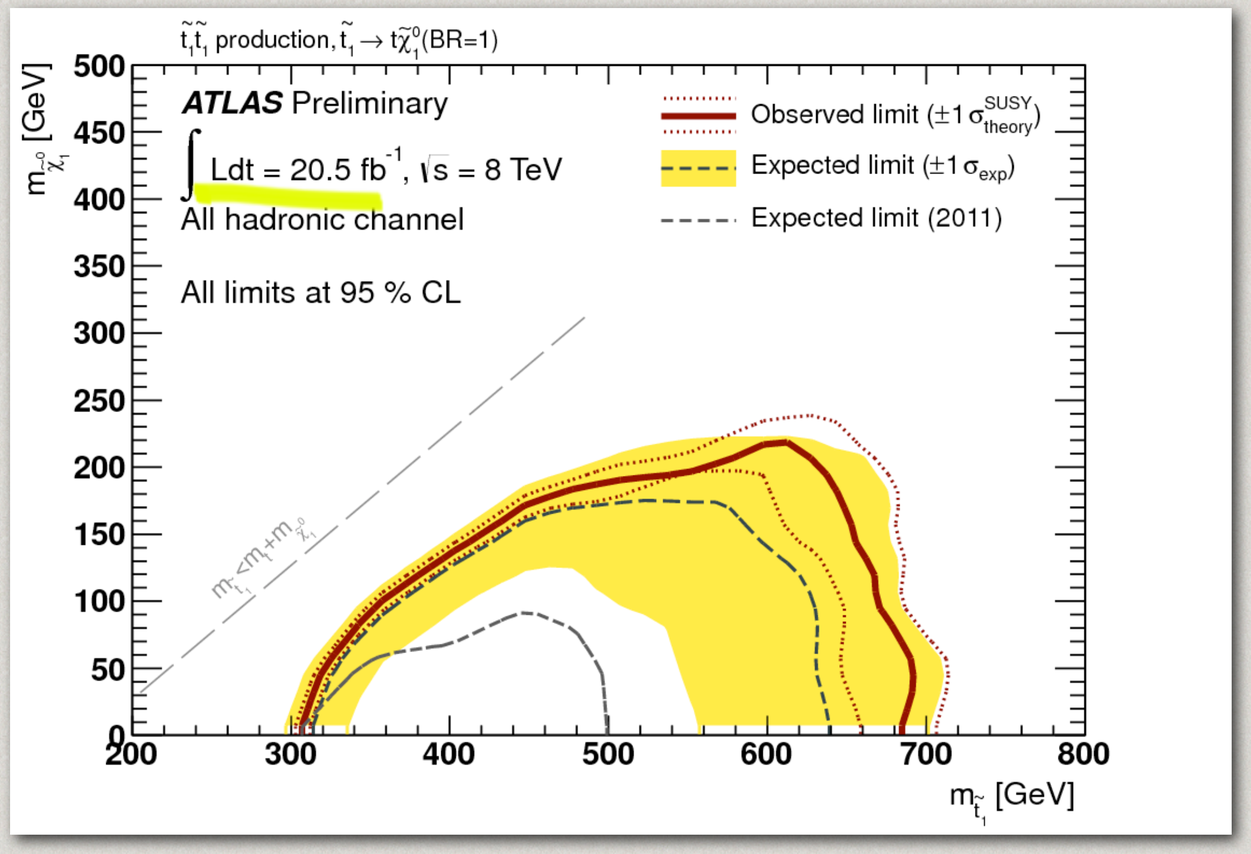


set limits...

SEARCH FOR SCALAR TOP (0 LEPTON CASE): LIMITS

SEARCH FOR SCALAR TOP (0 LEPTON CASE): LIMITS

neutralino-stop mass limits



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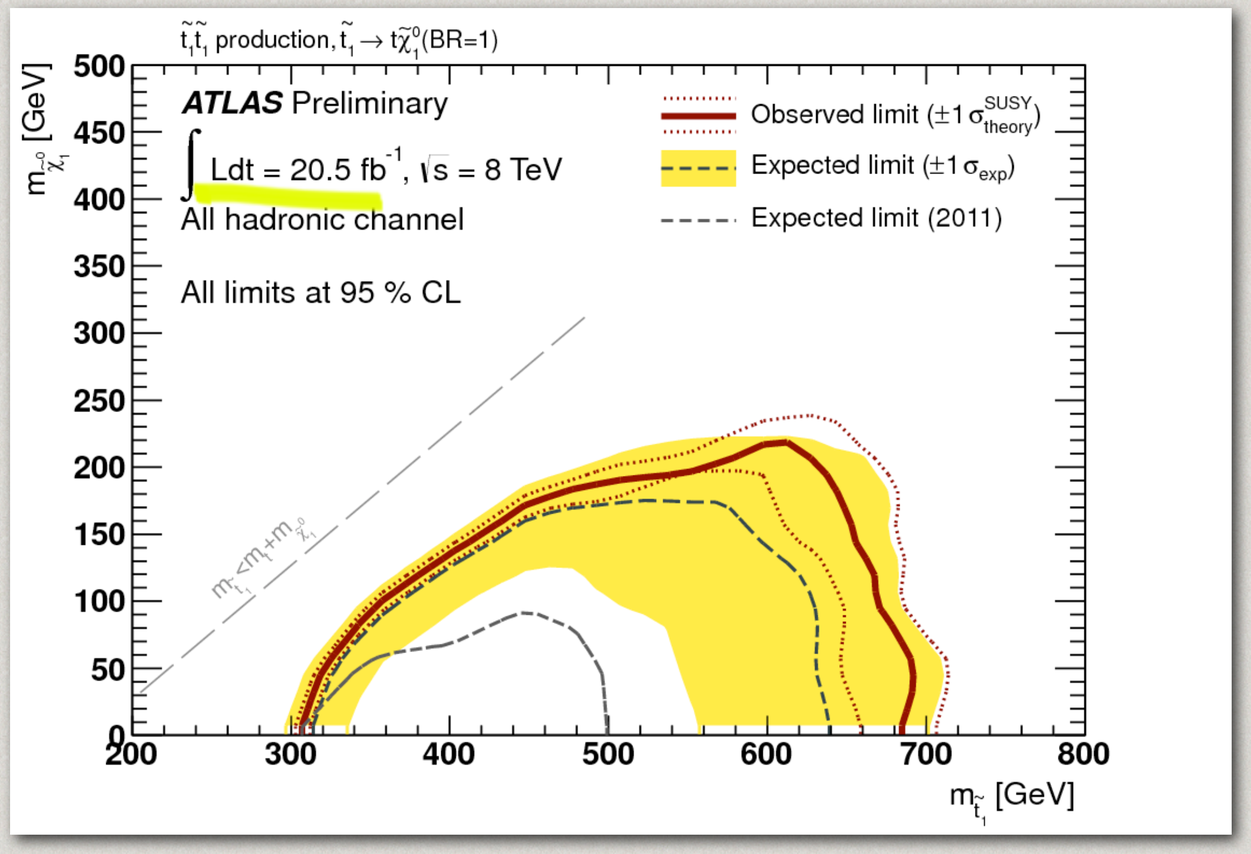
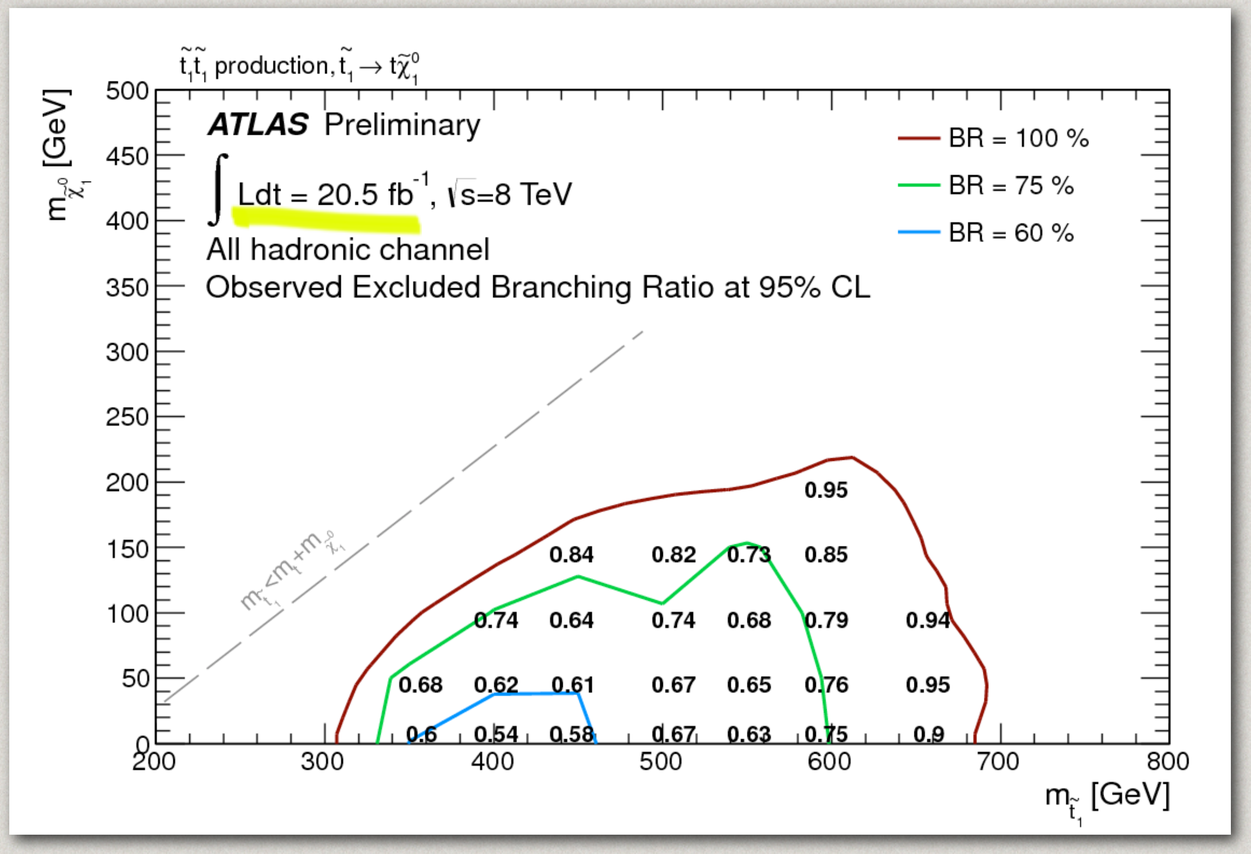


limits on branching ratio



SUMMARY ATLAS SCALAR TOP SEARCHES

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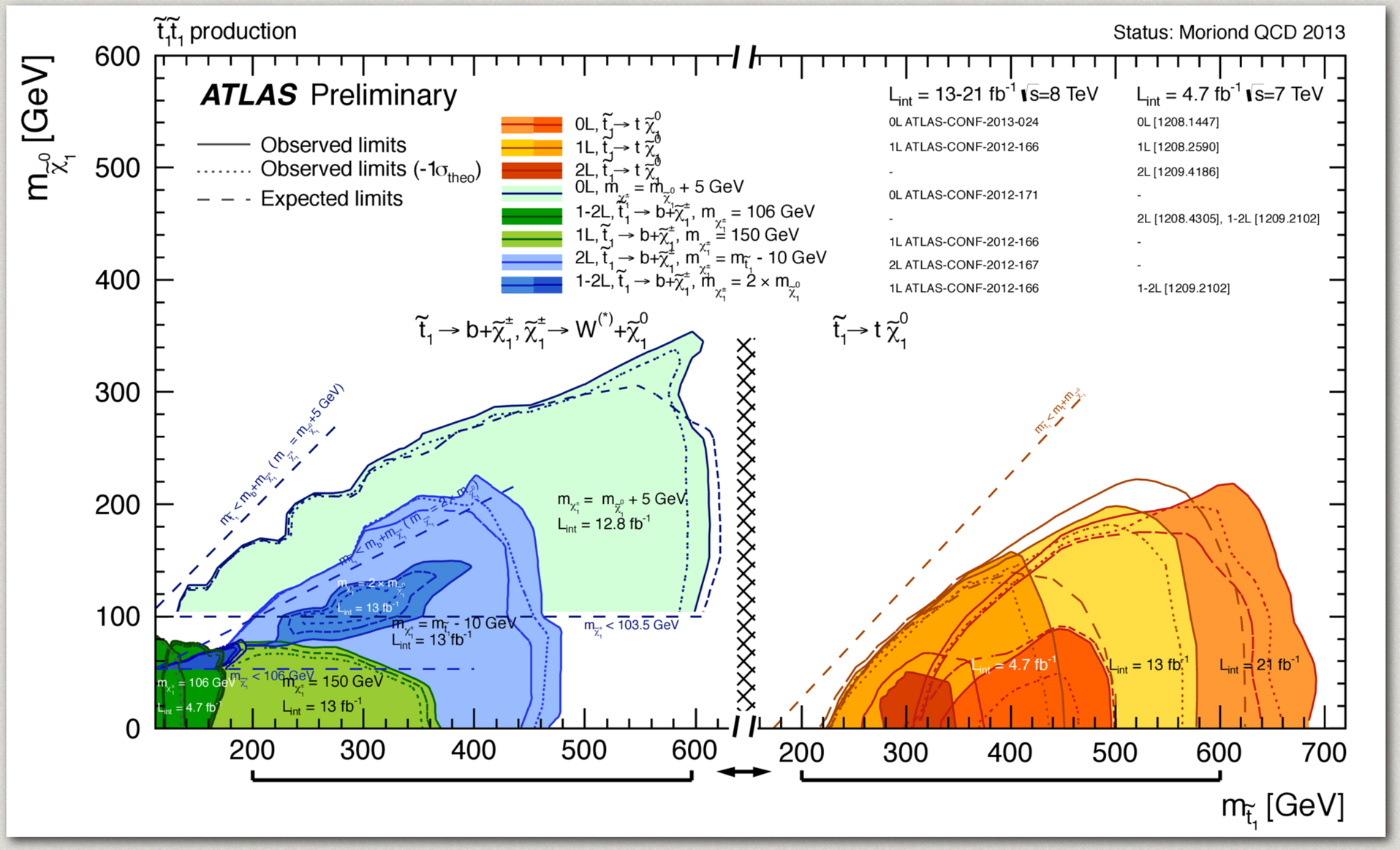

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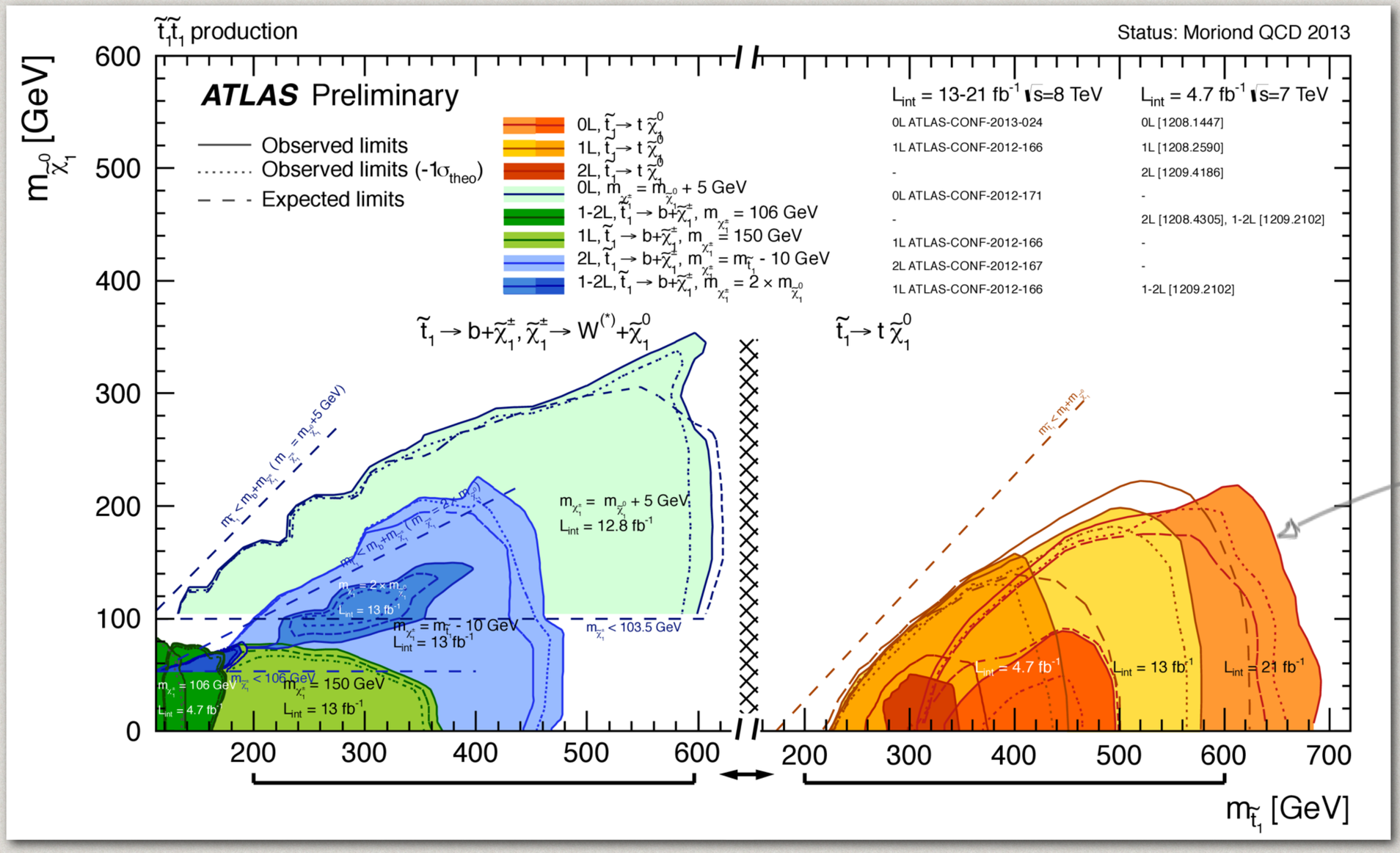

just shown

SUSY CROSS-SECTIONS

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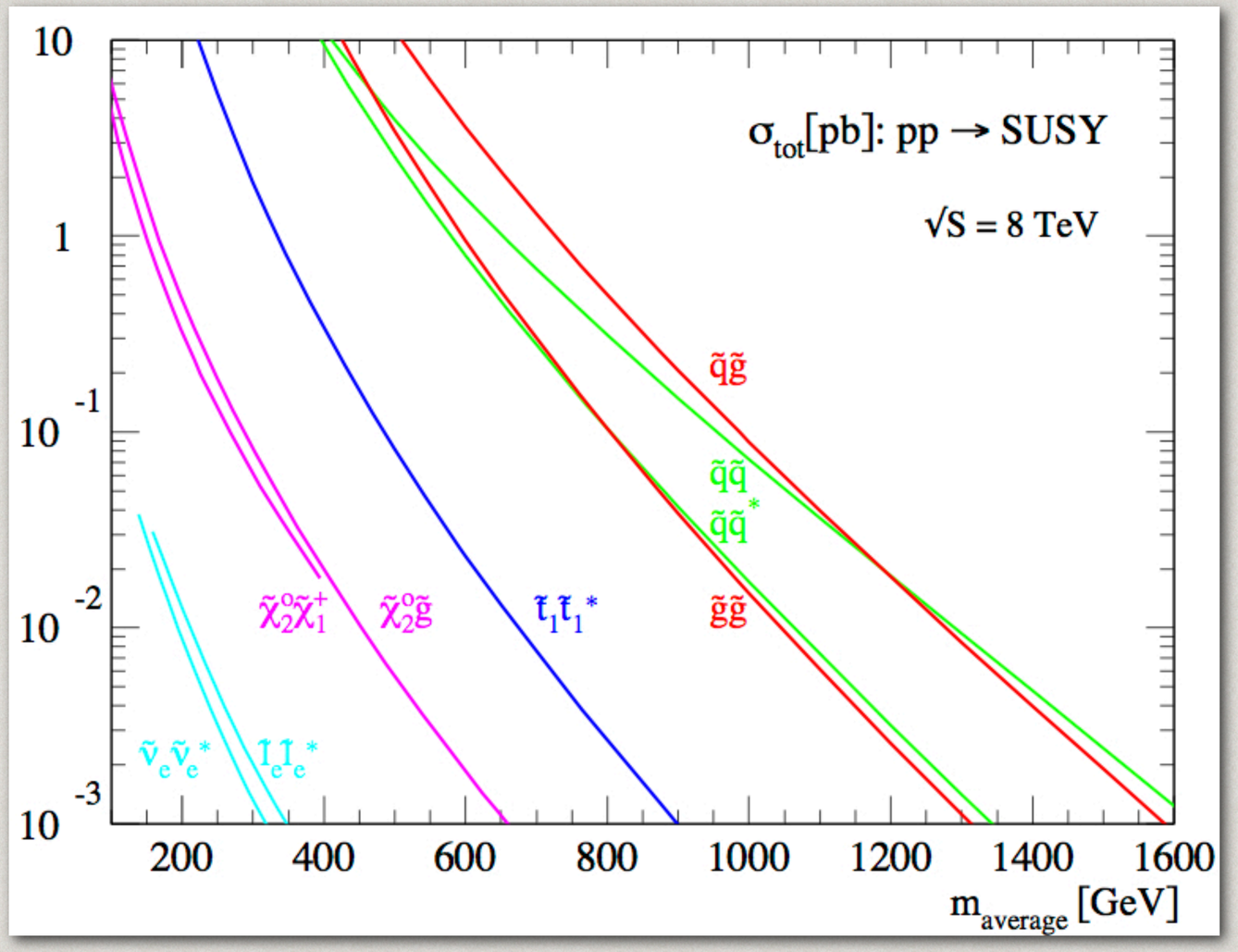

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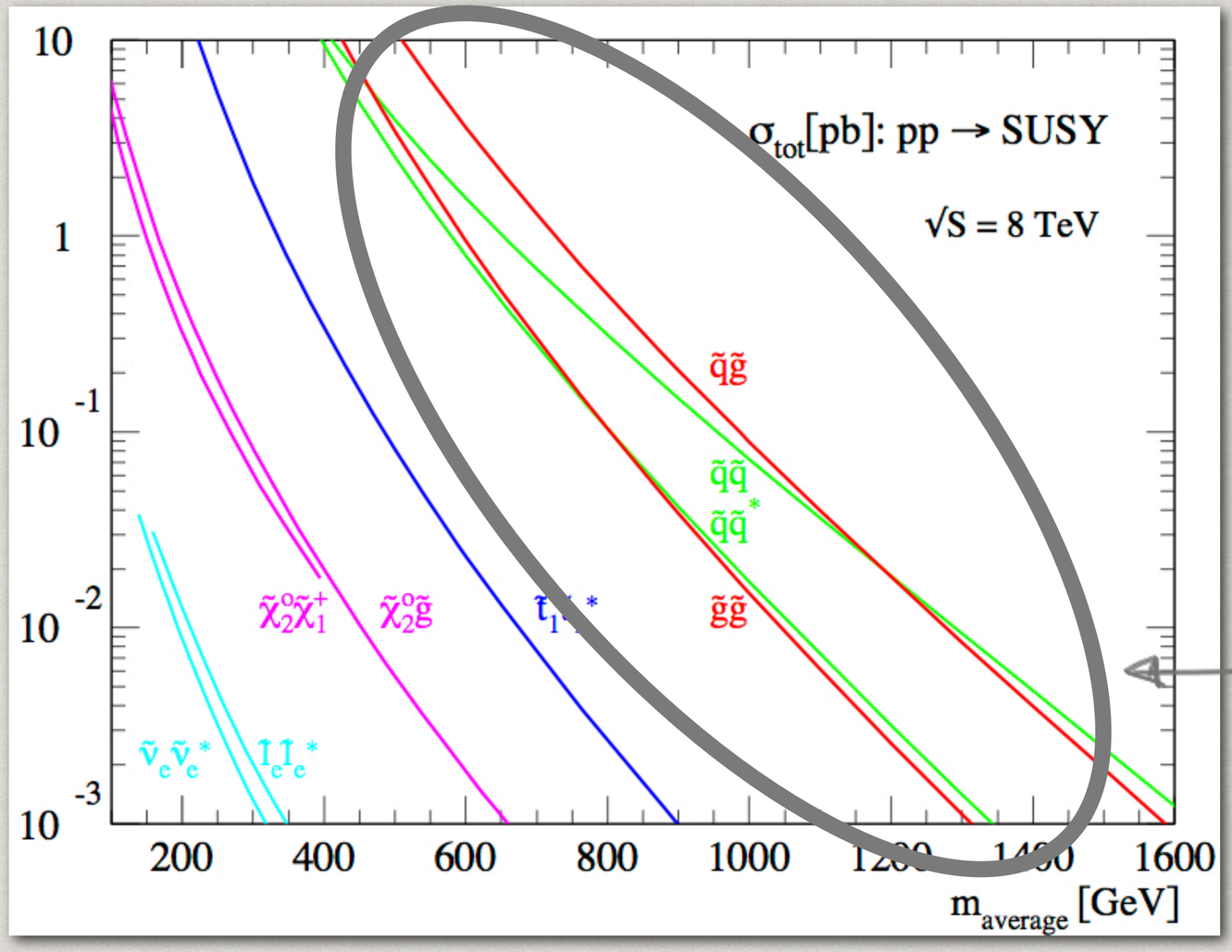

strong production

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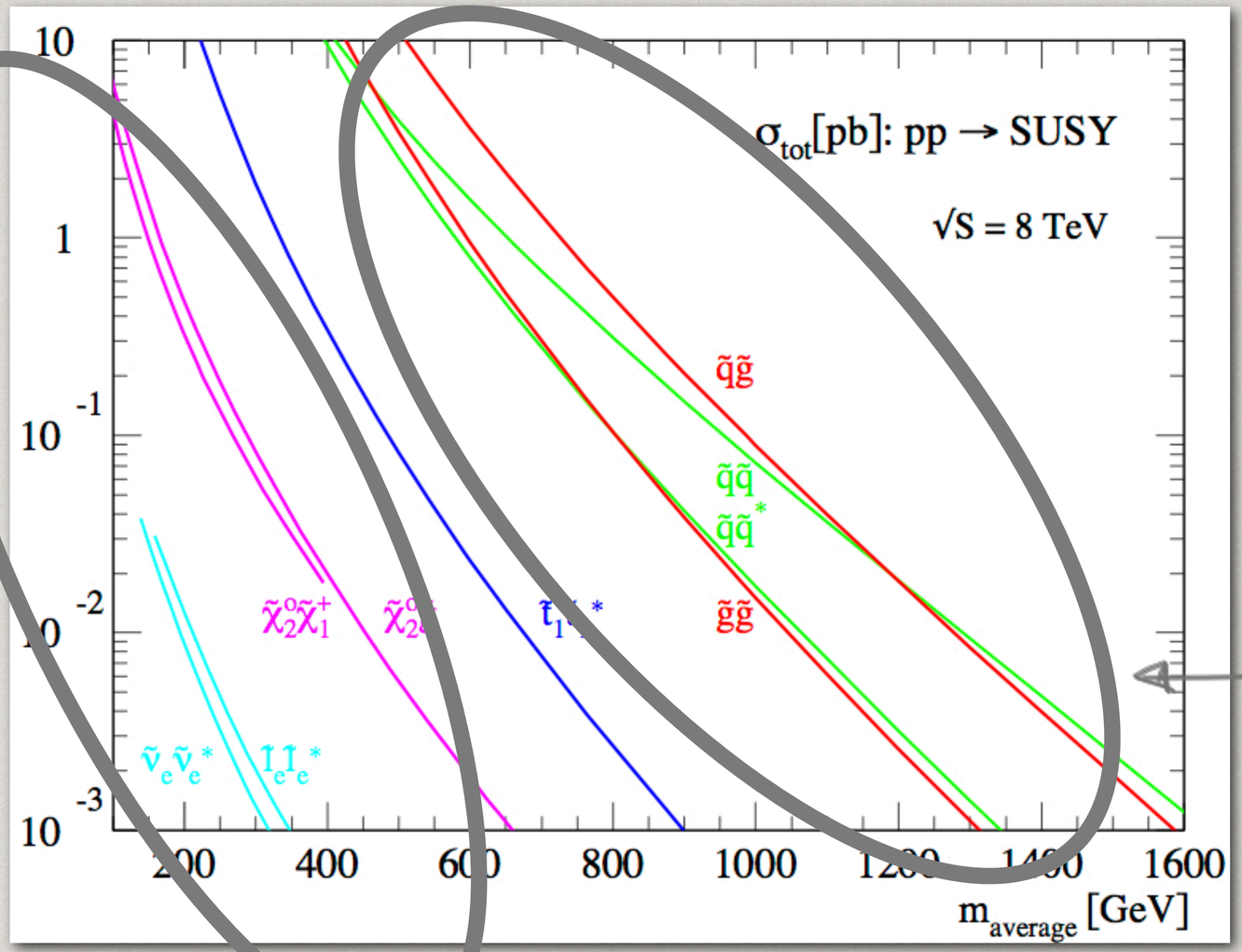
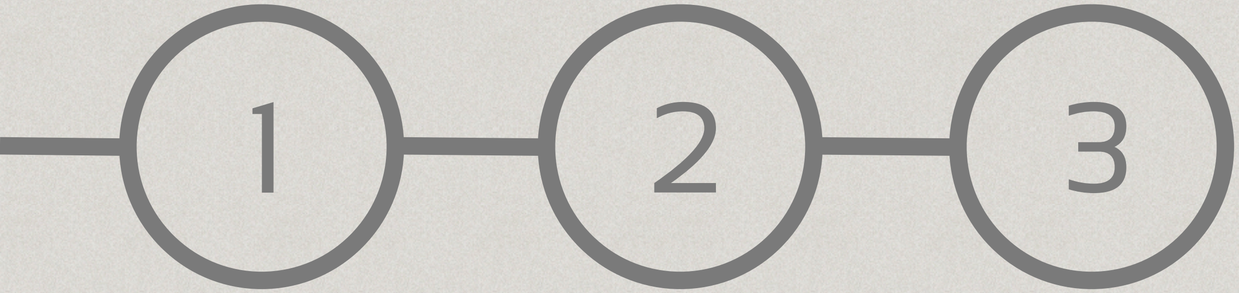


electroweak production

strong production

Outline



INTRO

SUSY, ATLAS

SETUP

What are we looking for?

SEARCHES 1

Strong Production

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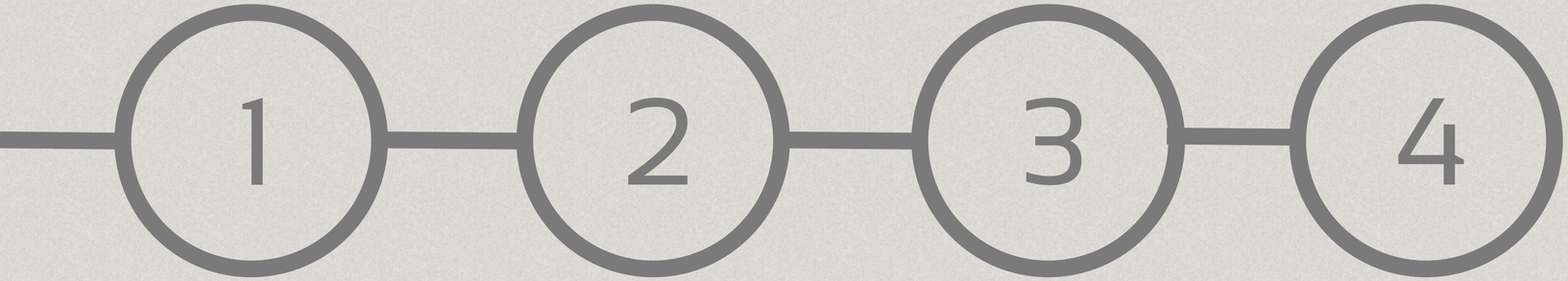

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SEARCHES 2

EWK Production

DIRECT CHARGINO/NEUTRALINO PRODUCTION

- scenario:
  - masses of gluinos/squarks might be too high
  - direct production of charginos/neutralinos dominant
  - subsequent decay into leptons
  - neutralino LSP
  - at least three final state leptons
- models:
  - simplified models
  - phenomenological MSSM (pMSSM)
- gaugino decay properties depend on M_1, M_2, tanβ, μ

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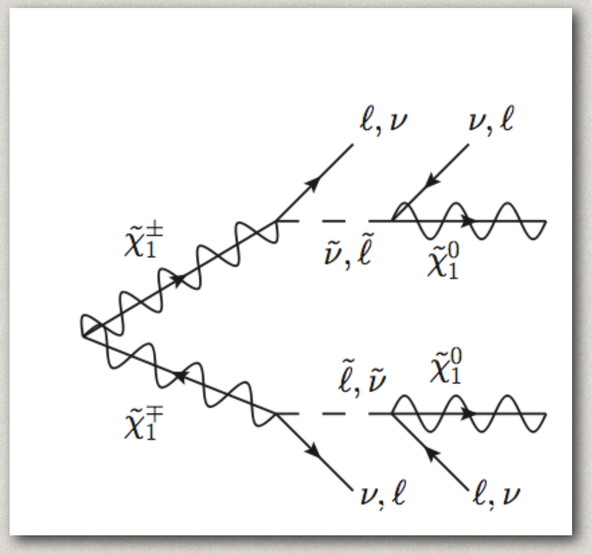

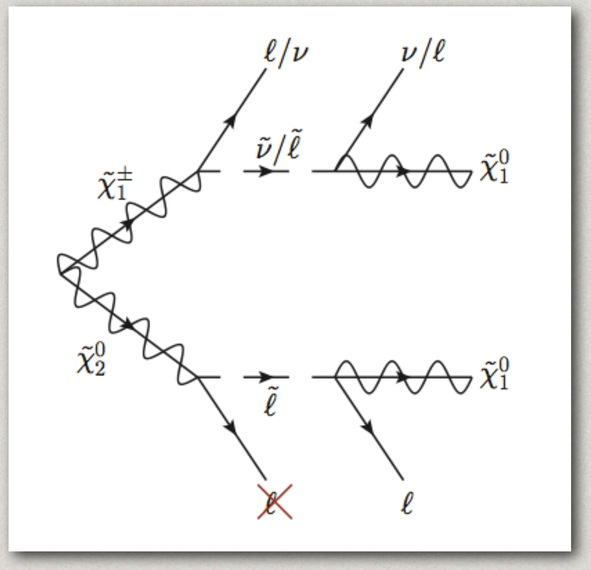

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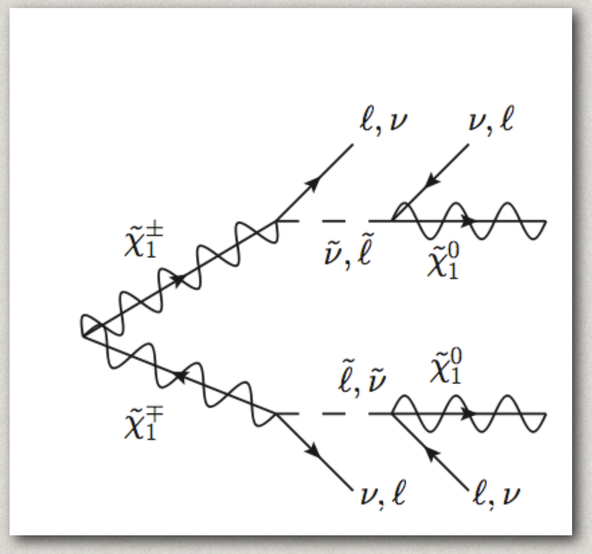

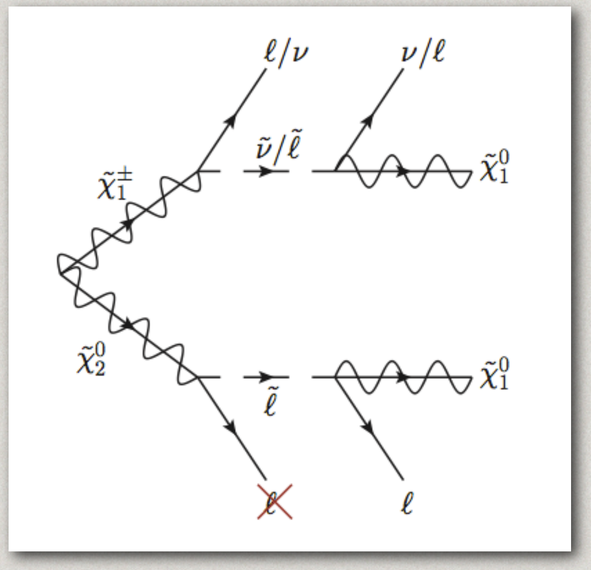

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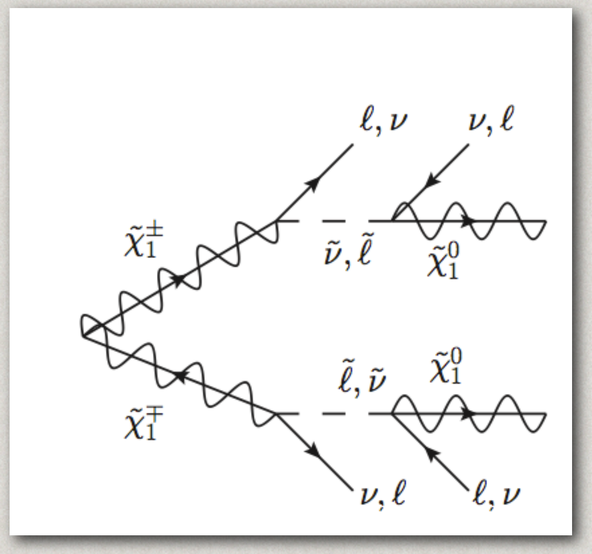

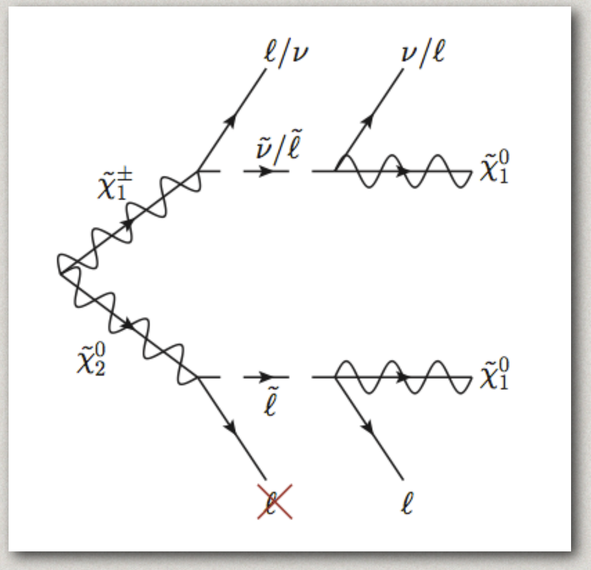

DIRECT CHARGINO/NEUTRALINO PRODUCTION: DETAILS

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signal region definition

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$\lvert m_{\mathrm{SFOS}} - m_Z \rvert$	> 10 GeV		< 10 GeV
Number of b-jets	0		any
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 75 GeV		> 120 GeV
m_{T}	any	> 110 GeV	> 110 GeV
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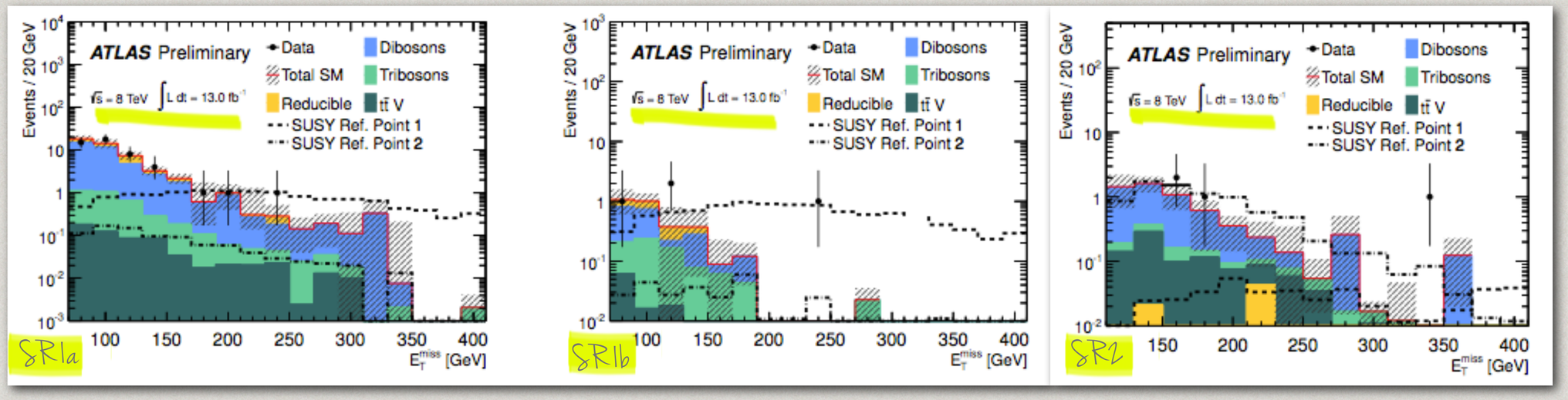

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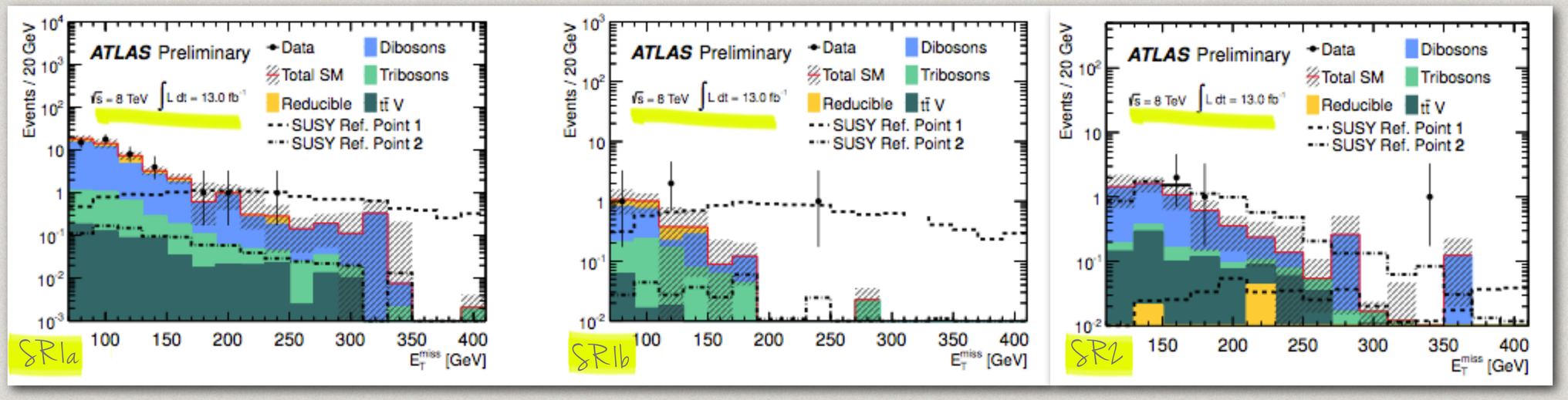
ZZ	2.0 ± 0.7	0.30 ± 0.23	0.10 ± 0.10
WZ (normalised)	34 ± 4	1.2 ± 0.6	4.7 ± 0.8
Reducible Bkg.	10 ± 6	0.8 ± 0.4	$0.012^{+1.6}_{-0.012}$
Total Bkg.	50 ± 8	3.1 ± 1.0	$6.1^{+2.0}_{-1.2}$
Data	48	4	4
SUSY Ref. Point 1	13.9 ± 1.0	11.4 ± 0.9	0.5 ± 0.1
SUSY Ref. Point 2	0.9 ± 0.1	0.3 ± 0.1	8.0 ± 0.6
Visible σ (exp)	< 1.5 fb	< 0.4 fb	< 0.5 fb
Visible σ (obs)	< 1.3 fb	< 0.5 fb	< 0.4 fb



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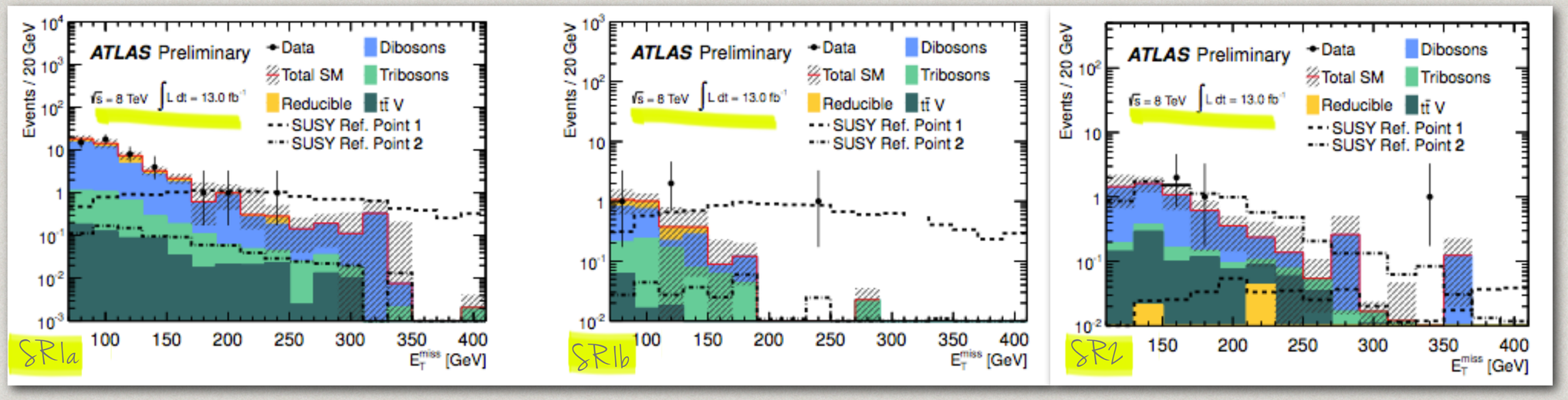

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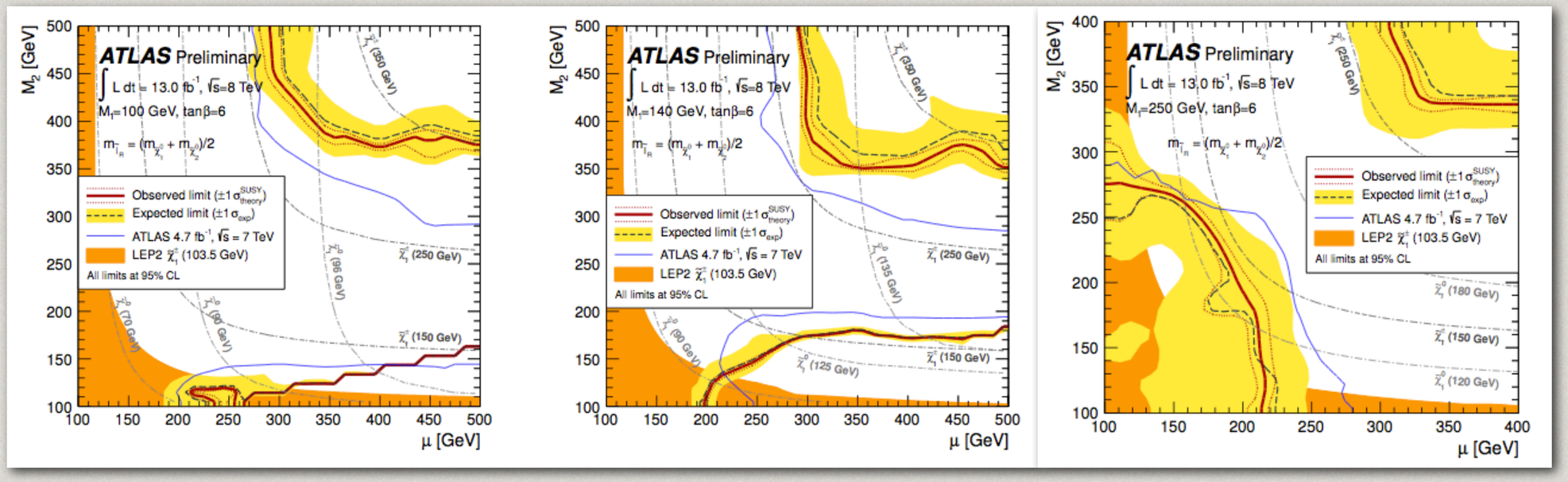

pMSSM limits

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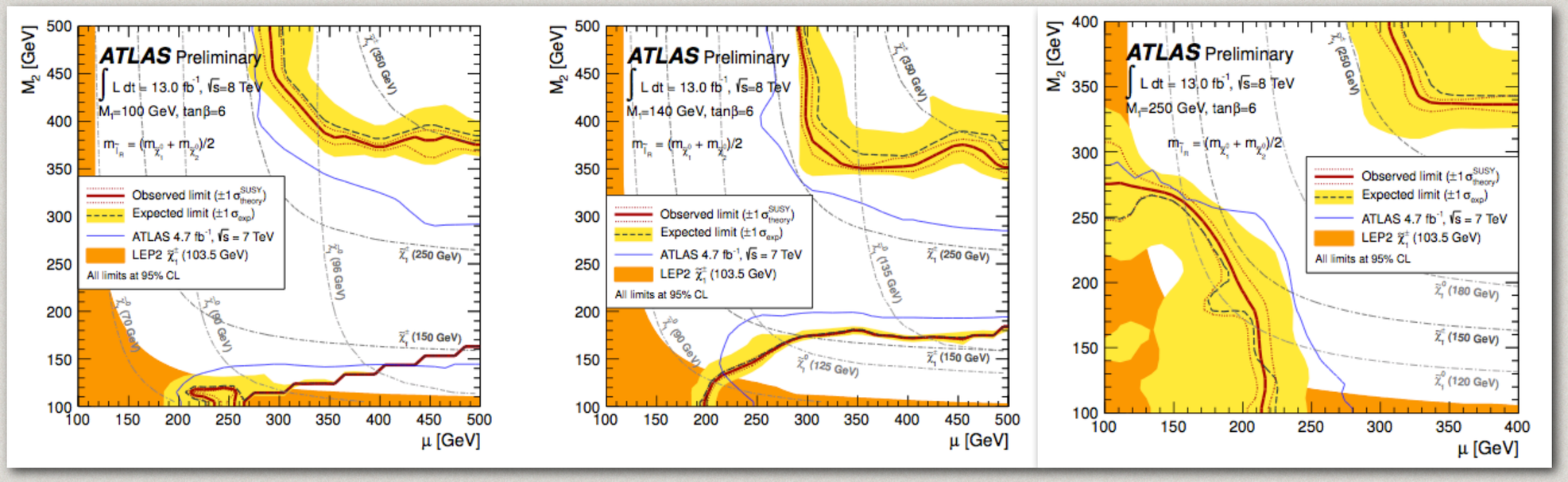

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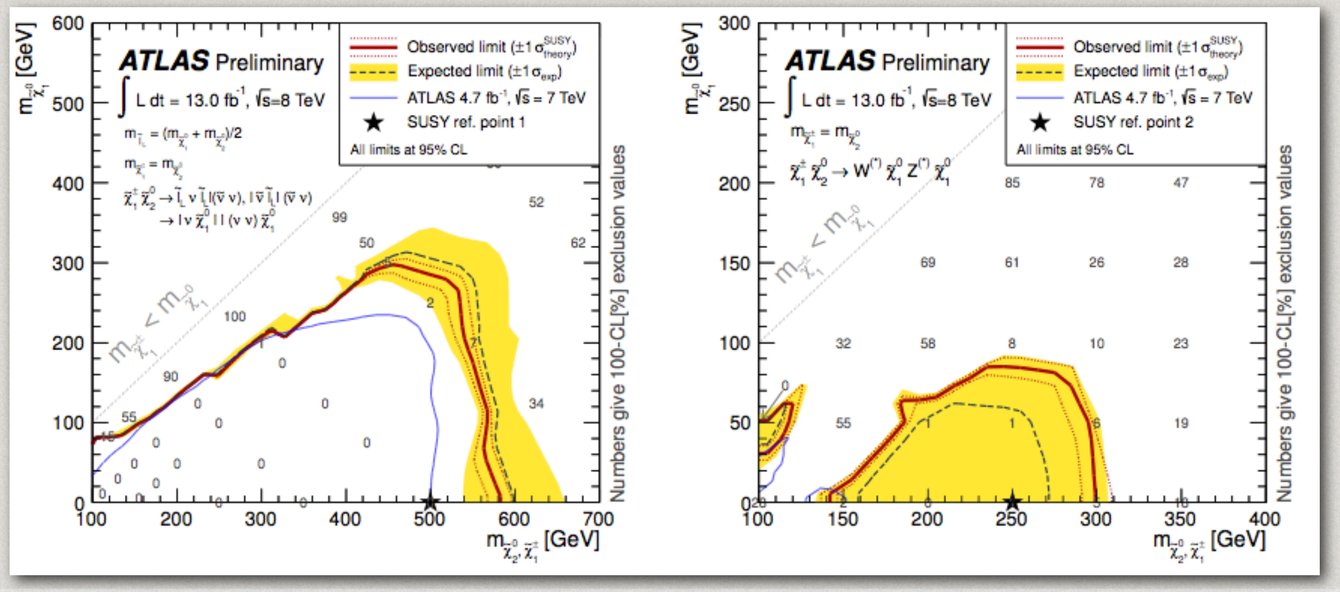
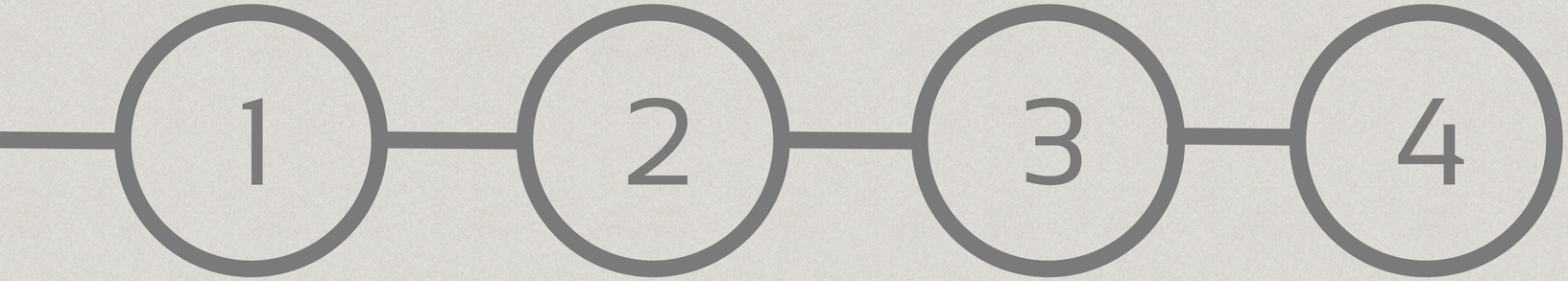


simplified model limits

Outline



INTRO

SUSY, ATLAS

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What are we looking for?

SEARCHES 1

Strong Production

SEARCHES 2

EWK Production

Outline

1	2	3	4	5
INTRO	SETUP	SEARCHES 1	SEARCHES 2	SEARCHES 3
SUSY, ATLAS	What are we looking for?	Strong Production	EWK Production	What if...?

R-PARITY VIOLATION

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- R-parity: $R=(-1)^{3(B-L)+2S}$
- R-parity conservation
  - leads to stable LSP
- However, this is merely an auxiliary assumption.
  - Proton decay constraints simultanous violation of lepton and baryon number.

$$W_{RPV} = \underbrace{\mu_i H_u L_i + \frac{1}{2}\lambda_{ijk} L_i L_j E^c_k + \lambda'_{ijk} L_i Q_j D^c_k}_{\text{L Violating}} + \underbrace{\frac{1}{2}\lambda''_{ijk} U^c_i D^c_j D^c_k}_{\text{B Violating}}$$

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- scenario:
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  - expect decay into 2 charged leptons

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  - final state: 4L + MET
- define signal regions:

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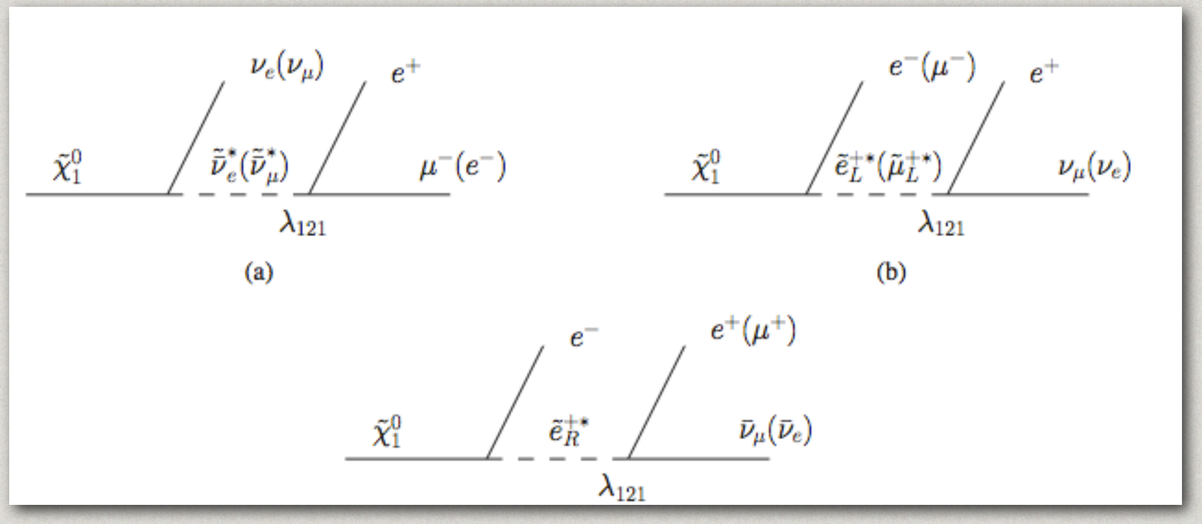

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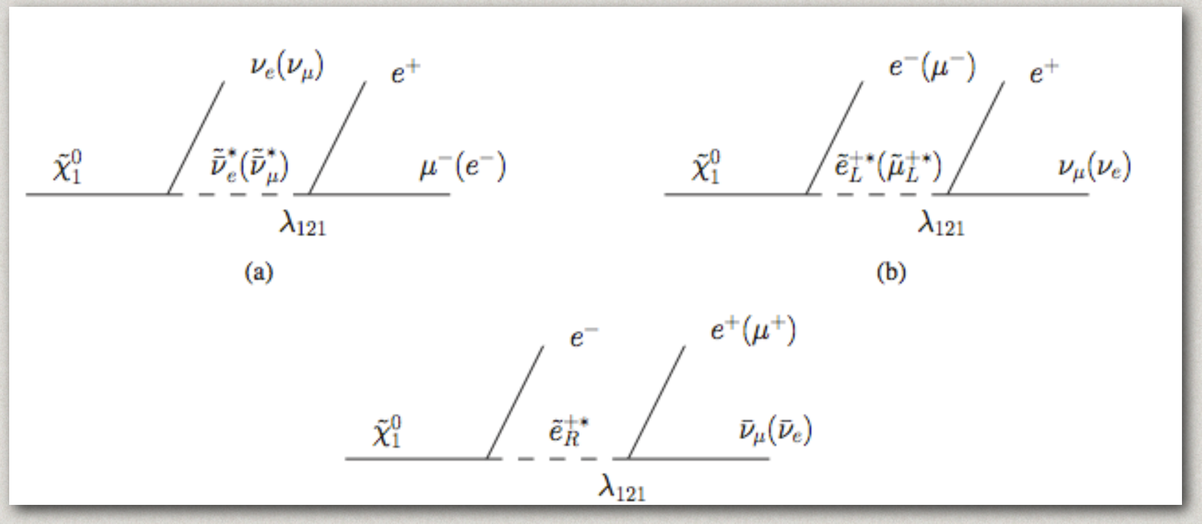

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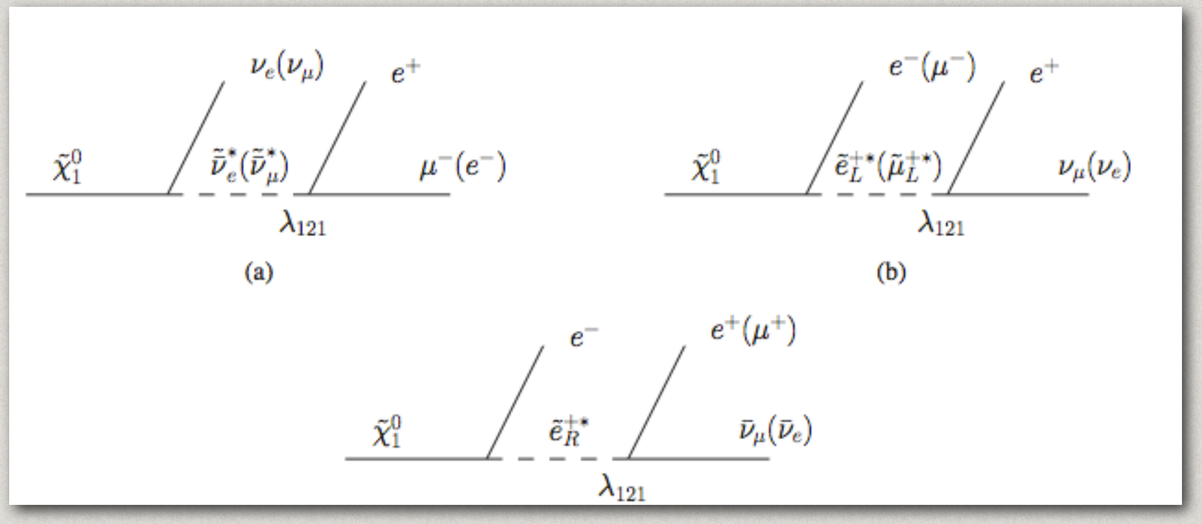

Selection	SR1	SR2	VR1	VR2	VR3
Number of leptons	≥ 4	≥ 4	3	≥ 4	≥ 4
SFOS pair	–	–	SFOS-veto	SFOS requirement	–
Z-candidate	Z-veto	Z-veto	Z-veto	Z requirement	Z-veto
$E_{\mathrm{T}}^{\mathrm{miss}}$/GeV	> 50	–	> 50	–	< 50
m_{eff}/GeV	–	> 300	–	–	< 300

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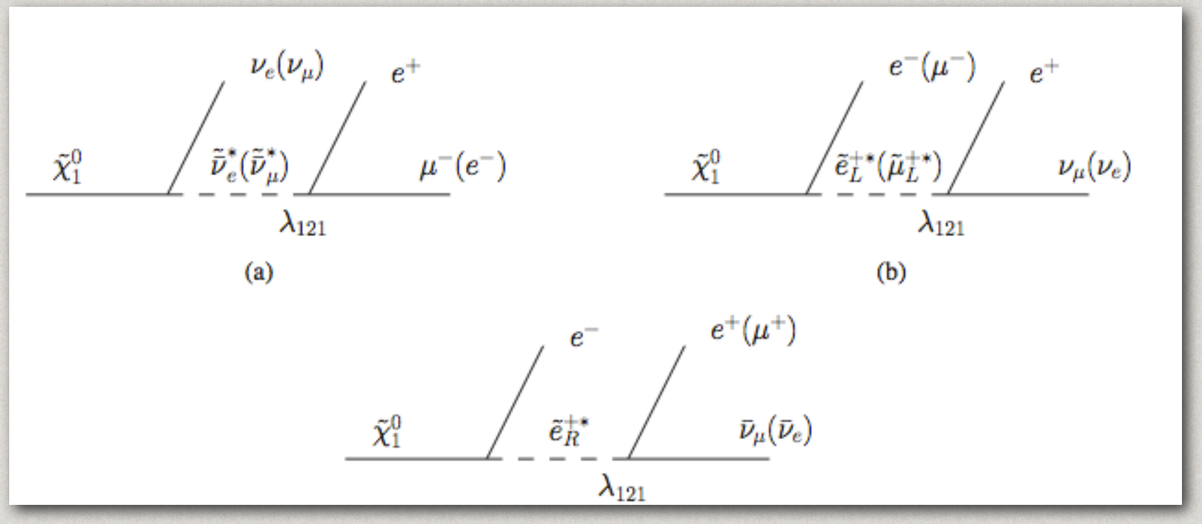

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$E_{\mathrm{T}}^{\mathrm{miss}}$/GeV	> 50	–	> 50	–	< 50
m_{eff}/GeV	–	> 300	–	–	< 300

- background sources:
  - WW, WZ, ZZ
  - ttbarW, ttbarWW, ttbarZ, Wγ, Zγ
  - WWW, ZWW
- reducible background:
  - 'fake' leptons from c-, b-decays

RPV SUSY SEARCH IN 4 LEPTON-FINAL STATES: RESULTS

RPV SUSY SEARCH IN 4 LEPTON-FINAL STATES: RESULTS

selected events @13fb^{-1}

Selection	SR1	SR2
ZZ	$0.07^{+0.22}_{-0.07}$	$1.0^{+0.4}_{-0.4}$
ZWW	$0.10^{+0.10}_{-0.10}$	$0.09^{+0.09}_{-0.09}$
$t\bar{t}Z$	$0.045^{+0.028}_{-0.028}$	$0.06^{+0.04}_{-0.04}$
$t\bar{t}WW$	$(6^{+6}_{-5})\times10^{-3}$	$(3.3^{+4.8}_{-3.3})\times10^{-3}$
Irreducible Bkg.	$0.22^{+0.27}_{-0.21}$	$1.1^{+0.5}_{-0.4}$
Reducible Bkg.	$0.028^{+0.107}_{-0.028}$	$0.10^{+0.14}_{-0.10}$
Total Bkg.	$0.25^{+0.29}_{-0.25}$	$1.2^{+0.5}_{-0.4}$
Data	1	2
p_0-value (σ)	0.037 (1.8)	0.16 (1.0)
σ_{vis} (exp)	<0.28 fb	<0.28 fb
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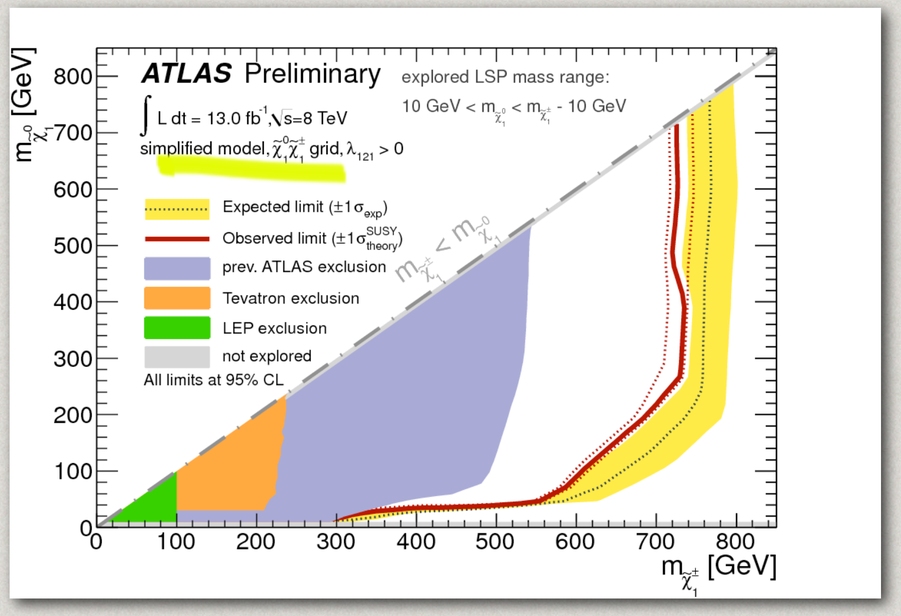

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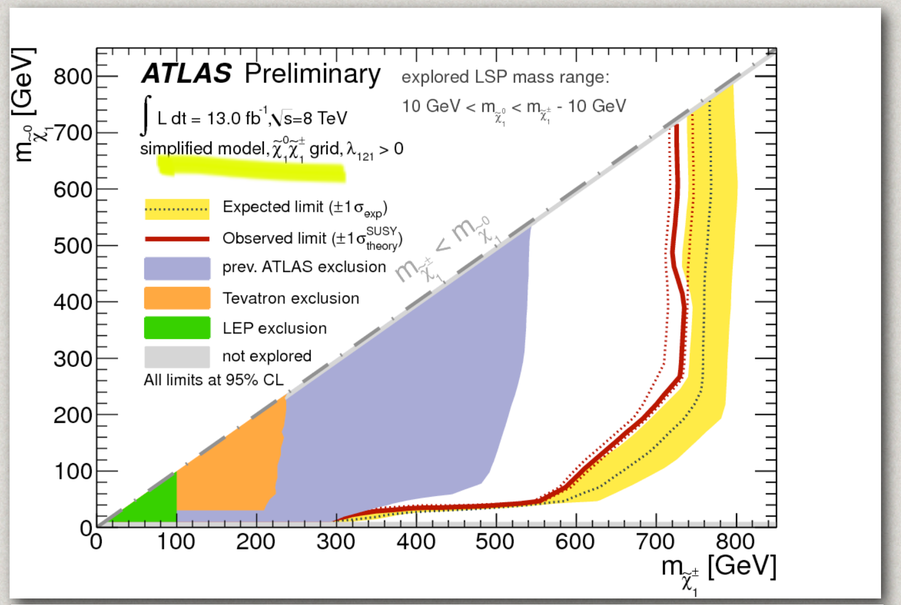

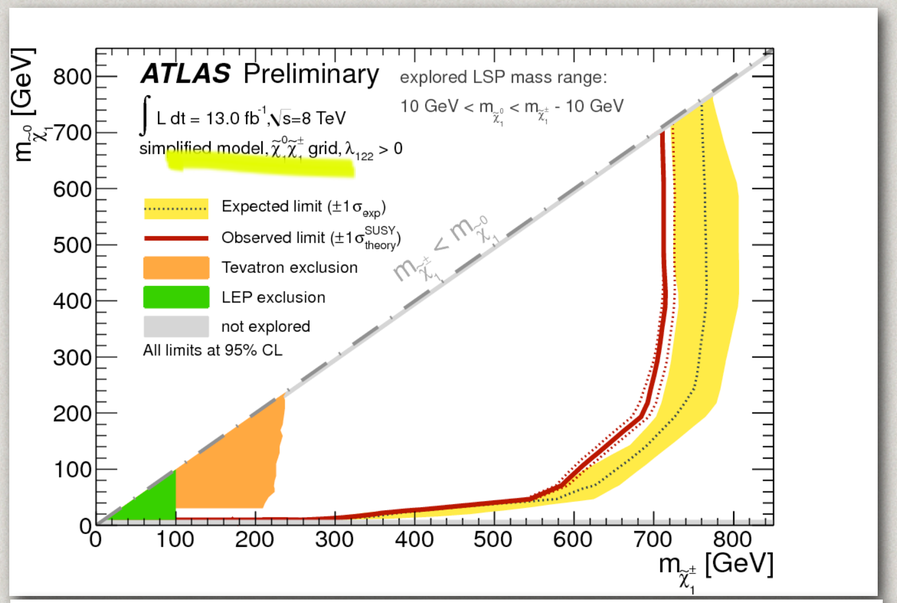

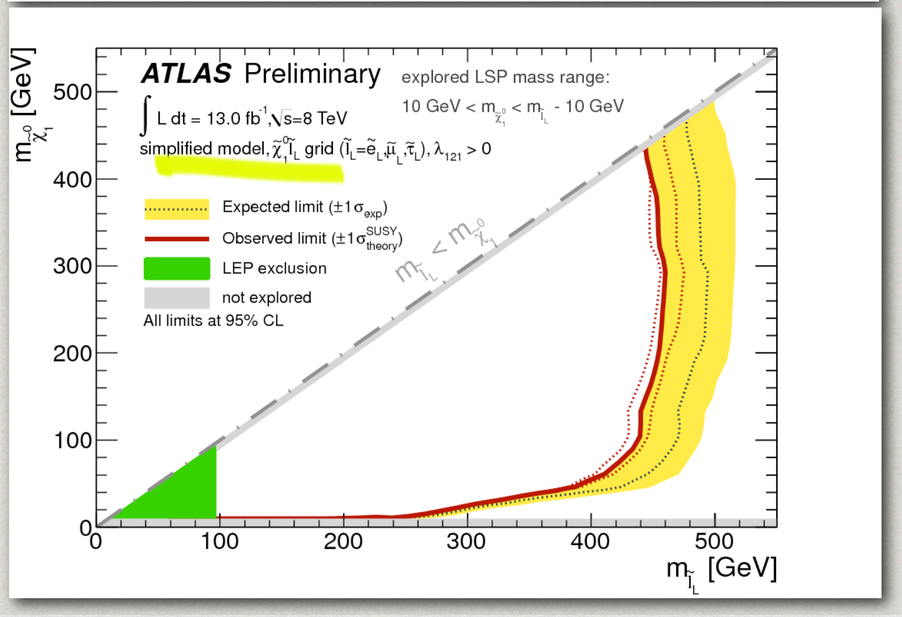

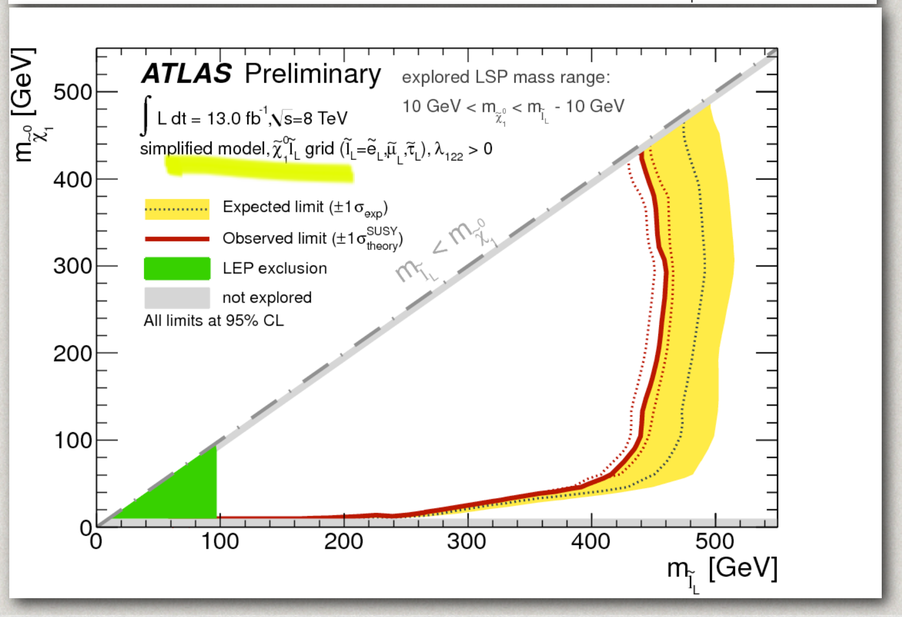

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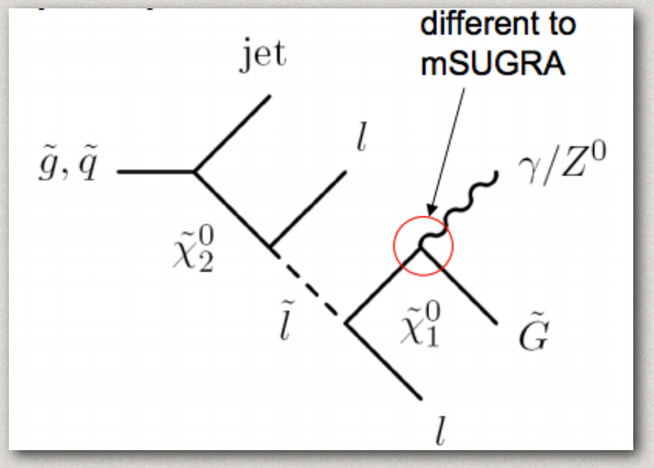

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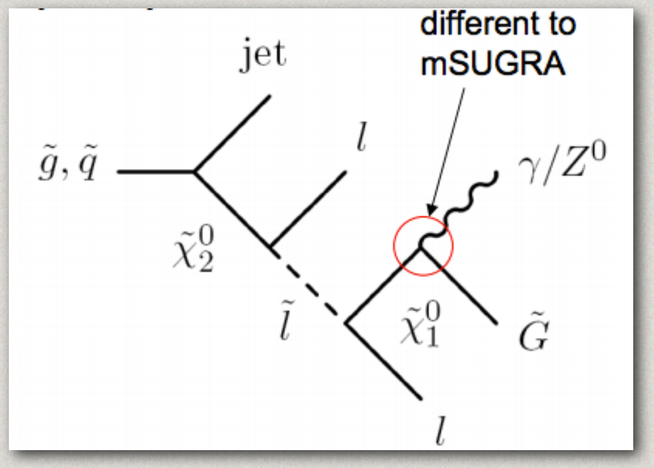

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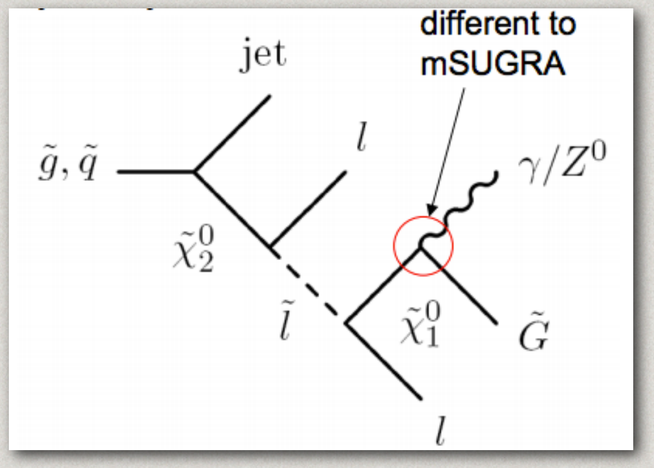

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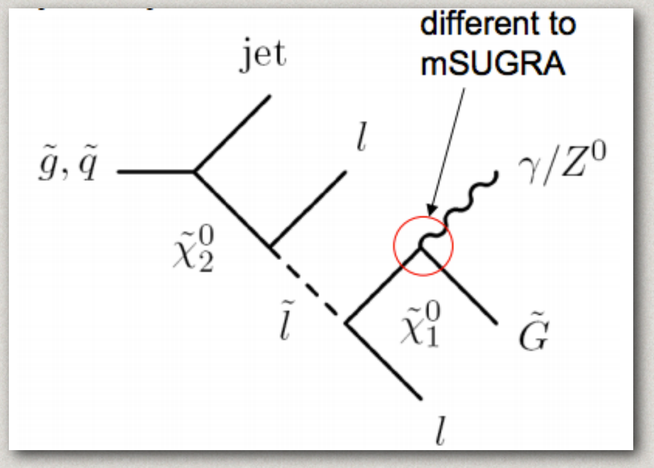

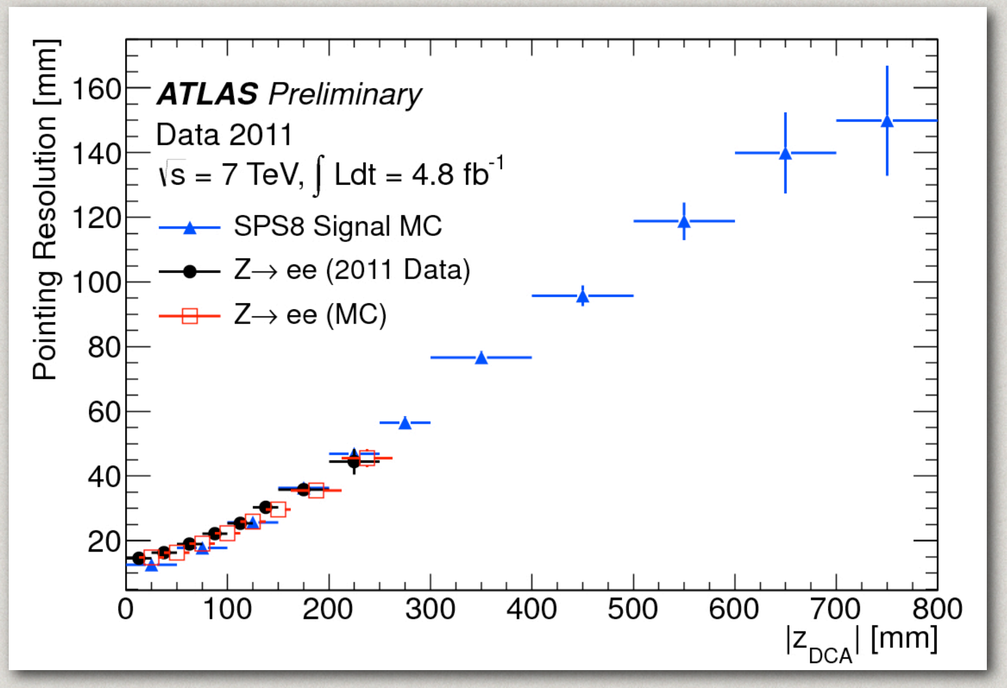

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τ (ns)	Λ (TeV)		
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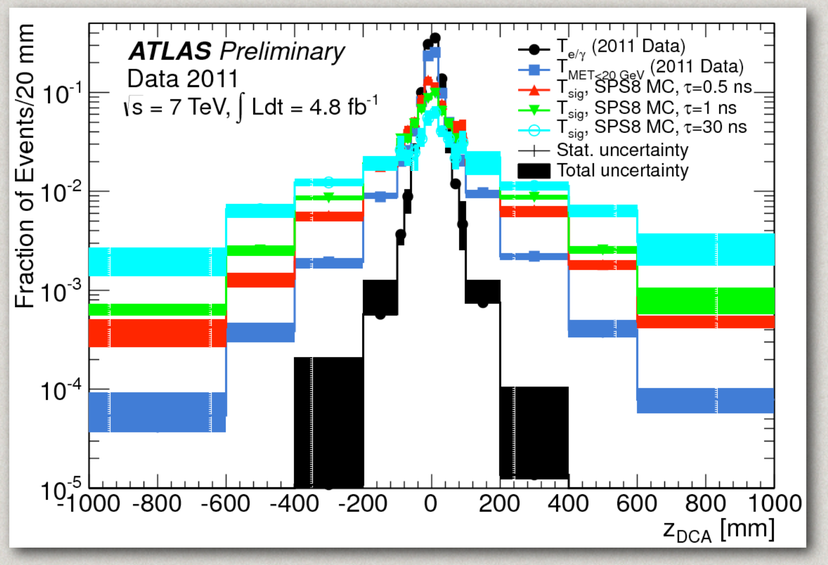

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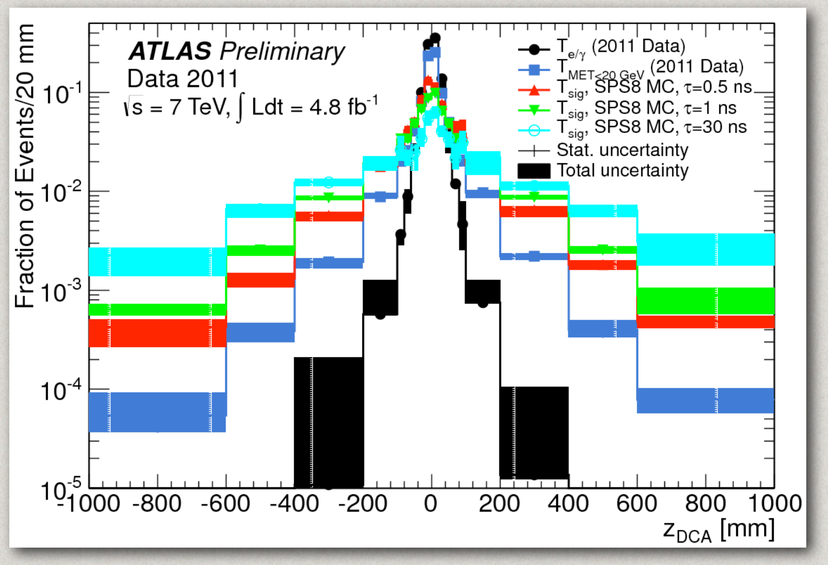
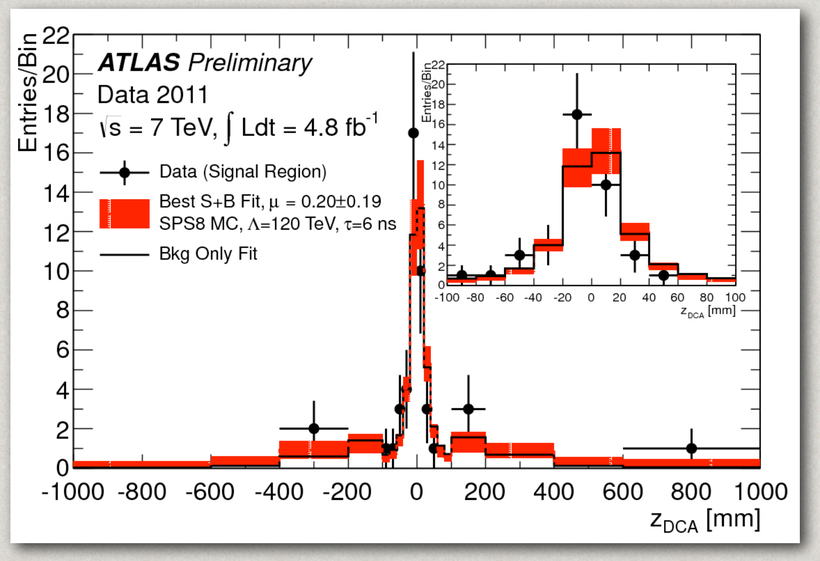


fit to data



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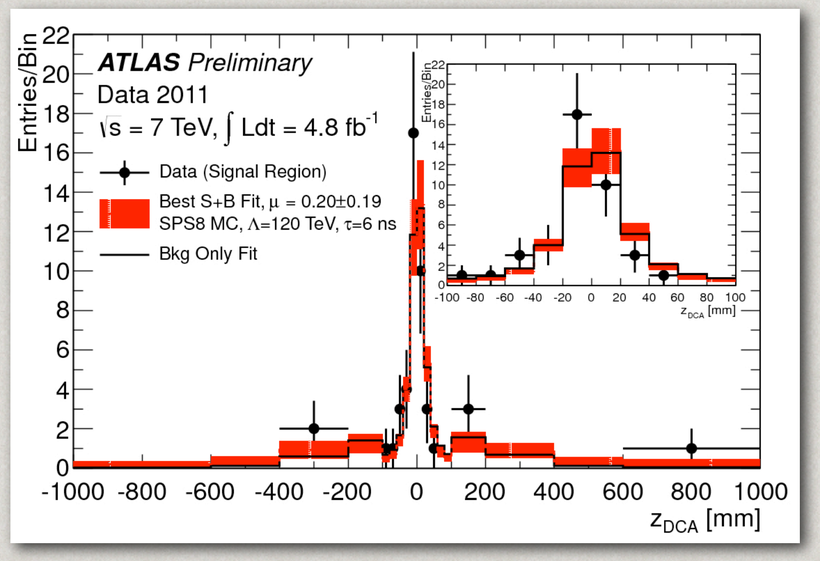

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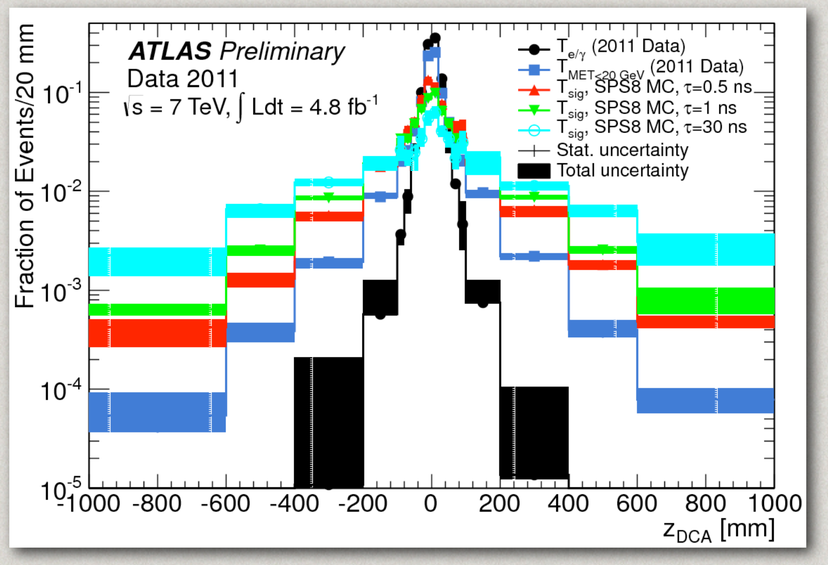

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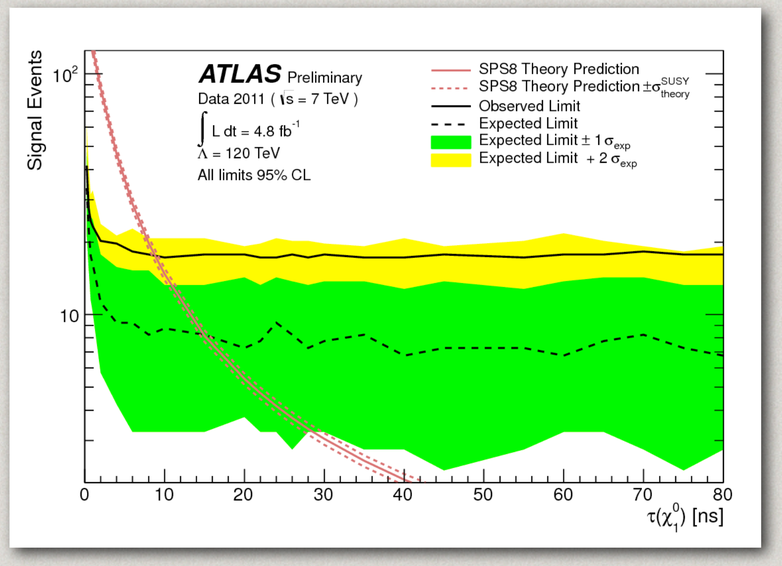

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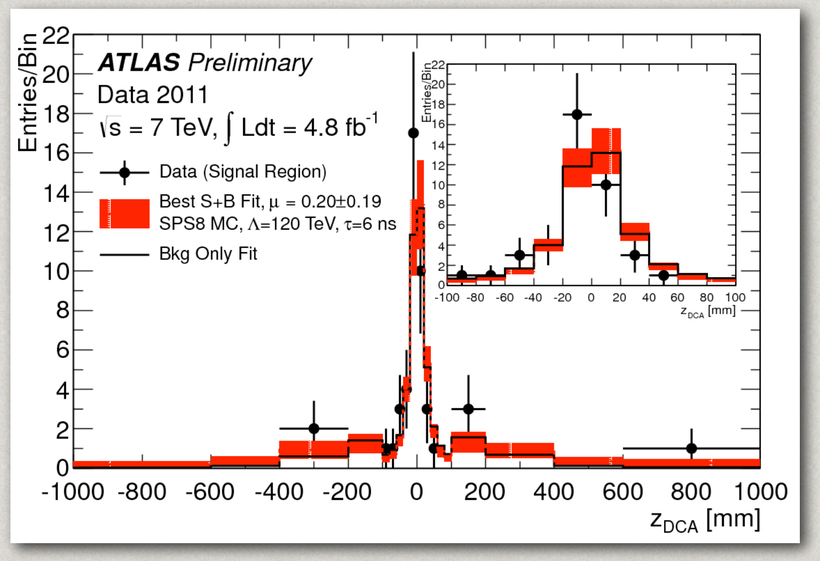

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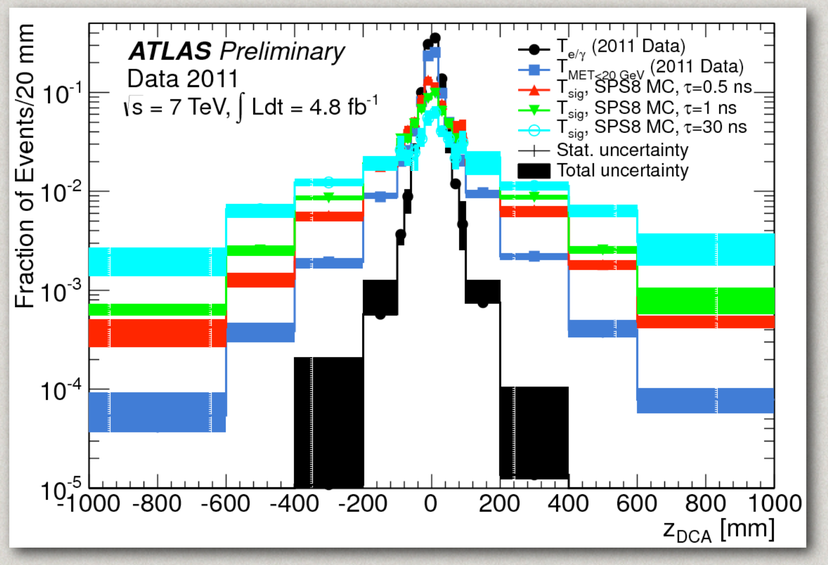

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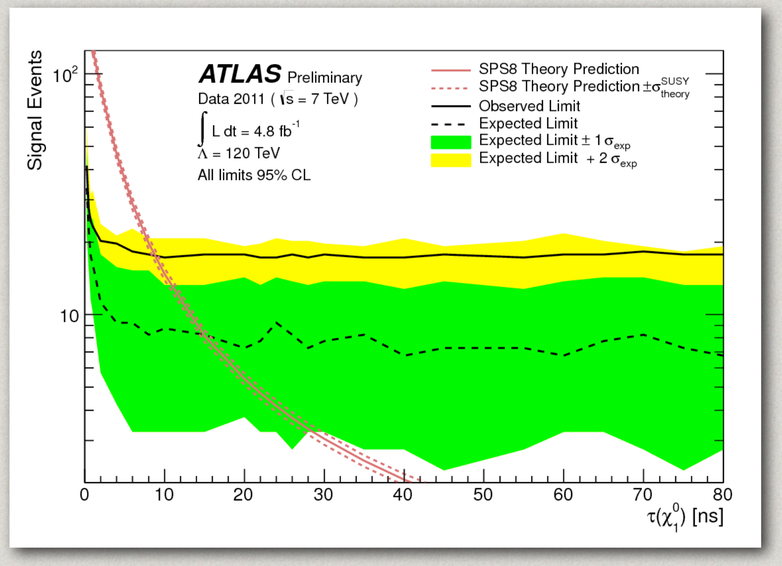

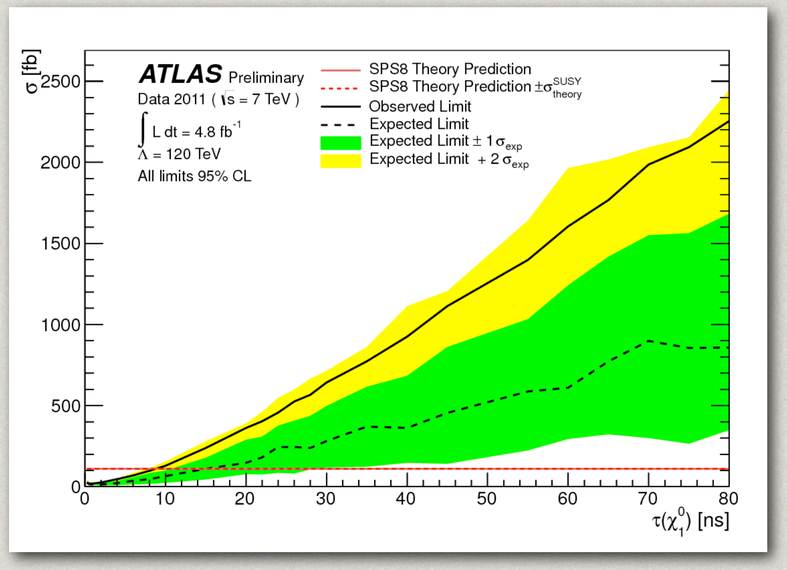

Outline

1	2	3	4	5
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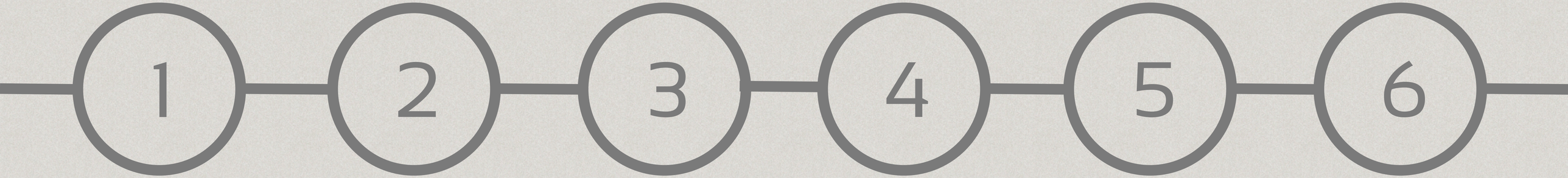

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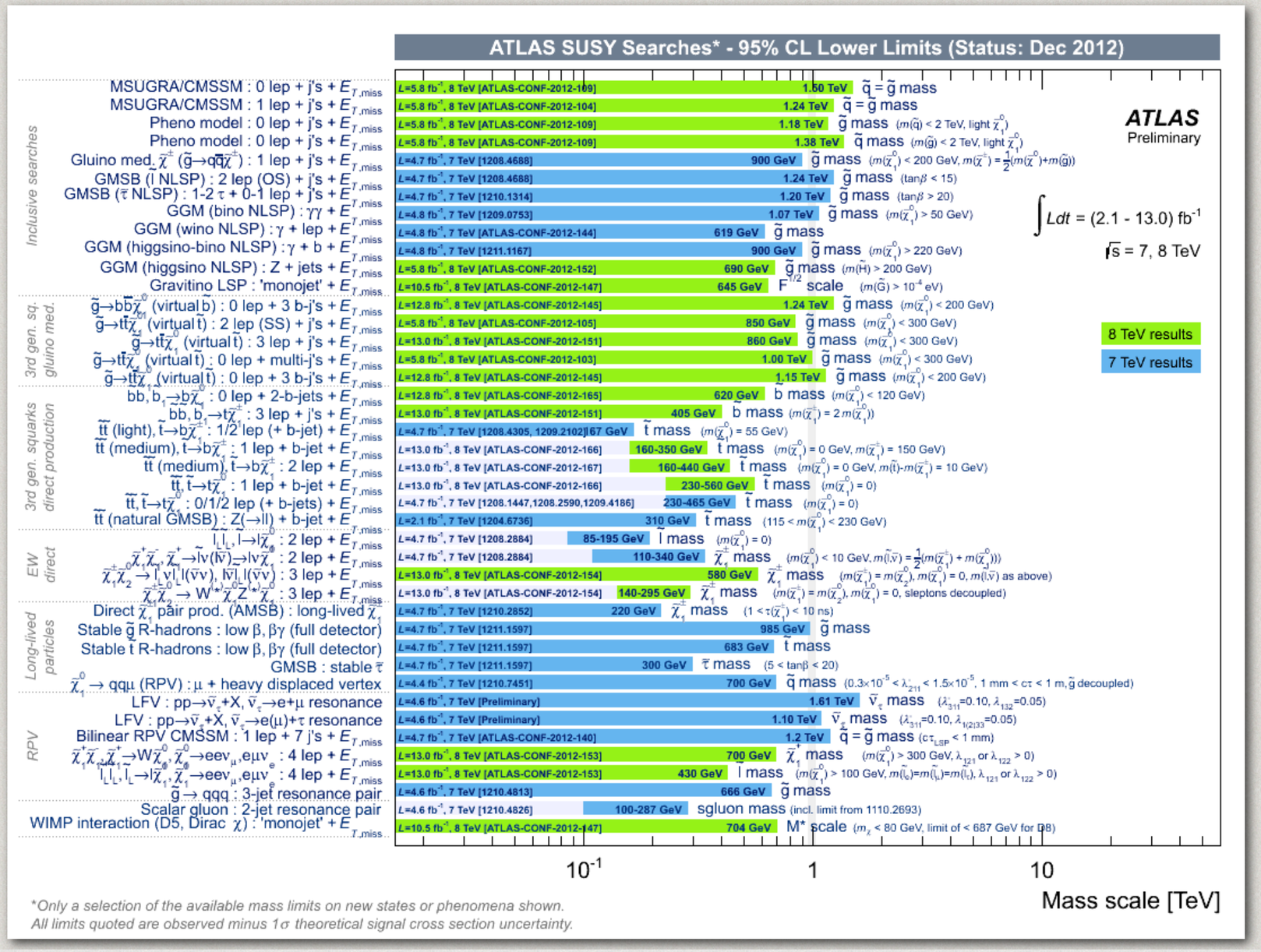

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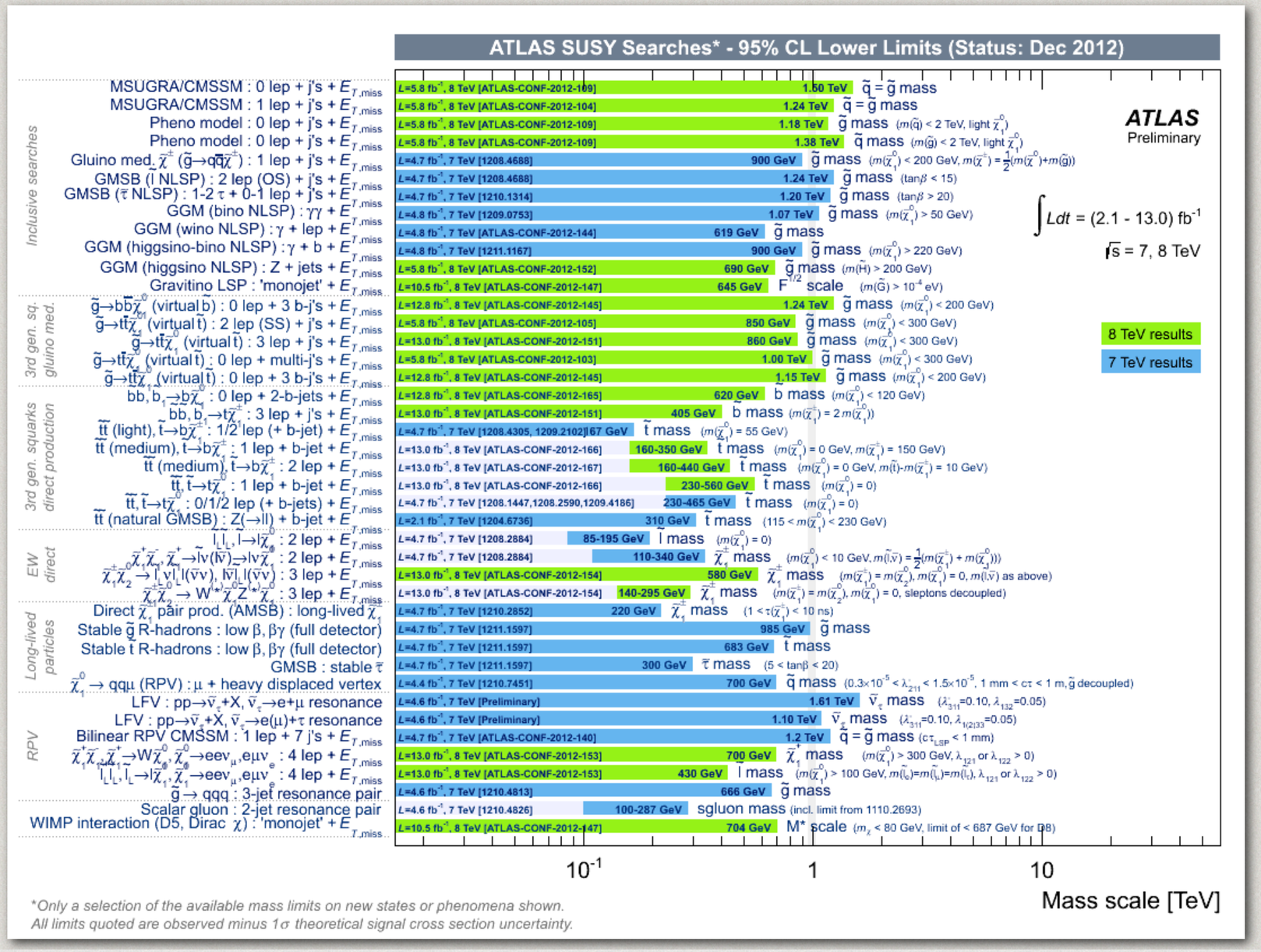

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probing new physics at the 1 TeV scale

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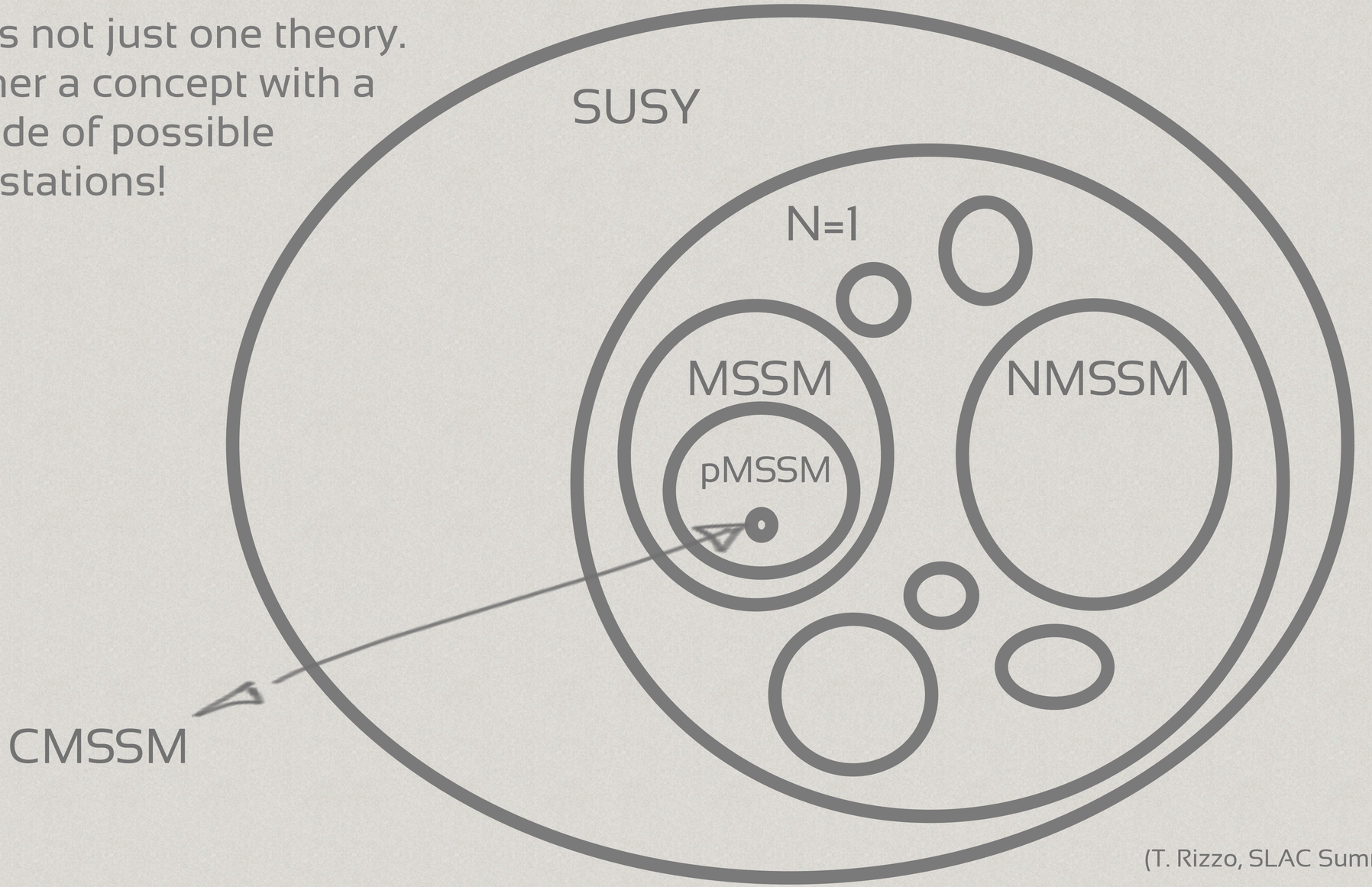

(T. Rizzo, SLAC Summer Institute, 2012)

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- No indication of supersymmetric partners of SM particles found.
- However, only small part of possible SUSY phase space has been explored.
  - Standard scenarios are probably hard to sustain.
  - But tests of more realistic (and more complicated) scenarios are on the way
  - ...and new analysis methods are investigated.
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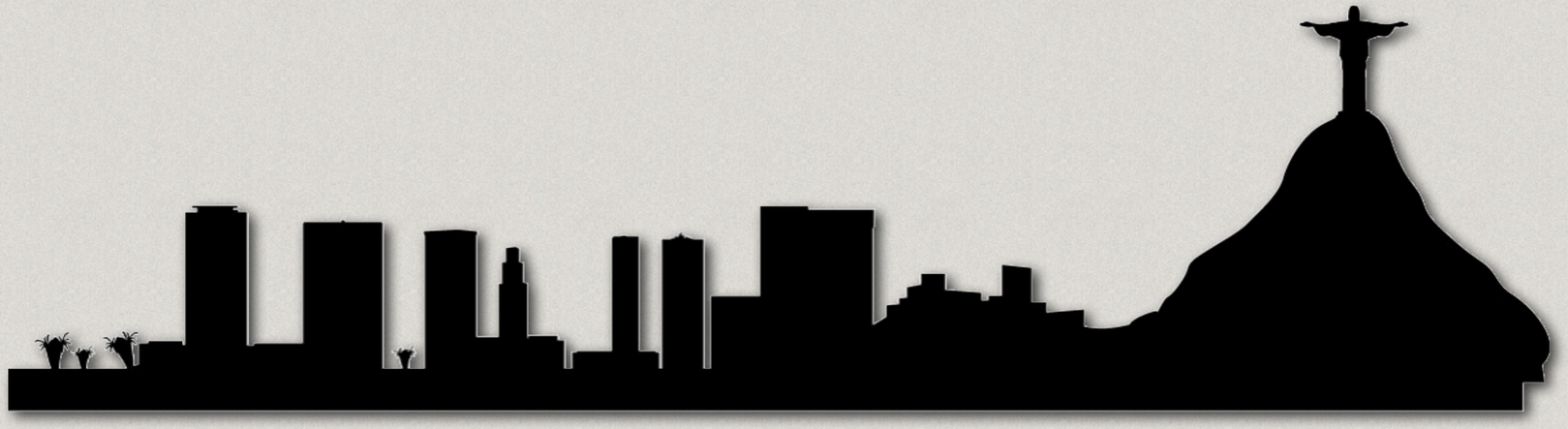
A big ‘Thank You’ to the organizers for putting together this interesting and wonderful conference!



Additional Information

SUSY AND A 125 GEV HIGGS - MORIOND NP SESSION

D. Denisov:

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D. Denisov:

- Due to 125 GeV Higgs, SUSY particles are multi-TeV and not yet probed directly.
- Phase space for SUSY is strongly constrained by direct and indirect searches.
- Input from other studies, like CDM searches, are important to take into consideration.
- It’s important to continue both indirect and direct searches, especially with 13 TeV energy.

THE ATLAS EXPERIMENT: DETAILS

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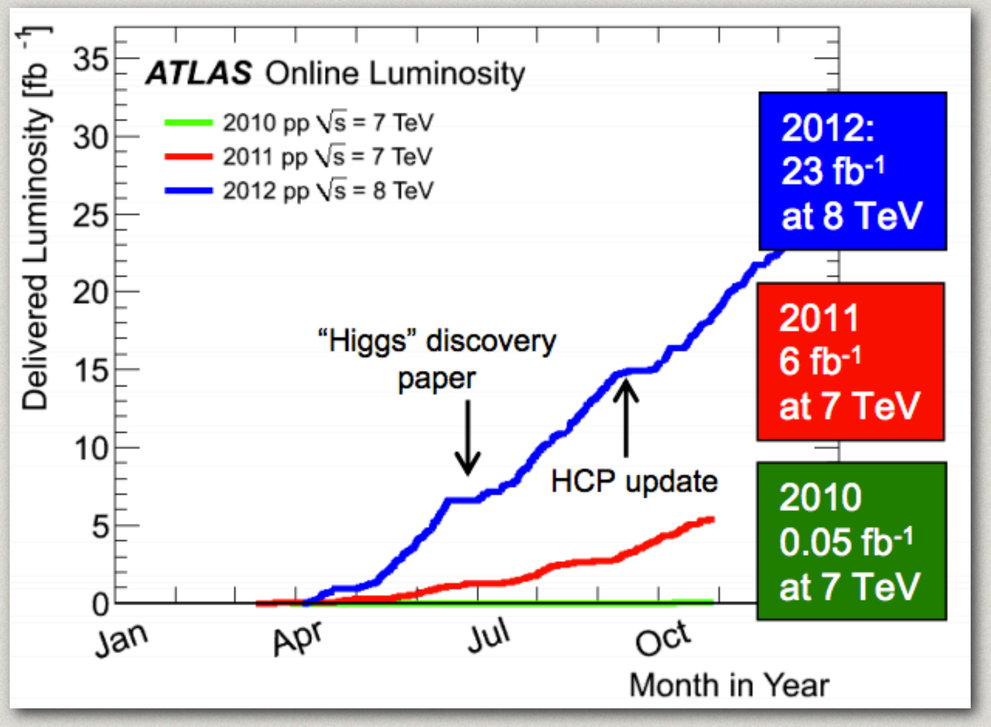
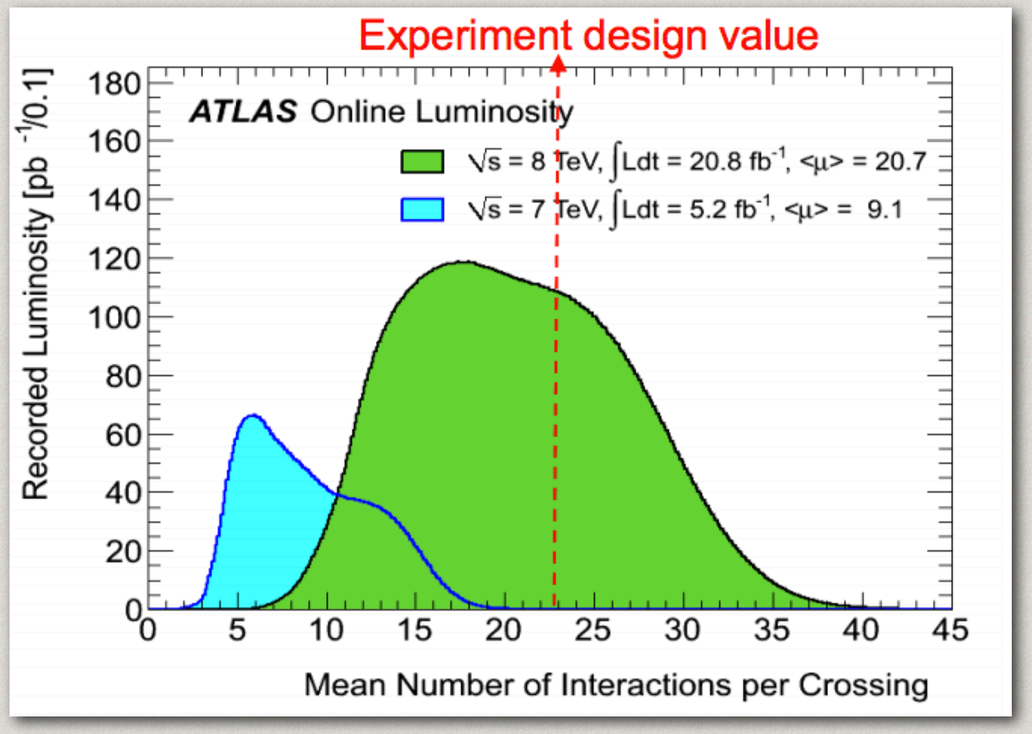
- inner detector with silicon pixel detector, silicon microstrip detector, and transition radiation tracker
- inside a 2T solenoid
- electromagnetic and hadronic calorimeters extend to $|\eta|<4.9$
- muon spectrometer within toroidal magnetic system $|\eta|<2.7$

DATA TAKING IN RETROSPECT

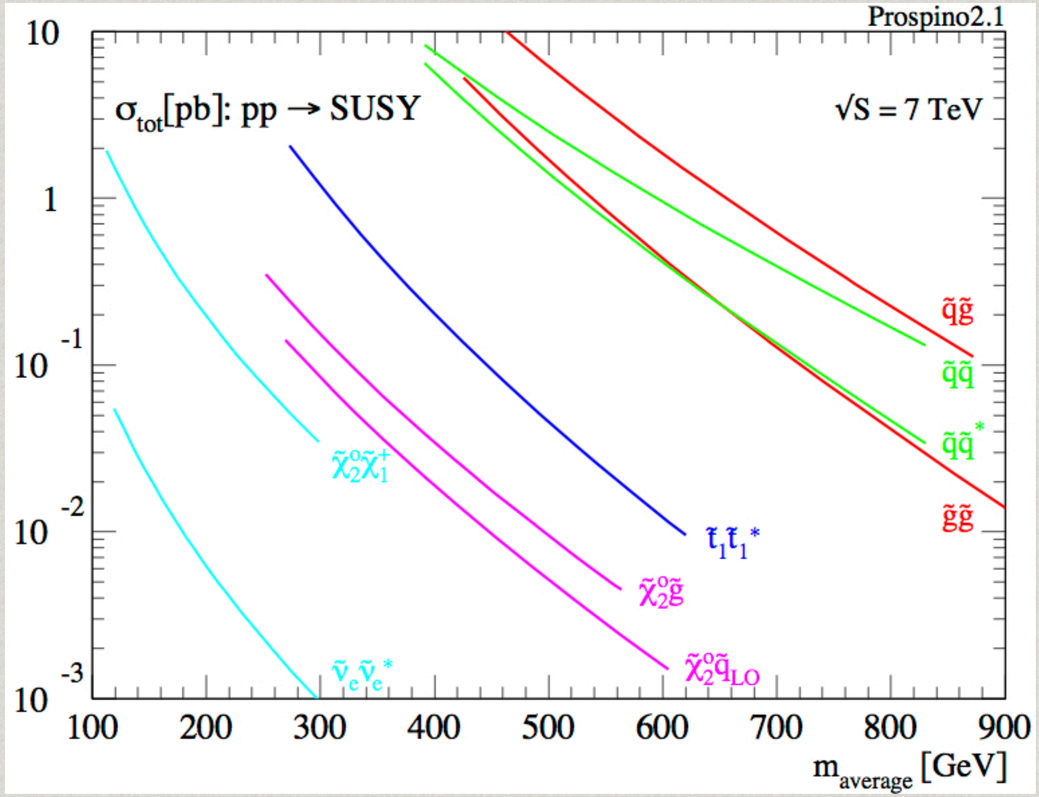


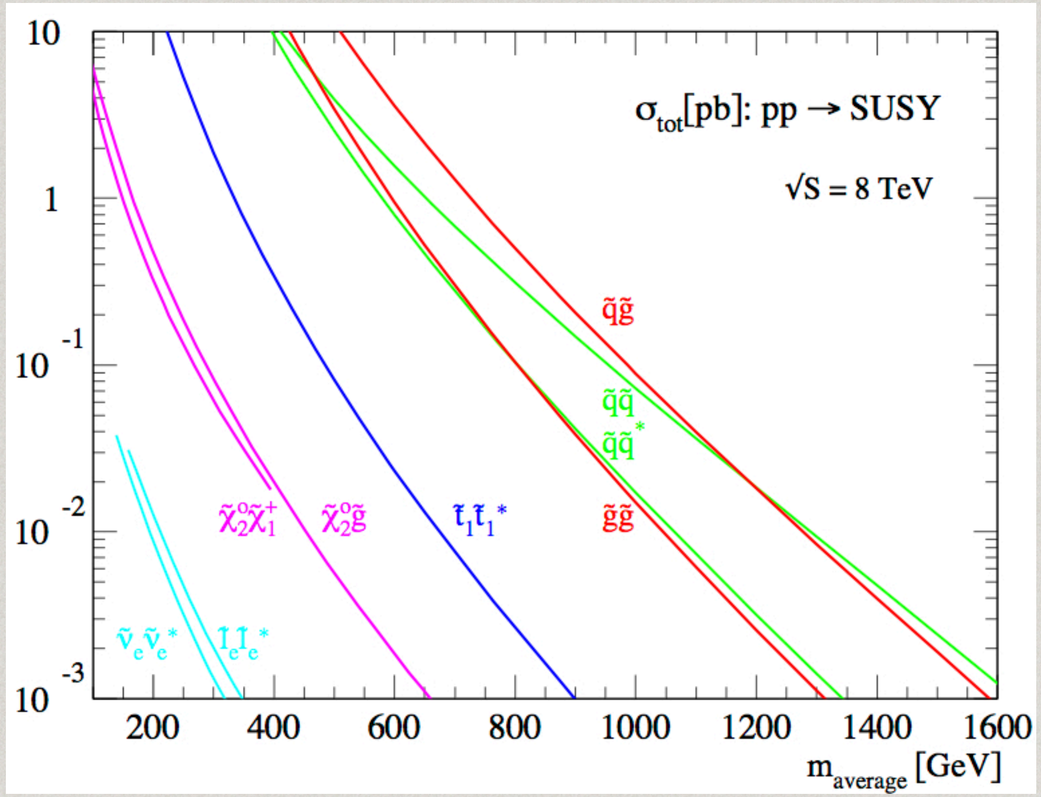


- peak luminosity: 7.7 x 10^{33} $cm^{-2}s^{-1}$
- 90% of delivered collisions used in analyses

- pile-up above design value
- challenge for trigger, computing, object ID, ...

CROSS-SECTIONS





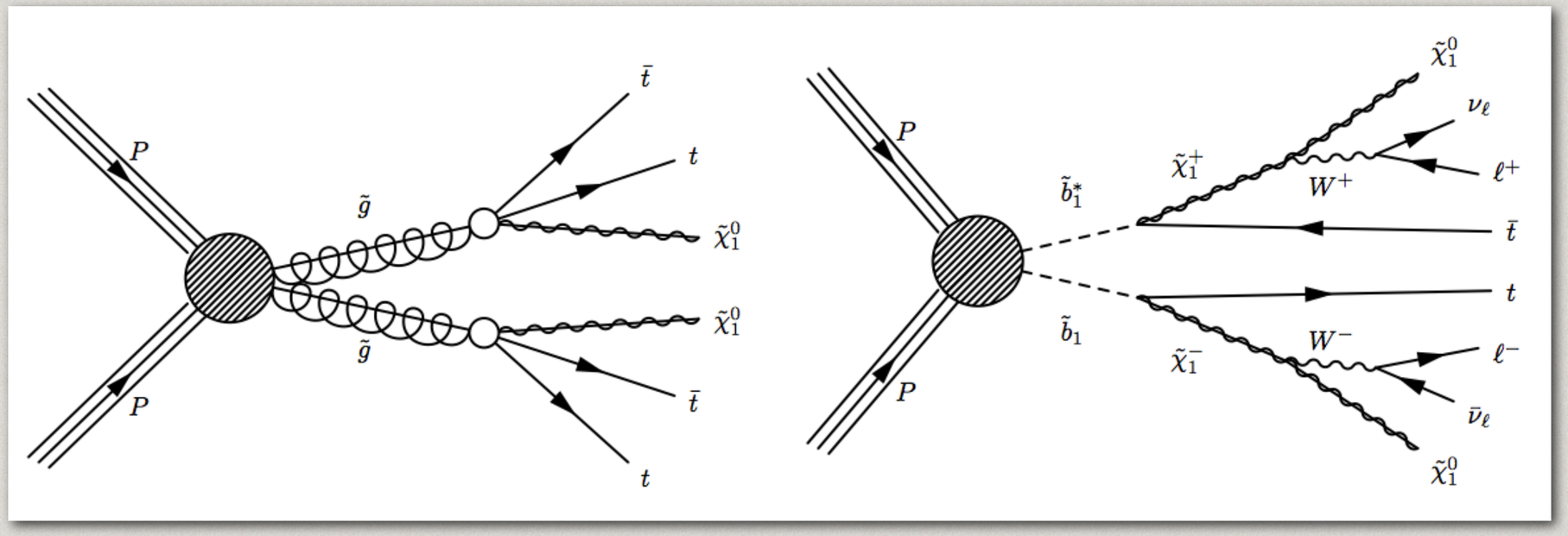
EFFECTIVE MASS AND TRANSVERSE MASS

- effective mass: scalar sum of transverse momenta
- transverse mass: $m_T = \sqrt{2p_{\mathrm{T}}^{\ell} E_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos[\Delta\phi(\ell, E_{\mathrm{T}}^{\mathrm{miss}})])}$
- ...

3rd GENERATION SQUARKS

Gluino-mediated stop production

Direct sbottom production



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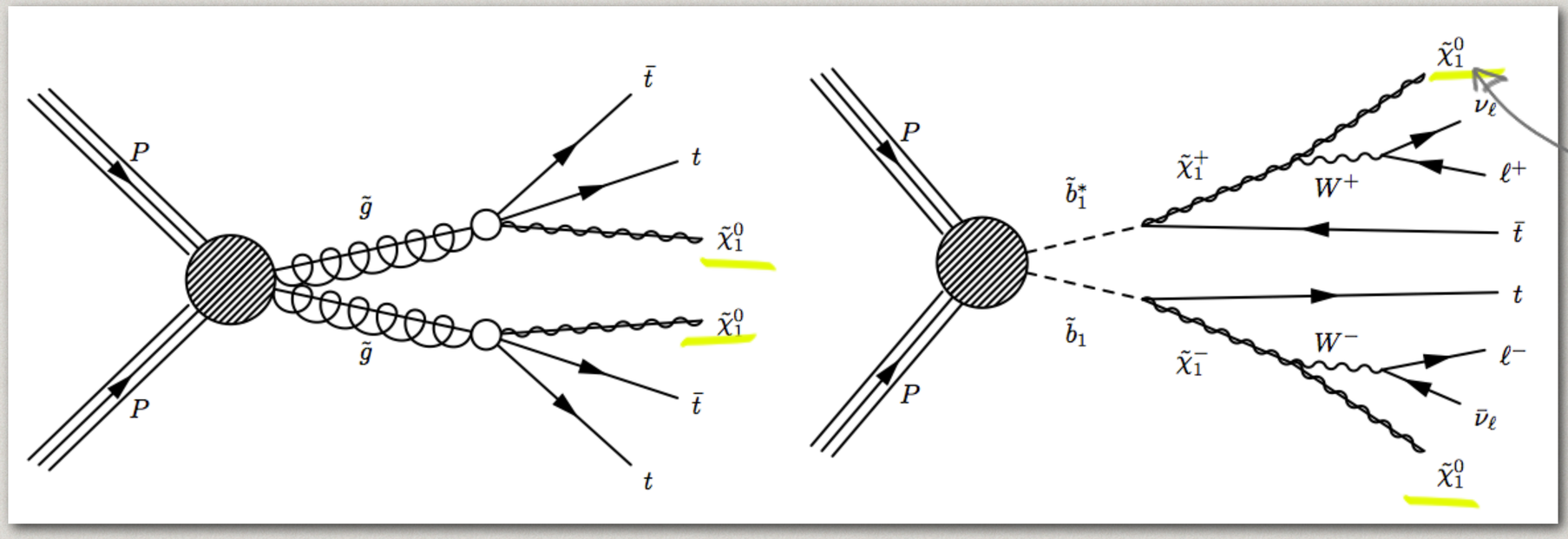

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  - 3 or more leptons (e, μ)
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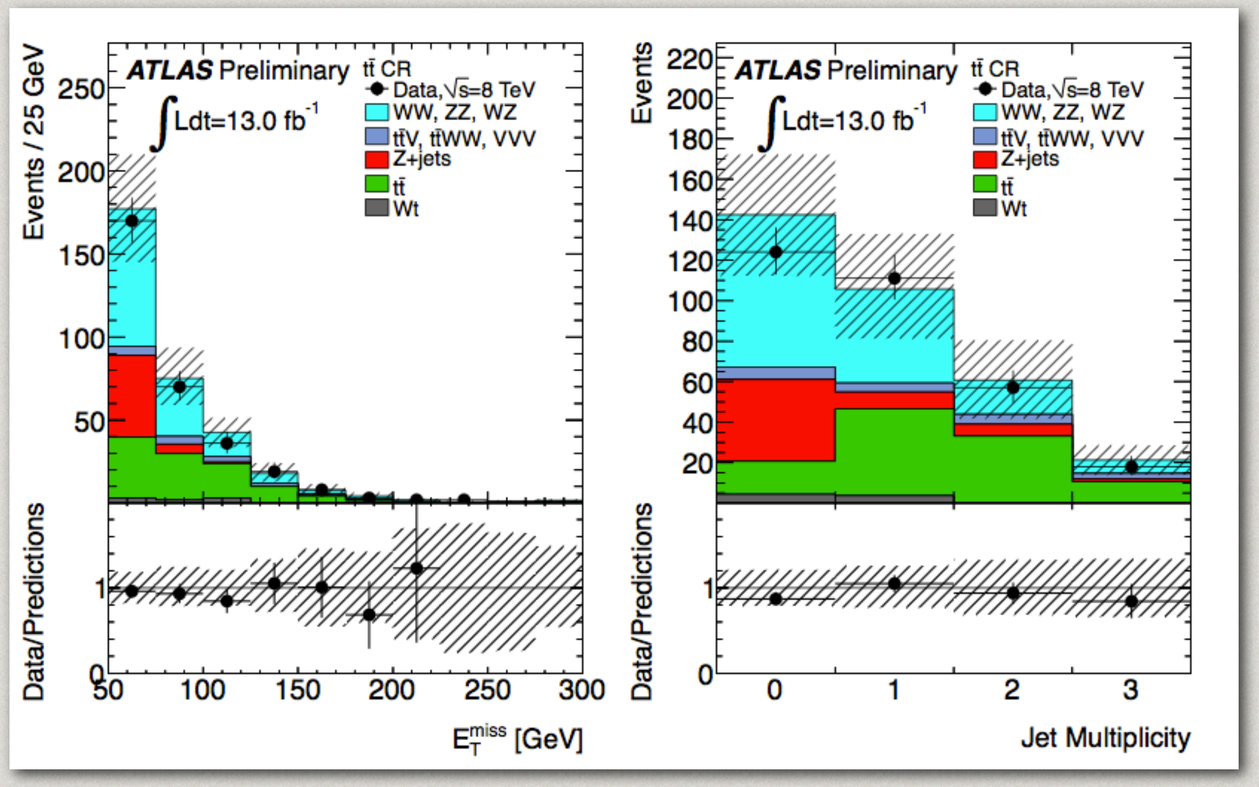

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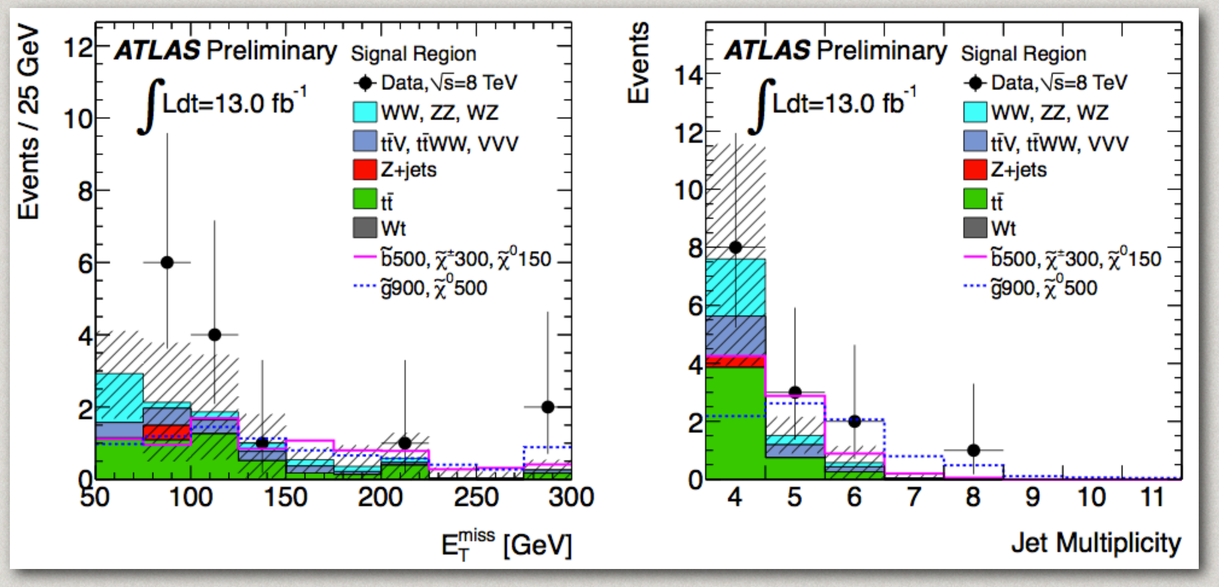

no excess in data

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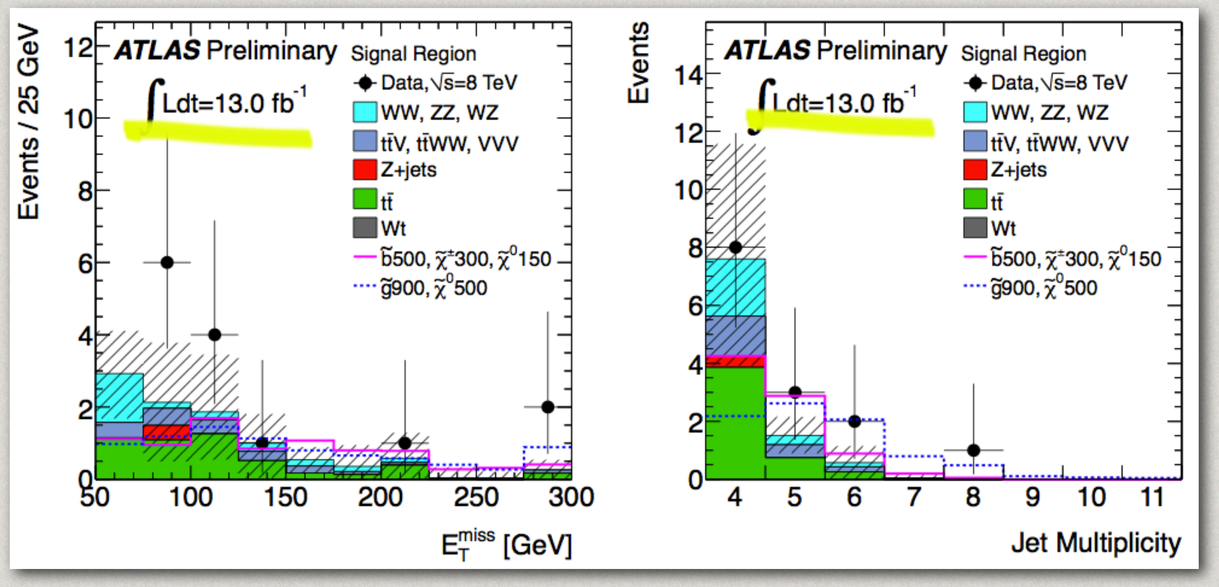

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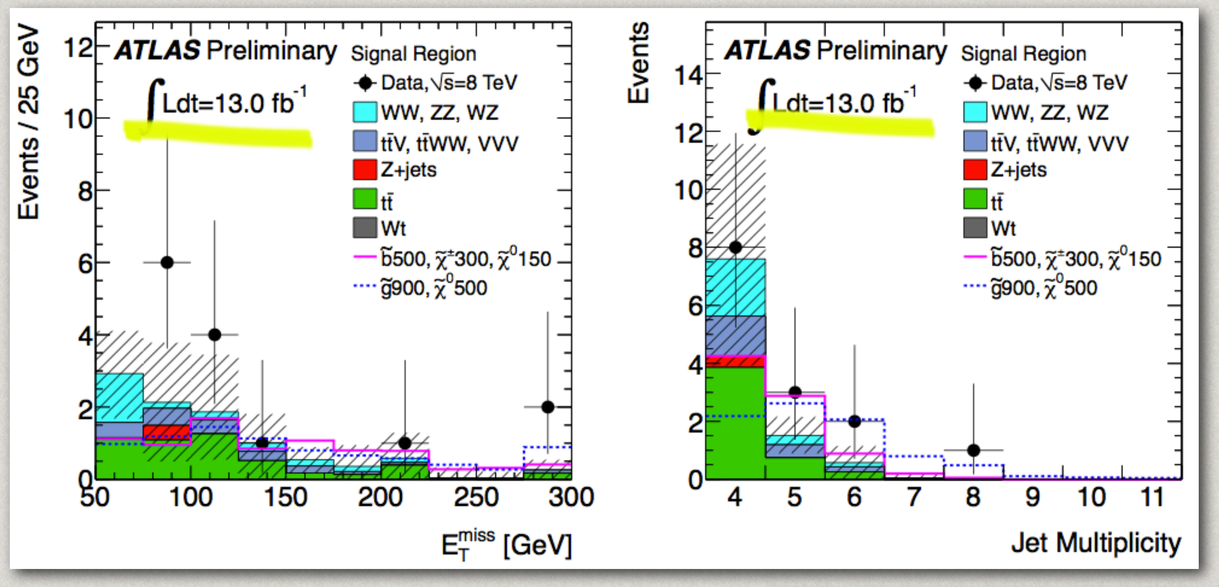

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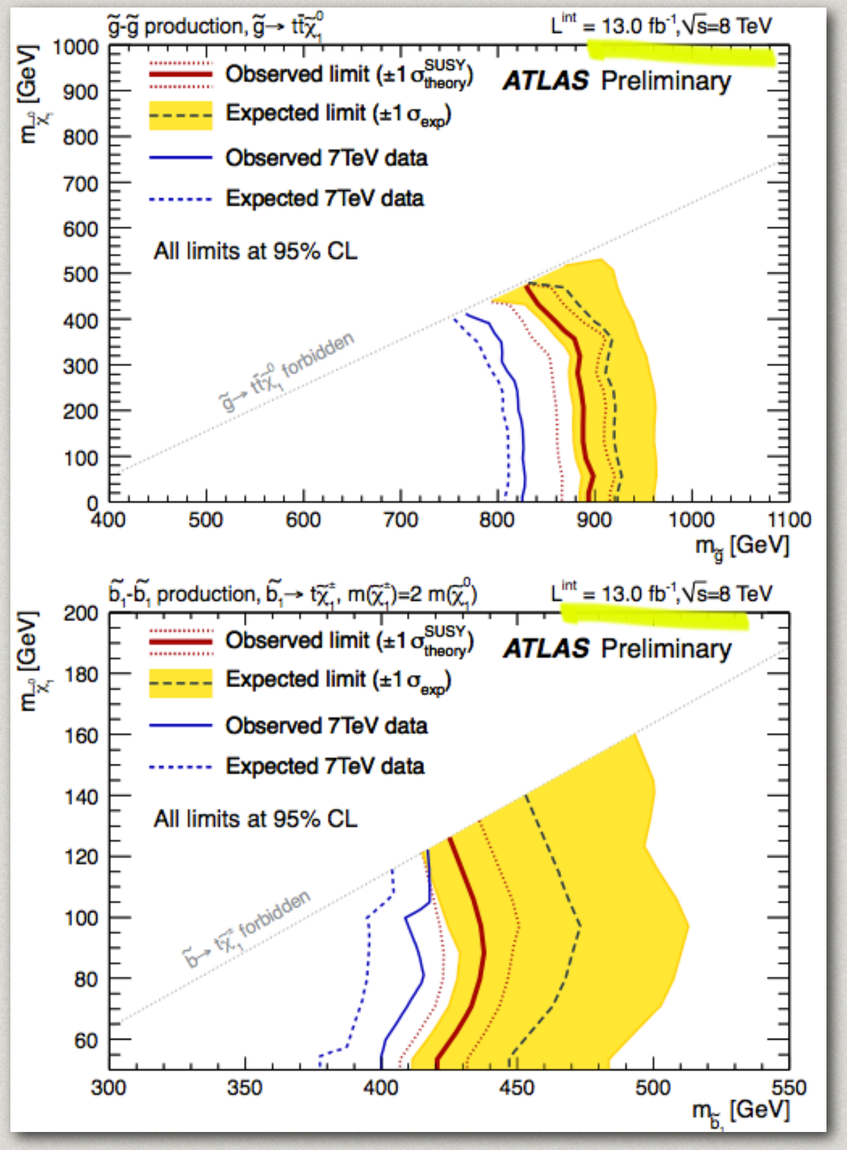

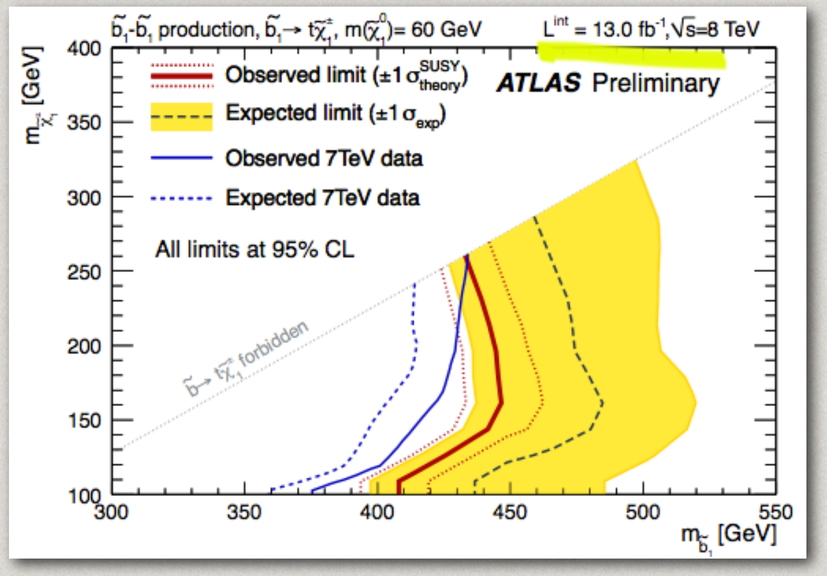

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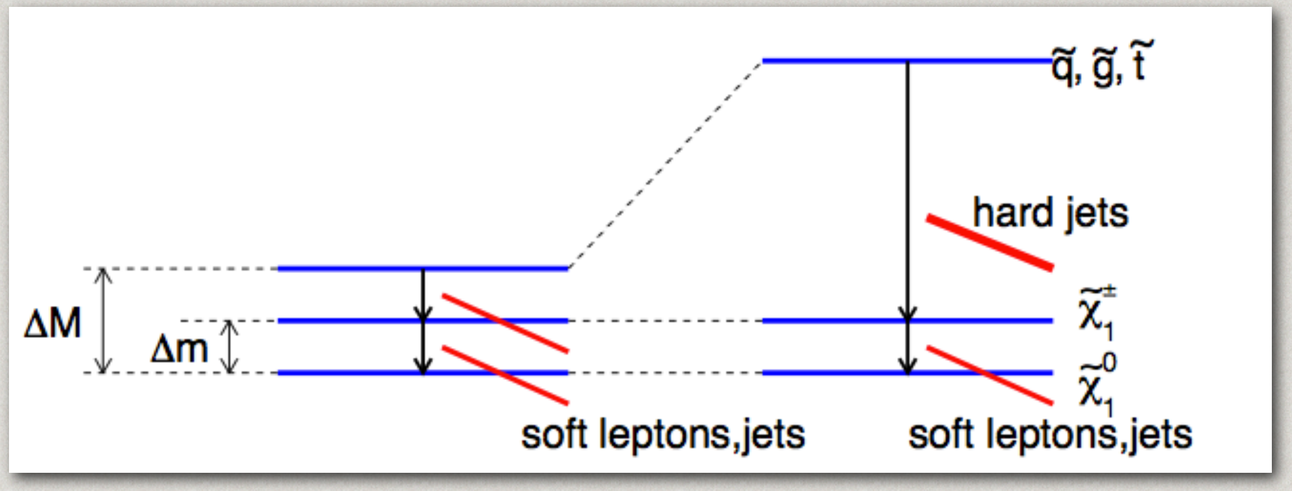

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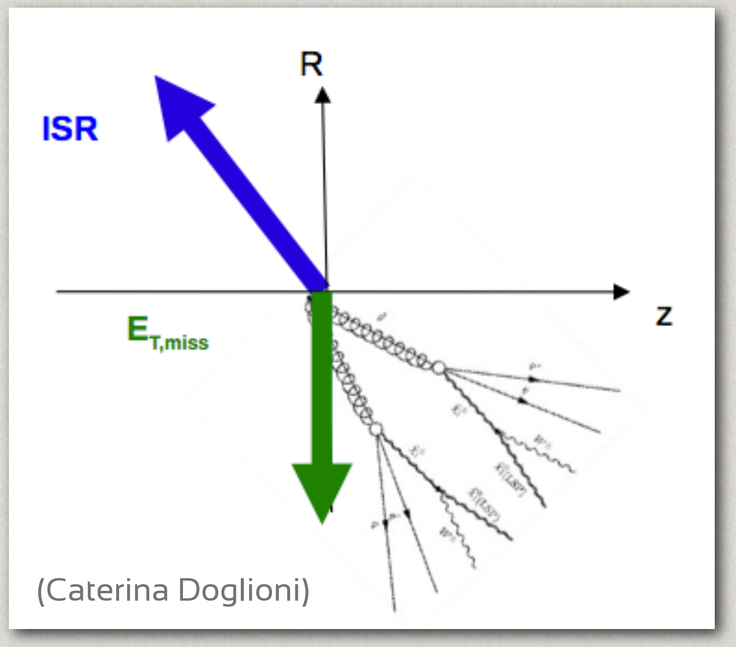
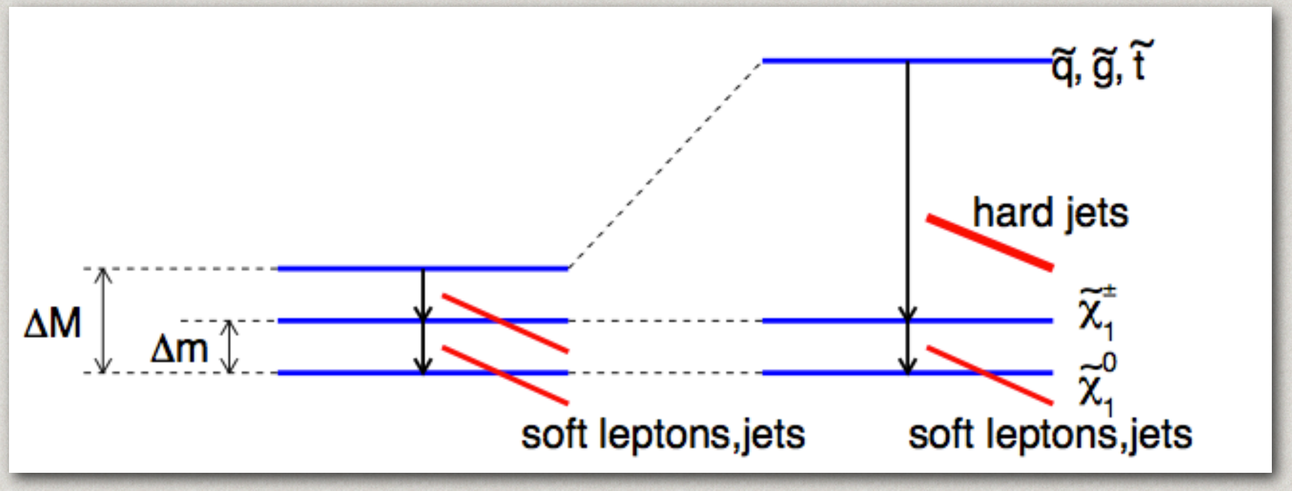


(Caterina Doglioni)



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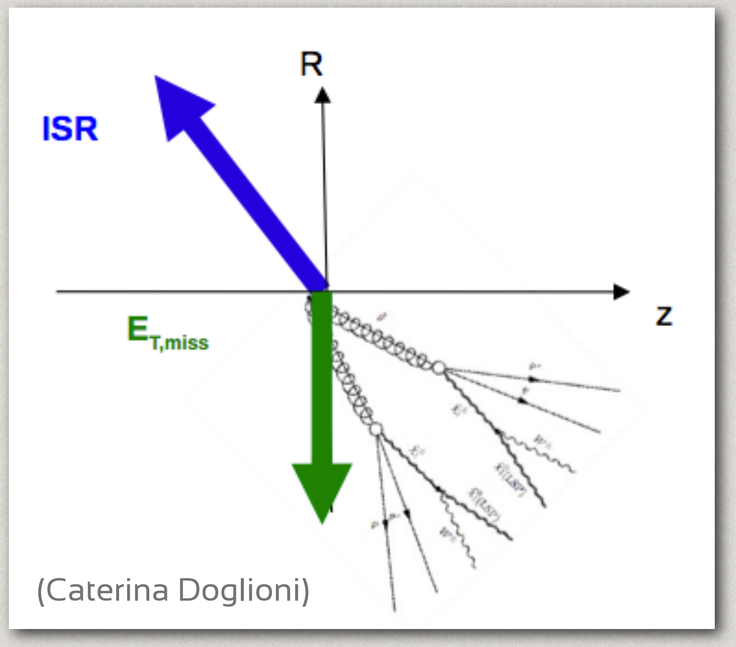

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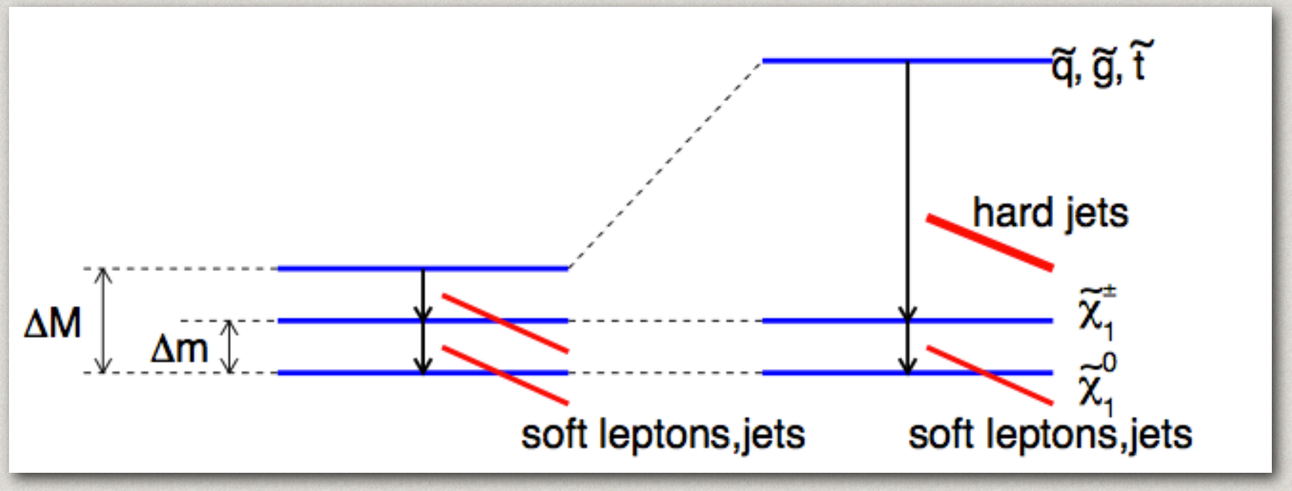

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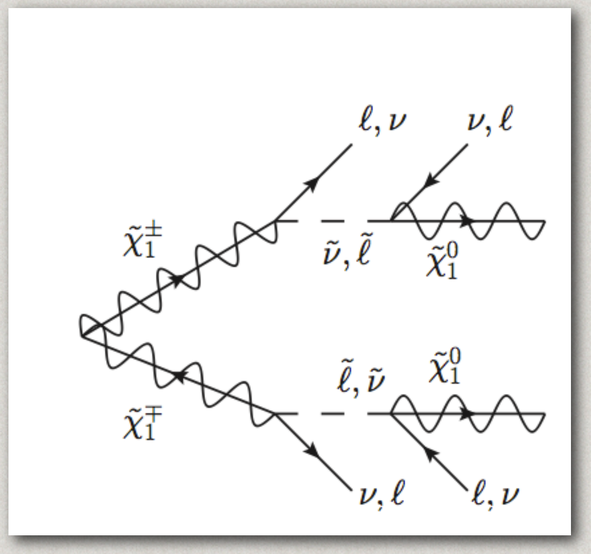

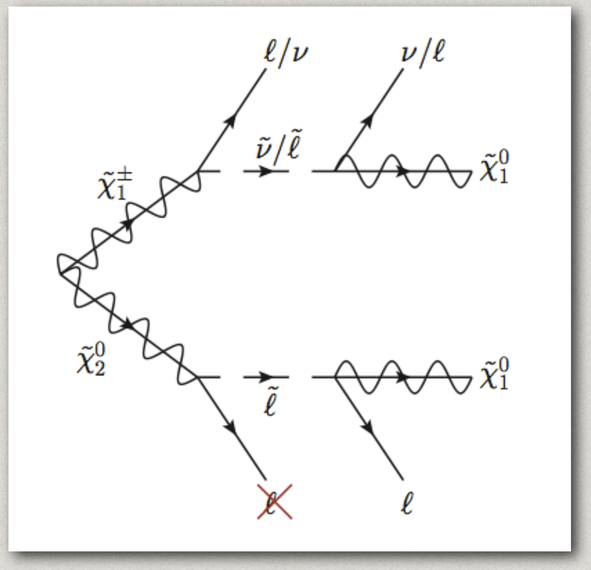

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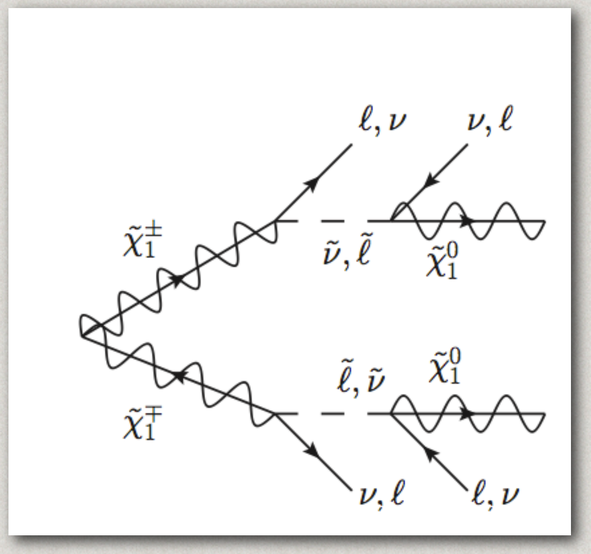

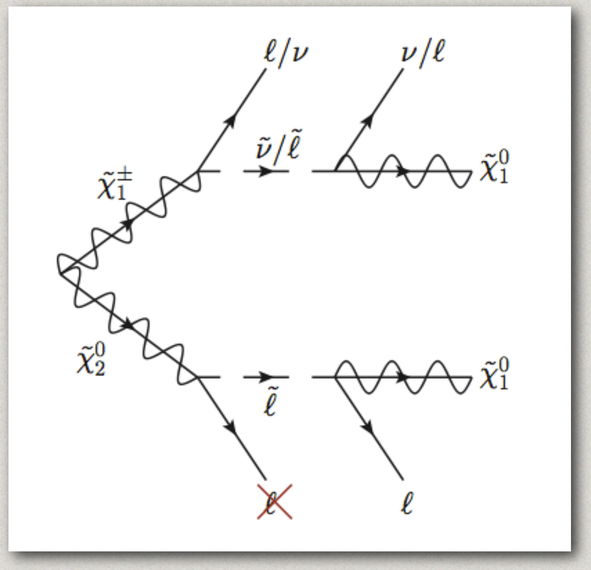

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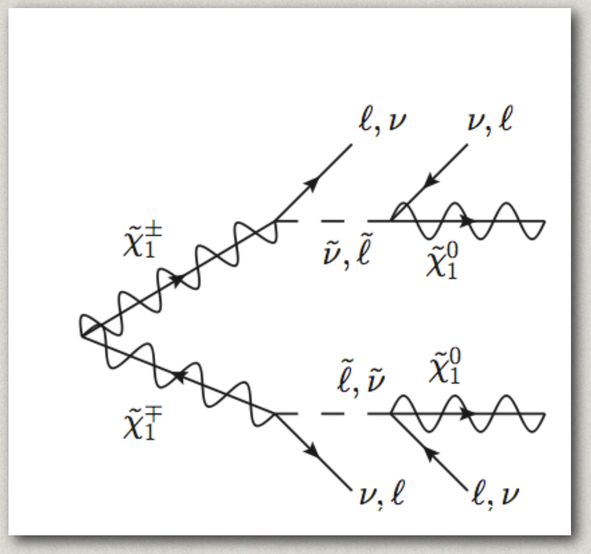

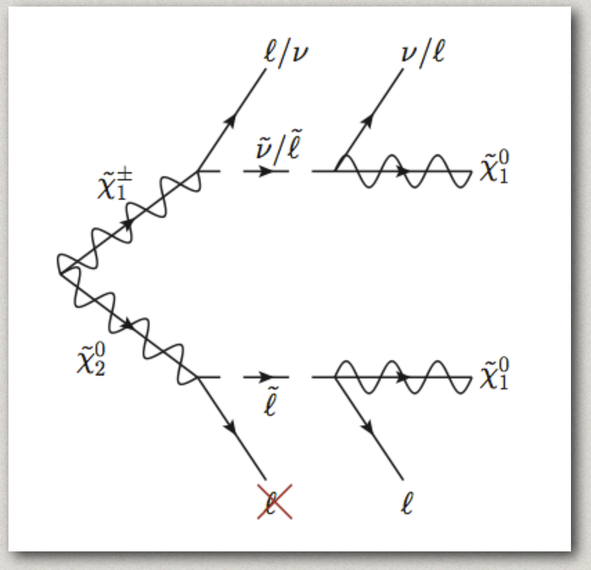

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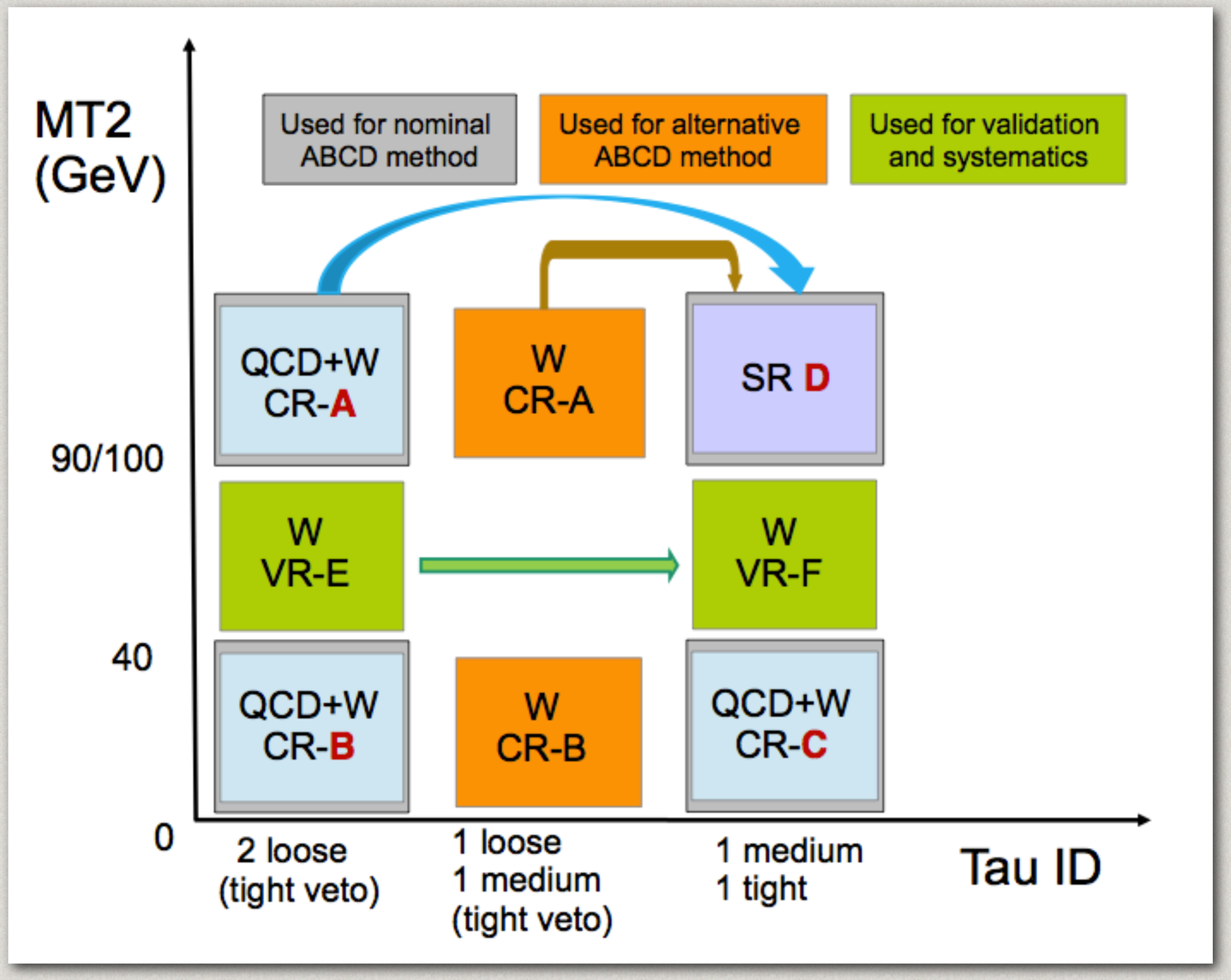

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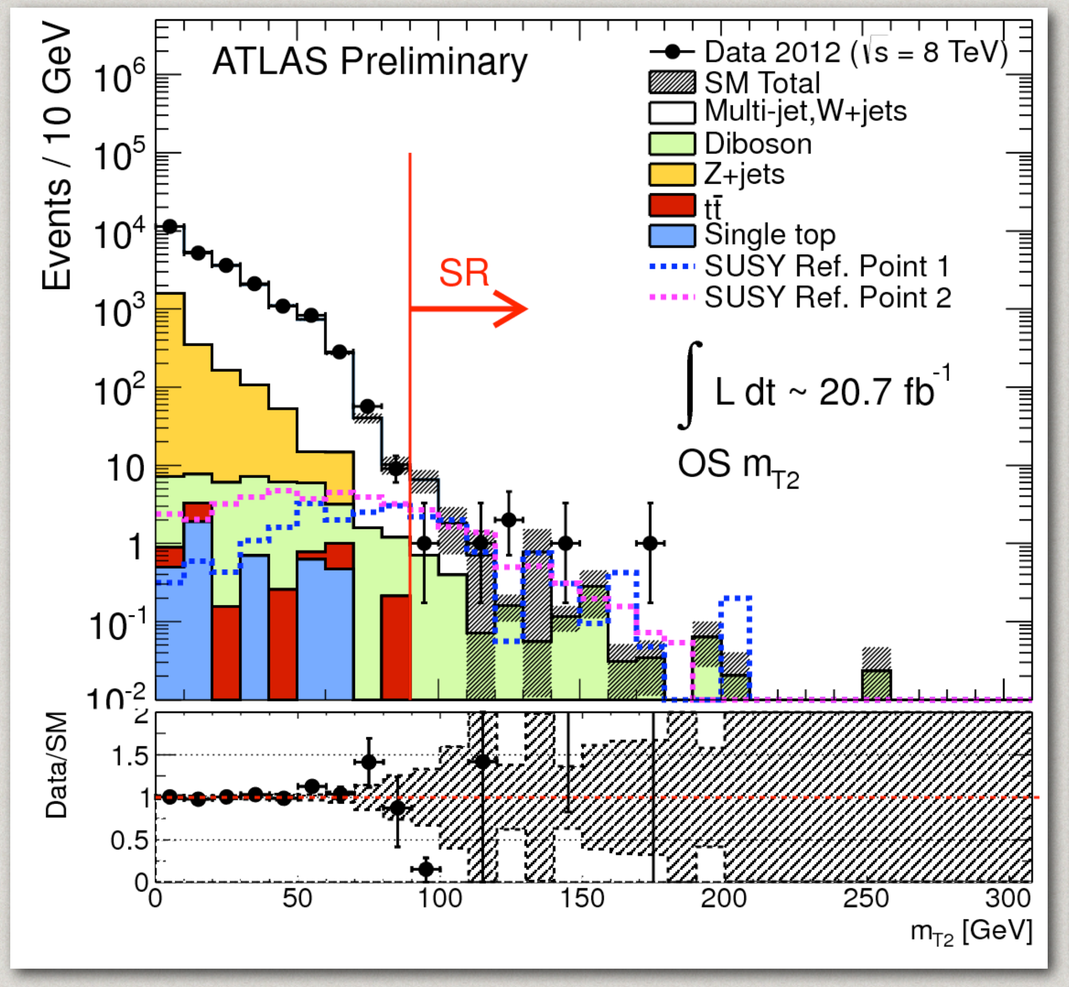

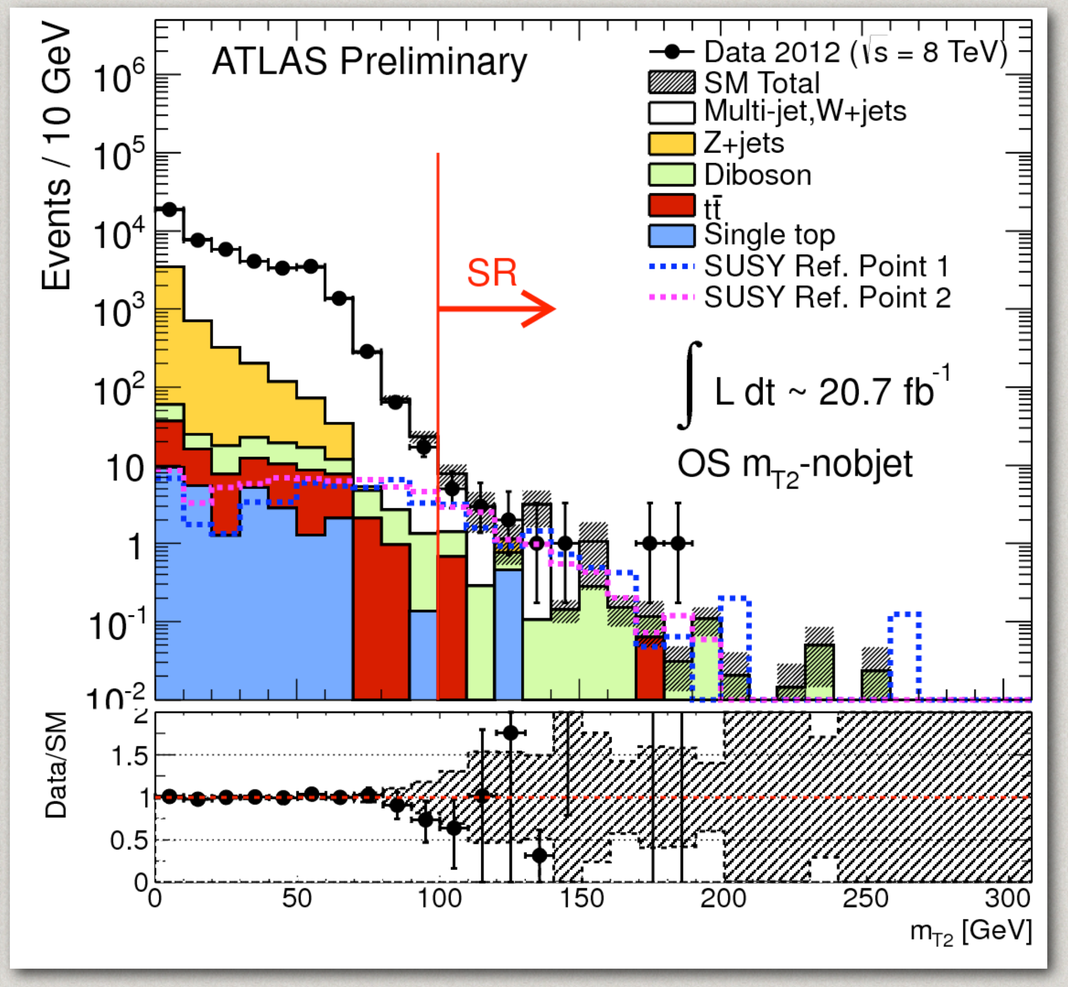

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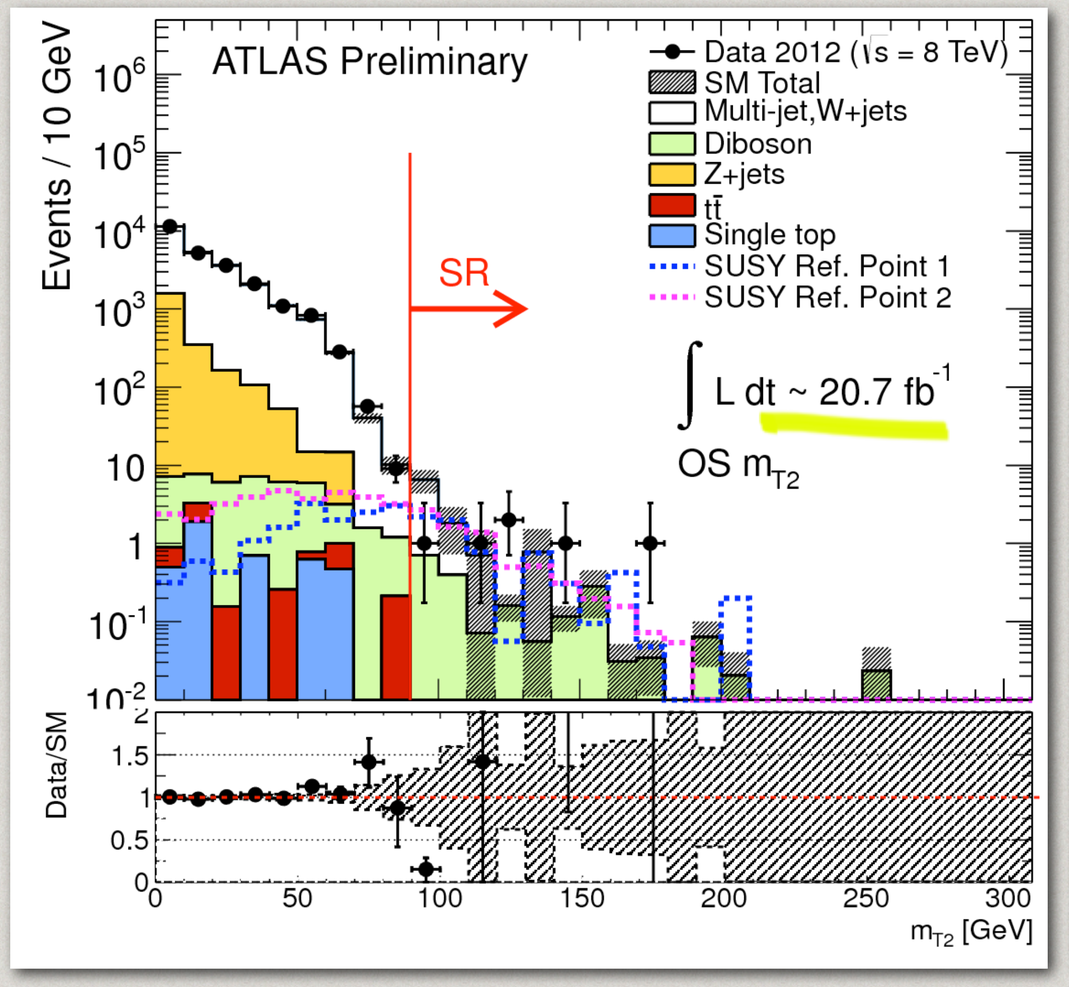

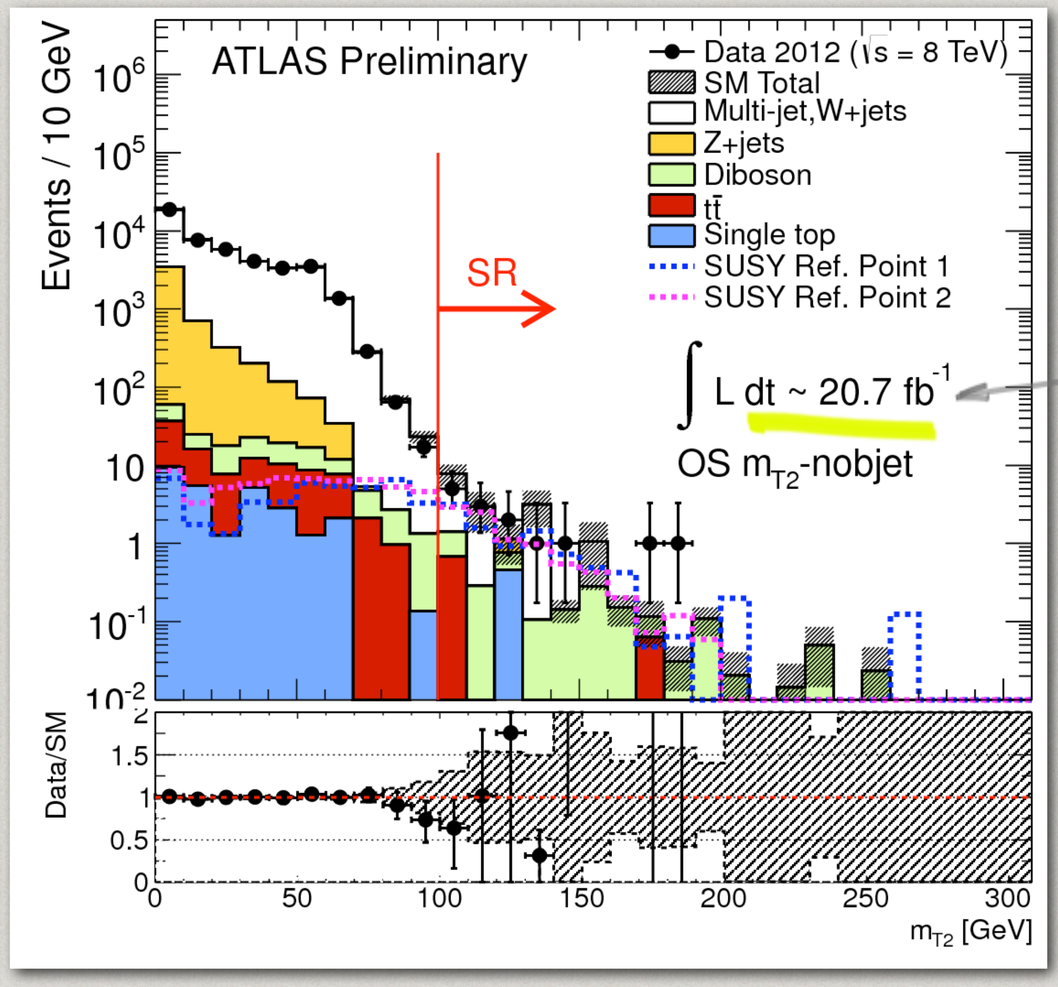

complete 2012 data set

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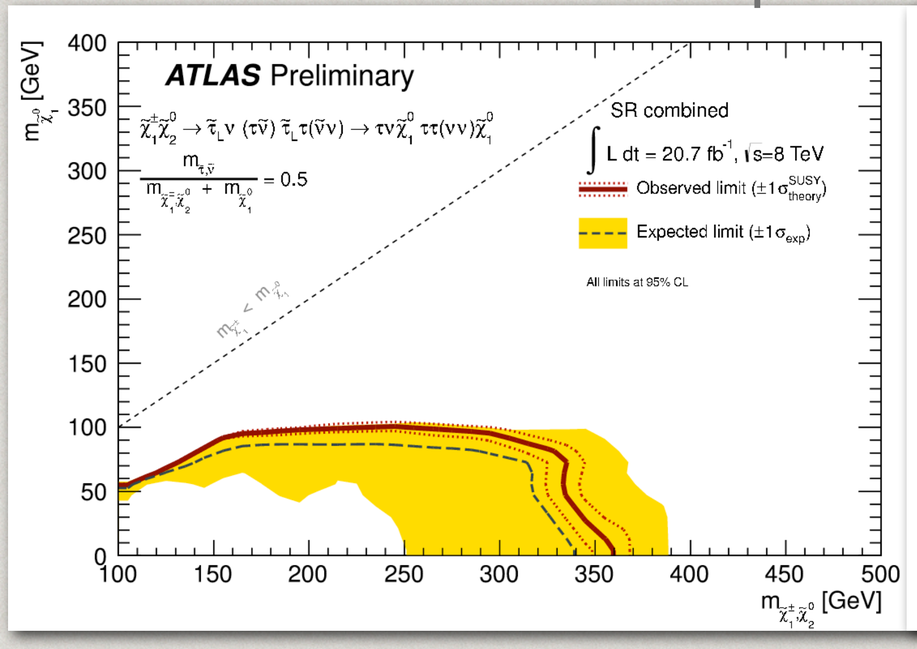

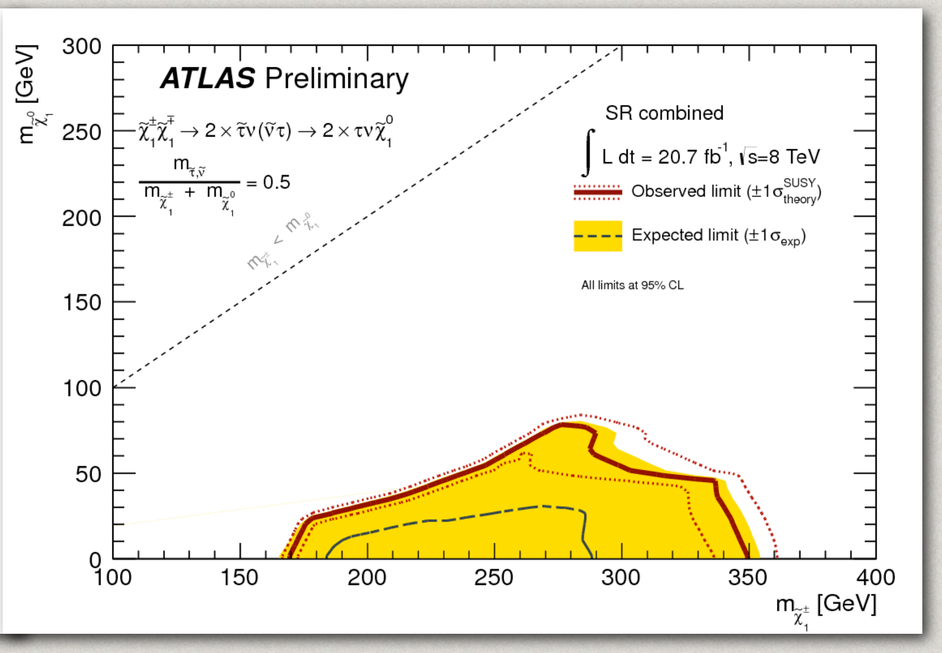

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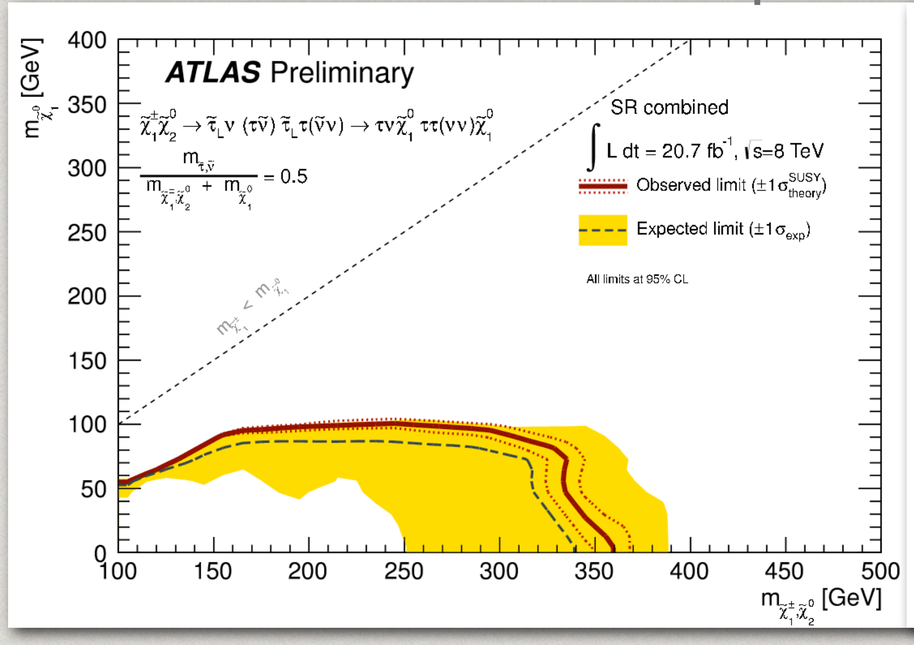
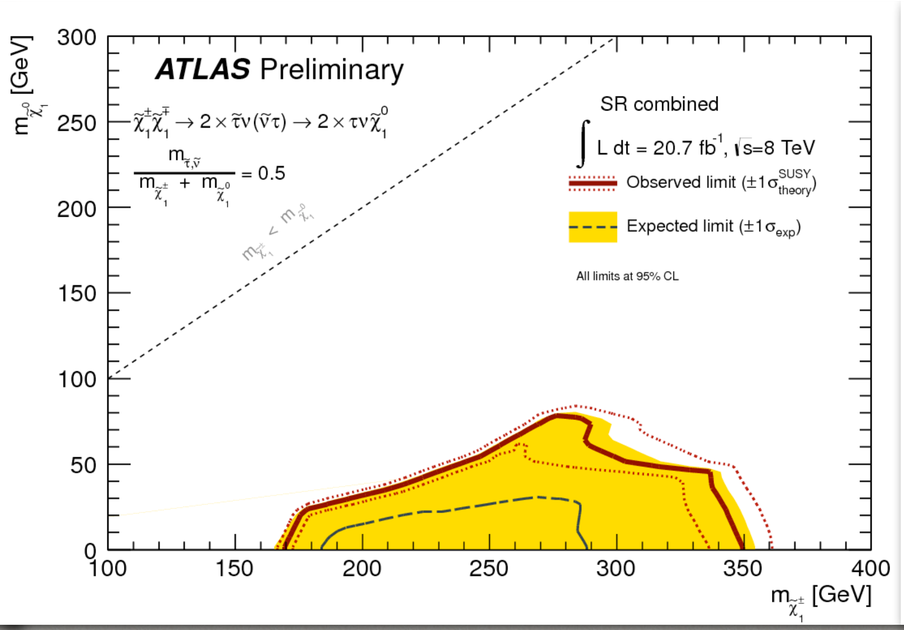
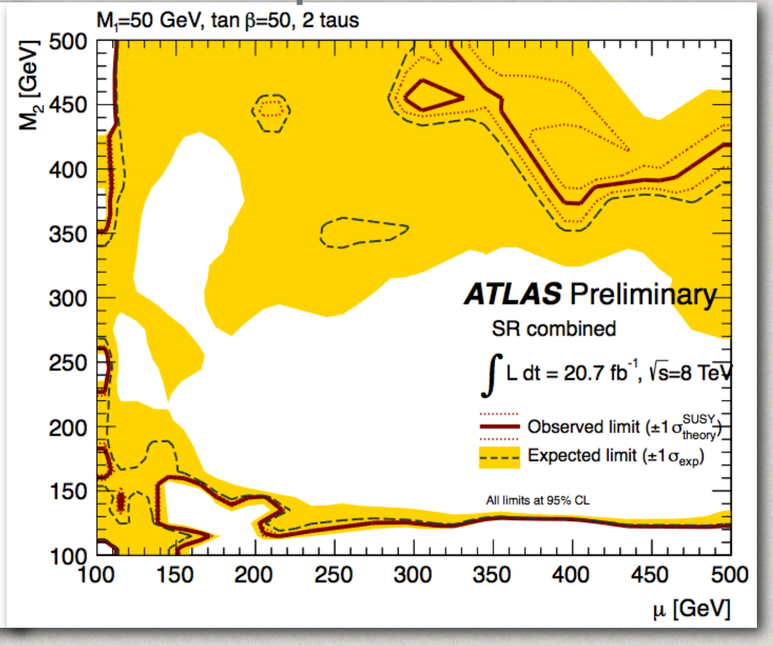


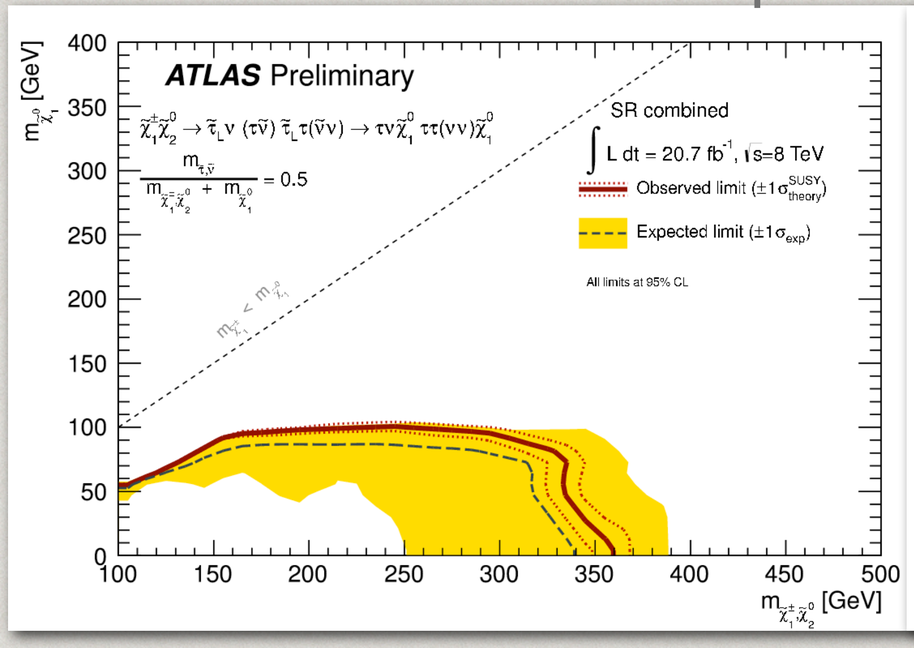


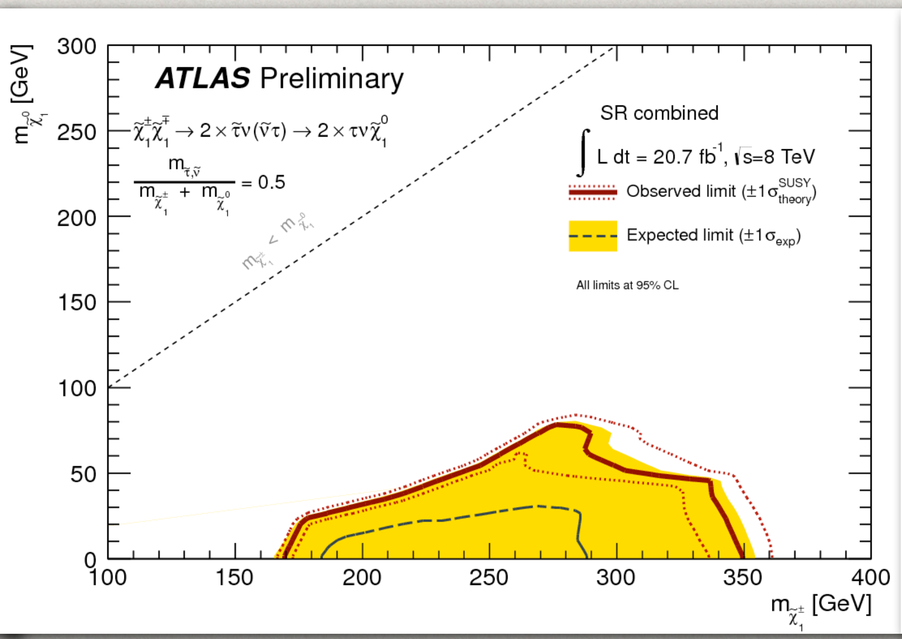
pMSSM



CHARGINO/NEUTRALINO-MEDIATED SUSY: LIMITS

simplified models





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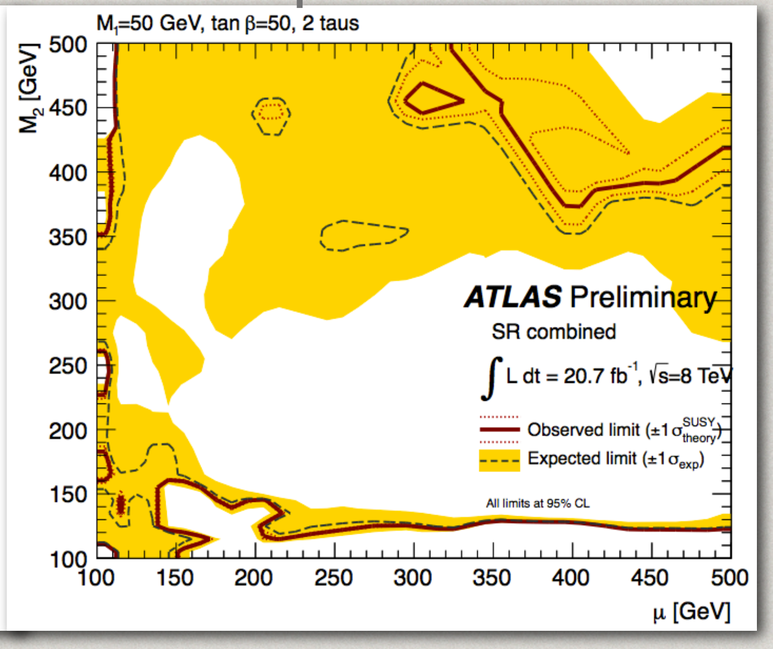

- only low sensitivity to direct production of tau sleptons ← due to low cross-section
- best limit found for M(stau)=140 GeV, M(neutralino)=10 GeV:
  - 0.17pb (predicted 0.04pb @ NLO)

DATA SETS

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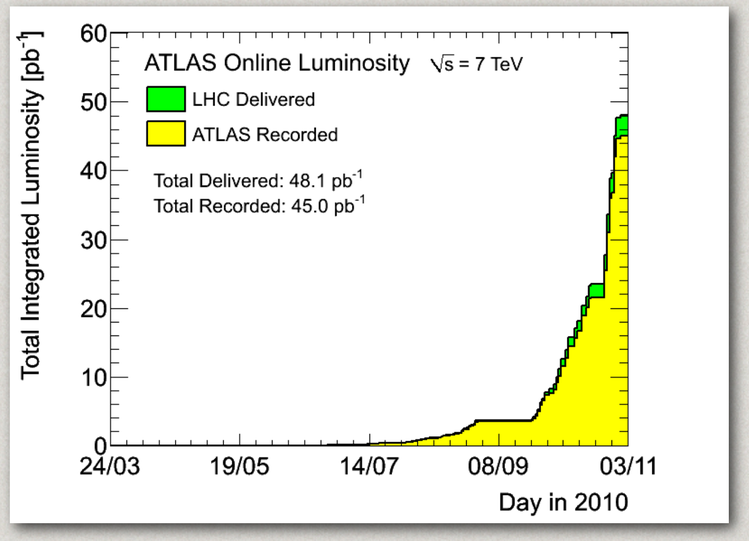
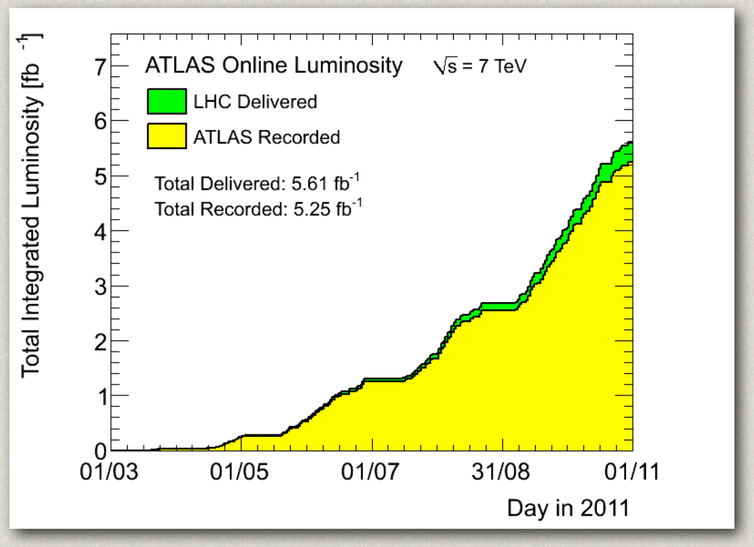
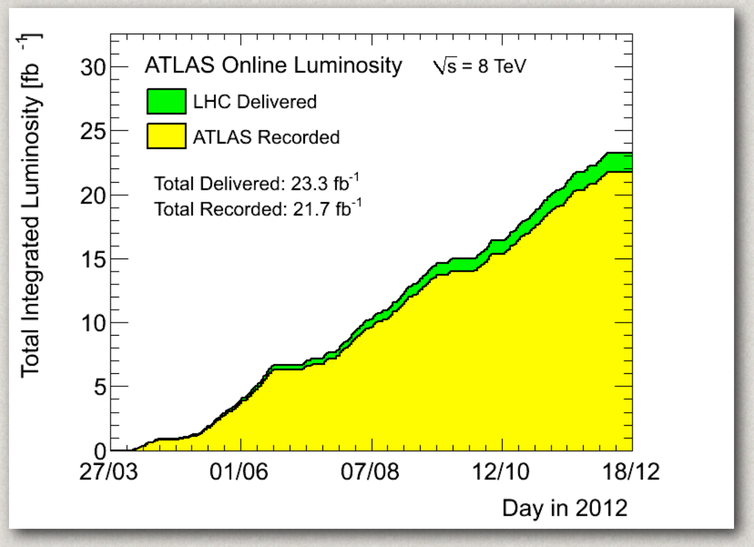
2010, 7 TeV, 45 pb^{-1}



2011, 7 TeV, 5.25 fb^{-1}



2012, 8 TeV, 21.7 fb^{-1}



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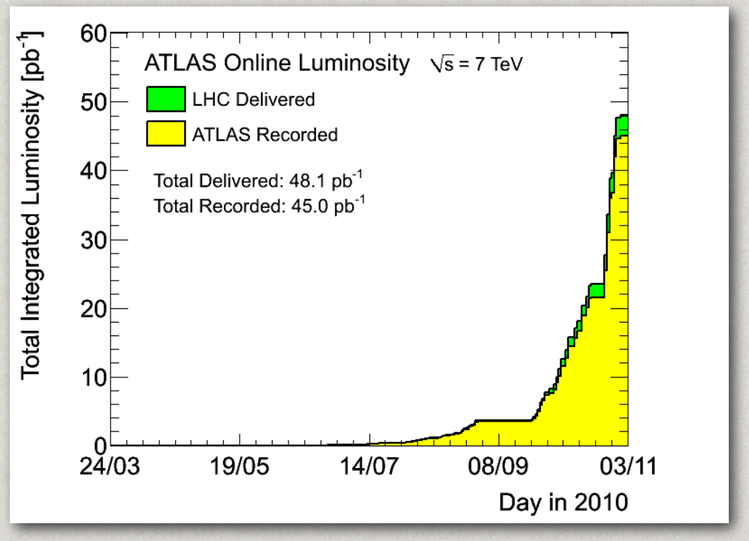

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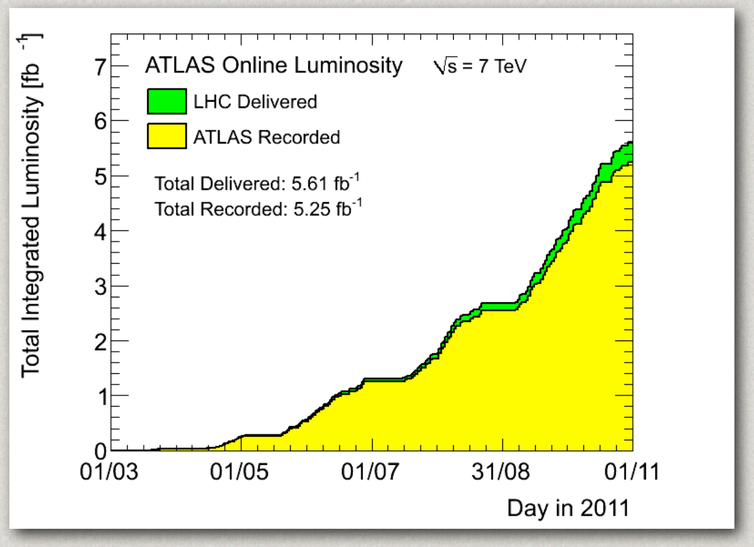

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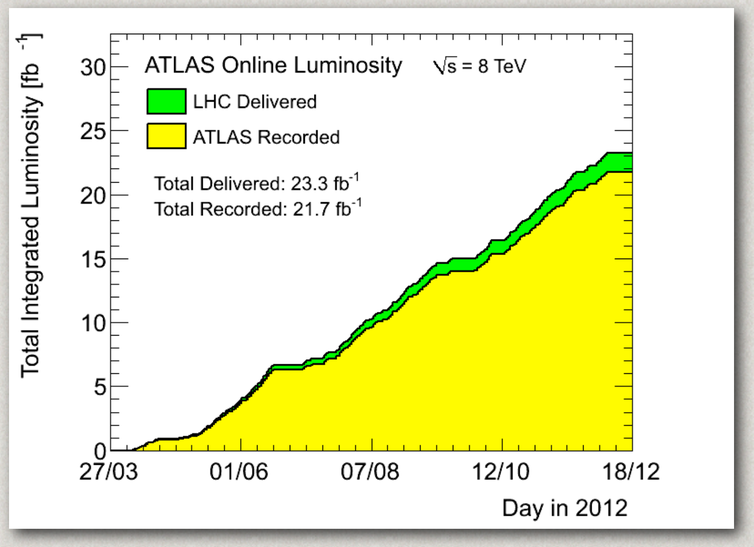
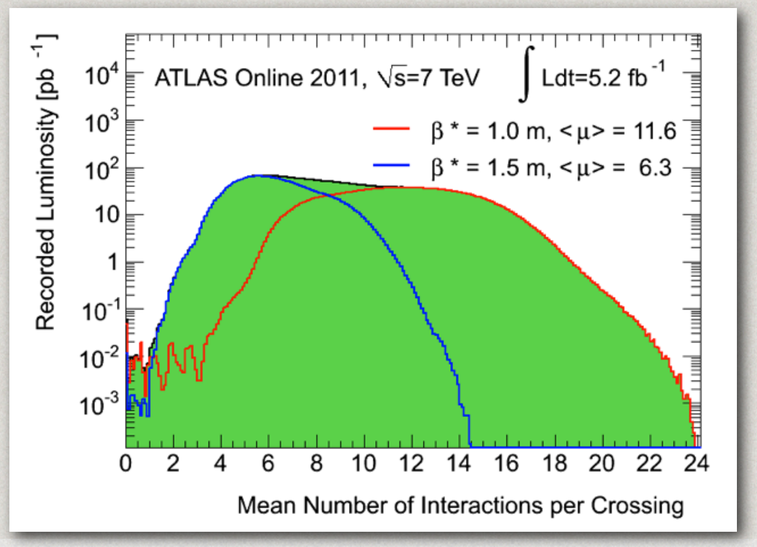
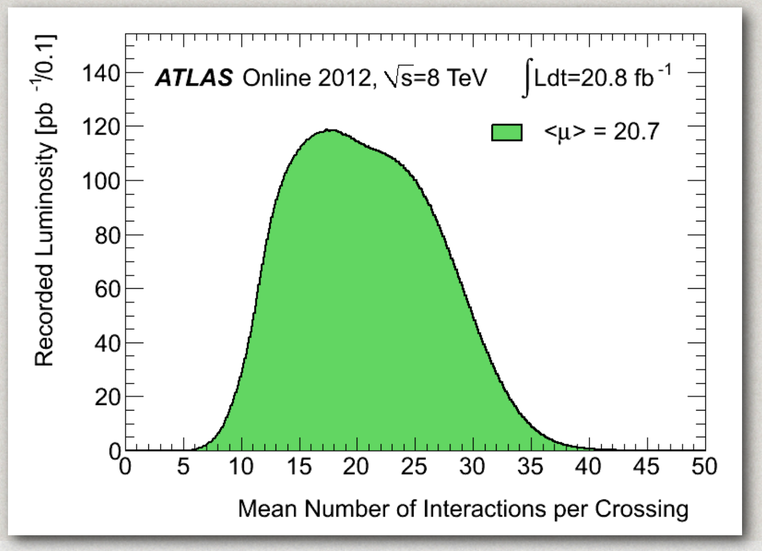


Luminosity weighted mean number of interactions per BX





SEARCH STRATEGY

- define signal region based on
  - full physics models
  - generalized models
  - simplified models
- signal topology then determines SM background
  - search variables
  - background determination

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SEARCH STRATEGY

- define signal region based on
  - full physics models — mSUGRA, GMSB, AMSB,...
  - generalized models — pMSSM, GGM
  - simplified models — described by a minimal set of parameters
- signal topology then determines SM background
  - search variables
  - background determination

THE SUSY THEORY PHASE SPACE

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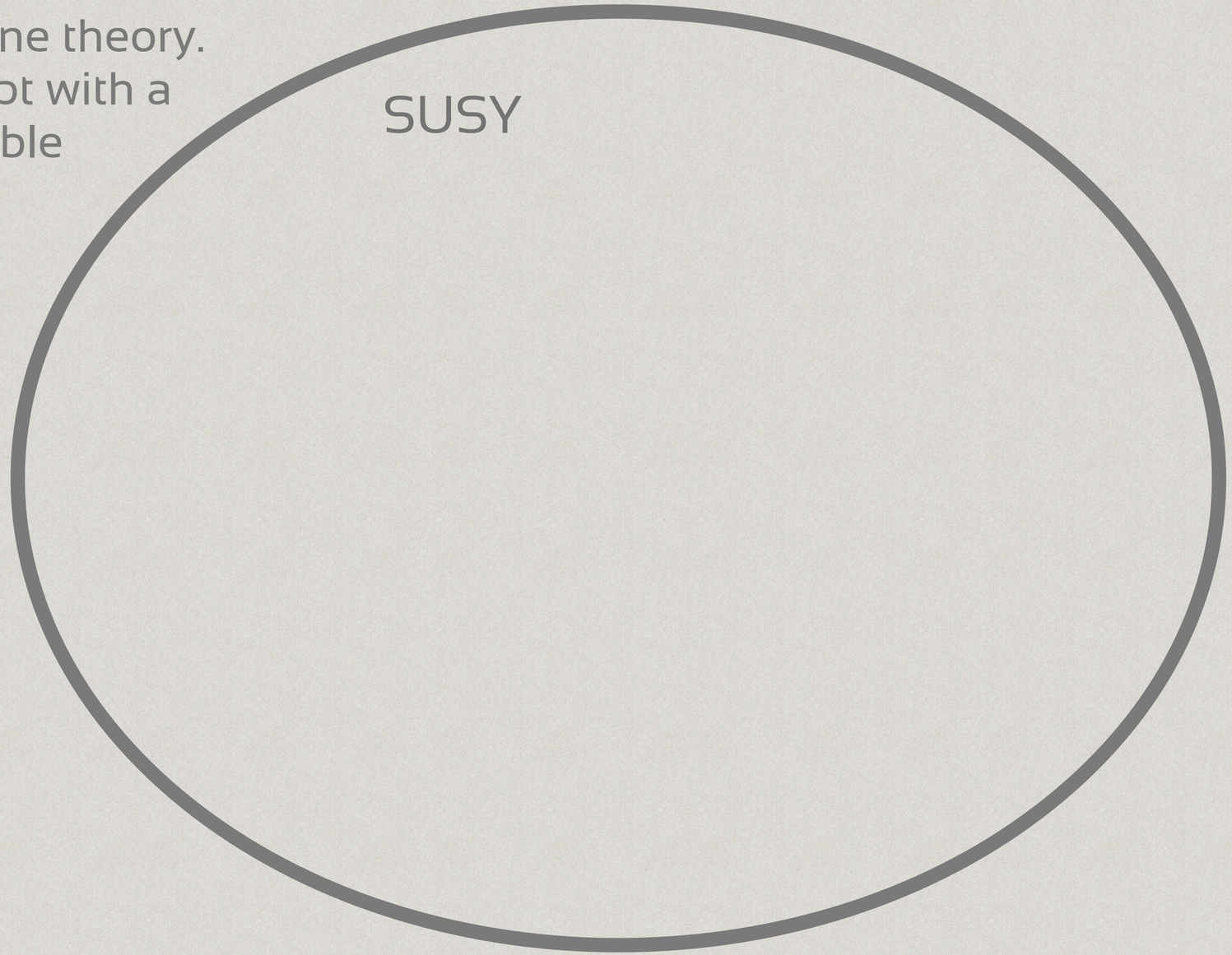

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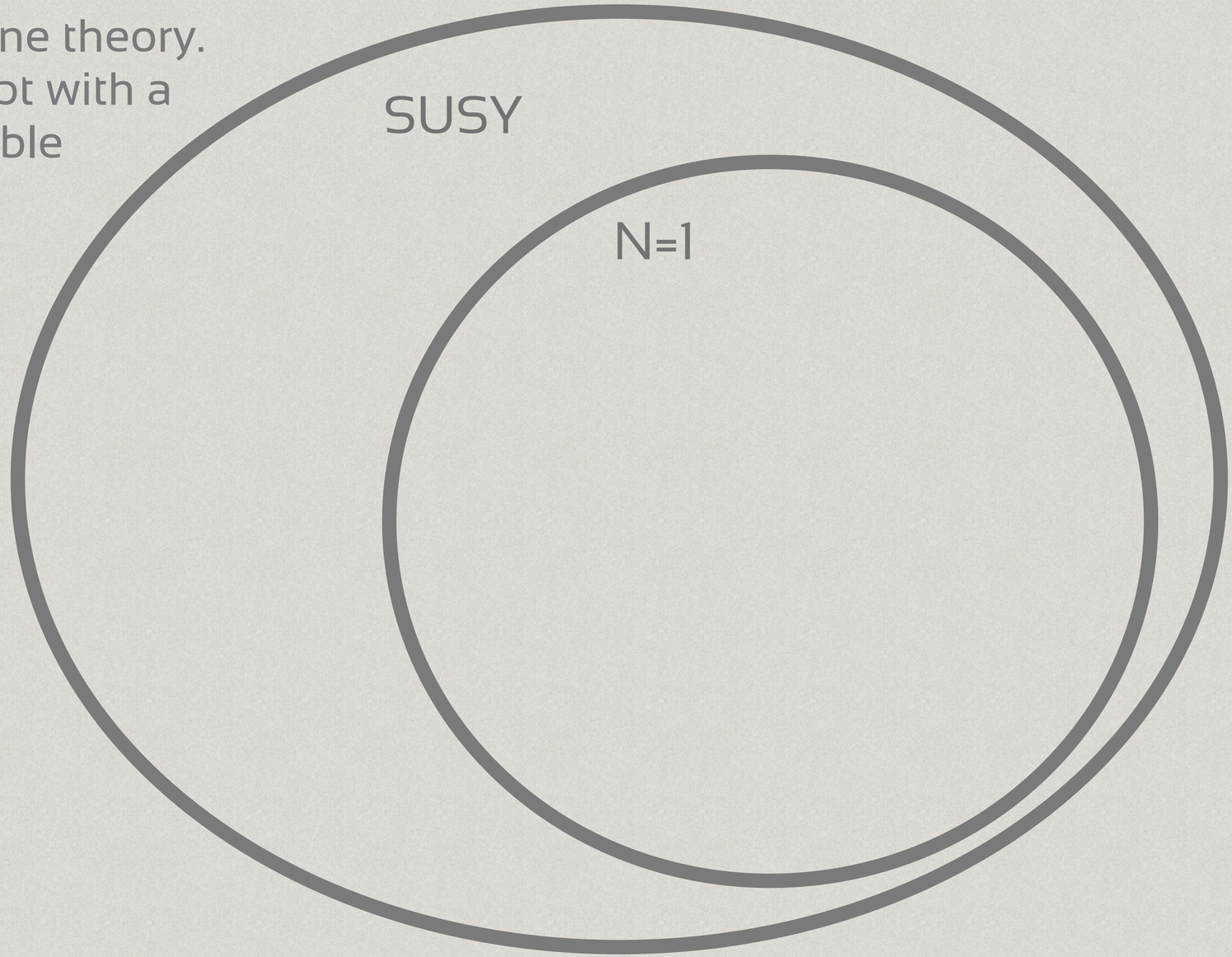

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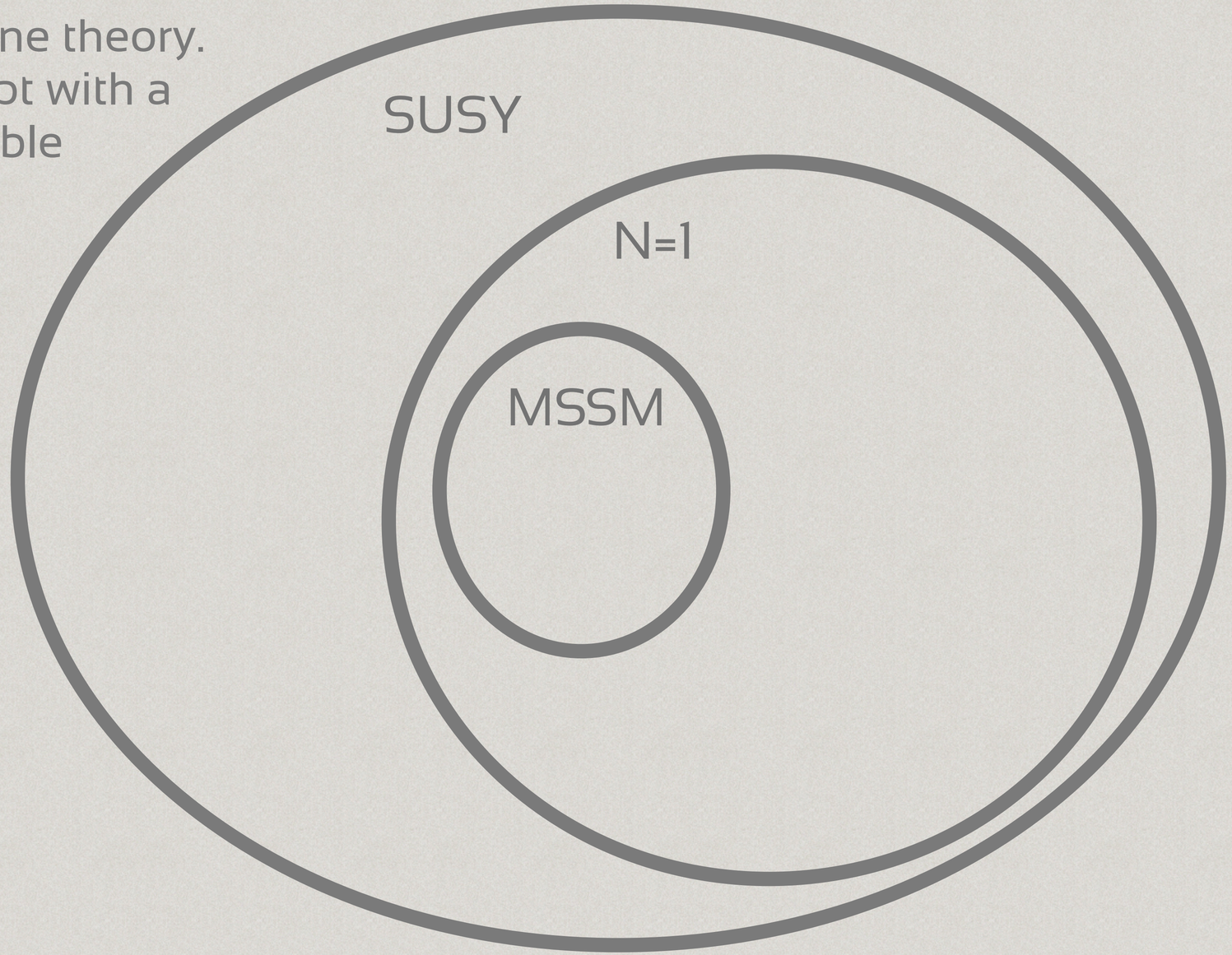

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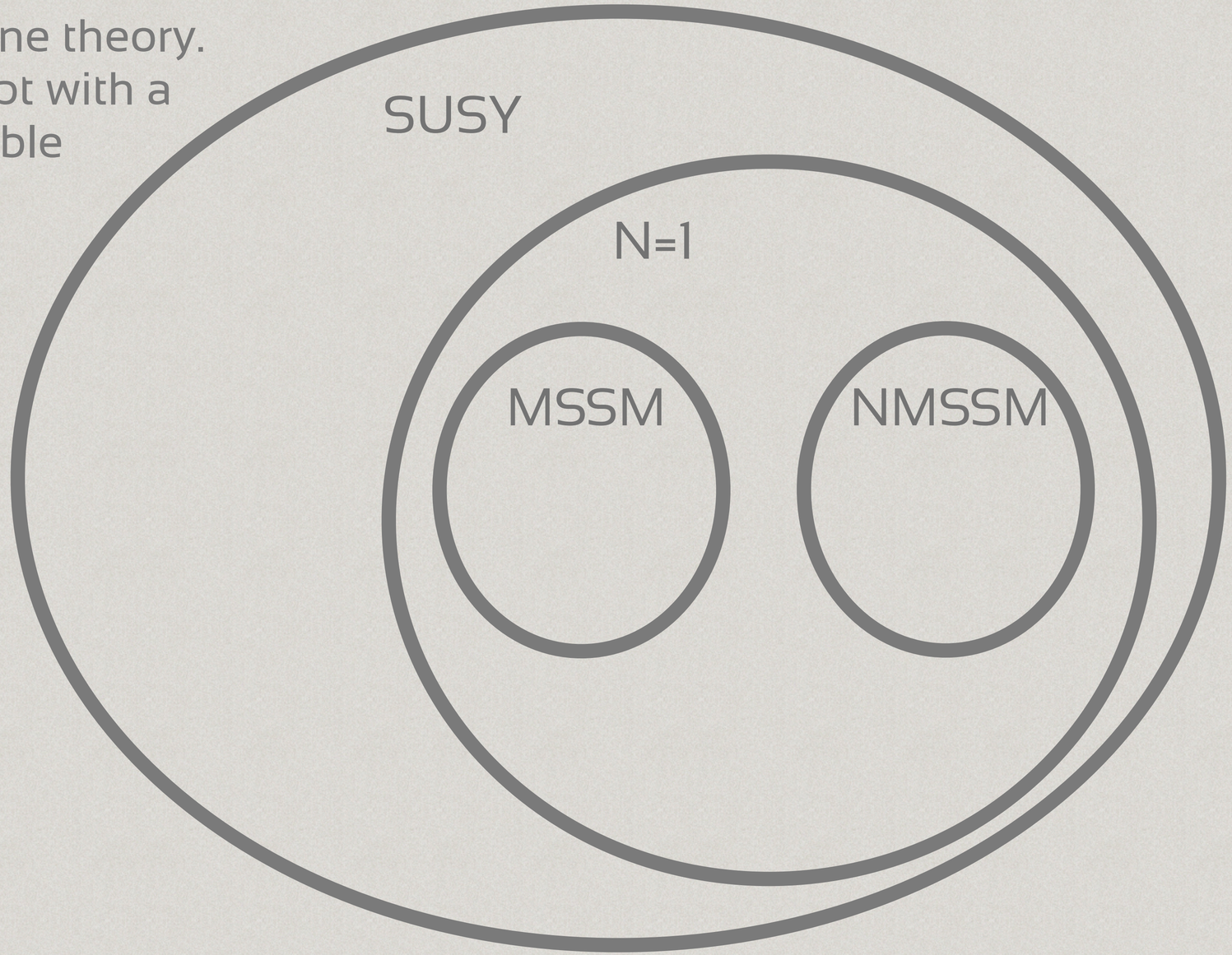

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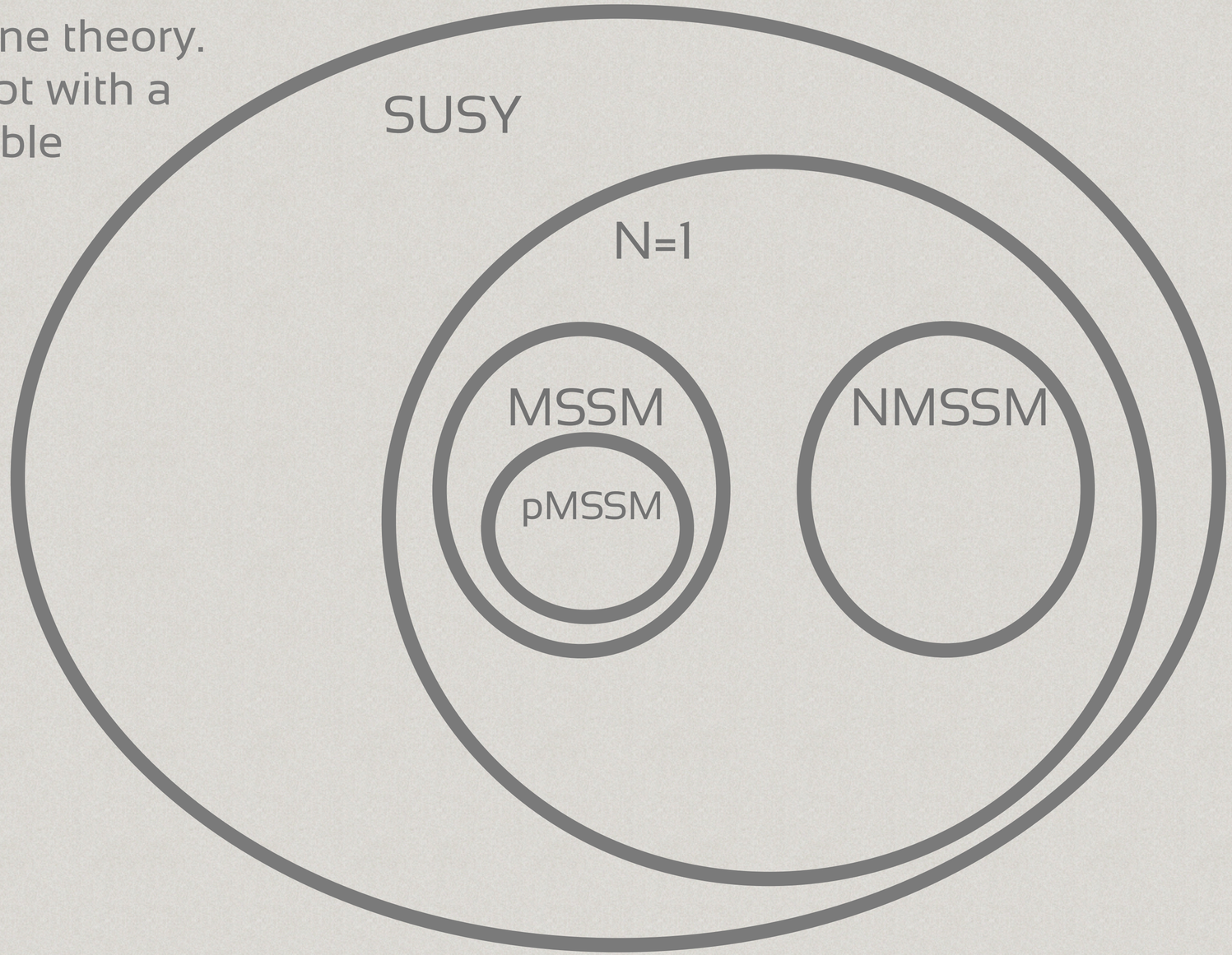

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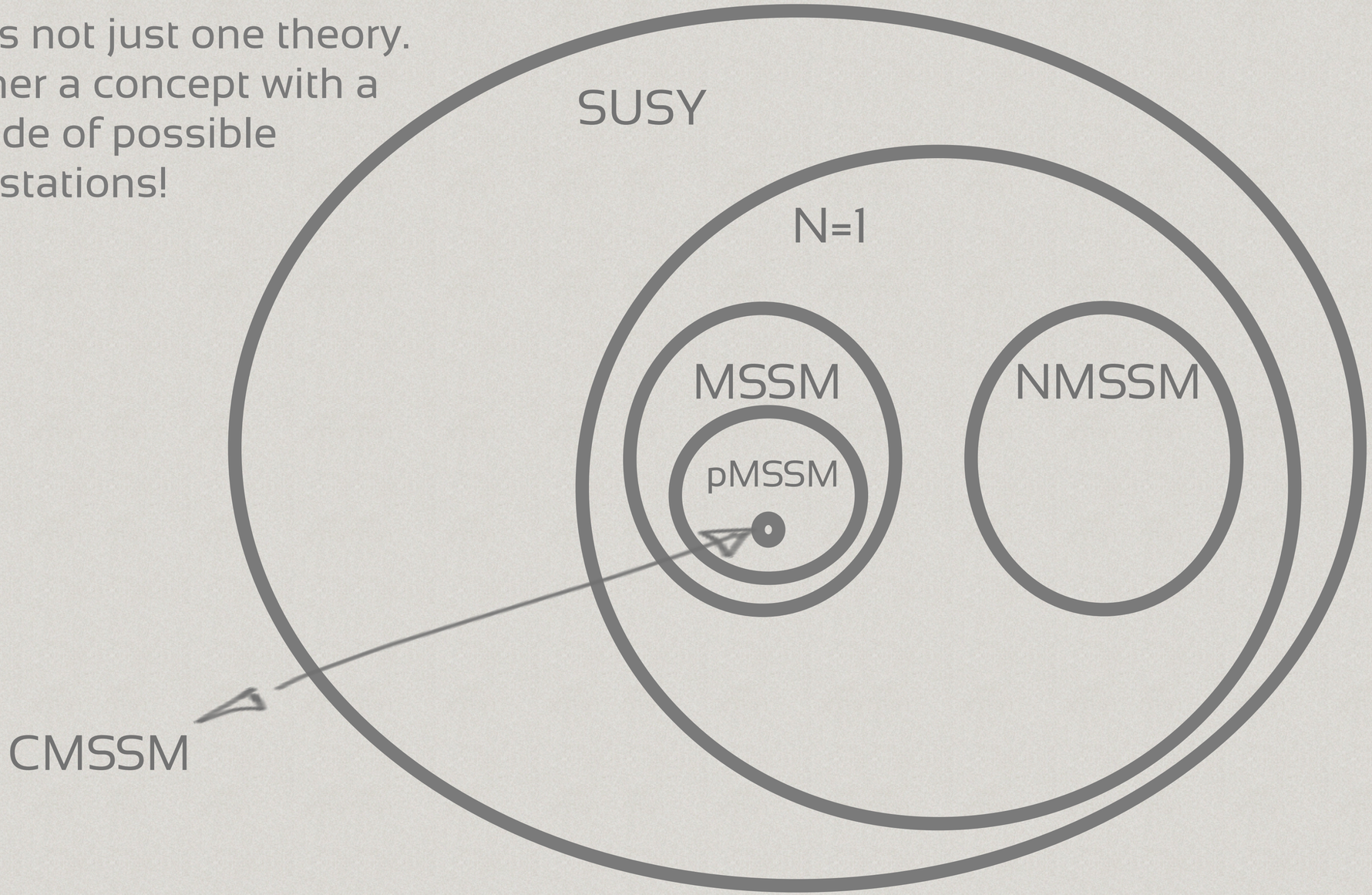

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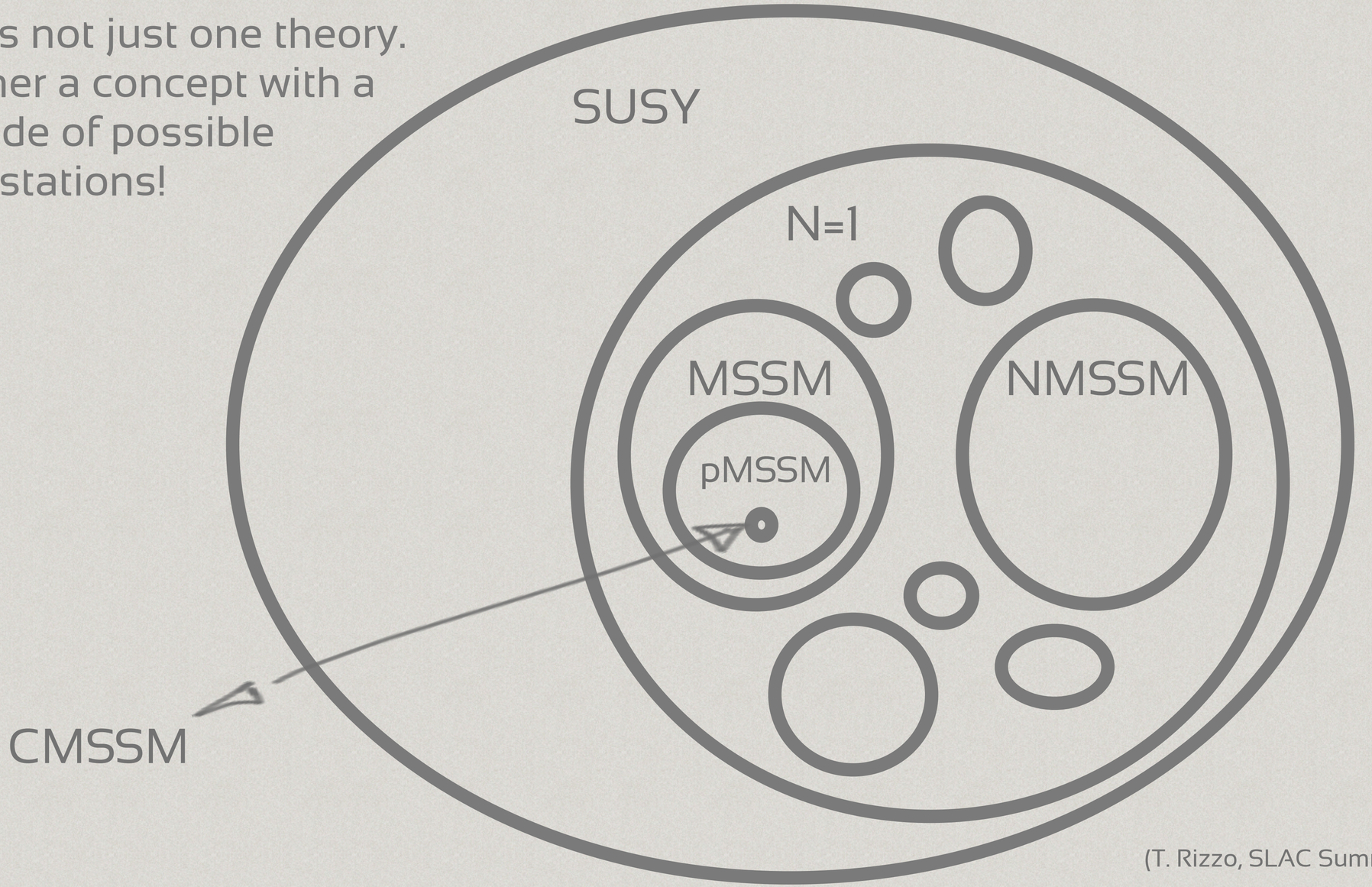

(T. Rizzo, SLAC Summer Institute, 2012)