Suche nach ersten Signalen der Supersymmetrie am LHC

DPG 2010

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Outline

- Reminder: Why is SUSY interesting?
- SUSY production at LHC
- LHC , ATLAS and CMS status
- What can we expect in the next 2 years ?
- Summary

SUSY Reminder

SUPERSYMMETRY (SUSY) is an extension of the Standard Model with a new symmetry between half-integer spin fermions and integer spin bosons

The SUSY particles are not always the mass eigenstates (mixing of particles)

The Higgs sector is extended (2HDM)

SUSY is a broken symmetry

A new Quantum Number (R-parity) is needed which forbids strong Baryon and Lepton number violation

SUSY Reminder

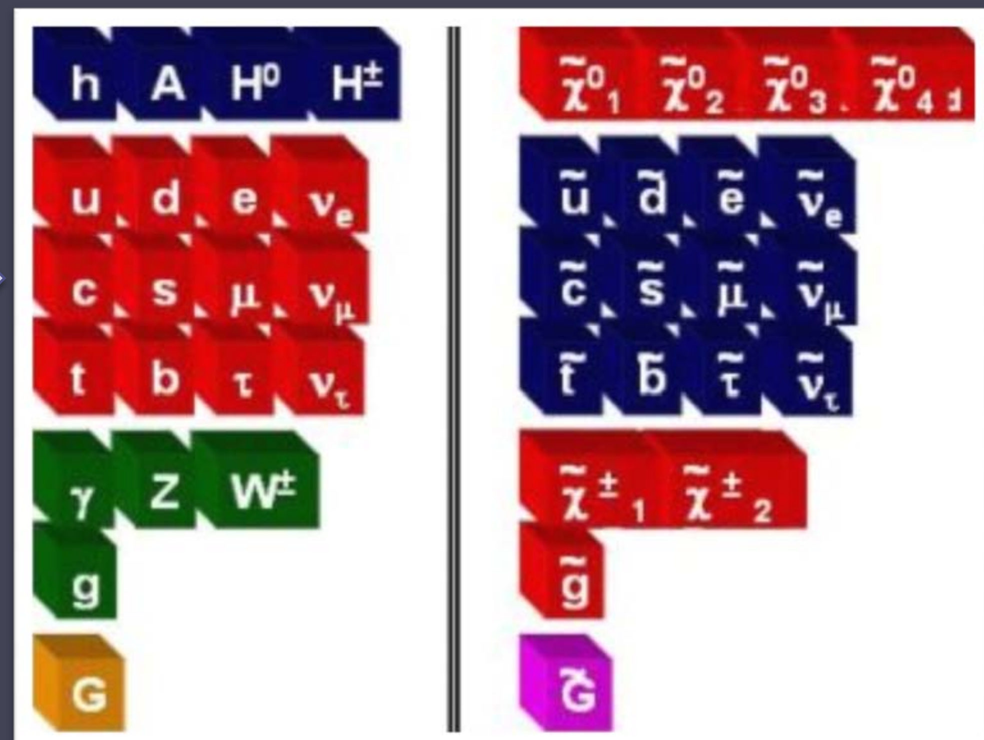
Models of SUSY breaking

>100 parameters in MSSM

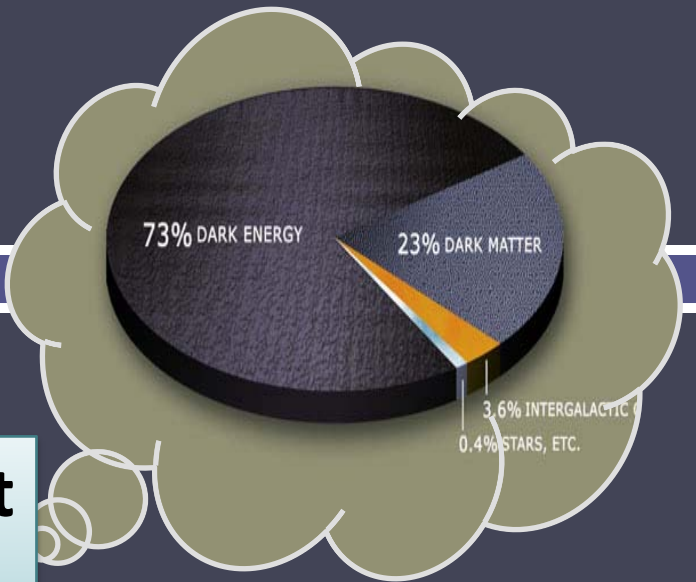
Sub-models with Less parameter:
mSUGRA
GMSB
AMSB
etc.

SUSY breaking mechanisms generate masses

MSSM particle Zoo



Why SUSY ?



Most studied new physics theory at LHC for several reasons :

-Fermion and Boson loops protect the Higgs mass at large energies (solves "fine tuning")

-SUSY is a broken symmetry and thus offers (with R-parity conservation) perfect candidates for Dark Matter with a WIMP mass of O(100) GeV

-Gauge couplings unification, "radiative" EWSB, …

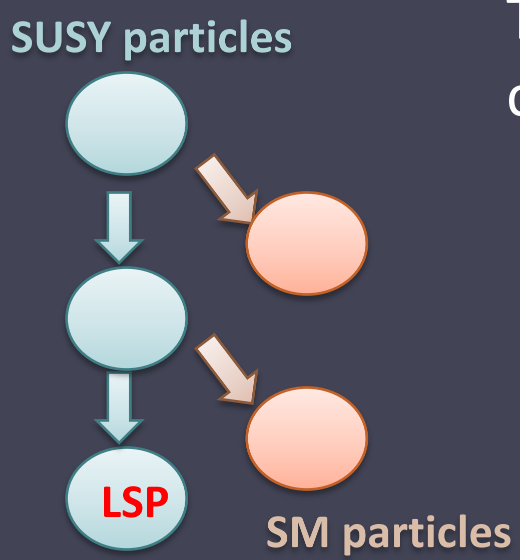
SUSY mass scale: *a priori* knowledge

Upper mass scale constrains	Lower mass scale constrains
Unification of couplings if mass scale is not too large	Bounds from other experiments
Fine tuning problem less severe if mass scale is not too large	Tevatron bounds (e.g gluino and squark mass)
Perfect DM candidate if mass scale not too large	Bounds from LEP (e.g. chargino, slepton, neutralino)

Are there SUSY particles at a scale of 0.2 - 1 TeV ?

SUSY and the LHC : Signal

SUSY leads to a huge increase in the number of particles and parameters which makes it *a priori* not so predictive for LHC phenomenology.
Searches need to be quite general and model-parameter-independent

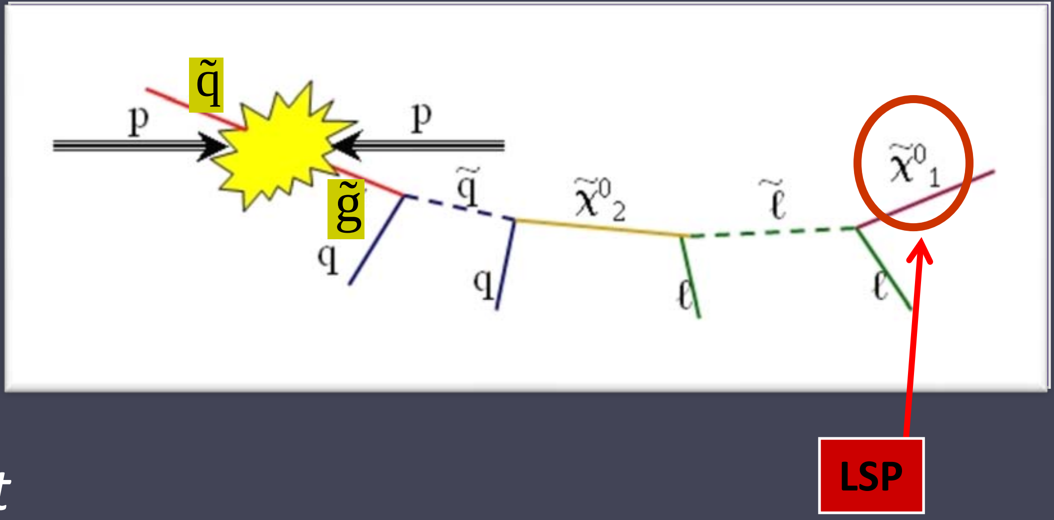


Typically production of SUSY particles which cascade decay to Lightest SUSY particle (LSP)

LSP candidates in Minimal Supersymmetric SM:
- Lightest Neutralino (the WIMP candidate)
- Gravitino (gravitational interacting spin 3/2)
- *Sneutrinos (largely excluded by direct DM searches)*

SUSY and the LHC : Signal

If R-Parity is conserved then SUSY particles are pair produced



LHC:

*Due to strong force dominant production of **squarks** and **gluinos** (if not too heavy)*
Cascade decay to lighter SUSY particles
and finally the lightest SUSY particle (LSP)

SUSY might have huge cross section of >100 pb
Might be visible this year ?

The "Standard signals":

Missing transverse energy (MET), maybe jets, maybe leptons, maybe photons

The "non-standard signals":

New heavy particles with lifetime, non pointing photons , no MET, ….

Interesting:

Similar conclusions for Universal Extra Dimension, ADD, Little Higgs, ….

LHC schedule

What happened till today ?

- Dec. 2009: Experiments collect data at $\sqrt{s}$= 900 GeV
- A small set of data even at $\sqrt{s}$= 2.4 TeV

Further schedule:

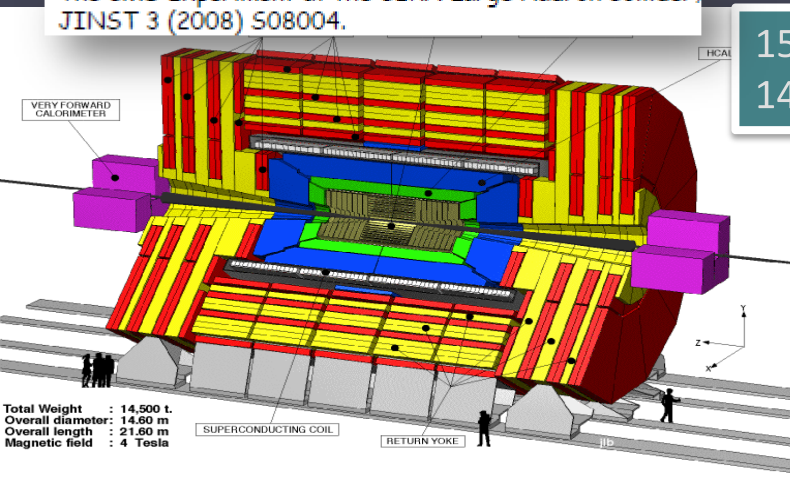
- 2010/2011: Long LHC run at 7 TeV centre-of-mass energy
- 2012: Long shutdown (repair of magnet interconnections)

Physics studies for the 2010/2011 run assume now $1000 pb^{-1}$ at $\sqrt{s}$= 7 TeV

Previous baseline was $200 pb^{-1}$ at $\sqrt{s}$= 10 TeV

CMS and ATLAS

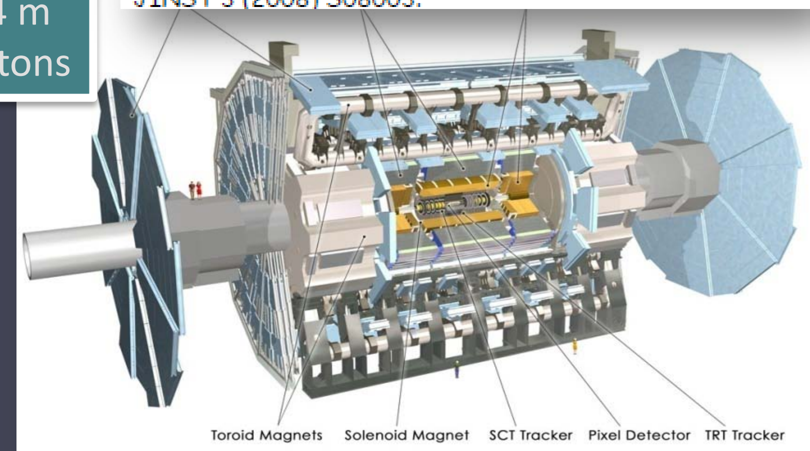
The CMS Experiment at the CERN Large Hadron Collider, JINST 3 (2008) S08004.



15*21 m
14500 tons

25*44 m
7000 tons

The ATLAS Experiment at the CERN Large Hadron Collider, JINST 3 (2008) S08003.



Huge silicon detector (pixel and strips)

4 Tesla solenoid

Crystal EM calorimeter: $\sigma(E)/E \sim 3\%/\sqrt{E} + 0.003$

Brass and scintillator had. Calorimeter: $\sigma(E)/E \sim 100\%/\sqrt{E} + 0.05$

Muon Chambers: $\sigma(p)/p < 10\%$ at 1TeV

Level 1 + higher level trigger

Silicon detector (pixel and strips) and Transition Radiation Tracker (TRT)

2 Tesla solenoid + barrel and endcap toroid

Em. calorimeter (PB+Lar) : $\sigma(E)/E \sim 10\%/\sqrt{E} + 0.007$

Hadronic calorimeter (Iron Tile + Scint., Cu +Lar HEC): $\sigma(E)/E \sim 50\%/\sqrt{E} + 0.03$

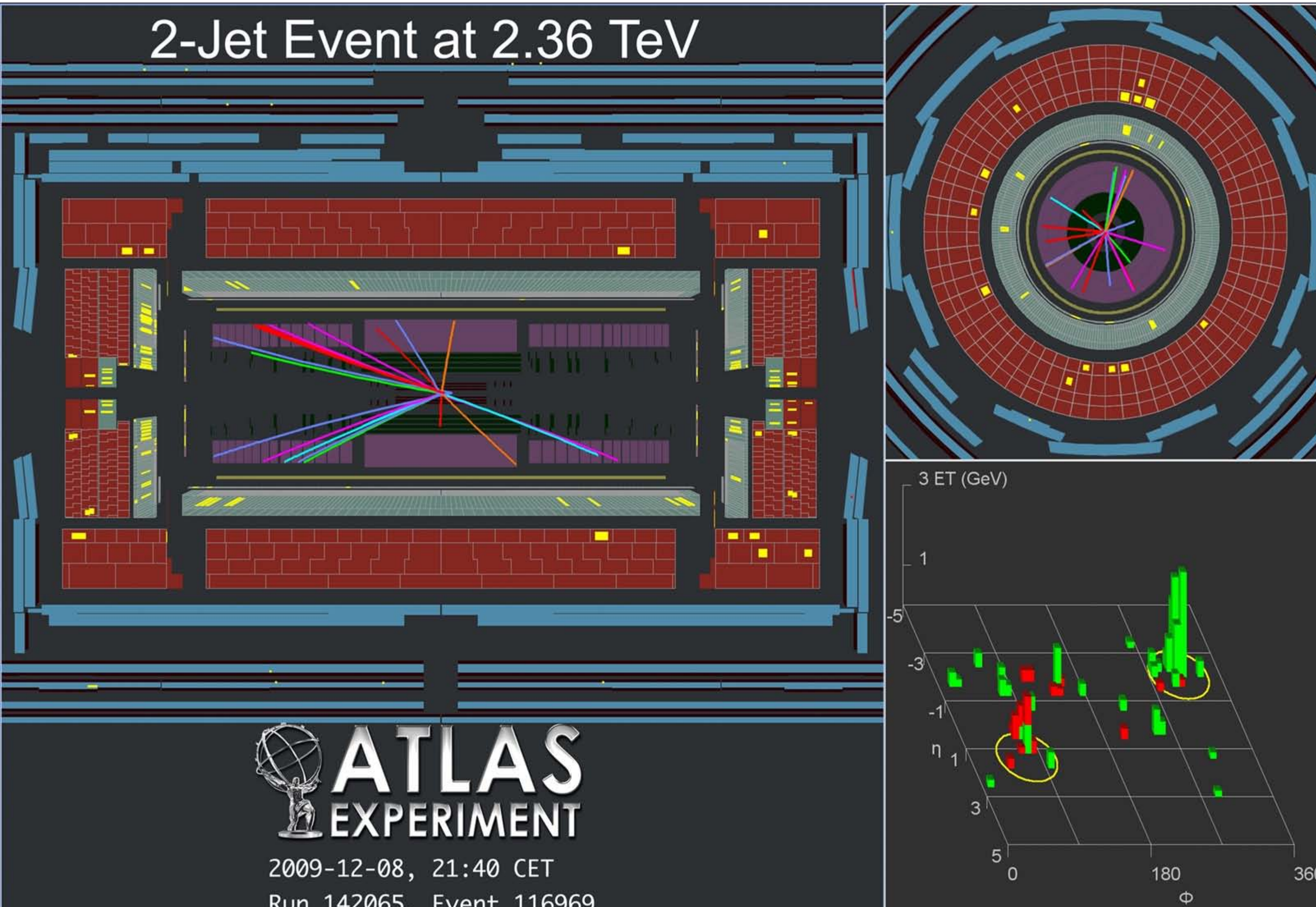
Muon Chambers (Drift Tubes): $\sigma(p)/p < 10\%$ at 1TeV

3 level trigger system

Resolutions might be measured in different experimental environments

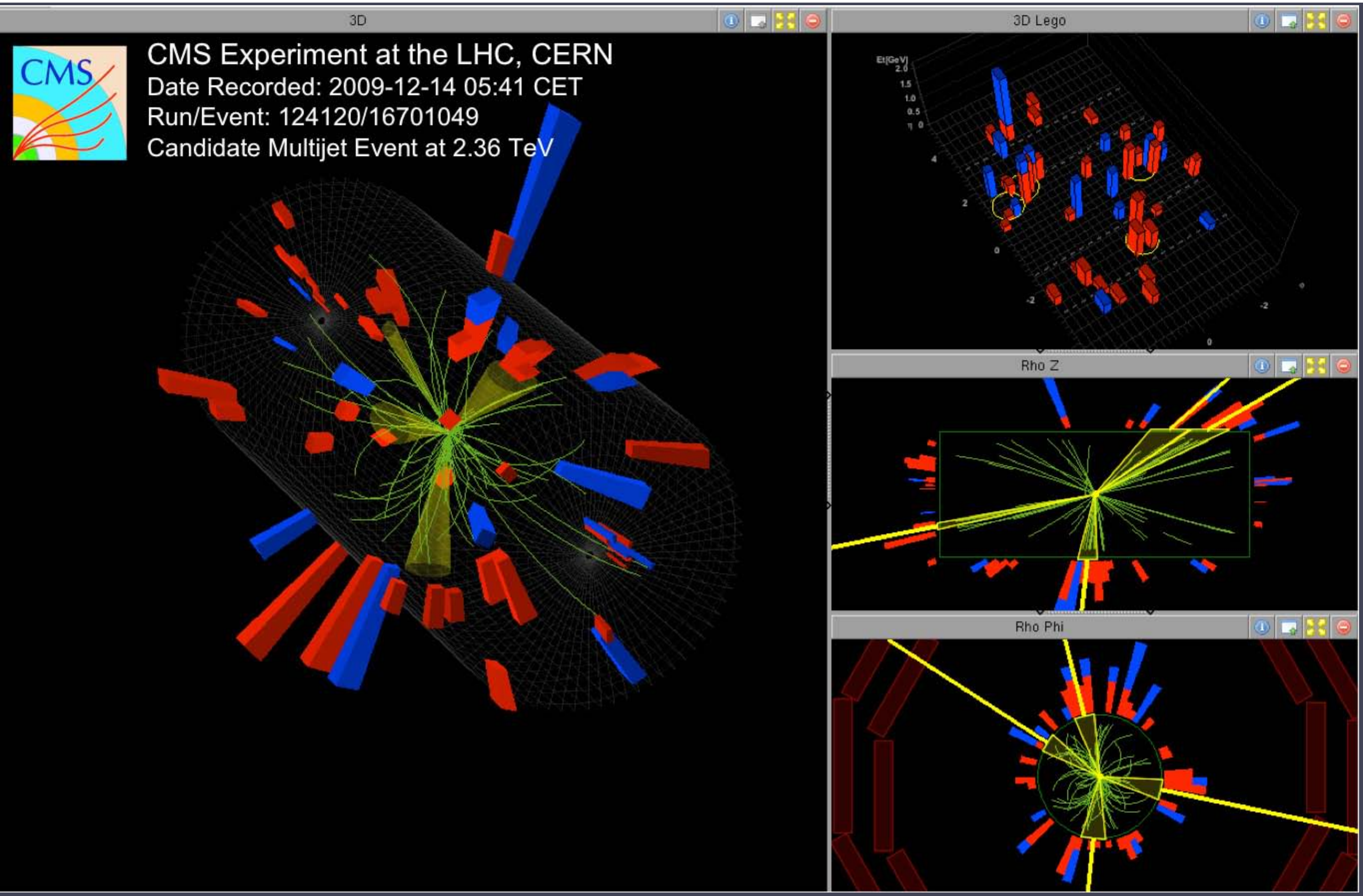
ATLAS and CMS are ready and take data

First data – ATLAS example



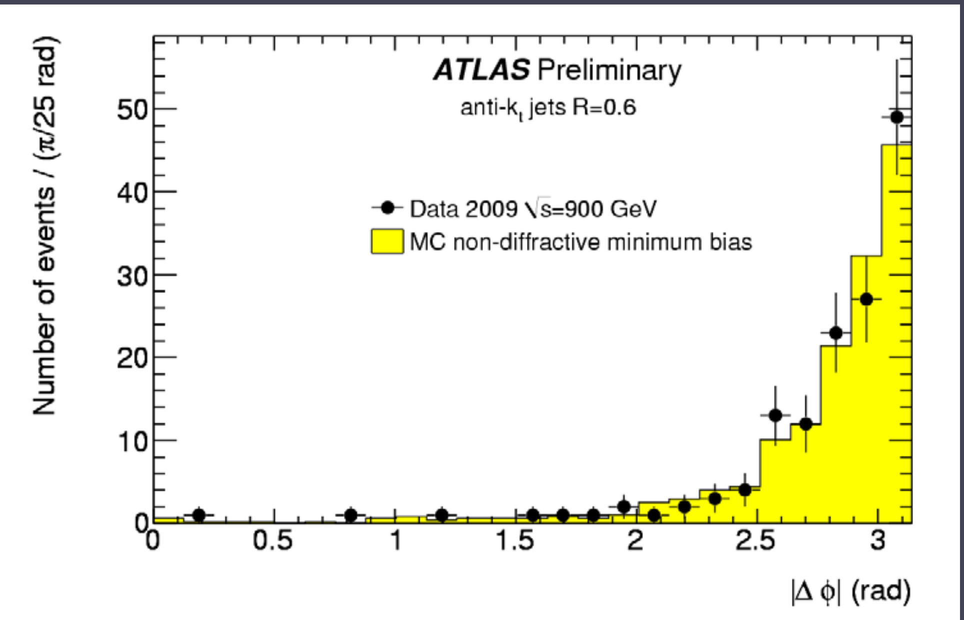
2 jets with E_T of 23 and 16 GeV

First data – CMS example

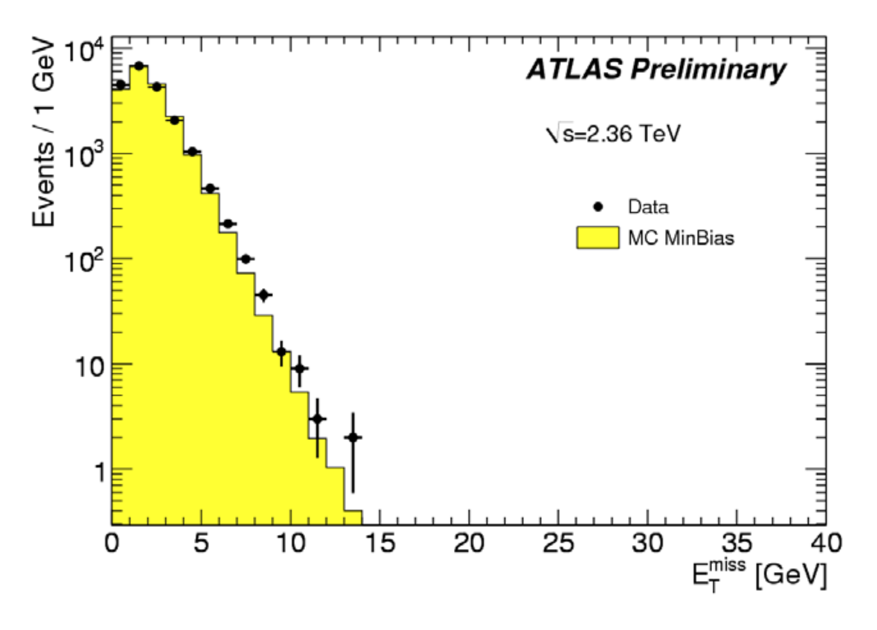


Multijet candidate

First data - distributions



Distribution of the difference of the azimuthal angle of the 2 highest P_T anti-kt jets



Distribution of missing transverse energy from 2.36 TeV minimum bias data (calibrated at EM scale)

Also resolution described well

First collisions at 7 TeV

Before claiming any discovery we need to understand our expectations (MC, detector response for tails of distributions)

First signals are the known SM particles (Z, W, top)
First SUSY papers will compare distributions with expectations in SUSY relevant phase space regions and show methods to determine the background expectations

Important: Control Measurements

Both ATLAS and CMS implemented many ways to verify each background:

Top *:*

Reconstruction of top events in SUSY signal region, define SUSY top control selections

W+jets *:*

Estimate in control selections and from Z+jets

Z+jets *:*

Estimate from Z➔ee or Z➔μμ or photon+jet events

QCD *:*

Derive calorimeter response function and apply it to good data,

find variables to remove QCD events most efficiently, …

Not beam induced *:*

study e.g. with overlayed cosmics

….

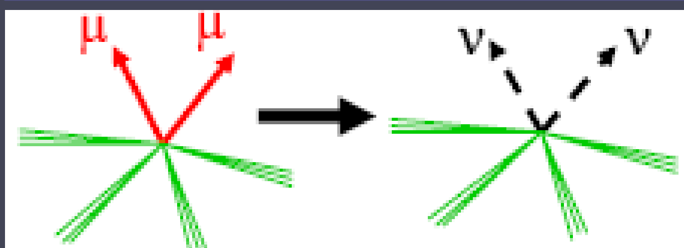
….

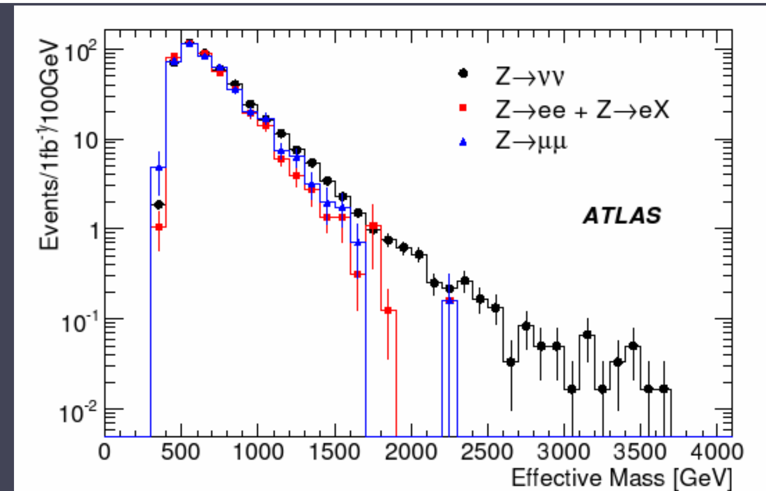
Students working hard…

Control Measurements and new variables

Estimate Z ➔ neutrinos background from data for 0 lepton channels

ATLAS/CMS: From Z➔ ee or μμ events





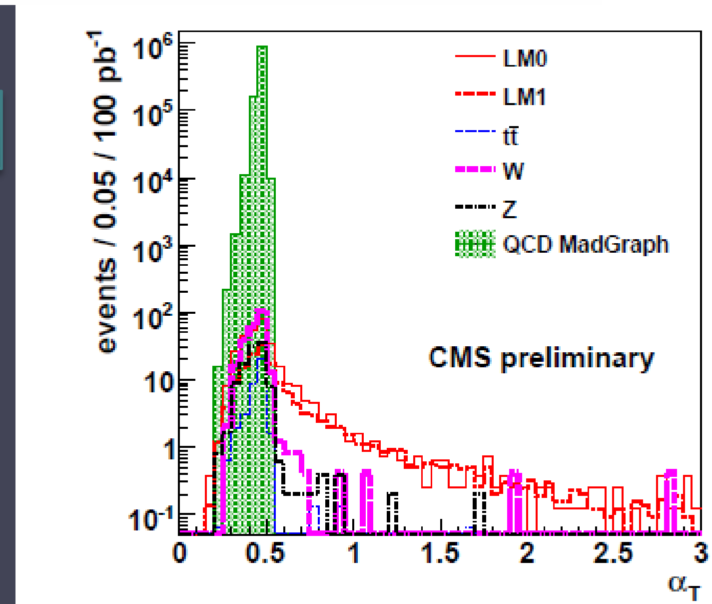
Find new variables to reduce QCD jet background

CMS:

$$\alpha_T = E_T^{j2} / M_T$$

- Exploits that QCD dijet events are back to back with equal P_T
- M_T is transverse mass
- Does also work for multijet events

Randall, Tucker-Smith



Example of a signal selection

- 0 leptons + 4 jets + large missing E_T

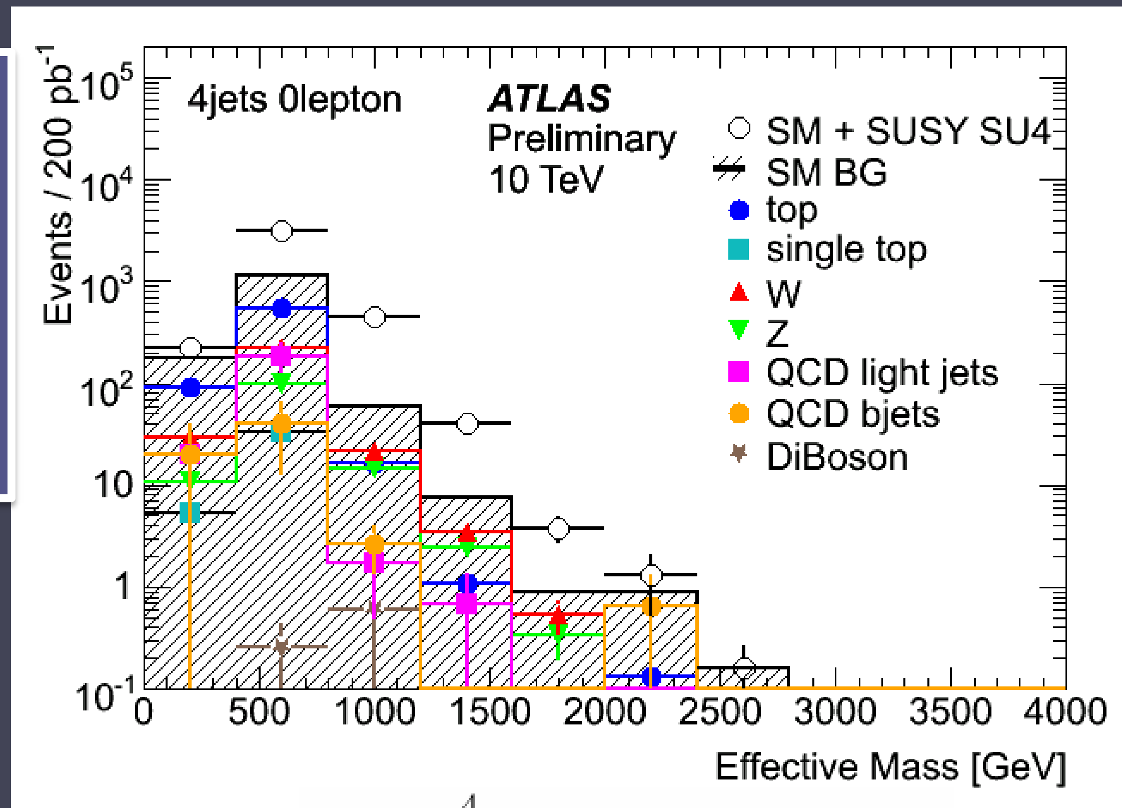
ATLAS baseline selection:

Trigger :

- Jet + MET or multi jets

Offline:

- 4 jets with E_T > 100, 40, 40, 40 GeV
- large MET
- Exclusive in lepton multiplicity
- Various cuts to reduce QCD background



$$M_{\rm eff} \equiv \sum_{i=1}^{4} p_T^{{\rm jet},i} + \sum_{i=1} p_T^{{\rm lep},i} + E_{\rm T}^{\rm miss}$$

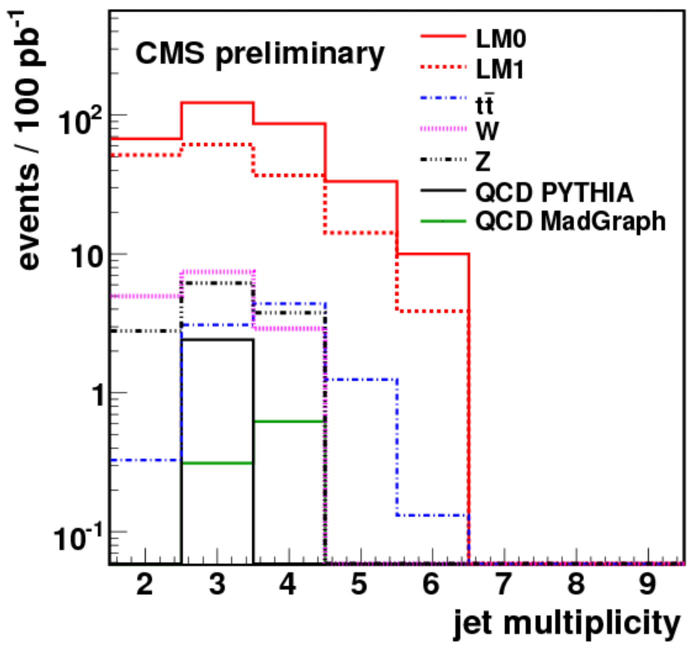
ATLAS benchmark point SU4

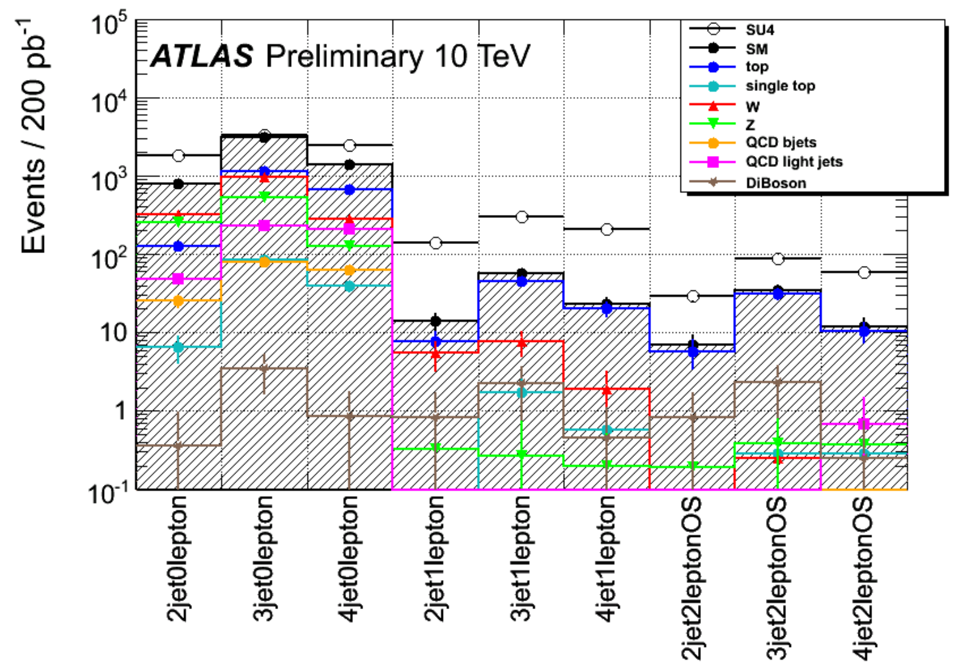
$m(\tilde{q},\tilde{g}) \sim 410$ GeV

visible !

Example Selections

1,2,3,4,5,6 Jets + 0,1,2 same and opposite sign, 3 leptons, tau, b-jets





Selection based on alpha_T, H_T and the MET balance between calculated using >50 and >30 GeV jets

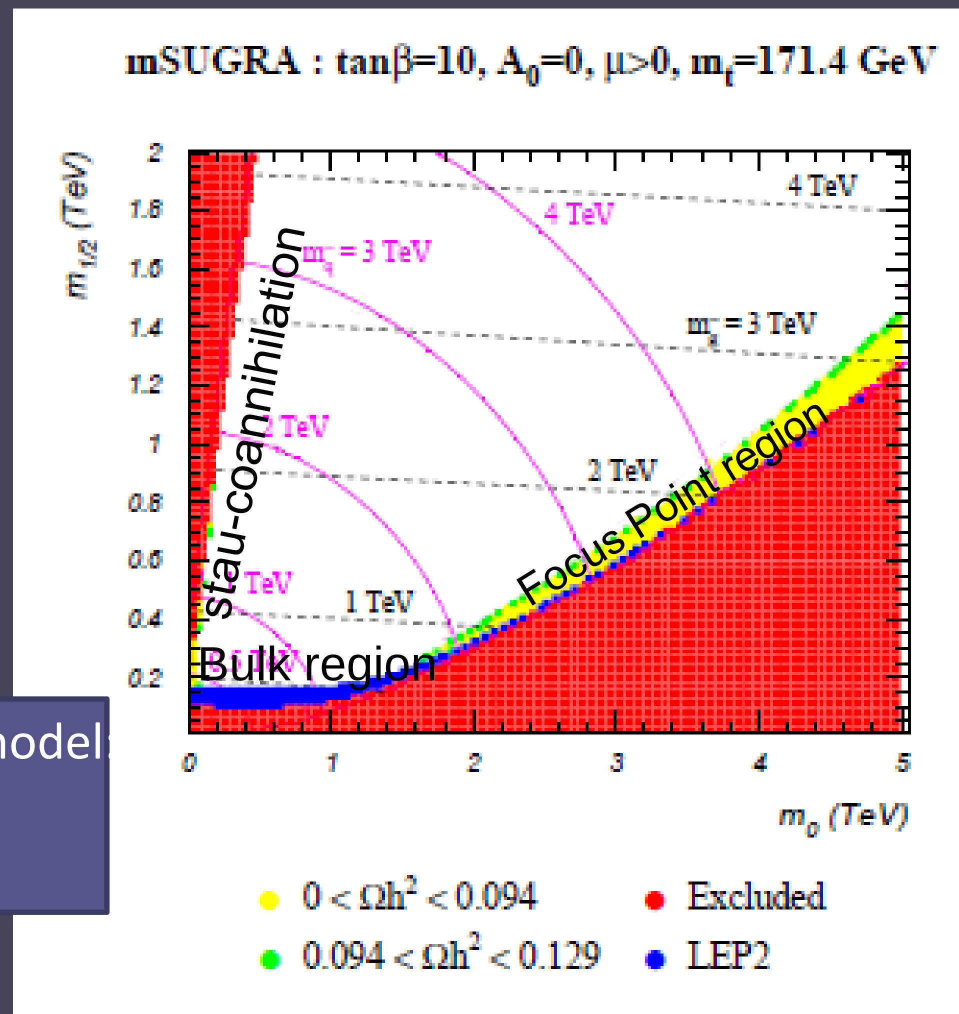
Selection based on the MET of the event, sum of ET and the delta phi between jets and MET

mSUGRA : Learning from DM for LHC

Most studied scenario is the 5 parameter mSUGRA model

M_0: common boson mass at GUT scale
$M_{1/2}$: common fermion mass at GUT scale
tan β: ratio of higgs vacuum expectation values
A_0: common GUT trilinear coupling
μ : sign of Higgs potential parameter

Large LSP annihilation cross section required by DM constraints
Huge restriction of parameter space in restrictive models



But if we are not in this restrictive model:
No stringent constraint on allowed SUSY masses from cosmology

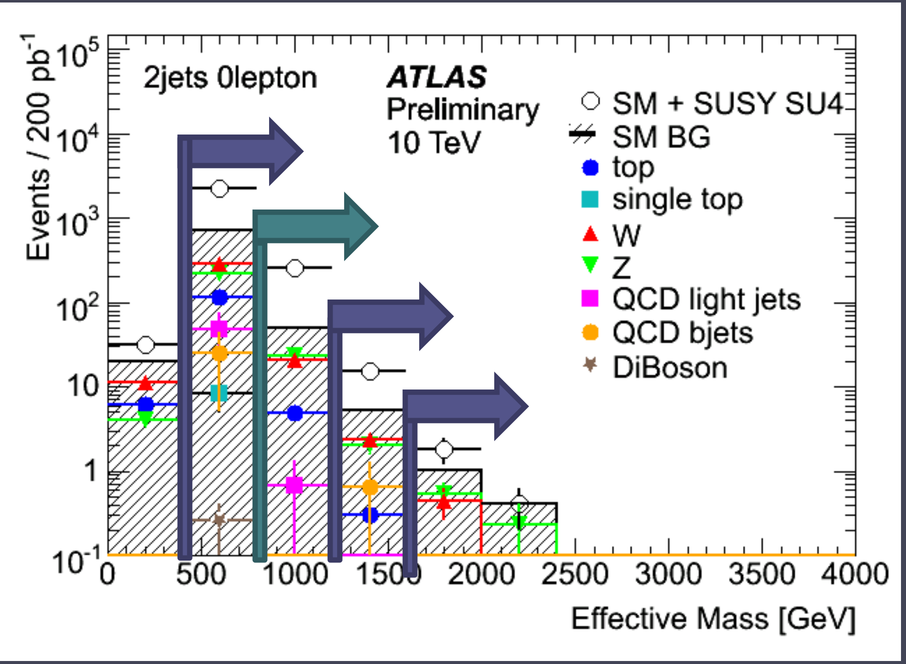
Search for new physics

Example from ATLAS:

Cut on effective mass optimized to get best signal significance

A set of cuts
➔ Sensitive to full mass range

HEP jargon:
- *> 5 sigma deviation means discovery*



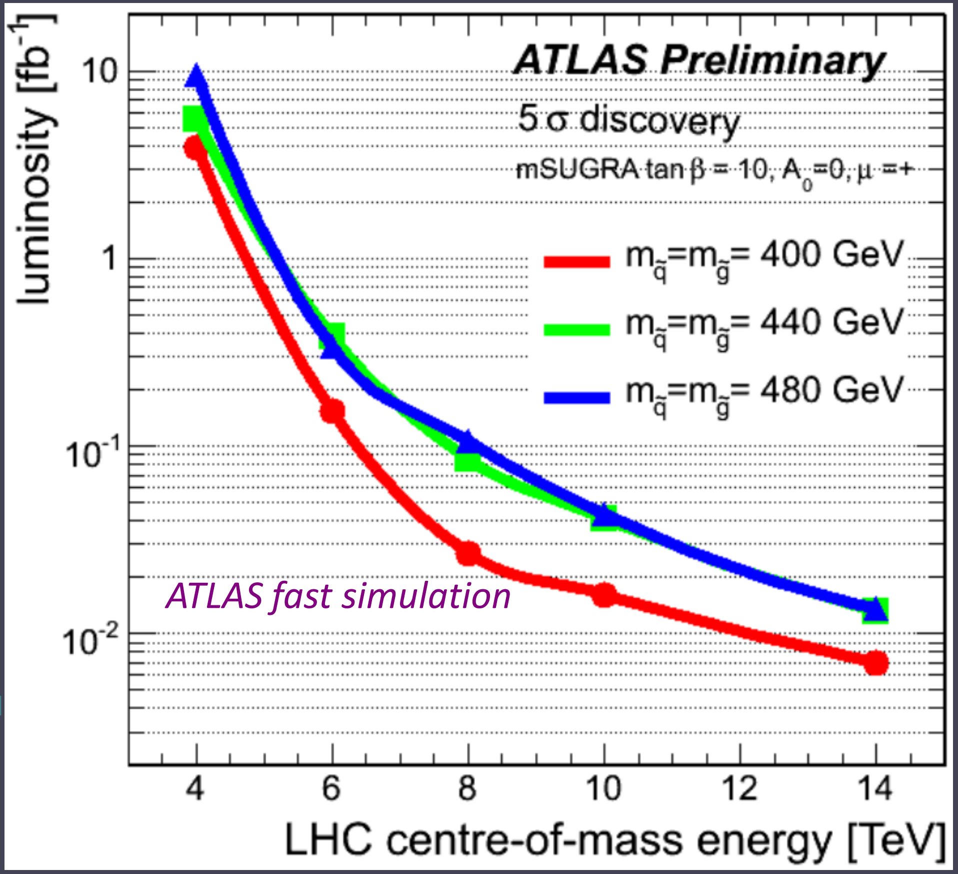
Some further information:
-Significance corrected for multiple tests
-Significance includes syst. error
(about 50% for first data)

SUSY : centre-of-mass dependence

LHC will run at 7 TeV

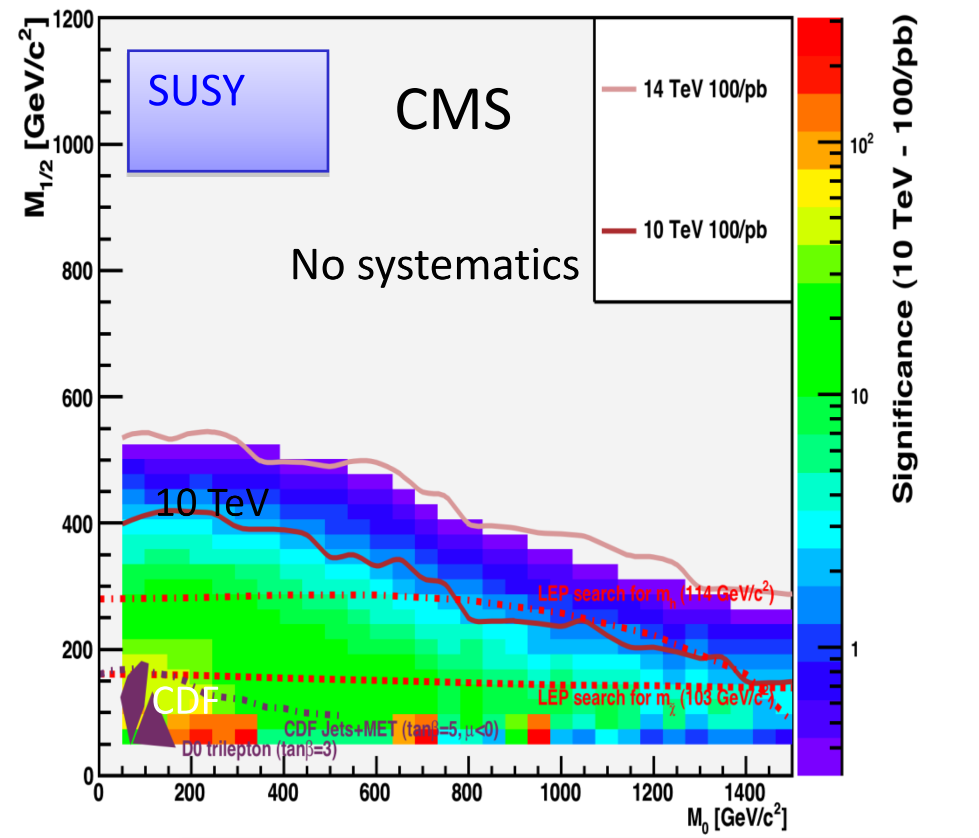
Going from 10 TeV to 7 TeV reduces the SUSY cross sections by factor 3-5 and background by around 3

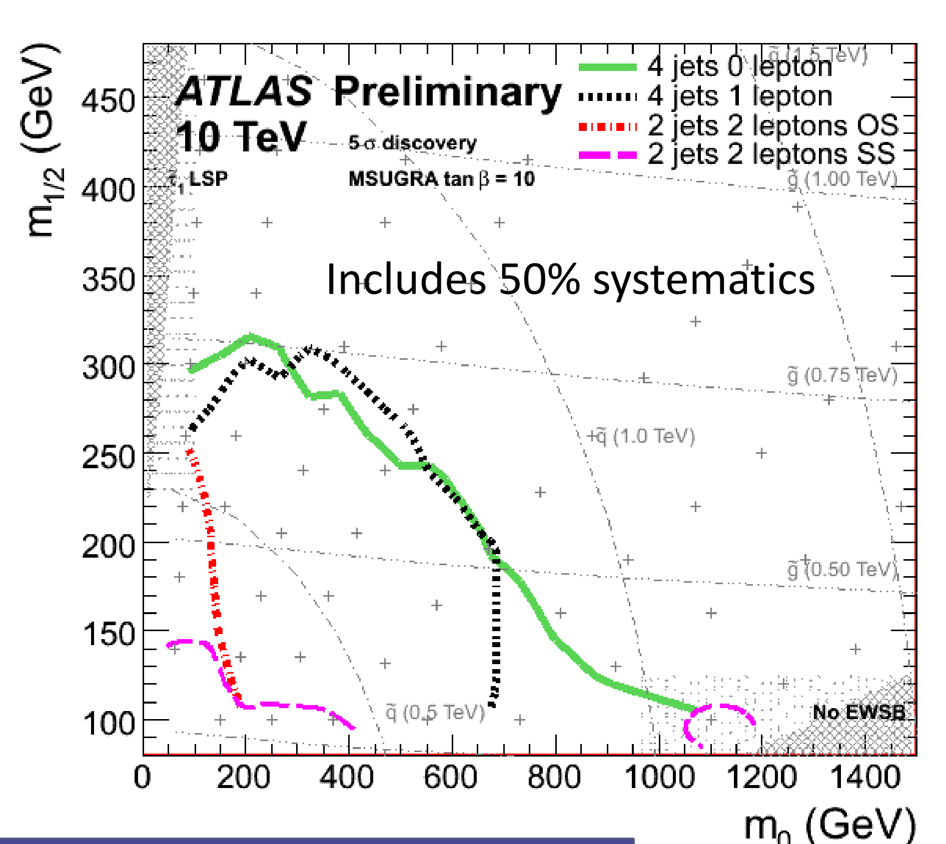
200 pb^{-1} at 10 TeV
corresponds very roughly
to 1000 pb^{-1} at 7 TeV



Tevatron limit currently is about 390 GeV in this mode (squark equal to gluino mass)

mSUGRA reach



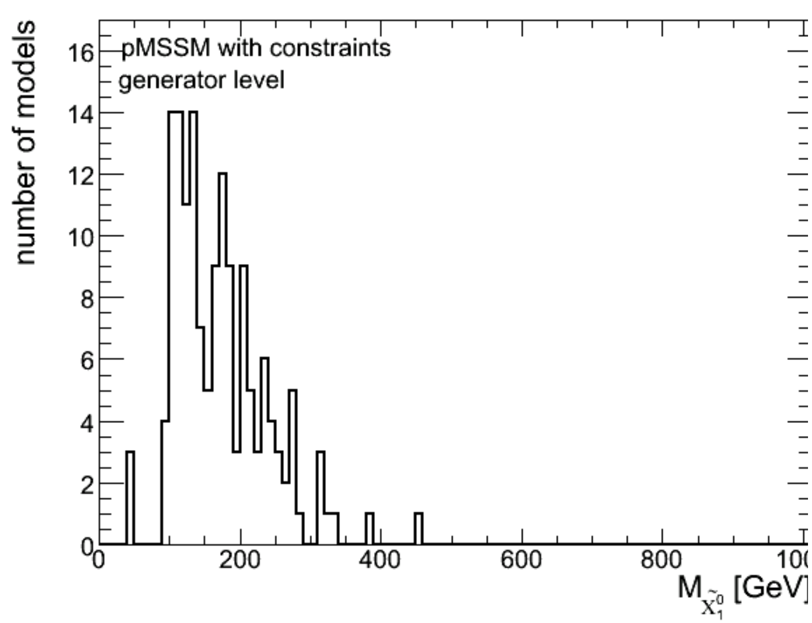


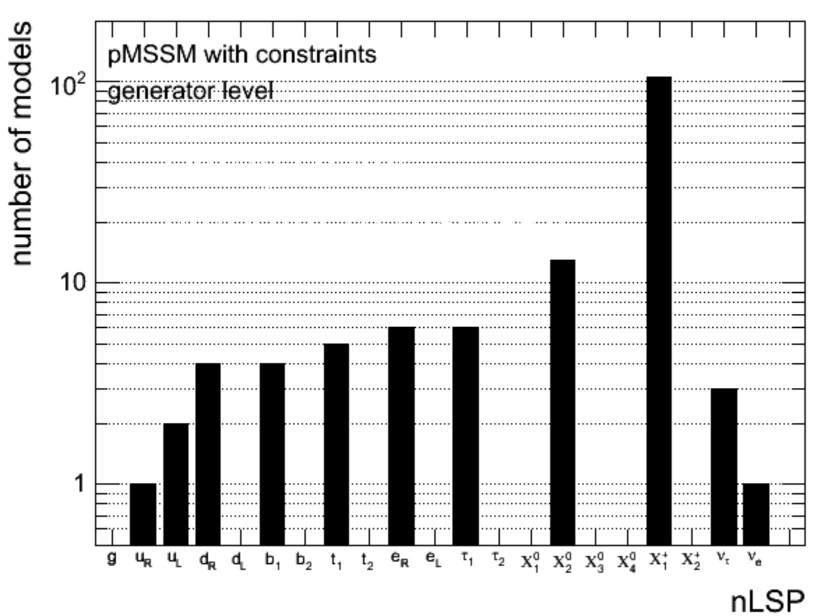
0 and 1 lepton channel have largest reach
With O(1000 pb^{-1}) at 7 TeV well understood data ATLAS and CMS reach well above Tevatron limits (300-400 GeV for squarks/gluinos)

Beyond mSUGRA

Parameter space of 19 parametric phenomenological MSSM was sampled with mass scale < 1TeV *(Berger, Gainer, Hewitt, Rizzo)*

ATLAS analyzed 200 points fulfilling all constraints from direct searches, DM and collider experiments

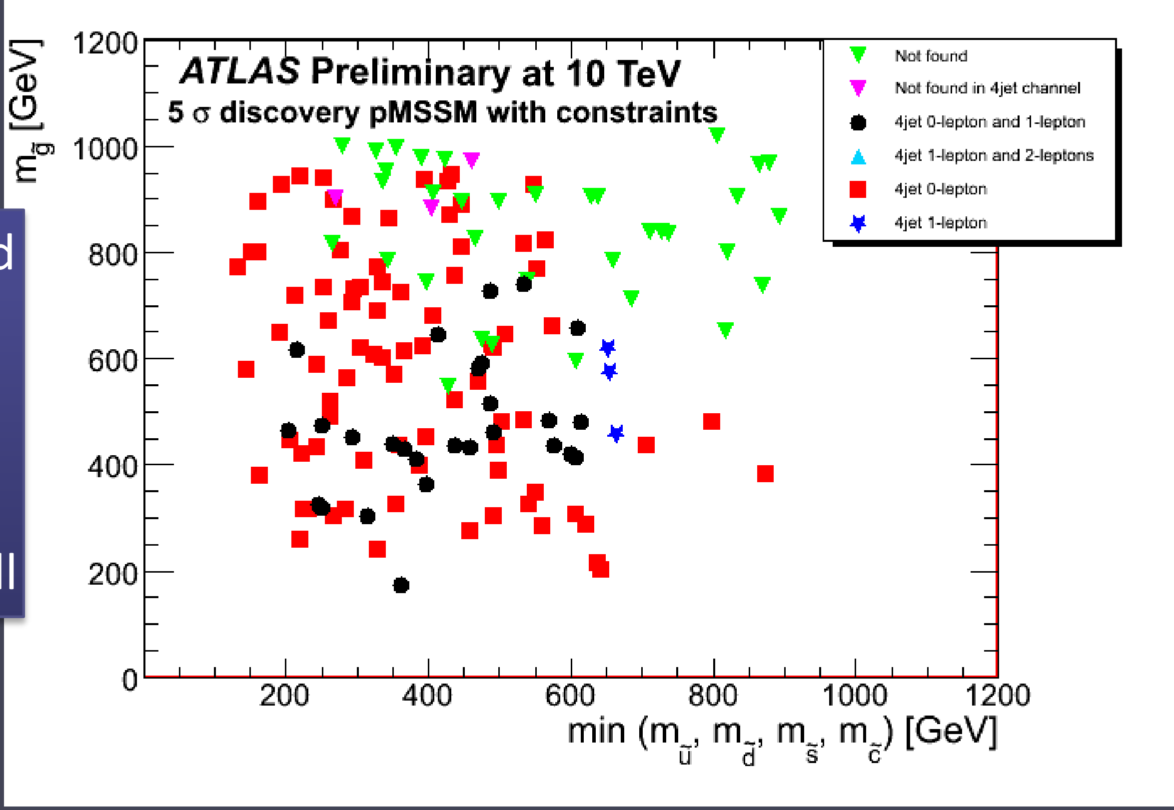




Beyond mSUGRA

Most models can be discovered also in this scenario

There are MSSM scenarios where no signal is discovered even though mass scale is small



Red, Black, Blue, Pink discovered

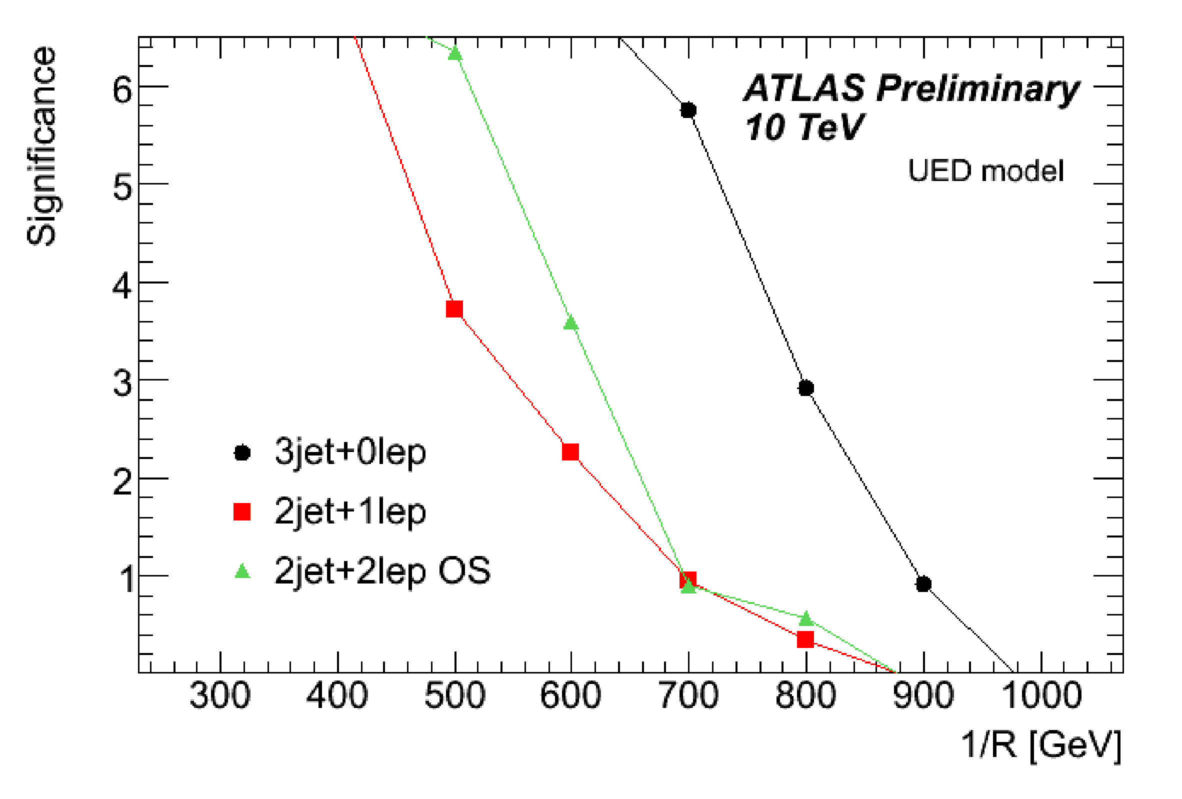
Green points are not discovered

Beyond SUSY: UED reach

Universal

Extra Dimension

Model



SM fields can

propagate into extra

dimensions with radius R.

➔ Kaluza Klein Towers of SM particles (same spin as SM)

➔ Here lightest KK particle is DM candidate

- Mass of new particles of O(1/R)
- Analysis identical with SUSY search
- Similar discovery reach

Parameter space in 2011

LHC "doubles" (in some metric) until 2011 the accessible parameter space for "colored particles" from theories like SUSY, UED, Little Higgs etc.

Tevatron/LEP : Limit up to 400 GeV
LHC: 5σ Discovery up to 800 GeV

Not shown today

- Searches with photons
- Searches with b-jets
- Searches with taus
- Searches for stops
- Multilepton
- Searches for SUSY Higgs
- Searches for R-Parity violating SUSY
- ....

Examples of non-standard signals

Long lived particles appear if decay is only possible via loops, via highly virtual particles or if coupling is small

Some studied examples are long lived hadrons, sleptons, neutralinos

Signal examples:

- (Slowly) travelling heavy hadron (muon like)
- Late muon like track (wrong bunch crossing)
- Neutralino (with lifetime) could in GMSB decay to photon and gravitino (non-pointing photons)

Challenging, but discovery possible in CMS and ATLAS in many scenarios in early data due to small backgrounds

After discovery: Models and Parameters

"Observation of events with high missing transverse energy in pp collisions"

Is it really Supersymmetry ? Is it any of the known candidates?

Perform a great many of exclusive measurements

-Measurement of possible decay chains
-Measurement of 3rd generation signals
-Measurement of mass differences
-Measurement of signal strenght and mass scale (is it comparable with assumed cross section)
-Measurement of Majorana nature of gluino via dileptons of same sign
-Measurement of particles spin
- ….

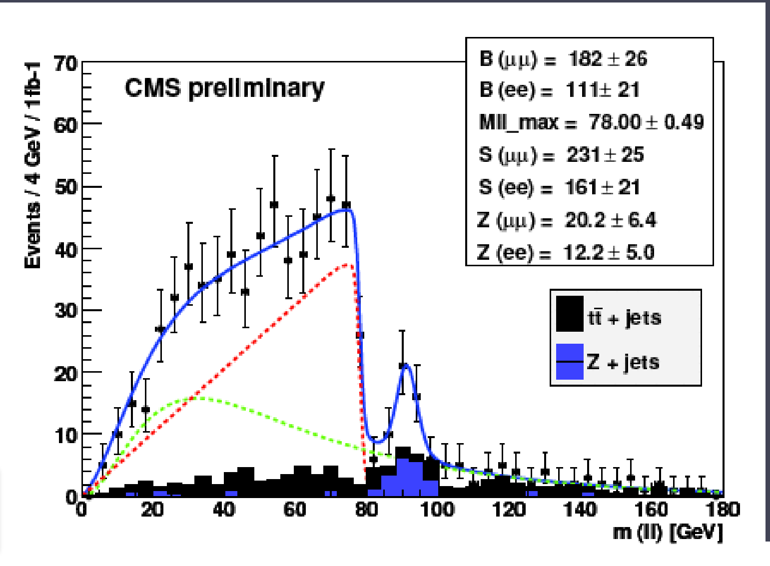
Test models against all those measurements

Example of an early measurement

Perform a great many of exclusive measurements

Example : Measurement of $\tilde{\chi}_2^0 \rightarrow \tilde{\ell}_{L,R}\ell \rightarrow \ell\ell\tilde{\chi}_1^0$ in OS dilepton events

Due to missing energy no mass peaks, but shapes and endpoints of mass distribution provide mass information



CMS

$$m_{\ell\ell}^{max} = m_{\tilde{\chi}_2^0}\sqrt{1 - \frac{m_{\tilde{\ell}_R}^2}{m_{\tilde{\chi}_2^0}^2}}\sqrt{1 - \frac{m_{\tilde{\chi}_1^0}^2}{m_{\tilde{\ell}_R}^2}}$$

$$\Delta m_{ee}^{max} = \pm 1.07(stat.) \pm 0.36(syst.) GeV/c^2$$

$$\Delta m_{\mu\mu}^{max} = \pm 0.75(stat.) \pm 0.18(syst.) GeV/c^2$$

Summary and Conclusions

- SUSY is the most studied theory on the market, for some good reasons
- First we need to understand the SM background
- LHC roughly doubles the accessible parameter space for SUSY (UED, Little Higgs) till 2011
- One of the greatest discoveries in particle physics could be made in the next 2 years

And then we should take a bath in Champagne !

EXTRA SLIDES

ATLAS benchmark points

SU1 $m_0 = 70$ GeV, $m_{1/2} = 350$ GeV, $A_0 = 0$, $\tan\beta = 10$, $\mu > 0$. Coannihilation region where $\tilde{\chi}_1^0$ annihilate with near-degenerate $\tilde{\ell}$.

SU2 $m_0 = 3550$ GeV, $m_{1/2} = 300$ GeV, $A_0 = 0$, $\tan\beta = 10$, $\mu > 0$. Focus point region near the boundary where $\mu^2 < 0$. This is the only region in mSUGRA where the $\tilde{\chi}_1^0$ has a high higgsino component, thereby enhancing the annihilation cross-section for processes such as $\tilde{\chi}_1^0\tilde{\chi}_1^0 \to WW$.

SU3 $m_0 = 100$ GeV, $m_{1/2} = 300$ GeV, $A_0 = -300$ GeV, $\tan\beta = 6$, $\mu > 0$. Bulk region: LSP annihilation happens through the exchange of light sleptons.

SU4 $m_0 = 200$ GeV, $m_{1/2} = 160$ GeV, $A_0 = -400$ GeV, $\tan\beta = 10$, $\mu > 0$. Low mass point close to Tevatron bound.

SU6 $m_0 = 320$ GeV, $m_{1/2} = 375$ GeV, $A_0 = 0$, $\tan\beta = 50$, $\mu > 0$. The funnel region where $2m_{\tilde{\chi}_1^0} \approx m_A$. Since $\tan\beta \gg 1$, the width of the pseudoscalar Higgs boson A is large and τ decays dominate.

SU8.1 $m_0 = 210$ GeV, $m_{1/2} = 360$ GeV, $A_0 = 0$, $\tan\beta = 40$, $\mu > 0$. Variant of coannihilation region with $\tan\beta \gg 1$, so that only $m_{\tilde{\tau}_1} - m_{\tilde{\chi}_1^0}$ is small.

SU9 $m_0 = 300$ GeV, $m_{1/2} = 425$ GeV, $A_0 = 20$, $\tan\beta = 20$, $\mu > 0$. Point in the bulk region with enhanced Higgs production

CMS LM benchmark points

- **Point LM1 :**
  - Same as post-WMAP benchmark point B′ and near DAQ TDR point 4.
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant
  - $B(\tilde{\chi}_2^0 \to \tilde{l}_R l) = 11.2\%$, $B(\tilde{\chi}_2^0 \to \tilde{\tau}_1 \tau) = 46\%$, $B(\tilde{\chi}_1^\pm \to \tilde{\nu}_l l) = 36\%$
- **Point LM2 :**
  - Almost identical to post-WMAP benchmark point I′.
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant ($\tilde{b}_1 b$ is 25%)
  - $B(\tilde{\chi}_2^0 \to \tilde{\tau}_1 \tau) = 96\%$ $B(\tilde{\chi}_1^\pm \to \tilde{\tau}\nu) = 95\%$
- **Point LM3 :**
  - Same as NUHM point γ and near DAQ TDR point 6.
  - $m(\tilde{g}) < m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is forbidden except $B(\tilde{g} \to \tilde{b}_{1,2} b) = 85\%$
  - $B(\tilde{\chi}_2^0 \to ll\tilde{\chi}_1^0) = 3.3\%$, $B(\tilde{\chi}_2^0 \to \tau\tau\tilde{\chi}_1^0) = 2.2\%$, $B(\tilde{\chi}_1^\pm \to W^\pm\tilde{\chi}_1^0) = 100\%$
- **Point LM4 :**
  - Near NUHM point α in the on-shell Z^0 decay region
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant with $\tilde{g} \to \tilde{b}_1 b = 24\%$
  - $B(\tilde{\chi}_2^0 \to Z^0\tilde{\chi}_1^0) = 97\%$, $B(\tilde{\chi}_1^\pm \to W^\pm\tilde{\chi}_1^0) = 100\%$
- **Point LM5 :**
  - In the h^0 decay region, same as NUHM point β.
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant with $B(\tilde{g} \to \tilde{b}_1 b) = 19.7\%$ and $B(\tilde{g} \to \tilde{t}_1 t) = 23.4\%$
  - $B(\tilde{\chi}_2^0 \to h^0\tilde{\chi}_1^0) = 85\%$, $B(\tilde{\chi}_2^0 \to Z^0\tilde{\chi}_1^0) = 11.5\%$, $B(\tilde{\chi}_1^\pm \to W^\pm\tilde{\chi}_1^0) = 97\%$
- **Point LM6 :**
  - Same as post-WMAP benchmark point C′.
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant
  - $B(\tilde{\chi}_2^0 \to \tilde{l}_L l) = 10.8\%$, $B(\tilde{\chi}_2^0 \to \tilde{l}_R l) = 1.9\%$, $B(\tilde{\chi}_2^0 \to \tilde{\tau}_1 \tau) = 14\%$, $B(\tilde{\chi}_1^\pm \to \tilde{\nu}_l l) = 44\%$

Point LM7 :

  - Very heavy squarks, outside reach, but light gluino.
  - $m(\tilde{g}) = 678$ GeV/c^2, hence $\tilde{g} \to$ 3-body is dominant
  - $B(\tilde{\chi}_2^0 \to ll\tilde{\chi}_1^0) = 10\%$, $B(\tilde{\chi}_1^\pm \to \nu l\tilde{\chi}_1^0) = 33\%$
  - EW chargino-neutralino production cross-section is about 73% of total.

Point LM8 :

  - Gluino lighter than squarks, except $\tilde{b}_1$ and $\tilde{t}_1$
  - $m(\tilde{g}) = 745$ GeV/c^2, $M(\tilde{t}_1) = 548$ GeV/c^2, $\tilde{g} \to \tilde{t}_1 t$ is dominant
  - $B(\tilde{g} \to \tilde{t}_1 t) = 81\%$, $B(\tilde{g} \to \tilde{b}_1 b) = 14\%$, $B(\tilde{q}_L \to q\tilde{\chi}_2^0) = 26 - 27\%$,
  - $B(\tilde{\chi}_2^0 \to Z^0\tilde{\chi}_1^0) = 100\%$, $B(\tilde{\chi}_1^\pm \to W^\pm\tilde{\chi}_1^0) = 100\%$

- **Point LM9 :**
  - Heavy squarks, light gluino. Consistent with EGRET data on diffuse gamma ray spectrum, WMAP results on CDM and mSUGRA [674]. Similar to LM7.
  - $m(\tilde{g}) = 507$ GeV/c^2, hence $\tilde{g} \to$ 3-body is dominant
  - $B(\tilde{\chi}_2^0 \to ll\tilde{\chi}_1^0) = 6.5\%$, $B(\tilde{\chi}_1^\pm \to \nu l\tilde{\chi}_1^0) = 22\%$
- **Point LM10 :**
  - Similar to LM7, but heavier gauginos.
  - Very heavy squarks, outside reach, but light gluino.
  - $m(\tilde{g}) = 1295$ GeV/c^2, hence $\tilde{g} \to$ 3-body is dominant
  - $B(\tilde{g} \to t\bar{t}\tilde{\chi}_4^0) = 11\%$, $B(\tilde{g} \to tb\tilde{\chi}_2^\pm) = 27\%$

Other benchmark points

- SPS1: bulk region

m0 = 100 GeV, m1/2 = 250 GeV,

tan = 10, A = 100 GeV, sign mu > 0

(Baltz, Battag
Peskin, Wizan
2006, page 25

Point	m_0	$m_{\frac{1}{2}}$	$\tan\beta$	A_0	sign mu	m_t	reference	$\Omega_\chi h^2$
LCC1	100	250	10	−100	+	175	[86]	0.192
LCC2	3280	300	10	0	+	175	[87]	0.109
LCC3	213	360	40	0	+	175	[88]	0.101
LCC4	380	420	53	0	+	178	[90]	0.114
SPS1a′	70	250	10	−300	+	175	[91]	0.115

Table 1: mSUGRA parameter sets for four illustrative models of neutralino dark matter. Masses are given in GeV. The table also lists the value of $\Omega_\chi h^2$. The references given are the primary references for simulation studies of the accuracy of spectrum measurements at colliders. The point SPS1a′ has a phenomenology similar to that of LCC1 but gives a more correct value of the relic density.

e^+e^-, $\mu^+\mu^-$, and $\tau^+\tau^-$. The sleptons are not quite light enough; the spectrum achieves a relic density $\Omega h^2 = 0.19$, almost doubly the WMAP value. Point LCC2 is chosen as a point with substantial gaugino-Higgsino mixing at which the neutralino annihilation is dominated by annihilation to W^+W^-, Z^0Z^0, and Z^0h^0. Point LCC3 is chosen in the region where coannihilation with the $\tilde{\tau}$ plays an important role. Point LCC4 is chosen in a region where the A^0 resonance makes an important contribution to the neutralino annihilation cross section.

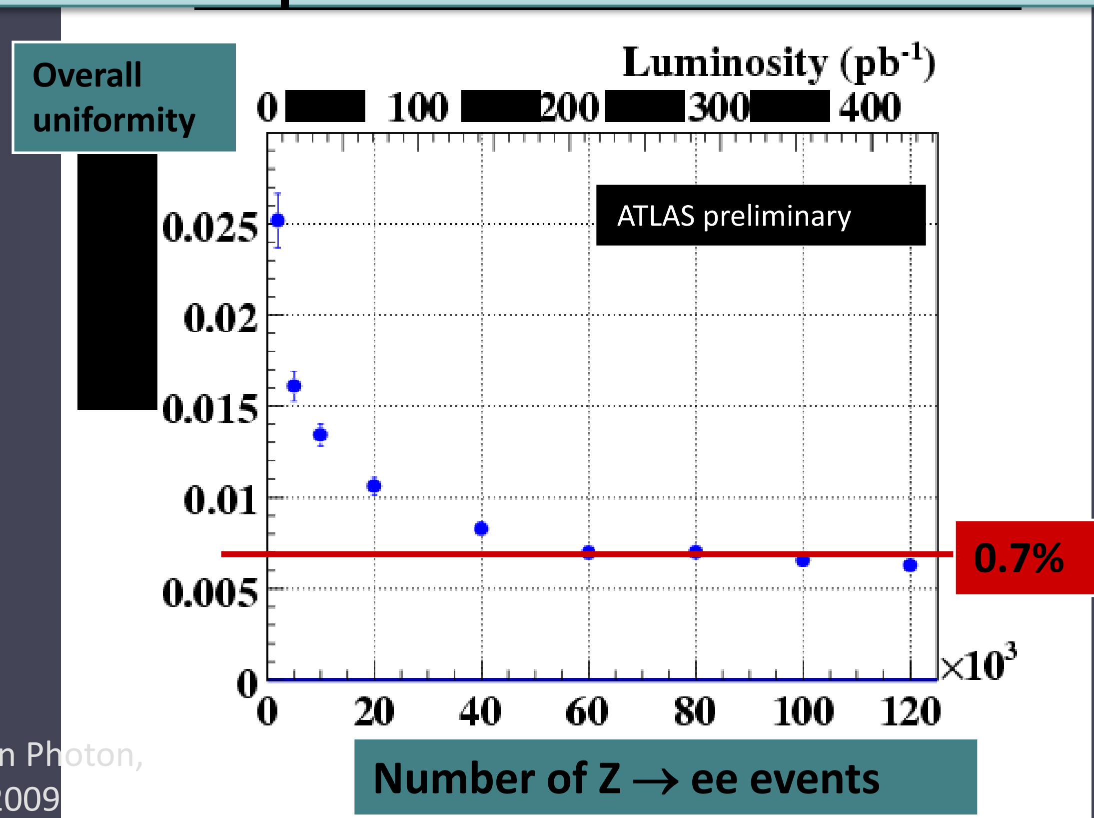
Expected ATLAS performance on "Day-1"

(examples based on test-beam, simulation, and cosmics results)

	Initial Day-1	Ultimate goal	Physics samples to improve(examples)
ECAL uniformity	~2.5%	0.7%	Isolated electrons, $Z \rightarrow ee$
e/γ E-scale	2-3%	<0.1%	J/ψ, $Z \rightarrow ee$, E/p for electrons
Jet E-scale	5-10%	1%	γ/Z + 1j, $W \rightarrow jj$ in tt events
ID alignment	20-200 μm	5 μm	Generic tracks, isolated μ, $Z \rightarrow \mu\mu$
Muon alignment	40-1000 μm	30 μm	Straight μ, $Z \rightarrow \mu\mu$

ECAL uniformity:

- local uniformity by construction/test: 0.5%
- residual long-range non-uniformities (upstream material, etc.): ~ few percent
  → use Z-mass constraint to correct
  ~ 10^5 $Z \rightarrow ee$ events enough to achieve the goal response uniformity of ~ 0.7%



Inclusive SUSY searches

Example : jets + 0 lepton channel baseline channel

Main backgrounds for 0 lepton search

QCD : missing P_T due to jet mis-measurements and jet resolutions

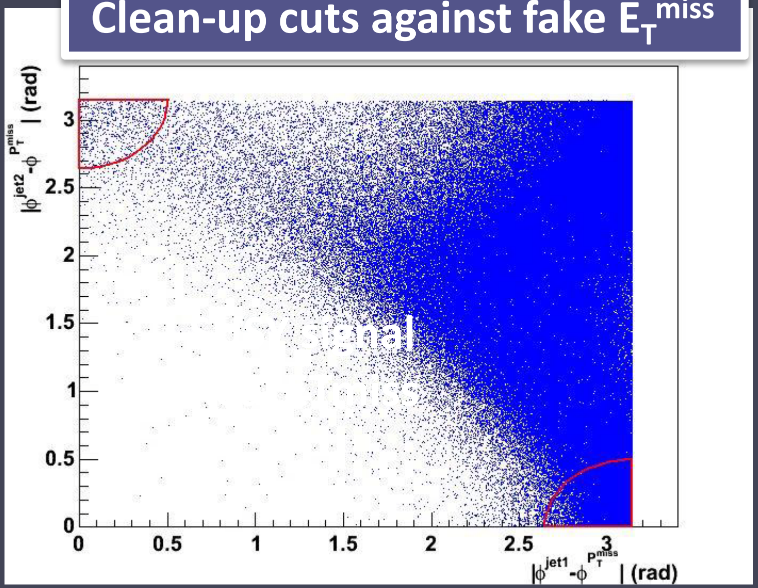
Z ➔ neutrinos : irreducible, we need to measure

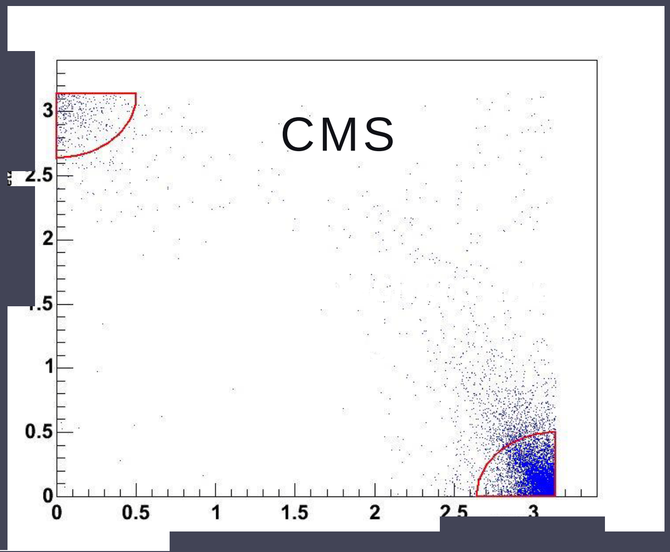
Top : 1 or 2 leptons not identified

W   : 1 lepton not identified

QCD background reduction and control

Clean-up cuts against fake E_T^{miss}





|Φjet2 - Φmissing momentum|

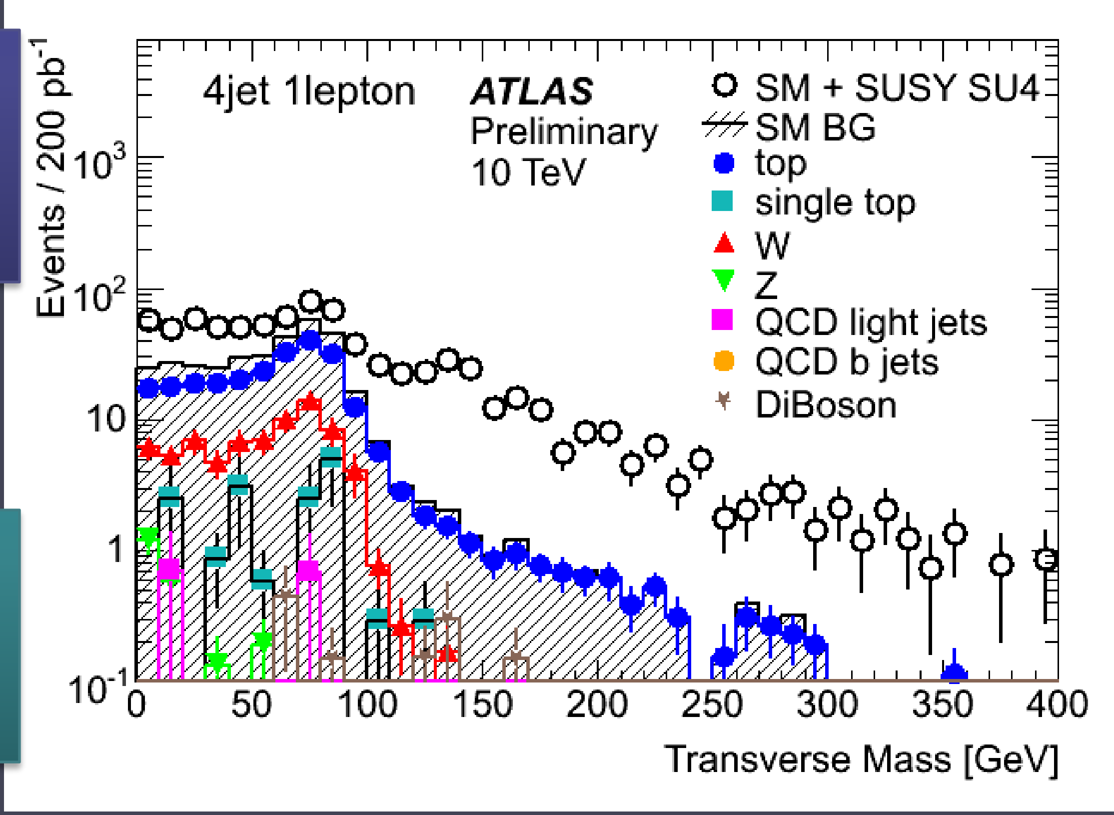
|Φjet1 - Φmissing momentum|

Control Measurements

- 1 leptons + 2/3/4 jets + large missing E_T

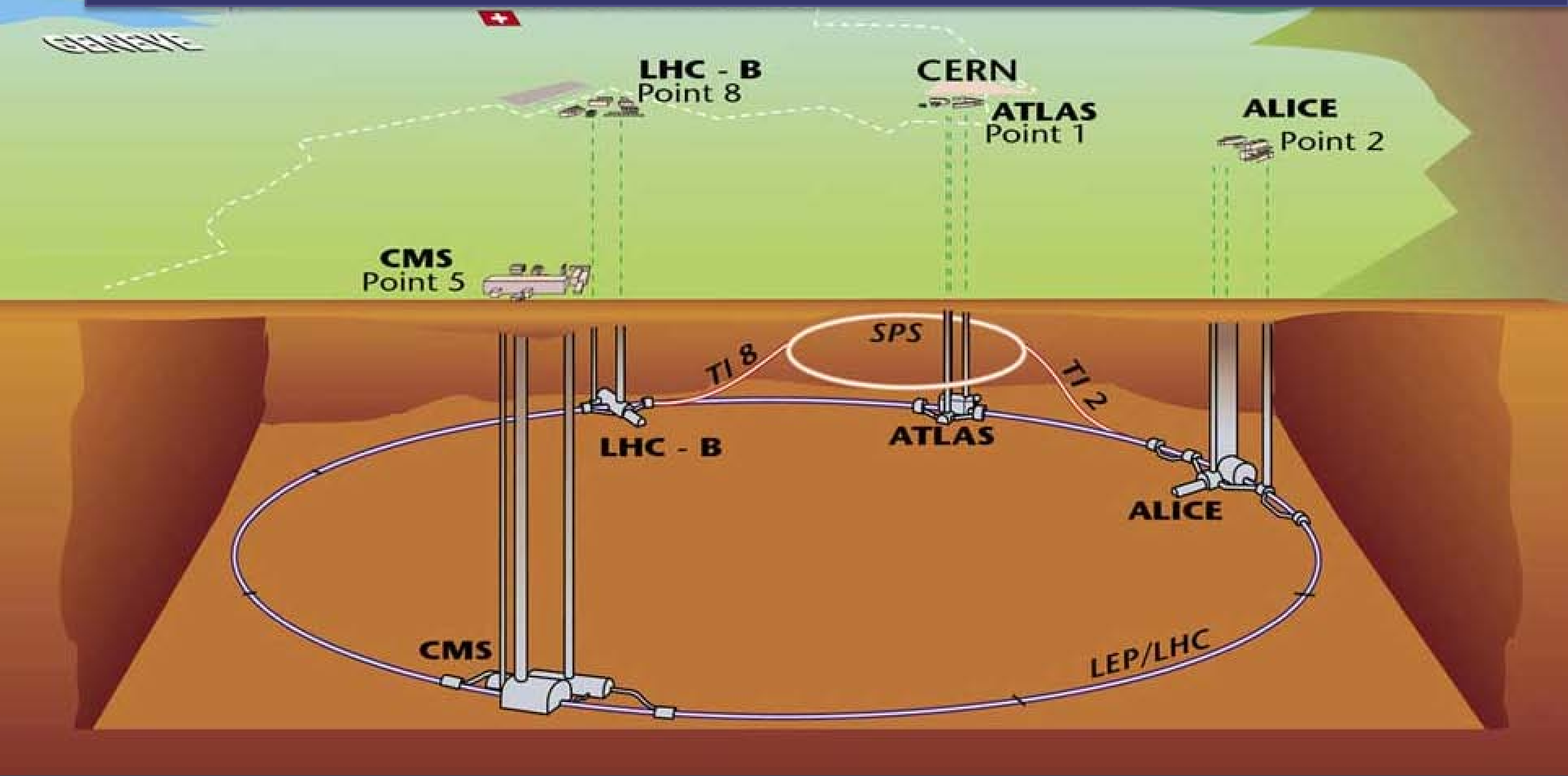
ATLAS:
control region with M_T < 100 GeV
Here we have more SM events than new physics signal

effective mass distribution in control region can be used to predict distribution in signal region (M_T > 100 GeV)

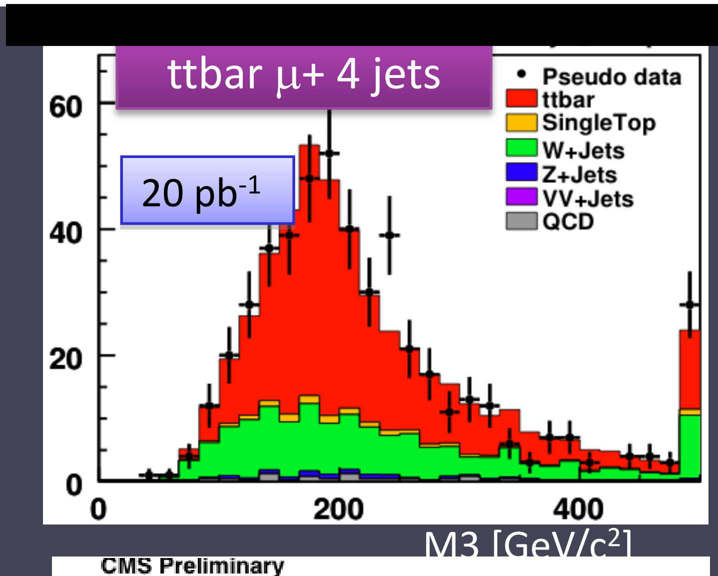


LHC is a proton-proton (and lead nuclei) collider with a design centre-of-mass energy of 14 TeV and an integrated luminosity of 10^{34} $cm^{-2}s^{-1}$

- 10. September 2008: LHC Start with single beam energy of 450 GeV
- 19. September 2008: During 5 TeV magnet commisioning a high resistance appeared in a faulty interconnection between two magnets
  ➔Serious incident (He released, large forces displaced magnets)
- Since then various preventive systems installed, √s initially reduced to 7 TeV



First data: Top production in Europe

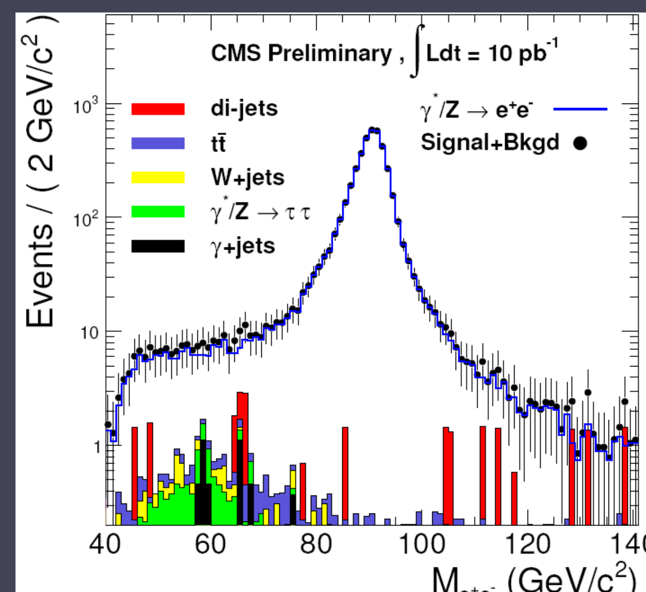


Tops are most important SUSY background and needed to understand reconstruction efficiencies in busy events

M3 = inv. mass of 3 jets with highest vector sum

1o TeV

Clear Z and W events with 10 pb^{-1}



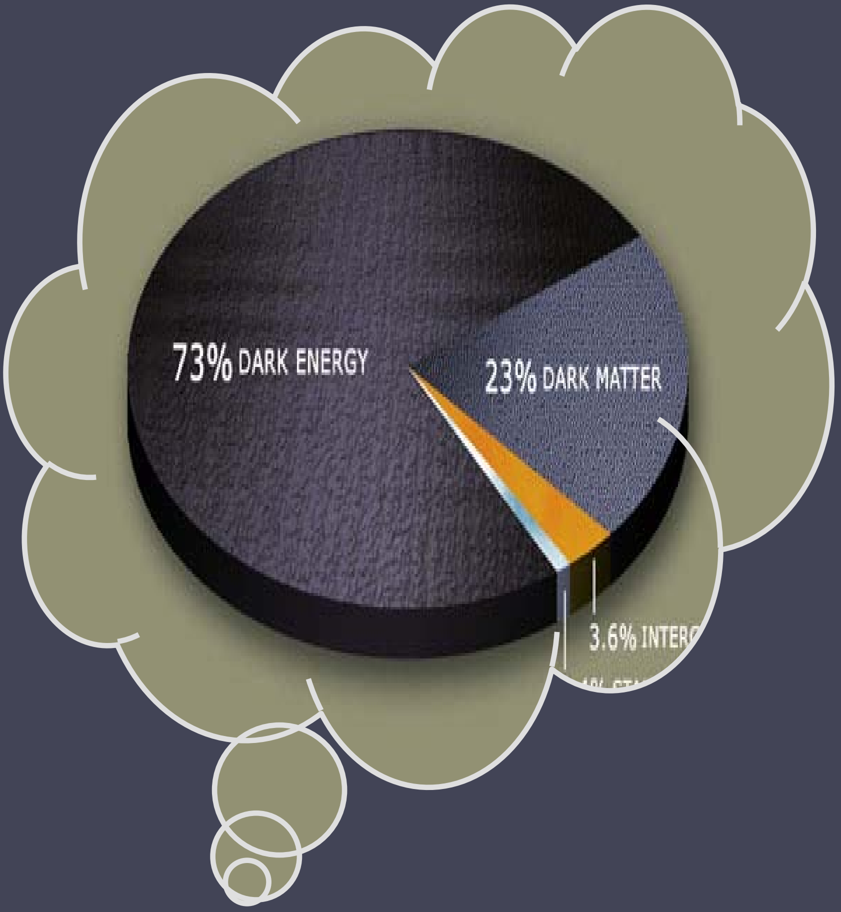
Z events can be used to study all kinds of efficiencies, e.g. using so called tag and probe methods

Why SUSY ? Personal highlight

Dark Matter evidence from Astroparticle physics

Good candidate:
- Non-relativistic (Cold Dark Matter)
- Massive
- Electrically and color neutral

If it's a WIMP (Weakly interacting) :
- The amount of WIMP DM suggests a new particle (in thermal equilibrium in early Universe) with a mass of O(100 GeV) at an electroweak annihilation cross section



LSP is a perfect Dark Matter candidate