SUSY searches with ATLAS

What did we learn with few fb^{-1}?

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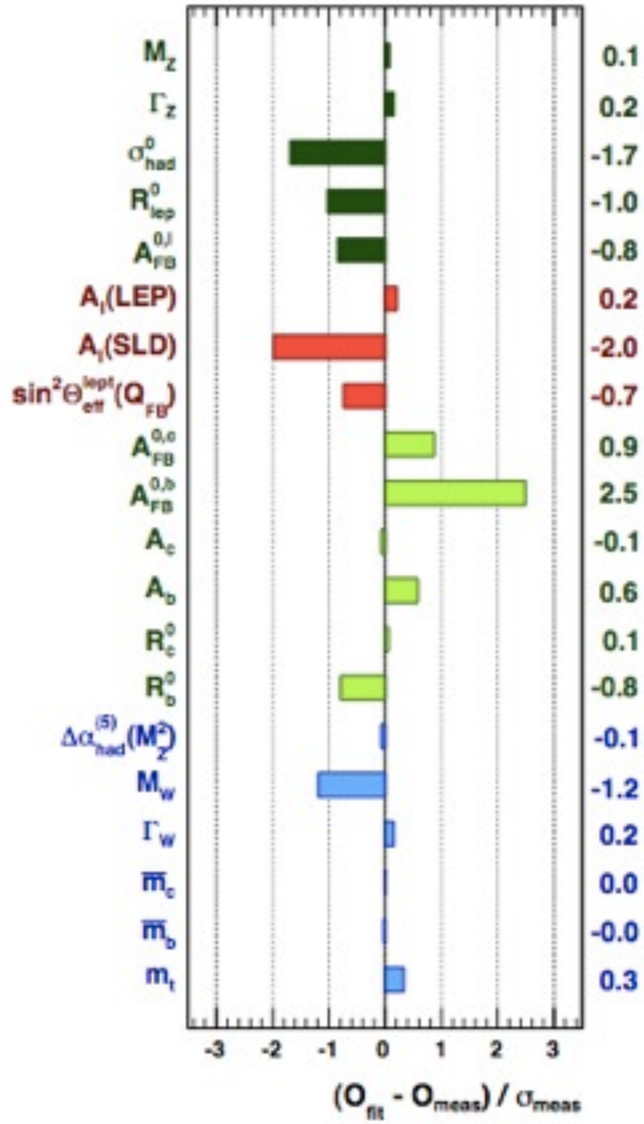
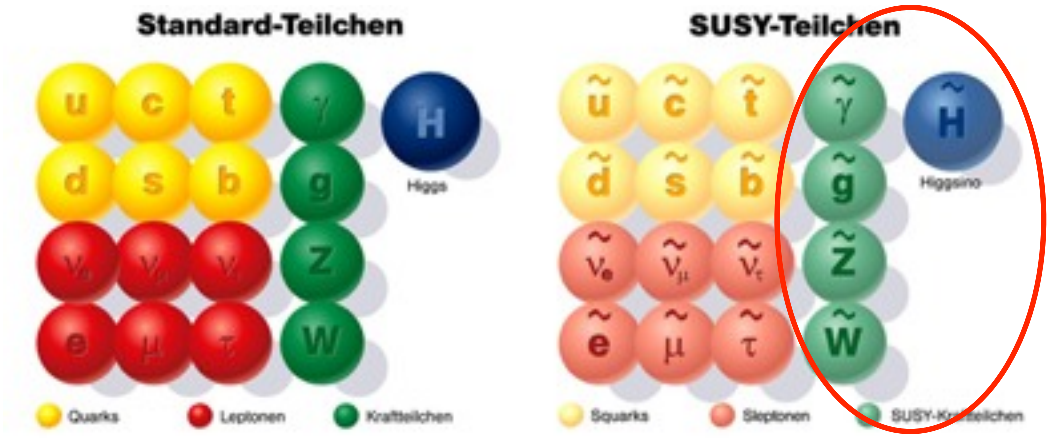
Is the Standard Model enough?

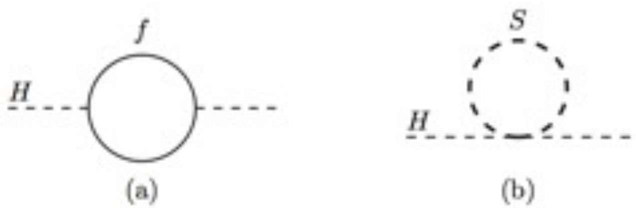
- The Standard Model has accumulated more than 30 years of striking successes in particle physics experiments, but:
  - a) The Higgs sector suffers from quadratically divergent loop corrections mainly from top (the so called hierarchy problem)
  - b) Cosmological data call for a dark matter candidate: no such candidate is present in the SM
  - c) No further unification between the EW and QCD possible
- *<u>Supersymmetry (SUSY) offers an elegant solution for a), which can simultaneously address b) and c)</u>*



Supersymmetry (SUSY)

- SUSY is a spin symmetry that relates bosons and fermions
- In the Minimal Supersymmetric Extension of the Standard Model (MSSM):
  - a new set of fields differing in spin by 1/2 w.r.t. the SM partners (hierarchy problem solved "naturally")





Mix into neutralinos and charginos

- Running of coupling constants above the EW scale modified: unification possible
- If R-parity conservation assumed, the Lightest Supersymmetric Particle (LSP) is stable: natural Dark Matter candidate

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

-1 for sparticles

1 for particles

Minimal SUSY extension of SM (MSSM)

- If SUSY is unbroken, $M_{sparticle} = M_{particle}$. Since sparticles are not yet observed, SUSY must be (softly) broken:
  - $L_{SUSY} = L_{SUSY\ conserving} + L_{SUSY\ soft\ breaking}$

2 higgs doublets needed → 5 Higgs bosons

MSSM parameters:

SUSY conserving sector	SUSY breaking sector
3 coupling constants for SU(3) xSU(2)sU(1)	5 3x3 hermitian mass matrices (one per EW multiplet)
4 Yukawa couplings per generation	3 complex 3x3 matrices (Higgs trilinear couplings to sfermions)
	3 mass terms for the Higgs sector + 2 additional off-diagonal terms
	Higgs VEV expectation angle β

A total of 124 parameters.
Constraints needed:

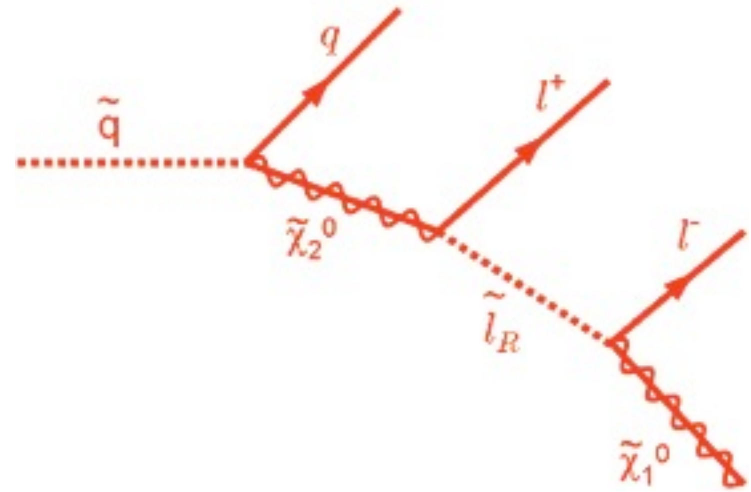
Bottom up: separate lepton number conservation, FCNC suppression, CP violation constrain the MSSM parameters

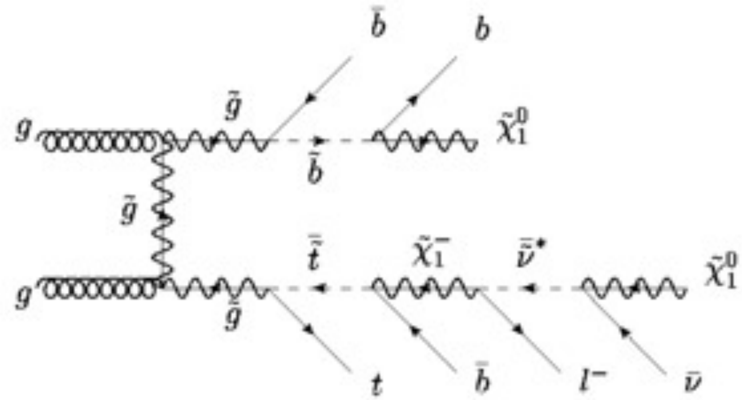
Top-down: Precise assumptions are made on the way SUSY is broken:

- mSUGRA/CMSSM
- GMSB
- AMSB

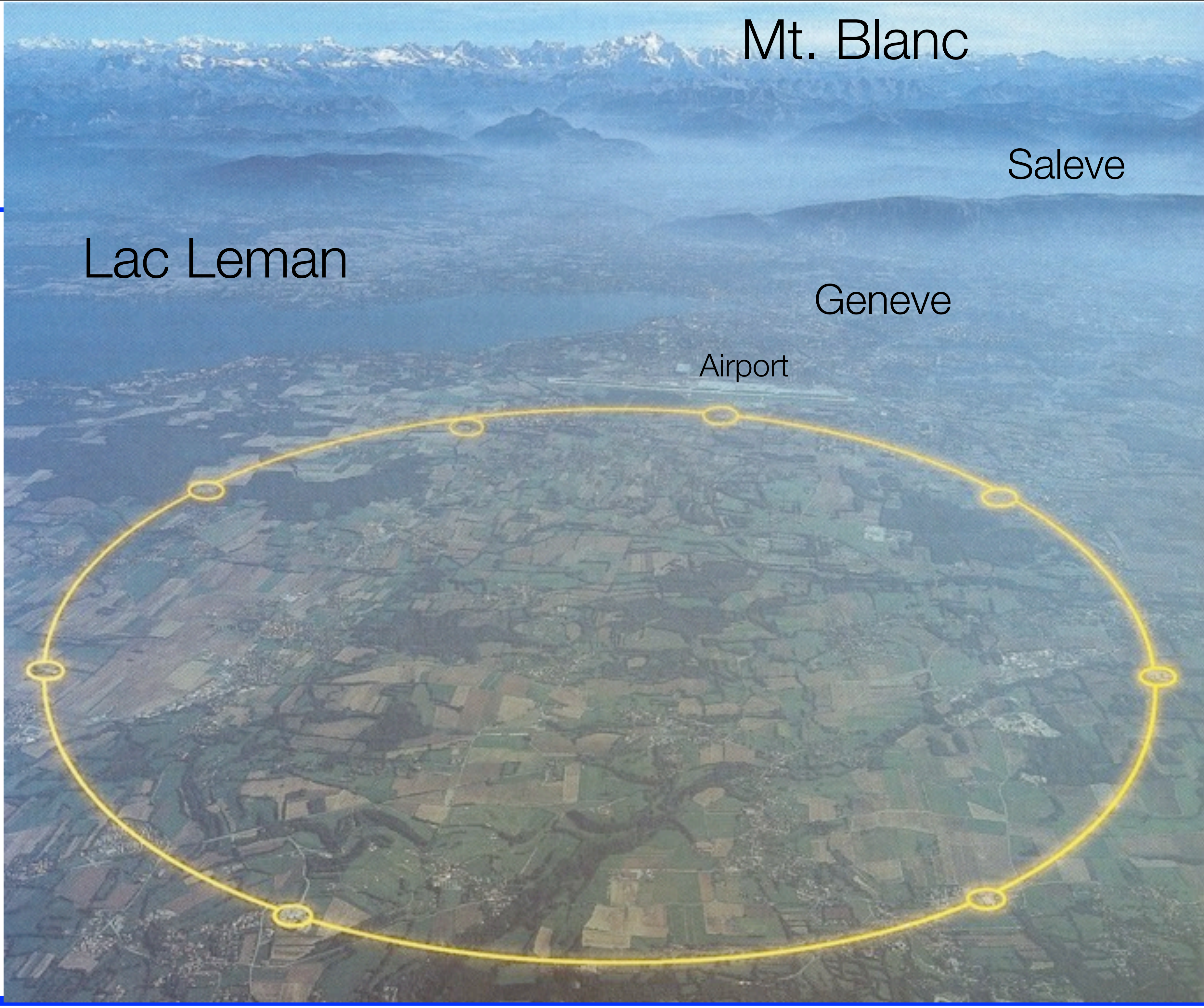
(R-parity) conserving SUSY phenomenology

- Missing E_T **<u>is the main signature</u>** (although not unique)
- General R-parity signatures:
  - The LSP (typically $\tilde{\chi}_1^0$ or $\tilde{\nu}$ in mSUGRA) is stable and weakly interacting (dark matter candidate) → large missing transverse momentum
  - squarks and gluinos produced in pp collision → large particle multiplicity typically produced in the decay.
- Large jet multiplicities and/or lepton produced in large regions of the parameter space (although not mandatory, e.g. $pp \to \tilde{q}\tilde{q} \to qq\,\tilde{\chi}_1^0\,\tilde{\chi}_1^0$)





Experimental setup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Saleve
Lac Leman
Geneve
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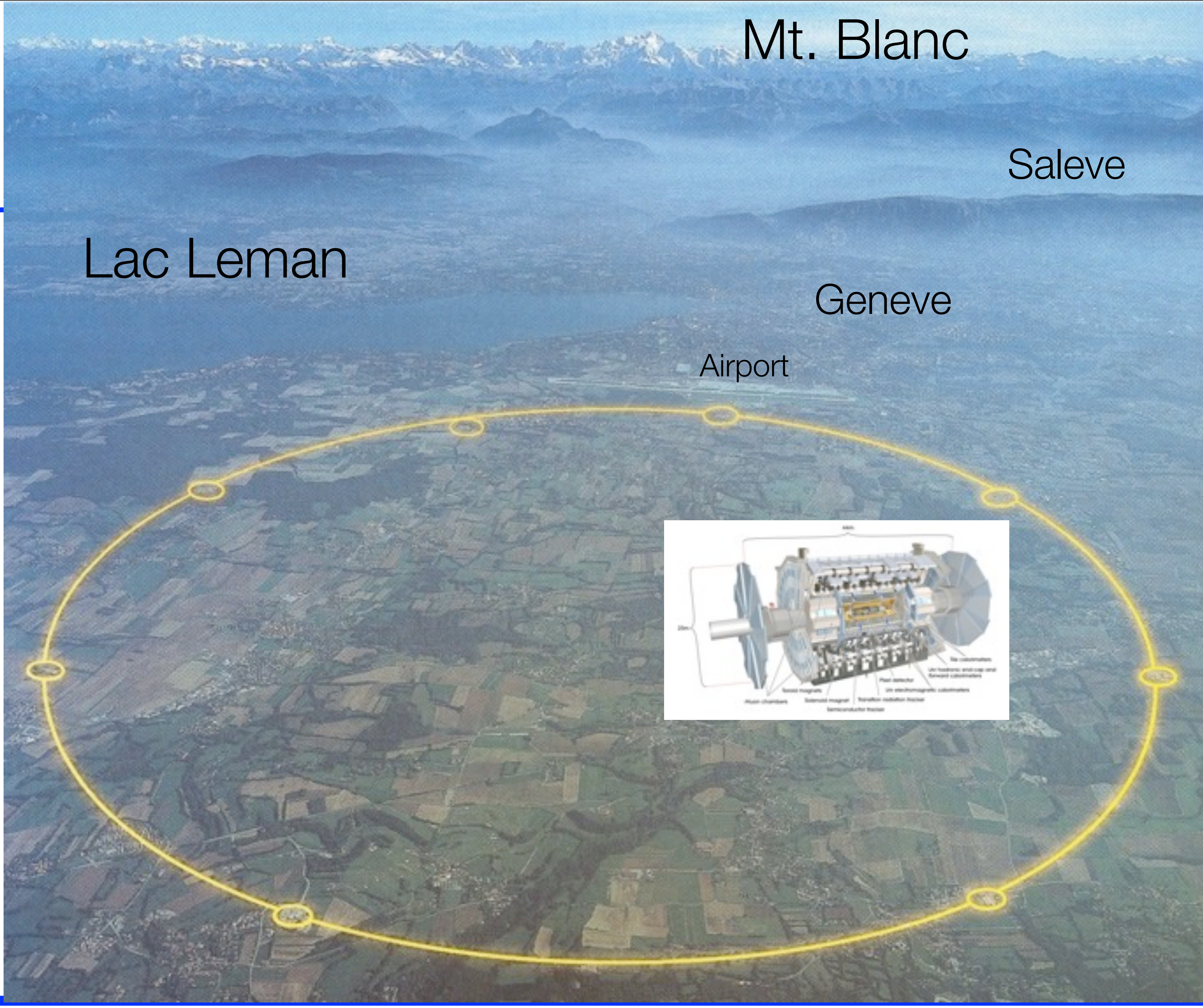
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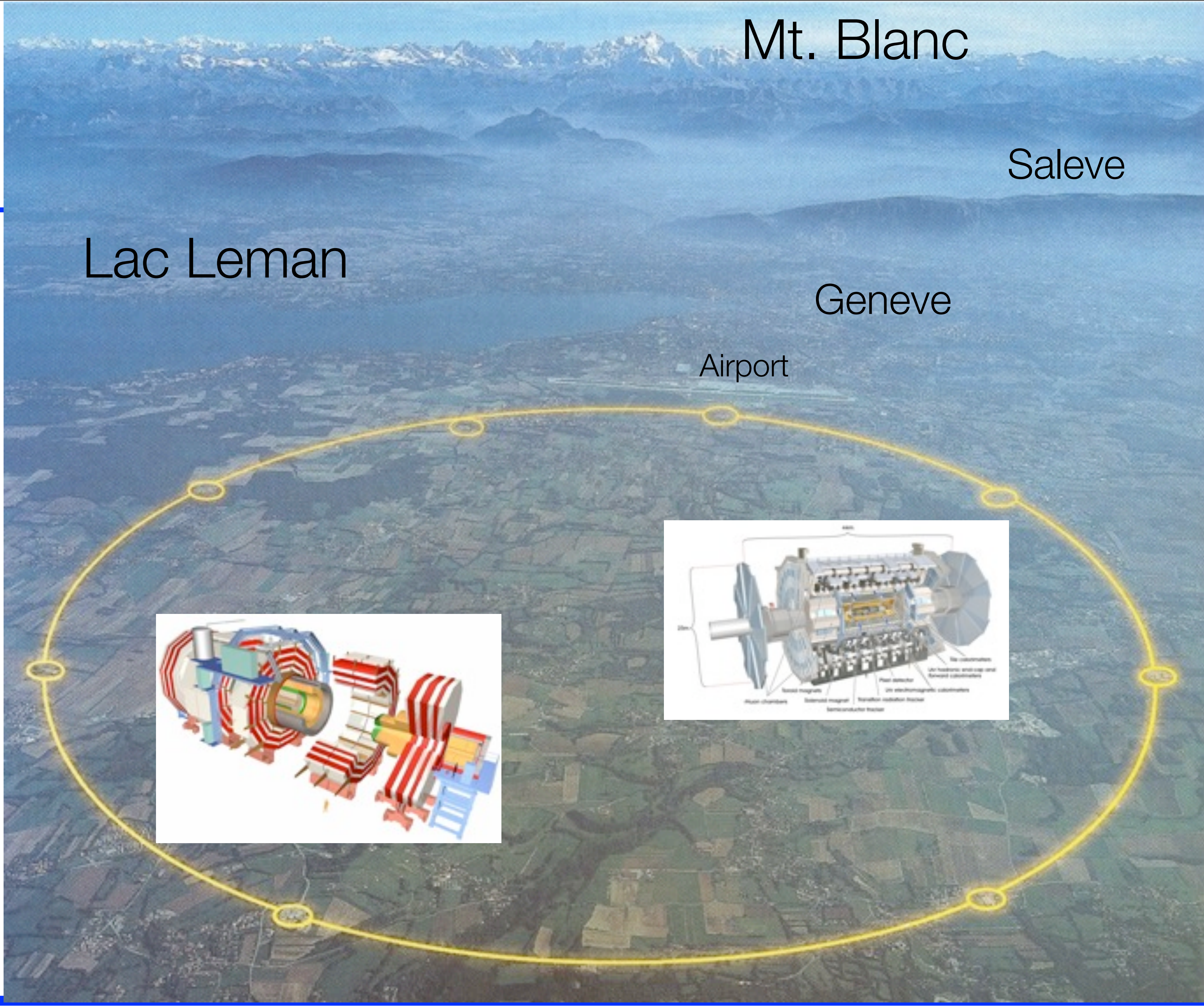
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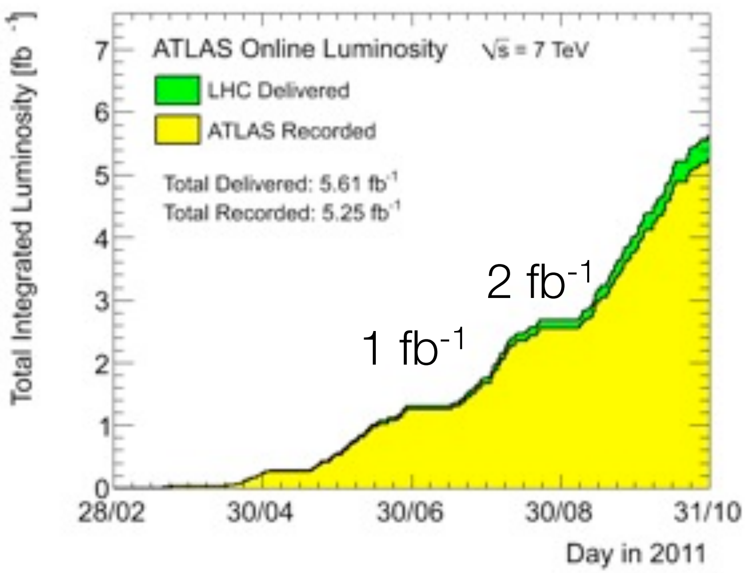
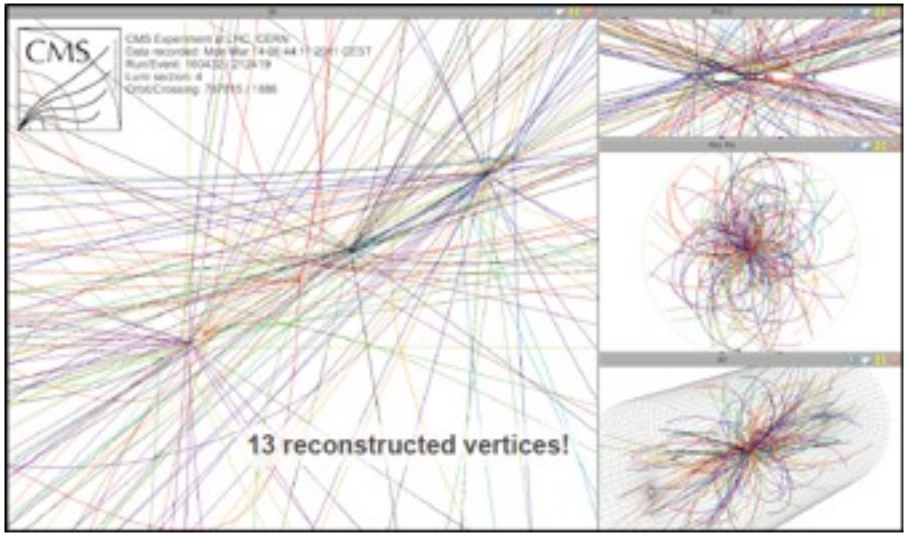
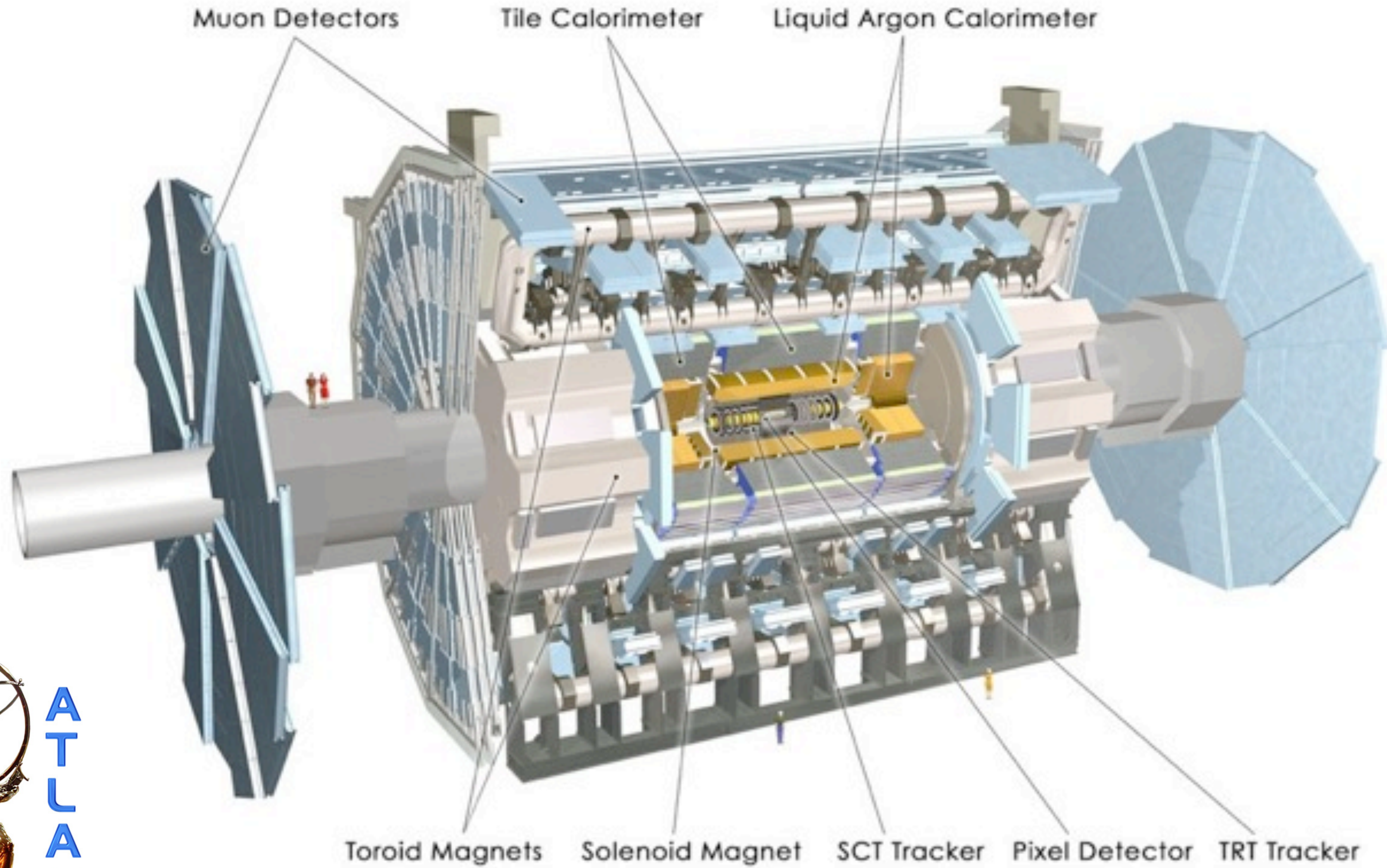
LHC - performance of the machine

- About 5 fb^{-1} collected per experiment in 2011
  - Most of which with more than 99% of the detectors operational (talking about millions of channels that need to be maintained and calibrated)
- Most of the analysis so far use 1-2 fb^{-1}. results being updated for the winter conferences
- Large luminosity means large pileup. Analysing data while implementing pileup suppression strategies





The detector

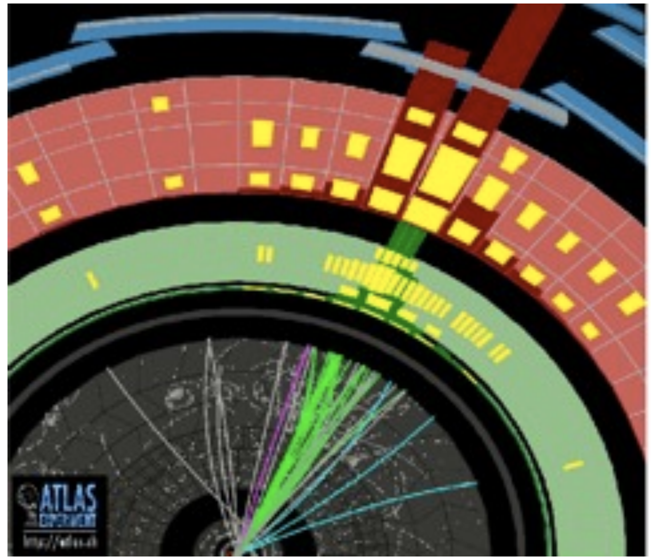


ATLAS in a nutshell

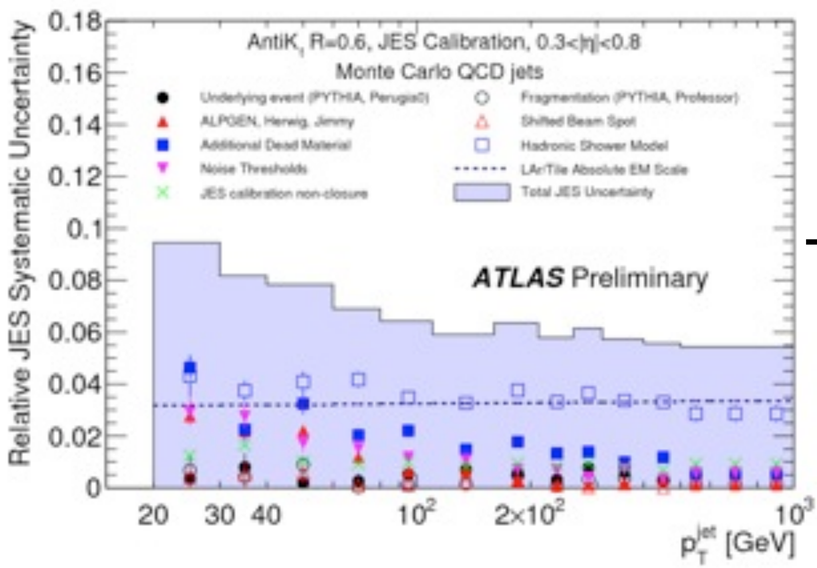
- From inside out:
  - ID made up of three different detectors (Pixel, SCT, TRT):
    - *High resolution tracking down to P_T > o(100) MeV, |η| < 2.5*
  - EM calorimeter - two sections covering up to |η| ≈ 3.2.
    - *High resolution on e/γ objects.*
  - HAD calorimeter - 3 sections covering up to |η|≈5
    - *Good containment, good resolution for jet measurement*
  - Muon system (4 different technologies) covering up to |η|=2.7
- Magnetic field: one solenoid surrounding the ID (2T), three toroids (muon spectrometer - 4T peak)

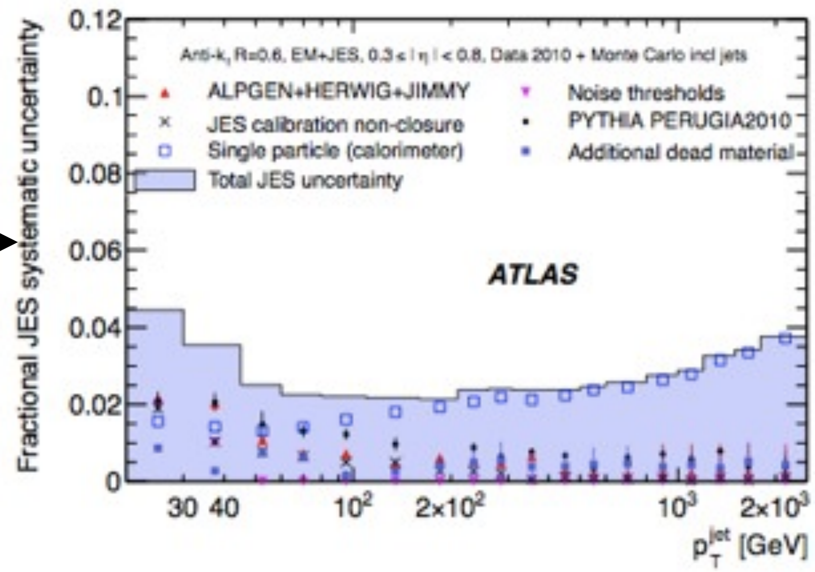
Jet measurement

- Constant improvement on jet measurement
- Jet energy scale known at few percent
- ... and the in-situ measurements (gamma + jet balancing) not yet in the game......



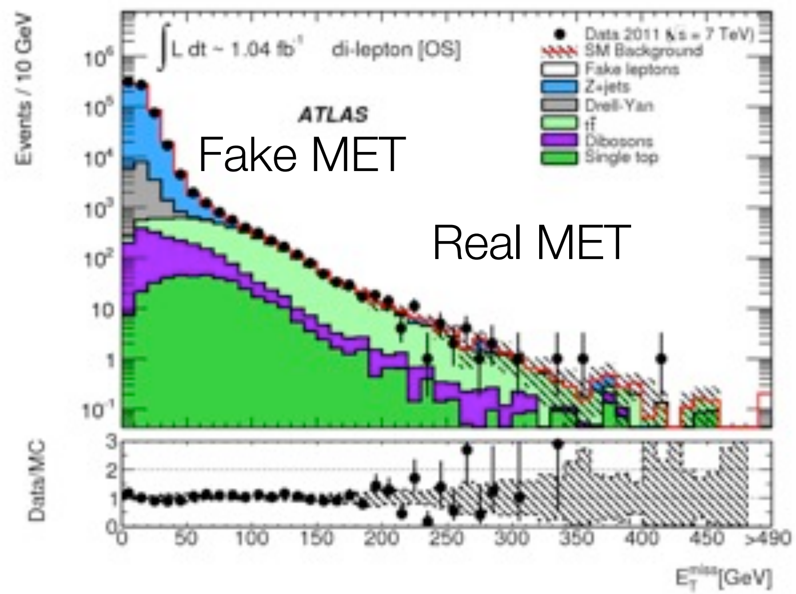
Last year

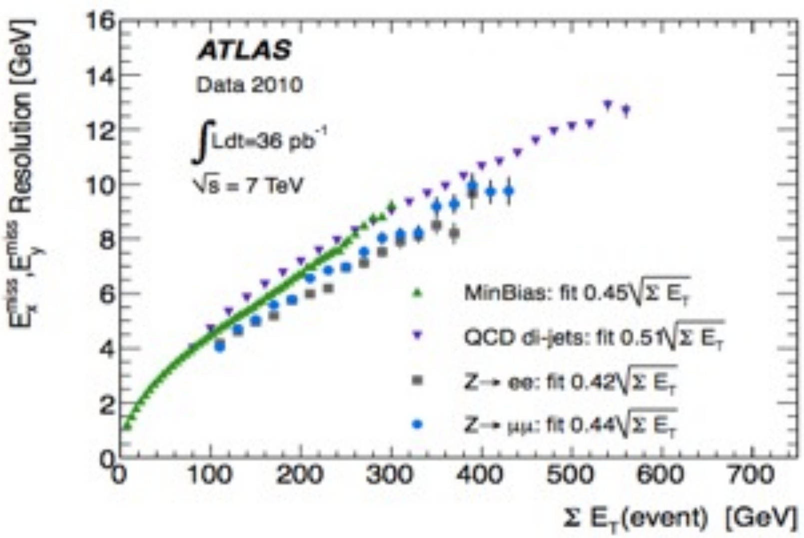


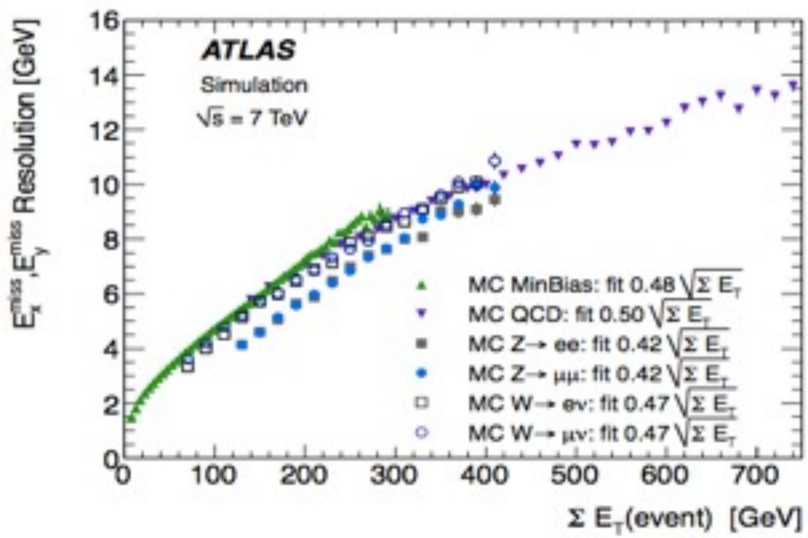


Missing transverse energy

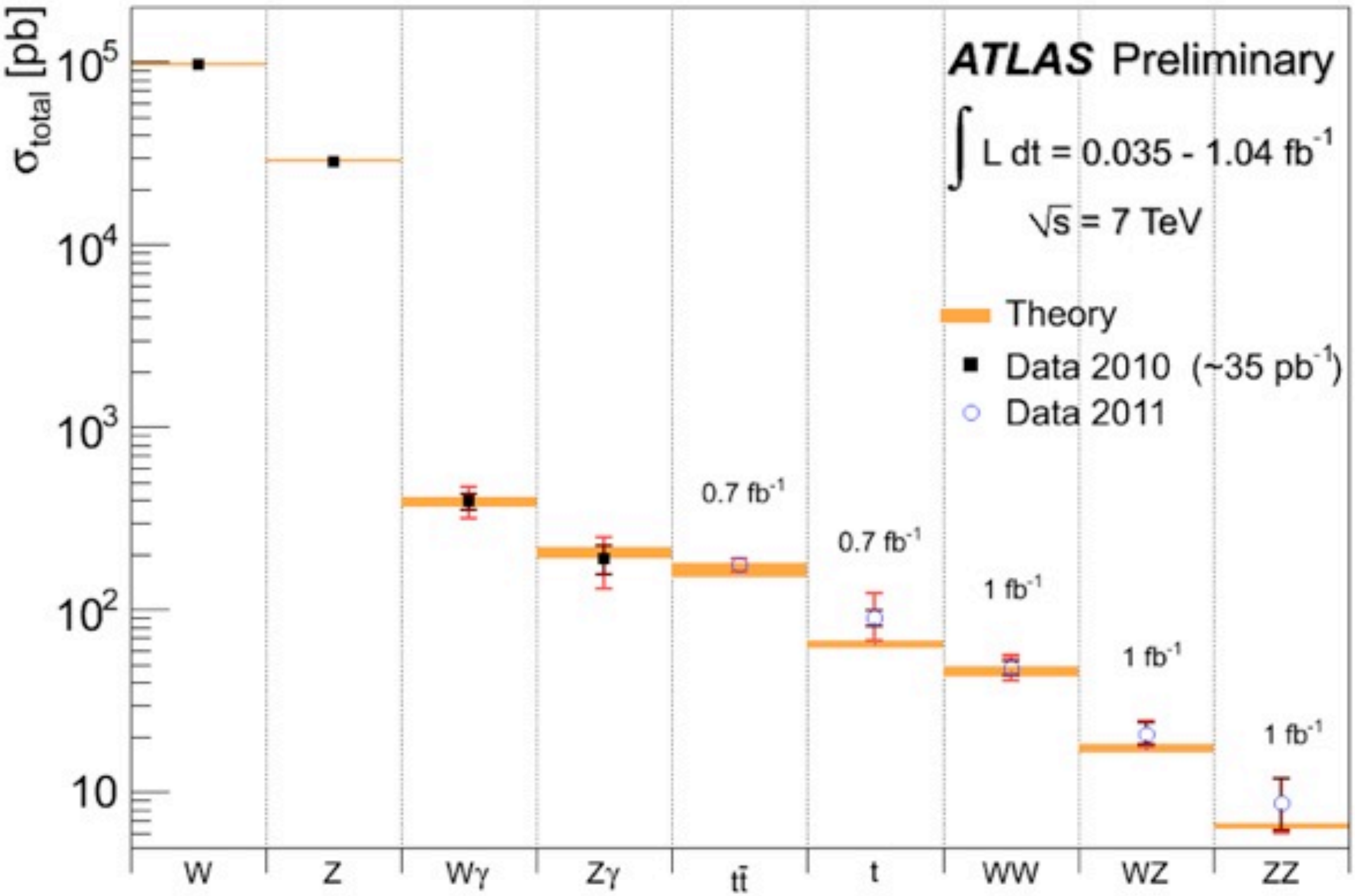
- Missing E_T reconstructed from the vectorial sum of all final state objects (including non-associated clusters).
  - Dedicated calibration for each type of object



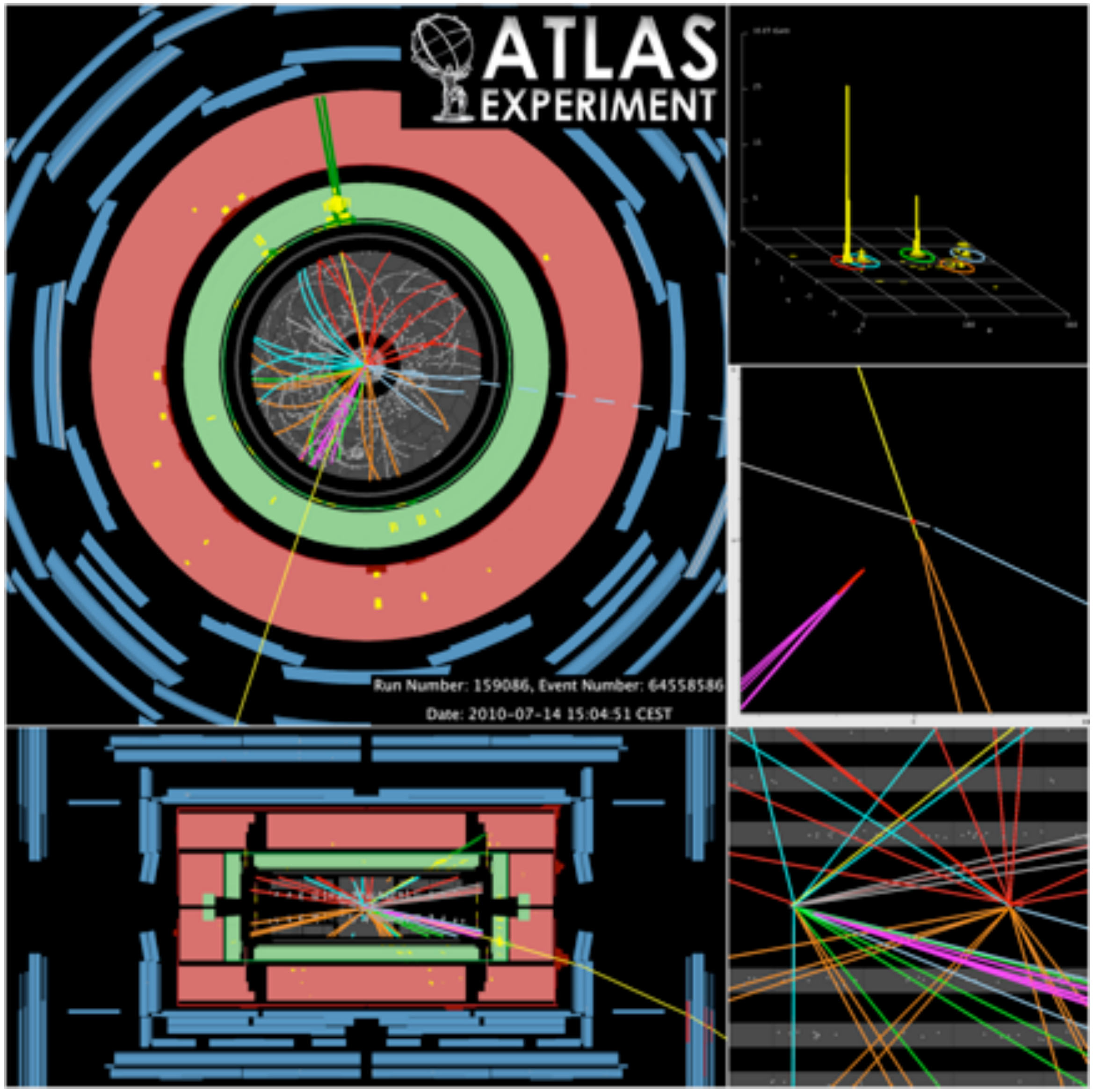




The Standard Model in one slide

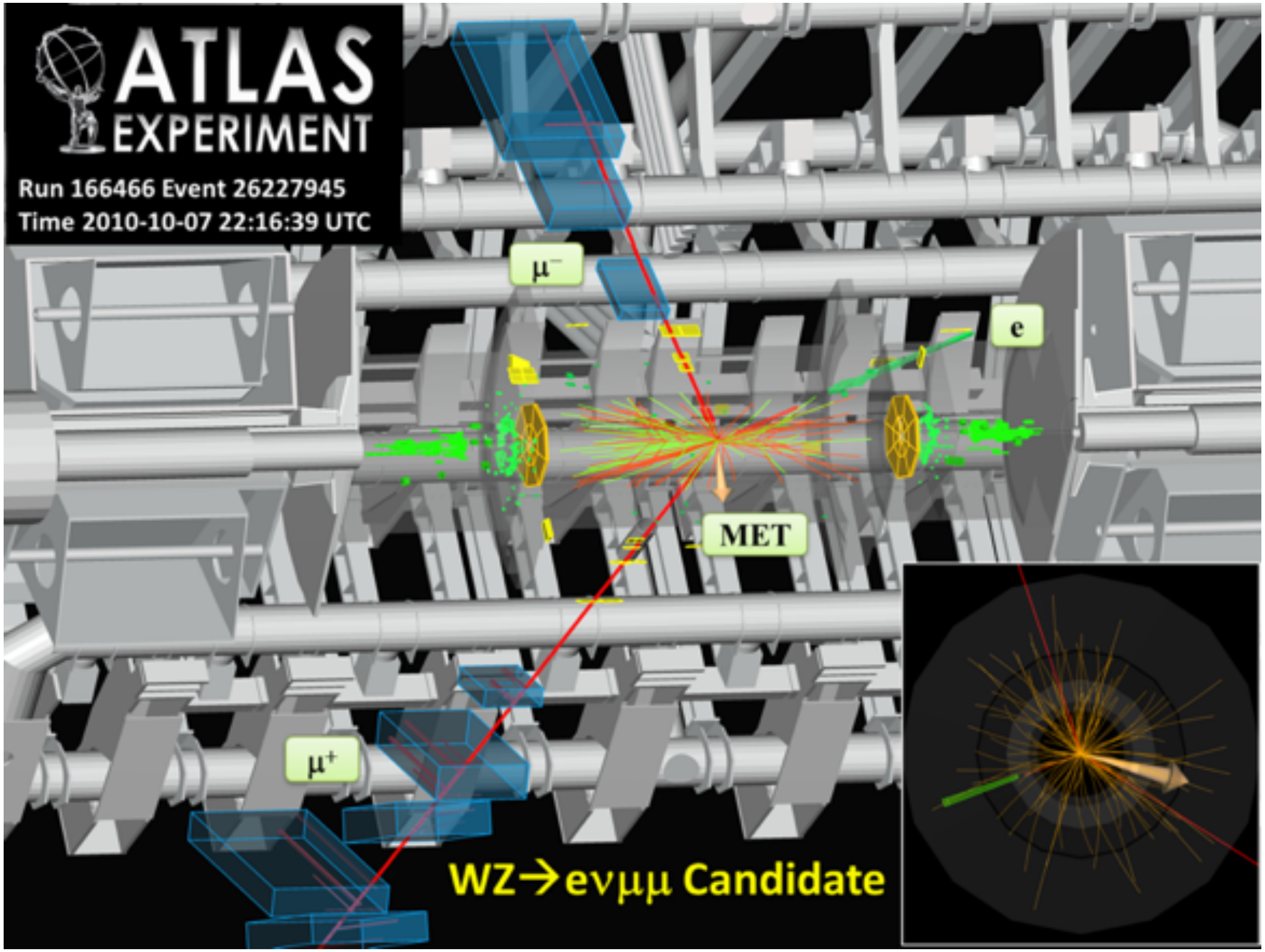


ATLAS in a nutshell (II)



A dileptonic ttbar event candidate

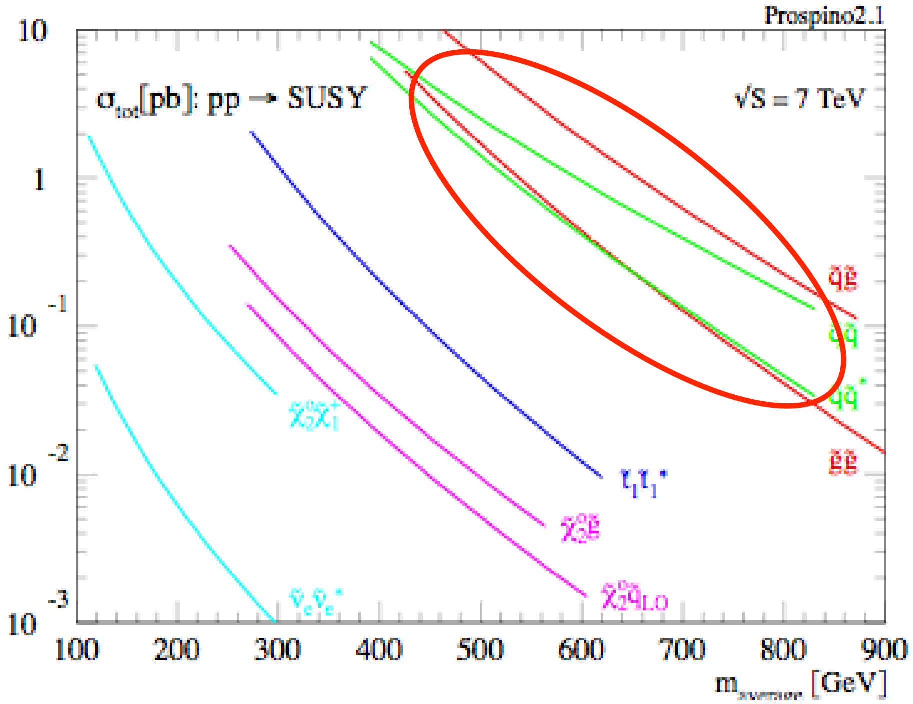
An ATLAS event



SUSY searches

What are we sensitive to?

- LHC is a pp machine → produce gluino and squarks with strong interaction size cross sections
- If squarks and gluinos are not accessible, then direct gauginos might be the only SUSY production (with weak interaction size cross section - order of magnitudes lower)



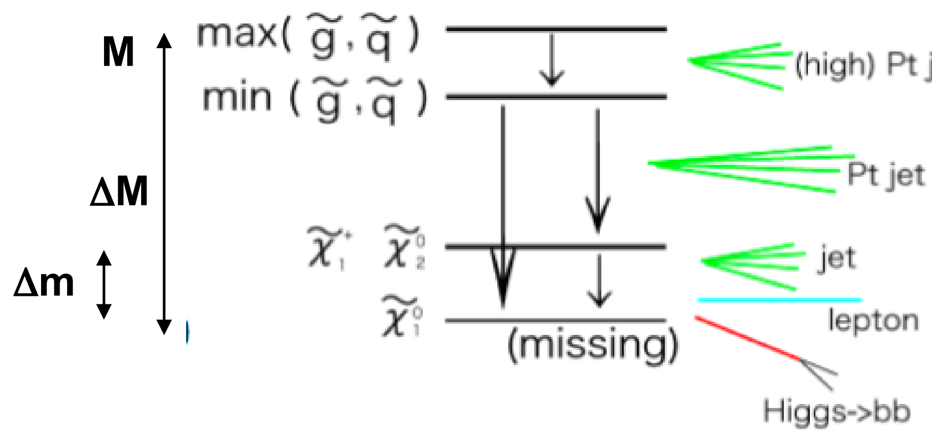
- 1-2 fb^{-1} → Essentially sensitive to strong production → set direct limits on $\tilde{q}$ and $\tilde{g}$ masses
- Need higher lumi for gauginos (one of the targets of the 5 fb^{-1} analysis)

What we are typically doing

- Heavy sparticles produced in the primary collision
- They decay into lighter objects, emitting (high) P_T jets and possibly other objects (leptons, photons) and MET (LSP)
- A "typical" SUSY event will have large MET and large H_T
- Useful variables:

$$H_T = \sum_{jets} p_T^{jets} (+ \sum_l p_T^l + ...)$$

$$M_{eff} = E_T^{miss} + H_T$$



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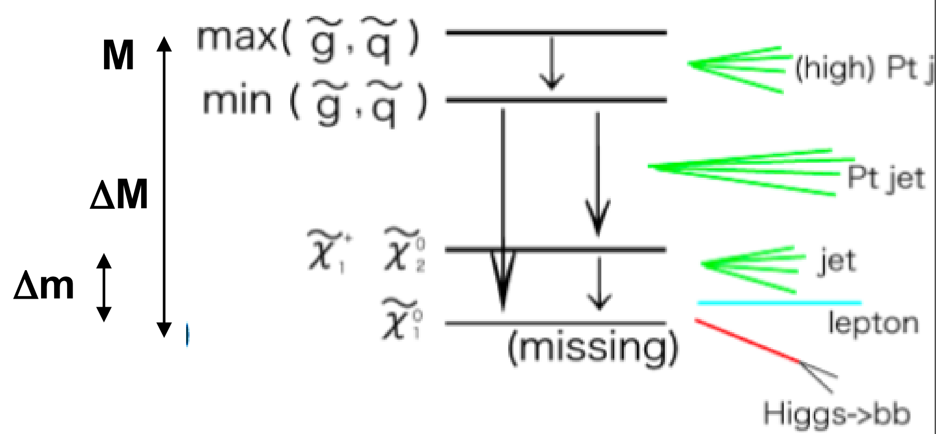

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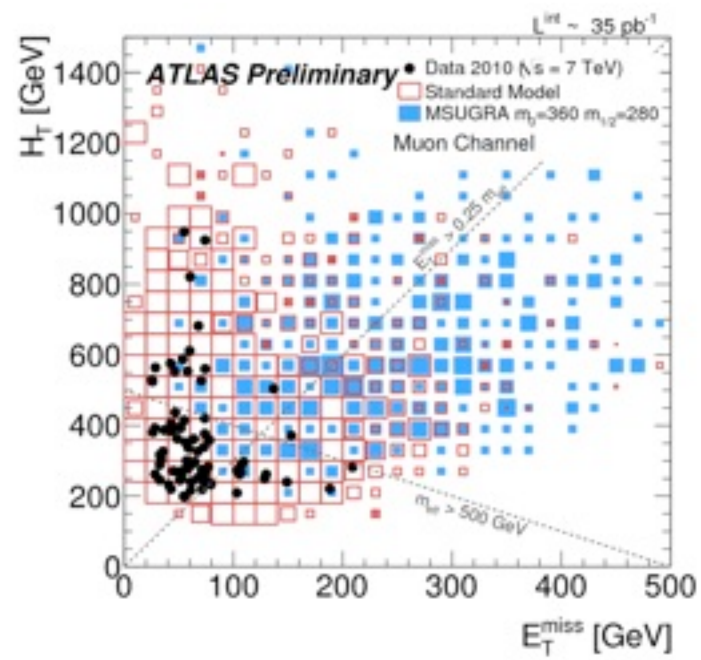


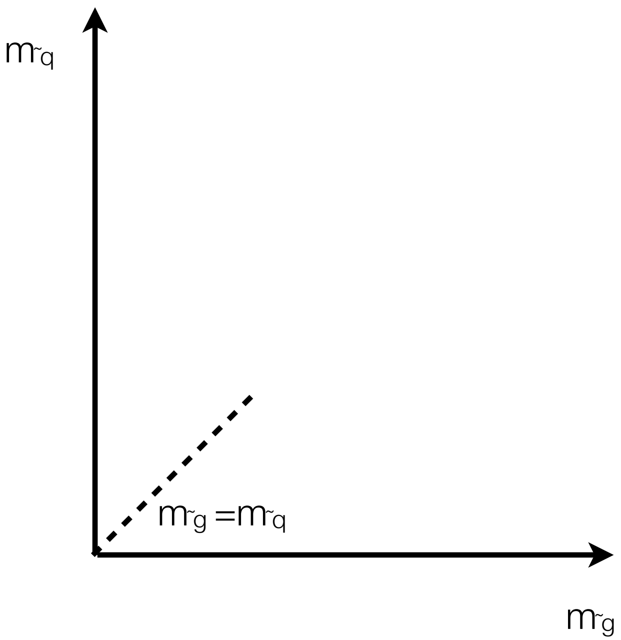
List all analysis

- A wide research program trying to cover all possible SUSY configurations
  - 0-lepton, jets, MET → all, simple and more complex gluino-squarks decay chains
  - 1-lepton, jets, MET → More complex decay chains of the $\tilde{g}$,$\tilde{q}$ (involving, e.g., charginos)
  - 2-leptons → Long decay chains (also direct gaugino production)
  - multilepton → Long decay chains, very low background, very low signal acceptance
  - b-jets → Third generation squark production
  - photons → Mainly GMSB (Gauge Mediated Supersymmetry Breaking)
- taus → Mainly GMSB, but also high tan β mSUGRA

- **Analysis in blue discussed in some detail in the following**

0-lepton analysis (ATLAS)

- Depending on the SUSY mass hierarchy, different production processes favoured ($\tilde{g}\tilde{g}, \tilde{g}\tilde{q}, \tilde{q}\tilde{q}$)
  - Signal regions optimised to maximise sensitivity to different production processes



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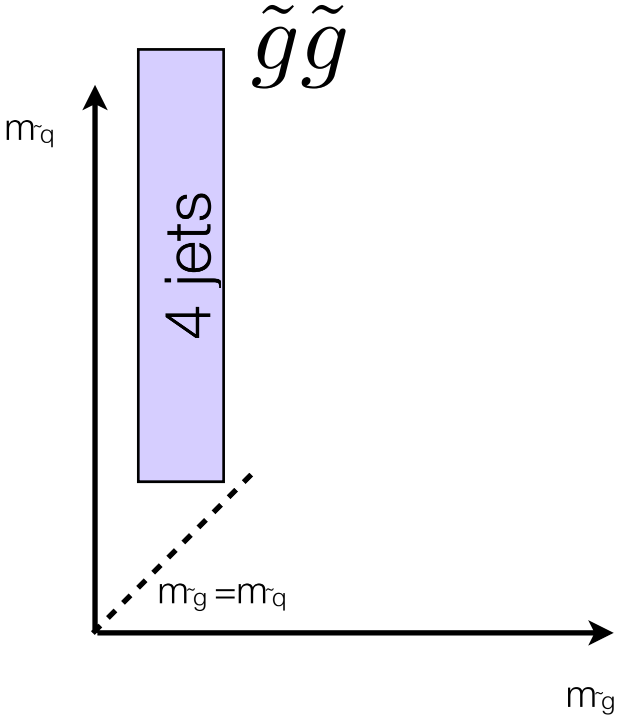

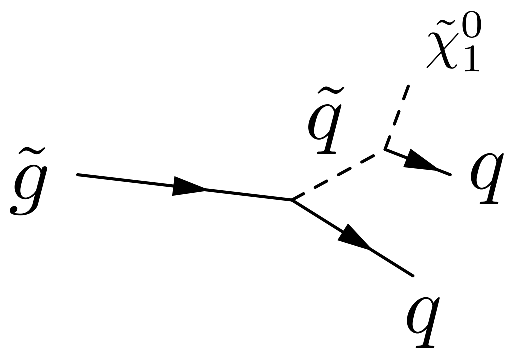

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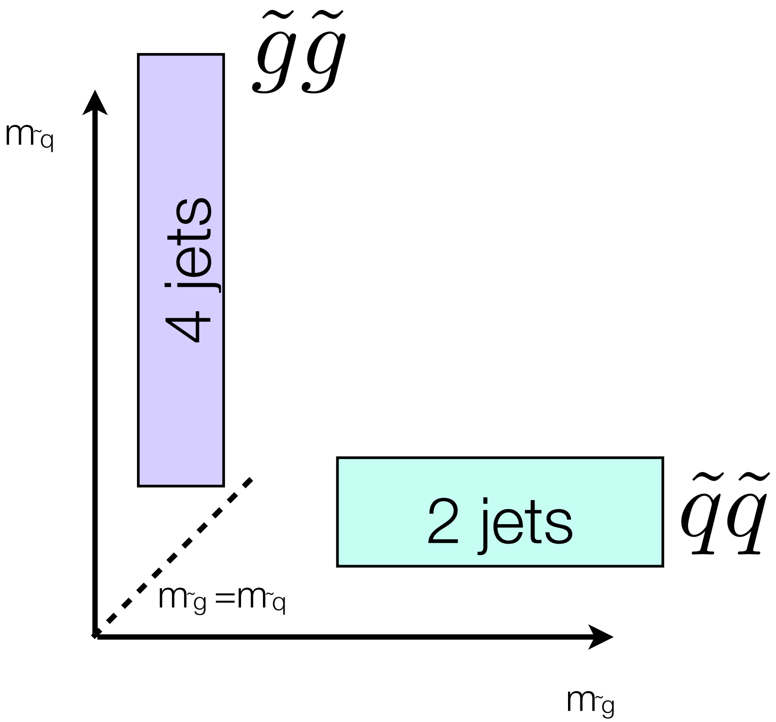

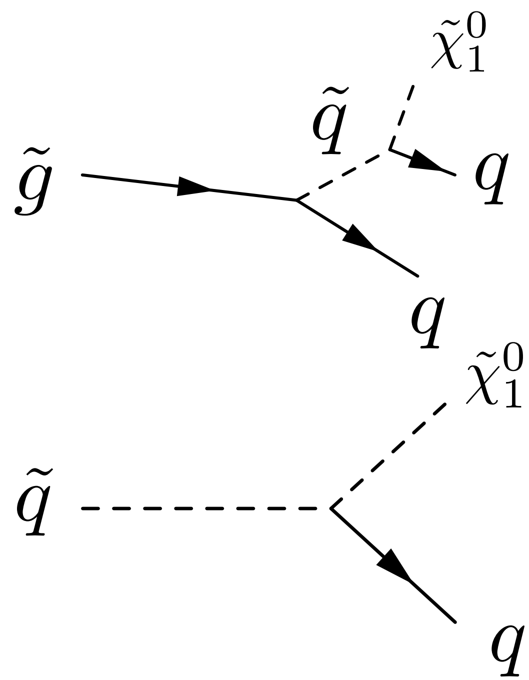

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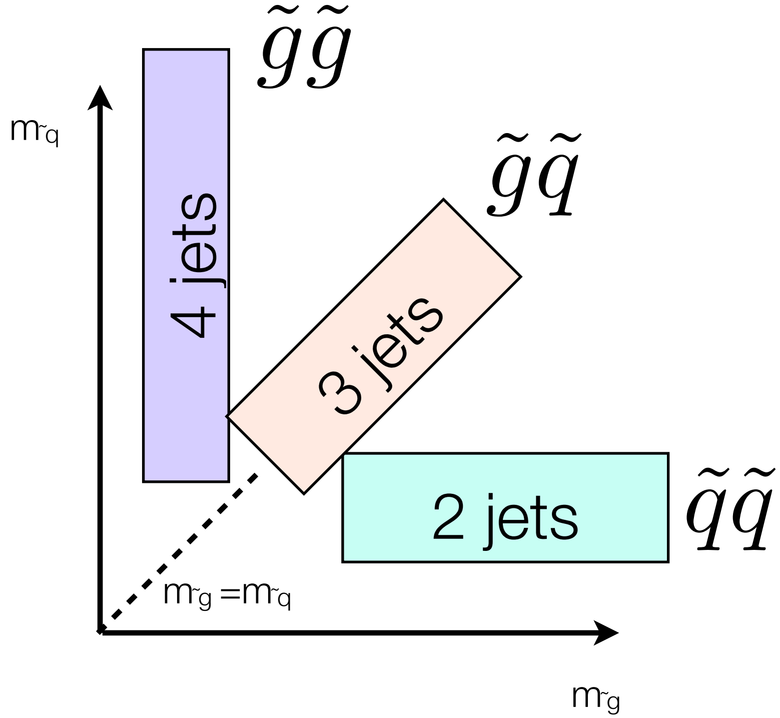

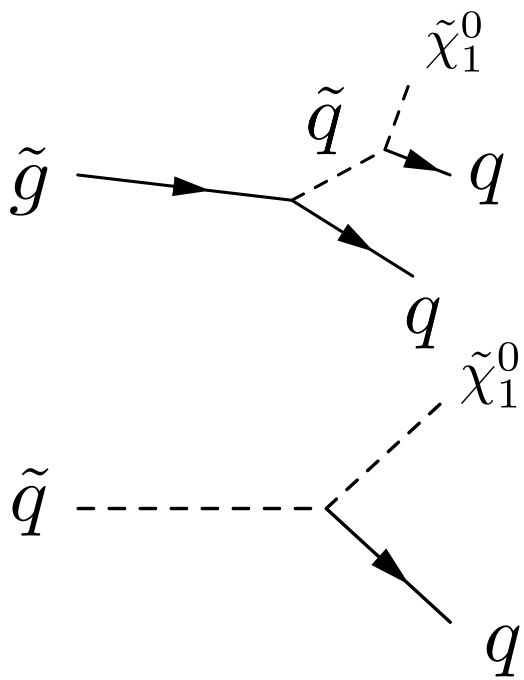

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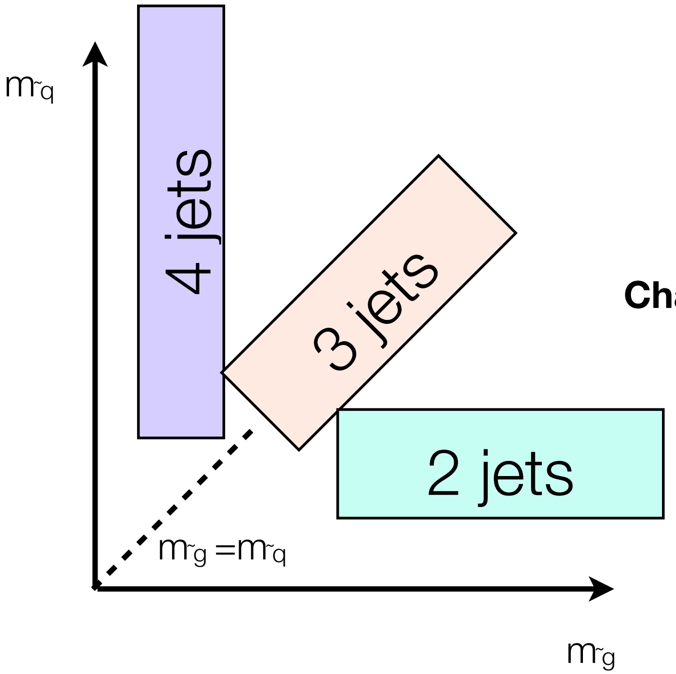
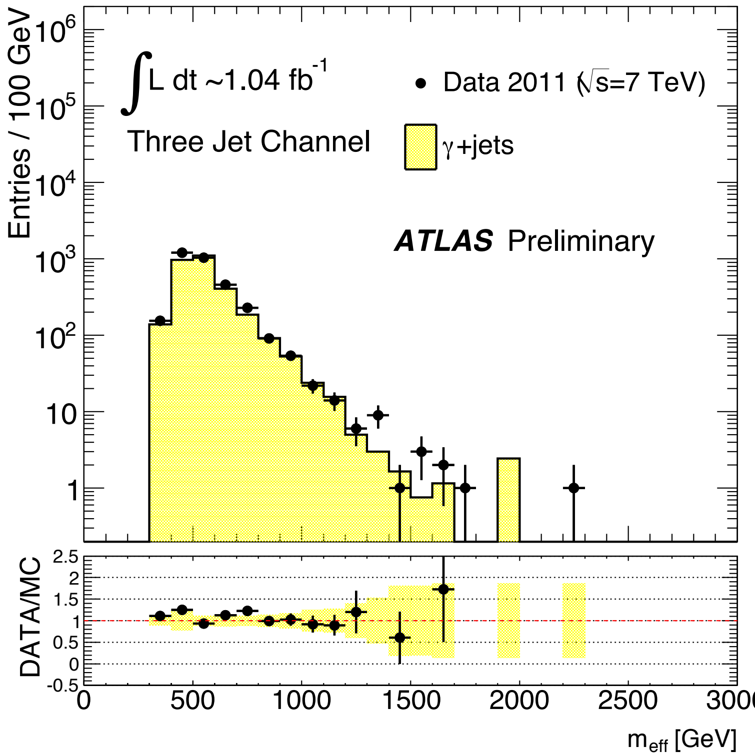


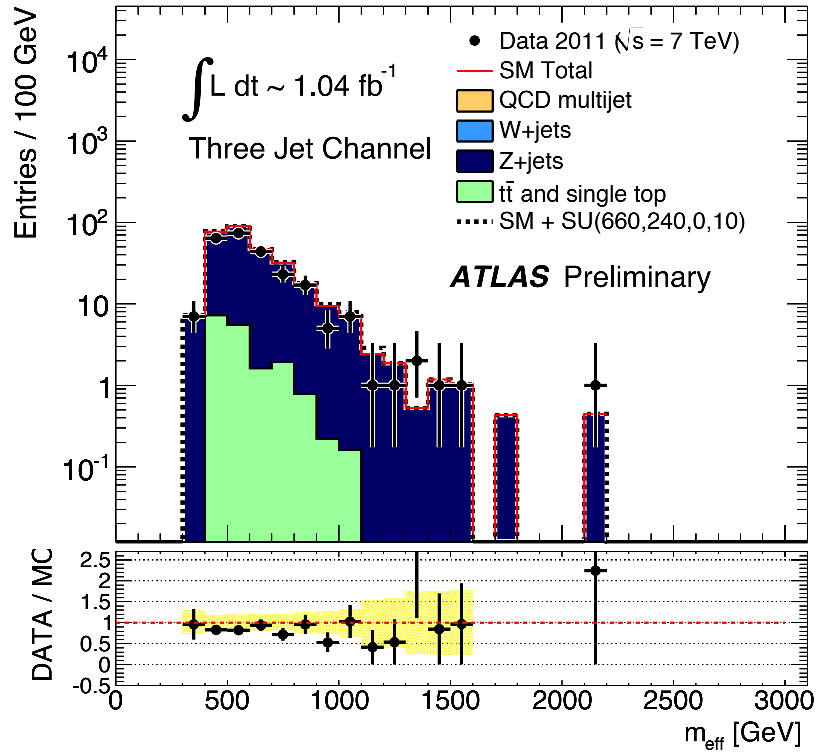
	Signal Region	≥ 2 jets	≥ 3 jets	≥ 4 jets	High mass
Trigger requirements	E_T^{miss}	> 130	> 130	> 130	> 130
	Leading jet p_T	> 130	> 130	> 130	> 130
Channel definition	Second jet p_T	> 40	> 40	> 40	> 80
	Third jet p_T	–	> 40	> 40	> 80
	Fourth jet p_T	–	–	> 40	> 80
Reduce QCD	$\Delta\phi(\text{jet}, E_T^{miss})_{min}$	> 0.4	> 0.4	> 0.4	> 0.4
	E_T^{miss}/m_{eff}	> 0.3	> 0.25	> 0.25	> 0.2
Enhance signal	m_{eff} [GeV]	> 1000	> 1000	> 500/1000	> 1100

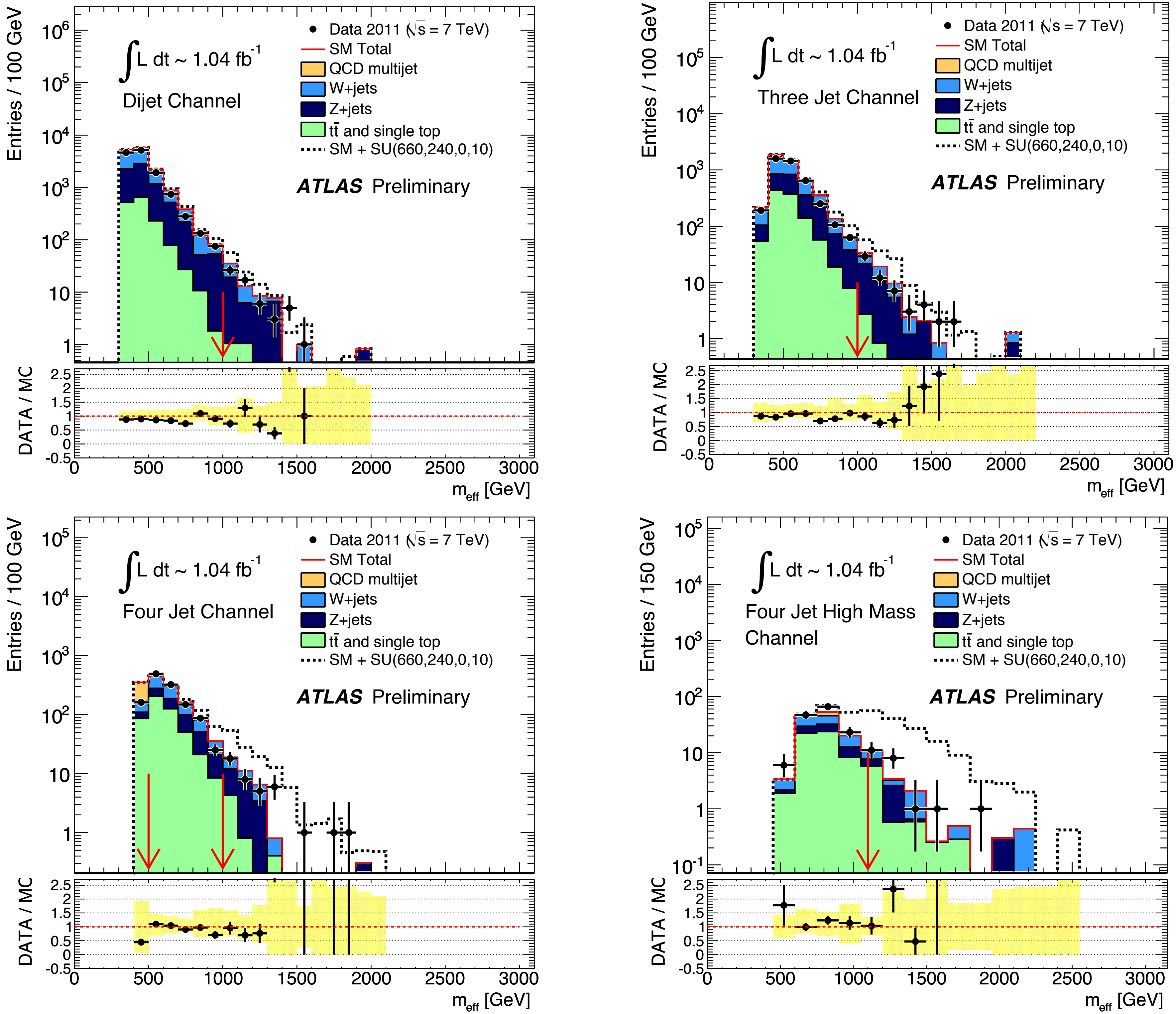
$$m_{eff} = \sum_{i=1}^{n} |\vec{p}_T^{\,jet\ i}| + E_T^{miss}$$

0-lepton analysis (ATLAS)

- As much background information as possible extracted from the data:
- One example: Z→νν is the dominant component of the total Z background
- Estimation done in 2 CR (in both cases replacing the boson with MET):
  - γ+jets events (use robustness of ratio between photon and Z production cross section)
  - Z (→ee,μμ) + jets







Dijet Channel
Three Jet Channel
Four Jet Channel
Four Jet High Mass Channel
∫L dt ~ 1.04 fb^{-1}
Data 2011 ($\sqrt{s}$ = 7 TeV)
SM Total
QCD multijet
W+jets
Z+jets
$t\bar{t}$ and single top
SM + SU(660,240,0,10)
ATLAS Preliminary
Entries / 100 GeV
Entries / 150 GeV
DATA / MC
m_{eff} [GeV]

0-lepton analysis (ATLAS)

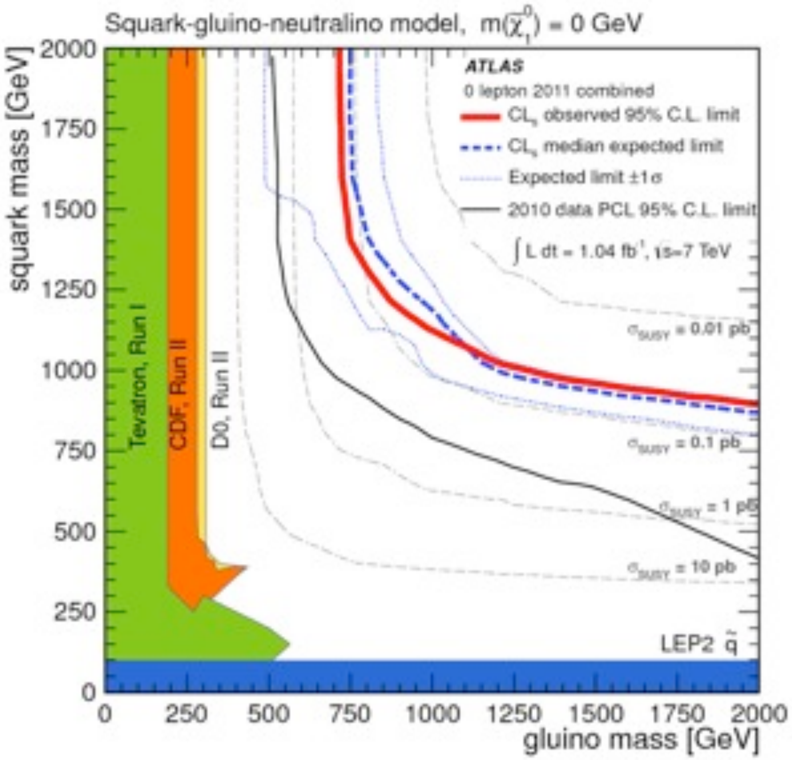
Process	Signal Region				
	$\geq$ 2-jet	$\geq$ 3-jet	$\geq$ 4-jet, $m_{\rm eff}$ > 500 GeV	$\geq$ 4-jet, $m_{\rm eff}$ > 1000 GeV	High mass
Z/γ+jets	$32.5 \pm 2.6 \pm 6.8$	$25.8 \pm 2.6 \pm 4.9$	$208 \pm 9 \pm 37$	$16.2 \pm 2.1 \pm 3.6$	$3.3 \pm 1.0 \pm 1.3$
W+jets	$26.2 \pm 3.9 \pm 6.7$	$22.7 \pm 3.5 \pm 5.8$	$367 \pm 30 \pm 126$	$12.7 \pm 2.1 \pm 4.7$	$2.2 \pm 0.9 \pm 1.2$
$t\bar{t}$+ single top	$3.4 \pm 1.5 \pm 1.6$	$5.6 \pm 2.0 \pm 2.2$	$375 \pm 37 \pm 74$	$3.7 \pm 1.2 \pm 2.0$	$5.6 \pm 1.7 \pm 2.1$
QCD jets	$0.22 \pm 0.06 \pm 0.24$	$0.92 \pm 0.12 \pm 0.46$	$34 \pm 2 \pm 29$	$0.74 \pm 0.14 \pm 0.51$	$2.10 \pm 0.37 \pm 0.83$
Total	$62.3 \pm 4.3 \pm 9.2$	$55 \pm 3.8 \pm 7.3$	$984 \pm 39 \pm 145$	$33.4 \pm 2.9 \pm 6.3$	$13.2 \pm 1.9 \pm 2.6$
Data	58	59	1118	40	18
excluded σx acc x eff (fb)	24	30	477	32	17

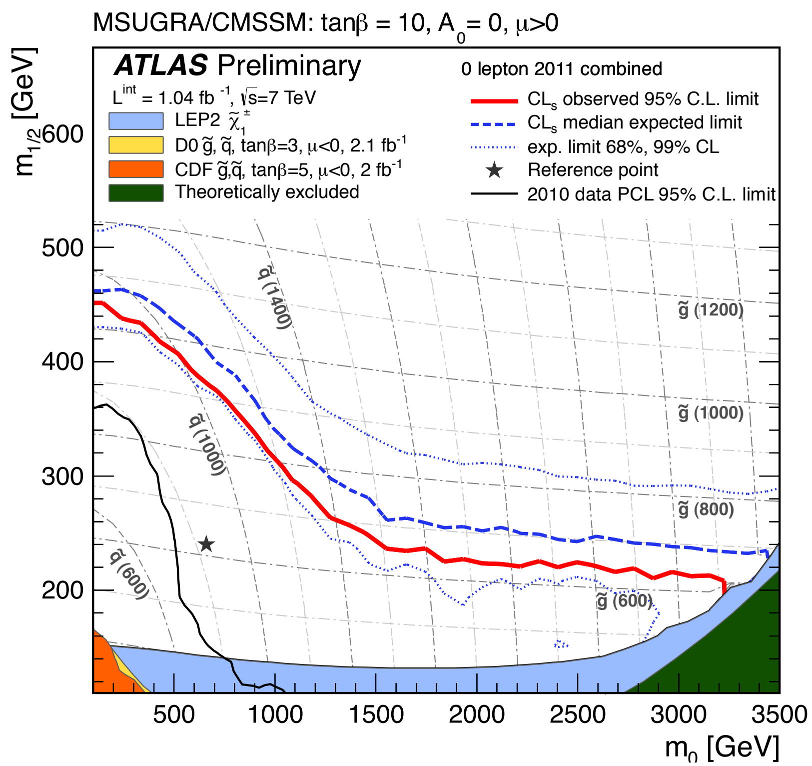
- No discrepancy with respect to SM predictions.
- The result is interpreted as a 95% CL exclusion limit on effective cross sections
- Analysis giving best expected limit used in each point.

0-lepton analysis (ATLAS)

- Simplified model (pheno MSSM) interpretation:
  - LSP mass set to 0, all other sparticles (except gluinos and 1st and 2nd gen quarks) set to 5 TeV
  - $\tilde{g} \rightarrow \tilde{q}q$ and $\tilde{q} \rightarrow q\chi_1^0$ with BR 100%
  - Limit as a function of the squark and gluino mass

- mSUGRA limit (m_0, $m_{1/2}$)





Limits

- A lot of model-dependent limits obtained for strong production

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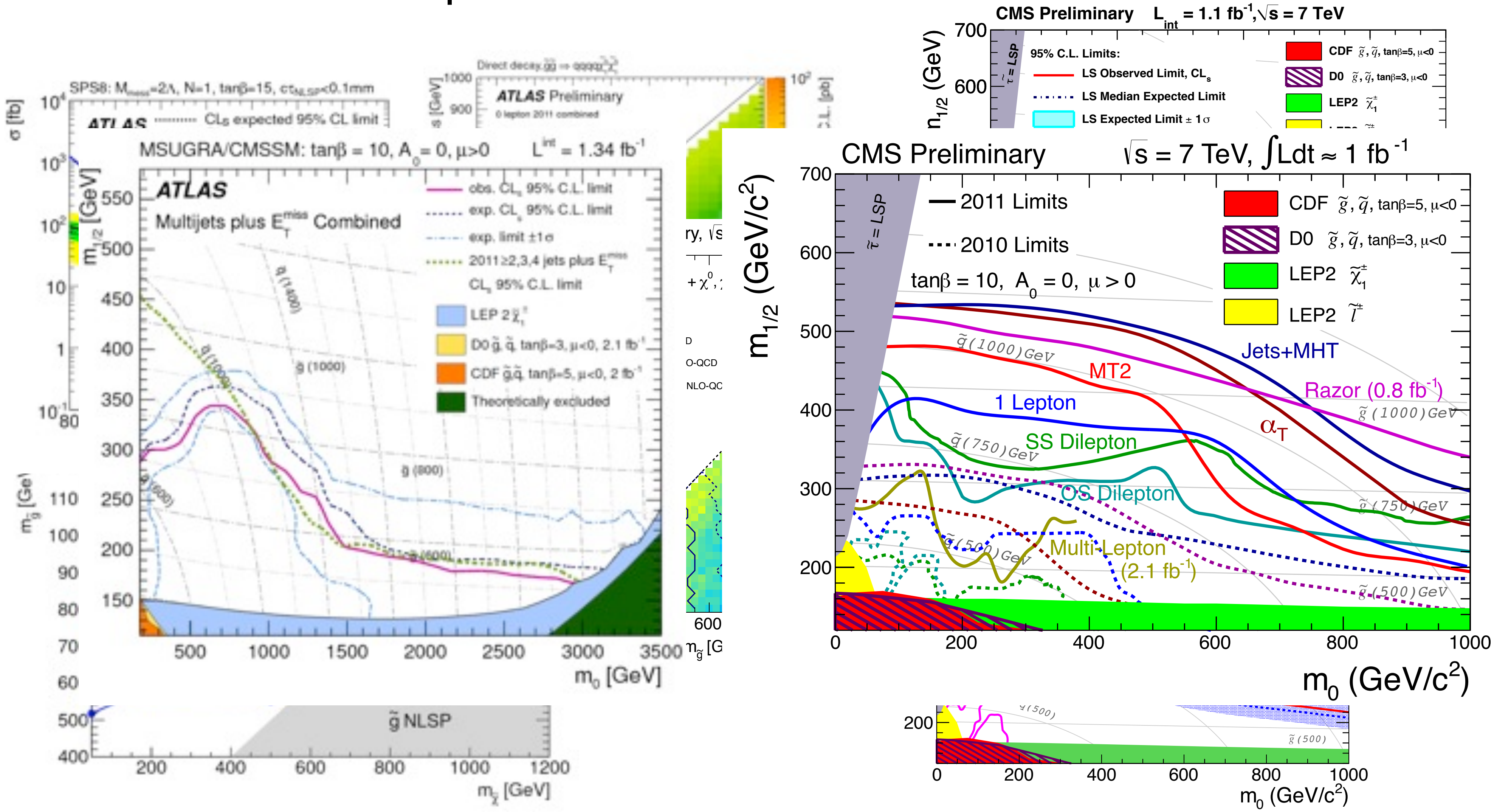
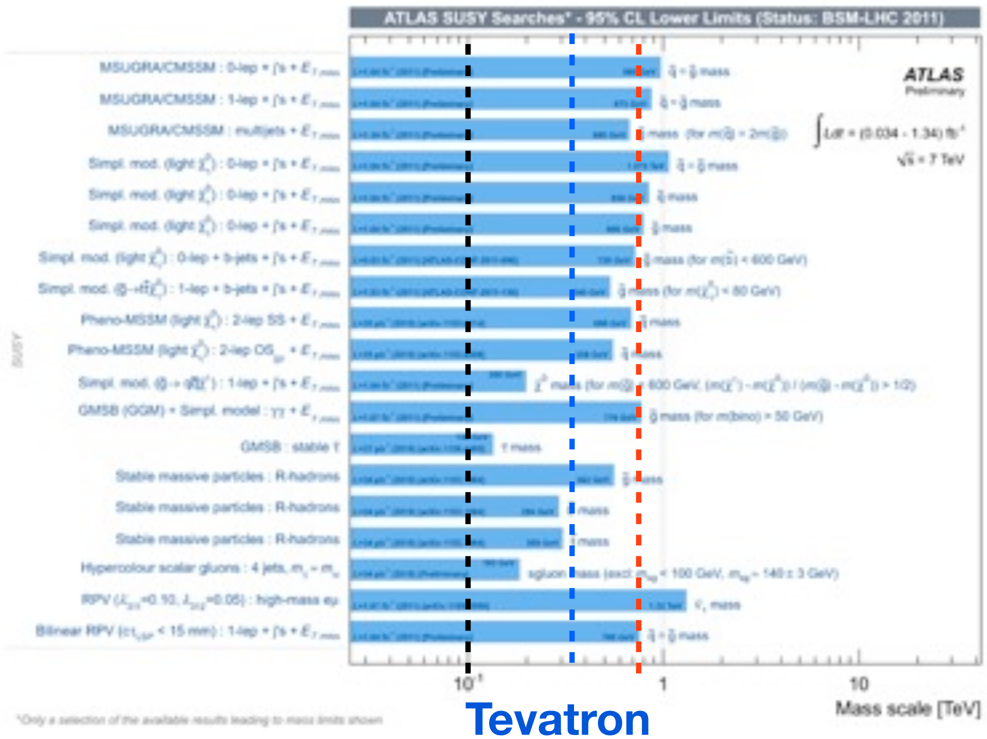


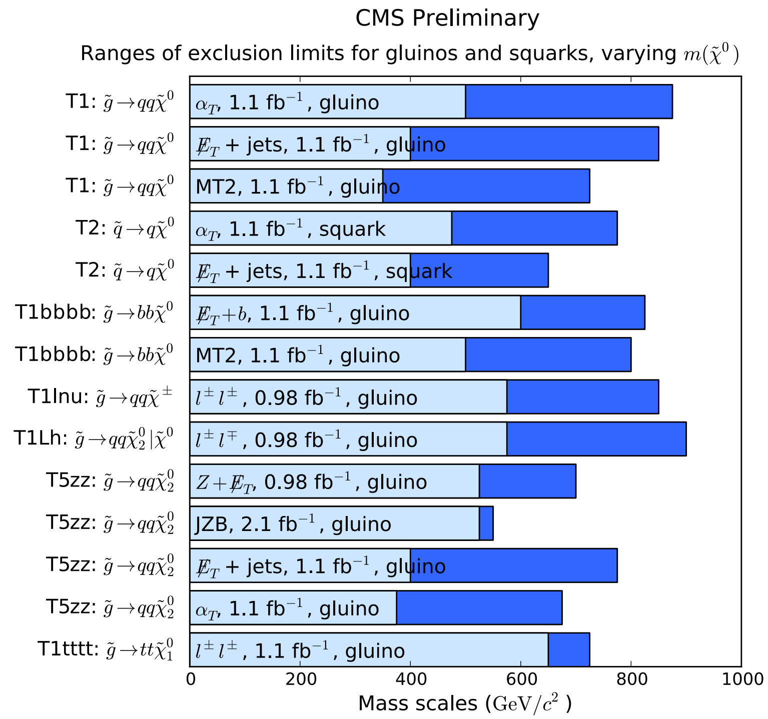
In short.....

- No sign of SUSY, yet. Where do we stand?

LEP **LHC**



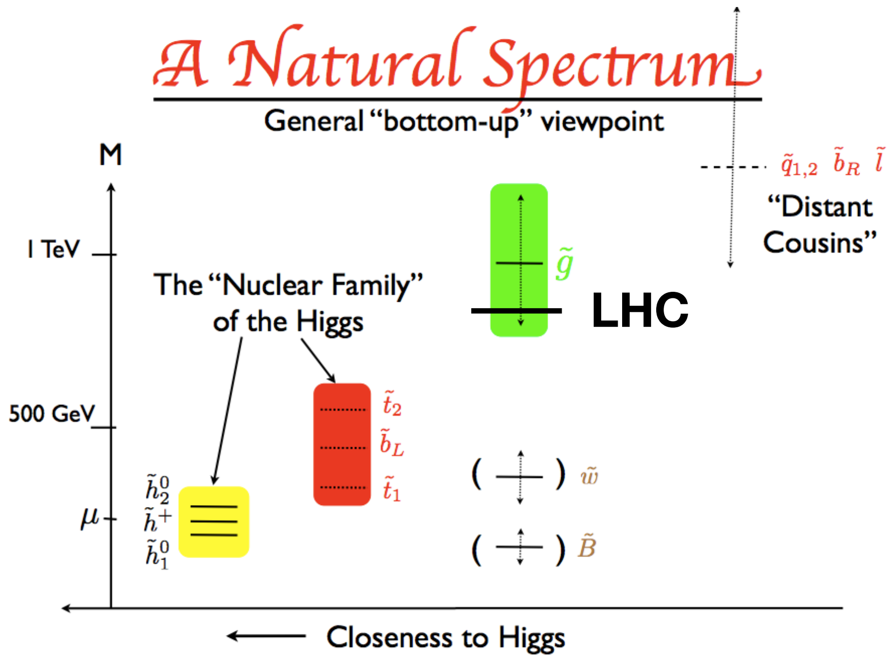
Tevatron



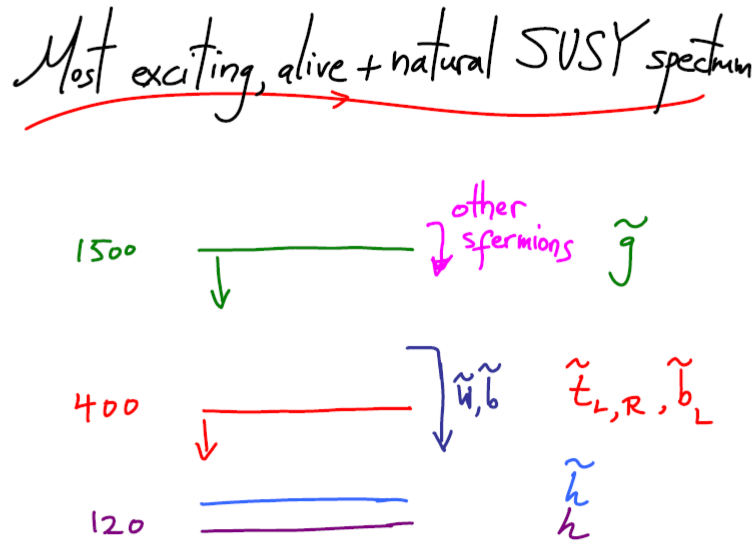
If gluinos and squarks (1st and 2nd gen) exist, they have M > 1 TeV

Is then SUSY dead?

- **No!** (pretty consistent theoretical view on the subject)
- Gluinos and 1st and 2nd generation squarks can be heavy, provided that the superpartners of the heavy fermions are relatively light (still "natural" hierarchy)
- Higgsinos should also be light



L. Hall (LBL Workshop, 21-Oct11)



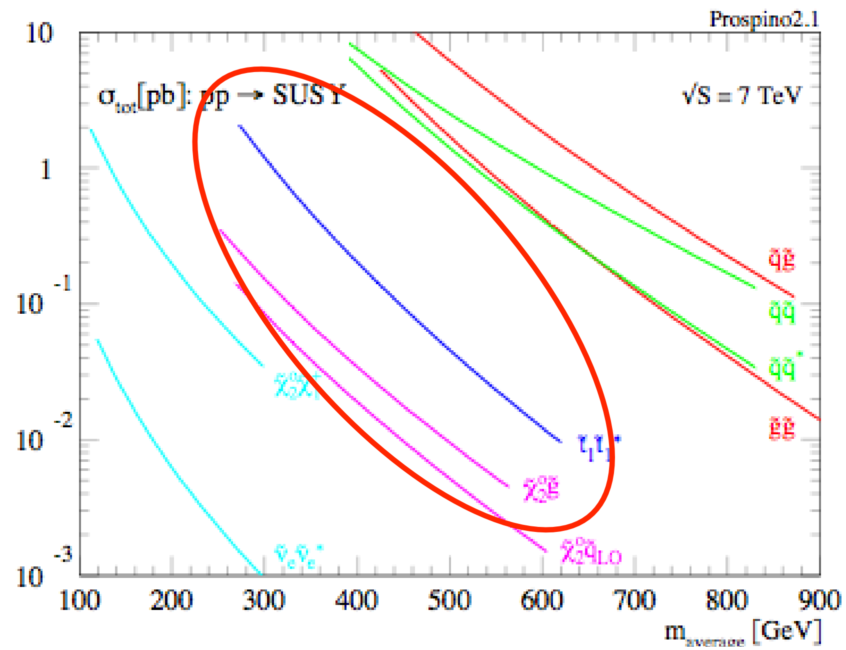
N. Arkani-Ahmed (CERN Workshop, 31-Oct'11)

... and this is not yet covered by LHC

3rd generation production

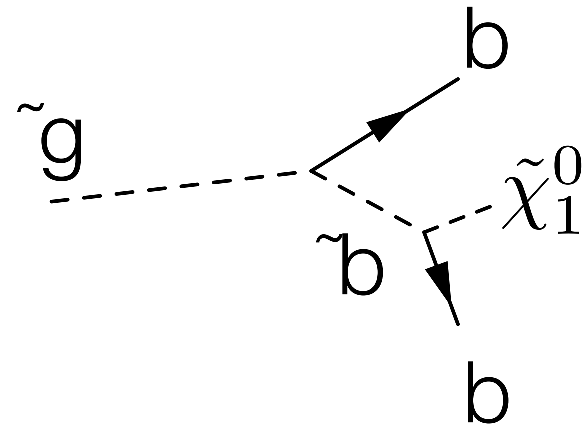
- The third generation squarks are special

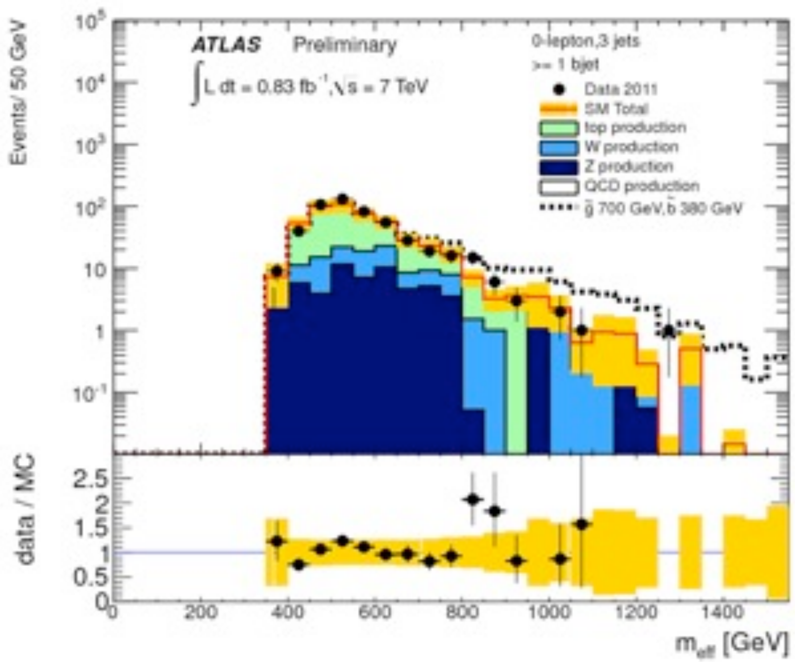
- Mixing between L and R component of squarks proportional to the fermion partner mass → large mixing for 3rd generation squarks → generally expected to be the lightest squarks
- Previous limits on squark masses do not apply to sbottom and stop
- The stop directly counter-balance quadratically divergent top loop corrections to the Higgs mass

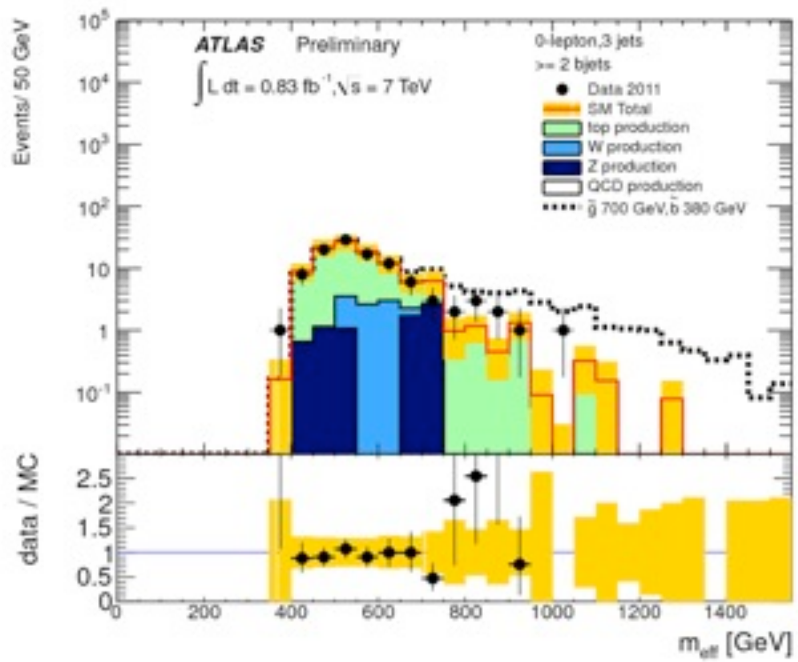


3rd generation (gluino mediated sbottom)

- stop, sbottom can be produced via gluino decay or directly in pairs
- Expected to produce abundance of b-jets in the final state
- Existing analysis mainly probing gluino mediated production
  - They set limits mainly on the gluino mass

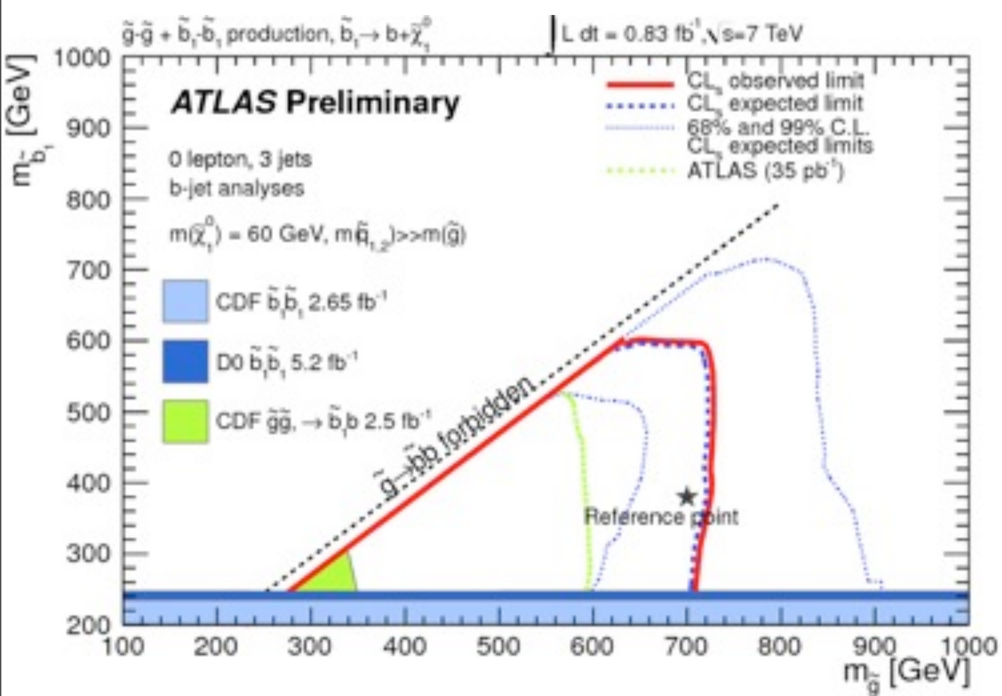


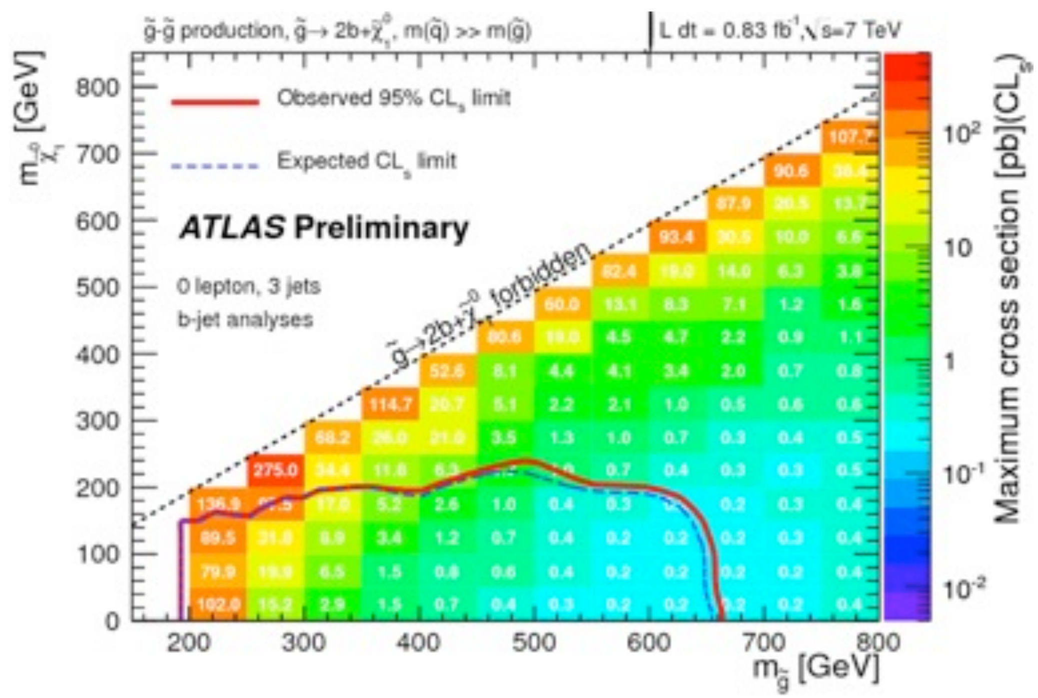




3rd generation (gluino mediated sbottom)

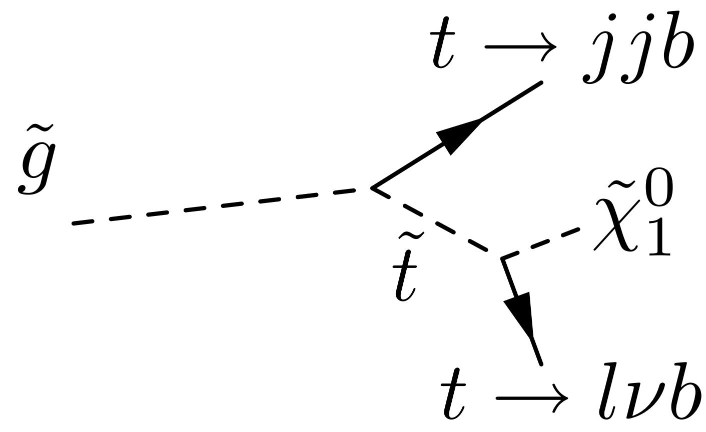
- Interpretation: $\tilde{g} \to \tilde{b}b$ with BR: 100%, $\tilde{b} \to \tilde{\chi}_0^1\, b$ with BR: 100%
- On-shell sbottom production: $m_{\tilde{g}} > m_{\tilde{b}}$ (left), and all other sparticles with large mass (beside LSP)
- Off-shell sbottom production (fixed sbottom mass at 1 TeV) but still all other sparticles with even larger masses

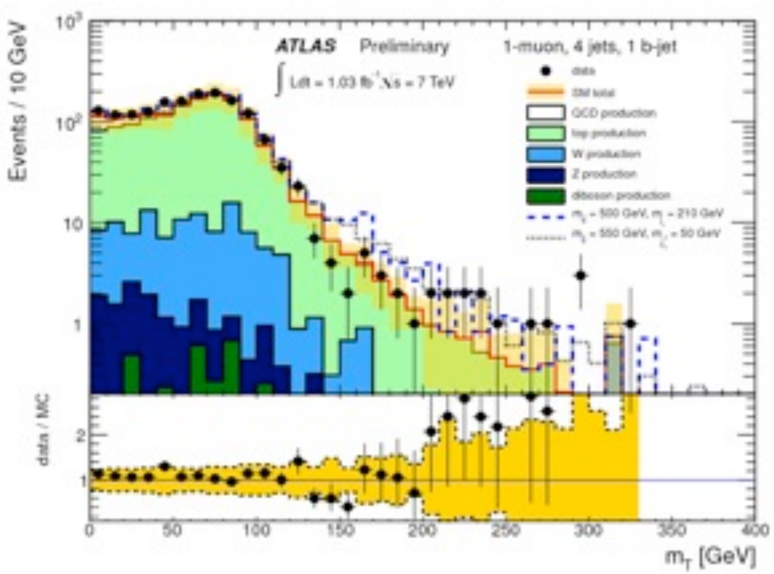


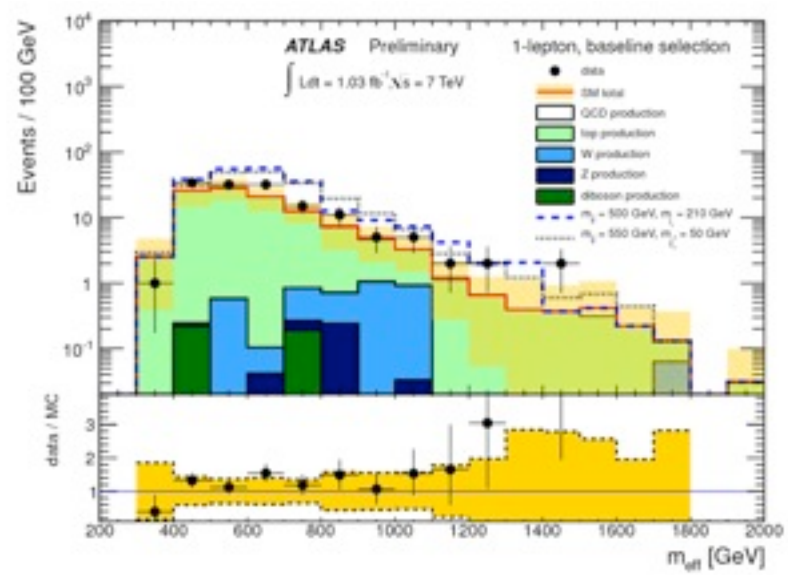


3rd generation (gluino mediated stop)

- stop, sbottom can be produced via gluino decay or directly in pairs
- Selection:
  - 1 lepton, 4 jets (1 b-tagged), large MET, large M_T
  - Main background: SM ttbar
  - Results consistent with the Standard Model

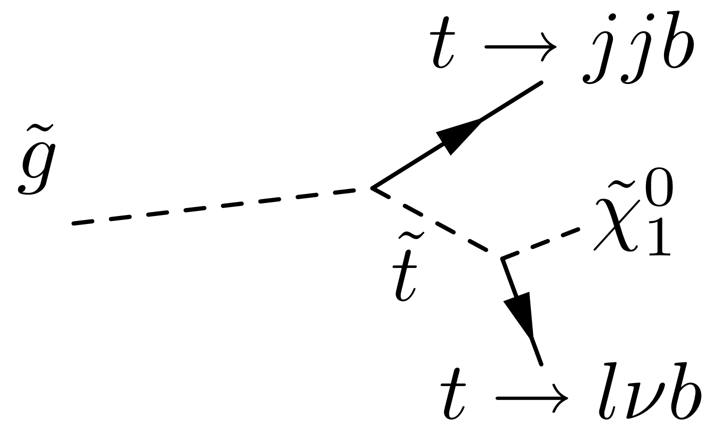


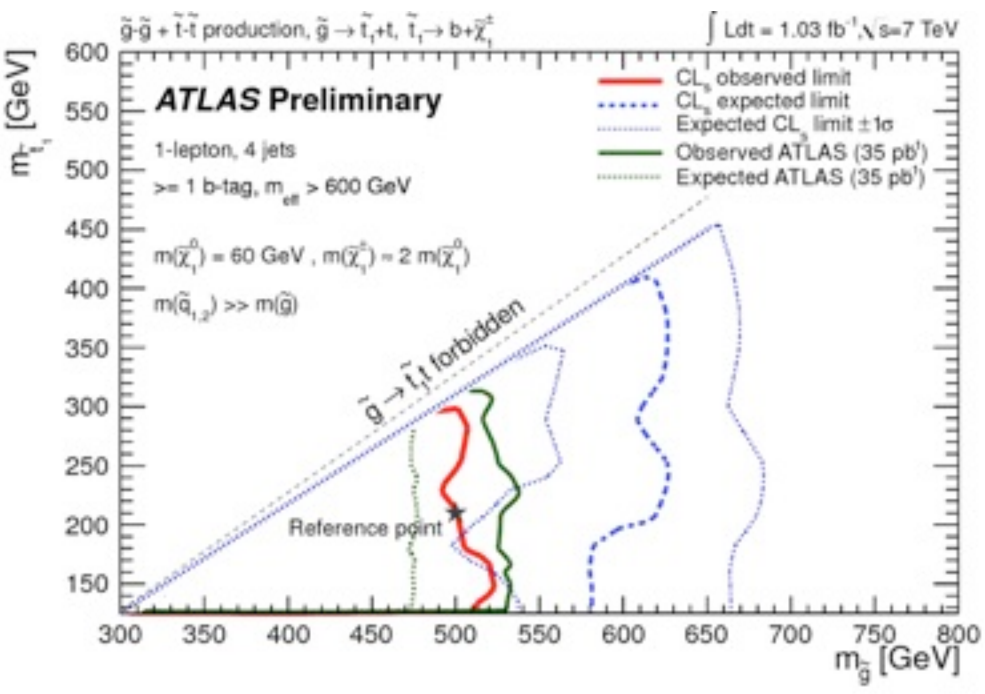


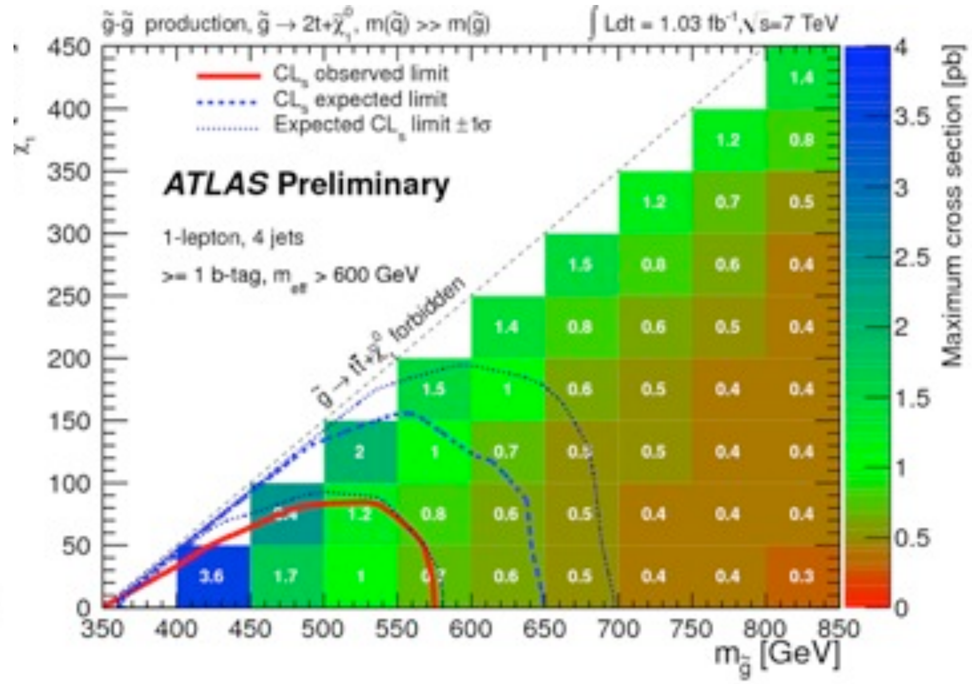


3rd generation (gluino mediated stop)

- Signal interpretation similar to the sbottom (on- and off-shell stop-mediated three body decay of the gluino)
- Some non-significant excess observed above the Standard Model predictions

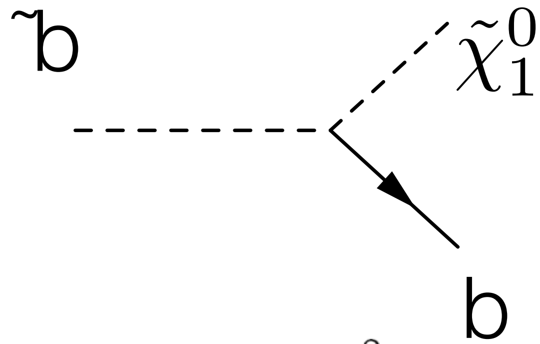






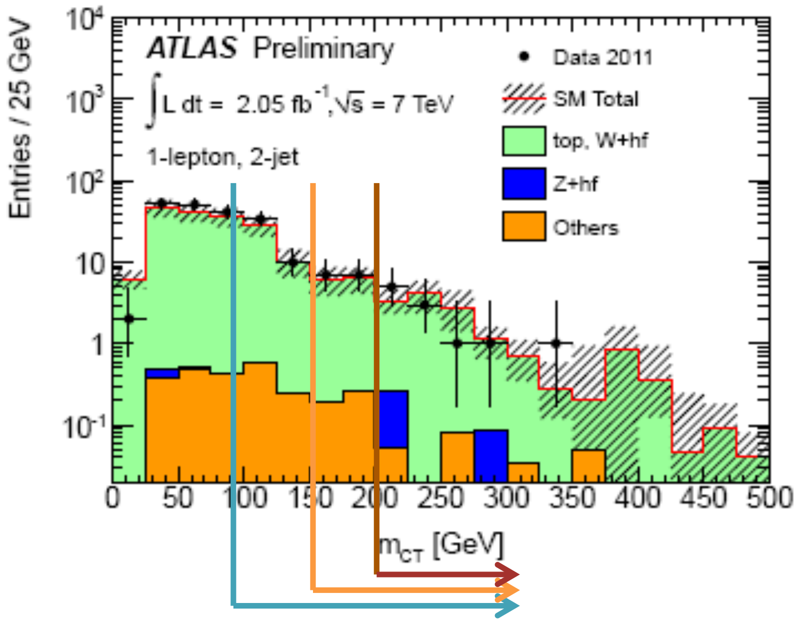
Getting closer to the stop....

- With 2 fb^{-1} we are sensitive to sbottom pair production (same cross section as stop, easier to separate from the background)
- 2 b-jets (130, 50 GeV) and large MET (130 GeV)



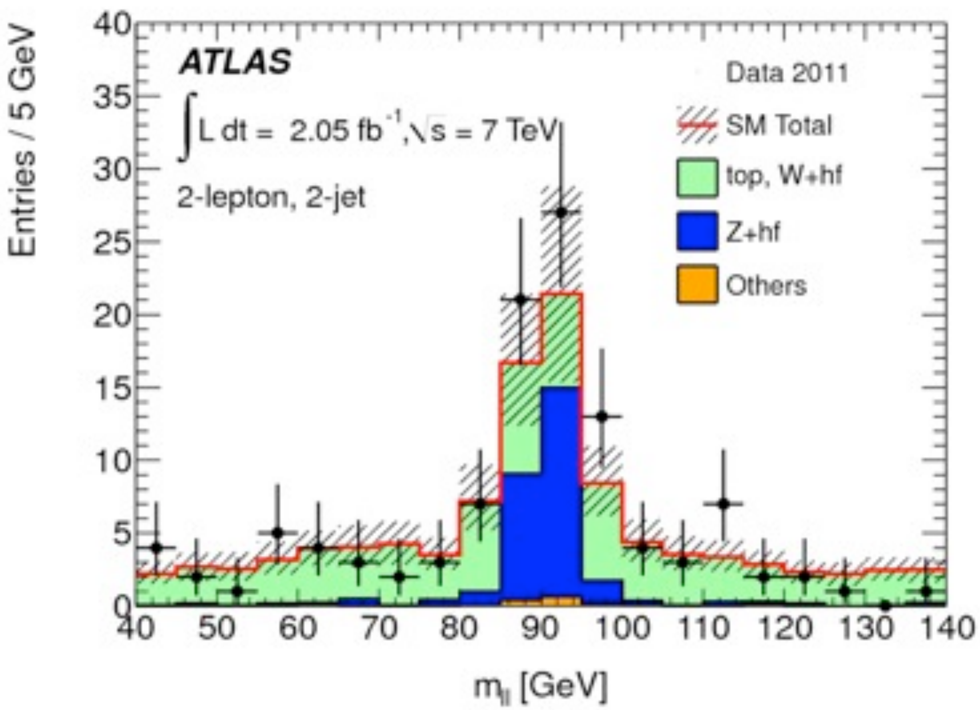
$$\left([E_{\rm T}(b_1)+E_{\rm T}(b_2)]^2-[\mathbf{p_T}(b_1)-\mathbf{p_T}(b_2)]^2\right)^{1/2}$$

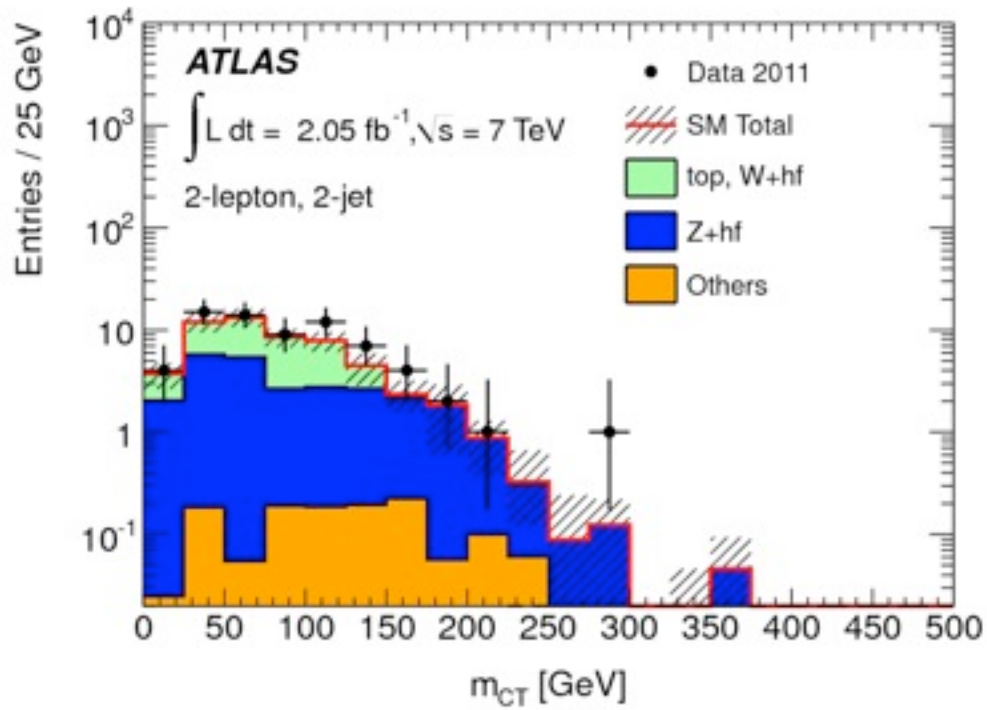
- Make use of the contransverse mass
- ... corrected for the boost of the objects
- Kinematical end point for the top at 138 GeV
- Three different cuts on MCT to maximize sensitivity in the $m_{\tilde{b}}$-$m_{neutralino}$ plane
- Data driven top estimate using a 1-lepton control region



Getting closer to the stop....

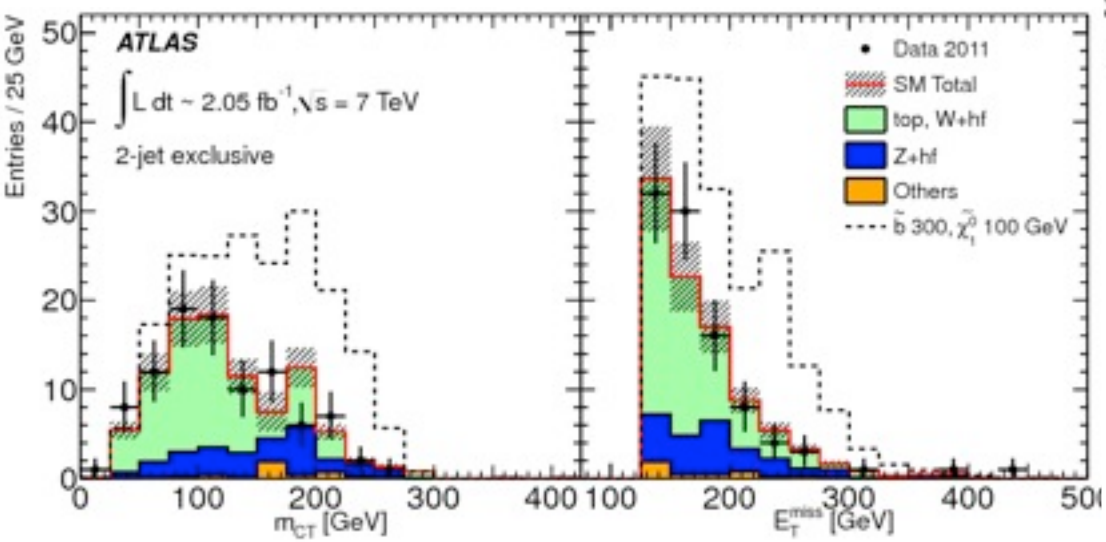
- Z+hf background estimated in a 2-lepton control region on the Z peak
- top contamination measured in the sidebands of the M_{ll} distribution

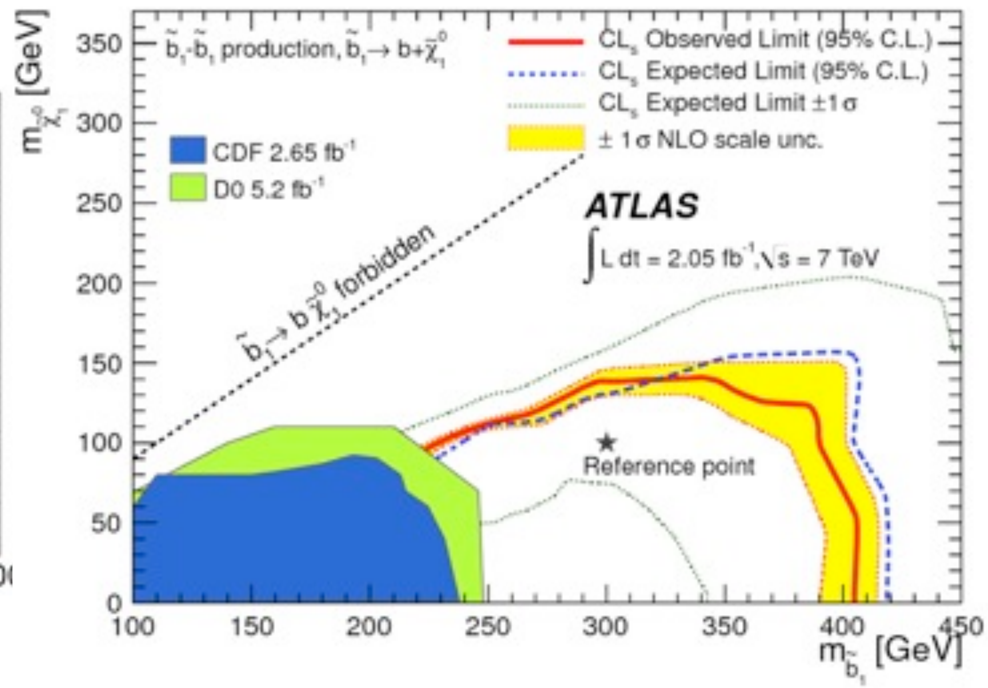




Getting closer to the stop....

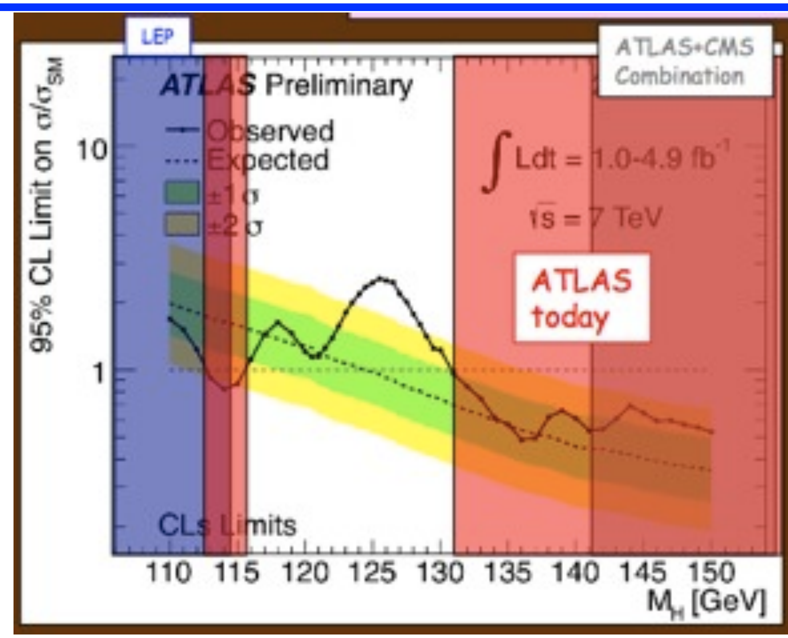
- Final M_{CT} distribution consistent with the SM predictions
- Model for the interpretation of the result: $\tilde{b} \rightarrow b\,\tilde{\chi}_1^0$ with BR 100%
- Tevatron limit significantly extended
- Stay tuned for the stop....

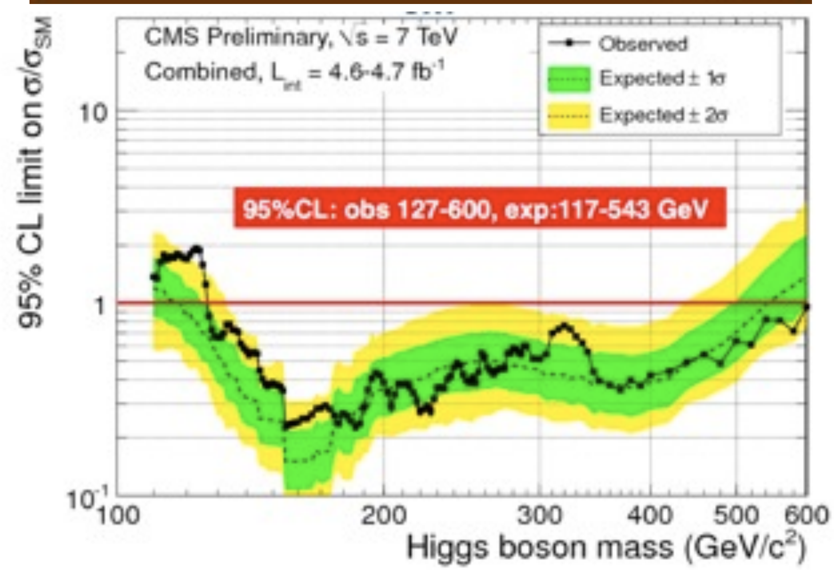




Before concluding......

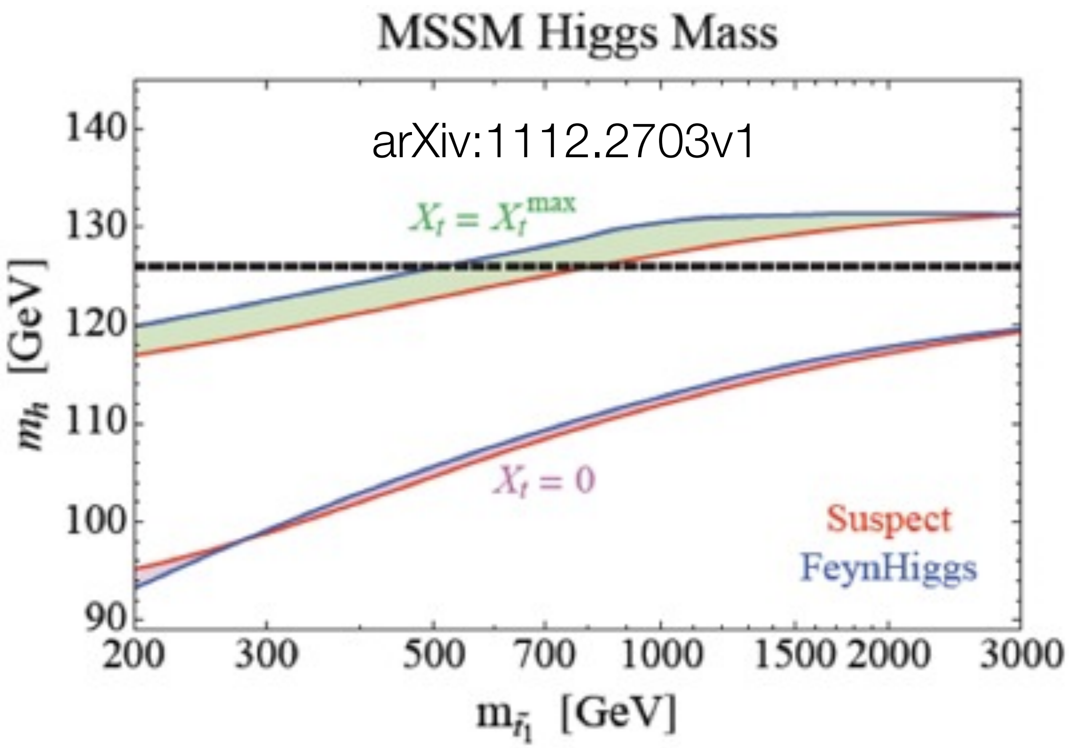
- The data from Higgs boson searches (will) tell us a lot about SUSY.
- Status:
    - new Higgs limits exclude a Higgs boson with mass above ~130 GeV or below 115 GeV.
    - An excess is observed at 124 GeV in CMS (126 GeV in ATLAS):
        - 2.5 σ ATLAS
        - 1.9 σ CMS



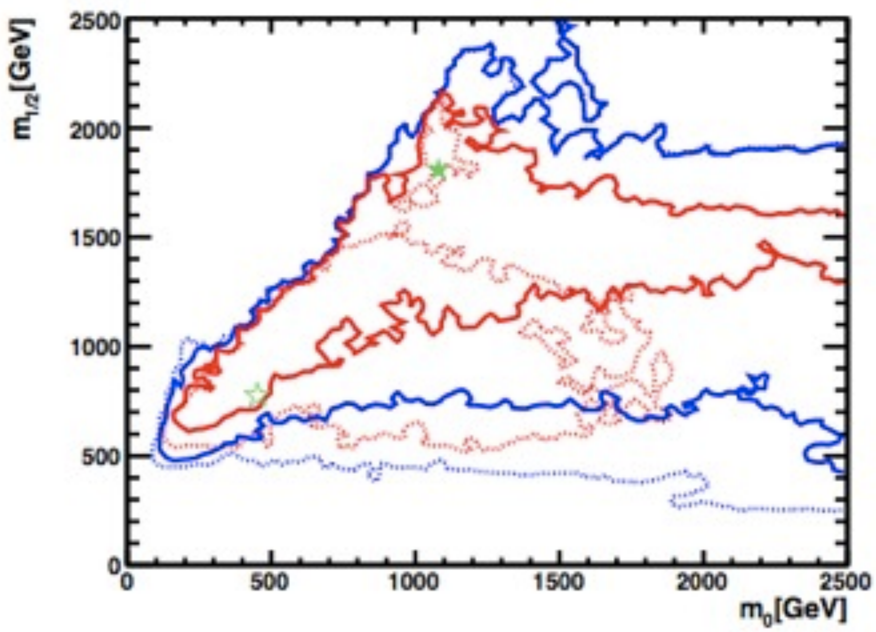


Consequences for SUSY

- Let's assume the Higgs boson exists and it has a mass of 125 GeV:
  - Then the two stop are either both moderately heavy (multi-TeV) or their mass splitting is very large (and anyhow, m_{t1} > 500 GeV)
  - In general, SUSY spectrum pushed at high energies, perhaps not accessible by the 7 TeV LHC



arXiv:1112.3564v1



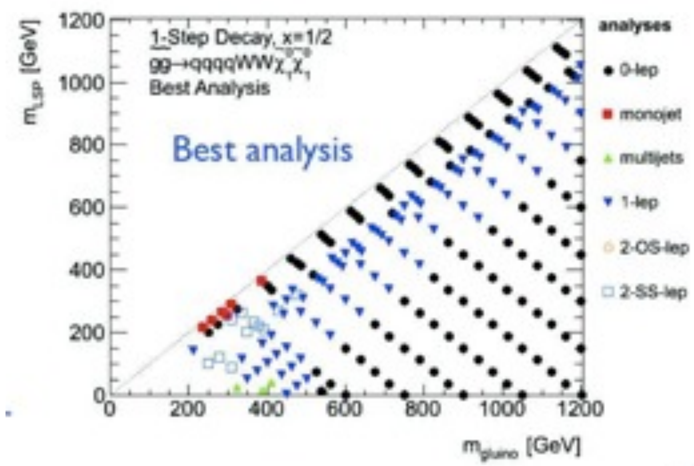
Summary

- LHC has opened a new era in the search for Supersymmetry
- No SUSY yet, but:
  - The detector and the machine are working well, this is only the beginning.
  - The analysis strategies are solid and constantly improved
  - So far mostly sensitive to strong production of gluinos and 1st and 2nd generation squarks, becoming sensitive to direct gaugino and 3rd generation production
- Higgs searches putting already quite strong constraints on SUSY
- New CMS energy of LHC will significantly increase the sensitivity

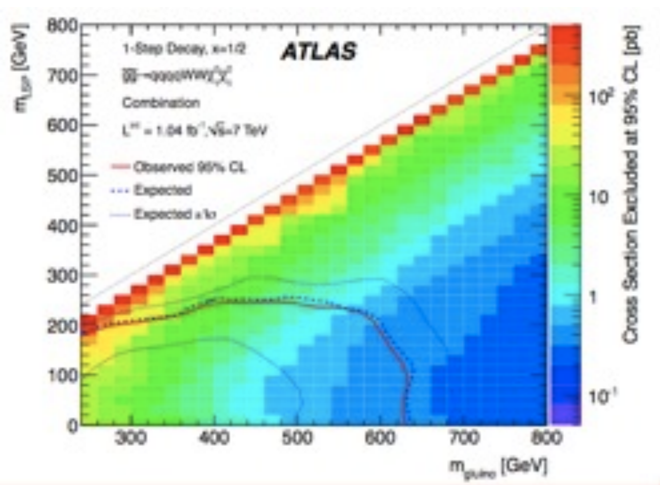
BACKUP

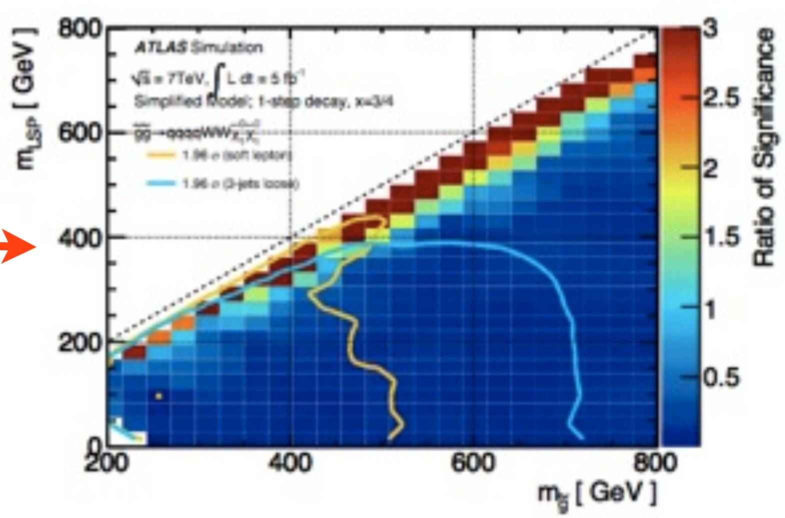
Strong production with leptons

- The 0-lepton analysis is very powerful, but it does not cover at best all possible scenarios



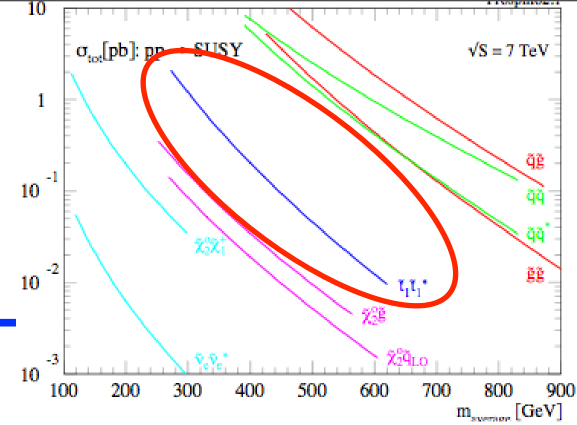
- Longer gluino decay chains ($\tilde{g} \to \tilde{q}q \to qq\tilde{\chi}_1^{\pm} \to qqW\tilde{\chi}_1^0$) better addressed by strategy involving leptons
- baseline 1-lepton analysis being reviewed:
  - soft lepton analysis (changing trigger strategy) brings sensitivity close to the diagonal
  - re-optimization of the signal regions

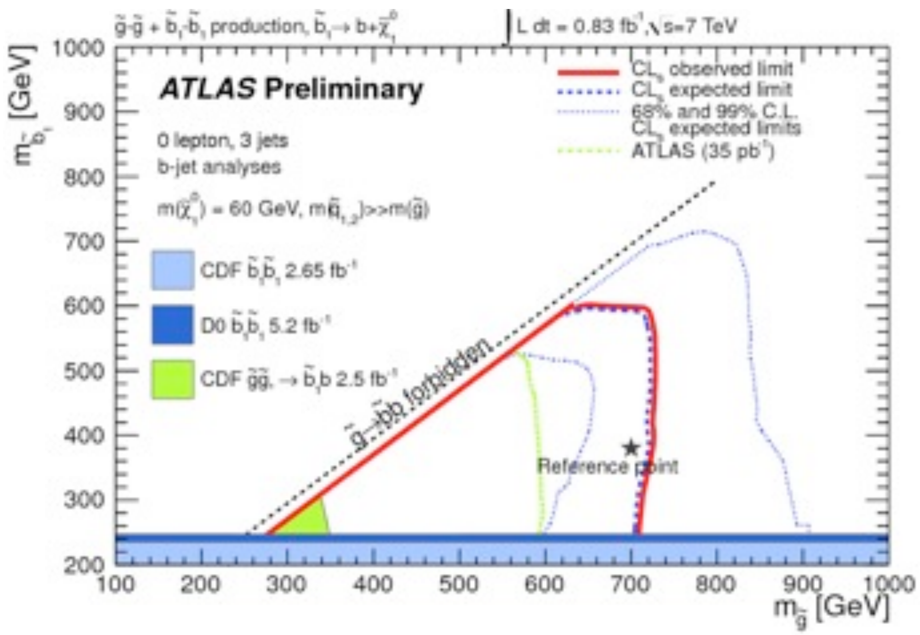




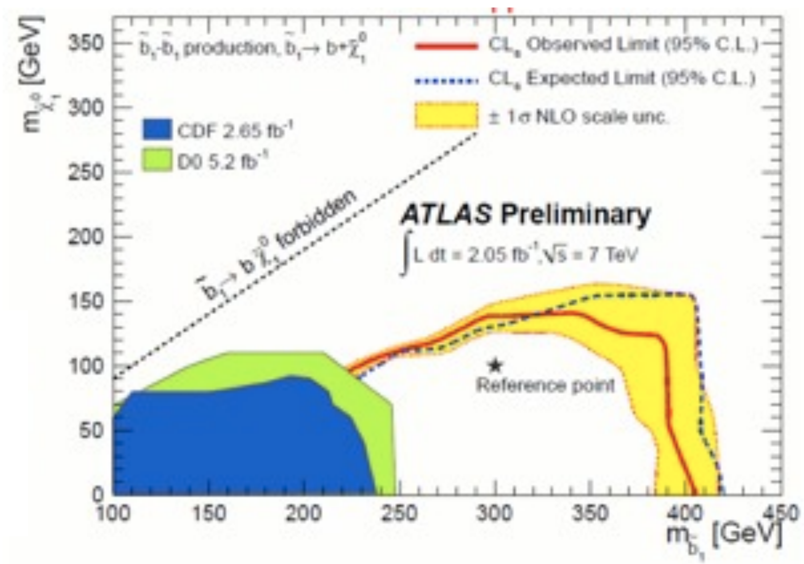
- Two lepton analysis demonstrated to have sensitivity in, e.g. GMSB
- Joined effort desirable
- taus soon included
- Z+MET analysis close to release results

Strong production - 3rd generation





- A particularly hot topic is the search for third generation squarks
- Searches performed so far mostly sensitive to sbottom and stop produced via gluino decay



- But quickly becoming sensitive to the third generation squark direct production
    - directly attacking the "natural spectrum"

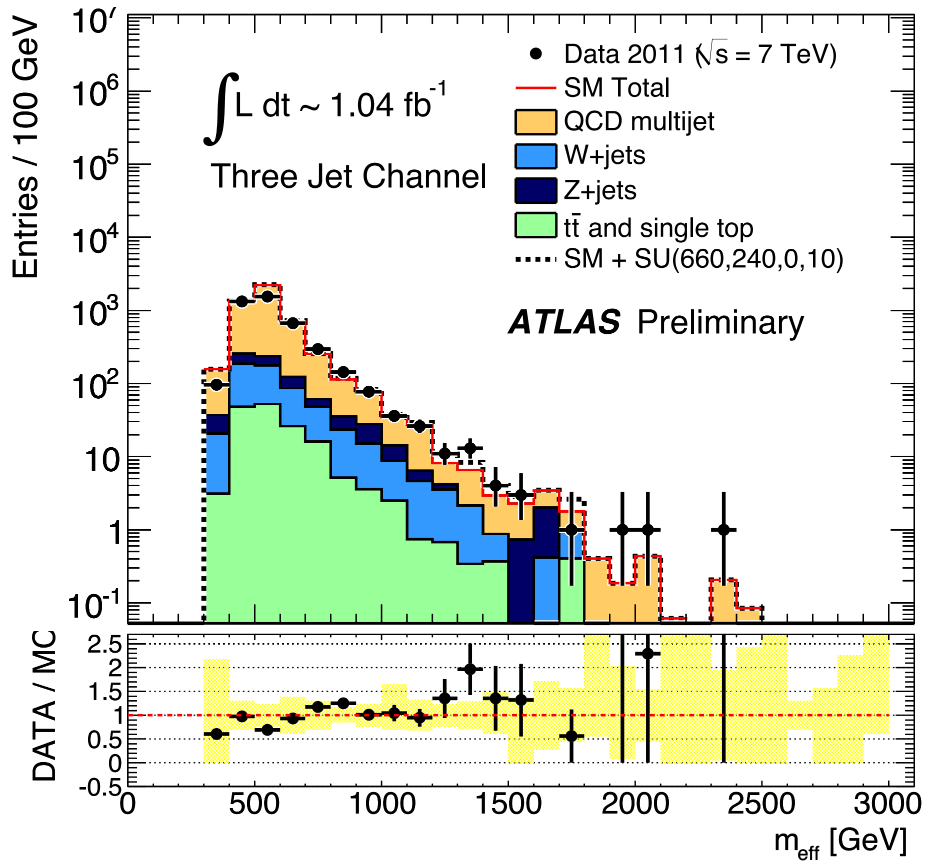
Systematic uncertainties

- Systematic uncertainties are reduced by the use of the transfer factors
- Jet energy scale and resolution uncertainties derived using 2010 data
  - Additional, conservative, uncertainties due to pileup considered
  - (typical effect on TF ~15%)
- Monte Carlo modelling uncertainties addressed by comparing transfer factor obtained with, e.g., ALPGEN or MC@NLO and varying renormalisation and factorisation scales (~25%)
- Depending on the CR: CR available statistics, lepton identification, b-tagging, etc. considered, typically with a smaller impact.

QCD background estimation

- QCD pseudo-events obtained by smearing low E_T significance events with a jet response function.

- Validation:
  - QCD prediction from pseudo-events compared to data in events where $\Delta\phi_{min\ (jet, E_T^{miss})} < 0.4$
  - QCD multi-jet events have large MET because of jet mis-measurement or heavy flavours leptonic decays.
  - In both cases MET tends to align with one of the jets



Minimal SUSY extension of SM (MSSM)

- If SUSY is unbroken, $M_{sparticle} = M_{particle}$. Since sparticles are not yet observed, SUSY must be (softly) broken:
  - $L_{SUSY} = L_{SUSY\ conserving} + L_{SUSY\ soft\ breaking}$

2 higgs doublets needed → 5 Higgs bosons

MSSM parameters:

SUSY conserving sector	SUSY breaking sector
3 coupling constants for SU(3) xSU(2)sU(1)	5 3x3 hermitian mass matrices (one per EW multiplet)
4 Yukawa couplings per generation	3 complex 3x3 matrices (Higgs trilinear couplings to sfermions)
	3 mass terms for the Higgs sector + 2 additional off-diagonal terms
	Higgs VEV expectation angle β

A total of 124 parameters. Constraints needed:

Bottom up: separate lepton number conservation, FCNC suppression, CP violation constrain the MSSM parameters

Top-down: Precise assumptions are made on the way SUSY is broken:

- mSUGRA/CMSSM
- GMSB
- AMSB

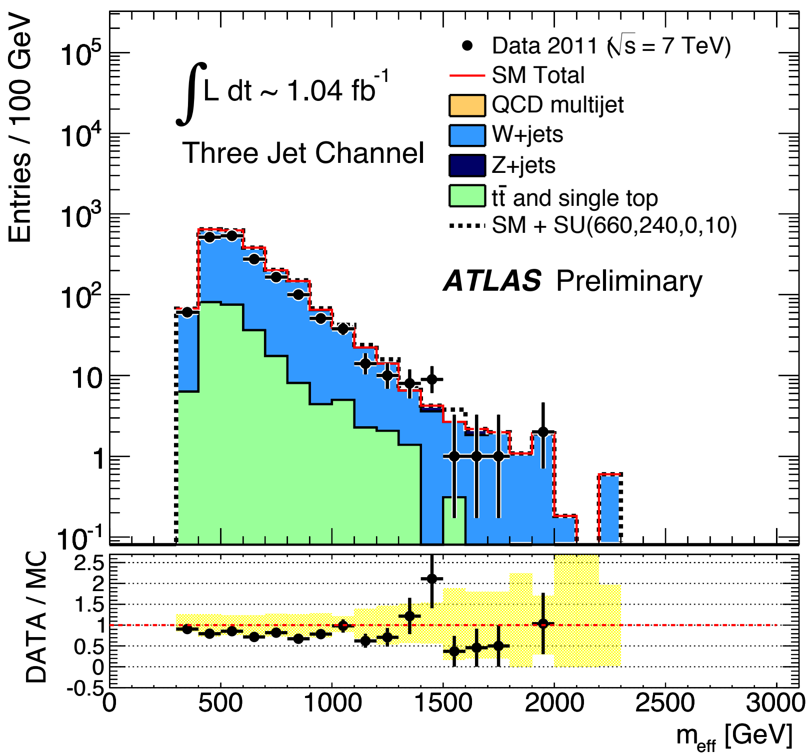
Analysis strategy

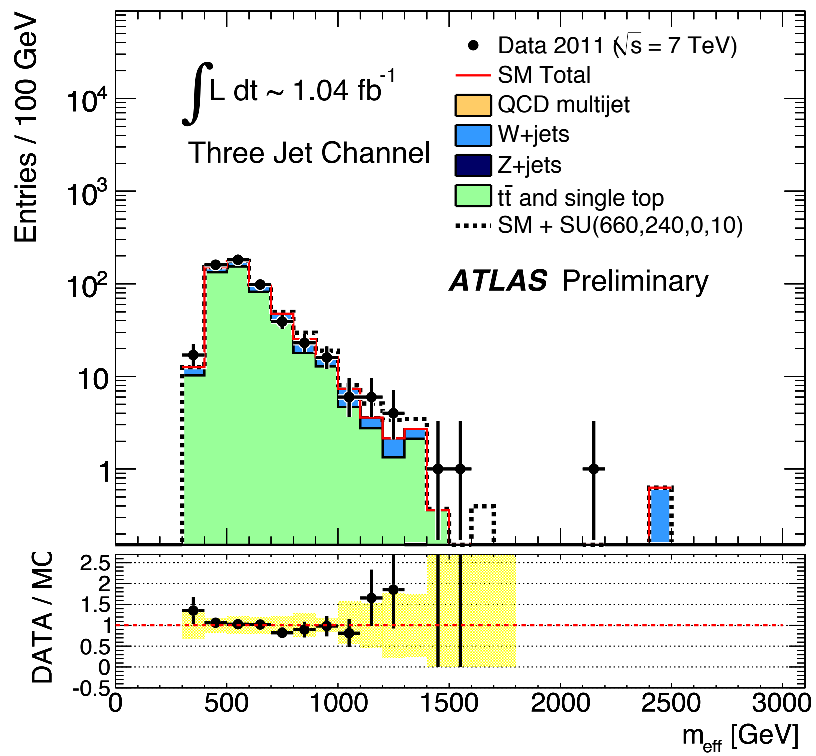
- Main expected SM background: W/Z + jets, top production, QCD multi-jet
- For each background, for each signal region, one or more dedicated control regions (CR)
- Background determination done with a combined fit to all CRs (mutual background contamination in CR and correlations automatically taken into account)
- Transfer factors (TF) from each background process CR to the SR are computed using a mix of data-driven and Monte Carlo driven techniques.

$$N(\mathrm{SR}, \mathrm{est}, \mathrm{proc}) = N(\mathrm{CR}, \mathrm{obs}, \mathrm{proc}) * \left[\frac{N(\mathrm{SR}, \mathrm{raw}, \mathrm{proc})}{N(\mathrm{CR}, \mathrm{raw}, \mathrm{proc})}\right]$$

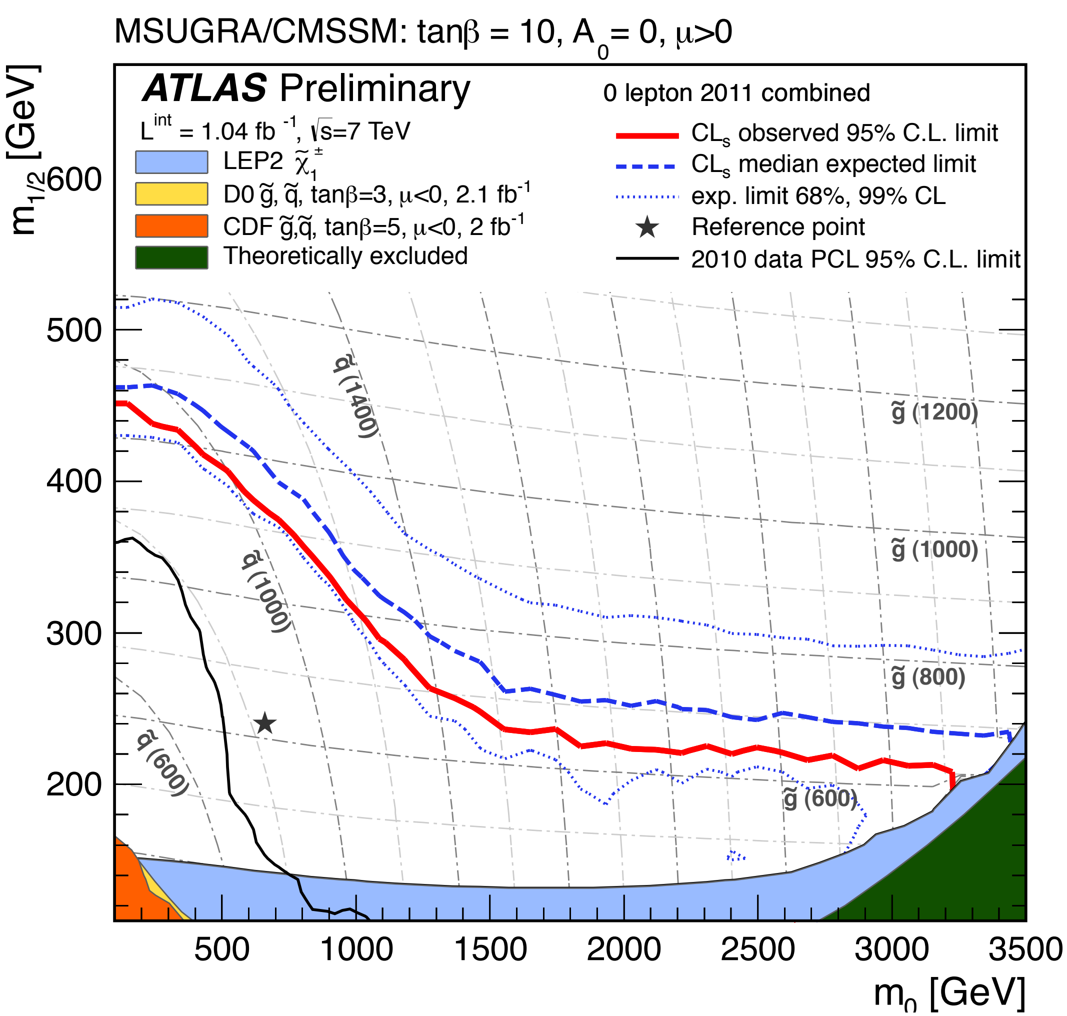
W and top control regions

- Two control regions defined in events containing one additional lepton (additional selection 30 GeV < M_T < 100 GeV):
  - Applying a b-tag veto a W control region is obtained.
  - Applying a b-tag requirement a top control region is obtained.





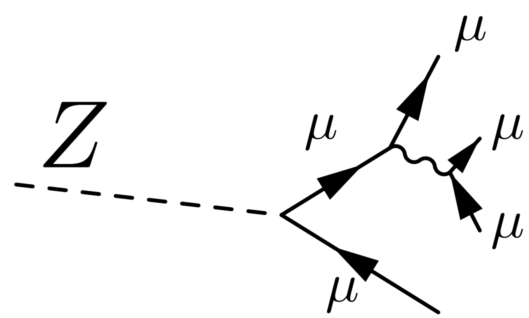
Result interpretation (2)



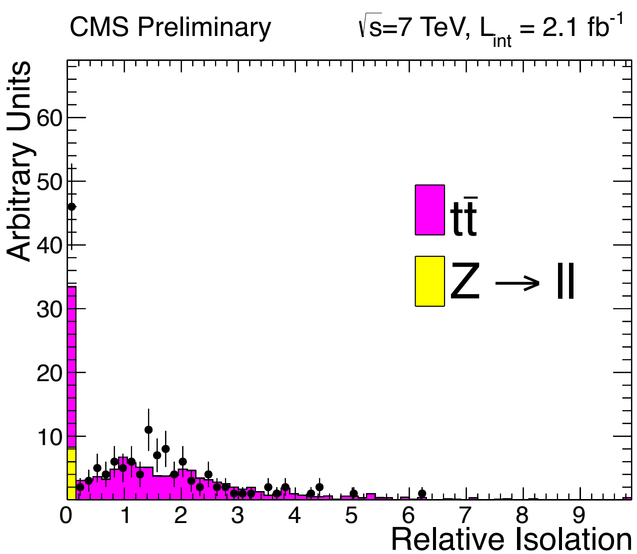
- Results interpreted in mSUGRA/CMSSM (A_0 = 0, tanβ = 10, μ>0)
- Limit in large m_0 region profits from the introduction of signal regions with large jet multiplicities.
- Equal squark-gluino masses excluded below 980 GeV

Multilepton analysis (CMS)

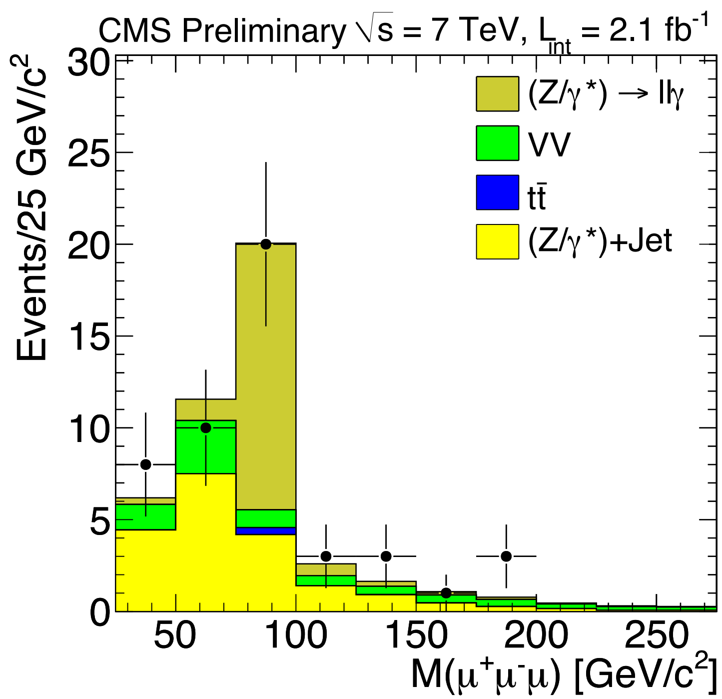
- Background from fake leptons:
    - e/mu: Compute probability that an isolated track fakes a lepton in QCD events → estimate background from a 2-lepton sample
    - tau: use sidebands of isolation distribution

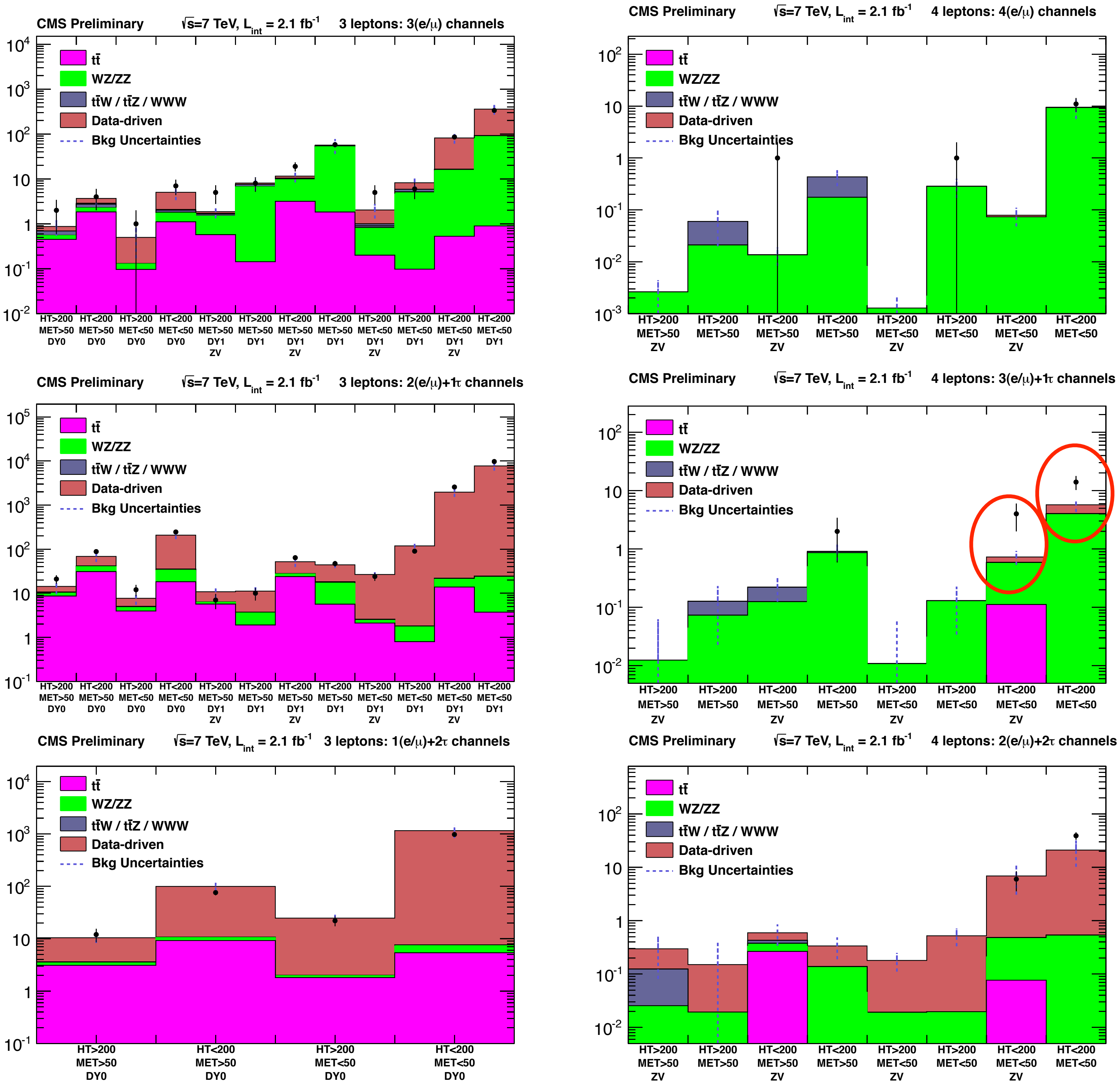


- Background from asymmetric conversions:
    - Estimated comparing lll to llγ at the Z peak



- **top and di-boson background estimated using MC (validated in CR)**




CMS Preliminary √s=7 TeV, L_int = 2.1 fb-1 3 leptons: 3(e/μ) channels
CMS Preliminary √s=7 TeV, L_int = 2.1 fb-1 4 leptons: 4(e/μ) channels
CMS Preliminary √s=7 TeV, L_int = 2.1 fb-1 3 leptons: 2(e/μ)+1τ channels
CMS Preliminary √s=7 TeV, L_int = 2.1 fb-1 4 leptons: 3(e/μ)+1τ channels
CMS Preliminary √s=7 TeV, L_int = 2.1 fb-1 3 leptons: 1(e/μ)+2τ channels
CMS Preliminary √s=7 TeV, L_int = 2.1 fb-1 4 leptons: 2(e/μ)+2τ channels
tt̄
WZ/ZZ
tt̄W / tt̄Z / WWW
Data-driven
Bkg Uncertainties
HT>200 MET>50 DY0
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HT<200 MET<50

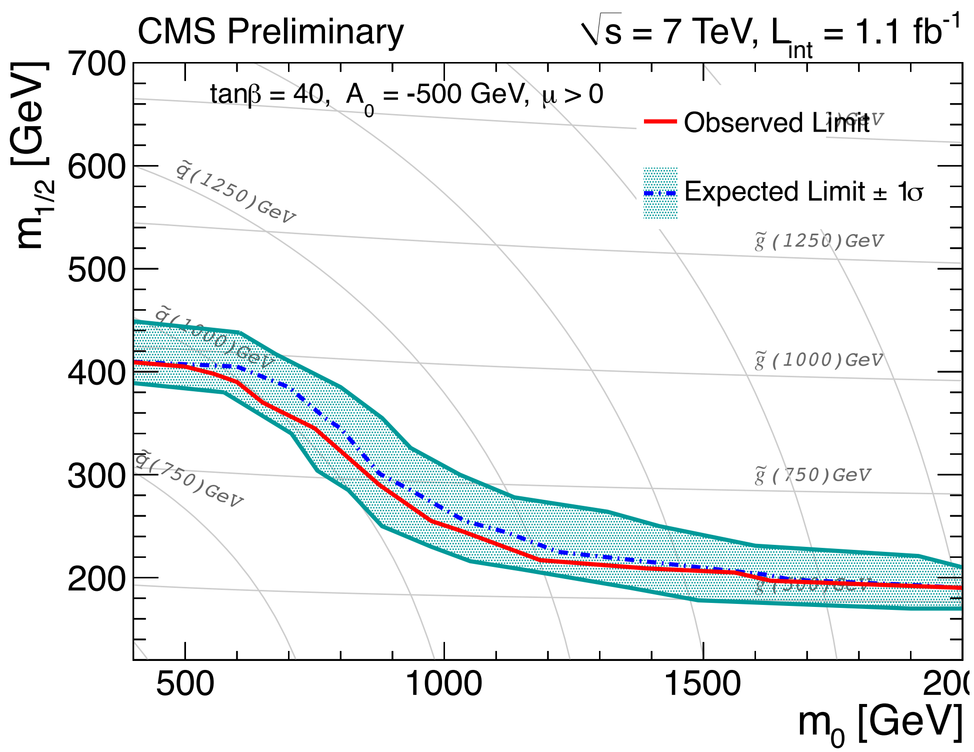
0τ

1τ

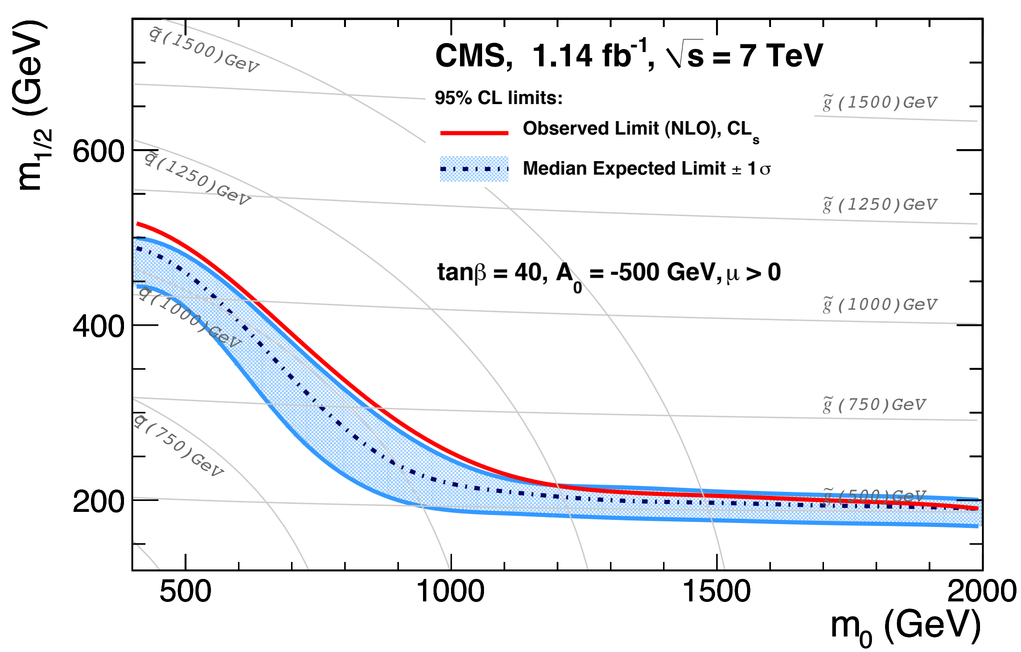
2τ

tan β = 40

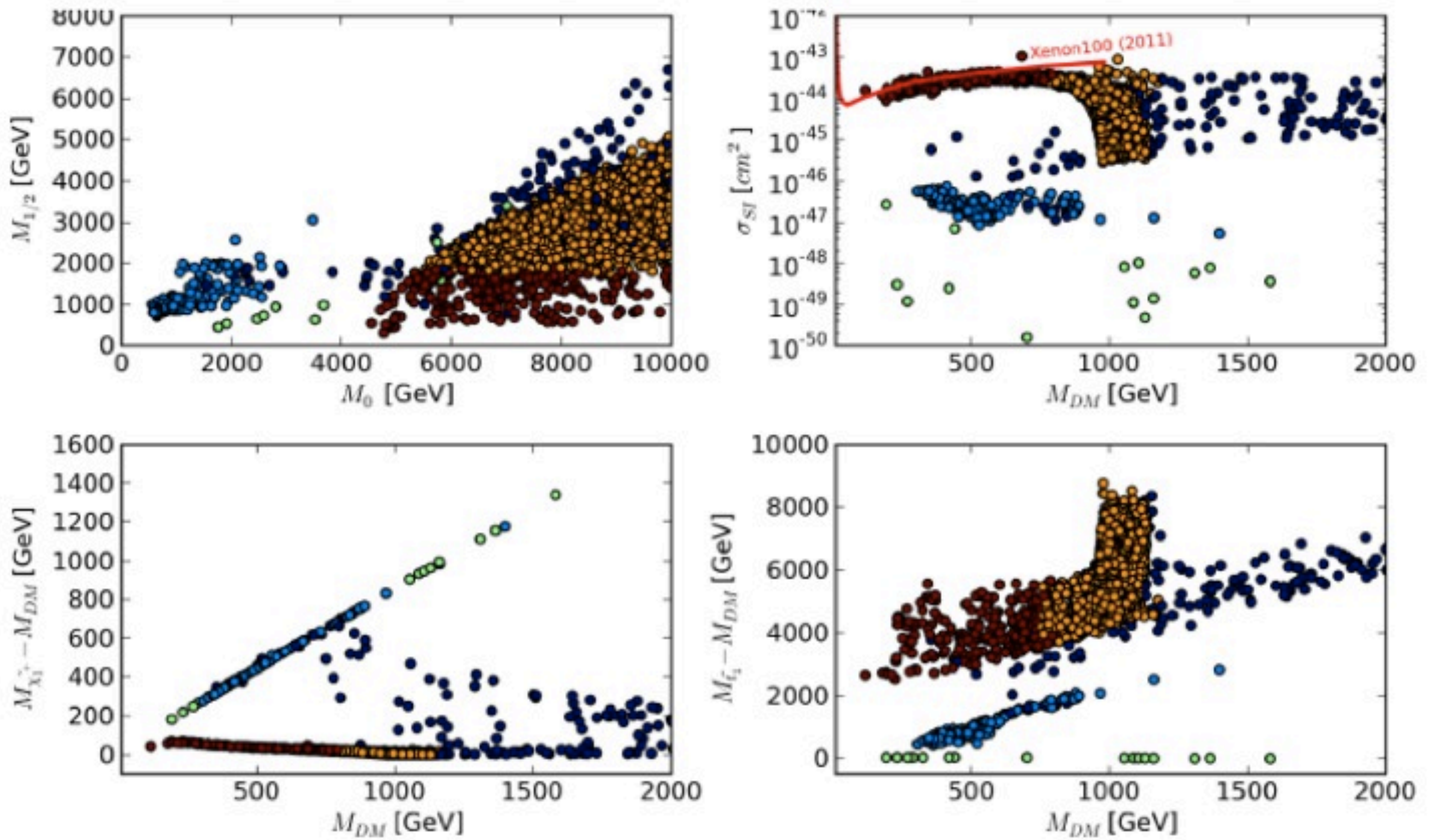
SUSY with b-jets



SUSY with alpha_T



Dark matter indirect results

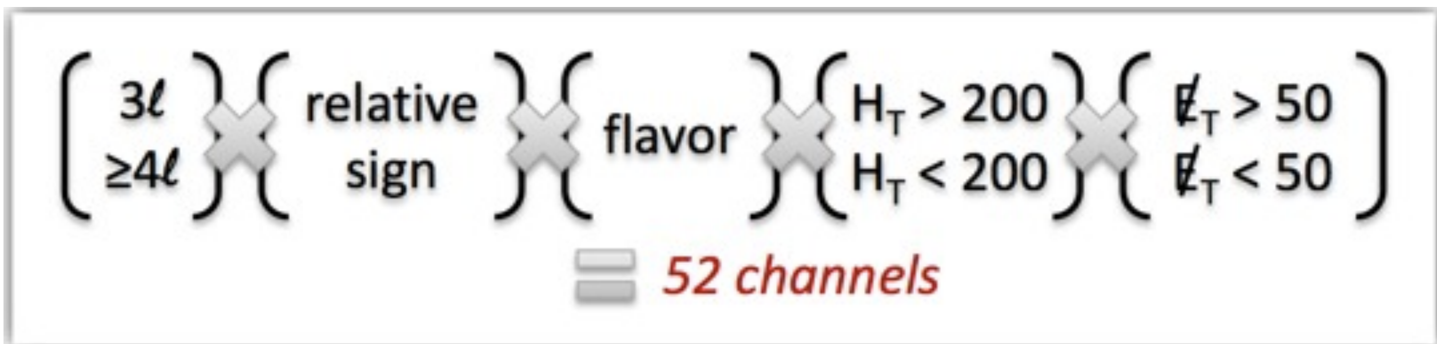


Multilepton analysis (CMS)

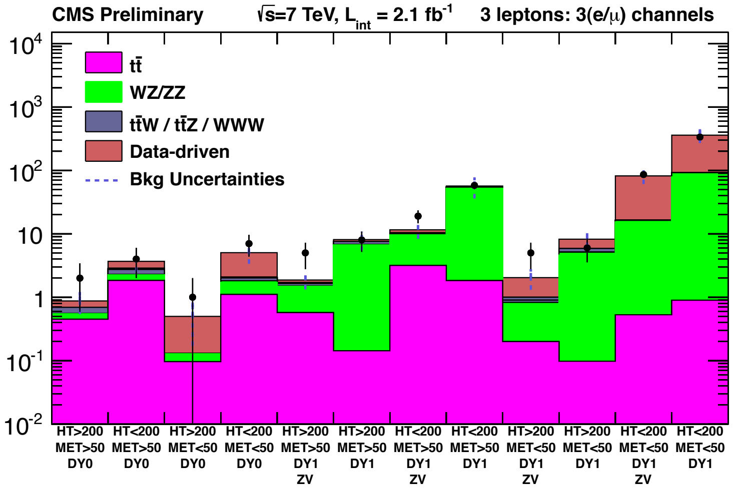
- A completely different analysis: focus on 3-lepton and >= 4 lepton signatures:
  - Sensitive to R-parity conserving SUSY with many-steps gluino-squark decay and/or sleptons in the decay chain. MET expected in the final state
  - Sensitive to R-parity violating SUSY → no MET in final state

Reminder

$$H_T = \sum_{jets} P_T$$



- **<u>Very clean in principle</u>**
  - However, need to be careful with fake leptons and (internal and non) photon conversions


CMS Preliminary √s=7 TeV, L_int = 2.1 fb^-1 3 leptons: 3(e/μ) channels
tt̄
WZ/ZZ
tt̄W / tt̄Z / WWW
Data-driven
Bkg Uncertainties
HT>200 MET>50 DY0
HT<200 MET>50 DY0
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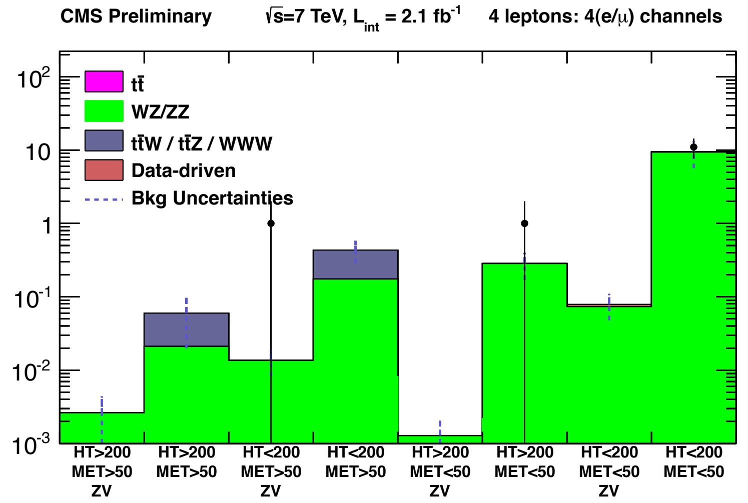
CMS Preliminary √s=7 TeV, L_int = 2.1 fb^-1 4 leptons: 4(e/μ) channels
tt̄
WZ/ZZ
tt̄W / tt̄Z / WWW
Data-driven
Bkg Uncertainties
HT>200 MET>50 ZV
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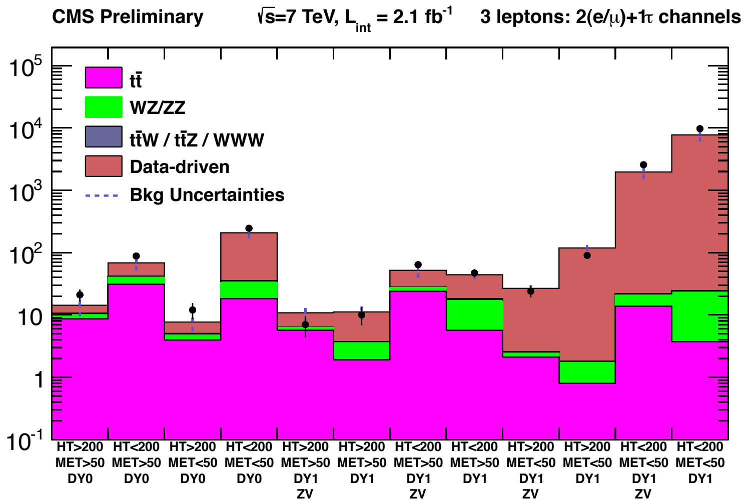
0τ


CMS Preliminary √s=7 TeV, L_int = 2.1 fb^-1 3 leptons: 2(e/μ)+1τ channels
tt̄
WZ/ZZ
tt̄W / tt̄Z / WWW
Data-driven
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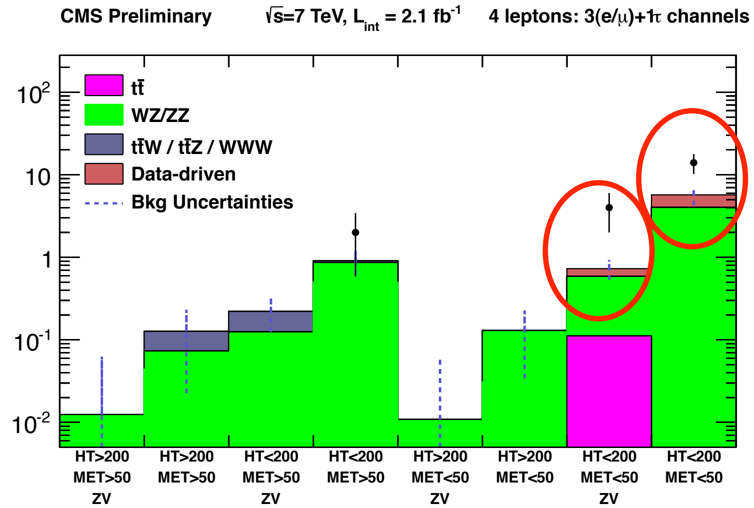
CMS Preliminary √s=7 TeV, L_int = 2.1 fb^-1 4 leptons: 3(e/μ)+1τ channels
tt̄
WZ/ZZ
tt̄W / tt̄Z / WWW
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Bkg Uncertainties
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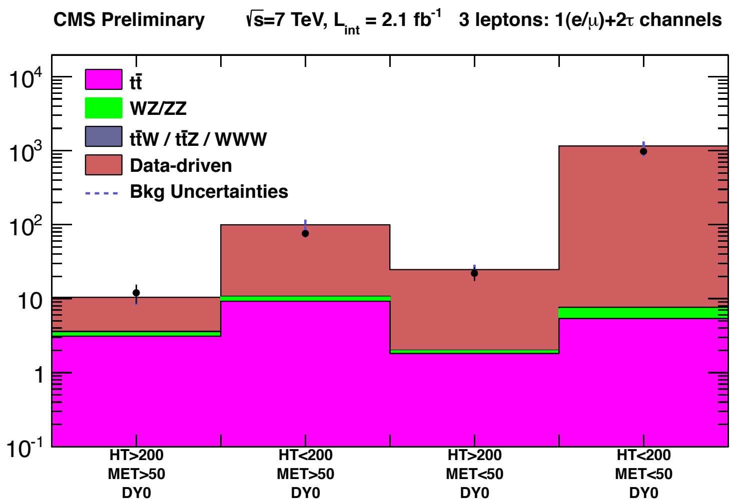
1τ


CMS Preliminary √s=7 TeV, L_int = 2.1 fb^-1 3 leptons: 1(e/μ)+2τ channels
tt̄
WZ/ZZ
tt̄W / tt̄Z / WWW
Data-driven
Bkg Uncertainties
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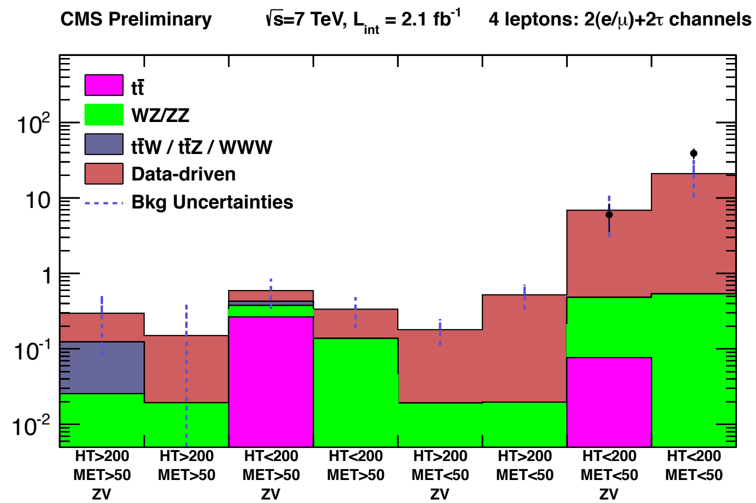
HT>200 MET<50 DY0
HT<200 MET<50 DY0


CMS Preliminary √s=7 TeV, L_int = 2.1 fb^-1 4 leptons: 2(e/μ)+2τ channels
tt̄
WZ/ZZ
tt̄W / tt̄Z / WWW
Data-driven
Bkg Uncertainties
HT>200 MET>50 ZV
HT>200 MET>50
HT<200 MET>50 ZV
HT<200 MET>50
HT>200 MET<50 ZV
HT>200 MET<50
HT<200 MET<50 ZV
HT<200 MET<50

2τ

Multilepton analysis (CMS)

- Some excess present (especially in 4 leptons with taus), large trial factor. Result still consisted as SM.
- Interpreted as a 95% CL limit in specific mSUGRA scenarios