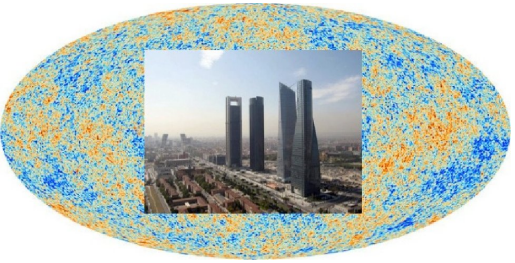
Overview of ATLAS results

Mario Martínez



PACT 2013 Extended Workshop, Madrid, October 2013

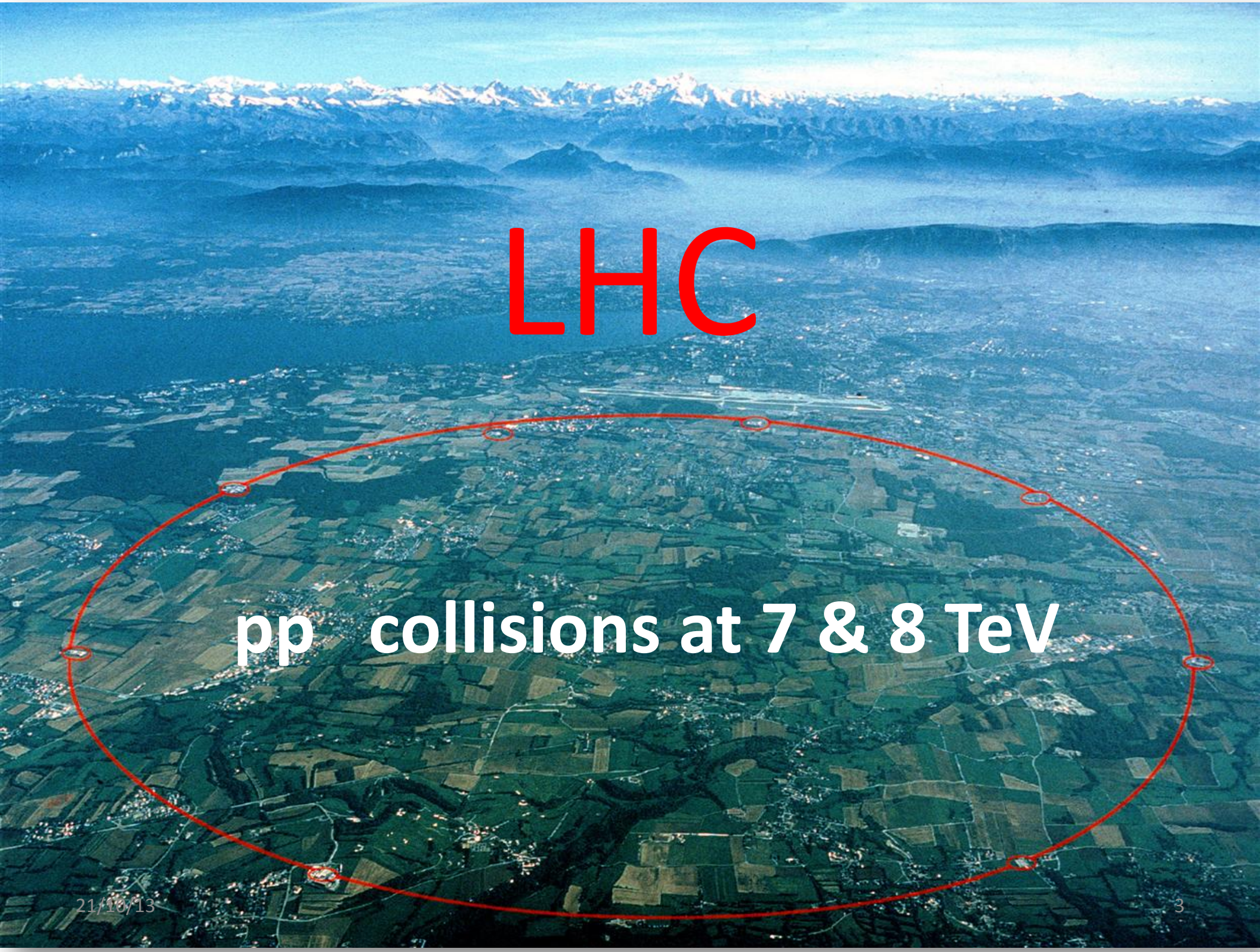
Outline

- LHC and ATLAS
- Selected SM Results
- Higgs
- **SUSY and DM searches**
- **Non-SUSY searches**
- **Final notes**

Mostly centered in high-p_T physics

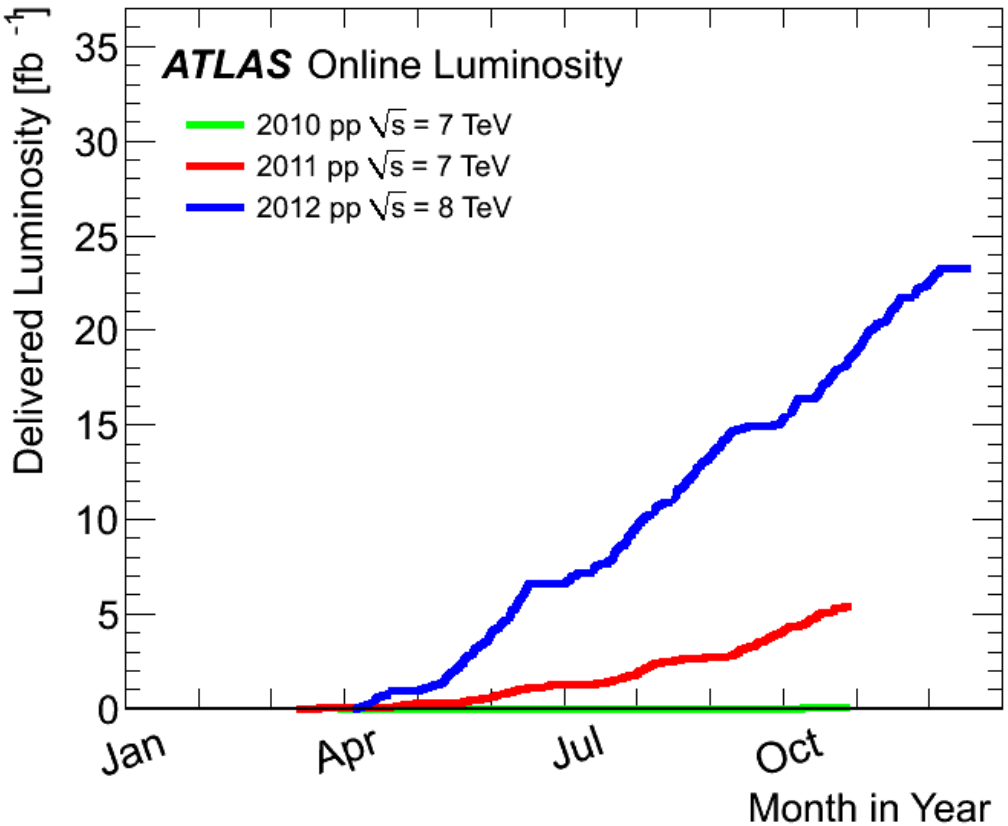
Impossible to cover ATLAS results in 45'
(a total of 273 papers submitted/published)
(a total of 538 conference notes)

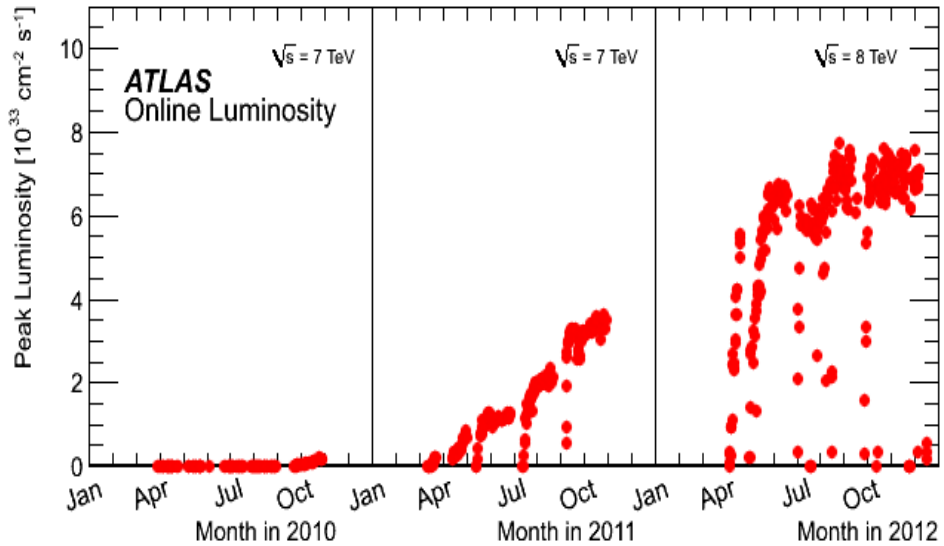
A long list of topics not covered here…
No results on Heavy Ions, B-Physics,…


LHC
pp collisions at 7 & 8 TeV

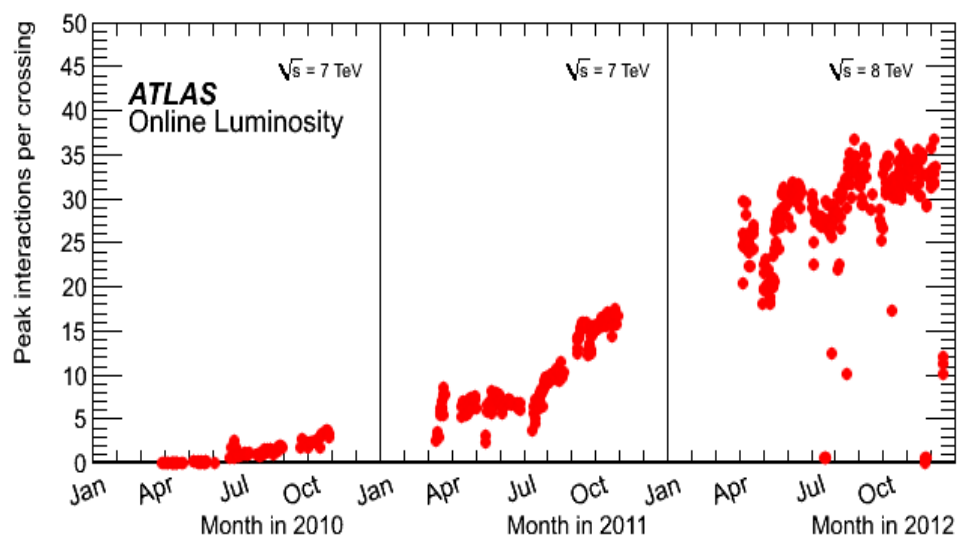
LHC Performance (2010-2012)

Spectacular LHC performance (rapid increase of data samples)





… rapid increase of pile-up conditions

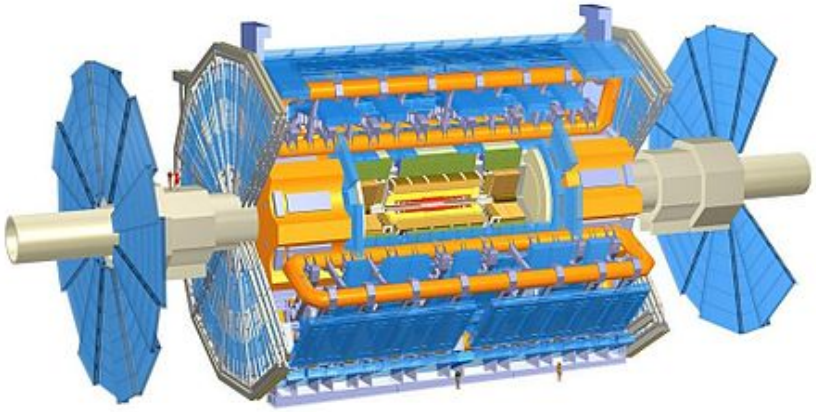


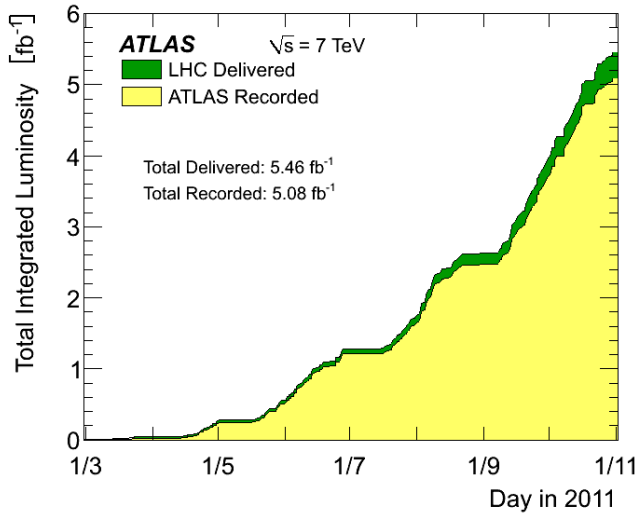
LHC ended pp run at 7+8 TeV after delivering more than 28 fb^{-1}

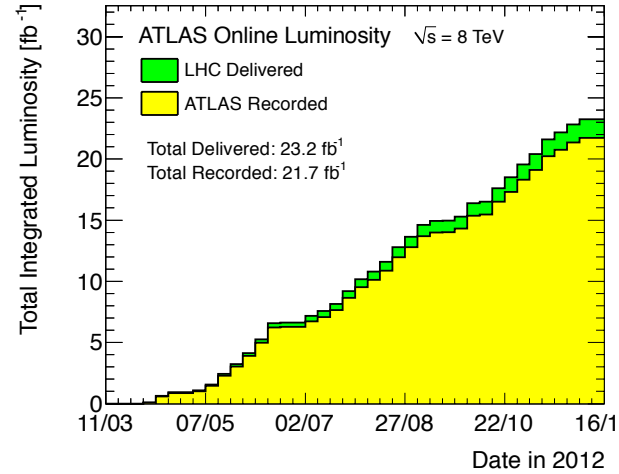
…will come back in 2015 with 13-14 TeV collisions

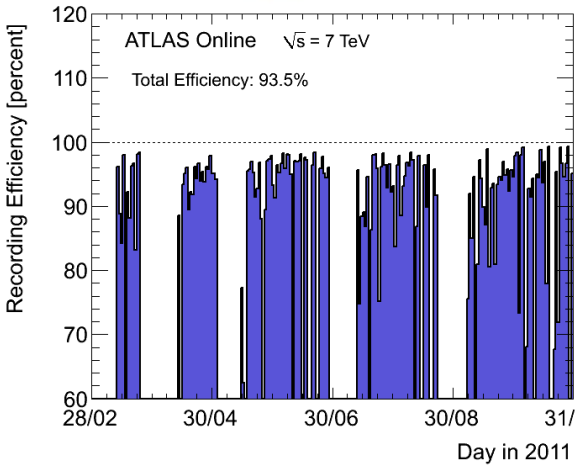
ATLAS

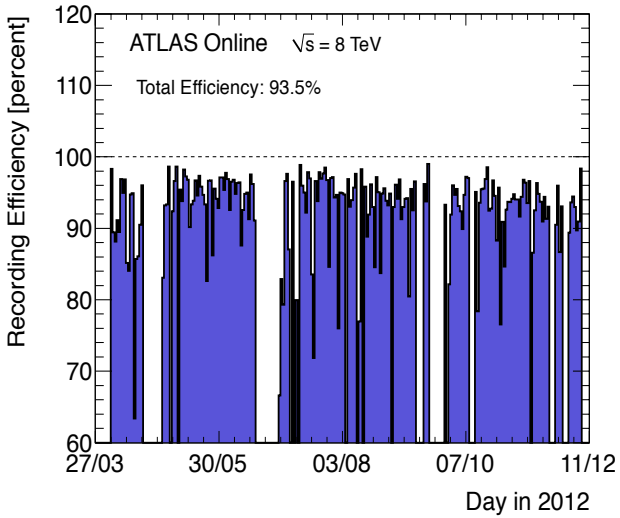
ATLAS



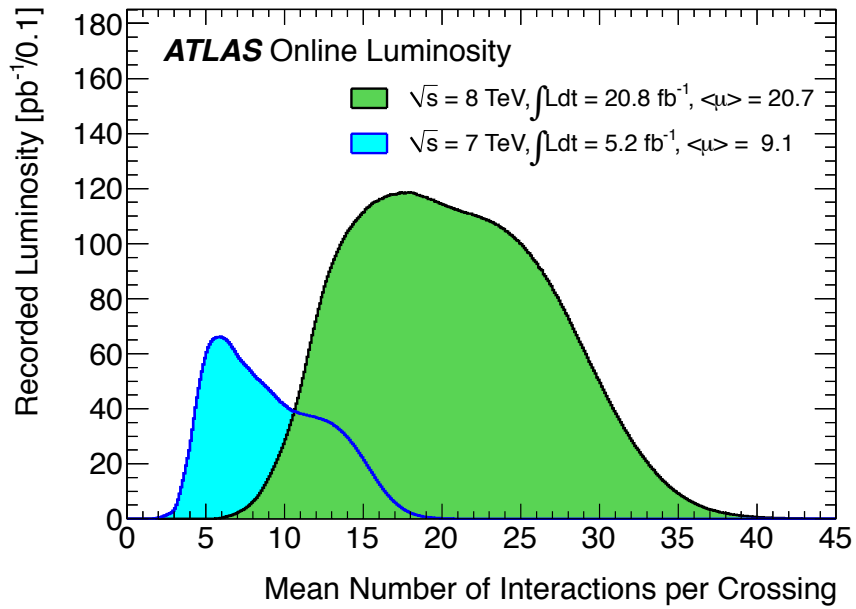








93.5% efficiency



Challenging pile up conditions for the physics analysis

SM Physics

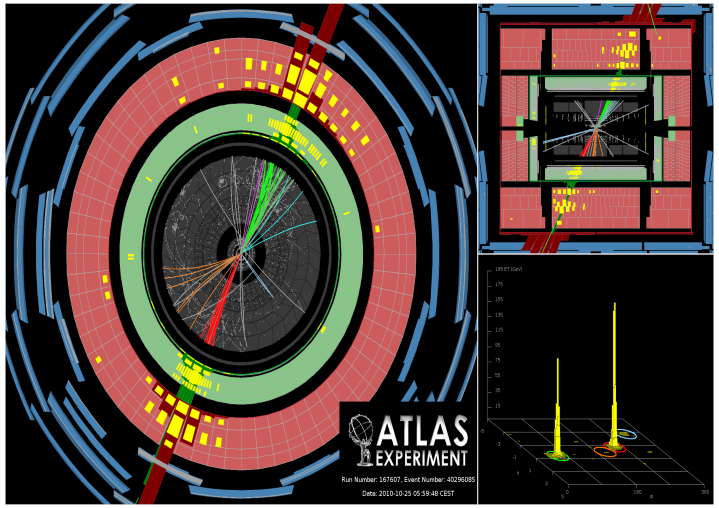
Selected results on

jets, photons, W/Z+jets,Top quark, Dibosons….

Just to illustrate the Glory of the SM
(processes relevant for searches later on…)

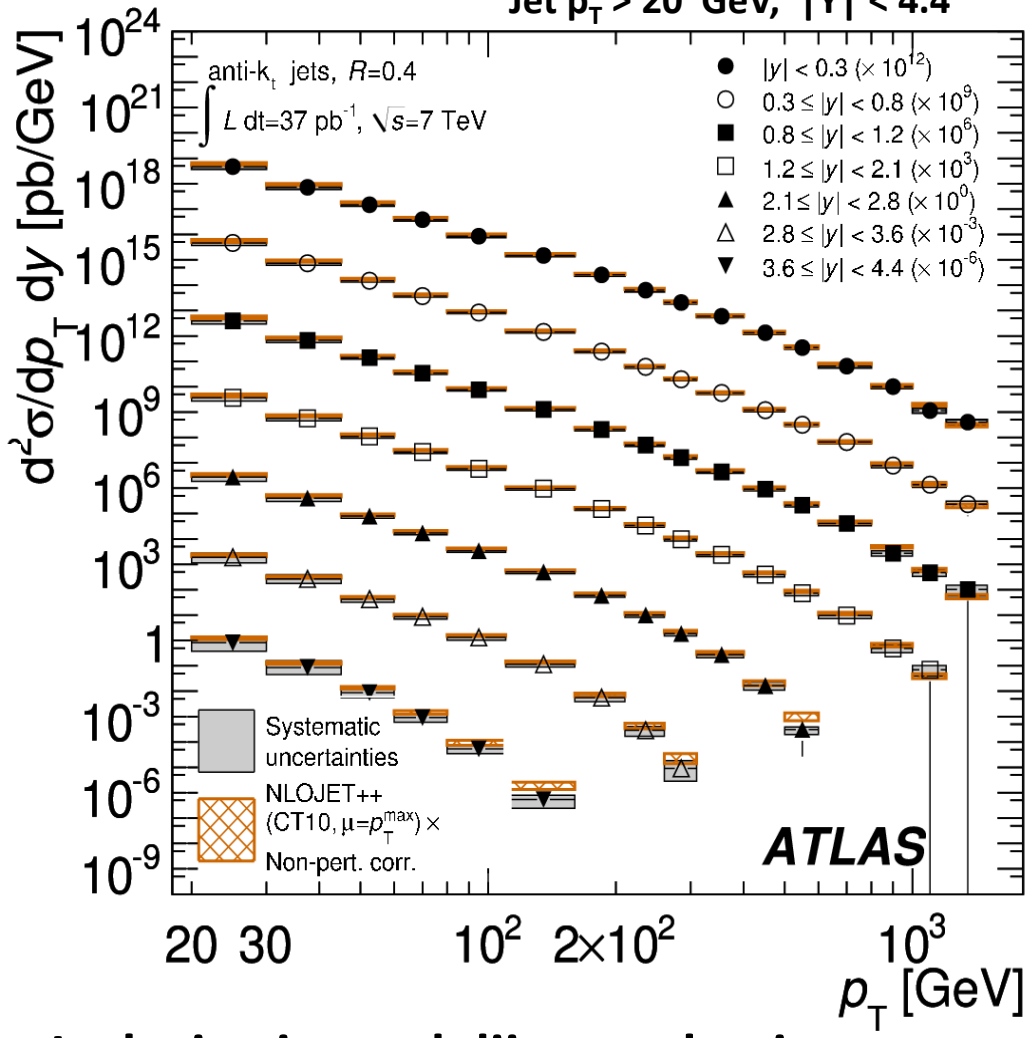
Jet Production

PRD86(2012)014022



anti-K_T jets with R=0.4, 0.6

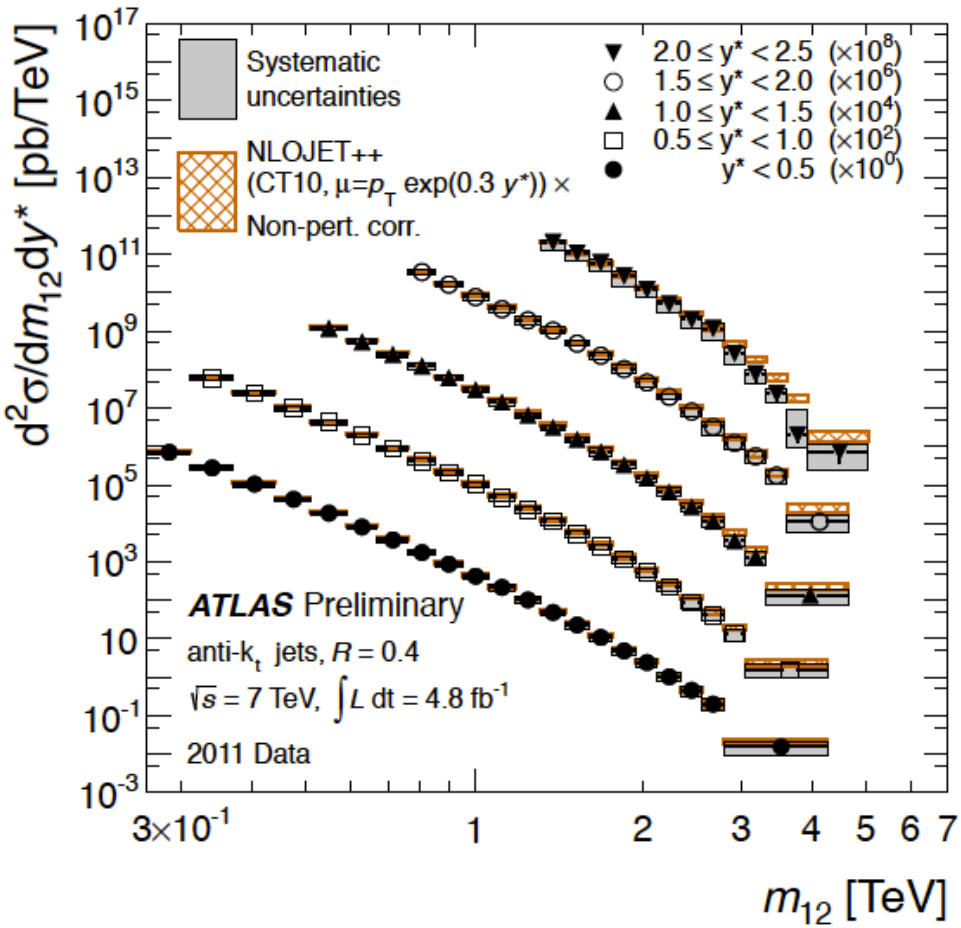
Jet p_T > 20 GeV, |Y| < 4.4



ATLAS-CONF-2012-021

$M_{jj} > 260 GeV$

$y^* = |y^1 - y^2|/2 < 2.5$



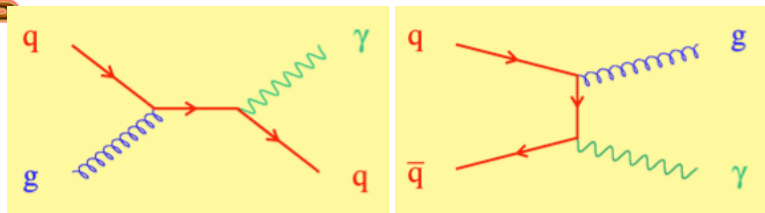
Inclusive jet and dijet production measured in a wide range of jet p_T , rapidity and dijet mass.

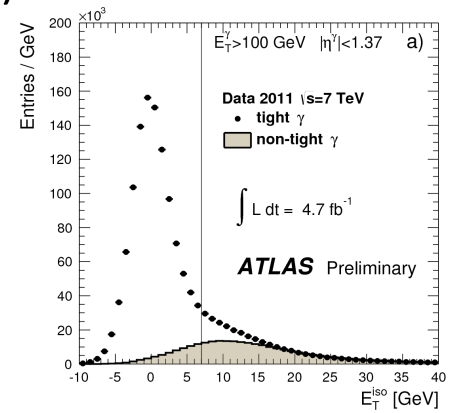
Well described by NLO pQCD predictions

Inclusive photons

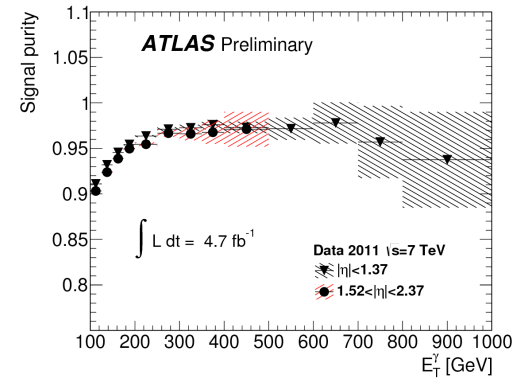
(cross section for isolated photons)

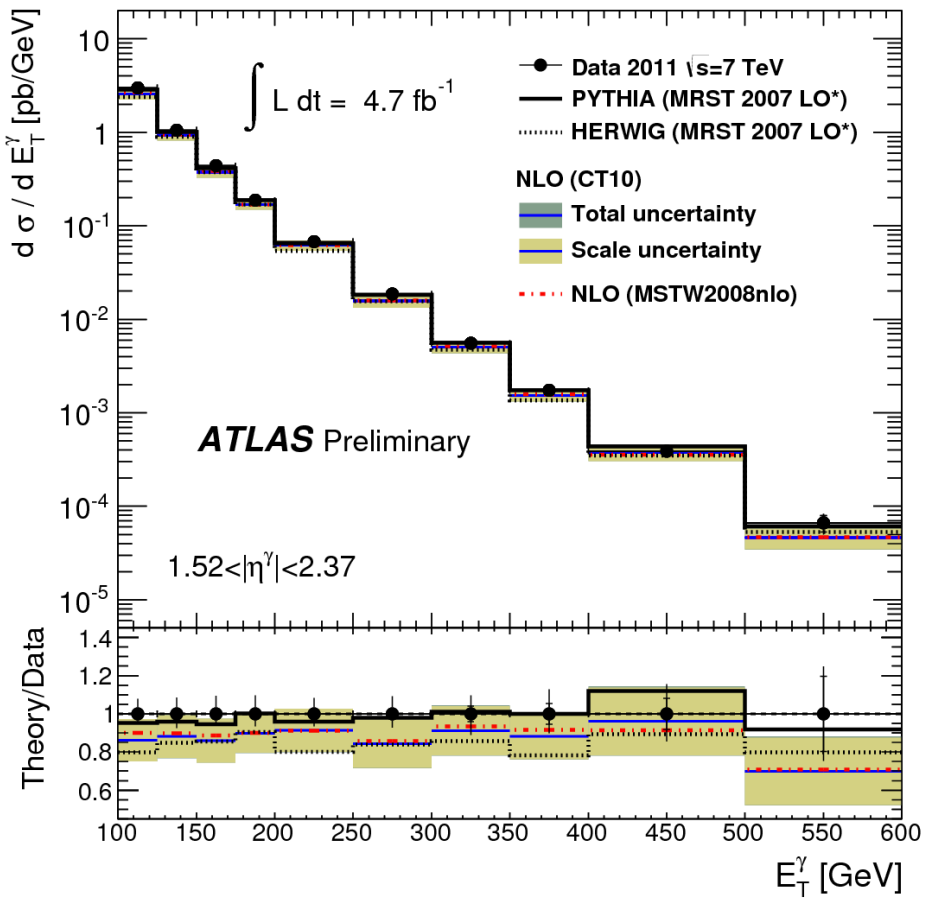
Phys. Lett. B706 (2011) 150-167
Phys. Rev. D83 (2011) 052005
ATLAS-CONF-2013-022

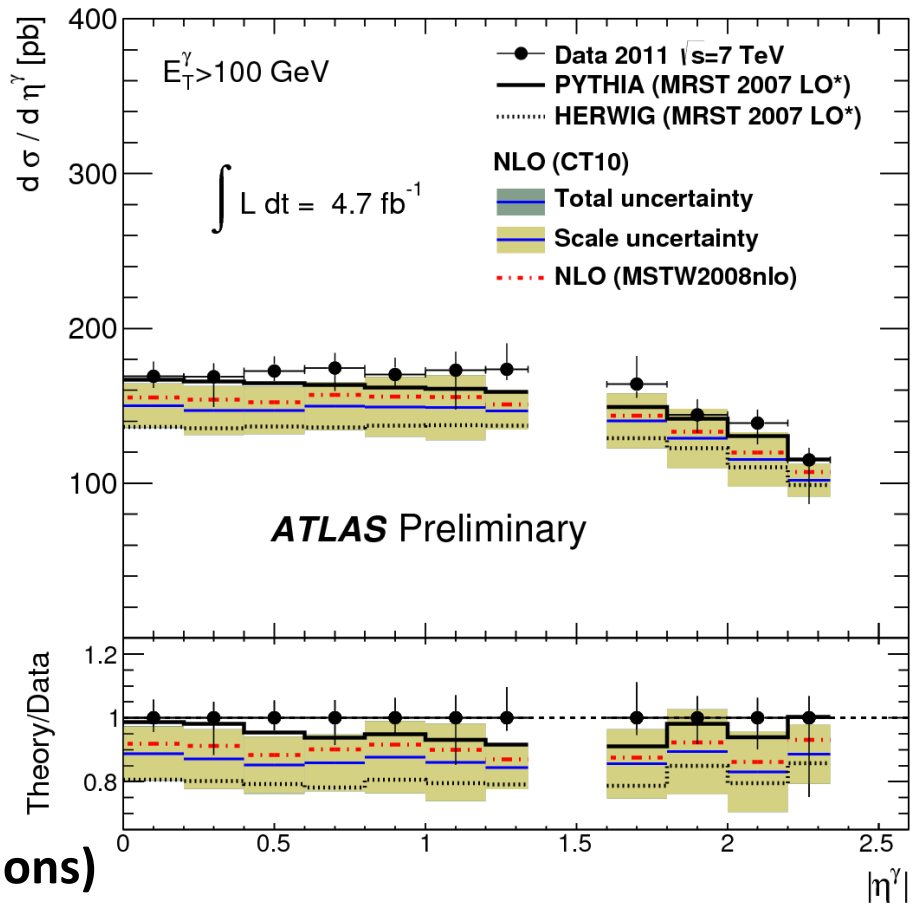




Isolation distribution used to extract the background contributions

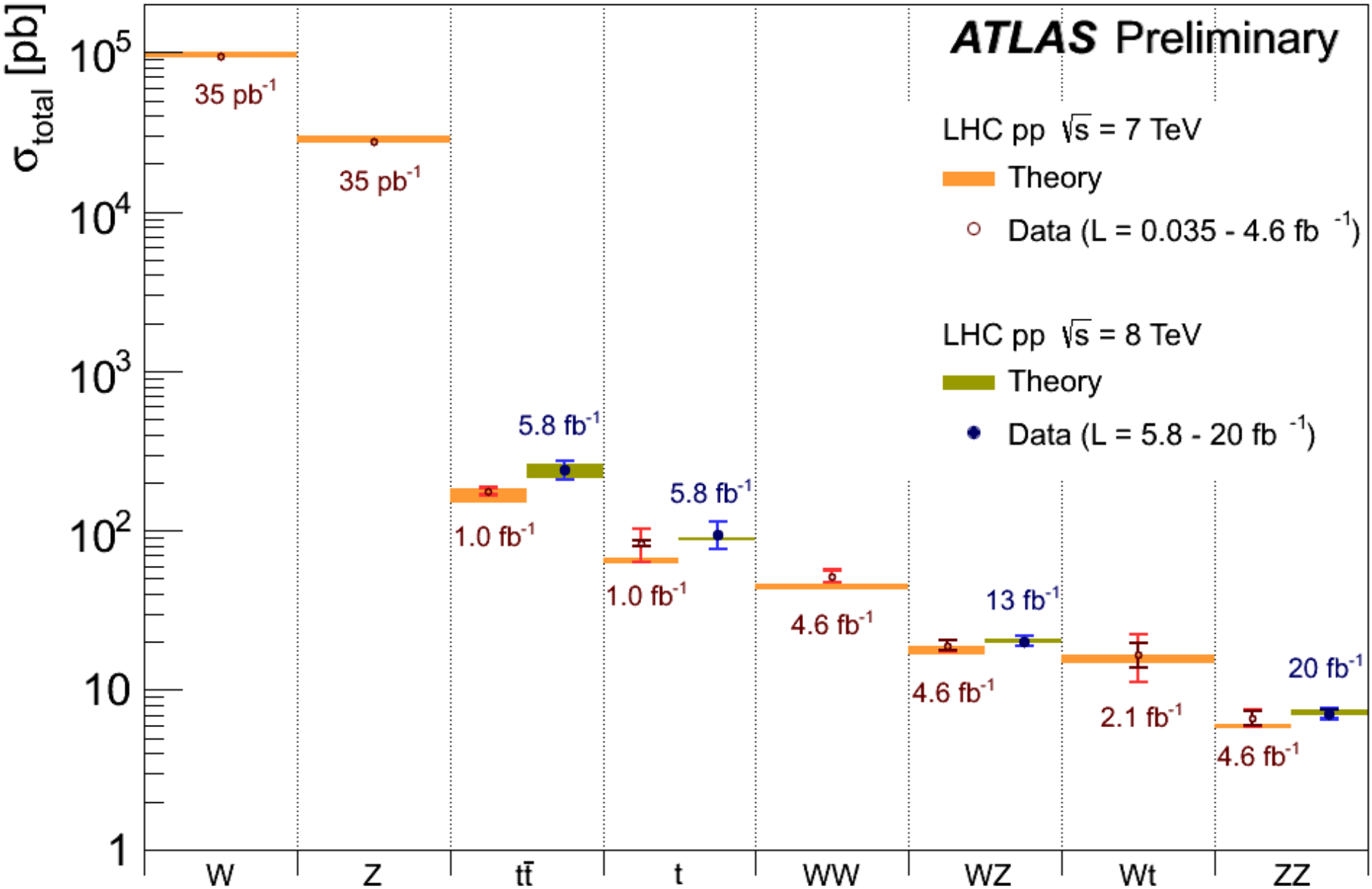






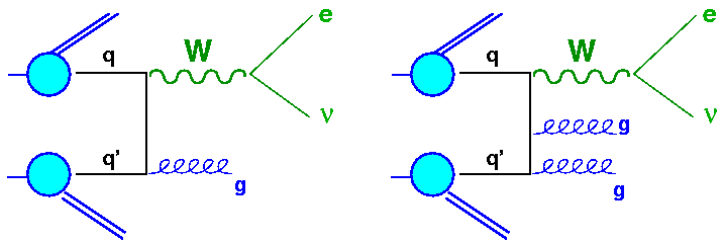
Good agreement with NLO pQCD predictions (at very low E_T^γ predictions are affected by the limited knowledge of the fragmentation contributions)

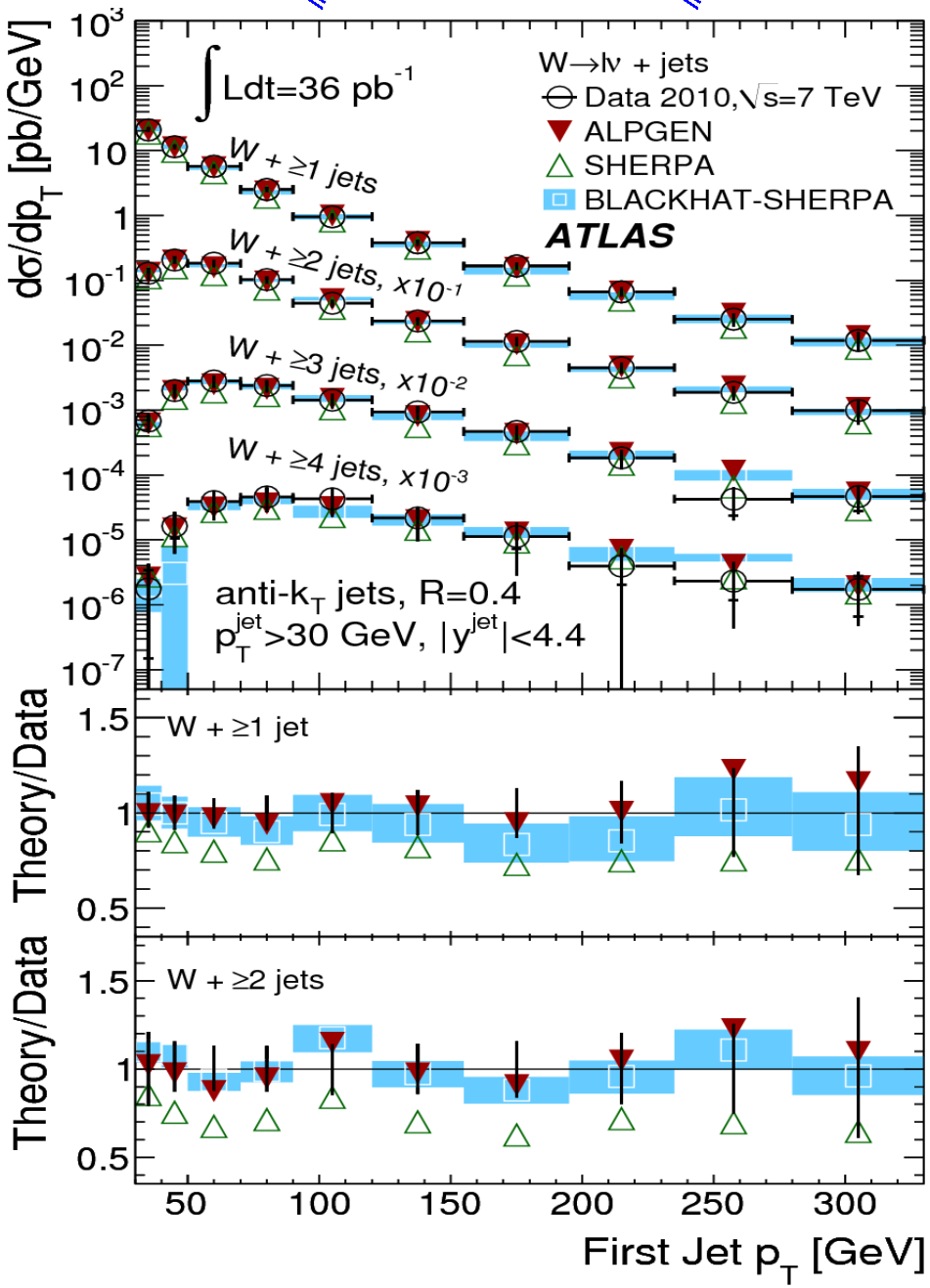
Summary EWK/Top Physics

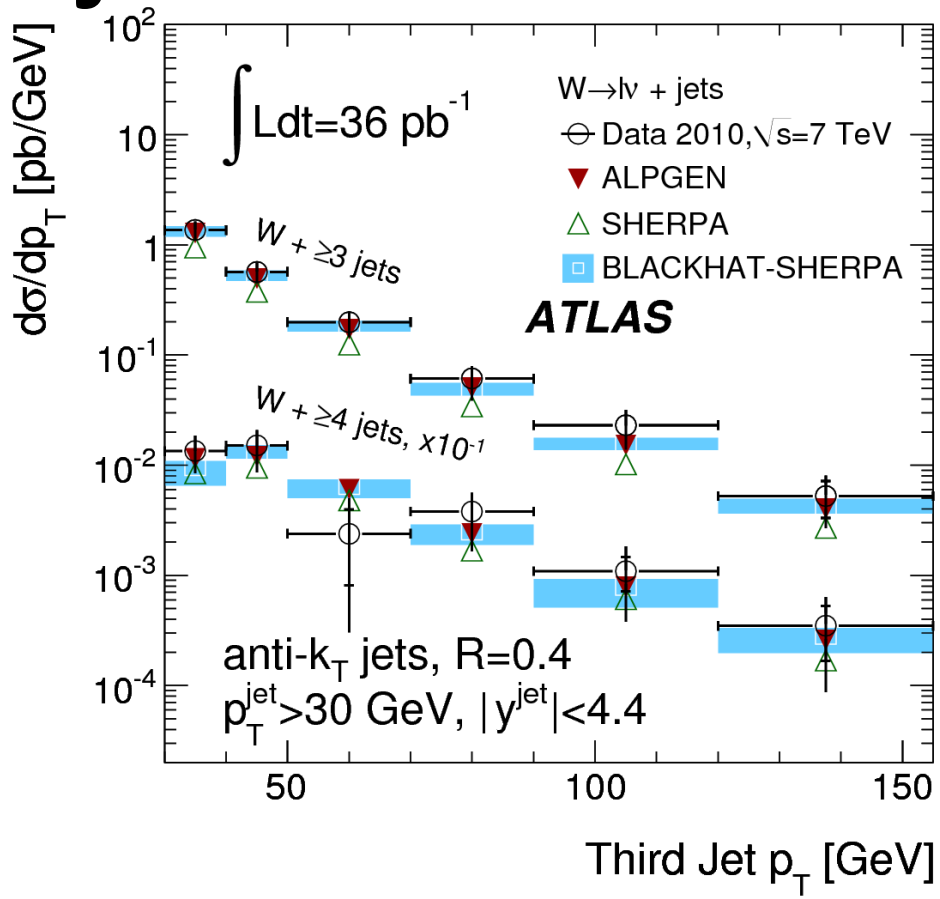


W+jets

Phys. Rev. D85 (2012) 092002







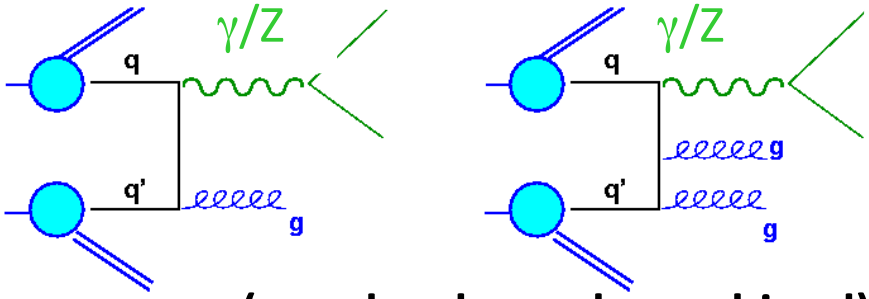
Very good description of the different Jet p_T distributions by NLO pQCD and LO ME + PS (ALPGEN)

Non trivial test of the ME - PS implementation & matching procedures built inside the MCs

→ Input to future MC tunes

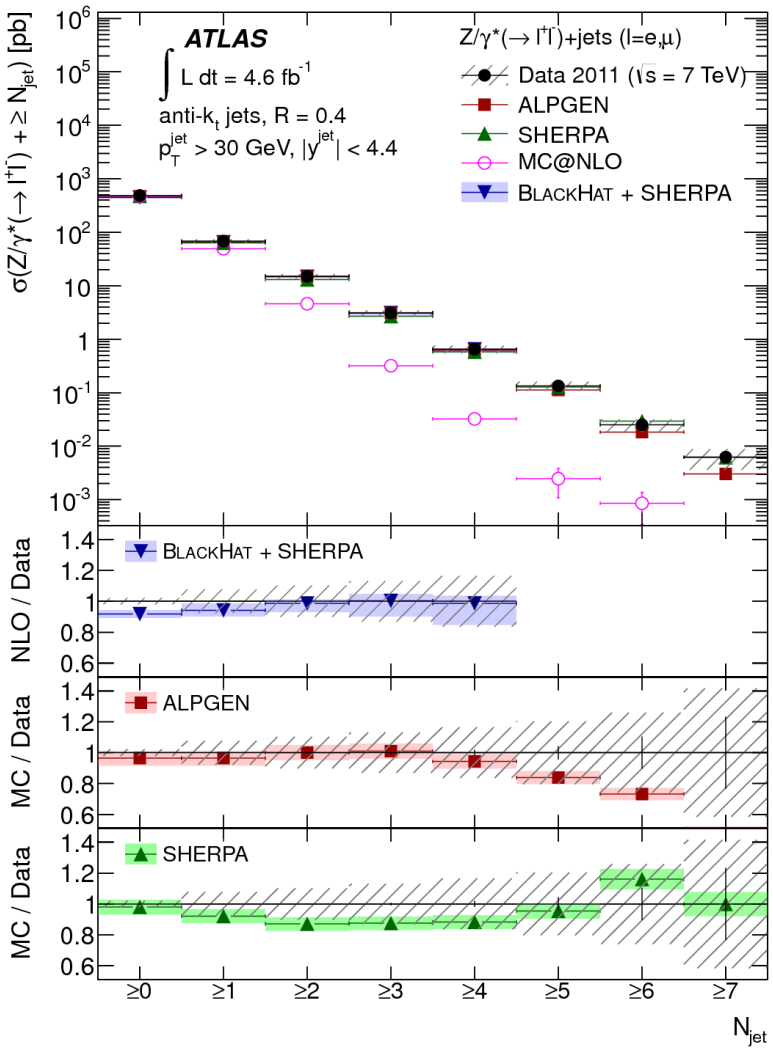
Z+jets

JHEP07(2013)032



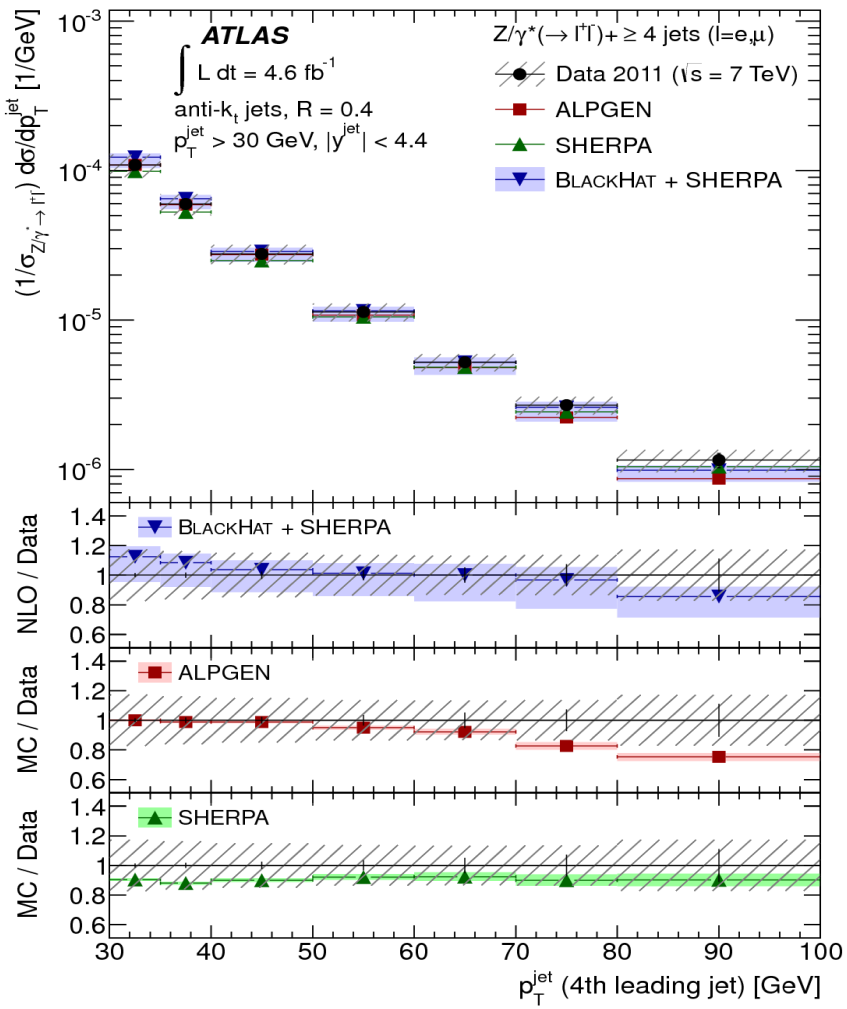
Z (→ νν)+jets irreducible background
In searches for SUSY, LED, etc….

(e and μ channels combined)



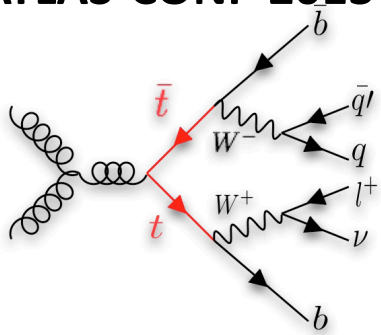
Data well described by NLO pQCD and ME + PS (ALPGEN/SHERPA) predictions

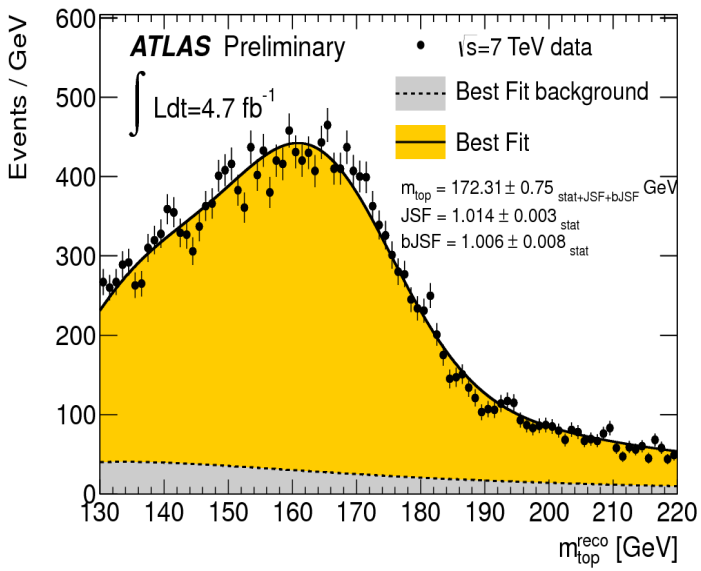
Z (→ ll)+jets fundamental SM measurement…
→ Very clean samples with no missing E_T

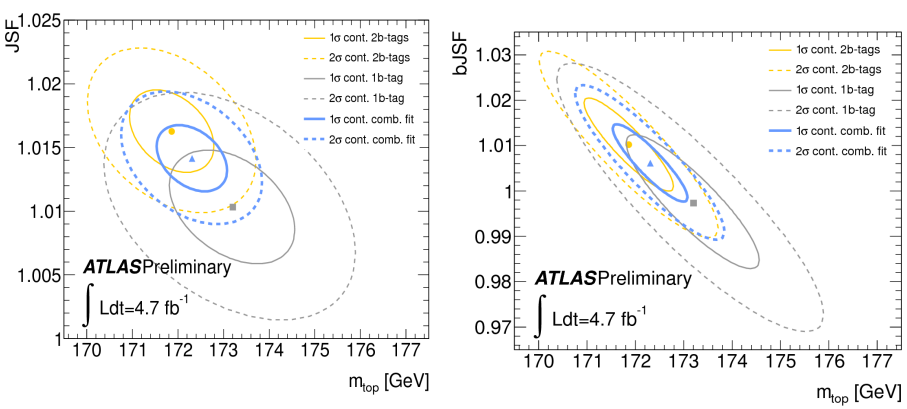


Top Mass

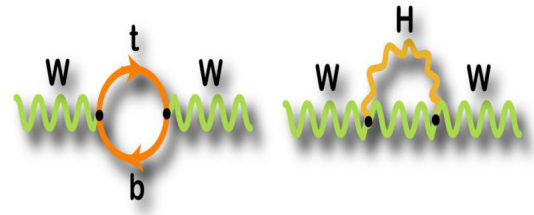
ATLAS-CONF-2013-046



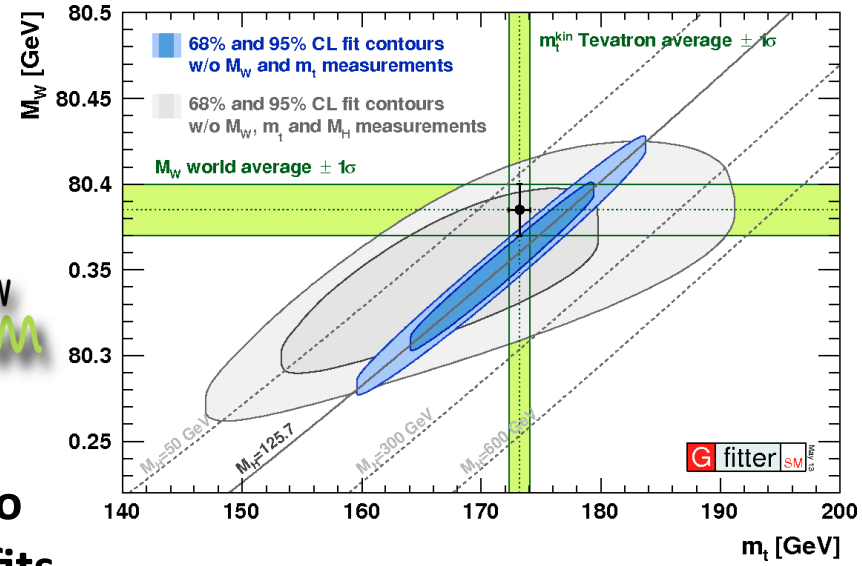




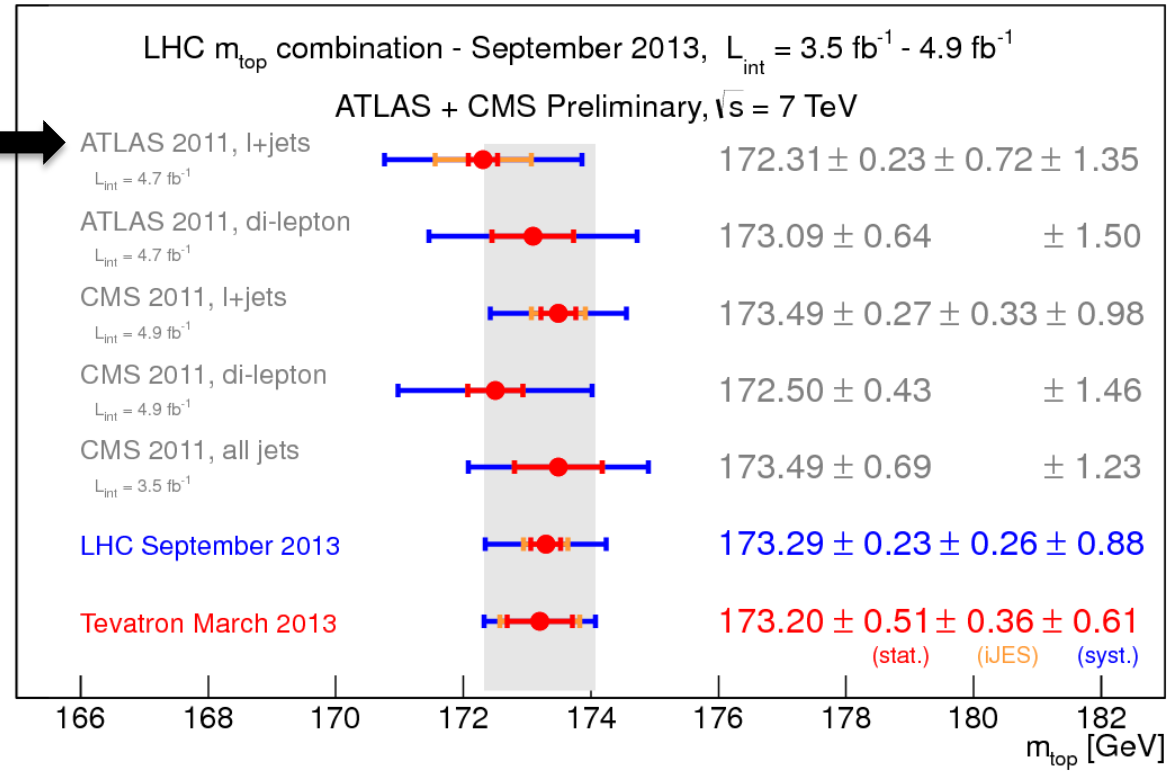
Simultaneous fit to top mass and JES



Fundamental input to global electroweak fits



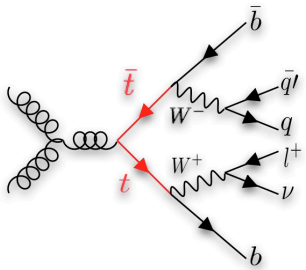
ATLAS-CONF-2013-102



LHC precision approaching Tevatron's

Asymmetries in Top

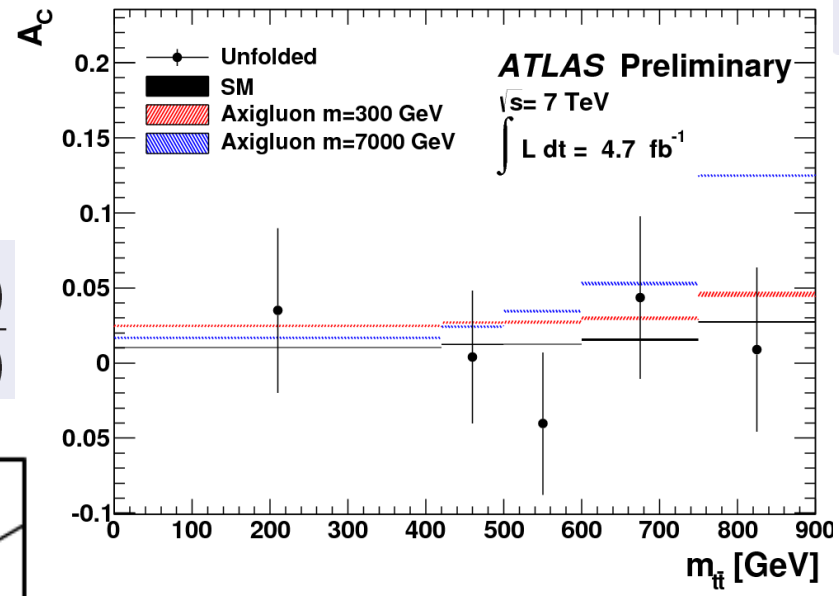
ATLAS-CONF-2013-078

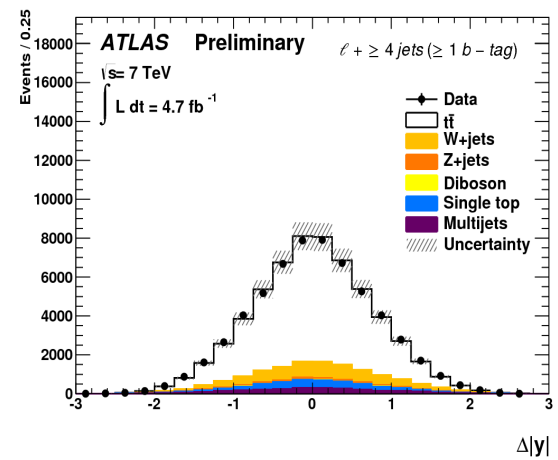


Measurement of the top quark charge asymmetry:

$$A_C = \frac{N(\Delta|Y| > 0) - N(\Delta|Y| < 0)}{N(\Delta|Y| > 0) + N(\Delta|Y| < 0)}$$

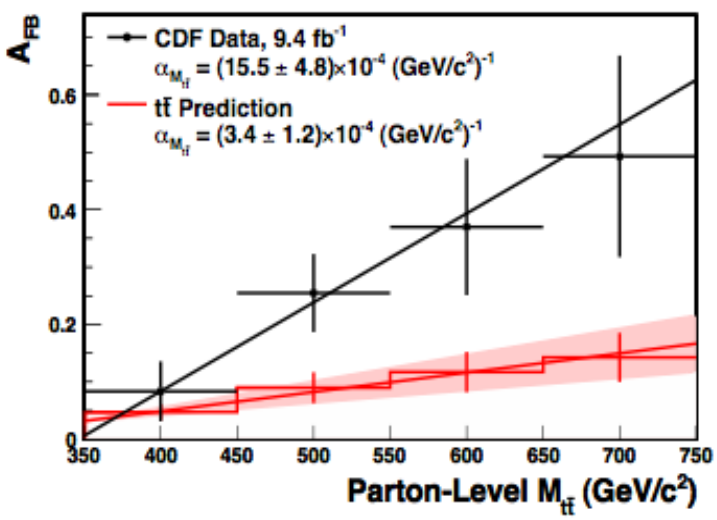
where $\Delta|Y| = |Y_t| - |Y_{\bar{t}}|$

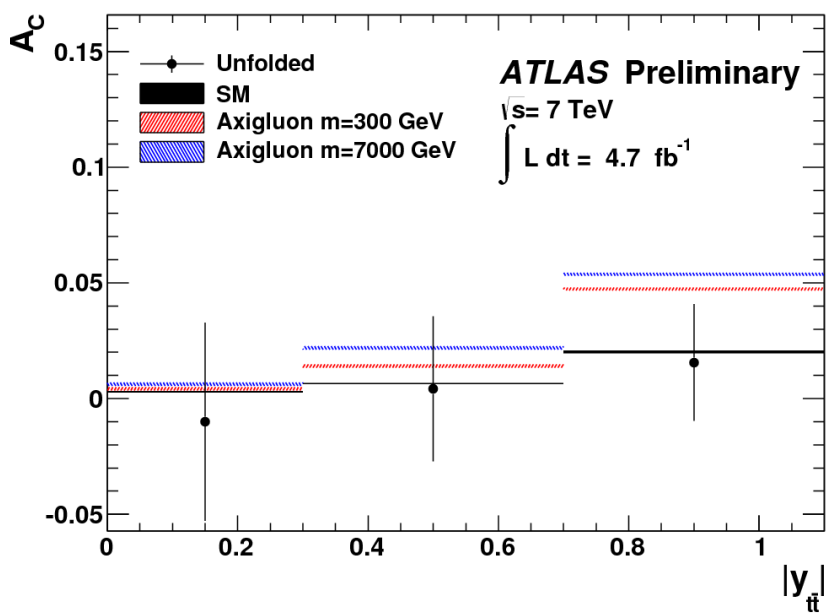




Tevatron experiments measure a larger A_{FB} than predicted

$$A_{t\bar{t}} = \frac{N(y_t^{t\bar{t}} > 0) - N(y_t^{t\bar{t}} < 0)}{N(y_t^{t\bar{t}} > 0) + N(y_t^{t\bar{t}} < 0)}$$





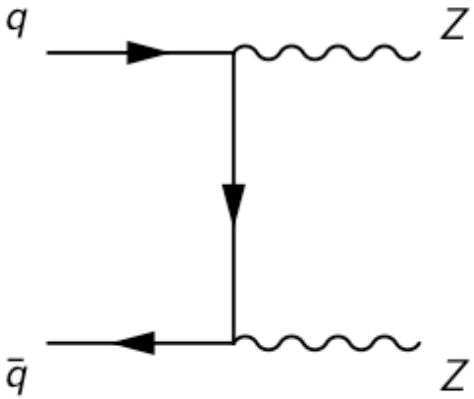
Good agreement with SM predictions

DATA

$$A_c^{t\bar{t}} = 0.006 \pm 0.010(stat + syst)$$
$$A_c^{t\bar{t}} = 0.0123 \pm 0.0005$$

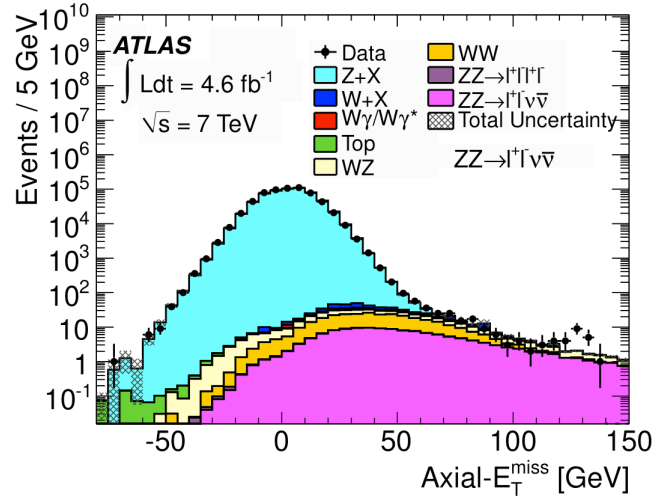
SM

At CDF somehow the top preferred the proton direction at high masses



ZZ
(ZZ → ll νν)

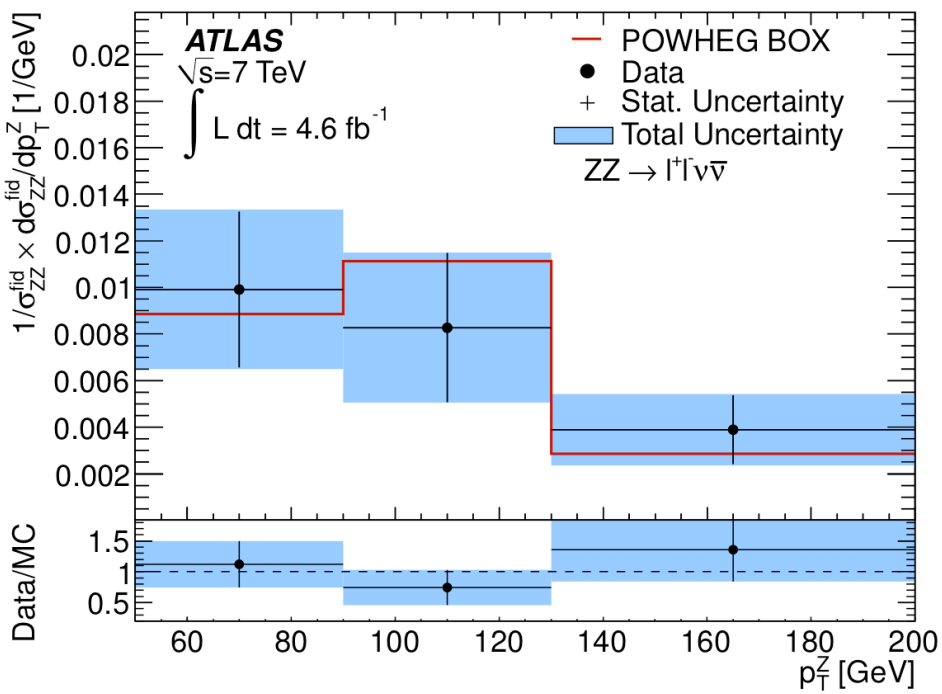
arXiv:1211.6096

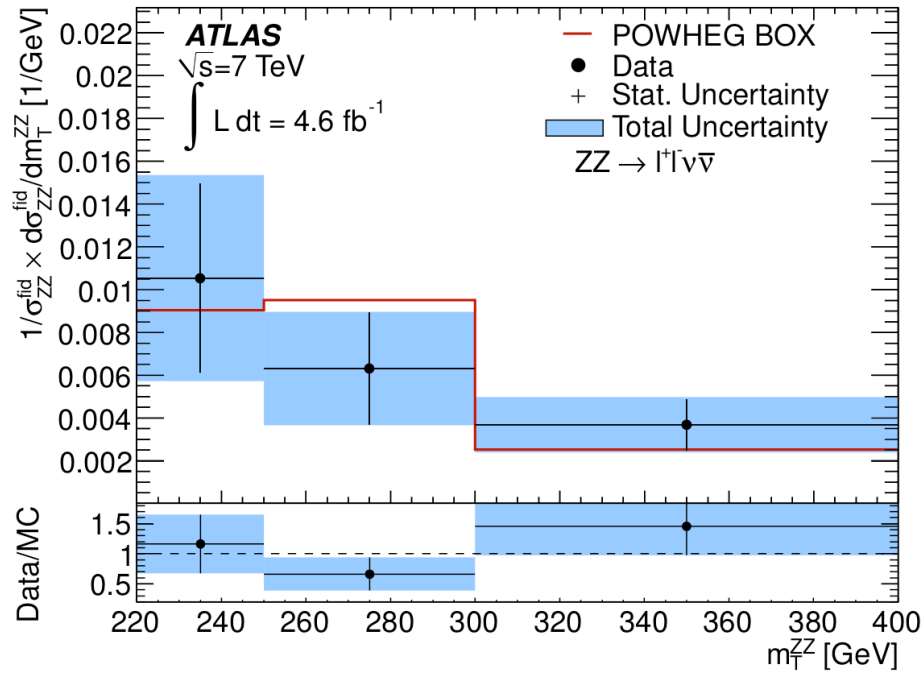


No jets with p_T above 25 GeV

$$(|p_T^{\nu\bar{\nu}} - p_T^Z|)/p_T^Z < 0.6$$

$$-p_T^{\nu\bar{\nu}} \times \cos(\Delta\phi(p_T^{\nu\bar{\nu}}, p_T^Z)) > 80 \text{ GeV}$$





$$\sigma^{\text{fid}}_{ZZ\to\ell^+\ell^-\nu\bar{\nu}} = 12.7^{+3.1}_{-2.9}\ (\text{stat.})\ ^{+1.7}_{-1.7}\ (\text{syst.}) \pm 0.5\ (\text{lumi.})\ \text{fb}.$$

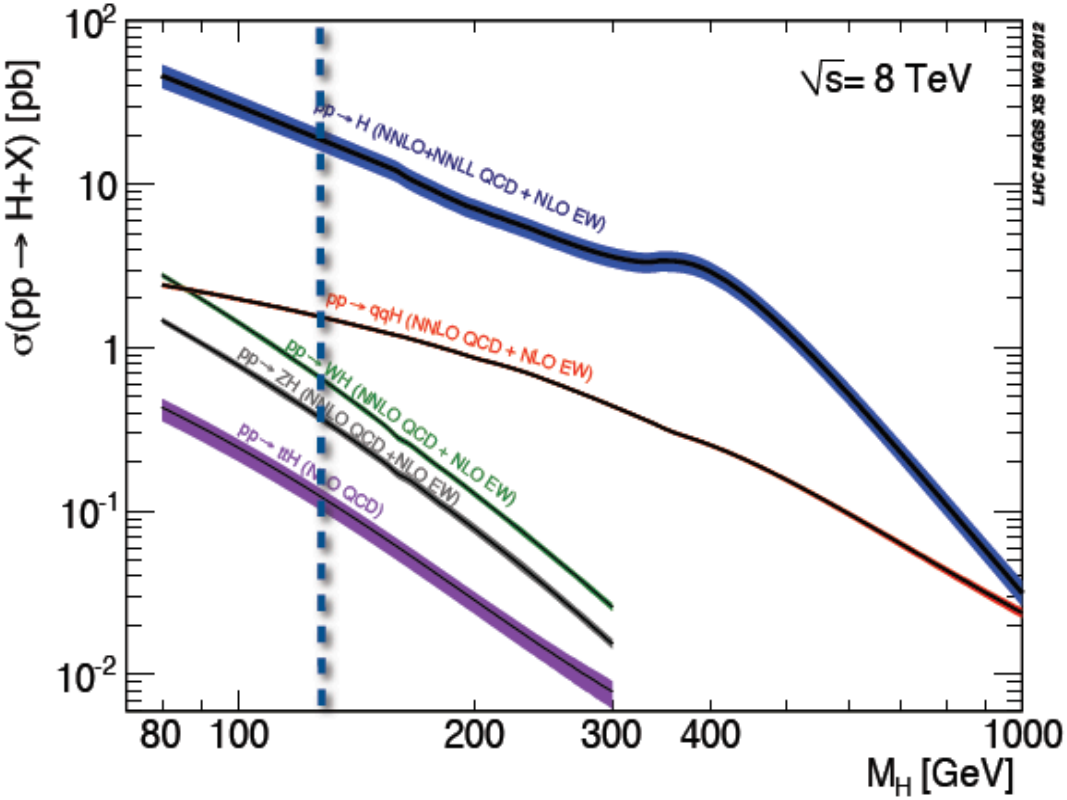
In good agreement with SM predictions

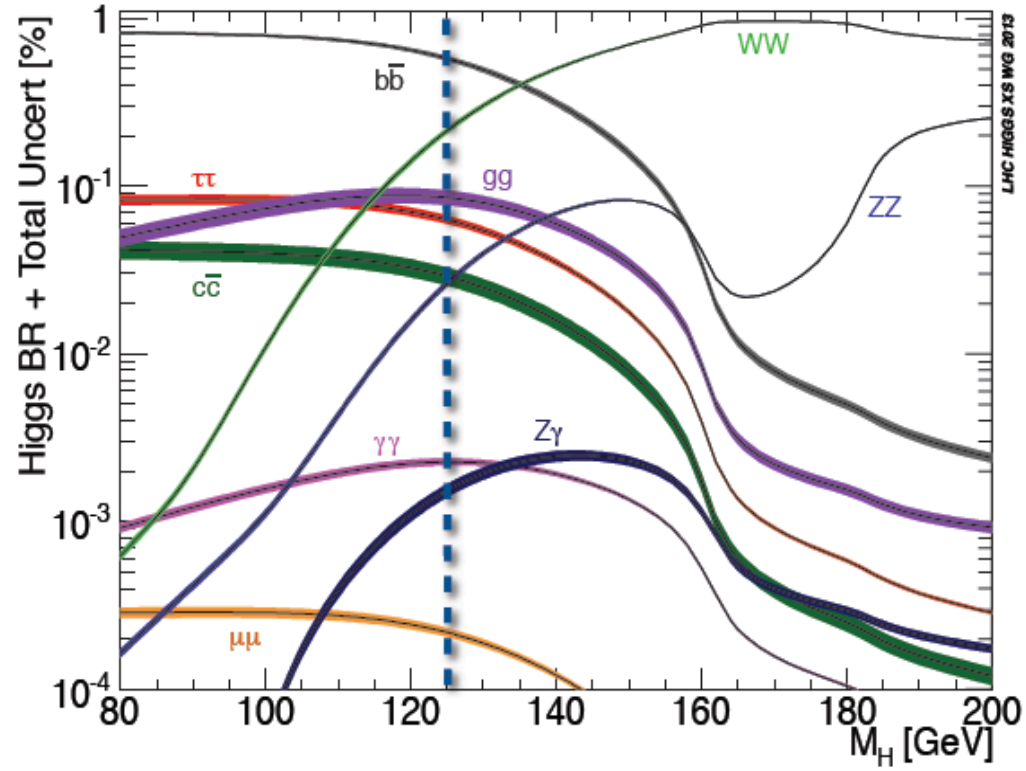
Higgs Physics

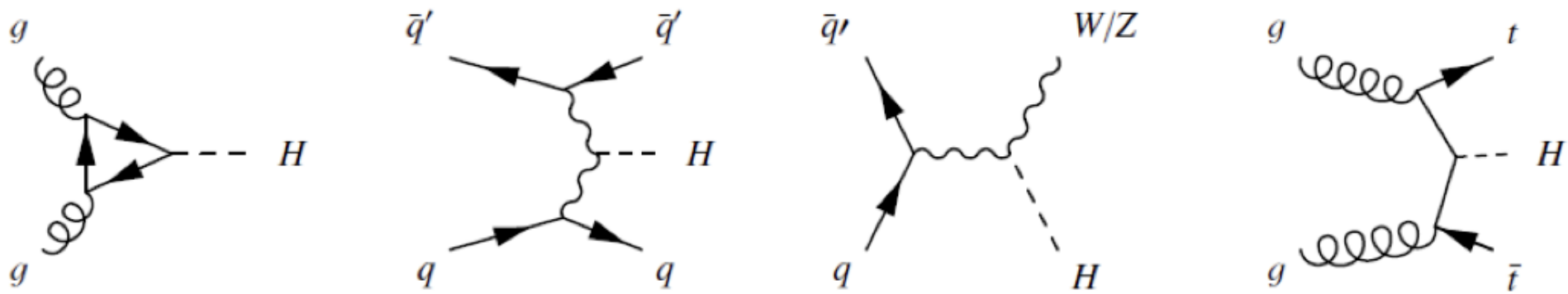
Discovery, Properties

Rather brief and fast review….

Higgs Production/Decay

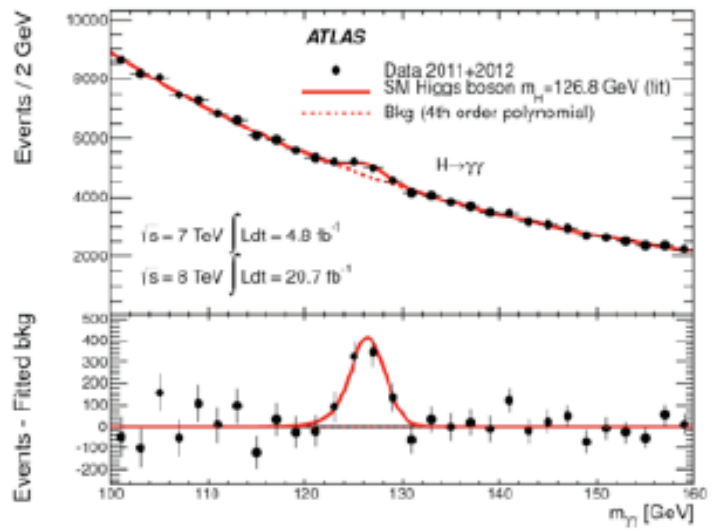


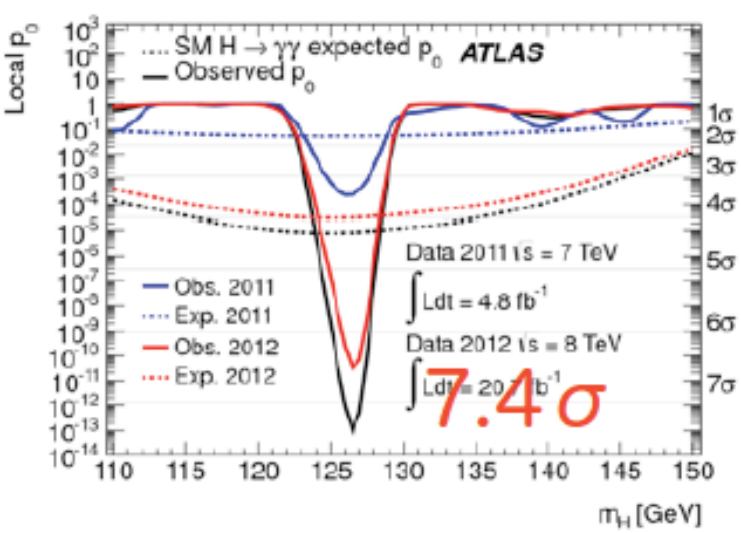




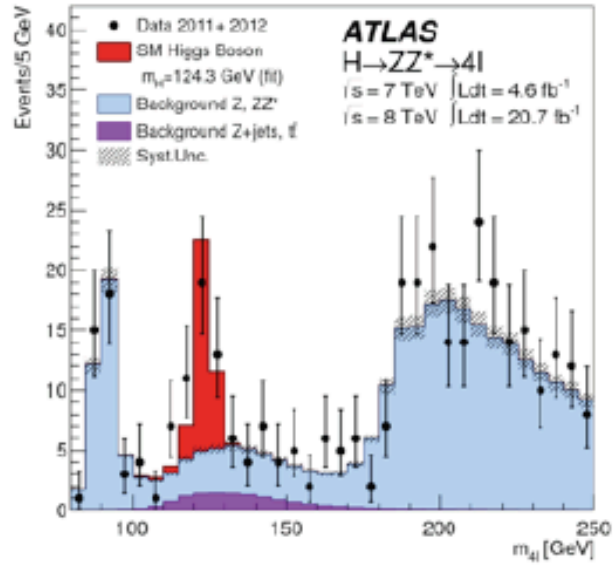
Discovery Channels

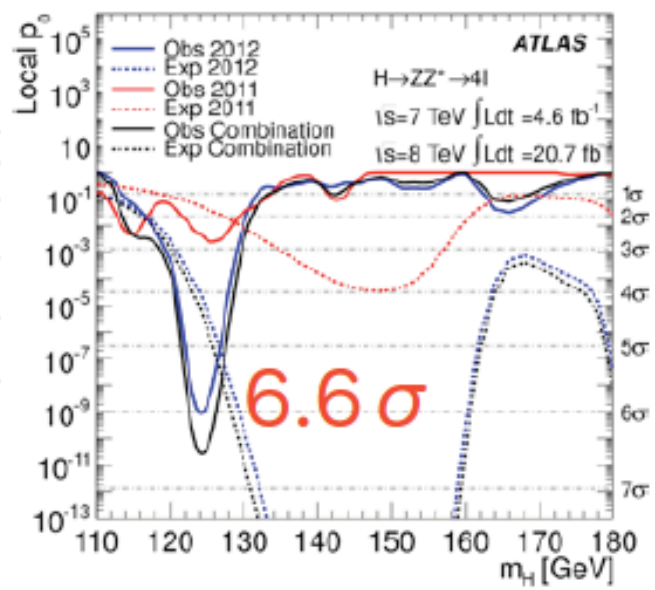
$H \to \gamma\gamma$



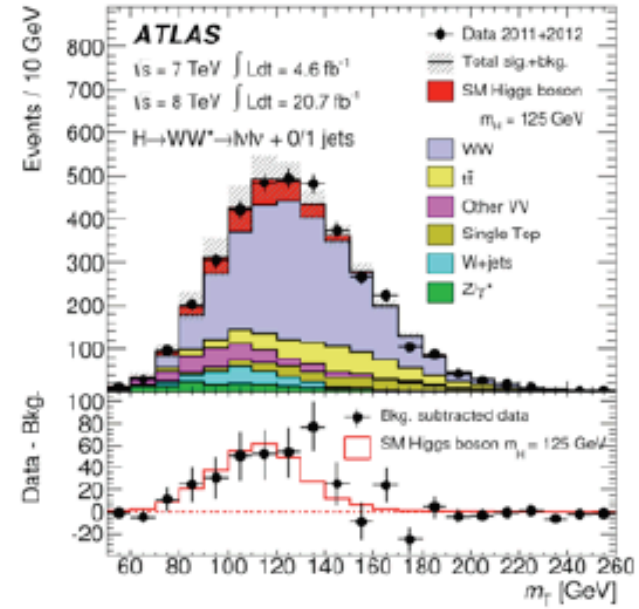


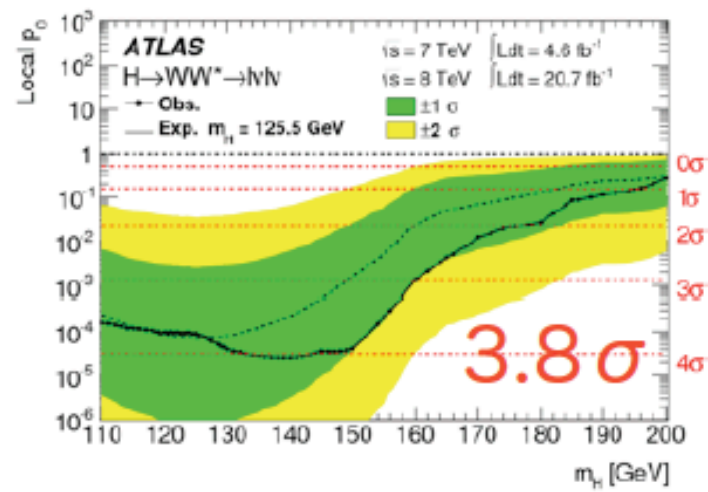
$H \to ZZ$



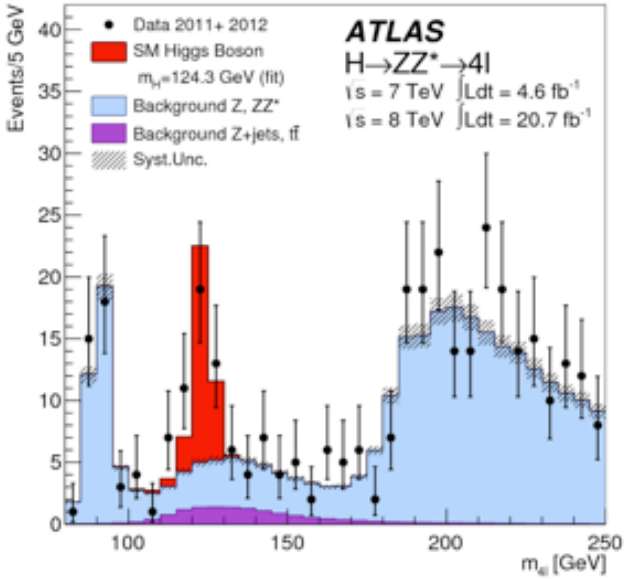


$H \to WW$

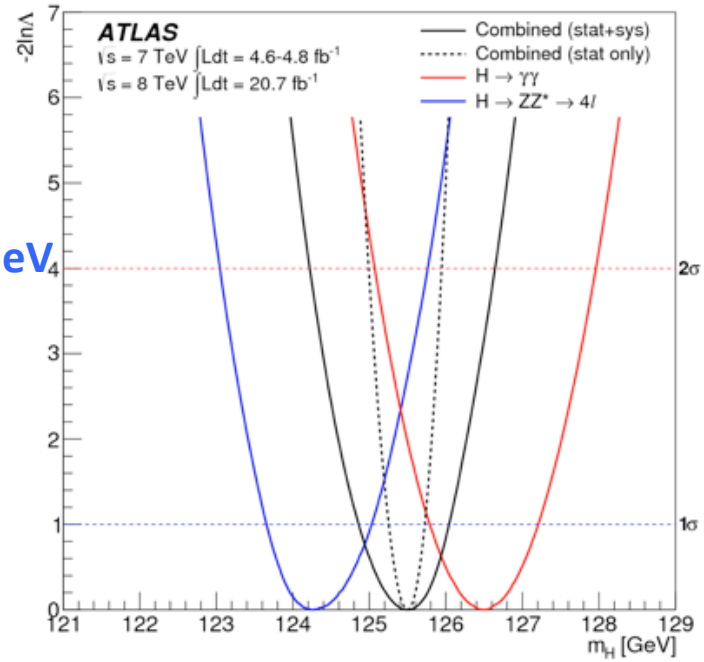


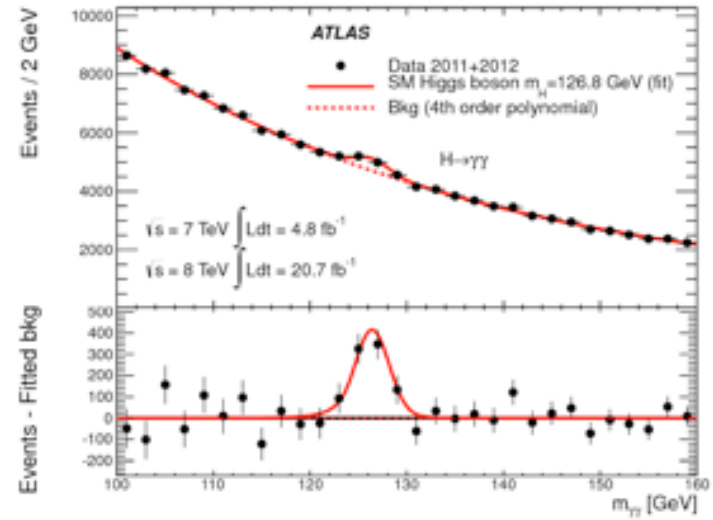


Higgs Mass

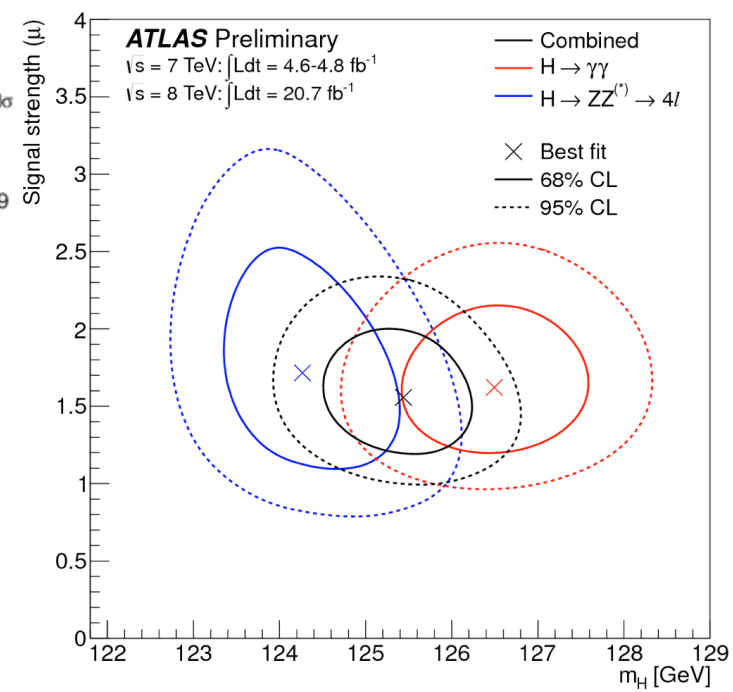


$m_H = 124.3^{+0.6}_{-0.5}(stat)^{+0.5}_{-0.3}(syst)$ GeV





$m_H = 126.8 \pm 0.2(stat) \pm 0.7(syst)$ GeV

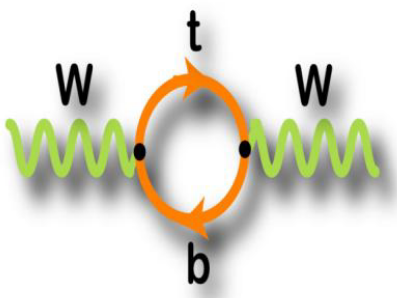


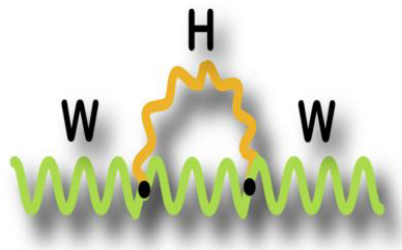
$$m_H = 125.5 \pm 0.2(stat)^{+0.5}_{-0.6}(syst) \text{ GeV}$$

Mass difference about 2.4σ (1.5% prob.)

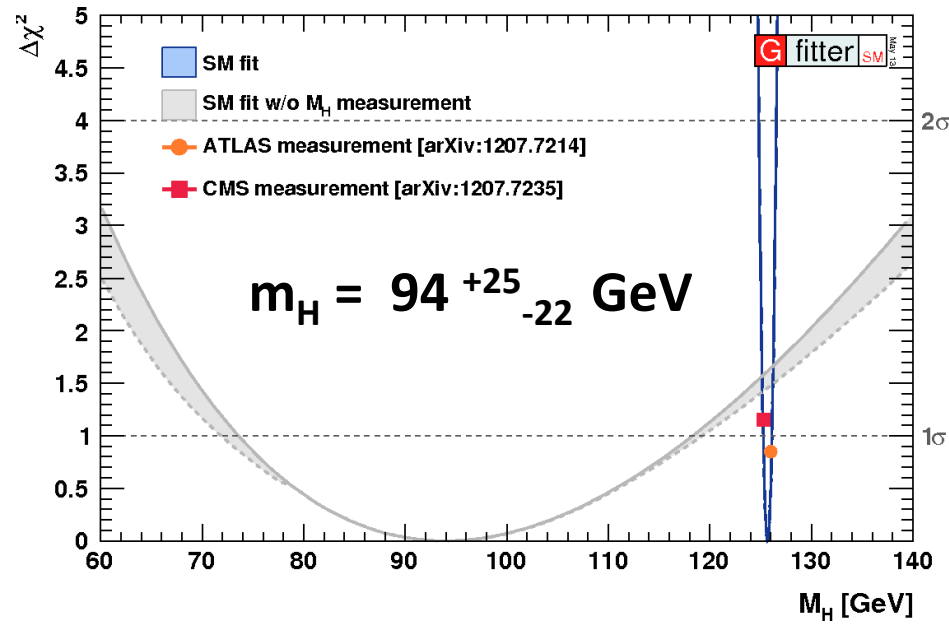
EWK fits vs Higgs

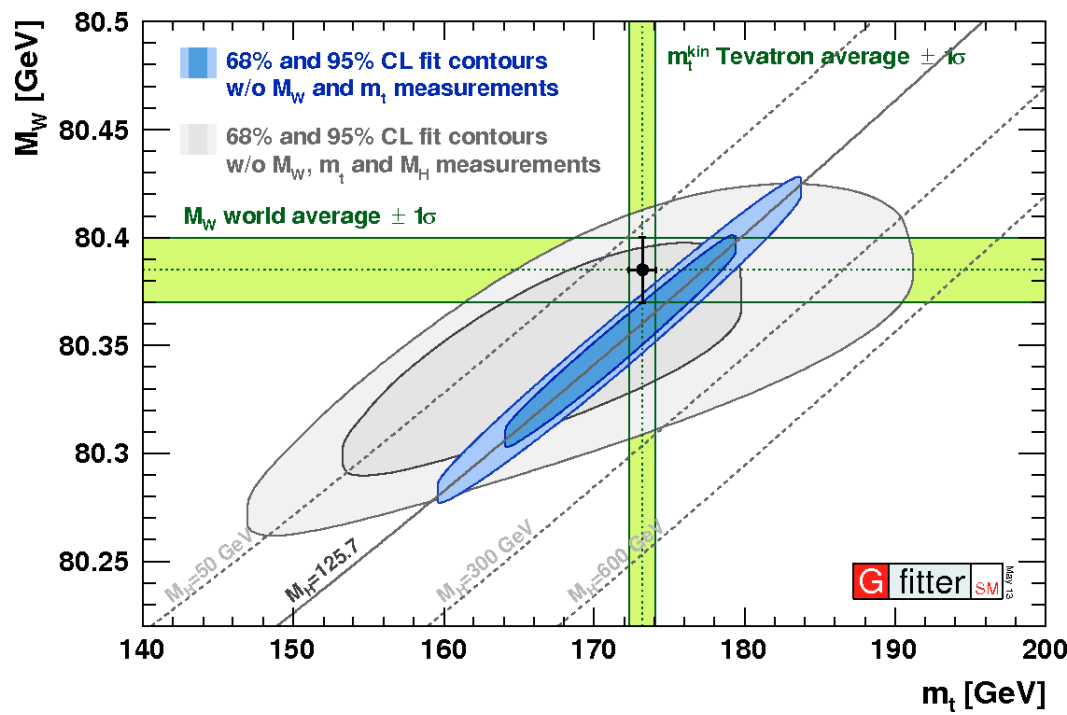
$$m_W^2\left(1-\frac{m_W^2}{m_Z^2}\right)=\frac{\pi\alpha}{\sqrt{2}G_F}(1+\Delta r)$$





$\Delta r \sim m_{top}^2$ $\Delta r \sim \ln(m_H)$

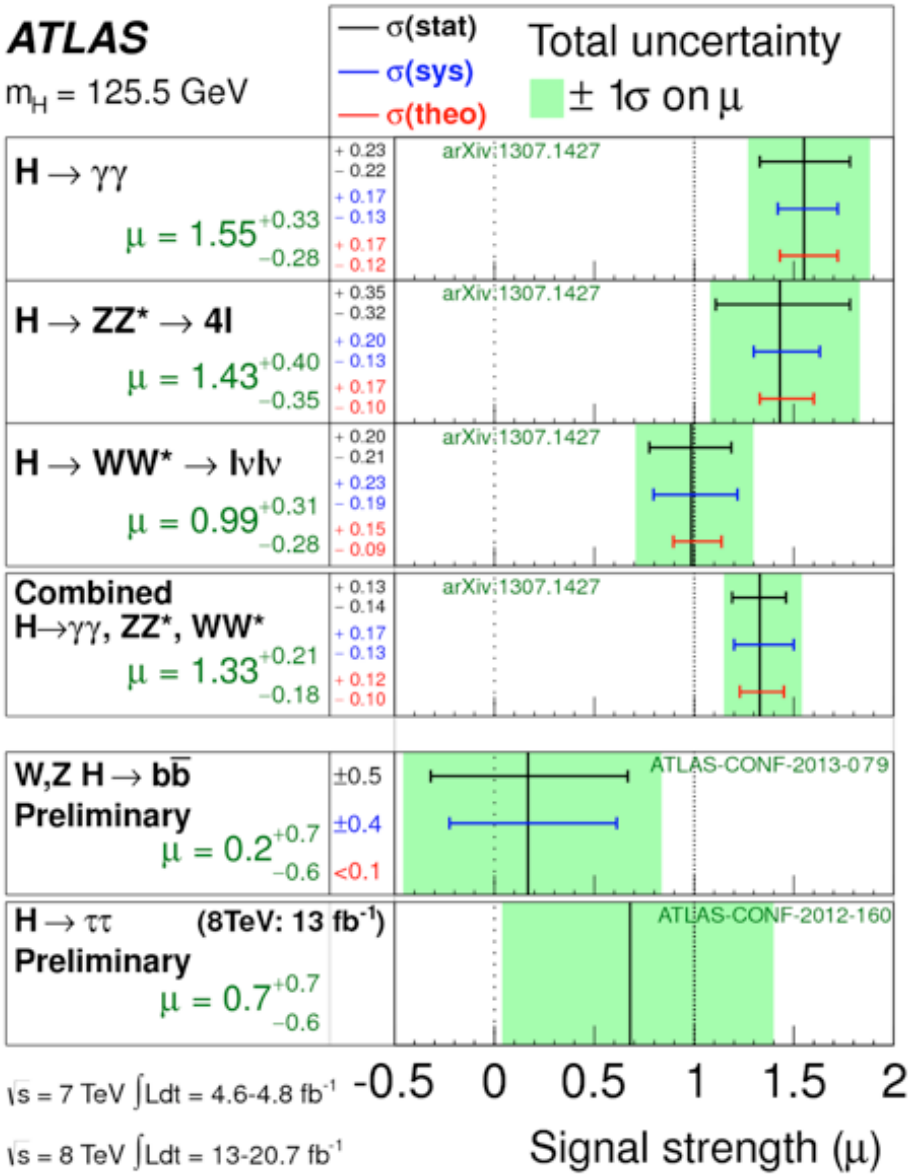




Very remarkable agreement (within 1.3 σ) between direct m_H measurement and the indirect determination via EWK fits

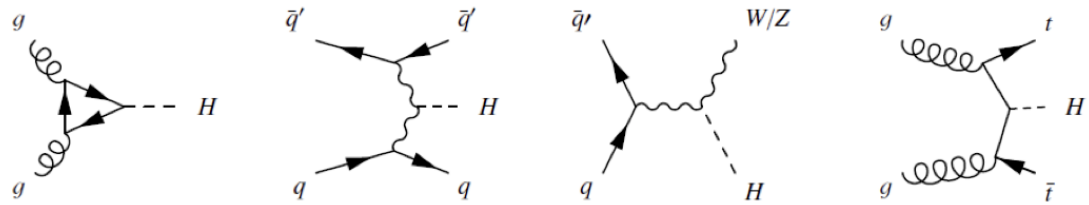
$\mu = (\sigma \times Br)/(\sigma \times Br)_{SM}$

Signal Strength



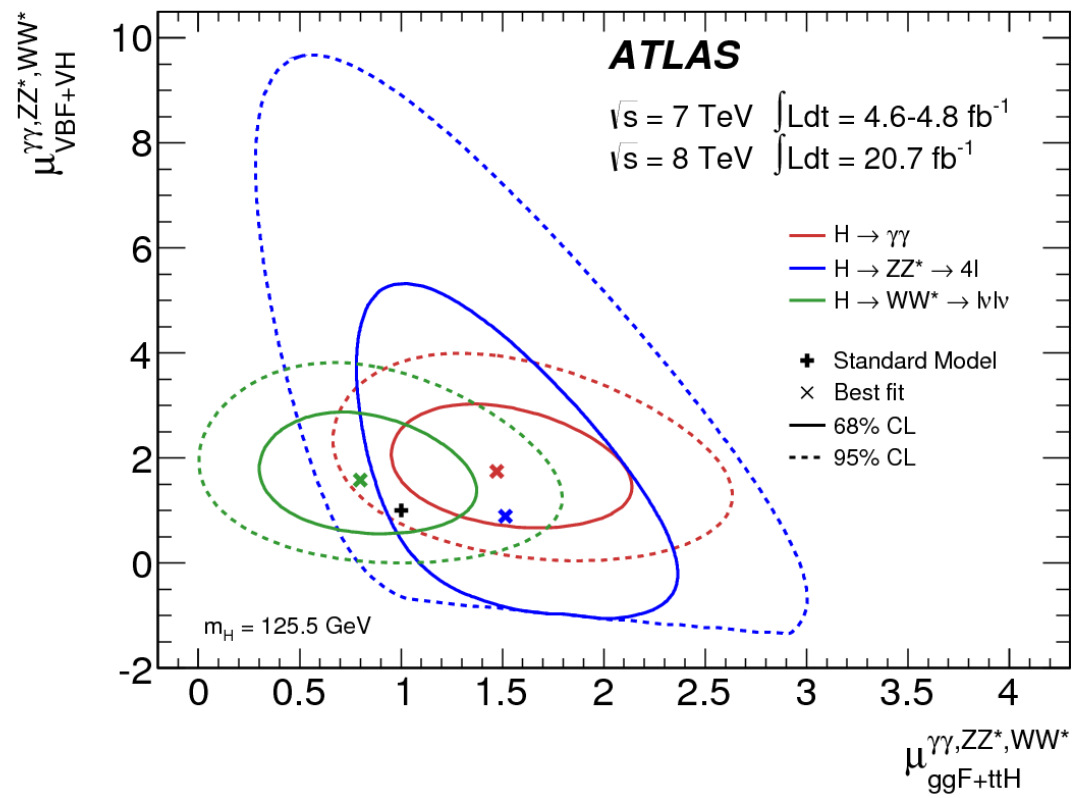
$\mu = 1.33 \pm 0.14(stat) \pm 0.15(syst)$

(compatible with SM with 7% prob.)



$\mu_{VBF}/\mu_{ggF+ttH} = 1.4^{+0.4}_{-0.3}(stat)^{+0.6}_{-0.4}(syst)$

(3.3σ evidence for VBF production)

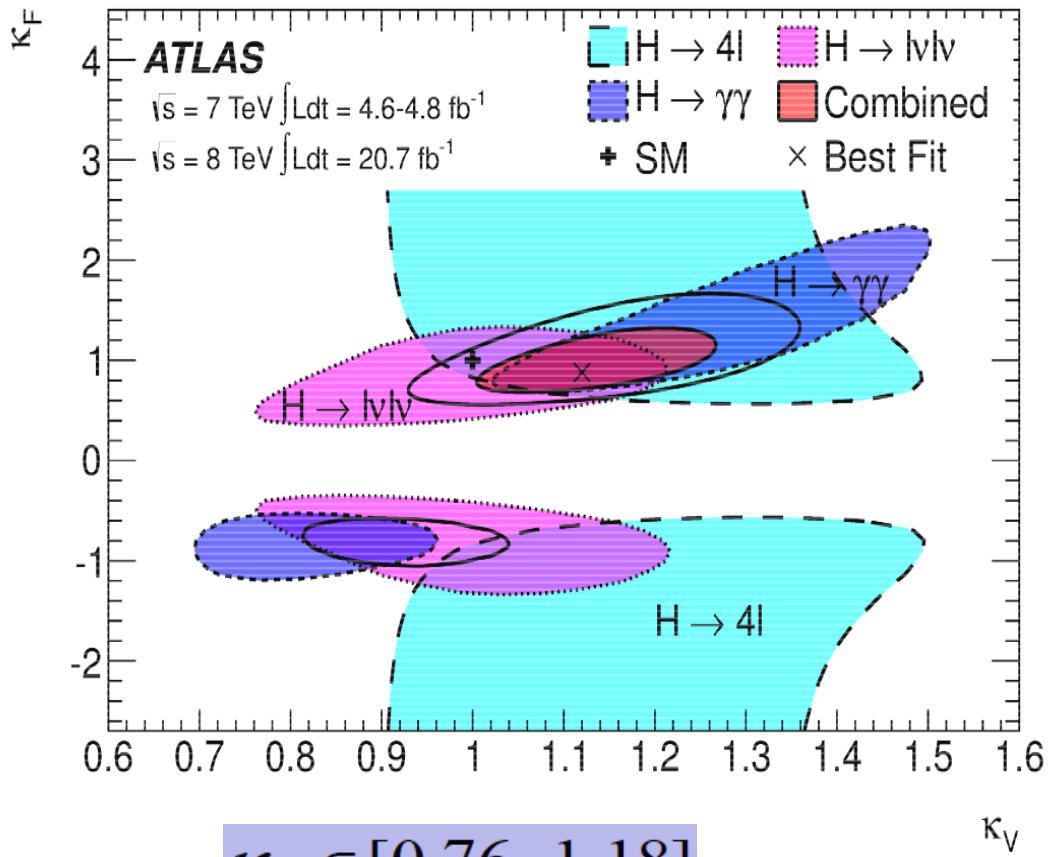


Higgs Couplings

κ_F, κ_V : scale factors fermion/boson couplings

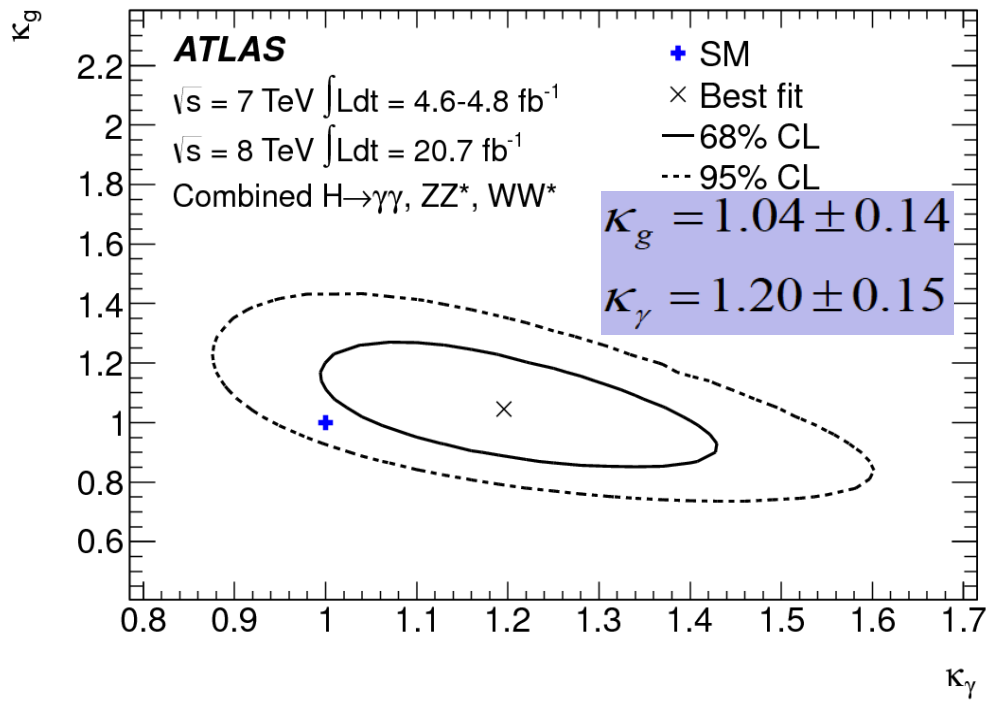
κ_g, κ_γ : scale factors gg→H and H→ γγ loops

$\lambda_{WZ} : \kappa_W/\kappa_Z$

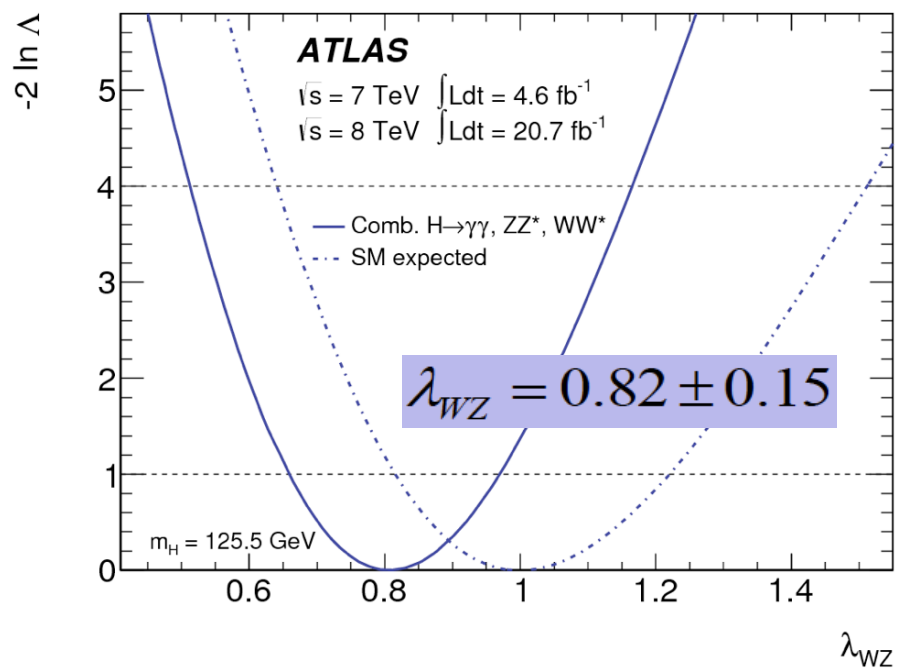


$$\kappa_F \in [0.76,\ 1.18]$$
$$\kappa_V \in [1.05,\ 1.22]$$

@ 68% CL



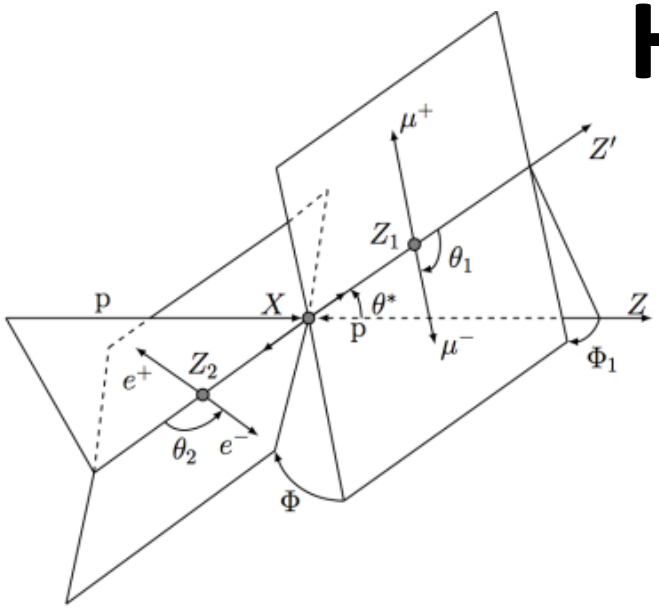
$$\kappa_g = 1.04 \pm 0.14$$
$$\kappa_\gamma = 1.20 \pm 0.15$$



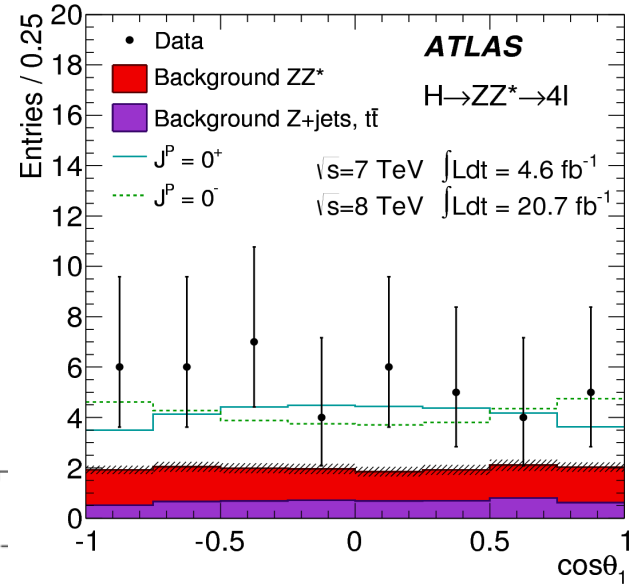
$$\lambda_{WZ} = 0.82 \pm 0.15$$

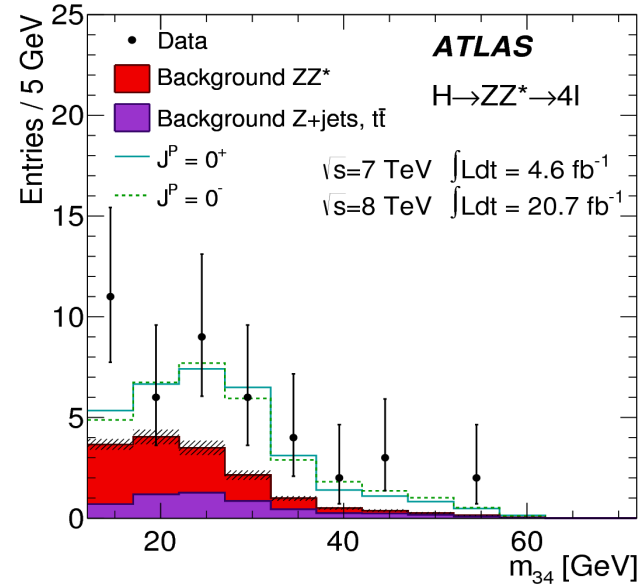
Consistent with SM predictions

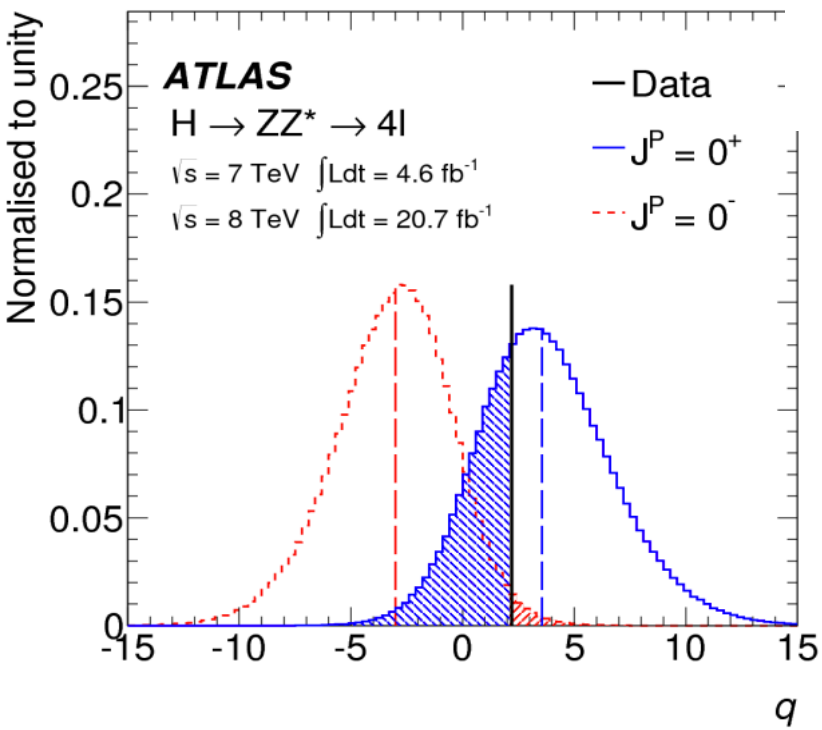
Higgs Spin/Parity ($J^P = 0^+$ vs 0^-)



Phys. Lett. B 726 (2013), pp. 120







$$q = \log \frac{L(J^p = 0^+)}{L(J^p = 0^-)}$$

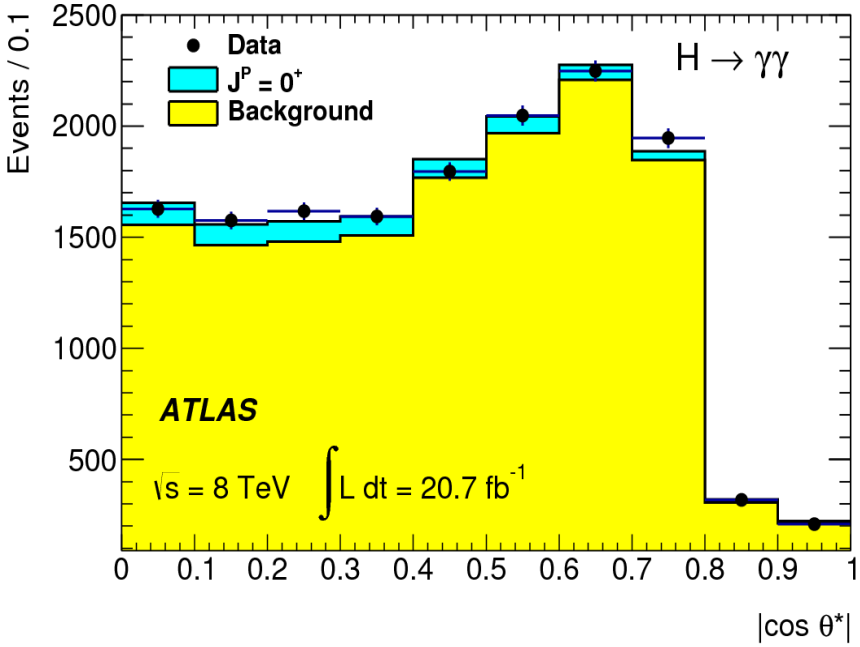
Data agree with 0^+ hypothesis

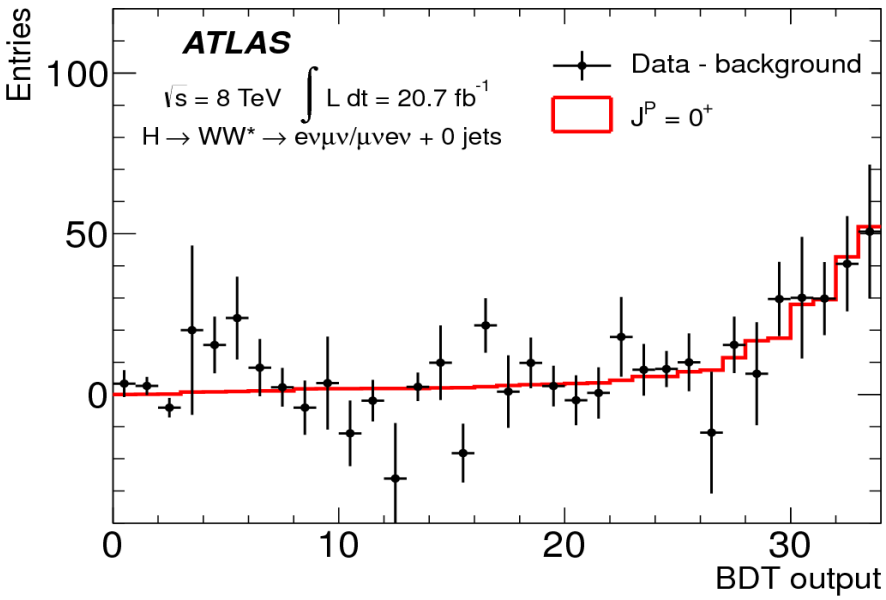
0^- solution excluded at 97.8 % CL

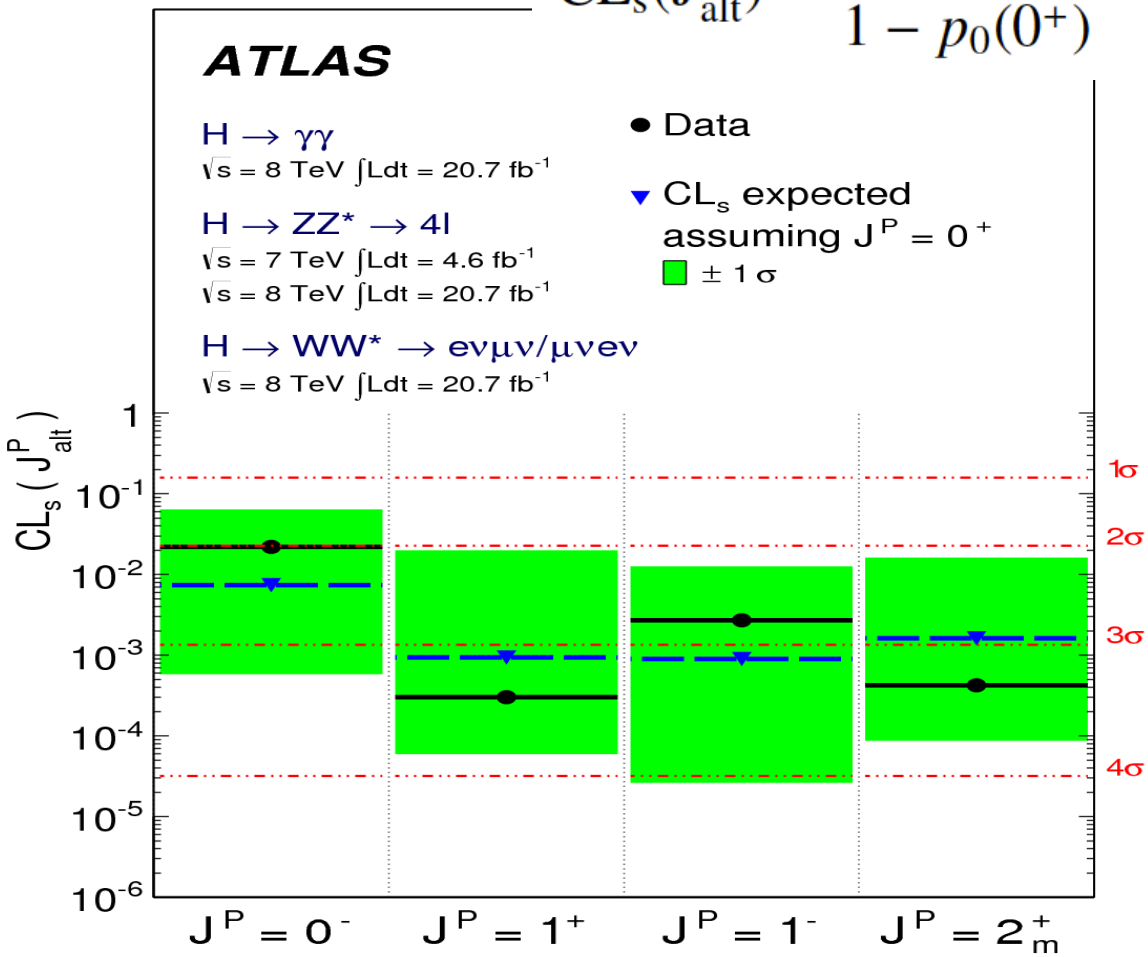
Phys. Lett. B 726 (2013), pp. 120

Higgs Spin/Parity

$$\mathrm{CL_s}(J^P_{\mathrm{alt}}) = \frac{p_0(J^P_{\mathrm{alt}})}{1 - p_0(0^+)}$$







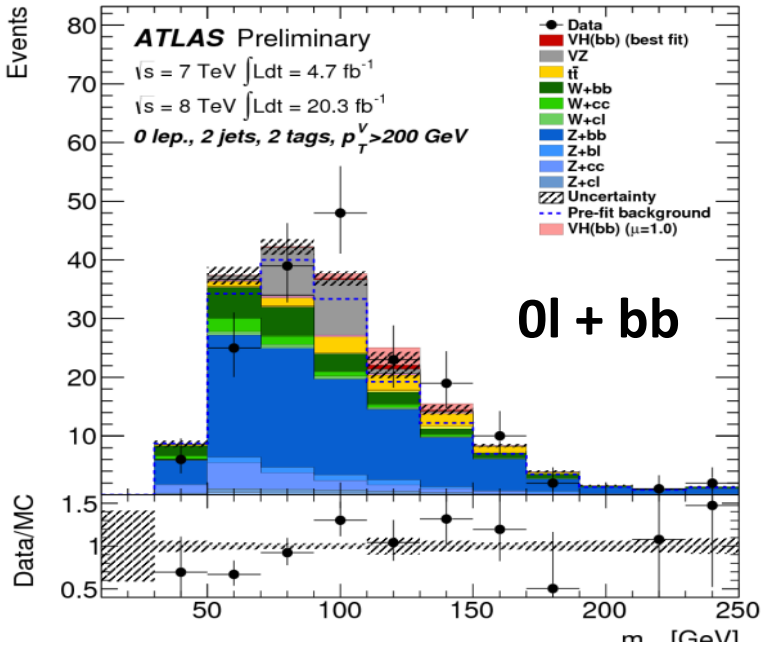
$J^P = 1^+$ and 1^- rejected at 99.7% CL

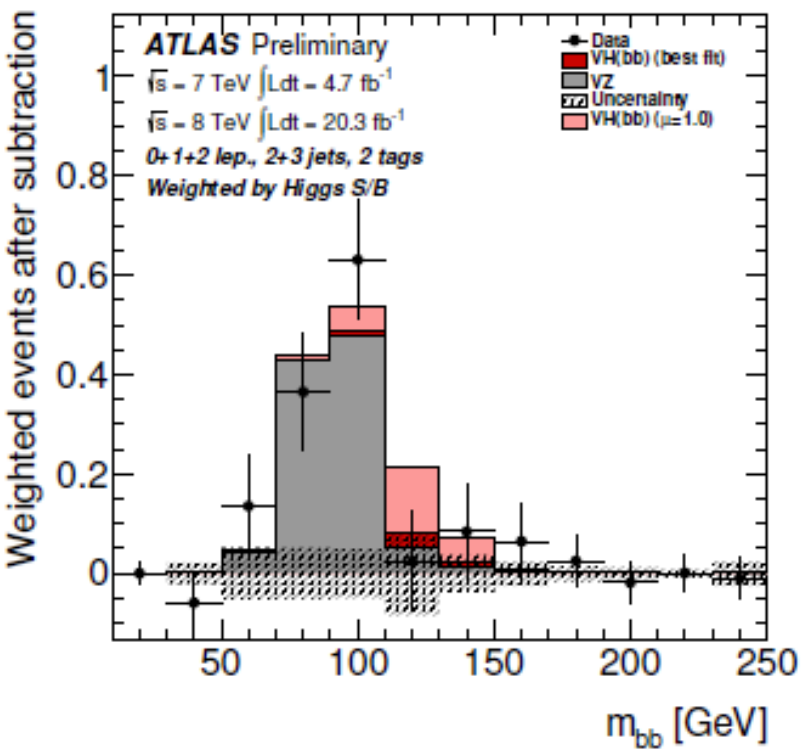
$J^P = 2^+$ rejected at 99.9% CL

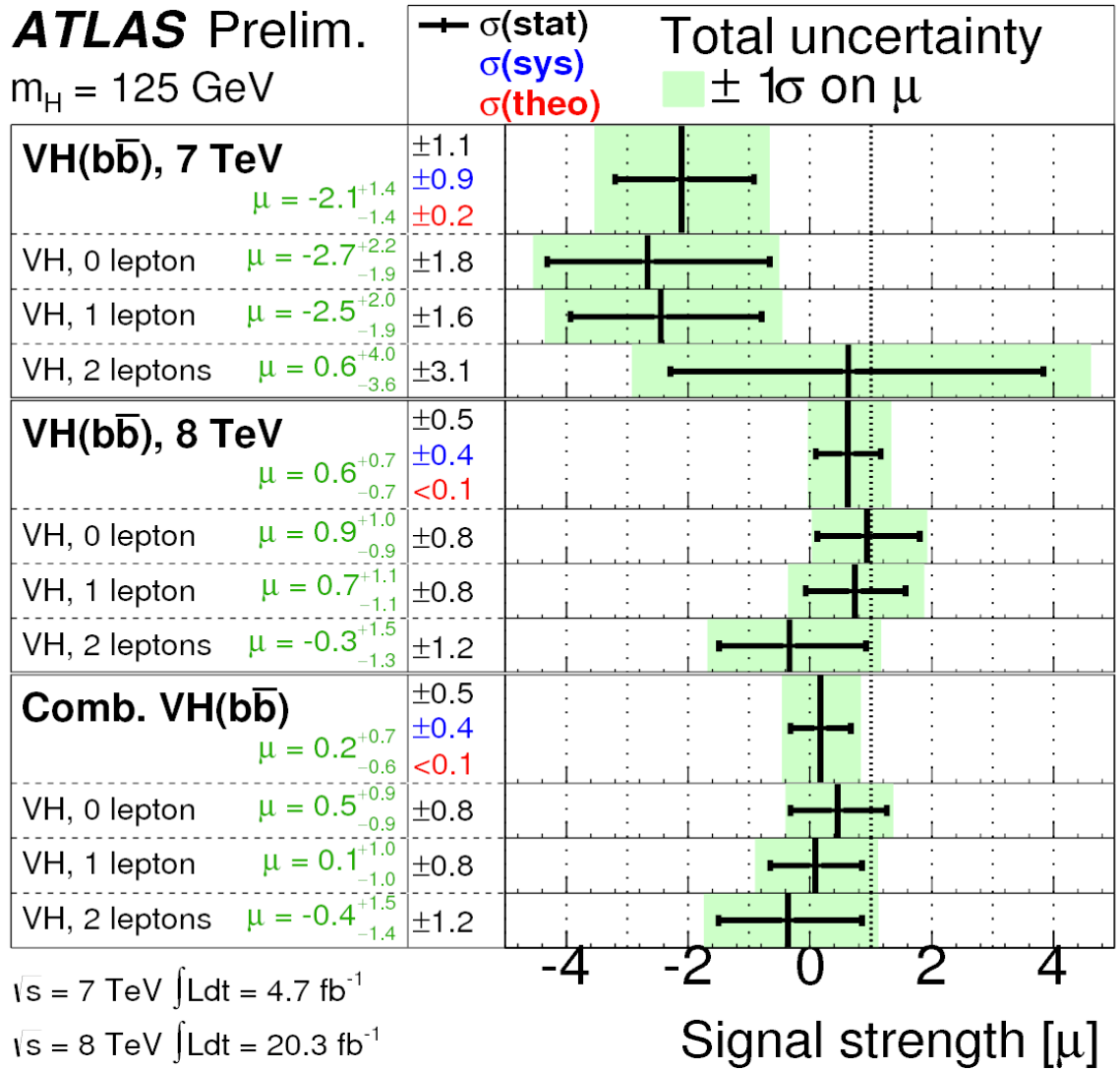
→ Evidence for $J^P = 0^+$

ATLAS-CONF-2013-079

(W/Z)(H → bb)







Best fit signal strength: $\mu = 0.2^{+0.7}_{-0.6}$

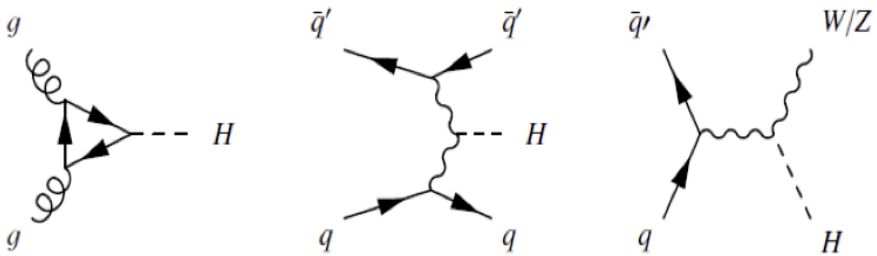
ATLAS-CONF-2012-160

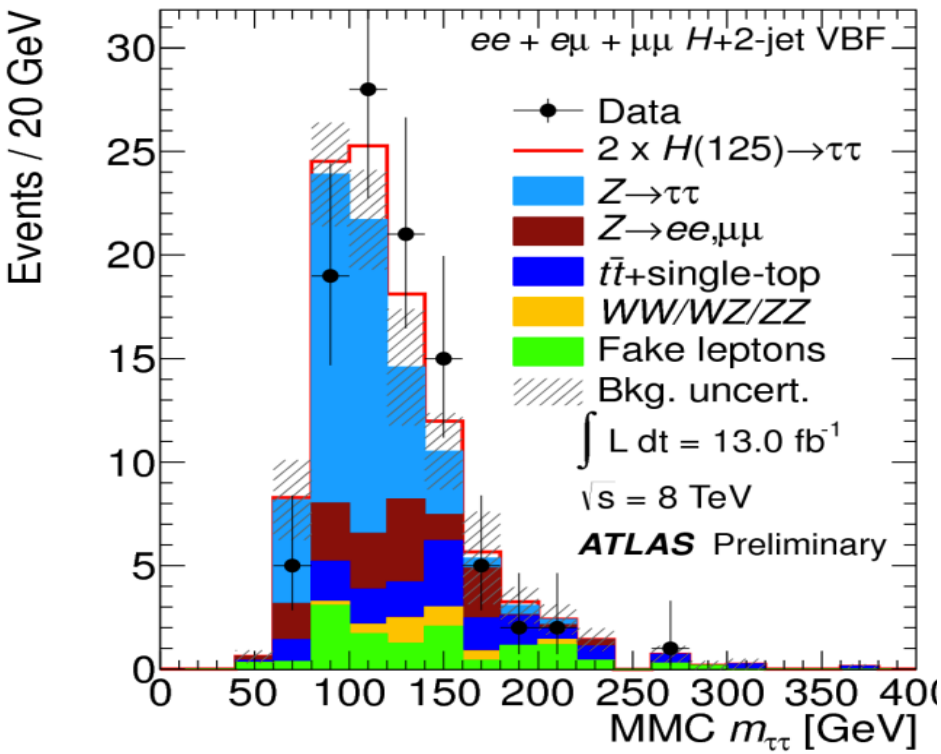
H → ττ

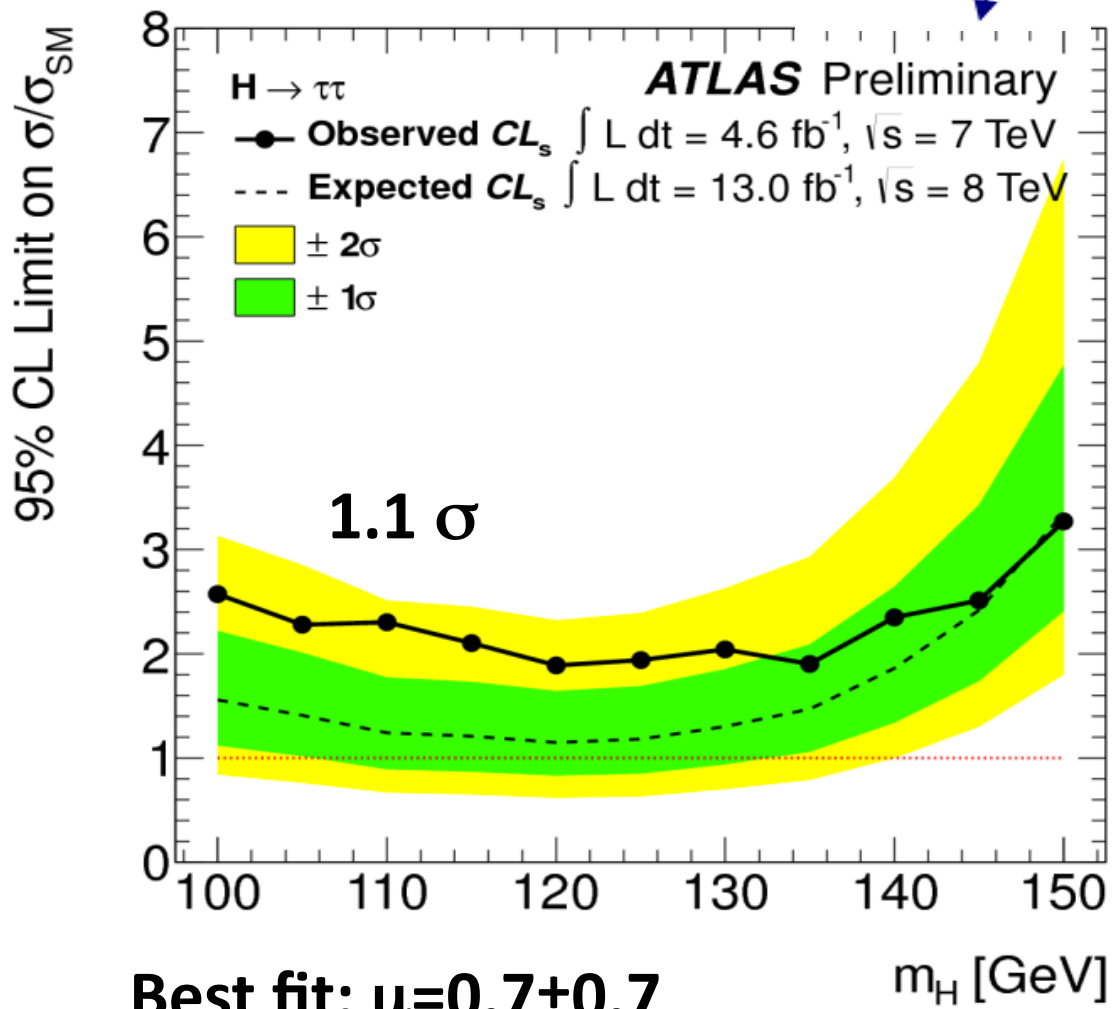
Analysis in mutiple channels with +0/1/2-jets in the final state

Considering lepton-lepton, lepton-hadron and hadron-hadron tau decay channels

2-jet channels optimized for VBF and VH





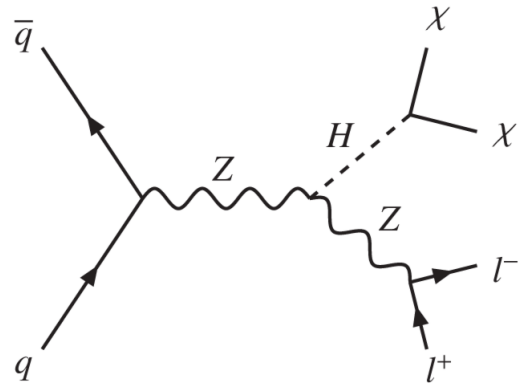


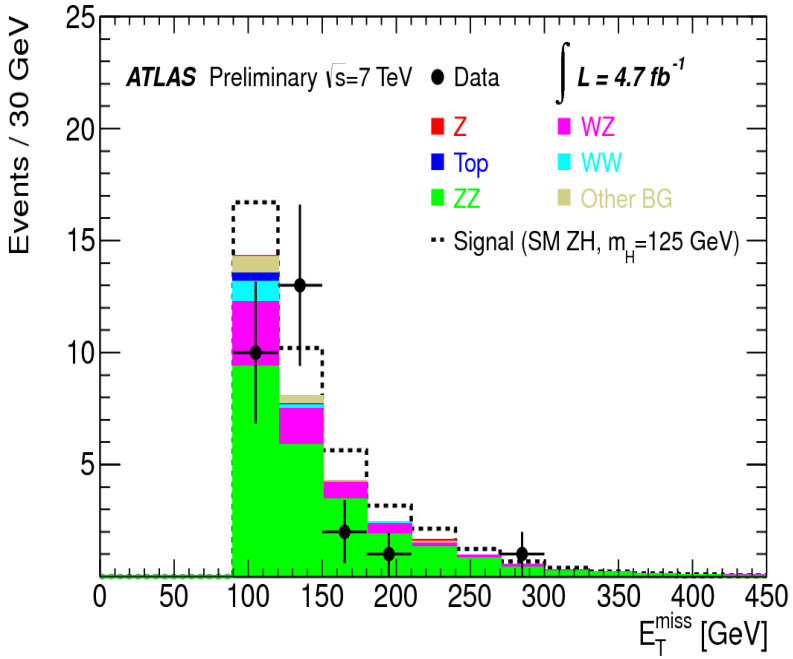
Best fit: μ=0.7±0.7

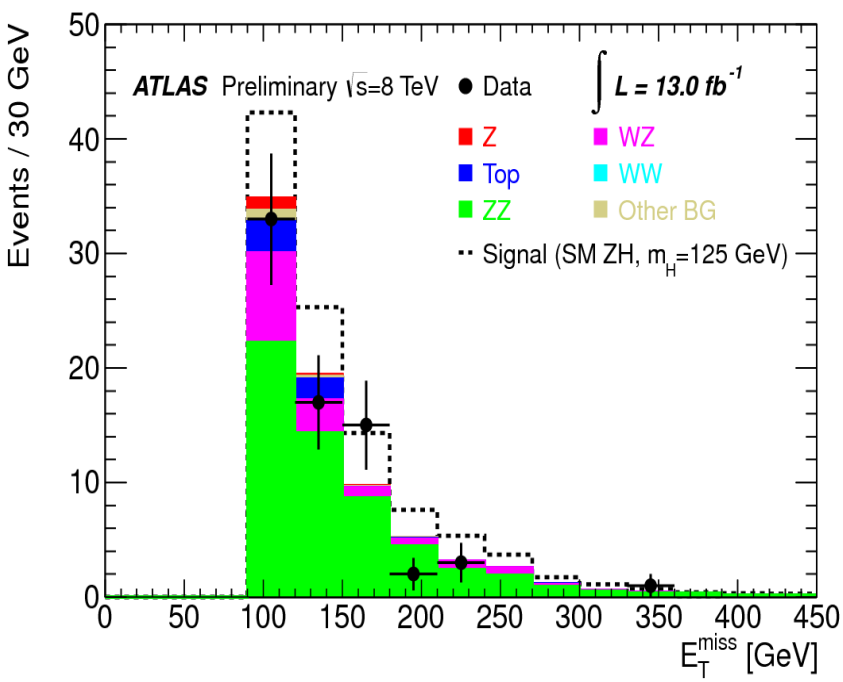
ATLAS-CONF-2013-011

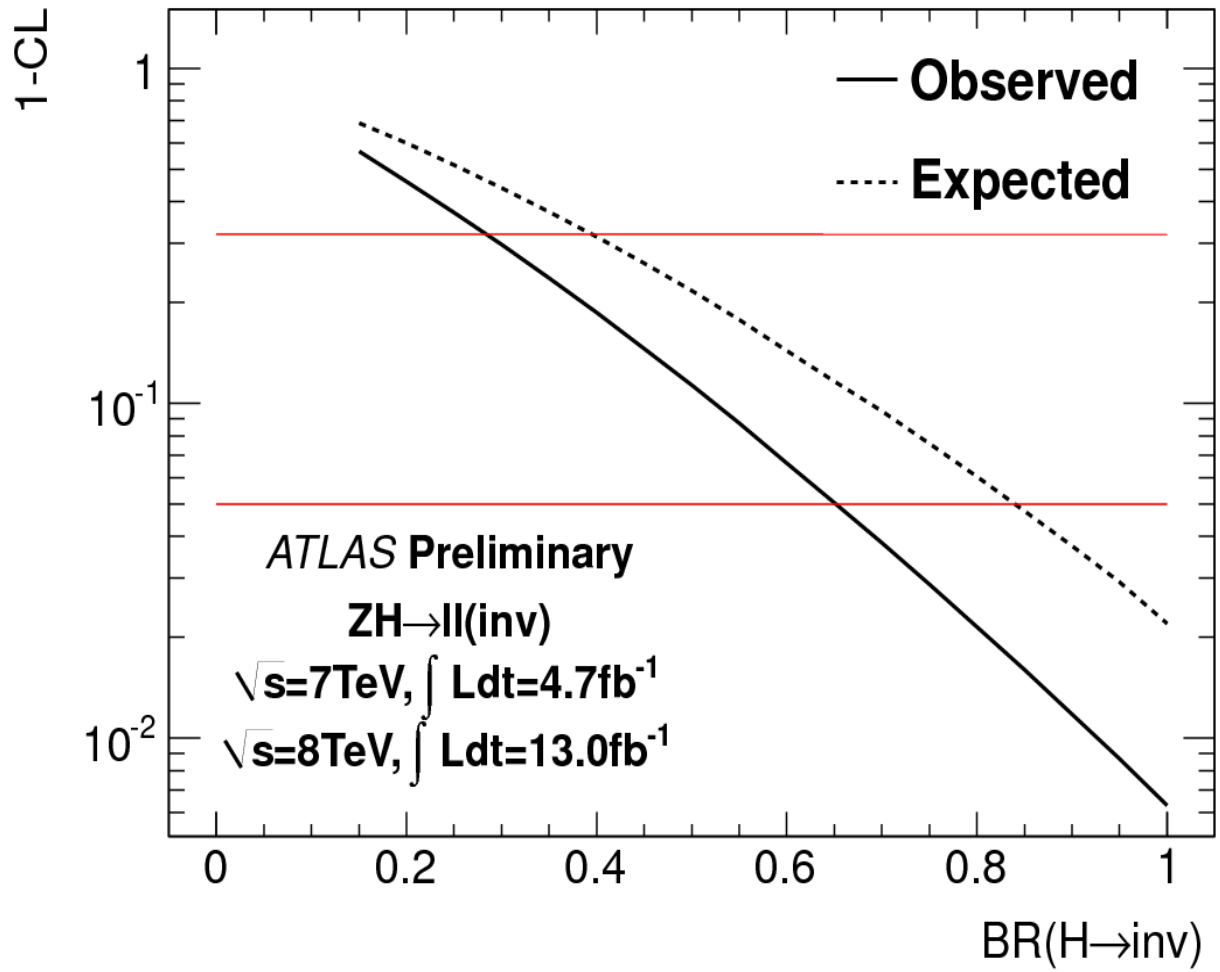
H → χχ

2l + E_T^{miss}









Br (H → invisible) < 65% at 95% CL

8th Oct. 2013

The Nobel Prize in Physics 2013
François Englert, Peter Higgs

The Nobel Prize in Physics 2013

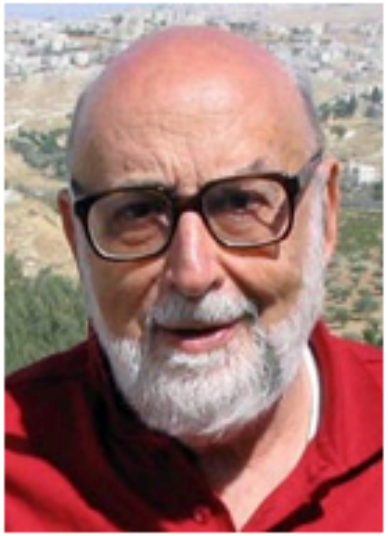


Photo: Pnicolet via Wikimedia Commons

François Englert

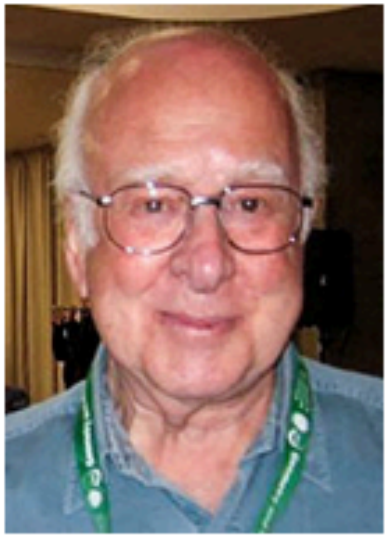


Photo: G-M Greuel via Wikimedia Commons

Peter W. Higgs

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"*

Fundación Príncipe de Asturias

S.A.R. el Príncipe de Asturias
Presidente de Honor
de la Fundación

"…acuerda por unanimidad conceder el

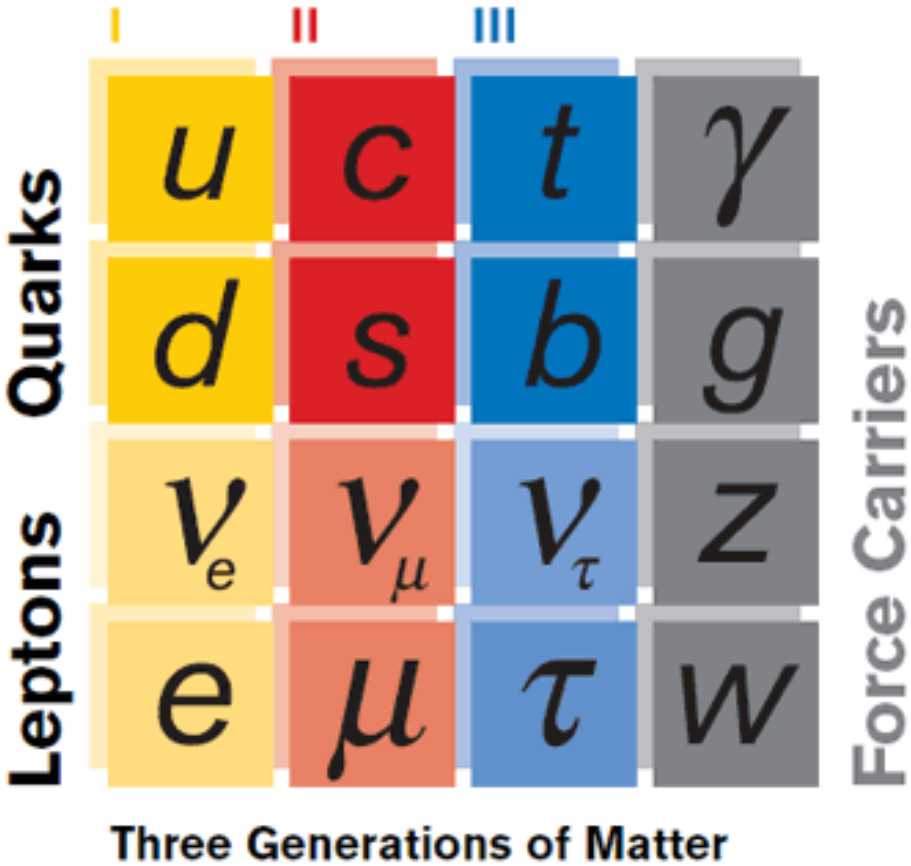
Premio Príncipe de Asturias de Investigación Científica y Técnica 2013

de forma conjunta a los físicos Peter Higgs (Reino Unido) y François Englert (Bélgica) y a la institución internacional CERN, el Laboratorio Europeo de Física de Partículas, por la predicción teórica y detección experimental del Bosón de Higgs."

Oviedo, 29 de Mayo de 2013
(Ceremony this Friday…)

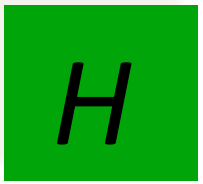
Some of the open questions

(i.e., the need for new physics)



- Who ordered 3 generations?
- Matter/Anti-Matter ?
- ……..

- Hierarchy Problem …
- Unification at Large Scale?
- Dark Matter in the Cosmos?
- …….
- What about Gravity ?
- …….



New Physics (!)

O(TeV) scale phenomenology

Search for SUSY

Inclusive searches, third generation squarks, charginos/neutralinos…

Centered in RP conserving scenarios and somehow driven by DM searches…

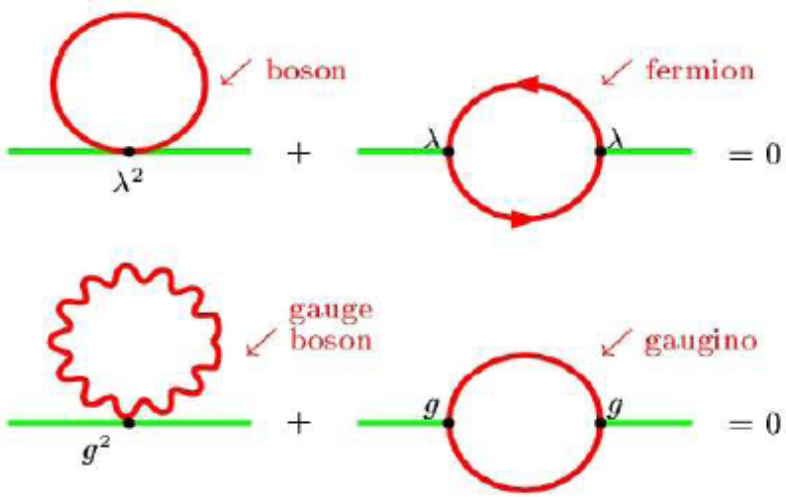
SuperSymmetry in 30"

- **Fermion/Boson symmetry**

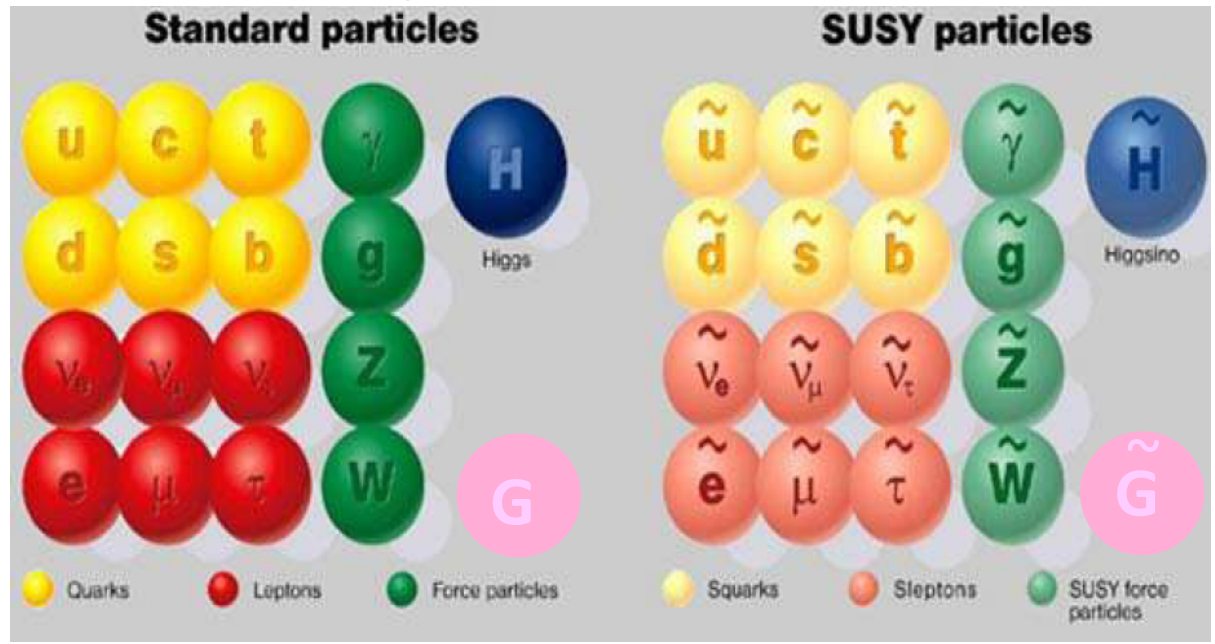
$$Q\,|\,\text{fermion}\,> = |\,\text{boson}\,>$$

$$Q\,|\,\text{boson}\,> = |\,\text{fermion}\,>$$

- **Exact cancellation between fermion & boson loops for Higgs**



Double Spectra of Particles



..will mix to form mass eigenstates..

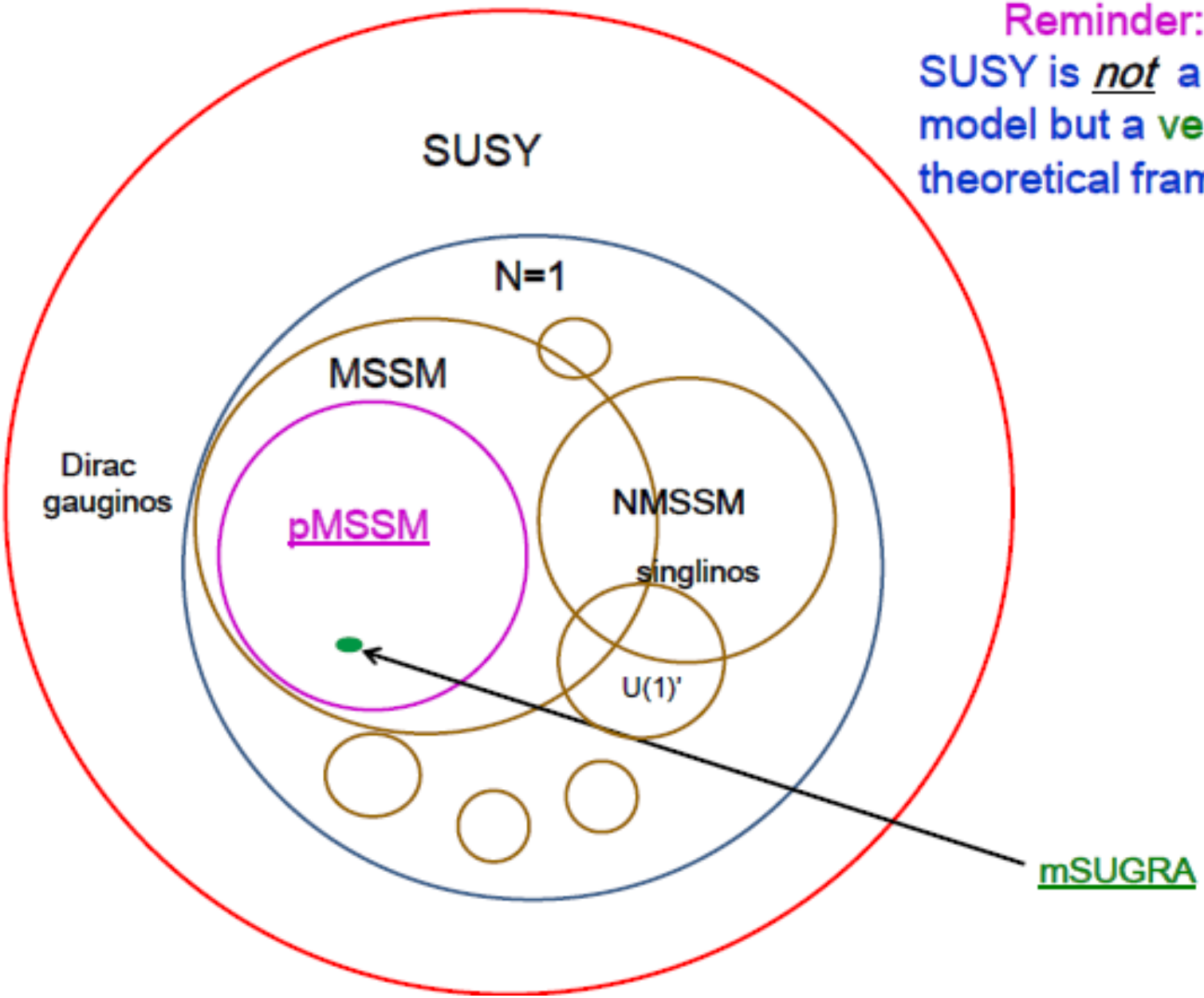
Higgs sector with 2 doublets

$$H_U, H_D \longrightarrow h, H, A, H^{\pm}$$

..SUSY must be broken..... model-dependent phenomenology

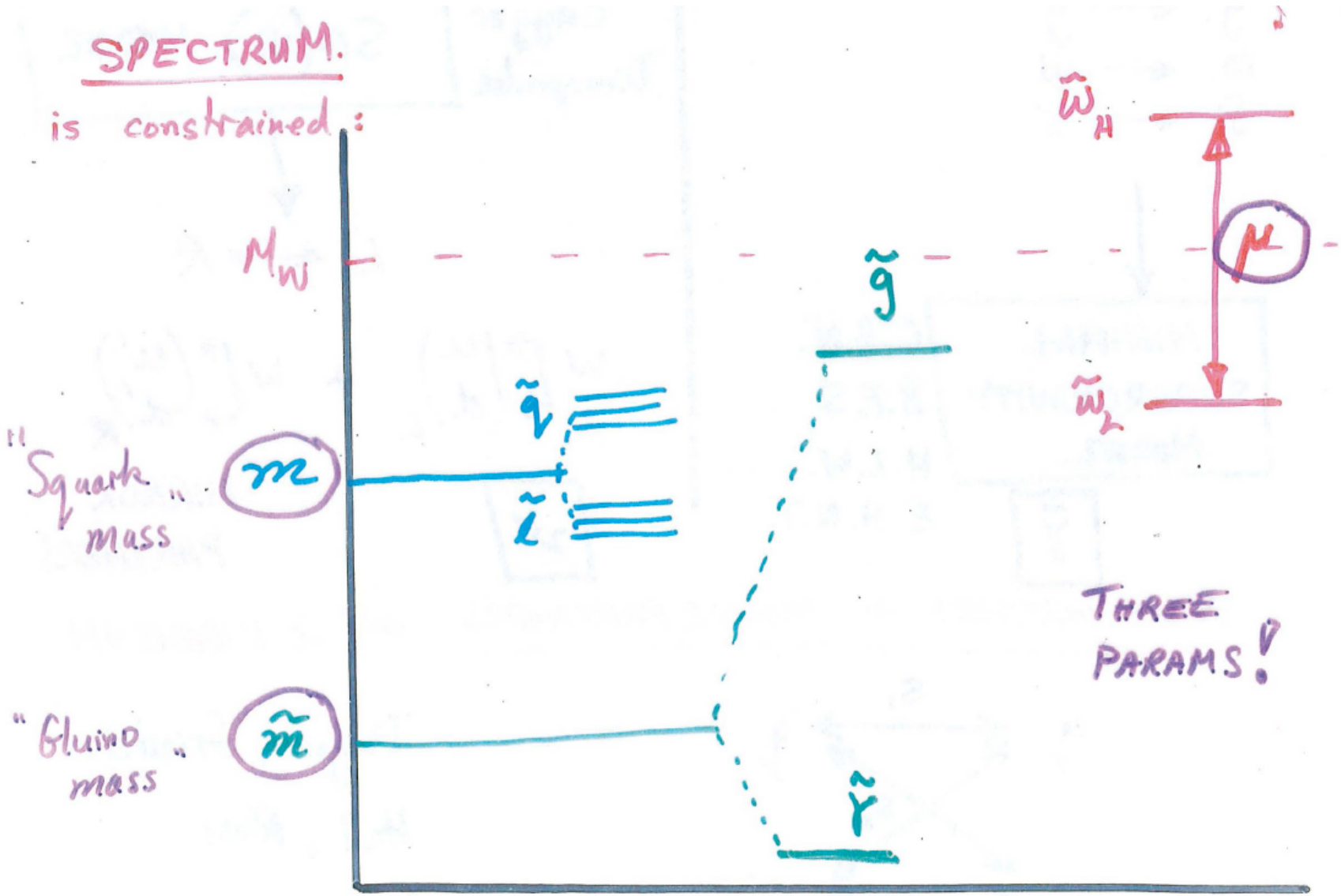
Taken from T. Rizzo

SUSY ZOO

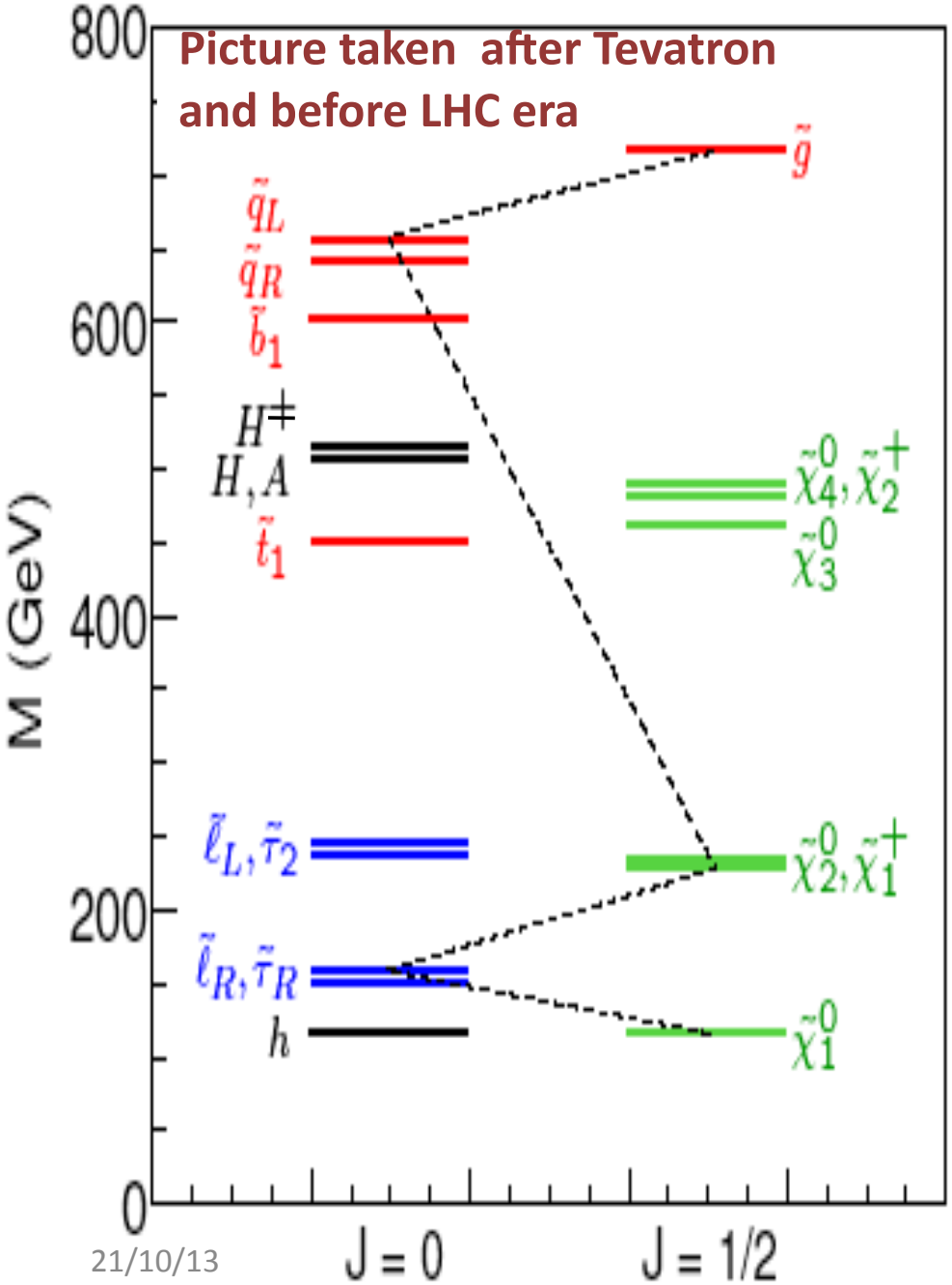


Reminder:
SUSY is *not* a single model but a very large theoretical framework

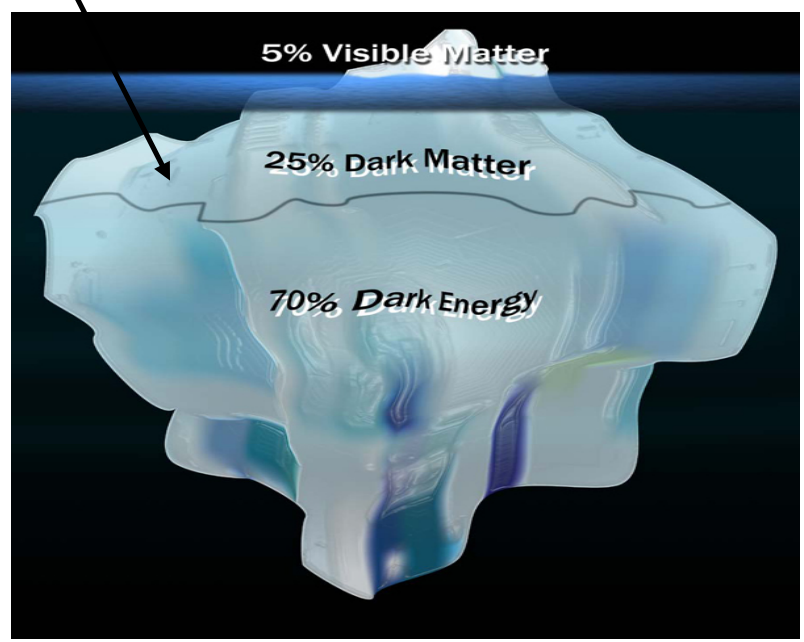
"Natural SUSY in 1984"



SUSY candidate for Dark Matter

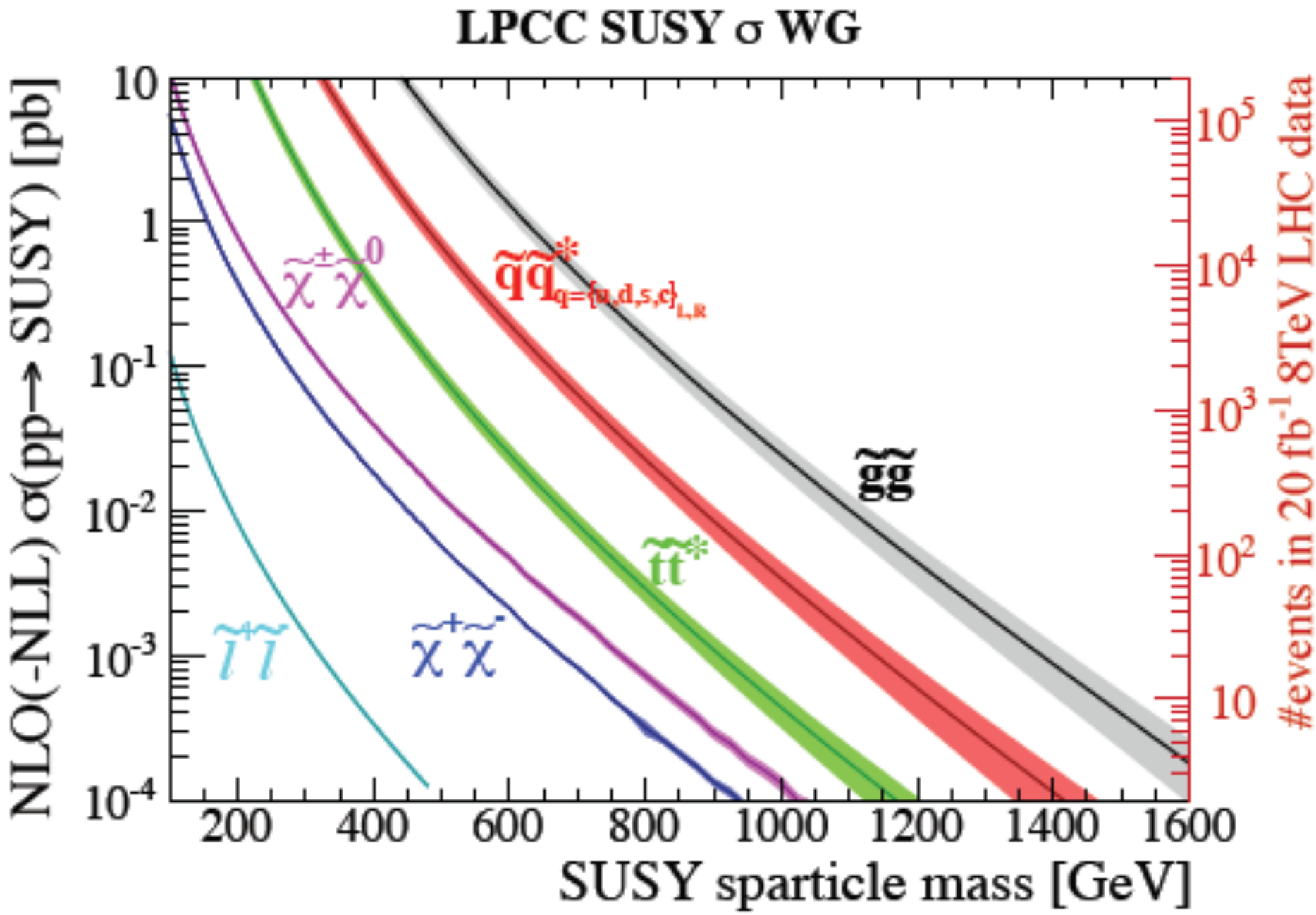


1. Squarks and Gluinos are heavy
2. mixing of third generation leads to light stop and sbottom
3. χ_1^0 good candidate for Dark Matter



4. One higgs is very light (< 135 GeV)

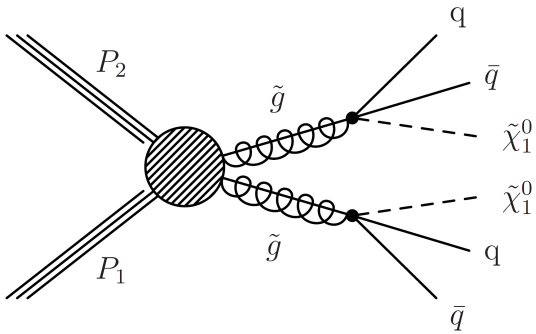
SUSY Cross Sections @ LHC (8 TeV)

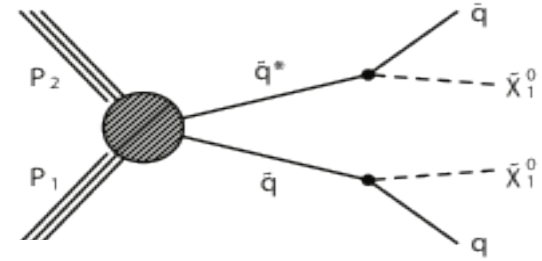


https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections arXiv:1206.2892

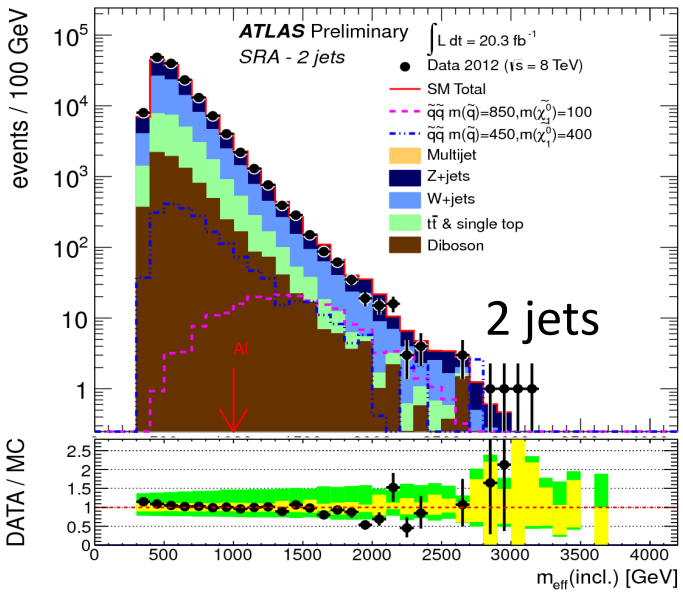
Inclusive Searches

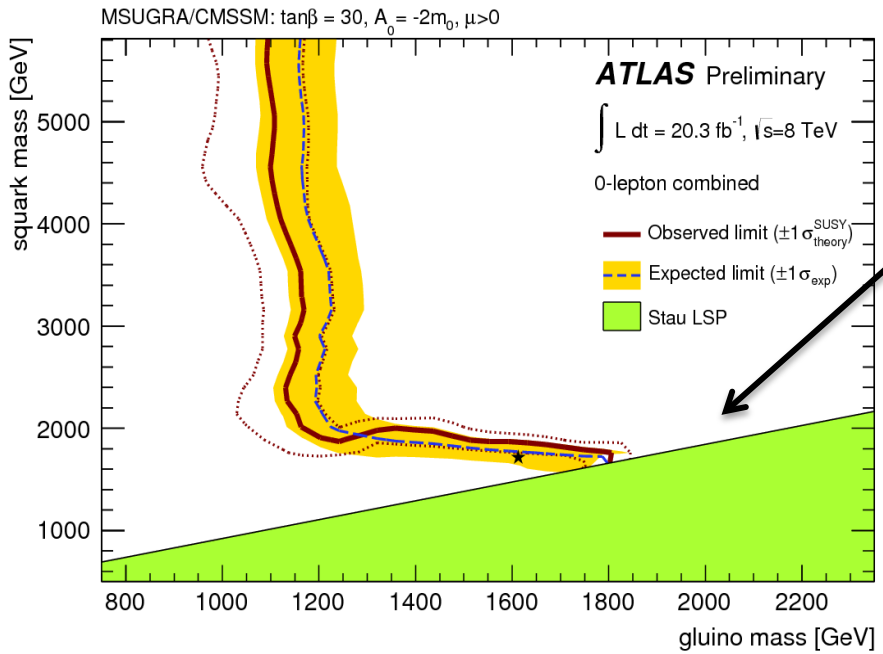
Multiple-jets and large E_T^{miss}





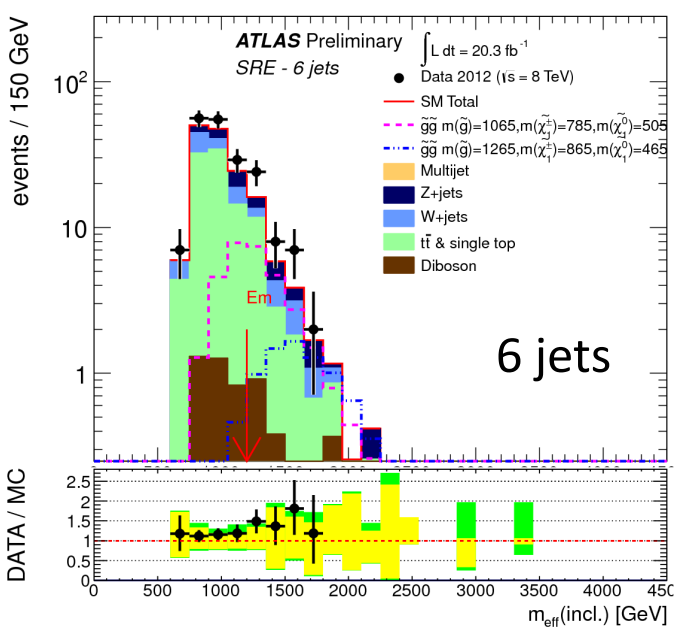
ATLAS-CONF-2013-047





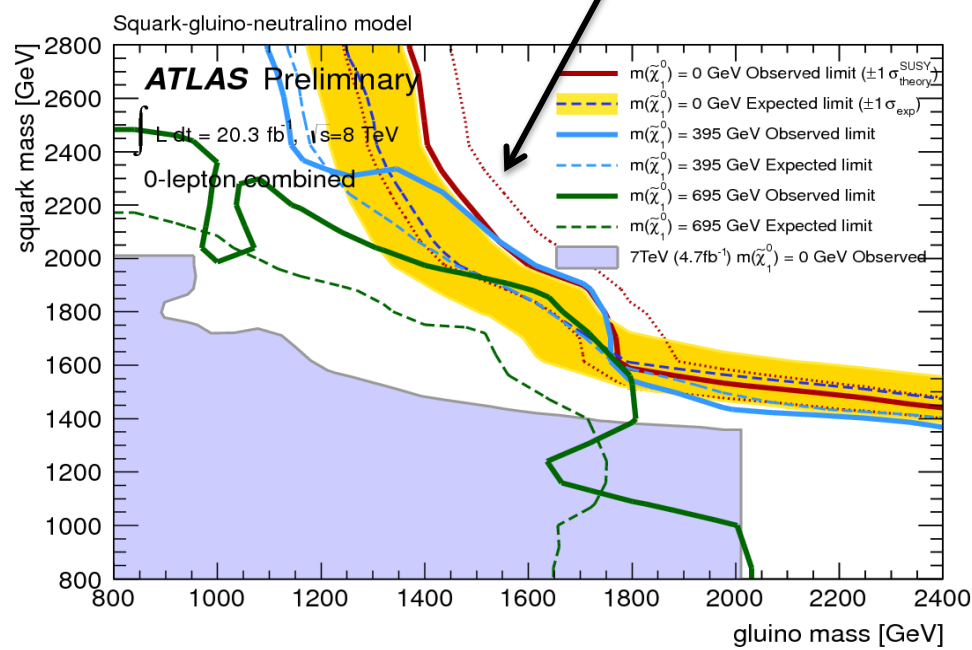
MSUGRA

SIMPLIFIED SCENARIO



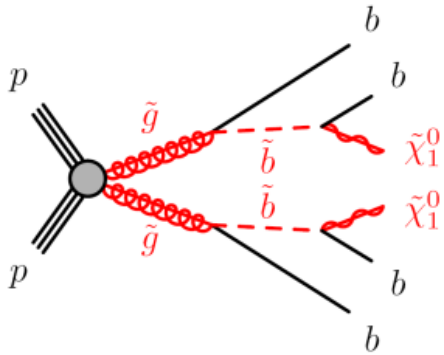
$$m_{eff} = E_T^{miss} + H_T$$

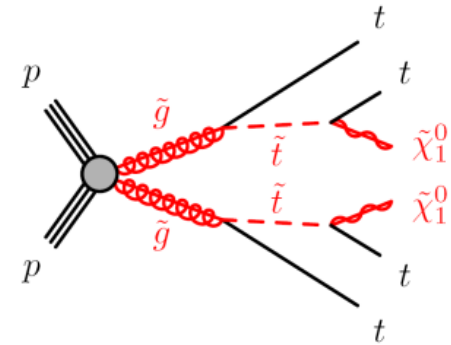
$$H_T = \sum_{jets} p_T$$



ATLAS-CONF-2013-061

Gluino-mediated
Stop/Sbottom Production

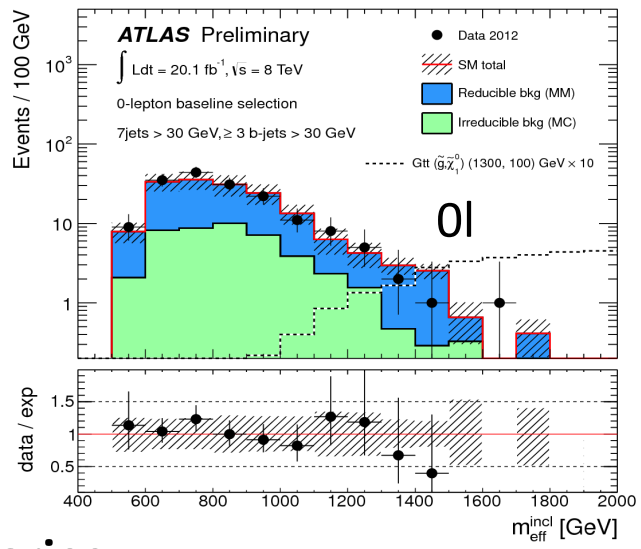


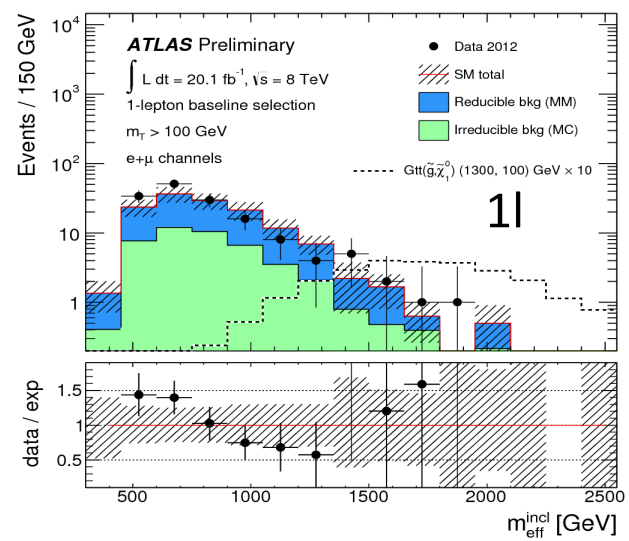


0/1 lepton + 3b-jets + E_t^{miss}

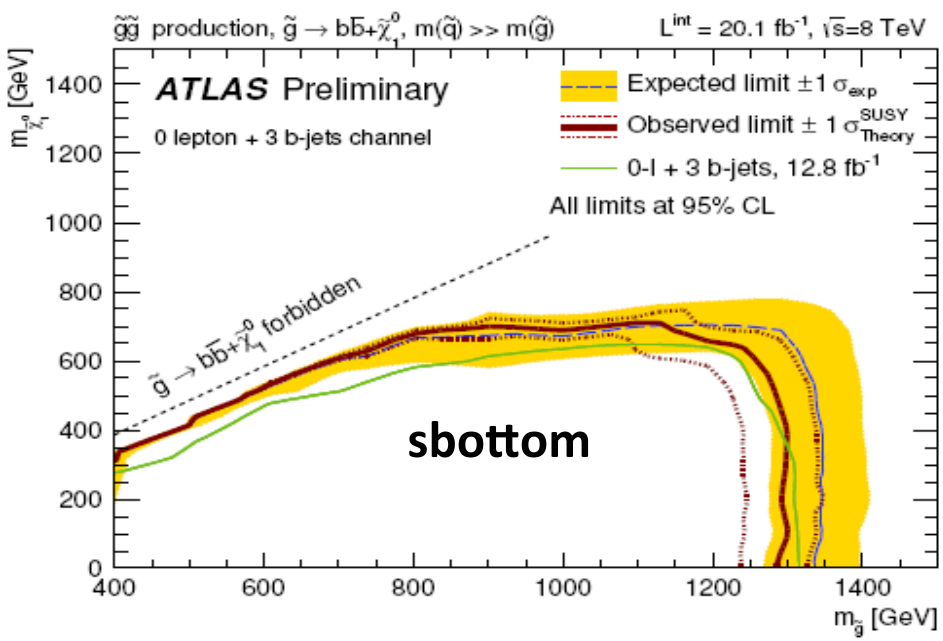
Background dominated by tt+bb, tt+V and tt+fakes

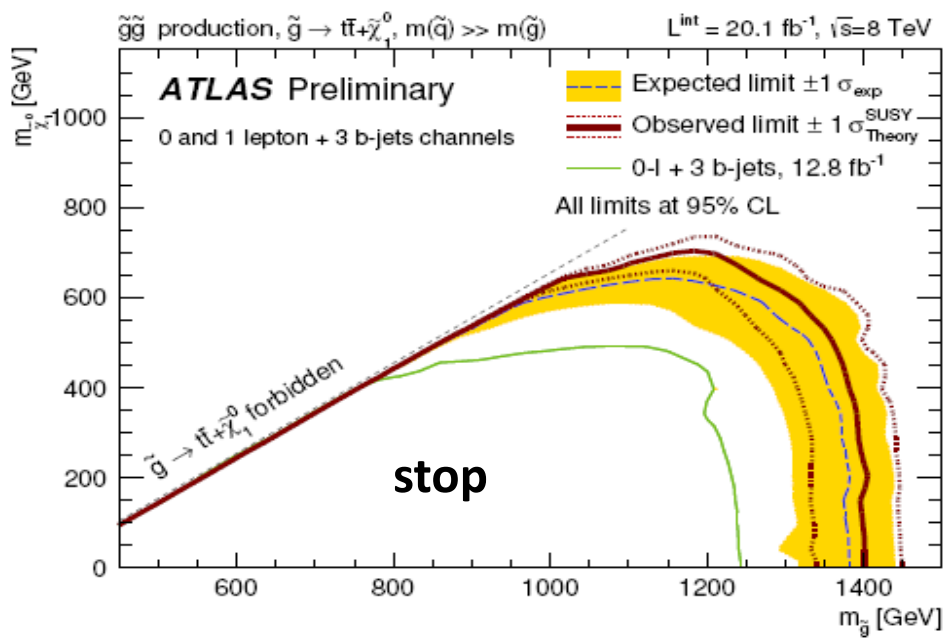
most powerful for very heavy gluinos



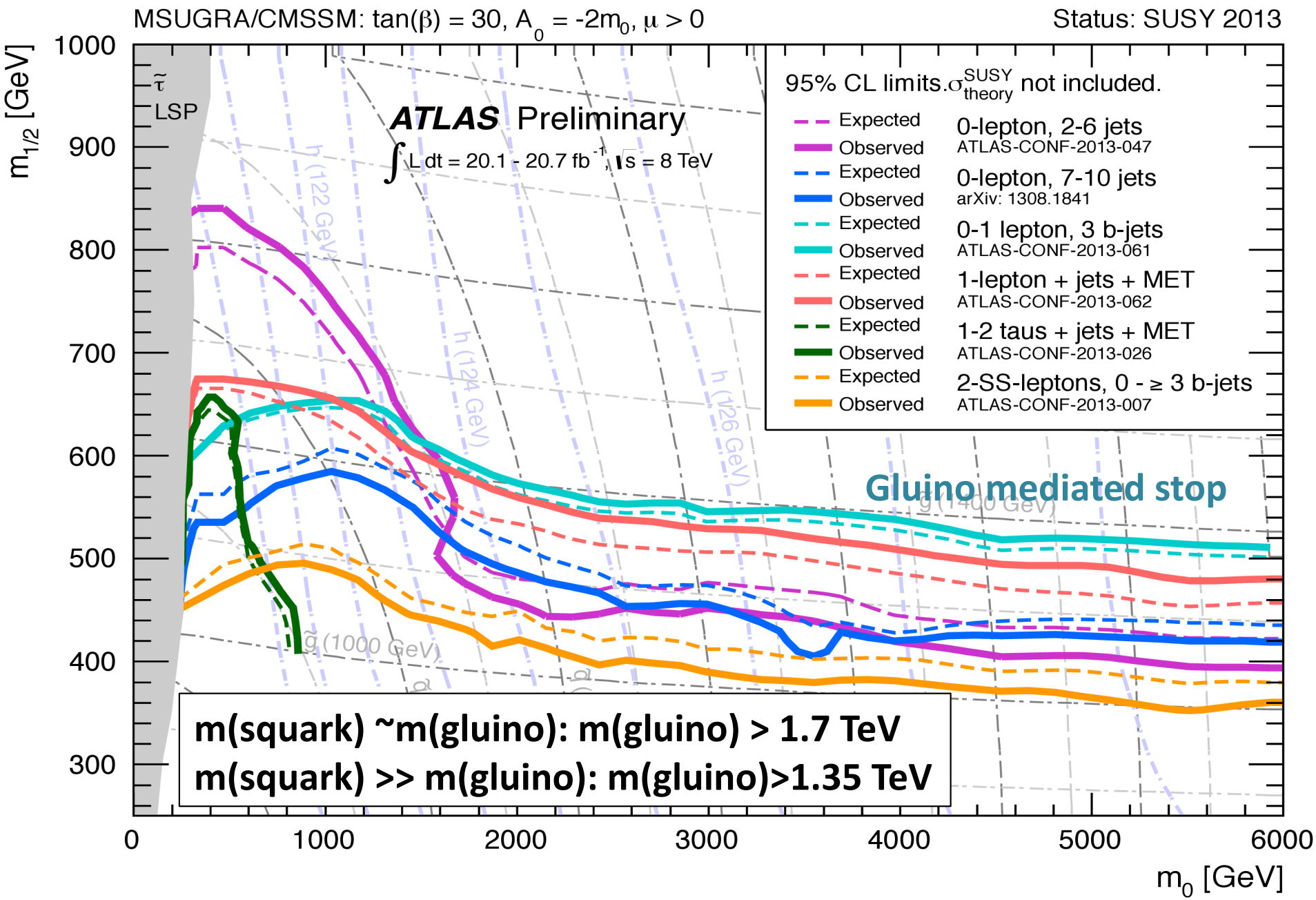


Interpreted in simplified scenarios

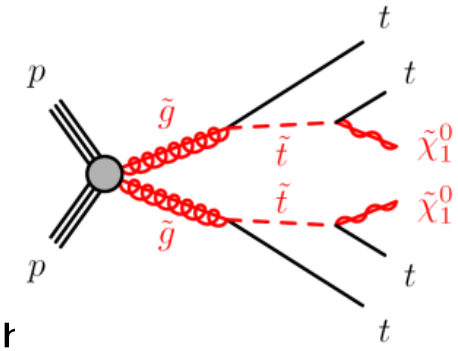




MSUGRA Scenario



Simplified model



$\tilde{g}\tilde{g}$ production, $\tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$, $m(\tilde{q}) >> m(\tilde{g})$, $\sqrt{s}$ = 8 TeV Lepton & Ph

ATLAS
Preliminary

95% CL limits. σ^{SUSY}_{theory} not included.

Expected / Observed	0-lepton, 7 - ≥ 10 jets ATLAS-CONF-2013-054	[L_{int} = 20.3 fb^{-1}]
Expected / Observed	0-1 lepton, ≥ 3 b-jets ATLAS-CONF-2013-061	[L_{int} = 20.1 fb^{-1}]
Expected / Observed	3-leptons, ≥ 4 jets ATLAS-CONF-2012-151	[L_{int} = 12.8 fb^{-1}]
Expected / Observed	2-SS-leptons, 0 - ≥ 3 b-jets ATLAS-CONF-2013-007	[L_{int} = 20.7 fb^{-1}]

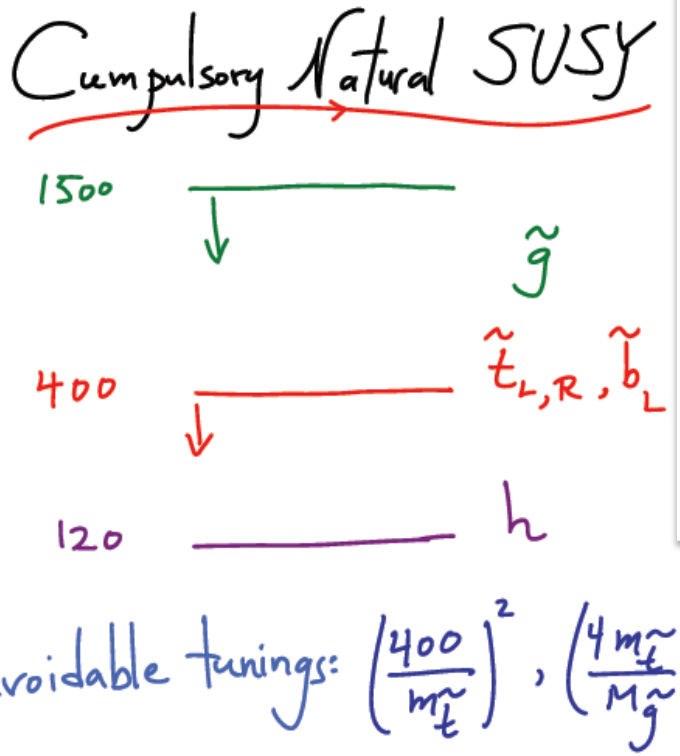
$\tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$ forbidden

No exclusion for M(LSP) ≥ 700 GeV
Strongest limit: m(~g) ≥ 1400 GeV

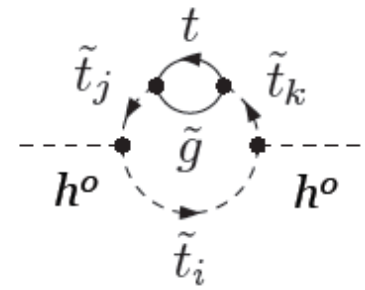
$m_{\tilde{\chi}_1^0}$ [GeV]: 200, 400, 600, 800, 1000, 1200

$m_{\tilde{g}}$ [GeV]: 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600

“Natural SUSY 2012”



N. Arkani-Hamed talk at CERN Oct. 2012



$$\frac{m_H^2}{2} = -|\mu|^2 + \ldots + \delta m_H^2$$

$$\delta m_H^2\Big|_{stop} \cong -\frac{3y_t^2}{8\pi^2}\left(m_{Q_3}^2 + m_{U_3}^2 + |A_t|^2\right)\ln\left(\frac{\Lambda}{TeV}\right)$$

$$\delta m_H^2\Big|_{gluino} \cong -\frac{2y_t^2}{\pi^2}\left(\frac{\alpha_s}{\pi}\right)|M_3|^2 \ln^2\left(\frac{\Lambda}{TeV}\right)$$

$$\begin{pmatrix} \tilde{t}_1 \\ \tilde{t}_2 \end{pmatrix} = \begin{pmatrix} \cos\theta_t & \sin\theta_t \\ -\sin\theta_t & \cos\theta_t \end{pmatrix} \begin{pmatrix} \tilde{t}_L \\ \tilde{t}_R \end{pmatrix}$$

→ Light higgsinos

→ Light stop (t_1 < 1 TeV)

→ Light gluinos (< 1-2 TeV)

One light stop and sbotton ….rest of sparticles can be decoupled….

$$\begin{pmatrix} \tilde{t}_L \\ \tilde{b}_L \end{pmatrix} \quad \tilde{t}_R \quad \tilde{b}_R$$

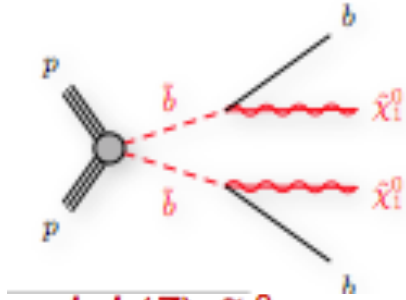
(same weak isospin multiplet)

Direct Stop/Sbottom

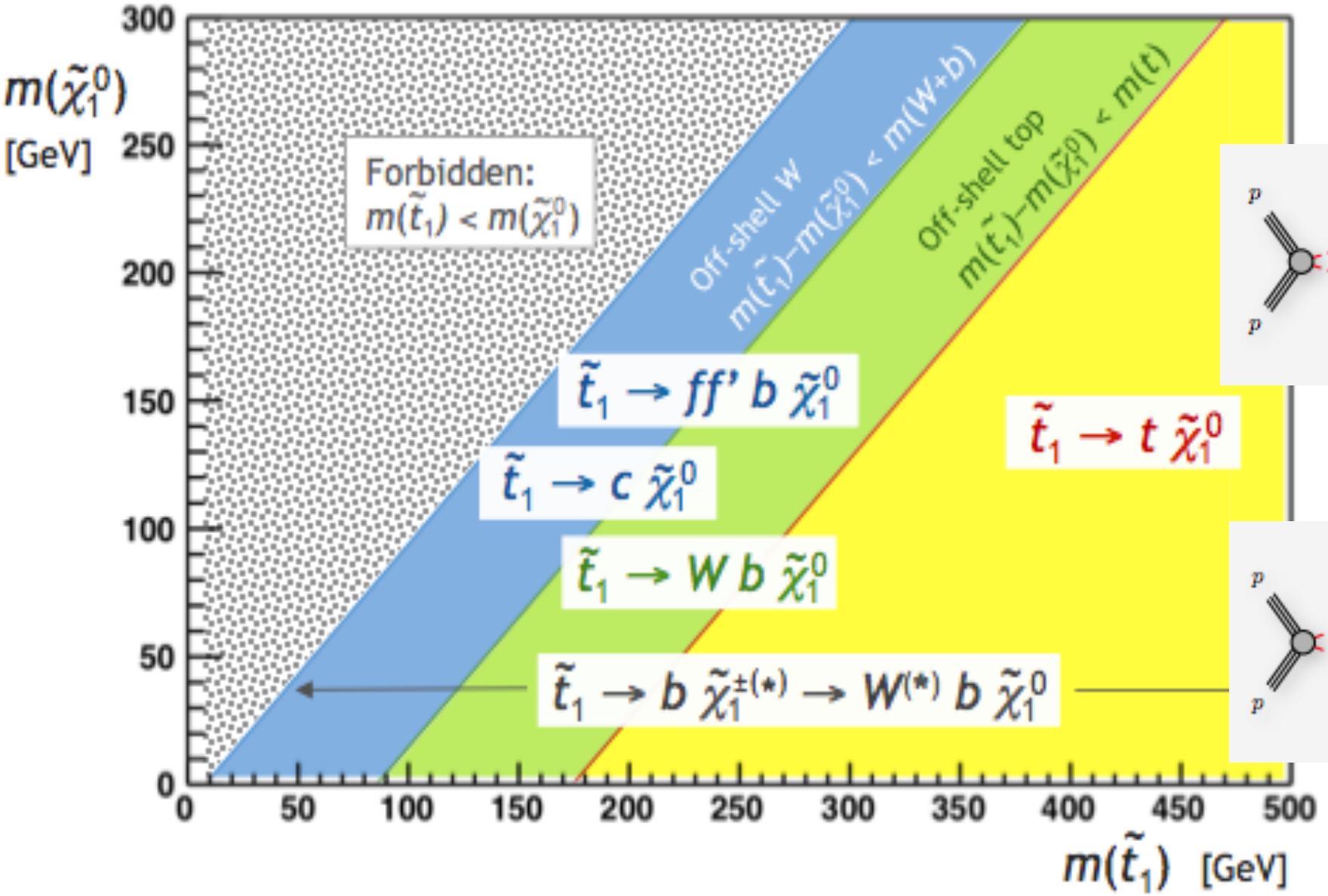
$\tilde{b}_1 \to b\,\tilde{\chi}_1^0$

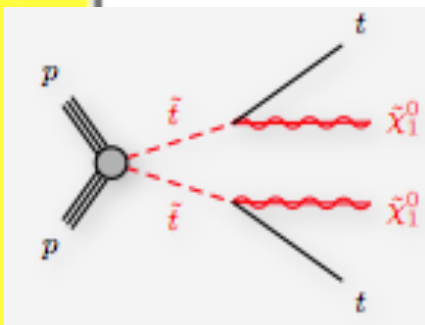
$\tilde{b}_1 \to t\,\tilde{\chi}_1^\pm$

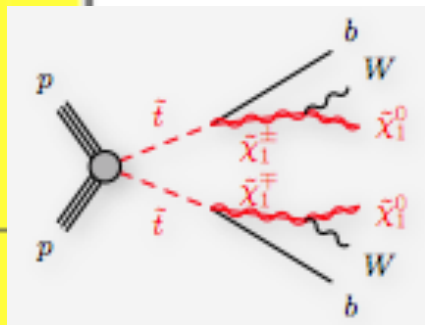
$\tilde{b}_1 \to b\,\tilde{\chi}_2^0 \to b\,h(Z)\,\tilde{\chi}_1^0$



In the scenario with TeV gluinos / squarks (1st/2nd generations)
All the attention is put now in searches for stop/sbottom
Multiple channels according to the decays

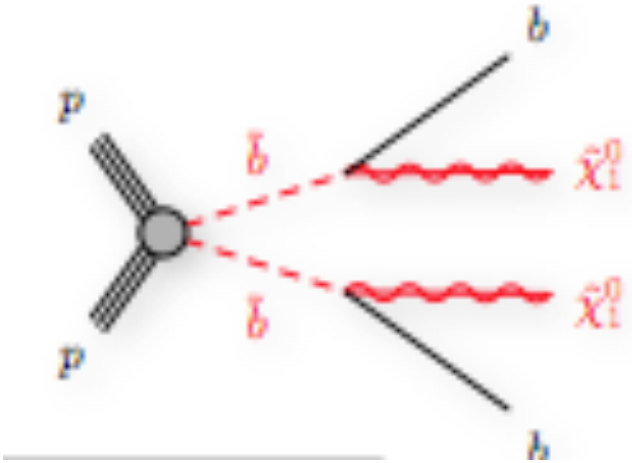






arXiv:1308.2631

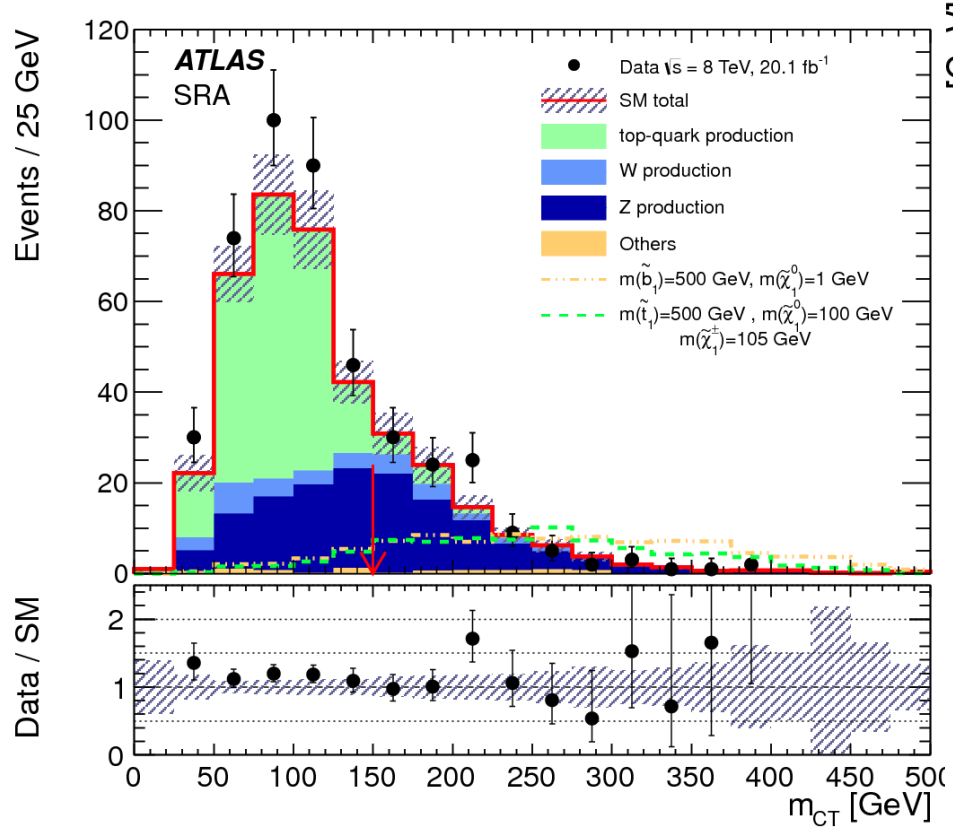
Sbottom Direct Production

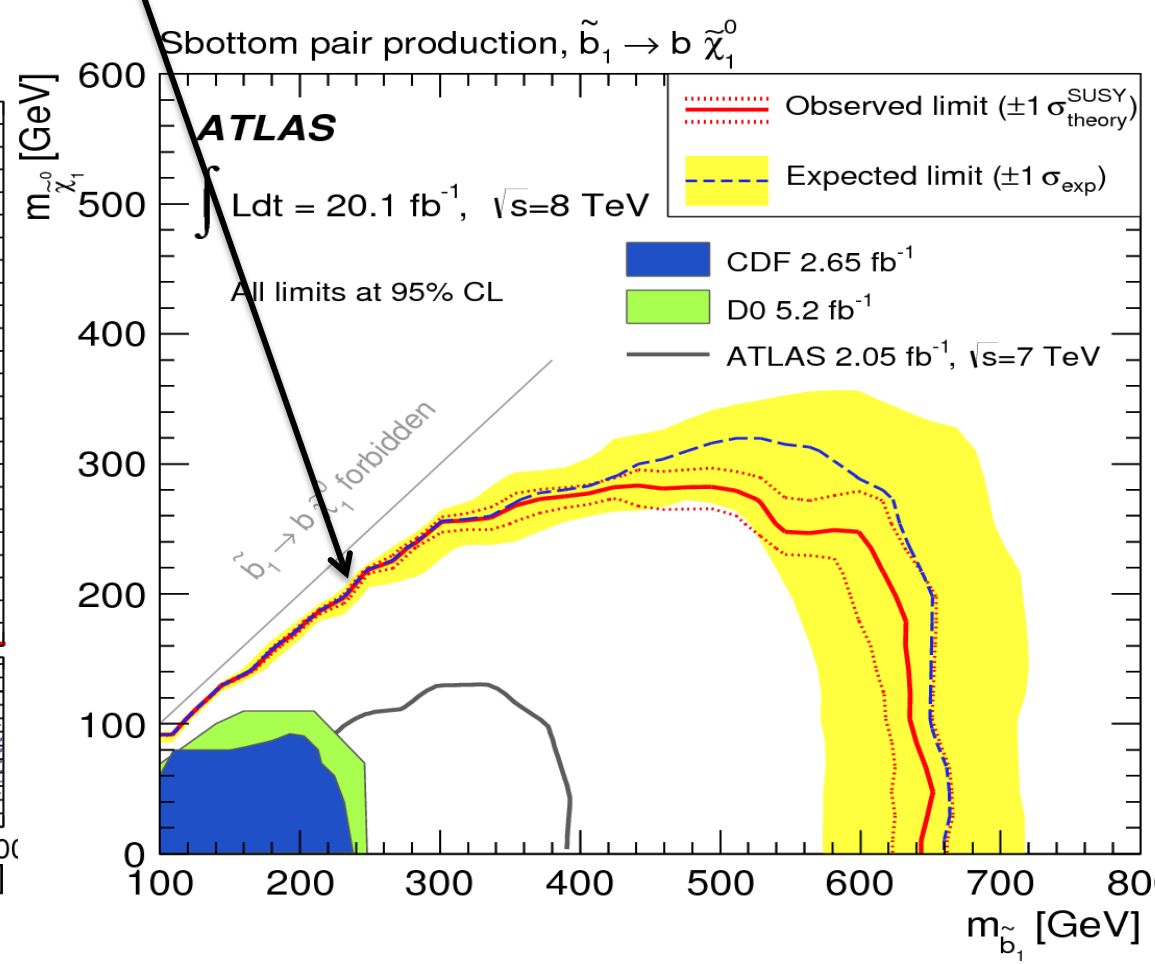


Large E_T^{miss} and 2 b-jets
Discriminating variable MCT

Additional selections to target also compressed scenarios (assisted with ISR jets)

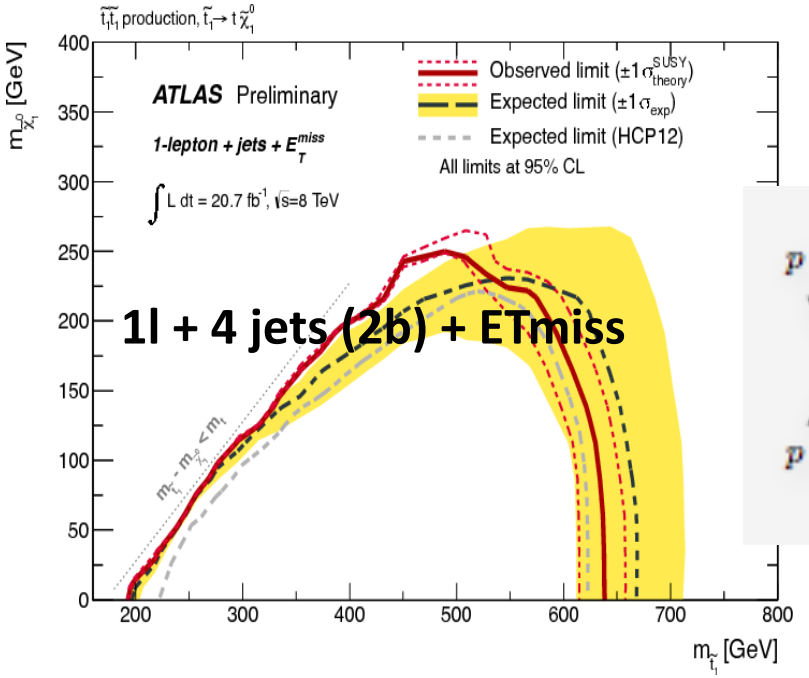
$$m_{CT}^2(v_1, v_2) = [E_T(v_1) + E_T(v_2)]^2 - [\boldsymbol{p}_T(v_1) - \boldsymbol{p}_T(v_2)]^2$$

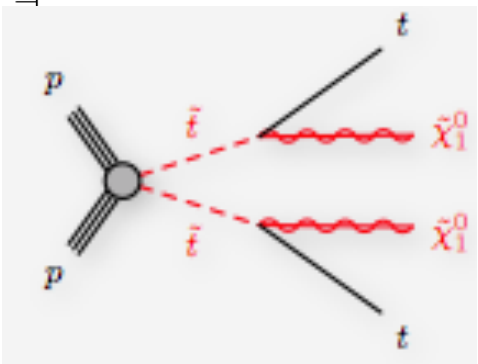




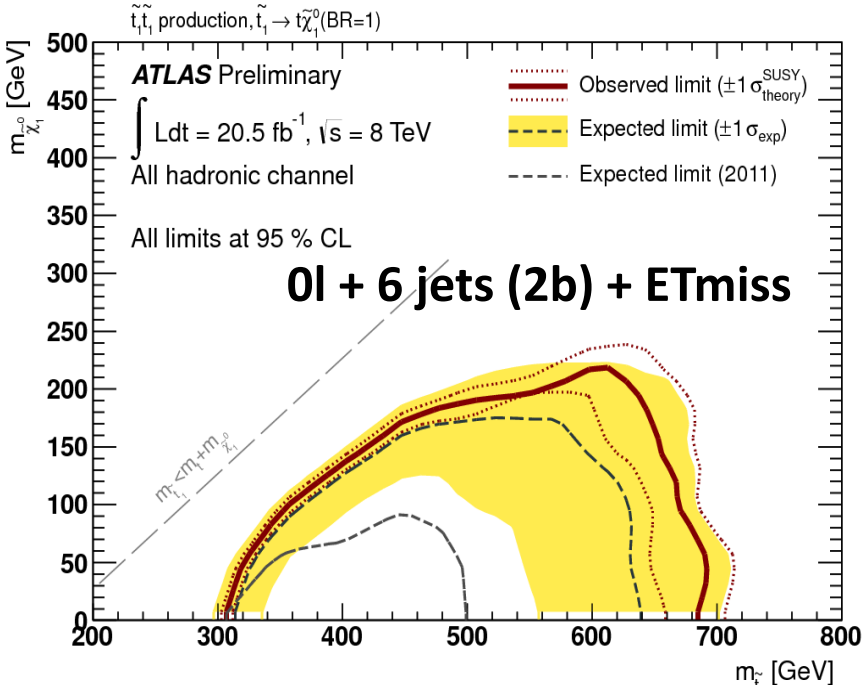
Direct Stop

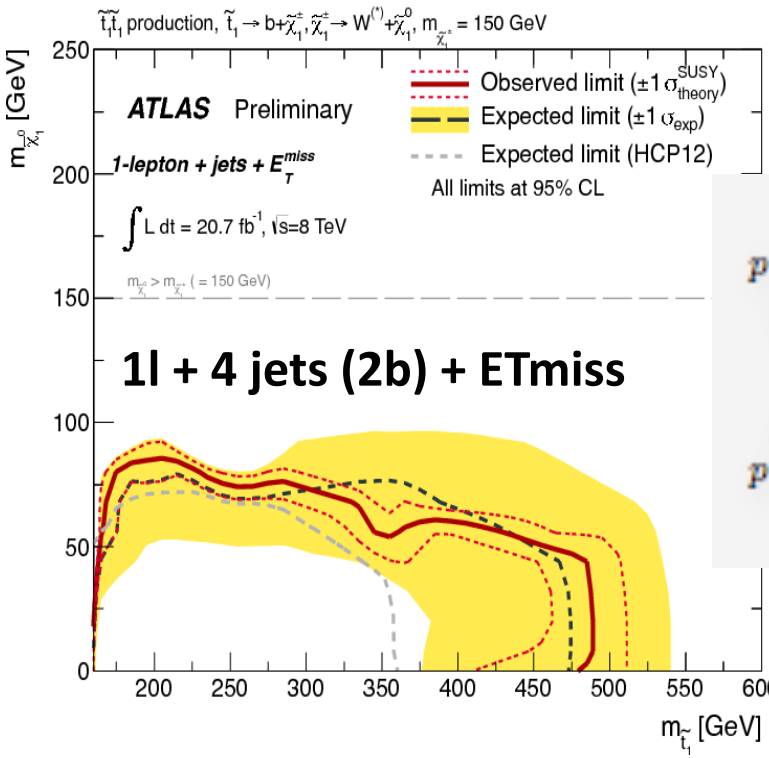
ATLAS-CONF-2013-037

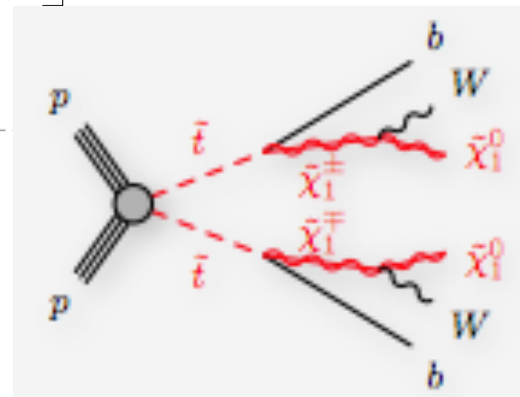


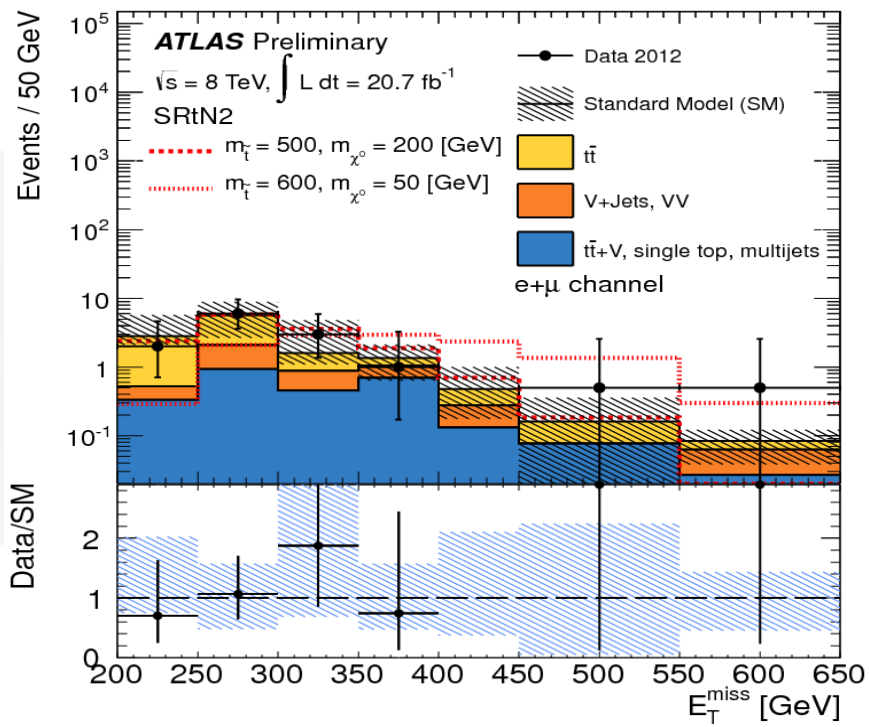


ATLAS-CONF-2013-024









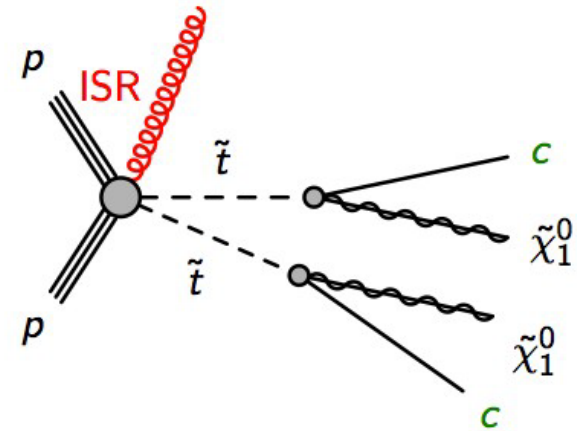
ATLAS-CONF-2013-068

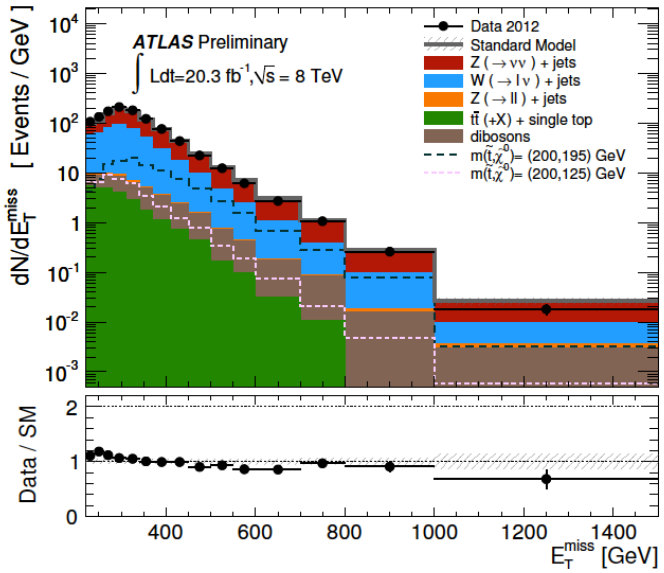
Direct Stop

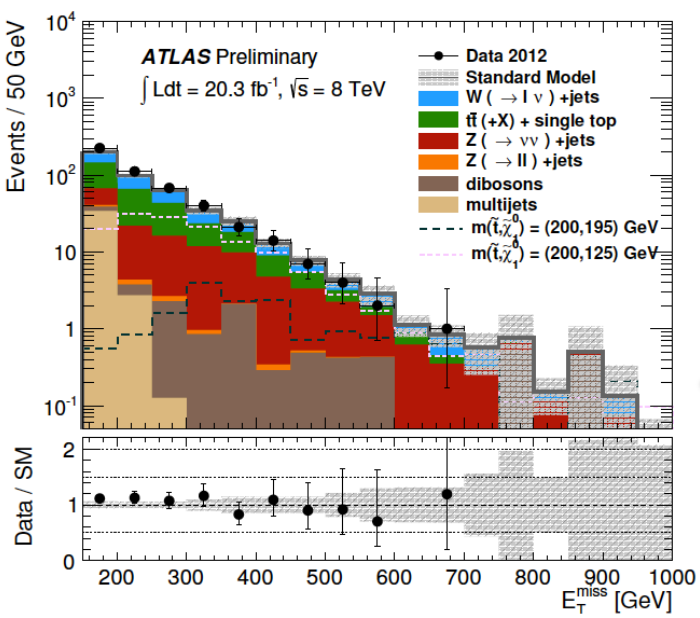
Two selections:

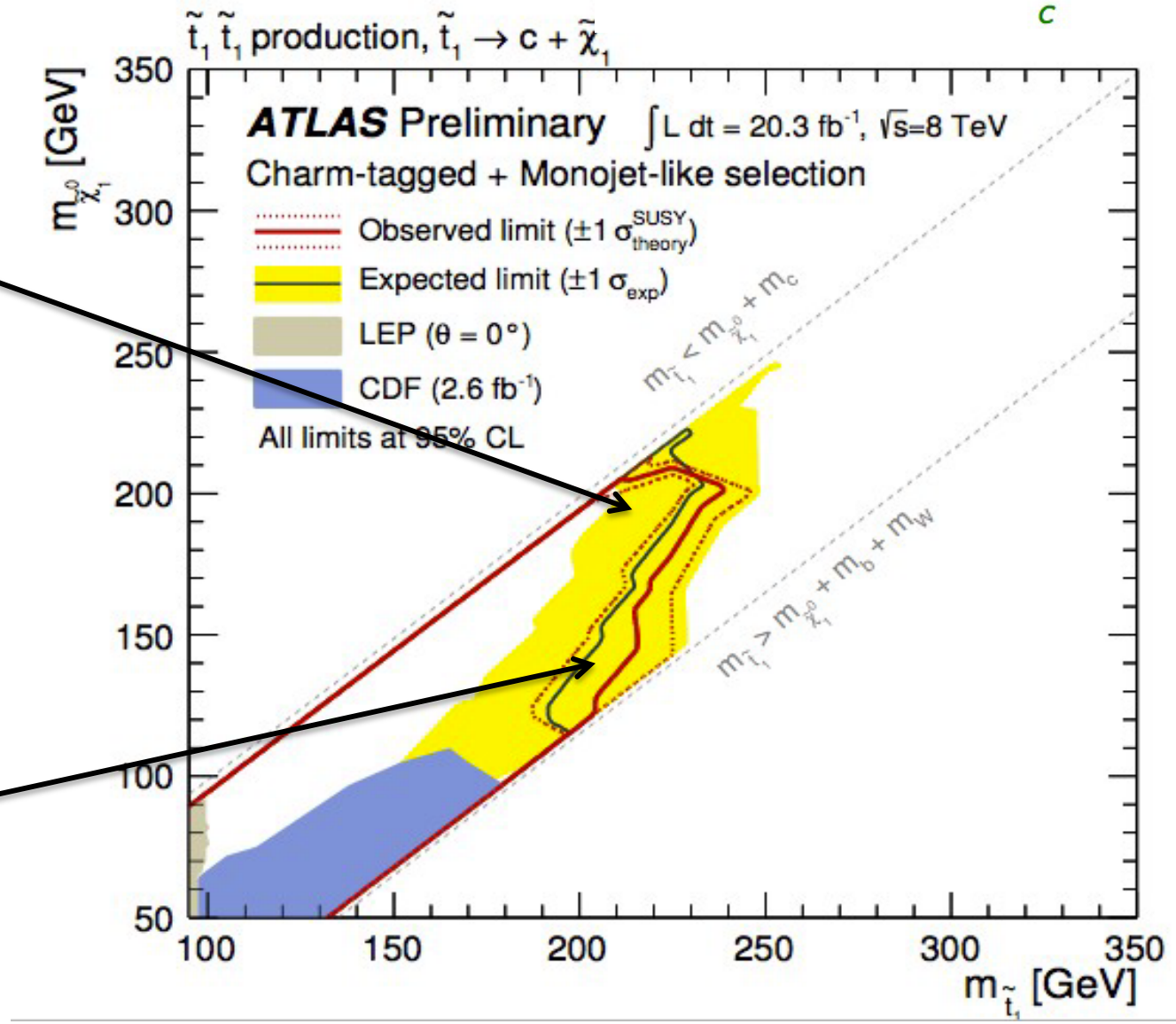
- **Monojet for compressed scenario**
- **Large E_T^{miss} and c-jets**

Very light stop



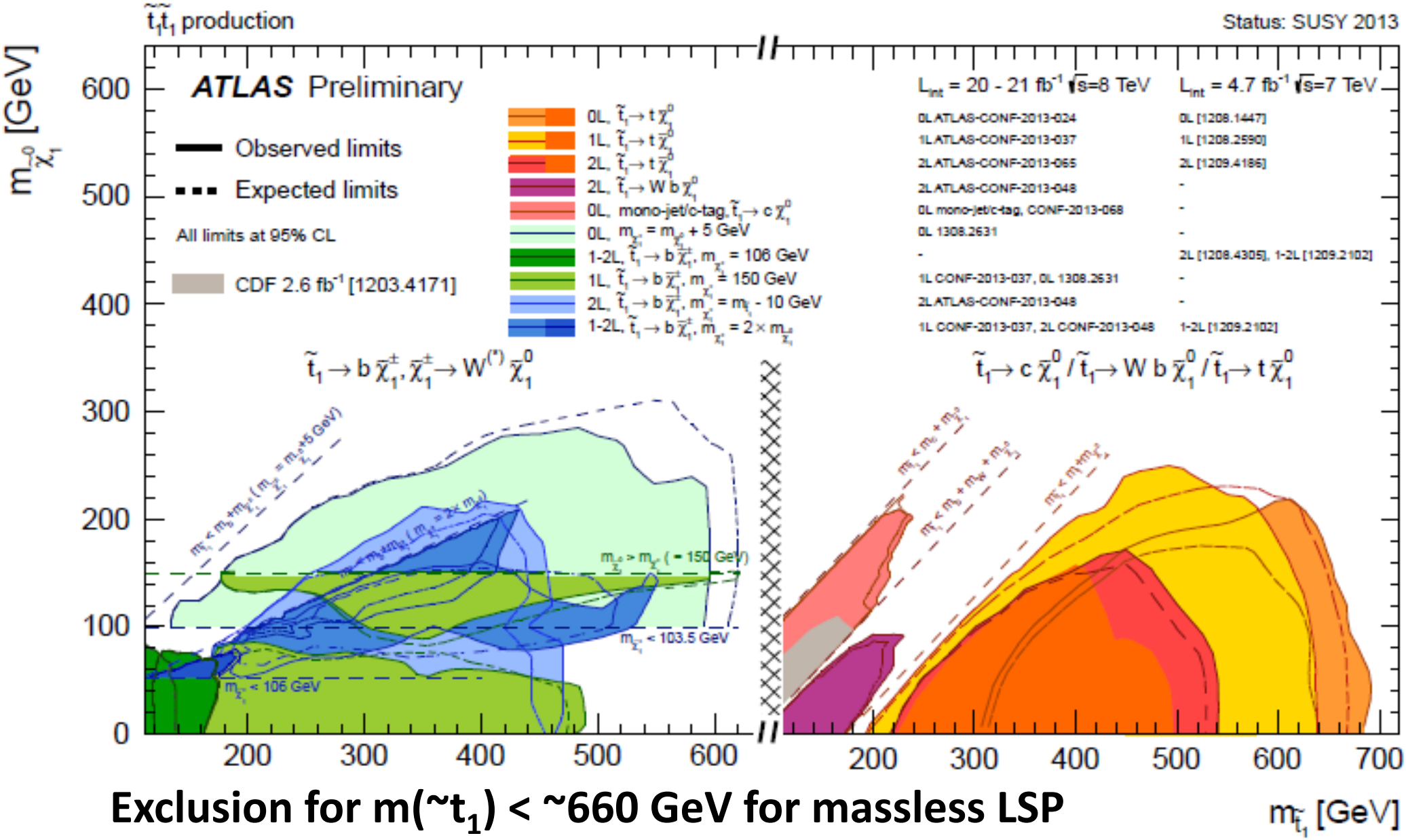






Summary Searches for Stop

(different mass hierarchies, simplified models)



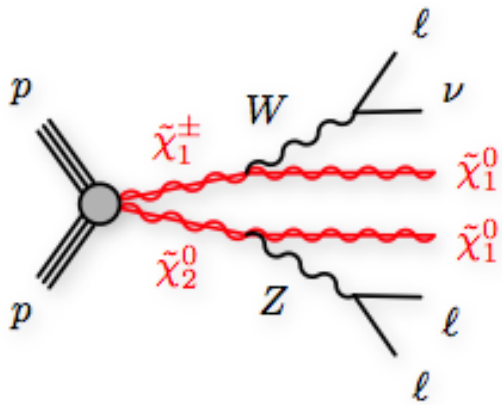
Exclusion for m(~t_1) < ~660 GeV for massless LSP

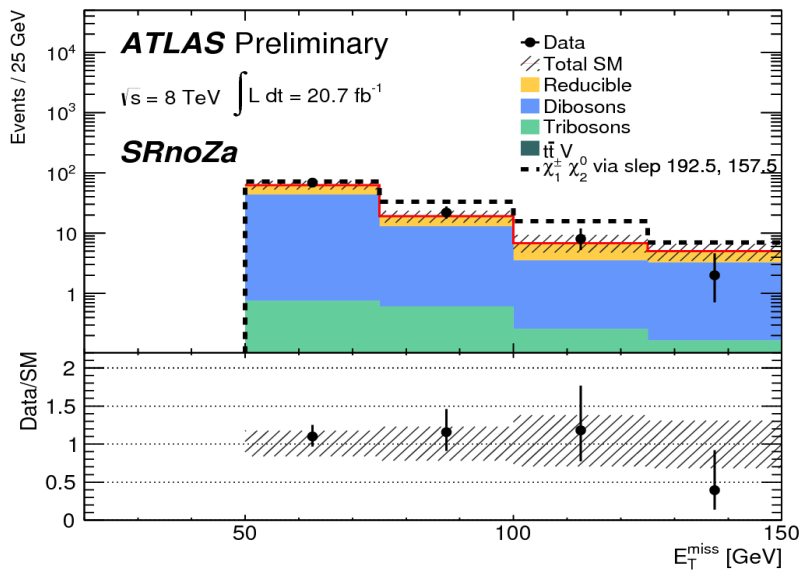
Exclusion up to m(LSP) ~250 GeV

ATLAS-CONF-2013-035

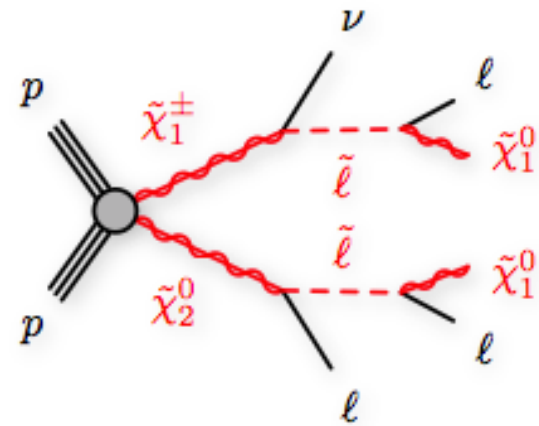
Chargino/Neutralino

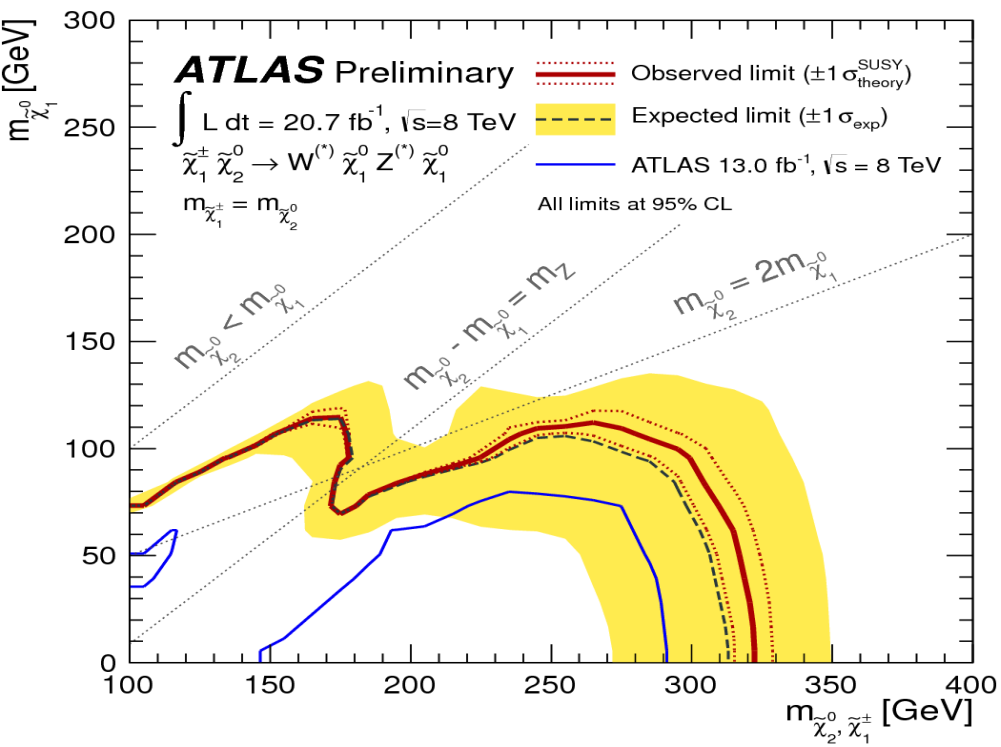
3 leptons + E_T^{miss}

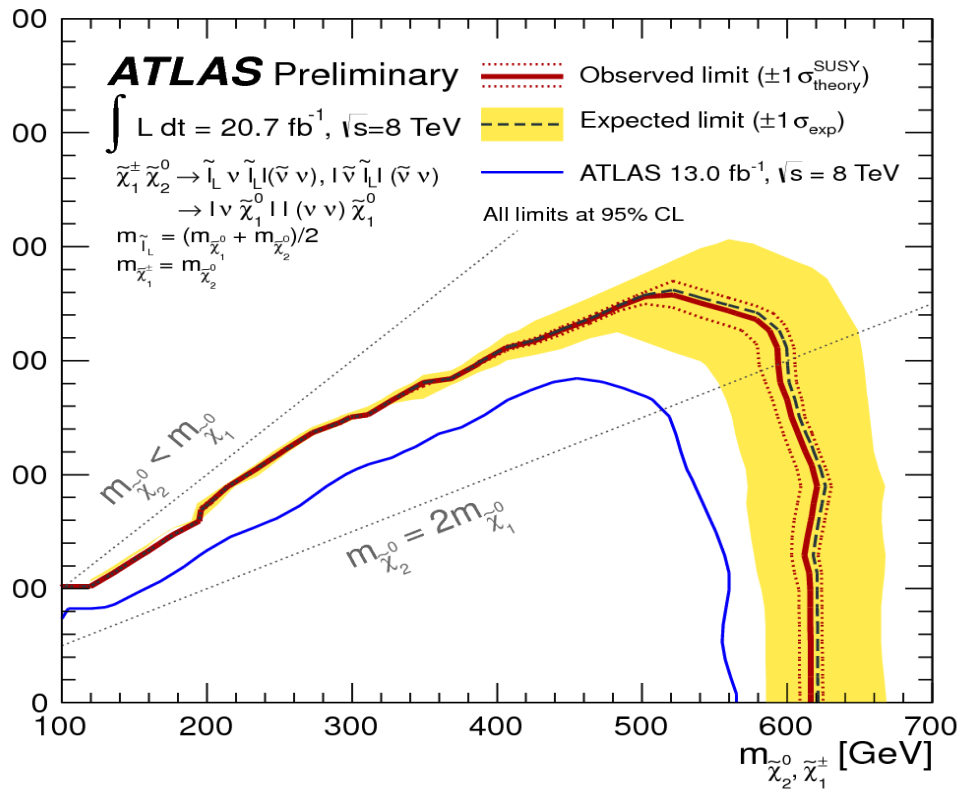




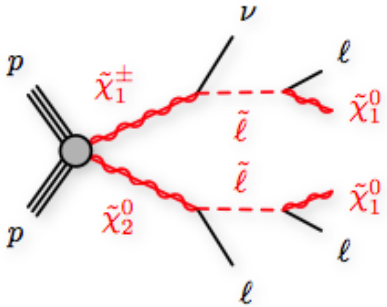
Background mostly WZ, ZZ followed by ttV and tribosons





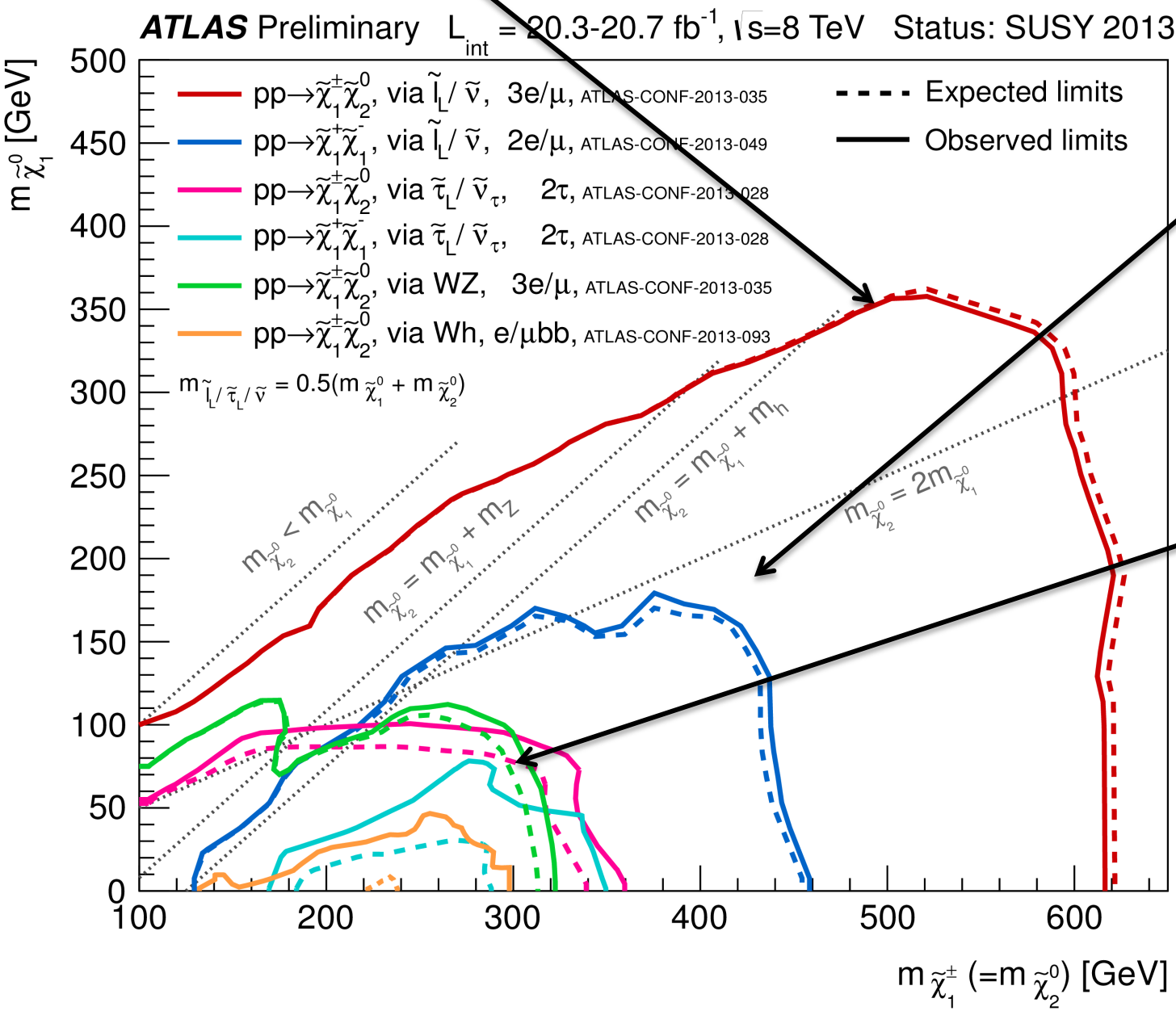


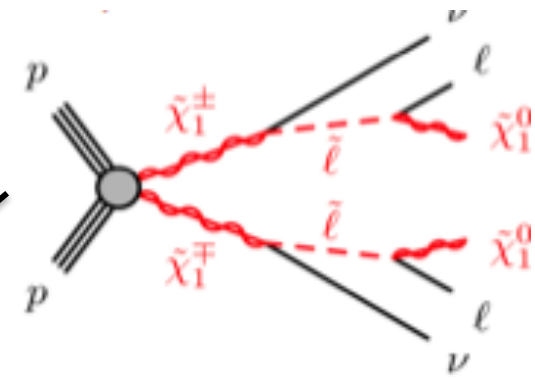
Electroweak production

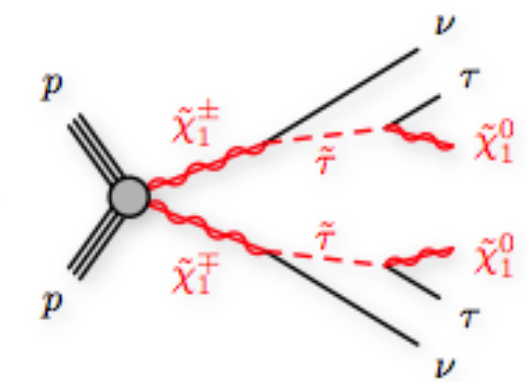


3 leptons + E_T^{miss}

2 leptons + E_T^{miss}







Chargino mass > ~600 GeV

Neutralino mass > ~250 GeV

Very sensitive to the details of the scenario considered

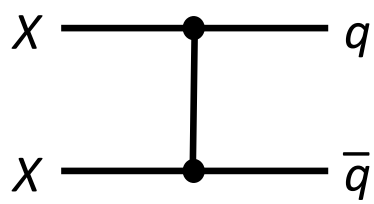
Search for Dark Matter

Generic Search for WIMPS..

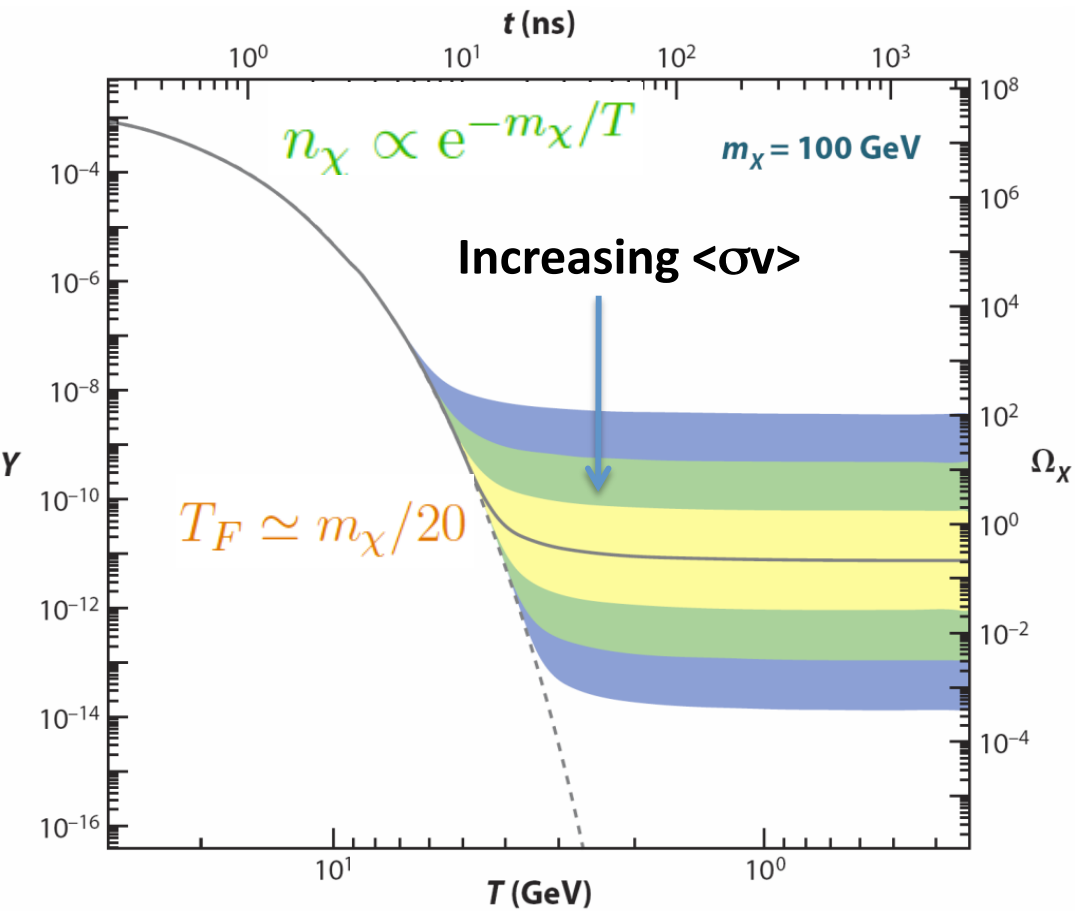
Mono-X final states…

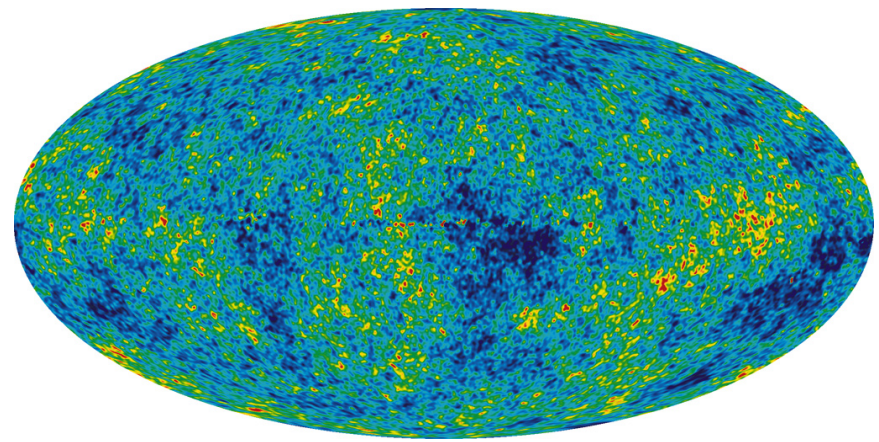
WMAP results

arXiv:1212.5226v2
(January 30th 2013)

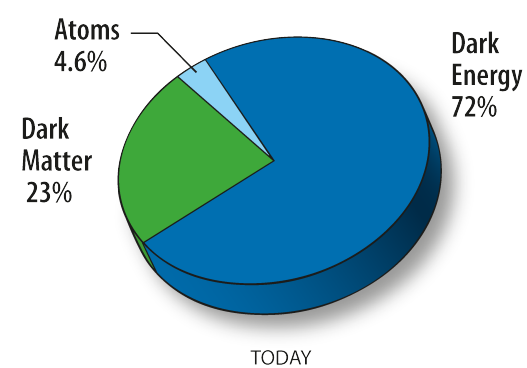


$$\Omega_X \propto \frac{1}{\langle \sigma v \rangle} \sim \frac{m_X^2}{g_X^4}$$





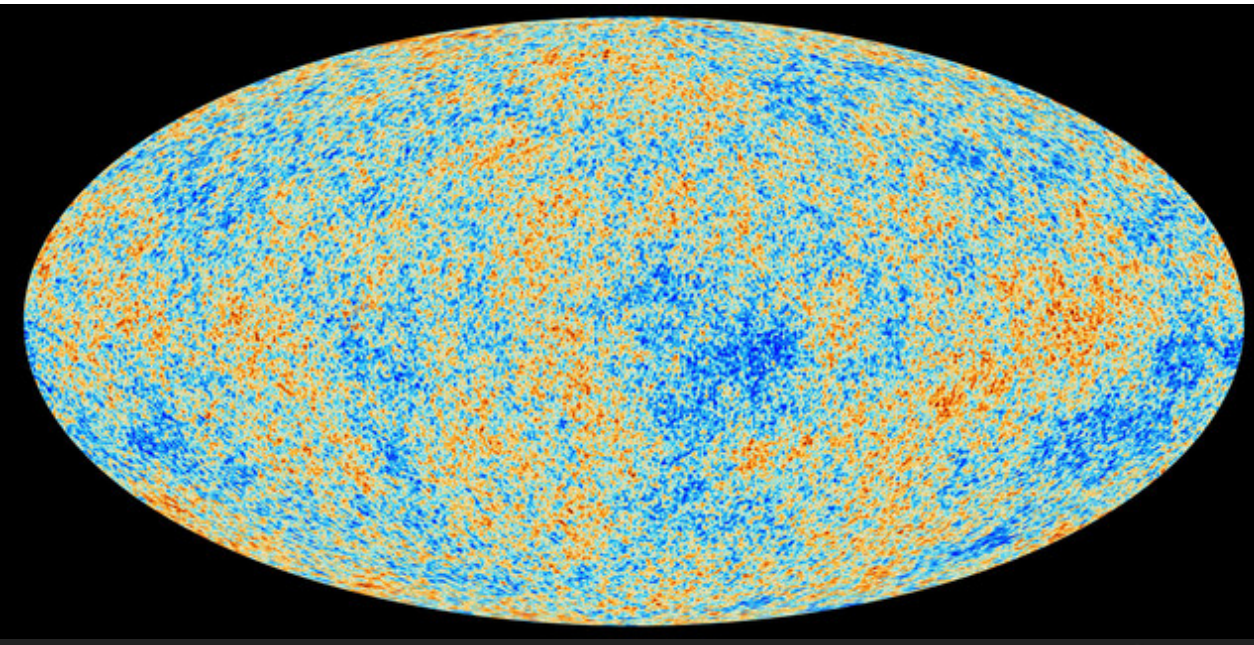
$$\Omega_\chi h^2 \simeq \frac{0.1\ \mathrm{pb} \cdot c}{\langle \sigma(\chi\chi \to \mathrm{SM}) v \rangle}$$



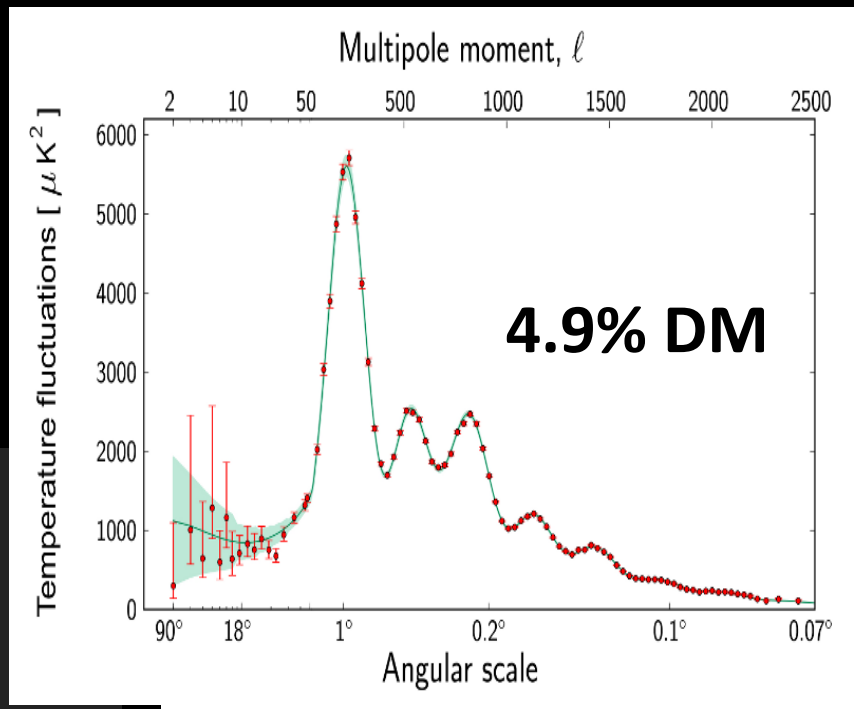
$$\langle \sigma(\chi\chi \to \mathrm{any}) v \rangle \simeq 3 \cdot 10^{-26} \mathrm{cm}^3 \mathrm{s}^{-1}$$

WMAP : $\Omega_{CMD} h^2 \sim 0.1$

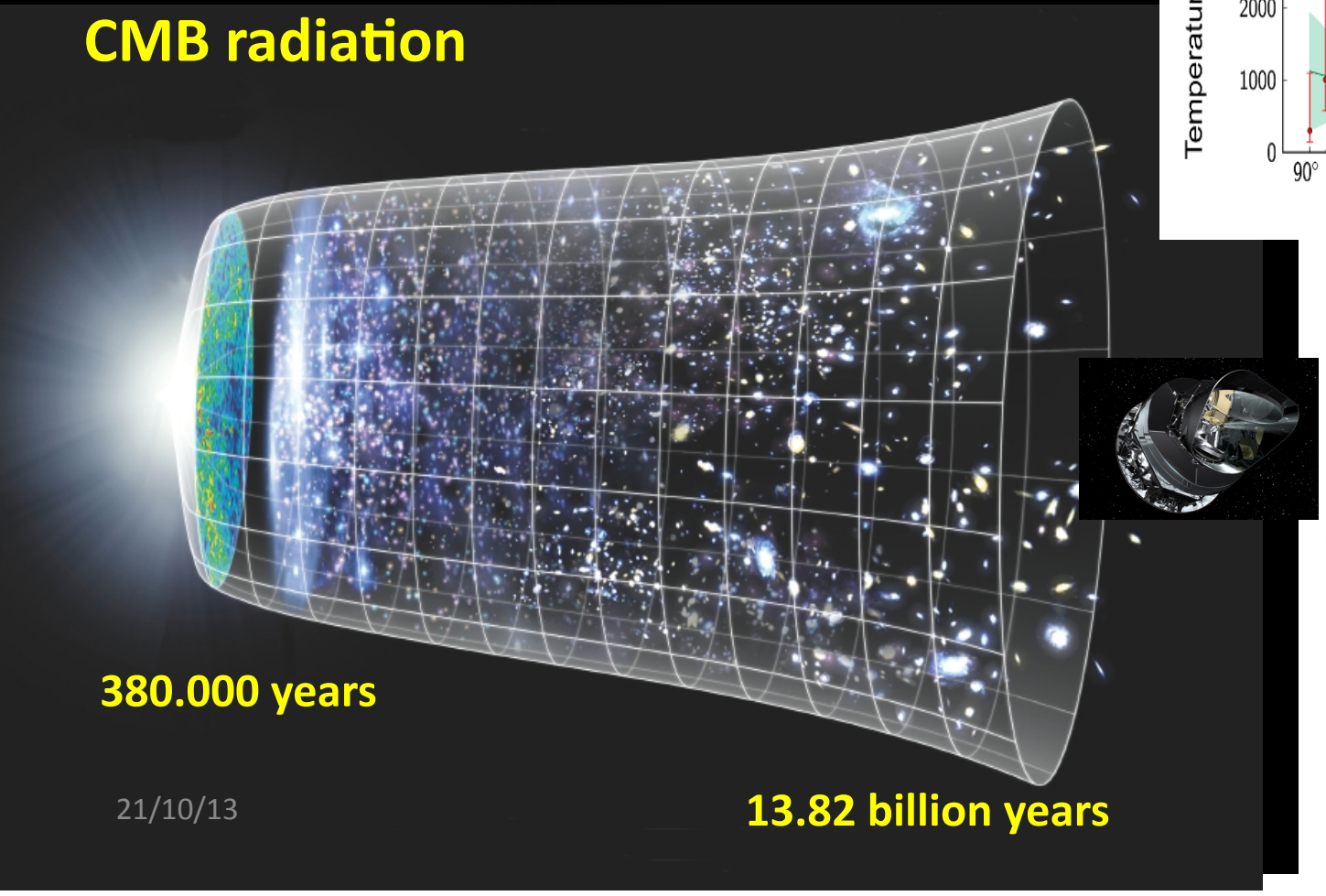
Weak scale for $\chi\chi$ annihilation cross section

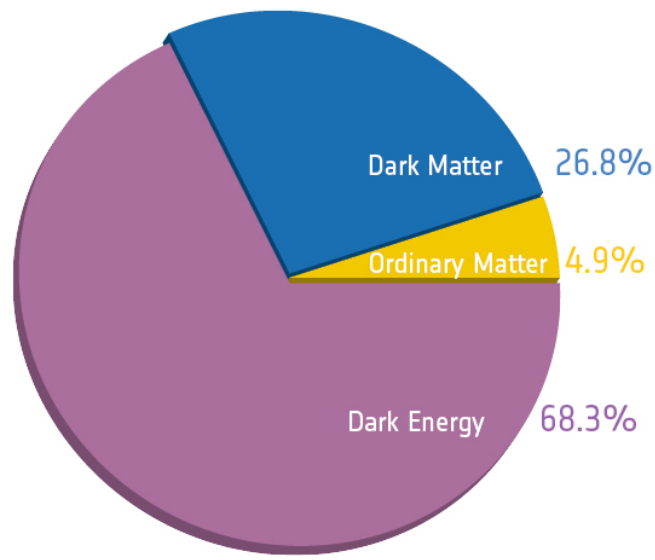


Planck (20 March 2013)
arXiv:1303.5062v1



CMB radiation





After Planck

Dark Matter Candidates

- Neutrinos ? ($\Omega_\nu h^2 < 0.0067$ @ 95%CL)
- Sterile Neutrinos
- Axions
- SUSY particles
  - Lightest neutralino
  - Sneutrinos
  - Gravitinos
  - Axinos
- KK states (UED)
- Wimpzillas
- ……
- ……

General requirements

- Electrically Neutral ("dark")
- Stable (lifetime larger than age of the Universe)
- Massive and Weakly interacting ($\Omega_{CDM} h^2 \sim 0.1$)

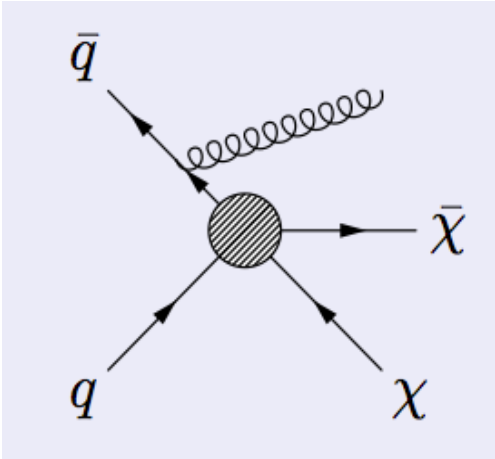
→WIMPS

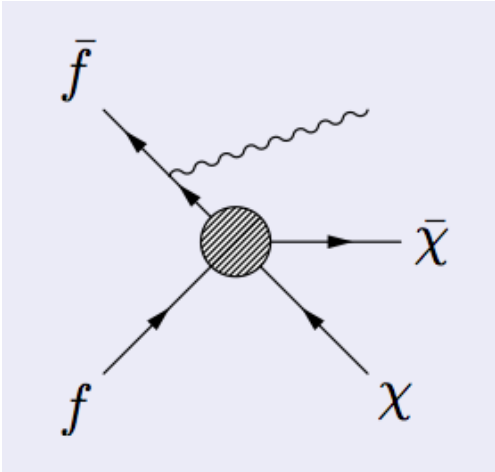
Note: No reason DM should be made out of a single component (neutrinos exist)

WIMP Pair Production at Colliders

At colliders (LHC) WIMPs can be produced in pairs leading to "nothing to detect" in the final state

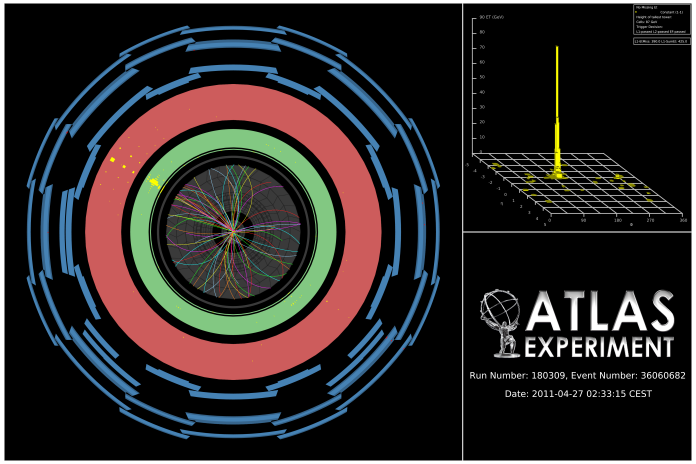
Such events are tagged via the presence of an energetic jet or a photon from initial state radiation

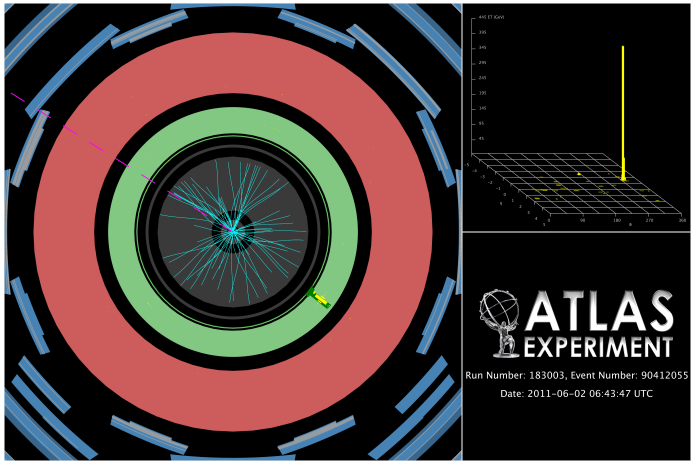




→Monojets and Monophotons

(complementary….but QCD wins in rate)

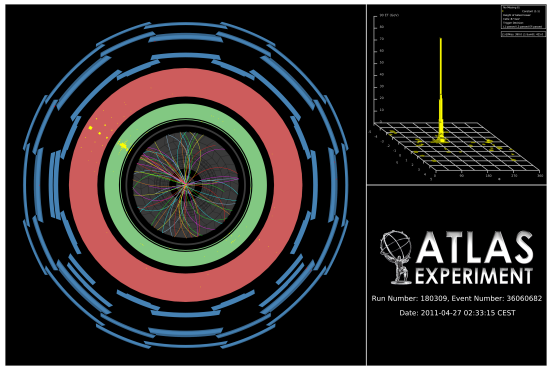


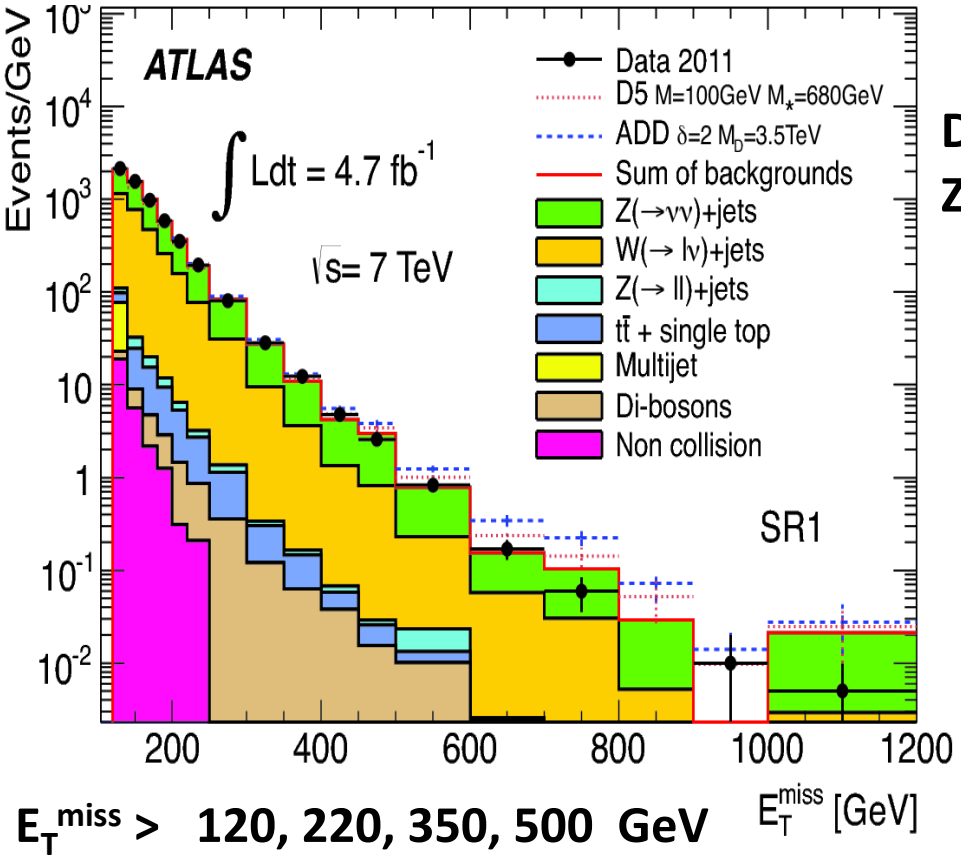


Rather spectacular and distinctive signature to search for new physics
(also relevant in searches for large extra spatial dimensions, etc…)

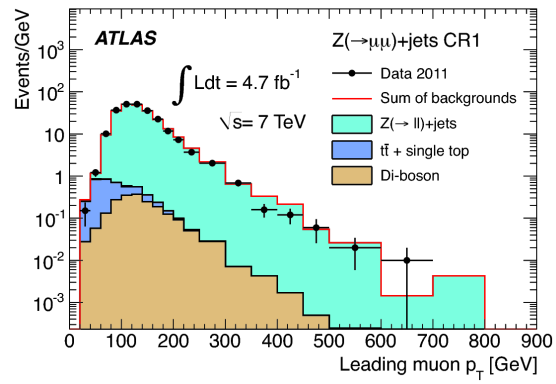
arXiv:1210.4491
(submitted to JHEP)

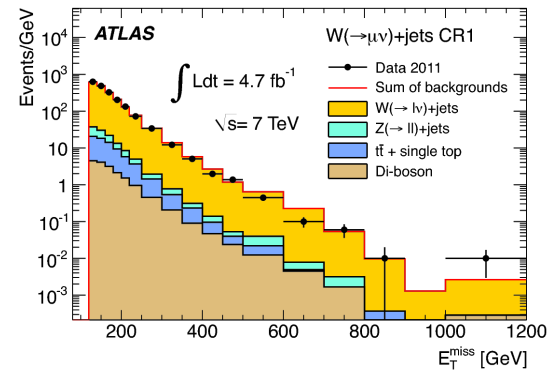
Monojet





Data driven estimation of the dominant Z+jets and W+jets background using control regions





	SR1	SR2	SR3	SR4
$Z \to \nu\bar{\nu}$+jets	63000 ± 2100	5300 ± 280	500 ± 40	58 ± 9
$W \to \tau\nu$+jets	31400 ± 1000	1853 ± 81	133 ± 13	13 ± 3
$W \to e\nu$+jets	14600 ± 500	679 ± 43	40 ± 8	5 ± 2
$W \to \mu\nu$+jets	11100 ± 600	704 ± 60	55 ± 6	6 ± 1
$t\bar{t}$ + single t	1240 ± 250	57 ± 12	4 ± 1	-
Multijets	1100 ± 900	64 ± 64	8^{+9}_{-8}	-
Non-coll. Background	575 ± 83	25 ± 13	-	-
$Z/\gamma^* \to \tau\tau$+jets	421 ± 25	15 ± 2	2 ± 1	-
Di-bosons	302 ± 61	29 ± 5	5 ± 1	1 ± 1
$Z/\gamma^* \to \mu\mu$+jets	204 ± 19	8 ± 4	-	-
Total Background	124000 ± 4000	8800 ± 400	750 ± 60	83 ± 14
Events in Data (4.7 fb^{-1})	124703	8631	785	77

E_T^{miss} > 120, 220, 350, 500 GeV
p_T (j1) > 120, 220, 350, 500 GeV
$N_{jet}(p_T$ > 30 GeV) < 3

$\Delta\phi$ (E_T^{miss}, j2) > 0.5
Lepton vetoes

Good agreement with SM

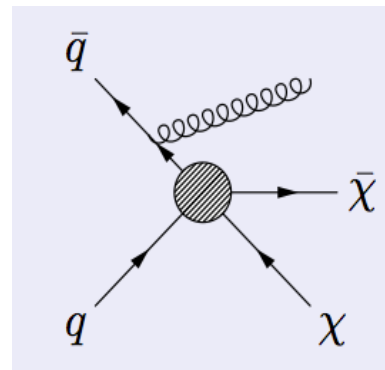
Effective Theory

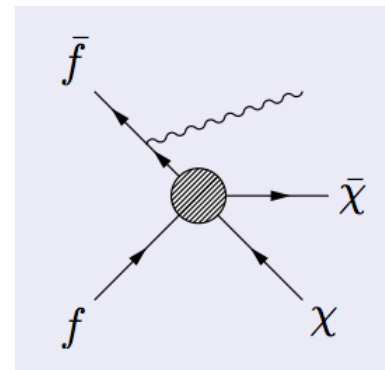
(model independent approach)

Effective Lagrangian approach (contact interaction) with parameters M_* and m_χ

$$M_*^2 \sim M^2/g_1 g_2$$

assuming the interaction is mediated by a heavy particle with mass M and couplings g_1 and g_2





Different operators are considered with different structures and here χ will be taken as Dirac fermions

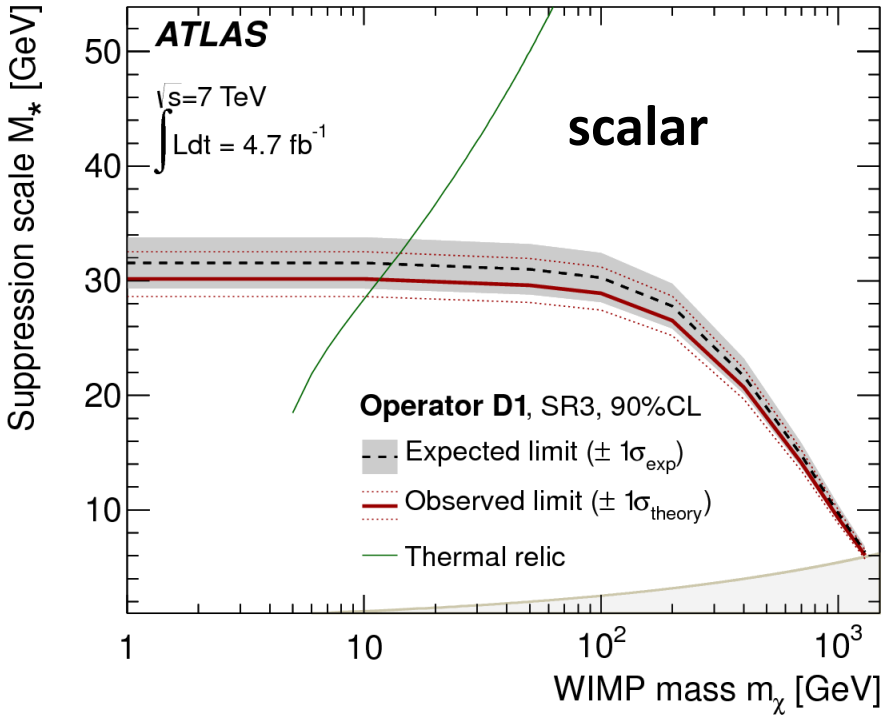
Name	Initial state	Type	Operator
D1	qq	scalar	$\frac{m_q}{M_\star^3}\bar{\chi}\chi\bar{q}q$
D5	qq	vector	$\frac{1}{M_\star^2}\bar{\chi}\gamma^\mu\chi\bar{q}\gamma_\mu q$
D8	qq	axial-vector	$\frac{1}{M_\star^2}\bar{\chi}\gamma^\mu\gamma^5\chi\bar{q}\gamma_\mu\gamma^5 q$
D9	qq	tensor	$\frac{1}{M_\star^2}\bar{\chi}\sigma^{\mu\nu}\chi\bar{q}\sigma_{\mu\nu}q$
D11	gg	scalar	$\frac{1}{4M_\star^3}\bar{\chi}\chi\alpha_s(G^a_{\mu\nu})^2$

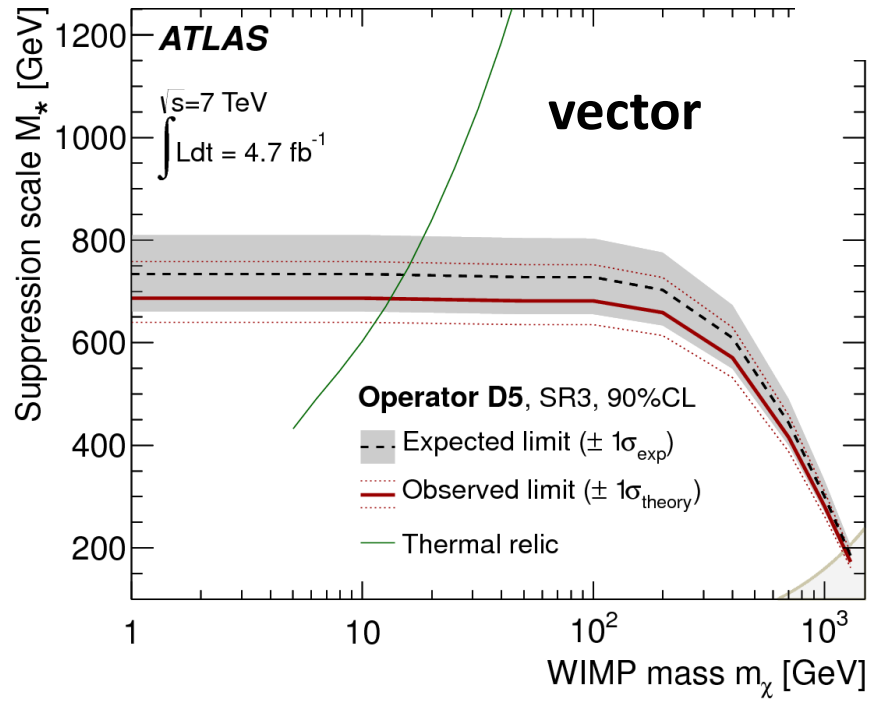
Important note:

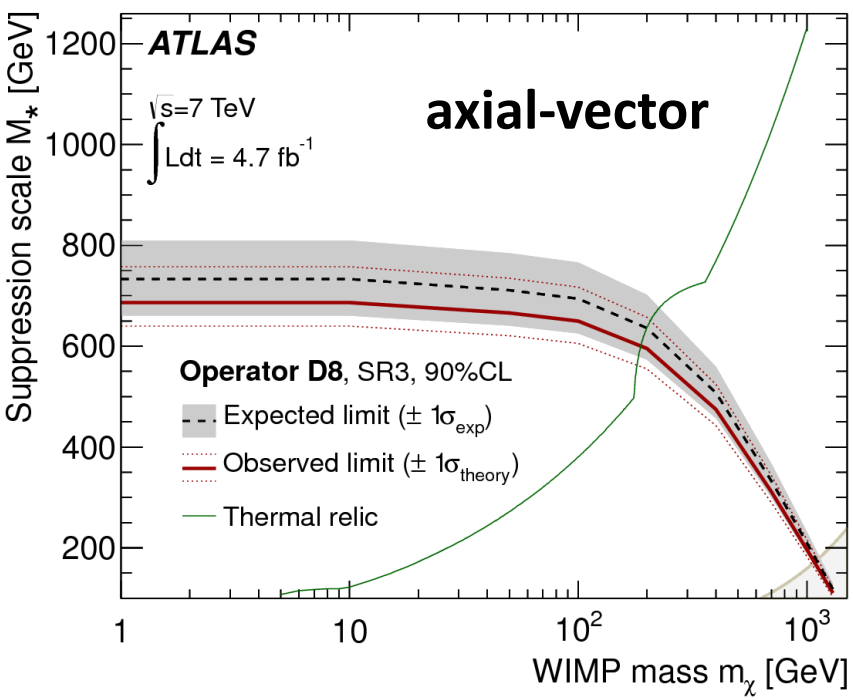
Not clear whether the effective approach under- or over-estimates the cross sections since this depends on the details of the unknown UV limit of the theory

Strictly speaking theory only applicable when M is much larger than the energy scale present in the reaction [$Q^2 \ll (4\pi M_*)^2$]

Limits on WIMP production



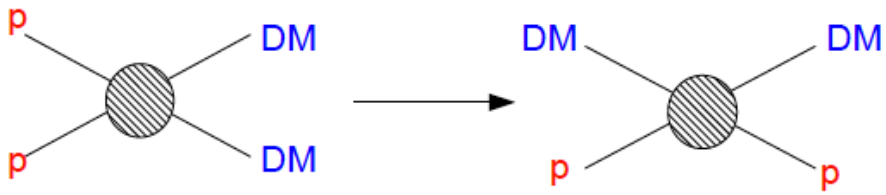




90% CL on the visible cross sections for new physics are translated into limits on M_* as a function of the WIMP mass for the different operators

Line indicates the values for M_* and m_χ leading to the proper abundance (WMAP)

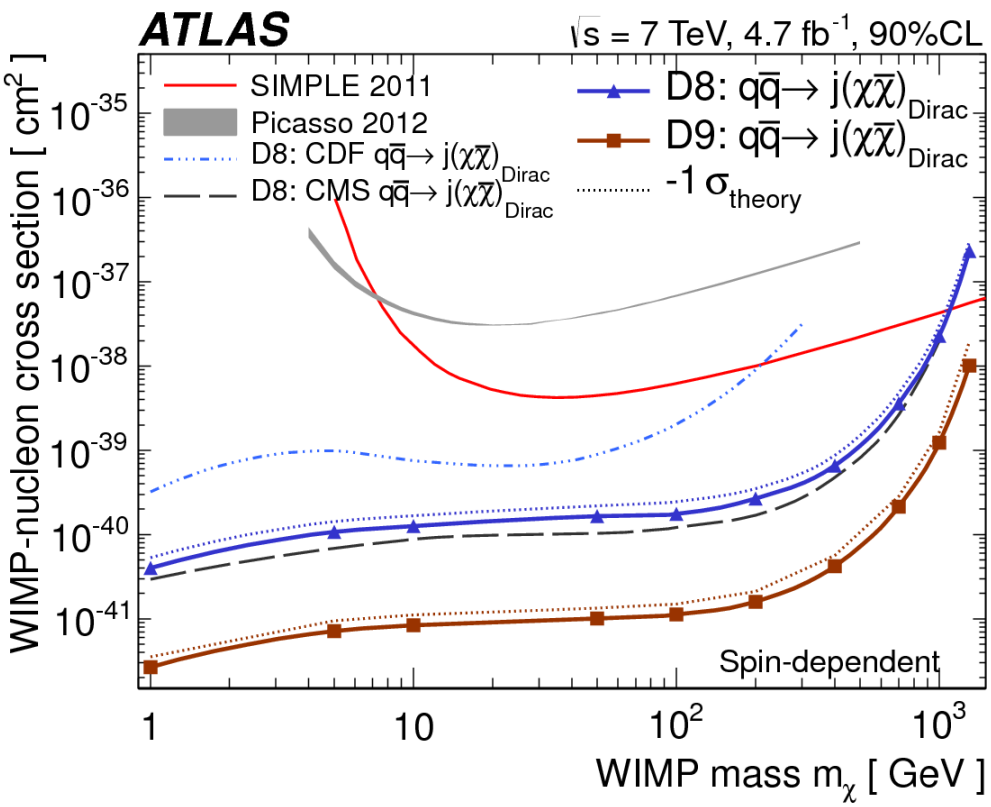
WIMP-nucleon cross section

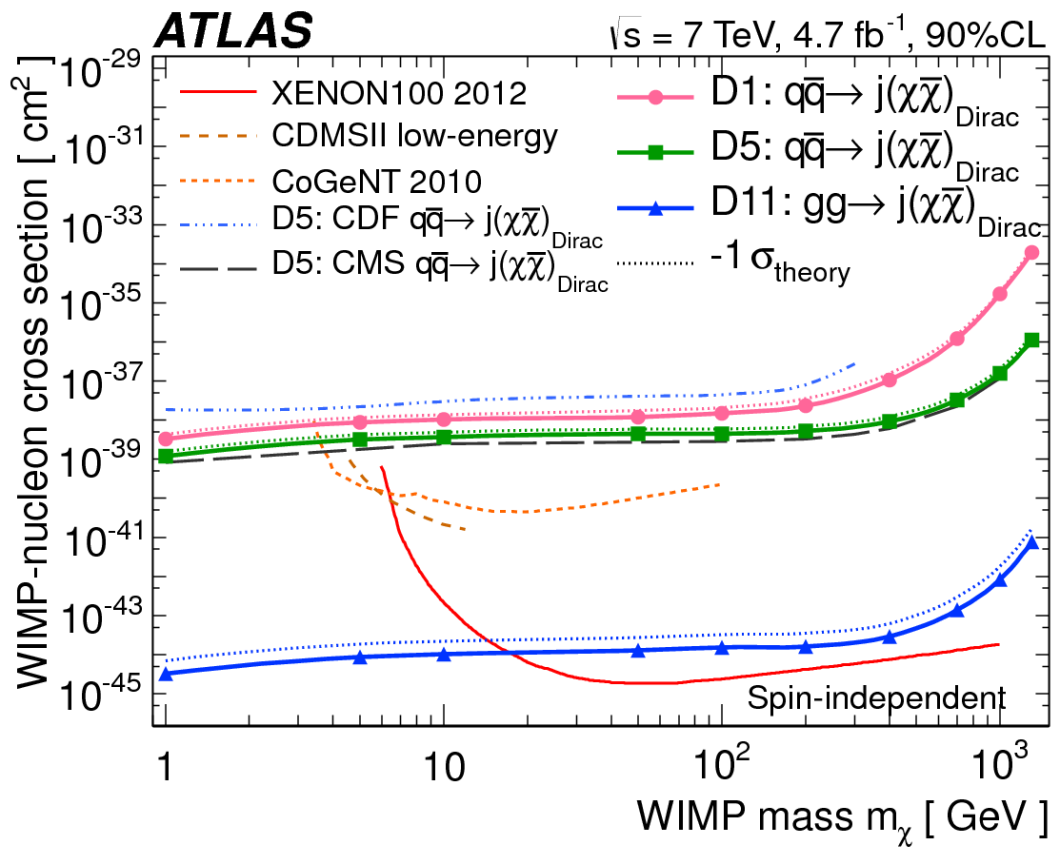


$$\sigma_0^{D1} = 1.60 \times 10^{-37}\mathrm{cm}^2 \left(\frac{\mu_\chi}{1\mathrm{GeV}}\right)^2 \left(\frac{20\mathrm{GeV}}{M_*}\right)^6,$$

$$\sigma_0^{D5,C3} = 1.38 \times 10^{-37}\mathrm{cm}^2 \left(\frac{\mu_\chi}{1\mathrm{GeV}}\right)^2 \left(\frac{300\mathrm{GeV}}{M_*}\right)^4,$$

Different operators contribute either to spin-dependent or spin-independent WIMP-nucleon cross sections

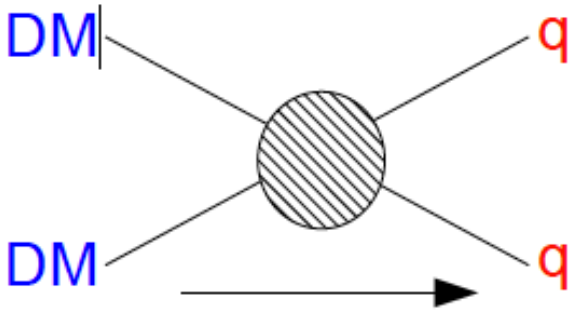




Within the assumption of the validity of the effective theory **the LHC results are competitive to direct detector experiments (particularly relevant at m_χ < 10 GeV)**

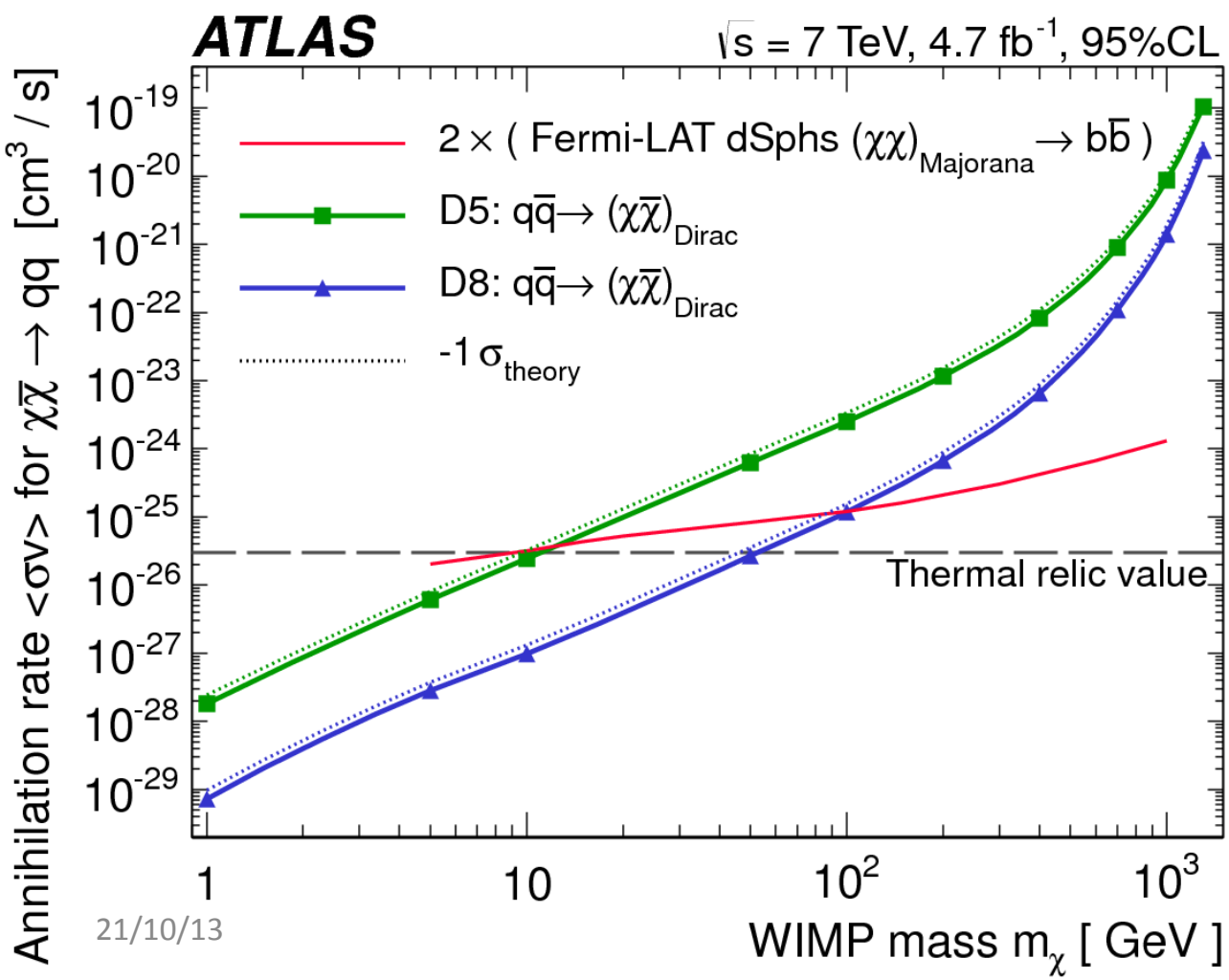
Large sensitivity in case of D11 (gg initiated)

WIMP-WIMP annihilation



$$\sigma_V v_{\rm rel} = \frac{1}{16\pi\Lambda^4}\sum_q \sqrt{1-\frac{m_q^2}{m_\chi^2}}\left(24(2m_\chi^2+m_q^2)+\frac{8m_\chi^4-4m_\chi^2 m_q^2+5m_q^4}{m_\chi^2-m_q^2}\,v_{\rm rel}^2\right),$$

$$\sigma_A v_{\rm rel} = \frac{1}{16\pi\Lambda^4}\sum_q \sqrt{1-\frac{m_q^2}{m_\chi^2}}\left(24m_q^2+\frac{8m_\chi^4-22m_\chi^2 m_q^2+17m_q^4}{m_\chi^2-m_q^2}\,v_{\rm rel}^2\right).$$



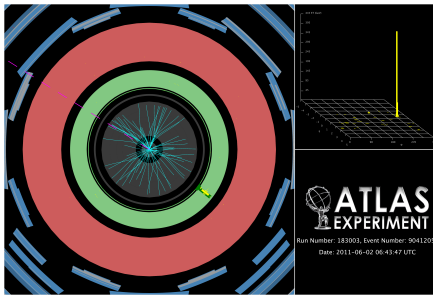
Results can be expressed in terms of limits on WIMP-WIMP annihilation cross section (assuming the interaction is dominated by a given operator)

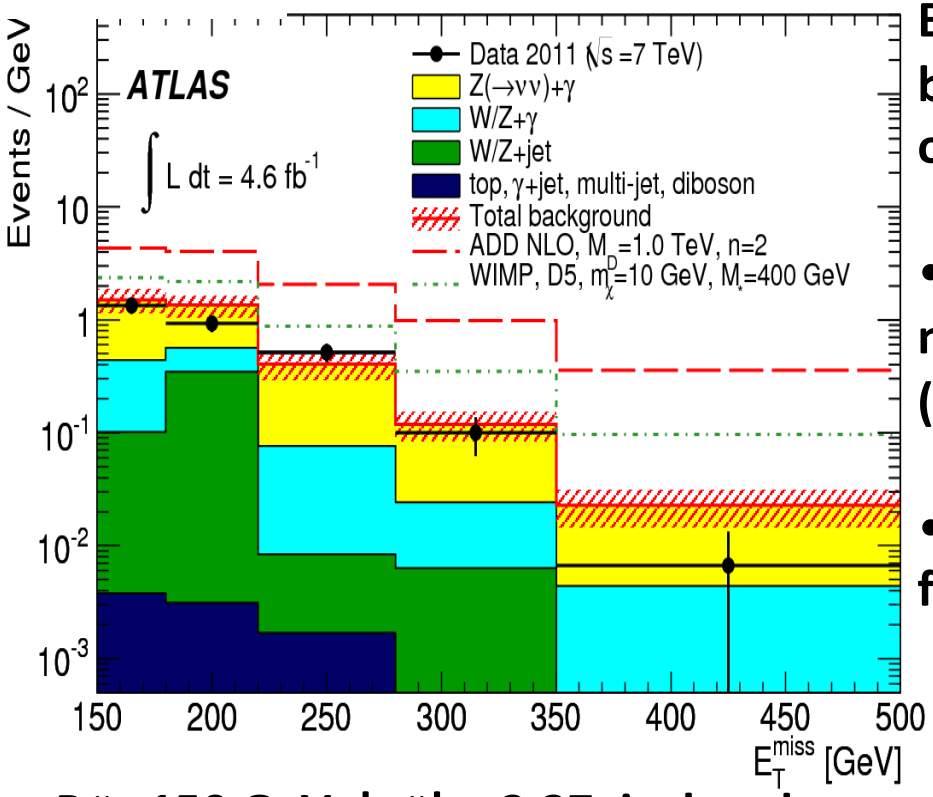
For a given operator, WIMPS are required to have a minimum mass to meet the annihilation rate (and therefore the proper relic abundance)

Alternatively, for light WIMPS more than a single process is needed

Mono-photons

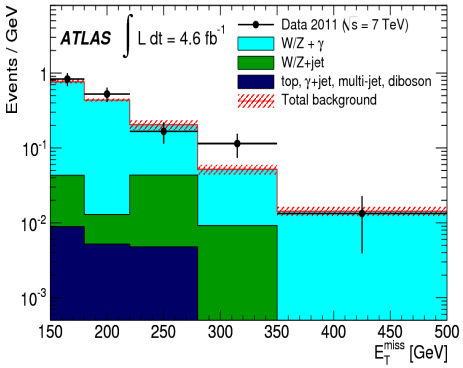
Phys. Rev. Lett 110, 011802 (2013)





Background dominated by Z/W+γ followed by contributions with jets faking photons plus other small contributions

- **Z/W+γ contributions from MC normalized in control regions ($\gamma + \mu + E_t^{miss}$ control sample)**



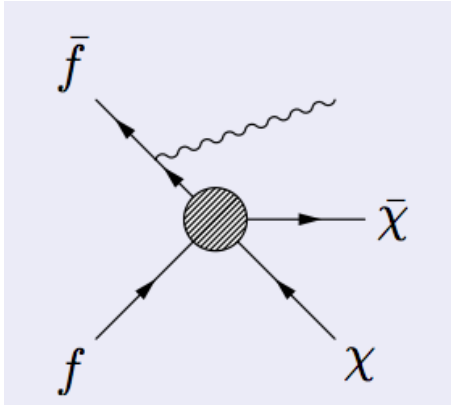
- **Jet and electron fakes fully data driven**

P_t^{γ} >150 GeV, $|\eta^{\gamma}|$ < 2.37, isolated
E_t^{miss} > 150 GeV
N^{jet} < 2 (p_T > 30 GeV)
$\Delta\phi$ (γ, E_T^{miss}) >0.4, $\Delta\phi$ (jet, E_T^{miss}) >0.4
Veto on leptons

Good agreement with SM

Background source	Prediction	± (stat.)	± (syst.)
$Z(\to \nu\bar{\nu}) + \gamma$	93	± 16	± 8
$Z/\gamma^*(\to \ell^+\ell^-) + \gamma$	0.4	± 0.2	± 0.1
$W(\to \ell\nu) + \gamma$	24	± 5	± 2
W/Z + jets	18	–	± 6
Top	0.07	± 0.07	± 0.01
$WW, WZ, ZZ, \gamma\gamma$	0.3	± 0.1	± 0.1
γ+jets and multi-jet	1.0	–	± 0.5
Total background	137	± 18	± 9
Events in data (4.6 fb^{-1})	116		

90% CL Limits on M_*



A x ε in the range between 11% (D1) and 23% (D9) (due to different E_t^{miss} spectrum)

Name	Initial state	Type	Operator
D1	qq	scalar	$\frac{m_q}{M_*^3}\bar{\chi}\chi\bar{q}q$
D5	qq	vector	$\frac{1}{M_*^2}\bar{\chi}\gamma^\mu\chi\bar{q}\gamma_\mu q$
D8	qq	axial-vector	$\frac{1}{M_*^2}\bar{\chi}\gamma^\mu\gamma^5\chi\bar{q}\gamma_\mu\gamma^5 q$
D9	qq	tensor	$\frac{1}{M_*^2}\bar{\chi}\sigma^{\mu\nu}\chi\bar{q}\sigma_{\mu\nu}q$
D11	gg	scalar	$\frac{1}{4M_*^3}\bar{\chi}\chi\alpha_s(G^a_{\mu\nu})^2$

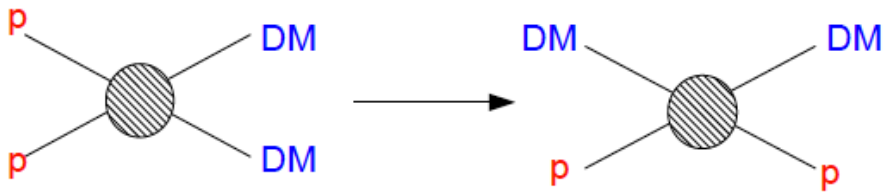
On signal yields:
Experimental uncertainties (7%)
Theoretical uncertainties
ISR/FSR (4 % – 10%)
PDFs (5% - 30%)
$\mu_{R,F}$ (8%)

$$\sigma^{D1} \propto (1/M^*)^6$$
$$\sigma^{D5,D8,D9} \propto (1/M^*)^4$$

WIMP MASS	M_* in D1 (GeV)	M_* in D5 (GeV)	M_* in D8 (GeV)	M_* in D9 (GeV)
1 GeV	> 31	> 585	> 585	> 794
1.3 TeV	> 5	> 156	> 100	> 188

Results are translated *into 90% CL limits* on M_* for different operators and as a function of WIMP mass (RED: EFT compromised)

WIMP-nucleon cross section

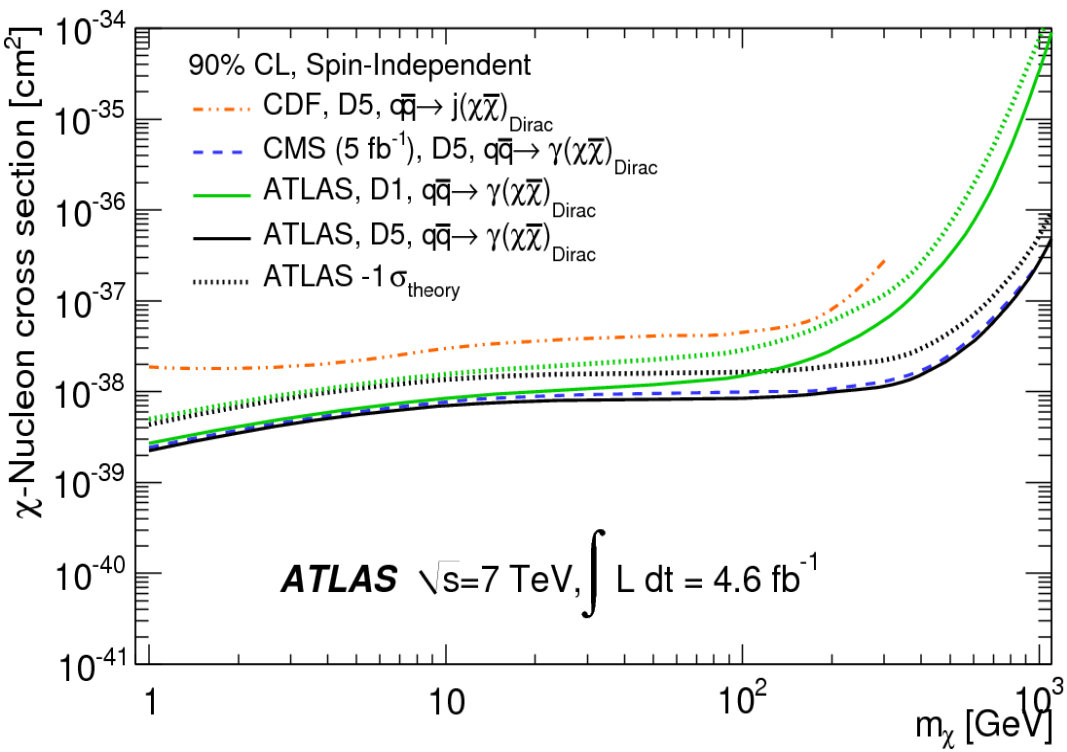


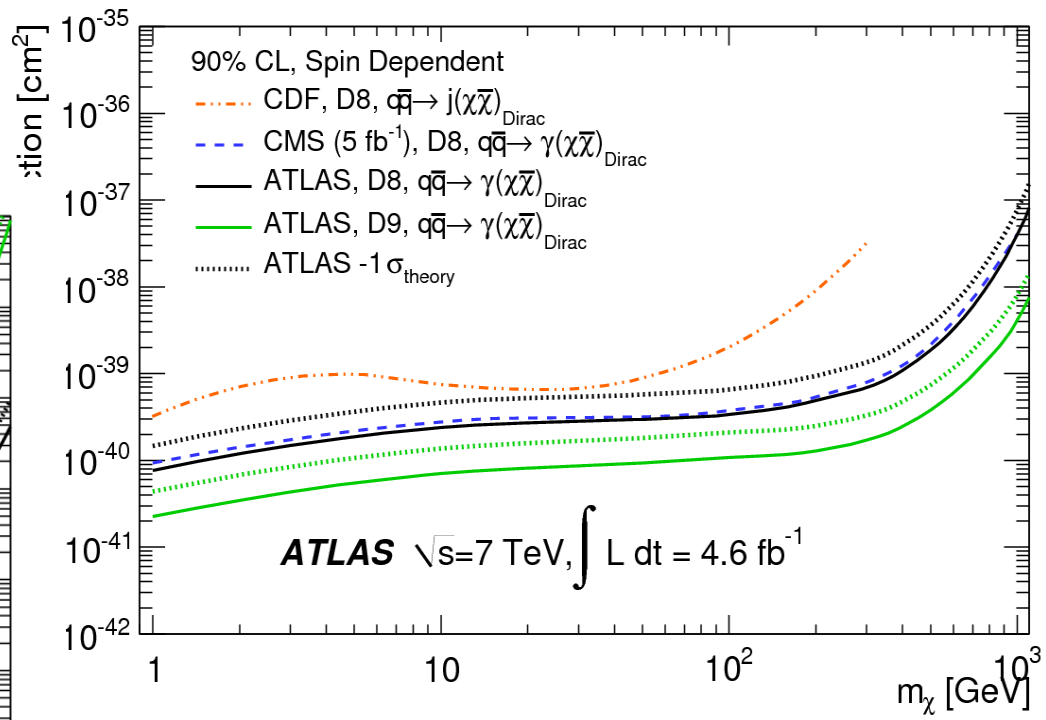
$$\sigma^{D1} = 1.60 \times 10^{-37} \mathrm{cm}^2 \left(\frac{\mu_\chi}{1\ \mathrm{GeV}}\right)^2 \left(\frac{20\ GeV}{M^*}\right)^6$$

$$\sigma^{D5} = 1.38 \times 10^{-37} \mathrm{cm}^2 \left(\frac{\mu_\chi}{1\ \mathrm{GeV}}\right)^2 \left(\frac{300\ GeV}{M^*}\right)^4$$

$$\sigma^{D8,D9} = 4.7 \times 10^{-39} \mathrm{cm}^2 \left(\frac{\mu_\chi}{1\ \mathrm{GeV}}\right)^2 \left(\frac{300\ GeV}{M^*}\right)^4$$

Different operators contribute either to spin-dependent or spin-independent WIMP-nucleon cross sections

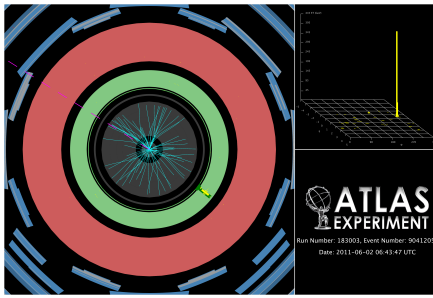


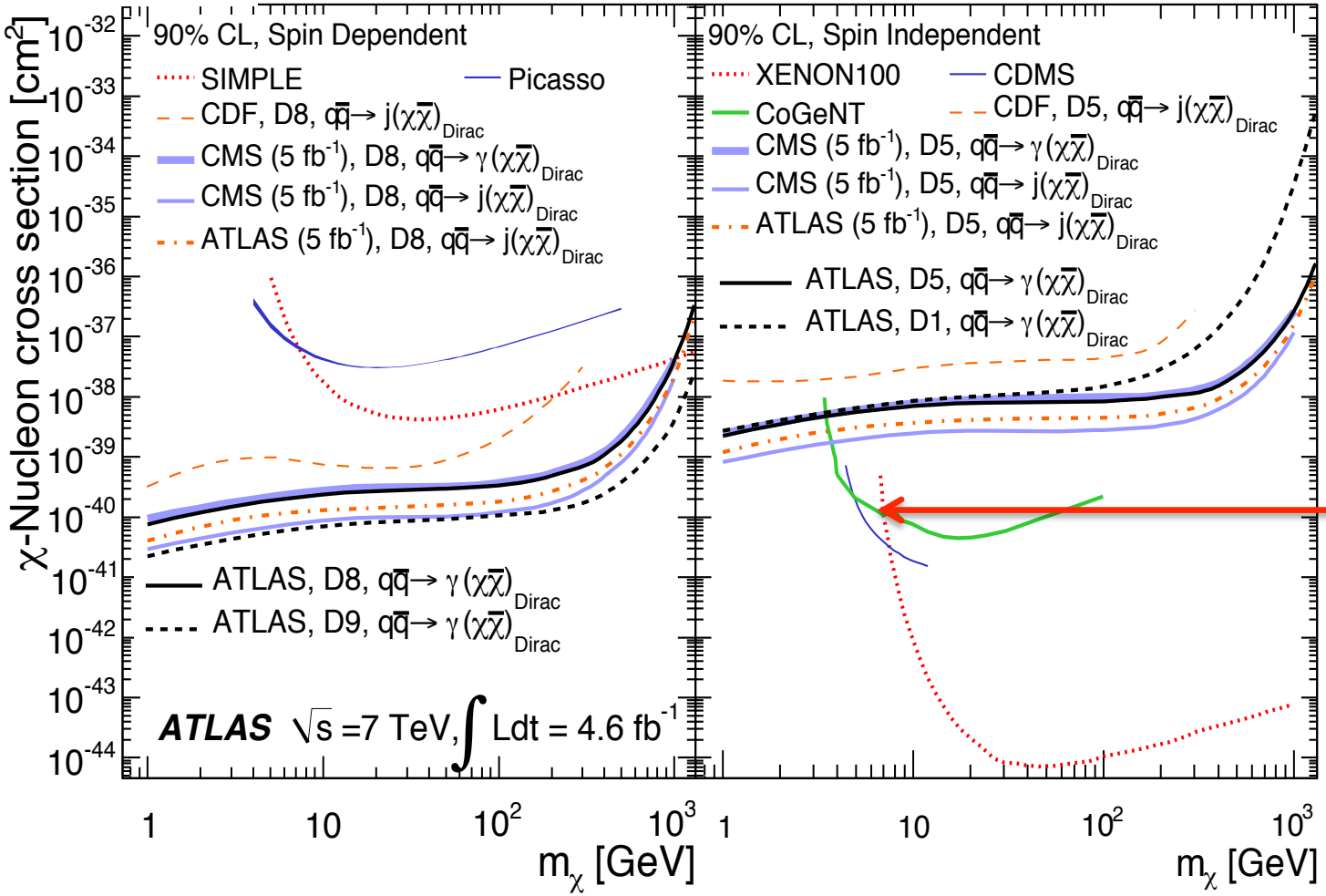


Within the assumption of the validity of the effective theory **the LHC results complement direct detection searches (particularly relevant at m_χ < 10 GeV)**

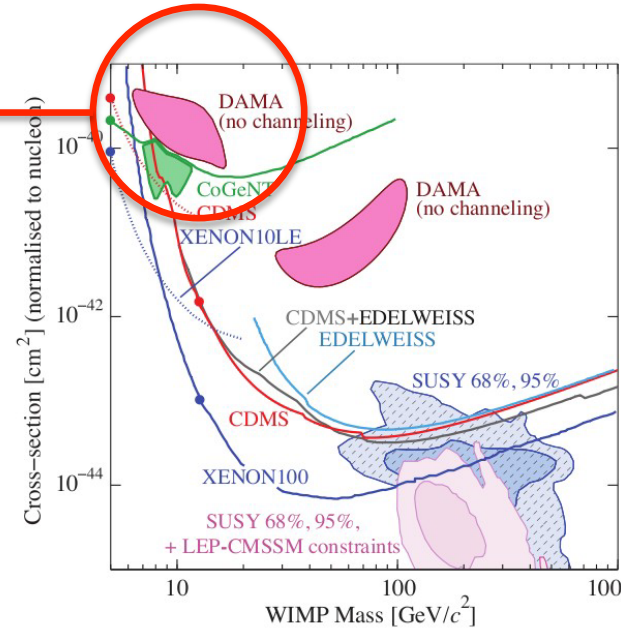
WIMPS

(monojets & monophotons)





Not enough sensitivity yet to exclude/confirm the CoGeNT/DAMA excess at m_χ~10 GeV in case the of D1/D5 models



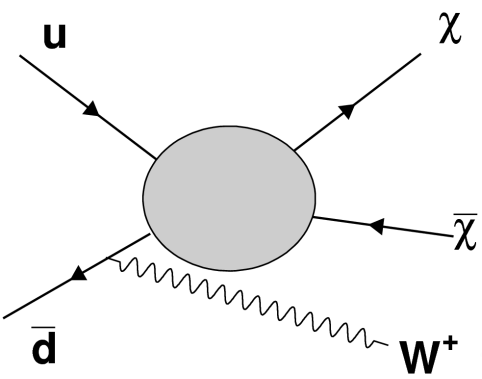
Very significant improvement on limits compared to Tevatron

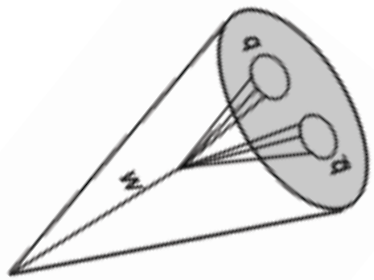
For m_χ < 100 GeV : WIMPS-nucleon cross sections above

3 x10^{-40} cm^2 (10^{-39} cm^2) are excluded for spin –dependent (spin-independent) operators

Mono-W/Z

ATLAS-CONF-2013-073

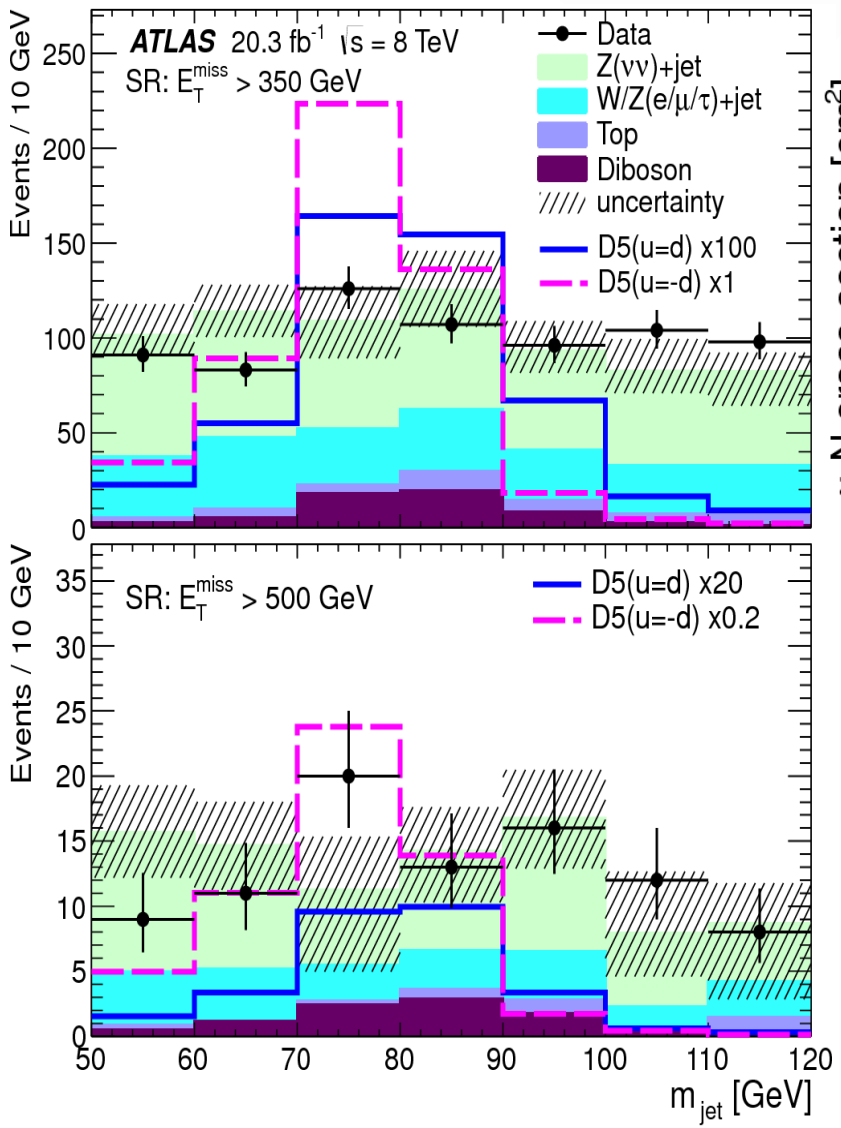


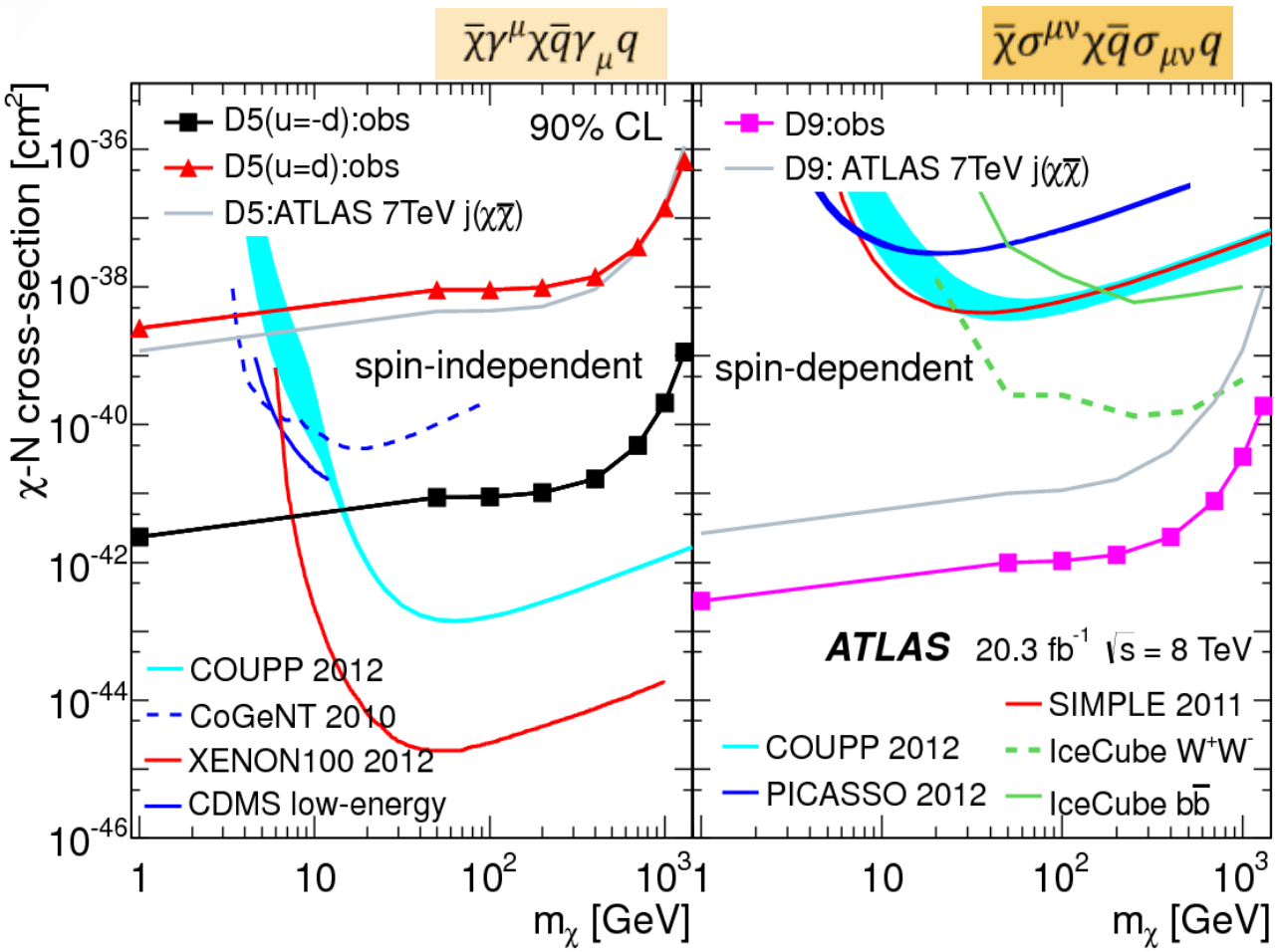


Based on the W/Z hadronic decay reconstructed as subjects from CA R=1.2 jets

Jet $P_t > 250$ GeV, $|\eta| < 2.1$, $50 < M_{jet} < 120$ GeV)

No additional jet (anti-kT 0.4) with $p_T > 40$ GeV





Results expressed in terms of limits on χ-nucleon interactions for D5 and D9 operators

Summary of SUSY Searches

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: SUSY 2013

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt[fb^{-1}]$	Mass limit		
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	
	MSUGRA/CMSSM	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.2 TeV	any $m(\tilde{q})$	
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	any $m(\tilde{q})$	
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$ 740 GeV	$m(\tilde{\chi}_1^0)$=0 G	
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)$=0 G	
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^{\pm}\to qqW^{\pm}\tilde{\chi}_1^0$	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.18 TeV	$m(\tilde{\chi}_1^0)$<20(	
	$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ	0-3 jets	-	20.3	$\tilde{g}$ 1.12 TeV	$m(\tilde{\chi}_1^0)$=0 G	
	GMSB ($\tilde{\ell}$ NLSP)	2 e,μ	2-4 jets	Yes	4.7	$\tilde{g}$ 1.24 TeV	$\tan\beta$<15	
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$ 1.4 TeV	$\tan\beta$ >18	
	GGM (bino NLSP)	2 γ	-	Yes	4.8	$\tilde{g}$ 1.07 TeV	$m(\tilde{\chi}_1^0)$>50 (	
	GGM (wino NLSP)	1 $e,\mu+\gamma$	-	Yes	4.8	$\tilde{g}$ 619 GeV	$m(\tilde{\chi}_1^0)$>50 (	
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$ 900 GeV	$m(\tilde{\chi}_1^0)$>22(	
	GGM (higgsino NLSP)	2 e,μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$ 690 GeV	$m(\tilde{H})$>200	
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale 645 GeV	$m(\tilde{g})>10^{-4}$	
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$ 1.2 TeV	$m(\tilde{\chi}_1^0)$<60(	
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	$m(\tilde{\chi}_1^0)$ <35	
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	$m(\tilde{\chi}_1^0)$<40(	
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)$<30(	
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$ 100-620 GeV	$m(\tilde{\chi}_1^0)$<90 (	
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^{\pm}$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$ 275-430 GeV	$m(\tilde{\chi}_1^{\pm})$=2 m	
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^{\pm}$	1-2 e,μ	1-2 b	Yes	4.7	$\tilde{t}_1$ 110-167 GeV	$m(\tilde{\chi}_1^0)$=55 (	
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e,μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 130-220 GeV	$m(\tilde{\chi}_1^0)$ =m(	
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}_1^0$	2 e,μ	2 jets	Yes	20.3	$\tilde{t}_1$ 225-525 GeV	$m(\tilde{\chi}_1^0)$=0 G	
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^{\pm}$	0	2 b	Yes	20.1	$\tilde{t}_1$ 150-580 GeV	$m(\tilde{\chi}_1^0)$<20(	
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e,μ	1 b	Yes	20.7	$\tilde{t}_1$ 200-610 GeV	$m(\tilde{\chi}_1^0)$=0 G	
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$ 320-660 GeV	$m(\tilde{\chi}_1^0)$=0 G	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$ 90-200 GeV	$m(\tilde{t}_1)$-$m(\tilde{\chi}_1^0)$	
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e,μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$ 500 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$ 271-520 GeV	$m(\tilde{t}_1)=m(\tilde{\chi}_1^0)$+180 GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$ 85-315 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	$\tilde{\chi}_1^{\pm}$ 125-450 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.7	$\tilde{\chi}_1^{\pm}$ 180-330 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.7	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$ 600 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	3 e,μ	0	Yes	20.7	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$ 315 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$	1 e,μ	2 b	Yes	20.3	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$ 285 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-093
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^{\pm}$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^{\pm}$ 270 GeV	$m(\tilde{\chi}_1^{\pm})$-$m(\tilde{\chi}_1^0)$=160 MeV, $\tau(\tilde{\chi}_1^{\pm})$=0.2 ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$ 832 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}_1^0$ 475 GeV	10<$\tan\beta$<50	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	4.7	$\tilde{\chi}_1^0$ 230 GeV	0.4<$\tau(\tilde{\chi}_1^0)$<2 ns	1304.6310
	$\tilde{q}\tilde{q}, \tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$ 1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, $m(\tilde{\chi}_1^0)$=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e+\mu$	2 e,μ	-	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e(\mu)+\tau$	1 $e,\mu+\tau$	-	-	4.6	$\tilde{\nu}_\tau$ 1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e,μ	7 jets	Yes	4.7	$\tilde{q},\tilde{g}$ 1.2 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}$<1 mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	-	Yes	20.7	$\tilde{\chi}_1^{\pm}$ 760 GeV	$m(\tilde{\chi}_1^0)$>300 GeV, λ_{121}>0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e,\mu+\tau$	-	Yes	20.7	$\tilde{\chi}_1^{\pm}$ 350 GeV	$m(\tilde{\chi}_1^0)$>80 GeV, λ_{133}>0	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$ 880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon pair, sgluon$\to q\bar{q}$	0	4 jets	-	4.6	sgluon 100-287 GeV	incl. limit from 1110.2693	1210.4826
	Scalar gluon pair, sgluon$\to t\bar{t}$	2 e,μ (SS)	1 b	Yes	14.3	sgluon 800 GeV		ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale 704 GeV	$m(\chi)$<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

10^{-1} 1 **Mass scale [TeV]**

$\sqrt{s}$ = 7 TeV full data | $\sqrt{s}$ = 8 TeV partial data | $\sqrt{s}$ = 8 TeV full data

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

95% CL exclusions for (best) massless LSP scenarios:

$m(\tilde{g})$ < 1300 GeV

$m(\tilde{q})$ < 1400 GeV

$m(\tilde{b})$ < 650 GeV

$m(\tilde{t})$ < 680 GeV

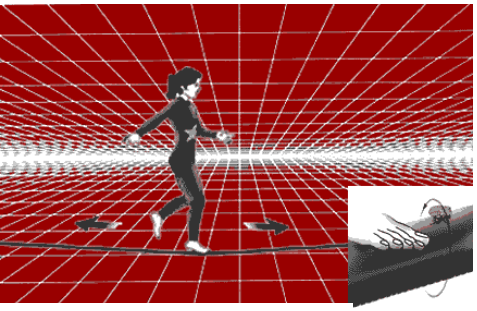
$m(\tilde{\ell}_L)$ < 300 GeV

$m(\chi^{\pm}=\chi^0)_{\text{light }\tilde{\ell}}$ < 650 GeV

$m(\chi^{\pm}=\chi^0)_{\text{heavy }\tilde{\ell}}$ < 340 GeV

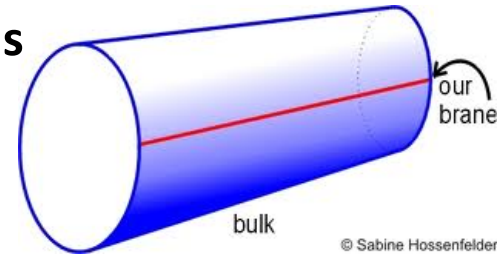
Non-SUSY Searches

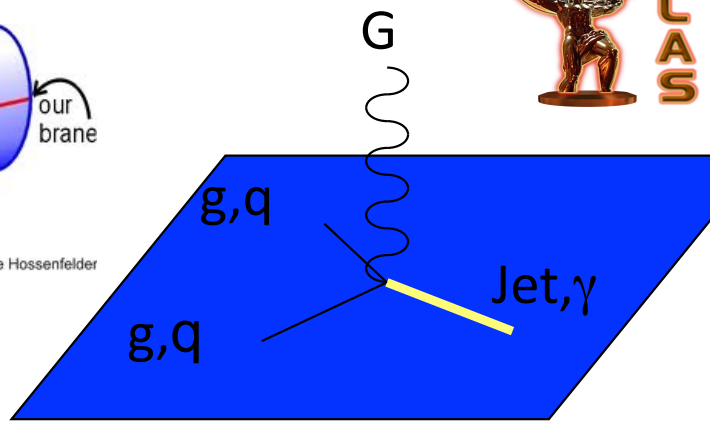
Extra dimensions, q, new bosons, vector-like quarks, ...*

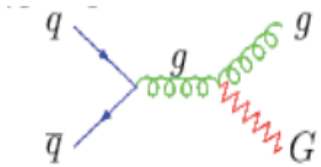


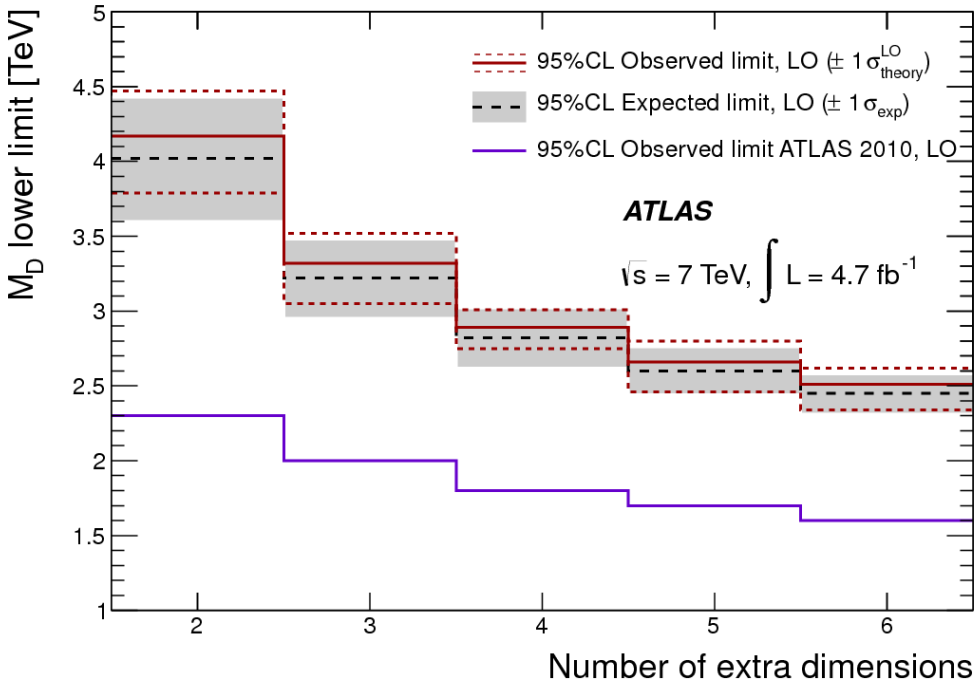
Large Extra Dimensions

Extra spatial dimensions explain the apparent weakness of Gravity (relevant scale ~TeV)

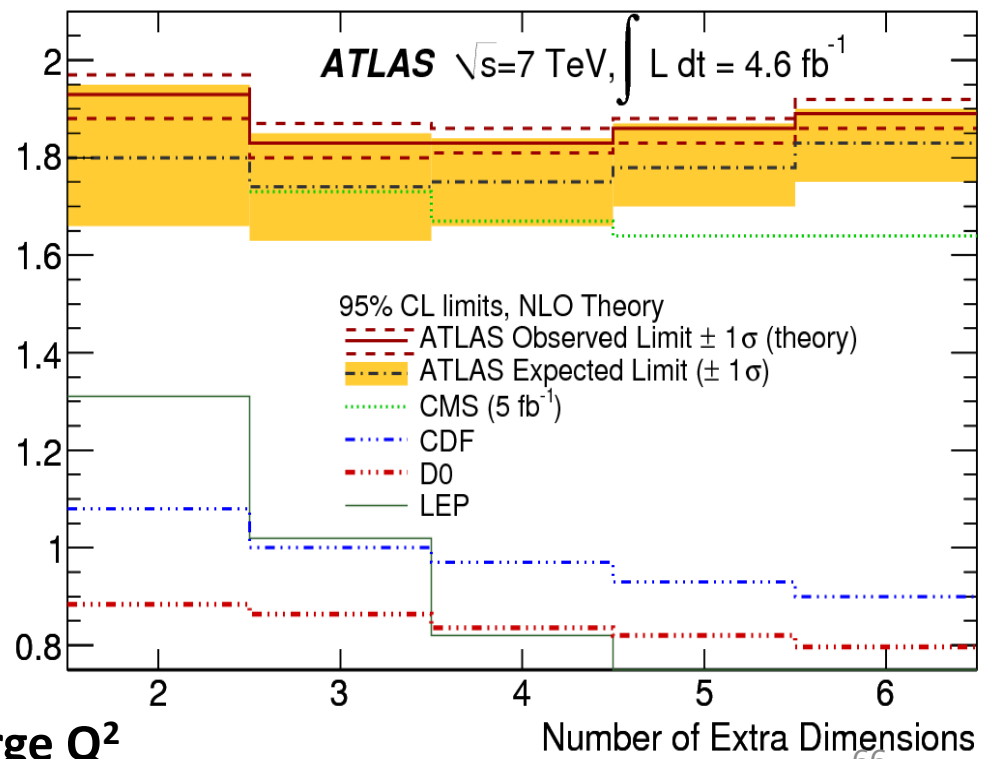






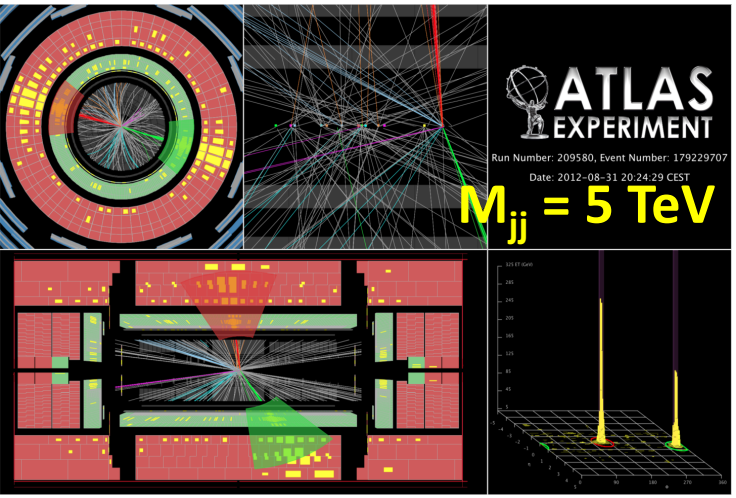


$$(M_{PL})^2 \sim R^n (M_D)^{2+n}$$



Limits on M_D beyond 3 TeV
(a real challenge of the model model validity)

Note: Limits sensitive to the truncation strategy for s-hat > M_D^2 … LHC probing phase space at large Q^2

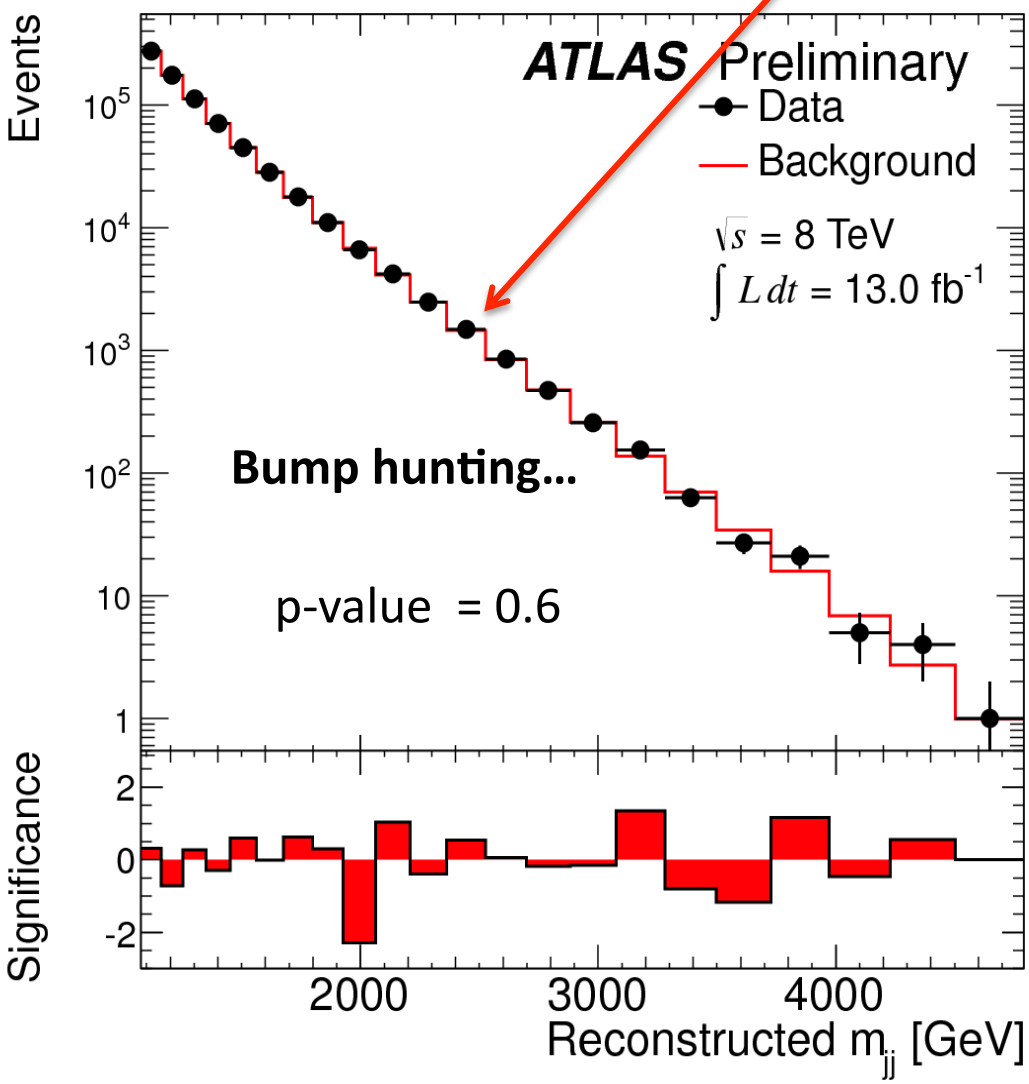


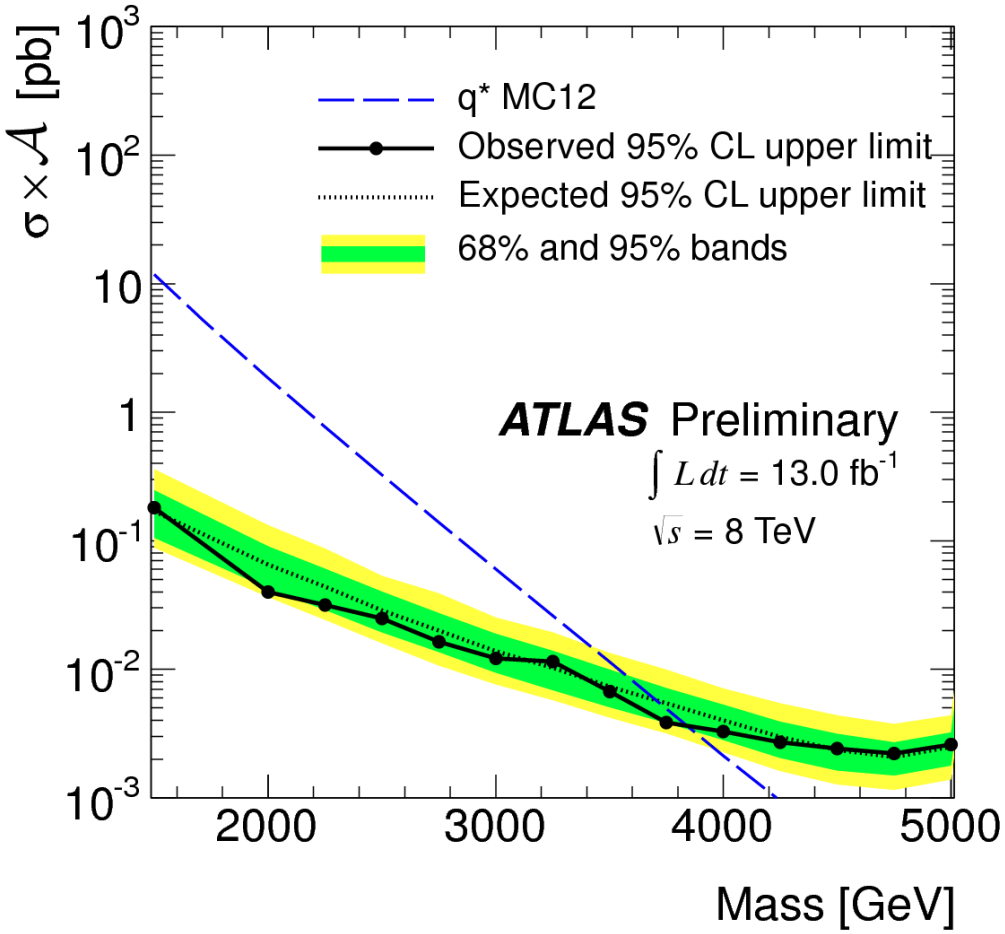
Dijets

ATLAS-CONF-2012-148

Dijet mass spectrum fitted to the functional form

$$f(x) = p_1(1-x)^{p_2} x^{p_3 + p_4 \ln x} \qquad x \equiv m_{jj}/\sqrt{s}$$

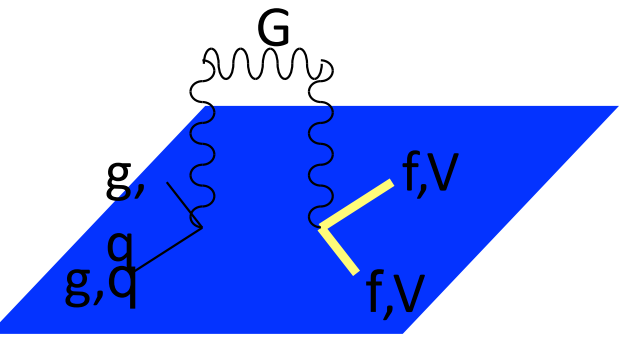


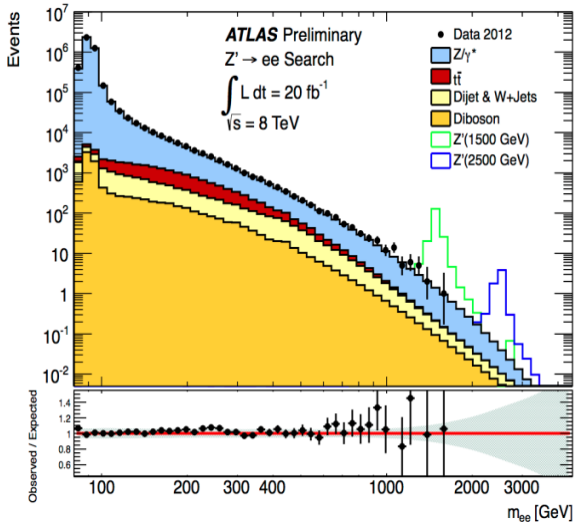


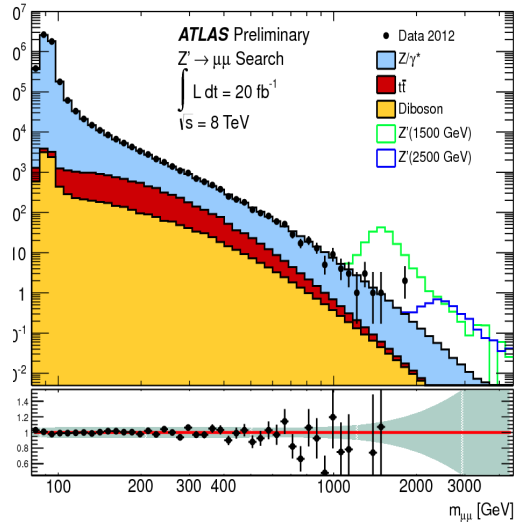
Excited quarks with mass < 3.84 TeV excluded at 95% CL

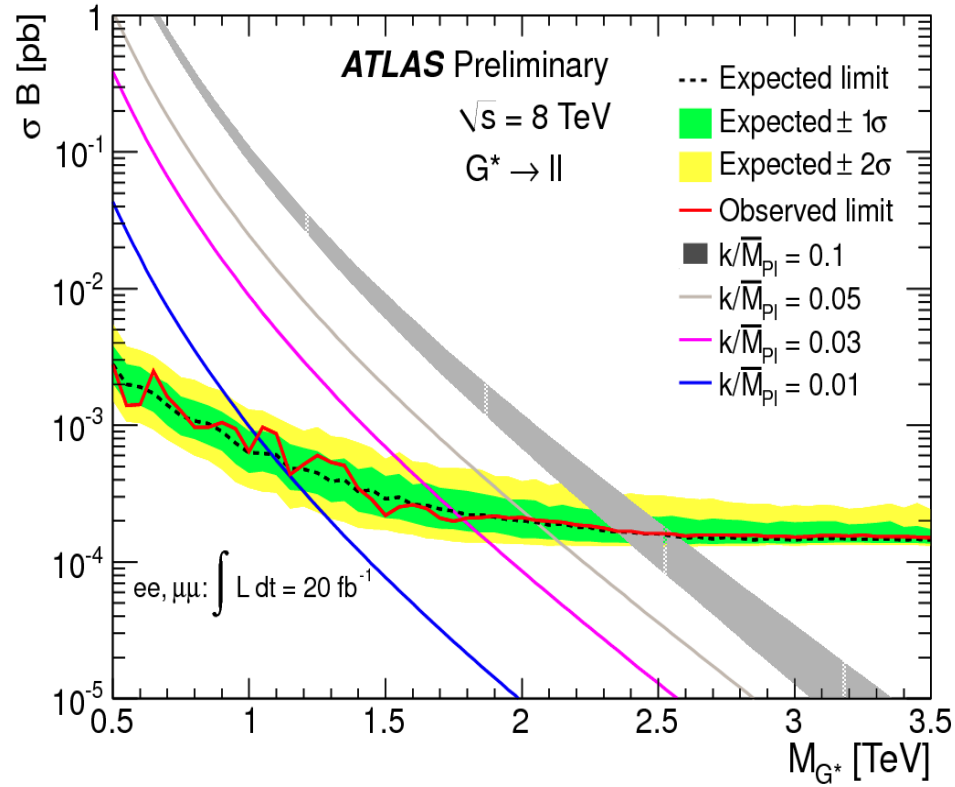
Dileptons

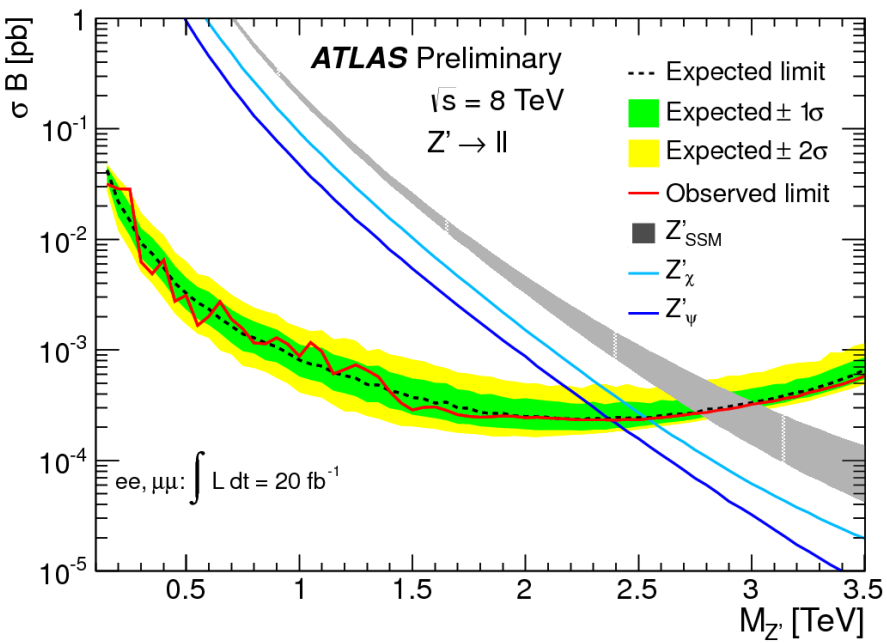
ATLAS-CONF-2013-017











Limits on RS (ED) Graviton mass vs coupling

→95% CL exclusion in the mass range

M_G = 1.2 TeV – 2.5 TeV

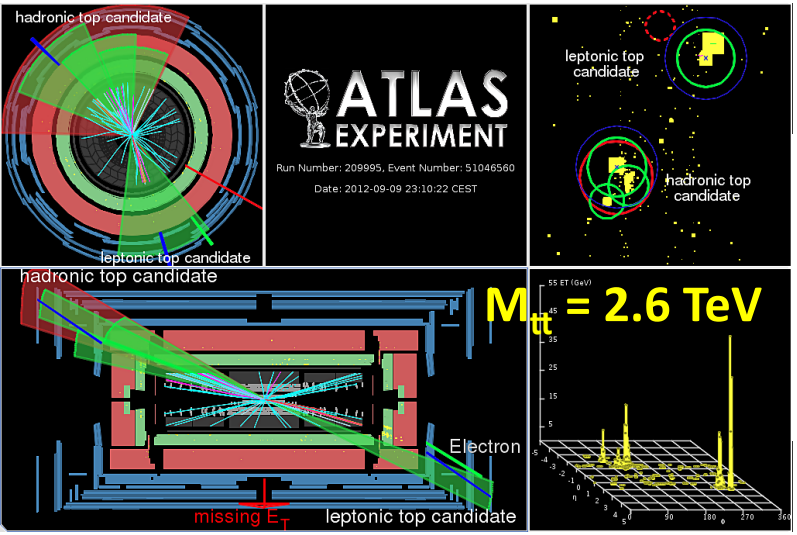
Limits on SSM and E_6 GUT inspired models

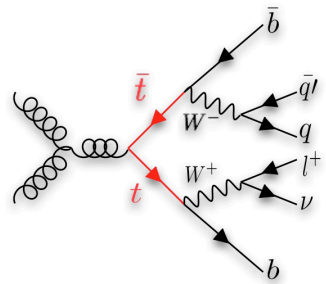
→$M_{Z'}$ (SSM) < 2.86 TeV excluded

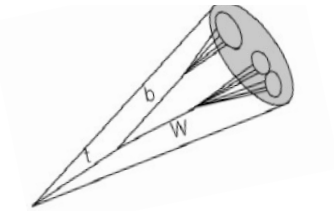
→$M_{Z'}$ (E_6) < 2.4 TeV – 2.6 TeV excluded

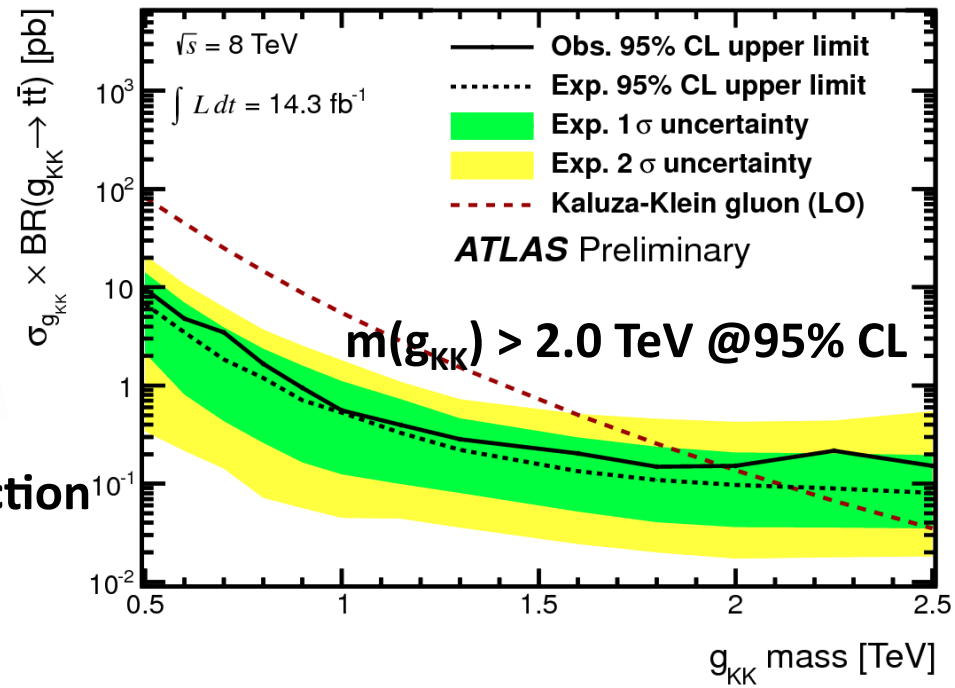
tt Resonances

ATLAS-CONF-2013-052

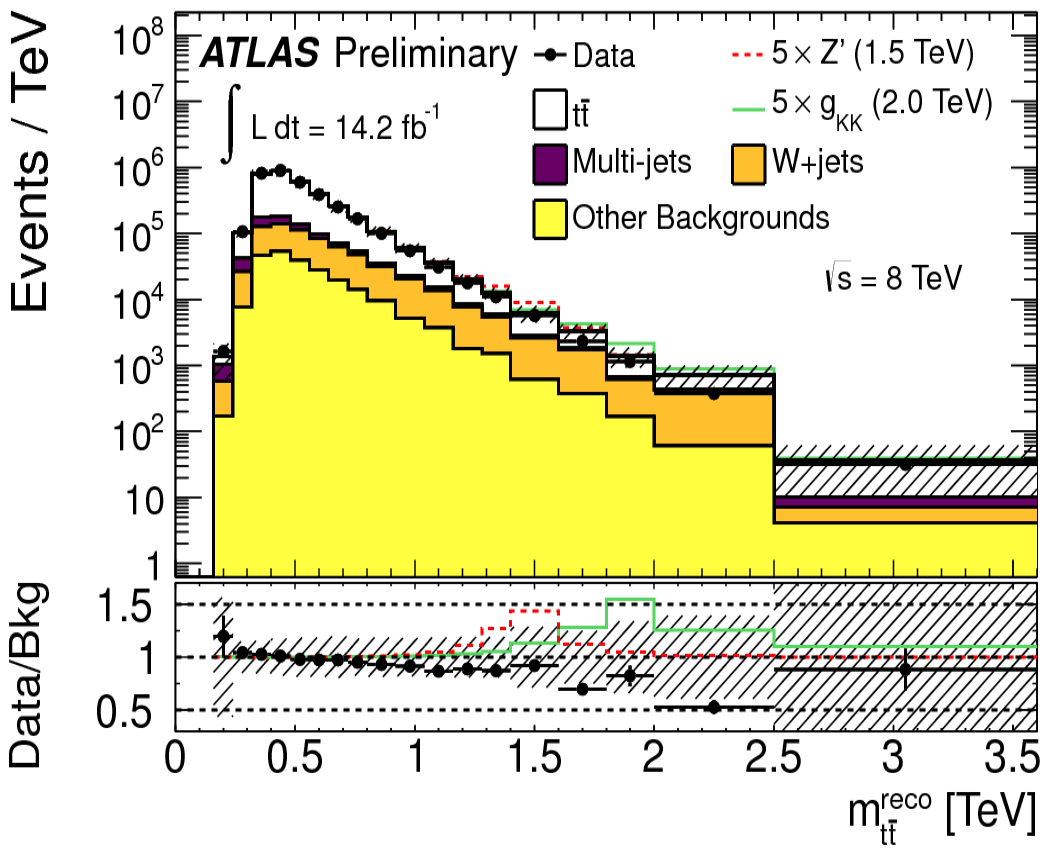


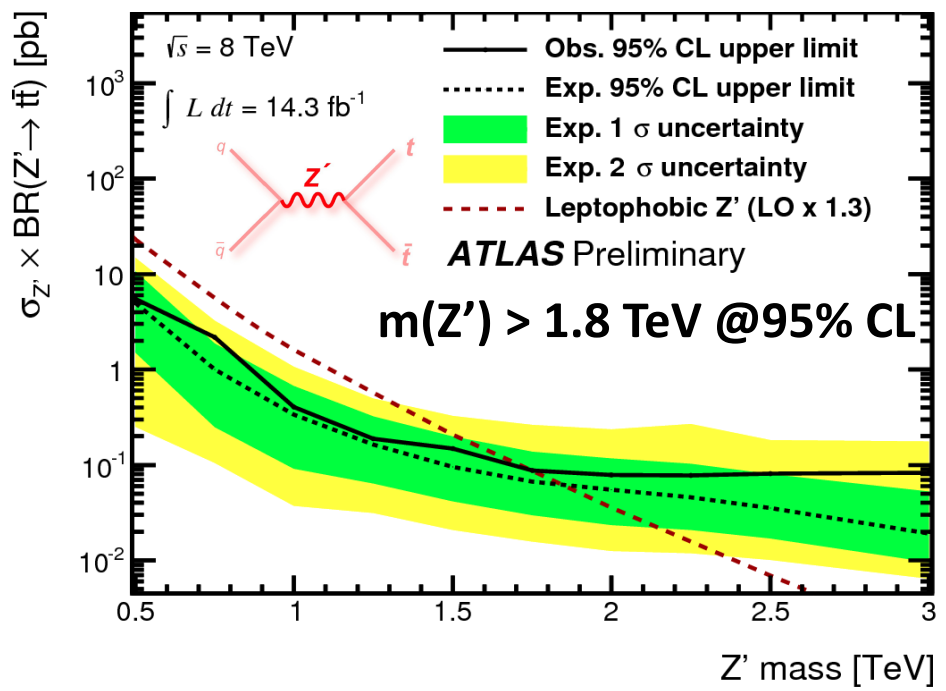


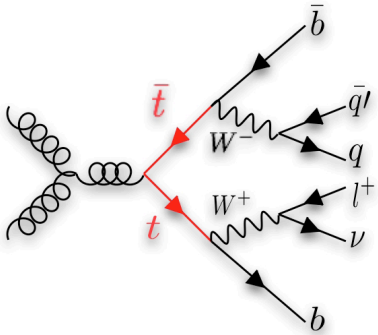




Using both resolved and boosted t→ Wb reconstruction

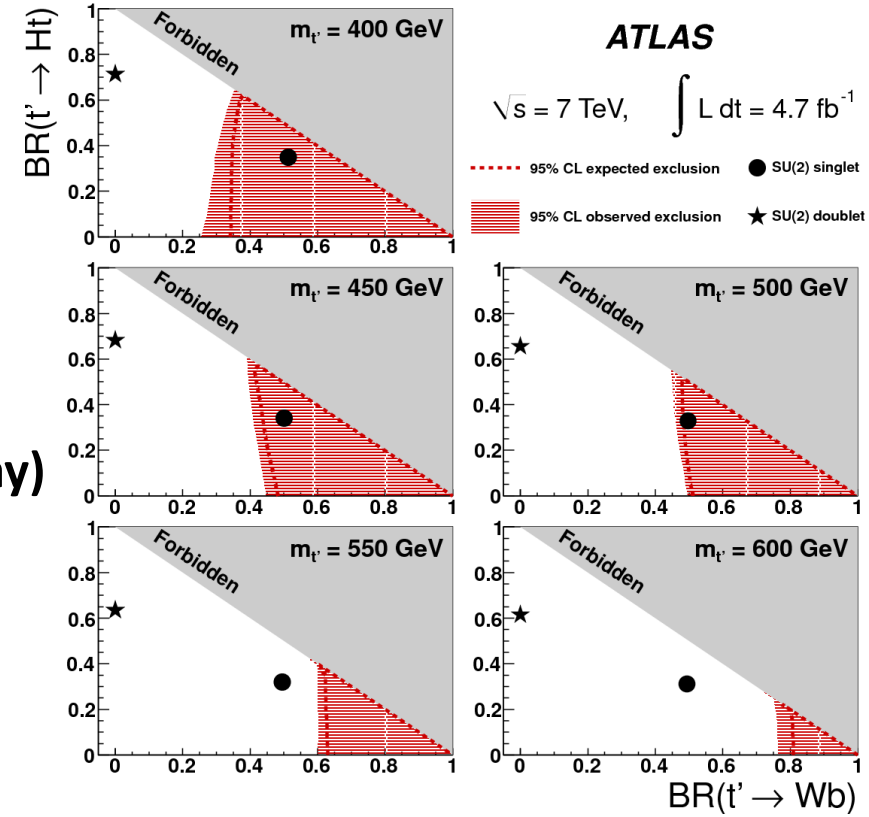






t' searches

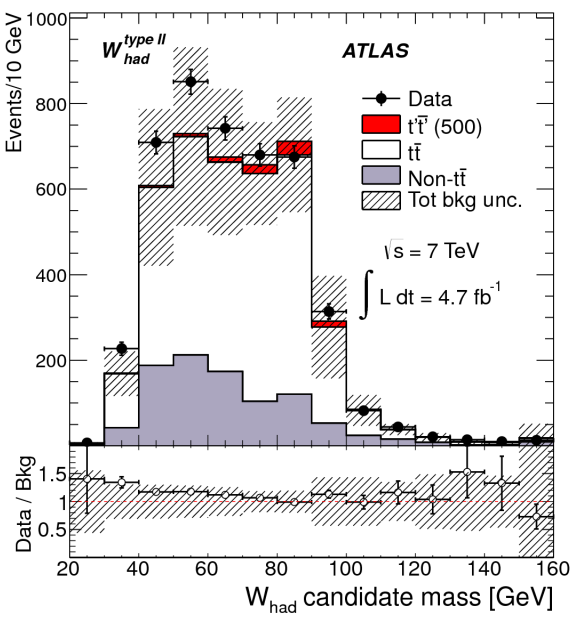
Phys. Lett. B 718 (2013)1284-1302

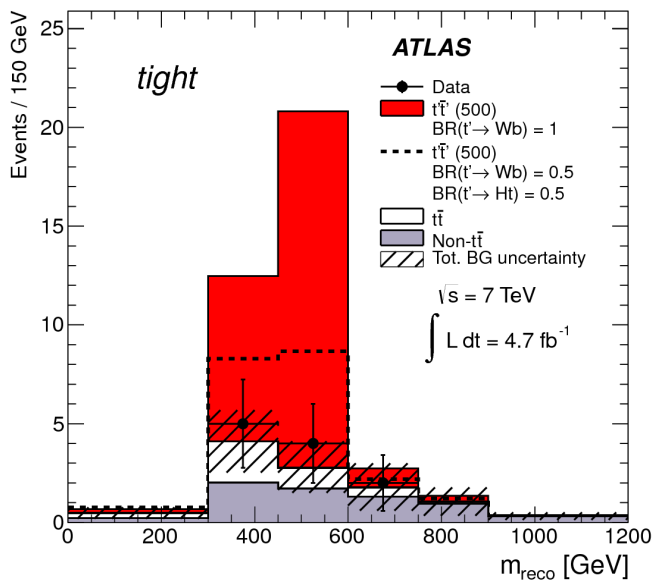


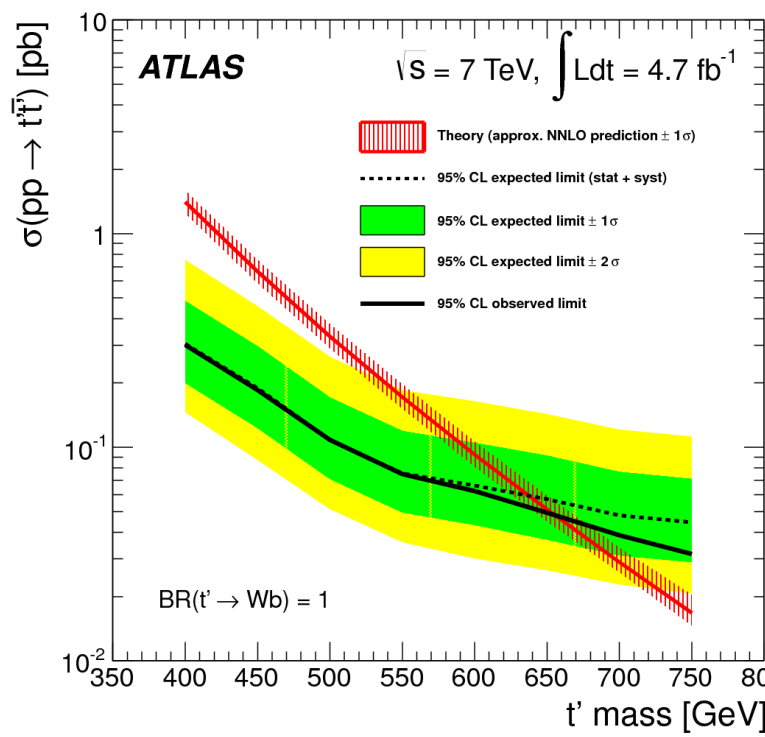
Analysis optimized for m (t') > 400 GeV
Reconstruction of highly boosted W (hadronic decay)

t' masses above 656 GeV excluded at 95% CL

For vector-like quarks limits as a function of the mass and the BR (t' → Wb) and (t' → Ht)

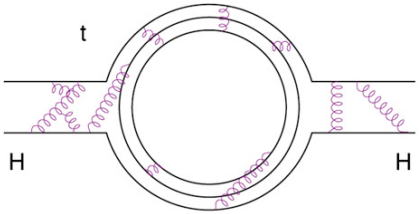


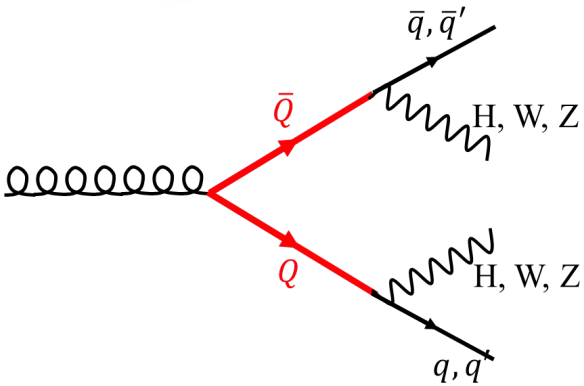




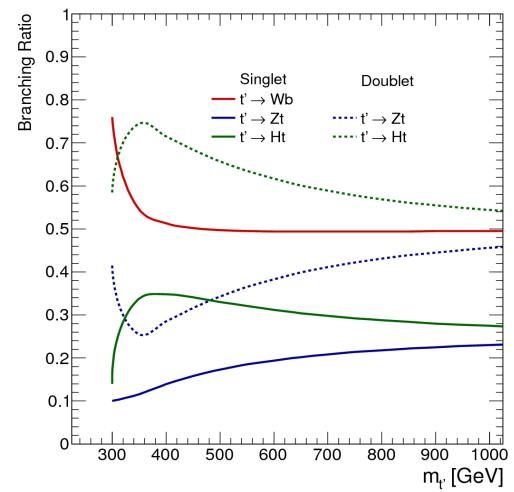
Search for vector-like quarks

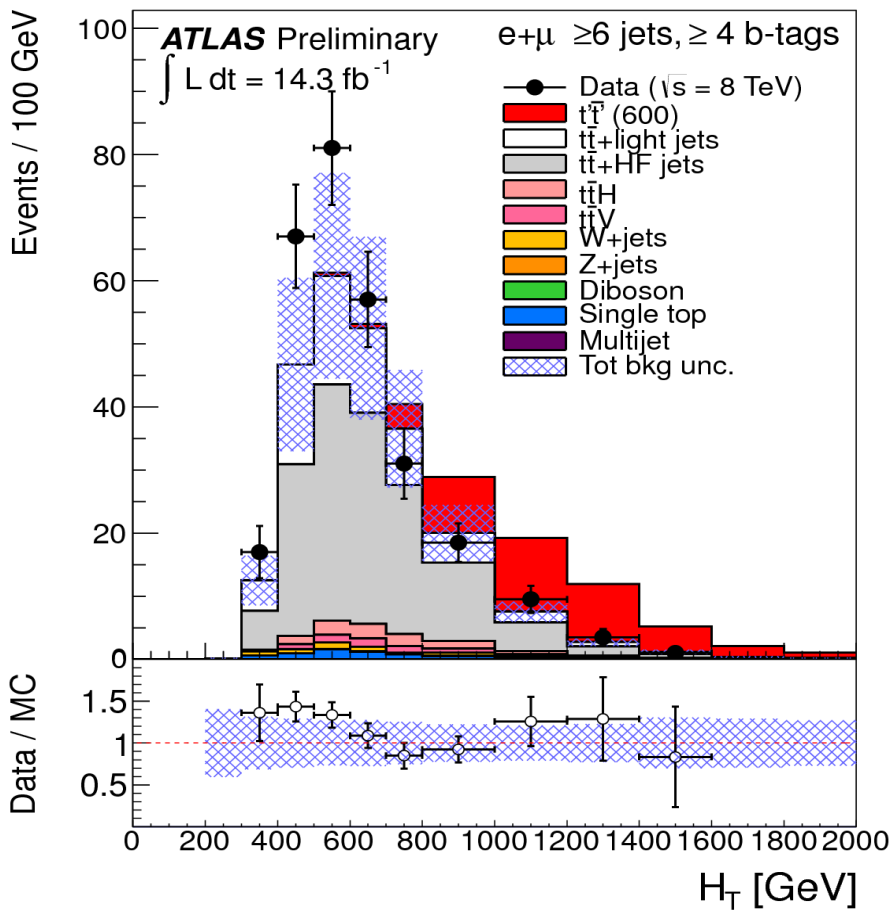
ATLAS-CONF-2013-018

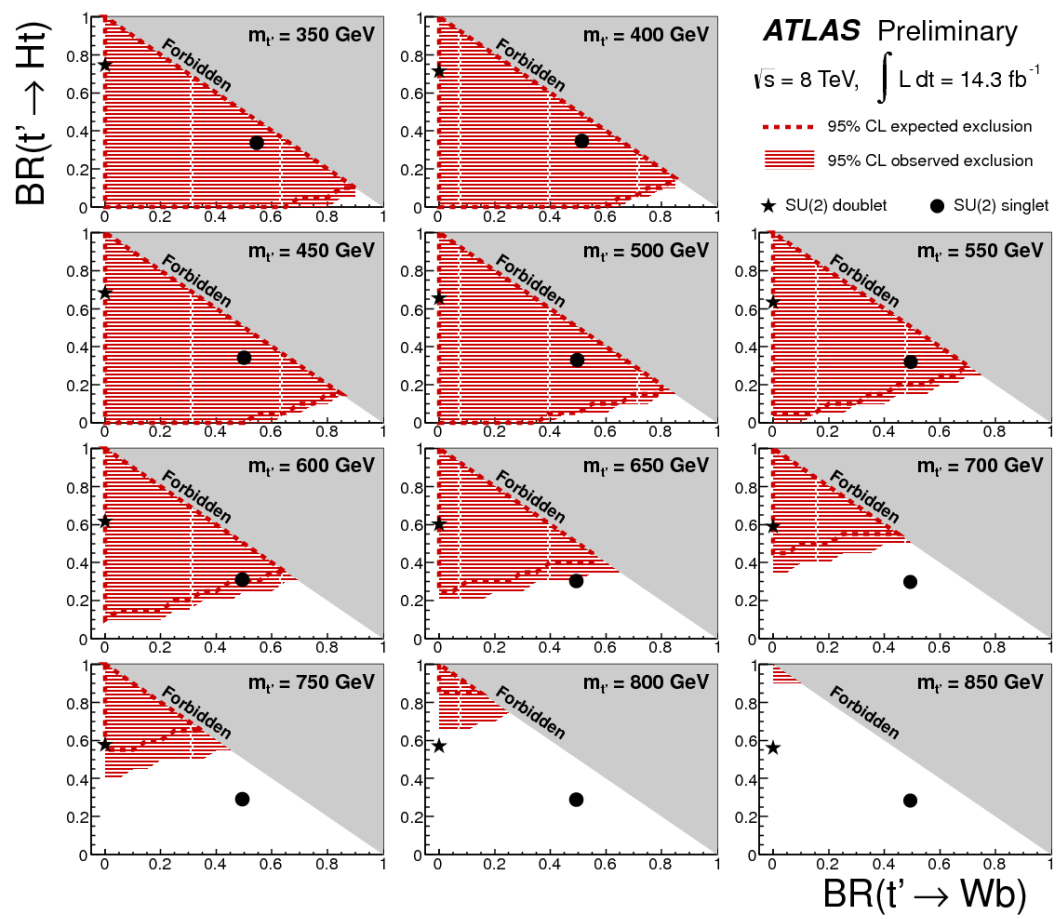


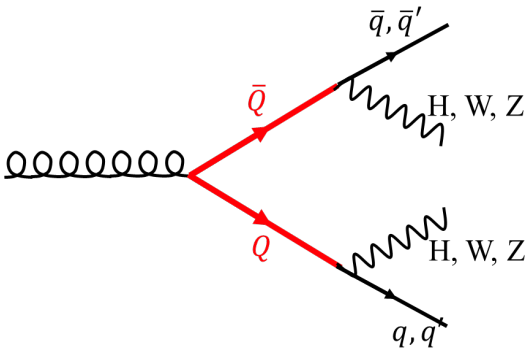


Explores the decay
t' → Ht (H → bb)

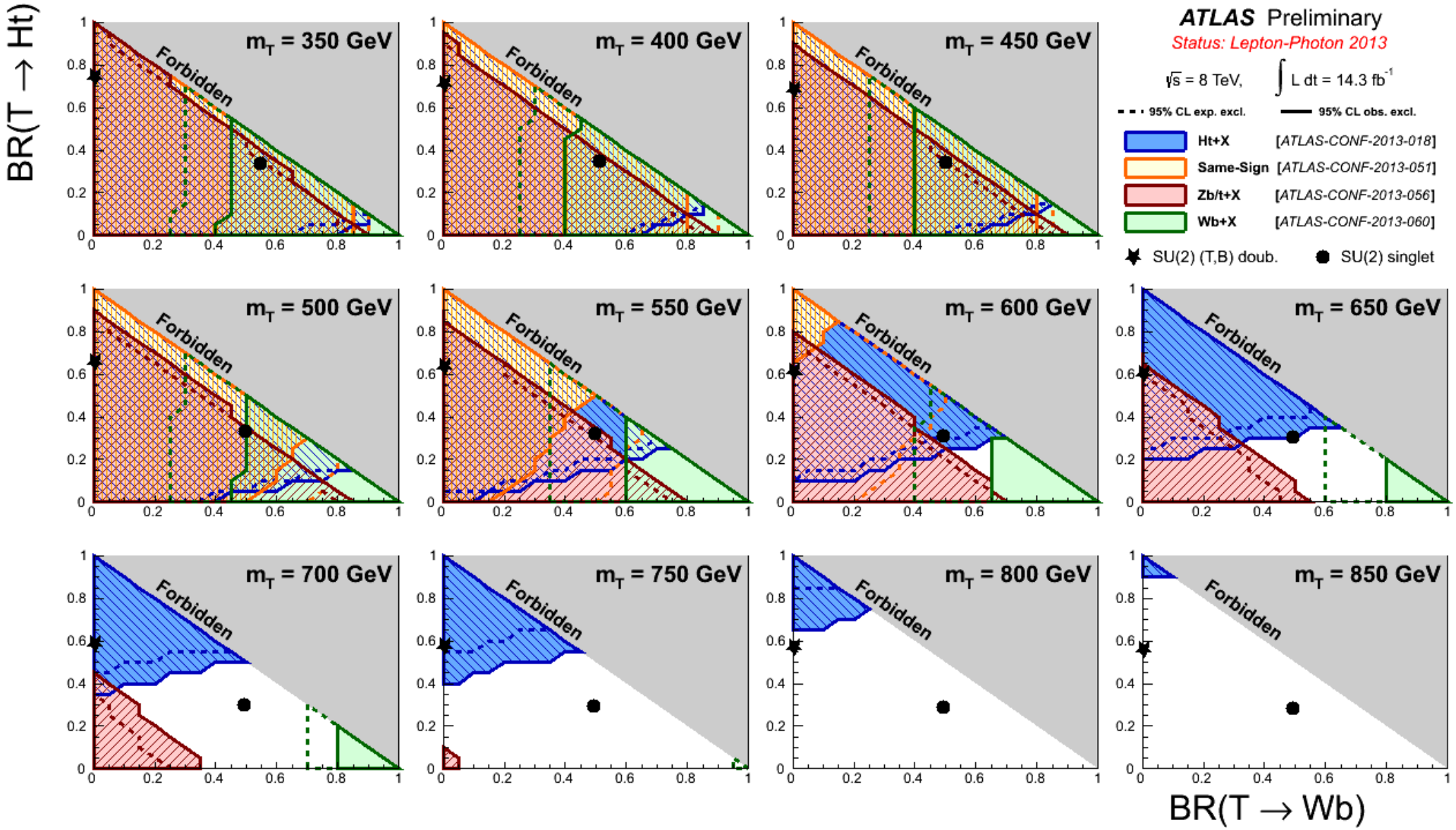




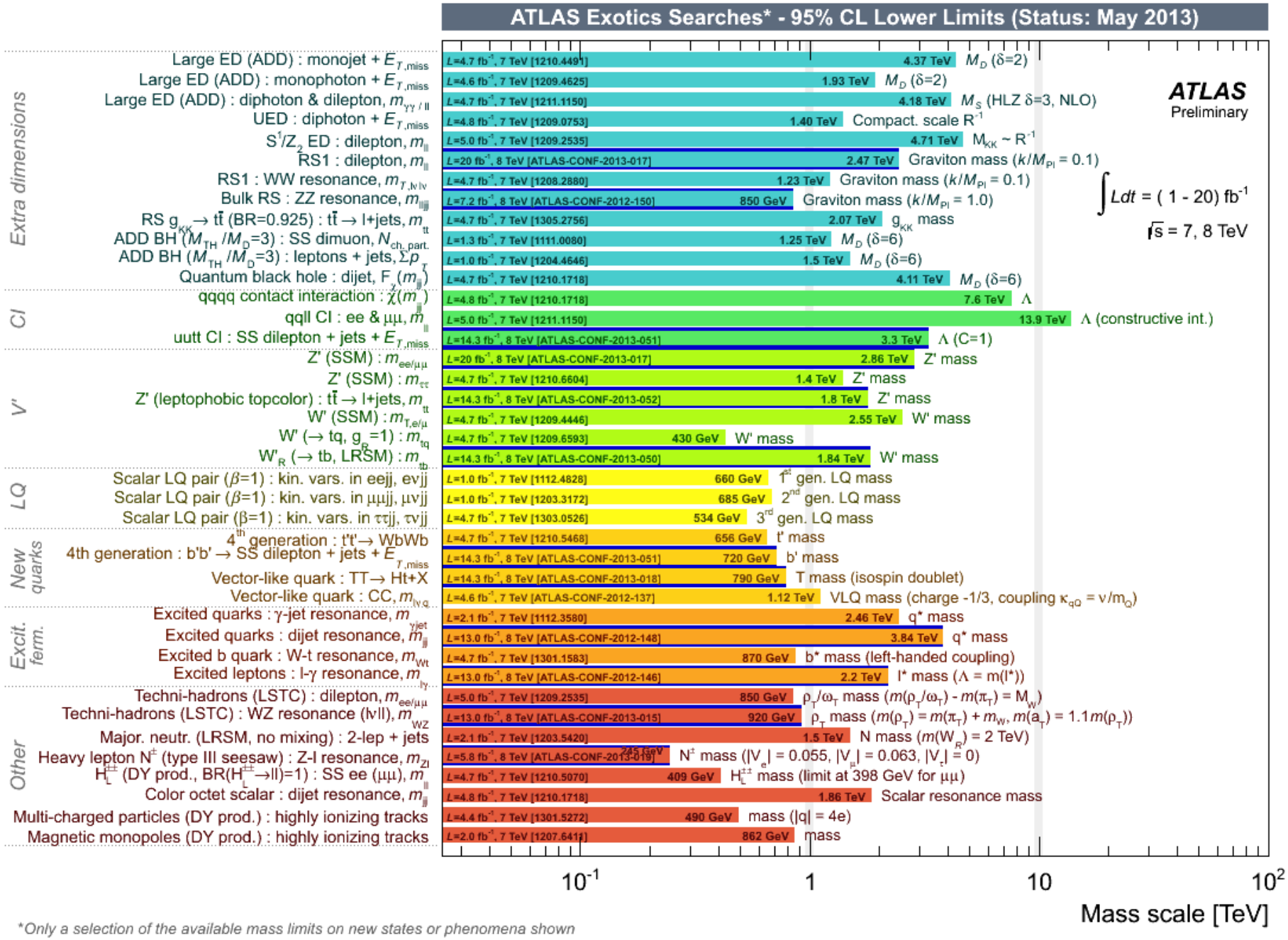




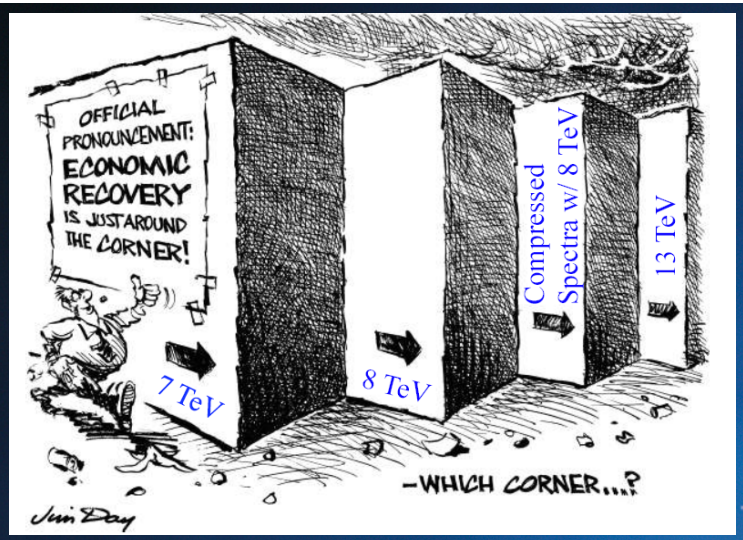
Summary VLQ (T)



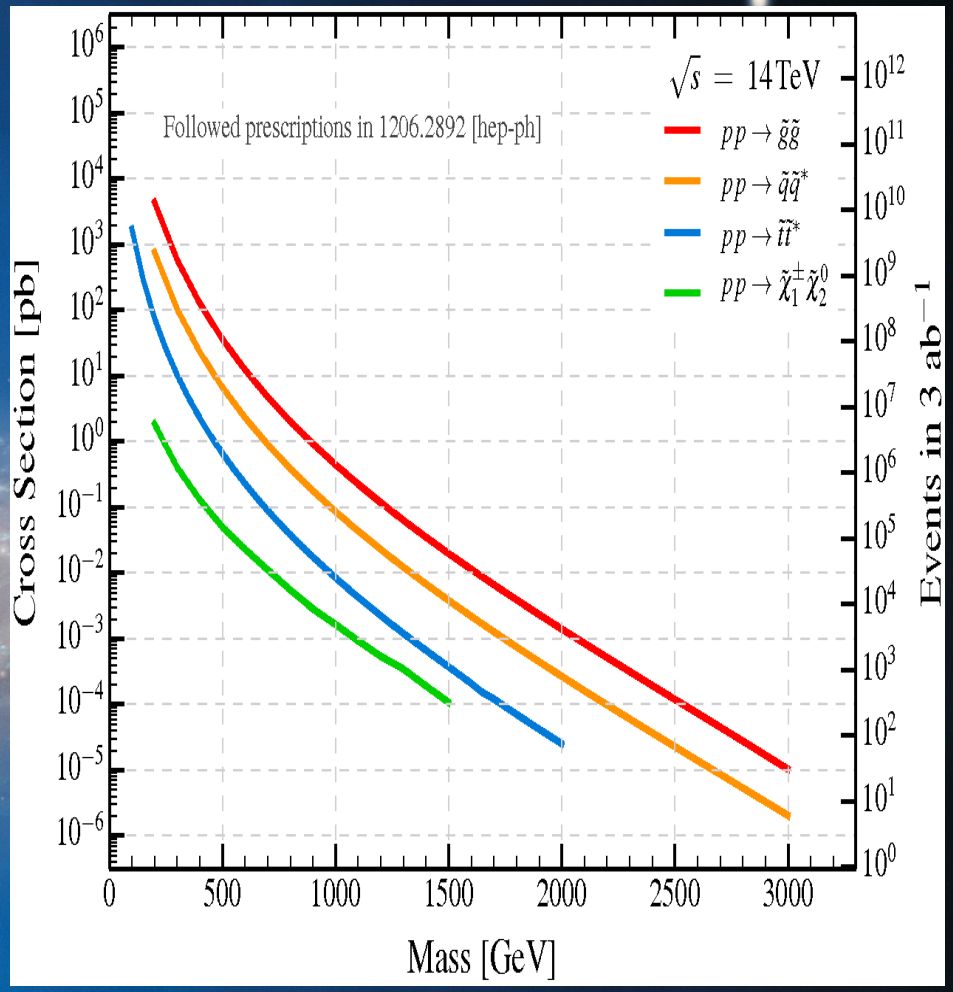
Summary of Exotic Searches



*Only a selection of the available mass limits on new states or phenomena shown



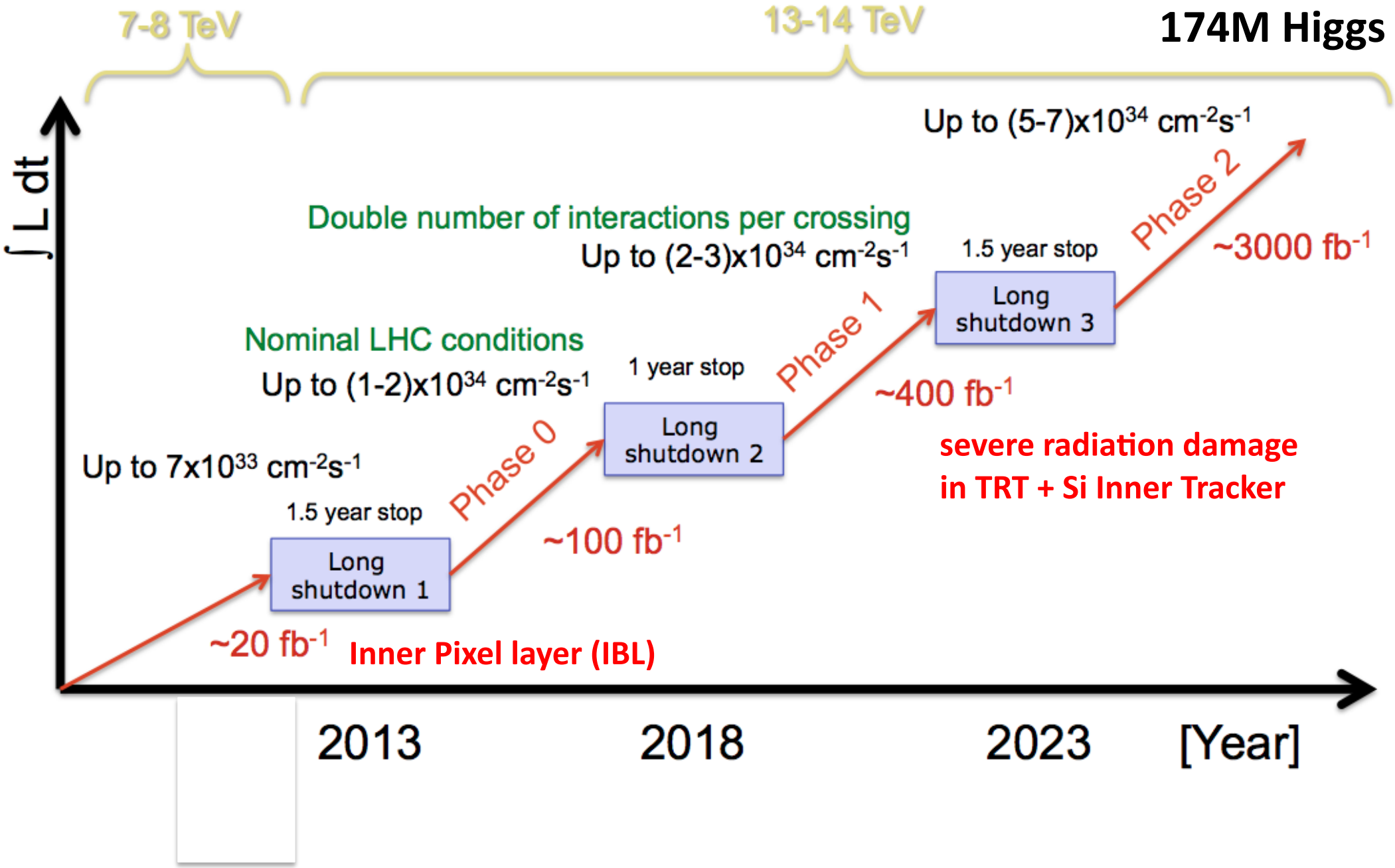
?



The discovery of New Phyiscs requires more energy and more data ……

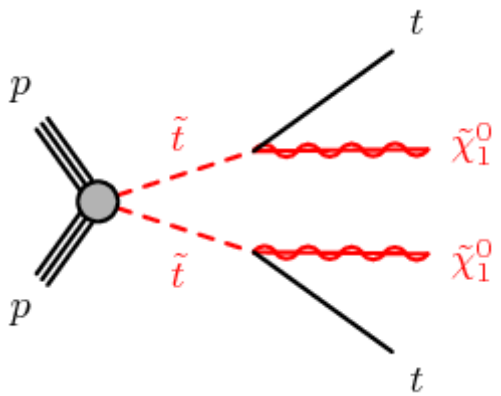
LHC Plan

Producción
174M Higgs

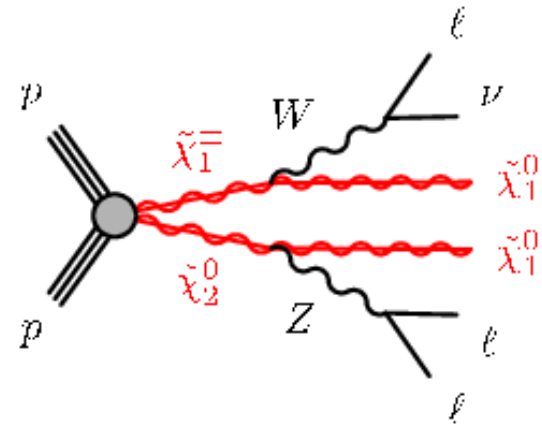


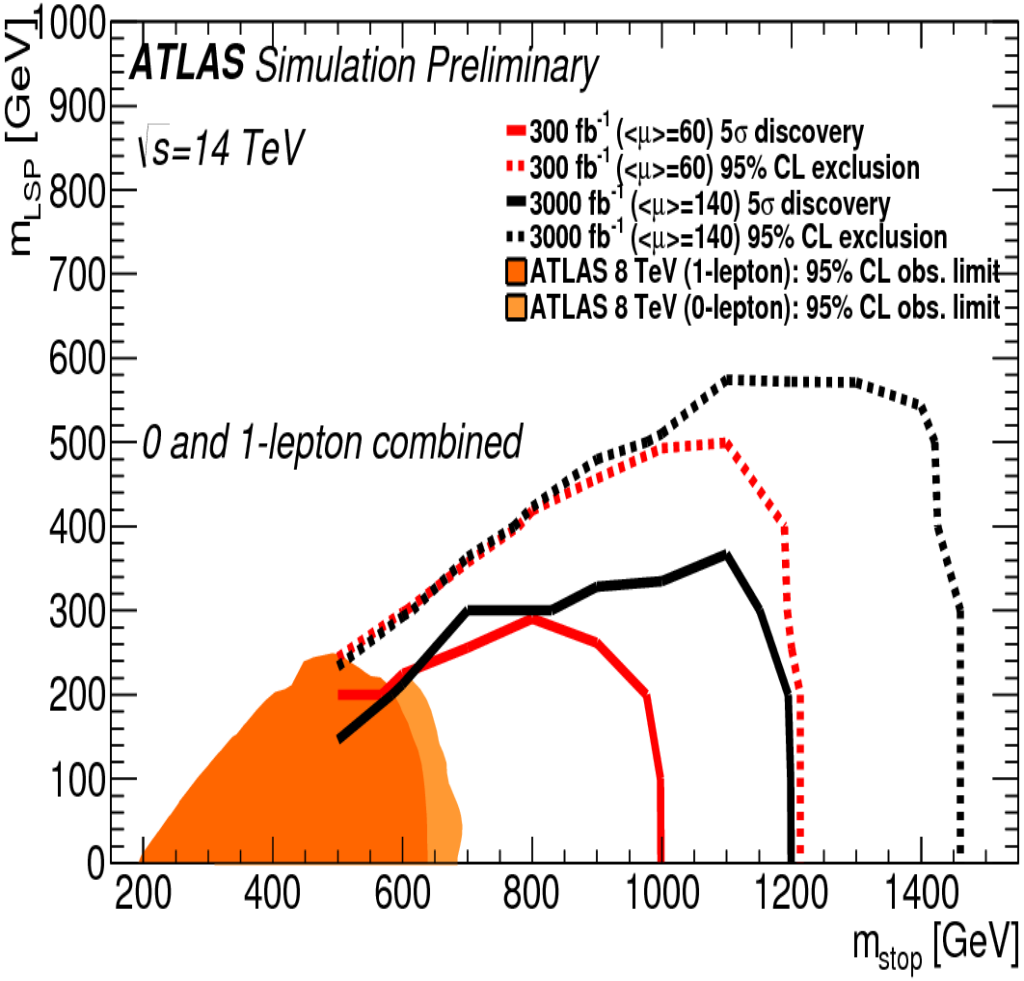
ATL-PHYS-PUB-2013-011

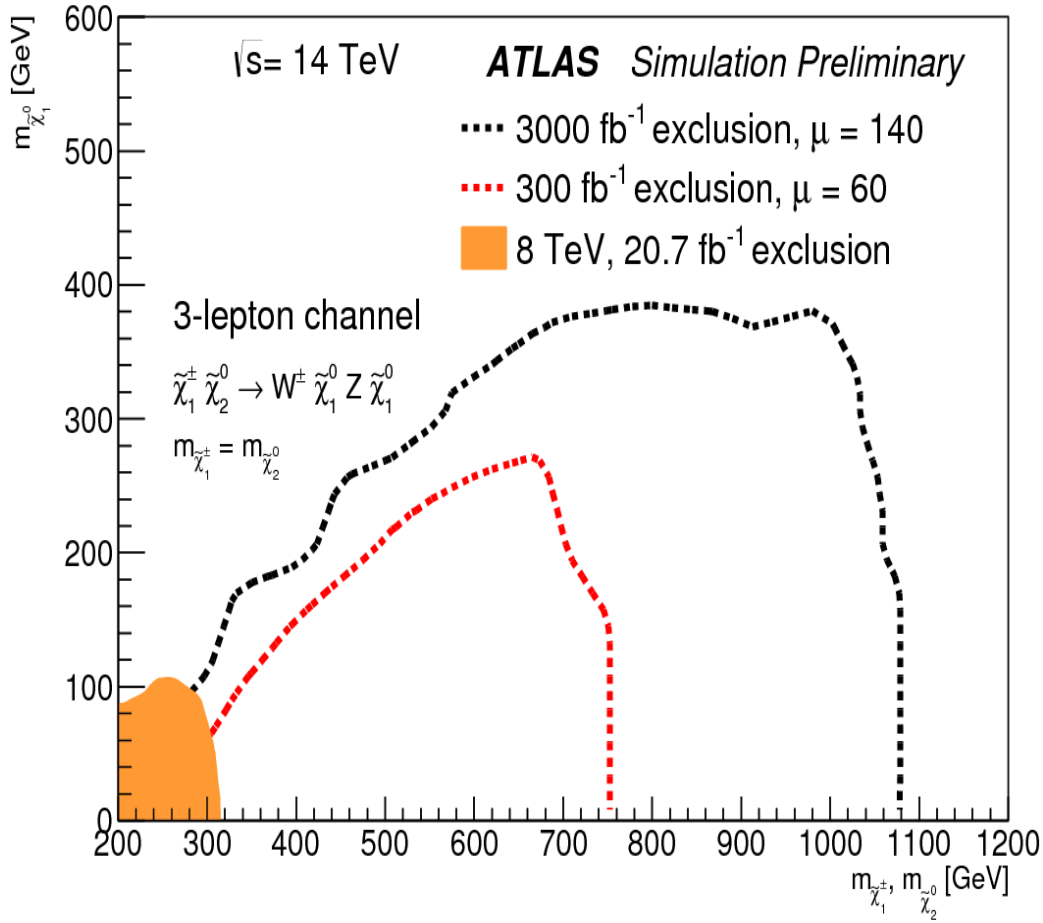
14 TeV Prospects



Will be in the position to "kill natural SUSY"







Final Notes

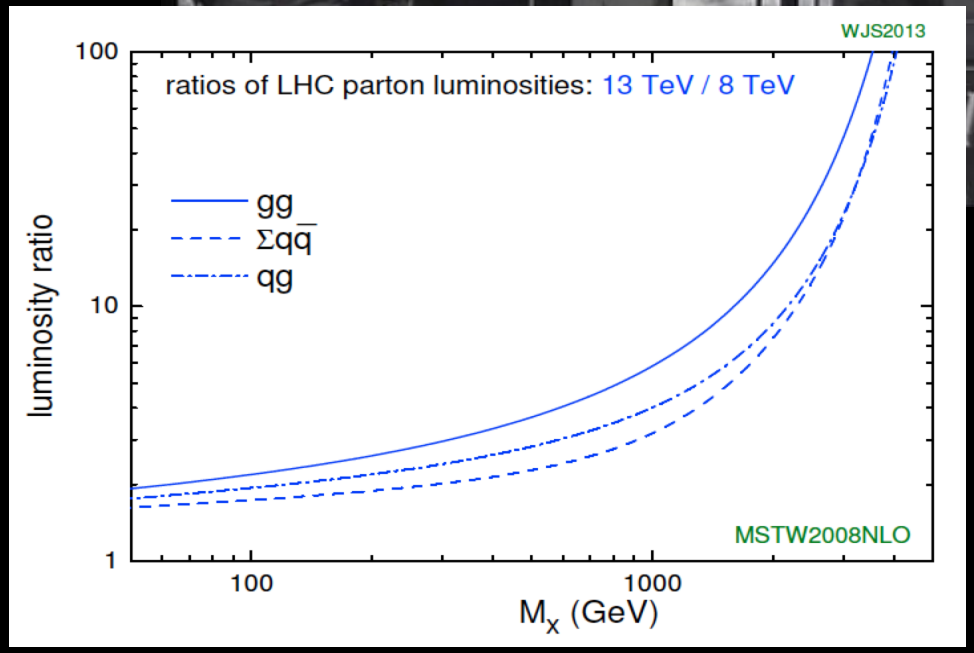
More energy and more data !

El LHC will almost double the centre-of-mass energy in 2015

8 TeV → 13 TeV

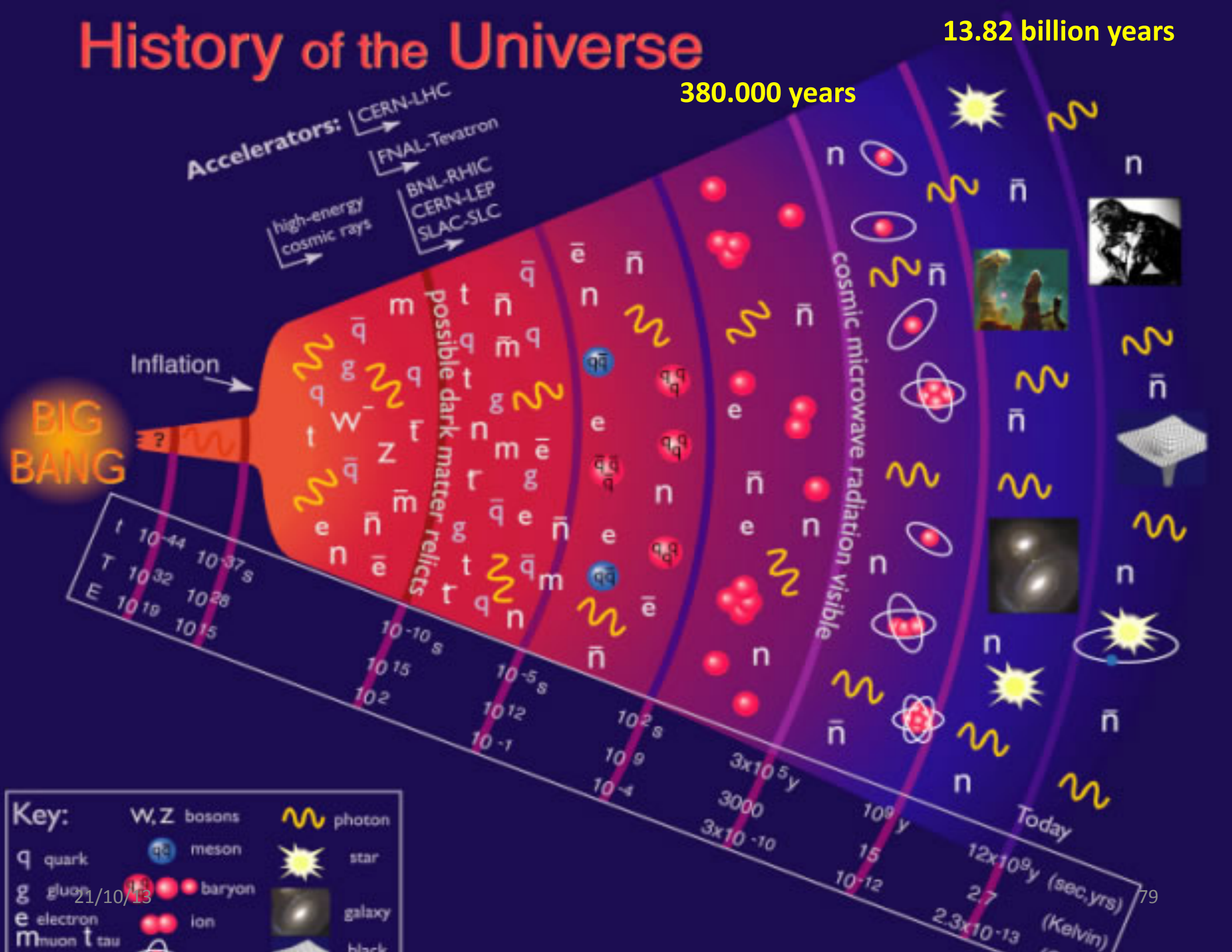
(about 20 – 30 fb-1 in 2015…my guess)

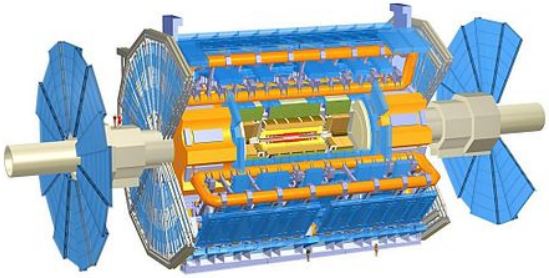
Cross section for stop (0.9 TeV mass) pair production @ 13 TeV = 12 x @ 8 TeV



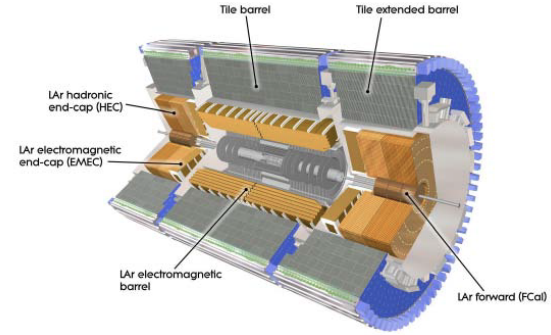
Ready for a new discovery ?

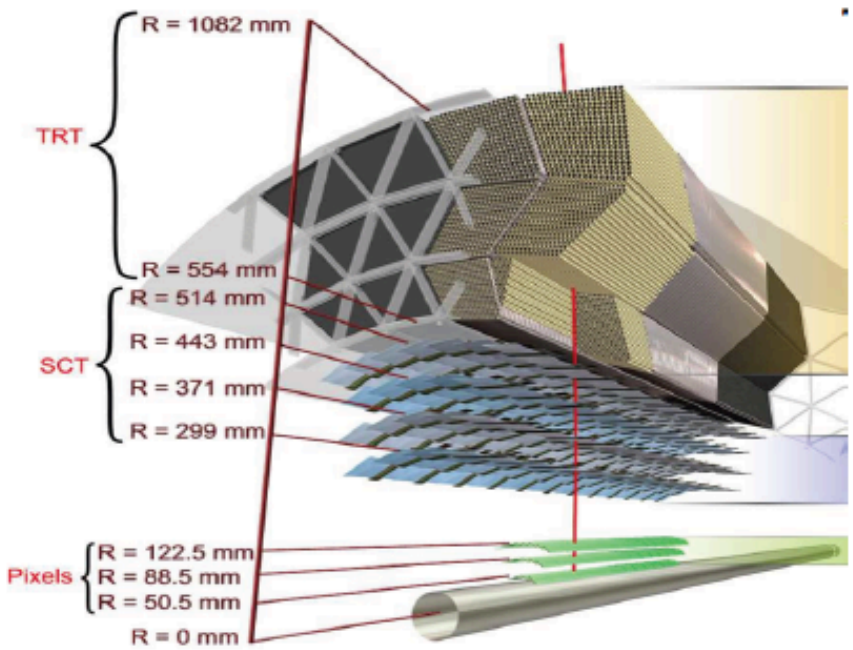
Backup Material


History of the Universe
13.82 billion years
380.000 years
Accelerators:
CERN-LHC
FNAL-Tevatron
BNL-RHIC
CERN-LEP
SLAC-SLC
high-energy cosmic rays
Inflation
BIG BANG
possible dark matter relicts
cosmic microwave radiation visible
Today
Key:
W,Z bosons
photon
q quark
meson
star
g gluon
baryon
galaxy
e electron
ion
m muon t tau



ATLAS
(relevant to photon ID)



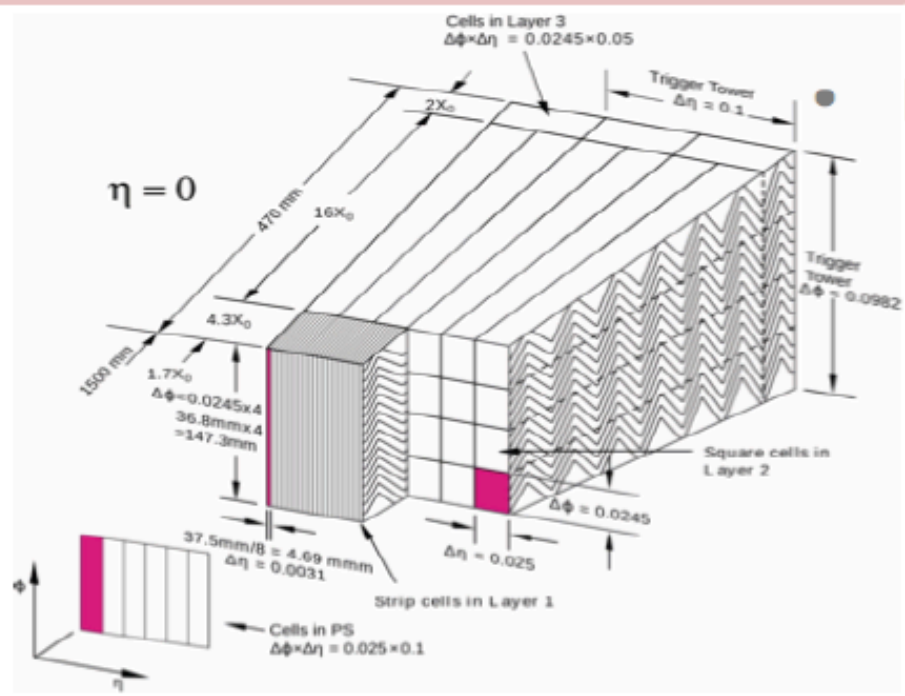


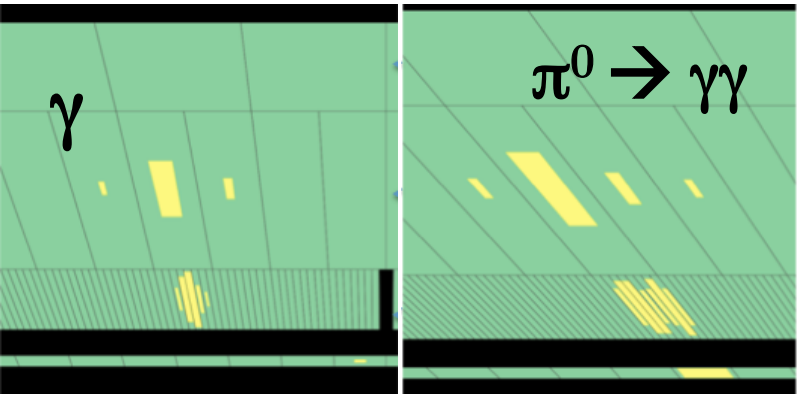
Inner Detector - Barrel (B)&End-cap (E) in 2T solenoidal magnetic field:

- Track reconstruction up to $|\eta|<2.47$;
- Conversion verticies reconstruction;
- e/γ and $e/\pi^{\pm}$ separation;
- Pixel: (B) 3 layers +(E) 2x3 disks $\sigma_{r\varphi}$~10 μm, σ_z~115 μm;
- Semi Conductor Tracker: (B) 4 layers +(E) 2x9 disks $\sigma_{r\varphi}$~17 μm, σ_z~580 μm;
- Transition Radiation Tracker: (B) 73 layers +(E) 2x160 layers σ_z~130 μm;

LAr lead sampling calorimeter with an 'accordion' geometry.

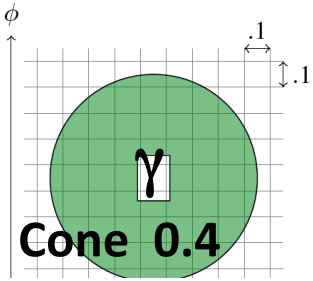
- 3 longitudinal layers with cell of $\Delta\eta \times \Delta\varphi$:
  - 1st layer (0.003÷0.006)x0.1;
  - 2nd layer 0.025x0.025;
  - 3rd layer 0.050x0.025.
- Presampler for $|\eta|<1.8$ $\Delta\eta \times \Delta\varphi$~0.025x0.1.
- Barrel-end-cap crack $|\eta|=1.37\div1.52$.
- $\sigma(E)/E=(10\text{-}17\%)(\eta)/\sqrt{E(\text{GeV})} \oplus (1.2\div1.8\%)$.

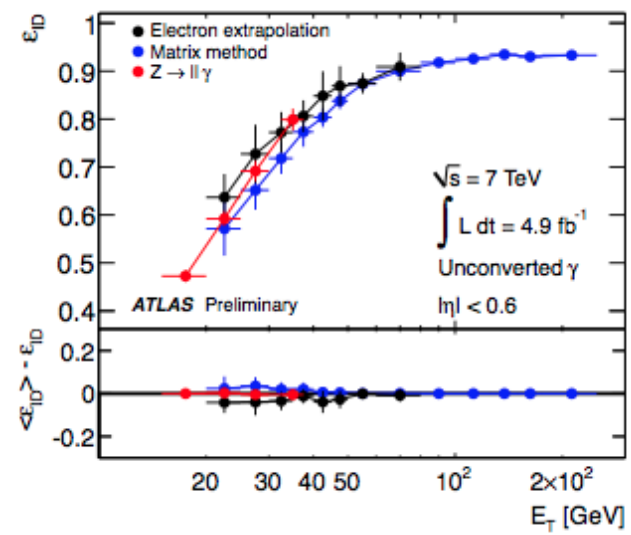




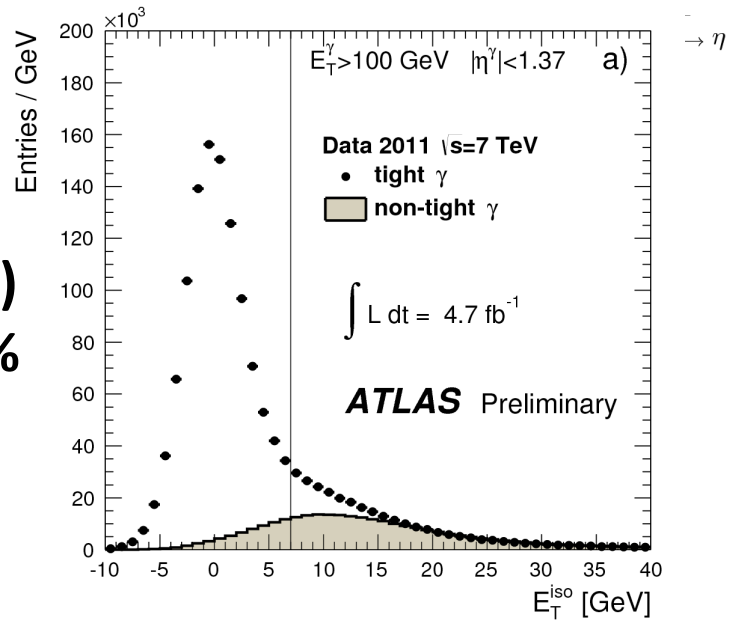
γ ID

ATLAS-CONF-2012-123
ATLAS-CONF-2013-022

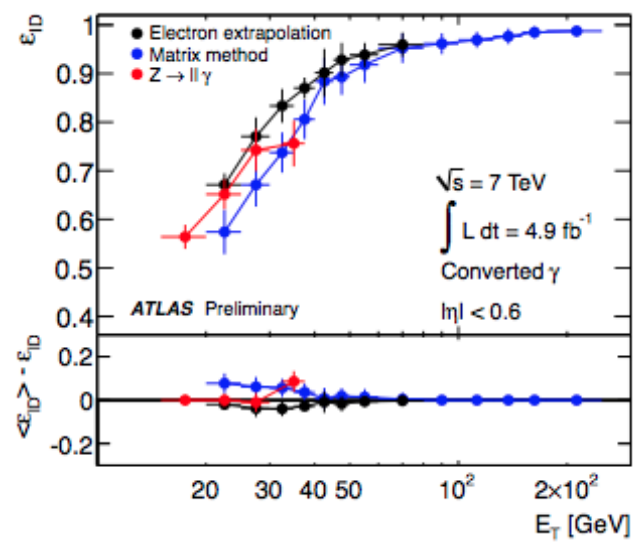




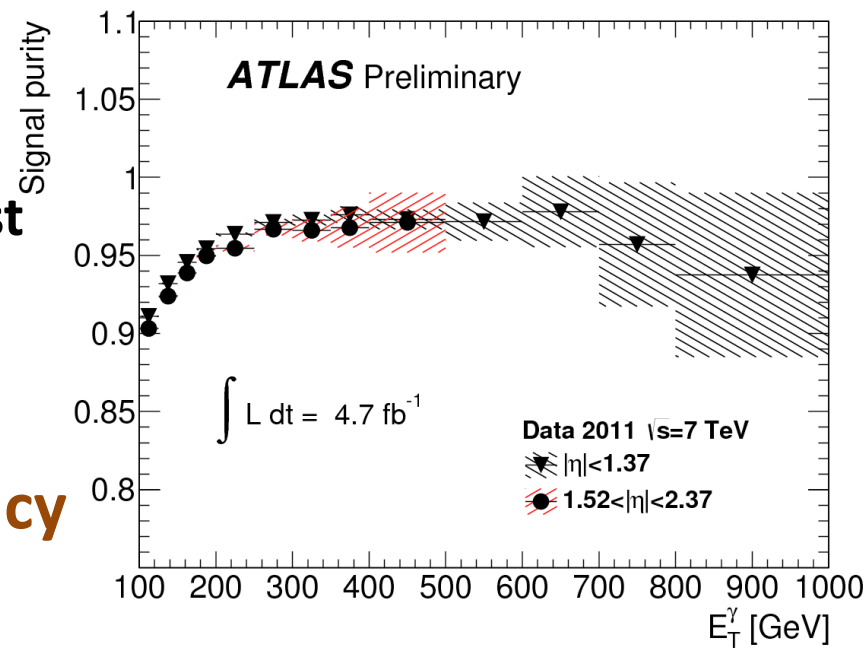
Slicing windown algoritm to determine the em-cluster (good photon– π^0 separation) E-scale known better than 1%



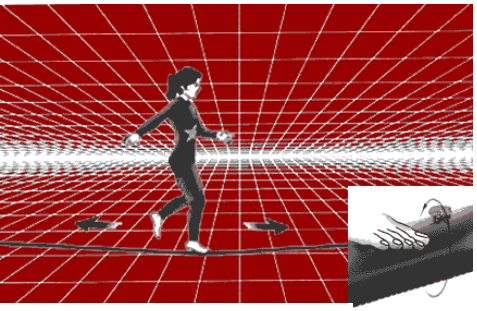
Reconstruction of both unconverted/converted photons



Photon isolation against multijet background

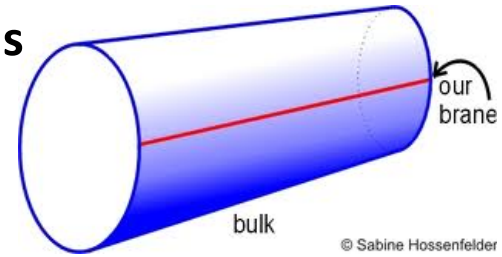


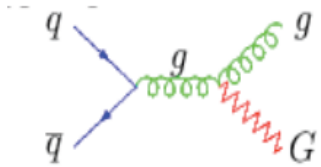
High purity/efficiency at large photon p_t

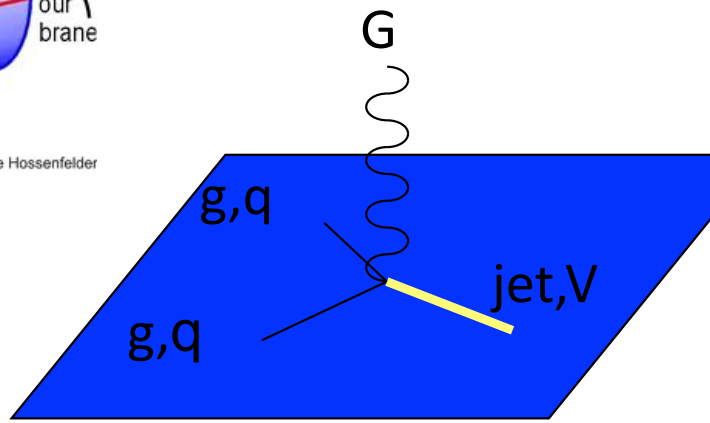


Large Extra Dimensions

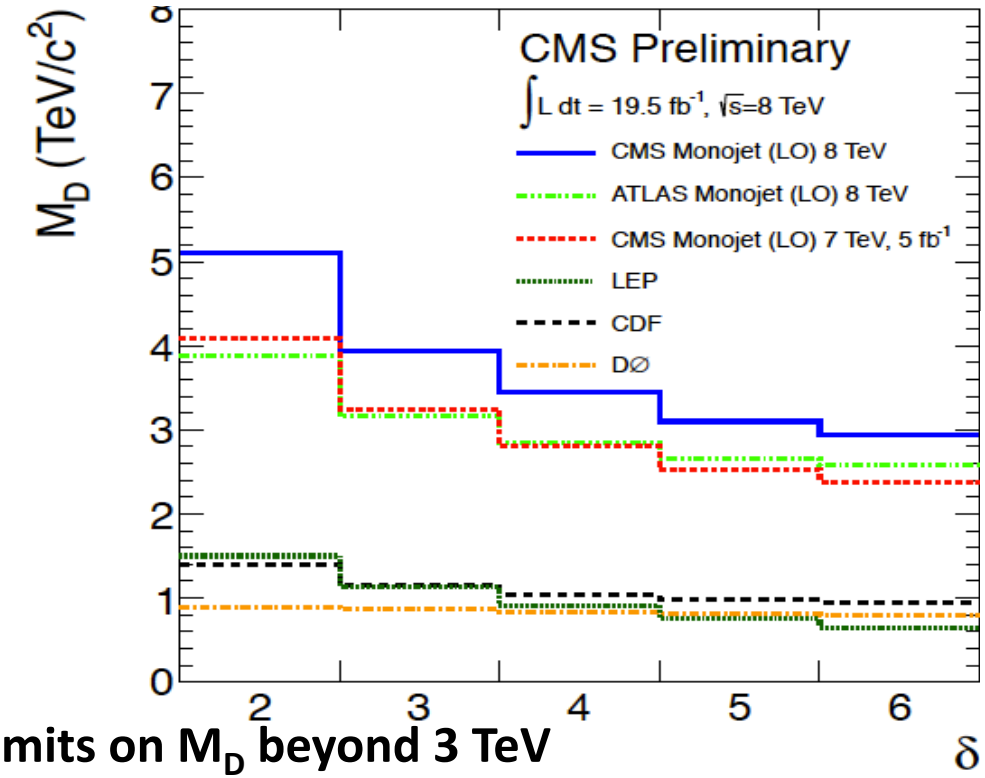
Extra spatial dimensions explain the apparent weakness of Gravity (relevant scale ~TeV)

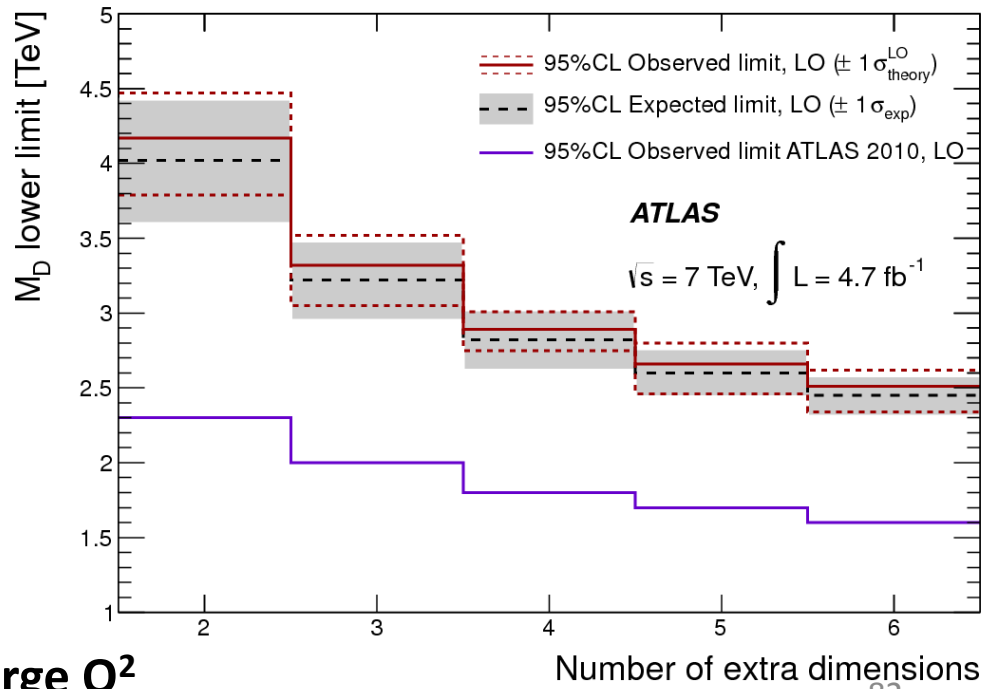






$$(M_{PL})^2 \sim R^n (M_D)^{2+n}$$





Limits on M_D beyond 3 TeV
(a real challenge of the model model validity)

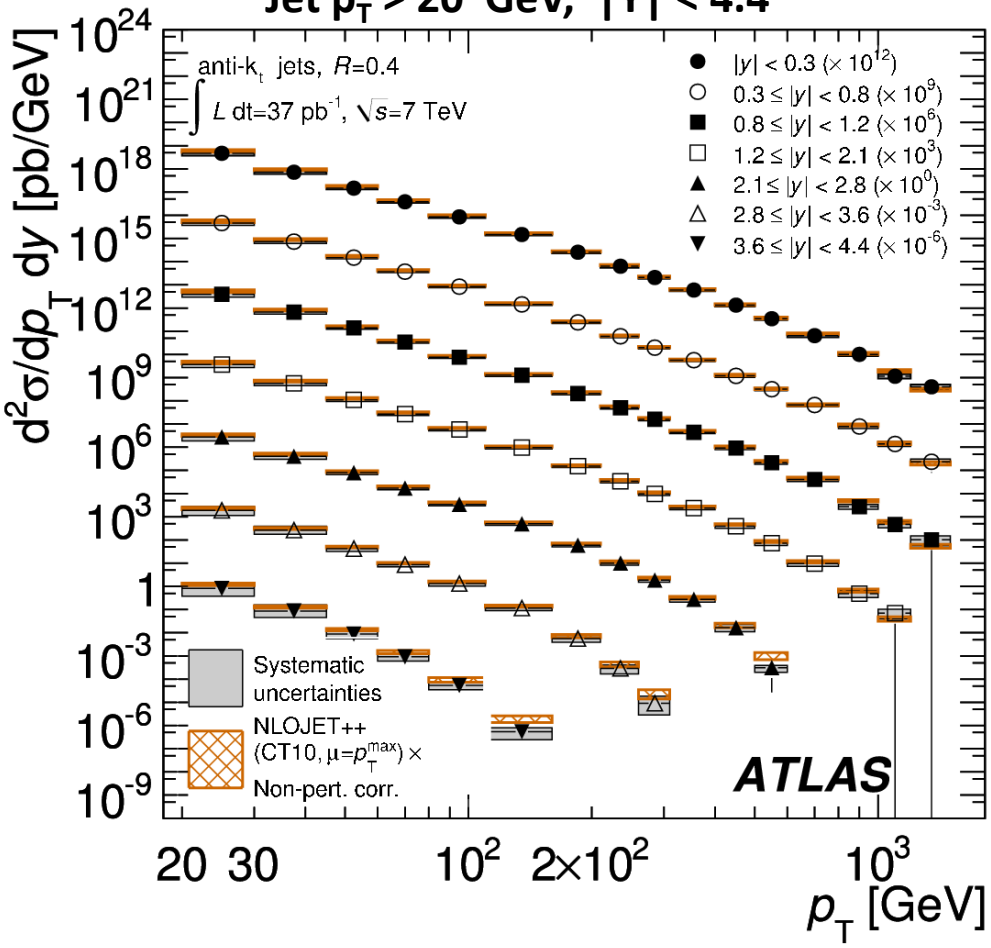
Note: Limits sensitive to the truncation strategy for s-hat > M_D^2 … LHC probing phase space at large Q^2

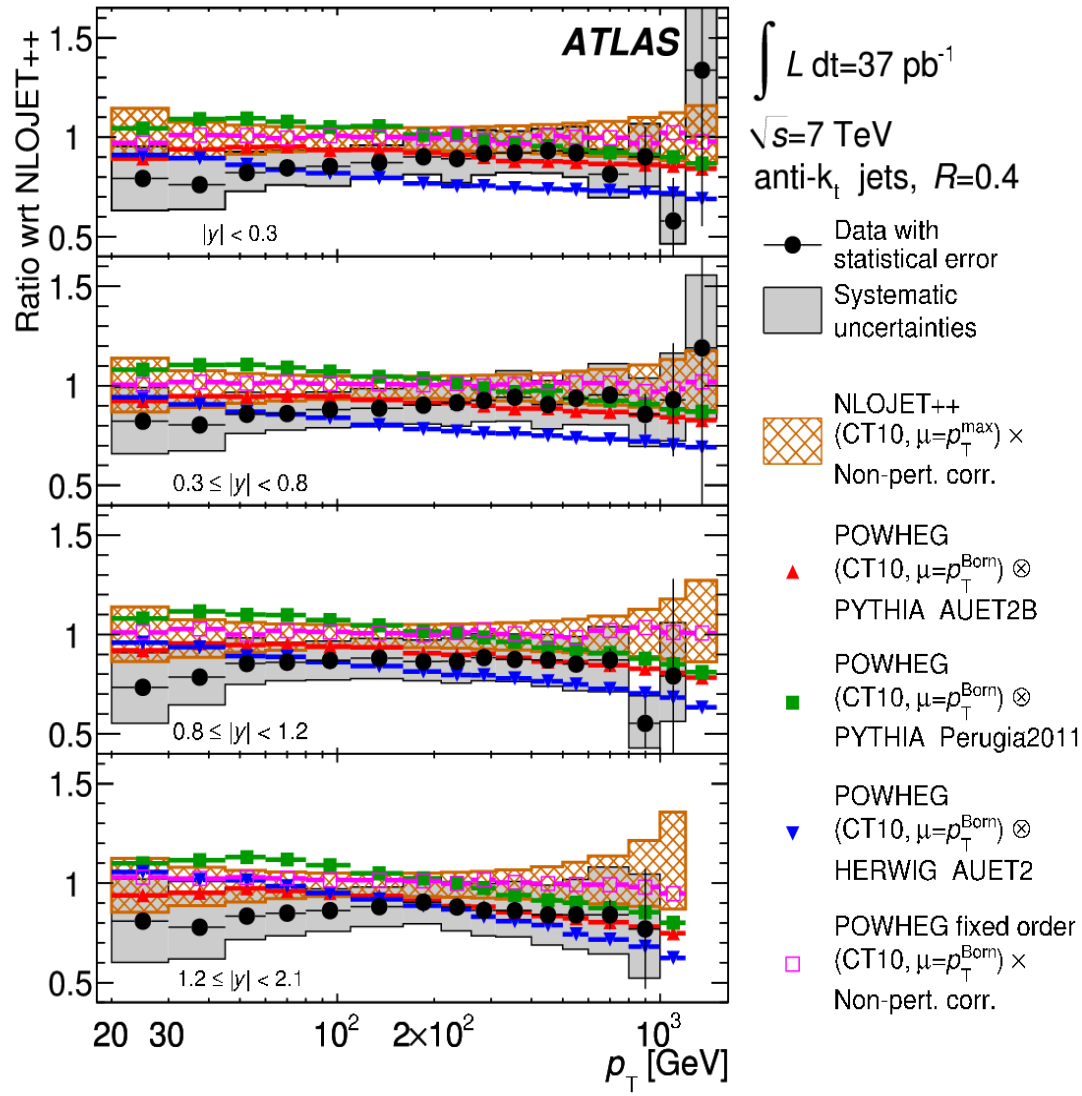
Inclusive Jet Production

PRD86(2012)014022

Stringent test of pQCD predictions (sensitive to quark compositeness)

anti-K_T jets with R=0.4, 0.6
Jet p_T > 20 GeV, |Y| < 4.4





Data compared to NLO pQCD predictions (including non-pQCD corrections) and to NLO ME + PS (POWHEG) with different PS + UE/MPI implementations

Measured cross section in agreement with NLO pQCD predictions

Clear sensitivity to the details of the NLO ME+PS implementation

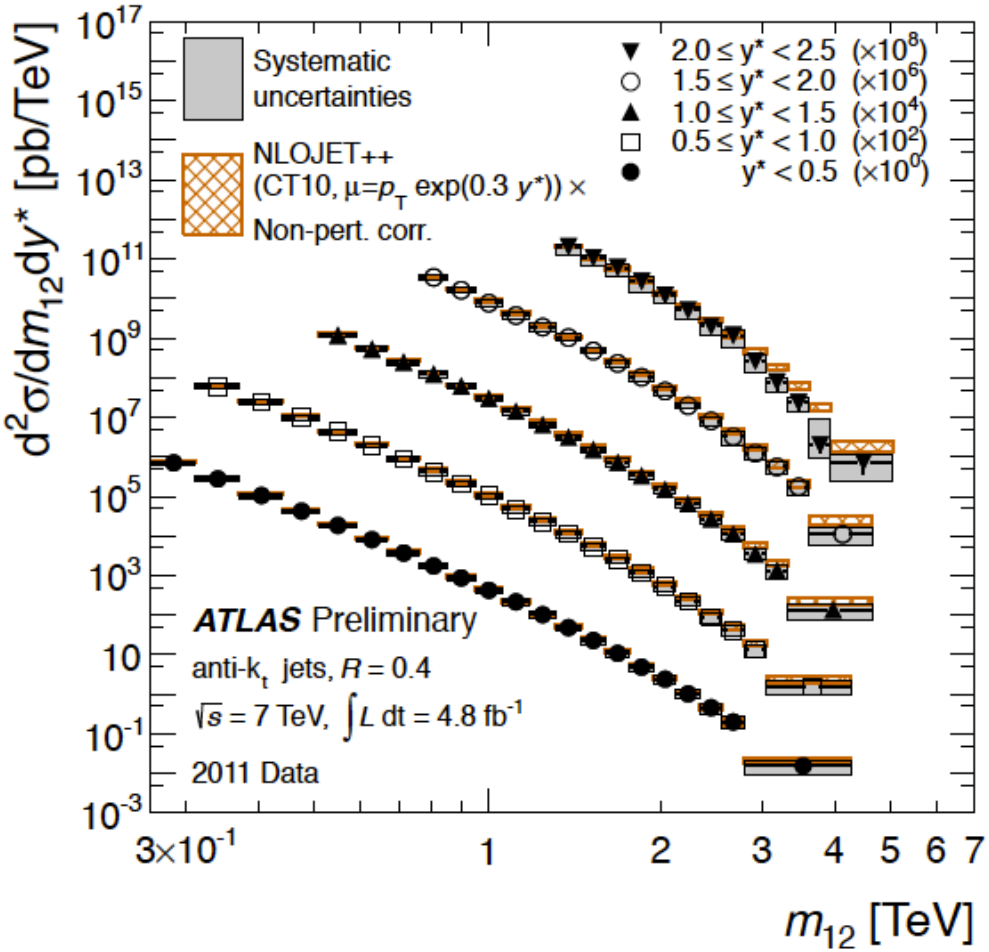
Di-jets

4.8 fb^{-1}

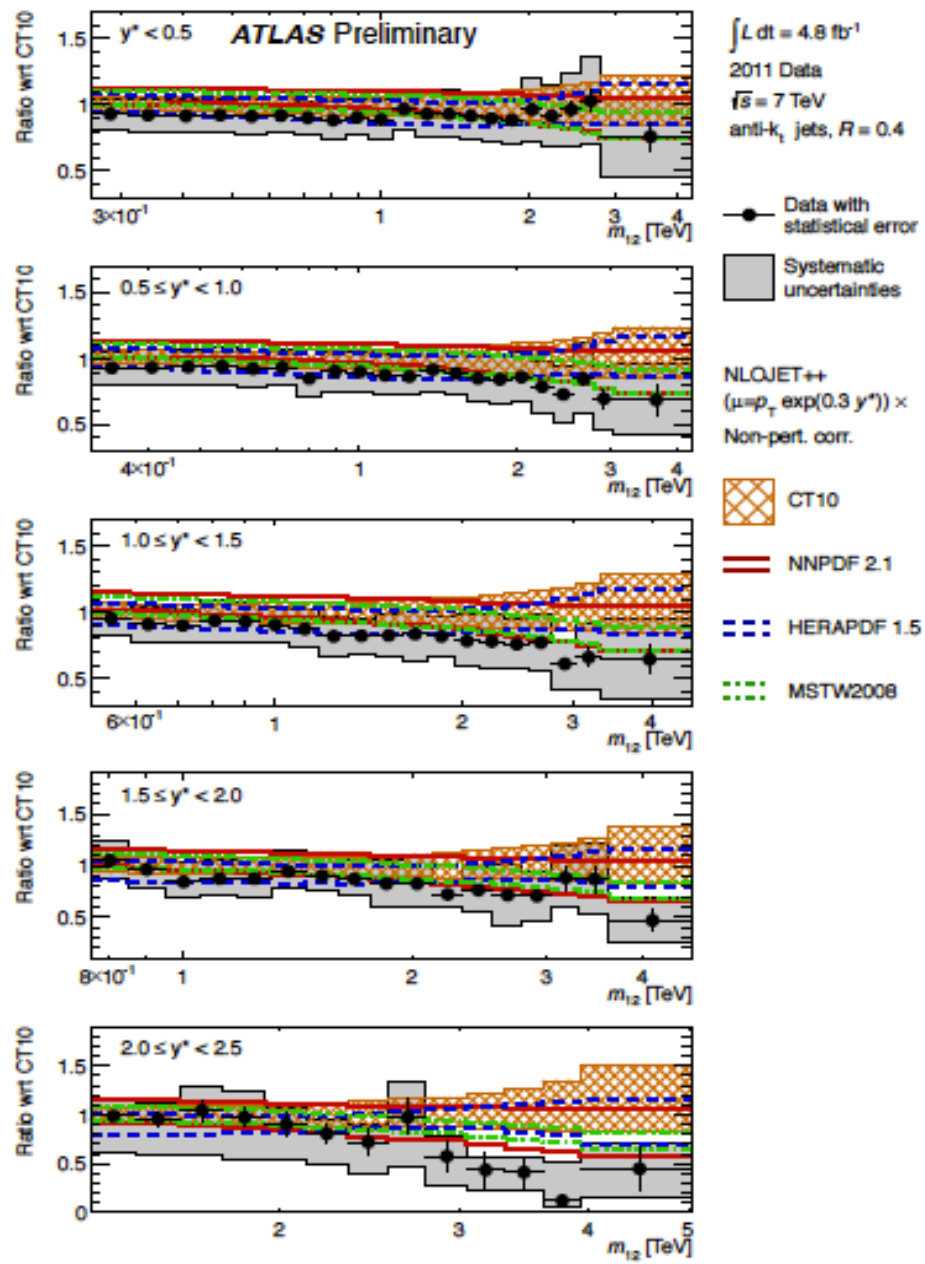
ATLAS-CONF-2012-021

$M_{jj} > 260 GeV$

$y^* = | y^1 - y^2 | / 2 < 2.5$



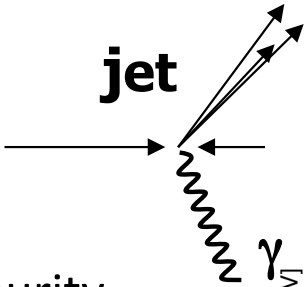
Stringent pQCD test
(sensitive to new dijet resonance production)



Invariant masses up to 5 TeV
Reasonably well described by NLO pQCD
(some tension at very large dijet masses)

γ+jet

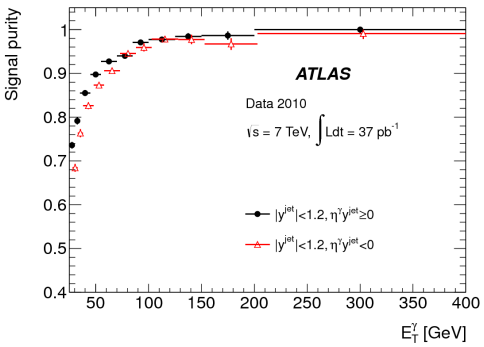
CERN-PH-EP-2012-009

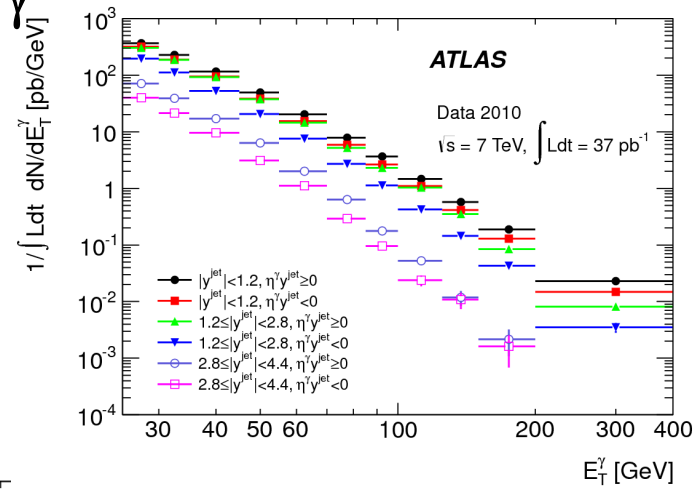


Jet p_T > 20 GeV
photon E_T > 25 GeV

Measured cross sections with
$\eta^\gamma y^{jet} > 0$ & $\eta^\gamma y^{jet} < 0$

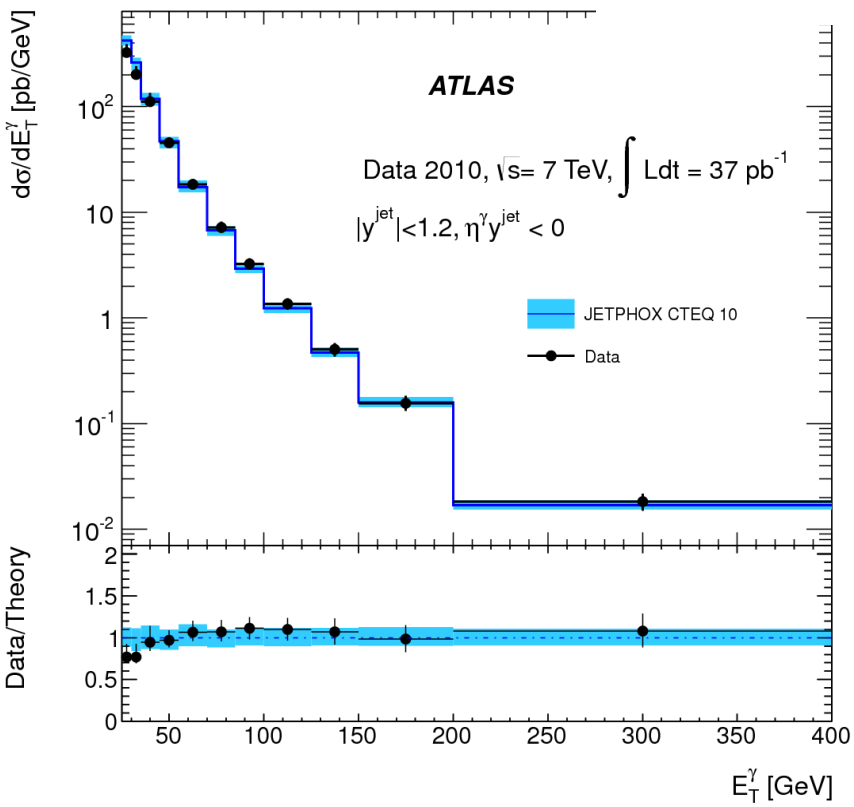
photon purity



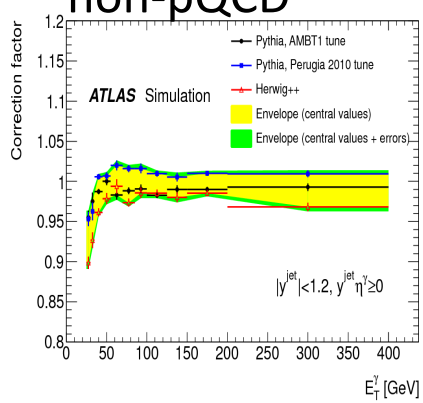


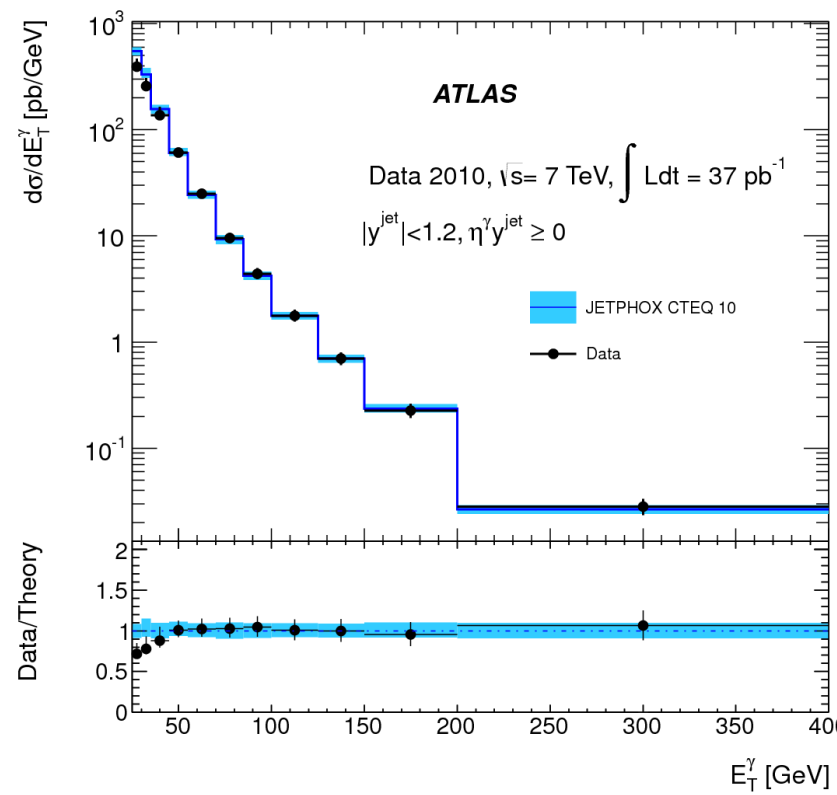
Fair agreement with NLO pQCD except at very low E_T^γ (< 45 GeV)

difficult region where photon purity decreases and non-pQCD corrections are sizable



non-pQCD



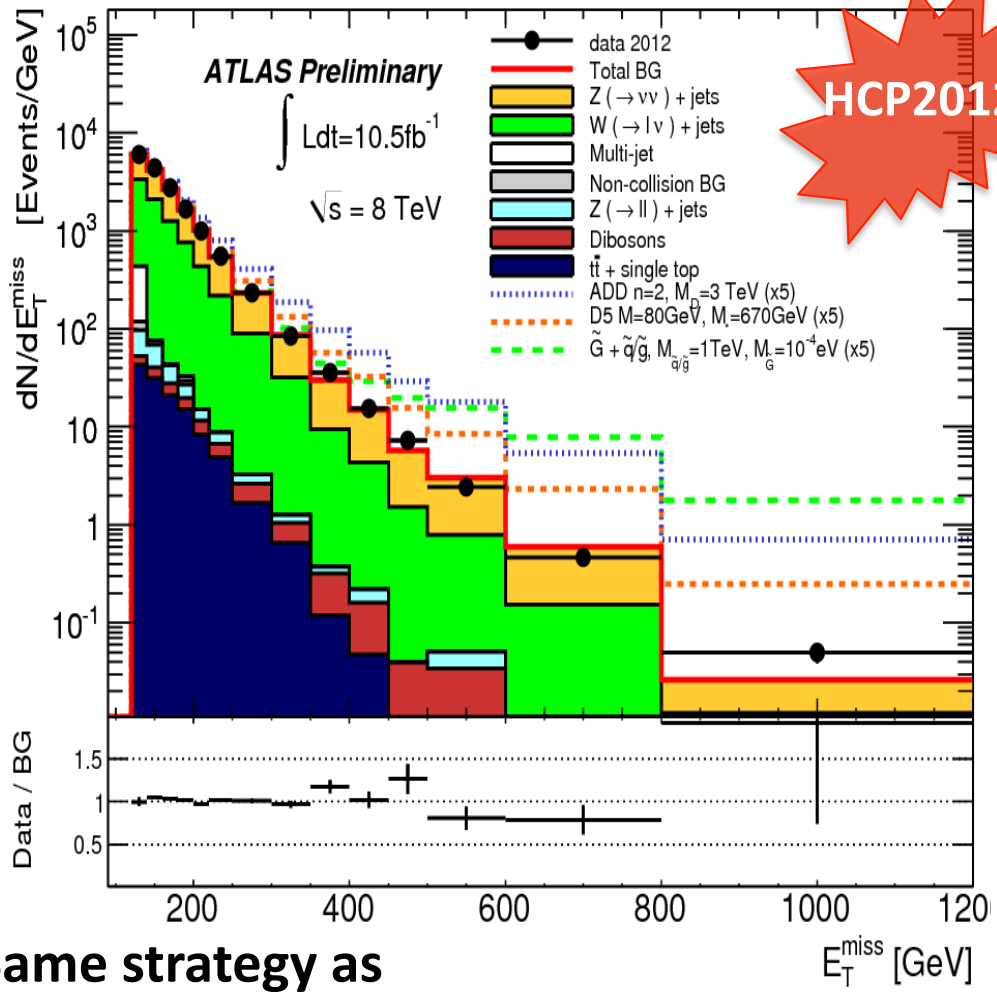


8 TeV Monojets

HCP2012

10 fb^{-1}

ATLAS-CONF-2012-147



Same strategy as in the 7 TeV analysis

E_T^{miss} > 120, 220, 350, 500 GeV

p_T (j1) > 120, 220, 350, 500 GeV

$N_{jet}(p_T$ > 30 GeV) < 3

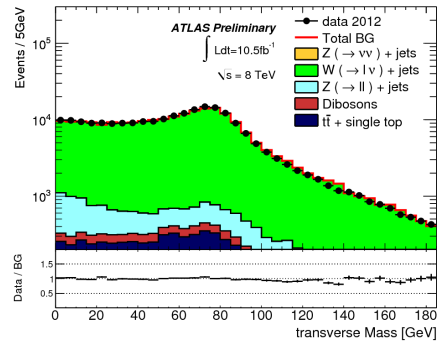
$\Delta\phi$ (E_T^{miss}, j2) > 0.5

Lepton vetoes

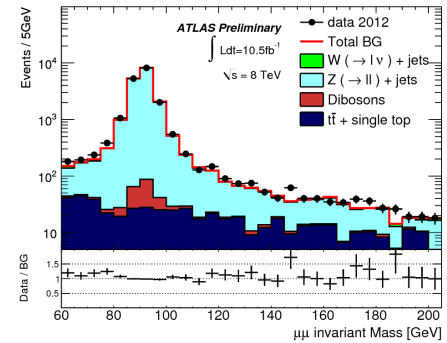
Good agreement with SM predictions

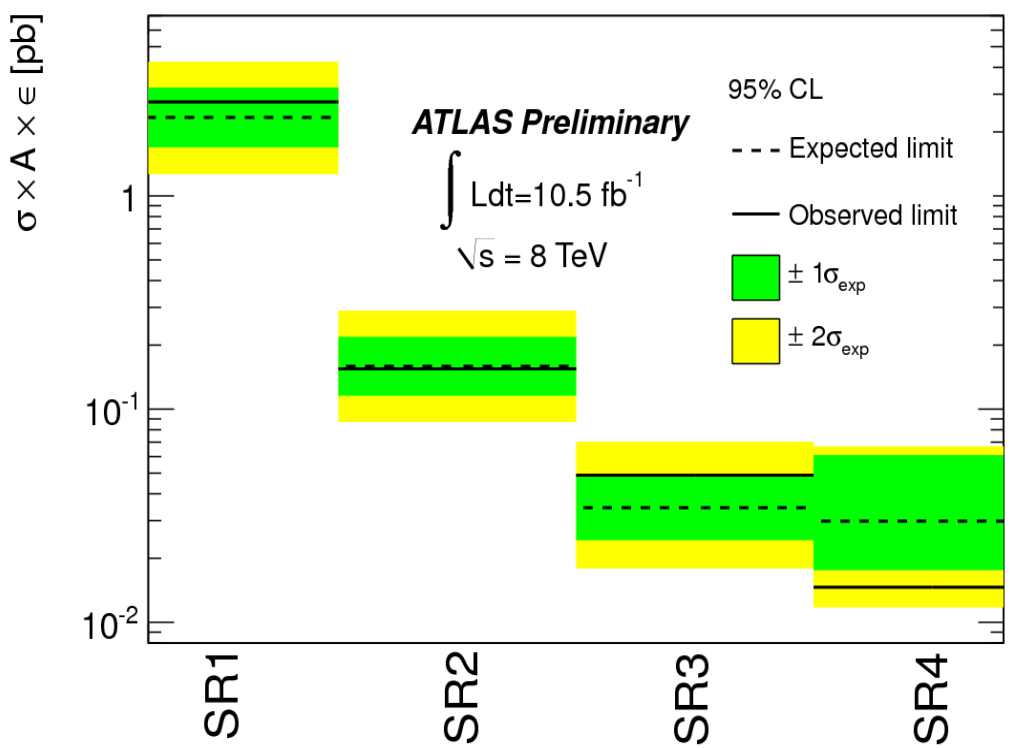
(suffered from lack of MC statistics)

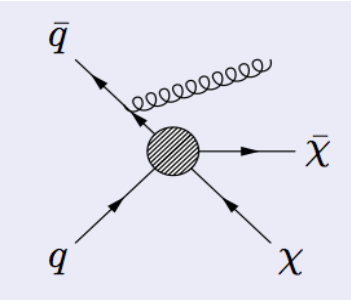
single-muon events



dimuon events

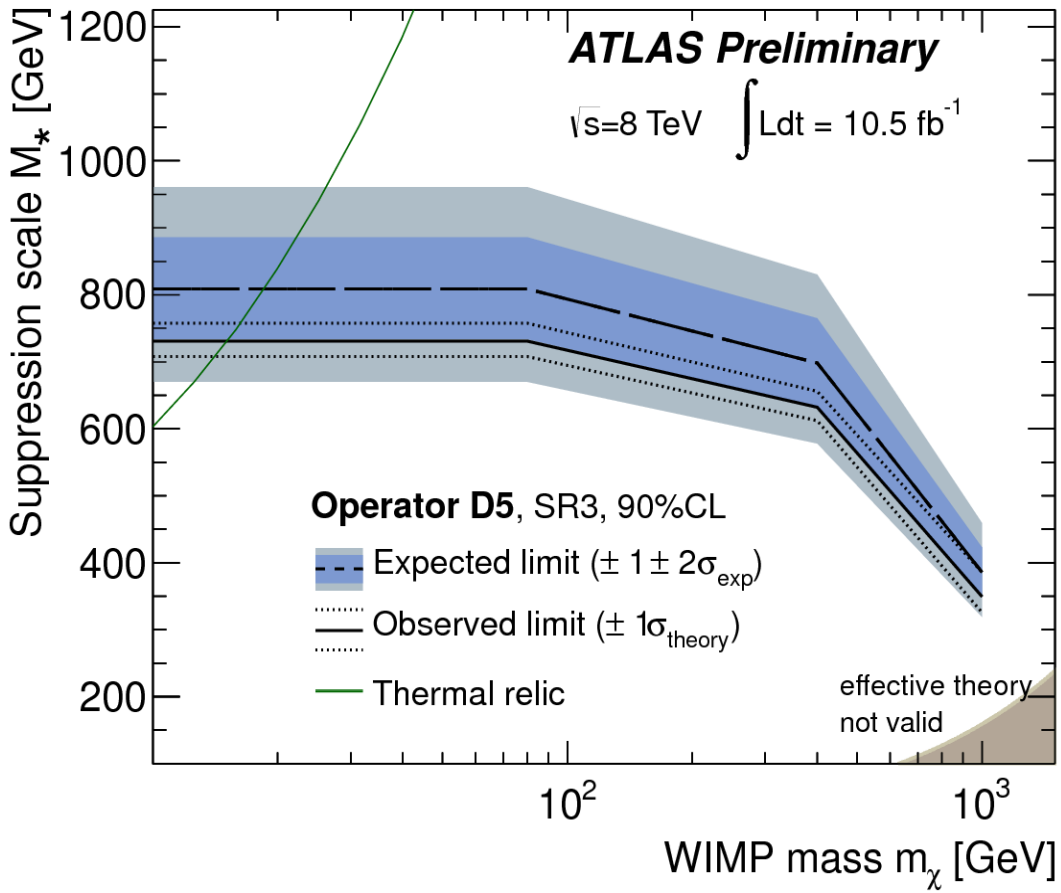




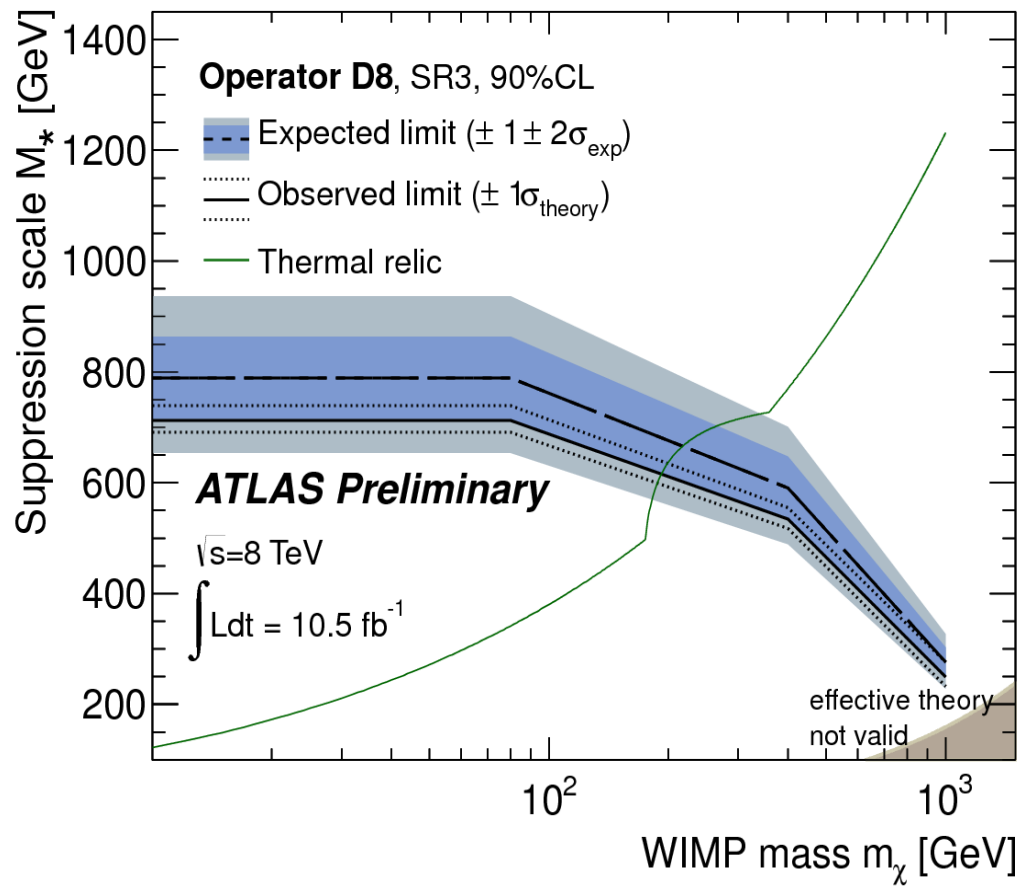


90% CL Limits on suppression scale

VECTOR

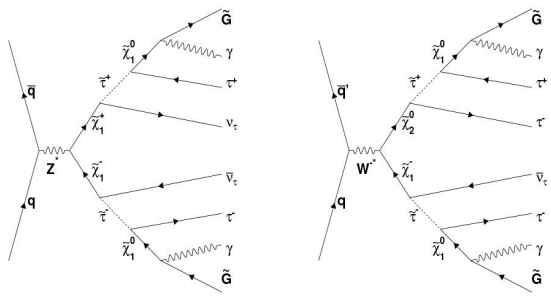


AXIAL-VECTOR



Modest (~10%) improved with respect to 7 TeV limits (due to Backg. MC statistics limitations)

γγ + Missing E_T

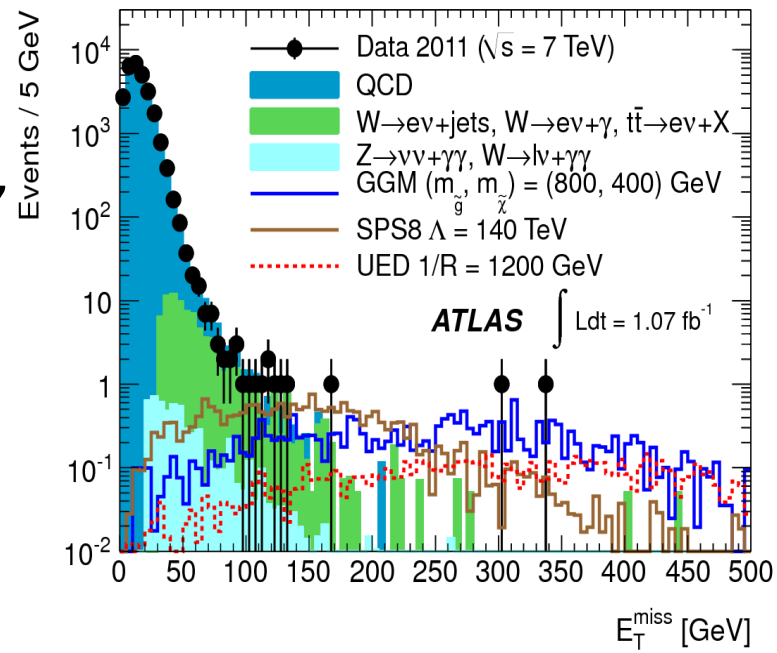


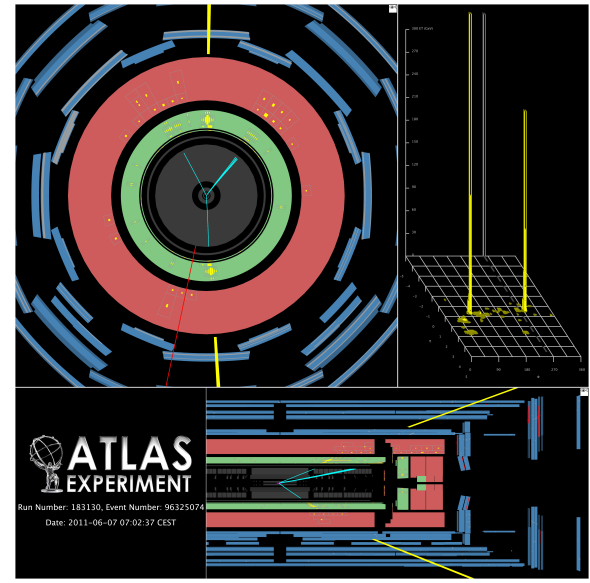
Phys.Lett.B710 (2012) 519-537

Good agreement with SM

Limits on generic GMSB

Λ < 145 TeV excluded

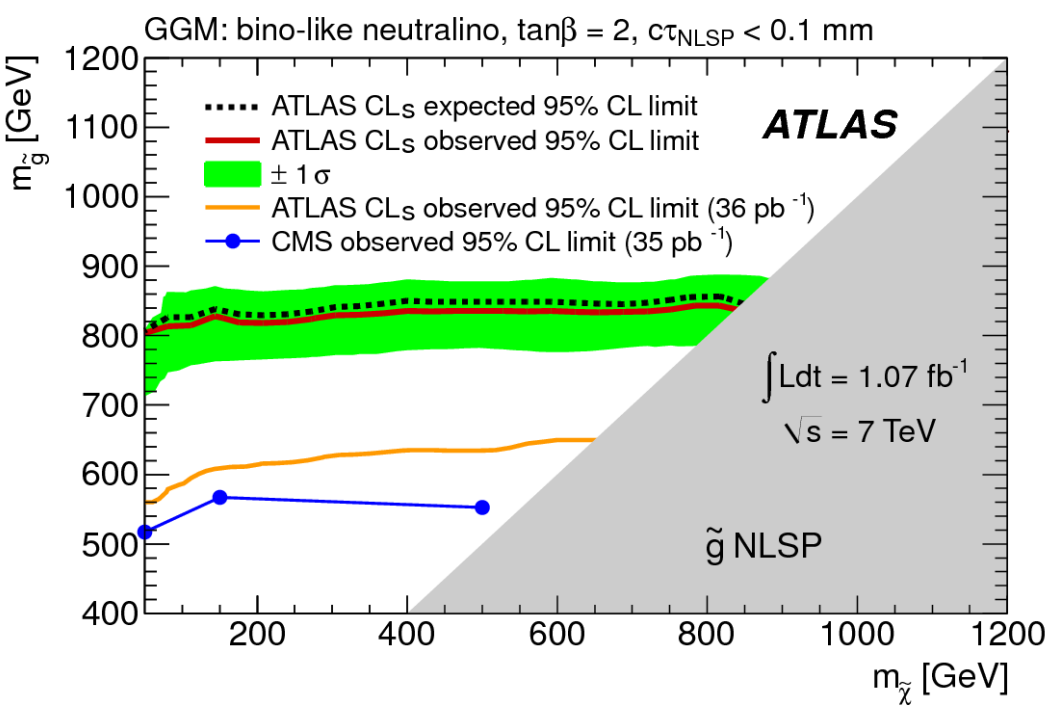


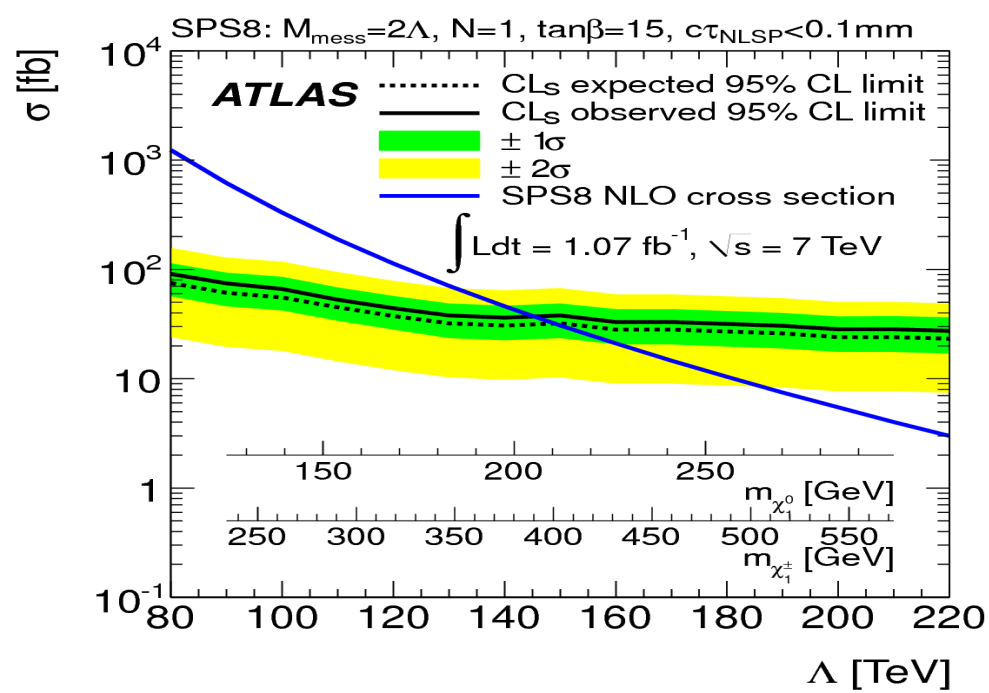


Limits on simplified model

Gluino for production

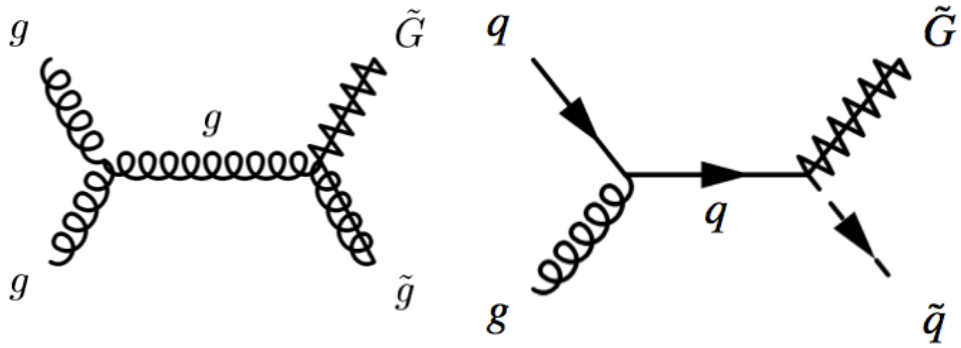
Bino-like neutralino as NLSP





GMSB Gravitino

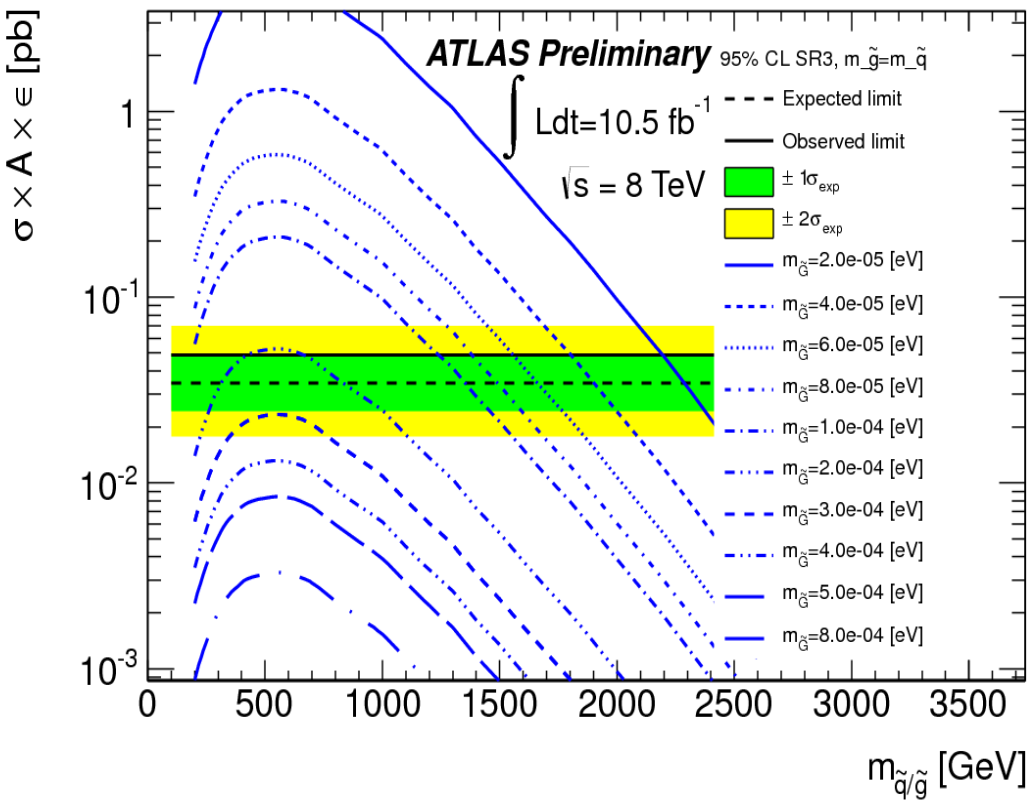
$$m_{3/2} = \langle F \rangle / \sqrt{3}\, \overline{M}_{\mathrm{Pl}}$$

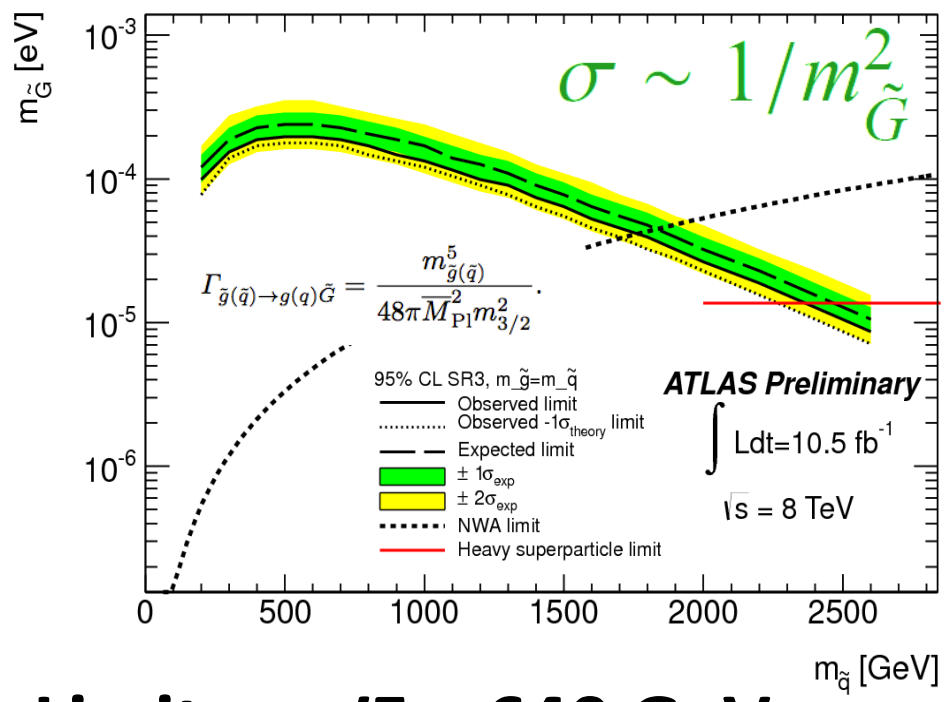


Interpreted in terms of GMSB gravitino+squark/gluino production

gluinos (squarks) decay to gluon (quark) plus Gravitino (100%)

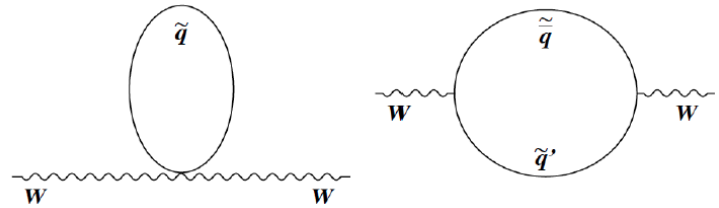
Best limits to date on the gravitino mass





Limit on √F > 640 GeV
(LEP limit 240 GeV)

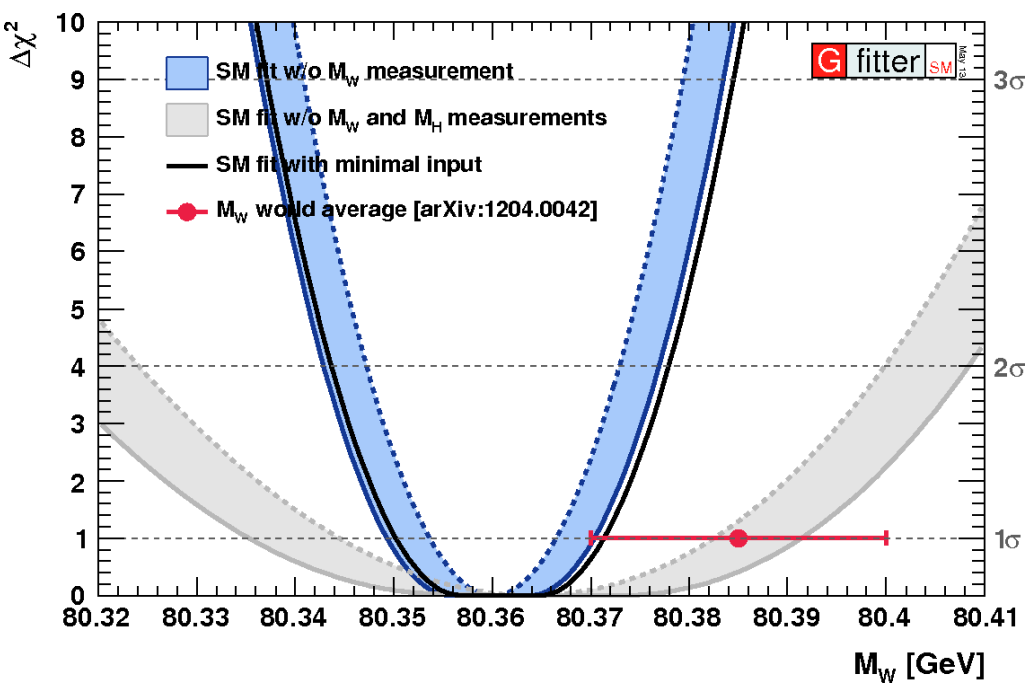
EWK fits vs Higgs

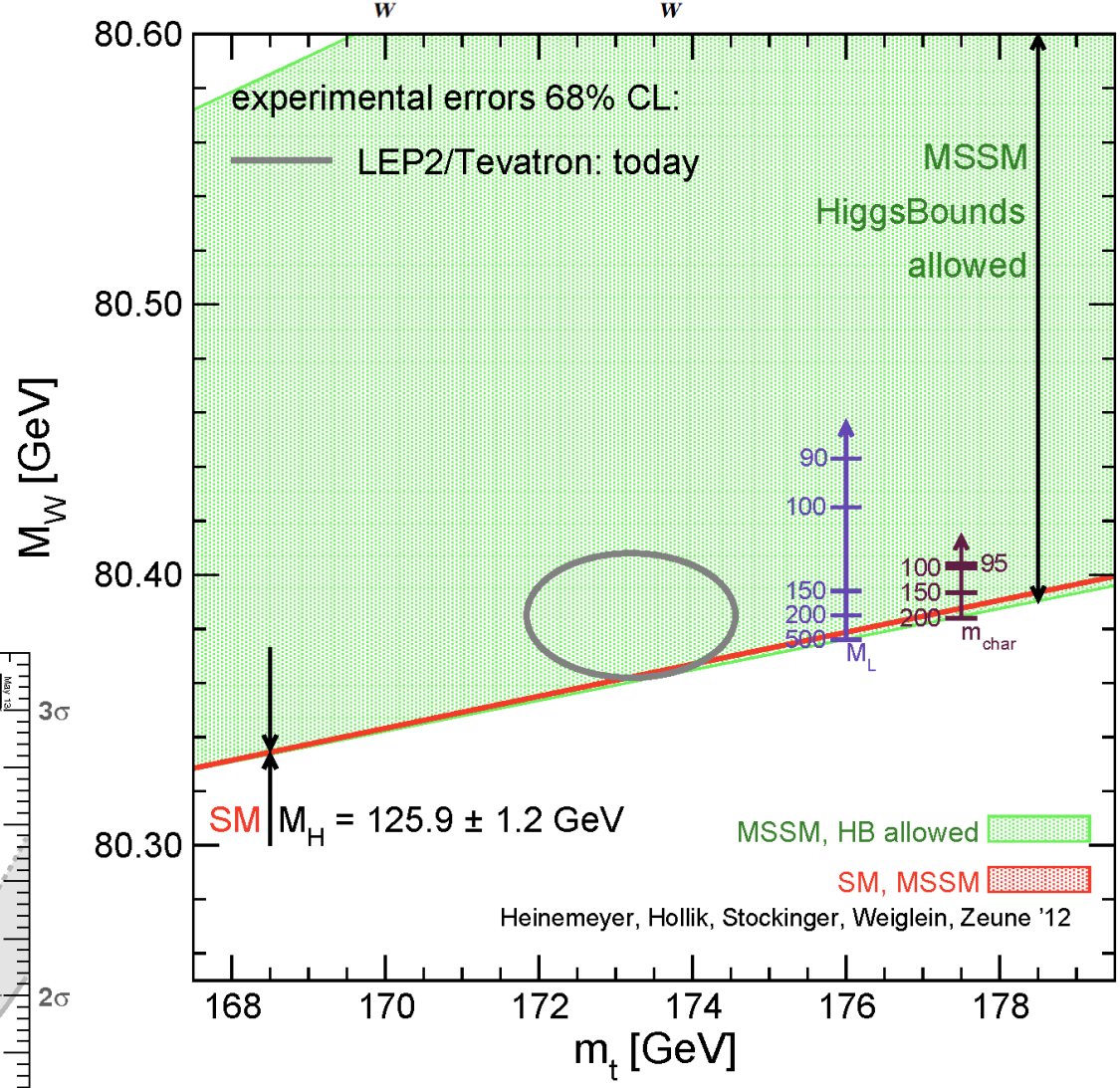


Indirect determination of M_W using measured Higgs mass as input leads to

M_W (indirect) = 80.359 +- 0.011 GeV

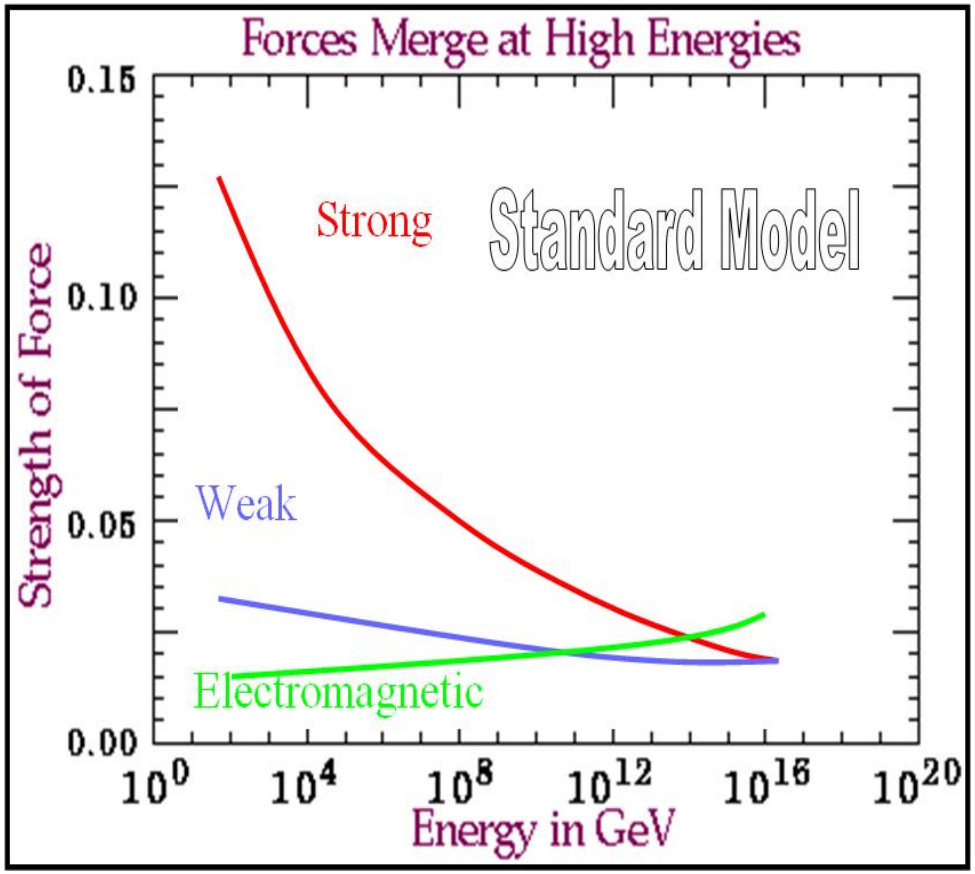
→ Better than direct measurement (World Average : 15 MeV)

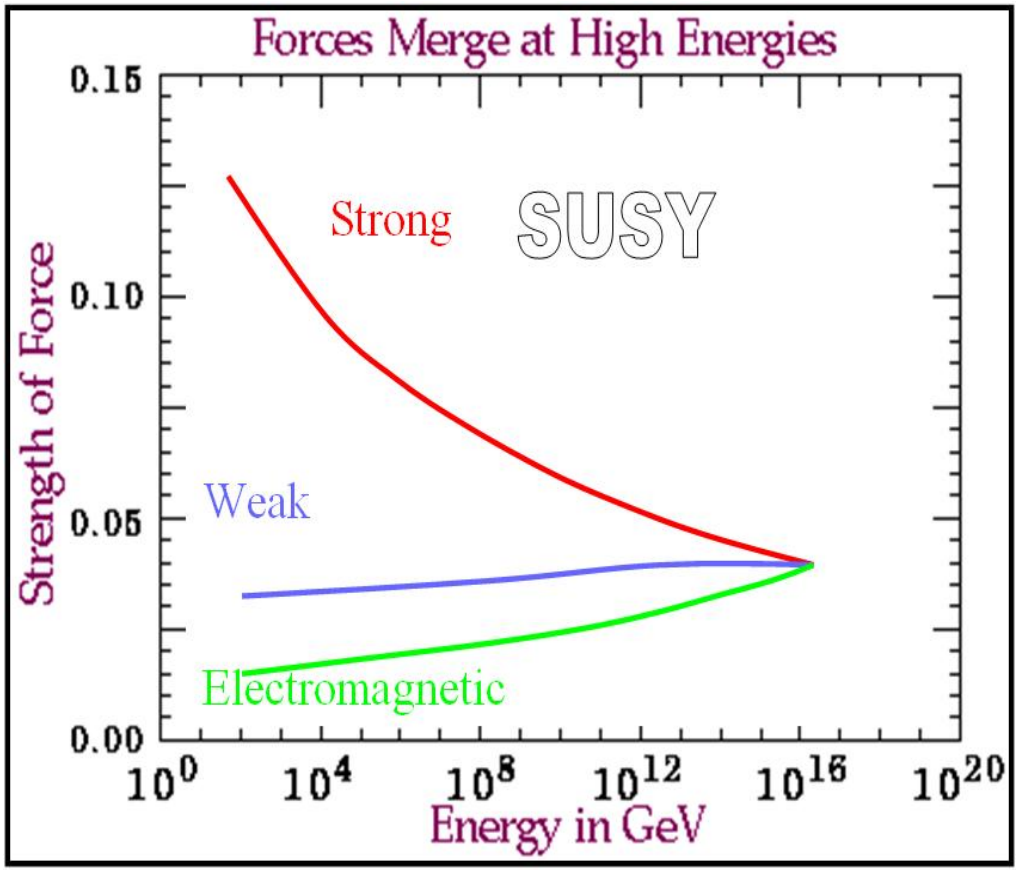




Room for improvement in M_W measurement (sensitive via loops to presence of new physics)

Unification of Forces…





ttH (H → bb)

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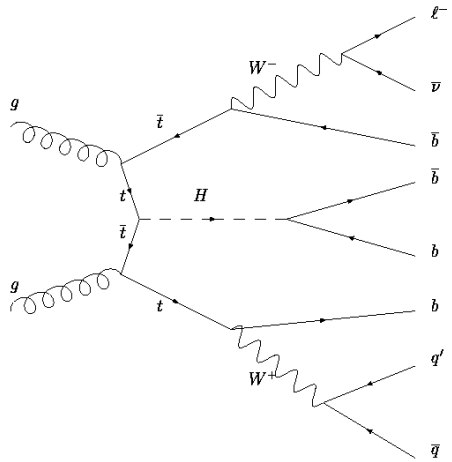
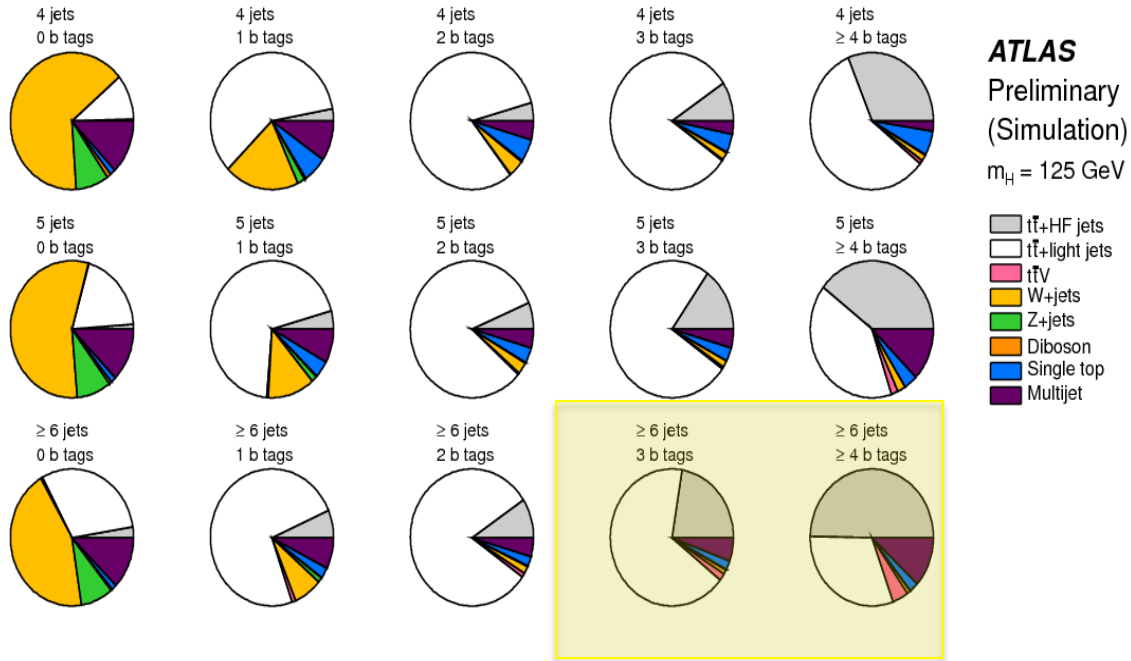


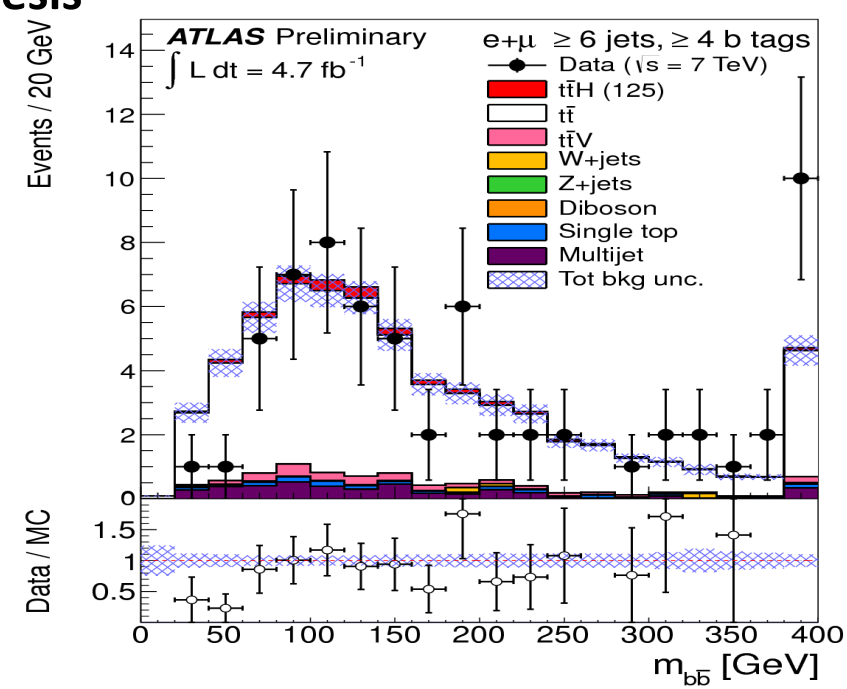
l+jets channel

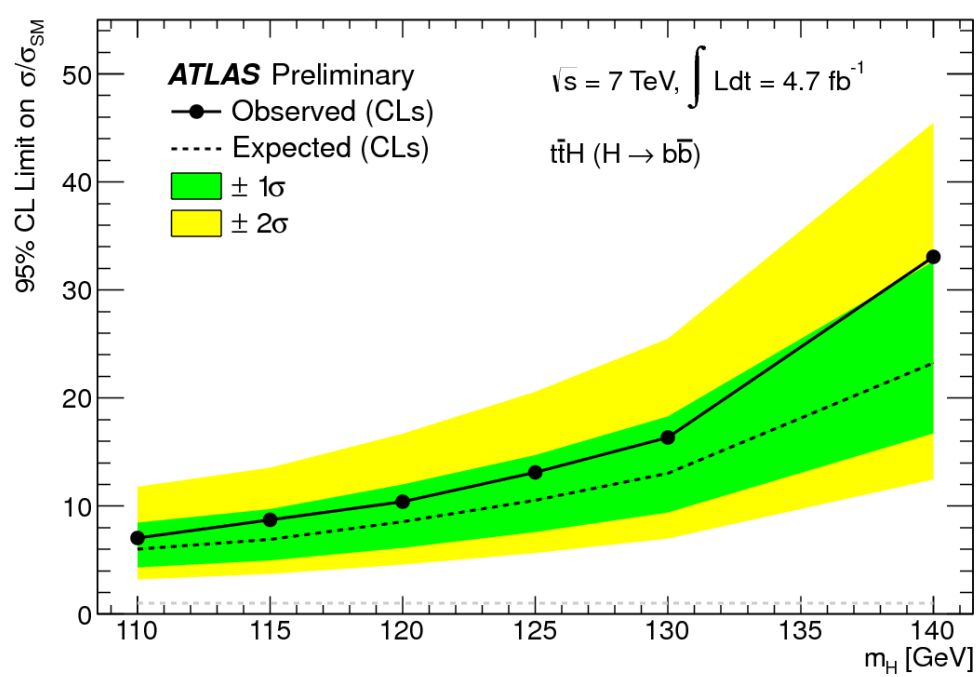


Considers many jet and b-jet multiplicity bins to constrain simultaneously signal and background

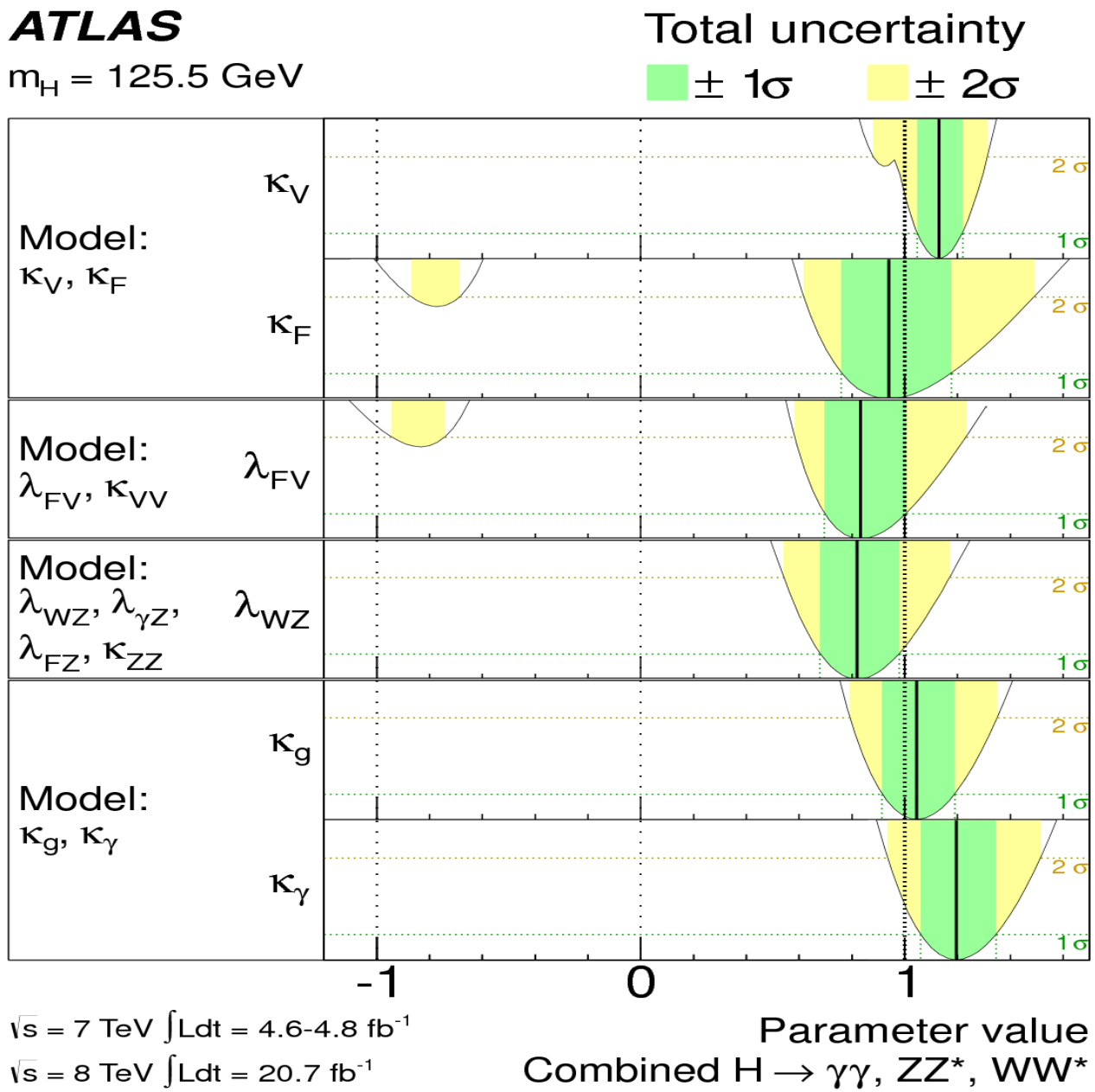
Profiling of systematic uncertainties

Kinematic fit in signal region for ttH hypothesis





Higgs Couplings



Consistent with SM predictions