Searches for Mono-X at the LHC

DIS 2014

IFAE

A.Cortés-Gonzalez
Institut de Fisica d'Altes Energies, Barcelona

On behalf of the **ATLAS** and **CMS** collaborations

May 1, 2014

Outline

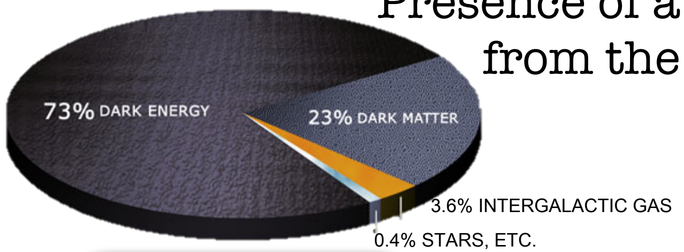
- Introduction / Motivation.
- **ATLAS** and **CMS** experiments
- **Searches** (7 and 8 TeV):
  - Mono-jets
  - Mono-photons
  - Mono-W/Z

interpretations

- Dark Matter
- Large Extra Dimensions.
- Super symmetry.
- Higgs to invisible particles.

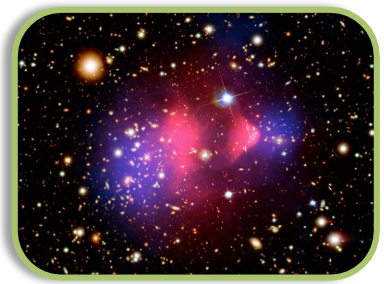
- Conclusions

Motivation Dark Matter



Presence of a **dark matter** component in the universe inferred from the observation of its gravitational interactions.

- **Rotation of stars** around the center of the galaxies is not consistent with the amount of mass *observed*.

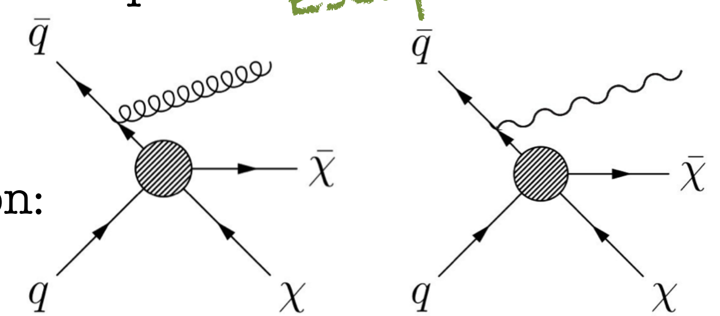


- **Collisions of cluster of galaxies**.
  ← The bullet cluster.
- **Gravitational Lensing**:
  Large distortion of images of distant galaxies due to gravitational lensing (indication of DM in galaxy clusters).

- **Requirements**:
  - Stable.
  - Electrically Neutral.
  - Massive & weakly interacting.
- **Candidates**:
  - Neutrinos not a good candidate.
  - SUSY particles? E.g. Lightest neutralino.
  - WIMPs.

At colliders like the LHC, WIMPs can be produced in pairs. Escaping detection

- We can tag those events via the presence of an energetic jet, a photon or a boson from initial state radiation:



Effective theories of SM interaction with **WIMPs**.

- Effective Lagrangian approach with parameters M* and m_χ. Assuming interaction is mediated by a heavy particle with mass M and coupling g_1 and g_2.

$$M^{*2} = \frac{M^2}{g_1 g_2}$$

- χ taken as a *Dirac fermion*.

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	$\frac{1}{4M_\star^3}\bar{\chi}\chi\alpha_s(G^a_{\mu\nu})^2$

- Different operators, with different structures, are considered.

- *Theory only applicable when M is much larger than the energy scale present in the reaction.*
- Natural solution to **EFT validity**: **simplified models** (with mediator).
  - Three regimes can be studied: off-shell, resonance, contact interaction.

Motivation SUSY

SM is a very successful theory, but...

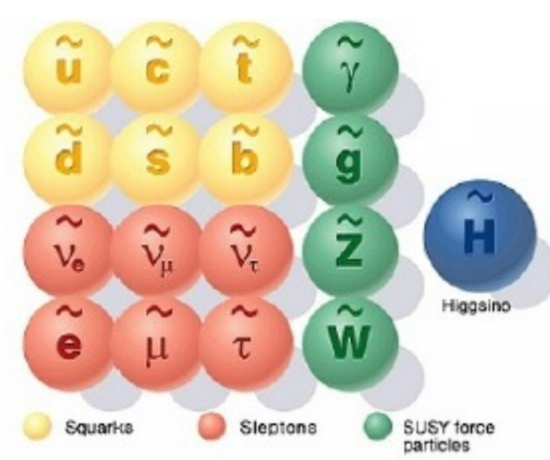
- Particles in the SM have masses in the EW scale.
  No new particles between m_W(~10^2 GeV) and m_P(~10^8 GeV).

- High levels of fine tuning needed to avoid divergences in Higgs mass corrections.
  Corrections can be up to 30 orders of magnitude larger than m_H.

Hierarchy problem!

- No Dark matter candidate.

SUSY:



- Hierarchy problem? New super-partner loop roughly cancels the SM loop.

- DM? If R-parity is conserved, lightest SUSY particle (LSP) is stable. Good candidate for Dark Matter.

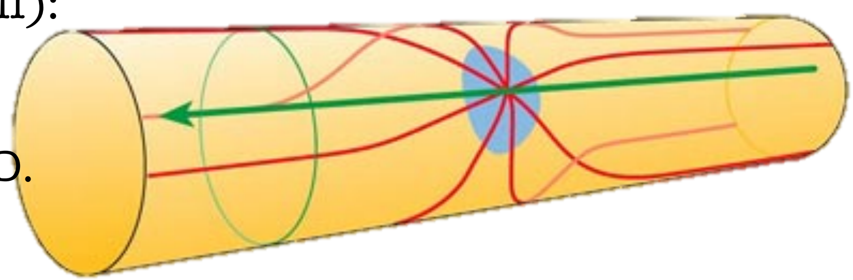
Mono jet/photon signatures:

- Gravitino.
- Stop in compressed scenarios.

Large Extra Dimensions:

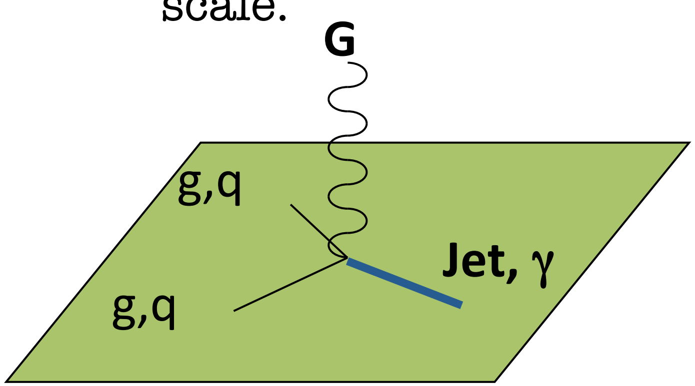
- Extra spatial dimensions proposed as a way to solve the hierarchy problem.
  Explain the apparent weakness of Gravity (relevant scale ~TeV).

- ADD (Arkani-Hamed, Dimopoulos, Dvali):
  Gravity propagates through
  4+n dimensional bulk.
  Other **SM fields** confined to the usual 4D.



  - $m^2_{Pl} \sim m^{2+n}_D R^n$

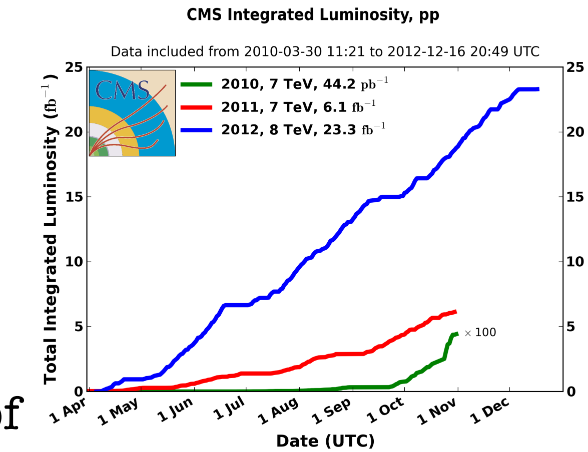
  - Allows a fundamental Planck scale of the order of EW scale.

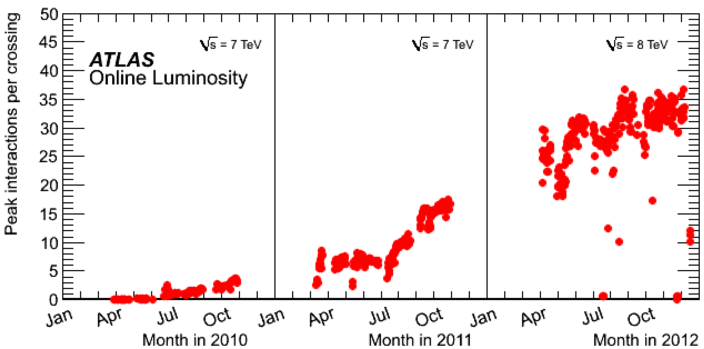


Signature of these events:
1 photon/jet + Graviton (missing transverse energy)

LHC Data

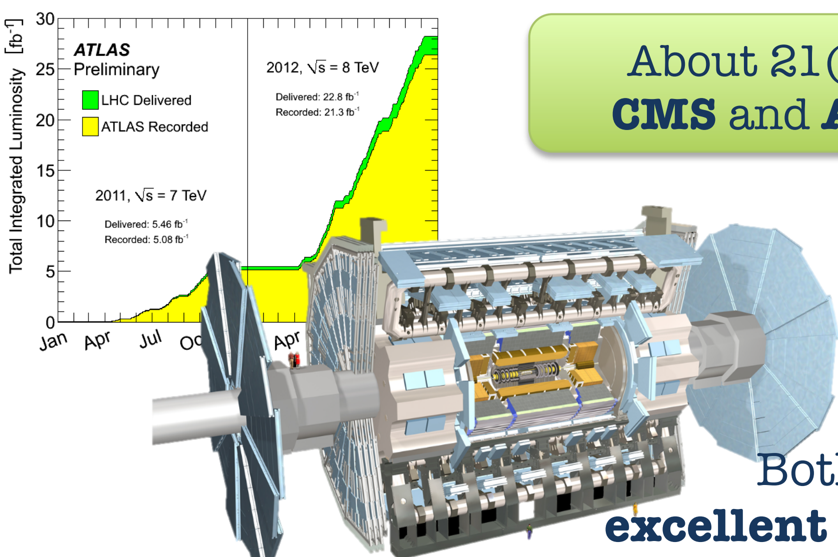
- Superb LHC performance in Run I.
  - Rapidly accumulating large data samples!
  - Large Luminosity → Large Pileup



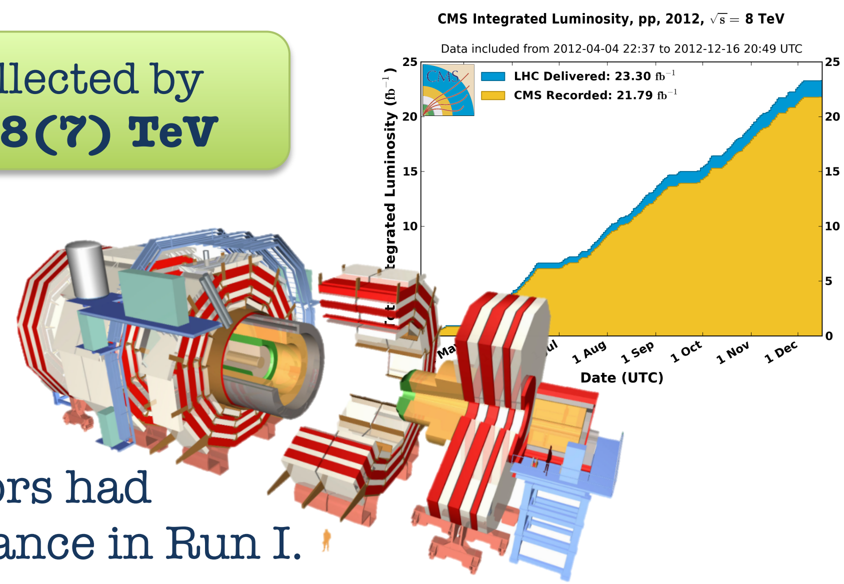


These challenging conditions require a lot of work to achieve **great physics performance**.

13-14 TeV collisions coming in 2015!



About 21(5) fb^{-1} collected by **CMS** and **ATLAS** @ **8(7) TeV**



Both detectors had **excellent** performance in Run I.
More than 90% of the delivered data used for physics…

Monojet searches at 7 TeV

Search for new physics in events with a high-energy jet + large E_T^{miss}.

Main bkg.: **W/Z+jets** estimated via data-driven methods using dedicated CRs.

7 TeV, 4.7 fb^{-1}

JHEP 04 (2013) 75

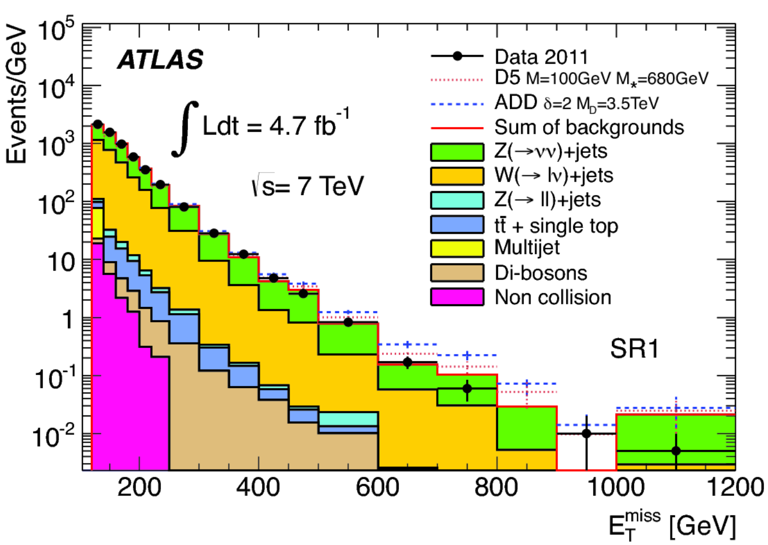
Good agreement between observation in data and SM expectation.

7 TeV, 5.0 fb^{-1}

JHEP 09 (2012) 94

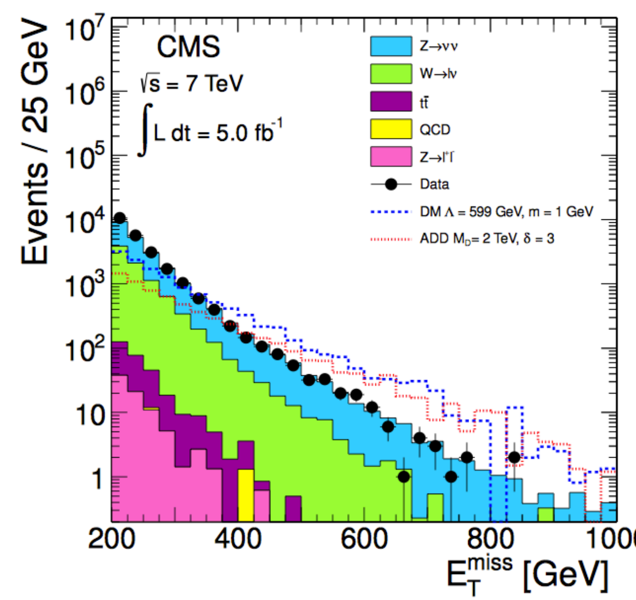
4 signal regions:
E_T^{miss}, p_T(j1) > 120, 220, 350, 500 GeV

	SR1	SR2	SR3	SR4
Total Background	124000 ± 4000	8800 ± 400	750 ± 60	83 ± 14
Events in Data (4.7 fb^{-1})	124703	8631	785	77



p_T(j1) >110 GeV. 4 signal regions:
E_T^{miss}> 250, 300, 350, 400 GeV

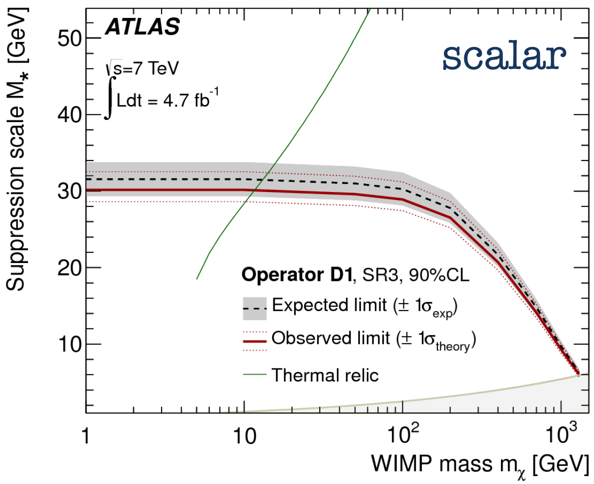
E_T^{miss} (GeV/c) →	≥ 250	≥ 300	≥ 350	≥ 400
Total SM	7842 ± 367	2757 ± 167	1225 ± 101	573 ± 65
Data	7584	2774	1142	522

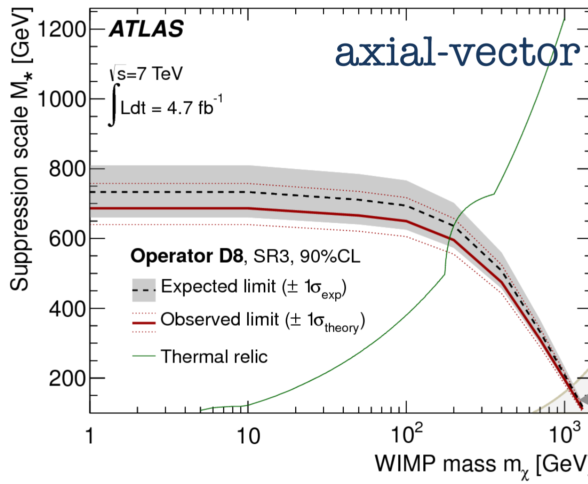


Limits on WIMP production

JHEP 04 (2013) 75

90% CL limits on the visible cross-sections are translated into limits on **M* as a function of m_χ** (WIMP mass) for different operators.

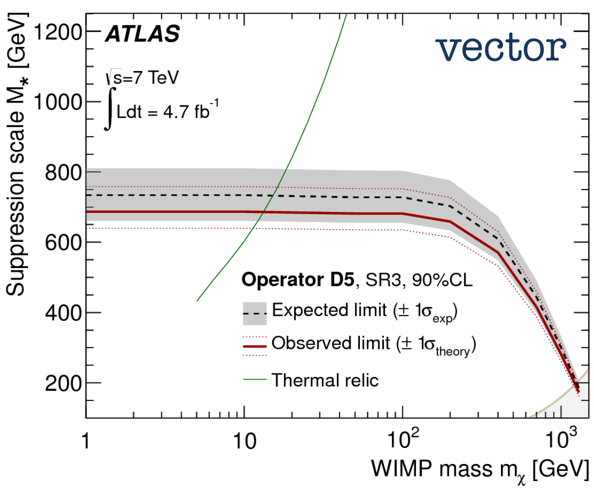


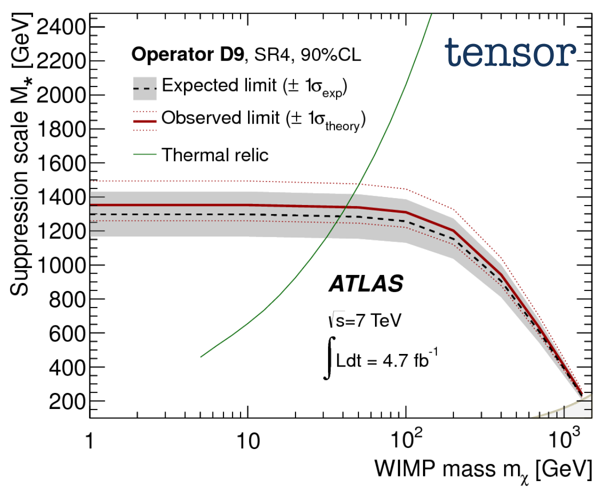


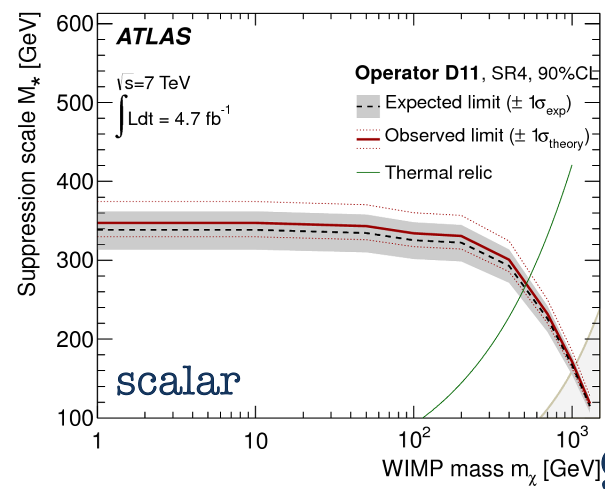
Thermal relic

Indicates the values for M* and m_χ leading to the proper abundance (WMAP).

EFT no longer valid.





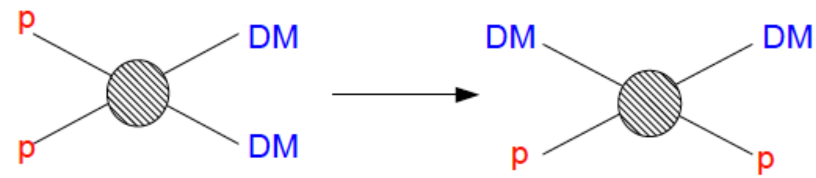


WIMP-nucleon cross section

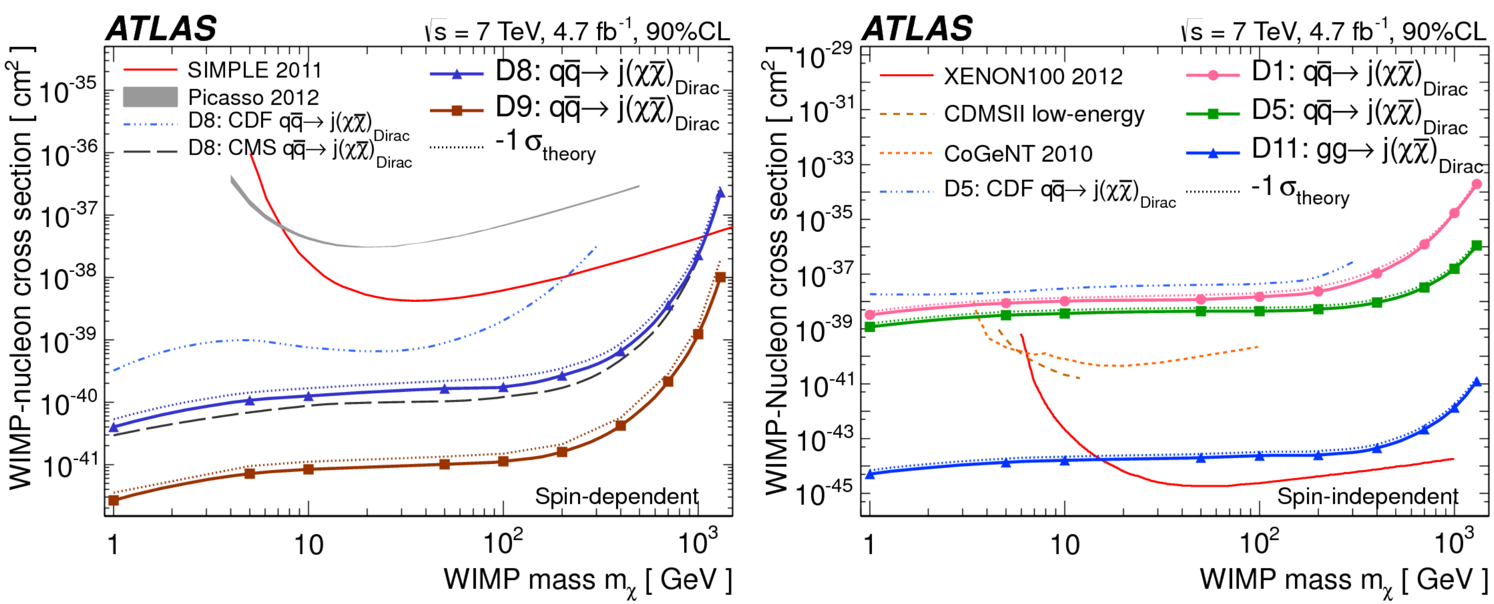
JHEP 04 (2013) 75

JHEP 09 (2012) 94

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



Under **assumption of the validity of the EFT**, LHC results are competitive to direct detector experiments (mainly for m_χ < 10 GeV).



Strong limits in spin-dependent processes.
Large sensitivity in case of spin-independent D11 (gg initiated).

Mono-photon searches at 7 TeV

Search for new physics in events with a photon + large E_T^{miss}.

Main background: irreducible **W/Zγ(→ννγ)** and jets/electrons faking photons.

7 TeV, 5.0 fb^{-1}

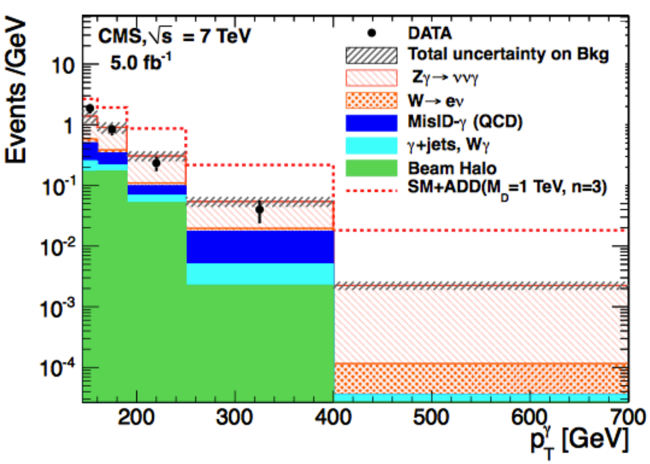
PRL108, 261803 (2012)

Isolated photon:

- $p_T(\gamma) > 145$ GeV, $|\eta^\gamma| < 1.44$

$E_T^{miss} > 130$ GeV

Veto on leptons, isolated tracks, jets



7 TeV, 4.6 fb^{-1}

PRL110, 011802 (2013)

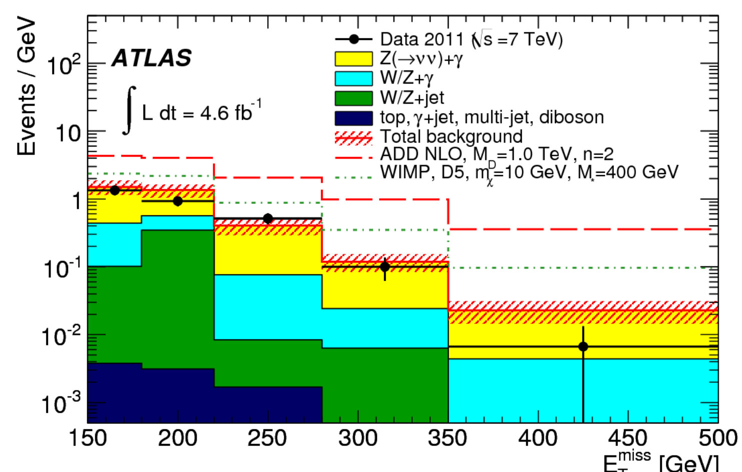
Isolated photon:

- $p_T(\gamma) > 150$ GeV, $|\eta^\gamma| < 2.37$

$E_T^{miss} > 150$ GeV

$N_{jets}(p_T > 30\text{ GeV}) < 2$, $\Delta\phi(E_T^{miss}, \text{jets}/\gamma) > 0.5$

Veto on leptons



Good agreement with SM expectation

Total Background	75.1 ± 9.5
Total Observed Candidates	73

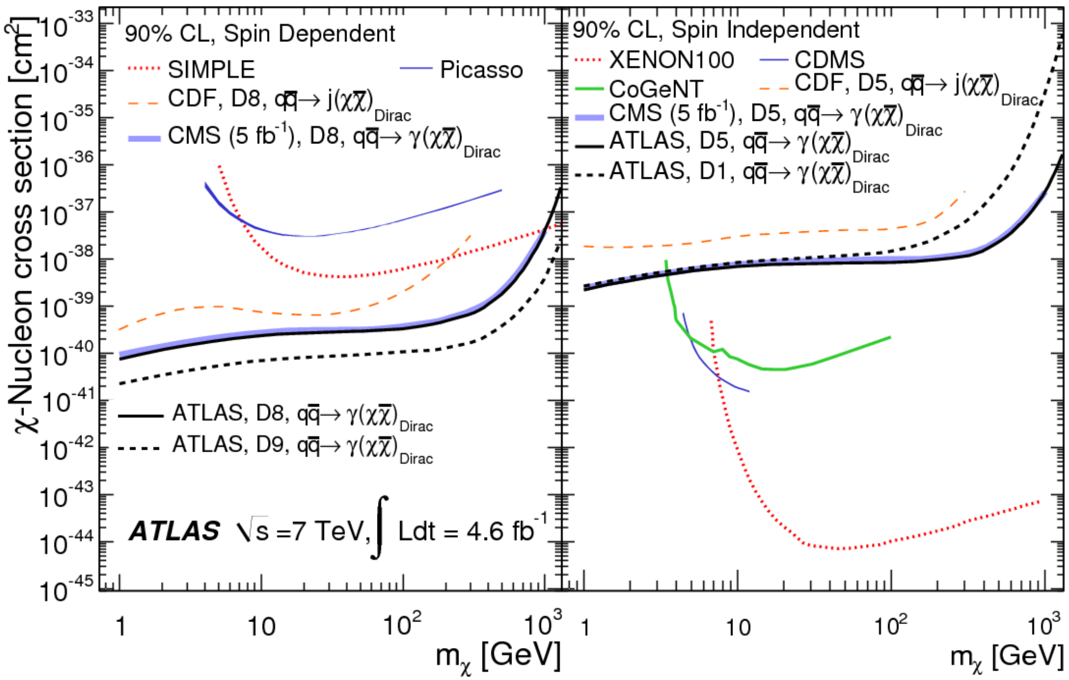
	Prediction	± (stat.)	± (syst.)
Total background	137	± 18	± 9
Events in data (4.6 fb^{-1})	116		

WIMP-nucleon cross section

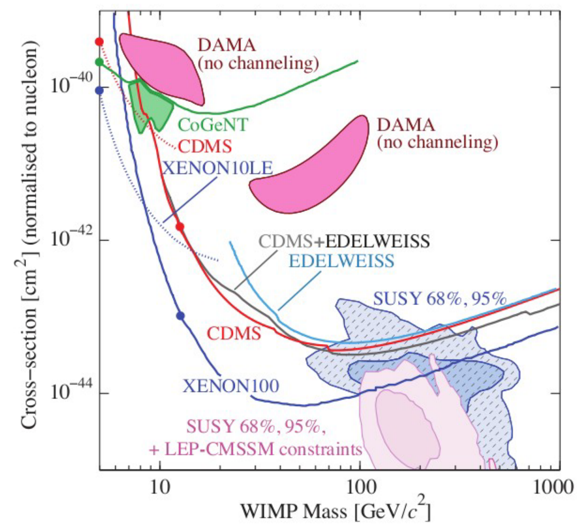
PRL108, 261803 (2012)

PRL110, 011802 (2013)

assumption of the validity of the EFT!



Not enough sensitivity yet to exclude/confirm the CoGeNT/DAMA excess* at $m_\chi \sim 10$ GeV in D1/D5 models



**not confirmed by Xenon100 and LUX results*

Rather strong limits from LHC:

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 .

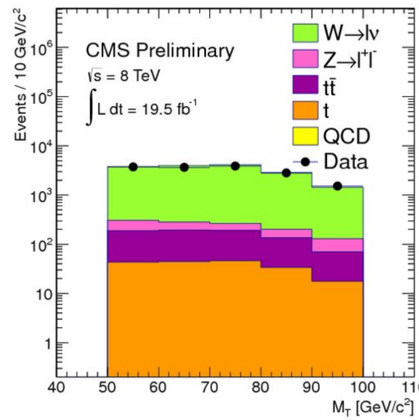
Monojet searches in CMS

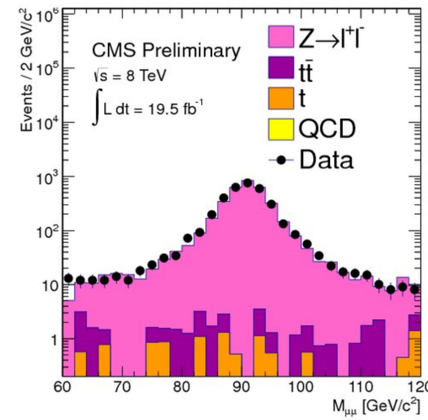
8 TeV, 19.5 fb^{-1}

CMS-PAS-EXO-12-048

Following **similar strategy** as 7 TeV analysis.

Main bkg.: **W/Z+jets** estimated via data-driven methods using dedicated control regions.
CRs: μ+jets, Z($\rightarrow\mu\mu$)+jets

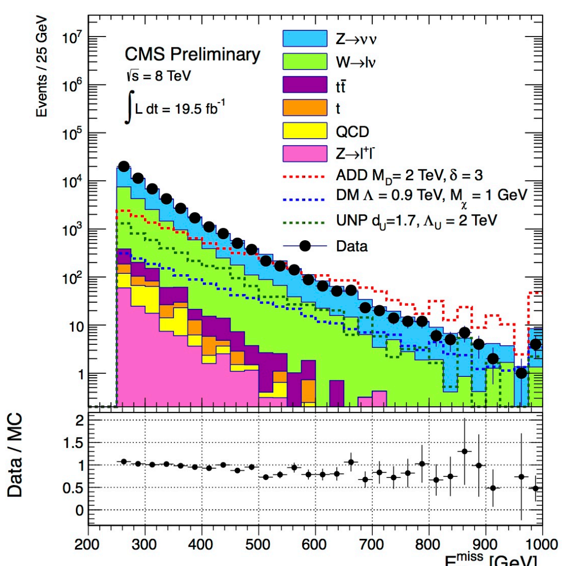




Lepton* veto, $\Delta\phi(j_1, j_2)$>2.5, $N_{jets}(p_T$>30 GeV)<3

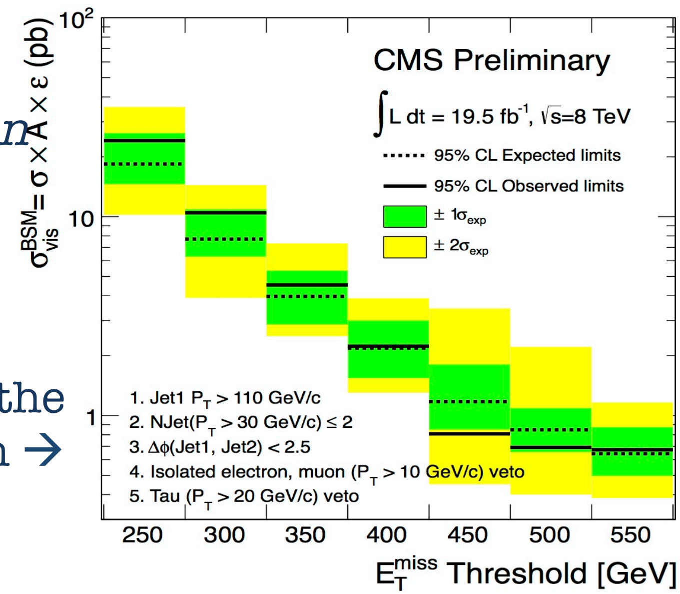
Leading jet p_T >110 GeV.
E_T^{miss}> 250-550 GeV

E_T^{miss} (GeV) →	> 250	> 300	> 350	> 400	> 450	> 500	> 550
Total SM	49154 ± 1663	18506 ± 690	7875 ± 341	3663 ± 196	1931 ± 131	949 ± 83	501 ± 59
Data	50419	19108	8056	3677	1772	894	508



Good agreement between observation in data and SM expectation.

Limits on the visible cross section →

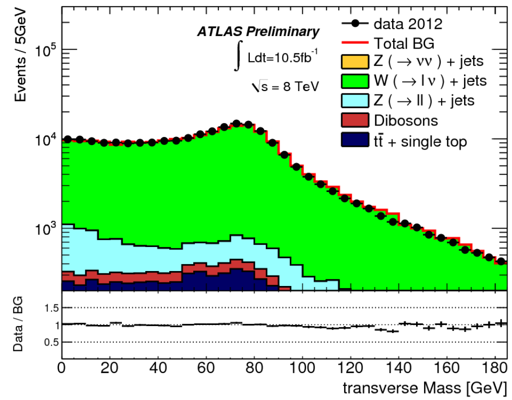


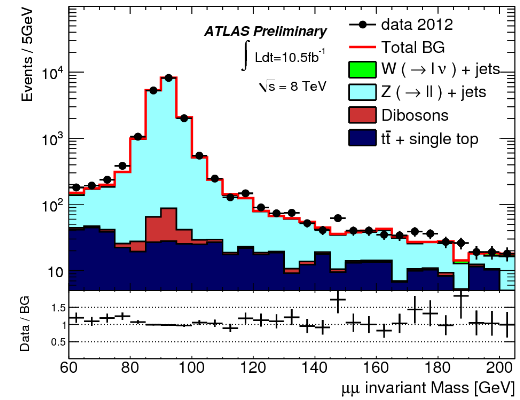
Monojet searches in ATLAS

8 TeV, 10 fb^{-1}

ATLAS-CONF-2012-147

Following **similar strategy** as 7 TeV analysis.





Main bkg.: **W/Z+jets** estimated via data-driven methods using dedicated control regions.

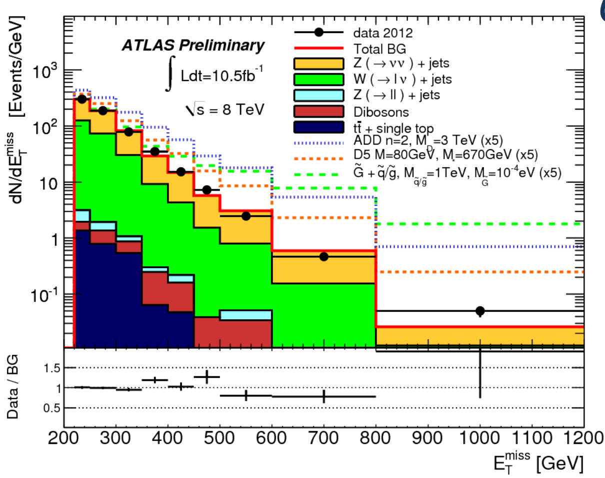
CRs: W(→e/μν)+jets, Z(→ee/μμ)+jets

Background Predictions ± (stat.data)± (stat.MC) ± (syst.)	SR1	SR2	SR3	SR4
Total background	344400 ± 900 ± 2200 ± 12600	25600 ± 240 ± 500 ± 900	2180 ± 70 ± 120 ± 100	380 ± 30 ± 60 ± 30
Data	350932	25515	2353	268

Lepton veto, $\Delta\phi(E_T^{miss}, j_2)>0.5$, $N_{jets}(p_T>30\ \text{GeV})<3$

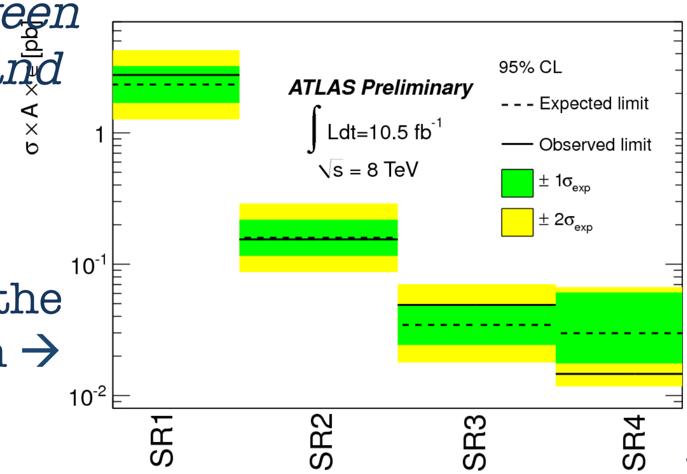
4 signal regions:

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



Good agreement between observation in data and SM expectation.

Limits on the visible cross section →



Event Displays

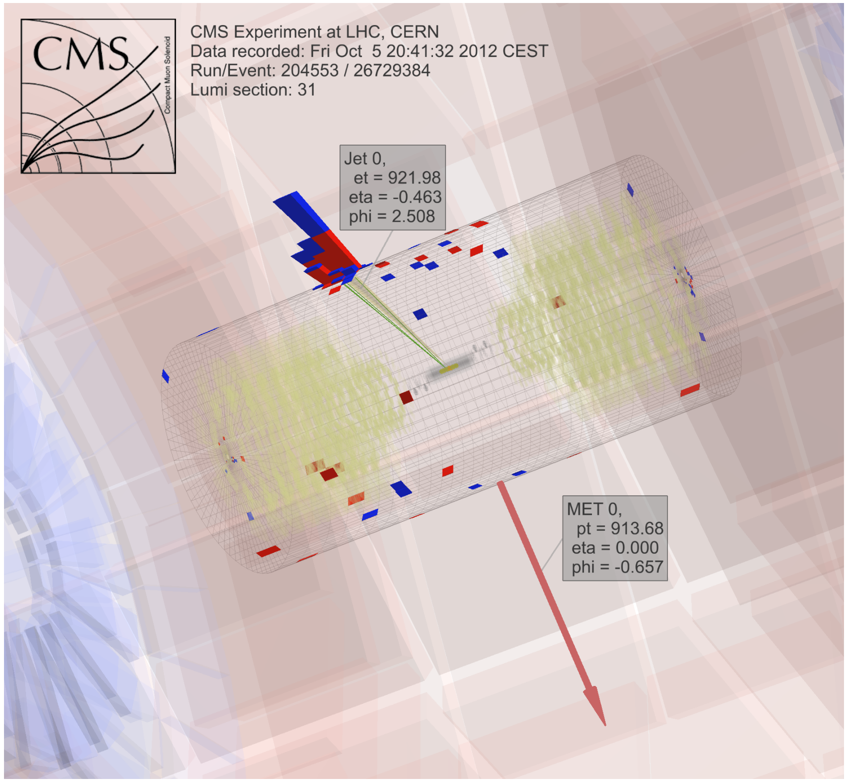
Monojet candidate events.

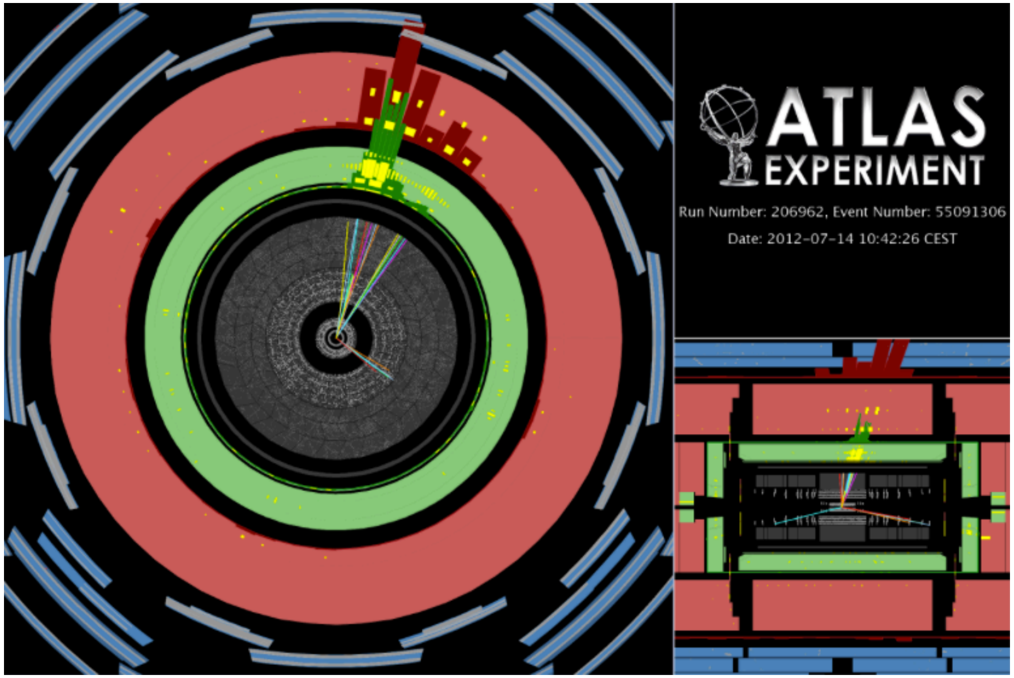
8 TeV, 19.5 fb^{-1}

CMS-PAS-EXO-12-048

8 TeV, 10 fb^{-1}

ATLAS-CONF-2012-147





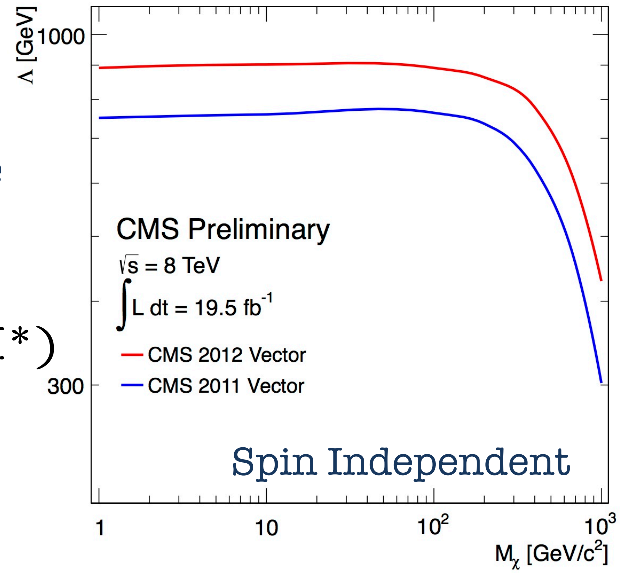
90% CL Limits on...

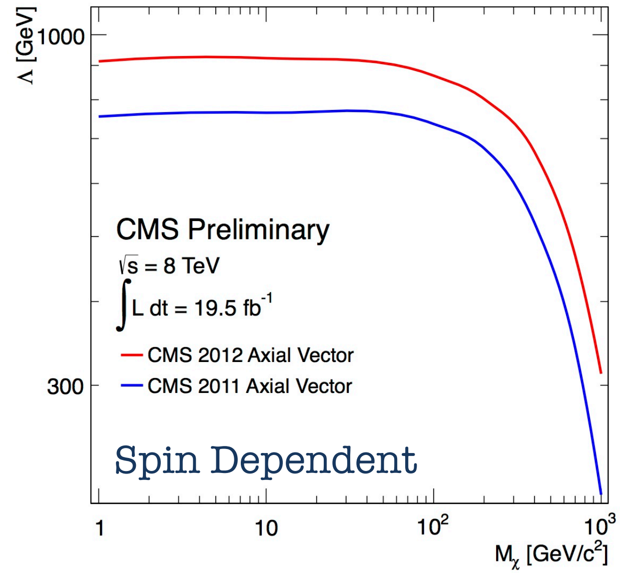
CMS-PAS-EXO-12-048

Suppression Scale

8 TeV data improves previous limits on $\Lambda(M^*)$ by about 150 GeV.

assumption of the validity of the EFT

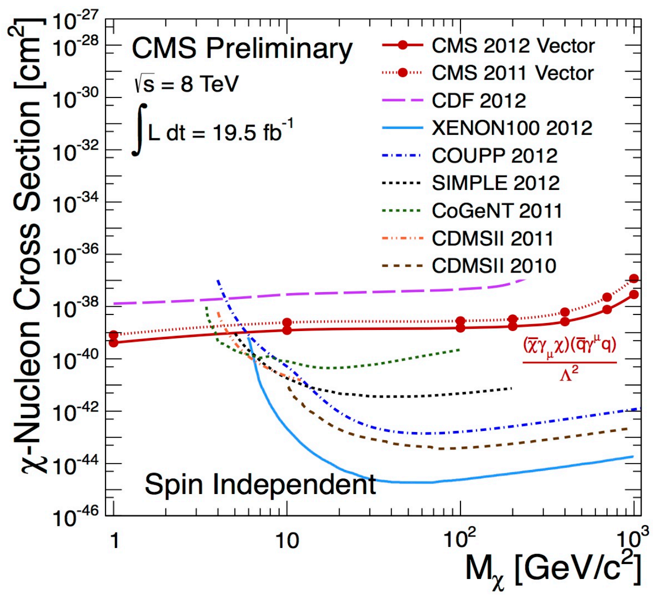


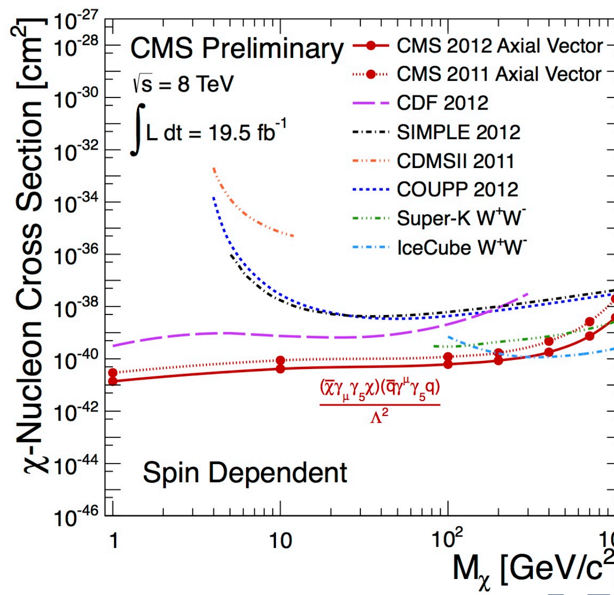


WIMP-Nucleon

Excluding, at $m_\chi \sim 10$GeV:

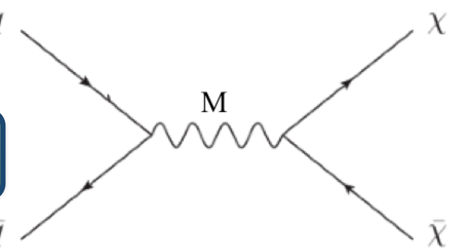
- **Vector** operator:
  WIMP-Nucleon σ > 1.2x10^{-39}cm^2
- **Axial-vector** operator:
  WIMP-Nucleon σ > 4.2x10^{-41}cm^2
- **Scalar** operator:
  WIMP-Nucleon σ > 1.1x10^{-44}cm^2





Light Mediators

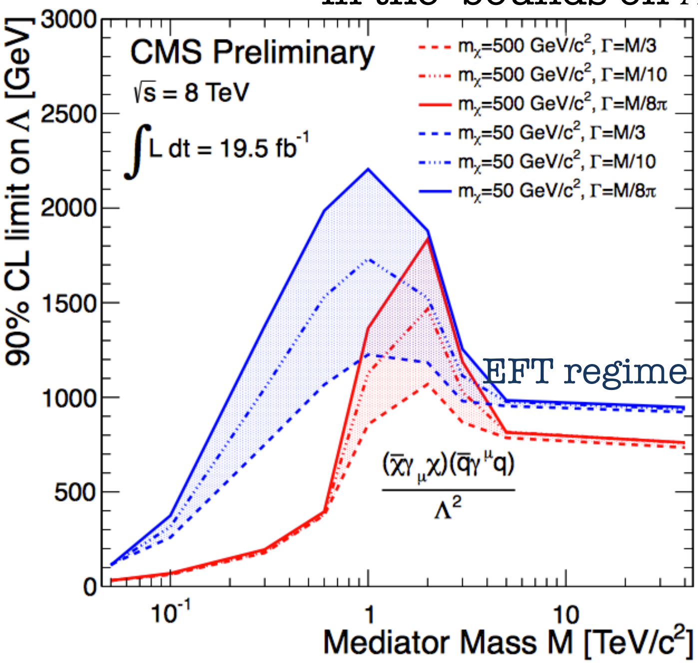
CMS-PAS-EXO-12-048



$$\sigma(pp \to \bar{\chi}\chi + X) \sim \frac{g_q^2 g_\chi^2}{(q^2 - M^2)^2 + \Gamma^2/4} E^2$$

Exploring the scenario with a vector-like coupling and a light **mediator** with given mass and Γ (width) and different DM masses.

For M > few hundred GeV, we enter in the EFT regime, conservative in the bounds on Λ (though effective couplings become large).

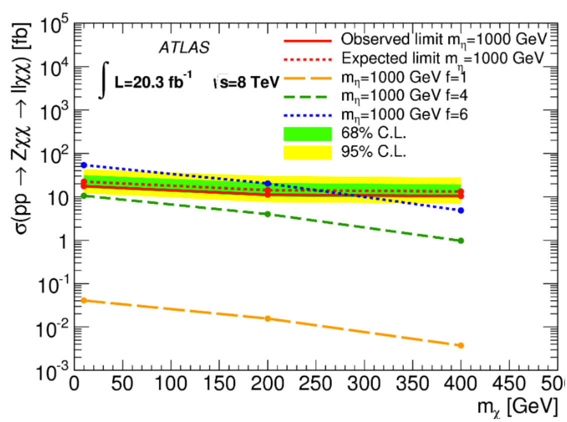


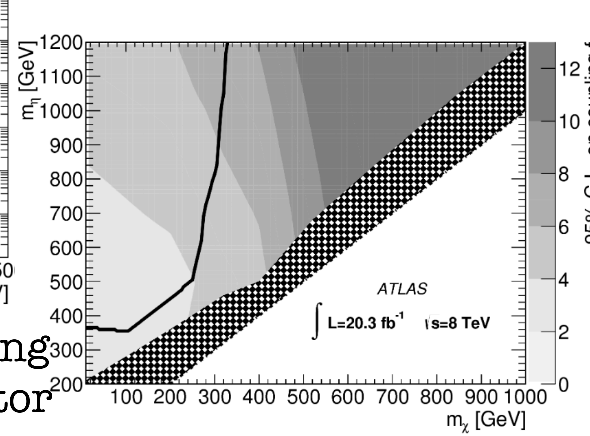
For M < 100 GeV the collider bounds are weakened.

ATLAS Search for DM in **Z-boson (ll) +E_T^{miss}**

8 TeV, 20.3 fb^{-1}

arXiv:1404.0051



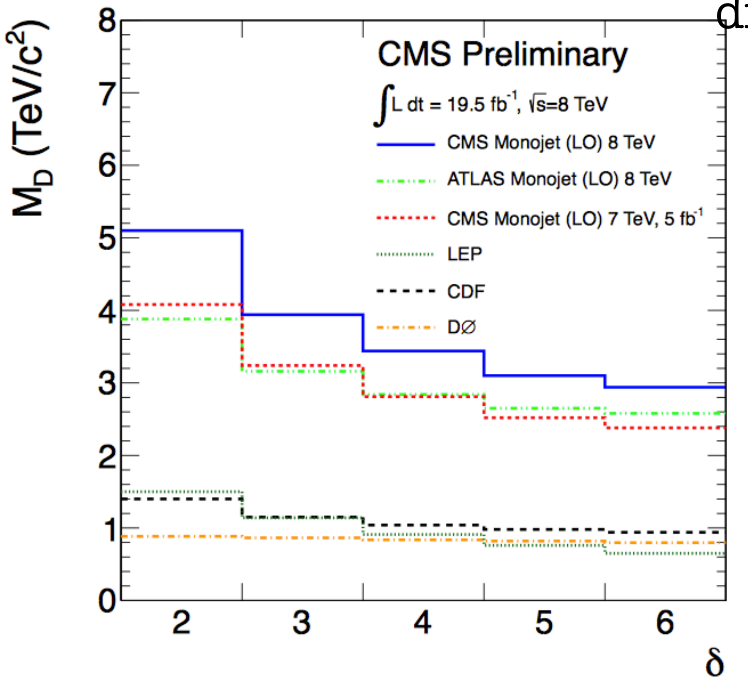


Limits are set on the coupling and mediator mass (mediator is a scalar particle).

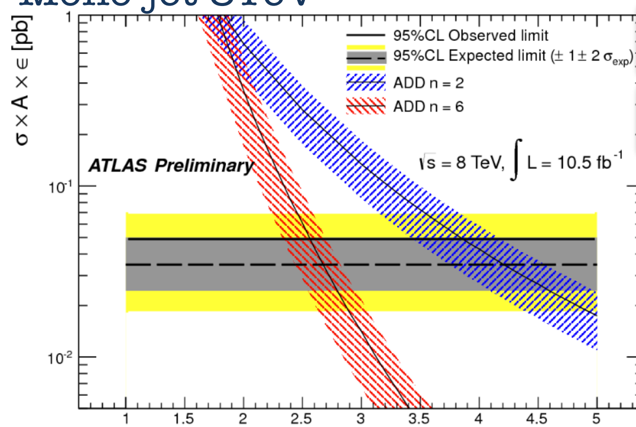
Limits on LED

CMS-PAS-EXO-12-048

95% CL on the visible cross-section for the effective ADD theory are translated to limits on M_D for different number of extra dimensions.



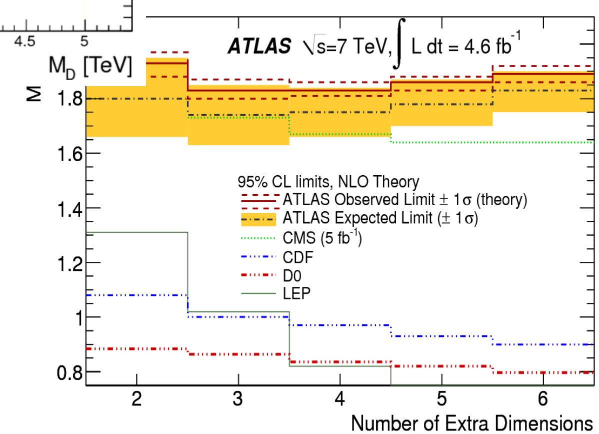
Mono-jet 8TeV



ATLAS-CONF-2012-147

PRL110, 011802 (2013)

Mono-photon 7TeV



Limits on M_D beyond 5 - 3 TeV

δ	LO Exp. Limit	LO Obs. Limit	NLO Exp. Limit	NLO Obs. Limit
2	5.12	5.10	5.70	5.67
3	3.96	3.94	4.31	4.29
4	3.46	3.44	3.72	3.71
5	3.11	3.10	3.32	3.31
6	2.95	2.94	3.13	3.12

The models starts being *challenged* by the limits, exclusion ~TeV scale.

Limits sensitive to the truncation strategy for

s-hat > M_D^2

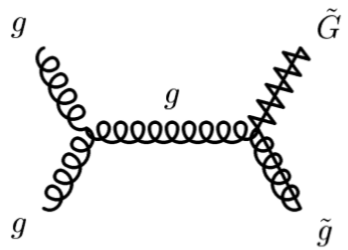
LHC probing phase space at large Q^2

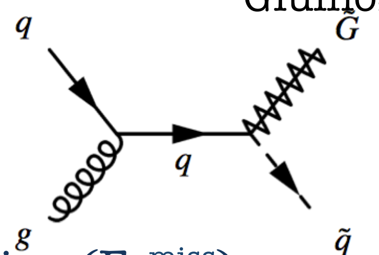
Limits on Gravitino

ATLAS-CONF-2012-147

- Gravitino is considered the LSP in gauge-mediated SUSY breaking (GMSB) scenarios.
- Results interpreted in terms of GMSB gravitino+squark/ gluino production.

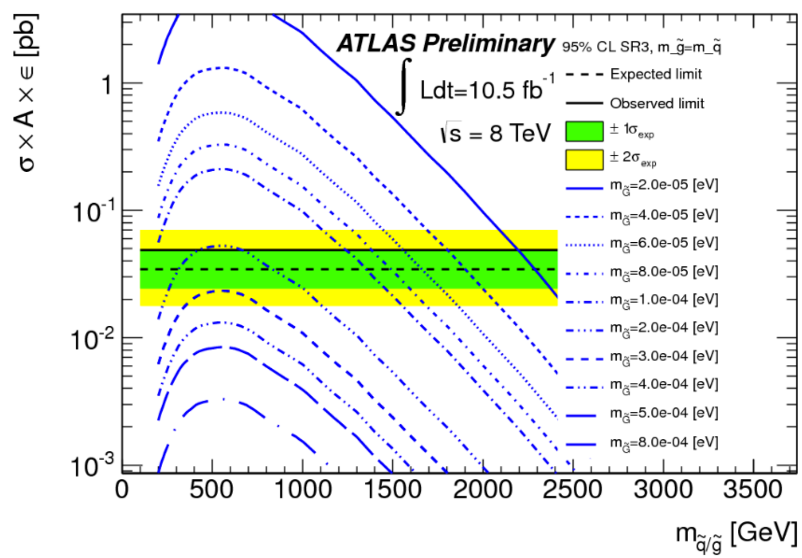
Gluinos (squarks) decay to gluon(quark) + gravitino (100%).

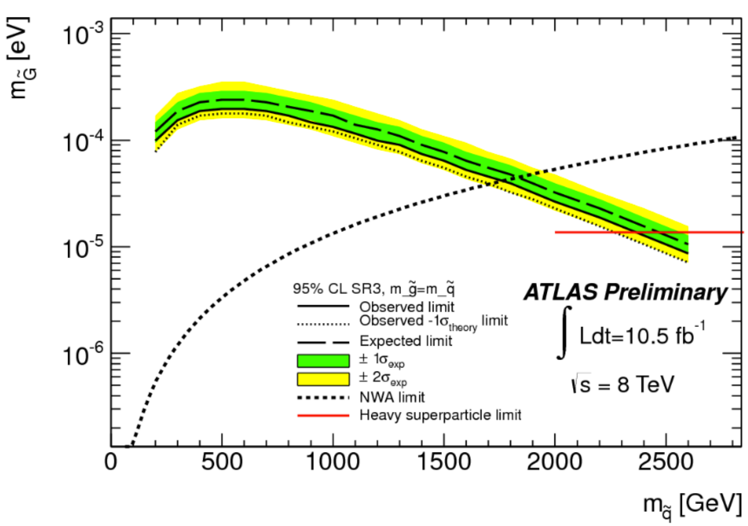




Final state:

1 jet + Gravitino (E_T^{miss})





95% CL limits on the mass of the GMSB gravitino as a function of the squark or gluino masses.

$$m_{3/2} = \langle F \rangle / \sqrt{3} \bar{M}_{\rm Pl}$$

SUSY Breaking scale
Limits on **$\sqrt{F}$ > 640 GeV**
(LEP limit at 240 GeV)

Excluding $M_{Gravitino}$ in the range [3x10^{-4}, 4x10^{-9}] eV
Depending on m_{squark} and m_{gluino}.

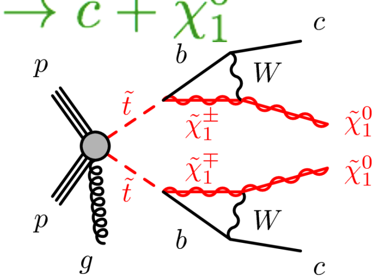
Limits on Stop production

8 TeV, 20.3 fb^{-1}

ATLAS-CONF-2013-068

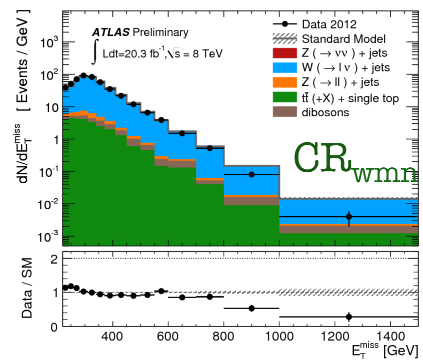
- **Dedicated analysis targeting compressed scenario.**

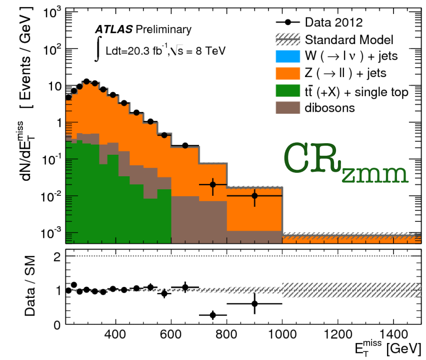
$$\tilde{t}_1 \rightarrow c + \tilde{\chi}_1^0$$

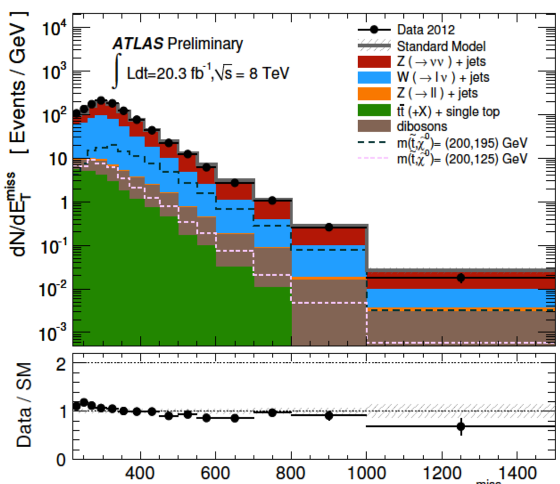


$$\Delta m = m_{\tilde{t}_1} - m_{\tilde{\chi}_1^0} \leq m_b + m_W$$

Main bkg W/Z+jets estimated via data driven methods.
CRs: W(→e/μν)+jets, Z(→μμ)+jets.



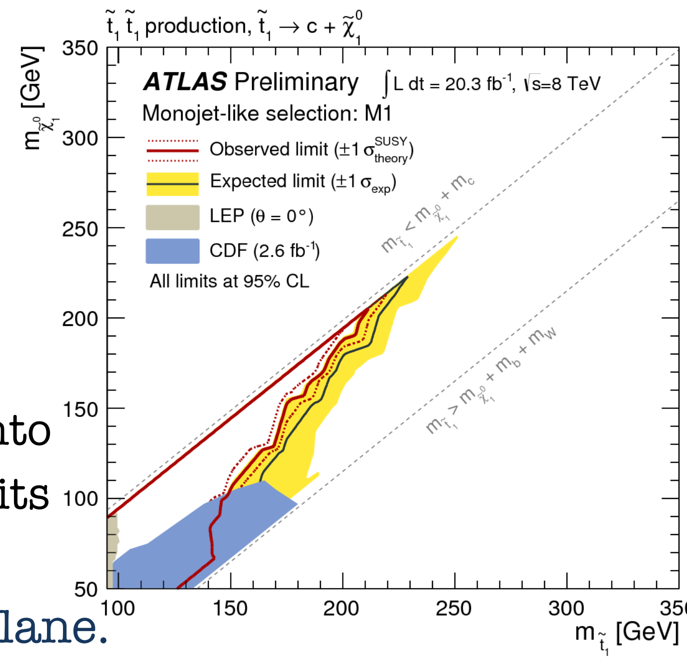




E_T^{miss} > 220 GeV
p_T (j1) > 280 GeV
N_{jet}(p_T > 30 GeV) < 4
$\Delta\phi$ (E_T^{miss}, jets) > 0.4
Lepton vetoes

Signal Region	M1
Observed events (20.3 fb^{-1})	30793
SM prediction	29800 ± 900

Results interpreted into 95% CL exclusion limits on the SUSY stop-neutralino mass plane.

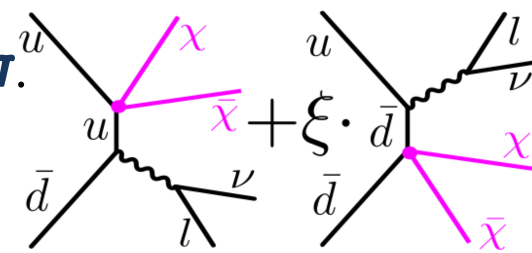


Mono-W

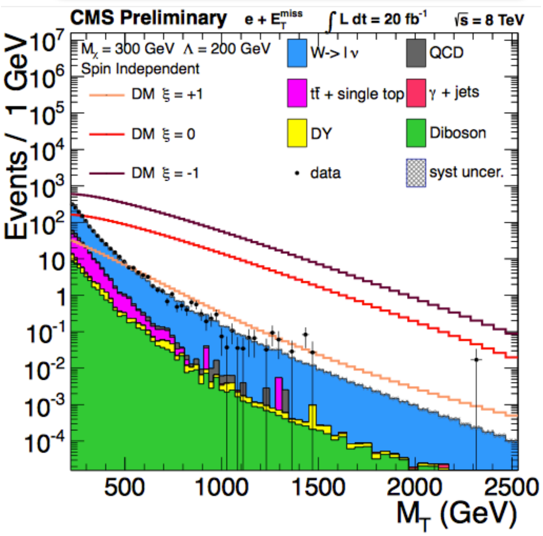
8 TeV, 20.3 fb^{-1}

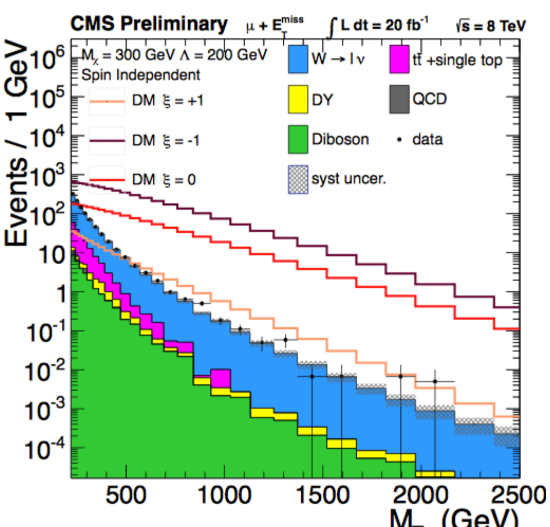
CMS-PAS-EXO-13-004

Search for mono-W (e/μ channel), interpreted in terms of **DM-DM + W**.



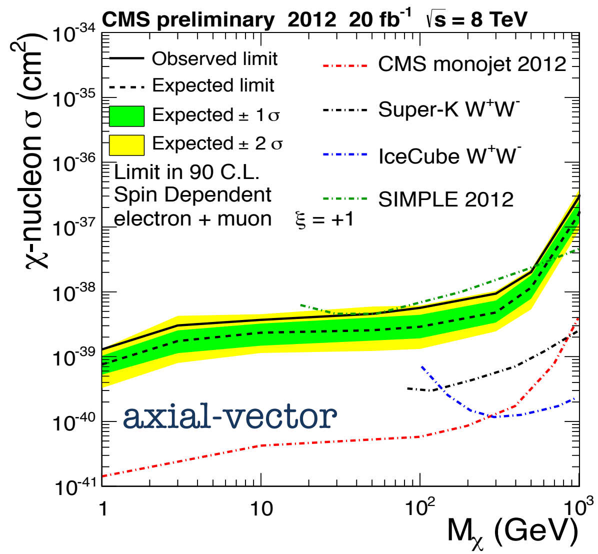
Considering vector and axial-vector operators and interference between different contributions (ξ = +1, -1 , 0).

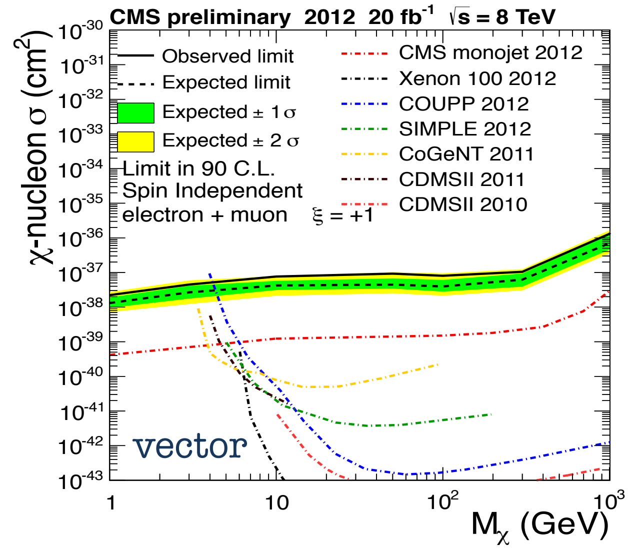




90% CL limits on DM-Nucleon σ

cross section enhancement when interference is constructive : ξ = -1





	$\xi = -1$		$\xi = 0$	
M_χ	Λ[TeV]	$\sigma_{p\chi}$[cm^2]	Λ[TeV]	$\sigma_{p\chi}$[cm^2]
1	1.02	1.3×10^{-40}	0.72	2.3×10^{-40}
10	0.10	4.4×10^{-40}	0.72	7.3×10^{-40}
300	0.85	1.0×10^{-39}	0.60	1.7×10^{-39}
1000	0.33	4.4×10^{-38}	0.24	7.6×10^{-38}

	$\xi = -1$		$\xi = 0$	
M_χ	Λ[TeV]	$\sigma_{p\chi}$[cm^2]	Λ[TeV]	$\sigma_{p\chi}$[cm^2]
1	0.95	3.5×10^{-41}	0.68	5.5×10^{-40}
10	0.97	1.0×10^{-40}	0.68	1.7×10^{-39}
300	0.86	1.9×10^{-40}	0.60	3.2×10^{-39}
1000	0.44	3.0×10^{-39}	0.31	4.6×10^{-38}

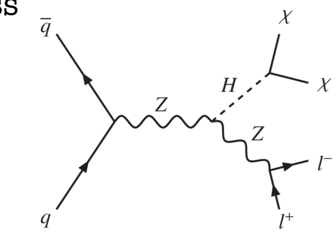
Mono-Z

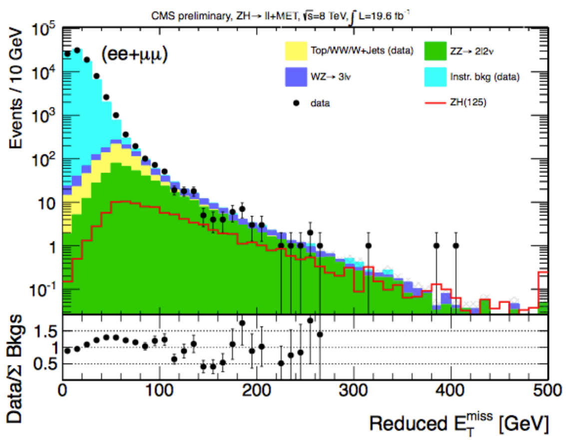
8 TeV, 19.5 fb^{-1}

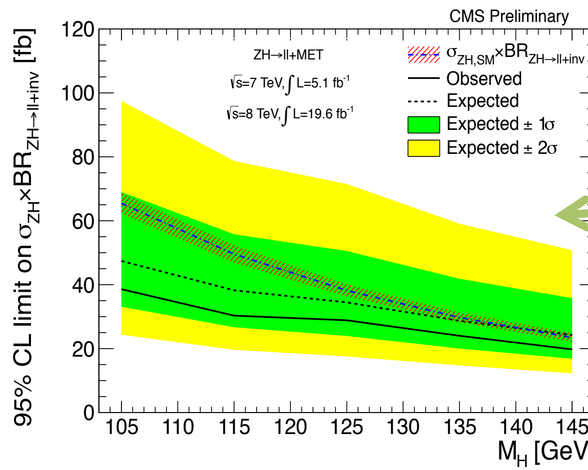
CMS-PAS-HIG-13-018

Mono-Z(→ll): Search for 2 leptons + E_T^{miss}

$$\text{red-}E_T^{miss\,i} = p_T^{\ell\ell i} - min(R^i_{clust}, R^i_{uncl})$$







BR (H → invisible) < 75% at 95% CL for m_H = 125 GeV

Ratio to SM σ_{ZH} < 1.82 at 95% CL for m_H= 125 GeV

8 TeV, 18.9 fb^{-1}

CMS-PAS-HIG-13-028

Mono-Z(→bb): Very similar to CMS ZH(H→bb) SM analysis.

E_T^{miss}: (100-130,130-170,>170) GeV

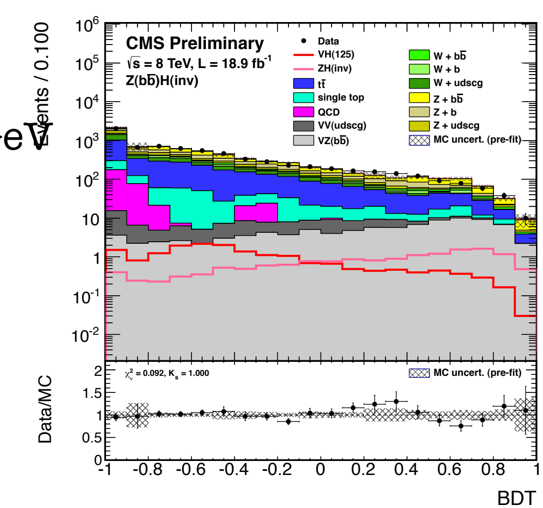
Two b-jets p_T > 25 GeV

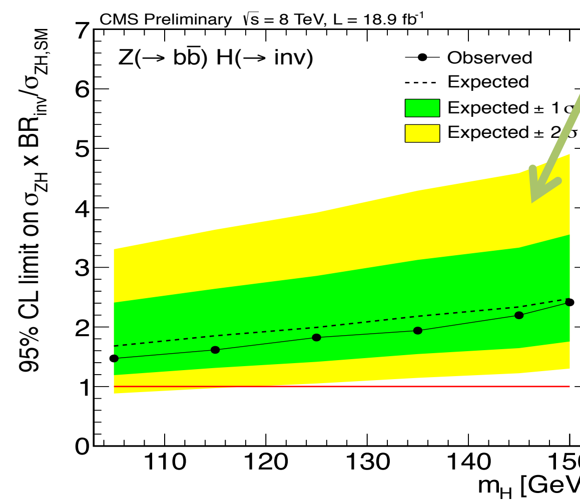
$\Delta\phi_{min}$ (E_T^{miss}, P_T^{miss}) > 0.7 - 0.5

$\Delta\phi_{min}$(E_T^{miss}, jet) > 0.5

Lepton vetoes

Fit to BDT to extract the H→inv signal.





Mono-W/Z

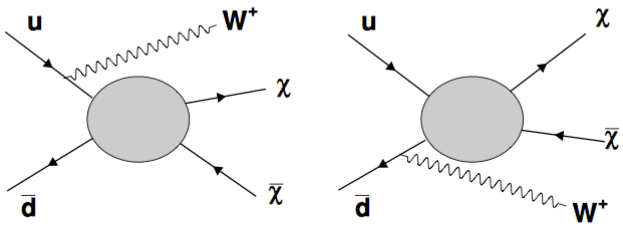
8 TeV, 20 fb^{-1}

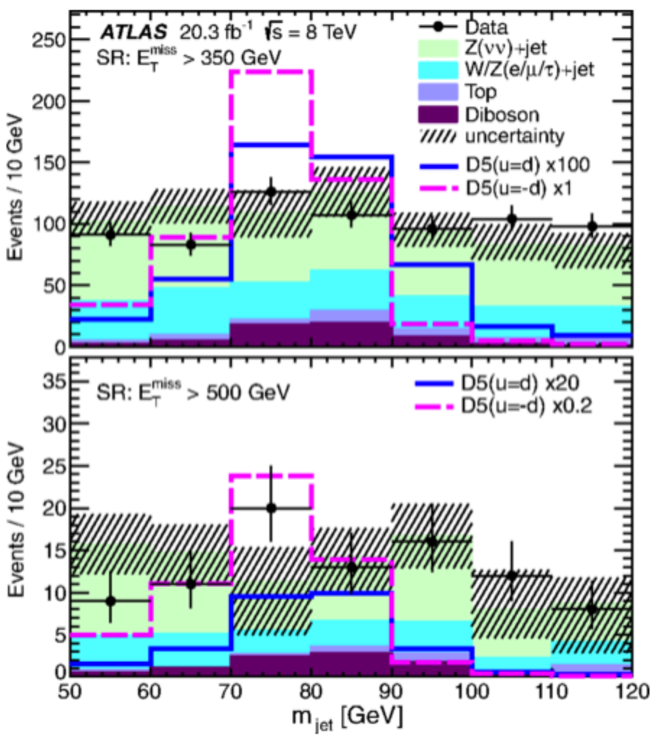
PRL 112.041802

Search based on the hadronic decay products of W/Z.

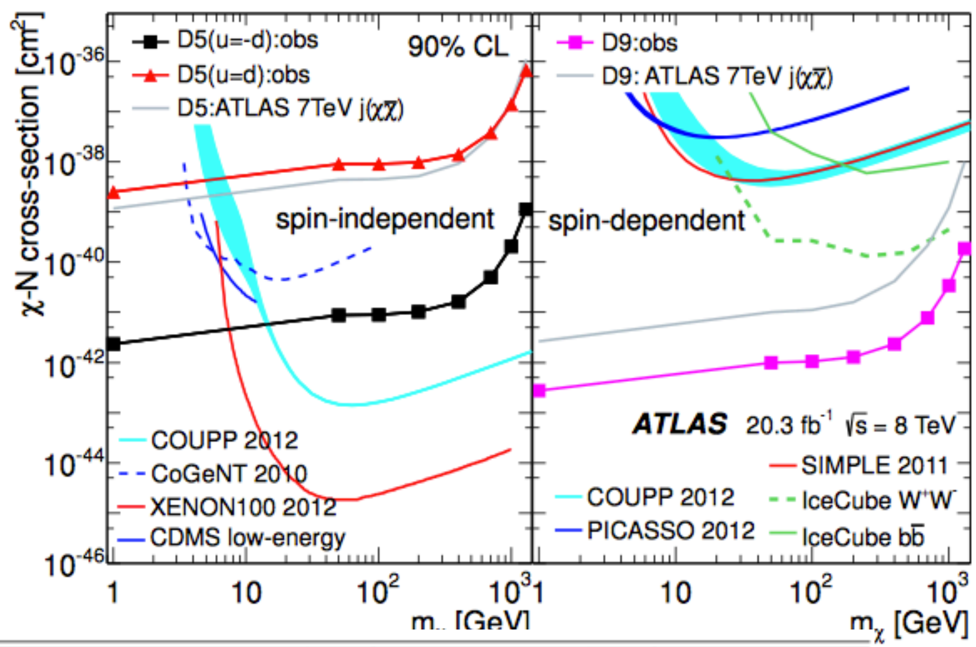
Decays reconstructed as a **single massive jet**:

- CA R=1.2 jets.
- Jet p_T > 250 GeV, $|\eta|$ < 2.1, 50 < M_{jet} < 120 GeV .
- No additional jet (anti-k_T 0.4) with p_T > 40 GeV.





Limits in terms of **DM-nucleon** scattering cross section.



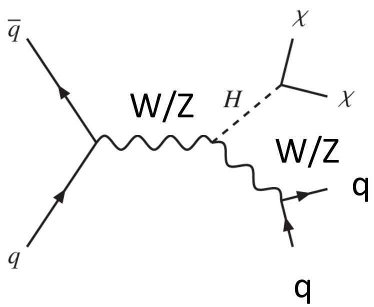
Good agreement with SM expectation

Process	E_T^{miss} > 350 GeV	E_T^{miss} > 500 GeV
Total	710^{+48}_{-38}	89^{+9}_{-12}
Data	705	89

Mono-W/Z

8 TeV, 20 fb^{-1}

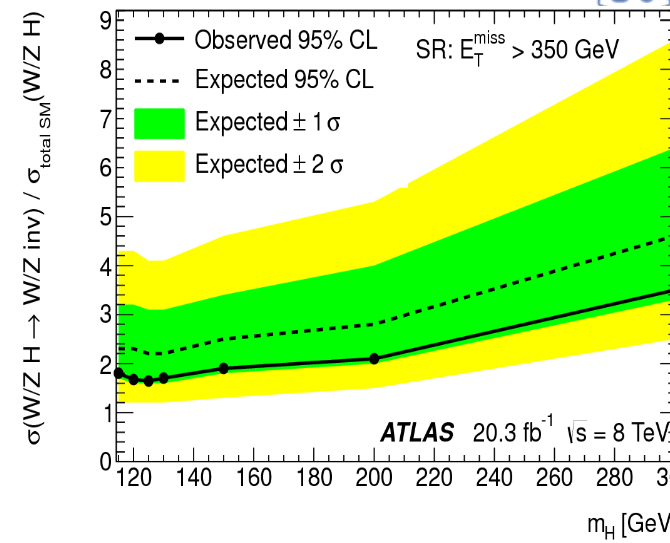
PRL 112.041802



Mono-W/Z

Limits in terms of **VH(H→invisible)** process.

σ(VH, H→invisible) / σ(VH)$_{SM}$ → 1.6 @ m_H = 125 GeV

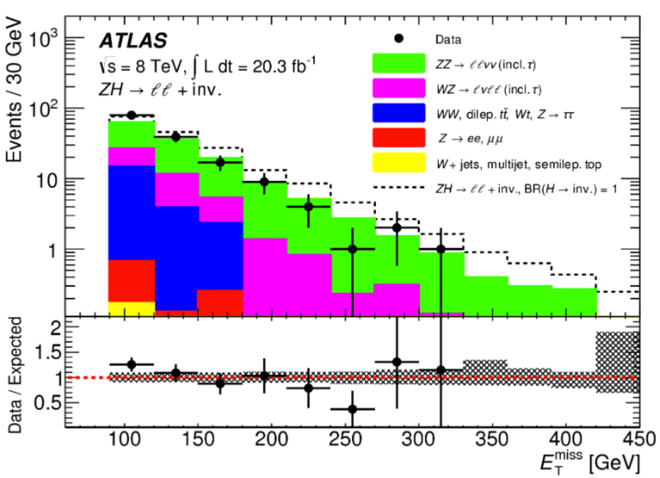


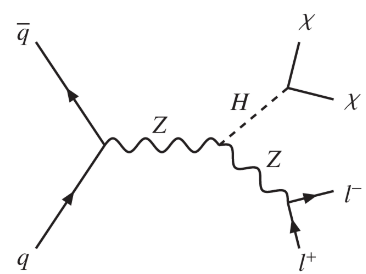
7+8 TeV, 4.7+13 fb^{-1}

arXiv:1402.3244

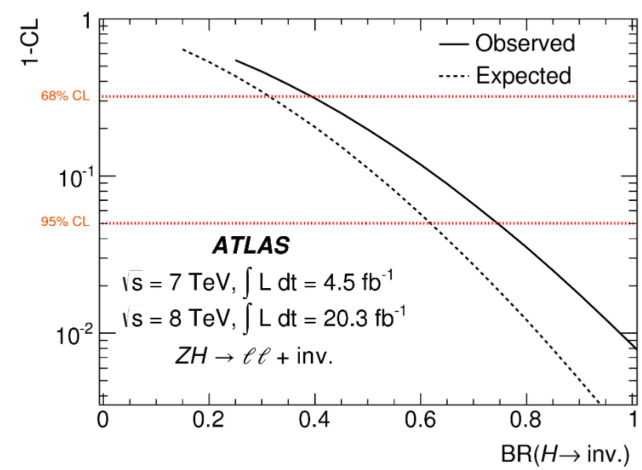
Mono-Z(→ll):

Search for 2 leptons + E_T^{miss}





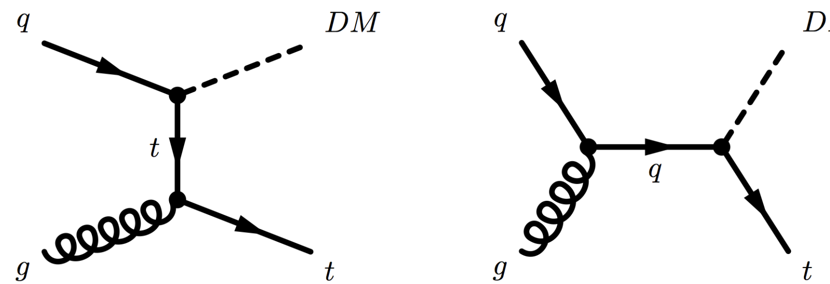
BR (H → invisible) < 65% at 95% CL for m_H = 125 GeV



Mono-top

8 TeV, 19.7 fb^{-1}

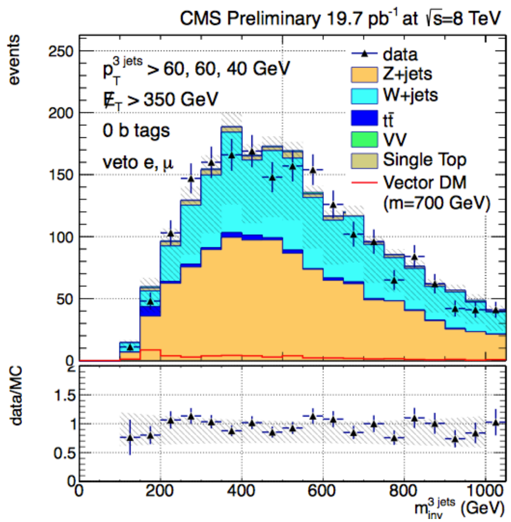
CMS-PAS-B2G-12-022

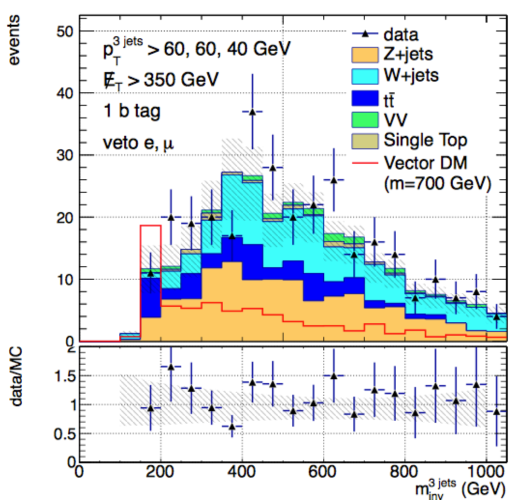


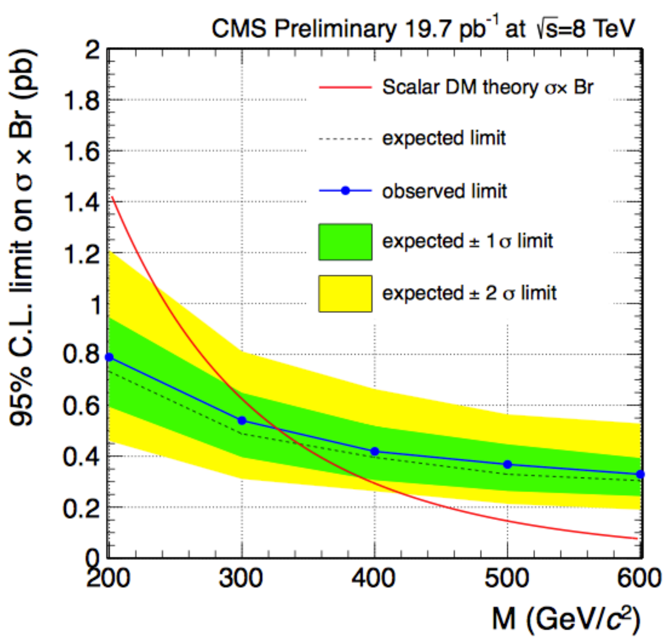
Search for mono-top final states.

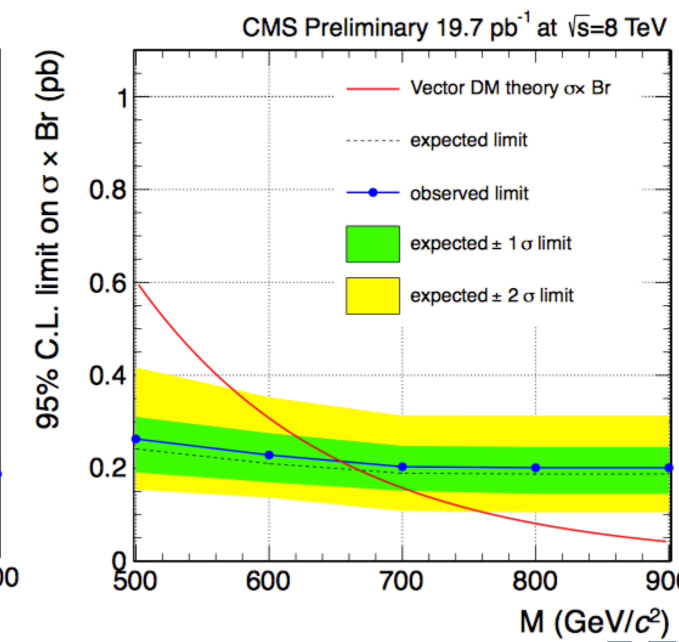
Single top quark + large E_T^{miss}. Two SRs: 0 and 1 b-tagged jets.

# of b tags	Zero CSVm b tag	One CSVm b tag
sum	140±36	28±16
Data	143	30









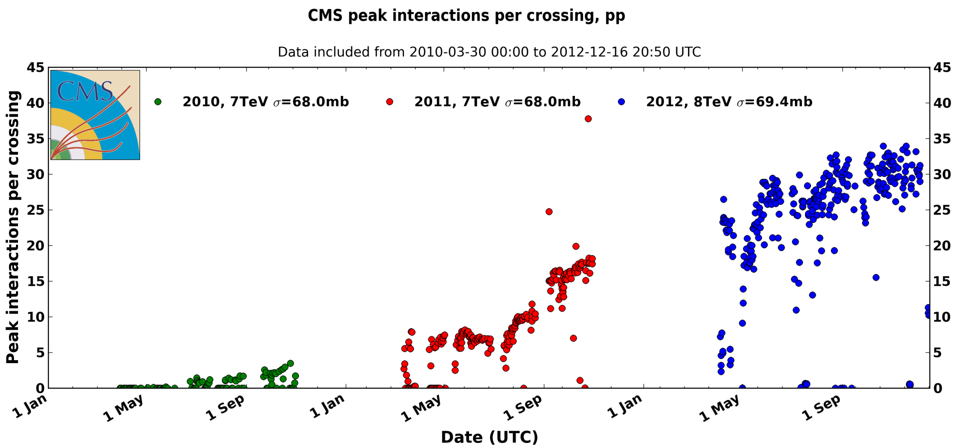
Conclusions

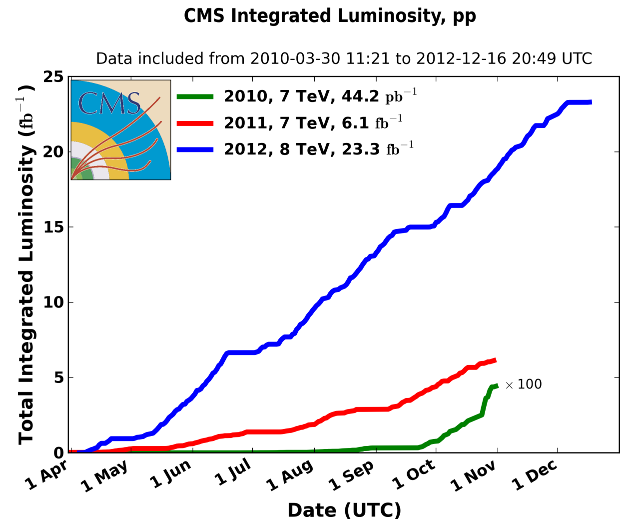
- More than **25 fb^{-1}** of LHC data (7 TeV + 8 TeV) analyzed by **ATLAS** and **CMS** experiments.
    - Very successful Run I program.
- **Mono-X** final states are very **sensitive** in several searches for physics beyond the SM.
    - DM, Large Extra Dimensions, SUSY, Higgs...
- As of now, **no significant excess** wrt SM expectations has been observed.
    - Improvement on limits on LED ADD model.
    - Limits on M^* and WIMP-nucleon scattering cross section.
    - Within EFT framework: LHC DM searches competitive for low WIMP masses.
        - ***Validity of EFT approach***, use of **simplified models**, etc. undergoing.
    - Limits on Gravitino mass, stop pair production.
- **Stay tuned for 13-14 TeV data next year!**

Bonus Slides

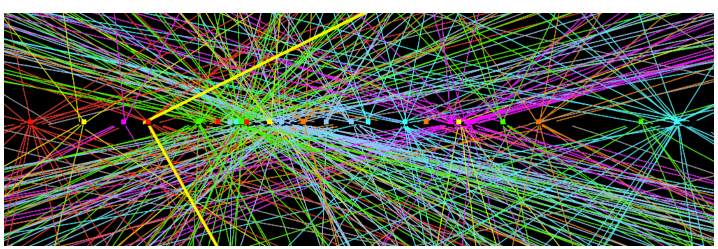
LHC Data

- Superb LHC performance in Run I.
  - Rapidly accumulating large data samples!

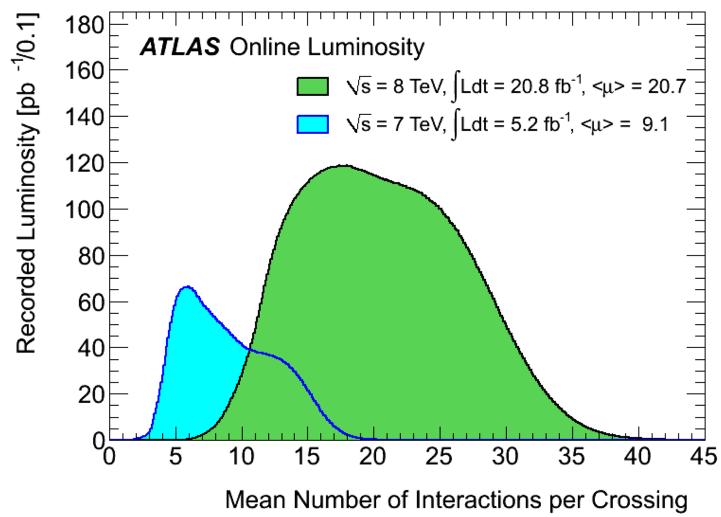




Large luminosity → Large pileup.
These challenging conditions require a lot of work to achieve **great physics performance**.

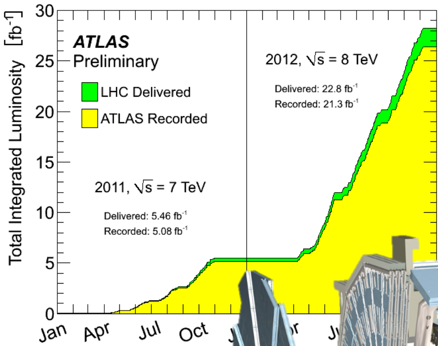


ATLAS 2012 Z→μμ event with high pileup (25 reco vtx).

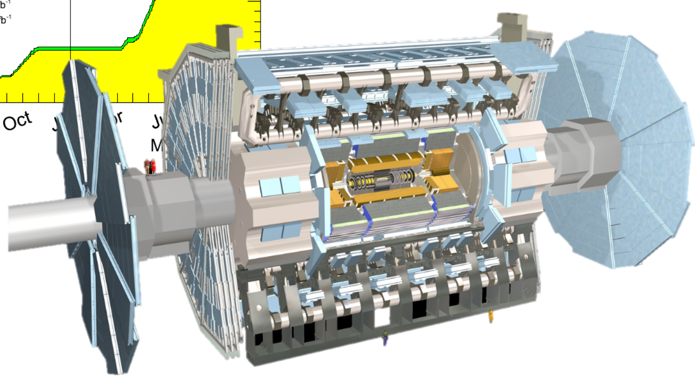


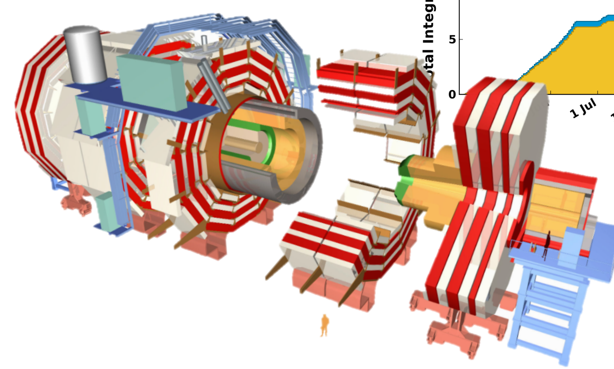
13-14 TeV collisions coming in 2015!

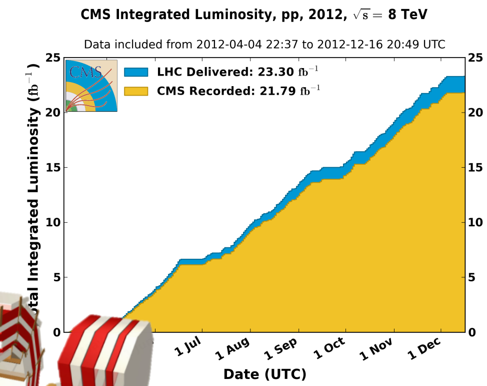
ATLAS and CMS Experiments



About 21(5) fb^{-1} collected by
CMS and **ATLAS @ 8(7) TeV**



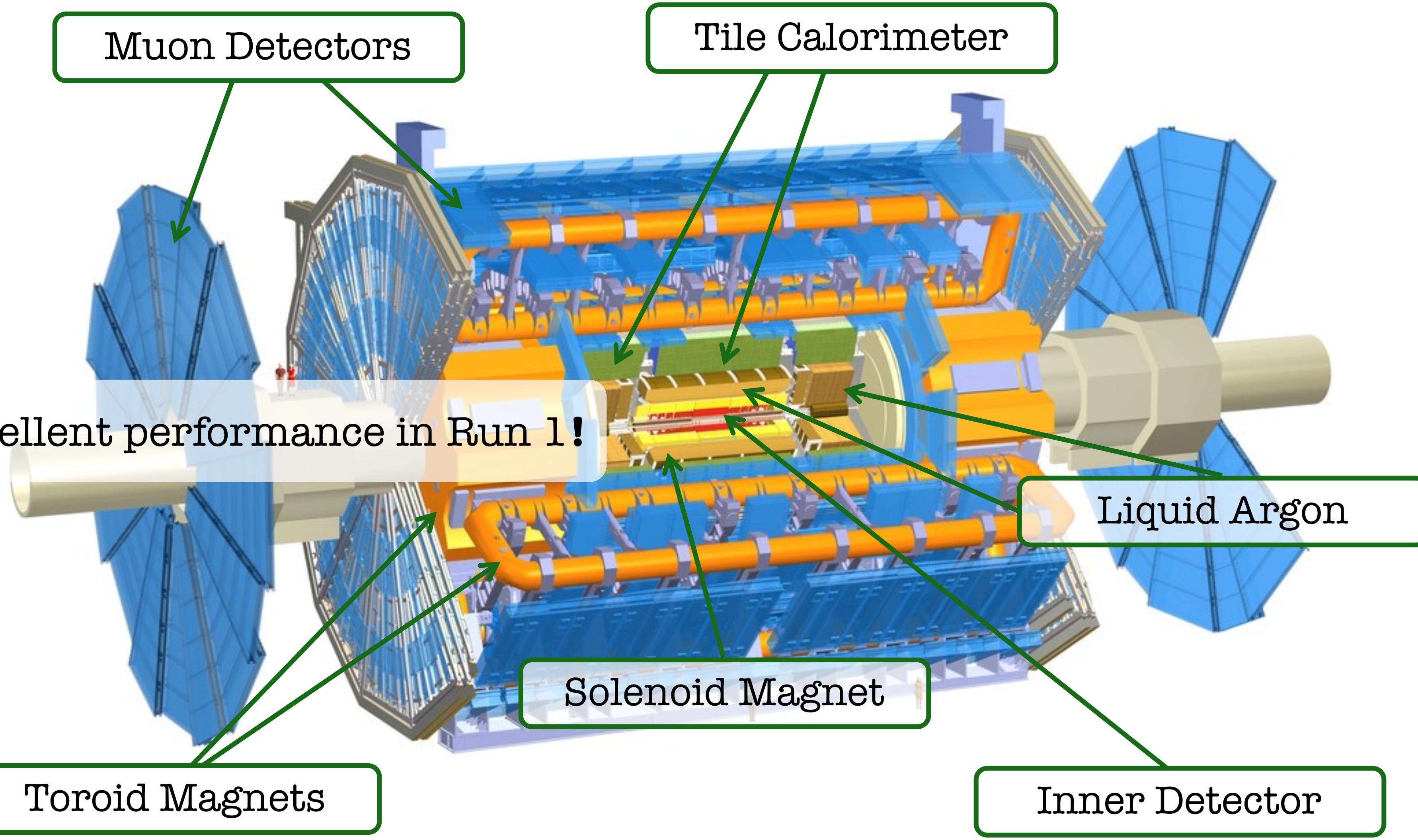




	ATLAS	CMS
Inner tracker : |η| coverage	2.5	2.5
$\sigma(P_T)/P_T$ at P_T=100 GeV	3.8%	1.5%
EM calorimeter: |η| coverage	3.2	3.0
σ(E)/E	10%/√E+0.7%	3%/√E+0.5%
HAD calorimeter: |η| coverage	4.9	5.2
σ(E)/E (EM+HAD combined)	50%/√E+3%	85%/√E+7%
Muon system: |η| coverage	2.7	2.4
$\sigma(P_T)/P_T$ at P_T=1 TeV (standalone)	12% (|η|<1.5)	15-40% (depend on η range)

Both detectors had **excellent** performance in Run I.
More than 90% of the delivered data used for physics...

ATLAS



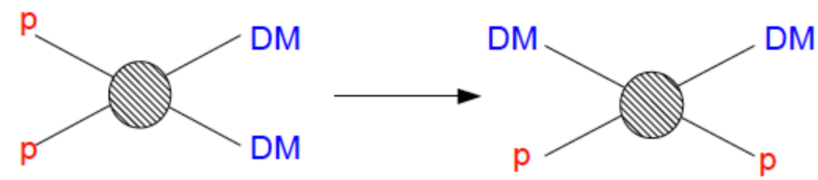
Excellent performance in Run 1!

WIMP-nucleon cross section

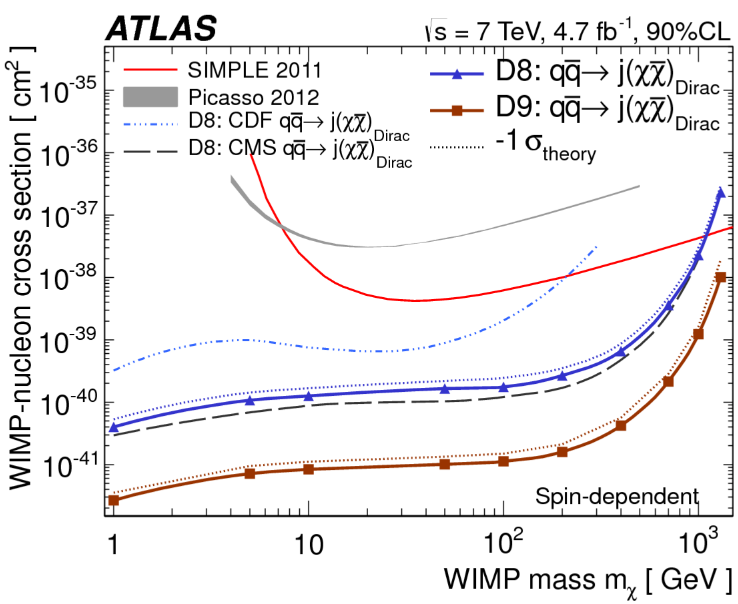
JHEP 04 (2013) 75

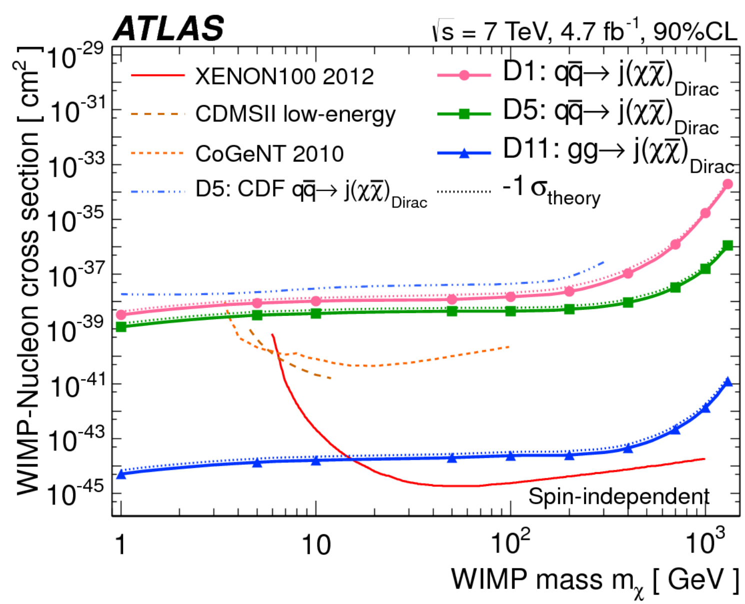
JHEP 09 (2012) 94

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



Under **assumption of the validity of the EFT**, LHC results are competitive to direct detector experiments (mainly for m_χ < 10 GeV).

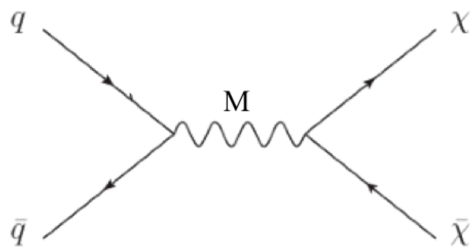




Strong limits in spin-dependent processes.
Large sensitivity in case of spin-independent D11 (gg initiated).

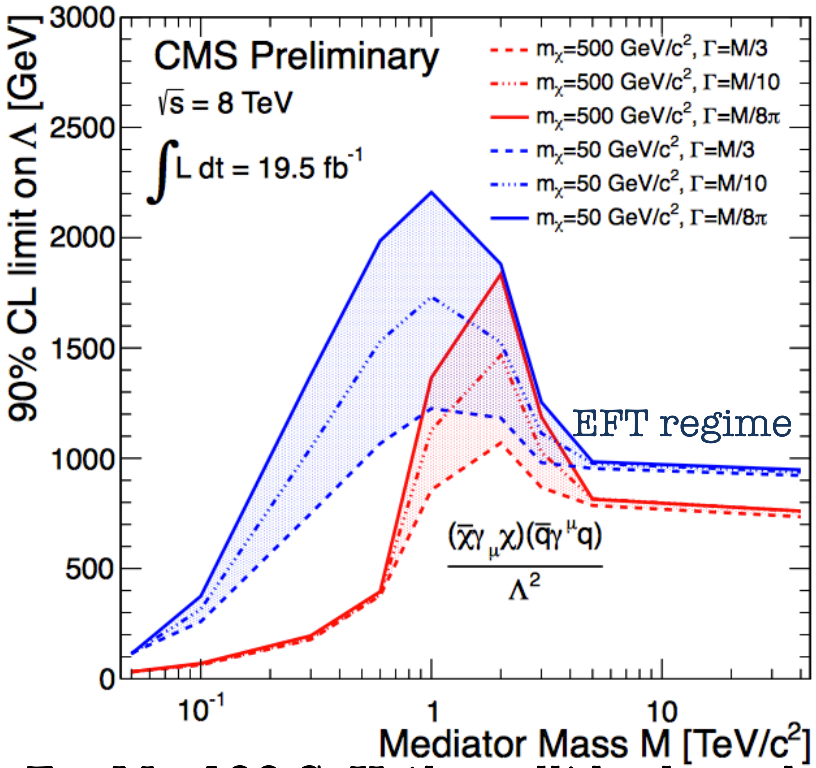
Light Mediators

CMS-PAS-EXO-12-048



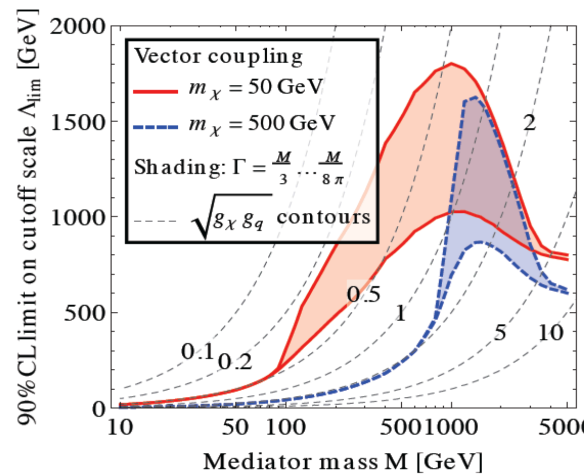
$$\sigma(pp \to \bar{\chi}\chi + X) \sim \frac{g_q^2 g_\chi^2}{(q^2 - M^2)^2 + \Gamma^2/4} E^2$$

Exploring the scenario with a vector-like coupling and
a light **mediator** with given mass and Γ (width) and different DM masses.



For M < 100 GeV the collider bounds are weakened.

For M > few hundred GeV, we enter in the EFT regime, conservative in the bounds on Λ (though effective couplings become large).



P.J. Fox et al., PhysRevD.85.056011
(based on ATLAS 7 TeV monojet data)

Monojet searches in ATLAS

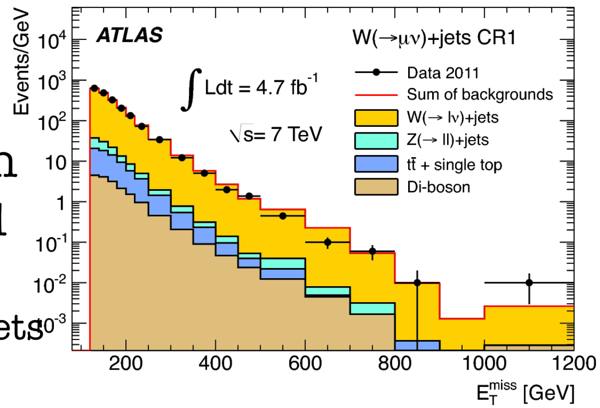
7 TeV, 4.7 fb^{-1}

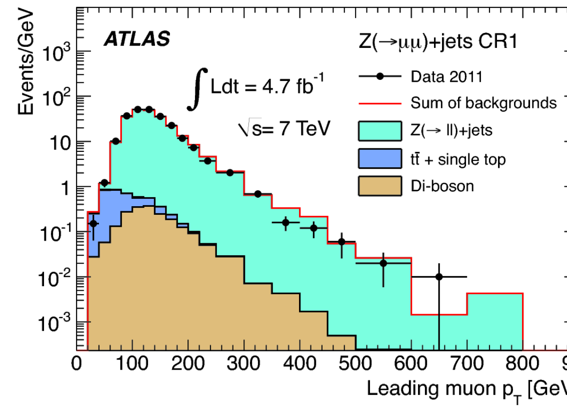
JHEP 04 (2013) 75

Search for new physics in events with a high-energy jet + large missing transverse momentum.

Main bkg.: **W/Z+jets** estimated via data-driven methods using dedicated control regions.

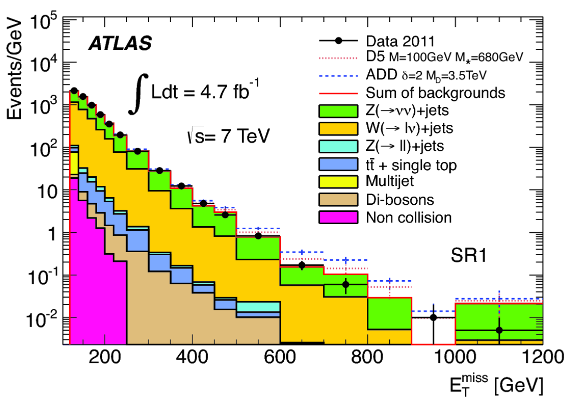
CRs: W(→e/μν)+jets, Z(→ee/μμ)+jets

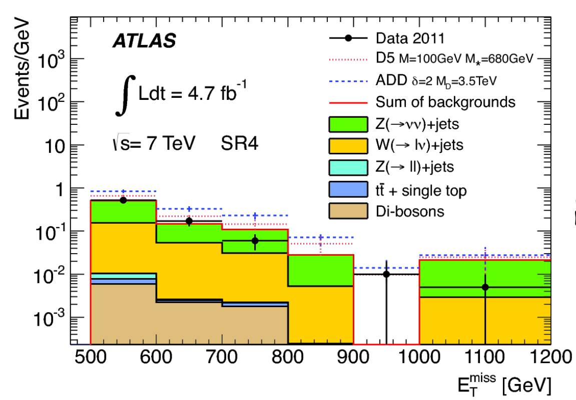




Lepton veto, $\Delta\phi(E_T^{miss}, j_2)>0.5$, $N_{jets}(p_T>30\ GeV)<3$

4 signal regions: E_T^{miss}, leading jet p_T > 120, 220, 350, 500 GeV





	SR1	SR2	SR3	SR4
Total Background	124000 ± 4000	8800 ± 400	750 ± 60	83 ± 14
Events in Data (4.7 fb^{-1})	124703	8631	785	77

Main systematic uncert.
W/Z MC modeling ~3%
JES/JER/E_T^{miss} ~1-6%
Stats. of CR (higher E_T^{miss} cuts).

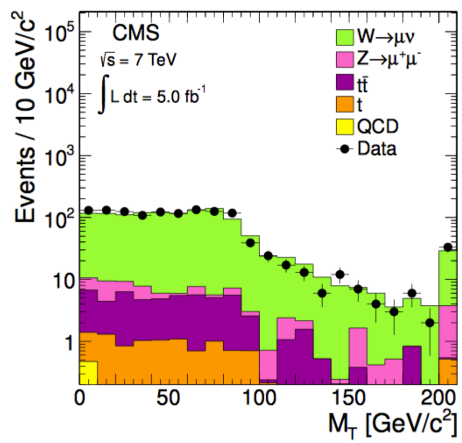
Good agreement between observation in data and SM expectation.

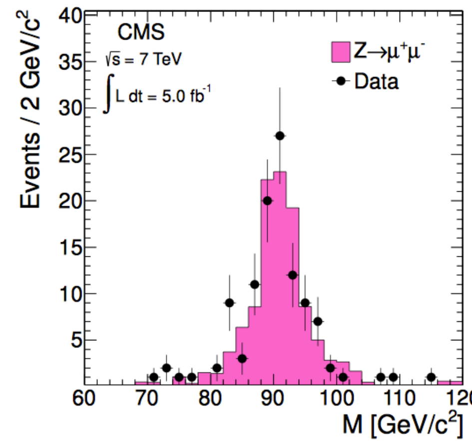
Monojet searches in CMS

7 TeV, 5.0 fb^{-1}

JHEP 09 (2012) 94

Search for new physics in events with a high-energy jet + large missing transverse momentum.



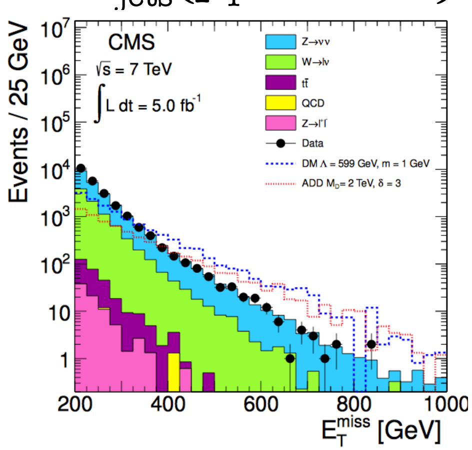


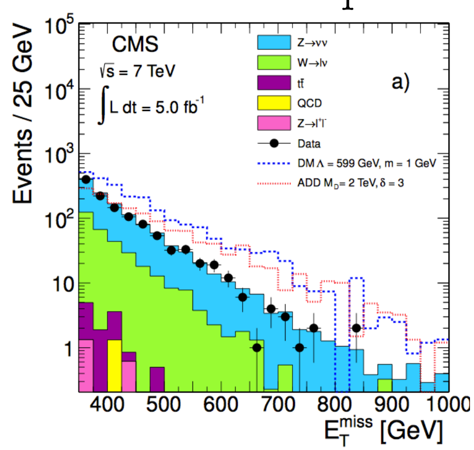
Main bkg.: **W/Z+jets** estimated via data-driven methods using dedicated control regions.

CRs: μ+jets, Z(→μμ)+jets

Lepton* veto, $\Delta\phi(j_1, j_2)>2.5$, $N_{jets}(p_T>30\text{ GeV})<3$

Leading jet p_T >110 GeV. 4 signal regions: E_T^{miss}> 250, 300, 350, 400 GeV





Main systematic uncert. Statistical uncert. in CRs, PDF uncertainties.

Good agreement between observation in data and SM expectation.

E_T^{miss} (GeV/c) →	≥ 250	≥ 300	≥ 350	≥ 400
Total SM	7842 ± 367	2757 ± 167	1225 ± 101	573± 65
Data	7584	2774	1142	522