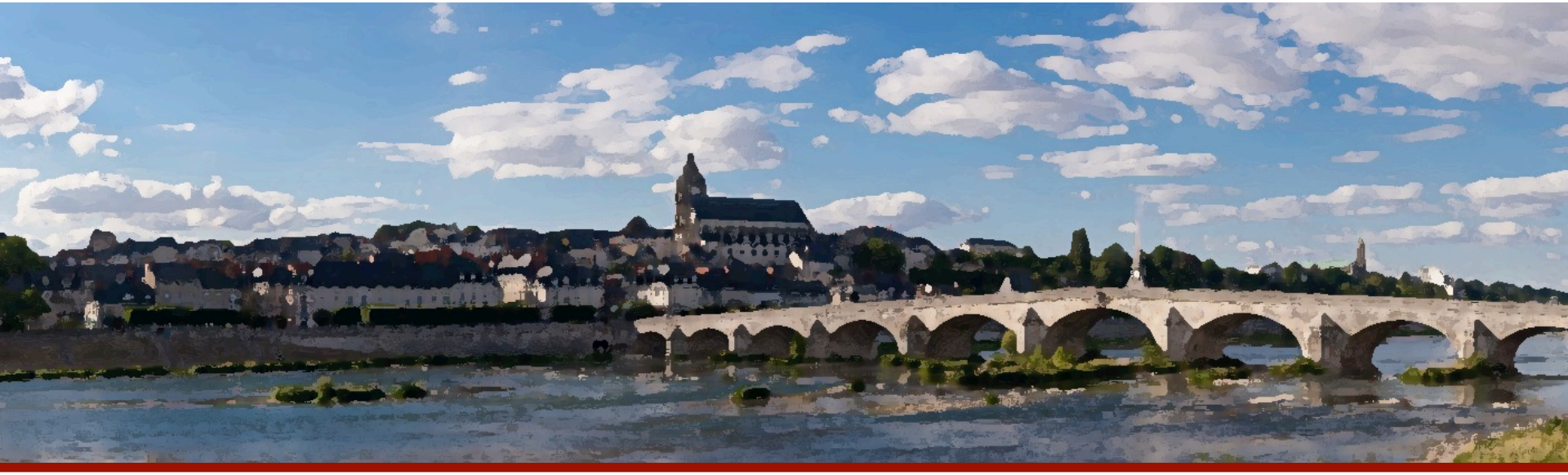
SEARCHES FOR DARK MATTER AND NEW PHYSICS IN ATLAS AND CMS

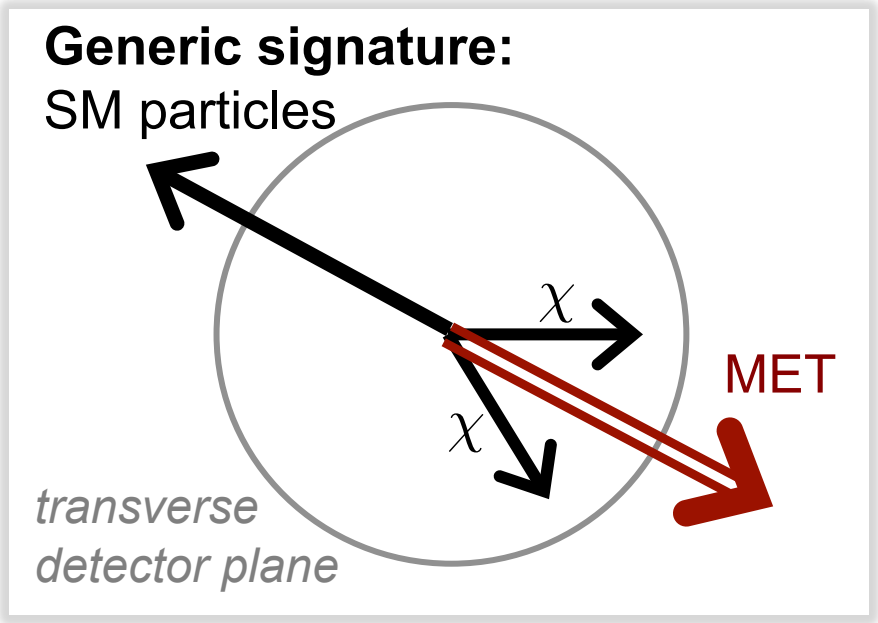
Oleg Brandt
on behalf of ATLAS and CMS Collaborations

30th Rencontres de Blois, 3-8 June 2018



OUTLINE #1

- **Dark Matter searches:**
  - Higgs → invisible
    - Overview
    - VBF channel
    - Combo
  - V+MET, Z'+MET, H+MET

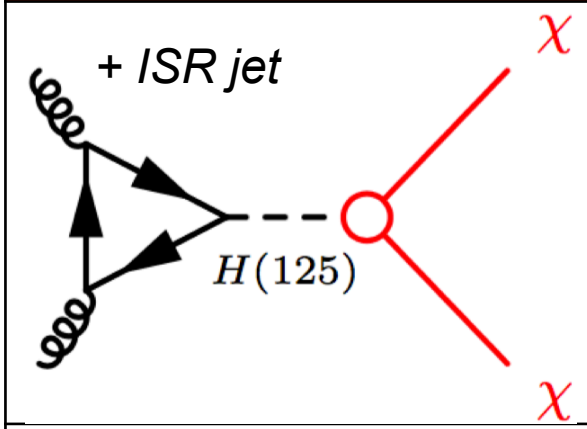
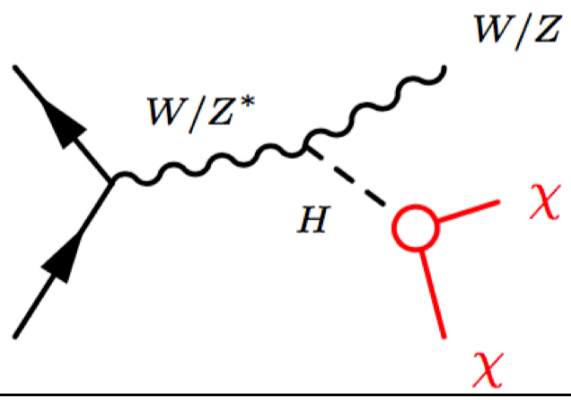
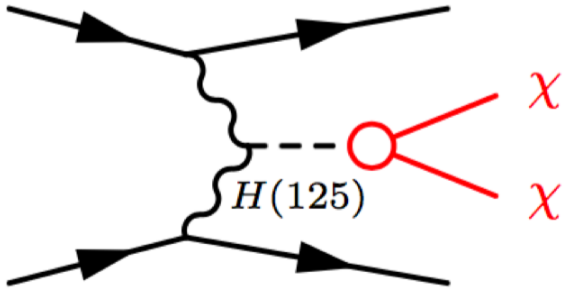


- More Exotics results:
  - https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ExoticsPublicResults
  - https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO
  - https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsB2G

MET: missing transverse momentum

- **Motivation:**
  - Higgs couples to massive particles
  - Dark Matter particles massive…
  - $H \to \chi\chi$ possible if $M_\chi \leq M_H$
- **Competitive – Higgs production as tag:**

[1] CONF-2018-005
[2] 1708.09624
[3] 1508.07869
[4] 1712.02345
[5] 1711.00431
[6] HIG-17-023

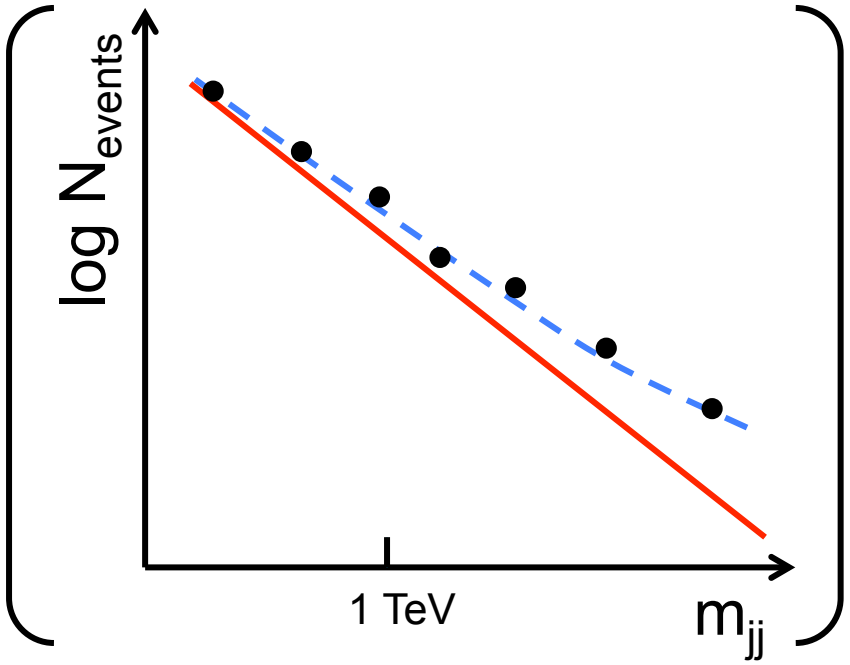
	ggF H [49 pb]	VH [2.3 pb]	VBF H [3.8 pb]
			
ATLAS	ggF+V(had)H(inv): 0.83 (0.58) [1] Z(ℓℓ)H(inv): 0.67 (0.39) [2]		0.28 (0.31) [3]
CMS	ggF+V(had)H(inv): 0.53 (0.40) [4] Z(ℓℓ)H(inv): 0.40 (0.42) [5]		0.28 (0.21) [6]

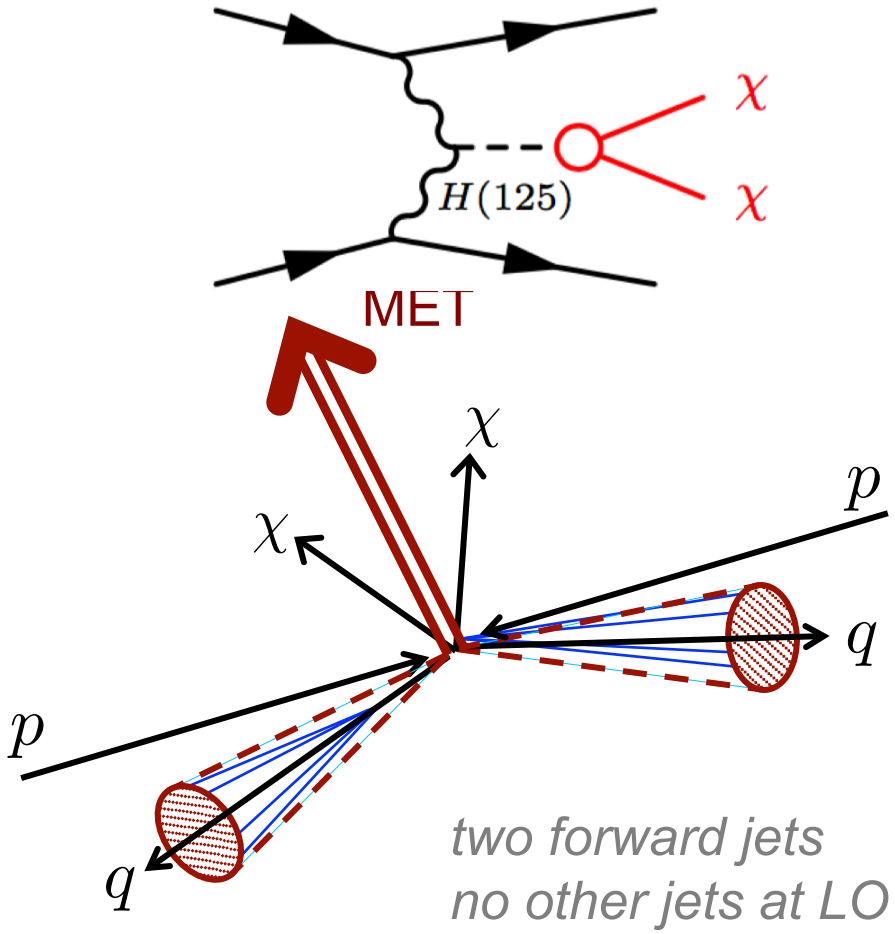
Next slides

KIRCHHOFF-INSTITUT FÜR PHYSIK

HIG-17-023

- **Analysis strategy:**
  - Require MET > 250 GeV
  - Require high $\Delta\eta_{jj}$
  - Look for excess at high m_{jj}:





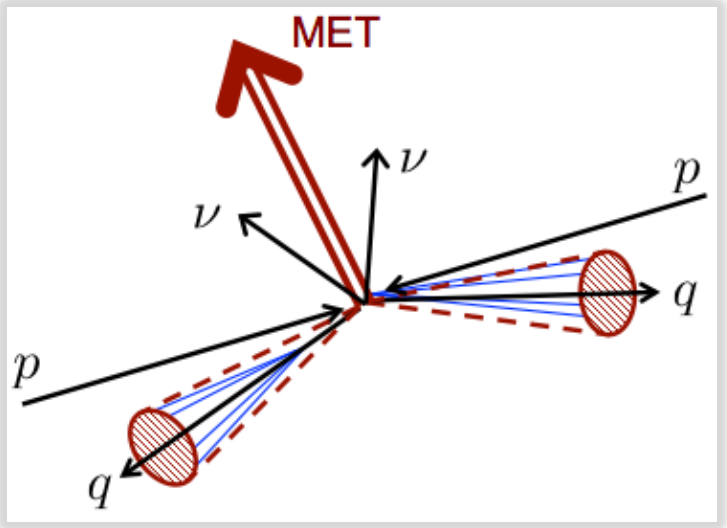
1) Cut & count:
m_{jj} > 1.3 TeV, $\Delta\eta_{jj}$ > 4

2) Shape fit:
m_{jj} > 0.2 TeV, $\Delta\eta_{jj}$ > 1

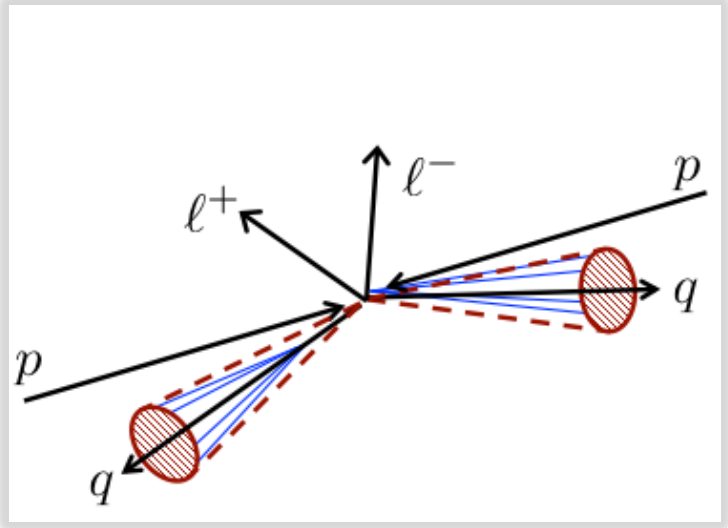
- Constrain Z(vv)+jets, W+jets in signal region (SR) using control regions (CR):

0 lepton SR	1 lepton CR	2 lepton CR
Signal + constrain Z(vv)+jets etc. at low mjj	Constrain W+jets	Constrain Z(vv)+jets using Z($\ell\ell$)+jets

Z(vv)+jets



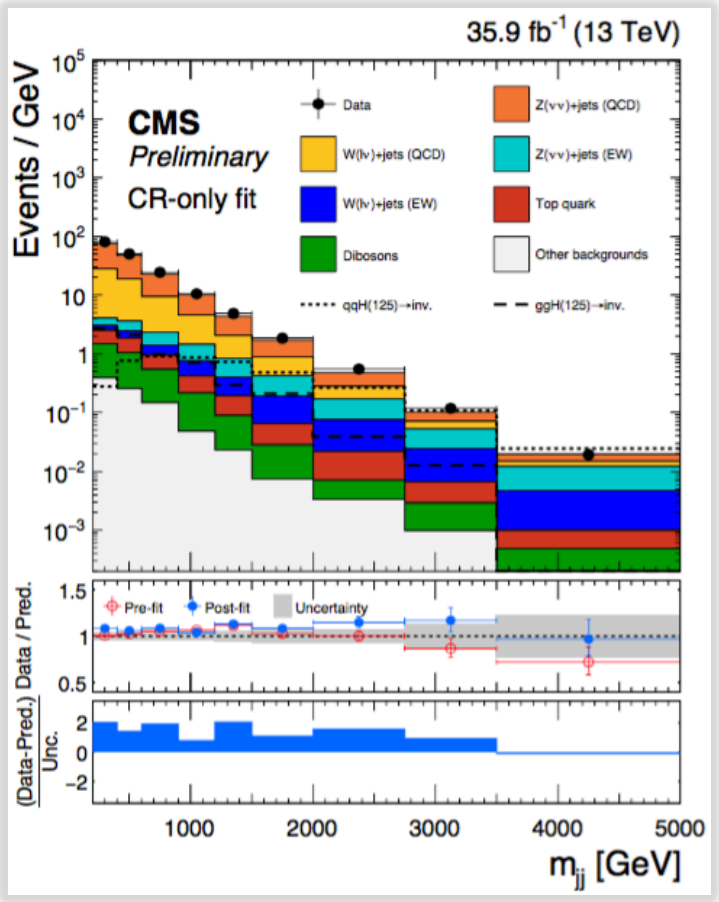
Z($\ell\ell$)+jets

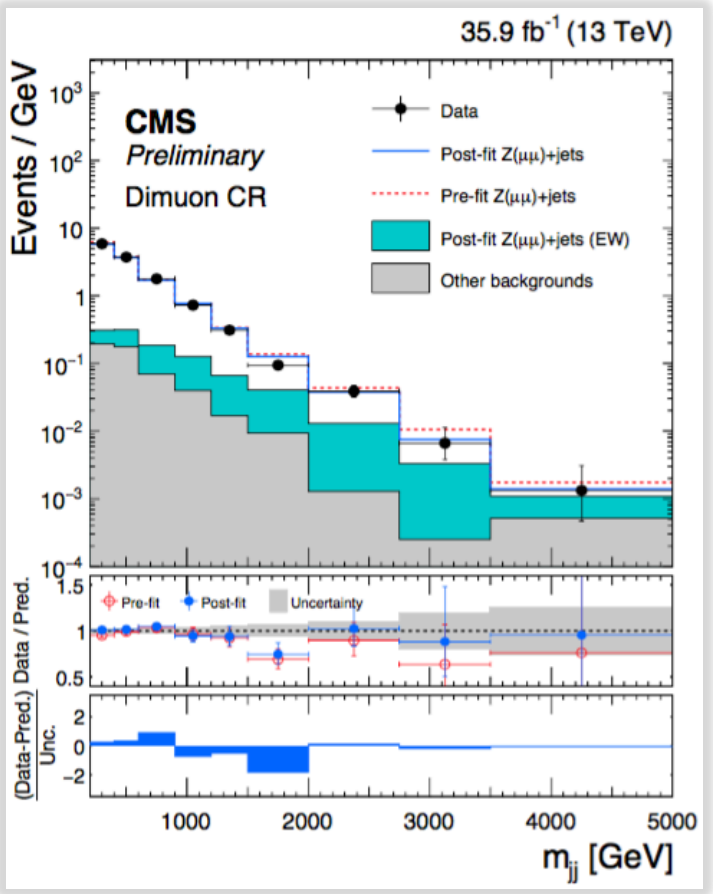


HIG-17-023

- Constrain Z(vv)+jets, W+jets in signal region (SR) using control regions (CR):

0 lepton SR	1 lepton CR	2 lepton CR
Signal + constrain Z(vv)+jets etc. at low mjj	Constrain W+jets	Constrain Z(vv)+jets using Z($\ell\ell$)+jets

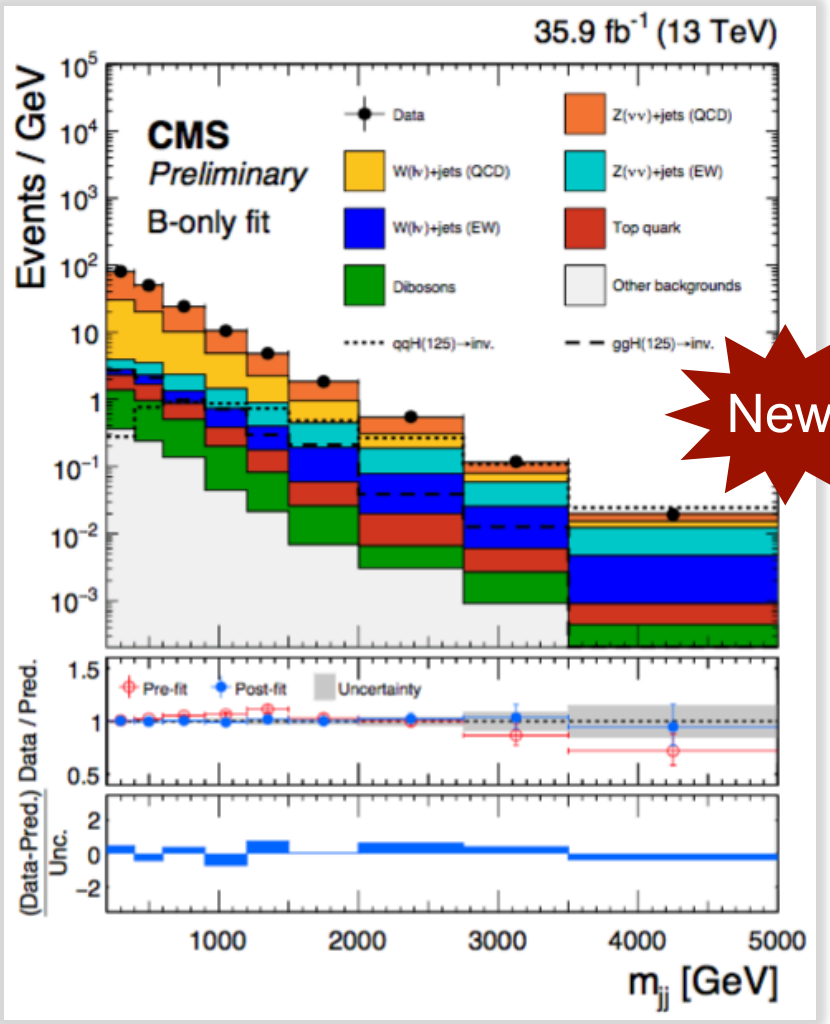




HIG-17-023

KIRCHHOFF-INSTITUT FÜR PHYSIK

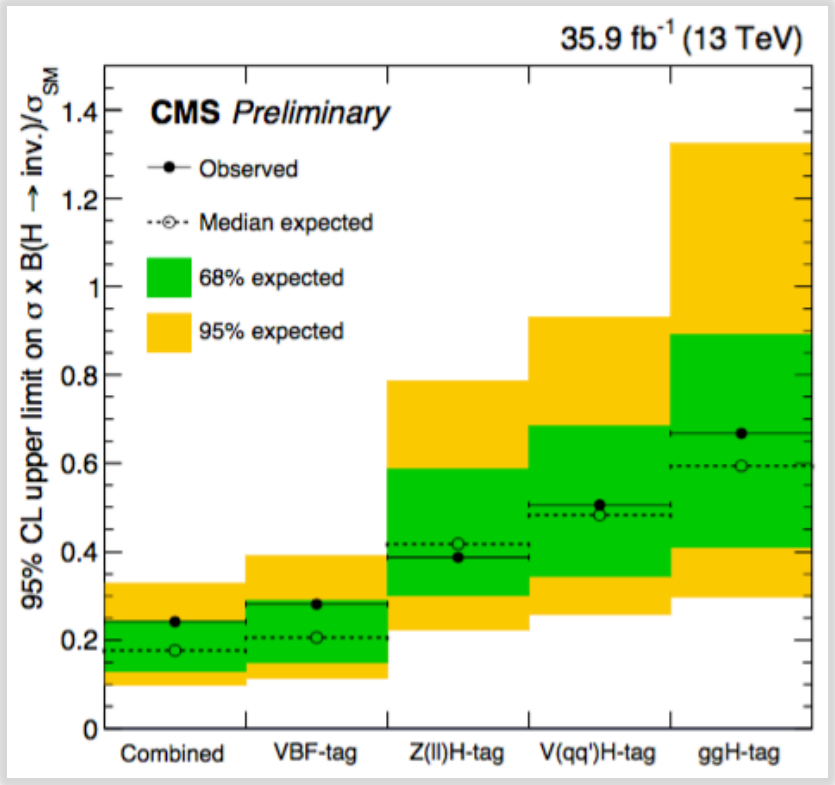
- **Result:**
  - BR(H→inv) < 0.28 (0.21)



New!

HIG-17-023

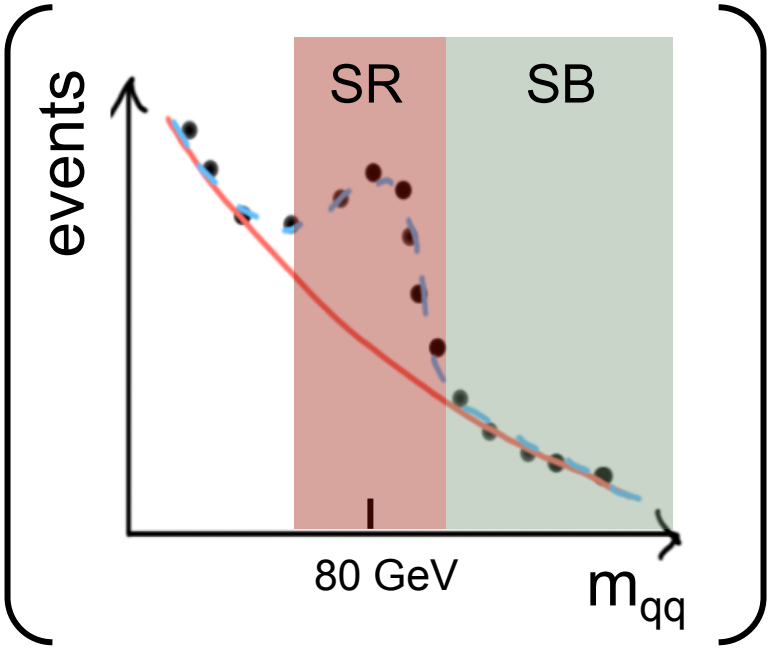
- **Combination with other channels:**
  - BR(H→inv) < 0.24 (0.18)



- **Run 1 combinations:**
  - ATLAS: <0.23 (0.24) [1509.00672]
  - CMS: <0.24 (0.23) [1610.09218]
  - LHC: <0.34 [1606.02266] (indir.)

KIRCHHOFF-INSTITUT FÜR PHYSIK

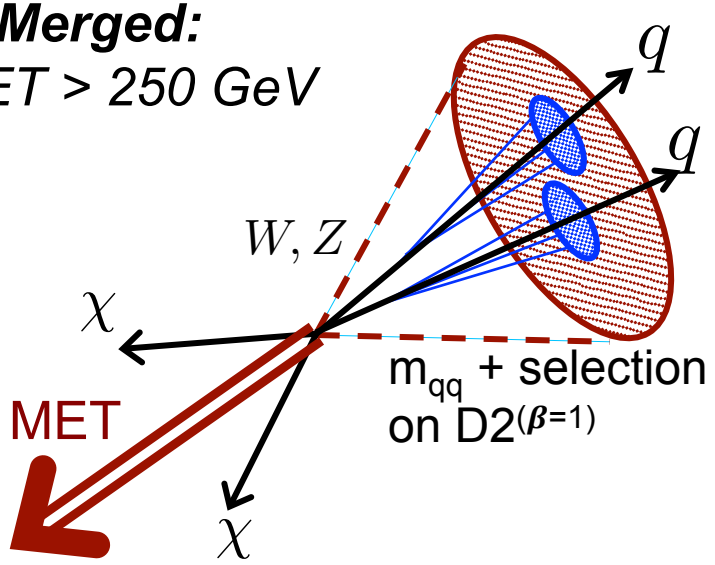
- **Analysis strategy:**
  - Require MET
  - Look for excess in m_{qq} distribution:



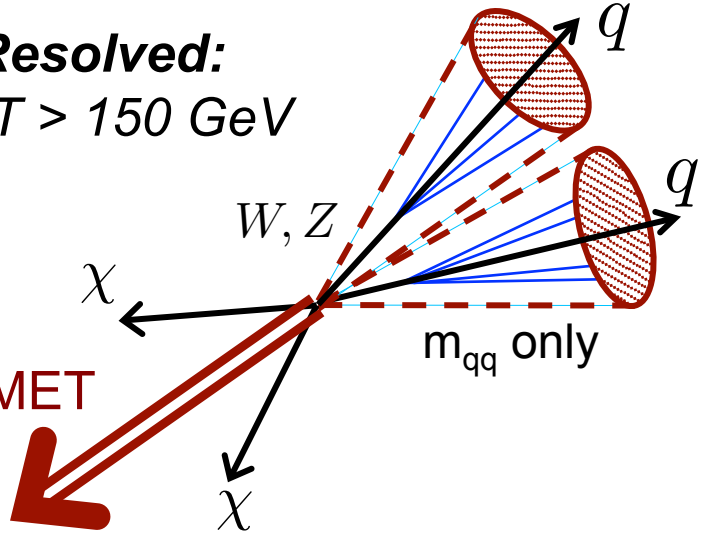
× ~10 MET bins
× (0,1, 2 b-tags)
× ~merged/resolved

ATLAS-CONF-2018-005

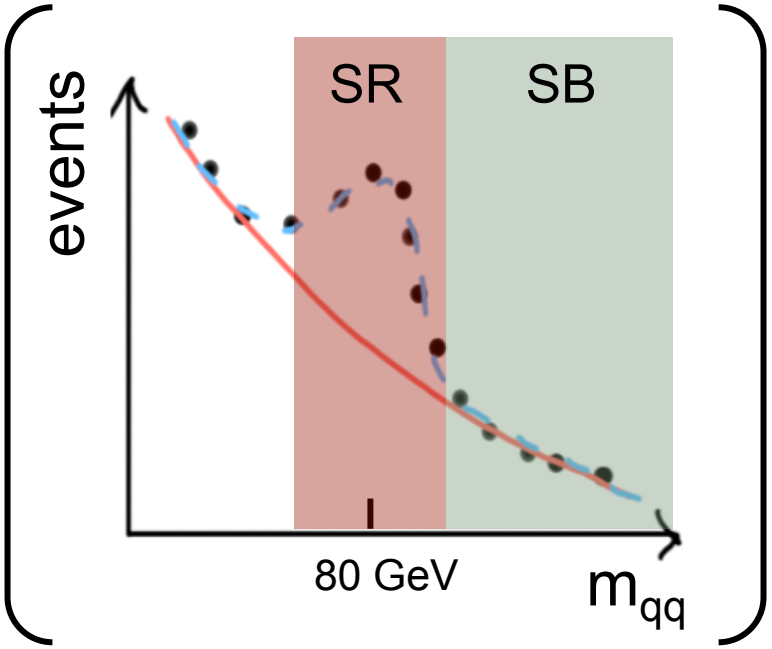
1) Merged:
MET > 250 GeV



2) Resolved:
MET > 150 GeV

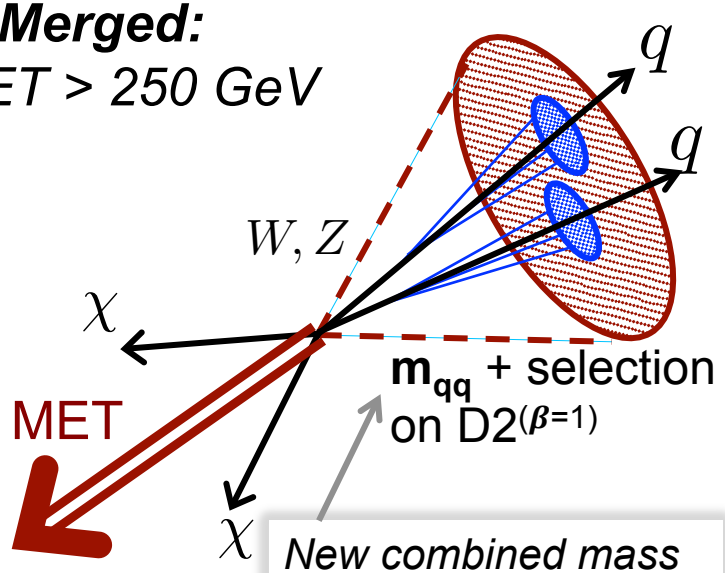


- **Analysis strategy:**
  - Require MET
  - Look for excess in m_{qq} distribution:

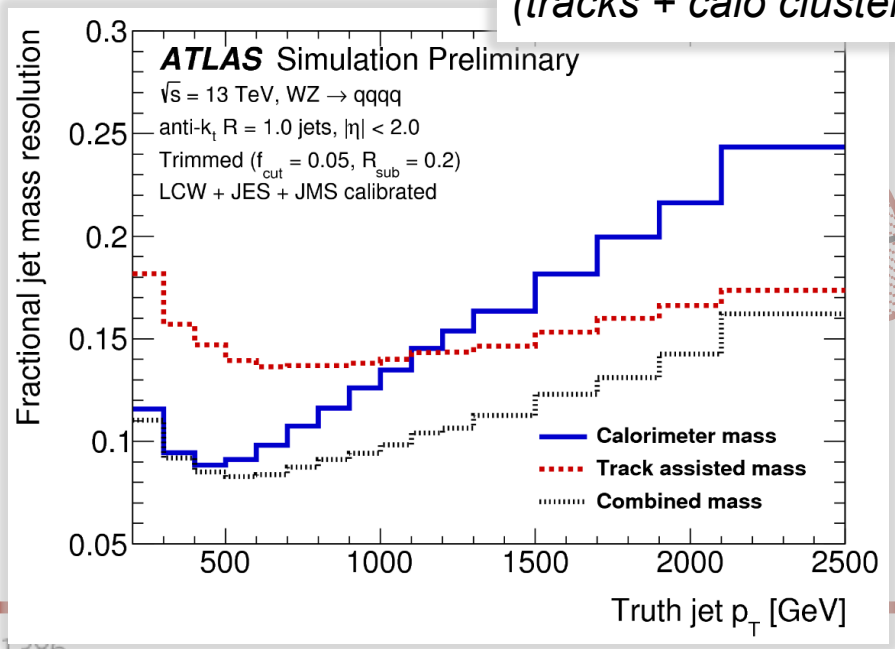


× ~10 MET bins
× (0,1, 2 b-tags)
× ~merged/resolved

1) Merged:
MET > 250 GeV



New combined mass (tracks + calo clusters)

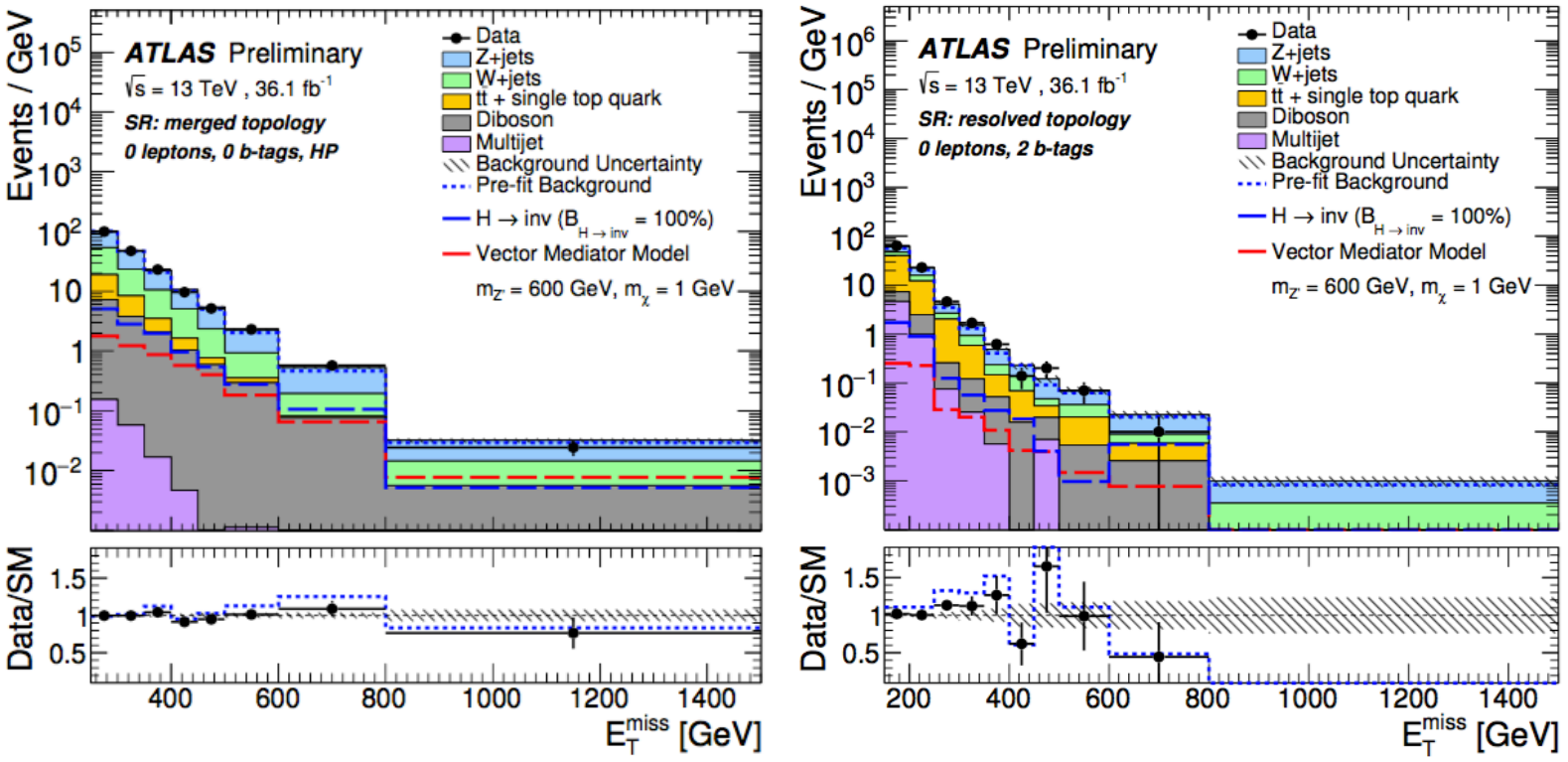


q

ATLAS-CONF-2018-005

V+MET: BACKGROUND ESTIMATION

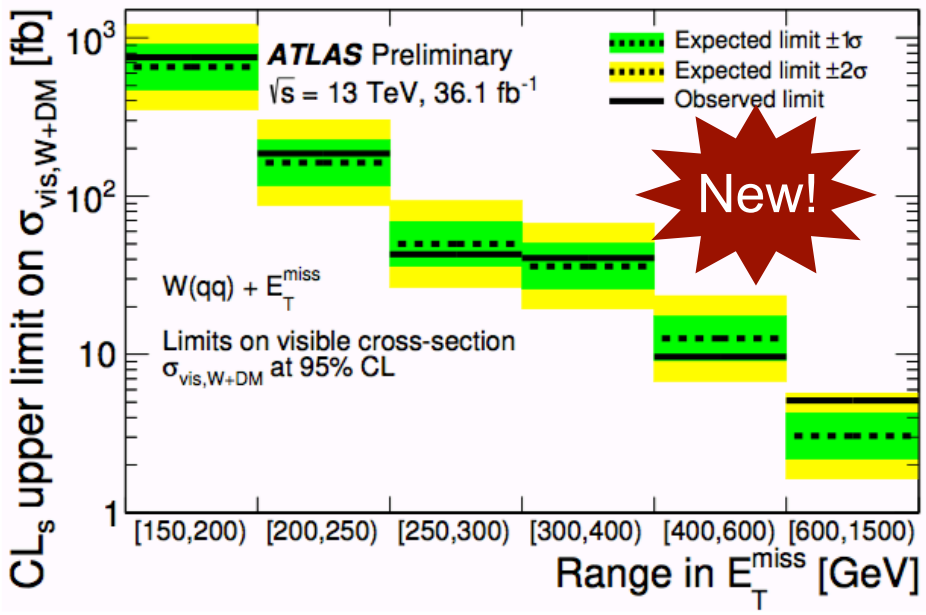
- Constrain Z(vv)+jets, W+jets in signal region (SR) using control regions (CR)
  - Similar to VBF Higgs → invisible analysis
- Representative SR plots:

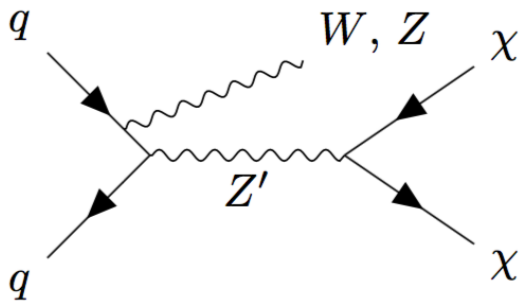


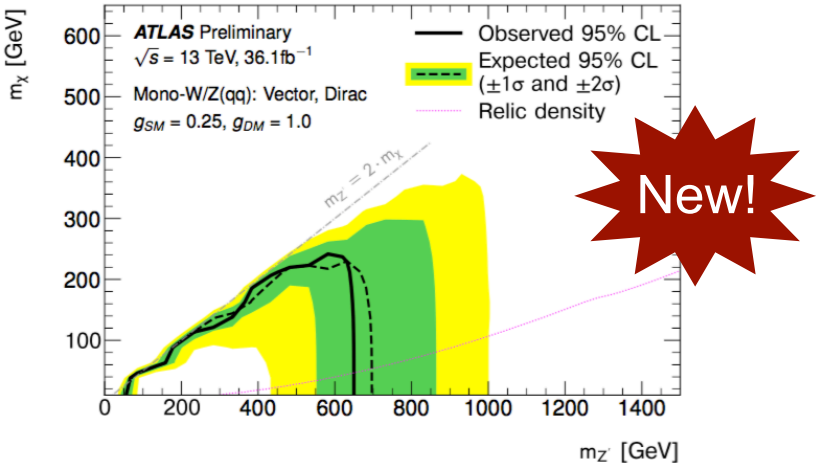
ATLAS-CONF-2018-005

$$\sigma_{\text{vis, W+DM}}(E_{\text{T}}^{\text{miss}}) \equiv \sigma_{W+\text{DM}}(E_{\text{T}}^{\text{miss}}) \times \mathcal{B}_{W\to q'q} \times (A \times \varepsilon)(E_{\text{T}}^{\text{miss}})$$

Provided → partonic Xsec limits





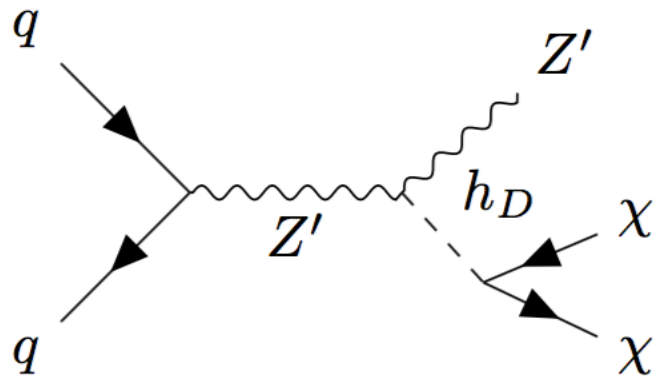


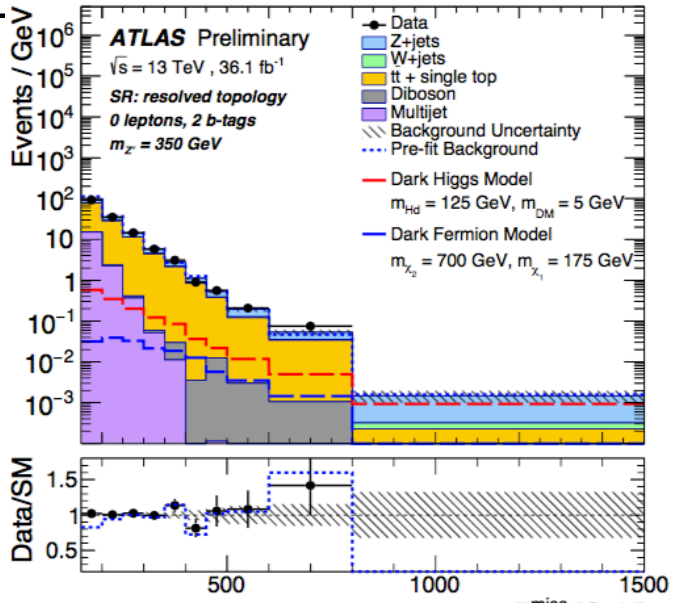
ATLAS-CONF-2018-005

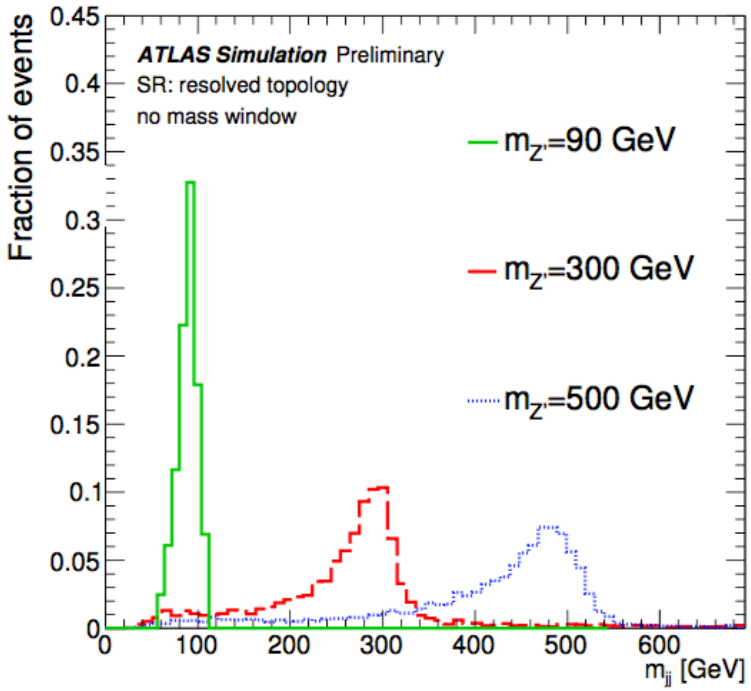
Z'+MET: SUMMARY + RESULTS

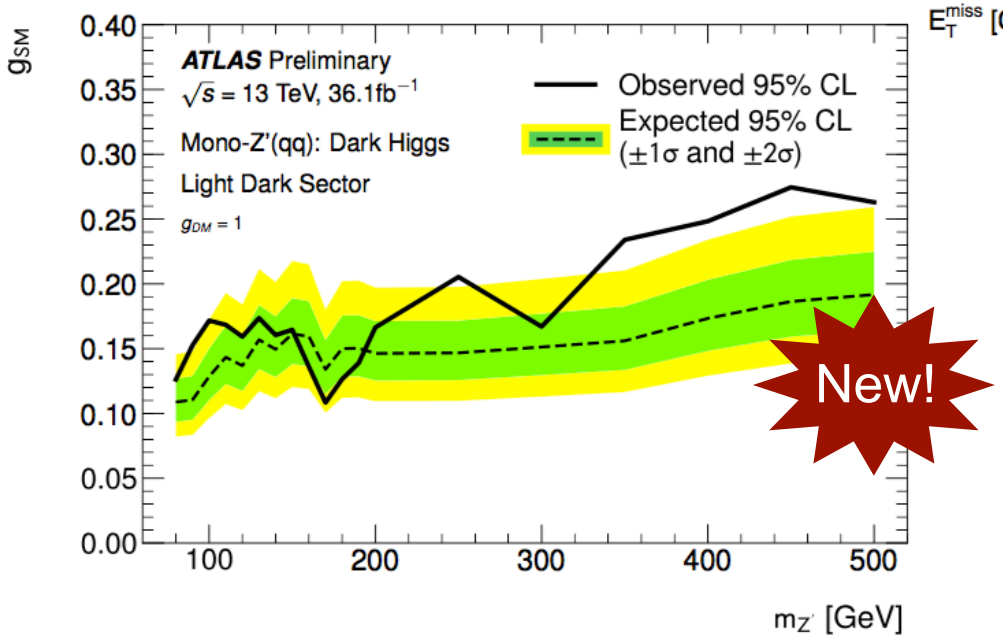
- **Strategy:** change the mass hypothesis in V+MET
  - For $m_{Z'} \geq 100$ GeV only resolved regime

First search for Z'+DM!







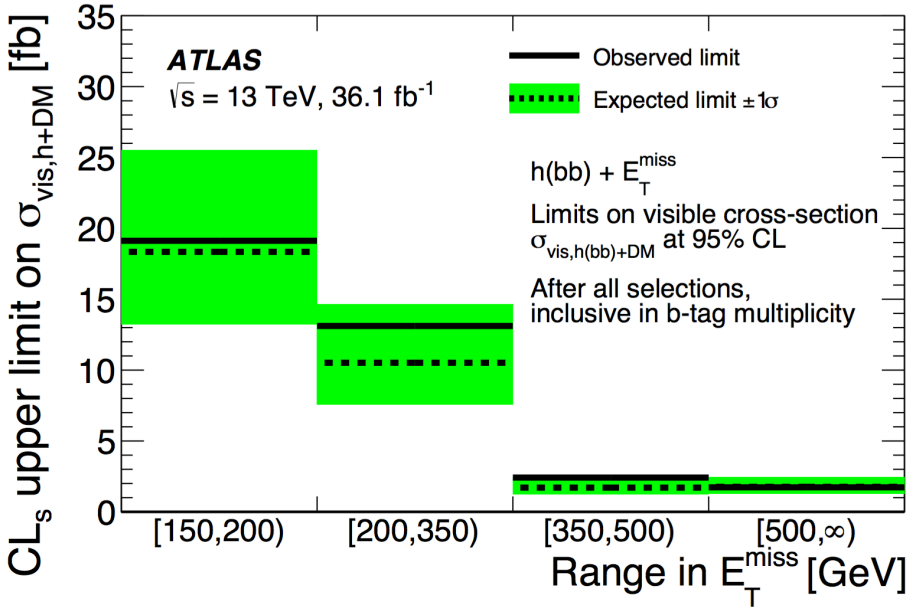


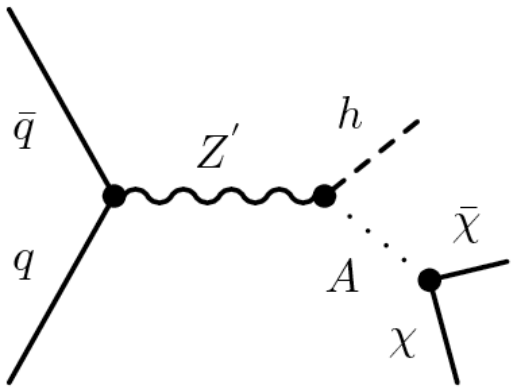
ATLAS-CONF-2018-005

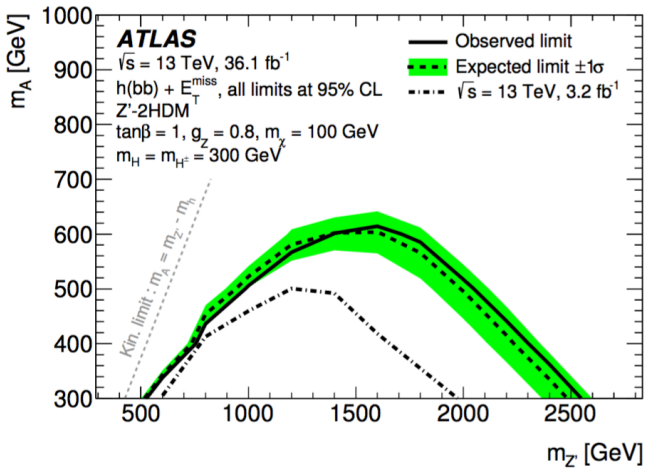
$$\sigma_{\text{vis},h+\text{DM}} \equiv \sigma_{h+\text{DM}} \times BR(h \rightarrow b\bar{b}) \times \mathcal{A} \times \varepsilon$$

Provided → partonic Xsec limits

Strategy similar to V+MET
Require 1,2 b-tags
Full m_{bb} fit



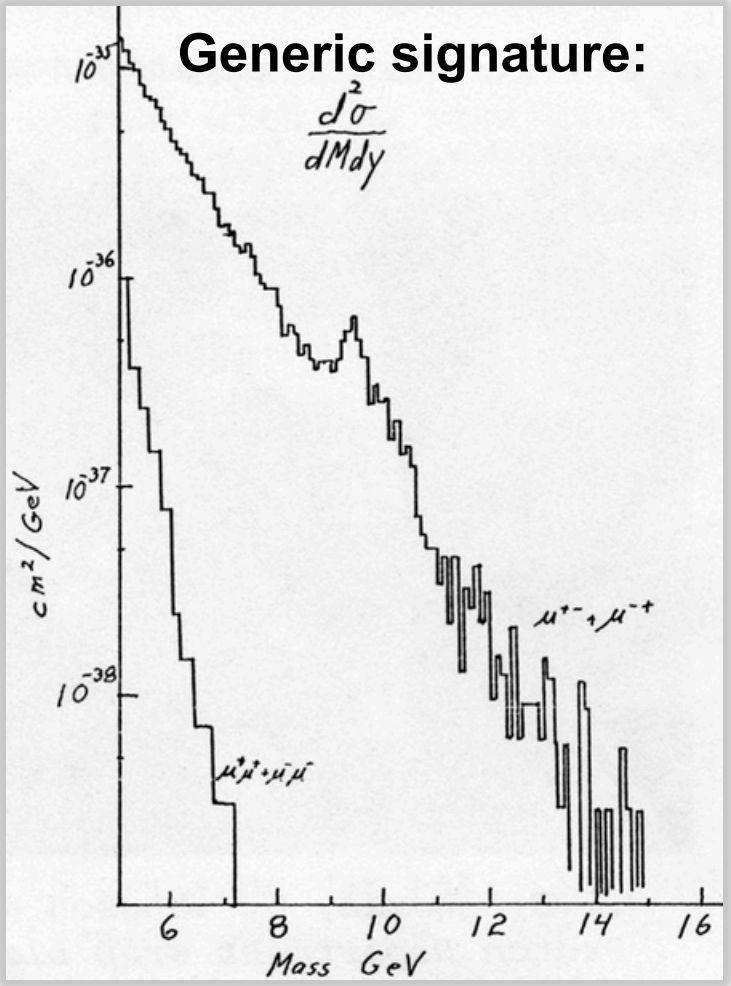




PRL 119 (2017) 181804

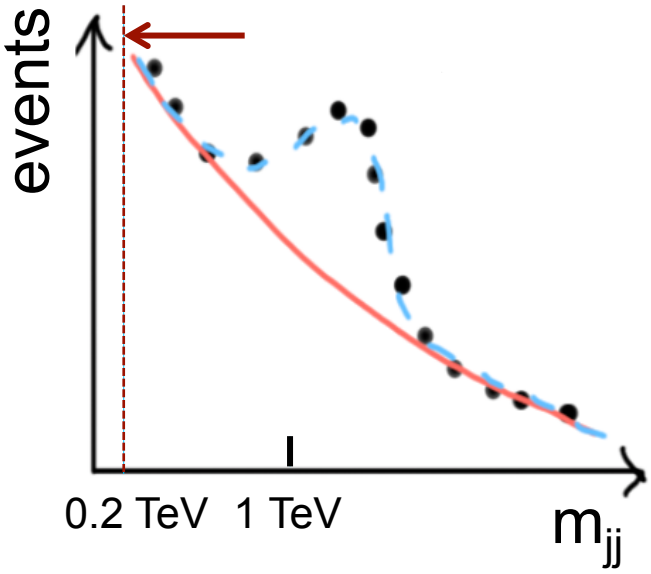
OUTLINE #2

- **Resonance searches:**
  - Dijet resonances + lepton (80 fb^{-1})
  - HH resonances
  - Hy resonances
  - W' → lv resonances (80 fb^{-1})



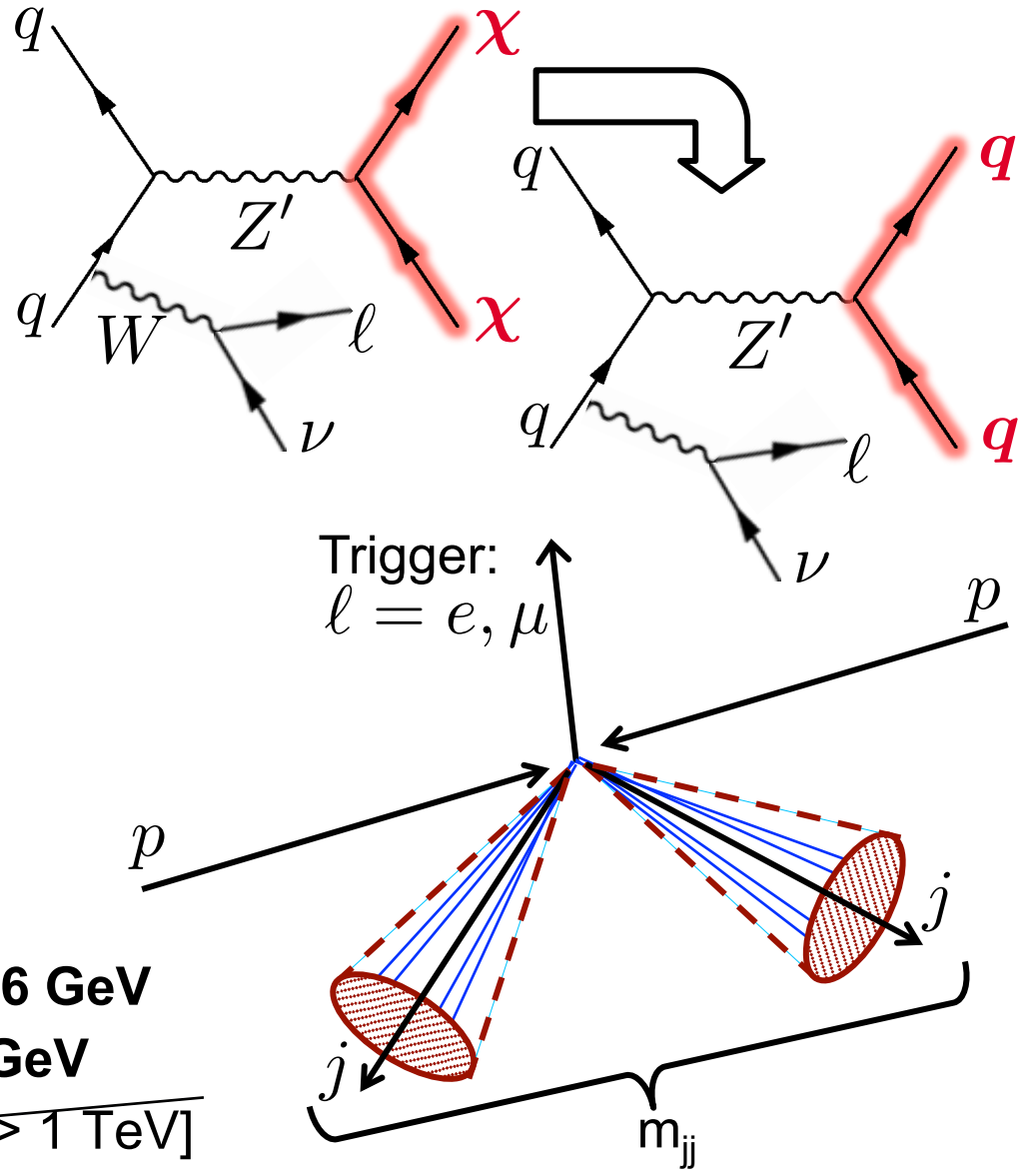
- More Exotics results:
  - https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ExoticsPublicResults
  - https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO
  - https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsB2G

- **Analysis strategy:**
  - Look for a resonance in m_{jj}
  - Trigger on lepton
    - push to low dijet masses:



  - Lowest unprescaled triggers:
    - **Isolated electrons: p_T > 26 GeV**
    - **Isolated muons: p_T > 24 GeV**
    - [Jets: ~~p_T > 420 GeV → m_{jj} > 1 TeV~~]

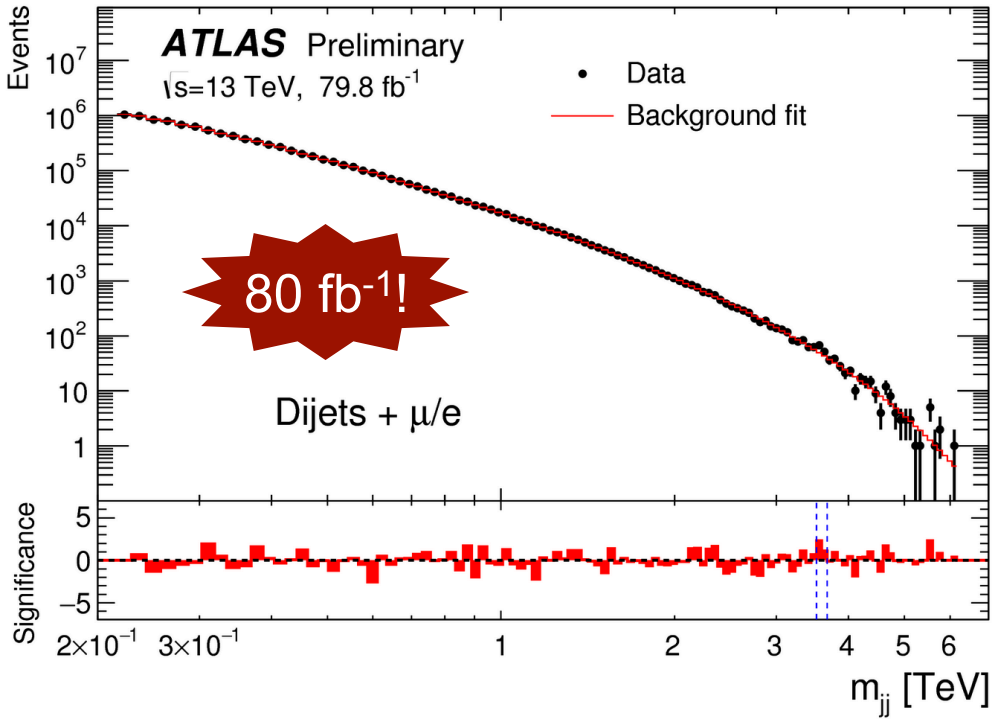
Motivation: search for Dark Sector mediator

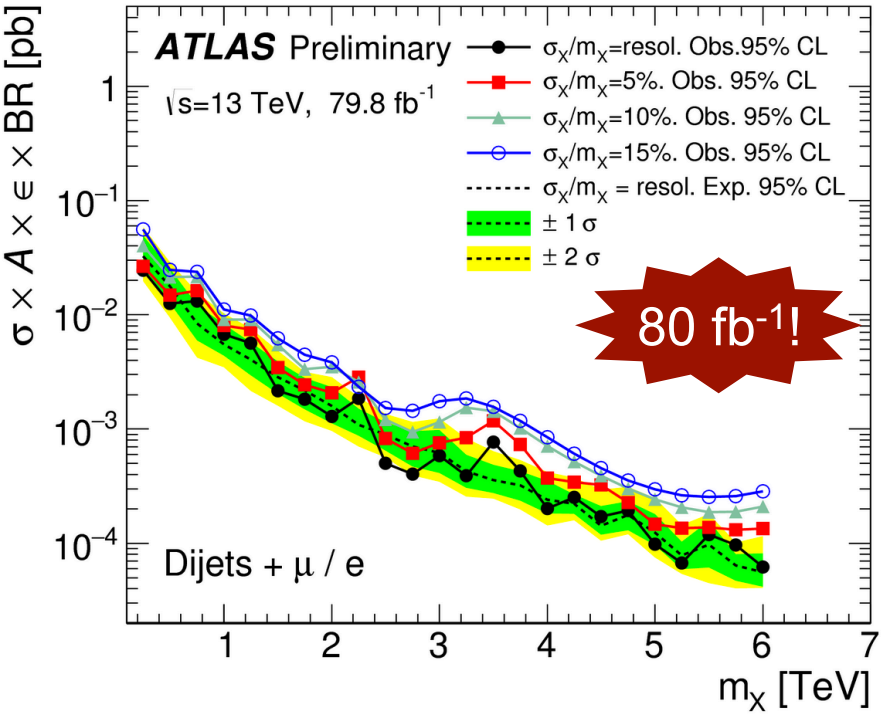


- **Results with 80 fb^{-1}:**

Empirical fit function:

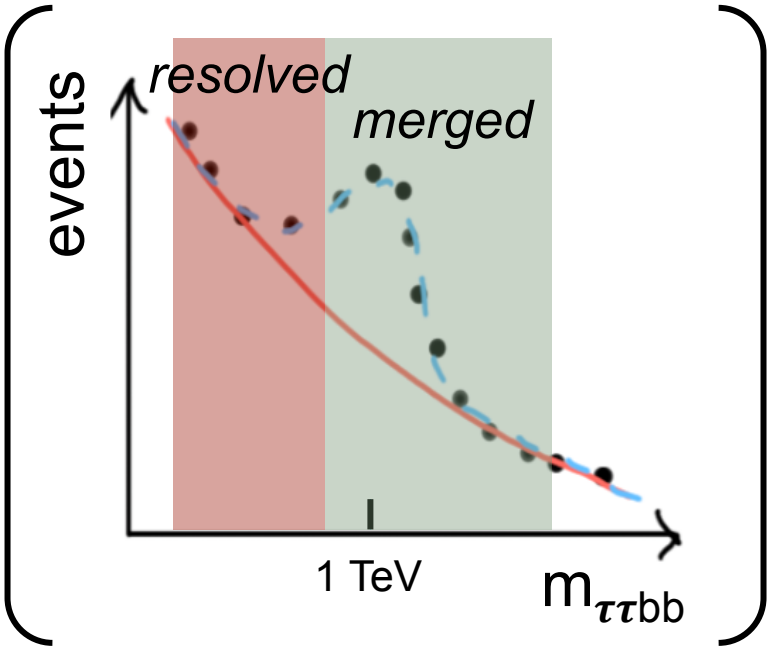
$$f(x) = p_1(1-x)^{p_2} x^{p_3 + p_4 \ln x + p_5 \ln^2 x}$$





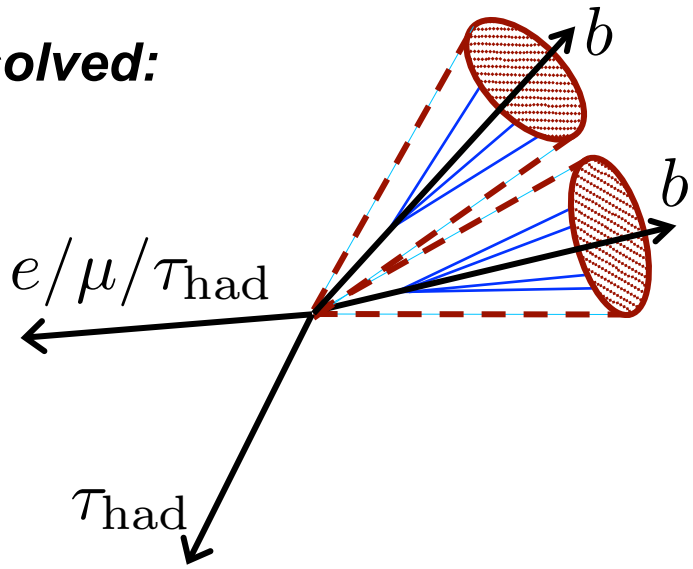
ATLAS-CONF-2018-015

- **Analysis strategy:**
  - Resolved: τ_{had} + e/μ/τ_{had} + 2 jets
  - Merged: 2τ_{had} + 1 large-R jet
  - Look for excess in $m_{\tau\tau bb}$ distribution:

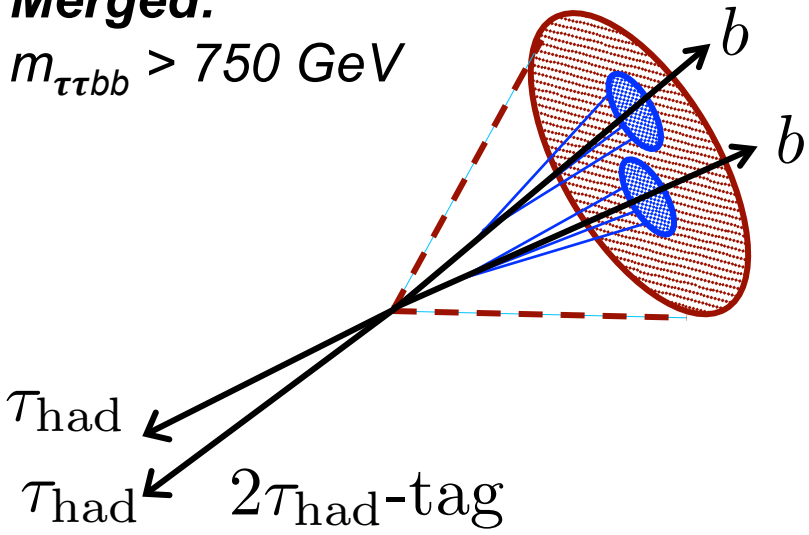


× (1, 2 b-tags)
× ~merged/resolved

Resolved:

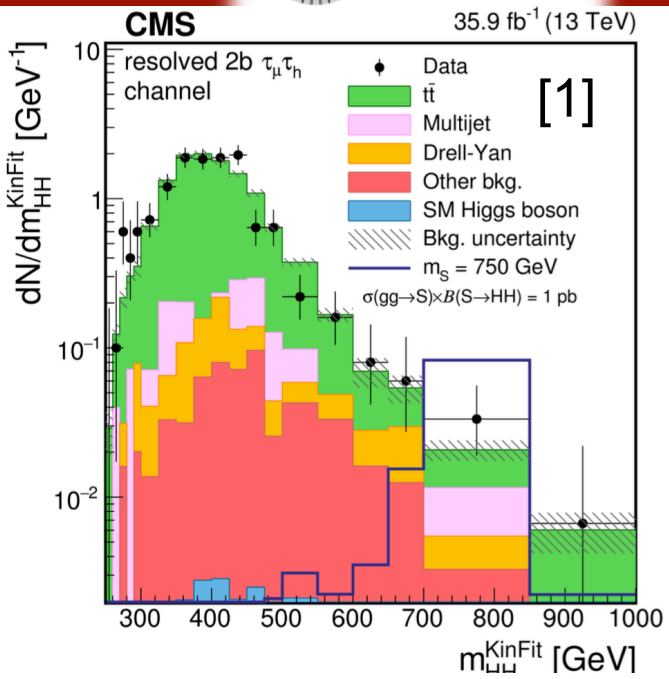


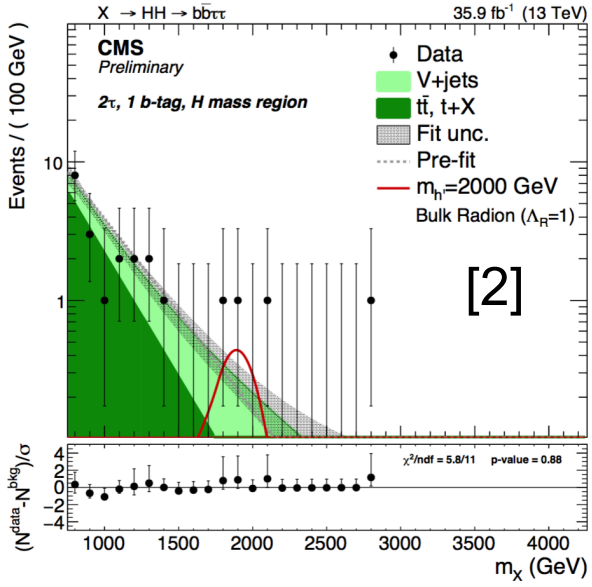
Merged:
$m_{\tau\tau bb}$ > 750 GeV

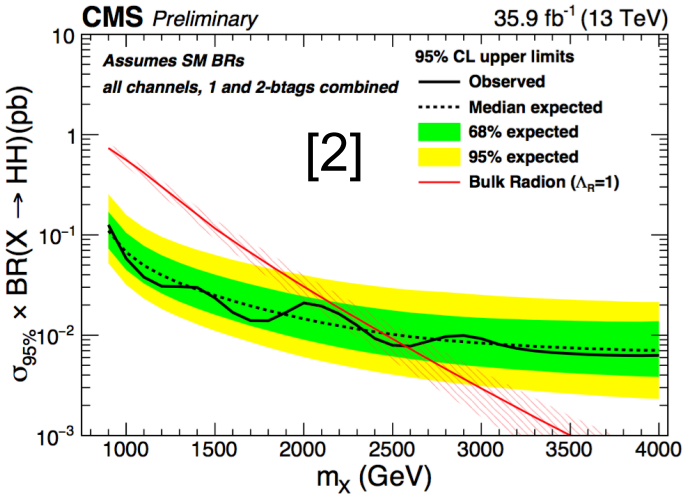


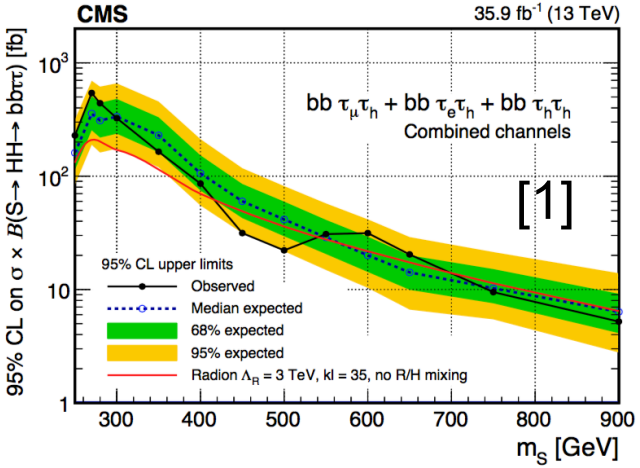
HH → $\tau\tau bb$: RESULTS

- **Main backgrounds:**
  - Top production
    - BDT in $e/\mu + \tau_{\mathrm{had}}$
  - Z($\tau\tau$)+jets (esp. merged)
- Reconstruct m_{HH} with kinematic fit (resolved)
- **Results:**



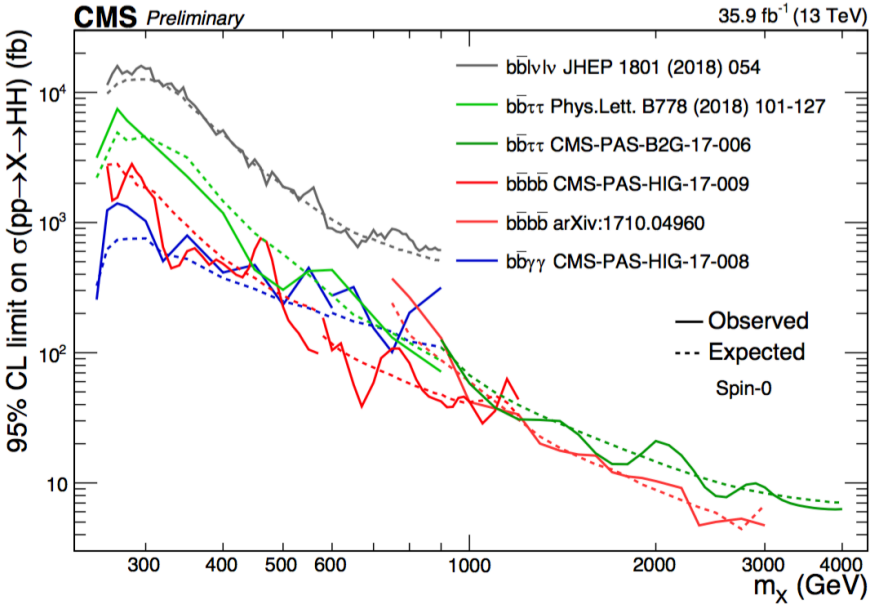




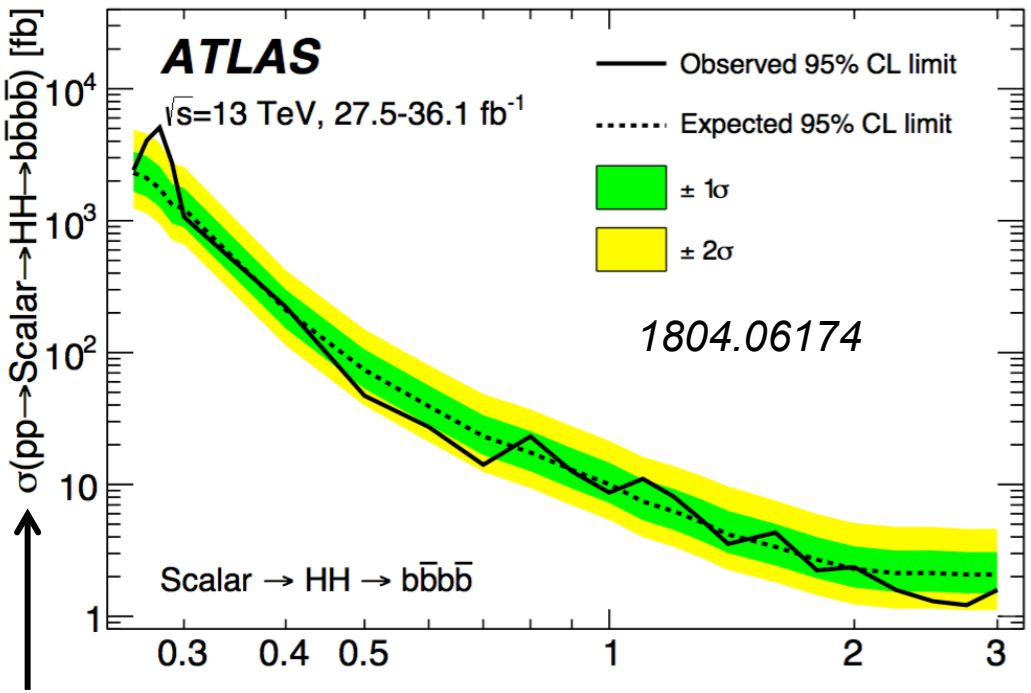


[1] PLB 778 (2018) 101
[2] CMS-PAS-B2G-17-006

CMS overview:



ATLAS' most sensitive result:

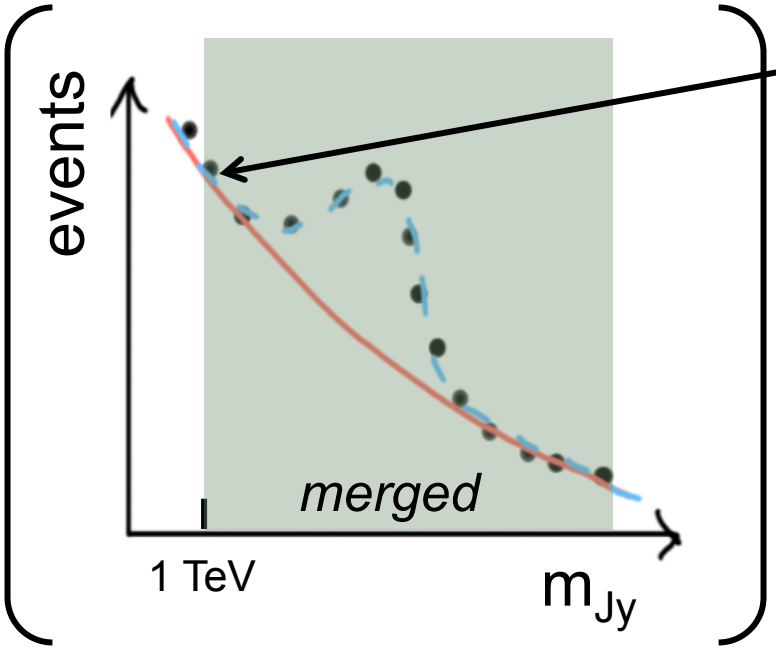


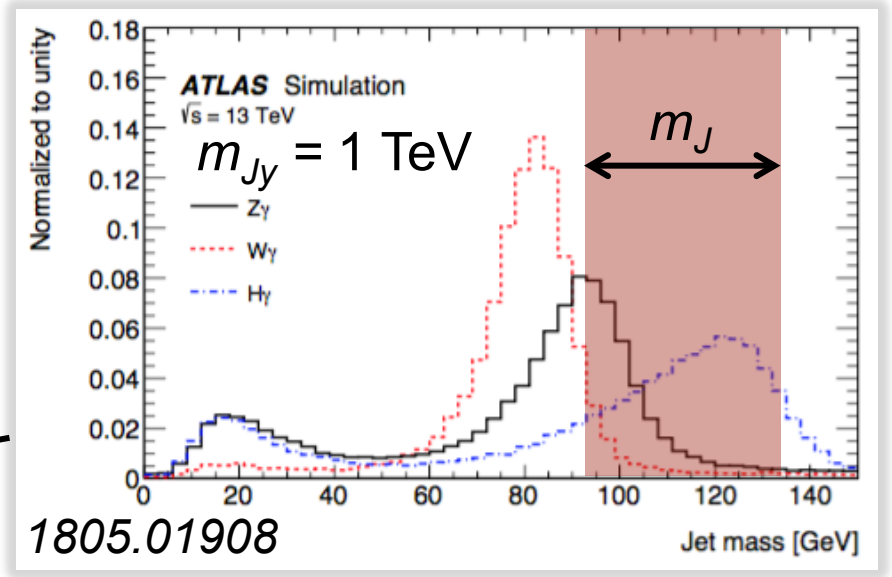
Axes aligned, but ATLAS includes BR(H→bb)

- **Non-resonant production** (best limits only):
  - ATLAS: 13 (21) in HH → 4b [1804.06174]
  - CMS: 19 (17) in HH → yybb [HIG-17-008]

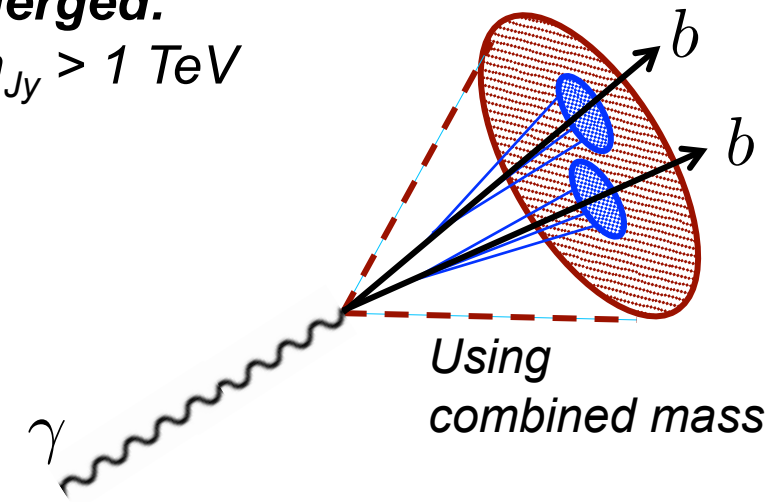
Hγ → $bb\gamma$: Motivation & strategy

- **Analysis strategy:**
  - Merged only: y + 1 large-R jet
  - 2 b-tags
  - 93 < m_J/GeV < 134
  - Look for excess in m_{Jy} distribution:





Merged:
m_{Jy} > 1 TeV



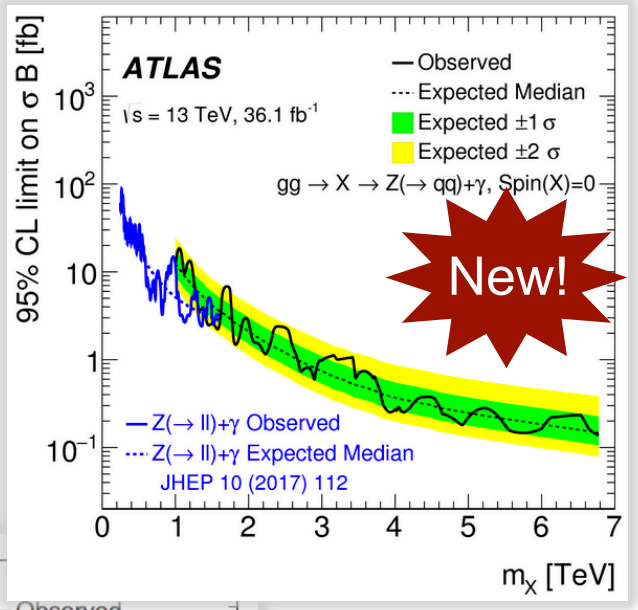
- Search also for Vy resonance (not shown)

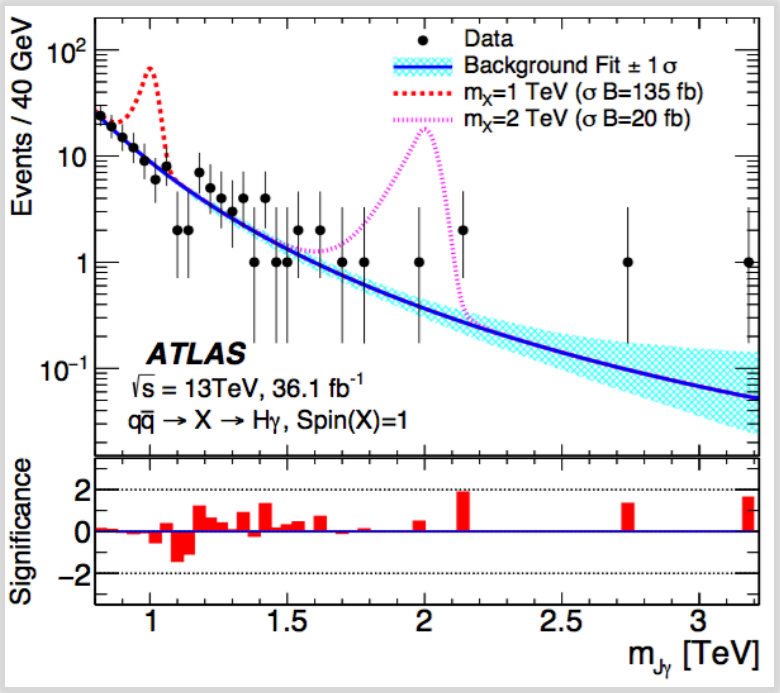
Hγ → $bb\gamma$: Motivation & strategy

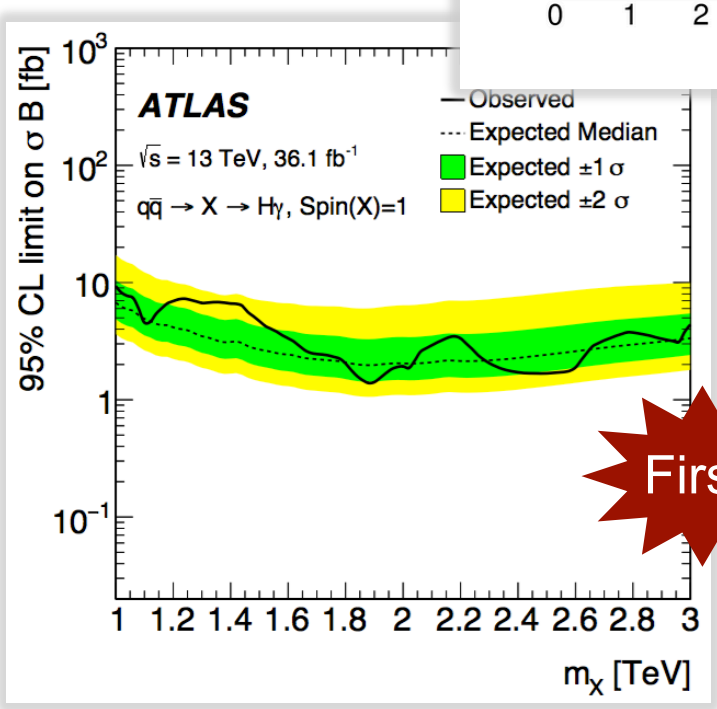
KIRCHHOFF-INSTITUT FÜR PHYSIK

- Main background:
  - γ + jets, parametric fit:
  - $B(m_{J\gamma}; \boldsymbol{p}) = (1-x)^{p_1} x^{p_2+p_3 \log(x)}$

- **Results:**

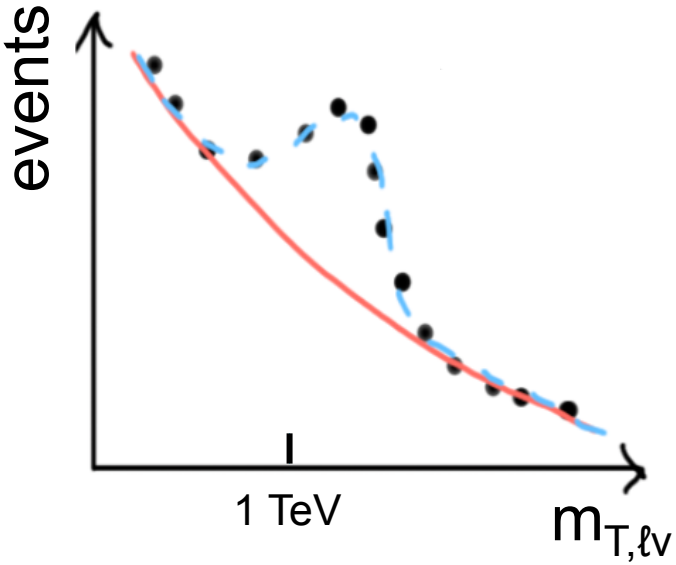




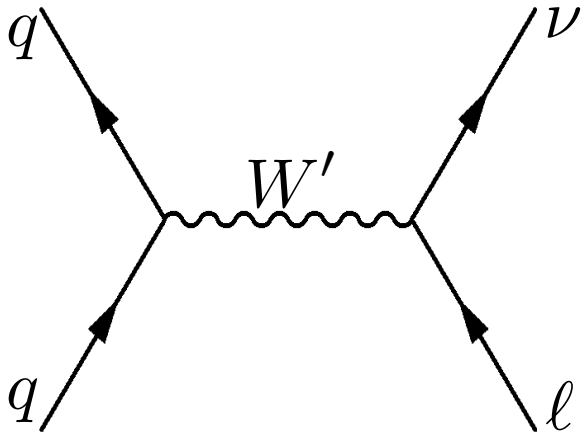


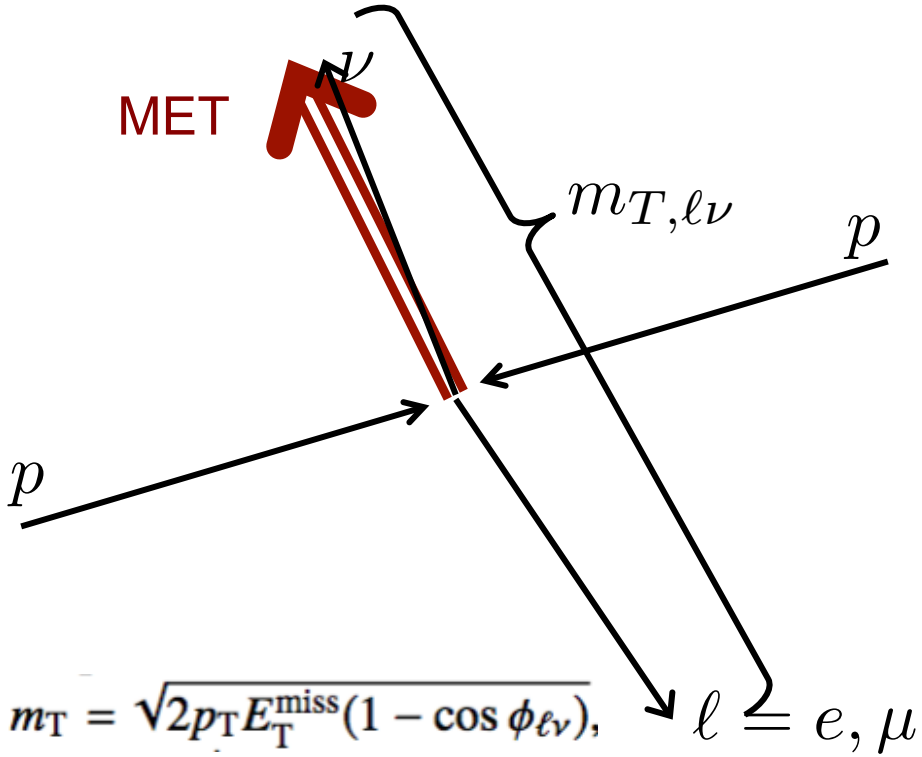
1805.01908

- **Analysis strategy:**
  - Look for a a resonance in $m_{\ell\nu}$



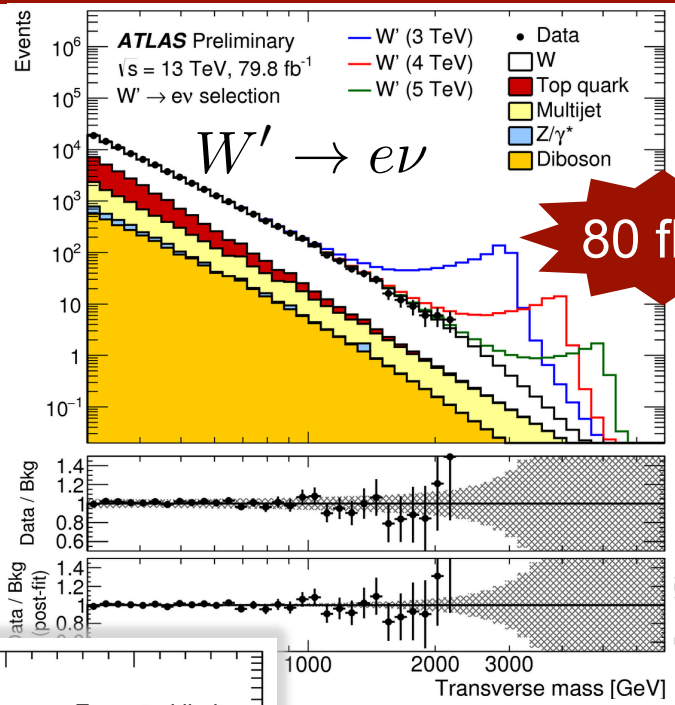
  - **Backgrounds:**
    - W+jets (dominant), Z+jets, tt, …
  - **Challenge:**
    - μ momentum at high p_T
    - Modelling of W+jets and Z+jets
      - Normalise to NNLO in $m_{T,\ell\nu}$
      - Correct for EW at NLO

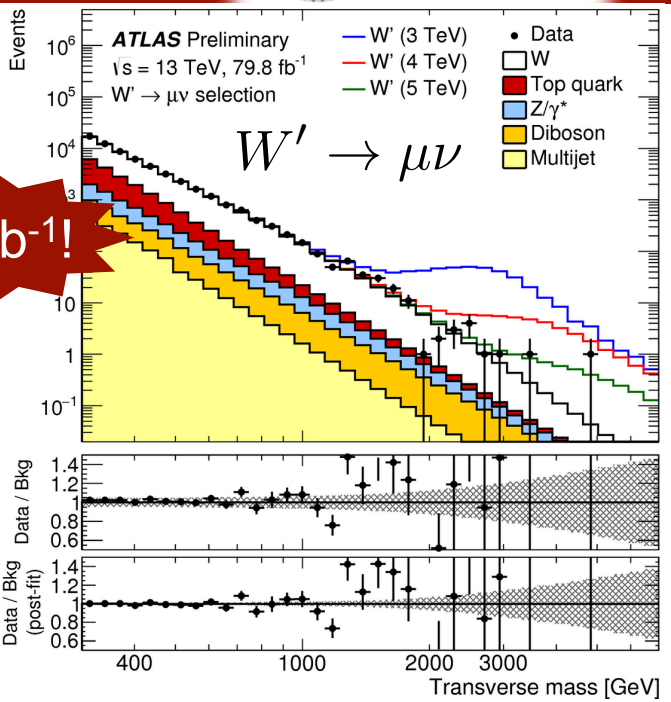




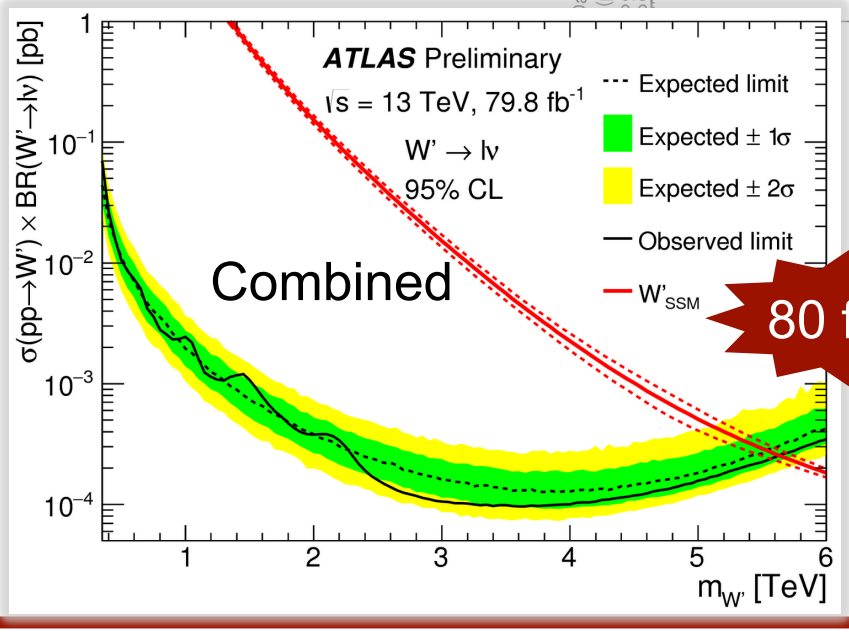
$$m_T = \sqrt{2 p_T E_T^{miss} (1 - \cos \phi_{\ell\nu})},$$

W' → ℓν RESONANCES: RESULTS WITH 80 FB^{-1}





80 fb^{-1}!



80 fb^{-1}!

ATLAS-CONF-2018-017

SUMMARY + OUTLOOK

- **Dark Matter searches:**
  - Diverse research programme, few examples:
    - H → invisible searches:
      - scratch BR < 20% benchmark!
    - V+MET, H+MET:
      - Generic limits on σ × BR x (A × ε)!
    - Z'+MET: first ever!
- **New resonance searches:**
  - Dijet resonances + lepton → probe m_{jj}>200 GeV
  - HH resonances: strong cut into model phase space
    - Non-resonant exclusion limits O(10 x $\sigma_{SM)}$!
  - Hy: first ever, Vy: first up to 6.8 TeV!
  - W' → ℓν: probe up to $m_{W'}$ < 6 TeV
- **First results including 2017 data shown (80 fb^{-1} total)**
- Will **probe more extreme regions of phase space** with more data + further analysis improvements

Spares

Table 2: Event selection criteria in the mono-W/Z and mono-Z' signal regions with merged and resolved event topologies. The symbols "j" and "J" denote the reconstructed small-R and large-R jets, respectively. The abbreviations HP and LP denote respectively the high- and low-purity signal regions with merged topology, as defined by the cut on the large-R jet substructure variable $D_2^{(\beta=1)}$.

	Merged topology	**Resolved topology**
General requirements		
$E_{\mathrm{T}}^{\mathrm{miss}}$ Jets, leptons b-jets	> 250 GeV $\geq 1J, 0\ell$ no b-tagged track jets outside of J	> 150 GeV $\geq 2j, 0\ell$ ≤ 2 b-tagged small-R jets
Multijet suppression	$\Delta\phi(\boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}}, J \text{ or } jj) > 120^{\circ}$ $\min_{i\in\{1,2,3\}} \left[\Delta\phi(\boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}}, j_i)\right] > 20^{\circ}$ $p_{\mathrm{T}}^{\mathrm{miss}} > 30$ GeV or ≥ 2 b-jets $\Delta\phi(\boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}}, \boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}) < 90^{\circ}$	
Signal properties		$p_{\mathrm{T}}^{j_1} > 45$ GeV $\sum p_{\mathrm{T}}^{j_i} > 120$ (150) GeV for 2 (≥ 3) jets

Mono-W/Z signal regions

	0b HP	**0b LP**	**1b HP**	**1b LP**	**2b**	**0b**	**1b**	**2b**
ΔR_{jj}	-	-	-	-	-	< 1.4	< 1.4	< 1.25
$D_2^{(\beta=1)}$ p_{T}^{J}-dep.	pass	fail	pass	fail	-	-	-	-
Mass requirement (GeV)	m_J W/Z tagger requirement				m_J [75, 100]	m_{jj} [65, 105]		m_{jj} [65, 100]

Mono-Z' signal regions

	0b HP	**0b LP**	**1b HP**	**1b LP**	**2b**	**0b**	**1b**	**2b**
$D_2^{(\beta=1)}$ <1.2	pass	fail	pass	fail	-	-	-	-
Mass requirement (GeV)	For $m_{Z'}$ < 100 GeV: $[0.85m_{Z'}, m_{Z'} + 10]$		$[0.75m_{Z'}, m_{Z'} + 10]$			For $m_{Z'}$ < 200 GeV: $[0.85m_{Z'}, m_{Z'} + 10]$	$[0.75m_{Z'}, m_{Z'} + 10]$	
	For $m_{Z'} \geq 100$ GeV: no merged-topology selection applied					For $m_{Z'} \geq 200$ GeV: $[0.85m_{Z'}, m_{Z'} + 20]$	$[0.80m_{Z'}, m_{Z'} + 20]$	

V + MET: STRATEGY

- **Backgrounds (from MC):**
  - Resonant in m_{qq}:
    - SM Z(vv)V(qq)
  - Non-resonant (dominant):
    - Z(vv)+jets, W+jets, tt
    - Rest: single top, multijets (from data)
- **Overview of signal regions (SR) and control regions (CR):**

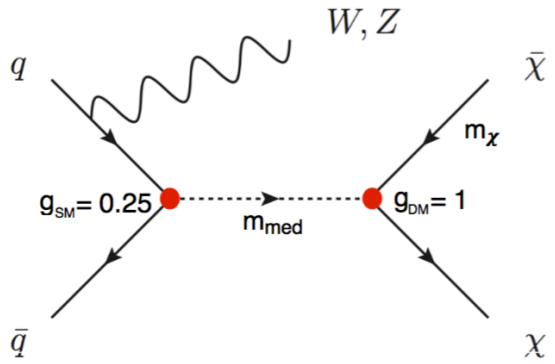
0 lepton SR	1 lepton CR	2 lepton CR
Signal + constrain Z(vv)+jets in m_{qq} sideband	Constrain W+jets and tt in m_{qq} window+sideband	Constrain Z(vv)+jets using Z($\ell\ell$)+jets in m_{qq} window+sideband

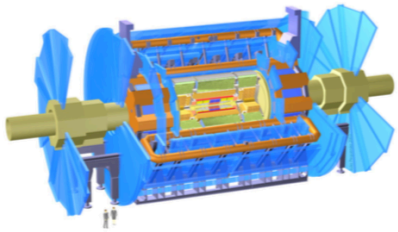
- **Kinematic similarity** between SR and CRs:
  - SR (0 leptons): p_T^V = MET V = Z→νν
  - 1μCR: $p_T^V = p_T(\mu,\text{MET})$ V = W→$\mu\nu$
  - 2ℓCR (ee or $\mu\mu$): $p_T^V = p_T(\ell\ell)$ V = Z→$\ell\ell$

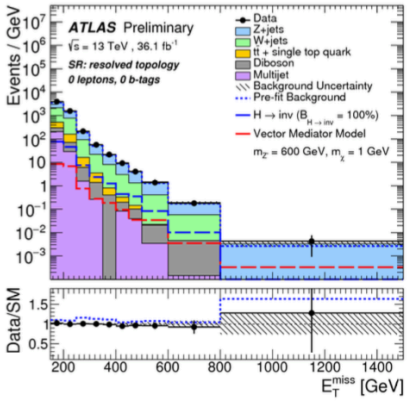
  } $p_T^V > 150$ GeV
  - Most selections identical in SR, 1μCR, 2ℓ-CR

KIRCHHOFF-INSTITUT FÜR PHYSIK

Generic limits on ***parton level:*** $W/Z/h + E_T^{miss}$







Parton/Particle level ⟷ Detector level

$$A \times \varepsilon$$

$A \times \varepsilon$ is probability to

reconstruct in the same E_T^{miss} bin as generated + pass selection (**cannot factorize to A and ε**):

$$A \times \varepsilon \equiv \frac{N_{\text{evt}} \text{ in same } (E_T^{\text{miss}})_{\text{truth}} \text{ and } (E_T^{\text{miss}})_{\text{reco}} \text{ bin after reco+selection}}{N_{\text{evt}} \text{ in } (E_T^{\text{miss}})_{\text{truth}} \text{ bin}}$$

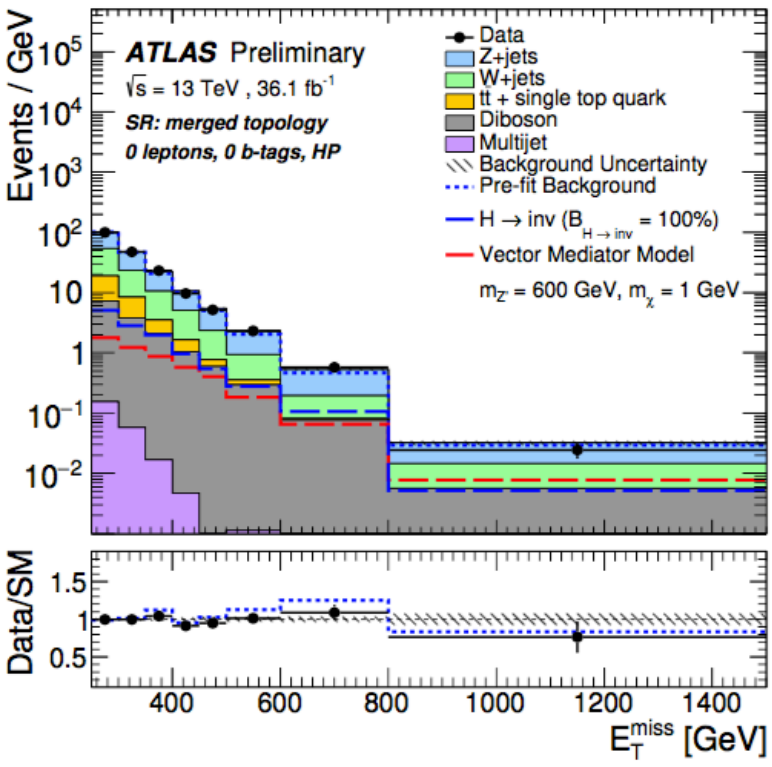
E_T^{miss} range [GeV]	Upper limit at 95% CL [fb] σ_{vis}^{obs}	σ_{vis}^{exp}	-1σ	$+1\sigma$	$A \times \varepsilon$
W+DM, $W \to q'q$					
[150, 200)	750	650	470	910	20%
[200, 250)	185	163	117	226	20%
[250, 300)	43	50	36	69	30%
[300, 400)	41	36	26	50	45%
[400, 600)	9.7	12.6	9.1	17.6	55%
[600, 1500)	5.1	3.1	2.2	4.3	55%

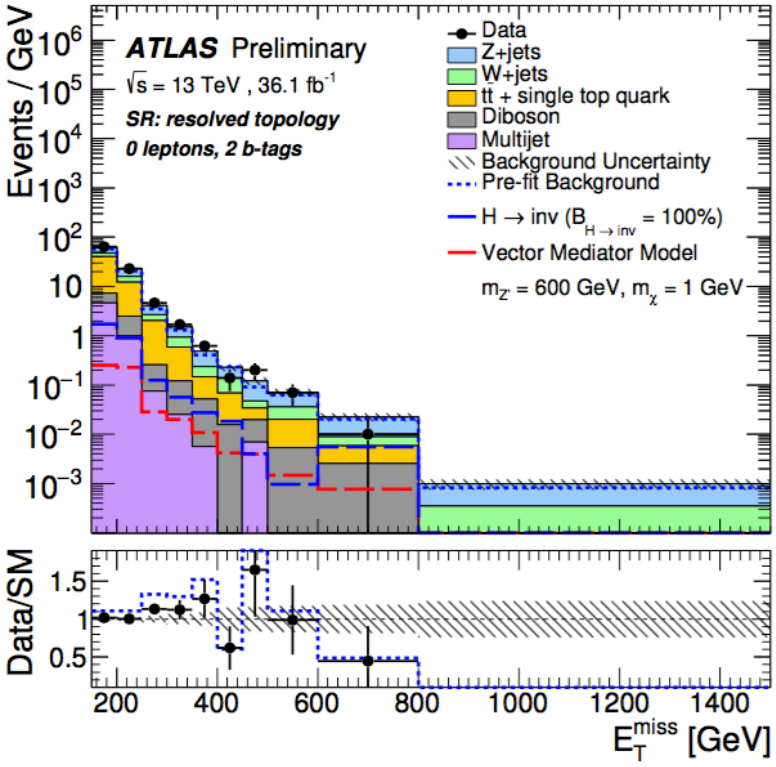
E_T^{miss} range [GeV]	Upper limit at 95% CL [fb] σ_{vis}^{obs}	σ_{vis}^{exp}	-1σ	$+1\sigma$	$A \times \varepsilon$
Z+DM, $Z \to q\bar{q}$					
[150, 200)	313	225	162	314	20%
[200, 250)	69	60	43	83	20%
[250, 300)	39	29	21	40	30%
[300, 400)	31.1	18.5	13.3	25.7	45%
[400, 600)	9.2	9.1	6.5	12.6	50%
[600, 1500)	3.0	2.6	1.9	3.6	55%

- **Overview of signal regions (SR) and control regions (CR):**

0 lepton SR	1 lepton CR	2 lepton CR
Signal + constrain Z(vv)+jets in m_{qq} sideband	Constrain W+jets and tt in m_{qq} window+sideband	Constrain Z(vv)+jets using Z($\ell\ell$)+jets in m_{qq} window+sideband

- Most selections identical in SR, 1μCR, 2ℓ-CR





ATLAS-CONF-2018-005

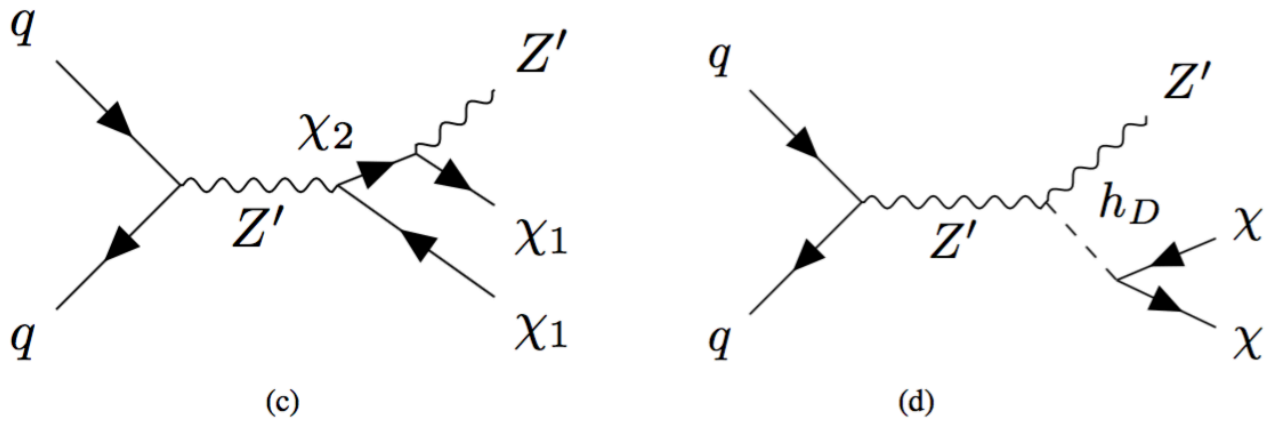
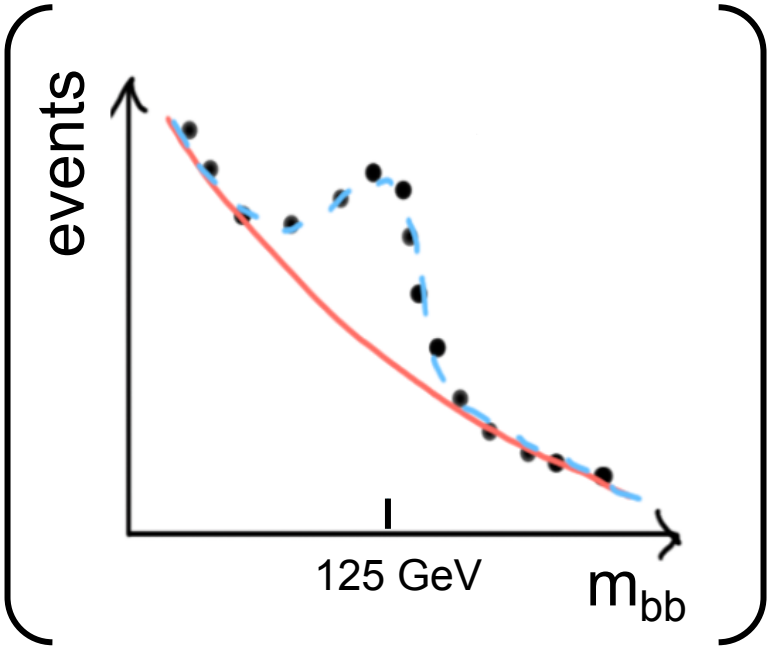


Figure 1: Examples of dark matter particle (χ) pair-production in association with (a) a W or Z boson in a simplified model with a vector mediator Z' between the dark sector and the SM [19] and (b) via decay of the SM-like Higgs boson produced in association with the vector boson [9–13] or in association with a final-state Z' boson via (c) an additional heavy dark-sector fermion (χ_2) [15] or (d) via a dark-sector Higgs boson (h_D) [15].

Table 1: Particle mass settings in the simulated mono-Z' samples for a given mediator mass $m_{Z'}$.

Scenario	Dark-fermion model	Dark-Higgs model
Light dark sector	$m_{\chi_1} = 5$ GeV $m_{\chi_2} = m_{\chi_1} + m_{Z'} + 25$ GeV	$m_\chi = 5$ GeV $m_{h_D} = \begin{cases} m_{Z'} & , m_{Z'} < 125 \text{ GeV} \\ 125 \text{ GeV} & , m_{Z'} > 125 \text{ GeV} \end{cases}$
Heavy dark sector	$m_{\chi_1} = m_{Z'}/2$ $m_{\chi_2} = 2m_{Z'}$	$m_\chi = 5$ GeV $m_{h_D} = \begin{cases} 125 \text{ GeV} & , m_{Z'} < 125 \text{ GeV} \\ m_{Z'} & , m_{Z'} > 125 \text{ GeV} \end{cases}$

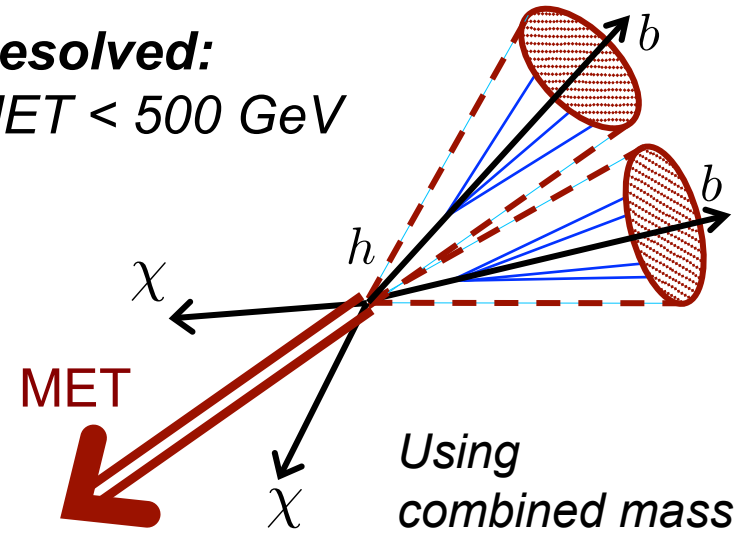
- **Analysis strategy similar to V+MET:**
  - Require E_T^{miss}
  - Look for excess in m_{bb} distribution:



× (1, 2 b-tags)
× 4 E_T^{miss} bins

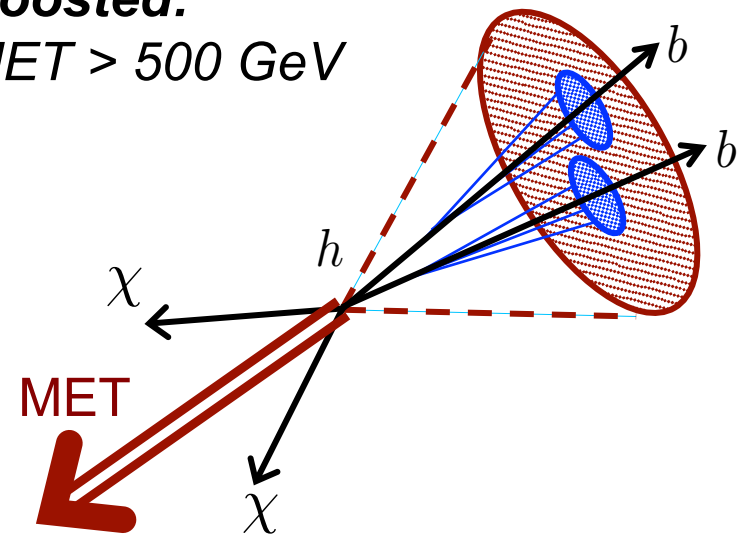
PRL 119 (2017) 181804

Resolved:
MET < 500 GeV



Using combined mass

Boosted:
MET > 500 GeV



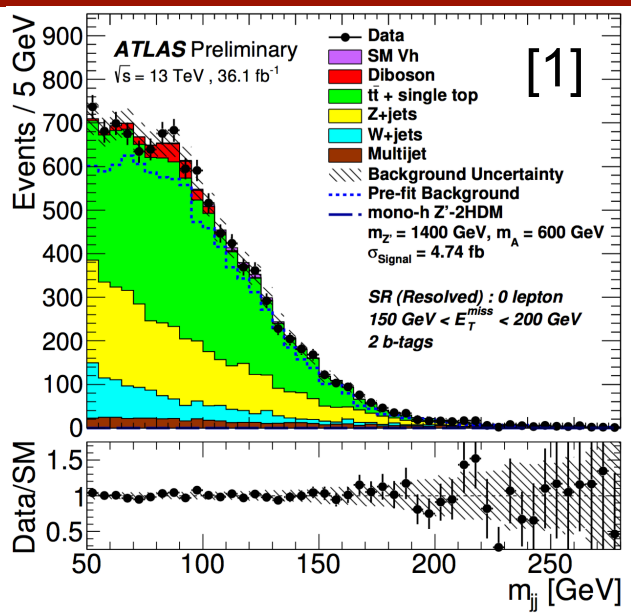
- **Backgrounds (from MC):**
  - Resonant:
    - SM Z(vv)h(bb)
  - Non-resonant (dominant):
    - Z(vv)+jets (30-70%), W+jets (10-20%), tt (10-50%) + rest
- **Overview of signal regions (SR) and control regions (CR):**

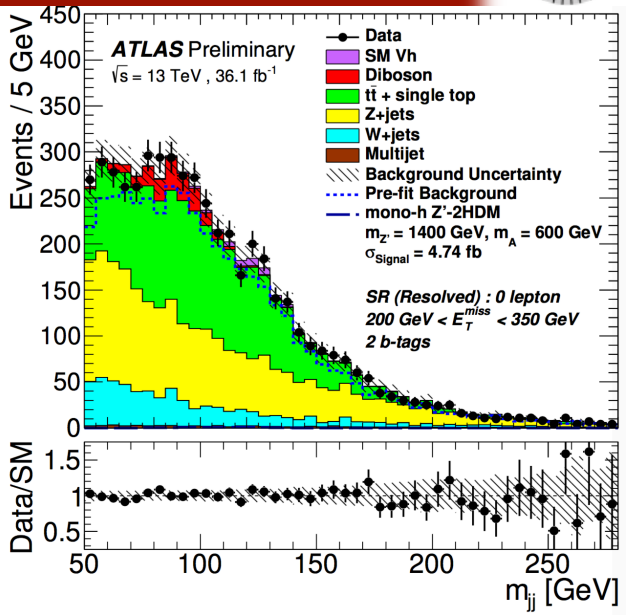
0 lepton signal region	1 lepton control region	2 lepton control region
Signal + constrain Z(vv)+jets in m_{bb} sidebands	Constrain tt and W+jets	Constrain Z(vv)+jets using Z($\ell\ell$)+jets

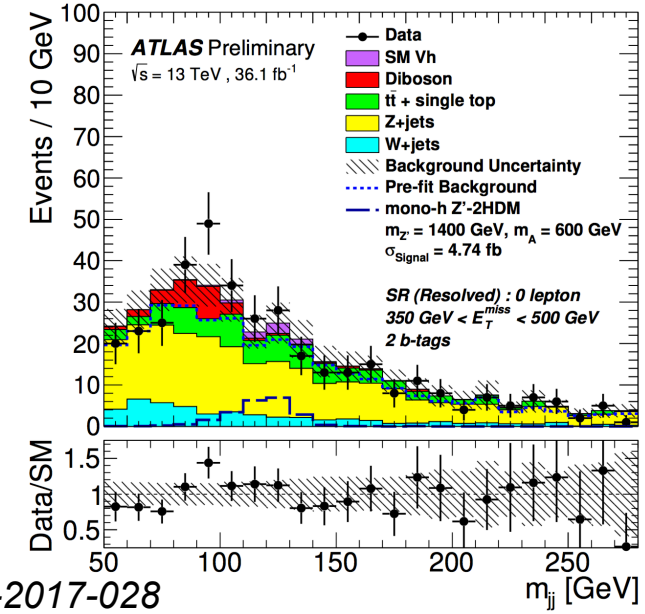
- **Kinematic similarity** between SR and CRs:
  - SR (0 leptons): $p_T^V = E_t^{miss}$ V = Z→vv
  - 1μCR: $p_T^V = p_T(\mu, E_t^{miss})$ V = W→μv
  - 2ℓCR (ee or $\mu\mu$): $p_T^V = p_T(\ell\ell)$ V = Z→$\ell\ell$

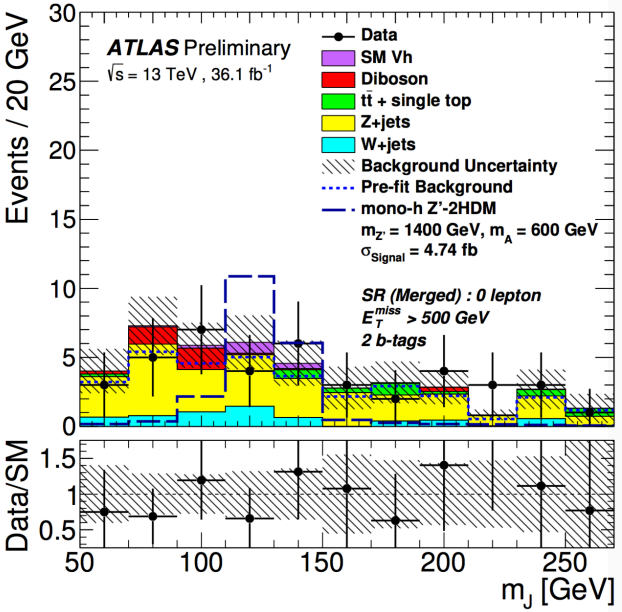
  } $p_T^V > 150$ GeV
  - Most selections identical in SR, 1μCR, 2ℓ-CR

HIGGS(*bb*) + E_T^{MISS}: RESULTS







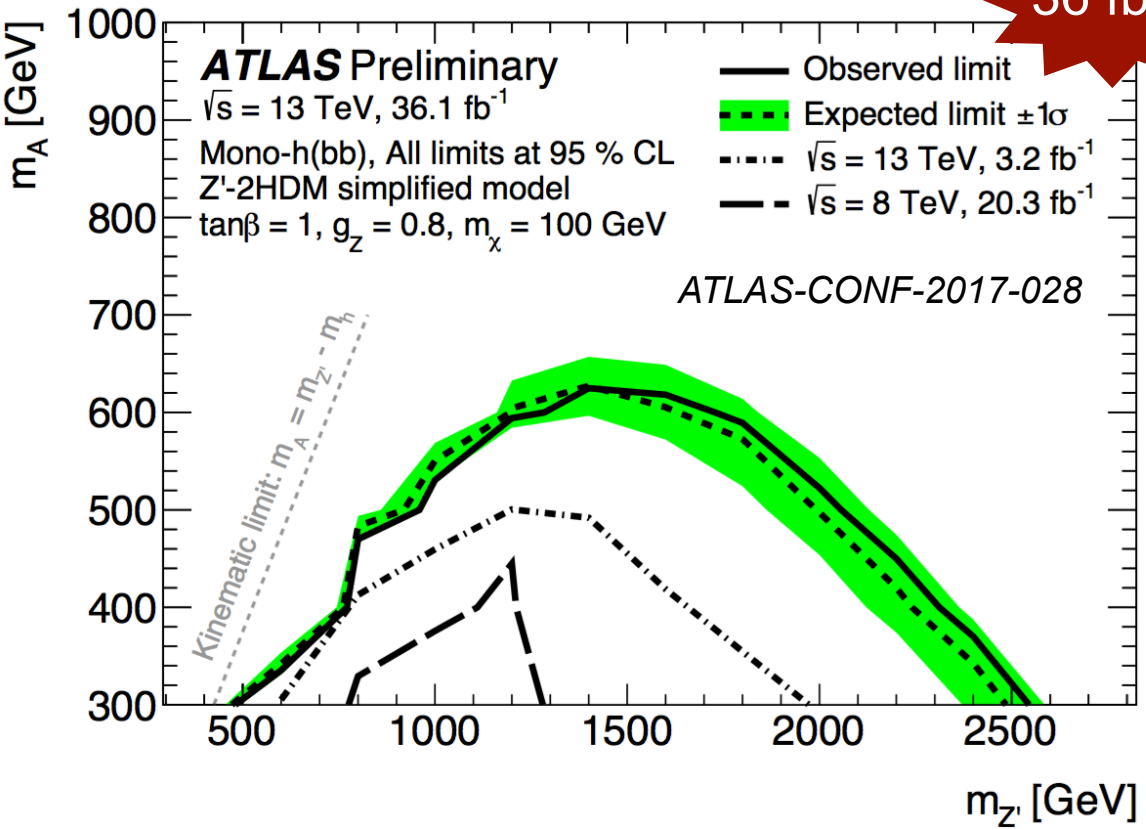


[1] *ATLAS-CONF-2017-028*

- **Results for Z'-2HDM model:**
  - Large portion of parameter space excluded
    - Stronger sensitivity than mono-h($\gamma\gamma$) for $p_{T,h} \gtrsim 150$ GeV
    - Complementarity for $p_{T,h} \lesssim 150$GeV

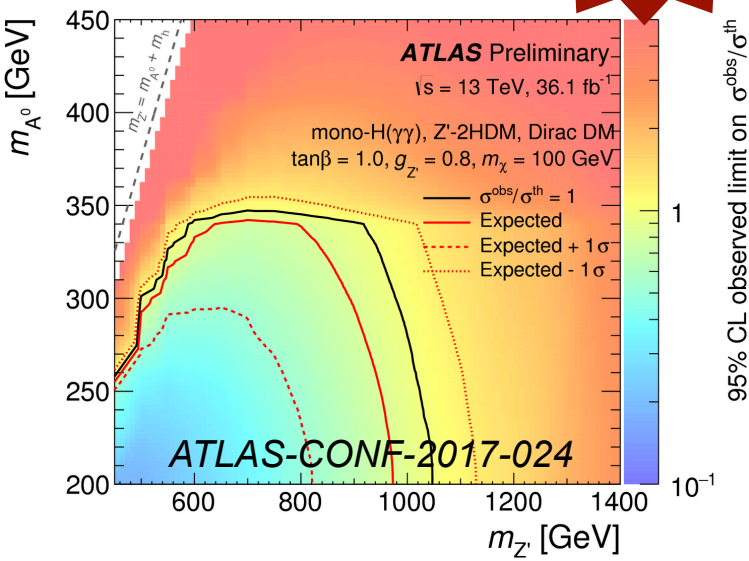
mono-h(bb)

36 fb^{-1}!



mono-h($\gamma\gamma$)

36 fb^{-1}!



HIGGS(*bb*) + E_T^{MISS}: "MODEL-INDEPENDENT" LIMITS

- **Limits on h+DM events with minimal model dependence**
  - Assume SM-like Higgs boson ($m_h \approx 125$ GeV, BR(h→bb) ≈ 58%)
  - Assume back-to-back topology of Higgs and E_T^{miss}
- **Set limits on visible cross section:**

$$\sigma_{\text{vis},h+\text{DM}} \equiv \sigma_{h+\text{DM}} \times BR(h \rightarrow b\bar{b}) \times \mathcal{A} \times \varepsilon$$

- $\mathcal{A} \times \varepsilon$ probability to reconstructed in same E_T^{miss} bin as generated and to pass all selections except b-tagging and $m_{h,reco}$ (measurement-specific)
  - $\sigma_{h+\text{DM}}$ at **parton level** → can compare with $\int_{E_T^{\text{miss}}\ \text{bin}} \mathrm{d}\sigma/\mathrm{d}E_T^{\text{miss}}$

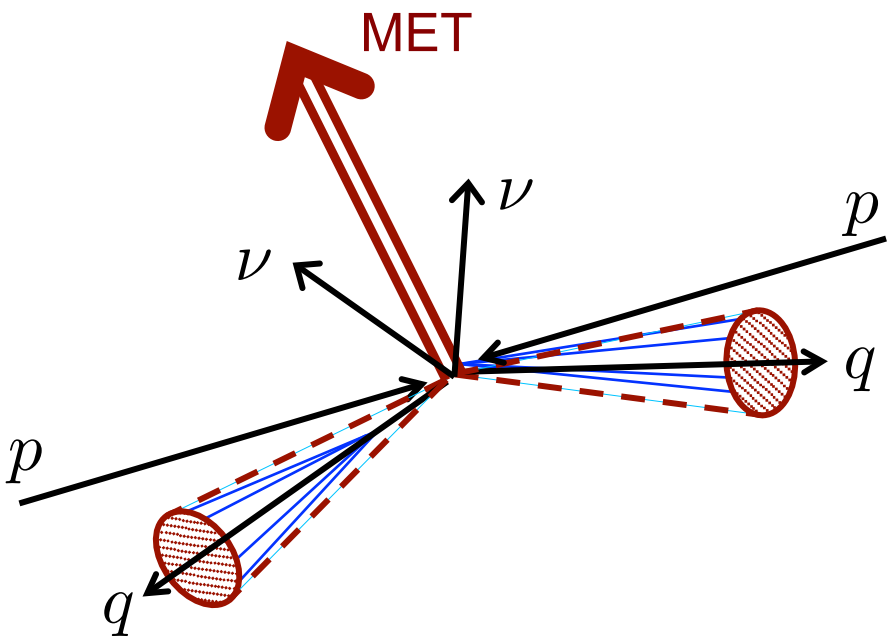
ATLAS-CONF-2017-028

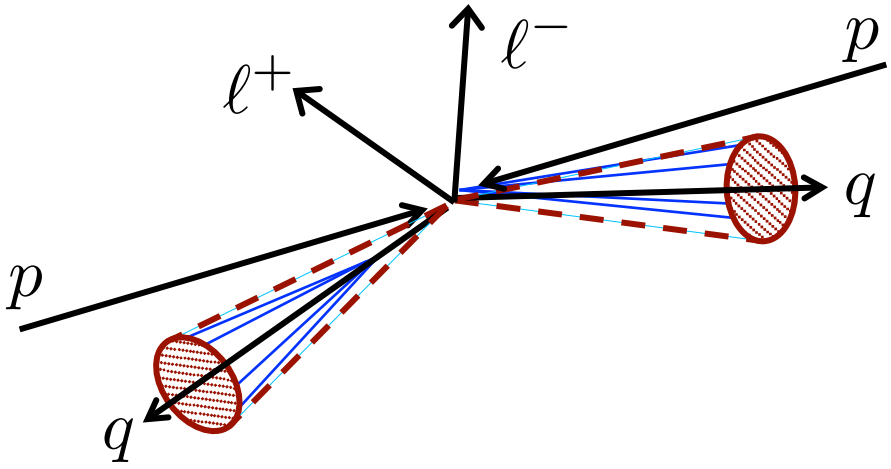
Range in E_T^{miss}/GeV	$\sigma^{\text{obs}}_{\text{vis},h+\text{DM}}$ [fb]	$\sigma^{\text{exp}}_{\text{vis},h+\text{DM}}$ [fb]	$\mathcal{A} \times \varepsilon$ %
[150, 200)	19.1	$18.3^{+7.2}_{-5.1}$	15
[200, 350)	13.1	$10.5^{+4.1}_{-2.9}$	35
[350, 500)	2.4	$1.7^{+0.7}_{-0.5}$	40
[500, ∞)	1.7	$1.8^{+0.7}_{-0.5}$	55

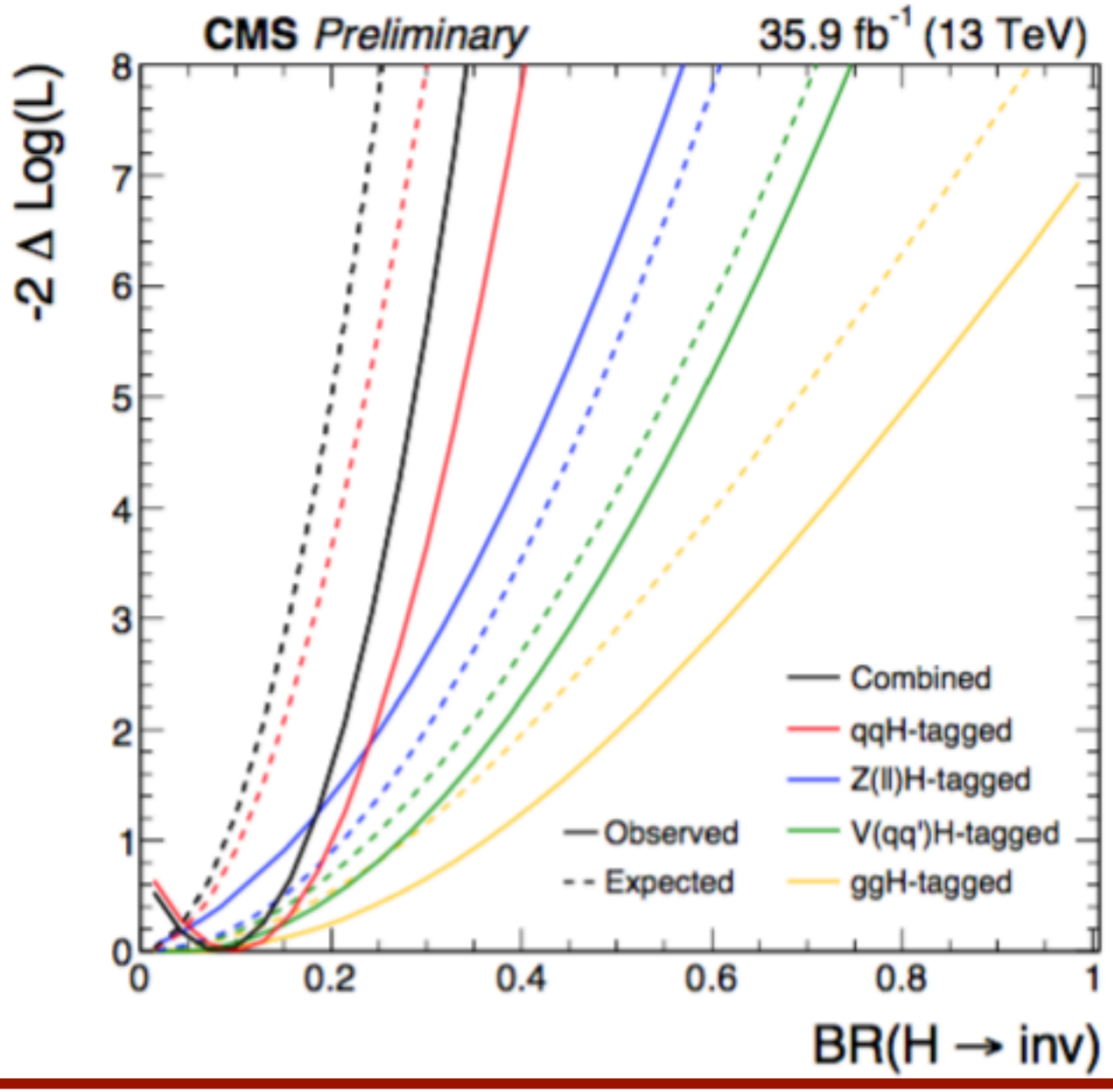
Weakest limit from a range of Z'-2HDM models

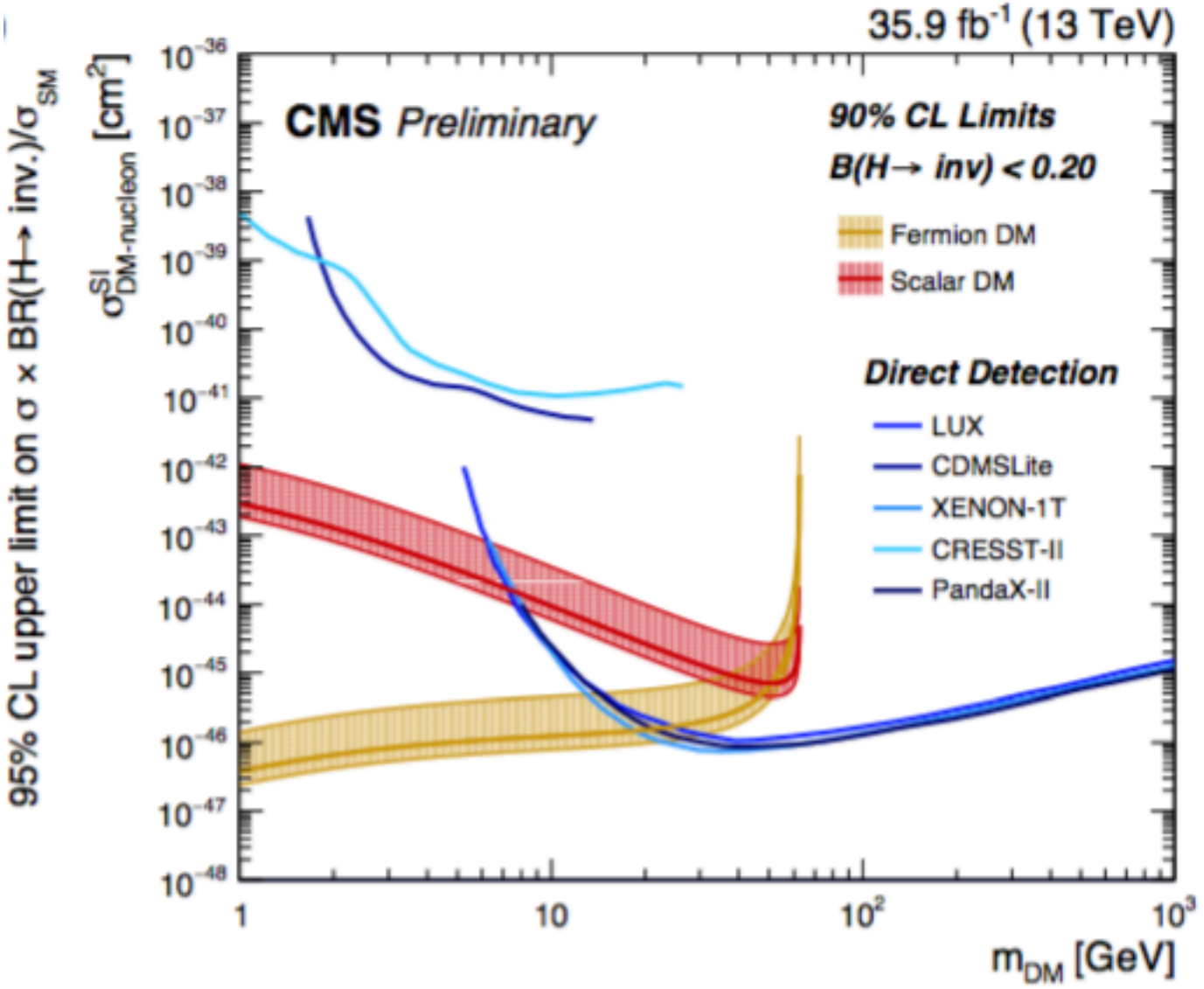
- Constrain Z(vv)+jets, W+jets in signal region (SR) using control regions (CR):

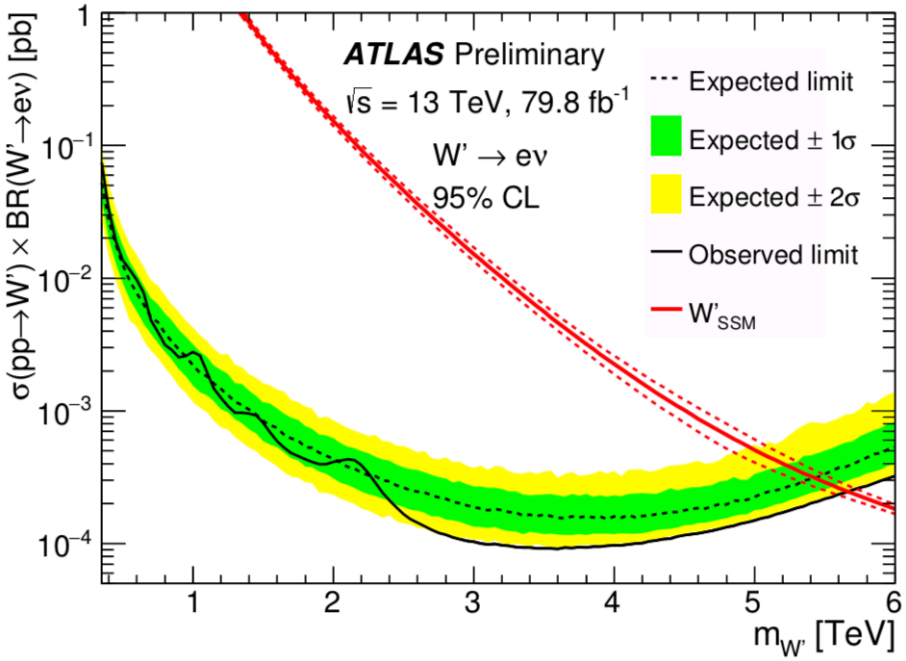
0 lepton SR	1 lepton CR	2 lepton CR
Signal + constrain Z(vv)+jets etc. at low mjj	Constrain W+jets	Constrain Z(vv)+jets using Z($\ell\ell$)+jets






CMS Preliminary
35.9 fb-1 (13 TeV)
-2 Δ Log(L)
BR(H → inv)
Combined
qqH-tagged
Z(ll)H-tagged
V(qq')H-tagged
ggH-tagged
Observed
Expected
0
1
2
3
4
5
6
7
8
0
0.2
0.4
0.6
0.8
1


35.9 fb-1 (13 TeV)
CMS Preliminary
90% CL Limits
B(H→ inv) < 0.20
Fermion DM
Scalar DM
Direct Detection
LUX
CDMSLite
XENON-1T
CRESST-II
PandaX-II
95% CL upper limit on σ × BR(H→ inv.)/σSM
σSIDM-nucleon [cm2]
mDM [GeV]


ATLAS Preliminary
√s = 13 TeV, 79.8 fb-1
W' → eν
95% CL
Expected limit
Expected ± 1σ
Expected ± 2σ
Observed limit
W'SSM
σ(pp→W') × BR(W'→eν) [pb]
mW' [TeV]

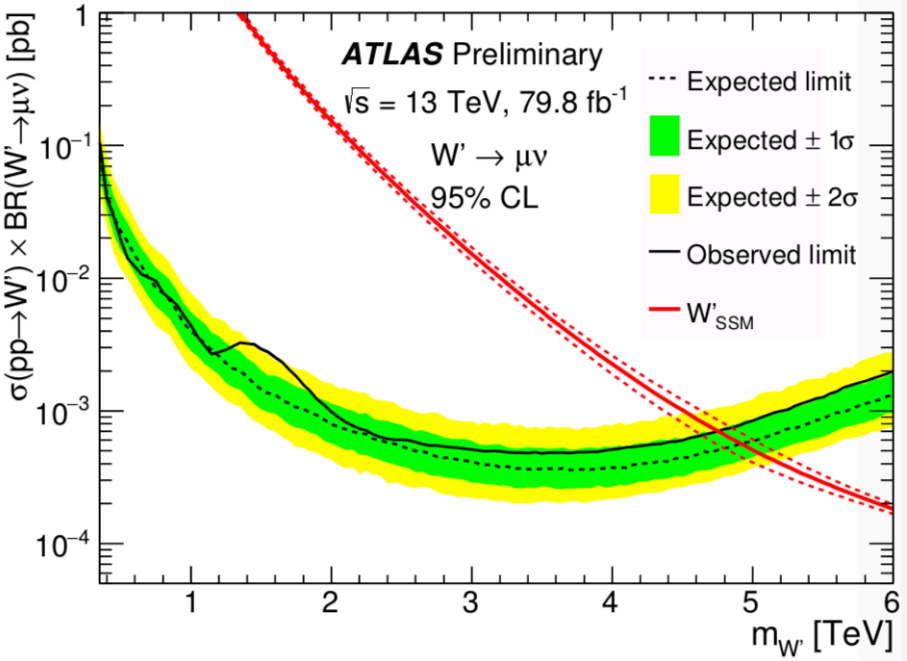
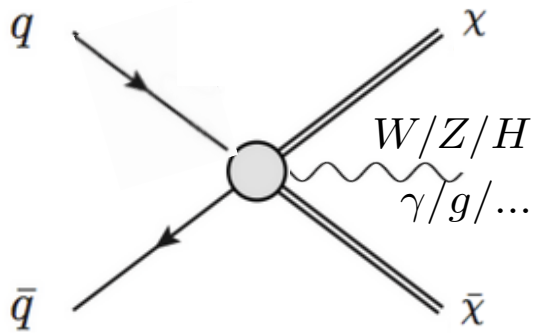

ATLAS Preliminary
√s = 13 TeV, 79.8 fb-1
W' → μν
95% CL
Expected limit
Expected ± 1σ
Expected ± 2σ
Observed limit
W'SSM
σ(pp→W') × BR(W'→μν) [pb]
mW' [TeV]

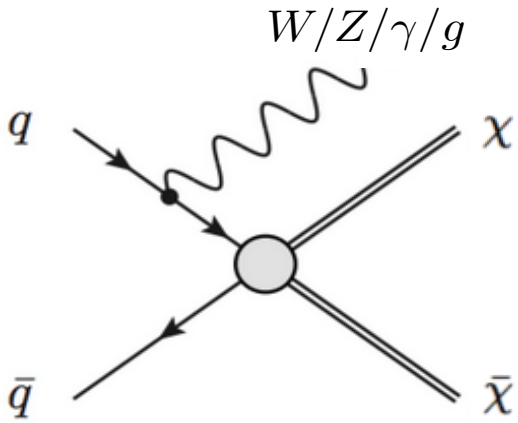
Table 2: Systematic uncertainties in the expected number of events as estimated for the total background and for signal with a W'_{SSM} mass of 2 (4) TeV. The uncertainty is estimated with the binning shown in Figure 1 at $m_{\mathrm{T}} = 2$ (4) TeV for the background and in a three-bin window around $m_{\mathrm{T}} = 2$ (4) TeV for the signal. Uncertainties that are not applicable are denoted "N/A", and "negl." means that the uncertainty is not included in the statistical analysis. Sources of uncertainties not included in the table are neglected in the statistical analysis.

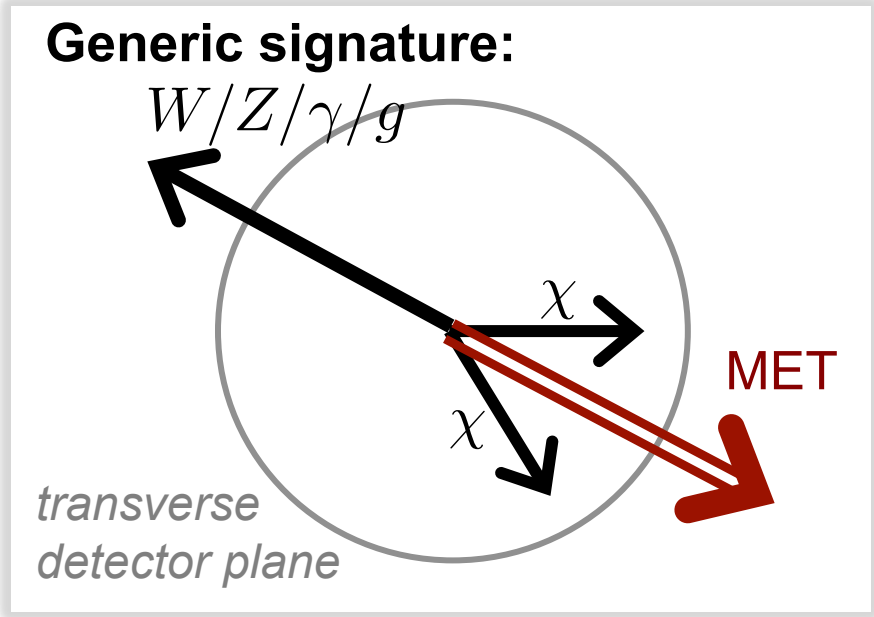
Source	Electron channel		Muon channel	
	Background	Signal	Background	Signal
Trigger	negl. (negl.)	negl. (negl.)	1% (1%)	2% (2%)
Lepton reconstruction and identification	negl. (negl.)	negl. (negl.)	7% (21%)	5% (29%)
Lepton momentum scale and resolution	4% (3%)	4% (3%)	3% (12%)	7% (10%)
Multijet background	7% (113%)	N/A (N/A)	1% (1%)	N/A (N/A)
Top extrapolation	2% (5%)	N/A (N/A)	3% (3%)	N/A (N/A)
Top normalization	< 0.5% (< 0.5%)	N/A (N/A)	< 0.5% (< 0.5%)	N/A (N/A)
Diboson extrapolation	2% (9%)	N/A (N/A)	3% (10%)	N/A (N/A)
PDF choice for DY	1% (14%)	N/A (N/A)	< 0.5% (< 0.5%)	N/A (N/A)
PDF variation for DY	8% (12%)	N/A (N/A)	7% (11%)	N/A (N/A)
EW corrections for DY	4% (5%)	N/A (N/A)	4% (6%)	N/A (N/A)
Luminosity	2% (1%)	2% (2%)	2% (2%)	2% (2%)
Total	13% (115%)	4% (4%)	12% (29%)	9% (31%)

OUTLINE #1

- **Dark Matter searches:**
  - Higgs → invisible
    - Overview
    - VBF channel
    - Combo
  - V+MET, Z'+MET, H+MET







- More Exotics results:
  - https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ExoticsPublicResults
  - https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO
  - https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsB2G

MET: missing transverse momentum