



# Search for squarks and gluinos

with the ATLAS detector in final states with jets and missing transverse momentum using 20.3 fb<sup>-1</sup> of  $\sqrt{s} = 8$  TeV proton-proton collision data

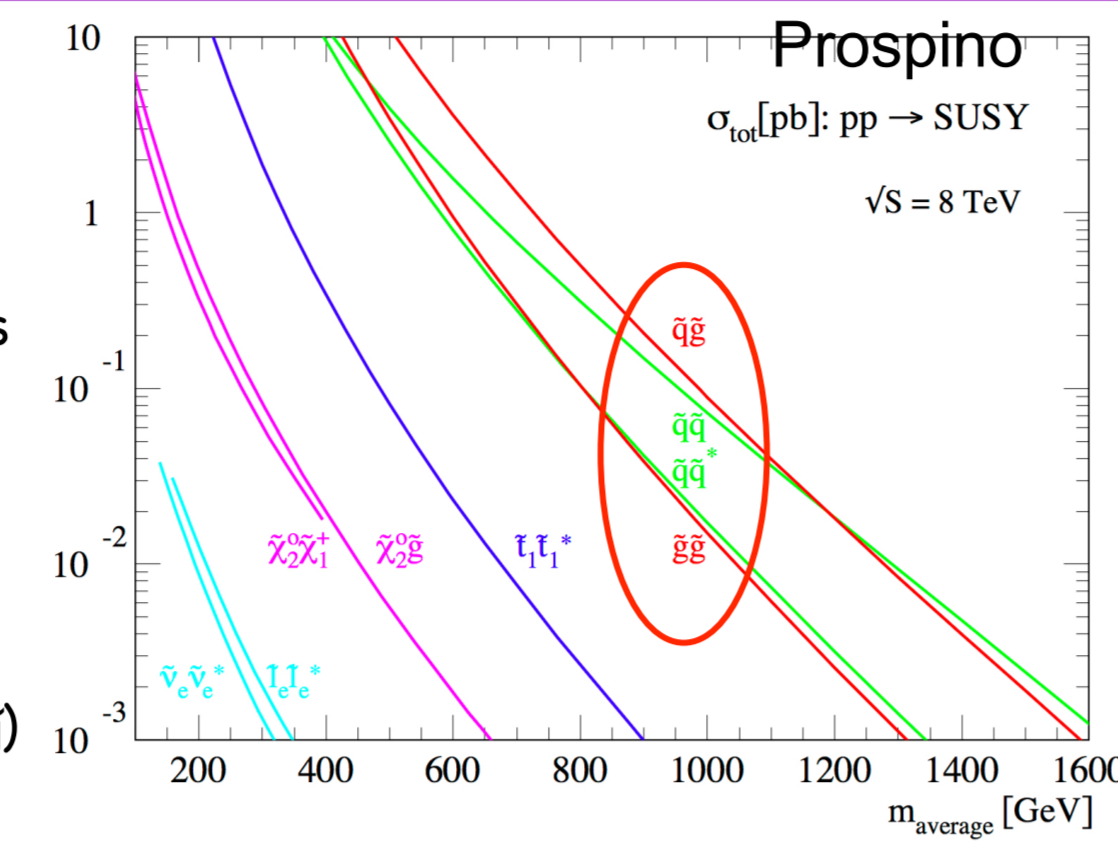
arxiv:1405.7875

Marija Marjanović on behalf of the ATLAS collaboration

marija.marjanovic@cern.ch

## What are we trying to find?

- Squarks and gluinos are SUSY partners of quarks and gluons
- The partners of the neutral and charged SM gauge and Higgs bosons are respectively the neutralinos ( $\tilde{\chi}_i^0$ ) and charginos ( $\tilde{\chi}^\pm$ )
- We assume:
  - R-parity conservation: therefore squarks and gluinos must be produced in pairs ( $\tilde{q}\tilde{q}, \tilde{q}\tilde{q}, \tilde{q}\tilde{g}$ )
  - the neutralino ( $\tilde{\chi}_1^0$ ) is the LSP
- Strong production is the dominant mode for the production of SUSY sparticles at the LHC
- This search is looking in final states containing 2 to 6 jets and large  $E_T^{\text{miss}}$ , veto on leptons
- Interpretation are given in:
  - Simplified models,
  - mSUGRA/CMSSM
- The main results of this analysis are relevant for constraining any BSM physics that predicts production of jets in association with  $E_T^{\text{miss}}$

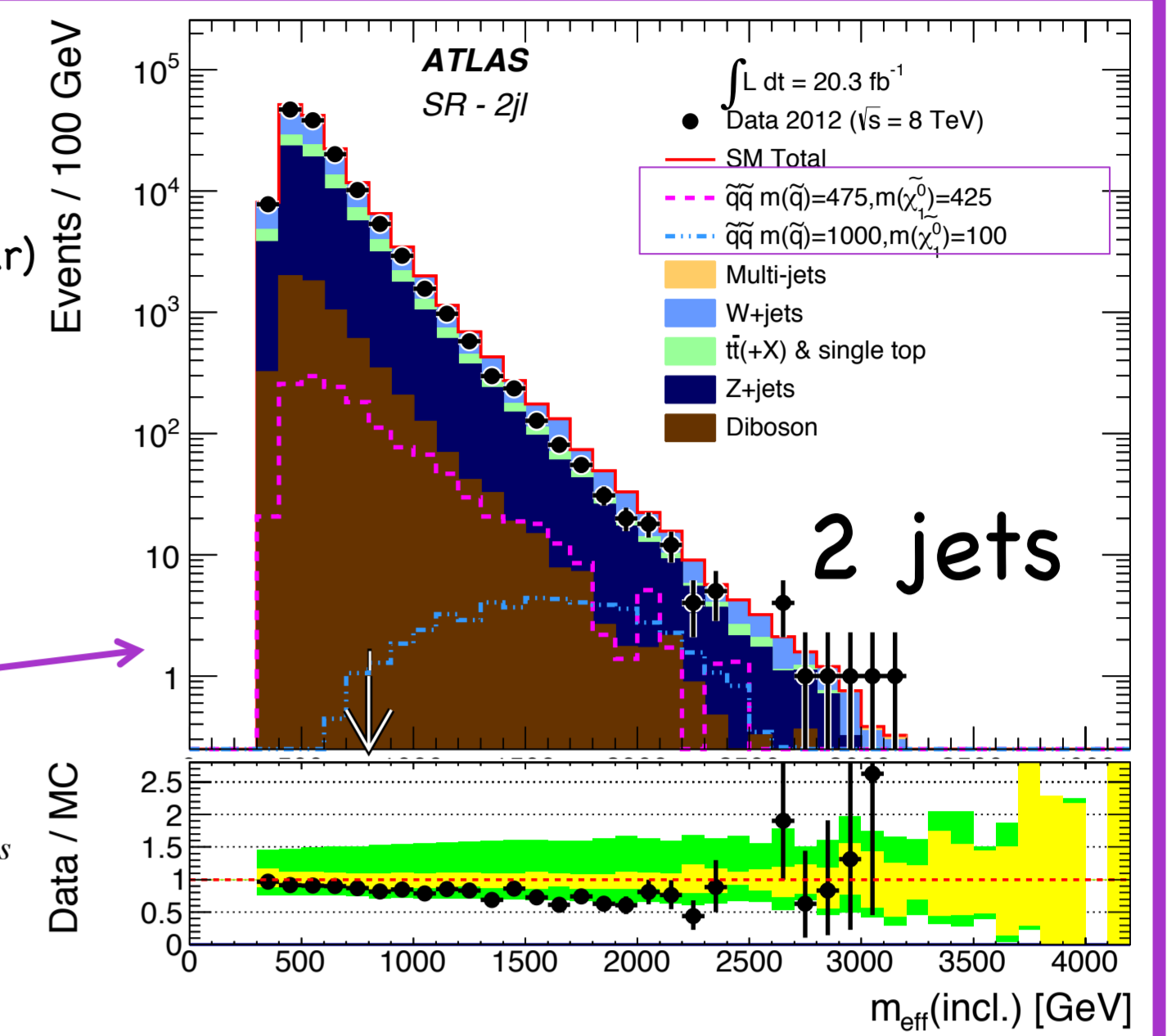


## Event selection

- Combined jet +  $E_T^{\text{miss}}$  trigger
- No isolated electron or muon (suppress W+jets and ttbar)
- $E_T^{\text{miss}} > 160$  GeV
- 1<sup>st</sup> jet  $p_T > 130$  GeV
- 2<sup>nd</sup> - 6<sup>th</sup> jet  $p_T > 60$  GeV
- Variables used for discriminating SUSY signal from backgrounds:

$$m_{\text{eff}}(\text{incl.}) = \sum_{p_T > 40 \text{ GeV}} p_T^{\text{jets}} + E_T^{\text{miss}}$$

$$H_T = \sum_{p_T > 40 \text{ GeV}} p_T^{\text{jets}} \quad m_{\text{eff}}(N\text{jet}) = \sum_{i=1}^N p_T^{\text{jet},i} + E_T^{\text{miss}}$$

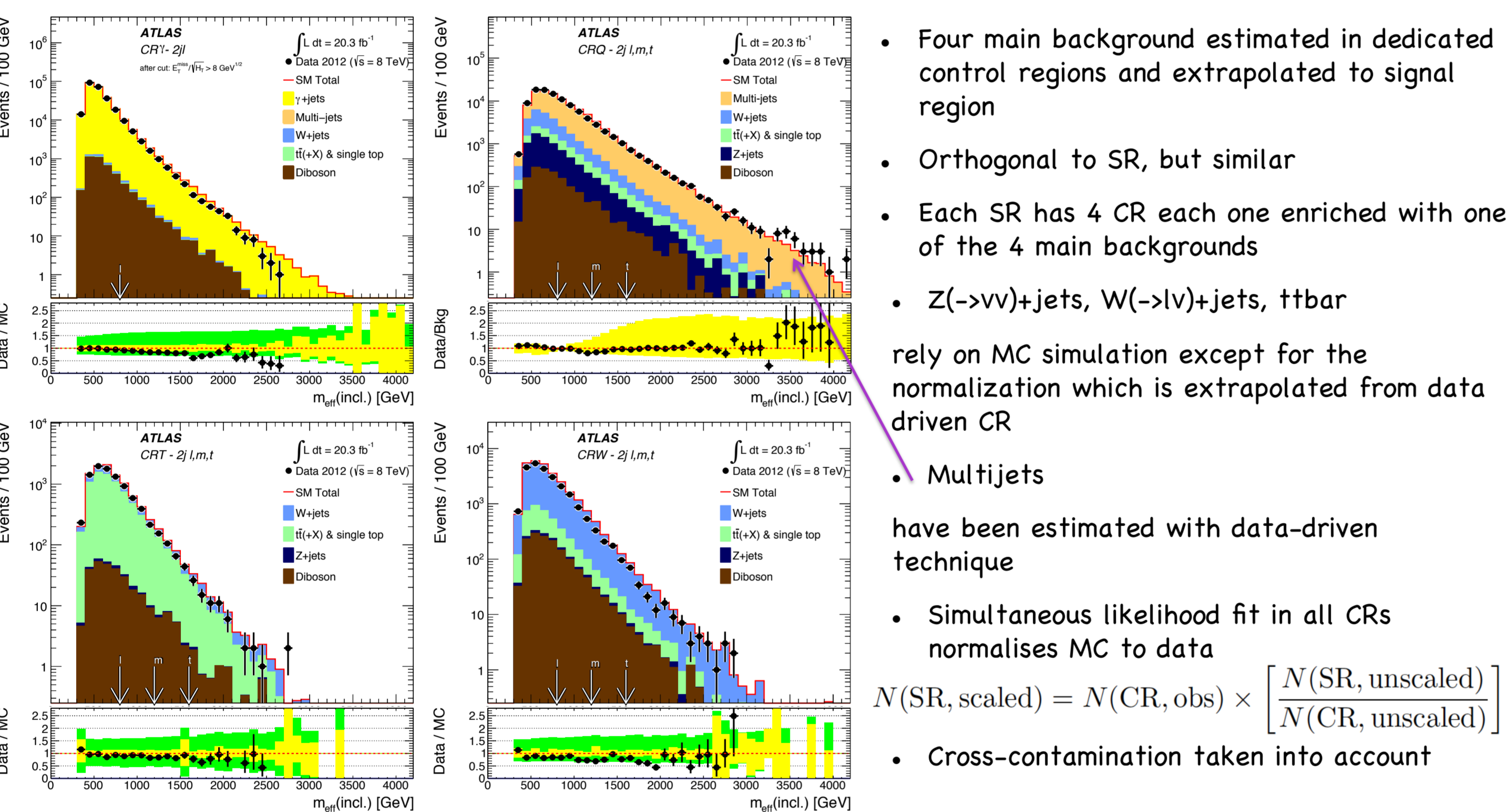


## Signal regions (SR)

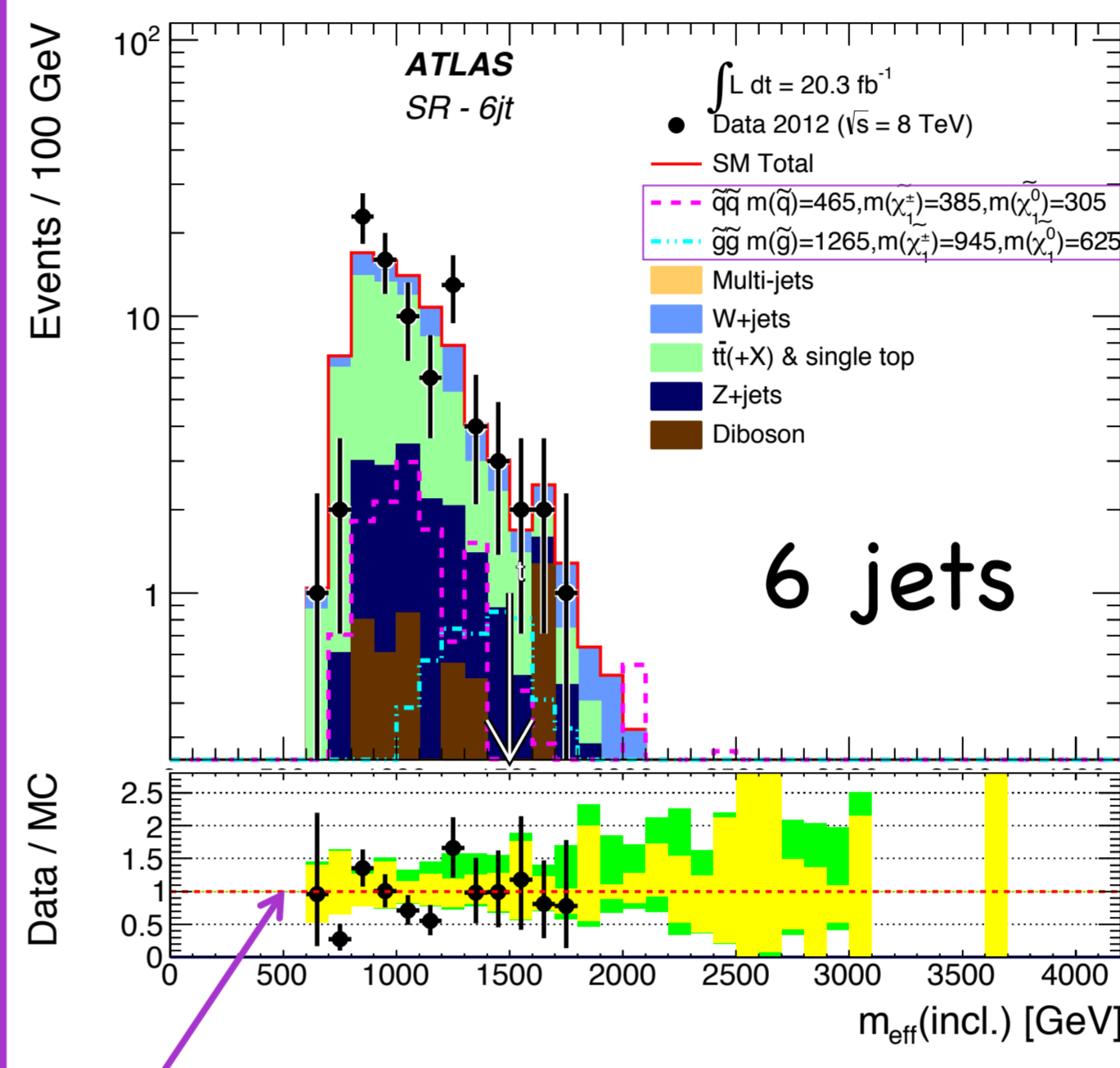
- 5 SRs depending on the number of jets
- 2 jets regions dominated by W/Z+jets
- 6 jets regions dominated by ttbar
- $E_T^{\text{miss}}/\sqrt{H_T}$ ,  $E_T^{\text{miss}}/m_{\text{eff}}(N\text{jet})$  rejecting the multijets background
- Signal/background discrimination based on the  $m_{\text{eff}}$  sensitive to the SUSY mass scale (loose/medium/tight)
- Two dedicated SRs (2jW and 4jW) place additional requirements on the invariant masses of candidate W bosons decaying to hadrons

## Background estimation

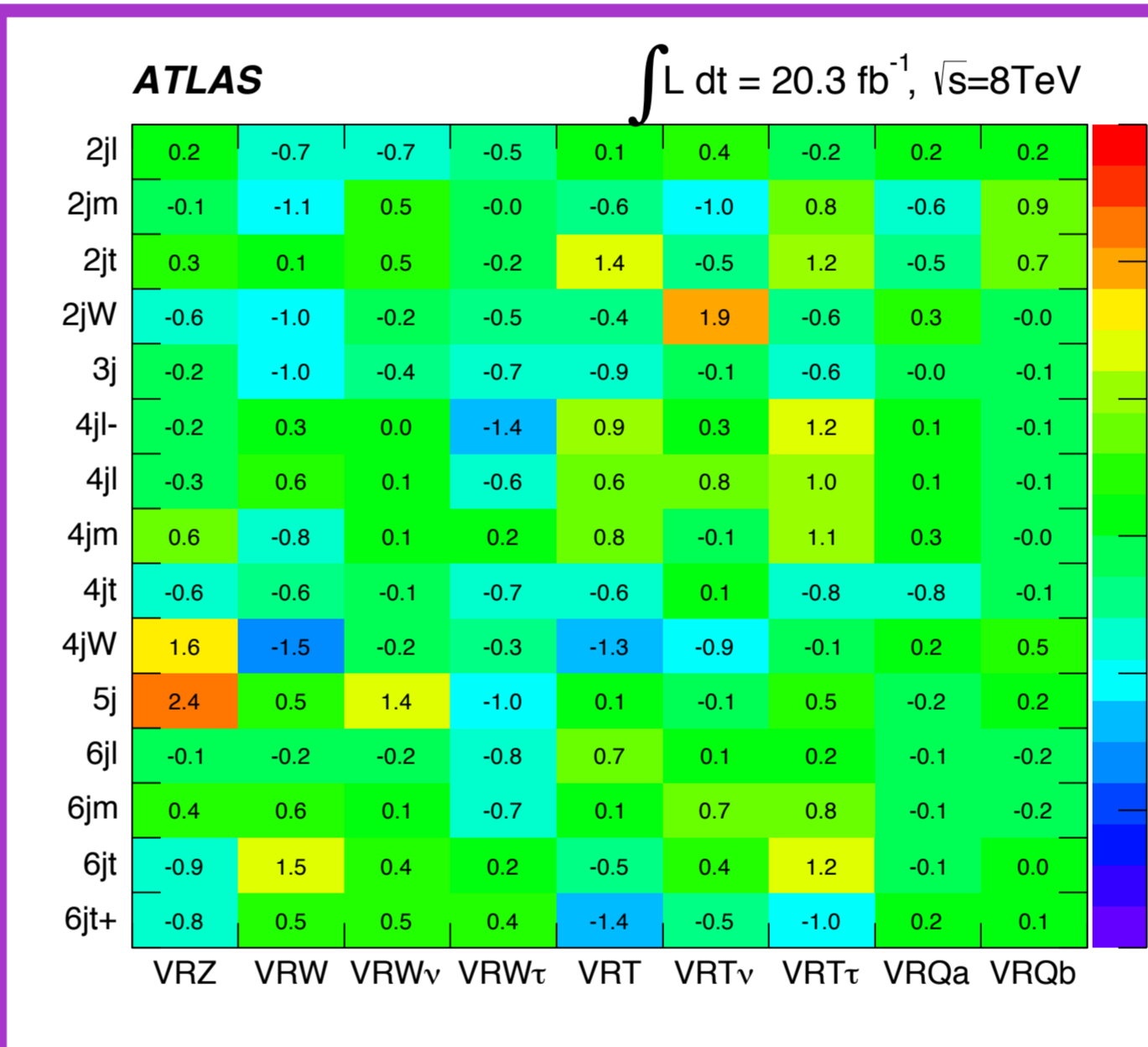
CR	SR background	CR process	CR selection
CR $\gamma$	Z( $\rightarrow \nu\nu$ )+jets	$\gamma$ +jets	Isolated photon
CRQ	Multi-jets	Multi-jets	SR with reversed requirements on (i) $\Delta\phi(\text{jet}, E_T^{\text{miss}})_{\text{min}}$ and (ii) $E_T^{\text{miss}}/m_{\text{eff}}(Nj)$ or $E_T^{\text{miss}}/\sqrt{H_T}$
CRW	W( $\rightarrow l\nu$ )+jets	W( $\rightarrow l\nu$ )+jets	30 GeV < $m_T(l, E_T^{\text{miss}})$ < 100 GeV, b-veto
CRT	tt and single-t	$t\bar{t} \rightarrow b\bar{b}q\bar{q}'l\nu$	30 GeV < $m_T(l, E_T^{\text{miss}})$ < 100 GeV, b-tag



- Four main background estimated in dedicated control regions and extrapolated to signal region
- Orthogonal to SR, but similar
- Each SR has 4 CR each one enriched with one of the 4 main backgrounds
- Z( $\rightarrow \nu\nu$ )+jets, W( $\rightarrow l\nu$ )+jets, ttbar rely on MC simulation except for the normalization which is extrapolated from data driven CR
- Multijets have been estimated with data-driven technique
- Simultaneous likelihood fit in all CRs normalises MC to data
- Cross-contamination taken into account



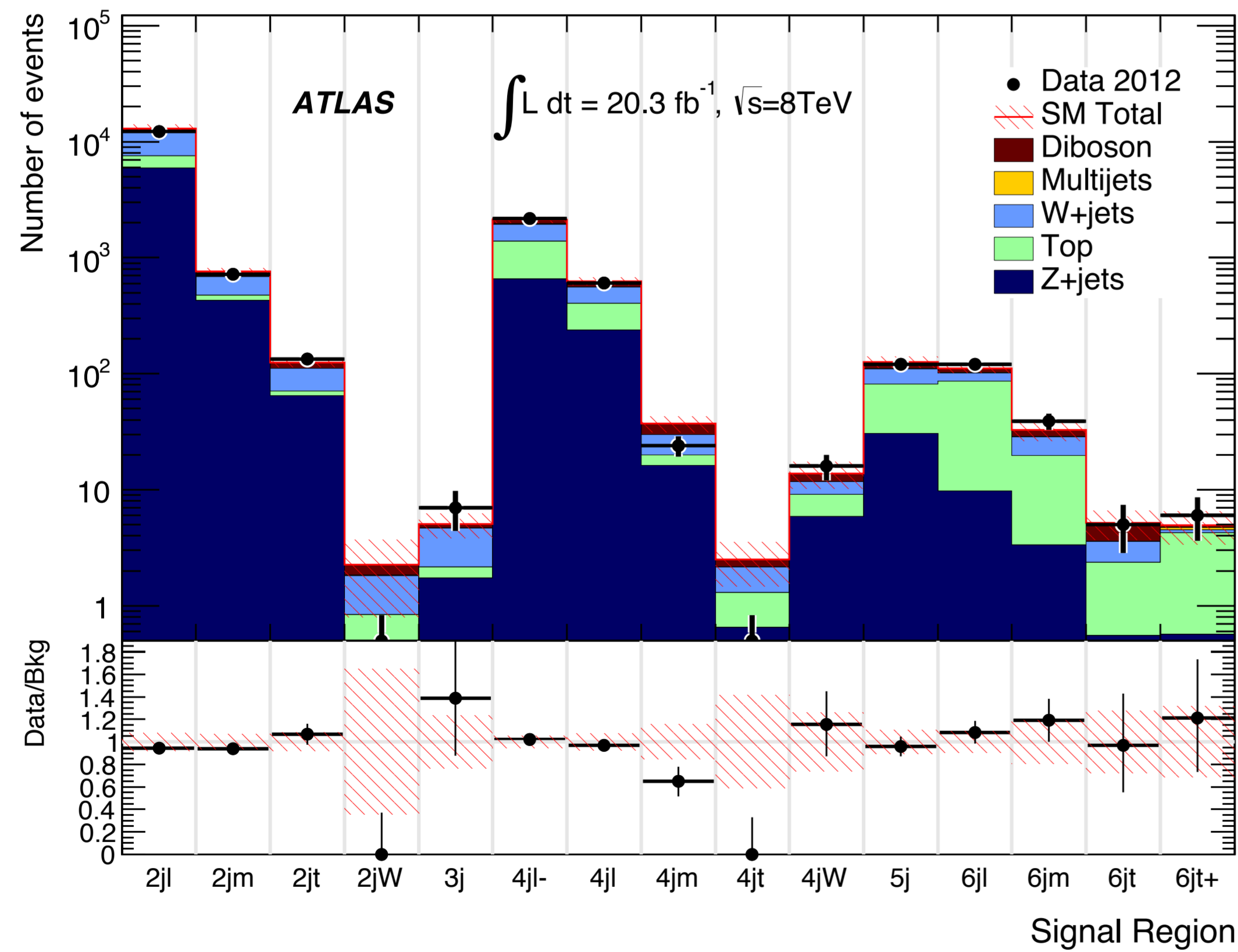
the experimental and MC statistical uncertainties  
the total uncertainty



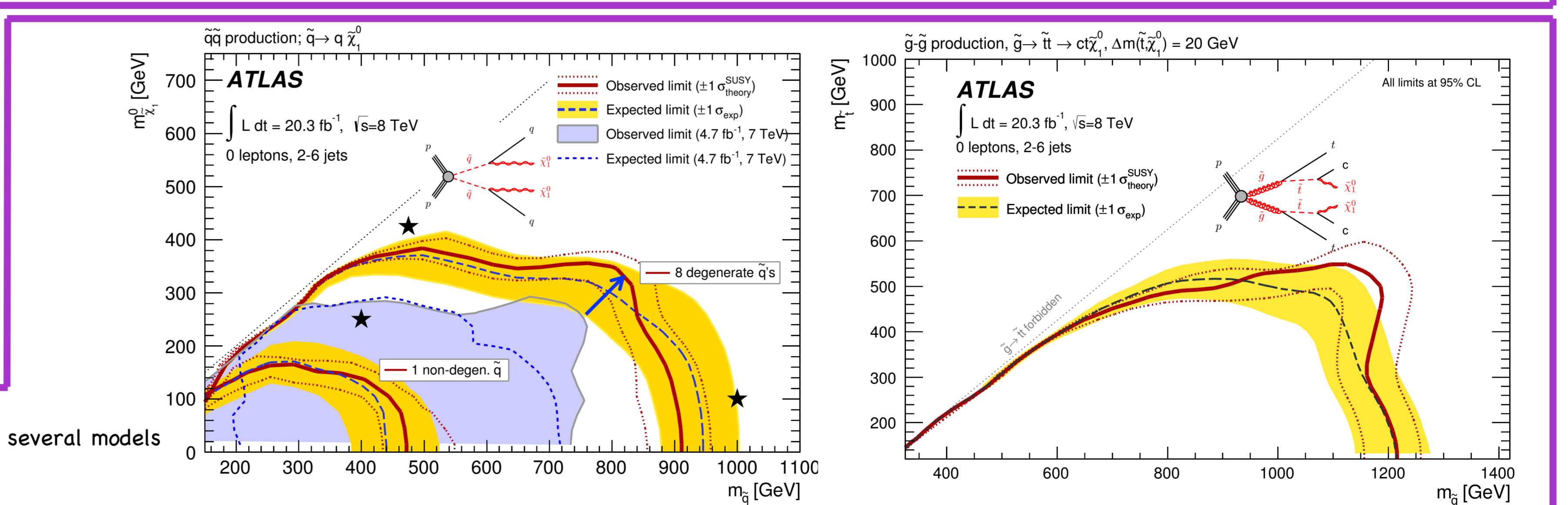
## Validation regions (VR)

- The results of the fit are cross checked in Validation regions
- Orthogonal both to CRs and SRs
- Validate the predictions:
  - from CR $\gamma$  using Z( $\rightarrow l\nu$ )+jets
  - from CRT and CRW requiring hadronically decaying taus...
- The differences between the numbers of observed and expected events expressed as fractions of the 1 $\sigma$  uncertainties on the latter  $\frac{n_{\text{expected}} - n_{\text{observed}}}{\sigma_{\text{total}}}$
- Most VR observations lie within 1 $\sigma$  of the background expectations

## Results



Description	Channel														
	2j	2jm	2jt	2j(W)	3j	4j	4jm	4jt	4j(W)	5j	6j	6jm	6jt	6jt+	
$E_T^{\text{miss}} [\text{GeV}] >$	160														
$p_T(j_1) [\text{GeV}] >$	130														
$p_T(j_2) [\text{GeV}] >$	60				60				60					60	
W candidates				2 W $\rightarrow$ j					W $\rightarrow$ j + W $\rightarrow$ jj						
$\Delta\phi(j_{1,2}, E_T^{\text{miss}}) >$	0.4														
$\Delta\phi(j_{3,4}, E_T^{\text{miss}}) >$	0.2														
$E_T^{\text{miss}}/\sqrt{H_T} >$	8	15	15												
$E_T^{\text{miss}}/m_{\text{eff}}(Nj) >$				0.25	0.3				0.4	0.25	0.35	0.2	0.2	0.25	0.15
$\langle\sigma\rangle_{\text{obs}}^{\text{95}} [\text{fb}]$	62	3.98	1.8	0.12	0.40	13	4.3	0.45	0.12	0.63	1.6	1.8	1.1	0.30	0.36
$\sigma_{\text{obs}}^{\text{95}}$	1259	81	37	2.5	8.1	268	87	9.2	2.5	13	32	37	22	6.1	7.3
$\sigma_{\text{exp}}^{\text{95}}$	1586 <sup>+560</sup> <sub>-430</sub>	105 <sup>+39</sup> <sub>-29</sub>	31 <sup>+12</sup> <sub>-8</sub>	4.1 <sup>+2.4</sup> <sub>-1.4</sub>	6.3 <sup>+3.2</sup> <sub>-2.0</sub>	242 <sup>+87</sup> <sub>-65</sub>	97 <sup>+35</sup> <sub>-25</sub>	15 <sup>+6</sup> <sub>-4</sub>	4.0 <sup>+2.4</sup> <sub>-1.4</sub>	11 <sup>+5</sup> <sub>-3</sub>	35 <sup>+13</sup> <sub>-10</sub>	30 <sup>+12</sup> <sub>-8</sub>	18 <sup>+7</sup> <sub>-5</sub>	6.3 <sup>+3.1</sup> <sub>-2.0</sub>	6.4 <sup>+3.2</sup> <sub>-2.0</sub>
$p_0(Z)$	0.50 (0.0)	0.49 (0.0)	0.29 (0.5)	0.50 (0.0)	0.24 (0.7)	0.35 (0.4)	0.50 (0.0)	0.50 (0.0)	0.50 (0.0)	0.34 (0.4)	0.50 (0.0)	0.27 (0.6)	0.25 (0.7)	0.50 (0.0)	0.36 (0.4)



No significant excess  $\rightarrow$  Results are interpreted in terms of limits on several models

## Interpretations

- The results of exclusion fits in all the SRs are used to compute limits in several slices of the SUSY parameter spaces
- The combined limits were achieved choosing the best expected signal region per model point
- Limits are shown for:
  - mSUGRA model: squarks and gluinos of equal mass are excluded for masses below 1650 GeV
  - Simplified models in which only direct production of gluino pairs, gluino squark pairs or light-flavour squark pairs are considered
    - all other superpartners, except for the neutralino LSP  $\tilde{\chi}_1^0$  are decoupled thereby forcing each lightflavour squark or gluino to decay directly to one or more quarks and a  $\tilde{\chi}_1^0$
    - Direct squark pair production limits are shown for 8 degenerate squarks, as well as for 1 nondegenerate squark (8 times lower xsec)
    - When the  $\tilde{\chi}_1^0$  is massless the limit on the gluino mass is 1400 GeV, and the limit on the squark mass is 900 GeV

