

*Search for New Phenomena  
in dijet events  
with the ATLAS detector at LHC*

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## Why dijet?

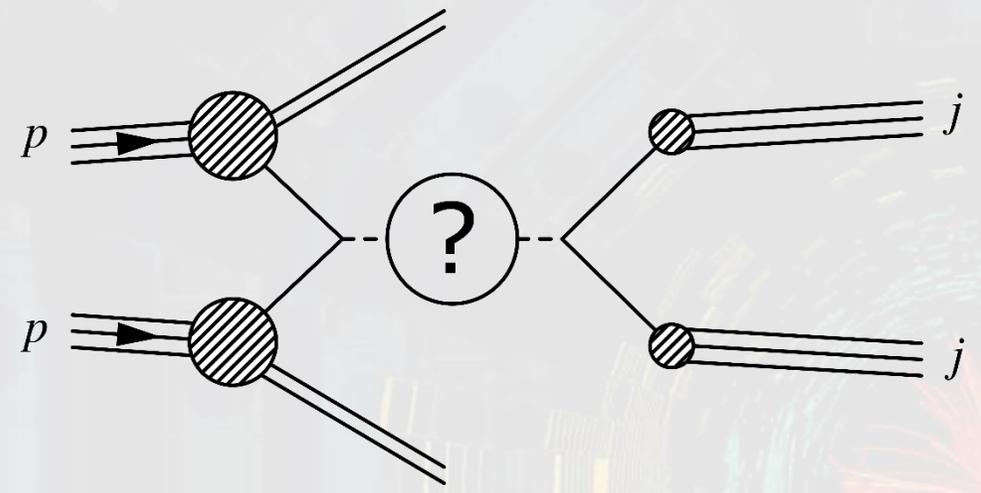
- Dijet events provide an exceptional opportunity to test BSM theories
- Clear signature
- High statistics → lower statistical uncertainties → gain in sensitivity

?

## Why New Physics?

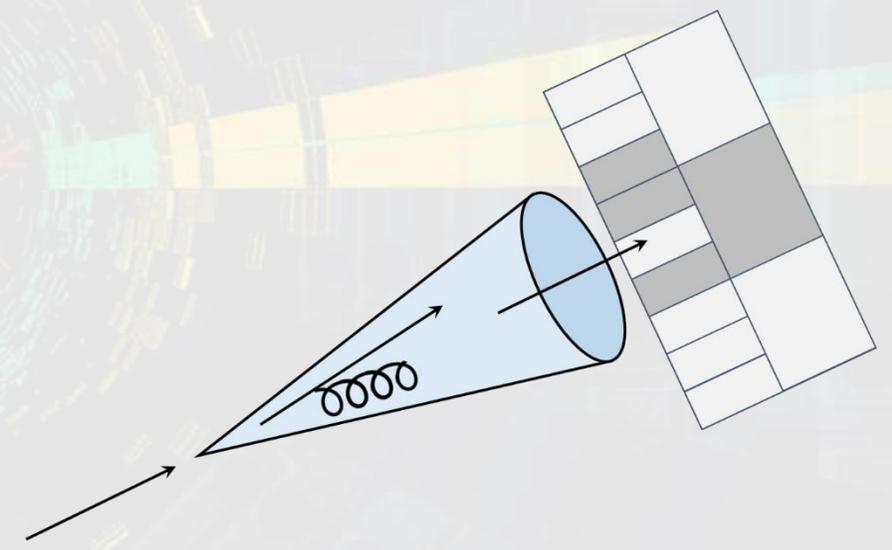
- SM is self-consistent but it leaves some phenomena unexplained
- Dark Matter?

# Jets and dijets



- Quarks/gluons in final state → jets
- States with jets dominant at LHC

- Experimentally: jets=narrow cone of hadrons
- Localized deposit of energy



Dijet events have a clear signature

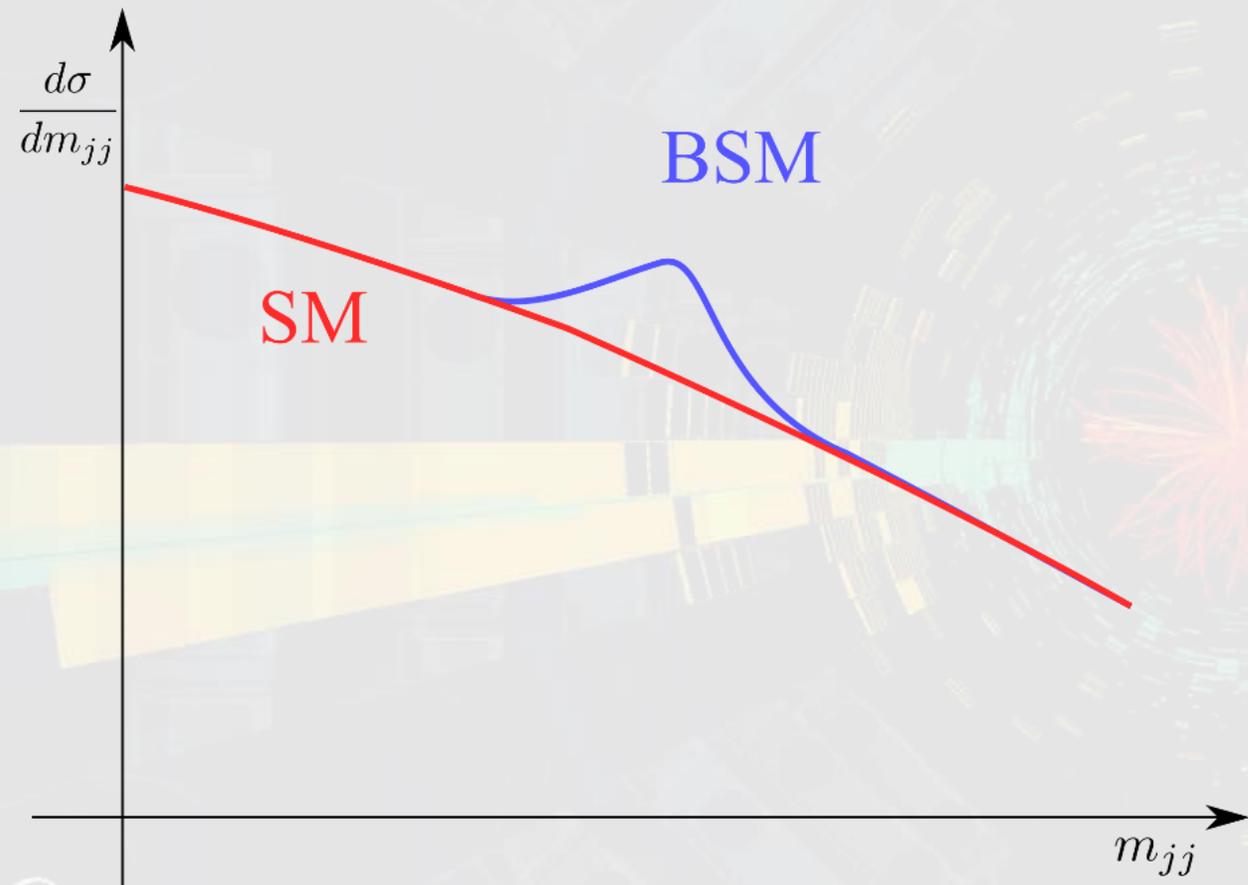
# A remarkable dijet event

$p_T = 3.79 \text{ TeV}$

$m_{jj} = 8.12 \text{ TeV}$

$p_T = 3.79 \text{ TeV}$

# Search for resonances with dijets – Standard approach



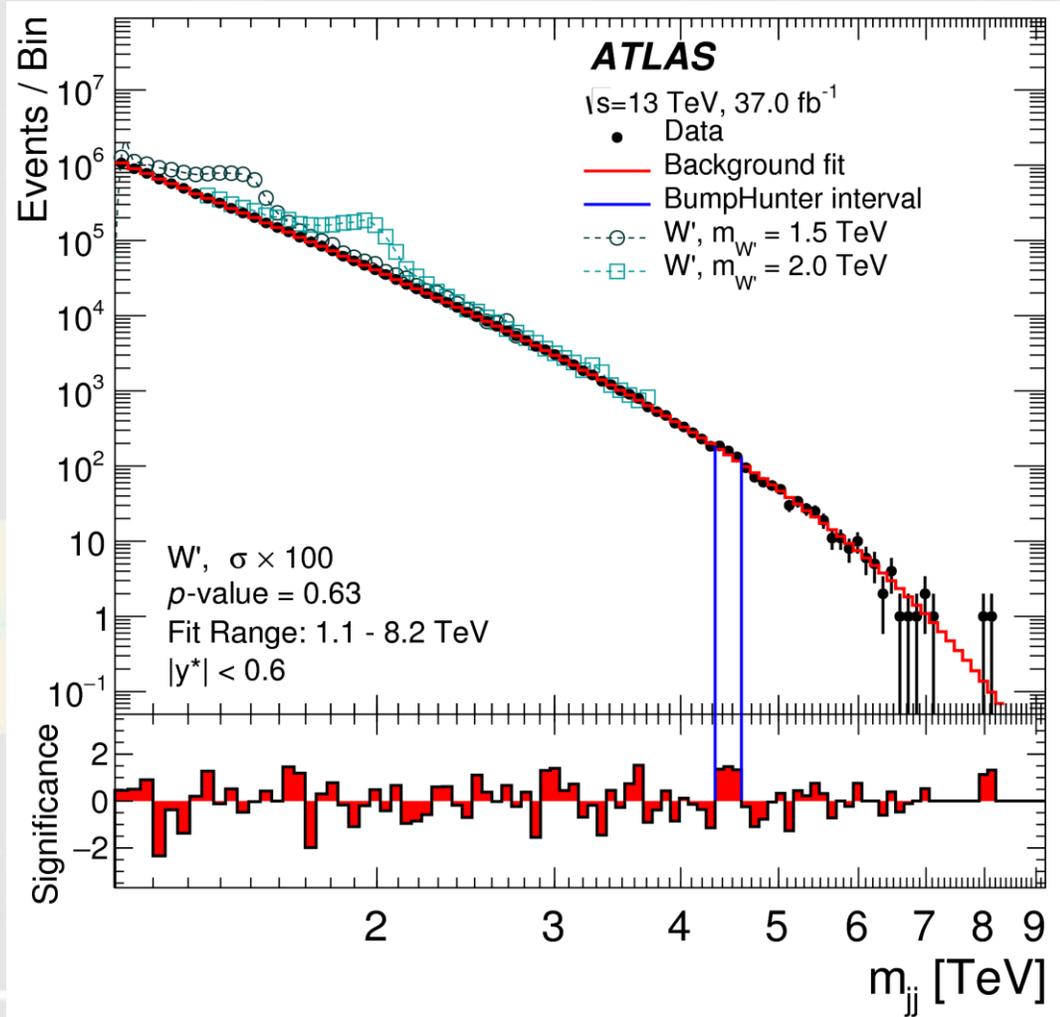
- SM expected as a smooth function
  - QCD dominant background contribution

- Background estimated with a fit

$$f(z) = p_1(1 - z)^{p_2} z^{p_3} z^{p_4} \log z$$

- Signal expected as a peak

# Search for resonances with dijets – Standard approach



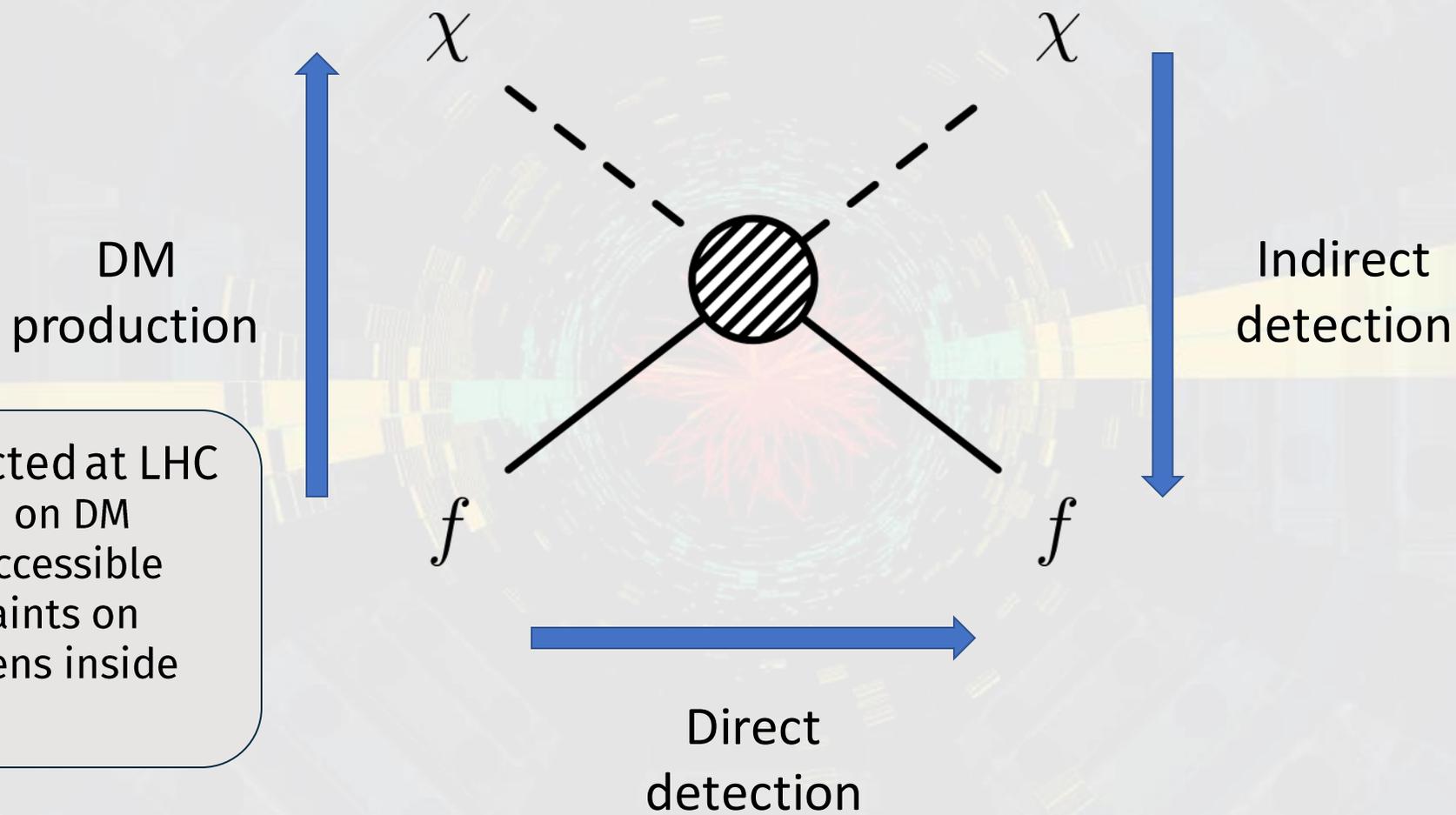
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$$f(z) = p_1(1-z)^{p_2} z^{p_3} z^{p_4} \log z$$

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# Dark Matter quest at LHC



DM not detected at LHC

- Information on DM indirectly accessible
- ~no constraints on what happens inside the blob

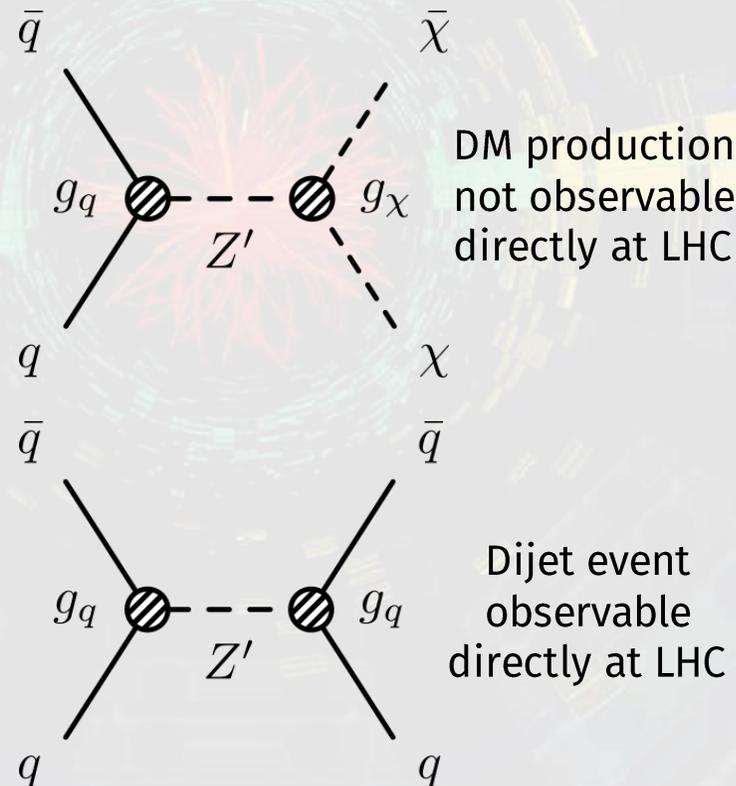
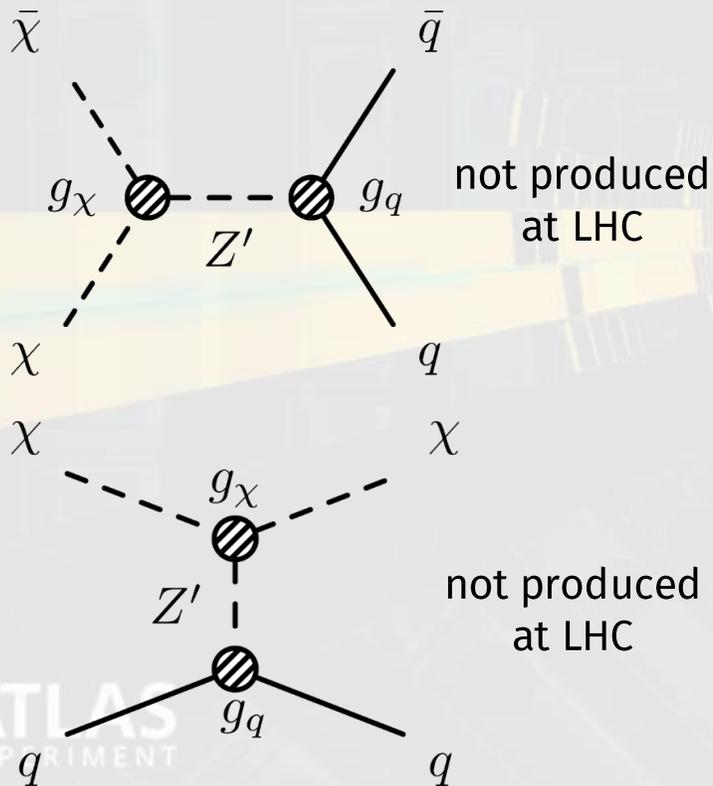
# Z' model

A simple U(1) gauge extension:

- Mediator SM-DS
- Jet signatures available: mono-jet, dijet, ...
- Neglecting leptonic coupling

$$\mathcal{L}_{\text{axial}}^{Z'} = \sum_q g_q \bar{q} \gamma^\mu \gamma^5 q Z'_\mu + g_\chi \bar{\chi} \gamma^\mu \gamma^5 \chi Z'_\mu$$

Universal quark coupling

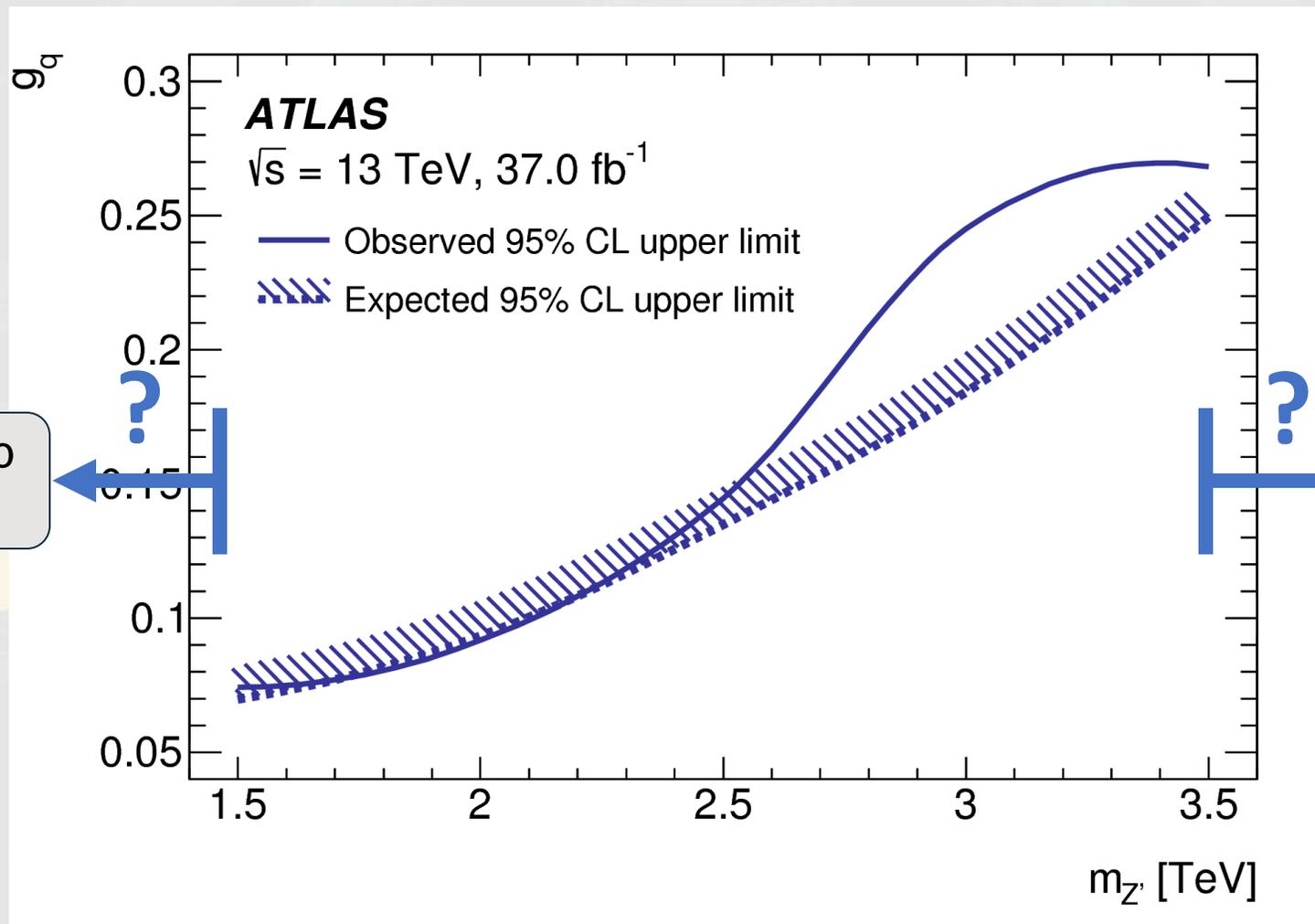


$$\Gamma = \sum_q \Gamma_{q\bar{q}} + \Gamma_{\chi\bar{\chi}} \approx \sum_q \Gamma_{q\bar{q}}$$

$$m_\chi = 10 \text{ TeV} \quad g_\chi = 1.5$$

!!

# Limits to $Z'$ model – Resonant dijet search

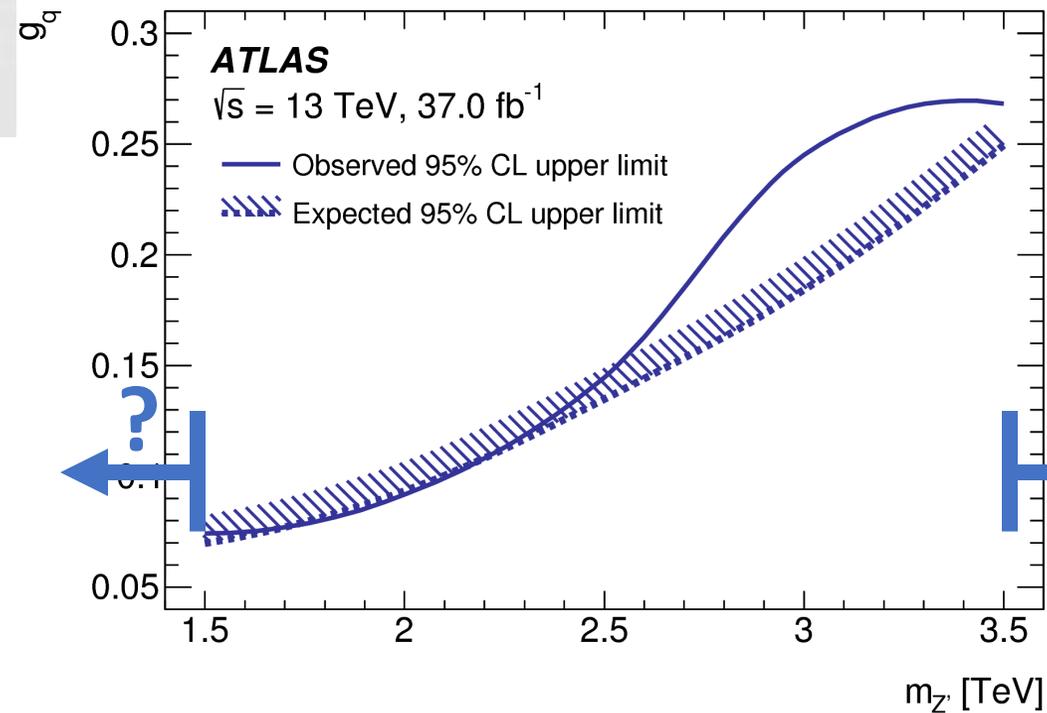
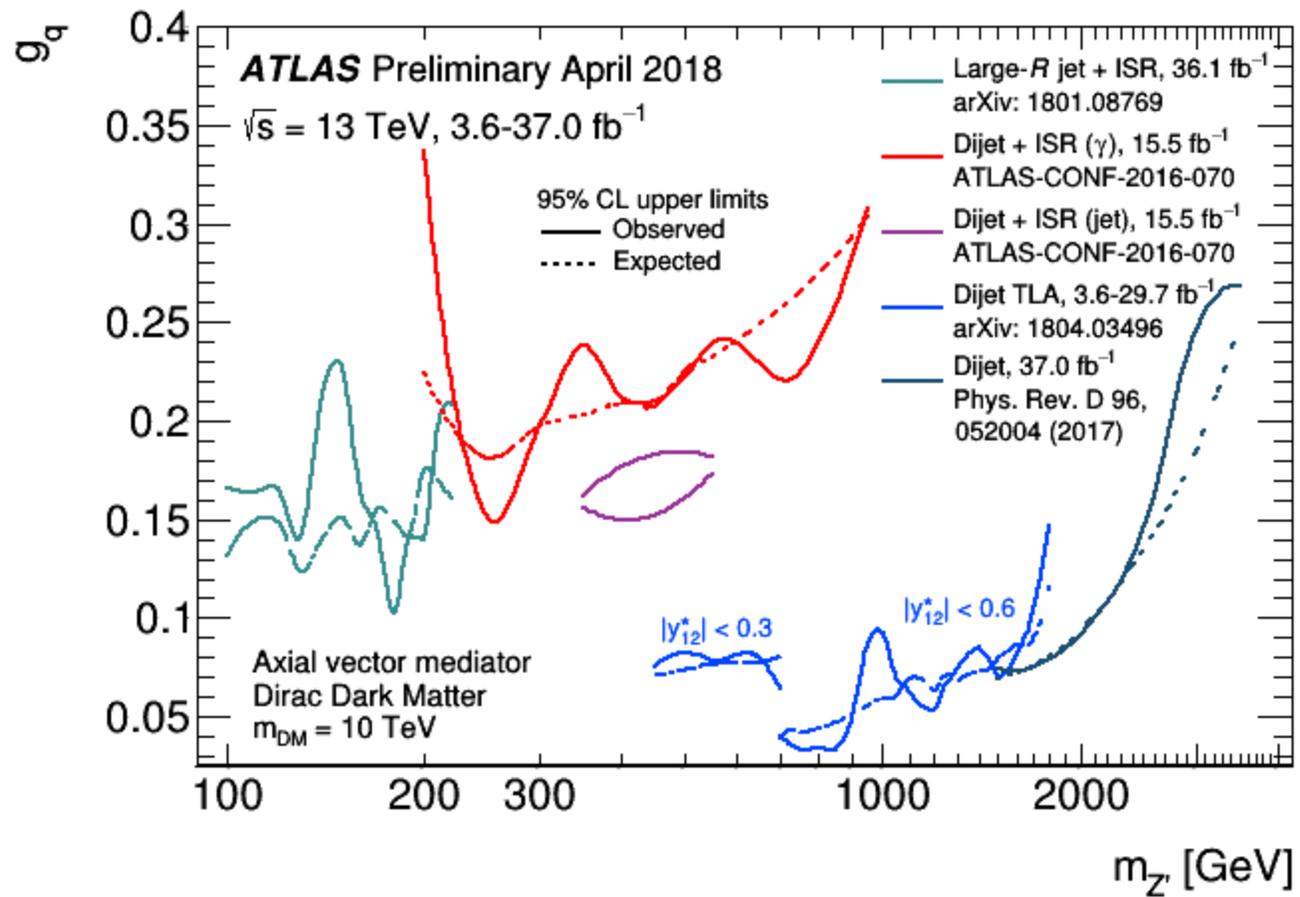


Trigger constraints to mass range

Background fitting techniques cannot distinguish signal wider than  $\sim 15\%$

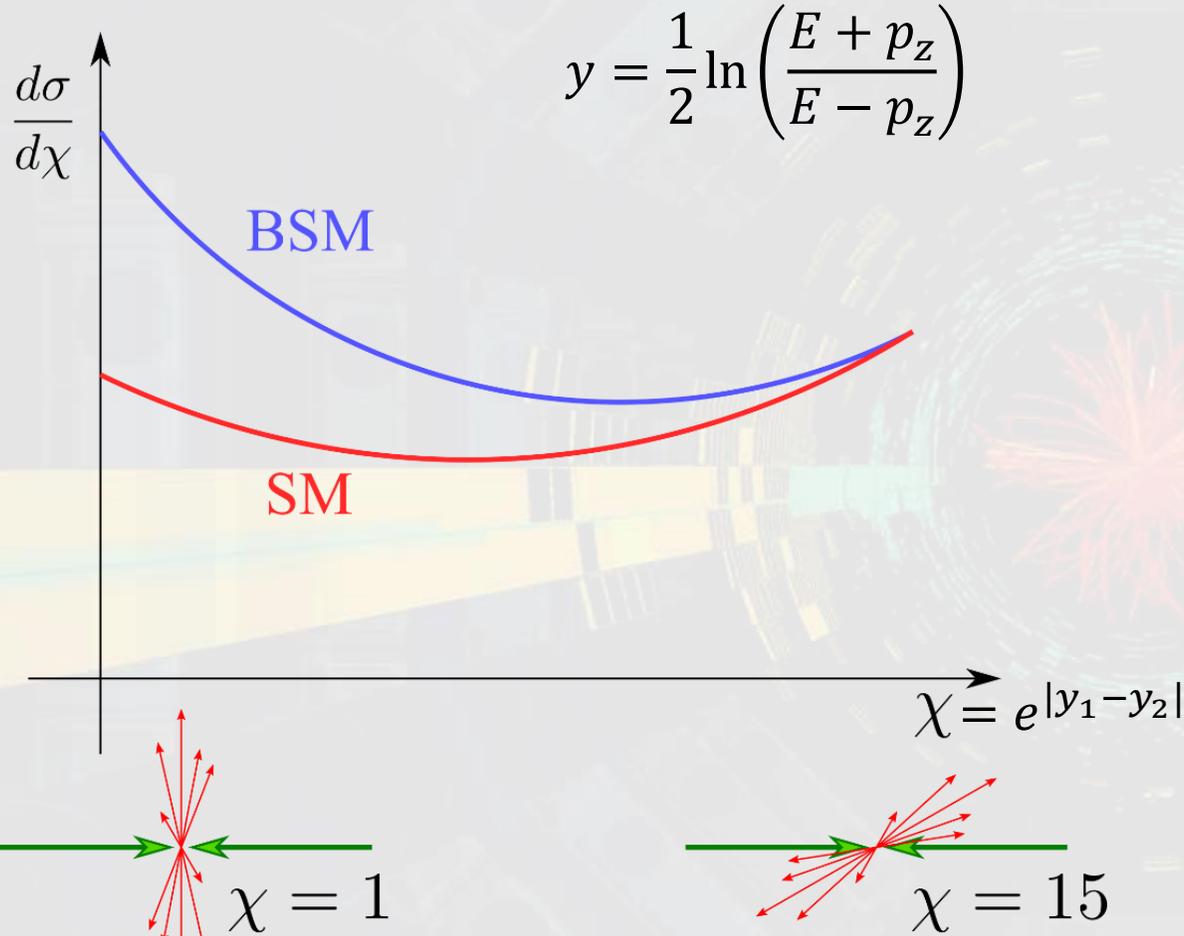
$$\Gamma_{q\bar{q}} = \frac{g_q^2 m_{Z'}}{4\pi} \left(1 - \frac{4m_q^2}{m_{Z'}^2}\right)^{\frac{3}{2}}$$

# Limits to $Z'$ model – Lower masses



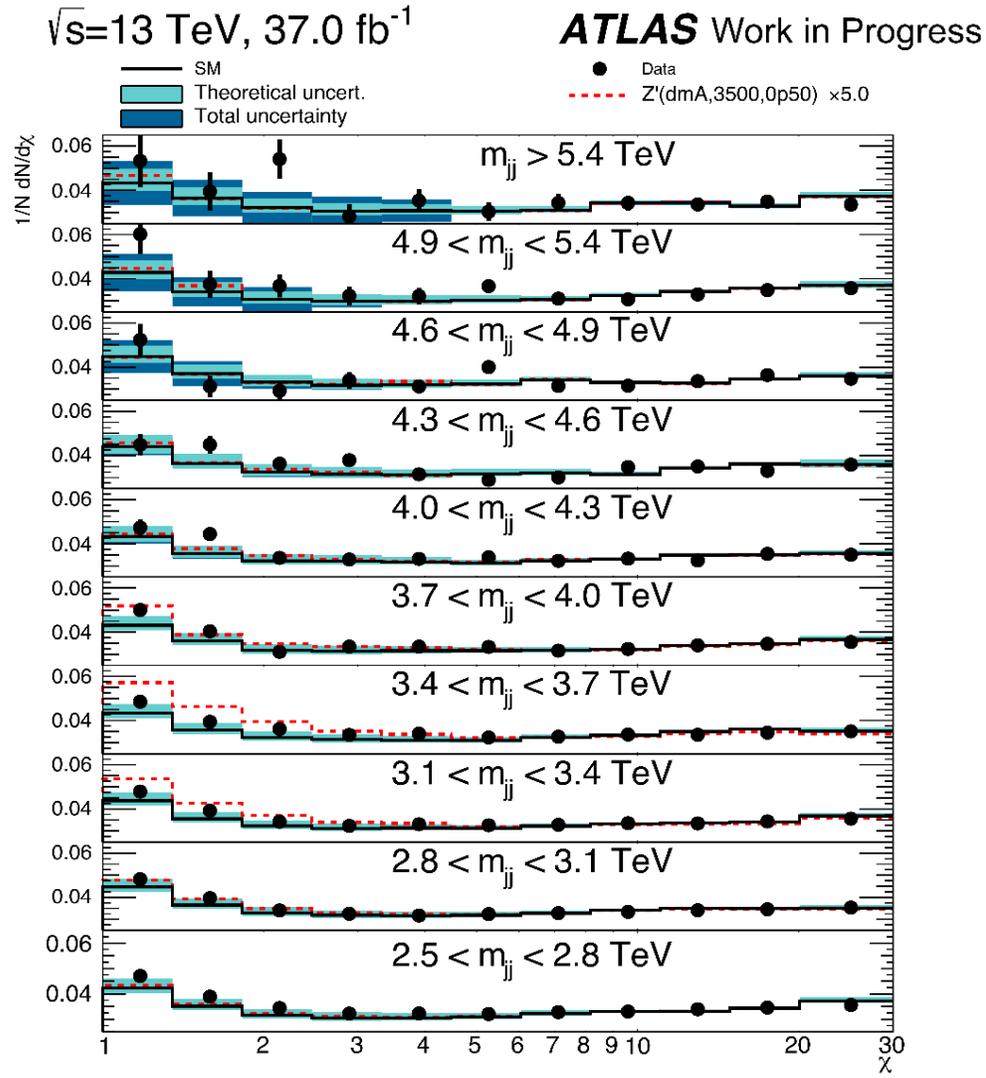
[\[hep-ex\]1703.09127](https://arxiv.org/abs/1703.09127)

# Search for dijet resonances – Angular Analysis



- $\chi$  is the Rutherford variable
- QCD almost flat
  - t-channel processes dominate
  - Small log dependence on  $m_{jj}$
- BSM expected as an excess at low  $\chi$ 
  - More isotropic events
  - Useful for resonant/non resonant searches

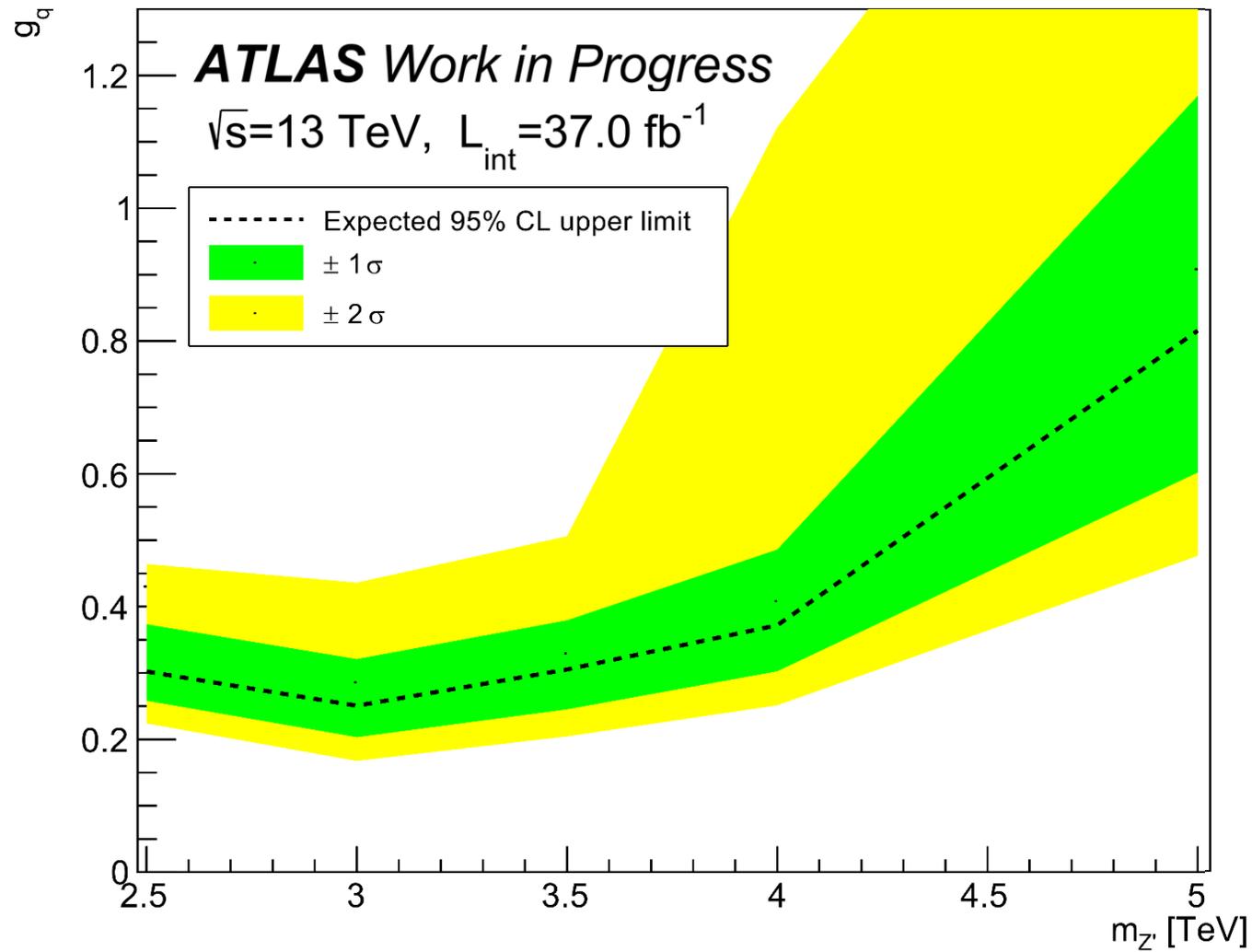
# Angular distributions



## Idea:

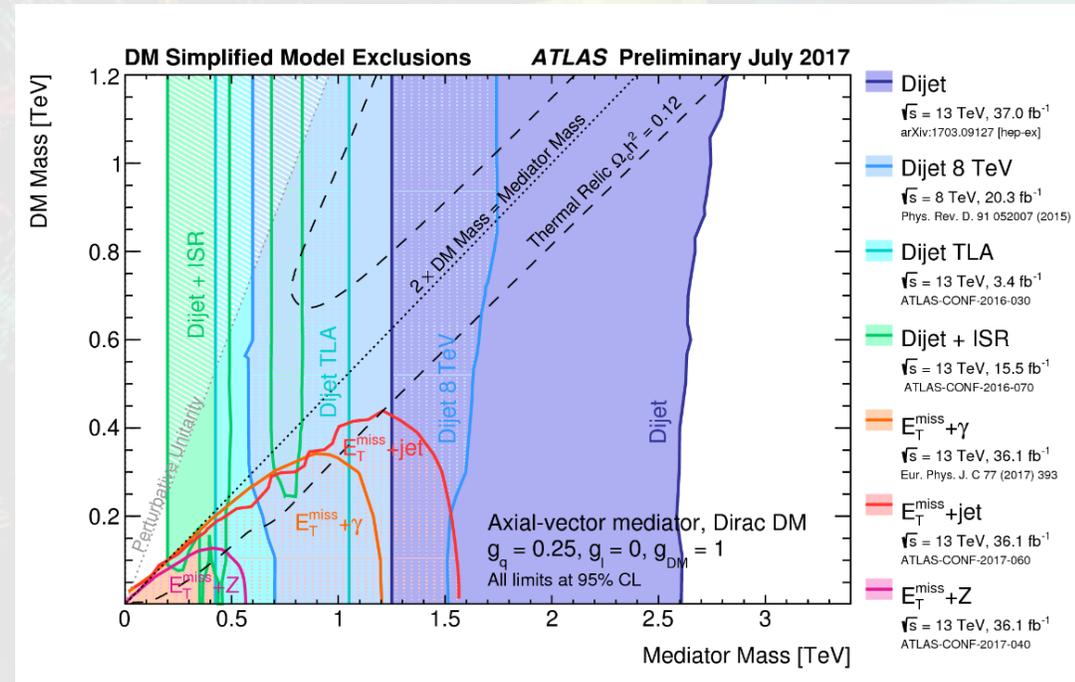
- Combined shape fit in several mass bins
- Background prediction obtained via MC
  - QCD @LO + (QCD+EW) NLO corr.
- Consider several systematical effects
  - JES+JER+Intercalibration unc.
  - $\mu_F$  and  $\mu_R$  scales, pdf, MC tune unc.
- Assume complete correlation between NPs in all mass bins
- Limitation at “low” mass
  - Trigger constraints

# Exclusion using angular distribution



# Conclusion

- Dijet events provide an exceptional opportunity to test BMS theories
  - High statistics
  - Events in an interesting region
- Particular attention to DM model
  - Direct search for new mediators
  - Constraints also on DM particle mass
- Angular correlation can be used to explore new region of the parameter space
  - Some limitation due to MC precision
  - 2D needs more data!
  - Promising approach



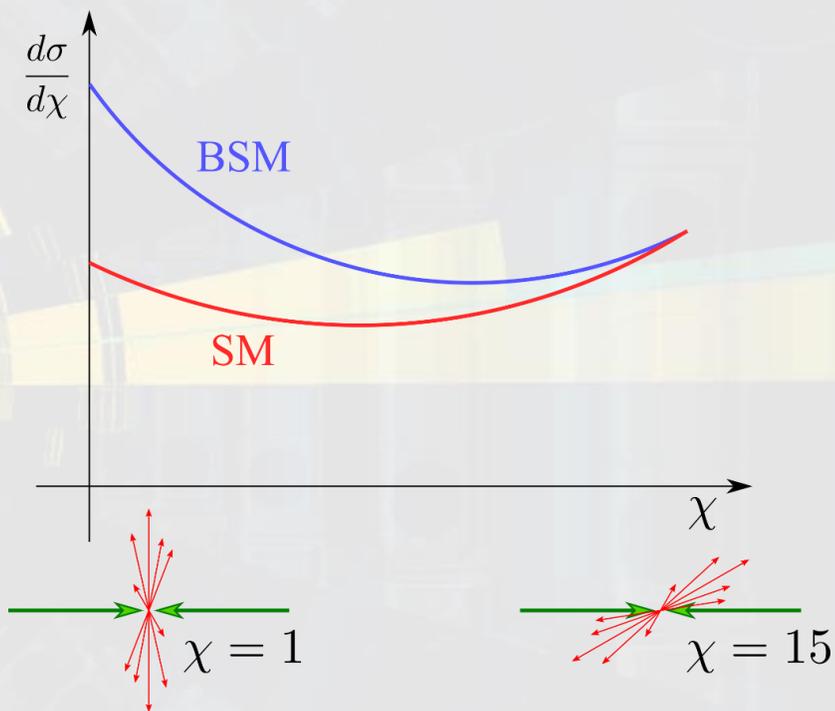
*Thank you!*

*Backup*

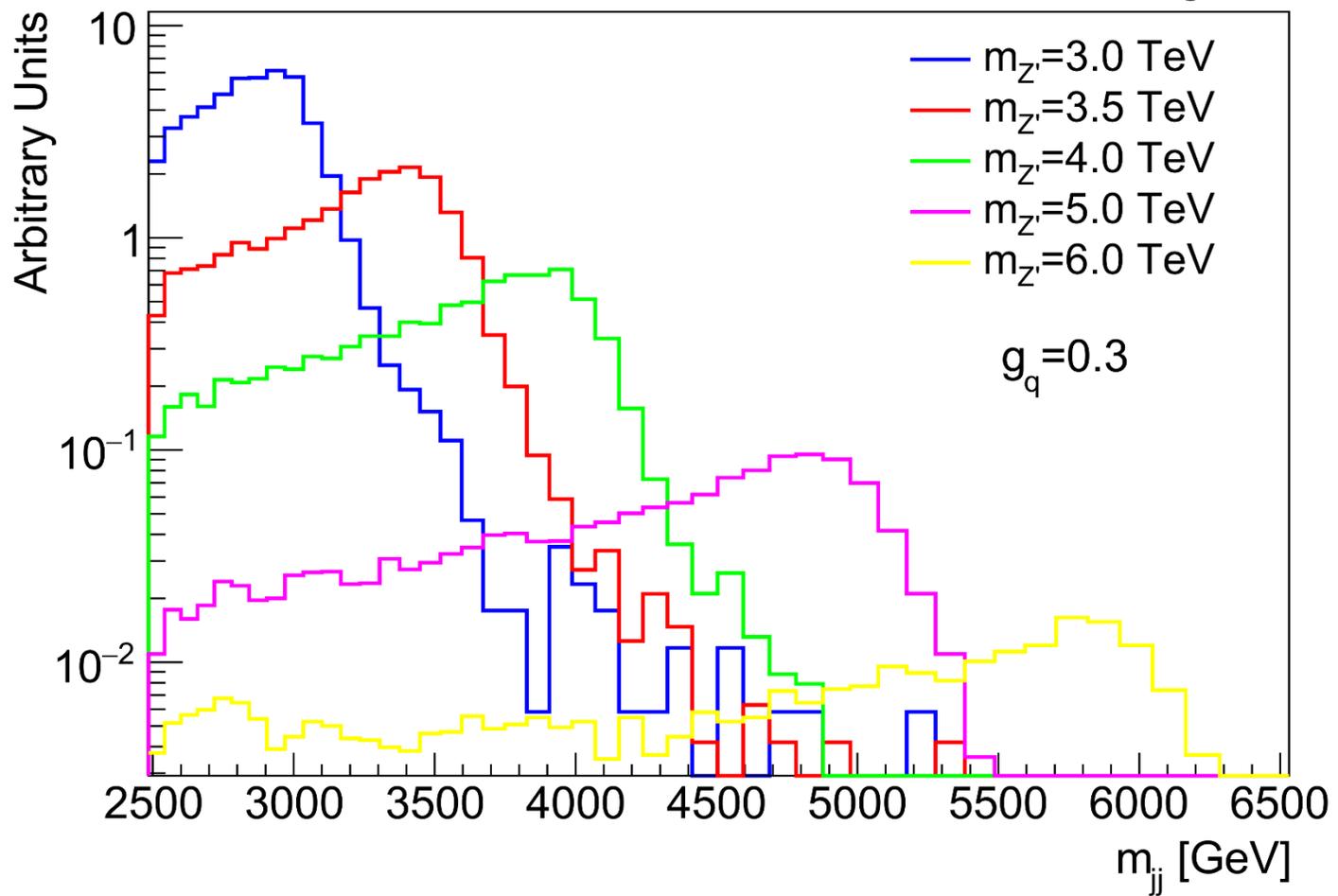
# Angular distributions – strategy and selection

Selection criteria:

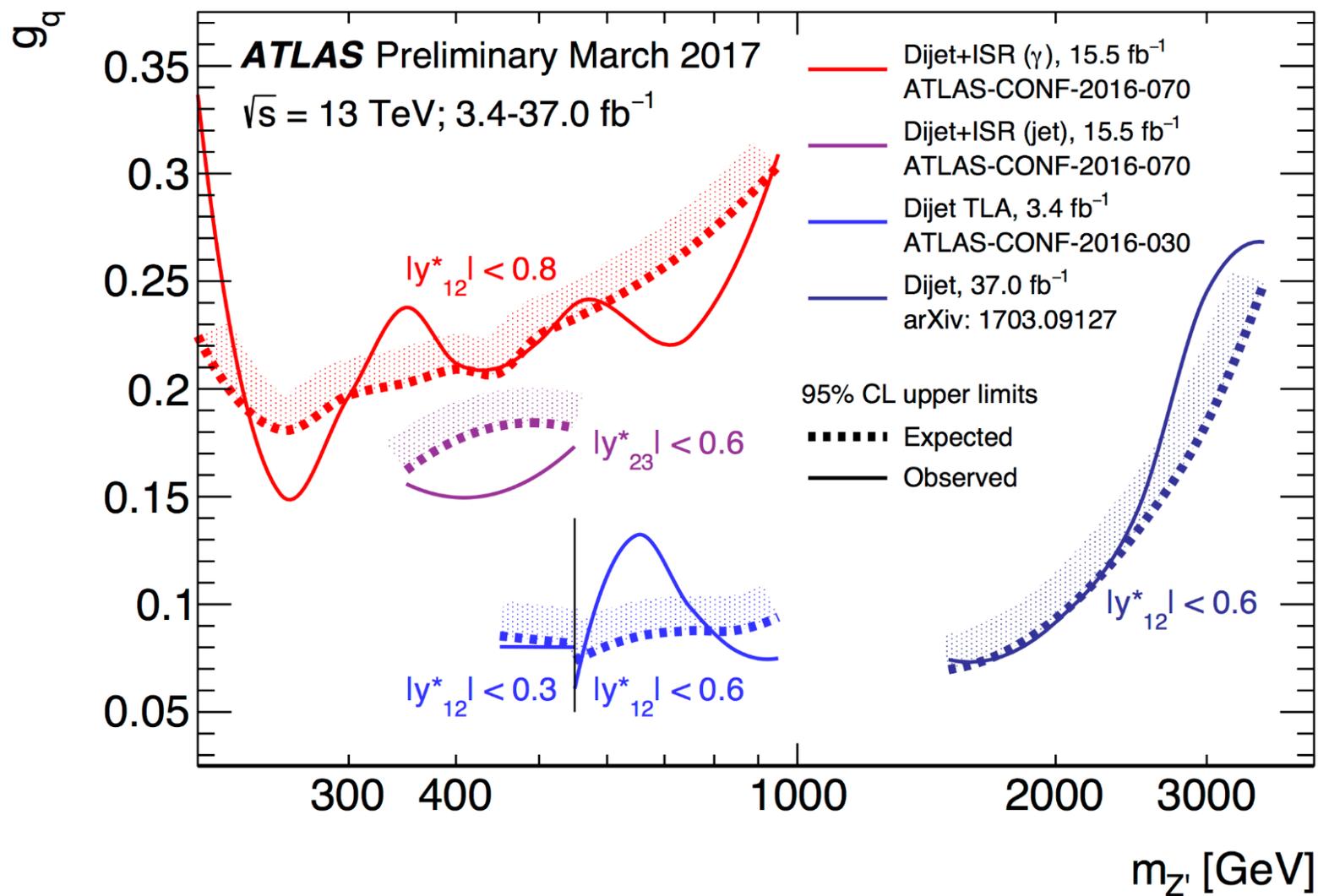
- Trigger  $p_T^{jet} > 380$  GeV
- $m_{jj} > 2.5$  TeV
- $p_T^{lead(sublead)} > 440(60)$  GeV
- $|y^*| = \frac{1}{2}|y_1 - y_2| < 1.7$
- $|y_B| = \frac{1}{2}|y_1 + y_2| < 1.1$

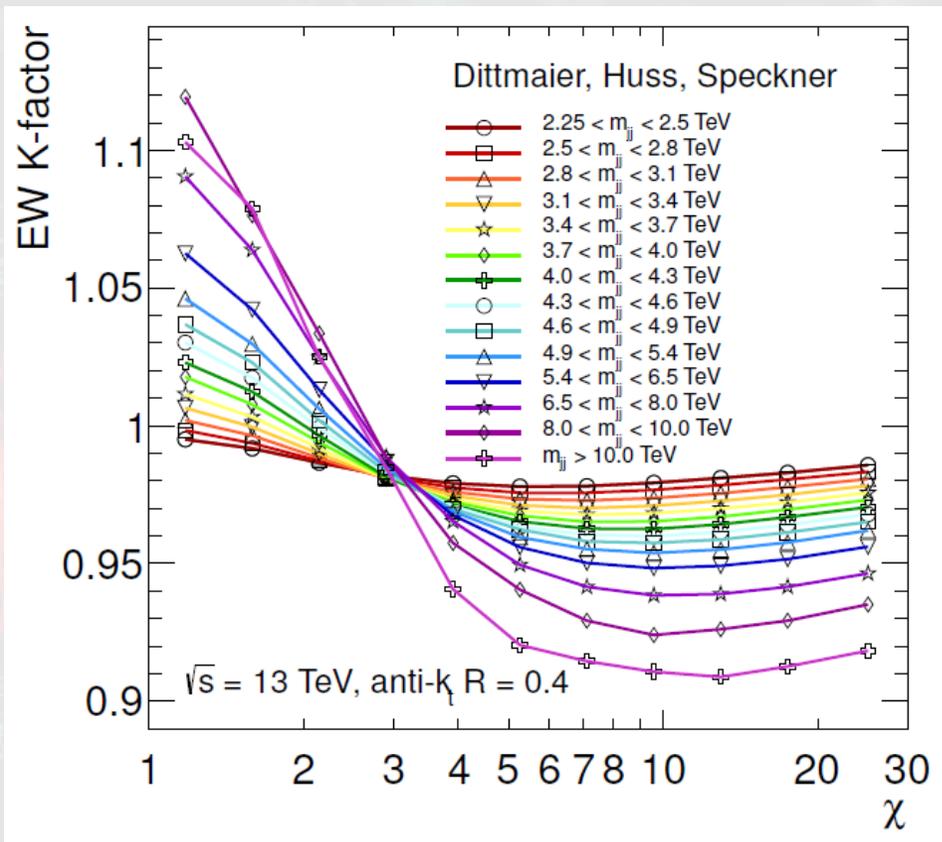
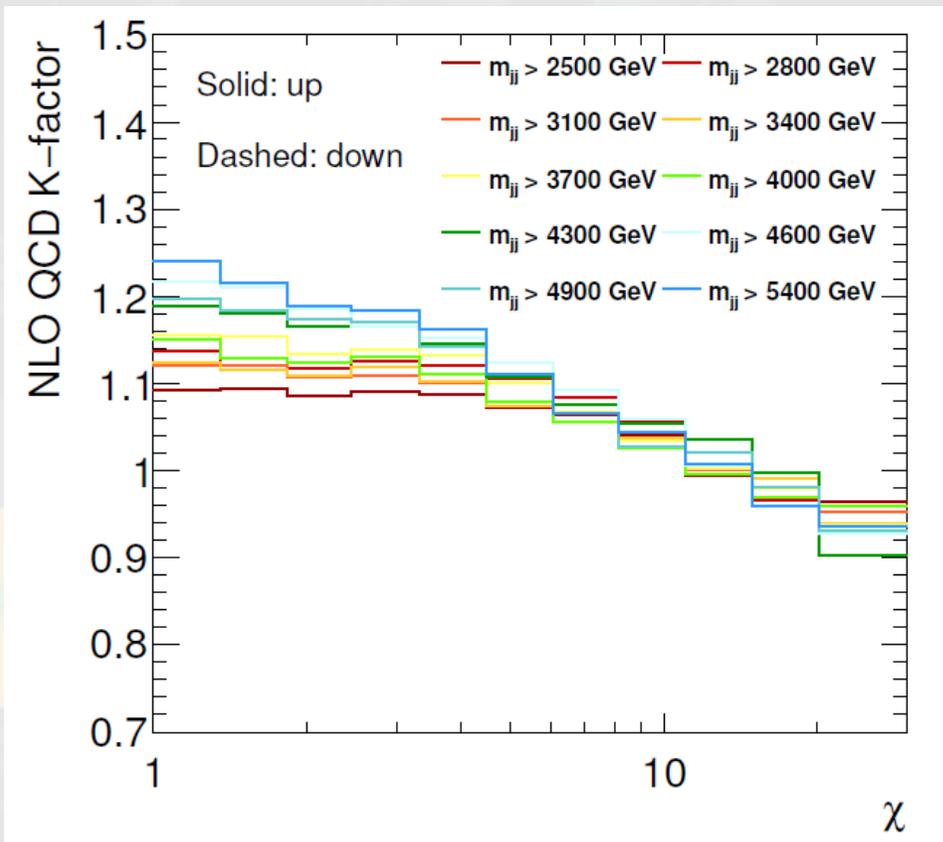


# ATLAS Work in Progress



# Limits to $Z'$ model





[\[hep-th\]1210.0438](https://arxiv.org/abs/hep-th/1210.0438)