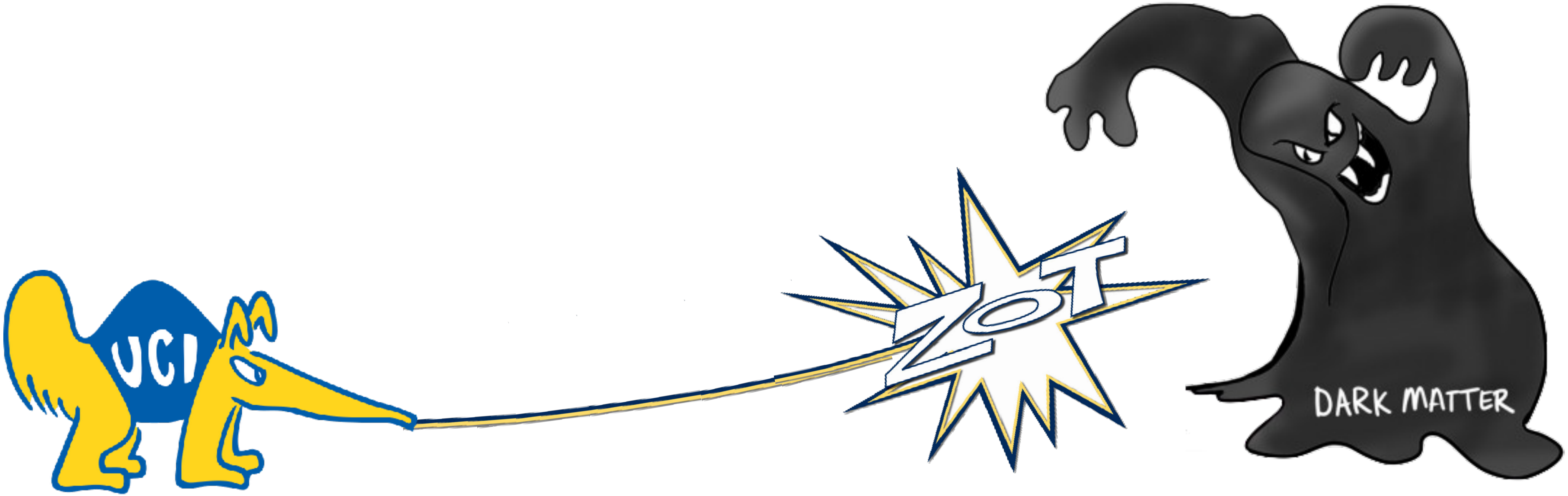


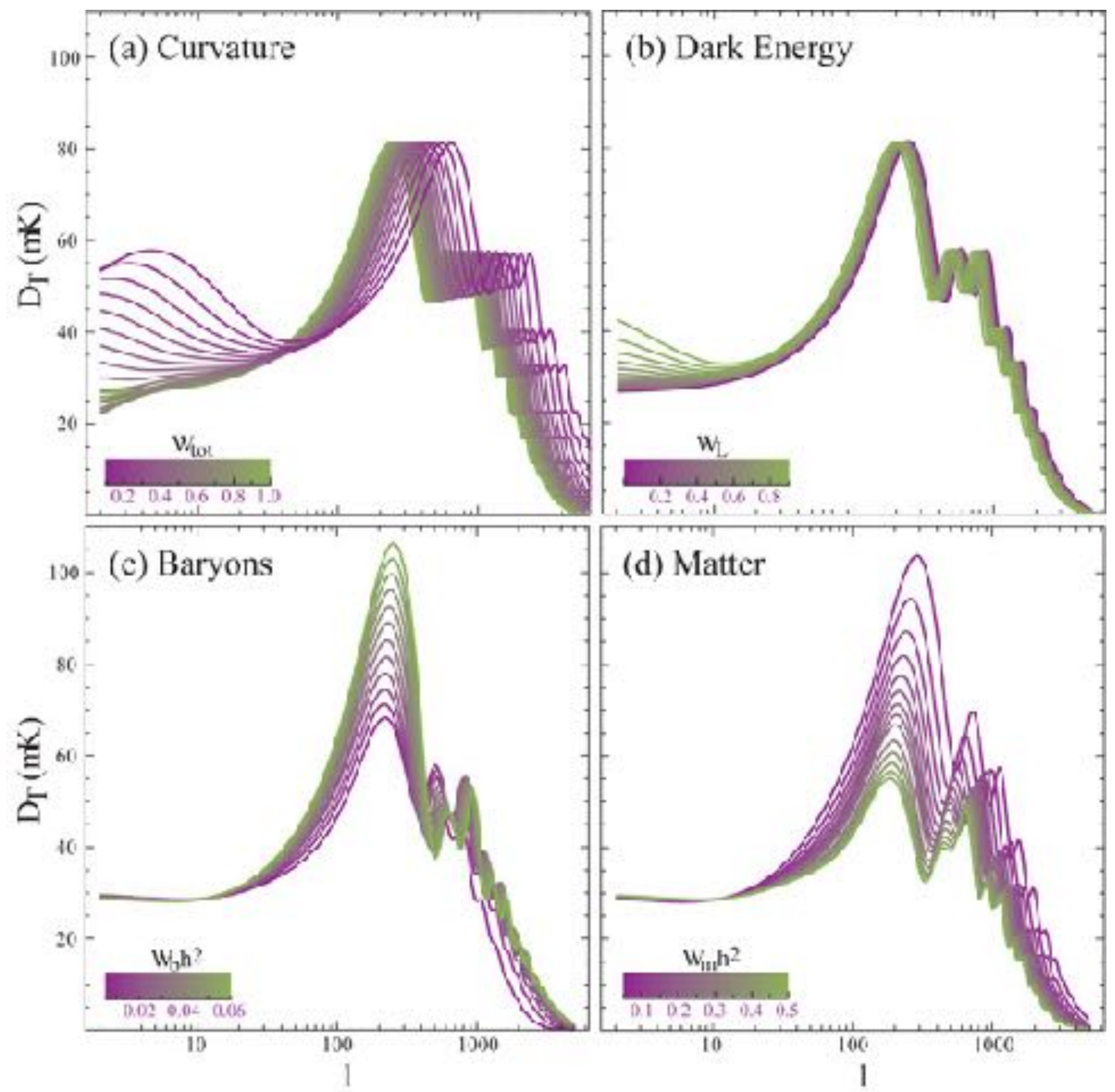
YVONNE NG (UNIVERSITY OF CALIFORNIA, IRVINE)
—— ON BEHALF OF THE ATLAS COLLABORATION FOR SILAFAE 2018

DARK MATTER SEARCHES WITH THE ATLAS DETECTOR

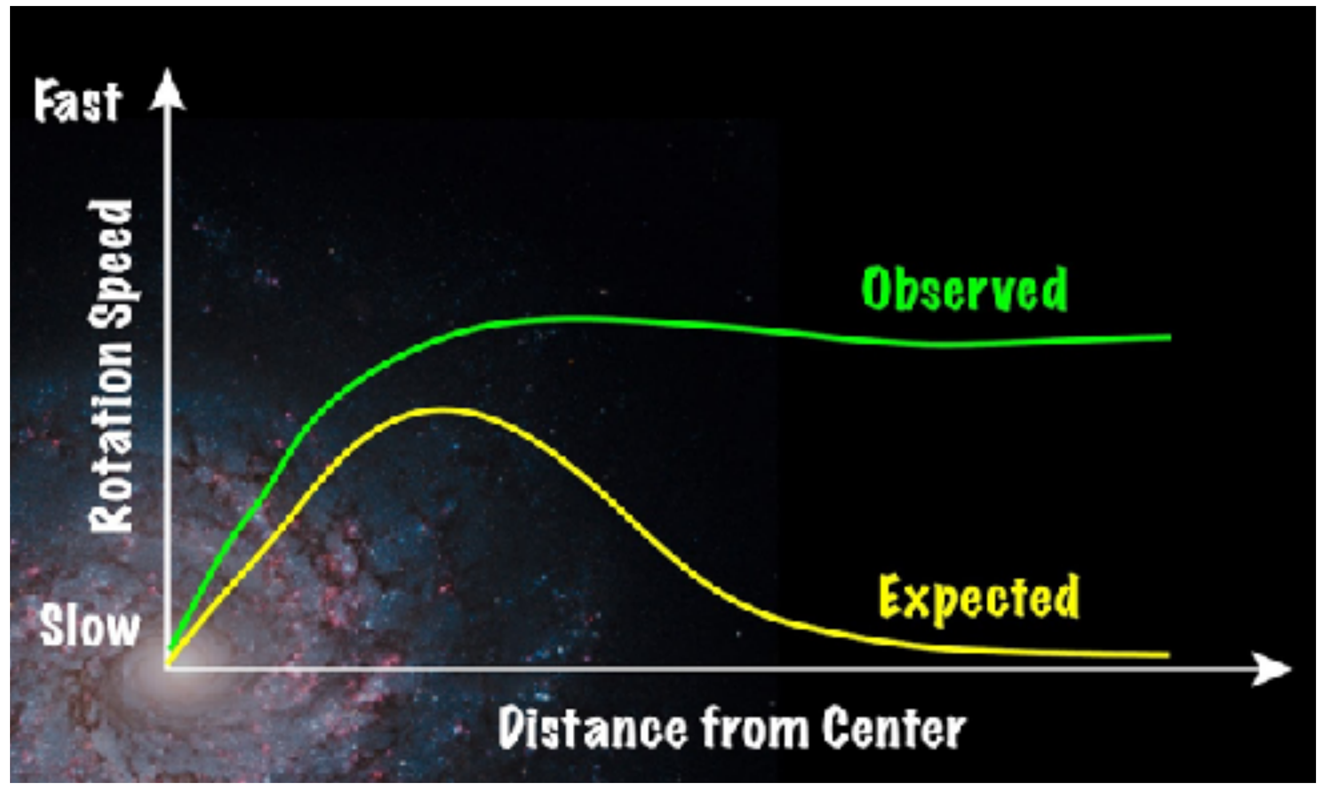
29nd November, 2018

INDICATIONS FOR DARK MATTER:

- **Indications** for new, unknown matter outside of SM
- **Dark matter candidates** offered by SM extensions:
  - Axions
  - Sterile neutrinos
  - Weakly interacting Massive Particles (W.I.M.P)



Cosmic microwave background (CMB)

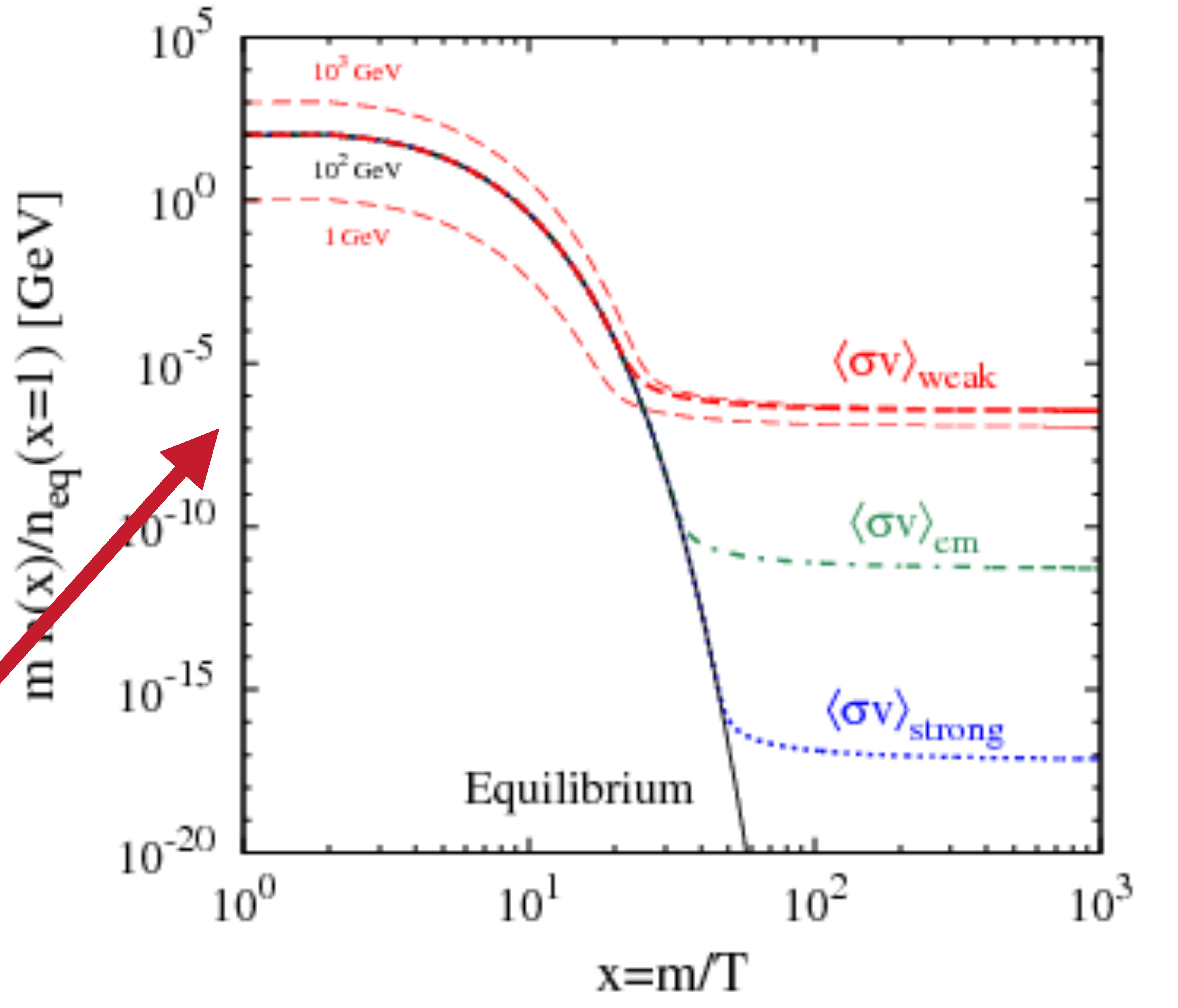


Galactic rotational curves


Bullet clusters collisions

EVIDENCE FOR DARK MATTER:

- **Evidence** for new, unknown matter outside of SM
- **Dark matter candidates** offered by SM extensions:
    - Axions
    - Sterile neutrinos
    - Weakly interacting Massive Particles (W.I.M.P)

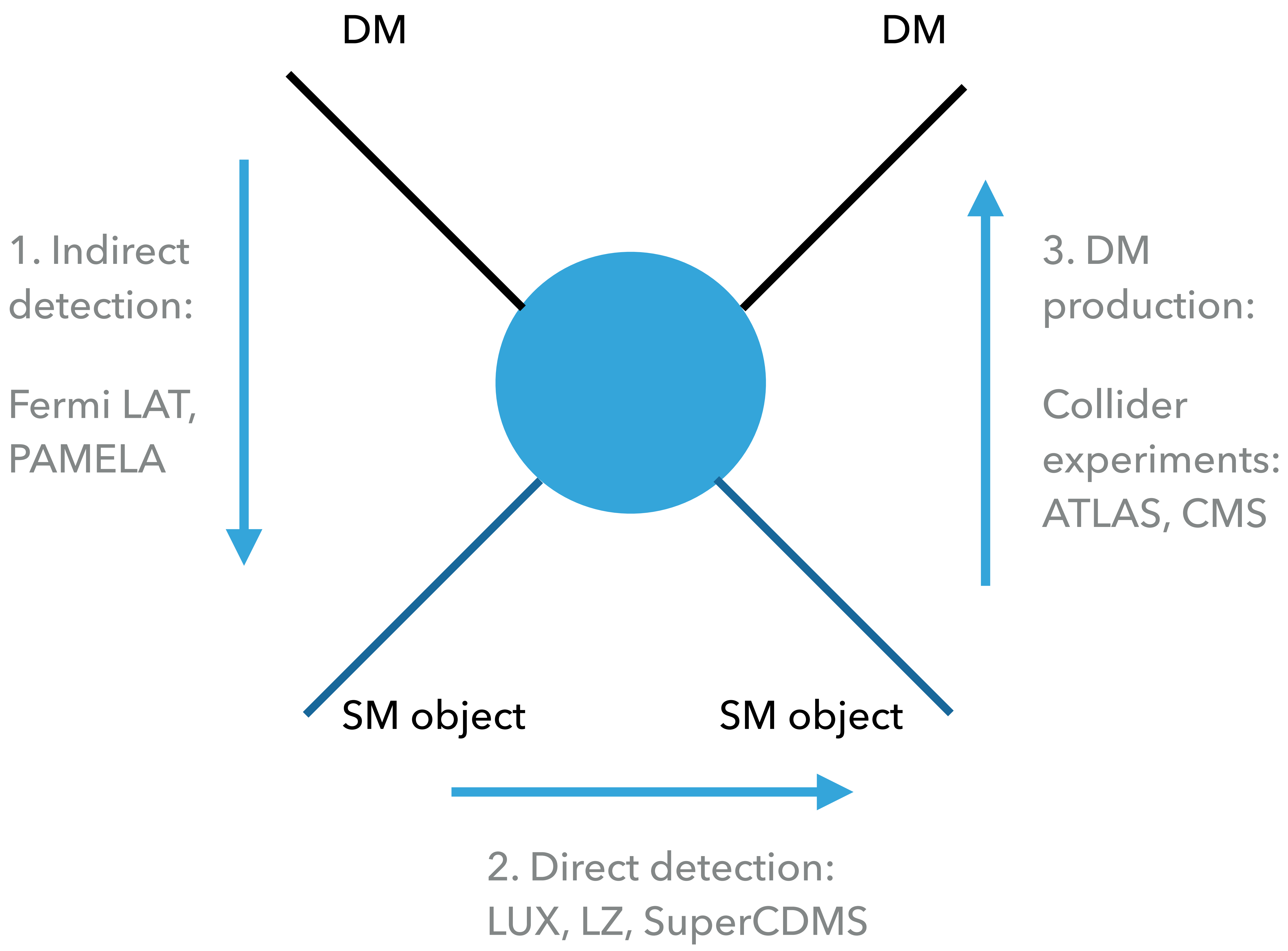


Supported by the relic density calculation

A well motivated DM Candidate searched for by many experiments

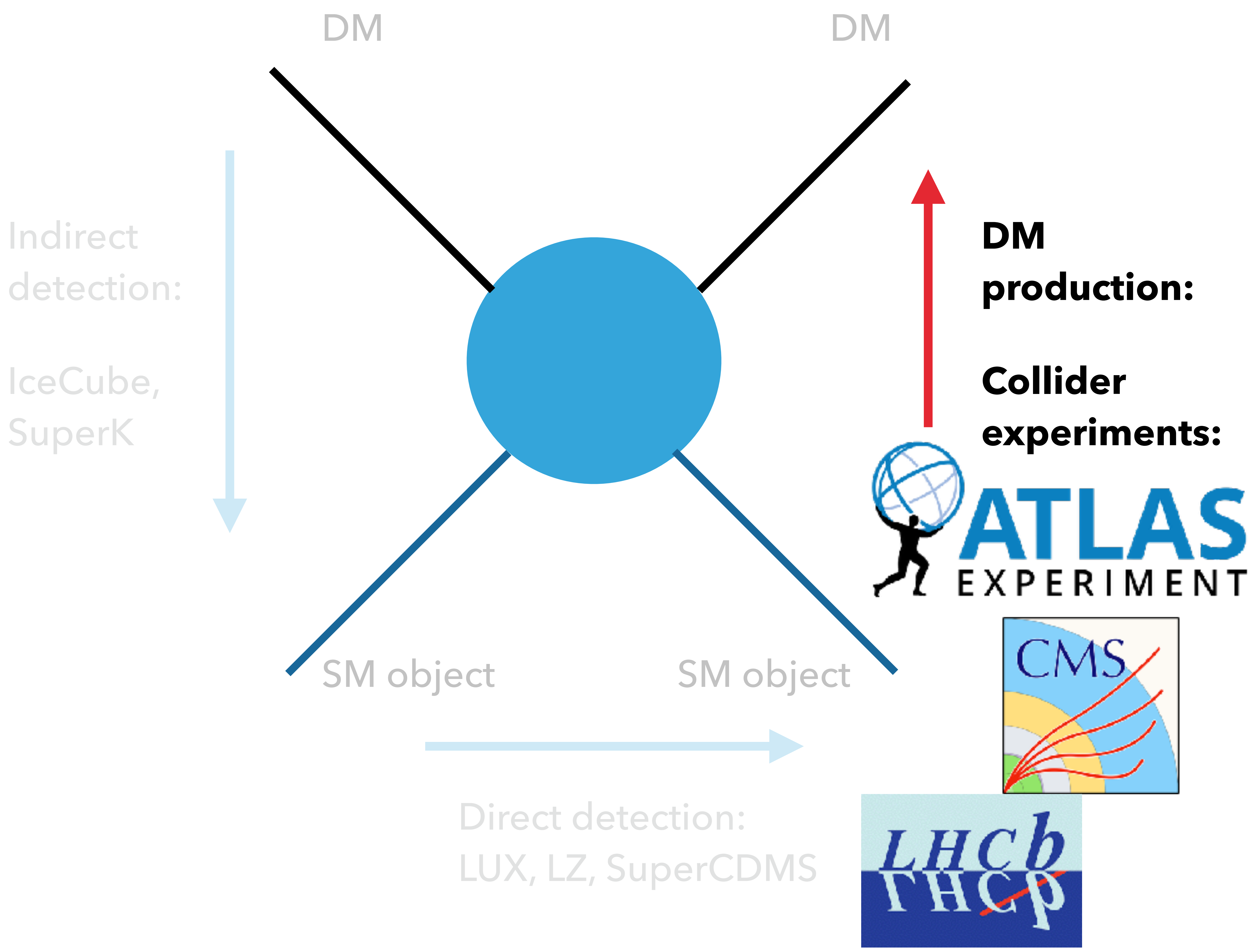
HOW CAN WE FIND DARK MATTER?

- Three different approaches to look for DM



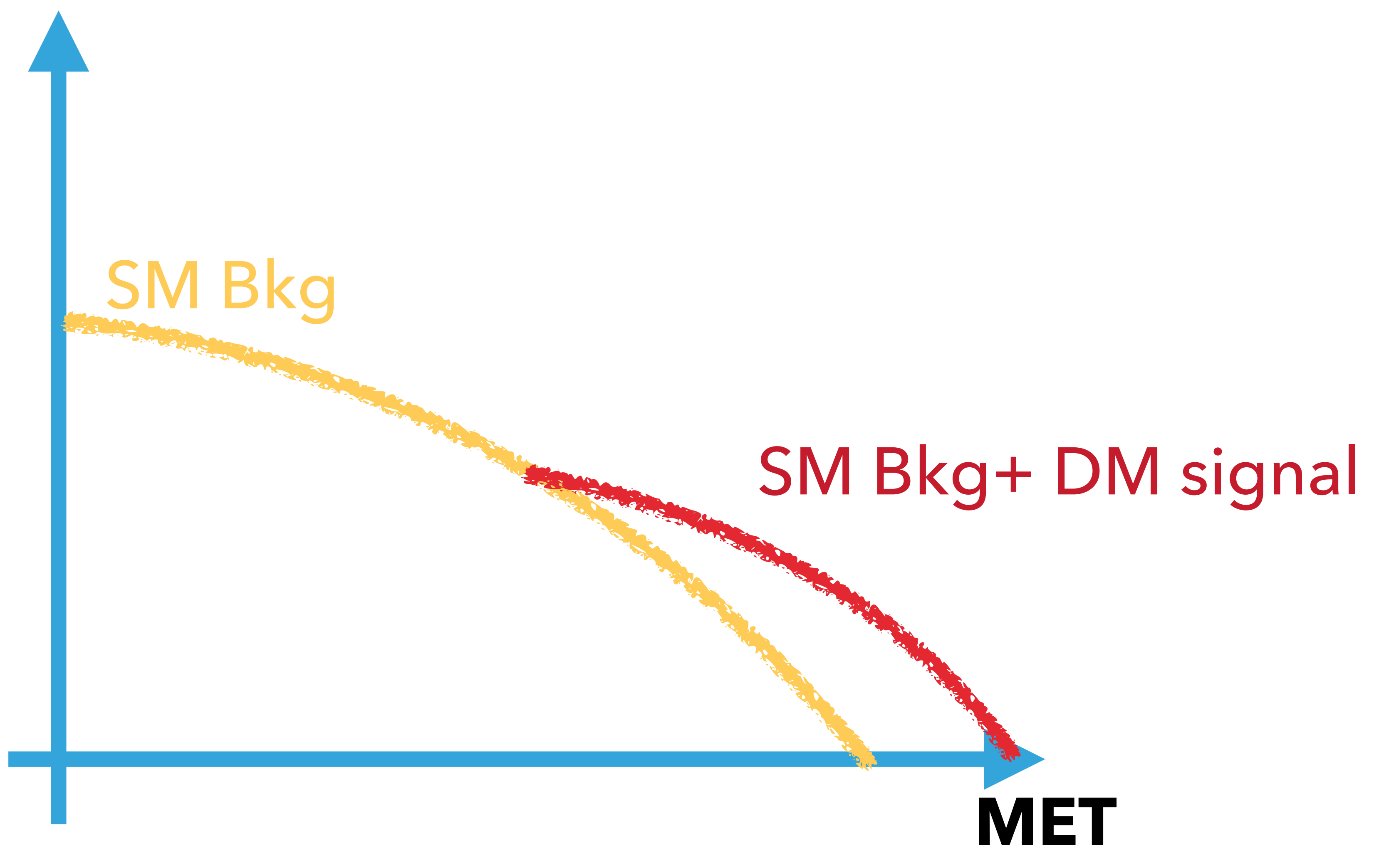
DARK MATTER DETECTION THROUGH COLLIDER PRODUCTION

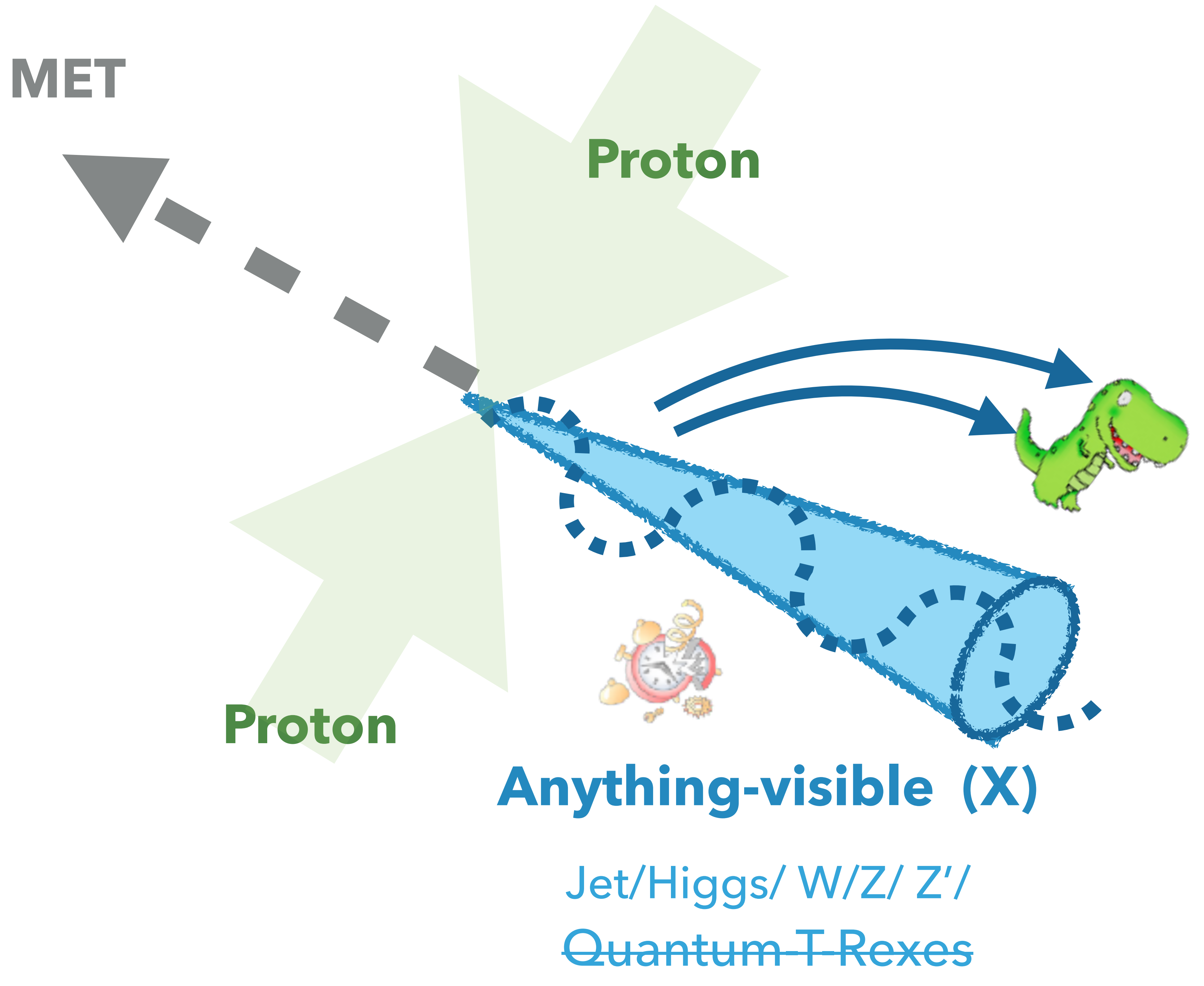
- Or we can… **produce them!**
- **Collider production:**
  - **Strength:** DM/SM interactions and decay channels
  - **Weakness**: No information about the found "Dark matter"'s lifetime, to be complemented by DD/ID.



CLASSIC COLLIDER DARK MATTER SEARCHES: (A.K.A: MONO-X)

- DM invisible in the ATLAS detector:
  - Look for MET + something
- Mono-X DM search signature :





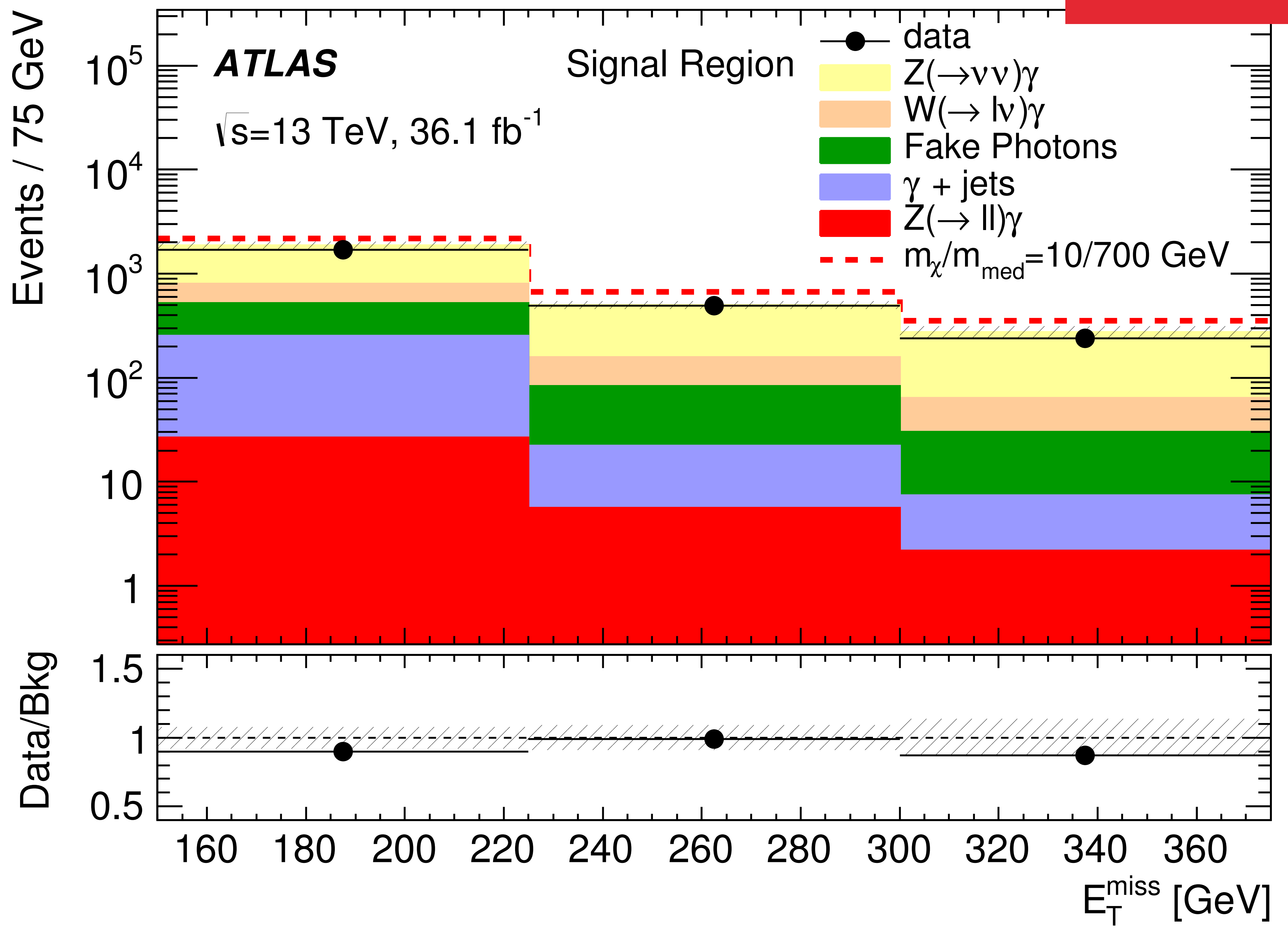
- E.G: Mono-jet, mono-photon, mono-W

MONO-PHOTON AND MONO-JET

Mono-Photon

(Eur. Phys. J. C 77 (2017) 393)

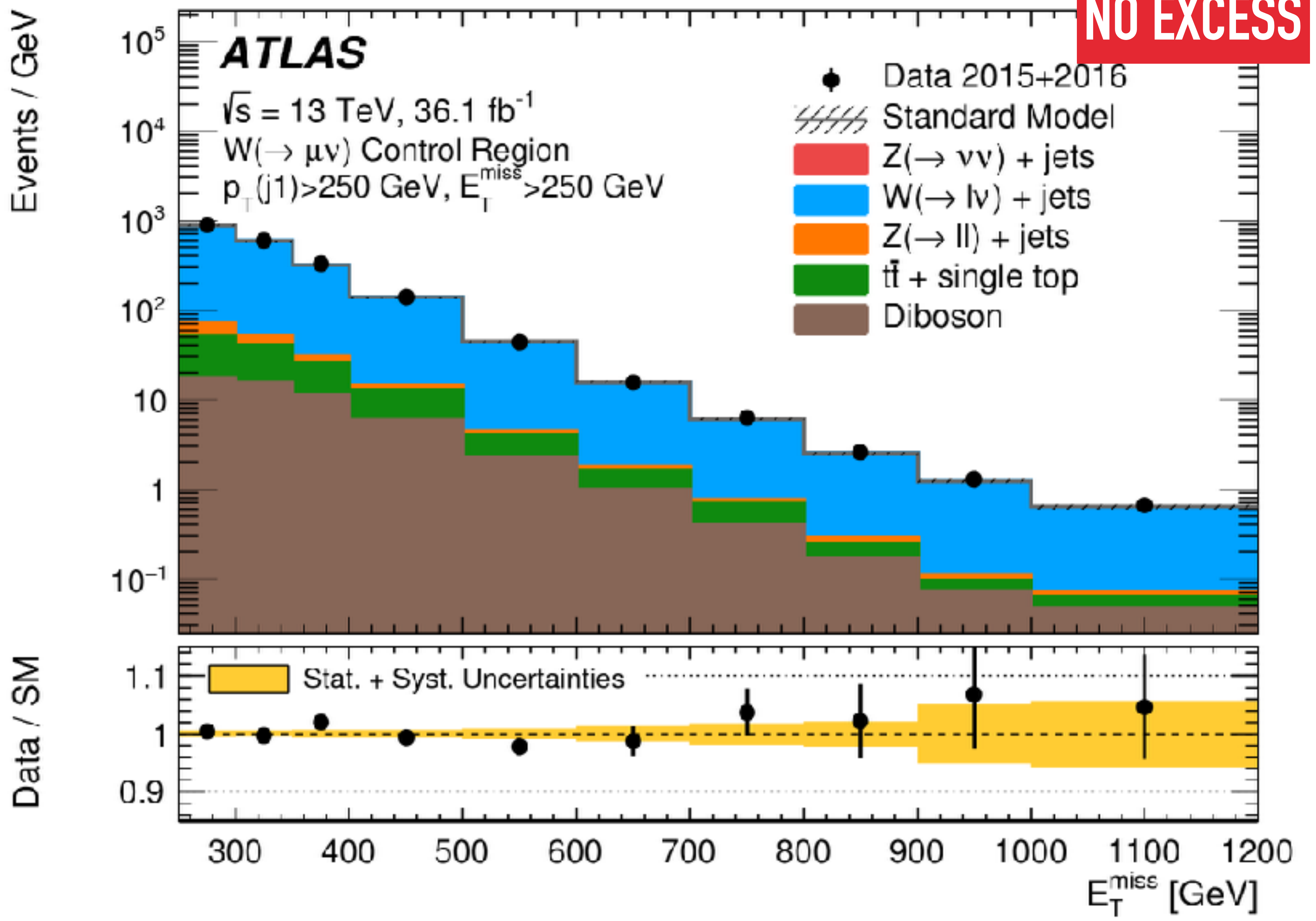
NO EXCESS



Mono-Jet

(JHEP 01 (2018) 126)

NO EXCESS

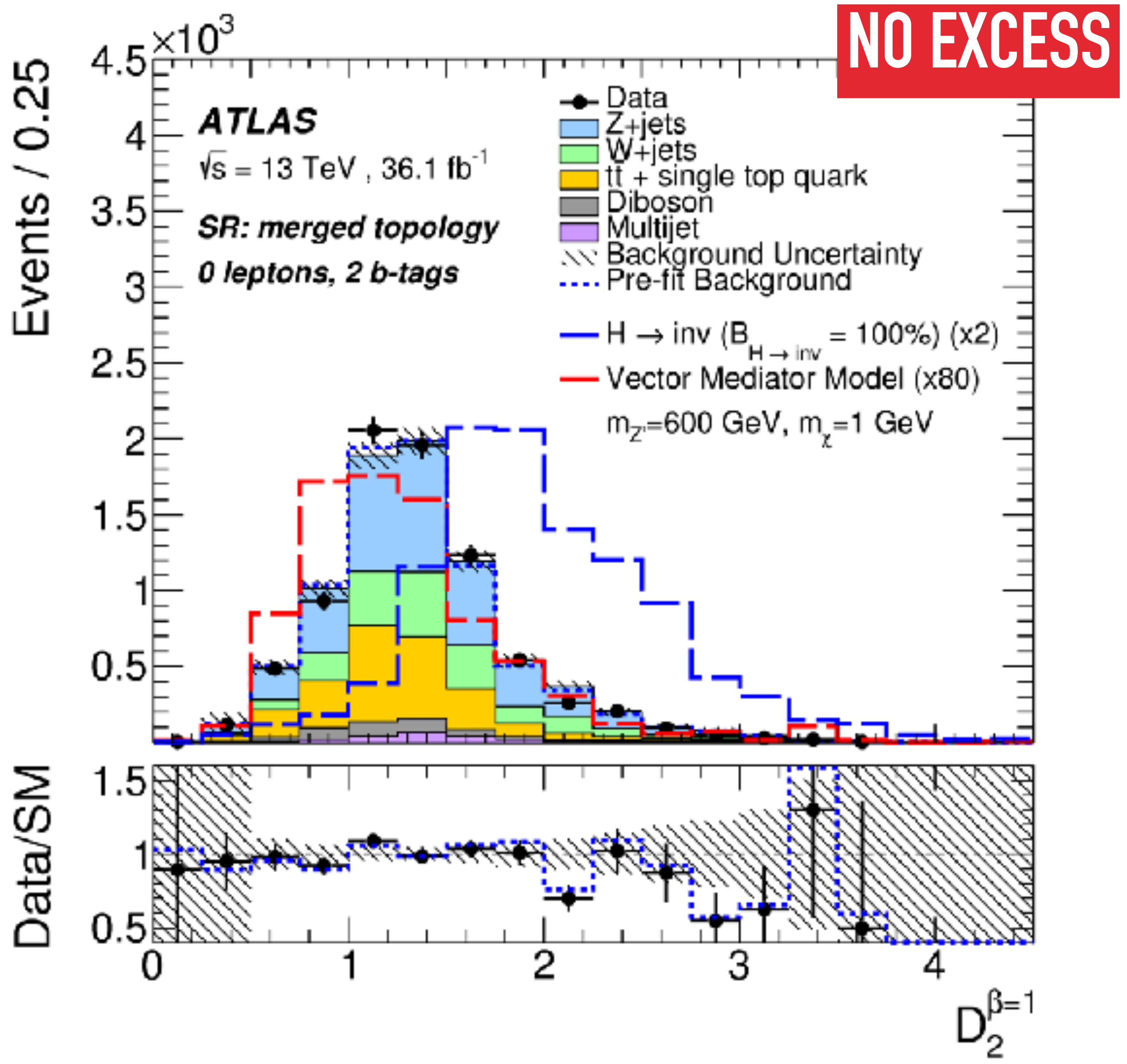


- Challenges: Precise object calibration, SM background prediction and MET measurement.
- Fake particles vetoed, various control regions used to measure SM background prediction.

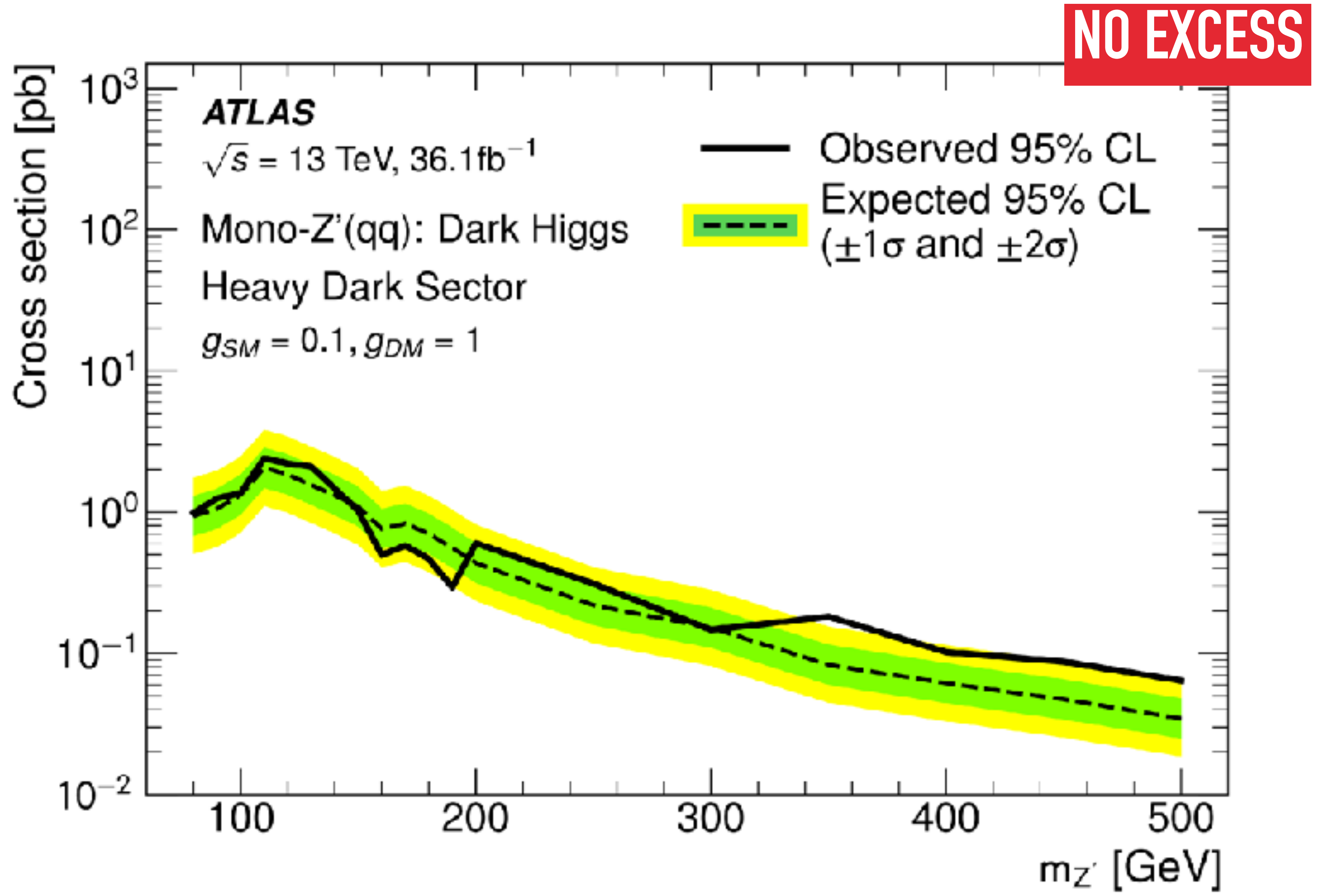
MONO-BOSON (W,Z,Z')

Mono-W/Z/Z'

(JHEP 10 (2018) 180)

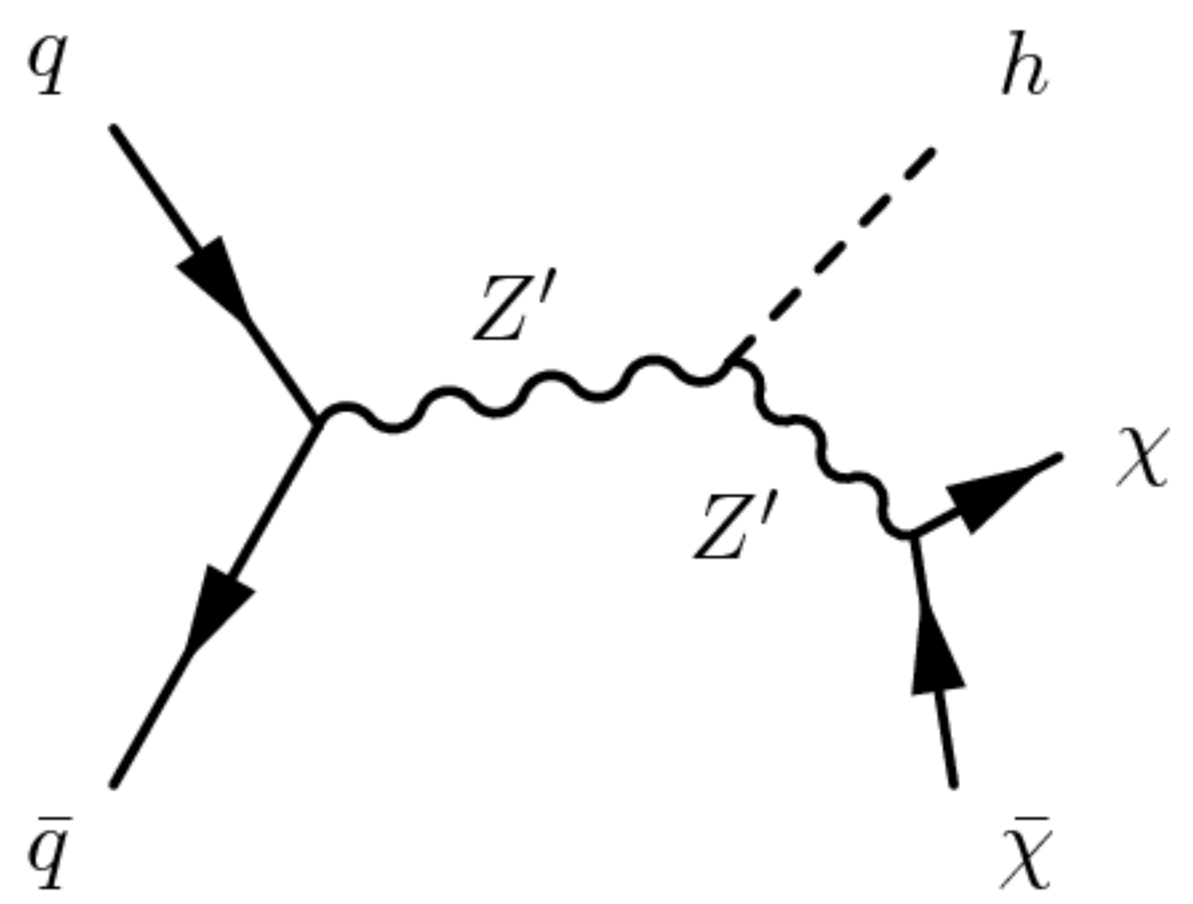


Jet substructure to improve sensitivity



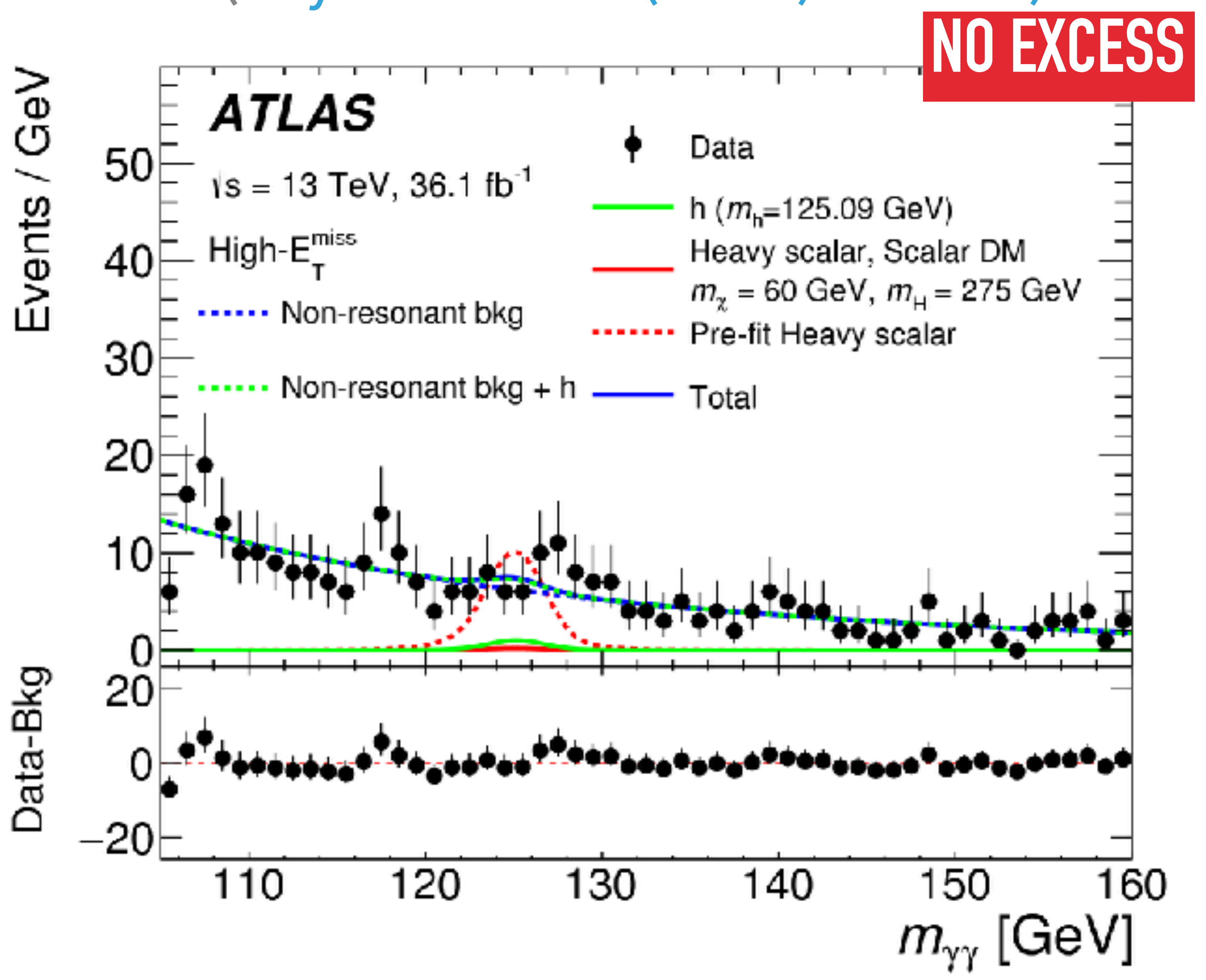
First ever Mono-Z′ Result

MONO-HIGGS(VISIBLE)



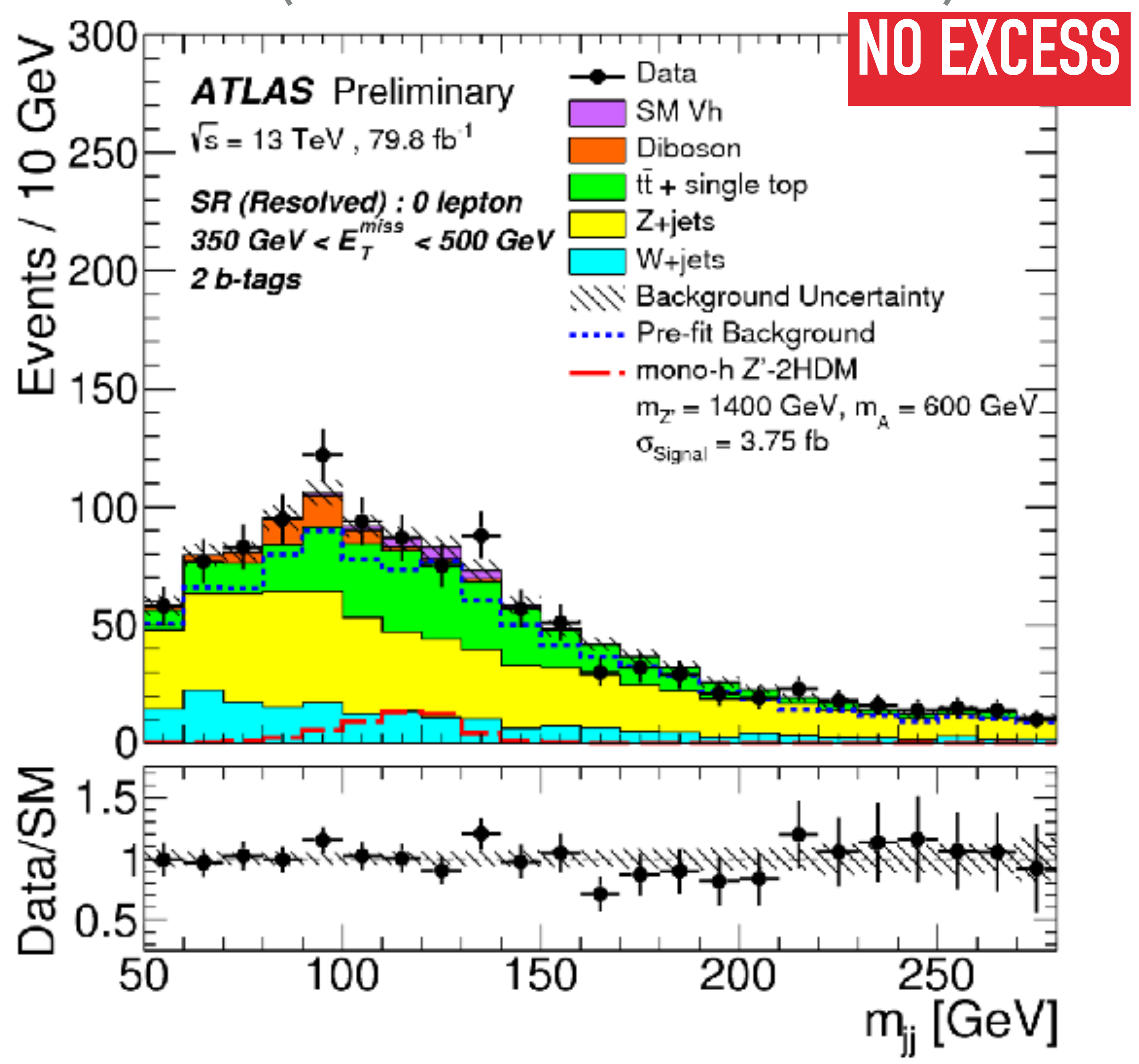
Mono-Higgs(->γγ)

(Phys. Rev. D 96 (2017) 112004)



Mono-Higgs(->bb)

(ATLAS-CONF-2018-039)

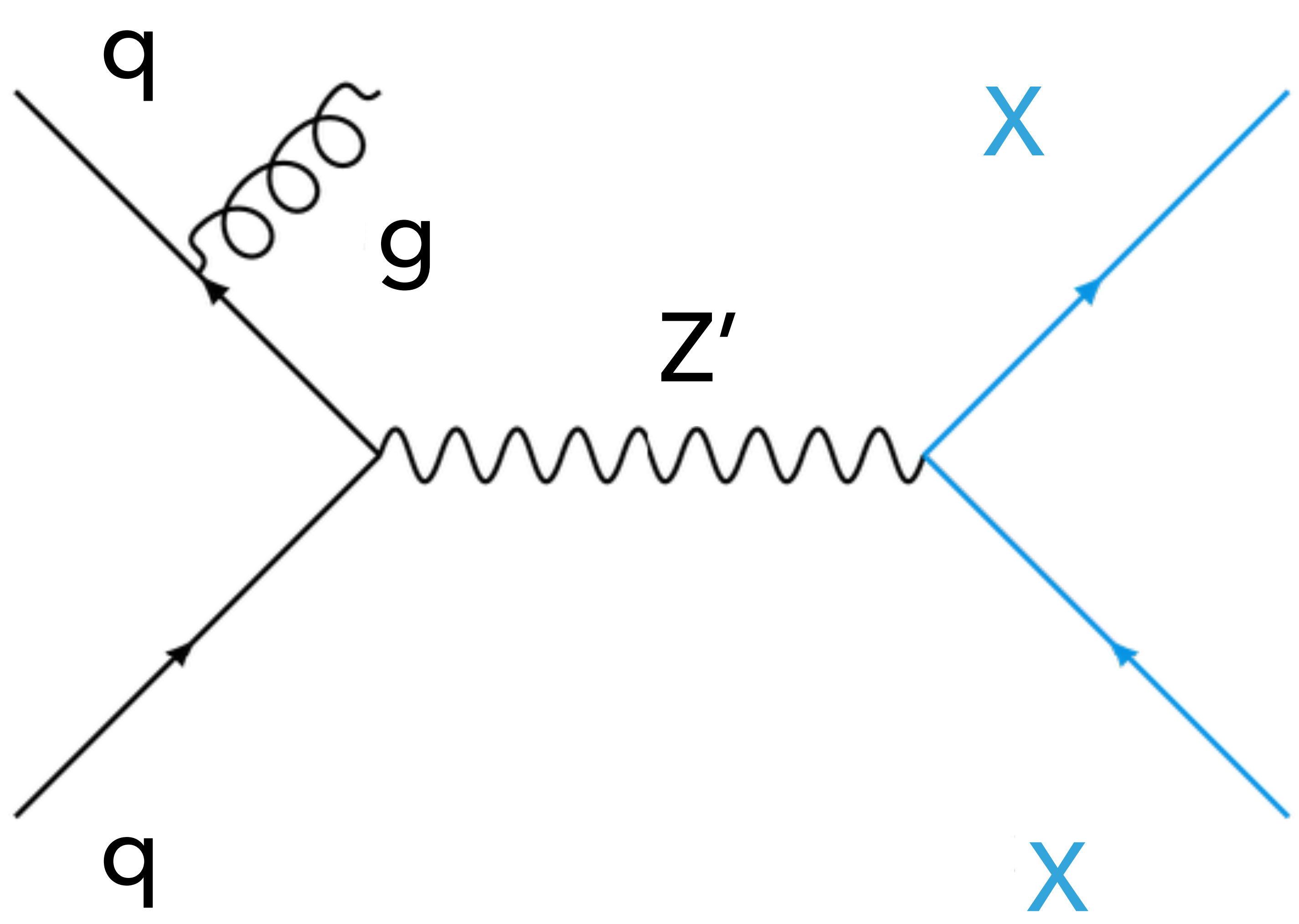


First 79.8 fb-1 results

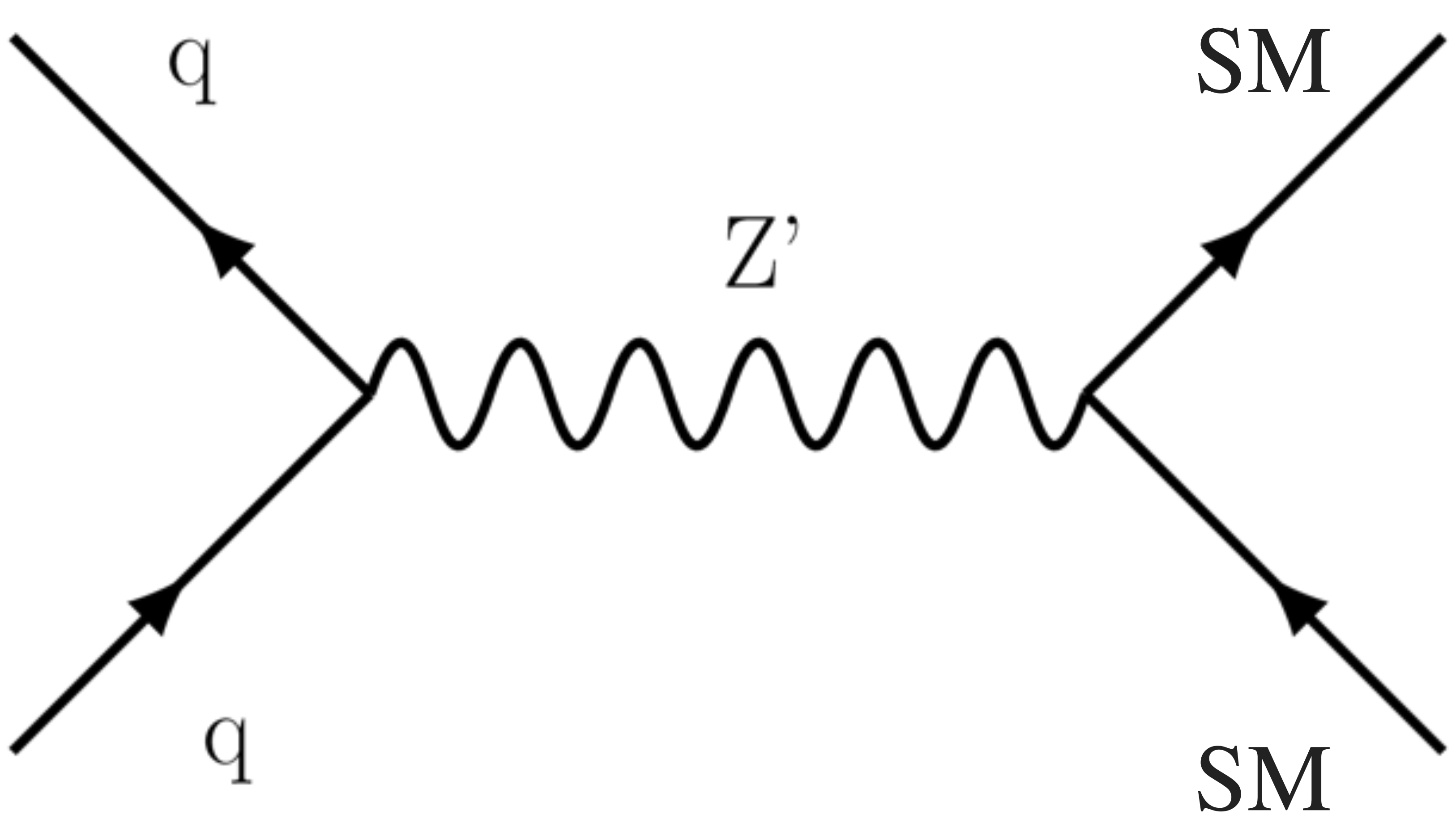
DARK MATTER SEARCHES THROUGH MEDIATOR

- ***"For DM to be made from quarks, it means that there is a process that can decay back into quarks."***
- Can we look for the simplified force mediator instead?

  - **Mono-X analyses**



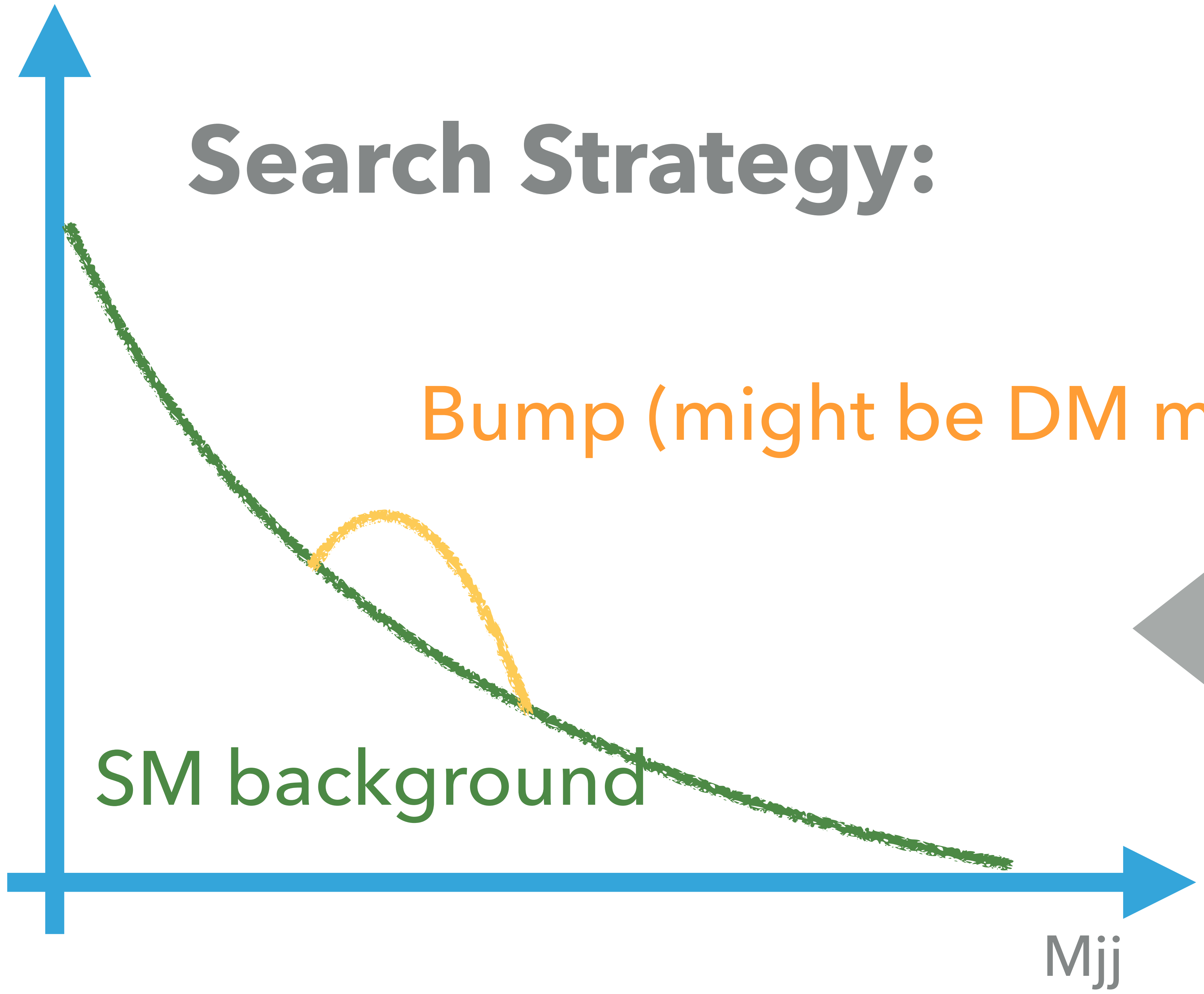
  - **Two Body Decays**



DARK MATTER SEARCHES THROUGH MEDIATOR

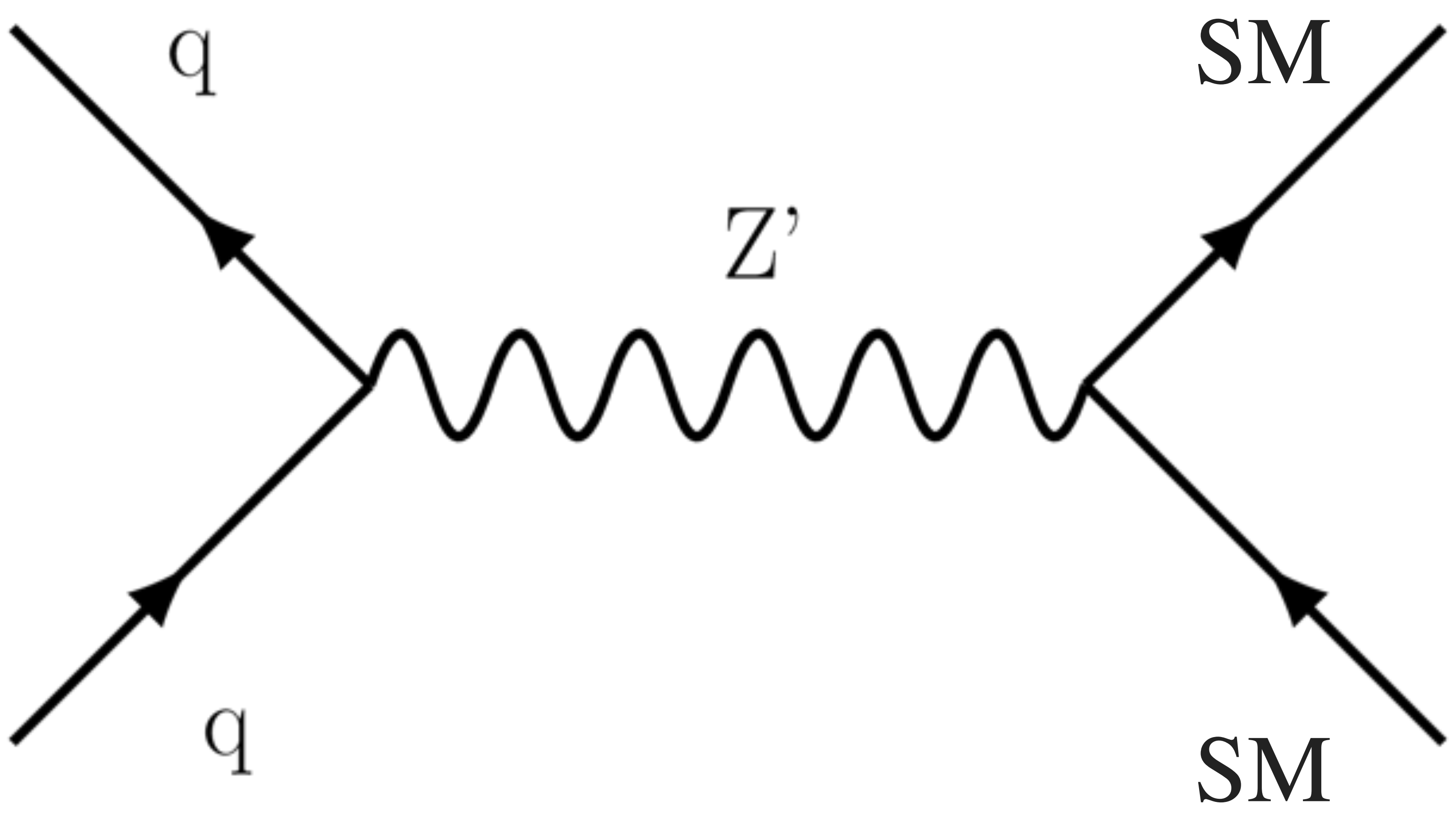
- ***"For DM to be made from quarks, it means that there is a process that can decay back into quarks."***
- Can we look for the simplified force mediator instead?

Search Strategy:



Look for a bump on top of SM background!

- **Two Body Decays**

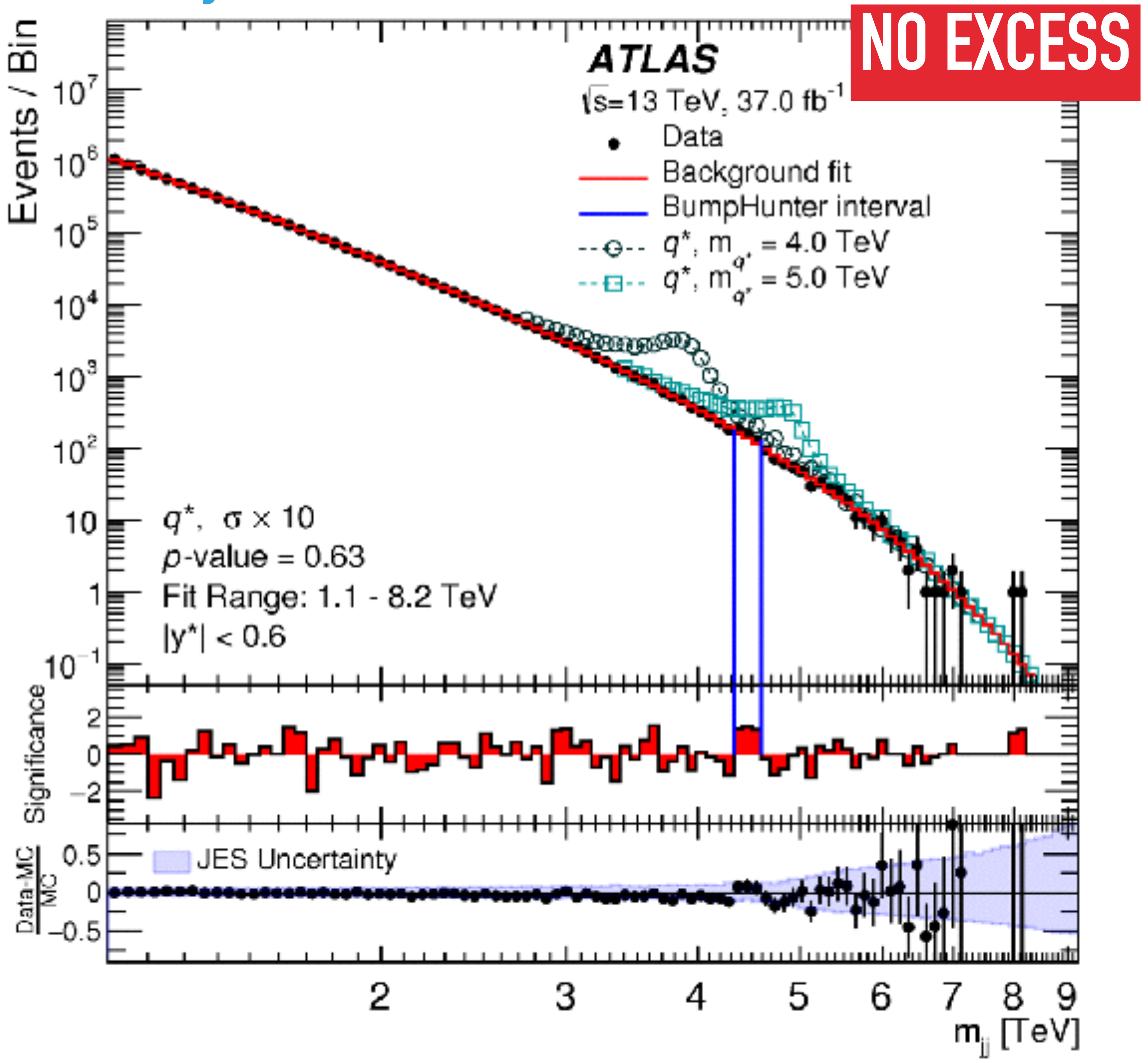


DIJET AND DI-B JETS

- Little is known about the force mediators, based on different assumptions, different signatures are preferred.

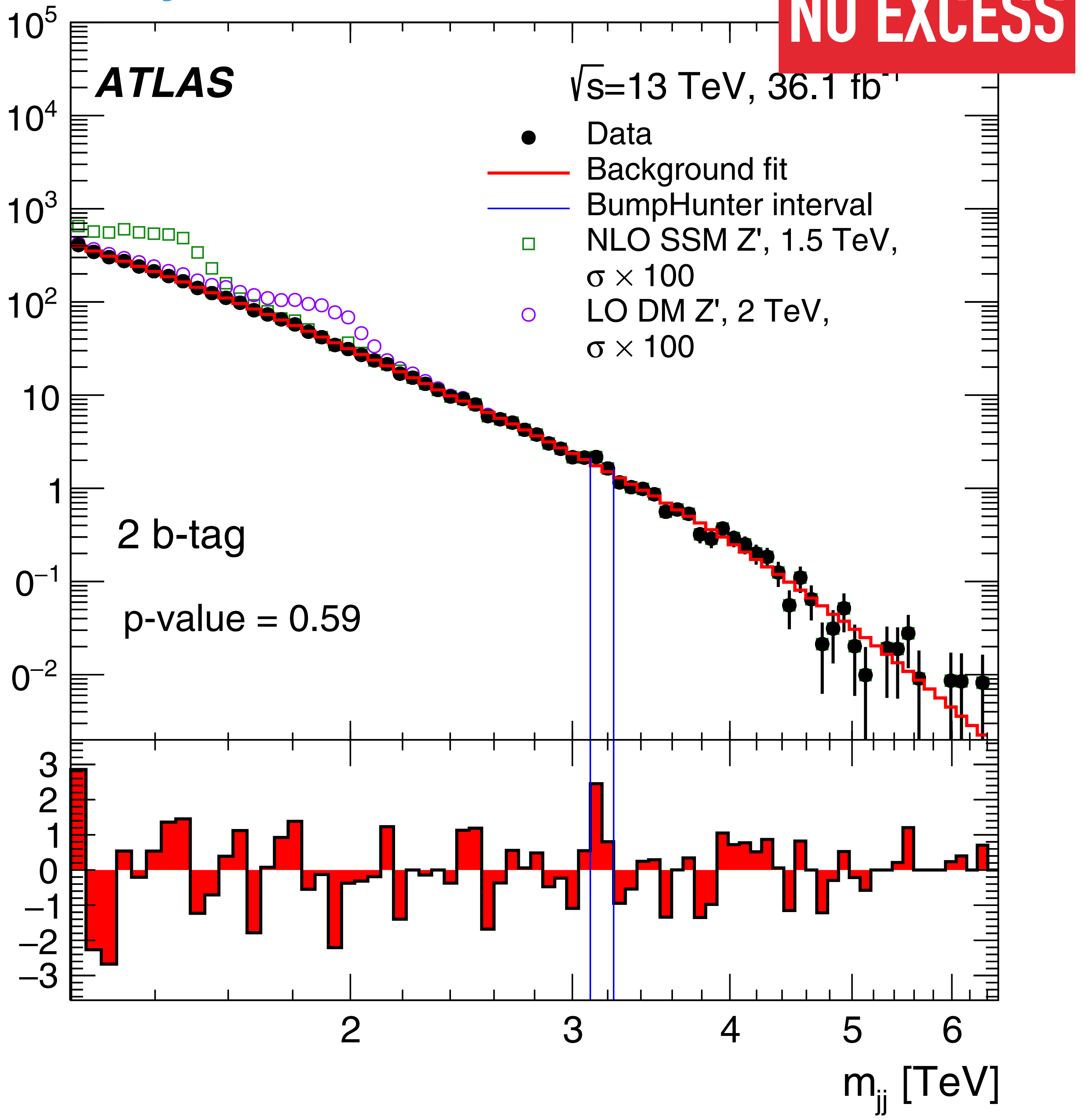
Dijet

(Phys. Rev. D 96 (2017) 052004)



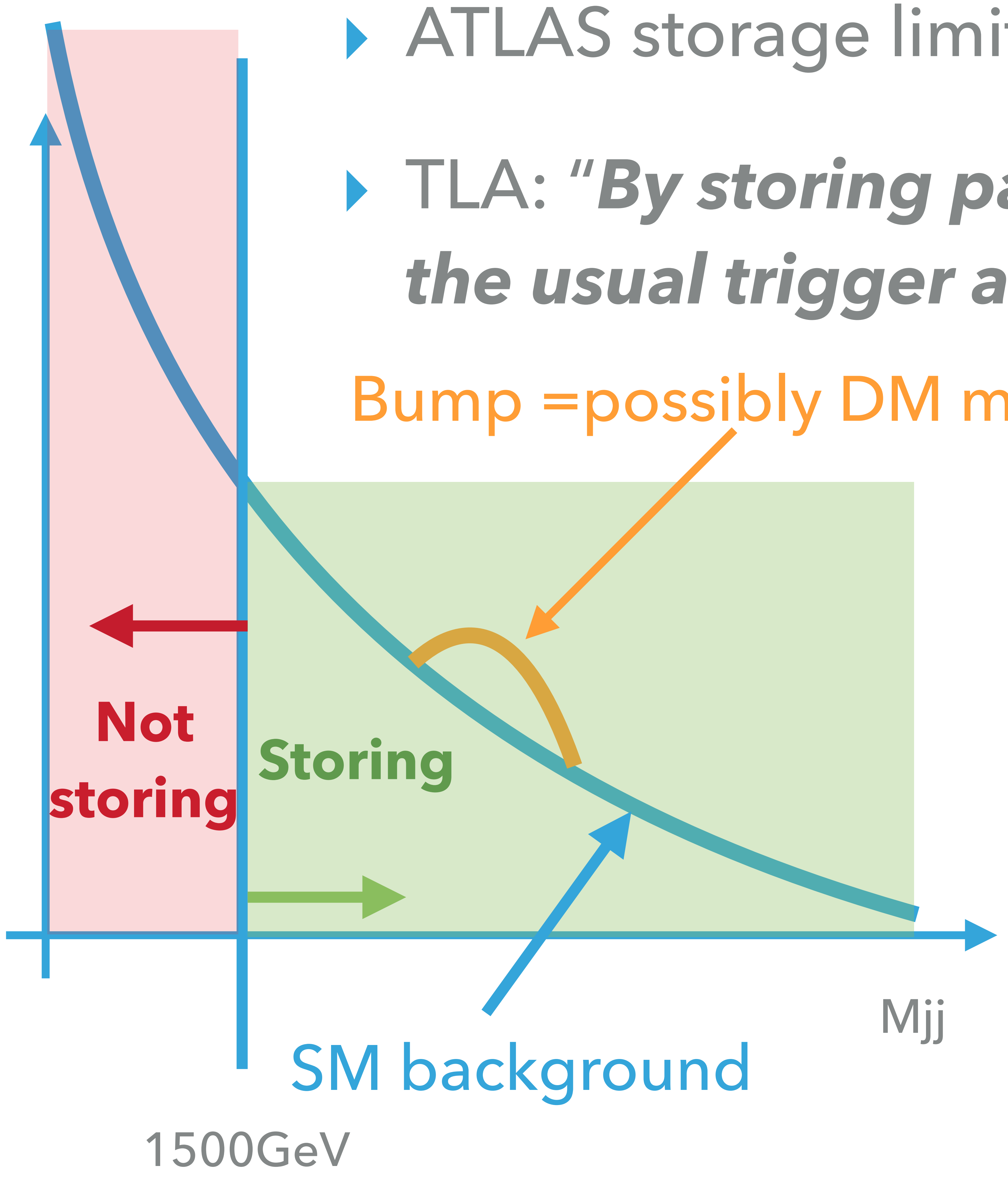
Di-b jets

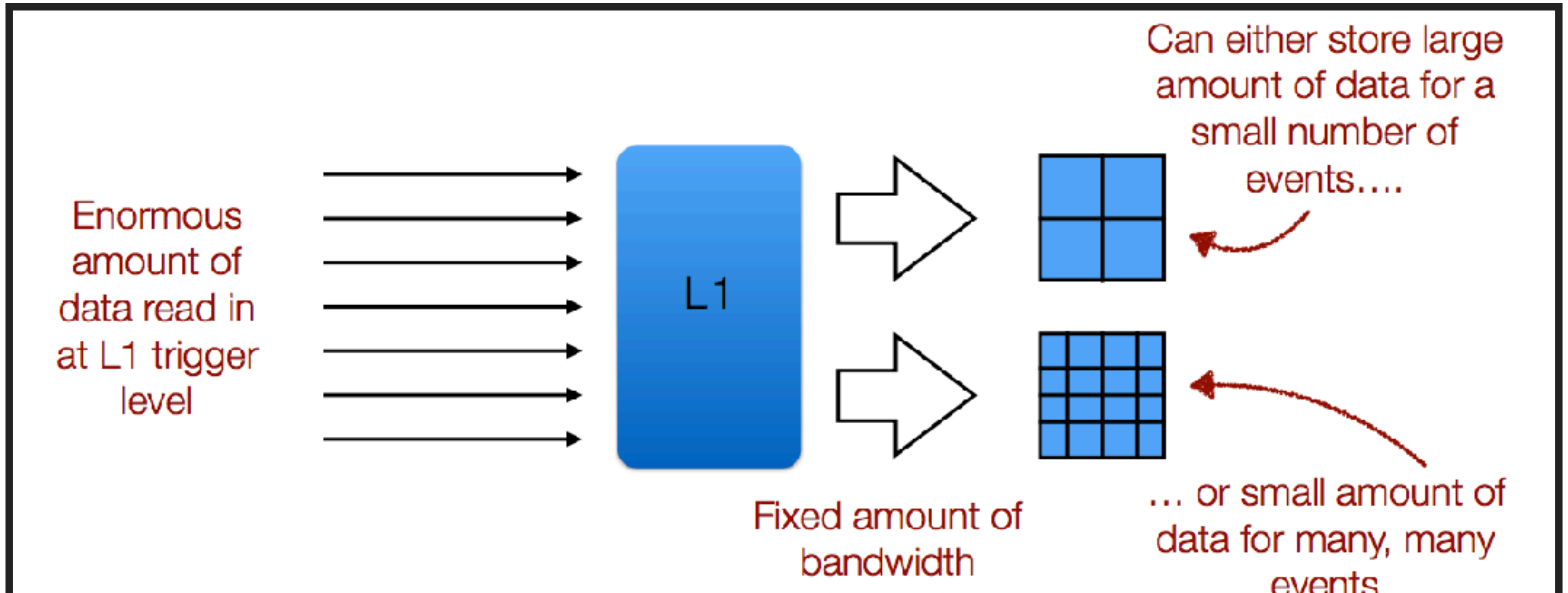
(Phys. Rev. D 98 (2018) 032016)



TRIGGER LEVEL ANALYSIS (TLA)

- ATLAS storage limit-> We don't store events below a jet pT threshold
- TLA: "***By storing partial information in events, we can go below the usual trigger and look for Z' lower in mass than dijet.*** "

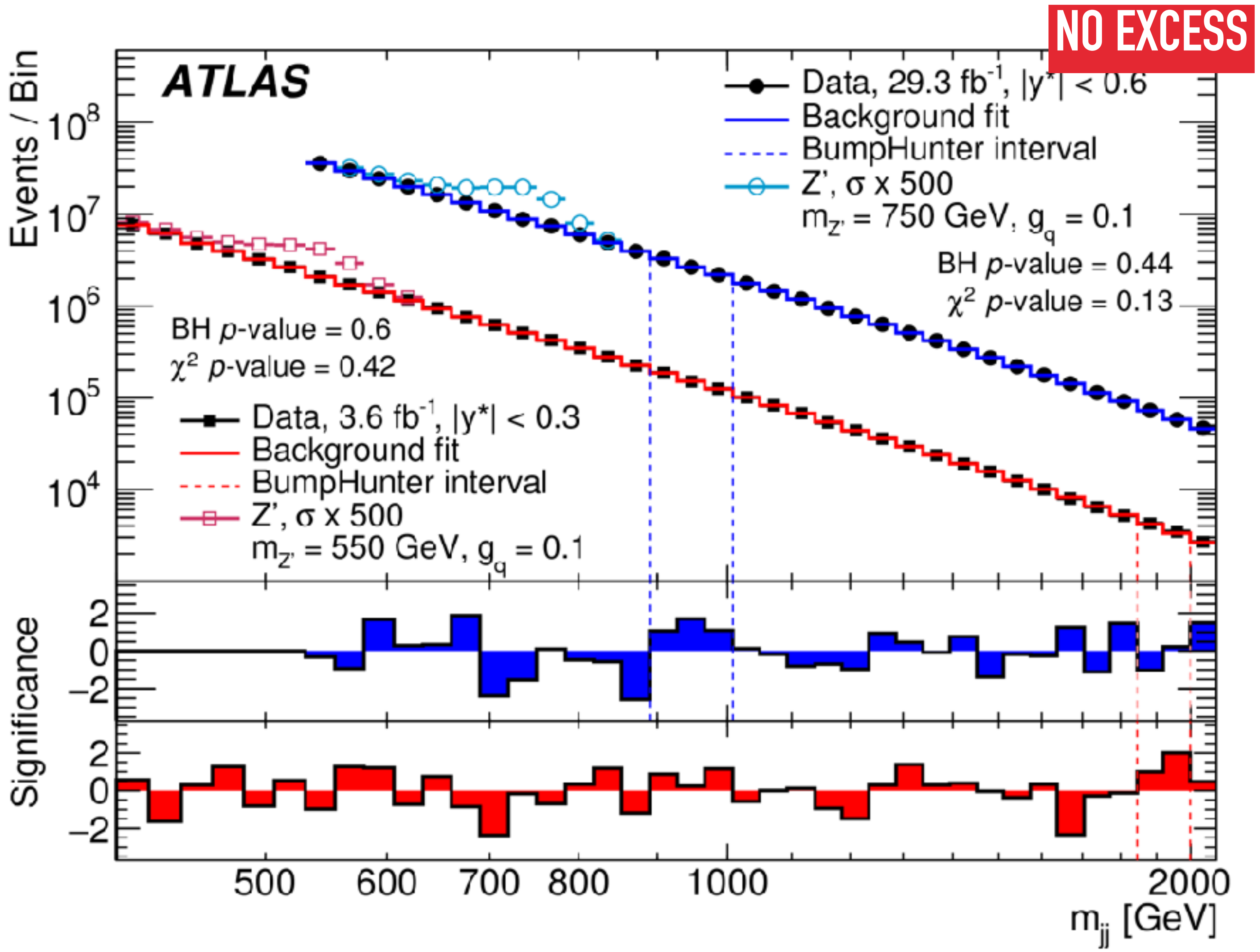




TLA Cartoon by Katherine Pachal

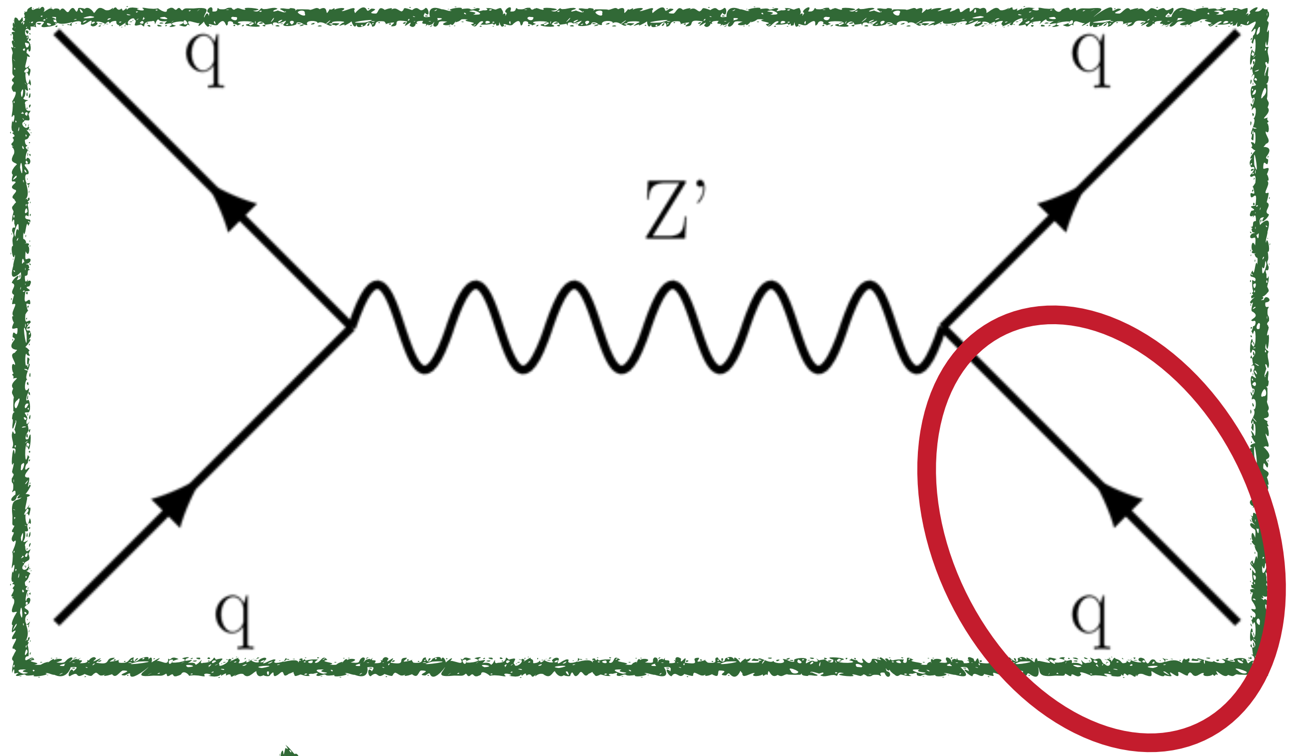
TRIGGER LEVEL ANALYSIS (TLA) RESULTS

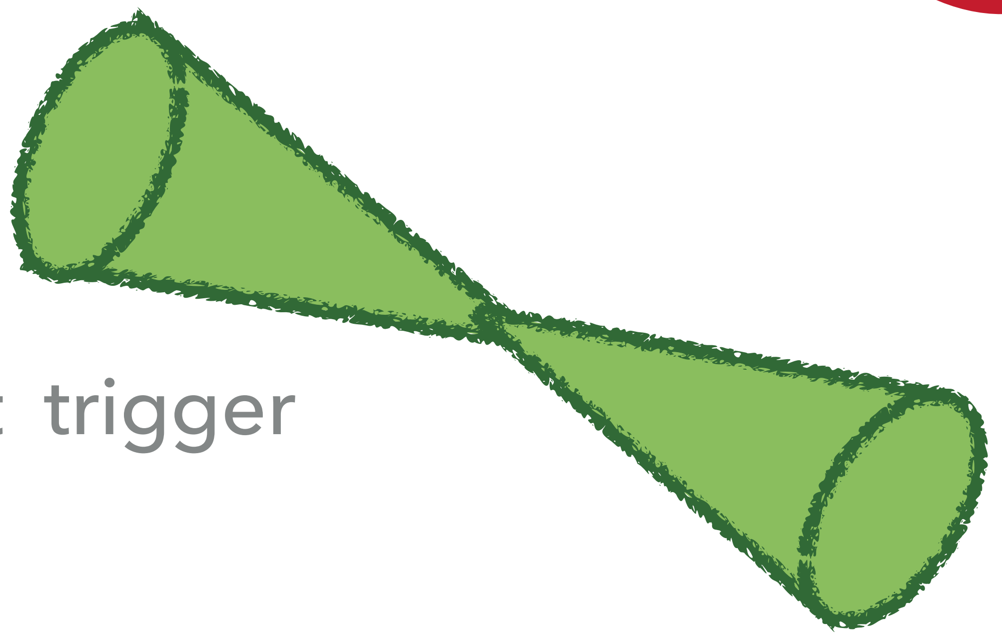
- (Phys. Rev. Lett. 121 (2018) 081801)
- Covering a lower mass range than dijet



CAN WE GO EVEN LOWER IN THE Z' SEARCH MASS?

Dijet/TLA:





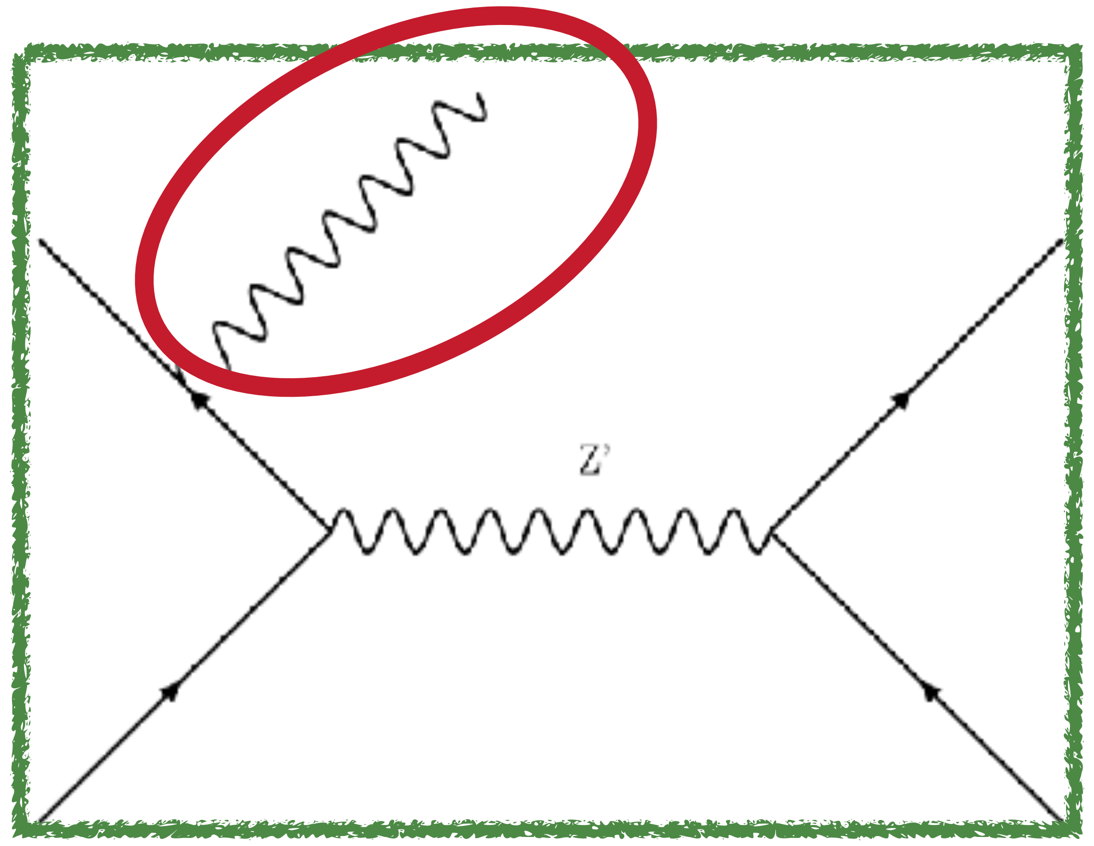
1. One jet pT at trigger

2. Other jet pT ≈ trigger

HIGH MASS Z' !
1500GEV AND UP

Average net PT= 0

DijetISR:



1. A photon at trigger

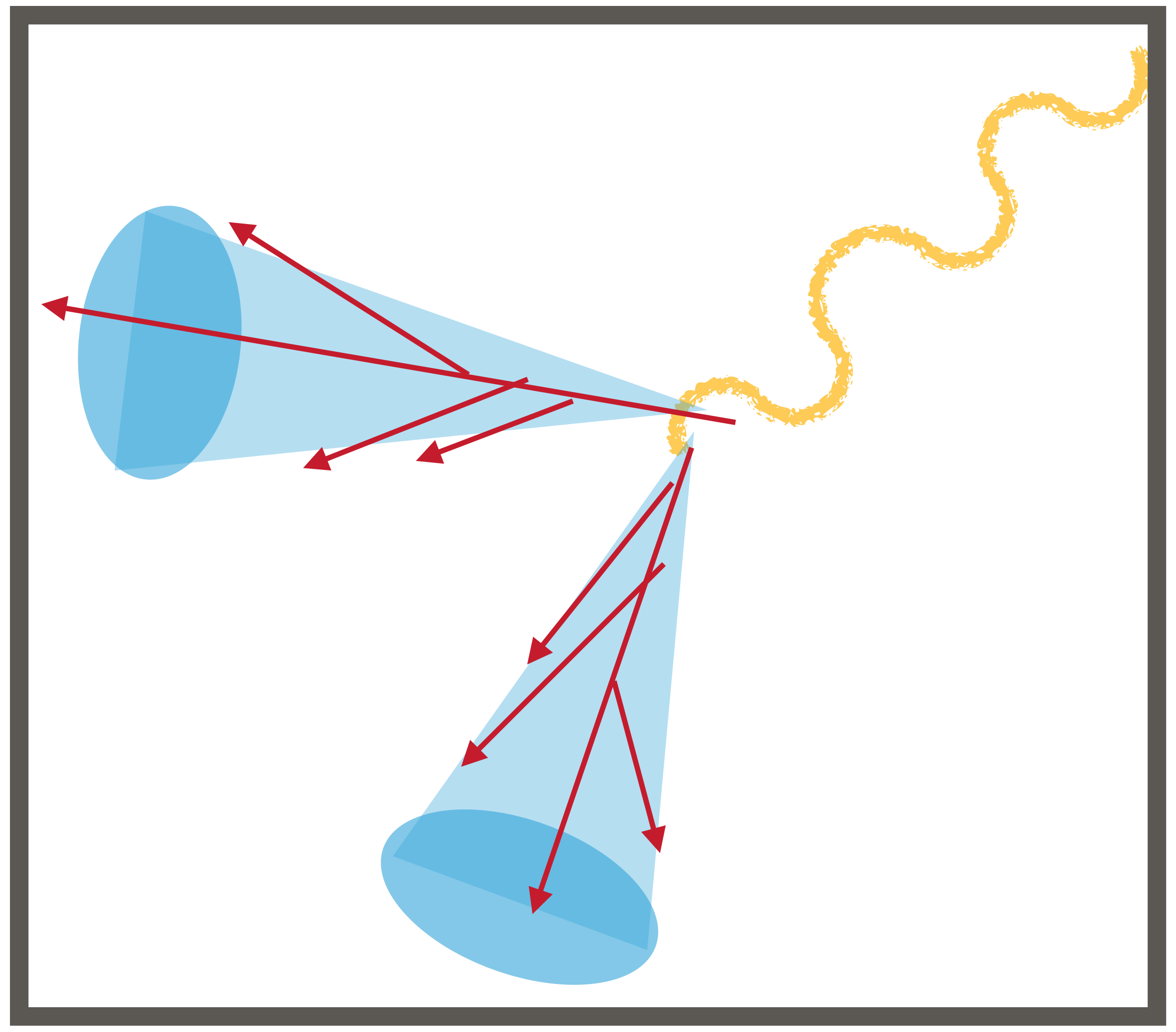
2. Balanced by 2 softer jets

LOW MASS Z' !
100-1200GEV

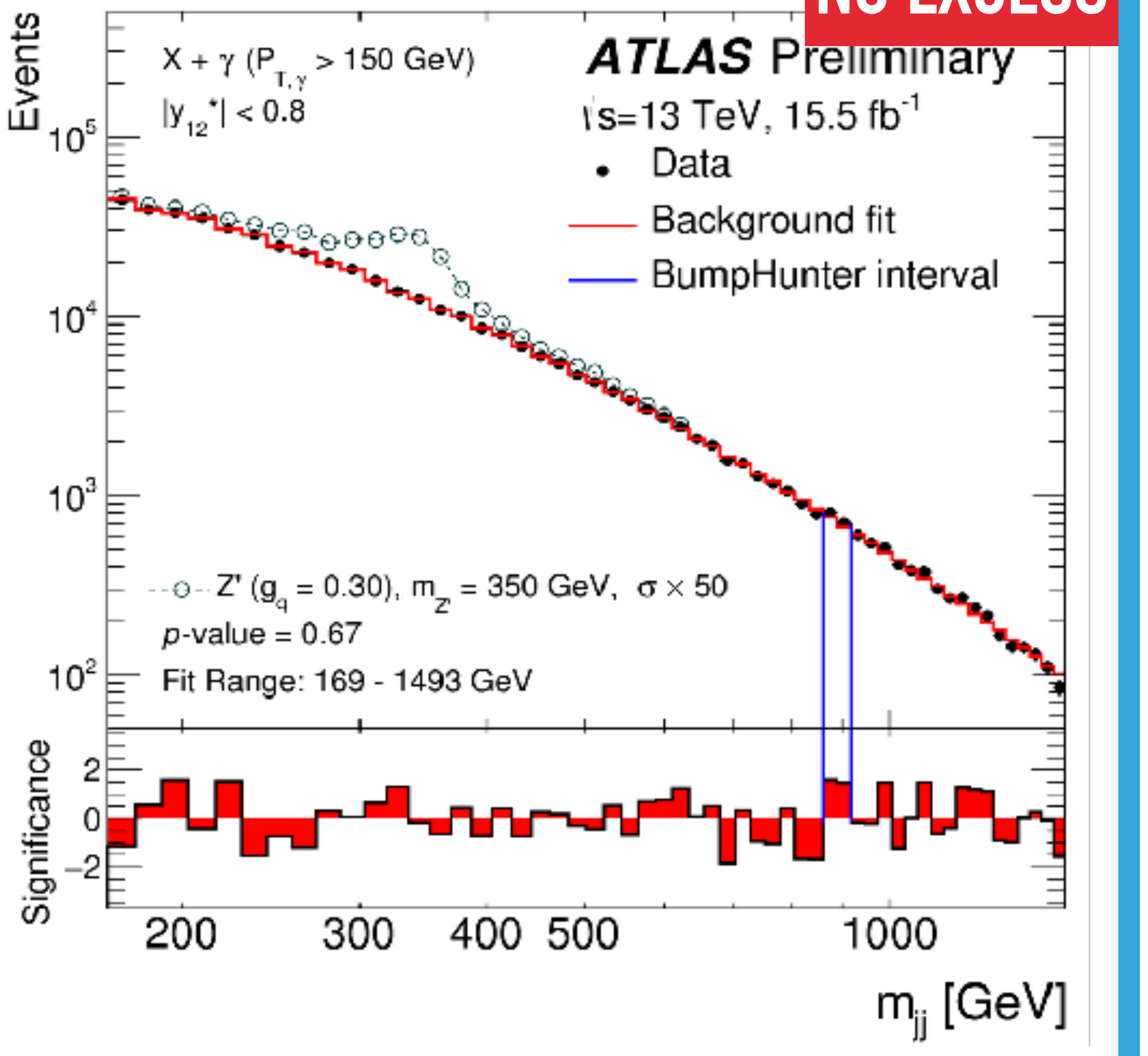
DIJET-ISR

Dijet-ISR Resolved

(ATLAS-CONF-2016-070)



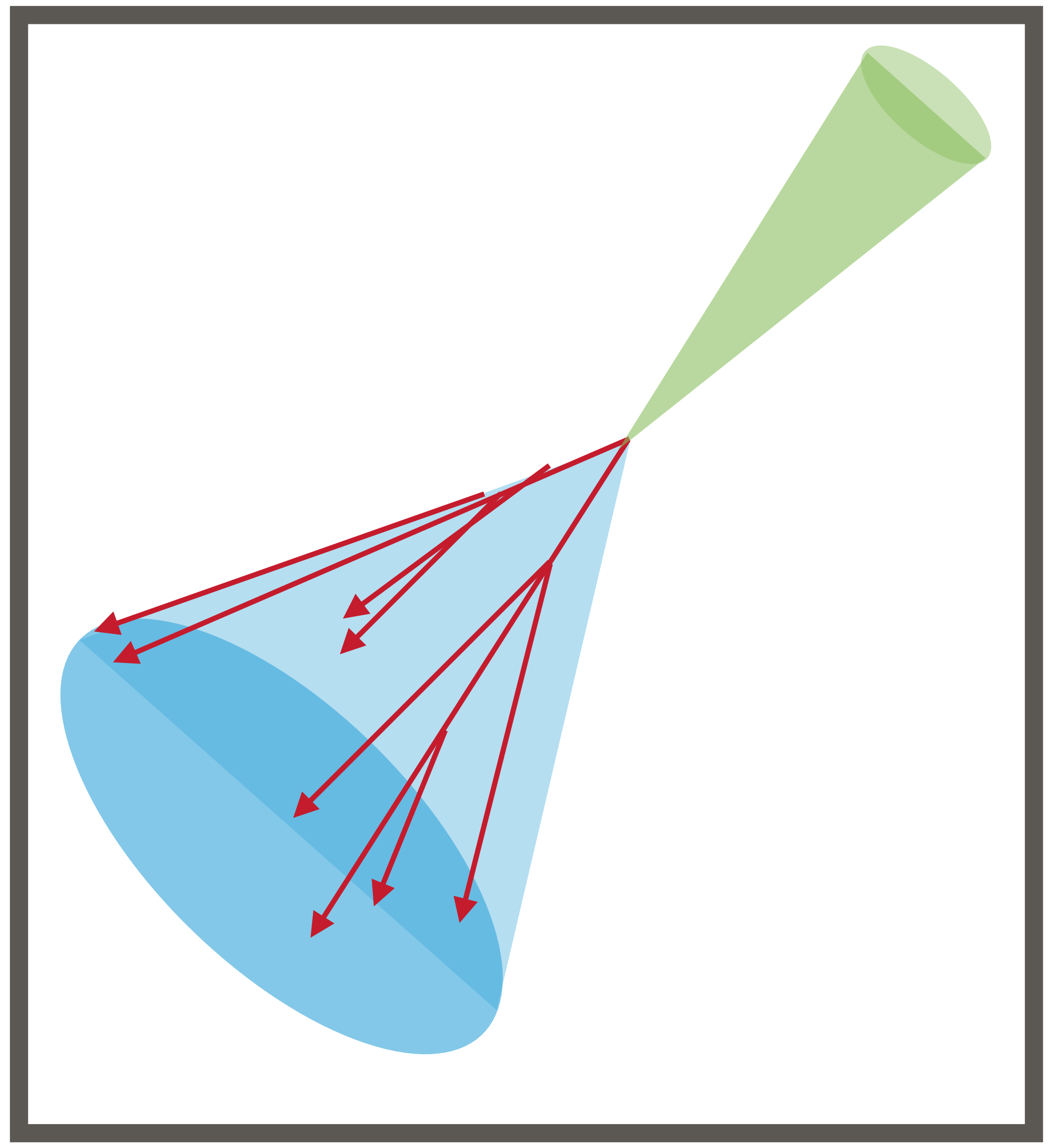
NO EXCESS



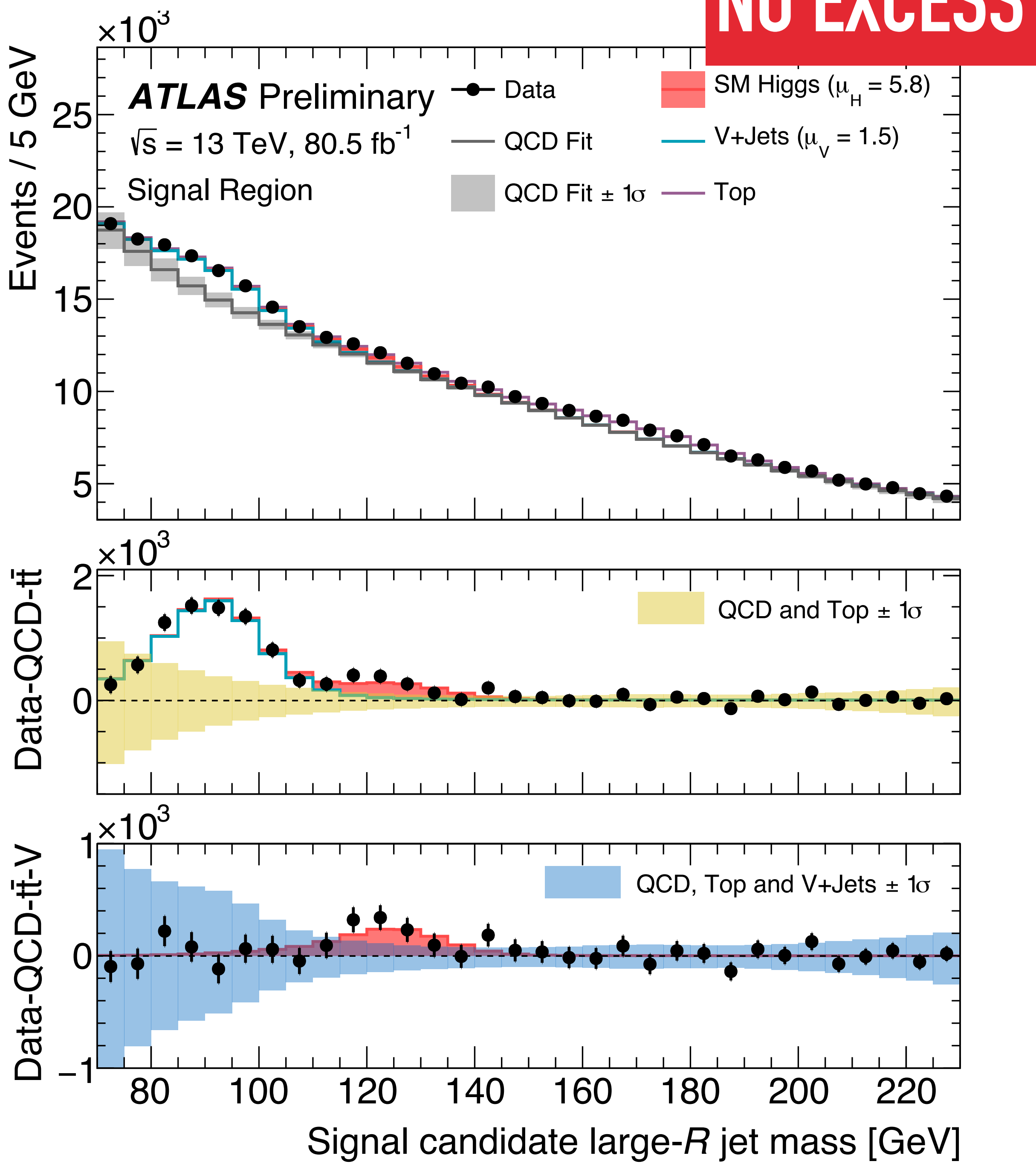
Z′ Mass range 169- 1500 GeV. Exciting new paper coming soon!!

Dijet-ISR Boosted Btagged

(ATLAS-CONF-2018-052)



NO EXCESS

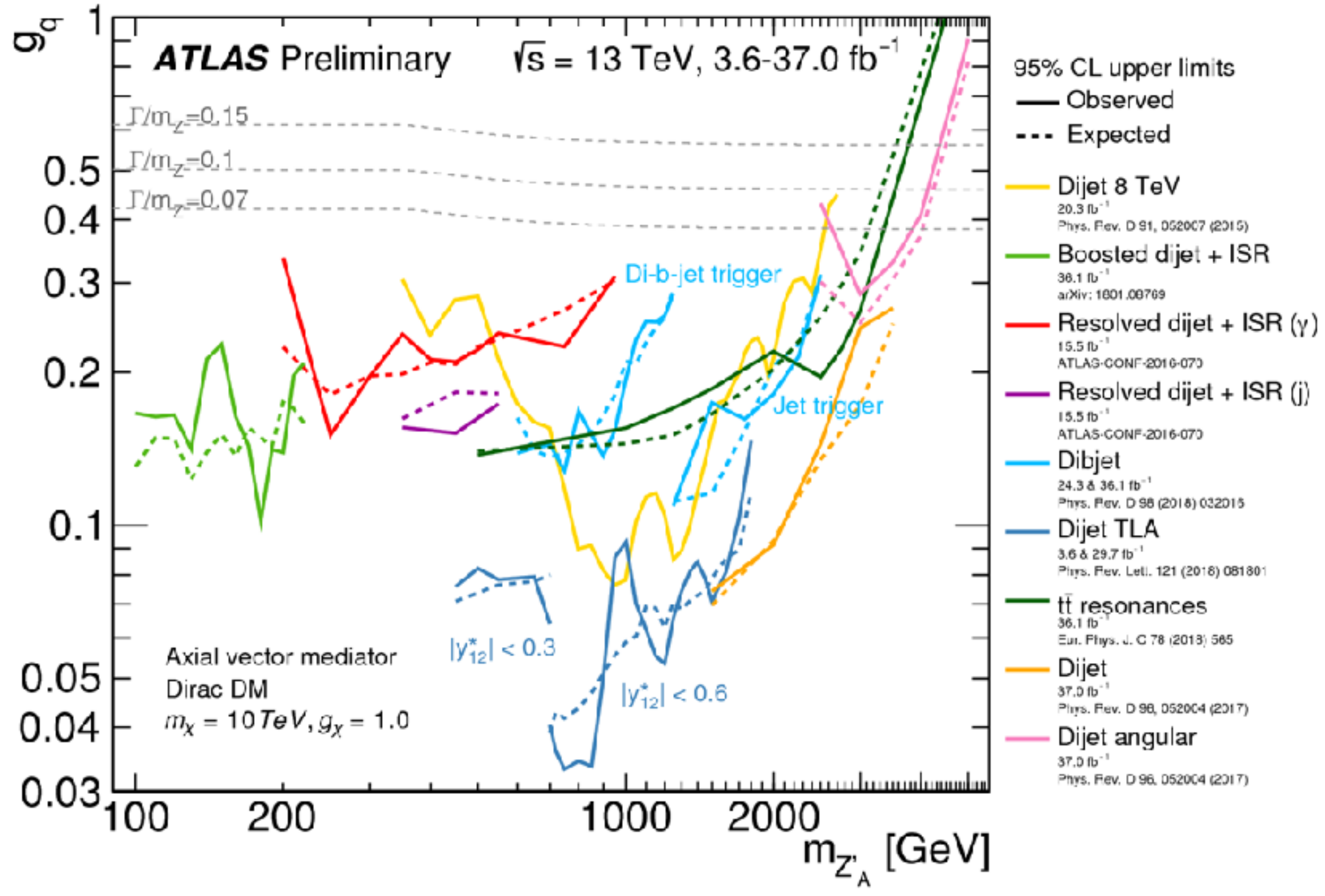


Z′ Mass range 70- 230 GeV. First ever b-tagged result!

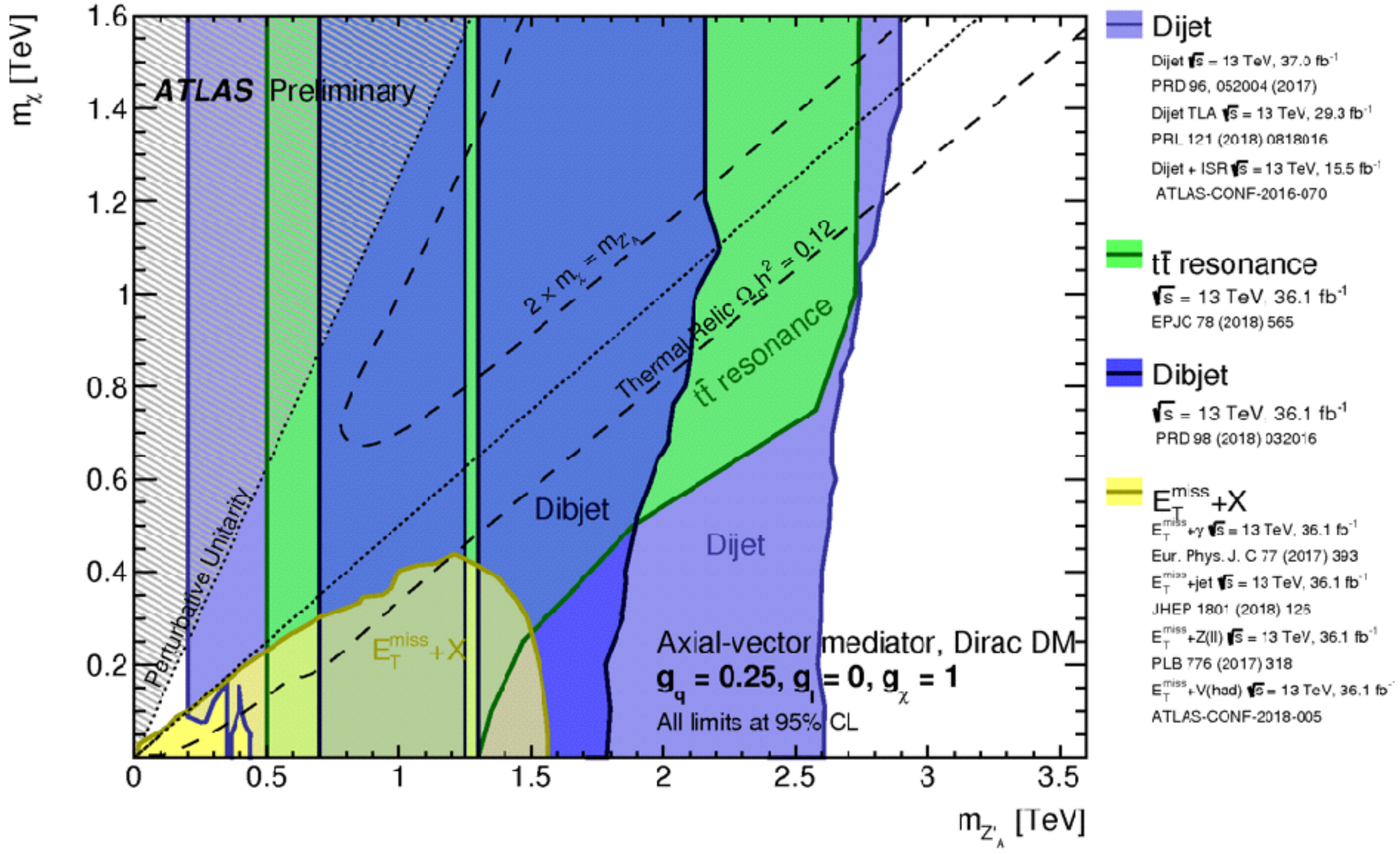
IS THAT ALL? OTHER DARK MATTER SEARCHES IN THE ATLAS DETECTOR

- **Other Mono-X signatures:**
  - Mono-H to invisible particles
  - DM with heavy flavor quarks
- **Other two-body decays:**
  - di-leptons
- **Supersymmetry (SUSY)**
  - Many SUSY searches that looks for gravitino, neutralino etc are natural candidates of DM.

DARK MATTER SUMMARY



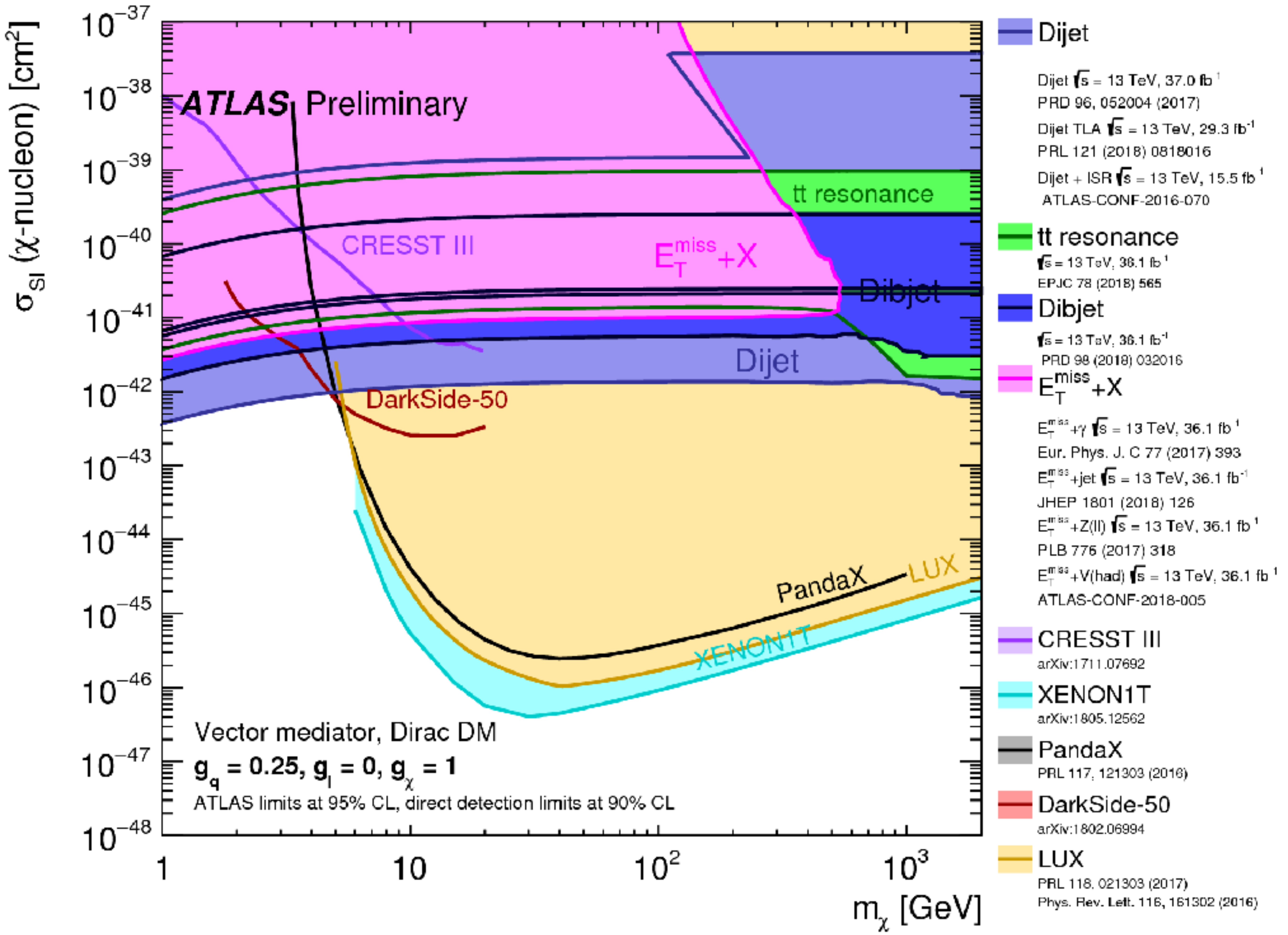
Excluded the Z′ Mass Range from 50GeV to 5000GeV+



Extra exclusion phase space from the mono-X and dijet searchess

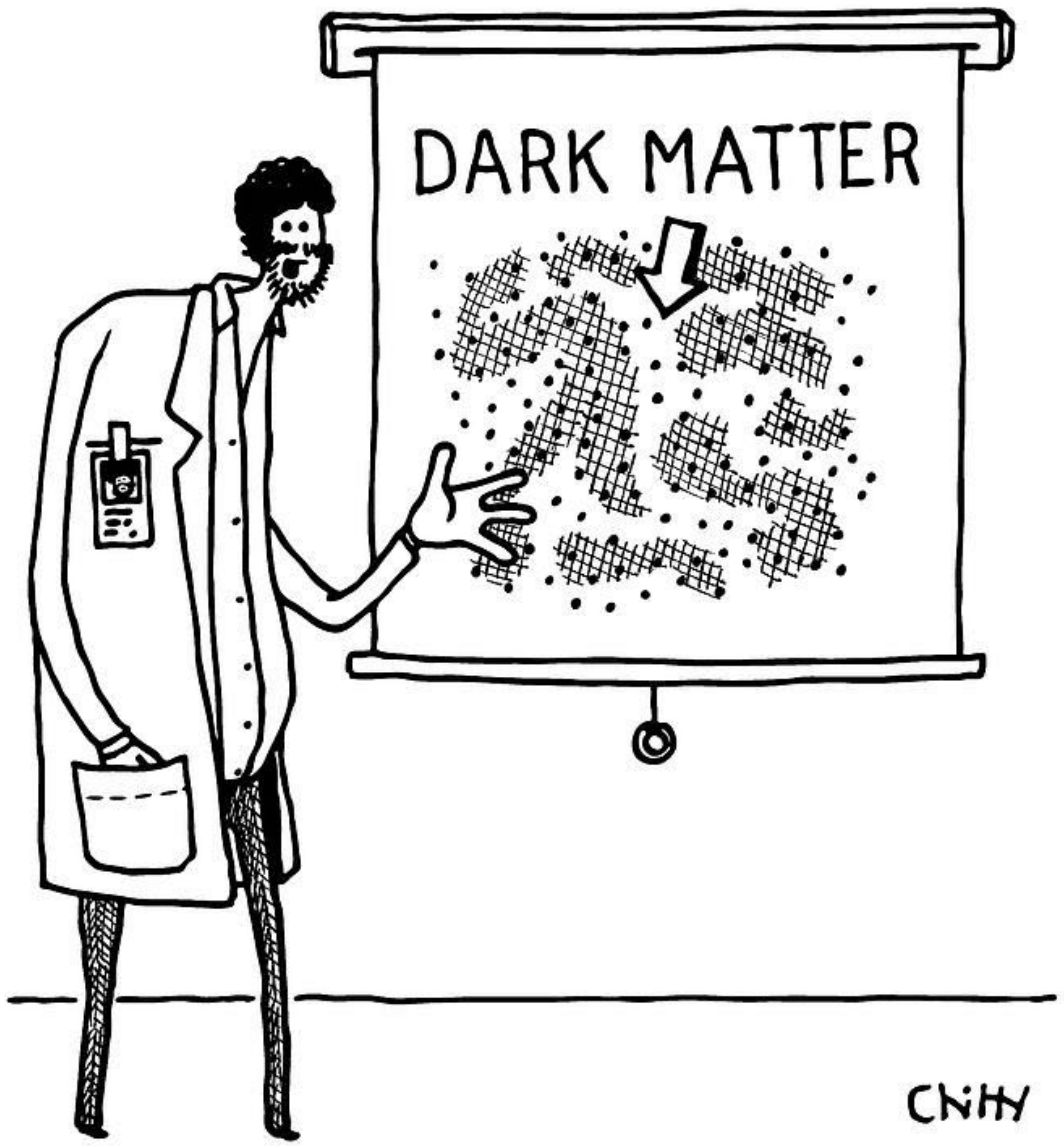
DM SEARCHES IN ATLAS

- ATLAS DM searches makes model assumptions, it is complementary to ID + DD in the overall DM search.



CONCLUSION

- No signs of DM yet! But in ATLAS, we have:
  - More data than ever
  - Continuous advancements in our search techniques
  - Expect to gain sensitivity in all variable phase space
- Future of DM searches in ATLAS:
  - Long lived particle signature searches
  - Moving towards more detailed models



"We're quietly confident that it smells of cinnamon."


COMING SOON???
DARK MATTER

ACKNOWLEDGEMENTS

- I'd like to thank these awesome ATLAS physicists: ***Daniel Antrim, Matteo Bauce, Caterina Doglioni, Johanna Gramling, Daniel Guest, Zach Marshall, Sam Meehan, Daniel Whiteson and Lidija Zivkovic*** for their ***feedback on the physics and the aesthetics*** through the process of making these slides. They would not have been the same without their meticulous scrutinies.
- I would also like to thank ***Andy Dang and Tamara Rodriguez*** for their ***feedback on the cartoons*** used in these slides. The talk would not have been as interesting without them. :)

BACK UP

MONO-HIGGS(INVISIBLE)

Mono-Higgs(->Invisible Decay)

(arXiv:1807.11471/HIGG-2018-54)