



**EUROPEAN OPEN  
SCIENCE CLOUD**



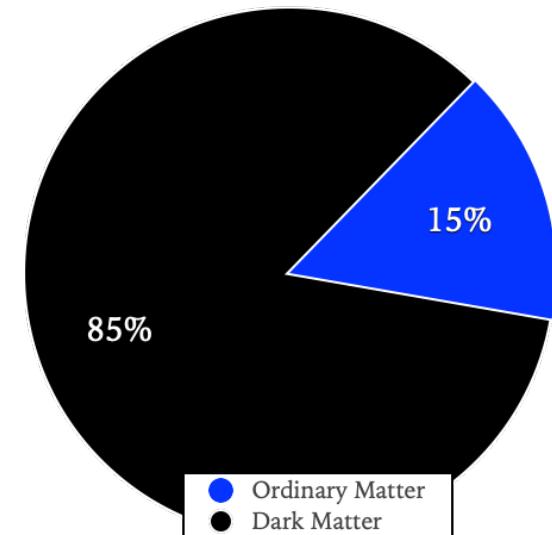
# ESCAPE – ATLAS Dark Matter Contribution

JARED LITTLE

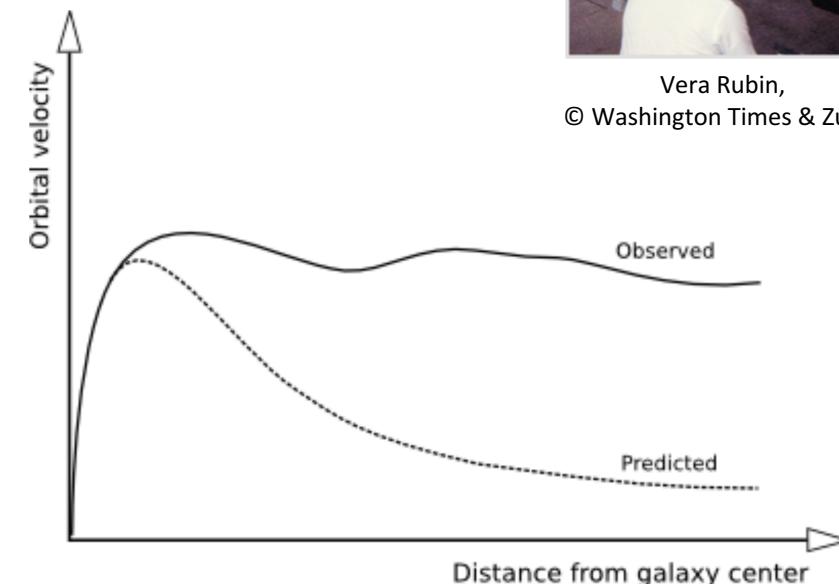
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# Science Question: Dark Matter



Vera Rubin,  
© Washington Times & Zuma



JARED LITTLE

# Workflow: Direct Detection

Discussions on improving interpretations/plots

Discussions on standardized  
data formats for  
other experiments

Theory input & code [LAPP/LAPTH]

ATLAS/CMS [LAPP+Lund/INFN]



**reana**



Discussions on using  
common steering  
(declarative?) analysis code

Darkside [INFN]

LHC Data

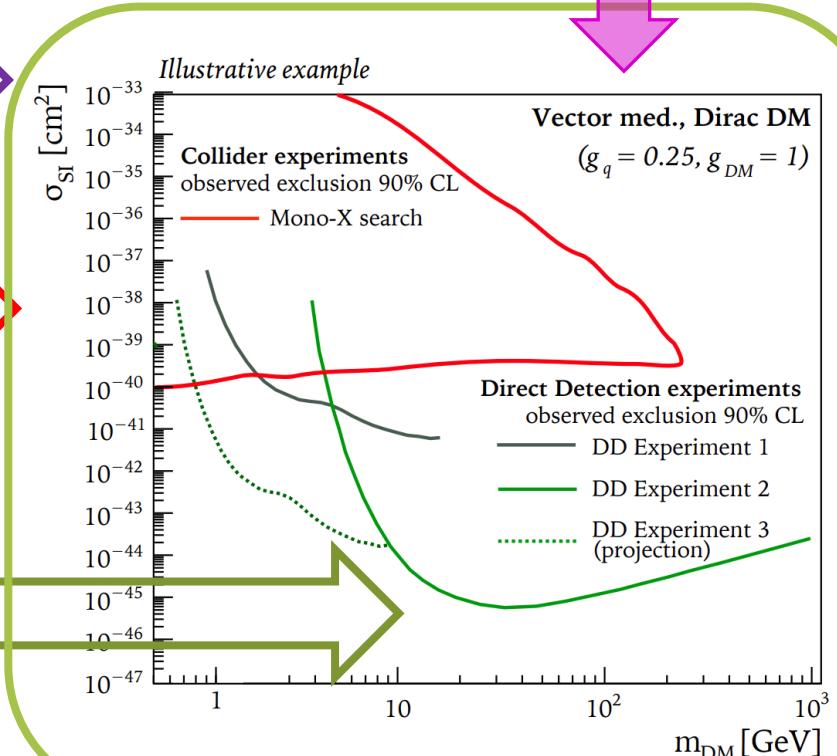
Direct  
Detection Data

Data Lake

Software Catalogue

Science Output

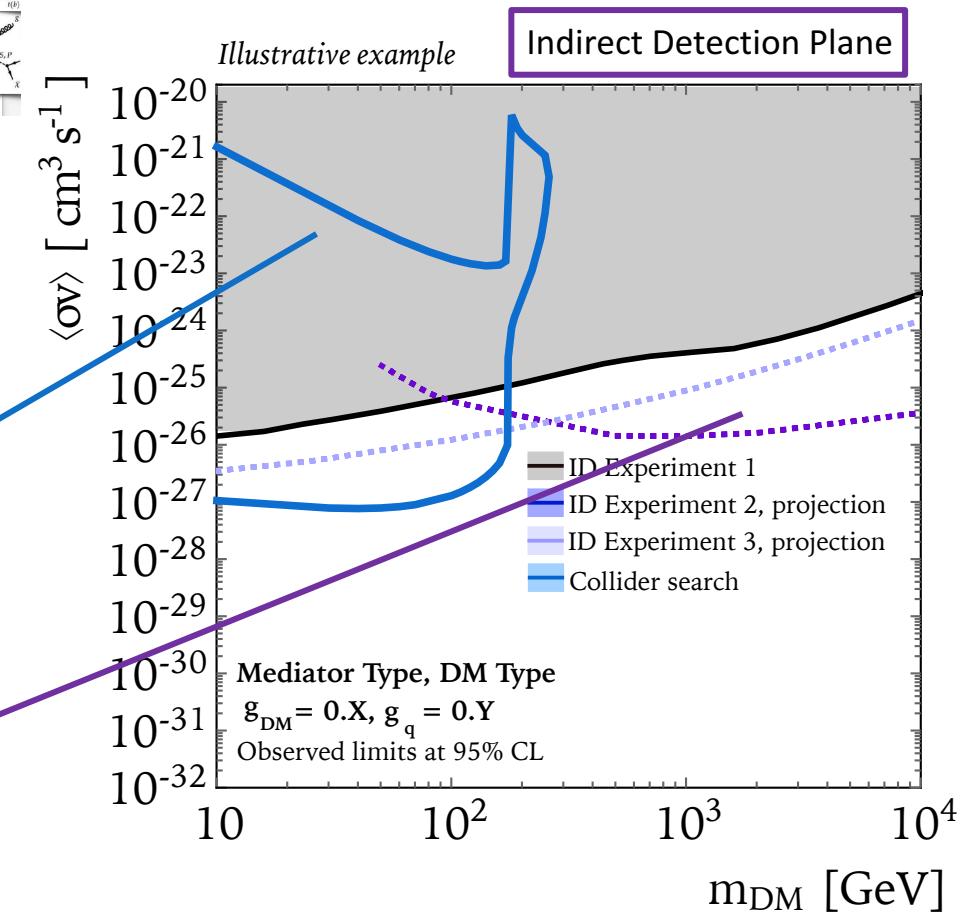
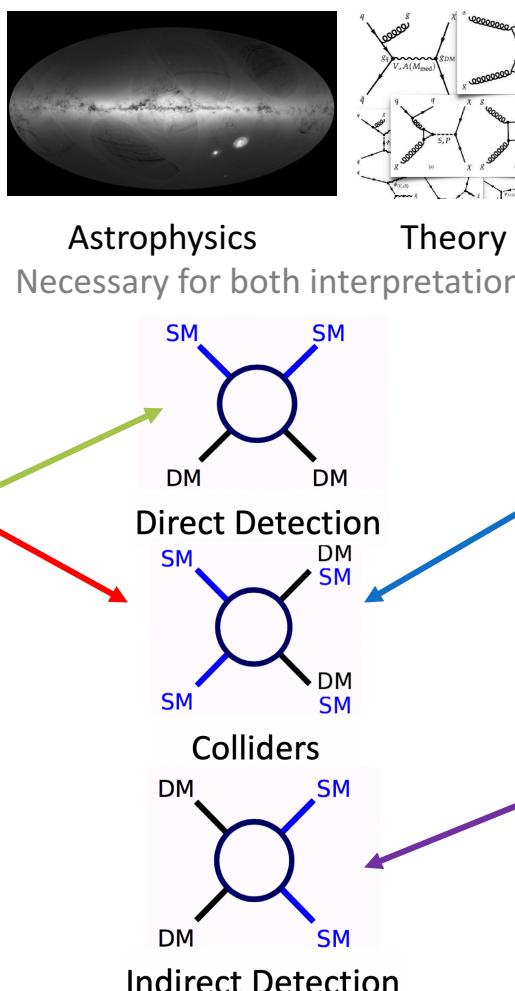
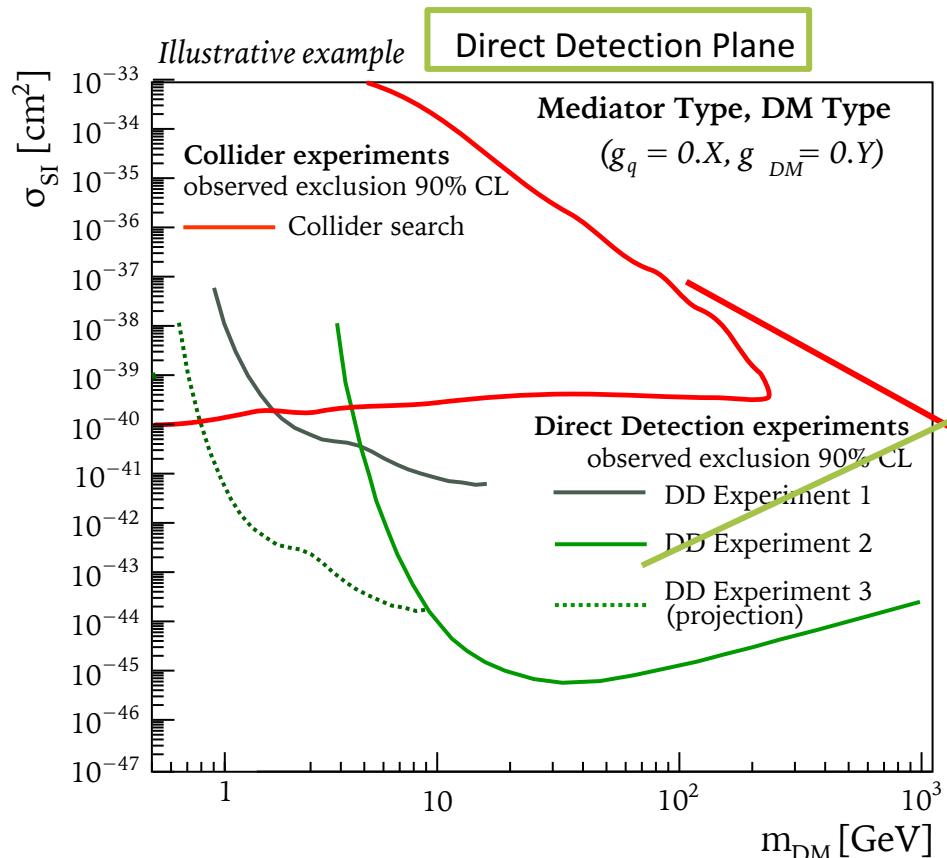
Cross-Science Project: novel algorithms



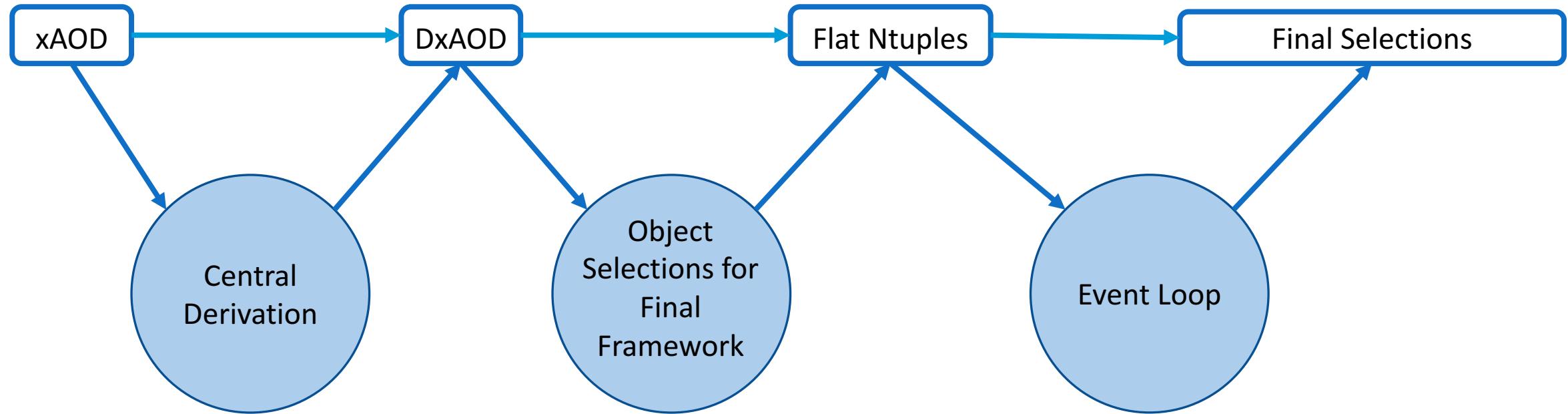
# Scientific Output: Baseline

New analyses will be performed, with their results being compared (example curves below).

- Results and analyses will be made available on the Virtual Research Environment.



# ATLAS Analysis Workflow



## Users – Internal

<https://projectescape.eu/internal>

### RECAST in simplified terms:

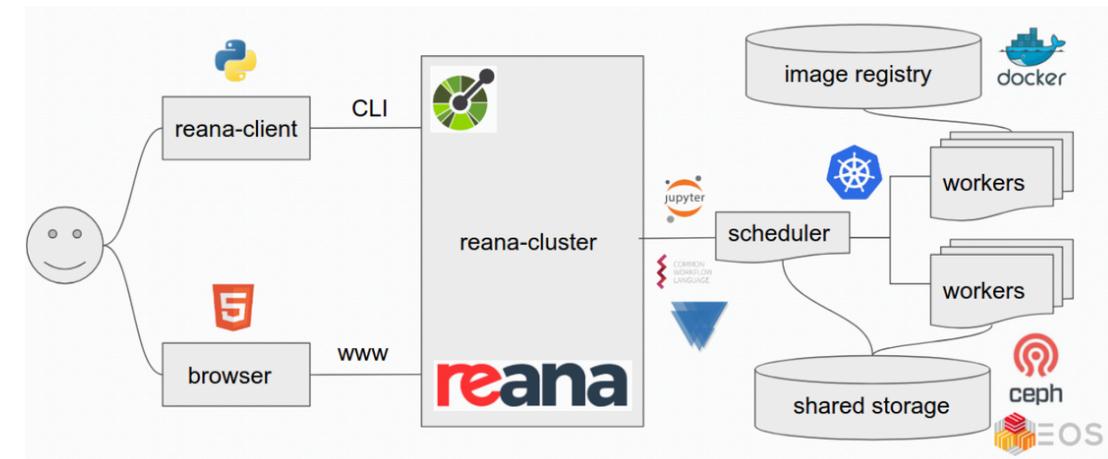
1. Analysis code preservation.  
Analysts preserve the code framework (git).
2. Environment preservation.  
ATLAS has developed version-controlled docker images, encapsulating the OS, compilers, and standard libraries.
3. Automated re-interpretation.  
Automate the steps for passing a new signal model through the analysis chain (yadage).

<https://danikam.github.io/2019-08-19-usatlas-recast-tutorial/>

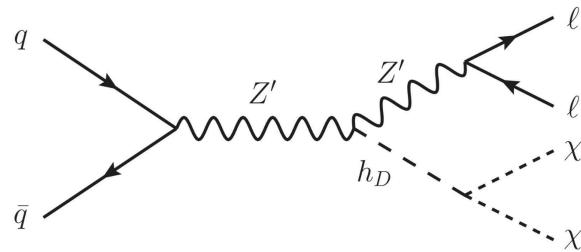
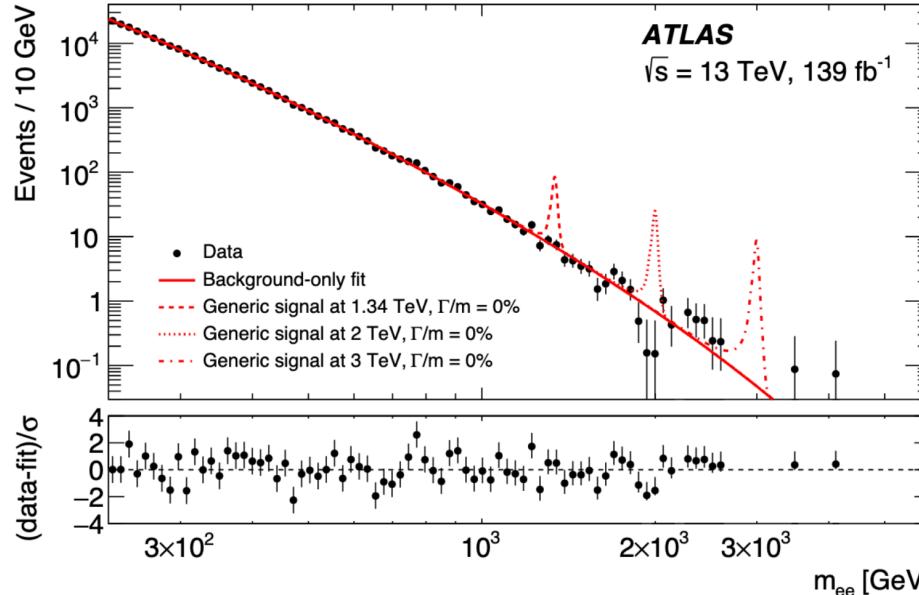
## Pipelines Preservation

RECAST – a framework for reusing estimates of backgrounds, uncertainties, and observations in the data to test alternative signal hypothesis.

REANA - **reproducible analysis** platform for running containerized data analysis pipelines on remote clouds.

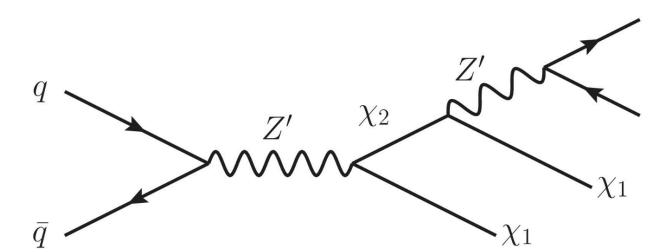


<https://docs.reana.io/>



### Dark Higgs

- New massive scalar ( $h_D$ ) with couplings to Z' and Dark Matter ( $\chi$ ).
- Assume minimal mixing between  $h_D$  and SM higgs.



### Light Vector

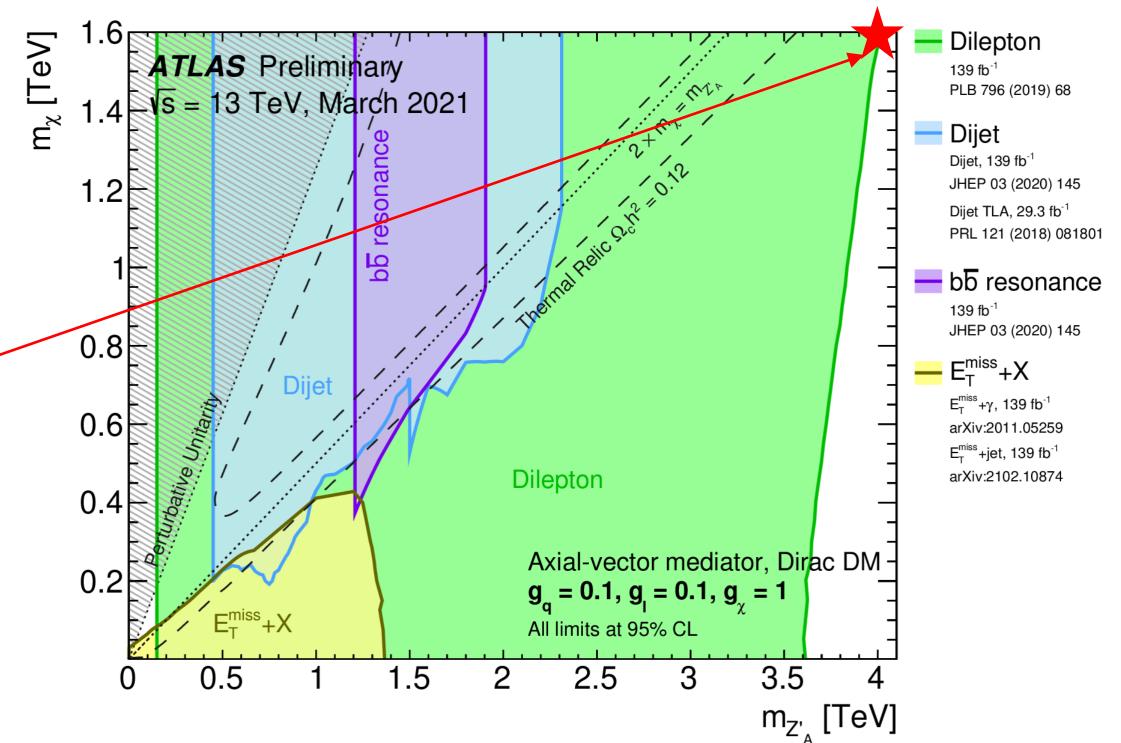
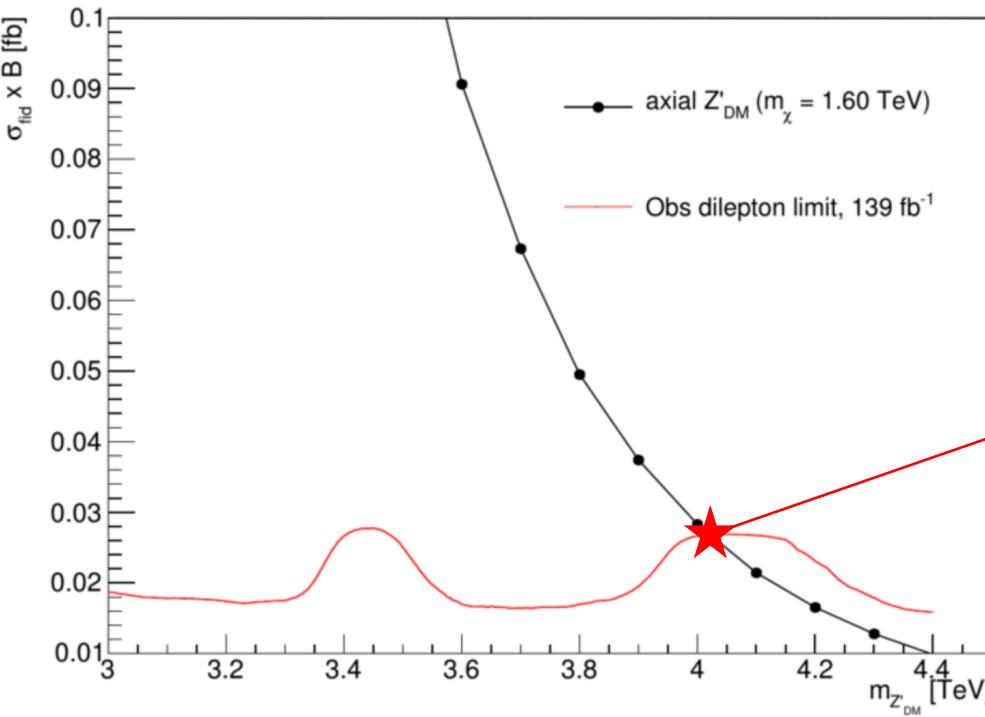
- Relatively light Z' with off-diagonal coupling to dark sector fermions ( $\chi_1, \chi_2$ ).

<https://arxiv.org/pdf/1504.01386.pdf>

# Integration of Collider Search – Short Term

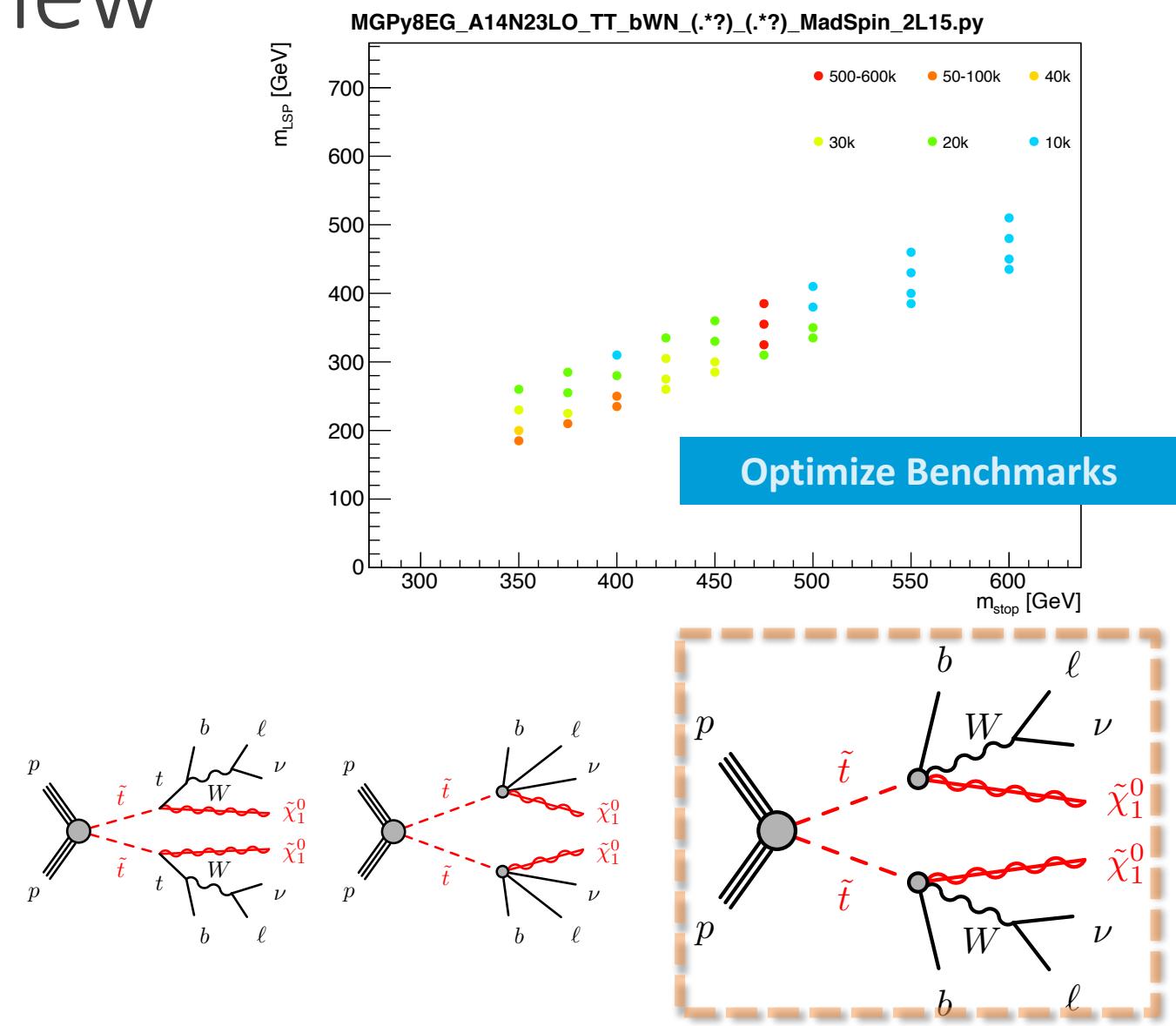
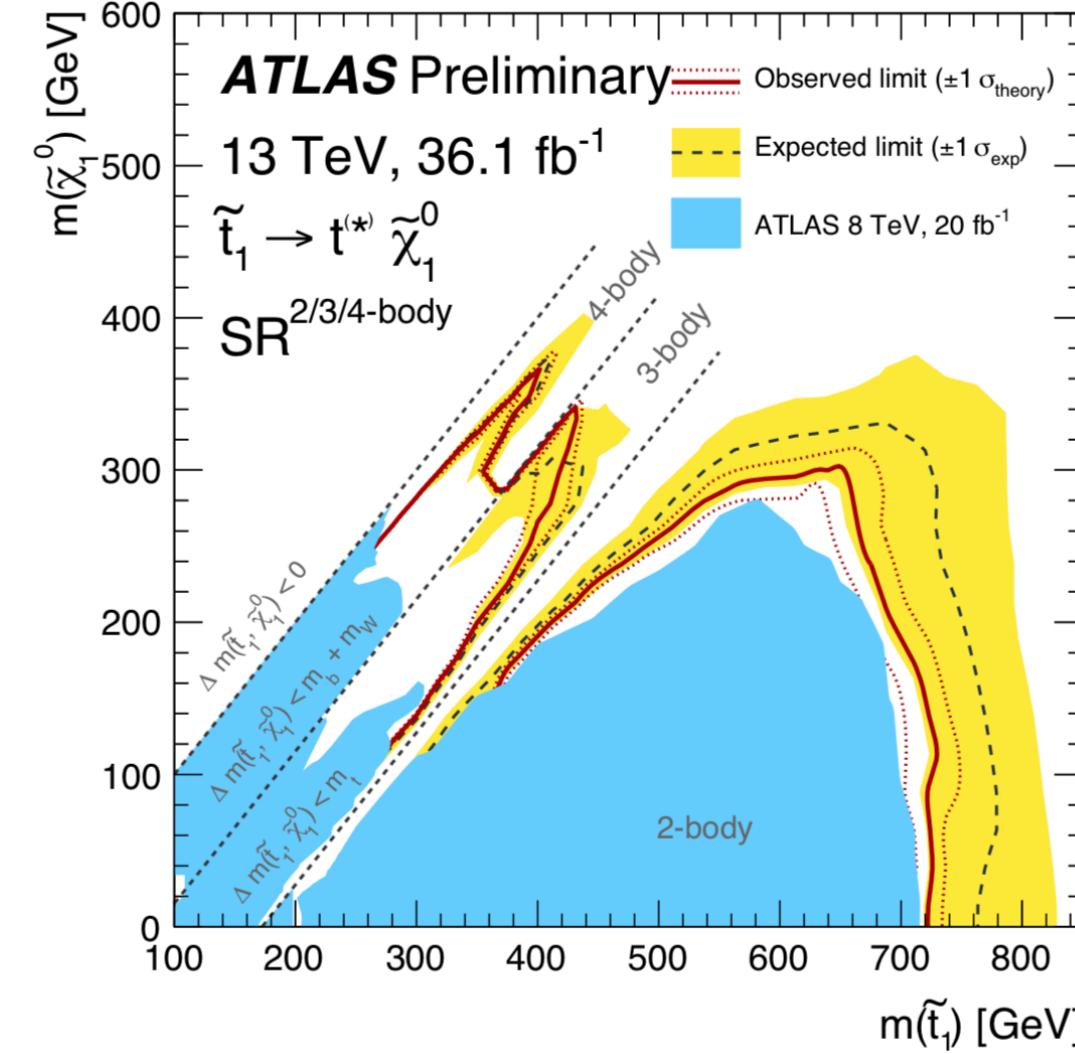
**Using dilepton resonant search for constraining dark matter mediators.**

- Setting limits on  $Z'_{DM}$
- Use as test-case scenario within ESCAPE platform for quick results!

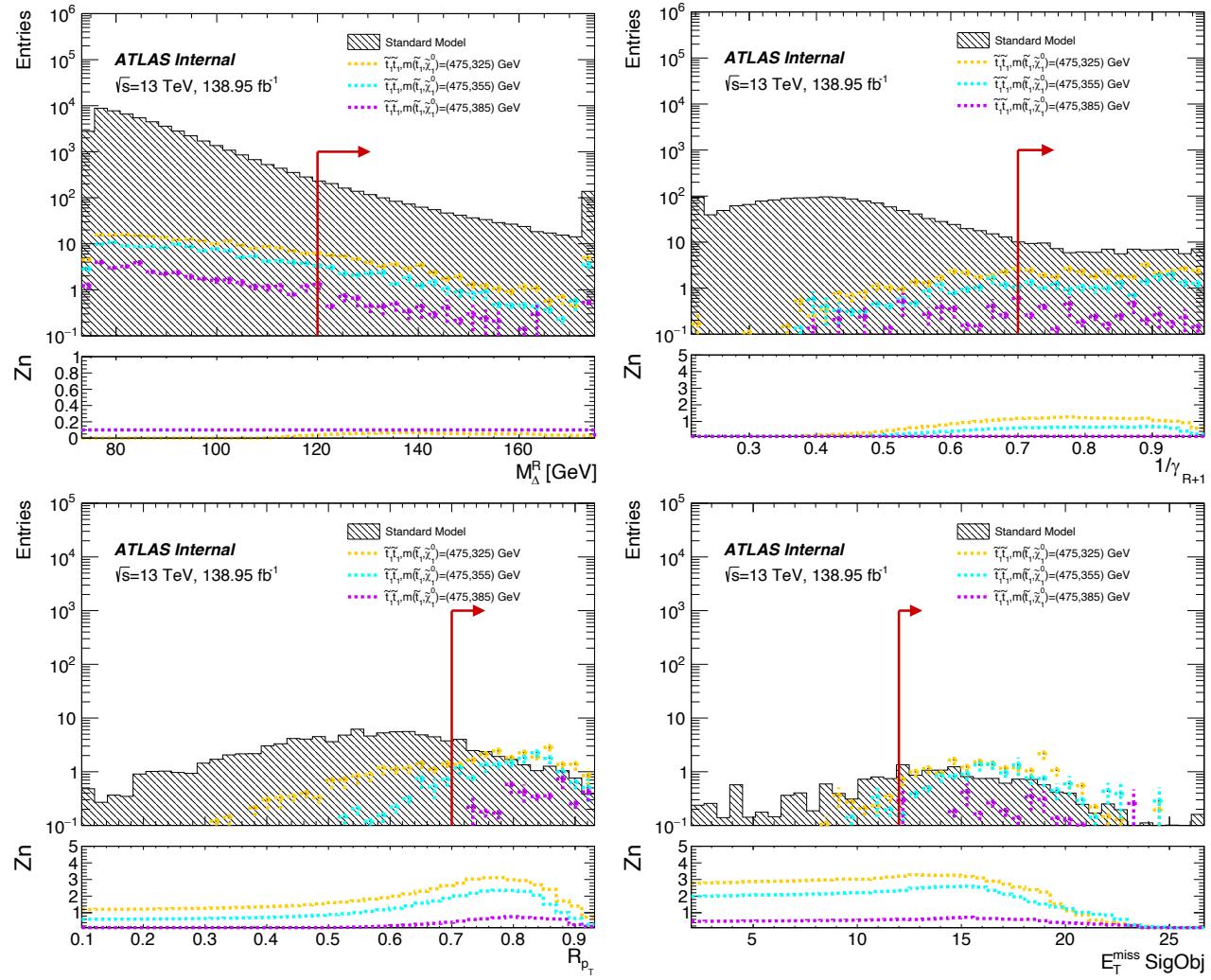
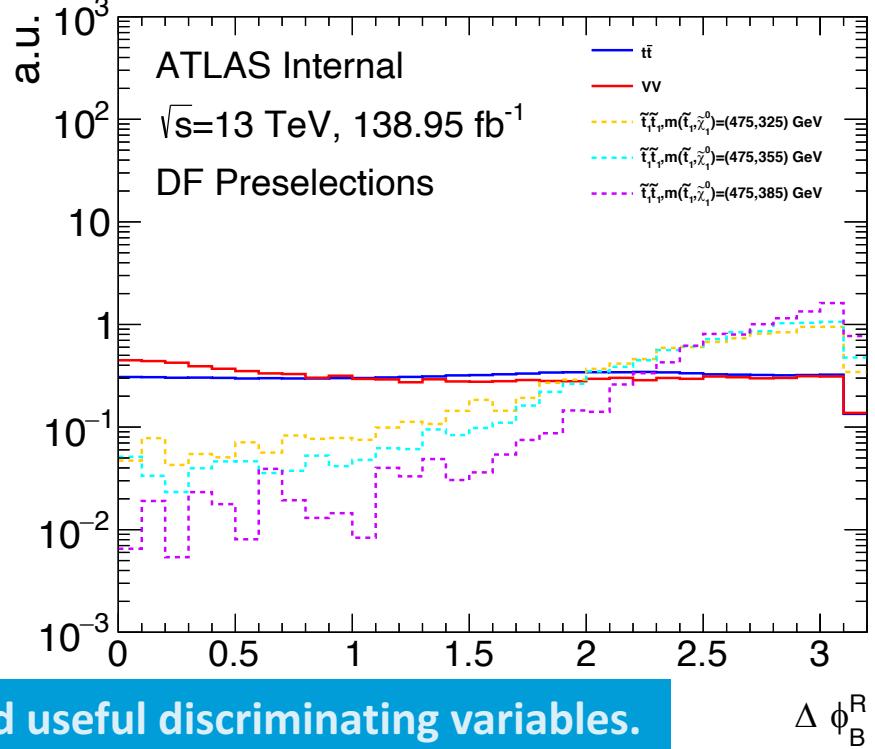


# General Analysis Overview?

# Generic Analysis Overview

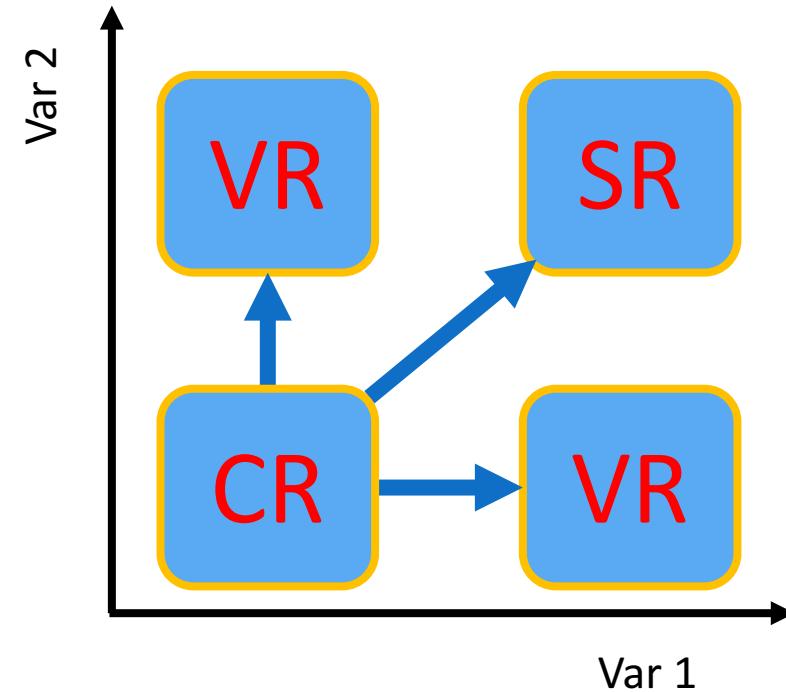
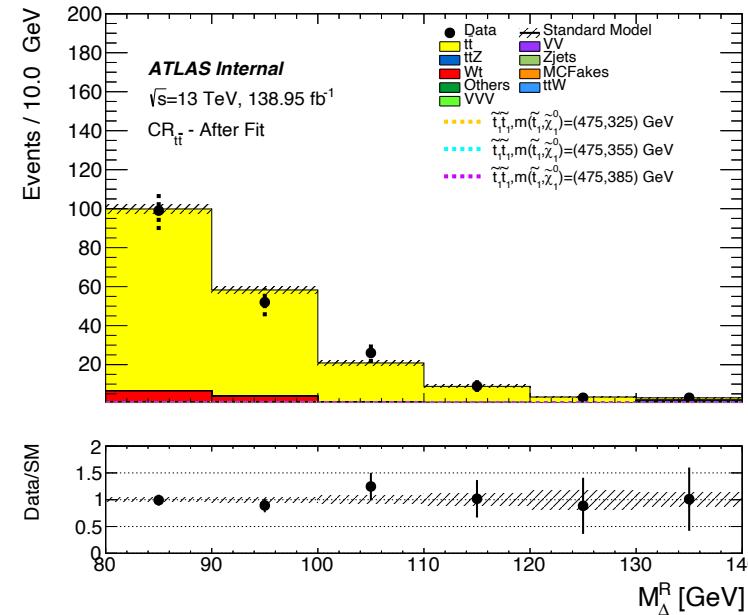
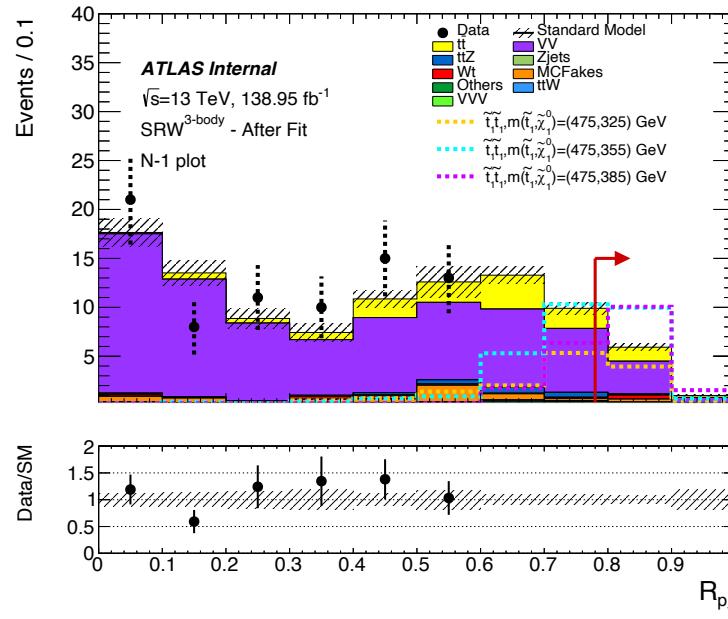
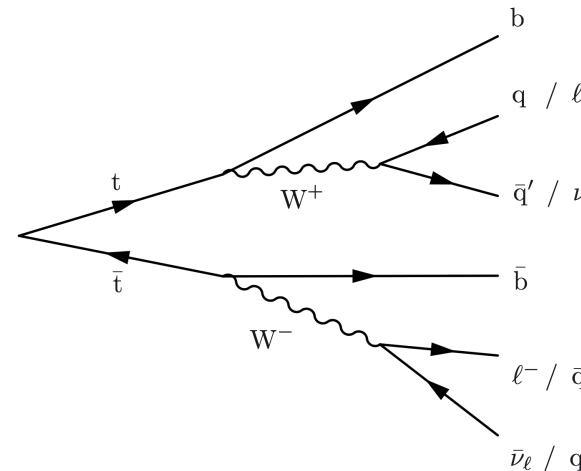
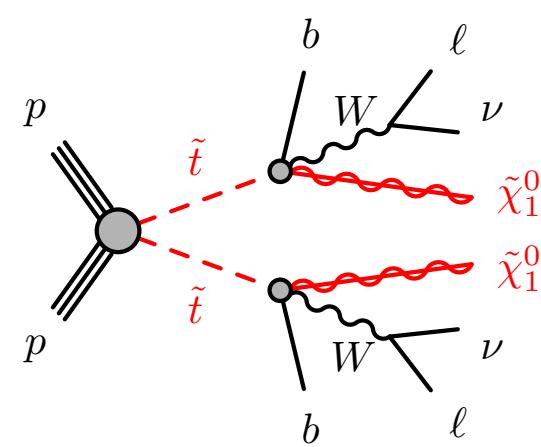


# Generic Analysis Overview

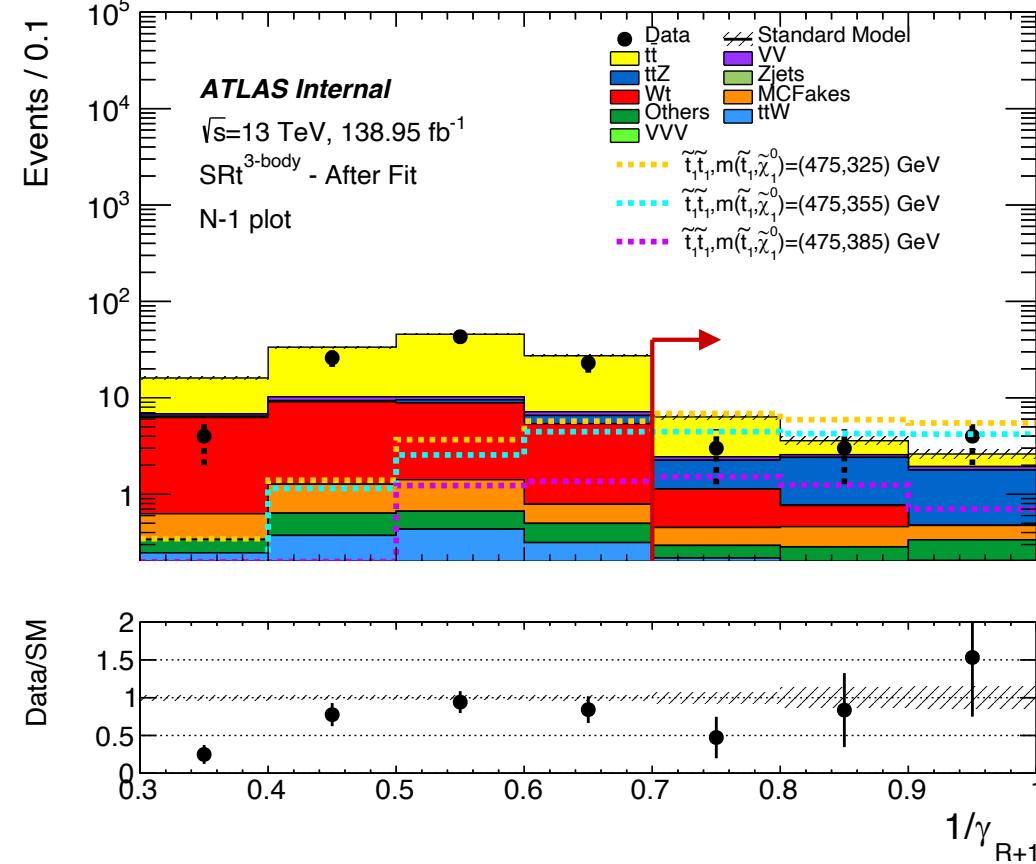


# Generic Analysis Overview

## Main SM Backgrounds



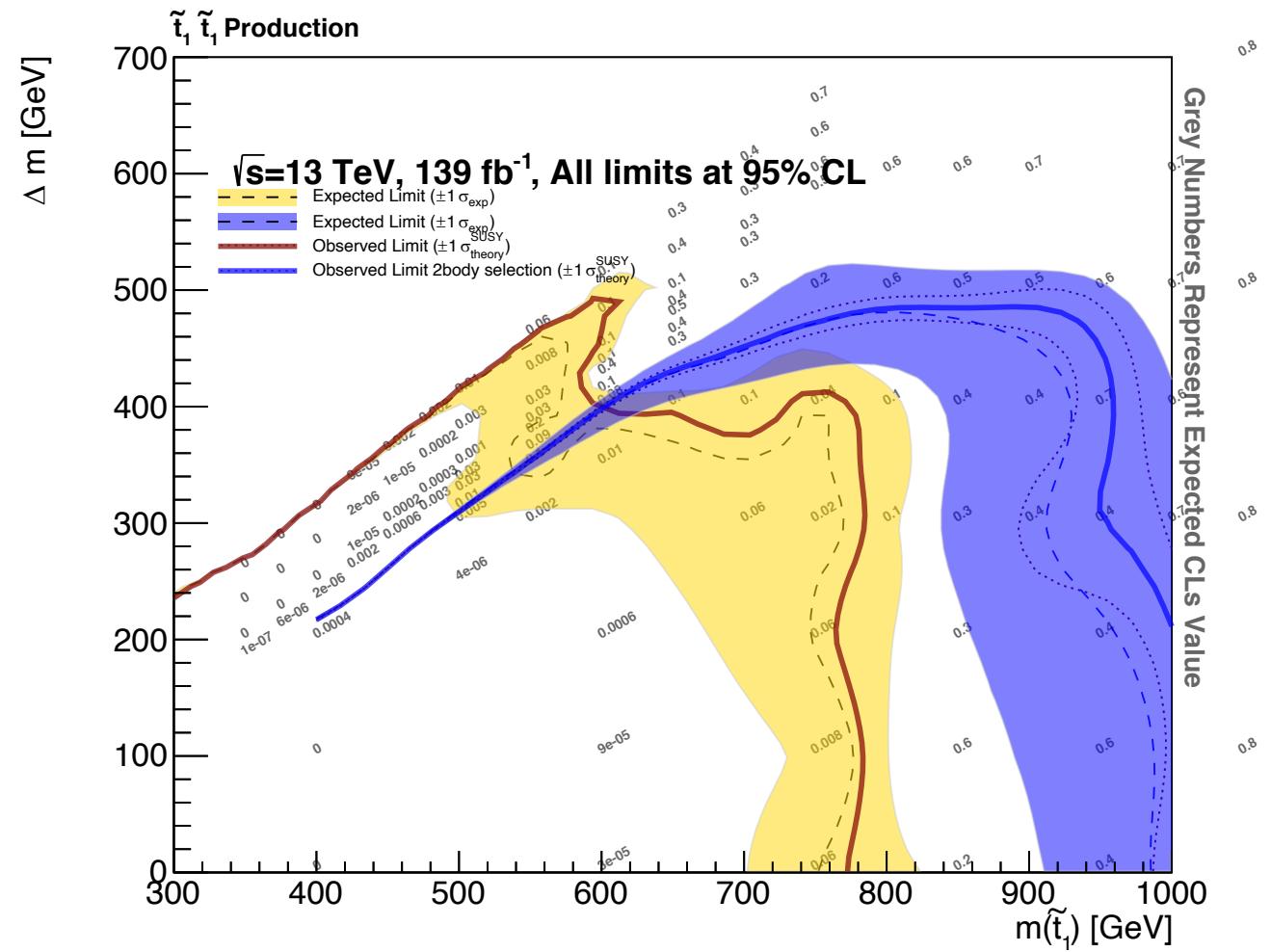
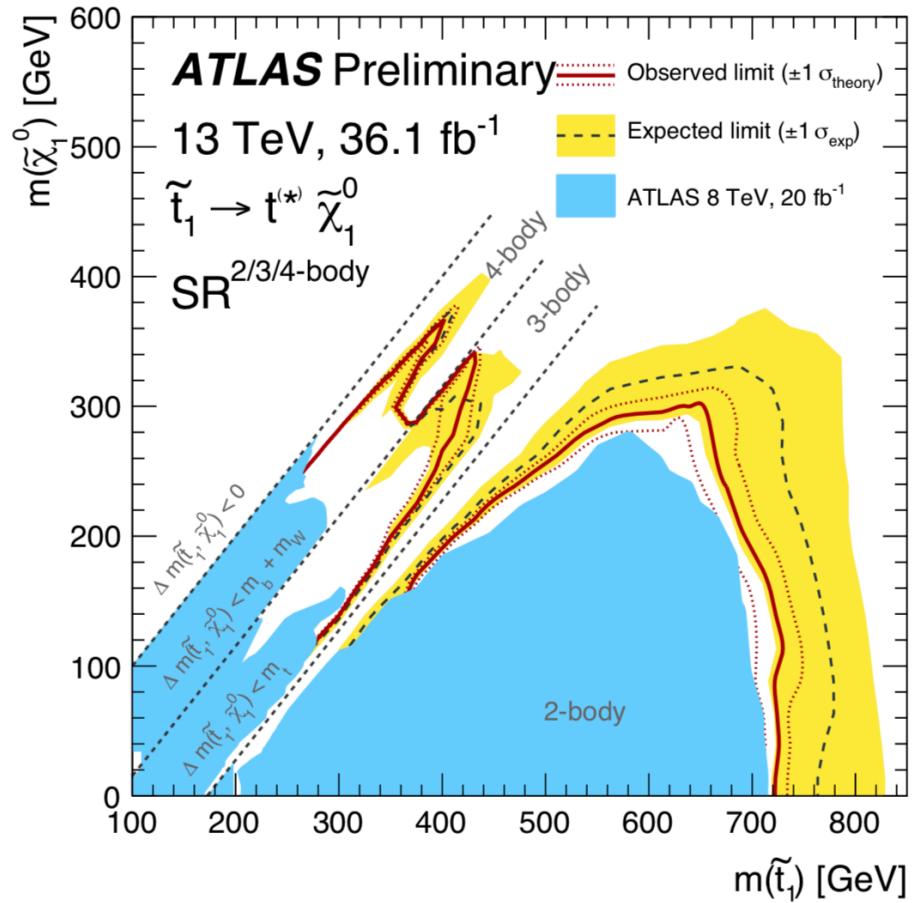
# Results



No fluctuation above the Standard Model was observed in any of the signal regions.

	$SRW_{DF}^{3\text{-body}}$	$SRW_{SF}^{3\text{-body}}$	$SRt_{DF}^{3\text{-body}}$	$SRt_{SF}^{3\text{-body}}$
Observed events	1	5	5	5
Fitted bkg events	$5.07 \pm 0.94$	$3.74 \pm 0.99$	$7.30 \pm 1.39$	$4.90 \pm 1.07$
Fitted ttbar events	$1.26 \pm 0.49$	$0.76 \pm 0.32$	$3.86 \pm 1.07$	$1.76 \pm 0.71$
Fitted Wt events	$0.30 \pm 0.05$	$0.21 \pm 0.03$	$0.44^{+0.54}_{-0.44}$	$0.54 \pm 0.19$
Fitted Zjets events	$0.00 \pm 0.00$	$0.04 \pm 0.02$	$0.00 \pm 0.00$	$0.01^{+0.03}_{-0.01}$
Fitted VV events	$2.50 \pm 0.97$	$2.47 \pm 0.94$	$0.17 \pm 0.09$	$0.34 \pm 0.14$
Fitted VVV events	$0.18 \pm 0.01$	$0.13 \pm 0.01$	$0.03 \pm 0.01$	$0.02 \pm 0.00$
Fitted ttZ events	$0.08 \pm 0.03$	$0.08 \pm 0.05$	$2.30 \pm 0.33$	$1.69 \pm 0.32$
Fitted ttW events	$0.01 \pm 0.00$	$0.02 \pm 0.01$	$0.31 \pm 0.05$	$0.21 \pm 0.03$
Fitted other events	$0.02 \pm 0.01$	$0.03 \pm 0.00$	$0.18 \pm 0.03$	$0.15 \pm 0.03$
Fitted DDFakes events	$0.71 \pm 0.11$	$0.00^{+0.25}_{-0.00}$	$0.00^{+0.23}_{-0.00}$	$0.17 \pm 0.03$
MC exp. SM events	$5.30 \pm 0.80$	$3.96 \pm 0.81$	$7.32 \pm 1.42$	$4.90 \pm 1.11$
MC exp. ttbar events	$1.31 \pm 0.52$	$0.79 \pm 0.35$	$4.01 \pm 1.13$	$1.83 \pm 0.75$
MC exp. Wt events	$0.30 \pm 0.05$	$0.21 \pm 0.03$	$0.44^{+0.54}_{-0.44}$	$0.54 \pm 0.19$
MC exp. Zjets events	$0.00 \pm 0.00$	$0.04 \pm 0.02$	$0.00 \pm 0.00$	$0.01^{+0.03}_{-0.01}$
MC exp. VV events	$2.69 \pm 0.59$	$2.66 \pm 0.60$	$0.18 \pm 0.07$	$0.36 \pm 0.12$
MC exp. VVV events	$0.18 \pm 0.01$	$0.13 \pm 0.01$	$0.03 \pm 0.01$	$0.02 \pm 0.00$
MC exp. ttZ events	$0.08 \pm 0.03$	$0.07 \pm 0.04$	$2.17 \pm 0.21$	$1.59 \pm 0.26$
MC exp. ttW events	$0.01 \pm 0.00$	$0.02 \pm 0.01$	$0.31 \pm 0.05$	$0.21 \pm 0.03$
MC exp. other events	$0.02 \pm 0.01$	$0.03 \pm 0.00$	$0.18 \pm 0.03$	$0.15 \pm 0.03$
MC exp. DDFakes events	$0.71 \pm 0.11$	$0.00^{+0.50}_{-0.00}$	$0.00^{+0.46}_{-0.00}$	$0.17 \pm 0.03$

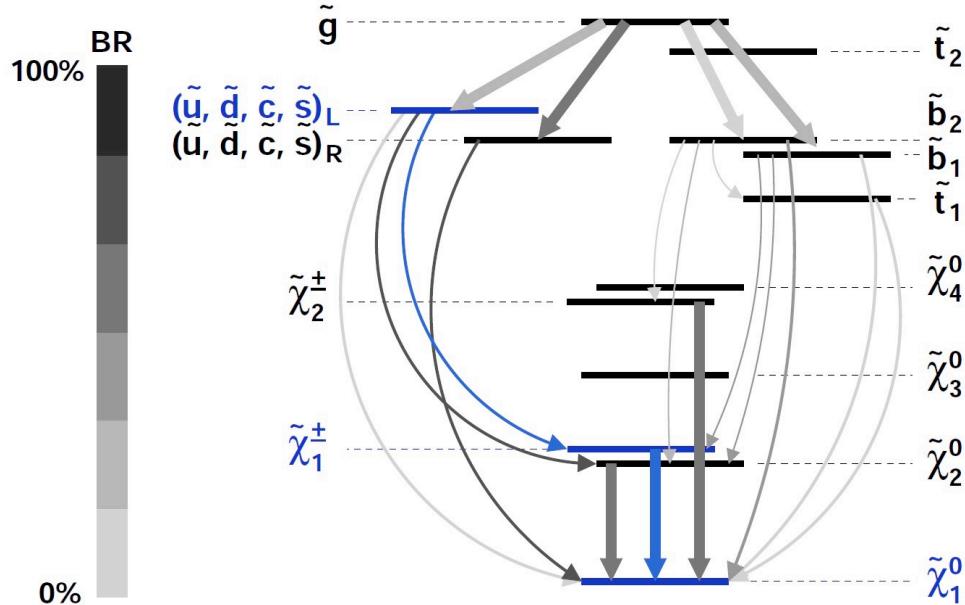
# Interpretation – Exclusion Limits



# Simplified Models

## Full SUSY model

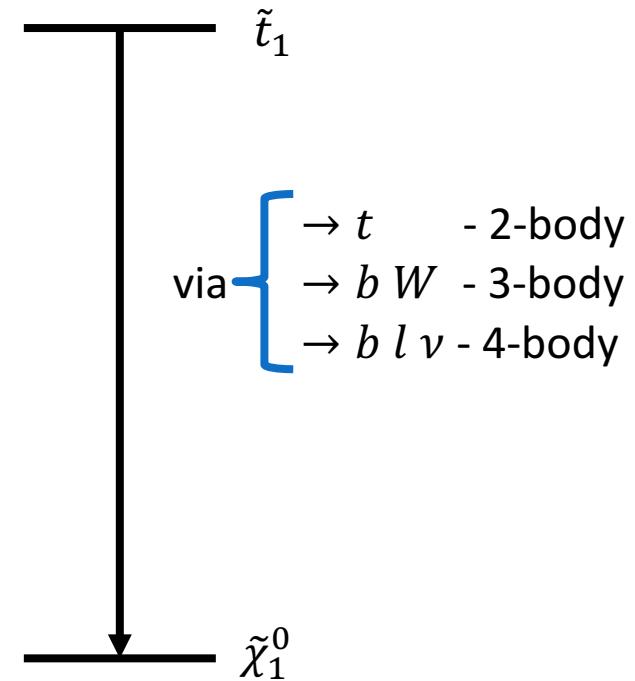
i.e. mSUGRA, CMSSM



A full SUSY spectrum:

- Involves many sparticles with different masses.
- Many possible decays with different branching ratios.

## Simplified physics model



A simplified SUSY spectrum:

- Consider a small number of sparticles.
- Assume 100% Branching Ratio (BR).
- Results can be extrapolated to more general models.

# END