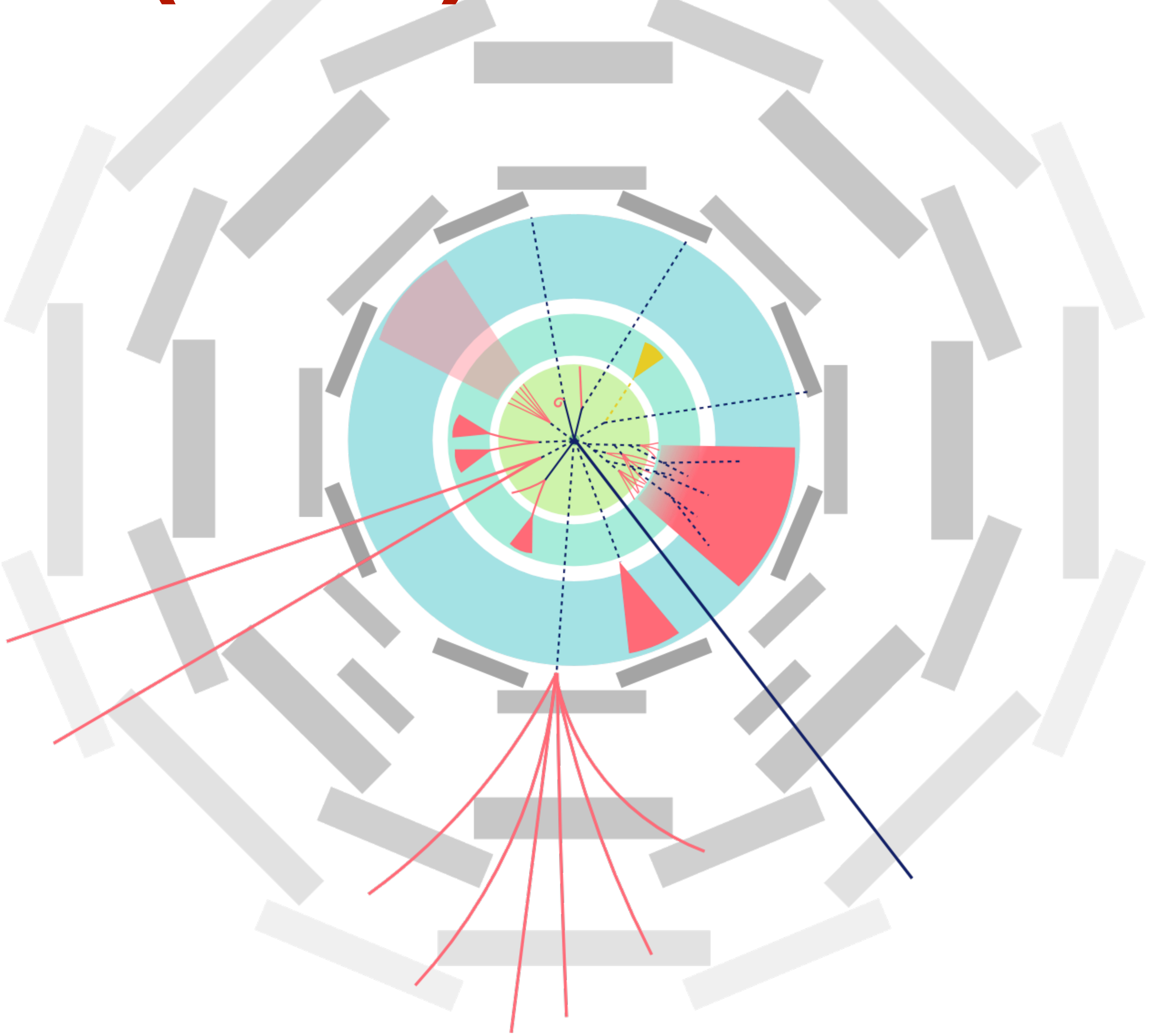
Recent Results on LLPs in ATLAS

LHCP 2024
Northeastern University, Boston
Friday, June/07/2024

Ismet Siral (CERN) on Behalf Of ATLAS Collaboration

Why Long Lived Particles (LLPs)

- ATLAS has a broad LLP program, targeting a wide range off LLP signatures and lifetimes.
- Why do we look for LLPs?
  - LLPs breaks the conventional prompt ATLAS signature searches opening up a new sea of particle signatures
  - It is an uncharted territory
    - Requires dedicated approach for triggering, reconstruction and background handling.



Prompt Decays | Displaced Tracks | Disappearing Tracks Displaced Vertices | Emerging Jets Dark Photon Jets | LLP particles that decay inside detector | Detector Stable Particles

*Not precise representation!!

0.01 — 0.1 — 1 — 10 — 100 — 1000 — $c\tau$[mm]

Why Long Lived Particles (LLPs)

- ATLAS has a b
  targeting a wi
  signatures an
- Why do we lo
  - LLPs break
    prompt ATL
    opening up
    signatures
  - It is an unc
    - Requires
      triggering
      backgrou

Prompt Decays

*Not precis

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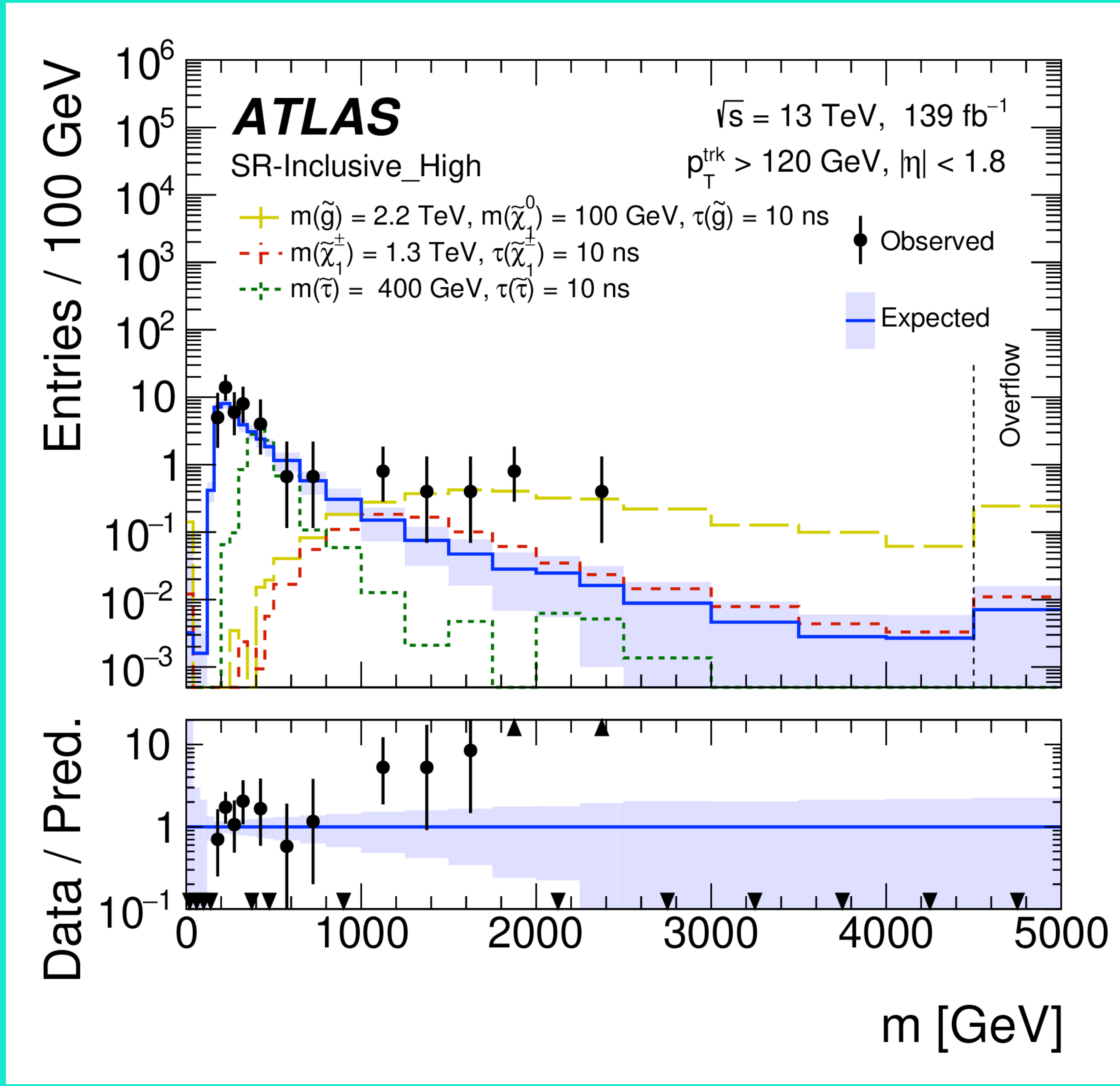
ctor Stable Particles

$c\tau$[mm]

And we also have interesting excesses that need to be understood.



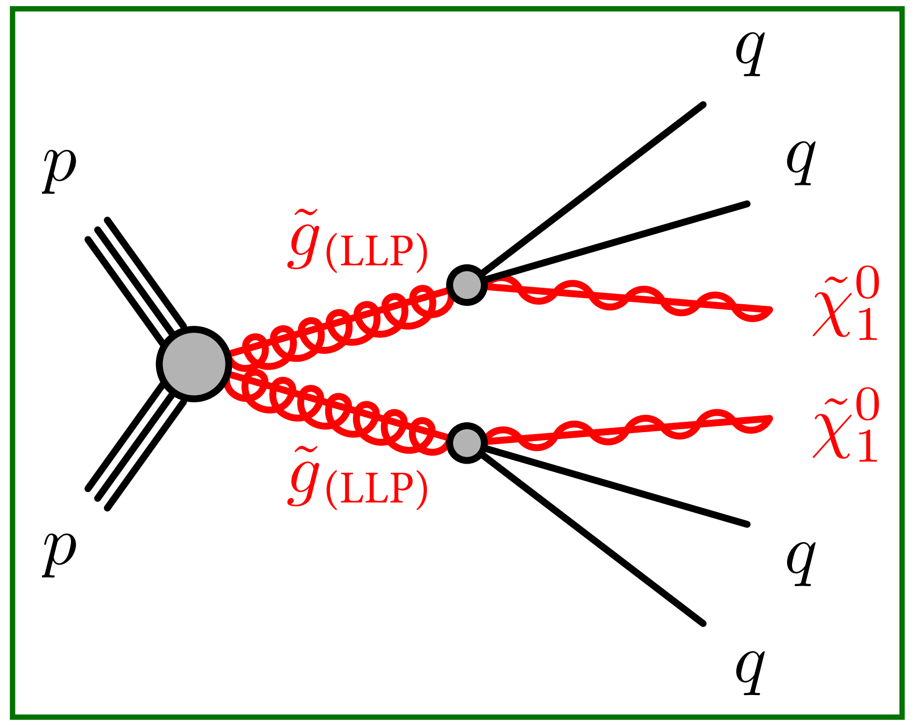
Introduction

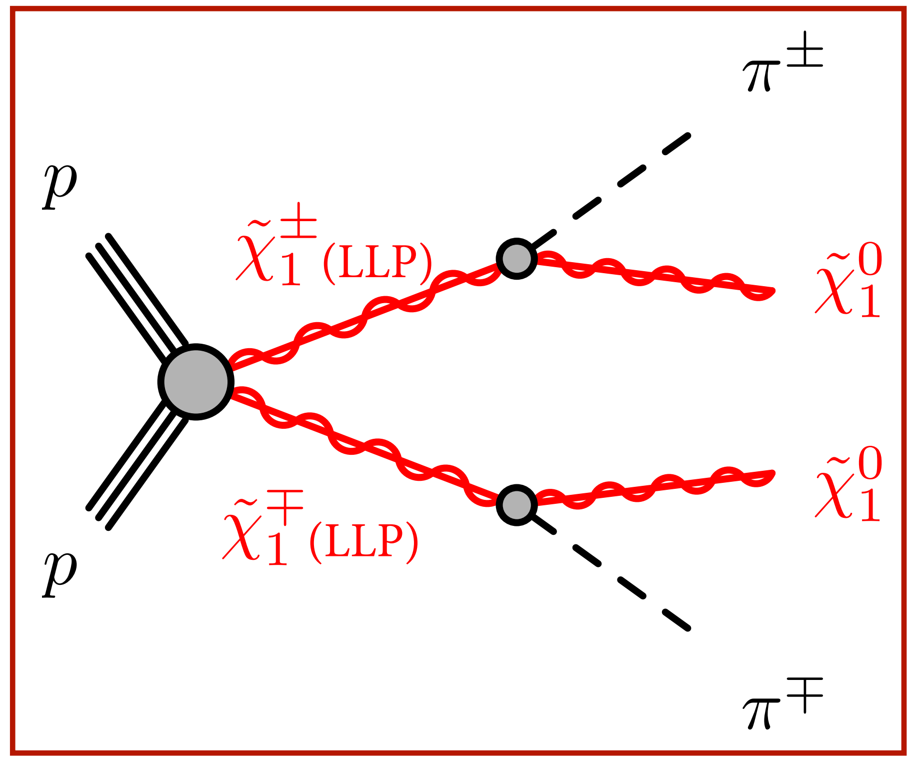
- Today we have two ATLAS talks on these LLP signatures,
  - This talk that will try to give a broad view of the LLP signatures
  - Another talk on LLP signatures with displaced vertices.
- Today we will be covering three new results:
  - Search for LLPs with Large dE/dx
  - Search for light neutral LLPs
  - Reinterpretation SUSY searches with Tau final states

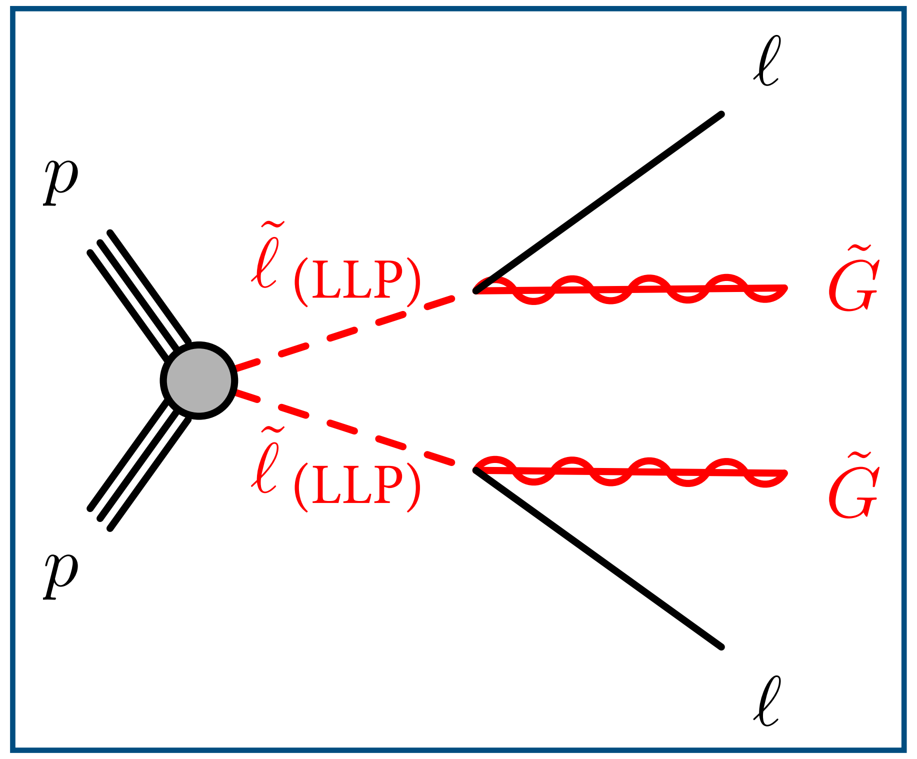
Search for LLPs with Large dE/dx

Search for LLPs with Large dE/dx

- The goal of this search is to detect the masses LLPs in ATLAS using:
  - Using the ionisation energy loss (dE/dx) in ATLAS Pixels we can extract the $\beta\gamma$
  - Using ATLAS calorimeter to measure the time-of-flight to extract the velocity
  - Reconstruct the mass of these tracks using $p/\beta\gamma = M$
- It's sensitive to majority of charged LLPs with life-times longer than 1ns.
  - Considered models are charginos, sleptons and R-hadrons.
    - Today new chargino results will become public.
- This analysis is a continuation of the analyses: ATLAS-CONF-2023-044, JHEP 2306 (2023) 158







Search for LLPs with Large dE/dx

Analysis Strategy

- The search strategy of this analysis is:
  - Identifying isolated tracks with high transverse momentum (p_T), large specific ionisation and a long time-of-flight.
  - Reconstruct the mass using the p/βγ = M
  - Generate data-driven background distributions
- Identify 2-D trapezoidal mass windows containing good signal over background ratio.

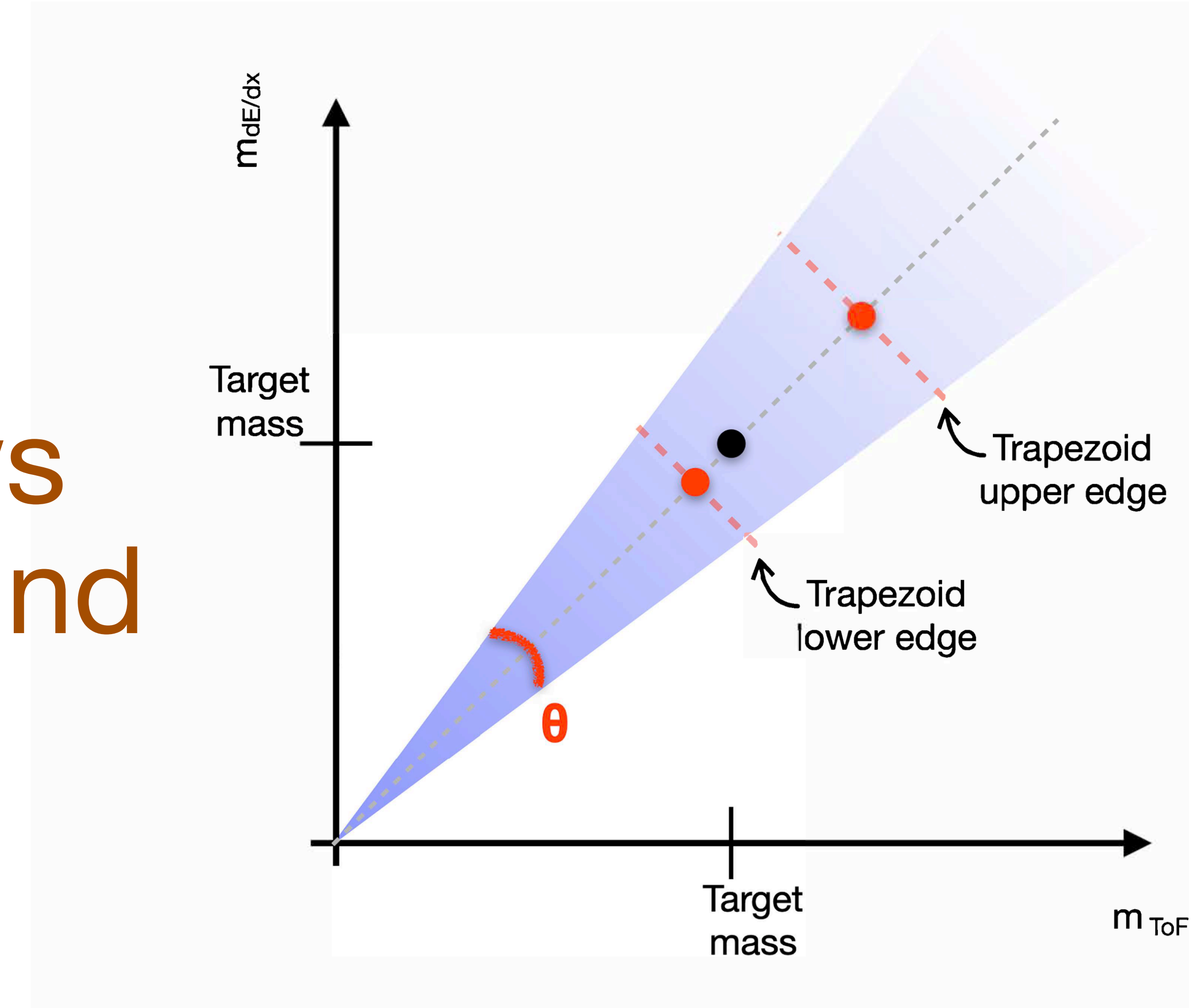
Events are triggered with a E_T^{miss} Trigger

Good quality , high $p_T > 120$ GeV, central $|\eta| < 1.6$ tracks are selected. The quality is ensured by hit requirements.

Tracks associated with jets, w bosons, tau's and electrons are removed by various isolation and $m_T(\text{Track}, E_T^{\text{miss}})$ requirements

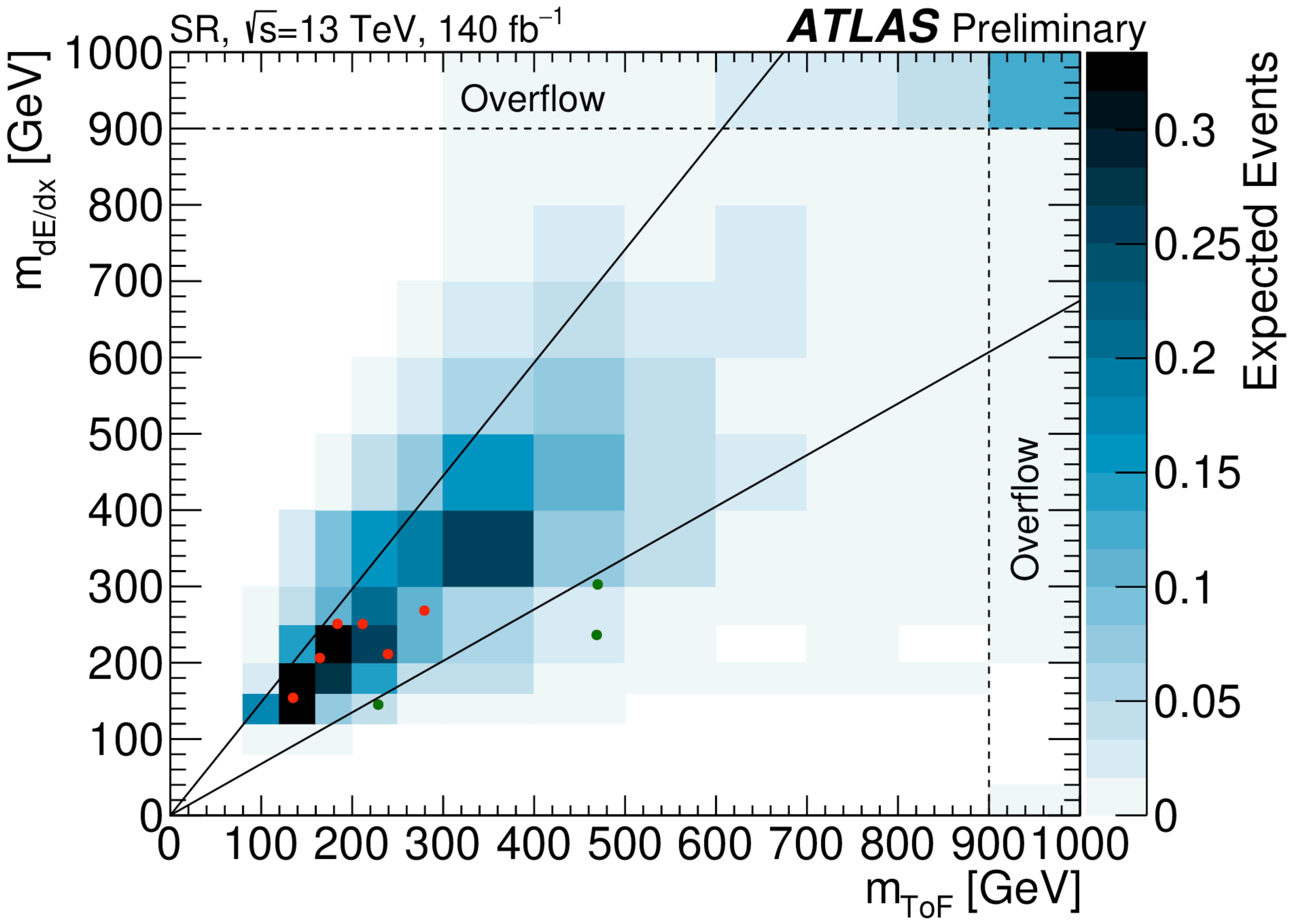
An ionization cut $dE/dx > 1.8$ is applied in-order to identify particles that have low $\beta\gamma$ which is correlated to large dE/dx. The ionization cut varies across signal categories.

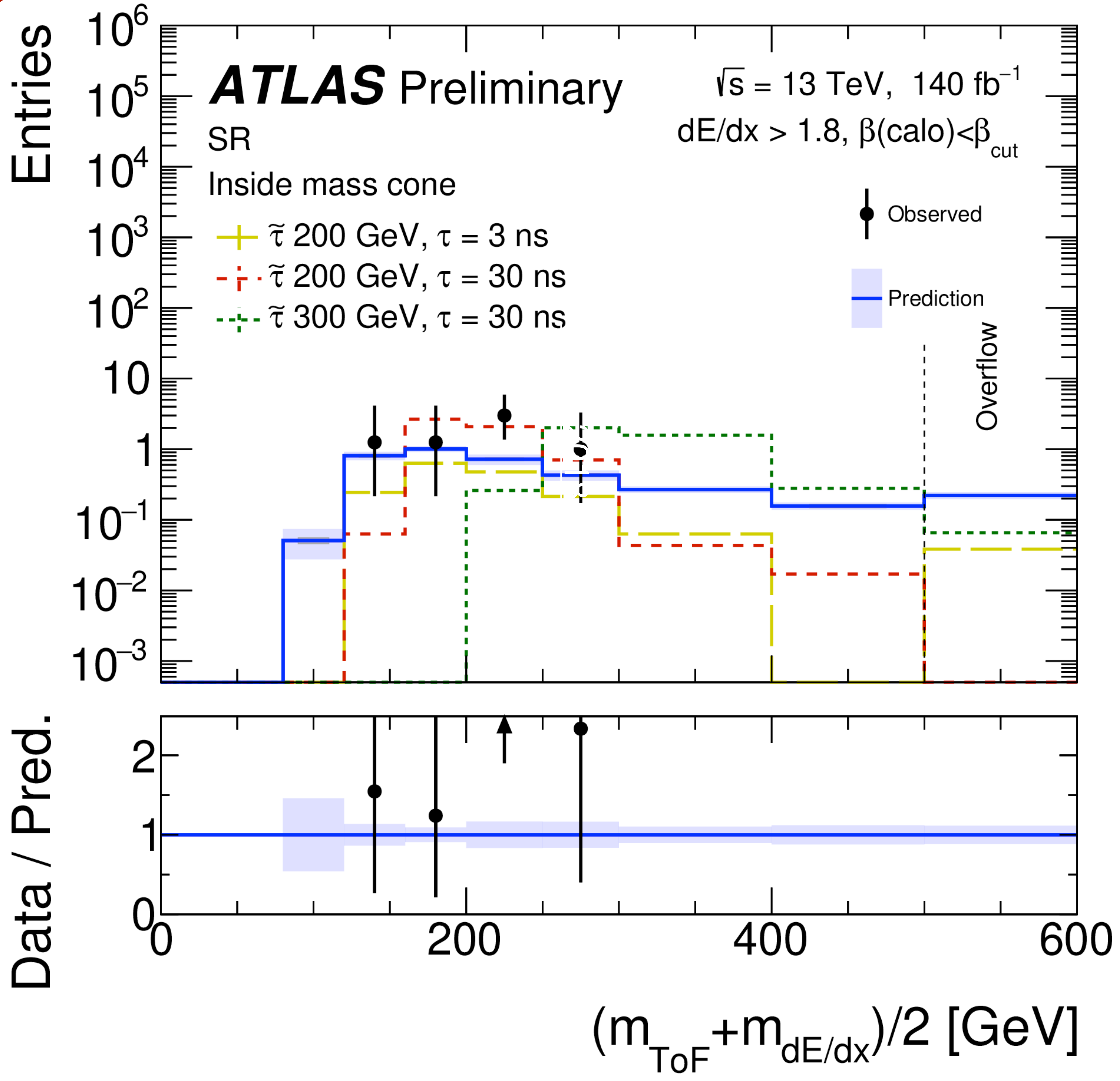
A $\beta_{ToF} < \beta_{\text{cut}}(\eta)$ where $\beta_{\text{cut}}(\eta) = 1 - 2\sigma_{ToF}$ is applied to detect particles that are slow moving.



	trapezoid parameters, cone angle Θ=22 degrees	
target mass [GeV]	lower edge mass [GeV]	upper edge mass [GeV]
700	530	1390
800	570	2380
900	620	5340
1000	720	6170
1100	780	6170
1200	860	6170
1300	950	6170
1400	960	6170

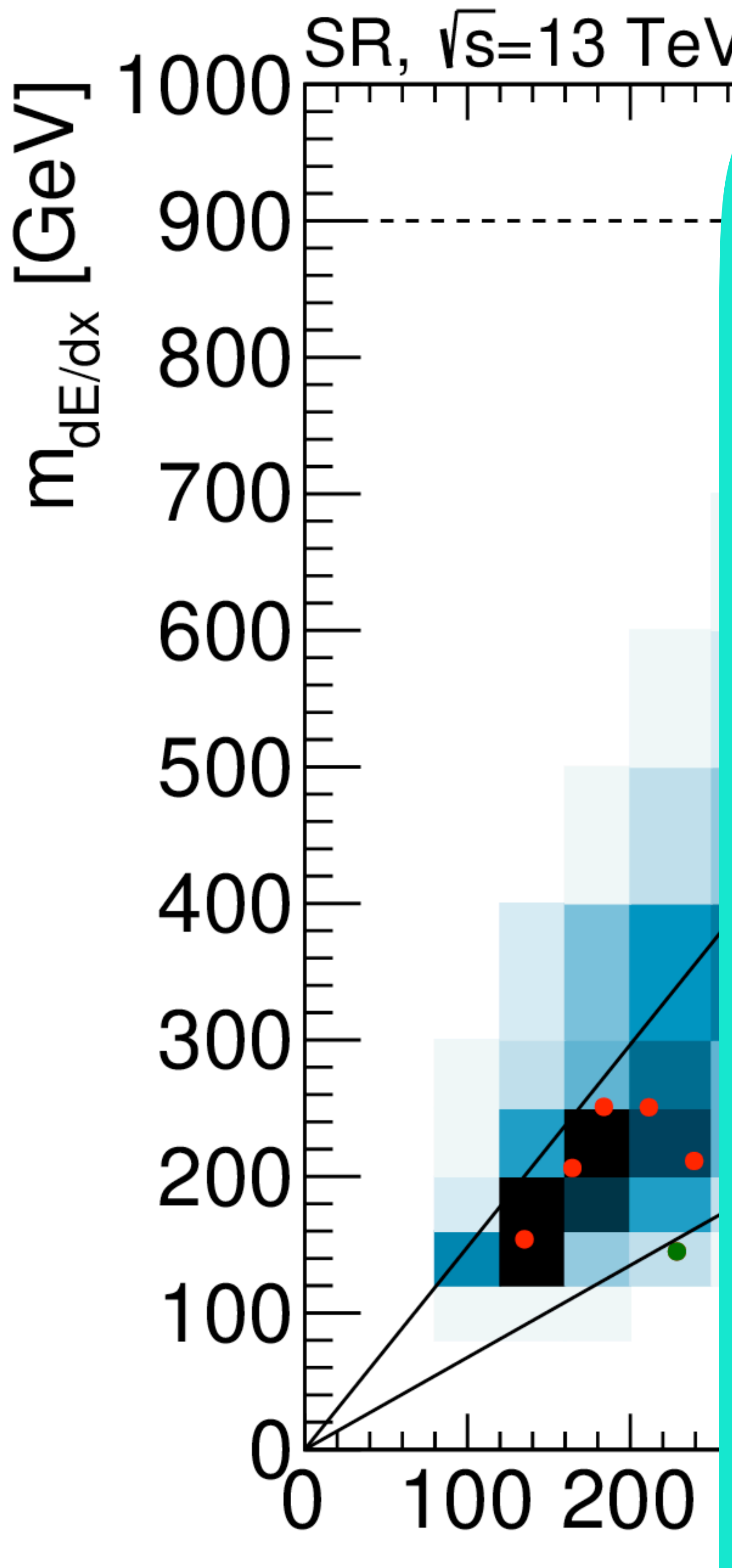
Search for LLPs with Large dE/dx



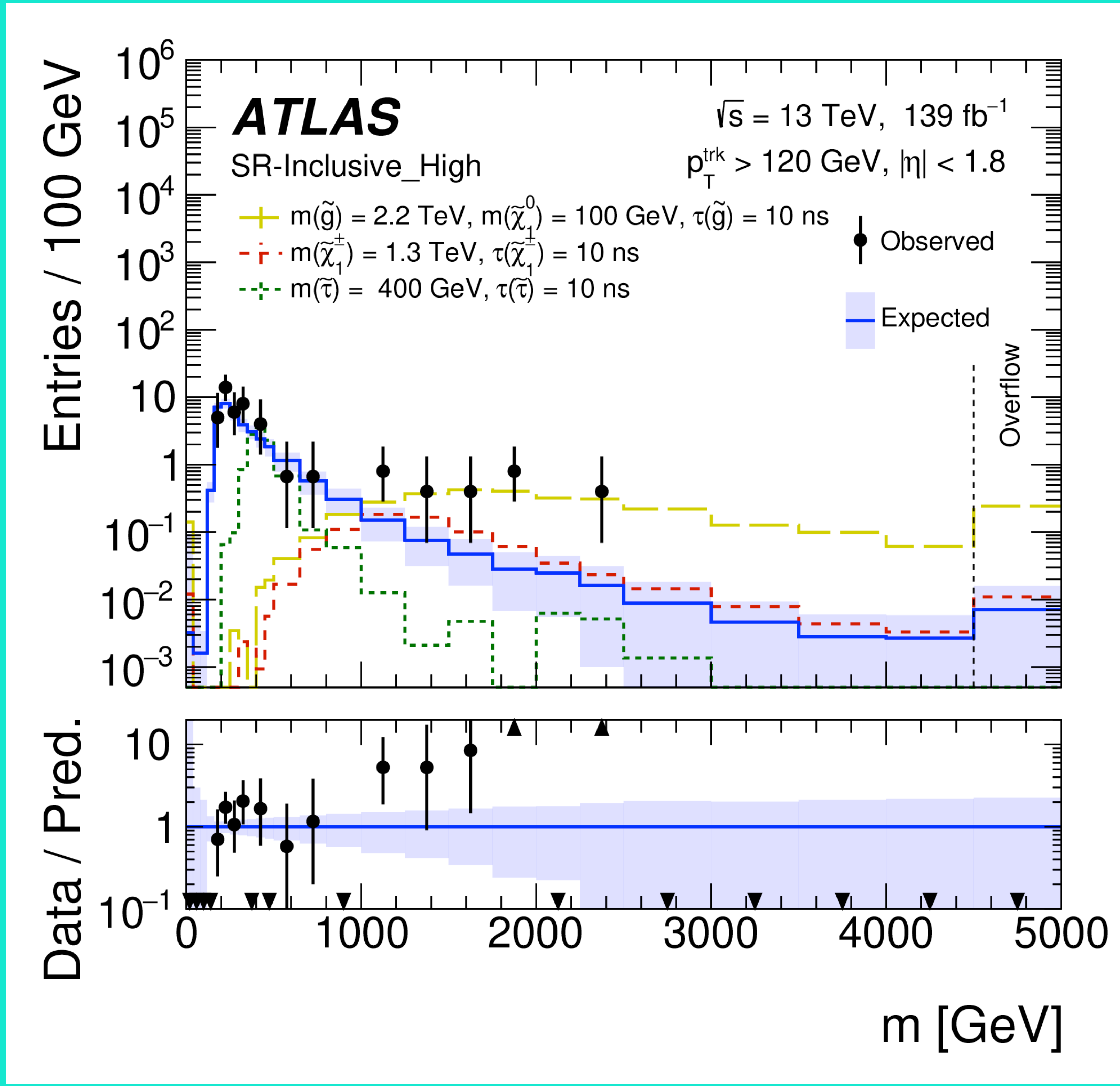


- In total 9 events are observed over an expected background of 5.1 events.
  - Six of these events are inside the mass compatibility cone containing the trapezoid

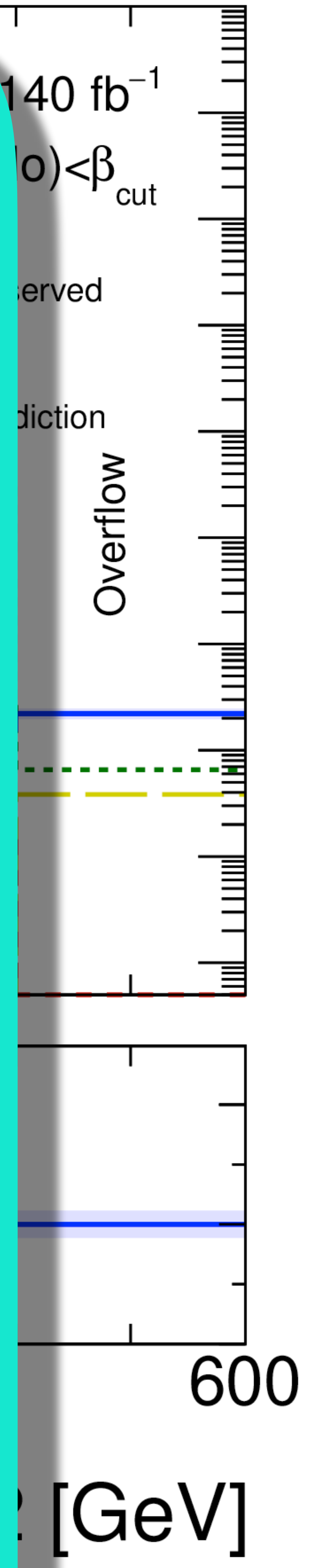
Search for LLPs with Large dE/dx



From the previous round of the analysis, without a cut on time of flight from the caloirmeter.



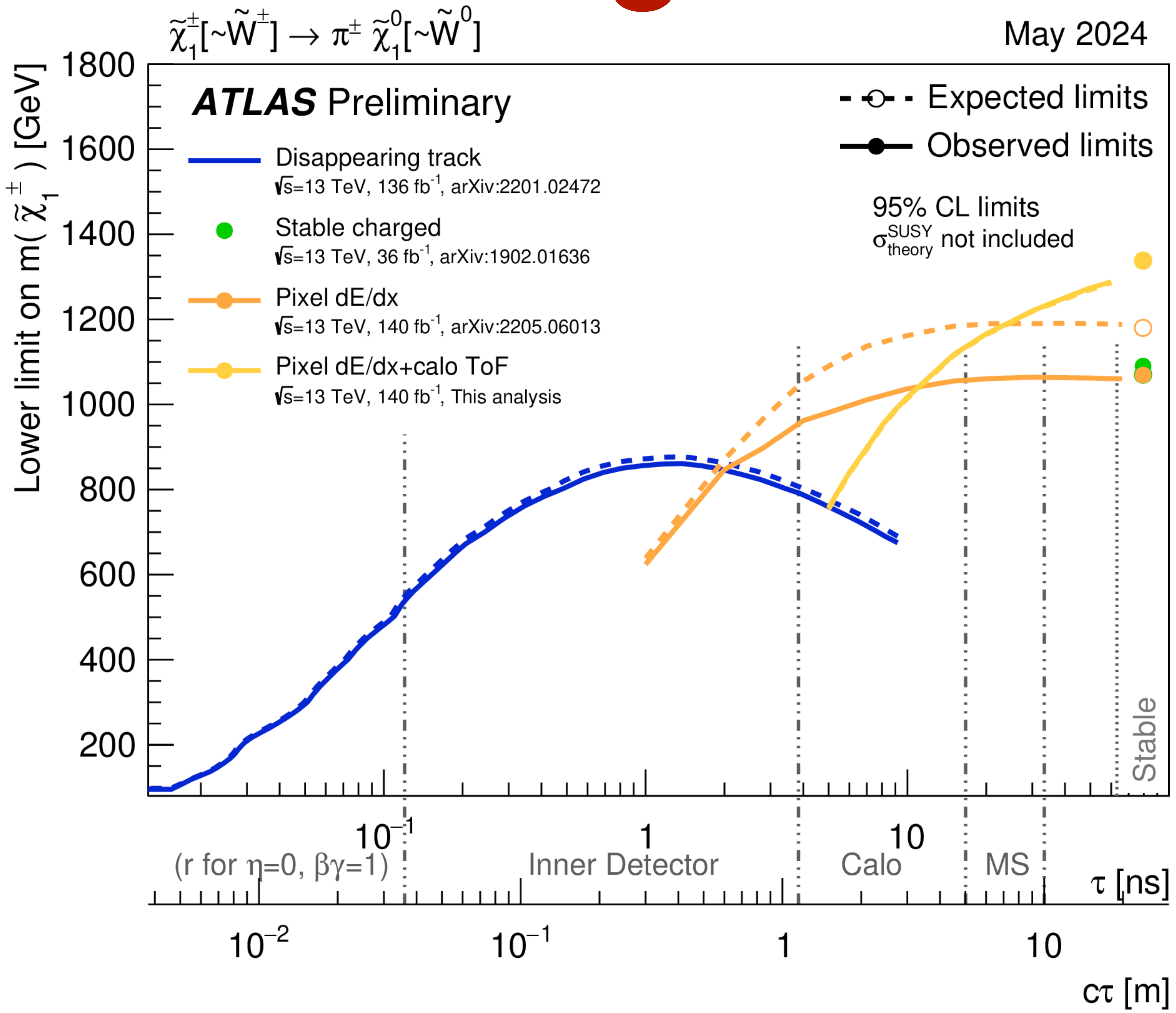
SUSY-2018-42



- In total 9 ev
  - Six of thes … e trapezoid

Search for LLPs with Large dE/dx

Results

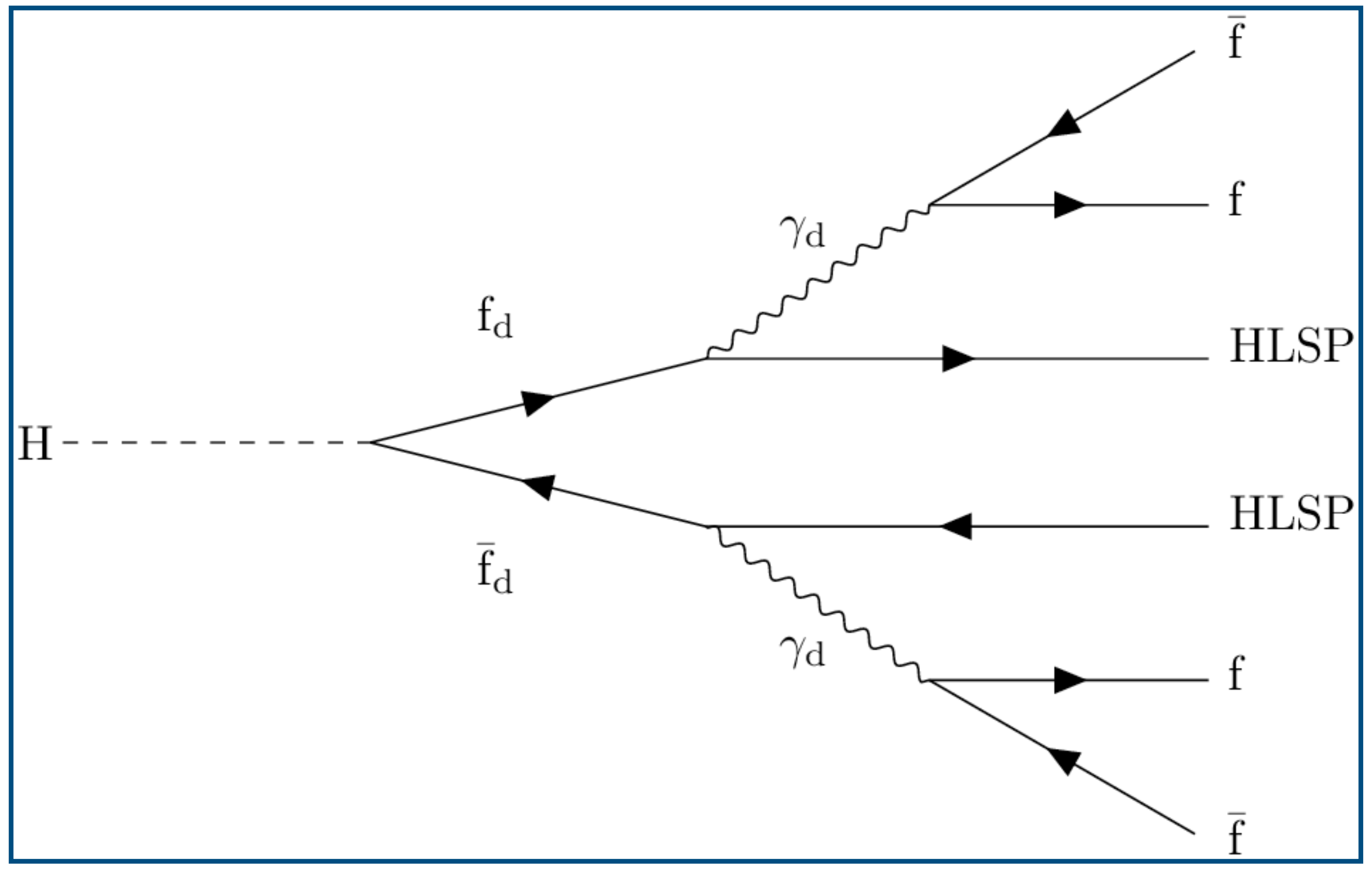


- With this search, we have expanded our existing chargino limits above lifetimes of 10 ns setting the mass limits upto 1.327 TeV
- With combination of other ATLAS analysis, we have good coverage of Wino like charginos.
  - Our sensitivity drops short lifetimes which we plan to improve on with future studies that target disappearing or displaced tracks

Search for light and natural LLPs

Search for light and neutral LLPs

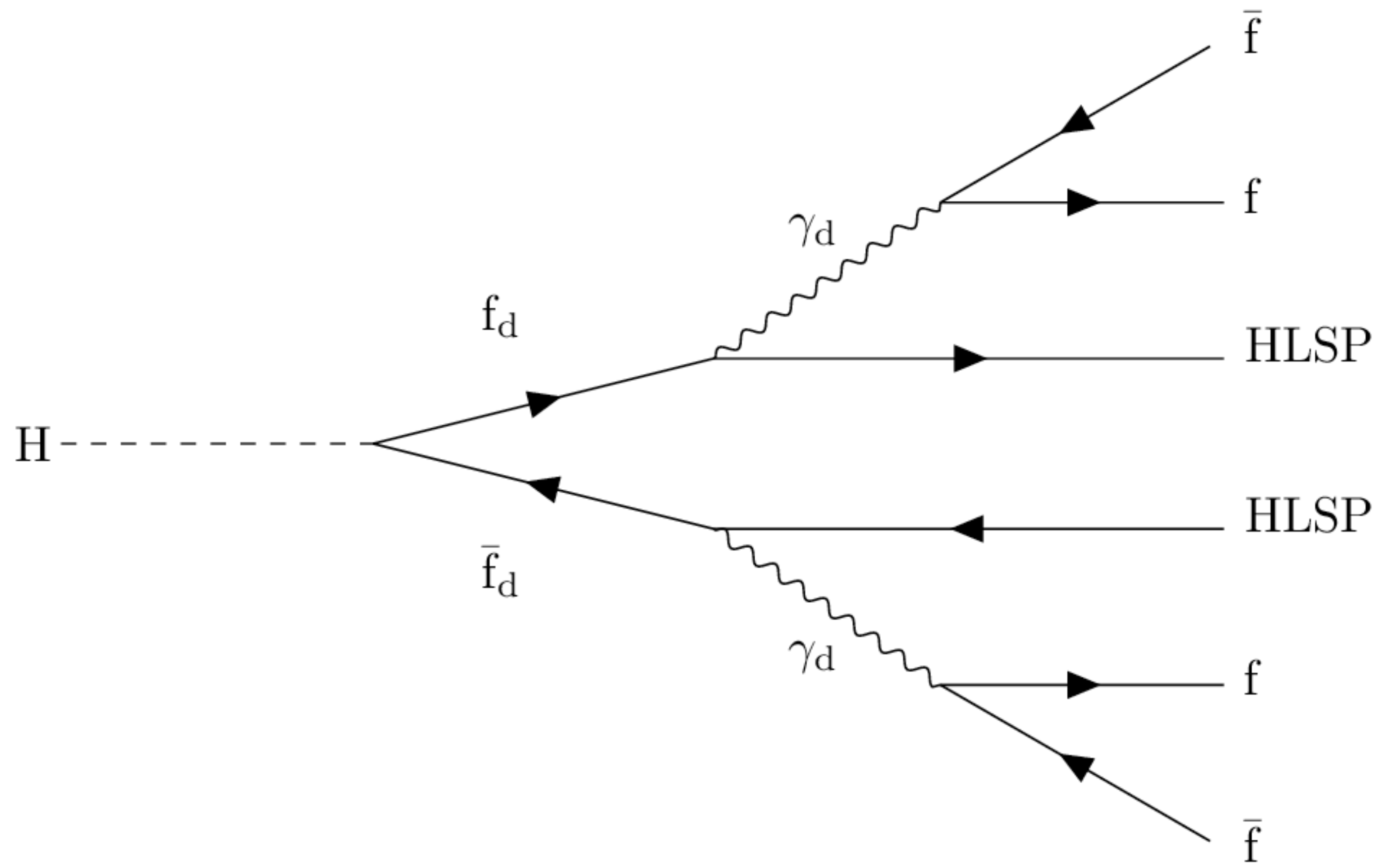
- If the LLP candidate is neutral and when they decay inside the muon or calorimeter system we can have a jet like structure.
  - These can come from the dark-sector.
- In this paper **EXOT-2022-15**, dark-photons (FRVZ model) are searched
  - These dark photons are mixing with the SM hypercharge.
  - The decay of dark photons produces collimated fermions, similar to a jet, called a dark photon jet (DPJs)
  - This search targets dark photons from generated by the Higgs boson decays.

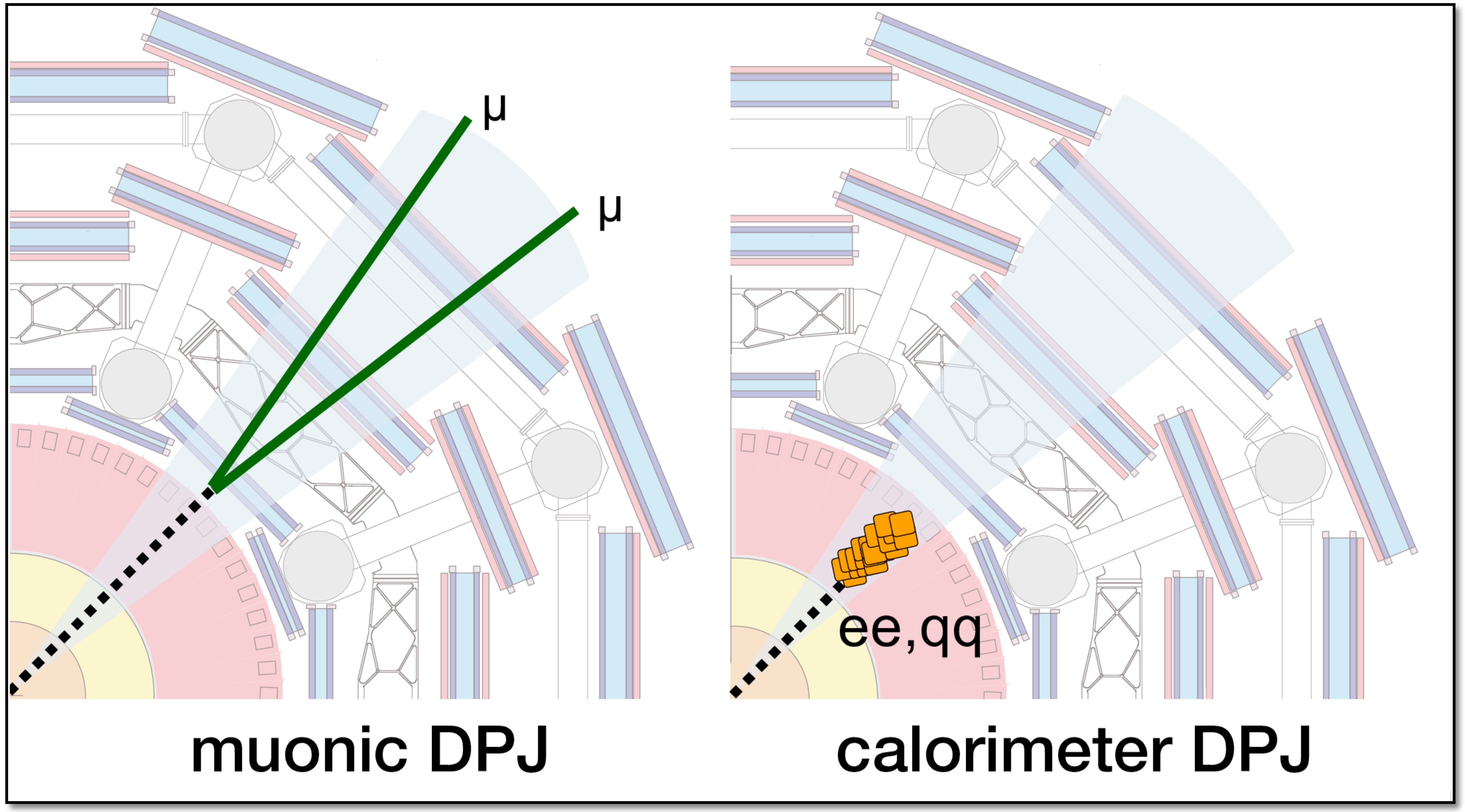


Analysis Strategy

In this work these Higgs boson are generated via the VBF process.

- Where Higgs decays into dark-fermions which then decays into dark photon jets.





Other production mechanisms were investigated in EXOT-2019-05 (WH) EXOT-2017-28 (ggF)

The analysis tries to identify DPJs in either the ATLAS muon or calorimeter system and categorises the signal region accordingly:

- μDPJ: Reconstructed from stand-alone tracks in the MS that lies in a fixed-size cone of $\Delta R = 0.4$
- caloDPJ: Reconstructed from energy deposits where with low electromagnetic fraction (EMF<0.4)
  - EMF = E (EM Calorimeter) / E(Total)

Search for light and neutral LLPs

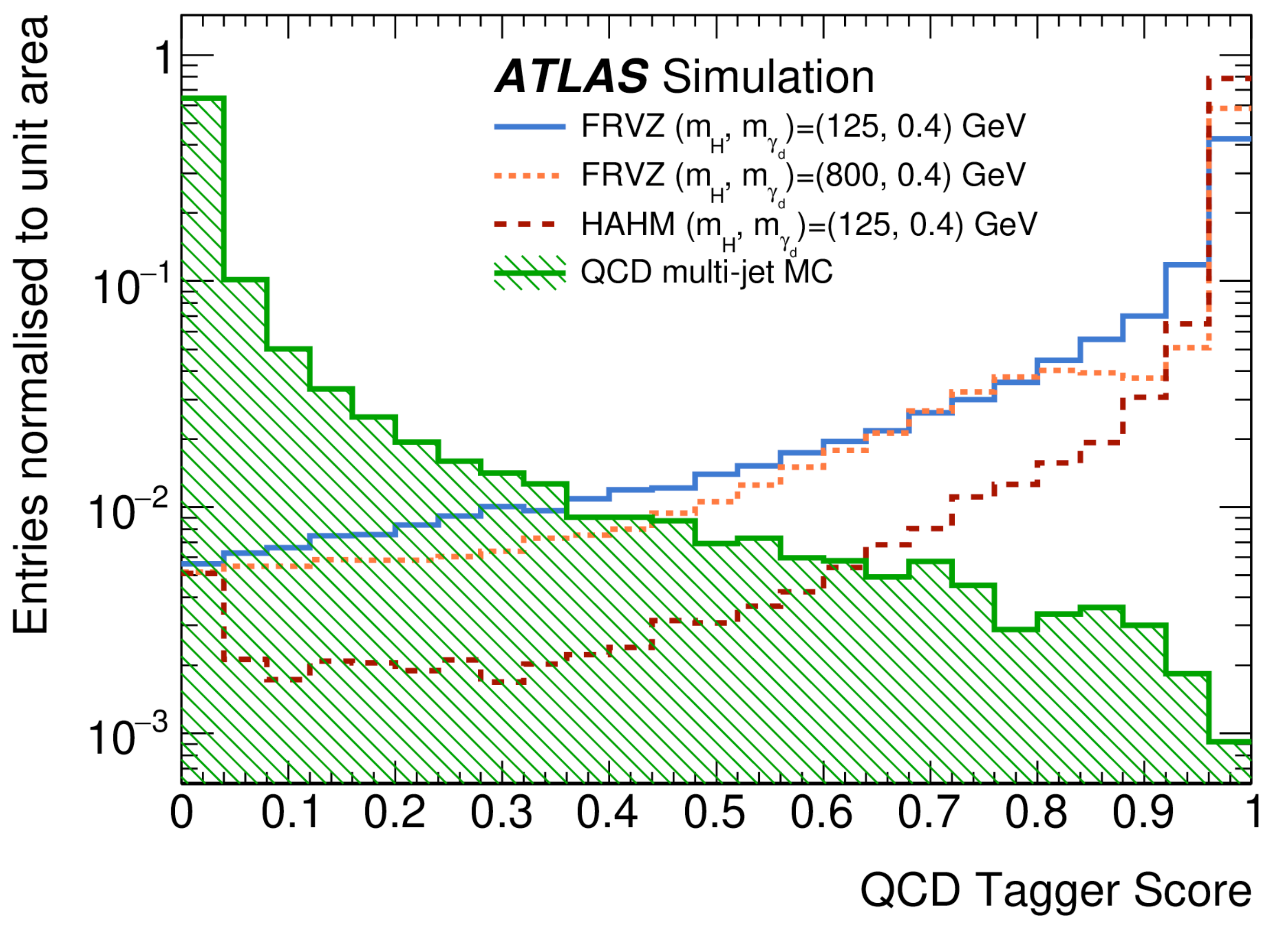
Analysis Strategy

First categorise the event into DPJ flavor

Triggered MET trigger or for μDPJ specialised triggers.

Signal Sensitivity Cuts

- MET cut increase signal sensitivity
- $\Sigma_{\Delta R=0.5}\, p_T [GeV]$ scalar sum of of all momenta around the DPJ
- μDPJ charge to be neutral
- Calo DPJ tagger to differentiate multi-jet events from CaloDPJ



Plot from EXOT-2019-05

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Requirement / Region	SR_μ (μDPJ)	$SR_c^{L/H}$ (caloDPJ)
Number of DPJs	≥ 1	≥ 1
Leading DPJ type	μDPJ	caloDPJ
Trigger	E_T^{miss} Tri-muon MS-only Muon narrow-scan	E_T^{miss}
p_T(jet) [GeV]	> 30	> 30
N_{jet}	≥ 2	≥ 2
m_{jj} [GeV]	≥ 1000	≥ 1000
$\|\Delta\eta_{jj}\|$	> 3	> 3
$\|\Delta\phi_{jj}\|$	< 2.5	< 2.5
N_ℓ	0	0
$N_{b\text{-jet}}$	0	0
C_{DPJ}	> 0.7	-
$\Delta\phi_{min}$	-	> 0.4
E_T^{miss} [GeV]	> 100	SR_c^L: [100, 225] SR_c^H: > 225
~~μDPJ charge~~	0	-
caloDPJ tagger	-	> 0.9
$\sum_{\Delta R=0.5} p_T$ [GeV]	< 2	< 2

Cuts to select VBF Processes

$$C_{DPJ} = \exp\left(-\frac{4}{(\eta_{j1}-\eta_{j2})^2}\left(\eta_{DPJ} - \frac{\eta_{j1}+\eta_{j2}}{2}\right)^2\right).$$

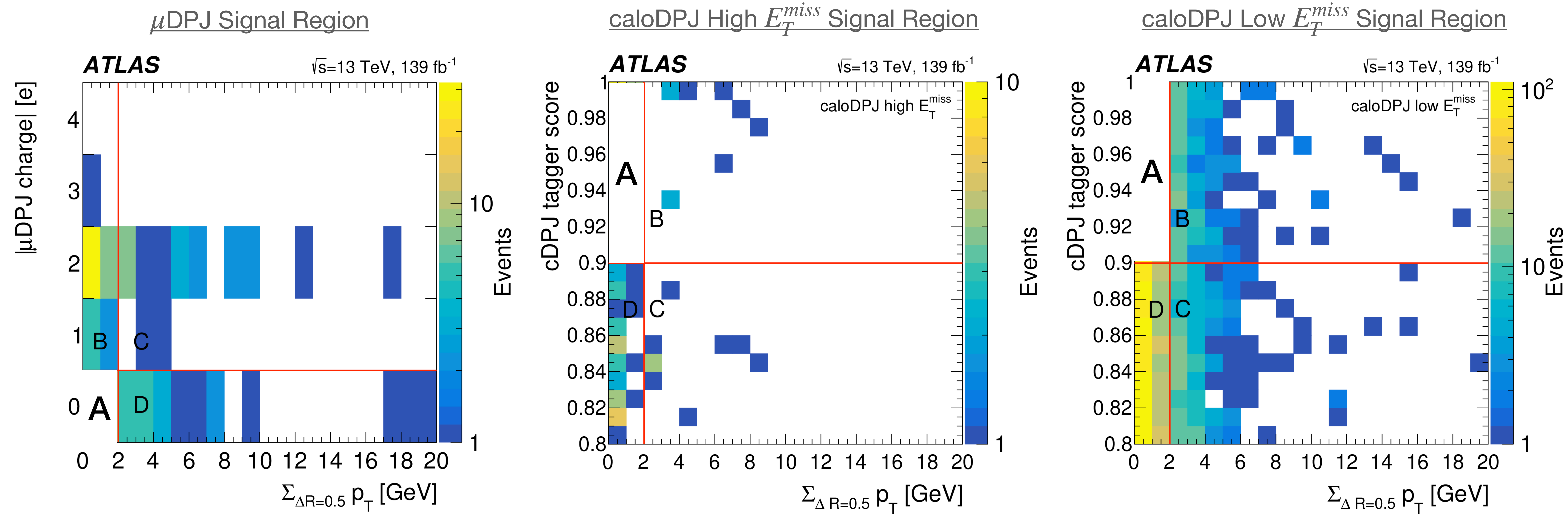
centrality selection for μDPJ between the two VBF jets.

$\Delta\phi_{min}$ azimuthal distance between $\vec{p}_{T miss}$ and $\vec{p}_{T_j}$ of 4 leading jets

Search for light and neutral LLPs

Results

Selection	CRB	CRC	CRD	SR expected
SR_μ	44	22	21	42 ± 14
SR_c^L	224	256	1123	983 ± 95
SR_c^H	9	11	35	29 ± 14



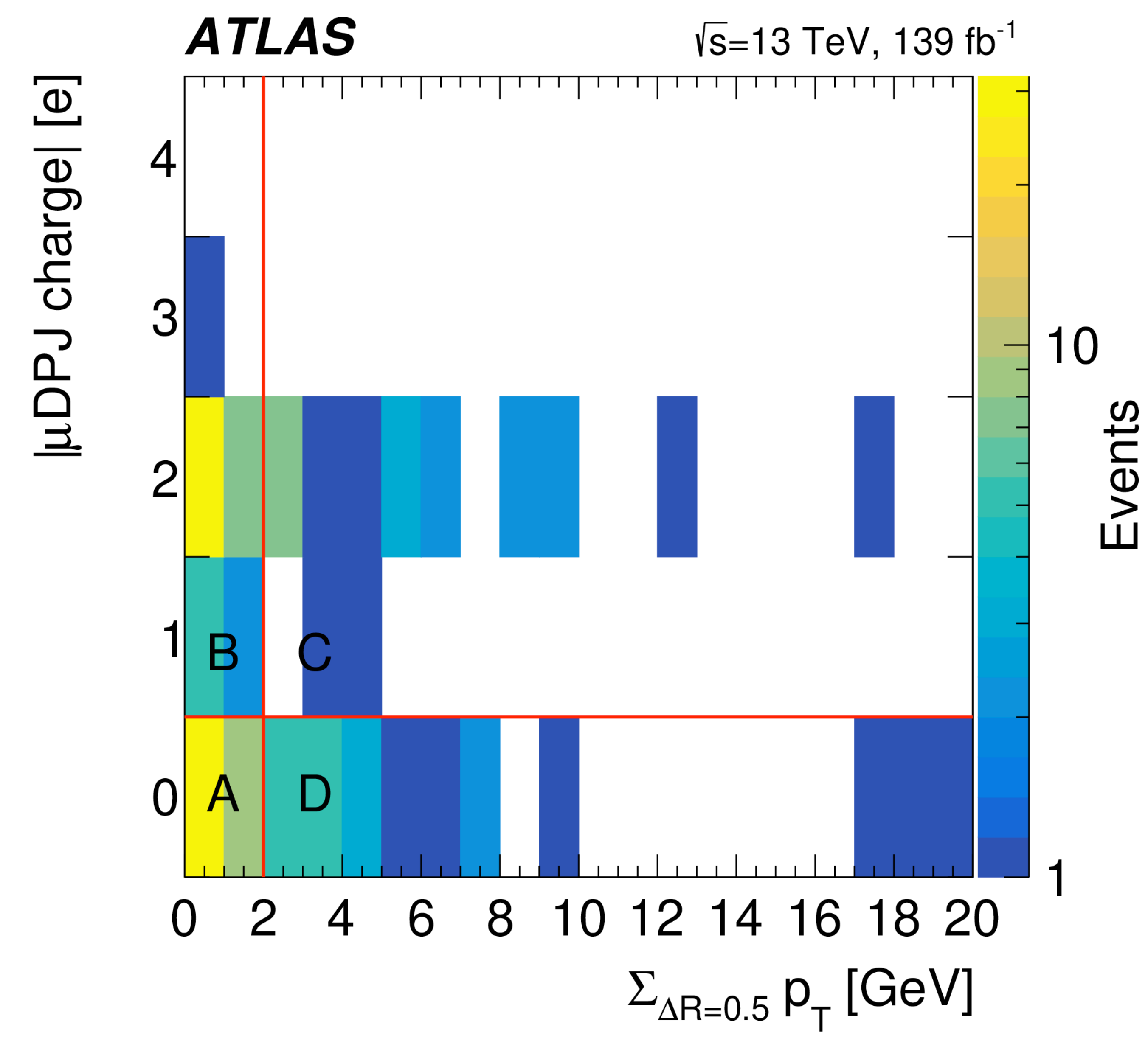
- The expected BG in the SR is estimated using the ABCD method.
  - The BCD regions are defined by changing the isolation, μDPJ charge and caloDPJ tagger score.

Search for light and neutral LLPs

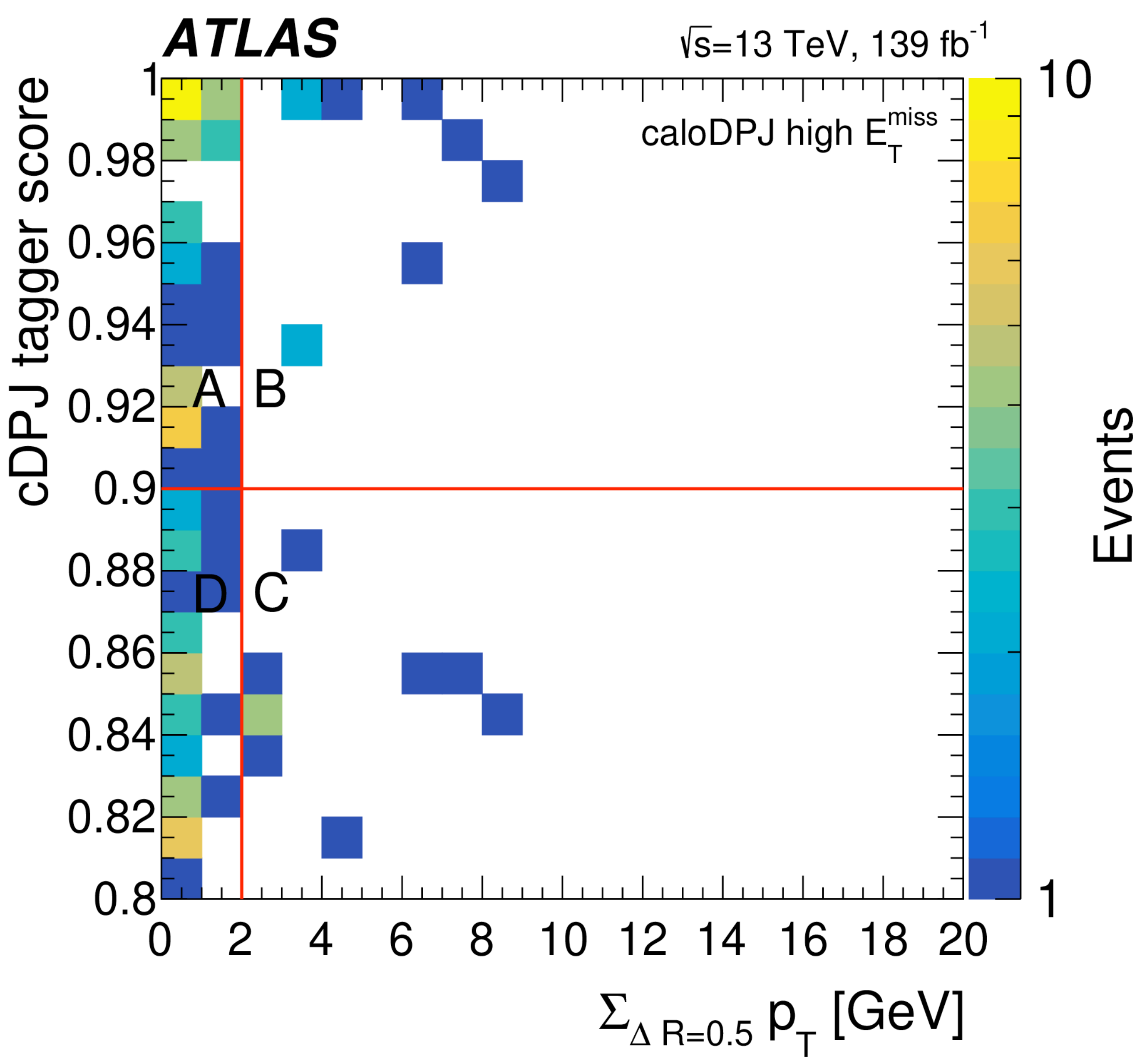
Unblinded Results

Selection	CRB	CRC	CRD	SR expected	SR observed
SR_{μ}	44	22	21	42 ± 14	41
SR_c^L	224	256	1123	983 ± 95	923
SR_c^H	9	11	35	29 ± 14	46

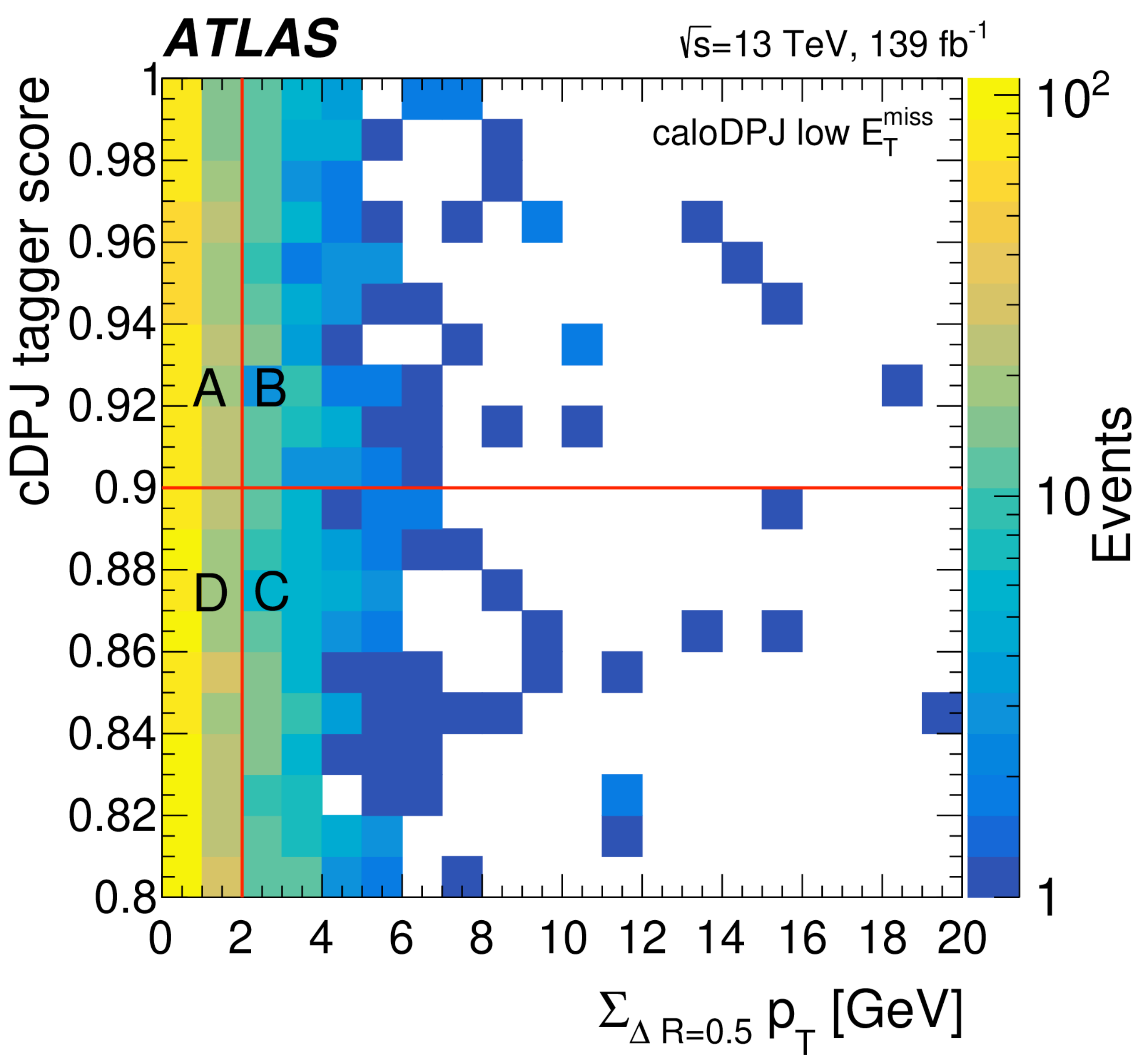
μDPJ Signal Region



caloDPJ High E_T^{miss} Signal Region



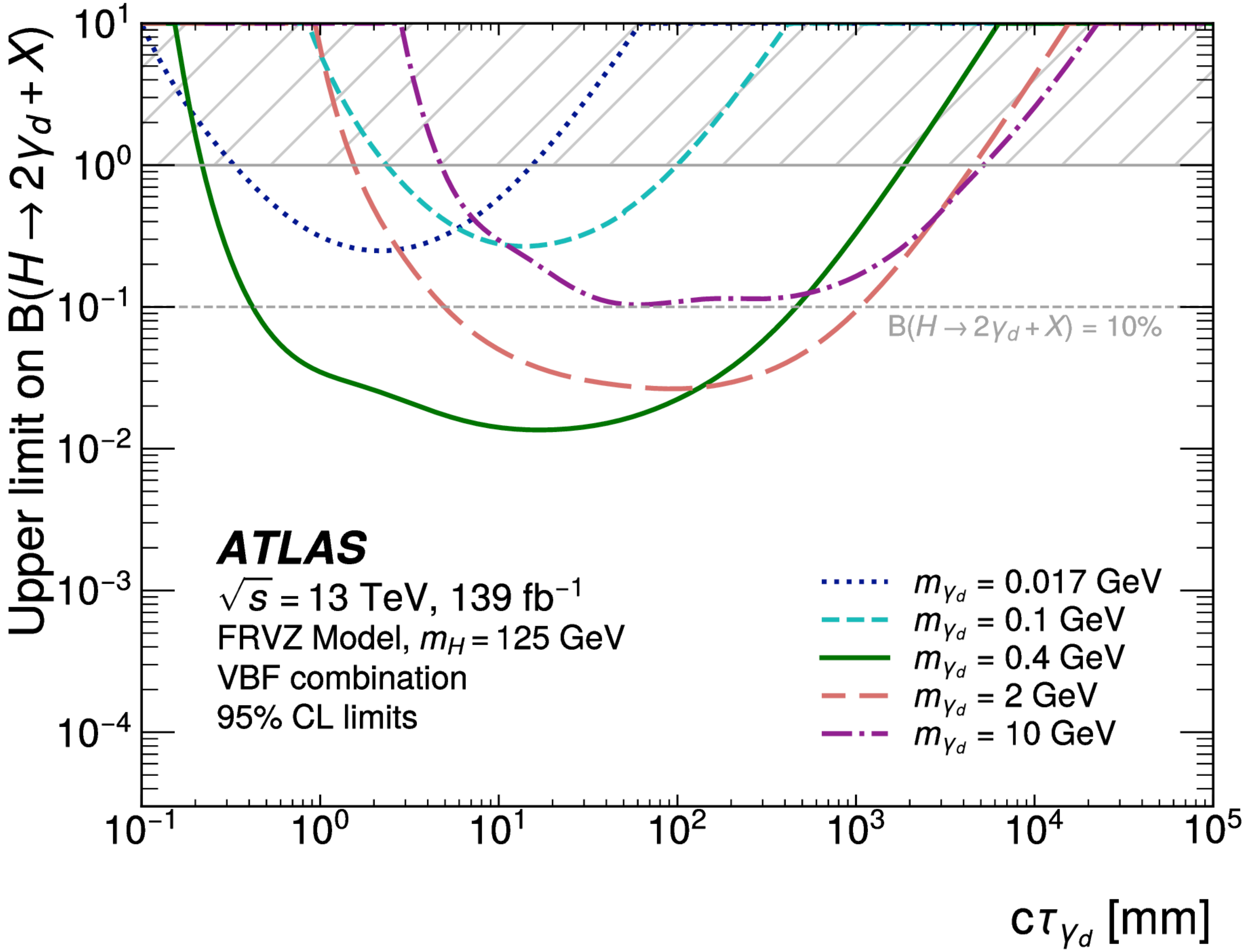
caloDPJ Low E_T^{miss} Signal Region



- The expected vs observed events agree within uncertainties.
  - No significant excess has been observed.
- New limits are set for the Dark-photon production

Search for light and neutral LLPs

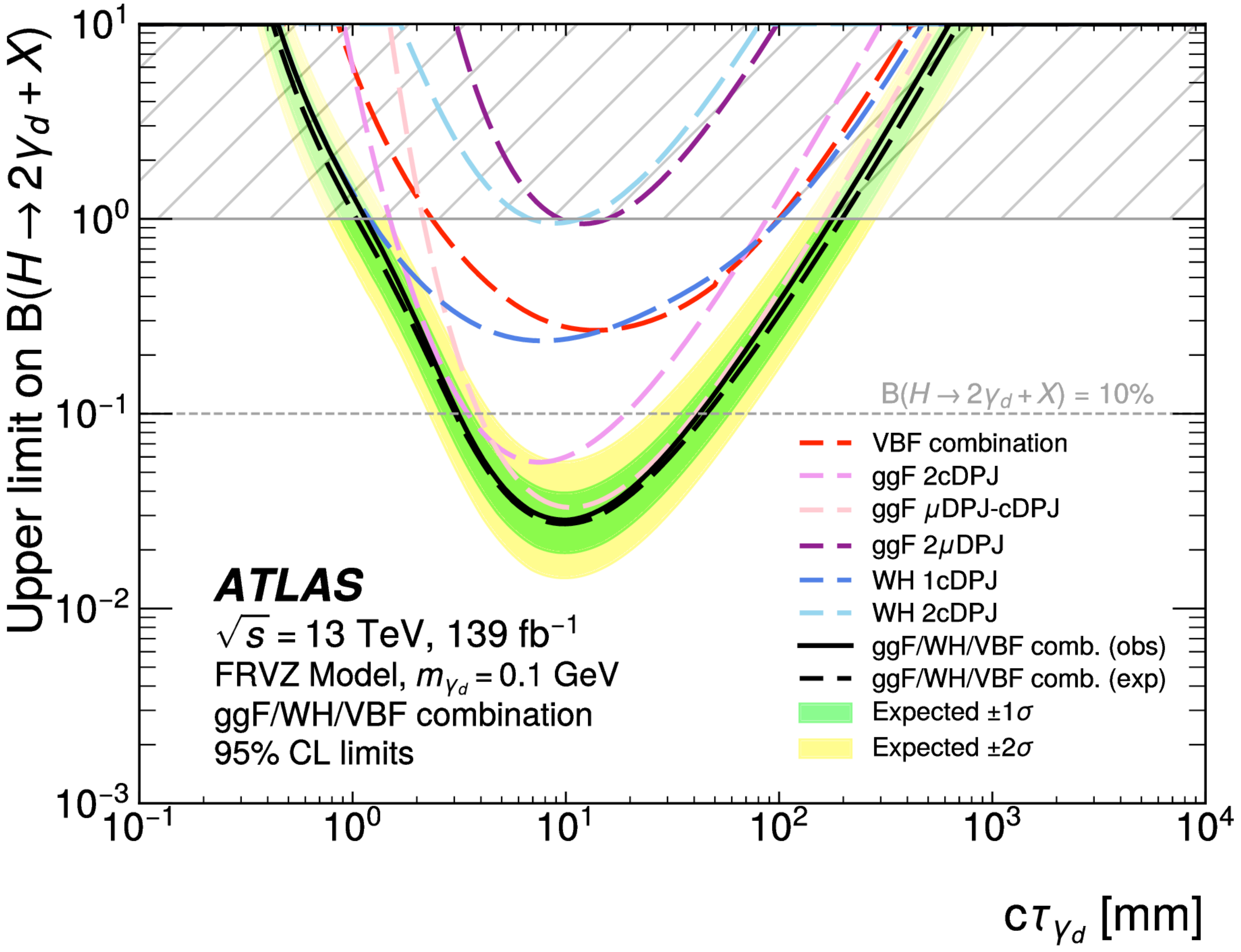
Limits

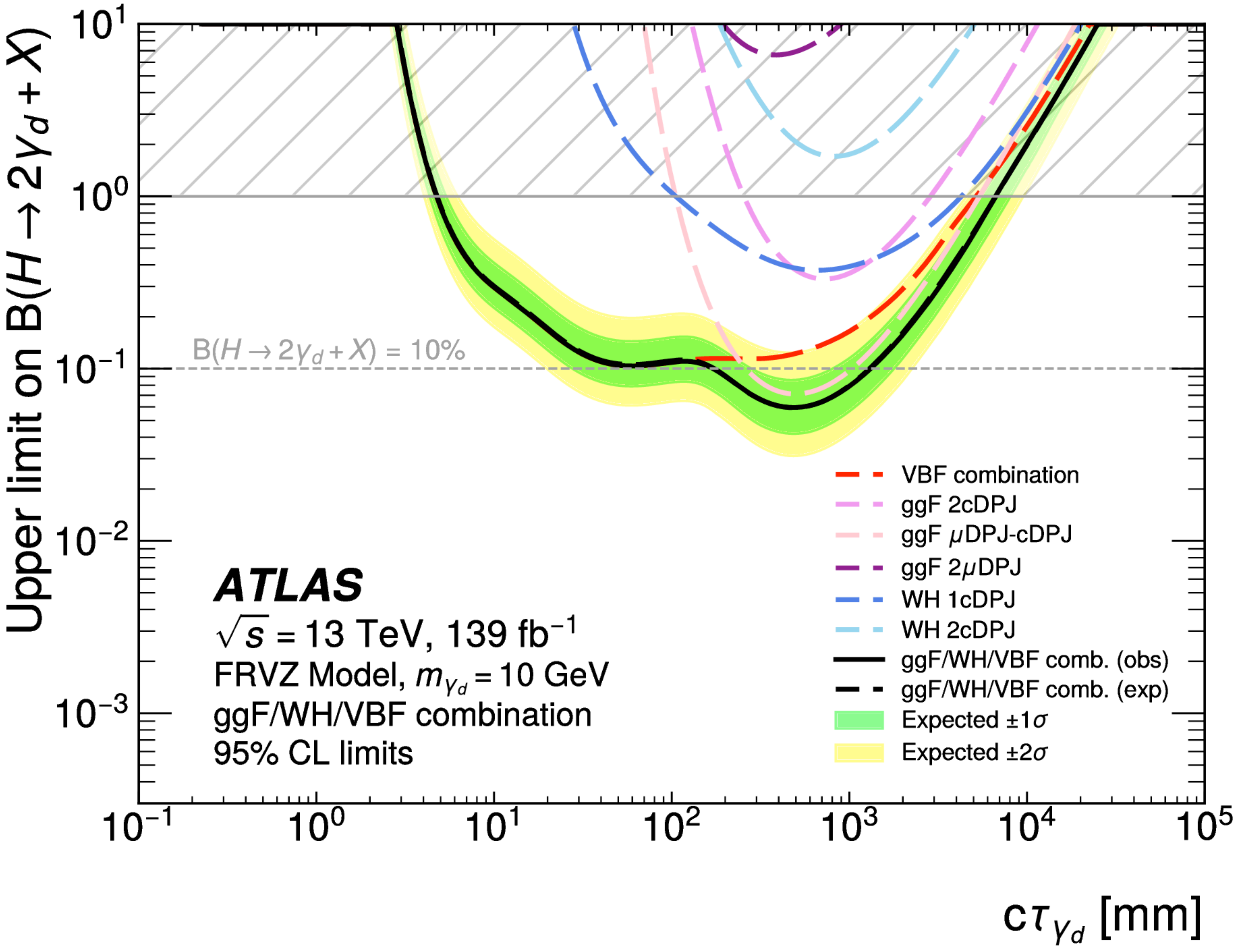


- This search alone excludes wide range of dark-photons with varying masses and life-times

Search for light and neutral LLPs

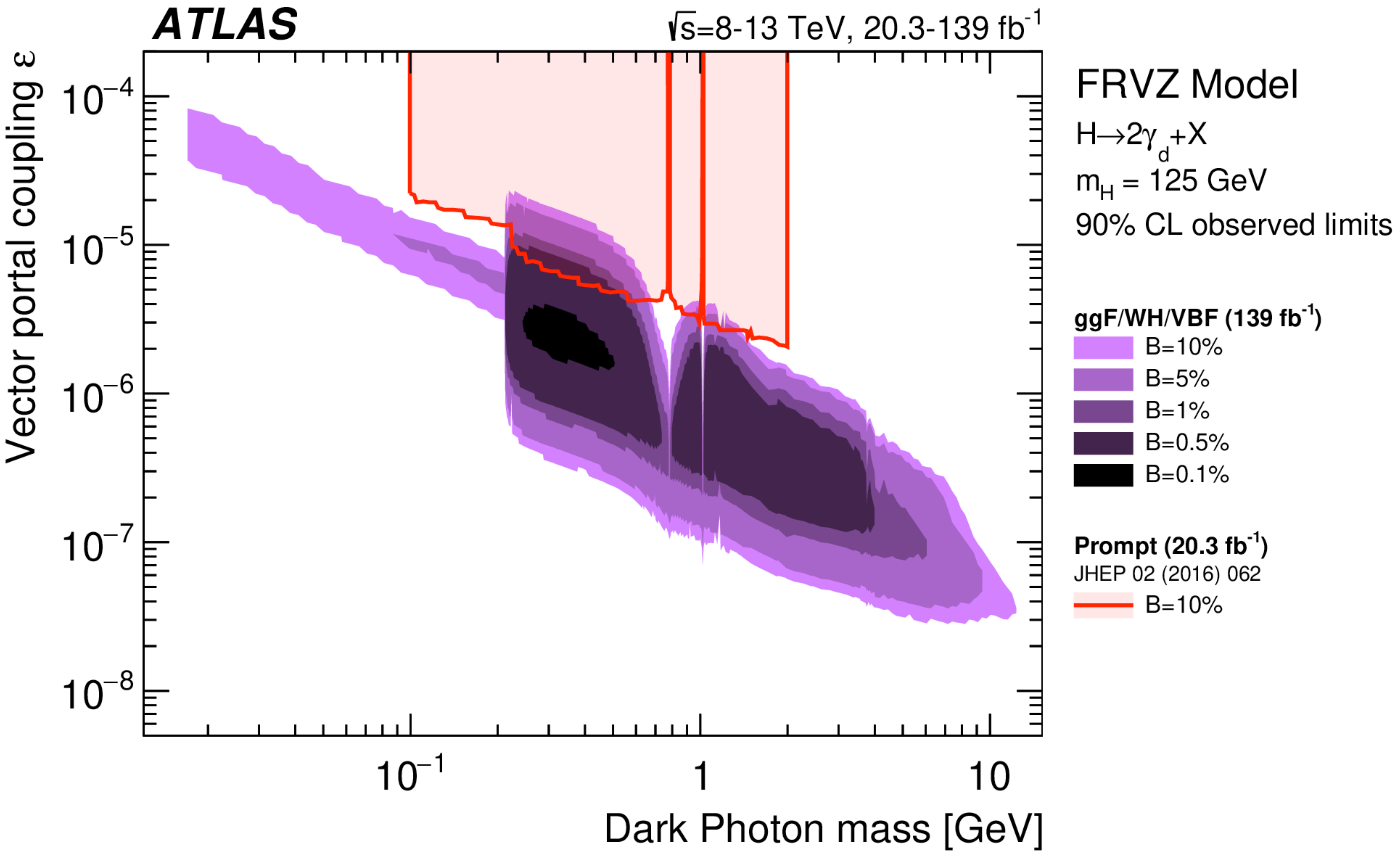
Limits





- When combined with other production modes, branching fraction above 10% can be excluded for decay lengths between 173 and 1296 mm for 10 GeV dark photons with the new VBF results

Search for light and neutral LLPs



Reinterpretation SUSY searches with Tau final states

Reinterpretation SUSY searches with Tau final states

Analysis Strategy

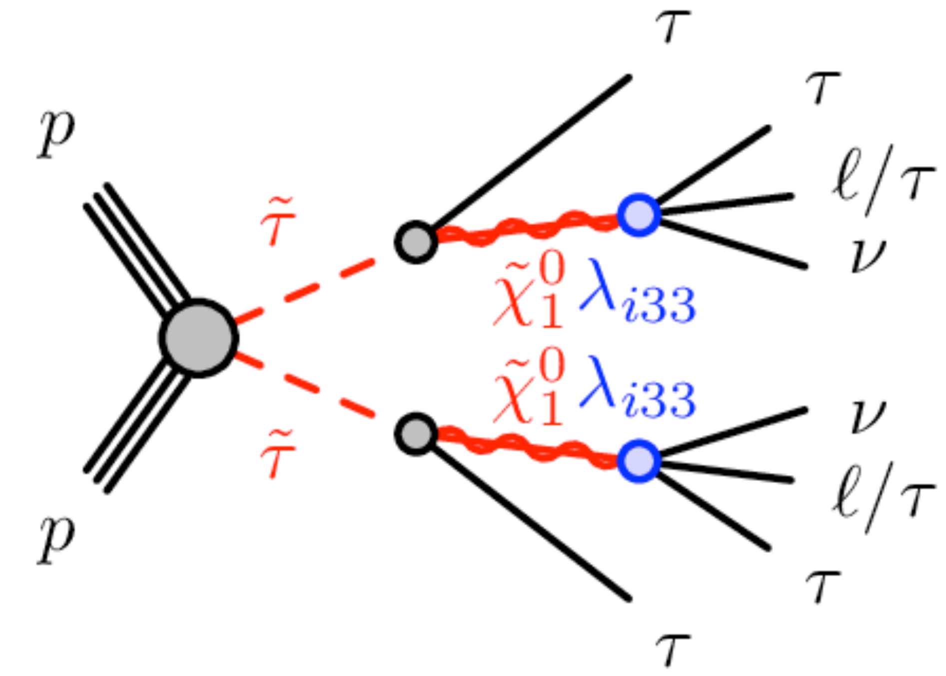
The PUB note ATL-PHYS-PUB-2024-007 reinterprets the two old results for LLP decays

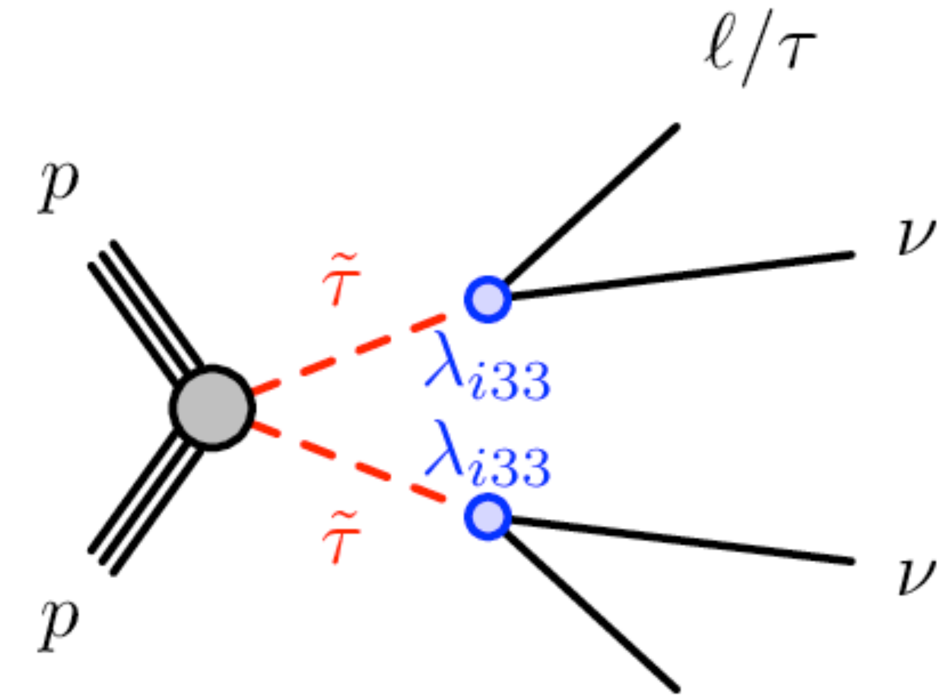
- 2τ final states: JHEP05(2024)150 with hadronically decaying Tau's
- $> 4\ell$ final states: JHEP07(2021)167 with upto two hadronically decaying Tau's

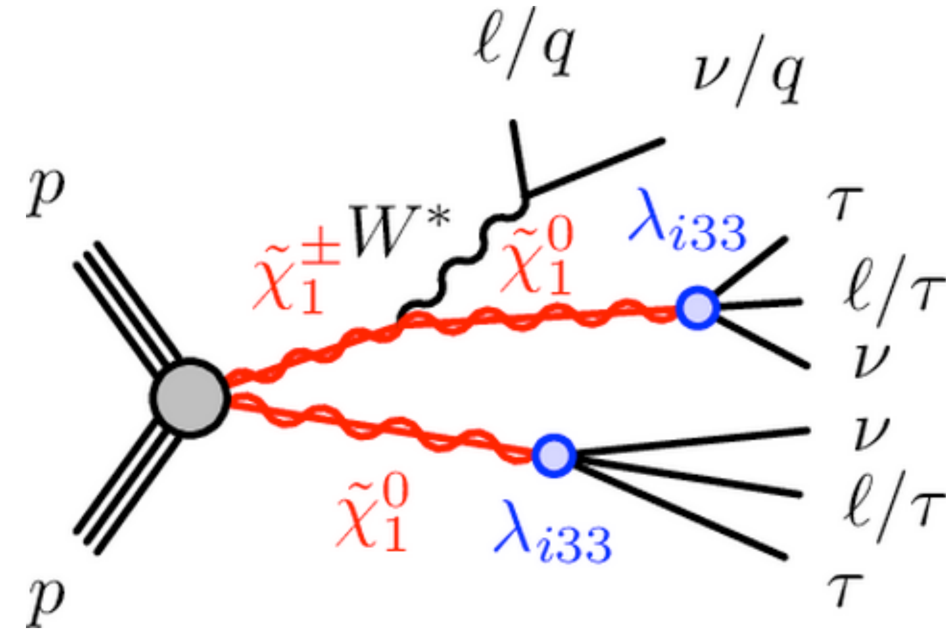
$$W_{\text{RPV}} = \frac{\lambda_{ijk}}{2} L_i L_j \bar{E}_k + \lambda'_{ijk} L_i Q_j \bar{D}_k + \frac{\lambda''_{ijk}}{2} \bar{U}_i \bar{D}_j \bar{D}_k + k_i L_i H_u$$

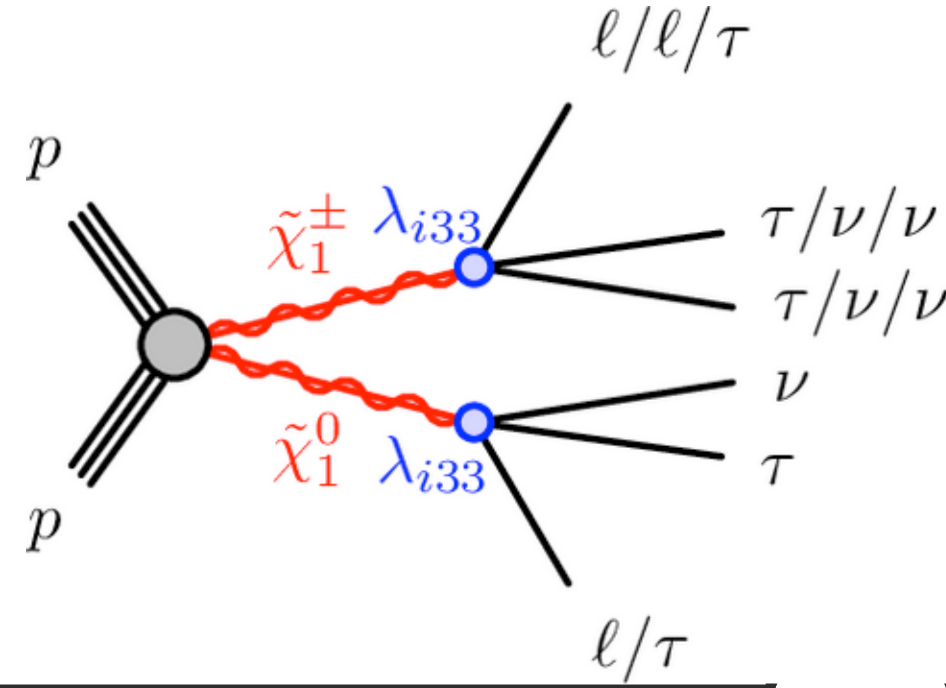
In this reinterpretation we use this general supper potential with a focus on mass-degenerate higgsino pairs and staus

- When λ_{133} and λ_{233} are non-zero results in a non-stable LSP that decays into SM leptons.
- Depending on the choice of RPV couplings and LSP and stau masses the LSP particles:
  - Becomes long-lived and decays beyond the detector momentum resulting in MET signature
  - Decays inside the detector resulting in displaced signatures





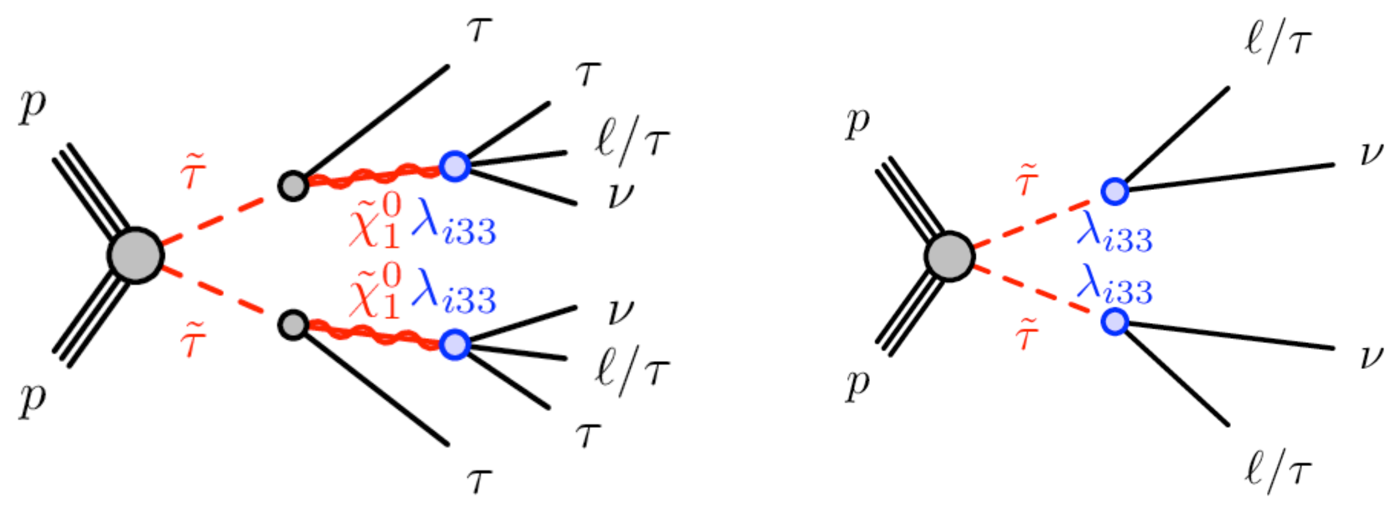


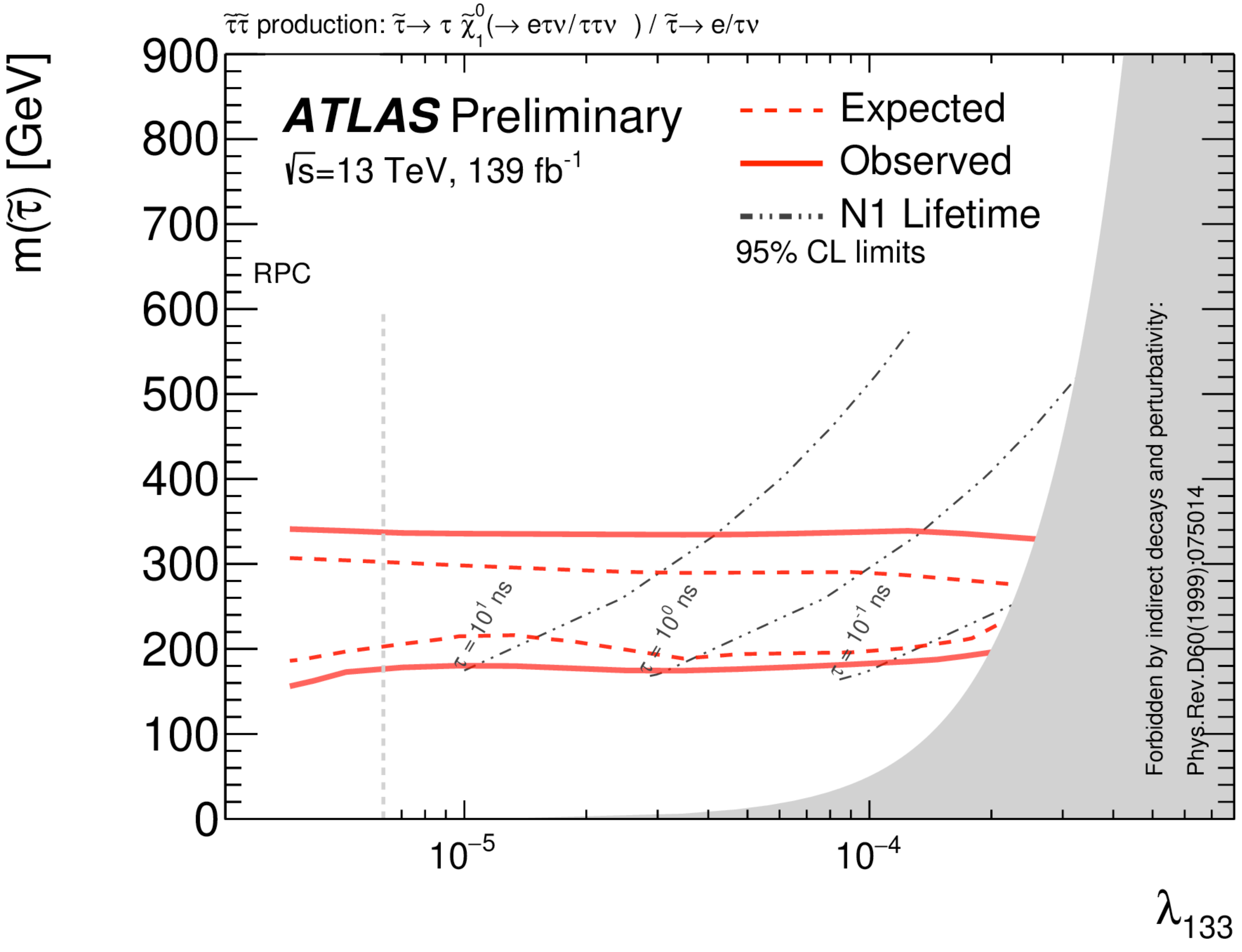


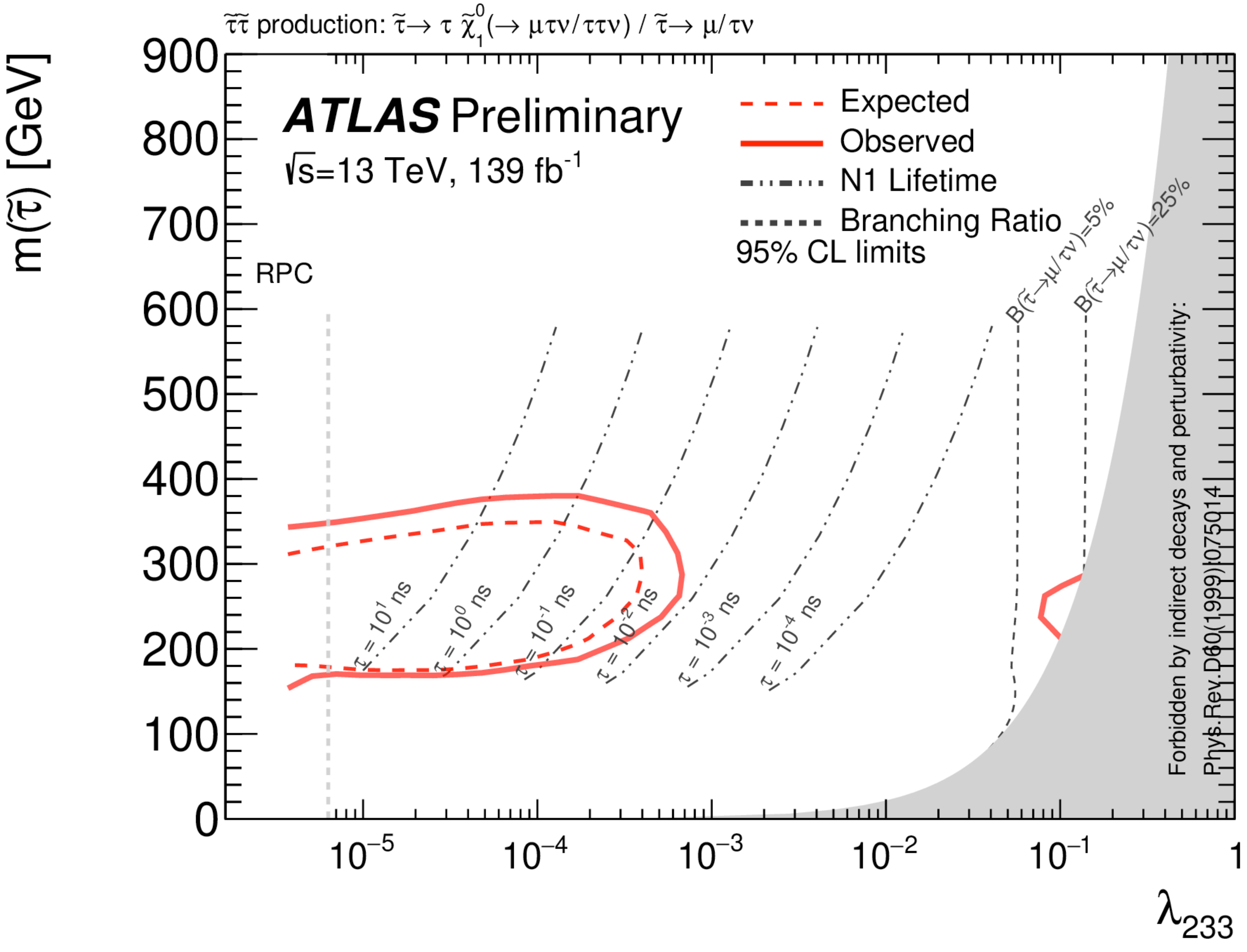
Reinterpretation SUSY searches with Tau final states

Stau Limits

$$W_{\mathrm{RPV}} = \frac{\lambda_{ijk}}{2} L_i L_j \bar{E}_k + \lambda'_{ijk} L_i Q_j \bar{D}_k + \frac{\lambda''_{ijk}}{2} \bar{U}_i \bar{D}_j \bar{D}_k + k_i L_i H_u$$





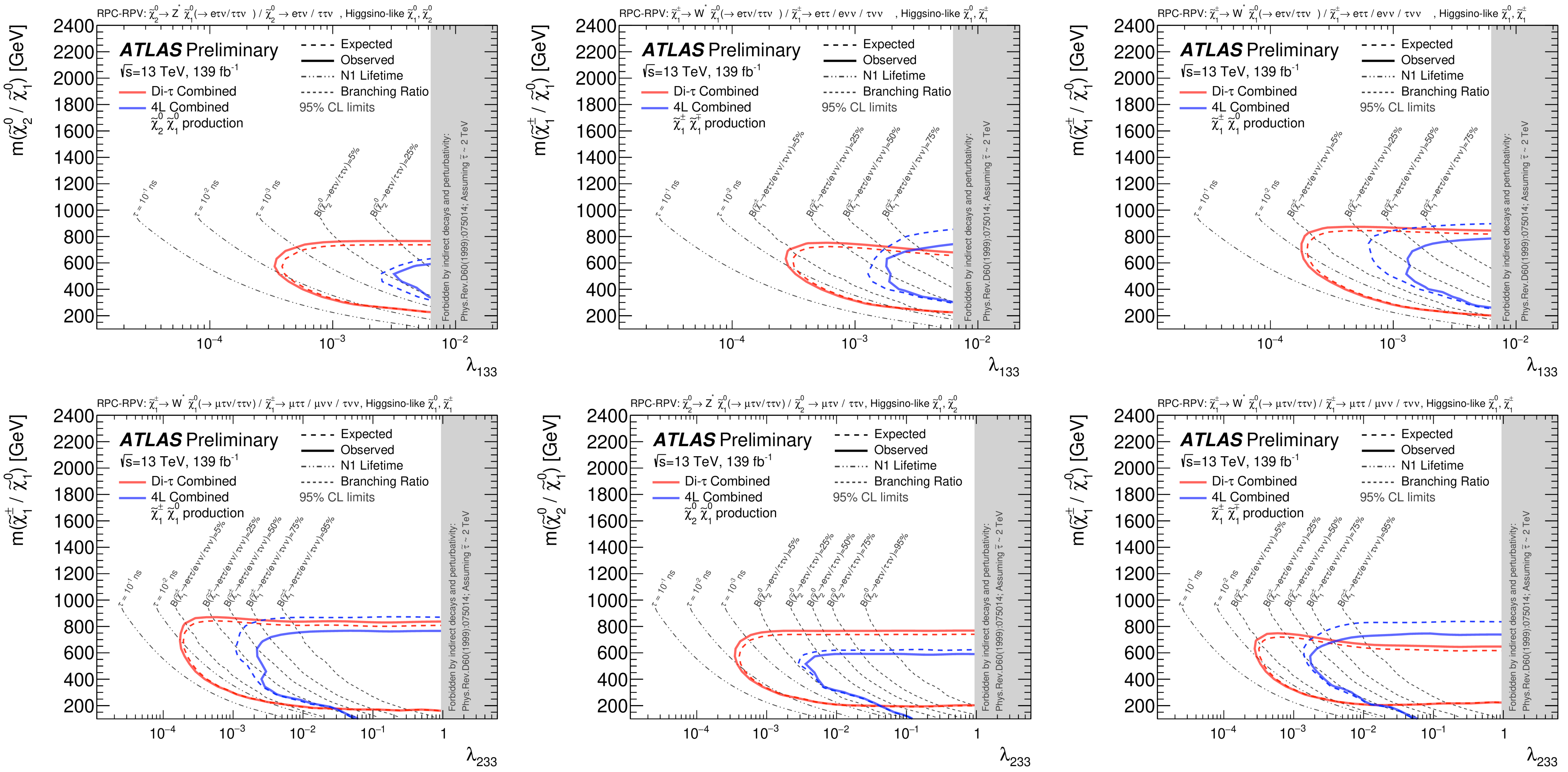


Stau masses in the range of 180 GeV to 340 GeV are excluded at 95% confidence level for neutralino lifetimes exceeding 10^{-1} ns

Reinterpretation SUSY searches with Tau final states

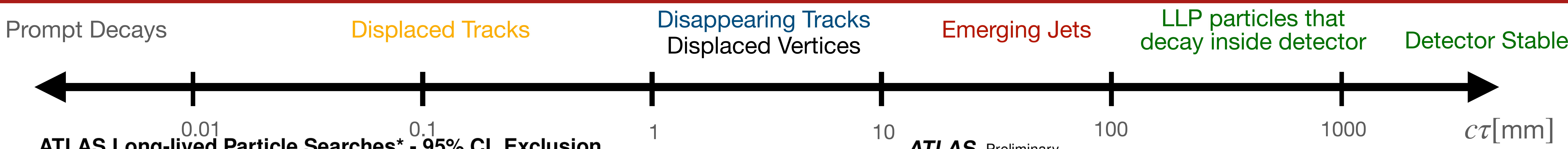
Higgsino Limits

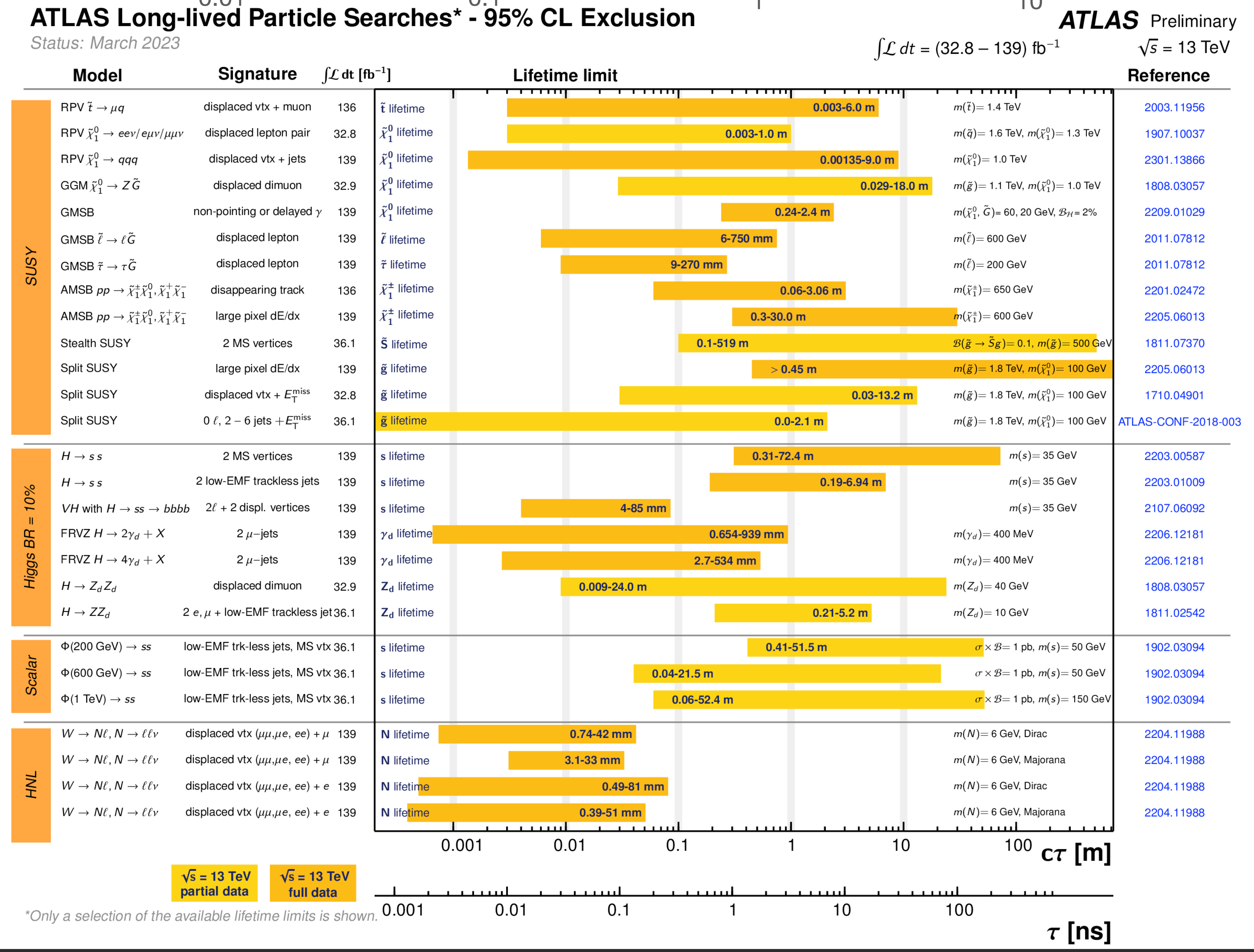
$$W_{\mathrm{RPV}} = \frac{\lambda_{ijk}}{2} L_i L_j \bar{E}_k + \lambda'_{ijk} L_i Q_j \bar{D}_k + \frac{\lambda''_{ijk}}{2} \bar{U}_i \bar{D}_j \bar{D}_k + k_i L_i H_u$$



The exclusion limits on higgsino masses reach up to 800 GeV in scenarios with lifetimes below 10^{-3} ns.

Where Do We Stand In Other LLP Searches?





Other Mentions

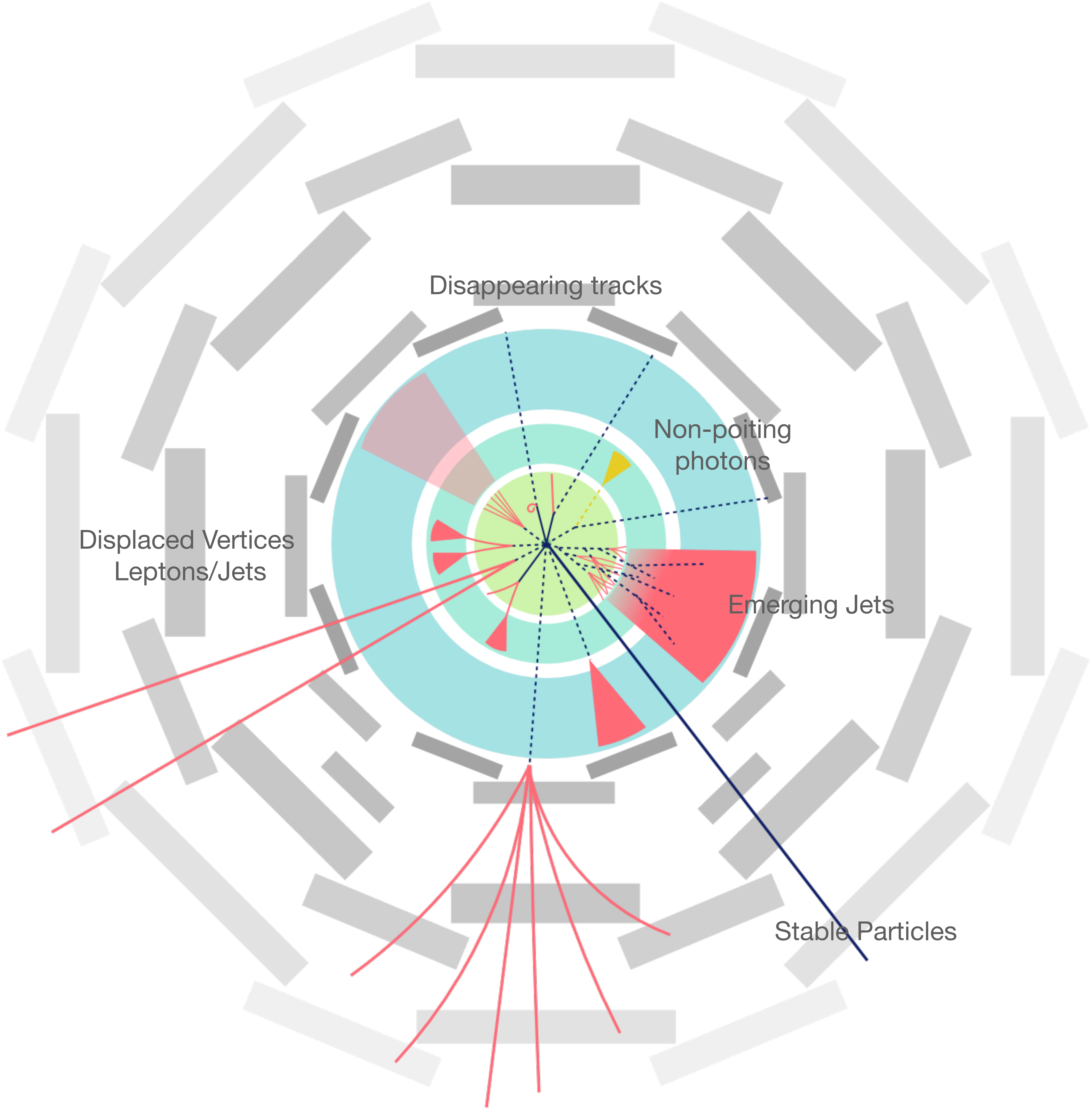
- **Multi-Charged Particles EXOT-2018-54**
- **SUSY dE/dx + Beta Calo: ATLAS-CONF-2023-044**
- **Magnetic Monopoles: EXOT-2019-33**
- **Micro Displaced Muons: SUSY-2020-09**

Conclusion

- As the ATLAS LLP community, we have been working hard to cover variety of LLP signatures.
  - Uncovering each of these signatures comes with unique challenges.
- Today we presented a small subset of these.
- Although we have not discovered any new physics, we are optimistic for Run-3 so stay tuned for new results.

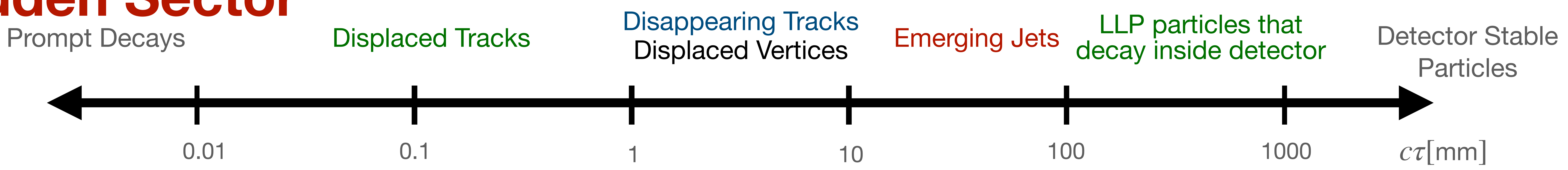
Thank you for listening!

Backups

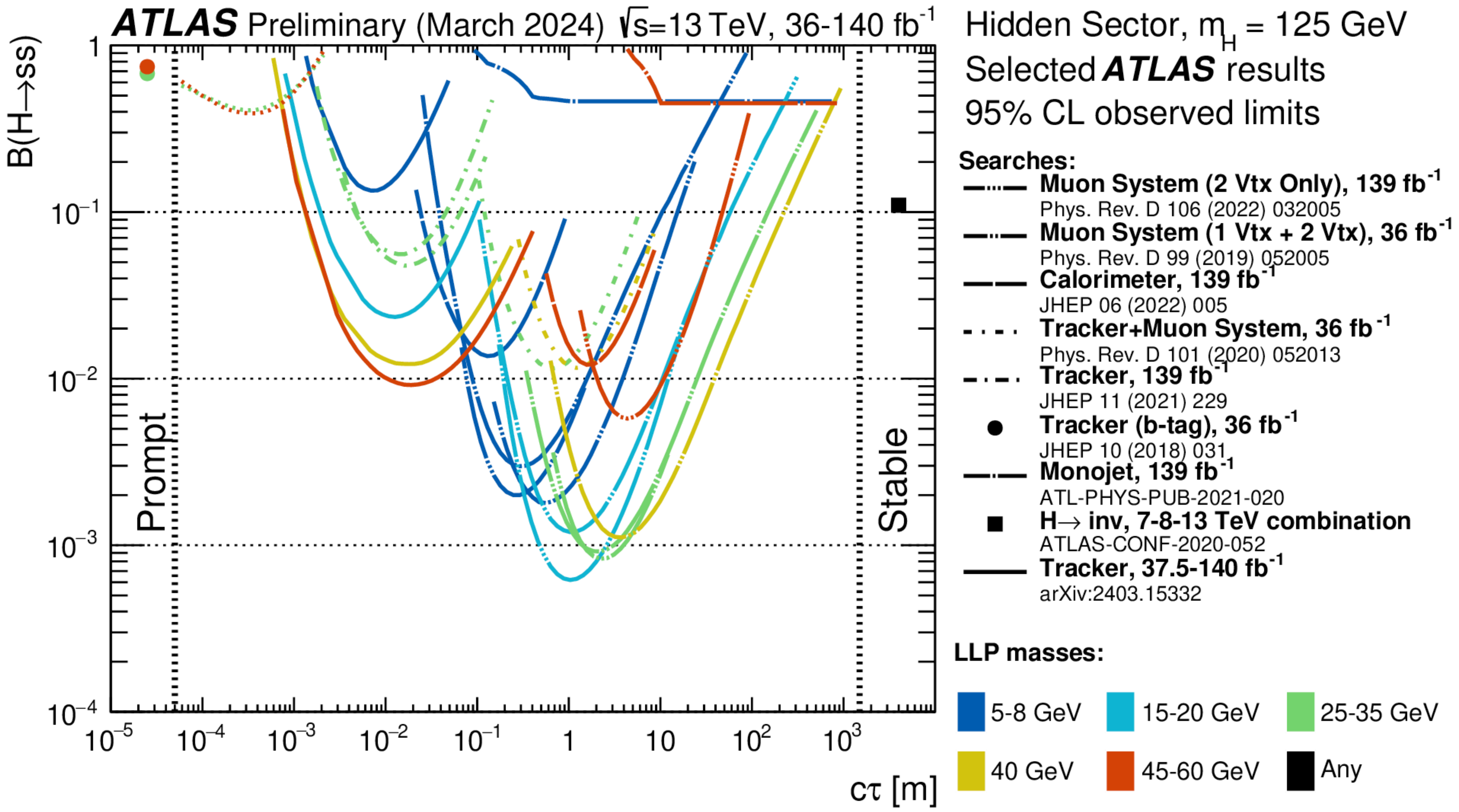

Disappearing tracks
Non-poiting
photons
Displaced Vertices
Leptons/Jets
Emerging Jets
Stable Particles

Where do we Stand in LLP Searches?

Hidden Sector



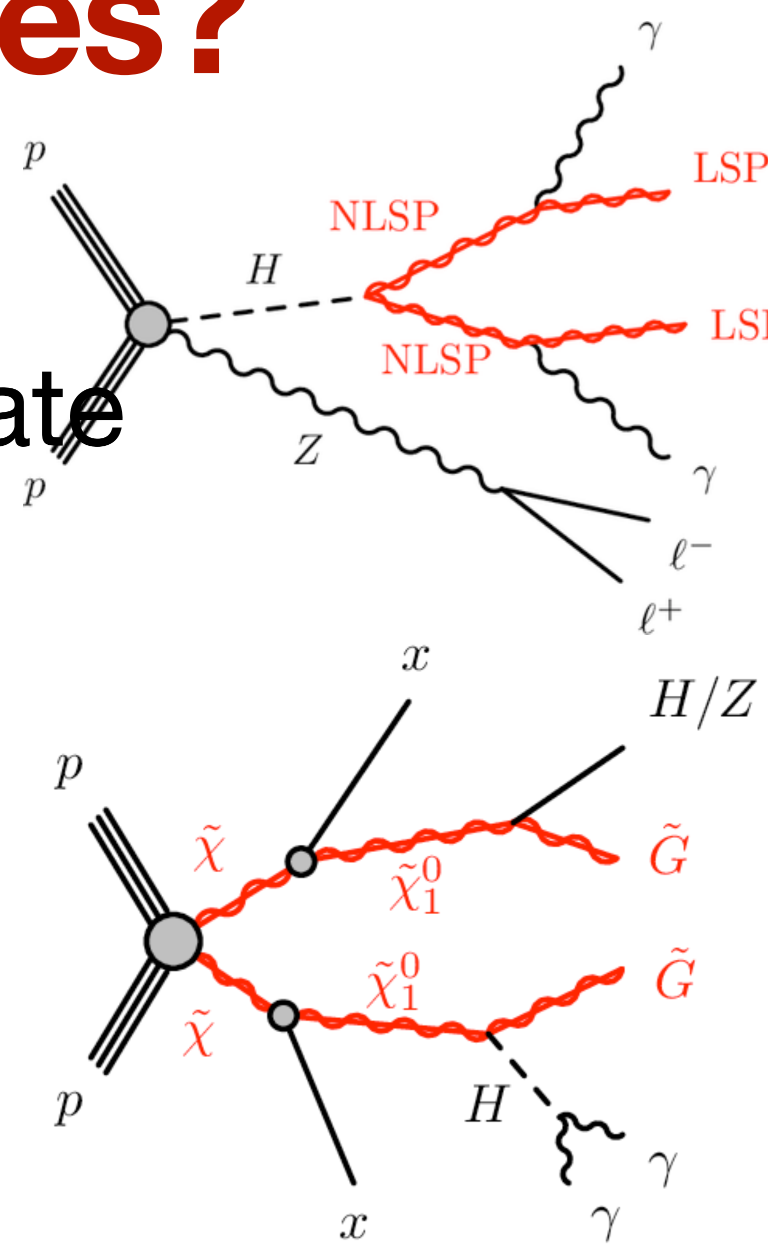
- For Higgs decaying into neutral spin-0 bosons, we cover a large sector of different LLP masses and life-times.

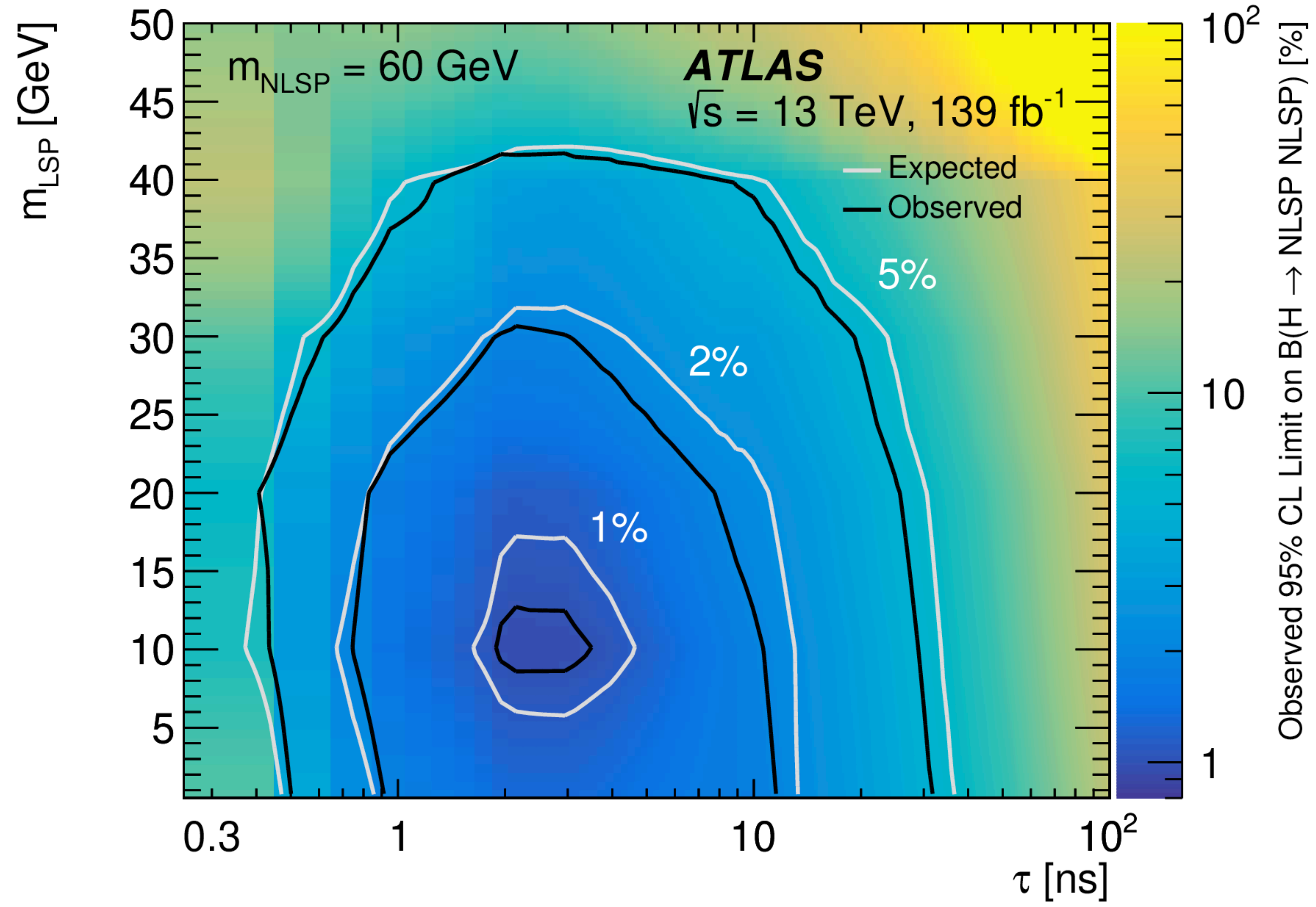


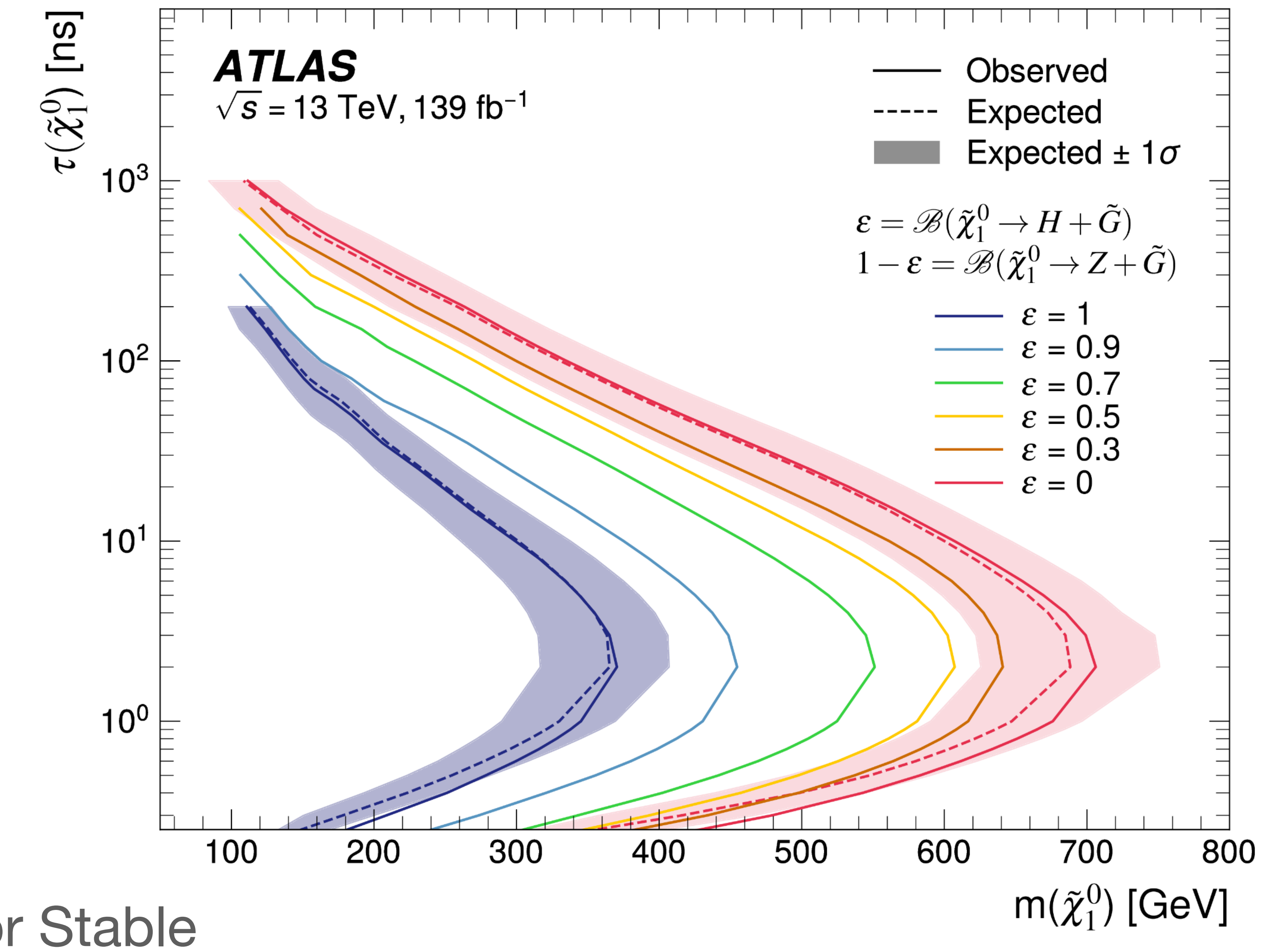
Where Do We Stand in LLP Searches?

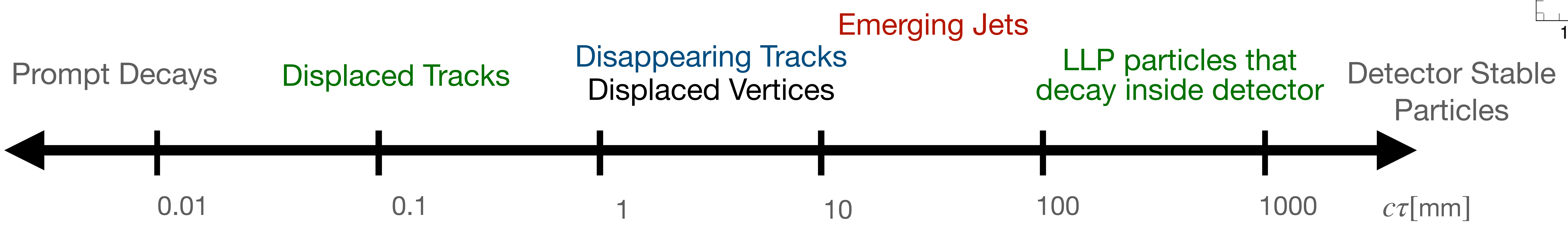
SUSY, Neutralino

- Neutralinos predicted by SUSY can demonstrate them selves as:
  - Displaced tracks
  - Emerging jets
  - Displaced Vertices
- They can have a similar signatures to hidden-sector particles
- The exclusion models for neutralino's are model specific but there is an active program to cover these SUSY models



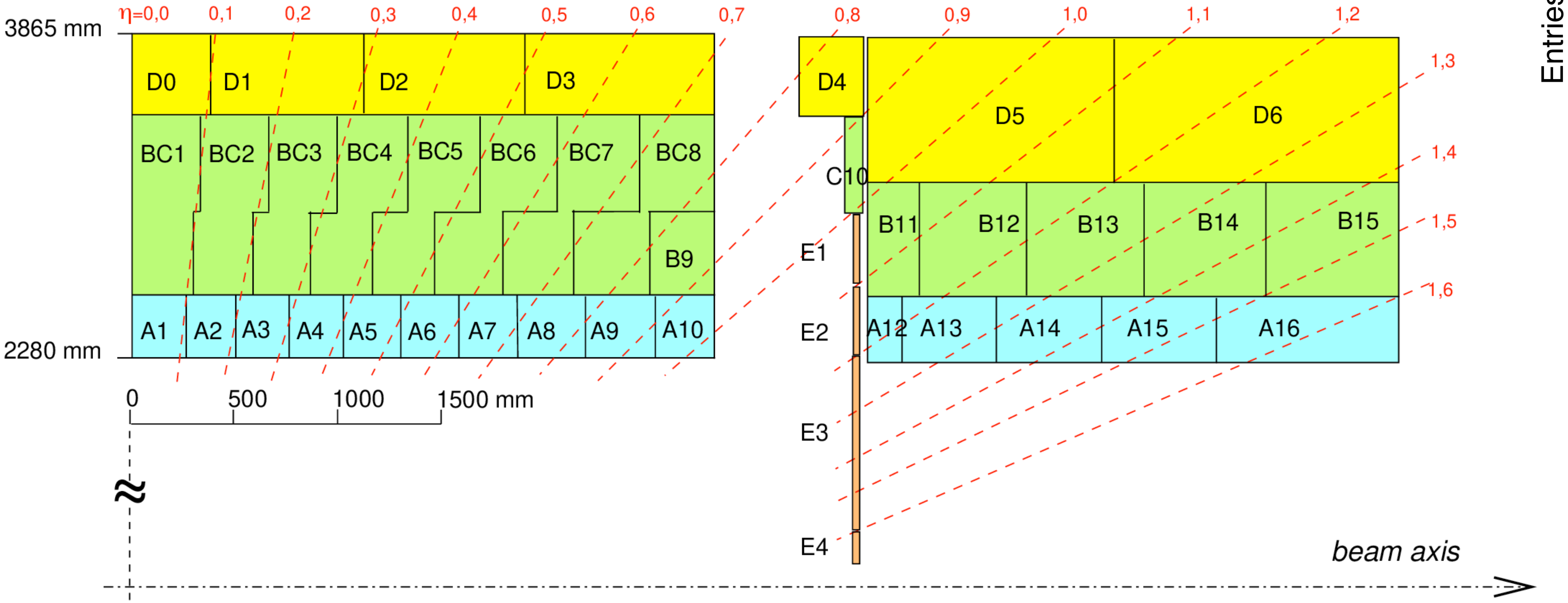


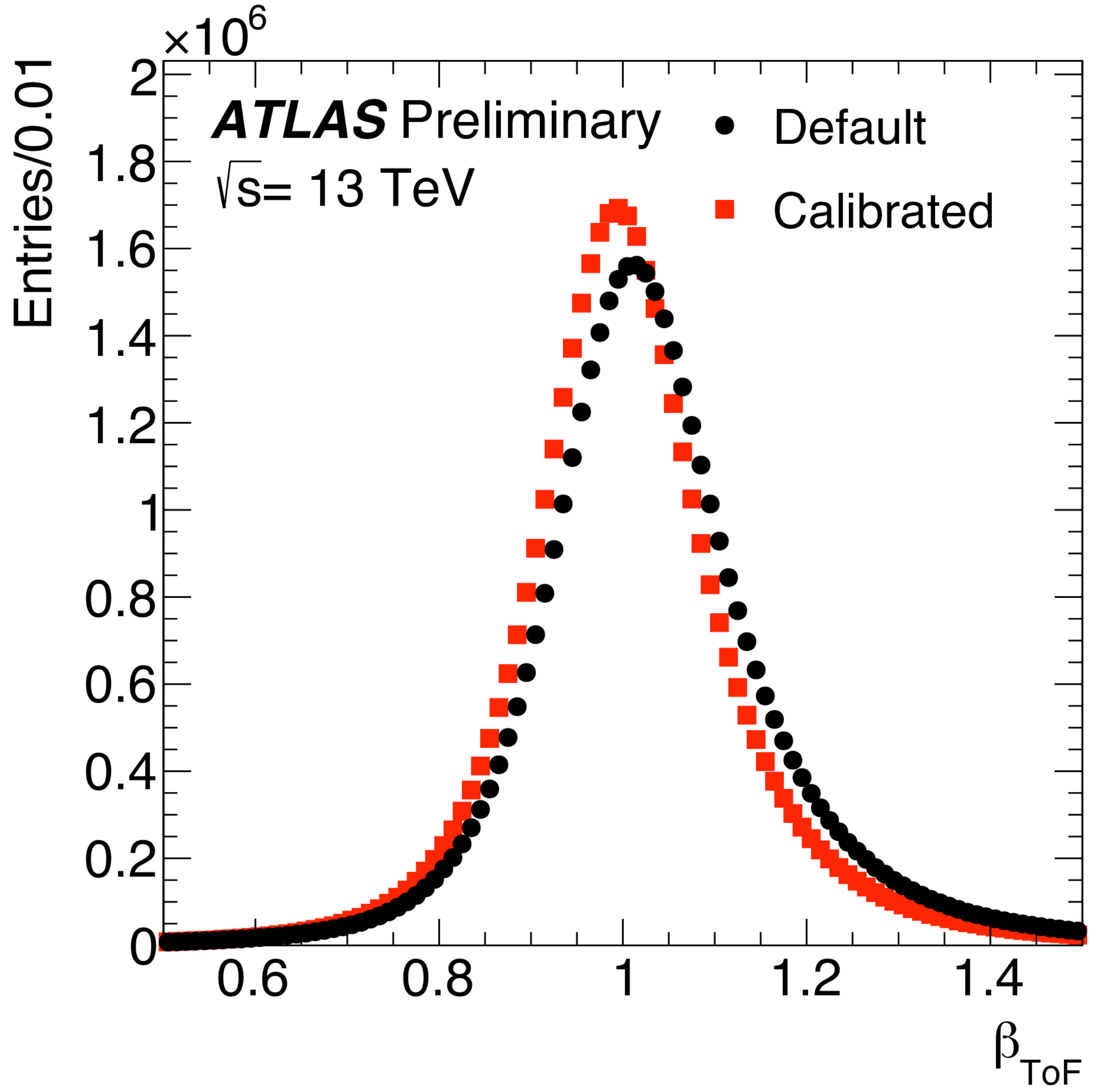


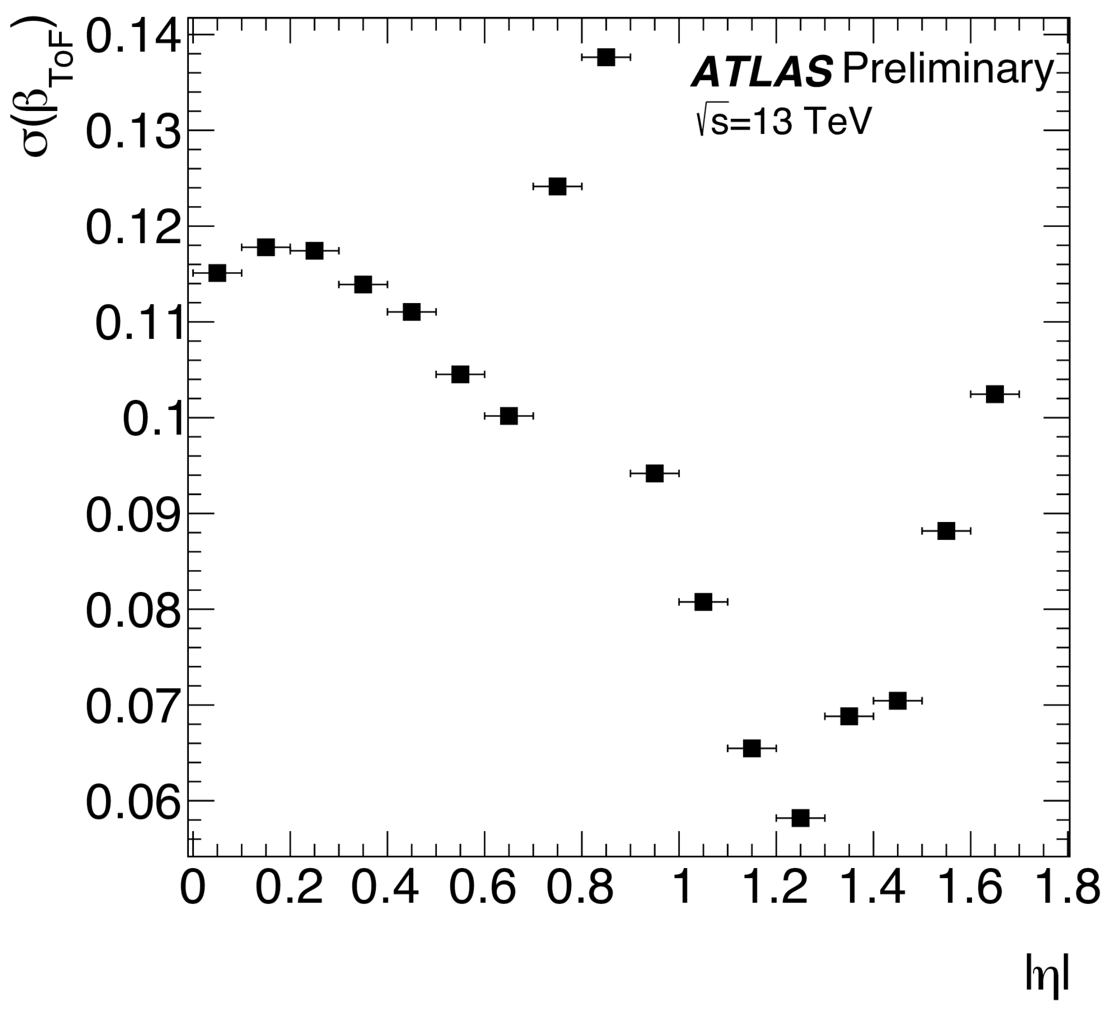


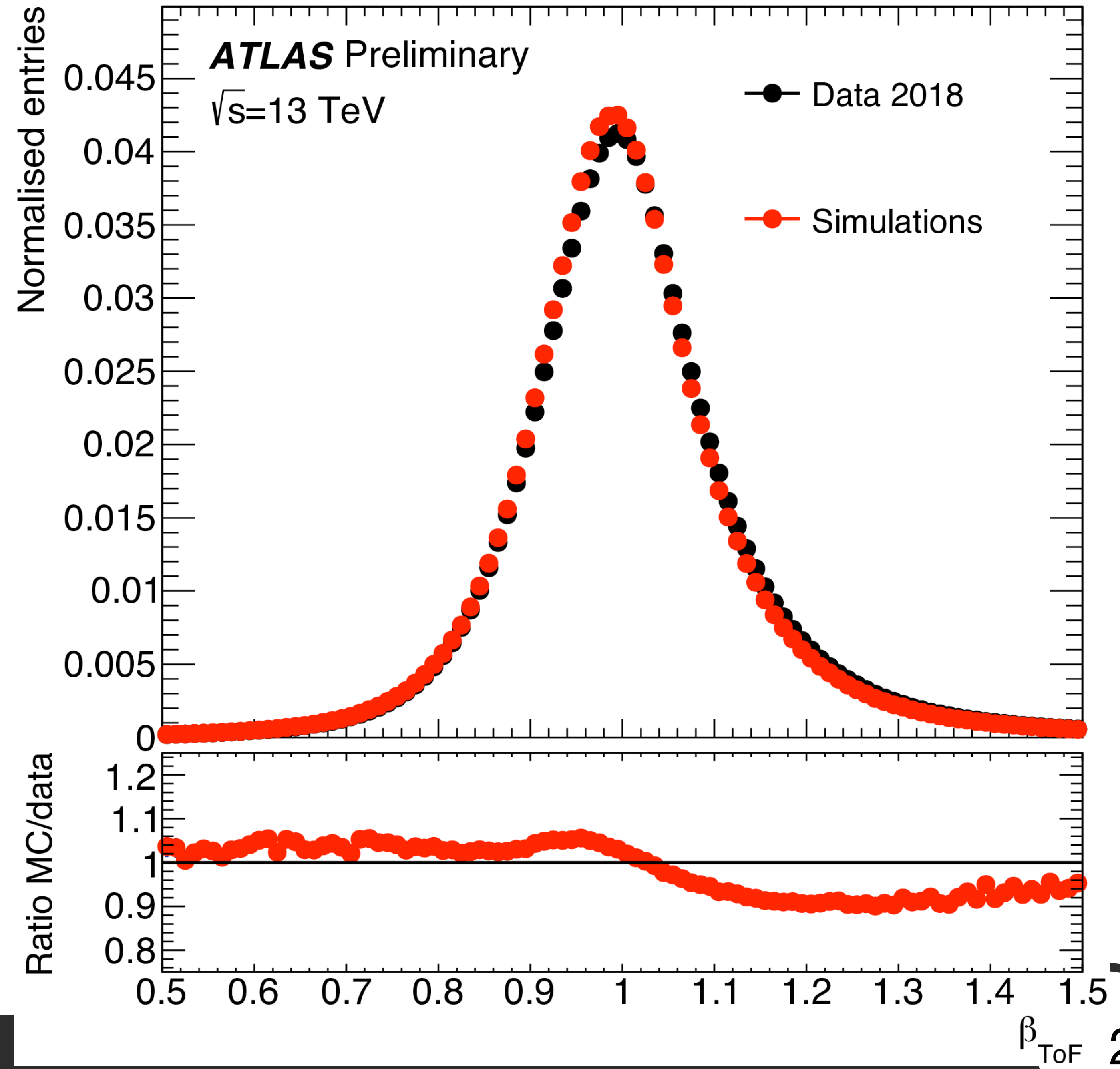
SUSY dE/dx Analysis Backups

Beta Calo Calibration

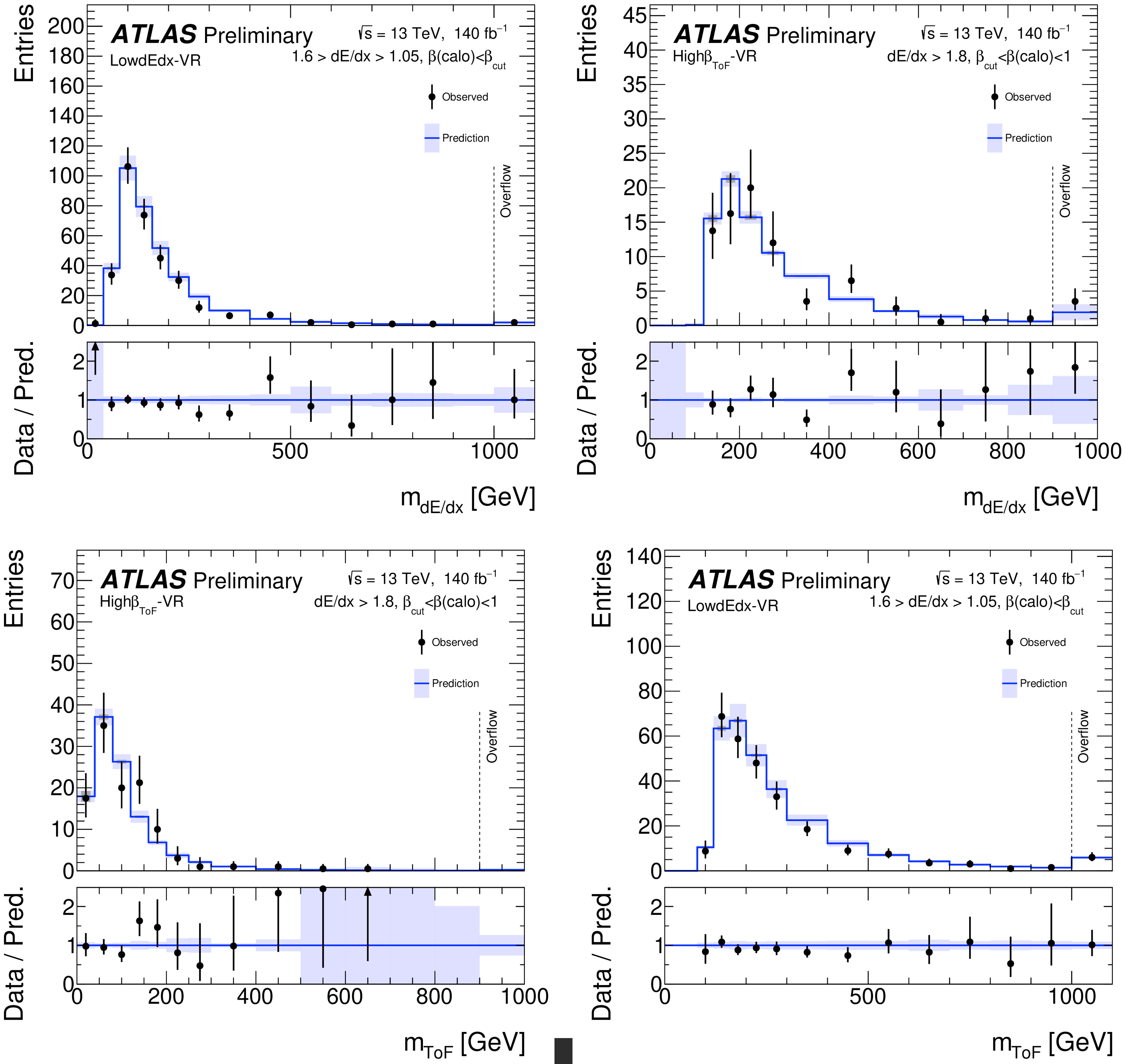








Validation Regions



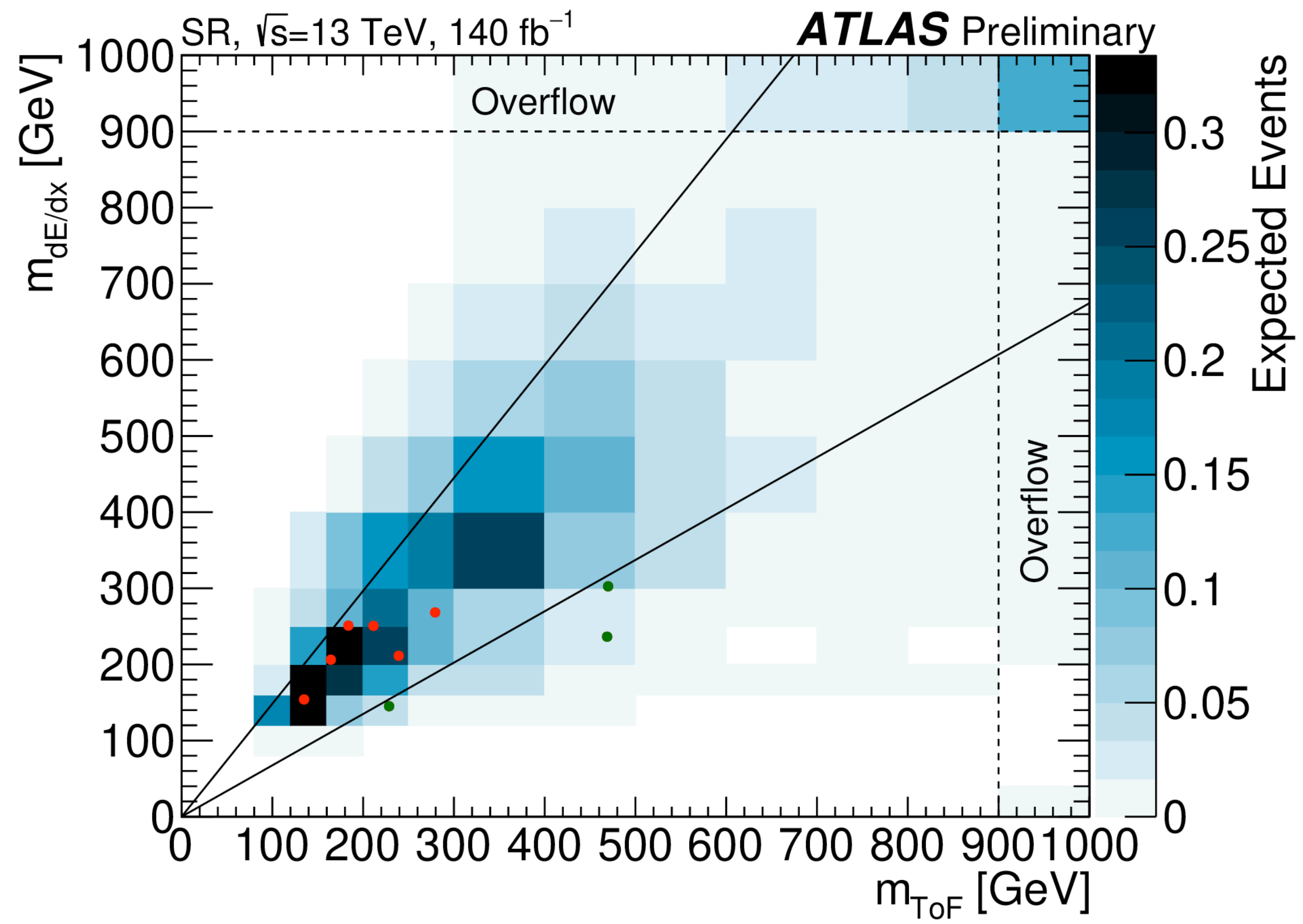
Selections

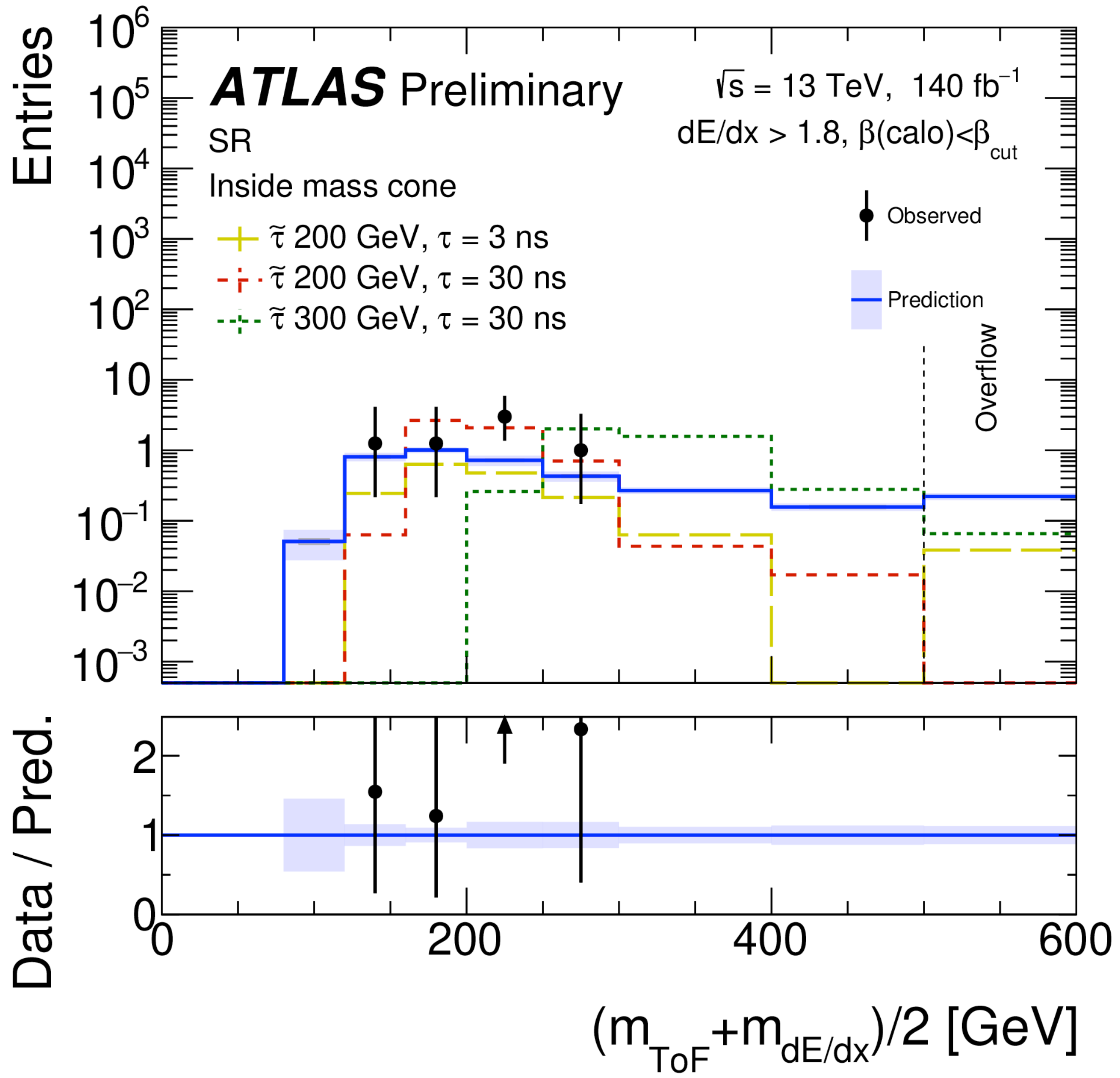
Region	E_T^{miss} [GeV]	dE/dx [MeV g^{-1}cm^2]	β_{ToF}
SR	> 170	> 1.8	$< \beta_{cut}$
kin-CR		< 1.6	< 1.0
$\beta\gamma$-CR	< 150	-	< 1.0
Highβ_{ToF}-VR	> 170	> 1.8	$[\beta_{cut}, 1.0]$
Highβ_{ToF}-VR kin-CR		< 1.6	$[\beta_{cut}, 1.0]$
Highβ_{ToF}-VR $\beta\gamma$-CR	< 150	-	$[\beta_{cut}, 1.0]$
LowdEdx-VR	> 170	[1.05,1.6]	$< \beta_{cut}$
LowdEdx kin-CR		< 1.05	< 1.0
LowdEdx $\beta\gamma$-CR	< 150	< 1.6	< 1.0

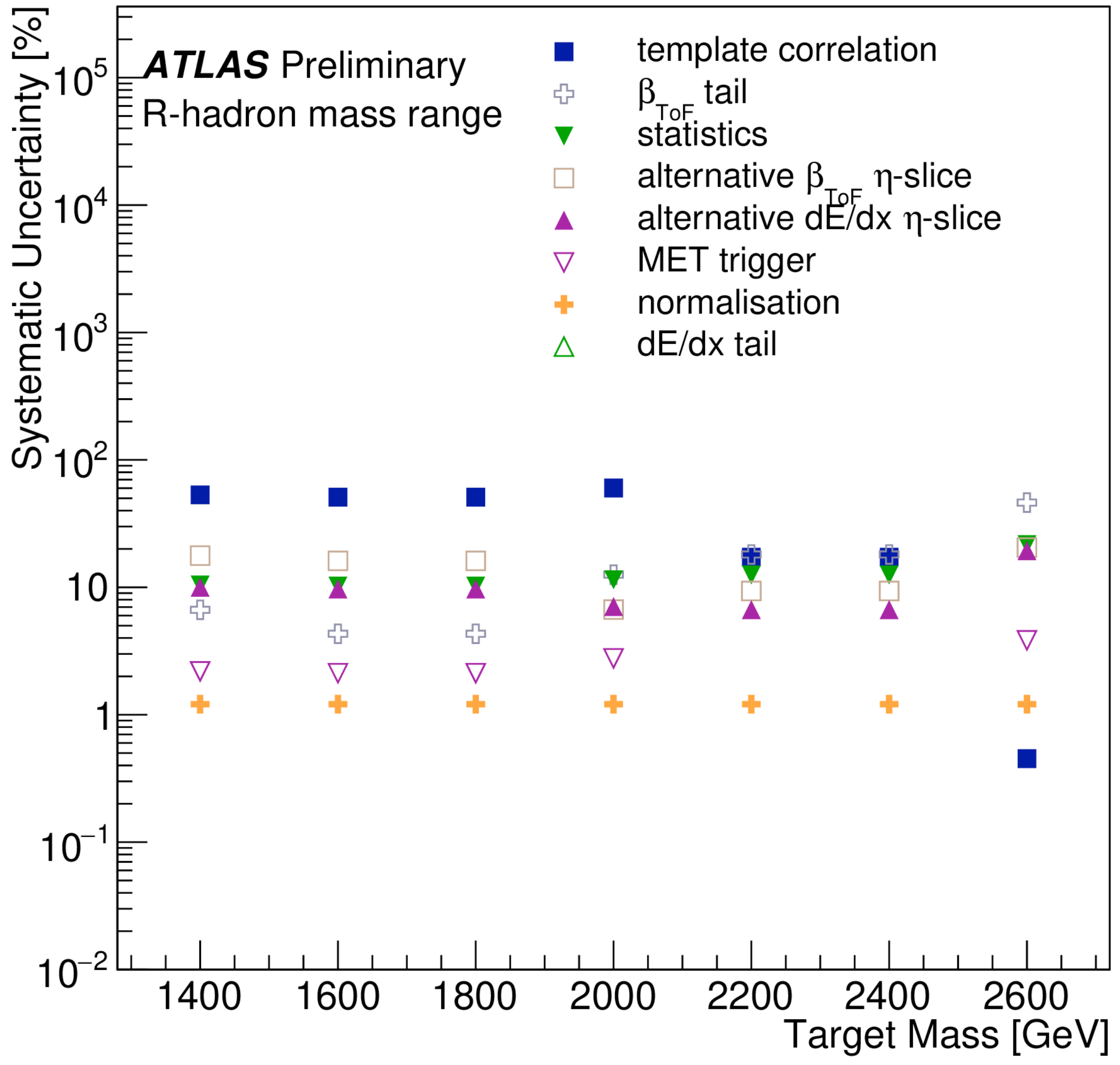
	trapezoid parameters, cone angle Θ=22 degrees	
target mass [GeV]	lower edge mass [GeV]	upper edge mass [GeV]
150	120	210
200	160	290
250	210	380
300	250	490
350	270	640
400	320	680
450	370	700
500	400	810
550	470	930
600	480	1360
650	530	1360
700	530	1360
800	580	1760
900	710	2610
1000	820	2380
1400	860	7000
1600	950	7000
1800	950	7000
2000	1100	7000
2200	1200	7000
2400	1200	7000
2600	1660	7000

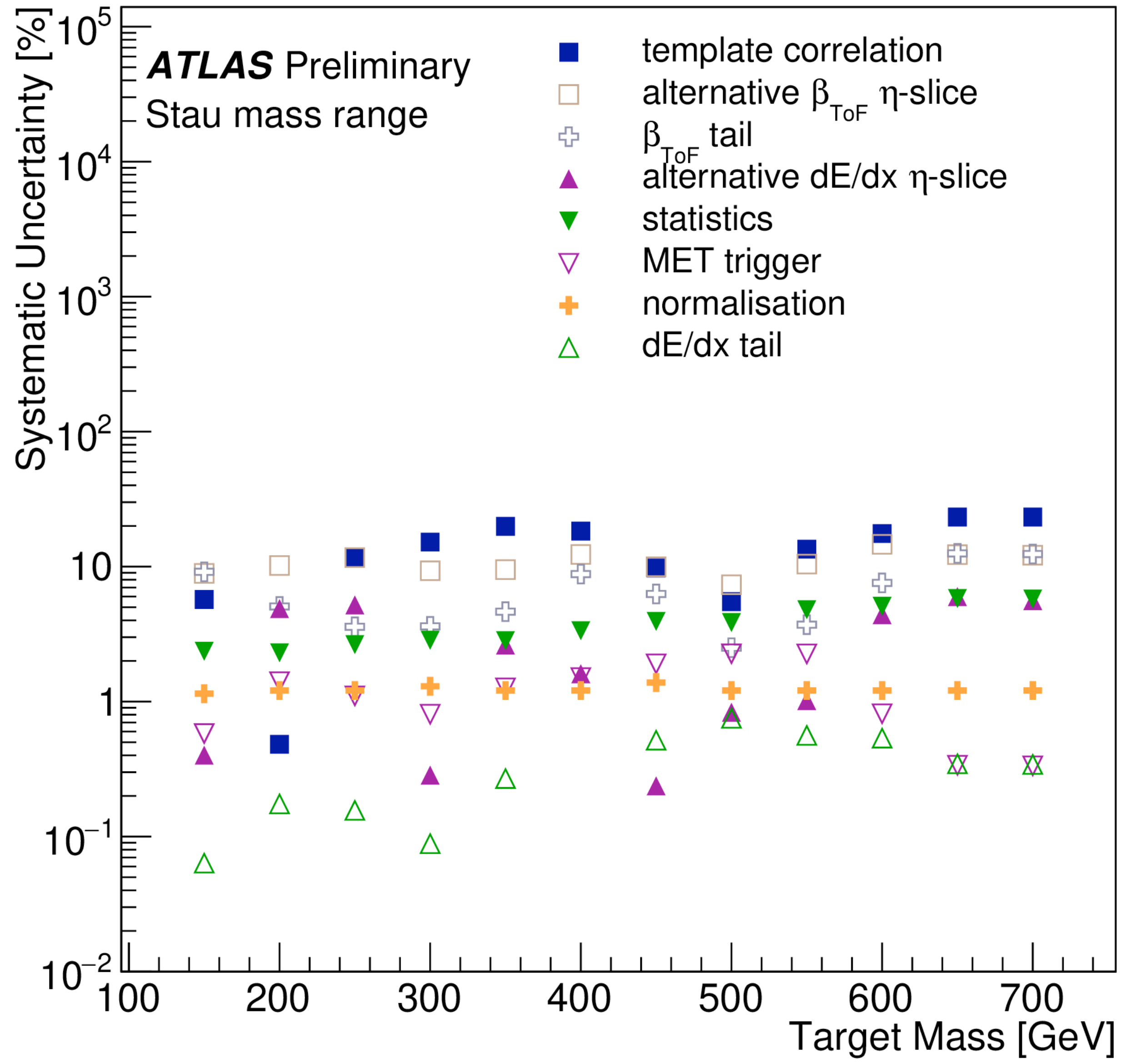
	trapezoid parameters, cone angle Θ=22 degrees	
target mass [GeV]	lower edge mass [GeV]	upper edge mass [GeV]
700	530	1390
800	570	2380
900	620	5340
1000	720	6170
1100	780	6170
1200	860	6170
1300	950	6170
1400	960	6170

Yields

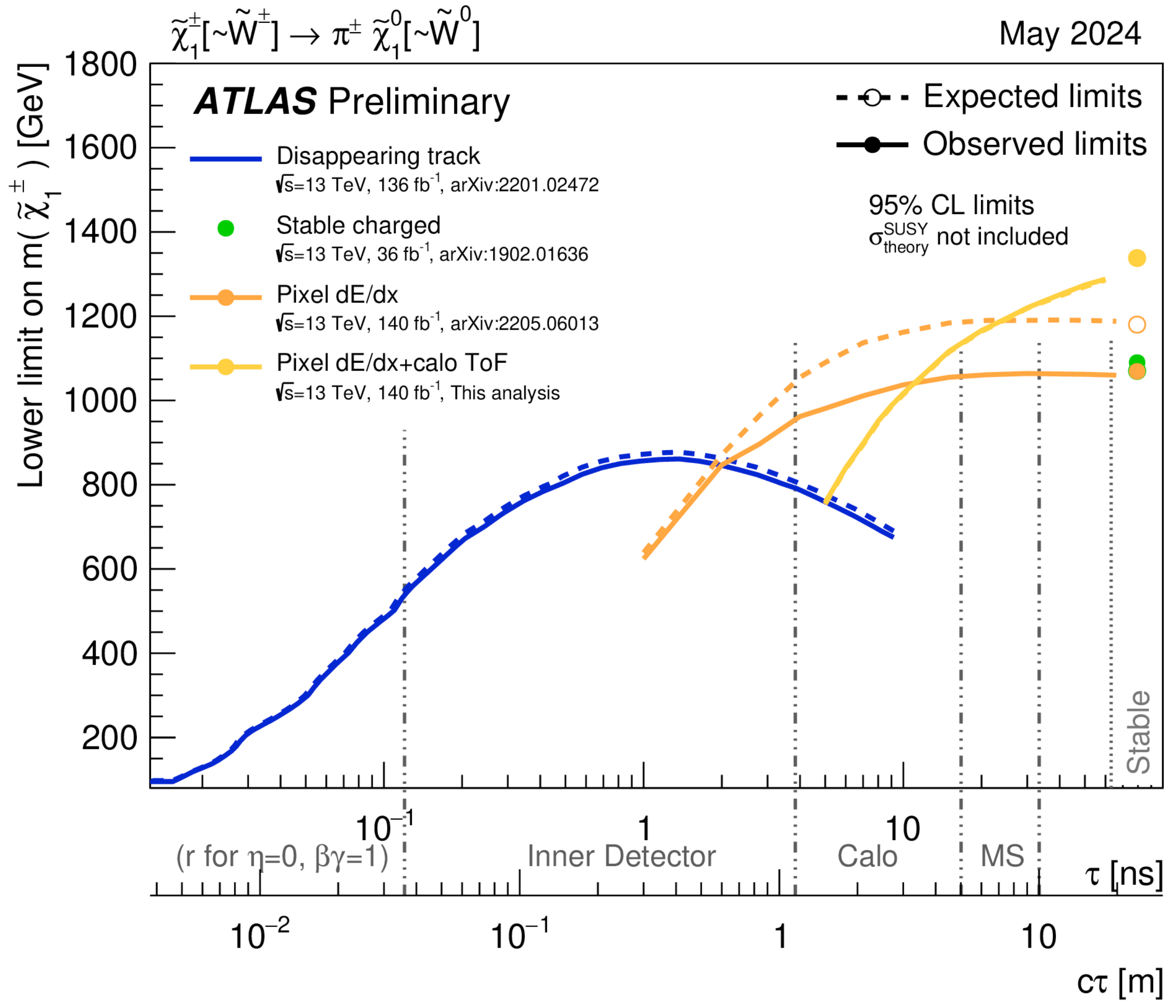


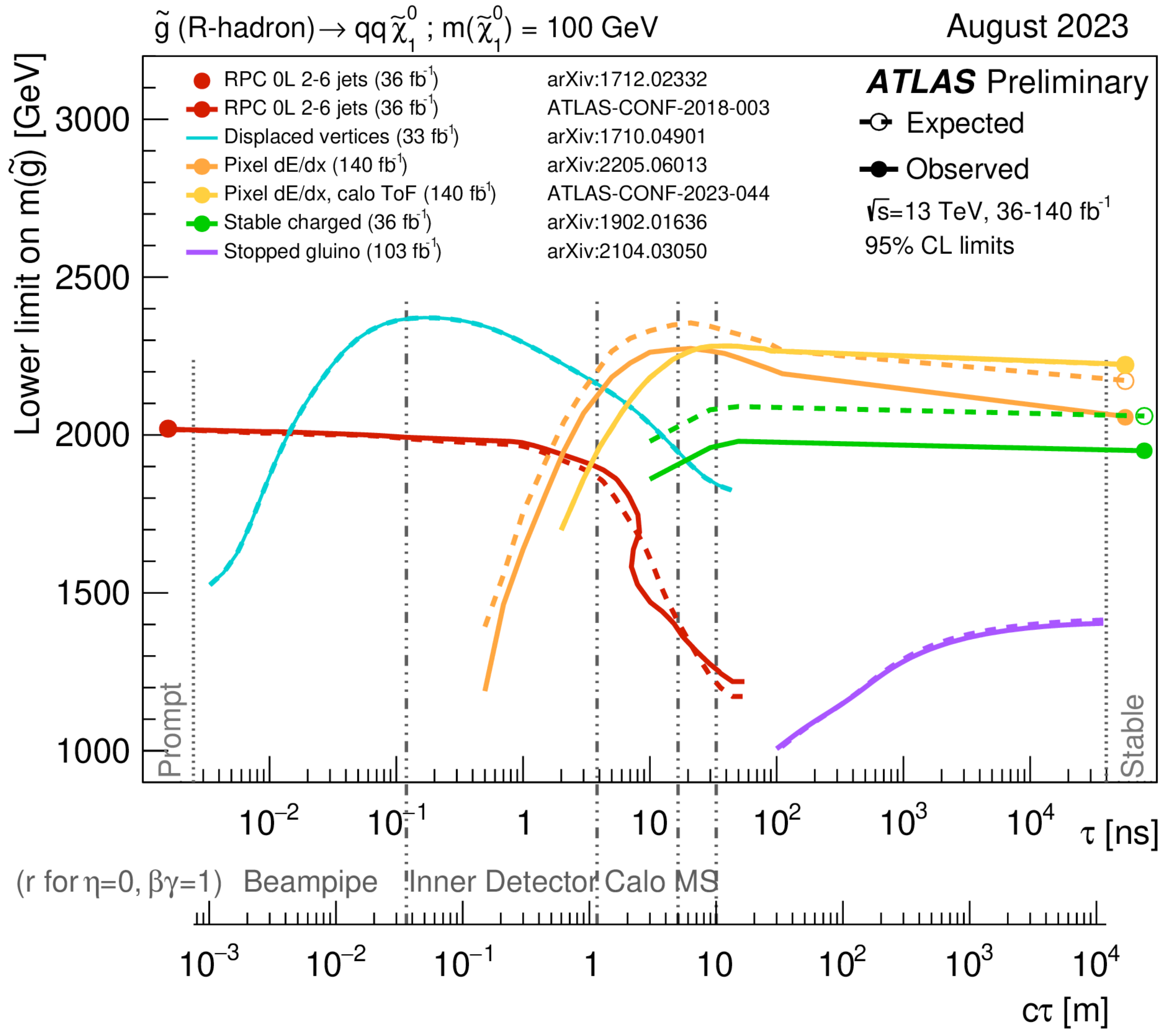


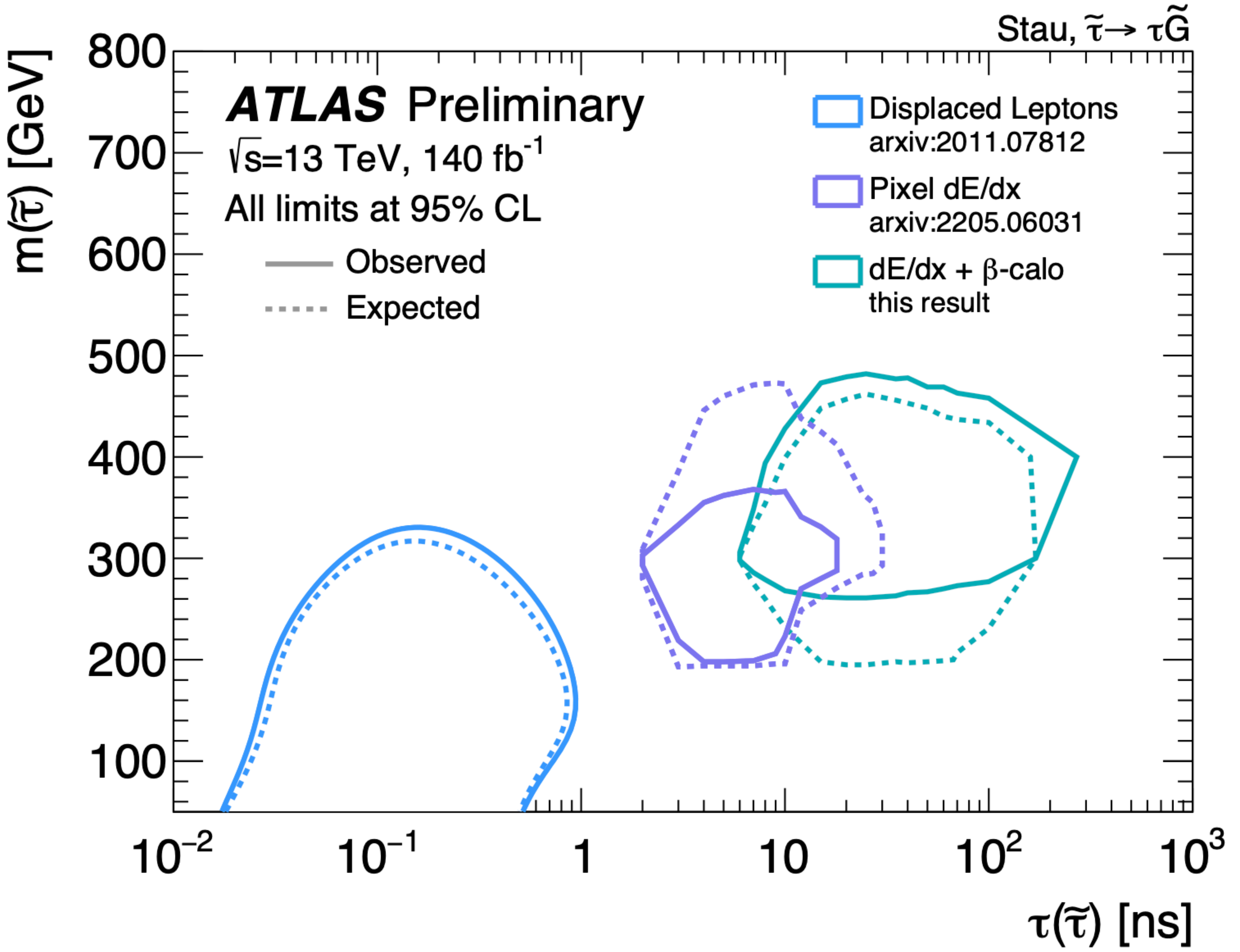




Limits


May 2024
ATLAS Preliminary
Expected limits
Observed limits
Disappearing track
Stable charged
Pixel dE/dx
Pixel dE/dx+calo ToF
95% CL limits
Lower limit on m [GeV]
Inner Detector
Calo
MS
Stable
τ [ns]
cτ [m]


August 2023
ATLAS Preliminary
Expected
Observed
RPC 0L 2-6 jets
Displaced vertices
Pixel dE/dx
Pixel dE/dx, calo ToF
Stable charged
Stopped gluino
95% CL limits
Prompt
Beampipe
Inner Detector
Calo
MS
Stable
τ [ns]
cτ [m]


ATLAS Preliminary
All limits at 95% CL
Observed
Expected
Displaced Leptons
arxiv:2011.07812
Pixel dE/dx
arxiv:2205.06031
this result

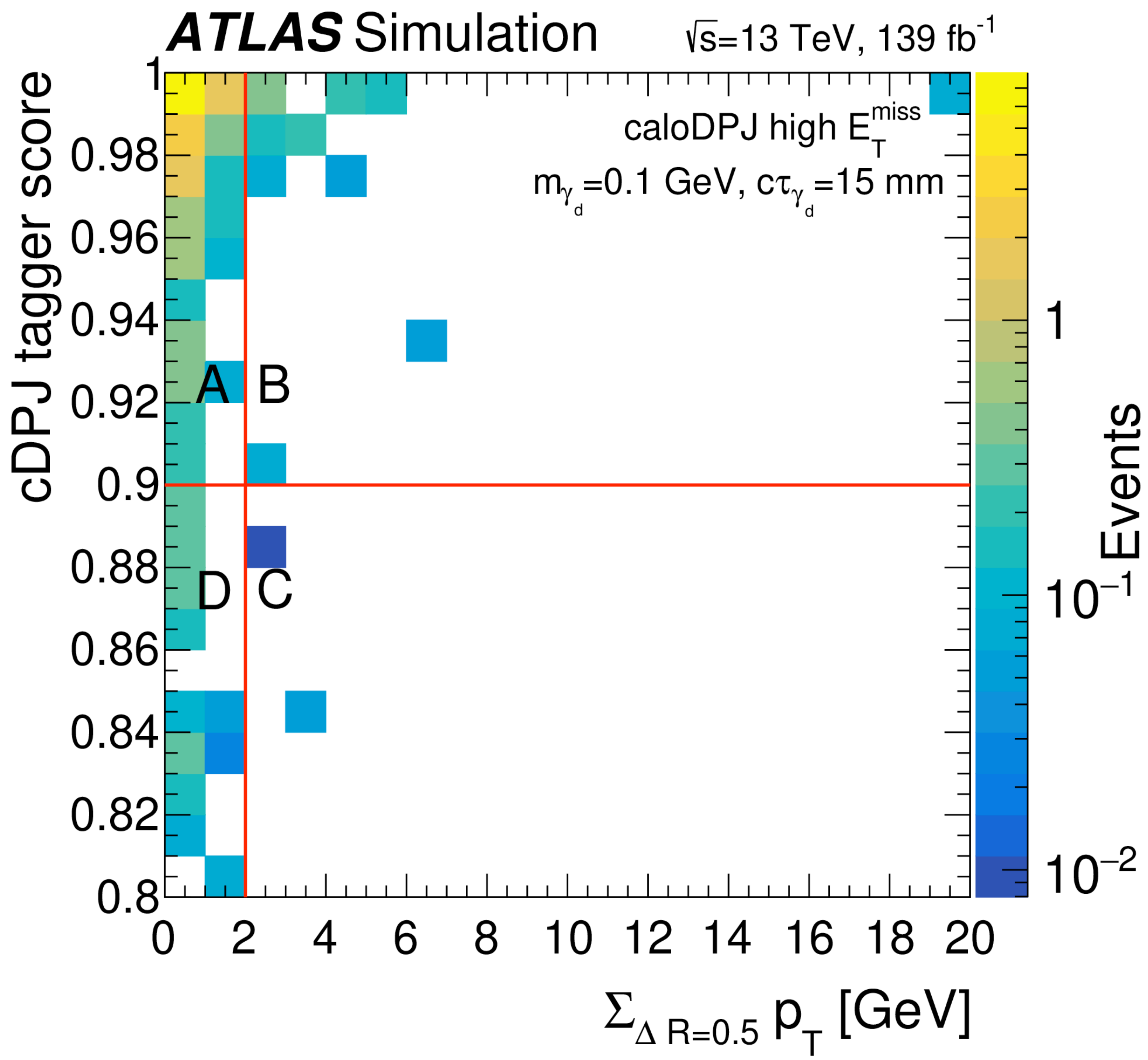
Dark Photons Backups

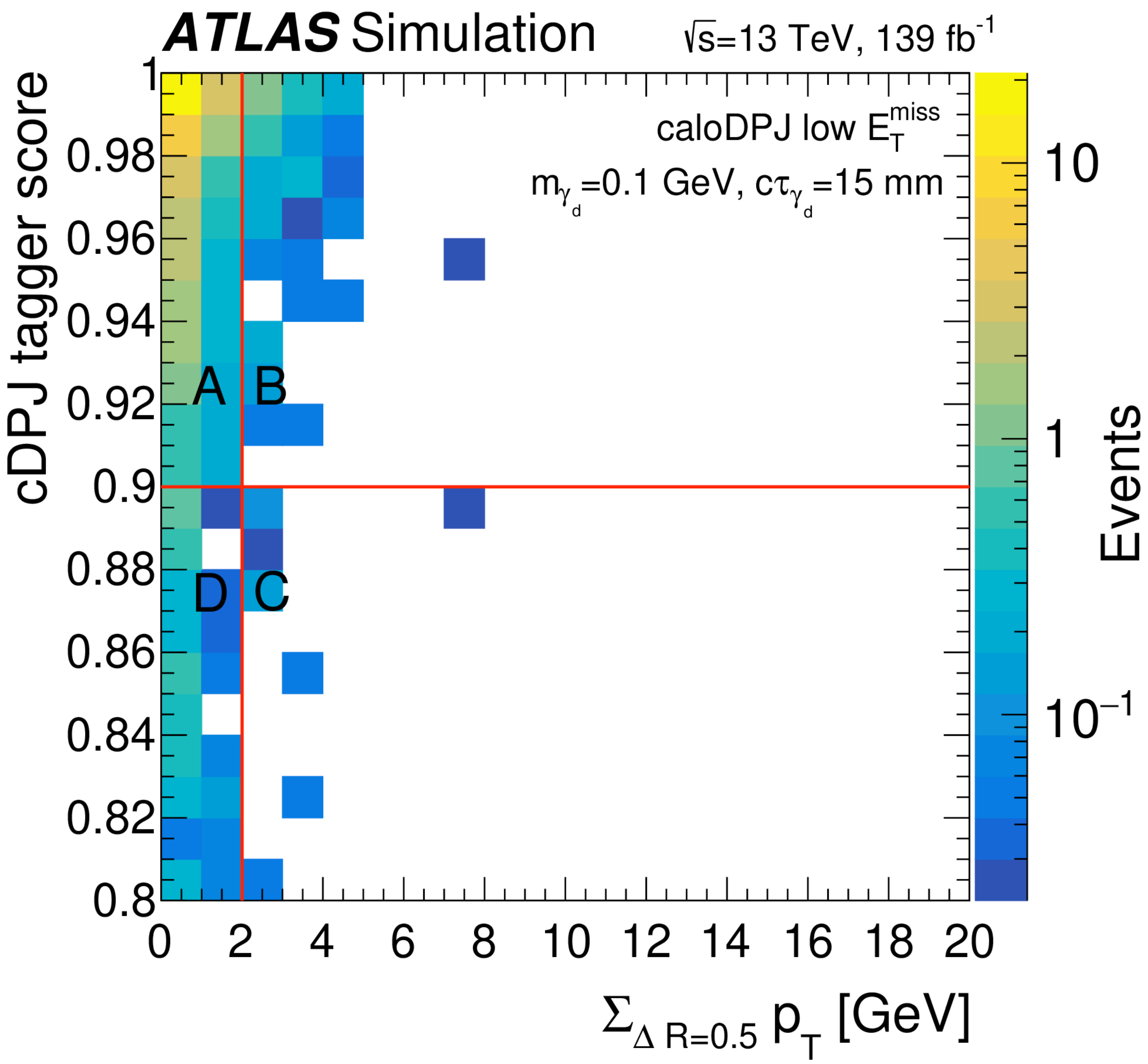
Validation regions for Dark photon

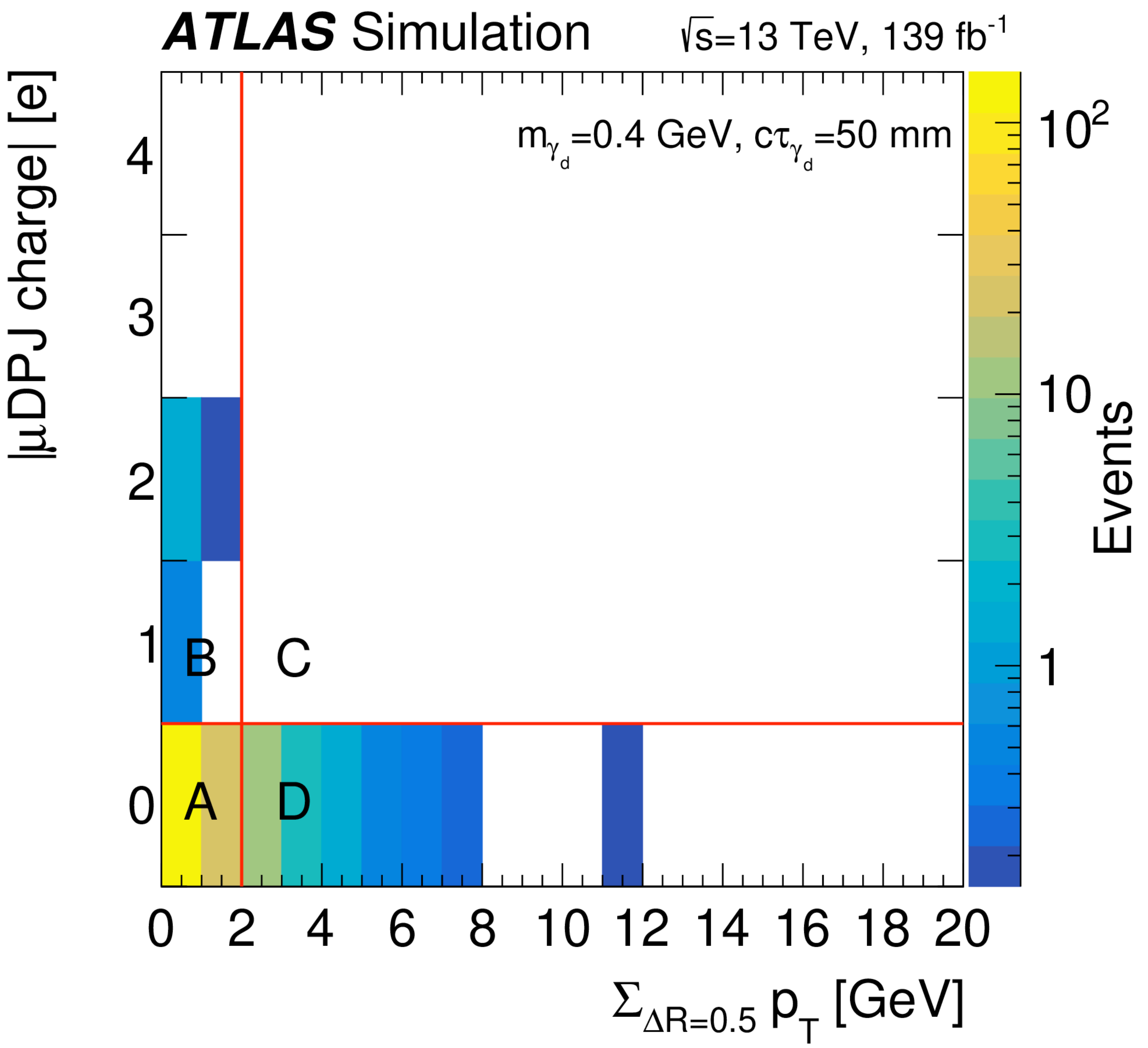
Requirement / Region	CRB_{μ}	CRC_{μ}	CRD_{μ}
—μDPJ charge—	$[1,5)$	$[1,5)$	0
$\sum_{\Delta R=0.5} p_{\mathrm{T}}$ [GeV]	$[0,2.0)$	$[2.0,20)$	$[2.0,20)$
Requirement / Region	$\mathrm{CRB}_{\mathrm{c}}^{\mathrm{L/H}}$	$\mathrm{CRC}_{\mathrm{c}}^{\mathrm{L/H}}$	$\mathrm{CRD}_{\mathrm{c}}^{\mathrm{L/H}}$
caloDPJ QCD tagger score	$[0.9,1]$	$[0.8,0.9)$	$[0.8,0.9)$
$\sum_{\Delta R=0.5} p_{\mathrm{T}}$ [GeV]	$[2.0,20)$	$[2.0,20)$	$[0,2.0)$

Distributions

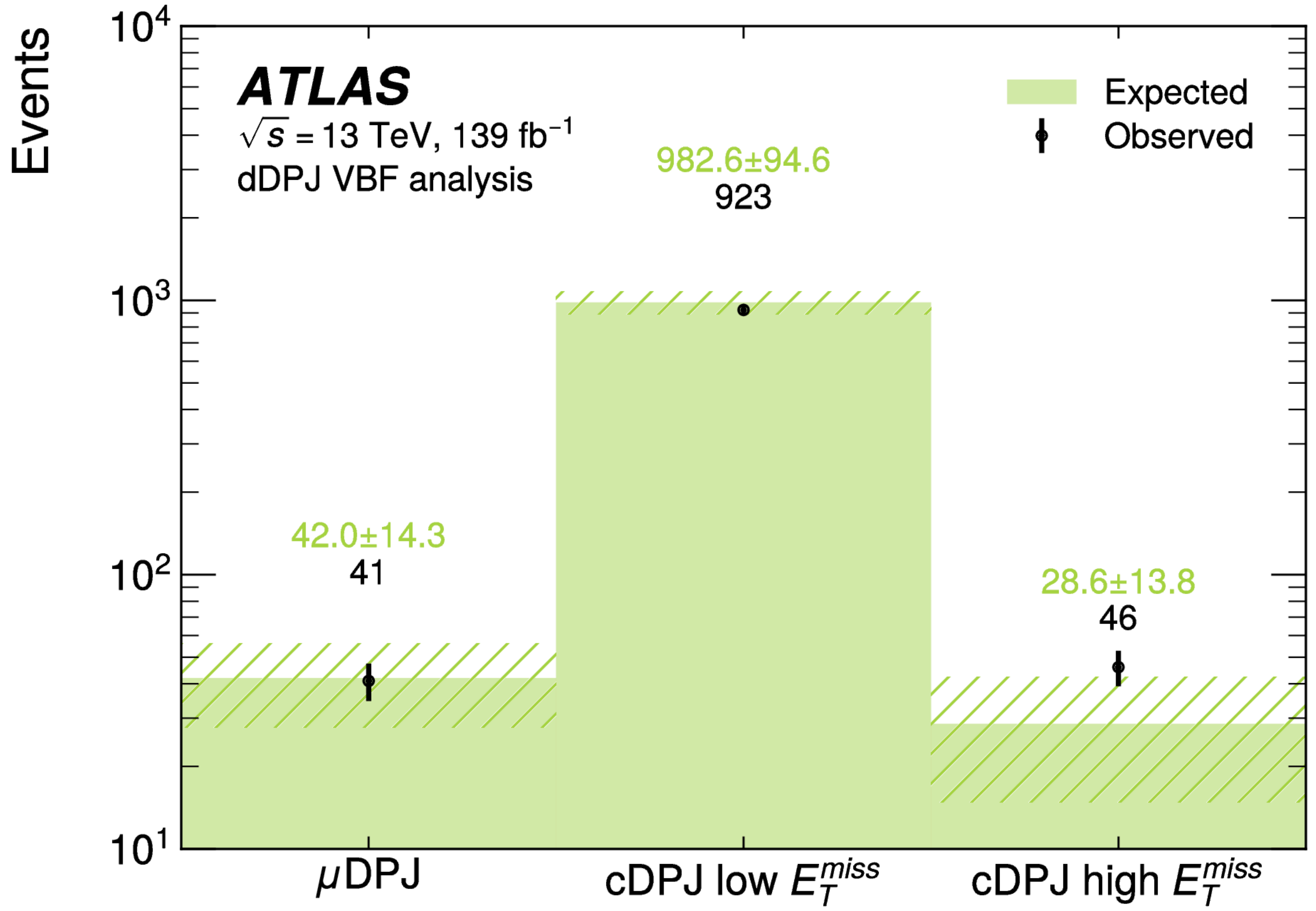
Signal MC

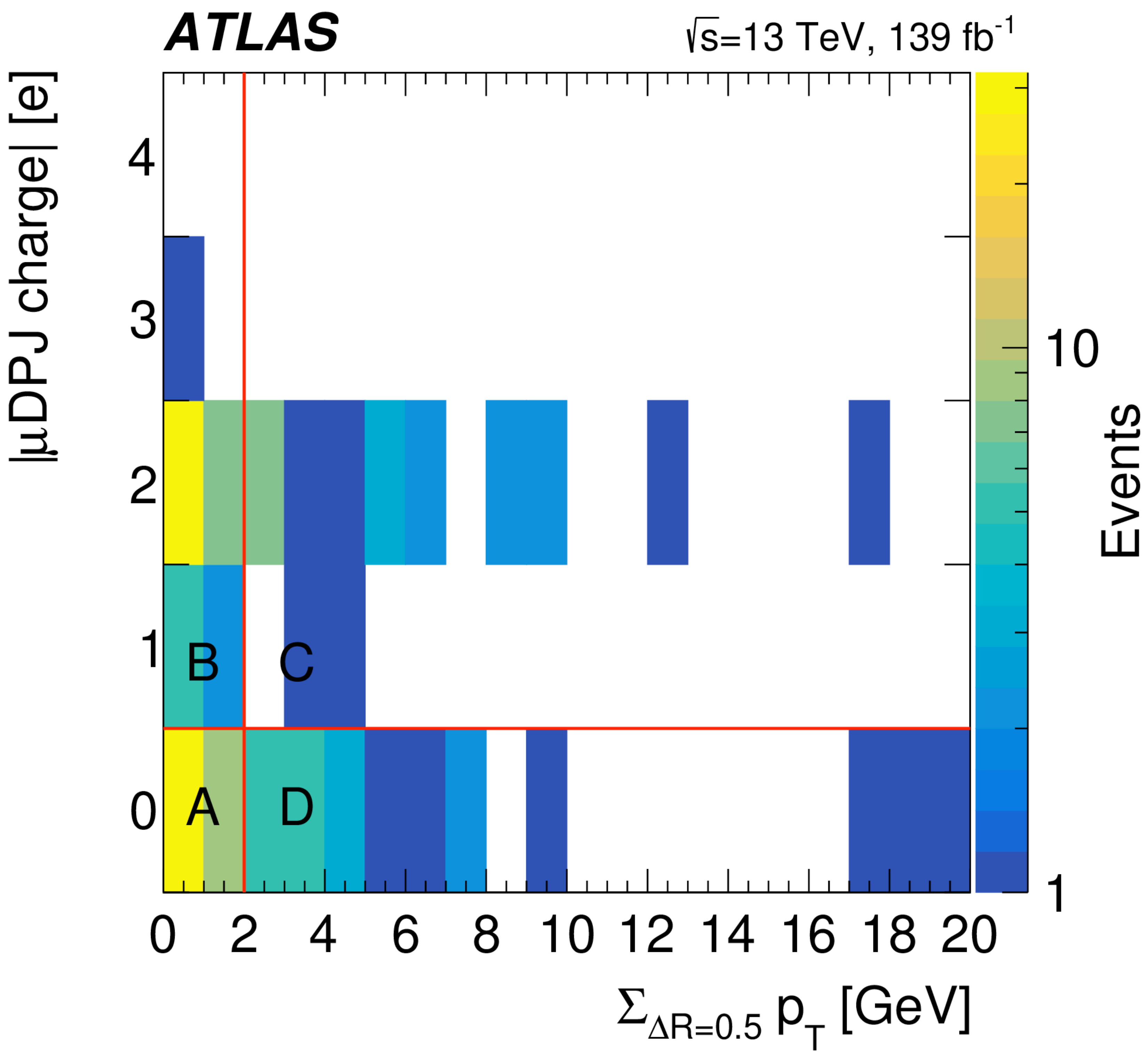


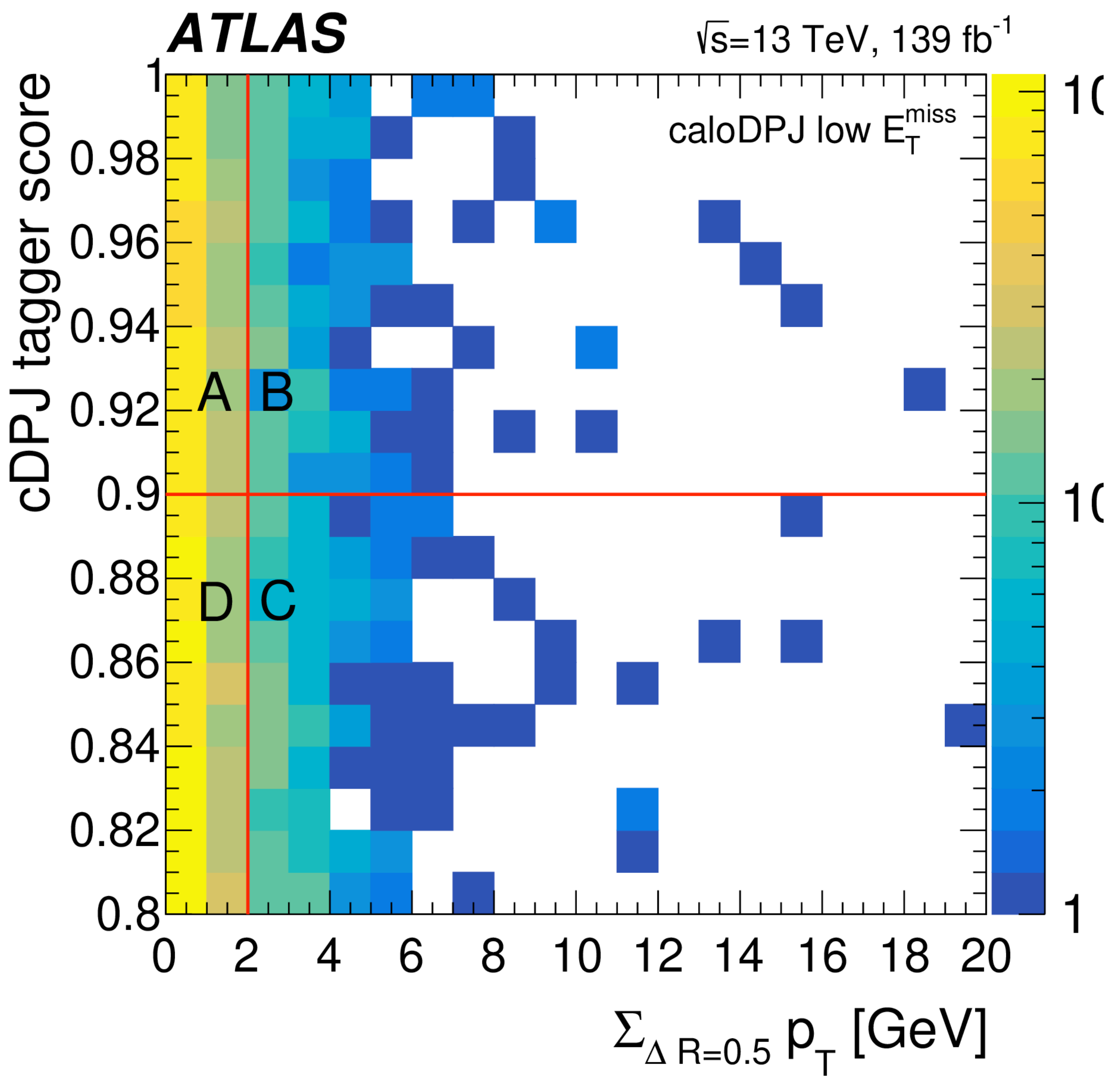


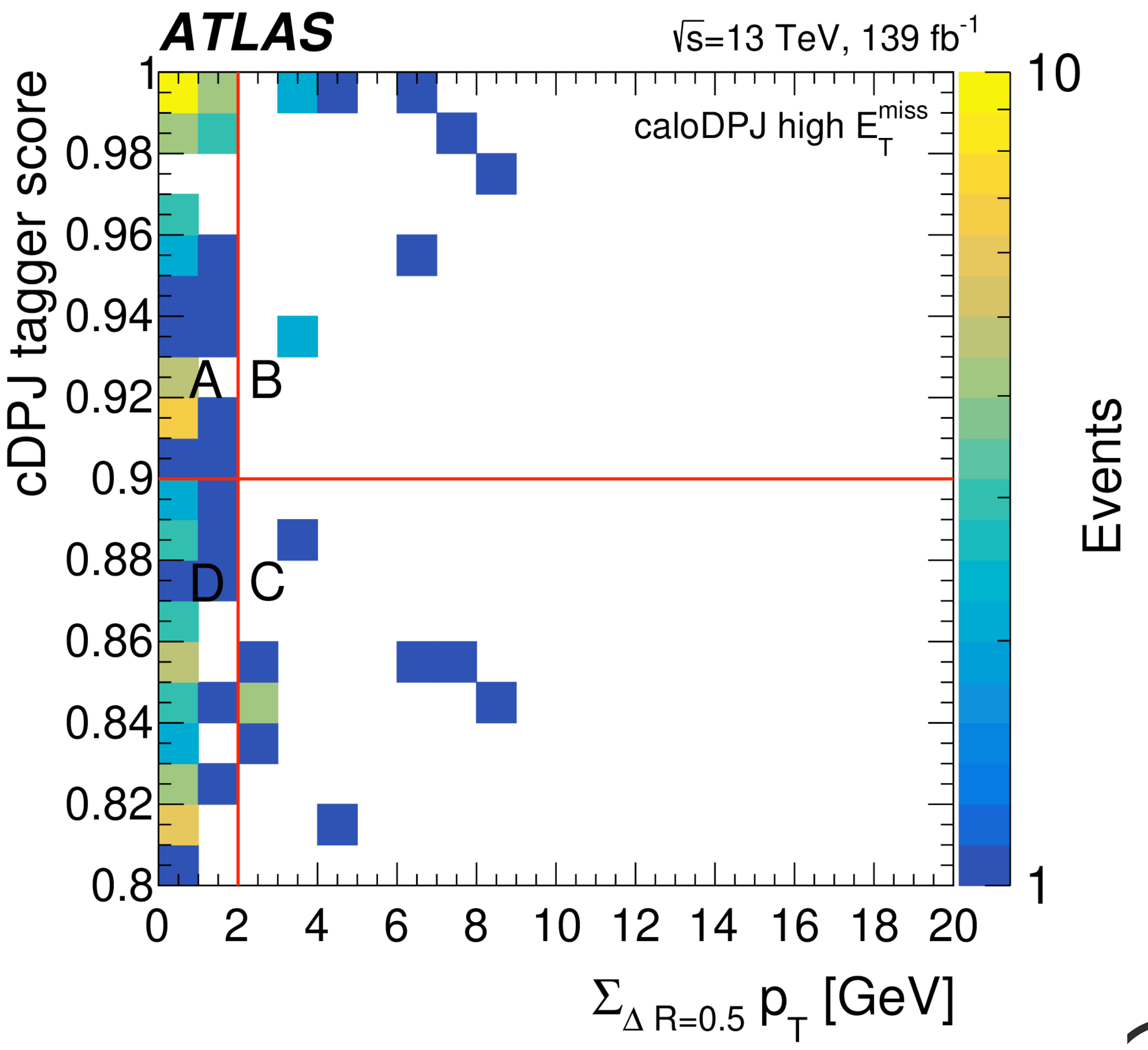


Distributions Data



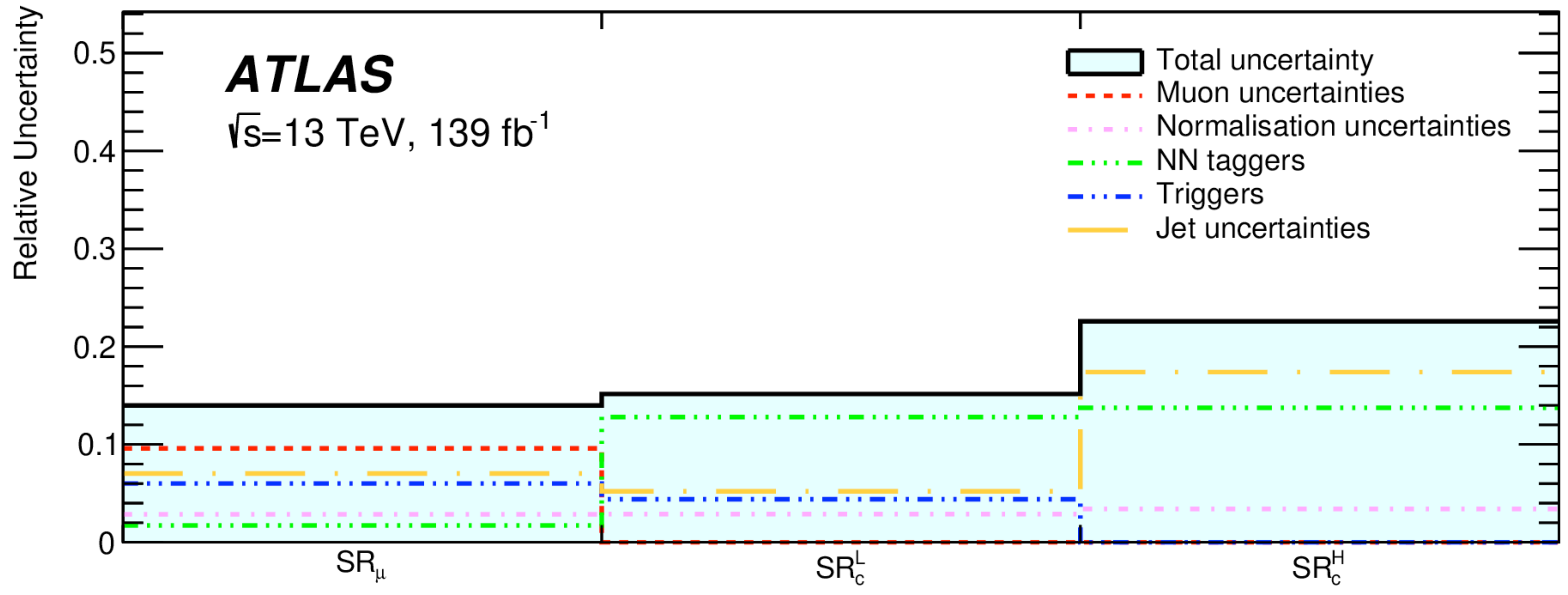




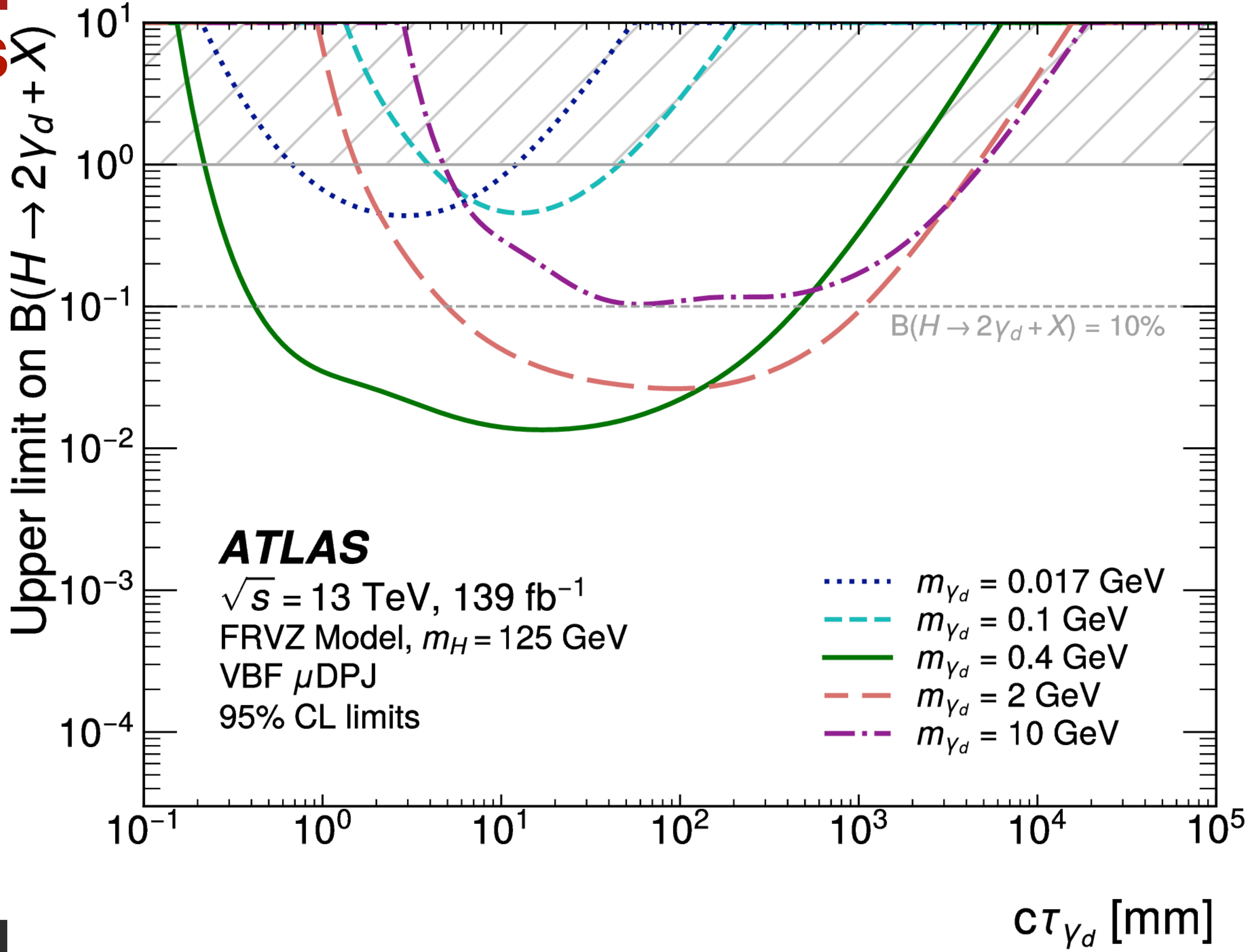


Systematics

	FRVZ model $pp \to H\text{jj(VBF)} \to 2\gamma_d + X + \text{jj}$ process $m_H = 125$ GeV						
γ_d mass [GeV]	Channel	Normalisation	Trigger	Muon	Jet	NN taggers	Total
0.017	SR_μ	5.3	6.0	9.6	5.8	0.6	13.8
	SR_c^L	1.8	4.7	-	2.1	13.6	14.6
	SR_c^H	5.0	-	-	12.1	11.2	17.2
0.05	SR_μ	1.8	6.1	9.6	5.0	0.6	12.6
	SR_c^L	2.1	4.6	-	2.6	13.7	14.8
	SR_c^H	3.3	-	-	14.6	15.1	21.4
0.1	SR_μ	3.2	6.0	9.6	10.8	0.2	15.9
	SR_c^L	1.8	4.5	-	4.6	14.9	16.3
	SR_c^H	3.2	0	-	14.9	13.8	20.6
0.4	SR_μ	2.4	6.0	9.6	7.5	0.9	13.8
	SR_c^L	2.7	4.5	-	3.2	14.2	15.5
	SR_c^H	2.1	0	-	24.3	12.9	27.6
0.9	SR_μ	2.0	6.0	9.6	6.0	1.3	13.0
	SR_c^L	2.0	4.4	-	5.2	12.4	14.3
	SR_c^H	3.0	0	-	19.3	11.9	22.8
2	SR_μ	2.7	6.0	9.6	6.0	1.6	13.2
	SR_c^L	2.6	4.7	-	4.0	12.8	14.4
	SR_c^H	3.7	0	-	13.5	12.5	18.7
6	SR_μ	2.6	6.0	9.6	6.2	2.8	13.5
	SR_c^L	2.5	3.9	-	3.9	12.5	13.9
	SR_c^H	2.0	-	-	15.5	13.9	20.9
10	SR_μ	1.9	6.0	9.6	4.0	4.0	12.8
	SR_c^L	2.6	4.5	-	9.8	14.5	18.3
	SR_c^H	4.5	-	-	21.3	16.9	27.6
15	SR_μ	4.1	6.0	9.6	11.9	3.6	17.3
	SR_c^L	2.6	3.8	-	11.9	6.7	14.5
	SR_c^H	4.1	-	-	21.2	15.5	26.6

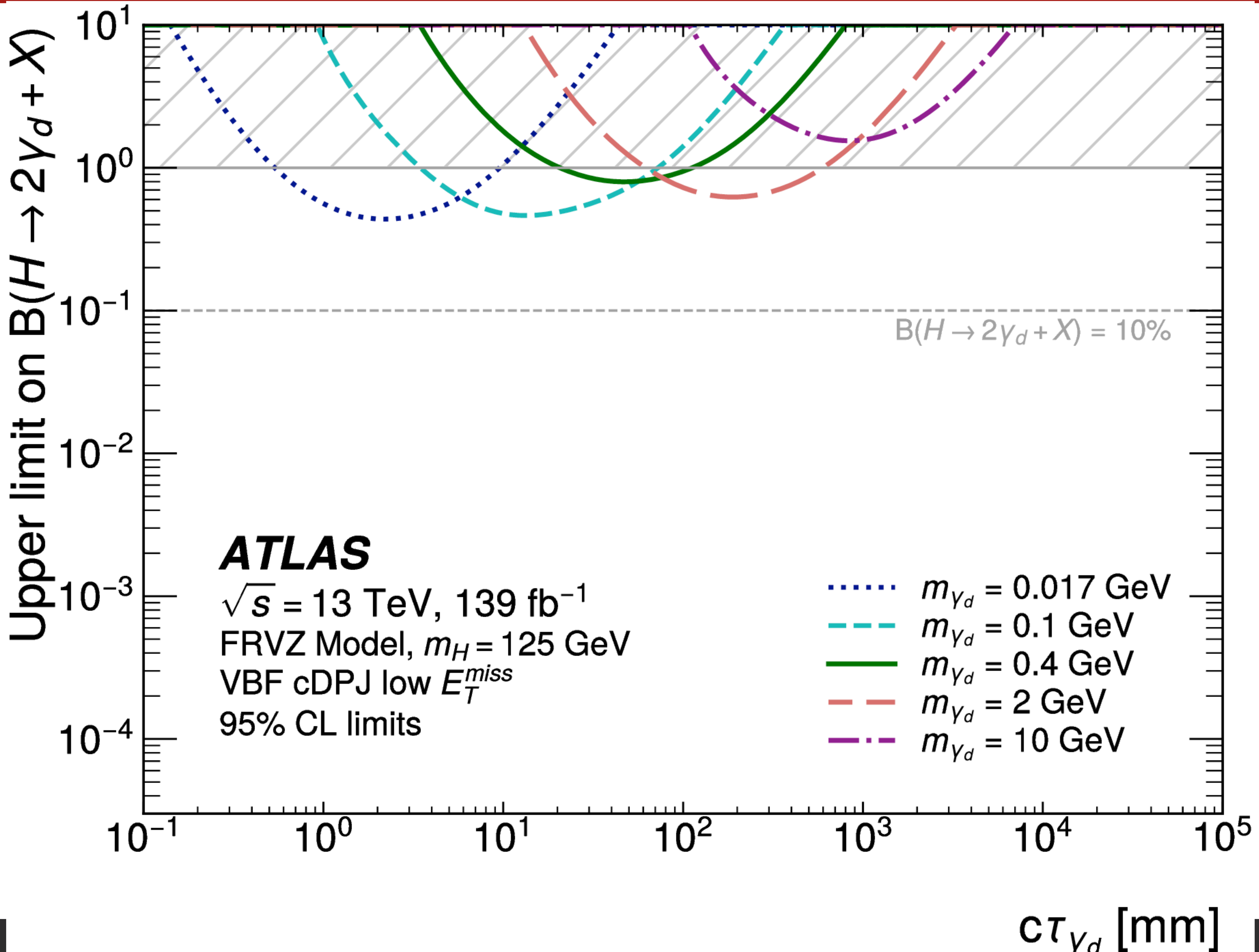


Limits



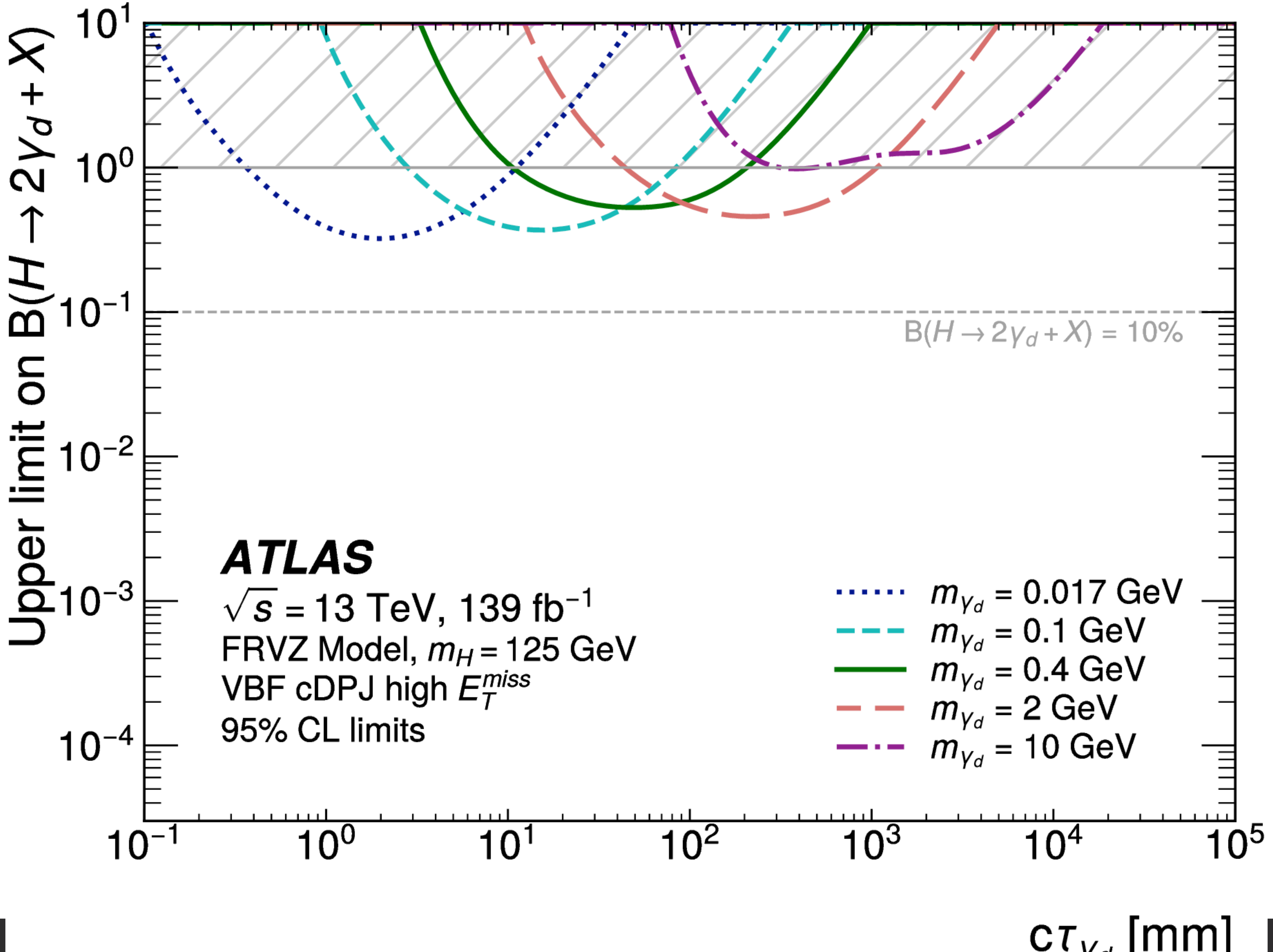
Upper limit on B($H \to 2\gamma_d + X$)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
B($H \to 2\gamma_d + X$) = 10%
ATLAS
$\sqrt{s}$ = 13 TeV, 139 fb^{-1}
FRVZ Model, m_H = 125 GeV
VBF μDPJ
95% CL limits
m_{γ_d} = 0.017 GeV
m_{γ_d} = 0.1 GeV
m_{γ_d} = 0.4 GeV
m_{γ_d} = 2 GeV
m_{γ_d} = 10 GeV
10^{-1}
10^0
10^1
10^2
10^3
10^4
10^5
$c\tau_{\gamma_d}$ [mm]

Limits



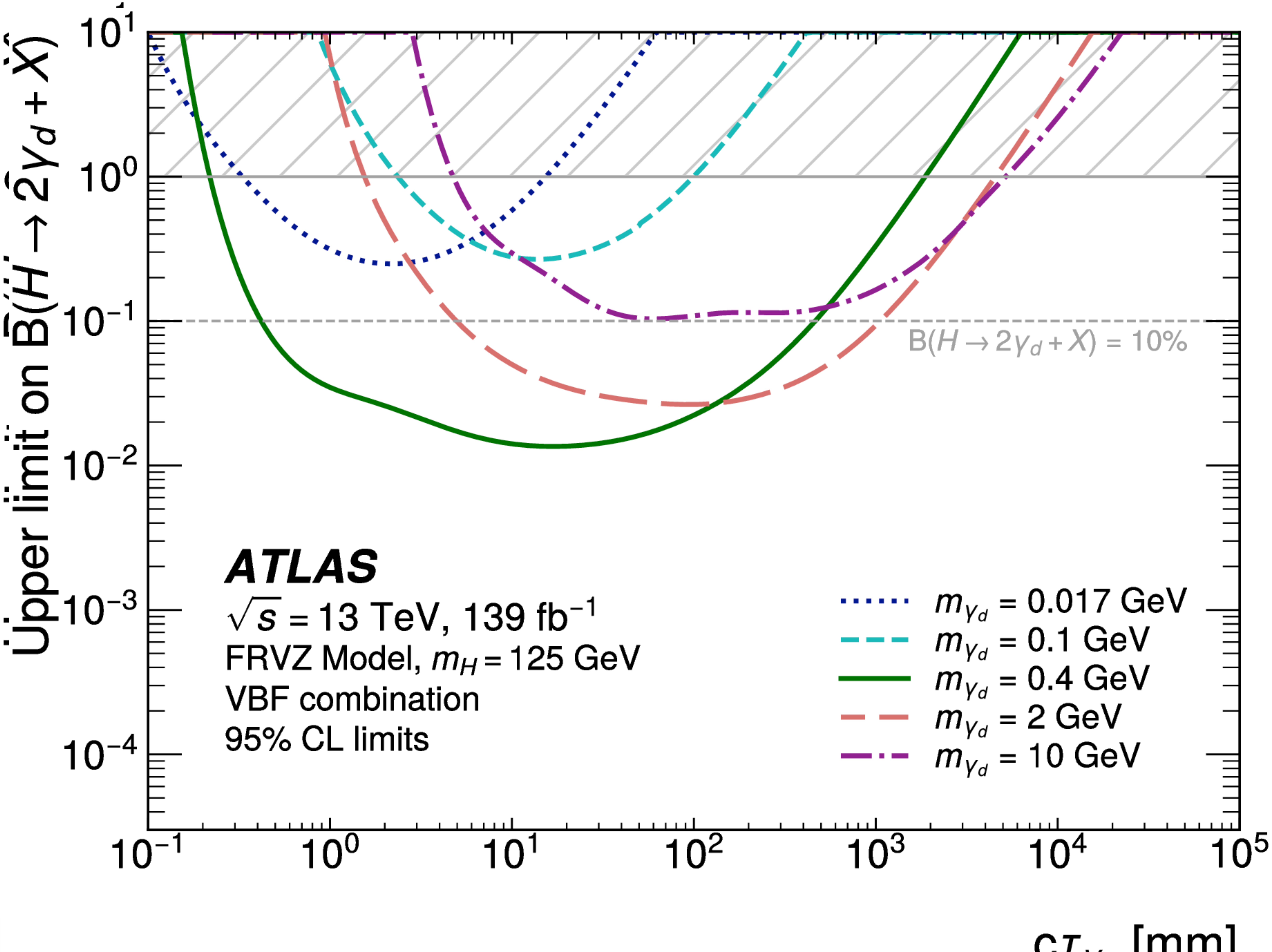
Upper limit on B(H → 2γ_d + X)
10^1
10^0
10^-1
10^-2
10^-3
10^-4
B(H → 2γ_d + X) = 10%
ATLAS
√s = 13 TeV, 139 fb^-1
FRVZ Model, m_H = 125 GeV
VBF cDPJ low E_T^miss
95% CL limits
m_γd = 0.017 GeV
m_γd = 0.1 GeV
m_γd = 0.4 GeV
m_γd = 2 GeV
m_γd = 10 GeV
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
cτ_γd [mm]

Limits



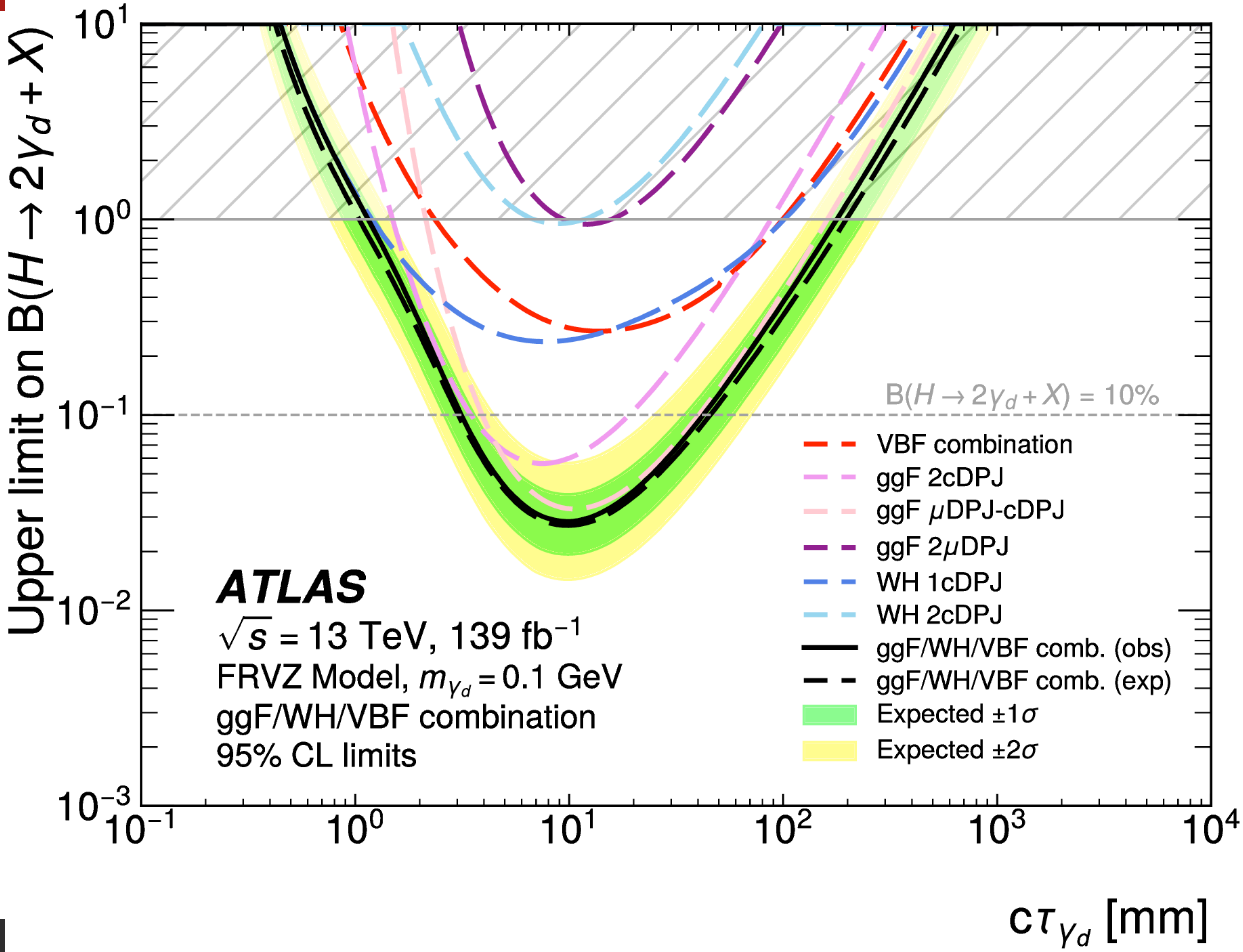
Upper limit on B($H \rightarrow 2\gamma_d + X$)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
B($H \rightarrow 2\gamma_d + X$) = 10%
ATLAS
$\sqrt{s}$ = 13 TeV, 139 fb^{-1}
FRVZ Model, $m_H = 125$ GeV
VBF cDPJ high E_T^{miss}
95% CL limits
m_{γ_d} = 0.017 GeV
m_{γ_d} = 0.1 GeV
m_{γ_d} = 0.4 GeV
m_{γ_d} = 2 GeV
m_{γ_d} = 10 GeV
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
$c\tau_{\gamma_d}$ [mm]

Limits



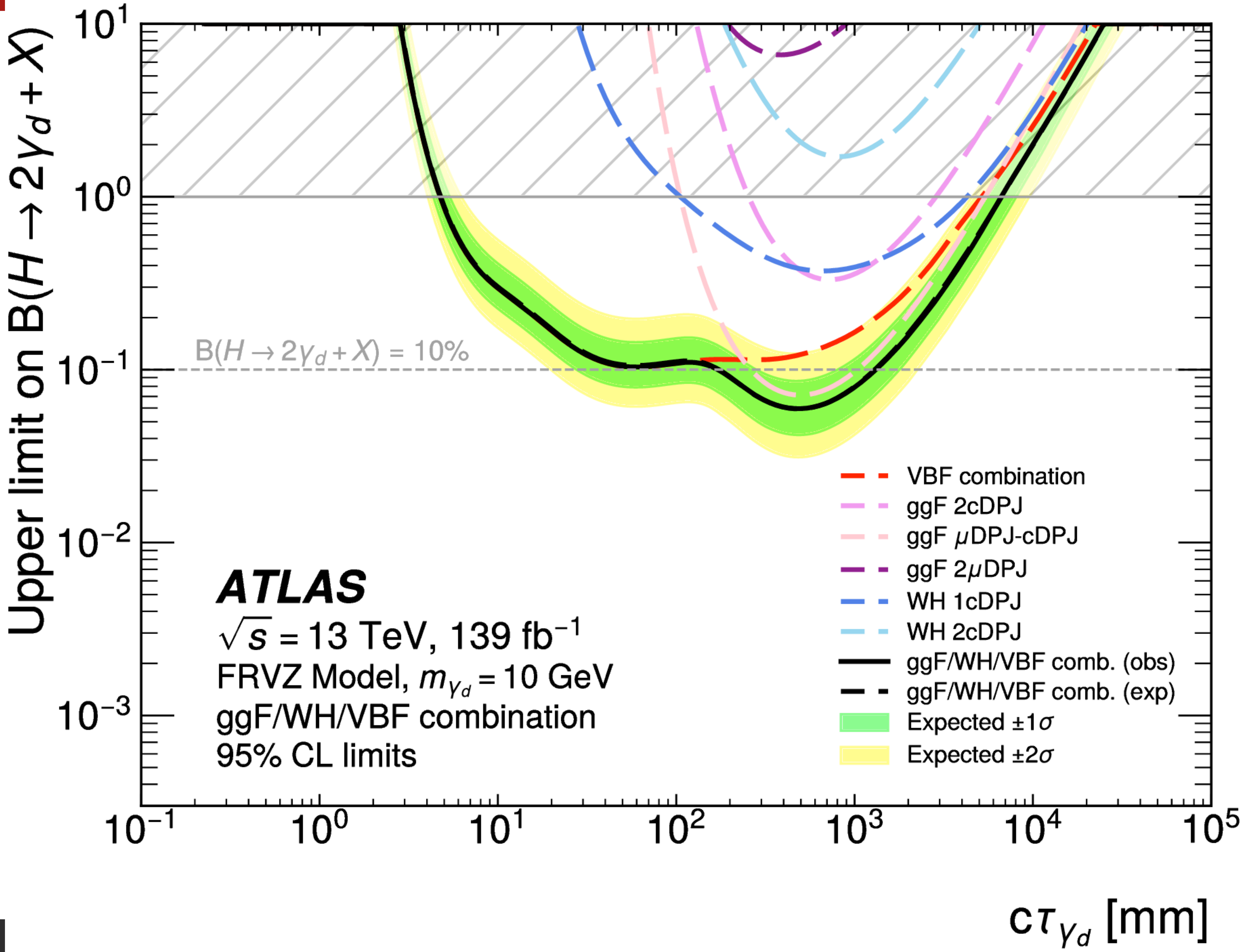
Upper limit on B(H → 2γ_d + X)
10^1
10^0
10^-1
10^-2
10^-3
10^-4
B(H → 2γ_d + X) = 10%
ATLAS
√s = 13 TeV, 139 fb^-1
FRVZ Model, m_H = 125 GeV
VBF combination
95% CL limits
m_γd = 0.017 GeV
m_γd = 0.1 GeV
m_γd = 0.4 GeV
m_γd = 2 GeV
m_γd = 10 GeV
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
cτ_γd [mm]

Limits

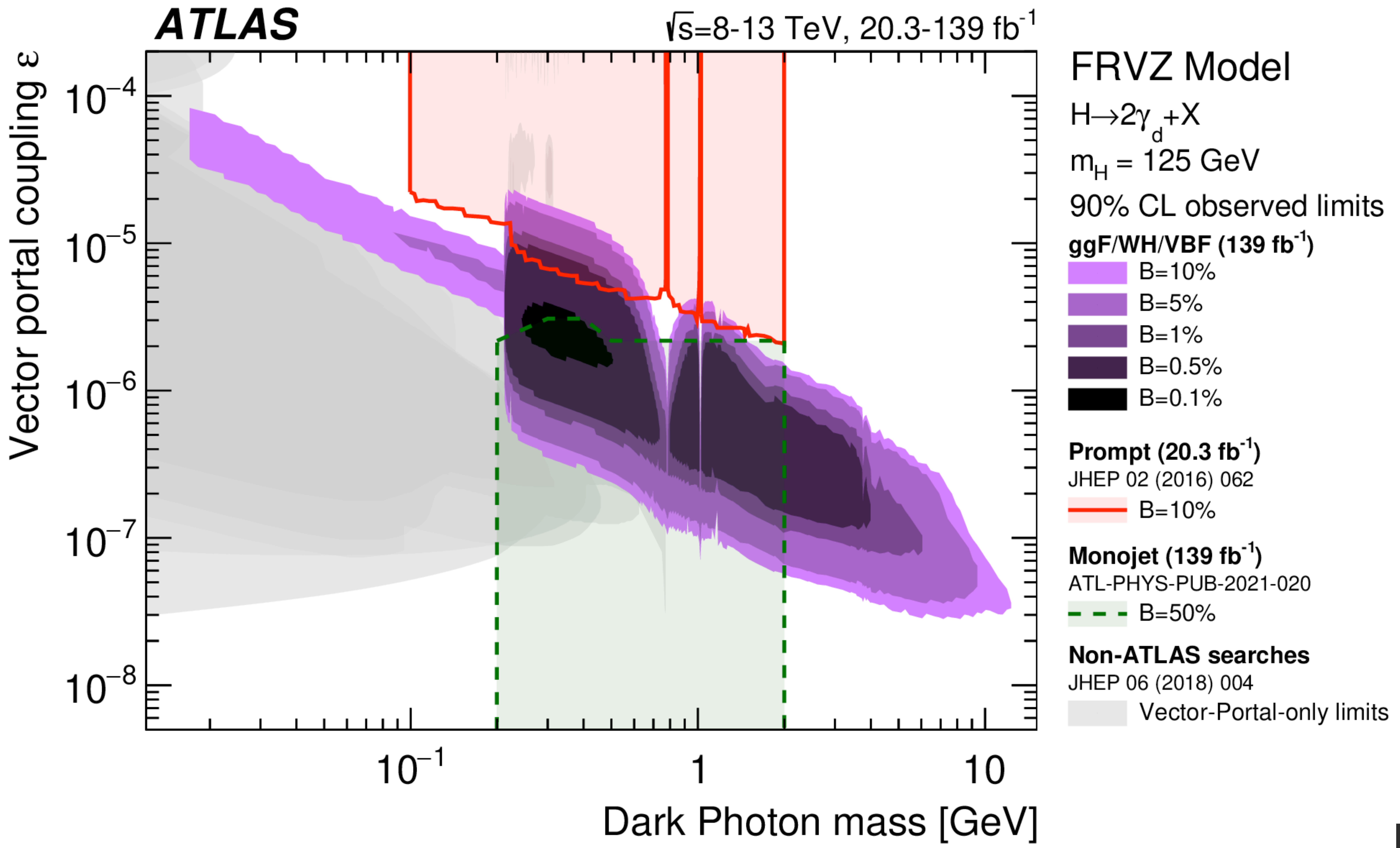


Upper limit on B($H \to 2\gamma_d + X$)
$c\tau_{\gamma_d}$ [mm]
B($H \to 2\gamma_d + X$) = 10%
ATLAS
$\sqrt{s}$ = 13 TeV, 139 fb^{-1}
FRVZ Model, m_{γ_d} = 0.1 GeV
ggF/WH/VBF combination
95% CL limits
VBF combination
ggF 2cDPJ
ggF μDPJ-cDPJ
ggF 2μDPJ
WH 1cDPJ
WH 2cDPJ
ggF/WH/VBF comb. (obs)
ggF/WH/VBF comb. (exp)
Expected ±1σ
Expected ±2σ

Limits

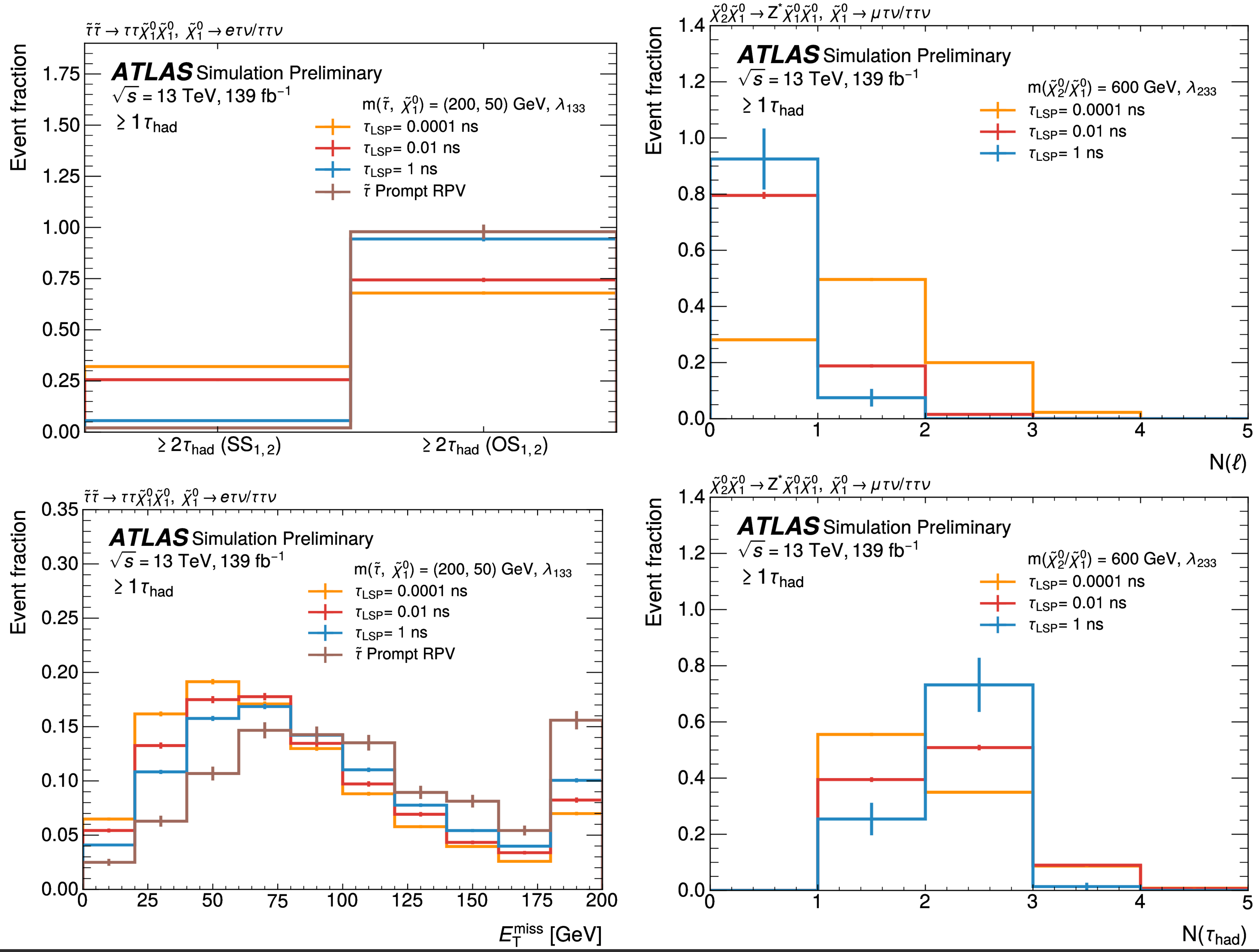


Upper limit on $B(H \to 2\gamma_d + X)$
$B(H \to 2\gamma_d + X)$ = 10%
ATLAS
$\sqrt{s}$ = 13 TeV, 139 fb^{-1}
FRVZ Model, m_{γ_d} = 10 GeV
ggF/WH/VBF combination
95% CL limits
VBF combination
ggF 2cDPJ
ggF μDPJ-cDPJ
ggF 2μDPJ
WH 1cDPJ
WH 2cDPJ
ggF/WH/VBF comb. (obs)
ggF/WH/VBF comb. (exp)
Expected ±1σ
Expected ±2σ
$c\tau_{\gamma_d}$ [mm]


ATLAS
√s=8-13 TeV, 20.3-139 fb-1
Vector portal coupling ε
10−4
10−5
10−6
10−7
10−8
10−1
1
10
Dark Photon mass [GeV]
FRVZ Model
H→2γd+X
mH = 125 GeV
90% CL observed limits
ggF/WH/VBF (139 fb-1)
B=10%
B=5%
B=1%
B=0.5%
B=0.1%
Prompt (20.3 fb-1)
JHEP 02 (2016) 062
B=10%
Monojet (139 fb-1)
ATL-PHYS-PUB-2021-020
B=50%
Non-ATLAS searches
JHEP 06 (2018) 004
Vector-Portal-only limits

Reinterpretation SUSY searches with Tau final states

Distributions of the number of events presenting the two highest-pT τhad



Signal Models

	Stau model	Higgsino model
Decays	$\tilde{\tau} \to \tau \tilde{\chi}_1^0$ $\tilde{\tau} \to \tau \tilde{\chi}_1^0,\ \tilde{\chi}_1^0 \to \ell\tau\nu/\tau\tau\nu$ $\tilde{\tau} \to \tau\nu$	$\tilde{\chi}_1^{\pm} \to qq'(\ell\nu)\tilde{\chi}_1^0$ $\tilde{\chi}_1^{\pm} \to qq'(\ell\nu)\tilde{\chi}_1^0,\ \tilde{\chi}_1^0 \to \ell\tau\nu/\tau\tau\nu$ $\tilde{\chi}_1^{\pm} \to \ell\tau\tau/\ell\nu\nu/\tau\nu\nu$
		$\tilde{\chi}_2^0 \to q\bar{q}(\ell\bar{\ell})\tilde{\chi}_1^0$ $\tilde{\chi}_2^0 \to q\bar{q}(\ell\bar{\ell})\tilde{\chi}_1^0,\ \tilde{\chi}_1^0 \to \ell\tau\nu/\tau\tau\nu$ $\tilde{\chi}_2^0 \to \ell\tau\nu/\tau\tau\nu$
Other sparticle masses	$\mathrm{m}(\tilde{\ell}) = 5$ TeV	$\mathrm{m}(\tilde{\tau}) = 2$ TeV $\mathrm{m}(\tilde{\ell}) = 5$ TeV
LSP	bino-like $\tilde{\chi}_1^0$ $\mathrm{m}(\tilde{\chi}_1^0) = 50$ GeV	higgsino-like $\tilde{\chi}_1^0$ $\Delta\mathrm{m}(\tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0) = 0.25$ GeV $\Delta\mathrm{m}(\tilde{\chi}_2^0, \tilde{\chi}_1^0) = 0.5$ GeV

2 Tau Signal Selection

Medium τ_{had}	Tight τ_{had}	b-tags	Z/h	$E_{\mathrm{T}}^{\mathrm{miss}}$ requirement	Representative cuts
$= 2$, $\mathrm{OS}_{1,2}$	≥ 1	veto	veto	$\in [60,\ 150]\ GeV$	$m_{\mathrm{T2}} > 80\ GeV$
	-	veto	veto	$> 150\ GeV$	$m_{\mathrm{T2}} > 85\ GeV$, $m_{\mathrm{Tsum}} > 400\ GeV$
≥ 2, $\mathrm{OS}_{1,2}$	≥ 1	veto	veto	$\in [60,\ 150]\ GeV$	$m_{\mathrm{T2}} > 70\ GeV$
	-	veto	veto	$> 150\ GeV$	$m_{\mathrm{T2}} > 85\ GeV$, $m_{\mathrm{Tsum}} > 400\ GeV$

4 Lepton Signal Selection

Light leptons	Medium τ_{had}	b-tags	Z boson	Representative cuts
≥ 4	≥ 0	veto	require 2 candidates	$E_{\text{T}}^{\text{miss}} > 100\ GeV$
		veto	require 2 candidates	$E_{\text{T}}^{\text{miss}} > 200\ GeV$
		veto	veto	$m_{\text{eff}} > 600\ GeV$
		veto	veto	$m_{\text{eff}} > 1250\ GeV$
$= 3$	≥ 1	veto	veto	$m_{\text{eff}} > 600\ GeV$
		veto	veto	$m_{\text{eff}} > 1000\ GeV$
$= 2$	≥ 2	veto	veto	$m_{\text{eff}} > 600\ GeV$
		veto	veto	$m_{\text{eff}} > 1000\ GeV$