Searches for BSM physics using **challenging and long-lived signatures** with the ATLAS detector

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ATLAS EXPERIMENT

BERKELEY LAB
Lawrence Berkeley National Laboratory

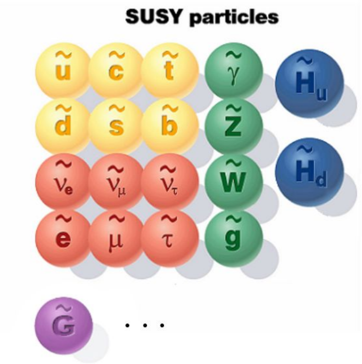
Searches for BSM physics using **challenging and long-lived signatures** with the ATLAS detector

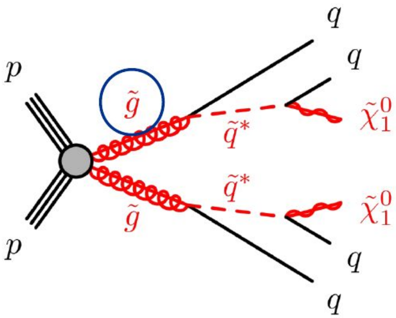
Challenging Signatures: Does not use “standard” objects/ data-flow/… and/or defy in some sense our theoretical prejudice of how new physics would appear.

Long-Lived Particles: Beyond-Standard-Model particles that travel macroscopic distances (compared to our detector resolution)

Theory Motivation: lifetime is everywhere!

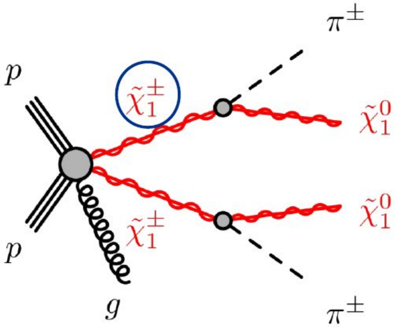
Mechanisms that induce macroscopic lifetime are far from rare, both in the SM and beyond.





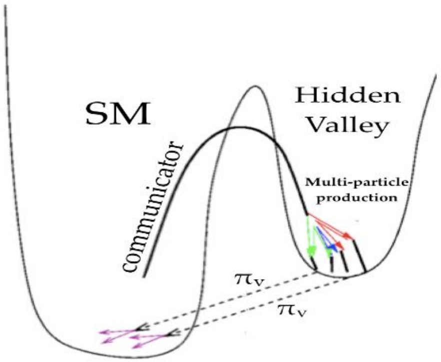
off-shell decays

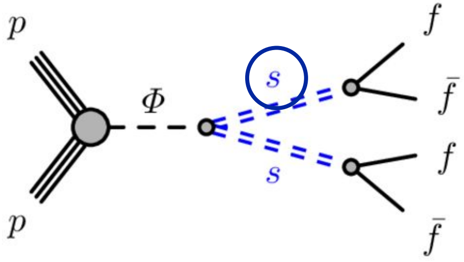
e.g. split-SUSY with squarks mass > 10 TeV



phase-space

Small mass splitting e.g. AMSB





small couplings
e.g. weakly-coupled dark sector, small R-parity violation, …

Strong interplay between theory and experiments:

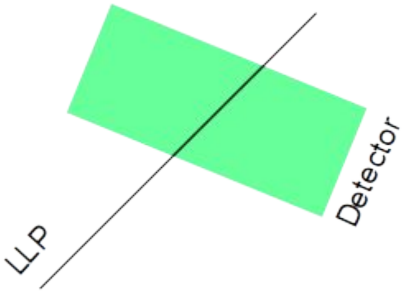
- Specific theories can suggest new signatures to explore
- Results presented for representative benchmark scenarios
  - ability to re-interpret results in a different model to ensure full exploration

Experimental approach: signature-based

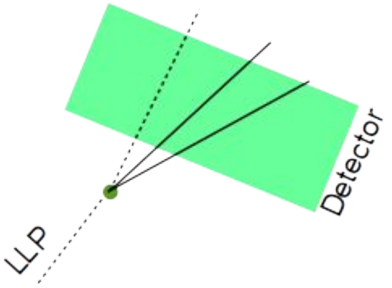
Best experimental strategy depends on the properties of the particle

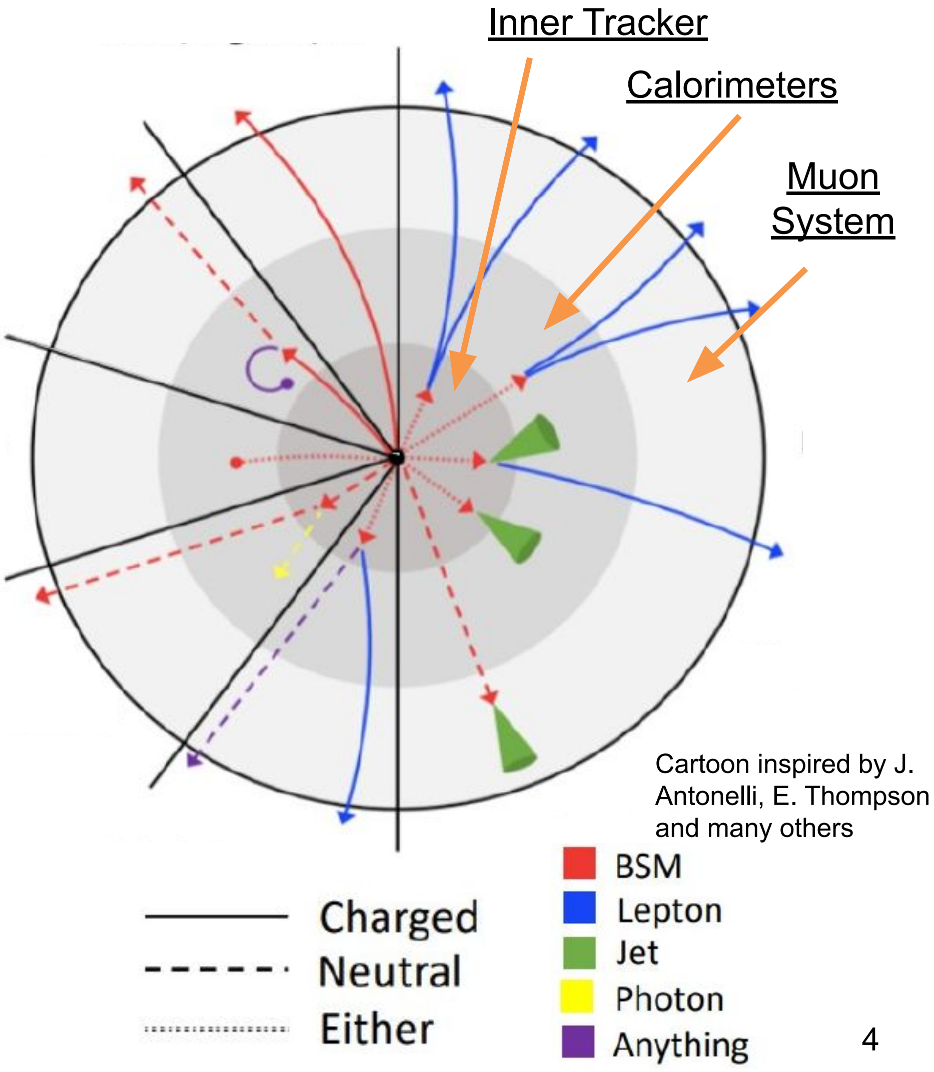
- Electric charge
- Production
- Mass & Lifetime
- Decay products

Direct detection



Indirect detection





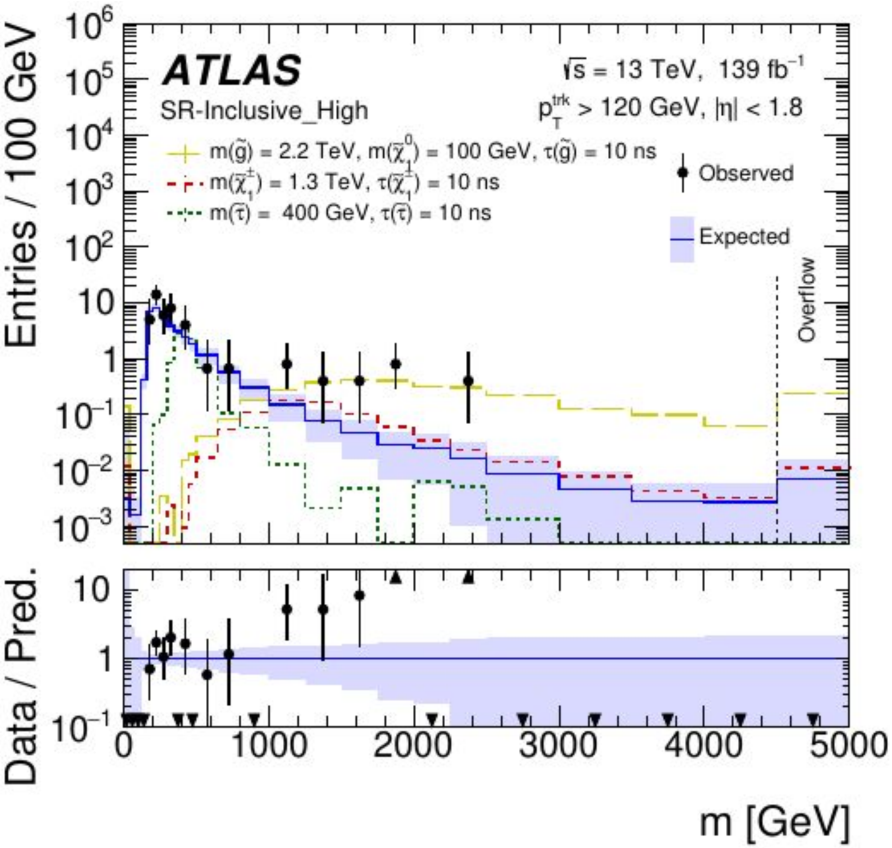
Cartoon inspired by J. Antonelli, E. Thompson and many others

Inner-Tracker charged particles

High-p_T, high-quality reconstructed track with large ionization energy loss (dE/dx)

SUSY-2018-42

- Triggering on missing transverse-momentum
- Entirely data-driven background estimation



$$m = p/(\beta\gamma)$$

from Inner Detector

from Pixel Detector

Excess found.

- Local: 3.6σ
- Global: 3.3σ

Many cross-checks performed.

No obvious instrumental / analysis problem found.

Inner-Tracker charged particles

What can cause an excess with high dE/dx?

$$\frac{\mathrm{d}E}{\mathrm{d}x} \propto \frac{z^2}{\beta^2}$$

charge / e$^-$

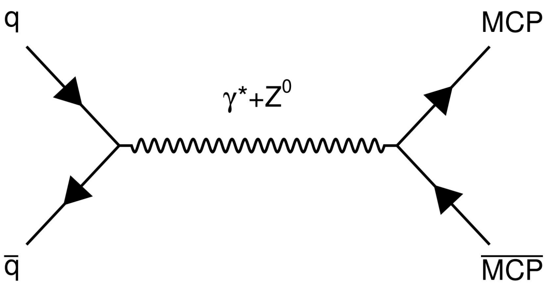
velocity

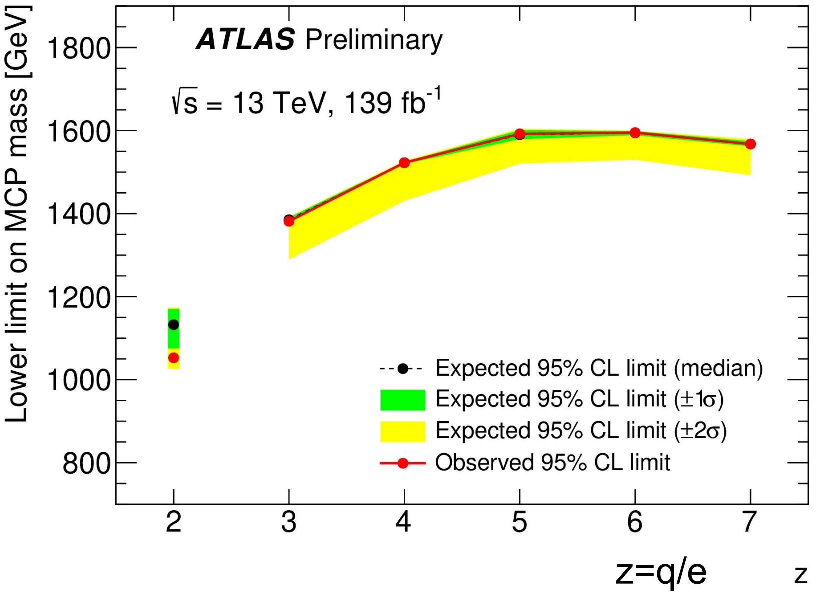
1) Slow particles (momentum << mass).
   Checked time-of-flight of excess candidates using muon spectrometer.
   Consistent with β~1

2) Multi-charged. Recent new results, but not sensitive enough to probe relevant cross-sections.

   ATLAS-CONF-2022-034

   - Measuring high-energy loss in Transition-Radiation Tracker





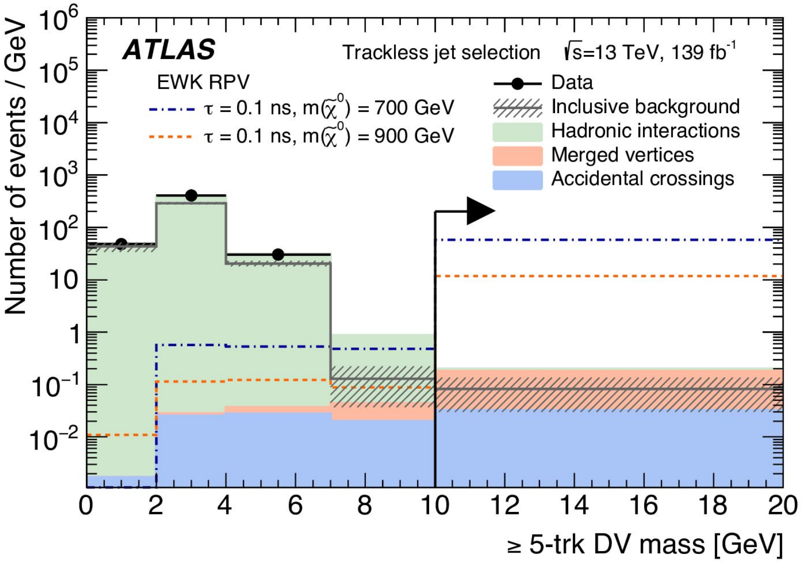
Displaced Vertices

Identify SM decay products of LLP decay inside the Inner Tracker.
Dedicated track reconstruction to be sensitive to non-prompt particles.

- ran only on a pre-selected O(10%) of collected data

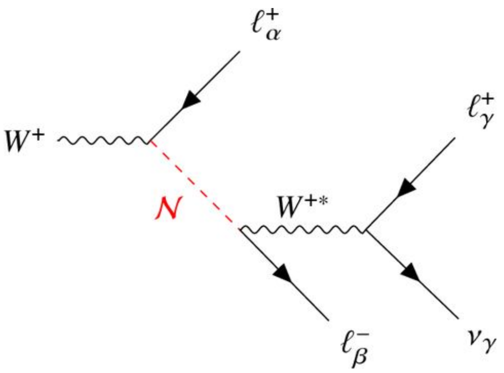
SUSY-2018-13

- >= 1 Displaced Vertex
  - mass > 10 GeV, n_{tracks} >=5
- High-p_T jets (2 to >=7, vary p_T)
- Dedicated signal region for displaced lower-p_T jets
- Strong and ewk SUSY models



EXOT-2019-29

- Trigger: prompt lepton
- Di-lepton displaced vertex
- Interpreted in Heavy-Neutral Lepton scenarios
  - $3 < \mathcal{N} < 15$ GeV
  - Single-flavor and multi-flavor mixing
- No excess observed, limits set



Displaced Photons

Non-prompt photons from BSM decays before EM calo:

- Delayed in time: EM calo timing up to ~0.2 ns resolution
- Longitudinally displaced: EM pointing information up to O(10 mm) resolution

1. Photons from different decays

SUSY-2019-14

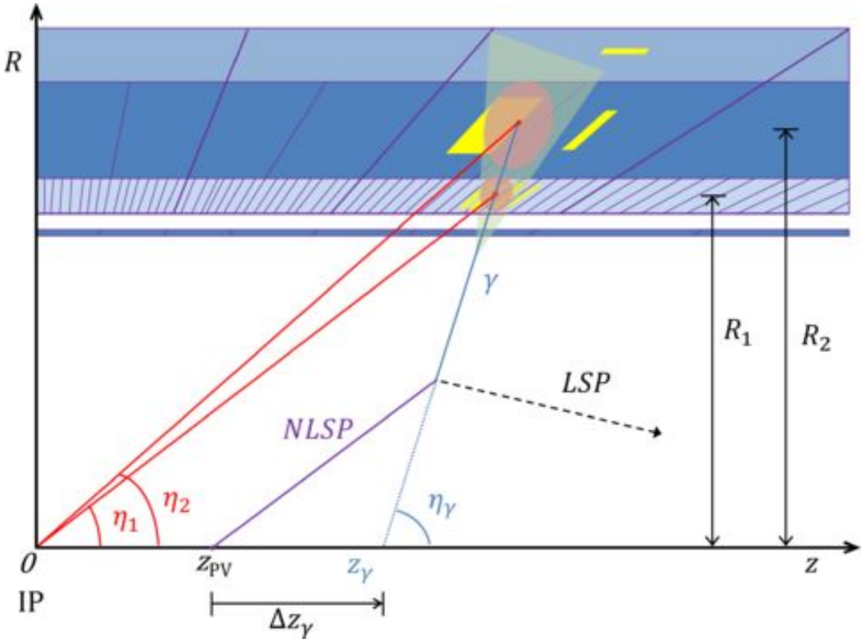
Signal region for 1 and >=2 photons.

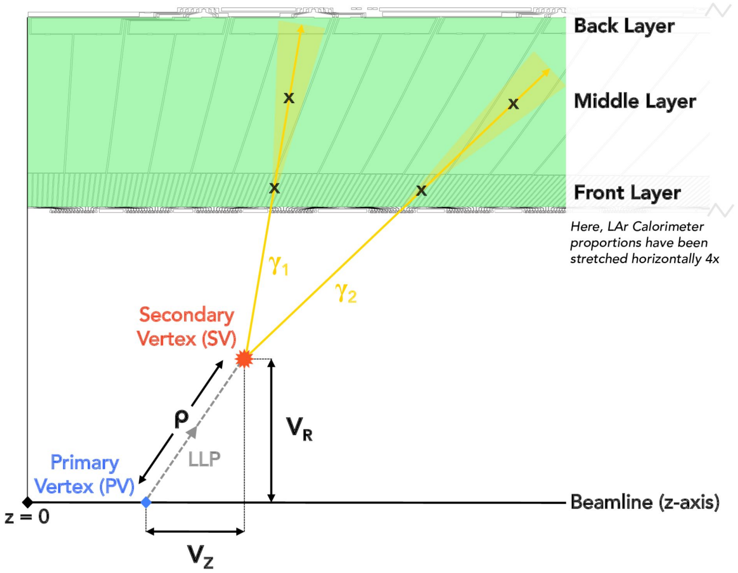
2. Photons from the same decay

ATLAS-CONF-2022-051

Dedicated vertexing from photon pointing with resolution as good as 10mm.

Also sensitive to displaced electrons.





Displaced Photons

Non-prompt photons from BSM decays before EM calo:

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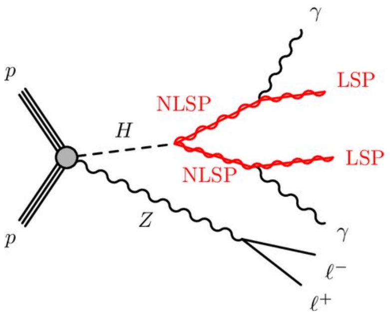
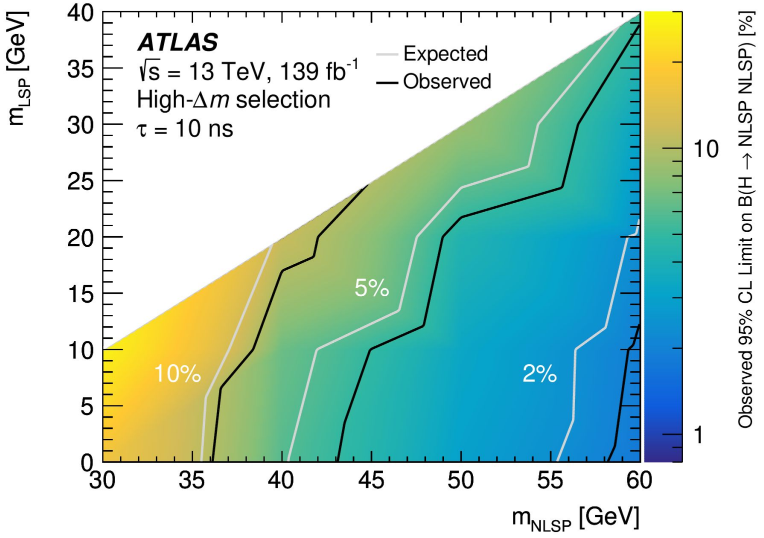
1. Photons from different decays

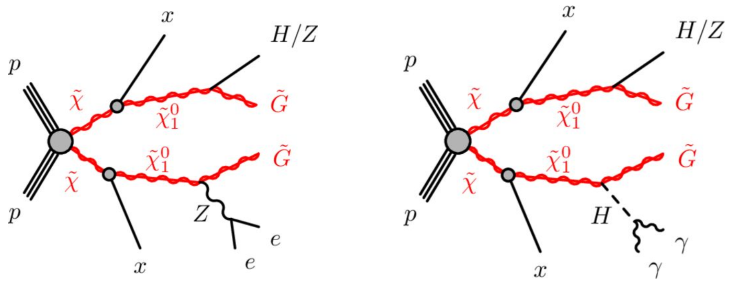
SUSY-2019-14

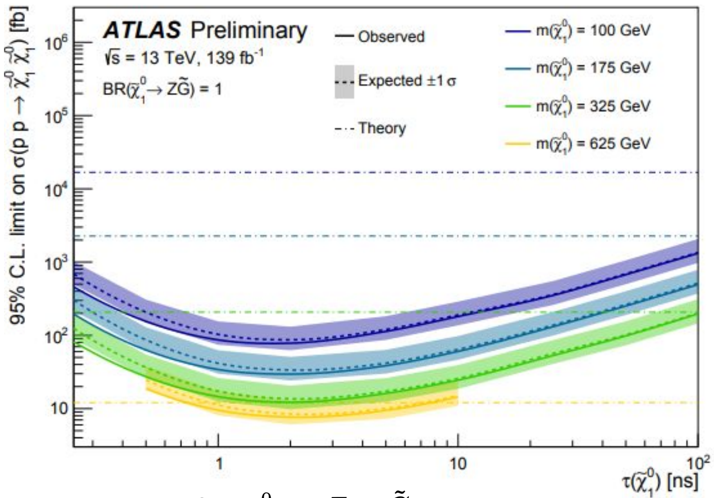




2. Photons from the same decay

ATLAS-CONF-2022-051





example for $\tilde{\chi}_1^0 \rightarrow Z + \tilde{G}$, more results avail.

Displaced “Hadronic” Jets

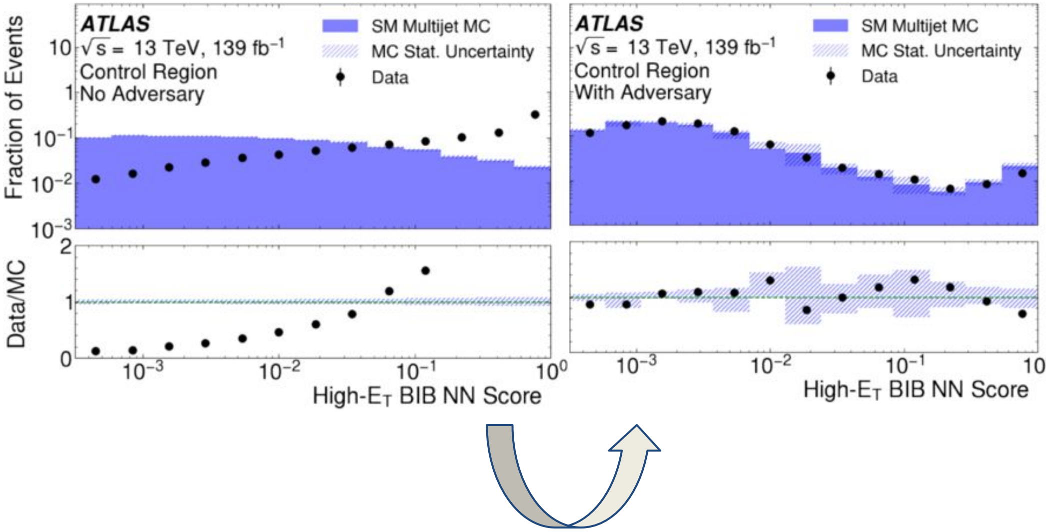
Chosen benchmarks: hidden sector models

EXOT-2019-23

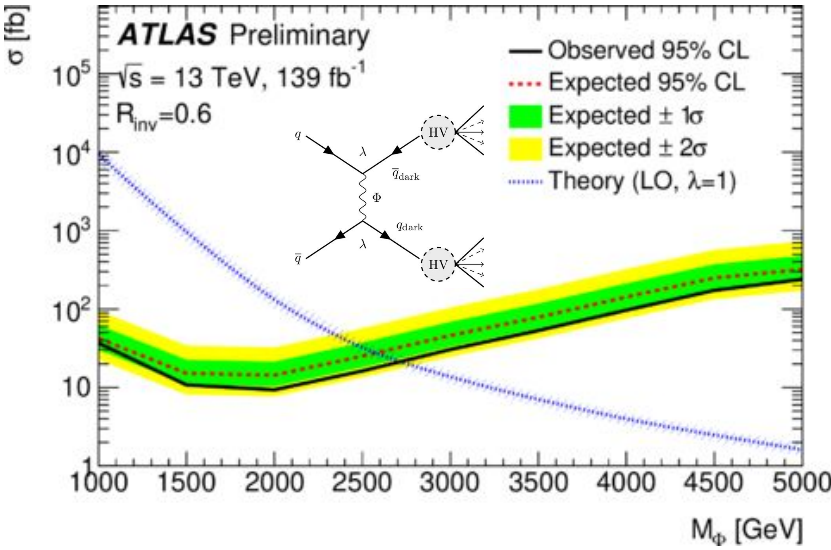
- Isolated calorimeter activity
- Dedicated trigger
- Sophisticated NN-based rejection of beam-induced and multijet backgrounds
- Data compatible with expected backgrounds

ATLAS-CONF-2022-038

- Semi-visible jets from partial decays back to SM
- Two main observables:
    - back-to-back jets balance
    - Missing momentum aligned with high-p_T jet



Aversary Network to avoid using information of variables not well modelled in simulation

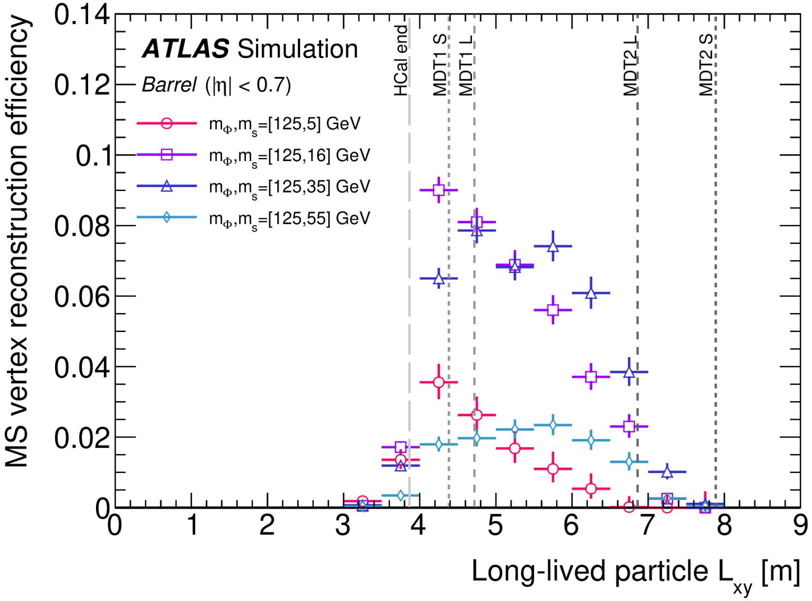


Varying fraction of visible decays in jets, see CONF for full results!

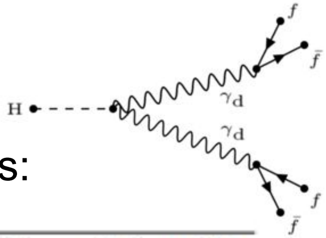
Decays in the Muon System

EXOT-2019-24

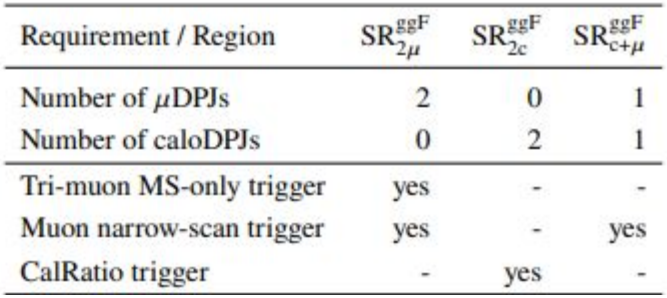
- Two displaced decays in the muon system
  - large volume: 3-14m decay length
- Veto activity in inner tracker and calorimeters
- Dedicated trigger
- Data compatible with expected backgrounds



EXOT-2019-05

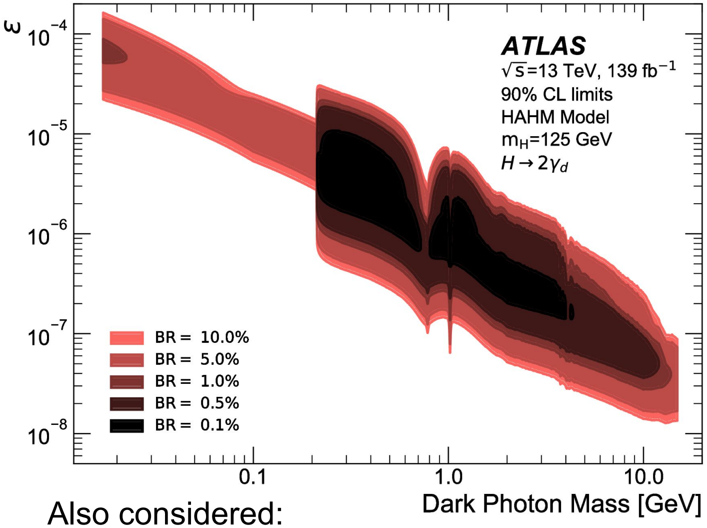


- Two displaced decays:



Requirement / Region	$SR^{ggF}_{2\mu}$	SR^{ggF}_{2c}	$SR^{ggF}_{c+\mu}$
Number of μDPJs	2	0	1
Number of caloDPJs	0	2	1
Tri-muon MS-only trigger	yes	-	-
Muon narrow-scan trigger	yes	-	yes
CalRatio trigger	-	yes	-

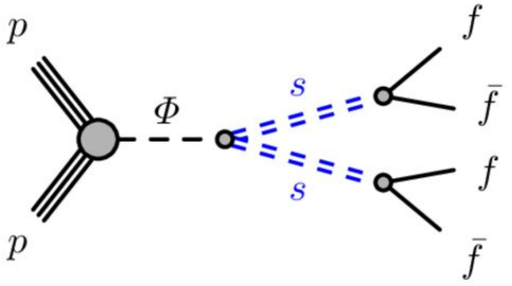
- Veto activity in inner tracker (and calorimeters, when applicable)

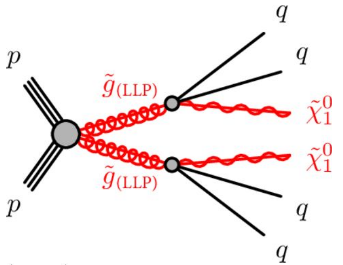


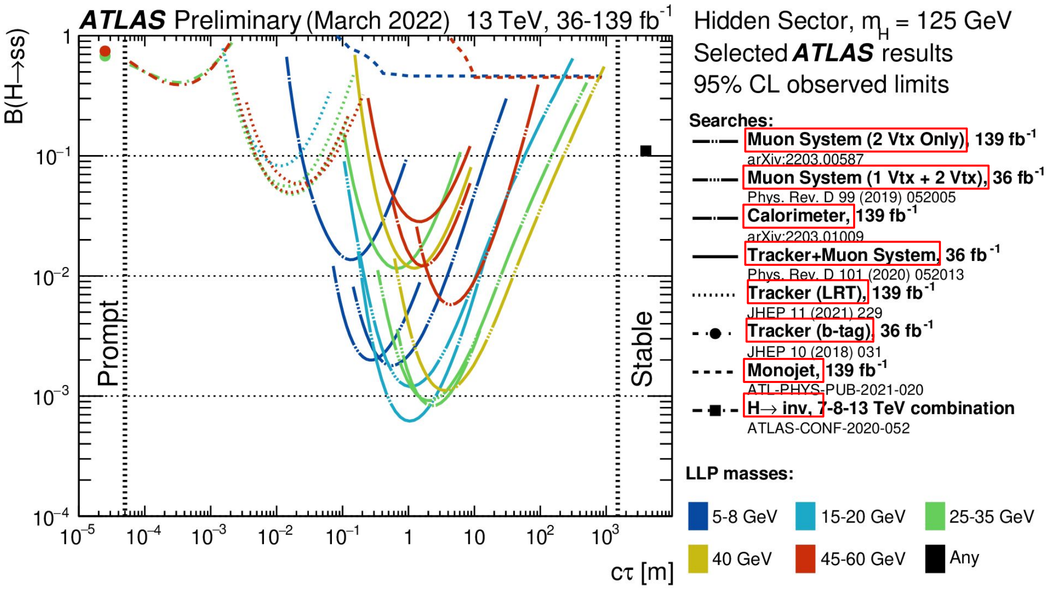
Also considered:
H decay through dark-fermion.

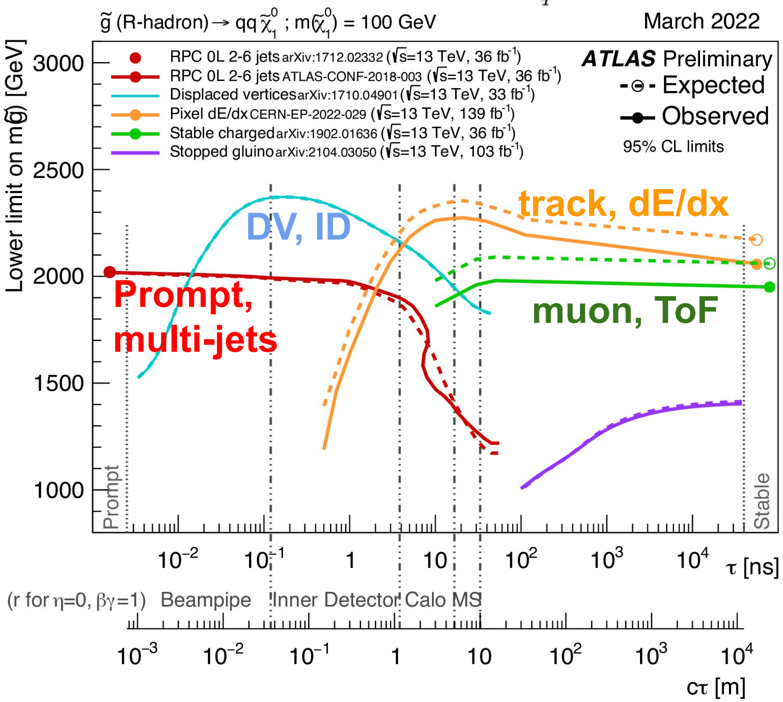
Complementarity and Gaps

Standardized benchmarks help ensuring coverage across signatures.









With more analyses using the full run 2 datasets, expect more updates soon!

Conclusions and Outlook

In this presentation: a snapshot of the most recent results

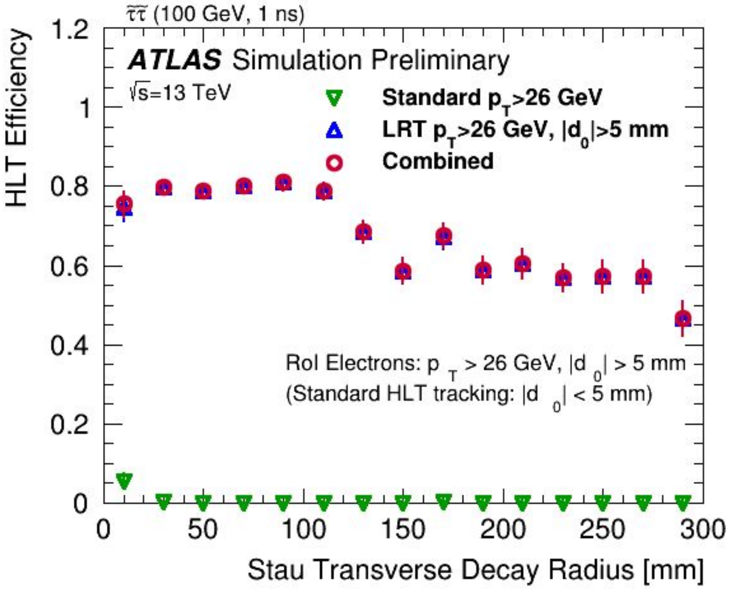
- one intriguing excess that will be followed up; lots of new and updated searches gave null results but strong new bounds
- many more analyses in progress using the full Run 2 dataset

In the meantime, an exciting Run 3 dataset is being collected since 2022!

Lots of exciting developments that will enhance the discovery potential of the Run 3 dataset, especially for long-lived signatures:

- Many new dedicated triggers
    - increase acceptance in difficult regimes, e.g. compressed scenarios

- Ability to reconstruct displaced tracks for all the events recorded
    - increase number of signatures accessible with non-prompt activity



BACKUP and References

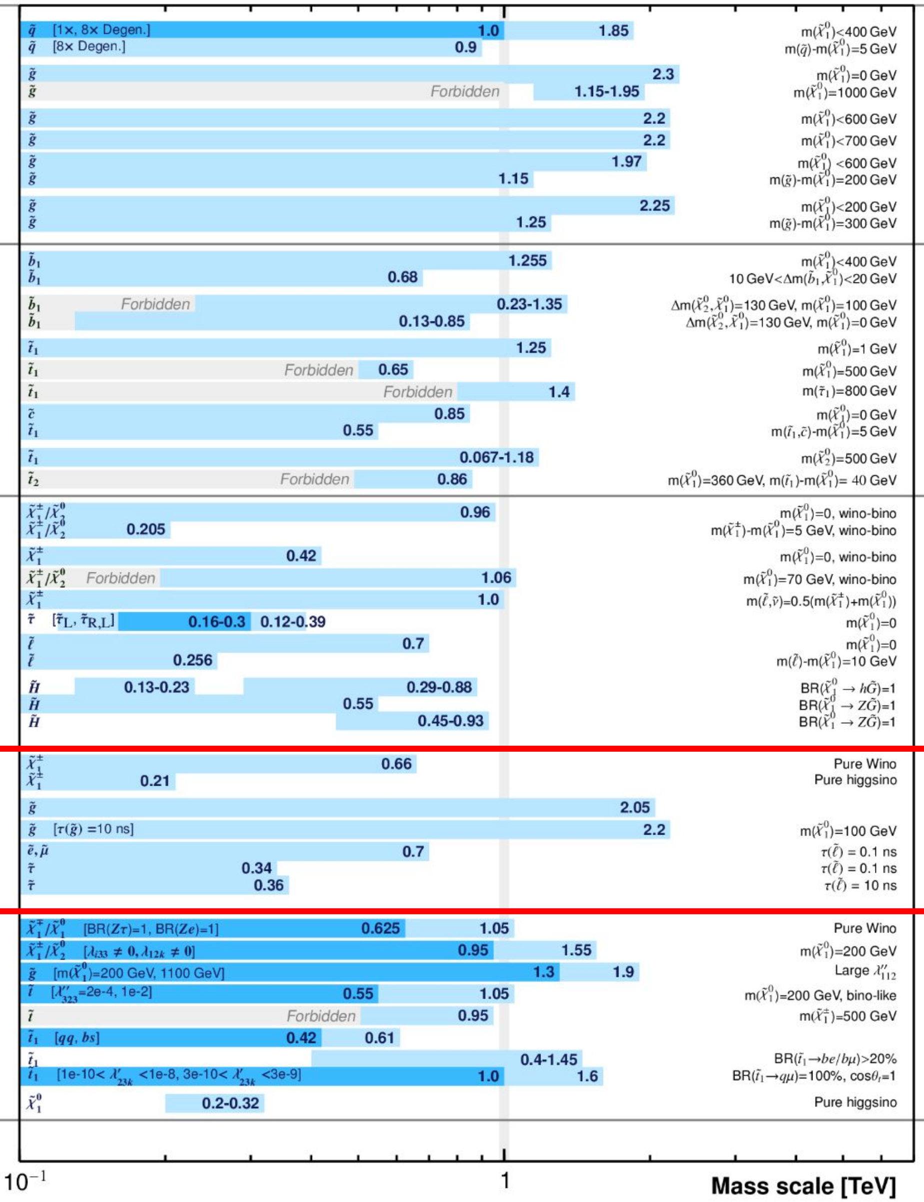
- SUSY-2018-42 Pixel dE/dx (SUSY)
- ATLAS-CONF-2022-034 Multi-charged particles (w/ TRT, DY-like)
- SUSY-2018-13 DV+Jets (SUSY)
- EXOT-2019-29 Displaced Vertex ID with prompt lepton (HNL)
- SUSY-2019-14 Displaced Photons (different vertices, Higgs+SUSY)
- ATLAS-CONF-2022-051 Displaced photons (vertexed approach, SUSY)
- ATLAS-CONF-2022-038 Semi-visible jets (dark sector, jets aligned w/ MET)
- EXOT-2019-23 Displaced hadronic jets in calo (Higgs, Heavy-scalar)
- EXOT-2019-24 Two DVs in muon spectrometer (Higgs, Heavy-scalar)
- EXOT-2019-05 Displaced activity in Calo and MS (Higgs, Dark Photons)
- ATL-PHYS-PUB-2021-012 Displaced Tracking in Run 3 (CPU timing performance only)
- Public Plots on Trigger Menu Run 3

ATLAS SUSY Searches* - 95% CL Lower Limits

March 2022

ATLAS Preliminary

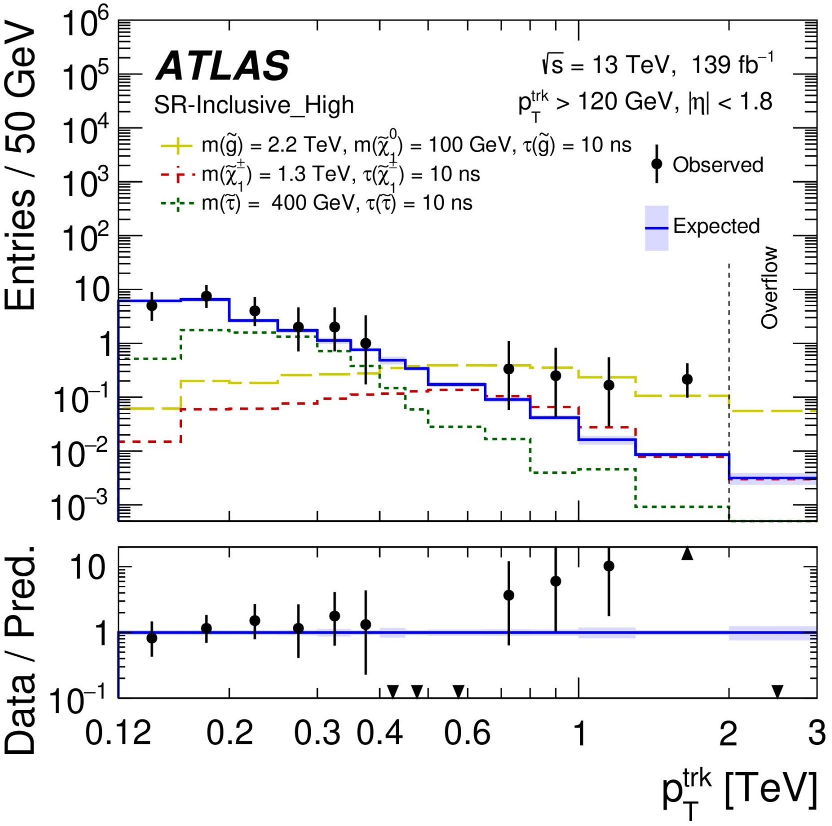
$\sqrt{s}$ = 13 TeV

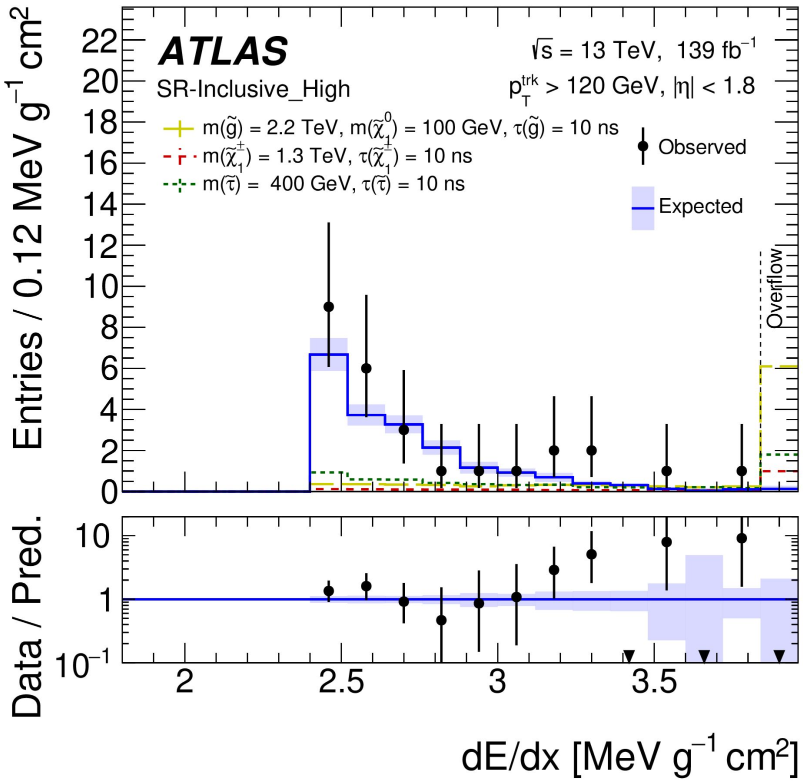


	Model	Signature			$\int\mathcal{L}\,dt$ [fb^{-1}]	Mass limit				Reference
Inclusive Searches	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}^0_1$	0 e,μ	2-6 jets	$E_T^{\rm miss}$	139	$\tilde{q}$	[1×, 8× Degen.]	1.0 1.85	m($\tilde{\chi}^0_1$)<400 GeV	2010.14293
		mono-jet	1-3 jets	$E_T^{\rm miss}$	139	$\tilde{q}$	[8× Degen.]	0.9	m($\tilde{q}$)-m($\tilde{\chi}^0_1$)=5 GeV	2102.10874
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}^0_1$	0 e,μ	2-6 jets	$E_T^{\rm miss}$	139	$\tilde{g}$		2.3	m($\tilde{\chi}^0_1$)=0 GeV	2010.14293
						$\tilde{g}$	Forbidden	1.15-1.95	m($\tilde{\chi}^0_1$)=1000 GeV	2010.14293
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}W\tilde{\chi}^0_1$	1 e,μ	2-6 jets		139	$\tilde{g}$		2.2	m($\tilde{\chi}^0_1$)<600 GeV	2101.01629
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}(\ell\ell)\tilde{\chi}^0_1$	$ee,\mu\mu$	2 jets	$E_T^{\rm miss}$	139	$\tilde{g}$		2.2	m($\tilde{\chi}^0_1$)<700 GeV	CERN-EP-2022-014
	$\tilde{g}\tilde{g}, \tilde{g}\to qqWZ\tilde{\chi}^0_1$	0 e,μ	7-11 jets	$E_T^{\rm miss}$	139	$\tilde{g}$		1.97	m($\tilde{\chi}^0_1$) <600 GeV	2008.06032
		SS e,μ	6 jets		139	$\tilde{g}$		1.15	m($\tilde{g}$)-m($\tilde{\chi}^0_1$)=200 GeV	1909.08457
	$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}^0_1$	0-1 e,μ	3 b	$E_T^{\rm miss}$	79.8	$\tilde{g}$		2.25	m($\tilde{\chi}^0_1$)<200 GeV	ATLAS-CONF-2018-041
		SS e,μ	6 jets		139	$\tilde{g}$		1.25	m($\tilde{g}$)-m($\tilde{\chi}^0_1$)=300 GeV	1909.08457
3^{rd} gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$	0 e,μ	2 b	$E_T^{\rm miss}$	139	$\tilde{b}_1$		1.255	m($\tilde{\chi}^0_1$)<400 GeV	2101.12527
						$\tilde{b}_1$		0.68	10 GeV<Δm($\tilde{b}_1$,$\tilde{\chi}^0_1$)<20 GeV	2101.12527
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}^0_2\to bh\tilde{\chi}^0_1$	0 e,μ	6 b	$E_T^{\rm miss}$	139	$\tilde{b}_1$	Forbidden	0.23-1.35	Δm($\tilde{\chi}^0_2$,$\tilde{\chi}^0_1$)=130 GeV, m($\tilde{\chi}^0_1$)=100 GeV	1908.03122
		2 τ	2 b	$E_T^{\rm miss}$	139	$\tilde{b}_1$		0.13-0.85	Δm($\tilde{\chi}^0_2$,$\tilde{\chi}^0_1$)=130 GeV, m($\tilde{\chi}^0_1$)=0 GeV	2103.08189
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to t\tilde{\chi}^0_1$	0-1 e,μ	$\geq$ 1 jet	$E_T^{\rm miss}$	139	$\tilde{t}_1$		1.25	m($\tilde{\chi}^0_1$)=1 GeV	2004.14060,2012.03799
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to Wb\tilde{\chi}^0_1$	1 e,μ	3 jets/1 b	$E_T^{\rm miss}$	139	$\tilde{t}_1$	Forbidden	0.65	m($\tilde{\chi}^0_1$)=500 GeV	2012.03799
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to\tilde{\tau}_1 b\nu, \tilde{\tau}_1\to\tau\tilde{G}$	1-2 τ	2 jets/1 b	$E_T^{\rm miss}$	139	$\tilde{t}_1$	Forbidden	1.4	m($\tilde{\tau}_1$)=800 GeV	2108.07665
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}^0_1$ / $\tilde{c}\tilde{c}, \tilde{c}\to c\tilde{\chi}^0_1$	0 e,μ	2 c	$E_T^{\rm miss}$	36.1	$\tilde{c}$		0.85	m($\tilde{\chi}^0_1$)=0 GeV	1805.01649
		0 e,μ	mono-jet	$E_T^{\rm miss}$	139	$\tilde{t}_1$		0.55	m($\tilde{t}_1$,$\tilde{c}$)-m($\tilde{\chi}^0_1$)=5 GeV	2102.10874
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to t\tilde{\chi}^0_2, \tilde{\chi}^0_2\to Z/h\tilde{\chi}^0_1$	1-2 e,μ	1-4 b	$E_T^{\rm miss}$	139	$\tilde{t}_1$		0.067-1.18	m($\tilde{\chi}^0_2$)=500 GeV	2006.05880
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ	1 b	$E_T^{\rm miss}$	139	$\tilde{t}_2$	Forbidden	0.86	m($\tilde{\chi}^0_1$)=360 GeV, m($\tilde{t}_1$)-m($\tilde{\chi}^0_1$)= 40 GeV	2006.05880
EW direct	$\tilde{\chi}^\pm_1\tilde{\chi}^0_2$ via WZ	Multiple ℓ/jets		$E_T^{\rm miss}$	139	$\tilde{\chi}^\pm_1/\tilde{\chi}^0_2$		0.96	m($\tilde{\chi}^0_1$)=0, wino-bino	2106.01676, 2108.07586
		$ee,\mu\mu$	$\geq$ 1 jet	$E_T^{\rm miss}$	139	$\tilde{\chi}^\pm_1/\tilde{\chi}^0_2$		0.205	m($\tilde{\chi}^\pm_1$)-m($\tilde{\chi}^0_1$)=5 GeV, wino-bino	1911.12606
	$\tilde{\chi}^\pm_1\tilde{\chi}^\mp_1$ via WW	2 e,μ		$E_T^{\rm miss}$	139	$\tilde{\chi}^\pm_1$		0.42	m($\tilde{\chi}^0_1$)=0, wino-bino	1908.08215
	$\tilde{\chi}^\pm_1\tilde{\chi}^0_2$ via Wh	Multiple ℓ/jets		$E_T^{\rm miss}$	139	$\tilde{\chi}^\pm_1/\tilde{\chi}^0_2$	Forbidden	1.06	m($\tilde{\chi}^0_1$)=70 GeV, wino-bino	2004.10894, 2108.07586
	$\tilde{\chi}^\pm_1\tilde{\chi}^\mp_1$ via $\tilde{\ell}_L/\tilde{\nu}$	2 e,μ		$E_T^{\rm miss}$	139	$\tilde{\chi}^\pm_1$		1.0	m($\tilde{\ell}$,$\tilde{\nu}$)=0.5(m($\tilde{\chi}^\pm_1$)+m($\tilde{\chi}^0_1$))	1908.08215
	$\tilde{\tau}\tilde{\tau}, \tilde{\tau}\to\tau\tilde{\chi}^0_1$	2 τ		$E_T^{\rm miss}$	139	$\tilde{\tau}$	[$\tilde{\tau}_{\rm L}$, $\tilde{\tau}_{\rm R,L}$]	0.16-0.3 0.12-0.39	m($\tilde{\chi}^0_1$)=0	1911.06660
	$\tilde{\ell}_{\rm L,R}\tilde{\ell}_{\rm L,R}, \tilde{\ell}\to\ell\tilde{\chi}^0_1$	2 e,μ	0 jets	$E_T^{\rm miss}$	139	$\tilde{\ell}$		0.7	m($\tilde{\chi}^0_1$)=0	1908.08215
		$ee,\mu\mu$	$\geq$ 1 jet	$E_T^{\rm miss}$	139	$\tilde{\ell}$		0.256	m($\tilde{\ell}$)-m($\tilde{\chi}^0_1$)=10 GeV	1911.12606
	$\tilde{H}\tilde{H}, \tilde{H}\to h\tilde{G}/Z\tilde{G}$	0 e,μ	$\geq$ 3 b	$E_T^{\rm miss}$	36.1	$\tilde{H}$		0.13-0.23 0.29-0.88	BR($\tilde{\chi}^0_1\to h\tilde{G}$)=1	1806.04030
		4 e,μ	0 jets	$E_T^{\rm miss}$	139	$\tilde{H}$		0.55	BR($\tilde{\chi}^0_1\to Z\tilde{G}$)=1	2103.11684
		0 e,μ	$\geq$ 2 large jets	$E_T^{\rm miss}$	139	$\tilde{H}$		0.45-0.93	BR($\tilde{\chi}^0_1\to Z\tilde{G}$)=1	2108.07586
Long-lived particles	Direct $\tilde{\chi}^+_1\tilde{\chi}^-_1$ prod., long-lived $\tilde{\chi}^\pm_1$	Disapp. trk	1 jet	$E_T^{\rm miss}$	139	$\tilde{\chi}^\pm_1$		0.66	Pure Wino	2201.02472
						$\tilde{\chi}^\pm_1$		0.21	Pure higgsino	2201.02472
	Stable $\tilde{g}$ R-hadron	pixel dE/dx		$E_T^{\rm miss}$	139	$\tilde{g}$		2.05		CERN-EP-2022-029
	Metastable $\tilde{g}$ R-hadron, $\tilde{g}\to qq\tilde{\chi}^0_1$	pixel dE/dx		$E_T^{\rm miss}$	139	$\tilde{g}$	[$\tau(\tilde{g})$ =10 ns]	2.2	m($\tilde{\chi}^0_1$)=100 GeV	CERN-EP-2022-029
	$\tilde{\ell}\tilde{\ell}, \tilde{\ell}\to\ell\tilde{G}$	Displ. lep		$E_T^{\rm miss}$	139	$\tilde{e},\tilde{\mu}$		0.7	$\tau(\tilde{\ell})$ = 0.1 ns	2011.07812
						$\tilde{\tau}$		0.34	$\tau(\tilde{\ell})$ = 0.1 ns	2011.07812
		pixel dE/dx		$E_T^{\rm miss}$	139	$\tilde{\tau}$		0.36	$\tau(\tilde{\ell})$ = 10 ns	CERN-EP-2022-029
RPV	$\tilde{\chi}^\pm_1\tilde{\chi}^\mp_1/\tilde{\chi}^0_1, \tilde{\chi}^\pm_1\to Z\ell\to\ell\ell\ell$	3 e,μ			139	$\tilde{\chi}^\mp_1/\tilde{\chi}^0_1$	[BR($Z\tau$)=1, BR(Ze)=1]	0.625 1.05	Pure Wino	2011.10543
	$\tilde{\chi}^\pm_1\tilde{\chi}^\mp_1/\tilde{\chi}^0_2\to WW/Z\ell\ell\ell\ell\nu\nu$	4 e,μ	0 jets	$E_T^{\rm miss}$	139	$\tilde{\chi}^\pm_1/\tilde{\chi}^0_2$	[$\lambda_{i33}\neq 0, \lambda_{12k}\neq 0$]	0.95 1.55	m($\tilde{\chi}^0_1$)=200 GeV	2103.11684
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}^0_1, \tilde{\chi}^0_1\to qqq$		4-5 large jets		36.1	$\tilde{g}$	[m($\tilde{\chi}^0_1$)=200 GeV, 1100 GeV]	1.3 1.9	Large λ''_{112}	1804.03568
	$\tilde{t}\tilde{t}, \tilde{t}\to t\tilde{\chi}^0_1, \tilde{\chi}^0_1\to tbs$		Multiple		36.1	$\tilde{t}$	[λ''_{323}=2e-4, 1e-2]	0.55 1.05	m($\tilde{\chi}^0_1$)=200 GeV, bino-like	ATLAS-CONF-2018-003
	$\tilde{t}\tilde{t}, \tilde{t}\to b\tilde{\chi}^\pm_1, \tilde{\chi}^\pm_1\to bbs$		$\geq 4b$		139	$\tilde{t}$	Forbidden	0.95	m($\tilde{\chi}^\pm_1$)=500 GeV	2010.01015
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to bs$		2 jets + 2 b		36.7	$\tilde{t}_1$	[qq, bs]	0.42 0.61		1710.07171
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to q\ell$	2 e,μ	2 b		36.1	$\tilde{t}_1$		0.4-1.45	BR($\tilde{t}_1\to be/b\mu$)>20%	1710.05544
		1 μ	DV		136	$\tilde{t}_1$	[1e-10< λ'_{23k} <1e-8, 3e-10< λ'_{23k} <3e-9]	1.0 1.6	BR($\tilde{t}_1\to q\mu$)=100%, cosθ_t=1	2003.11956
	$\tilde{\chi}^\pm_1/\tilde{\chi}^0_2/\tilde{\chi}^0_1, \tilde{\chi}^0_{1,2}\to tbs, \tilde{\chi}^+_1\to bbs$	1-2 e,μ	$\geq$6 jets		139	$\tilde{\chi}^0_1$		0.2-0.32	Pure higgsino	2106.09609

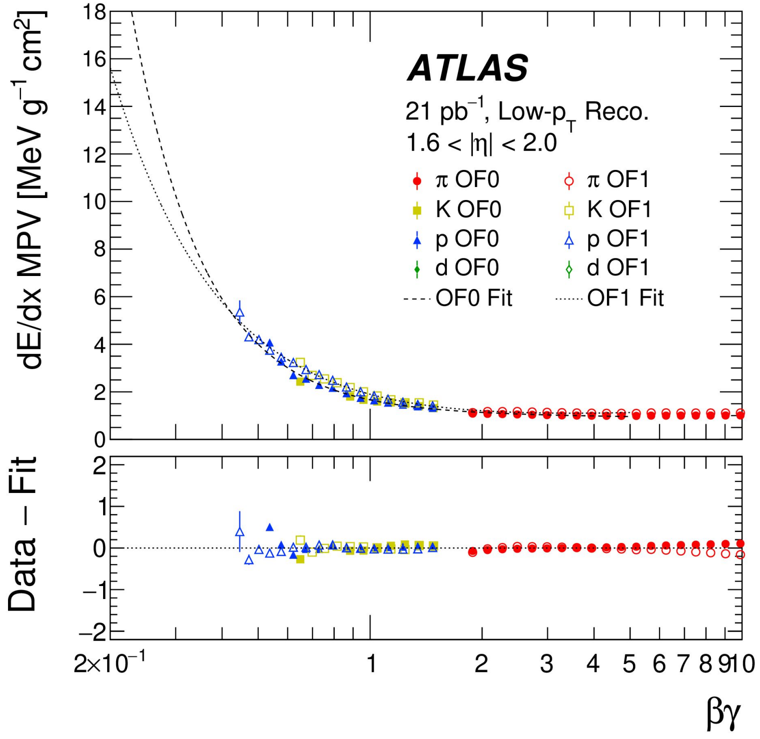
*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

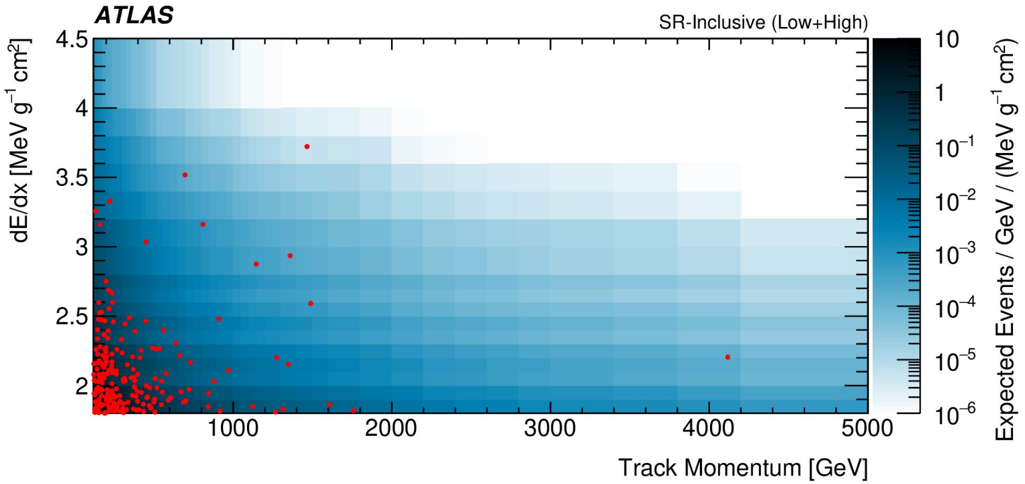
Pixel dE/dx

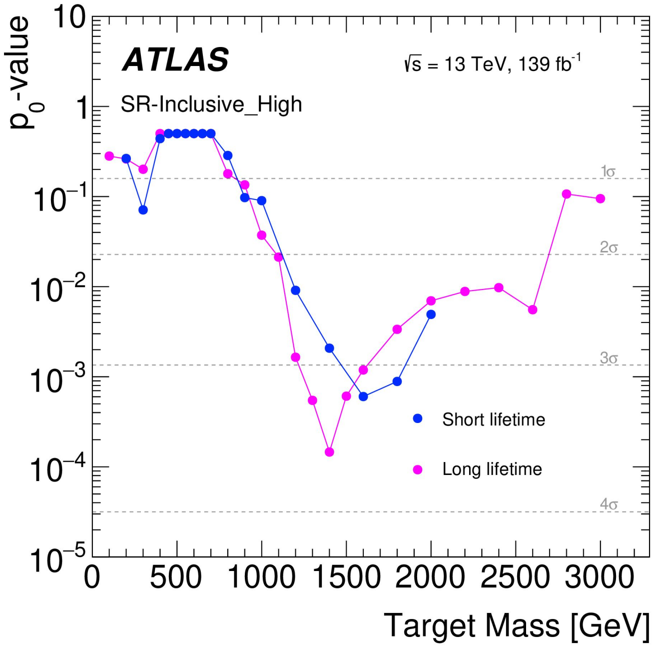

ATLAS
$\sqrt{s}$ = 13 TeV, 139 fb^{-1}
SR-Inclusive_High
p_T^{trk} > 120 GeV, |η| < 1.8
m($\tilde{g}$) = 2.2 TeV, m($\tilde{\chi}_1^0$) = 100 GeV, τ($\tilde{g}$) = 10 ns
m($\tilde{\chi}_1^\pm$) = 1.3 TeV, τ($\tilde{\chi}_1^\pm$) = 10 ns
m($\tilde{\tau}$) = 400 GeV, τ($\tilde{\tau}$) = 10 ns
Observed
Expected
Overflow
Entries / 50 GeV
10^6
10^5
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
Data / Pred.
10
1
10^{-1}
0.12
0.2
0.3
0.4
0.6
1
2
3
p_T^{trk} [TeV]


ATLAS
$\sqrt{s}$ = 13 TeV, 139 fb^{-1}
SR-Inclusive_High
p_T^{trk} > 120 GeV, |η| < 1.8
m($\tilde{g}$) = 2.2 TeV, m($\tilde{\chi}_1^0$) = 100 GeV, τ($\tilde{g}$) = 10 ns
m($\tilde{\chi}_1^\pm$) = 1.3 TeV, τ($\tilde{\chi}_1^\pm$) = 10 ns
m($\tilde{\tau}$) = 400 GeV, τ($\tilde{\tau}$) = 10 ns
Observed
Expected
Overflow
Entries / 0.12 MeV g^{-1} cm^2
22
20
18
16
14
12
10
8
6
4
2
0
Data / Pred.
10
1
10^{-1}
2
2.5
3
3.5
dE/dx [MeV g^{-1} cm^2]

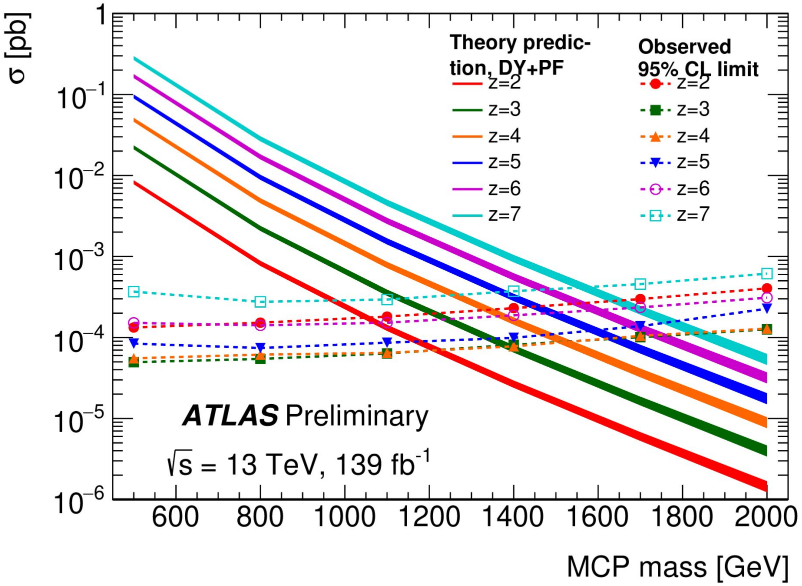
Pixel dE/dx

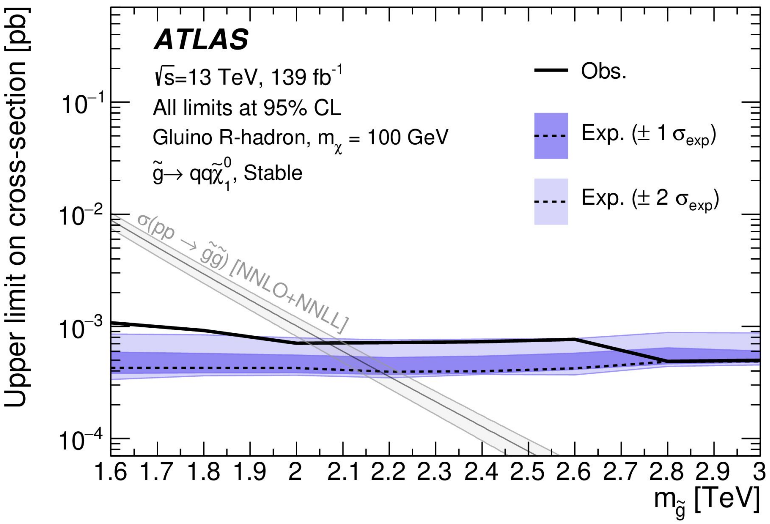

ATLAS
21 pb^{-1}, Low-p$_T$ Reco.
1.6 < |η| < 2.0
π OF0
π OF1
K OF0
K OF1
p OF0
p OF1
d OF0
d OF1
OF0 Fit
OF1 Fit
dE/dx MPV [MeV g^{-1} cm^2]
Data − Fit
βγ
0
2
4
6
8
10
12
14
16
18
−2
−1
0
1
2
2×10^{-1}
1
2
3
4
5
6
7
8
9
10


ATLAS
SR-Inclusive (Low+High)
dE/dx [MeV g^{-1} cm^2]
2
2.5
3
3.5
4
4.5
1000
2000
3000
4000
5000
Track Momentum [GeV]
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
Expected Events / GeV / (MeV g^{-1} cm^2)


ATLAS
√s = 13 TeV, 139 fb^{-1}
SR-Inclusive_High
p$_0$-value
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
1σ
2σ
3σ
4σ
Short lifetime
Long lifetime
0
500
1000
1500
2000
2500
3000
Target Mass [GeV]

Multi-charged particles and Pixel dE/dx sensitivity





Experimental approach: signature-based

Long-Lived Particles: non-SM particles that travel macroscopic distances
Challenging Signatures: Does not use “standard” objects/data-flow/… and/or defy in some sense our theoretical prejudice of how new physics would appear.

Best experimental strategy depends on the properties of the particle

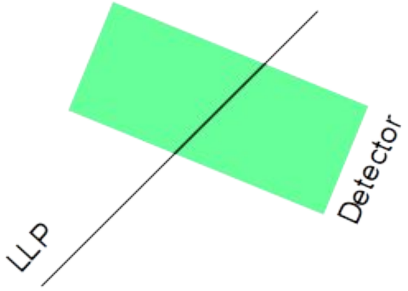
Electric charge

Pro-duction

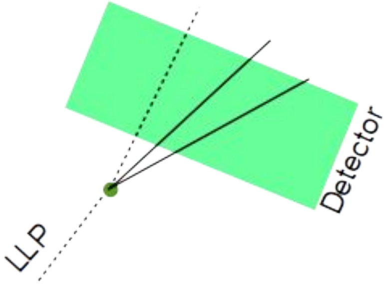
Mass & Lifetime

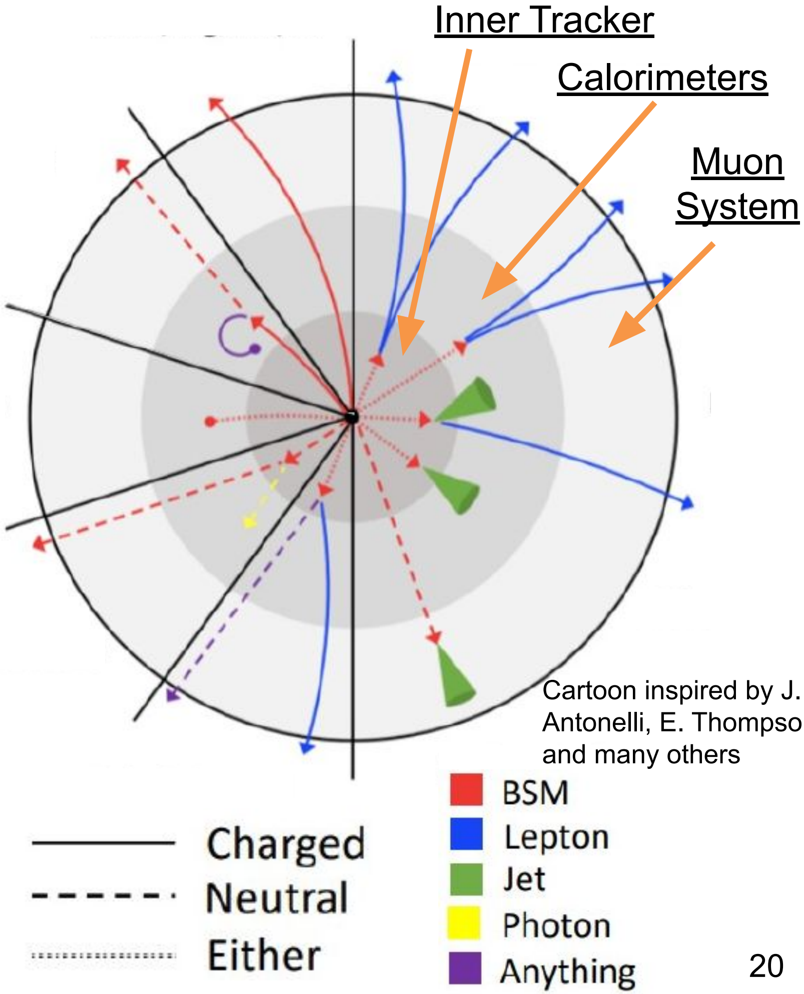
Decay products

Direct detection



Indirect detection





Cartoon inspired by J. Antonelli, E. Thompson and many others