GAMBIT Dark matter

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Outline

– Global Fitting and GAMBIT

– Recent Code updates

– Recent Physics works (primarily focussing on DM):

  – Bounds on Neutrino Masses

  – Thermal WIMPS (Dirac DM EFT)

  – Cosmological decaying ALPs

  – Simplified DM models

  – Electroweakinos + gravitino

– What to look forward to from GAMBIT

BSM Physics is a balancing act

Theories may need to sit in some sweet spot to solve the problem they were created for (e.g. strong cp), whilst also satisfying all existing constraints.

This motivates comprehensive studies, including as many effects as possible.

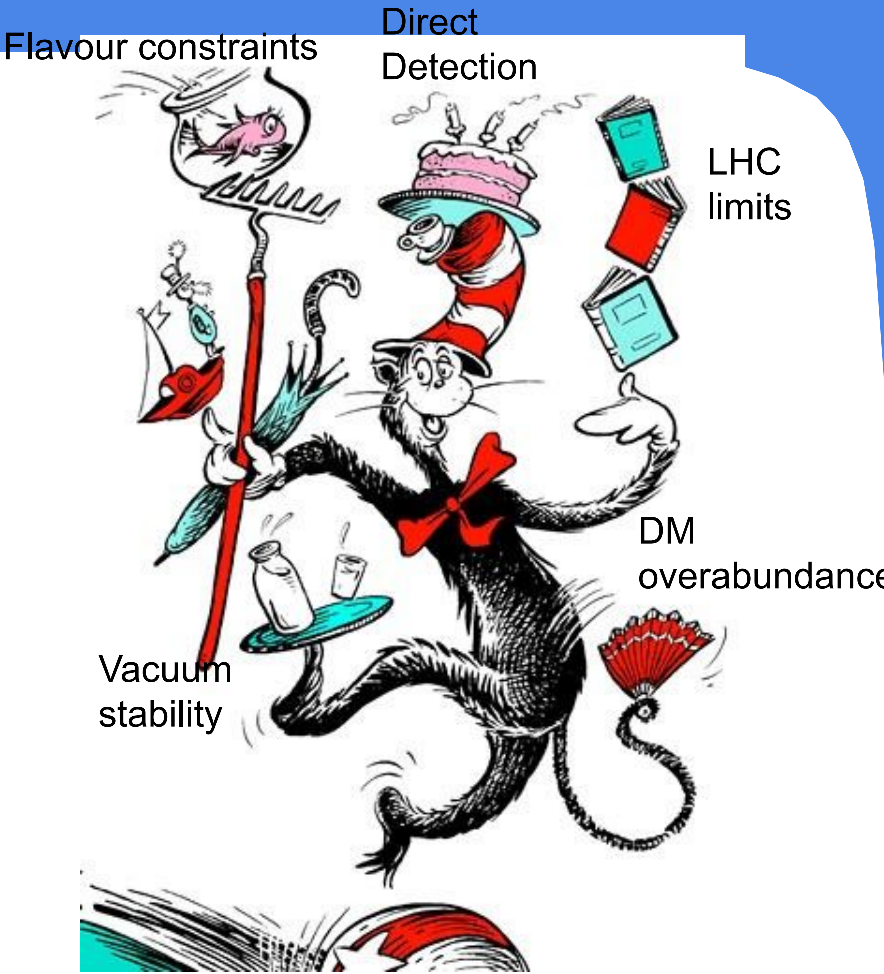


Image credit: Cat in the Hat

Global Fitting

We want to test a theory against a range of experiments over the wide range of possible model parameters.

Need a joint likelihood function:

$$\mathcal{L}_{Total} = \mathcal{L}_{DD} \times \mathcal{L}_{ID} \times \mathcal{L}_{Collider} \times \ldots$$

Simple overlays of limits may not be fully informative.

Can be complicated and slow -> needs an efficient way to do this.

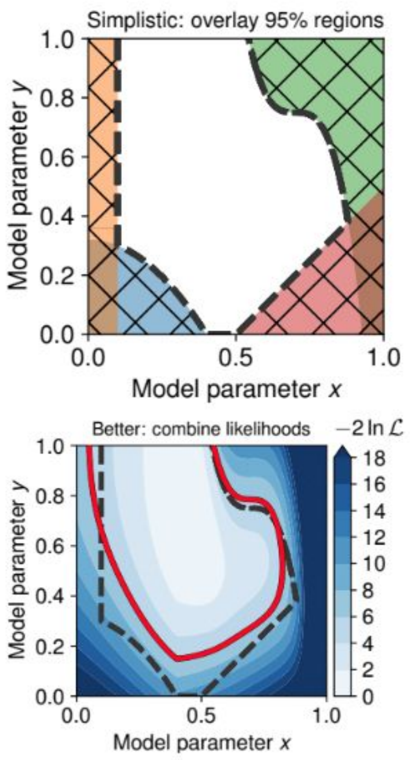
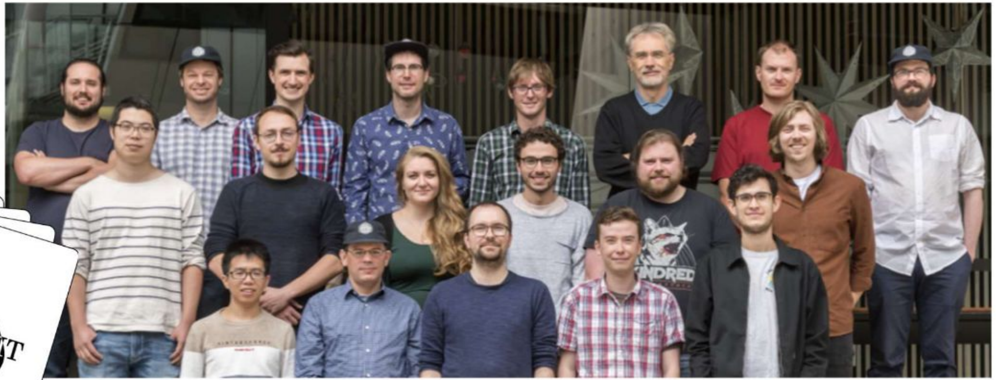


Image: S. S. AbdusSalam et al. Simple and statistically sound recommendations for analysing physical theories, Rept. Prog. Phys. 85 (2022) [arXiv: 2012.09874]

GAMBIT: The Global And Modular BSM Inference Tool

gambit.hepforge.org   github.com/GambitBSM   EPJC 77 (2017) 784   arXiv:1705.07908

- Extensive model database, beyond SUSY
- Fast definition of new datasets, theories
- Extensive observable/data libraries
- Plug&play scanning/physics/likelihood packages
- Various statistical options (frequentist /Bayesian)
- Fast LHC likelihood calculator
- Massively parallel
- Fully open-source



Members of: ATLAS, Belle-II, CLiC, CMS, CTA, Fermi-LAT, DARWIN, IceCube, LHCb, SHiP, XENON

Authors of: BubbleProfiler, Capt'n General, Contur, DarkAges, DarkSUSY, DDCalc, DirectDM, Diver, EasyScanHEP, ExoCLASS, FlexibleSUSY, gamLike, GM2Calc, HEPLike, IsaTools, MARTY, nuLike, PhaseTracer, PolyChord, Rivet, SOFTSUSY, Superlso, SUSY-AI, xsec, Vevacious, WIMPSim

Recent collaborators: P Athron, C Balázs, A Beniwal, S Bloor, T Bringmann, A Buckley, J-E Camargo-Molina, C Chang, M Chrzaszcz, J Conrad, J Cornell, M Danninger, J Edsjö, T Emken, A Fowlie, T Gonzalo, W Handley, J Harz, S Hoof, F Kahlhoefer, A Kvellestad, P Jackson, D Jacob, C Lin, N Mahmoudi, G Martinez, MT Prim, A Raklev, C Rogan, R Ruiz, P Scott, N Serra, P Stöcker , W. Su, A Vincent, C Weniger, M White, Y Zhang, ++

70+ participants in many experiments and numerous major theory codes

GAMBIT Physics Modules

ColliderBit: Collider observables [arXiv:1705.07919]

DarkBit: Relic Density, Direct detection,... [arXiv:1705.07920]

FlavBit: Flavour observables [arXiv:1705.07933]

SpecBit: Computes particle masses [arXiv:1705.07936]

DecayBit: Particle decay rates [arXiv:1705.07936]

PrecisionBit: tests based on rare processes [arXiv:1705.07936]

NeutrinoBit: neutrino physics [arXiv:1908.02302]

CosmoBit: cosmology [arXiv:2009.03286]

For details on most likelihood implementations, see the relevant GAMBIT module code papers.

Recent code updates

– GUM: The GAMBIT Model Machine: from Lagrangians to Likelihoods

– Many new backend interfaces, including:

-> SM Measurements (Contur, Rivet)

-> Cosmology (AlterBBN, ACROPOLIS, MontePython)

-> EFT matching (DirectDM)

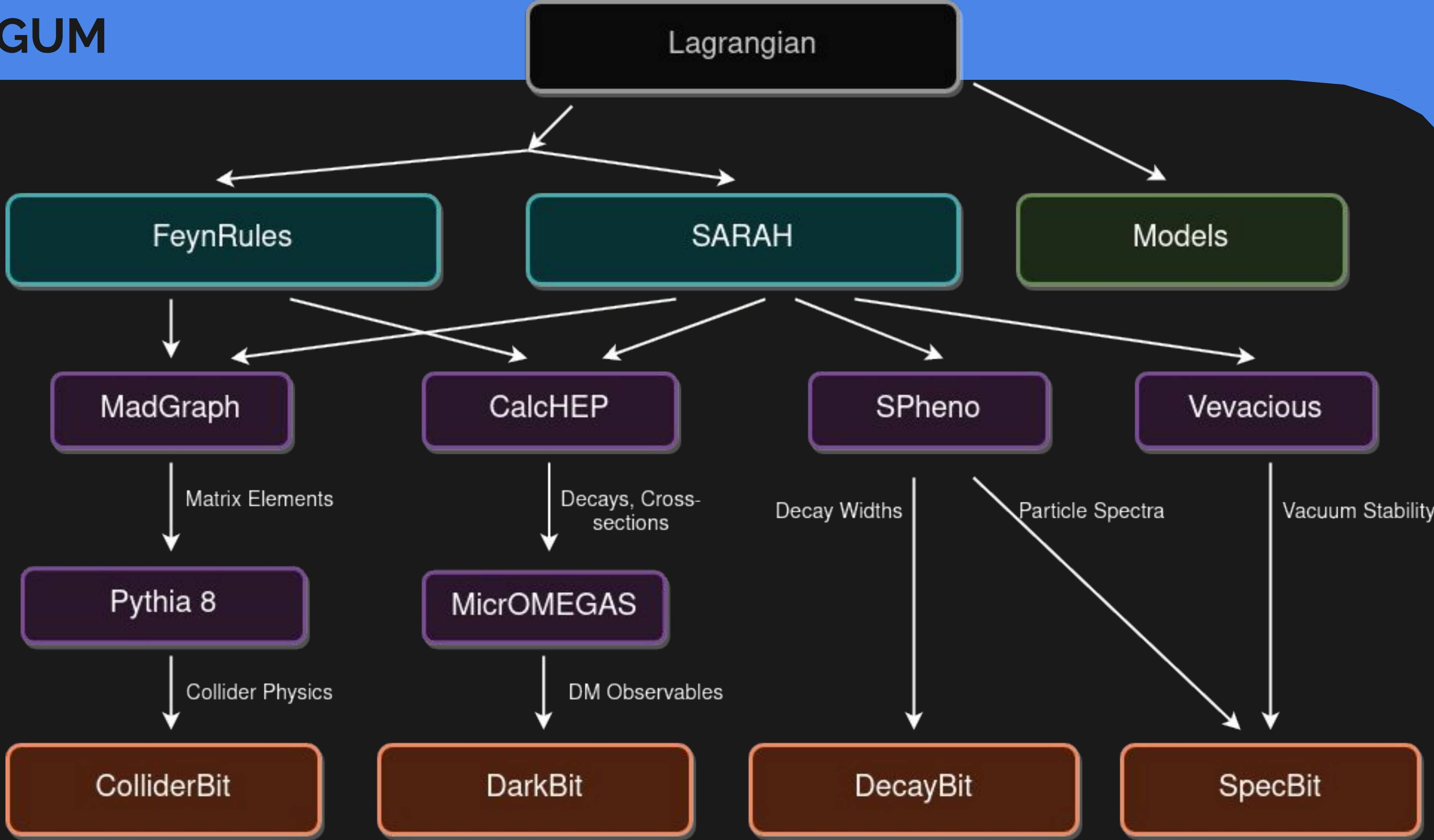
-> Vacuum Stability (Vevacious)

– Support for ATLAS full likelihoods

– Full support for Clang and AppleClang

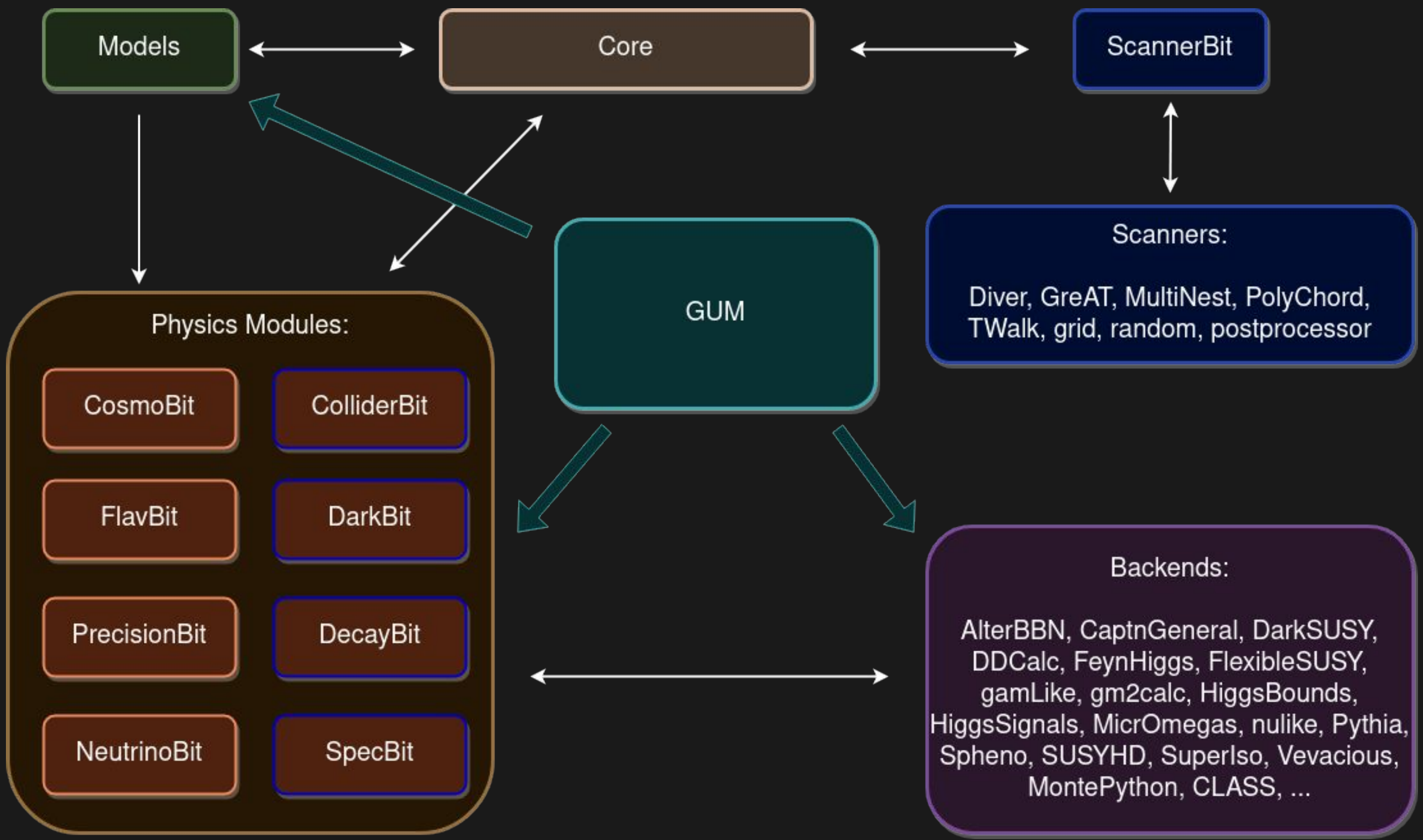
– Many quality of life core changes

GUM



Lagrangian
FeynRules
SARAH
Models
MadGraph
CalcHEP
SPheno
Vevacious
Matrix Elements
Decays, Cross-sections
Decay Widths
Particle Spectra
Vacuum Stability
Pythia 8
MicrOMEGAS
Collider Physics
DM Observables
ColliderBit
DarkBit
DecayBit
SpecBit

GUM


Models
Core
ScannerBit
Physics Modules:
CosmoBit
ColliderBit
FlavBit
DarkBit
PrecisionBit
DecayBit
NeutrinoBit
SpecBit
GUM
Scanners:
Diver, GreAT, MultiNest, PolyChord, TWalk, grid, random, postprocessor
Backends:
AlterBBN, CaptnGeneral, DarkSUSY, DDCalc, FeynHiggs, FlexibleSUSY, gamLike, gm2calc, HiggsBounds, HiggsSignals, MicrOmegas, nulike, Pythia, Spheno, SUSYHD, SuperIso, Vevacious, MontePython, CLASS, ...

GAMBIT results relevant to DM

EFTS (Scalar Singlet, simplified models, …):

– arXiv:1705.07931

– arXiv:1806.11281

– arXiv:1808.10465

– arXiv:2106.02056

– arXiv:2209.13266

Axions/ALPS:

– arXiv:1810.07192

– arXiv:2007.05517

– arXiv:2205.13549

SUSY (constrained SUSY, low-dim SUSY):

– arXiv:1705.07935

– arXiv:1705.07917

– arXiv:1809.02097

Neutrinos (SM Neutrinos, Right-handed):

– arXiv:1908.02302

– arXiv:2009.03287

Code Papers:

– arXiv:1705.07920: DarkBit

– arXiv:2107.00030: CosmoBit

– arXiv:2009.03286: GUM

I will focus on...

– arxiv:2009.03287: Bounds on the lightest neutrino mass

– arxiv:2106.02056: Thermal WIMPs and the Scale of New Physics

– arxiv:2205.13549: Cosmological Constraints on decaying ALPs

– arxiv:2209.13266: s-channel Simplified DM Models

– EW-MSSM + light gravitino ⟹ Both the gravitino and NLSP would contribute to the DM relic abundance, but we focus only on collider constraints.

Thermal WIMPs and the scale of new physics: arXiv:2106.02056

Sum of all dimension 6 & 7 operators for a Dirac fermion EFT valid up to some new physics scale Λ.

$$\mathcal{L}_{\rm int} = \sum_{a,d} \frac{\mathcal{C}_a^{(d)}}{\Lambda^{d-4}} \mathcal{Q}_a^{(d)}$$

Include couplings to SM quarks, gluons and photon.

$$\begin{aligned}
\mathcal{Q}_{1,q}^{(6)} &= (\overline{\chi}\gamma_\mu\chi)(\overline{q}\gamma^\mu q)\,, \\
\mathcal{Q}_{2,q}^{(6)} &= (\overline{\chi}\gamma_\mu\gamma_5\chi)(\overline{q}\gamma^\mu q)\,, \\
\mathcal{Q}_{3,q}^{(6)} &= (\overline{\chi}\gamma_\mu\chi)(\overline{q}\gamma^\mu\gamma_5 q)\,, \\
\mathcal{Q}_{4,q}^{(6)} &= (\overline{\chi}\gamma_\mu\gamma_5\chi)(\overline{q}\gamma^\mu\gamma_5 q)\,.
\end{aligned}$$

$$\begin{aligned}
\mathcal{Q}_1^{(7)} &= \frac{\alpha_s}{12\pi}(\overline{\chi}\chi)G^{a\mu\nu}G^a_{\mu\nu}\,, \\
\mathcal{Q}_2^{(7)} &= \frac{\alpha_s}{12\pi}(\overline{\chi}i\gamma_5\chi)G^{a\mu\nu}G^a_{\mu\nu}\,, \\
\mathcal{Q}_3^{(7)} &= \frac{\alpha_s}{8\pi}(\overline{\chi}\chi)G^{a\mu\nu}\widetilde{G}^a_{\mu\nu}\,, \\
\mathcal{Q}_4^{(7)} &= \frac{\alpha_s}{8\pi}(\overline{\chi}i\gamma_5\chi)G^{a\mu\nu}\widetilde{G}^a_{\mu\nu}\,, \\
\mathcal{Q}_{5,q}^{(7)} &= m_q(\overline{\chi}\chi)(\overline{q}q)\,, \\
\mathcal{Q}_{6,q}^{(7)} &= m_q(\overline{\chi}i\gamma_5\chi)(\overline{q}q)\,, \\
\mathcal{Q}_{7,q}^{(7)} &= m_q(\overline{\chi}\chi)(\overline{q}i\gamma_5 q)\,, \\
\mathcal{Q}_{8,q}^{(7)} &= m_q(\overline{\chi}i\gamma_5\chi)(\overline{q}i\gamma_5 q)\,, \\
\mathcal{Q}_{9,q}^{(7)} &= m_q(\overline{\chi}\sigma^{\mu\nu}\chi)(\overline{q}\sigma_{\mu\nu}q)\,, \\
\mathcal{Q}_{10,q}^{(7)} &= m_q(\overline{\chi}i\sigma^{\mu\nu}\gamma_5\chi)(\overline{q}\sigma_{\mu\nu}q)\,.
\end{aligned}$$

Thermal WIMPs and the scale of new physics: arXiv:2106.02056

EFT is valid if Λ > largest pT bin in analysis.

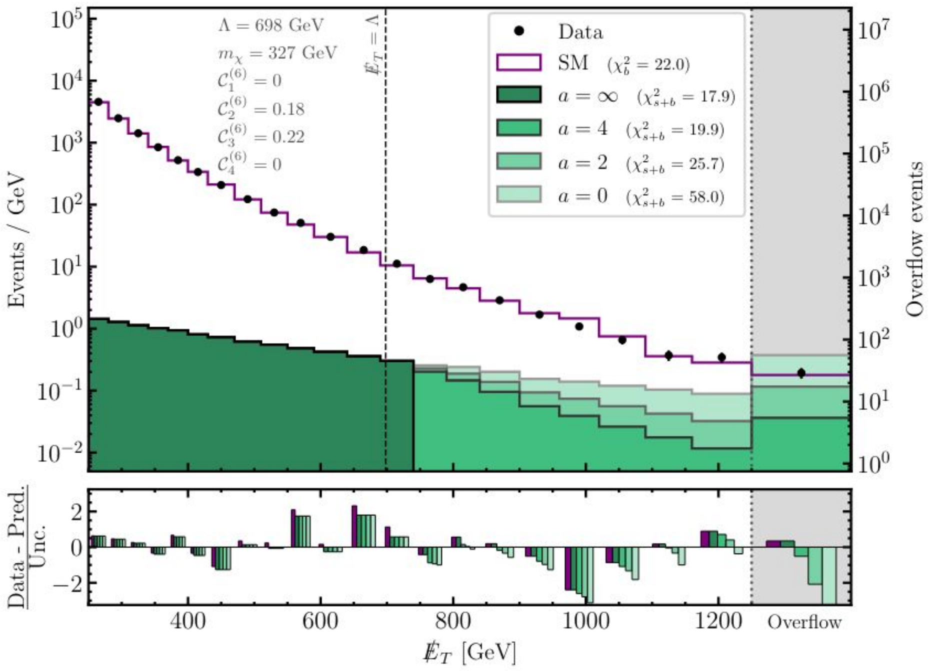
We use a falling missing energy spectra above Λ. The nature of this signal drop off would depend on the UV completion.

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\not{E}_T} \rightarrow \frac{\mathrm{d}\sigma}{\mathrm{d}\not{E}_T}\left(\frac{\not{E}_T}{\Lambda}\right)^{-a}$$

Two cases:

1. Hard cutoff (a = ∞)
2. Scanning over a range [0,4] to find the best fit.

I will only show the results for the **hard cutoff**

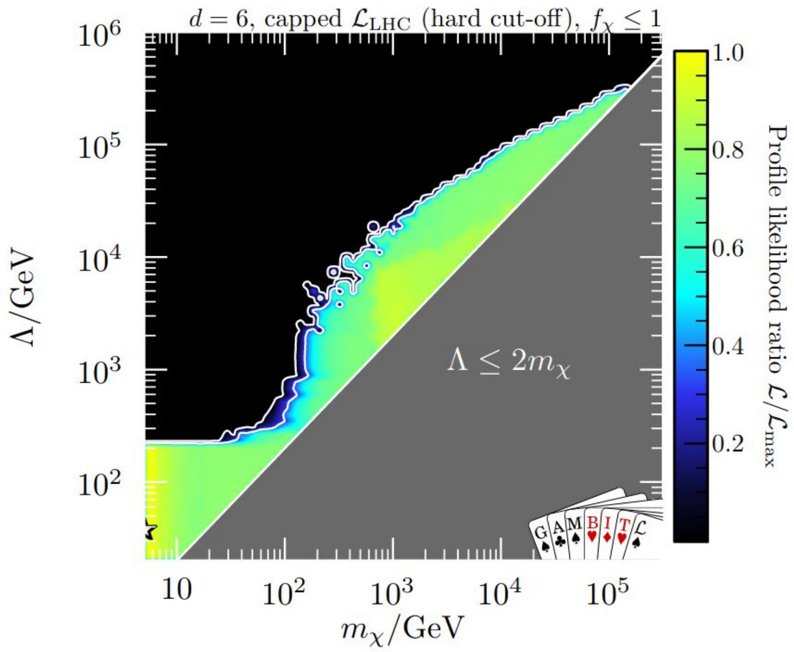


Thermal WIMPs and the scale of new physics: arXiv:2106.02056

High Λ high m_χ: Relic density exceeds planck measurement unless couplings become non-perturbative

High Λ low m_χ: Strong LHC constraints prevent any surviving regions that satisfy relic abundance.

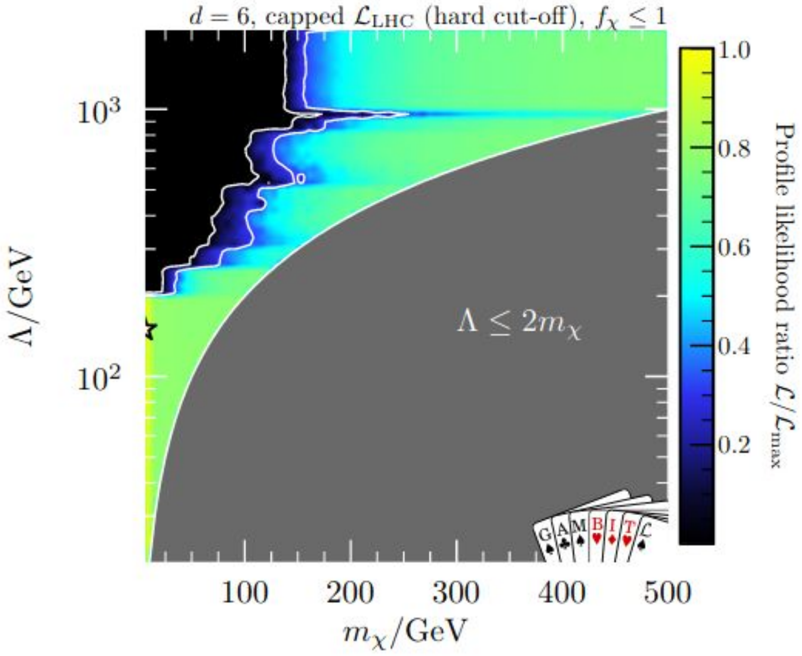
Below Λ = 200 GeV, LHC has no impact given EFT validity cutoff.

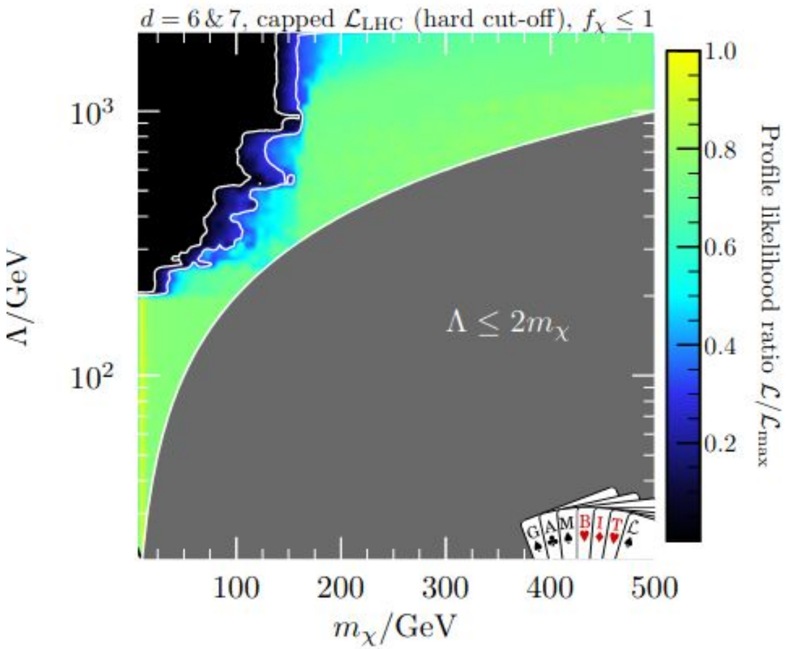


Thermal WIMPs and the scale of new physics: arXiv:2106.02056

The addition of the dimension 7 operators has very little impact in the m_χ/Λ plane.

Surviving parameter regions change abruptly with Λ, whenever additional signal regions enter the calculation.





Cosmological constraints on decaying ALPs: arXiv:2205.13549

Focus on Axion-Like-Particles (ALPS) in the keV - MeV mass range, and lifetimes: $10^4\,\mathrm{s} < \tau_a < 10^{13}\,\mathrm{s}$,

Corresponds to ALPs that decay sometime between the end of BBN and CMB.

ALP-photon effective coupling:

$$\mathcal{L} = \frac{g_{a\gamma}}{4} a F^{\mu\nu} \tilde{F}_{\mu\nu}$$

4 ALP free parameters: ALP mass, ALP lifetime, ALP-photon coupling and ALP abundance (ξ)

$$\xi = \frac{m_a\, n_{a,0}^{\tau_a \to \infty}}{\rho_{\mathrm{DM},0}}$$

ξ cannot be arbitrarily small, due to the irreducible contribution from freeze-in.

Cosmological constraints on decaying ALPs: arXiv:2205.13549

Constraints from energy injection:

– CMB power spectra

– Modifications to N_{eff} & photon-baryon ratio (η_b)

– Primordial Nucleosynthesis (light element photo-disintegration)

– ALP induced spectral distortions

– ALP decays after SN1987A

– Stellar Evolution (ratio of HB/RGB stars)

Model parameter		**Scan range**	
ALP mass	m_a	[0.001, 200]	MeV
ALP lifetime	τ_a	$[10^4, 10^{13}]$	s
ALP abundance	ξ	$[10^{-12}, 10^2]$	
Baryon abundance	ω_b	[0.020, 0.024]	
Dark matter abundance	ω_{DM}	[0.10, 0.13]	
Hubble constant	H_0	[62, 74]	$\mathrm{km\,s^{-1}\,Mpc^{-1}}$
Redshift of reionisation	z_{reio}	[4.5, 9.5]	
Primordial curvature	$\ln(10^{10}A_s)$	[2.9, 3.2]	
Scalar spectral index	n_s	[0.9, 1.1]	
Neutron lifetime	τ_n	[875, 895]	s
Planck nuisance parameter	A_{Planck}	[0.9, 1.1]	
Pantheon nuisance parameter	M	[−20, −18]	

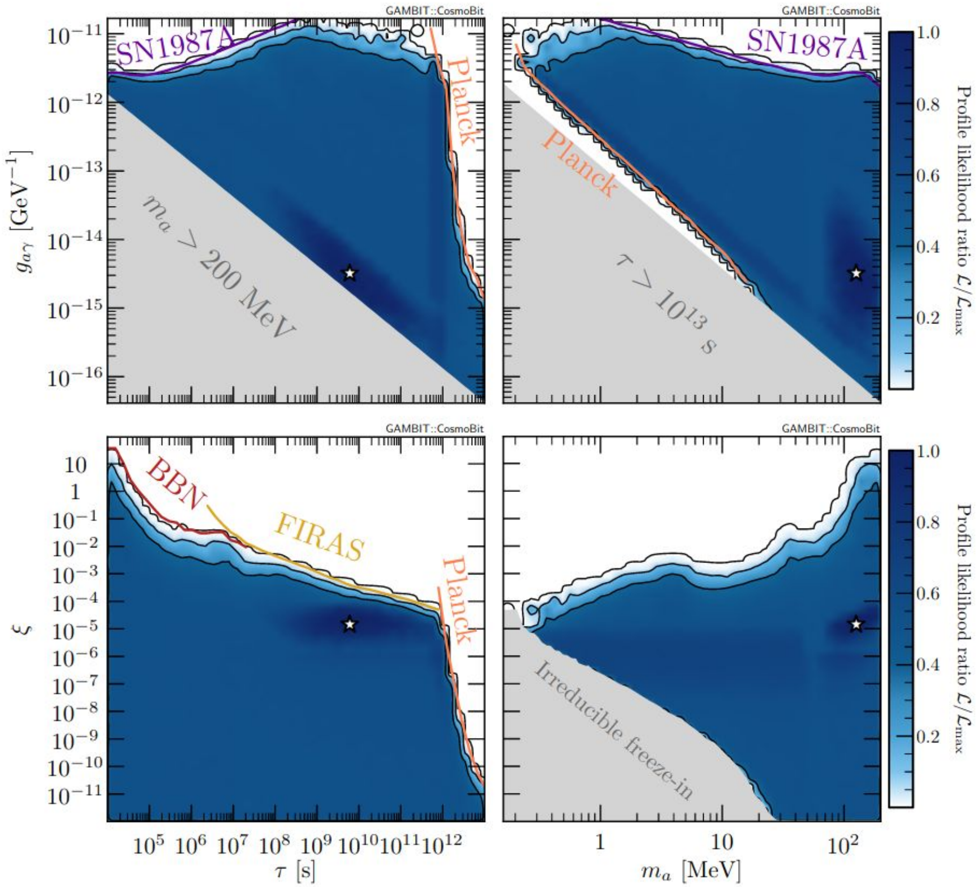
Cosmological constraints on decaying ALPs: arXiv:2205.13549

We find m_a > 300 keV, which can only be evaded if ALPS are stable on cosmological timescales.

Viable regions exist that could constitute a high ALP abundance in the very early universe, but decay away before recombination.

No strong effect from N_{eff}, η_b or R parameter.

Slight preference at best-fit point is due to additional deuterium abundance from photodisintegration.



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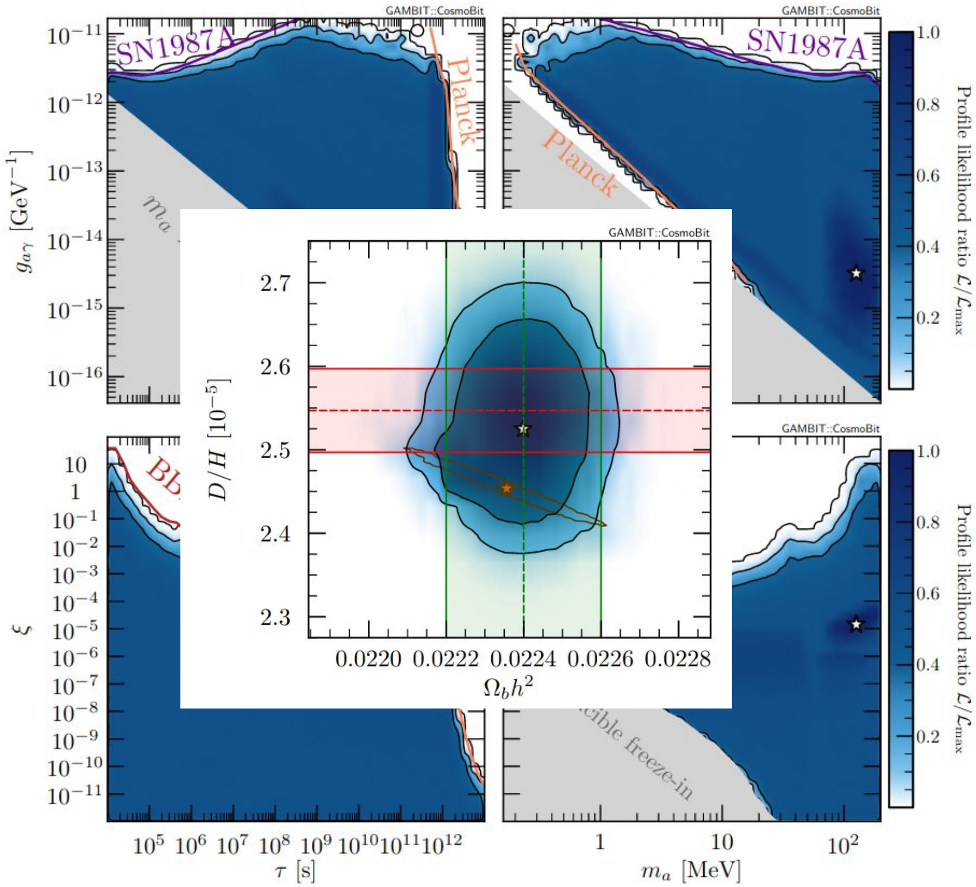

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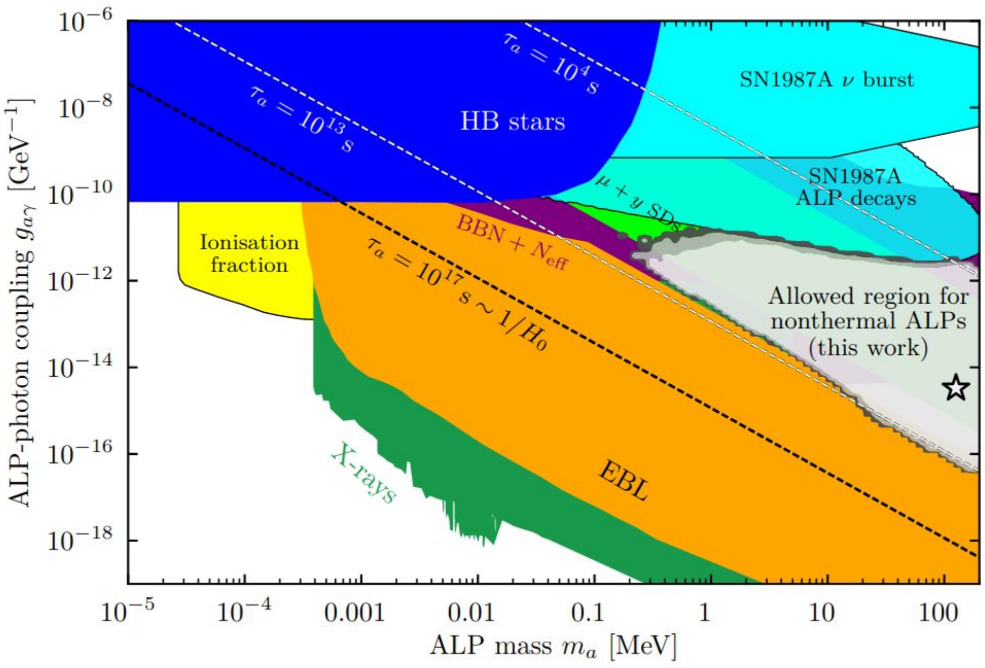


S-channel Simplified Models: arXiv:2209.13266

Scalar DM:

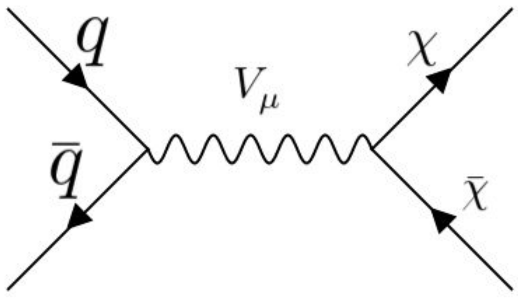
$$\mathcal{L}_{BSM} = \frac{1}{2}\partial_\mu\phi\partial^\mu\phi - \frac{1}{2}m_{DM}^2\phi^2 - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{1}{2}m_M^2 V_\mu V^\mu$$
$$+ g_q V_\mu \bar{q}\gamma^\mu q + i g_{DM}^V V_\mu \left(\phi^\dagger(\partial^\mu\phi) - (\partial^\mu\phi^\dagger)\phi\right)$$

Dirac fermion DM:

$$\mathcal{L}_{BSM} = i\bar{\chi}\gamma^\mu\partial_\mu\chi - m_{DM}\bar{\chi}\chi - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{1}{2}m_M^2 V_\mu V^\mu$$
$$+ g_q V_\mu \bar{q}\gamma^\mu q + V_\mu\bar{\chi}(g_{DM}^V + g_{DM}^A\gamma^5)\gamma^\mu\chi$$

Majorana fermion DM:

$$\mathcal{L}_{BSM} = \frac{1}{2}i\bar{\psi}\gamma^\mu\partial_\mu\psi - \frac{1}{2}m_{DM}\bar{\psi}\psi - \frac{1}{4}V_{\mu\nu}V^{\mu\nu} - \frac{1}{2}m_M^2 V_\mu V^\mu$$
$$+ g_q V_\mu \bar{q}\gamma^\mu q + \frac{1}{2}g_{DM}^A V_\mu\bar{\psi}\gamma^5\gamma^\mu\psi$$



Assumptions:

No lepton couplings

No axial-vector quark couplings

Flavour universal couplings

In each model, there are 4 or 5 model parameters: DM mass (m_{DM}), Mediator mass (m_M), mediator-quark coupling (g_q), mediator-DM coupling (g_{DM}) (either vector or axial-vector)

S-channel Simplified Models: arXiv:2209.13266

The presence of an axial-vector couplings for the Dirac and Majorana models implies a bound from unitarity: [3]

$$m_{DM} \leq \sqrt{\frac{\pi}{2}} \frac{m_M}{g_{DM}^A}$$

Vector DM models will face strong unitarity violation -> An upcoming paper will go into detail about this violation.

[3] F. Kahlhoefer, K. Schmidt-Hoberg, T. Schwetz, and S. Vogl, Implications of unitarity and gauge invariance for simplified dark matter models, JHEP 02 (2016) 016

S-channel Simplified Models: arXiv:2209.13266

Scan Parameters:

Parameters	Range
DM mass, m_{DM}	$[50, 10000]$ GeV
Mediator mass, m_M	$[50, 10000]$ GeV
quark-mediator coupling, g_q	$[0.01, 1.0]$
mediator-DM coupling (vector), g^V_{DM}	$[0.01, 3.0]$
mediator-DM coupling (axial vector), g^A_{DM}	$[0.01, 3.0]$
Nuisance Parameters	
Pion-nucleon sigma term, $\sigma_{\pi N}$	$[5, 95]$ MeV
strange quark cont. to nucleon spin, Δ_s	$[-0.062, -0.008]$
strange quark nuclear tensor charge, g^s_T	$[-0.075, 0.021]$
strange quark proton charge radius, r^2_s	$[-0.22, -0.01]\,\mathrm{GeV}^{-2}$
Local DM density, ρ_0	$[0.2, 0.8]\,\mathrm{GeV\,cm}^{-3}$
Most probably speed, v_{esc}	$[216, 264]\,\mathrm{km\,s}^{-1}$
Galactic escape speed, v_{peak}	$[453, 603]\,\mathrm{km\,s}^{-1}$

Constraints:

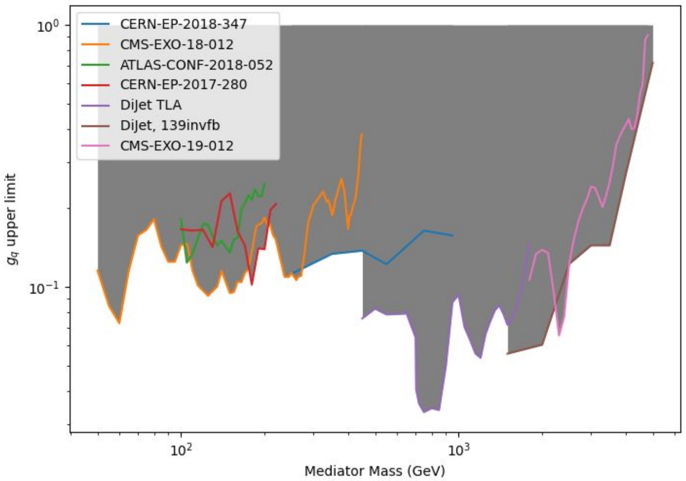
Experiment
CDMSlite [4]
CRESST-II [5]
CRESST-III [6]
DarkSide 50 [7]
LUX 2016 [8]
PICO-60 [9, 10]
PandaX [11, 12]
XENON1T [13]
LZ 2022 [28]
LHC Dijets [14–22]
ATLAS monojet [23]
CMS monojet [24]
Fermi-LAT [25]
Planck 2018: Ωh^2 [26]
Nuisances

S-channel Simplified Models: arXiv:2209.13266

Direct Detection: Majorana model only has NREOs that lead to suppressed signals.

Effective Operator	Relevant models
$1_{DM}1_N$	Scalar, Dirac
$i\hat{\mathbf{S}} \cdot \left(\hat{\mathbf{S}}_N \times \frac{\hat{q}}{m_N}\right)$, $\hat{\mathbf{S}} \cdot \hat{\mathbf{v}}^{\perp} 1_N$	Dirac, Majorana

Di-jets:

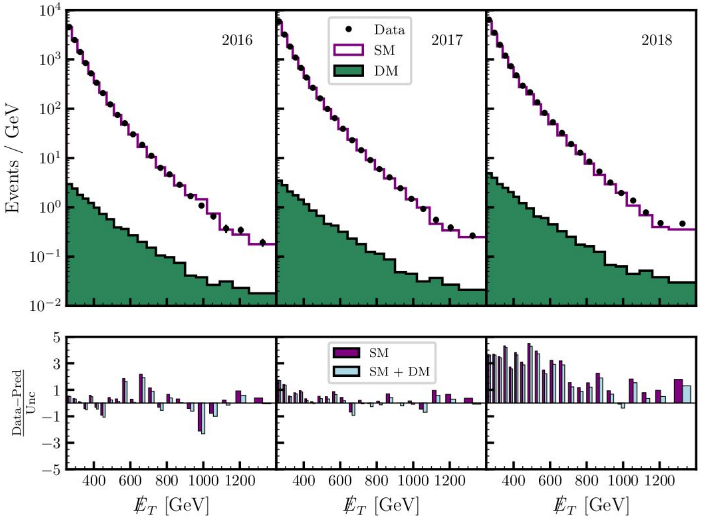


DM Abundance:

2 Annihilation channels:

- DM DM -> quark pair
- DM DM -> mediator pair

Collider Missing Energy searches:

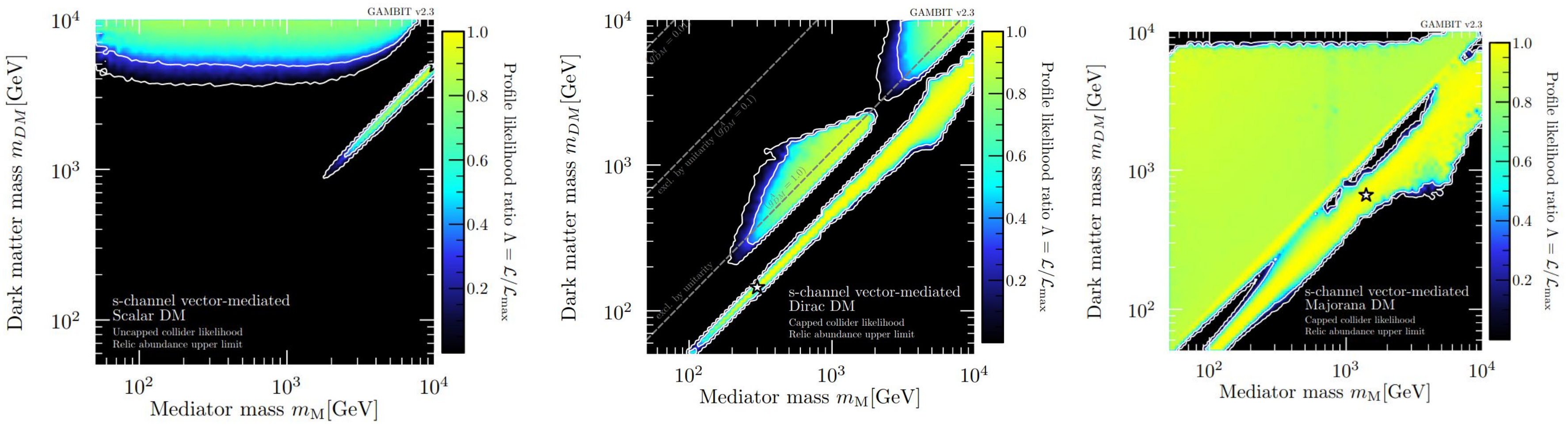


S-channel Simplified Models: arXiv:2209.13266

On/off-resonance regions are generally split by the annihilation channels (qq/MM).

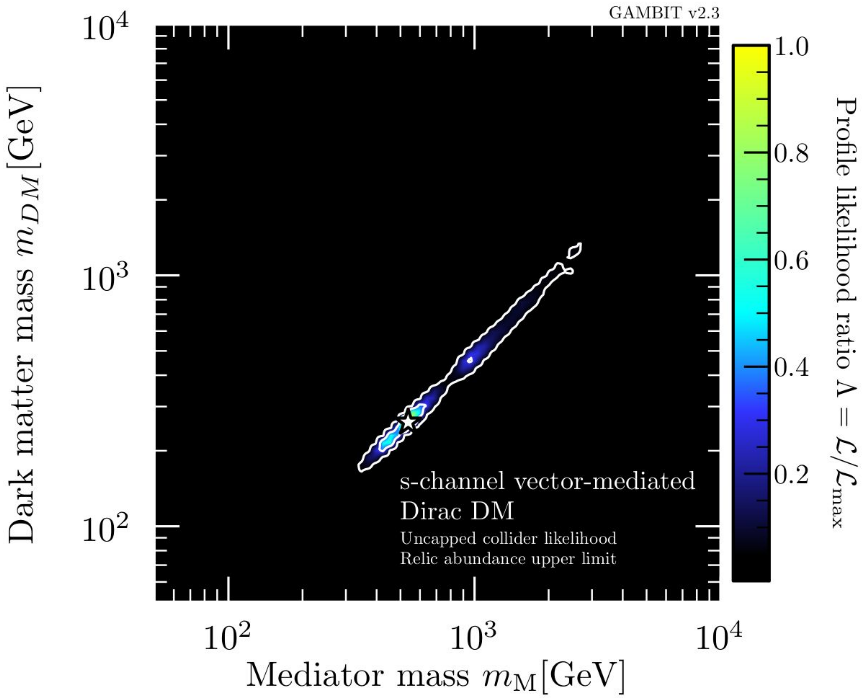
Dirac DM: Combination of unitarity violation and direct detection limits give two distinct regions off resonance.

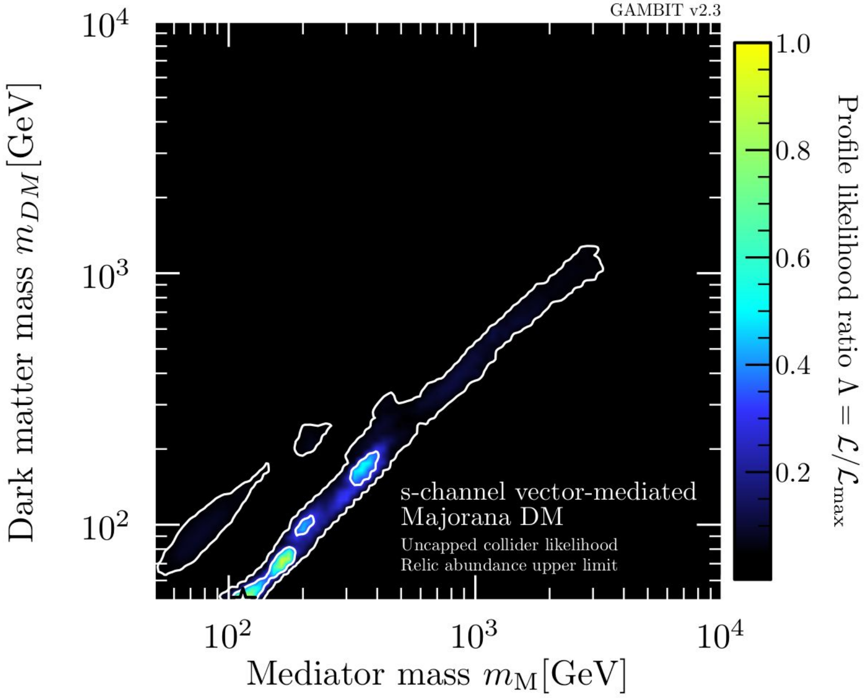
Majorana DM: Weak exclusion when DM mass > Mediator mass due to suppressed NREOs.



S-channel Simplified Models: arXiv:2209.13266

By fitting the fluctuations in the monojet data, the Dirac and Majorana DM models have an overall preference for a small regions primarily along the resonance.





Bounds on the lightest neutrino mass: arXiv:2009.03287

Use both terrestrial and cosmological experiments to set a CL on the lightest neutrino mass and the sum of neutrino masses.

Constraints:

Neutrino oscillations (chi-squared tables from NuFit)

Primordial BBN abundances

CMB

Supernova Type 1a

BAO

$$\mathrm{NH}:(m_1^2, m_2^2, m_3^2) = m_{\nu_0}^2 + (0, \Delta m_{21}^2, \Delta m_{3l}^2)$$
$$\mathrm{IH}:(m_3^2, m_1^2, m_2^2) = m_{\nu_0}^2 + (0, |\Delta m_{3l}^2| - \Delta m_{21}^2, |\Delta m_{3l}^2|).$$

Sector	Parameter	Range
ν masses	m_{ν_0}	$[0,\ 1.1]\,\mathrm{eV}$
	Δm_{21}^2	$[6,\ 9] \times 10^{-5}\,\mathrm{eV}^2$
(NH)	Δm_{3l}^2	$[2.2,\ 2.8] \times 10^{-3}\,\mathrm{eV}^2$
(IH)	Δm_{3l}^2	$[-2.8,\ -2.2] \times 10^{-3}\,\mathrm{eV}^2$
ΛCDM	H_0	$[50,\ 80]\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$
	$\Omega_\mathrm{b} h^2$	$[0.020,\ 0.024]$
	$\Omega_\mathrm{cdm} h^2$	$[0.10,\ 0.15]$
	$\tau_\mathrm{reionization}$	$[0.004,\ 0.20]$
	$\ln(10^{10} A_s)$	$[2.5,\ 3.5]$
	n_s	$[0.90,\ 1.10]$
N_eff	r_ν	$[0.75,\ 1.15]$
Nuisance	SN Ia abs. magnitude M	$[-20,\ -18]$
	Neutron lifetime τ_n	$[876,\ 883]\,\mathrm{s}$
	Planck likelihood	21 parameters varied

Bounds on the lightest neutrino mass: arXiv:2009.03287

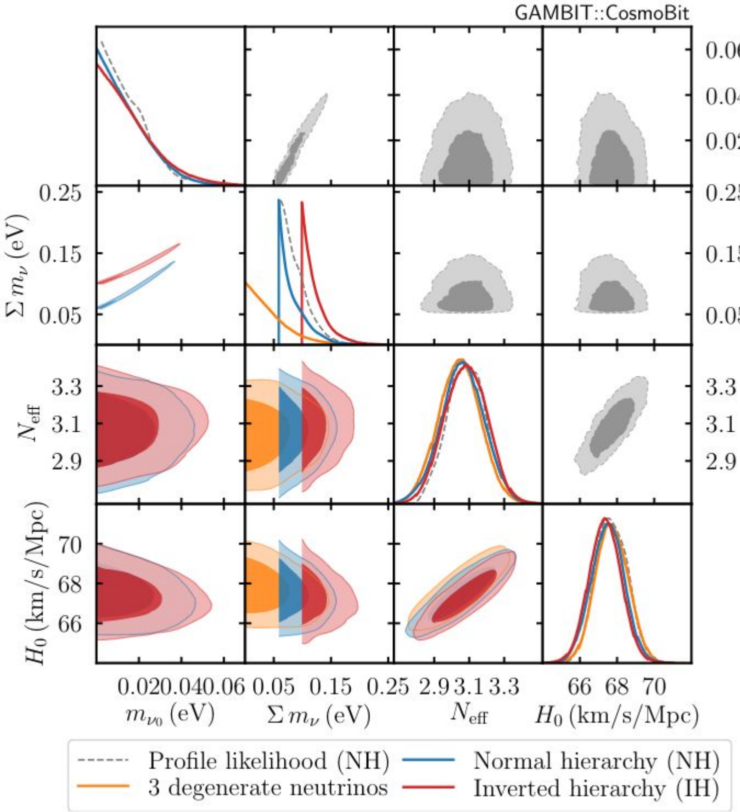
$$m_{\nu_0} < 0.037 \text{ eV}$$ (NH)

$$m_{\nu_0} < 0.042 \text{ eV}$$ (IH)

$$0.058 < \sum m_\nu < 0.139 \text{ eV}$$ (NH)

$$0.098 < \sum m_\nu < 0.174 \text{ eV}$$ (IH)

Highest likelihood corresponds to a massless lightest neutrino



Electroweakinos + light gravitino

Electroweakino effective field theory + light (1 eV) gravitino LSP (rest of SUSY decoupled).

The gravitino (and NLSP) would contribute to the DM relic abundance, but we don't include these constraints (collider focussed study).

Main collider signal: production + decay of light EWinos

15 ATLAS + 12 CMS searches for new physics, and collection of SM measurements.

Paper to be released soon.

Parameter	Range/value	Sampling priors
$M_1(Q)$	$[-1, 1]$ TeV	hybrid, flat
$M_2(Q)$	$[0, 1]$ TeV	hybrid, flat
$\mu(Q)$	$[-1, 1]$ TeV	hybrid, flat
$\tan\beta(m_Z)$	$[1, 70]$	log, flat
$m_{3/2}$	1 eV	fixed
Q	3 TeV	fixed
$\alpha_s^{\overline{\rm MS}}(m_Z)$	0.1181	fixed
Top quark pole mass	171.06 GeV	fixed
Higgs mass	125.09 GeV	fixed

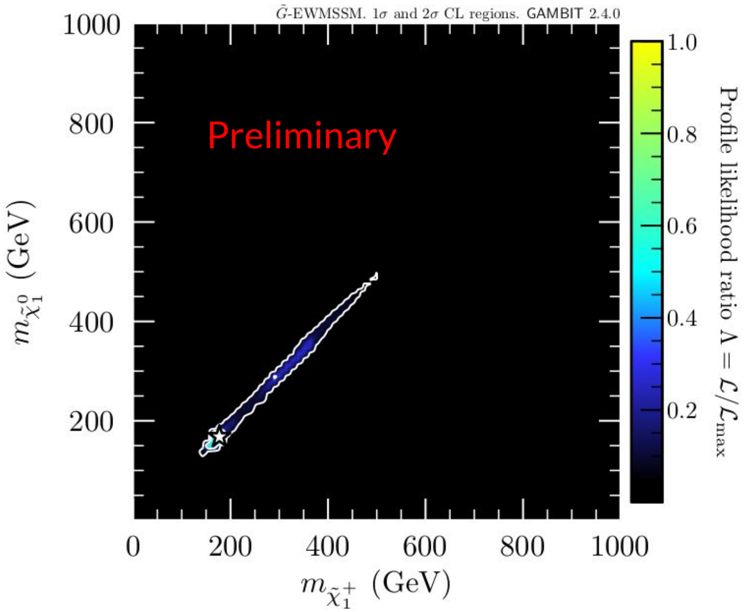
Search label	Luminosity	Source
ATLAS_2BoostedBosons	139 fb^{-1}	ATLAS hadronic chargino/neutralino search [102]
ATLAS_0lep	139 fb^{-1}	ATLAS 0-lepton search [94]
ATLAS_0lep_stop	36 fb^{-1}	ATLAS 0-lepton stop search [103]
ATLAS_1lep_stop	36 fb^{-1}	ATLAS 1-lepton stop search [104]
ATLAS_2lep_stop	139 fb^{-1}	ATLAS 2-lepton stop search [105]
ATLAS_2OSlep_Z	139 fb^{-1}	ATLAS stop search with Z/H final states [107]
ATLAS_2OSlep_chargino	139 fb^{-1}	ATLAS 2-lepton chargino search [95]
ATLAS_2b	36 fb^{-1}	ATLAS 2-b-jet stop/sbottom search [108]
ATLAS_3b	24 fb^{-1}	ATLAS 3-b-jet Higgsino search [109]
ATLAS_3lep	139 fb^{-1}	ATLAS 3-lepton chargino/neutralino search [96]
ATLAS_4lep	139 fb^{-1}	ATLAS 4-lepton search [97]
ATLAS_MultiLep_strong	139 fb^{-1}	ATLAS leptons + jets search [98]
ATLAS_PhotonGGM_1photon	139 fb^{-1}	ATLAS 1-photon GGM search [110]
ATLAS_PhotonGGM_2photon	36 fb^{-1}	ATLAS 2-photon GGM search [111]
ATLAS_Z_photon	80 fb^{-1}	ATLAS Z + photon search [112]
CMS_0lep	137 fb^{-1}	CMS 0-lepton search [113]
CMS_1lep_bb	36 fb^{-1}	CMS 1-lepton + b-jets chargino/neutralino search [115]
CMS_1lep_stop	36 fb^{-1}	CMS 1-lepton stop search [116]
CMS_2lep_stop	36 fb^{-1}	CMS 2-lepton stop search [117]
CMS_2lep_soft	36 fb^{-1}	CMS 2 soft lepton search [118]
CMS_2OSlep	137 fb^{-1}	CMS 2-lepton search [119]
CMS_2OSlep_chargino_stop	36 fb^{-1}	CMS 2-lepton chargino/stop search [120]
CMS_2SSlep_stop	137 fb^{-1}	CMS 2 same-sign lepton stop search [121]
CMS_MultiLep	137 fb^{-1}	CMS multilepton chargino/neutralino search [100]
CMS_photon	36 fb^{-1}	CMS 1-photon GMSB search [122]
CMS_2photon	36 fb^{-1}	CMS 2-photon GMSB search [123]
CMS_1photon_1lepton	36 fb^{-1}	CMS 1-photon + 1-lepton GMSB search [124]

Electroweakinos + light gravitino

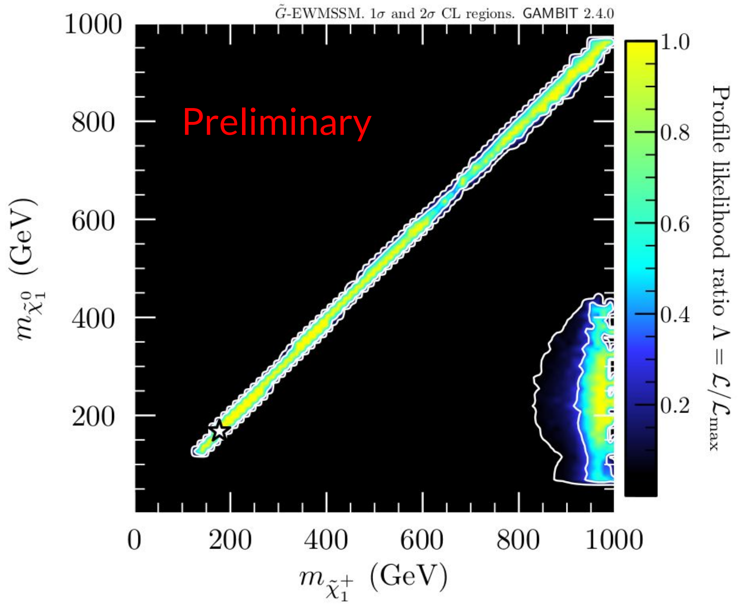
Most preferred: 3 nearly degenerate higgsinos which can fit small excesses in several searches.

Escapes photon + MET searches with low BR to photons.

Allowed region in capped collider scan in the bottom right is due to diminishing production xsec.



Uncapped collider



Capped collider

What’s coming up from GAMBIT

Code:

Computational speed up for performing global fits:

-> Machine learning of cross sections, cosmic ray fluxes

-> GPU parallelisation of computational bottlenecks

ColliderBit Solo

-> Allows processing collider events generated elsewhere and passed to ColliderBit

Physics:

Light dark matter

-> Sub-GeV DM fits, including Beam dump experiments, direct & indirect detection, cosmology, ...

Vector DM Simplified Models

-> Studying the effect of unitarity violation and its impact on fits

2HDMs

-> Fits of Type 1, Type 2 and inert doublet models

Neutrino Oscillation

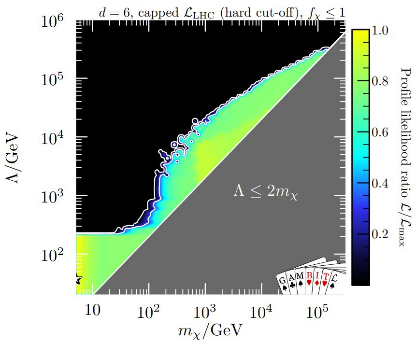
-> Fit of left-handed neutrinos reproducing oscillation data with detailed treatment of systematic uncertainties.

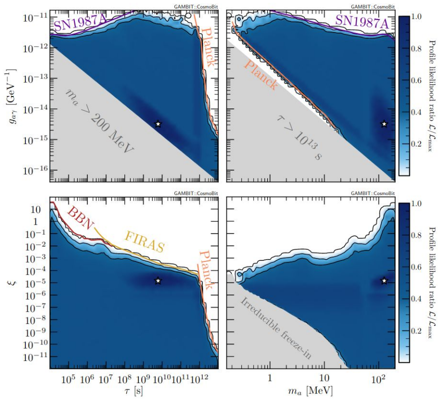
Summary

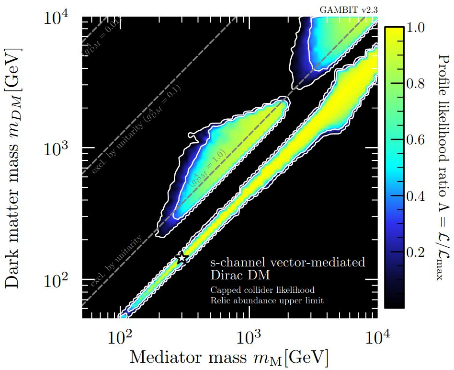
We have GAMBIT studies of many different theories, ranging from SUSY, ALPs, EFTs,...

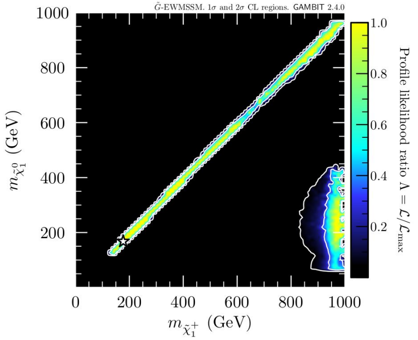
I've discussed results from a few DM related recent studies.

Stay tuned for more physics results to come.









Website (tutorials, documentation): https://gambitbsm.github.io

GitHub: https://github.com/GambitBSM/gambit

Code Paper: GAMBIT: The Global and Modular Beyond-the-Standard-Model Inference Tool, Eur. Phys. J. C 77 (2017) 784, Addendum: Eur. Phys. J. C 78 (2018) 98, arXiv:1705.07908

GUM Paper: The GAMBIT Universal Model Machine: from Lagrangians to Likelihoods, Eur. Phys. J. C 81 (2021) 12, 1103, arXiv:2107.00030.