PPD Seminar

December 3, 2025

Democratizing Dark-Matter Constraints through Reinterpretation and Re-normalisation

https://darkmatter.web.cern.ch

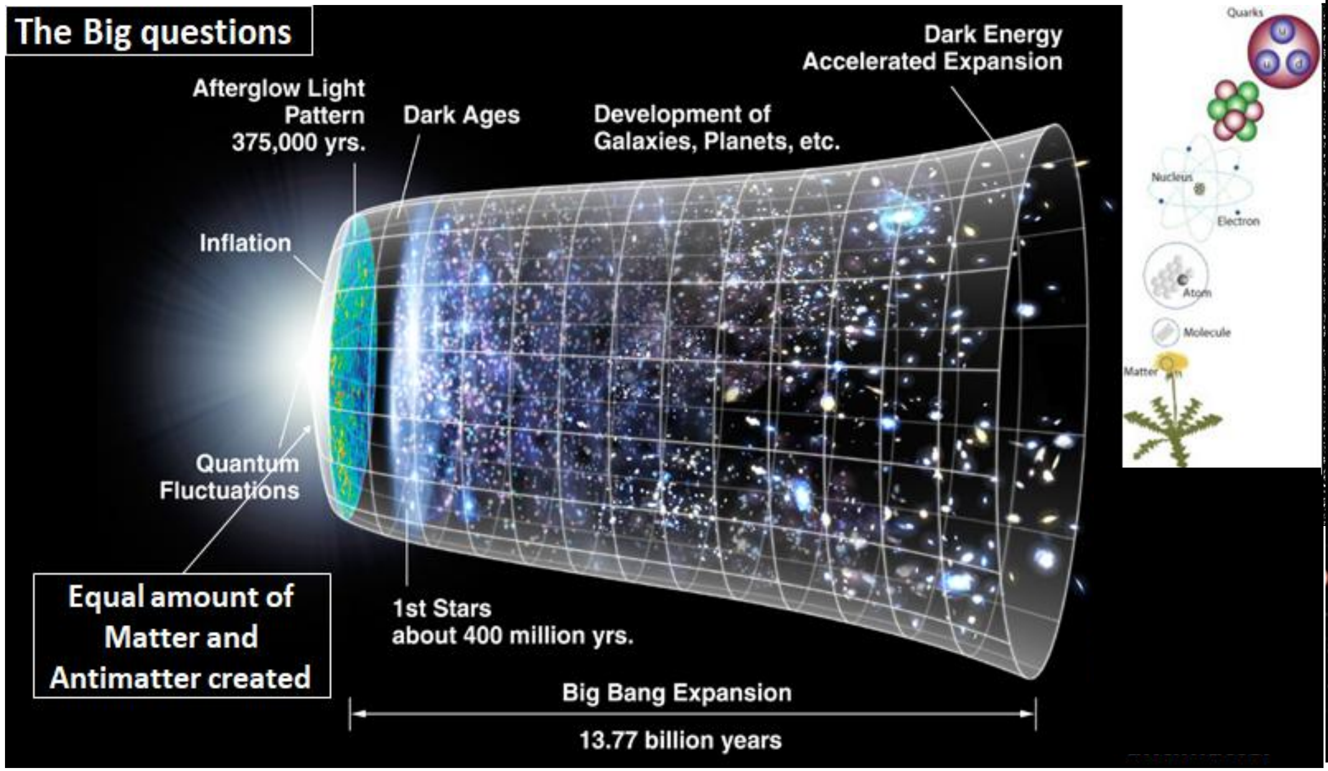
Brij Kishor Jashal
Particle Physics Department,
Rutherford Appleton Laboratory

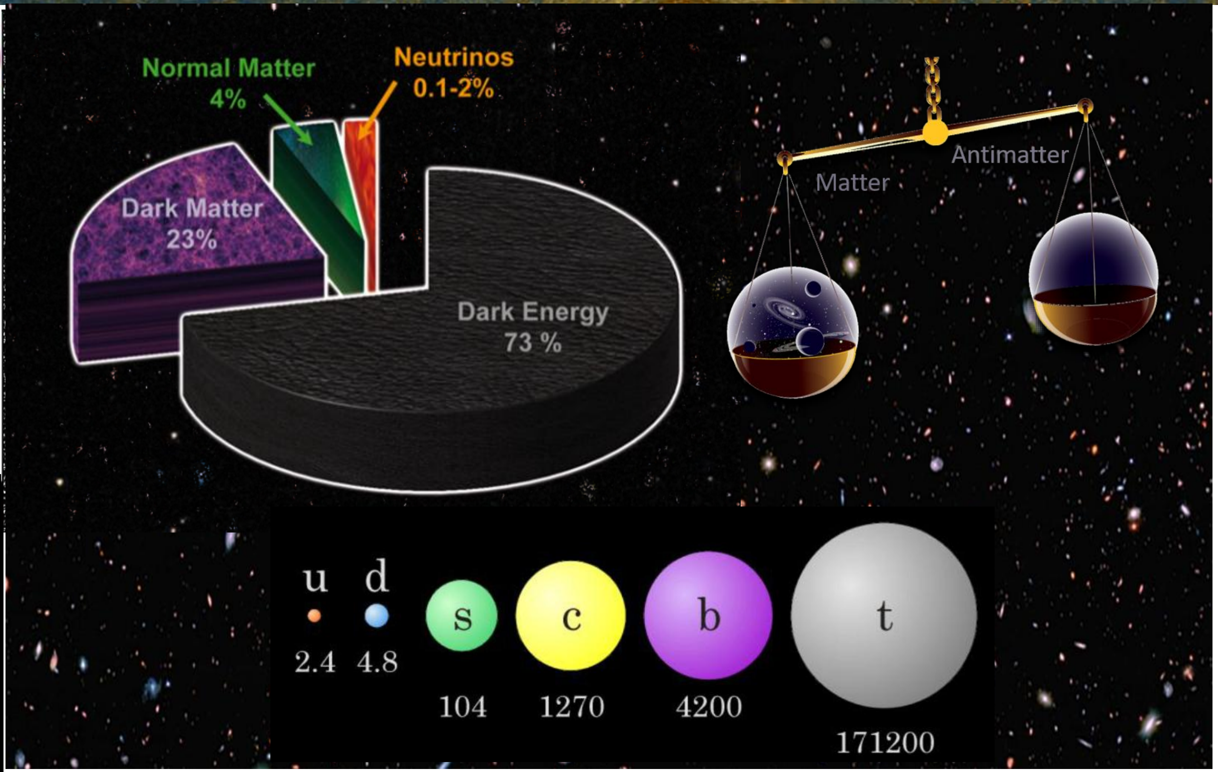
UKRI Science and Technology Facilities Council Rutherford Appleton Laboratory

ATLAS EXPERIMENT

GridPP UK Computing for Particle Physics

Underexplored challenges: Cosmology





Friedman equations 1922 --- CMB in 1964

rotational symmetry and space time symmetry and also time translation symmetry

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

$$\left(\frac{\dot{a}(t)}{a(t)}\right)^2 = \frac{8\pi G}{3}\rho(t) - \frac{\kappa c^2}{a^2(t)} + \frac{\Lambda c^2}{3}$$

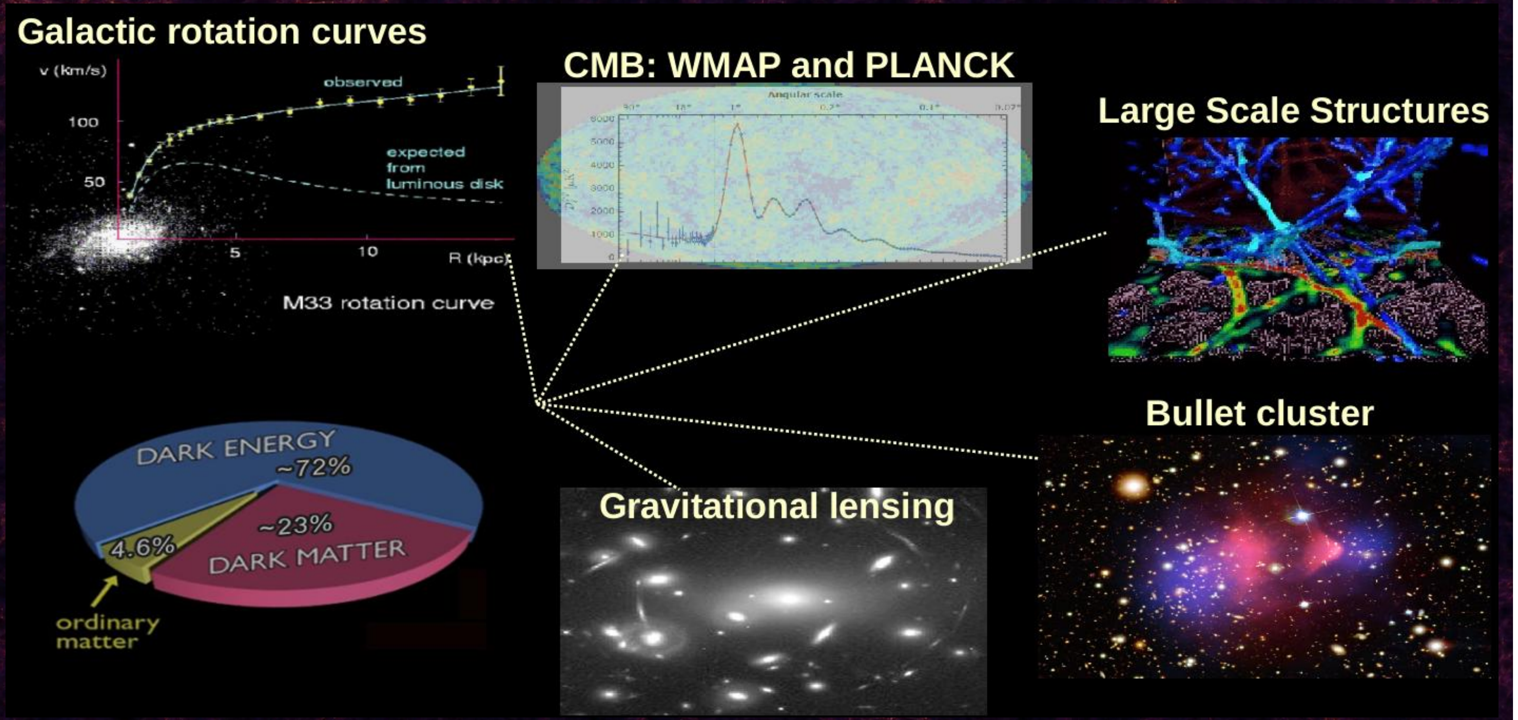
Do we really know that we don’t know ~95% of the universe. ??

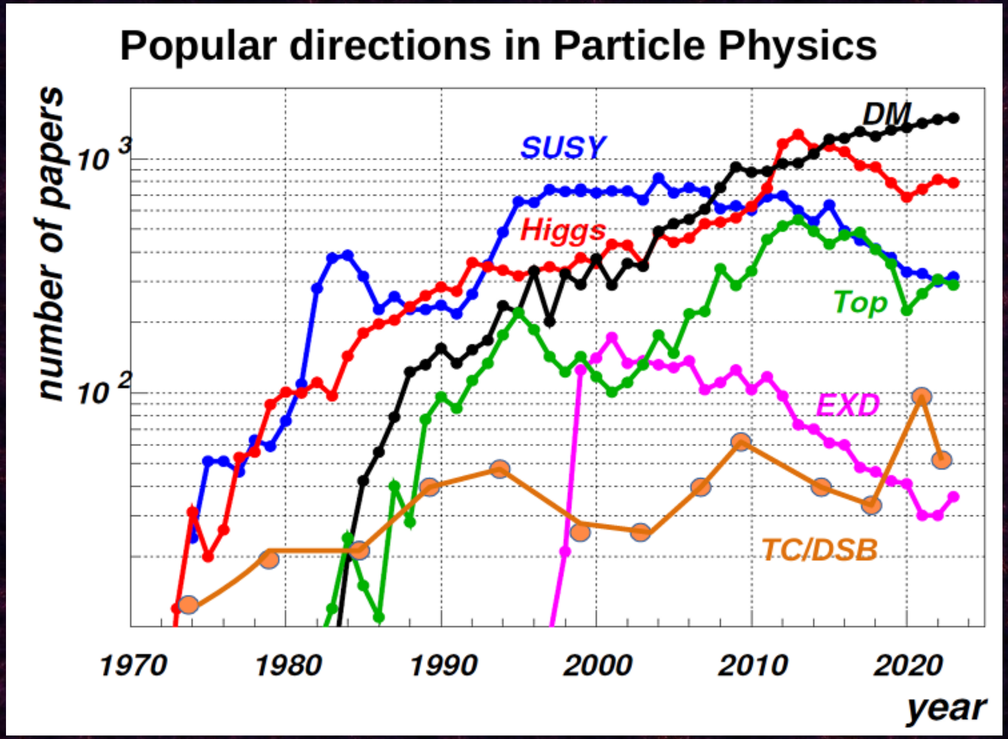
“Degree of skepticism must not only be pardonable but should be laudable”

$$\frac{\ddot{a}(t)}{a(t)} = -\frac{4\pi G}{3}\left(\rho(t) + \frac{3p(t)}{c^2}\right) + \frac{\Lambda c^2}{3}$$

ΛCDM concordance cosmology, based on Friedman equations(1922) recently going through a crises

Dark matter:
Compelling physics case and huge interest of the community





On testing CDM and geometry-driven Milky Way rotation curve models with *Gaia* DR2
M. Crosta et al. 10.1093/mnras/staa1511

PAPER • OPEN ACCESS

Exploring Milky Way rotation curves with Gaia DR3: a comparison between ΛCDM, MOND, and general relativistic approaches

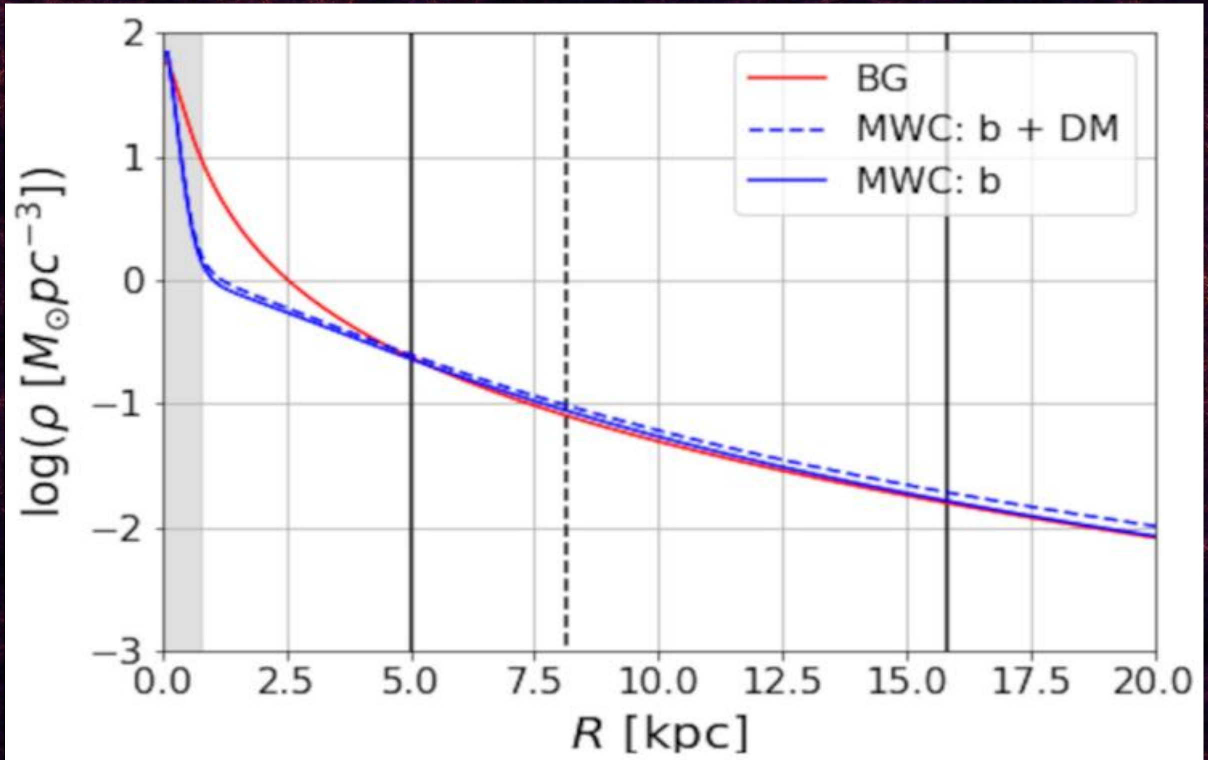
William Beordo, Mariateresa Crosta and Mario Gilberto Lattanzi

Published 11 December 2024 • © 2024 The Author(s)

Journal of Cosmology and Astroparticle Physics, Volume 2024, December 2024

Citation William Beordo *et al* JCAP12(2024)024

DOI 10.1088/1475-7516/2024/12/024



JOURNAL ARTICLE

On testing CDM and geometry-driven Milky Way rotation curve models with *Gaia* DR2 FREE

Mariateresa Crosta ✉, Marco Giammaria, Mario G Lattanzi, Eloisa Poggio

Monthly Notices of the Royal Astronomical Society, Volume 496, Issue 2, August 2020, Pages 2107–2122, https://doi.org/10.1093/mnras/staa1511

Published: 02 June 2020 **Article history** ▾

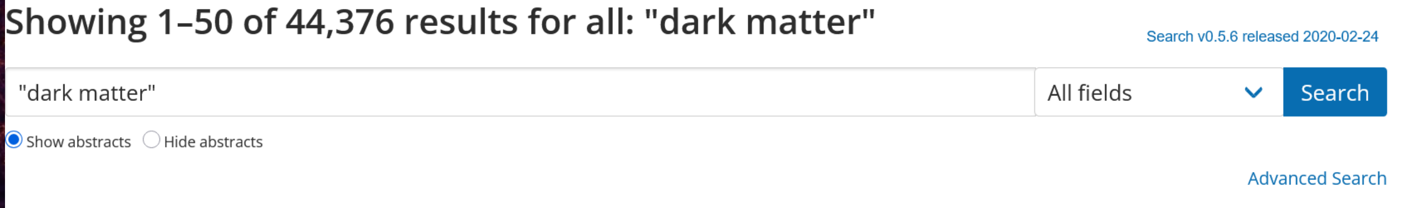
ABSTRACT

Flat rotation curves (RCs) in disc galaxies provide the main observational support to the hypothesis of surrounding dark matter (DM). Despite of the difficulty in identifying the DM contribution to the total mass density in our Galaxy, stellar kinematics, as tracer of gravitational potential, is the most reliable observable for gauging different matter components. From the *Gaia* second data release catalogue, we extracted parallaxes, proper motions, and line-of-sight velocities of unprecedented accuracy for a carefully selected sample of disc stars. This is the angular momentum supported population of the Milky Way (MW) that better traces its observed RC. We fitted such data to both a classical, i.e. including a DM halo, velocity profile model, and a general relativistic one derived from a stationary axisymmetric galaxy-scale metric. The general relativistic MW RC results statistically indistinguishable from its state-of-the-art DM analogue. This supports the ansatz that a weak gravitational contribution due to the off-diagonal term of the metric, by explaining the observed flatness of MW's RC, could fill the gap in a baryons-only MW, thus rendering the Newtonian-origin DM a general relativity-like effect. In the context of Local Cosmology, our findings are suggestive of the Galaxy's phase space as the exterior gravitational field in equilibrium far from a Kerr-like inner source, possibly with no need for extra matter to account for the disc kinematics.

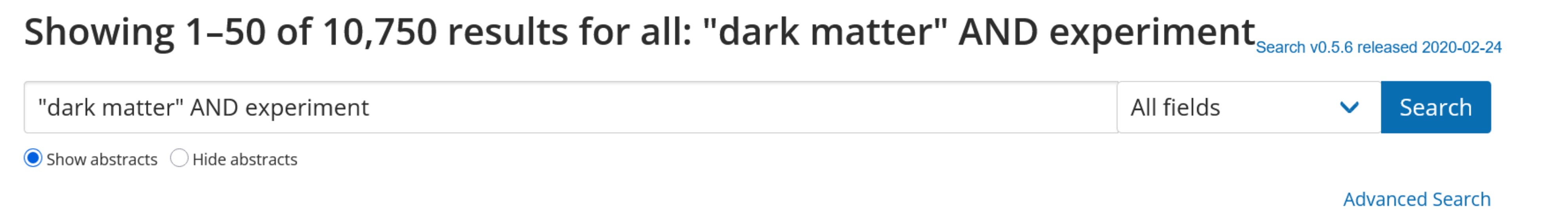
Balasin & Grumiller (2008, BG)

McMillan (2017), Pouliasis et al. (2017), and Eilers et al. (2019).

Dark matter community is huge

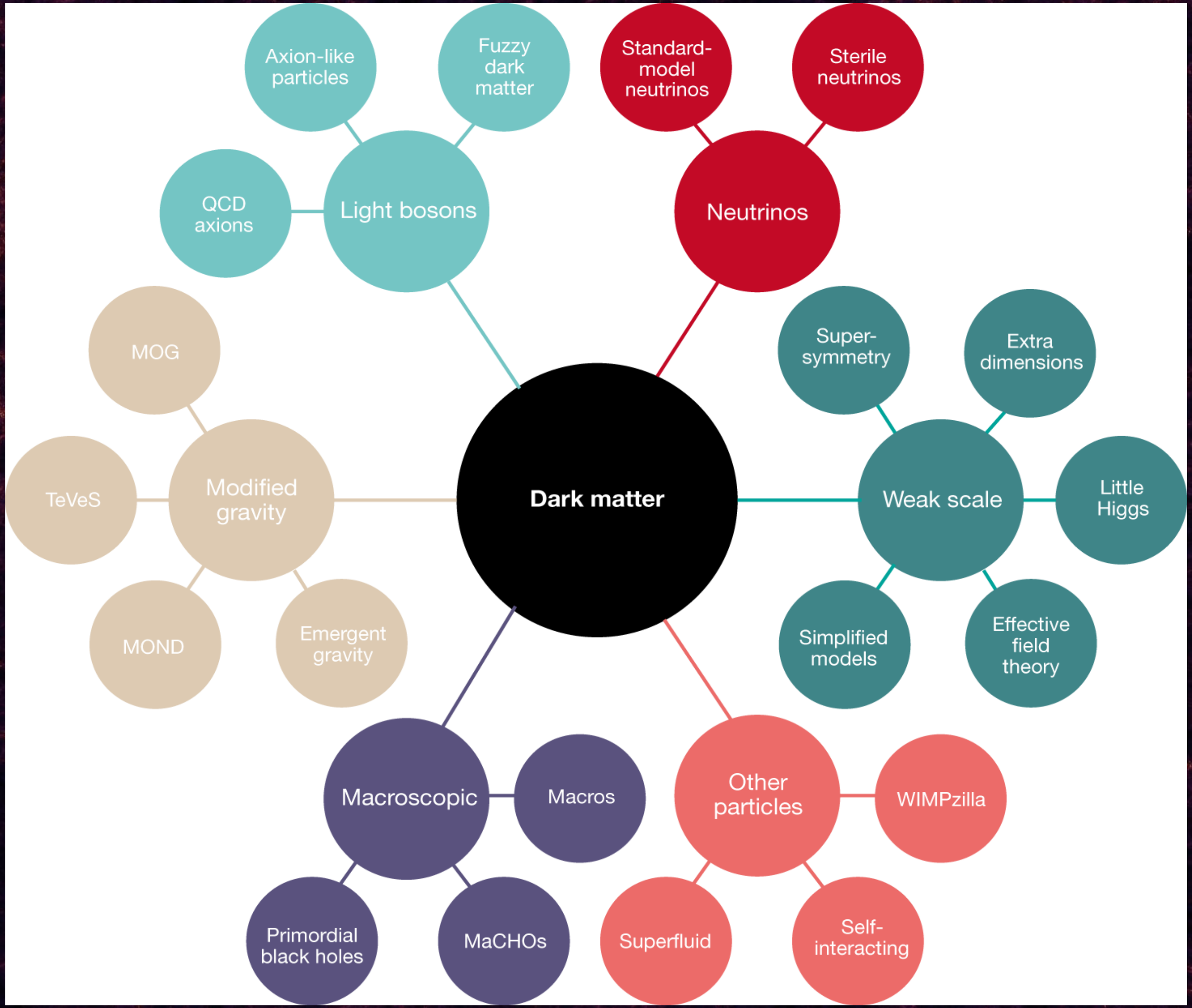


Number of papers on the arXiv that mention “dark matter”, which represents 1.7% of the entire arXiv database.



If you count all distinct collaborations, major phases of existing facilities, and dedicated smaller experiments (current, operational, and funded future projects), the total number of searches is easily **over 80**, and possibly **well over 100**, depending on how granular you are with distinguishing sub-experiments within a larger umbrella

Dark matter community is huge



<u>A lot of different models and couplings</u>

No unified description for most of them!

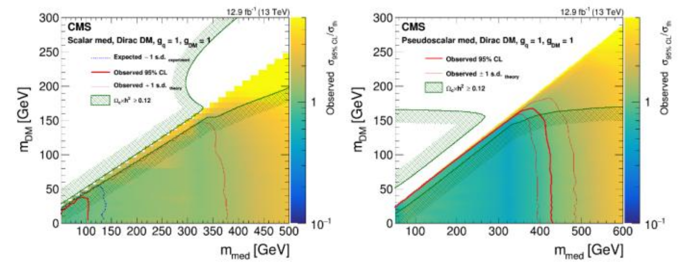
- Different conventions for measurables

- Diverse range of experiments, from table top experiments to colliders and cosmology

- Combining constraints from different experiments is a challenging and time taking endeavor.

Dark matter community is huge

How do we build our collective understanding ?



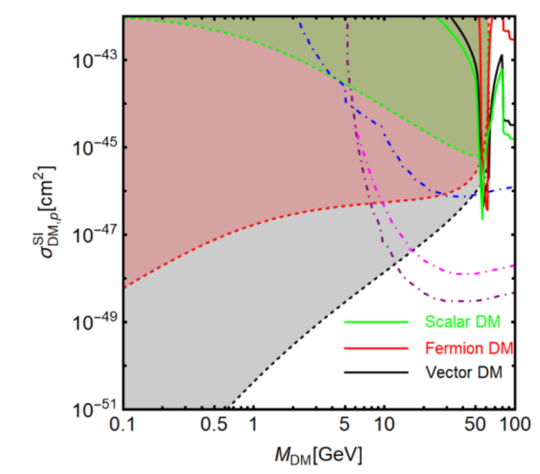
Search for dark matter with an energetic jet or a hadronically decaying W or Z boson at s =13 TeV" (CMS Collaboration, arXiv:1703.01651 2017)

Experiment (Data Analysis & Results)
Designs, builds, and operates experiments, Performs data analysis and publishes results, setting exclusion limits across the targeted parameter spaces.
Output: Published Exclusion Limits (Experiment-Specific)

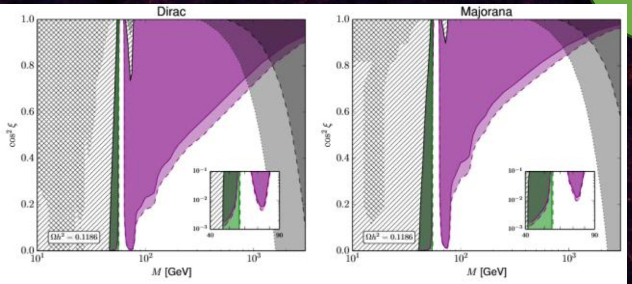
Model Builders (Theoreticians)
Develop specific models and define the parameter space (e.g mass vs. cross-section) that experiments should target.
Output: Phase Space Maps, Target Constraints

Phenomenology (Global Synthesis)
Take published experimental results, re-interprets them and re-normalizes them across diverse theoretical models, synthesizing the data into combined Global Exclusion Plot
Output: Global Parameter Limits, Model Testing Results

"The Higgs-portal for Dark Matter: effective field theories versus concrete realizations" (arXiv:2101.02507 2022)



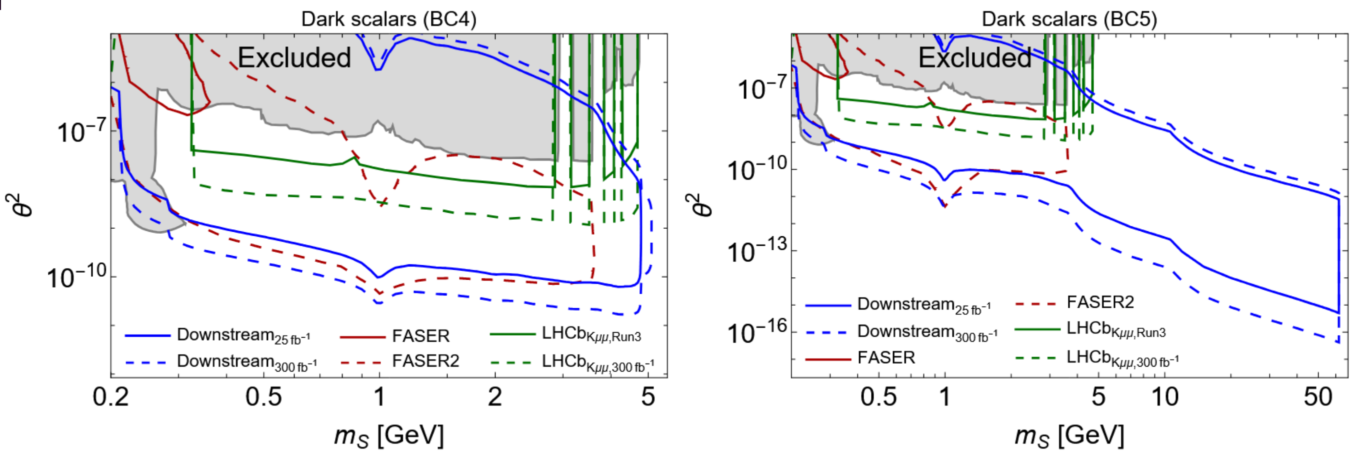
"The Fermionic Dark Matter Higgs Portal: an effective field theory approach" (arXiv:1404.2283) (2014)

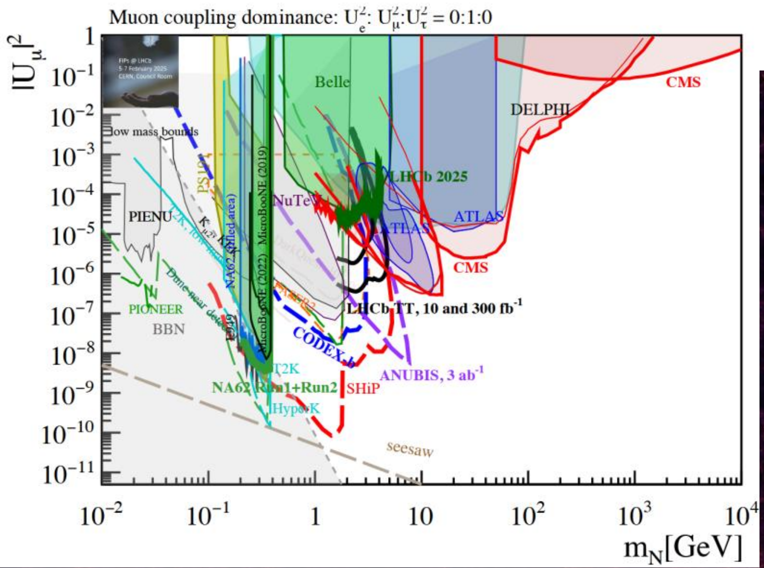


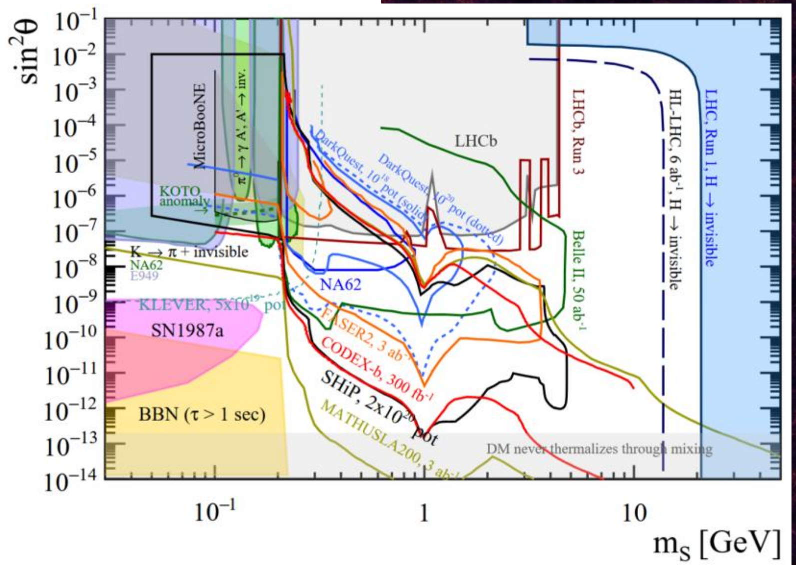
https://arxiv.org/pdf/2510.05257

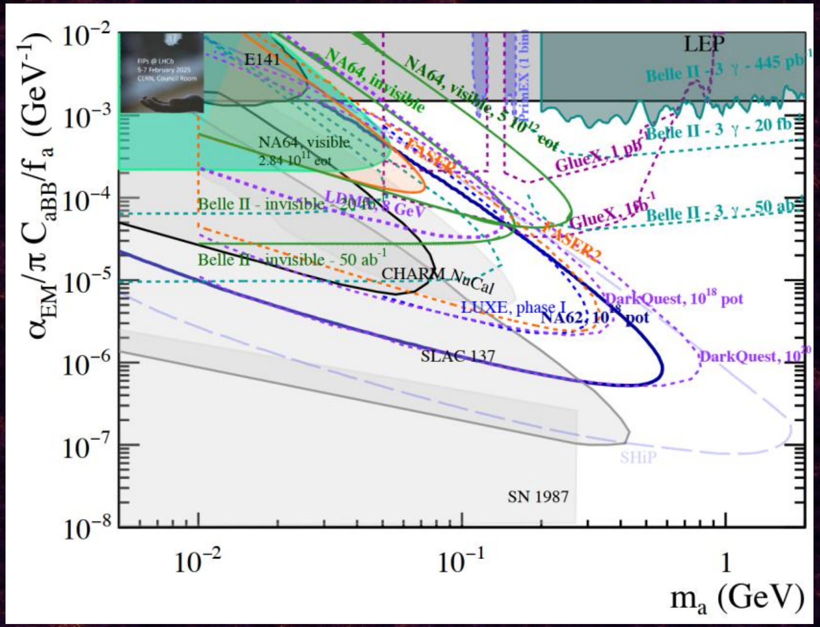
Feebly-Interacting Particles: FIPs at LHCb — Workshop Report 2025 Edition

J. Alimena[1], J. Boyd[2], G. Cacciapaglia[3], A. Casais Vidal[4,*], X. Cid Vidal[5], S. Collaviti[6], A. De Oyanguren Campos[7], G. Dalla Valle Garcia[8], G. Elor[9], G. Ferretti[10], D. Gorbunov[11], E. Goudzovski[12], J. Hajer[13], J. Jerhot[14], B. Kishor Jashal[7], V. Kholoimov[7], J. Klaric[15], F. Kling[1,27], E. Kriukova[11,29], Y. Kyselov[16], G. Lanfranchi[17,*], C. Langenbruch[18], S. Libralon[7], F. Martinez Vidal[7], A. Merli[6], M. Ovchynnikov[2], J. Pfaller[19], G. Perez[20], P. Reimitz[21,28], I. Sanderswood[7], L. Shchutska[6], V. Svintozelskyi[7], E. Torro Pastor[22], Y. Tsai[23] A. Usachov[24,*], L. Vale Silva[25], C. Vázquez Sierra[26,*], F. Volle[12], J. Zhuo[7], J. Zurita[7]









Constraints for dark matter models

Dark matter models are typically characterized by:

the <u>couplings</u> (λ_1, λ_2...) and <u>masses</u> (m_1, m_2...) of the particles they introduce

Typical example of the extension of Standard Model. Scalar Higgs-portal has a form:

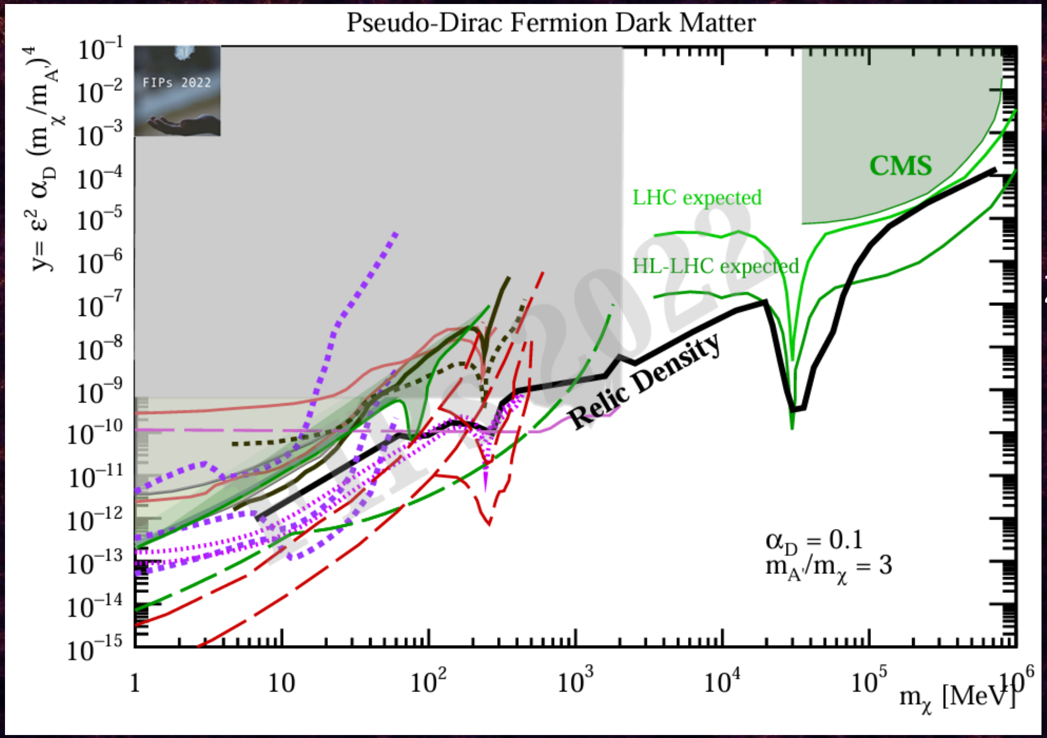
$$\mathcal{L}_{\mathrm{BSM}} \supset \frac{1}{2}(\partial_\mu \chi)(\partial^\mu \chi) - \frac{1}{2} m_\chi^2 \chi^2 - \lambda \chi^2 H^\dagger H$$

Kinetic term — Mass term — Interaction term

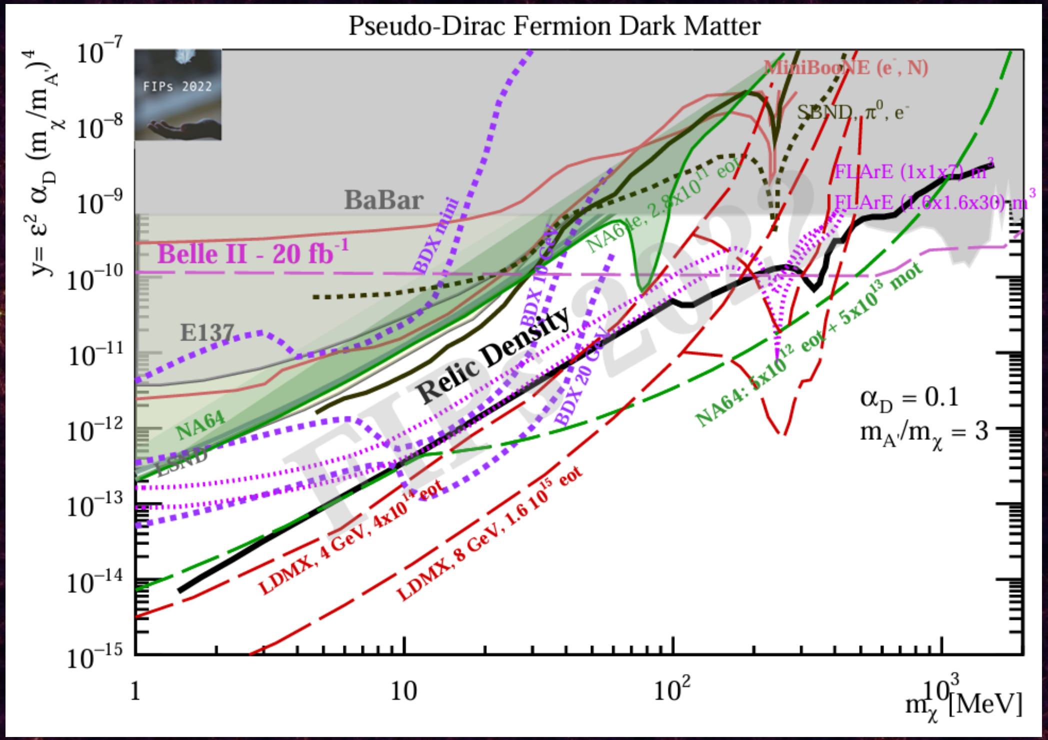
<u>Constraints are usually shown in the coupling-mass (λ, m) parameter space</u>

Scaling problem with global limit plots

Source



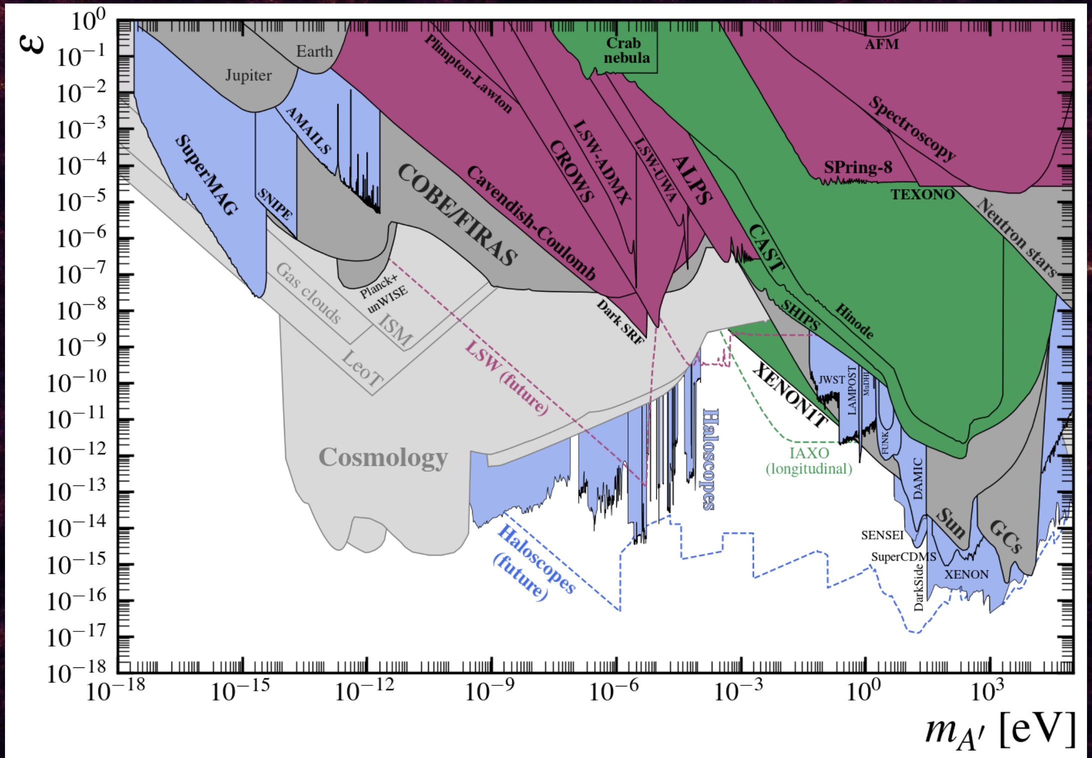
Zoom in



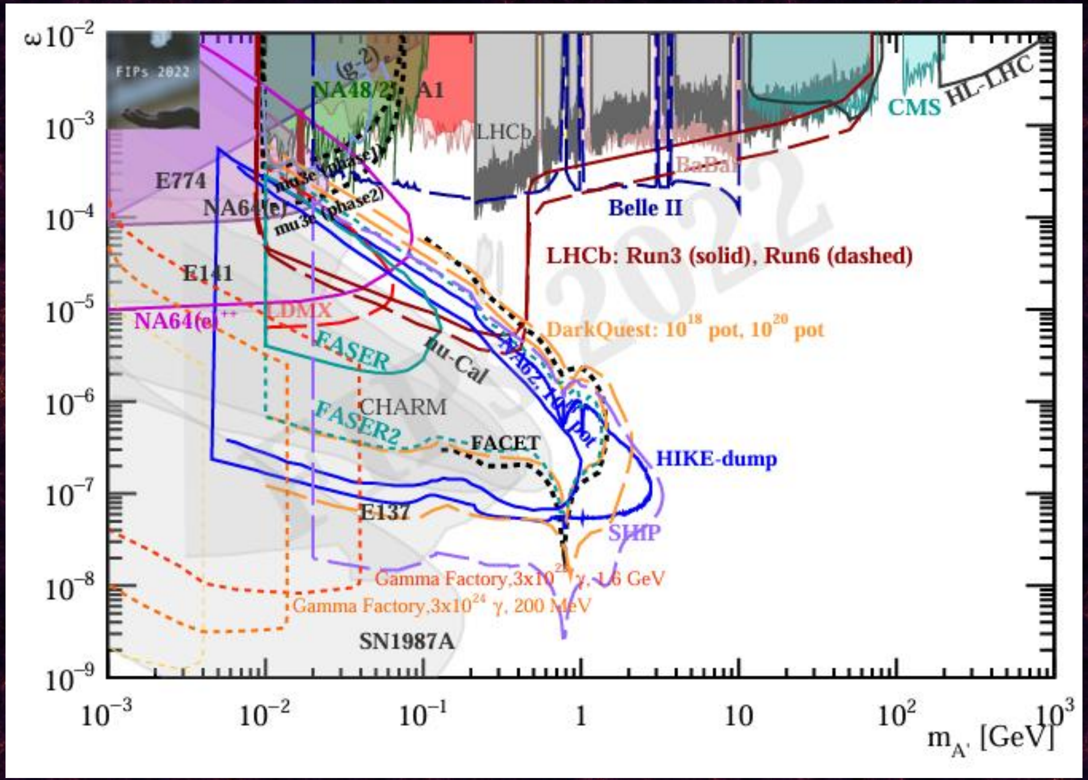
For plots with a lot of data, you often must to zoom the plot to understand what's going on

Visualisation problem of these increasingly busy global limit plots

Exclusion plot in range of 10^{-18} to 10^{5} eV



Exclusion plot in range of 10^{6} to 10^{12} eV



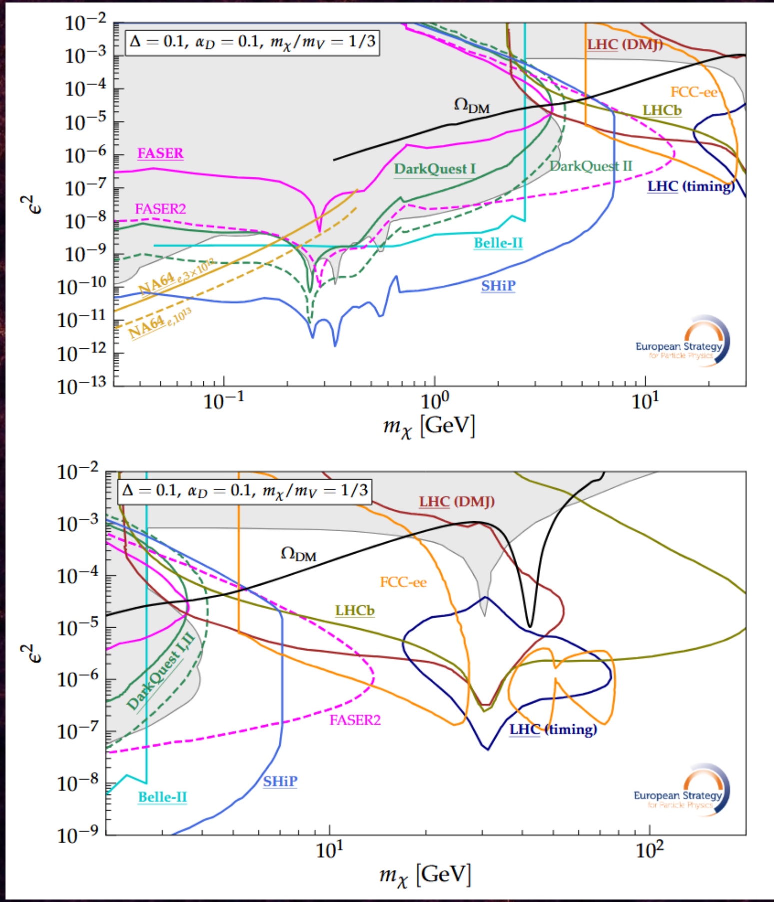
How can we properly unite these regions?

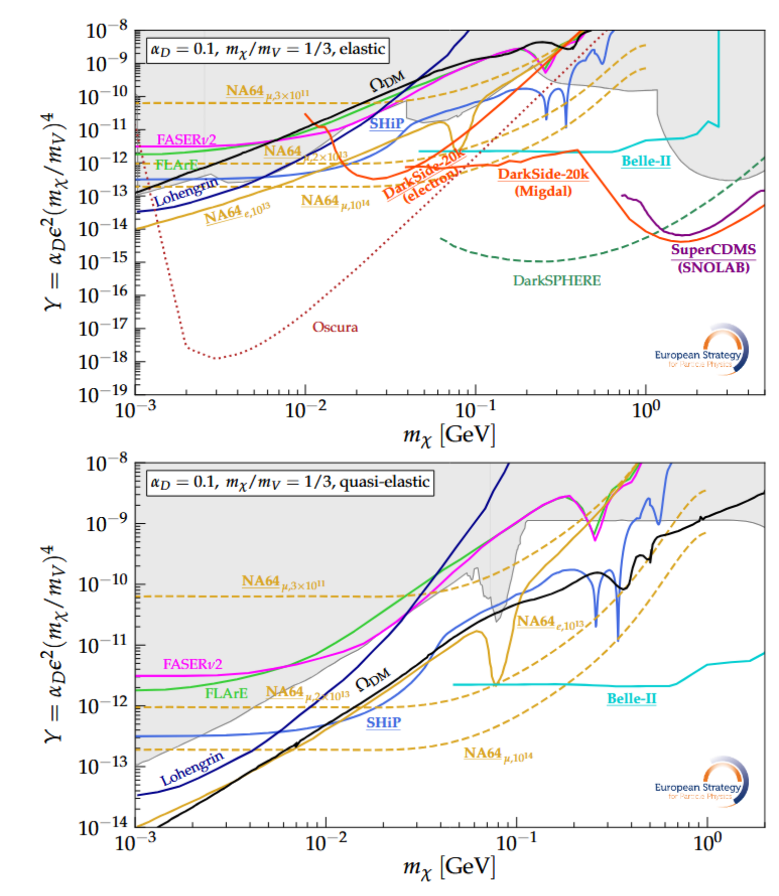
https://arxiv.org/pdf/2511.03883

CERN-ESU-2025-001
4 November 2025

Physics Briefing Book

Input for the 2026 update of the European Strategy for Particle Physics





Chapter 9

Dark Matter and Dark Sector

- 333 direct references in chapter 9 https://arxiv.org/pdf/2511.03883

- Hundreds of individual LHC data analysis results behind each curve.

https://arxiv.org/pdf/2511.03883

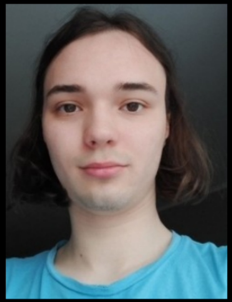
Challenges in the Dark-Matter Interpretation Process:

- Requires **deep specialized knowledge** of physics and of each model.
- **Software, tools, and scripts** used for re-interpretation and global-limit production are **hard to access, track, or reproduce**.
- Only a **small number of experts** produce global re-interpretation plots — often in narrow sub-domains — resulting in **significant, often unacknowledged effort**.
- A **sociological challenge** emerges as a highly diverse community tries to collaborate to build a shared understanding.


I wrote a grant proposal which reviewers couldn't refuse
by wes & tony

https://iris-hep.org/fellows/happydarkness.html

IRIS-HEP Fellow: Andrii Anataichuk



Fellowship dates: Jun – Aug, 2025

Home Institution: Taras Shevchenko National University of Kyiv

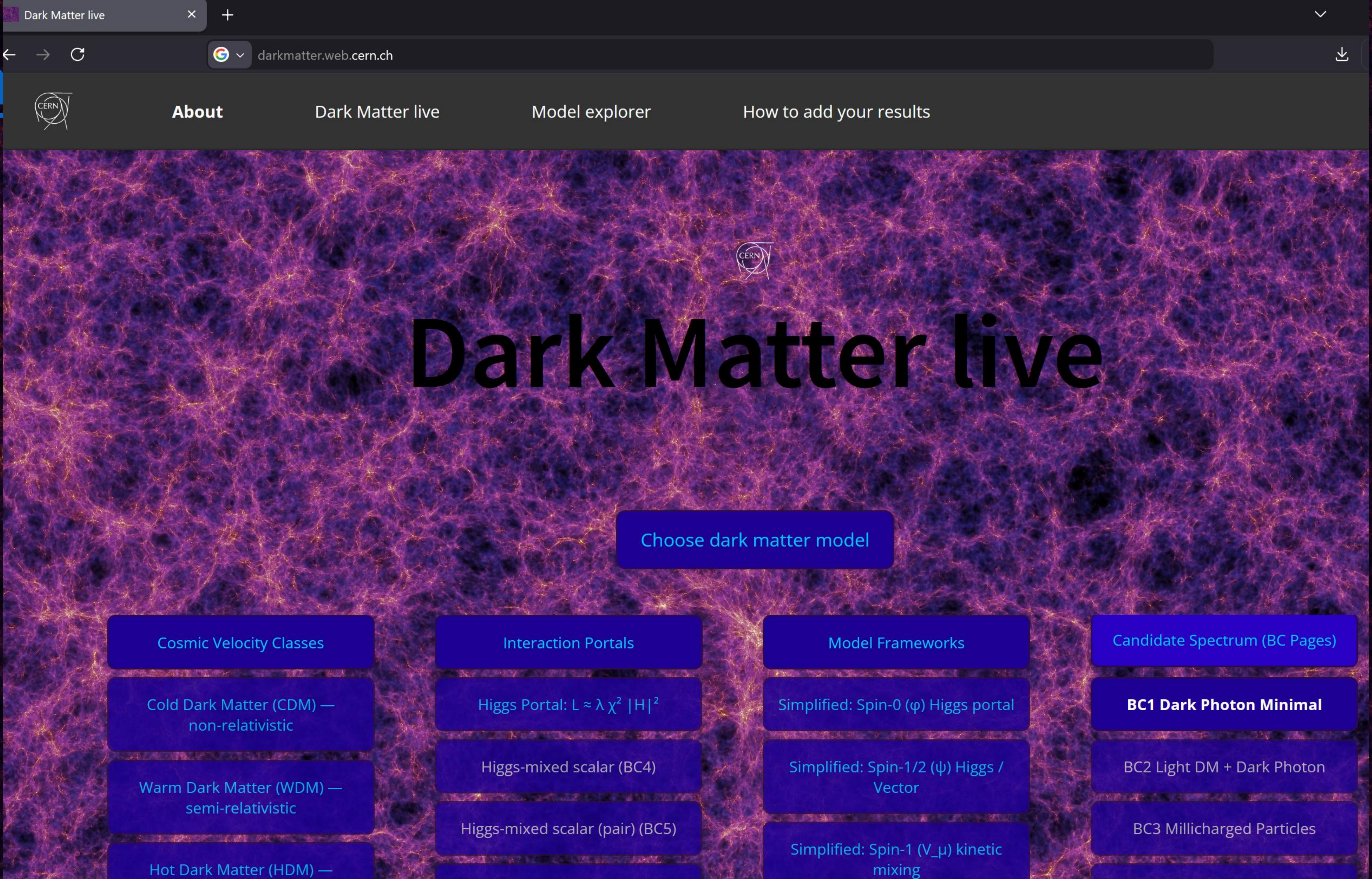
Project: Unified Co on L osmo

The project consists of calcul eady e and cos fully combining these results into a unified picture gions data (AT hes, LHCb displaced vertex results) with cosmolo ck relic erence m will construct posterior distributions for key χ, gDgD ts that h meter space accessible to both colliders and cosmology.

More information: My project proposal

Mentors:

- Brij Kishor Jashal (Rutherford Appleton Laboratory)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darkmatter.web.cern.ch
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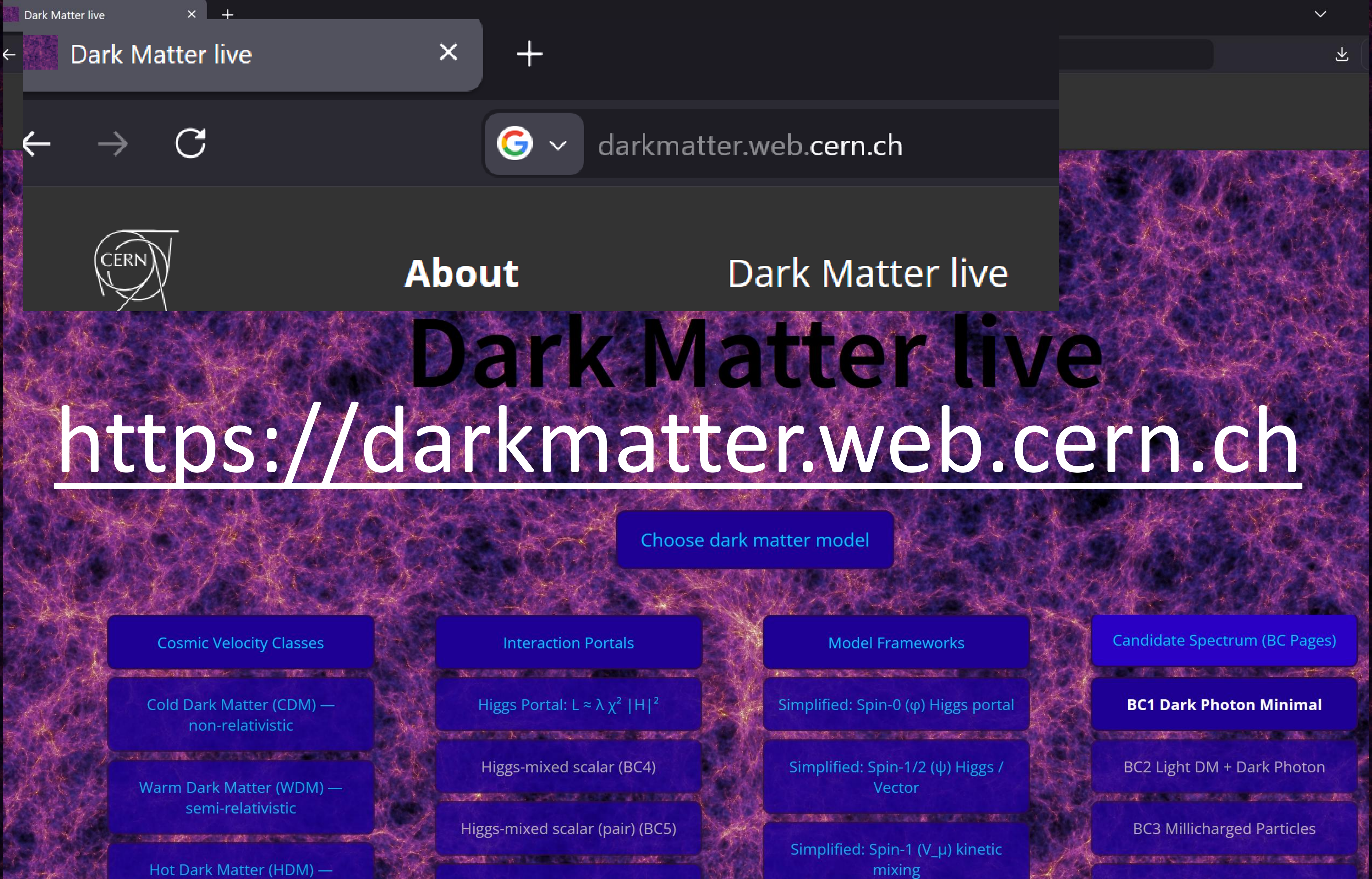
About
Dark Matter live
Model explorer
How to add your results
CERN
Dark Matter live
Choose dark matter model
Cosmic Velocity Classes
Interaction Portals
Model Frameworks
Candidate Spectrum (BC Pages)
Cold Dark Matter (CDM) — non-relativistic
Higgs Portal: L ≈ λ χ² |H|²
Simplified: Spin-0 (φ) Higgs portal
BC1 Dark Photon Minimal
Warm Dark Matter (WDM) — semi-relativistic
Higgs-mixed scalar (BC4)
Simplified: Spin-1/2 (ψ) Higgs / Vector
BC2 Light DM + Dark Photon
Higgs-mixed scalar (pair) (BC5)
BC3 Millicharged Particles
Simplified: Spin-1 (V_μ) kinetic mixing
Hot Dark Matter (HDM) —



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BC2 Light DM + Dark Photon
Higgs-mixed scalar (pair) (BC5)
BC3 Millicharged Particles
Hot Dark Matter (HDM) —
Simplified: Spin-1 (V_μ) kinetic mixing

About Dark Matter live

Dark-Matter-Live is a static website project that provides interactive visualisations of experimental and observational constraints on dark-matter models. The site collects published limits and renders them as exclusion and projection curves so researchers and the public can compare results across experiments.

Goals

- Make published constraints discoverable and comparable in a single place.
- Provide an easy-to-use format for submitting new data via pull requests.
- Maintain a transparent and reproducible dataset with references to original publications.

Data formats, notation and normalisation

Results published by experimental, collider and cosmological communities are frequently reported using different conventions, units and parameterisations. Limits may appear as bounds on cross-sections, event rates, branching fractions, effective couplings or model-specific parameters (for example kinetic mixing parameters, mediator couplings, or axion-photon couplings), and different communities sometimes adopt different shorthand notation or normalisation choices. This heterogeneity makes direct, side-by-side comparison difficult without careful translation.

One of the objectives of Dark Matter live is to renormalise and map incoming results onto a consistent, model-aware parameter space so they can be compared coherently. Where possible we re-express published limits into the standard coupling and mass variables used by the broader community (following widely-adopted conventions such as those used in the Beyond Collider classification of dark-matter scenarios and related literature). The site records the original source, the assumptions made in any translation, and any additional caveats so users can trace how a displayed curve was derived.

How to contribute

To add a new result, follow the instructions on the How to add your results page. It explains required file formats, JSON fields, and validation steps. Contributions via pull request are welcome; maintainers will review and merge validated submissions.

Repository

The source code and data are available on GitHub and on the CERN GitLab mirror: GitLab.

Contact

For questions or to discuss contributions, contact Brij Kishor Jashal at brij@cern.ch

How to add your results

Contributing

Thank you for contributing to **Dark-Matter-Live**. This page explains how to add new constraint curves and how to validate your data before opening a Pull Request.

Basic rules

- Only add published results. Include at least one link to the published paper (arXiv, DOI, or official experiment note).
- Add one CSV and one JSON metadata file per curve.
- Keep file names clear and lowercase (use hyphens or underscores).

Folder layout

Place files under data/<model>/ — each model or model family gets its own folder. Put CSV and JSON pairs there.

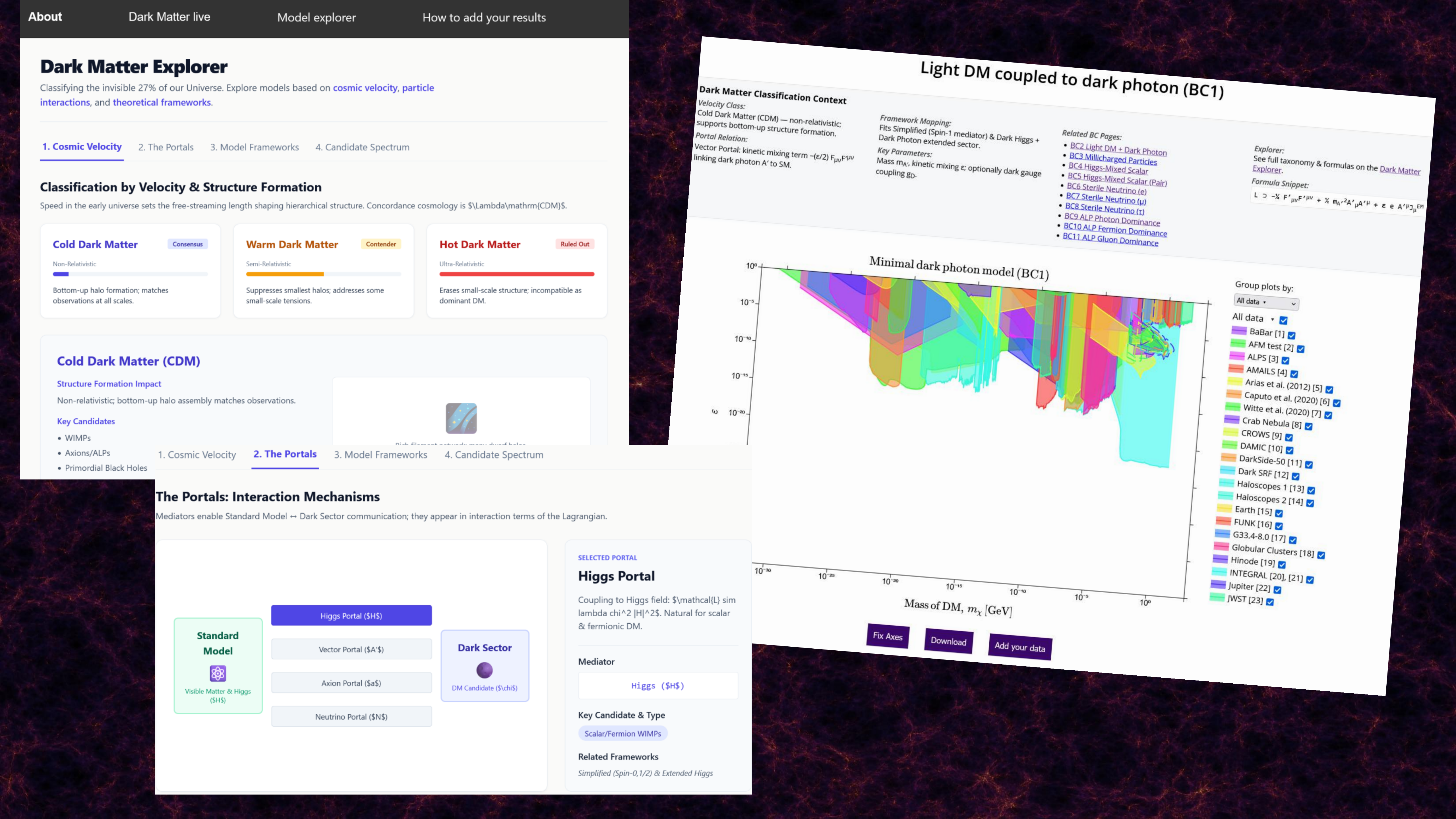
File formats

- CSV must be a numeric two-column file with header `x,y`.
- JSON must include at least the following keys:
  - `labelName` (string)
  - `id` (string)
  - `url` (string) — relative path to the CSV file
  - `paperUrls` (array) — at least one URL to the published result

Validation

Run the validator included in `scripts/validate_data.py` before opening a PR. It checks that JSON files parse, required fields exist, the CSV file exists, and the CSV contains a header `x,y` and numeric rows.

Run (PowerShell):


About
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Model explorer
How to add your results
Dark Matter Explorer
Classifying the invisible 27% of our Universe. Explore models based on cosmic velocity, particle interactions, and theoretical frameworks.
1. Cosmic Velocity
2. The Portals
3. Model Frameworks
4. Candidate Spectrum
Classification by Velocity & Structure Formation
Speed in the early universe sets the free-streaming length shaping hierarchical structure. Concordance cosmology is $\Lambda\mathrm{CDM}$.
Cold Dark Matter
Consensus
Non-Relativistic
Bottom-up halo formation; matches observations at all scales.
Warm Dark Matter
Contender
Semi-Relativistic
Suppresses smallest halos; addresses some small-scale tensions.
Hot Dark Matter
Ruled Out
Ultra-Relativistic
Erases small-scale structure; incompatible as dominant DM.
Cold Dark Matter (CDM)
Structure Formation Impact
Non-relativistic; bottom-up halo assembly matches observations.
Key Candidates
WIMPs
Axions/ALPs
Primordial Black Holes
1. Cosmic Velocity
2. The Portals
3. Model Frameworks
4. Candidate Spectrum
The Portals: Interaction Mechanisms
Mediators enable Standard Model ↔ Dark Sector communication; they appear in interaction terms of the Lagrangian.
Standard Model
Visible Matter & Higgs (H)
Higgs Portal (H)
Vector Portal (A')
Axion Portal (a)
Neutrino Portal (N)
Dark Sector
DM Candidate (χ)
SELECTED PORTAL
Higgs Portal
Coupling to Higgs field: $\mathcal{L} sim lambda chi^2 |H|^2$. Natural for scalar & fermionic DM.
Mediator
Higgs (H)
Key Candidate & Type
Scalar/Fermion WIMPs
Related Frameworks
Simplified (Spin-0,1/2) & Extended Higgs
Light DM coupled to dark photon (BC1)
Dark Matter Classification Context
Velocity Class:
Cold Dark Matter (CDM) — non-relativistic; supports bottom-up structure formation.
Portal Relation:
Vector Portal: kinetic mixing term −(ε/2) F_μν F′^μν linking dark photon A′ to SM.
Framework Mapping:
Fits Simplified (Spin-1 mediator) & Dark Higgs + Dark Photon extended sector.
Key Parameters:
Mass m_A′, kinetic mixing ε; optionally dark gauge coupling g_D.
Related BC Pages:
BC2 Light DM + Dark Photon
BC3 Millicharged Particles
BC4 Higgs-Mixed Scalar
BC5 Higgs-Mixed Scalar (Pair)
BC6 Sterile Neutrino (e)
BC7 Sterile Neutrino (μ)
BC8 Sterile Neutrino (τ)
BC9 ALP Photon Dominance
BC10 ALP Fermion Dominance
BC11 ALP Gluon Dominance
Explorer:
See full taxonomy & formulas on the Dark Matter Explorer.
Formula Snippet:
Minimal dark photon model (BC1)
Mass of DM, m_χ [GeV]
ε
Group plots by:
All data
BaBar [1]
AFM test [2]
ALPS [3]
AMAILS [4]
Arias et al. (2012) [5]
Caputo et al. (2020) [6]
Witte et al. (2020) [7]
Crab Nebula [8]
CROWS [9]
DAMIC [10]
DarkSide-50 [11]
Dark SRF [12]
Haloscopes 1 [13]
Haloscopes 2 [14]
Earth [15]
FUNK [16]
G33.4-8.0 [17]
Globular Clusters [18]
Hinode [19]
INTEGRAL [20], [21]
Jupiter [22]
JWST [23]
Fix Axes
Download
Add your data

Light DM coupled to dark photon (BC1)

Dark Matter Classification Context

Velocity Class:
Cold Dark Matter (CDM) — non-relativistic; supports bottom-up structure formation.

Portal Relation:
Vector Portal: kinetic mixing term $-(\varepsilon/2) F_{\mu\nu}F'^{\mu\nu}$ linking dark photon A′ to SM.

Framework Mapping:
Fits Simplified (Spin-1 mediator) & Dark Higgs + Dark Photon extended sector.

Key Parameters:
Mass $m_{A'}$, kinetic mixing ε; optionally dark gauge coupling g_D.

Related BC Pages:

- BC2 Light DM + Dark Photon
- BC3 Millicharged Particles
- BC4 Higgs-Mixed Scalar
- BC5 Higgs-Mixed Scalar (Pair)
- BC6 Sterile Neutrino (e)
- BC7 Sterile Neutrino (μ)
- BC8 Sterile Neutrino (τ)
- BC9 ALP Photon Dominance
- BC10 ALP Fermion Dominance
- BC11 ALP Gluon Dominance

Explorer:
See full taxonomy & formulas on the Dark Matter Explorer.

Formula Snippet:

```
L ⊃ −¼ F′μνF′μν + ½ mA′²A′μA′μ + ε e A′μJμEM
```

Description of the model

In the minimal dark photon framework, the Standard Model (SM) is extended by an additional $\mathrm{U}(1)_D$ gauge symmetry under which all SM particles are neutral. The new gauge field, typically denoted A'_μ, mixes kinetically with the SM hypercharge gauge field B_μ. The most compact Lagrangian capturing this minimal extension reads:

$$\mathcal{L} \supset -\tfrac{1}{4} F'_{\mu\nu}F'^{\mu\nu} + \tfrac{1}{2} m_{A'}^2 A'_\mu A'^\mu + \epsilon\, e\, A'^\mu J_\mu^{\mathrm{EM}}\,,$$

where $F'_{\mu\nu}$ is the dark photon field strength, $m_{A'}$ is its mass (generation might be not specified, commonly accepted a Stueckelberg or dark Higgs mechanism), and ϵ parametrizes the strength of kinetic mixing with the electromagnetic current $J_\mu^{\mathrm{EM}} = \sum_f Q_f\, \bar{f}\gamma_\mu f$.

The dark photon originates from the new $\mathrm{U}(1)_D$ gauge symmetry. If $\mathrm{U}(1)_D$ remains unbroken, the dark photon is massless and its interactions with the SM are extremely suppressed. More commonly, the symmetry is broken (e.g., via the Stueckelberg or dark Higgs mechanism), leading to a massive dark photon. The two central free parameters of the minimal model are $m_{A'}$ and ϵ.

Detection

There are two types of channels that are usually considered: visible ($m_{A'} > 2m_e$) and invisible ($m_{A'} < 2m_e$).

In the first case, seaches concentrated on detection of SM signatures related to the dark photon in detector, e.g., di-jet and missing energy/momentum searches. These experiments are usually built around colliders, like LHC, SPS, Fermilab etc.

In the second case, the dark photon, in minimal dark photon model, do not have obvious visible SM decay channels, exept neutrinos, which are suppressed and extremely hard to detect, and so-called photon trident decay ($A' \to 3\gamma$), which is one-loop processes and highly suppressed. Therefore, these particles are long-lived and escape the detector, leading to missing energy/momentum signatures, which are extremely weak compared to the background and imposible to track at current resolution.

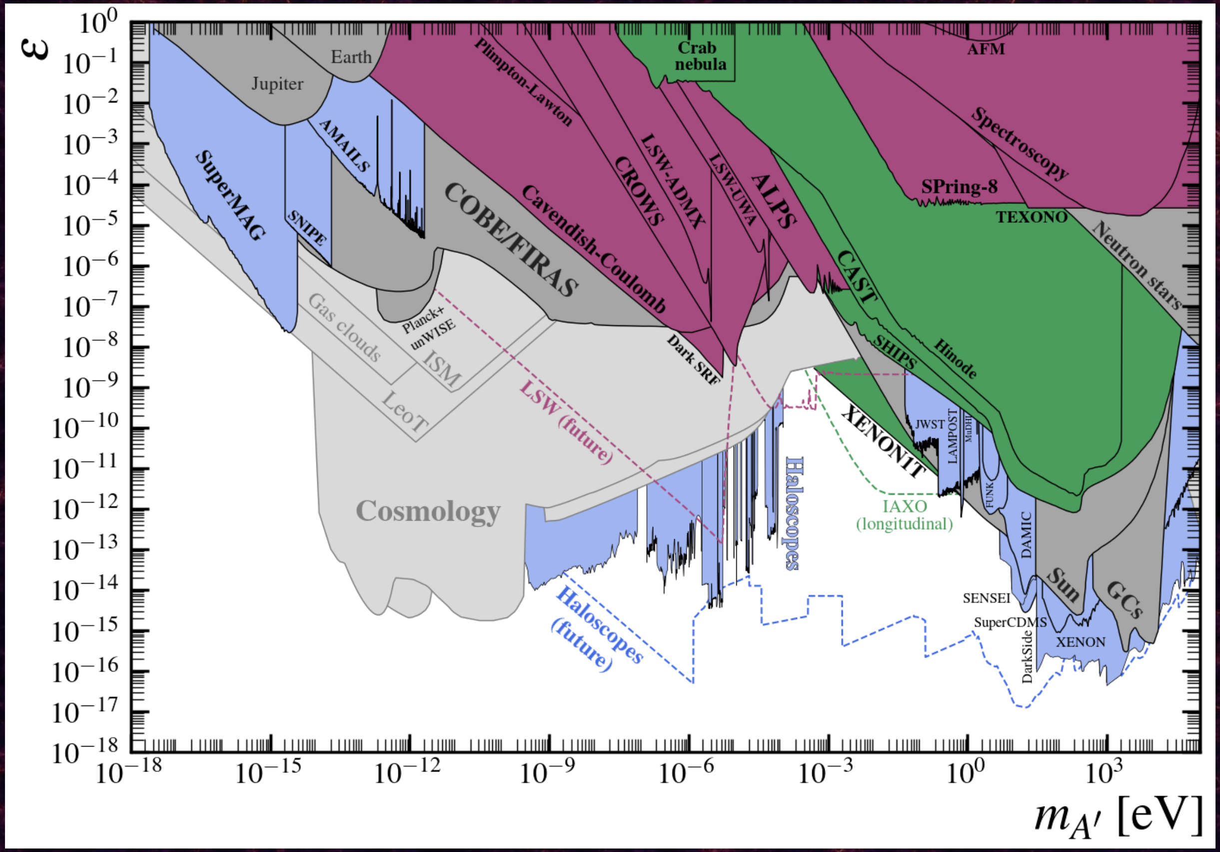
So, most seaches at sub-MeV range are based on indirect detection methods.

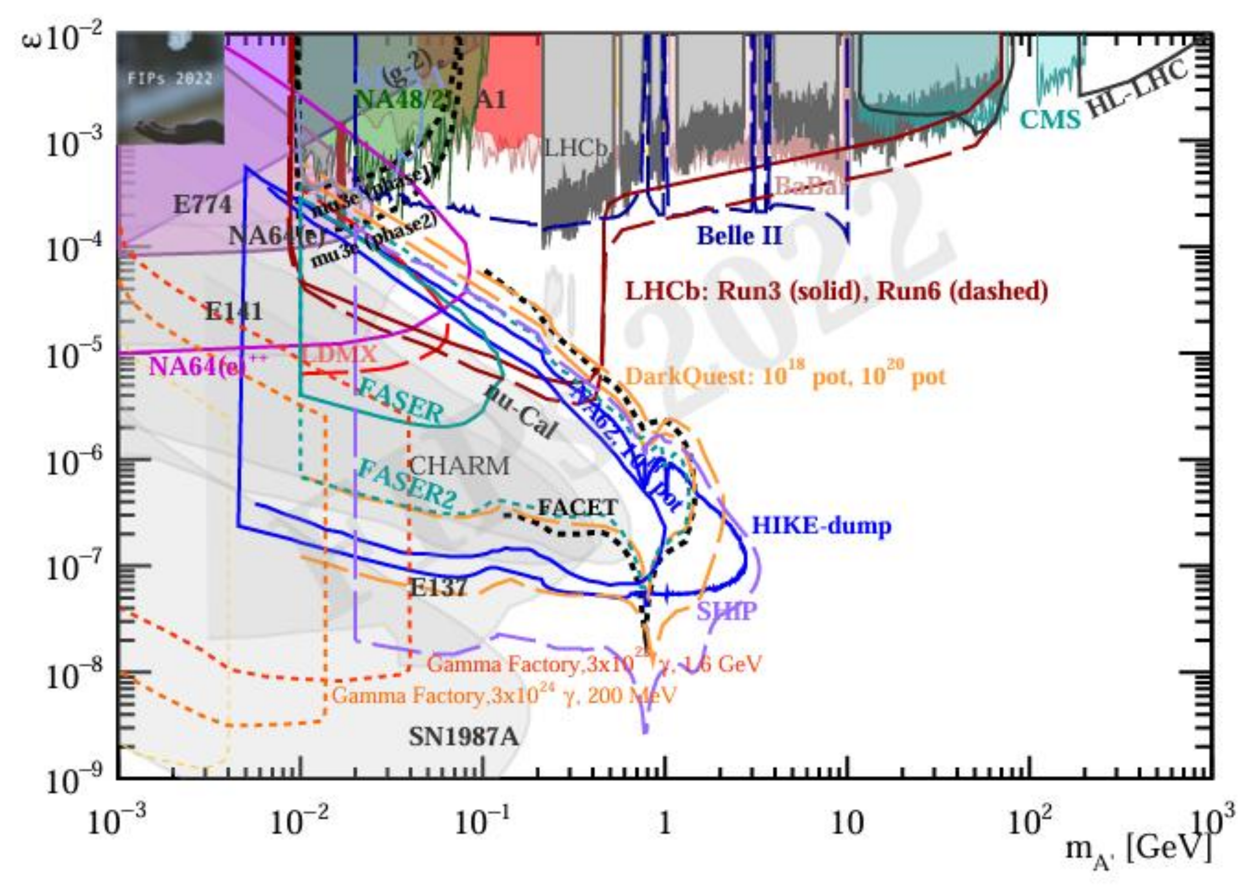
Explorer:

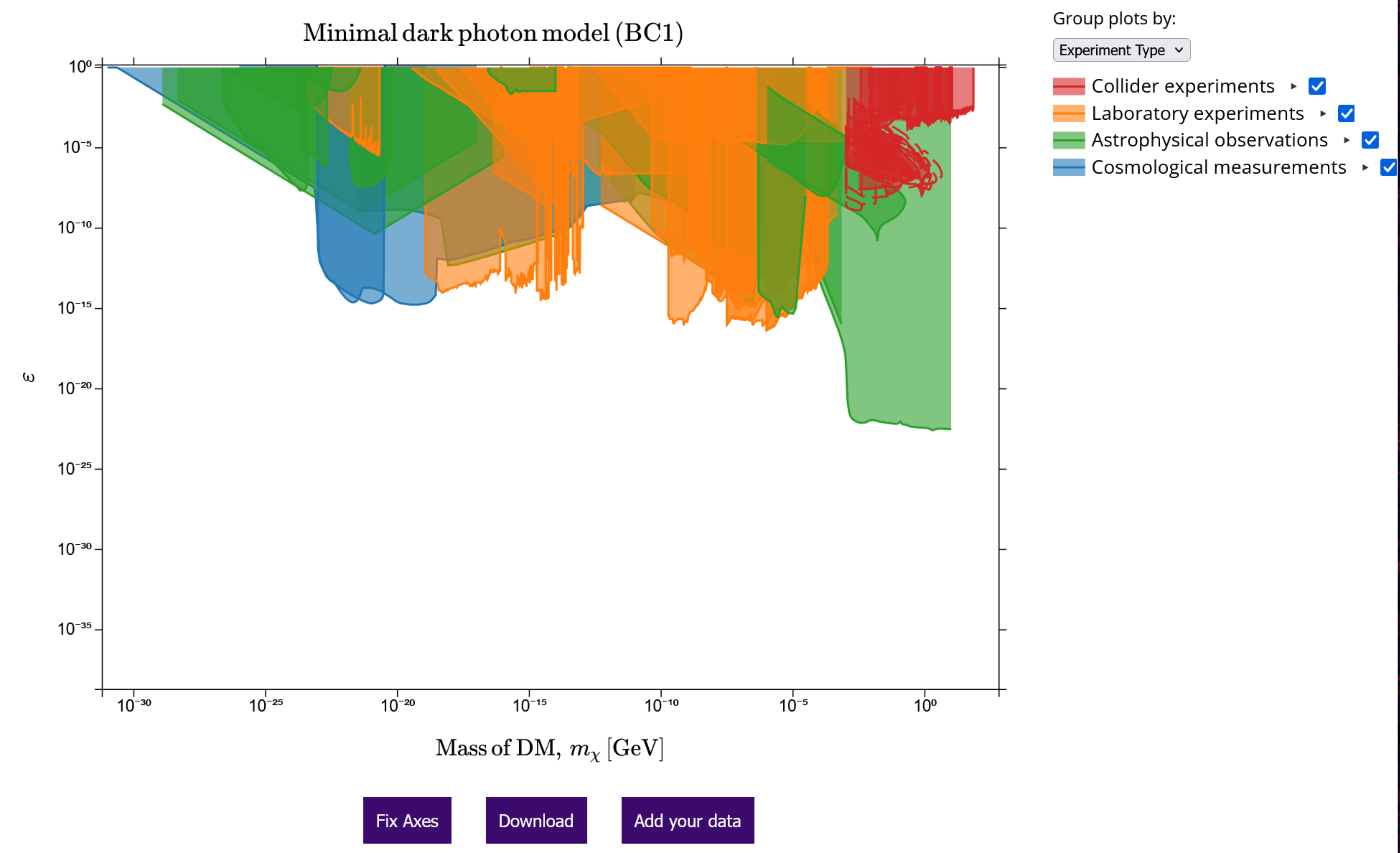
See full taxonomy & formulas on the Dark Matter Explorer.

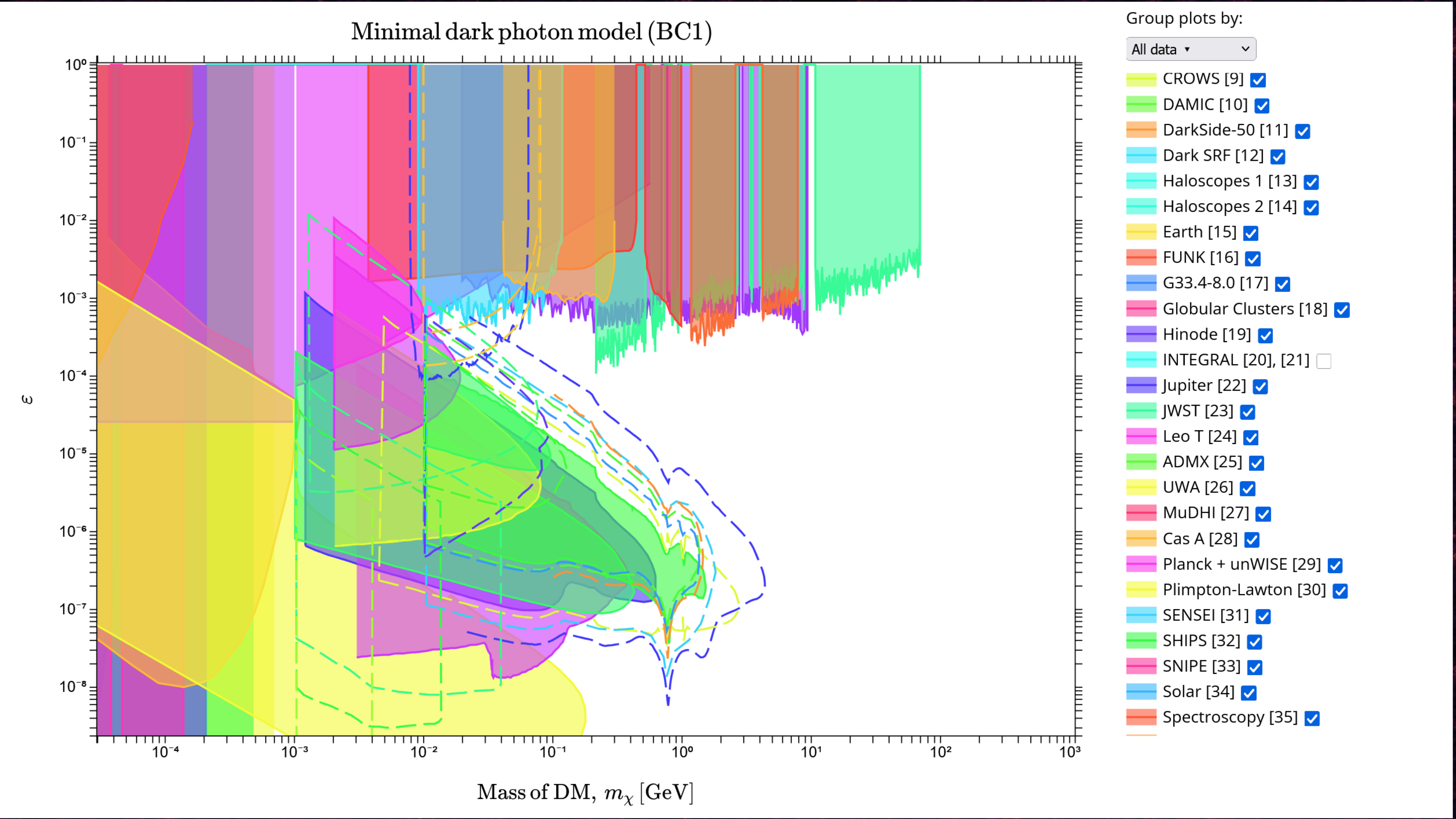
Formula Snippet:

$$L \supset -\tfrac{1}{4} F'_{\mu\nu}F'^{\mu\nu} + \tfrac{1}{2} m_{A'}^{2}A'_{\mu}A'^{\mu} + \varepsilon\, e\, A'^{\mu}J_{\mu}^{EM}$$

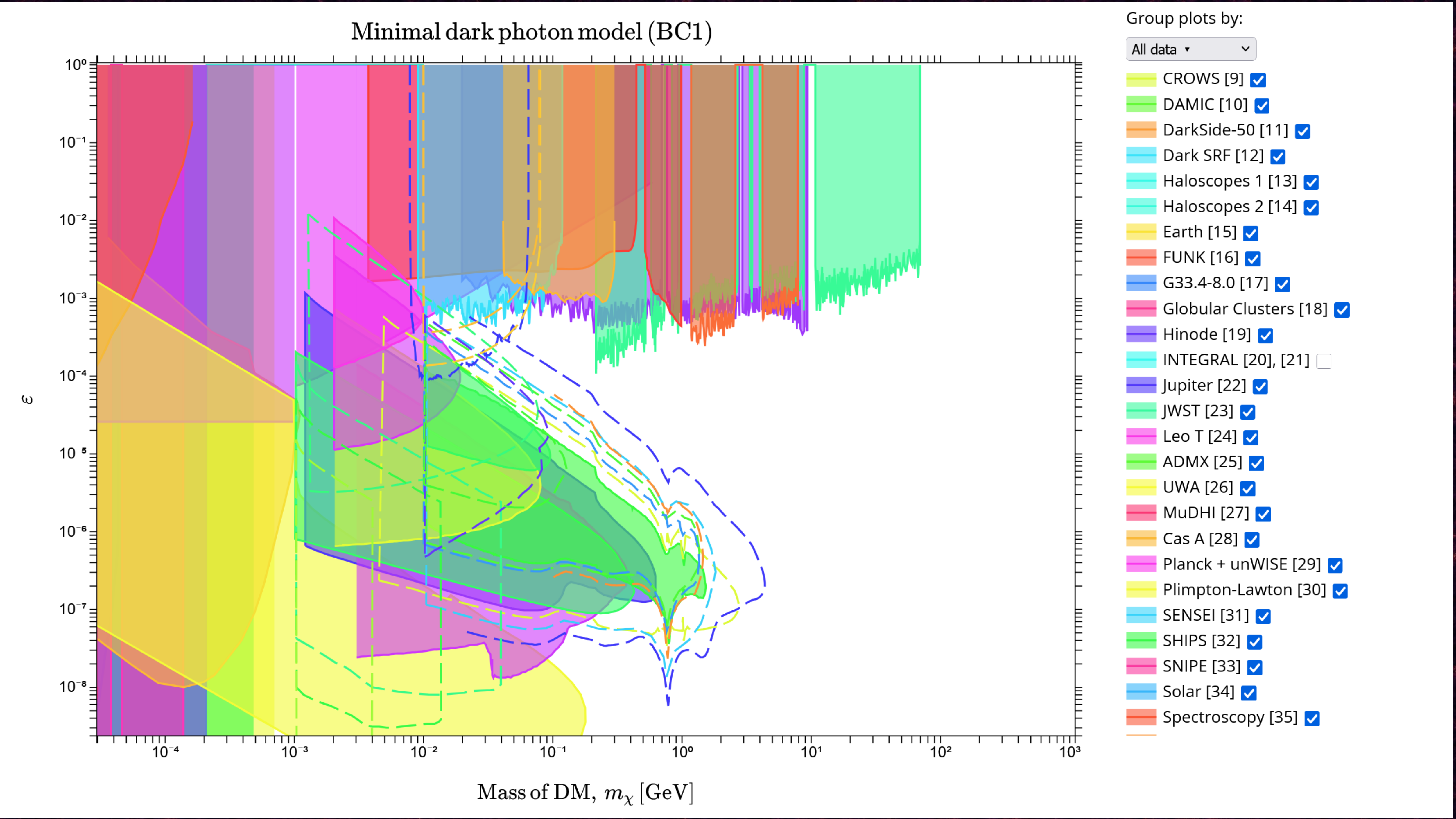





Minimal dark photon model (BC1)
ε
Mass of DM, m_χ [GeV]
10^{0}
10^{-5}
10^{-10}
10^{-15}
10^{-20}
10^{-25}
10^{-30}
10^{-35}
10^{-30}
10^{-25}
10^{-20}
10^{-15}
10^{-10}
10^{-5}
10^{0}
Group plots by:
Experiment Type
Collider experiments
Laboratory experiments
Astrophysical observations
Cosmological measurements
Fix Axes
Download
Add your data



Minimal dark photon model (BC1)
ε
Mass of DM, m_χ [GeV]
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
Group plots by:
All data
CROWS [9]
DAMIC [10]
DarkSide-50 [11]
Dark SRF [12]
Haloscopes 1 [13]
Haloscopes 2 [14]
Earth [15]
FUNK [16]
G33.4-8.0 [17]
Globular Clusters [18]
Hinode [19]
INTEGRAL [20], [21]
Jupiter [22]
JWST [23]
Leo T [24]
ADMX [25]
UWA [26]
MuDHI [27]
Cas A [28]
Planck + unWISE [29]
Plimpton-Lawton [30]
SENSEI [31]
SHIPS [32]
SNIPE [33]
Solar [34]
Spectroscopy [35]



Minimal dark photon model (BC1)
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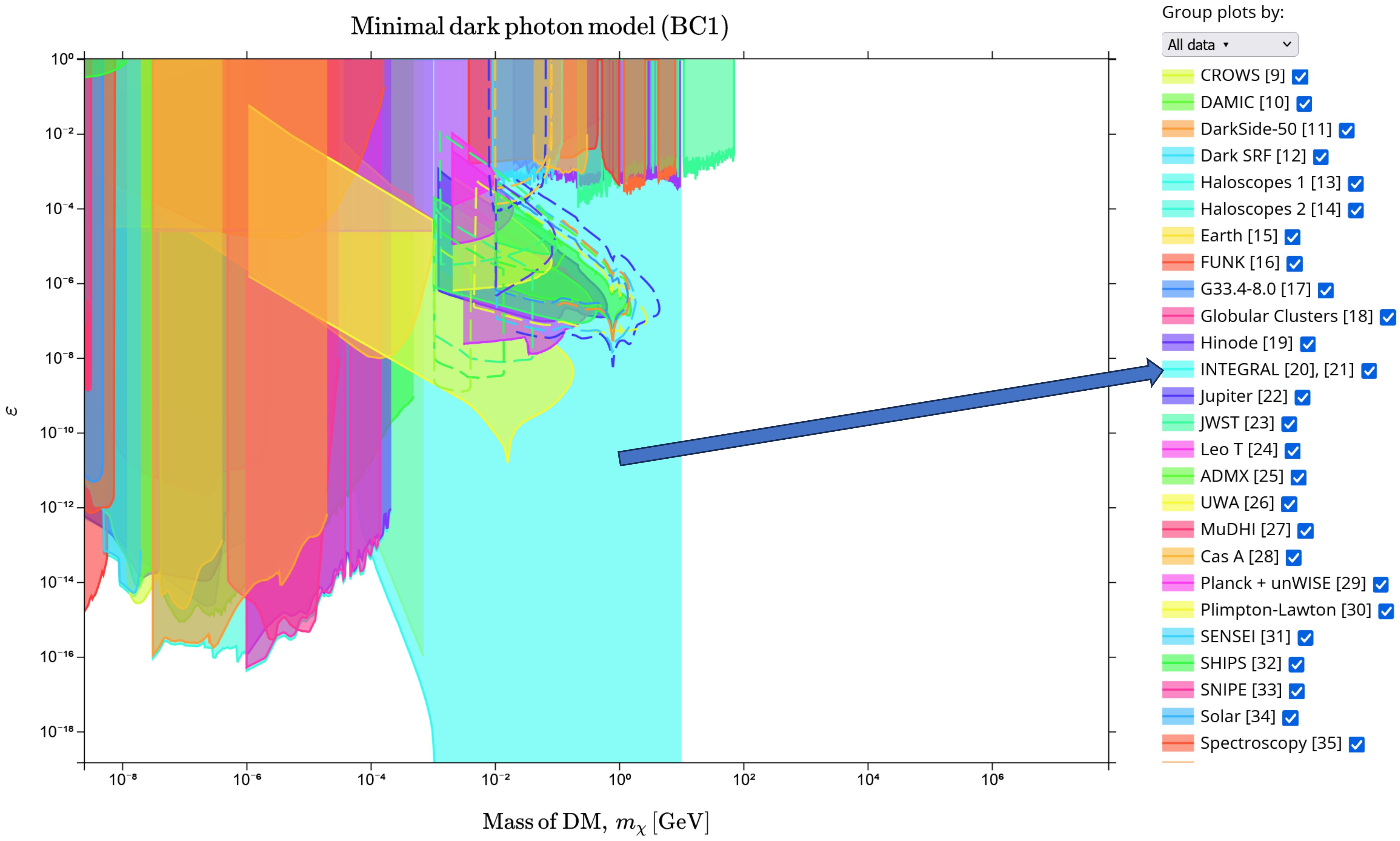

Minimal dark photon model (BC1)
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High Energy Physics - Phenomenology

[Submitted on 27 Jun 2024 (v1), last revised 21 Jul 2025 (this version, v2)]

X-Ray Constraints on Dark Photon Tridents

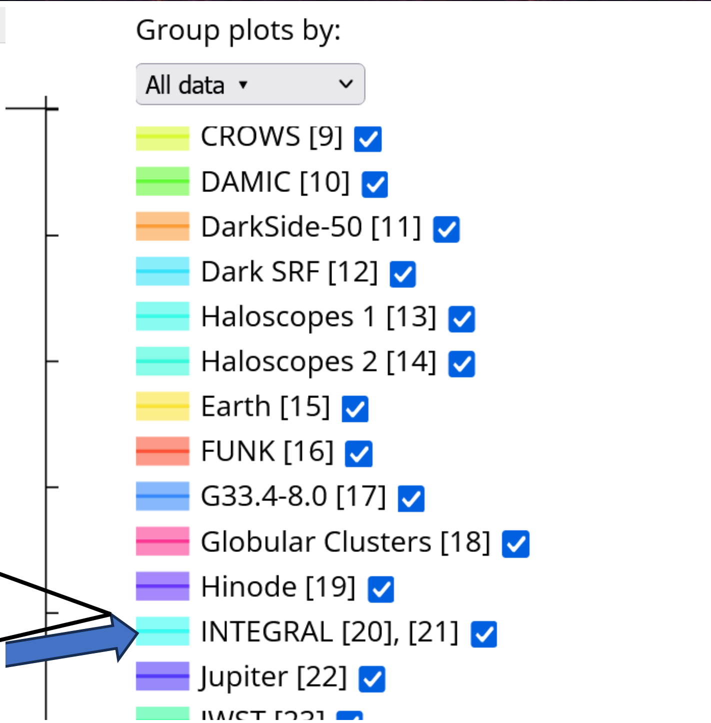
Tim Linden, Thong T. Q. Nguyen, Tim M. P. Tait

Dark photons that are sufficiently light and/or weakly-interacting represent a compelling vision of dark matter. Dark photon decay into three photons, which we call the dark photon trident, can be the dominant channel when the dark photon mass falls below the electron pair threshold and can produce a significant flux of x-rays. We use 16 years of data from INTEGRAL/SPI to constrain sub-MeV dark photon decay, producing new worlds-best constraints on the kinetic mixing parameter for dark photon masses between 61 keV and 1022 keV, and comment on the potential for future x-ray observatories to discover the trident decay process.

Comments:	4+3 pages, 4 figures. Published version on PRD
Subjects:	**High Energy Physics - Phenomenology (hep-ph)**; High Energy Astrophysical Phenomena (astro-ph.HE)
Report number:	UCI-HEP-TR-2024-10
Cite as:	arXiv:2406.19445 **[hep-ph]**
	(or arXiv:2406.19445v2 **[hep-ph]** for this version)
	https://doi.org/10.48550/arXiv.2406.19445
Journal reference:	Phys.Rev.D 112 (2025) 2, 023026
Related DOI:	https://doi.org/10.1103/37gn-x3y1

Submission history

From: Tran Quang Thong Nguyen [view email]
[v1] Thu, 27 Jun 2024 18:00:01 UTC (323 KB)
[v2] Mon, 21 Jul 2025 16:45:13 UTC (323 KB)



[Submitted on 29 Nov 2024]

Strong Constraints on Dark Photon and Scalar Dark Matter Decay from INTEGRAL and AMS-02

Thong T.Q. Nguyen, Isabelle John, Tim Linden, Tim M.P. Tait

We investigate the decay of bosonic dark matter with masses between 1 MeV and 2 TeV into Standard Model final states. We specifically focus on dark photons that kinetically mix with the Standard Model, as well as scalar dark matter models that have Yukawa couplings with the Standard Model. Using INTEGRAL and AMS-02 data, we constrain the dark matter decay lifetime into final states that include photons or positrons, setting strong constraints on the dark matter lifetime that reach 10^{25} s for dark matter below 10 GeV and up to 10^{29} s for dark matter above 10 GeV.

Comments:	13 pages, 8 figures. Appendix: 2 pages, 1 figure. Comments are welcome!
Subjects:	**High Energy Physics - Phenomenology (hep-ph)**; High Energy Astrophysical Phenomena (astro-ph.HE)
Report number:	UCI-HEP-TR-2024-19
Cite as:	arXiv:2412.00180 **[hep-ph]**
	(or arXiv:2412.00180v1 **[hep-ph]** for this version)
	https://doi.org/10.48550/arXiv.2412.00180

Submission history

From: Tran Quang Thong Nguyen [view email]
[v1] Fri, 29 Nov 2024 19:00:00 UTC (300 KB)

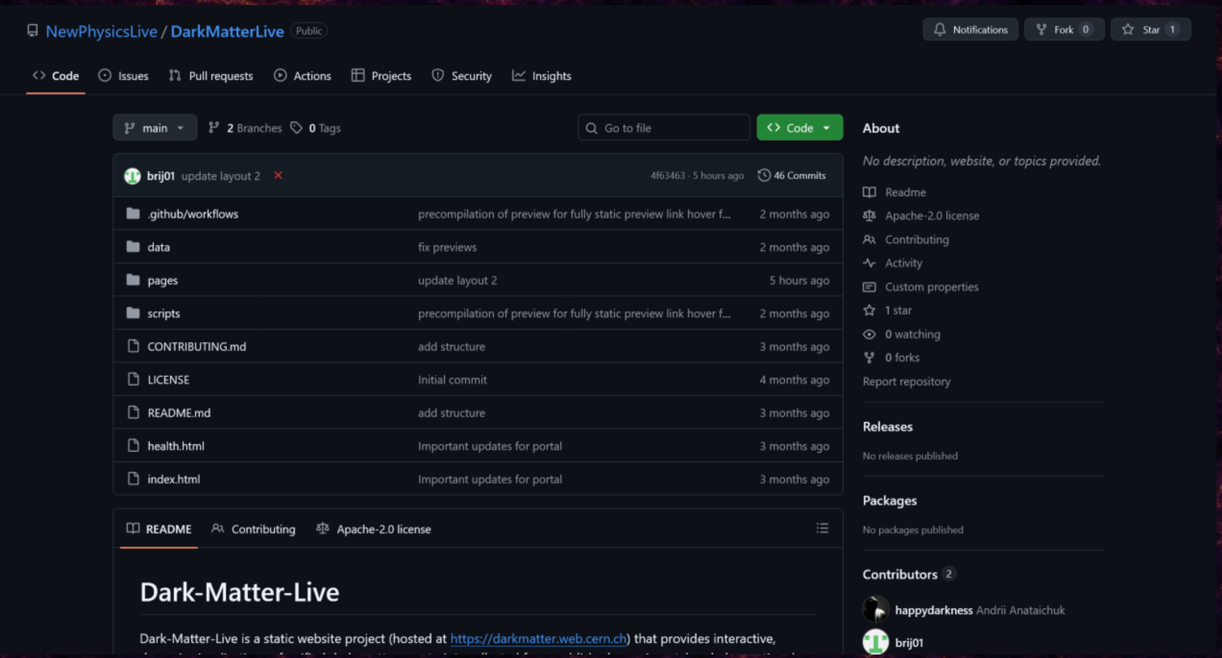
So how can we have a Open, Transparent, and Collaborative Global-Limit Framework

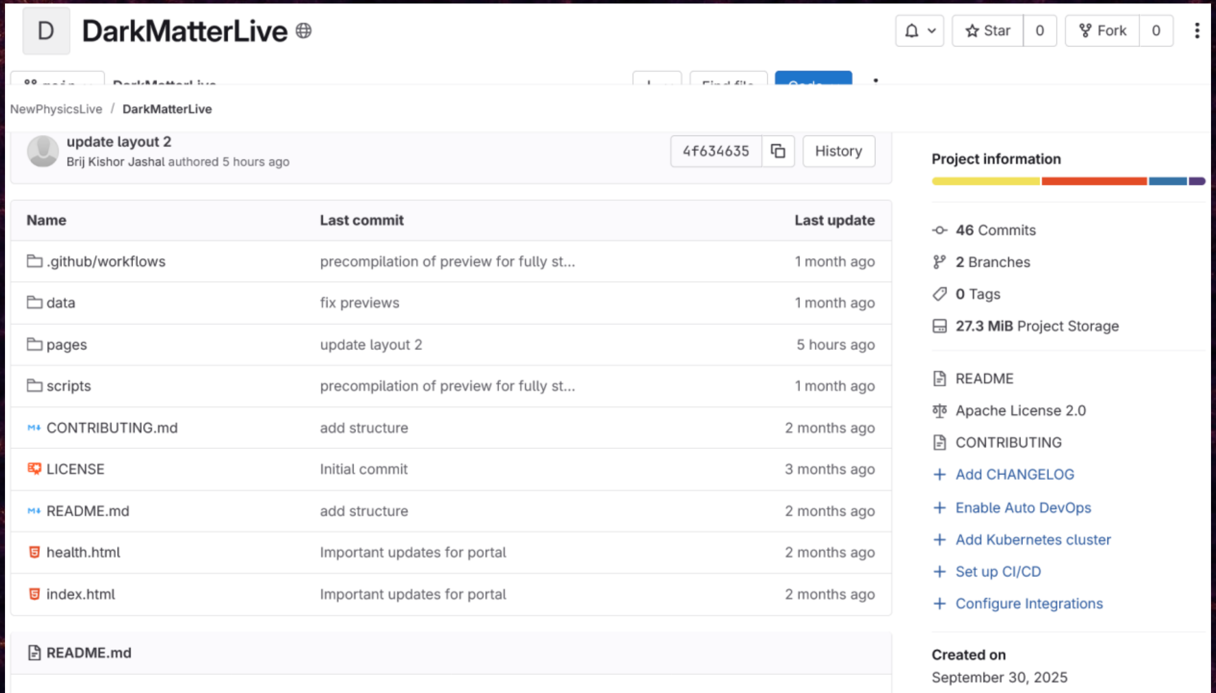
Motivation: Lessons from Software Development

- **Git** to manage the growing Linux kernel (40 Million lines of code), enabling **distributed collaboration**, **transparent history**, and **community-driven review**.

Public and Open Repositories:

- The source code and data are available on GitHub and on the CERN GitLab mirror: **CERN** GitLab.
- Designed to ensure **collaboration**, **reproducibility**, and **shared ownership**.





Transparent Contribution Workflow

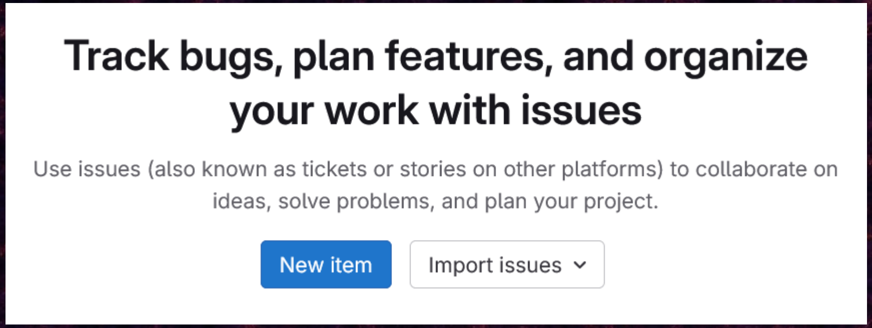
- New data points enter the global-limit framework via **Pull Requests (PRs)** or **Merge Requests (MRs)**.
- Expert review happens in the open, with discussions **publicly documented**.
- Use GIT raise issue feature to track requests for new features, bug fixes or corrections

Open Tools and Automated Pipelines

- Interpretation scripts and global-exclusion-plot algorithms become part of the repo as CI/CD code.
- A **CI/CD pipeline** automates processing when new PRs/MRs update results (for e.g., coupling vs mass for a particular model), ensuring consistent and reproducible outputs.

Versioning and Citation

- Each **tagged version** of the project is archived on **Zenodo**, generating a **DOI** for long-term preservation and citation.
  Contributors of the project will automatically become part of author list.



Demo

https://darkmatter.web.cern.ch

Challenges:

- Huge model parameter space.
- Classification is challenging
- How do we account for uncertainties in these exclusion plots
- We need to be very careful with what and how we are excluding a region.
-

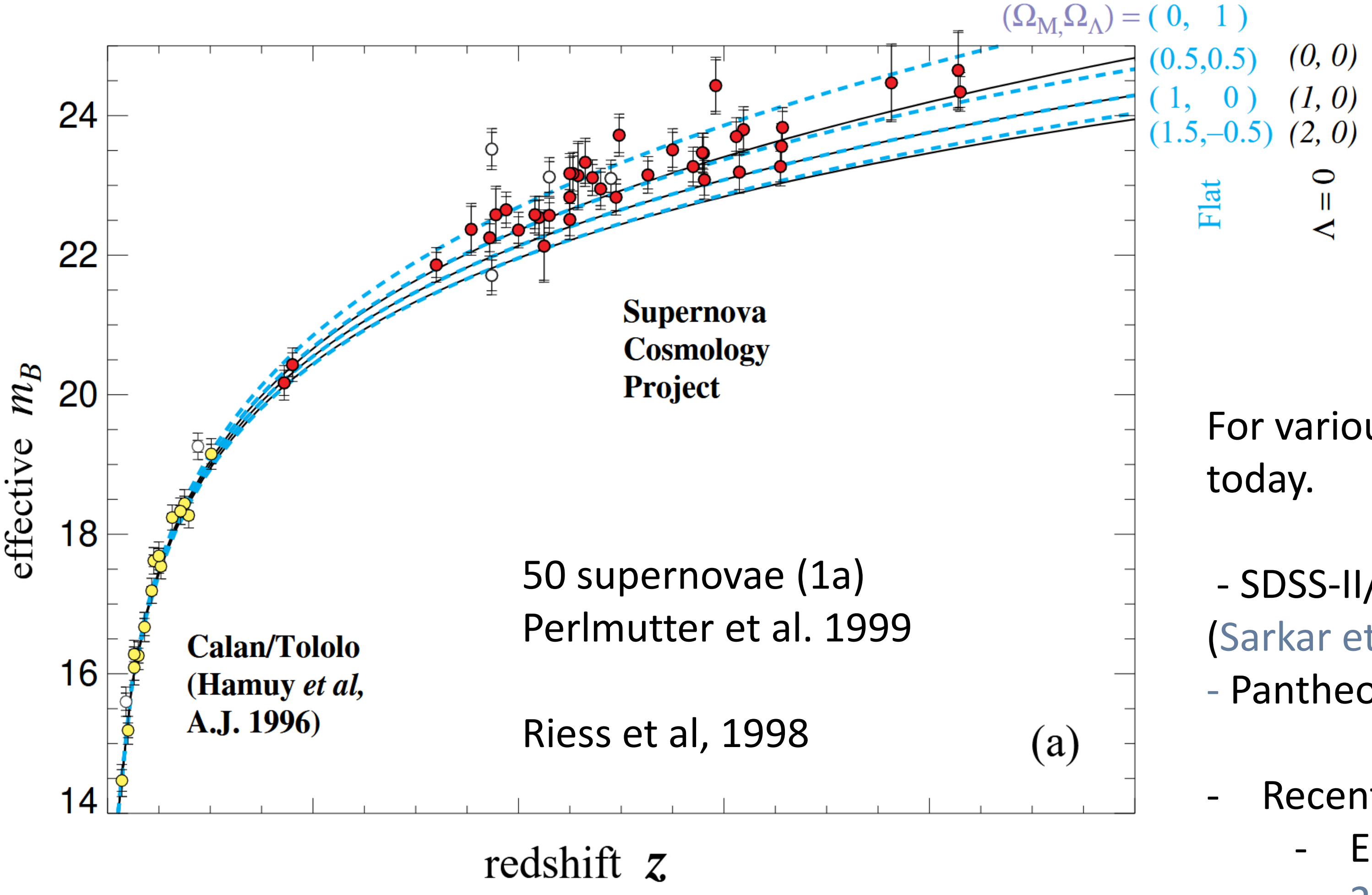
Thank you

Backup

Underexplored challenges: Cosmology: Dark energy

Manifesto: Challenging the standard cosmological model [10.1098/rsta.2024.0036]

Sarkar et al, 29 May 2025 [2505.23526]



"…. High redshift supernovae appear almost 0.15 mag (~15% in flux) fainter than the low redshift supernovae" (Compared to expectations for $\Lambda = 0$ universe)

For various reasons people are revisiting this conclusion today.

- SDSS-II/SNLS-3 Joint Lightcurve Analysis (JLA) 740 SNe, (Sarkar et al 2019)
- Pantheon+ - 1540 Rameez et al. 2024, 2411.10838

- Recent challenges to cosmological principle
  - Ellis & Balldwin test anomaly (Secrest et al. 2021, 2022, Wagenveld et al, 2023)
  - Cosmic dipole anomaly, Sarkar et al, 2505.23526 Bulk flows in local universe (Watkins et al. 2023)

The statistical method critics: March et al.(2011), Karpenka (2014), Nielsen et al (2015), Dam et al. (2017)