

MANCHESTER
1824

The University of Manchester

Dark Matter in Europe and Beyond:

The iDMEu initiative, and the European Strategy Update

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SHE/HER

UNIVERSITY OF MANCHESTER



** on maternity leave, so reaction time is a little longer than usual*

Introductions

Who am I?

A (relatively new to DMUK) collider physicist, aware that many experiments will be needed to determine the nature of DM!

Note: I don't speak on behalf of any experiment, but I've co-organised the LHC Dark Matter Forum and Working Group

Why this talk? Looking forward to collaborate and build upon

(I) the iDMEu initiative

(II) activities on dark matter complementarity, possibly with a UK focus for the European Strategy for Particle Physics Update 2025



The initiative for Dark Matter in Europe and beyond (iDMEu)

In October 2019, the proponents participated in [the first JENAS meeting](#) (2025: JENAS at RAL)

- Common **shared interest in dark matter**, coming from different communities
- We realised that we all have similar questions...
 - *E.g. “what are your assumptions?” “why do you use this technique?” “how will findings in your DM research impact my DM research?” “where can we meet and discuss this topic in depth after this seminar?”*
- ...and that we didn't have a place to learn more or discuss in detail

Current organisers

Marco Cirelli
Caterina Doglioni
Federica Petricca
Gabrijela Zaharjias
Silvia Scorza

Original proponents

Elena Cuoco
Marco Cirelli
Caterina Doglioni
Gaia Lanfranchi
Jocelyn Monroe
Silvia Pascoli
Federica Petricca
Florian Reindl

→ We decided to submit a
JENAS expression of interest [\[link\]](#)



JENAS Expressions of Interest

List of submitted Eoi:

1. Dark Matter - iDMEu (<https://indico.cern.ch/event/869195/overview>)

iDMEu goals

Discovering or constraining dark matter requires **broad discussion**
... but there is to date **no common platform to do so**



aims to be this **common**
dark matter
resources & discussion platform

where the different communities can
identify cross-fertilization opportunities for mutual benefits,
with the **broader perspective** of a **complementary** set of participants
(experimentalists, astrophysicists, cosmologists, theorists)



iDMEu goals, in a nutshell



About us ▾ Projects & communities ▾ Experiments ▾ News & Events ▾ Resources

Initiative for Dark Matter
in Europe and beyond

Collect dark matter
resources in an
online meta-
repository

Website:
iDMEu.org

Collection of
lectures and
outreach material
on website

Help develop a
common dark matter
story for different
audiences

Hans G. Oberlack, CC BY-SA 4.0, via Wikimedia Commons

iDMEu is still developing,
ideas & feedback welcome at
idmeu-organizers@cern.ch

Facilitate (and
participate in) new
cross-community
scientific
collaborations

- Kick-off (2021)
- Town Hall meetings (2023)
- *Wishlist*: Q&A forum, platform to initiate projects and collaborations



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Who is iDMEu? The curators

Curators

Home > About us > Curators

iDMEu Curators

The contents of this site have been developed by the Early Career Researchers in this page. You can reach the current iDMEu curators (with names in blue) at idmeu.jenaa.eoi.curators@gmail.com.

Join the iDMEu Curators team

If you are a Bachelor, Master or PhD student (or a supervisor) interested in internships and theses on iDMEu in collaboration with dark matter researchers, you can get in touch with [the iDMEu organizers](#) or use the [contact form](#). For a list of tasks that we'd like help with, see [this page](#).



Gabriella Szabó

Bachelor student, Lund University, Sweden

Contribution (Spring 2021): indirect detection table.

- [Link to Bachelor's thesis.](#)
- [Link to poster presented at the JENAA conference in 2022.](#)



Tom Laclavère

Bachelor student, Université de Paris, France

Contribution (Spring 2021): outreach table.



Sarah Ayoub

Bachelor student, PSL University, Paris, France

Contribution (Spring 2021): software table (TBC by M)



Aryaman Bhutani

Bachelor Student, IISc Bengaluru, India



Aloise Dijoux

Bachelor student, Université d'Angers, France

Contribution (Summer 2023): indirect detection table.



Romane Kulesza

Master student, Sorbonne University, Paris, France

Contribution (Spring 2021): direct detection table.



Joshua Greaves

Master's student, Lund University, Sweden

Contribution (2021-2022): dark photon page.



Maximilian Amerl

PhD Student, University of Manchester, United Kingdom

Contribution (2023): colliders page.

- [Link to Bachelor's thesis.](#)
- [Link to poster presented at the JENAA conference in 2022.](#)



Danielle Wilson-Edwards

PhD student, University of Manchester, United Kingdom

Contribution (2023): collider page.



Tobias Fitschen

Postdoctoral researcher, University of Manchester, United Kingdom

Contribution (2023): collider page, website maintenance.



Sukanya Sinha

Postdoctoral Researcher, University of Manchester, United Kingdom

Contribution (2023): collider page, website maintenance.



Pratik Jawahar

PhD student, University of Manchester, United Kingdom

Contribution (2023): cross-checks and updates of dark matter primer page.



Looking for PIs and ECRs who can help maintain the website within MPhys/MScR/Bachelor's theses (e.g. update experiment tables, see next slide)

Reward: invitations to JENA conferences, networking...



The iDMEu website: a sample



Example: **indirect detection**, but we also have **lectures** and **outreach resources**

Name ▲	Home page	Location ▲	Type of experiment ▲	Start year ▲	End year ▲	Low energy limit (GeV) ▲	High energy limit (GeV) ▲	TDR
Completed experiment								
PAMELA	Home	Low Earth orbit	Charged cosmic rays - electrons	2006	2016	0.50	5.00E+02	Link
PAMELA	Home	Low Earth orbit	Charged cosmic rays - positrons	2006	2016	0.05	3.00E+02	Link
PAMELA	Home	Low Earth orbit	Charged cosmic rays - antiprotons	2006	2016	0.08	2.00E+02	Link
Running experiment								
LHAASO	Home	Sichuan Province, China	Gamma rays	2019		100.00	1.00E+06	Link
Future experiment								
KM3NeT	Home	Mediterranean sea, Italy	Neutrinos	Future project		100.00	1.00E+08	Link

Fields for available tables:

Direct detection

Name
Phase/run
Location
Commissioning year
End year
Detection technique
Target material
Unit mass
Total mass
Exposure
Homepage
Main publication(s)

Indirect detection

Name
Homepage
Location
Type (CR species)
Start year
End year
Energy range
TDR publication

Wave-like DM exps

Name
Phase/run
Homepage
Location
Detection principle
DM mass range
Coupling sensitivity
Start year
End year
Main results publication(s)
TDR publication

Numerical simulations

Name
Simulation type/code
Number bodies
Volume
Minimal mass
Spatial resolution
Year
Main publication(s)

Current version:
last updated in 2023

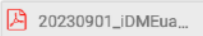

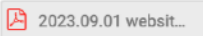

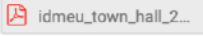



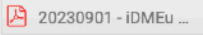
The iDMEu town hall at TAUP 2023

Facilitate (and participate in) new cross-community scientific collaborations

iDMEu Town Hall at TAUP (Vienna) and online

Friday 1 Sept 2023, 13:00 → 16:05 Europe/London

Seminar Room 1 (SR1) (University of Vienna)

13:30 → 13:35	Introduction from iDMEu organizers	5m
	 https://indico.cern.ch/e/idmeu-townhall-taup	
13:35 → 13:40	Introduction from JENA chairpersons	5m
	Speaker: Andreas Haungs 	
13:40 → 14:00	iDMEu virtual platform and feedback - Part 1	20m
	Speaker: Marco Cirelli (CNRS LPTHE Jussieu) 	
14:00 → 14:30	Theory landscape and new directions (20' + 10')	30m
	This contribution includes a talk and a brief discussion on the general topic of "the future of DM models and of phenomenology". This is intended as a critical reflection on the current status of the theory landscape on DM, covering developments that can be expected, as well as most promising perspectives and directions. Speaker: Dr Giorgio Arcadi (University of Messina (Italy)) 	
14:30 → 15:05	ECFA Detector R&D (DRD) process: liquid detectors/dark matter implications (10'+15'+10')	35m
	Following the interest at the iDMEu kick-off meeting to understanding potential synergies in detector technologies for dark matter experiments, these two contributions focus on the ongoing ECFA Detector R&D (DRD) process and dark matter with liquid detectors as a case study, and there will be time to discuss the implications for dark matter experiments in general. Speakers: Dr Anyssa Navrer-Agasson (University of Manchester), Ian Shipsey (University of Oxford (GB))   	
15:05 → 15:35	Dark matter complementarity in Snowmass (20' + 10')	30m
	In this contribution and discussion session we will highlight the efforts on dark matter complementarity within Snowmass (summarised in https://arxiv.org/abs/2210.01770), and use the discussion to understand whether there is anything to add to the white paper wishlist, to fully take advantage of complementary efforts that we would like to eventually bring forward in the future. Speaker: Deborah Pinna (University of Wisconsin Madison (US)) 	
15:35 → 16:00	iDMEu virtual platform (Part 2) and early feedback (10' + 15')	25m
	Speakers: Caterina Doglioni (University of Manchester (GB)), Federica Petricca (Max-Planck-Institut für Physik), Dr Gabrijela Zaharijas (University of Nova Gorica), Marco Cirelli (CNRS LPTHE Jussieu) 	

- September 2023, during TAUP
- Focus
 - Theory/experiment status
 - European Detector Roadmap (DRD) for DM experiments
 - Update from Snowmass
- Q&A question with the audience about website and directions
- Proceedings of TAUP: <https://arxiv.org/abs/2312.14192>



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“A story for different audiences”: an example

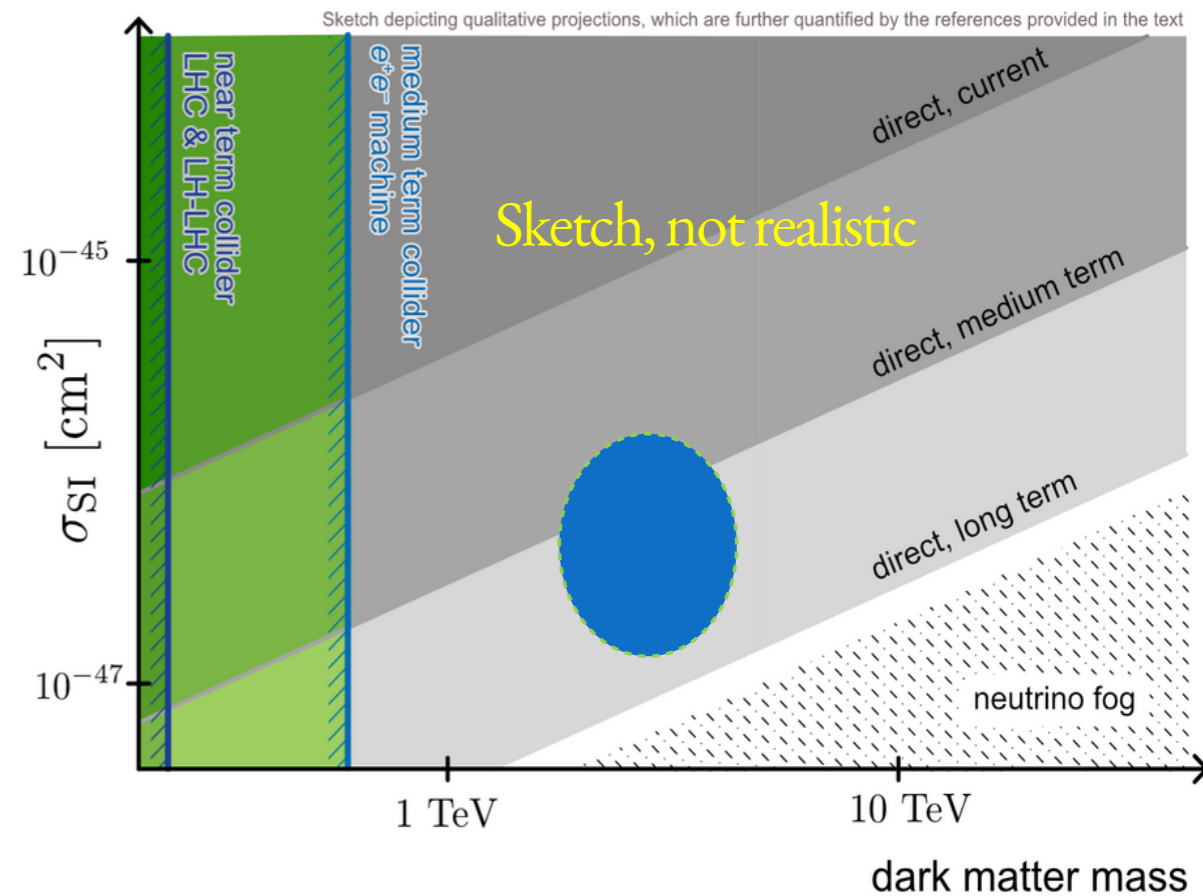
Help develop a common dark matter story for different audiences

Example of a discovery scenario

Late 2020s Direct detection experiment sees a hint of a signal, with characteristics compatible with WIMP DM

Mid 2030s

2040s



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Inspired by:
[Dark Matter Complementarity \(Snowmass report\), arXiv:2210.01770](#)
[T. Slatyer's "Paths to discovery" talk at Snowmass 2022](#)



“A story for different audiences”: an example

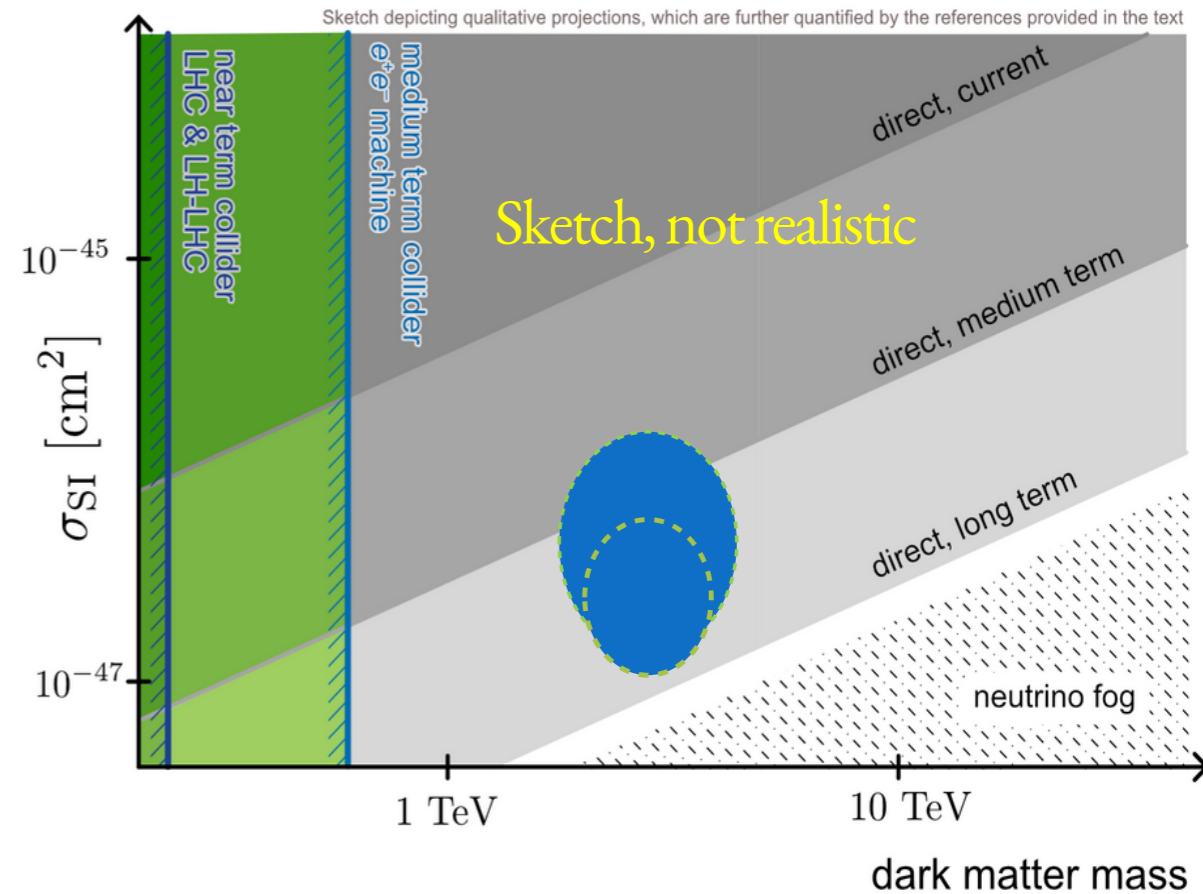
Help develop a common dark matter story for different audiences

Example of a discovery scenario

Late 2020s Direct detection experiment sees a hint of a signal, with characteristics compatible with WIMP DM

Mid 2030s Direct detection experiment (using another technique) confirms these hints

2040s



Inspired by:
[Dark Matter Complementarity \(Snowmass report\), arXiv:2210.01770](#)
[T. Slatyer's "Paths to discovery" talk at Snowmass 2022](#)



“A story for different audiences”: an example

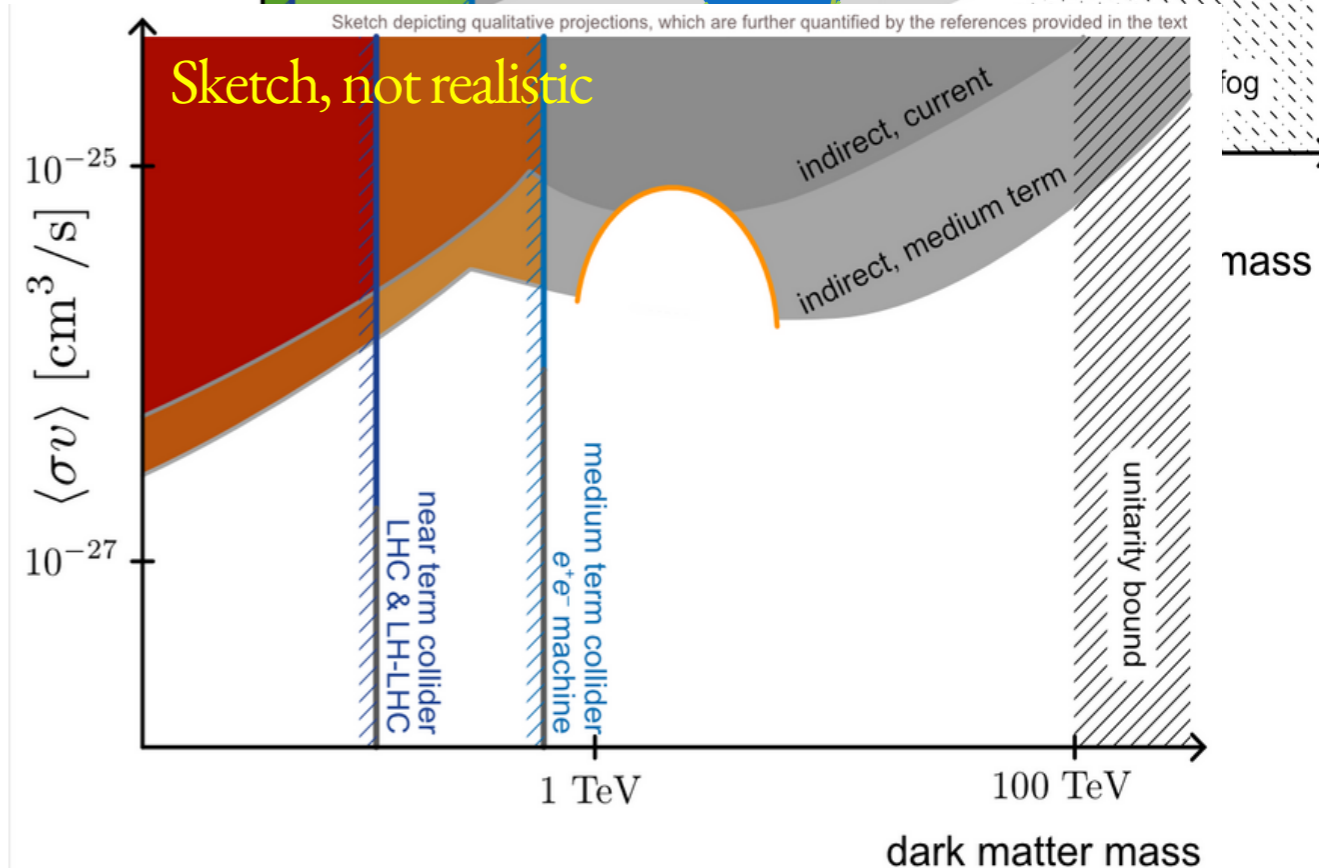
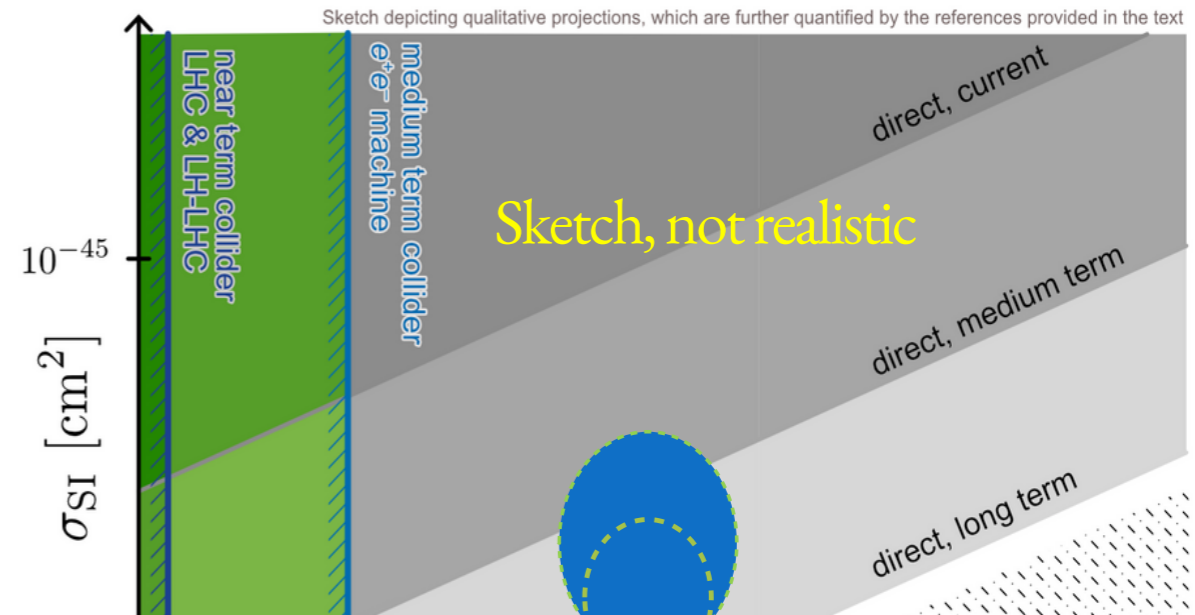
Help develop a common dark matter story for different audiences

Example of a discovery scenario

- Late 2020s** Direct detection experiment sees a hint of a signal, with characteristics compatible with WIMP DM
- Direct detection experiment (using another technique) confirms these hints
- Mid 2030s** Indirect detection experiment observes signals of DM annihilation
- 2040s**

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Inspired by:
[Dark Matter Complementarity \(Snowmass report\), arXiv:2210.01770](#)
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“A story for different audiences”: an example

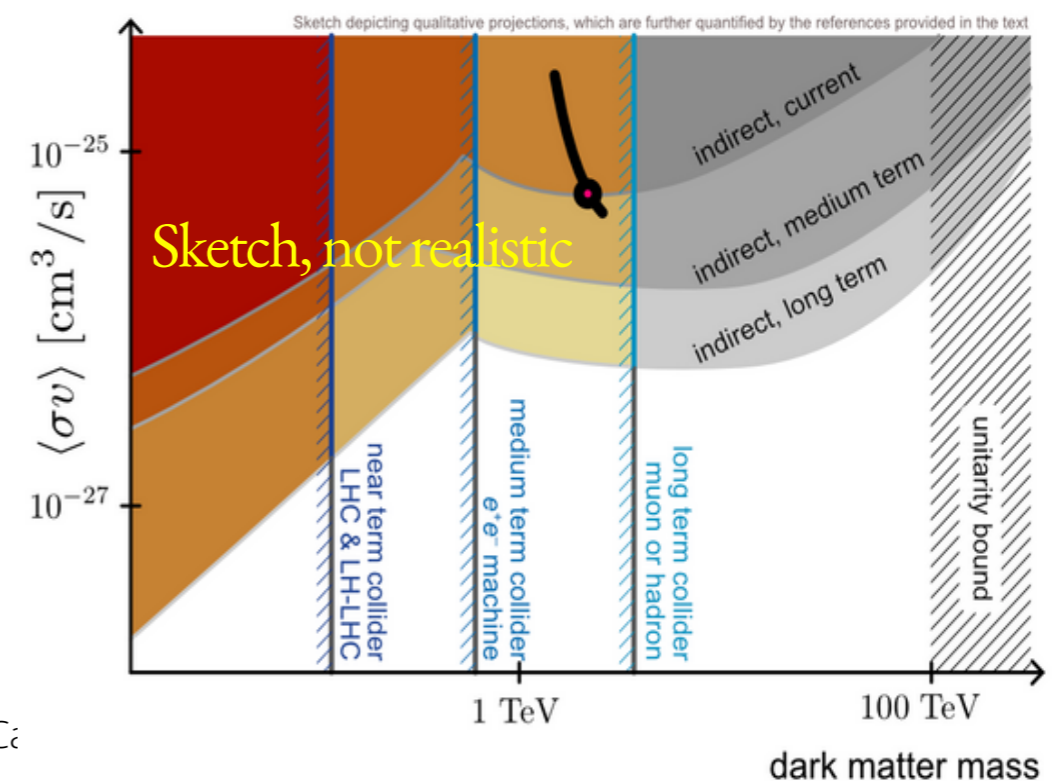
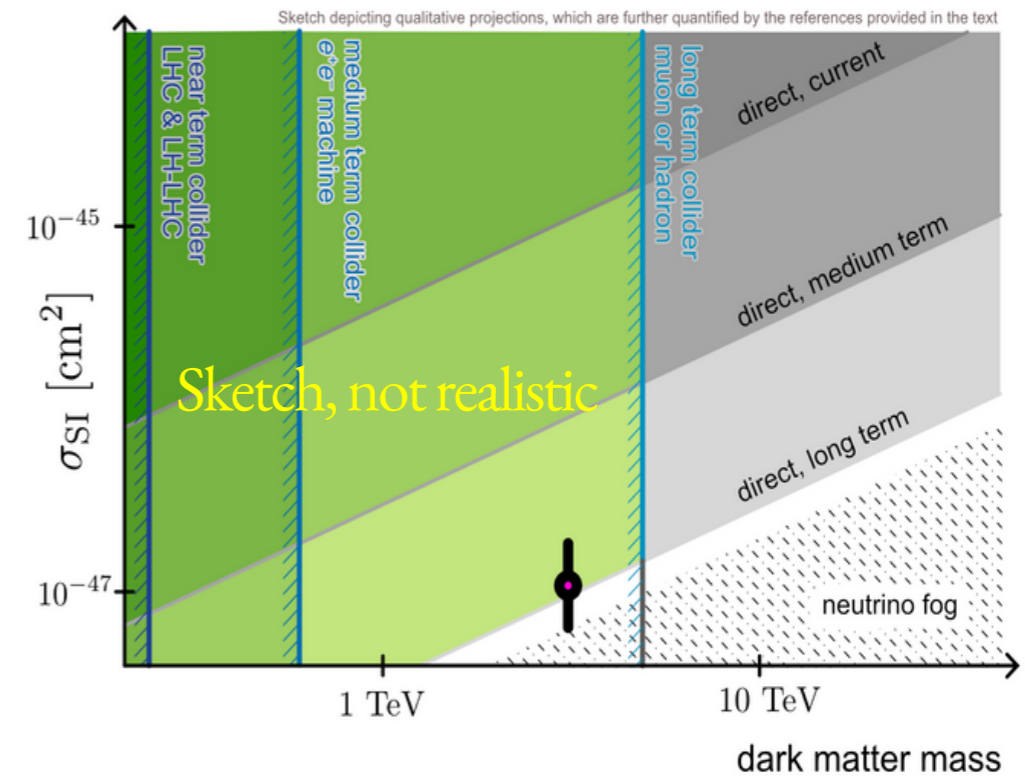
Help develop a common dark matter story for different audiences

Example of a discovery scenario

- Late 2020s
 - Direct detection experiment sees a hint of a signal, with characteristics compatible with WIMP DM
 - Direct detection experiment (using another technique) confirms these hints
- Mid 2030s
 - Indirect detection experiment observes signals of DM annihilation
- 2040s
 - Future collider, built to target particles with the mass of the putative DM candidate, sheds light on interactions between DM and ordinary matter

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Inspired by:
[Dark Matter Complementarity \(Snowmass report\), arXiv:2210.01770](#)
[T. Slatyer's "Paths to discovery" talk at Snowmass 2022](#)



Just finished: Snowmass DM complementarity

Deborah Pinna, Snowmass update @ iDMEu Town Hall TAUP

What is Snowmass?

see <https://snowmass21.org>



► Particle physics community planning exercise organized by the Division of Particles and Fields (DPF) of the American Physical Society

► **Snowmass goals:**

- work on/collect **new scientific studies**, mostly concerning on future directions for the field
- **engage** the community and junior scientists
- to prepare a collective **vision** for the **next decade of US particle physics**

- 10 thematic Frontiers (most relevant for DM: Cosmic/Energy/Underground...but all Frontiers are!)

- Community-written Letters Of Intent → o(500) Whitepapers, summarised in Frontiers reports and finally in Snowmass report (see snowmass21.org)

- Cross-Frontier report on DM complementarity

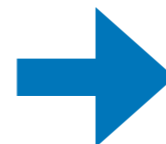
Word Clouds

Word clouds are made by looking at the word frequency in text. The more frequent the word, the larger the font-size in the word cloud. <https://gordonwatts.github.io/snowmass-loi-words>

All LOI's



<https://arxiv.org/abs/2210.01770>



arXiv > hep-ph > arXiv:2210.01770 Search... Help | Advan

High Energy Physics – Phenomenology

[Submitted on 4 Oct 2022 (v1), last revised 23 Jul 2024 (this version, v3)]

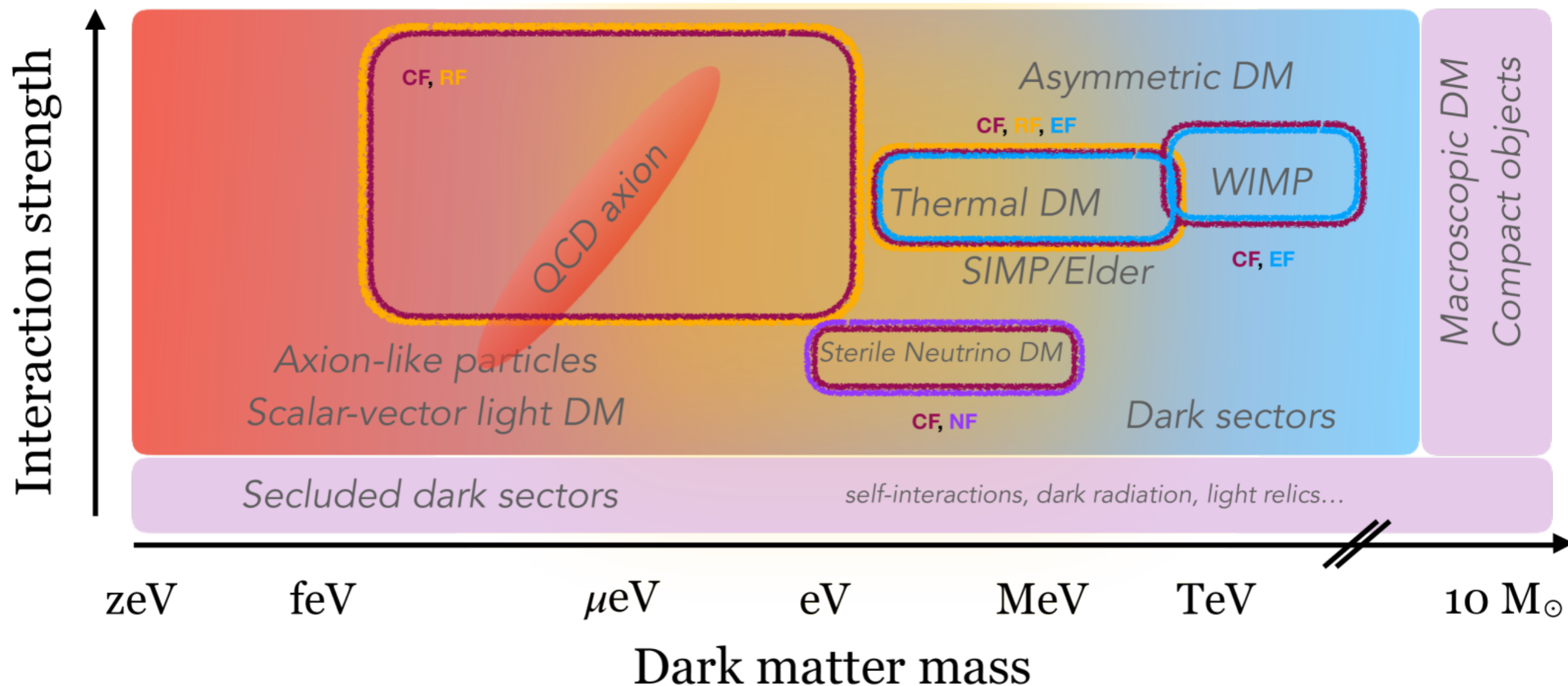
Snowmass 2021 Cross Frontier Report: Dark Matter Complementarity (Extended Version)

...where the previous figures/story come from



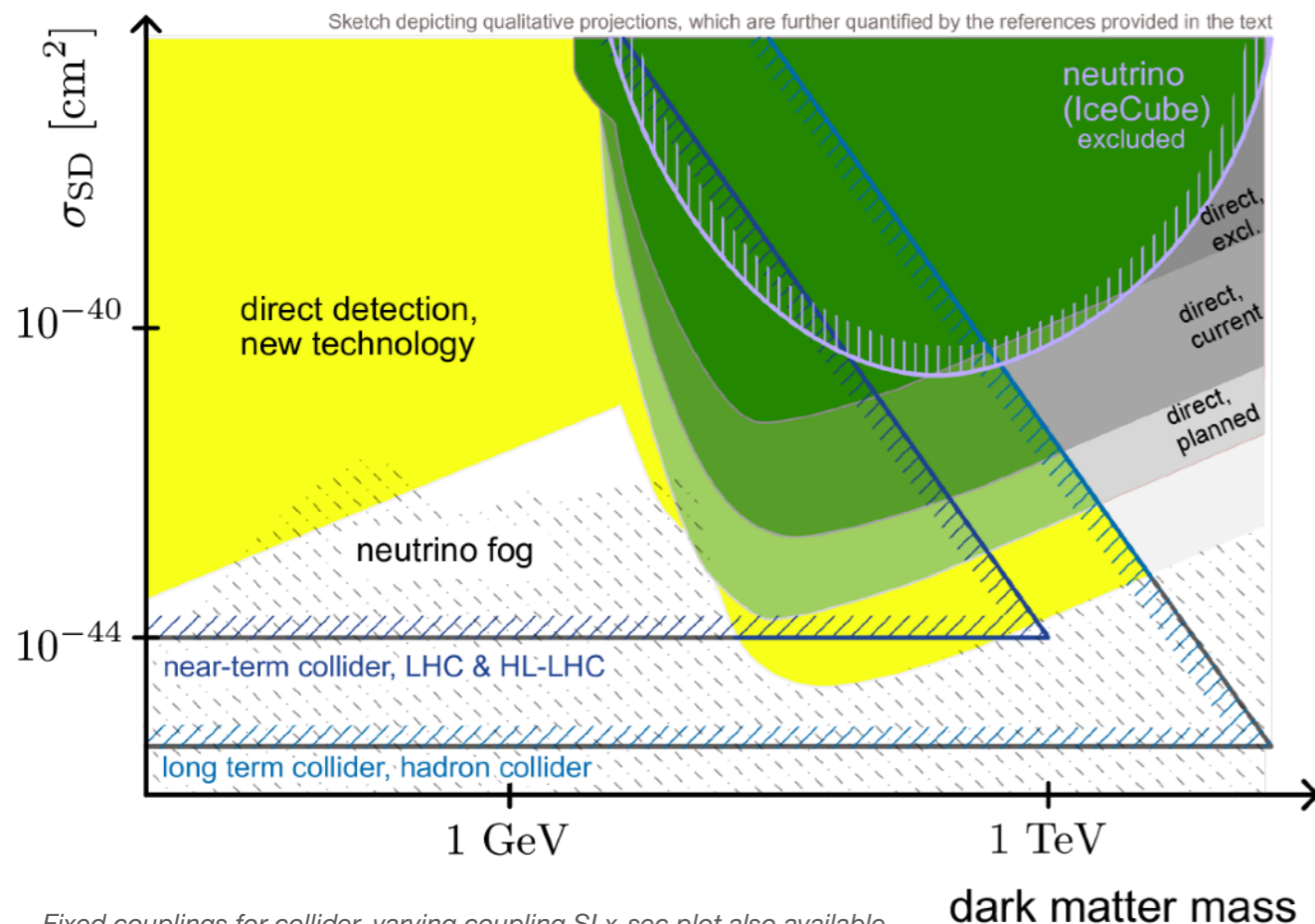
Snowmass DM complementarity scenarios

Four "case studies" to show interplay between different experiments

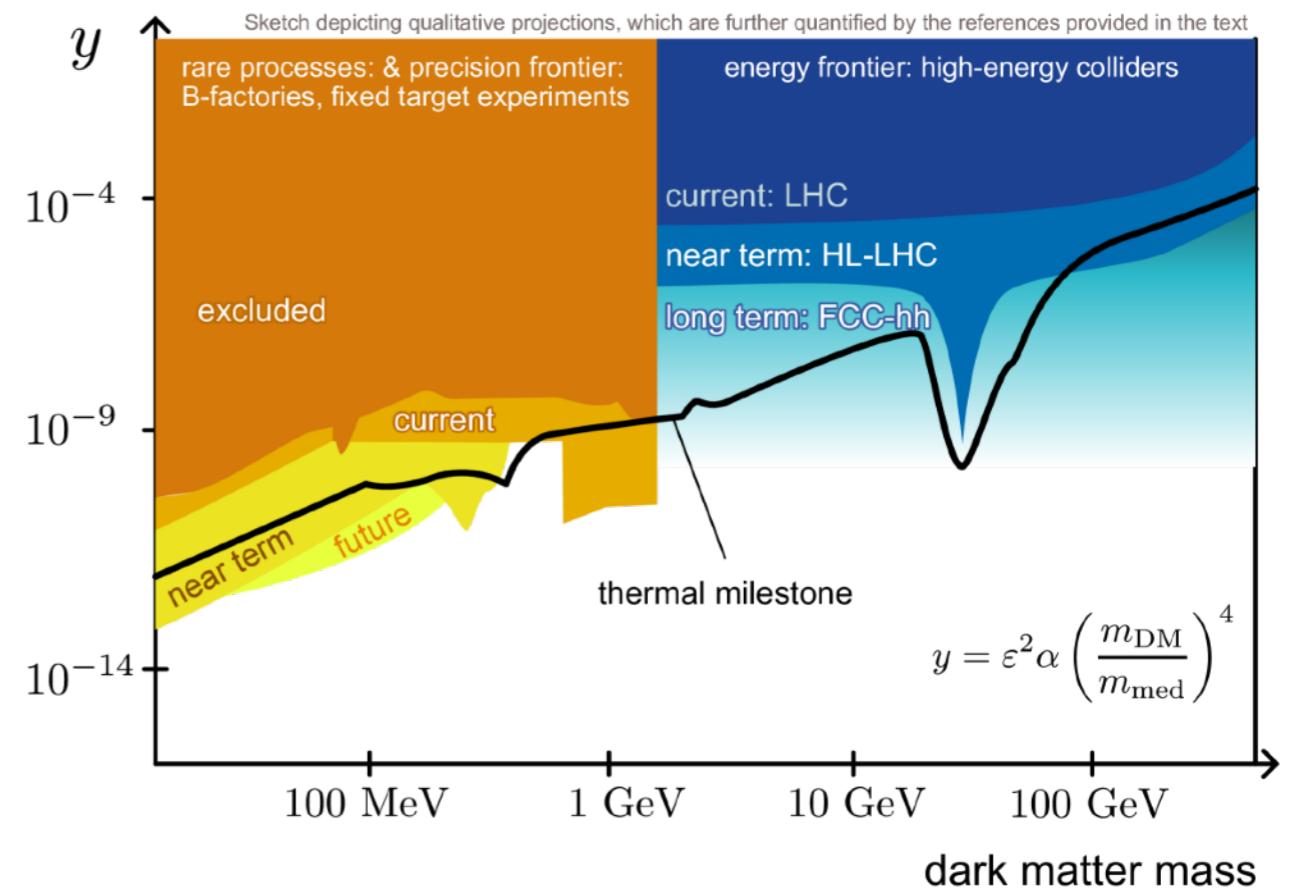


Snowmass DM complementarity scenarios

Four "case studies" to show interplay between different experiments
 Two examples: BSM-mediated DM and minimal dark photon



showing overlapping regions in colour
 (ideal/necessary for a discovery)



showing that different kinds of experiments are needed
 to cover the relic density target



Coming up: the European Particle Physics Strategy Update (EPPSU)

<https://europeanstrategy.cern/>

More complete description in talk by D. Bortoletto, Durham 2024

European Strategy for Particle Physics

Launched in 2005

The European Strategy for Particle Physics is the cornerstone of Europe's decision-making process for the long-term future of the field. Mandated by the CERN Council, it is formed through a broad consultation of the grass-roots particle physics community, it actively solicits the opinions of physicists from around the world, and it is developed in close coordination with similar processes in the US and Asia to ensure coordination between regions and optimal use of resources globally.

...

Third update

The third update of the European Strategy for Particle Physics was launched by the CERN Council in June 2024. One of its main goals is to develop a visionary and concrete plan that greatly advances knowledge in fundamental physics through the realisation of the next flagship collider at CERN, and to prioritize alternative options to be pursued if the preferred plan turns out not to be feasible or competitive.

- Organised in physics groups, one of which is **dark matter and dark sector**

(chaired by Jocelyn Monroe & Matt McCullough)

- Community-written inputs (including UK input: 2nd drafting session on 9/1) summarised in Briefing Book and finally in strategy recommendations

Timeline for the update of the European Strategy for Particle Physics



Not just CERN-centric: complementarity in the last EPPSU

[Last European Strategy Briefing Book:](#)

Outlook on synergies: Focusing on the quest for DM in the coming decades, at the Granada Symposium there was consensus in further developing synergies between the efforts of the high energy physics and astrophysics communities. The discussion highlighted the need for enhanced communication between accelerator/collider-based, direct detection and indirect detection dark sector searches, as well as the potential benefits of common technology platforms (see Chapter 11).

Consensus on common search targets is important for a joint interpretation of results from different searches, and will be of fundamental importance to validate a putative DM discovery in different experiments and channels. This can be facilitated by the existing LHC Dark Matter and EuCAPT Astroparticle

Further discussions among

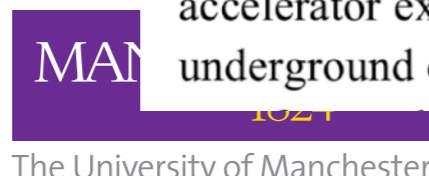
[Last European Strategy Update document:](#)

4. Other essential scientific activities for particle physics

- a) The quest for dark matter and the exploration of flavour and fundamental symmetries are crucial components of the search for new physics. This search can be done in many ways, for example through precision measurements of flavour physics and electric or magnetic dipole moments, and searches for axions, dark sector candidates and feebly interacting particles. There are many options to address such physics topics including energy-frontier colliders, accelerator and non-accelerator experiments. A diverse programme that is complementary to the particle physics Strategy. *Experimental physics programmes at laboratories and experiments in other regions*

5. Synergies with neighbouring fields

There are multiple synergies between particle and astroparticle physics, at the level of infrastructure, detectors, computing, interaction models and physics goals. These connections are through neutrino physics, dark matter searches, cosmic ray physics and, potentially in the future, gravitational waves. The precision measurements of the neutrino properties rely on solar and atmospheric neutrinos for the determination of several mass and mixing parameters. Large underground neutrino detectors are used both in long-baseline accelerator experiments and in astroparticle physics. Searches for dark matter are performed by dedicated underground experiments and by large astroparticle detectors like H.E.S.S., Antares or IceCube and, in the



Proposal: update of DM(UK) complementarity plots

Goal: Build on Snowmass complementarity cases and prepare message/plots focusing on UK(/European) experimental sensitivities

- **Why?**

- Target a white paper for the European Strategy update (deadline 31/03), but can also be used to strengthen UK funding cases
- Can be in sync with iDMEu goals
 - It doesn't have to be formally linked, although linking may provide platforms for visibility

- **How?**

- Code to make plots exists in various repositories, inputs from experiments needed
 - would still need some discussion on whether the assumptions work for everyone

- **Who?**

- Past work has been mainly done by MPhys/PhD students (with supervision)
- Anyone is welcome! Timescale isn't too long so dedication needed
- E-mail caterina.doglioni@manchester.ac.uk by 15/01 to be included in further communication



Thanks for your attention!