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

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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**

iDMEu

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)

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MANCHESTER 1824
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iDMEu goals, in a nutshell

Collect dark matter resources in an online meta-repository

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

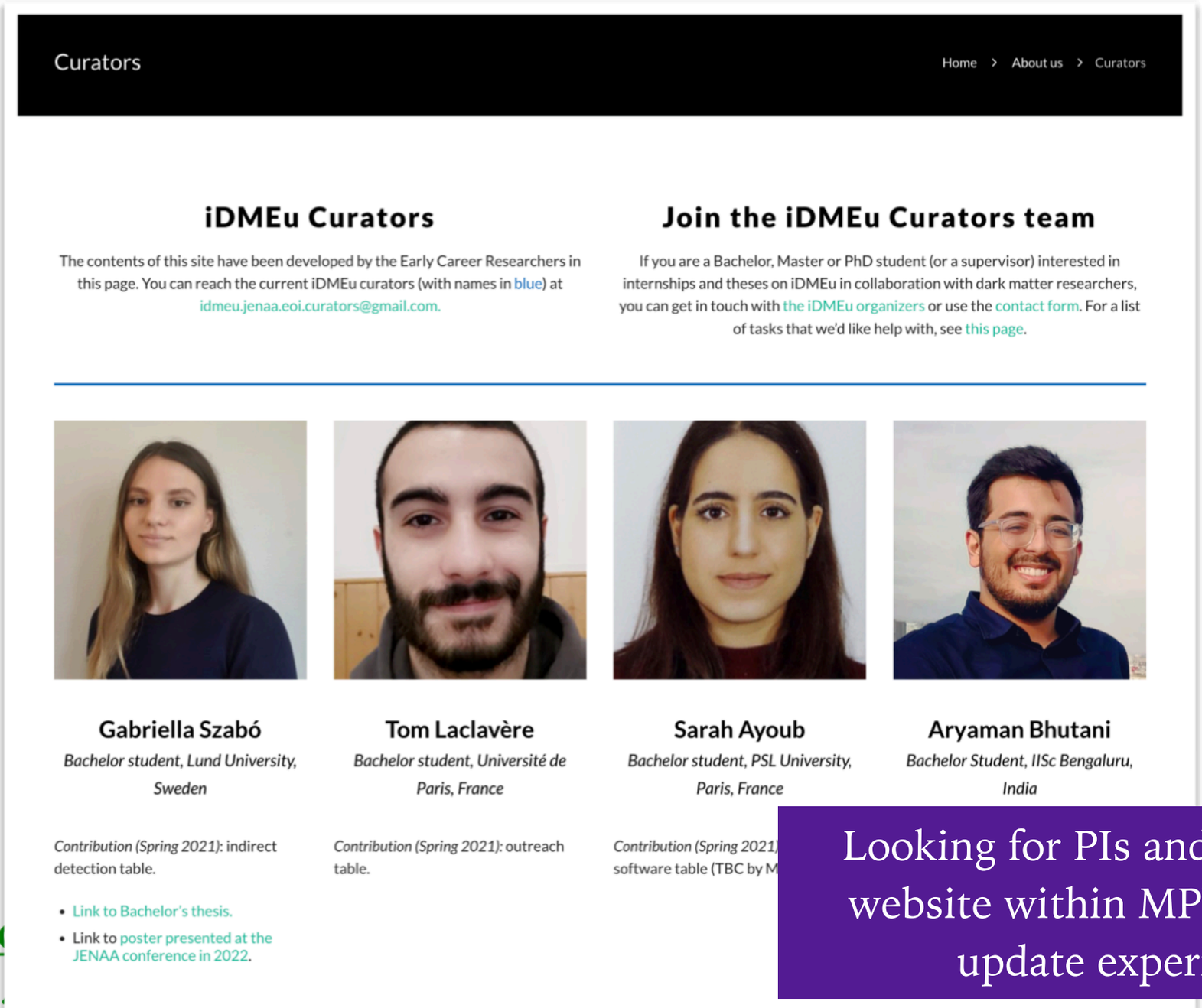
Help develop a common dark matter story for different audiences

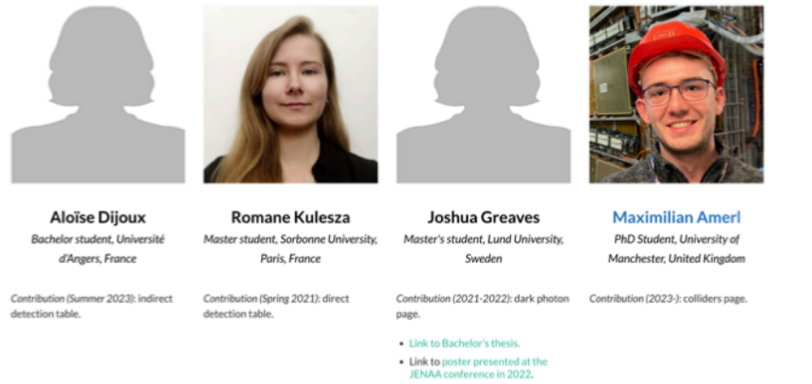
Collection of **lectures** and **outreach material** on website

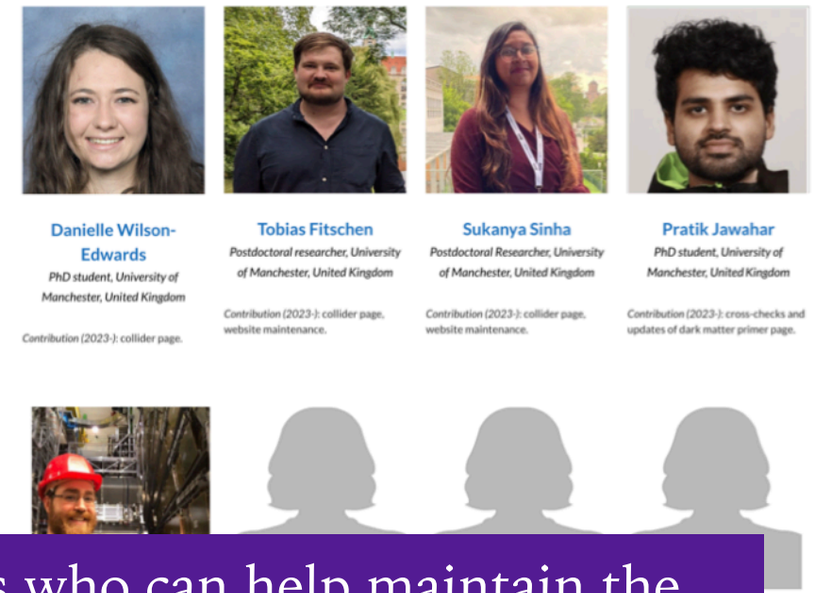
iDMEu is still developing, ideas & feedback welcome at idmeu-organizers@cern.ch

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

Who is iDMEu? The curators







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

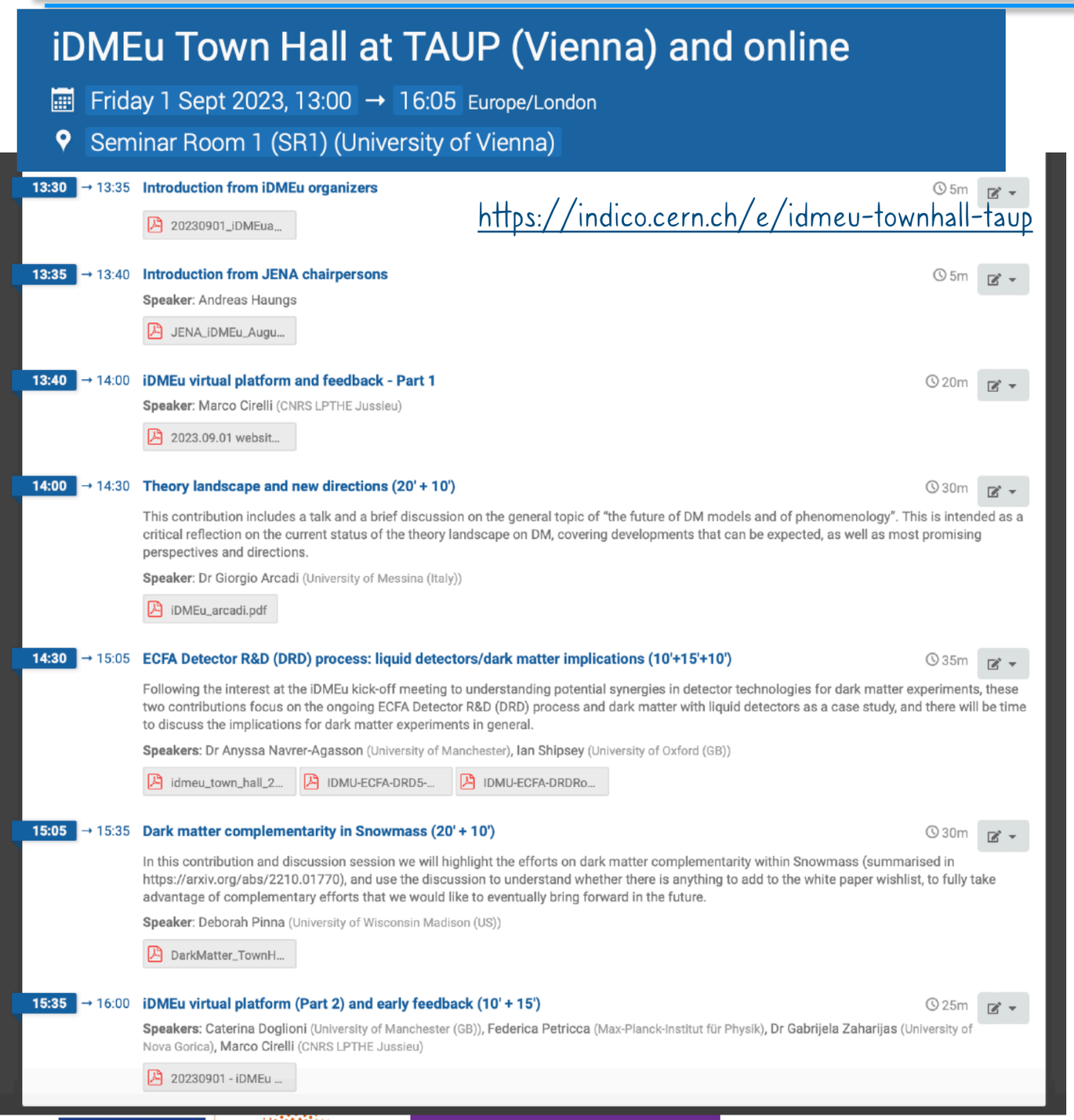
Wave-like DM exps
- Name
- Phase/run
- Homepage
- Location
- Detection principle
- DM mass range
- Coupling sensitivity
- Start year
- End year
- Main results publication(s)
- TDR publication

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



https://indico.cern.ch/e/idmeu-townhall-taup

- 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

"A story for different audiences": an example

Help develop a common dark matter story for different audiences

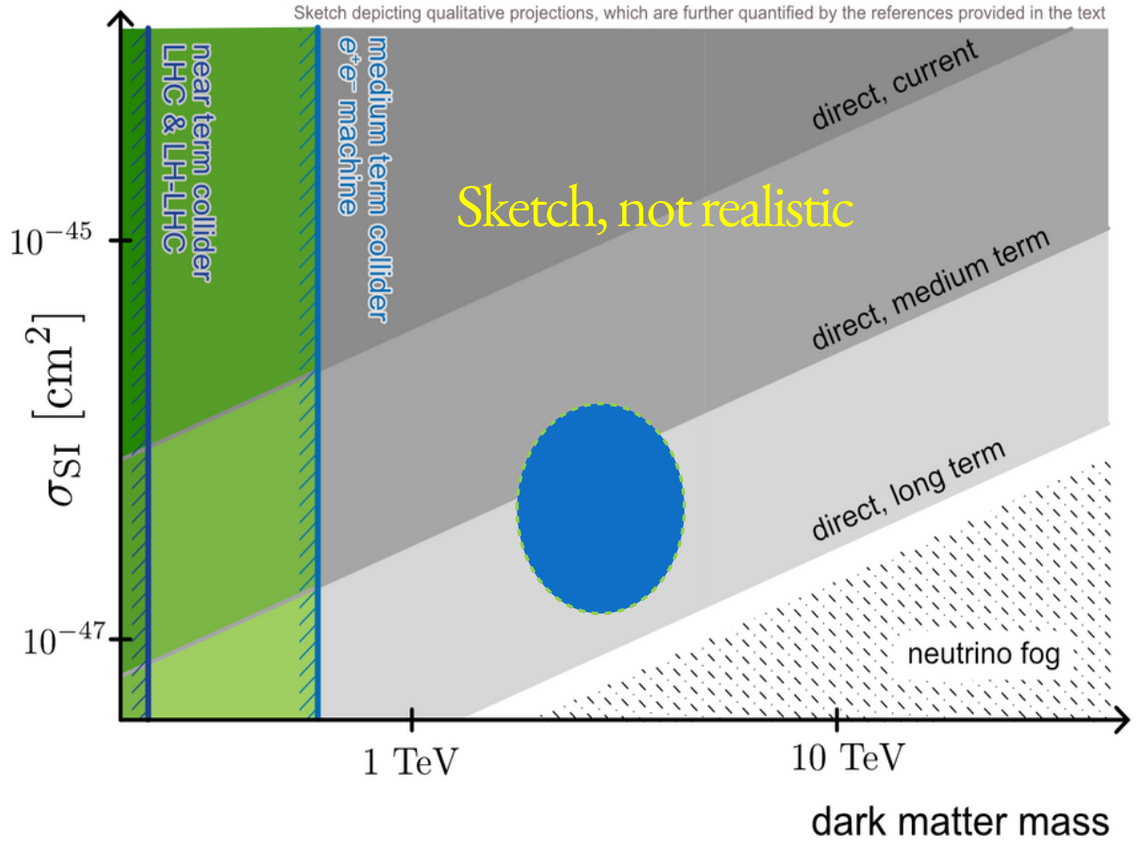
Example of a discovery scenario

Late 2020s

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

Mid 2030s

2040s



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

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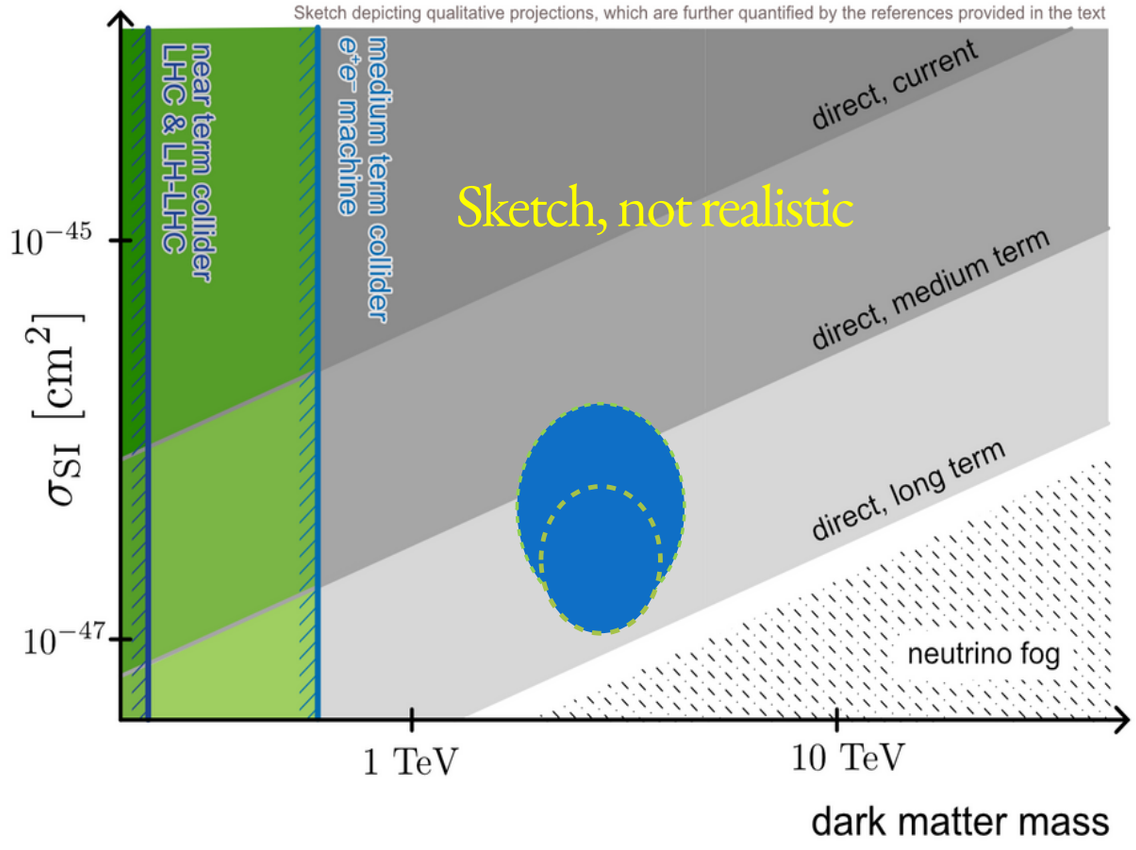

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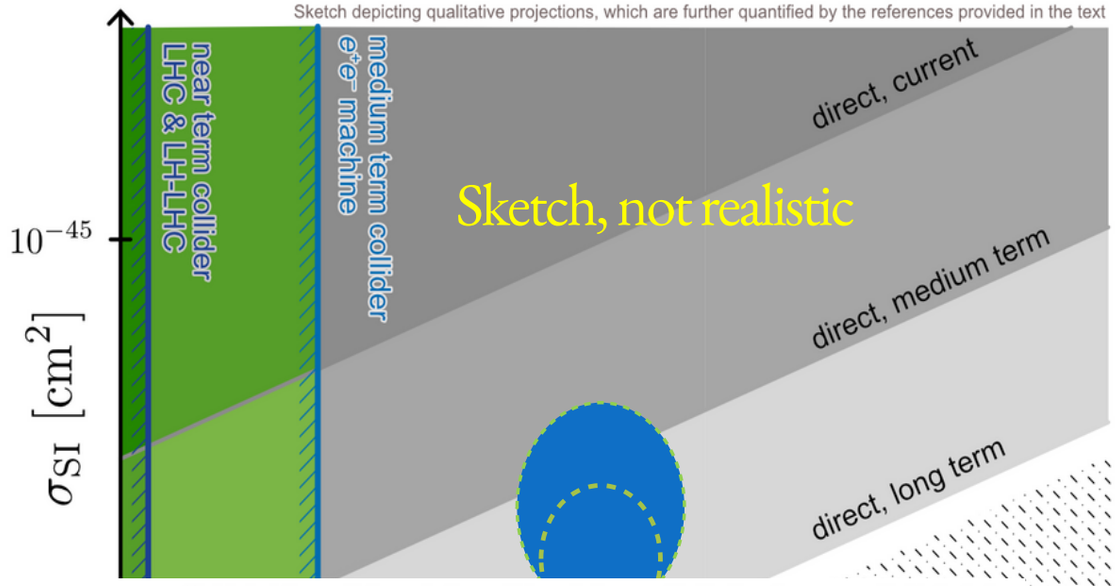

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Future collider, built to target particles with the mass of the putative DM candidate, sheds light on interactions between DM and ordinary matter

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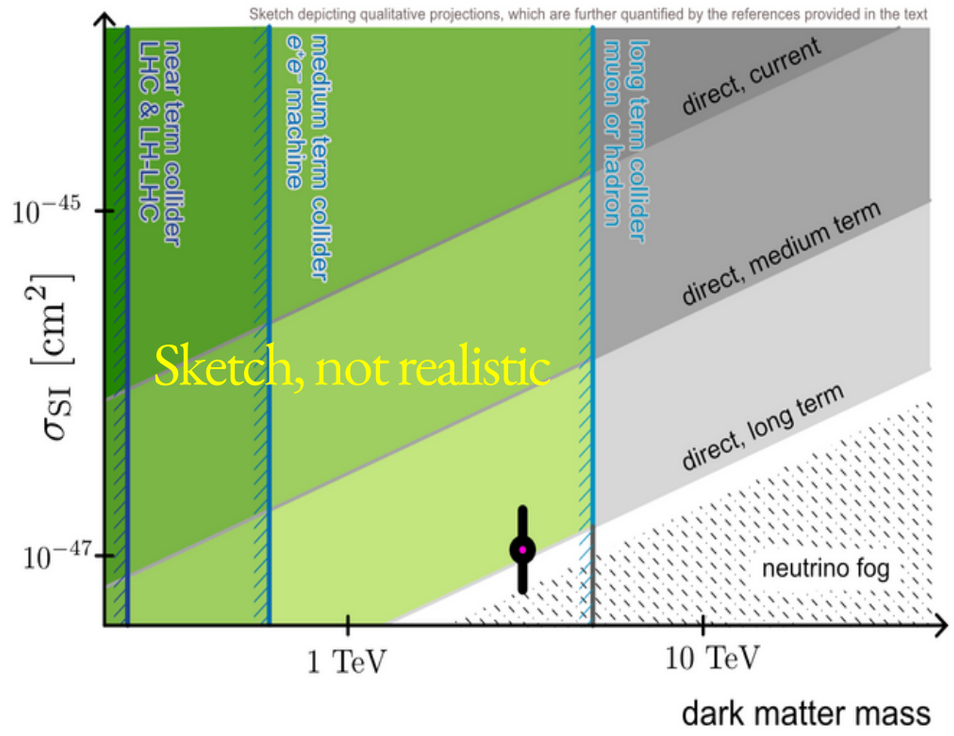

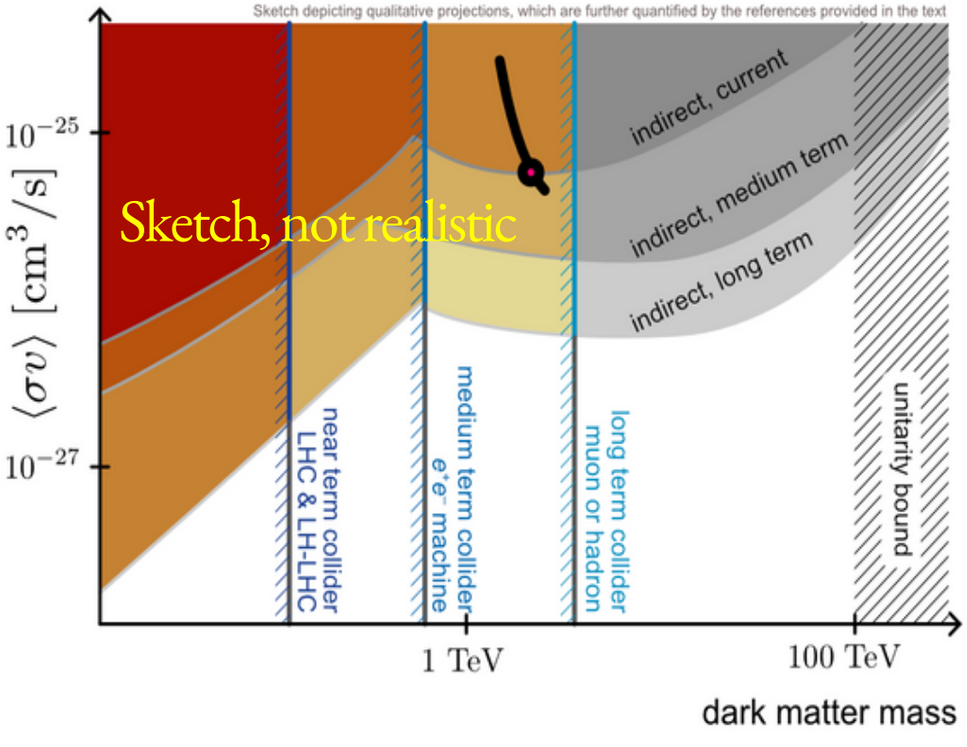

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Just finished: Snowmass DM complementarity

Deborah Pinna, Snowmass update @ iDMEu Town Hall TAUP

What is Snowmass?

see https://snowmass21.org

Snowmass 2021

- 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)

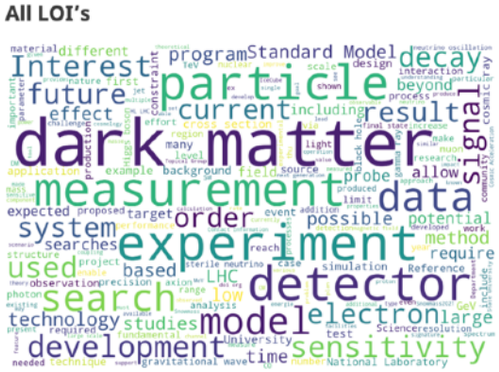
- Cross-Frontier report on DM complementarity

Word Clouds

Word clouds are made by looking at the word frequency in the LOI's. The more frequent the word, the larger the font-size in the word cloud.

https://gordonwatts.github.io/snowmass-loi-words

All LOI's



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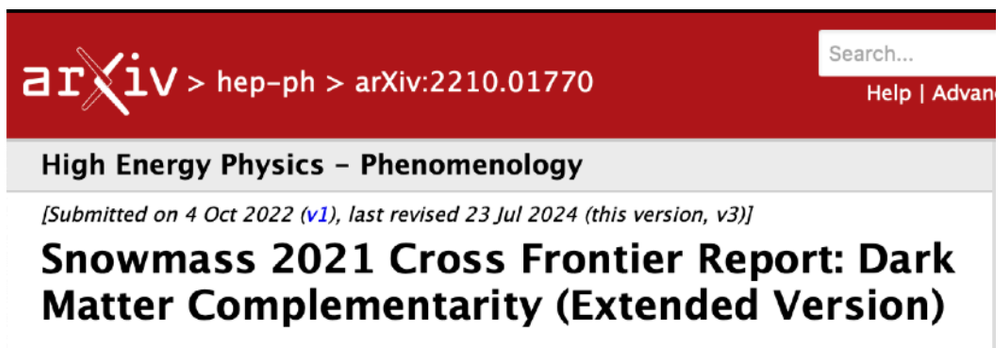

…where the previous figures/story come from

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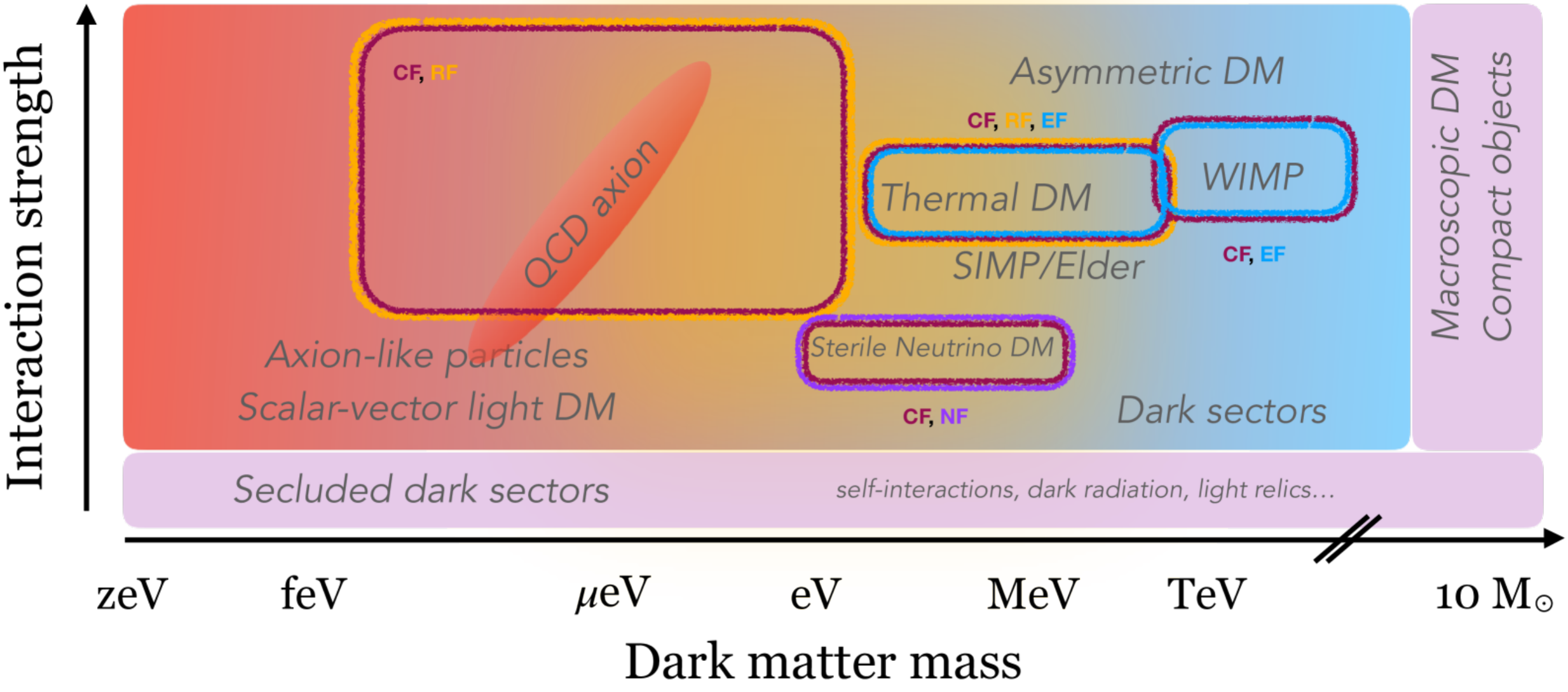
Snowmass DM complementarity scenarios

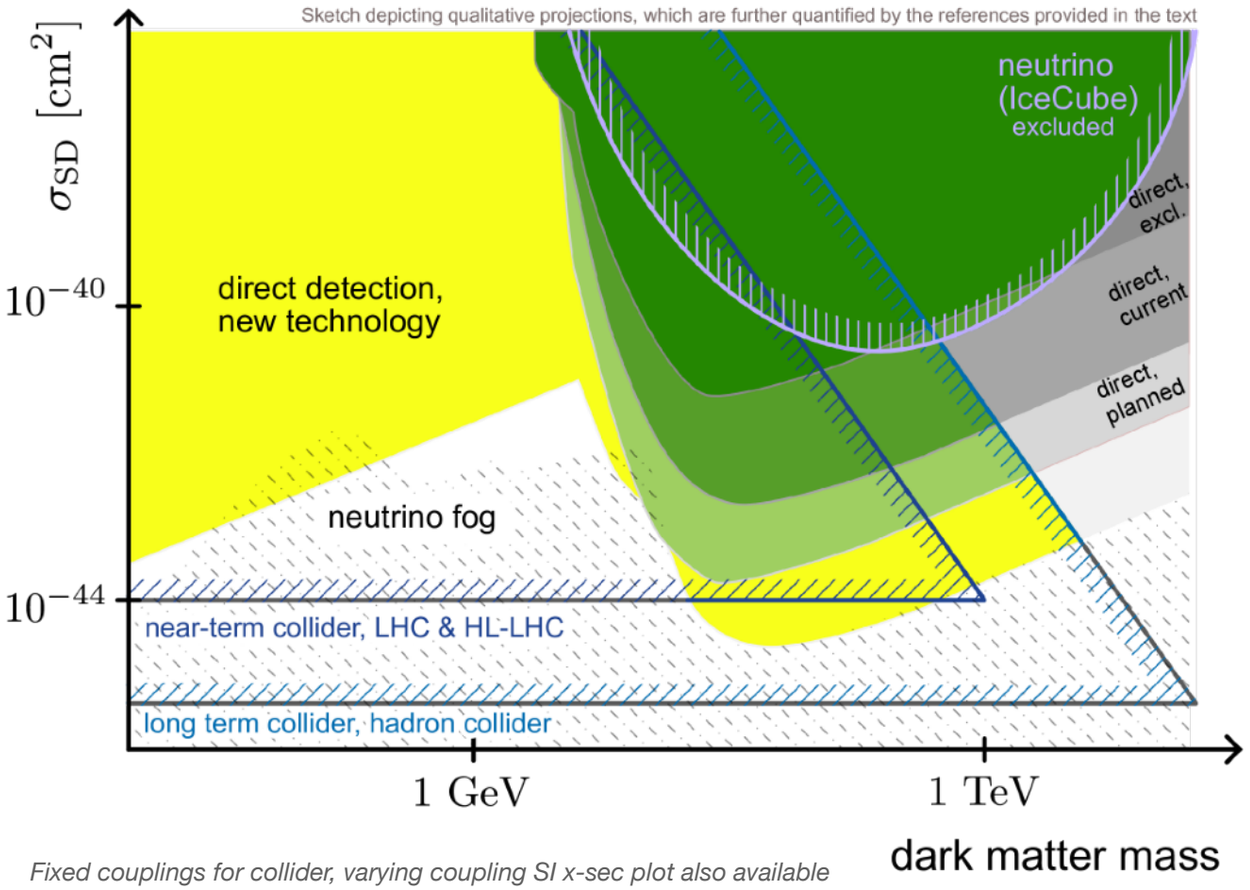
Four "case studies" to show interplay between different experiments



Snowmass DM complementarity scenarios

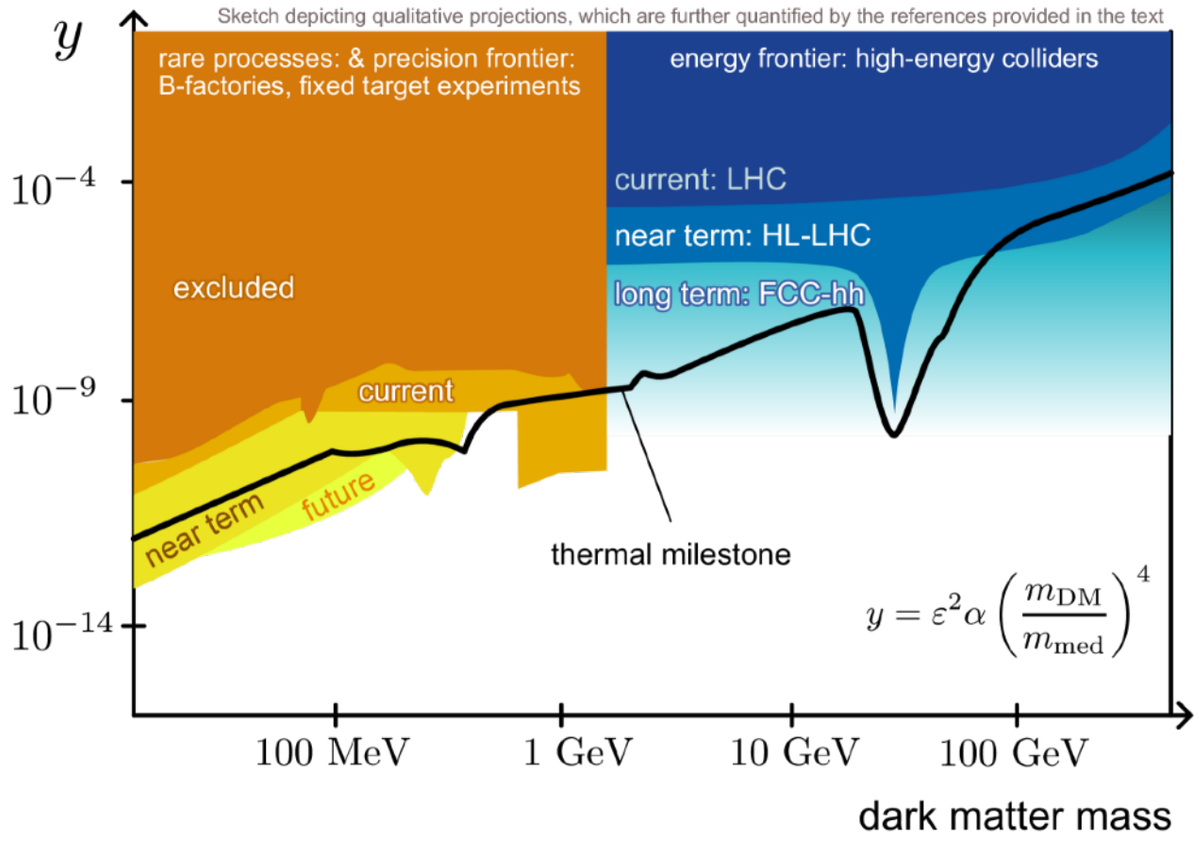
Four "case studies" to show interplay between different experiments

Two examples: BSM-mediated DM and minimal dark photon



Fixed couplings for collider, varying coupling SI x-sec plot also available

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, Durhamn 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.

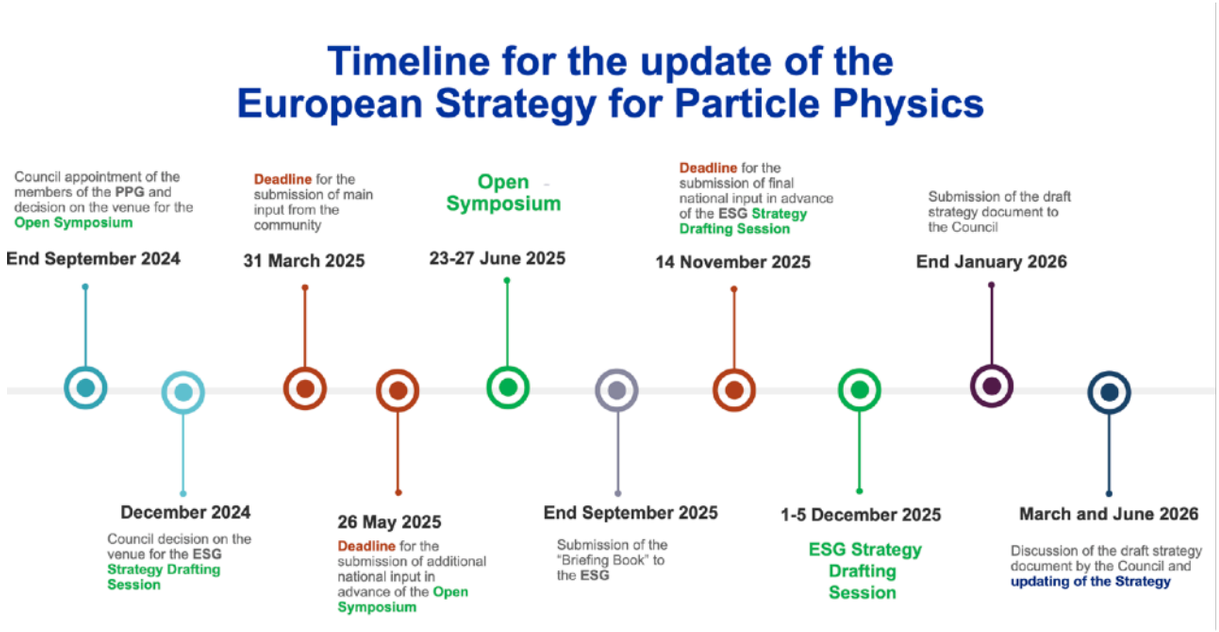
. . .

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



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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

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 com

particle physics Strategy. *Exp*

physics programmes at labor

experiments in other regions

ed EuCAPT Astroparticle

urther discussions among

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!