

iDMEu:

Initiative for Dark Matter in Europe and Beyond

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ICHEP, July 2020



What? [what is all about?]

JENAS: first Joint ECFA-NuPECC-APPEC Seminar [Orsay, October 2019]

✓ <u>Large attendance</u>

- 230 participants, present the chairs of the three communities
(J. d'Hondt, T. Montaruli and M. Lewitowicz)
the Research & Computing CERN Director (E. Elsen),
head of CERN EP Department (M. Krammer),
CERN Council Chair (U. Bassler), former ECFA Chair (T. Nakada)
and many representatives of European funding agencies.

✓ <u>Goal: Establish a common platform to seek synergies for:</u>

- Analysis and interpretation of results, theory models;
- Technology challenges;
- Data sharing, software and computing.
- Outreach (a unique story to tell?).

<u>Result of the meeting:</u> Open call for novel Expressions of Interest (EoIs)

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ApPEC Stan Bentvelsen, Nikhef Antonio Masiero, INFN Teresa Montaruli, University of Geneva

> Cocal Organization G. BERNARDI, LPNHE D. BOWE AND D. BOWE AND V. BROUILLARDI, JAL V. BROUILLARDI, JAL V. FROS, JENNO M. GUIDAL, IPNO A. KORICHI, CSNSM N. PALANGUE-OBLABROUILE, IFRU







proponents



iDMEu EoI: a joint-venture ECFA-APPEC-NuPECC About 300 signatories to date, sign it if you want to keep

https://indico.cern.ch/event/869195/overview

JENAS EoI: Initiative for Dark Matter in Europe and beyond: Towards facilitating communication and result sharing in the Dark Matter community (iDMEu)

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

Main reasons:

The broad community working on dark matter is active and diversified. It includes particle physics theorists and astrophysicists with a wide range of interests, as well as particle physics experimentalists focusing on collider, fixed-target, beam-dump, direct and indirect DM detection experiments, as well as dedicated axion/ALP, and neutrino experiments. A broad approach to dark matter research is necessary given the nature of the challenge.

Main goals: build a permanent platform where different DM communities can discuss, exchange results, and exploit cross-fertilization opportunities for mutual benefits.

Why ?

[Why cross-experimental collaboration?]

Dark Matter: Where to start looking ? Very little clue on the mass scale...



Cosmic Visions, arXiv:1707.04591

Going beyond the WIMP paradigm $\rightarrow \sim 80$ orders of magnitude to explore



80 orders of magnitude: No single experiment or experimental approach is sufficient alone to cover the large parameter space in terms of masses and couplings that DM models suggest.

Hence:

Synergy and complementarity among a great variety of experimental facilities are paramount, calling for a deep collaboration and cross-fertilization across different communities.

<u>Communities involved:</u> DM Direct and Indirect detection, collider, Beam-dump, fixed target, neutrino, axion/ALP experiments, Particle and astroparticle theory, and cosmology.

We are all intertwined. We need to talk together and to develop a "common language" [or - at least – to have a translator ;-)]

Dark Matter and fundamental physics questions

Fundamental Physics Questions might be naturally intertwined.



Dark Matter: the problem [a journey across the orders of magnitude]

Dark Matter: Where to start looking ? Very little clue on the mass scale...



From MACHOs searches

Cosmic Visions, arXiv:1707.04591

Going beyond the WIMP paradigm $\rightarrow \sim 80$ orders of magnitude to explore

i) The axion as DM candidate in the µeV-meV mass range but simple extension of this paradigm (ALP) can enlarge the possible range



Example of complementarity across communities:

axion/ALP with photon coupling [accelerator-based exps vs axion/ALP exps vs astroparticle bounds]





Example of complementarity across communities:

axion/ALP with photon coupling

[accelerator-based exps vs axion/ALP exps vs astroparticle bounds]



ADMX, CAST and MADMAX, ABRACADABRA, IAXO,....

Dark Matter: the problem

Dark Matter: Where to start looking? Very little clue on the mass scale...



From MACHOs searches

Cosmic Visions, arXiv:1707.04591

Going beyond the WIMP paradigm $\rightarrow \sim 80$ orders of magnitude to explore

ii) Dark Photon as DM candidate in the zeV-keV mass range



Example of complementarity across communities:

Dark Photon as Light DM candidate (mass < 1 MeV) [accelerator-based exps vs DM direct detection vs astroparticle bounds]



Dark Matter as a thermal relic: MeV-GeV range

Marcela Carena @ Granada



iii) Dark Matter as thermal relic in MeV-GeV mass range

Direct Detection Light (MeV-GeV) Dark Matter Searches: a vibrant field.

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IDM

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F. Reindl

Amazing effort by DD experiments to push the exploration in the MeV-GeV range down to the neutrino floor: \rightarrow connection with neutrino physics/stellar astrophysics

However:

✓ Many experiments:

In WIMP-like: 1300 scientists, 15-20 experiments, only 4 with > 100 people

✓ Many technologies:

Low-mass / low-energy frontier: New backgrounds, new processes

 \rightarrow connection to solid state and nuclear physics

✓ Many places:

- Gran Sasso, SNOLAB, etc..



→ Communication is a key challenge and needs to be improved

Making the most of DD data

What we have: Compilation of experimental results in certain scenarios/models

What we need: Sharing of (reduced) data sets to:

- Interpret for different scenarios/models
- Interpret with common statistic tools
- Combine results inside direct detection but also beyond (with accelerators and indirect detection)



Data repository + tools for theory interpretation

(Use and connect existing tools wherever possible)



Example of synergy across communities: Light DM with thermal origin via **Vector Portal**

[accelerator-based exps vs DM direct detection experiments vs cosmological bounds]





Example of synergy across communities:

Light DM with thermal origin via Vector Portal

[accelerator-based exps vs DM direct detection experiments vs cosmological bounds]



Dark Matter as a thermal relic: standard WIMP range

Marcela Carena @ Granada



iii) Dark Matter as thermal relic in WIMP mass range

Dark Matter as a thermal relic: standard WIMP range



Next generation of DD large experiments (Argo, DARWIN, ...) will push the exploration down to the neutrino floor in the standard WIMP window (10 GeV- few TeV): An opportunity for neutrino detection from different astrophysical sources? Moreover: DARWIN, thanks to its large mass, can play a role in the search for neutrino less double beta decay ...

Light DM with thermal origin via <u>Vector Portal</u> [ATLAS/CMS versus Direct Detection DM exps]



- ATLAS/CMS currently use o(1) reference couplings for DD/ID comparison plots:

- Work ongoing to reinterpret current searches and projections for future colliders using smaller couplings, to better depict the complementarity with non-collider experiments

- Following the European Strategy update, the Snowmass process (US particle physics input to prioritization effort) and the LHC DM WG hosting efforts that will be input to iDMEu

See Phys.Dark Univ. 27 (2020) 100365 for reference

Cosmology connection

DM is inherently a cosmological problem...







...with (perhaps) a particle physics solution...



...to be thoroughly tested in cosmology / astrophysics





large and diverse astro/cosmo communityworking ongalaxy formation/evolution, Large Scale Structure formation,numerical simulations, CMB, InterGalactic Medium,reionization, Lyman-α, γray- Xray- radio- astronomy...20

Indirect Detection

The WIMP regime (~1 GeV \rightarrow 100 TeV) continues to be thoroughly probed, new frontiers outside its '3 borders'

γ-rays: FERMI, HESS, VERITAS, MAGIC, HAWC, CTA, LHAASO...



WIMPs & very weakly coupled DM

Making the most of ID data

What we have: Plethora of excellent exp results.



What we need:

- map the community (tens of experiments w different techniques)
- harmonization (e.g. of astro assumptions)
- improve cross-talk (with DD, Collider, theory & astro/cosmo)

Lists & Meta-repositories Shared (Evolving?) Benchmarks? FAQ cross-talks

Neutrino Detectors and DM searches

Neutrino detectors can search for the annihilation of DM particles in high density regions.





iDMEu: Next steps

- ✓ Look for synergies and complementarities across very different communities:
- colliders, fixed-target, beam dump, flavor, axions/ALPs, DM direct and indirect detection, neutrino detectors,
- astroparticle, and cosmology.

\checkmark by developing a common platform where :

- Results and underlying models are discussed and compared
- Pointers to Data, Results and relative analysis tools are shared (via meta-repositories)
- Common plots are compiled
- Main scientific (workshop, conferences, seminars,...) and general public events are advertised.

✓ Communities we plan to involve:

- DM and LLP @ LHC WG
- Physics Beyond Colliders (including fixed-target/beam dump exps);
- DM direct and indirect detection experiments;
- Neutrino experiments;
- axion/ALP communities;
- particle theory (CERN-TH, others) and astroparticle theory (EuCAPT = European Consortium for AstroParticle Theory)
- ✓ And (on more technical side):
- ESCAPE (European Science Cluster of Astronomy and Particle Physics ESFRI research infrastructures,
- The Phystat-DM community
- direct detection plotting tools developers, e.g. DMTools and SuperCDMS limit plotter



The European Consortium for Astroparticle Theory

https://www.eucapt.org/

- ✓ The European Consortium for Astroparticle Theory (EuCAPT) aims to bring together the European community of theoretical astroparticle physicists and cosmologists. It was established in 2019 and CERN is its "hub" for the next 5 years. The director is Gianfranco Bertone aided by a Steering Committee.
- ✓ A main scientific focus is Dark Matter. EuCAPT will endeavour to play an important role in the theoretical effort in understanding the nature and properties of dark matter, facilitating exchanges and discussions in the community.
- ✓ It has already started several (mainly online) activities such as regular colloquia and workshops, including a face-to-face workshop on gravitational waves last year. An inaugural symposium is planned for next year.

EuCAPT endorses iDMEu, and looks forward to contrributing to its success



Expressions-of-Interest (EoI) from JENAS

In general, these topics have been noted in the updated Strategy for particle physics. What can APPEC, ECFA and NuPECC offer to strengthen the synergies for an EoI topic:

- Supporting the organization of (tele-)gatherings across communities on the EoI topic (workshops, town meetings, platforms for continuous discussions, ...)
- Make announcements related to the EoI topic through our channels across the three disciplines
- Help with the dissemination of the activities and potential reports of the EoI topic (reports at APPEC, ECFA and/or NuPECC meetings, articles in our newsletters, ...)
- Link the project specific **website** on the APPEC, ECFA and/or NuPECC websites
- Help with community wide calls to seek collaborators, with calls for venues for specific events and with funding applications for the EoI topic
- Raise the awareness of the EoI topic in our scientific communities and to policy-making bodies
- Organize dedicated sessions at the JENAS events on the EoI topic

Conclusions

The breath of the open questions in particle physics and their deep interconnection, together with the failure so far of standard paradigms, requires today more than ever a diversified research programme with different experimental objectives and techniques, and with strong and focused theoretical involvement.

The ability to develop innovative theoretical ideas to be tested at existing or proposed experiments while keeping the outcoming results framed and structured and including also results from neighboring fields, like cosmology and astrophysics, will be crucial to define the future of this field.

First iDMEu kick-off meeting planned by end of the year. More news after summer. Register here if you want to follow our next steps: https://indico.cern.ch/event/869195/overview



Thank you for your attention.

Please, join me in my zoom room if you want to continue the discussion: https://lu-se.zoom.us/j/65057668977, today 12:00-13:00 (CEST).