Snowmass2021 - Letter of Interest

The ESCAPE Dark Matter Test Science Project

Thematic Areas: (check all that apply □/■)

■ (CompF7) Reinterpretation and long-term preservation of data and code
■ (CF1) Dark Matter: Particle Like
■ (CF3) Dark Matter: Cosmic Probes
■ (EF10) Dark Matter at colliders
■ (CommF4) Physics Education
■ (CommF5) Public Education and Outreach

Contact Information:
Caterina Doglioni (caterina.doglioni@cern.ch);

Authors:

Note: The list of authors below does not yet reflect all those interested in working on this topic - that will grow as we kick-start the work on this project (Fall/Winter 2020)

Elena Cuoco - EGO and Scuola Normale Superiore di Pisa; Caterina Doglioni - Lund University; Giovanni Lamanna - LAPP (Laboratoire d'Annecy de Physique des Particules), CNRS/IN2P3 and USMB; Kay Graf - FAU; Samuel Meehan - CERN;

Content:

One overarching objective of science is to further our understanding of the universe and its composition. The nature of dark matter (DM), corresponding to 85% of the matter currently present in the universe is still unknown[1]. The presence and distribution of DM is detected through its gravitational interactions by observatories and experiments, while the interactions of DM with ordinary matter particles can be observed indirectly and directly in astrophysics experiments[2,3]. These interactions also allow for DM to be produced in collisions of ordinary matter and observed in experiments at colliders[4] and at particle accelerators [ref], and provide complementary information about dark matter - ordinary matter interactions. Data from this wealth of astrophysics and particle physics experiments, combined with theoretical models and interpretations, will shed new light on dark matter.

The presence of DM in astrophysical observations, combined with the absence of clues for DM particles in experiments, indicates that if DM has interactions with ordinary matter they must be very feeble, and produce subtle experimental signals. Connecting results and potential discoveries from different experiments requires the involvement of all communities involved - astrophysics, particle physics and nuclear physics. Besides the interpretation of results in terms of dark matter theories, synergies also exist between different communities and experiments in the tools needed to produce those results, in particular in terms of data management, data analysis and computing. This is why this LOI presents the Dark Matter Test Science Project (TSP) within the European Science Cluster of Astronomy and Particle physics ESFRI research infrastructures (ESCAPE) project, to create a link between DM as a fundamental science question and the computational tools needed to answer it.

As part of this TSP, we will convert the existing experimental data and software procedures to sustainable

analysis pipelines as a prototype for selected direct detection, indirect detection, and collider experiments involved in ESCAPE, relying on the ESCAPE service infrastructure. We will make use of the ESCAPE Data Infrastructure for Open Science in the European Open Science Cloud to store, distribute and provide data access to the dark matter scientific community, also making this data searchable, while respecting experiment Open Data Policies. The work within this TSP aims to include all the science data and digital objects (for example data management, metadata, reconstruction software, analysis pipelines, simulations...). The final output of each workflow will be individual experimental curves to be interpreted in terms of dark matter particle properties. The pipelines will also be designed so that they can ultimately automatically (re)produce this kind of plots with new models.

Another objective of this TSP is to support the creation of a collection of versioned repositories for experimental results as well as for theory predictions and interpretations. We will implement this service by making available experimental data, results and their interpretations discoverable through the ESCAPE Science Analysis Platform.

Another objective of this TSP is to catalogue and create new resources for citizen science and crowd-sourced data mining, aided by citizen participation within the ESCAPE Citizen Science program. Finally, the DM-TSP will help DM researchers with the implementation of Particle Physics Masterclass exercises in which high school students can become dark matter scientists for a day and analyse experimental data.

In the context of Snowmass, we propose to hold ”hackathons” in collaboration with the HEP Software Foundation to both educate a broader community about existing tools available for analysis preservation (e.g. REANA) and further *apply* these tools to a select number of analyses from the relevant scientific frontier working groups. This hackathon will provide examples of sustainable end-to-end science workflows for dark matter experiments with US involvement and better enable future collaboration with the DM TSP. We will benefit from discussions and cross-talk between the Cosmic, Energy, Rare and Precision and Computational Frontiers, as already recommended within the update of the European Strategy of Particle Physics[5,6] .

References

[1] G. Bertone and D. Hooper, *History of dark matter*, *Rev. Mod. Phys.* **90** (2018) 045002 [1605.04909].

[2] J. M. Gaskins, *A review of indirect searches for particle dark matter*, *Contemp. Phys.* **57** (2016) 496 [1604.00014].

[3] M. Schumann, *Direct Detection of WIMP Dark Matter: Concepts and Status*, *J. Phys.* **G46** (2019) 103003 [1903.03026].

[4] A. Boveia and C. Doglioni, *Dark Matter Searches at Colliders*, *Ann. Rev. Nucl. Part. Sci.* **68** (2018) 429 [1810.12238].

[5] R. K. Ellis et al., *Physics Briefing Book: Input for the European Strategy for Particle Physics Update 2020*, 1910.11775.

[6] The European Strategy Group, *Deliberation document on the 2020 Update of the European Strategy for Particle Physics*, Tech. Rep. CERN-ESU-014, Geneva, 2020. 10.17181/ESU2020Deliberation.