Throughout my career, I have been driven by finding out more about the constituents of matter as well as by the challenges related to the “big science” needed to study them (complex instruments, vast amounts of data, an international community working together). I chose to pursue my research at the Large Hadron Collider (LHC), the largest discovery machine ever built by humankind that could produce dark matter (DM) particles in controlled conditions, contributing to the solution of a mystery of our universe. Here I outline the path I took to establish myself as a leading actor for LHC DM searches, using novel data selection techniques essential for discoveries in a “big data” environment.

During my PhD at the University of Oxford (2008-2011) I have become an expert in the **identification, reconstruction and performance of the most common physics signature produced at the LHC: jets** of particles originating from the constituents of the collided protons. My thesis provides the first-ever estimate of the uncertainty on jet energy measurements in the ATLAS experiment, described in one of the 10 most cited LHC papers.

At the start of my post-doc at the University of Geneva I used my PhD knowledge to perform **the first search for new particles decaying into two jets with early 2012 LHC data**, probing the highest possible energy scales.

In October 2012, I was appointed **convener of the Jets and Dark Matter group**, leading 70 members to the publication of papers on searches for new physics with jets, focusing on DM. During this period, I recognized the importance of searching for new particles at the energy scale where the Higgs, W and Z boson are. So, I published a paper with an analysis that set the most stringent constraints in this range at the time. It also highlighted **an unexplored region** out of the reach of traditional data taking techniques, due to the inability of recording all events including jets and consequent discarding of potential signal together with background.

In 2014, I was appointed by the ATLAS and CMS management to co-**lead the Dark Matter Forum**, a group of more than 250 physicists actively working in searches for DM at the LHC. While the LHC can’t solve the problem of DM in the universe alone, it complements results from other experiments where DM is detected from cosmological processes as it allows studying the interaction between known initial state particles and measured final state particles. For this reason, I led the Dark Matter Forum to **contextualize LHC dark matter search results within the global landscape of dark matter searches**. With a community-driven process, we defined the search targets for LHC searches that most dark matter searches in the ATLAS and CMS collaboration would use, and have been used by other DM experiments. Following this success, in 2016 I was asked to co-lead the [**Dark Matter Working Group**](https://lpcc.web.cern.ch/content/lhc-dm-wg-wg-dark-matter-searches-lhc) **within the LHC Physics Center at CERN** to develop and disseminate recommendations on the interpretation of LHC DM searches.

In this context, I realized the **connection between dark matter searches and two-jet new particle searches**, and the problem that experiments needed to solve. A widely used dark matter model (also included within this research program) includes a “mediator” particle, similar to known particles mediating interactions of ordinary matter. This mediator can decay to DM particles and to jets. For this model to reproduce the observed DM amount, the mediator mass would have to fall in the unexplored and inaccessible region mentioned above. For this reason, I designed what would become the ***DARKJETS* search program to begin the exploration of low-mass DM mediators**.

As an assistant professor at Lund University since April 2015, I work with a post-doctoral researcher and two PhD students supported by the ERC *DARKJETS* Starting grant[[1]](#footnote-1). We deployed a technique called “Trigger-Level Analysis” (TLA) for the first time in the ATLAS experiment and applied it to dark matter searches. In TLA, data recording and analysis are performed in real-time, avoiding the storage of large amounts of intermediate data. Using TLA and new search signatures, we set the **strongest constraints to date** on DM mediator models. We disseminated our results through peer-reviewed papers that I edited, contributions at international conferences, press releases and outreach events. TLA has been added to the upcoming issue of *The Swedish Guide for Big Science*.

**Real-time analysis** goes beyond ATLAS, as it is considered by the cross-experiment High-Energy Physics Software Foundation (HSF) as crucial for future experiments[[2]](#footnote-2). Because of my involvement in this topic I have been recently (2018) chosen to **lead the HSF on matters of trigger and reconstruction** and to be one of the program committee chairs for the main conference for computing in high energy physics (CHEP, to be held in Adelaide in 2019). I am active in a number of **interdisciplinary networks and research projects** to collaborate with research and industry on real-time analysis solutions and machine learning. These include a EU MSCA International Training Network that I submitted in 2019 as coordinator ([SMARTHEP](http://smarthep.hep.lu.se/)), a collaboration with the University of Hamburg ([THALIS](https://www.staff.lu.se/sites/staff.lu.se/files/uhh_lu_seed_fund_project_descriptions.pdf)), involvement in the newly created [DarkMachines](http://darkmachines.org/) machine learning community for DM. These interdisciplinary efforts have been rewarded with the Sten Von Friesen prize by the Lund Royal Physiographic Society.

This Consolidator grant is a **natural extension of my research program, significantly expanded in ambition and experimental coverage**. It extends real-time analysis as the stepping stone to new, more sensitive DM searches with broad theoretical motivations, uses machine learning techniques to make sure no stone is left unturned, and brings the Lund group and the Swedish community together to make a major contribution to the global DM landscape. This grant would establish me further as a leader in my field and responsible for a research program with implications beyond high energy physics.

**Ongoing external funding**

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| --- | --- | --- | --- | --- | --- |
| **Period** | **Funding source** | **Total SEK/Euro** | **Project title** | **Role** | **Relation to current proposal** |
| 2016-2021 | European Research Council | 13198600 (1270000) | Discovery strategies for DM and new phenomena in hadronic signatures with the ATLAS detector at the LHC | PI | Preliminary results for WP1 and WP2 |
| 2019-2024 | VR (Swedish Research Council) | 4400000 (423020) | Real-time Strategies and Precision Searches for Dark Sector Particles | PI | Prototyping searches in WP4 (not included in this proposal) |

**Previous external funding**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Period** | **Funding source** | **Total SEK (Euro)** | **Project title** | **Role** | **Relation to current proposal** |
| 2015-2018 | VR (Swedish Research Council) | 2400000 (230760) | Searches for DM and New Phenomena with the ATLAS detector at the Large Hadron Collider and beyond. | PI | None |

1. For a popular summary of DARKJETS and its team (in Swedish), see <https://www.lu.se/article/fysiker-forfinar-sokandet-efter-mork-materia>. [↑](#footnote-ref-1)
2. The HEP Software Foundation, A Roadmap for HEP Software and Computing R&D for the 2020s, HSF-CWP-2017-001 [[arXiv:1712.06982](https://arxiv.org/abs/1712.06982)] [↑](#footnote-ref-2)