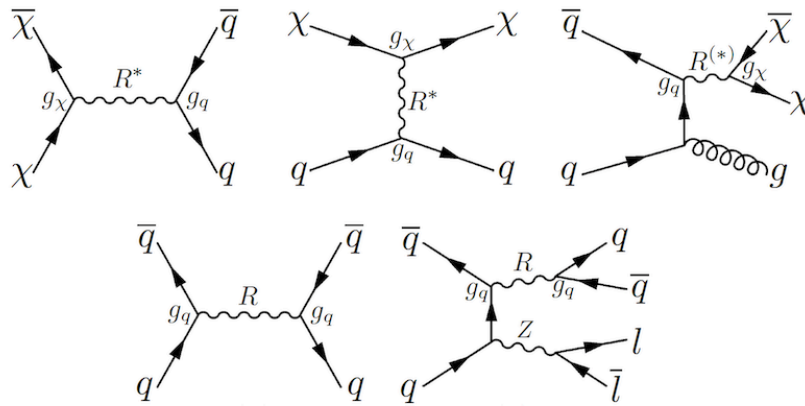


# Dark Matter @ LHC 2020 (DM@LHC)



## Report of Contributions

Contribution ID: 1

Type: **not specified**

## Group picture

Contribution ID: 4

Type: **Talk**

## Casting a GraphNet to catch dark showers (8'+2')

*Friday, June 5, 2020 2:50 PM (10 minutes)*

Strongly interacting dark sectors predict dark showers, which give rise to novel LHC signatures such as semi-visible jets. However, these are difficult to search for with conventional analysis techniques. In my talk I will first consider the sensitivity of existing and prospective LHC searches to semi-visible jets and then discuss how deep learning can help to distinguish dark showers from background. I will compare different network architectures and show that dynamic graph convolutional networks are particularly well suited to this task. I will then demonstrate that a deep-learned dark shower tagger can strongly improve the sensitivity of existing and prospective searches.

**Primary author:** BERNREUTHER, Elias (RWTH Aachen University)

**Co-authors:** Mr FINKE, Thorben (RWTH Aachen University); KAHLHOEFER, Felix (RWTH Aachen); KRAMER, Michael (Rheinisch Westfaelische Tech. Hoch. (DE)); MUECK, Alexander

**Presenter:** BERNREUTHER, Elias (RWTH Aachen University)

**Session Classification:** Friday

Contribution ID: 5

Type: **Talk**

## **A novel density estimator and its use for LHC signal detection (8'+2')**

*Thursday, June 4, 2020 5:20 PM (10 minutes)*

We introduce a new density estimator based on Markov Chains. This estimator presents several benefits with respect to the usual ones and can be used straightforwardly in all density-based approaches to data science. After showing its consistency, we will present some promising results when applied to general scope datasets. Finally, we perform a preliminary analysis of a subset of the latest high energy physics dataset from darkmachines, establishing encouraging prospects for future use.

**Primary authors:** MORANDINI, Alessandro (SISSA); DE SIMONE, Andrea (SISSA)

**Presenter:** MORANDINI, Alessandro (SISSA)

**Session Classification:** Thursday

Contribution ID: 6

Type: **Talk**

## **The Inert Doublet Model at current and future colliders (15' + 5')**

*Tuesday, June 2, 2020 4:20 PM (20 minutes)*

I will discuss the Inert Doublet Model, a Two Higgs Doublet Model with an exact  $Z_2$  symmetry that provides a dark matter candidate. I will elaborate on current constraints on the parameter space as well as discovery prospects at current and future colliders.

**Primary author:** ROBENS, Tania Natalie (Rudjer Boskovic Institute (HR))

**Presenter:** ROBENS, Tania Natalie (Rudjer Boskovic Institute (HR))

**Session Classification:** Tuesday

Contribution ID: 7

Type: **Talk**

## Baryogenesis and Dark Matter from B Mesons (8'+2')

*Wednesday, June 3, 2020 3:20 PM (10 minutes)*

In this talk, based on arXiv:1810.00880 and ongoing work, I will present a new mechanism of Baryogenesis and Dark Matter production in which both the dark matter relic abundance and the baryon asymmetry arise from neutral B meson oscillations and subsequent decays in the early Universe.

This mechanism would have distinctive experimental signals that I will discuss in detail:

- i) the new decay mode of B mesons into a baryon and missing energy, with a BR  $> 10^{-3}$ .
- ii) a positive semileptonic asymmetry in neutral B meson decays,  $> 10^{-5}$ .
- iii) the new decay mode of b-flavored baryons into mesons and missing energy, with BR  $> 10^{-3}$ .

These unique collider signatures are testable at current collider experiments, such as the LHC and Belle-II, allowing for a distinct probe of this mechanism.

**Primary authors:** ESCUDERO, Miguel (King's College London); ALONSO-ÁLVAREZ, Gonzalo (Universität Heidelberg); ELOR, Gilly

**Presenter:** ESCUDERO, Miguel (King's College London)

**Session Classification:** Wednesday

Contribution ID: 8

Type: **Talk**

## Probing the real triplet scalar dark matter at colliders (8'+2')

*Friday, June 5, 2020 3:10 PM (10 minutes)*

We study discovery prospects of the real triplet model at the LHC and a future 100TeV  $pp$  collider. The model provides a dark matter candidate and its smoking-gun signature is the so-called “disappearing charged tracks”. We recast current 13TeV LHC searches for disappearing tracks and find that the LHC presently excludes a real triplet scalar lighter than 287GeV with  $\mathcal{L} = 36 \text{ fb}^{-1}$ . The reach will extend to 608GeV and 761GeV with  $\mathcal{L} = 300 \text{ fb}^{-1}$  and  $3000 \text{ fb}^{-1}$  respectively. We extrapolate the 13TeV analysis to a prospective 100TeV  $pp$  collider and find that a  $\sim 3\text{TeV}$  triplet scalar could be discoverable with  $\mathcal{L} = 30 \text{ ab}^{-1}$  depending on the degree to which pileup effects are under control. We also investigate present and prospective constraints on this model from dark matter direct detection. We find that currently, XENON1T can exclude a real triplet dark matter lighter than  $\sim 3\text{TeV}$  for a Higgs portal coupling of order one or larger, and the future XENON20T will cover almost the entire dark matter viable parameter space except for vanishingly small portal coupling.

**Primary authors:** Prof. CHIANG, Cheng-Wei (National Taiwan University); COTTIN, Giovanna (Universidad Adolfo Ibañez); DU, Yong (University of Massachusetts-Amherst); FUYUTO, Kaori (Los Alamos National Laboratory); RAMSEY-MUSOLF, Michael (U. Massachusetts Amherst)

**Presenter:** DU, Yong (University of Massachusetts-Amherst)

**Session Classification:** Friday

Contribution ID: **10**

Type: **Talk**

## Welcome and Introduction

*Tuesday, June 2, 2020 2:00 PM (20 minutes)*

**Presenter:** BEHR, Janna Katharina (Deutsches Elektronen-Synchrotron (DE))

**Session Classification:** Tuesday



Contribution ID: 11

Type: **Talk**

## **Dark Matter Working Group report (15'+5')**

*Tuesday, June 2, 2020 2:20 PM (20 minutes)*

**Presenter:** BRANDT, Oleg (University of Cambridge (GB))

**Session Classification:** Tuesday

Contribution ID: 12

Type: **Talk**

## **Simplified models: s-channel (15'+5')**

*Tuesday, June 2, 2020 2:40 PM (20 minutes)*

**Presenter:** FREER, Chad Wells (Northeastern University (US))

**Session Classification:** Tuesday

Contribution ID: 13

Type: **Talk**

## **A universal framework for t-channel dark matter models (15'+5')**

*Tuesday, June 2, 2020 3:00 PM (20 minutes)*

**Presenter:** ARINA, Chiara (CP3 UCLouvain)

**Session Classification:** Tuesday

Contribution ID: 14

Type: **Talk**

## **Invisible Higgs decays (15'+5')**

*Tuesday, June 2, 2020 4:00 PM (20 minutes)*

**Presenter:** MILOSEVIC, Vukasin (Imperial College (GB))

**Session Classification:** Tuesday

Contribution ID: 15

Type: **not specified**

## **Higgs and top tales of dark matter (15'+5')**

**Presenter:** WESTHOFF, Susanne (Heidelberg University)

**Session Classification:** Tuesday

Contribution ID: 16

Type: **Talk**

## **A less simplified model: 2HDM+pseudoscalar (15'+5')**

*Tuesday, June 2, 2020 4:40 PM (20 minutes)*

**Presenter:** BJOERKE, Kristian (University of Oslo (NO))

**Session Classification:** Tuesday

Contribution ID: 17

Type: **not specified**

## **Theory overview (25'+5')**

*Tuesday, June 2, 2020 5:00 PM (30 minutes)*

**Presenter:** MURAYAMA, Hitoshi (University of California Berkeley (US))

**Session Classification:** Tuesday

Contribution ID: **18**

Type: **Talk**

## **LHCb dark sector searches (15'+5')**

*Wednesday, June 3, 2020 2:00 PM (20 minutes)*

**Presenter:** BORSATO, Martino (Ruprecht Karls Universitaet Heidelberg (DE))

**Session Classification:** Wednesday



Contribution ID: 19

Type: **not specified**

## **DM-flavour connection (15'+5')**

*Wednesday, June 3, 2020 2:20 PM (20 minutes)*

**Presenter:** ARCADI, Giorgio

**Session Classification:** Wednesday

Contribution ID: 20

Type: **not specified**

## **Lepton Flavour Universality: LHCb results and prospects (15'+5')**

*Wednesday, June 3, 2020 2:40 PM (20 minutes)*

**Presenter:** WORMSER, Guy Henri Maurice (Université Paris-Saclay (FR))

**Session Classification:** Wednesday

Contribution ID: 21

Type: **not specified**

## **Strongly interacting dark sectors (15'+5')**

*Wednesday, June 3, 2020 3:00 PM (20 minutes)*

**Presenter:** Dr GRILLI DI CORTONA, Giovanni (University of Sao Paulo)

**Session Classification:** Wednesday

Contribution ID: 22

Type: **Talk**

## **Axion-like particles (15'+5')**

*Wednesday, June 3, 2020 4:00 PM (20 minutes)*

**Presenter:** BAUER, Martin (Heidelberg University)

**Session Classification:** Wednesday

Contribution ID: 23

Type: **Talk**

## **Dark photons and axion-like particles at the LHC (15'+5')**

*Wednesday, June 3, 2020 4:20 PM (20 minutes)*

**Presenter:** COELHO LOPES DE SA, Rafael (University of Massachusetts (US))

**Session Classification:** Wednesday

Contribution ID: 24

Type: **not specified**

## **Long-lived Particle Experiments at the LHC: FASER, MATHUSLA, and others (15'+5')**

*Wednesday, June 3, 2020 4:40 PM (20 minutes)*

**Presenter:** MEEHAN, Samuel Ross (CERN)

**Session Classification:** Wednesday

Contribution ID: 25

Type: **not specified**

## **Intensity frontier (15'+5')**

*Wednesday, June 3, 2020 5:10 PM (20 minutes)*

**Presenter:** KLING, Felix (SLAC)

**Session Classification:** Wednesday

Contribution ID: 26

Type: **Talk**

## **Dark Matter Capture in Neutron Stars (15'+5')**

*Thursday, June 4, 2020 2:00 PM (20 minutes)*

**Presenter:** BELL, Nicole (University of Melbourne)

**Session Classification:** Thursday



Contribution ID: 27

Type: **Talk**

## **SUSY dark matter searches (15'+5')**

*Thursday, June 4, 2020 2:50 PM (20 minutes)*

**Presenter:** WANG, Sicheng (Univ. of California Santa Barbara (US))

**Session Classification:** Thursday

Contribution ID: 28

Type: **Talk**

## **Global fits of supersymmetry - can we still have light neutralino DM? (15'+5')**

*Thursday, June 4, 2020 3:10 PM (20 minutes)*

**Presenter:** RAKLEV, Are (University of Oslo (NO))

**Session Classification:** Thursday

Contribution ID: 29

Type: **not specified**

## **Gravitational waves and dark matter (15'+5')**

*Thursday, June 4, 2020 2:20 PM (20 minutes)*

**Presenter:** OPFERKUCH, Toby (CERN)

**Session Classification:** Thursday

Contribution ID: **30**

Type: **not specified**

## **Performance improvements at ATLAS (15'+5')**

*Thursday, June 4, 2020 4:00 PM (20 minutes)*

**Presenter:** LORENZ, Jeanette Miriam (Ludwig Maximilians Universitat (DE))

**Session Classification:** Thursday

Contribution ID: **31**

Type: **not specified**

## **Object performance improvements at CMS (15'+5')**

*Thursday, June 4, 2020 4:20 PM (20 minutes)*

**Presenters:** THOMAS, Laurent (Universite Libre de Bruxelles (BE)); THOMAS, Laurent (Universite Libre de Bruxelles (BE))

**Session Classification:** Thursday

Contribution ID: 32

Type: **not specified**

## **ML approaches in phenomenology (15'+5')**

*Thursday, June 4, 2020 4:40 PM (20 minutes)*

**Presenter:** CARON, Sascha (Nikhef National institute for subatomic physics (NL))

**Session Classification:** Thursday

Contribution ID: 33

Type: **not specified**

## **ML for Jet Tagging and Event Classification on ATLAS and CMS (15'+5')**

*Thursday, June 4, 2020 5:00 PM (20 minutes)*

**Presenter:** KAGAN, Michael Aaron (SLAC National Accelerator Laboratory (US))

**Session Classification:** Thursday

Contribution ID: 34

Type: **not specified**

## **Dark matter and long-lived particles at the LHC (15'+5')**

*Friday, June 5, 2020 2:00 PM (20 minutes)*

**Presenter:** GOUDELIS, Andreas (LPTHE - Paris)

**Session Classification:** Friday



Contribution ID: 35

Type: **not specified**

## **Long-lived particle searches in ATLAS and CMS (15'+5')**

*Friday, June 5, 2020 2:20 PM (20 minutes)*

**Presenter:** MORINAGA, Masahiro (Waseda University (JP))

**Session Classification:** Friday

Contribution ID: 36

Type: **not specified**

## Lightning talks

**Session Classification:** Friday

Contribution ID: 37

Type: **Talk**

## **DM and feebly-interacting particles: ideas for cross-experimental collaborations (15'+5')**

*Friday, June 5, 2020 4:05 PM (20 minutes)*

**Presenter:** LANFRANCHI, Gaia (INFN e Laboratori Nazionali di Frascati (IT))

**Session Classification:** Friday

Contribution ID: 38

Type: **Talk**

## **Reinterpretation tools for dark matter searches (20'+5')**

*Friday, June 5, 2020 4:25 PM (25 minutes)*

**Presenter:** Prof. BUTTERWORTH, Jonathan (UCL)

**Session Classification:** Friday

Contribution ID: 39

Type: **Talk**

## Panel discussion

*Friday, June 5, 2020 4:50 PM (40 minutes)*

**Presenters:** DOGLIONI, Caterina (Lund University (SE)); KULKARNI, Suchita (Austrian Academy of Sciences (AT))

**Session Classification:** Friday

Contribution ID: 40

Type: **Talk**

## Dark photons from hadronic showers (8'+2')

*Friday, June 5, 2020 3:00 PM (10 minutes)*

Neutral mesons decay is often considered the dominant production mechanism for light dark photons in proton-proton and proton-nucleus collision. However, the produced hadronic showers also transfer a relevant amount of their energies into electromagnetic subshowers. We show that in certain cases, the positrons created in these sub-showers can lead to dark photon production rates significantly larger than the meson decay ones. We present the main characteristics of this production mode and update correspondingly standard limits on vector-mediator scenarios for light dark matter.

**Primary authors:** DARMÉ, Luc Jean Marie (INFN - National Institute for Nuclear Physics); NARDI, Enrico; CELENTANO, Andrea (INFN-Genova); Dr MARSICANO, Luca (INFN)

**Presenter:** DARMÉ, Luc Jean Marie (INFN - National Institute for Nuclear Physics)

**Session Classification:** Friday

Contribution ID: 41

Type: **Talk**

## Exploring jet substructure in semi-visible jets (8'+2')

*Friday, June 5, 2020 2:40 PM (10 minutes)*

Semi-visible jets arise in strongly interacting dark sectors, where parton evolution includes dark sector emissions, resulting in jets overlapping with missing transverse momentum. The implementation of semi-visible jets is done using the Pythia Hidden valley module to duplicate the dark sector showering. In this work, several jet substructure observables have been examined to compare semi-visible jets and light quark/gluon jets. These comparisons were performed using different dark hadron fraction in the semi-visible jets (signal). The extreme scenarios where signal consists either of entirely dark hadrons or visible hadrons offers a chance to understand the effect of the specific dark shower model employed in these comparisons.

**Primary author:** SINHA, Sukanya (University of Witwatersrand)

**Co-author:** KAR, Deepak (University of the Witwatersrand (ZA))

**Presenter:** SINHA, Sukanya (University of Witwatersrand)

**Session Classification:** Friday

Contribution ID: 43

Type: **Talk**

## Robust cosmological constraints on axion-like particles (8'+2')

*Thursday, June 4, 2020 2:40 PM (10 minutes)*

Axion-like particles with masses in the keV-GeV range have a profound impact on the cosmological evolution of our Universe, in particular on the abundance of light elements produced during Big Bang Nucleosynthesis. The resulting limits are complementary to searches in the laboratory and provide valuable additional information regarding the validity of a given point in parameter space. A potential drawback is that altering the cosmological history may potentially weaken or even fully invalidate these bounds. The main objective of this article is therefore to evaluate the robustness of cosmological constraints on axion-like particles in the keV-GeV region, allowing for various additional effects which may weaken the bounds of the standard scenario. Employing the latest determinations of the primordial abundances as well as information from the cosmic microwave background we find that while bounds can indeed be weakened, very relevant robust constraints remain.

**Primary authors:** DEPTA, Paul Frederik (Deutsches Elektronen-Synchrotron (DESY)); SCHMIDT-HOBERG, Kai Ronald (Deutsches Elektronen-Synchrotron (DE)); Mr HUFNAGEL, Marco (Deutsches Elektronen-Synchrotron (DESY))

**Presenter:** DEPTA, Paul Frederik (Deutsches Elektronen-Synchrotron (DESY))

**Session Classification:** Thursday



Contribution ID: 44

Type: **Talk**

## Interference effects in dilepton resonance searches for $Z'$ bosons and dark matter mediators (8'+2')

*Tuesday, June 2, 2020 3:20 PM (10 minutes)*

New  $Z'$  gauge bosons arise in many extensions of the Standard Model and predict resonances in the dilepton invariant mass spectrum. We present ZPEED ( $Z'$  Exclusions from Experimental Data), an open-source code providing fast likelihoods and exclusion bounds for general  $Z'$  models based on the most recently published  $139 \text{ fb}^{-1}$  ATLAS dilepton data. PDF and detector effects as well as higher-order corrections are effectively implemented by tabulated functions enabling a fast computation of various test statistics. Moreover, interference effects with the Standard Model Drell-Yan background can be added to the signal cross section in the analysis, which can strengthen constraints on model parameters substantially. For generic  $Z'$  models, upper bounds on the couplings can improve by up to a factor of 1.5. In simplified dark matter models, in which the dark matter contributes to the decay width of the  $Z'$ , the sensitivity of dilepton resonance searches on the mediator mass can be increased by 40%.

**Primary author:** SCHULTE, Stefan (Max Planck Institute for Physics (Munich))

**Co-authors:** KAHLHOEFER, Felix (RWTH Aachen); MUECK, Alexander; TUNNEY, Patrick (RWTH Aachen)

**Presenter:** SCHULTE, Stefan (Max Planck Institute for Physics (Munich))

**Session Classification:** Tuesday

Contribution ID: 45

Type: **Talk**

## Search for millicharged particles in proton-proton collisions at $\sqrt{s}=13$ TeV with the milliQan Demonstrator (8' + 2')

*Wednesday, June 3, 2020 5:00 PM (10 minutes)*

In this talk, we will present the results of a recent search for fractionally charged particles using a data sample of proton-proton collisions provided by the CERN Large Hadron Collider in 2018. This search was carried out with a prototype scintillator-based detector, which allows the first sensitivity to particles with charges  $\leq 0.1e$  at a hadron collider. The existence of new particles with masses between 20 and 4700 MeV is excluded at 95% confidence level for charges between 0.006e and 0.3e, depending on their mass. New sensitivity is achieved for masses larger than 700 MeV. We will discuss the concept of the experiment, the results of the search, and the plan for the full milliQan detector given the successful operation of the prototype.

**Primary authors:** Prof. HILL, Christopher (Ohio State University); SCHMITZ, Ryan (UCSB)

**Presenter:** SCHMITZ, Ryan (UCSB)

**Session Classification:** Wednesday

Contribution ID: 46

Type: **not specified**

## Conference picture!

*Thursday, June 4, 2020 3:30 PM (2 minutes)*

**Session Classification:** Thursday

Contribution ID: 47

Type: **Talk**

## Closing remarks

*Friday, June 5, 2020 4:00 PM (5 minutes)*

**Presenter:** KAHLHOEFER, Felix (RWTH Aachen)

**Session Classification:** Friday