Light Dark Matter Searches

721. WE-Heraeus-Seminar

08 - 11 June 2021
ONLINE

WILHELM UND ELSE
HERAEUS-STIFTUNG

Introduction

The Wilhelm und Else Heraeus-Stiftung is a private foundation that supports research and education in science with an emphasis on physics. It is recognized as Germany's most important private institution funding physics. Some of the activities of the foundation are carried out in close cooperation with the German Physical Society (Deutsche Physikalische Gesellschaft). For detailed information see https://www.we-heraeus-stiftung.de

Aims and scope of the 721. WE-Heraeus-Seminar:

Dark matter is the name assigned to one of the most important contemporary challenges that fundamental physics research is facing. In recent years, the hypothesis that dark matter might be "light" is gaining interest. Following this idea, dark matter particles belong to a new, unexplored dark sector, that is communicating with the Standard Model through one (or more) dark mediator particles. The mass scale of such dark sector particles, i.e. the mediators and the stable dark matter particles, could be comparable to the proton mass or below.

Light dark matter would be very difficult to detect with high-energy colliders or with direct detection experiments, so that accelerator-based dark matter searches with smaller, but dedicated experiments are important. The capabilities of high-intensity cw electron and proton beams enable unique opportunities for probing the dark sector. These experimental approaches are complementary to searches for dark matter at the high-energy frontier with the LHC at CERN.

The aim of the workshop is to discuss light dark matter searches with national and international experts from experiments as well as from theory.

Introduction

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Program

Program *(CEST)*

Tuesday, 8 June 2021

12:45 – 13:00	Patrick Achenbach Marco Battaglieri Luca Doria	**Welcome and Introduction**
Chair: Caterina Doglioni		
13:00 – 13:45	Pedro Schwaller	**Light but Substantial: Dark Matter Models Below the WIMP Scale**
13:45 – 14:30	Claudia Frugiuele	**Searching for Physics Beyond the Standard Model @ the Next Generation Neutrino Fixed Target Experiments**
14:30 – 15:00	*BREAK & networking opportunity*	
Chair: Michael Kohl		
15:00 – 15:45	Andrea Celentano	**Light Dark Matter Search with the BDX Experiment at Jefferson Laboratory**
15:45 – 16:30	Babette Döbrich	**Exotics Searches at NA62**
16:30 – 17:00	*BREAK & networking opportunity*	
Chair: Patrick Achenbach		
17:00 – 17:45	Mirco Christmann	**The DarkMESA Experiment**
17:45 – 18:30	Bjoern Soeren Schlimme	**Dark Photon Searches at MAGIX**
18:30 – 19:00	***DISCUSSION***	

Program *(CEST)*

Wednesday, 9 June 2021

12:45 – 13:00	**Welcome Desk**	
Chair: Federica Petricca		
13:00 – 13:45	Felix Kahlhöfer	**Self-Interacting Dark Matter**
13:45 – 14:30	Paolo Valente	**Searching Light Dark Particles in Positron Annihilations at PADME**
14:30 – 15:00	*BREAK & networking opportunity*	
Chair: Belina von Krosigk		
15:00 – 15:45	Ruth Pöttgen	**The Light Dark Matter eXperiment - Status, Plans and Prospects**
15:45 – 16:30	Maurik Holtrop	**The Heavy Photon Search Experiment at Jlab**
16:30 – 17:00	*BREAK & networking opportunity*	
Chair: Achim Denig		
17:00 – 17:45	Heiko Lacker	**Light Dark Matter Search with SHiP**
17:45 – 18:30	Stepan Stepanyan	**Dark Matter Searches at Jefferson Lab**
18:30 – 19:00	***DISCUSSION***	

Program *(CEST)*

Thursday, 10 June 2021

12:45 – 13:00	**Welcome Desk**	
Chair: Andrea Celentano		
13:00 – 13:45	Tina Pollmann	**DEAP-3600 and the Global Argon Dark Matter Programme**
13:45 – 14:30	Federica Petricca	**Low-Mass Dark Matter Search with the CRESST-III Experiment**
14:30 – 15:00	*BREAK & networking opportunity*	
15:00 – 16:30	***POSTER SESSION***	
16:30 – 17:00	*BREAK & networking opportunity*	
Chair: Marco Battaglieri		
17:00 – 17:45	Belina von Krosigk	**Light Dark Matter Searches with Cryogenic Silicon Detectors**
17:45 – 18:30	Michelle Galloway	**Low-Mass Dark Matter Searches with XENON1T**
18:30 – 19:00	***DISCUSSION***	

Program *(CEST)*

Friday, 11 June 2021

12:45 – 13:00	**Welcome Desk**	

Chair: Felix Kahlhöfer

13:00 – 13:45	Torben Ferber	**Light Dark Matter Searches at (Super) B-Factories**
13:45 – 14:30	Caterina Doglioni	**Dark Matter Searches at the Large Hadron Collider and Synergies with Other Experiments**
14:30 – 15:00	*BREAK & networking opportunity*	

Chair: Torben Ferber

15:00 – 15:45	Dayong Wang	**Dark Sector Searches at BESIII**
15:45 – 16:30	Viktor Zacek	**X17 and the Search for New Physics in Nuclear Transitions**
16:30 – 17:00	*BREAK & networking opportunity*	

Chair: Torben Ferber

17:00 – 17:45	Jan Bernauer	**DarkLight@ARIEL: A Search for New Physics with Invariant Mass Between 10 and 20 MeV**
17:45 – 18:30	Michael Kohl	**Status of the TREK/E36 Experiment at J-PARC**
18:30 – 19:00	***DISCUSSION***	

END OF THE SEMINAR

Posters

Posters

1	Stephan Aulenbacher	**The MAGIX Jet-Target System**
2	Riccardo Bolzonella	**An Experimental Setup for Detection of e+e- Pairs in the Decay of 8Be***
3	Philipp Brand	**Studies on the Performance of the MAGIX Jet Target**
4	Ethan Cline	**Illuminating the Dark Photon with Darklight**
5	Jennifer Geimer	**The Silicon Strip Detector Setup for MAGIX**
6	Jannik Geisen	**Shining Light into the Dark (jets) with ATLAS**
7	Pepe Gülker	**Simulation of Exclusion Limits for the Invisible Decay of Dark Photons at MAGIX**
8	Saniya Heeba	**Light. Dark. Resonant: Sub-GeV Thermal Dark Matter**
9	Matteo Lauß	**The DarkMESA Veto Detector**
10	Stefan Lunkenheimer	**MAGIX Slow Control**
11	Luca Marsicano	**Dark Photon Production Via Positron Annihilation In Electron-Beam Thick-Target Experiments**
12	Manuel Mauch	**Readout System for DarkMESA Veto Detector**
13	Wolfram Ratzinger	**Audible Axions**
14	Christiane Scherb	**Charming ALPs**

Posters

15	Goran Stanić	**Position Reconstruction in DEAP-3600 Experiment Using Neural Networks**
16	Sebastian Stengel	**The MAGIX Trigger Veto System**
17	Sophia Vestrick	**Münster Jet-Target for Future Dark Photon Searches at MAGIX**

Abstracts of Lectures

(in alphabetical order)

DarkLight@ARIEL: A search for new physics with invariant mass between 10 and 20 MeV

Jan C. Bernauer[1,2] **for the DarkLight collaboration**

[1]Center for Frontiers in Nuclear Science, Stony Brook University, Stony Brook, NY, USA

[2] RIKEN BNL Research Center, BNL, Upton, NY, USA

Motivated by the recent anomalies found in ^{8}Be and ^{4}He, as well as muon g-2, the DarkLight@ARIEL experiment aims to search for a dark sector particle with preferential leptonic coupling. To this end, the experiment will measure the invariant mass spectrum of $e^{+}e^{-}$ pairs produced in electron scattering off a thin tantalum target. Optimized for the search around the predicted mass, the experiment will make use of the high intensity electron beam of ARIEL. In the talk, I will describe the motivation and history of the DarkLight experiment, as well as the current design and status.

Light Dark Matter Search with the BDX experiment at Jefferson Laboratory

A. Celentano (for the BDX collaboration)

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The Beam Dump eXperiment (BDX) at Jefferson Laboratory is an electron-beam thick-target experiment aimed to investigate the existence of Light Dark Matter (LDM) particles in the MeV-GeV mas. The experiment will detect LDM particles produced by the interaction of the primary CEBAF electron beam impinging on the Hall-A beam dump with a downstream electromagnetic calorimeter, installed in a new dedicated experimental hall. The expected signal signature is the electromagnetic shower induced by the scattering of LDM particles with atomic electrons of the detector material, resulting to a visible energy deposition. The electromagnetic calorimeter is surrounded by a dual-layer active veto counter to reject cosmic backgrounds. Beam-related backgrounds, on the other hand, are suppressed by passive shielding (iron blocks) installed between the dump and the detector.
A proof-of-concept measurement has been performed in 2020 at JLAB in the present unshielded configuration, with a 2.2 GeV primary electron beam. The prototype detector (BDX-MINI) consists of a $PbWO_4$ electromagnetic calorimeter, surrounded by a layer of tungsten shielding and two hermetic plastic scintillator veto systems. The sensitivity of the test will reach some of the best limits to date for selected regions of the LDM parameters space.

In this talk, after presenting the BDX physics case, I'll discuss the experiment design and foreseen performances. Finally, I'll present some preliminary results from the BDX-MINI measurement campaign.

The DarkMESA Experiment

P. Achenbach[1,2,3], M. Christmann[1,2], L. Doria[1,3], M. Lauss[1,2], M. Mauch[1,2] and S. Stengel[1,2] for the MAGIX-Collaboration

[1] *Institute for Nuclear Physics, Mainz University, Germany*
[2] *Helmholtz Institute Mainz, Mainz University, Germany*
[3] *PRISMA+ Cluster of Excellence, Mainz University, Germany*

At the Institute for Nuclear Physics in Mainz the new electron accelerator MESA will go into operation within the next years. In the extracted beam operation (150 MeV, 150 μA) the P2 experiment will measure the weak mixing angle in electron-proton scattering in 10,000 hours operation time. Therefore, the high-power beam dump of this experiment is ideally suited for a parasitic dark sector experiment – DarkMESA. [1,2]
The experiment is designed for the detection of Light Dark Matter (LDM) which in the simplest model couples to a massive vector particle, the dark photon γ'. It can potentially be produced in the P2 beam dump by a process analogous to photon bremsstrahlung and can then decay in Dark Matter (DM) particle pairs $\chi\overline{\chi}$. A fraction of them scatter off electrons or nuclei in the DarkMESA calorimeter. [3]
Suggested calorimeter materials were tested at MAMI in 2018 with electrons below 14 MeV. During this beam tests PbF_2 and the lead glass Schott SF5 performed best. This was consistent with a Geant4 optical photon study [4,5].
For DarkMESA we will use about 1,000 PbF_2 crystals from the previous A4 experiment at MAMI, with a total active volume of 0.13 m^3. In a further stage the active volume will be increased by adding more than 1,000 Pb-glass blocks (0.58 m^3) from the previous WA98 experiment at CERN.
Within a MadGraph and Geant4 simulation the accessible parameter space was estimated. The experimental setup was optimized and further concepts were investigated. DarkMESA-Drift is such an additional approach. A directional Time Projection Chamber (TPC) filled with CS_2 at low pressure serves as DM detector. With the nuclear recoil threshold being in the keV range the accessible parameter space can be extended. [2]
Simulation studies and experimental studies on beam-related and beam-unrelated backgrounds at DarkMESA are presented and the current status of a prototype detector array including a veto system as well as a veto concept for the final DarkMESA experiment will be discussed.

References

[1] L. Doria, et al., ALPS19, arXiv:1908.07921 (2019)
[2] M. Battaglieri, et al., JLab PAC 44, arXiv:1607.01390v1 (2016)
[3] J. D. Bjorken, et al., Phys. Rev. D 80, 075018, arXiv:0906.0580 (2009)
[4] M. Christmann, et al., Nucl. Instrum. Meth. A 958, 162398 (2020)
[5] M. Christmann, et al., Nucl. Instrum. Meth. A 960, 163665 (2020)

Exotics searches at NA62

Babette Döbrich 1

[1]CERN

Thanks to its high intensity beam and detector performance (redundant particle-identification capability, extremely efficient veto system and high resolution measurements of momentum, time, and energy), NA62 can achieve sensitivities to long-lived light mediators in a variety of new-physics scenarios. This talk will cover phenomenological aspects of exotics searches at NA62 highlighting the need of a close theory/experiment interface to optimize search strategies.

References

[1]

Dark matter searches at the Large Hadron Collider and synergies with other experiments

C. Doglioni[1]

[1]Fysikum, Lund University, Lund, Sweden

One overarching objective of science is to further our understanding of the universe, from its early stages to its current state and future evolution. This depends on gaining insight on the universe's most macroscopic components, for example galaxies and stars, as well as describing its smallest components, namely elementary particles and nuclei and their interactions. The apparent excess of "dark matter" in the universe remains one of the outstanding questions in science. If dark matter is a particle, then it can be produced and sought at the Large Hadron Collider, complementing searches in other experiments. This talk focuses on the searches for dark matter by experiments at the Large Hadron Collider [1], with a special highlight on the searches that allow to probe dark matter hypotheses that are complementary to other experiments.

It is clear that solving the dark matter puzzle requires combined expertise from the fields of particle physics, astroparticle physics and nuclear physics.
Pursuing common scientific drivers such as dark matter also requires mastering challenges related to instrumentation (e.g. beams and detectors), data acquisition, selection and analysis, as well as making data and results available to the broader science communities. This contribution also presents the work that various communities and experiments are doing in this direction, and the ongoing initiatives aiming to exploit synergies across different communities.

References

[1] A. Boveia and C. Doglioni, **"Dark Matter Searches at colliders".** Ann.Rev.Nucl.Part.Sci. **68** (2018) 429-459, arXiv:1810.12238.

Light Dark Matter searches at (Super) B-Factories

T. Ferber[1]

[1]*Deutsches Elektronen-Synchrotron (DESY), Notkestr. 85, 22607 Hamburg*

The B-Factories Belle and BaBar provided an excellent environment to search for light mediators in the GeV mass range at e+e- colliders. I will first give an overview of the searches at Belle and BaBar. In the second part I will describe the sensitivity and first results of the Super B-Factory Belle II that started data taking in 2019. With dedicated triggers for light mediator searches, Belle II offers unique opportunities to search for axion-like particles, light Z', invisible final states, and extended Dark Matter models with long-lived signatures.

Searching for Physics Beyond the Standard Model @ the Next Generation Neutrino Fixed Target Experiments

C. Frugiuele[1]

[1]*CERN, Switzerland*

Next generation neutrino oscillation experiments are multi-purpose observatories, with a rich physics program beyond oscillation measurements. A special role is played by their near detector facilities, which are particularly well-suited to search for weakly coupled dark sector particles produced in the primary target. I will discuss the sensitivity for such scenarios of present and future facilities like the SBN program and DUNE.

Low-mass dark matter searches with XENON1T

Michelle Galloway[1] **for the XENON Collaboration**

[1]*University of Zurich, Zurich, Switzerland*

The XENON1T experiment was designed primarily to detect interactions of GeV-scale Weakly Interacting Massive Particle (WIMP) dark matter from its recoil off of a xenon nucleus. To reach high sensitivity for WIMP searches, an ultra-low background for electronic recoils was achieved, thus enabling searches for low-mass dark matter candidates, such as dark photons and axion-like particles. In this talk I will present the most recent results from these searches with XENON1T and exemplify the reach of xenon-based detectors to probe the light dark matter parameter space.

References

1. E. Aprile et al. (XENON Collaboration), Phys. Rev. Lett. **121**, 111302 (2018)
2. E. Aprile et al. (XENON Collaboration), Phys. Rev. D **102**, 072004 (2020)

The Heavy Photon Search Experiment at JLab

Maurik Holtrop[1], for the HPS Collaboration.

[1] University of New Hampshire, Durham NH 03824, U.S.A.

The Heavy Photon Search (HPS) experiment at Jefferson Lab is searching for a new $U(1)$ vector boson ("heavy photon", "dark photon" or A') in the mass range of 20-500 MeV/c^2. An A' in this mass region is natural in hidden sector models of light, thermal dark matter. The A' couples to the ordinary photon through kinetic mixing, which induces its coupling to electric charge. Since heavy photons couple to electrons, they can be produced through a process analogous to bremsstrahlung, subsequently decaying to an e^+e^- pair, which can be observed as a narrow resonance above the dominant QED trident background. For suitably small couplings, heavy photons travel detectable distances before decaying, providing a second signature. HPS accesses unexplored regions in the mass-coupling parameter space.

The experiment uses the CEBAF electron beam located at Jefferson Lab to accelerate electrons which are then incident on a thin tungsten target. The outgoing e^+e^- pair is detected in a compact, large acceptance forward spectrometer consisting of a silicon vertex tracker, a hodoscope, and a lead tungstate electromagnetic calorimeter.

HPS conducted successful engineering runs in the spring of 2015 using a 1.056 GeV, 50 nA beam and in the spring of 2016 using a 2.3 GeV, 200 nA beam, and an extended physics run using a 4.5 GeV beam during the summer of 2019. This talk will present the results of the 2015 run, preliminary results of the 2016 and 2019 runs, and prospects for future runs.

Self-interacting Dark Matter

Felix Kahlhoefer

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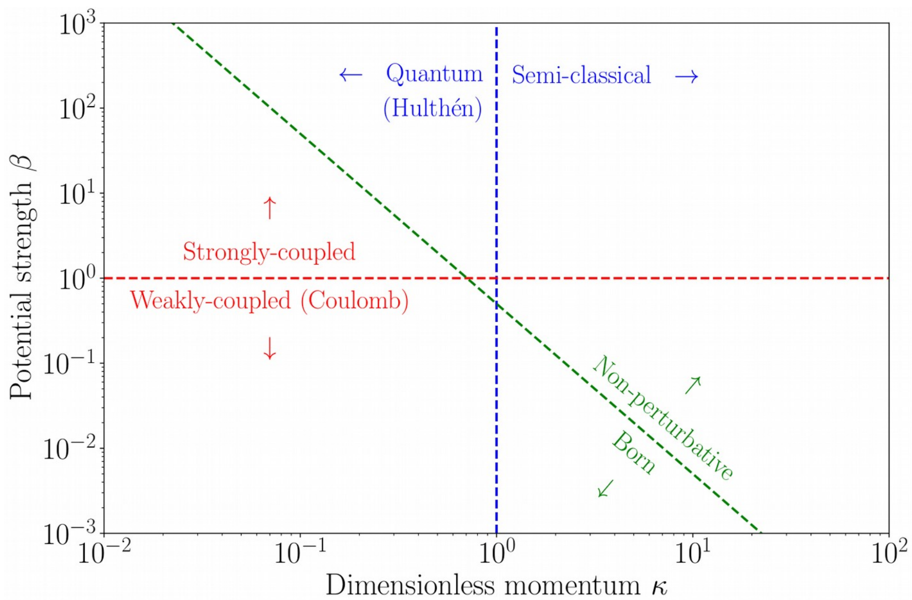
Self-interactions between dark matter particles can affect the evolution of dark matter halos, giving rise to observable effects in a wide range of astrophysical systems and potentially explaining the puzzling observation of constant-density cores in dwarf galaxies. To study these effects one needs to find a way to map the scattering of elementary particles onto macroscopic scales. In this talk I will discuss how to calculate transfer cross sections for the case that dark matter particles interact via the exchange of a light mediator such as a dark photon with a particular focus on the semi-classical regime. I will then show how such scattering may give rise to an effective drag force that can be implemented in numerical simulations of structure formation in order to study merging galaxy clusters. Finally, I will present analytical methods that can be used to describe the evolution of the central density of a dark matter halo and address the question whether dark matter self-interactions resolve the small-scale problems of collisionless cold dark matter.



References:

[1] Fischer et al., Monthly Notices of the Royal Astronomical Society, in press

[2] Colquhoun et al., Phys.Rev.D 103 (2021) 3, 035006

[3] Kahlhoefer et al., JCAP 12 (2019) 010

Status of the TREK/E36 experiment at J-PARC

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Experiment TREK/E36 has collected stopped-kaon decay data at the J-PARC K1.1BR beamline for a precision measurement of the ratio of decay widths BR($K^+ \rightarrow e^+ \nu$) and BR($K^+ \rightarrow \mu^+ \nu$), respectively, to test lepton universality, and to search for rare decay modes producing light neutral bosons, which may serve as explanations for particle anomalies and light dark matter. An overview of the experiment and analysis status will be presented.
This work has been supported by DOE awards DE-SC0003884 and DE-SC0013941 in the US, NSERC in Canada, and Kaken-hi in Japan.

Light Dark Matter Search with SHiP

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Within the Physics-Beyond-Collider initiative [1] and in the context of the European Strategy of Particle Physics Update, a beam-dump facility (BDF) is being discussed at CERN's SPS [2]. The first experiment proposed at the BDF is the Search for Hidden Particles (SHiP) experiment, see e.g. [3]. "Hidden" particles (such as heavy neutral leptons, dark photons/ scalars, axion-like particles, and light dark matter (LDM) particles) are predicted in many Standard Model (SM) extensions with masses well below the electroweak scale and with very small couplings to SM particles, which is why they might have escaped detection so far. For SHiP, the high-intensity 400 GeV SPS proton beam will be dumped in a heavy-metal target. Hadrons emerging from the target are stopped in an absorber. Muons from hadron decays are swept out by a magnet-based filter. SHiP consists of two parts: A 50 m-long evacuated vessel followed by a spectro/calorimeter allows one to reconstruct decays of long-lived neutral particles produced in the SHiP target, which allows to search for hidden particles through their decay with a very small expected background. Between the muon filter and the decay vessel, the Scattering-and-Neutrino Detector (SND) is placed. One goal of the SND is to study large statistics (anti-)tau-neutrino interactions as well as muon-neutrino interactions to measure the strange-quark content of the proton and to search for charmed pentaquark final states. Its special design allows SND to search in particular for LDM particles that are potentially produced in the beam-dump target and are scattered off electrons in the SND. An SND-like detector has been proposed to measure TeV-neutrinos of all flavours produced in the very-forward directions of proton-proton collisions at the LHC. This so-called SND@LHC experiment has been recently approved to be built and to take data from 2022 onwards.

The presentation provides a general introduction to SHiP, discusses its prospects to search for LDM particles below a few 100 MeV and ends with the SND@LHC project.

References

[1] J. Beacham et al., *Physics Beyond Colliders at CERN: Beyond the Standard Model Working Group Report*, arXiv: 1901.0966 [hep-ex]

[2] C. C. Ahdida et al., *SPS Beam Dump Facility–Comprehensive Design Study*, arXiv:1912.06356 [physics.acc-ph].

[3] SHiP collaboration, *A facility to Search for Hidden Particles (SHiP) at the CERN SPS*, arXiv:1504.04956, [physics.ins-det]; *Measurement of the muon flux from 400 GeV/c protons interacting in a thick molybdenum/tungsten target,* EPJ C 80 (2020) no.3, 284; *The Magnet of the Scattering and Neutrino Detector for the SHiP experiment at CERN*, arXiv:1910.02952 [physics.ins-det]; *Sensitivity of the SHiP experiment to Heavy Neutral Leptons*, JHEP **1904** (2019) 077; *The experimental facility for the Search for Hidden Particles at the CERN SPS*, JINST **14** (2019) no.03, P03025; *The active muon shield in the SHiP experiment*, JINST **12** (2017) no.05, P05011

[4] *SND@LHC - Scattering and Neutrino Detector at the LHC (Technical Proposal)*, CERN-LHCC-2021-003 ; LHCC-P-016

Low-mass Dark Matter Search with the CRESST-III Experiment

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CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) is a direct dark matter search experiment located at the Gran Sasso underground Laboratory (LNGS, Italy). Scintillating $CaWO_4$ crystals, operated as cryogenic calorimeters at millikelvin temperature, are used as target material for elastic DM-nucleus scattering. The experiment, optimized for low-energy nuclear recoil detection, reached an unprecedented threshold of 30eV [1] for nuclear recoil energies and it is currently leading the field of low-mass dark matter search, for values below 1.6 GeV/c^2. In this contribution, the current stage of the CRESST-III experiment, together with the most recent dark matter results will be presented. The perspective for the next phase of the experiment will be also discussed.

References

[1] CRESST Collaboration, Phys.Rev.D **100**, 102002 (2019)

DEAP-3600 and the global argon Dark Matter programme

T.R. Pollmann[1] for the DEAP-3600 collaboration

[1]*NIKHEF/University of Amsterdam, Science Park, 1098XG Amsterdam, Netherlands*

The DEAP-3600 experiment is designed to look for elastic scattering of WIMP Dark Matter on argon, using a 1 tonne liquid argon fiducial volume in single-phase configuration. DEAP-3600 finished its first, four-year science run last year, demonstrating excellent stability and superb pulse-shape discrimination power against electromagnetic backgrounds. The DEAP-3600 detector is currently being upgraded for a second science run and R&D work toward future detectors.

DEAP-3600 will be followed by the DarkSide-20k experiment that is currently being constructed by the Global Argon Dark Matter Collaboration (GADMC). The ultimate goal of GADMC is a O(100 tonne) detector with WIMP sensitivity reaching to the neutrino-mist region in parameter space for WIMP masses above 10 GeV.

The Light Dark Matter eXperiment — Status, Plans and Prospects

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An elegant explanation for the origin and observed abundance of dark matter in the Universe is the thermal freeze-out mechanism. Within this mechanism, possible masses for dark matter particle candidates are restricted approximately to the MeV - TeV range. The GeV-TeV mass range is being explored intensely by a variety of experiments searching for Weakly Interacting Massive Particles. The sub-GeV region occurs naturally in Hidden Sector dark matter models, but has been tested much less by experiments to date. Exploring this mass range is imperative as part of a comprehensive Dark Matter search programme, but requires new experimental approaches.

The freeze-out mechanism assumes a non-gravitational interaction between dark and ordinary matter, which necessarily implies a production mechanism for dark matter at accelerator experiments. Recent advancements in particle accelerators and detectors in combination with software developments like machine learning techniques open new possibilities to observe such processes.

The planned Light Dark Matter eXperiment [1] (LDMX) is an electron-beam, fixed-target experiment that exploits these developments, enabling us to observe processes orders of magnitudes rarer than what is detectable today. The key to this is a multi-GeV beam providing a few electrons 46-million times per second, and a detector that monitors how each individual electron interacts in the target — for up to 10^{16} electrons. First beam for commissioning the experiment is expected in 2023 at SLAC, Stanford, marking the starting point of a first data-taking period of about 1.5 years. A second run with higher beam-energy and -intensity is foreseen soon thereafter, either at SLAC or potentially CERN.

This presentation will give an overview of the different components of the LDMX detector concept, the main experimental challenges and how they are addressed. It will also briefly describe the special requirements on the beam needed and how these are met. Finally, it will discuss projected sensitivities and possible future upgrades towards covering a large portion of the viable phase-space for sub-GeV thermal relic dark matter and other models.

References

1. T. Åkesson et al., Light Dark Matter eXperiment (LDMX), arxiv:1808.05219

Dark Photon Searches at MAGIX

S. Schlimme[1] **for the MAGIX-Collaboration**

[1] *Institute for Nuclear Physics, Mainz University, Germany*

From the very beginning, the research topic of the dark photon was an important motivation for the construction of the Mainz Energy-Recovering Superconducting Accelerator MESA [1], an electron accelerator which will come into operation at the Institute for Nuclear Physics of the Mainz University in a few years.
Dark photon searches will be perfomed at the MAinz Gas Internal target eXperiment MAGIX [2], which will be installed in the Energy Recovery Linac (ERL) arc of MESA. The ERL mode provides a power-efficient beam acceleration with a maximum beam energy of $105\,\mathrm{MeV}$ and a maximum beam current of $1000\,\mu\mathrm{A}$ or higher.
The internal, windowless MAGIX gas jet target [3] can be operated with different target gases such as hydrogen or xenon. The setup comprises two high-resolution magnetic spectrometers which will be used for the detection of scattered electrons and produced particles. Their focal planes will be equipped with TPCs (time projection chambers) with GEM (gas electron multiplier) readout for tracking, and with scintillation detectors for trigger, timing, and particle identification purposes. Additional detectors dedicated to the measurement of low-energetic recoil nuclei complement the spectrometers and will be mounted in the target chamber.
With the MAGIX setup, the searches for dark photons, which assume a production of the dark photon through a mechanism similar to the bremsstrahlung process, will be extended to lower dark photon masses than were probed before in Mainz at the A1 spectrometer facility [4,5]. In this type of experiments a dark photon γ' could radiatively be produced off a nuclear target Z via the reaction $e^-Z \to e^-Z\gamma'$. If the dark photon decays into standard model particles (visible decay), e.g. $\gamma' \to e^+e^-$, the electron/positron final state can be detected in coincidence in the two spectrometers. A peak-search on the QED background can thus be performed.
These searches will be extended to invisible decay channels, in which a dark photon decays by $\gamma' \to \chi\bar{\chi}$ in a pair of possible light dark matter particles, requiring a missing mass analysis of the scattered electron in coincidence with the recoil nucleus.

References

[1] F. Hug, *et al.*, LINAC2016 313 (2017)
[2] Harald Merkel, PoS BORMIO2016 037 (2016)
[3] S. Grieser, *et al.*, Nucl. Instrum. Meth. A 906 120 (2018)
[4] H. Merkel, *et al.*, Phys. Rev. Lett. 106 251802 (2011)
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Light but Substantial: Dark Matter Models Below the WIMP Scale

Pedro Schwaller

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What is “light” dark matter? I will give an overview of the allowed mass range for dark matter, and then introduce a few of the theoretically well motivated models that predict dark matter masses significantly below the electroweak scale, such as axions, sterile neutrinos, and asymmetric dark matter. I will highlight possible connections of these models with the puzzle of the baryon asymmetry of the universe, and then present a few recent ideas for probing such dark matter scenarios, from fixed target experiments to gravitational waves.

Dark matter searches at Jefferson Lab

S. Stepanyan

Thomas Jefferson Nation Accelerator Facility

The overwhelming evidence for dark matter (DM) in cosmological observations, manifested by its gravitational interactions, has inspired a major experimental effort to uncover its particle nature. The LHC, as well as direct and indirect detection experiments, have significantly constrained one of the best-motivated weak-scale DM models (WIMPs as dark matter candidates). In contrast, scenarios involving a light hidden sector dark matter with masses in the MeV-GeV range has garnered a good deal of attention. Models with hidden U(1) gauge symmetry are particularly attractive as they can be tested experimentally. If these vector gauge bosons or dark/heavy photons exist, they mix with ordinary photons through kinetic mixing, which induces their weak coupling to electrons, ϵe. Since they couple to electrons, heavy photons are radiated in electron scattering and can subsequently decay into e^+e^- or to a pair of light dark matter particles. Experiments at Jefferson Lab use these signatures to search for heavy photons or light dark matter particles in the MeV to GeV mass range.

In this talk, I will summarize the experimental program and introduce facilities at Jefferson Lab for dark matter searches.

Searching light dark particles in positron annihilations at PADME

Paolo Valente[1] on behalf of the PADME Collaboration
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The lack of direct experimental observation of dark matter candidates at the electroweak scale so far could be justified with the introduction of a dark sector that can only feebly interact with the ordinary matter. A simple possibility would be an additional *U(1)* symmetry, which corresponding gauge boson is a massive vector particle, a dark photon.

Several experiments are searching for a dark photon in the visible (to lepton pairs) or invisible decays (to lighter, dark sector particles).
PADME is the first experiment using the annihilation of a positron beam against a thin target, as a production channel for the dark photon, and the missing mass technique to discover the dark photon as a peak above a smooth background.

In 2019-2020 PADME has collected a sample of 5 10^{12} positron on target annihilations, in order to probe a mass range up to 21 MeV/c^2. Thanks to the excellent performance of the photon detectors, also other processes can be studied, like the visible decays of a axion-like particle, or the hypothetical X17 particle advocated for interpreting the anomalies in ^{8}Be and ^{4}He transitions.

Light Dark Matter Searches with Cryogenic Silicon Detectors

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A new era has begun for direct Dark Matter searches using cryogenic silicon detectors with reaching single electron-hole pair sensitivity. The corresponding ultra-low threshold and high resolution allow to search for Light Dark Matter candidates of masses as low as 500 keV. This reach is possible through the Dark Matter electron scattering detection channel, a channel that was inaccessible for these detectors before. I will give an overview on respective state-of-the-art direct detection experiments and will review the current searches for Light Dark Matter with electron recoil signatures in the detectors. I will conclude with an outlook on where the next few years are expected to take us in this quest.

Dark sector searches at BESIII

Dayong Wang[1,2]

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Low energy, high luminosity e+ e- colliders are believed to be good places to search for some exotic particles predicted in new physics models with dark sector phenomenology. BESIII as the only currently running tau-charm factory has great potential to probe these particles and models, with the largest samples of directly produced charmonia. In this talk, we will report some of such searches and related results, including searches of dark photons and invisible decays in several decay modes. In this talk, we will report some of such searches and related results, including dark photon searches using both the initial state radiation and Jpsi decays in association with a pseudoscalar meson(eta, eta'), the searches for a lepto-phobic dark photon, light Higgs etc, and more generally the study of processes with invisible signatures, such as invisible decays of vector meson (omega, phi), pseudoscalar mesons(eta, eta'), charm mesons, hyperons(Lambda), J/\psi-> gamma + invisible etc.
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References

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X17 and the Search for New Physics in Nuclear Transitions

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Nuclear transitions provide a means to probe light, weakly-coupled new physics and portals into the dark sector. Particularly promising are those transitions that can be accessed through excited nuclear states that are resonantly produced, providing a high-statistics laboratory to search for MeV-scale new physics. In this talk the so-called X-17 anomaly will be discussed, which is a 7σ discrepancy reported by the ATOMKI group in the observation of the decays of excited ^{8}Be and ^{4}He nuclei to their ground states via internal e^{+} - e^{-} pair creation. The anomaly can be explained by the emission of a neutral boson with a mass of about 17 MeV/c^{2}. The ATOMKI results and their interpretations are discussed, as well as follow-up experiments, among which an ongoing project at the Montreal tandem accelerator facility.

Abstracts of Posters

(in alphabetical order)

The MAGIX Jet-Target System

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For the planned Light Dark Matter Experiments @MAGIX a high precision is one of the most crucial goals, MAGIX is aiming for. Since the passage of electrons through matter is introducing uncertainties on the angle and the energy of the final as well as on the initial electrons, one has to keep the material budged low. Therefore, the investigated in the implementation of a so call Jet-Target, developed by the University of Münster. This target realizes the completely windowless scattering of electrons on a gas Target, by shooting a Gas-Jet through the vacuum chamber.

This poster is an overview on the entire target system, from the gas source to the exhaust of the gas. It will give a short explanation on each subsystem of the MAGIX target section.

An experimental setup for detection of $e^{+}e^{-}$ pairs in the decay of $^{8}Be^{*}$

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Recent papers of A.J. Krasznahorkay and collaborators proposed the existence of a light neutral boson, named X17, for the interpretation of anomalies in the correlation angle distribution between $e^{-}\text{and } e^{+}$ emitted in the decay of excited states in ^{8}Be and ^{4}He.
A new experimental setup is being developed at the National Laboratories of Legnaro to provide an independent measurement of the effect.
In this contribution I will focus on the design of a dedicated setup, describing the detector layout, the simulation work done for its optimization and the experimental characterization of the first prototypes.
The current layout is constituted by $\Delta\text{E-E}$ organic scintillator telescopes, gathered in groups of four, whose dimensions have been optimized, with the goal of improving the angular resolution obtainable. The telescopes are read out by Silicon PhotoMultipliers (SiPMs), that allow to keep small dimensions to fit the detectors in a scattering chamber and would also be compatible with a future use within a magnetic field.
The first layer of the telescopes is used to gather informations on the particles' positions: it is composed by 2 layers of orthogonal bars, which allow to measure the two coordinates of the entry position and the ΔE deposited energy. Also the bars are read with an array of SiPM, for which an innovative readout scheme is proposed.
As a first step, a complete simulation of the setup will be discussed. It has been performed using the GEANT4 package to optimize the geometry and estimate the detection efficiency.
Moreover, a preliminary characterization of the detector prototypes will be discussed. This characterization allows to estimate the expected resolution on the energy measured by a detector and the resolution on the reconstructed invariant mass. Eventually, this work is the preparation of a test beam that will be performed to observe the pairs produced in the $^{19}F(p,\alpha e^{+}e^{-})^{16}O$ reaction, to characterize in-beam the prototype detectors together with the acquisition and analysis systems.

Studies on the Performance of the MAGIX Jet Target

<u>P. Brand</u>[1], S. Vestrick[1] and A. Khoukaz[1]

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The MAGIX experiment is a versatile experiment which allows, e.g., to search for dark photons, and to measure the proton radius and astrophysical S-factor. To allow for this challenging experimental program the powerful, future energy recovery linac MESA will be used in combination with a jet target, that allows target thicknesses of more than 10^{18} atoms/cm^2. This target was constructed and built up at the University of Münster and is already in routine operation at MAMI in Mainz.

Extensive studies have been performed with the MAGIX target at the existing MAMI facility to analyze and improve the jet target performance. This includes a simulation-based optimization of the nozzle shape to reduce the divergence of the resulting supersonic gas jet, which then also has a positive influence on the vacuum conditions within the scattering chamber. The results of this optimization process will be presented and discussed by comparing jet profiles and vacuum conditions for different nozzle designs.

Illuminating the Dark Photon with Darklight

E. Cline[1]

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The search for a dark photon holds considerable interest in the physics community as such a force carrier would begin to illuminate the dark sector. Many experiments have searched for such a particle, but so far it has proven elusive. In recent years the concept of a low mass dark photon has gained popularity in the physics community. Of particular recent interest is the ^8Be anomaly, which could be explained by a 17 MeV mass dark photon. The proposed Darklight experiment would search for this potential low mass force carrier at TRIUMF in the 10-20 MeV e^+e^- invariant mass range. This poster will focus on the experimental design and physics case of the Darklight experiment.

Search for Light Neutral Bosons in the TREK/E36 Experiment

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May 6, 2021

Abstract

The Standard Model (SM) represents our best description of the subatomic world and has been very successful in explaining how elementary particles interact under the influence of the fundamental forces. Despite its far reaching success in describing the building blocks of matter, the SM is still incomplete; falling short to explain dark matter, baryogenesis, neutrino masses and much more. The E36 experiment was conducted at J-PARC in Japan, it was designed to test lepton universality, and it has additional sensitivity to search for light U(1) gauge bosons. Of particular interest is the muonic K+ decay channel. Such $U(1)$ bosons could be associated with dark matter or explain established muon-related anomalies such as the muon $g-2$ value, and perhaps the proton radius puzzle. A realistic simulation study was employed for these rare searches in a mass range of 20 MeV/c^2 to 110 MeV/c^2. Preliminary upper limits for the A' branching ratio $\mathcal{B}r(A')$ extracted at 95% CL will be presented.

Prepared by LLNL under Contract DE-AC52-07NA27344.
∗This work has been supported by DOE awards DE-SC0003884 and DE-SC0013941

The silicon strip detector setup for MAGIX

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The MAGIX (Mainz Gas Internal Target Experiment) experiment will take place at the energy recovering superconducting accelerator MESA in Mainz.
At MAGIX, high-precision electron scattering experiments will be performed covering a wide experimental program like investigations of hadron physics, reactions of astrophysical relevance as well as dark sector searches.
The experimental setup is currently under development and provides a windowless gas jet target and two identical high-resolution magnetic spectrometers including a GEM-based time projection chamber.
Additionally, a silicon strip detector is planned to detect recoil particles inside the scattering chamber. Its main requirements are suited to the simulation of the S-factor determination of the nucleosynthesis reaction of Carbon and alpha which defines the lower limit of the energy sensitivity to 0.3 MeV.
Other reactions like the invisible decay of the dark photon $p(e, e'p)\chi\bar{\chi}$ increase the needed energy range of the recoil detector to several MeVs.
Therefore the silicon detector will be extended by an additional plastic scintillator layer.

The current state of the silicon strip detector development and its underlying working concept will be presented on this poster.

Shining light into the dark (jets) with ATLAS

C. Doglioni[1] and J. Geisen[1]

[1]*Department of Physics, Lund, Sweden*

The Large Hadron Collider (LHC) at CERN, Switzerland reached the conclusion of its second data taking period from 2015 to 2018, and with that produced the largest proton-proton collision particle physics dataset to date. These data are being analysed by the ATLAS experiment with ever increasing precision and even more sophisticated strategies. In particular, discovering the nature of Dark Matter in high energy proton-proton collisions is one of the experiment's major goals.

I will present a new approach to search for Dark Matter in the full Run-2 dataset with the ATLAS experiment. Similar to the Standard Model (SM), a Dark Sector could exist in the Universe, containing new particles as well as new interactions such as a dark version of Quantum Chromodynamics (QCD). Dark QCD includes dark quarks which could be produced at the LHC. These dark quarks undergo a dark showering and hadronisation process inside the ATLAS detector producing a large number of light dark and/or SM hadrons bundled together into jets. The search that I will present exploits the internal structure of such dark jets. Furthermore, since the dark sector could be manifested in different ways [1] resulting in different detector signatures, I will highlight the phenomenological studies which depict these features and offer optimisation strategies.

References

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Simulation of exclusion limits for the invisible decay of dark photons at MAGIX

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With the planned MAGIX experiment in Mainz a versatile apparatus will be available to search for radiatively produced dark photons with a mass below $100\,\mathrm{MeV/c^2}$ down to a coupling constant ϵ smaller than 10^{-5}, a region that has yet to be proped intensively.

The missing mass spectra will be recorded by the unique electron scattering setup consisting of two rotateable high resolution magnetic spectrometers, and a set of dedicated recoil detectors surrounding a central gas jet target. The very intense electron beam of up to $10\,\mathrm{mA}$ will be provided by the energy recovering superconducting accelerator MESA.

This contribution focusses on the simulation of the invisible decay channel and shows the path from the generators to the extraction of exclusion limits in detail. It also provides the theoretical framework and motivates the requirements for hardware related contributions in the scope of MAGIX presented during this seminar.

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Light. Dark. Resonant: Sub-GeV Thermal Dark Matter

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The particle-physics description of dark matter remains an open question in high energy physics and cosmology. With increasing sensitivities of various experiments and an absence of a clear dark matter signal, alternatives to the conventionally studied WIMP paradigm have gained traction. One class of such alternatives looks at light (sub-GeV) dark matter. These models necessarily require some alteration to the DM production history to ensure compatibility with cosmological bounds such as those coming from the CMB. One can do this by considering models in which dark matter annihilation is resonantly enhanced during freeze-out but suppressed at CMB times. Interestingly, the viable parameter space in such models is testable by direct detection and beam dump experiments in complementary ways making them a good target for current and future dark matter searches.

This poster will illustrate the theoretical intricacies of such models and highlight the different approaches one can take to probe them experimentally.

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The DarkMESA Veto Detector

P. Achenbach[1,2,3], M. Christmann[1,2], L. Doria[1,3], M. Lauss[1,2], M. Mauch[1,2] and S. Stengel[1,2] for the MAGIX-Collaboration

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At the Institute for Nuclear Physics in Mainz the new electron accelerator MESA will go into operation within the next years. In the extracted beam operation (150 MeV, 150 μA) the P2 experiment will measure the weak mixing angle in electron-proton scattering in 10,000 hours operation time. Therefore, the high-power beam dump of this experiment is ideally suited for a parasitic dark sector experiment – DarkMESA. [1,2]
The experiment is designed for the detection of Light Dark Matter (LDM) which in the simplest model couples to a massive vector particle, the dark photon γ'. It can potentially be produced in the P2 beam dump by a process analogous to photon bremsstrahlung and can then decay in Dark Matter (DM) particle pairs $\chi\overline{\chi}$. A fraction of them scatter off electrons or nuclei in the DarkMESA calorimeter. [3]
The better the supression of background radiation (e.g. cosmic muons) the better the sensitivity of the experiment. Therefore a highly efficient veto detector surrounding the calorimeter hermetically is essential to probe the target parameter space of DarkMESA successfully. The veto detector will consist of two layers of plastic scintillation counters separated by a lead layer. To test the characteristics of such a detector a prototype is currently under construction using 2 cm thick plastic scintillators of type EJ-200 and a matrix of 5 $\times$ 5 lead fluoride crystal bars as the calorimeter. The efficiency of the veto system at shielding the calorimeter from cosmic background radiation has been simulated using the `Geant4` software. Results and practical implications will be discussed. Furthermore the option of using Gadolinium loaded scintillators to increase the detection efficiency of slow neutrons will be examined. The production of beam related neutrons is currently being studied within a `FLUKA` simulation showing no thermal neutrons reaching the darkMESA calorimeter until now.

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MAGIX Slow Control

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MAGIX (Mainz Gas Injection Target Experiment) is a versatile fixed-target experiment and will be built at the new electron accelerator MESA (Mainz Energy-Recovering Superconducting Accelerator) in Mainz. The accelerator will provide a polarized and unpolarized electron beam with a current up to $1\,\mathrm{mA}$ and a beam energy up to $105\,\mathrm{MeV}$. Using its internal gas jet target, MAGIX will reach a luminosity of $\mathcal{O}(10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1})$. In a rich physical program MAGIX allows to study processes with very low cross sections at small momentum transfer.

The existence of a dark photon that acts as an exchange particle for dark matter is a well-motivated extension of the Standard Model of particle physics. Through the mixing of the dark photon with the ordinary photon, the dark photon can couple very weakly to charged baryonic particles. One possible way to identify the dark photon is to perform an electron scattering experiment to determine the missing mass of the invisible decay reaction: $p(e,e'p)\chi\bar{\chi}$. MAGIX can use the high-resolution spectrometer in combination with the silicon-strip detector array to take part in the search for the radiatively produced dark photon. Together with the thin gas jet target the kinetic parameters and thus the missing mass can be determined with high precission. For such an high-precission measurement, it is necessary to control all parameters with high accuracy. MAGIX therefore needs a comprehensive slow control system for the entire experiment.

On the poster we will present the requirements for such a slow control system as well as the current developments. MAGIX will use an EPICS-based slow control system that is already applied for the existing MAGIX components. EPICS is a decentralized system with which all parts for the experiment can simply be separated and combined. MESA and DarkMESA also use EPICS, which means that all parameters can easily be shared between the experiments and the accelerator. In the current test stands the MAGIX slow control system controls a total of around 1500 parameters.

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Dark Photon Production Via Positron Annihilation In Electron-Beam Thick-Target Experiments

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In a popular class of models, Dark Matter is composed of particles with mass in the MeV-GeV range, interacting with the Standard Model via a new force, mediated by a massive vector boson, the Dark Photon or A'. High energy positron annihilation is a viable mechanism to produce Dark Photons. This reaction plays a significant role in beam-dump experiments using multi-GeV electron-beams on thick targets by enhancing the sensitivity to A' production. The positron-rich environment generated by the electromagnetic shower initiated by the electron beam in the target allows to produce a significant number of A's via non-resonant ($e^+e^-\rightarrow\gamma A'$) and resonant annihilation ($e^+e^- \rightarrow A'$) on atomic electrons. For both visible and invisible A' decays, the contribution of resonant annihilation results in a larger sensitivity with respect to limits derived by the commonly used A'-strahlung in certain kinematic regions. The sensitivity enhancement due to this process has been evaluated for different past and proposed electron-beam thick-target experiments: E137, BDX, NA64 and LDMX. This contribution will present the results of this study, with a detailed description of the procedure adopted for the calculation.

Readout System for DarkMESA Veto Detector

P. Achenbach[1,2,3], M. Mauch[1,2], L. Doria[1,3], M. Lauss[1,2], M. Christmann[1,2] and S. Stengel[1,2] for the MAGIX-Collaboration

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At the Institute for Nuclear Physics in Mainz a new beam dump experiment, called DarkMESA, will go into operation during the next years. This experiment is designed for the search for light dark matter particles with a crystal-based calorimeter. The detector will leverage on over 10000 hours of available measuring time at the new MESA electron accelerator. [1,2]
A key issue will be the rejection of background events like cosmics, environmental radioactivity, and beam particles. To this end, a veto detector system is being developed, consisting of scintillator plates coupled to silicon photomultipliers (SiPMs).
The readout electronics currently developed is tested with the help of a prototype laboratory setup which consists on a calorimeter comprised of a 5x5 crystal matrix, completely enveloped in scintillator plates. The scintillators are read out with specifically designed ”carrier boards” on which are installed SiPMs and corresponding preamplifiers. The signals of several carrier boards will be transferred to a second ”collector” board.
It will be possible to further process the signals on an external FPGA board while the analog signals will be digitized on a sampling ADC. First measurements with the carrier and collector boards will be presented, and concepts for the FPGA boards and the ADC will be discussed.

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Audible Axions

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Conventional approaches to probing axions and axion-like particles (ALPs) typically rely on a coupling to photons. However, if this coupling is extremely weak, ALPs become invisible and are effectively decoupled from the Standard Model. We show that such invisible axions, which are viable candidates for dark matter, can produce a stochastic gravitational wave background in the early universe. This signal is generated in models where the invisible axion couples to a dark gauge boson that experiences a tachyonic instability when the axion begins to oscillate. Quantum fluctuations amplified by the exponentially growing gauge boson modes source chiral gravitational waves. We present lattice calculations of the resulting GW signal and highlight its detectability as well as the possibility of explaining the recent NANOGrav result. Finally we show that this mechanism can produce GWs in a wide range of axion scenarios, considering the relaxion and an kinetically misaligned axion.

Charming ALPs

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Axion-like particles (ALPs) are ubiquitous in models of new physics explaining some of the most pressing puzzles of the Standard Model. However, until relatively recently, little attention has been paid to its interplay with flavour. In this work, we study in detail the phenomenology of ALPs that exclusively interact with up-type quarks at the tree-level, which arise in some well-motivated ultra-violet completions such as QCD-like dark sectors or Froggatt-Nielsen type models of flavour. Our study is performed in the low-energy effective theory to highlight the key features of these scenarios in a model independent way. We derive all the existing constraints on these models and demonstrate how upcoming experiments at fixed-target facilities and the LHC can probe regions of the parameter space which are currently not excluded by cosmological and astrophysical bounds. We also emphasize how a future measurement of the currently unavailable meson decay $D \to \pi$+invisible could complement these upcoming searches. For small masses the charming ALP is a dark matter candidate.

Position reconstruction in DEAP-3600 experiment using Neural Networks

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The DEAP-3600 is a direct-detection dark matter experiment, located in the SNOLAB facility in Sudbury, Canada. With its spherical acrylic vessel filled with 3.3 tonnes of single-phase liquid argon, it aims at detecting spin-independent WIMP (Weakly Interacting Massive Particle)-nucleon scattering,
Argon scintillation light (wavelength-shifted by TPB coating) is detected by 255 PMTs arranged around the vessel.
Position reconstruction in DEAP-3600 is of utmost importance for background rejection and fiducialization [1].
Existing algorithms are based on the charge or time pattern of the PMTs [2].
The goal of this work is to train and test two neural network architectures – the Feedforward and the Convolutional Neural Network – in order to achieve optimal event position reconstruction and try to improve on existing algorithms.
The results obtained point to a precision of less than 50mm in position reconstruction for both neural network architectures. The potential for identifying events coming from the detector's "neck" is also investigated.

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The MAGIX trigger veto system

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The MAGIX setup will be used for Dark Photon searches using the visible as well as the invisible decay channel. The MAGIX trigger veto system will enable the fast timing characteristics needed for investigating the visible Dark Photon decay channel A’ -> e+e-. It will further be used for energy-loss measurements and will provide the basic hit and position information for the triggered readout of the MAGIX time projection chamber.

The MAGIX trigger veto system will consist of one segmented trigger layer of plastic scintillator bars and a flexible veto system of additional scintillation detectors and lead absorbers placed beneath the trigger layer.

The data readout will use the ultrafast preamplifier-discriminator NINO chip developed for use in the ALICE detector followed by FPGAs programmed as TDCs.

Münster Jet Target for future Dark Photon Searches at MAGIX

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The MAGIX experiment at MESA using a quasi-internal gas-jet target initially aims for high precision measurements of scattering between the MESA electron beam and various gases from the Münster jet target at low momenta.
One research topic from high interest is the search for dark photons, which can be produced radiatively in the electron-nucleus-scattering. Precise measurements of this dark photons require a high resolution of the MAGIX Spectrometers and a gas-jet target with a thickness of more than 10^{18} atoms/cm², allowing for luminosities of up to 10^{35}/(cm²s).
The MAGIX gas-jet target was build and tested in the Münster laboratories and is currently installed at the A1 Experiment at MAMI. First beam times using this jet target have been performed and showed that stable jet beam conditions with a target thickness of $>10^{18}$ atoms/cm² have been confirmed. This proofs the excellent suitability of this jet target for high precision, rare event measurements at MAGIX.