Mineral Detection of Neutrinos and Dark Matter 2026 (MDvDM’26)

Tuesday, April 14, 2026 - Friday, April 17, 2026

Karlsruhe, Germany

Book of Abstracts

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Low mass Dark Matter prospects with LiF defects

Authors: Hagar Landsman[None]; Mahmoud Abu-Rmilah[None]; Nadav Hargittai[None]; Ranny Budnik[1]

[1] *Weizmann Institute of Science*

Color centers in lithium fluoride (LiF) crystals provide a promising approach for detecting sub-GeV dark matter via low-energy excitations. We present new results on the formation of relevant defect centers in LiF, together with advances in their treatment and characterization. We study the response of these centers to different interaction channels, including electronic and nuclear recoils, and discuss operational aspects relevant for low-threshold detection.

Do you plan to give the talk in person?:

Yes

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Dark Matter Subhalo Abundance in the Solar Neighborhood and Its Effect on Direct Detections

Author: Xiuyuan Zhang[1]

[1] *MIT*

Lambda cold dark matter (Λ CDM) is widely considered as the standard model of the Big Bang cosmology that contains a postulated new particle called dark matter (DM), which makes up for 85% of the matter of the universe. However, DM has yet to be detected non gravitationally. One of the major ways of probing it is through direct detection experiments measuring the cross section of dark matter particles scattering off nuclei. Additionally, under Λ CDM, DM clumps up into halos and subhalos, potentially affecting our direct detection measurements if they happen to fly past the solar system and temporarily boost the local dark matter density. In this talk, I will give an estimation of the local abundance of low mass subhalos in the solar neighborhood and discuss the effect of their existence on direct detection. I will first introduce the local differential number density of subhalos, focusing on the dark low mass subhalos.I will then define the encounter cross section and further introduce the differential encounter rate for a subhalo to scatter off the Earth gravitationally that allows us to give an expected total number of yearly encounter events. Finally, I will discuss how such events are expected to affect the direct detection experiments. Although the rate is found to be quite small for the lifetime of direct detection experiments, this study inspires us to look for new ways to study the low mass subhalos, potentially through effects that can accumulate through years such as paleo detectors, and thus enable us to explore the lower end of the mass spectrum where the particle nature of DM plays a more important role.

Do you plan to give the talk in person?:

Yes

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A physicist's noise is a geologist's signal: mutual benefits of palaeodetector research for particle physics and geochronology

Author: Pieter Vermeesch[1]

Co-author: David Waters [1]

[1] *University College London*

The 2017 discovery of coherent elastic neutrino-nucleus scattering (CEνNS) confirmed experimentally for the first time the process that gives rise to palaeo-neutrino damage tracks. By increasing the exposure time of neutrino detectors from human to geological timescales, it is possible to shrink their physical size from thousands of tonnes to mere kilograms. Realising palaeo-detection (the "signal") requires geological background rates from cosmic radiation and natural radioactivity (the "noise") to be both low and precisely quantified. The search for suitable materials and readout techniques offers mutual benefits to particle physicists and geologists:

1) Geological settings with low background levels are attractive for fundamental physics. With nanometre-scale resolution and sufficient exposure, palaeo-detectors can probe unexplored dark-matter phase space. At micron-scale resolution, they may also record integrated signals from higher-energy supernova neutrinos over geological timescales. Reconstructing fossil tracks further provides the only direct archive of Earth's long-term cosmic-ray history.

2) Materials with high background levels are well suited for geochronology. Recoil-track dating could fill the gap between radiocarbon dating (<50 kyr) and conventional radiometric methods (>1 Myr). This interval spans critical phases of human evolution and Quaternary climate change.

A major source of geological background noise arises from cosmic-ray neutrons and muons. Their interaction with near-surface rocks produces spallation products, cosmogenic nuclides, and cosmic-ray tracks (CRTs). For physicists, CRTs represent an unwanted background that must be quantified and minimised. Neutron-induced tracks attenuate rapidly and are suppressed by a few metres of overburden, whereas muons penetrate hundreds of metres, requiring deep underground settings. Accurate characterisation of cosmogenic backgrounds is therefore essential for selecting suitable mineral targets and subtracting residual tracks.

For geologists, cosmogenic nuclides are powerful tracers of Earth surface processes. If the production rate of a nuclide such as ^{21}Ne is known and its concentration measured, exposure ages and erosion rates can be determined over millennial timescales. Extending this principle to CRTs would enable a new form of exposure dating. Owing to minimal sample-size requirements, CRT dating could be applied to individual sediment grains, allowing probability distributions of exposure ages to be used to reconstruct spatial and temporal variations in erosion.

A second important background source is α-recoil tracks (ARTs) produced by the decay of ^{238}U, ^{235}U, and ^{232}Th. Recoil of daughter nuclei damages the crystal lattice, generating tracks initially ~100 nm in size. Partial annealing at elevated temperatures may reduce track sizes, potentially causing overlap between ART and neutrino-track size distributions.

Minimising confusion between ARTs and neutrino tracks requires that ARTs are both minimised and well characterised. Mica minerals are ideal for this purpose due to their strongly anisotropic sheet structure, which enables efficient nuclear track detection by acid etching. Micas are routinely used in geochronology as detectors for induced fission of ^{235}U. The most important members are muscovite ("white mica") and biotite ("dark mica"). Muscovite typically contains ppt−ppb levels of U and Th, making it well suited for neutrino detection. Biotite, relatively enriched in U and Th, is unsuitable for palaeo-detection but ideal for ART-based geochronology.

Despite being proposed nearly 60 years ago, ART dating remains underdeveloped due to difficulties in determining track *densities* and U−Th *concentrations* using acid-etching methods, particularly in compositionally zoned minerals. Emerging palaeo-particle readout techniques offer a solution by enabling (1) direct counting of total recoil tracks *numbers* using 3D imaging, and (2) precise determination of parent-nuclide *amounts* by isotope dilution mass spectrometry. This new approach can be validated using geochronological reference materials of known age. Following validation, the method will be ready for broad application in geology and archaeology, while also providing training data for machine-learning algorithms to distinguish ARTs from other forms of crystal damage.

By joining forces, physicists and geochronologists can significantly reduce the risk-to-reward ratio of their research efforts.

Do you plan to give the talk in person?:

Yes

6

Direct Searches for Particle Dark Matter: An Overview

Author: Belina von Krosigk[1]

[1] *Heidelberg University*

The existence of dark matter is well established through its gravitational effects on astrophysical and cosmological scales, yet its particle nature remains unknown. Among the most compelling candidates are weakly interacting massive particles (WIMPs) and other particle-like dark matter scenarios that can be probed through direct detection experiments. In this overview talk, I will provide a broad introduction to the theoretical and phenomenological framework underlying direct detection of particle dark matter and will highlight some of the most sensitive ongoing and upcoming experimental searches with a focus on conventional detection concepts.

Do you plan to give the talk in person?:

Yes

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Welcome

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TBD

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Discussion

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Color center defect optical properties and formation dynamics across mineral candidates for dark matter detection

The presence of color center defects in ancient minerals can be used to infer rare, high-energy nuclear recoil events due to neutrinos and dark matter. In order to be suitable for this approach, a mineral needs to have a propensity to form optically active color center defects as a result of lattice damage and subsequent relaxation. First-principles methods for computing electronic and optical properties have been very successful in explaining the behavior of color center defects for quantum applications in silicon, diamond, and other pristine, non-polar materials. However, accurate prediction of defect properties in natural minerals such as halite, olivine, and corundum pose a challenge for ab initio methods, due to their polar structures, complex compositions, and disorder. We overview the various computational approaches used to predict optical properties and formation of color center defects in minerals, including the selection of hybrid functionals to reproduce experimental optical transitions [1,2], charge and spin state effects on formation energies and barriers, and configurational averaging to account for lattice disorder. We present recent results on promising mineral candidates and discuss their suitability for detecting nuclear recoil events.

Acknowledgement: This work has been supported through the U.S. National Science Foundation Growing Convergence Research Grant OIA-2428507, titled "Collaborative Research: GCR: Mineral Detection of Dark Matter"and by the National Nuclear Security Administration Office of Defense Nuclear Nonproliferation R&D through the "Consortium for Monitoring, Technology and Verification" under award number DE-NA0003920.

[1] Gabriela A. Araujo, Laura Baudis, Nathaniel Bowden, Jordan Chapman, Anna Erickson, Mariano Guerrero Perez, Adam A. Hecht, Samuel C. Hedges, Patrick Huber, Vsevolod Ivanov, Igor Jovanovic, Giti A. Khodaparast, Brenden A. Magill, Jose Maria Mateos, Maverick Morrison, Nicholas W. G. Smith, Patrick Stengel, Stuti Surani, Nikita Vladimirov, Keegan Walkup, Christian Wittweg, Xianyi Zhang. "Nuclear recoil detection with color centers in bulk lithium fluoride." arXiv:2503.20732 (2025).

[2] Mariano Guerrero Perez, Keegan Walkup, Jordan Chapman, Pranshu Bhaumik, Giti A. Khodaparast, Brenden A. Magill, Patrick Huber, Vsevolod Ivanov. "First-principles spin and optical properties of vacancy clusters in lithium fluoride." J. Appl. Phys. 28 June 2025; 137 (24): 244401. https://doi.org/10.1063/5.0255905 (2024).

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Discussion

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Discussion

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Discussion

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Discussion

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Searching Dark Matter with Muscovite Mica

Author: Anupam Ray[1]

[1] *Queen's University & Perimeter Institute*

The nature of dark matter remains one of the central open questions in physics, with conventional direct-detection experiments losing sensitivity for very heavy candidates due to their extremely low number densities. In this talk, I will present the potential of muscovite mica crystals as paleo-detectors to search for dark matter with masses far above the weak scale, leveraging their billion-year exposure and exceptional ability to preserve damage tracks. I will highlight how modern readout techniques can enable the identification and characterization of rare dark matter–induced tracks, opening a new window onto ultra-heavy dark matter parameter space beyond the reach of existing experiments.

Do you plan to give the talk in person?:

Yes

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Probing WIMP–Nucleon Effective Interactions with Paleo-Detectors

Author: Dionysios Theodosopoulos[1]

Co-authors: Chris Kelso ; Katherine Freese [1]; Patrick Stengel [2]

[1] *The University of Texas at Austin*

[2] *Jožef Stefan Institute*

Within the framework of a non-relativistic effective field theory (NREFT), WIMP–nucleon interactions are described by a complete basis of operators that capture momentum and spin dependencies beyond the standard spin-independent and spin-dependent cases. We present projections of the sensitivity of paleo-detectors to the full set of elastic and inelastic NREFT operators and compare their performance to that of conventional direct-detection experiments. We further investigate the capability of paleo-detectors to discriminate between different operator structures and explore prospects for dark matter mass reconstruction. These studies highlight the complementarity of paleo-detectors in probing non-standard WIMP interactions and characterizing potential dark matter signals.

Do you plan to give the talk in person?:

Yes

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(Minicharged) magnetic monopole with mineral detectors

Author: Ayuki Kamada[1]

[1] *University of Warsaw*

A remarkable aspect of mineral-detector search for dark matter is its long exposure.
It can overcome so-called flux limit of ordinary dark matter search.
This allows us to probe not only a dominant component of dark matter, but also sub-dominant or even rare objects in the Universe, including topological defects.
In this talk, we examine a possibility of detecting cosmological relic of magnetic monopoles in mineral detectors, while taking into account other constraints.
We also extend our discussion to minicharged monopole, arising from a dark sector.

Do you plan to give the talk in person?:

Yes

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Investigating cosmic-ray signatures in paleodetectors with PRImuS: scientific cases and experimental efforts

Author: Claudio Galelli[1]

Co-author: Lorenzo Caccianiga

[1] *INFN Milano*

The PRImuS experiment is an experimental effort to validate natural minerals as solid-state detectors for paleo-cosmic ray fluxes. This talk presents recent simulative efforts and the experimental status of the project. I will first highlight the results from our latest published paper, in which we simulate the cosmic-ray-induced track count in olivine xenoliths from the Chaîne des Puys, France. Volcanic annealing reset their track records, providing a pristine chronosequence to measure secondary muon and neutron fluxes over the last ~50,000 years. Additionally, I will discuss ongoing simulations of quartz from the Cradle of Humankind, where paleo-detector data may provide essential context and aid for the dating of hominid fossils. While the olivine study is finalized from a modeling perspective, both the olivine and quartz targets are now transitioning to the experimental phase. I will outline the PRImuS laboratory pipeline, including plasma etching and automated optical microscopy readout with micron precision, and track detection and measurement via the OptimusPrimus ML model. I will also discuss how to simulate the distortion coming from the chosen experimental technique to better compare observations to expectations from theory.

Do you plan to give the talk in person?:

Yes

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A complete framework for the modeling of the effect of cosmic rays in paleodetectors

Authors: Claudio Galelli[1]; Lorenzo Caccianiga[2]

[1] *INFN Milano*

[2] *Istituto Nazionale di Fisica Nucleare - Sezione di Milano*

Cosmic rays are usually treated as a background to be suppressed in dark matter and neutrino physics. However, for mineral paleo-detectors, they serve as the primary signal, encoding high-energy astrophysical history over millions of years. This talk details the interaction of cosmic rays with natural minerals and the methodology used to reconstruct past astrophysical fluxes from latent damage tracks. We present our simulation pipeline designed to model these observables: using MCEq-based atmospheric cascade models to propagate primary flux variations into secondary muon and neutron populations, Geant4 for subsurface particle transport, and SRIM to derive the resulting track-length distributions. By quantifying this cosmic-ray-induced "track budget," we can provide the necessary tools for both paleo-astrophysics and the determination of background floors for future rare-event searches.

Do you plan to give the talk in person?:

Yes

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Crystal Defect Creation by Nuclear Recoils in Cryogenic Calorimeters

Author: Holger Kluck[1]

Co-author: Jens Burkhart [1]

[1] *Marietta Blau Institute for Particle Physics of the Austrian Academy of Sciences*

Mineral detectors look for signals of new and interesting physics by studying defects in the crystal lattice of natural minerals caused by recoiling nuclei. As the measurement happens sometimes Gyr after the searched-for interaction, this can be understood as the extreme case of a "long-lived"signal. In contrast, cryogenic calorimeters are used to study the temperature increase caused by the nuclear recoil in the laboratory –a very "short-lived"signal. For cryogenic calorimeters, crystal defects are a source of systematic uncertainty, as their creation energy is missing from the temperature signal. Although the detection methods are different, nuclear recoils and crystal defect creation are of common interest for mineral detectors and cryogenic calorimeters alike.
In this contribution, I will discuss crystal defects from the perspective of cryogenic calorimetry. After briefly introducing rare-event searches with cryogenic calorimeters, I will present the simulation of crystal defect creation by nuclear recoils using the Molecular Dynamics program LAMMPS. The possibility of comparing simulation and measurement will be discussed based on direct measurements of the thermal signal caused by single, monoenergetic nuclear recoils by the CRESST and CRAB & NUCLEUS experiments. Finally, I give an outlook on the CRAB facility at TU Wien, which aims at precision measurements of nuclear recoils in cryogenic detectors using thermal neutron capture.

Do you plan to give the talk in person?:

Yes

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Extensions of the 'paleoSens'/'paleoSpec' Codes

Author: Shigenobu Hirose[1]

[1] *JAMSTEC*

The Python packages paleoSens and paleoSpec, developed by Baum *et al.*, are widely used to forecast the sensitivity of paleo-detectors. In the standard framework, paleoSpec computes recoil-energy spectra for signal and backgrounds and converts them into track-length histograms, while paleoSens

derives projected sensitivities from the resulting signal and background histograms through a statistical analysis.

This treatment assumes an ideal readout in which track lengths are directly measurable. However, this is not always the case. In DMICA (after Snowden-Ifft *et al.*, 1994), recoils intersecting the mica cleavage plane are read out by chemical etching and appear as nanometer-scale etch pits. The relevant observable is therefore the pit-depth histogram rather than the track-length distribution. We have extended paleoSpec to compute pit-depth spectra for both signal and backgrounds.

In this talk, I present two further extensions:
- paleoSens: a module that evaluates the overburden-limited upper reach in cross section, i.e. the maximum cross section for which particles can still reach the sample with sufficient energy after attenuation in the overburden.
- paleoSpec: a module that computes pit-depth histograms from the double-differential recoil spectrum
$\mathrm{d}^2R_{\overline{dE\,d\mu, \qquad \mu\equiv\cos\theta,}}$
$enablingforecastsforanisotropicscenariossuchasthedark-matterwind, thecosmic-wallscenario(arXiv:$
$2505.15764), andneutron-irradiationcalibrationexperiments, wherethepit-depthspectrumdependsontheang$

These extensions broaden the applicability of paleoSens/paleoSpec to alternative readout observables and to physics cases in which directionality must be taken into account.

Do you plan to give the talk in person?:

Yes

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Potential for paleodetector studies at the LMV and the LPCA

Authors: Andreas Goudelis[1]; Denis Andrault[2]; Emmanuel Gardes[3]; Luca Terray[None]; Pierre-Jean Gauthier[3]; Thierry Pilleyre[4]; Valentin Niess[1]; Vincent Breton[5]

[1] *LPCA CNRS-IN2P3*

[2] *LMV - Clermont-Auvergne University*

[3] *LMV - CNRS-INSU*

[4] *LPCA Clermont-Auvergne University*

[5] *CNRS-IN2P3*

The LMV and the LPCA are two French research laboratories focusing on the study of volcanology, petrology, and geochemistry (LMV) and of particle physics, cosmology and their applications (LPCA). They have been collaborating since many years at the interface between geosciences, nuclear and particle physics on a variety of topics. Two platforms are of particular interest for paleodetector studies: the LMV CarMa experimental platform, dedicated to the characterization, 2D & 3D imaging and chemical analysis of materials; the LPCA PAVIRMA platform, equipped with instruments dedicated to nuclear spectrometry and/or counting (alphas, betas) as well as thermoluminescence dosimetry and dating. Moreover, the LPCA has a long-standing expertise in the development of numerical libraries to describe the transport of particles through matter.

LMV and LPCA are located in the center of France in close proximity to the Chaîne des Puys, a dense, 40 km-long, north-south oriented alignment of approximately 80 monogenetic volcanoes, all formed within the last 95,000 years. The volcanic activity is characterized by relatively small, discrete eruptions of magmas in which crystals form (e.g. olivine). Crystals in the eruptive products of a volcanic chronosequence could be used as a time-resolved paleo-detector array to study the cosmic-ray flux in the Late Pleistocene and Holocene.

In this talk we will describe LMV and LPCA capabilities and discuss their relevance for paleodetector studies.

Do you plan to give the talk in person?:

Yes

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Imaging nuclear recoil damage in minerals with light-sheet microscopy

Authors: Patrick Huber[None]; Samuel Hedges[1]

[1] *Virginia Tech*

Nuclear recoils can induce damage in crystal lattices; in certain materials, these defects can capture electrons, turning them optically active (i.e. color centers). At Virginia Tech, we have constructed the mesoSPIM light-sheet fluorescence microscope, which can rapidly image recoil-induced defects in cm3-volumes with micrometer-scale precision. In this talk, I will present commissioning data from the VT mesoSPIM and discuss prospects for imaging recoil damage in natural minerals.

Do you plan to give the talk in person?:

Yes

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Mineral Detectors for Neutrinos

Author: Patrick Stengel[1]

[1] *Jožef Stefan Institute*

Mineral detectors are a novel probe of neutrino physics. Low effective nuclear recoil energy detection thresholds allow mineral detectors to potentially measure coherent elastic neutrino–nucleus scattering. Mineral detectors are also envisioned to have exposures comparable to neutrino observatories and, thus, could probe the nuclear recoil signatures of astrophysical neutrino fluxes. While inaccessible to conventional neutrino observatories, mineral detectors could measure the evolution of solar neutrino fluxes over geological timescales, which could shed light on the solar composition problem. Mineral detectors could also measure changes in the flux of neutrinos from galactic core-collapse supernovae, probing associated changes in the supernova rate and, hence, the Milky Way's star formation history and the flavor content of supernova neutrino bursts. Atmospheric neutrinos interact with atomic nuclei predominantly via quasi-elastic and deep-inelastic scattering. Searching for the damage features produced by the corresponding nuclear recoil cascades may allow mineral detectors to probe the cosmic ray history of the Milky Way.

Do you plan to give the talk in person?:

Yes

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Light-sheet microscopy and astrophysics, an unexpected match.

Author: Nikita Vladimirov[1]

Co-authors: Gabriela Araujo [2]; Laura Baudis [2]

[1] *Universität Zürich*

[2] *University of Zurich*

The mesoSPIM is a grass-root initiative of microscopy builders (www.mesospim.org) that started in Laboratory of Neural Circuit Dynamics at the University of Zurich (UZH) in 2015 with the aim of democratizing access to DIY high-performance light-sheet microscopes. It gradually gained recognition among biomedical research labs and light microscopy facilities around the world. Unexpectedly to its developers, the light-sheet microscopes that were intended for biologists found applications in detection of neutrinos and dark matter. In my talk I will review the principles used in mesoSPIM, such as axially scanned light-sheet microscopy (ASLM), share the latest developments in our project, and discuss possible useful variations of this open-source microscope.

Do you plan to give the talk in person?:

Yes

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Mining CHAMP relics from terrestrial matter

Authors: Reza Ebadi[None]; Peter Graham[None]; Surjeet Rajendran[None]; Erwin Tanin[None]; Samuel Wong[1]

[1] *University of Washington*

We propose a method for detecting an ambient density of heavy, electrically charged particles around the Earth. Such particles would impinge the Earth, lose energy in terrestrial matter, and become trapped. We examine the accumulation of these rare particles in multiple target materials that offer substantial exposure, such as large monitored water/ice volumes, geological rocks, and ancient ice cores. We also discuss strategies for enriching target samples to increase the concentration of captured heavy particles, along with precision techniques for their subsequent identification. This technique enables the discovery of charged relics with mass $1-10^{12}$ TeV constituting a tiny fraction of the local dark matter density, down to $f_X \sim 10^{-18}$ for the lowest masses.

Do you plan to give the talk in person?:

Yes

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Observation of Natural tracks in Muscovite by AFM

Author: Noriko Hasebe[1]

Co-authors: Atsuo Omote [1]; Ruby Connemara Marsden [1]; Zhe Shi [1]

[1] *Kanazawa University*

This study examines tracks found in natural muscovite using atomic force microscopy (AFM). The muscovite samples were etched in 47% HF at 32 ℃ for durations ranging from 6 minutes to 2 hours, and naturally occurring ARTs were observed. Sparse but well-defined ART etch pits were present in all samples regardless of etching duration, indicating that ARTs are revealed rapidly. The track densities estimated by AFM were consistent with those obtained by phase contrast microscopy (Nakamura et al., 2024).
The size and morphology of ARTs varied, and step etch observations of the same area demonstrated the appearance of new tracks as etching progressed. Well etched ARTs exhibited shell like shapes with clear step shaped rims, and the step height corresponded to a single crystallographic layer.
When the muscovite sheets were observed at higher resolution, many more tiny tracks—far more numerous than the ARTs—were detected. The formation mechanism of these tiny tracks remains unknown. Artificial irradiation with various particles is expected to help clarify the origin of these puzzling features.

Do you plan to give the talk in person?:

No

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Directional Dark Matter Detection and Beyond: Diamond as a Platform for Mineral Detectors

Author: Daniel Ang[1]

Co-authors: Jiashen Tang ; Mason Camp ; Maximilian Shen ; Gavishta Liyanage ; Chinmay Bharathulwar ; Priyanshu Bhattacharya ; Anson Cook ; Ronald Walsworth

[1] *University of Maryland*

Diamond is uniquely suitable as a model system for mineral-based detection of dark matter (DM) and neutrinos, benefitting from an unmatched suite of quantum defect sensors for imaging damage tracks, the wide availability of high-quality synthetic samples, and decades of systematic gemological study producing vast, well-characterized libraries of natural samples. Insights from diamond therefore have broad applicability to the wider mineral detection program. Beyond its role as a model system, synthetic diamond uniquely enables directional WIMP detection, overcoming the 'neutrino fog' limitation of conventional detectors. We present progress on developing diamond as a mineral detector on three experimental fronts. First, we describe our experiments studying the formation and properties of damage tracks from nuclear recoil cascades in diamond via ion implantation, including confocal microscopy, Kinetic Monte Carlo annealing simulations, spin measurements, and track morphology analysis. Second, we report progress in developing a light-sheet quantum diamond microscope, enabling high-speed, high-resolution 3D imaging of diamond lattice strain. Third, we describe ongoing work in machine-learning-accelerated molecular dynamics simulations, achieving a 100x speedup over conventional methods, as well as development of neural network algorithms for nuclear recoil event reconstruction.

Do you plan to give the talk in person?:

No

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Investigating Track Formation and Morphology in Paleo-Detectors: Research Updates from the University of Michigan

Authors: Emilie LaVoie-Ingram[1]; Kai Sun[None]

[1] *University of Michigan*

The use of ancient minerals as paleo-detectors is an emerging experimental technique capable of transforming the fields of neutrino and dark matter detection. Towards developing a successful mineral detector, we can utilize tools like simulation and track measurement algorithms to help understand the complex dynamics of defect formation in a variety of minerals. Progress on the use of these tools for mineral selection and sensitivity projection at the University of Michigan will be presented. Ongoing research includes molecular dynamics for low-energy (<100 keV) recoil simulation, cosmogenic background modeling with PROPOSAL and Geant4, and automatic track measurement to study the morphology of track formation in a variety of energy (O(100) keV - O(10) MeV) regimes.

Do you plan to give the talk in person?:

Yes

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Developing Experimental Techniques for Paleo-Detectors: Research Updates from the University of Michigan

Author: Hannah Ross[1]

Co-authors: Emilie LaVoie-Ingram [1]; Joshua Spitz [1]; Kai Sun

[1] *University of Michigan*

Paleo-detector research at the University of Michigan aims to use ancient minerals as solid-state detectors, preserving evidence of neutrino and dark matter interactions over geologic timescales. Once a mineral sample has been selected as a promising paleo-detector candidate, preparing the sample and determining the proper analysis techniques requires thoughtfulness and care. Track geometry, mineral properties, and sample preservation considerations are examples of the many factors that guide experimental planning. This talk will discuss experimental progress, including sample preparation workflow development, light-Z ion implantation studies, and track enhancement techniques alternative to etching, as well as progress towards bulk track imaging using x-ray microscopy, striving for nanometer-resolution with high volumetric throughput.

Do you plan to give the talk in person?:

Yes

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Ultra-heavy Exotic Particle Search with Olivine in Meteorites

Author: Tatsuhiro Naka[1]

[1] *Toho University*

Ultra-heavy exotic particles (UHPs) are motivated by several proposed solutions to outstanding problems in particle physics. In this work, we focus on Q-balls and strange quark matter (SQM), which are well-motivated candidates for new physics and dark matter.
So far, we have investigated the track formation performance of muscovite mica and olivine, and found that both minerals are promising candidates for detecting such UHPs. In particular, olivine in meteorites is an especially attractive target for lighter particles with high dE/dx, as such particles

may not be able to penetrate the Earth's atmosphere and rock.
Moreover, meteoritic olivine is also sensitive to rare galactic heavy cosmic rays. In this talk, we discuss the detection performance and the searchable parameter space of meteoritic olivine as a paleo-detector material.

Do you plan to give the talk in person?:

Yes

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Calorimetric vs track readout of paleo detectors

Author: Patrick Huber[1]

[1] *Virginia Tech*

We will compare calorimetric readout using color center counting with track length based dark matter searches in paleo detectors.

Do you plan to give the talk in person?:

Yes

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Mineral Detection of Cosmic-Ray Boosted Dark Matter

Author: Jin-Wei Wang[1]

[1] *UESTC*

We present the first dedicated analysis of cosmic-ray boosted dark matter (CRDM) in paleo detectors. Owing to their large kinetic energies, CRDM particles generate nuclear-recoil tracks that extend to substantially larger lengths than those produced by dominant backgrounds from neutrinos and intrinsic radioactivity. Combined with the ultra-large effective geological exposure of 10^5 tyr, paleo detectors provide a uniquely sensitive probe of sub-GeV DM. Considering both constant and vector-mediator interactions, we find that paleo detectors improve the sensitivity to the DM-proton scattering cross section by one to two orders of magnitude compared with the latest XENONnT limits.

Do you plan to give the talk in person?:

No

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Surface characterization of mineral samples relevant for particle detection

Author: Chris Kelso[1]

Co-authors: Emilie LaVoie-Ingram [2]; Greg Wurtz [1]; Rabeya Rabu [1]

[1] *University of North Florida*

[2] *University of Michigan*

This talk will present results from several techniques utilized for surface characterization of mineral samples relevant for particle detection as part of the NSF Growing Convergence Research group. Atomic force microscopy was utilized to measure the stiffness and strain of quartz and olivine samples with tracks created by 15 MeV Au^{5+} ions. We utilized non-irradiated reference samples from the same minerals to identify and characterize track/impact morphology. We measured the diffusivity of the diffraction pattern using electron backscatter diffraction (EBSD) in these samples as a function of position, which is expected to reveal track defects in the crystal structure of the samples. We also utilized EBSD to characterize the crystal orientation on olivine samples for preliminary measurements at the Advanced Photon Source Center for NanoMaterials (APS/CNM) that will support an upcoming full proposal to the APS/CNM to characterize tracks with high throughput.

Do you plan to give the talk in person?:

Yes

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Prospects for Detecting High-Energy Dark Matter with Paleodetectors

Author: Kohta Murase[None]

Paleodetectors offer a novel approach to dark matter searches by recording damage tracks produced by rare scattering events over geological timescales. In this talk, I discuss the prospects for probing boosted or heavy dark matter with paleodetectors, especially with a focus on the proposed DMica concept.

Do you plan to give the talk in person?:

No

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From geology to low background physics: The Bedretto underground laboratory under the Gotthard massif

Authors: Florian Jörg[1]; Luisa Hötzsch[1]

[1] *Universität Zürich*

Deep underground laboratories provide the low-background environments essential for rare-event searches. The Bedretto tunnel, situated under the Gotthard massif in Switzerland, offers an exciting opportunity to establish such a facility. Located within two hours of the University of Zürich, the site is conveniently accessible for iterative detector development and commissioning. The tunnel currently hosts a geology laboratory operated by ETH Zürich, and provides a maximum overburden of approximately 3500 metres water equivalent. We present results from a first measurement campaign, characterising the site's radioactive backgrounds and showing the site's suitability for low background experiments. Looking ahead, we give an overview of the project timeline and discuss the prospects for deploying crystal detectors and dedicated measurement infrastructure underground at Bedretto.

Do you plan to give the talk in person?:

Yes