25th Symposium on Astroparticle Physics in the Netherlands, 25/26 March 2021, ZOOM

Thursday 25 March 2021 - Friday 26 March 2021

Book of Abstracts

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Cherenkov Telescope Array Sensitivity to the Putative Millisecond Pulsar Population responsible for the Galactic Center Excess

Author: Oscar Macias[1]

Co-author: Shin'ichiro Ando [1]

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Summary:

The leading explanation of the Fermi Galactic center gamma-ray excess is the extended emission from a unresolved population of millisecond pulsars (MSPs) in the Galactic bulge. Such a population would, along with the prompt \gammaγ rays, also inject large quantities of electrons/positrons (e+e-)into the interstellar medium. These e+e- could potentially inverse-Compton (IC) scatter ambient photons into gamma rays that fall within the sensitivity range of the upcoming Cherenkov Telescope Array (CTA). In this article, we examine the detection potential of CTA to this signature by making a realistic estimation of the systematic uncertainties on the Galactic diffuse emission model at TeV-scale gamma-ray energies. We forecast that, in the event that e+e- injection spectra are harder than E^{-2}, CTA has the potential to robustly discover the IC signature of a putative Galactic bulge MSP population sufficient to explain the GCE for e+e- injection efficiencies in the range approximately 2.9% to 74.1%, or higher, depending on the level of mismodeling of the Galactic diffuse emission components. On the other hand, for spectra softer than E^{-2.5}, a reliable CTA detection would require an unphysically large e+e- injection efficiency of 158%. However, even this pessimistic conclusion may be avoided in the plausible event that MSP observational and/or modeling uncertainties can be reduced. We further find that, in the event that an IC signal were detected, CTA can successfully discriminate between an MSP and a dark matter origin for the radiating e+e-.

Contributed talks / 26

A new window to Axion-Like Particles from the upcoming CMB experiments

Author: Suvodip Mukherjee[1]

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Summary:

Cosmic Microwave Background (CMB) is a powerful probe to the Universe which carries signatures of cosmic secrets over a vast range of redshifts. Along with spatial fluctuations, spectral distortions of CMB blackbody are also a rich source of cosmological information. In my talk, I will introduce a new kind of spectral distortion of CMB which can arise due to the conversion of CMB photons into Axion-Like Particles (ALPs) in the presence of an external magnetic field. This effect leads to both polarized and unpolarized spatially varying spectral distortion signals with a unique spectral shape when CMB photons undergo resonant and non-resonant conversion into ALPs in the presence of the magnetic field of the Milky Way, galaxy clusters, and voids. I will discuss the spatial structure of this distortion which can arise from Milky Way and galaxy clusters and will show its uniqueness from other known cosmological and astrophysical signals using which we can probe unexplored parameter space of photon ALPs coupling.

Contributed talks / 27

Multimessenger constraints on the neutron-star equation of state and the Hubble constant

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Co-authors: Ingo Tews [2]; Jack Heinzel [3]; Lina Issa [4]; Mattia Bulla [5]; Michael Coughlin [3]; Peter T. H. Pang [6]; Sarah Antier [7]

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Summary:

Observations of neutron-star mergers based on distinct messengers, including gravitational waves and electromagnetic signals, can be used to study the behavior of matter denser than an atomic nucleus, and to measure the expansion rate of the Universe described by the Hubble constant. We perform a joint analysis of the gravitational-wave signal GW170817 with its electromagnetic counterparts AT2017gfo and GRB170817A, and the gravitational-wave signal GW190425, both originating from neutron-star mergers. We combine these with previous measurements of pulsars using X-ray and radio observations, and nuclear-theory computations using chiral effective field theory to constrain the neutron-star equation of state. We find that the radius of a 1.41.4 solar mass neutron star is $11.75^{+0.86}_{-0.81}$ km at 90% confidence and the Hubble constant is $66.2^{+4.4}_{-4.2}\ \mathrm{km\,Mpc^{-1}\,s^{-1}}$ at 1σ uncertainty.

Lunch and Poster session / 28

A fast and precise methodology to search for strong gravitational-wave lensing

Author: Justin Janquart[None]

Co-authors: Chris Van Den Broeck ; Haris Maliyamveettil ; Otto Hannuksela

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Summary:

Gravitational waves (GWs), like electromagnetic signals, can undergo gravitational lensing when a massive object (a galaxy or galaxy cluster) is present on the path from source to the detector. In the case of GWs, lensing will manifest itself through several images arriving at our interferometers at different times, separated by seconds to months. According to the current forecasts, gravitational-wave lensing observations can become quite likely with Advanced LIGO and Advanced Virgo at design sensitivity. Discovering lensing of GWs presents a computational challenge, given the large number of GW signal pairs (including sub-threshold triggers) that need to be investigated to see whether they represent images of a lensed event. We present GOLUM (Gravitational-wave analysis Of Lensed and Unlensed waveform Models), a method that considerably speeds up the search for lensed events (by up to factors of hundreds) by marginalizing over parameters that are unaffected by lensing before jointly analyzing two GW signals under the lensing hypothesis. This allows for analysis of large sets of GW pairs, enabling future lensing searches.

Lunch and Poster session / 29

Evolution of black hole shadows from superradiance

Author: Gastón Creci[1]

Co-authors: Helvi Witek [2]; Stefan Vandoren [1]

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Summary:

Black holes have turned into cosmic laboratories to search for ultralight scalars by virtue of the superradiant instability. In this poster we present a study of the impact of the superradiant evolution on the black hole shadow and investigate the exciting possibility to explore it with future observations of very long baseline interferometry. We simulated the superradiant evolution numerically, in the adiabatic regime, and derived analytic approximations modeling the process. Driven by superradiance, we evolve the black hole shadow diameter and (i) find that it can change by a few μas, just below the current resolution of the Event Horizon Telescope, albeit on timescales that are longer than realistic observation times; (ii) show that the shadow diameter can either shrink or grow; and (iii) explore in detail how the shadow's end state is determined by the initial parameters and coupling.

Contributed talks / 30

Status of ETpathfinder

Author: Sebastian Steinlechner[None]

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Summary:

The discovery of gravitational waves from merging black holes and neutron stars by Advanced LIGO and Advanced Virgo marked the beginning of a new era in observing our universe. The Einstein Telescope (ET) is a proposed third-generation gravitational wave detector that will detect several hundred thousand gravitational wave signals per year and allow us listen to the sound of merging black holes across the entire universe. In order to develop new technologies required for the Einstein Telescope, a multi-national collaboration is setting up a research prototype at Maastricht University, ETpathfinder. It is intended to develop and test precision interferometry with cryogenically-cooled suspended mirrors, as well as measurement and control techniques, which will be required to achieve the targeted sensitivity of the Einstein Telescope. We will report on recent progress of the design and manufacturing of ETpathfinder, and highlight collaboration opportunities.

Contributed talks / 31

The LISA mission and the NL involvement

Author: Gijs Nelemans[1]

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Summary:

The LISA mission is ESA's space Gravitational Wave mission, sensitive to frequencies between 0.1 and 100 mHz. In this frequency range many types of sources are expected, some in large numbers. They range from stellar mass binaries in our Milky Way and beyond to super-massive black hole mergers throughout the Universe, from extreme mass-ratio inspirals to stochastic backgrounds. We will summarise the LISA science and the involvement of the Netherlands in instrumentation and science to make clear how people can become involved.

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Axion-Photon Conversion in Magnetospheres: The Role of the Plasma

Authors: Samuel Witte[1]; Christoph Weniger[None]; Dion Noordhuis[2]; Thomas Edwards[3]

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Summary:

The most promising indirect search for the existence of axion dark matter uses radio telescopes to look for narrow spectral lines generated from the resonant conversion of axions in the magnetospheres of neutron stars. Unfortunately, a large list of theoretical uncertainties has prevented this search strategy from being fully accepted as robust. In this talk I will present a recently end-to-end pipeline based on an auto-differentiable ray-tracing algorithm that allows one assess many of the outstanding uncertainties related to the role of the plasma, including: (1) do refraction and reflection induce strong inhomogeneous features in the flux, (2) can refraction induce premature axion-photon de-phasing, (3) what is the expected width of the line, (4) does the flux have a strong time-dependence, and (5) can these radio photons be efficiently absorbed.

Lunch and Poster session / 33

Axion dark matter around black holes with numerical relativity

Author: Alexandra Wernersson[1]

[1] *Utrecht University*

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Summary:

The broad objective is to probe physics beyond the standard model with gravitational waves,
in particular ultralight bosons as dark matter candidates. The main aim of the project is to
study the effect of ultralight bosons on binary black holes using numerical relativity. So far we have studied the single black hole case and included self-interactions for the scalar bosons.

Update talks / 35

The Cherenkov Telescope Array: a new eye on the TeV sky

Very-high-energy (VHE) gamma-ray astroparticle physics is a relatively young field, and observations over the past decade have surprisingly revealed almost two hundred VHE emitters which appear to act as cosmic particle accelerators. These sources are an important component of the Universe, influencing the evolution of stars and galaxies. At the same time, they also act as a probe of physics in the most extreme environments known - such as in supernova explosions, and around or after the merging of black holes and neutron stars. However, the existing experiments have provided exciting glimpses, but often falling short of supplying the full answer. A deeper understanding of the TeV sky requires a significant improvement in sensitivity at TeV energies, a wider energy coverage from tens of GeV to hundreds of TeV and a much better angular and energy resolution with respect to the currently running facilities. The next generation gamma-ray observatory, the Cherenkov Telescope Array (CTA), is the answer to this need. In this talk I will present this upcoming observatory from its design to the construction, and its potential science exploitation. CTA will allow the entire astronomical community to explore a new discovery space that will likely lead to paradigm-changing breakthroughs. In particular, CTA has an unprecedented sensitivity to short (sub-minute) timescale phenomena, placing it as a key instrument in the future of multi-messenger and multi-wavelength time domain astronomy.

Summary:

Highlight talk / 36

Clarifying the Hubble Constant Tension

Abstract: Our best estimate of the Universe's current expansion rate (the Hubble constant) from the local Universe (via the Cepheid distance ladder) is in four-sigma tension with the value extrapolated from cosmic microwave background data assuming the standard cosmology. Whether this discrepancy represents physics beyond the Standard Model or deficiencies in our understanding of the data is the subject of intense debate. In this talk, I will review the community's attempts to explain and interpret the Hubble constant tension, clarifying the current picture using Bayesian probability theory, and consider the potential for independent gravitational wave observations to arbitrate the dispute.

Welcome & CAN update / 37

Welcome and CAN update

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Update talks / 38

Detection of ultra-high-energy particles with the Pierre Auger Observatory and GRAND

Corresponding Author: c.galea@nikhef.nl

Ultra-high-energy cosmic rays are unique probes of both cosmic phenomena and particle interactions at energies well beyond what is achievable with human-made accelerators. In the past decade, much progress has been made in their detection and study, notably also with the Pierre Auger Observatory. Definitive answers on questions such as their cosmic sources and precise models for hadronic physics at the sqrt(s)=100 TeV scale require knowledge of the ultra-high-energy cosmic ray composition. The detection of ultra-high-energy neutrinos and photons will provide important complementary information to that of cosmic rays. The AugerPrime upgrades aim at improving composition information and neutrino and photon identification. It is already clear that for detailed ultra-high-energy cosmic ray, neutrino and photon astronomy a next generation observatory will be needed, for which the Giant Radio Array for Neutrino Detection (GRAND) has the most advanced design. The Dutch cosmic ray science group plays leading roles in both the AugerPrime upgrade and the preparations for GRAND. The status of the field based on the Pierre Auger Observatory data, as well as the progress on the AugerPrime upgrade and GRAND prototypes will be presented.

Summary:

Update talks / 39

Investigating the universe with gravitational waves: recent results and future prospects

Corresponding Author: a.puecher@nikhef.nl

In the past few years, gravitational waves have proved an incredible tool to investigate the Universe. The third LIGO-Virgo observation run was concluded last Spring and results from its first half, O3a, are now available. I will give an overview of these new events and their implications, focusing on the so-called "special events", whose unexpected features require us to question our current understanding of the astrophysics of compact objects. I will then outline the future prospects in gravitational waves, in particular for what concerns the Dutch efforts in this field.

Summary:

Update talks / 41

Direct searches for Dark Matter

Corresponding Author: t.pollmann@nikhef.nl

Direct searches for Dark Matter in the form of WIMP-like particles continue to push toward the neutrino floor. Researchers in the Netherlands play a leading role in the XENON class of detectors. The XENON1T experiment has finished its data-taking phase, reaching an unprecedented sensitivity of $4 \cdot 10^{-}47$ cm^2 spin-independent WIMP-nucleon scattering cross section at 25~GeV WIMP mass. The next generation XENONnT detector, which is expected to increase sensitivity by more than an order of magnitude, is being commissioned now, while the DARWIN detector, which will be sensitive down to the neutrino floor, is in the planning stage. This presentation reviews the status of the field of direct searches world-wide, with a focus on the experiments with significant Dutch contributions.

Summary:

Contributed talks / 42

First results from the AugerPrime Radio Detector

Author: Tomáš Fodran[1]

[1] *Radboud University*

Corresponding Author: t.fodran@astro.ru.nl

Summary:

The Pierre Auger Observatory investigates the properties of the highest-energy cosmic rays with unprecedented precision. The aim of the AugerPrime upgrade is to improve the sensitivity to the primary particle type. The improved mass sensitivity is the key to exploring the origin of the highest-energy particles in the Universe. The purpose of the Radio Detector (as part of AugerPrime) is to extend the sensitivity of the mass measurements to zenith angles above 60°. A radio antenna, sensitive in two polarization directions and covering a bandwidth from 30 to 80 MHz, will be added to each of the 1661 surface detector stations over the full 3000 km^2 area, forming the world's largest radio array for the detection of cosmic particles. Since November 2018, an engineering array
comprised of ten stations has been installed in the field.

The radio antennas are calibrated using the Galactic (diffuse) emission. The sidereal modulation of this signal is monitored continuously and is used to obtain an end-to-end calibration from the receiving antenna to the ADC in the read-out electronics. The calibration method and first results
will be presented.

The engineering array is also fully integrated in the data acquisition of the Observatory and records air showers regularly. The first air showers detected simultaneously with the water-Cherenkov detectors and the Radio Detectors will be presented. Simulations of the detected showers, based on
the reconstructed quantities, have been conducted with CORSIKA/CoREAS. A comparison of the measured radio signals with those predicted by simulations exhibits satisfying agreement.

Contributed talks / 43

Dark Matter Searches with the KM3NeT Neutrino Telescope

Author: Suzan Basegmez du Pree[None]

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Summary:

In this talk after introducing an angular power spectrum analysis method for the future sensitivity of KM3NeT neutrino telescope on the annihilating dark matter signals, I will discuss the implications of the results on the various particle dark matter models. Particular attention will be made on the assessment of limits complementing the current dark matter searches and possibly addressing some of the anomalies observed. I will emphasise that future neutrino telescopes will be able to competitively probe significant portions of parameter space and will provide critical complementary information on the dark matter searches.

Contributed talks / 44

A high-energy neutrino coincident with a tidal disruption event

Author: Sjoert van Velzen[1]

[1] *Leiden Observatory*

Corresponding Author: sjoert@strw.leidenuniv.nl

Summary:

The IceCube Collaboration recently associated one high-energy neutrino with a flare from the relativistic jet of an accreting black hole. However a combined analysis of many similar active galaxies revealed no excess from the broader population, leaving the vast majority of the cosmic neutrino flux unexplained. In this talk I will present the association of a radio-emitting tidal disruption event with another high-energy neutrino, identified in a systematic search for optical counterparts to high-energy neutrinos with the Zwicky Transient Facility (ZTF). The probability of finding any radio-emitting tidal disruption event by chance is 0.5%. Our electromagnetic observations can be explained through a multi-zone model, with radio analysis revealing a central engine, embedded in a UV photosphere, that powers an extended synchrotron-emitting outflow. The system provides an ideal site for PeV neutrino production. The association suggests that tidal disruption events contribute to the cosmic neutrino flux. Unlike previous work, which considered the rare subset of tidal disruption events with relativistic jets, our observations of AT2019dsg imply that a mildly-relativistic outflow could be sufficient of PeV-scale particle acceleration.

Contributed talks / 45

First neutrinos with KM3NeT/ORCA

Author: Valentin Pestel[None]

Corresponding Author: v.pestel@nikhef.nl

Summary:

KM3NeT is a cubic kilometer scale neutrino observatory located at the bottom of the Mediterranean Sea. The two detectors, ORCA and ARCA, are respectively optimised for energy of 1GeV to 100 GeV and 1TeV to 10PeV. It allows the collaboration to cover a broad range of physics topics, from neutrino oscillation to neutrino astronomy.
Currently under construction and deployment, the ORCA detector will reach its full volume of 115 detection units at the 2025 horizon. When completed, It will offer a competitive sensitivity for the Neutrino Mass Hierarchy as well as for the atmospheric neutrino oscillation parameters. For now, it was operated with 4 lines during 2019, and with 6 lines since the early 2020. This preliminary step validates the Phase 1 of the detector integration, opening the way to more frequent deployments until the instrument completion.
This contribution will focus on the analysis of the early data collected during the 2 past years with ORCA. With only a fraction of the detector volume, it is already possible to reconstruct charged particles passing through the instrument. Furthermore, the detector performances allow for first atmospheric neutrino study, already reaching the edge of the neutrino oscillation sensitivity. This preliminary work allowed the collaboration to develop a good understanding of the detector, showing promising perspective for the coming years.

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Search for high-energy gamma rays from supernovae

Authors: Dmitry Prokhorov[1]; Anthony Moraghan[2]; Jacco Vink[1]

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[2] *Academia Sinica Institute of Astronomy and Astrophysics*

Corresponding Authors: d.prokhorov@uva.nl, j.vink@uva.nl

Summary:

We present a systematic search for gamma-ray emission from supernovae (SNe) in the Fermi Large Area Telescope (LAT) Pass 8 data. We searched for gamma rays from SNe by means of a variable-size sliding-time-window analysis. Our results confirm the presence of transient gamma-ray emission from some non-AGN classes sources, including transitional pulsars, solar flares, gamma-ray bursts, novae, and the Crab Nebula, which are projected near some of these SN's positions, and also strengthen support to the variable signal in the direction of SN iPTF14hls. The analysis is successful in finding both short (e.g. solar flares) and long (e.g. transitional pulsars) high flux states. Our search reveals new gamma-ray transient signals where their flux increases within 6 months after the dates of SN's discoveries. These signals are bright and their variability is at a higher statistical level than that of iPTF14hls. In addition, we report the results of an all-sky search for gamma-ray transient sources.

Update talks / **47**

Cosmic neutrinos: from meV to PeV

Author: Shin'ichiro Ando[1]

[1] *University of Amsterdam*

Corresponding Author: s.ando@uva.nl

Summary:

In this overview talk, I will cover wide range of energy spectrum of cosmic neutrinos from meV to PeV, focusing on experimental activities in which the Netherlands is heavily involved.

Firstly, I will discuss TeV-PeV range, where IceCube telescope at the South Pole detected many astrophysical neutrino events. Even though there are a few interesting coincident events claimed with blazar flares and a tidal disruption event, no source counterpart has been identified robustly. Better angular resolution and much deeper coverage of the Galactic center region might be the key to this, for both of which KM3NeT is well positioned.

Secondly, I will go down to MeV range, where both solar and supernova neutrinos are an interesting target. XENONnT and DARWIN, which are mainly a dark matter detector, are also capable of doing unique neutrino science for these sources.

Lastly, I will discuss an ambitious project PTOLEMY, which is aimed at detecting the relic neutrino background from the Big Bang – a neutrino counterpart of the cosmic microwave background. Since the temperature is only 2K, it is extremely challenging to detect these neutrinos. I will discuss possible detection strategies and related physics that has to be explored in the future to achieve this enormous goal.

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Waveform simulation in XENONnT

Author: Peter Gaemers[None]

Corresponding Author: pgaemers@nikhef.nl

Summary:

For any experiment detailed knowledge of the detector response and the performance of the reconstruction algorithms is required. One of the parts in modeling this for XENONnT is the Waveform Simulator (WFSim) which takes quanta produced in the detector and simulates the corresponding PMT waveforms. I will, briefly, discus the steps needed in this process and the status of this software package

Contributed talks / 49

The Dutch involvement in the H.E.S.S. and CTA gamma-ray observatories

Author: Jacco Vink[1]

[1] *University of Amsterdam*

Corresponding Author: j.vink@uva.nl

Summary:

Gamma-rays provide us with a direct probe of cosmic rays in still in their sources of origin, or interacting with the interstellar medium. The last two decades have seen a remarkable coming of age of gamma-ray astronomy, with ground based experiments like H.E.S.S., MAGIC, VERITAS and HAWC targeting gamma-rays above >100 GeV, and space-based instruments like Fermi-LAT targeting the 100 MeV-100 GeV range.

Minitalks / 50

Minitalks round 1

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Oscar Macias
Alexandra Wernersson
Samuel Witte
Joran Angevaare
Béatrice Bonga
Andrei Utina

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Minitalks round 2

Patrick Decowski
Serena Di Pede
Cristina Galea
Bouke Jisse Jung
Lodewijk Nauta
Barbara Paetsch

Mischa Sallé
Charles Timmermans
Suzan Basegmez du Pree
Chris van den Oetelaar

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Minitalks round 3

Adam Coogan
Stefan Danilishin
Ariane Dekker
Eduardo Ferronato Bueno
Andreas Freise
Ugo Giaccari
Otto Hannuksela
Jan-Simon Hennig
Stefan Hild
Jesse van Dongen

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Minitalks round 4

Gastón Creci
Jann Aschersleben
Maricke Flierman
Dimitrios Kantzas
Rasa Muller
Khung Sang Phukon
Tomislav Prokopec
Soumen Roy
Viola Spagnuolo
Christoph Weniger

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Minitalks round 5

Joerg Hoerandel
Sijbrand de Jong
Manuela Vecchi
Abha Khakurdikar
Gideon Koekoek
Sera Markoff
Gijs Nelemans
Dion Noordhuis
Brían Ó Fearraigh
Peter T. H. Pang

Mart Pothast
Matthieu Schaller
Ayatri Singha
Sebastian Steinlechner

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Breakout room 1 - Gravitational waves

Chair: Chris van den Broek

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Breakout room 2 - Gamma rays

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Parralel session / 57

Breakout room 3 - Cosmic rays

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Breakout room 4 - Neutrinos

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Summary:

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Breakout room 5 - Dark matter

Corresponding Author: decowski@nikhef.nl