CHIPP Experiments (updated on 16 October. 2024)

22 November 2024

0.1 Experiments

0.1.1 Experiments with Swiss contributions at particle accelerators (energy and intensity frontiers)

- **ATLAS:** (A Toroidal LHC ApparatuS) is the largest general-purpose particle detector at the LHC. The ATLAS Detector is 46 metres long, 25 metres in diameter, and weighs about 7'000 tonnes. The ATLAS Collaboration consists of approximately 5'000 members and about 3'000 scientific authors from 183 institutions in 38 countries. (https://atlas.cern/)

- **Beam EDM:** The Beam EDM (Electric Dipole Moment) Experiment will measure the neutron EDM using a pulsed cold neutron beam. The experiment is intended to be conducted at the future European Spallation Source.
(https://www.lhep.unibe.ch/research/neutron_and_precision)

- **CMS:** (Compact Muon Solenoid) is one of two large general-purpose particle physics detectors at the LHC. The CMS Detector is 21 metres long, 15 metres in diameter, and weighs about 14'000 tonnes. The CMS Collaboration is formed by more than 4'000 people from around 240 institutes in more than 50 countries.
(https://cms.cern/)

- **CREMA:** (Charge Radius Experiments with Muonic Atoms) is an international collaboration aiming at high-accuracy measurements of the Lamb shift in muonic atoms, to be conducted using laser spectroscopy.
(https://www.psi.ch/en/muonic-atoms).

- **FASER:** (ForwArd Search ExpeRiment at the LHC) is a small experiment 480 metres downstream of the ATLAS Detector at the CERN LHC. FASER is designed to capture decays of exotic particles produced in the very forward region, which are outside of the ATLAS Detector's acceptance. FASERnu, a FASER sub-detector, is designed to detect collider neutrinos for the first time and to study their properties. The experiment will take data during Run 3 of the LHC.
(https://faser.web.cern.ch/)

- **GBAR:** (Gravitational Behaviour of Antimatter at Rest) is an experiment that measures the gravitational free-fall acceleration of antimatter. It operates in the Antiproton Decelerator Hall at CERN, using antiprotons slowed down by the ELENA facility. GBAR first combines the antiprotons with two antielectrons, to form antihydrogen ions with a positive charge. Using laser-cooling techniques, these ions are brought to micro-Kelvin temperatures before they are stripped of their additional antielectron, transforming them into antihydrogen atoms. These antihydrogen atoms are then allowed to fall from a height of 20 centimetres, and their annihilation at the end of the fall is recorded. GBAR was approved in May 2012 and received its first beam of antiprotons in 2018.
(https://gbar.web.cern.ch/public/)

- **LHCb:** (Large Hadron Collider beauty) is a specialised *b*-physics experiment at the LHC, which was primarily designed to measure the parameters of CP violation in decays of bottom (beauty) and charm hadrons. Its evolving physics scope has turned LHCb into a multi-purpose experiment uniquely sensitive to the forward region of LHC collisions, studying not only proton-proton interactions, but also collisions from heavy-ion runs and from a dedicated fixed-target programme. The detector is a forward spectrometer with a length of about 20

metres. It has a polar angular coverage from 10 to 300 milliradians in the horizontal plane and 250 milliradians in the vertical plane. The LHCb Collaboration is composed of approximately 1500 people from 87 institutes, representing 17 countries.
(https://lhcb-public.web.cern.ch/)

- **MEG:** (Mu to E Gamma) was an experiment located at PSI dedicated to measuring the rate at which a muon decays into an electron and a photon; this decay mode is heavily suppressed in the SM by lepton-flavour conservation, but is enhanced in many BSM models. MEG took data from 2008 until 2013, and in doing so established the world's best limit on the decay $\mu \to e\gamma$. In order to increase the sensitivity reach by an order of magnitude, a total upgrade involving substantial changes to the experiment has been performed; this new experiment is known as MEG II.
(https://meg.web.psi.ch/)

- **Mu3e:** the Mu3e Experiment at PSI is designed to search for the lepton-flavour-violating decay of a positive muon converting into two positrons and one electron, which violates lepton-flavour conservation. Since this decay is extremely suppressed in the SM, to the order of $\mathcal{O}(10^{50})$, any measurement of this decay would be a clear sign of new physics. In order to reach its ultimate sensitivity, the Mu3e Experiment will observe more than 10^{16} muon decays. This enormous number of muons will be reached by using the world's most intense muon beam, located at PSI, which delivers 10^9 muon-decays/s to the Mu3e detector.
(https://www.psi.ch/en/mu3e)

- **mu-Mass:** (MUoniuM lASer Spectroscopy) is an experiment at PSI which is pushing the frontier of muonium spectroscopy, with the aim of measuring the 1S-2S transition frequency of muonium, an exotic atom consisting of a positive antimuon and an electron. The mu-Mass Experiment plans to measure this transition at an unprecedented precision of 10 kHz, a 1000-fold improvement over previous measurements. This will allow for the best determination of the muon mass at the level of one part per billion.
(https://www.psi.ch/en/ltp/mu-mass)

- **muX:** The muX Experiment measures the charge radii of highly radioactive elements, in addition to measuring atomic parity violation signals in the 2S-1S transition of muonic atoms.
(https://www.psi.ch/en/ltp/mux)

- **NA62:**

- **NA64:** (North Area 64) is a fixed-target experiment using the 100 GeV electron beam of the CERN SPS fired at a fixed target, where the target is located in the CERN experimental North Area. The primary goal of NA64 is to search for light, dark bosons that are coupled to photons. The experiment started to take data in 2016, and will resume operation with an upgraded detector after the end of LS2 in 2021.
(https://na64.web.cern.ch/)

- **nEDM/n2EDM:** (search for the Neutron Electric Dipole Moment) was designed to measure the electric dipole moment of the neutron with unprecedented precision. It used the ultracold neutron source at PSI, which supplies neutrons at a comparatively slow speed. The collaboration recently published the most sensitive measurement

of the neutron EDM to date based on data collected during 2015 and 2016.
(https://www.psi.ch/en/nedm)

- **piHe:** (PIonic HElium) was an experiment at PSI that used laser spectroscopy and exotic atoms: starting from Helium atoms, one electron was replaced by a pion. This combination enabled high-precision measurements of the mass and other properties of the pion.
(https://www.psi.ch/en/ltp/experiments)

- **SHiP:** (Search for Hidden Particles) is a proposed general-purpose experiment to be installed in a beam dump facility at the CERN SPS. The primary objective of SHiP is to search for hidden particles, as predicted by models of hidden sectors, which are capable of accommodating dark matter, neutrino oscillations, and the origin of the full baryon asymmetry in the Universe. The present detector design incorporates two complementary apparatuses which are capable of searching for hidden particles through both visible decays and scattering signatures involving recoiling electrons or nuclei. Moreover, the facility is ideally suited to study the interactions of tau neutrinos.
(https://ship.web.cern.ch/)

- **SND@LHC:** (Scattering and Neutrino Detector at the LHC)
(https://snd-lhc.web.cern.ch/)

0.1.2 Experiments with Swiss contributions in neutrino physics

- **DUNE:** (Deep Underground Neutrino Experiment) is a leading-edge, international experiment for neutrino science and proton decay studies supported by the Long-Baseline Neutrino Facility (LBNF). DUNE will consist of two neutrino detectors positioned in the path of an intense neutrino beam. One detector will be located close to the source of the beam, at the Fermi National Accelerator Laboratory in Illinois, USA. A second detector will be deep underground, and 1300 km away from the source, at the Sanford Underground Research Laboratory in South Dakota. Two prototype far detectors are at CERN; the first started taking data in September 2018 and the second is under construction.
(https://www.dunescience.org/)

- **GERDA:** (GERmanium Detector Array) was an experiment searching for neutrinoless double-beta decay ($0\nu\beta\beta$) in ^{76}Ge at the underground Laboratori Nazionali del Gran Sasso (LNGS) in Italy. Evidence of such decays would prove that neutrinos and antineutrinos are identical particles. The observation of $0\nu\beta\beta$, a lepton-number-conservation-violating process, is beyond the Standard Model of particle physics. Such an observation could reveal the nature of neutrinos and give hints on both the neutrino absolute mass scale and ordering.
(https://www.mpi-hd.mpg.de/gerda/)

- **Hyper-K:** (HYPER-Kamiokande) is a neutrino observatory being constructed at the site of the Kamioka Observatory, near Kamioka, Japan. It will be the next generation of large-scale water Cherenkov detector, consisting of a tank with a billion litres of ultra-pure water. The first data-taking period is planned for 2027.
(https://www.hyperk.org/)

- **K2K:** (KEK to Kamioka) was a neutrino experiment that ran from 1999 to 2004 in Japan. It was the first

experiment that measured neutrino oscillations in a neutrino beam.
(https://neutrino.kek.jp/)

- **LEGEND:** (Large Enriched Germanium Experiment for Neutrinoless double-beta Decay) is the next-generation experiment searching for neutrinoless double-beta decay ($0\nu\beta\beta$) in ^{76}Ge. In the first phase of LEGEND, approximately 200 kg of enriched ^{76}Ge detectors will be operated. LEGEND-200 will be located at LNGS, and will largely reuse the existing GERDA infrastructure, including some of the germanium detectors, the outer water tank, and the inner cryostat. The first data-taking period is planned for mid-2021.
(http://legend-exp.org/)

- **MicroBooNE:** (Micro BOOster Neutrino Experiment) is a large neutrino experiment based at the Fermilab Booster neutrino beamline. The experiment first started to take data in 2015. It uses a large 170-tonne liquid argon time projection chamber for neutrino detection.
(https://microboone.fnal.gov/)

- **OPERA:** (Oscillation Project with Emulsion tRacking Apparatus) was a neutrino experiment at LNGS. It used the CERN neutrino beam and was optimised for detecting tau neutrinos from muon neutrino oscillations. The data-taking period ended in 2012.
(http://operaweb.lngs.infn.it/)

- **T2K:** (Tokai to Kamioka) is a neutrino experiment in Japan studying accelerator neutrino oscillations. T2K was the first experiment which observed the appearance of electron neutrinos in a a beam of muon neutrinos. It uses an intense beam of muon neutrinos produced in the J-PARC facility (Japan Proton Accelerator Research Complex) in Tokai; neutrinos are then detected at the Super-K far detector located 295 km away.
(https://t2k-experiment.org/)

Other neutrino physics experiments are described in Sect. 0.1.4.

0.1.3 Experiments with Swiss contributions in astroparticle physics in the Roadmap update

0.1.4 Ground-based experiments in multi-messenger astrophysics and cosmology

- **The Cherenkov Telescope Array Observatory (CTAO):** it is the new generation of gamma-ray observatory accessible by scientists worldwide through a science-driven observing time allocation process. It is driven by a consortium of about 1500 scientists from 25 countries and by a final legal entity CTAO European Research Infrastructure Consortium (ERIC) that should start operation in 2025. The construction of the first four telescopes will be completed at the end of 2026 and the construction of two arrays of telescopes should be completed by 2030. These Imaging Atmospheric Cherenkov Telescopes will be located at about 2000 m a.s.l. at the ESO premises in Paranal, Chile, and at the site of Roque de Los Muchachos La Palma, Canary Islands. One of the offsite data centres will be at CSCS. Its Key Science Cases [CA+19] concern: cosmic rays (how and where they are accelerated; their propagation and their impact on the environment); probing extreme environments and the processes close to neutron stars, black holes and relativistic jets, winds and explosions; exploring cosmic voids and magnetic fields; physics frontiers beyond the standard model of particle physics (the nature of the dark matter and how is it distributed, the existence of axion-like particles, violations of Lorentz invariance for high-energy photons.

The work of involved scientists in Switzerland is described in the recent CTAO-CH Collaboration white paper. Involved PIs: Adrian Biland (ETHZ), Domenico della Volpe (UNIGE), Teresa Montaruli (UNIGE), Prasenjit Saha (UZH), Nicola Serra (UZH), Roland Walter (UNIGE). Other PI Professors: Edoardo Charbon (EPFL), Jean Paul Kneib (EPFL), Andrii Neronov (EPFL), Stephan Paltani (UNIGE), Thomas Schulthess (CSCS/ETHZ), Maurizio Falanga (UBern). Senior Scientists/Engineers: Ermanno Bernasconi (EPFL), Pablo Fernandez (CSCS), Matthieu Heller (UNIGE), Victor Holanda (CSCS), Nicolas Produit (UNIGE), Luca Giangrande (UNIGE), Magda Stodulska (UNIGE).

- **Major Atmospheric Gamma-Imaging Cherenkov telescopes (MAGIC)** is a stereoscopic system of two 17 m-diameter Cherenkov telescopes located at the Canary island La Palma, which celebrated in 2023 the 20^{th} anniversary of operation. It measures the dim flashes of Cherenkov light emitted from showers of secondary particles induced when a very high energetic (VHE) photon hits the atmosphere. The main background is due to hadronic showers induced by the several orders of magnitude more abundant charged cosmic ray particles. The distinctive characteristics of the signal of electromagnetic showers induced by gamma rays can be evidenced by the telescope atmospheric imaging technique (IACT) and background rejection improved when showers are observed in stereo mode.

  While the original goal of MAGIC and the similar H.E.S.S. and VERITAS arrays was to search for the sources of the enigmatic high energetic cosmic ray particles, the unexpected richness of galactic and extragalactic sources found so far is turning focus to the newly evolving field of multi-messenger astrophysics. This initiated the CTAO project to significantly improve the sensitivity by using large arrays of Cherenkov telescopes.

  Close to the MAGIC telescopes, the First g-Apd Cherenkov Telescope (**FACT**) is a small 4-metre Cherenkov telescope pioneering the usage of silicon photomultipliers (also called G-APD: Geiger-mode Avalanche PhotoDiodes) and performing the first unbiased monitoring of variable extragalactic objects at energies above 1 TeV. Involved PIs: Adrian Biland, Roland Walter, Andrii Neronov.

- **IceCube** is a 1 cubic kilometre neutrino telescope instrumented in the deep polar ice, between 1.5 to 2.5 km at the South Pole. With 5'600 photomultipliers attached to 86 strings on a triangular grid of 124 m side, IceCube is designed to detect neutrinos beyond 100 GeV. Eight of these strings are more densely instrumented to form the DeepCore for netrino oscillation studies with energy threshod of a few GeV. Completed in 2011, it is undergoing since 2023 refurbishment of the drilling equipment for an upgrade of additiona 7 strings dedicated to neutrino property studies. A volume a factor of 10 larger will constitute IceCube-Gen2 dedicated to cosmic neutrino sources and cosmogenic neutrinos induced by the highest energy cosmic rays in a multi-messenger context.

Space-based experiment on multi-messenger astrophysics and dark matter

- **The Alpha Magnetic Spectrometer (AMS-02):** is the largest magnetic spectrometer ever installed in space and the only one currently in operation [A+21]. From its installation on the international space station (ISS) in

2011, it is the most precise cosmic-ray detector in the energy range from 0.5 GeV to few TeV. It will continue its operation for the entire lifetime of ISS through 2030.

- **DArk Matter Particle Explorer (DAMPE):** The largest calorimeter-based space mission [Cha17]. Since its launch in 2015, it is taking data in excellent working conditions. Its acceptance is a factor of 3 larger than AMS-02. It is currently providing the most precise cosmic-ray measurements up to 100 TeV. Both the excellent hardware status and the significant scientific returns ensure that its operation will continue for 5—10 more years.

- **The High-Energy cosmic Radiation Detection (HERD):** The next-generation calorimeter-based space mission [Kyr22]. Thanks to its unprecedented acceptance (10 times that of DAMPE) and precision, it will extend the energy range of the direct cosmic-ray measurements beyond the PeV. HERD will be also able to perform a gamma-ray full-sky survey from 100 MeV to 100 TeV. HERD is a China-Europe mission that is currently in the final selection phase, and if adopted, will be installed on the China Space Station in around 2028.
  Involved PIs (AMS-02/DAMPE/HERD): Xin Wu (UNIGE), Andrii Tykhonov (UNIGE), Chiara Perrina (EPFL), Mercedes Paniccia (UNIGE).

- **NUSES/EUSO:** The NeUtrino and Seismic Electromagnetic Signals (NUSES) experiment financed by the Italian Ministry for introducing new technologies for space and with participation from UNIGE. It aims at the launch of a satellite in 2026 implementing a new concept of trays for middle size satellites by THALES and carrying payloads for the first Cherenkov detection from space by cosmic neutrinos, protons and ionized nuclei beyond 100 PeV, detecting 0.1 MeV–10 MeV photons for the study of transient gamma sources, monitoring of low energy (¡250 MeV) cosmic ray fluxes to study Van Allen belts; space weather and lithosphere-ionosphere-magnetosphere couplings. This mission collaborates with the (Extreme Universe Space Observatory) is an american-led collaboration fostering programs (balloons and satellites) to measure the fluorescence and Cherenkov light emitted by Ultra-High-Energy Cosmic Rays (UHECR) in the atmosphere and Earth-skimming neutrinos in the multi-10 PeV energy region. Involved PIs: T. Montaruli (UNIGE), M. Heller (UNIGE), A. Neronov (EPFL)

0.1.5 Ground-based experiments in gravitational-wave science

- **Virgo** is the European current-generation gravitational-wave observatory. The Virgo Scientific Collaboration is an international collaboration with approximately 900 members from over 150 institutions in 20 countries. Virgo is part of the larger LIGO-Virgo-KAGRA (LVK) Collaboration, which coordinates joint operations with Virgo and KAGRA to optimize the performance of the global gravitational-wave network. The Virgo detector is an L-shaped laser interferometer with 3 km arm lengths, and is hosted by the European Gravitational Observatory (EGO) in Cascina (Pisa, Italy). Virgo joined LIGO in the second observing run, missing the first ever observation of a gravitational-wave signal, but playing a key role in the first observation of a binary neutron star coalescence event (GW170817) and the associated birth of multi-messenger astronomy involving gravitational waves. Virgo and LVK completed the O3 observing run in 2020, including the observation of many more binary coalescence events, leading to a total of nearly 100 such observations. Following an extended period of downtime for upgrades to the experimental apparatuses and subsequent commissioning, the O4 observing run began in mid-2023 and

should last until mid-2025. The fifth observing run has been approved for 2027-2030, and a sixth run in the early-mid 2030s has been proposed; this would serve as a technological pathfinder and scientific transition towards the next-generation observatories.
Involved PIs: Anastasios Fragkos (UNIGE, CHAPS), Federico Sanchez-Nieto (UNIGE, CHIPP), Michel Lauria (HEPIA), Stephane Paltani (UNIGE, CHAPS), Steven Schramm (UNIGE, CHIPP)
Senior scientists: Paul Laycock (UNIGE, CHAPS)

- **Laser Interferometer Gravitational-wave Observatory (LIGO)** is the most sensitive gravitational-wave observatory to date. The LIGO Scientific Collaboration is an international collaboration with approximately 1000 members from over 100 institutions in 18 countries. LIGO is part of the larger LIGO-Virgo-KAGRA (LVK) Collaboration, which coordinates joint operations with Virgo and KAGRA to optimize the performance of the global gravitational-wave network. The LIGO detectors are L-shaped laser interferometers with 4 km arm lengths, one at Hanford (Washington, USA) and one in Livingston (Louisiana, USA). LIGO was responsible for the first ever observation of a gravitational-wave signal (GW150914), resulting in the 2017 Nobel Prize in Physics, and has since participated in all subsequent observations of gravitational-wave signals playing a key role, for example, in the first observation of a binary neutron star coalescence event (GW170817) and the associated birth of multi-messenger astrophysics with gravitational waves. LIGO and LVK completed the O3 observing run in 2020, including the observation of many more binary coalescence events, leading to a total of nearly 100 such observations. Following an extended period of downtime for upgrades to the experimental apparatuses and subsequent commissioning, the O4 observing run began in mid-2023 and should last until mid-2025. The fifth observing run has been approved for 2027-2030, and a sixth run in the early-mid 2030s has been proposed; this would serve as a technological pathfinder and scientific transition towards the next-generation observatories.
  Involved PIs: Marcelle Soares-Santos (UZH, CHIPP), Philippe Jetzer (UZH, CHAPS)
  Senior scientists: Cecilio García Quirós (UZH, CHAPS), Felipe Andrade-Oliveira (UZH, CHIPP), Shubhanshu Tiwari (UZH, CHAPS)

- **The Einstein Telescope (ET)** is a proposed next-generation gravitational-wave observatory, currently in the preparatory stage, which is intended to be built in Europe. ET would present a revolutionary step forward in our ability to study the Universe through gravitational waves, with many significant implications to both the astronomy and particle physics communities. The ET project was submitted to the European Strategy Forum on Research Infrastructures (ESFRI) in 2020, and was approved as the largest-ever ESFRI project in 2021; M. Maggiore (CHIPP) led the science case [M+20]. Following this milestone, the ET Scientific Collaboration and ET Organisation were both formed in 2022, with Swiss researchers holding leadership roles in both entities. The Einstein Telescope Scientific Collaboration is an international collaboration with approximately 1700 members from over 250 institutions in 30 countries. Substantial progress has since been made on evaluating the scientific potential of different possible ET configurations, co-led by M. Maggiore [B+23], and on several other topics in demonstration of the feasibility and potential of the ET research infrastructure.
  Involved PIs: Anastasios Fragkos (UNIGE, CHAPS), Antonio Riotto (UNIGE, CHIPP), Camille Bonvin (UNIGE), Corrine Charbonnel (UNIGE, CHAPS), Marcelle Soares-Santos (UZH, CHIPP), Michele Maggiore (UNIGE, CHIPP), Steven Schramm (UNIGE, CHIPP)

Senior scientists: Felipe Andrade-Oliveira (UZH, CHIPP), Giulia Cusin (UNIGE, CHAPS), Paul Laycock (UNIGE, CHAPS), Stefano Foffa (UNIGE)

0.1.6 Experiments with Swiss contributions for direct dark matter detection

- **XLZD/DARWIN (DARk matter WImp search with liquid xenoN** will be a new observatory in astroparticle physics, with the aim to identify the nature of dark matter, to reveal the nature of neutrinos (via the search for the neutrinoless double beta decay of ^{136}Xe), to observe solar neutrinos via elastic neutrino-electron and coherent neutrino-nucleus scatters, as well as solar axions and axion-like particles. It will employ a time projection chamber (TPC) filled with liquid xenon (75 tons in total, 60 tons inside the TPC, in the nominal design), viewed by arrays of VUV-sensitive photosensors to detect both light and charge signals after a particle interacts with the xenon target. The TPC and its cryostat will be surrounded by a 12 m water Cherenkov shield, to veto interactions of cosmic muons and their secondary particles. A likely location of the observatory is Hall C of LNGS in Italy, however other locations (SURF in USA, an extensions of the Boulby Laboratory in the UK) are under consideration. The direct dark matter search via collisions of dark matter particles with atomic nuclei is highly complementary to indirect searches with AMS, CTA and IceCube and with direct dark matter production at the LHC, and many of the science channels complement independent experimental efforts in these areas by providing new information. An initiative on Cryogenic instrumentation for Dark Matter experiments as been initiated at UZH and it is called QROCODILE.

  Involved PIs: Laura Baudis, Ben Kilminster, Bjoern Penning (UZH).

- **XENONnT** is located at the Laboratori Nazionali del Gran Sasso (LNGS) of INFN, at a depth of 3600 mwe. XENONnT [A$^+$24] operates a two-phase xenon time projection chamber (TPC) with 5.9 t of active Liquid xenon (LXe) mass (8.5 t LXe in total). In a two-phase (liquid and gas) TPC, the interactions of particles are observed via two distinct signals: the first is the prompt scintillation light (S1), while the second is caused by ionisation electrons that are drifted and extracted into the gaseous phase where they produce electro-luminescence (S2). The photons are detected by two arrays of 3-inch diameter PMTs, and the difference in arrival time between the S1 and S2 signals yields the depth, or z-position, of an interaction. The S2 light distribution in the top PMT array yields the (x, y)-position of an event, while the S2/S1 ratio allows to discriminate electronic recoils (ERs) from nuclear recoils (NRs). XENONnT started a first science run in July 2021 and is presently acquiring data towards its design exposure. It achieved the lowest background in the field and was able to exclude the low-energy excess observed in XENON1T [A$^+$22]. In a blind analysis of its first science run nuclear recoil data, XENONnT also improved constraints on WIMP-nucleon interactions [A$^+$23].

  Involved PI: Laura Baudis (UZH).

- **LUX-ZEPLIN:** The LUX-ZEPLIN (LZ) Experiment is operating at the Sanford Underground Research Laboratory (SURF) since December 2020 and is currently the world's most sensitive experiments for WIMP-type dark matter with a cross section of 2.2×10^{-48}cm^2 for a 43 GeV/c^2 mass WIMP based on 280 days of data. The

full exposure of 1000 live days is expected to improve by about a factor of ten. The experiment utilises 7 tonnes of liquid xenon in it's active region, 5.5 tonnes of those fiducial. LZ performs also a range of other searches, for example axion like DM, low-mass DM, neutrino physics, high nuclear recoil searchese using EFTs and rare event searches.
Involved PI: Bjoern Penning (UZH).

- **DArk Matter in CCDs (DAMIC):** DAMIC are a series of experiments using scientific-grade CCDs with low-ionization energy thresholds to search for low-mass (≤ 5 GeV/c^2) WIMPs and hidden-sector DM candidates with masses in the 1-1000 MeV/c^2 and 1-100 eV/c^2 range. The first DAMIC prototype began operation in 2010, and demonstrated the potential for dedicated low-mass ($\lesssim 5$ GeV/c^2) dark matter experiments. Since 2014, DAMIC has been operating at SNOLAB, having undergone several phases of upgrades, including to use new "skipper" readout amplifiers with an order of magnitude improvement in noise reduction, to continue to probe new phase space. The next major phase of DAMIC is DAMIC-M in the Laboratoire Souterrain de Modane (LSM). DAMIC-M utilizes skipper readout to achieve an order of magnitude reduction in energy threshold, almost 100 times lower background rates, and has a detector mass 100 times that of DAMIC@SNOLAB. DAMIC-M is under construction with installation planned in 2025. A first prototype of DAMIC-M called the Low Background Chamber (LBC) utilizing skipper CCDs has been operational in LSM since 2022, and has been instrumental in characterizing key DAMIC-M components. **OSCURA** is the future generation of DAMIC experiments to achieve an order of magnitude improvement in detector mass and background levels and is being spear-headed by the U.S. DOE with a target date for commissioning of 2028. Swiss groups may join this effort in the future. However, it is expected that DAMIC-M will continue to provide important physics results into the 2030s.
  Involved PIs: Ben Kiliminster, Peter Robmann, Anna Macchiolo and Stefanos Leontsinis (UZH).
- **TESSERACT:** The new TESSERACT experiment will probe low-mass DM models with unpredecented sensitivity and develop new technologies to reach even lower masses. TESSERACT will be sensitive to DM masses from approximately a GeV, about the mass of a proton, to sub-eV. At least three targets, LHe, GaAs, and sapphire, will be read out by identical Transition Edge Sensor (TES) sensors. A 273 meV (RMS) baseline energy resolution has already been achieved. The total mass for each target type will be between 100 g and 1 kg, depending on the target. The crystal targets will be segmented into multiple pixels with independent but identical readouts, and the targets will be housed in a single dilution fridge and cryostat vacuum vessel. The combination of joint readout and setup but different targets provides a powerful tool to assess backgrounds and systematic uncertainties and simplifies the design and construction of the experiment. The TESSERACT experiment will be built at the Modane Underground Laboratory, close to Geneva. Involved PIs: Björn Penning (UZH).

1 References

[A$^+$21] M. Aguilar et al. The alpha magnetic spectrometer (ams) on the international space station: Part ii — results from the first seven years. *Physics Reports*, 894:1–116, 2021.

[A+22] E. Aprile et al. Search for New Physics in Electronic Recoil Data from XENONnT. *Phys. Rev. Lett.*, 129(16):161805, 2022.

[A+23] E. Aprile et al. First Dark Matter Search with Nuclear Recoils from the XENONnT Experiment. *Phys. Rev. Lett.*, 131(4):041003, 2023.

[A+24] E. Aprile et al. The XENONnT Dark Matter Experiment. *Eur. Phys. J. C*, 2 2024.

[B+23] Marica Branchesi et al. Science with the Einstein Telescope: a comparison of different designs. *JCAP*, 07:068, 2023.

[CA+19] Cherenkov Telescope Array Consortium, B. S. Acharya, et al. *Science with the Cherenkov Telescope Array.* 2019.

[Cha17] Chang, J. and others, the DAMPE collaboration. The DArk Matter Particle Explorer mission. *Astropart. Phys.*, 95:6–24, 2017.

[Kyr22] Dimitrios Kyratzis. Overview of the HERD space mission. *Phys. Scripta*, 97(5):054010, 2022.

[M+20] Michele Maggiore et al. Science Case for the Einstein Telescope. *JCAP*, 03:050, 2020.