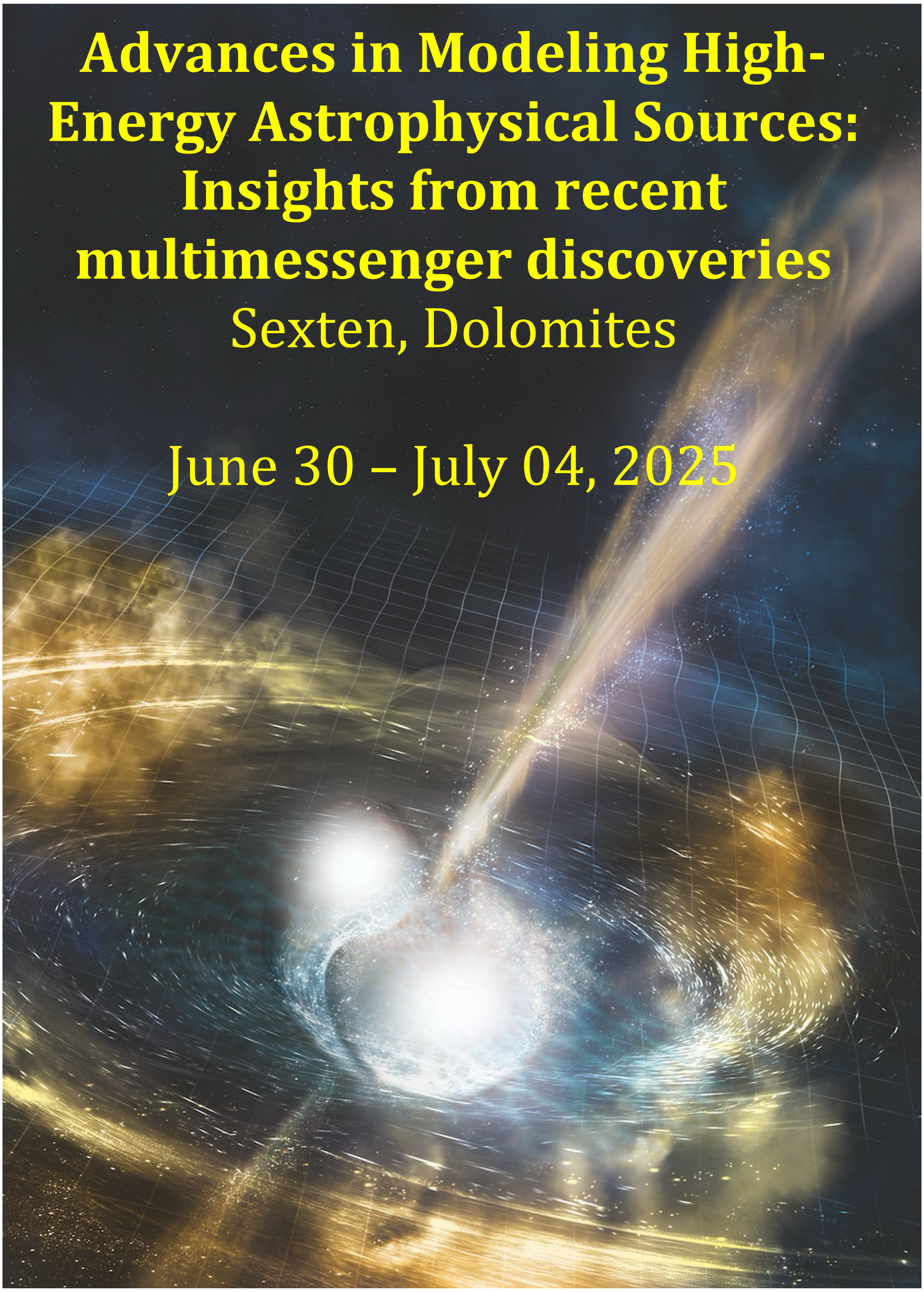
SEXTEN CENTER FOR ASTROPHYSICS RICCARDO GIACCONI

Advances in Modeling High-Energy Astrophysical Sources: Insights from recent multimessenger discoveries

Sexten, Dolomites

June 30 – July 04, 2025



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INAF ISTITUTO NAZIONALE DI ASTROFISICA NATIONAL INSTITUTE FOR ASTROPHYSICS

UNIVERSITÀ DEGLI STUDI DI TRIESTE

INFN Istituto Nazionale di Fisica Nucleare

Sexten 2025

Advances in Modeling High-Energy Astrophysical Sources: Insights from recent multimessenger discoveries

Scientific program

Monday 30.06.2025

Gamma rays from Space

10:00 Francesco Longo: Introduction to the workshop (online)

10:15 Patrizia Caraveo: High Energy Gamma Ray Astrophysics. An historical perspective (online)

10:45 Sara Cutini: Observation of the Gamma Ray Sky from Space

11:15 coffee break

GRB modeling

11:45 Zeljka Bosnjak: GRB prompt modeling (online)

12:15 Lara Nava: GRB afterglow modeling

12:45 Davide Miceli: VHE emission from GRBs

13:15 Lunch break

Contributed talks – GRB - 1st session

15:00 - 15:15 Oscar Wistemar: Photospheric emission from GRB211211A altered by a strong radiation-mediated shock

15:15 - 15:30 Stefano Giarratana: Measuring the expansion of GRB afterglows

15:30 - 15:45 Aldana Holzmann Airasca: Towards a joint time-resolved systematic analysis of GRBs

15:45 - 16:00 Davide Depalo: Systematic time resolved analysis of gamma-ray bursts detected by Fermi-GBM

Hands On Session

16:00 Hands On : Stefano Vercellone: Academic presentations

17:00 coffee break

17:30 Hand On : Tarek Hassan: How to prepare a research grant (online)

18:30 End session

Tuesday 01.07.2025

Gamma rays from the ground

09:00 Alessio Berti: Observation of the Gamma Ray Sky from the ground – the IACT technique

09:30 Paolo Da Vela: The CTAO: status and perspectives

10:00 Jim Hinton: Ground-level particle detection for gamma-ray astronomy

10:30 coffee break

AGN modeling

11:00 Marina Manganaro: Multiwavelength modeling of Active Galactic Nuclei or: Camels in the sky

11:30 Fabrizio Tavecchio: Blazar polarization

12:00 Matteo Cerruti: Leptonic and hadronic modeling of blazars

12:30 Lunch break

Contributed talks – AGN session

15:15 - 15:30 Anna Luashvili: Two-zone modelling of the very bright and variable FSRQ 3C 279

15:30 - 15:45 Luana Passos Reis: High-Energy Neutrino Emission in NGC1068 driven by turbulent magnetic reconnection

15:45 - 16:00 Pierre Pichard: TeV transient sources with H.E.S.S

Hands On Session

16:00 Hands On : Guillem Martì Devesa: Gammapy analysis

17:00 coffee break

17:30 Hand On : Axel Arbert Engels: How to crosscheck models and data

18:30 End session

21:30 *Evening event with grappa and sangria, with Tyrolean music*

Wednesday 02.07.2025

Multimessenger observations

09:00 Manuela Vecchi: Cosmic ray recent observations

09:30 Massimiliano Razzano: Observations of Gravitational Waves (online)

10:00 Giovanni Marsella: Observation of high energy neutrinos

10:30 coffee break

Multimessenger modeling

11:00 Denise Boncioli: UHECR emission models

11:30 Barbara Patricelli: Modeling of Gravitational Wave sources

12:00 Aldo Morselli: Multimessenger searches for Dark Matter

12:30 Lunch break

Contributed talks: GRB second session

15:00 - 15:15 Alessandro Armando Vigliano: Insight on GRB physics from a novel data driven method for systematic analysis of X-ray light-curves

15:15 - 15:30 Kaitlyn Parrinello: FRBs and GRBs

15:30 - 15:45 Gustavo Soares: The role of internal shocks in prompt gamma-ray burst emission: implications for synchrotron emission and spectral breaks

15:45 - 16:00 Tobia Matcovich: Estimation of joint detection probabilities of Gamma-Ray Burst and Gravitational Waves produced by NSBH binary mergers

Hands On Session

16:00 Hands On : Rossella Spiga: Science and Society: why communicate scientific research

17:00 coffee break

17:30 Hand On : Carla Aramo: Astroparticle Science Communication

18:30 End session

21:30 *Evening event with observation of the night sky*

Thursday 03.07.2025

Multiwavelength observations

09:00 Frederic Piron: First results from the SVOM mission

09:30 Raffaella Bonino: X-ray Polarimetry with IXPE: from detector design to scientific discoveries

10:00 Giovanni Pareschi: The ASTRI mini-array gamma ray experiment

10:30 coffee break

Multimessenger observations and modeling

11:00 Silvia Celli: The highest E neutrino from km3Net

11:30 Giovanni Morlino: Galactic source modeling

12:00 Aldo Morselli: The newAstrogam mission

12:30 Lunch break

Contributed talks: Technical talks session

15:00 - 15:15 Pierpaolo Loizzo The Antarctic Demonstrator for the Advanced Particle-astrophysics Telescope (ADAPT), overview and project status

15:15 - 15:30 Andrea Adelfio: Anomaly Detection with Machine Learning in Time Series: Unveiling Lost Transients

15:30 - 15:45 Antonio Zaccaro: Eyes on High-Energy Emissions: Ground- and Space-Based Perspectives in Gamma-Ray Research.

15:45 - 16:00 Jahanvi – Daniele Ambrosino: CTAO Divergent pointing

Hands On Session

16:00 Hands On: Guillem Martì Devesa: Gammapy

17:00 coffee break

17:30 Hand On: Guillem Martì Devesa: Gammapy

18:30 End session

Friday 04.07.2025

Contributed talks (1 hr) Galactic session

09:00 - 09:15 Gabriele Panebianco: CTAO LST−1 observations of magnetar SGR 1935+2154: deep limits on sub-second bursts and persistent TeV emission

09:15 - 09:30 Antonio Liguori: Solar-system gamma-ray sources with Fermi-LAT

09:30 - 09:45 Chun Kai Loo: Cosmic Rays' Energy Dependent Escape Time (CREDIT)

09:45 - 10:00 Fernando Frias: VHE binary systems with MAGIC+LST and brief introduction to SII.

Closing session

10:00 Elisabetta Bissaldi. Observational Lessons learned from Fermi.

10:30 Giacomo Bonnoli: The interplay of theory and observations.

11:00 coffee break

11:30 Francesco Longo: Conclusions (online)

Gamma rays from Space

High Energy Gamma Ray Astrophysics. An historical perspective
Patrizia Caraveo

Gamma ray Astrophysics from Space
Sara Cutini

Gamma-ray astronomy from space has opened a unique window into the most energetic processes in the Universe. Over the past few decades, missions such as NASA's Fermi Gamma-ray Space Telescope, equipped with the LAT and GBM detectors, have significantly advanced our understanding of high-energy astrophysical phenomena. With more than three billion photons collected from the entire sky and over 7000 detected sources, Fermi-LAT observations have been crucial in improving our knowledge of particle acceleration and gamma-ray production in astrophysical environments. In this talk, I will highlight some of the key scientific achievements of recent years, with a particular focus on time-domain astrophysics in the context of multi-wavelength and multi-messenger observations.

GRB modeling

GRB prompt modeling
Zeljka Bosnjak

The detection of gravitational waves associated with the short GRB and observations of the TeV photons from very energetic events were the main breakthroughs in the gamma-ray burst field in recent years. I will discuss the theoretical progress in modelling of prompt GRB emission based on the recent multi-wavelength observations. In particular, I will describe the details of the internal shock model and radiative processes, including the lepto-hadronic radiative model, the low energy spectral slopes, the radiation from electrons in a decaying magnetic field and the low-luminosity GRBs. I will present the most important results of the numerical modelling of the prompt emission including the time resolved and time integrated spectra and synthetic light curves in different energy bands. I will discuss as well the emission from structured GRB jets and the constraints derived from the soft-X-ray emission from dust-scattering halo.

GRB afterglow modeling
Lara Nava

Afterglow emission from GRBs is observed over a very large range of frequencies, from radio to multi-TeV energies. Its origin is firmly associated to shocks generated by the expansion of the jet into the surrounding environment. In this contribution, I present the general theory on the origin of afterglow radiation and discuss open issues and problems.
I review the methods commonly applied to interpret multi-wavelength observations and to constrain the still elusive details of the physics involved in jet-environment interactions.

VHE emission from GRBs
Davide Miceli

I will briefly summarize the recent discoveries of gamma-ray bursts in the VHE domain focusing on the detections in the last decades. I will describe the interpretation provided by the MAGIC, HESS, LST and LHAASO experiment both in terms of gamma-ray burst physics and in terms of studies of possible imprints of intergalactic magnetic fields.

Contributed talks – GRB - 1st session

Photospheric emission from GRB211211A altered by a strong radiation-mediated shock
Oscar Wistemar

We use a photospheric framework to interpret gamma-ray burst prompt emission based on radiation-mediated shocks (RMS) dissipating energy below the photosphere. We use the Kompaneets RMS approximation (KRA) model, which is an RMS analog, to fit the main emission episode of GRB211211A, a long duration but compact merger progenitor burst. The time-resolved bulk outflow Lorentz factor of the main emission is measured (following Wistemar et al 2025), and applied to resolve comoving spectra from observed spectra. The KRA model fits well for the entire main emission and captures the low-energy break (or curvature) in the spectra. The RMS properties are also converted to from the KRA fit, and their time-evolution is thus found. There is a strong shock occurring in a hot upstream at low to moderate optical depths. We can also analyze jet and central engine properties of the burst. Here we find that the jet outflow is most likely pair loaded, potentially from sideways diffusion of a neutron wind. In conclusion, photospheric emission altered by an RMS can explain the observations of GRB211211A and the KRA model can fit its spectra well, including the additional curvature at energies below the peak (i.e. a low-energy break).

Measuring the expansion of GRB afterglows
Stefano Giarratana

Radio observations employing the very long baseline interferometry (VLBI) technique offer a crucial insight into the structure and dynamics of Gamma-Ray Burst (GRB) jets. Specifically, VLBI serves as a fundamental tool for measuring the apparent superluminal expansion (in on-axis GRBs) and proper motion (in off-axis GRBs) of the GRB blast wave. These measurements enable constraints on the outflow geometry and characterisation of the circum-burst medium, complementary to light curve and spectral modelling. This presentation will focus on recent results concerning GRB221009A, the brightest GRB recorded to date. For the latter, the observed size evolution probed by VLBI measurements suggests that the reverse shock and the forward shock dominate the afterglow emission at different frequencies and times.

Towards a joint time-resolved systematic analysis of GRBs
Aldana Holzmann Airasca

The Fermi mission is a space-based observatory designed to study the gamma-ray sky. It consists of two main instruments: the Large Area Telescope (LAT) and the Gamma-ray Burst Monitor (GBM), covering a broad energy range from ~10 keV to > 300 GeV. One of its main objectives is to detect and study Gamma-ray Bursts (GRBs), though the mechanisms behind their prompt emission and emission sites are still not fully understood.
In this presentation we will focus on bright GRBs observed by both Fermi-GBM and Fermi-LAT. We performed a systematic time-integrated and time-resolved joint spectral analysis on a sample of approximately 50 GRBs. We will present preliminary distributions of the derived spectral parameters, such as photon indices, peak energy, and additional components. We also compare results with GBM-only analyses to assess the impact of high-energy components. Leveraging Fermi's broadband capabilities, this study provides new insights into GRB physics.

Systematic time resolved analysis of gamma-ray bursts detected by Fermi-GBM

Davide Depalo

The Fermi Gamma-Ray Space Telescope, launched in 2008, was designed for the detection of the electromagnetic radiation in the energy range from 8 keV to 300 GeV, allowing for the study of many different types of galactic and extragalactic sources. In particular, the Gamma-Ray Burst Monitor (GBM) is the most prolific gamma-ray burst (GRB) detector to date, with about 4000 observed events so far. Many publications dedicated to single GRBs and general catalogs have allowed us to reveal the temporal and spectral properties of these fascinating events

Here we present a systematic analysis of a subsample of bright GRBs detected by GBM in the first years of the mission, focusing on the temporal evolution of the parameters of the spectral models fitted to the data. The lightcurves are divided into time bins using the Bayesian Blocks method, whereas the time-resolved spectral analysis is done using the new dedicated toolkit Gamma-Ray Data Tools (GDT). For each bin, different spectral models are fitted to the data, and the best one is selected through appropriate statistical criteria. We illustrate the different analysis phases and some preliminary results, including the distributions of the best model fit parameters. The aim of this work is to implement an automated pipeline for a systematic analysis of all the GRBs detected by the GBM during the mission.

Gamma rays from the ground

Observation of the gamma-ray sky from the ground - the IACT technique
Alessio Berti

Gamma-ray astronomy is a relatively young branch of astrophysics, studying how cosmic sources can produce gamma rays in a broad energy range. While at the beginning gamma-ray astronomy was performed with space satellites, in the second half of the 20th century the imaging atmospheric Cherenkov technique was developed. This allows the detection of gamma rays with ground telescopes at energies above tens of GeV and up to tens of TeV with very good sensitivity also for short timescale events, like flares or transient sources. In this contribution I will describe the details of the technique, its development in the last decades and show the main scientific results obtained with Cherenkov telescopes.

The CTAO: status and perspectives
Paolo Da Vela

The Cherenkov Telescope Array Observatory (CTAO) marks a transformative advance in our ability to observe the very high-energy (VHE) universe. Covering an energy range from 20 GeV to 300 TeV, and offering unprecedented sensitivity, angular resolution, and temporal precision, CTAO is set to redefine gamma-ray astronomy. As an open observatory, it will support a broad scientific programme—from investigating the origin of cosmic rays and the physics of extreme astrophysical sources such as pulsar wind nebulae, supernova remnants, and active galactic nuclei, to exploring the nature of dark matter and testing fundamental physics. Operating from two complementary sites in the northern and southern hemispheres, CTAO will provide full-sky coverage and continuous monitoring capabilities for transient and variable phenomena. This talk will present the current status of the observatory and offer a forward-looking perspective on its scientific impact and role within the global astrophysical community.

Ground-level particle detection for gamma-ray astronomy
Jim Hinton

I will provide an overview of the status of wide-field/ground-level particle detection based gamma-ray observatories - both existing and planned, and discuss the scientific objectives of these instruments and complementarity to the Cherenkov Telescope Arrays.

AGN modeling

Multiwavelength modeling of Active Galactic Nuclei or: Camels in the sky
Marina Manganaro

The advances of astronomical techniques in the last few years are very impressive. The progress in instrumentation and techniques to detect photons emitted in all energies from many different types of celestial objects, can provide us with incredibly precise and high quality data, sometimes with a background rejection close to 100%. But what do we do with that? Is this impressive precision enough to solve the mystery of the emission mechanism of Active Galactic Nuclei? Spoiler alert: it's not. It's like asking a camel to pass through the eye of a needle. Why the camel? You don't know yet? Don't worry, I will tell you what you need to know. No animals were harmed during the preparation of this lecture.

Blazar polarization
Fabrizio Tavecchio

I will review current understanding of polarization of the multifrequency polarization of blazars, with particular focus on the X-ray band.

Leptonic and hadronic modeling of blazars
Matteo Cerruti

Contributed talks – AGN session

Two-zone modelling of the very bright and variable FSRQ 3C 279
Anna Luashvili

The very bright Flat Spectrum Radio Quasar (FSRQ) 3C 279 (z = 0.536) is the first source of this class to be detected at very high energy gamma-rays and is characterised by an abundance of bright multi-wavelength (MWL) flaring events, especially at highest energies, where the amplitude and variability timescales are most extreme. The source is particularly known for its complex spectral variability during its gigantic flaring events, flare-in-flare structures and chaotic multi-band correlation behaviours, with sometimes the appearance of orphan flares, that standard one-zone lepto-hadronic models fail to reproduce. 3C 279 exhibited dramatic changes in the optical polarization, contemporaneous with sharp high-energy gamma-ray and optical flares, that do not seem to be connected with the X-ray radiation of the source, pointing towards the need for multi-zone radiative models. In this work, we present the results of the statistical characterisation of the MWL variability of 3C 279 during such events and its two-zone leptonic modelling.

High-Energy Neutrino Emission in NGC1068 driven by turbulent magnetic reconnection
Luana Passos Reis

The Seyfert Type II galaxy NGC 1068 has been identified as a potential neutrino source by IceCube, with a 4.2 sigma significance detection of a 79(+22−20) neutrino excess from 2011 to 2020 (IceCube Collaboration 2020, 2024). The observed high-energy neutrino flux indicates efficient particle acceleration of hadronic nature along with strong gamma-ray absorption in the source.

In this work, we investigate turbulence-driven magnetic reconnection as a mechanism for particle acceleration in the coronal accretion flow surrounding the central black hole. We develop a one-zone model following the framework of de Gouveia Dal Pino & Lazarian (2005) and Kadowaki et al. (2015) to explore how fast magnetic reconnection in the inner coronal disk region accelerates protons and electrons, shaping the spectral energy distribution (SED). Under this scenario, the acceleration sites that inject relativistic protons are significantly smaller than the entire corona.

In contrast to recent studies, we find that the acceleration of hadrons is primarily driven by Fermi acceleration within the turbulent reconnection layers, rather than drift acceleration. Our results also indicate that the dominant cooling mechanism for accelerated protons is Bethe-Heitler pair production, driven by interactions with both the disk’s thermal OUV photon field and the coronal X-ray photons.

TeV transient sources with H.E.S.S
Pierre Pichard

I will be sharing a quick summary of my work within the H.E.S.S. transients and AGN working groups. In particular, I will highlight my contribution to PKS 1510-089 on both data analysis and modeling, the H.E.S.S. program for GRBs and the recent discovery of VHE emission from a new type of AGN by H.E.S.S.

Multimessenger Observations

Cosmic rays recent observations
Manuela Vecchi

In this talk, I will briefly overview the latest findings in galactic cosmic rays, focusing on the surprising features revealed by high-precision, space-based experiments such as AMS-02, CALET, and DAMPE. I will also discuss on some possible explanations for these unexpected results.

Gravitational Wave observations: status and prospects
Massimiliano Razzano

Gravitational wave observations have changed our view of the Universe, opening a new era in multimessenger astrophysics. Since the first detection in 2015 of the event GW150914, the number of detected gravitational wave signals has strongly increased. These results have been possible thanks to the international network of LIGO, Virgo and KAGRA (LVK) ground-based detectors, that have unprecedented sensitivity and localization capability, a key ingredient for multimessenger follow-up by ground-based and spaceborne telescopes. After the first three completed observing runs by the LVK network, we have collected a catalog of 90 confirmed signals produced by coalescences of compact binary systems of black holes and/or neutron stars. Currently, the fourth LVK observing run is ongoing and gravitational wave alerts are sent to the international community to support multimessenger follow-up observations. In this talk I will discuss the status of observational results by ground-based interferometers and present future prospects for gravitational wave observations and their connections to multimessenger astrophysics.

Observation of High Energy Neutrinos
Giovanni Marsella

Astrophysical neutrino detection has forseen an important technological development. Recent results from IceCube Neutrino Observatory and KM3NET are opening a new era in multimessenger Astronomy and in the detection of VHE neutrinos. A review of the principal results and future perspectives will be presented.

Multimessenger modeling

UHECR emission models
Denise Boncioli

Ultra-high-energy cosmic rays (UHECRs) constitute the highest-energy particles measured at Earth. Nowadays we know that their origin is to be searched for in extragalactic sources, but we still lack evidence about a specific source class able to accelerate them to extreme energies.
In order to associate the characteristics of the detected cosmic rays to the ones at the escape from their sources, we have to take into account the interactions they suffer encountering the photon fields in the extragalactic space while propagating from the sources. Moreover, the cosmic rays can interact with photons and matter in the source environment, with the consequence that their flux at the escape can be modified with respect to what predicted from the standard cosmic-ray acceleration theory. In this talk, the modelling of the some candidate UHECR sources will be discussed, together with the associated production of secondary messengers.

Modeling of Gravitational Wave sources
Barbara Patricelli

The era of Gravitational Wave (GW) Astronomy started in 2015, with the first observation of GWs from the merger of a binary black hole system. Since then, dozens of GW signals have been observed, and GW Astronomy has become pivotal to understand the most extreme phenomena in the Universe.
In this talk, I will briefly review the theory of GWs: from general relativity to the solutions of Einstein's equations. Then, I will describe the main astrophysical sources emitting GWs and the modeling of the GW emission, with particular focus on compact binary coalescing systems. Finally, I will show how GW observations can be used to constrain the formation and origin of astrophysical sources.

Multimessenger searches for Dark Matter
Aldo Morselli

In the last decades an incredible amount of evidence for the existence of dark matter has been accumulating. At the same time, many efforts have been undertaken to try to identify what dark matter is. Indirect searches look at places in the Universe where dark matter is known to be abundant and seek for possible annihilation or decay signatures. The Cherenkov Telescope Array (CTA) represents the next generation of imaging Cherenkov telescopes and, with one site in the Southern hemisphere and one in the Northern hemisphere, will be able to observe all the sky with unprecedented sensitivity and angular resolution above a few tens of GeV. The CTA Consortium will undertake an ambitious program of indirect dark matter searches in connection with all the other experiments in other wavelenths and with other messangers for which we report here the brightest prospects.

Contributed talks – GRB – 2nd session

Insight on GRB physics from a novel data driven method for systematic analysis of X-ray light-curves

Alessandro Armando Vigliano

Gamma-ray bursts (GRBs) exhibit a rich variety of X-ray lightcurve behaviours, including flares and plateau/shallow decay phases, whose origins remain debated. Existing studies often rely on diverse analysis techniques applied to limited GRB samples, leading to results that may be difficult to generalize. In this study, we introduce a new data-driven, model-independent method for automatically analyzing the Swift XRT dataset. This approach enables a consistent and comprehensive characterization of GRB afterglow X-ray lightcurves, covering an order of magnitude more events than previous studies.
Using data from the Swift satellite, we systematically compare the X-ray lightcurves of GRBs detected at high and very high energies (HE/VHE) with those detected in X-rays alone. Our analysis reveals significant differences in the lightcurve properties between the two groups: GRBs with HE/VHE emissions show simpler temporal evolution, characterized by fewer spectral breaks and distinct slope distributions. These results point to a correlation between HE/VHE emission and other lightcurve parameters, potentially providing new insights into the physical mechanisms driving GRB afterglows.

FRBs and GRBs
Kaitlyn Parrinello

The role of internal shocks in prompt gamma-ray burst emission: implications for synchrotron emission and spectral breaks
Gustavo Soares

The observed spectra of the prompt emission of gamma-ray bursts (GRBs) are commonly attributed to synchrotron radiation. Although GRB detectors such as those in the Fermi and Swift telescopes are sensitive to energies starting from ~10 keV, the emission in soft X-rays and optical wavelengths is also crucial to understand and model the bursts' spectral shapes. In particular, the observed presence of an additional break in the low-energy part of prompt GRB spectra warrants attention. Current attempts of modelling this feature include synchrotron contributions from both forward and reverse shocks, which form upon the collision of shells within the relativistic jet of a burst. We discuss the implications of this approach for the current state of observations, the changes brought upon by varying our parameter space, and the addition of new components to the models.

Estimation of joint detection probabilities of Gamma-Ray Burst and Gravitational Waves produced by NSBH binary mergers
Tobia Matcovich

Black hole-neutron star (NSBH) coalescence events are regarded as highly significant phenomena within the current multimessenger framework of gravitational waves, and they are poised to assume an increasingly prominent role in the foreseeable future. To date, only a handful of such events have been observed, with GW200105 and GW200115 being the most noteworthy among them. However, with the forthcoming upgrades to the LIGO-Virgo-Kagra (LVK) interferometers, and particularly with the prospective implementation of next-generation instruments such as the Einstein Telescope (ET), we anticipate a substantial increase in the detection rate of these events, potentially by orders of magnitude.

The study of NSBH coalescences, alongside neutron star binary (BNS) mergers, is pivotal due to their status as prime multimessenger candidates capable of producing a wide range of electromagnetic counterparts, including Gamma-ray Bursts (GRBs) and Kilonovae. By conducting joint analyses of both the gravitational and electromagnetic signals, it becomes feasible to derive more precise insights into the properties of the involved celestial objects and the myriad processes occurring during and subsequent to the merger, including the neutron star's stiffness and the mechanisms underlying GRB generation and beam structure.

This work provides an estimation of the combined detection capability for gravitational signals and GRBs originating from NSBH events, considering the anticipated upgrades to existing instruments and the deployment of next-generation facilities. In assessing the gravitational wave detectors, we compare the LVK interferometers with ET employing the GWFish software, while for evaluating the detectability of GRBs, particularly focusing on the afterglow component, we primarily reference Fermi and the prospective CTA array telescope. By utilizing state-of-the-art models for beam formation and propagation, we investigate how the goodness of information derived from these events is contingent upon the instruments utilized and the inherent characteristics of the coalescence itself.

Multiwavelength observations

First results from the SVOM mission
Frédéric Piron

The SVOM (Space-based multi-band astronomical Variable Objects Monitor) mission is dedicated to the study of Gamma-Ray Bursts (GRBs). Since the launch of its satellite on June 22, 2024, SVOM has detected more than one hundred GRBs. We will present the status of the mission, the space and ground instruments, and the performance of the alert system. We will report on the observations of the best-characterized GRBs, and show that SVOM can detect all known types of events (classical long bursts, short bursts with extended emission, X-ray flashes), covering their prompt emission over three decades in energy and allowing for X-ray and visible follow-up observations of their afterglow.

X-ray Polarimetry with IXPE: from detector design to scientific discoveries
Raffaella Bonino

The state-of-the-art of astrophysical X-ray polarimetry is the NASA Imaging X-ray Polarimetry Explorer (IXPE), launched on 9 December 2021 to measure the linear polarization of different astrophysical sources, over the photon energy range 2-8 keV. The core of IXPE is the Gas Pixel Detector, that exploits the photo-electric effect to measure the polarization of incident photons by reconstructing the emission direction of the photoelectrons.
An overview will be presented of this pioneering detector technology, the adopted reconstruction algorithm, and the most significant astrophysical results obtained thus far.

The ASTRI mini-array gamma ray experiment
Giovanni Pareschi

The ASTRI Mini–Array is currently being installed in Tenerife at the Observatorio del Teide to explore the gamma-ray sky in the 1-100 TeV energy range with unmatched angular resolution (a few arcminutes) across a wide field of view (10.5 deg). The array consists of nine IACTs (Imaging Atmospheric Cherenkov Telescopes), each equipped with a 4-meter-diameter dual-mirror system featuring a Schwarzschild-Couder-like optical configuration, which functions as an aplanatic system, and an innovative compact camera that utilizes SiPM (Silicon PhotoMultipliers) sensors. This contribution provides an overview of the ASTRI Mini–Array project's layout, capabilities, and scientific objectives. The ASTRI Mini-Array can play a crucial role in multi-messenger astronomy, enhancing our understanding of galactic and extragalactic astrophysical aspects by combining the information inferred from other observational facilities. In this respect, a parallel observation program with the ASTRI mini-array and Swift has already started.

Multimessenger observations and modeling

Observation of the highest energy neutrino with KM3NeT
Silvia Celli

KM3NeT is a multi-purpose neutrino observatory currently being deployed at the bottom of the Mediterranean Sea. It consists of two detectors, ORCA and ARCA (for Oscillation and Astroparticle Research with Cosmics in the Abyss), aiming at detecting cosmic neutrinos with energies between several tens of GeV and hundreds of PeV. These water-based Cherenkov neutrino detectors can benefit of extended field of view, accurate angular resolution, and high duty cycle to study high-energy neutrinos and their cosmic sources. While both telescopes are collecting data in a partial configuration, they are producing high-impact physics results like the observation of the ultra-high energy neutrino KM3-230213°. This demonstrates their great potential for the coming years. In this contribution, I will report on this recent observation by KM3NeT/ARCA.

Galactic source modeling
Giovanni Morlino

I will provide a summary of theoretical models to explain the high energy emission from a selected categories of sources in the Milky Way.

The newASTROGAM mission
Aldo Morselli

Contributed talks – Technical talks session

The Antarctic Demonstrator for the Advanced Particle-astrophysics Telescope (ADAPT), overview and project status
Pierpaolo Loizzo

The Antarctic Demonstrator for the Advanced Particle-astrophysics Telescope (ADAPT) is a NASA suborbital mission that will fly for ~30 days over Antarctica during the 2026-2027 season. In such a brief flight ADAPT aims to validate key detector technologies and functionalities of a larger future mission, the Advanced Particle-astrophysics Telescope (APT). APT is a mission concept for a future space-based experiment aiming to improve γ-ray sensitivity in the MeV-GeV energies of at least an order of magnitude over any current mission, to provide a better understanding of dark-matter nature and neutron-star mergers physics. To achieve these goals, APT makes use of scintillating fibers and a distributed Imaging CsI Calorimeter (ICC) to work both as a pair conversion telescope for 50 MeV to ~50 GeV γ-rays and as a Compton telescope down to MeV energies.
During his flight over the Antarctic, the ADAPT instrument will provide a demonstration of the APT's detector and readout electronics complement functionality. ADAPT's payload will consist of four ICC and scintillating-fiber tracker layers, a Silicon Strip Detector (SSD) to enhance Compton reconstruction and cosmic-ray (CR) measurements, and an Anti-Coincidence Detector (ACD) made of plastic scintillators as an outermost detector. An ICC module is composed of a 3x3 array of 150 mm x 150 mm x 5 mm CsI(Na) tiles, with top and bottom surfaces covered by 2 mm wavelength-shifting (WLS) fibers, oriented orthogonally along the x- and y-axes and read out by silicon photomultipliers (SiPMs). The ICC modules also have edge-mounted SiPMs for calorimetry. The fiber tracker, also called Hodoscope (Hodo), consists of 1.5 mm round scintillating fibers arranged in two interleaved layers for both the x- and y-coordinates. In addition, to extend the depth of the calorimeter, four CsI layers without WLS fibers will be included as tail counters.
In this contribution I will give a brief overview of the design of the ADAPT instrument, its scientific objectives and current project status.

Anomaly Detection with Machine Learning in Time Series: Unveiling Lost Transients
Andrea Adelfio

Multimessenger astrophysics relies on multiple observational data channels, necessitating efficient methods for analyzing events of astrophysical origin. With the continuous increase in both volume and complexity of data from modern observatories, advanced Machine Learning techniques have become very useful for identifying and classifying signals effectively.

My project aim at developing a framework using Machine Learning techniques to analyze time series data. The use case that will be presented regards the data from the Anti-Coincidence Detector (ACD) onboard the Fermi Gamma-ray Space Telescope. The primary objective is to enhance the detection of high-energy transient events, such as Gamma-Ray Bursts (GRBs) and other astrophysical signals. An ensamble of Neural Networks models may be employed to model and predict the temporal structure of the ACD background data. The network's predictions serve as a baseline for implementing a triggering algorithm designed for anomaly detection. By identifying significant deviations from the predicted background, the system effectively flags potential astrophysical transients in the ACD time series data.

In addressing challenges such as noise variability, this work explores advanced approaches to refine anomaly detection thresholds, by characterizing the noise amplitude in the data. Bayesian Neural Networks (BNNs) are highlighted as a promising method to dynamically adapt thresholds based on the noise characteristics of the data, offering a robust alternative to traditional fixed-threshold methods. These developments demonstrate a robust and adaptable framework for signal detection, applicable across various datasets and observatories in multimessenger astrophysics.

Eyes on High-Energy Emissions: Ground- and Space-Based Perspectives in Gamma-Ray Research
Antonio Zaccaro

Gamma-ray detection is explored from both spaceborne and ground-based perspectives. This work encompasses the investigation of space weather phenomena and the development of innovative detection systems through Geant4 simulations. On the terrestrial side, drone-based and in situ gamma spectrometry is employed for the analysis of environmental radioactivity and soil characterization.

CTAO Divergent Pointing
Jahanvi – Daniele Ambrosino

Contributed talks – Galactic Session

CTAO LST−1 observations of magnetar SGR 1935+2154: deep limits on sub-second bursts and persistent TeV emission

Gabriele Panebianco

The first observational evidence linking magnetars and Fast Radio Bursts (FRBs) was the detection of simultaneous radio and X-ray bursts from the Galactic magnetar SGR 1935+2154 in 2020.

We analysed over 25 hours of observations from the Large-Sized Telescope prototype (LST-1) of the Cherenkov Telescope Array Observatory (CTAO) during periods of high-energy activity in 2021 and 2022, searching for a potential TeV counterpart to both persistent and millisecond-scale burst emission.

For bursting emission, we examined nine 0.1-second windows centered on known short X-ray bursts, targeting possible millisecond-scale TeV signals in a low-photon-statistics regime.

While no persistent or bursting TeV emission was detected, our results place upper limits on the TeV flux of short magnetar bursts and highlight the potential of magnetars and FRBs as promising candidates for future CTAO observations.

Solar-system gamma-ray sources with Fermi-LAT
Antonio Liguori

Solar system bodies — such as the Sun, Moon, planets, and asteroids — can act as passive sources of high-energy gamma rays, produced when energetic cosmic rays interact with their surfaces. In the case of the Sun, the emission also includes a spatially extended component resulting from inverse Compton scattering of Galactic cosmic-ray electrons off the solar photon field. These gamma-ray fluxes are sensitive to solar activity, which modulates the flux of Galactic cosmic rays, and to the solar magnetic field, that affects the transport of charged particles in the heliosphere.

This talk will present Fermi-LAT observations of gamma-ray sources within the Solar System. In addition, some aspects of the modeling of the solar emission will be discussed.

Cosmic Rays' Energy Dependent Escape Time (CREDIT)
Chun Kai Loo

Supernova remnants (SNRs) have long been suspected to be the primary sources of Galactic cosmic rays. Over the past decades, great strides have been made in the modeling of particle acceleration, magnetic field amplification, and escape from SNRs. Yet while many SNRs have been observed in nonthermal emission in radio, X-rays, and gamma rays, there is no evidence for any individual object contributing to the locally observed flux. Here, we propose a particular spectral signature from individual remnants that is due to the energy-dependent escape from SNRs. For young and nearby sources, we predict fluxes enhanced by tens of percent in narrow rigidity intervals; given the percent-level flux uncertainties of contemporary cosmic-ray data, such features should be readily detectable. We model the spatial and temporal distribution of sources and the resulting distribution of fluxes with a Monte Carlo approach. The decision tree that we have trained on simulated data is able to discriminate with very high significance between the null hypothesis of a smooth distribution of sources and the scenario with a stochastic distribution of individual sources. We suggest that this cosmic-ray energy-dependent injection time (CREDIT) scenario be considered in experimental searches to identify individual SNRs as cosmic-ray sources.

VHE binary systems with MAGIC+LST and brief introduction to SII.
Fernando Frías

Very High-Energy (VHE; >100 GeV) binary systems such as non-accreting pulsars, microquasars, novae and colliding wind binaries (CWBs) are amongst the key astrophysical sources whose emission we are interested in studying and modelling. In this talk, I will present my ongoing PhD work focused on the analysis of data from the MAGIC and LST telescopes for some of the mentioned sources. Special attention will be given to the results from the 2024 observation campaign of the CWB WR140, designed to cover the periastron passage. Additionally, I will briefly comment how the same Imaging Atmospheric Cherenkov Telescopes (IACT) are being used to perform Stellar Intensity Interferometry (SII) and my involvement in some of the current proposals such as fast-rotating stars.