

# **Ricap09 Roma International Conference on Astroparticle Physics**

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## **Book of Abstracts**



# Contents

Welcome . . . . .	1
Results from the telescope Array Experiment . . . . .	1
AUGER status and result . . . . .	1
Mass composition measured by LOFAR . . . . .	1
Welcome . . . . .	2
Exploiting the radio signal from air showers: the AERA progress . . . . .	2
Status and perspectives of the radio detection technique of cosmic ray air showers . . . . .	2
Measurement of the cosmic rays flux with the ANITAexperiment . . . . .	3
The ARCADE project . . . . .	3
Models of supersymmetry for dark matter . . . . .	3
Dark Matter and 750 GeV resonance . . . . .	4
Fermi bubbles: what do we know about them and where do they come from? . . . . .	4
PeVatron in the Galact Center . . . . .	4
Search for annihilating Dark Matter towards dwarf galaxies by the Cherenkov Telescope Array . . . . .	5
Highlights from the IceCube neutrino observatory . . . . .	5
Results from the ANTARES neutrino telescope . . . . .	5
Km3Net . . . . .	6
From Gravitational Wave detection to Gravitational Wave astronomy . . . . .	6
Localization and broadband follow-up of the Gravitational-Wave Transient Gw150914 . . . . .	6
Electromagnetic follow ups of the GW event . . . . .	6
Fermi follow up of the GW event . . . . .	6
Agile follow up of the GW event . . . . .	6
Multimessenger follow-up of the gravitational wave event GW150914 with ANTARES . . . . .	7

Riccardo Cerulli - ZnWO <sub>4</sub> anisotropic scintillator for Dark Matter investigation with the directionality technique . . . . .	7
Measurement of the cosmic ray energy spectrum and composition with IceCube . . . . .	7
Baikal-GVD . . . . .	7
PWN as sources of high energy neutrinos . . . . .	8
Neutrino propagation in the galactic dark matter halo . . . . .	8
Search for high energy neutrinos from bright GRBs with ANTARES . . . . .	8
Searches for diffuse fluxes of astrophysical neutrinos with the ANTARES telescope . . . . .	9
Juno . . . . .	9
The Luna experiment . . . . .	9
HESS-II - Gamma ray astronomy from 20 GeV to hundreds of TeV's . . . . .	10
The ASTRI prototype and mini-array: telescopes precursors for the Cherenkov Telescope Array (CTA) . . . . .	10
HAWC . . . . .	10
LHAASO . . . . .	10
The Next Generation All-Sky TeV Gamma-Ray Observatory . . . . .	10
Dark Matter after LHC Run I: Clues to Unification . . . . .	11
First results of the HiSCORE timing array . . . . .	11
The gamma-ray observatory TAIGA: status and perspectives . . . . .	11
Astrophysical interpretation of Pierre Auger Observatory measurements of the UHECR energy spectrum and mass composition . . . . .	11
The Pierre Auger Observatory Upgrade . . . . .	12
e-ASTROGAM A Future space based gamma-ray observatory in a new energy window . . . . .	12
Vikas Joshi - HAWC upgrade with a sparse outrigger array . . . . .	13
DAMIC at SNOLAB: searching for low mass WIMPs with CCDs . . . . .	13
The DarkSide Program for Direct Dark Matter Search . . . . .	13
Directional Dark Matter Detection with Two-Phase Argon TPC Detectors . . . . .	13
Seasonal variations of the rate of multiple - muons in the MACRO experiment in the Gran Sasso underground laboratory . . . . .	13
Dama/LIBRA . . . . .	14
XENON1T . . . . .	14

Prospects of Dark Matter Direct Detection on Dark Portals . . . . .	14
ZnWO <sub>4</sub> anisotropic scintillator for Dark Matter investigation with the directionality technique . . . . .	14
Signatures of sneutrino dark matter in an extension of the CMSSM . . . . .	15
Background systematics for Dark Matter Searches . . . . .	15
Reconstructing WIMP properties through an interplay of signal measurements . . . . .	15
Particle dark matter signals in the anisotropic sky: a cross-correlations approach . . . . .	15
New measurement of the angular power spectrum of anisotropies in the data of Fermi-LAT . . . . .	15
Exotic needles in the Cherenkov telescopes haystack . . . . .	16
Isotropic extragalactic flux from dark matter annihilations . . . . .	16
Limits on Lorentz invariance violation at the Planck energy scale from H.E.S.S. spectral analysis of the blazar Mrk 501 . . . . .	16
Detection of VHE gamma-rays from AGN's with redshift close to $z=1$ . . . . .	16
HAWC upgrade with a sparse outrigger array . . . . .	16
The High Energy Particle Detector on board of the CSES mission . . . . .	17
Cut-off Characterization of Bright Fermi Sources: Current instrument limits and future possibilities. . . . .	17
Mid latitude sporadic E-layer Variability during ascending phase of solar cycle 24 . . . . .	18
Spikes of supra-thermal particles at interplanetary shock waves . . . . .	18
Feasibility study of the $^{13}\text{C}(\alpha, n)^{16}\text{O}$ reaction at LUNA . . . . .	18
Cosmic rays and their modulation in the heliosphere by studying gamma rays from the Sun with Fermi-LAT: updated models . . . . .	18
Observations of the gamma-ray emission from the quiescent Sun with the Fermi Large Area Telescope during the first 7 years in orbit . . . . .	18
A Major Upgrade of the H.E.S.S. Cherenkov Cameras . . . . .	18
Results from a Deep Hard X-Ray AGN Survey . . . . .	19
CaloCube: a novel calorimeter for high-energy cosmic rays in space . . . . .	19
Measuring space-time fuzziness with high energy gamma-ray detectors . . . . .	19
Recent development on the realization of a 1-inch VSiPMT prototype . . . . .	19
The Fermi GBM gamma-ray burst and the Fermi LAT follow up of the GW event . . . . .	19
Cosmic-ray electron+positron spectrum with the Fermi Large Area Telescope . . . . .	20

The proton and helium anomalies in the light of the Myriad model . . . . .	20
The Solar Event of May 22 of 2013: observations by the PAMELA experiment . . . . .	21
PAMELA's measurements of the January 6, 2014 solar energetic particle event . . . . .	21
Electron and Positron Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International SpaceStation . . . . .	21
Antiproton Flux and Antiproton-to-Proton Flux Ration Measured by with the Alpha Magnetic Spectrometer on the International Space Station . . . . .	21
Precision Measurement of Nuclei Fluxes and their Ratios in Primary Cosmic Rays with the Alpha Magnetic Spectrometer on the International Space Station . . . . .	22
Anomalies in the gamma-ray diffuse emission of the Galaxy and implications for the interpretation of IceCube results . . . . .	22
The EEE Project, science in school: recent results on cosmic rays detection and performances . . . . .	22
The FAST project - Next Generation UHECR Observatory . . . . .	23
VERITAS latest results . . . . .	23
VHE pulsed gamma-ray emission from the Crab Pulsar by MAGIC . . . . .	23
Recent results in gamma-ray astronomy with the ARGO-YBJ detector . . . . .	24
LATTES: a new gamma-ray detector concept for South America . . . . .	24
Very-high-energy steady spectrum of Crab nebula . . . . .	24
A few eV sterile neutrino as partial dark matter . . . . .	25
The PAMELA Experiment: A decade of Cosmic Rays Investigation . . . . .	25
The AMS-02 detector on the International Space Station - Status and highlights, after the first 5 years on orbit . . . . .	25
The Fermi Telescope results and Future space based gamma-ray observatories . . . . .	26
First data from the DAMPE space mission . . . . .	26
Gamma-ray Signatures of Dark Matter . . . . .	26
Hadronic interactions and cosmic rays physics . . . . .	26
High-Energy Emission from Starburst Galaxies . . . . .	26
The CTA Observatory . . . . .	27
Recent development on the realization of a 1-inch VSiPMT prototype . . . . .	27
Prospects for detecting Gamma-Ray Bursts with the Cherenkov Telescope Array . . . .	27
Underground Study of Big Bang Nucleosynthesis in the Precision Era of Cosmology . . .	27

Development of a SiPM based camera for Cherenkov Telescope Array . . . . .	28
Supernova Remnants with Fermi Large Area Telescope . . . . .	28
The First Fermi-LAT SNR Catalog SNR and Cosmic Ray Implications . . . . .	28
Modeling the Galactic center emission from GeV to PeV . . . . .	29
The Fermi-GBM Gamma-Ray Burst Catalogs: The First Six Years . . . . .	29
The Science Case for a future gamma-ray missions in the 300 KeV- 100 MeV domain . . .	29
Integral follow up of the GW event . . . . .	29
GW Open Discussion . . . . .	30
New results on the indirect search for dark matter using the ANTARES neutrino telescope	30
.. . . .	30
Results and simulation of the prototype detection unit of KM3NeT-ARCA . . . . .	30
... . . . .	31
... . . . .	31
Interpretation of the cosmic ray positron and anti-proton fluxes . . . . .	31
Gamma ray astronomy above 100 TeV and the IceCube results . . . . .	31
... . . . .	32
RPC for gamma-ray detectors at high latitude . . . . .	32
The pLISA project in ASTERICS . . . . .	32
On Fermi-LAT, H.E.S.S. and the Cherenkov Array Telescope Sensitivity to Dark Matter Annihilation . . . . .	32
The cosmic ray spectrum in the energy region between $10^{12}$ - $10^{16}$ eV measured by ARGO-YBJ . . . . .	32
Design and Production of the Digital Optical Modules of the KM3NeT project . . . . .	33
Precision Timing and Triggering for distributed astroparticle experiments . . . . .	33
Z' portal for a keV dark matter . . . . .	33
... . . . .	33
Arap Prize . . . . .	33
Measuring space-time fuzziness with high energy gamma-ray detectors . . . . .	34
White Rabbit Facility . . . . .	34
A TIME-DEPENDENT SEARCH FOR HIGH ENERGY NEUTRINOS FROM BRIGHT GRBs WITH ANTARES . . . . .	34





**Particle and Astroparticle / 15****Welcome**

**Corresponding Author:** anna.diciaccio@roma2.infn.it

**CR and Gamma / 25****Results from the telescope Array Experiment**

**Corresponding Author:** cchjui@gmail.com

The Telescope Array (TA) is a hybrid experiment observing ultrahigh energy cosmic rays in the northern sky. Three fluorescence stations each view 108 degrees in azimuth and up to 30 degrees in elevation. They are located at the periphery of a ground array consisting of 507 plastic scintillator counters, of 1.2km spacing, and covering over 700 square kilometers. We will present the cosmic ray spectra from both TA and its low energy extension (TALE), covering a range of energies from 10 PeV to over 100 EeV. We will also discuss the latest results from the measurements of mass composition by the TA group. Finally, we will present our results from the search for arrival direction anisotropy. Based on the current results, TA is vigorously pursuing expansion of our detectors to four times its current size.

**CR and Gamma / 26****AUGER status and result**

**Corresponding Author:** berat@lpsc.in2p3.fr

The Pierre Auger Observatory, in Argentina, is the present flagship experiment studying ultra-high energy cosmic rays. Facing the challenge due to low cosmic ray flux at the highest energies, the Observatory has been taking data since more than a decade, reaching an exposure of over 50 000 km<sup>2</sup> sr yr. The combination of a large surface detector array and fluorescence telescopes provides a substantial improvement in energy calibration and extensive air shower measurements, resulting in data of unprecedented quality. Moreover, the installation of a denser subarray has allowed extending the sensitivity to lower energies. Altogether, this contributes to provide important information on key questions in the UHECR field in the energy range from 0.1 EeV up to 100 EeV. A review of main results from the Pierre Auger Observatory is presented with a particular focus on the energy spectrum measurements, the mass composition studies, the arrival directions analyses, the search for neutral cosmic messengers, and the investigation of high-energy hadronic interactions. Despite this large amount of valuable results, the understanding of the nature of UHECR and of their origin remains an open science case that the Auger collaboration is willing to address with the Auger PRIME project to upgrade the Observatory.

**Presentation type: oral or poster:**

Oral

**CR and Gamma / 27**

## Mass composition measured by LOFAR

**Co-author:** Joerg Hoerandel <sup>1</sup>

<sup>1</sup> *Radboud University Nijmegen*

**Corresponding Author:** j.horandel@astro.ru.nl

High-energy cosmic rays, impinging on the atmosphere of the Earth initiate cascades of secondary particles, the extensive air showers. The electrons and positrons in the air shower emit electromagnetic radiation. This emission is detected with the LOFAR radio telescope in the frequency range from 30 to 240 MHz.

The data are used to determine the properties of the incoming cosmic rays. The radio technique is now routinely used to measure the arrival direction, the energy, and the particle type (atomic mass) of cosmic rays in the energy range from  $10^{17}$  to  $10^{18}$  eV.

This energy region is of particular astrophysical interest, since in this regime a transition from a Galactic to an extra-galactic origin of cosmic rays is expected.

Recent results from LOFAR will be reviewed and their implications on our understanding of the origin of high-energy cosmic rays will be discussed.

Particle and Astroparticle / 39

## Welcome

**Corresponding Author:** aldo.morselli@roma2.infn.it

CR / 41

## Exploiting the radio signal from air showers: the AERA progress

**Corresponding Author:** revenu@in2p3.fr

We will present the last results and status of the Auger Engineering Radio Array (AERA), located inside the Pierre Auger Observatory. AERA, with more than 150 radio stations spread over 17 km<sup>2</sup>, is the largest radio detector of extensive air showers above 1017 eV. The electric field emitted by secondary electrons and positrons allows to estimate all characteristics of the primary cosmic ray: arrival direction, energy and composition estimation. The performance of AERA together with the analysis methods will be described. The final aim of AERA is mainly to improve the composition estimation of ultra-high energy cosmic rays as a stand-alone detector or in association with other instruments such as a ground particle detector or a fluorescence telescope.

CR / 43

## Status and perspectives of the radio detection technique of cosmic ray air showers

**Corresponding Author:** scholten@kvi.nl

At LOFAR we measure the radio emission from extensive air showers (EAS) in the frequency band of 30-80 MHz in dual-polarized antennas. Through an accurate antenna calibration we can determine the complete set of four Stokes parameters that uniquely determine the linear and/or circular

polarization of the radio signal for an EAS. The observed dependency of the circular polarization on azimuth angle and distance to the shower axis is explained as due to the interfering contributions from the two different radiation mechanisms, a main contribution due to a geomagnetically-induced transverse current and a secondary component due to the Askaryan effect.

The same Askaryan mechanism is also driving radio emission from ultra-high energy particles (neutrinos as well as cosmic rays) impinging on the moon. Plans will be discussed for observations of ultra-high energy neutrinos and cosmic rays on the basis of this process with LOFAR and SKA.

Having a very detailed understanding of radio emission from EAS, the emitted radio signal can be used to determine the magnitude and direction of the induced currents in an EAS. We will show that the linear as well as the circular polarization of the radio waves carry clear information on the magnitude and orientation of the electric fields at different heights in the thunderstorm clouds.

CR / 44

## Measurement of the cosmic rays flux with the ANITAexperiment

The ANITA experiment consists on an aerostatic balloon flying over Antarctica and carrying a payload with antennas. It was designed to detect the electric field of neutrino-induced showers. However, ANITA has detected the electric field of cosmic ray-induced showers and the ANITA collaboration has used these data to produce the first cosmic ray flux measurement obtained by employing radio as a stand-alone technique. We review the experimental results and its interpretation. We also focus on the simulations and the method used for obtaining the cosmic ray flux.

CR / 45

## The ARCADE project

**Corresponding Author:** [laura.valore@na.infn.it](mailto:laura.valore@na.infn.it)

The Atmospheric Research for Climate and Astroparticle DETection (ARCADE) project started in 2012 and involves research groups from Italy (Naples, Turin and L'Aquila) and Colorado.

The target of ARCADE is the comparison of the techniques mostly used in cosmic-rays and gamma-rays experiments to measure the atmospheric aerosol attenuation profiles of the UV light, for a better understanding of the systematics, limits of applicability and possible enhancements of each method. The experimental setup includes a steerable Raman Lidar, completely designed and realized within this project, and a telescope for the detection of UV light (AMT, Atmospheric Monitoring Telescope). The instruments have been installed in Lamar, Colorado and took data for one year. Simulations of the Lidar optics and of the AMT light profiles have been performed. Specific calibration runs of the AMT have been performed using a closeby laser facility. The analysis of the collected data is in progress and first results are shown.

Particle and Astroparticle / 49

## Models of supersymmetry for dark matter

**Corresponding Author:** [carlos.munnoz@uam.es](mailto:carlos.munnoz@uam.es)

Supersymmetric models (with and without R parity conservation) and the associated particle candidates for dark matter (neutralino, sneutrino, gravitino) will be discussed in the light of experimental results.

**Particle and Astroparticle / 50**

## **Dark Matter and 750 GeV resonance**

**Corresponding Author:** yann.mambrini@th.u-psud.fr

Recently, ATLAS and CMS released their first analysis of the RUN II of the LHC. Their results seem to show an excess in the diphoton channel at 750 GeV, which could correspond to a (pseudo)scalar resonance with a relatively large width. We will show how this resonance can be embedded in models of dark matter, and the perspective of discoveries in the future direct and indirect detection experiments.

**g-rays / 52**

## **Fermi bubbles: what do we know about them and where do they come from?**

**Corresponding Author:** dvmalyshev@gmail.com

The Fermi bubbles are two gamma-ray lobes extending up to 55 degrees above and below the Galactic center. The Fermi bubbles are unique in that, in contrast to lobes in other galaxies, they were discovered in gamma rays, rather than radio waves or X rays. In the talk I will overview the observations of the Fermi bubbles in gamma rays, X rays, UV and radio waves. I will present a recent analysis of the Fermi bubbles near the Galactic plane based on Pass 8 Fermi LAT data. In spite of the observational progress, both the nature of the gamma-ray emission and the origin of the bubbles are still unknown. Possible processes that can create the bubbles include AGN-like activity of the supermassive black hole at the center of our Galaxy or a period of starburst activity near the Galactic center.

**g-rays / 53**

## **PeVatron in the Galact Center**

**Corresponding Author:** emmanuel.moulin@cea.fr

The Galactic Centre region has been observed by the High Energy Stereoscopic System (H.E.S.S.) array of ground-based Cherenkov telescopes since 2004 leading to the detection of the very-high-energy (VHE,  $E > 100$  GeV) gamma-ray source HESS J1745–290 spatially coincident with the supermassive black hole Sgr A\*. Diffuse TeV gamma-ray emission has been detected along the Galactic plane, most likely due to hadronic cosmic-ray interactions with the dense gas of the Central Molecular Zone. The rich 2004–2013 dataset permits detailed spectral and morphological studies of diffuse emission in the inner 200 pc of the Galactic Centre region. The new results permit to make an important statement regarding the location and origin of the accelerator of PeV protons. The H.E.S.S. observations of the Galactic Centre region will be discussed in the context of the origin of Galactic cosmic rays.

DM / 56

## Search for annihilating Dark Matter towards dwarf galaxies by the Cherenkov Telescope Array

**Corresponding Author:** gonzalo.rodriguez.fernandez@roma2.infn.it

The standard model of cosmology indicates that approximately 27% of the energy density of the universe is in the form of dark matter. The nature of dark matter is an open question in modern physics. The concordance cosmological model ( $\Lambda$ CDM) suggests a non-baryonic dark matter compatible with a gas of cold and weakly interacting massive particles (WIMPs). Indirect dark matter searches with imaging atmospheric Cherenkov telescopes (IACTs) are playing a crucial role in constraining the nature of the dark matter particle through the study of their potential annihilation to produce very high energy (VHE) gamma rays from different astrophysical structures. The Cherenkov Telescope Array (CTA) will provide a good sensitivity over a range of dark matter mass from  $\sim 100$  GeV to  $\sim 30$  TeV. In this contribution we review the status of the study of indirect dark matter searches from the dwarf spheroidal galaxies that provide straight-forward separation of signal from dark matter from that of other astronomical sources of gamma rays.

Nu / 74

## Highlights from the IceCube neutrino observatory

**Corresponding Author:** juan.aguilar@unige.ch

In 2013 the IceCube Neutrino Observatory, a cubic-kilometer deep ice detector located at the geographic South Pole, observed a flux of high-energy neutrinos of extra-terrestrial origin marking the beginning of a new era in neutrino astronomy. The observed neutrino flux lies in the 30 TeV - 2 PeV energy range and its detection has been further confirmed by different analysis techniques and in different detection channels.

This detection did not indicate the sources of these neutrinos as their direction in the sky does not seem to be correlated with any known class of astrophysical sources.

In this talk I will summarize the latest IceCube results and the current understanding of the properties of this astrophysical neutrino flux. I will also discuss the future of neutrino astronomy at the South Pole.

Nu / 75

## Results from the ANTARES neutrino telescope

**Corresponding Author:** agustin.sanchez@ba.infn.it

The ANTARES detector is an underwater neutrino telescope, the largest in the Northern Hemisphere and the first one ever built under the sea, located in the Mediterranean Sea 40 km off the Southern coast of France, at a depth of 2.5 km. It comprises 885 photomultiplier tubes distributed in twelve detection lines. The signal due to neutrinos is searched by reconstructing the tracks of secondary particles produced in the surroundings of the detector. The detector is in data taking with its final configuration since 2008. It is aimed at identifying the sources, either steady or flaring, of cosmic neutrinos, and is also suitable for detection of dark matter within the Sun and/or Galactic Centre. ANTARES is in particular in an optimal location to cross-check the signal of cosmic neutrinos reported from IceCube. Several multi-messenger analyses have been also attempted, including the search of coincidence signals of neutrinos with gravitational waves. Additional topics include neu-

trino oscillations or the search of exotic particles, like nuclearites and magnetic monopoles. Results from the all such analyses will be presented.

**CR and Gamma / 76**

## **Km3Net**

**Corresponding Author:** [brunner@cppm.in2p3.fr](mailto:brunner@cppm.in2p3.fr)

**GW / 77**

## **From Gravitational Wave detection to Gravitational Wave astronomy**

**Corresponding Author:** [piero.rapagnani@roma1.infn.it](mailto:piero.rapagnani@roma1.infn.it)

**GW / 78**

## **Localization and broadband follow-up of the Gravitational-Wave Transient Gw150914**

**Corresponding Author:** [marica.branchesi@uniurb.it](mailto:marica.branchesi@uniurb.it)

**GW / 79**

## **Electromagnetic follow ups of the GW event**

**Corresponding Author:** [ibartos@phys.columbia.edu](mailto:ibartos@phys.columbia.edu)

**80**

## **Fermi follow up of the GW event**

**Corresponding Author:** [nicola.omodei@pi.infn.it](mailto:nicola.omodei@pi.infn.it)

**GW / 81**

## **Agile follow up of the GW event**

**Corresponding Author:** [marco.tavani@roma2.infn.it](mailto:marco.tavani@roma2.infn.it)

GW / 82

## Multimessenger follow-up of the gravitational wave event GW150914 with ANTARES

**Corresponding Author:** coleiro@apc.in2p3.fr

On September 14th 2015, LIGO/Virgo collaboration has detected the first significant gravitational wave event. A neutrino follow-up was performed using ANTARES and IceCube online data to search for a potential neutrino counterpart to this event. No neutrino candidate in both temporal and spatial coincidence with GW 150914 had been detected within  $\pm 500$  s from the event. Consequently, the neutrino fluence and the total energy emitted in neutrinos have been constrained. This first joint study does demonstrate the multimessenger synergies between ANTARES, IceCube and LIGO/Virgo. More generally, by constantly monitoring at least one complete hemisphere of the sky, neutrino telescopes are well designed to detect neutrinos emitted by transient astrophysical sources. Searches for ANTARES neutrino candidates coincident with multi-wavelength astrophysical transient phenomena are performed by triggering optical, X-ray and radio observations immediately after the detection of an interesting event. The latest results of these analysis will be presented.

96

## Riccardo Cerulli - ZnWO<sub>4</sub> anisotropic scintillator for Dark Matter investigation with the directionality technique

**Author:** Riccardo Cerulli<sup>1</sup>

<sup>1</sup> *Istituto Nazionale di Fisica Nucleare*

**Corresponding Author:** riccardo.cerulli@roma2.infn.it

Nu / 97

## Measurement of the cosmic ray energy spectrum and composition with IceCube

**Corresponding Author:** timo.karg@desy.de

The IceCube Neutrino Observatory at the geographic South Pole includes the cubic-kilometer deep-ice detector as well as a square-kilometer particle detector at the surface, IceTop. This unique combination allows measuring multiple components of cosmic-ray induced air showers in the PeV to EeV energy range: IceTop samples the electromagnetic component at the ground level and allows studying GeV muons in the periphery of the air shower; the deep-ice detector is sensitive to TeV muons in the shower core and in addition has collected a high-statistics sample of atmospheric muons from cosmic rays in the tens to hundreds TeV energy range. I will discuss the cosmic ray energy spectrum and mass composition measured with three years of IceCube data. Further, I will present a measurement of the muon LDF in IceTop, which gives an additional and complementary handle on cosmic-ray composition.

Nu / 98

## Baikal-GVD

**Corresponding Author:** suvorova@cpc.inr.ac.ru

We present the status of newly constructed cluster of the Gigaton Volume Detector in Lake Baikal (Baikal-GVD) designed for registration of very high energy neutrinos of astrophysical origin. This “Dubna” cluster has been upgraded to its baseline configuration, with 288 optical modules (OMs) arranged on eight vertical strings. Thus the instrumented water volume has been gotten up to about 5.9 Mtons. The array was commissioned in early April 2016 and takes data since then. Preliminary results of data analysis with former cluster configuration operated during 2015 are discussed.

Nu / 99

## PWN as sources of high energy neutrinos

**Corresponding Author:** guetta@mporzio.astro.it

Nu / 100

## Neutrino propagation in the galactic dark matter halo

**Corresponding Author:** roberto.lineros@to.infn.it

The observation of PeV neutrinos has opened a window to study astrophysics and New Physics processes. Among PeV neutrino observables, the neutrino flavor composition become very interesting because it can reveal underlying interactions during the neutrino propagation. We consider the effect of galactic dark matter interactions on the neutrino oscillations. We estimate the effective interaction strength required to produce sizable deviations with respect to expected flavor composition from oscillations in vacuum. In addition, the spatial distribution of dark matter can lead to even larger deviations and can also produce a flavor composition that depends on the neutrino’s arrival direction. These features might be observed in neutrino telescopes, like IceCube and KM3NET, depending on the telescope’s sky coverage. Also, a positive signal has interesting insights for particle physics models.

Nu / 101

## Search for high energy neutrinos from bright GRBs with ANTARES

**Corresponding Author:** matteo.sanguineti@ge.infn.it

The ANTARES telescope is currently the largest neutrino detector of the Northern Hemisphere, fully operational since 2008. The search for high-energy neutrinos from astrophysical sources is one of the main purposes of the ANTARES scientific project; among them gamma-ray bursts are thought to be site of hadronic acceleration, thus neutrinos are expected from the decay of charged mesons, produced in  $pp$  interactions. The methods and the results of a search for neutrinos from the brightest GRBs observed between 2008 and 2013 are presented. Two scenarios of the fireball model have been investigated: the internal shock scenario, leading to the production of high-energy neutrinos, and the photospheric scenario, characterized by a low energy component in neutrinos spectrum due to the assumption of neutrinos production closer to the central engine. Since no events have been detected in time and space coincidence with these bursts, ANTARES upper limits at 90% C.L. on the



expected neutrinos fluxes are derived. Such non detections allow us to directly constrain the bulk Lorentz factor of the jet and the baryon loading.

Nu / 102

## **Searches for diffuse fluxes of astrophysical neutrinos with the ANTARES telescope**

**Corresponding Author:** lfusco@bo.infn.it

The ANTARES detector is the largest and longest operated neutrino telescope in the Northern Hemisphere. A highly-significant cosmic neutrino signal has been observed by the Antarctic IceCube detector and can be studied in details with ANTARES, exploiting the complementarity of its fields of view. All-flavour neutrino interactions can be observed and reconstructed by the experiment. Its good exposure, effective area and pointing accuracy have allowed putting limits on the neutrino emission from the Southern Sky from individual sources. Searches for a diffuse neutrino signal have been prepared, using data collected with ANTARES from 2007 to 2015. These searches look for neutrino fluxes coming from both all-sky and special regions such as the Galactic Plane and the Fermi Bubbles, from which an enhanced neutrino emission is predicted. The outcome of the analysis of ANTARES data will be reported in this contribution.

Nu / 107

## **Juno**

**Corresponding Author:** gioacchino.ranucci@mi.infn.it

The JUNO Jiangmen Underground Neutrino Observatory, a 20 kton multi-purpose underground liquid scintillator detector, has been proposed and approved for realization in the south of China. After an intense design phase, the overall concept of the structure of the detector has been finalized, paving the way towards the construction of the several components and subsystems, which will compose it. Meanwhile, the excavation of the site which will host the experiment has been started and is rapidly progressing.

The main physics target of JUNO is the determination of the neutrino mass hierarchy, which will be accessible through the measurement of the antineutrino spectrum from two high power nuclear complexes under installation 52 km away from the experimental site.

In this talk, after the description of the broad physics capabilities of the experiment, which include in addition to the crucial measure of the neutrino hierarchy the high precision determination of three oscillation parameters, as well as a rich astroparticle program, I will illustrate the technical characteristics of the detector, with particular emphasis on the technological challenges which are being addressed along the path towards its realization.

Nu / 108

## **The Luna experiment**

**Corresponding Author:** carlo.broggini@pd.infn.it

The thermo-nuclear reactions responsible for the luminosity and for the chemical evolution of stars take place in a narrow energy window: the Gamow peak. The extremely low value of the cross

section inside the Gamow peak has always prevented its direct measurement in a laboratory at the surface of the Earth, where the signal to background ratio is too small mainly because of cosmic ray interactions. In order to explore this new domain of astrophysics LUNA (Laboratory for Underground Nuclear Astrophysics) started its activity in 1991 by installing a 50 kV electrostatic accelerator deep underground inside the Gran Sasso Laboratory, followed in the year 2000 by a 400 kV one.

In the talk I will first describe the background suppression achievable deep underground, then I will give an overview of the main contributions provided by LUNA to the study of hydrogen burning in stars, from the Sun to classical Novae. In particular, I will discuss the new results of the experiment performed to study  $^{22}\text{Ne}(p,\gamma)^{23}\text{Na}$ , the most uncertain reaction of neon-sodium cycle. Finally, I will outline the scientific motivations of the LUNA program with the new underground accelerator of 3.5 MV. This accelerator will start running underground in 2018 and it will be devoted to the study of the key reactions responsible for the helium and carbon burning in stars.

**CR and Gamma / 117**

## **HESS-II - Gamma ray astronomy from 20 GeV to hundreds of TeV's**

**Corresponding Author:** denauroi@in2p3.fr

**CR and Gamma / 119**

## **The ASTRI prototype and mini-array: telescopes precursors for the Cherenkov Telescope Array (CTA)**

**Corresponding Author:** angelo.antonelli@oa-roma.inaf.it

**Particle and Astroparticle / 120**

## **HAWC**

**Corresponding Author:** sabrina.casanova@mpi-hd.mpg.de

**121**

## **LHAASO**

**CR and Gamma / 122**

## **The Next Generation All-Sky TeV Gamma-Ray Observatory**

**Corresponding Author:** gus@lanl.gov

**Particle and Astroparticle / 177**

## **Dark Matter after LHC Run I: Clues to Unification**

**Corresponding Author:** olive@umn.edu**CR / 179**

## **First results of the HiSCORE timing array**

**Corresponding Author:** martin.tluczykont@physik.uni-hamburg.de

The very high energy gamma-ray regime is the key to several questions in high energy astrophysics, the most prominent being the search for the origin of cosmic rays. Observations of gamma rays up to several 100 TeV are particularly important to spectrally resolve the cutoff regime of the long-sought Pevatrons, the accelerators of PeV cosmic rays.

The HiSCORE timing array is part of the international TAIGA collaboration. HiSCORE currently consists of 28 air Cherenkov timing stations distributed on an area of  $0.25 \text{ km}^2$ . A HiSCORE station consists of 4 Photomultiplier tubes (PMT), each equipped with a light collector (Winston Cone), resulting in a light collection area of  $0.5 \text{ m}^2$  per station and a field of view with a half opening angle of 30 deg. The signals of the four PMTs are sampled in the GHz regime. The analog sum of all four PMT channels is used for triggering. Air shower events are reconstructed using the signal amplitudes and their timing. A relative time synchronization of the array is performed in the sub-ns regime.

Other detector components of TAIGA (imaging air Cherenkov Telescopes and scintillation muon counters) are not part of this presentation.

Here, the status and first results of the HiSCORE timing array will be presented.

**CR / 180**

## **The gamma-ray observatory TAIGA: status and perspectives**

**Corresponding Author:** kuz@dec1.sinp.msu.ru

The gamma-ray observatory TAIGA (Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy) is designed for the study of gamma rays and fluxes of charged cosmic rays in the energy range 1013 eV – 1018 eV. The installation will include a network of wide-angle (FOV - 0.6 sr) Cherenkov stations and up to 16 IACTs (FOV -  $10 \times 10$  degrees) on an area of  $5 \text{ km}^2$  and muon detectors with a total area of  $2000 \text{ m}^2$  distributed on an area of  $1 \text{ km}^2$ . The expected sensitivity of the Observatory to search for local sources of gamma-quanta in the energy range 30 - 200 TeV is about  $10^{-13} \text{ erg/cm}^2 \text{ sec}$ .

The report covers the main physics tasks of the new installation, the design and the methods of extracting gamma-ray events. This paper presents the results of the operation of the first 28 wide-angle Cherenkov stations.

**CR / 181**

## **Astrophysical interpretation of Pierre Auger Observatory measurements of the UHECR energy spectrum and mass composition**

**Corresponding Author:** army1987@email.it

We present a combined fit of a simple astrophysical model of UHECR sources to both the energy spectrum and mass composition data measured by the Pierre Auger Observatory. The fit has been performed for energies above 5 EeV, i.e. the region of the all-particle spectrum above the so-called “ankle” feature. The astrophysical model we adopted consists of identical sources uniformly distributed in a comoving volume, where nuclei are accelerated with a rigidity-dependent mechanism. The fit results suggest sources characterized by relatively low maximum injection energies and hard spectral indices. The impact of various systematic uncertainties on the above result is discussed.

CR / 182

## The Pierre Auger Observatory Upgrade

**Corresponding Author:** giovanni.marsella@le.infn.it

It is planned to operate the Pierre Auger Observatory until the end of 2024. An Upgrade of the experiment has been proposed in order to provide additional measurements to allow to elucidate the mass composition and the origin of the flux suppression at the highest energies, to search for a flux contribution of protons up to the highest energies and to reach a sensitivity to a contribution as small as 10% in the flux suppression region, to study extensive air showers and hadronic multiparticle production.

With operation planned until 2024, event statistics will more than double compared with the existing Auger data set, with the critical added advantage that every event will now have mass information. Obtaining additional composition-sensitive information will not only help to better reconstruct the properties of the primary particles at the highest energies, but also improve the measurements in the important energy range just above the ankle. Furthermore, measurements with the new detectors will help to reduce systematic uncertainties related to modeling hadronic showers and to limitations of reconstruction algorithms.

A description of the principal proposed Auger upgrade will be presented.

The Auger upgrade promises high-quality future data, and real scope for new physics.

g-rays / 183

## e-ASTROGAM A Future space based gamma-ray observatory in a new energy window

e-ASTROGAM is a gamma-ray observatory to be proposed as the M5 Medium-size mission of the European Space Agency. It is dedicated to the observation of the Universe with unprecedented sensitivity in the energy range 0.3-100 MeV, extending up to GeV energies, together with a ground-breaking polarization capability. e-ASTROGAM will operate as an open astronomical observatory, with a core science focused on (1) the activity from extreme particle accelerators, including gamma-ray bursts, jet astrophysics of active galactic nuclei and the link to new astronomies (gravitational waves, neutrinos, ultra-high energy cosmic rays), (2) the high-energy mysteries of the Galactic center and inner Galaxy, including the activity of the supermassive black hole, the Fermi Bubbles, the origin of the Galactic positrons, and the search for dark matter signatures in a new energy window; (3) nucleosynthesis and chemical evolution, including the life cycle of elements produced by supernovae in the Milky Way and the Local Group of galaxies. e-ASTROGAM will be ideal for the study of high-energy sources in general, including pulsars and pulsar wind nebulae, accreting neutron stars and black holes, novae, supernova remnants, magnetars, and it will also provide important contributions to solar and terrestrial physics. The e-ASTROGAM payload consists of a single instrument for the simultaneous detection of Compton and pair-producing gamma-ray events. It is based on a

very high technology readiness level for all subsystems and includes many innovative features for the main detectors and associated electronics.

186

## **Vikas Joshi - HAWC upgrade with a sparse outrigger array**

DM / 187

## **DAMIC at SNOLAB: searching for low mass WIMPs with CCDs**

**Corresponding Author:** [paolo.privitera@roma2.infn.it](mailto:paolo.privitera@roma2.infn.it)

DM / 188

## **The DarkSide Program for Direct Dark Matter Search**

**Corresponding Author:** [giuliana.fiorillo@na.infn.it](mailto:giuliana.fiorillo@na.infn.it)

DM / 189

## **Directional Dark Matter Detection with Two-Phase Argon TPC Detectors**

**Corresponding Author:** [susan.walker@unina.it](mailto:susan.walker@unina.it)

DM / 190

## **Seasonal variations of the rate of multiple - muons in the MACRO experiment in the Gran Sasso underground laboratory**

**Corresponding Author:** [francesco.ronga@lnf.infn.it](mailto:francesco.ronga@lnf.infn.it)

It's well known that the rate of cosmic ray muons depends from the atmospheric temperature, and that for events with a single muon the peak of rate is in summer, in the northern hemisphere.

In 2015 the MINOS experiment, in USA, reported the seasonal modulation of the rate of cosmic ray multiple-muon events at two underground sites, the MINOS near detector and the MINOS far detector site at 2100 mwe. The peak of the seasonal rate depends from the distance between the muons. MINOS found that, for small distances between the multiple muons, the rate peaks is in the winter and that the amplitude of the modulation is smaller than in the case of a single muon. I have done a reanalysis of data of the past MACRO experiment at the Gran Sasso Laboratory (Italy) analyzing data from 1994 up to December 2010. I have found roughly similar results but with the peak rate of multiple-muon events slightly delayed respect to the peak of single muons.

This difference between MINOS and MACRO may be due to differences in the depth of the detectors and in the temperature seasonal variations in the two sites.

This results could be of interest for dark matter experiments looking to dark matter seasonal modulation due to the Earth's motion.

**DM / 191**

## **Dama/LIBRA**

**Corresponding Author:** pierluigi.belli@roma2.infn.it

The DAMA/LIBRA set-up (about 250 kg highly radiopure NaI(Tl)) is running at Gran Sasso underground Laboratory. The positive results in terms of the model independent Dark Matter annual modulation signature and the results of recent investigations on possible diurnal effects and their implications will be presented. Presently DAMA/LIBRA is in data taking in the new configuration (DAMA/LIBRA-phase2) with lower energy threshold. Results, implications and perspectives will be addressed.

**DM / 192**

## **XENON1T**

**Corresponding Author:** oberlack@uni-mainz.de

Establishing the nature of Dark Matter is one of the great challenges in science today. The XENON Dark Matter project has successfully established the dual phase liquid xenon time projection chamber as the world-leading technique in searches for Weakly Interacting Massive Particles (WIMPs). This year, we are starting the third generation of Dark Matter searches with the XENON1T experiment, where the first two generations (XENON10, XENON100) have been leaders in the field. XENON1T sets out to push current best limits by the LUX experiment by another factor of ~25 in sensitivity, opening vast discovery space. I will review recent accomplishments and current status of the XENON project.

Authors: Uwe Oberlack, on behalf of the XENON Collaboration

**DM / 193**

## **Prospects of Dark Matter Direct Detection on Dark Portals**

**Corresponding Author:** arcadi.giorgio@gmail.com

**DM / 194**

## **ZnWO<sub>4</sub> anisotropic scintillator for Dark Matter investigation with the directionality technique**

**Corresponding Author:** riccardo.cerulli@roma2.infn.it

**Particle and Astroparticle / 195**

## **Signatures of sneutrino dark matter in an extension of the CMSSM**

**Corresponding Author:** belanger@lapp.in2p3.fr

**Particle and Astroparticle / 196**

## **Background systematics for Dark Matter Searches**

**Corresponding Author:** c.weniger@uva.nl

**DM / 197**

## **Reconstructing WIMP properties through an interplay of signal measurements**

**DM / 198**

## **Particle dark matter signals in the anisotropic sky: a cross-correlations approach**

**Corresponding Author:** marco.regis@to.infn.it

Anisotropies in the electromagnetic emission induced by dark matter (DM) annihilation or decay in the extragalactic sky are a recent tool in the quest for a particle DM evidence.

In this talk, I will review on-going searches involving the two-point angular cross-correlation signal between the multi-wavelength emission from WIMP DM and gravitational tracers of the DM distribution in the Universe, including weak-lensing cosmic shear, galaxy catalogs and CMB-lensing.

**DM / 199**

## **New measurement of the angular power spectrum of anisotropies in the data of Fermi-LAT**

**Corresponding Author:** fornasam@gmail.com

The Diffuse Gamma-Ray Background (DGRB) collects the radiation produced by all those sources that are not bright enough to be resolved individually. Therefore, it represents an essential tool to study faint gamma-ray emitters, like star-forming or radio galaxies and the exotic Dark Matter. The anisotropy pattern of the DGRB is extremely informative: I will review the recent measurement of the anisotropy angular power spectrum performed by the Fermi LAT Collaboration with almost 80 months of data. This brand-new result can be used to infer the composition of the DGRB. In particular, I will show how it constrains the emission expected from Dark Matter.

DM / 200

## Exotic needles in the Cherenkov telescopes haystack

**Corresponding Author:** michele.doro@pd.infn.it

Ground-based Imaging Cherenkov Telescopes observed the Cherenkov radiation emitted in extended atmospheric showers generated by cosmic gamma rays in the TeV regime. The rate of these events is normally overwhelmed by many orders of magnitude larger triggers from cosmic rays induced showers. A large fraction of these “background” events is vetoed at the on-line trigger level, but a substantial fraction still go through the trigger and is saved on data for the off-line reconstruction. What kind of information can carry those events, normally rejected in the analysis? Is there the possibility that an exotic signature is hidden in those data? In the presentation, we will discuss some science case, and the problems related to those searches, for the current and future generation of these telescopes.

201

## Isotropic extragalactic flux from dark matter annihilations

**Corresponding Author:** c.m.boehm@durham.ac.uk

g-rays / 202

## Limits on Lorentz invariance violation at the Planck energy scale from H.E.S.S. spectral analysis of the blazar Mrk 501

**Corresponding Author:** matthias.lorentz@cea.fr

ome extensions to the Standard Model lead to the introduction of Lorentz symmetry breaking terms, expected to induce deviations from Lorentz symmetry around the Planck scale. A parameterization of Lorentz invariance violating (LIV) effects can be introduced by adding an effective term to the photon dispersion relation. This affects the kinematics of electron-positron pair creation by TeV gamma rays on the extragalactic background light (EBL) and translates into modifications of the standard EBL opacity for the TeV photon spectra of extragalactic sources. Exclusion limits are presented, obtained with the spectral analysis of H.E.S.S. observations taken on the blazar Mrk 501 during the exceptional 2014 flare. The energy spectrum, extending very significantly above 10 TeV, allows us to place strong limits on the LIV in the photon sector at the level of the Planck energy scale for linear perturbations in the photon dispersion relation, and provides the strongest constraints presently for the case of quadratic perturbations.

g-rays / 203

## Detection of VHE gamma-rays from AGN's with redshift close to $z=1$

g-rays / 204



## HAWC upgrade with a sparse outrigger array

**Corresponding Author:** vikas.joshi@mpi-hd.mpg.de

The High Altitude Water Cherenkov (HAWC) high-energy gamma-ray observatory has recently been completed near the Sierra Negra in central Mexico. HAWC consists of 300 Water Cherenkov Detectors, each containing 200 tons of purified water and 4 PMT's (three 8" and one 10"), that cover a total surface area of 20,000 m<sup>2</sup>. HAWC observes gamma rays in the 0.1–100 TeV range and has a sensitivity to TeV-scale gamma-ray sources an order of magnitude better than previous air-shower arrays. Its two steradians field-of-view and >90% duty cycle make HAWC an ideal instrument for surveying the high-energy sky.

HAWC collects multi-TeV gamma rays with an effective area of 10<sup>5</sup> m<sup>2</sup>, but the performance of the reconstruction is not efficient for showers falling outside the array. An upgrade that increases the present fraction of well reconstructed multi-TeV showers by a factor of 3–4 can be done with a sparse outrigger array of small water Cherenkov detectors. It will help to pinpoint the core position and by that improve the angular resolution of the reconstructed showers. Such an outrigger array is of the order of ~300 small water Cherenkov detectors of 2.5 m<sup>3</sup> equipped with one 8" PMT, placed over an area four times larger than HAWC. In this contribution, we will give an overview of the outrigger array and present the results for the layout optimization using different tank and PMT options. We will also present the performance of the FADC electronics used on the outrigger readout.

**Posters / 205**

## The High Energy Particle Detector on board of the CSES mission

**Corresponding Author:** vincenzo.vitale@roma2.infn.it

The China Seismo-Electromagnetic Satellite (CSES) has the purpose to measure electromagnetic waves emissions, plasma properties and particles fluxes in the Earth ionosphere and magnetosphere, to investigate the possible correlation with seismic events.

Phenomena related to the solar-terrestrial interactions, such as Coronal Mass Ejections (CMEs), and the study of low energy cosmic rays are also within the scientific objectives of this mission. CSES, prepared by a Chinese-Italian collaboration, is scheduled to be launched in the first half of 2017 and has an expected lifetime of 5 years. The satellite will have a circular Sun-synchronous orbit with 98 degrees inclination and 500 km altitude.

A series of instruments will be used to investigate the many aspects of the electromagnetic environment:

2 magnetometers, an electrical field detector, a plasma analyzer, a Langmuir probe and the High Energy Particle Detector (HEPD).

The HEPD is built by the Italian collaborators. It includes a silicon tracker for the precision measurement of the particles pitch angle and a segmented (plastic scintillator and LYSO) calorimeter for the particle identification and the energy measurement.

The HEPD will measure electrons and protons up to few hundreds of MeV, as also heavier nuclei. A description of the HEPD and its characteristics will be reported.

**Posters / 206**

## Cut-off Characterization of Bright Fermi Sources: Current instrument limits and future possibilities.

**Corresponding Author:** romolic@cp.dias.ie

**Posters / 207**

### **Mid latitude sporadic E-layer Variability during ascending phase of solar cycle 24**

**Corresponding Author:** purohit\_pk2004@yahoo.com

**Posters / 208**

### **Spikes of supra-thermal particles at interplanetary shock waves**

**Corresponding Author:** ffrasche@lpl.arizona.edu

**Posters / 209**

### **Feasibility study of the $^{13}\text{C}(\alpha, n)^{16}\text{O}$ reaction at LUNA**

**Corresponding Author:** iza.kochanek@lngs.infn.it

**Posters / 210**

### **Cosmic rays and their modulation in the heliosphere by studying gamma rays from the Sun with Fermi-LAT: updated models**

**Corresponding Author:** orlandele@gmail.com

**Posters / 211**

### **Observations of the gamma-ray emission from the quiescent Sun with the Fermi Large Area Telescope during the first 7 years in orbit**

**Corresponding Author:** silvia.raino@ba.infn.it

**Posters / 212**

### **A Major Upgrade of the H.E.S.S. Cherenkov Cameras**

**Posters / 213****Results from a Deep Hard X-Ray AGN Survey**

**Corresponding Author:** eugenio.bottacini@stanford.edu

**Posters / 214****CaloCube: a novel calorimeter for high-energy cosmic rays in space**

**Corresponding Author:** paolo.cattaneo@pv.infn.it

The direct observation of high-energy cosmic rays, up to the PeV region needs highly performing calorimeters.

Space operation requires great effort in optimizing size and mass. Calocube is a homogeneous calorimeter whose basic geometry is cubic and isotropic, so as to detect particles from every direction, maximizing the acceptance. High granularity is obtained by filling the volume with small cubic scintillating crystals. Extensive optimization of the construction parameters has been studied.

The problematic of calibration and monitoring during space operation is being addressed combining software and hardware approaches. A prototype, instrumented with CsI(Tl) cubic crystals, has been constructed and tested with particle beams. An overview

of the obtained results will be presented and the perspectives for future space experiments will be discussed.

215

**Measuring space-time fuzziness with high energy gamma-ray detectors**

**Corresponding Author:** paolo.cattaneo@pv.infn.it

216

**Recent development on the realization of a 1-inch VSiPMT prototype**

**Corresponding Author:** feliciabarbato@gmail.com

**GW / 217****The Fermi GBM gamma-ray burst and the Fermi LAT follow up of the GW event**

**Corresponding Author:** elisabetta.bissaldi@ba.infn.it

“On behalf of the Fermi-GBM Collaboration”

Since its launch in 2008, the Fermi Gamma-ray Burst Monitor (GBM) has triggered and located on average approximately two gamma-ray bursts (GRBs) every three days. Here we present the main results from the latest two catalogs provided by the Fermi GBM science team, namely the third GBM GRB catalog and the first GBM time-resolved spectral catalog.

The intention of the GBM GRB catalog is to provide information to the community on the most important observables of the GBM detected bursts. It comprises 1405 triggers identified as GRBs. For each one, location and main characteristics of the prompt emission, the duration, peak flux and fluence are derived.

The GBM time-resolved spectral catalog presents high-quality time-resolved spectral analysis with high temporal and spectral resolution of the brightest bursts observed by Fermi GBM in a shorter period than the former catalog, namely four years. It comprises 1491 spectra from 81 bursts. Distributions of parameters, statistics of the parameter populations, parameter-parameter and parameter-uncertainty correlations, and their exact values are obtained.

With its broad field-of-view and excellent sensitivity to short Gamma-Ray Bursts (GRBs), the Fermi Gamma-ray Burst Monitor (GBM) is an ideal partner for LIGO/Virgo in the search for electromagnetic counterparts to the gravitational waves detected from the merger of compact objects in binary systems.

Here we present Fermi-GBM observations of the LIGO Gravitational Wave event GW150914, which has been associated to the merger of two stellar-mass black holes, and report the presence of a weak transient event, close in time to the LIGO one. We discuss the characteristics of the GBM transient, which are consistent with a weak short GRB arriving at a large angle to the direction in which Fermi was pointing.

Future joint observations of GW events by LIGO/Virgo and Fermi GBM could reveal whether the weak transient reported here is a plausible counterpart to GW150914 or a chance coincidence, and will further probe the connection between compact binary mergers and short GRBs.

CR / 218

## **Cosmic-ray electron+positron spectrum with the Fermi Large Area Telescope**

**Corresponding Author:** raffaella.bonino@to.infn.it

We present a measurement of the inclusive cosmic-ray electron and positron (CRE) spectrum between 7 GeV and 2 TeV performed with almost seven years of data collected with the Fermi Large Area Telescope. The spectrum above 100 GeV can explore the properties of local CRE sources.

Because of the long live time and the very large acceptance of the LAT, our data are the largest CRE sample available to date, with  $\sim 10k$  events above 1 TeV. In this talk I will present the results of the analysis and discuss some possible implications.

CR / 219

## **The proton and helium anomalies in the light of the Myriad model**

**Corresponding Author:** salati@lapth.cnrs.fr

A hardening of the proton and helium fluxes is observed above a few hundreds of GeV/nuc. The actual distribution of the local sources of primary cosmic rays has been suggested as a potential solution to this puzzling behavior. Some authors even claim that a single source is responsible for the proton and helium anomalies. But how probable are such explanations? To answer that question, I will discuss the Myriad model and the probabilistic nature of the predictions on primary cosmic

ray fluxes. I will show that at any given energy, these fluxes are distributed according to a stable law well-known to financial analysts.

CR / 220

## **The Solar Event of May 22 of 2013: observations by the PAMELA experiment**

CR / 221

## **PAMELA's measurements of the January 6, 2014 solar energetic particle event**

**Corresponding Author:** [alessandro.bruno@ba.infn.it](mailto:alessandro.bruno@ba.infn.it)

CR / 222

## **Electron and Positron Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station**

**Corresponding Author:** [henning@physik.rwth-aachen.de](mailto:henning@physik.rwth-aachen.de)

Precision measurements by the Alpha Magnetic Spectrometer on the International Space Station of the primary cosmic-ray electron flux in the range 0.5 to 700 GeV and the positron flux in the range 0.5 to 500 GeV are presented. The electron flux and the positron flux each require a description beyond a single power-law spectrum. Both the electron flux and the positron flux change their behavior at ~30 GeV

but the fluxes are significantly different in their magnitude and energy dependence. Between 20 and 200 GeV the positron spectral index is significantly harder than the electron spectral index. The results show, for the first time, that neither  $e^+$  nor  $e^-$  can be described by a single power law above 27.2 and 52.3 GeV, respectively. The determination of the differing behavior of the spectral indices versus energy is a new observation and provides important information on the origins of cosmic-ray electrons and positrons.

The dependence of the electron and positron fluxes on time will also be discussed.

CR / 223

## **Antiproton Flux and Antiproton-to-Proton Flux Ratio Measured by with the Alpha Magnetic Spectrometer on the International Space Station**

**Corresponding Author:** [weiwei.xu@cern.ch](mailto:weiwei.xu@cern.ch)

A precision measurement by AMS of the antiproton flux and the antiproton-to-proton flux ratio in

primary cosmic rays in the absolute rigidity range from 1 to 450 GV is presented based on  $3.49 \times 10^5$  antiproton events and  $2.42 \times 10^9$  proton events. The antiproton-to-proton flux ratio reaches a maximum at  $\sim 20$  GV and is rigidity independent above 60.3 GV

CR / 225

## **Precision Measurement of Nuclei Fluxes and their Ratios in Primary Cosmic Rays with the Alpha Magnetic Spectrometer on the International Space Station**

**Corresponding Author:** mheil@cern.ch

The exact behavior of the nuclei fluxes with rigidity and how they relate to each other is important for understanding the production, acceleration and propagation mechanisms of charged cosmic rays. Precise measurements with the Alpha Magnetic Spectrometer on the International Space Station of the light nuclei fluxes and their ratios in primary cosmic rays with rigidities from 2 GV to 2 TV will be presented. Their dependence with rigidity will be shown.

g-rays / 226

## **Anomalies in the gamma-ray diffuse emission of the Galaxy and implications for the interpretation of IceCube results**

**Corresponding Author:** dario.grasso@pi.infn.it

Several independent analyzes of Fermi-LAT results found evidences of a spatial dependence of the cosmic ray (CR) proton spectral index which is not accounted for in conventional models of CR transport in the Galaxy.

Moreover, several CR experiments have established the presence of a CR spectral hardening above few hundred GeV.

We show that these results may have a relevant impact on the gamma-ray and neutrino diffuse emissions of the Galaxy above the TeV. Indeed a phenomenological model which adopts a spatial dependent diffusion coefficient, so to account for those features, also reproduces the gamma-ray excess found by Milagro at 15 TeV as well as other gamma-ray data sets. HAWC and LHAASO should soon confirm or reject this scenario.

The same model predicts a neutrino emission along the Galactic plane which is significantly larger than expected on the basis of conventional models. This emission is compatible with ANTARES upper limits and may soon be detected by IceCube.

CR / 227

## **The EEE Project, science in school: recent results on cosmic rays detection and performances**

**Corresponding Author:** silvia.miozzi@roma2.infn.it

The EEE (Extreme Energy Event) project will study extensive air showers through the detection of the muon component by means of a network of tracking detectors, installed inside high schools distributed all over Italy. Project's aim is to involve teachers and students in a frontier cosmic ray

experiment, as well.

The EEE telescope is based on a large but simplified and cheap version of the detector designed for the time of flight measurements (TOF) of the ALICE experiment at LHC: 3 large (~2 m<sup>2</sup>) Multi-gap Resistive Plate Chambers (MRPC), built at CERN by high school students and teachers, which contribute directly to the full operation of the telescope.

Using multiple small gas gaps combined with the use of high gain and fast gas mixture (C<sub>2</sub>H<sub>2</sub>F<sub>4</sub> and SF<sub>6</sub> based), these MRPCs show a time resolution better than 100 ps. Particle tracking is performed equipping MRPCs with 24 strips read at both ends, by front-end electronics based on NINO ASIC and using commercial multi-hit TDCs.

The two-dimensional information on the cosmic muon impact point is obtained by the hit strip, in one direction, and by the time difference of the signals arriving at the two strip ends in the other direction, thus providing space resolution of the order of 1 cm. By using the three impact points it is possible to reconstruct the direction of the crossing muon. The angular resolution obtained for the muon zenith angle is better than 1°. The GPS synchronization of the telescopes will open the way to search for coincidences between far away sites exploiting muon timing and direction.

The first phase of the project is started with the installation of the detector telescopes in 21 high schools in 7 cities. Nowadays a total of 52 telescopes has been built and more than 40 telescopes are installed in schools covering an area of about 3x10<sup>5</sup> km<sup>2</sup> of the Italian surface.

About 35 telescopes during the last 2 years are successfully running in a network.

Data are collected at CNAF where they are stored and elaborated to be analysed in an easy way also by students.

Recent results of the last data taking are presented showing the performances of the telescopes network and MRPC detectors with over than 20 billion of muon tracks.

The main field of investigation are search for coincidences between far telescopes, forrush decrease studies, upward going particles, east-west asymmetry, observation of moon shadow, CR anisotropy. The educational aspect will also be showed.

CR / 228

## The FAST project - Next Generation UHECR Observatory

Corresponding Author: [fujii@icrr.u-tokyo.ac.jp](mailto:fujii@icrr.u-tokyo.ac.jp)

CR and Gamma / 229

## VERITAS latest results

Corresponding Author: [hanna@physics.mcgill.ca](mailto:hanna@physics.mcgill.ca)

VERITAS is an array of four imaging atmospheric Cherenkov telescopes near Tucson, Arizona and is one of the world's most sensitive detectors of very high energy (VHE: >100 GeV) gamma rays and cosmic rays. The scientific reach of VERITAS covers the study of both Extragalactic and Galactic objects and the search for astrophysical Dark Matter. In this talk I will discuss the status of VERITAS operations and present a selection of recent results.

g-rays / 230

## VHE pulsed gamma-ray emission from the Crab Pulsar by MAGIC

**Corresponding Author:** roberta@ifae.es

The last six years have witnessed major revisions of our knowledge about the Crab Pulsar, the central engine of the remnant of the supernova explosion that occurred in 1054 AD. The consensus scenario for the origin of the high-energy pulsed emission has been challenged with the discovery of a very-high-energy power law tail extending up to  $\sim 400$  GeV, above the expected spectral cut off at a few GeV. Now, new measurements obtained by the MAGIC collaboration, with more than 300 hours of observation time, extend the energy spectrum of the Crab Pulsar even further, on the TeV regime. Above  $\sim 400$  GeV the pulsed emission comes mainly from the interpulse, which becomes more prominent with energy due to a harder spectral index.

These findings require gamma-ray production via inverse Compton scattering close to or beyond the light cylinder radius by an underlying particle population with Lorentz factors greater than  $5 \times 10^6$ . We will present those new results and discuss the implications in our current knowledge concerning pulsar environments.

**g-rays / 231**

## **Recent results in gamma-ray astronomy with the ARGO-YBJ detector**

**Corresponding Author:** tristano.digirolamo@na.infn.it

The ARGO-YBJ air shower detector has been in stable data taking for five years at the YangBaJing Cosmic Ray Laboratory (Tibet, P.R. China, 4300m a.s.l.) with a duty cycle  $>86\%$  and an energy threshold of a few hundreds of GeV. With the scaler mode technique, the minimum threshold of 1 GeV can be reached. In this talk recent results in gamma-ray astronomy will be presented, including those from 4.5 years of observations of the blazar Mrk 421 in common with the Fermi satellite.

**g-rays / 232**

## **LATTES: a new gamma-ray detector concept for South America**

**Corresponding Author:** ruben@lip.pt

Currently the detection of Very High Energy gamma-rays for astrophysics rely on the measurement of the Extensive Air Showers (EAS) either using Cherenkov detectors or EAS arrays with larger field of views but also larger energy thresholds. In this talk we present a novel hybrid detector concept for a EAS array with an improved sensitivity in the lower energies ( $\sim 100$  GeV). We discuss its main features, capabilities and present preliminary results on its expected performances and sensitivities. This wide field of view experiment is planned to be installed at high altitude in South America making it a complementary project to the planned Cherenkov telescope experiments and a powerful tool to trigger further observations of variable sources and to detect transients phenomena.

**g-rays / 233**

## **Very-high-energy steady spectrum of Crab nebula**

**Corresponding Author:** ffrasche@lpl.arizona.edu



The very-high-energy steady emission (beyond 50 GeV) of the Crab nebula is believed to originate from Inverse Compton scattering of low energy photons off energetic electrons. However, the mechanism accelerating the electrons to TeV energies and the resulting particle distribution are still a topic of debate. Benefitting from a wealth of data collected with ground-based gamma-ray observatories in the past decade (HEGRA, HESS II, MAGIC, VERITAS), we develop a simple one-zone interpretation of the steady-state Crab nebula spectrum in the range between 50 GeV and 100 TeV. Modeling the differential photon spectrum as inverse-Compton emission of far-infrared photons and electrons energized at the nebula termination shock with a log-parabola energy distribution, we estimate the parameters (index and curvature) of the log-parabola parent electron distribution, constraining the scale of the acceleration region and the anisotropy of the magnetic turbulence downstream of the termination shock. We conclude that the rise of the spectrum observed by Fermi-LAT originates from a distinct energetic particle population.

Nu / 234

## A few eV sterile neutrino as partial dark matter

**Corresponding Author:** subinoy@iiap.res.in

Recent short baseline experiments (MiniBooNE and LSND) as well as reactor experiments (Daya bay and T2K) might be hinting for an extra eV scale light sterile neutrino state. But these results are in tension with the recent Planck data as it does not allow an extra thermalized neutrino. To alleviate this conflict, we propose a scenario where the light sterile neutrino is in thermal equilibrium with a hidden sector which has a temperature lower than CNB temperature. We have studied analytically the effects of this sterile neutrino on CMB temperature power spectrum and matter power spectrum. We have modified `\texttt{CAMB}` accordingly and we are running an MCMC analysis to see whether this scenario can make a friendship between the Planck data and the short baseline experiments. We show that, to be consistent with all data, this light neutrino can only serve a tiny fraction of DM.

CR and Gamma / 235

## The PAMELA Experiment: A decade of Cosmic Rays Investigation

**Corresponding Author:** riccardo.munini@ts.infn.it

CR and Gamma / 236

## The AMS-02 detector on the International Space Station - Status and highlights, after the first 5 years on orbit

**Corresponding Author:** matteo.duranti@pg.infn.it

The AMS-02 detector is operating on the International Space Station (ISS) since May the 19th, 2011. More than 80 billion events have been collected by the instrument in the first 5 years of data taking. This unprecedented amount of data is being used to perform accurate measurements of the different Cosmic Rays components. In this contribution, the published results and the highlights of the ongoing analyses will be presented.

**CR and Gamma / 237**

## **The Fermi Telescope results and Future space based gamma-ray observatories**

**CR and Gamma / 238**

## **First data from the DAMPE space mission**

**Corresponding Author:** [ivan.demitri@gssi.it](mailto:ivan.demitri@gssi.it)

The DAMPE (DARk Matter Particle Explorer) satellite was launched on December 17, 2015 and is in smooth data taking since few days after. It was designed in order to properly work for at least three years and, thanks to its large geometric factor (about 0.3 m<sup>2</sup> sr for protons and nuclei), is integrating one of the largest exposure for galactic cosmic ray studies in space.

Even if primarily optimized for the study of electrons and gammas, the detector provides good tracking and calorimetric performances also in the case of protons and nuclei, together with the possibility of ion identification through multiple charge measurements.

This will allow precise measurement of proton and nuclei energy spectra from tens of GeV up to about 100 TeV, the high energy limit being essentially determined by the overall geometric factor and the calorimeter's dynamic range.

In particular, the energy region between 1-100 TeV will be explored with higher precision compared to previous experiments: spectral indexes for individual species could then be well measured and evidence for the observed hardenings could be checked and better quantified.

This would be very important for a comparison with state-of-the-art models of galactic CR acceleration/propagation mechanisms.

The information from the various subdetectors (e.g. ion charge measurement, precision tracking, shower topology) allows an efficient identification of the electron signal over the large (mainly proton-induced) background. As a result, the all-electron spectrum will be measured with excellent resolution from few GeV up to few TeV, thus giving the possibility to identify possible contribution of nearby sources.

**Particle and Astroparticle / 239**

## **Gamma-ray Signatures of Dark Matter**

I will briefly review the different ways in which Dark Matter (annihilations or decays) can produce high energy photons, and then focus on some current interesting cases from the experiments (and their phenomenological interpretation).

**Particle and Astroparticle / 240**

## **Hadronic interactions and cosmic rays physics**

**Corresponding Author:** [ralph.engel@kit.edu](mailto:ralph.engel@kit.edu)

**CR and Gamma / 241**

## High-Energy Emission from Starburst Galaxies

**Corresponding Author:** massimo.persic@gmail.com

Detection of high-energy gamma-ray emission from starburst galaxies (such as nearby M82 and NGC 253, and faraway Arp 220) has established a direct link between leptonic and hadronic processes in an extragalactic non-AGN environment. We review the most relevant aspects of these processes, and contrast theoretical predictions with available radio and gamma-ray measurements, in order to determine the particles' spectral properties and energy densities in these galaxies.

**CR and Gamma / 242**

## The CTA Observatory

**Corresponding Author:** angelo.antonelli@oa-roma.inaf.it**CR / 243**

## Recent development on the realization of a 1-inch VSiPMT prototype

**Author:** Felicia Carla Tiziana Barbato<sup>1</sup><sup>1</sup> NA**Corresponding Author:** feliciabarbato@gmail.com

The VSiPMT (Vacuum Silicon PhotoMultiplier Tube) is an innovative design for a revolutionary hybrid photodetector. The idea, born with the purpose to use a SiPM for large detection volumes, consists in replacing the classical dynode chain with a SiPM. In this configuration, we match the large sensitive area of a photocathode with the performances of the SiPM technology, which therefore acts like an electron detector and so like a current amplifier. The excellent photon counting capability, fast response, low power consumption and great stability are among the most attractive features of the VSiPMT. In order to realize such a device we first studied the feasibility of this detector both from theoretical and experimental point of view, by implementing a Geant4-based simulation and studying the response of a special non-windowed MPPC by Hamamatsu with an electron beam. Thanks to this result Hamamatsu realized two VSiPMT industrial prototypes with a photocathode of 3mm diameter. We now present an overview of the full characterization of the VSiPMT industrial prototypes with an analysis of their pro and contra. We also present the progress on the realization of a 1-inch prototype and the preliminary tests we are performing on it.

**Posters / 250**

## Prospects for detecting Gamma-Ray Bursts with the Cherenkov Telescope Array

**Corresponding Author:** elisabetta.bissaldi@ba.infn.it

Nu / 251

## Underground Study of Big Bang Nucleosynthesis in the Precision Era of Cosmology

**Corresponding Author:** carlo.gustavino@roma1.infn.it

Big Bang Nucleosynthesis (BBN) is the first probe of cosmology and particle physics. Assuming Standard model of cosmology and particle physics, light elements such as deuterium, helium and lithium were produced in the first minutes of cosmic time. The amount of each primordial nuclide depends on the expansion rate of the Universe and on the baryon density. The expansion rate is governed by the number of relativistic species (photons and three neutrino families in the standard model), while the baryon density has been recently inferred with high accuracy by the PLANCK collaboration, through the analysis of cosmic microwave background (CMB) data. Thus, BBN theory provides definite predictions for the abundances of primordial elements, as far as the knowledge of the relevant nuclear processes of the BBN chain is accurate. At BBN energies ( $E_{\text{cm}}$  between 30 and 300 MeV) the cross section of many BBN processes is very low because of the Coulomb repulsion between the interacting nuclei. For this reason it is convenient (if not mandatory) to perform the measurements deep underground. Presently the world's only facility operating underground is LUNA (Laboratory for Underground Nuclear astrophysics) at LNGS (Laboratorio Nazionale del Gran Sasso, Italy). In this presentation the BBN measurement of LUNA are briefly reviewed and discussed. The ongoing study of the  $D(p,\gamma)^3\text{He}$  reaction at BBN energies will be discussed more in detail. It will be shown that a precise measurement of this process is of primary importance to: derive the baryon density of universe with accuracy comparable to the one obtained by Cosmic Microwave Background (CMB) experiments; constrain the existence of dark radiation, i.e. unknown relativistic species existing in the universe, in order to constrain; Compare the experimental data with nuclear ab initio calculations.

Posters / 252

## Development of a SiPM based camera for Cherenkov Telescope Array

**Corresponding Author:** elisabetta.bissaldi@ba.infn.it

g-rays / 253

## Supernova Remnants with Fermi Large Area Telescope

**Corresponding Author:** micaela.caragiulo@ba.infn.it

The Large Area Telescope (LAT), onboard the Fermi satellite, proved to be, after more than 7 years of data taking, an excellent instrument to detect and observe Supernova Remnants (SNRs) in a range of energies running from few hundred MeV up to few hundred GeV. It provides essential information on physical processes that occur at the source, involving both accelerated leptons and hadrons, in order to understand the mechanisms responsible for the primary Cosmic Ray acceleration.

I show the latest results in the observation of Galactic SNRs by Fermi-LAT.

g-rays / 254

## **The First Fermi-LAT SNR Catalog SNR and Cosmic Ray Implications**

While supernova remnants (SNRs) are widely thought to be powerful cosmic-ray accelerators, indirect evidence comes from a small number of well-studied cases. Here we systematically determine the gamma-ray emission detected by the Fermi Large Area Telescope (LAT) from all known Galactic SNRs, disentangling them from the sea of cosmic-ray generated photons in the Galactic plane. Using LAT data we have characterized the 1-100 GeV emission in 279 regions containing SNRs, accounting for systematic uncertainties caused by source confusion and instrumental response. We classified 30 sources as SNRs, using spatial overlap with the radio position. For all the remaining regions we evaluated upper limits on SNRs' emission. In the First Fermi-LAT SNR Catalog there is a study of the aggregate characteristics of these SNRs, such as comparisons between GeV, radio and TeV quantities. We show that previously sufficient models of SNRs' GeV emission no longer adequately describe the data. To address the question of CR origins, we also examine the SNRs' maximal CR contribution assuming the GeV emission arises solely from proton interactions. Improved breadth and quality of multiwavelength data, including distances and local densities, and more, higher resolution gamma-ray data with correspondingly improved Galactic diffuse models will strengthen this constraint.

This abstract is on behalf of the Fermi-LAT collaboration

DM / 255

## **Modeling the Galactic center emission from GeV to PeV**

**Corresponding Author:** antonio.marinelli@pi.infn.it

Posters / 256

## **The Fermi-GBM Gamma-Ray Burst Catalogs: The First Six Years**

**Corresponding Author:** elisabetta.bissaldi@ba.infn.it

g-rays / 257

## **The Science Case for a future gamma-ray missions in the 300 KeV-100 MeV domain**

**Corresponding Author:** pvb@irap.omp.eu

GW / 258

## **Integral follow up of the GW event**

**Corresponding Author:** pietro.ubertini@iaps.inaf.it

GW / 259

## GW Open Discussion

Nu / 261

### New results on the indirect search for dark matter using the ANTARES neutrino telescope

Neutrino telescopes have a wide scientific scope. One of their main goals is the detection of dark matter, for which they have specific advantages. The understanding of the nature of dark matter requires a multi-front approach since we still do not know many of their properties. Neutrino telescopes offer the possibility of look at several kinds of sources, not all of them available to other indirect searches. In this work we provide an overview of the results obtained by the ANTARES neutrino telescope, which has been taking data for almost ten years. It is installed in the Mediterranean Sea at a depth of 2475 m, off the coast of Toulon (France).

The results presented in this work include searches for neutrino excess from several astrophysical sources. One of the most interesting ones is the Sun. Dark matter particles by the solar system would scatter with nuclei of the Sun, lose energy and accumulate in its centre. Among the final products of their annihilations, only neutrinos could escape. Therefore, a detection of high energy neutrinos from the Sun would be a very clean indication of dark matter, since no significant astrophysical backgrounds are expected, contrary to other indirect searches. Moreover, the limits from neutrino telescopes for spin-dependent cross section are the most restrictive ones. Another interesting source is the Galactic Centre, for which ANTARES has a better visibility than IceCube, due to its geographical location. This search gives limits on the annihilation cross section. Other dark matter searches carried out in ANTARES include the Earth and dwarf galaxies. Results with the most recent data sample will be presented, for the first time.

262

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Nu / 269

### Results and simulation of the prototype detection unit of KM3NeT-ARCA

**Corresponding Author:** christophe.hugon@ge.infn.it

KM3NeT-ARCA is the successor of the ANTARES Mediterranean neutrino telescope. It is a km<sup>3</sup> detector using a new design for the light detection units: the digital optical module. These optical modules were developed by the KM3NeT Collaboration to improve the detection capability of neutrino interactions in the fiducial volume thanks to their large total photocathode area, summed on the 31 three inch photomultiplier tubes used in each optical module. Prototypes of these detection modules has been installed in the deep sea sites of the future full detector. The directionality and the number of hit PMTs allow the identification of the Cherenkov light from natural 40K decay and of the atmospheric muons, with a sensitivity to its arrival directions. It can also identify the bioluminescence activity in the neighborhood. These results show good agreement with the Monte Carlo

simulations and will be presented together with the description of the very last status of the full ray tracing simulation.

The purpose of this simulation is to give a high precision simulated response of the digital optical module. It is based on GEANT4 and takes into account all the parameters such as the medium characteristics, the geometry and material characteristics of the modules. Its major innovation lies in the simulation of the thin layer optics of the photo-multiplier tubes (PMTs). As a result, this simulation provide very precise understanding of the optical module sensitivity in function of photon directionality and wavelength, therefore a better understanding of its response to the signal and background.

270

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271

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CR / 274

## Interpretation of the cosmic ray positron and anti-proton fluxes

**Corresponding Author:** paolo.lipari@roma1.infn.it

In this work we discuss possible interpretations of the measurements of fluxes of positrons and anti-proton in cosmic rays. We underline the interest of studying the ratios of the fluxes for different particles. It is remarkable that the observed positron/antiproton ratio is consistent with the theoretical expectations (both in the spectral shape and in the relative normalization) of the ratio at production, when the injection of both particles is due to the conventional mechanism. This has to be contrasted with an electron/proton ratio that falls rapidly with energy. We discuss possible interpretations of these results, and possible methods to establish the correct explanation. The solution of this problem is of central importance for astroparticle physics.

g-rays / 275

## Gamma ray astronomy above 100 TeV and the IceCube results

**Corresponding Author:** vermetto@to.infn.it

In this work we discuss the interest and scientific potential of galactic gamma astronomy at very high energy ( $E > 100$  TeV), illustrating different predictions for the properties of the diffuse galactic gamma ray fluxes. For photons of such high energy it is very important to take into account absorption due to pair production interactions, including the contribution of interactions with the galactic infrared radiation field. The energy range considered is where IceCube has obtained evidence

for an astrophysical neutrino signal, and gammaastronomy can clarify if a fraction of this signal has its origin in the Milky Way, and determine the properties of the galactic neutrino emission.

CR / 276

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g-rays / 277

## **RPC for gamma-ray detectors at high latitude**

**Corresponding Author:** rinaldo.santonico@roma2.infn.it

Posters / 280

## **The pLISA project in ASTERICS**

**Corresponding Author:** giulia.debonis@roma1.infn.it

DM / 284

## **On Fermi-LAT, H.E.S.S. and the Cherenkov Array Telescope Sensitivity to Dark Matter Annihilation**

**Corresponding Author:** farinaldo.queiroz@mpi-hd.mpg.de

I discuss how one can extend Fermi-LAT and H.E.S.S. limits on gamma-ray lines from dark matter annihilation to energies larger than currently accessible. Moreover, I present Fermi-LAT, H.E.S.S. and the Cherenkov Array Telescope sensitivity to neutrino signals and show that we have already entered into a new era where gamma-ray telescopes are more sensitive than neutrino detectors to neutrino lines from dark matter annihilation with the potential to distinguish the flavor of the final state neutrinos.

CR / 285

## **The cosmic ray spectrum in the energy region between $10^{12}$ - $10^{16}$ eV measured by ARGO-YBJ**

The ARGO-YBJ experiment is a full-coverage air shower detector operating at the Yangbajing International Cosmic Ray Observatory (Tibet, P.R China, 4300 m a.s.l.). The detector was in stable data taking in its full configuration from Nov. 2007 to Dec 2012. More than  $10^{11}$  events have been collected and reconstructed. Due to its characteristics (full-coverage, high segmentation, high altitude operation) the ARGO-YBJ experiment is able to investigate the cosmic ray energy spectrum in



a wide energy range. In this work we present the measurement of the Proton and Helium spectra in the energy range 1-300 TeV by using a large data sample collected between Jan. 2008 and Dec. 2011.

**Posters / 286**

## **Design and Production of the Digital Optical Modules of the KM3NeT project**

**Corresponding Author:** emanuele.leonora@ct.infn.it

**Posters / 288**

## **Precision Timing and Triggering for distributed astroparticle experiments**

**Corresponding Author:** ralf.wischnewski@desy.de

**Posters / 289**

## **Z' portal for a keV dark matter**

**Corresponding Author:** maira.dutra@th.u-psud.fr

While astrophysical evidences for the existence of dark matter (DM) have been accumulated during the past decades, it is still not understood the fundamental physics involved. No unambiguous positive signal of DM particles have been found in searches specially dedicated to the well motivated WIMP candidates, whose mass vary from GeV to a few TeV. This encourage us to consider non-standard scenarios such as keV DM in the wake of an elusive 3.5 keV gamma-ray line. Such a very light DM must have been decoupled from the primordial thermal bath while relativistic. In order to reach the observed relic density, we could include a huge amount of new particles or, as we will consider in this work, one very heavy field that decays into standard particles. Such “diluton” field would inject a huge amount of entropy into the thermal bath, diluting the abundance of the already decoupled keV DM. In this work we will explore the case in which the diluton field is a new neutral gauge boson,  $Z'$ , that also constitute a portal between dark matter and standard particles.

291

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**CR and Gamma / 292**

## **Arap Prize**

**Posters / 293****Measuring space-time fuzziness with high energy gamma-ray detectors**

**Corresponding Author:** andrea.rappoldi@pv.infn.it

There are several suggestions to probe space-time fuzziness (also space-time foam) due to the quantum mechanics nature of space-time. These effects are predicted to be very small, being related to the Planck length, so that the only hope to experimentally detect them is to look at propagation of particles along cosmological distances. A phenomenological approach suggests that photons from point-like sources at cosmological distance experience path length fluctuations that could be detected.

Also the direction of flight of such photons will be subject to a dispersion such that the image of a point-like source will be blurred and detected as a disk.

This foam-induced blurring is expected to increase with the photon energy and with the distance. A signature of foam-induced blurring will be images of point-like sources larger than the size due to the PSF of the instrument. The gamma-ray experiments AGILE and FERMI with their optimal angular resolutions offer ideal conditions for such searches. A preliminary study of the potentiality of this approach is presented.

**Posters / 294****White Rabbit Facility**

**Corresponding Author:** gonzalo.rodriquez.fernandez@roma2.infn.it

**Posters / 295****A TIME-DEPENDENT SEARCH FOR HIGH ENERGY NEUTRINOS FROM BRIGHT GRBs WITH ANTARES**

**Corresponding Author:** silvia.celli@roma1.infn.it