Cosmic Ray International Seminar 2015

Monday 14 September 2015 - Wednesday 16 September 2015

Castello Angioino, Gallipoli, ITALY

Book of Abstracts

Contents

Cosmic Ray and Astrophysical Neutrino Detection / **30**

Cosmic ray physics with ARGO—YBJ

Author: Paolo Montini[1]

[1] *ROMA2*

The ARGO—YBJ experiment has been in stable data taking for more than five years at the Yangbajing cosmic ray observatory (Tibet, P.R. China, 4300 m a.s.l.). The detector collected about 5X10^11 events in a wide energy range from few TeVs up to the PeV region. In this work we summarize the latest results in cosmic ray physics particularly focusing on the cosmic ray energy spectrum. The results of the measurement of the all—particle and proton plus helium energy spectra in the energy region between 10^12 - 10^16 eV are discussed. A precise measurement of the cosmic ray energy spectrum and composition in this energy region allows a better understanding of the origin of the knee and provides a powerful cross—check among different experimental techniques.

New Technologies and Next generation of Experiments / **37**

Cosmic rays 2020: the INFN view

Author: Marco Pallavicini[1]

[1] *GE*

Corresponding Author: marco.pallavicini@ge.infn.it

The talk will outline the status and the medium / long term prospectivesof INFN Astroparticle and Fundamental Physics commission in the study of cosmic radiation, both with ground/sea based detectors and from space.

Cosmic Ray and Astrophysical Neutrino Detection / **19**

First results from coordinated data taking by the Extreme Energy Events experiment

Author: Daniele De Gruttola[1]

[1] *NA*

Corresponding Author: degruttola@sa.infn.it

The Extreme Energy Events (EEE) Project is an experiment, managed by the Fermi Centre, for the study of extremely high-energy cosmic rays, which exploits the Multagap Resistive Plate Chamber (MRPC) technology. The excellent time resolution and good tracking capability of this detector allows us to study Extensive Air Showers with an array of telescopes distributed all over the Italian territory. Each telescope is installed in a High School, with the additional goal to introduce students to particle and astroparticle Physics. The EEE array is composed of 47 telescopes, each made of three MRPC planes, spanning more than 10 degrees in latitude and 11 in longitude, organized in clusters and single telescope stations. The status of the experiment and the results, obtained during two recent coordinated data taking periods, will be reported. The observation of Forbush decreases, coincidence events among different telescopes and the muon decay, using more than 5 billions tracks collected in the last few months, are of particular interest.

Summary:

overview of EEE results presented by D. De Gruttola for EEE Collaboration

Interplay between LHC and UHECR physics / 18

Hadronic physics with the Pierre Auger Observatory

Author: Lorenzo Cazon[1]

Co-author: Pierre Auger Observatory Pierre Auger Collaboration [2]

[1] *LIP*

[2] *Malargue, Argentina*

Corresponding Author: cazon@lip.pt

Extensive air showers are the result of billions of particle reactions initiated by single cosmic rays at ultra-high energy. Their characteristics are sensitive both to the mass of the primary cosmic ray and to the details of hadronic interactions, including energies and kinematic regions beyond those tested by human-made accelerators.

We report on how the Pierre Auger Observatory is able to measure the proton-air cross section for particle production at a center-of-mass energy per nucleon of 39 TeV and 56 TeV and also to constrain the new LHC-tuned hadronic interaction models by measuring the muon content and muon production depth of air showers with a primary center-of-mass energy per nucleon around and above 140 TeV.

Cosmic Ray and Astrophysical Neutrino Detection / 14

Highlights from the Pierre Auger Observatory

Authors: Observatorio Pierre Auger Pierre Auger Collaboration[1] ; Stephane Coutu[2]

[1] *Malargue, Argentina*

[2] *Penn State University*

Corresponding Author: coutu@phys.psu.edu

With an accumulated exposure of over 50,000 km^2 sr yr, the Auger Observatory has the largest statistical sample of ultra-high energy cosmic rays. We will present highlights of recent results from Auger, including details of the energy spectrum, sensitivity to primary composition, searches for anisotropies and candidate sources, and searches for neutral cosmic messengers. Explorations of hadronic interaction physics with Auger, as well as upgrade plans for the Observatory will be alluded to, but will be featured in more detail in companion presentations.

Interplay between LHC and UHECR physics / 27

LHCf experiment: physics results

Author: Massimo Bongi[1]

[1] *FI*

Corresponding Author: bongi@fi.infn.it

LHCf is an experiment designed to study the very-forward emission of neutral particles produced in proton-proton and proton-nucleus collisions at the LHC. The detectors consists of a pair of electromagnetic sampling calorimeters installed on both sides of the ATLAS interaction point IP1 at a distance of 140 m, covering the pseudorapidity range from 8.6 to infinity. The experiment has successfully measured the energy spectra of gamma rays, neutral pions and neutrons in p-p collisions at 0.9 TeV and 7 TeV, and of neutral pions in p-Pb collisions at 5.02 TeV and in p-p collisions at 2.76 TeV. The most recent data set has been acquired during a special physics run of p-p collisions at 13 TeV in June 2015 after the restart of the LHC. This set of measurements represent an useful contribution to the calibration and tuning of the hadronic interaction models used for the simulation of atmospheric showers induced by very-high energy cosmic rays, as the measured energy interval corresponds to the range 10^14 - 10^17 eV in the laboratory frame.

Gamma Rays Detection / **8**

MAGIC highlights

Author: Barbara De Lotto[1]

[1] *UD*

Corresponding Author: barbara.delotto@uniud.it

The MAGIC system of two 17 m diameter Atmospheric Gamma-ray Imaging Cherenkov Telescopes has undergone a major upgrade during the last years and is now completing its tenth observations cycle. In this talk I will present the detector's performance and a selection of scientific highlights.

Cosmic Ray and Astrophysical Neutrino Detection / **4**

Neutrino Physics and Astrophysics with IceCube

Author: Teresa Montaruli[1]

[1] *Geneve University*

In this contribution we summarize the selected highlights of IceCube in the domain of high-energy astrophysics and particle physics. We discuss the highest-energy neutrino detection and its interpretation after 4 years of data. The high energy non-atmospheric component is seen also in other analyses with smaller significance, for instance when using muon neutrinos coming from the Northern hemisphere. Flavor mixing is probed along cosmic distances in an analysis using also cascade neutrino events. The results on the search for neutrino sources will be presented including the results of a joint analysis with Pierre Auger and Telescope Array which is sensitive to correlations between highest energy neutrinos and UHECRs measured by the three experiments. Moreover, recent results on dark matter searches from the Sun will be discussed. Finally, the results on standard neutrino oscillations will be presented.

Cosmic Ray and Astrophysical Neutrino Detection / **31**

Overview of AMS results

Author: Bruna Bertucci[1]

[1] *PG*

Corresponding Author: bruna.bertucci@pg.infn.it

The Alpha Magnetic Spectrometer (AMS) experiment operates since
May 2011 on board of the International Space Station to search for primordial anti-matter, to study the light anti-matter components in the Cosmic Rays (CR) and to perform a precision study of the CR composition and energy spectrum. More than 60 billion events have been collected by the instrument up to now thanks to its large acceptance and the long exposure time. In this contribution we will discuss the most recent results, reviewing the instrument design and performances as well
as the data analysis procedures enabling their achievement

New Technologies and Next generation of Experiments / 12

Present status and perspectives of the KM3NeT detector

Author: Annarita Margiotta[1]

[1] *BO*

Corresponding Author: annarita.margiotta@bo.infn.it

KM3NeT is a distributed research infrastructure comprising a network of deep-sea neutrino telescopes in the Mediterranean Sea. It will consist of building blocks of 115 vertical detection units anchored at the seabed, connected to shore. Each detection unit carries 18 optical modules equipped with 31 3" photomultipliers. Two configurations are defined to detect neutrinos in different ranges of energy. The ARCA setup will search for neutrinos from defined sources or sky regions with unprecedented resolution and for high-energy neutrino diffuse fluxes. Two building blocks with a total instrumented volume of 1 km3 will be installed at the KM3NeT-It site, at a depth of 3500 m, about 100 km offshore Capo Passero, Sicily. A third building block, with a compact distribution of the optical modules, will be deployed at the KM3NeT-Fr site (ORCA), 40 km offshore Toulon at a depth of 2500 m. It will study the neutrino mass-hierarchy problem and explore the low energy region of the spectrum. The status of the first phase of implementation of KM3NeT and a survey of the physics potentiality of the telescope will be described in the talk, with particular emphasis on the high energy studies.

Cosmic Ray and Astrophysical Neutrino Detection / 6

Primary spectrum and composition with IceCube/IceTop

Author: thomas gaisser[1]

[1] *University of Delaware*

Corresponding Author: gaisser@bartol.udel.edu

IceCube, with its surface array IceTop, detects three different components of extensive air showers: the total signal at the surface, GeV muons in the periphery of the showers and TeV muons in the deep array of IceCube. The spectrum is measured with high resolution from the knee to the ankle with IceTop. Composition and spectrum are extracted from events seen in coincidence by the surface array and the deep array of IceCube. The muon lateral distribution at the surface is obtained from the data and used to provide a measurement of the muon density at 600 meters from the shower core up to 30 PeV. Results will be compared to measurements from other experiments to obtain an overview of the spectrum and composition over an extended range of energy. Consistency of the surface muon measurements with hadronic interaction models and with measurements at higher energy will be discussed.

New Technologies and Next generation of Experiments / 11

Radio Detection of Cosmic Ray Air Showers

Author: Frank Schröder[1]

[1] *Karlsruhe Institute of Technology (KIT)*

Corresponding Author: frank.schroeder@kit.edu

Radio measurements yield calorimetric information on the electromagnetic shower component around the clock. However, until recently it was not clear whether radio measurements can compete in accuracy with established night-time techniques like air-Cherenkov or fluorescence detection. Due to recent progress in the radio technique as well as in the understanding of the emission mechanisms, the performance of current radio experiments has significantly improved. Above 100 PeV, digital, state-of-the-art antenna arrays achieve a reconstruction accuracy for the energy similar to that of other techniques, and can provide an independent measurement of the absolute energy scale. Furthermore, radio measurements are sensitive to the mass-composition of the primary particles: First, the position of the shower maximum can be reconstructed from the radio signal. Second, in combination with muon detectors the measurement of the electromagnetic component provides complementary information on the primary mass. Since the radio footprint is huge for inclined showers, and the radio signal does not suffer absorption, future radio arrays either focus on inclined showers at the highest energy, or on ultra-high precision measurements with extremely dense arrays. This talk reviews the current status of radio experiments and simulations as well as future plans.

Interplay between LHC and UHECR physics / 35

Recent Results from NA61/SHINE

Author: Michael Unger[1]

[1] *NYU&KIT*

Corresponding Author: michael.unger@nyu.edu

The interpretation of extensive air shower measurements, produced by ultra-high energy cosmic rays, relies on the correct modelling of the hadron-air interactions that occur during the shower development. The majority of hadronic particles is produced at equivalent beam energies below the TeV range. NA61/SHINE is a fixed target experiment using secondary beams produced at CERN using the SPS. Hadron-hadron interactions have been recorded at beam momenta between 13 and 350 GeV/c with a wide-acceptance spectrometer. In this talk we present measurements of the identified secondary hadron spectra and the resonance production from pion-carbon interactions, which are essential for modelling air showers. Moreover, we will show results from p+C and p+p interactions.

Cosmic Ray and Astrophysical Neutrino Detection / 9

Recent Results from the Telescope Array Project

Author: William Hanlon[1]

[1] *University of Utah, Department of Physics and Astronomy and High Energy Astrophysics Institute*

Corresponding Author: whanlon@cosmic.utah.edu

The Telescope Array Project (TA) is the largest cosmic ray observatory in the northern hemisphere and has entered its eighth year of data collection exploring astrophysical phenomena at the highest ends of the cosmic ray energy spectrum. New additions to TA have expanded its reach down to lower parts of the energy spectrum thus allowing it to probe over an unprecedented 4.5 decades of energy via hybrid detection techniques. Recent results suggestive of anisotropy in the arrival direction of cosmic rays will be presented as well updated measurements of the spectrum, primary source composition, and a new measurement of the inelastic proton-air cross section.

Cosmic Ray and Astrophysical Neutrino Detection / **16**

Results and Perspectives of the Tunka Experiments for Cosmic Ray Study.

Author: Vasily Prosin[1]

[1] *Skobeltsyn Institute of Nuclear Physics of Lomonosov Moscow State University*

Corresponding Author: v-prosin@yandex.ru

The experimental data of Tunka-133 obtained during 5 years of observation and preliminary data from the Tunka-HiSCORE prototype array with its first 9 stations allowed a study of primary cosmic rays in the wide energy range 3x10^14 – 10^18 eV.
Reconstruction of the depth-of-shower maximum Xmax by an analysis of the Cherenkov light lateral distribution and the pulse width provides a reliable estimation of the energy dependence of the mean logarithmic mass in the energy range 10^16 – 10^18 eV.
Further mass composition analyses at the knee energy range will be based on the data of the new version of the Tunka-HiSCORE prototype, consisting of 28 stations. The mass composition analysis at the highest energies (10^17 – 10^18 eV) will be based on the comparison of the primary energy measured by the radio method with the flux of charged particles on ground. The high duty cycle of the common operation of the new scintillation array (Tunka-Grande) and the radio extension of the experiment (Tunka-Rex) will provide a high statistics of events.

Interplay between LHC and UHECR physics / **5**

Results and perspectives of forward physics in ATLAS

Author: Benedetto Giacobbe[1]

[1] *BO*

Corresponding Author: benedetto.giacobbe@bo.infn.it

A review of the results of the ATLAS forward physics program will be given. This includes a complete set of proton-proton cross section measurements at $\sqrt{s} = 7TeV$, diffractive physics studies using rapidity gaps, forward jet production and energy flow as a function of pseudorapidity. The ATLAS future perspectives will also be discussed, focused on the phase 1 upgrade project AFP, underlying its complementarity with the existing ALFA detector in terms of acceptance for diffractive processes, and its potential for a wide forward physics program both at low and high luminosity.

Cosmic Ray and Astrophysical Neutrino Detection / **34**

Results from the PAMELA Experiment after nine years of cosmic ray investigation.

Author: Francesco Saverio Cafagna[1]

[1] *BA*

Corresponding Author: francesco.cafagna@ba.infn.it

PAMELA is taking date in Space since nine years, heralding a new era in precision cosmic ray physics. The measurements of both particle and antiparticle components of cosmic rays, is providing interesting information concerning the origin and propagation of both galactic and solar cosmic rays.
The measured antiparticle component shows features that can be interpreted in terms of dark matter annihilation or pulsar contribution. The precise measurements of the energy spectra of protons, helium and light nuclei, electrons, as well as of their arrival distribution challenges our basic vision of the mechanisms of production, acceleration and propagation of cosmic rays.
Moreover, PAMELA measurements of the energy spectra during solar energetic particle events, fills the existing energy gap between the highest energy particles measured in space and the ground-based domain. Furthermore, providing pitch angle measurements, it allows the study of the effects of particle transport within interplanetary space over a broad range in energy. Besides, by sampling the particle radiation in different regions of the magnetosphere, PAMELA data provide a detailed study of the Earth's magnetosphere. This contribution reviews the most recent scientific results obtained by the PAMELA experiment.

Gamma Rays Detection / **26**

Results of the ARGO-YBJ experiment in detection of gamma rays

Author: Tristano Di Girolamo[1]

[1] *Università "Federico II" and INFN, Napoli*

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 a selection of results in gamma ray astronomy will be presented, including those from the study of the diffuse emission from the Galactic plane.

Gamma Rays Detection / **22**

Seven years of gamma-ray astrophysics with the Fermi LAT

Author: Francesco Loparco[1]

[1] *BA*

Corresponding Author: francesco.loparco@ba.infn.it

The Fermi Gamma-ray Space Telescope was launched into Earth orbit in June 2008. The Large Area Telescope (LAT) is the main instrument onboard the Fermi satellite and is designed to be sensitive to gamma rays in the energy range from about 20 MeV up to more than 300 GeV. During its first seven years of operation, the LAT has provided an increasingly detailed portrait of the Universe's most extraordinary phenomena. In this talk some of the main results obtained by LAT in the field of gamma-ray astrophysics will be reviewed.

Interplay between LHC and UHECR physics / 13

Stability of the electoroweak vacuum (Universe) and Cosmic Rays

Author: Vincenzo Branchina[1]

[1] *CT*

Corresponding Author: vincenzo.branchina@ct.infn.it

The analysis of the stability condition of the electroweak vacuum (and then of our Universe as a whole) is of the greatest importance for our understanding of physics beyond the Standard Model. The possibility that cosmic rays could destabilize the present state of our Universe, and that the cosmic ray induced vacuum decay could be faster than the spontaneous decay has been investigated in the past. It has been recently shown that, contrary to previous expectations, new physics that live at very high energy scales can have a great impact on the stability condition of the Universe. The role of cosmic rays on the stability issue will be considered in the light of these recent results.

Cosmic Ray and Astrophysical Neutrino Detection / 17

Study of charged cosmic rays with the Fermi Large Area Telescope

Author: Carmelo Sgro'[1]

[1] *PI*

Corresponding Author: carmelo.sgro@pi.infn.it

The Fermi Large Area Telescope (LAT) is a space-based observatory conceived to study high-energy gamma rays, but also capable to detect charged cosmic-ray electrons and positrons.It is operating in low Earth orbit since June 2008 and thanks to its large acceptance, has collected the largest high-energy cosmic-ray electron sample to date, with more than 10k events above 1 TeV. The new Pass 8 event-level analysis, recently released by the Fermi-LAT Collaboration, provides several improvements, from the instrument simulation to the reconstruction algorithms, and opens new opportunity for cosmic-ray studies. In this talk we describe the instrument capabilities as a cosmic-ray detector and review its previous results. Recent new measurements and future prospects will also be discussed.

Cosmic Ray and Astrophysical Neutrino Detection / 21

Summary of the KASCADE-Grande experiment results

Author: Andrea Chiavassa[1]

[1] *Universita' degli Studi di Torino*

The KASCADE-Grande experiment operated since 2003 to 2012 measuring cosmic rays in the 10^16-10^18 eV energy range.
In this talk I will show and discuss the main results obtained in the study of the primary spectrum

(that cannot be described by a single power law in this energy range), chemical composition (a steepening of the haevy component spectrum and a hardening of the light one have been detected) and large scale anistropies.
I will also show the more recent analysis performed on the muonic EAS component and on the search for gamma rays geneerated events.
We will show that the spectral features detected in the primary spectrum do not depend on the hadronic interaction models used in the EAS simulations to calibrate the experiment.

Cosmic Ray: Theoretical Implication / **24**

Surprises from extra galactic propagation of UHECRs

Authors: Armando Di Matteo[1] ; Aurelio Grillo[2]

[1] *INFN L'Aquila*

[2] *LNGS INFN*

Corresponding Author: armando.dimatteo@aquila.infn.it

Ultra High Energy Cosmic Rays experimental data are now of very good statistical significance even in the region of the expected GZK feature. The identification of their sources requires sophisticate analysis of their propagation in the extra galactic space. When looking at the details of this propagation some unforeseen features emerge. I will discuss some of these "surprises".

New Technologies and Next generation of Experiments / **2**

Tau Now

Author: Daniele Fargion[1]

[1] *ROMA1*

Corresponding Author: daniele.fargion@roma1.infn.it

PeV neutrino has been found in ICECUBE. The mixing along galactic distance guarantee the presence of PeV Tau neutrinos among astrophysical signals, whose direct detection is subject of deep research since a decade at different UHECR experiments , mostly at EeV energies; these UHE tau neutrino while skimming the Earth (Horizontal Tau airshowers) may shower upward to the sky.
The EeV tau neutrino are a guaranteed signal if UHECR are nucleons: But if they are mostly nuclei the expected signals is at PeVs. Therefore, kwowing their angular distribution and rate, we propose here a novel detection signature that has not been yet considered. The signal, may be already recorded in AUGER and TA records.

Summary:

Tau airshower are a guaranteed corollary of PeVs neutrino astronomy. We show here that after of a decade of unsuccesfull research the Tau Airshower signal is at hand, now.

New Technologies and Next generation of Experiments / **38**

Telescope Array Extension

Author: Hiroyuki Sagawa[1]

[1] *Institute for Cosmic Ray Research, the University of Tokyo*

Corresponding Author: hsagawa@icrr.u-tokyo.ac.jp

The Telescope Array (TA) has an array of surface detectors (SD) 700 km^2 in area and three fluorescence telescope stations (FD) to explore the origin of ultra-high-energy cosmic rays.
We found evidence for the hotspot of arrival directions of the highest-energy cosmic rays above 5.7x10^19 eV, of which size is about 20 degrees in radius. To confirm what the origin of the hotspot is, we proposed to quadruple the TA. This proposal is called TAx4.
From 10^15.6 eV to 10^18 eV, we expect the transition from galactic cosmic rays to extra-galactic cosmic rays. We constructed the TALE (TA Low-Energy extension) FD fully and the TALE SD partially. Since we found two breaks at 10^16.3 eV and 10^17.3 eV with the TALE FD, we proposed to construct remaining TALE SD to improve the resolution of the shower maximum depth measured with the TALE FD for composition identification. This proposal is called the TALE SD.
In the spring of this year, both TAx4 SD and TALE SD were approved by a Japanese funding agency. Here we present the status of these projects.

New Technologies and Next generation of Experiments / 28

The Cherenkov Telescope Array

Author: Ciro Bigongiari[1]

[1] *TO*

Corresponding Author: ciro.bigongiari@to.infn.it

The Cherenkov Telescope Array (CTA) is planned to be the next generation ground based observatory for very high energy (VHE) gamma-ray astronomy. It will provide a full sky-coverage by featuring an array of imaging atmospheric Cherenkov telescopes both in the northern and southern hemispheres.
Sites close to Cerro Paranal (Chile) and on La Palma (Spain) have been recently chosen for final negotiations to host southern and northern array respectively.The southern array will be composed by telescopes of three different sizes to detect gamma rays with energies between 20 GeV and more than 100 TeV while the northern one will comprise only large and medium size telescopes with a significant sensitivity up to 50 TeV.
Such arrangement as well as many technical improvements will provide an order of magnitude enhanced flux sensitivity and a substantially better angular and energy resolution compared tocurrent generation of Cherenkov telescope arrays.In this presentation I will provide an overview of the technical design and summarize the current
status of the project before discussing CTA prospects for some key science topics like the origin of relativistic cosmic particles and the acceleration mechanisms in extreme environments such as neutron
stars and black holes.

New Technologies and Next generation of Experiments / 36

The DAMPE mission

Author: Giovanni Ambrosi[1]

[1] *PG*

Corresponding Author: giovanni.ambrosi@pg.infn.it

The DAMPE experiment (DArk Matter Particle Explorer) is one of the five satellite missions in the frame- work of the Strategic Pioneer Research Program in Space Science of the Chinese Academy of

Science (CAS). DAMPE is a powerful space telescope which has as main scientific objective the identification of possible Dark Matter signatures thanks to the capability to detect electrons and photons in a wide range of energy from 5 GeV up to 10 TeV and with unprecedented energy resolution. Moreover, the DAMPE satellite will contribute to a better understanding of the origin and propagation mechanisms of high energy cosmic rays thanks to the measurement of the flux of nuclei up to 100 TeV. Hints in the sector of high energy gamma astronomy are also expected thanks to its excellent photon detection capability.
The detector is currently undergoing the final integration and acceptance tests and being prepared for the launch scheduled in December 2015.
The status of the detector and its performance as measured with beam test will be discussed.

Gamma Rays Detection / **15**

The High Altitude Water Cherenkov (HAWC) Observatory

Author: Wayne Springer[1]

[1] *University of Utah*

Corresponding Author: wayne.springer@utah.edu

HAWC is a continuously operated, wide field of view detector comprised of three hundred 200,000 liter water Cherenkov detectors, each instrumented with four photomultipliers providing charge and timing information. HAWC covers approximately ~22,000 m2 at an altitude of 4100m and reliably estimates the energy and arrival direction of gamma and cosmic rays with significant sensitivity over energies from several hundred GeV to several hundred TeV. With an instantaneous field of view of 2 steradians, HAWC observes 2/3 of the sky in 24 hours. HAWC has been optimized to study transient and steady emission from both galactic and extragalactic sources of gamma rays and serves as a survey instrument for multi-wavelength studies. HAWC has significant discovery potential, including the possibility of indirect detection of dark matter through the observation of gamma rays produced via dark-matter particle annihilation. Given the large number of cosmic-ray events observed, measurements of the cosmic ray flux are also performed. HAWC has been making observations since summer 2012 and officially commenced data-taking operations with the completed detector on March 20, 2015. A discussion of the detector design, science capabilities, current status, and first results will be presented.

New Technologies and Next generation of Experiments / **20**

The High Energy cosmic-Radiation Detection (HERD) Facility onboard China's Future Space Station

Author: ming xu[1]

[1] *Institute of High Energy Physics, Chinese Academy of Sciences / ISDC, University of Geneva*

Corresponding Author: mingxu@ihep.ac.cn

The High Energy cosmic-Radiation Detection (HERD) facility is one of several space astronomy payloads onboard China's Space Station, which is planned for operation starting around 2020. It is designed as a next generation space facility focused on indirect dark matter search, precise cosmic ray spectrum and composition measurements up to the knee energy, and high energy gamma-ray monitoring and survey. HERD is composed of a calorimeter (CALO) surrounded by microstrip silicon trackers (STKs) from five sides except the bottom. CALO is made of about 10^4 cubes of LYSO crystals, corresponding to 55 radiation lengths and 3 nuclear interaction lengths, respectively. Mont Carlo simulation shows that electrons and photons with a high energy resolution (~ 1% for electrons and photons and 20% for nuclei) and a large effective geometry factor (> 3 m2sr for electrons and diffuse photons and > 2 m2sr for nuclei) can be achieved under this design. Moreover, R&D is under

way for reading out the LYSO signals with optical fiber coupled to image intensified CCD and the prototype of 1/40 CALO for beam test at CERN.

New Technologies and Next generation of Experiments / 33

The JEM-EUSO mission status and pathfinder results

Author: Francesco Saverio Cafagna[1]

[1] *BA*

Corresponding Author: francesco.cafagna@ba.infn.it

The JEM-EUSO mission, on board of the International Space Station (ISS), has the primary objective of doing astrophysics detecting extreme energy cosmic rays (EECRs), above 3x10^19eV. This Extreme Universe Space Observatory (EUSO), will be the first space mission to be devoted to the study of this energy range with the aim of extending the knowledge on sources, spectra and composition of cosmic rays in this energy range.
The instrument has been designed to detect the UV photons emitted in the shower produced by the EECR interaction with the atmosphere and reconstruct its arrival direction and energy.
To validate this technique, three pathfinders and one precursor has been approved. EUSO-Balloon, flew on board of a stratospheric balloon, in collaboration with the French Space Agency CNES. EUSO-TA, is taking data on ground at the Telescope Array experiment site in Utah, US. Mini-EUSO, approved by the Russian Space Agency, will be installed in the ISS. K-EUSO, a modification of the KLYPVE experiment, will be attached at the Russian module of the ISS.
The tatus of the mission and precursors will be reviewed and details will be given on the EUSO-BALLOON and EUSO-TA results.

New Technologies and Next generation of Experiments / 29

The LHAASO project: from Gamma-Ray Astronomy to Cosmic Rays.

Author: Giuseppe Di Sciascio[1]

[1] *ROMA2*

Corresponding Author: giuseppe.disciascio@roma2.infn.it

Despite large progresses in building new detectors and in the analysis techniques, the key questions concerning the origin, acceleration and propagation of Galactic Cosmic Rays are still open. A number of new extensive air showers arrays is in progress.
The most ambitious and sensitive project between them is LHAASO, a new generation multi-component experiment to be installed at very high altitude in China (Daocheng, Sichuan province, 4400 m a.s.l.).
The experiment will face the open problems through a combined study of photon- and charged particle-induced extensive air showers in the wide energy range 10^{11} - 10^{18} eV.
In this talk the status of the experiment will be summarized, the science program presented and the outlook discussed in comparison with leading new projects.

New Technologies and Next generation of Experiments / 25

The Pierre Auger Observatory Upgrade Program

Author: Claudio Di Giulio[1]

Co-author: Observatorio Pierre Auger Pierre Auger Collaboration [2]

[1] *ROMA2*

[2] *Malargue, Argentina*

The Pierre Auger Observatory have been taking data since 2004 and with the complete set of detectors since 2008, with an efficiency above 95%, with very low downtime. Our accurancy in the results have had a deep impact on the area of ultra high energy cosmic rays and new questions and open challenges call for an upgrade of the Observatory.
The planned detector upgrade is presented and the expected performance and improved physics sensitivity of the upgraded Auger Observatory are discussed.

Cosmic Ray: Theoretical Implication / **7**

The energy interval above the ankle where the cosmic radiation consists only of ultraheavy nuclei from Zinc to the actinides

Author: antonio codino[1]

[1] *university of Perugia and INFN*

Corresponding Author: antonio.codino@pg.infn.it

According to recent measurements the tendency of the chemical composition above the ankle is characterized by increasing fractions of intermediate and heavy nuclei and a dominance of light nuclei around the ankle featured by a minimum of the log(A) profile. Calculations of the chemical composition in the range 3.5x10**18-5x10**19 eV according to new principles are reported and compared with the experimental data. The calculation outcomes explain both the rising tendency and the minimum of log(A). The estimate is prolonged to the adjacent interval 5x10**19-10**21 eV using the same theoretical background and some features of the cosmic-ray spectrum at the maximum observed energies. It results that above the energy of 6.7x10**20 eV the cosmic radiation consists only of nuclei heavier than Zinc with a rate of (1-5)x10**-34 particles/m2 s sr GeV. The support of the data on this last estimate is debated.

Interplay between LHC and UHECR physics / **39**

Ultra High energy Cosmic Rays Propagation and the Production of Secondary Cosmogenic Particles

Author: Roberto Aloisio[1]

[1] *GSSI*

The main experimental evidences of UHECR will be reviewed with a particular emphasis on the propagation of these extremely energetic particles and the subsequent production of secondary cosmogenic neutrinos and gamma rays. The cross analysis of the observations of different messengers is of paramount importance in the study of UHECR, principally to determine the physical conditions associated to astrophysical sources. The final part of the talk will be devoted to the discussion of exotic (top-down) models for the origin of UHECR, models that recently have been reconsidered linking the physics of UHECR with cosmological observations.

Cosmic Ray: Theoretical Implication / 40

Ultra-high energy cosmic ray physics in the post-LHC era

Author: Ralf Ulrich[1]

[1] *KIT*

Corresponding Author: ralf.ulrich@kit.edu

With the LHC basically reaching its design beam energy the measurements most relevant for the cosmic ray community are becoming available. First data do not indicate major difficulties within the existing interaction models. An eventual new generation of updated models to describe LHC data at 13TeV will further lower the model discrepancies at ultra-high energies. The cosmic ray community has to face two facts: firstly, there will be no further accelerator data at higher center-of-mass energies over a long time scale, secondly, there are still significant uncertainties in the modelling of air-showers originating from phase-space regions so far not explored sufficiently. There should be made all possible efforts to address the latter point with dedicated forward-data from LHC, with fixed target experiments at LHC, and with light-nuclei collisions in the LHC.

Interplay between LHC and UHECR physics / 41

Universality (and its limitations) in cosmic ray shower development

Author: Paolo Lipari[1]

[1] *ROMA1*

In this talk we review the concept of "universality" in the development
of very high energy cosmic rays showers. The main result
is that the distributions of photons and electrons in a shower
have shapes that are essentially determined by the
the stage of shower development (the shower age)
independently from the energy and identity of the primary particle.
The implications of this result for the interpretation of
the observations will be discussed.

Gamma Rays Detection / 23

VERITAS and Cosmic Rays: An Update

Author: Brian Humensky[1]

[1] *Columbia University*

Corresponding Author: humensky@nevis.columbia.edu

VERITAS is a ground-based array of four 12-meter telescopes near Tucson, Arizona and is one of the world's most sensitive detectors of very high energy (VHE, E > 100 GeV) gamma rays. VERITAS has a broad scientific reach that addresses direct studies of cosmic-ray accelerators, the propagation of cosmic rays, and direct measurements of cosmic-ray spectra. Recent results include deep studies of the Galactic supernova remnants Tycho, Cassiopeia A, and IC 443, the search for gamma-ray emission associated with astrophysical neutrinos detected by IceCube, and a new measurement of the spectrum of cosmic-ray electrons. In this presentation, we will summarize the current status of the VERITAS observatory and present these and other recent results from VERITAS.