Cosmic Ray Anisotropy Workshop 2011

Report of Contributions

https://events.icecube.wisc.edu/e/39

Contribution ID: **0** Type: **not specified**

Interaction of the solar wind with the interstellar medium: structure and implications for galactic cosmic rays

Saturday, 29 October 2011 10:00 (20 minutes)

The solar wind interacts with the local interstellar medium via both ionized and neutral gases. The primary coupling mechanism, charge exchange between protons and interstellar hydrogen, plays a critical role in determining the local structure, as does the interstellar magnetic field. We will describe the basic physical processes underlying the interaction between the solar wind and local interstellar medium, discuss the overall structure itself, with particular emphasis on magnetic structures in the inner heliosheath, the heliotail, and associated turbulence. We will also illustrate how IBEX measurements yield an estimate of the strength and orientation of the local interstellar magnetic field. Finally, we will illustrate the effect of heliospheric boundaries and structure on the entrance of galactic cosmic rays into the heliosphere.

Primary author: Prof. ZANK, Gary (University of Alabama in Huntsville)

Presenter: Prof. ZANK, Gary (University of Alabama in Huntsville)

Session Classification: Leptonic CR anisotropy, propagation models, and ISM

Contribution ID: **1** Type: **not specified**

Angular distribution of energetic particles scattered by strongly anisotropic MHD turbulence: understanding Milagro/IceCube results

Friday, 28 October 2011 11:50 (20 minutes)

Both the acceleration of cosmic rays (CR) in supernova remnant shocks
and their subsequent propagation through the random magnetic field
of the Galaxy deem to result in an almost isotropic CR spectrum. Yet
the MILAGRO TeV observatory and the IceCube discovered sharp
(~10 deg)
arrival anisotropies of CR nuclei. We suggest a mechanism for producing
such a CR beam which operates en route to the observer. The key assumption
is that CRs are scattered by a strongly anisotropic Alfven wave spectrum
formed by the turbulent cascade across the local field direction.
The strongest pitch-angle scattering occurs for particles moving almost
precisely along the field line. Partly because this direction is also
the direction of minimum of the large scale CR angular distribution,
the enhanced scattering results in a weak but narrow particle excess.
The width, the fractional excess and the maximum momentum of the beam
are calculated from a systematic transport theory depending on a single
scale l which can be associated with the longest Alfven wave,
efficiently
scattering the beam. The best match to all the three characteristics
of the beam is achieved at l~1 pc. The distance to a possible
source of the beam is estimated to be within a few 100pc. Possible
approaches to determination of the scale l from the characteristics
of the source are discussed. The beam related
large scale anisotropic CR component is found to be energy independent
which is also consistent with the observations. The beam splitting
mechanism to explain the combined Milagro and IceCube observations is
suggested.

Presenter: Dr MALKOV, Mikhail (University of California, San Diego)

Session Classification: Models and implications of CR anisotropy

Contribution ID: **2** Type: **not specified**

Cosmic Ray Anisotropy at TeV energies with ARGO-YBJ

Friday, 28 October 2011 10:00 (20 minutes)

The ARGO-YBJ experiment, located at the Yangbajing Cosmic Ray Laboratory (Tibet, 4300 m asl, 606 g/cm2), is an EAS-array exploiting the full coverage approach at high altitude. We analyzed the data taken since November 2007 looking for anisotropies in the arrival directions of cosmic rays on different angular scales. The results of the analysis are reported and compared with other experiments.

Primary authors: Prof. DI SCIASCIO, Giuseppe (INFN, Roma 2); IUPPA, Roberto (INFN, Roma 2)

Presenter: IUPPA, Roberto (INFN, Roma 2)

Session Classification: Anisotropy measurements

Contribution ID: **3** Type: **not specified**

TeV and PeV CR anisotropy as observed with IceCube and IceTop

Friday, 28 October 2011 10:30 (20 minutes)

The IceCube Neutrino Observatory, located at the geographic South Pole, employs a km³ of Antarctic ice as a particle detector to search for sources of astrophysical neutrinos across the southern sky. The high rate of CR events in the detector has allowed to search for anisotropy in this data sample at the per-mille level. I'll report on the observation of CR anisotropy in the 20 TeV to 1 PeV range observed across a wide range of angular scales.
The IceTop air shower array, sitting on top of the IceCube detector on the ice surface, has also observed an anisotropy in the PeV range that is compatible with that observed with the in-ice detector.

Presenter: SANTANDER, Marcos (University of Wisconsin-Madison)

Session Classification: Anisotropy measurements

Contribution ID: **4** Type: **not specified**

Features in cosmic-ray elemental spectra

Saturday, 29 October 2011 11:00 (20 minutes)

Additional information: http://iopscience.iop.org/2041-8205/714/1/L89/

Presenter: Prof. SEO, Eun-Suk (University of Maryland)

Session Classification: CR spectral features and anisotropy

Contribution ID: **5** Type: **not specified**

The small-scale anisotropy of the cosmic radiation: results from Milagro

Friday, 28 October 2011 09:00 (20 minutes)

The presence of a large-scale anisotropy in the cosmic radiation has been known for several decades. Earlier experiments lacked the statistical power to observe small-scale anisotropies in the cosmic radiation and there were good reasons to expect that on small scales the cosmic radiation would be smooth. The Milagro extensive air shower array discovered the presence of at least two small (of order 5-10 degrees) regions with significant excess (with respect to the expectations from the large-scale anisotropy) in the cosmic radiation near 10 TeV. The observed fractional excess is roughly 5x10^{-4} - about one order of magnitude smaller than the large-scale anisotropy. Because the Larmor radius of a 10 TeV proton is 0.005 pc explanations of these observations are difficult, however they seem to imply a relatively nearby source and non-standard diffusion of cosmic rays in the solar neighborhood. In this talk I will discuss the results from Milagro and several potential explanations of these observations.

Presenter: Dr PRETZ, John (LANL)

Session Classification: Anisotropy measurements

Contribution ID: **6** Type: **not specified**

Cosmic-Ray Measurements with the PAMELA Experiment

Saturday, 29 October 2011 11:30 (20 minutes)

After five years of data taking in space, the PAMELA experiment has presented new results on the energy spectra of protons, helium nuclei, electrons and positrons that might change our current understanding of the mechanisms of production, acceleration and propagation of cosmic rays in the Galaxy. In addition, PAMELA measurements of cosmic antiproton and positron fluxes are setting strong constraints to the nature of Dark Matter. PAMELA is also searching for primordial antinuclei (anti-helium) and studying the acceleration and propagation models through precision studies of light nuclei and their isotopes. This talk illustrates the most recent scientific results obtained by the PAMELA experiment.

Presenter: Dr BOEZIO, Mirko (INFN Trieste)

Session Classification: CR spectral features and anisotropy

Contribution ID: **7** Type: **not specified**

The cosmic ray anisotropy measured by the ARGO-YBJ experiment and the status of the LHASSO project

Friday, 28 October 2011 09:30 (20 minutes)

The ARGO-YBJ experiment is located at Yang Ba Jing (P.R. China), at 4300 m a.s.l. and atmospheric depth of 606 g/cm^2. It is an air shower detector array with a fully covered layer of Resistive Plate Chambers. It is designed to detect EAS in the primary energy range between few hundred GeV and a few PeV. It has been continuously operated with a duty cycle above 86% since November 2007 observing about 4x10^11 air showers. With such unprecedented statistics, it is very suitable for the study of anisotropy. Here we will report its result for cosmic ray anisotropy.
The LHASSO project is designed for greatly boost the capability of current YBJ observatory with a large complex air shower detector array in an area of 1km^2. Hybrid detection with multi-techniques will allow a good discrimination between different types of primary particles. Here we will report its status and future capabilities for the anisotropy studies.

Presenter: Dr CHEN, Songzhan (Institute of High Energy Physics (IHEP))

Session Classification: Anisotropy measurements

Contribution ID: **8** Type: **not specified**

TeV Cosmic-ray Anisotropy and Tibet Air shower Array

The talk will focus focuses on the measurement and analysis of the cosmic ray anisotropy obtained by Tibet air shower array.

Presenter: Dr YI, Zhang (Institute of High Energy Physics (IHEP))

Contribution ID: **10** Type: **not specified**

A measurement of the cosmic ray anisotropy at and above 10^14 eV

Friday, 28 October 2011 15:00 (20 minutes)

The EAS-TOP Extensive Air Shower array was located at Campo Imperatore (2005 m a.s.l., latitude 42◦27N, longitude 13◦34E, INFN Gran Sasso National Laboratory). It took cosmic ray data in the energy range 10^13 eV-10^16 eV from the end of 1980s up to 2000. A first data-set (including 4 years of data) was exploited for the measurement of the cosmic ray anisotropy at E≈10^14 eV (Ap. J. 470, 1996, 501). At this energy, the EAS-TOP results demonstrated that the main features of the anisotropy (i.e., of cosmic-ray propagation) are similar to those measured at lower energies (10^11–10^14 eV), both with respect to amplitude ((3–6) ~ 10^−4) and phase ((0–4) hr local sidereal time (LST)). Thanks to the final data-set (spanning over 8 years) the EAS-TOP measurement could be extended to higher energy, about 4x10^14 eV. The observed anisotropy shows an amplitude larger than at 10^14 eV and a different phase (ApjL 692, 2009, 130). Different checks of stability of the detector and consistency of the data are presented. The significance of the observation for the understanding of cosmic-ray propagation is discussed.

Presenter: Dr GHIA, Piera Luisa (LPNHE (CNRS))

Session Classification: Anisotropy measurements and methods

Contribution ID: **11** Type: **not specified**

The Anisotropy of TeV Cosmic Rays: an interpretation

Saturday, 29 October 2011 17:00 (15 minutes)

The history of anisotropy measurements has a long history and some attempts at interpretations have already been made.
The early measurements are important in view of giving a check on the validity of the contemporary exciting measurements. So far they seem to confirm and complement them, at least for the large scale anisotropies.
The small scale anisotropies, forming 'striations' perpendicular to the Ecliptic Plane, pose a challenge and may indicate new features of the Local Interstellar Medium.
An attempt will be made to give an explanation of the features and predictions will be given as to what to expect next.

Primary authors: Prof. ERLYKIN, Anatoliy (Lebedev Institute, Moscow, Russia); Prof. WOLFENDALE, Arnold (Durham University)

Presenter: Dr ABBASI, Rasha (University of Wisconsin-Madison)

Session Classification: Heliosphere and Local ISM II

Contribution ID: **12** Type: **not specified**

Searches for Cosmic Ray Electron Anisotropies with the Fermi Large Area Telescope

Saturday, 29 October 2011 09:00 (20 minutes)

The Large Area Telescope on board the Fermi satellite detected more than 1.6 million cosmic-ray electrons/positrons with energies above 60 GeV during its first year of operation. The arrival directions of these events were searched for anisotropies of angular scales from ~10deg up to 90deg, and of minimum energy extending from 60GeV up to 480GeV. Two independent techniques were used to search for anisotropies, both resulting in no detections. Upper limits on the anisotropy level for different energy ranges and angular scales were set. The analysis methods and the implications of the upper limits on the existence of nearby CRE sources and on some classes of dark matter models will be discussed.

Presenter: Dr VASILEIOU, Vlasios (Laboratoire Univers et Particules de Montpellier)

Session Classification: Leptonic CR anisotropy, propagation models, and ISM

Contribution ID: **13** Type: **not specified**

Solar Wind Interaction with the Local Interstellar Medium: Heliosheath and Heliotail Flows

Saturday, 29 October 2011 16:00 (20 minutes)

The Sun moves through the local interstellar medium (LISM) ejecting charged particles with velocities that eventually become greater
than the fast magnetosonic velocity. A surface separating the LISM material from the solar wind (SW) plasma is called
the heliopause. The SW is decelerated by the heliopause creating a heliospheric termination shock. A region of the
SW plasma between the termination shock and the head of the heliopause is called the inner heliosheath (IHS). The LISM plasma is also decelerated by the heliopause creating a so-called outer heliosheath (OHS). The tail of the SW-LISM interaction region can be very long,
extending to a few thousand astronomical units (AU). The LISM being partially ionized (about three times more neutral atoms than ions),
charge exchange plays a major role in the heliospheric structure. I will describe the differences between purely MHD and
MHD-neutral scenarios for different orientations and strengths of the interstellar magnetic field. The constraints on the
LISM properties derived from the Interstellar Boundary Explorer will be discussed. The peculiarities of the SW plasma flow
in the heliotail will be analyzed in the framework of a realistic model that takes into account solar cycle effects.

Presenter: Prof. POGORELOV, Nikolai (University of Alabama in Huntsville)

Session Classification: Heliosphere and Local ISM II

Contribution ID: **14** Type: **not specified**

Cosmic Ray Anisotropies

Saturday, 29 October 2011 12:30 (20 minutes)

I will discuss the role of anisotropy as a tool to discriminate among different scenarios for the origin of Galactic cosmic rays. The main aim of the presentation is that of stressing the need for a unified picture of acceleration, propagation, chemical composition and anisotropy. I will summarize the different contributions to cosmic ray anisotropies and the problems with current observations, especially with anisotropy on small angular scales.

Presenter: Prof. BLASI, Pasquale (INAF/Osservatorio Astrofisico di Arcetri)

Session Classification: CR spectral features and anisotropy

Contribution ID: **15** Type: **not specified**

Large scale distribution of arrival directions of cosmic rays above ~100 PeV

Friday, 28 October 2011 16:40 (20 minutes)

Scrutiny of the large scale distribution of arrival directions of cosmic rays with energies above ~100 PeV is one important observable to provide key elements for understanding the end of Galactic cosmic rays, and for establishing at which energy the flux of extragalactic cosmic rays starts to dominate the cosmic ray energy spectrum. Using the large amount of data collected by the Pierre Auger Observatory, upper limits on the dipole component in the equatorial plane obtained in different energy ranges above ~100 PeV are presented, being below 2% at 99% CL for EeV energies. Even though the measured amplitudes are within the statistical fluctuations, an apparent consistency of the phases in adjacent energy bins is observed and discussed.

Presenter: Dr DELIGNY, Olivier (Institut de Physique Nucléaire Orsay)

Session Classification: Anisotropy measurements and astrophysical models

Contribution ID: **16** Type: **not specified**

Direction of the Interstellar Magnetic Field in the Solar Vicinity

Saturday, 29 October 2011 16:30 (20 minutes)

Similar directions are obtained for the local interstellar magnetic field (ISMF) by comparing diverse data that sample five orders of magnetic in spatial scales. The direction of the ISMF that shapes the heliosphere, and that is traced by the ribbon of energetic neutral atoms discovered by the Interstellar Boundary Explorer (IBEX) mission, is compared to the ISMF direction obtained from linearly polarized light from nearby stars, the ISMF of the Loop I superbubble that has expanded to the solar vicinity, and the ISMF direction towards pulsars within 100-300 pc. Together these data suggest that the local ISMF direction is correlated over spatial scales of about 100 pc, such as would be expected for the interarm region of the galaxy.

Presenter: Dr FRISCH, Priscilla (University of Chicago)

Session Classification: Heliosphere and Local ISM II

Contribution ID: **17** Type: **not specified**

GALPROP Code for Galactic Cosmic Ray Propagation and Associated Photon Emissions

Saturday, 29 October 2011 09:30 (20 minutes)

Research in many areas of modern physics such as, e.g., indirect searches for dark matter and particle acceleration in supernova remnant shocks rely heavily on studies of cosmic rays (CRs) and associated diffuse emissions (radio, microwave, X-rays, gamma rays). The numerical Galactic CR propagation code GALPROP has been shown to reproduce simultaneously observational data of many kinds related to CR origin and propagation. I will report on the latest updates of GALPROP and provide an overview of recent results.

Presenter: Dr MOSKALENKO, Igor (Stanford University)

Session Classification: Leptonic CR anisotropy, propagation models, and ISM

Contribution ID: **18** Type: **not specified**

A brief summary of IBEX observations of the heliospheric interaction

Saturday, 29 October 2011 14:30 (20 minutes)

This talk summarizes the recent observations of the interaction of the heliosphere with the local interstellar medium as observed remotely by the Interstellar Boundary Explorer (IBEX). IBEX observations have shown that the interaction is far more complex and dynamic than previously anticipated and raised many new questions about this important interaction.

Presenter: Dr MCCOMAS, David (Southwest Research Institute)

Session Classification: Heliosphere and Local ISM I

Contribution ID: **19** Type: **not specified**

Dynamics, structure and signatures of the sector region in the outer heliosphere: a turbulent sea of bubbles

Saturday, 29 October 2011 15:00 (20 minutes)

All current global models of the heliosphere are based on the assumption that the magnetic field in the heliosheath connects back to the Sun. In particular, models of transports of galactic cosmic rays (GCR) assume the heliospheric current sheet is laminar as well. The sectored magnetic field due to the flapping of the heliospheric current sheet compresses across the termination shock and may reconnect in the heliosheath, driving the anomalous cosmic rays and producing a sea of elongated magnetic bubbles. These magnetic islands/bubbles will be convected with ambient flows as the sector region is carried to higher latitudes filling the heliosheath. We present a three-dimensional MHD simulation with very high numerical resolution that captures the north-south boundaries of the sector region.
We show that due to the high pressure of interstellar magnetic field a north-south asymmetry develops such that the disordered sectored region fills a large portion of the northern part of the heliosphere with a smaller extension in the southern hemisphere. We present particle-in-cell simulations that capture the development and dynamics of the bubbles. A number of Voyager observations are consistent with the bubble picture of the heliostheath, including flow enhancements, magnetic field compressions, and strongly-altered transport properties. The magnetic field outside the sector will be laminar connecting back to the Sun. We expect then that the diffusive nature will be very different inside vs outside the sector region. Under this new scenario, the heliopause will not be the traditional thought tangential discontinuity separating the heliosphere from the interstellar medium, but more like a porous membrane. A porous heliosphere might allow GCRs to enter more easily into the heliosphere. Once they enter inside the sector region they get trapped in the magnetic bubbles slowly making their way into the heliosphere. If they diffuse into the unipolar region they quickly escape into the heliosphere.

Co-authors: DRAKE, J.F. (University of Maryland); SCHOEFFLER, K (University of Maryland); SWISDAK, M (University of Maryland)

Presenter: Prof. OPHER, Merav (Boston University)

Session Classification: Heliosphere and Local ISM I

Contribution ID: **20** Type: **not specified**

Cosmic ray anisotropy from AMANDAs point of view

Friday, 28 October 2011 14:30 (20 minutes)

The AMANDA detector has been operated at the South Pole until 2006 and recorded a total ~9·10^9 muons above ~1 TeV between 2000 and 2006. With a data set of this size, it is possible to probe the southern sky for per-mil anisotropy on all angular scales in the arrival direction distribution of cosmic rays thereby extending anisotropy measurements performed with IceCube.
The data presented here were collected with the AMANDA MuonDAQ. Great care has been taken to apply proper data selection cuts and to account for temporal instabilities during data taking. We shall describe the analysis including corrections for spatial asymmetries of the detector and for down times of data taking. For each single year we find asymmetries in the distribution of right ascension with amplitudes of about 5x10-4 and phases around 50 degree, well in agreement with earlier results from IceCube. No significant long term variation is found in the data.

Presenter: GURTNER, Maria (University of Wuppertal)

Session Classification: Anisotropy measurements and methods

Contribution ID: **22** Type: **not specified**

The Elemental Composition of Galactic Cosmic Rays

Saturday, 29 October 2011 12:00 (20 minutes)

One of the key observables to understand the origin and the sources of Galactic cosmic rays is their elemental composition. The abundance of elements is measured directly with detectors above the atmosphere on balloons and satellites. At energies exceeding 10^14 eV information on the composition is derived from the observation of extensive air showers. Results of recent measurements will be reviewed and the implications on our current understanding of the origin of Galactic cosmic rays will be discussed.

Presenter: Prof. HÖRANDEL, Jörg (Radboud University Nijmegen)

Session Classification: CR spectral features and anisotropy

Contribution ID: **23** Type: **not specified**

Trying to Understand the Interstellar Transport and Resulting Anisotropies of Galactic Cosmic Rays

Friday, 28 October 2011 12:20 (20 minutes)

The observed interstellar anisotropies of galactic cosmic rays, and their energy dependence, are a major source of information concerning their origin and transport in the galaxy. They also present significant challenges to our understanding. I will discuss possible interpretations of some of the anisotropies in terms of interstellar transport in the interstellar magnetic field and some of the resulting implications for our understanding of interstellar turbulence.

Presenter: Prof. JOKIPII, J.R. (Randy) (University of Arizona)

Session Classification: Models and implications of CR anisotropy

Contribution ID: **24** Type: **not specified**

Anisotropy in the TeV Cosmic Rays: A Challenge for Interpretation

Friday, 28 October 2011 16:00 (15 minutes)

To measure the per-mille anisotropy in the TeV cosmic rays with a ground-based experiment, it is necessary to estimate the exposure of the detector to cosmic ray air showers. The estimate must account for drifts that occur in the detector during the course of the measurement, as well as changes in the shower signal at ground level caused by atmospheric conditions. Due to the difficulty of the exposure calculation, all experiments follow a similar procedure in which the exposure is calculated in small time steps using real events. Using this method, the exposure can be estimated with sufficient accuracy to measure per-mille effects in the data. However, calculating the exposure using the data themselves also introduces significant and surprising artifacts into the resulting sky maps. Using simulated events, we will demonstrate the difficulty of interpreting the cosmic ray anisotropy in light of these artifacts.

Presenter: Dr BENZVI, Segev (University of Wisconsin-Madison)

Session Classification: Anisotropy measurements and methods

Contribution ID: **25** Type: **not specified**

An explanation for the cosmic ray anisotropies at multiple scales

Friday, 28 October 2011 17:10 (20 minutes)

We propose an explanation for the origin of the observed cosmic ray anisotropies at multiple scales. We discuss its implications, and future perspectives.

Presenter: Dr GIACINTI, Gwenael (NTNU Trondheim and APC Paris)

Session Classification: Anisotropy measurements and astrophysical models

Contribution ID: **26** Type: **not specified**

Acceleration of cosmic ray by reconnection in realistically turbulent environments

Friday, 28 October 2011 11:20 (20 minutes)

Magnetic reconnection in realistically turbulent astrophysical environments does not depend on electric conductivity of plasma, but instead is controlled by the degree of turbulent stochasticity of magnetic field lines. Such a reconnection can induce the first order Fermi acceleration of energetic particles. I will show that this acceleration is different in 2D and 3D reconnection with 3D reconnection being more efficient in the particle acceleration. I shall discuss the importance of plasma effect both for magnetic reconnection and for particle acceleration.

Presenter: Prof. LAZARIAN, Alex (UW-)

Session Classification: Models and implications of CR anisotropy

Contribution ID: **27** Type: **not specified**

The origin of the cosmic ray positron/electron excess and beyond

Friday, 28 October 2011 17:40 (20 minutes)

The spectra of cosmic electrons and positrons should have contributions from known sources such as particles accelerated in supernova remnants and from interactions of cosmic and interstellar protons. Any evidence for an additional component, as reported by PAMELA, Fermi and HESS experiments, may carry hints of a new phenomenon. I will examine the implications of the recent detection of extended, multi-TeV gamma-ray emission from Geminga pulsar wind nebula by Milagro experiment, which reveals the existence of an ancient/nearby cosmic ray accelerator that can also plausibly account for all these observations.

Presenter: Dr YUKSEL, Hasan (LANL)

Session Classification: Anisotropy measurements and astrophysical models

Contribution ID: **28** Type: **not specified**

Introduction

Friday, 28 October 2011 08:45 (15 minutes)

Presenter: Dr DESIATI, Paolo (UW-Madison)

Session Classification: Welcome and workshop information

Contribution ID: **29** Type: **not specified**

A needlet-based approach to directional data analysis

Friday, 28 October 2011 15:30 (20 minutes)

EAS array dataset contains signal laying on different angular scales: point-like and extended gamma-ray sources, as well as large and intermediate scale cosmic-ray anisotropies. The separation of all these contributions is crucial, mostly when they overlap with each other.
In recent years, the needlet transform has proved to be an effective tool in the analysis of cosmological and astrophysical data, because of the easiness of implementation and the remarkable double-localization properties (in real and harmonic domain). Nevertheless, it has been never used in cosmic-ray and very high energy gamma-ray physics so far.
Here the results of the application of this technique to the whole ARGO-YBJ dataset are presented, pointing out the advantages of this new approach
with respect to the standard methods of analysis employed in astroparticle physics.

Presenter: IUPPA, Roberto (INFN, Roma 2)

Session Classification: Anisotropy measurements and methods