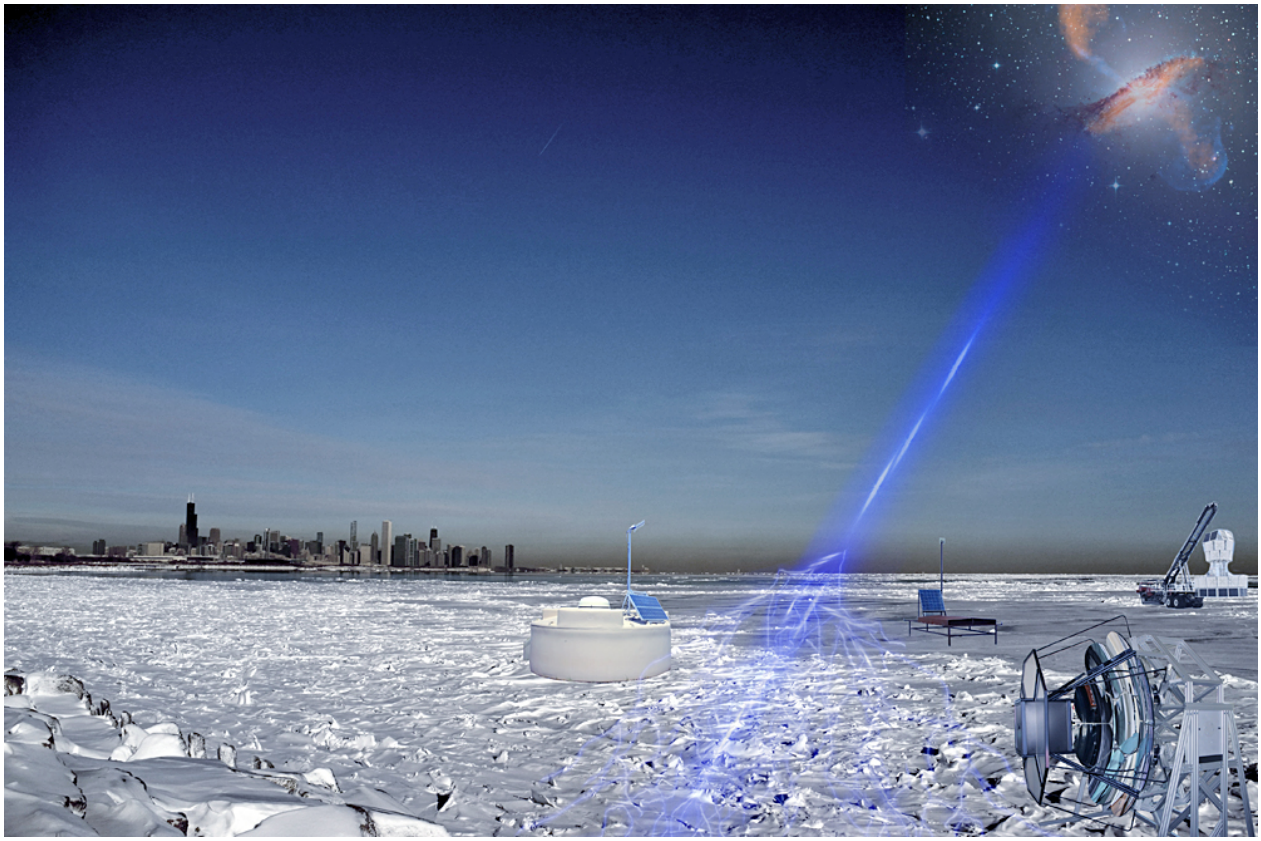

http://kicp-workshops.uchicago.edu/uheap2016/

WORKSHOP PRESENTATIONS

The Kavli Institute for Cosmological Physics at the University of Chicago is hosting a workshop this winter on the Next Generation Techniques for Ultra-High Energy (UHE) Astroparticle Physics. The origin of the most energetic particles in the universe could be related to extremely energetic astronomical phenomena or other exotic processes, such as the decay of the super-heavy dark matter in the halo of our galaxy or topological defects created in an early phase of the development of the universe. In order to clarify their origin, it is essential to develop next-generation techniques for detection of their particles by large amounts of statistics. The workshop will address the road map and near-future prospects of cosmic rays and neutrinos above the PeV scale. Included topics are reviews of the latest results, upcoming detectors and techniques, and related theory topics. The anticipated structure is a series of presentations with ample time for discussion and working sessions.

Organizing Committee

Cosmin Deaconu
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Paolo Privitera
Kavli Institute for Cosmological Physics

Abigail Vieregg
Kavli Institute for Cosmological Physics

Invited Speakers

Markus Ahlers
UW-Madison & WIPAC

Thomas Bretz
RWTH Aachen University

Stijn Buitink
Vrije Universiteit Brussel (VUB)

Mauricio Bustamante
Center for Cosmology and AstroParticle Physics, The Ohio State University

Marco Casolino
RIKEN and INFN

Ke Fang
University of Maryland

Toshihiro Fujii
University of Chicago

Jordan Hanson
The Ohio State University

Kael Hanson
University of Wisconsin - Madison (WIPAC)

Daisuke Ikeda
Institute for Cosmic Ray Research, University of Tokyo

Claudio Kopper
University of Alberta

Thomas Meures
UW-Madison

Pavel Motloch
KICP, U Chicago

Ryan Nichol
UCL

Foteini Oikonomou
Penn State

Carl Pfendner
Ohio State University

Mariangela Settimo
LPNHE-CNRS

Radomir Smida
KIT

Yuichiro Tameda
Kanagawa University

Andrew Taylor
DIAS

Lenka Tomankova
Karlsruhe Institute of Technology (KIT)

Nonaka Toshiyuki
Institute for Cosmic Ray Research , University of Tokyo

Stephanie Wissel
Cal Poly SLO

1. **Markus Ahlers**, UW-Madison & WIPAC
   Invited Talk: Multi-Messenger Aspects of Cosmic Neutrinos

   March 2, 2016 (11:15 AM - 11:45 AM)

   I will discuss the recent observation of TeV to PeV neutrinos by the IceCube Cherenkov telescope in the context of multi-messenger astronomy. The corresponding energy range of hadronic gamma-rays is not directly accessible by extragalactic gamma-ray astronomy due to interactions with cosmic radiation backgrounds. Nevertheless, the isotropic sub-TeV gamma-ray background observed by Fermi-LAT contains indirect information from secondary emission produced in electromagnetic cascades and constrains hadronic emission scenarios. On the other hand, observation of PeV gamma-rays would provide a smoking-gun signal for Galactic emission. Interestingly, the overall energy density of the observed neutrino flux is close to a theoretical limit for neutrino production in the sources of ultra-high energy cosmic rays and might indicate a common origin of these phenomena. I will highlight various multi-messenger relations involving cosmic neutrinos and proposed source scenarios.

2. **Thomas Bretz**, RWTH Aachen University
   Invited Talk: SiPMs for AugerPrime and IceCube Gen2

   February 29, 2016 (4:15 PM - 4:45 PM)

   Co-authors: et al.
   For several years, semi-conductor photo sensors are now investigated in astroparticle physics as photo sensors. Since 2011 the first large scale application outside of a laboratory is in operation with the First G-APD Cherenkov Telescope (FACT). Nowadays, they are not only considered as a reasonable option for the upcoming Cherenkov Telescope Array (CTA) but also for the future upgrades of of the Auger Observatory (AugerPrime) and the the IceCube detector (IceCube Gen2). The goal for AugerPrime is the replacement of classical PMTs in the planned scintillator detectors by the more robust SiPMs. First measurements in the laboratory and in the field have been successful. In addition, a small telescope with refractive optics has been developed for the detection of fluorescence showers. Measurements with a seven pixel prototype were conducted in the field and a 61-pixel version is under construction. For a possible future veto detector for IceCube, it has been modified and a seven pixel prototype is installed at South Pole where it is successfully operated for several weeks. Experiences with SiPMs, measurements and results of all three project will be presented.

3. **Stijn Buitink**, Vrije Universiteit Brussel (VUB)
   Invited Talk: Radio detection of air showers with LOPES and LOFAR

   March 1, 2016 (9:30 AM - 10:00 AM)

   The detection of the radio emission from extended air showers is a promising technique that complements more traditional methods. Like fluorescence detection it can probe the longitudinal development of the air shower, with the advantage that it has a duty cycle of nearly 100%. Over the last decade the radio detection technique has become mature. Several experiments have measured the radio pulse properties and developed methods to reconstruct shower parameters. The emission mechanism is mostly understood and modern simulations are in agreement with all existing measurements. In this talk I focus on two experiments that played a large role in this process. While measurements had already been done in the 1960s and 1970s, LOPES was one of the first experiments that used modern digital techniques in the early 2000s. Over the years, LOPES has demonstrated key aspects of the radio emission properties as well as the ability to perform reconstructions of the cosmic-ray energy, direction and mass. Since a few years, air showers are measured at LOFAR with an incredible antenna density, allowing high-precision measurements of the complicated radio pattern on the ground and the shape of the wavefront. It has been shown that Xmax can be measured with a precision comparable to that of fluorescence detection, allowing cosmic-ray mass composition measurements. In addition, LOFAR is exploring the interaction between cosmic rays and thunderstorms.

4. **Mauricio Bustamante**, Center for Cosmology and AstroParticle Physics, The Ohio State University
   Invited Talk: Flavor composition of high-energy astrophysical neutrinos: present and future

   March 2, 2016 (10:45 AM - 11:15 AM)

   The flavor composition of high-energy astrophysical neutrinos --i.e., the proportion of electron, muon, and tau flavor-- is a rich observable: it can reveal physical conditions present during their production, propagation, and detection. IceCube has recently published the first flavor composition results, between 30 TeV and 2 PeV. I will comment on what we can infer from them. I will also present the region of flavor composition accessible via standard mixing, taking into account uncertainties in neutrino production and mixing parameters. Measurements outside this region would signal new physics at previously unexplored energies. Current and next-generation radio neutrino detectors will probe a new regime of EeV-scale fluxes, cosmogenic and from sources. I will show prospects for measuring flavor in them.

5. **Marco Casolino**, RIKEN and INFN
   Invited Talk: Perspectives and techniques of UHECR observation from space with EUSO detectors

   February 29, 2016 (2:00 PM - 2:30 PM)

   Co-authors: for the JEM-EUSO Collaboration

6. **Ke Fang**, University of Maryland
   Invited Talk: The Giant Radio Array for Neutrino Detection: Present and Perspectives

   March 1, 2016 (3:45 PM - 4:15 PM)

   Co-authors: The GRAND Collaboration
   The Giant Radio Array for Neutrino Detection (GRAND) aims at detecting high-energy neutrinos via the air showers induced by the decay of atmospheric tau leptons produced by the interaction of astrophysical neutrinos under the Earth surface. Consisting of an array of ~10^5 radio antennas deployed over ~ 2x10^5 km^2 , GRAND is objected to reach a sensitivity of 3x10^-11 E^-2 GeV^-1 s^-1 sr^-1 above 3x10^16 eV in 3 years and a sub-degree angular resolution. In this talk we will show some of our preliminary designs and simulation results, and discuss the scientific goals that could be reached with the proposed sensitivity and angular resolution of GRAND.

7. **Toshihiro Fujii**, University of Chicago
   Invited Talk: Next-Generation Observatory: Fluorescence detector Array of Single-pixel Telescopes

   February 29, 2016 (4:45 PM - 5:15 PM)

   Co-authors: for the FAST Collaboration
   We present a concept for large-area, low-cost detection of ultra-high energy cosmic rays (UHECRs) with a Fluorescence detector Array of Single-pixel Telescopes (FAST), addressing the requirements for the next generation of UHECR experiments. In the FAST design, a large field of view is covered by a few pixels at the focal plane of a mirror or Fresnel lens. We report results of a FAST prototype installed at the Telescope Array site and future plans.

8. **Toshihiro Fujii**, University of Chicago
   Talk: Workshop Information

   February 29, 2016 (10:10 AM - 10:15 AM)

9. **Toshihiro Fujii**, University of Chicago
   Talk: Closing Remarks

   March 2, 2016 (11:45 AM - 12:00 PM)

10. **Jordan C Hanson**, The Ohio State University
Invited Talk: A review of UHE neutrino detection using the Askaryan Effect

March 1, 2016 (2:00 PM - 2:30 PM)

Interaction of the highest energy cosmic rays with the cosmic microwave background would produce neutrinos with energies of ~1 EeV. The spectrum of these cosmogenic neutrinos is now being constrained, and a generation of experiments based on the Askaryan effect are underway. We review the creation of high-energy cascades created in dielectric materials by electroweak interactions, and discuss how the Askaryan effect in this situation leads to a radio-frequency electromagnetic pulse. Further, we have studied two corrections to the basic approach: the Landau-Pomeranchuk-Migdal (LPM) effect, and the shower form factor. Both effects modify the electromagnetic pulse, and we present an open-source code that attempts to include these effects. A future direction for this work includes using the form factor technique to model the radio emission from extensive air showers.

11. **Kael D Hanson**, University of Wisconsin - Madison (WIPAC)
Invited Talk: IceCube Gen2: The Next Generation Neutrino Observatory

March 1, 2016 (11:45 AM - 12:15 PM)

The twenty-teens may earn a footnote in astronomy texts to come as the decade where the photon surrendered its absolute reign. In the span of only a few years, neutrinos and now gravitons, separately at two large facilities, have emerged as viable astronomical messengers bringing new vistas to the scientific endeavor to understand distant, highly energetic phenomena, and to the understanding of the nature of the particles themselves. Speaking now only of the neutrinos, IceCube has published results on over 50 high-energy events clearly of extraterrestrial origin. The events offer only hints at the sources underlying their origin and thus the scientific collaboration is planning a future facility which will enable detailed study of the cosmic accelerators by expanding the neutrino effective volume by an order of magnitude. This facility, named IceCube Gen2, will be more than a simple extension of the existing optical array, however. First, to achieve the ambitious gain in performance, the Collaboration recognizes the need for aggressive R&D on optical detection technology. Moreover, co-deployment of an RF antenna array will search for Askaryan radiation from EHE neutrino interactions in the ice thus greatly enhancing Gen2's sensitivity to cosmogenic neutrinos. This talk presents the collaboration plans for this future facility and the research needed now to achieve these goals.

12. **Piotr Homola**, Institute of Nuclear Physics, Polish Academy of Sciences, Krakow
Talk: Brainstorming on a distributed, open and diversified cosmic ray detector

February 29, 2016 (11:45 AM - 12:00 AM)

A further progress in the area of UHE astroparticle physics seems to require, apart from the new technologies, also a novel approach to the organization of scientific efforts and to making the field attractive for the young enthusiasts. In the talk I will present an idea of a world-wide network of diversified cosmic ray detectors integrated within one data base. The performance and development of this network would be defined by a simple set of rules provided by the top experts in the field, to remain as flexible as possible not to suppress the creativity and enthusiasm of the contributors. The network organization, performance, data and other achievements like codes and know-how would be fully open, accessible to anybody. A particular stress should be put on the proper documentation and easy sharing in a common open library of the knowledge and expertise to be acquired by the network participants. This is to avoid discontinuities and losses of expertise when people are leaving the project. Apart from the access to the library of knowledge and expertise a potential contributor would be offered an easily applicable know-how on building or buying a variety of detectors, ranging from the most economic to more sophisticated ones. Also a personal connection to an expert would be available on a volunteer or commercial basis, through the Internet or directly, if possible. The priority goal of the network would be to serve as a world-wide cosmic ray laboratory: the area where enthusiasts, no matter their financial capabilities, can join the field, develop their knowledge and skills and get ready to join the most advanced scientific projects. Making the network global would bring many social profits like reaching talented and creative colleagues from poor countries, easy learning from one another and collaborating together resulting in reduction of inter-cultural and civilization barriers or general large-scale outreach to attract young people to science. Scientific benefits of the proposed network, although not guaranteed, are possible.

13. **Daisuke Ikeda**, Institute for Cosmic Ray Research, University of Tokyo
Invited Talk: Radio detection for the ultra-high energy cosmic rays

March 1, 2016 (10:30 AM - 11:00 AM)

Co-authors: Yamamoto Tokonatsu
For the future huge ultra-high energy cosmic ray observatory, we have carried out R&D projects to search for radar echo and molecular bremsstrahlung from cosmic ray induced extensive air showers. In addition, in order to confirm those techniques, experiments with the electron beam which is generated by the Electron Light Source (ELS) in the TA site were performed. The design of the experiments and results of the observed signals will be discussed.

14. **Claudio Kopper**, University of Alberta
Invited Talk: Recent Results from IceCube

February 29, 2016 (10:15 AM - 10:45 AM)

15. **Thomas Meures**, UW-Madison
Invited Talk: The Askaryan Radio Array - status and future plans

March 1, 2016 (3:00 PM - 3:30 PM)

This presentation includes an overview of the current status of the Askaryan Radio Array as well as ideas for future enhancements.

16. **Pavel Motloch**, KICP, U Chicago
Invited Talk: Properties of transition radiation induced by particle showers

March 1, 2016 (11:15 AM - 11:45 AM)

Co-authors: Jaime Alvarez-Muniz, Paolo Privitera, Enrique Zas
We present a method of calculating transition radiation emitted by particle showers leaving a dense medium (ice, ...) to air and comment on phenomenology of this radiation. Properties observed in numerical simulations suggest that it might be possible to build a large-aperture ultra-high energy neutrino experiment based on detection of transition radiation.

17. **Ryan Nichol**, UCL
Invited Talk: ANITA: Current status and future prospects

March 1, 2016 (2:30 PM - 3:00 PM)

The Antarctic Impulsive Transient Antenna is a balloon-borne radio interferometer searching for the Askaryan radio pulses emitted when ultra-high energy neutrinos or cosmic rays interact in the ice or atmosphere of Antarctica. I will report on the current status of the ANITA instrument and the plans and prospects for the fourth flight of the experiment, scheduled for December 2016.

18. **Foteini Oikonomou**, Penn State
Invited Talk: UHECRs and Neutrinos: Expectations for the next 20 years

March 2, 2016 (9:30 AM - 10:00 AM)

IceCube’s discovery of a high-energy astrophysical neutrino flux at a level compatible with the Waxman Bahcall bound, suggests a relation to ultra-high energy cosmic rays (UHECRs), whose sources remain a mystery. I will review the current status of experimental efforts, and the open questions about UHECRs, and neutrinos that the next-generation of astroparticle physics experiments might help address. In addition to stand alone experiments, I will discuss how the multi-messenger, time-domain initiatives, that have recently commenced, may help solve some of the mysteries surrounding the ultra-high energy Universe.

19. **Carl G Pfendner**, Ohio State University
Invited Talk: The ExaVolt Antenna: Concept and Development Updates

March 1, 2016 (4:15 PM - 4:45 PM)

Co-authors: The EVA Collaboration
In the past decade, searches for the cosmogenic neutrino flux produced by the interactions of ultra-high energy cosmic rays with the cosmic microwave background have not yet resulted in detection. Radio detection of ultra high energy neutrinos provides a cost-effective means probing large amounts of effective volume. The Antarctic Impulsive Transient Antenna (ANITA) balloon-borne experiment, with sensitivity to neutrinos with energies >10^19 eV, has provided some of the most stringent limits on cosmogenic neutrino production models by searching for coherent radio Cherenkov signals produced by the Askaryan effect in Antarctic ice. The ExaVolt Antenna (EVA) is a mission concept to extend the sensitivity of balloon-borne radio neutrino detection to energies 10^17 eV. EVA uses a novel antenna design that exploits the surface area of the balloon to provide a reflector antenna with 30 dBi gain (compared to 10 dBi on ANITA). We will present an overview of the mission concept and recent technology developments.

20. **Sean Quinn**, Case Western Reserve Univ.
Talk: Auger@TA: current progress and future plans

February 29, 2016 (3:15 PM - 3:30 PM)

Co-authors: Corbin Covault, Ryan Lorek, Fred Sarazin
In this talk we present the motivation for in situ observations of TA events with Auger SDs. We highlight progress made in installing Auger SDs at the TA CLF, setting up DAQ systems, and will share several months of local station trigger data. We conclude with a summary of results and future goals.

21. **Mariangela Settimo**, LPNHE-CNRS
Invited Talk: Recent Results from the Pierre Auger Observatory

February 29, 2016 (10:45 AM - 11:15 AM)

Co-authors: The Pierre Auger Collaboration
The nature and the origin of ultra-high energy cosmic rays (UHECRs), above 10^{17} eV, is still unknown. To answer the open questions on UHECRs, the Pierre Auger Observatory has been conceived as an hybrid detector consisting of fluorescence telescopes overlooking an array of water Cherenkov stations deployed over a surface of 3000 km2. This design and the huge exposure of the Auger Observatory provide us with a large set of high quality data. The analyses of these data has led to major breakthroughs in the last decade. Their coherent interpretation is still missing and has motivated several efforts for the design of an upgrade of the Observatory. The latest results and the plans for the future will be presented.

22. **Radomir Smida**, KIT
Invited Talk: Radio and microwave detection of extensive air showers at the Pierre Auger Observatory

March 1, 2016 (10:00 AM - 10:30 AM)

23. **Radomir Smida**, KIT
Talk: AugerPrime - Primary cosmic ray identification for the next 10 years

February 29, 2016 (3:00 PM - 3:15 PM)

Co-authors: for the Pierre Auger Collaboration

24. **Yuichiro Tameda**, Kanagawa University
Invited Talk: Recent Results from the Telescope Array Experiment

February 29, 2016 (11:15 AM - 11:45 AM)

The Telescope Array (TA) is the largest experiment to observe ultra-high-energy cosmic rays in the northern hemisphere. TA is a hybrid detector consisting of fluorescence detectors (FDs) and surface detector (SD) array. From May 2008, TA has started hybrid measurements using FDs and SDs. In this presentation, TA's recent results of the energy spectrum, the mass composition and the anisotropy will be reported.

25. **Andrew M Taylor**, DIAS
Invited Talk: Extragalactic Cosmic Rays in the Knee to Ankle Region

March 2, 2016 (10:00 AM - 10:30 AM)

Co-authors: Markus Ahlers, Dan Hoopper
Utilising the recent Pierre Auger Observatory results, I will highlight the "hardness problem" for the intrinsic spectrum required. A potential resolution to this problem will be put forward. Connected to this, the issue of the contribution of extragalactic cosmic rays to the isotropic gamma-ray background will also be highlighted.

26. **Lenka Tomankova**, Karlsruhe Institute of Technology (KIT)
Invited Talk: Studying telescope properties using an airborne light source

February 29, 2016 (3:45 PM - 4:15 PM)

27. **Nonaka Toshiyuki**, Institute for Cosmic Ray Research , University of Tokyo
Invited Talk: Surface detector for TAx4 expansion and status of Muon measurement at TA site.

February 29, 2016 (2:30 PM - 3:00 PM)

The Telescope Array experiment is now expanding it's detection area by adding surface detectors at north and south side of existing array. Also as a collaboration research with Pierr Auger Observatory, Water Tank SDs are operated together with shielded (600MeV) muon detector and Lead burger detector in TA air shower array. The SD developed recently employs photo-multiplier with higher sensitivity and optimized layout of wave length sifting fibers to suppress it's cost. In this talk technical details of TAx4 surface detectors and muon detectors are presented.

28. **Stephanie Wissel**, Cal Poly SLO
Invited Talk: Implications for Radio Detection of Cosmic Rays from Accelerator Measurements of Particle Showers in a Magnetic Field

March 1, 2016 (4:45 PM - 5:15 PM)

Growing evidence from observations of ultra-high-energy cosmic ray air showers supports the paradigm that transverse and longitudinal currents in particle air showers generate radio-frequency radiation. However, the expected amplitude and beam pattern of the RF emission in air showers depends on calculations of the electrodynamics within a particle cascade, which are complicated by uncertainties in hadronic interaction models, energies, and geometries of air showers. The T-510 experiment used a fixed energy electron beam injected into a dense dielectric embedded in a magnetic field to provide a benchmark by which microscopic models of the electrodynamics may be compared. In a controlled environment and with different systematics than air shower experiments, T-510 confirms both that currents in the particle showers generate RF emission and that the microscopic models accurately predict the characteristics of the emission.