ARENA 2014

Monday 09 June 2014 - Thursday 12 June 2014

Book of Abstracts

Contents

Mon AM II / 0

Recent developments in the construction of a line array projector for the calibration of Acoustic Neutrino Telescopes

Author: Sean Danaher[1]

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Recent developments in the construction of a line array projector for the calibration of Acoustic Neutrino Telescopes

Summary:

The existing line array calibrator developed for the ACoRNe collaboration lacks sufficient power to be reliably detected from a range over several kilometres needed for the calibration of acoustic arrays associated with ANTARES and the planned KM3NET. The calibrator is currently being upgraded to increase the transmit strength by a minimum of 20dB. Recent design, simulation and laboratory tests will be presented.

Wed AM I / 1

Advanced Reconstruction Strategies for the Auger Engineering Radio Array

Author: Qader Dorosti Hasankiadeh[1]

[1] *Karlsruher Institut für Technologie (KIT);*

The Auger Engineering Radio Array (AERA) aims to detect extensive air showers caused by the interactions of ultra-high energy cosmic rays with the Earth atmosphere, providing complementary information to the Auger surface, fluorescence and muon detectors. The second stage of AERA, currently consisting of 124 radio stations, has been completed at the Pierre Auger Observatory in early 2013, comprising a larger detection area compared to the first stage of AERA (AERA-24).
The main objective for exploiting a radio detector is to precisely measure the fundamental air-shower parameters, such as the direction, energy and composition. To this end, we have developed reconstruction strategies and algorithms to measure the air-shower parameters with high efficiency.
We will discuss the reconstruction strategies developed to determine the fundamental air-shower parameters. In addition, we will present the results obtained by applying the reconstruction strategies on a fraction of the experimental data.

Wed AM I / 2

Measuring and parameterizing the two-dimensional pattern of radio emission in air showers with LOFAR

Author: Anna Nelles[1]

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The detection of radio emission of air showers has rapidly advanced in the past years. New experiments have shed light on the details of the emission and air shower simulations provide rather accurate models of the measured emission. To exploit radio emission in large-scale experiments, a simple and analytic parametrization of the distribution of the radio signal at ground level is needed. Such a parametrization can allow for fast calculations of the expected signals and can be used to reconstruct the geometry of the measured air showers. Data taken with the Low- Frequency Array (LOFAR) show a complex two-dimensional pattern of pulse powers, which is sampled with hundreds of antennas per event. Earlier parametrizations of the lateral signal distribution have proven insufficient to describe these highly detailed data.

We present a two-dimensional model with five free parameters derived from air-shower simulations. All parameters show strong correlations with air shower properties, such as the energy of the shower, the arrival direction, and the height of the shower maximum. This parametrization represents the data taken with LOFAR very accurately. We present the application of this method to LOFAR data and discuss implications for the reconstruction of the shower geometry.

Th AM II / 3

An autonomous method for drilling deep in South Pole ice

Author: Rolf Nahnhauer[1]

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Information about thermal probes and how to use them for autonomous deep drilling in ice will be given. The method presented may be useful for drilling holes at large distances and/or large numbers, necessary for building big (hybrid) arrays for cosmogenic neutrino detection.

Weds AM II / 4

Technological developments for the Auger Engineering Radio Array (AERA)

Author: Jennifer Maller[1]

Co-author: The Pierre Auger Collaboration [2]

[1] *Subatech*

[2] .

The Auger Engineering Radio Array consists of 124 radio stations covering 6 km² installed within the low energy extension of the Pierre Auger Observatory in Argentina; this location allows a multi-hybrid measurement of air-showers with the fluorescence telescopes, the water-Cherenkov and the muon detectors close to the radio array. AERA detects the radio emission from cosmic-ray induced air showers above 10^17 eV. The measured electric field is used to constrain the characteristics of the primary particle: arrival direction, energy and particle type (mass). These studies are possible due to an instrumentation development allowing externally-triggered in parallel with self-triggered measurements in the MHz domain and an improved understanding of the radio emission processes. We will present the main technological developments of AERA that have been realized since 2010, within the Pierre Auger collaboration, to reach the requested quality allowing the accurate measurement of the electric field emitted by air showers. We will review the antennas and their Low Noise Amplifiers, the trigger board and the full acquisition chain up to the communication system. The current R&D on new technical developments will be also discussed.

Tues AM II / 5

Tunka-Rex experiment for detection of air-shower radio emission

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The Tunka-Rex experiment (Tunka Radio Extension) was created in 2012 at the Tunka Valley (Republic of Buryatia, Russia). Its purpose is to investigate methods for the energy spectrum and the mass composition of high energy cosmic rays based on the radio emission of air showers. Tunka-Rex is an array of 25 radio antennas distributed over an area of 3 km2. The most important feature of the project is that the air-shower radio emission is measured in coincidence with the Tunka-133 installation, which detects the Cherenkov radiation generated by the same atmospheric showers. Joint measurements of the radio emission and the Cherenkov light provide a unique opportunity for cross-calibration of both calorimetric detection methods. The main goal of Tunka-Rex is to determine the precision for the reconstruction of air-shower parameters using the radio detection technique. This report presents the current status of Tunka-Rex, and first results of Tunka-Rex including a discussion of the reconstruction methods for the parameters of the primary cosmic rays.

Summary:

The results of Tunka-Rex experiment will be represented.

Mon PM II / 6

Wavefront of the Radio Emission from Air Showers

Author: Frank Schröder[1]

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[2] -

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We investigated the radio wavefront of cosmic-ray air showers with LOPES measurements and CoREAS simulations: the wavefront is of hyperbolic shape and can be used to reconstruct the shower maximum.

LOPES was a digital, interferometric antenna array at the Karlsruhe Institute of Technology (KIT) at an altitude of 110 m. LOPES consisted of up to 30 antennas on an area with approximately 200 m diameter. It was externally triggered by the KASCADE particle detector array and measured the radio emission of air showers in the effective band from 43 to 74 MHz. Our analysis is based on 316 LOPES events with energies above 0.1 EeV and zenith angles below 45°. In addition, we have made two CoREAS simulations of the radio wavefront for each event, one for a proton and one for an iron nucleus as primary particle.

A hyperbola describes the wavefront shape significantly better than a sphere or a cone. On the one hand, this means that the radio emission cannot be approximated by a static point source at the shower maximum. On the other hand, a conical wavefront expected for a moving point source seems to be a sufficient approximation for axis distances > 50 m.

In first order, the angle between the shower plane and the limiting cone of the hyperbola depends on the distance of the radio array to the shower maximum. This implies dependences on the zenith angle as well as on the atmospheric depth of the shower maximum, Xmax. We exploit this for the reconstruction of Xmax based on the arrival times of the signal in the individual antennas. For the simulations, we obtain a resolution of approximately 25 g/cm². For the measurements, the resolution is only 140 g/cm², since LOPES in its radio-loud environment suffers from significant experimental uncertainties.

Mon AM II / 7

Simulation chain and signal classification for acoustic neutrino detection in sea water

Author: Dominik Kiessling[1]

[1] *Erlangen Centre for Astroparticle Physics*

Acoustic neutrino detection is a promising approach to extend the energy range of neutrino telescopes to energies beyond 10^{18} eV. Current water-Cherenkov-neutrino-telescopes, like e.g. KM3NeT, include acoustical sensors in addition to the optical ones. While the main purpose of these acoustic sensors is the position calibration of the detection units, they could be used as instruments for acoustic detection, too. In this article a Monte Carlo simulation chain for acoustic detectors will be presented, covering the initial interaction of the neutrino up to the signal classification of recorded events. The ambient and transient background in the simulation were implemented according to the data recorded by the acoustic set-up AMADEUS in ANTARES. The effects of refraction on the neutrino signature in the detector are studied, and a classification of the recorded events is implemented. As bipolar waveforms similar to those of the expected neutrino signals are also emitted from other sound sources, additional features like the geometrical shape of the propagation have to be considered for the signal classification. This leads to a large improvement of the background suppression by almost two orders of magnitude, since the cylindrical "pancake" propagation pattern is a distinctive trait of neutrino signals. An overview of the simulation chain and the signal classification will be presented and preliminary studies of the performance of the classification will be discussed.

Weds PM II / 8

PRIDE – Passive Radio Ice Depth Experiment - An Instrument to Measure Outer Planet Lunar Ice Depths from Orbit using EHE Neutrinos

Author: Timothy Miller[1]

Co-authors: Amy Connolly [2]; Andrew Romero-Wolf [3]; Brian Sequeira [4]; David Besson [5]; Gerald Patterson [4]; Grant Stephens [4]; Robert Schaefer [4]; Steven Barwick [6]; Stuart Kleinfelder [6]

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We describe a potential confluence between EeV neutrino detection and planetary science: a concept for an instrument to measure the thickness of the ice shell on a planetary body, such as Jupiter's moon Europa or Saturn's moon Enceladus, by making use of the Askaryan Effect RF signal from EHE neutrinos observed from an orbiting spacecraft. Unlike a large high powered active device, i.e., an ice-penetrating radar, this instrument is a passive receiver of the naturally occurring signal generated by interactions of deep penetrating cosmic ray neutrinos in the extremely thick, cold ice layer encasing outer solar system moons. It is therefore potentially less massive and requires less power, making it very attractive for interplanetary missions. Measuring the ice sheet thickness on such moons is a first step toward exploring potential oceans below, and is a very high scientific priority for outer planet missions, so new and economical approaches to this measurement are of great interest. We discuss the basic concept, including the correlations of event rate and direction distribution with ice sheet thickness, and consider the instrument design requirements from the perspective of a NASA Outer Planet Orbiter Mission. We show results [1] of simulations, compare signal-to-noise estimates, and examine possible components and configurations for the antenna, receiver, and electronics. We note some options that can be used to reduce mass and power. Finally, we identify issues that would need further study to produce a more concrete design.
[1] Miller, T., Schaefer, R.K., and Sequeira, H.B., Icarus, 220, 877-888, 2012.

Th AM II / 9

Use of Radar Depth Sounding Data to Estimate Radio Frequency Attenuation in Greenlandic and Antarctic Ice

Author: Mark Stockham[1]

[1] *University of Kansas*

Antarctic ice represents the interaction volume for multiple UHE neutrino experiments. When neutrinos collide with ice particles they produce radio waves that propagate to in-ice, surface, or balloon-borne detectors. The radio frequency signal strength observed at the detector, however, depends on the radio frequency attenuation length of the ice through which the neutrino-generated signal must travel. Attenuation length is a location-specific ice property and varies mainly as a function of temperature and chemistry. The Center for Remote Sensing of Ice Sheets (CReSIS) project has data from many locations in Antarctica and Greenland produced by radar depth sounding. Using methods developed by analyzing the continuum signal in radar depth sounding data from Greenland depth-dependent attenuation length estimates are compared to estimates derived from ice core data. Comparisons between Greenlandic and colder Antarctic ice will also be made.

Wed PM I / 10

Adaptable illumination and calibration of a high-gain antenna for cosmic ray air-shower experiments

Author: Lars Petzold[1]

Co-authors: Felix Werner [1]; Julian Rautenberg [2]; Karl-Heinz Kampert [3]; Marc Weber [1]; Matthias Kleifges [1]; Oliver Kroemer [1]; Phillip Papenbreer [2]; Radomir Smida [1]; Ralph Engel [1]; Sebastian Mathys [2]

[1] *KIT*

[2] *Bergische Universität Wuppertal*

[3] *Bergische Univerität Wuppertal*

At the Karlsruhe Institute of Technology (KIT) the microwave detector experiment CROME (Cosmic Ray Observation via Microwave Emission) has been built up. It was aimed to investigate radio emissions from cosmic ray air showers in L-Band (1.0 to 1.6 GHz) and the extended C-Band (3.4 to 4.2 GHz).

The final setup used high-gain parabolic reflector-type antennas which are illuminated either with cross-polarized dipoles or circular waveguide feeds. Both illumination techniques show an inhomogeneous illumination. The effect can be compensated by using a circular waveguide feed with movable choke ring after the design of A. Kumar (Reduce cross-polarization in reflector type antennas, A. Kumar, Microwaves 1978). Due to the expanded near field region
beyond 100m of high-gain antennas, calibration procedures are challenging.

To optimize the signal to noise ratio (SNR) we have developed a L-band feed for obtaining a homogeneous illumination of a parabolic reflector-type antenna. We also present a novel method to calibrate such high-gain antennas based on an airborne calibration transmitter mounted on a GPS-controlled model helicopter. Using this method the design parameters of the feed were verified.

Mon PM II / 11

Simulating radio signals from cosmic-ray induced air showers reflecting from a surface

Author: Jaime Alvarez-Muniz[1]

Co-authors: Daniel Garcia-Fernandez [2]; Enrique Zas [2]; Harm Schoorlemmer [3]; Washington R. Carvalho Jr. [2]

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The recent detection of radio pulses with the ANITA experiment has revealed characteristic signatures of geomagnetic emission and has been attributed to coherent radio flashes from air showers that get reflected on the ice cap. In spite of recent progress in simulating and understanding radio pulses from air showers, no detailed studies are available to date to address the impact of the reflection process on the characteristics of the signal and the extent to which coherence is affected. In this contribution we present a modified version of the ZHAireS code explicitly tailored to calculate radio emission reflected from a surface. We obtain predictions for the characteristics of the electric field for different shower orientations. The results of our simulations
are understood and validated with a raytracing algorithm and a simple model.

Mon PM II / 12

Testing a two component approach to describe radio emission from air showers

Author: Jaime Alvarez-Muniz[1]

Co-authors: Enrique Zas [2]; Harm Schoorlemmer [3]; Washington R. Carvalho Jr. [1]

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The radiation emitted by atmospheric showers is currently interpreted in terms of the deviation of the charged particles in the magnetic field of the Earth and the emission due to the charge excess (Askary'an effect). Each of these mechanisms has a distinctive polarization. The complex signal patterns obtained both in dedicated experiments measuring average behaviors and in simulations,

can be qualitatively explained as the interference (superposition) of the fields induced by each mechanism.

This work is an attempt to explicitly and quantitatively test a simple phenomenological model based on this idea (two dominant emission mechanisms). The model is constructed by isolating each of the two components at the simulation level and by making use of
approximate symmetries for each of the contributions separately. The results of the model are then checked against full ZHAireS simulations of the electric field calculated from first principles. With these simulations, that are now known to reproduce experimental data, we show that the simple model describes radio emission at a few percent level in a wide range of shower-observer geometries and on a shower-by-shower basis. This conclusion converts this approach in a simple method to reduce the computing time needed to accurately predict the electric field of radio pulses emitted from air showers, with many practical applications
in experimental situations of interest.

Weds AM II / 13

New developments around the Butterfly antenna

Author: Didier CHARRIER[1]

[1] *SUBATECH-UMR6457*

The Butterfly antenna is a compact, active and dual polarization antenna specifically developed for the radio detection of extensive air showers in the 20-200MHz frequency range. Butterfly antennas are in operations at Nançay for the CODALEMA experiment since october 2008, and at Auger for the AERA experiment since may 2013. The overall characteristics of an active antenna are given by the antenna itself, but also by its associated Low Noise Amplifier (LNA). A new LNA chip named LONAMOS has been designed to enhance the Butterfly characteristics. Strong constraints of linearity were imposed in this design in order to be compliant with the radio-astronomy needs.

Because of its characteristics, the Butterfly antenna has been chosen by many cosmic ray or radio astronomy experiments: 100 antennas for AERA located at the Pierre Auger Observatory (Argentina), 67 antennas for CODALEMA (France), 6 antennas for HELYCON (Greece). LNA boards using the LONAMOS chip have also been chosen by other experiments: 55 LNA boards for TREND (China), and 4000 LONAMOS chips for NenuFAR located at the Nançay observatory for a radio astronomy array of 1824 antennas.

In this contribution we will present the Butterfly antenna design keys, antenna modelization, characteristics enhancements with the new LONAMOS LNA, and measurements results.

Wed AM I / 17

Radio Detection of Horizontal Extensive Air Showers with AERA

Author: Olga Kambeitz[1]

Co-author: Collaboration Pierre Auger [2]

[1] *IEKP, KIT*

[2] *Pierre Auger Observatory, Malargüe, Argentina*

AERA, the Auger Engineering Radio Array, located at the Pierre Auger Observatory in Malargüe, Argentina measures the radio emission of extensive air showers in the 30-80 MHz frequency range. It consists of 124 antenna stations of which 24 are log periodic dipole antennas (LPDAs) and 100

are so-called butterfly antennas. Both antenna types measure two electric field components (North-South and East-West)
and are optimized for the detection of air showers up to 60° zenith angle. Together with the Auger surface detector, the fluorescence detector, as well as the muon detector of AMIGA, AERA is able to measure cosmic rays with energies above 10^17 eV in a hybrid detection mode.
Simulation studies have shown that for the reconstruction of inclined air showers the vertical electric field component becomes important. To investigate and improve the sensitivity of AERA to inclined showers, prototype stations including tripole antenna stations and whisk-type antennas as enhancement of the butterfly antennas have been deployed on the AERA site in November 2013. To study the emission in lower frequencies around 1 MHz one low-frequency tripole station has
been deployed as well.
In this contribution the motivation, the status, and first results of the analysis of horizontal air showers with AERA including the new prototype stations will be presented.

Wed PM I / 18

The AMY experiment to investigate the GHz emission from air shower plasmas.

Authors: Claudio Di Giulio[1]; Valerio Verzi[2]

[1] *INFN Tor Vergata*

[2] *Istituto Nazionale Fisica Nucleare*

The Air Microwave Yield (AMY) experiment investigate the molecular bremsstrahlung radiation emitted in the GHz regime from an electron beam induced air-shower .
The measurements have been performed with 510 MeV electron beam in a wide frequency range between 1 and 20 GHz.
We present the apparatus and the results of the tests performed at the Beam Test Facility (BTF) of Frascati INFN National Laboratories.

Wed PM I / 19

Measurements with the absolute calibrated L-band radio antenna of CROME for extensive air showers

Author: Philipp Papenbreer[1]

[1] *Bergische Universität Wuppertal*

The Cosmic-Ray Observation via Microwave Emission (CROME) experiment is designed to study GHz radio emissions from extensive air showers. Multiple radio antennas measure externally triggered by the KASCADE-Grande air-shower array. The experiment is designed to detect a potentially isotropic, unpolarized component as expected by molecular bremsstrahlung emission in the low-energy electron plasma indicated by a collider experiment.
This contribution shows the measurements using the L-band (1-2 GHz)
antenna of CROME. An absolute calibration of the receiver system was
performed successfully and could be used for a specific signal search.
In addition, the measurement results were compared to expected field
strengths of molecular bremsstrahlung and simulations of other emission
mechanisms.

Mon PM I / 20

Geant4 simulations of radio signals from particle showers for the SLAC T-510 experiment

Author: Anne Zilles[1]

Co-author: SLAC T-510 Collaboration [2]

[1] *KIT*

[2] *SLAC*

The SLAC T-510 experiment was designed to reproduce the physics of radio emission from air showers in a controlled lab experiment with the goal to test established formalisms for simulation of radio emission physics: the “end-point” formalism and the “ZHS” formalism.
Simulation results derived with these formalisms can be explained by a superposition of magnetically induced transverse current radiation and the Askaryan (charge-excess) effect.
Here, we present results of Geant4 simulations of the experiment with both formalisms, taking into account the details of the experimental setup (beam energy, target geometry and material, magnetic field configuration and refraction effects) to test this hypothesis.

Weds AM II / 21

LOPES-3D – studies on the benefits of direct measurements with vertically aligned antennas

Author: Daniel Huber[1]

Co-author: Tim Huege [2]

[1] *KIT*

[2] *Karlsruhe Institute of Technology*

The LOPES experiment was a radio interferometer built at the existing air shower array KASCADE-Grande in Karlsruhe, Germany. The last configuration of LOPES was called LOPES-3D and consisted of ten tripole antennas. Each of these antennas consisted of three crossed dipoles east-west, north-south and vertically aligned. With this, LOPES-3D had the unique possibility to study the benefits of additional, direct measurements with vertically aligned antennas in the environment of the well understood and calibrated particle detector array KASCADE-Grande. The measurements with three spacial coincident antennas led to a redundant reconstruction of the E-field vector. Thus, several methods to exploit the redundancy were developed and tested.
Furthermore, for the first time, the background noise could be studied polarization- and direction dependent.
With LOPES-3D it could be demonstrated that radio detection reaches a higher efficiency for inclined showers and that the vertical component gets more important for the measurement of inclined showers.
In this contribution we discuss the development of different weighting schemes for the best combination of the three redundant reconstructed E-field vectors. Furthermore we discuss the influence of these weighting schemes on the ability to reconstruct the showers in radio and on the geometry reconstruction. We show an estimate of the radio efficiency for inclined showers with focus on the benefits of measurements with vertically aligned antennas and we present the direction dependent noise in the different polarizations.

Weds AM II / 22

A dedicated antenna array for radio detection of Extended Air Showers.

Author: Alain Lecacheux[1]

Co-authors: Didier CHARRIER [2]; Laurent DENIS [3]; Lilian MARTIN [2]; Richard Dallier [2]

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[2] *SUBATECH-UMR6457*

[3] *Nançay Radio astronomy Station*

Radio pulses associated with Extended Air Showers (EAS) produced in terrestrial atmosphere by High Energy Cosmic Rays (UHECR) of energy 10^17 eV and above, are now routinely observed by dedicated radio instruments on ground. This may offer a new and appealing way for elucidating the nature and origin of involved primary particles, an open question still unsolved.
Unfortunately, the high occupancy of the electromagnetic spectrum by undesired signals from natural and anthropogenic origins has made unambiguous EAS radio detection a challenging problem. Former attempts based on timing coincidences from several independent radio antennas, or using auxiliary triggering by conventional particle detectors, are still not fully satisfying.
We present here a solution based on real time, coherent radio detection by using a small array of 10x2 cross polarized dipoles, distributed over a 150m x 150m surface area and operated in continuous sky surveying mode.
Preliminary results obtained with the new system are briefly reviewed and discussed.
The final detection scheme will be achieved by using on line, fast computing software based on a dedicated unsupervised recognition algorithm.
The new array is a part of the CODALEMA experiment located in Nançay radio astronomy observatory (France).

Wed AM I / 23

Measurement of the cosmic ray mass composition with the LOFAR radio telescope

Author: Stijn Buitink[1]

[1] *Radboud University Nijmegen, Netherlands*

LOFAR is a multipurpose radio telescope which can be used for radio detection of cosmic rays while running astronomical observations at the same time. In the dense core individual air showers are detected by hundreds of dipole antennas. The raw electromagnetic waveform as detected by each antenna is stored in a five-second ring buffer, which is read out when a trigger is issued by the LORA particle detector array. Hundreds of showers with energies above 10^17 eV have been measured in two frequency regimes: low band (10-90 MHz) and high band (110-250 MHz).

The complicated radio emission pattern on the ground can be accurately reproduced by modern radio simulation codes and contains information about the longitudinal shower development. With a hybrid reconstruction technique, we can measure the depth of the shower maximum with an accuracy of ~20 g/cm^2 in the energy regime of 10^17 eV to 10^18 eV. Cosmic-ray mass measurements in this range are of particular interest as it may harbor the transition from a Galactic to an extragalactic origin. We present a mass composition analysis based on the first results and discuss their implications for transition models.

Weds PM II / 24

The effects of surface roughness on lunar Askaryan pulses

Author: Clancy James[1]

[1] *University of Erlangen-Nuernberg*

The effects of lunar surface roughness, on both small and large scales, on Askaryan radio pulses generated by particle cascades beneath the lunar surface has never been fully estimated. Surface roughness affects the chances of a pulse escaping the lunar surface, its coherency, and the characteristic detection geometry. It will affect the expected signal shape, the relative utility of different frequency bands, the telescope pointing positions on the lunar disk, and most fundamentally, the chances of detecting the known UHE cosmic ray and any prospective UHE neutrino flux. Near-future radio-telescopes such as FAST and the SKA promise to be able to detect the flux of cosmic rays, and it is critical that surface roughness be treated appropriately in simulations. of the lunar Askaryan technique.
In this contribution, a facet model for lunar surface roughness is combined with a method to propagate coherent radio pulses through boundaries to estimate the full effects of lunar surface roughness on neutrino-detection probabilities. The method is able to produce pulses from parameterised particle cascades beneath the lunar surface as would be viewed by an observer at Earth, including all polarisation and coherency effects. Results from this calculation are presented for both characteristic cosmic ray and neutrino cascades, and estimates of the effects mentioned above - particularly signal shape, frequency-dependence, and sensitivity - are presented.

Tues AM II / 25

Radio detection of Cosmic Rays in the GHz band at the Pierre Auger Observatory

Author: Imen Al Samarai[1]

[1] *IPNO*

Observations of microwave radiation emitted by low energy electrons left after the passage of a high energy electron beam in accelerator experiments offered new possibilities of Ultra High Energy Cosmic Rays (UHECR) detection techniques based on microwave radiation. This would bring a tenfold increase in detector duty cycle compared to the standard fluorescence technique.
The emission mechanism interpreted as Molecular Bremsstrahlung Radiation (MBR) is expected to produce an unpolarized and isotropic signal. Motivated by the expected full duty cycle of such a technique and to its insensitivity to atmospheric attenuation, three microwave detectors; EASIER, MIDAS and AMBER are implemented in Auger.
The status and results of these microwave detectors are reported.

Wed PM I / 26

An estimate of the spectral intensity expected from the molecular Bremsstrahlung radiation in extensive air showers

Author: Imen Al Samarai[1]

Co-authors: Anne Stutz [2]; Antoine Letessier-Selvon [3]; Corinne Berat [2]; Didier Lebrun [2]; Francesco Salamida [1]; François Montanet [2]; Ioana Maris [4]; Isabelle Lhenry-Yvon [1]; Julien Aublin [3]; Mariangela Settimo [3]; Miguel Blanco [3]; Olivier Deligny [5]; Patrick Stassi [2]; Pierre Billoir [3]; Romain Gaior [3]; Sandra Le Coz [2]

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A detection technique of Ultra High Energy Cosmic Rays (UHECR) complementary to fluorescence and Radio techniques would be the use of the Molecular Bremsstrahlung Radiation (MBR) emitted by low energy electrons left after the passage of the showers in the atmosphere.

The emission mechanism is expected from quasi-elastic collisions of electrons produced in the shower by the ionization of molecules in the atmosphere.

In this contribution, we calculate the spectral intensity of photons at ground level originating from the transition bet ween unquantized energy states of free ionization electrons.

In the absence of absorption of the emitted photons in the plasma, we obtain a spectral intensity depending on the effective lifetime of the ionization electrons and compare it to the spectral intensity measurements provided by the SLAC experiment (Gorham et al. 2008).

Tues AM I / 27

Investigating the extensive air shower properties using the polarization and frequency features of the radio signals measured by the CODALEMA autonomous station array.

Author: Lilian Martin[1]

Co-author: Collaboration CODALEMA [2]

[1] *SUBATECH*

[2] *SUBATECH/LESIA/USN*

CODALEMA is the last experiment currently running in Europe dedicated to the extensive air shower detection using the observation of its induced radio electric field and with the ambition to promote this radio detection technique to a mature technology suited to a next generation giant cosmic ray observatory. The latest experimental upgrade of CODALEMA consisting in a large array of autonomous stations will be presented with a special emphasis put on the key technical features of this instrument. While the relative timings and the amplitudes of the electric field measured by antennas are now widely used to characterize the extensive air showers, the polarization patterns and the frequency contents are considered now as very useful information to strongly improve these measurement capabilities. The latest results obtained by the dual-polarization wide-band antennas of CODALEMA will be reviewed and their impact in terms of instrumental design and optimization will be investigated.

Mon PM II / 28

Ice surface roughness modeling for effect on radio signals from UHE particle showers

Author: Jessica Stockham[1]

[1] *University of Kansas*

For radio antenna neutrino and cosmic ray detectors located in or above the Antarctic ice sheet, the reconstruction of both ultra-high energy (UHE) neutrino and cosmic ray air shower events requires knowledge the transmission and reflection properties of the air-ice interface. To better understand

these properties, in-lab and field data will be obtained and analyzed. The in-lab experiment will measure reflected power from rough surfaces of a granular material in the frequency range of 2-3GHz. These meausrements are used to determine a model capable of predicting reflected power as a function of elevation angle and frequency based on measurable parameters of the surface and material. Field data is taken in the form of stereoscopic images of the surface as part of the Antarctic Geophysics Along the Vostok Expedition (AGAVE). 3D data from the stereoscopic images will be used to create similarly rough and appropriately scaled surfaces in the lab for comparison to the results of the reflection model and to the models currently being used for simulation and reconstruction of shower events.

Mon PM I / 29

Measurement of the polarization of the radio emission in air showers with LOFAR and the influence of atmospheric electric fields.

Author: Olaf Scholten[1]

Co-authors: Anna Nelles [2]; Stijn Buitink [3]

[1] *KVI-CART, Univ. of Groningen*

[2] *Radboud University Nijmegen*

[3] *Radboud University Nijmegen, Netherlands*

With the LOFAR antenna array we have measured the the polarization footprint of the radio emission from extensive air showers for a large number of single events. The polarization direction is determined from the Stokes parameters integrated over the time duration of the radio pulse.
It will be shown that for events for which no thunderstorm activity has been registered the polarization pattern obeys very well the expected characteristics based on a superposition of a geomagnetically-induced transverse current and charge excess contributions. The core-distance dependence of ratio of the two contributions is measured.
For events where thunderstorm activity is registered strong deviations from the fair-weather polarization pattern are observed. A semi-quantitative interpretation of the influence of atmospheric electric fields on the polarization pattern will be presented.

Tues AM II / 30

Detection and Characterisation of Microwave Emission of Extensive Air Showers with the CROME Experiment

Author: Felix Werner[1]

[1] *KIT*

Microwave radiation from high-energy air showers has been observed in the C band (3.4–4.2 GHz) with the Cosmic-Ray Observation via Microwave Emission (CROME) setup. The obtained dataset provides a unique opportunity to study the radio emission of air showers at microwave frequencies. The compatibility of the measured GHz signals with different hypotheses for the emission mechanism is discussed. It is shown that the component measured in the forward direction of an air shower is compatible with emission mechanisms known from the MHz frequency range, namely the geomagnetic charge separation and charge excess variation. Furthermore, a limit on a potentially isotropic, unpolarized component, as expected from molecular bremsstrahlung, is derived.

Mon PM I / 31

SLAC T-510: Radio emission from particle cascades in the presence of a magnetic field

Authors: Andrew Romero-Wolf[1]; Katharine Mulrey[2]; Konstantin Belov[3]; Stephanie Wissel[3]

Co-author: Collaboration SLAC T-510 [3]

[1] *JPL*

[2] *University of Delaware*

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Geomagnetic radiation from air showers is an attractive technique for detecting ultra-high energy cosmic rays. Macroscopic and microscopic models have been developed which qualitatively agree with field observations. A controlled laboratory experiment at the Stanford Linear Accelerator Center (SLAC) was designed to test these models. The experiment measures the radio frequency emission from cascades of secondary particles in a dense dielectric medium in the presence of a magnetic field. The cascades were induced by a ~4.5 GeV electron beam in a polyethylene target placed in magnetic fields up to +/-1000 G. The radio emission beam pattern was sampled in horizontal and vertical polarizations by multiple antennas with a total frequency band of 30-3000MHz. The emission was found to be in good agreement with model predictions, including a Cerenkov-like beam pattern and linear scaling with magnetic field.

Tues AM I / 32

Detection of Radio Emission from Air Showers in the MHz range at the Pierre Auger Observatory

Author: Jens Neuser[1]

Co-author: Collaboration Pierre Auger [2]

[1] *University of Wuppertal*

[2] *Av. San Martin Norte 306, 5613 Malargue, Mendoza, Argentina*

The Auger Engineering Radio Array (AERA) at the Pierre Auger Observatory in Argentinia is constructed in multiple stages starting in 2010. The current stage consists of 124 dual-polarized radio detector stations covering an area of 6 km^2. One of the main goals is to study the radio emission process for energies beyond 10^{17} eV in the range from 30-80 MHz. Having the unique opportunity for multi-hybrid measurements of air showers alongside the other detectors and also the low-energy extensions at the Pierre Auger Observatory, AERA is a milestone for further large-scale radio experiments. Combining the advantages of other detector types, AERA is investigating the sensitivity to air shower parameters.

This contribution gives an overview of the motivation and science goals of AERA and shows the current status and performance of the detector. First multi-hybrid events will be presented as well as the most recent results by the AERA group. Polarization measurements which show a strong evidence for a radial polarized component in the electric field vector will be discussed. An outlook with future perspectives will be given.

Tues AM II / 33

Characterisation of the radio signal emission from extensive air showers using the SELFAS code

Author: Benoît REVENU[1]

Co-authors: Karim Louédec [2]; Vincent MARIN [1]

[1] *Subatech*

[2] *LPSC*

The code SELFAS computes the electric field emitted by the secondary electrons and positrons in air showers initiated by high-energy cosmic rays.
SELFAS is based on the shower universality. We will focus on the main successes of the code to explain observations in the range MHz-GHz, and we will insist on the signal emitted by the sudden death of air showers when the front disappear in the ground, in the context of the new EXTASIS experiment.

Weds PM II / 34

On the feasibility of RADAR detection of high-energy cosmic neutrinos in ice

Author: Krijn de Vries[1]

Co-authors: Aongus O'Murchadha [2]; Hanson Kael [2]; Thomas Meures [1]

[1] *VUB*

[2] *ULB*

We discuss the radar detection technique for the detection of high-energy neutrino-induced particle cascades in ice. A high-energy neutrino interacting in ice will induce a particle cascade. When propagating through the ice, this cascade will ionize the medium producing a plasma. The different properties of this ionization plasma, such as its size and lifetime, will be discussed to determine an energy threshold for the over-dense scattering of the ionization plasma. This energy threshold is found to be at a few PeV. To determine the feasibility of the radar detection technique, we modeled the radar return power for a radio wave scattered off of the ionization plasma for a bi-static radar configuration. It follows that the radar detection technique, if successful, will be able to cover the currently existing energy gap between several PeV where IceCube runs out of events and a few EeV where the Askaryan radio detectors start to become sensitive.

Tues AM I / 35

Precision measurements of the shower front of the radio emission in air showers with LOFAR

Author: Joerg Hoerandel[1]

[1] *Radboud University Nijmegen*

High-energy cosmic rays impinging onto the atmosphere of the Earth initiate cascades of secondary particles: extensive air showers. The electrons and positrons in air showers interact with the geomagnetic field and emit radiation, which we record in the tens-of-MHz regime. The LOFAR radio telescope measures the radio emission with high antenna density and two polarization directions. We used LOFAR for measurements of the shape of the radio wave front of air showers with unprecedented precision with sub-nanosecond resolution. Our measurements show that the radio shower

front is described best by a hyperboloid - it fits the data significantly better than the shapes discussed in the literature (conical and spherical shapes). We present recent results and show a quantitative comparison of different shapes analyzed. These results put strong constraints on the models to describe the radio emission in air showers. We also point out correlations between the shape of the shower front and the properties of the shower-inducing primary particle.

Weds AM II / 36

Introducing TAXI: A Transportable Array for eXtremely large area Instrumentation studies

Author: Timo Karg[1]

Co-authors: Andreas Haungs [2]; Matthias Kleifges [2]; Rolf Nahnhauer [1]

[1] *DESY*

[2] *KIT*

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A challenge that is common to many experiments in high-energy astroparticle physics is the need for sparse instrumentation in areas of 100 km2 and above, often in remote and harsh environments. All these arrays have similar requirements for read-out and communication, power generation and distribution, and synchronization. Within the TAXI project we are developing a transportable, modular four-station test-array that allows us to study different approaches to solve the aforementioned problems in the laboratory and in the field. Well-defined interfaces will provide easy interchange of the components to be tested and easy transport and setup will allow in-situ testing at different sites. Every station consists of three well-understood 1 m2 scintillation detectors with nanosecond time resolution, which provide an air shower trigger. An analog sensor, currently a radio antenna for air shower detection in the 100 MHz band, is connected for testing and calibration purposes. We introduce the TAXI project and report the status and performance of the first TAXI station deployed at the Zeuthen site of DESY.

Weds PM II / 37

A Station For The Detection Of Ultra High Energy Cosmic Ray Induced Extensive Air Showers At The Telescope Array Radar (TARA)

Author: Samridha Kunwar[1]

[1] *The University of Kansas*

Corresponding Author: samridhak@gmail.com

The detection of high – energy cosmic rays is currently limited by the rarity of the most interesting rays striking Earth. We describe the development of an observatory based on a remote sensing technique known as bi-static radar, that aims to achieve remote coverage over large portions of the Earth's surface. The radar project's receiver and transmitter stations have already been functional for several months, in conjunction with North America's largest cosmic ray observatory (The Telescope Array) in radio quiet western Utah, giving insight into the detect-ability of air shower radar echoes. This has given impetus for further upgrades, including additional autonomously powered remote receiver stations. We describe the current status of the Telescope Array RAdar (TARA) project and the development of these remote stations.

Mon AM II / 38

Fiber based hydrophones for ultra-high energy neutrino detection

Author: Ernst-Jan Buis[1]

Co-authors: Daan van Eijk [1]; Ed Doppenberg [1]; Peter Toet [1]; Remco Nieuwland [1]; Robert Lahmann [2]

[1] *TNO Technical Sciences, Delft, The Netherlands*

[2] *Erlangen Centre for Astroparticle Physics*

To survey large volumes of water for acoustic signals from neutrino interactions, optical fiber-based hydrophones could potentially have several advantages over conventional hydrophones based on piezo ceramics. Optical fibers form a natural way to create a distributed sensing system in which several sensors are attached to a single fiber. The detection system in this case will consist of several sensors, an erbium doped fiber laser and an interferometric interrogator. Further advantages of this technology are low power consumption and the absence of electromagnetic interference with other read-out electronics. Maybe even more important, fiber optics technology provides a cost-effective and straightforward way for the installation of a large number of hydrophones. This allows to establish a large scale experimental set-up with tens or hundreds of km^3 detection volume that is required for the expected low event rate of neutrino interactions at energies exceeding 10 PeV.
In this talk we will discuss the fiber-based hydrophone technology, first measurements performed with test setups and the feasibility of a potential future large scale neutrino detector based on fiber-based hydrophones.

Summary:

In this talk we will discuss the fiber-based hydrophone technology, first measurements performed with test setups and the feasibility of a potential future large scale neutrino detector based on fiber-based hydrophones.

Th AM I / 39

Performance of the ARIANNA Neutrino Telescope

Author: Corey Reed[1]

[1] *UC Irvine*

The ARIANNA experiment uses low noise, low power and inexpensive technology to search for radio pulses emitted by extremely high energy cosmic neutrino interactions. Three detector stations have been deployed in the Ross Ice Shelf of Antarctica, taking both environmental as well as radio pulse data. The stations are powered by solar and wind generators and transfer data north via wireless Internet and satellite modem peripherals. The performance of the stations in 2014 will be discussed and the effectiveness of the Ross Ice Shelf as a radio quiet environment will be examined. Preliminary searches for neutrino signals in the data will be presented.

Th AM II / 40

End to end calibration of the ARA detector

Author: Keiichi Mase[1]

[1] *Chiba University*

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Coherent Cherenkov radio emissions from particle cascades were predicted by Askaryan, and the emissions were firstly detected at SLAC from the electro-magnetic cascades. Askaryan Radio Array (ARA) is being built at the South Pole to observe cosmogenic neutrinos by detecting the coherent radio emissions with the large instrumental area of about 100 km^2. We are planning an end to end calibration of the ARA detectors by using a LINAC installed at the Telescope Array experiment site. The detail of the calibration and the current status will be presented.

Th AM II / 41

First data analysis steps for the Askaryan Radio Array stations

Author: Thomas Meures[1]

[1] *o=ulb,ou=Institutions,dc=icecube,dc=wisc,dc=edu*

The Askaryan Radio Array (ARA) is one of the future neutrino observatories focusing on the detection of GZK-neutrinos with energies beyond 1017eV through secondary radio waves. Observing GZK-neutrinos is especially interesting because it is one of the few ways to investigate the CR-spectrum beyond the observed GZK-cutoff. These neutrinos, when reaching the earth, produce particle cascades in different media like ice and rock salt which, in case of the above mentioned energies, emit detectable radio waves through the Askaryan effect.
ARA is currently in the building phase and will be optimized to detect the radio emission from neutrino induced cascades with primary energies greater than 1017eV. A grid of 37 antenna clusters, spaced by 2 km, is planned to be deployed in the South Pole ice, at a depth of 200 m. The full ARA detector will cover an instrumented area of about 100 km2, and as built will be the most cost-effective neutrino detector in the energy range between 1017eV and 1019eV.
Three ARA stations, each consisting of 16 measurement antennas, and one prototype station are already deployed in the ice. All of them are functioning as independent detectors each with full detection and reconstruction capabilities.
In this contribution, the first analysis steps of data from two of the three stations are presented.

Th AM I / 42

Askaryan Radio Array (ARA): Status and Performance

Author: Carl Pfendner[1]

Co-authors: Amy Connolly [1]; Eugene Hong [1]

[1] *Ohio State University*

Corresponding Author: pfendner.1@osu.edu

The Askaryan Radio Array (ARA) is an ultra-high energy (UHE) cosmic neutrino detector located at the South Pole. The cosmic ray flux cut off above primary energies of 10^19.5 eV leads us to expect a UHE neutrino flux due to the GZK effect. The detection of these UHE cosmic neutrinos will add to the understanding of the sources and physics of UHE cosmic rays.

ARA uses the radio Cherenkov technique to search for UHE neutrinos by deploying radio frequency (RF) antennas at 200m depth in the Antarctic ice and searching for impulsive RF signals. A prototype ARA Testbed station was deployed in the 2010-2011 season and the first design-level ARA stations were deployed in the 2011-2012 and 2012-2013 seasons.

Three independent analysis methods have been developed in the search for UHE neutrinos with ARA. I will present the results of these first neutrino searches with 2011-2012 ARA Testbed data. I will also present the preliminary efforts of the extension of these methods to the analysis of the design-level stations.

Mon AM II / 43

Status and Recent Results of the Acoustic Neutrino Detection Test System AMADEUS of ANTARES

Author: Robert Lahmann[1]

[1] *Erlangen Centre for Astroparticle Physics*

The technique of acoustic neutrino detection is a promising approach for future large-scale ultra-high-energy neutrino detectors in water. To investigate this technique in the deep sea, the AMADEUS system has been integrated into the ANTARES neutrino telescope in the Mediterranean Sea. Installed at a depth of more than 2000m, the 36 acoustic sensors of AMADEUS are based on piezo-ceramics elements for the broadband recording of signals with frequencies ranging up to 125kHz. Acoustic data are continuously acquired and processed by applying online filter algorithms to pre-select a high-purity sample of neutrino-like signals. Transient signals in the deep sea are of manifold origin and can mimic the acoustic signature of a neutrino interaction. In order to assess the background for acoustic neutrino detection in the deep sea, the characteristics of these transient signals and of the ambient noise have been investigated. To this end, an offline analysis package for the pre-selected data was developed, including signal classification and acoustic source reconstruction algorithms. To test and validate the performance of the analysis package and to simulate the response of the system to neutrino interactions, a complete simulation chain was developed.
In the presentation, the AMADEUS system will be described. Selected recent AMADEUS results will be discussed and first conclusions concerning the feasibility of acoustic detection of ultra-high-energy neutrinos in the Mediterranean Sea presented.

Summary:

In the presentation, the AMADEUS system will be described and selected recent AMADEUS results will be discussed.

Mon AM II / 44

Lake Baikal acoustic neutrino activities

Author: Nikolay Budnev[1]

[1] *Irkutsk State University*

TBD

Mon AM I / 45

Muppets and the EeV sky

Author: Francis Halzen[1]

[1] *University of Wisconsin-Madison*

TBD

Mon AM I / 46

Radio detection of neutrinos

Author: Kara Hoffman[1]

[1] *o=umd,ou=Institutions,dc=icecube,dc=wisc,dc=edu*

TBD

Weds PM II / 47

From the earth to the moon.

Author: Olaf Scholten[1]

[1] *KVI-CART, Univ. of Groningen*

TBD

Th AM I / 48

GNO - Greenland Neutrino Observatory

Author: Keith Bechtol[1]

[1] *KICP, University of Chicago*

The goal of the proposed Greenland Neutrino Observatory (GNO) is to discover and study ultra-high energy neutrinos by looking for radio emission from particle cascades induced by these neutrinos in the Greenland ice sheet. GNO will consist of an array of radio antenna stations deployed near Summit Station in central Greenland, sitting atop a 3 km deep ice sheet. Preliminary analysis of field measurements indicate a radio attenuation length of approximately 1000 m at 300 MHz in the upper 1.5 km of ice. We are currently investigating the logistics of operating at Summit Station, assembling a prototype station to be deployed in spring/summer 2015, and developing simulation tools to optimize the design and configuration of the future array of antenna stations.

Mon PM I / 49

Modeling radio emission from particle showers in dense media and air: a pedagogical overview.

Author: Alvarez-Muniz Jaime[1]

[1] *Dept, of Particle Physics, Univ. of Santiago de Compostela, Spain*

I will review the current understanding of radio emission from particle showers in both dense dielectric media and the atmosphere. A net charge is generated in those showers due to the Askaryan effect in dense media, and to Askaryan as well as geomagnetic effects in air. I will discuss macroscopic and microscopic approaches to model the emitted radiation. The prominent role of shock wave effects similar to those observed in Cherenkov radiation will be emphasized.

Tues AM I / 50

Digital radio detection of cosmic rays: achievements, status and perspectives

Author: Tim Huege[1]

[1] *Karlsruhe Institute of Technology*

Over the past decade, radio detection of cosmic rays has matured from small-scale prototype experiments to installations spanning several km^2 with more than a hundred antennas. The physics of the radio signal is well understood and simulations and measurements are in good agreement. We have learned how to extract important cosmic ray parameters such as the geometry of the air shower and the energy of the primary particle from the radio signal, and have developed very promising approaches to also determine the mass of the primary particles. At the same time, limitations, both technical and intrinsic to the radio emission physics, have become increasingly clear. I will review the progress made in the past decade, discuss where the field stands and provide a personal view on the limitations of the technique and further potential for future development.

Th AM II / 51

Interferometric Techniques for Radio Impulses from Ultra-high Energy Particle Showers

Author: Andrew Romero-Wolf[1]

[1] *Jet Propulsion Laboratory*

Interferometric techniques are widely applied for a variety of radio detectors ranging from cosmology (redshifted 21 cm line and cosmic microwave background), radio astronomy (astrometry, imaging, and transient detection), and lightning. We present an interferometric technique for the reconstruction of ultra-wide band impulsive signals from ultra-high energy particles. This highly sensitive method was developed for the search for ultra-high energy neutrinos with the ANITA experiment but is fully generalizable to any antenna array detecting radio impulsive events from ultra-high energy particles. Applications of the interferometric method include event reconstruction, thermal noise and anthropogenic background rejection, and solar imaging for calibrations. We illustrate this

technique with applications from the analysis of the ANITA-I and ANITA-II data in the 200-1200 MHz band. The ANITA collaboration has been developing a real-time interferometric trigger for the detection of ultra-high energy neutrinos and cosmic rays. I will discuss some of the key trades required in the application of interferometry to a real-time high data rate system. The interferometric trigger is expected to fly in the ANITA-3 balloon experiment in the 2014-2015 season.

Th AM I / 52

ANITA: analysis and program status

Author: David Seckel[1]

[1] *University of Delaware*

A review of the instrument and science program is given, including the status of reanalysis of the cosmic ray events detected by the ANITA-I payload, and plans for ANITA-III.

Mon AM I / 53

Welcome

Authors: David Seckel[1]; Kara Hoffman[2]

[1] *University of Delaware*

[2] *o=umd,ou=Institutions,dc=icecube,dc=wisc,dc=edu*

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Washington DC Tour / 54

More information about DC

Pick up at Loews is between 1:15 and 1:30 PM. Guide will meet those who want the group tour at Smithsonian Castle on the Mall side. This tour will end at 5:00 PM. Bus will pick up passengers there and take them to the boat dock - the Dandy Zero on Prince Street in Alexandria, VA. The cruise will run from 6:30 PM to 9:30 PM, and includes dinner. The bus will pick up at the pier around 9:40 PM and return everyone to Loews.