Astron. Nachr. / AN **328**, No. 7, 593–624(2007) / **DOI** 10.1002/asna.200740001

Splinter Meeting A

Multi-Messenger Cosmic Particles

55 contributions

Chairperson:
JOHANNES BLÜMER, KARLSRUHE

Cosmic Ray Acceleration in Galactic Wind Shocks

A 54

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Galactic Cosmic Rays are observed over a wide range of energies from $\sim 10^9 - 10^{21}$eV. The energy spectrum of the particle flux is a powerlaw with an overall spectral index of -2.7 with a steepening at around 10^{15}eV (knee) and a flattening at $\sim 10^{18}$eV (ankle).

Diffusive shock acceleration quite naturally leads to a powerlaw with appropriate spectral index with an energy limit in SNRs at $\sim 10^{15}$eV, depending on the charge of the particle. Bell and Lucek (2001, *MNRAS*, **321**, 433), for example, reach higher energies by amplifying the upstream magnetic fields of SNRs non-linearly, whereas Völk and Zirakashvili (2004, *A&A*, **417**, 807) use 'Slipping Interaction Regions' generated by weak spiral density shocks in galactic winds to circumvent the limitations of SNRs.

According to CR clock measurements, energetic particles escape from the galaxy in a few times 10^7yrs. We therefore consider shock waves in galactic winds as a possible source of energetic particles between the knee and the ankle. If these shocks are strong they can reaccelerate these galactic cosmic rays to significantly higher energies.

We discuss a model in which galactic winds are described in a flux tube geometry (Breitschwerdt et al., 1991, *A&A*, **245**, 79) and reformulate the Fokker-Planck Equation in these coordinates. Approximate solutions for the particle distribution function, based on singular perturbation analysis, will be discussed. We find that it is possible to reaccelerate particles to energies up to 10^{18}eV.

Detection of Ultra-High Energy Cosmic Rays and Neutrinos with LOFAR

A 71

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It has been realized in the last couple of years that the new generation of digital radio telescopes, such as LOFAR, offers a unique opportunity to directly observe the impacts of ultra-high energy cosmic rays and neutrinos. Brief radio flashes are produced when these particles hit the earth atmosphere or a solid surface such as the ice sheet in Antartica or the lunar regolith. In the former case the emission process is due to geosychrotron emission produced through interaction of air shower electron/positron pairs gyrating in the earth magnetic field while in the latter case a Cerenkov-like process is expected and observed in accelerator experiments. Radio emission of ultra-high energy cosmic particles offers a number of interesting advantages. Since radio waves suffer no attenuation, radio measurements allow the detection of very distant or highly inclined showers, can be used day and night, and provide a bolometric measure of the leptonic shower component. Significant advances in this field have recently achieved with our LOPES (LOFAR Prototype Station) experiment which has been installed at the Forschungszentrum Karlsruhe in Germany next to the cosmic ray detector array ”KASCADE Grande”. The experiment has detected and imaged the radio emission from cosmic rays, confirmed the geosynchrotron effect for extensive air showers, and found an excellent correlation between radio pulse strength and primary particle energy. Future steps will be the installation of radio antennas at the AUGER experiment to measure the composition of ultra-high energy cosmic rays and the usage of the LOFAR radio telescope as a cosmic ray detector. Here an intriguing additional application is the search for low-frequency radio emission from neutrinos and cosmic rays hitting the moon. Simulations indicate that particle events above 10^{21} eV can be detected from the ground which promises the best detection limits for particles beyond the so-called GZK limit and allows one to go significantly beyond current ground-based detector arrays. A pathfinder experiment with the Westerbork Synthesis Radio Telescope is currently under way and first experiments with actual LOFAR hardware will commence soon.

Status of the gravitational-wave detector GEO600

A 80

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The German / British detector GEO600 operates within a worldwide network of large scale gravitational-wave detectors. This presentation will give an overview of the current performance and future prospects.

Recent Results and Future of the MAGIC gamma-ray telescope

A 87

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The latest generation of very high energy (VHE) gamma ray Cherenkov telescopes has recently made many exciting new discoveries. The 17m MAGIC telescope is currently the largest single dish Cherenkov telescope in the world. It is optimized for VHE gamma ray astronomy with a low energy threshold. Recent results both on galactic and extragalactic sources will be presented. A second MAGIC telescope is currently under construction and is scheduled to start operation in the second half of 2007. The combined operation of the two telescopes will significantly increase the sensitivity and the angular resolution.

Cosmic ray detection with the radio technique

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In the last few years, radio detection of cosmic rays has once again become a very active field of research. The LOPES project in particular has researched its application to cosmic rays with energies of up to ∼1 EeV. Radio detection combines ∼100% duty cycle with excellent angular resolution and promises a favourable cost per instrumented area. Consequently, it has great potential for a large scale application to ultra-high energy cosmic rays and would be ideally suited to localise their sources via true particle astronomy. This contribution gives an overview of the results gathered so far with the LOPES project and discusses the current and future activities aiming at a large scale application of the radio technique in the framework of the Pierre Auger Observatory.

Cosmic Ray Physics with IceCube

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The IceCube Observatory offers a wide scientific spectrum for high energy cosmic ray physics. In parallel to the $1\,\mathrm{km}^3$ muon detector that is presently being built deep in the ice, a $1\,\mathrm{km}^2$ sized, triangular grid of Ice Cherenkov Tanks (IceTop) is set up on top of the south polar glacier. With this detector array it is possible to measure extensive air showers (EAS) induced by charged cosmic rays in the energy regime of $500\,\mathrm{TeV}$ to $300\,\mathrm{PeV}$. IceTop is thus able to study galactic and extragalactic cosmic rays at and well above the "knee" of the cosmic ray spectrum.

In terms of detector spacing and size, IceTop is comparable to the Kaskade-Grande array, but is complementary to that in location, detector technique and muon detection abilities. At an altitude of $2835\,\mathrm{m}$, IceTop can measure $1\,\mathrm{PeV}$ showers in the maximum point of cascade development, and the comparably thick target of ice in the tanks offers a good measurement of energy deposited by the shower particles. The deep muon detector can reconstruct muon bundles $< 100\,\mathrm{TeV}$ and therewith gives a good handle for cosmic ray composition studies. In addition, IceTop also serves the deep neutrino telescope as a veto for muonic background and as a calibration tool.

To reconstruct the primary energy of a cosmic ray particle, a fit to the lateral distribution of the air shower signals has to be performed. A functional description of expected lateral distributions and of the corresponding fluctuations of the measured signals was developed and will be presented. In 2006, IceTop already consisted of 16 detector stations. Using one month of data from that array, it is possible to extract an initial energy spectrum, not corrected for acceptance near threshold yet, that will also be presented.

To extend IceTop, a radio air shower detector could be built to significantly increase the sensitivity at higher shower energies and for inclined showers. As air showers induced by cosmic rays are a major part of the muonic background in IceCube neutrino detection, this will also enhance the vetoing abilities of IceTop. Air showers are detectable by radio signals with a radio surface detector. The major emission process is the coherent synchrotron radiation (geosynchrotron effect), emitted by $\mathrm{e}^+\mathrm{e}^-$ shower particles in the Earth's magnetic field. Simulations of the expected radio signals of air showers are shown. The efficiency and the energy threshold of different antenna field configurations are estimated.

The resonance-like gamma-ray absorption processes for use in astrophysics

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Recently we reported the very first detection of the γ-ray resonant absorption along the line of sight towards γ-ray bright quasars (QSOs), like 3C279, PKS0528+0134, and BL Lacertae (Iyudin et al. 2005). Those detections resulted from the analysis of the source spectral energy distributions (SEDs) based on the COMPTEL and EGRET data that were collected during monitoring campaigns of the Virgo and galactic anticenter regions by the Compton Gamma-Ray Observatory (CGRO).

We discuss three resonant absorption regimes that affect the γ-ray spectrum of point-like sources, as well as the potential of this γ- ray absorption method (GRAM) to constrain the abundance of the absorber.

The most important processes for photon beam attenuation are the photo-effect for photon energies $\leq$ 100 keV in gaseous matter, followed by Compton scattering in the energy range of 100 keV$<E_\gamma<$10 MeV, and finally by e^+e^- pair production at higher energies (see, for example, Hubbell (1971)). At photon energies above $\approx$100 keV, both high-energy attenuation processes, Compton scattering and pair production, have a rather smooth functional dependence of the cross section on the photon energy (Hubbell 1971). These dependences are used to study different astrophysical phenomena in the gamma rays (Fichtel and Trombka 1981).
At the same time in the nuclear physics community is well known that the total absorption cross section of photons by nuclei have three energy bands with resonant-like features in the cross section, namely at energies of $\sim$7 MeV ("pygmy" dipole resonance (PDR) region), 20-30 MeV (giant dipole resonance (GDR) region), and $\sim$325 MeV (Δ-resonance region) (Ahrens 1985). The fourth regime of the resonance absorption in MeV energy range, the so-called nuclear resonance fluorescence (NRF), will be only briefly discussed in this talk. The best studied of above regimes are the giant dipole resonance (GDR) and the Δ-isobar region (Fig. 1 in Ahrens 1985). The total photon absorption cross section of nuclei has a nearly zero value at the energy slightly below the pion mass of $\sim$140 MeV, and is rather small in the "shadow" region, i.e. at $E_\gamma \geq$2 GeV. For the lightest nuclei after the Δ- resonance, one can see also a small bump related to the N^*-resonance production at $E_\gamma \sim$750 MeV, which is most pronounced in the photon-hydrogen interactions. For heavier nuclei this resonance is smeared due to the "shadow" effect, i.e. nucleons are shadowing each other in the nuclei; and this interference leads to almost zero value of the N^*-resonance cross section of heavy nuclei (Ahrens 1985).

Contribution of the resonant photo-absorption processes of nuclei relatively to the total photon attenuation varies from 2% to 9% for the GDR, depending on the nuclei mass number and nuclear structure (Hubbell 1971), and it is smaller for Δ-resonance absorption.

The PDR energy region with the resonant behaviour of the photon absorption cross section is located in the MeV region (Axel 1962; Van Isacker, Nagarajan, and Warner 1992), i.e. below the threshold energies of the photoparticle production in reactions like (γ, n), (γ, p), and/or (γ, X).

We discuss the advantages and drawbacks of applying this method to study absorbers in different astrophysical environments, and compare this new method to AGN's absorber studies at X-ray or other wavelengths. We discuss also GRAM applicability to identify the EGRET unidentified (EUID) sources as QSOs (Iyudin et al. 2007), or to studies of the early Universe.

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Geometry reconstruction of air shower fluorescence detectors revisited

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Since the 60's, when the use of extensive air shower (EAS) fluorescence light yield for the ultra high energy cosmic rays (UHECR's) detection was first proposed, many past, current and future experiments [1, 2, 3, 4] utilize the effect to get a clue about the origin of cosmic rays.

The emitted fluorescence light of EAS is used to reconstruct the shower geometry and energy. The standard fitting procedure for the shower core location and direction starts with the determination of the plane containing the shower axis and the detector. This so called shower-detector plane (SDP) fit uses pointing directions of the triggered photomultipliers (PMT). To determine the shower orientation within the SDP the correlation between viewing angle χ_i and trigger times of the PMTs are used and a best-fit geometry with the expected arrival time at the telescope is accomplished. The "classical" calculation of the light arrival time t_i is motivated by basic geometrical considerations and is derived in textbooks (e.g. [5]):

$$t_i = t_0 + \frac{R_p}{c} \tan\left(\frac{\chi_0 - \chi_i}{2}\right) \tag{1}$$

where t_0 is the time at which the shower passes the closest point at distance R_p to the detector, χ_0 the angle in the SDP between the shower axis and the horizon, and c the speed of light in vacuum. The best fit parameters R_p, t_0 and χ_0 in Equation (1) are then found by minimizing a χ^2-function. The uncertainty of the three parameters depends on the particular shower geometry and is propagated also for the determination of primary energy and depth of shower maximum.

In Eqn. (1), it is assumed that everything *(i)* propagates with vacuum speed of light, *(ii)* takes place instantaneously, and *(iii)* propagates on straight lines. We check these assumptions and provide corrections.

(i) The propagation speed of fluorescence light $v = c/n$ is reduced by an index of refraction $n > 1$ which is a function of the traversed medium and wavelength λ. To estimate the impact of a realistic atmosphere we calculated the difference of the light arrival times between the cases of vacuum and realistic speed of light from different parts of the atmosphere. Differences are larger for light propagating near the earth surface with average arrival time differences of 20-25 ns.

(ii) Another additional delay $\tau_\nu(h)$ to the expected arrival time are de-excitation processes within the shower development induced by low energy electrons and positrons (~ 40 MeV). Almost all of the air fluorescence (in the wavelength range between 300 nm and 400 nm) originates from transitions of molecular nitrogen N_2 or molecular nitrogen ions N_2^+. De-excitation times can be of the order of 30-40 ns but are reduced by quenching effects especially at low altitudes where the air-density is larger [6].

(iii) In addition to the time delay, the light path also changes according to Fermats principle resulting in an abberation of the viewing angle χ_i. Consequently a simple back-extrapolation of the light arrival direction overestimates the height of the actual point of emission. An angular difference of $\alpha_{obs} - \alpha_{real} \sim 0.05$ deg implies a 30 m shift in height at 30 km distance which would cause a delay of $\sim$100 ns for the expected impact time on ground. This is particularly important for so called hybrid observations where the same EAS is detected by the ground array and a fluorescence detector, as is realized at the Pierre Auger Observatory.

Taking these effects into account the corrected calculation of t_i becomes

$$t_i = t_0 + \frac{R_p}{c'_i}\left(\frac{1}{\sin(\chi_0 - \chi'_i)}\right) - \frac{R_p}{c}\left(\frac{1}{\tan(\chi_0 - \chi'_i)}\right) + \tau_\nu(h) \tag{2}$$

where c'_i accounts for the reduced speed of light, and χ'_i for the bended viewing angle and $\tau_\nu(h)$ for the delayed de-excitation. The corrected formula is being implemented in the standard Auger reconstruction software. The corrections amount up to $\simeq 0.2$ deg in arrival direction and a few percent in primary energy.

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Supermassive Binary Black Holes & Radio Jets

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Radio jets in Active Galactic Nuclei are complex phenomena and become even more complex in the the close vicinity to the assumed Black Hole. Highest resolution VLBI information in combination with broadband flux-density monitoring (from the radio- to the TeV-regime) enables us to study the emission as well as the kinematic processes in these objects. I will discuss jet-related phenomena like e.g., periodic oscillations, present evidence for a new kinematic scenario of plasma component motion and will speculate about supermassive binary black holes in the center of AGN.

Muonic Component of Air Showers Measured by KASCADE-Grande

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The KASCADE-Grande experiment, located at Forschungszentrum Karlsruhe, consists of a large scintillator array for the detection of charged particles from extensive air showers in the primary energy range $10^{16} - 10^{18}$ eV. While the KASCADE-Grande detectors measure the total number of charged particles in an air shower, the colocated KASCADE array (approximately 10 times smaller area than the Grande array) is able to measure the muonic component separately from the electronic one due to iron/lead absorbers above the muon detectors, resulting in a muon threshold of 230 MeV. Using an appropriate lateral distribution function, one can extrapolate the total muon number of the air shower from the muon signals measured locally with the KASCADE array, even in case the core is located in the KASCADE-Grande array, but not in the KASCADE array itself. Subtracting the estimated number of muons from the total number of charged particles measured with KASCADE-Grande yields the total number of shower electrons.

The separate measurement of muon and electron numbers is important for studying the energy spectra of different mass groups: starting with the two-dimensional electron–muon shower size spectrum and applying unfolding methods will lead to the desired spectrum. This pioneers the quest for a possible second knee in the total energy spectrum at E $\sim 10^{17}$ eV caused by heavy primaries. In addition, it will be possible to investigate the composition in the expected transition region of galactic to extragalactic cosmic rays. Investigating the muon number of air showers in combination with other observables also provides an opportunity to study hadronic interaction models.

For the goals described it is indispensable to reconstruct the shower sizes with highest accuracy. In our poster, investigations concerning systematic uncertainties in the reconstruction of the muon number are shown and the muon number spectra from KASCADE-Grande data for different zenith angle intervals are presented along with Monte Carlo simulations. The systematic error in the muon number reconstruction was determined to be smaller than 26% for zenith angles up to 70 degrees.

Furthermore, the measured muon lateral distributions are compared with simulated events and with the lateral distribution function used in the KASCADE-Grande reconstruction algorithm. The currently used function to describe the measured muon lateral distribution has only one free parameter, the total number of muons in the air shower:

$$\rho_\mu(r) = \mathrm{N}_\mu \cdot f(r) \text{ , with } f(r) = \frac{0.28}{r_0^2} \left(\frac{r}{r_0}\right)^{p1} \cdot \left(1 + \frac{r}{r_0}\right)^{p2} \cdot \left(1 + \left(\frac{r}{10 \cdot r_0}\right)^2\right)^{p3} .$$

The parameters $p1$, $p2$, $p3$ were obtained to be -0.69, -2.39 and -1.0 from simulated events produced with CORSIKA using the interaction model QGSJet 01. For this purpose, the fit results of the lateral distribution function to 10^{16} eV and 10^{17} eV proton and iron induced air showers were averaged. A scaling radius of $r_0 = 320$ m is used. In general, the used lateral distribution function provides good results in muon number reconstruction.

However, in some cases the above-mentioned comparison between measured muon lateral distributions and those predicted by the lateral distribution function show systematic differences because of the fixed shape parameter. At higher energies and core distances of less than 200 m the local muon density is underestimated by the used lateral distribution function by about 10%, whereas it is overestimated by about 10%–20% for distances larger than 500 m.
Finally, some results of the analyses of local muon density measurements are discussed.

Towards new frontiers: observation of photons with energies above 10^{18} eV

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The enormous progress of astronomy over the last decades is closely connected to the extension of observational windows beyond the optical. The current maximum energy of observed photons is $\sim 10^{14}$ eV. However, cosmic rays with energies as high as 10^{20} eV are measured. We discuss the prospects for detecting photons above 10^{18} eV using giant air showers (see also [1]). The search for these photons also completes current efforts of multimessenger observations of the universe using highest-energy neutrinos.

A "guaranteed" source of such photons is provided by the resonant photo-pion production by high-energy nucleons interacting with the cosmic microwave background. During propagation, the photons are sensitive to the universal radio background which is poorly known so far. Typical energy loss lengths estimated for $10^{19} - 10^{20}$ eV photons are of order 10 Mpc. At the earth, the photons induce air showers that can well be distinguished from hadron ones by the larger depth of shower maximum and the smaller content of shower muons. The detection sensitivity of the Pierre Auger Observatory greatly improves over the next years with increasing data statistics, particularly when completing the southern Auger site (in Argentina) with an extended northern one (planned in Colorado).

An observation of photons with energies above 10^{18} eV would bring the conquest of new observational photon windows to its natural upper end, and it would likely have significant impact on astronomy and physics in general.

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The IceCube Neutrino Telescope

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IceCube is a kilometer-scaled neutrino telescope presently under construction at the South Pole. It is the successor of the AMANDA neutrino telescope which takes data since the year 2000 and is now integrated into IceCube. Detectors such as IceCube are discovery experiments covering astronomy, particle physics and cosmology and are going to open a new window to the high energy Universe. Examples of their missions are given in the other contributions submitted to this Conference. They cover the search for diffuse or point-like astrophysical sources of high energy neutrinos, the measurement of atmospheric neutrinos and related particle physics questions, the measurement of spectrum and mass composition of charged cosmic rays, the search for exotic particles like dark matter candidates or magnetic monopoles, and the monitoring of the Galaxy for supernova explosions. For instance, with AMANDA the flux of atmospheric neutrinos, the standard candle of these telescopes - has been measured up to 100 TeV. With no sources of high energy extraterrestrial neutrinos yet found, limits on the corrresponding fluxes have been pushed down by more than one order of magnitude. This not only marks a step into unknown territory, but also allows to discard first realistic models for high energy neutrino production associated with the acceleration of hadrons.

Theoretical arguments suggest a cubic kilometer array for a reasonably high discovery chance. IceCube will cover a cubic kilometer of Antartic ice. The detector is located at the Amundsen-Scott Station at the South Pole. Photomultipliers in pressure-tight glass spheres detect the Cherenkov light emitted by charged particles which have been generated in neutrino interactions. The photomultipliers are fixed at cable-strings, at depths between 1.4 and 2.4 km. They are deployed into holes which have been drilled with hot water. IceCube will cover about 80 strings, in total 4800 photomultipliers. 22 strings have been deployed in the seasons 2004/05 (1 string), 2005/06 (8 strings) and 2006/07 (13 strings). The full detector is planned to be completed in the season 2010/11.

IceCube is complemented by IceTop, an air shower array at the surface just above IceCube. IceTop will consist of 160 tanks filled with ice. Photomultipliers record the Cherenkov light from air shower particles passing through the tanks. Operated together with IceCube, IceTop allows the study of cosmic ray mass composition. It also serves as veto and as calibration device for IceCube.

Presently, two extensions of IceCube are under discussion. For highest energies - above 100 PeV, a hybrid deep ice array including acoustic and radio detectors is conceived.This array might cover up to 100 square kilometers. For energies down to a few tens of GeV, a high density array of contained strings at the center of IceCube could be added. Also IceTop may be upgraded, with detectors recording the radio signals emitted by air shower particles.

The IceCube collaboration consists of 29 institutions in eight countries: Belgium, Germany, Japan, the Netherlands, New Zealand, Sweden, United Kingdom, USA. German participants are from DESY (Zeuthen), the Universities Aachen, Berlin (Humboldt), Dortmund, Mainz and Wuppertal, and the Max-Planck Institute for Nuclear Physics Heidelberg.

The ground-based gamma-ray observatory CTA

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Ground-based gamma-ray astronomy has witnessed a major breakthrough with the impressive physics results obtained by the current generation instruments, like H.E.S.S., MAGIC, CANGAROO and VERITAS. The excellent performance of the stereoscopic approach using imaging atmospheric Cherenkov telescopes has demonstrated the maturity of this type of technique. It makes possible precision measurements and in depth investigation of sources of very high energy gamma radiation (above $\sim$100GeV) as well as surveys of large fractions of the sky. The great success of this field has triggered an initiative to build the ground-based gamma-ray observatory CTA (Cherenkov Telescope Array). CTA aims for an improvement in sensitivity by about an order of magnitude with respect to current instruments, a significantly improved angular resolution and an extension of the accessible energy range from some 10 GeV to above 100 TeV. Together with the next generation instruments at other wavelength regimes, CTA will be a cornerstone in the multi-wavelength and multi-messenger exploration of the high-energy non-thermal universe. We will report on the status of the CTA initiative.

IceCube: Recent Results and Prospects

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IceCube, the only km^3-scale neutrino telescope under construction, has started recently physics data taking at the South Pole. A total of 22 deployed strings are now operating together with IceTop surface stations. The IceCube baseline design of string geometry, digital optical modules and DAQ is optimized to obtain the best performance in the energy range above 1-10 TeV, somewhat higher than the AMANDA threshold of around 50-100 GeV. Deployment of this baseline array is proceeding in parallel with the investigation of analysis and detection methods to exploit and extend the capabilities of the array at energies above and below this optimal

region. We will report about the principle physics results obtained with AMANDA detector. Moreover, first atmospheric neutrino spectrum seen in IceCube will be reported together with the expected performances of the full detector.

Acoustic and radio detectors could provide access to neutrino energies at the EeV and above. Neutrinos at such ultra-high energies are produced in interactions of highest energetic cosmic rays with photons of the cosmic micro-wave background. A large (100 km^3) hybrid detector around the IceCube instrumented region could give access to the detection of such "GZK-neutrinos". We will discuss here in particular about first results from in-situ measurements with the "South Pole Acoustic Test Setup" (SPATS) deployed during last season and future R&D plans.

AMANDA detector in operation since the year 2000, has been upgraded with a superior DAQ system (TWR) and its operations have been fully integrated with the newly deployed IceCube strings. In this way, AMANDA provides a densely instrumented region completely embedded in the volume of IceCube. The integration of the two detectors allows for cross-validation of the response of the newly deployed strings and provides increased sensitivity to events at lower energy, down to 50 GeV. Moreover, the IceCube strings nearest to AMANDA can be used in a veto configuration. This can in principle give access to the Southern Sky and in particular to the center part of our galaxy. Prospects for indirect dark matter search (WIMPs), neutrino galactic point source search and neutrino oscillation measurements using the integrated detector will be reported.

Particle Physics with AMANDA and IceCube

A 117

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Large neutrino telescopes are sensitive to neutrino energies well beyond those accessible in man-made accelerators and may therefore constrain poorly known heavy quark contributions, probe deviations from Standard model predictions to neutrino cross sections and test the theory of relativity. The extreme size of up to 1 km^3 provides sensitivity to rare and yet undiscovered particles such as magnetic monopoles and provides the potential to uncover the annihilation of dark matter particles gravitationally trapped in celestrial bodies such as the Sun. The extremely long base line to potential neutrino sources provides the chance to test tiny deviations of the flavor mixing angle, as expected to be induced by quantum gravity effects. In this contribution we concentrate on two analyses performed on data from the AMANDA-II experiment: the search for relativistic monopoles and tests of relativity using atmospheric neutrinos.

Search for monopoles: Cherenkov emissions of magnetic charges moving through matter will exceed those of electric charges by several orders of magnitude. The AMANDA neutrino telescope is therefore capable of efficiently detecting relativistic magnetic monopoles that pass through its sensitive volume. We present the most stringent limit to date on the flux of relativistic magnetic monopoles based on the analysis of one year of data taken with AMANDA-II. In contrast to previous analyses, which were restricted to monopoles entering from below the horizon, we also consider monopoles entering from above. The search for down-going monopoles has a lower mass-threshold, since lighter monopoles can penetrate the limited overburden above the detector. The analysis constrains the flux of relativistic magnetic monopoles with velocities close to the vacuum speed of light and $M_{\rm monopole} > 10^{11}$ GeV to less than $3.7 \times 10^{-17} {\rm cm}^{-2}{\rm s}^{-1}{\rm sr}^{-1}$ at the 90% confidence level. The flux of lighter monopoles ($M_{\rm monopole} > 10^{8}$ GeV) is limited to less than $28 \times 10^{-17} {\rm cm}^{-2}{\rm s}^{-1}{\rm sr}^{-1}$.

Tests of the Theory of Relativity: At energies beyond 100 GeV, the atmospheric neutrino zenith angle spectrum is minimally affected by mass-induced neutrino oscillations whose effect decrease inversely with neutrino energy. However, alternative oscillations that increase with energy may occur for example if maximal velocities of different neutrino flavors are allowed to differ by δc (violation of Lorentz invariance) or if neutrino species couple differently to the local gravitational potential ϕ. No indication for alternative oscillation effects were found in the AMANDA-II data from the years 2000 to 2003. For maximal mixing angles, an upper limit is set on both the Lorentz violation parameter $\delta c/c$ and the equivalence principle violation parameter $2|\phi|\delta\gamma$ of 5.3×10^{-27} at the 90% confidence level. One to two orders of magnitude higher sensitivities will be provided by the next-generation IceCube observatory.

Altitude dependence of fluorescence light emission by extensive air showers

A 118

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Fluorescence light is induced by extensive air showers while developing through the Earth's atmosphere. The actual fluorescence yield depends on the conditions of the air and on the energy deposited by the air shower at every stage of the development. In a formerly presented model calculation, basic pressure and temperature dependences have been considered. This study will show the additional influences of temperature-dependent collisional cross sections and of actual humidity profiles. The calculations will be applied to simulated air showers.

Neutrino-induced cascades in AMANDA & IceCube

A 120

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IceCube is a cubic-kilometer sized neutrino detector currently being constructed at the South Pole. Its forerunner, the prototype neutrino telescope AMANDA will be integrated in the new and larger detector. The charged-current interactions of high-energy electron or tau neutrinos, as well as neutral-current interactions of neutrinos of any flavor, can produce isolated electromagnetic or hadronic cascades. There are several advantages associated with the cascade channel in the search for a "diffuse" flux of astrophysical neutrinos, in particular the good energy resolution and the low background for such events. The energy resolution of AMANDA suffices to distinguish between a hard astrophysical spectrum and a soft atmospheric spectrum. In addition, the flux of atmospheric electron neutrinos is lower by an order of magnitude relative to atmospheric muon neutrinos, while the background from downward-going atmospheric muons can be suppressed due to their track-like topology. The low background in this channel allows us to attain 4π acceptance.

We show current results from the AMANDA detector and give an overview over the search for neutrino-induced cascades in IceCube. The data from AMANDA collected in 2000-2005 were analyzed for an astrophysical neutrino-flux. No indication for such a flux was found and we present a preliminary upper limit on the flux of the sum of electron-neutrinos, tau-neutrinos and muon-neutrinos of $\phi = 3.8 \times 10^{-7}(E_\nu/\mathrm{GeV})^2/(\mathrm{GeV\ s\ cm^2\ sr})$ (systematic error not included). The IceCube sensitivity to neutrino-induced cascade events, due to its volume of one cubic kilometer in its final configuration, will be almost two orders of magnitude better than the AMANDA sensitivity. We address the challenge of accurate simulation and reconstruction posed by the large energy range, from TeV up to hundreds of PeV, for which the detector may find neutrino induced cascades.

Enhancement Telescopes for the Pierre Auger Southern Observatory in Argentina

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The southern part of the Pierre Auger Observatory (PAO) is nearing completion in the province of Mendoza, Argentina. The instrument has been used to take air shower data at the highest energies since 2004. The energy threshold for high quality shower data is $3{\cdot}10^{18}$ eV for the 3000 km^2 surface array of particle detectors (SD). The data of the 24 fluorescence telescopes (FD) enable precise event reconstruction even below 10^{18} eV.

After the completion of the southern observatory in Argentina the Pierre Auger Collaboration intends to further expand its energy range down to nearly 10^{17} eV by three additional fluorescence telescopes (HEAT = High Elevation Auger Telescopes) with an elevated field of view from 30° to nearly 60°. It is planned to use these telescopes in hybrid mode in combination with a new part (25 km^2) of the Auger SD detector array with fourfold particle sampling density and additional underground muon detectors (AMIGA).

These enhancements will enable the southern PAO to cover the energy range of interest for the transition from galactic to extragalactic cosmic rays as well as the highest energy domain in a common experiment with good energy and mass resolution. Thus the Pierre Auger Observatory in Argentina will be extended to have a broad overlap with the data range of the KASCADE Grande experiment, as well as with the IceTop and Tunka projects, however, with 25 to 50 times the effective area of these. The HEAT layout and the properties of the combined Auger FD and enhancement telescopes are discussed.

Proton spectra from relativistic shock environments in AGN and GRBs

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The all particle spectrum of Cosmic Rays is typically explained by assuming shock acceleration of charged particles. Up to the first break in the energy spectrum ($E \sim 10^{15}$ eV), galactic sources like supernova remnants are the main source candidates. Above the second break ($E \sim 3 \cdot 10^{18.5}$ eV), extragalactic sources, in particular Active Galactic Nuclei (AGN) and Gamma Ray Bursts (GRBs) are among the most prominent candidates. In this contribution, Monte Carlo studies of relativistic shock environments as they occur in AGN and GRBs, are presented.

Astrophysical shocks can appear superluminal, meaning that the transformation into the de Hoffman-Teller frame ($\vec{E} = \vec{0}$) is not possible. Here, both super- and subluminal conditions are investigated. It is shown that superluminal shocks are only efficient up to energies of $E \sim 10^{14}$ eV and do not contribute significantly to the observed Cosmic Ray spectrum [1].

In the case of subluminal shocks, boost factors between $\Gamma = 10$ and $\Gamma = 1000$ are simulated. A single power-law fit is applied, $E^{-\alpha}$. The spectra reach maximum energies up to $E = 10^{21}$ eV and are therefore good candidates for the explanation of the Cosmic Ray spectrum above the ankle. The spectra are found to flatten significantly with increasing boost factor. While GRBs are highly relativistic ($\Gamma = 100 - 1000$), AGN have boost factors of around $\Gamma = 10$. This leads to spectral indices of AGN of around $\alpha \sim 2.2$, while GRBs have $\alpha \sim 1.5$, see also [2].

The results from the Monte-Carlo studies are compared to the observed Cosmic Ray spectrum by assuming that AGN and GRBs follow the star formation rate. Proton emission from GRBs does not fit the observed Cosmic Ray spectrum, since the simulated spectra ($\Gamma = 100 - 1000$) are too flat. The total AGN spectrum ($\Gamma = 10$), on the other hand, is shown to be well-suited to fit the energy spectrum of Ultra-High Energy Cosmic Rays.

References:
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[2] A. Meli, J. K. Becker. and J. J. Quenby *30th ICRC*, Mexico, July 2007.

The Baikal Neutrino Telescope - Physics Results

A 124

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The Baikal Neutrino Telescope is located in Lake Baikal, Siberia. It has been operating in its NT200 configuration from 1998-2004. In 2005, this telescope with 192 PMTs has been upgraded to NT200+. The new detector has an instrumented volume of 5 Mtons of water (almost 100 times more than NT200), and is tailored to the search for a diffuse signal from astrophysical neutrinos above 100 TeV.

In this contribution we report selected physics results obtained with NT200 on searches for astrophysical UHE neutrinos, on exotic particles like fast magnetic monopoles, and on neutralinos annihilating in the center of the Earth.

The Baikal-Telescope has been doing a number of pioneering works on the field of high energy neutrino astronomy with water Cerenkov detectors. Before the first permanent Mediterranean neutrino became operative very recently, Baikal was the only underwater high energy neutrino detector capable of monitoring the southern TeV-neutrino sky. Recently, an initative to construct a km3-scale detector in Lake Baikal has been started by the russian part of the collaboration. This instrument may contribute at the higher energy end (above few 10 TeV/ 100 TeV for muons/cascades) to the ongoing search for astrophysics neutrinos. DESY's mission in this pioneering experiment will be accomplished in 2008.

Searches for point-like sources of cosmic neutrinos with IceCube

A 127

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The IceCube observatory, located deep in the ice at the Geographic South Pole and including the AMANDA-II detector, can be used for searches for cosmic point sources of neutrinos over a wide range in energy. A primary channel is based on up-going tracks, using the Earth as a filter for atmospheric muons. With a sensitivity on the order of 10^{-7} GeV cm^{-2} s^{-1} for an E^{-2} spectrum, the analysis of data collected until the end of 2004 allows to set new limits on neutrino fluxes from pointlike sources in the northern hemisphere. Such a standard up-going analysis is limited to energies below the PeV scale due to the cross section of neutrinos increasing with energy. Above $5 \cdot 10^4$ GeV the interaction length becomes smaller than the diameter of the Earth, resulting in an angular window for a point source search at highest energies centered around the horizon. Several source models predict a significant neutrino flux in this part of the spectrum, for example from active galactic nuclei. The possibility of reducing the atmospheric muon background based on its softer spectrum makes an analysis feasible for these energies, enlarging the area were IceCube is sensitive to cosmic neutrino signals to parts of the southern sky. Improved algorithms for fitting muon tracks in the ice and event selection methods tuned to specifically select events with energies between 10^5 to 10^{10} GeV lead to a sensitivity that depends on the zenith angle with a best value of $5 \cdot 10^{-7}$ GeV cm^{-2} s^{-1} at the horizon. An analysis for highest energies based on AMANDA-II and one using the latest data taken with the still growing IceCube detector are performed in parallel. To identify the most promising source candidates, basic neutrino flux estimates are being calculated.

A particular class of promising source candidates are Starburst-Galaxies. What distinguishes Starburst-Galaxies from normal galaxies is their high star formation rate (SFR). The SFR of Starburst-Galaxies can be up to hundreds of times larger than the SFR in our own galaxy. Resulting from this high SFR, the rate of supernovae in Starburst-Galaxies is also high. Among these supernovae one expects also supernovae type 1c, which were found to be the predecessor of long duration Gamma-Ray-Bursts (GRBs). Thus a search for neutrinos from Starburst-Galaxies is also sensitive to undetected GRBs in these galaxies. A sample catalogue of Starburst-Galaxies is being developed, presently containing 199 galaxies. This sample can be used for an analysis with AMANDA-II or combined data from AMANDA-II and IceCube. The most promising analysis method for this task is the source stacking technique, which has previously been applied to Active Galactic Nuclei (astro-ph/0609534).

The MAGIC/IceCube Target of Opportunity Program test run

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Current neutrino telescopes are approaching a sensitivity that allows one to detect Active Galactic Nuclei (AGN) in their high state. However, the expected signals might be too weak to result in a significant detection. One possibility to increase the detection chance is to combine neutrino observations with the rich information available from observations in the electromagnetic regime (Multi Messenger Approach). A directional and time-like coincidence between one or more neutrino events with a signal, e.g. in the very high energy (VHE) gamma-ray regime, would increase the significance of the otherwise possibly too weak neutrino signal.

A major issue for such coincidence studies is the lack of simultaneous neutrino and VHE gamma-ray data. This is due to the low coverage of VHE gamma-ray observations in space and time. As opposed to that, neutrino telescopes operate at high duty-cycle ($> 80\,\%$) and cover more than 2π sr of the sky. Therefore, neutrino observations can be used to trigger follow-up observations by VHE gamma-ray telescopes. This is the idea of the the Neutrino triggered Target of Opportunity program (NToO), which aims at maximizing the amount of simultaneous neutrino/gamma-ray data, and enhance the significance of weak neutrino signals. In the long-term, the NToO prgram also aims at improving the knowledge about the phenomenology of the observed objects.

The NToO program was first implemented in a test run as a collaboration between the AMANDA-II and MAGIC telescope. The sources included in this test run were LSI+61 303, GRS 1915+105, 1ES 2344+514, 1ES 1959+650 and Mrk 421. These sources were chosen based on their known or expected variability in the VHE gamma-ray regime. The goal of the test run was to demonstrate the feasability of the concept and to gather experience with the technical details and with possible analysis schemes of the NToO program. The test run was successfully carried out from September 27th to November 27th 2006. An important ingredient for the NToO program is the estimation of the chance probability for coincidences of atmospheric neutrino events and gamma-ray high states (high state rate) which is needed for an estimation of possible coincidences. This contribution will present results from the NToO test run and address the question of estimation of high state rates and a possible method for the interpretation of the results.

Supernova detection with IceCube: from low to high energy neutrinos

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The AMANDA and IceCube observatories are optimized for the detection of neutrinos with energies beyond 100 GeV. Nevertheless, these detectors are also sensitive to intense flows of MeV neutrinos supernovae, producing leptons by charged and neutral current interactions in the ice surrounding the detectors. Bathed in the uniform glow of Cherenkov light, the photonsensors yield a coherent increase in their rates that can be distinguished from the low photomultiplier noise rate in the inert and cold ice. AMANDA is sensitive to supernovae in 92% of our galaxy and is contributing its signals to a supernova early warning system, that alerts optical astronomers. IceCube, with eight times more sensors and average noise rates below 300 Hz, will extend the sensitivity to the Magellanic Clouds. More importantly, IceCube will collect light from half a million neutrinos streaming out of a supernova collapse at the center of the galaxy, providing unprecedented precision for fine details in the emission time profile.

While core-collapse SNe are guaranteed sources of low-energy neutrinos, they might also be potent sources of high-energy TeV neutrinos. High energy neutrinos from Supernovae, besides being a remarkable discovery by itself, would proof the presence of internal jet production in Supernovae. Such jets are motivated by the recent association of Supernovae and Gamma-Ray Bursts. The predicted fluxes are large enough, that high-energy neutrino emission from Supernovae should be detectable with IceCube up to 100-200 Mpc distances. A novel search strategy will be discussed, which consists of complementing IceCube with optical follow-up observations. Triggered by a burst of high energy neutrinos, a network of optical telescopes scan the corresponding part of the sky. By searching for rising SN lightcurves as well as Gamma-Ray Burst afterglows through optical follow-up observations, one can significantly improve the perspectives for the detection of the transient sources. We describe the steps towards the creation of the global network of optical telescopes for follow-up observations of neutrino events and discuss its prospects.

Measurement of the UHECR energy spectrum from hybrid data of the Pierre Auger Observatory

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The world largest experiment for the measurement of cosmic radiation at highest energies is the Pierre Auger Observatory. Two complementary techniques are applied for the detection of the developing extensive air showers: surface detector stations measure the lateral distribution of particles at ground and fluorescence telescopes observe the longitudinal shower development in the atmosphere.

A combination of both measurements, so-called hybrid observations, i.e. measurements of the fluorescence telescopes in coincidence with at least one surface detector, permit a very accurate reconstruction of the characteristics of the air shower and the primary cosmic particle. In particular the energy reconstruction is very precise and almost independent of theoretical assumptions. However, due to the natural energy-dependence of the atmospheric volume observable by the fluorescence telescopes (higher energetic showers produce more fluorescence light and can be observed further away) and due to atmospheric effects, the aperture of hybrid measurements can only be determined by Monte Carlo simulations.

In the presented work the determination of the energy spectrum of cosmic rays from hybrid measurements is discussed. The determination of the fluorescence detector aperture and of its live-time is illustrated in detail and estimates of relevant systematic uncertainties are given. More than two years of hybrid data of the Pierre Auger Observatory are used to measure the flux and energy spectrum of cosmic rays above 10^{18} eV.

Extension of IceCube at Lower Energy: the Use of AMANDA as Nested Array and the Future Prospectives

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The IceCube design is optimized to obtain the best performances in the energy range from about 10 TeV up to highest energies exceeding 100 PeV. In parallel to the construction of the IceCube detector we are exploiting analysis and detection methods to extend the science capabilities of the experiment at higher and lower energies.

An efficient access to lower energies (below 10 TeV) is of primary importance for indirect dark matter search and for neutrino candidate galactic sources which present a steep energy spectra or cut-offs in high energy gamma-ray (for example the Crab nebula). Furthermore, if energies between 10 - 100 GeV can be accessed, atmospheric neutrinos can be used to study neutrino oscillations in this energy band.

A first and natural way to improve IceCube at lower energy is offered by the use of the AMANDA detector, IceCube predecessor taking data since the year 2000. AMANDA as densely spaced array is now fully embedded in the IceCube already instrumented volume. The operational status and the physics potential of the combined detectors is summarized. This includes hardware synchronization, combined triggering and online filtering as well as performance studies. A time synchronization between the both detectors providing a precision within a few nano seconds as required for the reconstruction of combined events was installed in the polar seasons 2005/06 and 2006/07. All AMANDA trigger enforce a readout of the IceCube detector also for low energy events below the IceCube energy threshold. The additional information from the IceCube strings allows for an improved reconstruction of the events with respect to the AMANDA detector only. A performance study of the combined detectors as currently operating is presented according to Monte Carlo simulations. An online filtering system at South Pole selects events of interest for physics analysis and transfers these information to the Northern Hemisphere taking into account the limited bandwidth for data transfer. The results of the simulations were used to optimize the low energy performance of this filter.

In the future, the low energy performance of the integrated IceCube detector can be further improved by an additional core of densely instrumented volume in the center of the completed IceCube array. This additional central core would have even better capabilities to separate contained events from passing tracks, as AMANDA will rather be near a corner of the instrumented volume. Moreover, it has recently been observed that the deepest ice (2100-2500 m depth) shows superior optical properties. This is where one would deploy such a dense core detector. The increased depth provides extra shielding against atmospheric muons and the minimal scattering of the Cherenkov light is particularly helpful for example in the reconstruction of contained events. Also the all-digital technology of the IceCube optical modules with time resolved signals will help in this respect when applied to this core. Performance studies of such a low energy extension are reported.

Searching for neutrinos with the Pierre Auger Observatory

A 135

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The Pierre Auger Observatory has the capability of detecting ultra-high energy neutrinos by searching for very inclined showers with a significant electromagnetic component. Such showers are characterised by a very elongated and asymmetric footprint. A significant electromagnetic component leads to broad detected signals which produce an asymmetry in the time structure. In this paper we study the possibility to detect neutrino induced extensive air showers at the Pierre Auger Observatory.

Search for Transient Emission of Neutrinos in IceCube

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Multi-wavelength studies of X-ray Binaries (XRBs) as well as Active Galactic Nuclei (AGN) have shown that the non-thermal emission of these sources can be strongly variable. It is reasonable to assume that a possible high energy neutrino emission from these sources could be also variable in time. We present here two strategies to search for neutrinos from these sources. In the first approach we search for clusters of neutrino events in the IceCube data and in the second approach we make use of astrophysical data to infer when we can expect neutrinos coming from the source (multi-messenger approach). We report about the principle of these searches, discuss their performances and give available results.

Cluster Search: For each preselected direction all combinations (clusters) of the arrival time of events within a certain angular bin are constructed. For each cluster its multiplicity is compared to the expected background and the significance of the cluster (S_{bg}) is calculated. The cluster with the highest significance (S_{bg}^{best}) is chosen as the "best". The overall probability (P), corrected for the trial factors due to many possible event combinations (clusters), to observe a cluster of significance S_{bg}^{best} or higher is calculated based on 10,000 Monte Carlo (MC) experiments. This approach is independent of any a priori assumption on the time structure of the potential signal. One of the most important requirements for this analysis is a correct background estimation over short time scales. So far the background was estimated using an ON/OFF-source approach, which is simple and fast, however fails when applied to short time scales due to the limited event statistics. To address this problem we developed a parametrization of the background which reduces its statistical uncertainty.

Multi-messenger approach: In the multi-wavelength approach we make use of the correlation between neutrinos and VHE γ-rays, due to the impossibility of distinguishing between a leptonic or hadronic nature of the γ-ray detections. In order to prevent a posteriori matching of the neutrino observations with γ-ray flares we first tested the event sample for a coincident γ-ray emission. For sources wich gamma-ray data for 2004 and 2006 are published, we establish a flux threshold above which we would consider the source as being in a high state. Then we calculate the number of neutrino events we observe and the integrated background in each of the high state periods, as well as the significance of this observation. The outcome of this test is declared positive if a significance equal or higher than 5σ is found. If no such an excess is found, we apply the time-clustering algorithm to the whole analysis period for a set of selected sources.

We also study some XRBs, using the available data from these sources to find out when they present suitable conditions for an efficient neutrino production; that is, when they present evidences of acceleration of particles and when they have a suitable target to interact. We investigate what are the posibilities of a neutrino detection given the energy budget available in these sources. In particular, we focus on LSI +61 303 a believed rotation-powered system, and on Cygnus X-3, an accretion-powered system. The modulation of the TeV emission detected in LSI+61 303 with the orbital period suggests that a hadronic origin is very likely. Due to the strong TeV absorption near the companion star, where we expect the neutrino production to be more efficient, we interpret the GeV emission detected by EGRET as absorption and subsequent cascading of the TeV photons produced in pp interactions between the accelerated protons and the matter from the very dense wind of the companion star. Assuming a distribution of protons matching the EGRET observations, we study the possible neutrino detection from this source. In the case of Cygnus X-3, we interpret the periods of strong radio flaring as an evidence of the injection of synchrotron emitting electrons. These radio flares are associated with transitions between different states in the system and with the production of powerful transient jets. We select this as a period of interest based on the assumption that the bulk Lorentz factor of these jets, and thus the energy available for accelerating particles, is higher than in other epochs of the system, such that we expect a more efficient neutrino production in this time. Since the presence of a considerable amount of accelerated protons in these sources is still a matter of debate, and therefore the neutrino production as well, we show the implications of either a detection or a non-detection from these sources in their current knowledge.

Acoustic Neutrino Detection in Antarctic Ice

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The measurement of neutrinos at highest energies $(E > 10^{17}eV)$ is one of the most challenging tasks in neutrino astronomy. A prominent source are the neutrinos produced in interactions of highest energy charged cosmic rays with photons of the cosmic micro-wave background during their propagation through the galaxy.

Required detection volumes are estimated to be of the order of 100 km^3 for the detection of typically ~20 events/year. A promising proposal is the construction of a large hybrid detector around the IceCube detector in the deep glacial ice-shield at the South-Pole. This detector aims for the coincident detection of the neutrino events with several different and complementary techniques. Besides the well established detection of optical Cherenkov photons this detector comprises acoustical sensors for the detection of sound due to the thermo-acoustic effect and radio antennas for the detection of the radio-Cherenkov signal, both generated by the hadronic cascade created in neutrino interactions with the ice.

These prospects have led to a sizable $R\&D$ program with the aim of acoustic neutrino detection. This contribution describes first results from in-situ measurements with the SSouth Pole Acoustic Test SetupSPATS- deployed in January 2007 in the upper part of three IceCube holes. Furthermore we detail the current and future $R\&D$ effort for the development of suitable sensors and detection systems, their calibration and the better understanding of the thermo-acoustic effect under laboratory conditions. For this purpose a test-facility has been established at the RWTH Aachen university in collaboration with DESY and the universities of Wuppertal and Ghent (Belgium).

AMANDA limits on the diffuse muon-neutrino flux: physics implications

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The Antarctic Muon and Neutrino Detector Array (AMANDA) in its final configuration has been taking data since 2000. In this contribution, the diffuse energy spectrum measured between 2000 and 2003 is presented. The unfolded spectrum follows the atmospheric prediction. Since no excess of an extagalactic signal is observed, limits can be set using the Feldman-Cousins method. At the highest energies ($E >$ 100 TeV), the limit to an E^{-2}-type flux $dN/dE \propto E^{-2}$ is given as

$$E^2 \cdot dN/dE < 2.6 \cdot 10^{-8}\,\mathrm{GeV\,cm^{-2}\,s^{-1}\,sr^{-1}}\,. \tag{3}$$

This value constrains different neutrino flux models, in particular those models assuming a connection between the diffuse X-ray background from Active Galactic Nuclei and neutrino emission [1,2,3]. The assumption of such a correlation contradicts the most recent limits. It can therefore be excluded, that X-ray emission from AGN is connected to neutrino emission [4]. This suggests that at most a low flux of ultra high energy cosmic rays emanates from X-ray selected AGN. Other scenarios like a correlation between high-energy (MeV-TeV) emission are still possible, since photohadronic processes can be responsible for the production of high-energy photons.

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Investigation of the Radio Emission of Cosmic Ray Air Showers with LOPES

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LOPES, a LOw Frequency ARray (LOFAR) - PrototypE Station, is an array of 30 inverted V-shaped dipole antennas which operates in the 40-80 MHz frequency range, measuring the radio emission of cosmic ray air showers in the Earth's atmosphere. The LOPES experiment is located at the site of the air shower experiment KASCADE-Grande (an extension of the KArlsruhe Shower Core and Array DEtector, KASCADE) at Forschungszentrum Karlsruhe, which provides the trigger and well reconstructed shower parameters (e.g. shower core position, shower direction, shower electron and muon sizes) for a primary energy up to 1 EeV.

Initially, the LOPES experiment was setup with 10 radio antennas (LOPES-10), aligned in the East-West polarization direction only. After one year of taking data with this configuration, the LOPES radio antenna array was extended to 30 antennas (LOPES-30), allowing a better investigation of the radio emission for individual air showers. In order to measure the full radio signal, the LOPES-30 experiment has recently been reconfigured for performing dual-polarization measurements. In addition, LOPES$^{\mathrm{STAR}}$, a 'Self Triggered Array of Radio detectors' has been developed for large scale applications of this technique, like at the Pierre Auger Observatory.

The LOPES antennas have an absolute amplitude calibration in order to estimate the electric field strength of the short radio pulse generated in air showers. To perform the calibration process, a commercial calibrated radio source is used as emitter for each LOPES antenna; all environmental effects like ground characteristics, atmospheric temperature and the set-up systematics are included. The emitter is a movable biconical reference antenna which is linearly polarized and has a nearly constant directivity near its principal axis. Each polarization direction corresponding to each LOPES antenna configuration is measured individually during the same campaign by varying the polarization angle of the reference antenna. By providing calibrated data, the LOPES experiment allows a direct comparison with theoretical predictions for the first time.

The general aim of LOPES is to investigate the radio signal by analyzing correlations with shower parameters. Dependence on the primary energy, the direction of the incoming shower (azimuth, zenith and geomagnetic angle), as well as the general detection threshold, the lateral extension and the polarization of the signal are important features in understanding the radio emission. In particular, the knowledge of the polarization characteristics is mandatory for the interpretation of experimental measurements to verify the geomagnetic origin of the radio emission from atmospheric showers.

For investigating the pulsed radio emission, air shower observables need to be known, e.g. shower size, number of muons, arrival direction and the shower core position as reconstructed by the KASCADE-Grande experiment. The showers have to fulfill quality cuts before a further processing of the radio information is performed. As the full LOPES data set consists mostly of low energetic showers ($\approx 10^{16}$ eV), the expected radio signal strength is relatively low. Therefore, for a first radio pulse analysis a preselection of high energetic showers based on restrictions in the electron and muon number is required. The further analysis of all candidate events requires a series of processing steps to determine the cross correlation (cc)-beam pulse height, which is the parameter of relevance for the correlation analyses. Such cc-beam radio pulses are fitted with a Gaussian function to quantify the height, which represents the emitted field strength.

The current status and first results of the LOPES experiment, including the analysis of dual-polarized measurements are presented.

The Northern Site of the Pierre Auger Observatory

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The Pierre Auger Observatory is a multi-national project for research on ultra-high energy cosmic rays. The Southern Auger Observatory in Mendoza province, Argentina, is approaching completion in 2007 with an instrumented area of 3,000 square kilometers. It will accurately measure the spectrum and composition of ultra-high energy cosmic rays up to and beyond the predicted GZK feature. We have obtained first results on the energy spectrum, mass composition and distribution of arrival directions on the southern sky. The Northern Auger Observatory is designed to complete and extend the investigations begun in the south. It will establish charged particle astronomy and thus open a new window into the universe. The distribution of arrival directions of the highest energy events will point the way to unveiling the almost century old mystery of the origin and nature of ultra-high energy cosmic rays. Achieving this goal requires collecting many more events in spite of the steeply falling energy spectrum. The planned northern site will have an instrumented area of 4,000 square miles (10,370 square kilometers) in South-East Colorado, USA.

Shower reconstruction and size spectra with KASCADE-Grande data

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KASCADE-Grande, located at Forschungszentrum Karlsruhe, is a multi detector experiment for the measurement of extensive air showers induced by primary cosmic rays in the energy range of $10^{14} - 10^{18}$ eV. With its 0.5 km^2 large field detector, in combination with the muon detectors of the KASCADE array, it allows the reconstruction of both the total electron and muon numbers, which are important observables for estimating the mass and the energy of the primary particles.

Grande consists of 37 scintillation detectors, with an average spacing of 137 m, organised in 18 hexagonal trigger cells of 7 stations each. Each station has a total detecting surface of 10 m^2. The signal is taken from by 16+4 PMTs of different gain and finally digitized by 3 Peak-ADCs covering the dynamic ranges $0.3 - 8, 2 - 80, 20 - 800$ particles/m^2 respectively. The systematic uncertainty on the measured particle density by each detector is less than 15% and the statistical uncertainties are dominated by poissonian fluctuations.

When requiring coincidence of all 7 stations of at least one trigger cell (0.5 Hz), the Grande array reaches full efficiency at a shower size $N_e \approx 10^{6.3}$, roughly corresponding to a primary energy of a few times 10^{16} eV.

Analysis of Grande array data provides information on core position, arrival direction and the total number of charged particles (N_{ch}) in the shower; the information on muon densities come instead from the KASCADE array. The analysis procedure develops in several steps: first, the total muon number and total number of charged particles are separately obtained by fitting the respective lateral distributions (a Lagutin function for muons and a modified NKG function for the electromagnetic component). In a second step, the contribution of muons to the densities of charged particles measured by Grande is taken into account and a combined fit of the muonic and electromagnetic component delivers the shower size N_e, the muon size N_μ, the position of the shower core and the arrival direction of the shower.

To test the reconstruction procedure and estimate the uncertainty, showers generated by CORSIKA, with QGSJetII/FLUKA interaction models, have been used as input for a detailed GEANT simulation of the apparatus. The output has been then analysed with the same procedure as used for real data.

Above the threshold of 2×10^6 electrons the core resolution is better than 12 m and shows no significant dependence on the primary particle. For the reconstructed electron number the statistical uncertainty is around 25% at threshold and with increasing shower size decreases slightly, as expected, while a bias evolves that reaches up to -15%. Furthermore, a comparison of real events independently reconstructed by Grande and KASCADE (core within a circle of 90 m radius from KASCADE centre) allows us to infer these accuracies directly from the data, using KASCADE reconstruction as reference. The results of this analysis show a resolution for core position and arrival direction of 6.4 m and $0.6°$ respectively; the shower size results have a systematic uncertainty of -5% and single event fluctuation up to 13%.

In this poster, preliminary results of the analysis of the current data set will be presented. In particular the lateral distribution of charged particles up to 700 m from the core and the shower size spectrum will be discussed. Also, with the capability of reconstructing both muon and electron numbers, it is possible to investigate the two-dimensional N_e vs N_μ size spectrum, that is the starting point for the application of an unfolding analysis that will lead to the determination of spectra for different mass groups.

Neutrinos from Gamma Ray Bursts: predictions and limits from AMANDA-II data

A 171

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The main purpose of the AMANDA-II experiment located in the deep ice at the geographic South Pole is the detection of high-energy neutrinos from astrophysical sources. One of the most interesting sources of such neutrinos are Gamma Ray Bursts (GRBs). Once detected by a GRB satellite, their position and time of occurrence is known, which gives the opportunity to reduce the atmospheric neutrino background significantly by the temporal and spatial selection of data. Since the bursts are selected according to the satellite detection, the satellites properties determine significantly, which kinds of bursts are used for the analysis. In this contribution, it is examined what the different GRB spectra look like for different satellite data sets. It can be shown that the coincident spectrum from BATSE bursts is about an order of magnitude brighter than the one for Swift bursts. In addition, a sample of short Konus bursts is investigated. Here, it can be shown that neutrino spectra from short bursts are generally one power steeper than the ones for long bursts.

The results from muon neutrino searches with AMANDA-II using temporal and spatial information provided by satellites of the third interplanetary network will be presented, focused on a class of not well localized bursts. These bursts are detected by two non-direction sensitive satellites, and thus can be localized within a narrow annulus or a banana shaped segment in the sky. This class of bursts has not been analyzed before. A new method to optimize background separation cuts for each burst individually will be introduced as well as improved detector stability tests. An upper limit on the muon neutrino flux will be presented.

Simulation study of shower profiles from ultra-high energy cosmic rays

A 172

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The identification of the primary particle type can provide important clues about the origin of ultra-high energy (UHE) cosmic rays above 10^{18} eV. The depth of shower maximum, X_{max}, of the air shower profile offers a good discrimination between different primaries. Its value can be extracted from a fit to the longitudinal shower profile. In this work we study the fit quality that is obtained with different functional forms for simulated shower profiles of nuclear and photon primaries. The impact of the functional form on the extrapolation to non-observed parts of the profile is commented on. We also investigate to what extent additional profile parameters such as the width of the profile or a reconstructed "first interaction" of the cascade can be exploited to improve the discrimination between the primaries.

A dedicated study has been performed on a set of simulated CORSIKA [1] showers induced by different primary particles. The sample consists of 750 protons, 500 iron nuclei, and 800 photons at an energy of 10 EeV.

FLUKA [2] and QGSJET1 [3] have been chosen as low and high-energy hadronic interaction models.

The average X_{max} of the simulated distribution for photons differs from that of hadrons by about 200 gcm^{-2} at 10 EeV. This evidence was used to set a limit to the photon fraction of the total cosmic-ray flux [4].

The possibility to exploit further information from the profile shape, like for instance the width, has been investigated. By the transformation into shower age, which aligns the profiles at their X_{max}, other trial functions, like a gaussian [5] and double gaussian [6], have been tested. The average relative residuals have been compared to quantify the agreement of the different fitting routines with the simulated profile.

Finally, a detailed study on the correlations among the parameters and the Principal Component Analysis (PCA) have been performed. The hadron-photon separation power of a simple X_{max} cut has been quantified and compared to the one achievable combining other sensitive observables. An enhancement of the photon-hadron separation power is found for both studied profile descriptions (gaussian and double gaussion in shower age). The PCA shows that the best cut is the one that combines X_{max} with the width of the single gaussian.
Further tests on those observables are planned especially for the Pierre Auger Fluorescence Detector including its full detector simulation.

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Upper limit to the photon fraction in cosmic rays above 10^{19} eV from the Pierre Auger Observatory

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The origin and nature of the most energetic cormic rays is still unknown. Many models have been introduced postulating exotic scenarios to explain the sources of these particles. A characteristic feature of these models is the prediction of a significant flux of photons at ultra-high energy [1].

The data taken at the Pierre Auger Observatory [2] offer a great potential to search for air showers initiated by ultra-high energy (UHE) photons, or to constrain the models with more stringent limits than previously measured.

Based on observations of the depth of shower maximum, we reported a limit to the fraction of photons in the integral cosmic-ray flux of 16% (95% c.l.) above 10 EeV based on 29 highquality hybrid events recorded in the period Jan. 2004-Feb. 2006 [3]. This is the first such limit on photons obtained by observing the fluorescence light profile of air showers. In this work we present an update of this analysis. We will also report results of an analysis using the Pierre Auger array data alone, which improves the event statistics by an order of magnitude.

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Astrophysics at MeV energies

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Radiation from cosmic objects in the astronomical window of MeV energies has not yet been explored in much detail. This is mainly due to the instrumental difficulties of overwhelming instrumental backgrounds and highly-penetrating radiation with a diversity of secondaries, which turn observations at sufficient sensitivity and resolution into a major experimental challenge. Experimental techniques from the fields of high-energy particle- and nuclear physics must be employed in space-based telescopes. Several experiments of the past decades have succeeded to lift the curtain and reveal a modest but already tantalizing number of cosmic phenomena and source types. Astrophysical emission processes are those of nuclear de-excitations, positron annihilations, and relativistic-particle emissions. Gamma-rays play an important role in efforts to clarify the nature of cosmic explosions and nucleosynthesis, because gamma-rays are more direct probes of these violent furnaces. Astronomy with radioactivities provides support for the basic concepts of synthesis of the isotopes in massive stars and supernovae. They also provide direct diagnostics of the dynamical state of the hot interstellar medium, and also from cores of supernova explosions. Gamma-ray burst emission is peaked at MeV energies, and we have yet to unravel what that tell us about the source of these most-energetic explosions in the universe. Gamma-rays from electron-positron annihilation, now mapped in the Galaxy, demonstrate a mismatch between expectations from nucleosynthesis with incurred positron production from beta+ decays and the observed annihilation rate. This suggests new positron-source astrophysics in the Galaxy, perhaps involving its dark matter content. We also have come to realize that our understanding of the high-energy universe is largely incomplete: Some sources of gamma radiation have not yet been fully explained or at least identified with known object types. Examples are the short gamma-ray bursts and the unidentified Galactic point sources, and MeV blazars, all of these constitute exciting frontiers of high-energy astrophysics. It is time for a concentrated effort of the community to 'dig deeper' and close the current gap in astronomical sensitivities in the MeV range.

Study of the Cosmic Ray Composition above 0.4 EeV using the Longitudinal Profiles of Showers observed at the Pierre Auger Observatory

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The Pierre Auger Observatory has been collecting data in a stable mann er since January 2004. We present here a study of the cosmic ray composition using events recorded in hybrid mode during the first years of data taking. These are air showers observed by the fluorescence detector as w ell as the surface detector, so the depth of shower maximum, $X_{\max}$, is measured directly. The cosmic ray compo sition is studied in different energy ranges by comparing the observed average $X_{\max}$ with predictio ns from air shower simulations for different nuclei. The change of $\langle X_{\max} \rangle$ with energy (elongat ion rate) is used to derive estimates of the change in primary composition.

Backgrounds for UHE horizontal neutrino showers

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The Pierre Auger Project is the largest cosmic rays detector ever built and it is covering an area of 3000 square kilometers on an elevated plain in western Argentina. The Auger Observatory is a "hybrid detector," employing two independent methods to detect and study high-energy cosmic rays. The detection of neutrinos is not the main aim of the Auger Observatory, but it can be considered as a very rich by-product. A possible signature of a neutrino-induced air shower is a near-horizontal event developing very deeply in the atmosphere at depths exceeding a few thousand g/cm^2. In order to study the characteristics of these showers, the Corsika program is used, with different input parameters and different primary particles. Making use of high-statistics shower libraries, we study the background for the neutrino events from:
(1) high-energy muons produced in primary proton events, which may propagate deeply into the atmosphere before initiating a subcascade.
(2) primary photons, which may start to cascade late due to a suppression of the Bethe-Heitler cross-section by the LPM effect.

The event rate of the background induced by high energy muons is investigated analytically. High energy muons from heavy flavor decay can induce young horizontal showers similar to the ν signatures. Several groups were investigating the prompt flux, and the debate over the years provided us several models. The theoretical uncertainties are huge, so the predicted possible background values spread over several orders of magnitude. This calculation neglects the energy loss, therefore, the estimated muon-induced event rates are upper limits. The estimate of the rate of the potential backgrounds for the neutrino showers detected by Auger is calculated and compared with various flux models of ultra-high energy neutrino production. For the most exotic perspective, the background rates almost rule out the ν detection, but, in such a case, one could think about an interesting capability to detect charm, once the appropriate tools to recognize the charm signature are there. However, this high rate is possible due to the assumption of a 10% charm production, which is not supported by the Akeno data. For the other two considered models, the predicted background rates are sufficiently low, opening an interesting window to study high energy neutrinos with Auger.

The Front-End Cards of the Pierre Auger Surface Detectors: Test Results and Performance in the Field

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The Pierre Auger Observatory, currently under construction in the Province of Mendoza (Argentina), aims at measuring cosmic rays at the highest energies with unprecedented statistics and resolution. The observatory comprises two major components: 1600 water Cherenkov detector stations distributed over an area of 3000 km^2 for measuring the charged particles associated with extensive air showers (EAS) and 24 telescopes with 30×30 degrees field of view and 12 m^2 mirror area each to observe the fluorescence light of EAS in clear moonless nights. The simultaneous observation of EAS by the ground array and the fluorescence light is called 'hybrid'-observation.

The Cherenkov light in each tank is detected by three 9-inch photo-multiplier tubes. The signals from the anodes (low-gain channel) and dynodes (high-gain channel) are transported on equal-length shielded cables to a Front End Board, attached to a Station Controller. The splitting of the signals allows extending the measured energy range to 15 bits with 5 bits overlapping. After passing 5-pole Bessel anti-aliasing filters with a cut-off frequency of 20 MHz, all analog signals are digitized at 40 MHz in AD9203 analog to digital converters (ADCs). The outputs of the six 10-bit Flash-ADCs are then processed by PLD Altera® chips (300MB/s) working as trigger/memory circuitry (TMC) supported additionally by Dual-Port RAM memory as a temporary buffer. The TMC evaluates the ADC outputs for interesting trigger patterns, stores the data in buffer memory, and informs the detector station micro-controller in case a trigger occurs. The station controller sends trigger packets and, when requested, event data to the observatory campus via a wireless network. A hierarchical event trigger is used to select events of interest and reject uninteresting events in order not to exceed the rate constraints imposed by the station micro-controller, the communications link bandwidth, and the central data acquisition system.

Prior to production of the full batch of 900 FEBs at Intratec-Elbau (Berlin, Germany), 10 units were manufactured in a preproduction batch to verify the new design. The boards were tested intensively in the lab and in the climate chamber and no malfunctioning was observed. In order to perform the acceptance tests of the full batch within a time period of about half a year, a highly automized test bench has been developed and installed in the laboratories at the Wuppertal and Siegen Universities each of which allowed to test up to 9 boards per day at temperatures of -20, $+25$, and $+70$ °C.

The FEBs had to pass the following acceptance tests at each of the three temperatures:

1. ADC noise $\sigma_n < 0.8$
2. ADC pedestal between 20 and 80 channels
3. Cross talk between channels $< 10^{-3}$
4. Cut-off frequency of analog filter in the range $15\ \mathrm{MHz} < f_C < 25\ \mathrm{MHz}$
5. global ADC non-linearity below $2 \cdot 10^{-5}$
6. differential non-linearity $\sigma_{\mathrm{ADC}} < 0.95$

In total, 29 of the 900 tested FEBs were rejected by the acceptance tests because of their ADC pedestal (2) or noise (7), differential non-linearities (6), global non-linearities (4), cut-off frequencies (6), non working ADCs (2), cross-talk (2), and problems in programming of the boards or wrong communication with registers (4). Some of these boards didn't pass several tests.

Finally accepted boards were coated with humidity sealer and shipped to the experimental site for installation. The results of the individual tests are compiled in a MySQL database and a graphical web-based interface is provided to make the data available to the collaboration and for future verifications.

By now, about 300 Cyclone FEBs are in operation in the field. No failure or malfunctioning was detected and the noise was found superior to previously used ACEX boards.

Monte Carlo Studies for MAGIC-II

A 187

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Located in the Canary island of La Palma, the MAGIC telescope is currently the largest imaging atmospheric Cherenkov telescope in operation. During the year 2007 it will be upgraded to a two telescopes system. The main goal is to improve the sensitivity with the stereoscopic operational mode. At the same time it will lower the analysis threshold of the currently running single MAGIC telescope. Results from the Monte Carlo simulations of this system will be discussed. A comparison of the two telescopes system with the performance of one single telescope will be shown in terms of sensitivity, angular resolution and energy resolution.

Measuring the proton-air cross section from logitudinal air shower profiles

A 194

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The current status and prospects of deducing the proton-air cross section from fluorescence telescope measurements of extensive air showers are discussed. As it is not possible to observe the point of first interaction, X_1, directly, other observables closely linked to X_1 must be inferred from the measured longitudinal profiles. This introduces a dependence on the models used to describe the shower development. Systematic uncertainties arising from this model dependence, from the reconstruction method itself and from a possible non-proton contamination of the selected shower sample are discussed.

The UHECR energy spectrum measured at the Pierre Auger Observatory

A 195

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The Southern part of the Pierre Auger Observatory is nearing completion, and has been in stable operation since January 2004 while it has grown in size. The large sample of data collected so far has led to a significant improvement in the measurement of the energy spectrum of UHE cosmic rays over that previously reported measurements, both in statistics and in systematic uncertainties.

We summarize the measurement of the energy spectrum based on the high-statistics surface detector data. The methods developed to determine the spectrum from reconstructed observables are described. The energy calibration of the observables, which exploits the correlation of surface detector data with fluorescence measurements in hybrid events, is presented in detail. The methods are simple and robust, exploiting the combination of fluorescence detector (FD) and surface detector (SD) and do not rely on detailed numerical simulation or any assumption about the chemical composition. Besides presenting statistical uncertainties, we address the impact of systematic uncertainties.

The complementarity of the two approaches to measure the energy spectrum, SD and hybrid, is emphasized and results are combined.

Highlights of Observations of Galactic Sources with the MAGIC telescope

A 203

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MAGIC [12,13] is currently the largest single-dish Imaging Air Cherenkov Telescope (IACT) in operation. Located on the Canary Island La Palma (28.8°N, 17.8°W, 2200 m a.s.l.), it has a 17-m diameter tessellated parabolic mirror, supported by a light-weight carbon fiber frame. It is equipped with a high-quantum-efficiency 576-pixel 3.5° field-of-view photomultiplier tube (PMT) camera. The analog signals are transported via optical fibers to the trigger electronics and the 2 GSamples/s FADC system.

We present the high lights of the observations of Galactic sources with the MAGIC telescope. The observations included the following objects:

• Unidentified VHE γ-ray sources coincident with Supernova remnants: MAGIC has taken data on a number of supernova remnants, resulting in the discovery of VHE γ-ray emission from a source in the SNR IC443, MAGIC

J0616+225 [8].Moreover, two recently discovered VHE γ-ray sources, which are spatially coincident with SNRs, HESS J1813-178 and HESS J1834-087 [1], have been observed with the MAGIC telescope [2,5].

• The supernova remnant Cas A [11].

• The Galactic Center [3].

• Pulsars and pulsar wind nebulae: the energy spectrum of the steady VHE γ-radiation from the Crab Nebula was determined from 60 GeV and 9 TeV [9]. Upper limits were derived to the pulsed VHE γ-ray emission from the Crab Nebula and and PSR B1951+3 [7].

• Binary system: variable VHE γ-ray emission was discovered from LS I +61 303 [4]. A hint for VHE γ-ray emission in an outburst of the black hole binary Cygnus X-1 was observed [10].

We briefly describe the observational strategy, the procedure implemented for the data analysis, and discuss the results for individual sources in the perspective of multifrequency observations. The observations give new insight into the physics of these objects and to the origin of cosmic rays.

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A design study for a 12.5 m Ø Imaging Air Cherenkov Telescope for ground-based γ-ray astronomy

A 207

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We present a design study for a new generation imaging air Cherenkov telescope (IACT) for future ground-based gamma-ray astronomy. The main goal is to considerably improve the performance (sensitivity, lower threshold) compared to current state of the art IACTs of the same mirror diameter, i.e. to reach eventually a better performance than that of the much larger 17 m Ø MAGIC telescope but at significantly lower costs. The key elements for the predicted improvements are:

• Use of Geiger mode avalanche photodiodes (G-APD) as photosensors yielding at least a factor 2 improvement in photon detection compared to classical bialkali photomultipliers. Tests of 3x3 mm prototype blue sensitive G-APDs installed on the MAGIC camera have confirmed the gain.

• A novel signal digitization using a 2-4 GHz ringsampler of 1024 channel depth, designed by the PSI. This novel design allows better signal recording, thus higher rejection of hadronic background and night sky background light. Other advantages of the sampler are very low cost, low power consumption and small size.

• Fewer and improved mirrors with higher reflectivity by dielectric coating, easier fabrication and lower costs, as well as improved light concentrators in front of the G-APDs. These optical elements should result in a 30% higher light collection onto the photosensors.

• The mechanical design of the telescope would be derived from the MAGIC design but be built nearly entirely from carbonfiber reinforced plastic components, resulting in a much lighter but stiffer telescope construction (total weight of moving parts < 15 tons).

Other parameters of the telescope are a gross hexagonal mirror with 12.5 m for the minor dimension, a focal length of 15 m (→ f/d ≈ 1.2), a segmented mirror of a parabolic profile and a 4.5° FOV camera of 1200 pixels. We estimate that the costs will be less than half of that of the MAGIC telescope (3.9 M Euro). The estimated performance improvement should be a 50% in sensitivity and a 30% lower threshold compared to MAGIC I. Based on the assumption that the majority of the component is produced in industry and a prepared site is available we estimate a 1.5-2 year construction time. This telescope could be used as evaluation model for the medium size telescopes of the CTA project or as a third telescope for the MAGIC array on La Palma.

The Future of Long-Wavelengths Radio-Astronomy in Germany: LOFAR and GLOW

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The German LOng Wavelength Consortium (GLOW) is a consortium of presently ten German institutions with the goal of coordinating the German participation in the LOFAR radio telescope and to represent German interests within the LOFAR project.

LOFAR stands for LOw Frequency Array and is a new radio telescope under construction by ASTRON in the Netherlands operating between 30 and 240 MHz. In this largely unexplored frequency range, LOFAR will be the dominant telescope over the next decade. The improvement in sensitivity and resolution by a factor of 100 - 1000 compared with present-day telescopes will open a new window to the Universe.

LOFAR leads the way for a new generation of radio telescopes that consist of a multitude of small and cheep antennas. Each station consists of 96 low-band (30-80 MHz) and high-band (110-240 MHz) antennas. 77 stations on five spiral arms of about 100 km total extent are planned and funded in the Netherlands. As there will be no moving parts, the costs for mechanical maintenance are low. The radio waves are sampled digitally, the signal then is transmitted over large baselines to a high-performance computing facility, where the radio images are synthesized in real time. This innovative design based on digital beam-forming will allow to point the telescope simultaneously at several positions on sky. Efficient suppression of disturbances by artificial signals (RFI) and the ionosphere that strongly limit present-day observations at low frequencies is possible with a digital telescope like LOFAR. The LOFAR design can be extended to a Wide Area Sensor Network which serves as ground breaking technology platform for a very broad range of science activities in fields such as geophysics or meteorology.

LOFAR can be considered as a pathfinder for a European participation in the Square Kilometre Array (SKA), the next-generation international radio telescope, which is envisaged for the years beyond 2015. The SKA is planned to cover most of the radio window accessible from the ground, from 100 MHz to about 25 GHz.

The key benefit of a German participation in LOFAR lies in the large baselines which, in turn, will lead to a significant increase of the power of this telescope and its astronomical applications. Similar LOFAR consortia have been founded in the UK, in France and in Poland. GLOW will be assigned a certain fraction of guaranteed observation time proportional to the hardware and software contributions. The experience gained with LOFAR is essential for a significant German participation at the SKA.

In Phase I from 2007-2009, four early German LOFAR Remote Stations located in Effelsberg, north of Garching, in Potsdam and in Tautenburg will be erected. The first station in Effelsberg has already started test observations in summer 2007. In order to reach the required resolution and sensitivity, in Phase II (2009-2012) another 6 stations or more should be established in Germany.

The science interests of the GLOW that LOFAR can address are in the fields of the Epoch of Reionization; cosmic rays and magnetic fields from the Milky Way, galaxies and galaxy clusters; extragalactic and stellar radio jets; surveys of radio sources; gravitational lensing; solar science; exoplanets; and astroparticle physics. GLOW will lead two LOFAR Key Science Projects on solar radio emission and on cosmic magnetism, and several GLOW scientists were invited to collaborate in Key Science Projects led by Dutch universities.

GLOW welcomes new partner institutes in Germany who want to invest themselves into the scientific and technological exploration of the new wavelength range opened by LOFAR.

Online Monitoring of the Pierre Auger Observatory

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The southern Pierre Auger Observatory is measuring cosmic rays at the highest energies in the Pampa Amarilla, Argentina, while awaiting the finish of its construction this year. The instrument has been designed to measure extensive air showers with energies ranging from 10^{18} – 10^{20} eV and beyond. It combines two complementary observational techniques, the detection of particles on the ground using an array of 1600 water Cherenkov detectors distributed on an area of 3000 km^2 (SD) and the observation of fluorescence light generated in the atmosphere above the ground by 24 wide-angle Schmidt telescopes positioned in four buildings on the border around the ground array (FD). The data taking of the different components of the Pierre Auger Observatory, has to be supervised by a shift crew on site to guarantee a smooth operation. A monitoring tool has been developed to support the shifter in judging and supervising the status of the detector components, the electronics and the data-acquisition (DAQ). The different detector sub-systems have different requirements. SD-tanks operate constantly in an semi-automated mode. Data acquisition must be monitored and failures of tanks or of their communication must be detected. The FD data-taking is organized in shifts. The sensitive cameras can only be operated in dark nights with not too strong wind and without rain. This makes the operation a full task for the shifters that have to judge the operation-mode on the bases of the information given. Data are collected online for this purpose in the regular measuring time as well as in dedicated modes e.g., for calibration or atmospheric surveys. While for some components like SD this information is directly transmitted to the DAQ on the central campus, for others it is stored in a database locally, e.g for FD within the four remote housings of the telescopes. These databases are replicated to the central server on the campus via a wireless long distance link. A web-interface implemented on a dedicated server can dynamically generate graphs and particular developed visualizations to be accessible not only for the shifter, but also for experts remotely from anywhere in the world. In addition, in case of special occurrences an alarm is triggered automatically. This tool does also offer a unique opportunity to monitor the long term stability of some key quantities and the data quality. The concept and its implementation will be presented.

OPTIMA-Burst - Catching GRB Afterglows (and other Transients) with High Time Resolution

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OPTIMA-Burst is a high time resolution optical photo/polarimeter specifically developed for the study of GRB afterglows. It combines a telescope with a quick response time to GRB triggers with a high-speed single-photon counting photo/polarimeter with accurate and absolute tagging of photon arrival-times. Thus the instrument facilitates cross-correlation studies with time resolved observations in other wavelengths, e.g. X-Rays. This allows unique insights into the physics of the ultrarelativistic jets assumed in GRBs and their Afterglows.

OPTIMA-Burst was deployed for three months in 2007 on the 1.3m Telescope of the Skinakas Observatory (Crete). On June 10th 2007, OPTIMA-Burst received trigger 281993 of the Burst Alert Telescope on board of the Swift satellite. OPTIMA-Burst slewed promptly to the burst's location, commenced CCD observations 1 minute, and high-time-resolution observations 5 minutes after the initial event. Our data reveals a flaring behaviour of the optical transient with a wealth of structure on timescales down to few seconds. The flaring activity was detectable with our instrument for the first three nights after the burst. We describe the activity, and discuss a possible type of source, explaining the observed characteristics.

JEM-EUSO mission

A 227

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JEM-EUSO is the mission to explore the extreme Universe with the Ultra High Energy Cosmic Rays. It is now in Phase A/B under the supervision of Japanese space agency JAXA. JEM-EUSO will increase number of events dramatically above GZK energy with the enough overlap with the present generation detectors Pierre Auger and Telescope Array. Above GZK energy we can expect the propagation distance of cosmic rays is limited and the deflection agnle of cosmic rays by the intergalactic magnetic field will be minimized, then we can have a fairly good prospect to indentify individual sources. In the talk, the status of JEM-EUSO and physics objectives will be discussed.

Rapid Variations in AGN: Clues on Particle Accelerators

A 232

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Rapid variations in AGN have continued to provide clues on new astrophysical concepts and processes ever since their discovery. Recent high-energy gamma-ray observations from HESS and MAGIC have illustrated that the most rapid variations occur at very high energies. This is not only at odds with the most simple synchrotron-self-Compton models for explaining the gamma-ray emission but also a genuine challenge to particle acceleration models in AGN and relativistic jets.

The spectral and temporal signatures are reviewed and discussed in the context of energetic constraints for models involving moderate and extreme relativistic corrections.

Systematic search for VHE gamma-ray emission from X-ray bright high-frequency peaked BL Lac objects

A 235

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Motivated by the fact that nearly all extragalactic sources detected so far at VHE energies belong to the so-called HBL class of high-frequency peaked BL Lac objects, a systematic scan of the compilation of X-ray blazars by Donato et al. (2001) has been performed using the MAGIC telescope. The observations took place from December 2004 to March 2006 and cover sources on the northern sky visible under small zenith distances $\mathrm{zd} < 30°$ at culmination, constraining the declination to values between $-2°$ and $+58°$.

The sensitivity of the search was planned for detecting X-ray bright ($F(1\,\mathrm{keV}) > 2\,\mu\mathrm{Jy}$) sources emitting at least the same energy flux at 200 GeV as at 1 keV. In order to avoid strong γ-ray attenuation close to the energy threshold, the redshift of the sources was constrained to values $z < 0.3$. Of the 14 sources observed, 1ES 1218+30.4 (for the first time at very high energies) and 1ES 2344+51.4 (strong detection in a low flux state) have been detected in addition to the known bright TeV blazars Mrk 421 and Mrk 501. For the remaining sources, we present here the 99% confidence level upper limits on the integral flux above $\sim 200\,\mathrm{GeV}$. A marginal excess of 3.5σ from the position of 1ES 1011+49.6 (with the largest redshift $z = 0.212$ so far reported for any extragalactic VHE source) may indicate another new source.

We compare the absorption corrected γ-ray luminosities at $200\,\mathrm{GeV}$ with simultaneous optical, archival X-ray, and radio luminosities, to constrain the statistical properties of the sample.

Prospects for GeV Astronomy in the Era of GLAST

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With the launch of the Gamma-Ray Large Area Space Telescope (GLAST) observatory imminent, we are about to enter a new epoch in observational gamma-ray astronomy. Improved sensitivity by more than a factor of thirty compared to the predecessor mission, better angular resolution, extended energetic coverage to allow for the first time ever overlap with low-threshold ground-based imaging atmospheric Cherenkov telescopes, and all-sky monitoring capability will truly provide us with a new window of opportunity for studying the objects and phenomena in high-energy gamma-rays. I'll describe how the expected performance of GLAST will predictably allow us to refine our current understanding of the GeV sky by giving various examples and an outlook in respect of its inherent discovery potential.

Improvements of the energy reconstruction for the MAGIC telescope by means of analysis and Monte Carlo techniques

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The Cherenkov telescopes of the third generation have delivered impressive results for several years and discovered lots of formerly unknown sources.

To crosscheck and optimize the energy reconstruction, we applied the unfolding algorithm with regularization (Blobel, Proc. CERN 85-09, 1985) to the problem and verified this method with an analysis of the crab nebula: The results are in good agreement with published energy spectra (e.g. Albert et al., ApJ, 2007). Within further research this unfolding is applied to extragalactic sources. This includes special studies to explore the energy range below 100 GeV.

Another approach to improve the quality of the energy reconstruction is to enhance realism of the Monte Carlo calculations used for it. Two seasonal atmopheric density models based on empiric models of the NASA program MSIS (Picone et al., JGR, 2002), which were derived from data taken by satellites and space probes, have been implemented in the MAGIC Monte Carlo software and show an impressive agreement with LIDAR (Schwarz, Thesis, 2002) measurements. This leads to improvements of the energy reconstruction especially below 100 GeV.

The results of both studies are presented.

Discovery of VHE γ-rays from BL Lacertae with the MAGIC telescope

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Out of 18 known extragalactic very high energy γ-ray sources, all except M87 (an FR-1 radio galaxy) belong to the so-called BL Lac objects, which have a relativistic jet that is closely aligned to the line of site. They are characterized by a two peak structure in the spectral energy distribution (SED), which spans from the radio, optical and X-ray band up to very high energies. Depending on the position of the first peak in the SED the BL Lac objects are further devided into the high peaked (HBL, peak in the X-ray band) and the low peaked (LBL, peak in the optical to UV band) BL Lac objects. BL Lacertae is the only LBL object, that has been detected at very high energies. This poster summarizes the results of observations during 2005 and 2006 and outlines the observation strategy for 2007. A possible correlation with the optical emission is also discussed.

Results of two observation cycles of LS I+61°303 with the MAGIC telescope

A 266

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The high mass X-ray binary (HMXB) system LS I+61°303 is composed of a Be star and a compact object, which can either be a black hole or a neutron star. The orbital period is 26.496 days with a periastron passage at ϕ=0.23±0.02. The system has been classified as a microquasar. However recent VLBA high resolution images show no jet light features, but reveal an extended structure, which evolves with the orbital period. The system is known for its periodic outbursts in the Radio and X-ray band. In the gamma ray regime EGRET measurements showed hints of variability.

The MAGIC telescope has observed LS I+61°303 for a total of 150 hours over two years resulting in a detection of the source during the first year. In this poster we present the results of these observations including the phase resolved lightcurve and spectrum.

Wide Range Multifrequency Observations of Northern TeV Blazars

A 267

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Blazars are amongst the most powerful astrophysical objects known. High frequency peaked BL Lac objects (HBLs), a subclass of blazars, represent to date the dominating species of established extragalactic VHE emitters. Despite extensive observational efforts, the knowledge on and understanding of these sources is rather limited. This is mainly due to the high flux variability on all timescales as well as a spectral energy distribution ranging from the radio band up to TeV gamma rays, making thorough investigations of the emission mechanisms only possible by simultaneous multifrequency observations.

The spectral energy distribution of HBLs is characterised by two pronounced peaks at X-ray and GeV - TeV energies, respectively. Hence, detections in these energy domains are essential to draw conclusions on the emission region. Former multifrequency campaigns were suffering from the low sensitivity of the VHE instruments which rendered only detections in high flux states possible. With the advent of the next generation of gamma telescopes, such as MAGIC and H.E.S.S., detections also in low or quiescent flux states as well as the localisation of the VHE peak become feasible.

We present the results of simultaneous observations in the optical (KVA), soft and hard X-ray (Suzaku) as well as very high energy range (MAGIC, H.E.S.S.) for different northern TeV blazars conducted in 2006.

Diffusive and convective cosmic ray transport in elliptical galaxies

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The origin of ultrahigh-energy cosmic rays is one of the open questions in astroparticle physics. These ionized atomic nuclei reach the Earth from outside the solar system with energy in the range of 10^9eV up to 10^{20} eV. The particles with energy $< 10^{17}$eV seem to originate in the Milky Way whereas the nuclei with the highest energies are usually considered of extragalactic origin.

Sources of these very high energy cosmic rays are still unknown. In literature mainly AGN and GRB are dicussed to be the major sources. Since AGN are surrounded by their host-galaxy, it becomes important to study the transport of the high energetic particles within these galaxies.

A special view is given to the nearby giant elliptical galaxy M87. Its AGN is because of the jet, in which particles are accelerated due to Fermi processes, a possible highly luminous source of cosmic rays. We developed an analytical solution of the diffusion/convection transport equation for cosmic ray protons in order to explain the spectra leaving the galaxy. The advantage of this is the fact that the model in general can be extended to all elliptical galaxies depending on the physical processes, which are responsible for spatial as well as momentum gains and losses.

We here present the obtained results for the analytical solution of the transport equation and give predictions for the proton-synchrotron spectrum in M87.

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