# Science with the New Generation of High Energy Gamma-Ray Experiments #6

Wednesday 8 October 2008 - Friday 10 October 2008

Padova

# Book of Abstracts

# Contents

**Galactic Sources 1 / 0**

## The time evolution of pulsar wind nebulae in the GeV-TeV domain

**Author:** Ocker Cornelis de Jager[1]

**Co-author:** Stefan Ferreira [2]

[1] *North-West University, Potchefstroom, South Africa*

[2] *Unit for Space Physics, NWU, South Africa*

**Corresponding Author:** okkie.dejager@nwu.ac.za

By solving the Euler equations with magnetization constraints, we can establish the time evolution of composite supernova remnants in the interstellar medium. For given pulsar/SNR parameters and ISM density, we obtain the radial profiles of the pulsar wind nebular field strength (for different sigma parameters) and adiabatic loss rates. Using these constraints we then solve for the time dependent transport of assumed lepton spectra injected at the pulsar wind termination shock, which can reproduce radio, X-ray and VHE gamma-ray observations. By following the evolution of these spectra we can also predict the time evolution of fluxes in the X-ray, GeV and TeV domain.

**Extragalactic Sources 2 / 1**

## Gamma ray emission and particle acceleration in galaxy clusters

**Author:** Gianfranco Brunetti[1]

**Co-authors:** Cassano Rossella [1]; Pasquale Blasi [2]; Stefano Gabici [3]

[1] *INAF-IRA, Bologna*

[2] *INAF-Osservatorio Astrofisico di Arcetri*

[3] *DIAS, Dublin*

**Corresponding Author:** brunetti@ira.inaf.it

The presence of non-thermal components in galaxy clusters, like relativistic electrons and magnetic fields, is demonstrated by radio observations that detect large scale synchrotron emission from the inter-galactic-medium of a fraction of massive clusters. On the other hand present observations can provide only upper limits to the energy content of relativistic protons.
GLAST has the potential to detect gamma-rays from the decay of pi-0 in galaxy clusters measuring for the first time the energy density and distribution of relativistic protons in the inter-galactic medium, while important constraints at higher energies may come from observations with Cherenkov arrays.
We discuss model expectations of non-thermal spectrum of galaxy clusters in the most general case in which relativistic electrons, protons and the generated secondary particles are embedded in a turbulent inter-galactic-medium.
In this scenario gamma rays are produced from the central Mpc-scale regions by pi-0 decay from long living relativistic protons, while radio (synchrotron) and hard X-rays (IC) are emitted from relativistic electrons re-accelerated by turbulence during cluster mergers.
We show that the combination of gamma-ray and radio observations will allow a leap forward in our understanding of the origin of relativistic particles and of the physics of particle acceleration mechanisms in galaxy clusters.

**Galactic Sources 2 / 2**

## Detection of pulsed gamma rays above 25 GeV from the Crab Pulsar with the MAGIC Telescope

**Authors:** Maxim Shayduk[1]; Michael Rissi[2]

**Co-authors:** Marcos Lopez [3]; Nepomuk Otte [1]; Thomas Schweizer [1]

[1] *Max-Planck-Institut fuer Physik, D-80805 Muenchen*

[2] *ETH Zuerich, CH-8093 Switzerland*

[3] *Universita di Padova and INFN, I-35131 Padova*

We present the detection of the Crab Pulsar above 25 GeV by the 17m diameter MAGIC telescope. We observed the Crab Pulsar between October 2007 and February 2008 using a newly developed trigger system, which allowed us to lower the energy threshold of the telescope from 55 GeV to 25 GeV. From previous non-detections of the Crab pulsar above 55 GeV and from the observations by the EGRET experiment below 10 GeV it is known that the Crab pulsar shows a spectral turnover in the energy region between 10 GeV and 55 GeV. We will present the energy of this turnover as well as a comparision of the light curve measured by our experiment with the one measured by EGRET.

**GRB, esotic and future 2 / 3**

## Cosmic Ray Nuclei in the Galaxy and their secondary products: a new comprehensive model.

**Author:** Dario Grasso[1]

**Co-authors:** Carmelo Evoli [2]; Daniele Gaggero [3]; Luca Maccione [2]

[1] *INFN, Pisa*

[2] *SISSA, Trieste*

[3] *Universita' di Pisa and INFN Pisa*

**Corresponding Author:** dario.grasso@pi.infn.it

We model the transport of cosmic ray (CR) nuclei in the Galaxy by means of a new numerical code which allows to account for a generic spatial distribution of the diffusion coefficient. We found that in the case of uniform diffusion, the main secondary/primary nuclei ratios and the modulated antiproton spectrum match consistently the available observations. We include in our analysis the recently released CREAM measurements and the preliminary PAMELA antiproton/proton data.
We generalise these results accounting for a radial dependence of the diffusion coefficient, which is assumed to trace that of supernova remnants. While this does not affect our successful predictions for the secondary nuclei and antiproton spectra, the simulated CR radial distribution and the gamma-ray diffuse emission longitude profile can be significantly different from the uniform case. We will discuss how this may play a role solving both the cosmic ray gradient and anisotropy problems.

**Galactic Sources 1 / 4**

## Massive stars in colliding wind systems: the high-energy gamma-ray perspective

**Author:** Anita Reimer[1]

**Co-author:** Olaf Reimer [1]

[1] *Stanford University*

**Corresponding Author:** afr@stanford.edu

Colliding winds of massive stars in binary systems are candidate sites of non-thermal high-energy photon emission. Long since, coincidences between massive star systems/associations and unidentified gamma-ray sources have been proposed. Only now, with the sensitivity of the Fermi Gamma Ray Observatory and current very-high-energy (VHE) Cherenkov instruments, will it be possible to conclusively probe these systems as high-energy emitters.

We will summarize the characteristics and broadband predictions of generic optically thin emission models in the observables accessible at GeV and TeV energies. The ability to constrain orbital parameters of massive star-star binaries by joined GeV-to-TeV observations will be discussed. As an example we will present orbital parameter constraints for the nearby Wolf-Rayet binary system WR 147 based on recently published VHE flux limits.
Combining the broadband emission model with the catalog of such systems and their individual parameters allows us to conclude on the expected population of massive star-star systems at high-energy gamma-rays.

**Extragalactic Sources 1 / 6**

# Formation of hard VHE gamma-ray spectra of blazars due to internal photon-photon absorption

**Author:** Dmitry Khangulyan[1]

**Co-authors:** Felix Aharonian [2]; Luigi Costamante [3]

[1] *MPI f. Kernphysik, Heidelberg*

[2] *DIAS, Dublin*

[3] *HEPL/KIPAC, Stanford*

**Corresponding Author:** dmitry.khangulyan@mpi-hd.mpg.de

The energy spectra of TeV gamma-rays from blazars, after being corrected for intergalatic absorption in the Extragalactic Background Light, appear unusually hard. We show that the internal absorption of gamma-rays caused by interactions with dense narrow-band radiation fields in the vicinity of compact gamma-ray production regions should lead to the formation of very hard gamma-ray spectra. Moreover, synchrotron radiation of secondary electron-positron pairs (which has rather unusual dependence on the production region bulk Lorenz factor) fits well into observation data of some objects (e.g of distant blazar 1ES 1101-232).

**Summary**:

The internal absorbition of VHE emission allows significant relaxation of the current tight constraints on particle acceleration and radiation models. The suggested scenario of formation of hard gamma-ray spectra predicts detectable synchrotron radiation of secondary electron-positron pairs which might require a revision of the current “standard paradigm” of spectral energy distributions of gamma-ray blazars.

**Galactic Sources 2 / 7**

## Fermi Gamma-ray Space Telescope Observations of Gamma-ray Pulsars

**Author:** Pablo Saz Parkinson[1]

[1] *University of California, Santa Cruz*

**Corresponding Author:** pablo@scipp.ucsc.edu

The Large Area Telescope on the recently launched Fermi Gamma-ray Space Telescope (formerly GLAST), with its large field of view and effective area, combined with its excellent timing capabilities is poised to revolutionize the field of gamma-ray astrophysics. The significant improvement in sensitivity of Fermi over EGRET is expected to result in the discovery of a large number of new gamma-ray pulsars, which in turn should lead to fundamental advances in our understanding of pulsar physics.
Almost immediately after launch, Fermi clearly detected all six previously
known gamma-ray pulsars and is producing high precision results on these.
An extensive radio and X-ray timing campaign of previously known pulsars
is being carried out in order to facilitate the discovery of new gamma-ray pulsars,
which has already paid off. In addition, a highly efficient time
differencing technique is used to carry out blind searches for radio-quiet
(Geminga-like) pulsars, which has also resulted in new discoveries.
I will present some recent results from searches for pulsars carried out on Fermi data, both blind searches and those using contemporaneous timing of known radiopulsars.

**Extragalactic Sources 2 / 8**

## Constraints on Extragalactic Background Light from Cherenkov telescopes: status and perspectives for the next 5 years

**Author:** Daniel Mazin[1]

[1] *IFAE, Barcelona*

**Corresponding Author:** mazin@ifae.es

Very high energy (VHE, E > 30 GeV) gamma-rays are absorbed via interaction with low-energy photons from the
extragalactic background light (EBL) if the involved photon energies are above the threshold for electron-positron pair creation. The VHE gamma-ray absorption,
which is energy dependent and increases strongly with redshift, distorts the VHE energy spectra observed from distant objects.
The observed energy spectra of the AGNs carry therefore an imprint of the EBL. Recent detections of hard spectra of distant
(z = 0.11 - 0.54) blazars by H.E.S.S. and MAGIC put strong constraints on the EBL density in the optical to near infrared waveband. It is, however, not yet
possible to distinguish between an intrinsic softening of blazar spectra and a softening caused by the interaction with low energy
EBL photons. In this talk, I shall give an overview of the EBL constraints, their limitations and perspectives for the joint
efforts of the Fermi Gamma-Ray Space telescope and imaging atmospheric Cherenkov telescopes.

**GRB, esotic and future 1 / 9**

## GRB observations with new generation IACTs in the GLAST era

**Author:** Stefano Covino[1]

[1] *INAF / Brera*

**Corresponding Author:** stefano.covino@brera.inaf.it

The availability of a new generation of instruments with capabilities to observe at high or very-high energies open an exciting perspective for GRB studies. The very large accessible energy band, including lower energy observations (soft X-rays down to optical and radio), will allow a reliable modeling of the GRB spectra both during the prompt phase and the afterglows. These information can then allow us to constrain the emission processes and therefore solve some of the hottest issue in GRB research.

**Extragalactic Sources 2 / 10**

## The blazar sequence: prospects for GeV and TeV observations

**Author:** Fabrizio Tavecchio[1]

[1] *INAF*

**Corresponding Author:** fabrizio.tavecchio@brera.inaf.it

I discuss the concept and the consequences of the so-called "blazar sequence", connecting the position of the peaks in the spectral energy distribution of blazars with the emitted luminosity. I also present a recent revision of the theoretical basis of the blazar sequence, which, contrary to the simplest interpretation, predicts a large population of low-power "red" blazars and possibly the existence of powerful "blue" quasar, whose high-energy spectral component extends to the multi-GeV energy band. A better characterization of the blazar sequence will be possible in the next years thanks to the large number of sources expected to be detected by the Fermi Gamma-ray
Space Telescope and by the new generation of Cherenkov telescopes.

**GRB, esotic and future 1 / 11**

## Exploring Quantum Gravity with Very-High-Energy Gamma-Ray Instruments - Prospects and Limitations

**Author:** Robert Wagner[1]

[1] *Max-Planck-Institut für Physik, München*

**Corresponding Author:** rwagner@mpp.mpg.de

Some models for quantum gravity (QG) violate Lorentz invariance (LIV) and predict an energy dependence of the speed of light, leading to a dispersion of high-energy gamma-ray signals that travel over cosmological distances. Limits on the dispersion from short-duration substructures observed in gamma-rays emitted by gamma-ray bursts (GRBs) at cosmological distances have provided interesting bounds on LIV. Recent observations of unprecedentedly fast flares in the very-high energy gamma-ray emission of the active galactic nuclei (AGNs) Mkn 501 in 2005 and PKS 2155-304 in 2006 resulted in the most constraining limits on LIV from light-travel observations, approaching the Planck mass scale, at which QG effects are assumed to become important. In the presentation, the current status of LIV searches using GRBs and AGN flare events will be reviewed. I will also discuss the limitations of light-travel time analyses and prospects for future instruments.

**Instruments 1 / 12**

## GeV - TeV Multiwavelength Opportunities

**Author:** David Thompson[1]

[1] *NASA Goddard Space Flight Center, on behalf of the Fermi LAT collaboration*

**Corresponding Author:** david.j.thompson@nasa.gov

With AGILE and Fermi now in orbit and TeV telescopes continuing to improve their performance, a variety of multiwavelength opportunities is increasingly available. One goal of such programs is to take advantage of the complementary capabilities of the two types of telescopes: the wide field surveys of the satellite detectors and the high sensitivity and resolution of the ground-based telescopes. Some aspects of these multiwavelength efforts will be carried out in near-real-time but must be anticipated with advance preparation. These include gamma-ray burst follow-ups and flare campaigns. Other projects such as long-term variability studies and gamma-ray source identification require deep observations and cooperative work with astrophysicists at longer wavelengths, along with the theoretical studies that tie the observations together.

**Galactic Sources 1 / 14**

## Supernova remnants interact with molecular clouds and reveal accelerated hadrons

**Authors:** Armand Fiasson[1]; Fabrice Feinstein[1]; Yves Gallant[1]

[1] *Université Montpellier 2*

**Corresponding Author:** fabrice.feinstein@lpta.in2p3.fr

Shell-type supernova remnants (SNR) are suspected to be hadronic cosmic-ray (CR) accelerators within our Galaxy. Several shell-type SNR emit very high energy gamma rays detected with H.E.S.S., including RX J1713.7-3946, RX J0852.0-4622, RCW 86 and most recently SN 1006. These observations confirm that these objects accelerate particles up to at least 100 TeV

Dense molecular clouds interacting with SNR blast waves provide direct indications of hadronic acceleration. Several sources detected by HESS may follow such a scenario. The front shock of the SNR CTB 37A is propagating through dense molecular clouds which could be thefabrice.feinstein source of the very high energy gamma-ray emission through the hadronic interactions of shock-accelerated CR.

All the above associations of molecular clouds with SNR coincide with unidentified EGRET sources and will be carefully studied by GLAST.

In addition to a greater sensitivity, the improved angular resolution of future ground-based observatories such as H.E.S.S. phase 2 and the Cherenkov Telescope Array will allow to explore details of the dynamics of such associations.

**Summary**:

Shell-type supernova remnants (SNR) are suspected to accelerate hadrons within our Galaxy. Several shell-type SNR emit very high
energy gamma rays detected with H.E.S.S., including RX J1713.7-3946,
RX J0852.0-4622, RCW 86 and most recently SN 1006. These observations confirm
that these objects accelerate particles up to at least 100 TeV; however,

gamma rays may be produced either by inverse Compton scattering from accelerated electrons or by neutral pion decay after hadronic interactions.

Dense molecular clouds interacting with SNR blast waves may provide more direct indications of hadronic acceleration. Several sources detected by, including those surrounding W28, the newly discovered source HESS J1714-385 coincident with SNR CTB 37A, and the unidentified source HESS J1745-303,
HESS, including those surrounding W28, the newly discovered source HESS J1714-385 coincident with SNR CTB 37A, and the unidentified source HESS J1745-303, may be explained by such a scenario. The front shock of the SNR CTB 37A is propagating through dense molecular clouds which could be the source of the very high energy gamma-ray emission through the hadronic interactions of shock-accelerated CR.

All the above associations of molecular clouds with SNR coincide with unidentified EGRET sources. The greatly improved angular resolution and sensitivity of GLAST should allow a precise determination of the GeV spectrum of these objects.

In addition to a greater sensitivity, the improved angular resolution of future ground-based observatories such as H.E.S.S. phase 2 and the Cherenkov Telescope Array will allow to explore details of the dynamics of such associations.

**GRB, esotic and future 2 / 15**

## Indirect search for Dark Matter with Fermi from the Galactic Center

**Author:** Vincenzo Vitale[1]

[1] *Dip. Fisica Roma 2*

**Corresponding Author:** vincenzo.vitale@roma2.infn.it

The FERMI gamma ray satellite, previously known as GLAST, is in orbit, since June 2008. After a commissioning period is now delivering data.
The Large Area Telescope (LAT), onboard of FERMI, is the most sensitive gamma-ray detector to date, in the 20 MeV - 300GeV energy band.
It provides large effective collection area(>8000cmˆ2@1GeV), wide field of view (>2sr) and good energy resolution (8%@1GeV).
FERMI data can be used for the indirect search for annihilating Dark Matter.
One of the possible observation strategy is the targeting of regions where high Dark Matter density is foreseen, such as the Galactic Center.
Galactic Center observation poses a challenge: to disentangle the possible Dark Matter signal from the bright gamma radiation of astrophysical sources.
A review on this searches will be given.

**Instruments 2 / 16**

## VERITAS - Status and results of the 2007/2008 season

**Author:** Matthias Beilicke[1]

[1] *Washington University*

**Corresponding Author:** beilicke@physics.wustl.edu

The VERITAS collaboration operates an array of four imaging atmospheric Cherenkov telescopes in southern Arizona. The first season of observations (including all four telescopes) was performed in 2007/2008.
Two new gamma-ray sources were discovered and a variety of other TeV sources were observed and detected, in many cases within coordinated multi-wavelength campaigns. The status, observational performances and results of the first year of observations (galactic and extragalactic sources) are presented.

**GRB, esotic and future 3 / 17**

## On the level of the cosmic ray sea flux.

**Author:** Sabrina Casanova[1]

**Co-authors:** Felix Aharonian [2]; Stefano Gabici [3]

[1] *Max Planck fuer Kernphysik*

[2] *DIAS & MPIK*

[3] *DIAS*

**Corresponding Author:** sabrina.casanova@mpi-hd.mpg.de

The bulk of cosmic rays (CRs) which we measure within the Solar System is believed to be representative of the sea CRs everywhere in the Galaxy . However, the local CR flux might be due to one or few local sources . Here we investigate the possibility of measuring the level of Galactic sea CRs by combining the high spatial resolution gamma ray maps, becoming available now from
state of the art instruments, GLAST and IACTs, and molecular line observations tracing the matter density of the ISM.

**GRB, esotic and future 3 / 18**

## Acceleration of UHE Protons at Cluster Accretion Shocks and Related Non-thermal Emission

**Author:** Giulia Vannoni[1]

**Co-authors:** Felix Aharonian [2]; Stefano Gabici [2]

[1] *Max-Planck-Institut für Kernphysik, Heidelberg*

[2] *Dublin Institute for Advanced Studies, Dublin*

**Corresponding Author:** giulia.vannoni@mpi-hd.mpg.de

Clusters of galaxies are believed to be able to accelerate Cosmic Rays to ultrahigh energies (~10^18 eV and beyond) at accretion shocks. At this energies, the energy losses induced by the interaction with the CMB
radiation become effective and determine the maximum energy of protons and the shape of the cutoff in the proton energy spectrum. In particular, the dominant energy loss channel becomes pair production.
We present a time dependent numerical calculation of the shock acceleration process where we include self-consistently the presence of energy losses. We accurately calculate the spectra of the produced electron-positron pairs and the X-ray and gamma-ray emission they produce via synchrotron and inverse Compton scattering processes respectively. We find that the radiation spectra show a cutoff harder than exponential and that the downstream and upstream regions contribute almost at the same level to the emission. For the typical characteristics of galaxy clusters, the synchrotron

and IC peaks of the electron broadband emission are at comparable levels. The expected emission in gamma-rays is at the limit of
the sensitivity of present generation instruments, however it may be detectable with the future generation of detectors.

**GRB, esotic and future 2 / 19**

## GRIPS: Gamma-Ray Burst Investigation via Polarimetry and Spectroscopy

**Author:** Kanbach Gottfried[1]

**Co-author:** Greiner Jochen [1]

[1] *MPE, Garching*

We describe a new generation gamma-ray observatory capable of unprecedented spectroscopy over a wide range of gamma-ray energies (200 keV–50 MeV) and polarimetry (100–1000 keV). This mission was proposed to ESA in the Cosmic Vision programme in 2008 and was presented to, but not selected by ESA's Astronomy working group.
The primary scientific goal of the GRIPS mission is to revolutionize our understanding of the early universe using gamma-ray bursts. Secondary goals achievable by this mission include direct measurements of supernova interiors through gamma-rays from radioactivity, nuclear astrophysics with massive stars and novae, and studies of particle acceleration near compact stars, interstellar shocks, and clusters of galaxies.

**Instruments 3 / 20**

## The hunt for cosmic sources with IceCube

**Author:** Elisa Bernardini[1]

[1] *DESY*

**Corresponding Author:** elisa.bernardini@desy.de

Cosmic neutrinos are promising messengers to help unveil very high energy cosmic accelerators. To date, no extraterrestrial high energy neutrino flux has been observed, but cubic-kilometer telescopes are under construction (IceCube) or being designed (KM3NeT), promising to soon achieve the detection volumes necessary for the discovery
of cosmic neutrino signals at energies above hundreds GeV. Potential neutrino candidate sources include supernova remnants, micro-quasars and active galactic nuclei, for
which a wealth of information on their possible phenomenology is availableat multi- GeV energies and beyond, thanks to the successful observations of
VHE gamma-rays. In this talk, the status of the search for cosmic sources with IceCube will
be overviewed. Special emphasis will be given to search strategies aimed at increasing the discovery potential by looking for correlations with established signals (e.g. high-energy gamma-rays).

**Galactic Sources 1 / 23**

## The GeV to TeV view of SNR IC443: predictions for GLAST

**Author:** Diego Torres[1]

**Co-authors:** Ana Yaiza Rodriguez Marrero [1]; Elsa de Cea del Pozo [1]

[1] *IEEC-CSIC*

We present a theoretical model that explains the high energy phenomenology of the neighborhood of SNR IC 443, as observed with the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescope and the Energetic Gamma-Ray Experiment Telescope (EGRET). We interpret MAGIC J0616+225 as delayed TeV emission of cosmic-rays diffusing from IC 443, what naturally explains the displacement between EGRET and MAGIC sources, their fluxes, and their spectra. We compare this model with others recently presented, and discuss how it can be tested with observations by the Gamma-ray Large Area Telescope (GLAST).

**Instruments 2 / 25**

## Status and recent results of MAGIC

**Author:** Javier Rico[1]

[1] *ICREA/IFAE*

**Corresponding Author:** jrico@ifae.es

The Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescope is a last-generation instrument for very high energy gamma-ray observations. It is located at La Palma (Spain) hence with an optimal view on the Northern sky. Sensitive in the 30 GeV - 30 TeV band (thanks mainly to its large, 17 m diameter reflector), it is nowadays the only ground-based instrument being able to measure high-energy gamma-rays below 100 GeV. The construction of a second telescope is now in its final stage and MAGIC will start steresocopic observations in the near future. We review the status and the most recent experimental results of MAGIC.