First GLAST Symposium. Stanford, February 2007

Pulsar observations with the MAGIC Telescope

M. López[1], N. Otte[2], E. Aliu[3], W. Bednarek[4], J.L Contreras[1], K. Hirotani[5], M. Rissi[6] for the MAGIC Collaboration

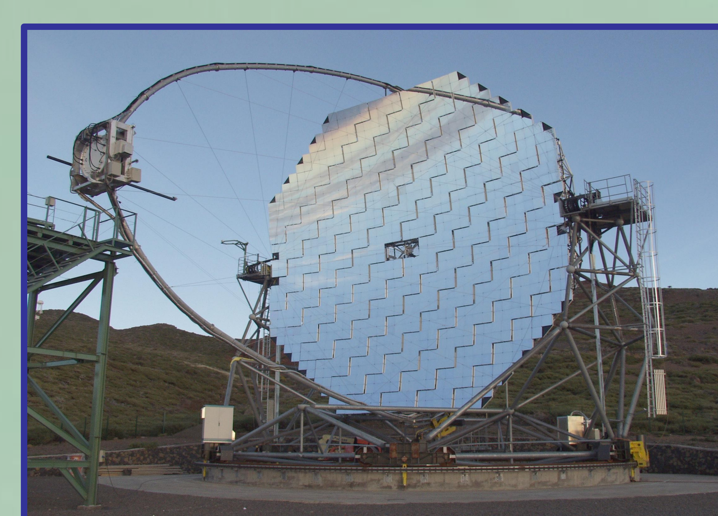
[1]Univ. Complutense de Madrid, Spain, [2]MPI München, Germany, [3]IFAE, Spain, [4]Lodz University, Poland, [5]ASIAA, Taiwan, [6]ETH Zurich, Switzerland

Pulsars were detected by EGRET up to energies of 20 GeV. Observations at higher energies with ground based experiments so far failed to detect pulsars, indicating a sharp cutoff of the pulsed emission. Here we evaluate the potential of MAGIC to detect pulsars and present the results of 31 hours of observations of PSR B1951+32.

The MAGIC Telescope

MAGIC [1] is currently the largest air Cherenkov telescope worldwide:

- 17 m. diameter reflector
- 50 GeV trigger threshold
- located at the Roque de los Muchachos (Spain)

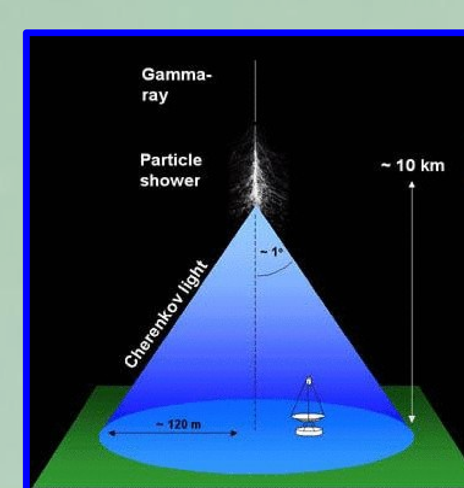


A second telescope (MAGIC II) is under construction for stereo observations:

- better sensitivity
- lower threshold

Detection technique

When γ-rays enter into the atmosphere a shower of particles is created. The charged particles emit Chrenkov light, which is detected by the telescope. An image of the shower is obtained, to distinguish gammas from cosmic rays.

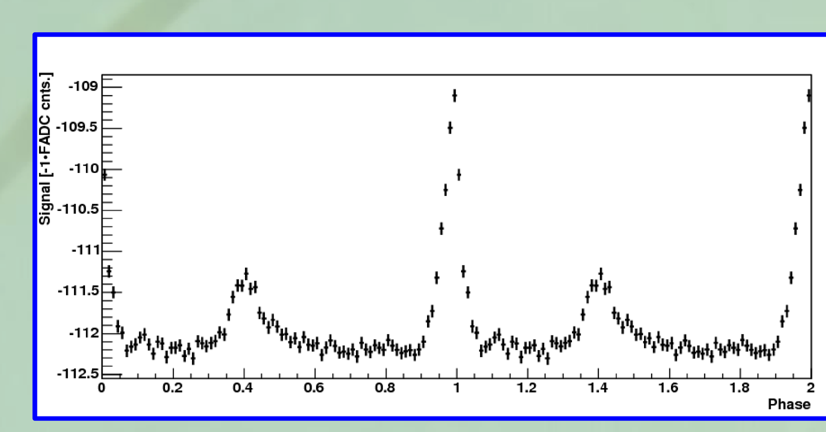


Pulsar observations with MAGIC

Several pulsars have been already observed by MAGIC for few hours during the first observation campaigns:

- EGRET pulsars: *Crab, PSR B1951+32, Geminga*
- Candidates to γ-ray pulsars as: *PSR B1957+20, PSR J0218+4232, PSR J1856+0113*

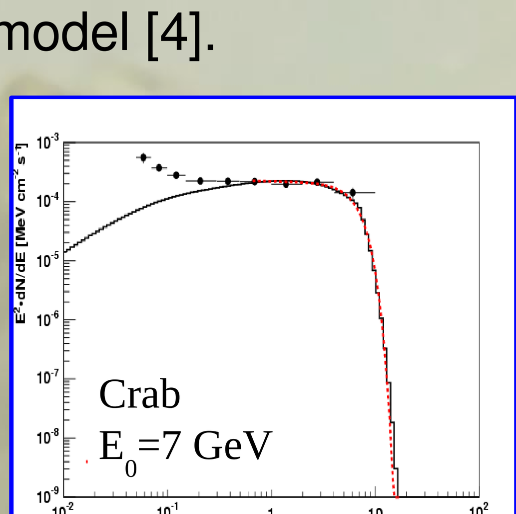
In parallel to γ-ray observations, optical observations are performed with a special pixel placed at the camera centre [2].

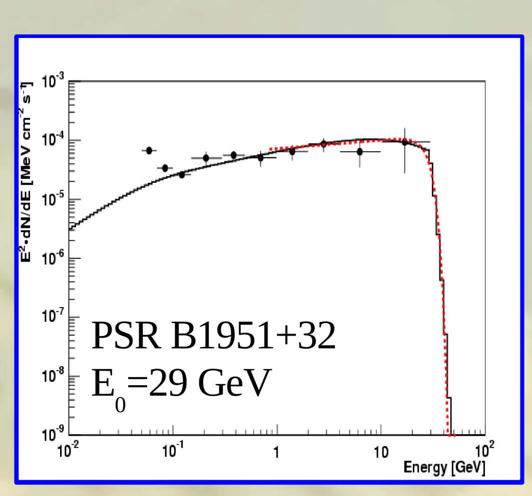


Crab pulsar light curve measured by MAGIC at optical wavelengths.

Capabilities of MAGIC to detect pulsars

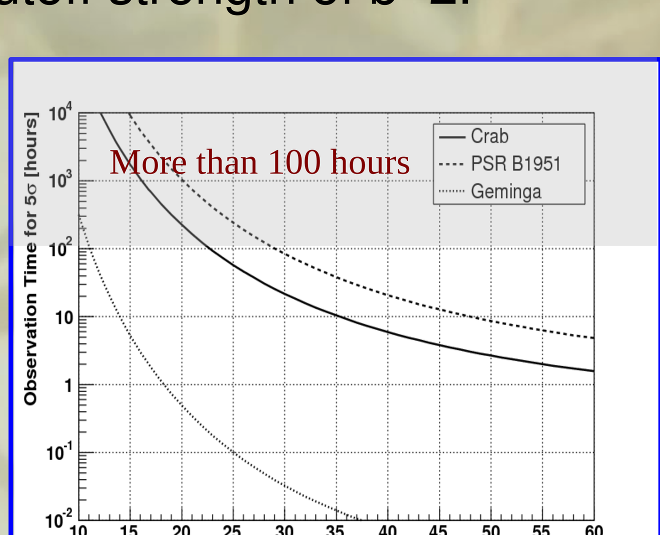
- We developed a numerical code to predict the shape of pulsar spectra tails [3]. The simulations were based on the *polar cap* model [4].





The energy cutoff for PSR B1951+32 is 3 times higher than the one for Crab, being this pulsar a prime candidate for MAGIC.

- Pulsar cutoffs are strongly model dependent. We study how the observability of pulsars is affected by the cutoff energy E_c, extrapolating the EGRET spectra with a super-exponential cuttof: $dN/dE = K \cdot E^{-\alpha} \cdot \exp(E^{-b} / E_c)$, assuming a cutoff strength of b=2.



The estimated observation times increase dramatically for low cutoffs.

Observations of PSR B1951+32 [5]

This pulsar (rotation period 39 ms) is the only one detected by EGRET up to ~20 GeV.
Its spectrum does not show evidence of a turnover. With a magnetic field nearly one order of magnitude lower than in other canonical pulsars, γ-rays can escape from the magnetosphere up to higher energies.

The pulsar is surrounded by the radio nebula CTB 80, which could be also a source of high-energy γ-rays.

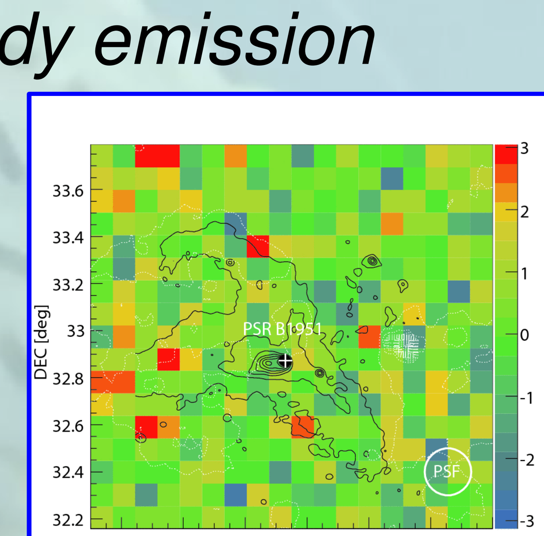
Data sample

The data analysed here were obtained between July and September 2006, at low zenith angles. A total 31 hours of data were selected.

Search for steady emission

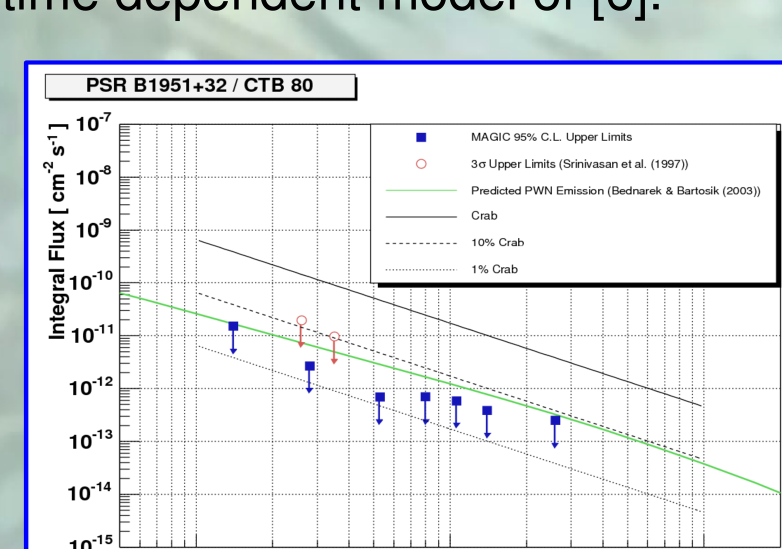
We investigate the presence of steady emission from the association PSR B1951+32/CTB 80.

- No signal was found at energies above 140 GeV.



Sky map with significances of VHE γ-ray emission

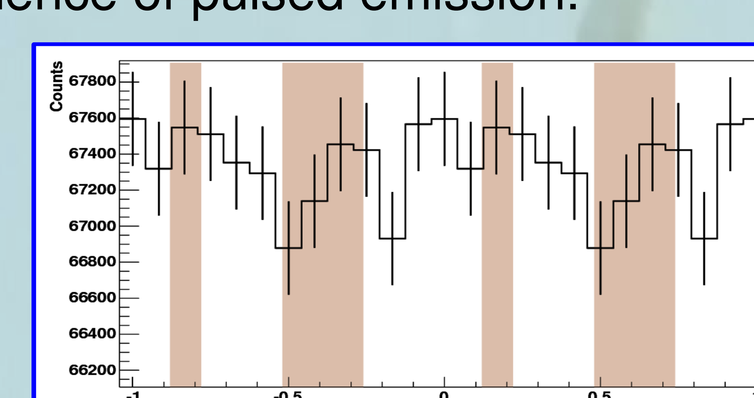
- The upper limits calculated at different energies rule out the steady emission predicted by the time dependent model of [6].



Search for pulsed emission

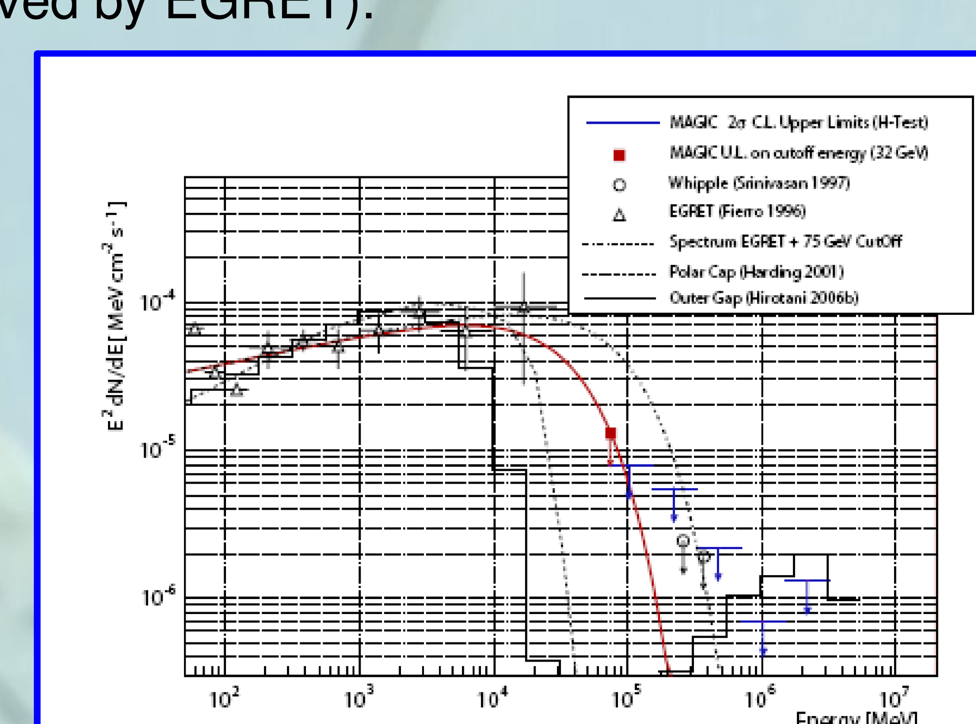
After applying looser γ/hadron separation cuts, we search for a periodic signal at the radio frequency (ephemeris provided by [7]).

- The light curve obtained does not show evidence of pulsed emission.



Light curve obtained from PSR B1951+32. The shaded areas are the phase regions of the emission detected by EGRET.

- Upper limits at different energies are calculated using the H-test, and assuming a 36% duty cycle for the pulsar light curve (as observed by EGRET).



- To constraint the energy cutoff of the pulsar, we extend the power law spectrum measured by EGRET to our energy domain with an exponential cutoff. The highest cutoff compatible with our upper limits is E<32 GeV.
- Polar cap models predict a cutoff within the allowed region derived from our results. The upper limits obtained are already below the upper boundary of possible TeV emission expected from current *outer gap* models.

References

[1] E. Lorenz, New Astron. Rev. vol. 48, 339-344 (2004)
[2] F. Lucarelli et al, ICRC 2005
[3] M. Lopez, Ph.D. thesis (2006)
[4] J. Daugherty and A. Harding, ApJ 458, 278 (1996)
[5] J. Albert et al. astro-ph 0702077v1 (2007)
[6] W. Bednareck and M. Bartosik, JPhG 31, 1465 (2005)
[7] http://www.jb.man.ac.uk/~pulsar

MAGIC Webpage @ *http://wwwmagic.mppmu.mpg.de/*