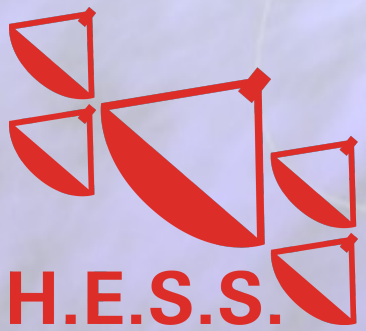
Observation of PSR B1259-63 at High Energy

Carlo Romoli – DIAS

Variable Galactic Gamma-ray Sources III

HEIDELBERG – 04-06/05/2015



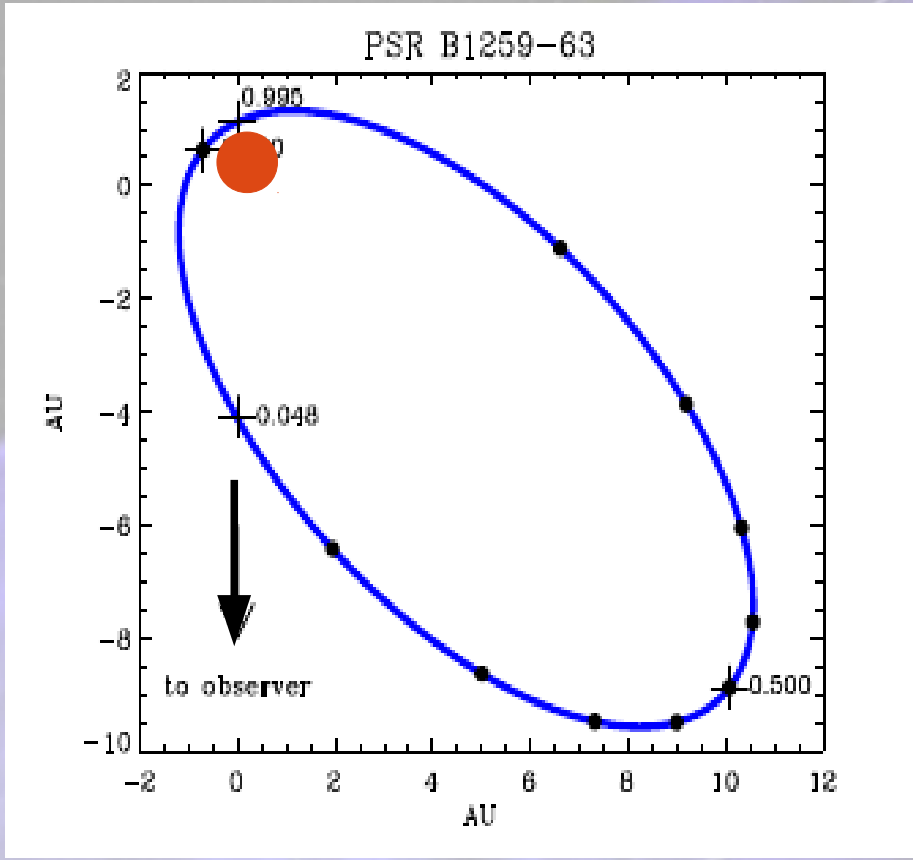
Background image credits:
Walt Feimer, NASA/Goddard
Space Flight Center

Outline

- The PSR B1259-63 system
- Historical observation in the VHE and HE window
- The 2014 event:
  - The *Fermi*-LAT
  - The H.E.S.S. experiment
  - What to expect in the next months

The PSR B1259-63/LS 2883 system

- Pulsar (PSR B1259-63) + Be star (LS 2883)



Adapted from Dubus, 2013

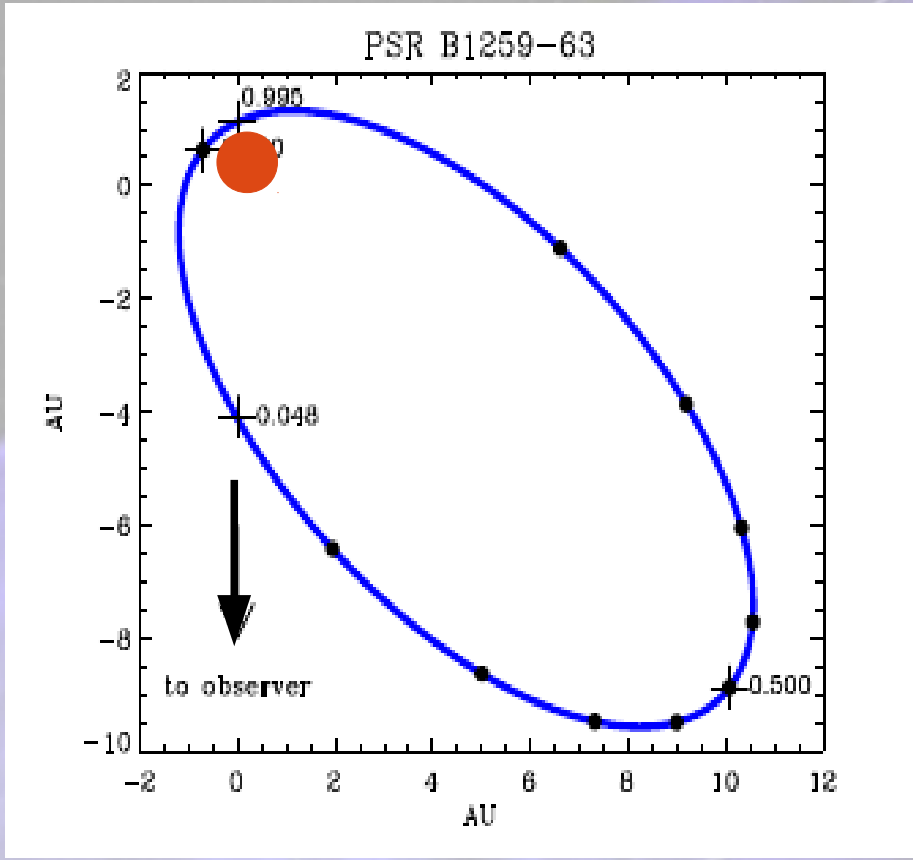
- The pulsar PSR B1259-63:
  - ➔ P = 47 ms
  - Spin down luminosity

$$\dot{E} \approx 8 \cdot 10^{35}\, erg/s$$

- The star LS 2883 (class Be)
  - ➔ Massive star ~30 $M_{\odot}$
  - ➔ Equatorial disc 15-20 R_{*}

The PSR B1259-63/LS 2883 system

- Pulsar (PSR B1259-63) + Be star (LS 2883)



Adapted from Dubus, 2013

Orbital parameters:

- T = 3.4 years
- Eccentricity *e* = 0.87
  - d_{peri} = 0.94 AU
  - d_{apo} = 13.4 AU
- Inclination of the orbit *i* ~ 20-30°

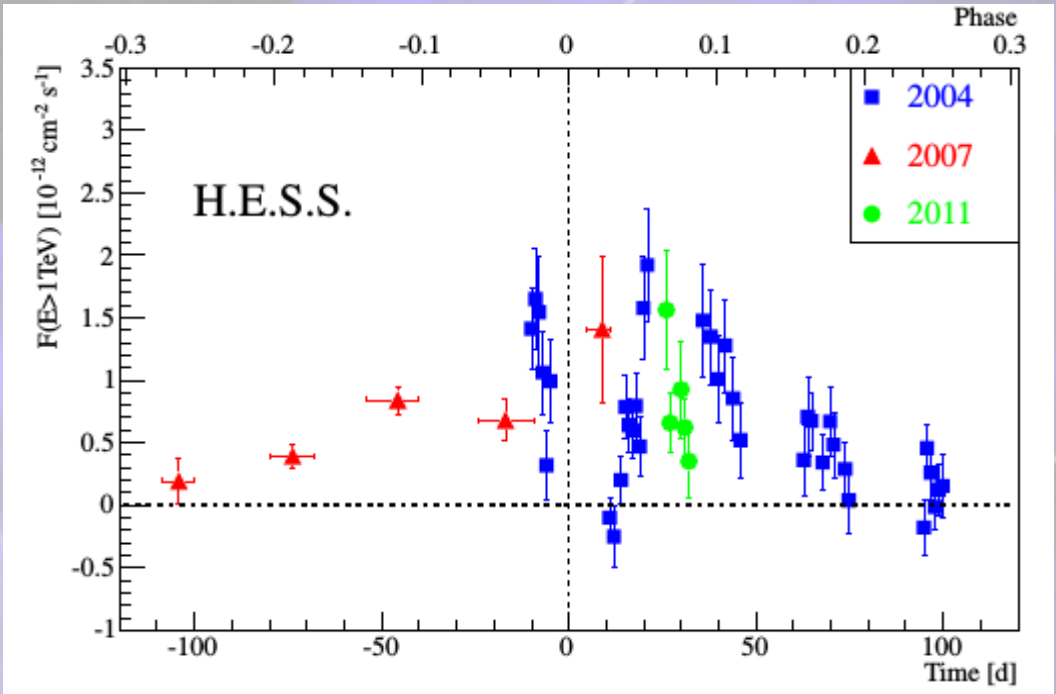
This means a double close interaction with the stellar disk every orbit

The (Very) High Energy emission

- Approaching the periastron, the pulsar starts to interact with the stellar disk emitting gamma rays.
- **Very High Energy** (~ TeV) 
  - First detection in the VHE domain by the **H.E.S.S.** experiment during the passage in 2004
- **High Energy** (~ GeV) 
  - ***Fermi*-LAT** started the operations in 2008, able to work in survey mode (2.4 sr FOV)
  - First observable passage in 2010/2011 --> with a big surprise

The Very High Energy emission

- In the VHE regime the system has been observed in 3 previous occasions by the HESS telescope

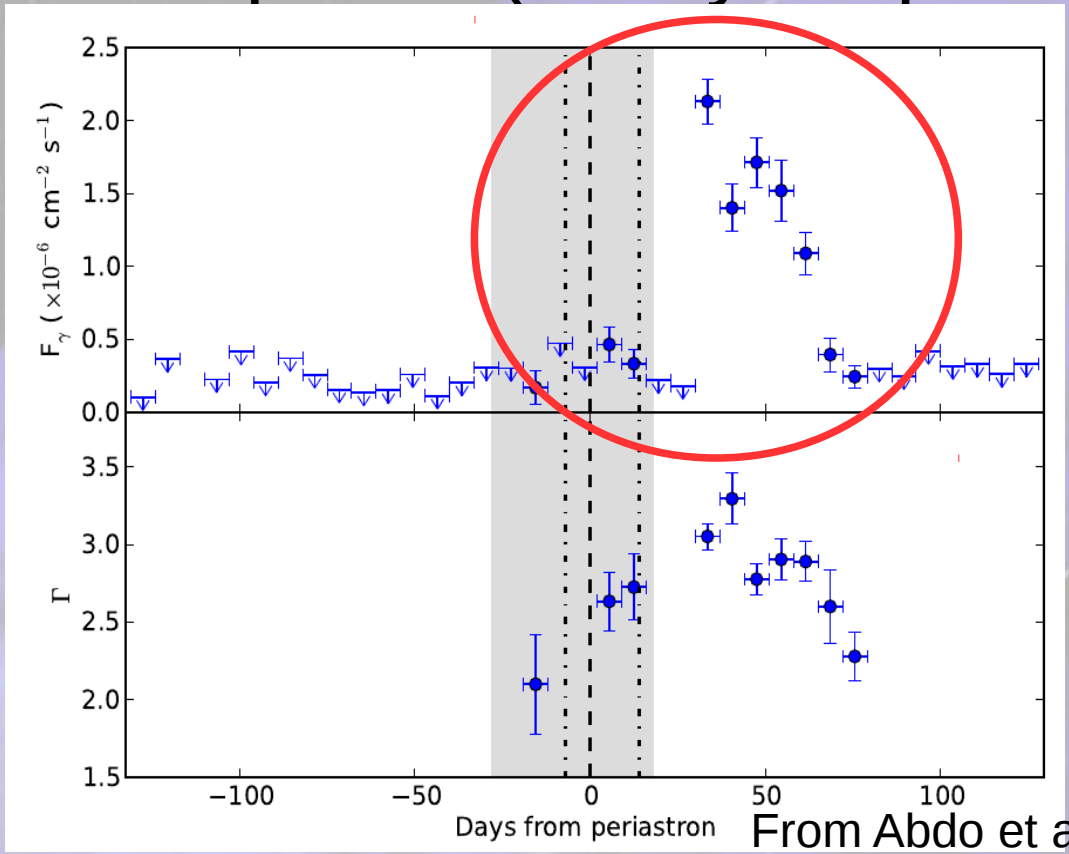


From HESS Collaboration, 2013

- Going from 100 days before the periastron to 100 days after the periastron
- Intrinsic limitations of IACTs, not possible to have a full coverage of the passage (position in the sky, Moon, ...)

The High Energy Emission

- *Fermi*-LAT data in 2010/2011 brought big surprises (new year present)

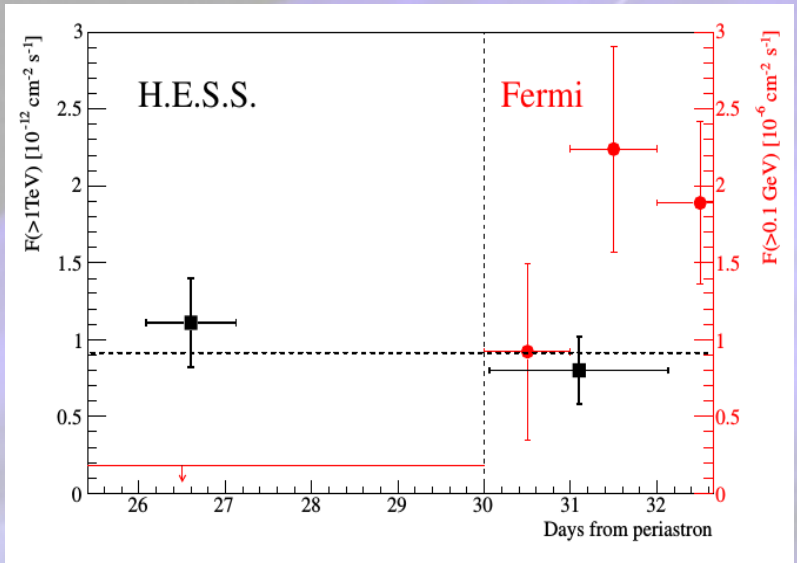


From Abdo et al., 2011

- Marginal detection of the source in the pre-periastron and periastron phase, but incredibly luminous flare ~ 30 days after periastron
- Peak luminosity of 7×10^{35} erg/s (80% of the spin-down power)

The 2010/2011 passage

- H.E.S.S. coverage not very good, possible observations during 5 nights and could not cover the full extension of the Fermi flare



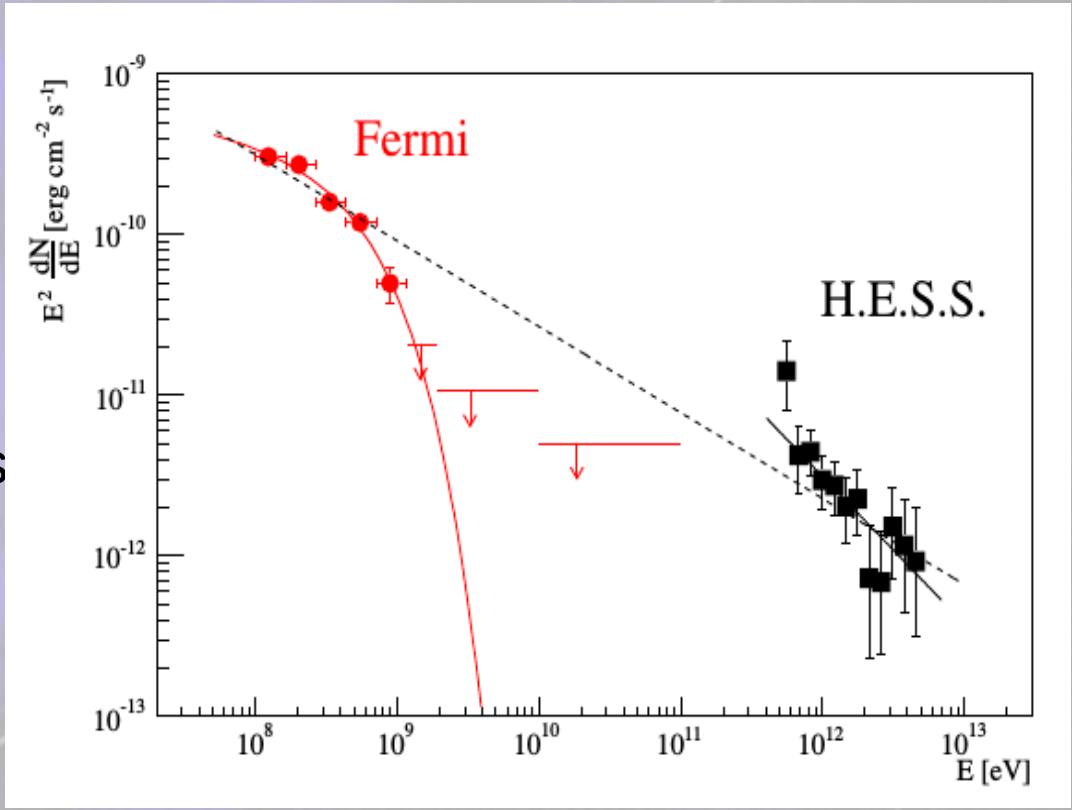
From HESS Collaboration, 2013

In the overlap region there is no indication of an enhancement of the flux

The 2010/2011 passage

Different spectral shapes:

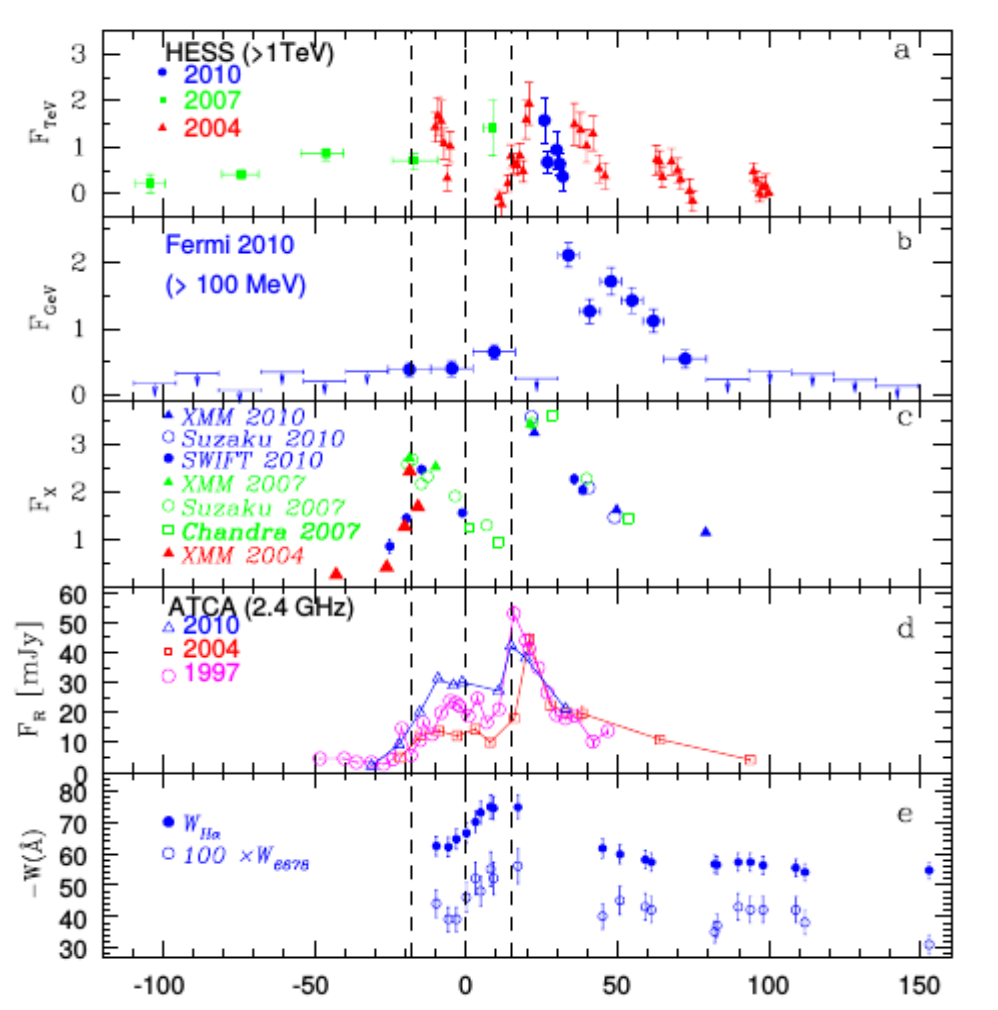
- *Fermi*-LAT: PLEC
  - $\alpha = 1.4 \pm 0.6_{stat} \pm 0.2_{sys}$
  - $E_c = 0.3 \pm 0.1_{stat} \pm 0.1_{sys}$ GeV
  - $F_{>100MeV} = (1.3 \pm 0.1_{stat} \pm 0.3_{sys}) \times 10^{-6}$ ph/cm^2/s
- H.E.S.S.: PL
  - $\alpha = 2.9 \pm 0.3$
  - $F_{>1\ TeV} = (1.01 \pm 0.18_{stat} \pm 0.2_{sys}) \times 10^{-12}$ ph/cm^2/s



From HESS Collaboration, 2013

The 2010/2011 passage

- In general the GeV flare does not seem to be correlated to any other wavelength



From Chernyakova et al., 2014

The 2014 passage

- Time of the periastron: 2014-05-04
- Multiwavelength campaign to cover as much as possible different energy ranges.
  - Fermi pointing mode during the days when the GeV flare was expected
  - Very good observation window for H.E.S.S.

Short-term X-ray/gamma-ray variability from PSR B1259-63

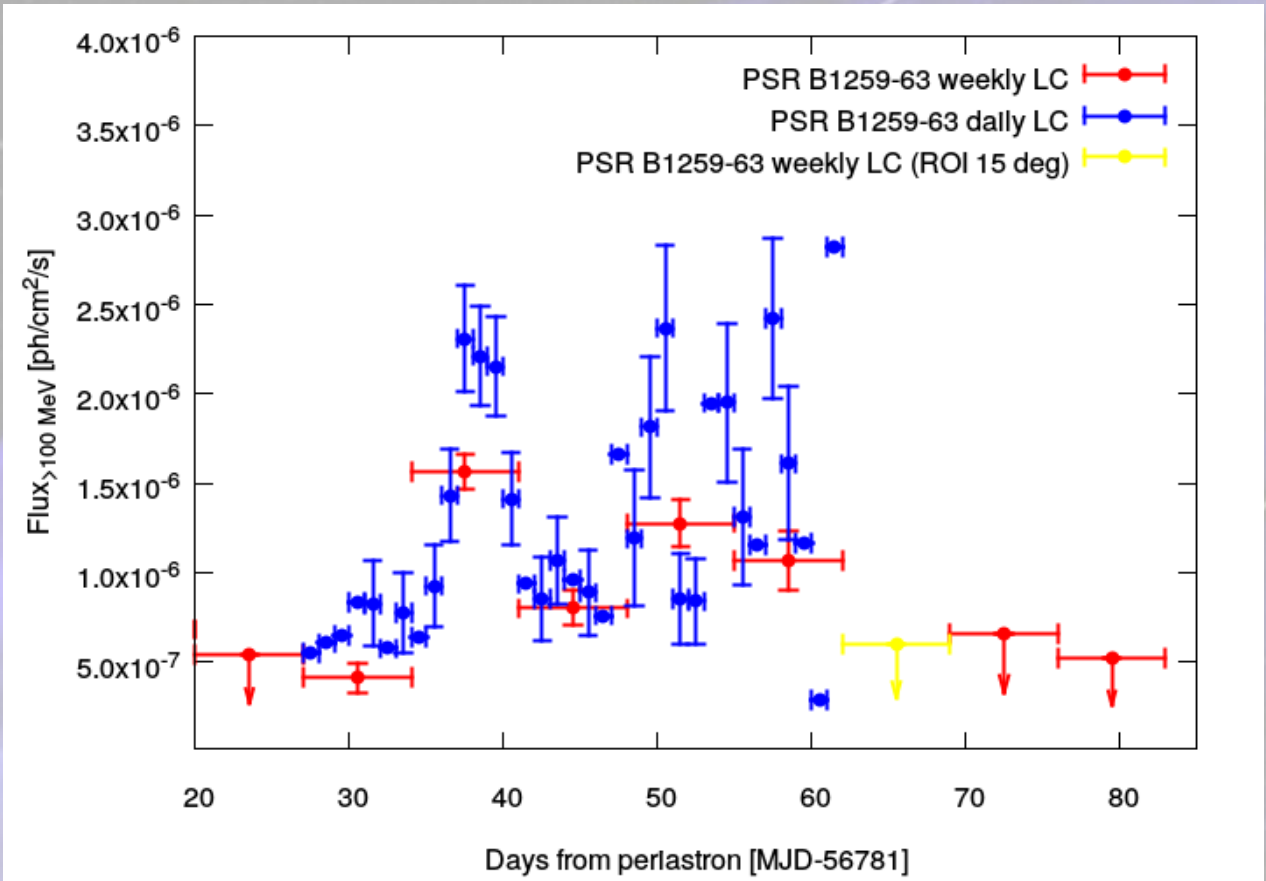
ATel #6248; *P. Bordas (Max-Planck-Institut fur Kernphysik), V. Zabalza (Department of Physics and Astronomy, University of Leicester), C. Romoli (Dublin Institute for Advanced Studies), D. Khangulyan (Institute of Space and Astronautical Science/JAXA) and G. Puehlhofer (Institut fur Astronomie und Astrophysik, Universitat Tuebingen)*
*on **19 Jun 2014; 14:06 UT***
Credential Certification: Pol Bordas (pol.bordas@mpi-hd.mpg.de)

Subjects: X-ray, Gamma Ray, Binary, Neutron Star, Pulsar

One of the many issued Atels during the monitoring

The 2014 passage with *Fermi*-LAT

- Fermi Lightcurve:

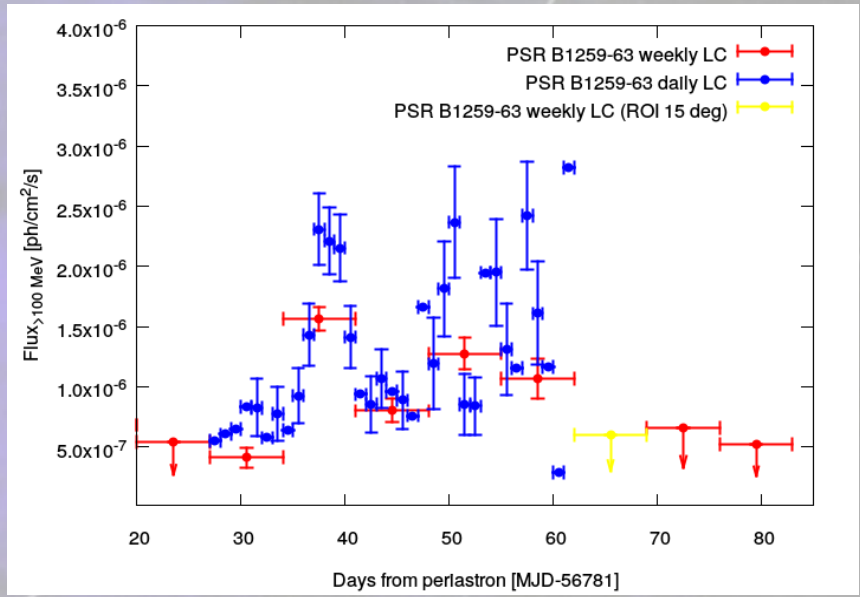


The GeV flare appeared again!

Not as bright as in the 2011 but approximatively at the same orbital phase

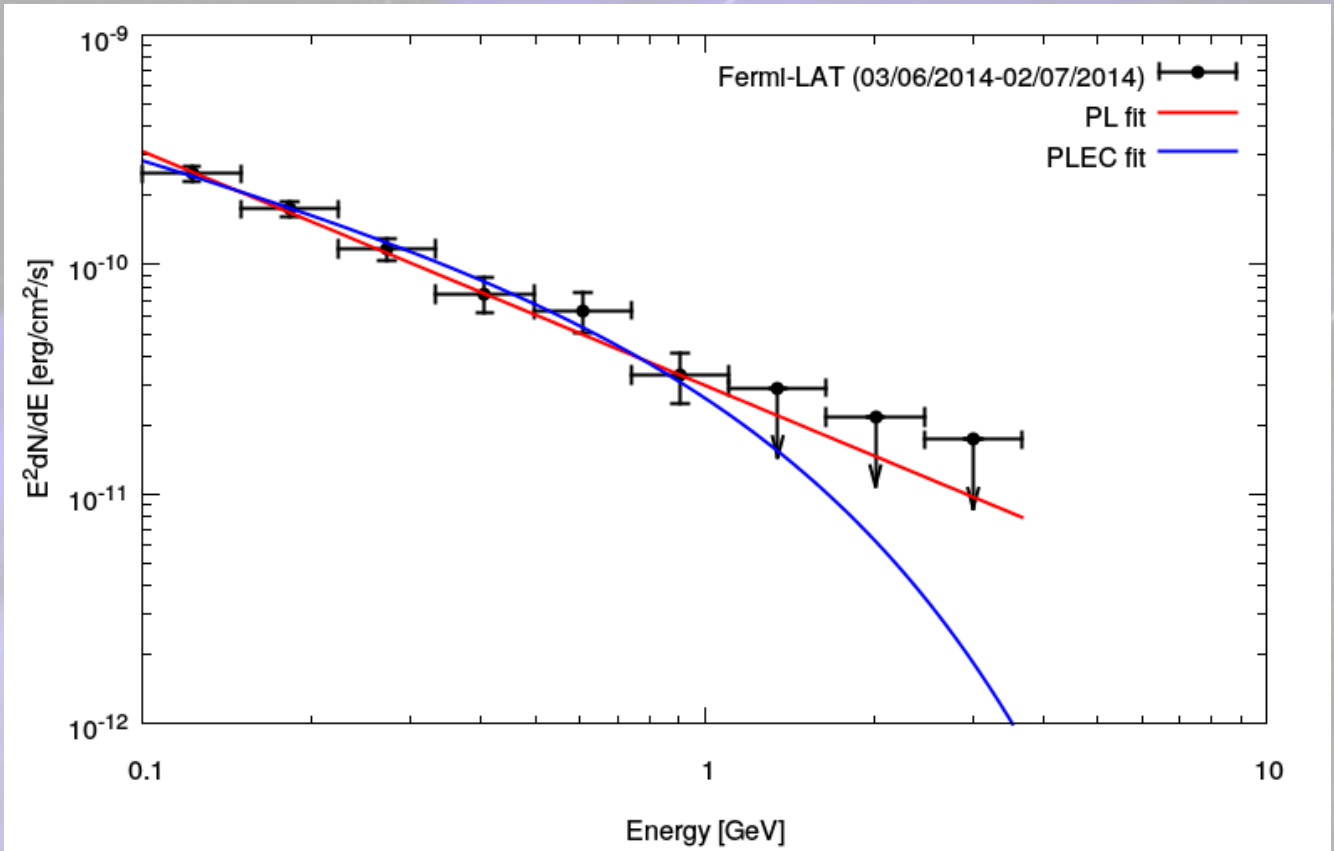
The 2014 passage with *Fermi*-LAT

- Analysis of the 5 weeks with significant emission:
  - ΔT = 03/June/2014 – 02/July/2014
  - $F_{>100MeV} = (1.0 \pm 0.5) \times 10^{-6}$ ph/cm^2/s
  - Ph. index = 3.02 ± 0.08



The 2014 passage with *Fermi*-LAT

- Comparison between a power-law and a power-law with exponential cut-off



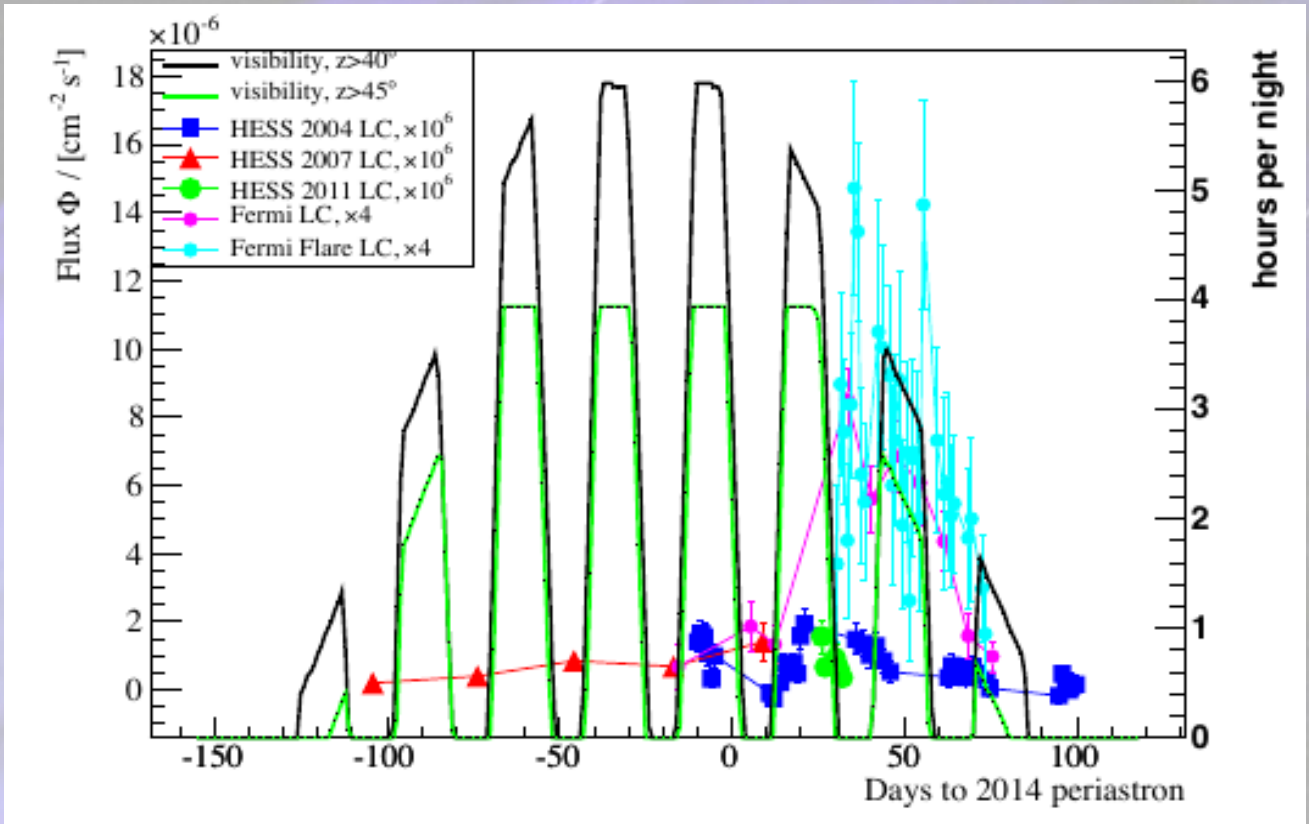
Spectrum seems to be a straight power law

Presence of a cut-off only marginally favoured

PL
α = 3.02 +/- 0.08
Loglike = 180954.9
PLEC
α = 2.66 +/- 0.21
Ec = 1.0 +/- 0.6 GeV
Loglike = 180953.1

The 2014 passage with H.E.S.S.

- For the first time possible to observe the full periastron event in one single campaign



- Direct comparison with all the previous observations
- Possibility to investigate long term variability

The 2014 passage with H.E.S.S.

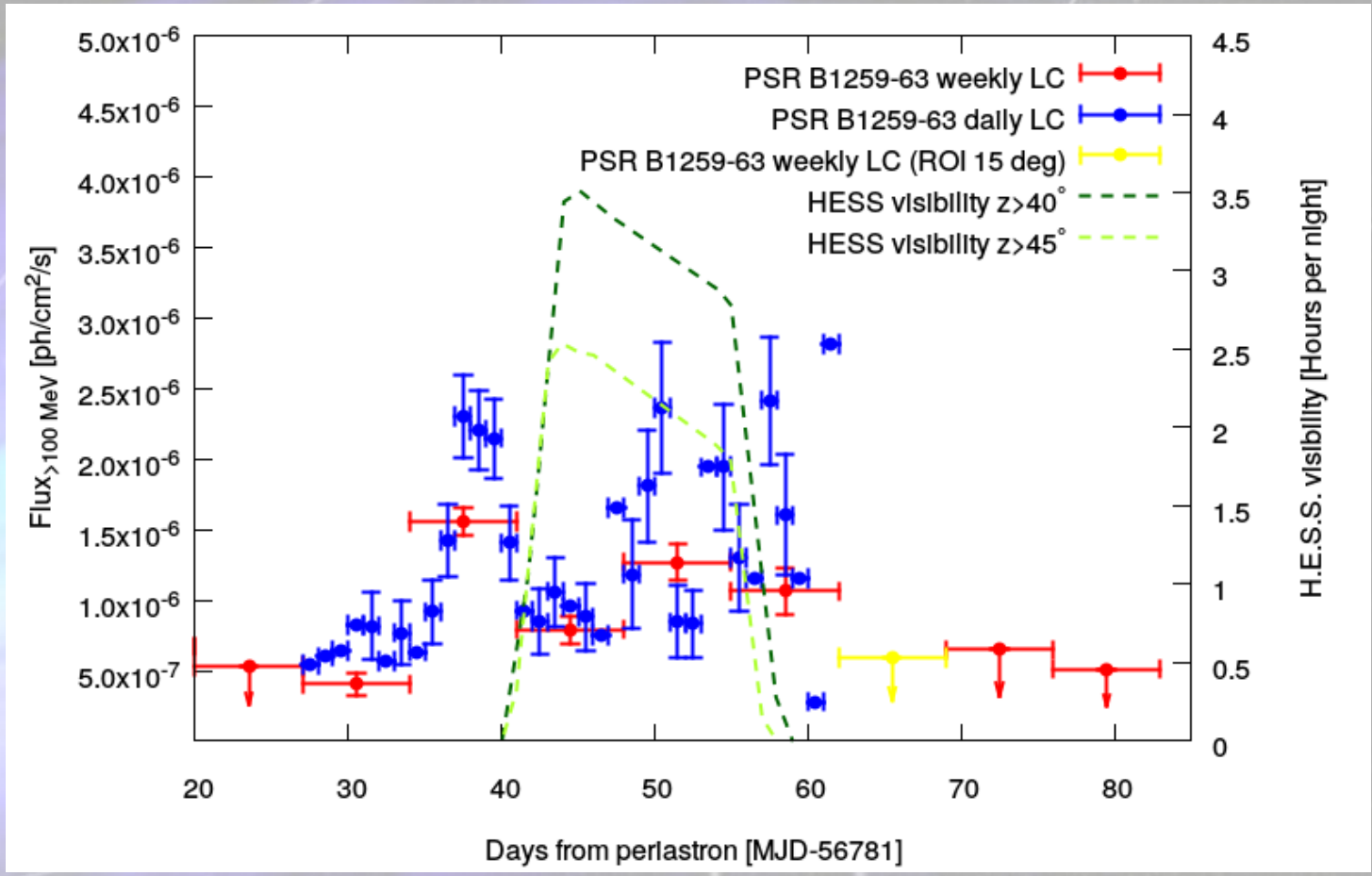
- For the first time possible to observe the full periastron event in one single campaign
- Good observation campaign in Namibia

HESS II fully operative!

The 2014 passage with H.E.S.S.

Observation window during the Fermi flare

- No start of the flare
- Good coverage of the high variable central part



The 2014 passage with H.E.S.S.

- Data under analysis within the H.E.S.S. Collaboration
- Release of the results planned for the summer
  - ICRC 2015

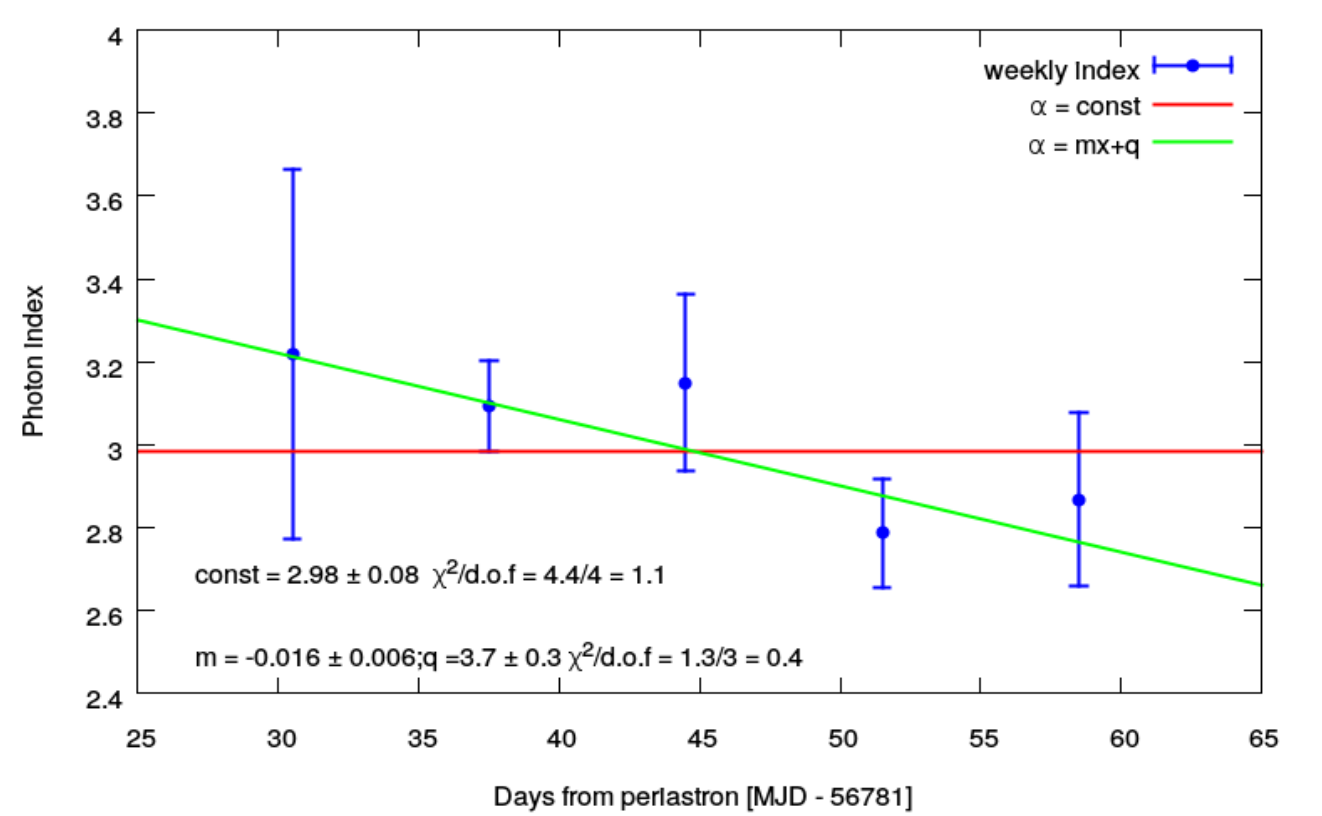
Conclusions

- Succeful observation campaign for the periastron passage in 2014
- PSR B1259-63 showed again the puzzling GeV flare at the ~same orbital phase
- Flare similar to the previous one
- H.E.S.S. monitoring succesful with results soon to be released.
  - Stay tuned for the upcoming conferences.


THANK YOU!

Backup slides

- Photon index variation in the weekly lightcurve



Backup slides

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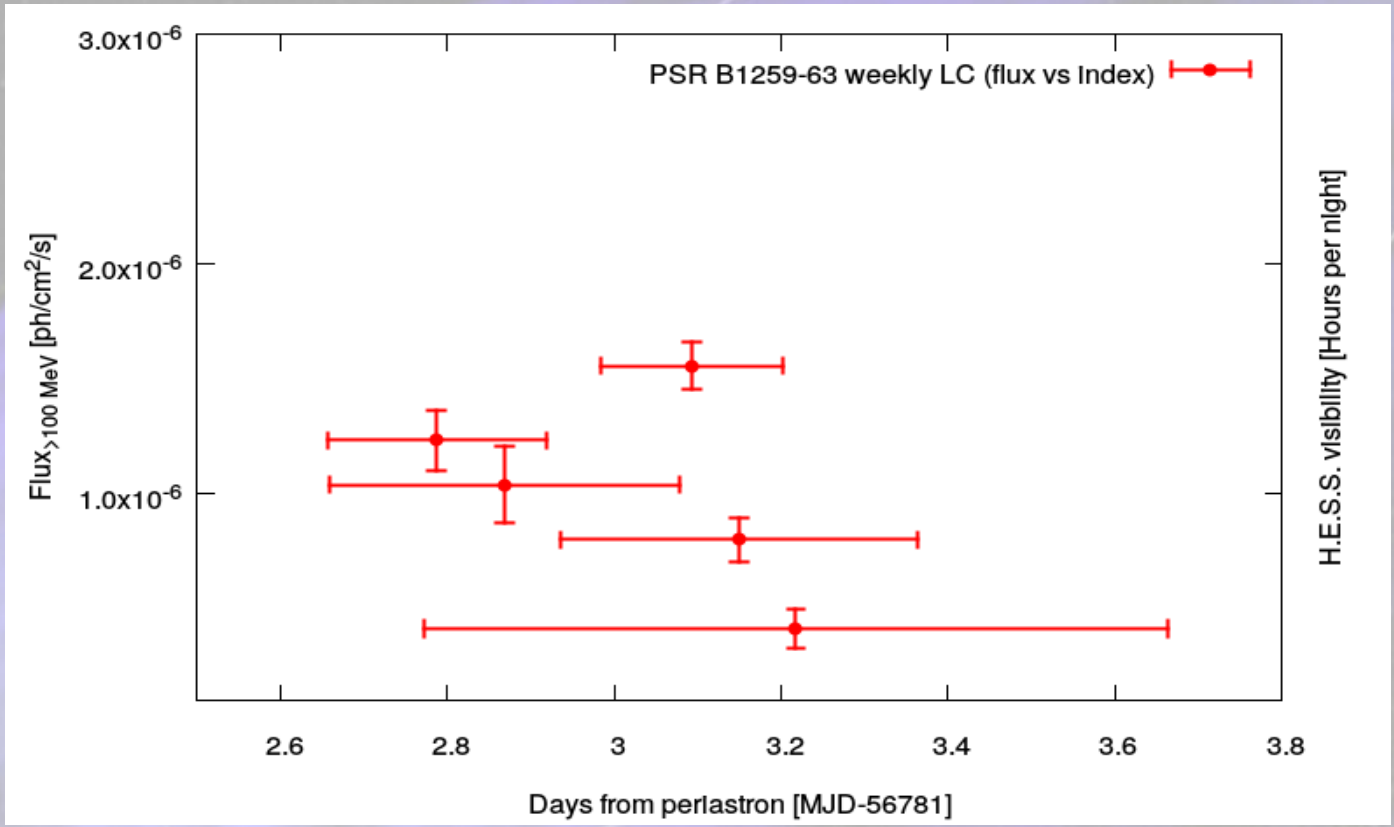

No statistical evidence of a dependance of the photon index with the flux level