

LS I +61 303 in the VHE gamma ray regime with the MAGIC telescope

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Outline



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(Werner-Heisenberg-Institut)

**Talk about the VHE part on LS I +61 303 of my PhD thesis
(MAGIC data but not official MAGIC talk)**

- **LS I +61 303 observation with MAGIC**
- **The VHE gamma-ray light curves**
- **Spectral energy distribution**
- **Interpretation of the VHE gamma-ray results**

The binary system LS I +61 303



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- Compact object still unknown
- Periodic emission with orbital period ($P = 26.496$ d)
- Difficult to study for IACTs since period close to Moon period
- Periastron at phase 0.275
- Eccentricity $e = 0.55$
- Orbital parameters were modified during VHE observations

Periastron

to observer

The MAGIC Telescope



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La Palma, asl. 2200m

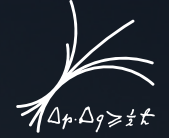
Sensitivity of 1.6 %
Crab flux

Can operate under
moonlight conditions



Very sensitive instrument to study faint VHE gamma ray sources

LS I +61 303 Observations



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- Effective observation time $T_{\text{obs}} = 225$ h
- 13 orbits covered between 2005 and 2008
- Zenith angle between 32° and 55° (Energy threshold ~ 300 - 400 GeV)
- Large fraction of the data ($\sim 20\%$) taken under moonlight conditions

Extensively studied in VHE with MAGIC!
Challenging to analyze due to the different observation conditions.

Light Curve of LS I +61 303

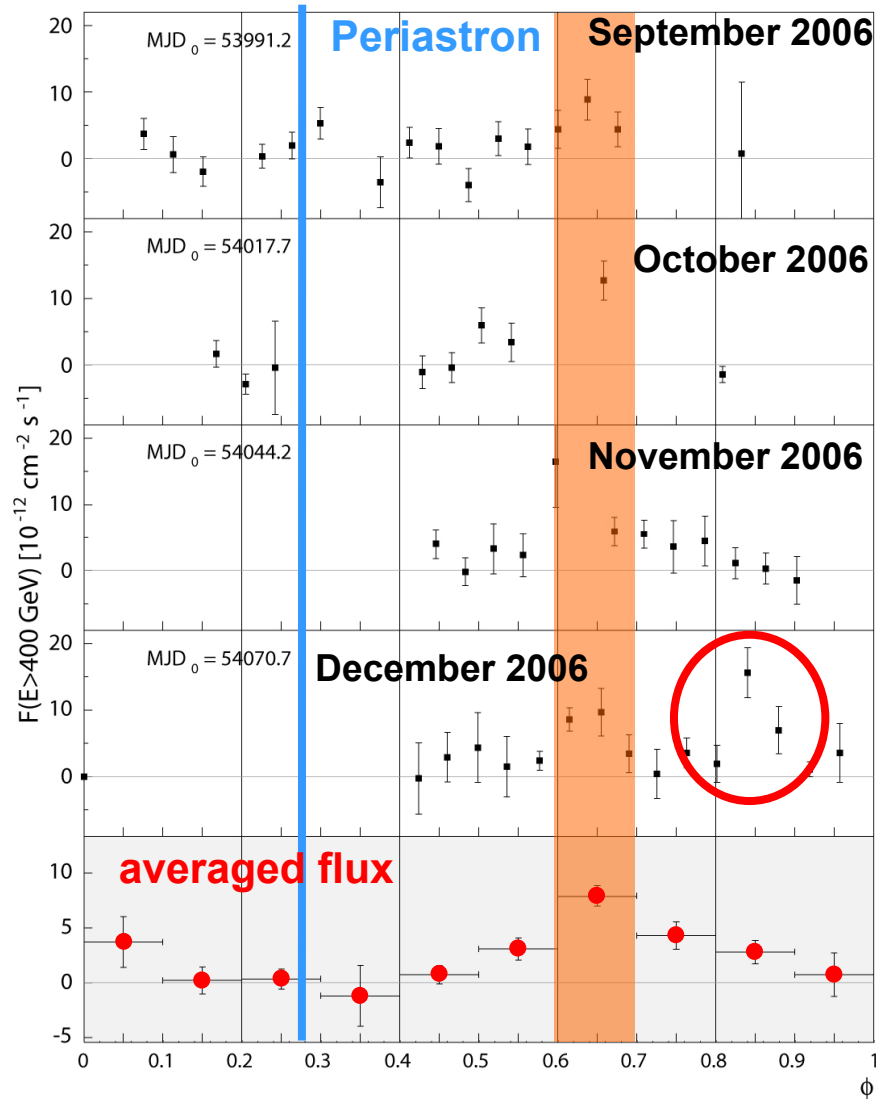
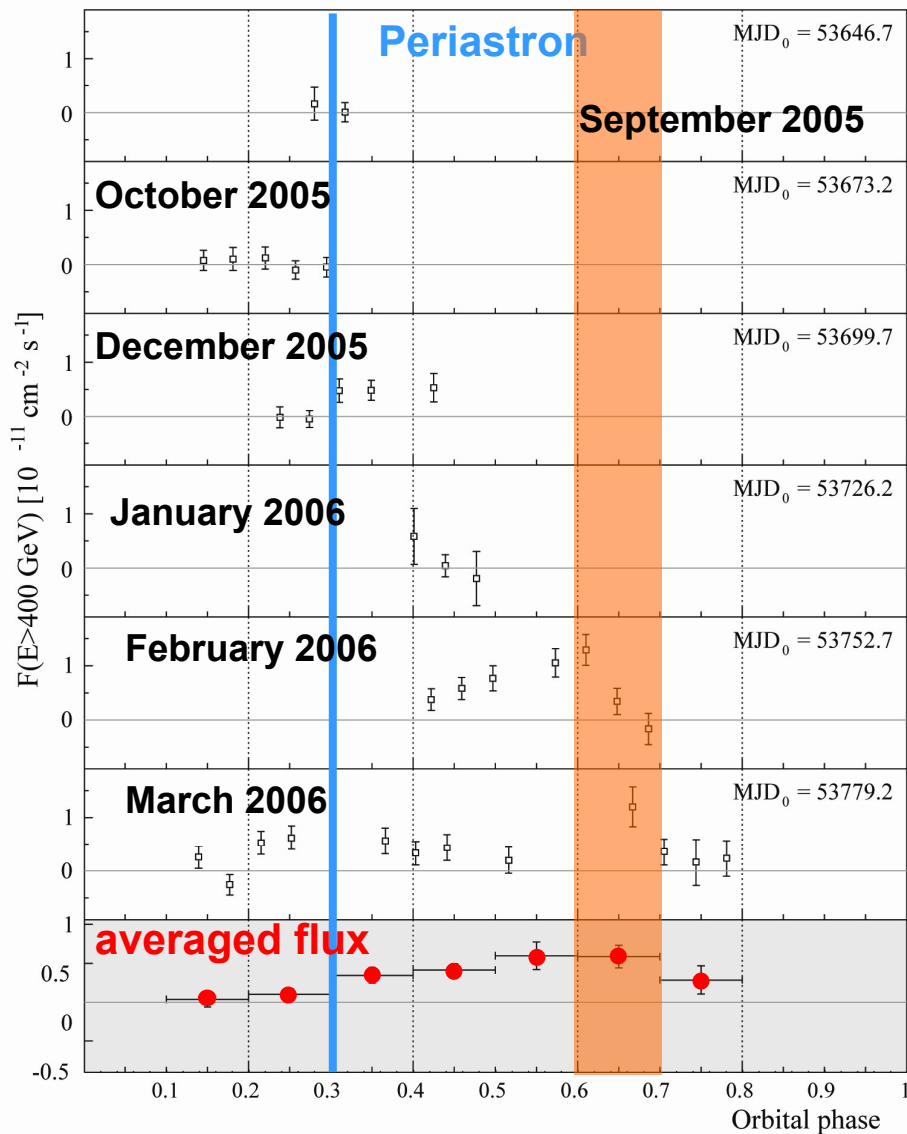


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09/2005 – 03/2006

Albert et al. Science (2006)

09/2006 – 12/2006



Light Curve of LS I +61 303

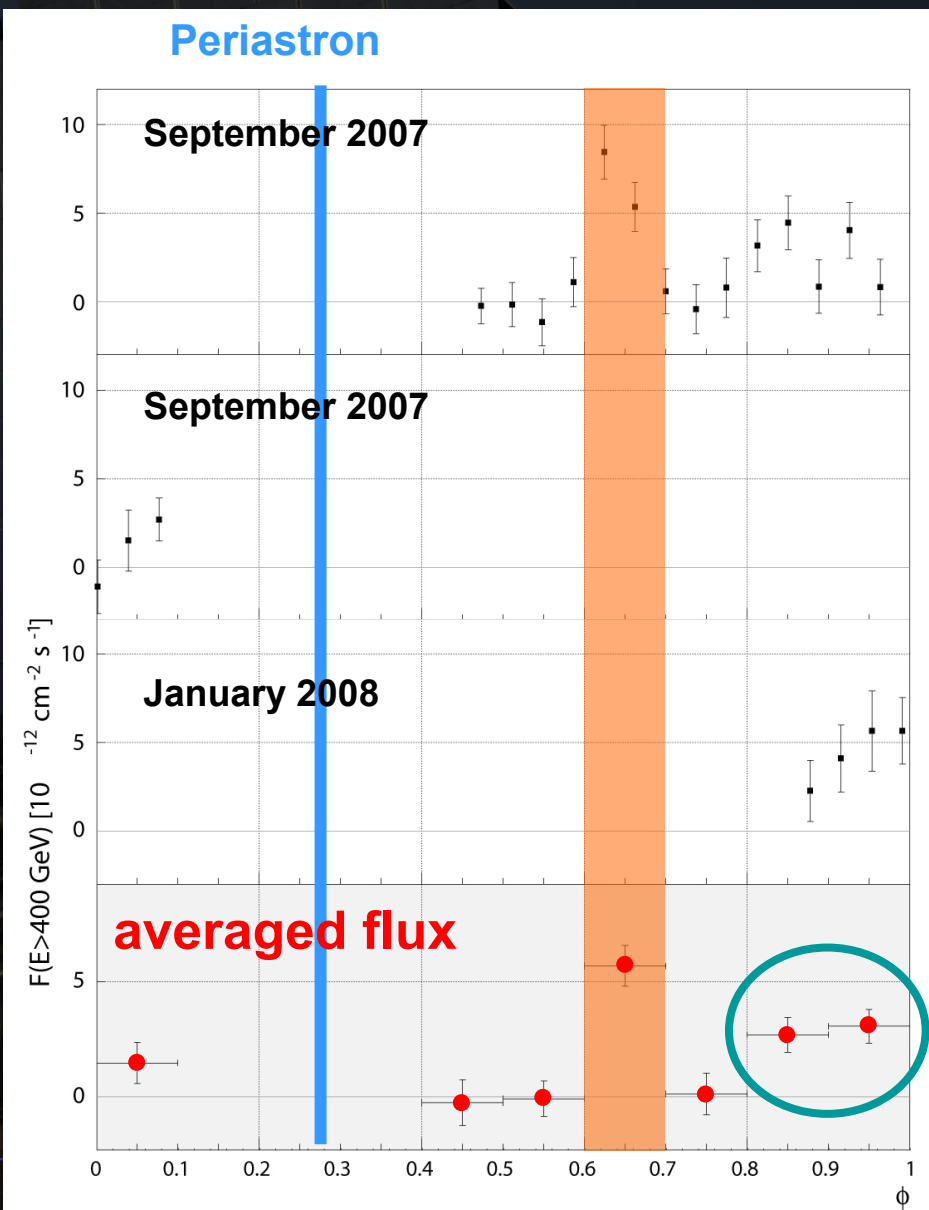


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All LC show the highest flux in phase 0.6-0.7

Some additional high fluxes

Is the LC periodic ?



Periodicity test

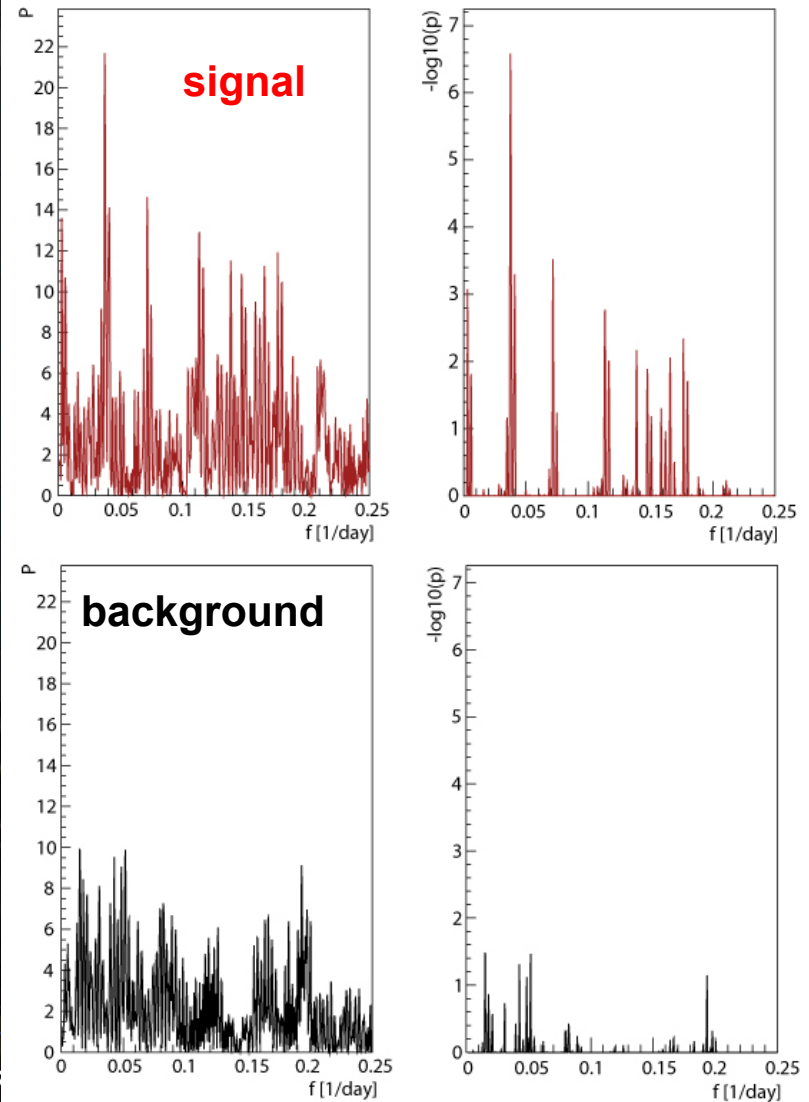


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All data tested with the Lomb Scargle method

Periodic in VHE

$P = 26.60 \pm 0.45$ days



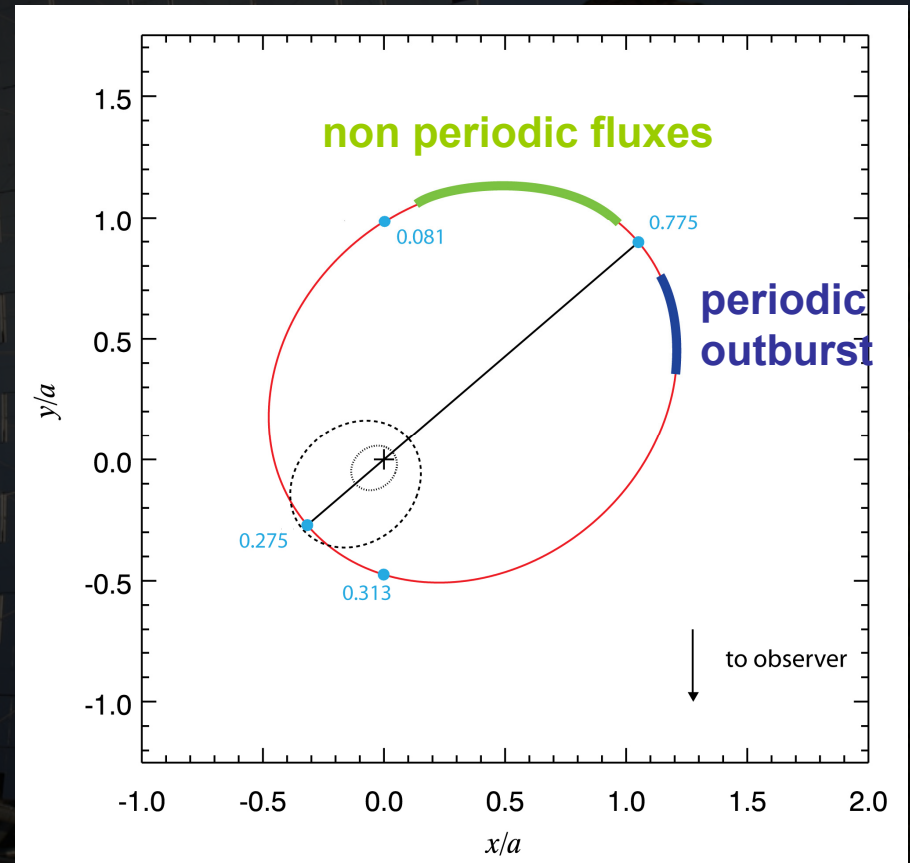
Same period in all energies

Periodicity in LS I +61 303



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- Periodic outburst in phase 0.6-0.7 modulated with orbital period
- Additional fluxes phase 0.8-1.0 not modulated with orbital period



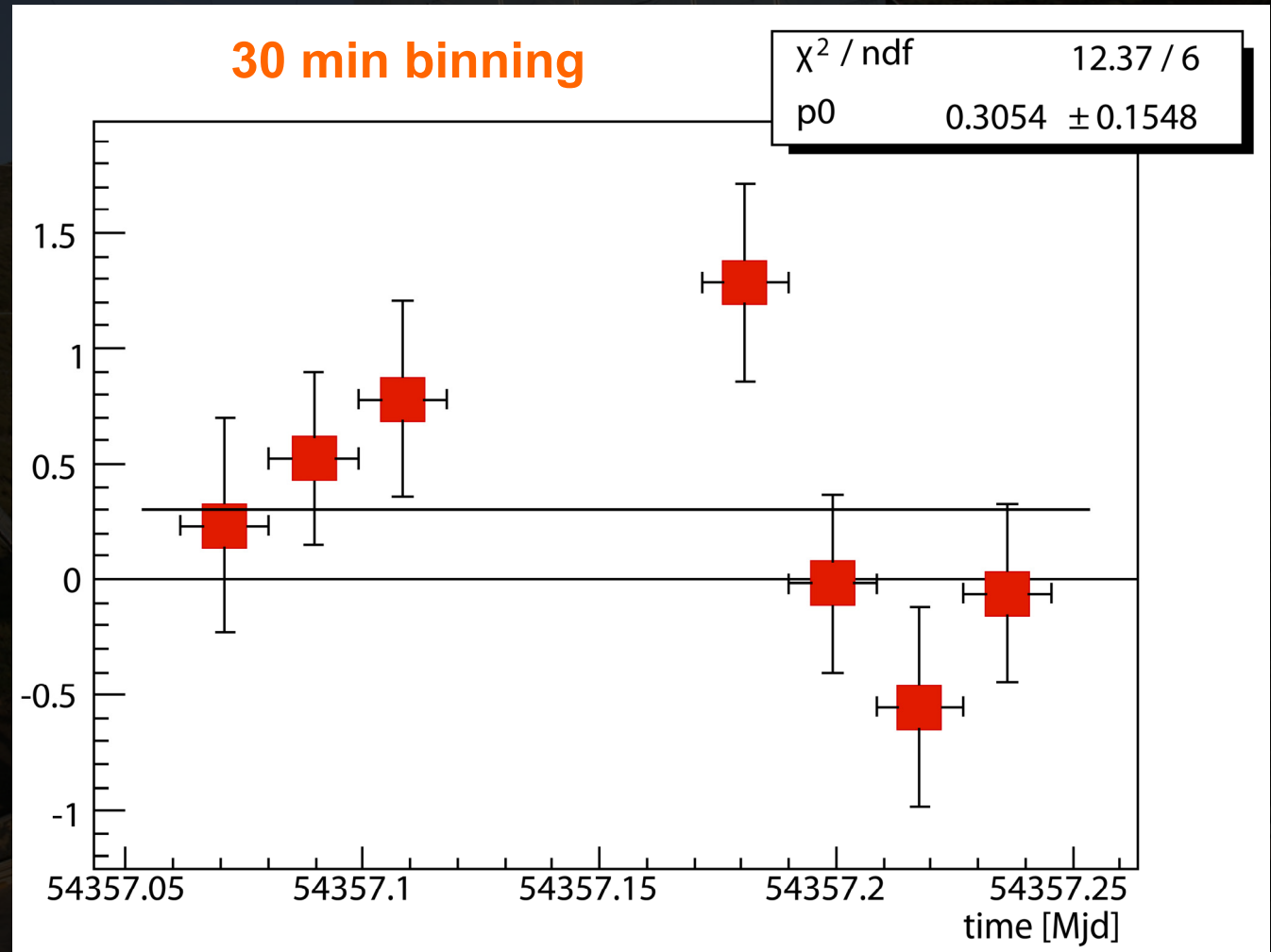
Periodic emission in phase 0.6-0.7 and additional emission varying from orbit to orbit

Short timescale variability



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Several intra-night LCs show indication of variability but not yet significant enough



Spectral behavior

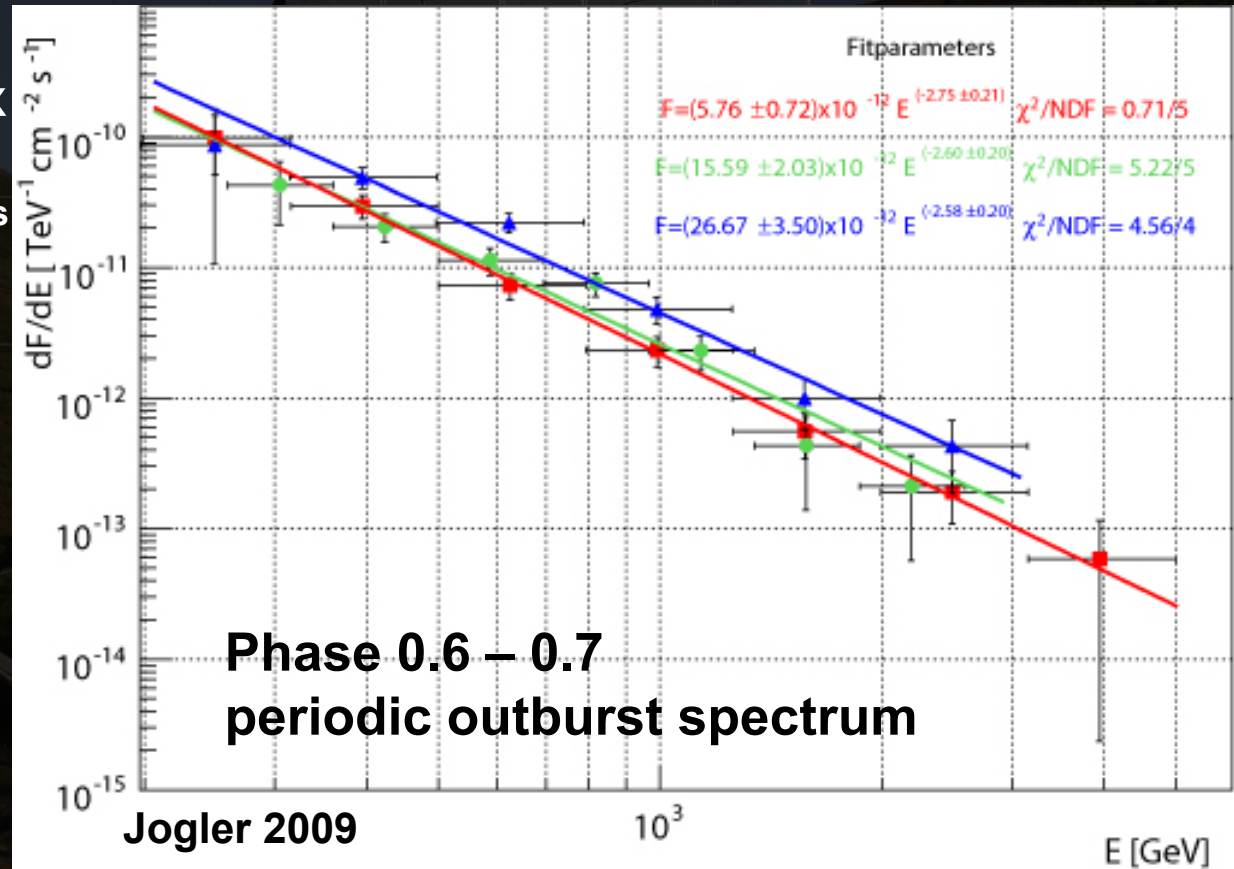


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Well fitted by a power-law with spectral index

$$\Gamma = -2.6 \pm 0.2_{\text{stat}} \pm 0.2_{\text{sys}}$$

Flux differences due to different sampling



Periodic outburst spectrum exhibits stable photon index

γ -ray emission from binaries



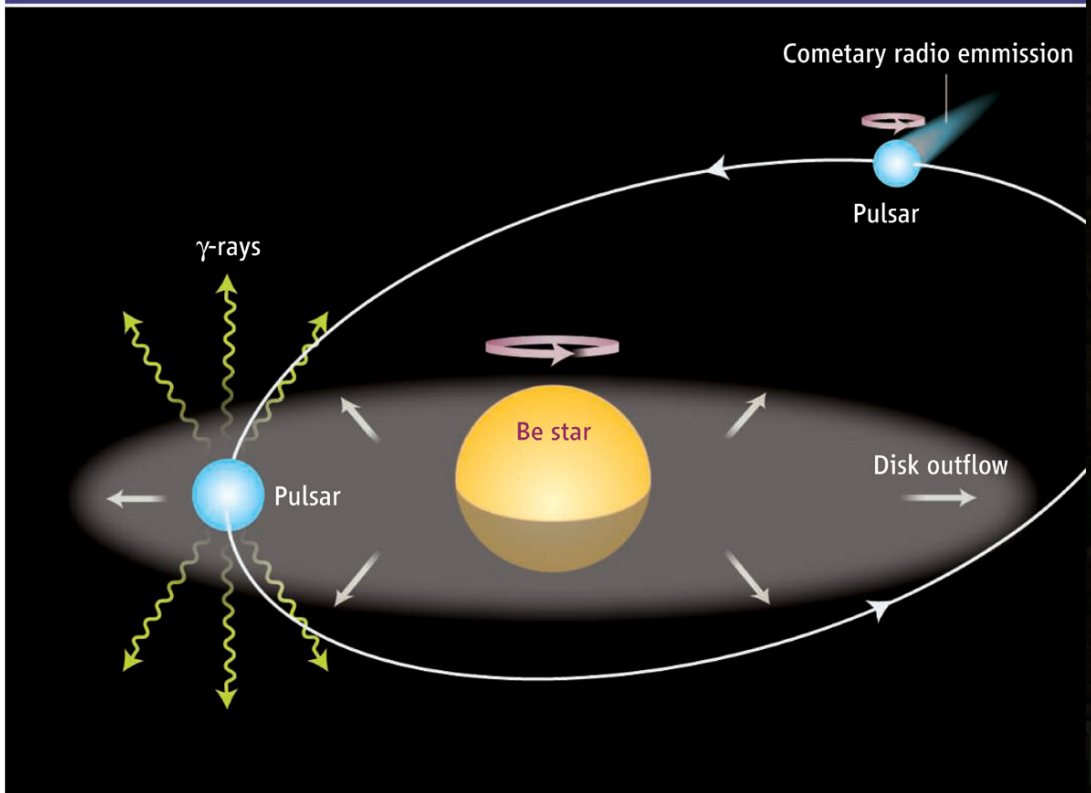
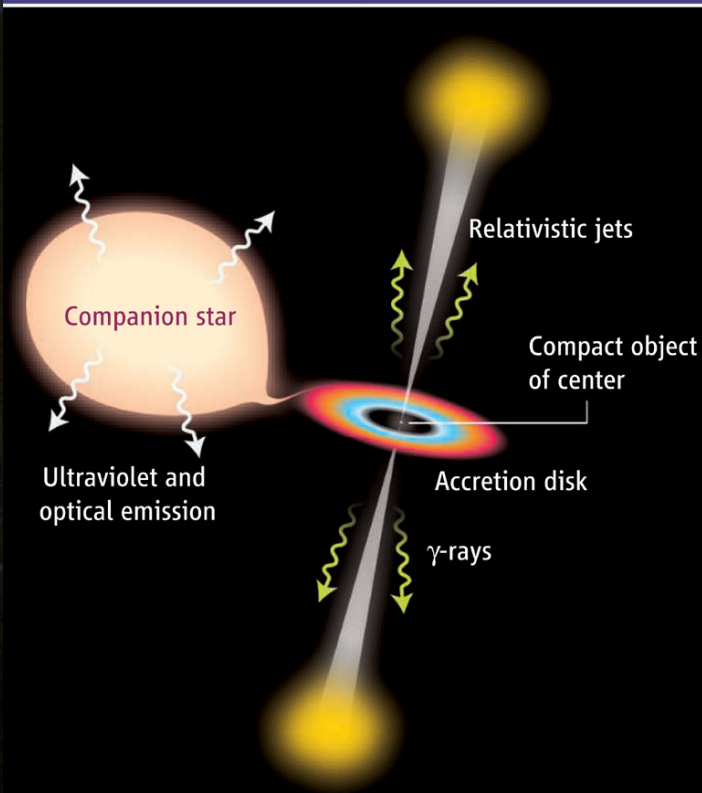
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accretion powered

rotation powered

MICROQUASAR

BINARY PULSAR



Mirabel 2006



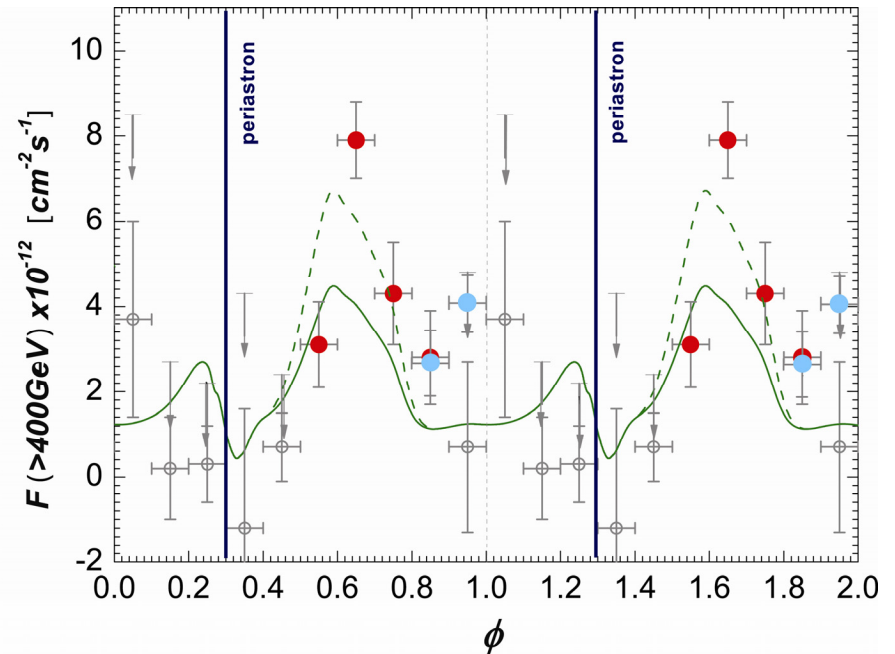
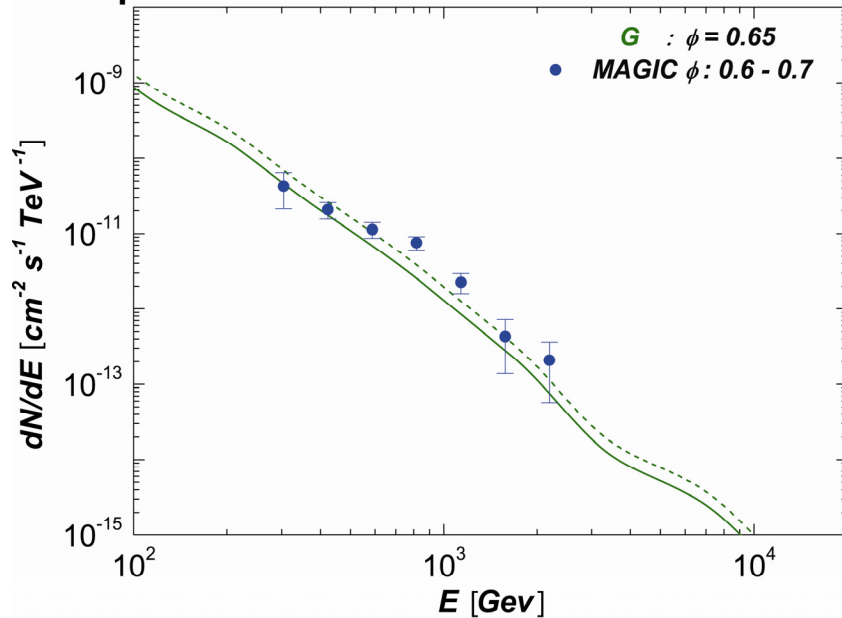
The free PWN model



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Model assumes free pulsar wind
with power law distribution of electron energies

Sierpowska-Bartosik & Torres 2009



Rather good agreement but not yet perfect

Conclusions



- **LS I +61 303 is a periodic VHE gamma ray emitter with outburst in orbital phase 0.6-0.7**
- **Additional phases show (sometimes) VHE gamma ray emission**
- **Flux variability on timescales less than 1 day**
- **Maybe short timescale variability (~ 0.5 -1 hour)**
- **Spectrum well described by power law with index 2.6 for periodic outburst**

Dens sampling of the orbital cycles and high dutycycle of the observation are mandatory for these studies!