CSIC

Fermi Gamma-ray Space Telescope

Results from the binaries LS I +61º 303 & LS 5039 after 2.5 years of Fermi monitoring

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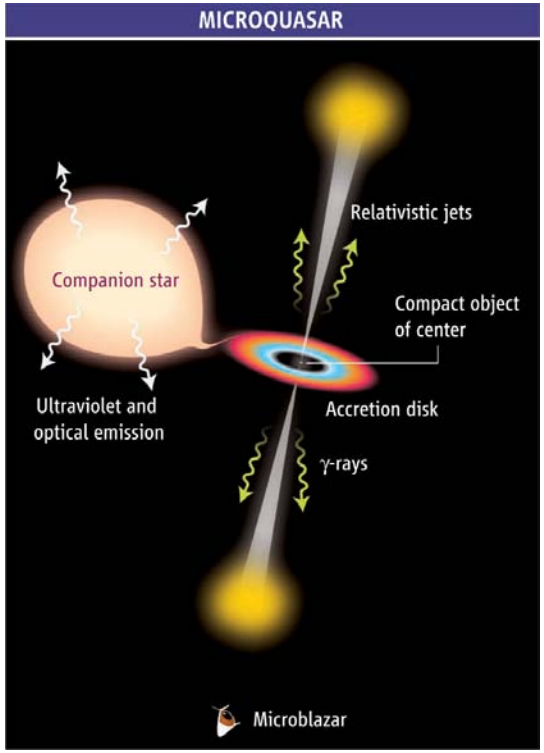
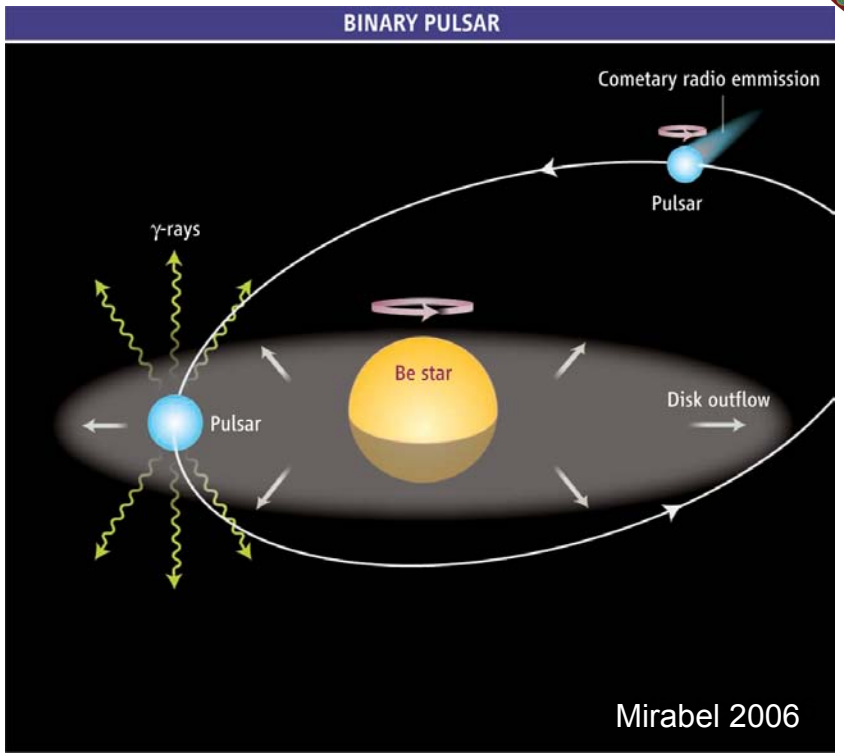
on behalf of the Fermi-LAT collaboration

Microquasars or binary pulsars?





γ_{LE}: synchrotron radiation or from star
e^- and p: accelerated in the jet
ion: from companion star

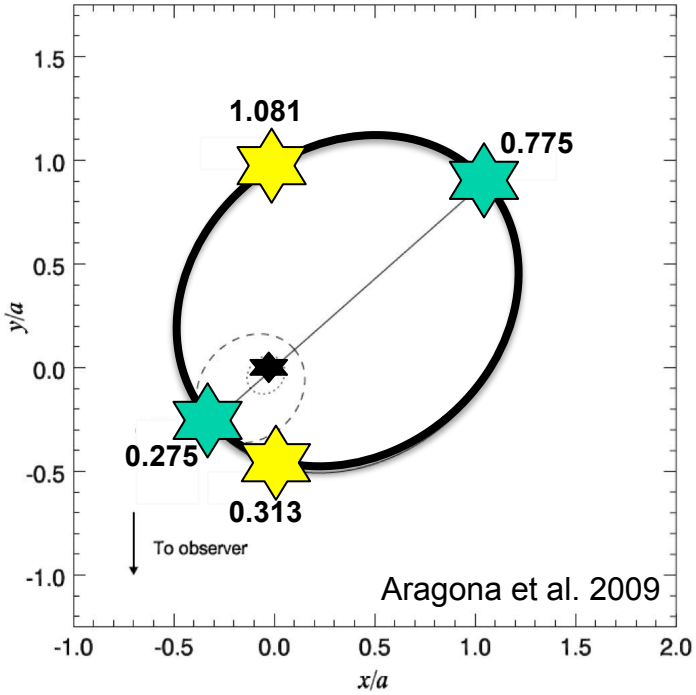
γ_{LE}: from companion star
e^- and p: from relativistic pulsar wind
ion: from companion star

Leptonic scenario: $e + \gamma_{LE} \rightarrow e + \gamma_{VHE}$

Hadronic scenario: $p + ion \rightarrow \pi_0 + \pi^{\pm}$, $\pi_0 \rightarrow \gamma\gamma$

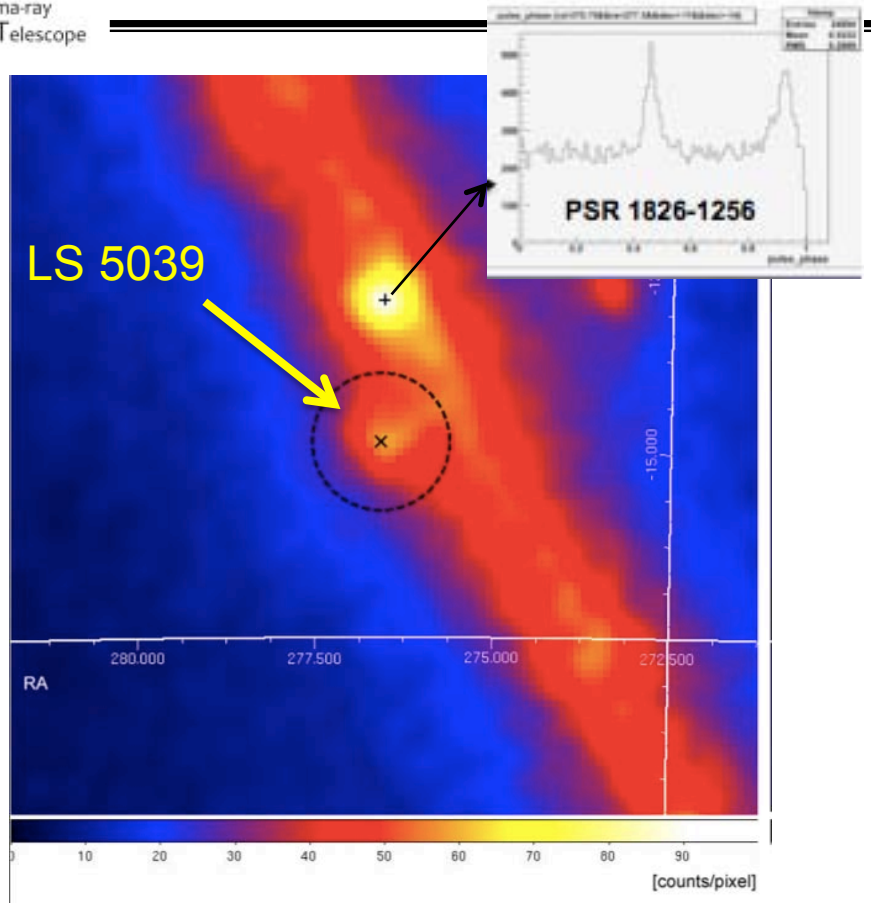
Phase definitions

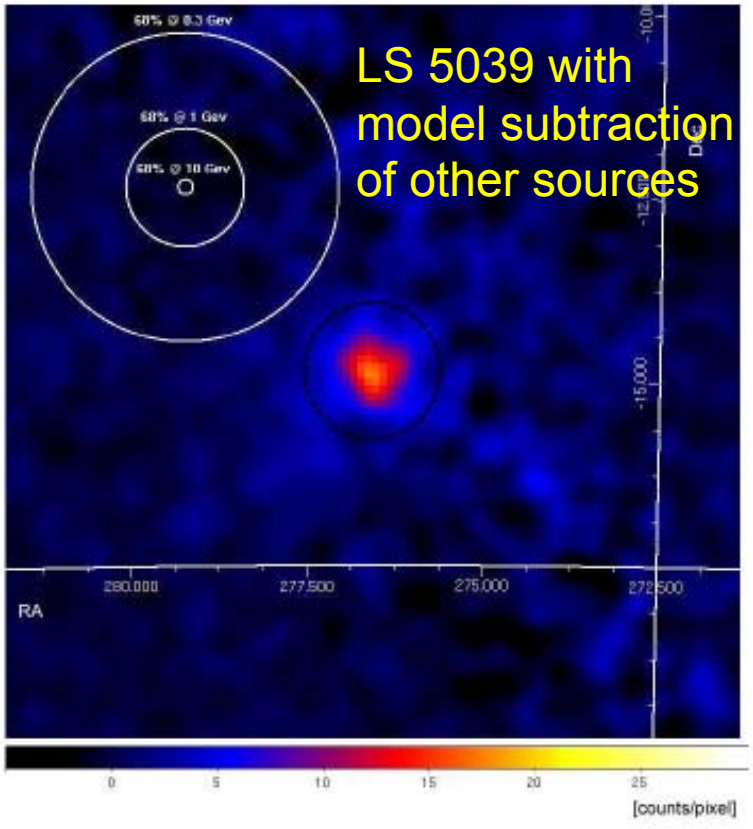
- Explain orbital phases on example of orbit of LS I +61º 303
- **Inferior conjunction**
  - Compact object in **front of the star** with respect to the observer
- **Superior conjunction**
  - Compact object **behind the star** with respect to the observer
- **Periastron**
  - Compact object and star **closest** to each other
- **Apastron**
  - Compact object and star **furthest** away from each other



LS 5039

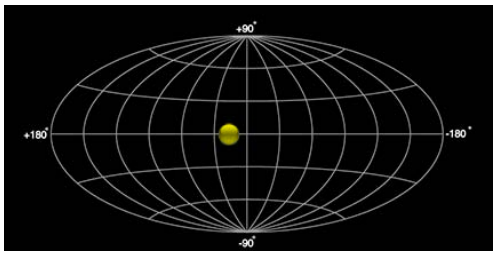
LS 5039



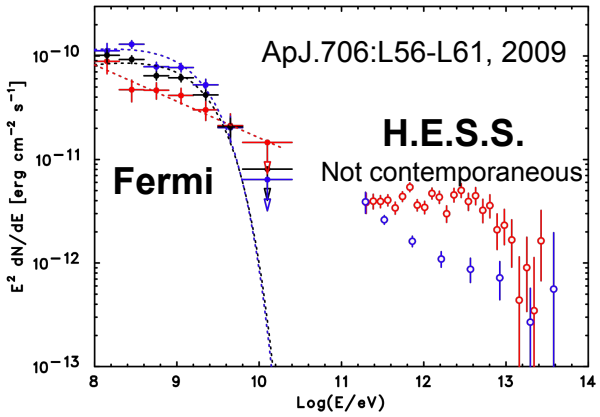


- **LS5039 detected at ~28σ**
- **It sits in a bath of galactic diffuse emission**

→ Faint compared to Galactic plane and also emission from nearby pulsar PSR 1826-1256



LS 5039 - spectra

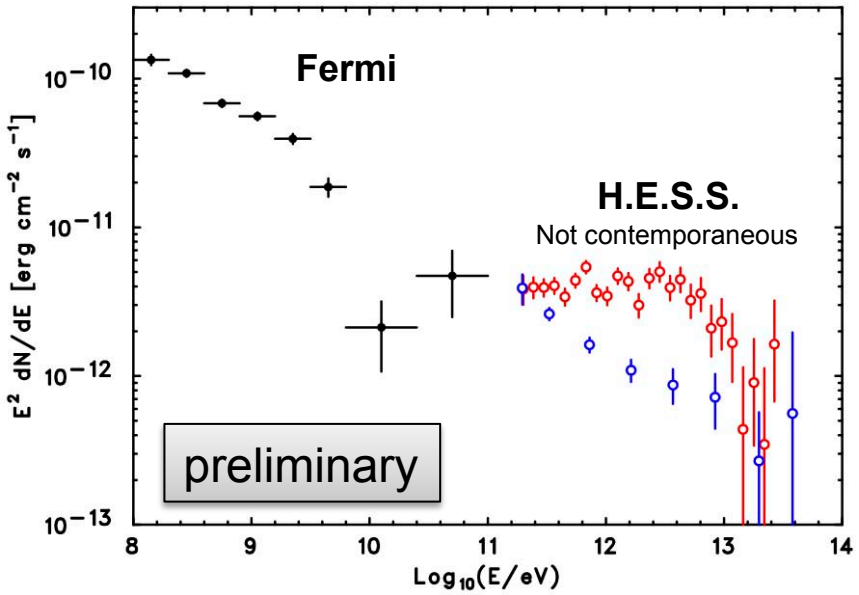


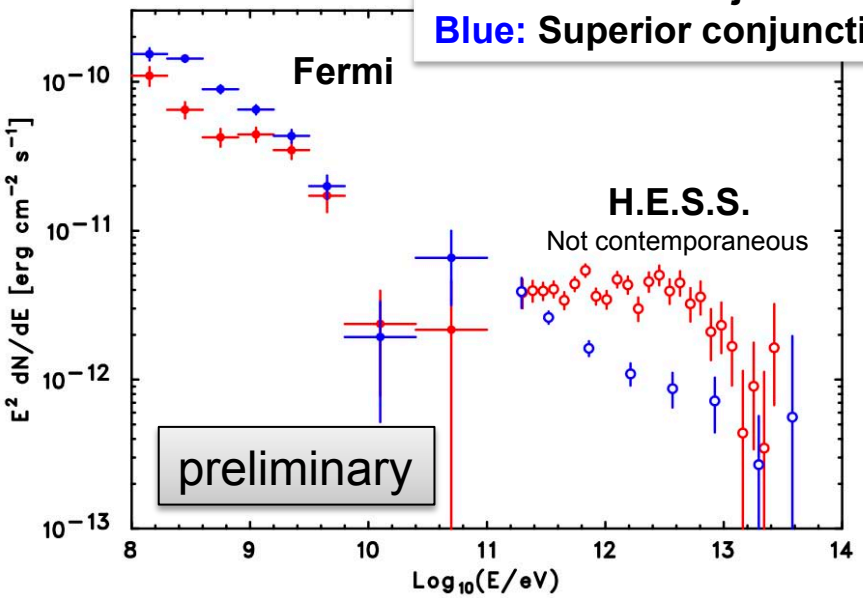
- New data set: 2 ½ years (Aug 2008 – Jan 2011)

→ **Additional data points** at higher energies

- Separated in inferior and superior conjunction
  - **exponential cutoff** at **superior conjunction**
  - now enough statistics at **inferior conjunction** to confirm exponential cutoff there, too

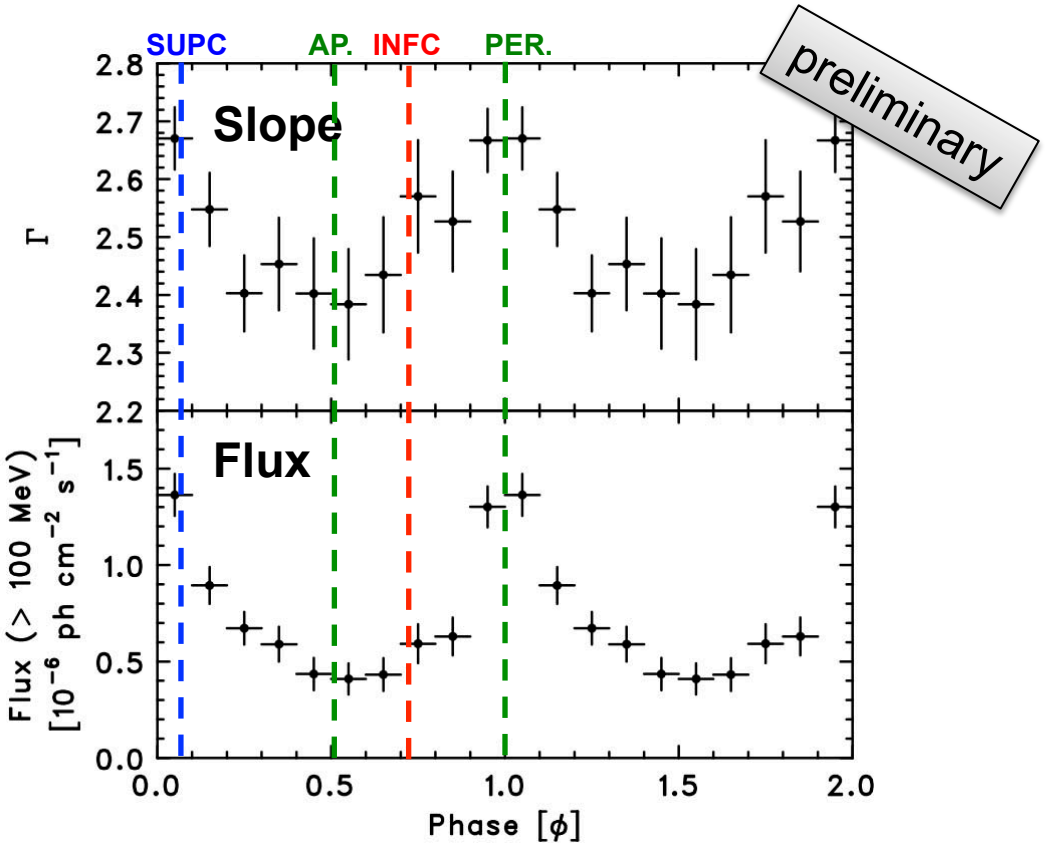
Red: Inferior conjunction
Blue: Superior conjunction





LS 5039 – light curve

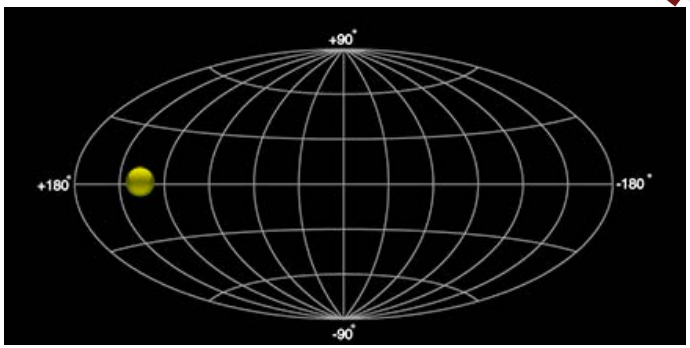
- Periodicity detected at **3.91±0.05 days**
- **No spectral or flux change** in 2 ½ years
  - Indications of **spectral variability** during one orbit still visible
  - Peak of emission around **periastron**, anti-correlated with VHE

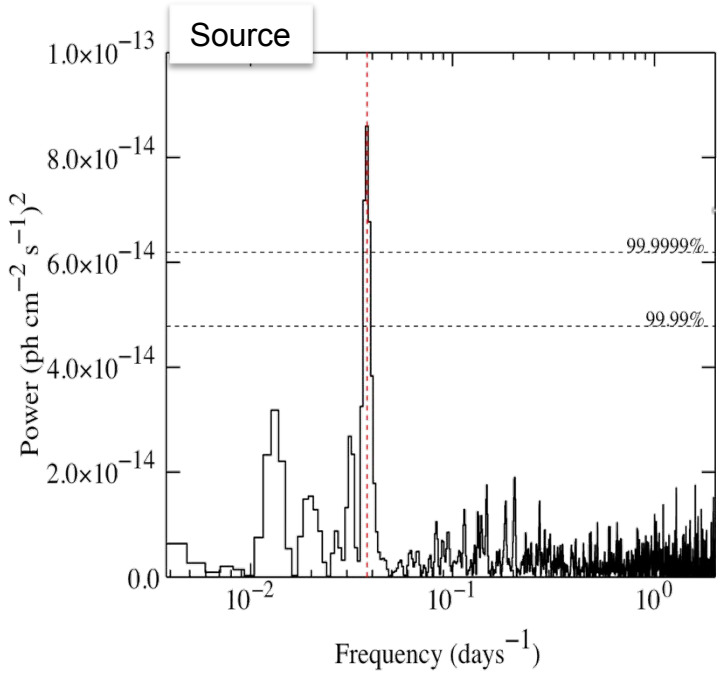


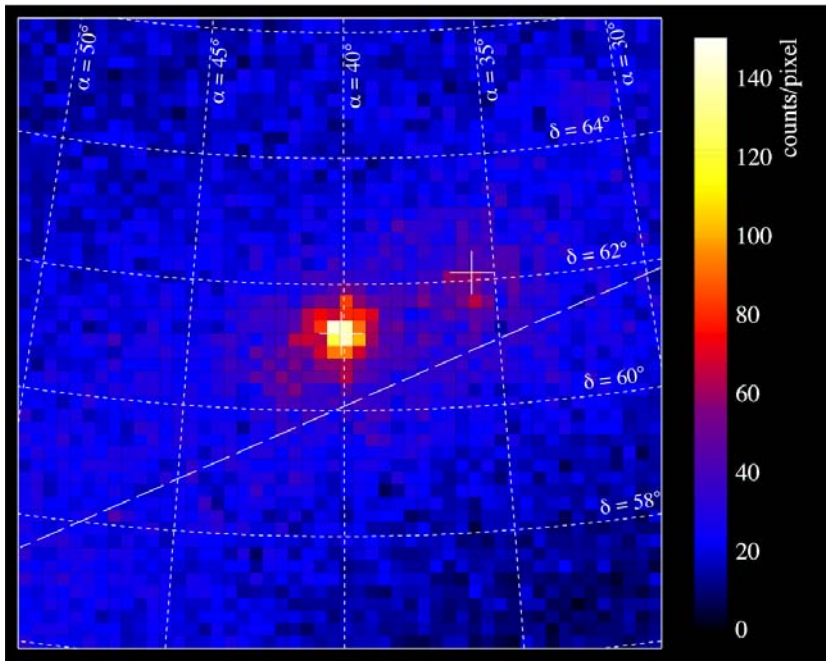
LS I +61º 303

LS I +61º 303 – whole data set

- **LS I +61º 303** was detected at **~70σ**
- Periodicity found at **26.6 ± 0.5 days**

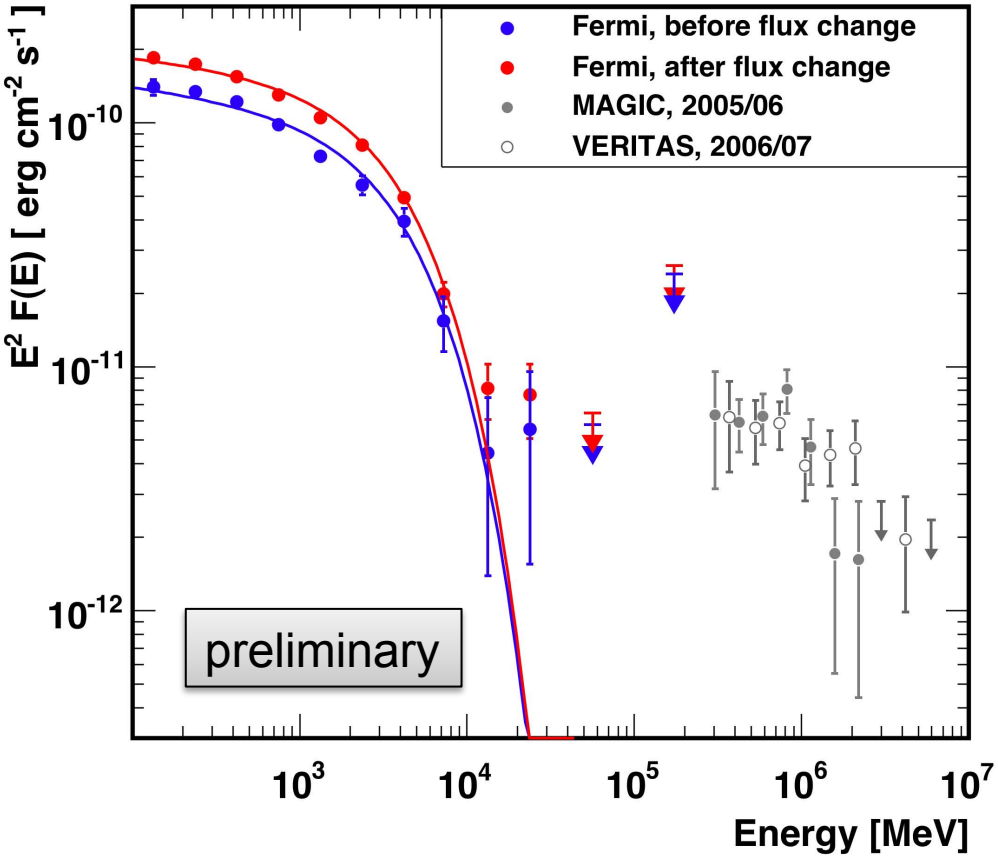


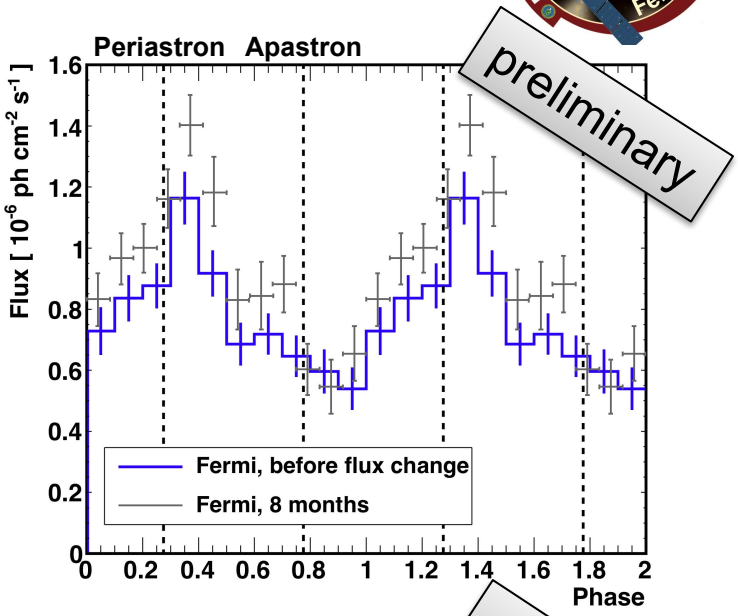


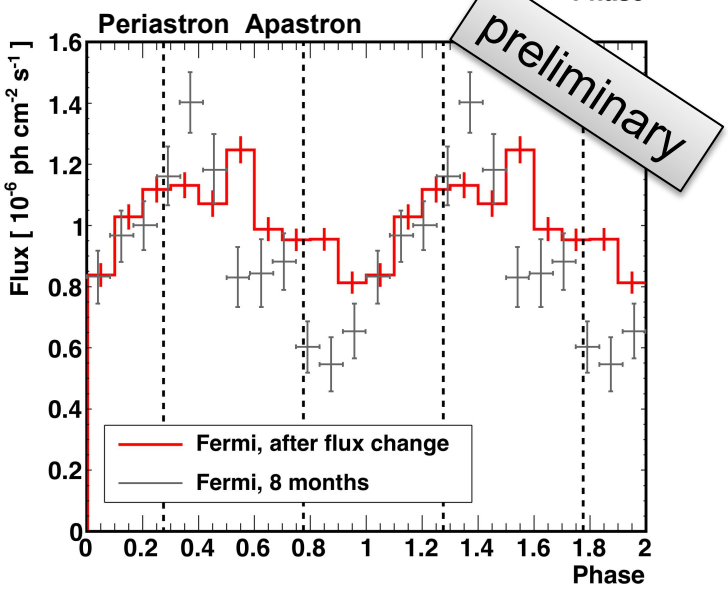


LSI – flux change

- **2 ½ years of data**: Aug 08 - Jan 11
  - **Flux rose** ~30% in March 2009
  - **Modulation decreased** after change



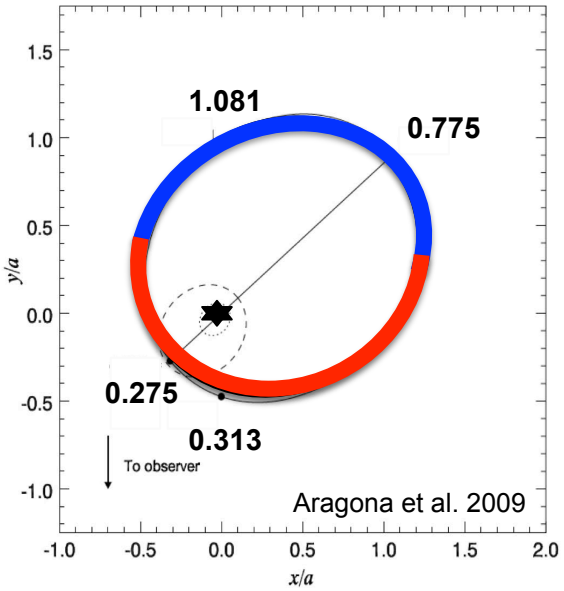




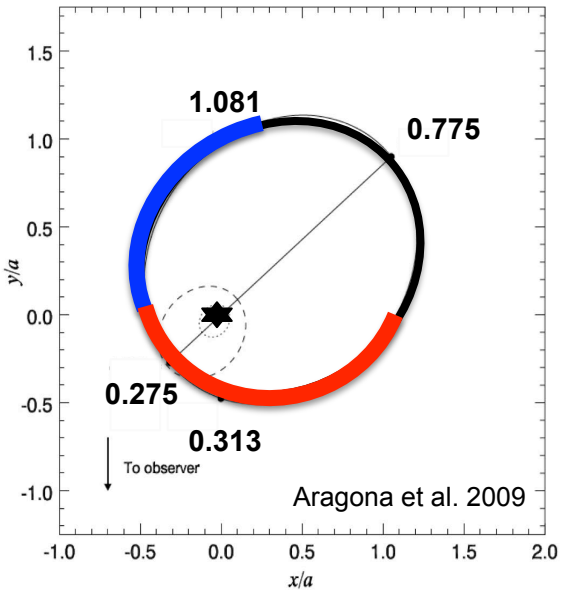
LS I – orbital cuts

- Cut in **inferior/ superior** conjunction: 2 ways

1. Cut **geometrically** looking at sketch
   - **Infc: 0.13 – 0.63**
   - **Supc: 0.63 – 0.13**
   - → **Whole orbit**

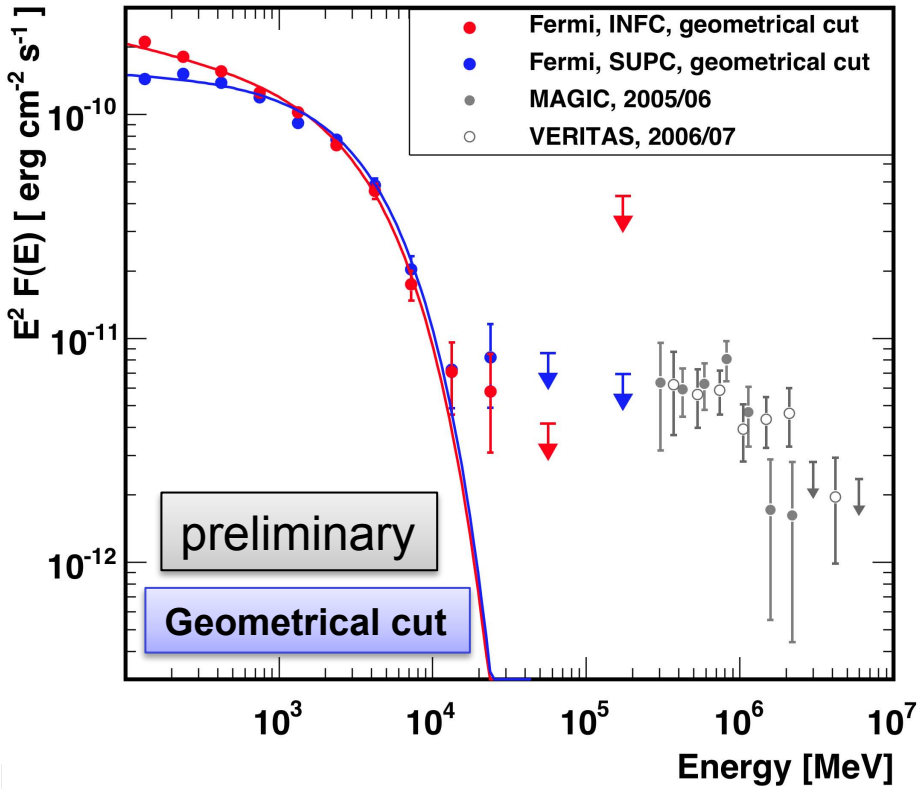


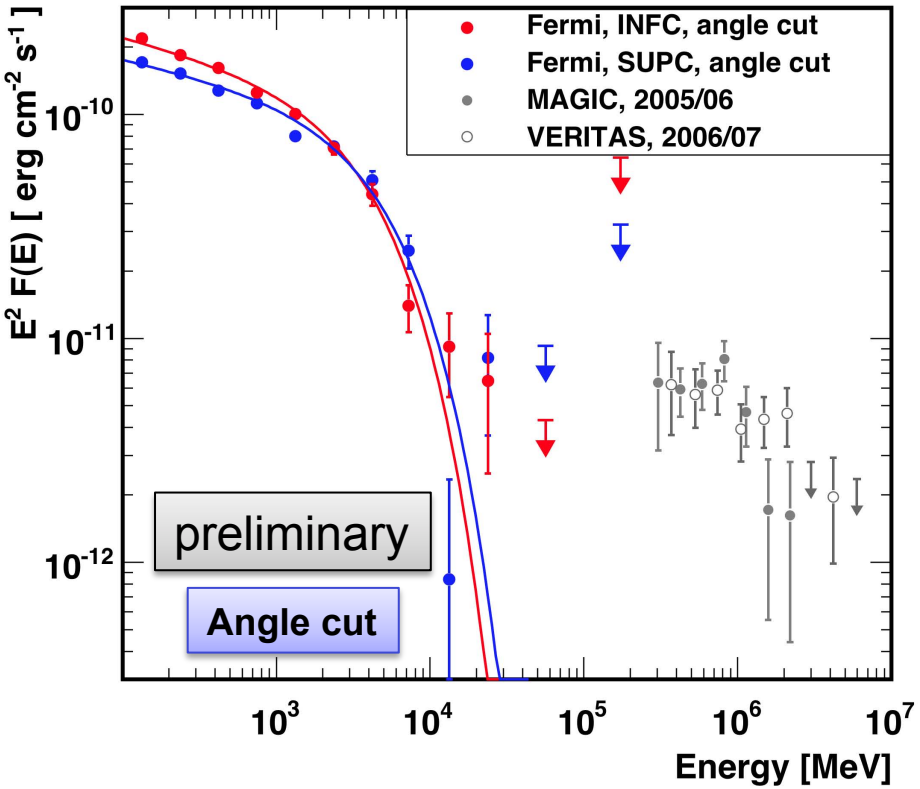
2. Cut in infc and supc regarding **compact object-star-observer angle**
   - **Infc: 0.244 – 0.507**
   - **Supc: 0.981 – 0.244**
   - → **Slices of orbit**



LSI – inferior and superior conjunction

- New data allows for **distinctions of spectra around the orbit**
  - **Exponential cutoff** always favored
  - **Inferior conjunction** higher in flux, specially at **low energies**
  - Both cuts give **similar results**

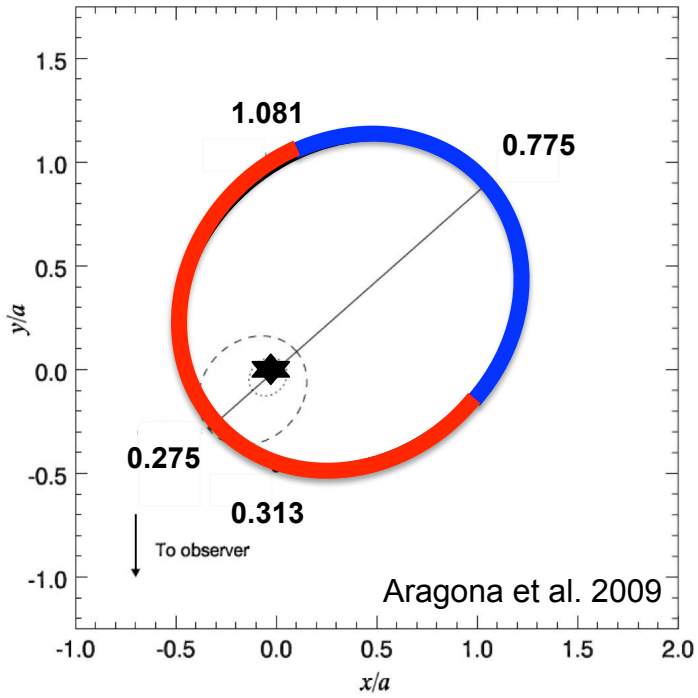




LS I – orbital cuts

- Cut in **periastron/ apastron** conjunction:
  - Regarding the **distance of the two objects**
    - **Periastron: 0.025 – 0.525**
    - **Apastron: 0.525 – 0.025**

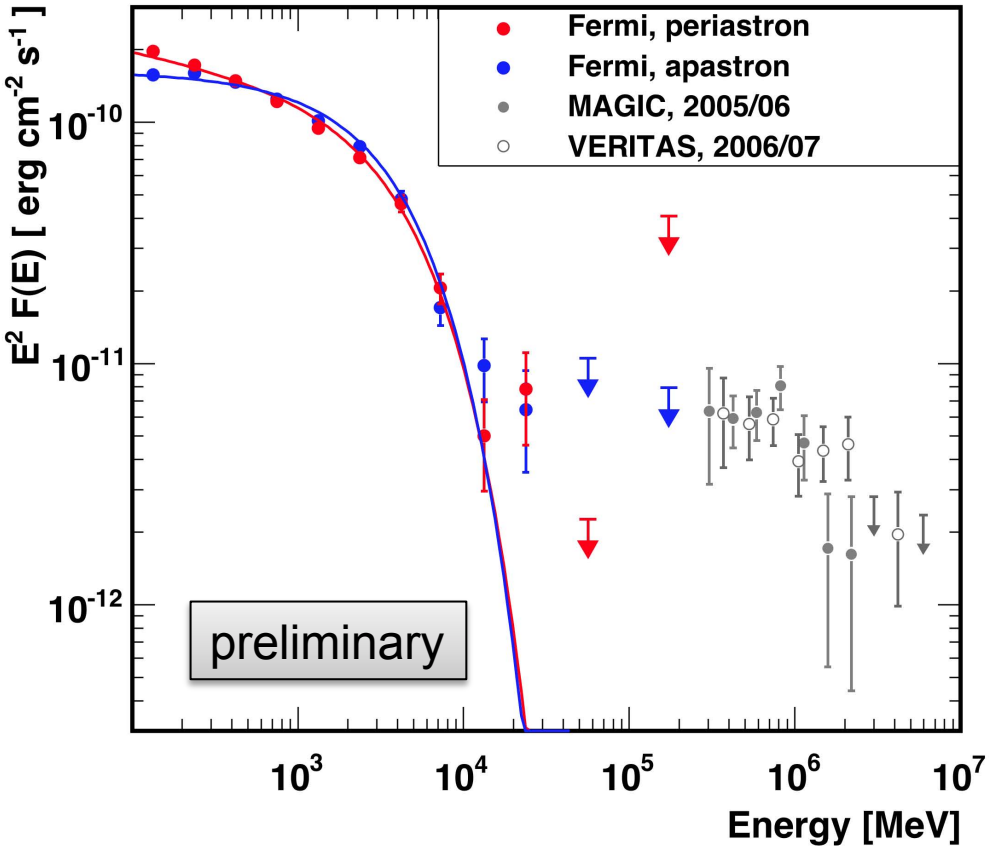
    → **Whole orbit**



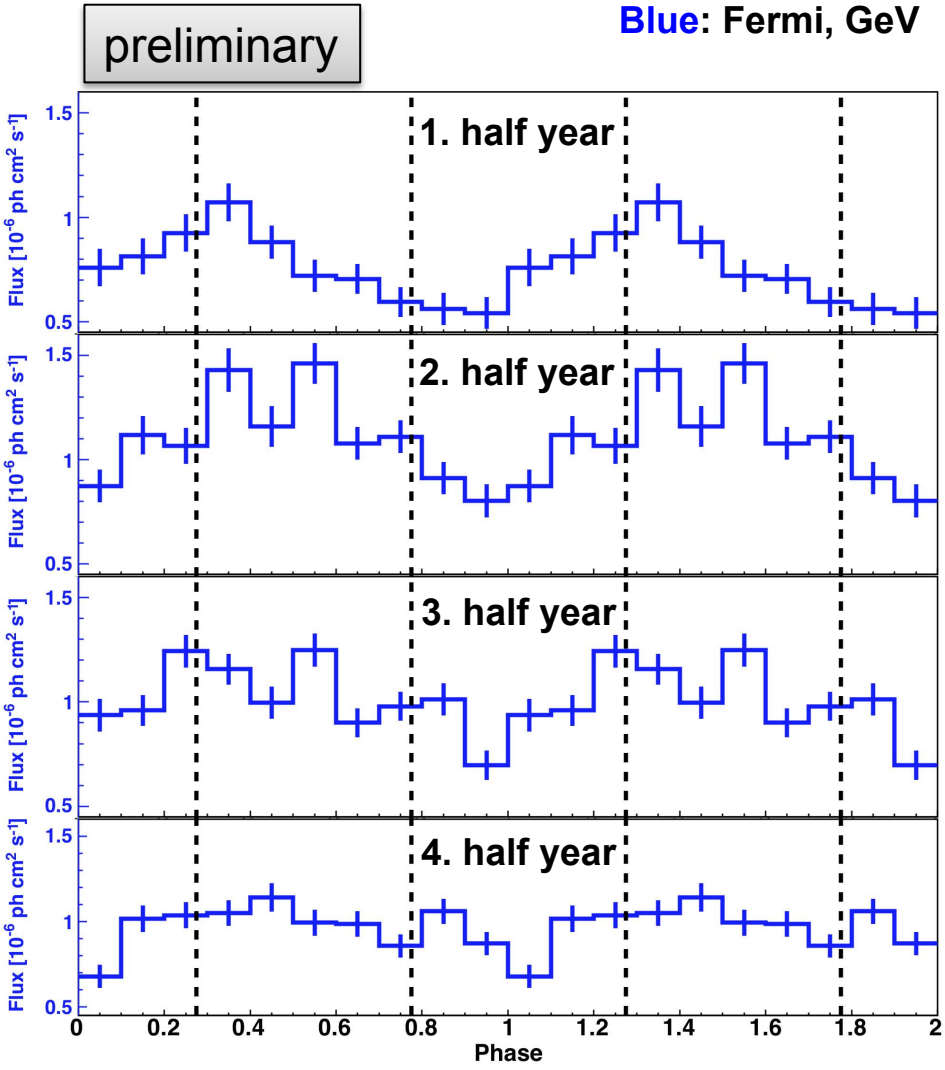
- The orbit is **elliptic** enough so that any cut in phase involves **cross-regions**

LSI – periastron and apastron

- Data sets include **cross regions** with inferior and superior conjunction
  - Flux at periastron slightly higher



LS I – long term behavior

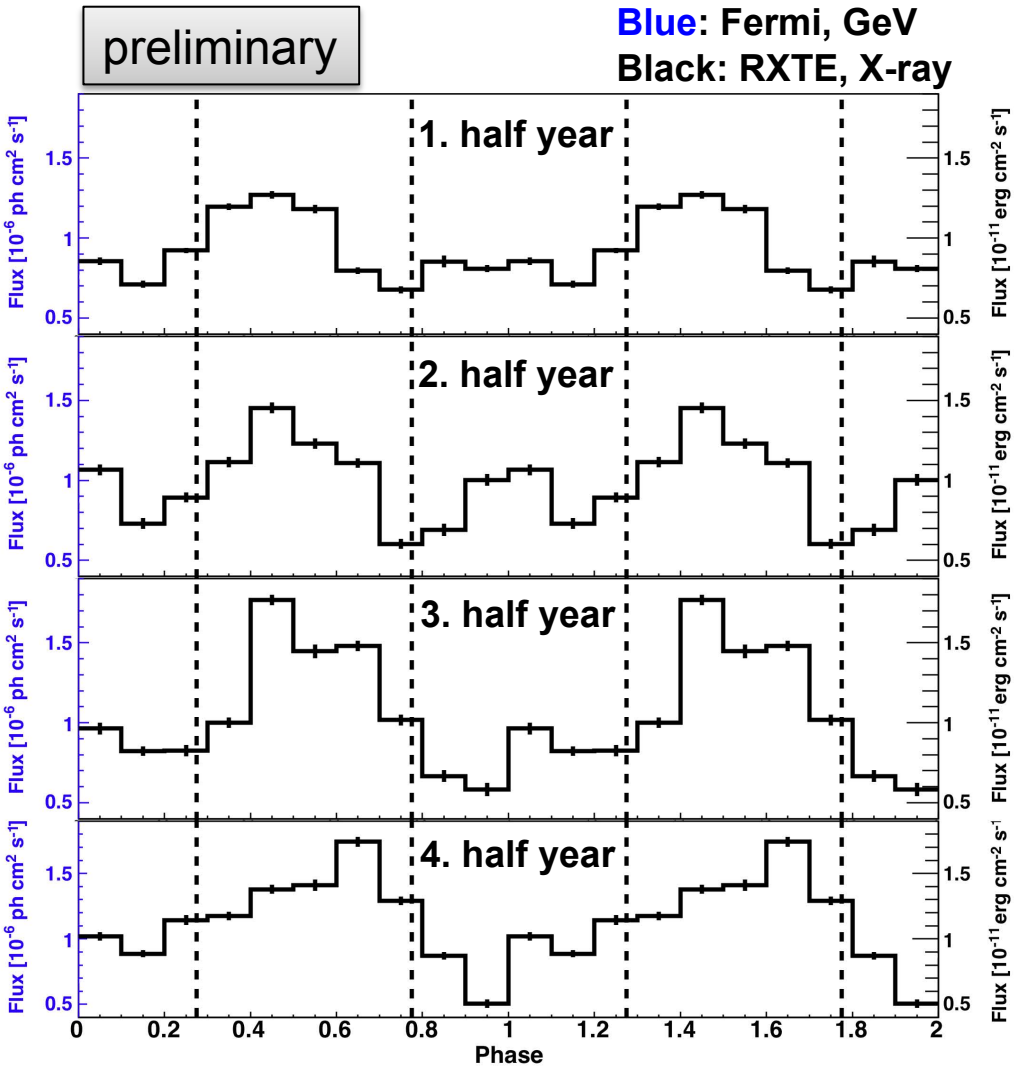


Folded **gamma-ray** light curves in half year bins:

→**Modulation** gets lower

→**Flux** increased after 1. half year

LSI – Comparison: GeV and X-ray



Folded **gamma-ray** light curves in half year bins:

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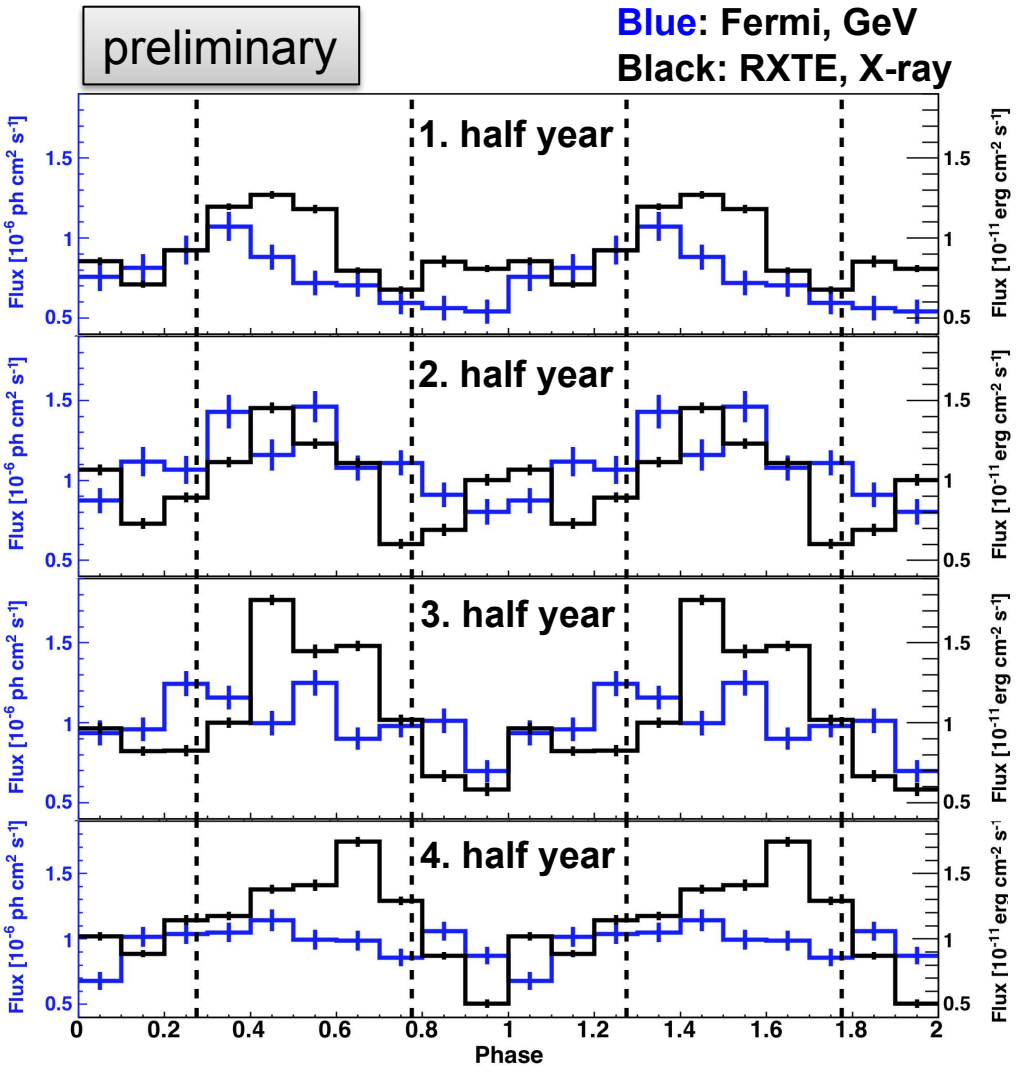
Folded **X-ray** light curves in half year bins:

→**Modulation** highly variable

→**Flux** increases

LSI – Comparison: GeV and X-ray



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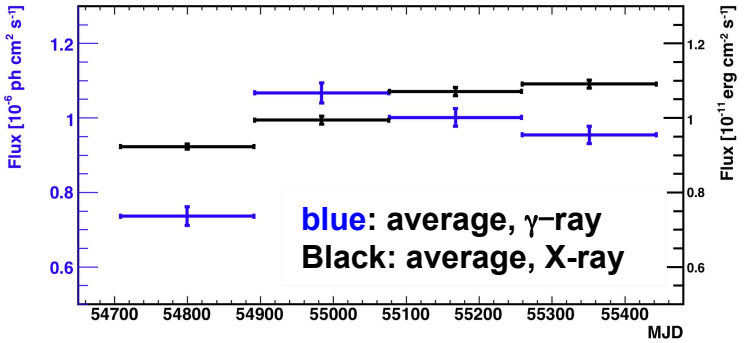


Summary

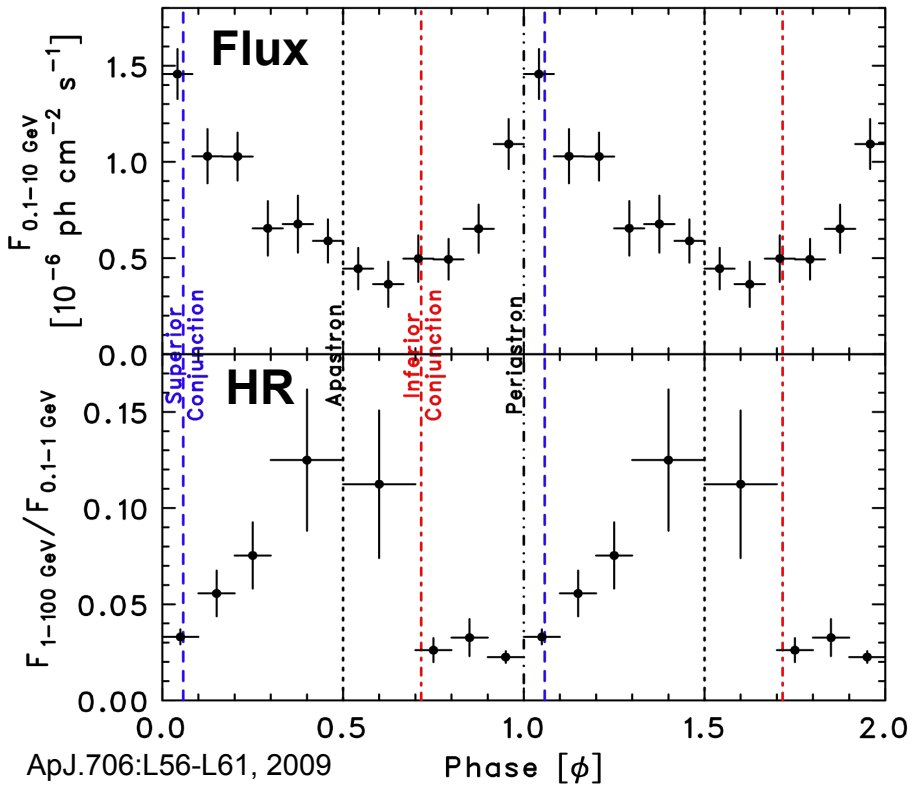
- **LS 5039 continues to show clear orbital modulation, stable over 2 ½ years of monitoring**
  - **Spectral parameters stable**
  - **Significant emission at highest energies**
  - **Peak emission around periastron**

- **LS I +61º 303 showed a ~30% flux change in March 2009**
  - **Now enough statistics to make spectral studies of the orbital phases**
  - **Flux is higher at inferior conjunction**
  - **Cutoff stable for different phases**
  - **Orbital modulation is fading away with time**
- **Monitoring of binaries ongoing → Poster by Tom Glanzman**
- **TeV observations of LS I +61º 303**
  - **Detections by MAGIC and VERITAS**
  - **Source appears fainter after 2009**

THANK YOU!

BACK UP

LS5039 - published



LS I +61º 303 – whole data set

- New data set: 2 ½ years (Aug 2008 – Jan 2011)
  - Power law with **exponential cutoff** clearly favored over power law
  - Modulation is **lower** now