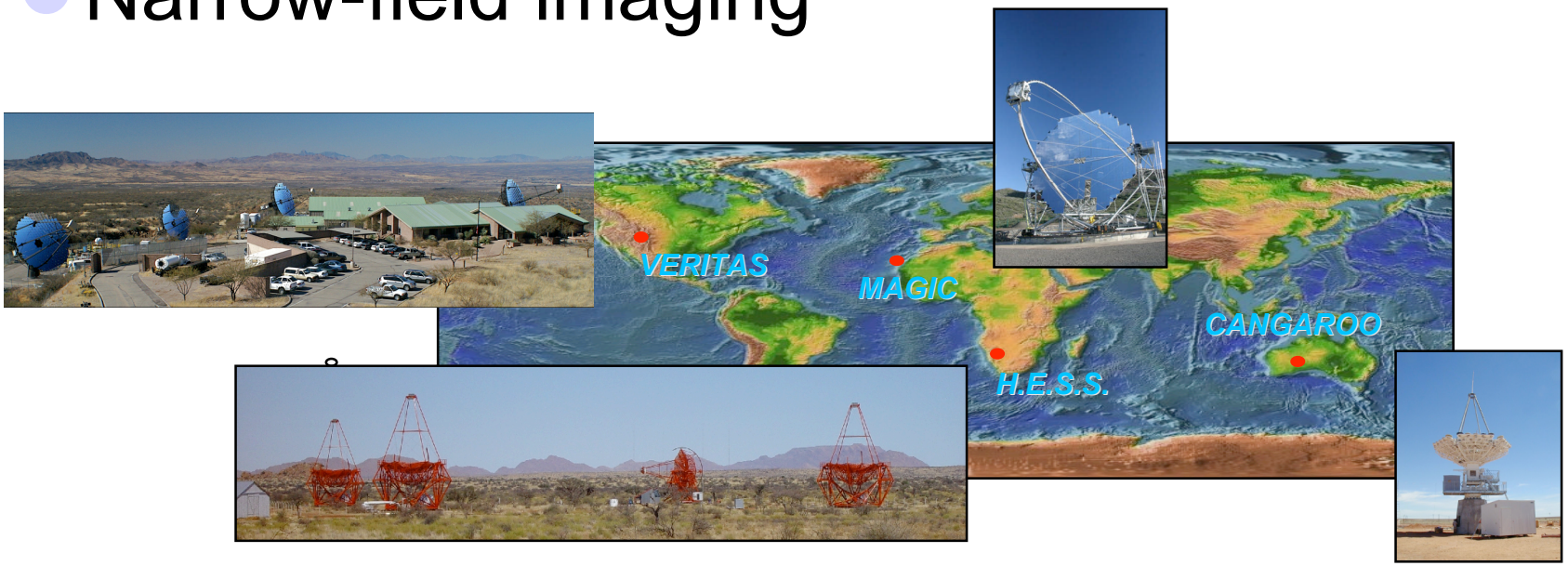
Cases for Sensitive Wide-Field TeV Gamma Ray Survey

Wei Cui

Department of Physics
Purdue University

Ground-Based Gamma Ray Experiments

- Narrow-field imaging



- Wide-field surveying

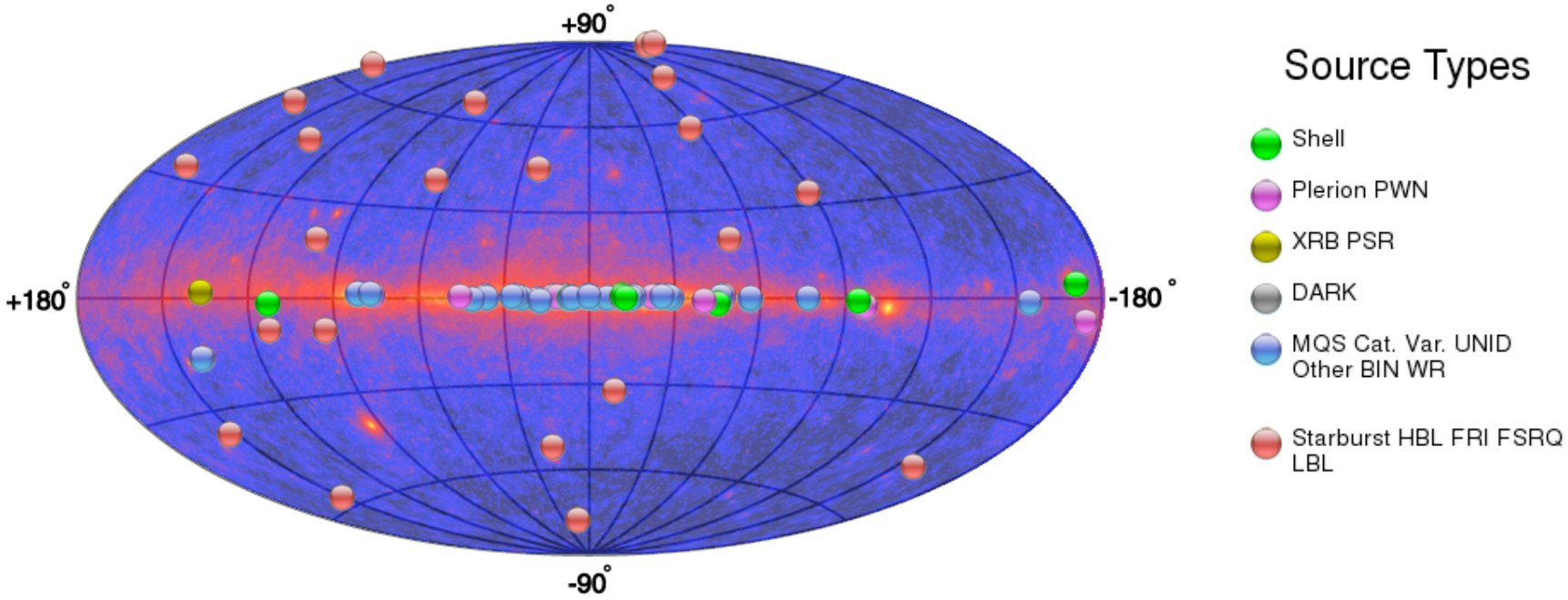
Complementarity: Technique

- Wide-Field Survey
  - Full-sky coverage
  - Long duty cycle
- Narrow-Field Imaging
  - High sensitivity
  - Low energy threshold
  - Superior energy resolution
  - Good spatial resolution

Complementarity: Science

- Wide-field survey
  - Discovery
  - Transient phenomena
  - Variable sources
  - Large-scale emission
- Narrow-field imaging
  - Detailed studies
    - Morphology, SED, etc.

TeV Gamma Ray Sources



http://tevcat.uchicago.edu/

Common Dilemma

- What to observe?
  - Theorist's guesses (aka theoretical predictions)
  - Observer's guesses
  - Politics
- How to distribute time among hot targets?
  - Well, each gets an hour
  - My targets are better than yours!
- Shall we go after that GRB?
- … …

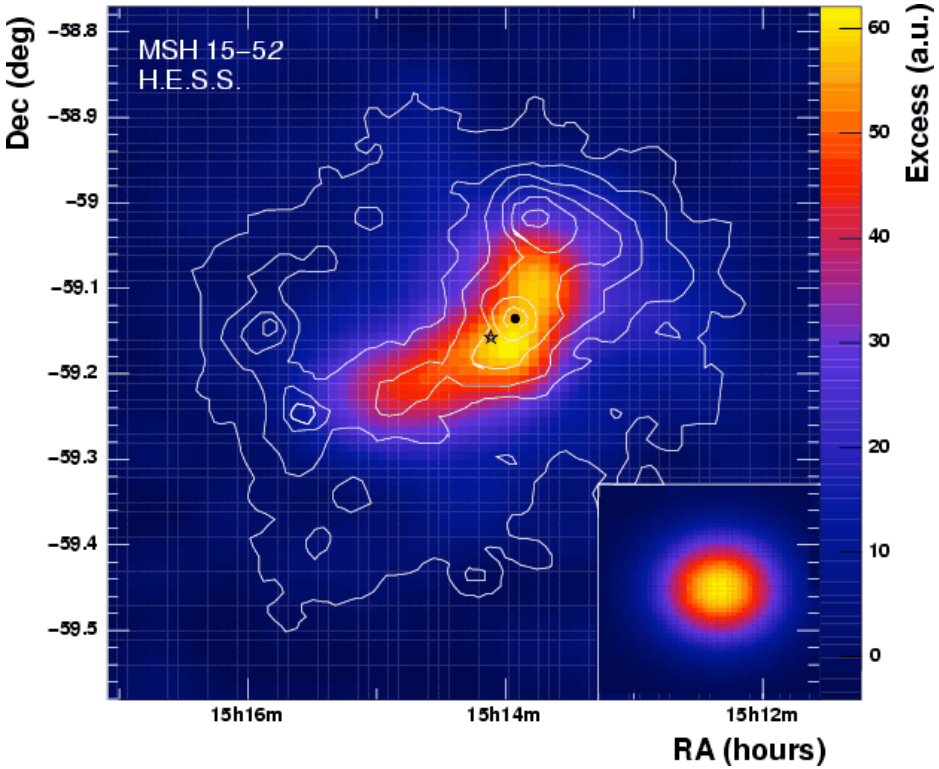
Solution

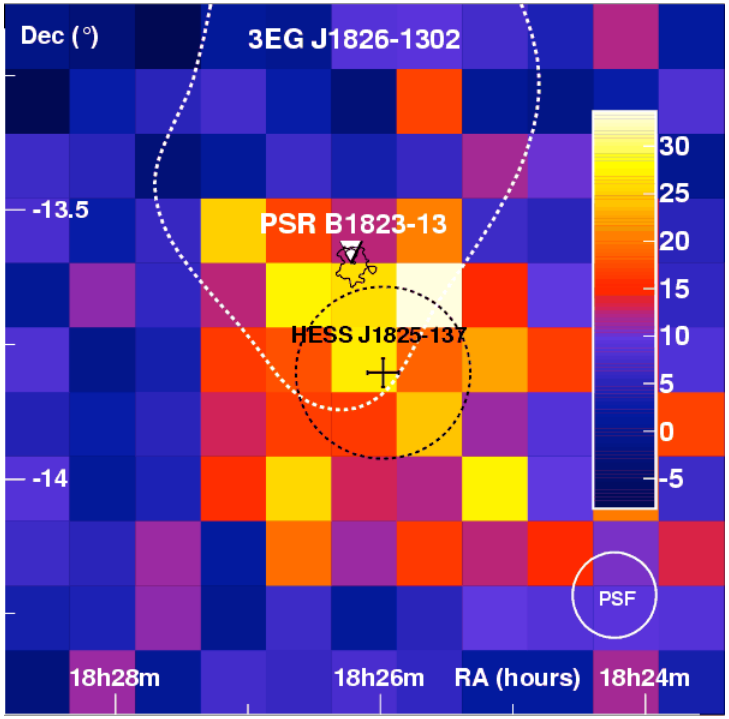
- Full-sky coverage at the sensitivity of the current narrow-field imaging experiments
  - Ideally, one experiment in each hemisphere
  - Complete sampling of the sky at a proven flux limit
  - Easy maintenance and thus long lifetime, reaching even lower fluxes
  - Upgradability

Scientific Questions

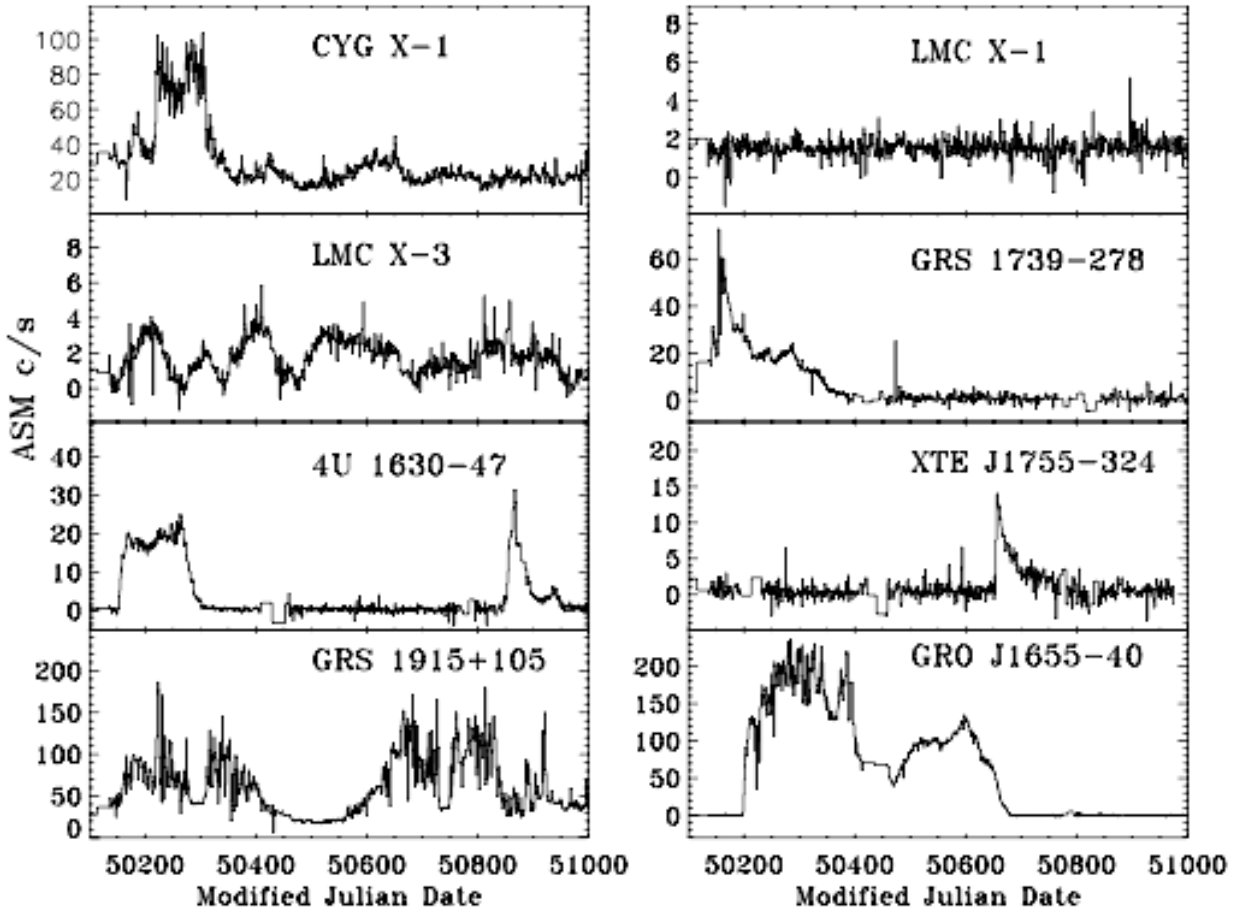
- Properties of radiating particles
  - Leptonic vs hadronic
- Radiation mechanisms
  - Inverse Compton scattering, π^0 decay, synchrotron,
- Particle acceleration processes
  - Shock, magnetic reconnection
- Origin of cosmic rays
  - SNR? GRB? AGN?
- Cosmic background radiation
  - Absorption of gamma rays
- Nature of dark matter

Common Physics vs "Personality"

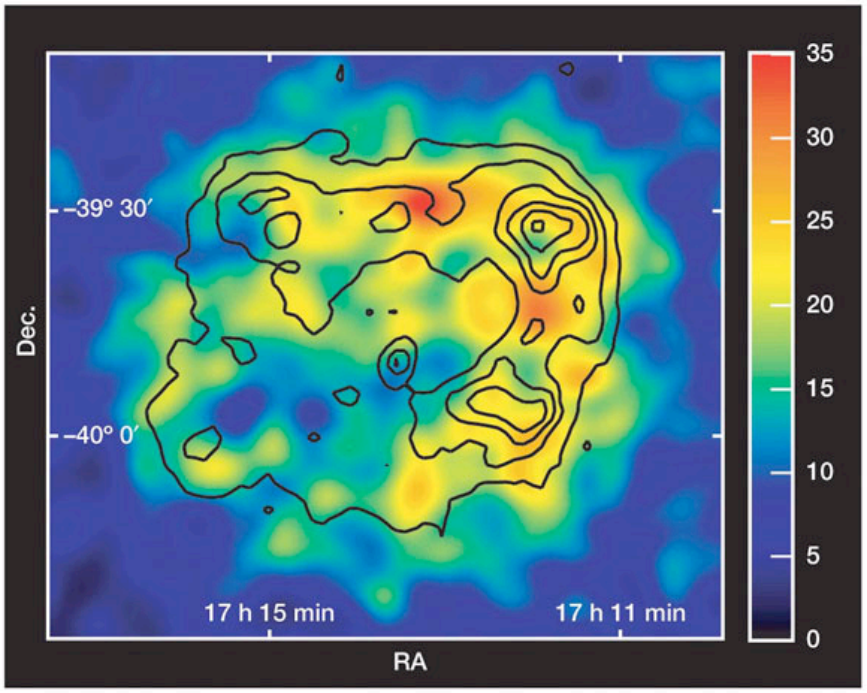




Messy Laboratories

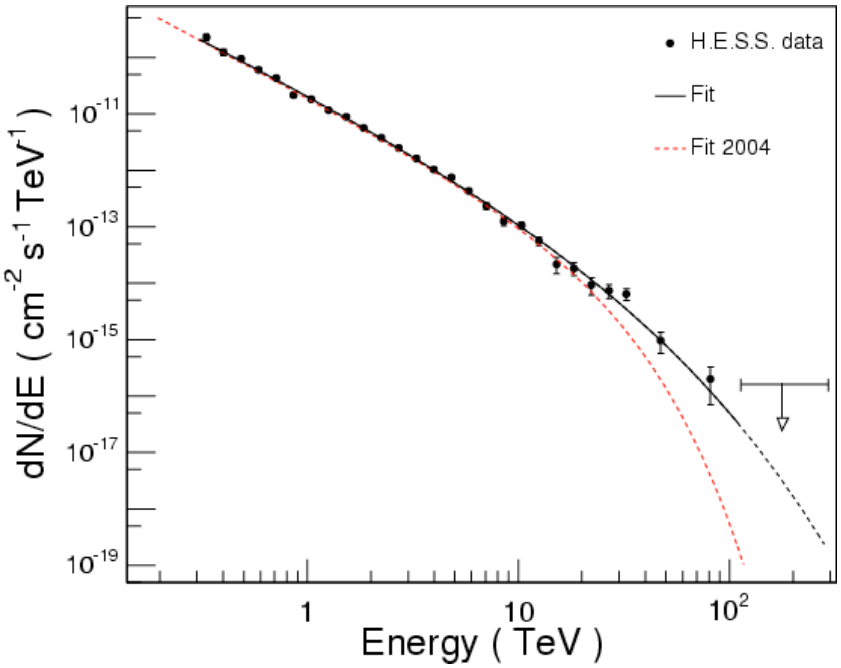


Degeneracy



RX J1713.7-3946

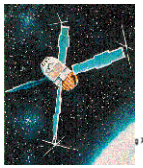
HESS Collaboration

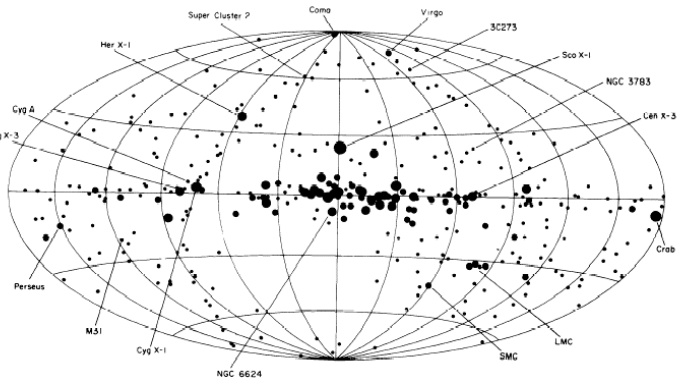


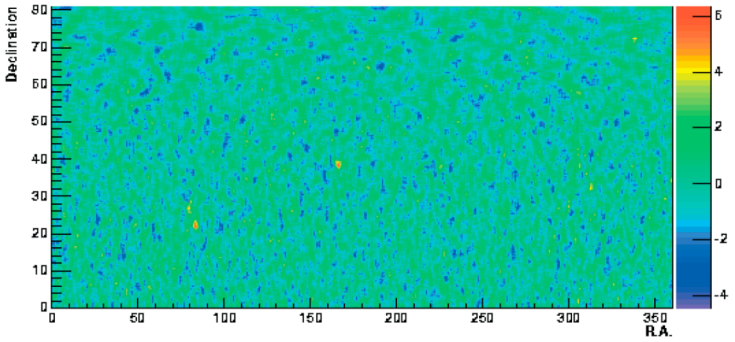
Development

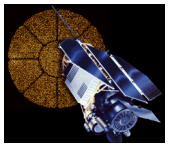
X-ray astronomy	TeV gamma-ray astronomy
Sounding rockets, balloons	Cherenkov and particle detectors
Sco X-1 ⟵ First detection	Crab Nebula ⟵ First detection
More sources detected	More sources detected
Uhuru survey	Milagro
Einstein satellite	HESS, VERITAS, MAGIC, CANGAROO
Ariel 5, Ginga, ROSAT, ASCA	HAWC? LHAASO? CTA? AGIS?
ROSAT all-sky survey	HAWC? LHAASO?
RXTE, Swift	LHAASO?
Chandra, XMM-Newton	CTA? AGIS?

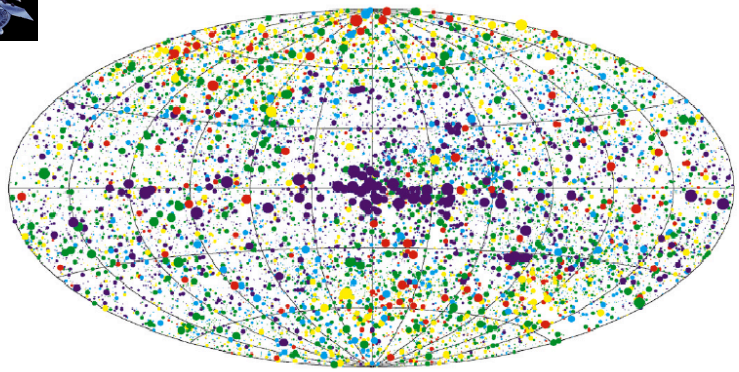
Comparison of Surveys

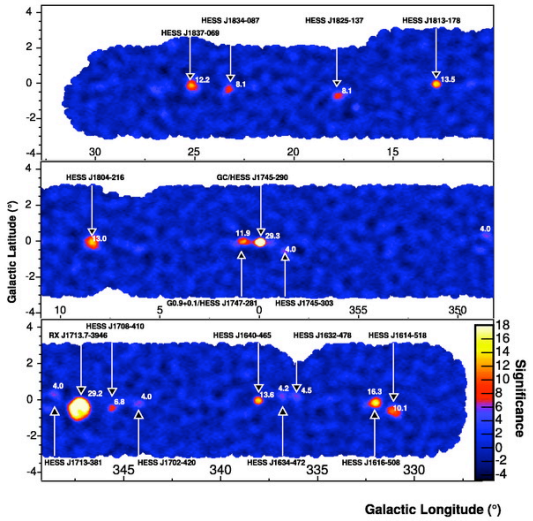








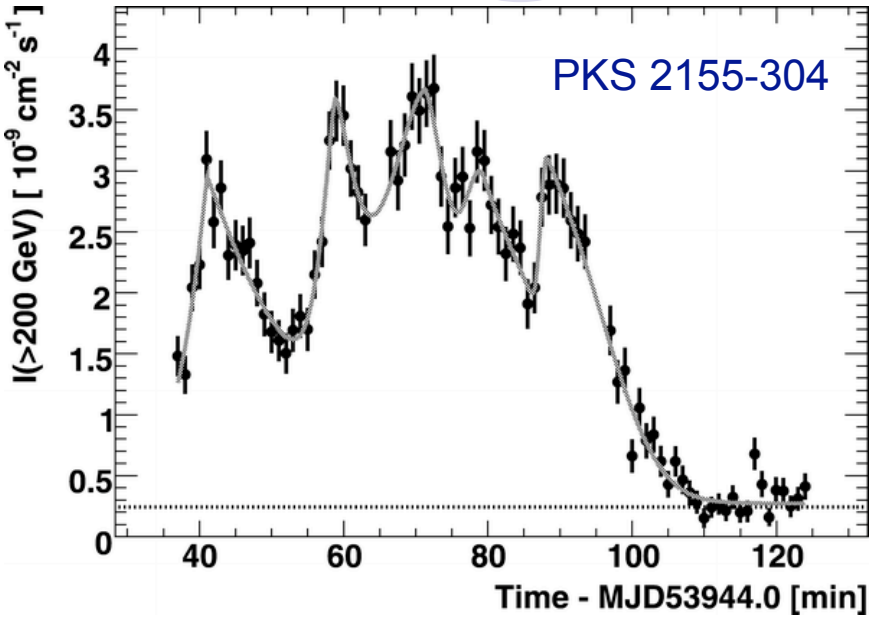




Transient Science

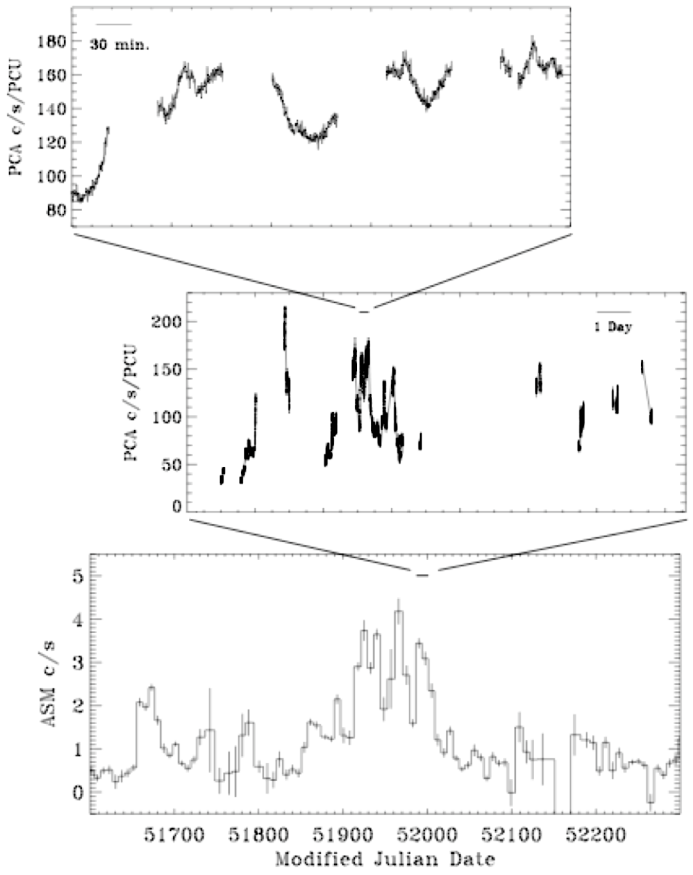
- Blazar outburst
  - Guaranteed: a large sample of sources
  - Population study: duty cycle, intrinsic vs extrinsic properties, TeV vs GeV blazars, …
  - Extragalactic background light
  - Multiwavelength studies
- Gamma-ray bursts
- Nova outbursts, Be transients, …
- Surprises!

Rapid Blazar Flares



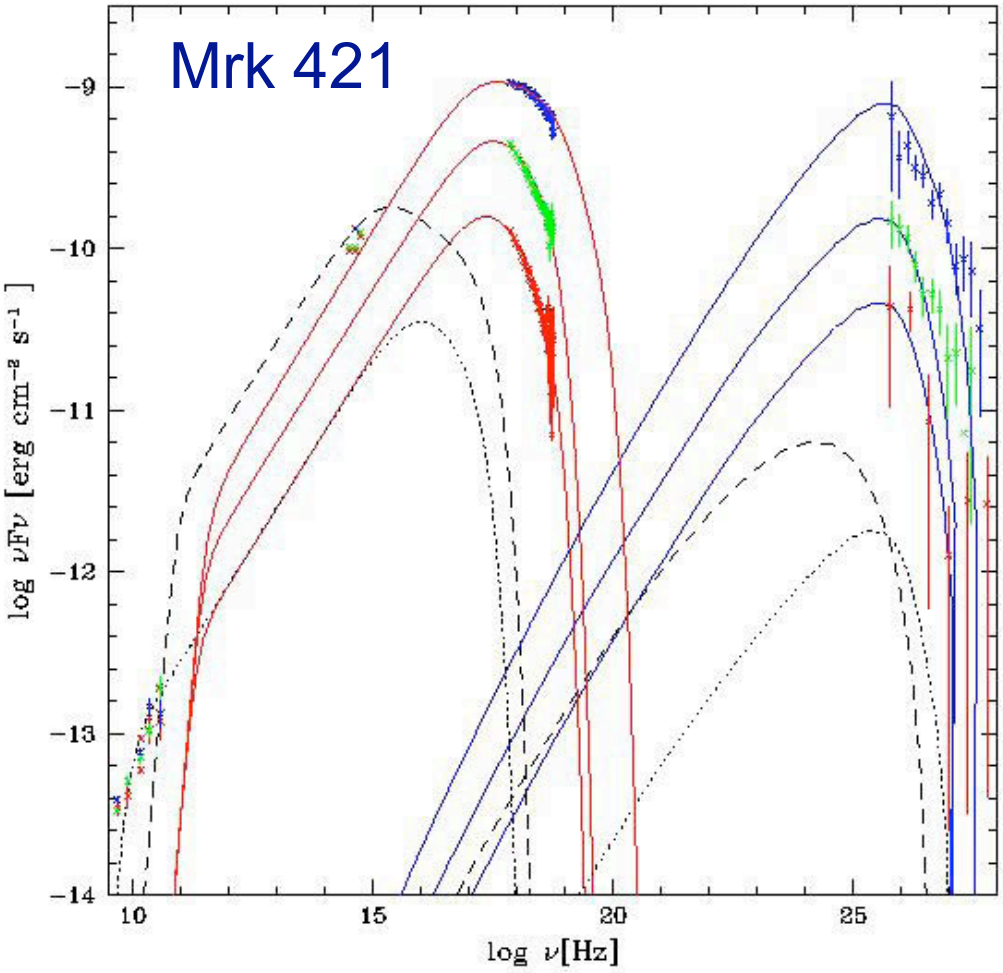
HESS Collaboration

MRK 421



Cui 2004

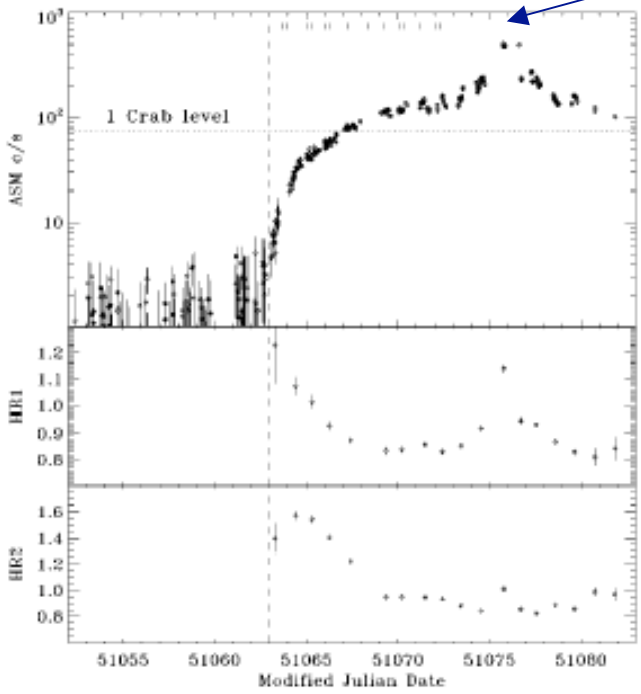
Multiwavelength Observations



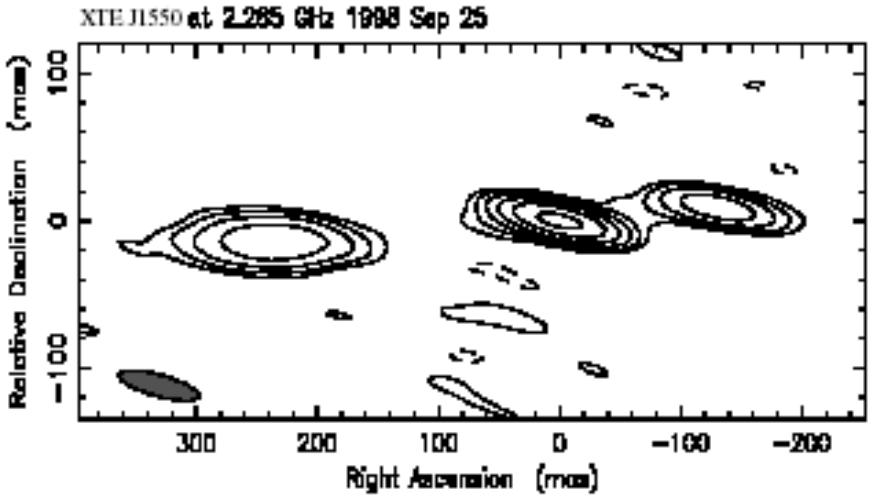
VERITAS Collaboration

Microquasar Outbursts

Triggering jet formation?



Cui et al. 1999

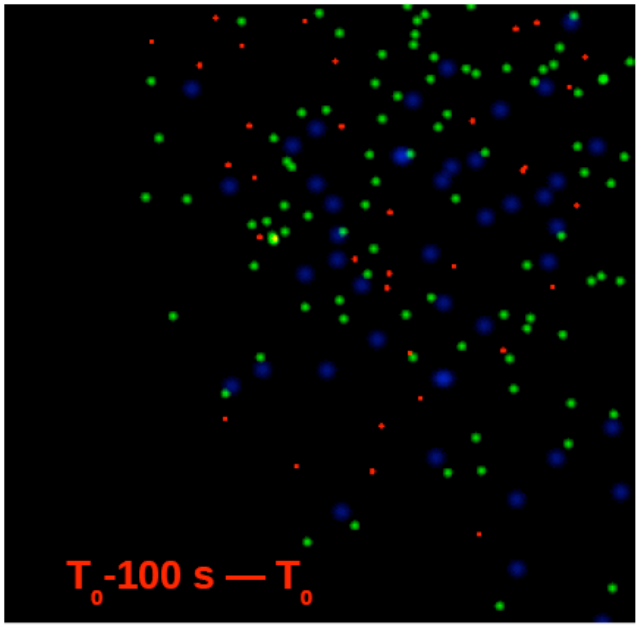


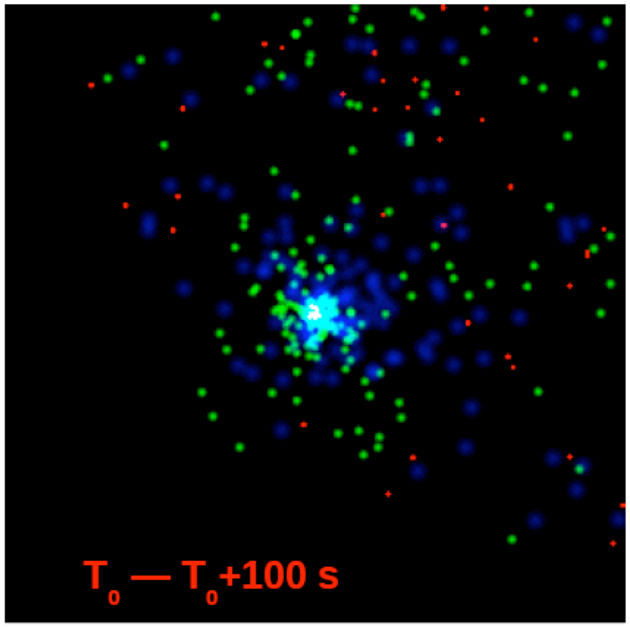
Hannikainen et al. 2001

Gamma Ray Bursts

From Fermi LAT:

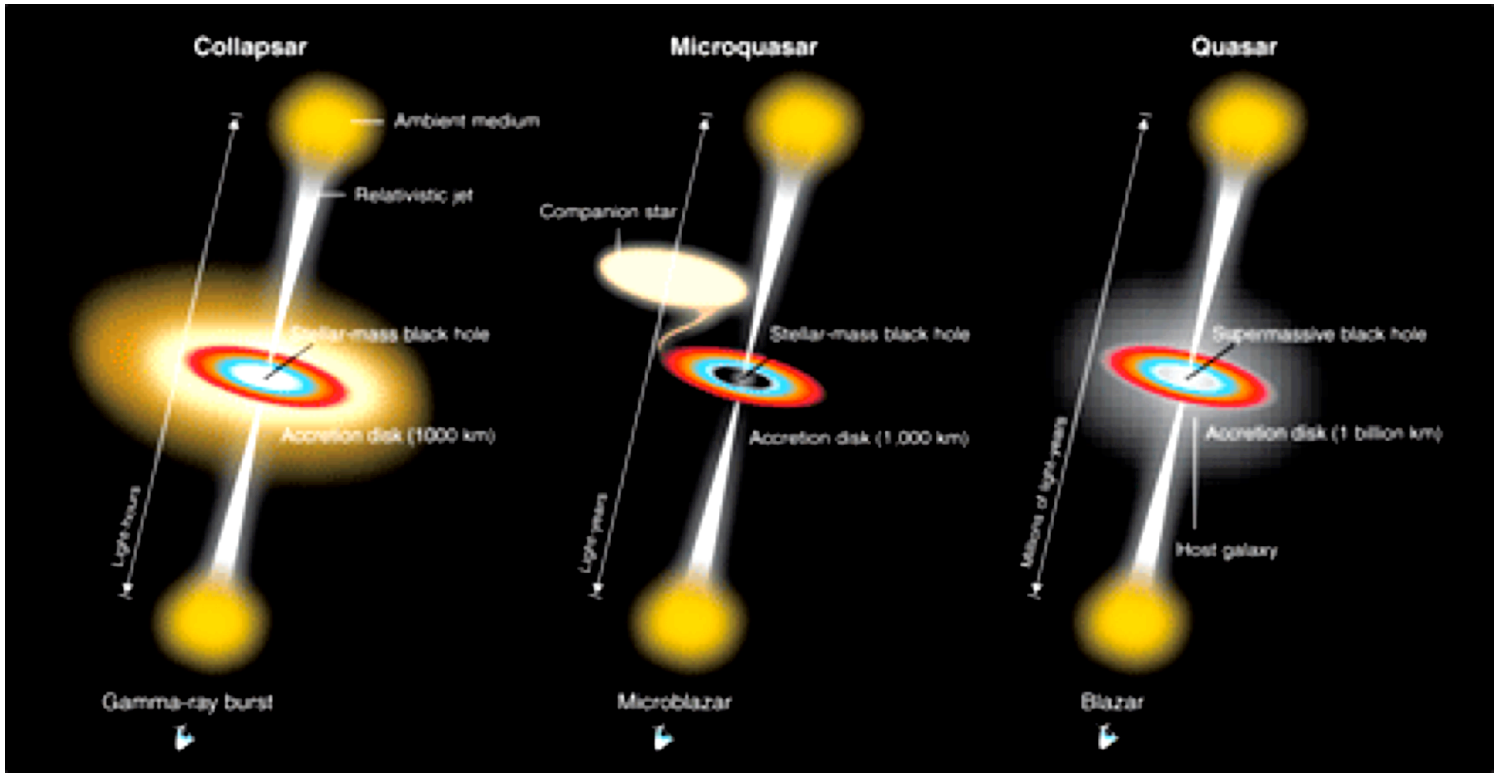
GRB 080916C





L. Baldini, Rencontres de Moriond 2009

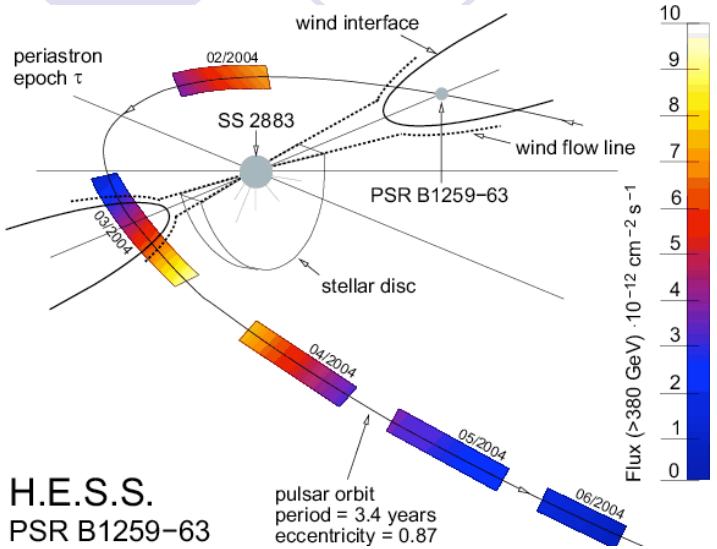
Common Physics?

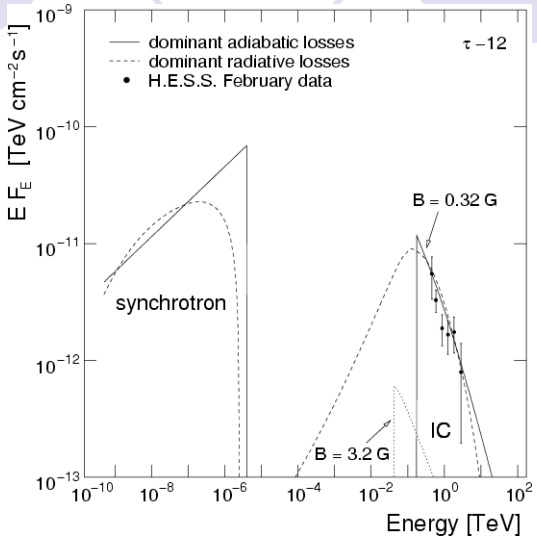


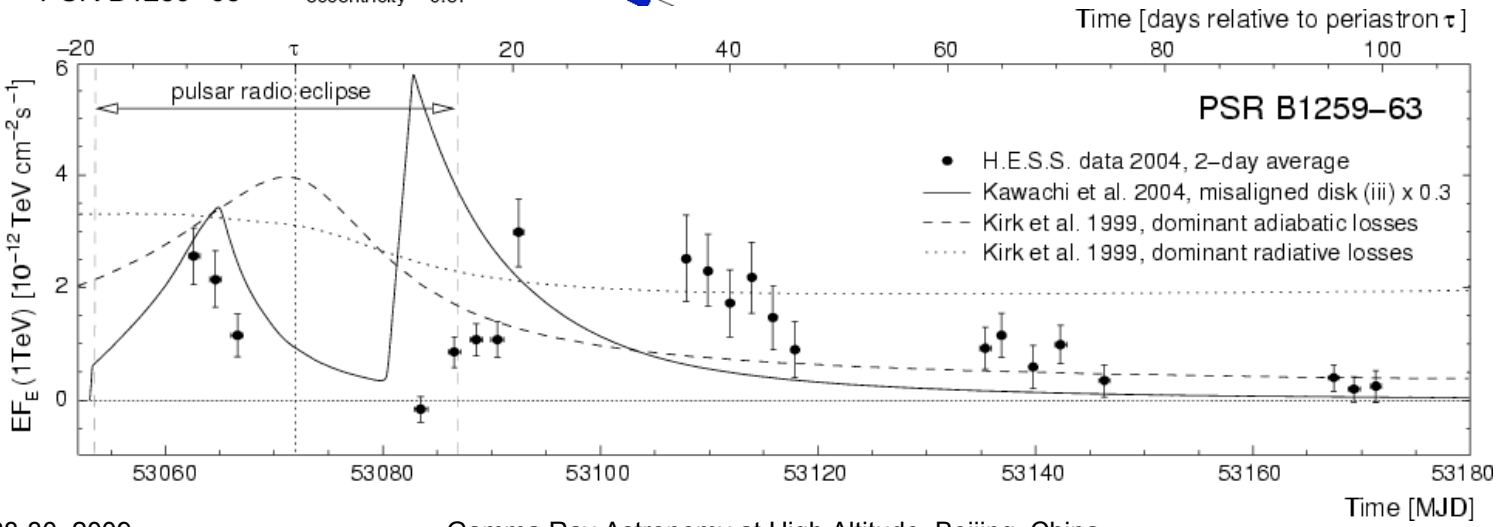
Variable Sources

- X-ray Binaries
  - Accreting pulsars
  - Microquasars
- Blazars

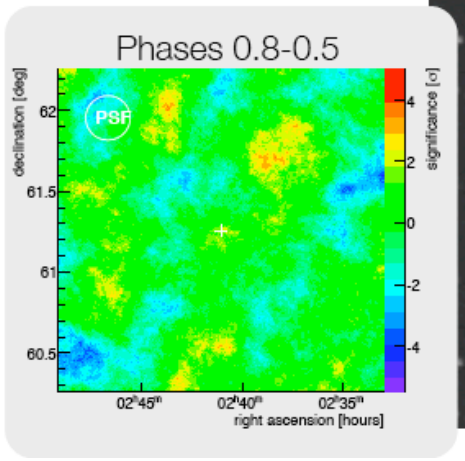
Binaries: Neutron Star

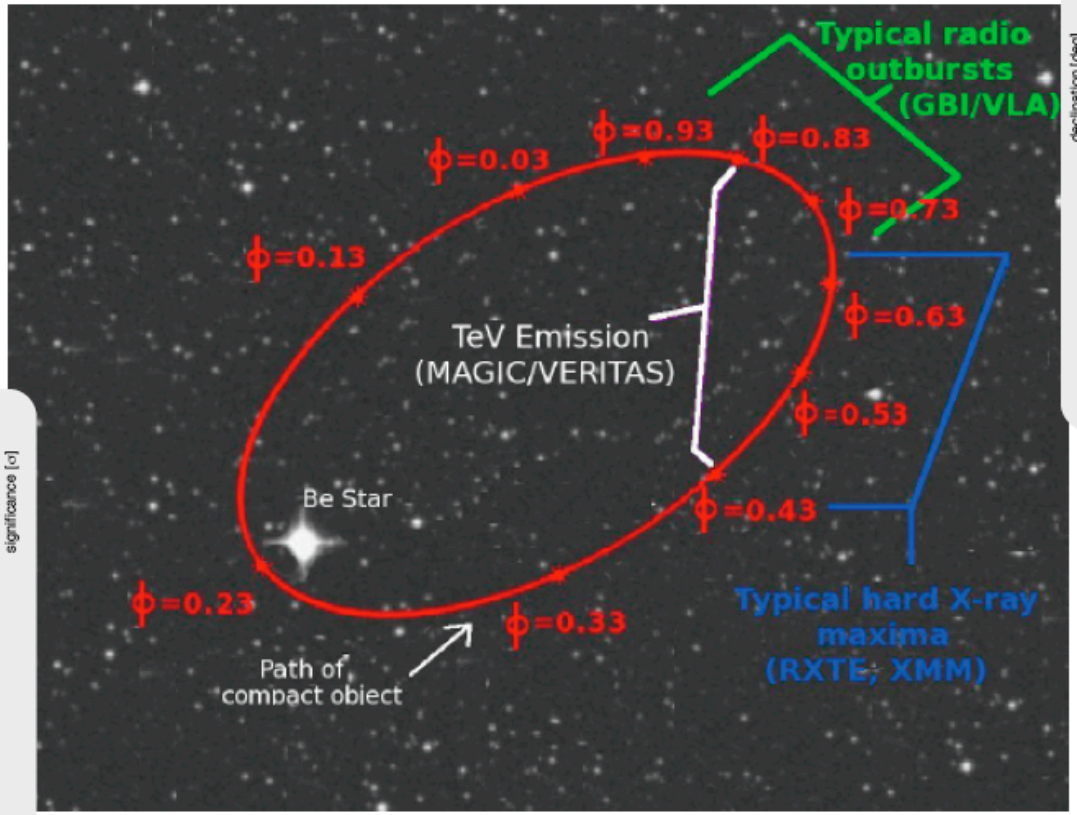


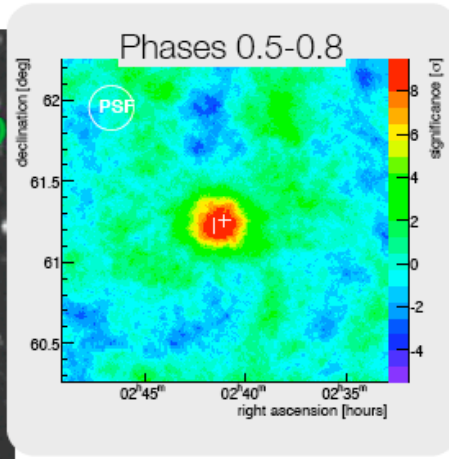




Binaries: Black Hole?







G. Maier, Gamma08

Fundamental Physics

- Cosmic ray physics
  - Supernova remnants
  - AGN? GRBs?
- Dark matter
  - Dwarf galaxies
- Lorentz invariance
  - Strong transient signals
- Primordial black holes, … …

Concluding Remarks

- TeV gamma ray astronomy has matured.
  - ⇨ Thanks to state-of-the-art imaging experiments
- Sensitive surveying experiments are required to move the field to the next level.
  - ⇨ discovering more sources
  - ⇨ catching new transient phenomena
  - ⇨ increasing statistics on known sources
  - ⇨ facilitating multiwavelength observations