# Monitoring the Sky at soft Gamma-Ray Energies with CGRO/COMPTEL for nine Years

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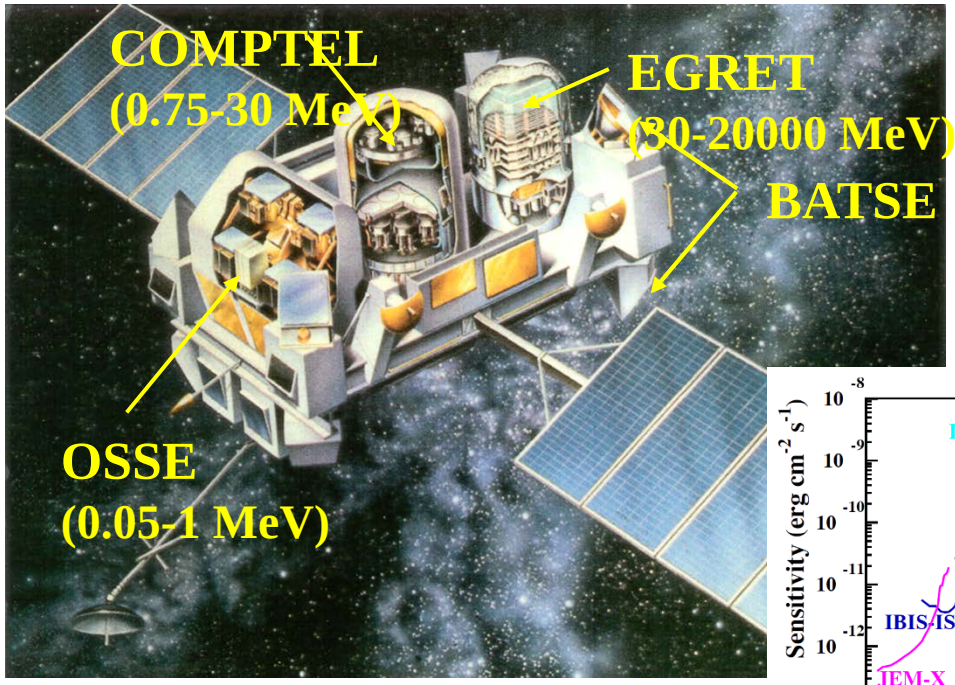
**MPE Garching**

## Outline

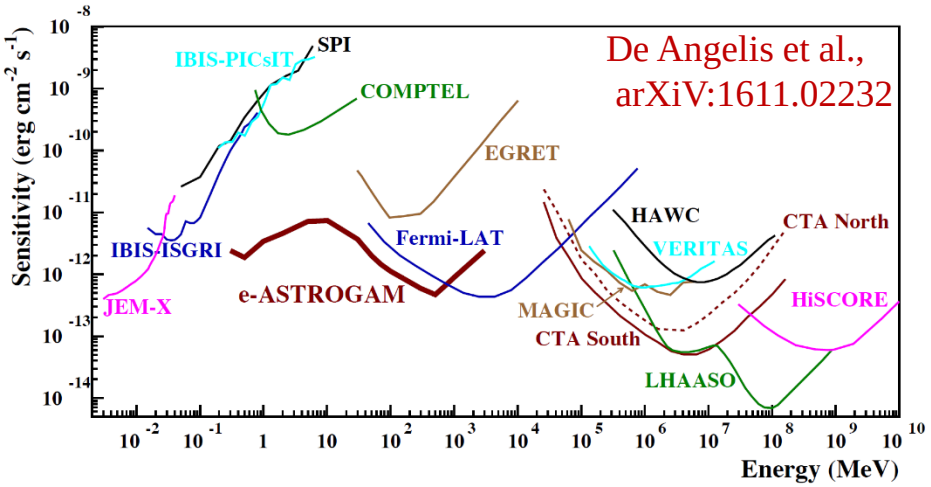
1) **COMPTEL on Compton Gamma-Ray Observatory (CGRO)**
2) **The first COMPTEL Source Catalog**
3) **MeV Properties of Blazars**
4) **Recent Developments in COMPTEL Data Analyses**
5) **Summary**

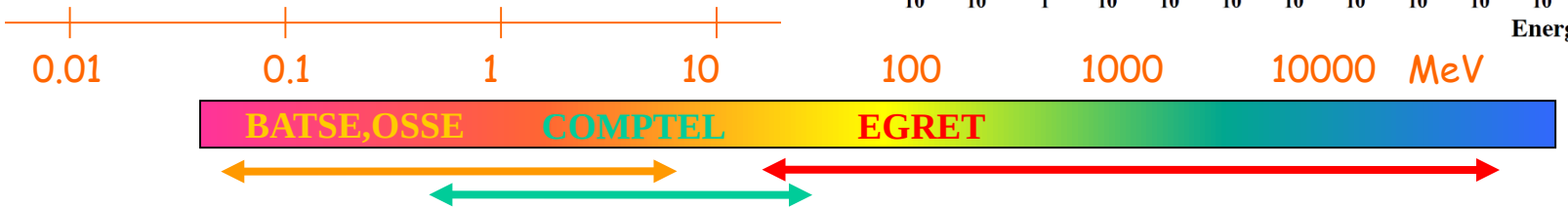
# COMPTEL on CGRO




**COMPTEL (Compton Telescope)**

- mission: Apr. 91 – June 2000
- energy range: 0.75 – 30 MeV
- mounted parallel to EGRET
- "first-generation" experiment
- **pioneered MeV band**

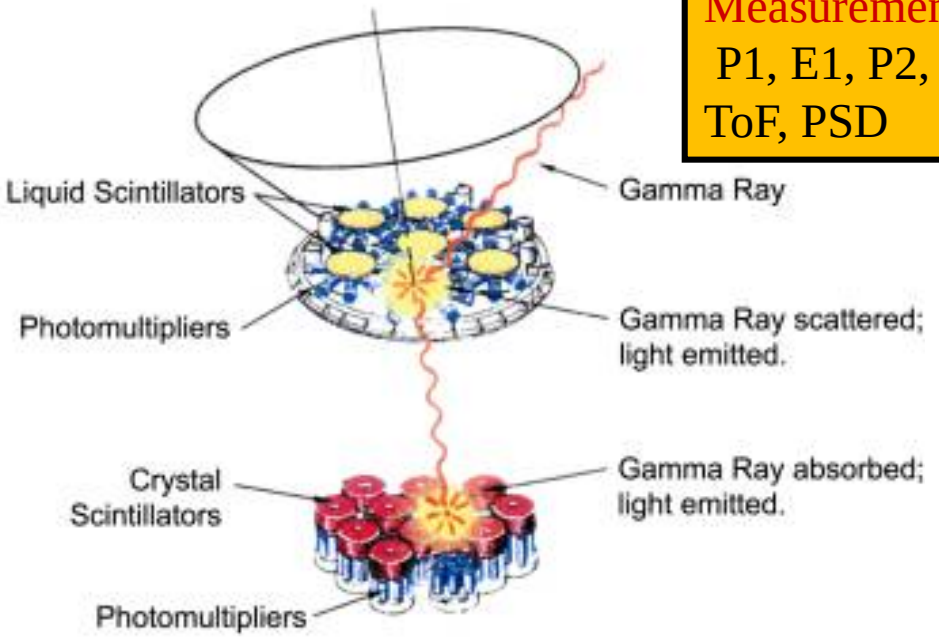


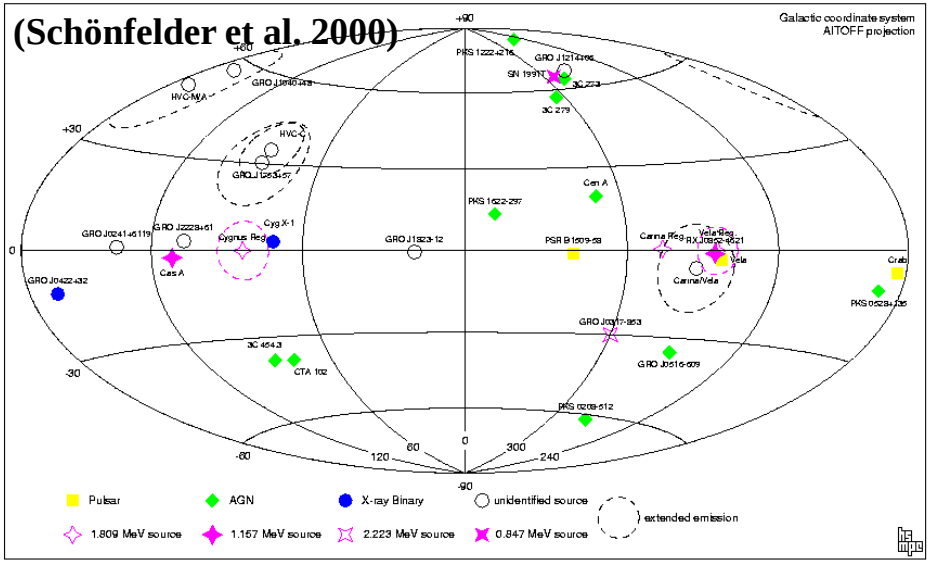
# COMPton TELescope “COMPTEL”


## Detection Principle

Measurements:
P1, E1, P2, E2
ToF, PSD



# Summary First COMPTEL Source Catalog

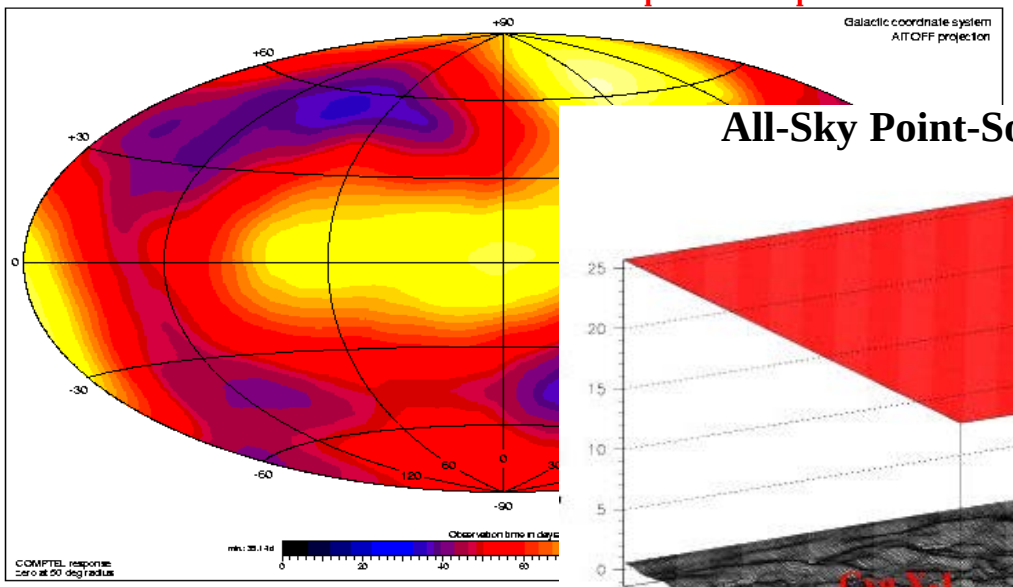



- contains published results of first 5.5 years (April ´91 – October ´96)
- 32 Sources (different nature)
- 31 GRBs / 21 solar flares
- upper limits for various types of objects (e.g. AGN, gal. BHs)

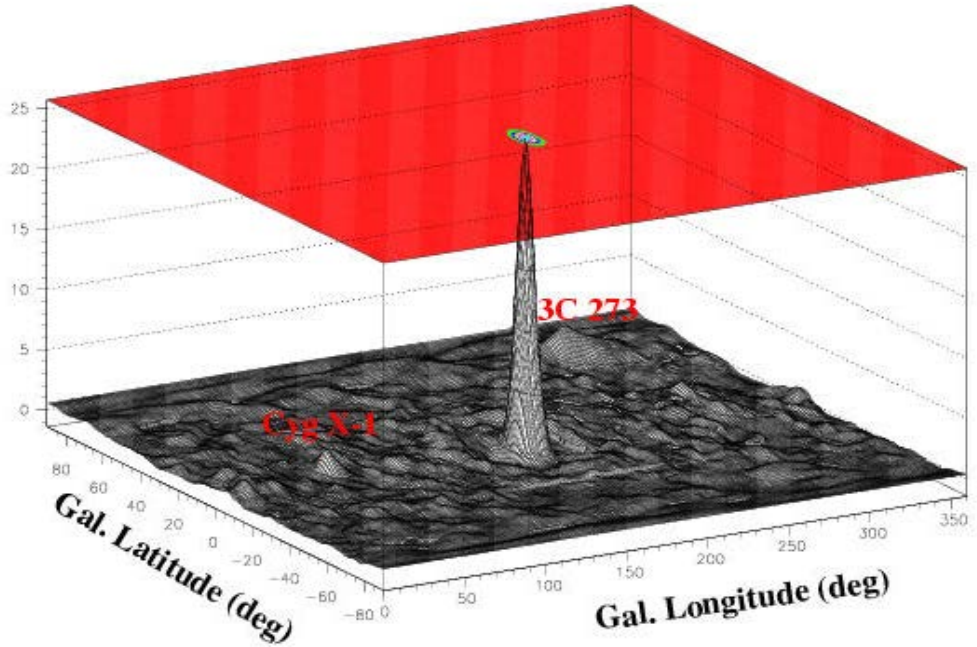
| Source Type | # |
|---|---|
| Pulsars | 3 |
| Stellar BH | 2 |
| SNR (continuum) | 1 |
| AGN | 10 |
| Unidentified Sources | |
| - $\|b\| < 10°$ | 4 |
| - $\|b\| > 10°$ | 5 |
| γ-line sources | |
| - 1.809 MeV ($^{26}$Al) | 3 |
| - 1.157 MeV ($^{44}$Ti) | 2 |
| -0.847/1.238 MeV ($^{56}$Co) | 1 |
| - 2.223 MeV (n-capt.) | 1 |

# COMPTEL ALL-Mission All-Sky Exposure

CGRO/COMPTEL All-Mission Exposure Map

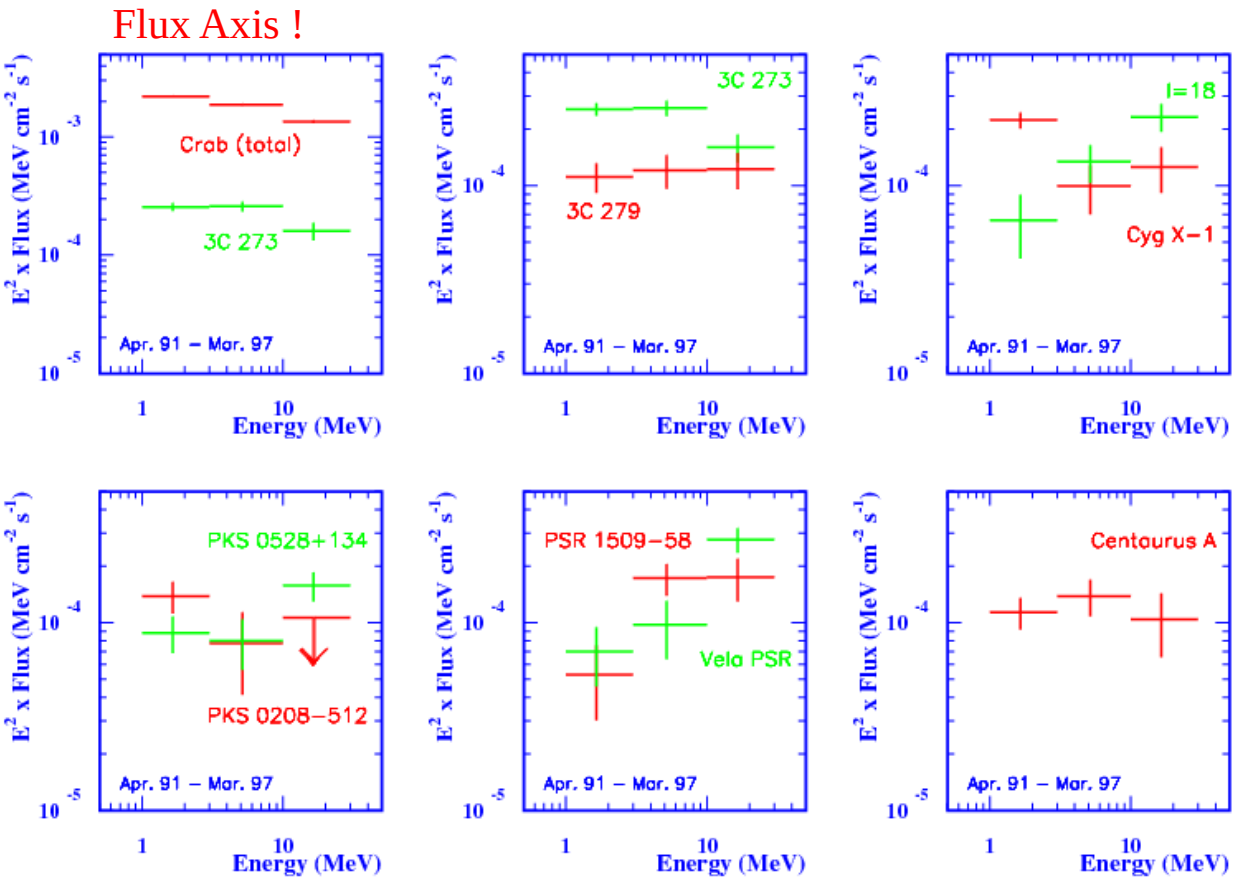



All-Sky Point-Source Flux Map

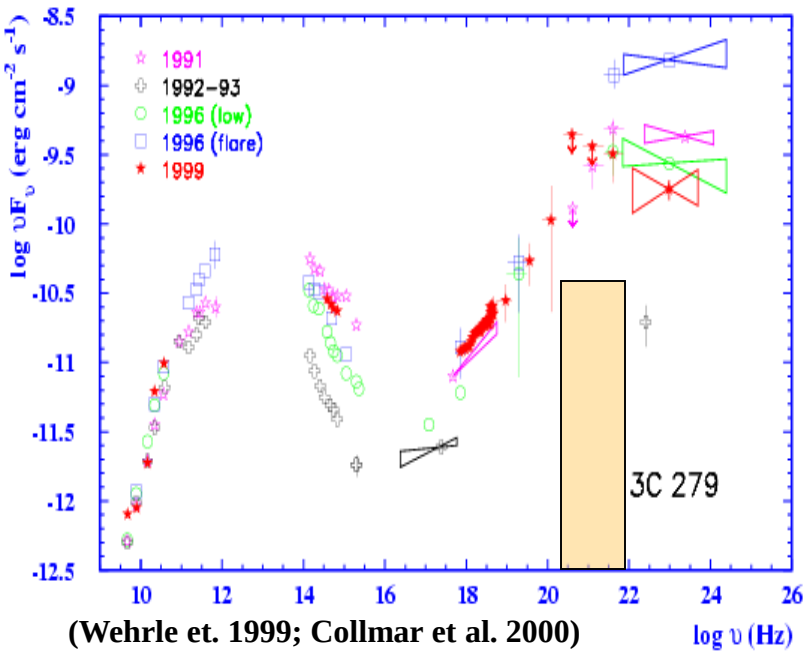



1-3 MeV; all-mission
(diffuse emission subtracted)

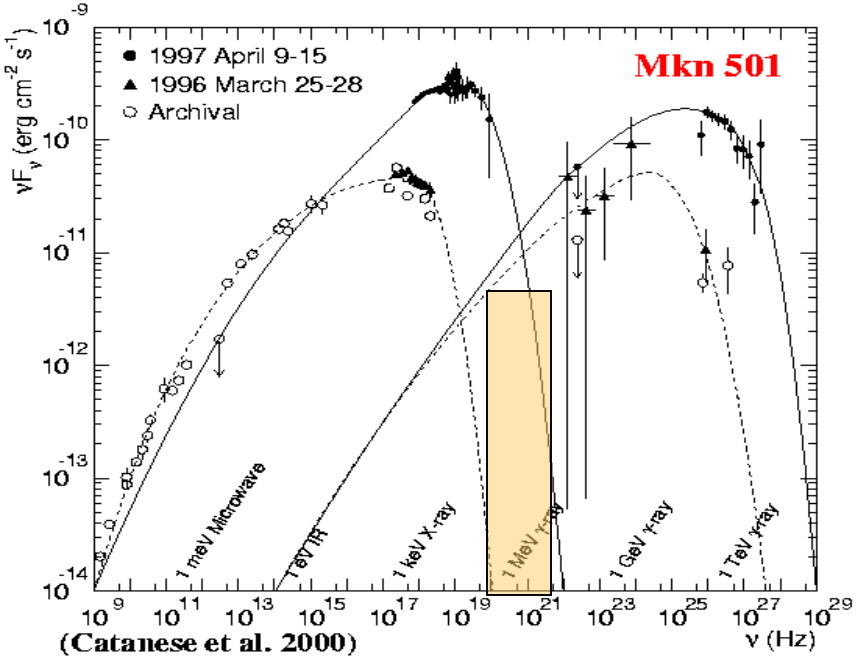
# “Top Ten” brightest COMPTEL MeV Sources



# COMPTEL Band in Blazars SEDs

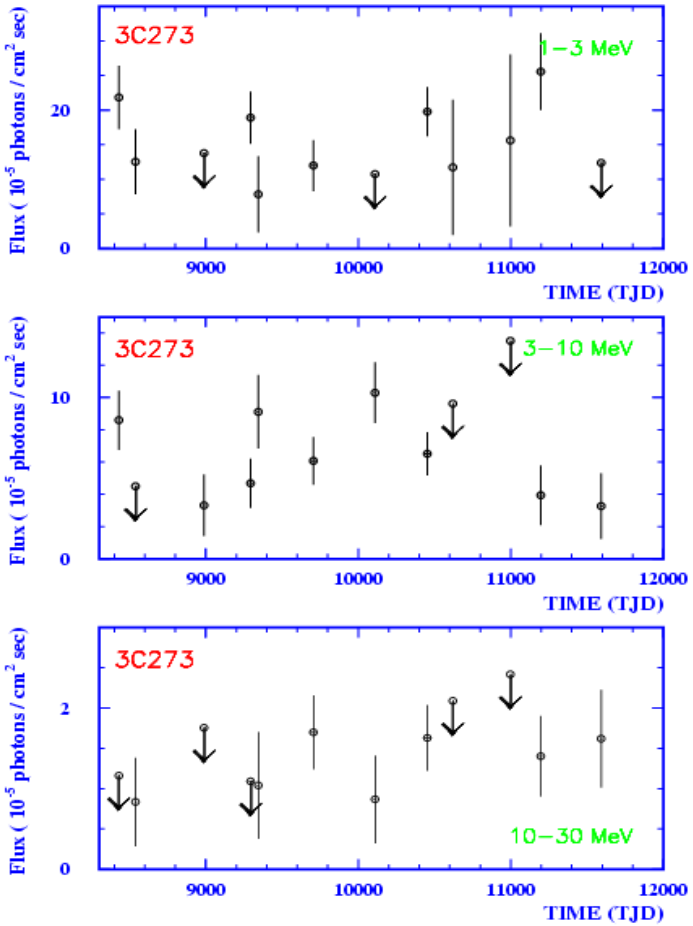



(Wehrle et. 1999; Collmar et al. 2000)



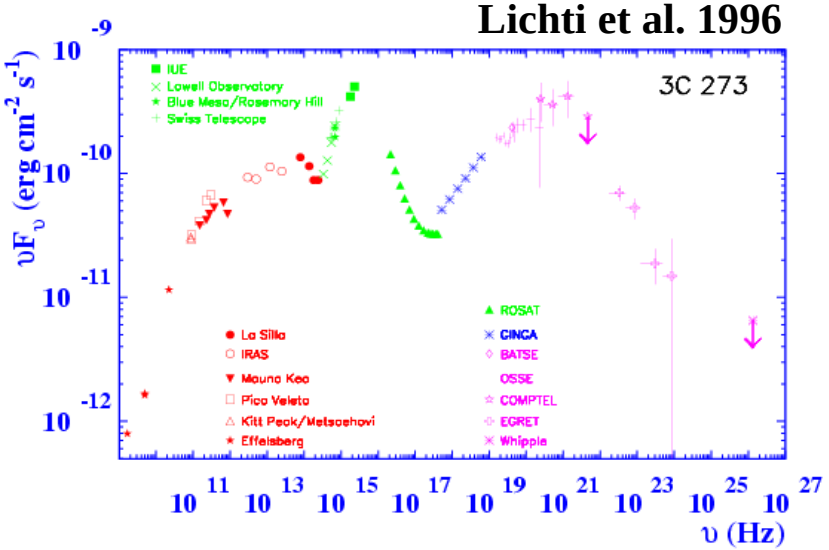

(Catanese et al. 2000)

# 3C 273 Mission Results

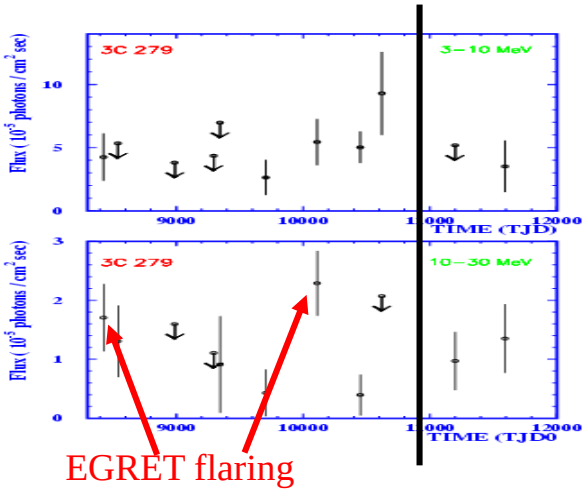


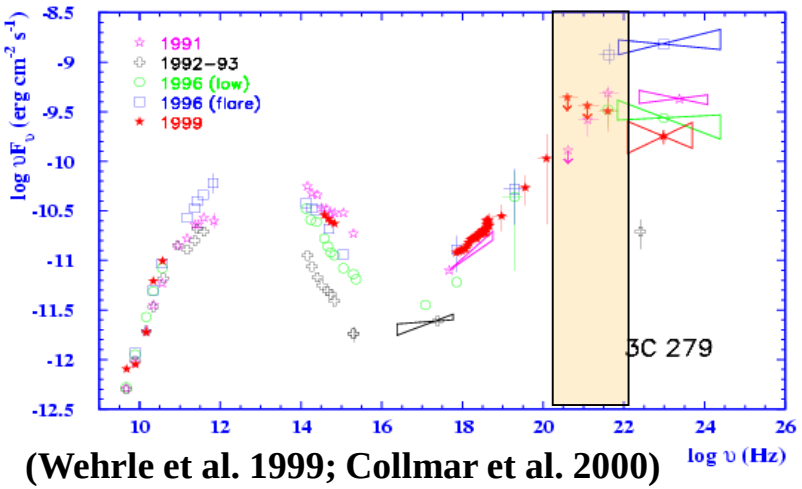

- 3C 273: 2nd brightest MeV Source
- all-mission light curves
- persistent MeV source

Lichti et al. 1996

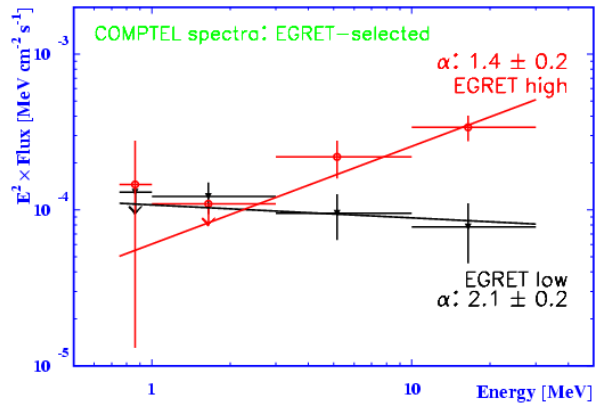


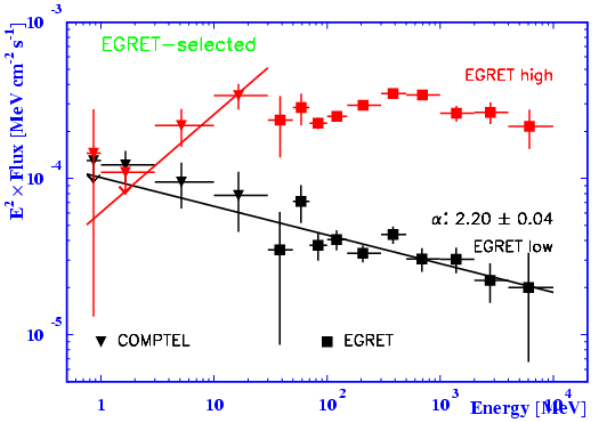
# 3C 279 Mission Results



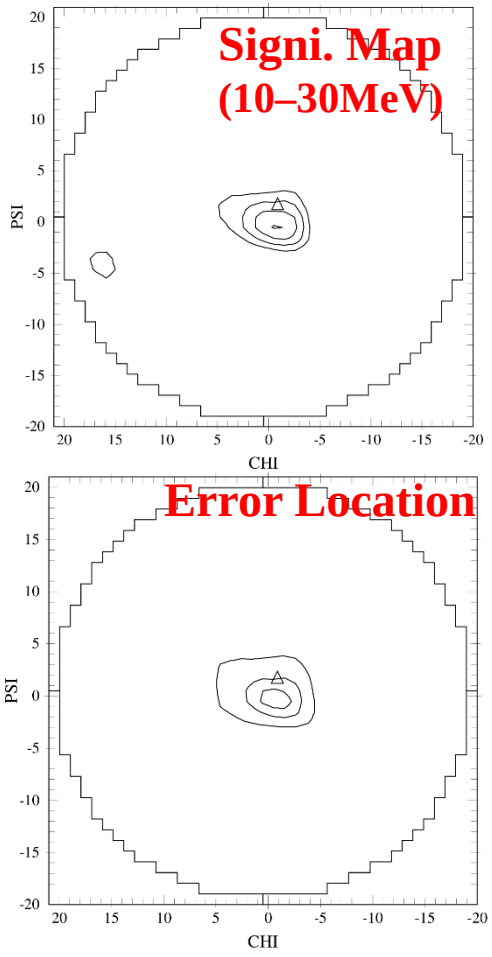



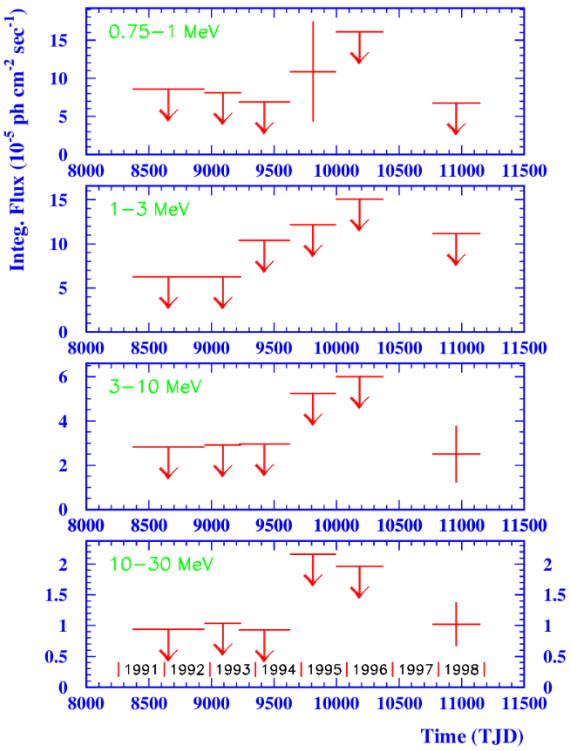

**(Wehrle et al. 1999; Collmar et al. 2000)**

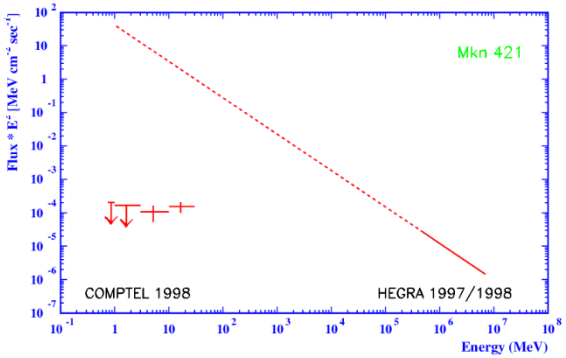


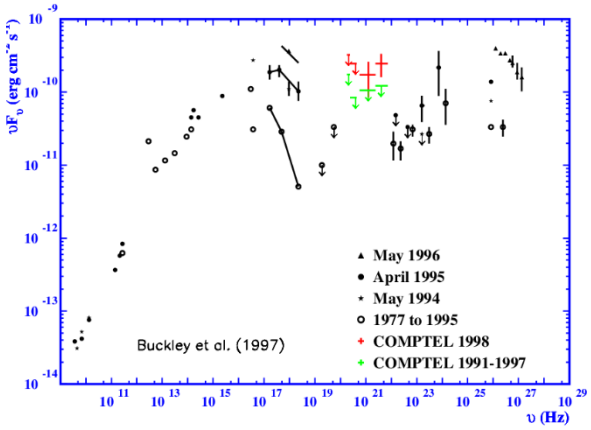



# Evidence for Mkn 421 (Collmar et al. 1999)



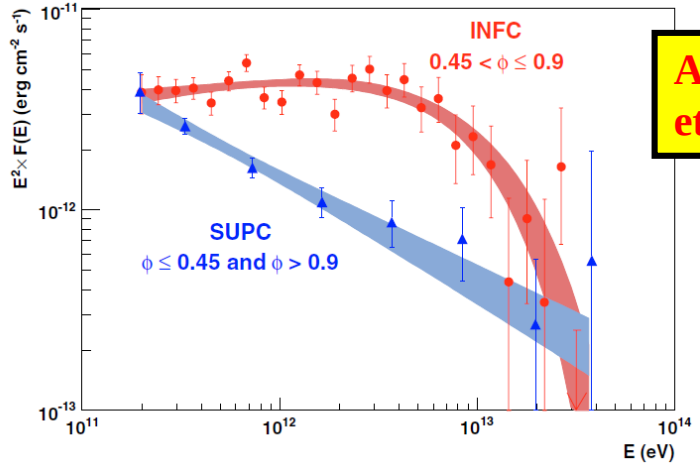



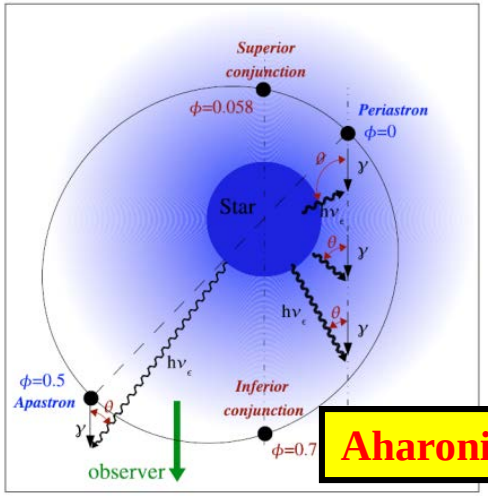
# Updated COMPTEL AGN List

| Source | z | Type | Det. Conf. |
|---|---|---|---|
| Cen A | 0.002 | Radio G. | high |
| Mkn 421 | 0.030 | BL Lac | low |
| 3C 273 | 0.158 | FSRQ | high |
| 0716+714 | 0.31 | BL Lac | low |
| PKS 1222+216 | 0.432 | FSRQ | medium |
| 3C 279 | 0.536 | FSRQ | high |
| 1622-297 | 0.815 | FSRQ | high |
| 3C 454.3 | 0.859 | FSRQ | high |
| PKS 0208-512 | 0.999 | FSRQ | high |
| CTA 102 | 1.037 | FSRQ | low |
| GRO J0516-609 | 1.09 | FSRQ | medium |
| 1127-145 | 1.184 | FSRQ | medium |
| PKS 0528+134 | 2.06 | FSRQ | high |
| 0836+710 | 2.17 | FSRQ | medium |
| PKS 1830-210 | 2.51 | FSRQ | high |

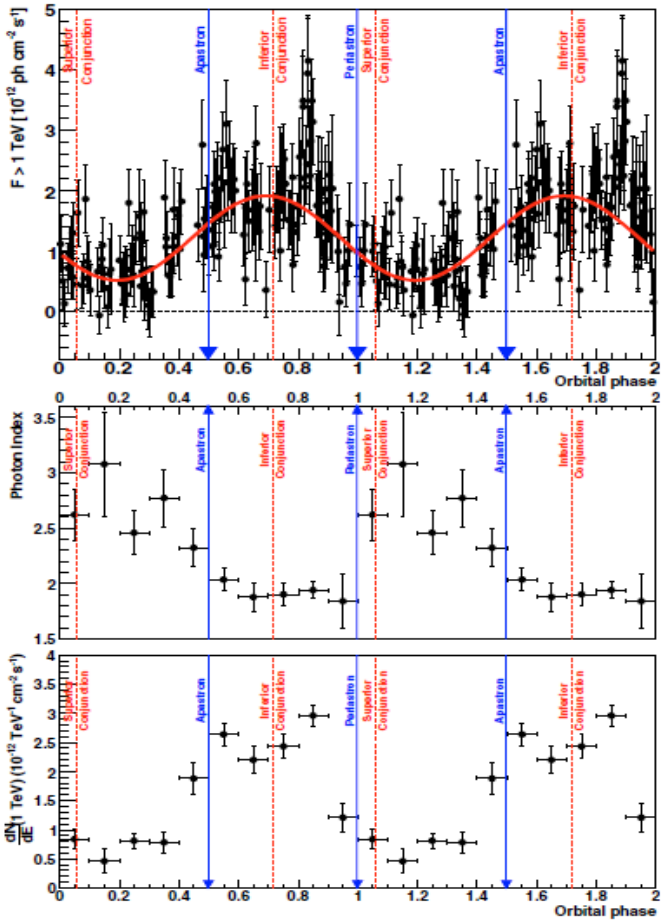
# HESS: Detection of LS 5039 as Gamma-Ray Source (TeV)




Aharonian et al. 2006

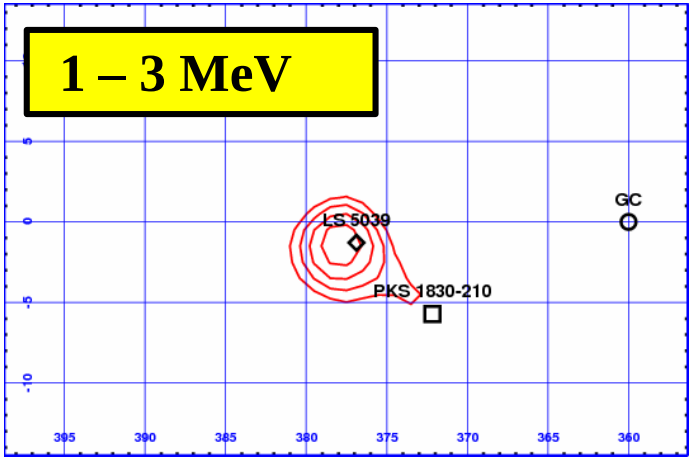


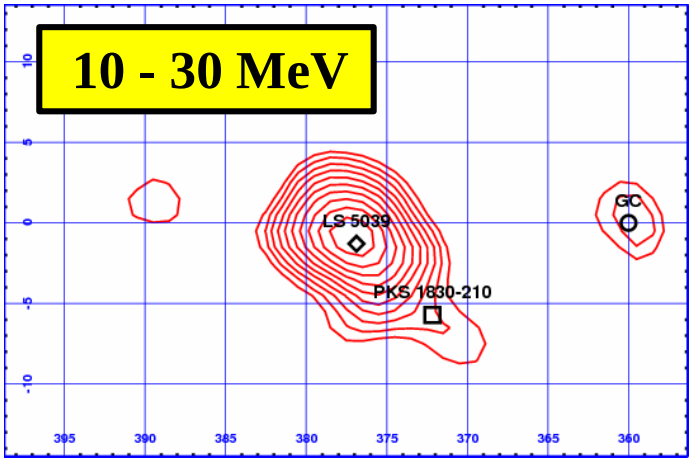

Aharonian et al. 2006

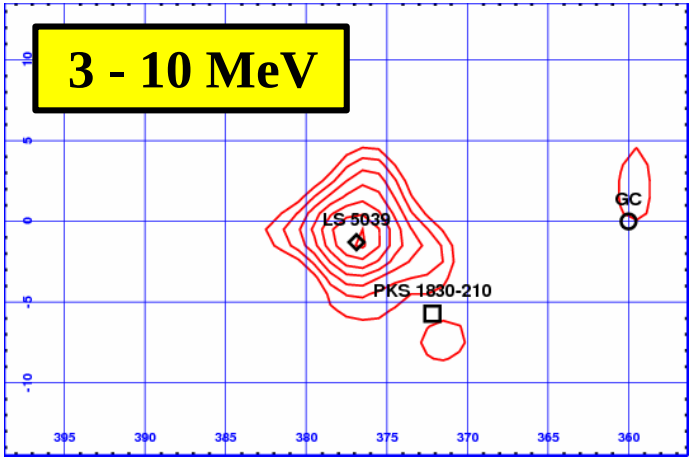


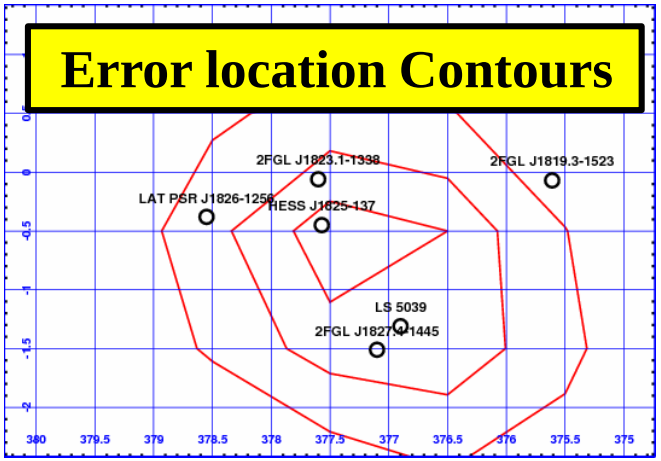
# GRO J1823-12 (LS 5039 ?)

## Orbit-averaged Analysis



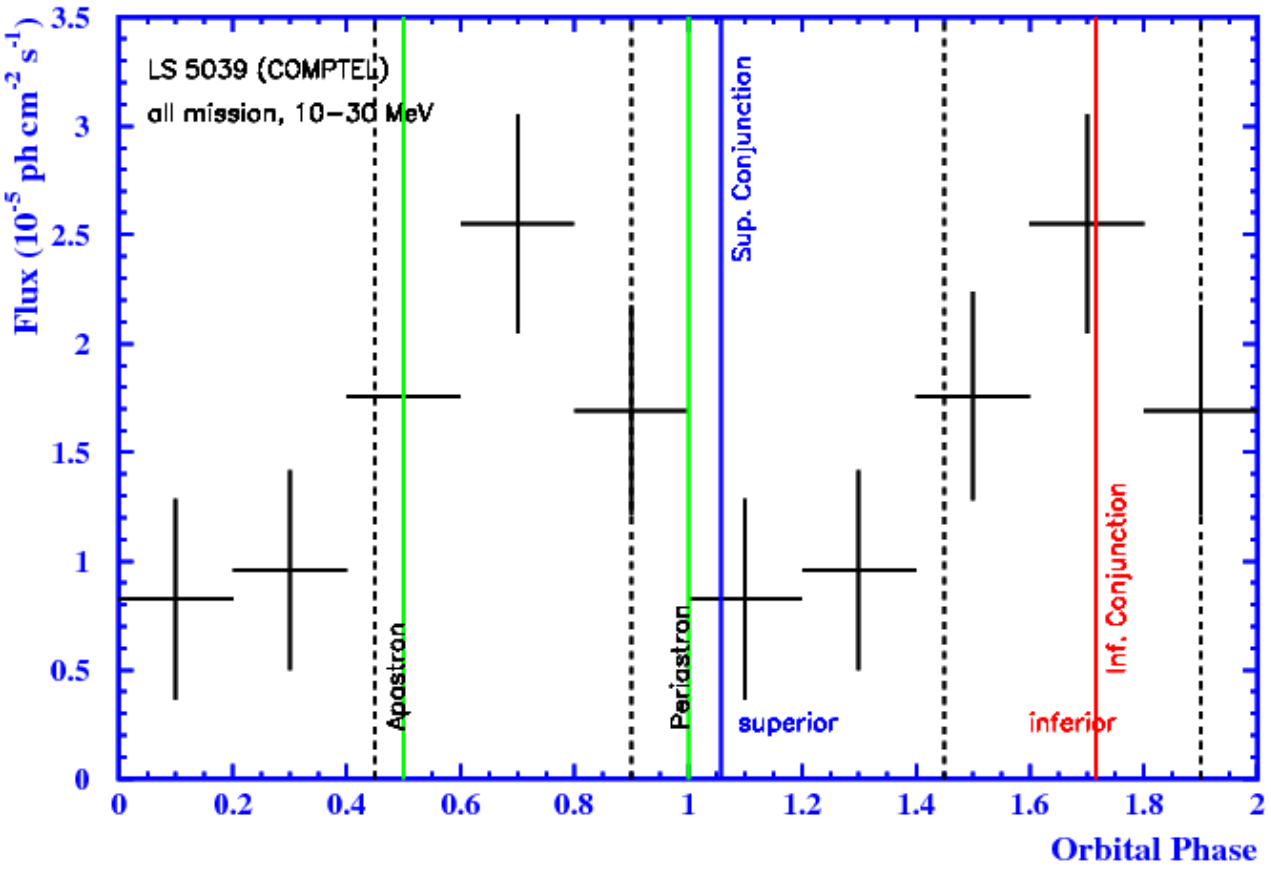



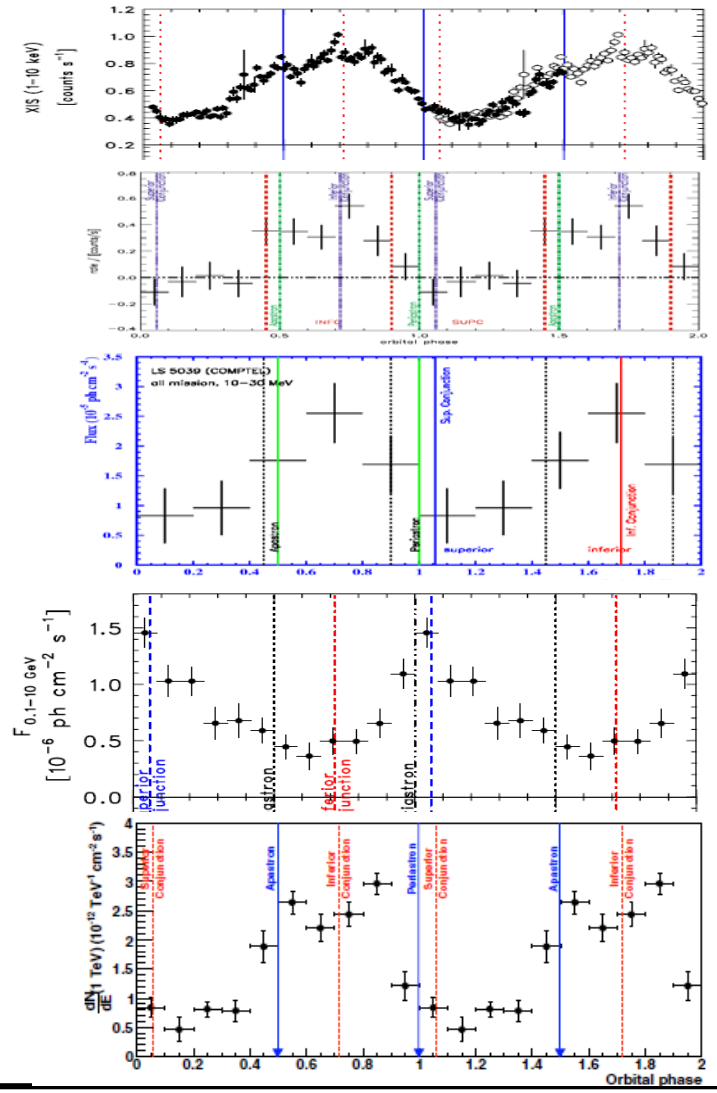



# GRO J1823-12 (LS 5039)

## Orbital Lightcurve (Ephemeris: Casares et al. 2005)



# LS 5039 High-Energy Light Curves




**1 – 10 keV: Suzaku (Takahashi et al. 2009)**

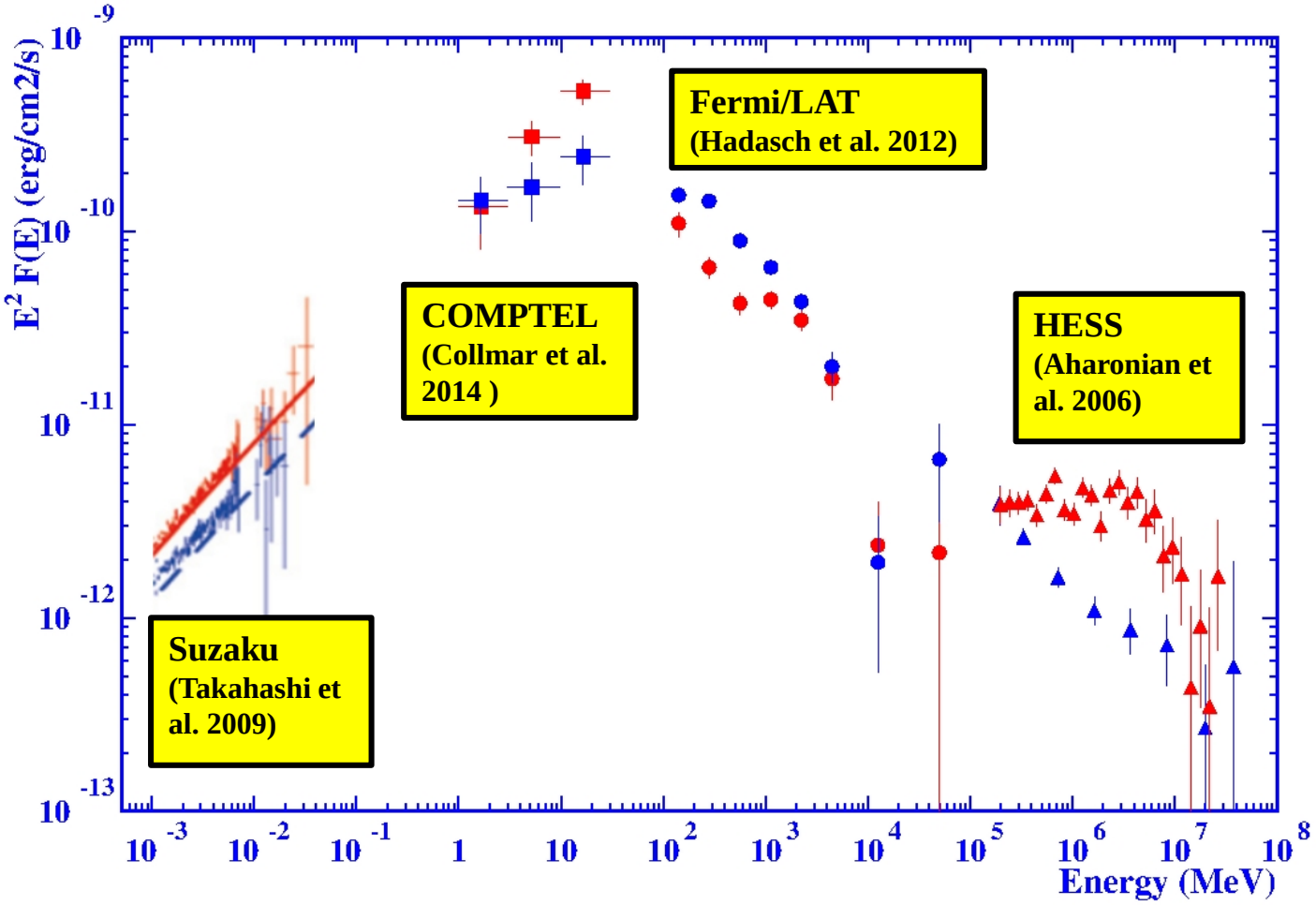
**25 – 200 keV: INTEGRAL (Hoffmann et al. 2009)**

**10 – 30 MeV: COMPTEL (Collmar et al. 2014 )**

**> 100 MeV: Fermi/LAT (Abdo et al. 2009)**

**at 1 TeV: HESS (Aharonian et al. 2006)**

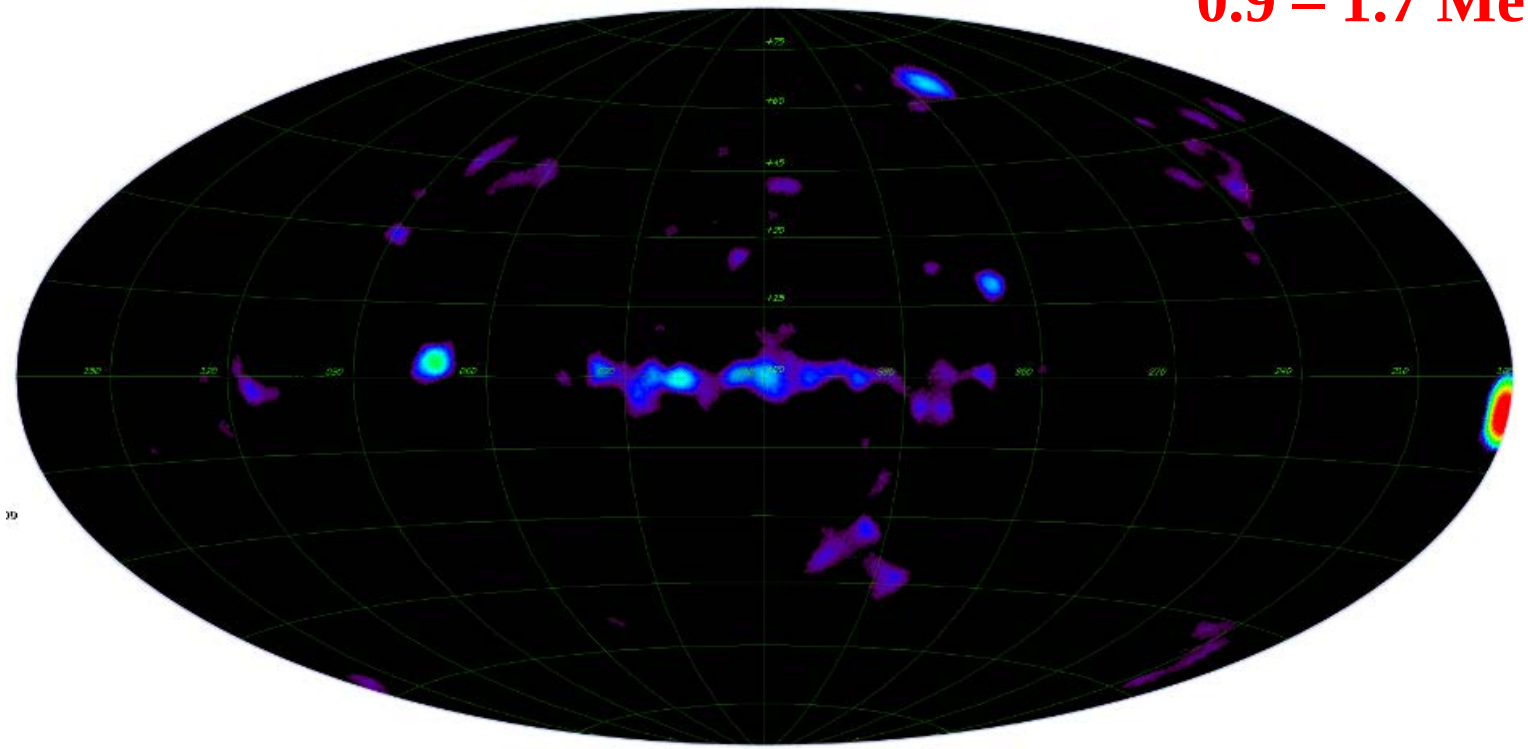
# LS 5039 High-Energy SED



# Current Developments: All-Sky Imaging

preliminary

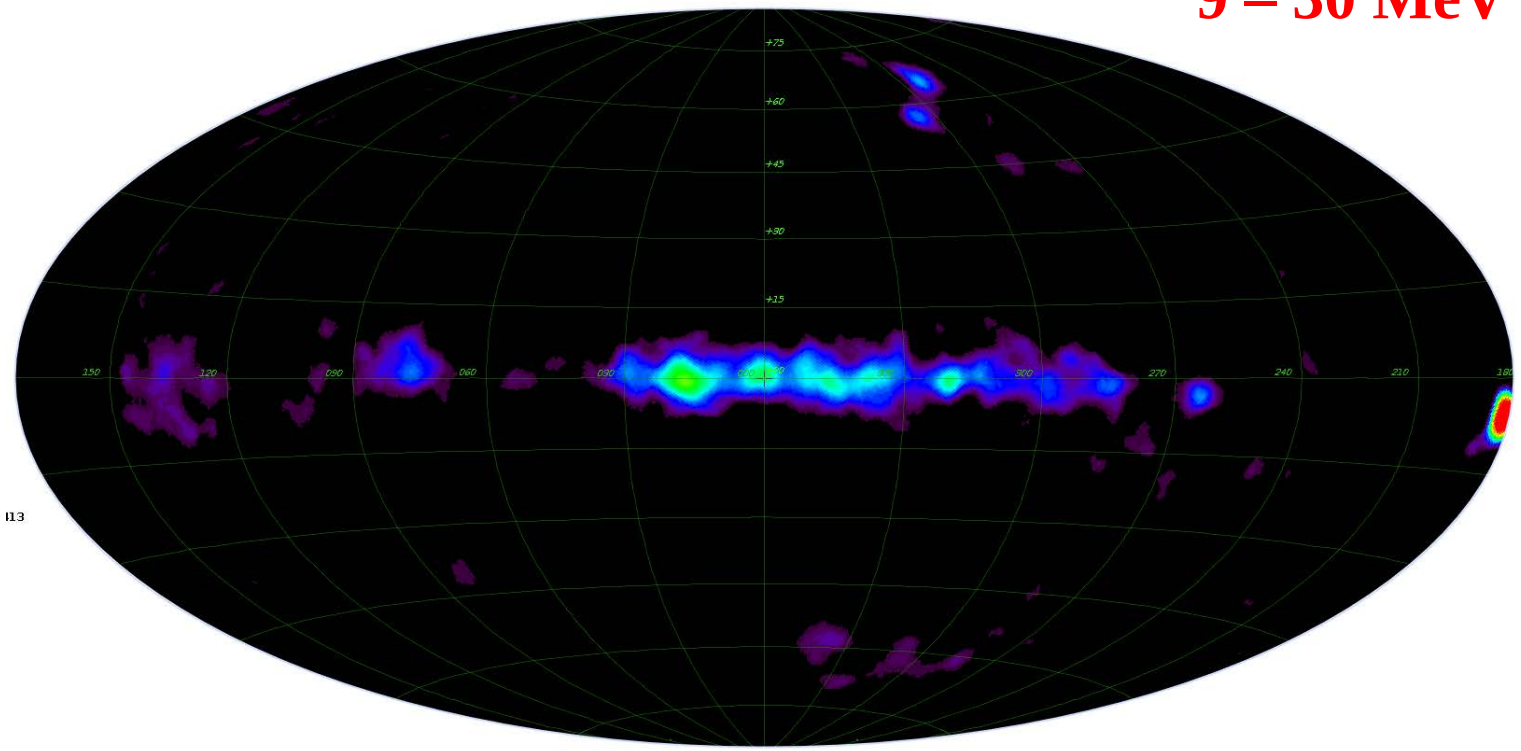
**0.9 – 1.7 MeV**



# Current Developments: All-Sky Imaging

preliminary

**9 – 30 MeV**



# Summary

- **COMPTEL opened the soft γ-ray sky (0.75 – 30 MeV) for science**
- **Crab (total) by far brightest MeV source,**
  **others at 100 mCrab (e.g. 3C 273) and below**
- **after '1st COMPTEL Catalog' the "MeV sky" was still populating**
  **with sources: 4 blazars, 4 unidentified sources, further candidates**
  **→ > 40 Sources**
- **COMPTEL data are still the most sensitive existing MeV data,**
  **parts (in particular late mission) are still unexplored**
- **Recent developments**
  **- calibrate reprocessed COMPTEL data (sensitiv. improvements)**
  **- apply polarization capability (GRBs, solar flares, binaries)**
  **- apply "modern" imaging techniques (e.g. incl. "HEALPIX")**
  **by using modern computer power**
- **Good News: COMPTEL data are still there …**
  **… and even ready again to be looked at**