Science Drivers for Multiwavelength Investigations Using the New Gamma-Ray Observatories and Missions

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Outline

1. The Multiwavelength Revolution
2. Topics of Special Interest to the Gamma-ray Community

A Revolution? Why?

Simple literature search using NASA ADS.
Search for the word "Multiwavelength" in titles.

1976	0
1986	2
1996	58
2006	97

Many astrophysicists have come to recognize the value of multiwavelength research.

One Reason – Facilities

The situation across the spectrum in 1982 – 25 yrs ago:

Radio telescopes – VLA open 2 years, no VLBA

Sub-mm – just getting started

IR – no satellites (IRAS 1983), detectors limited

Optical – largest telescopes: Hale 5 m, Soviet 6 m, few CCDs

UV – IUE (a bright spot)

X-ray – Hakucho Japanese satellite

Gamma-ray – COS-B turned off in that year

TeV – Whipple Observatory just getting started

Another Reason – Communication

1977 – 111 computers on ARPANET, forerunner of the Internet. Most information exchange was on paper.

1981 – First IBM PC

1983 – TCP/IP protocol; SENDMAIL program started; e-mail became practical.

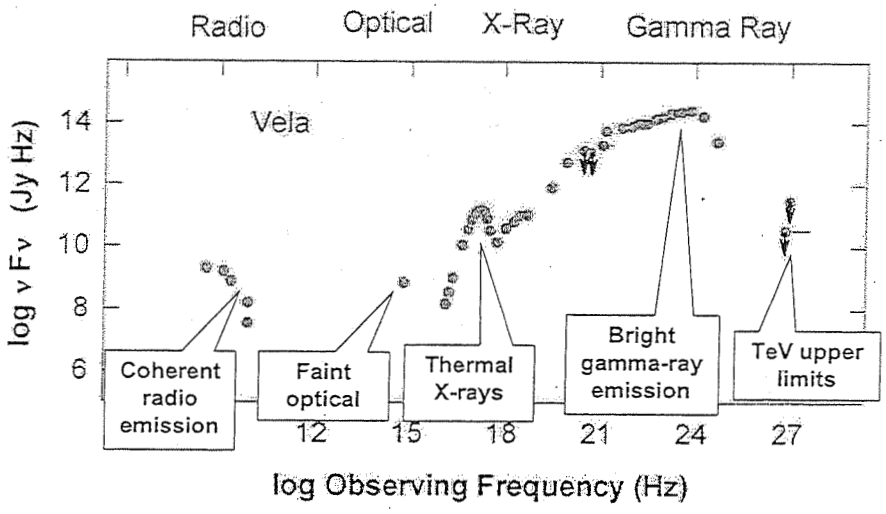
1988 – NSFNET backbone upgraded to 1.5 Mbps

1990 – Tim Berners-Lee and the first Web server

1993 – Mosaic Web browser

The major scientific driver for multiwavelength research comes from the fact that we mostly call ourselves astrophysicists, not astronomers. We want to explore what is there, but also to understand how those things work.

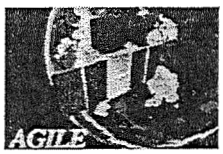
An Example – The Vela Pulsar

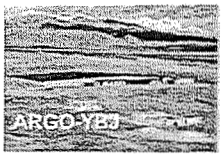


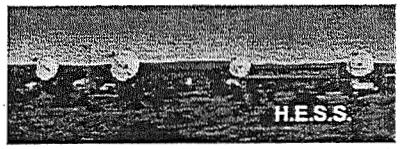
Multiwavelength Research:

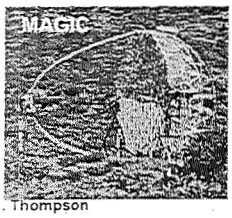
The Gamma-ray Perspective

Gamma-ray Facilities: More Numerous, More Capable

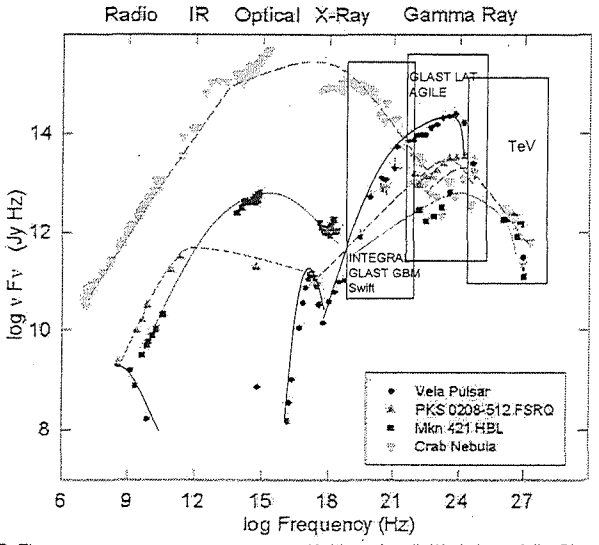








Known Gamma-ray Sources Are Multiwavelength



Gamma-ray sources are nonthermal, typically produced by interactions of high-energy particles.

Known classes of gamma-ray sources are multiwavelength objects, seen across much of the spectrum.

What Do Gamma-ray Measurements Offer?

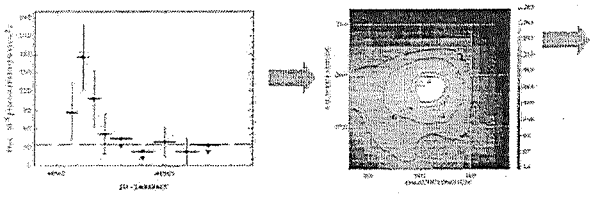
- Huge energy range – 9+ orders of magnitude
- All-sky coverage, from both ground and space
- Excellent sensitivity compared to previous instruments
- Good source locations – 1 arcmin in many cases
- High time resolution for individual photons
- Imaging for some extended sources

Some Other Needs for Astrophysics

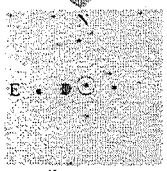
- Distance – redshift, Dispersion Measure, proper motion, column density
- Composition – spectroscopy
- Precise source locations and imaging
- Velocities
- Polarization
- Magnetic fields
- Theories to connect the observations to physical models

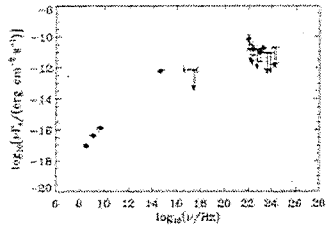
Source Identification: What Is It?

First Clue: Gamma-ray variability Radio sources in the error box



One flat-spectrum radio source, 260 mJy at 5 GHz; one marginally-flat source, 49 mJy; other sources are much weaker





Optical observations:

The 49 mJy source is a normal galaxy;

The 260 mJy source has an optical counterpart with a redshift z=0.83

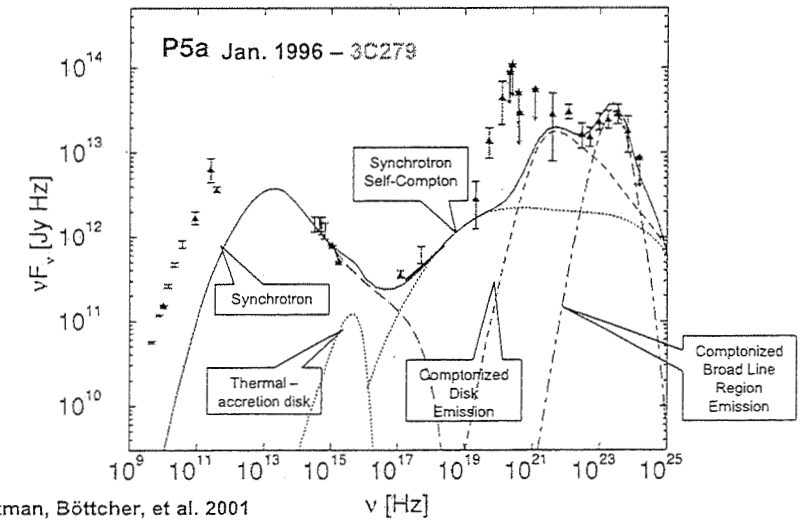
Variable optical polarization is seen.

Only an X-ray upper limit found.

Spectral energy distribution is bimodal like other blazars

Conclusion: a flat spectrum radio quasar (FSRQ) – Wallace et al., 2002

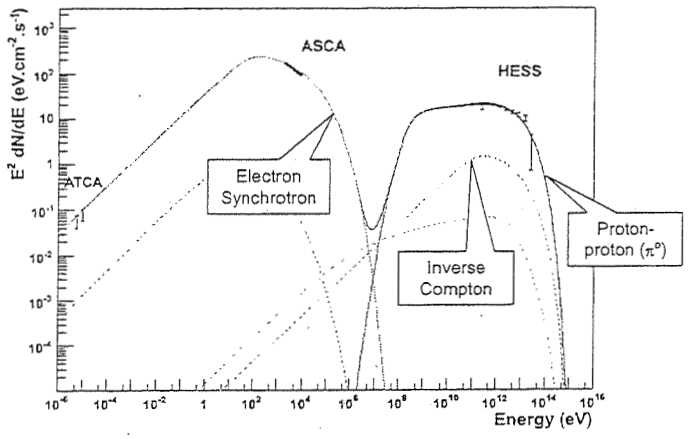
Time-Dependent Modeling: How Does It Work?



Hartman, Böttcher, et al. 2001

Incomplete Measurements: What Are the Implications?

RX J1713.7-3946 – Is This SNR Accelerating Cosmic Ray Protons?



Lemoine-Goumard, et al. 2007

Summary

Multiwavelength studies are valuable to many aspects of astrophysics.

They are particularly important to maximize the scientific return from the new gamma-ray facilities.