

# Blazar Observations with GLAST and the Upcoming Generation of Cherenkov Telescopes

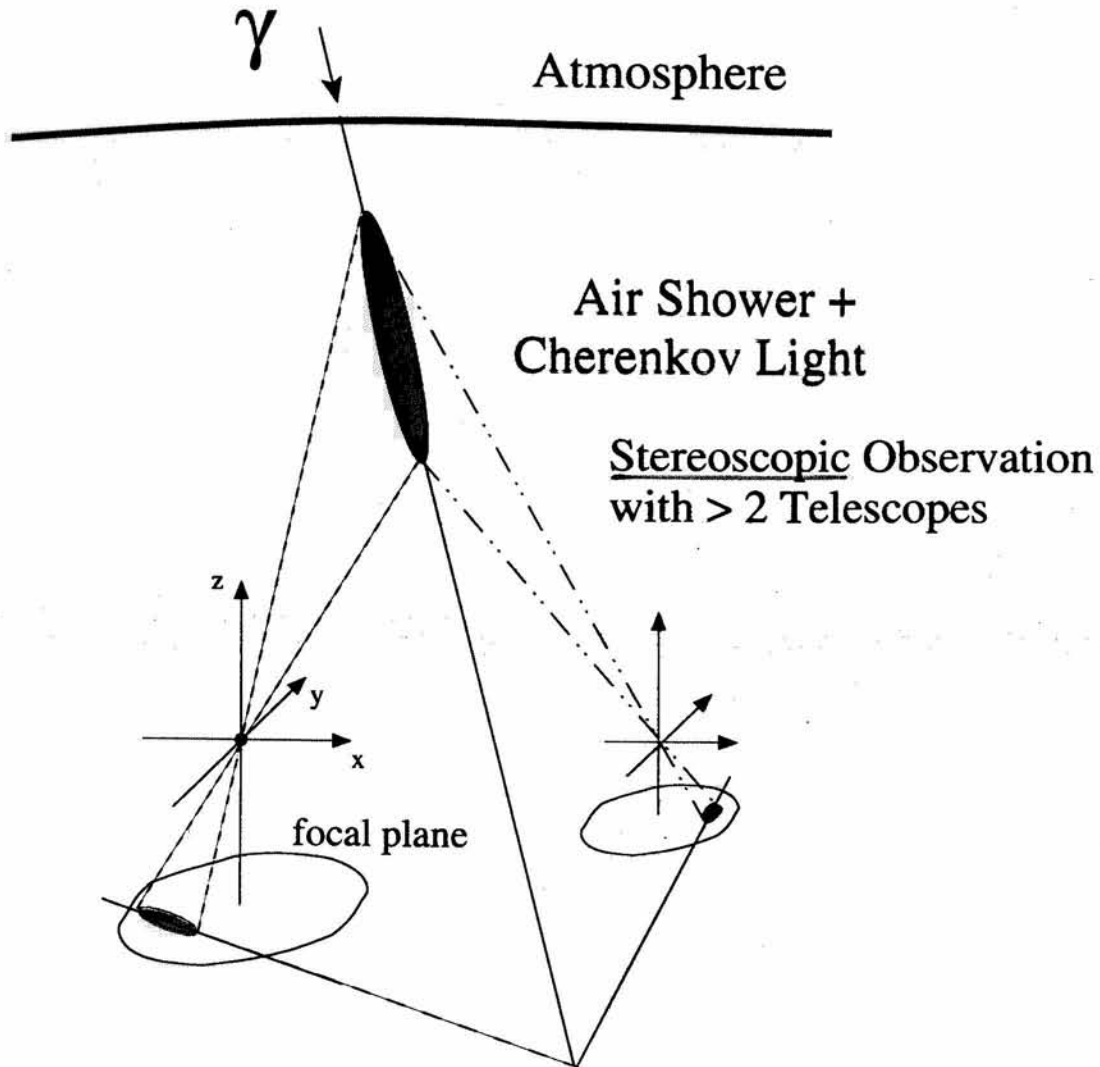
Henric Krawczynski (Yale)

04/02/2001

## Contents:

- (I) Cherenkov Telescopes:
  - Current Detectors
  - Upcoming Detectors
- (II) Complementarity of GLAST and Cherenkov Telescopes
  - Key TeV Gamma Ray Observations
  - Diffuse Extragalactic Background Radiation
  - Prospects of Future Observations
- (III) Summary and Wish-List

## Imaging Atmospheric Cherenkov Telescopes



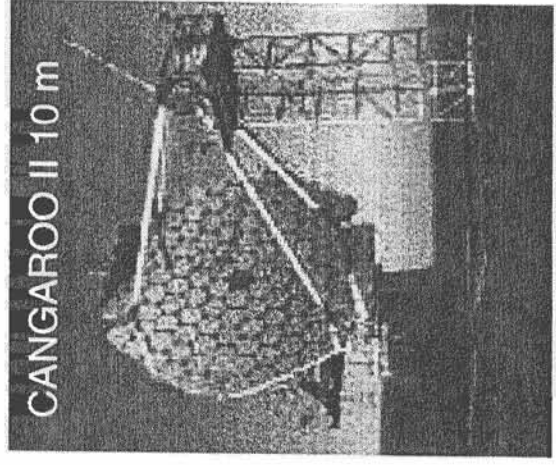
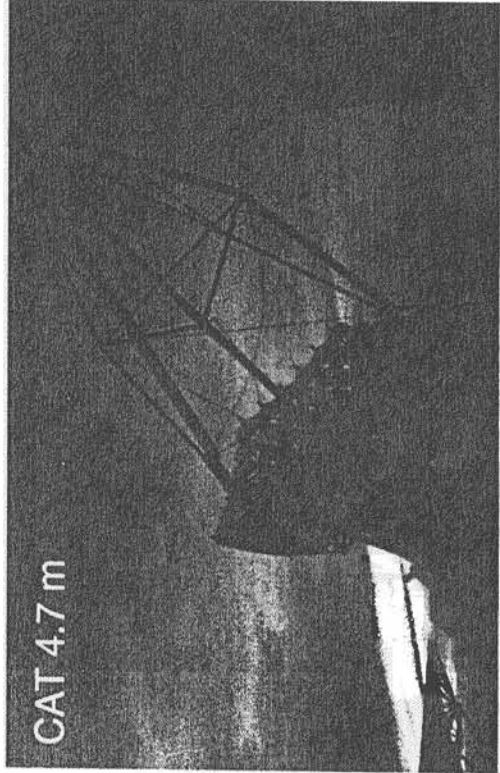
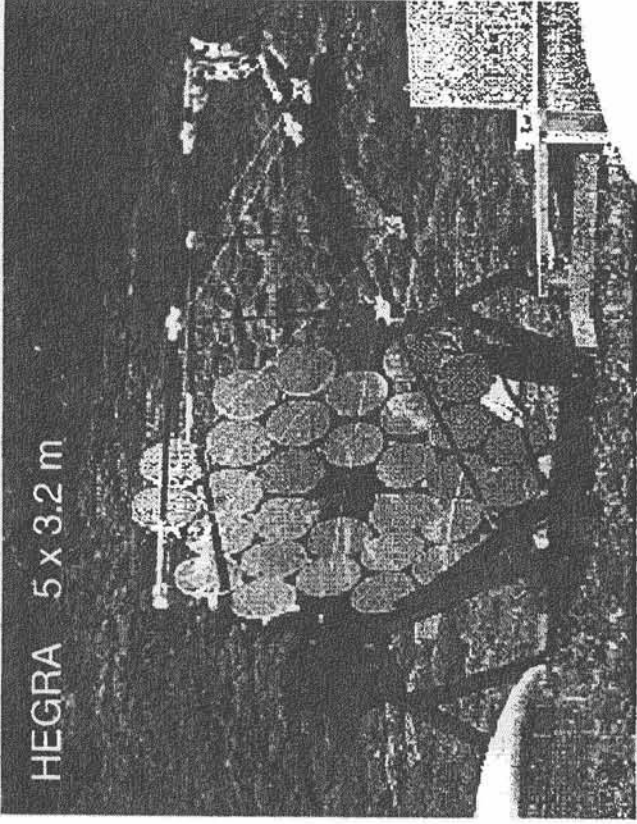
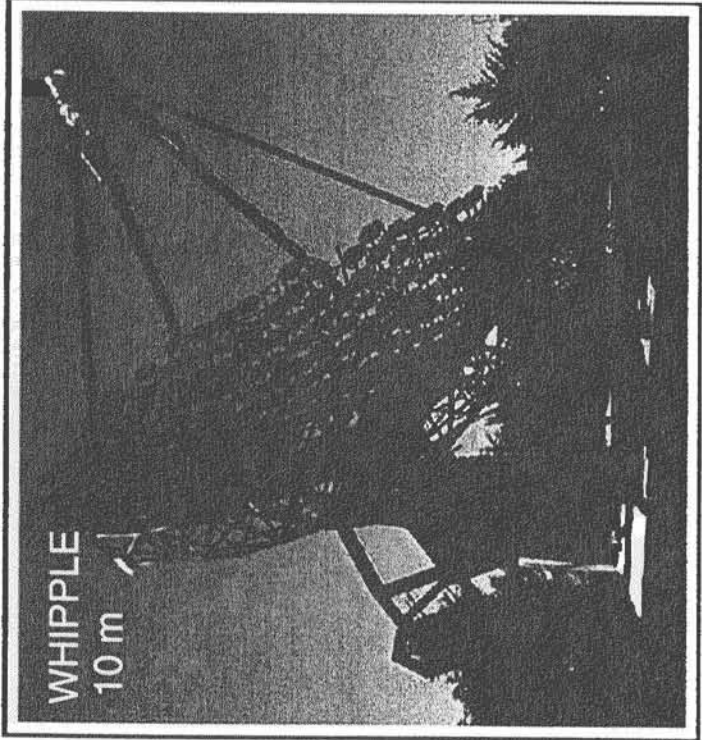
### Strengths:

Detection Area	$10^5 \text{ m}^2$
Angular Resolution	0.1 Degree
Energy Resolution	10%

### Weaknesses:

Field of View	4 msr (4 Degree Diameter)
Background of Cosmic Rays	

Imaging Atmospheric Cherenkov Telescopes



Energy Thresholds:  
200 GeV – 500 GeV

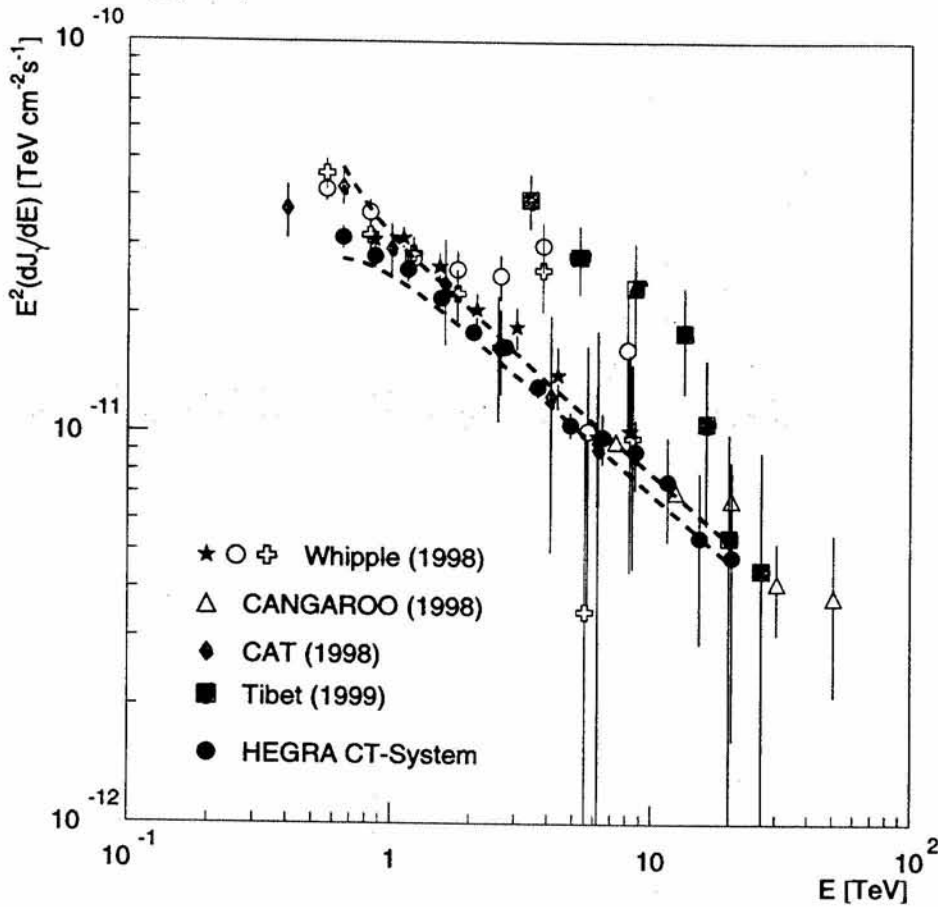
Sensitivities:  
30% Crab in 1 hr, 3% Crab in 100 hrs  
( $1E-11$  erg /  $cm^2$  s and  $1E-12$  erg /  $cm^2$  s @ 1 TeV)

# Crab Observations Crosscalibration of TeV Telescopes

Detection Rates:

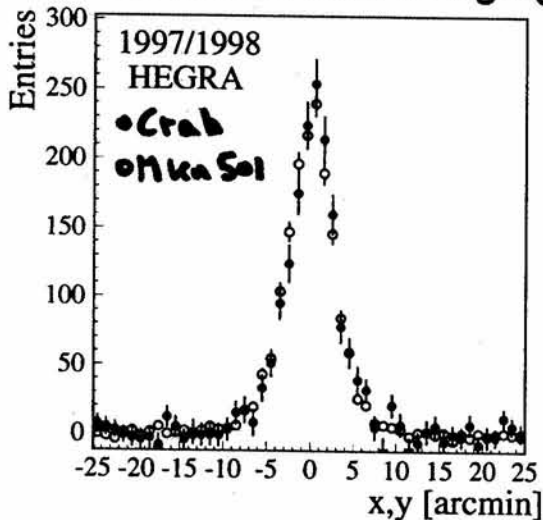
$\sim 60-180 \delta/hr$

Energy Spectrum:



=> Excellent Agreement Between Experiments!

Localization and Imaging:



Localization Accuracy:

$\sim 35$  arcsec

Future:

$< 10'' !$

Angular Extension:

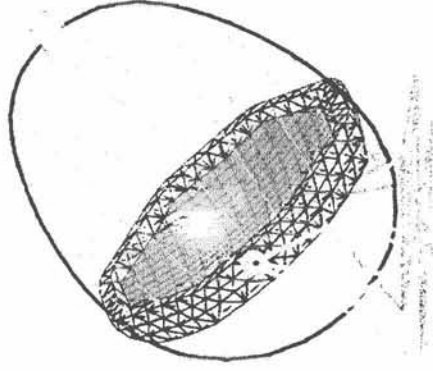
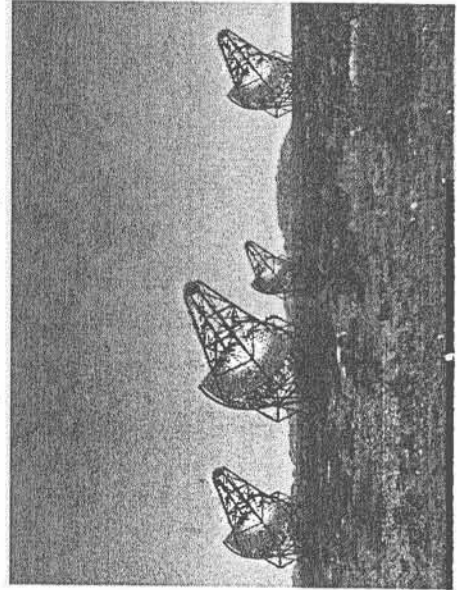
$< 1.5$  arcmin

# Upcoming Cherenkov Telescope Installations



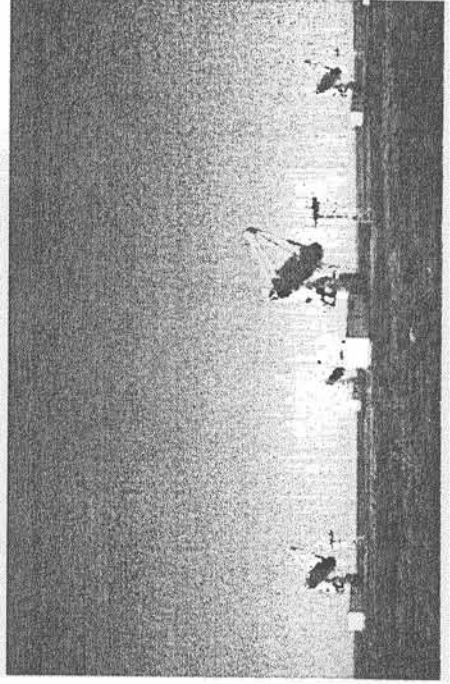
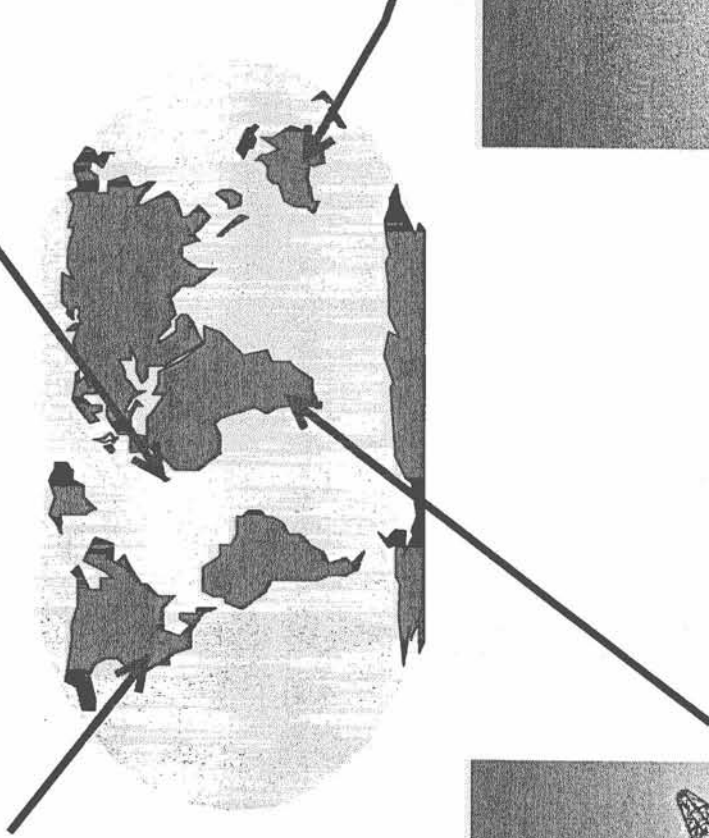
**VERITAS**  
7 x 10 m  
(3 in 2003)

**H.E.S.S.**  
4 (16) x 12 m  
(4 in 2002)

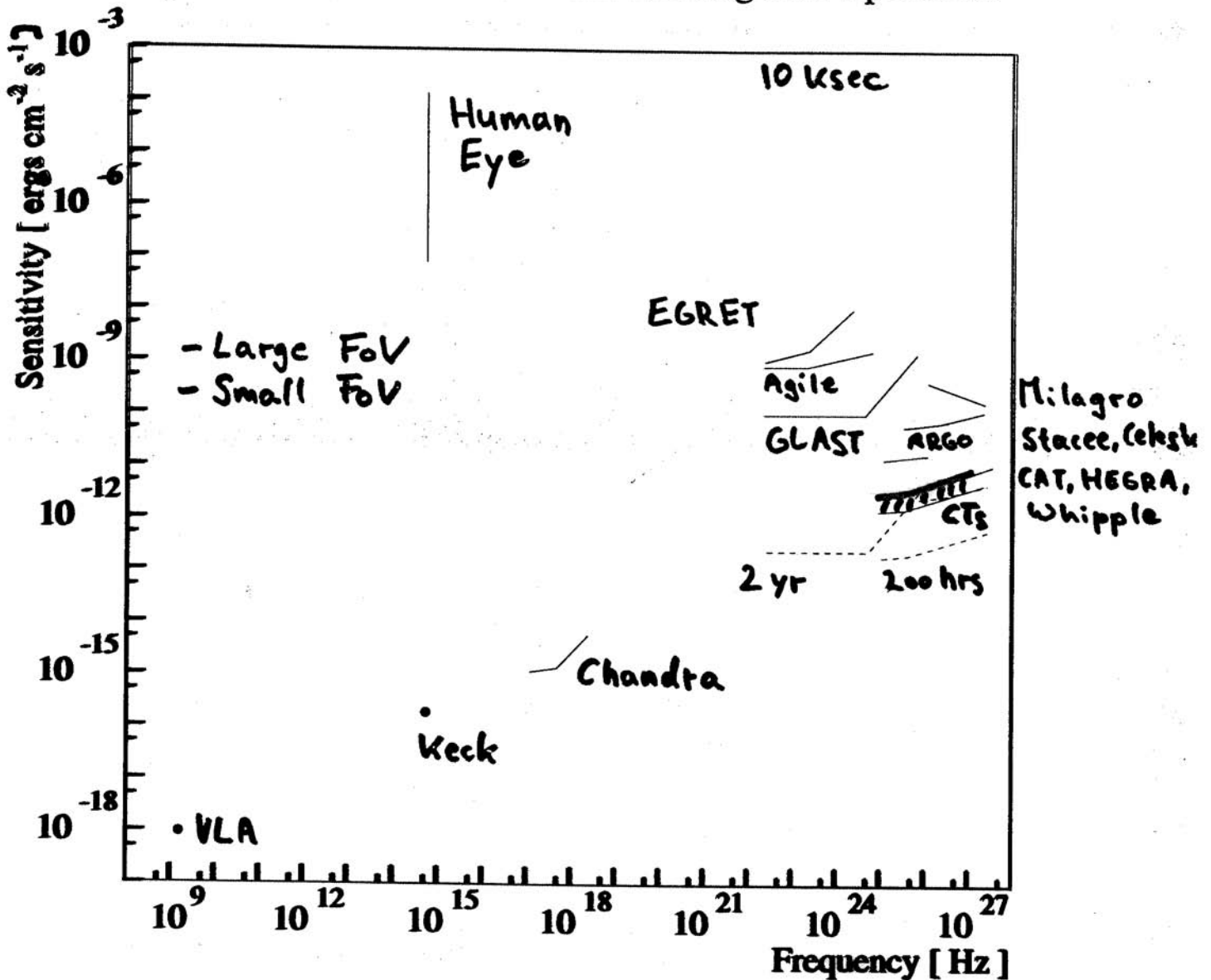


**MAGIC**  
1 x 17 m  
(2001)

**CANGAROO III**  
4 x 10 m  
(4 in 2004)



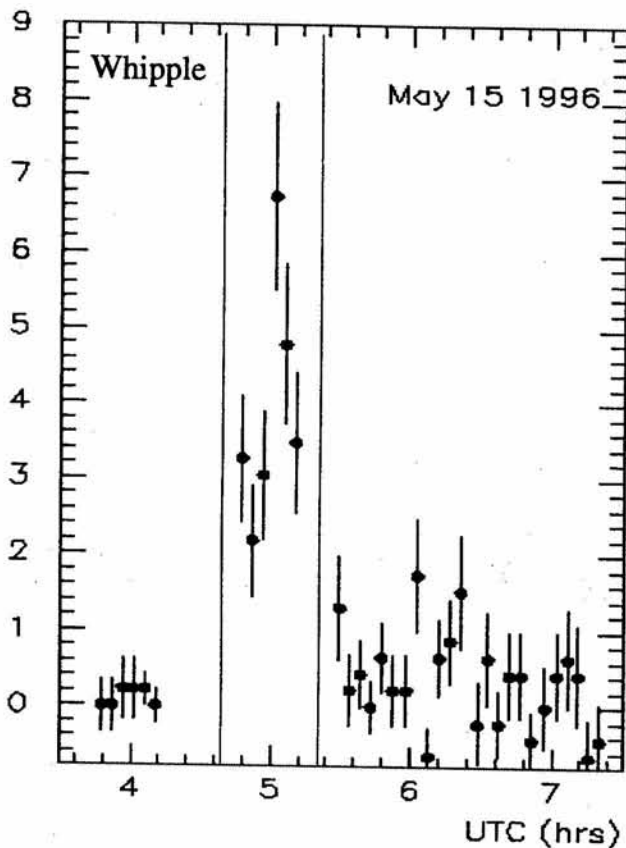
## Telescope Sensitivities Over the Electromagnetic Spectrum



## Cherenkov Telescopes:

- Best for Observation of (Sub-) Hour Variability
- Caveats:
  - Diurnal Observations ~5 hrs
  - 1 Week Moon-Pause for Every 3 Weeks of Observations
  - 251

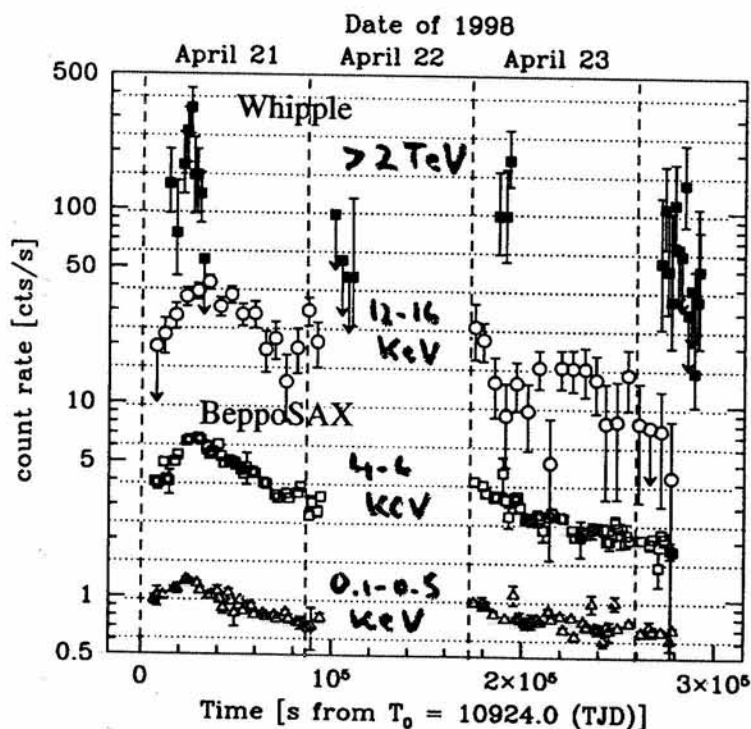
# Mrk 421 – Variability on Sub-Hour Time Scale



Gaidos et al., 1996

TeV Flux Variability  
on 15 min Time Scale

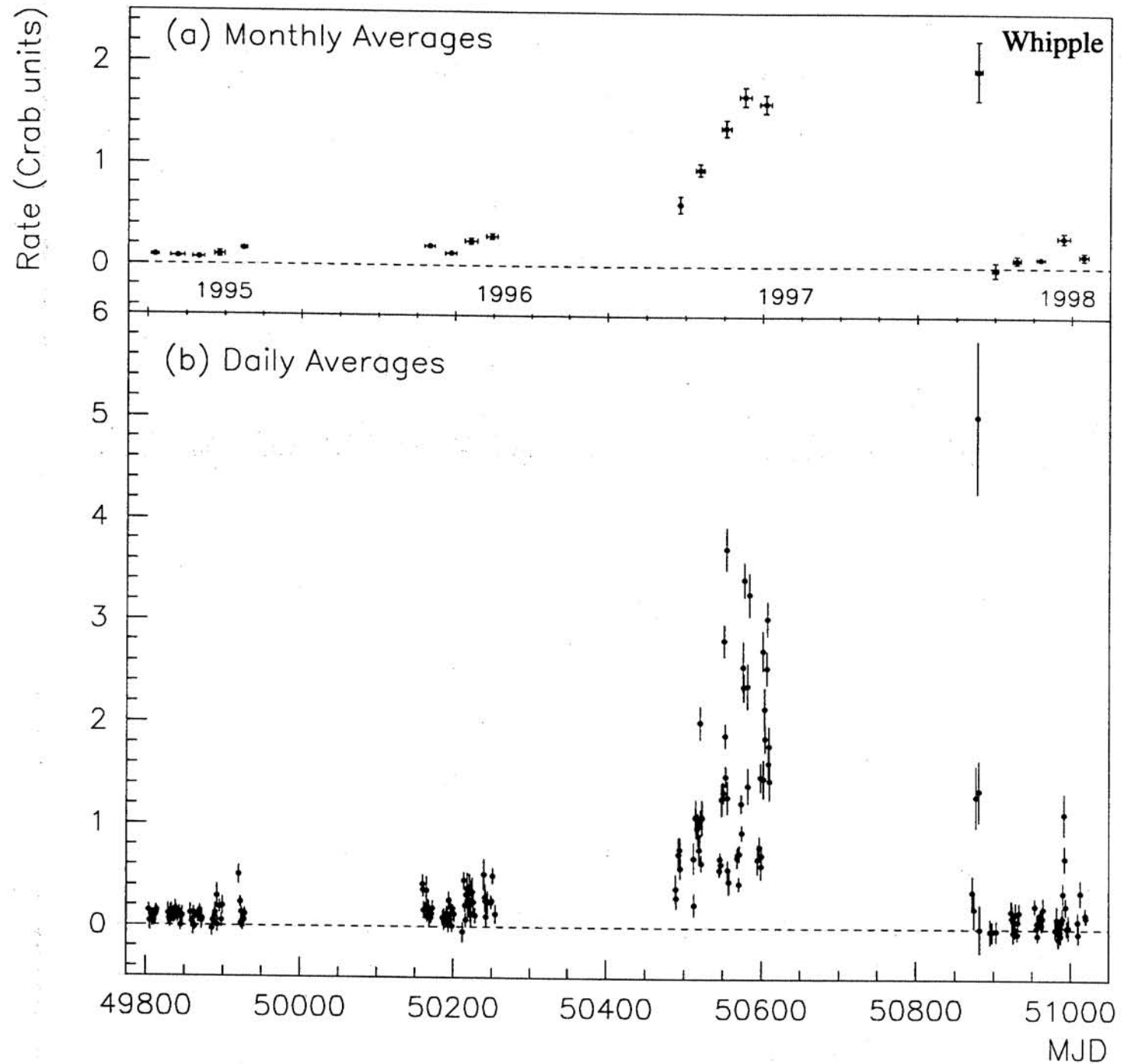
- ⇒ Simultaneous Multiwavelength Observations Required
- true flare not much smaller



Maraschi et al., 1999

TeV Flare Shorter  
Than X-Ray Flare

# Markarian 501



Quinn et al. 1999

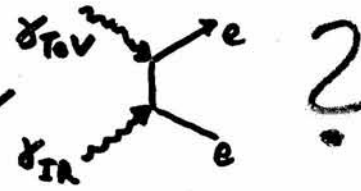
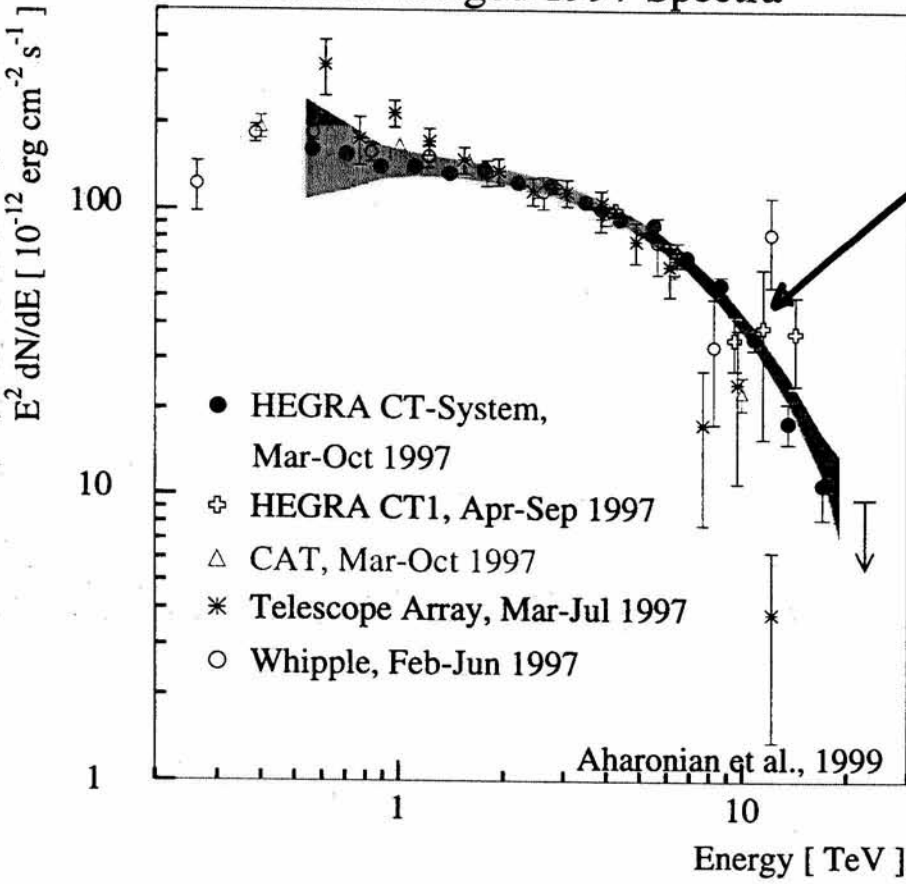
Large Variation Of Emission Strength  
On Time Scales of Several Months

=> Rapid Alerts Needed (a la BACODINE, RXTE ASM)

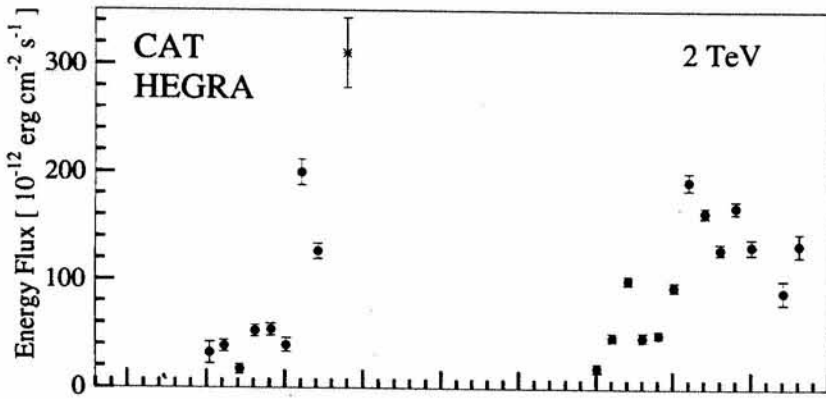


# Markarian 501

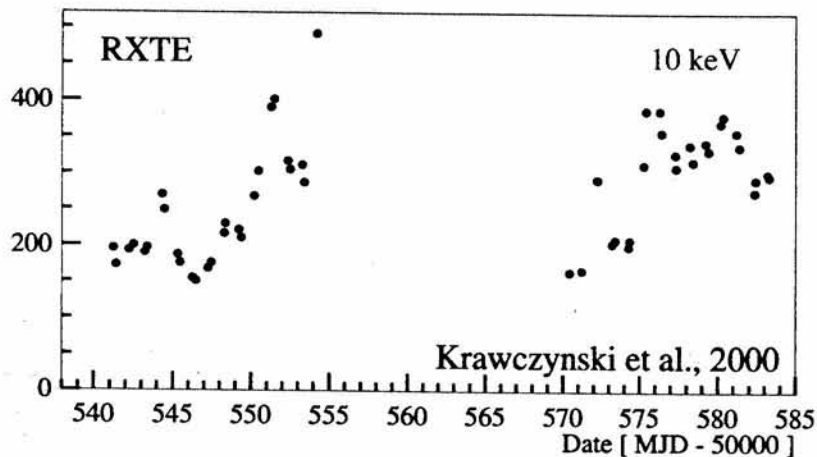
Time Averaged 1997 Spectra



Emission  
Up To 16 TeV



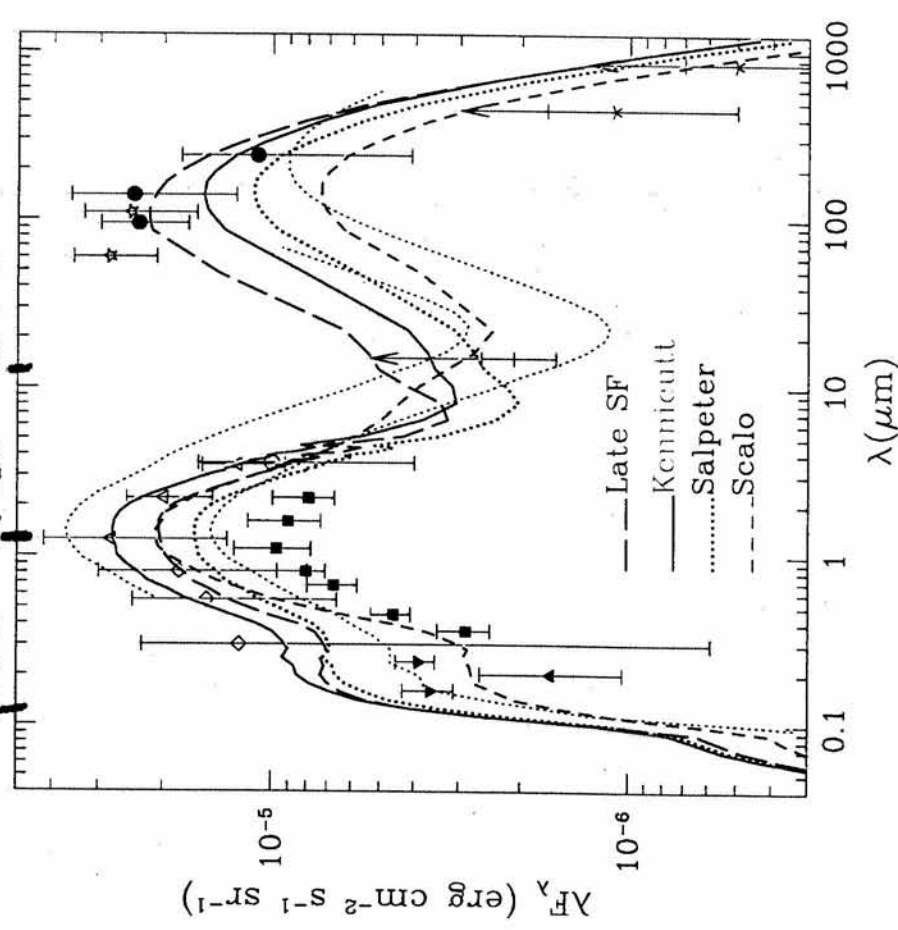
Spectral Indices: 0.1 (2 hrs)  
Required: 0.03 (2 hrs)



Tight X-Ray / TeV  
Correlation

# The Extragalactic Infrared Background

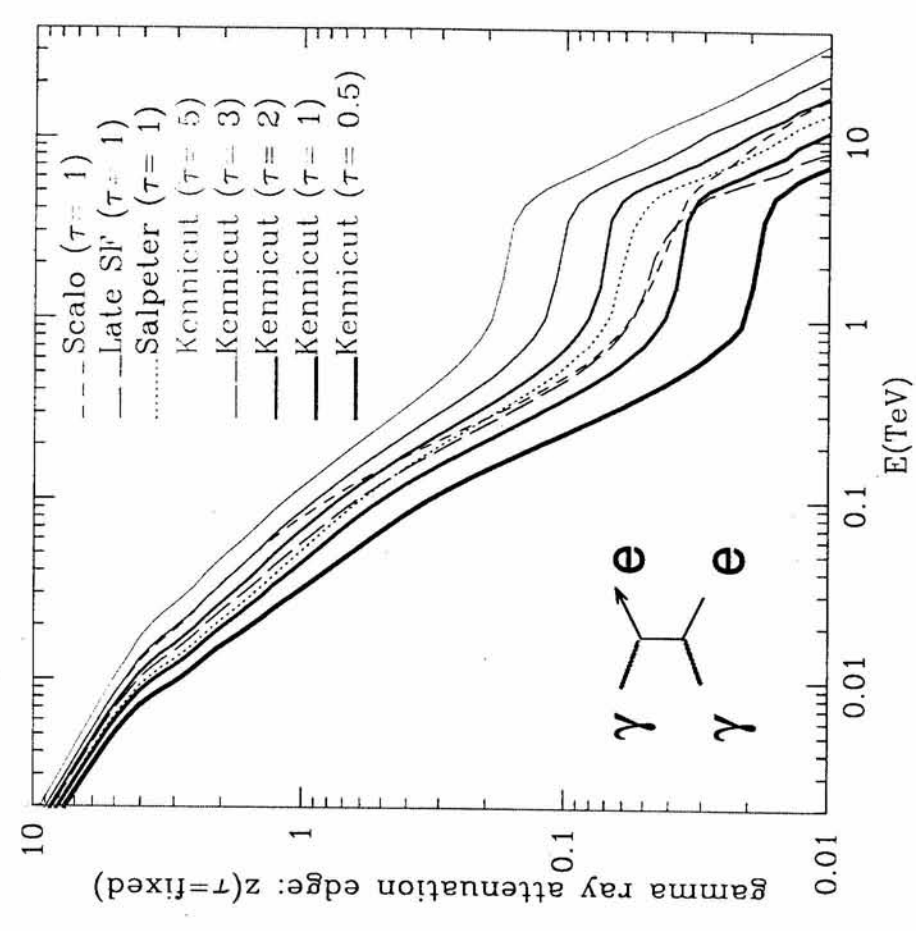
Model Calculations:  
100 GeV 1 TeV 10 TeV



- Infrared Background:
- Depends on Star Formation History and Cosmological Parameters

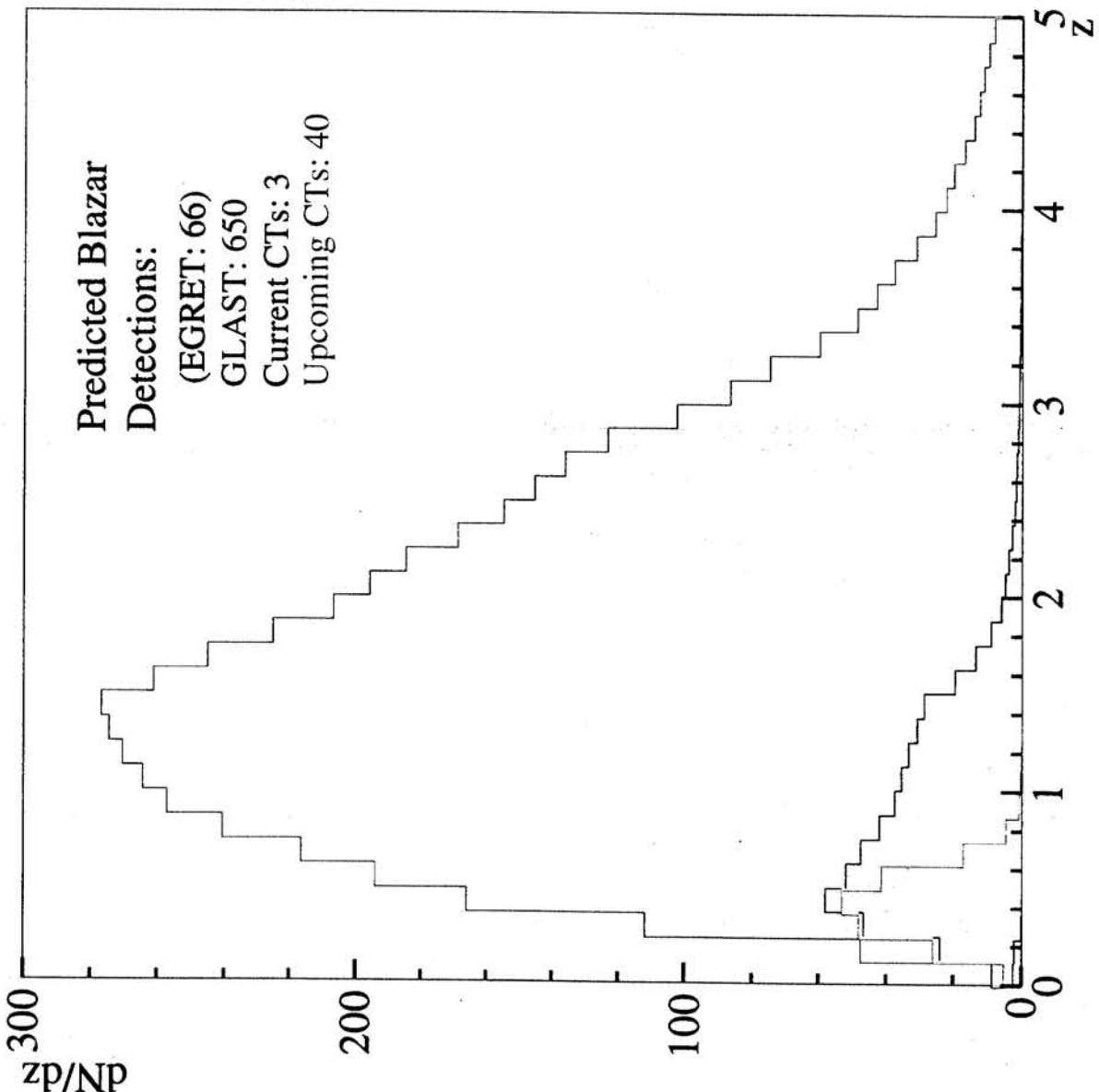
Primack et al., 2000

Extragalactic Extinction:

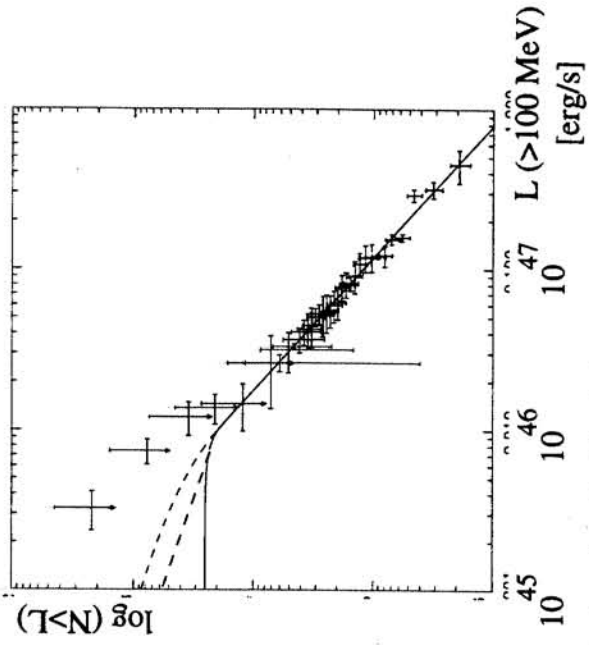


- Limits Accessible Volume
- Can Be Determined from GeV/TeV Observations

# Predicted Number of Blazar Detections



Luminosity Function from Chiang & Mukherjee 1998:



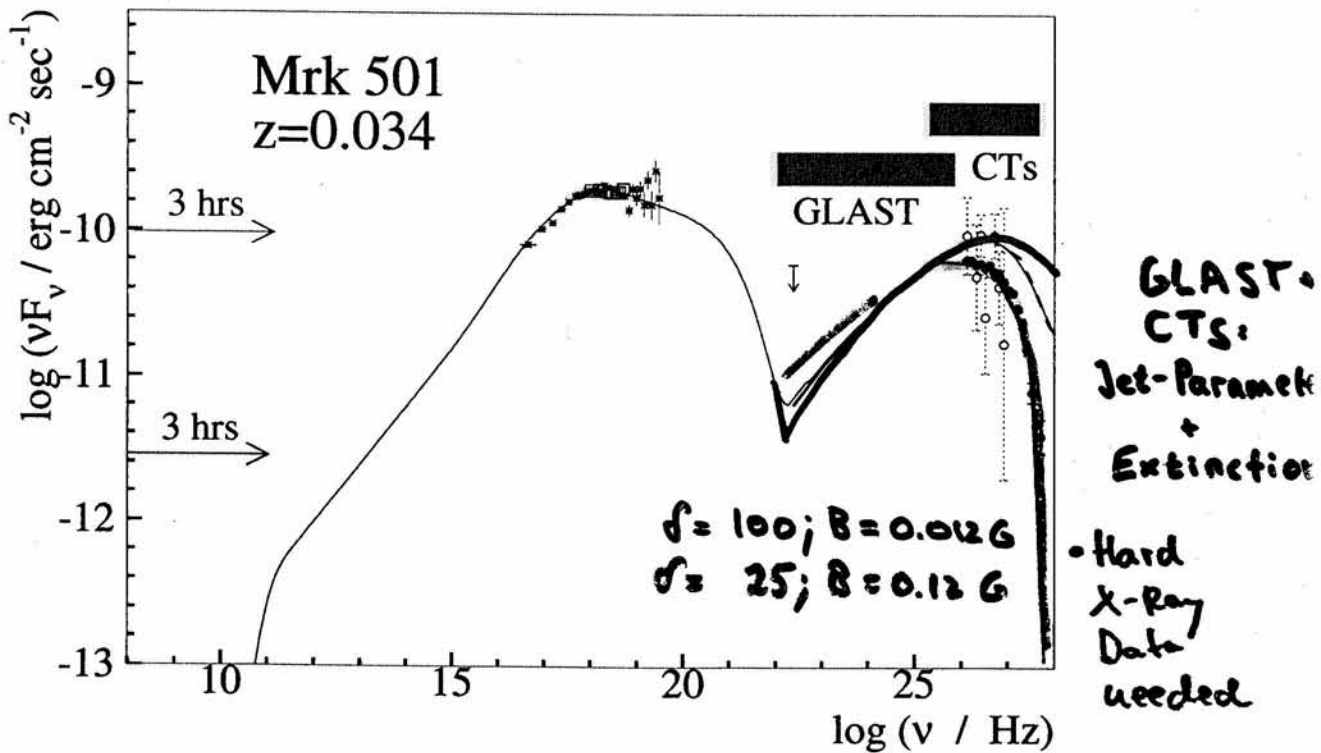
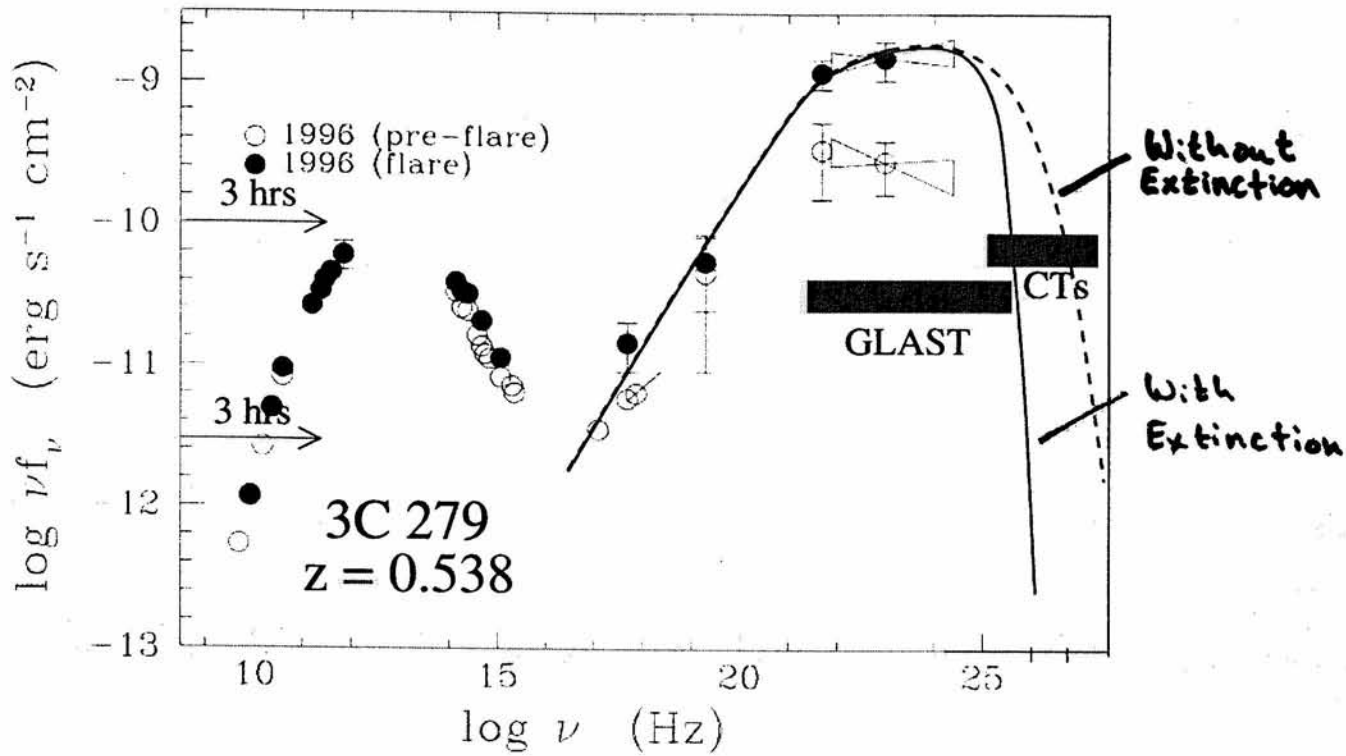
Luminosity Evolution:

$\rho \propto (1+z)^{2.7}$  with Exponential  
 Cutoff at  $z > 1.5$

Spectral Index:

$\alpha = -1.1$  for  $100 \text{ MeV} < E < 1 \text{ GeV}$   
 $\alpha = -1.5$  for  $E > 1 \text{ GeV}$

# Coordinated GLAST / VHE Observations



## GLAST and Cherenkov Telescopes:

- Inverse Compton Component Over 6 Orders of Magnitude in Frequency
- Most Promising: Strong Sources with  $z < 0.5$

## Summary And Conclusions

### GLAST:

- Large Data Sample of Blazars With Redshifts Up To 5  
=> New Classes of <Weak> or <Distant> Sources?  
Diffuse Extragalactic Gamma-Ray Background?
- Blazar Cosmology
- Correlation With Low Frequency Properties
- Time Resolved Studies: Bright EGRET Quasars

### Cherenkov Telescopes:

- Sources With Redshifts Up to  $\sim 1$
- Determination of IR-BG As Function of Redshift
- Time Resolved Studies: Strong + "Blue" Objects

### Joint Observations:

High Sensitivity Observations from 10 MeV to 20 TeV

### Wish List - GLAST:

- Rapid Email Alerts: Blazar Flares, Spectral Changes
- Uninterrupted Coverage for Duration of  
Typical Multiwavelength Campaigns ( $\sim 2$  Weeks)
- List of Nearby, "Blue" Sources

• X-Rays : 0.1keV - 200keV