Tackling the Disk/Jet Connection in AGN: Timing Analysis Methods and Outlook for GLAST

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GLAST Lunch
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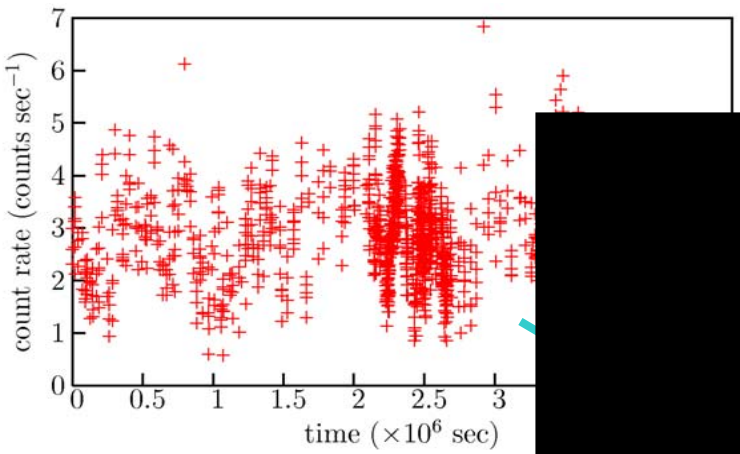
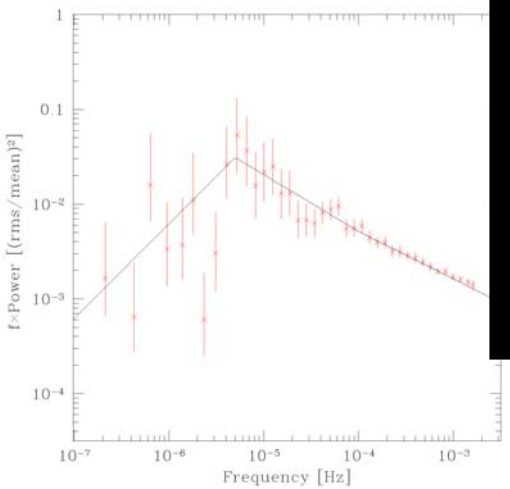
Outline

- The Big Black Box around the AGN Central Engine
- Time Series Analysis – Power Density Spectra
- Introduction to Method of Light Curve Simulations
- Results for NGC 4945 (Seyfert 2 galaxy)
- Application to GLAST
- Summary

The Big Black Box around the AGN Central Engine

NGC 4945

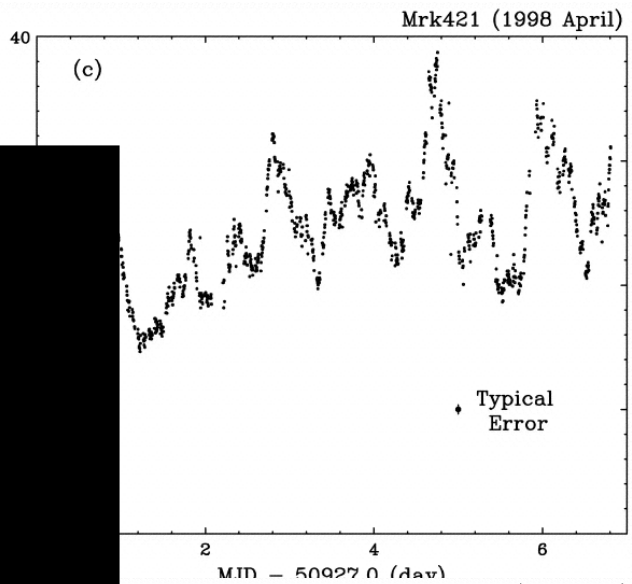


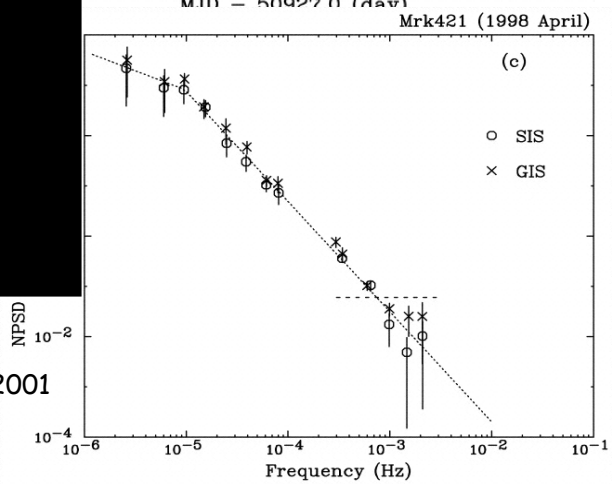


Mueller et al., in preparation

Big Black Box

Mrk421





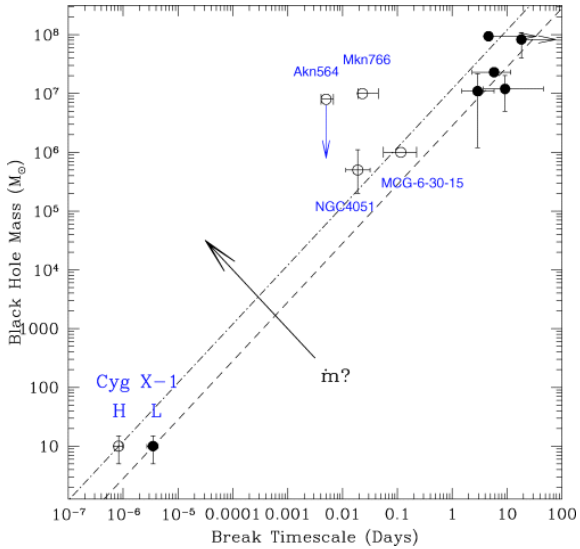
Kataoka et al. 2001

Timing Studies with AGN and Blazars

- characteristic time scales, search for QPOs
- determination of black hole mass
- evidence for accretion states

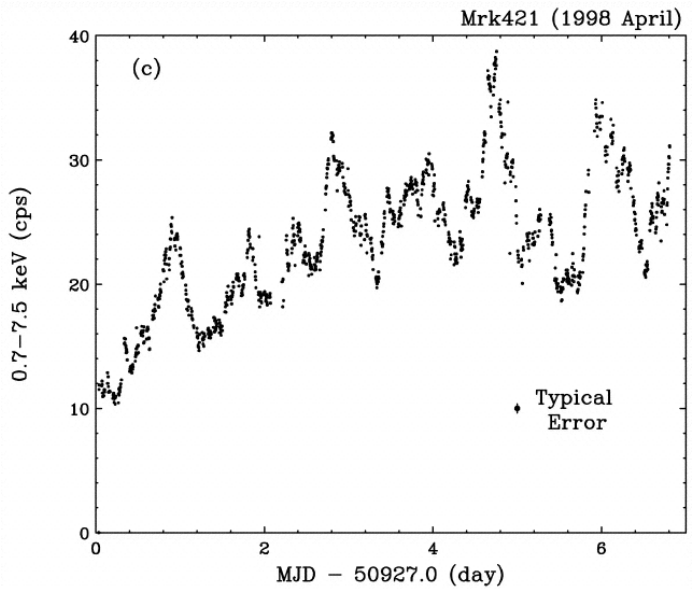
  in massive black holes

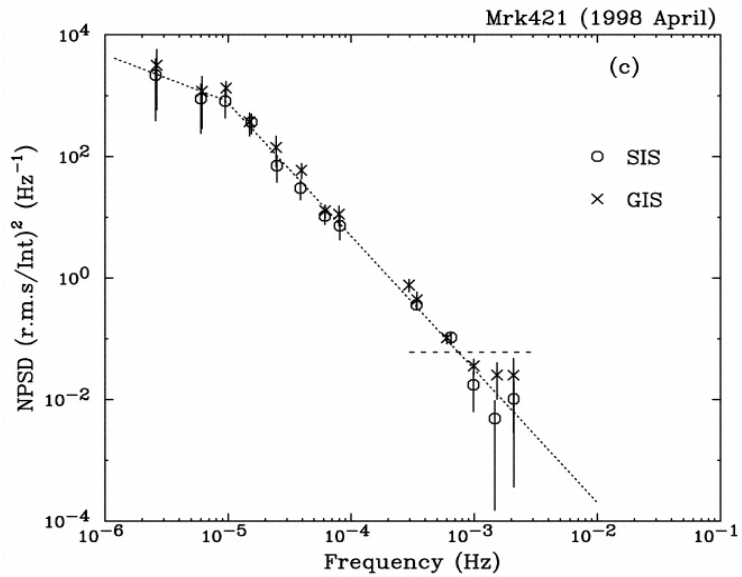
  → Unification of AGN phenomena
- multiwavelength campaigns:
  - correlation functions → time lags
  - flares, spectral changes



McHardy et al. 2004

Understanding Power Density Spectra



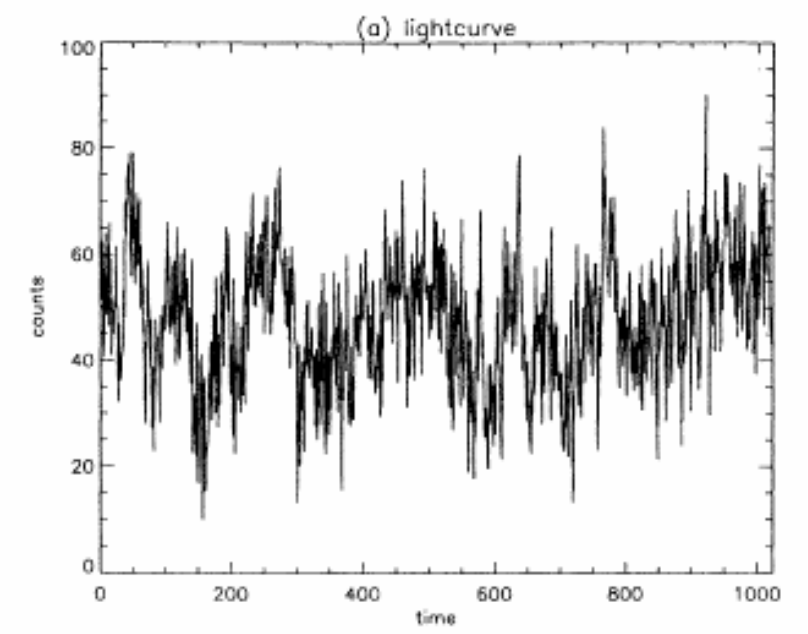


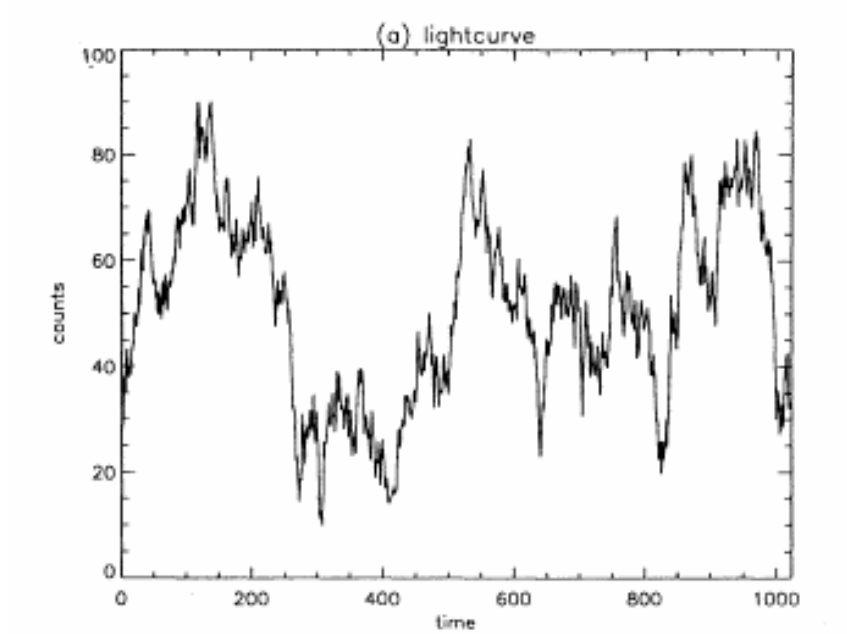
Kataoka et al. 2001

time domain
(light curve)

frequency domain
(power density spectrum)

Understanding Power Density Spectra



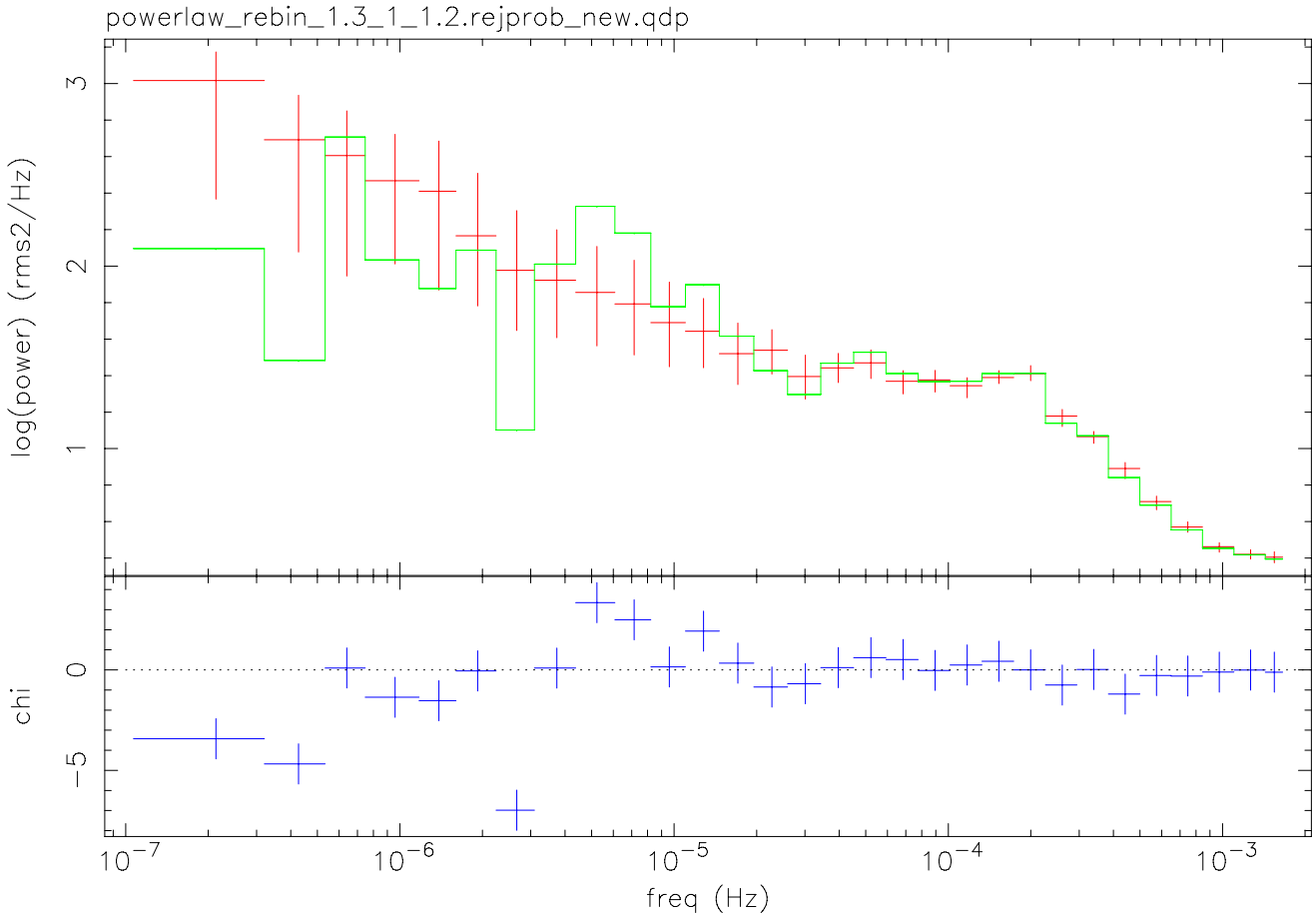


$P(f) = P_0 f^{-1}$

$P(f) = P_0 f^{-2}$

Timmer & Koenig 1995

The Trouble with Uneven Sampling



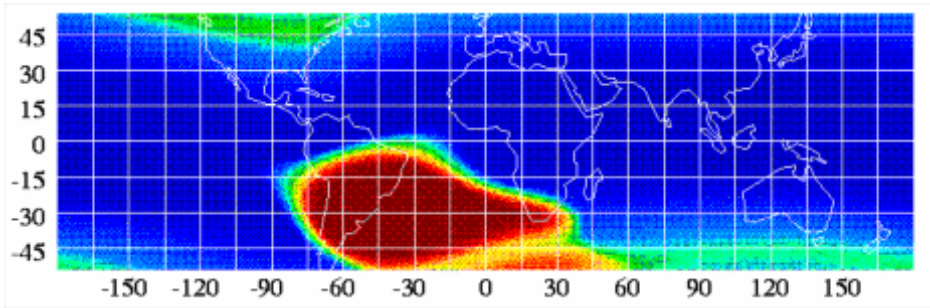
- distortions
- spurious peaks, troughs
- slope changes

NGC 4945 (Mueller et al., in preparation)

More on Uneven Sampling

Unevenly sampled light curves unavoidable in Astrophysics

- observation scheduling
- Earth occultations
- SAA passages
- observation mode (scanning vs. pointing)
- sparse photon data



Method of Light Curve Simulations

Conceptual basis:

- need to incorporate window function
- need reliable way to calculate uncertainties in frequency domain
- cannot remove effect of window function
  from distorted periodogram (unfolding problem)

→ **solution:** use ideas from X-ray spectral fitting:

forward-propagation of model for observed data

Method of Light Curve Simulations

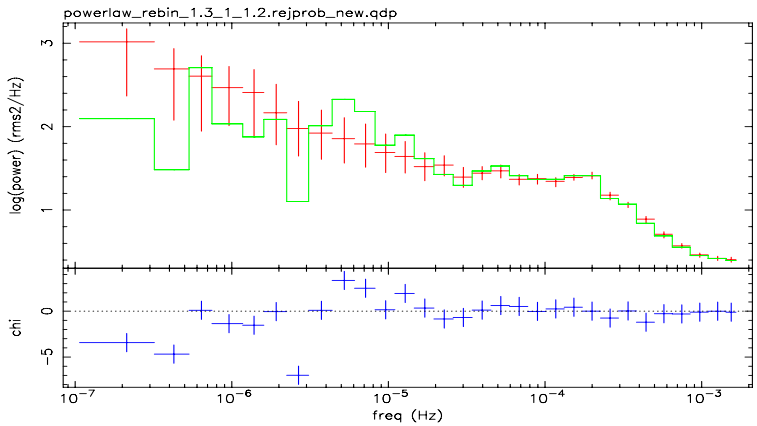
1. model for shape of PDS → simulated light curve
   → apply window function in time domain

2. use Lomb-Scargle periodogram for frequency analysis

3. compare periodogram from observed light curve
   against simulated set → goodness-of-fit

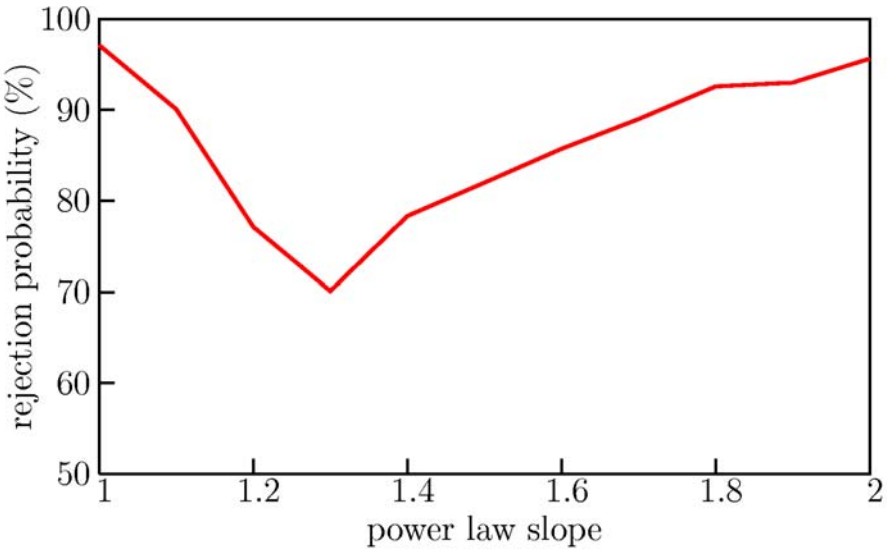
4. iterate to find best-fitting parameters of model

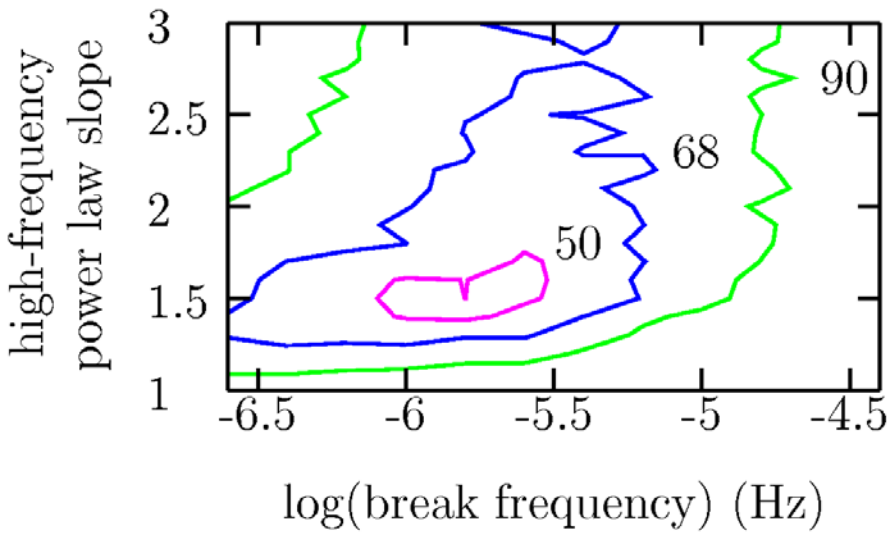
Done et al. (1992)
Uttley, McHardy, Papadakis (2002)
Markowitz et al. (2003)
Mueller et al. (2003, astro-ph/0312466)



Results from Light Curve Simulations

get goodness-of-fit as a function of the input model parameters:





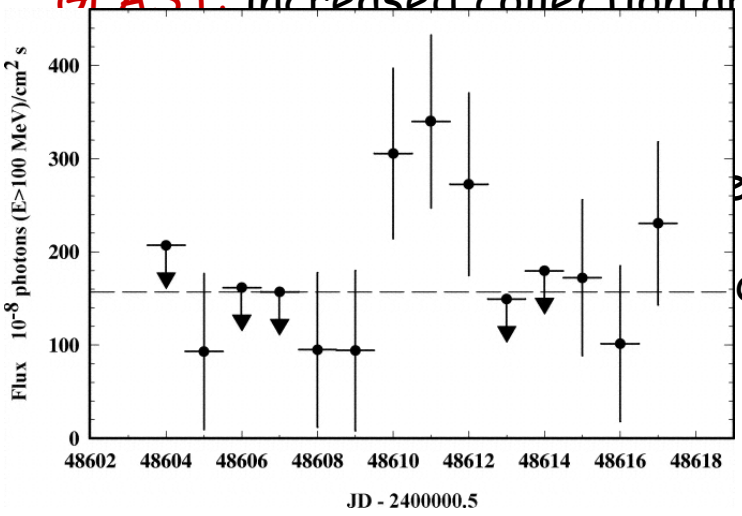
NGC 4945 unbroken power law fit

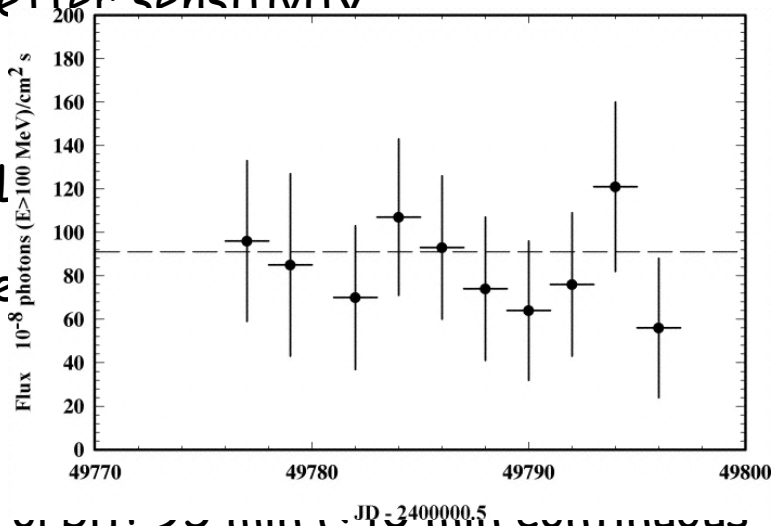
broken power law fit

Application to GLAST

EGRET: very sparse data, no point in trying this method

GLAST: increased collection area, better sensitivity





unevenly sampled?

OH, YES!

Wallace et al. 2000

on any object)

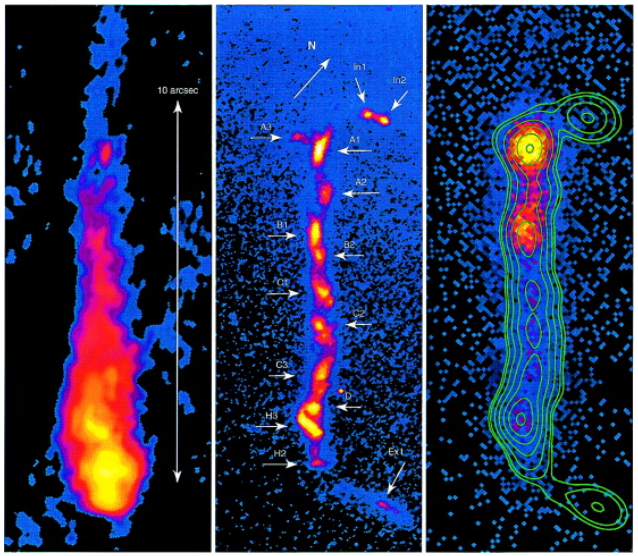
SAA passages: 24 hours

orbit precession: ~55 days

(from Jim Chiang's 2002 presentation)

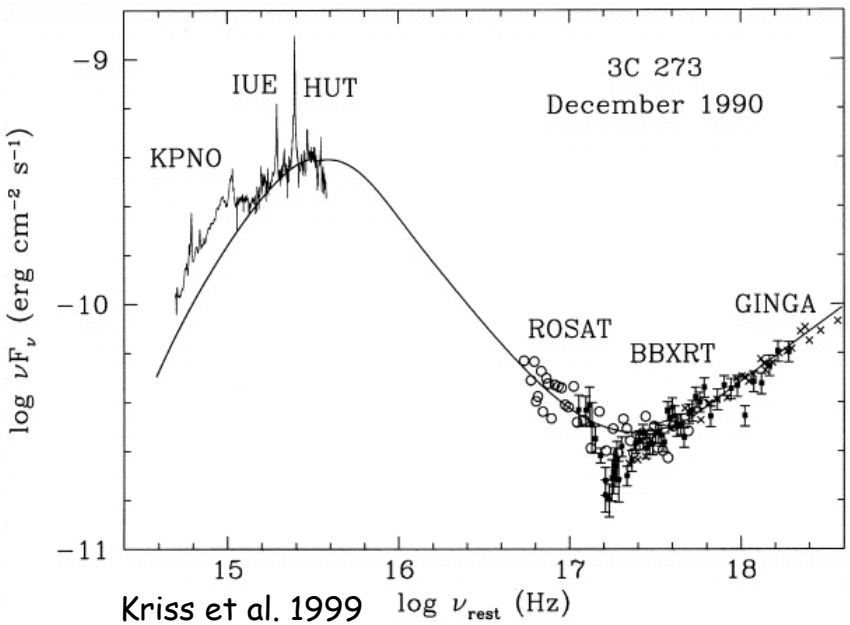
Interesting Target: 3C 273

Probing the disk/jet connection: need an object where both disk and jet visible



Marshall et al. 2001

jet resolved in radio, optical, X-ray



Kriss et al. 1999

spectrum showing evidence of both accretion flow and jet

Summary

- GLAST: expect unevenly sampled light curves for astrophysically interesting sources (e.g. blazars)
- observing pattern ideal for detecting transient sources (e.g. 3C 279)
- method of light curve simulations well suited for analysis of these data sets
- probing the disk/jet connection viable science goal for GLAST in connection with observations in other wavelength bands

Thank you!