The Role of UMRAO Data in Understanding γ-Ray Emission

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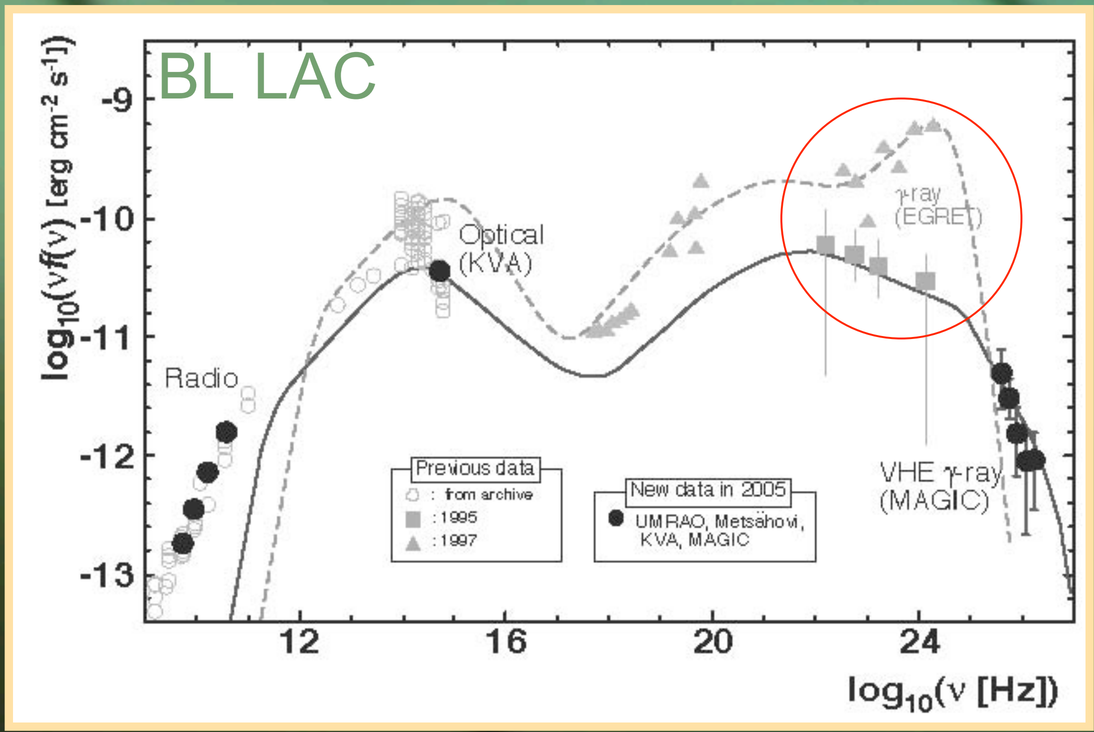


Albert et al. 2007

OUTLINE

1.Scope of program

2. EGRET & UMRAO

3. GLAST & UMRAO

UMRAO Variability Program

- Personnel: Aller, Aller, Latimer, Hughes
- Instrument: UMRAO 26-meter telescope
- Frequencies: 14.5, 8.0, 4.8 GHz (Flux & Pol.)
- Type of Data: integrated (evolving knots +underlying quiescent jet)
- Sources monitored: CP candidates (36), MOJAVE members, TeV sources (VERITAS)
- Fast, flexible scheduling: immediate-few hours

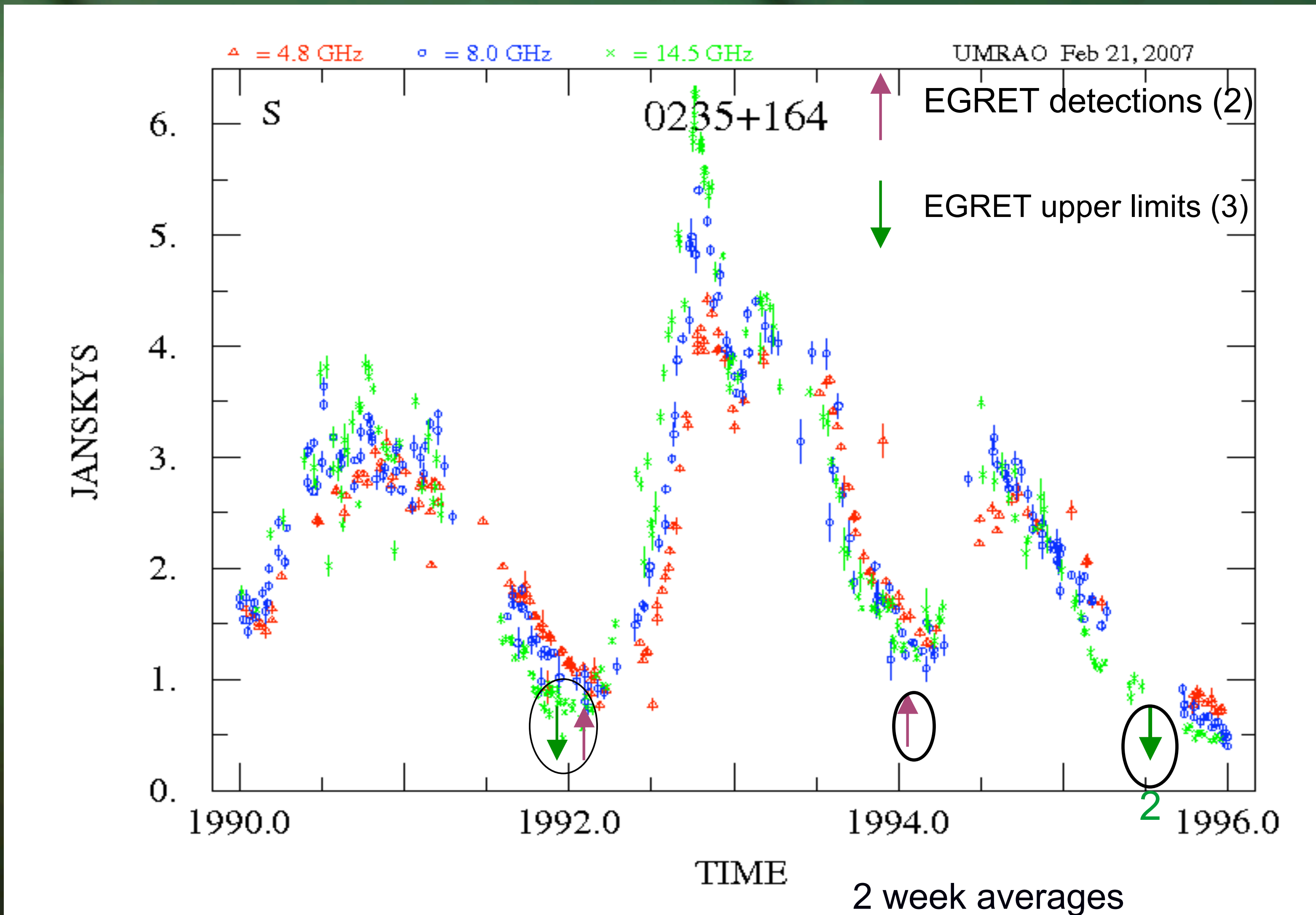
position constraint: -35°<dec<81° (mechanical limits, pointing)

total flux density constraint: S> 400 mJy for flux & LP
(to measure variability) S> 200 mJy for S only

sun limits: 30° at 14.5, 8.0 GHz; 60° at 4.8 GHz

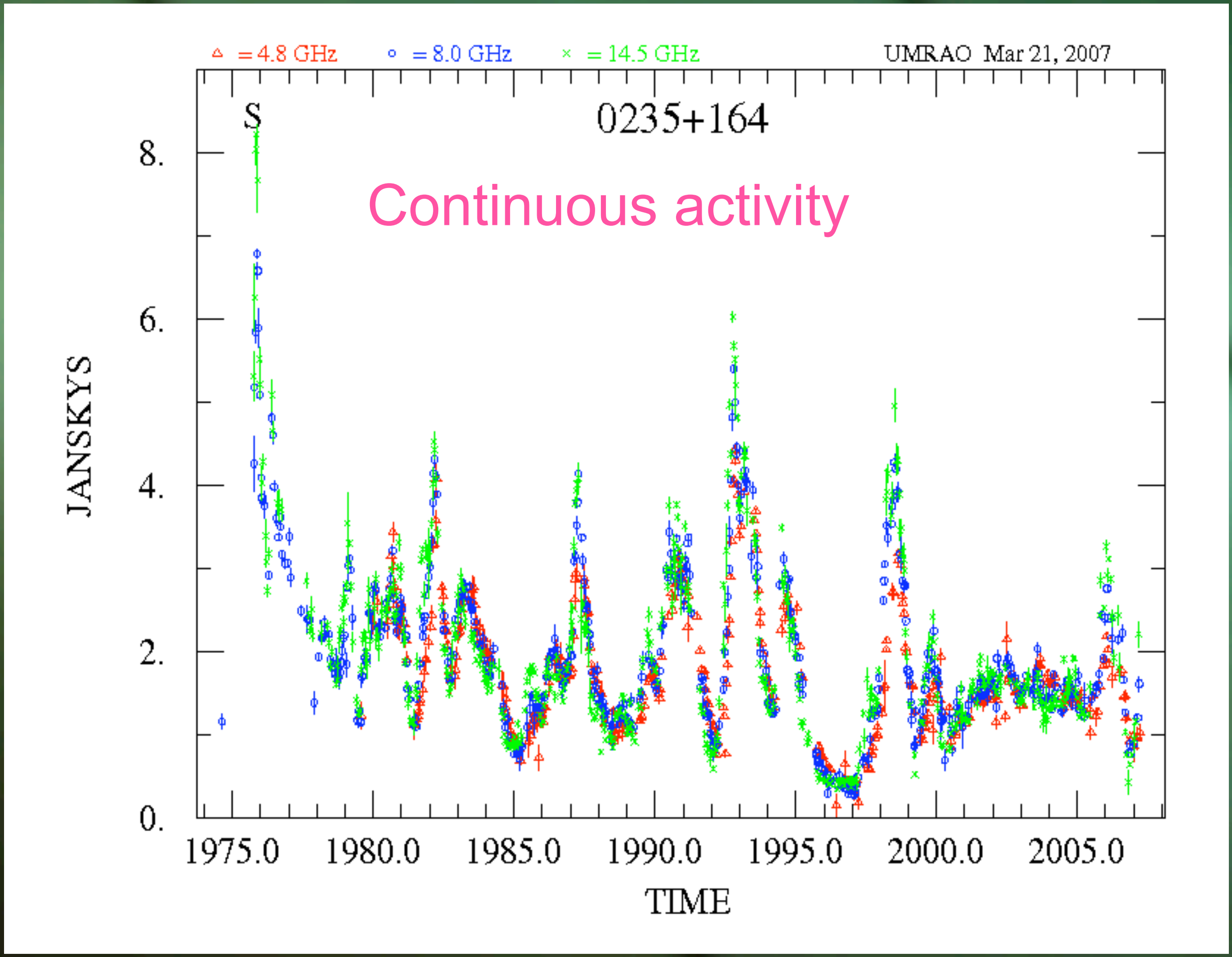
EGRET: direct comparison of flux light curves

Sampling, duty cycle, outburst duration

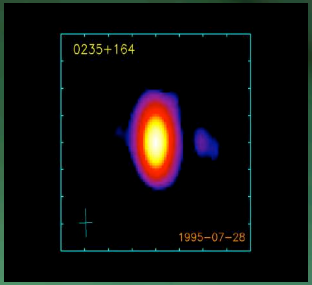


Are the radio/gamma flares causally related?

Problem: Insufficient data for rigorous, quantitative analysis of correlated activity

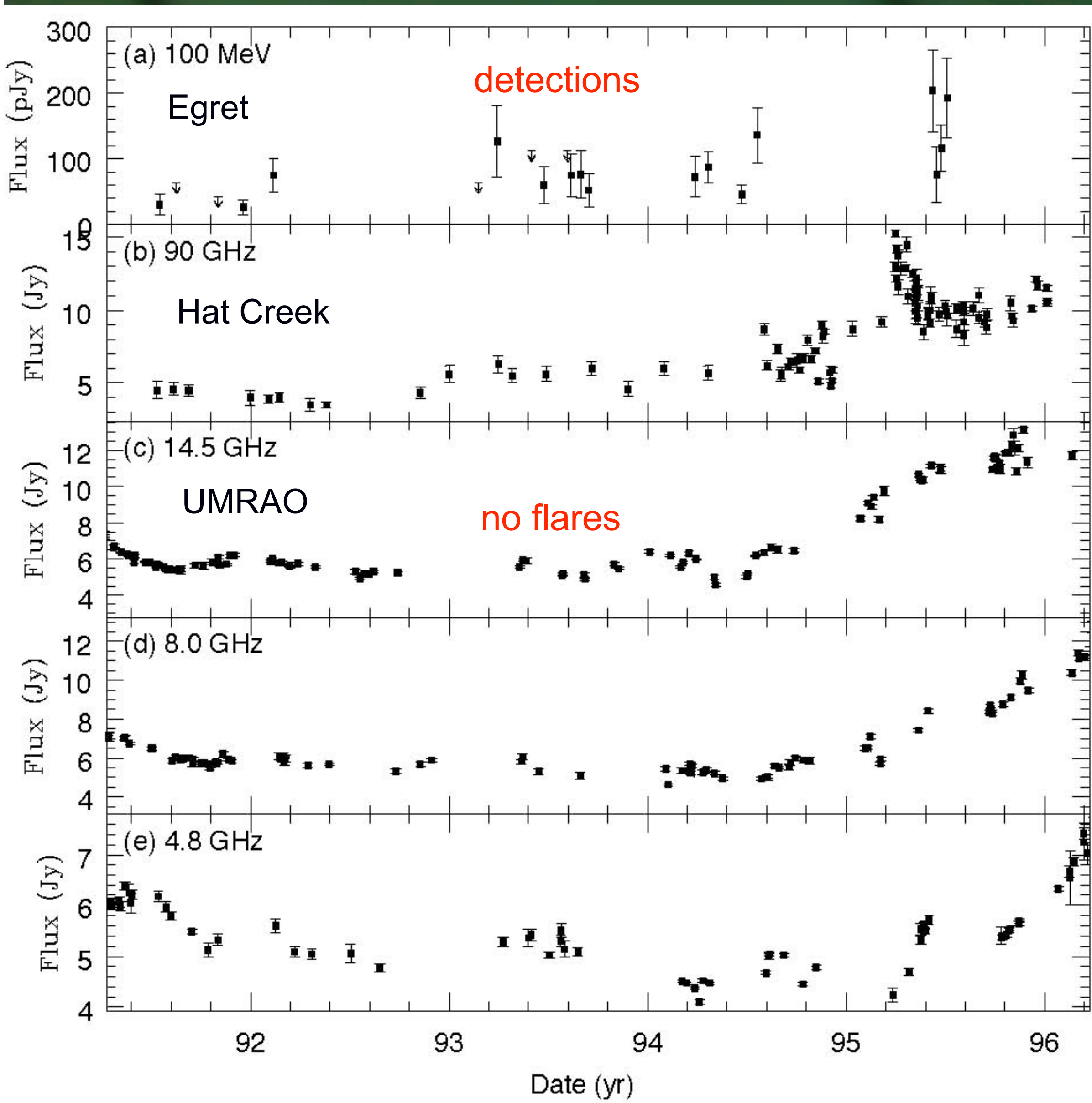


MOJAVE



Very compact; difficult to measure structural changes, component ejection times

NRAO 530 during EGRET: SD + 2- epoch VLBI



Gamma-ray detections do not always precede/match flares at mm/cm band: overall activity correlated but not specific flares

Global 1995 flux increase in all of the bands shown

New jet pc scale components evident in mm VLBI: 04/94, 04/95

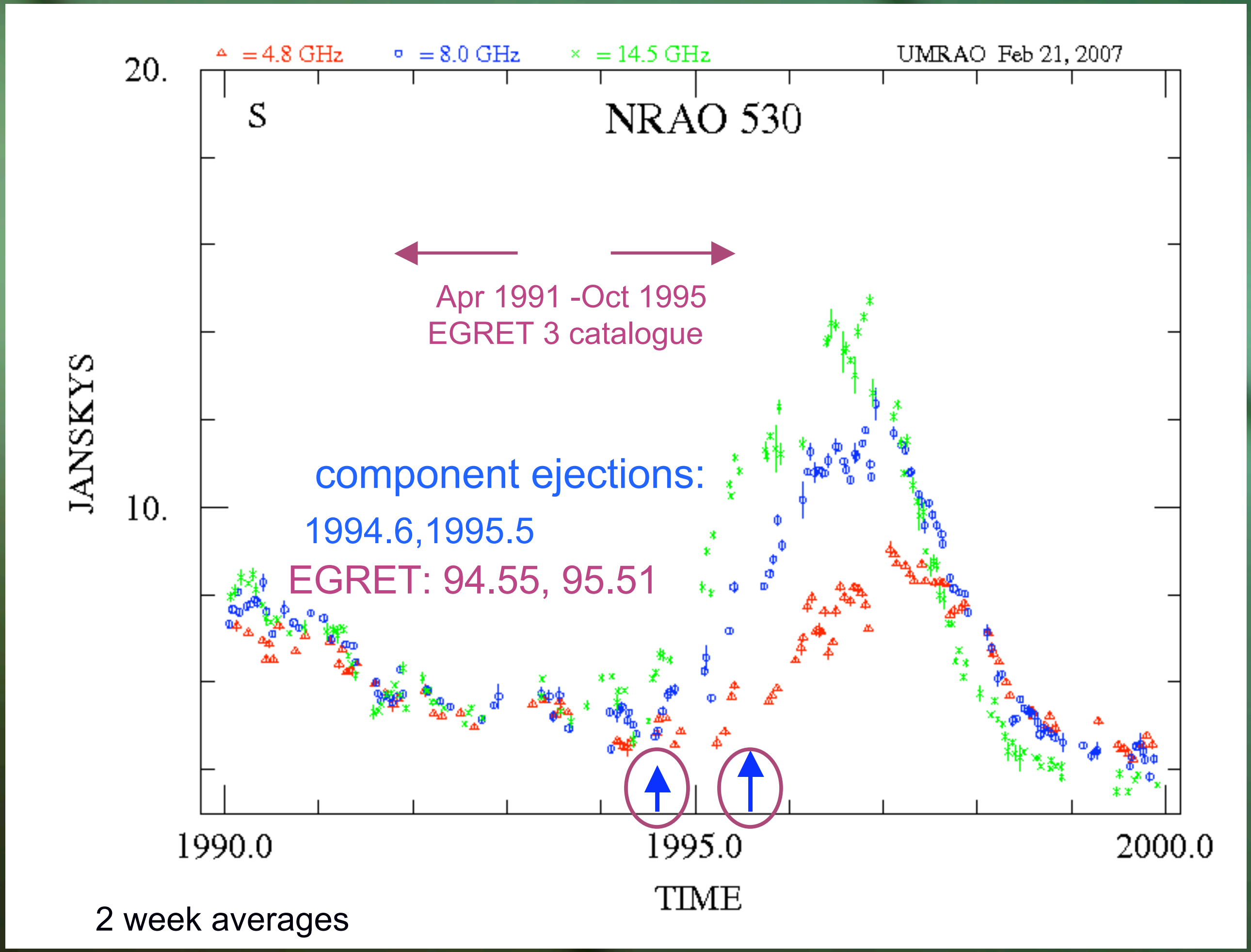
The activity is broadband suggesting that the same particles are responsible for the radio emission in the jet and the γ-ray emission.

Bower et al. 1997

EGRET: SD + VLBI monitoring

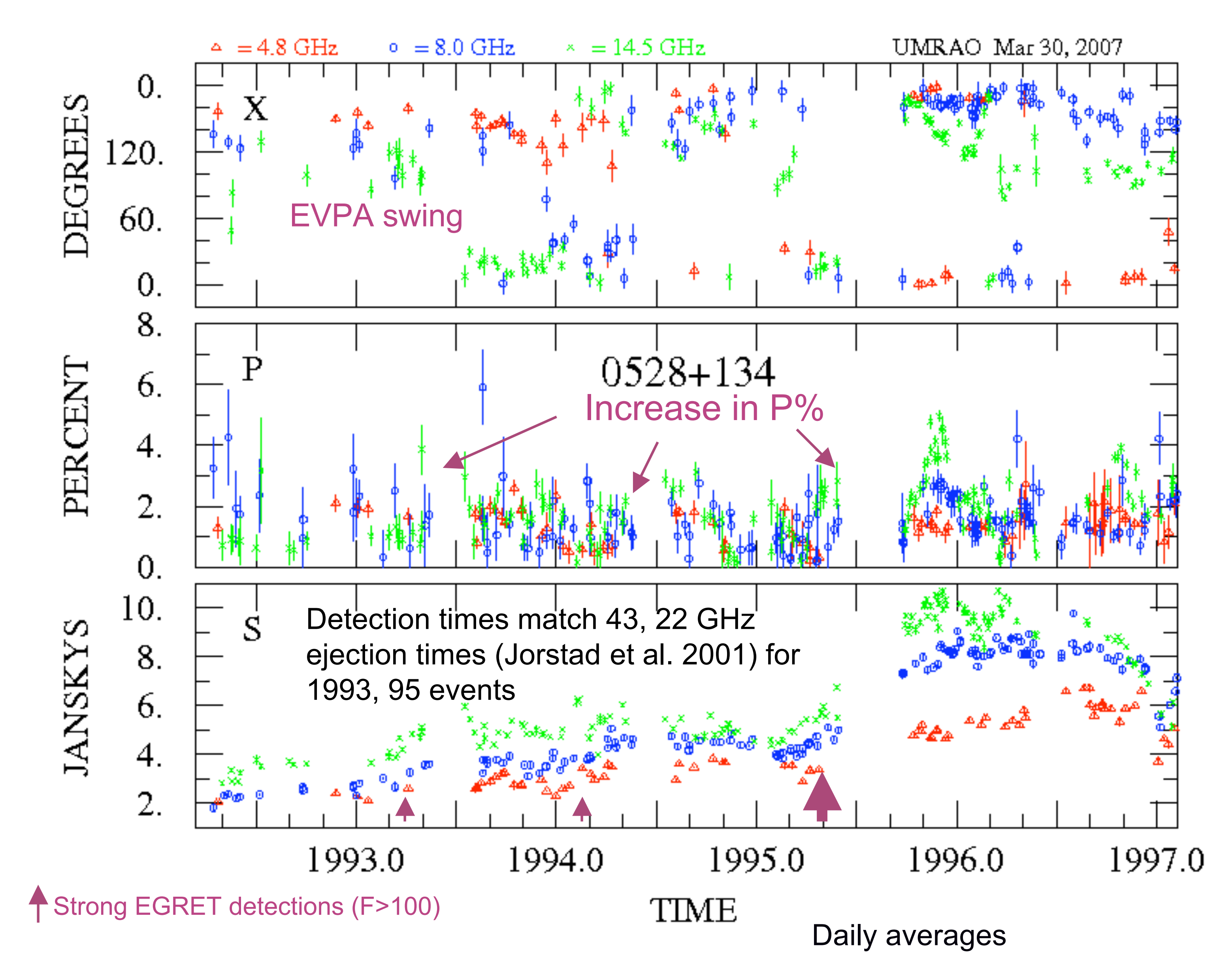
Extraordinary, high-amplitude flaring occurred during EGRET

Coupled with component ejection times from 43, 22 GHz VLBA data in well-resolved sources (Jorstad et al. 2001a,b), the time delays (detections often occur during rise phase) the data are consistent with a jet origin near the VLBI core for the γ-ray emission.



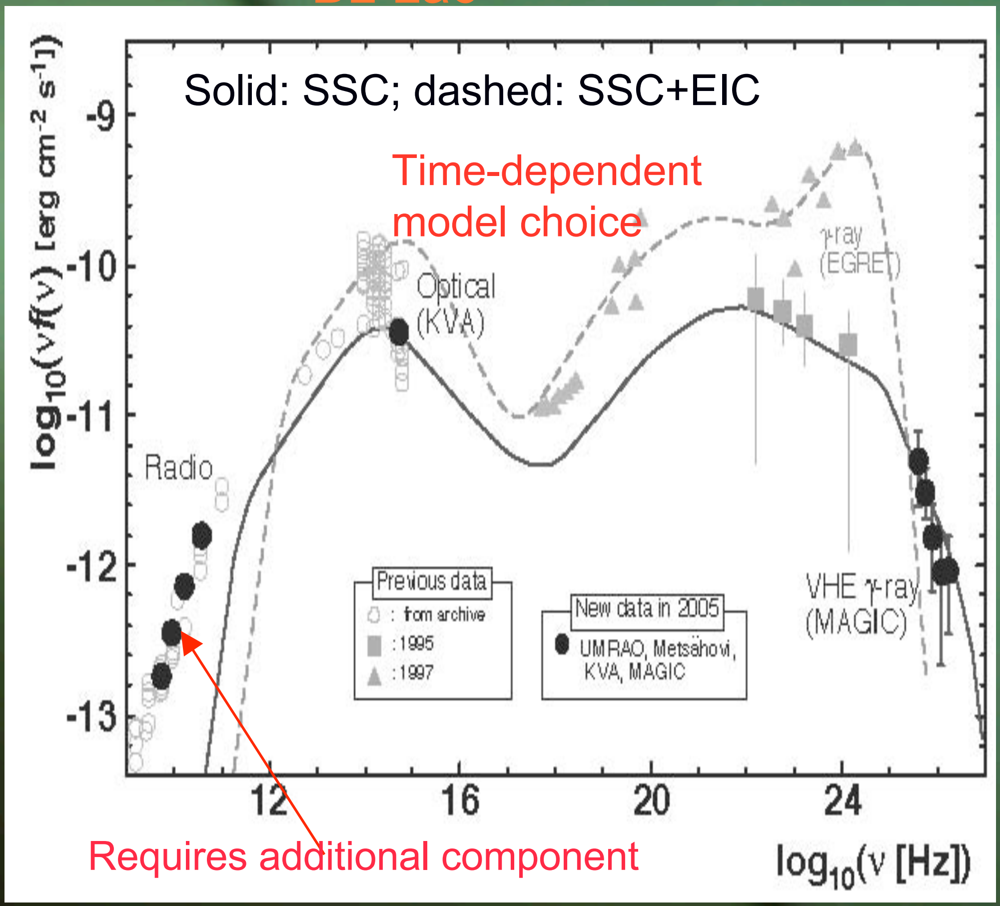
Linear polarization as a marker of shocks in the jet flow

The temporal association with EGRET detections & new VLBI components suggests internal shocks play a role in the generation of gamma-ray emission



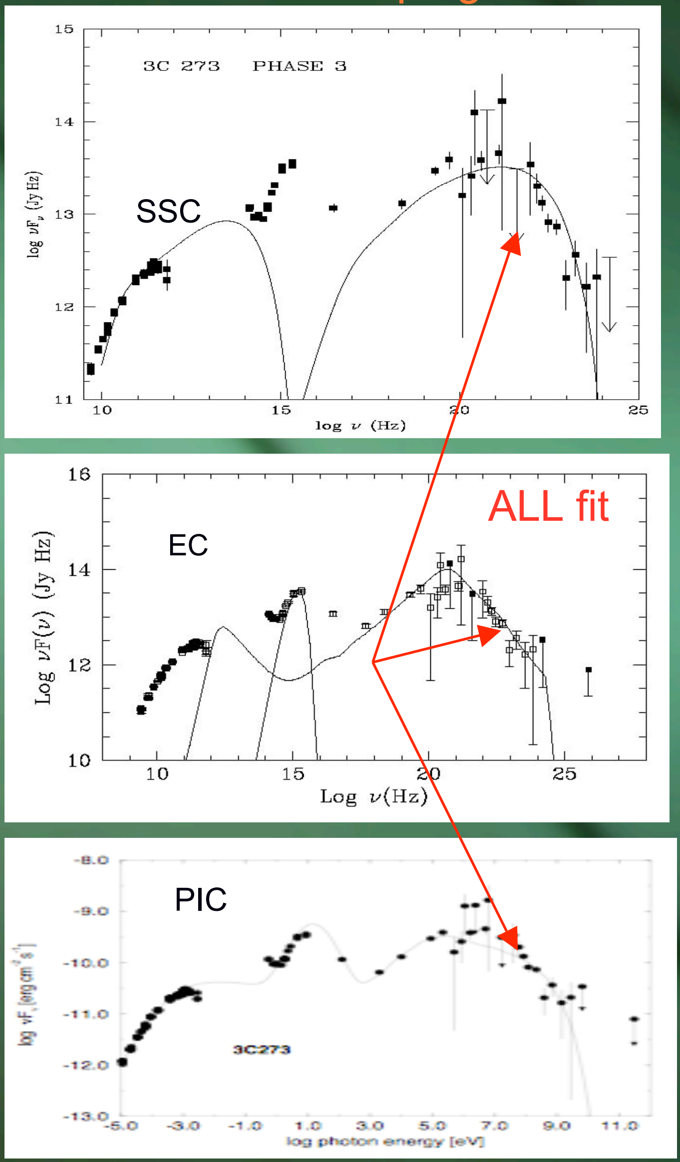
SEDS: emission models

BL Lac



Albert et al. 2007

3C 273 campaign



Von Montigny et al. 1997

Unresolved Questions

Can a single mechanism explain the range of observed characteristics/properties?

EMISSION SITE: BH/accretion disk vs radio jet [radio core]??

variability time scales   correlated activity (radio/γ ray)

ENERGIZATION: Shocks (where within the flow)??

PARTICLES: Nature of target photons??

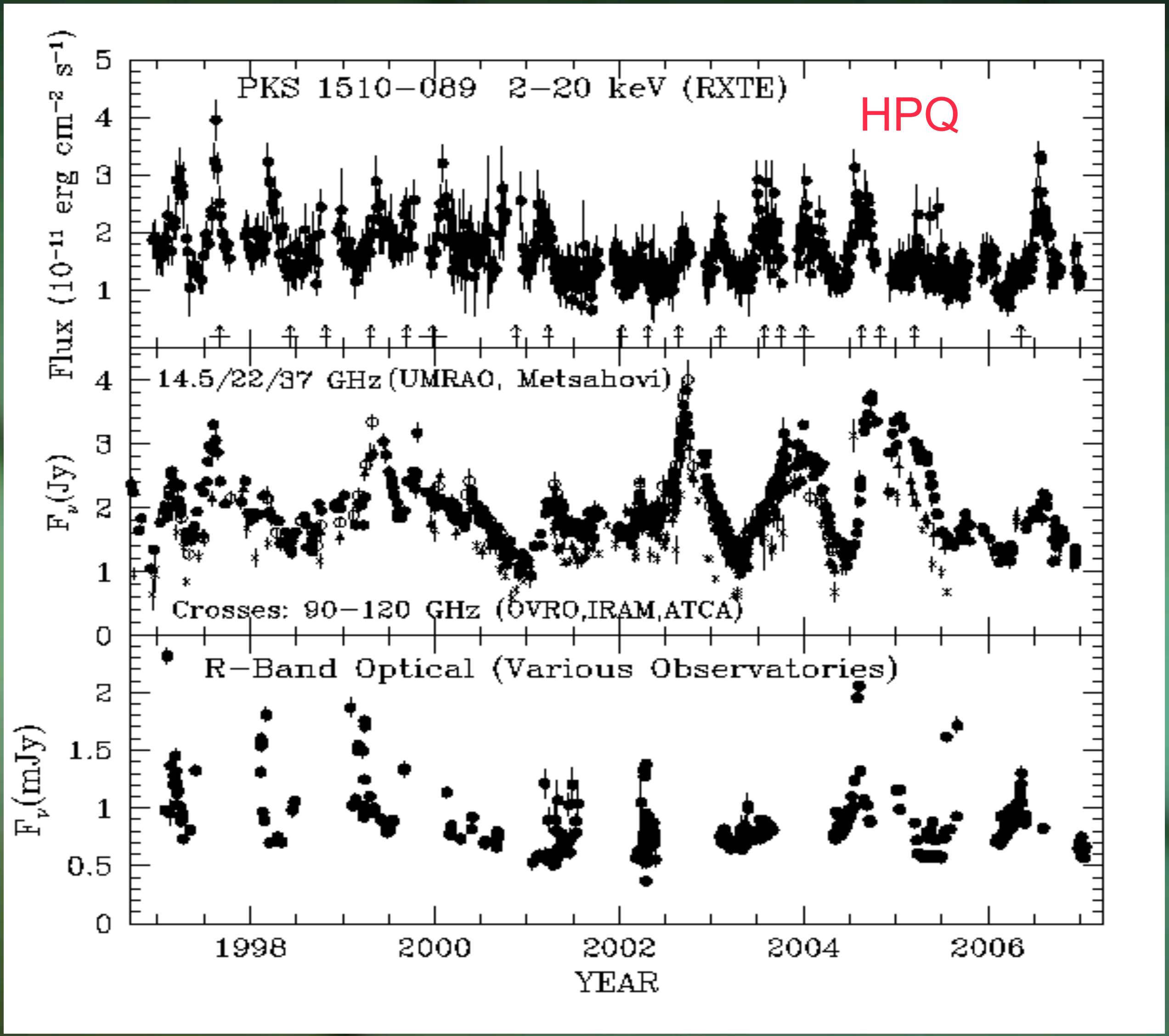
TOOLS: 1) imaging+variability data (probe geometry)

2) SEDs including cm/mm (probe energetics of seed photons; single vs multi-zone models)

NEW

3) well-sampled gamma-ray light curves

4) some well-sampled X-ray (keV band) light curves



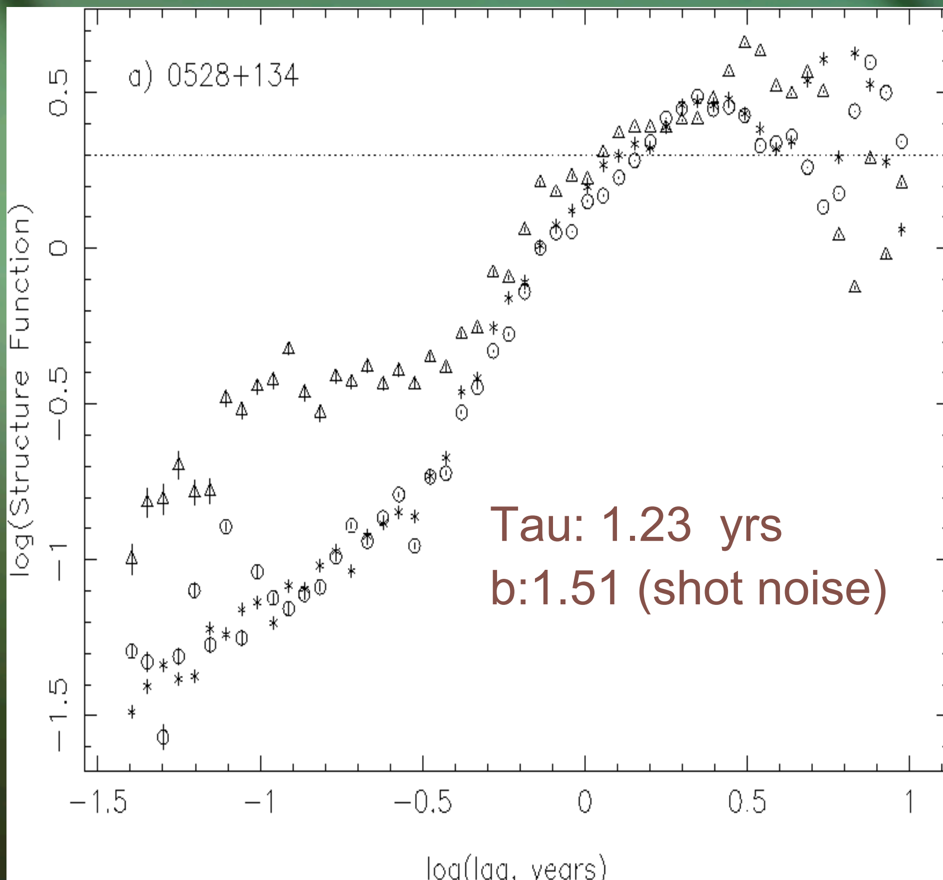
Marscher et al., RXTE program

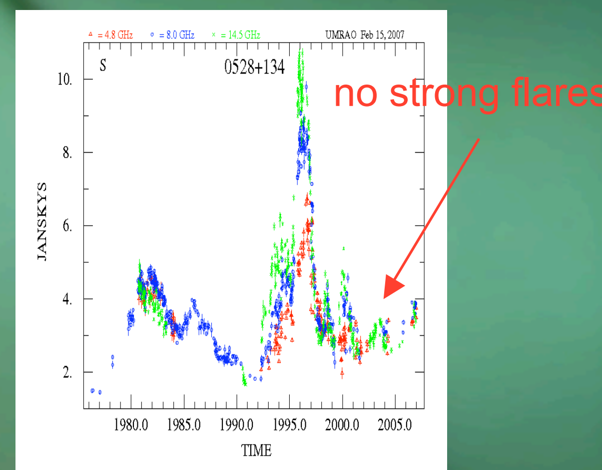
Well-sampled data in several key bands as model constraints

Which sources can we expect to exhibit variability in S and LP necessary for emission model constraints?

Characteristic behavior of the radio band variability from long term UMRAO data (> 4 decades)

1. timescales & noise process from 1st-order structure function analysis

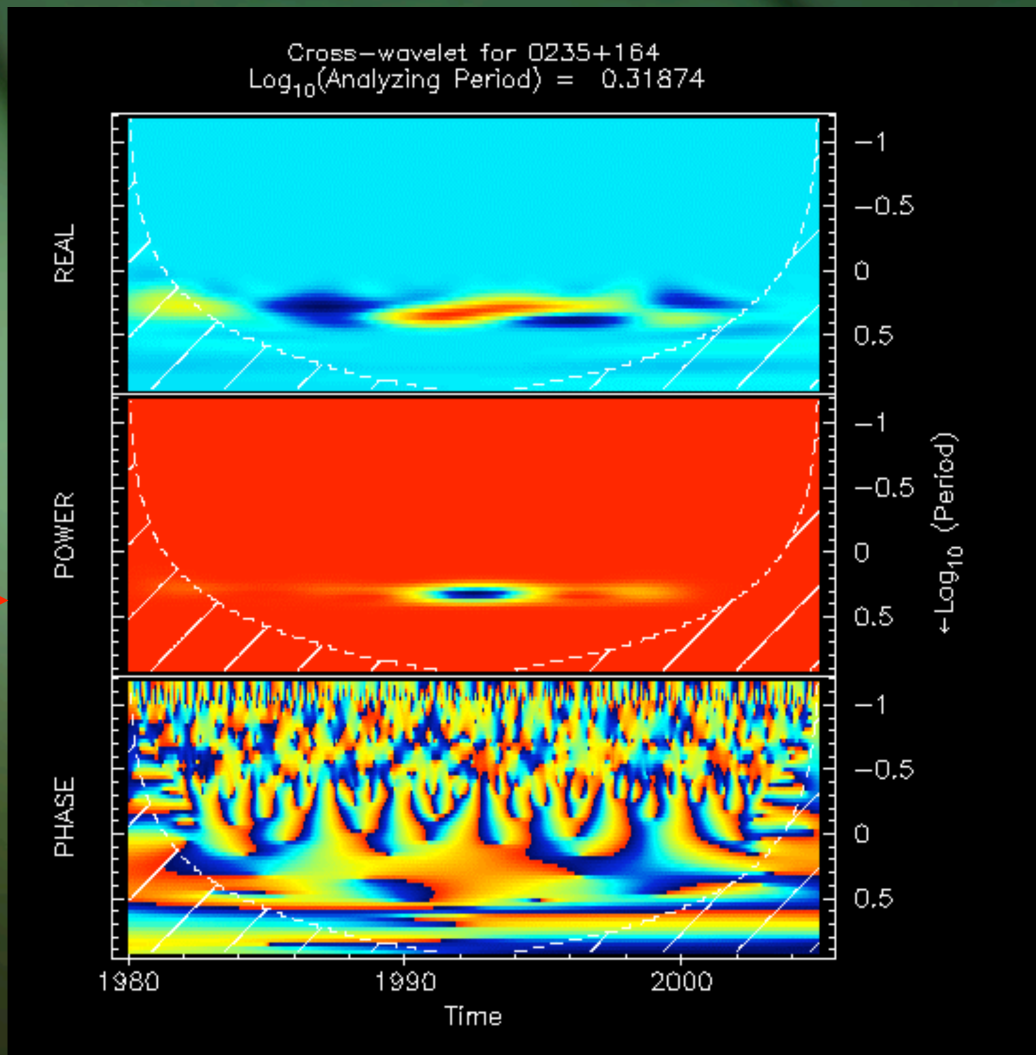


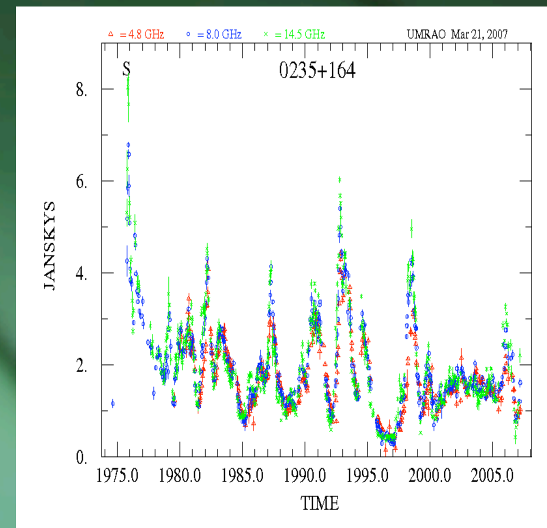


Maximum correlation time scale

Results from Long-term UMRAO data:

2) quasi-periodic behavior (wavelets, cross-wavelets)





Result: 1.9, 2.7 years

Interpretation: excitation of modes of oscillation in the jet flow

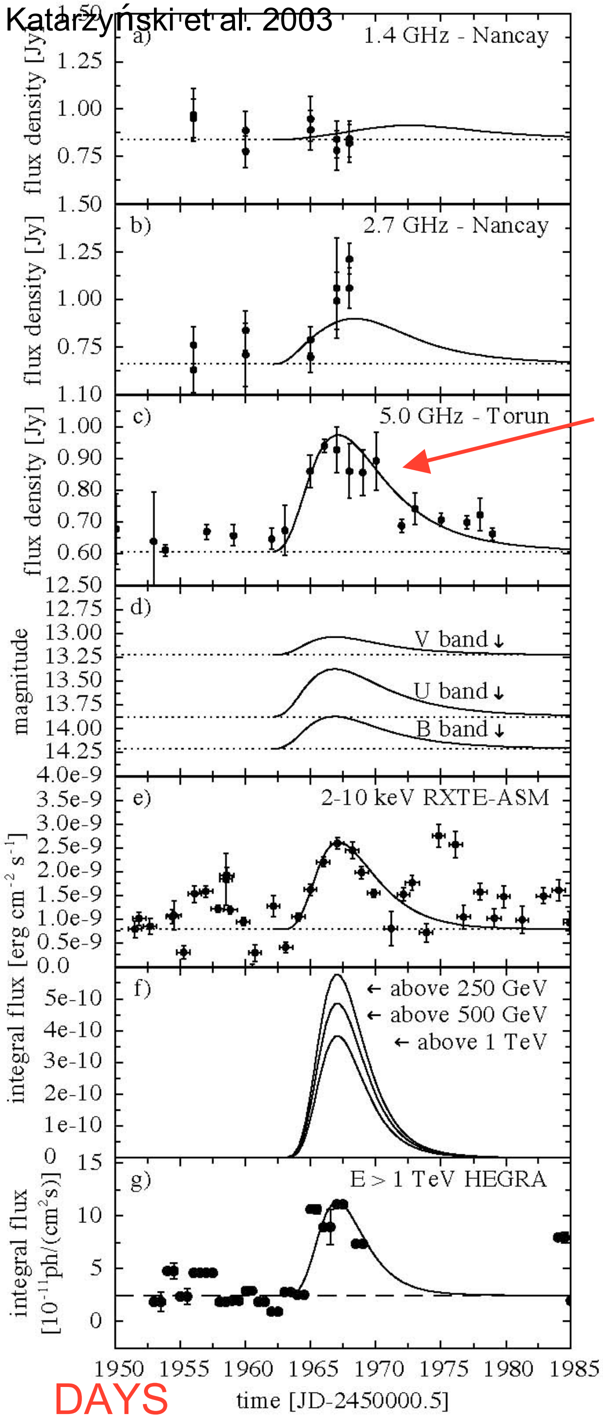
Pre Launch Source Selection Criteria

- ✓ Well-resolved & frequent outbursts (activity during GLAST observations)
- Sufficiently bright for good S/N in single dish and interferometric variability observations
- ✓ Well-defined shock signatures (dominant polarized component)
- Representatives from all optical class types (LPQ, HPQ, LBL, HBL, RG)
- ✓ Objects monitored with RXTE (additional constraints from time delays and relative amplitudes from continuous data)

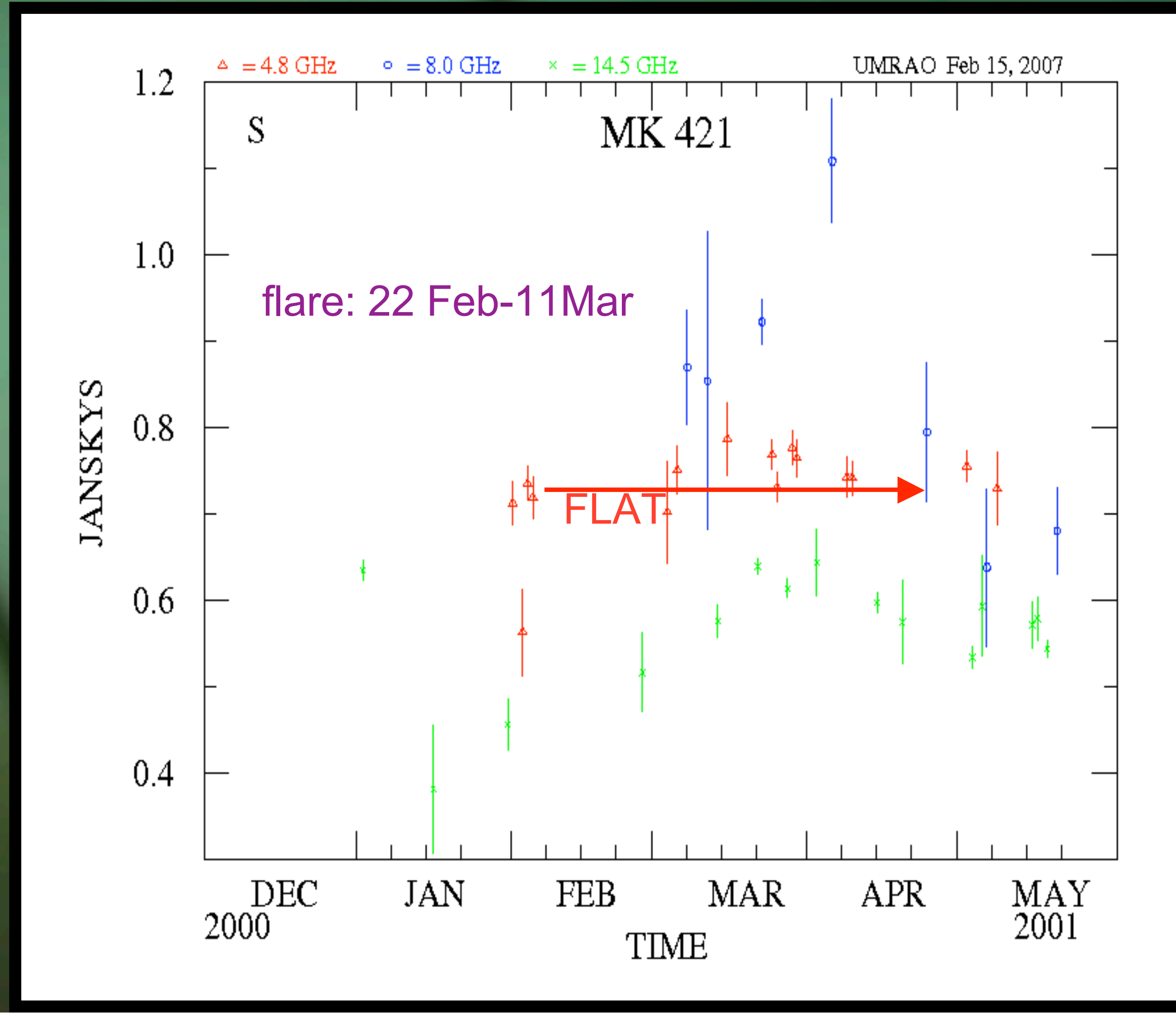
EGRET sources may not be active now: e.g. NRAO 530 has a quasi-periodicity of 6 yrs, 0528+134 has had no recent events.

Use CURRENT radio band activity as a guide in source selection.

Caveat 1: intensive, mf monitoring will be required



rapid flares may be missed



Caveat 2: Beware of oversimplification when extracting jet properties from radio band variability

Proper interpretation requires models incorporating 3D rel. hydro (with precession, magnetic fields) + radiative transfer

Simulation of helical flow viewed at a range of angles (Hughes 2007)