AGN STUDIES WITH GLAST

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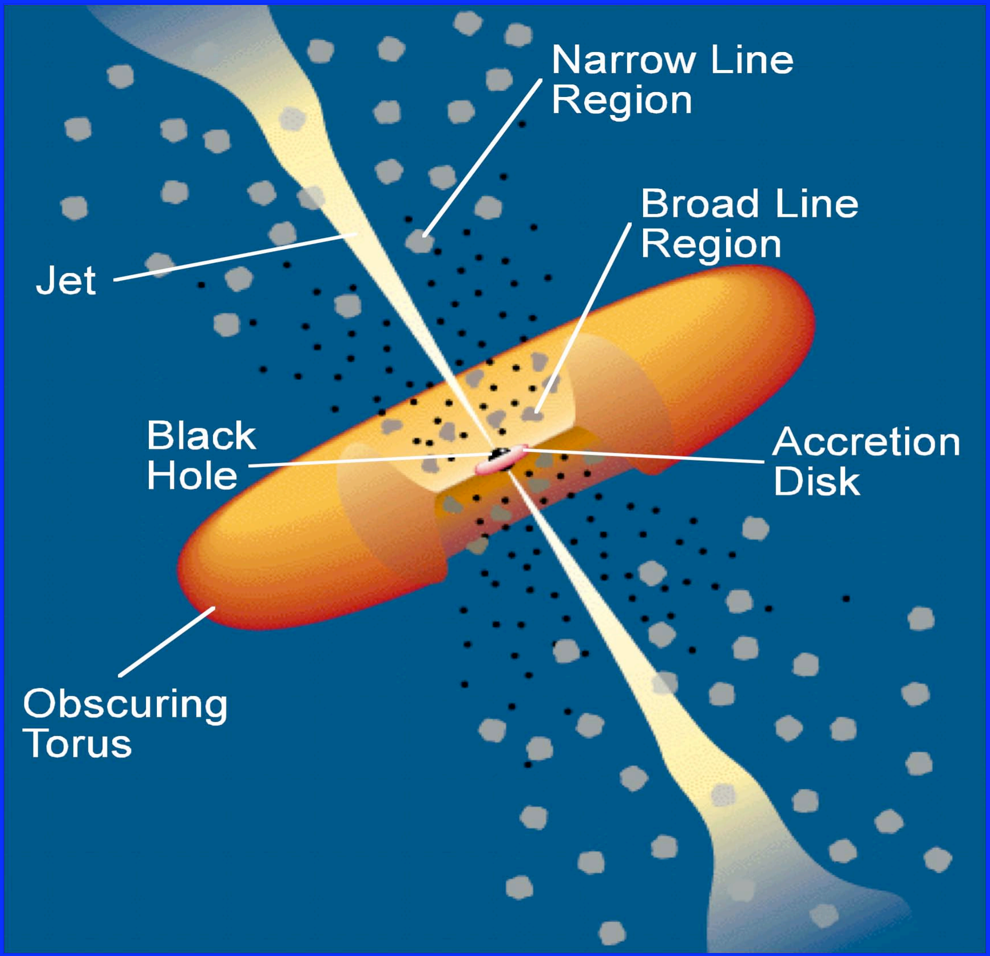
UNIFIED PICTURE OF AGN

Generic features:

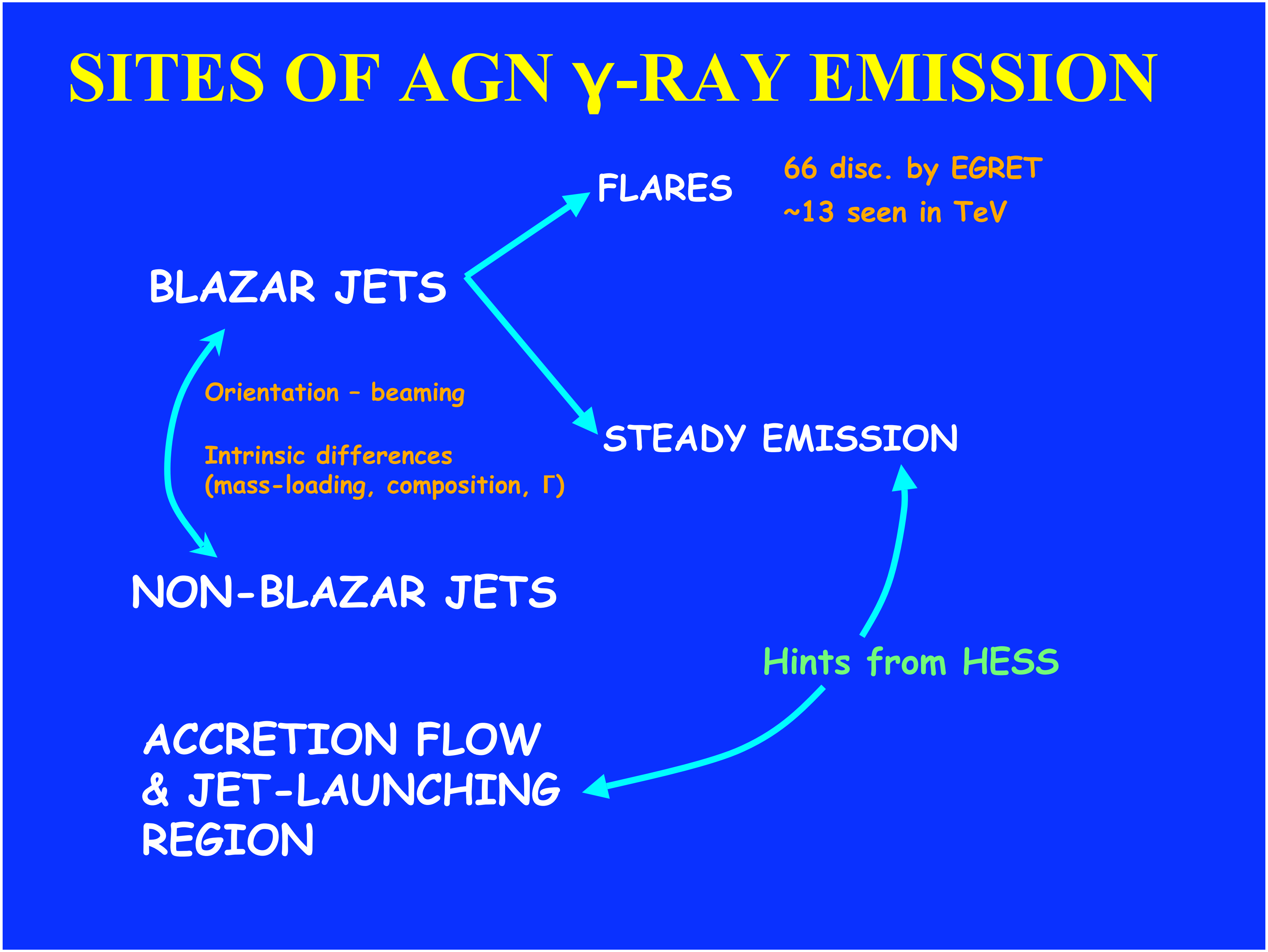
- Power supply: BH accretion
- Outflows: jets/winds/breezes
- Dependence on viewing angle: obscuration and/or Doppler beaming

Variations:

- Radiative efficiency of disk
- Prominence of relativistic jet: "blazars" (~10% AGN)
- Ambient radiation field: BL Lacs vs. quasars



Padovani & Urry


SITES OF AGN γ-RAY EMISSION
FLARES
66 disc. by EGRET
~13 seen in TeV
BLAZAR JETS
Orientation – beaming
Intrinsic differences
(mass-loading, composition, Γ)
STEADY EMISSION
NON-BLAZAR JETS
Hints from HESS
ACCRETION FLOW
& JET-LAUNCHING
REGION

WHAT DO WE WANT TO KNOW?

- **How do jets form?**
  - Magnetic propulsion?
  - Driven by disk or BH spin?
- **What are they made of?**
  - Baryonic vs. pair plasma?
- **How efficiently do they transport energy?**
  - Bulk Lorentz factor
  - Dissipation: internal shocks vs. reconnection?
  - Particle acceleration mechanisms
- **How do they interact with their surroundings?**
  - Gas: Boundary layers, entrainment
  - Ambient radiation field

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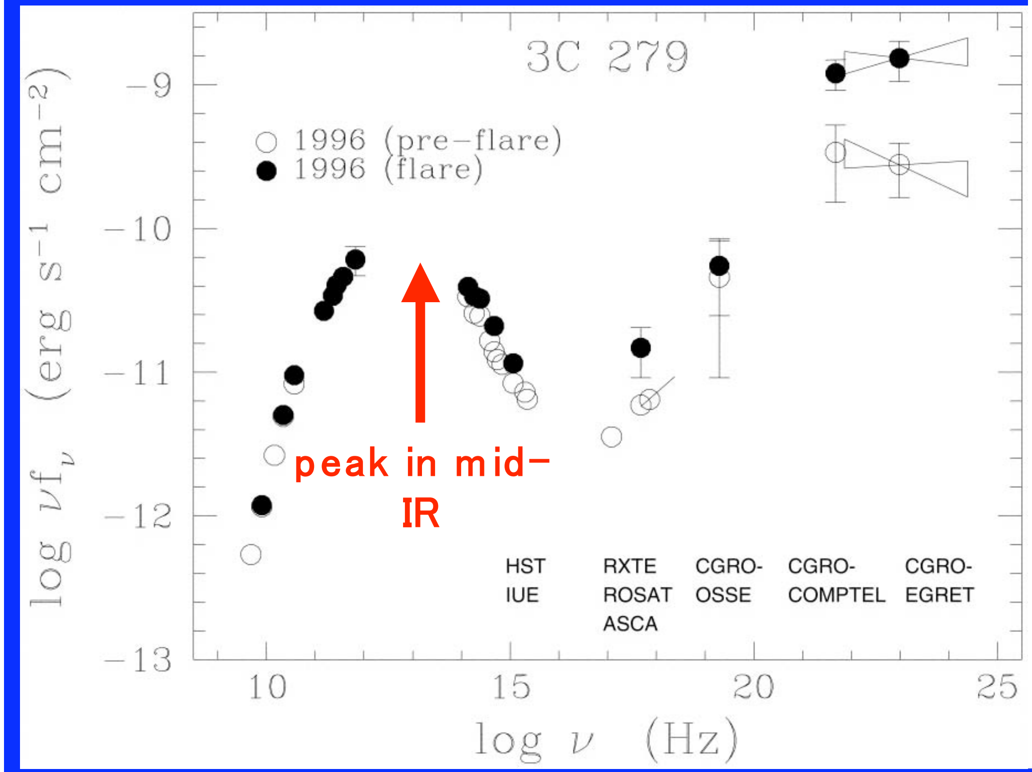
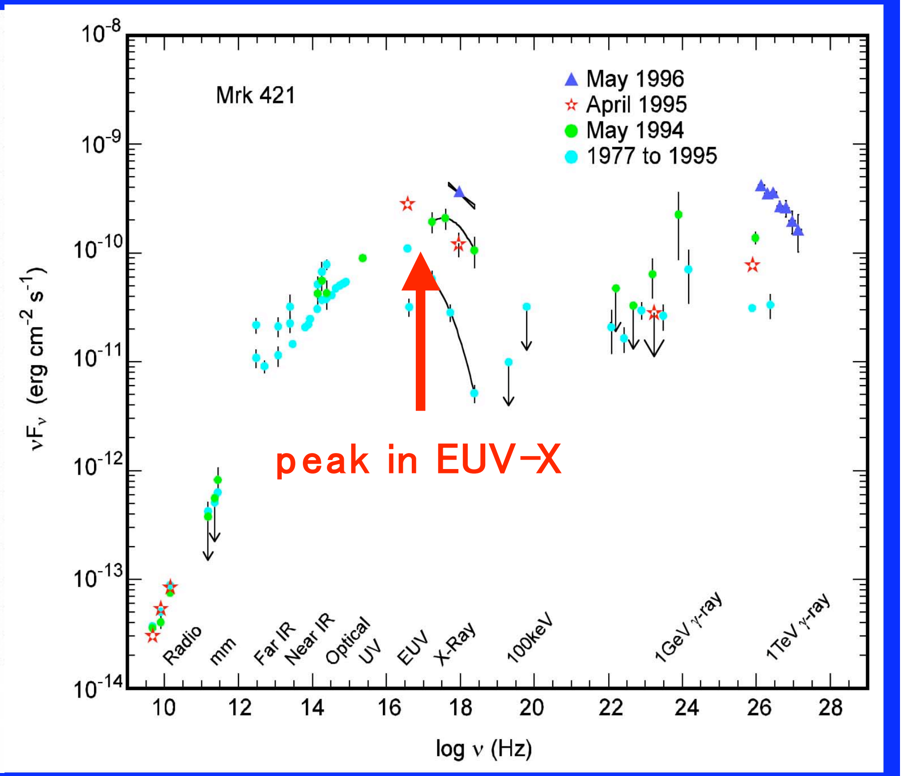
- What are they made of?
- How efficiently do they transport energy?
- How do they interact with their surroundings?

BLAZARS

- “Two-component” spectrum
  - Lo freq. peak ranges from < IR ⇒ X
  - Hi freq. peak at GeV ⇒TeV
  - Both components can be hard

BROADBAND BLAZAR SPECTRA:
Two Components





Bright EGRET-detected GeV-blazar: 3C279

(Wehrle et al. 1998)

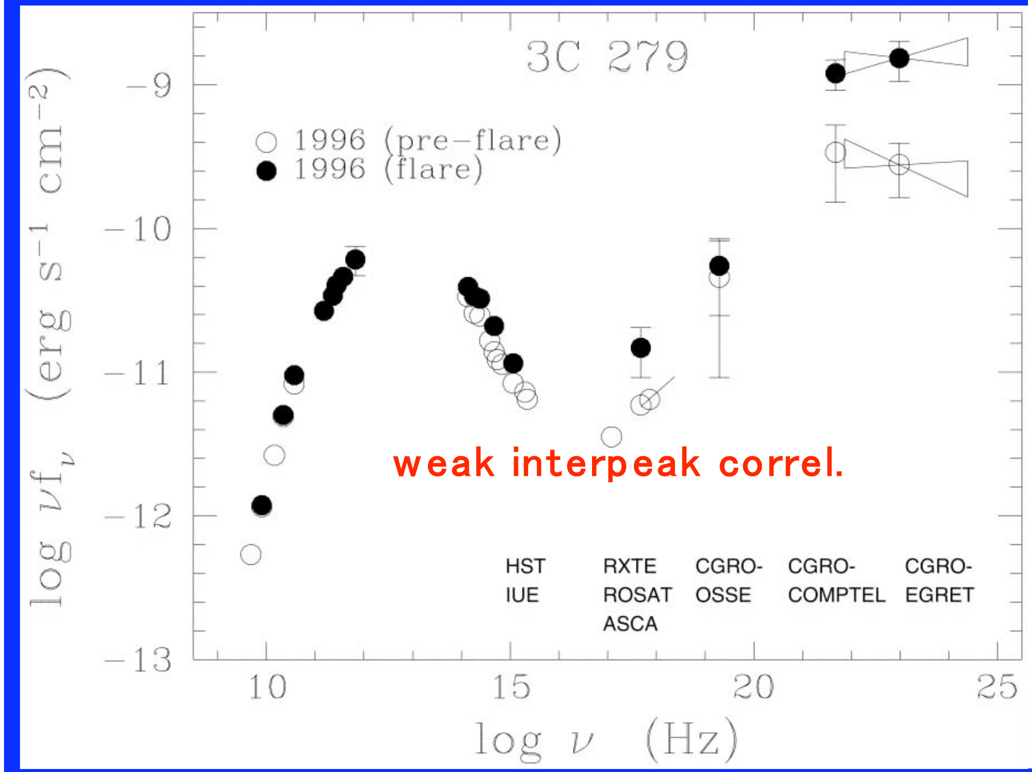
First TeV-emitting blazar: Mkn 421

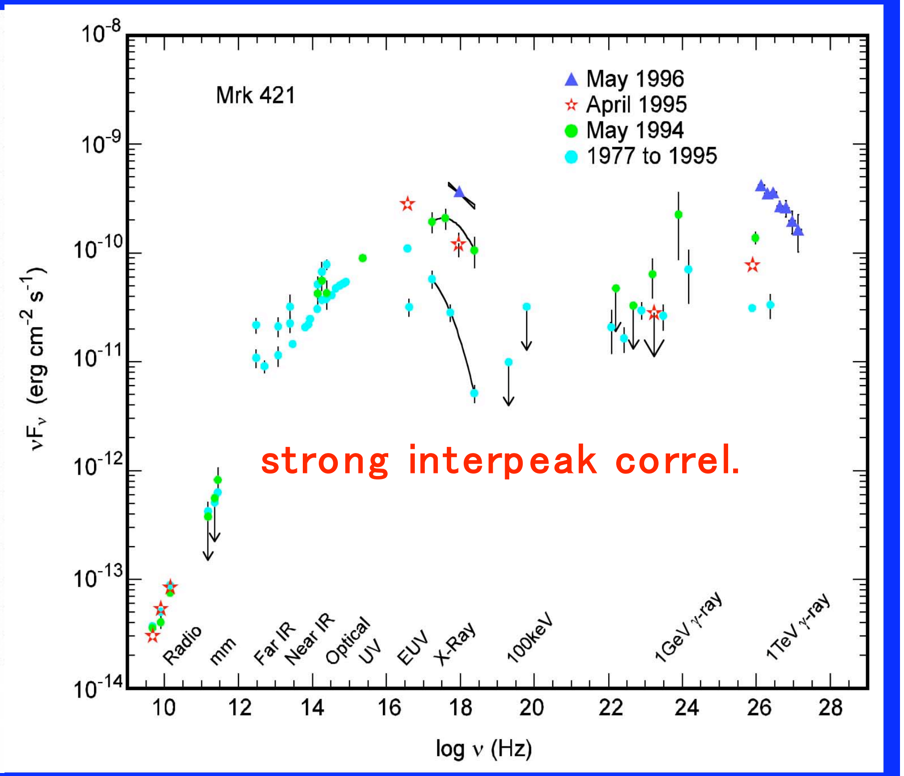
(data from Macomb et al. 1995)

BLAZARS

- **“Two-component” spectrum**
  - Lo freq. peak ranges from < IR ⇒ X
  - Hi freq. peak at GeV ⇒TeV
  - Both components can be hard
- **Rapid variability**
  - ~1 day with EGRET, limited by sensitivity
  - Shorter var. seen at TeV in brightest cases
  - Light travel time argument ⇒ $\gamma\gamma$ absorption of γ-rays
    - Avoid by Doppler beaming from Γ~10 jet
    - Emission from R~lt-mo. can vary in ~days
- **Multi-λ correlations?**
  - Sometimes - esp. shorter flares
  - Sub-mm/IR coverage poor

BROADBAND BLAZAR SPECTRA:
Two Components





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BLAZAR MODELING

- "Best guess": Same electrons produce both peaks
  - Lo freq. peak ~ synch (< IR ⇒ UV), synch. or IC (X)
  - Hi freq. peak IC
- Different sources of Compton seed photons
  - Synchrotron Self-Compton (SSC)

    vs.
  - External Radiation Compton (ERC)

ERC vs. SSC

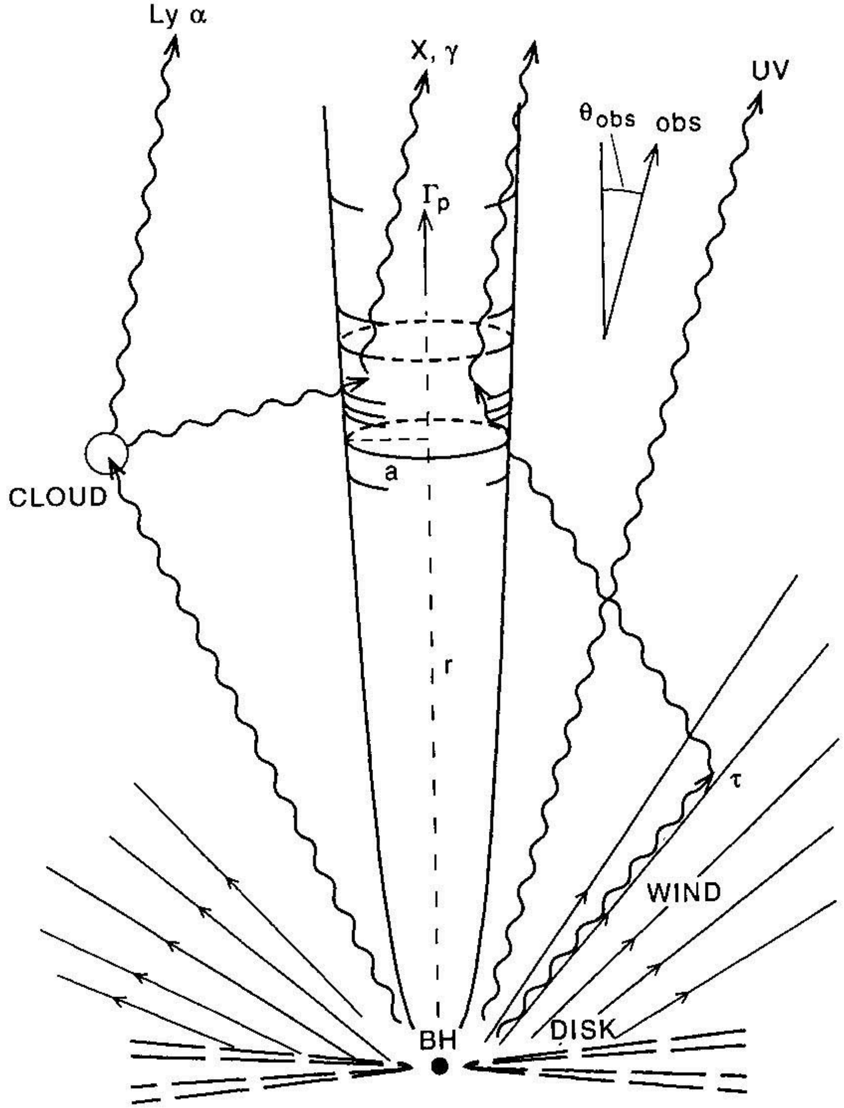
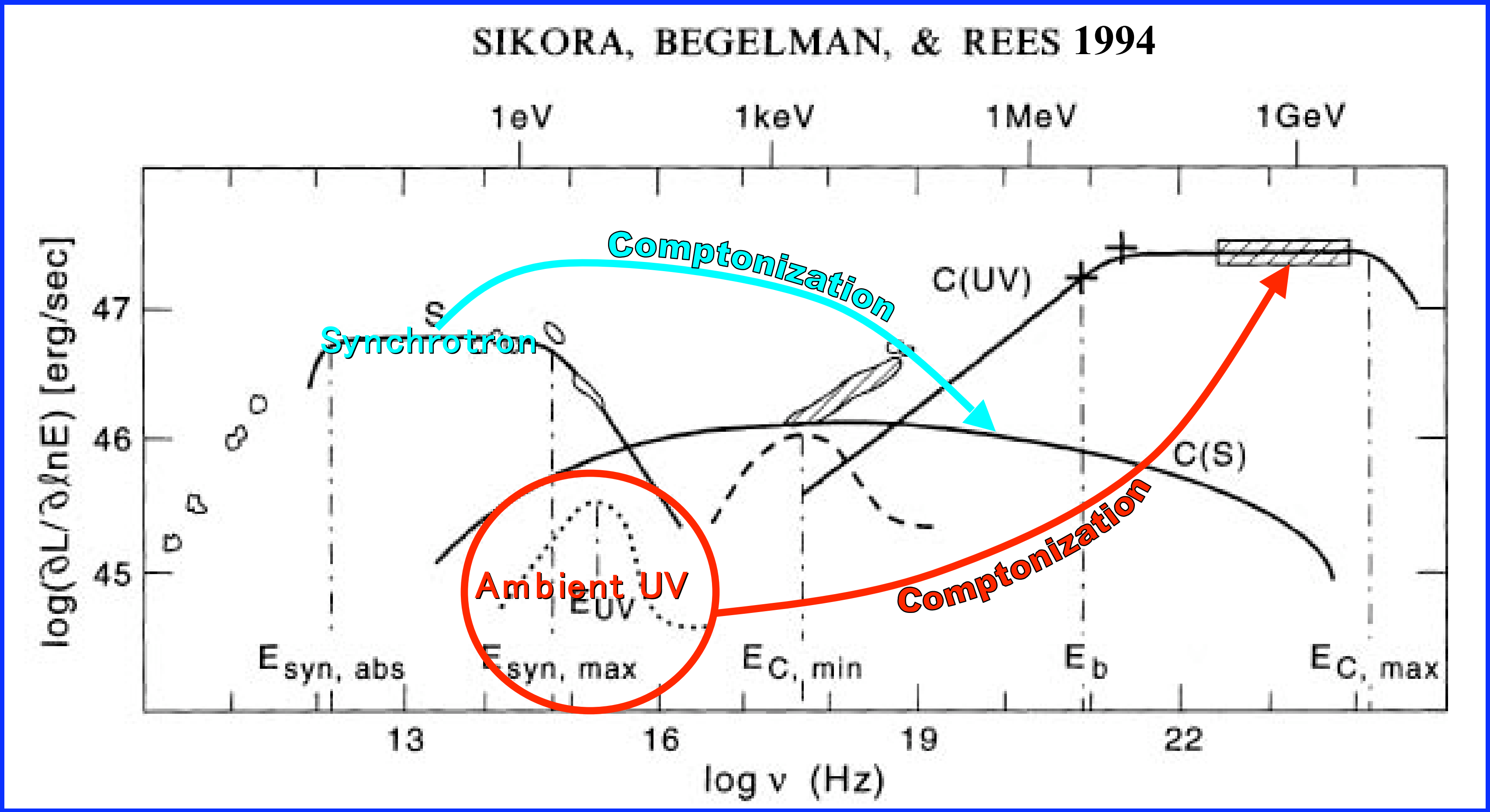


FIG. 2.—Geometry of the source. The radiating region, denoted by short cylinder of dimension a, moves along the jet with pattern Lorentz factor Γ_p. Underlying flow moves with Lorentz factor Γ, which may be different.

(Sikora, Begelman, and Rees 1994)

3C 279: Realization of an ERC Model



BLAZAR MODELING

- “Best guess”: Same electrons produce both peaks
  - Lo freq. peak ~ synch (< IR ⇒ UV), synch. or IC (X)
  - Hi freq. peak IC
- Diff. sources of Compton seed photons
  - Synchrotron Self-Compton (SSC)

    vs.

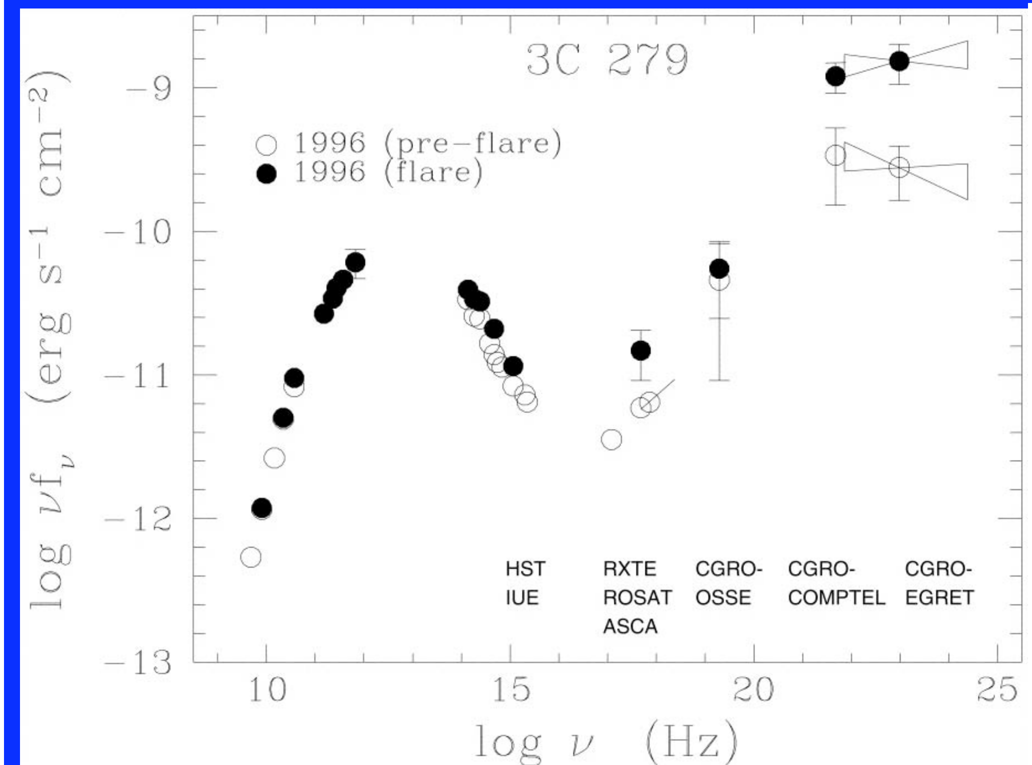
  - External Radiation Compton (ERC)
- Distinguishing the models
  - Multi-wavelength correlations
    - Strong for SSC, weaker for ERC
    - Sikora bump
    - Time-lags: propagation of jet disturbances, mapping ambient radiation field
  - “Hadronic” models less likely, but not ruled out

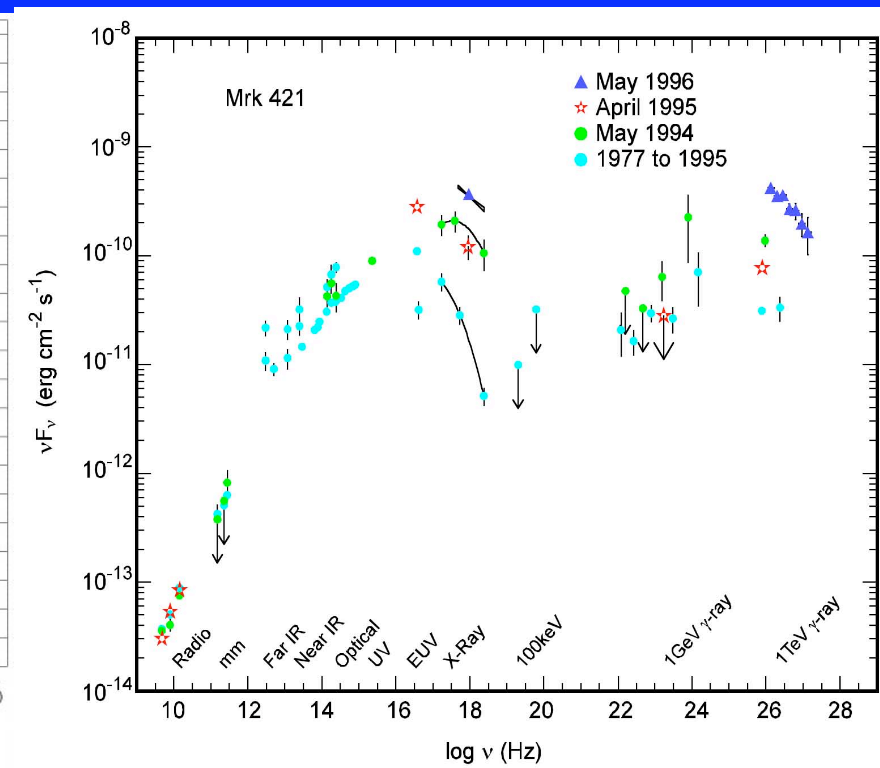
2 CLASSES OF BLAZARS?

Inter-peak correlations:

WEAK

STRONG





(Wehrle et al. 1998)

(Macomb et al. 1995)

QUASAR: Strong ambient radiation ERC?

BL LAC: Weak ambient radiation SSC?

WHAT CAN GLAST DO?

- Larger collecting area ⟶ track flares on timescales < 1 day
- Wide FOV ⟶ continuous monitoring of many sources, better chance to catch flares in multiple bands (e.g., if X-ray precursor is spotted)
- Overlap with groundbased TeV arrays
  - Better handle on absorption by NIRB
  - Klein-Nishina effects?
    - Constrain Comptonization models
    - Leptonic vs. Hadronic models

NON-BLAZAR JETS

- **"Quiescent" emission from beamed jets**
  - Need higher sensitivity than EGRET
  - TeV evidence from HESS
  - Clues to underlying jet physics (MHD turbulence vs. shock heating, boundary layers…)
- **"Unbeamed" jets**
  - Test unification: FRI ↔ BL Lacs, FRII ↔ quasars
- **Diagnose beaming patterns**
  - Do "misaligned" jets sometimes spray relativistic matter in our direction?
  - HESS: rapid TeV variability in M87

OUTWARD/INWARD BOUND

So far, γ-ray astronomy has probed AGNs on 0.1 pc scales. Can GLAST extend our view spatially?

- **Central engines & jet launching pads**
  - Scales ~100AU
  - Need sufficiently low compactness - radiatively inefficient accretion flows
  - HESS: rapid TeV variability in M87
- **Kpc-scale jets**
  - Chandra saw surprisingly large X-ray emission from extended regions in jets – mechanism controversial
  - Sites likely "hotspots": internal shocks, collisions with obstacles

SUMMARY

- **GLAST will provide key insights into the physics of relativistic jets from AGNs...**
- **On blazar (pc) scales...**
  - Will go well beyond EGRET to explore faster variability, non-flaring emission
  - Need adequate multi-wavelength coverage
  - Link to groundbased TeV experiments
- **May reveal new energetic phenomena...**
  - Scales ranging from the inner accretion flow to kpc scales