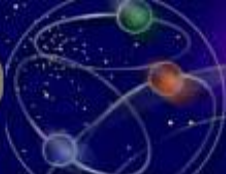




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Physics & Astronomy

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# Modeling the SED and variability of 3C66A in 2003/2004

Presented

By

Manasvita Joshi

Ohio University, Athens, OH

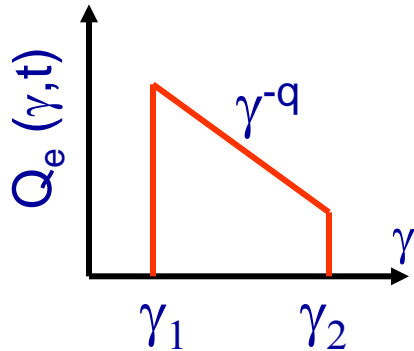
# Outline

- Model Sketch
- Observational Constraints
- Parameter Estimates
- Motivation of Parameters
- Work In Progress

# Blazar Modeling

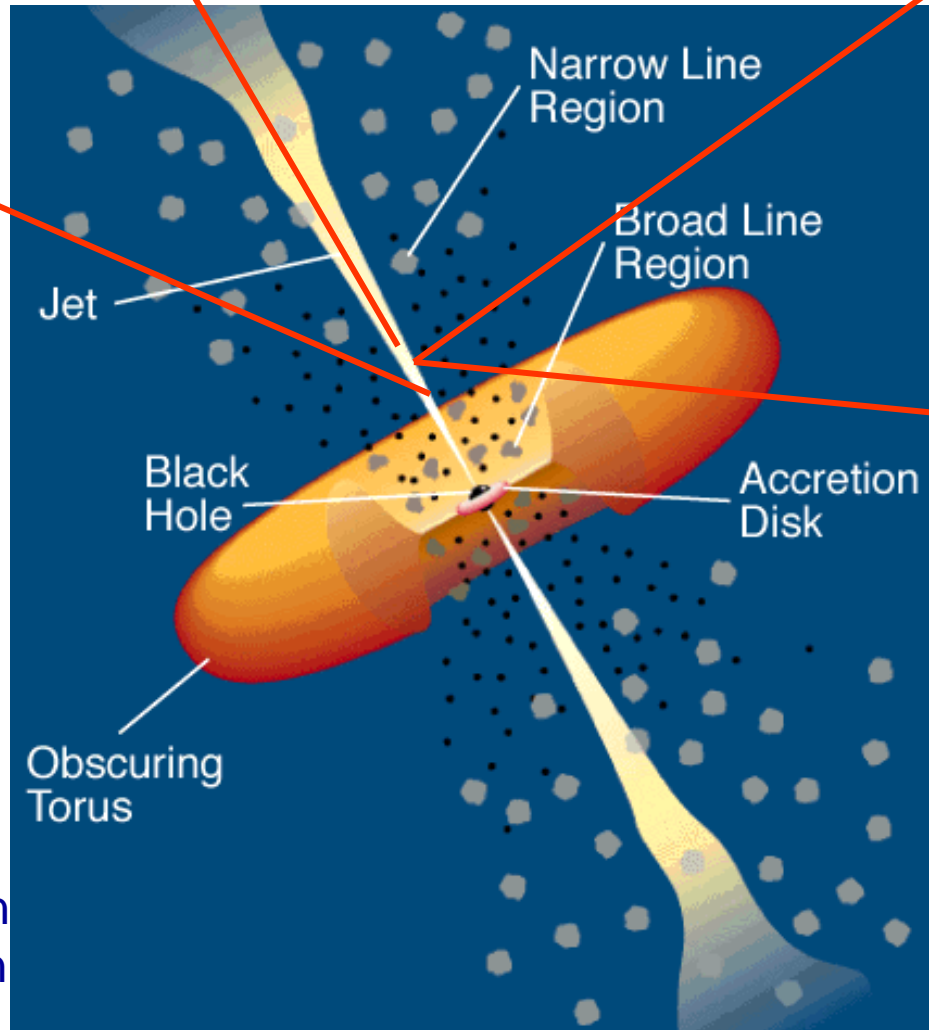
Relativistic jet outflow with  $\Gamma \approx 10$

Injection, acceleration of ultrarelativistic electrons

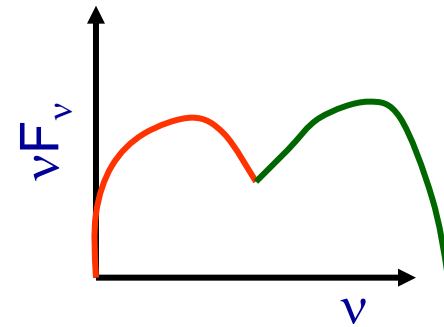


Injection over finite length near the base of the jet.

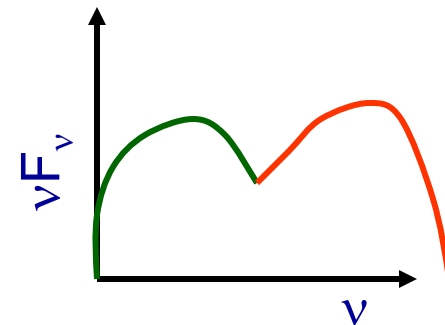
Additional contribution from  $\gamma\gamma$  absorption along the jet



Synchrotron emission



Compton emission



Seed photons:

Synchrotron (SSC),  
Accr. Disk + BLR (EC)

- One-zone homogenous, time-dependent leptonic model considered.
- Particle distribution and spectrum of emitted radiation calculated self-consistently.
- Instantaneous and time-integrated spectra calculated for various sets of parameters.

# Basic assumptions:

1. Emitting region as a sphere of constant co-moving radius  $R_B$ .
2. Homogenous and tangled magnetic field  $B$ .
3. Ultra-relativistic non-thermal  $e^-$ s injected at a time-dependent rate into the blob.

- Solve simultaneously for evolution of electron distribution,

$$\frac{\partial n_e(\gamma, t)}{\partial t} = -\frac{\partial}{\partial \gamma} (\kappa_e) + Q_e(\gamma, t) - \frac{n_e(\gamma, t)}{t_{esc, e}}$$

$\nearrow$   $n_e$  density       $\nearrow$  Rad. + Adiab. losses       $\nwarrow$  el./pair inj.       $\nwarrow$  escape

and co-moving photon distribution,

$$\frac{\partial n_{ph}(\varepsilon, t)}{\partial t} = \kappa_{ph, em}(\varepsilon, t) - \kappa_{ph, abs}(\varepsilon, t) - \frac{n_{ph}(\varepsilon, t)}{t_{esc, ph}}$$

$\nearrow$  Photon density       $\nwarrow$  Sy., comp. emission       $\nwarrow$  SSA,  $\gamma\gamma$  absorption       $\nwarrow$  escape

- Synchrotron self absorption calculated self-consistently.
- Pair production negligible for present choice of parameters.
- For SSC, isotropic (co-moving frame) radiation field assumed.
- EIC component not considered yet.

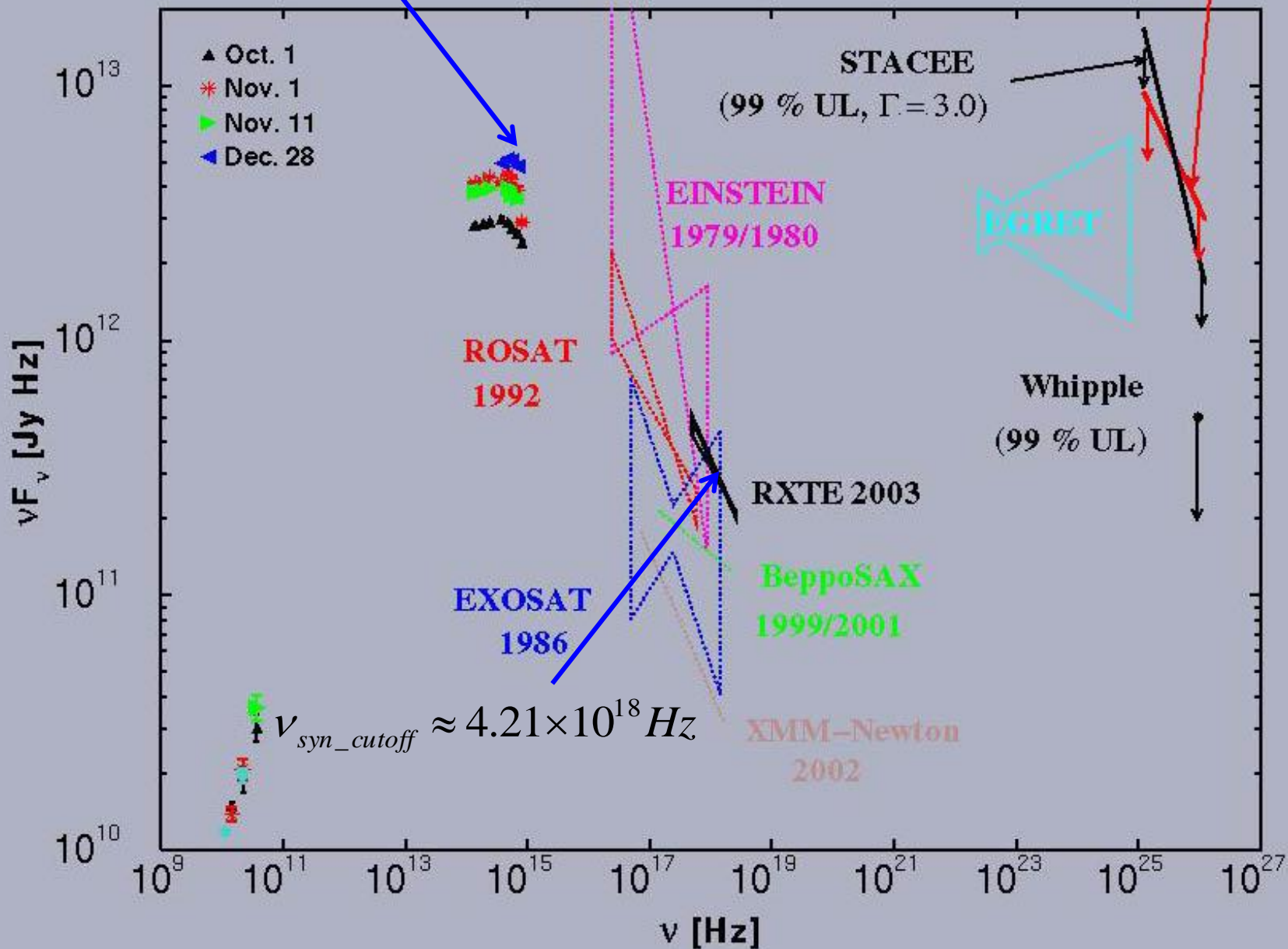
# Modeling Strategy

- Code of Boettcher & Chiang (2002) used.
  1. Reproduce broadband spectrum of 3C66A for equilibrium situation (quiescent state).
  2. Adjust parameters to fit both (time-averaged) SEDs and optical spectral variability patterns.

# Spectral Energy Distribution

$$\nu_{syn} \approx 4.45 \times 10^{15} \text{ Hz}$$

STACEE (99 % UL,  $\Gamma = 2.5$ )



# Observational Constraints

- SL motion up to  $\beta_{app} \sim 9 \Rightarrow \Gamma \geq 9$
- Optical variability,  $\Delta t_{\min} \sim 2 \text{ hr}$ ,  $R_B \leq 2.2 \times 10^{15} D_1 \text{ cm}$
- Doppler Factor,  $\Gamma = D = 10 D_1 \sim 15$
- Peak synchrotron flux  $f_{\varepsilon}^{sy} \sim 5 \times 10^{-11} \text{ ergs cm}^{-2} \text{ s}^{-1}$

# Analytical Parameter Estimates

- $D_1 \approx 1.5$  and  $e_B = 1$
- Magnetic field,  $B_{e_B} = 4.4 D_1^{-1} e_B^{2/7} \text{ G}$

- Electron Lorentz Factor,

$$\gamma \approx 3.1 \times 10^3 v_{15}^{1/2} \left( \frac{D}{15} \right)^{-1/2} \left( \frac{B}{2.9 \text{ G}} \right)^{-1/2}$$

synchrotron peak,  $\gamma_1 \approx 3.1 \times 10^3$

synchrotron high-energy cutoff,  $\gamma_2 \geq 1.5 \times 10^5$

- Synchrotron cooling time scale in observer's frame

$$\tau_{cool, sy}^{obs} \approx 2.8 \times 10^3 \left( \frac{D}{15} \right)^{-1/2} \left( \frac{B}{2.9G} \right)^{-3/2} v_{15}^{-1/2} \text{ s}$$

- For optical frequencies,  $\tau_{cool, sy}^{obs} \approx 2 \text{ hr}$
- Particle spectral index,  $p \sim 4$
- Particle injection spectral index,  $q \sim 3$
- Disk injection luminosity,  $L_{inj} \approx 6.8 \times 10^{41} \text{ ergs/sec}$

# Motivation of Parameters

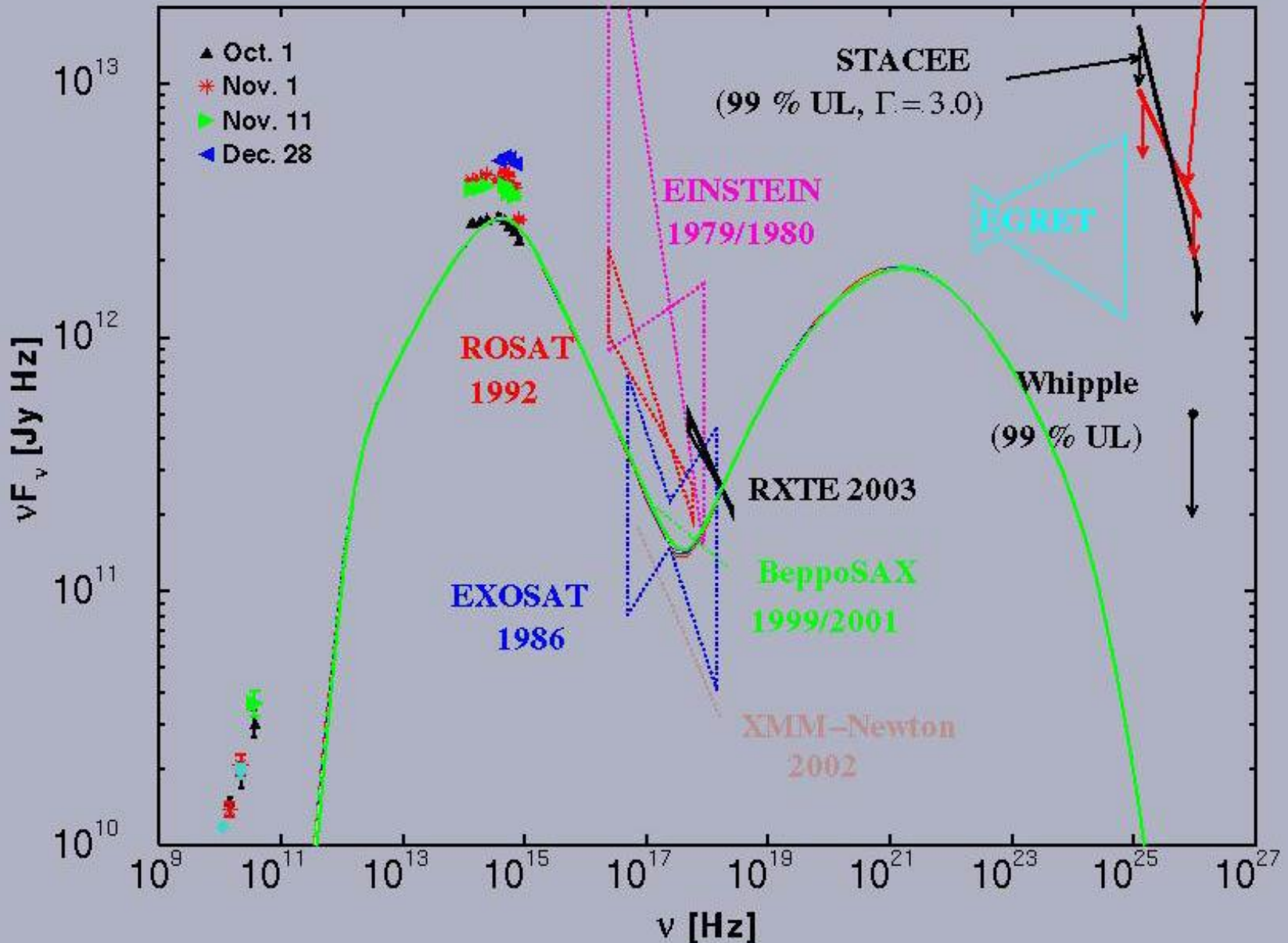
- VLBA observations indicate bending of jet in the line of sight
- Viewing angle,  $\theta_{obs} \sim 2.4^\circ$  assuming  $\theta \approx \frac{1}{\Gamma}$
- Jet components don't exhibit superluminal motion except one, hence Doppler Factor not well constrained.
- $D = \Gamma = 24$  gives good fit.
- X-rays being dominated by outbursts.

$$\tau_{syn,cool} \approx 41 \text{ min.}$$

# Spectral Energy Distribution

STACEE (99 % UL,  $\Gamma = 2.5$ )

3C66A (nFn\_ssc151)



# Work In Progress

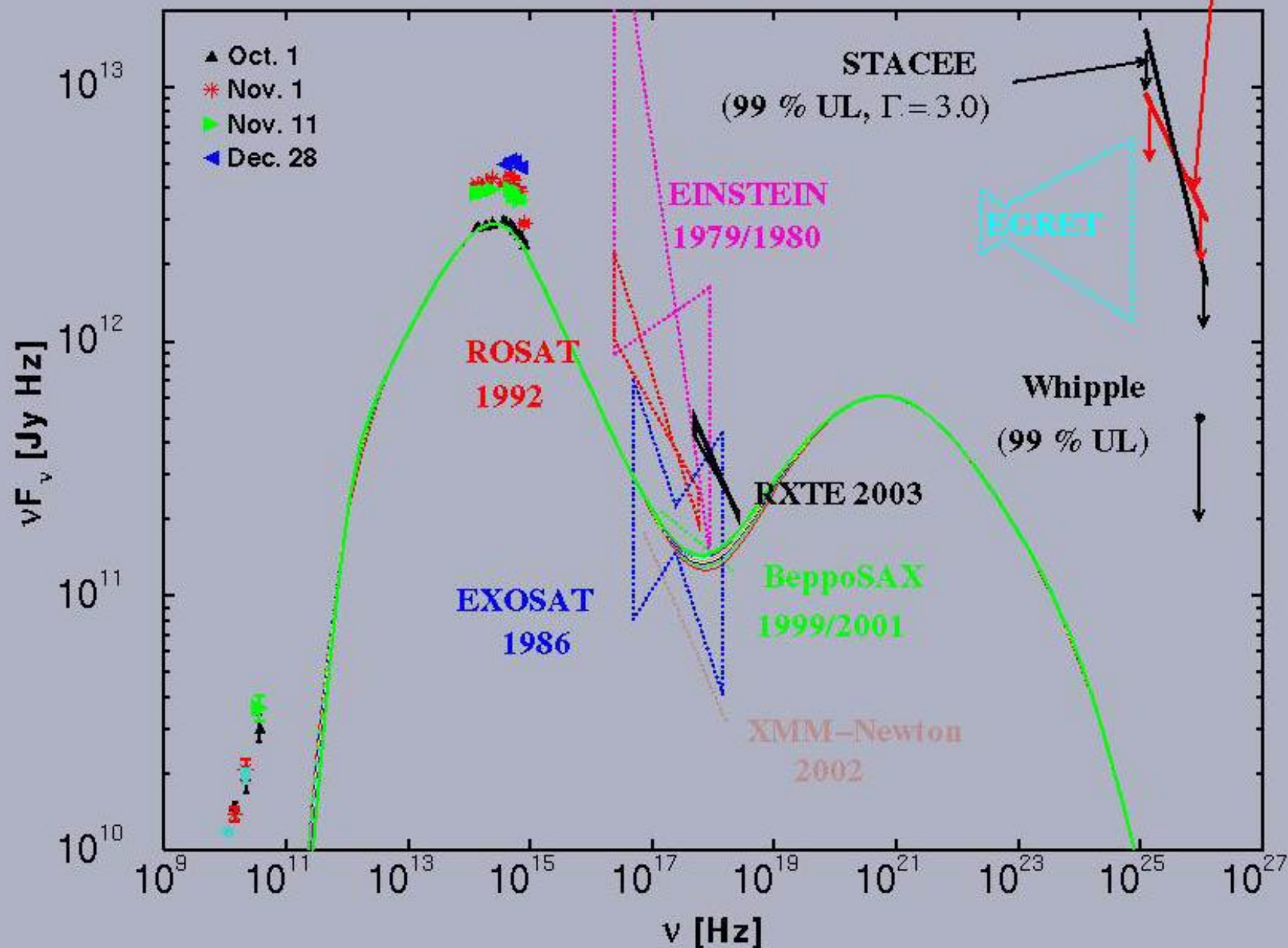
- Suitable set of parameters to explain the optical variability observed.
- Specific predictions concerning potentially observable X-ray spectral variability patterns and  $\gamma$ -ray emission.
- Investigate possible presence of EIC in  $\gamma$ -ray emission.



# Spectral energy Distribution

STACEE (99 % UL,  $\Gamma = 2.5$ )

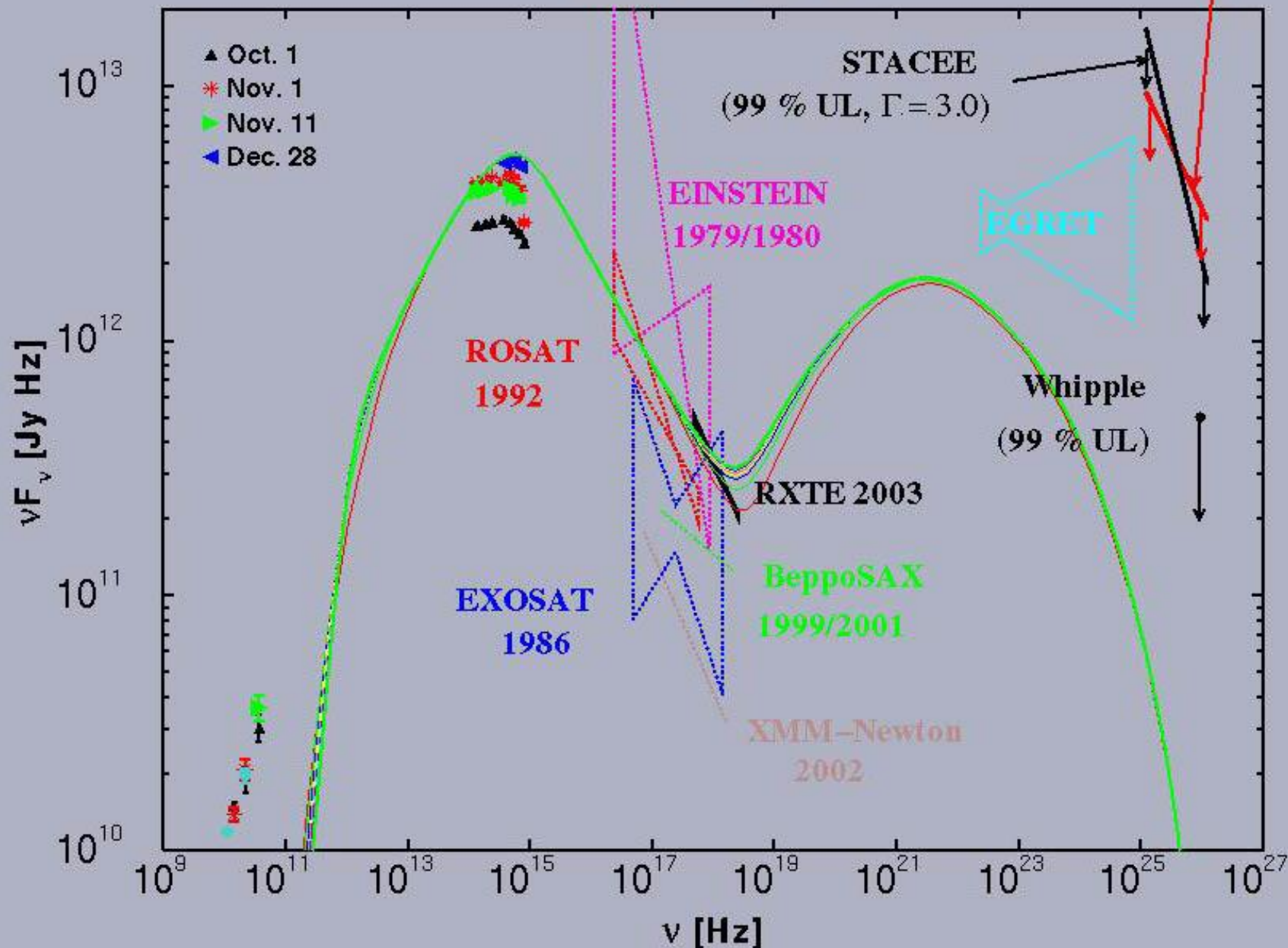
3C66A (nFn\_ssc91)



# Spectral Energy Distribution

**STACEE (99 % UL,  $\Gamma = 2.5$ )**

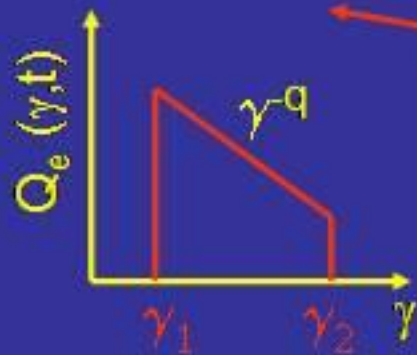
3C66A (nFn\_ssc110)



# Blazar Modeling

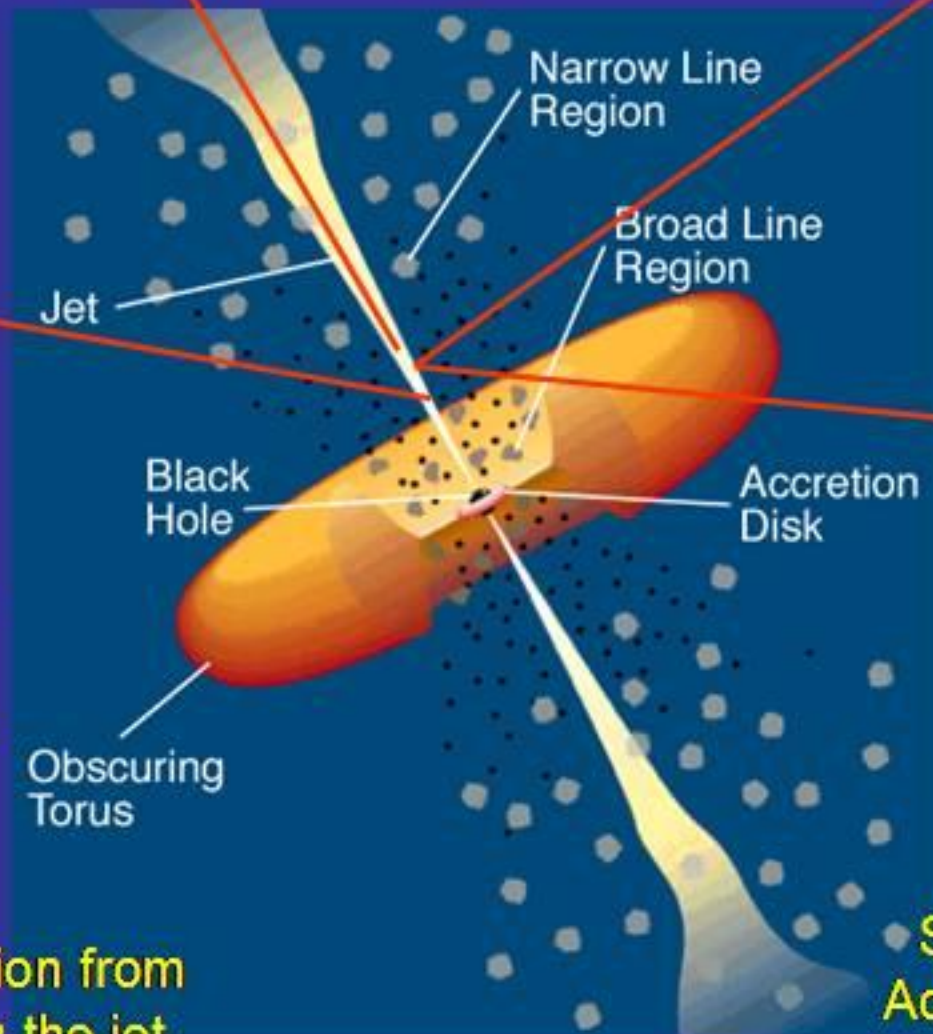
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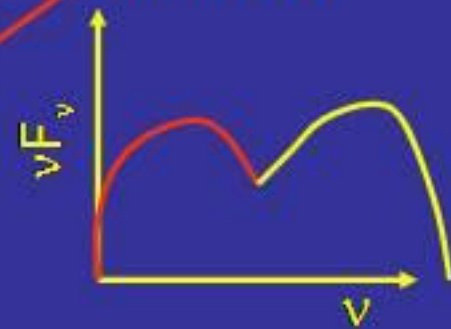


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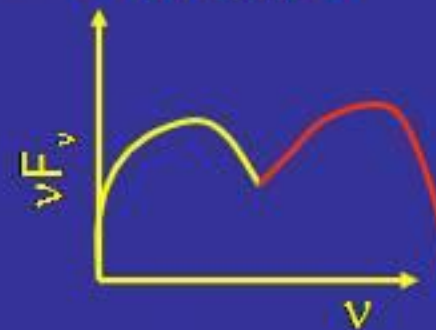
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