A model for periodic blazars

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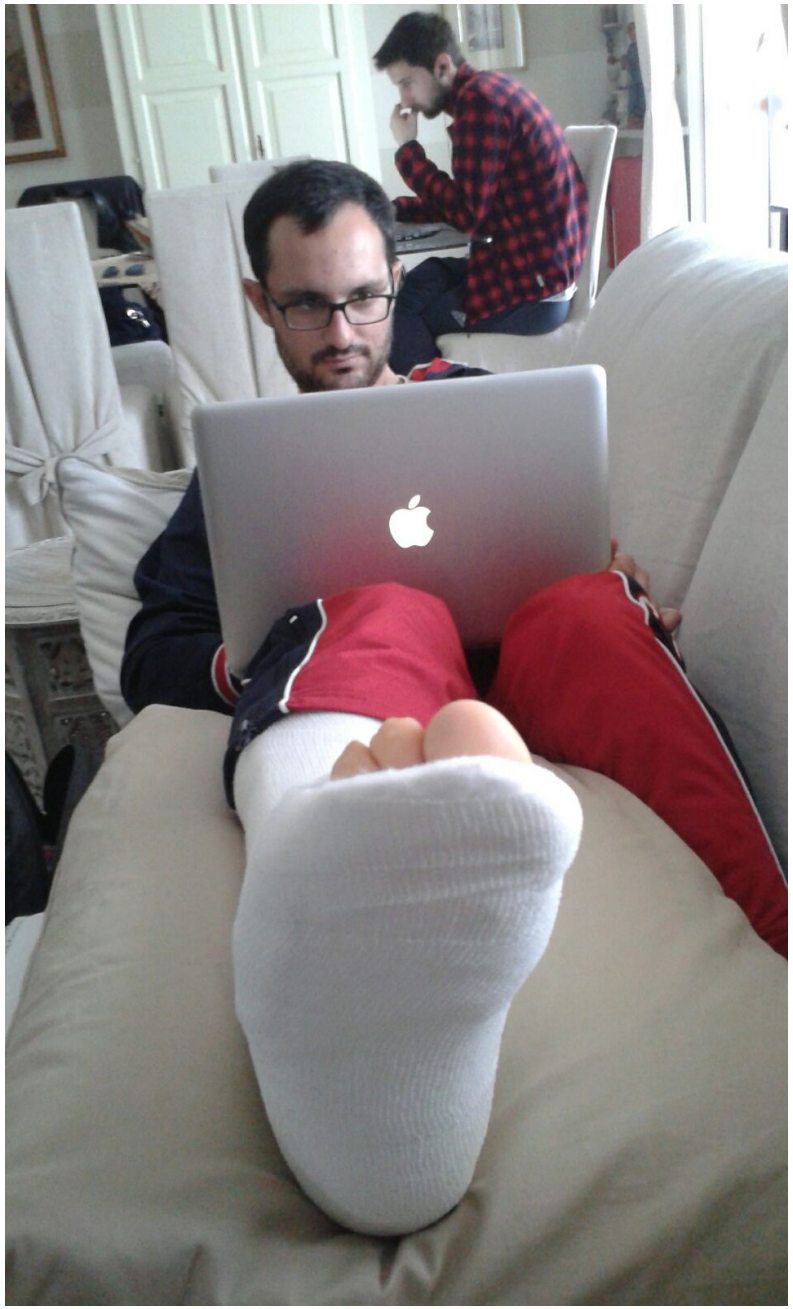
Based on: Arxiv 1610.04709

How it began

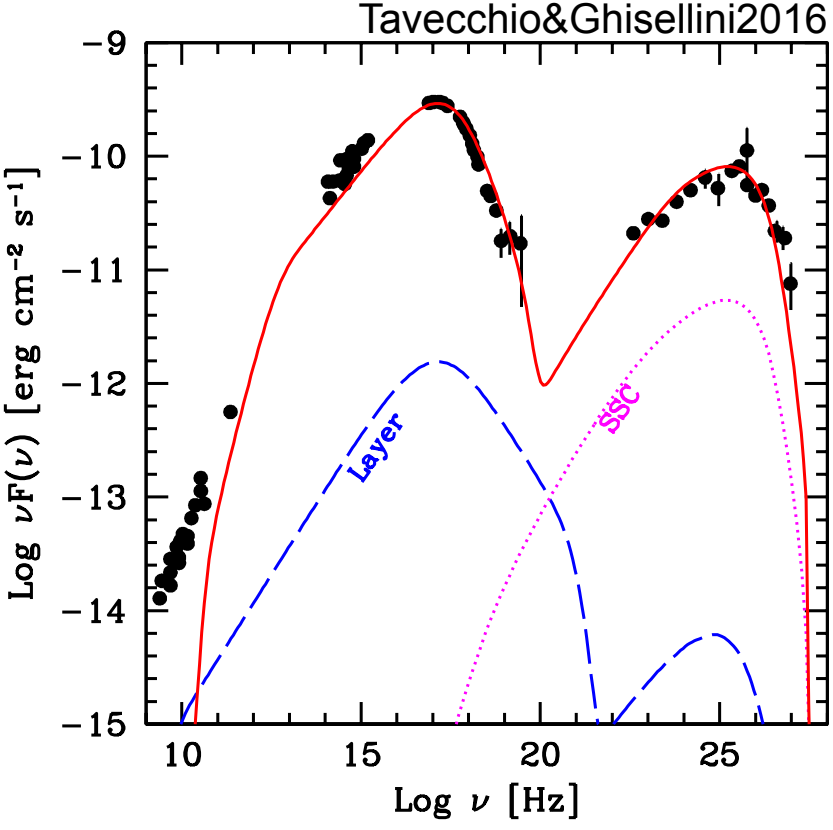
It was business as usual.



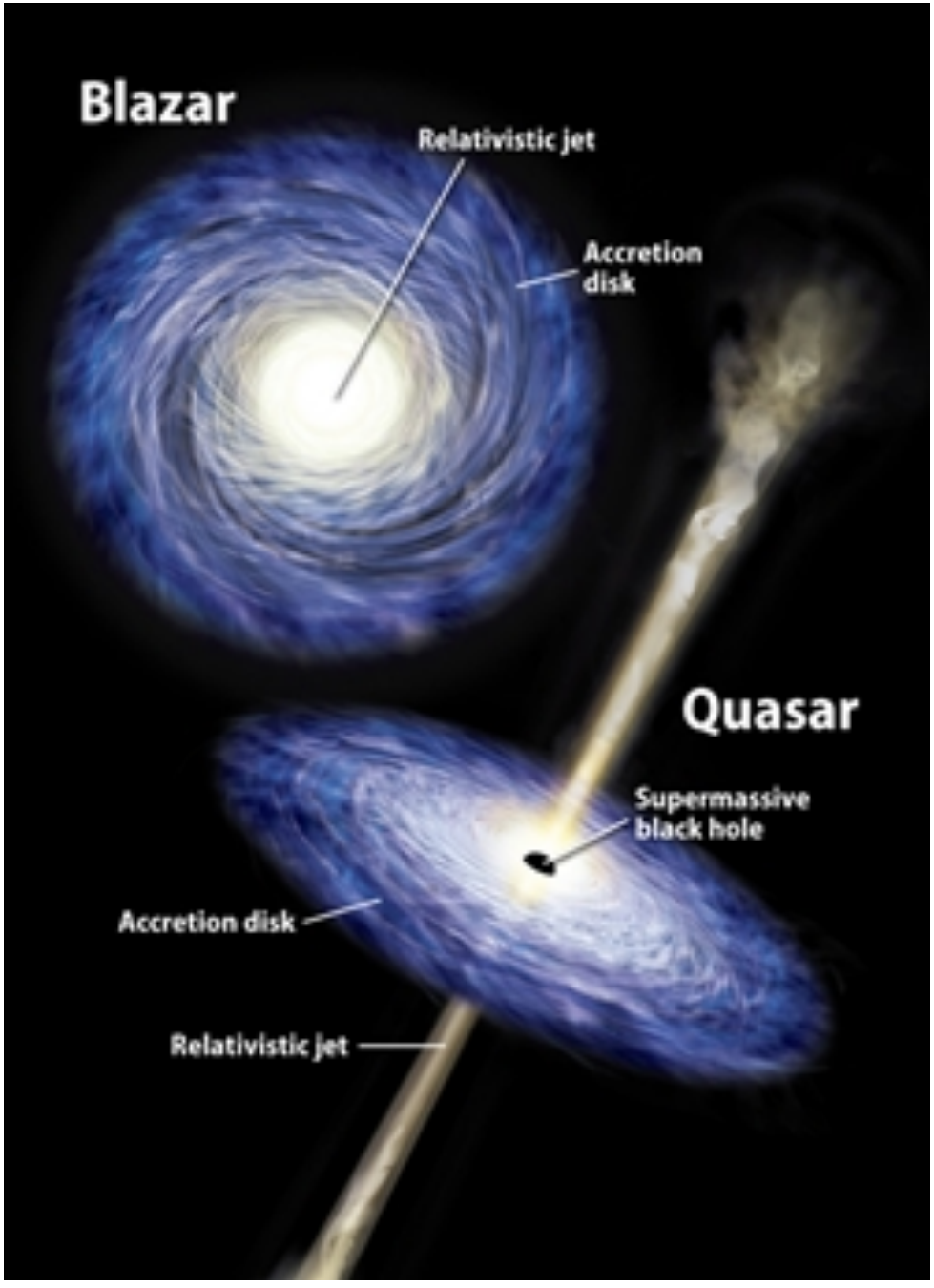
What is a blazar?

- Powerful source believed to consist in an **AGN with a jet** pointing in the **direction of the Earth**
- Google says:
- **Example** of spectral energy distribution: Mrk 421

Tavecchio&Ghisellini2016



credit: Roen Kelly

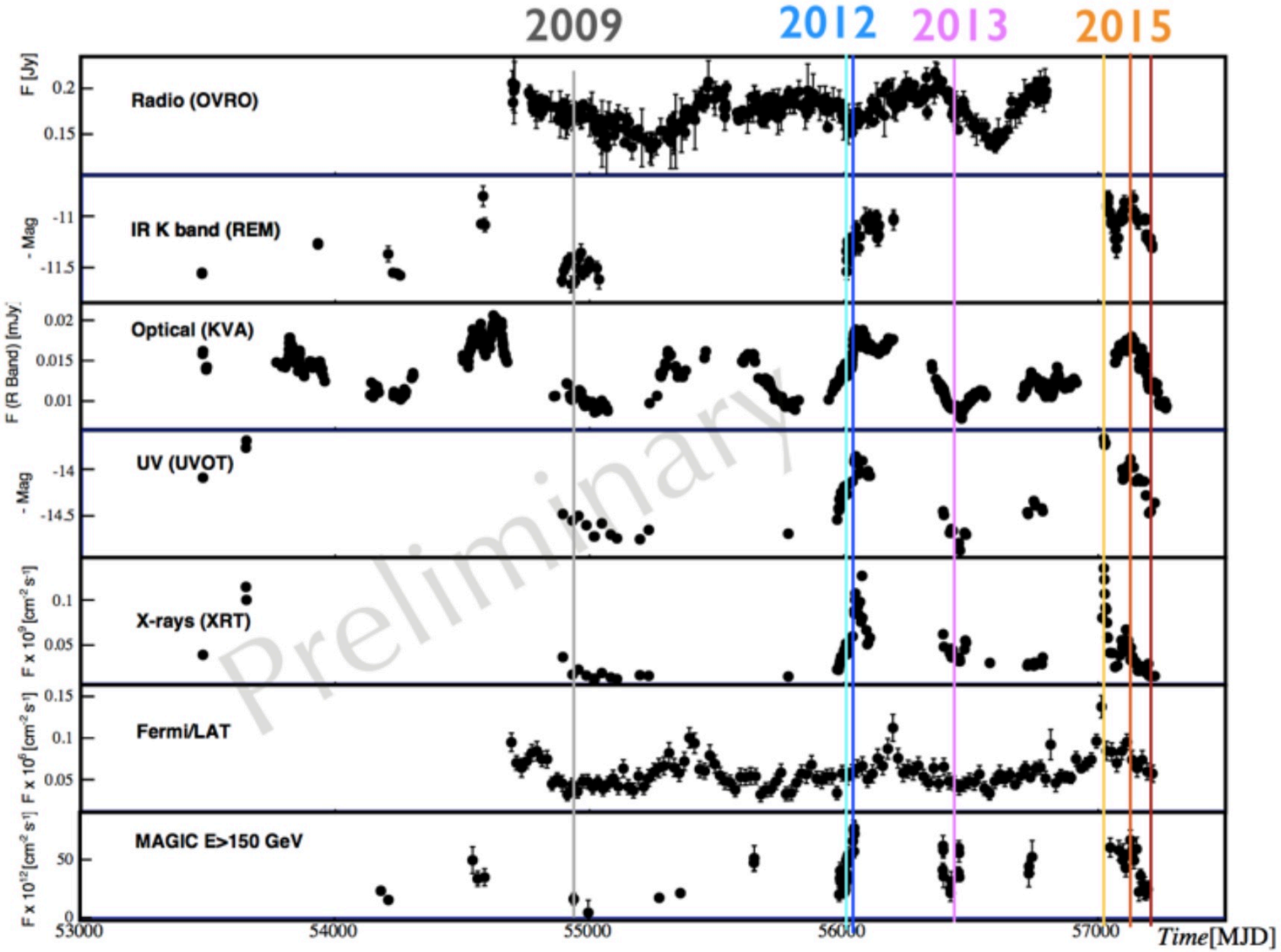


Variability

- variability on **wide range of timescales**:
  - **less than a day** (microvariabilities)
  - **from days to few months** (short-term variabilities)
  - **few years** (long-term)
- Longer term variabilities: **who knows?** We have not observed these objects for more than few years.
- **Observers favorite game**: argue that light curves show signs of **periodicity** (often requires imagination).

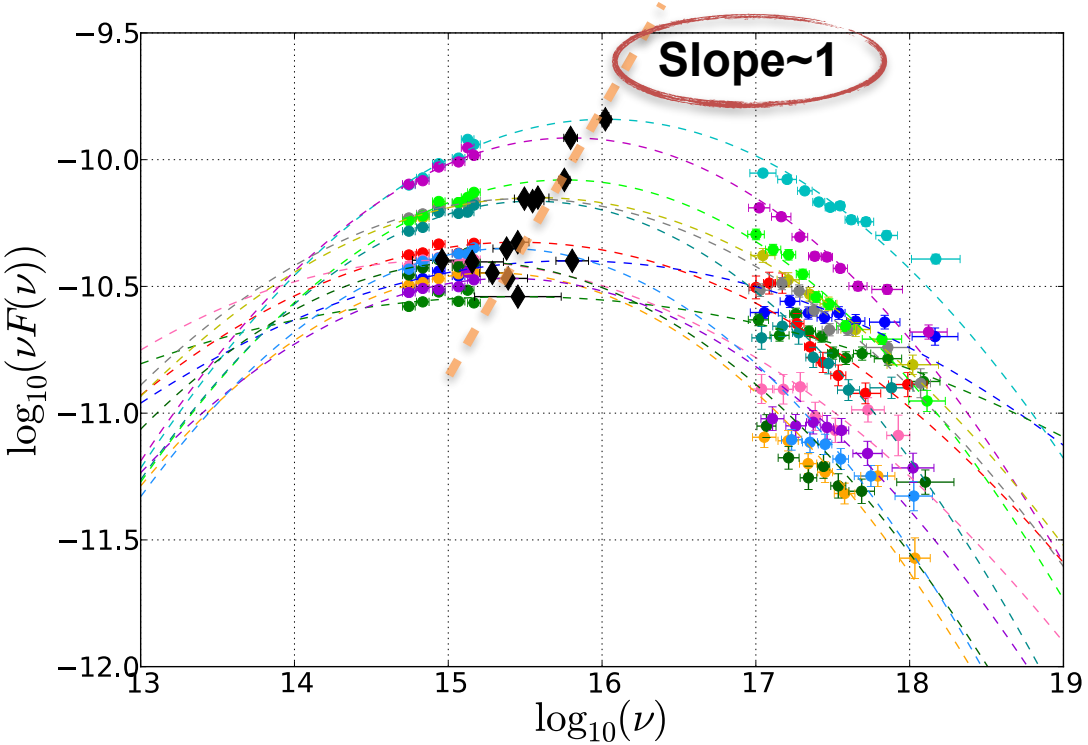
Light Curves of PG1553+113

credit: MAGIC collaboration + MWL partners, in preparation



PG 1553+113

- Ackermann+2015 says **light curve is periodic**. T=2.18years
- **Spectrum at different times** (this is the **left hump**)
- Moves up and down periodically. **Why?**
- **Dashed lines** show simple log-parabolic fit.
- **Geometric interpretation** seems natural, but naive model does not work

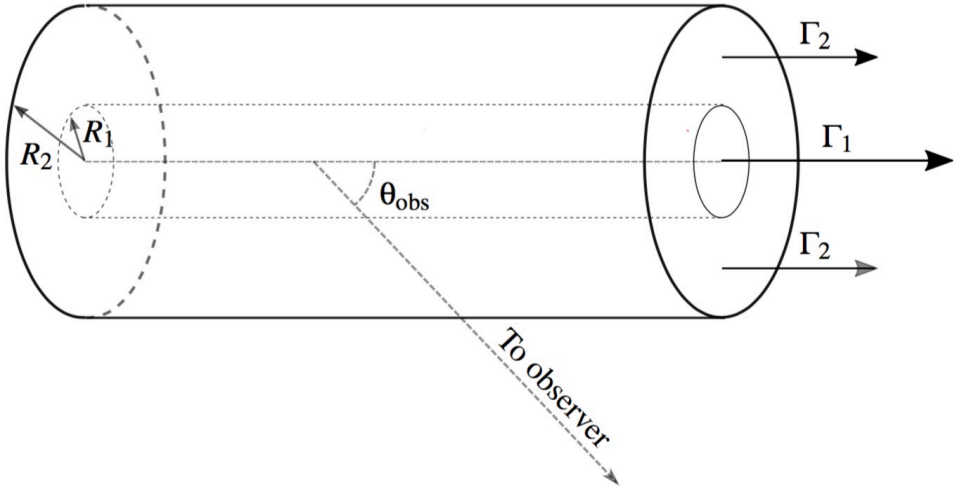


Two things to do:

1. **Find a jet structure that, if precesses, explains the observations**
2. **Find a reason why it should precess**

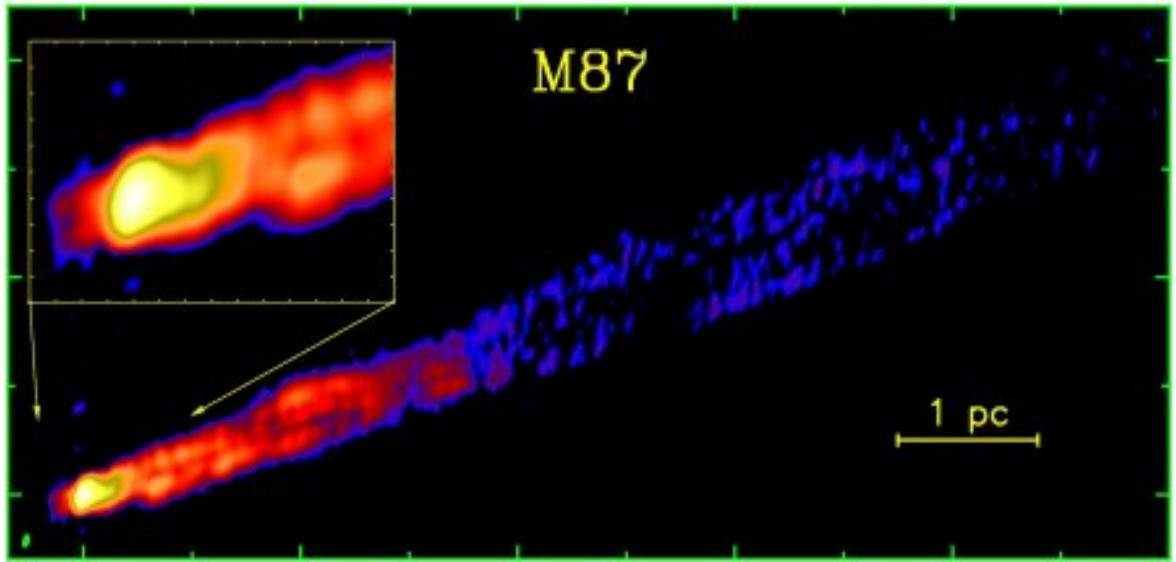
1. Jet structure

- **Stationary emission pattern**
  - Different than pattern moves with the fluid
- $\dot{j}_0$ = constant **isotropic emissivity** in fluid's rest frame
- Emission not isotropic in observer's frame because of **relativistic beaming**
- **Purely Kinematical** model
- **Naive model:** $\Gamma_1 = \Gamma_2 \rightarrow \text{slope} = 3$
- **Less naive model**: $\Gamma_1 > \Gamma_2 \rightarrow$ variable slope



$$F(\nu, \hat{\mathbf{n}}) = \frac{\pi L R_2^2}{D^2}\left[\lambda\delta_1^2 j_0\left(\frac{\nu}{\delta_1}\right) + (1-\lambda)\delta_2^2 j_0\left(\frac{\nu}{\delta_2}\right)\right]$$

$$\delta_i = \frac{1}{\Gamma_i\,(1 - \hat{\mathbf{n}}\cdot\boldsymbol{\beta}_\mathbf{i})} \qquad 0 \leq \lambda \leq 1$$



Kovalev+2007

Spine-sheath structure **observed** in the jet of M87. **Limb brightening**

2. Reasons for precession

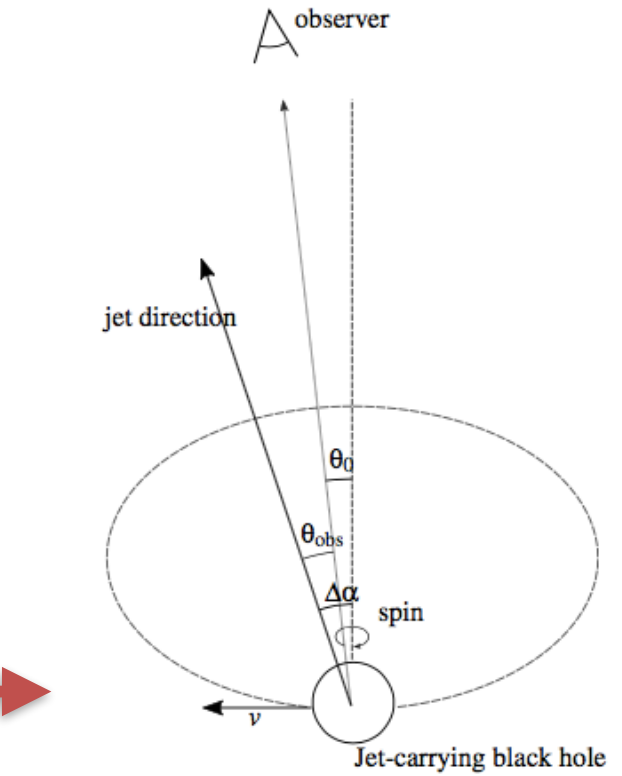
Brainstorming.

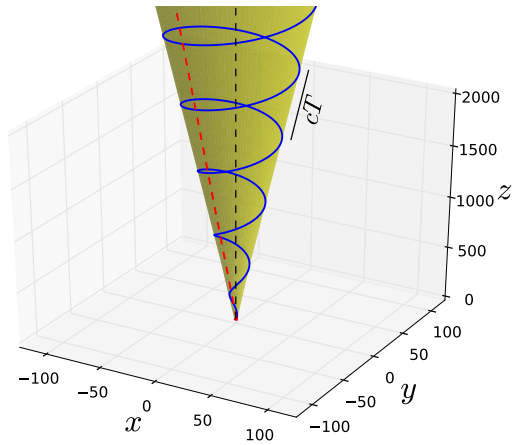
Ideas involving a **binary SMBH** system**:**

- **Lense-Thirring** of **one BH onto another**?
  Most popular in the literature. Timescale too long (~500years).
- **Gravitational deflection?**
  gravitational waves decay time too short.
- **Same as Earth-Moon system?**
  Works on the accretion disk. One then has to explain how that affects the jet.
- **Imprint of orbital v?**
  It works! And very simple

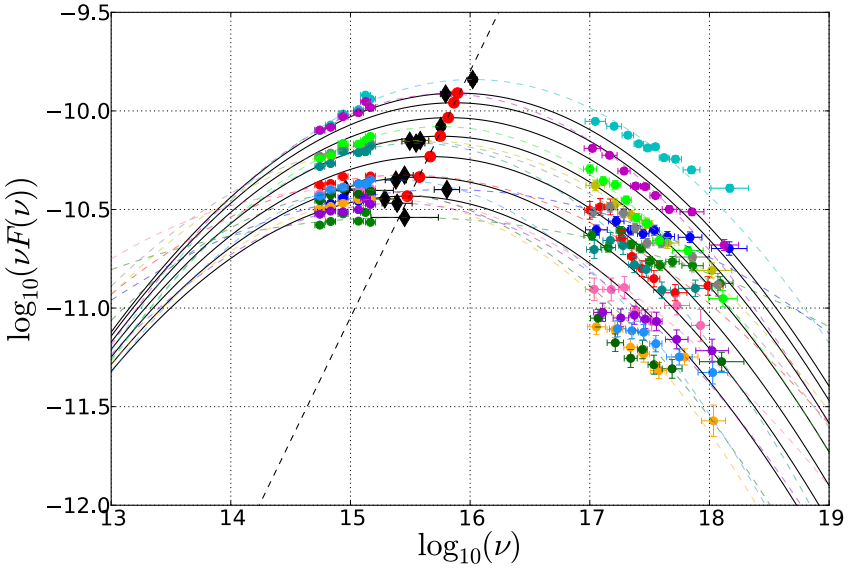
Ideas involving a **single SMBH**:

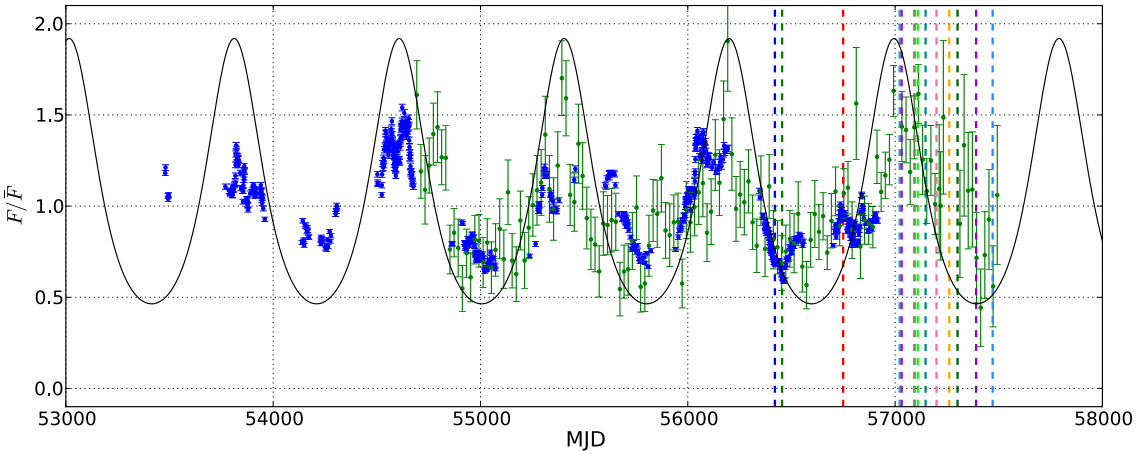
- **Lense-thirring** of SMBH on its own disk?
  Different rings have different precession rates and viscosity brings all to the same plane. Plus, same problems as earth-moon idea.
- **Hydro/MHD instabilities?**
  Difficult…!





Result for PG1553+113





Same model can explain multiple spectra ***and*** light curve

Estimate of system parameters

$$R = 1.1 \times 10^{16} \left(\frac{1+q}{q}\right) \text{ cm} \qquad M = 2.1 \times 10^{8} \left(\frac{1+q}{q}\right)^{3} M_{\odot}$$

$q \gtrsim 1$ mass ratio of the two BHs

Ending questions

- Other candidates to apply model to?
- Other mechanisms for precession?
  - Hydro/MHD instabilities?
  - Wobbling accretion disc?
- How does accretion disc dynamics work in a binary system?

Thank you!