A new approach to search for binary black holes with Fermi/LAT

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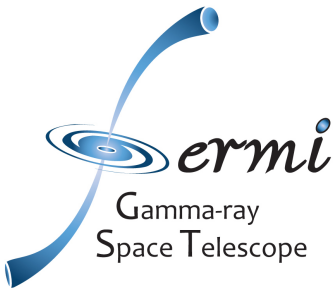
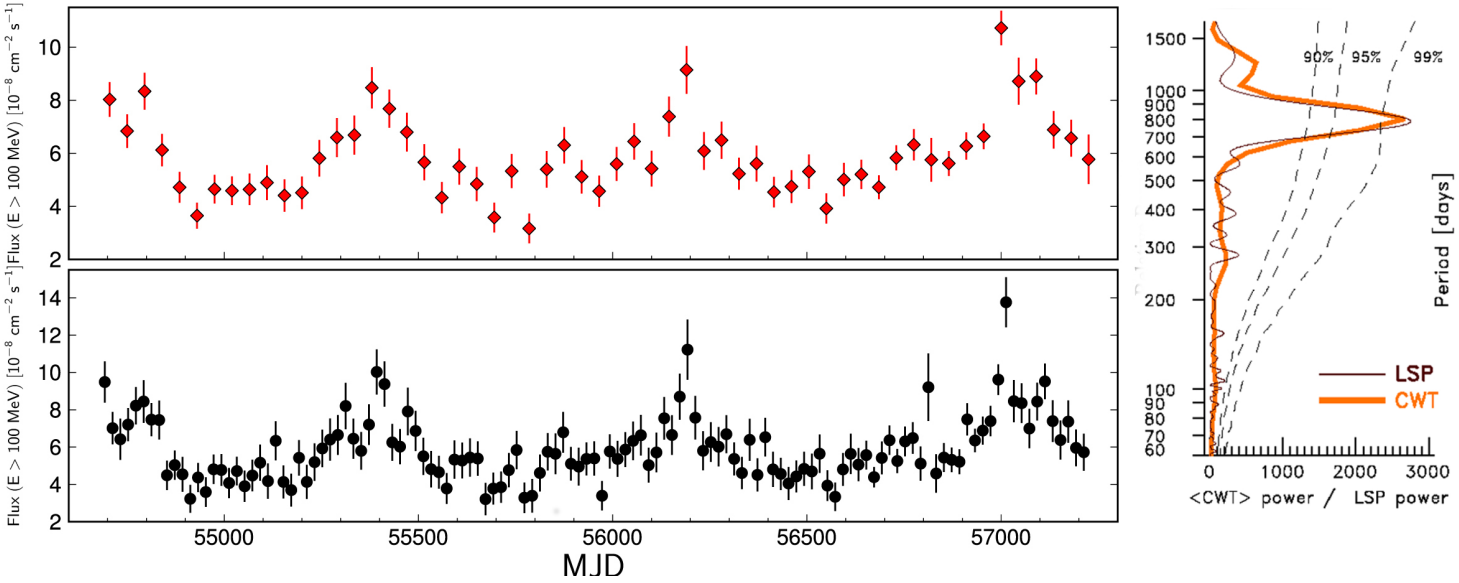


Periodicity in AGN

Example PG 1553+113:



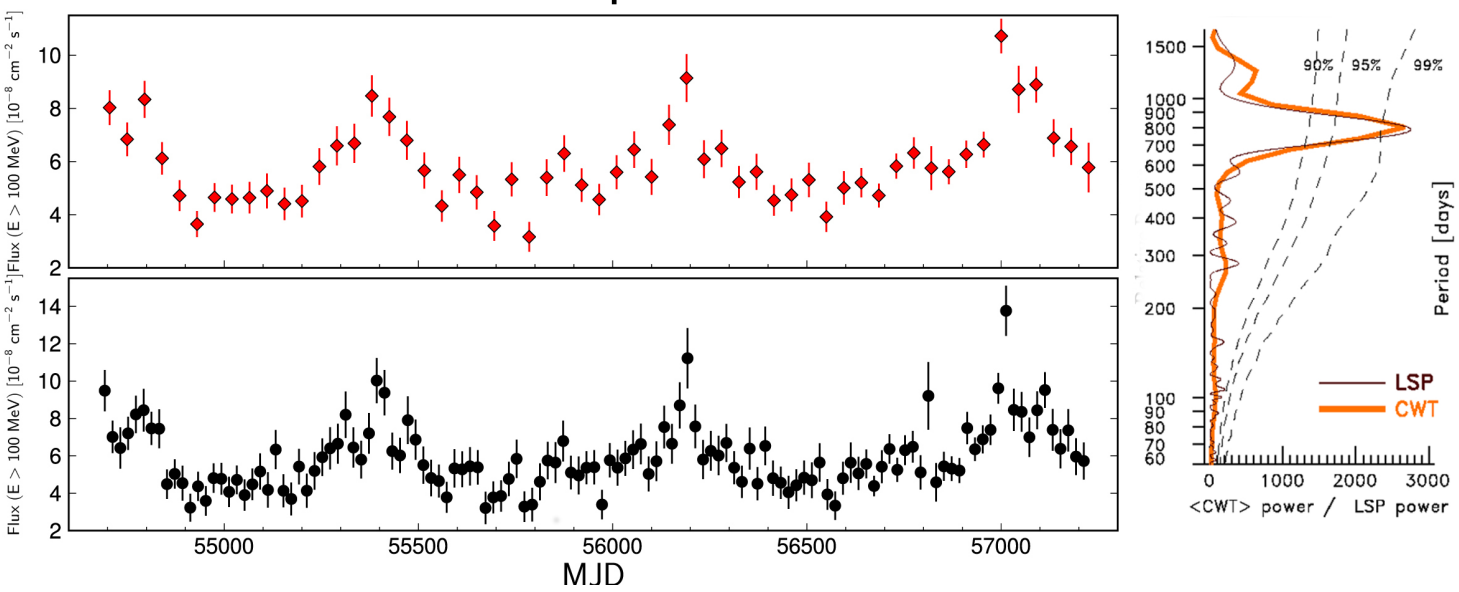
Credit: Ackermann, M., et al. 2015, The Astrophysical Journal Letters, 813, L41

- Periodic modulations with a period of 2.18 ± 0.08 years
- Hints of periodic signals from six blazars by Penil et. at 2020

How to improve?

Periodicity in AGN

Example PG 1553+113:



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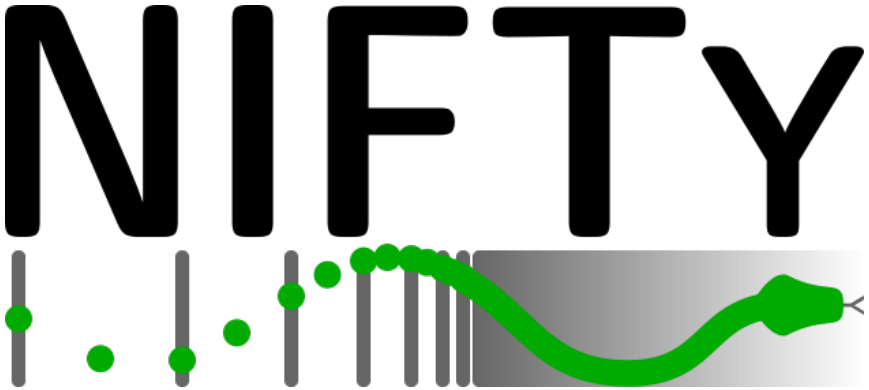
- Variety of different methods like e.g. Lomb-Scargle or Wavelet
- Traditional methods are based on fitted GeV flux
- Only valid under certain assumptions like e.g. sinusoidal period

Aim:

Develop new independent method based on Bayesian methods

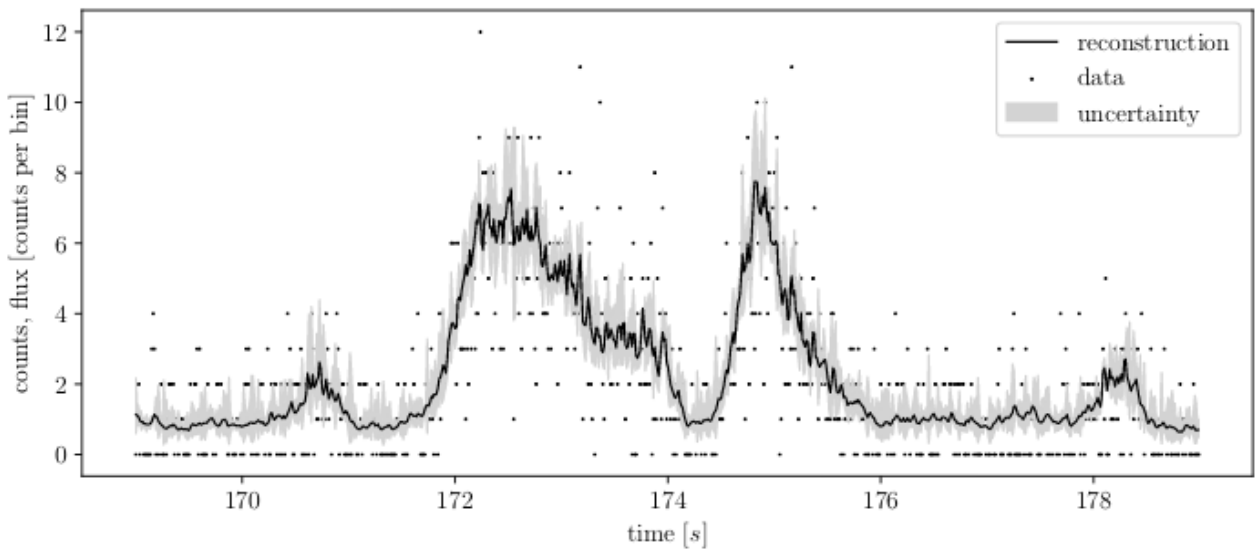
Numerical Information Field Theory



- Software package based on Bayesian methods
- Can handle incomplete data samples with gaps
- Combines advantages of traditional methods

How does it work?

Numerical Information Field Theory



Credit: D. Pumpe et. al., Astronomy & Astrophysics, 610, id.A61,12 p

- Search for quasi-periodic signals in magnetar giant flares
- Using X-ray counts rate of RXTE
- Bayesian method well suited to reconstruct light curve

Perfect toolkit to study periodicity in AGN

LAT Analysis

- Fermi Science Tools (v11r5p3)
- Pass 8 data (P8R3)
- Event Class: 128
- Event Type: 3
- zenith angle cut: 90 deg
- ROI: 1 deg
- Energy Range: 100 MeV to 300 GeV

Take low-level counts rate after running GTMKTIME

No likelihood analysis performed

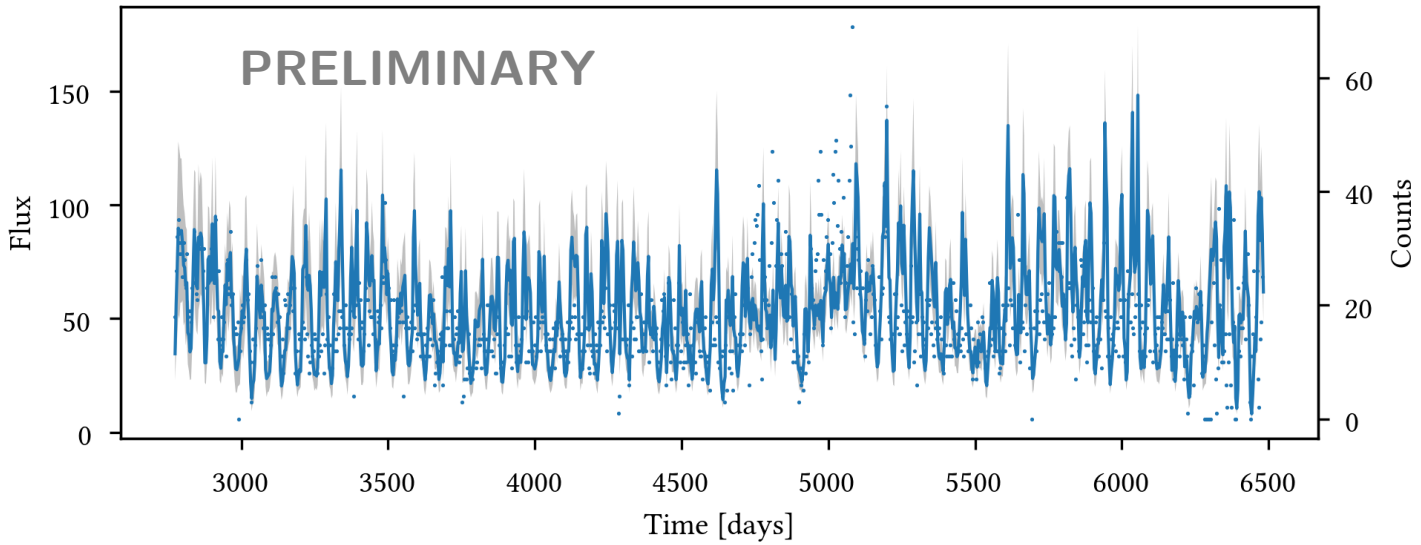
Prior definition

$$\mathcal{R} = \mathcal{T} \otimes \mathcal{S} \otimes \mathcal{E}$$

Response operator $\mathcal{R}$ includes:

- GTIs of observations $\rightarrow$ Detector ontime $\mathcal{T}$
- Long-term averaged spectrum from 4FGL $\mathcal{S}$
- Direction and energy dependent effective area $\mathcal{E}$

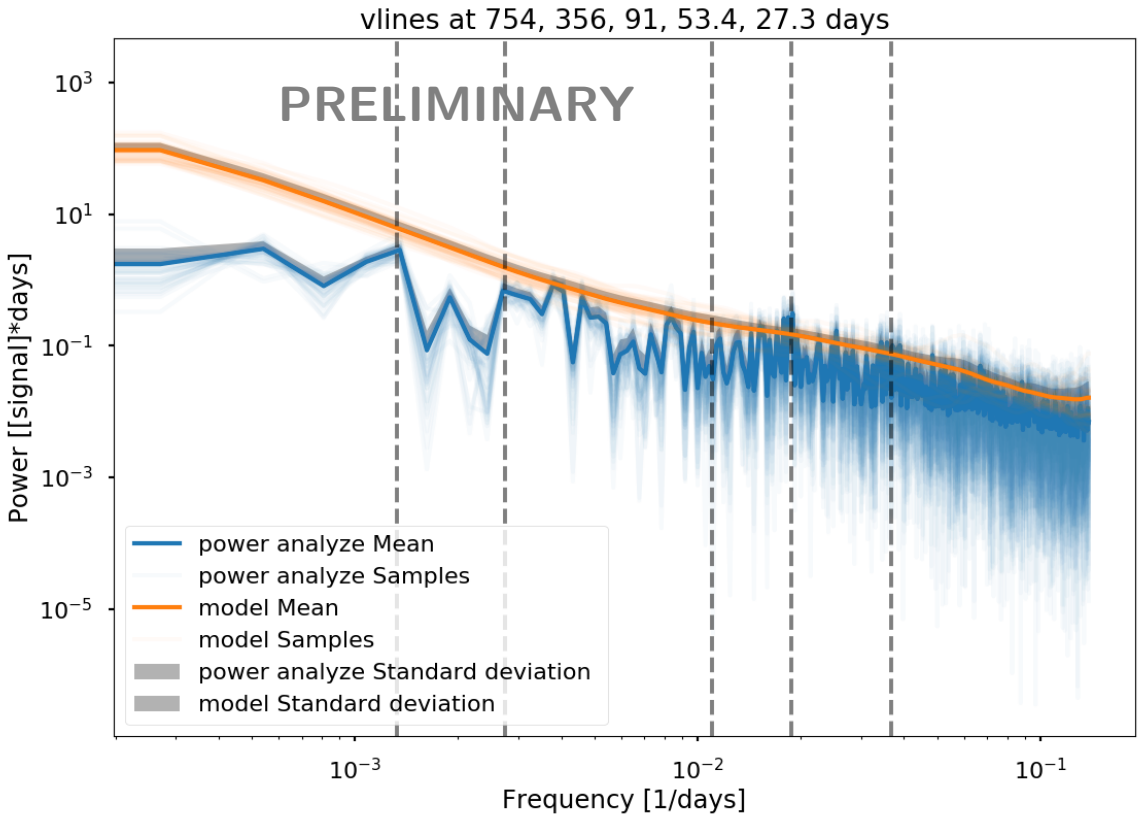
Light curve of PG 1553+113:



- Counts rate light curve selected after running GTMKTIME
- Reconstruction follows long-term trend

Power spectrum of PG 1553+113:

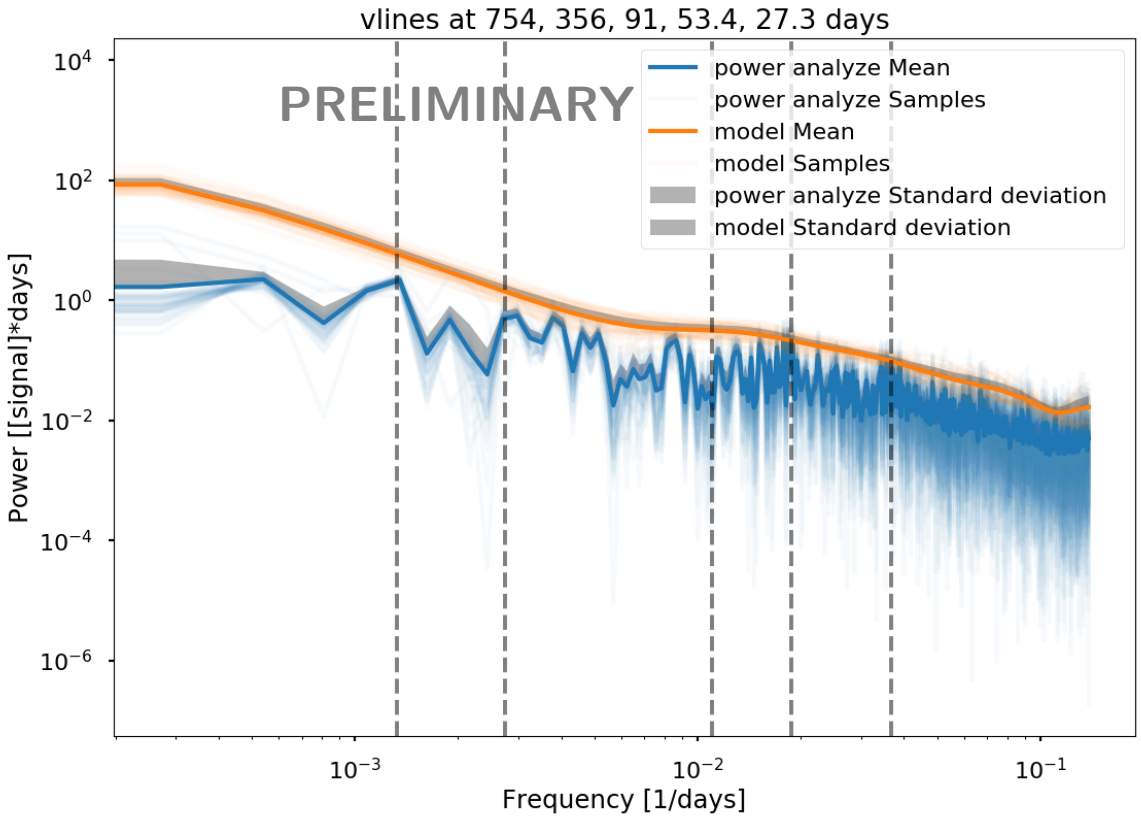
Test different priors: ontime ($\mathcal{R} = \mathcal{T}$):



No periodic signal found

Power spectrum of PG 1553+113:

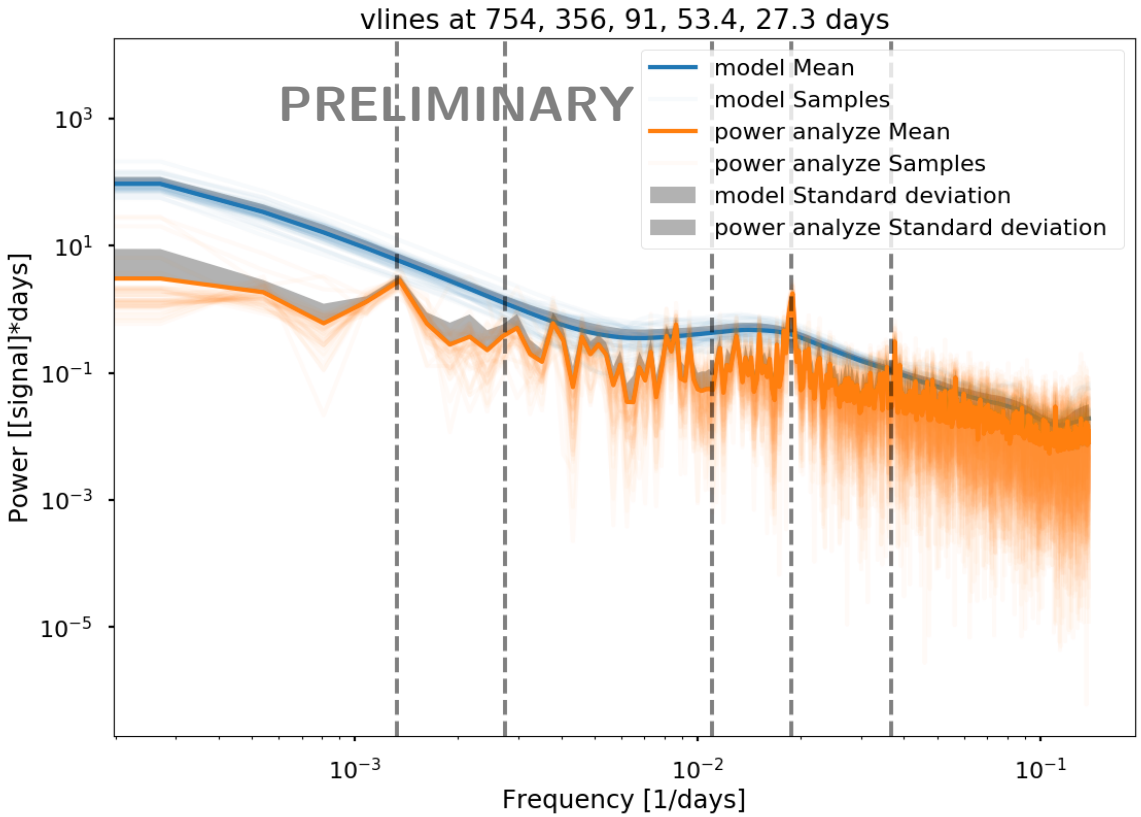
Test different priors: spectrum ($\mathcal{R} = \mathcal{S}$):



No periodic signal found

Power spectrum of PG 1553+113:

Test different priors: effective area ($\mathcal{R} = \mathcal{E}$):

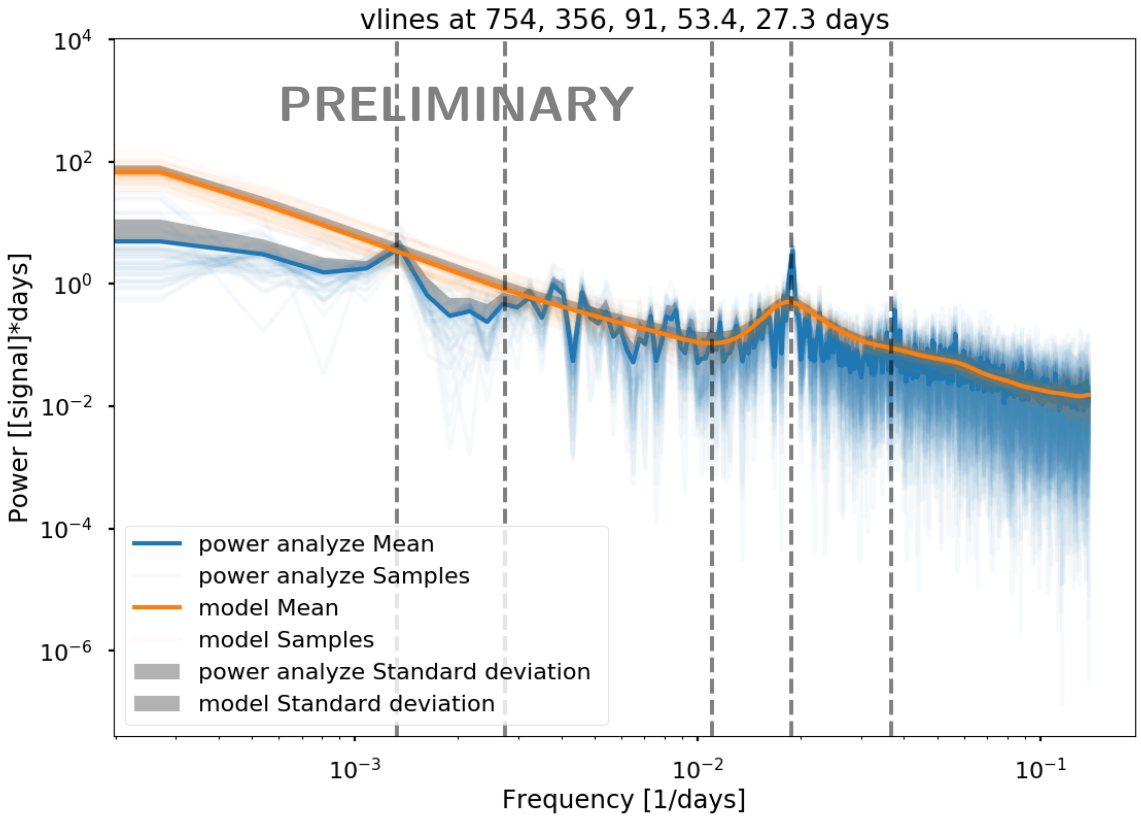


- Hint of moon period at 27.3 days
- Hint of orbital precession at 53.4 days

Effective area has largest impact on prior

Power spectrum of PG 1553+113:

Test different priors: ontime $\otimes$ effective area ($\mathcal{R} = \mathcal{T} \otimes \mathcal{E}$):



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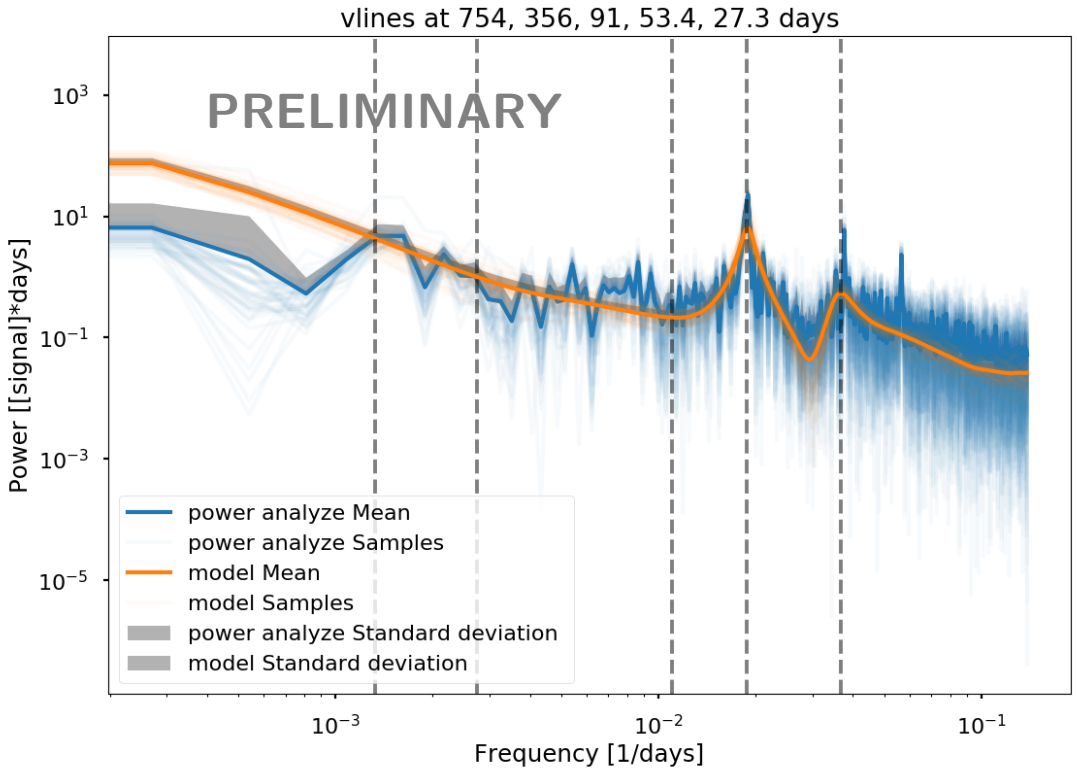
- Hint of orbital precession at 53.4 days

Identification of detector effects is getting stronger

Power spectrum of PG 1553+113:

Test different priors: spectrum $\otimes$ effective area $(\mathcal{R} = \mathcal{S} \otimes \mathcal{E})$:

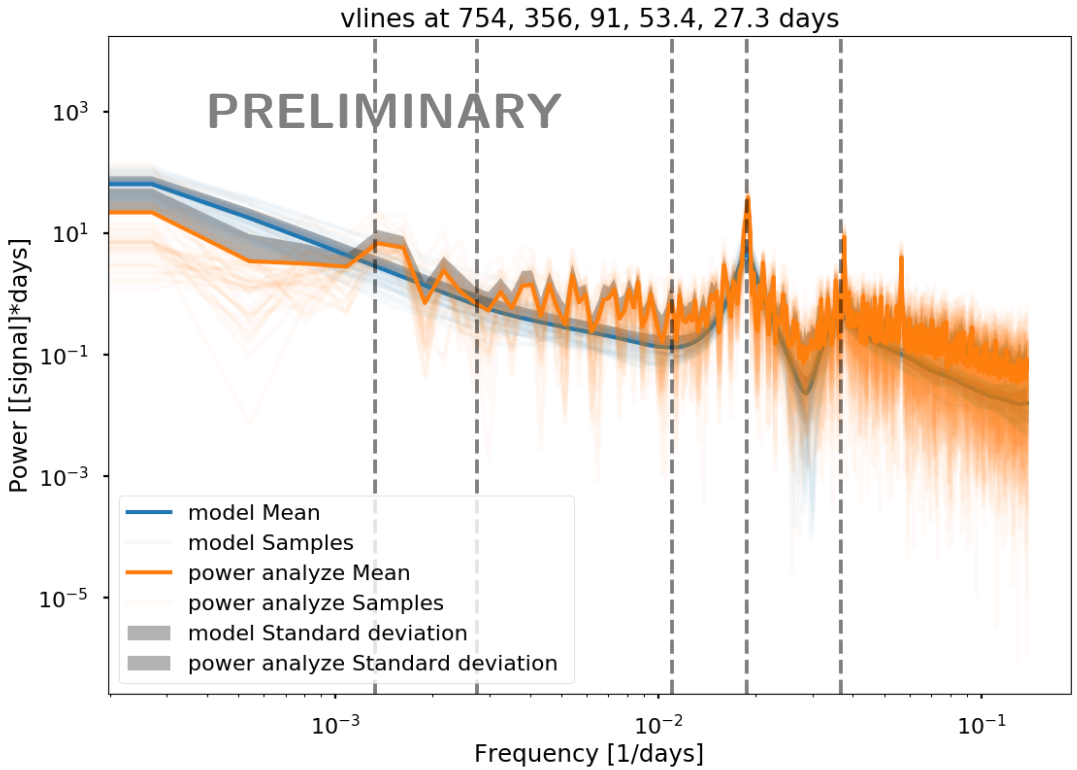


- Hint of moon period at 27.3 days
- Hint of orbital precession at 53.4 days
- Hint of periodic feature at $\sim$ 754 days

Identification of detector effects is getting stronger

Power spectrum of PG 1553+113:

Test different priors: ontime $\otimes$ spectrum $\otimes$ effective area ($\mathcal{R} = \mathcal{T} \otimes \mathcal{S} \otimes \mathcal{E}$):



- Hint of moon period at 27.3 days
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- Hint of periodic feature at $\sim$ 754 days

Best reconstruction with full detector response

Summary and Outlook

- Development of new analysis technique to analyze LAT data
- Computational fast, as no *Fermi*/LAT likelihood analysis preformed
- Proof of principle to reconstruct known detector effects

- Significance test ongoing
- Can be applied on large number of sources

NIFTy well suited to search for periodicity in AGN

Long-term plan:
Catalog on periodic sources based on 4LAC

Questions:
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