

Quasi-periodicities at year times scale in Blazars

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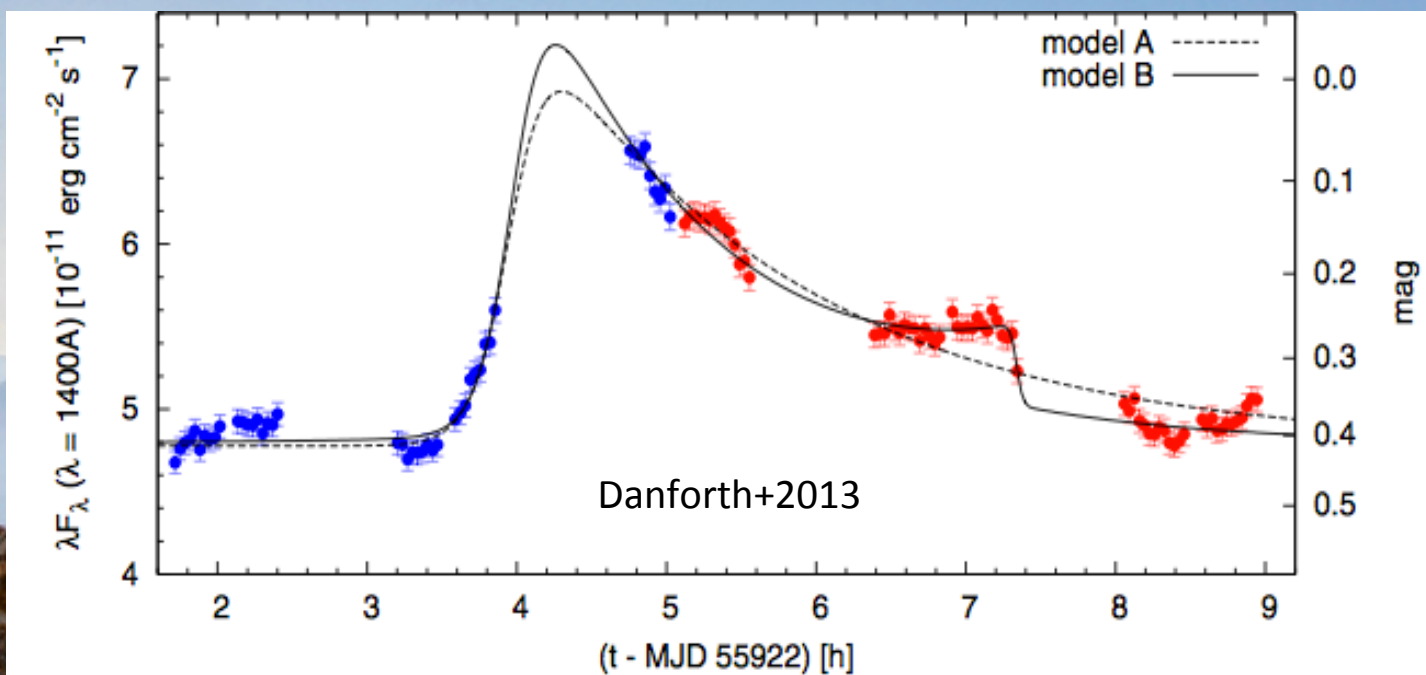
A. Sandrinelli et al. 2014 A&A 562 79

A. Sandrinelli et al. 2014 ApJ 713 L1

A. Sandrinelli et al. 2015 A&A, submitted

Variability of BL Lac objects

- S4 0954+65 0.2 mag/h R
- PKS 2155-30 timescale min (TeV)
- S5 0716+71 timescale min (UV)



Hour-day Quasi-periodicities

- PKS 2155-30 0.7 day (UV)
 4.6 h (X-rays)
- OJ 287 16 min (Optical)



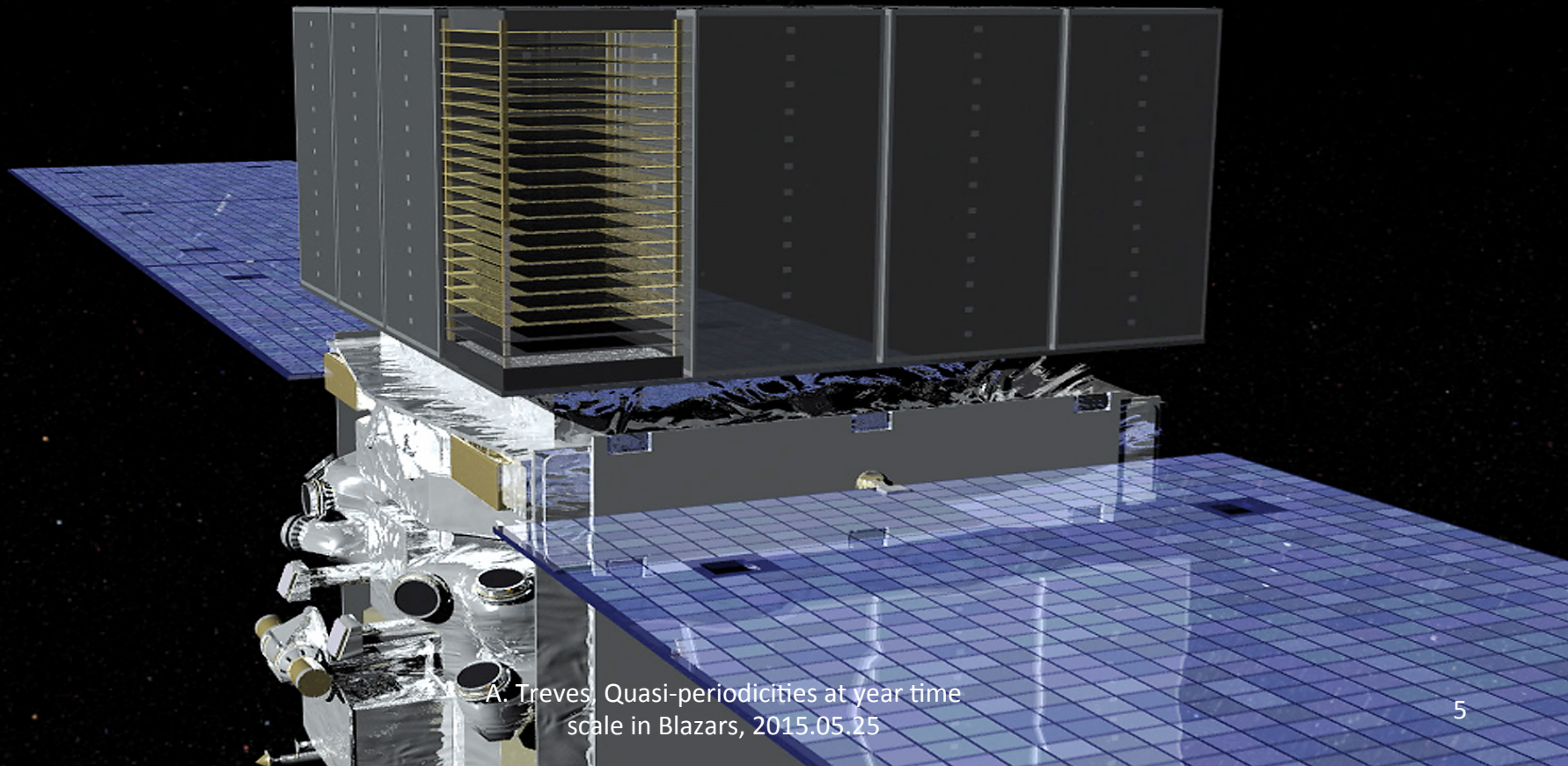
Year-long Quasi-periodicities

- OJ287 12 years
- 1128+59
- 0235+164
- 2321+410
- 1302-102 5.2 years



New Impetus

- Robotic Telescopes
- Fermi – AGILE Monitoring ($T \approx 10$ y)



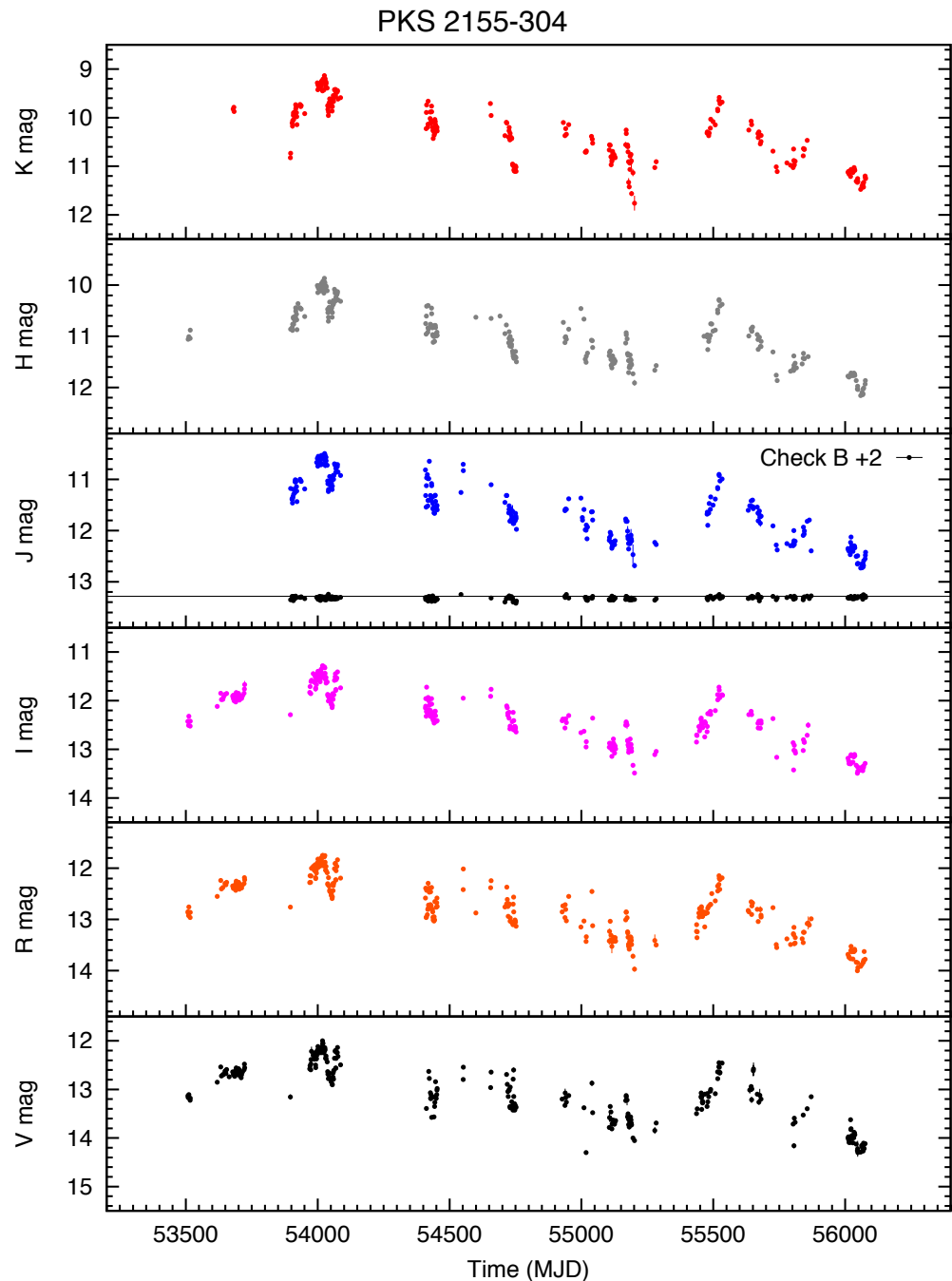
PKS 2155-304

- Zhang+2014 : 35 y observations, $T \approx 315$ Days
- Sandrinelli+2014 : REM VRIJHK + Fermi

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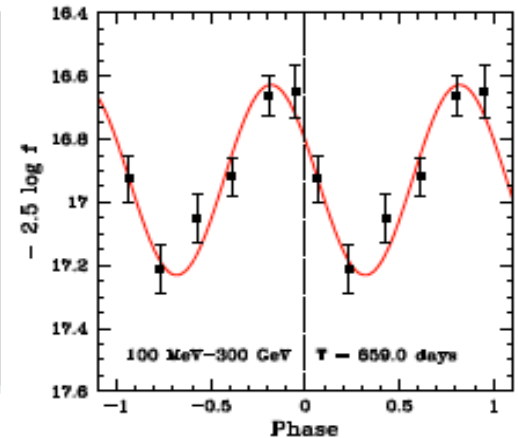
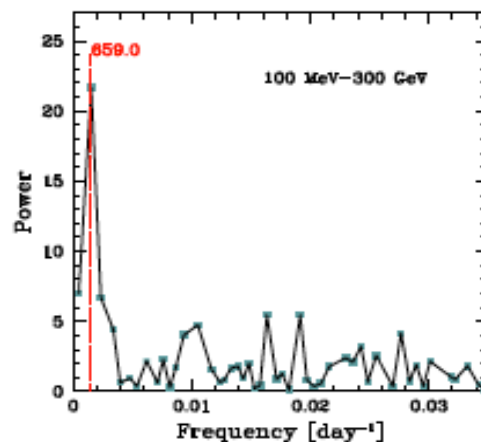
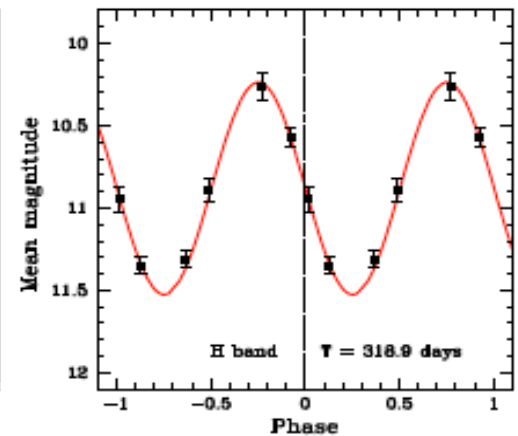
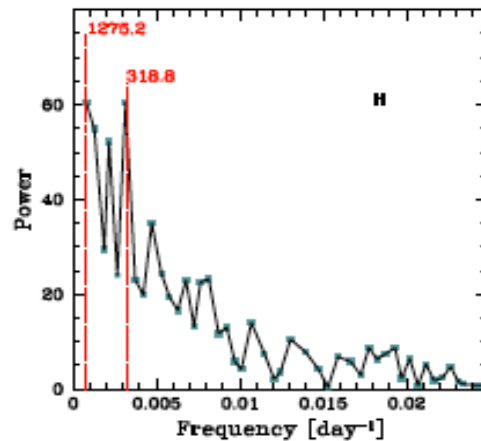
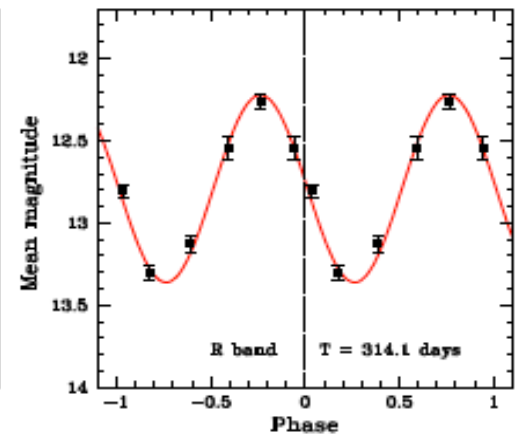
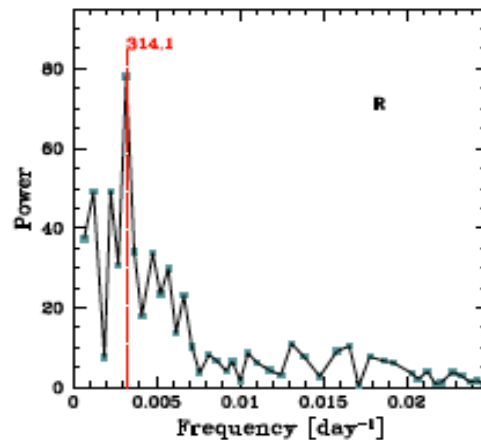
Photometry

9 years NIR-optical
light curves from
REM Telescope, La
Silla



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$T \approx 315$ Days



A. Treves, Quasi-periodicities at year time scale in Blazars, 2015.05.25

Further Progress REM+SMARTS

- REM → 2005
- SMART → 2008 V R J K
- Fermi 100 MeV-300 GeV



Sample

Source	ra ^a	dec ^a	Class ^b	SED ^c	Redshift ^a
PKS 0537-441	05:38:50	−44:05:09	BL Lac	LSP	0.896
OJ 287	08:54.48	+20.06:30	BL Lac	LSP	0.3060
3C 279	12:56:11	−05:47:21	FSRQ	LSP	0.536
PKS 1510-089	15:12:50	−09:05:59	FSRQ	LSP	0.3599
PKS 2005-489	20:09:25	−48:49:53	BL Lac	HSP	0.071
PKS 2155-304	21:58:52	−30:13:32	BL Lac	HSP	0.117

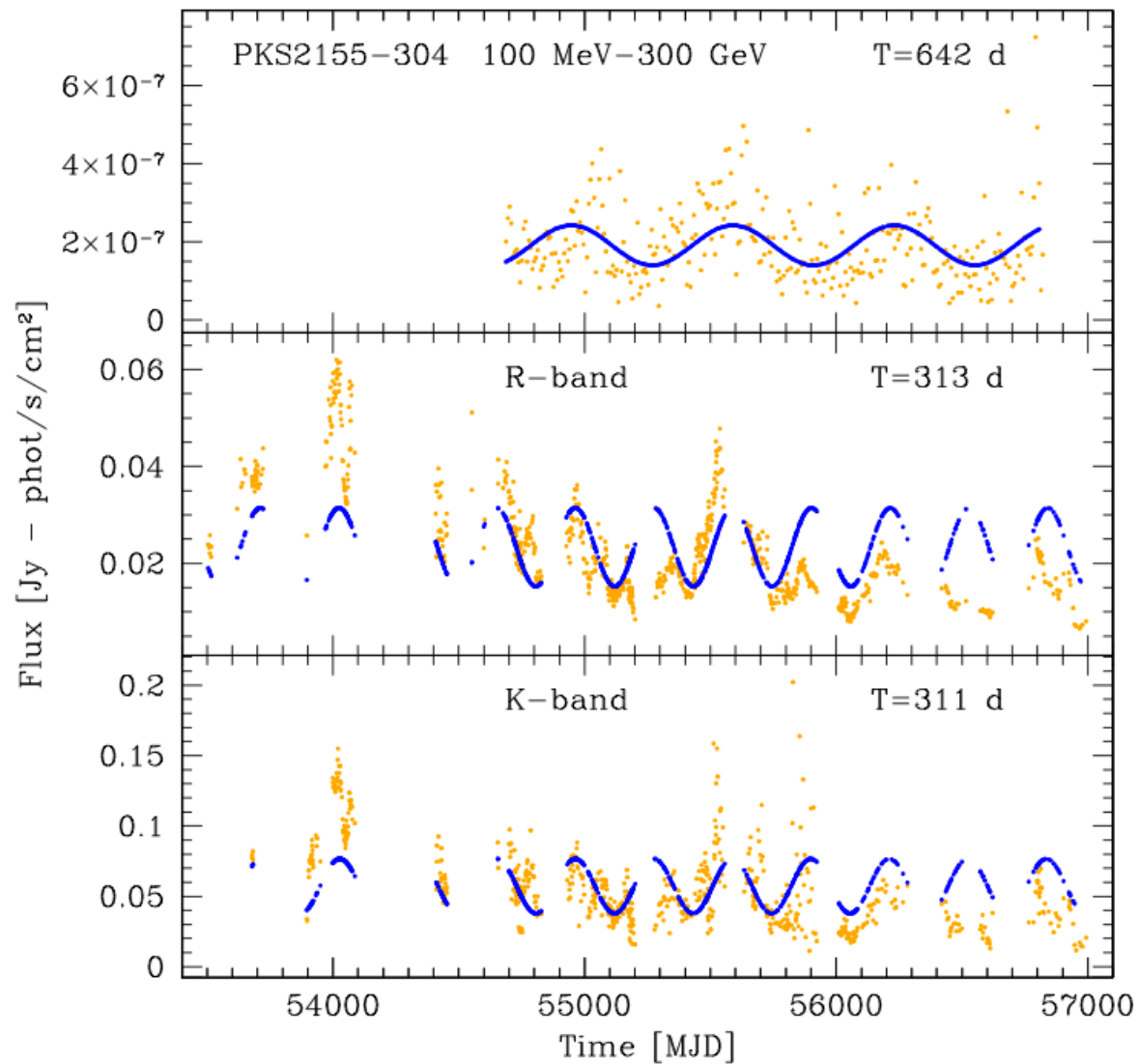


Significance of Peaks

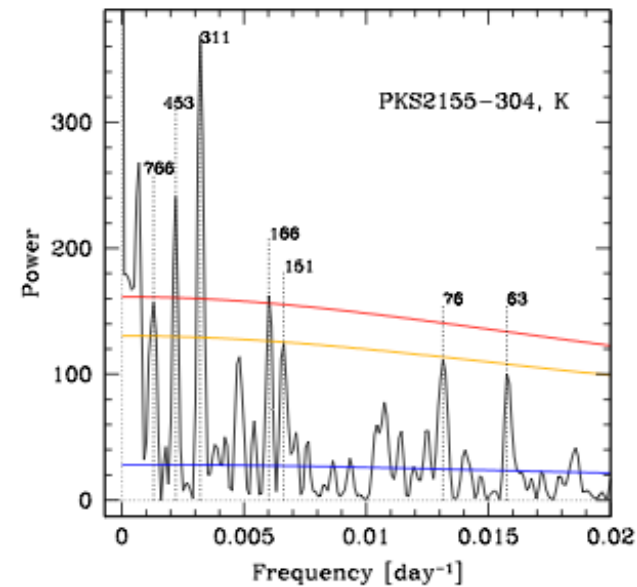
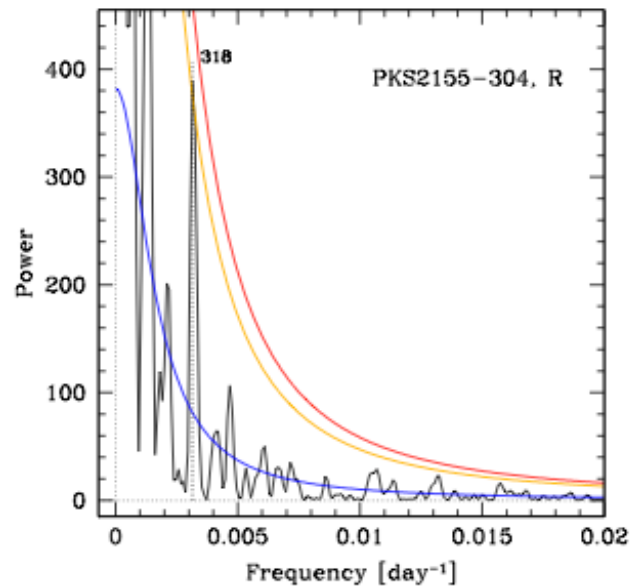
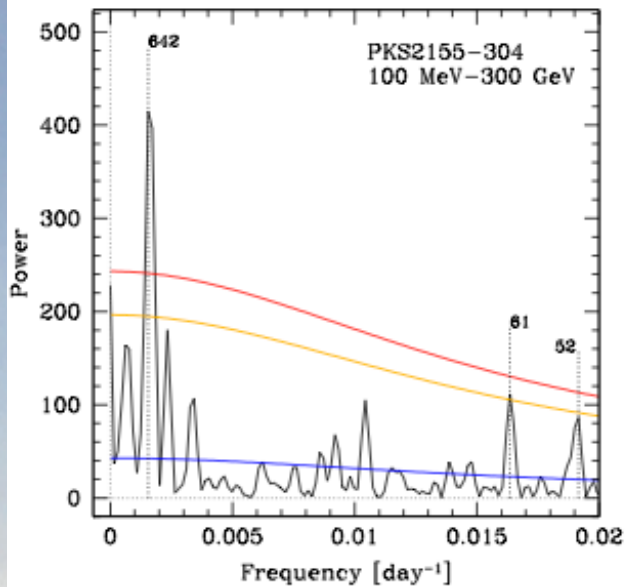
- Red Noise
 - Van der Klis 1987
 - Israel + Stella 1996
 - Vaughan 2005
- Irregular Sampling
- Shulz+Mudelsee 2002 (paleoclimatic time series)
- REDFIT



PKS 2155-304



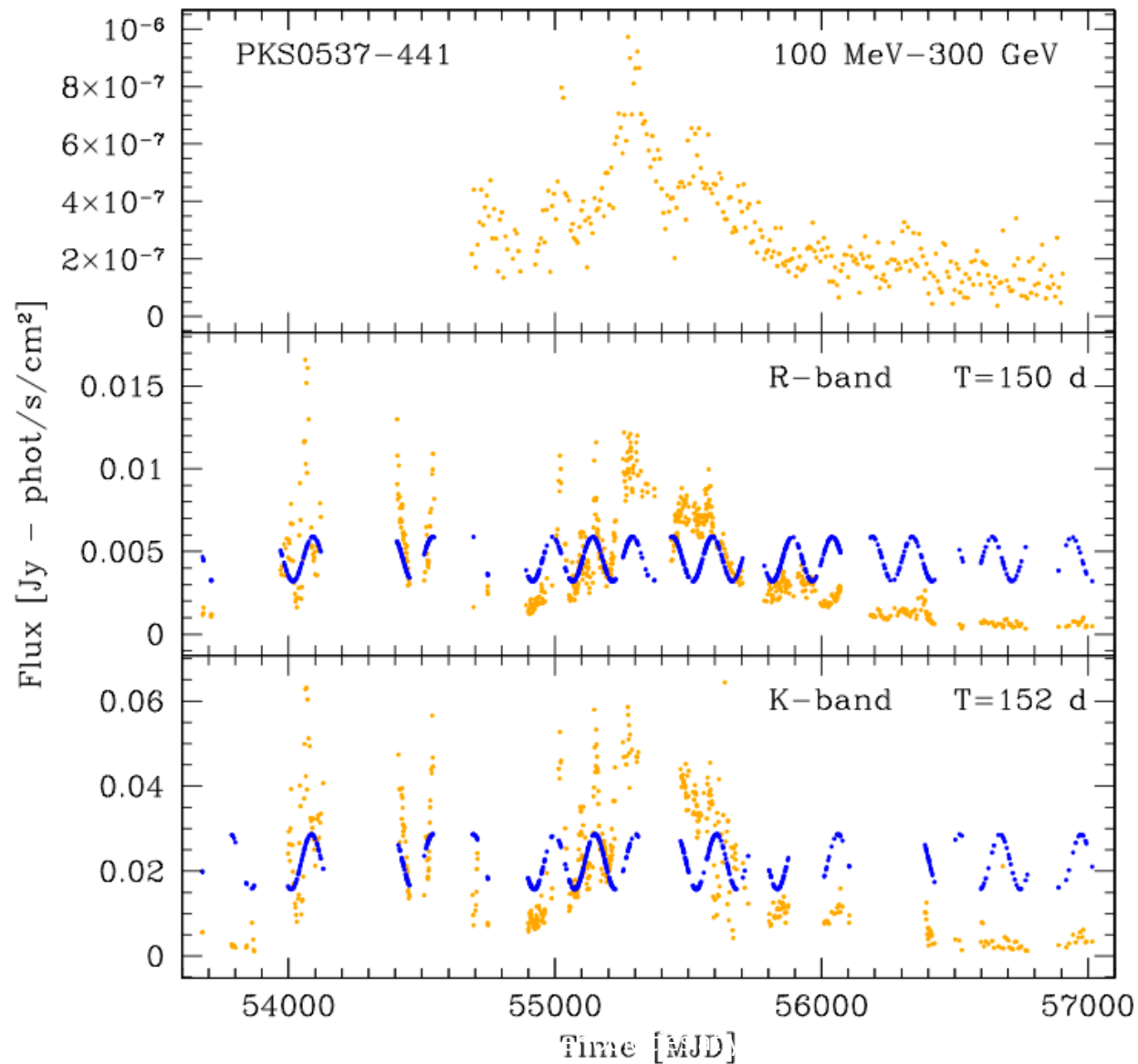
PKS 2155-304



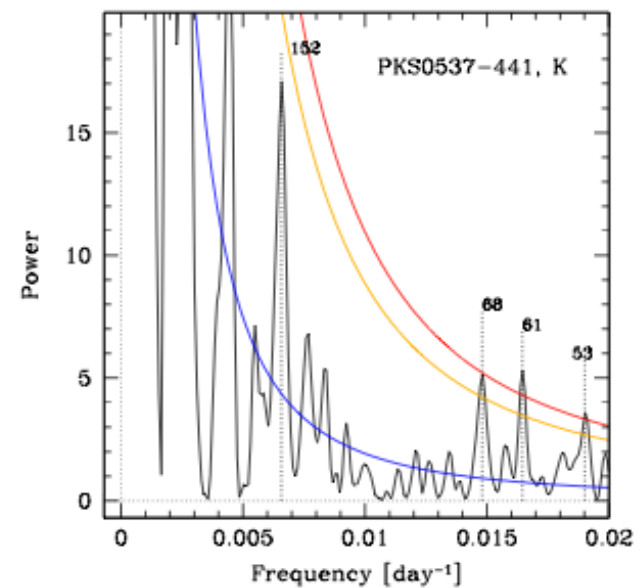
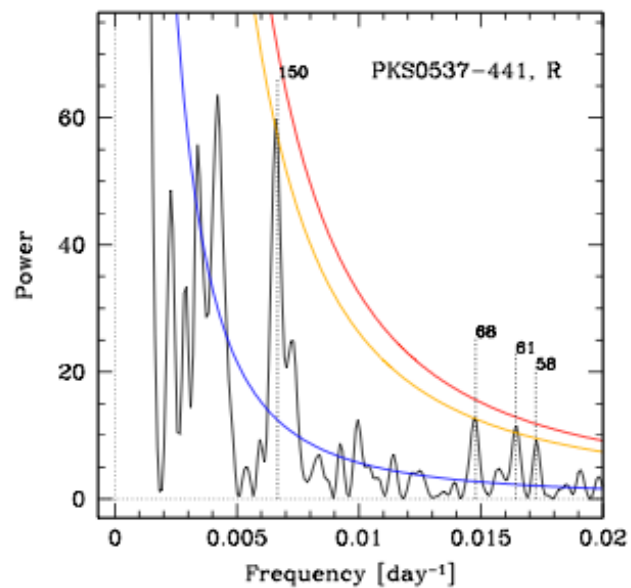
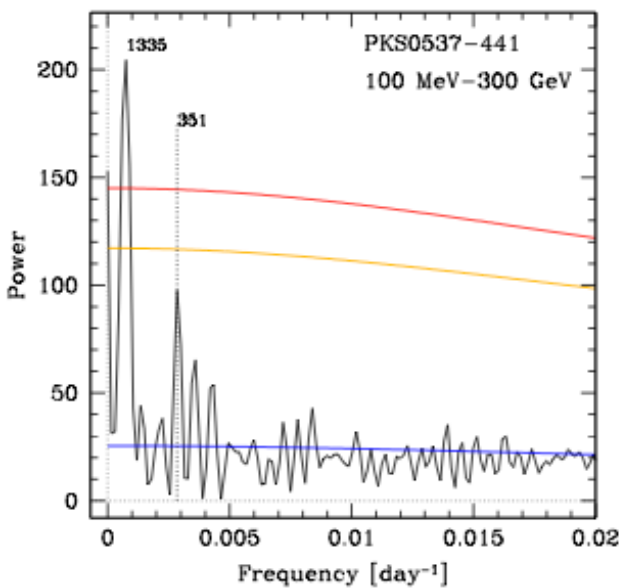
PKS 2155-304

Band	T_1	T_2	T_3	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	$S\% \geq$
100 MeV- 300 GeV	642±59	428±16					96±2		61±1	52±1	99.7 95.0 95.0 99.0 99.0
V			318±8				96±1	75±1	64±1		99.0 95.0 99.7 99.0
R			318±13				94±2	76±2	64±1		99.0 95.0 95.0 95.0
J			310±11				94±2	76±1	63±1		99.0 95.0 99.0 99.0
K		453±15	311±14	208±4	166±2	151±2	93±1	76±1	63±1		99.7 99.7 95.0 99.7 99.7 99.0 99.0 95.0

PKS 0537-441



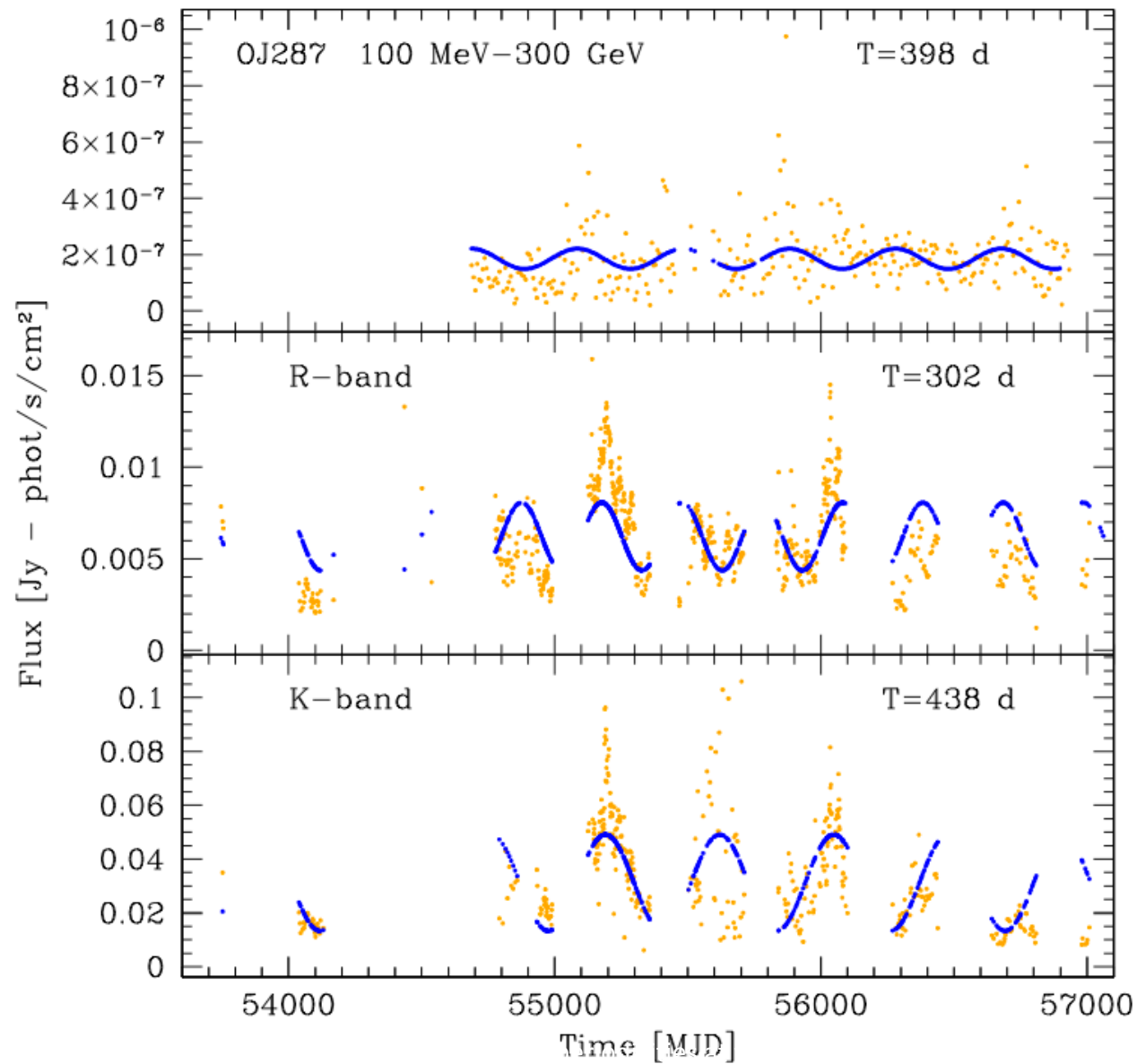
PKS 0537-441



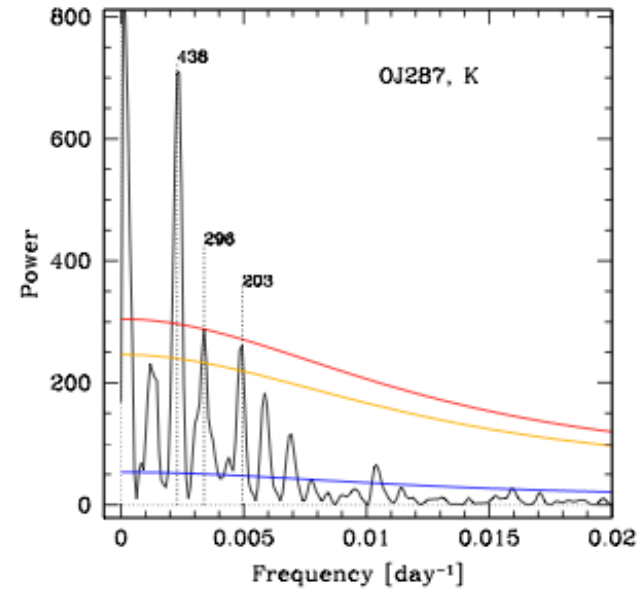
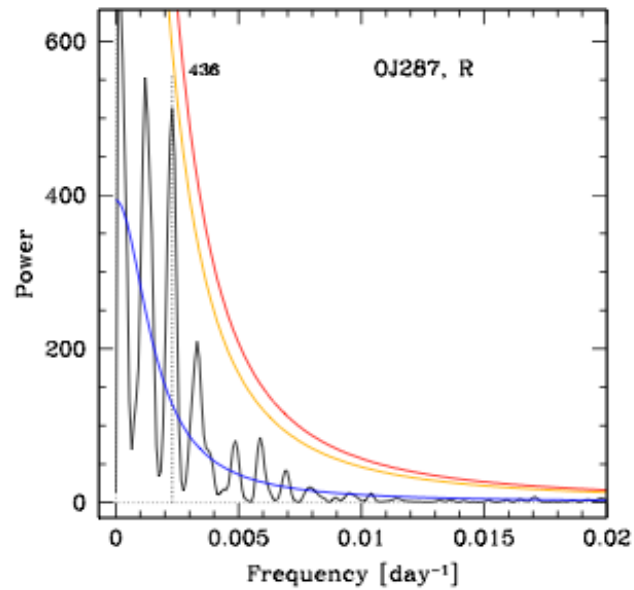
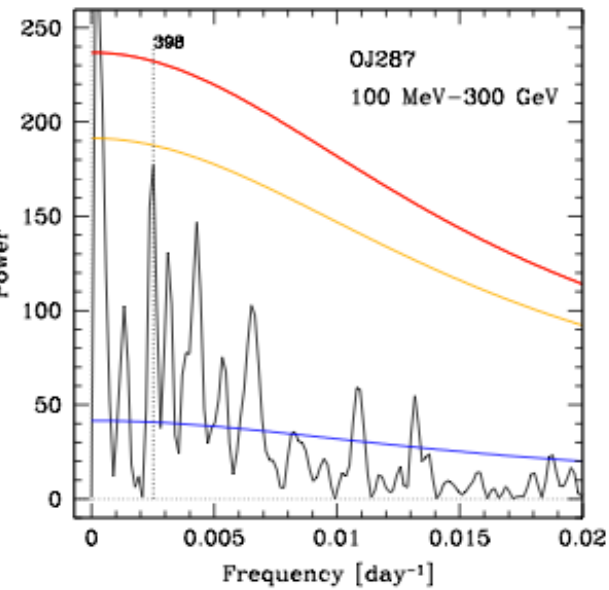
PKS 0537-441

Band	T_1	T_2	T_3	T_4	T_4	T_5	$S\% \gtrsim$
100 MeV- 300 GeV	351±16						95.0
R		150±3	68±1		61±1	58±1	99.0 99.0 99.0 99.0
J		153±3	68±1	63±1	61±1	53±1	99.0 99.0 99.0 99.7 99.0
K		152±3	68±1		61±1	53±1	97.0 99.7 99.7 99.7

OJ 287



OJ 287



OJ 287

Band	T_1	T_2	T_3	T_4	T_5	T_6	$S\% \gtrsim$
100 MeV -300 GeV		398 ± 25	322 ± 15	233 ± 8			99.0 95.0 95.0
V	837 ± 69	435 ± 19	302 ± 12			167 ± 4	95.0 99.7 95.0 95.0
R		436 ± 21	302 ± 14			170 ± 4	99.0 95.0 95.0
J	837 ± 70	436 ± 20	303 ± 9			171 ± 4	95.0 99.7 99.0 95.0
K	842 ± 196	438 ± 22	296 ± 10		203 ± 5	171 ± 7	95.0 99.7 99.7 99.7 95.0

Main Result

Quasi Variability on year time scale are not rare in Blazars

Models (basic ideas)

- 1. Orbital Period

$$M = 10^9 M_{\odot}$$

$$1 \text{ y} \longrightarrow 50 R_s$$

- 2. Disk precession

Future

- New sources observed in optical and gamma rays
- X-ray archives
- Gamma ray archives (AGILE)
- Monitoring in optical REM – SMARTS

