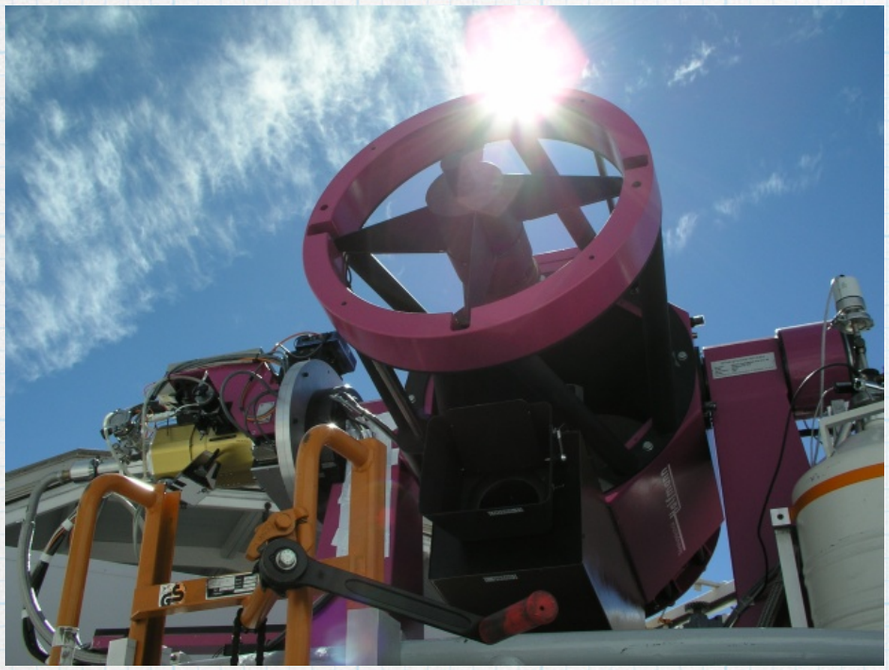
Quasi-Periodicities at Year Time Scales in Blazars

Stefano Covino

INAF / Brera Astronomical Observatory

Angela Sandrinelli, Aldo Treves, Elina Lindfors, Claudia Raiteri, etc.

Origin of the line of research

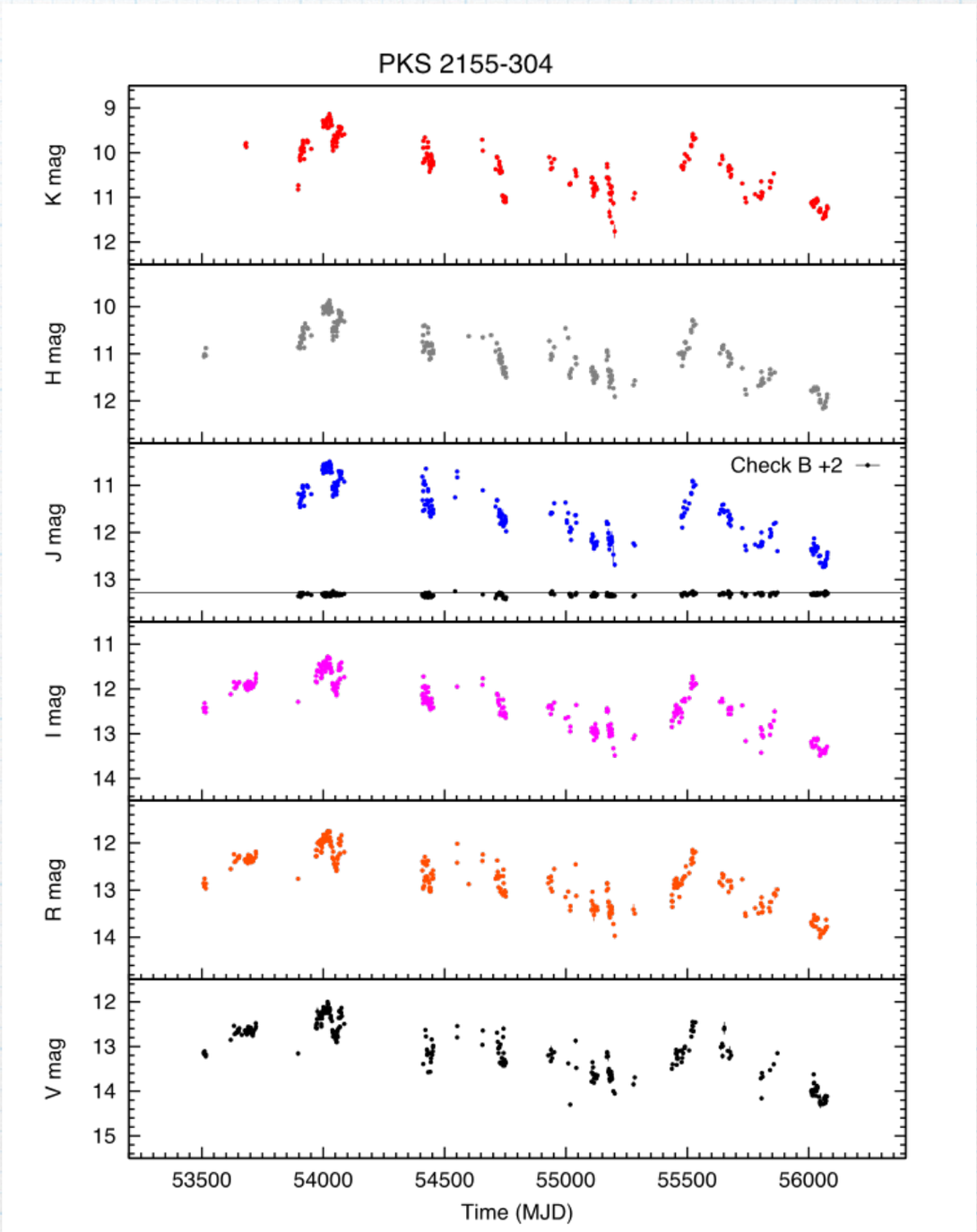


The REM telescope

Several years of blazer monitoring from robotic facilities are now available:

* PKS 0537-441, PKS 0735+17, OJ 287, 3C 279
* PKS 1510-089, PKS 2005-489, PKS 2155-304

Looking for variability on time-scales from hours to



The turning point: PKS 2155-304 and the Fermi data

* 35 years of photometry analyzed in Zhang et al. (2014)
  * Yielding T≈317 days
* In Sandrinelli et al. (2014) REM and and Fermi data were analyzed
  * T_{REM}≈317 days is confirmed and T_{Fermi}≈2T_{REM}

Looking for (quasi)periodicities

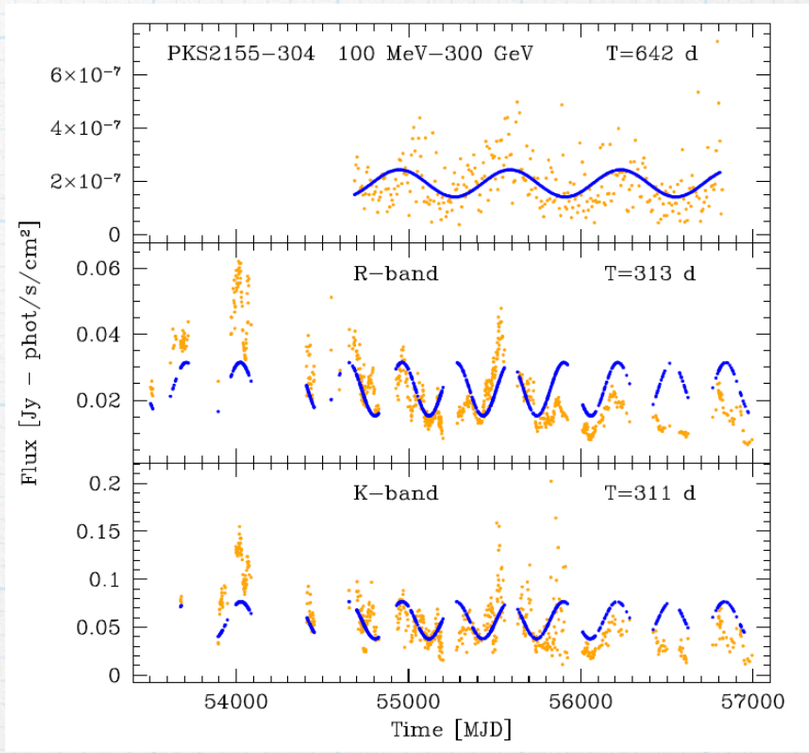
* Techniques are widely described in the literature (Lamb and Scargle 1982, Press 1988 and hundreds later...)

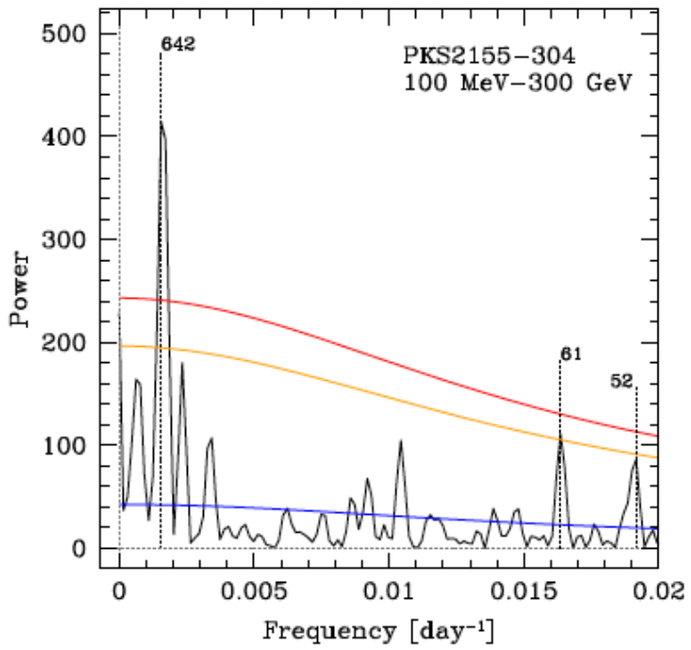
* If data are unevenly sampled things get considerably more complicated

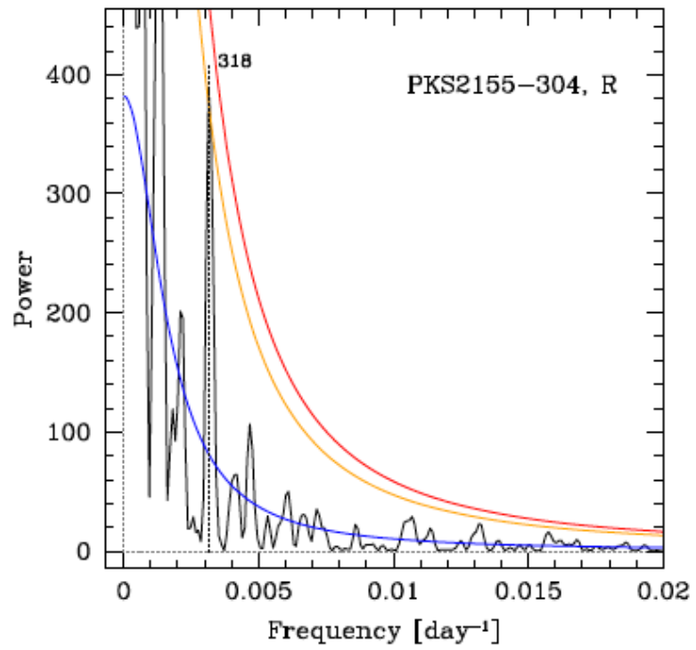
* Peak significance has to be evaluated by Monte Carlo simulations coupled with a noise model. In general no analytical solutions are available.

PKS 2155-305

* We collected all the available data after the launch of Fermi (Sandrinelli et al. 2016)

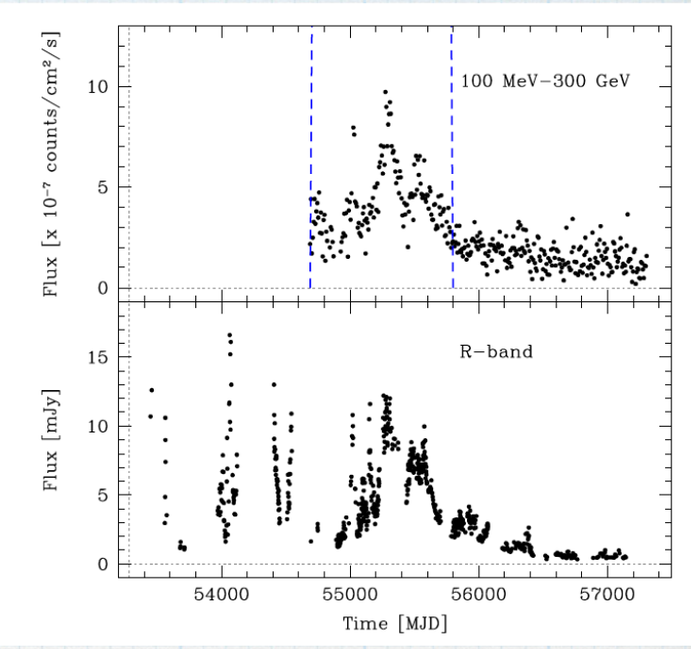


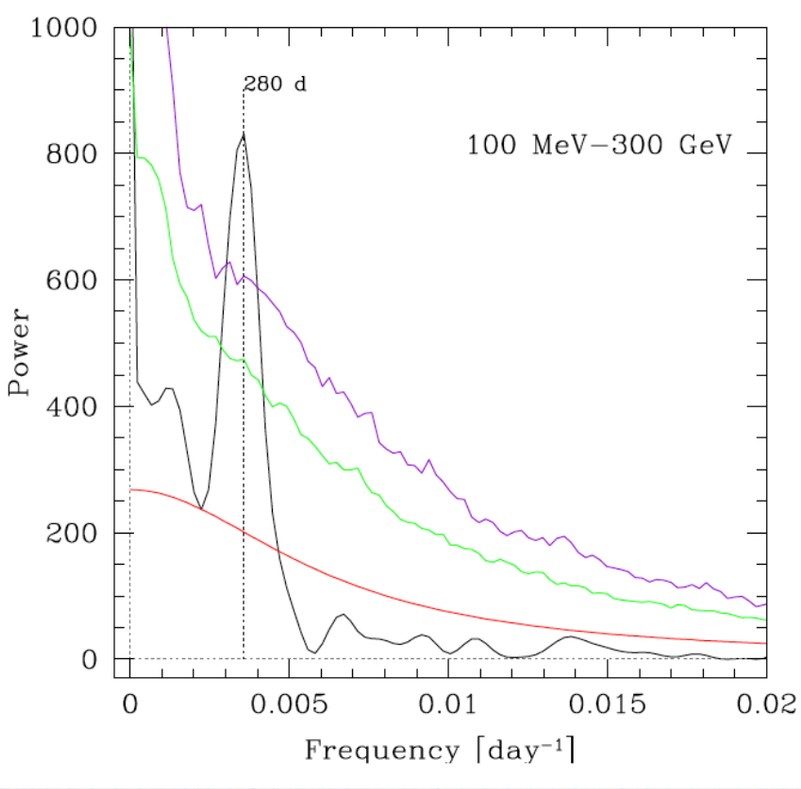


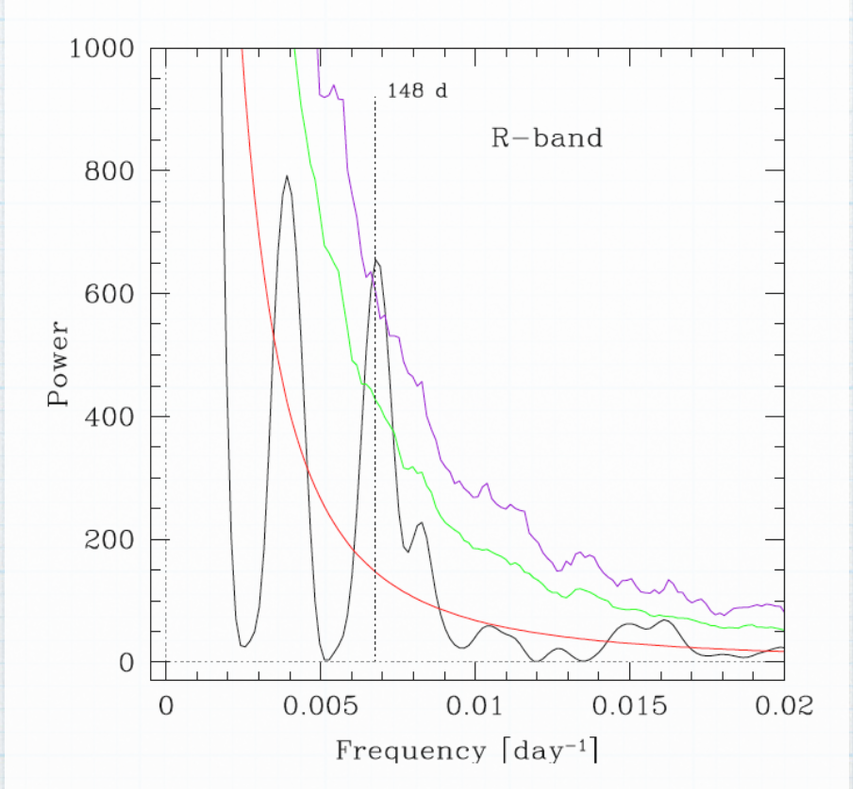


PKS 0537-441

* More than periodicities it seems there are oscillations during high-activity periods (D'Ammando et al. 2013; Sandrinelli et al. 2016).

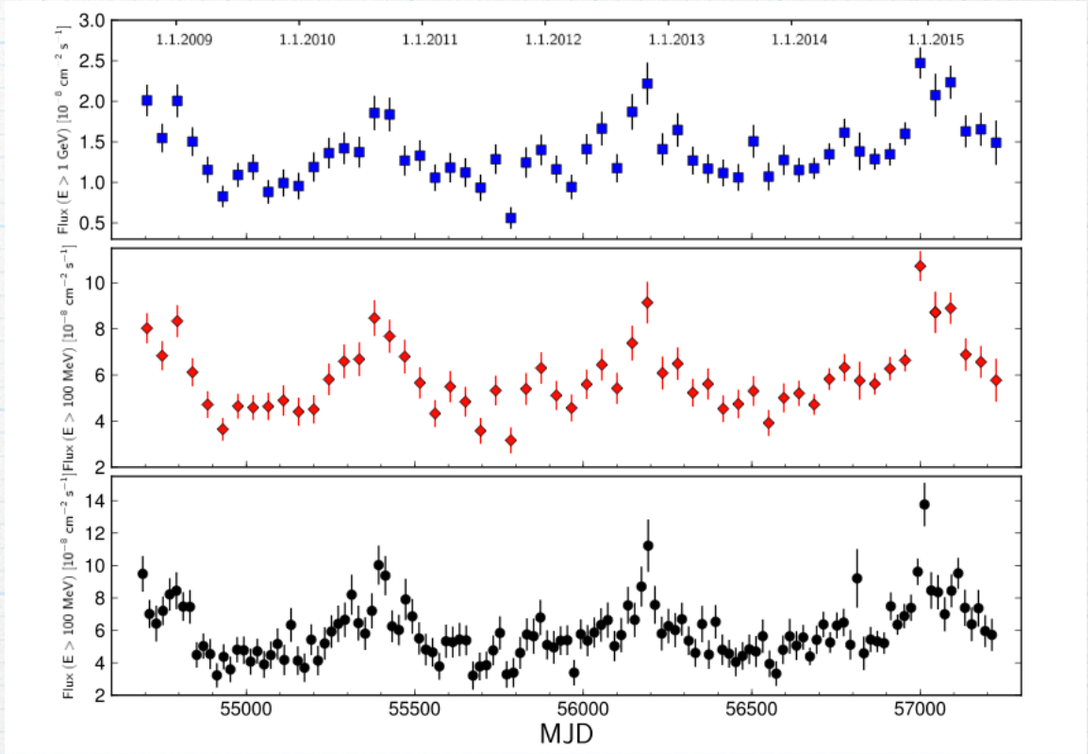


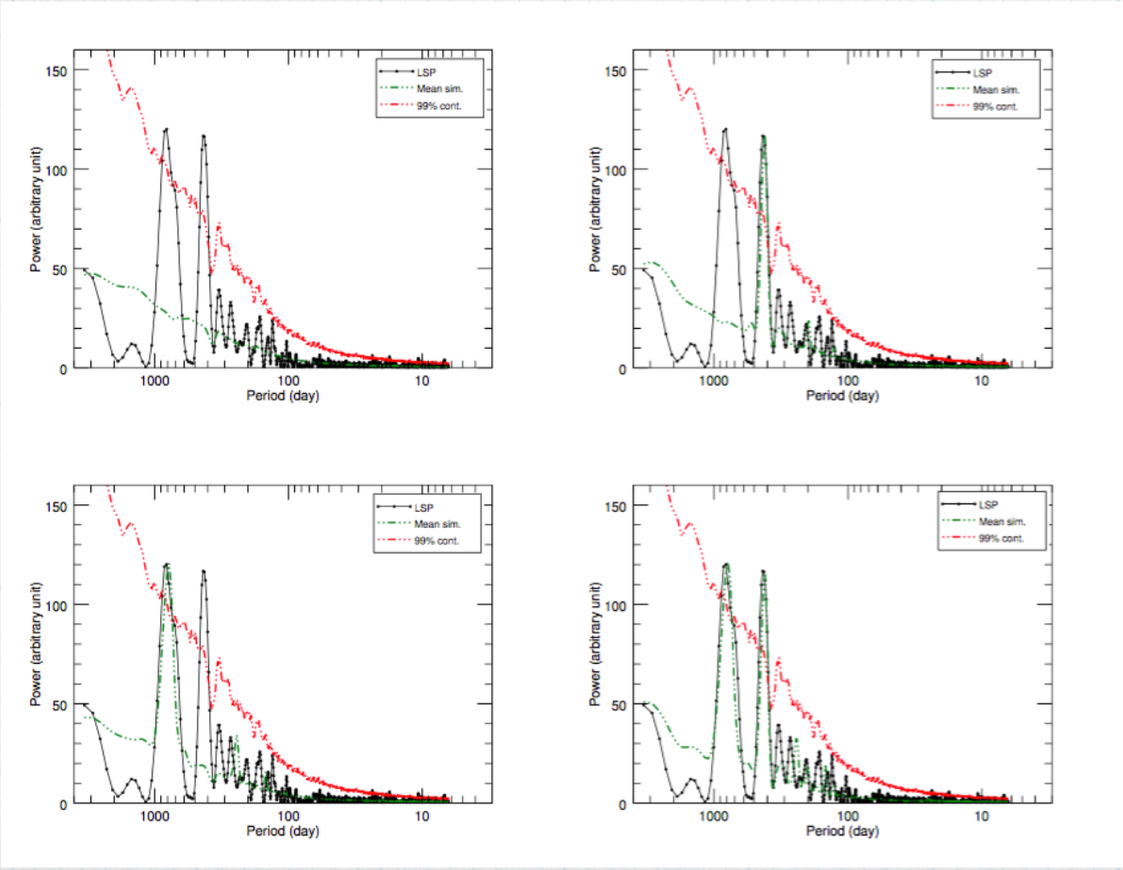




PG 1553+113 and OJ 287

* Other teams are carrying out similar analyses (Ackermann et al. 2015, PG 1553+0j287; Bhatia et al. 2016, OJ 287)





So...

* For a few well studied, bright, blazars (quasi)-periodicities with T≈several months / one year can be singled out.

* Typically the significance is modest (yet not negligible), however it is found independently in optical and high-energy bands

* In a sample of less than ten blazars four show hint of periodicities: PKS2155-304, PKS0537-441, PG1553+113, OJ287.

* It might be a fairly common phenomenon...

* There is also a (debated) claim about much less common periodicities for QSOs (Graham et al. 2015)

Blazars vs QSOs

* QSOs (no jets) → binaries?

* Blazars (jets) → more complicated scenarios

  * binary supermassive black holes, precessing jets, jets instabilities (Sandrinelli et al. 2014-16, Graham et al. 2015, Zheng et al. 2015, Liu et al. 2015, Ackermann et al. 2015, Bhatta et al. 2016)

Two comments

* It is not by chance that these results are now appearing in the literature (Fermi is collecting data since several years and robotic telescopes are operational since e.g. a decade)

* These results could have even been expected (Begelman, Blandford and Rees 1980) predicted T≈1.6 years periodicity.