Optical and radio variability of the northern VHE gamma-ray emitting BL Lac objects

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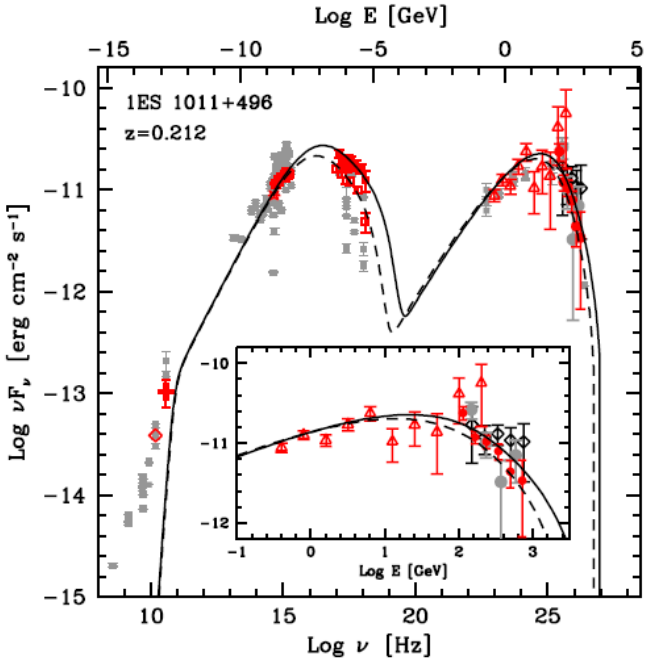
Motivation

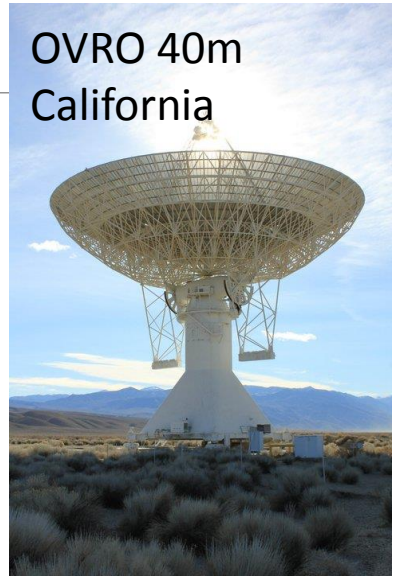
- The most numerous extragalactic VHE gamma-ray sources are high synchrotron peaking BL Lac objects, which are rather little studied in the radio bands (and even optical bands)
- It is rather common that we only look at the "snapshots" for this sources (no long term studies)
- One-zone SSC is extremely widely used to model the blazar spectral energy distributions and typically the radio data is ignored (with a statement that it originates from another region)

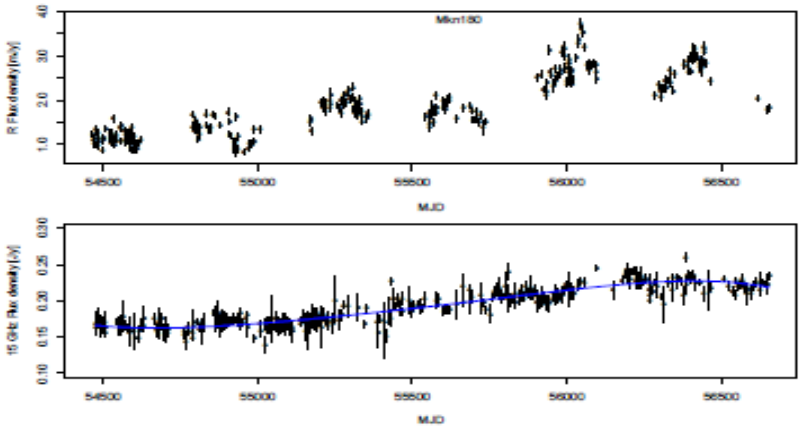


LINDFORS, HOVATTA ET AL. 2016, A&A IN PRESS (ARXIV:1606.0643)

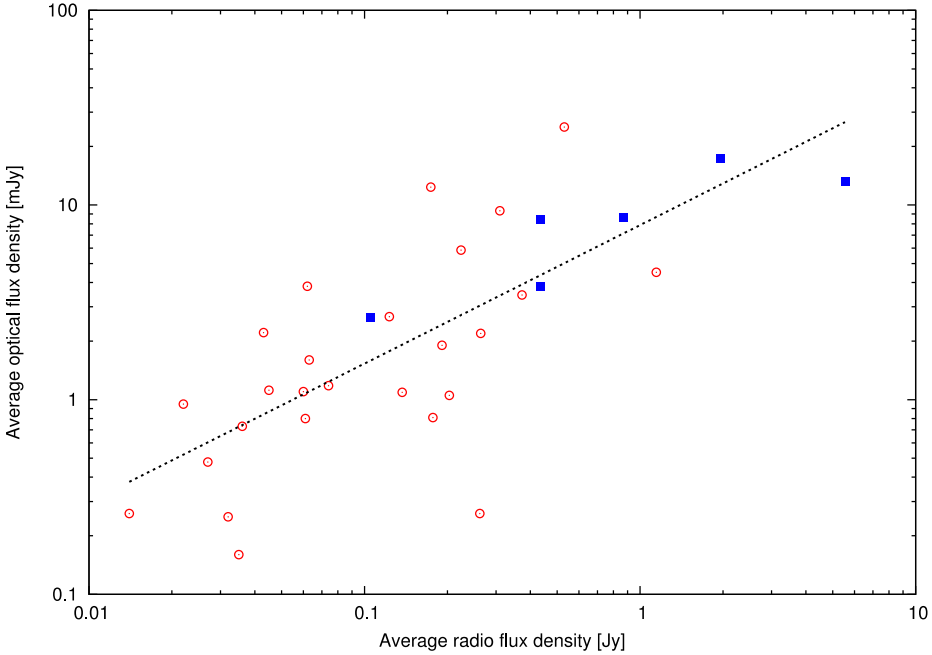
The data

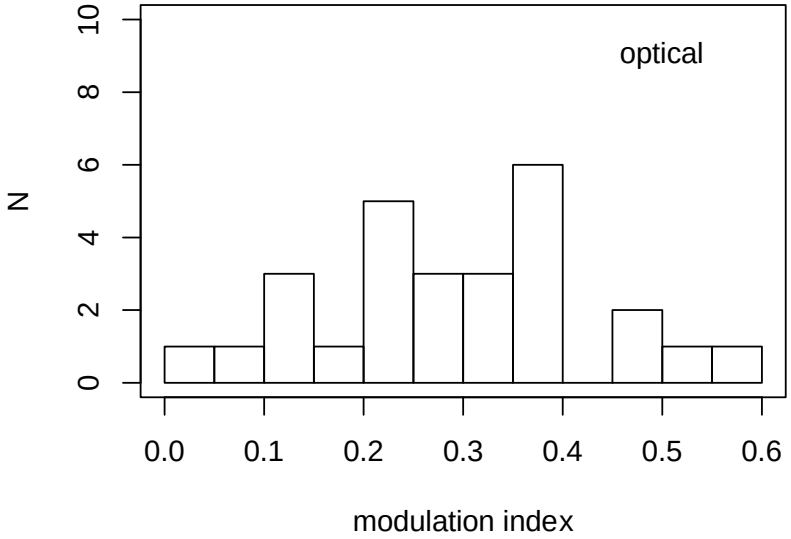
- 32 TeV-detected Northern BL Lac objects
- 15 GHz radio monitoring data from the OVRO telescope (http://www.astro.caltech.edu/ovroblazars/)
- Optical R-band monitoring from Tuorla blazar monitoring (http://users.utu.fi/kani/1m)

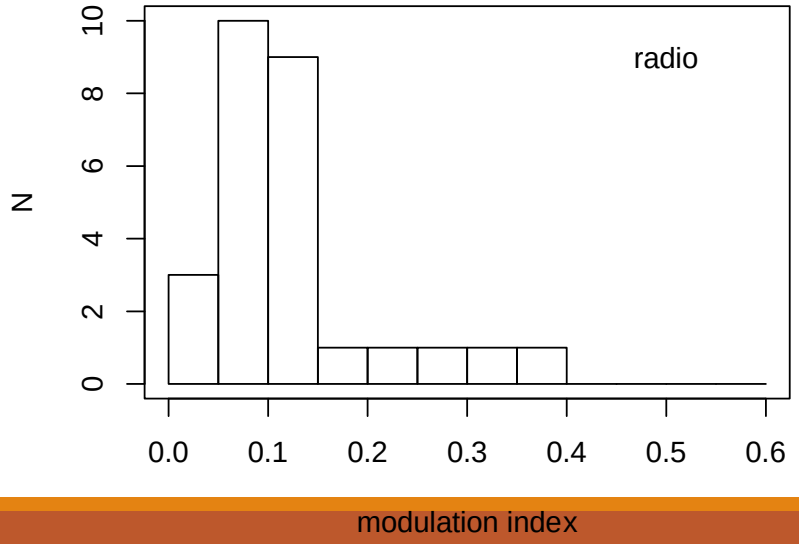




Optical vs. radio variability







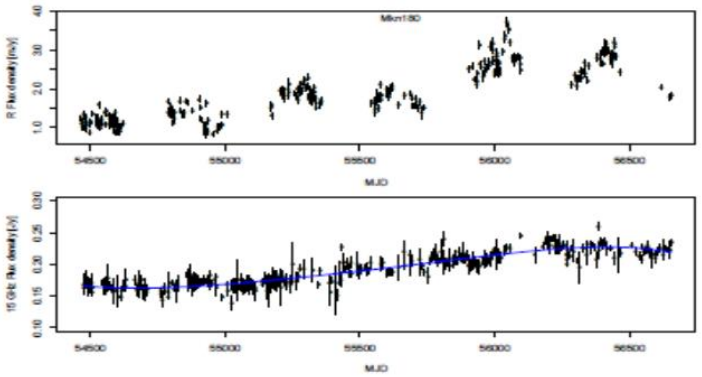
- Radio and optical fluxes correlated
- Optical has larger variability amplitudes than the radio
  - Modulation index = σ / mean

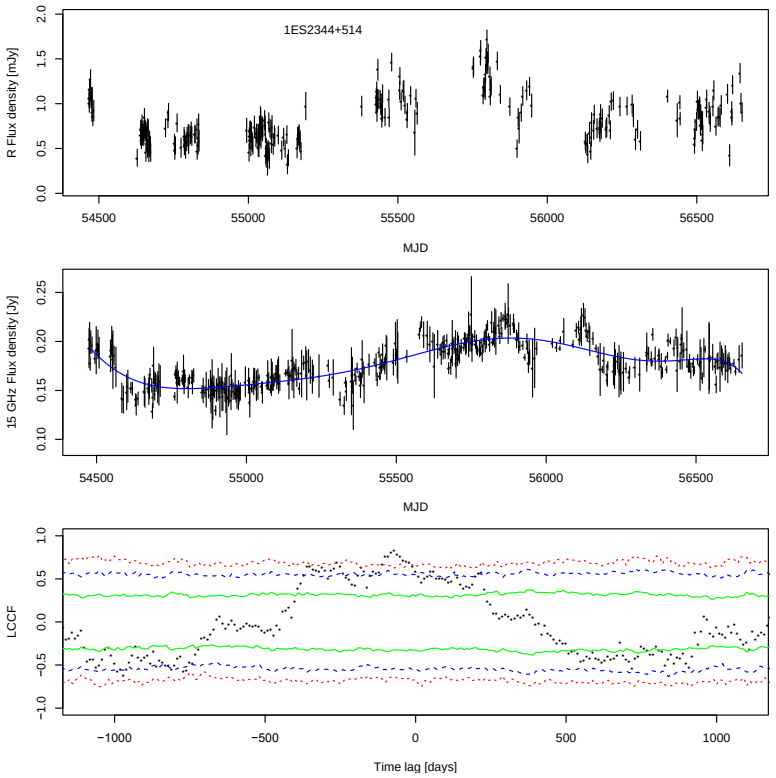
Common origin of variations

17 / 27 objects show significant peaks in correlation analysis

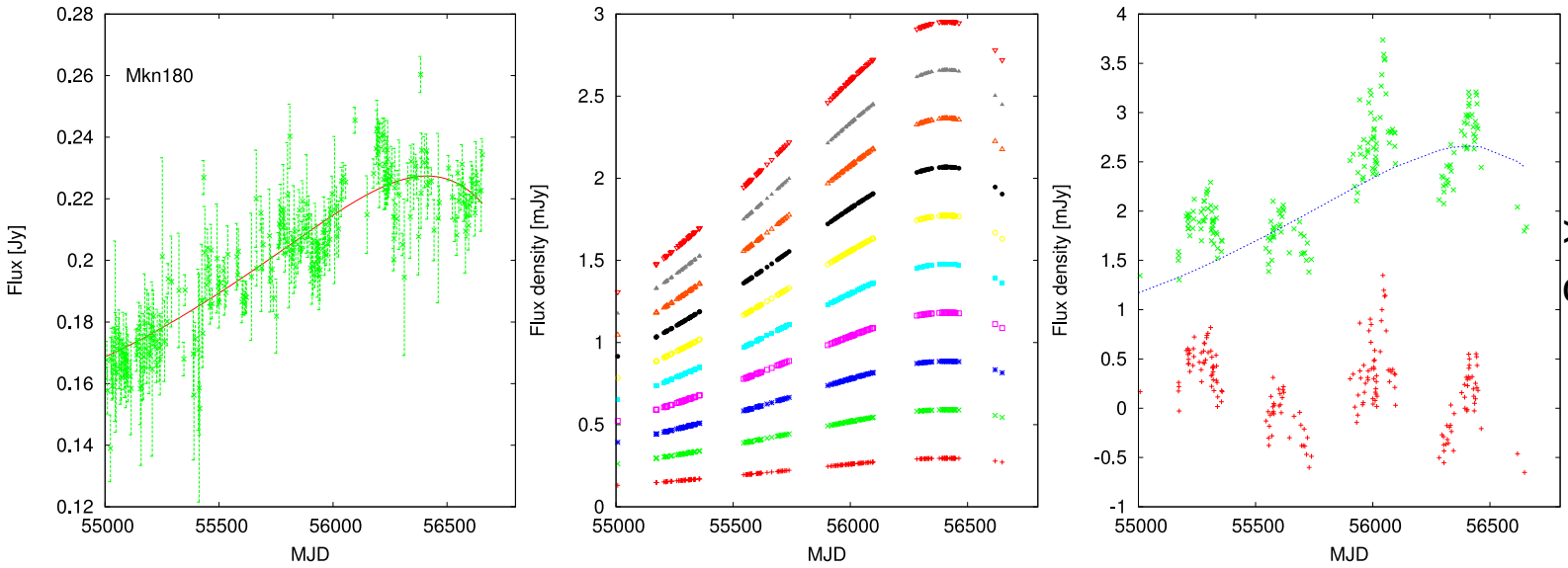
- Median lag 70 days, optical leading radio
- Radio variations in the “core”!

13 / 31 sources show common rising or declining trends

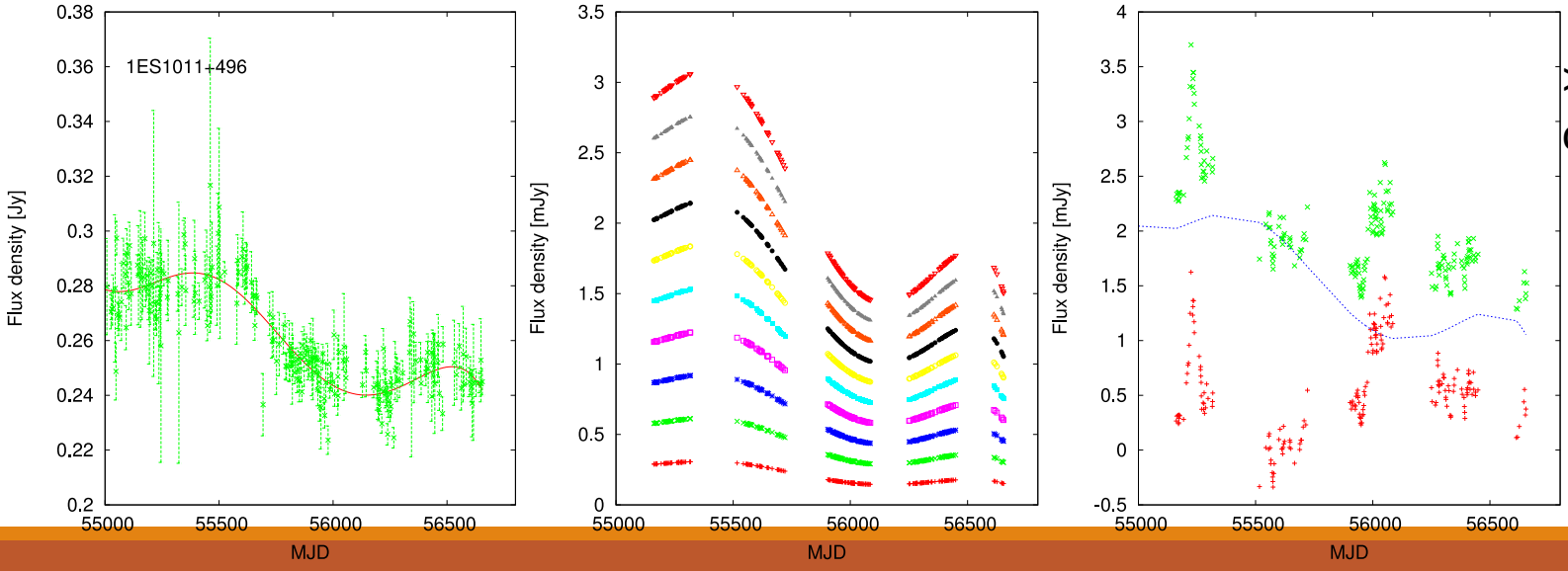




Common slow variability?



> 50% flux has common origin



> 25% flux has common origin

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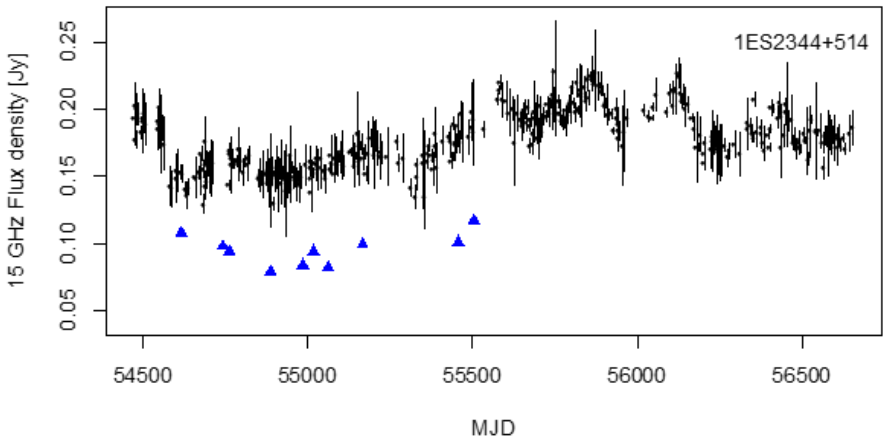
Nature of the slow variability

- Red noise with the highest frequency variations missing from the radio data? NO
- Radio core that we see with VLBA? YES

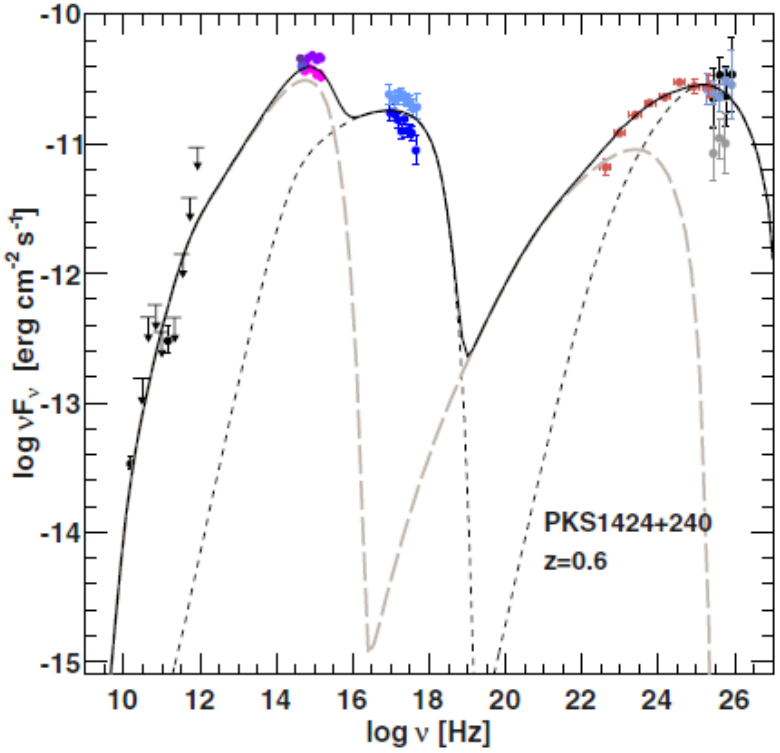


Blue: Core flux from MOJAVE (VLBA 15GHz)

SED modeling considerations

In about half of the sample sources at least some of the optical and radio emission (median >27 %) originates in the same emission region

- Single-zone models are not adequate for these objects
- Radio cannot always be ignored in SED modeling



Aleksic et al. 2014, A&A, 567, 135

Summary

About half of the Northern TeV-detected BL Lacs show a connection between optical and radio emission

- At least 27% of the emission in a common emission region
- Single-zone SED models not adequate
- Radio cannot be ignored

Looking at the other lower energy properties of the sample of VHE gamma-ray emitting population

- Work in progress
- Poster 19: V. Fallah Ramazani et al.