The RoboPol optopolarimetric blazar monitoring program

Vasiliki Pavlidou
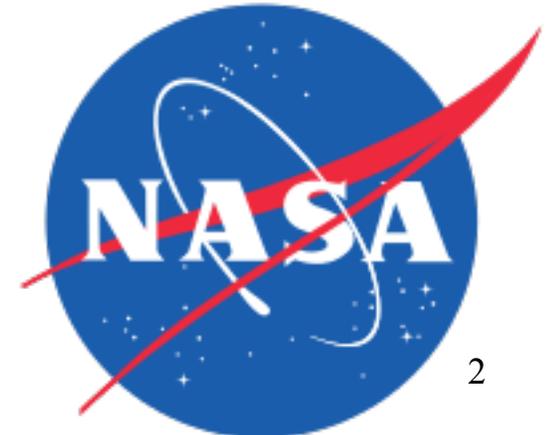
on behalf of the RoboPol Collaboration
U. Crete/FORTH-MPIfR-Caltech-IUCAA-NCU

Monitoring the non-thermal Universe 2018
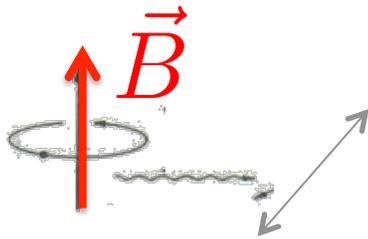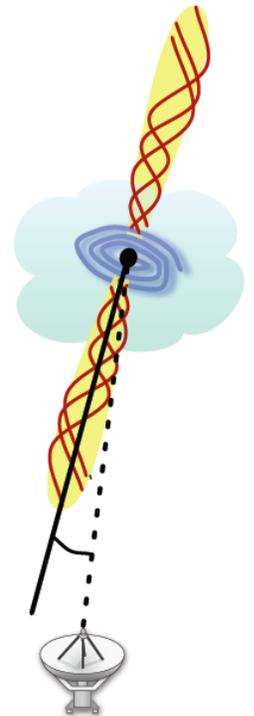
2

Blazars: Optical = optically thin Synchrotron:

- highly linearly polarized $\perp \vec{B}$
- contribution from all emitting regions along LOS

Optical polarization informs about:
- **geometry** of emission-region $\vec{B}$
- **number** of emitting cells along LOS
- how **ordered** $\vec{B}$ is
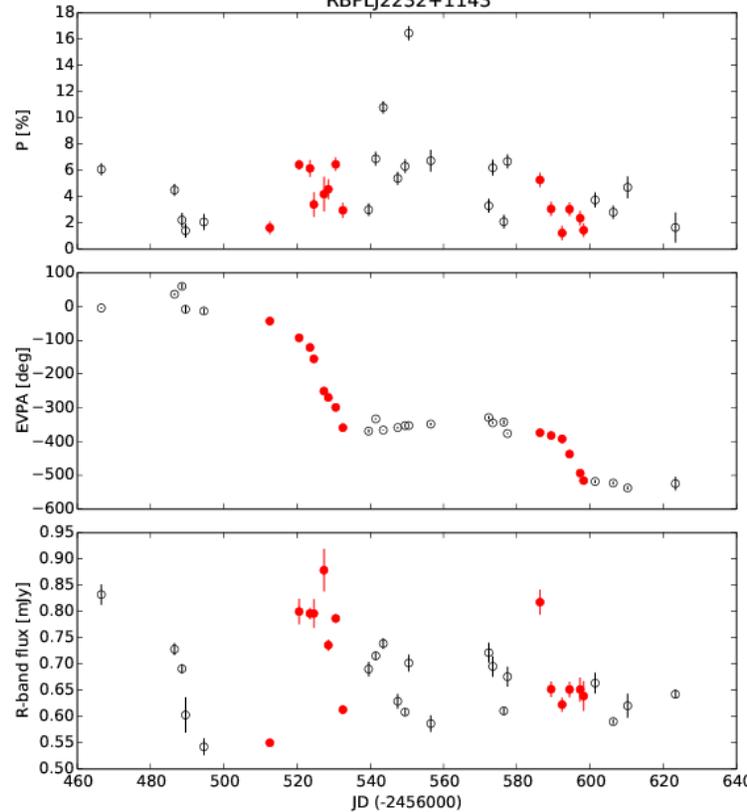
Optical polarization in blazars is *variable*

CTA 102
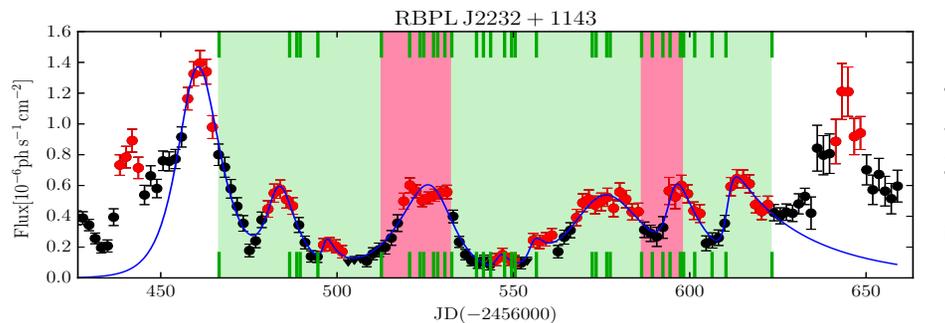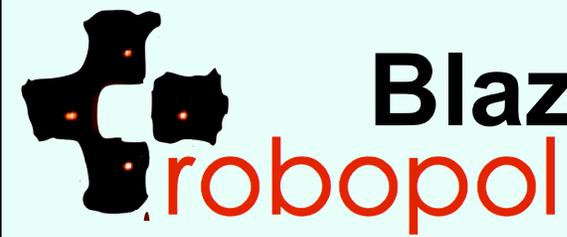

polarization fraction (RoboPol)

polarization angle (RoboPol)

optical flux   (RoboPol)

GeV gamma-ray flux (Fermi)

4

Blazar Optopolarimetry Questions:

-- **Are γ-ray—loud and γ-ray—quiet blazars different in optical polarization?**

-- **Do all blazars exhibit polarization rotations?**

-- **Are polarization rotations related to γ-ray flares?**

-- **What is a rotation? Does it matter?**

-- **What are the typical optopolarimetric properties of blazars?**
   Could we recognize yet-unknown blazars in the optical
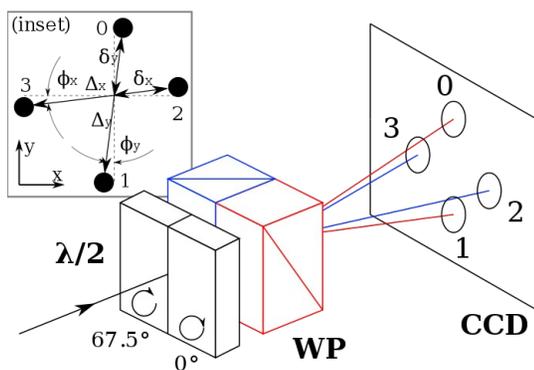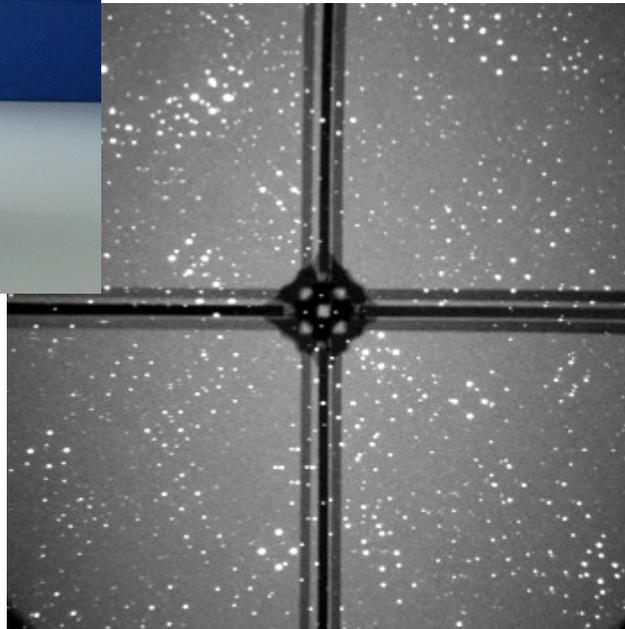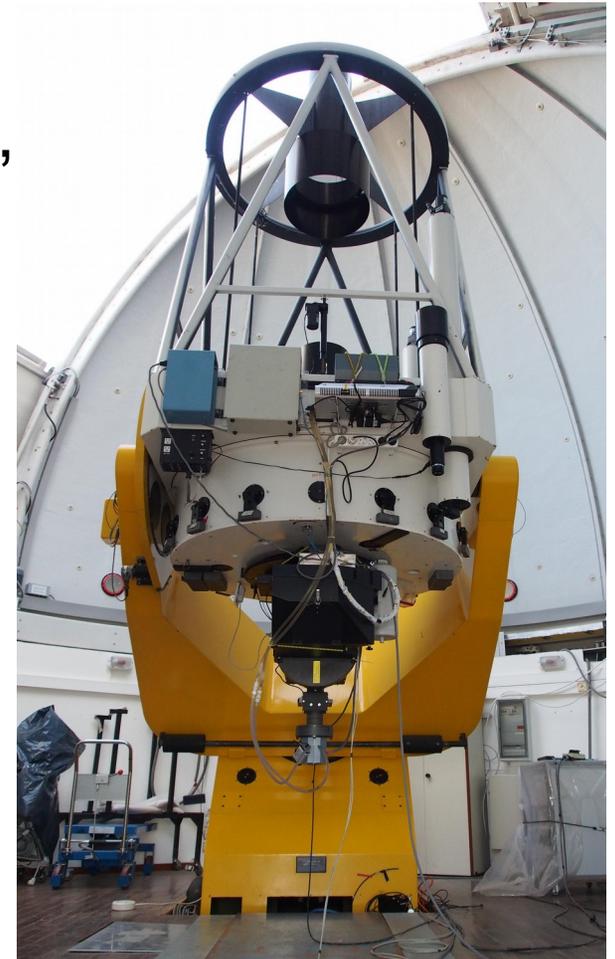   from their optopolarimetric signature?

Robopol Program Features

✓ **Low-systematics, high-sensitivity polarimeter**

✓ **Ample telescope time:** 4 nighs/week for 3 years at
  Skinakas 1.3 m telescope
  (1750m, median seeing 0.6 arcsec)

✓ **Statistically robust sample**

✓ **Unbiased observing strategy**
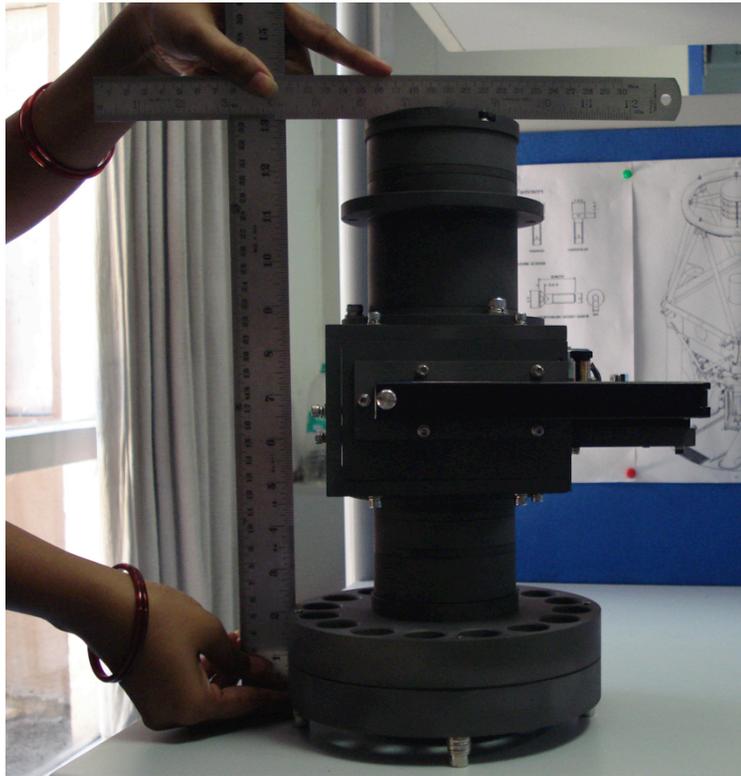
No moving parts,
low systematics,
high sensitivity

robopol

✓ **Main:** 62 γ-ray – loud blazars
   R<17.5 mag, F(>100 MeV) > 2×10^{-8} cm^{-2} s^{-1}

✓ **Control**: 15 γ-ray – quiet blazars, similar in
   radio flux, spectra, variability with main
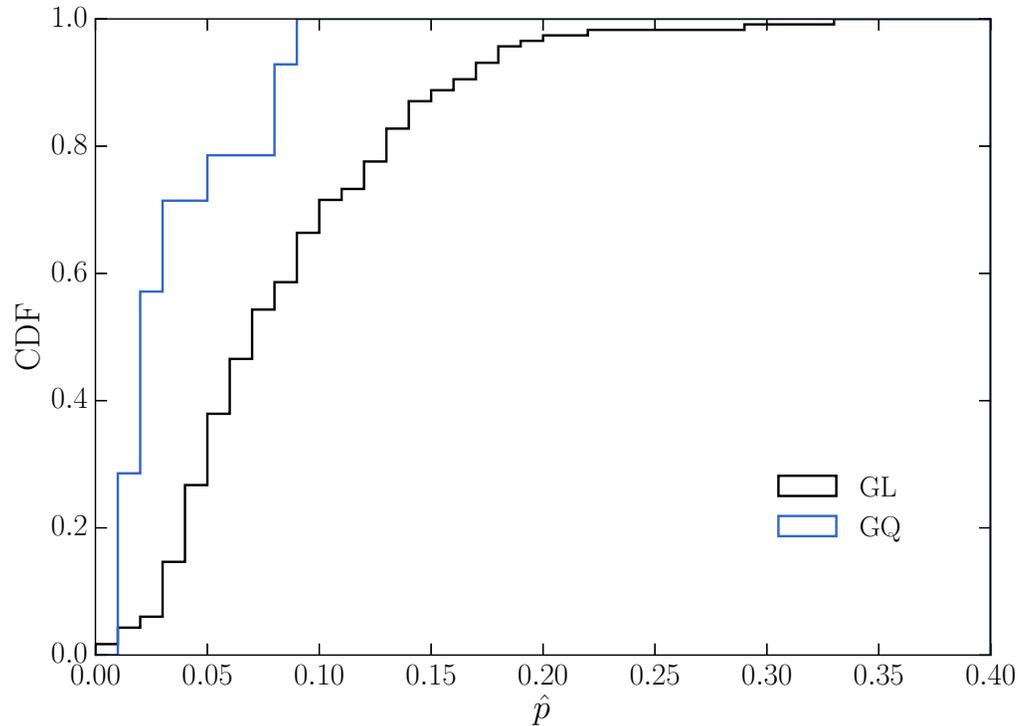
Pavlidou et al. 2014

RoboPol Rotation Definition

- ✓ **Continuous EVPA change > 90°**

- ✓ **Comprised by ≥ 4 measurements with significant swings between them**

- ✓ **Start/End points defined by x5 change in slope OR change in slope sign**

Blinov et al. 2015

Individual rotation properties depend on these choices Statistical results do not

Kiehlmann et al. 2018 in prep

Median p of γ-loud blazars almost **x3** median p of γ-quiet blazars

Median p, γ-loud: 0.074
Median p, γ-quiet: 0.025

different at >4σ

result persists independently of p quantification (median, mean, single-epoch)

Angelakis et al. 2016
Pavlidou et al. 2014

Are γ-ray—loud and γ-ray—quiet blazars different in optical polarization?
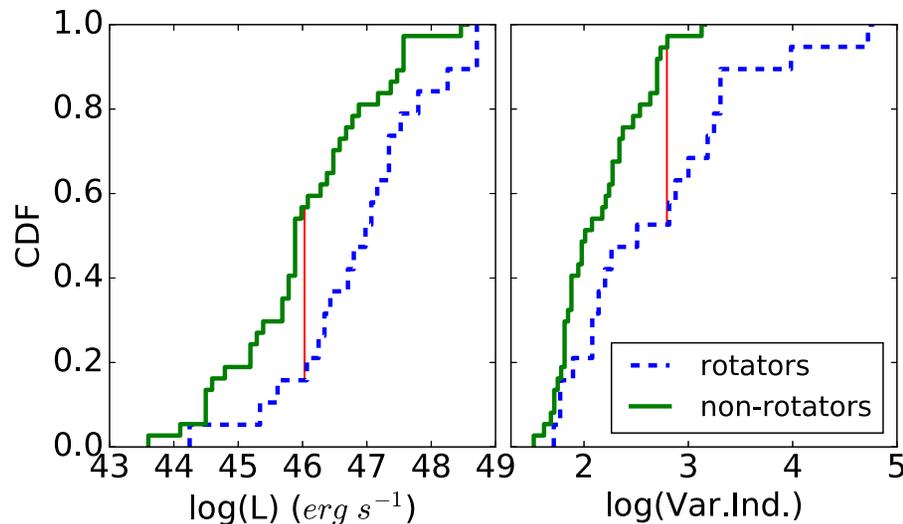
YES

Do all blazars rotate?

Prior to RoboPol: 16 rotations in 10 blazars
3 years of RoboPol: + 40 rotations in 24 blazars

1. Chance to find rotations only in 24 blazars if rotation frequency uniform in all blazars: **10^{-7}**
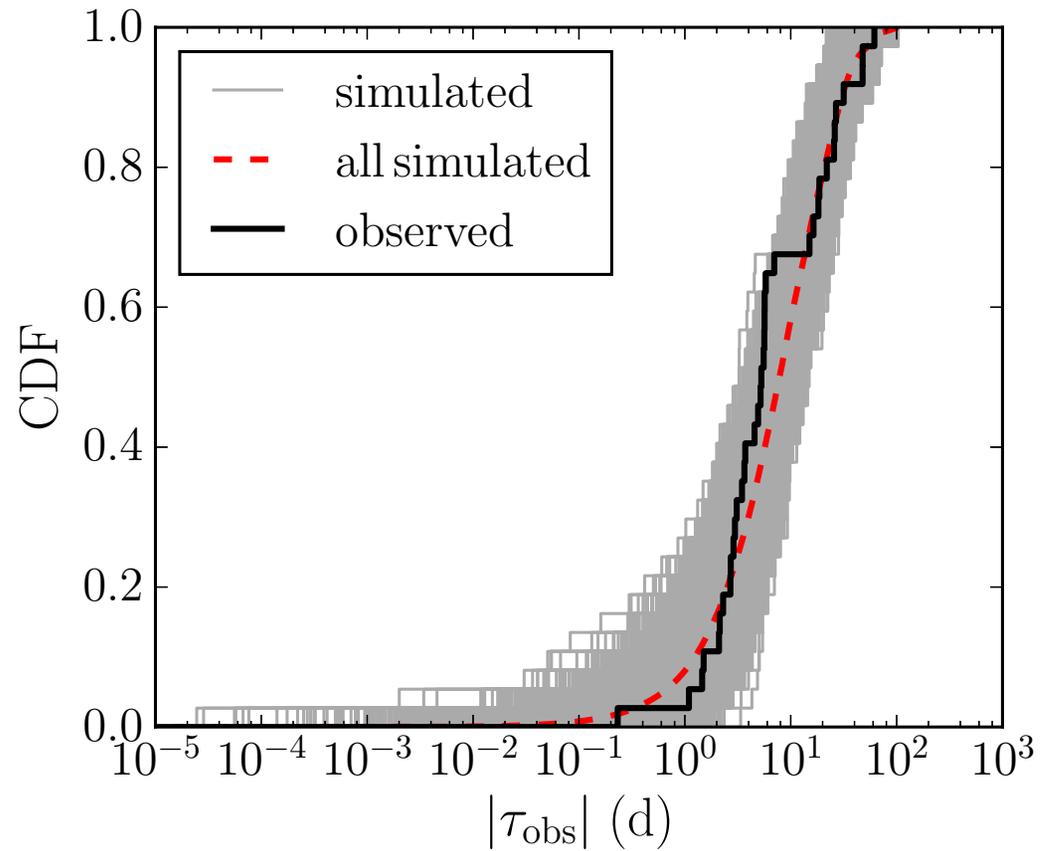
2. Rotators have different γ-ray properties than non-rotators

rotators are:
more luminous
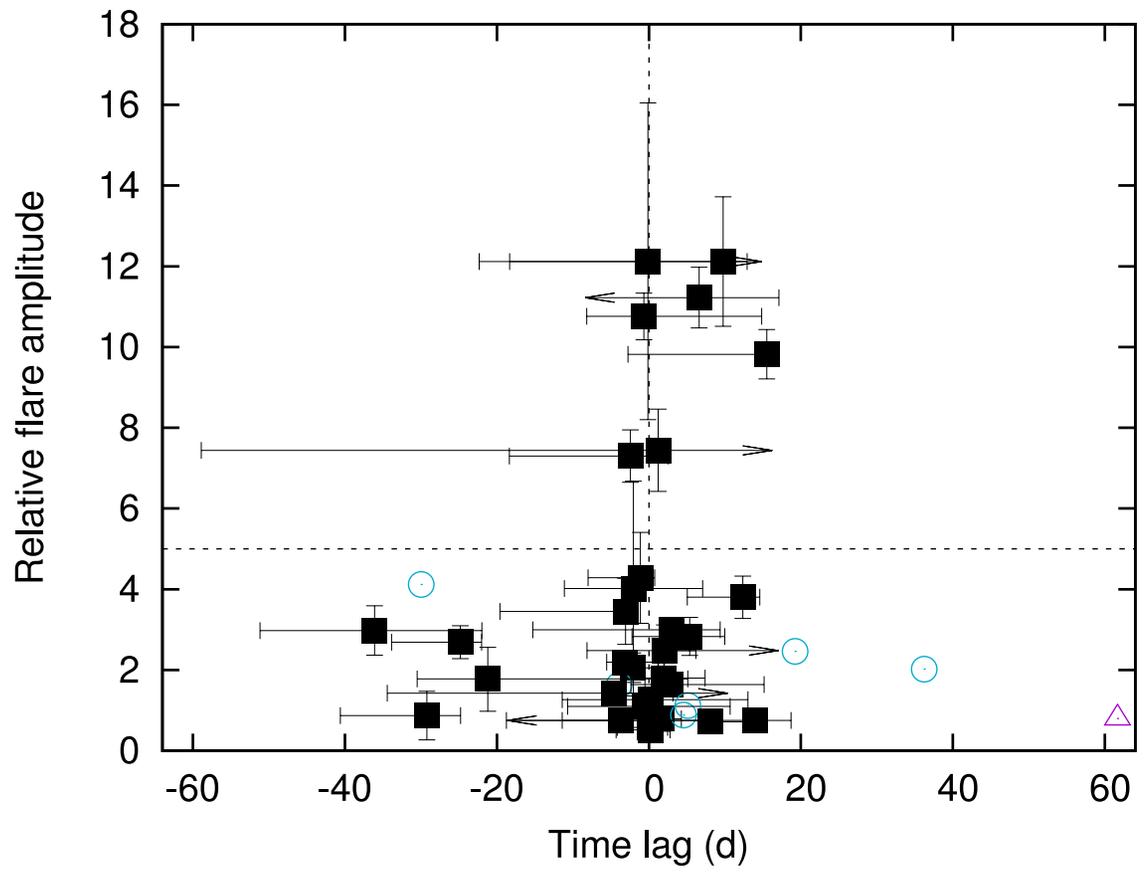**more variable**

Blinov et al. 2016

Do all blazars exhibit polarization rotations?

NO

P=2x10⁻⁴

Blinov et al. 2018   **Lags too small to be random**

Blinov et al. 2018

all lags consistent with zero
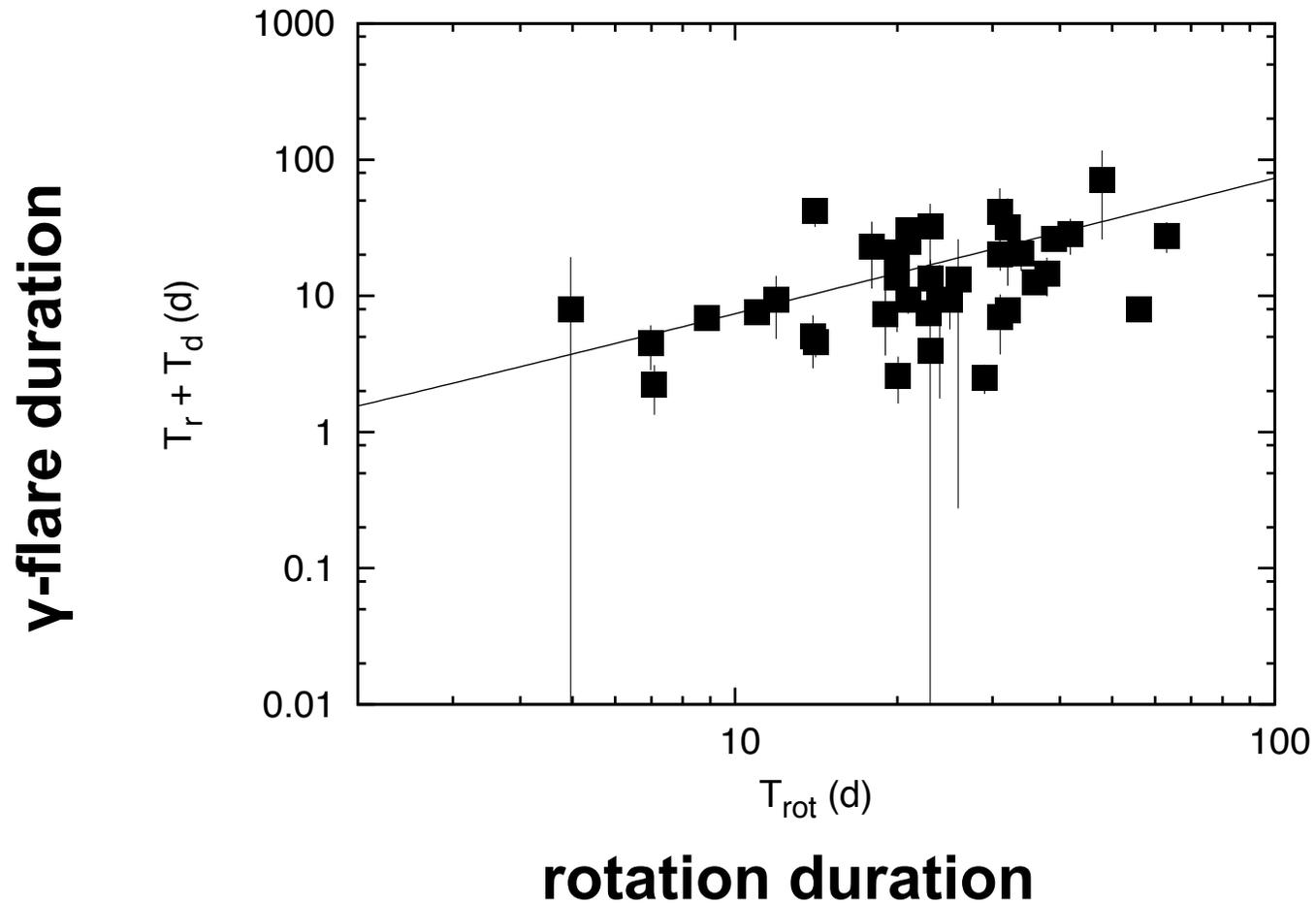
robopol

γ-flare duration

$T_r + T_d$ (d)

T_{rot} (d)

rotation duration

Blinov et al. 2018

Are γ-ray—loud and γ-ray quiet blazars different in optical polarization?
**YES**. γ-loud blazars are significantly more polarized

Do all blazars exhibit polarization rotations**?**
NO. Introducing the "rotator class of blazars":
rotates its polarization plane, brighter in γ-rays, more variable

Are polarization rotations related to γ-ray flares?
YES. Time lags with γ-flares too small for random associations.
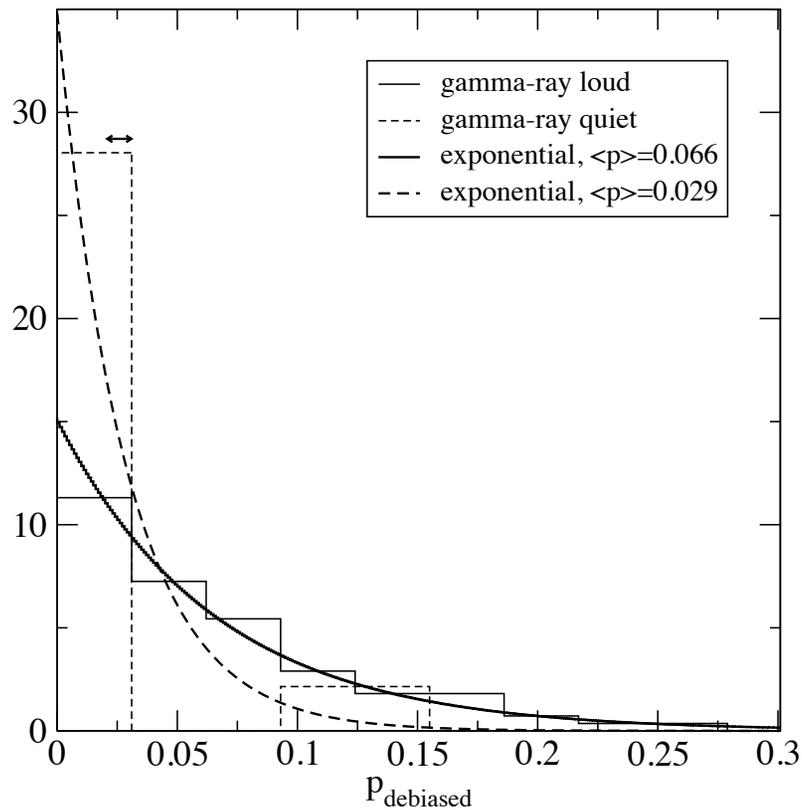Durations of rotations and nearest gamma-flares are correlated.

robopol

flare luminosity-rotation length anticorrelation

Blinov et al. 2018

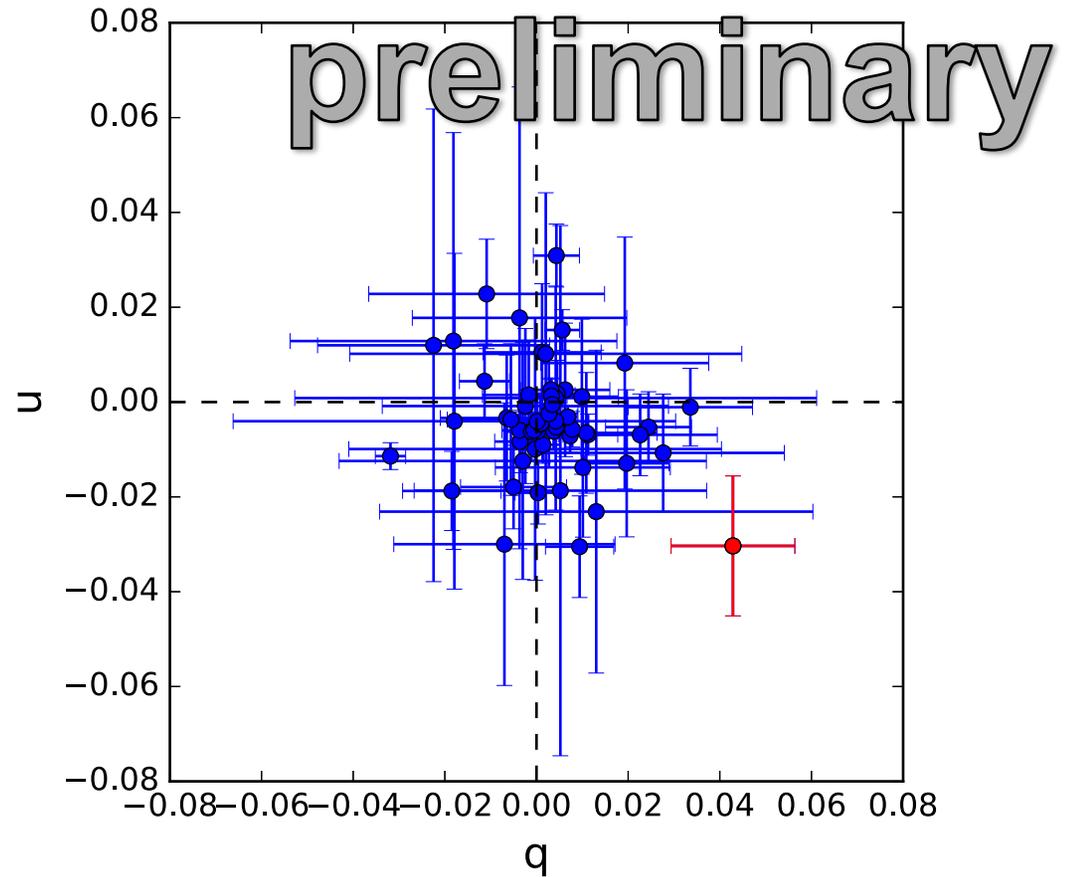# Rotations Bonus II:

NLSy1s rotate!

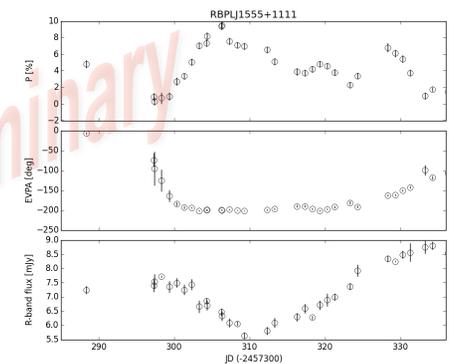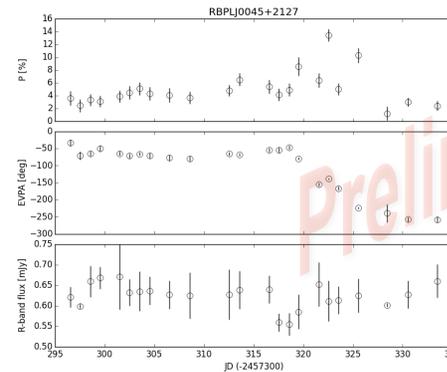Angelakis et al. 2018
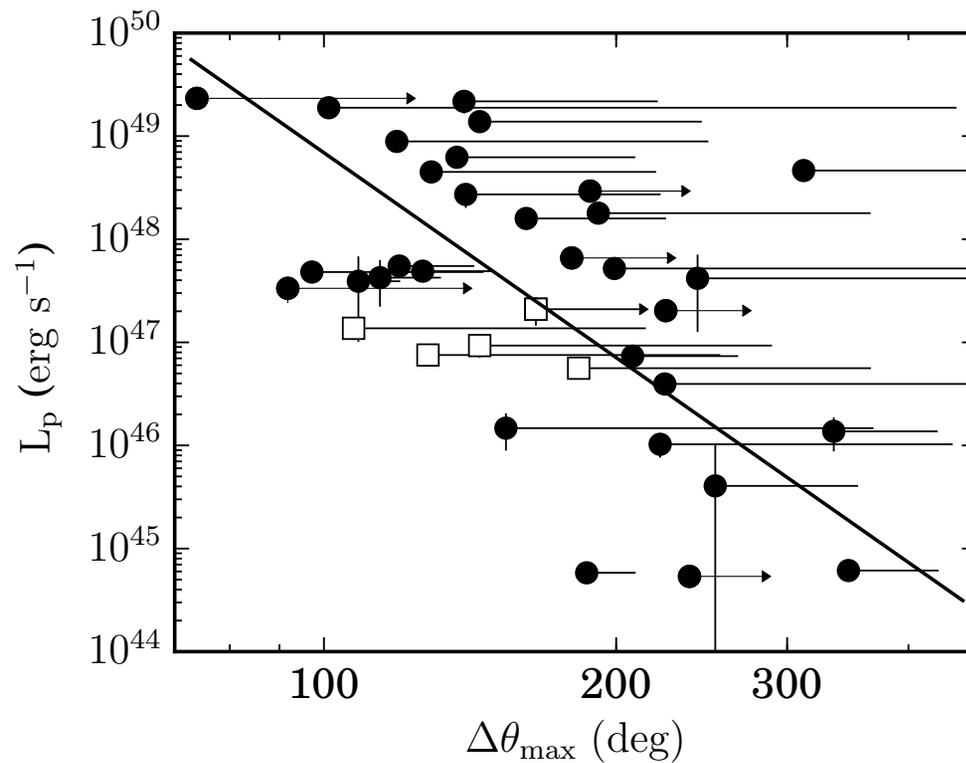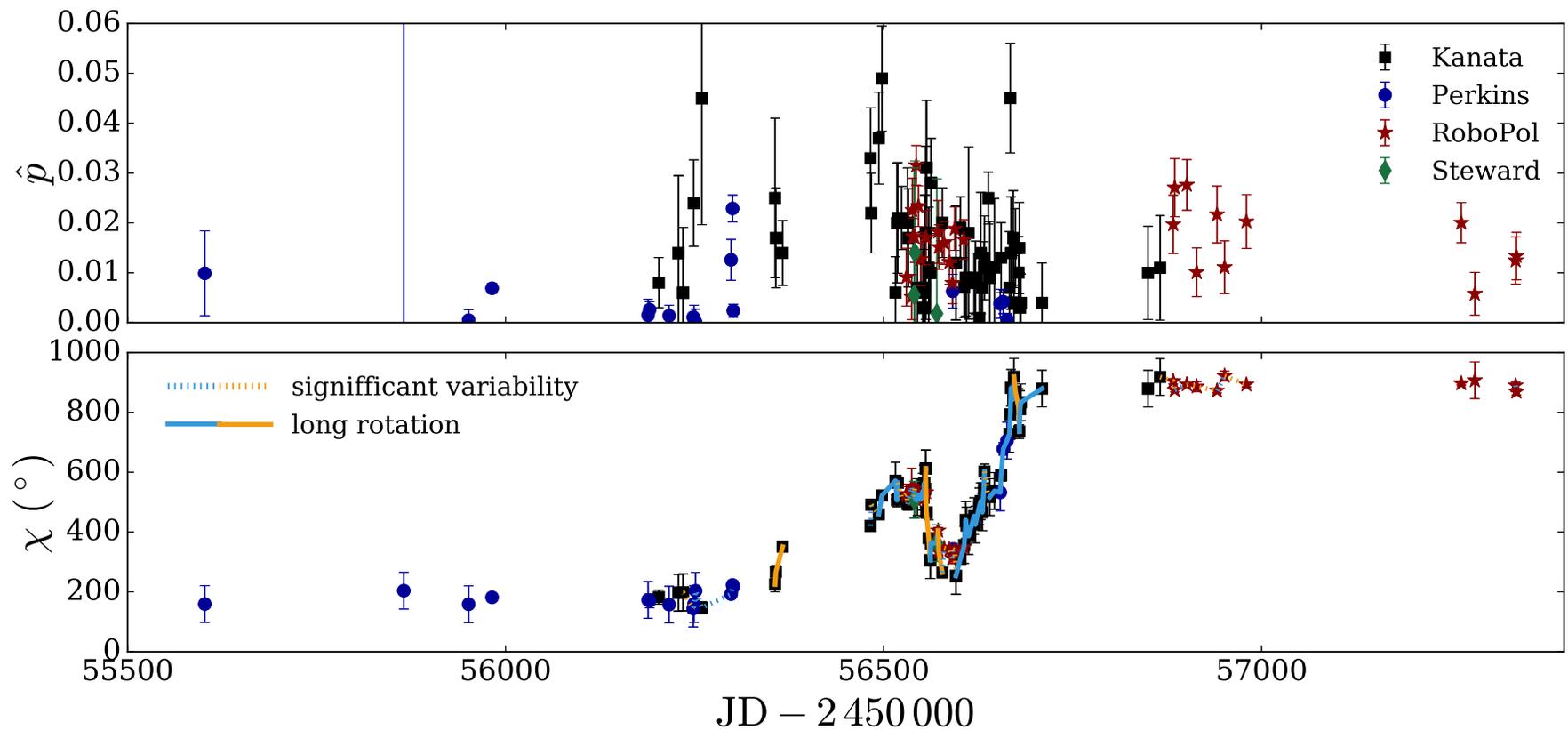
robopol

We found a blazar!

Pavlidou et al. 2014

Mandarakas, Blinov et al. 2018 in prep

✓ **High-cadence results on blazar rotations**
(Kielmann et al 2018, in prep.)

✓ **Full RoboPol data release
+ polarimetry workshop in Crete** (early 2019!)

✓ **OPTOPOLARIMETRIC STANDARDS!**
(ongoing, stay tuned)

robopol

V. Pavlidou