POLAMI: Polarization Monitoring of AGN at Millimeter Wavelengths

First Results and Impact on Blazar Science

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polami.iaa.es

Description of the POLAMI program

POLAMI is a long-term program to monitor the polarimetric properties (Stokes I, Q, U, and V) of a sample of around 40 bright active galactic nuclei (AGN) at 3.5 and 1.3 millimeter wavelengths with the IRAM 30m Telescope near Granada, Spain. The program has been kept running since October 2006 and it currently time samples with a goal cadence of ~2 weeks. The XPOL polarimetric observing setup has been routinely used as described in Thum et al. (2008) since the start of the program.

Data obtained by the POLAMI collaboration are combined with other IRAM 30m projects approved by the IRAM program committee as well as other survey and target-of-opportunity projects, and the results are presented here. Therefore, the POLAMI database includes measurements of over 200 AGN. Most of these sources were observed in the single-epoch surveys published in Agudo et al. (2010; 2014).

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First series of POLAMI papers

A series of 3 papers have just been published in MNRAS. In the first paper of this series (POLAMI Paper I) we present the results of the first 8 years of POLAMI observations, we provide detailed information about the observing program, the most intensively monitored source sample of ~40 sources, the data reduction and calibration, and we demonstrate the quality of our data by showing the results obtained for the main calibrators. The data obtained from the science targets, as well as the analysis and astrophysical implications of their circular polarisation properties and of their total flux and linear polarisation variability are shown in POLAMI Paper II and Paper III, respectively. Detailed studies of

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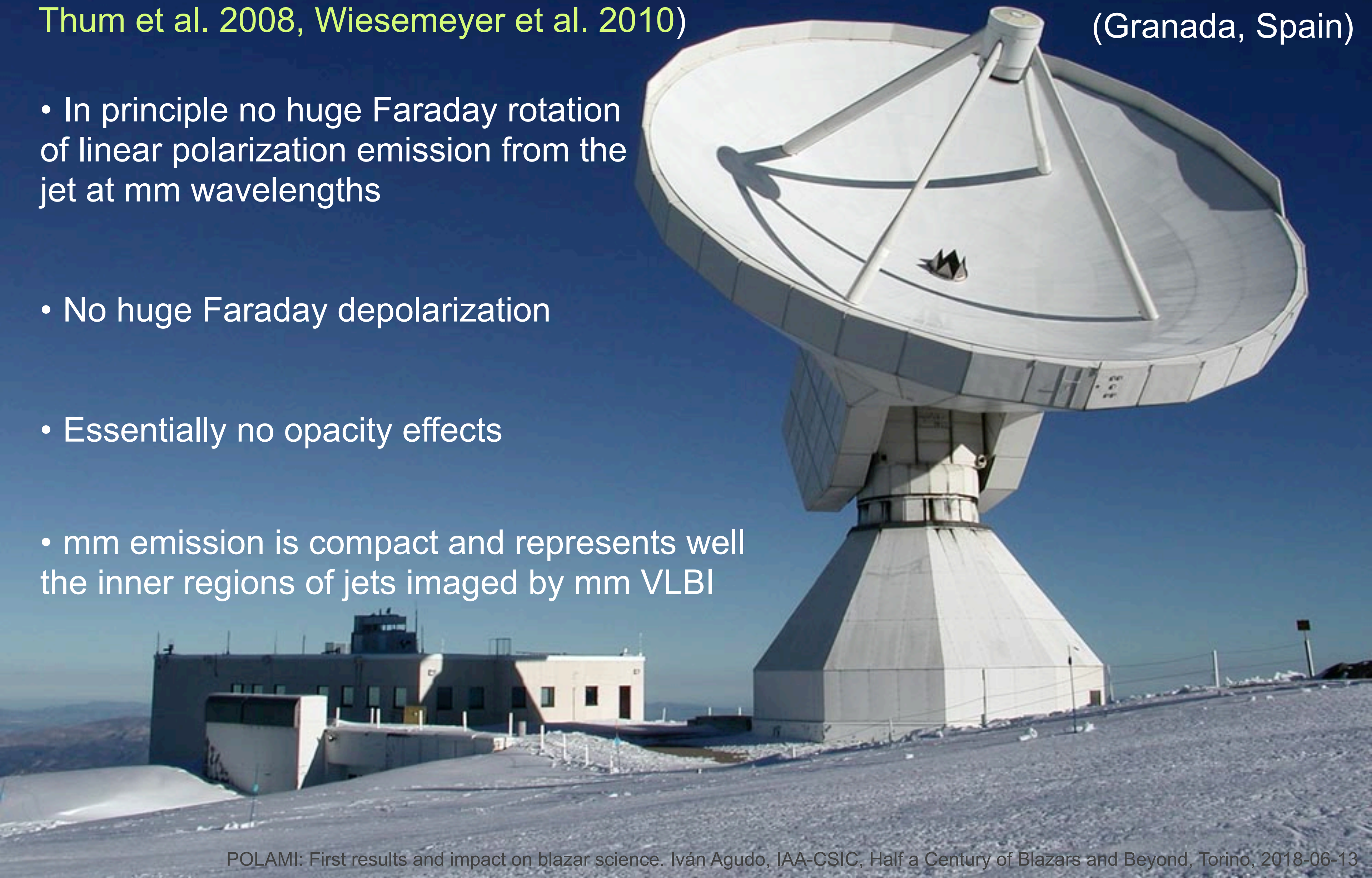
- mm emission is compact and represents well the inner regions of jets imaged by mm VLBI



POLAMI: Polarimetric Monitoring of AGN at Millimeter Wavelengths

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- AO 0235+16
- 3C 84
- CTA 26
- 3C 111
- PKS 0420−01
- 3C120
- PKS 0528+134
- S5 0716+71
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- OJ 248
- OJ 49
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- MRK 421
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- 4C 29.45
- ON 231
- PG 1222+216
- 3C 273
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- 3C 279
- B2 1308+30
- PKS 1406−076
- PKS 1510−08
- DA 406
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- 3C 345
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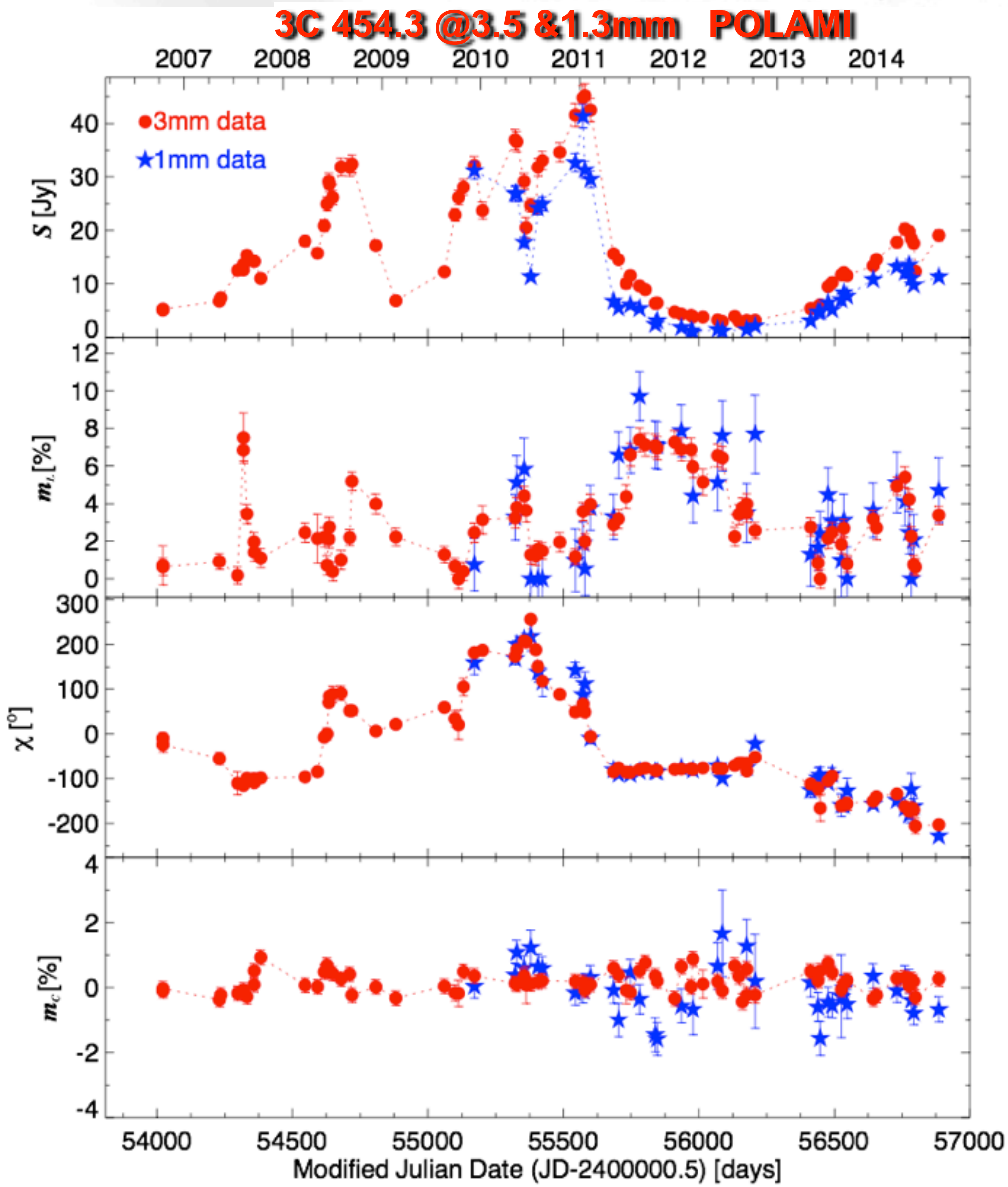

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- Time sampling ~2 weeks

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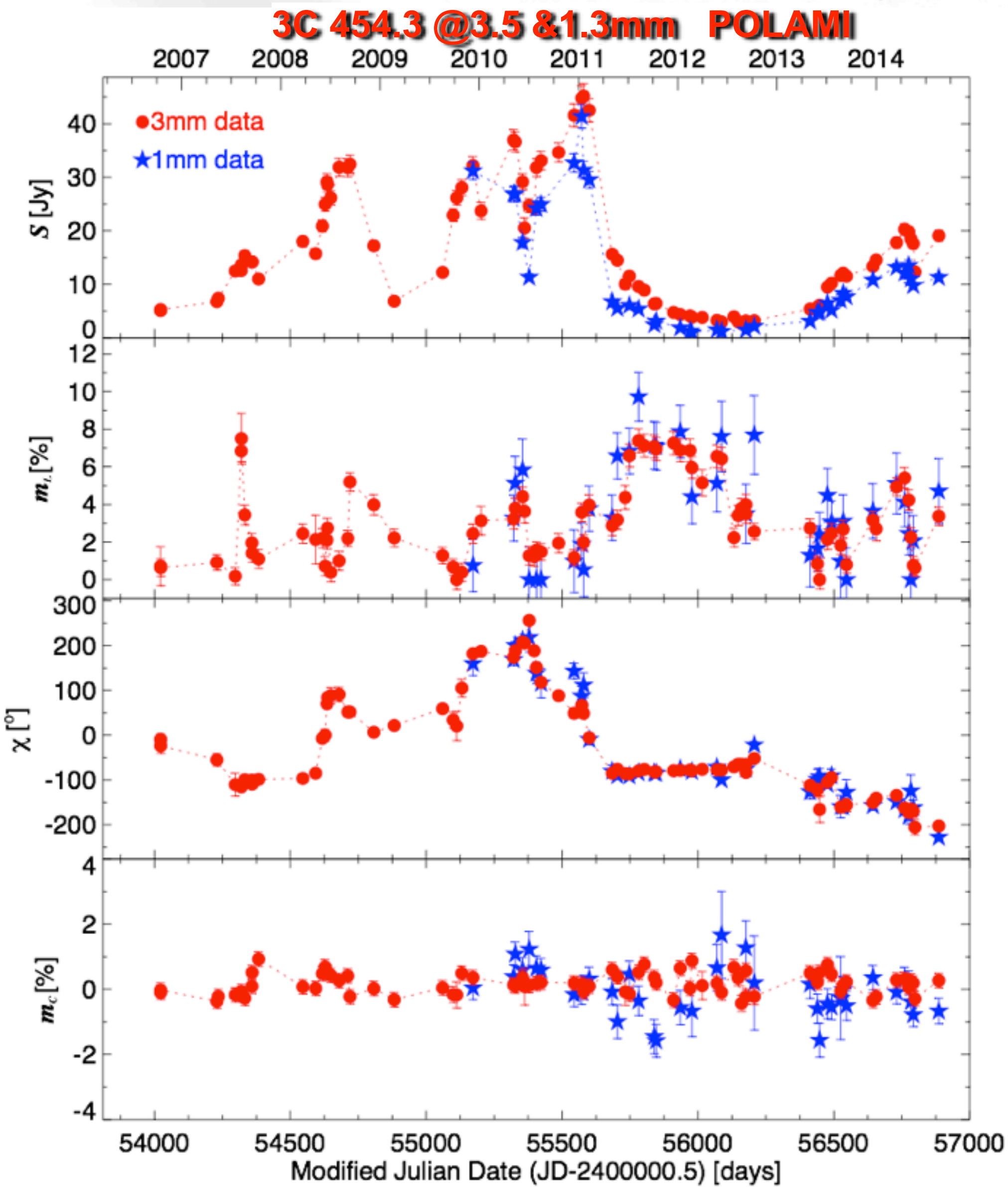

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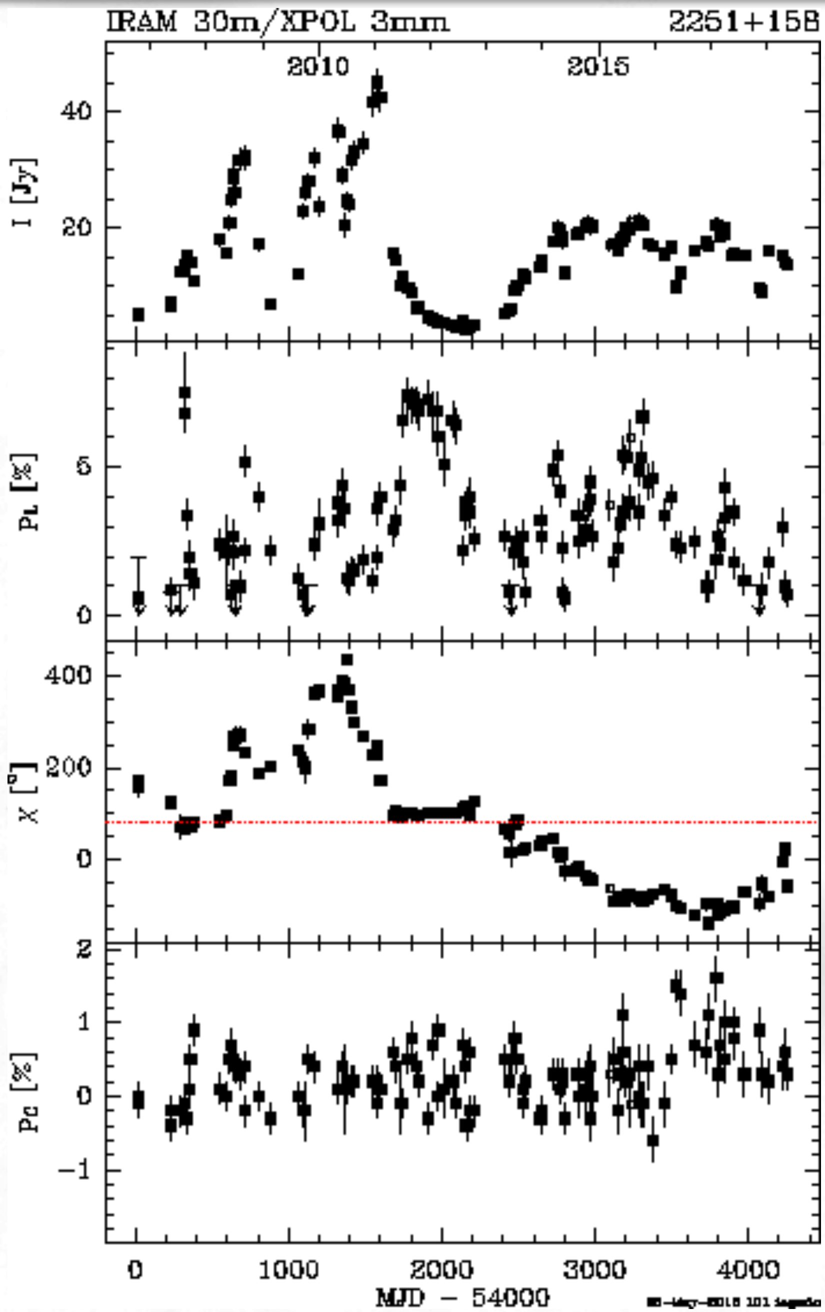

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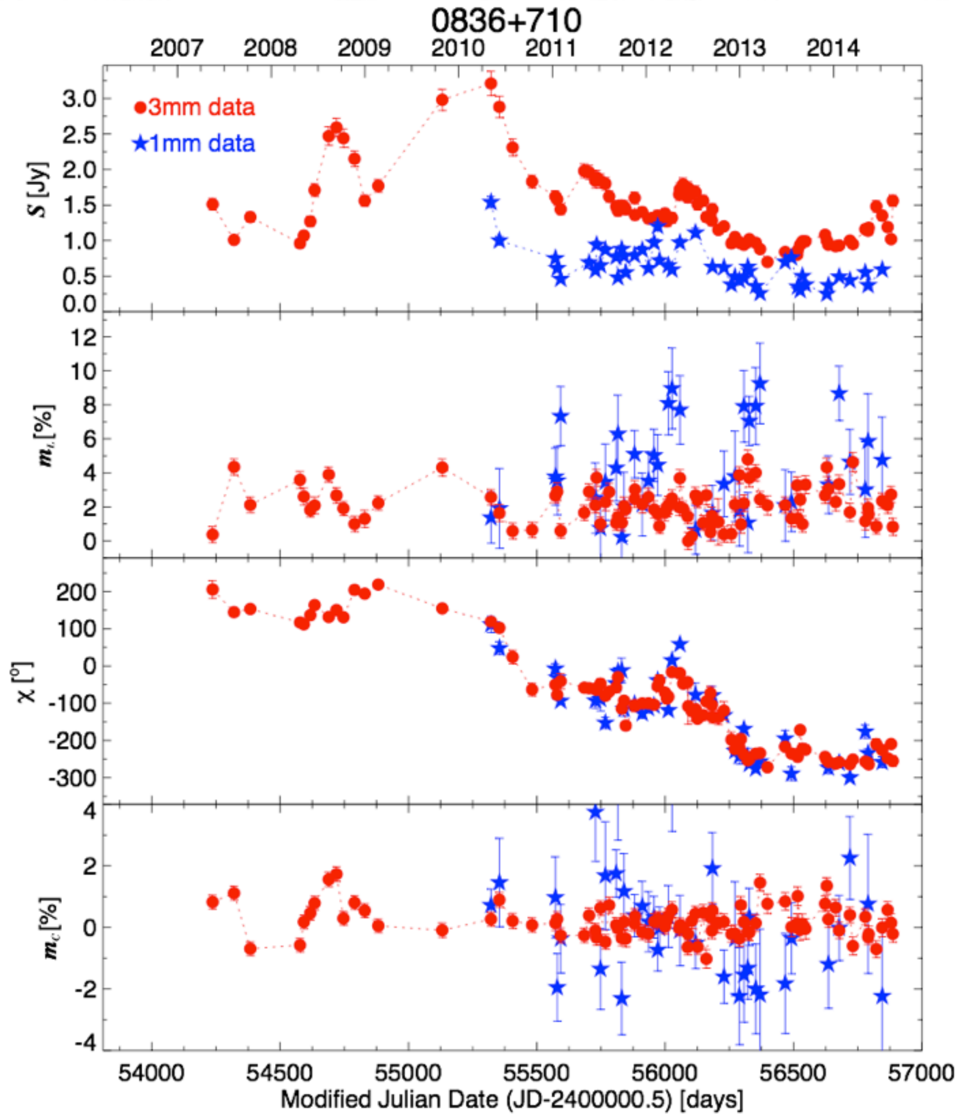
We still keep monitoring!

Increase of linear polarization degree with ν_{obs}

- Significantly larger fractional linear polarization at 1mm than at 3mm by median factor ~2.6 (over > 2000 measurements)



POLAMI Paper III

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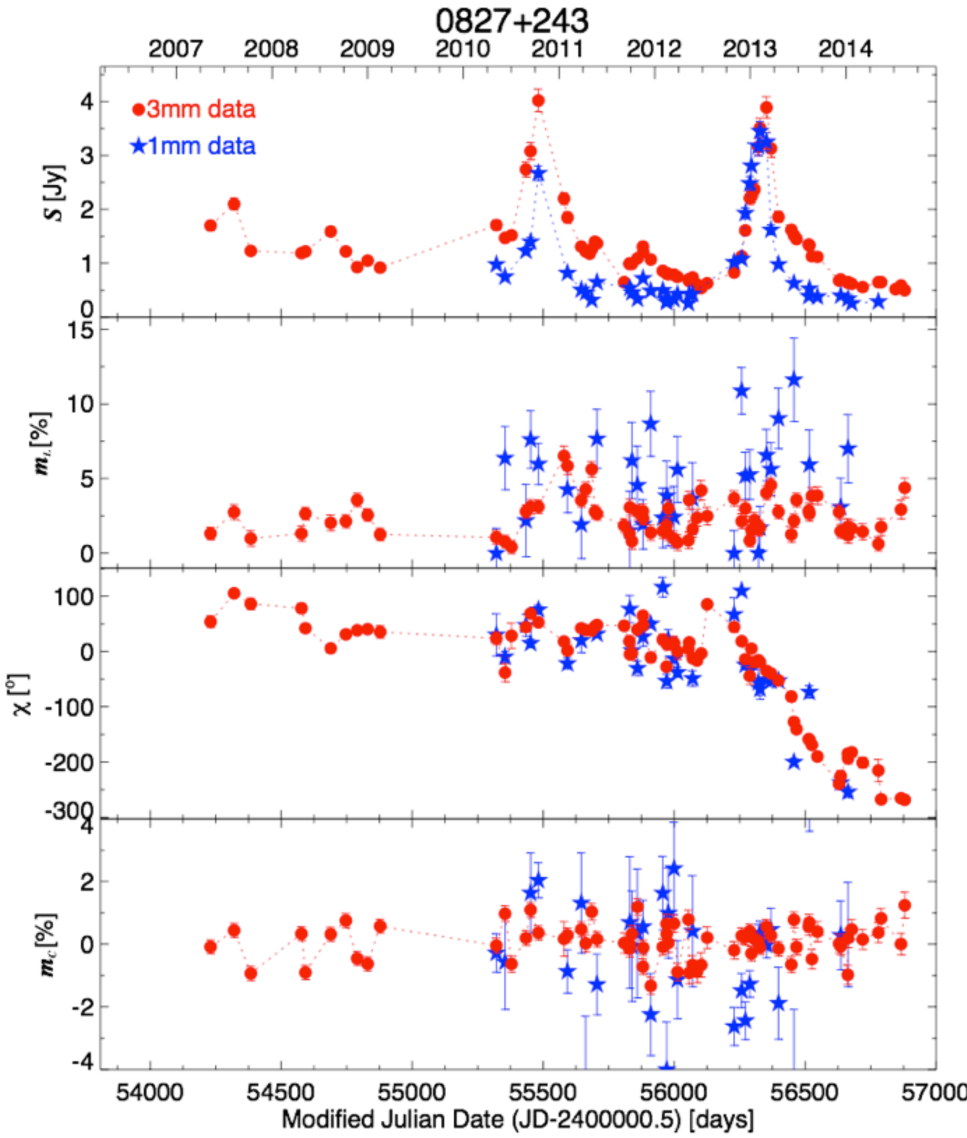

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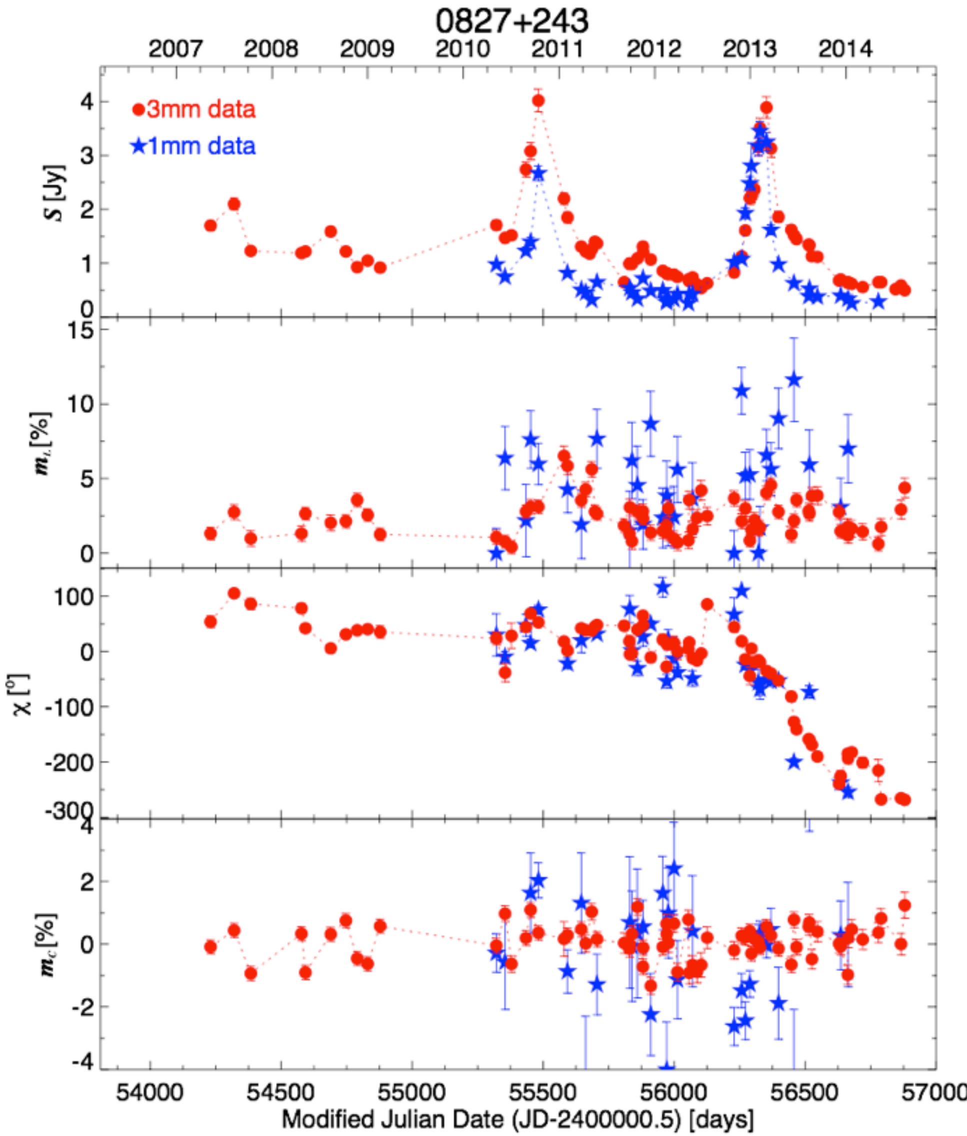
- Since we rule out strong opacity effects:

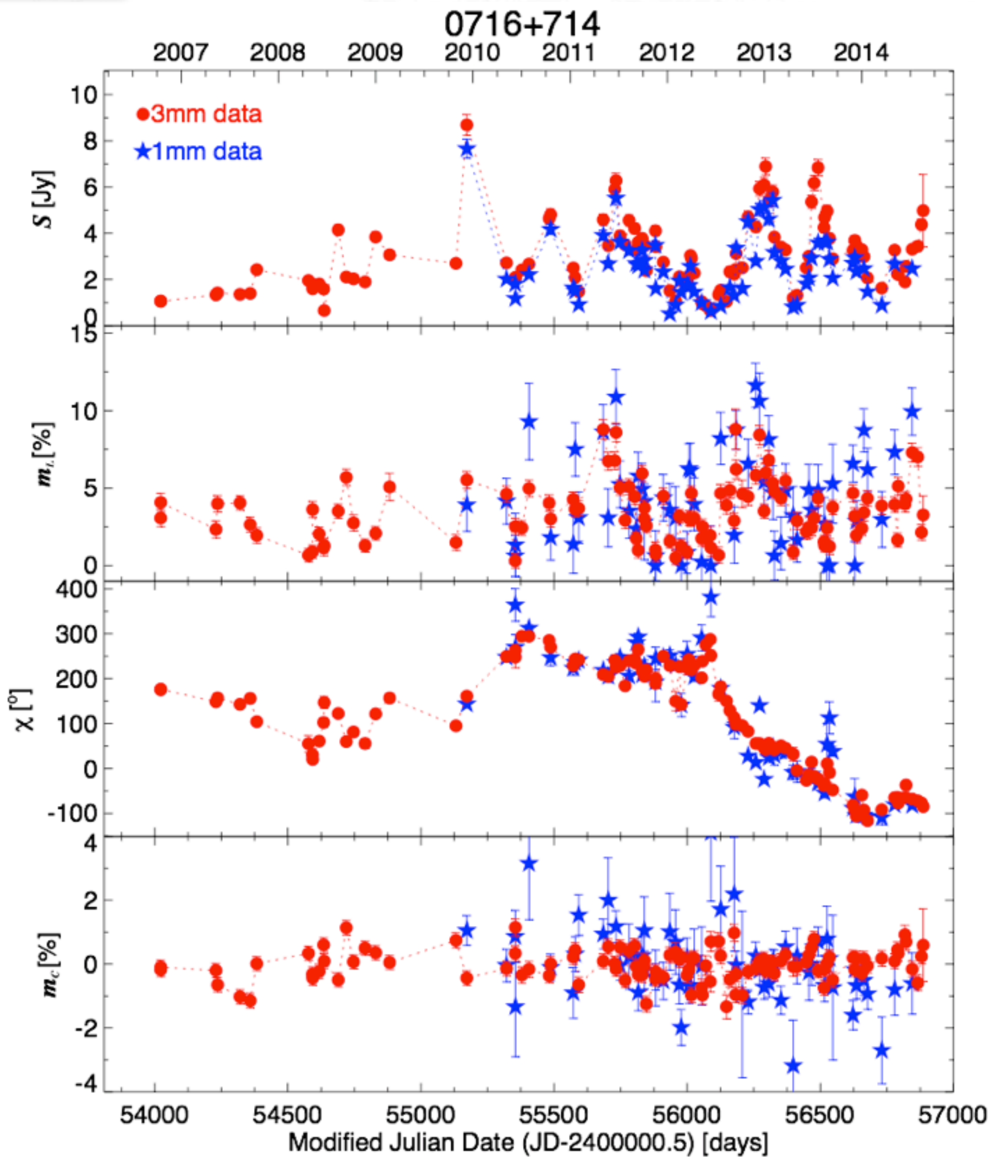
1) Average B is better ordered on the shorter λ regions as compared to the longer λ ones



POLAMI Paper III

Variability of linear polarization degree

- m_L also highly variable
- Range from ~ 0% to ~ 15%



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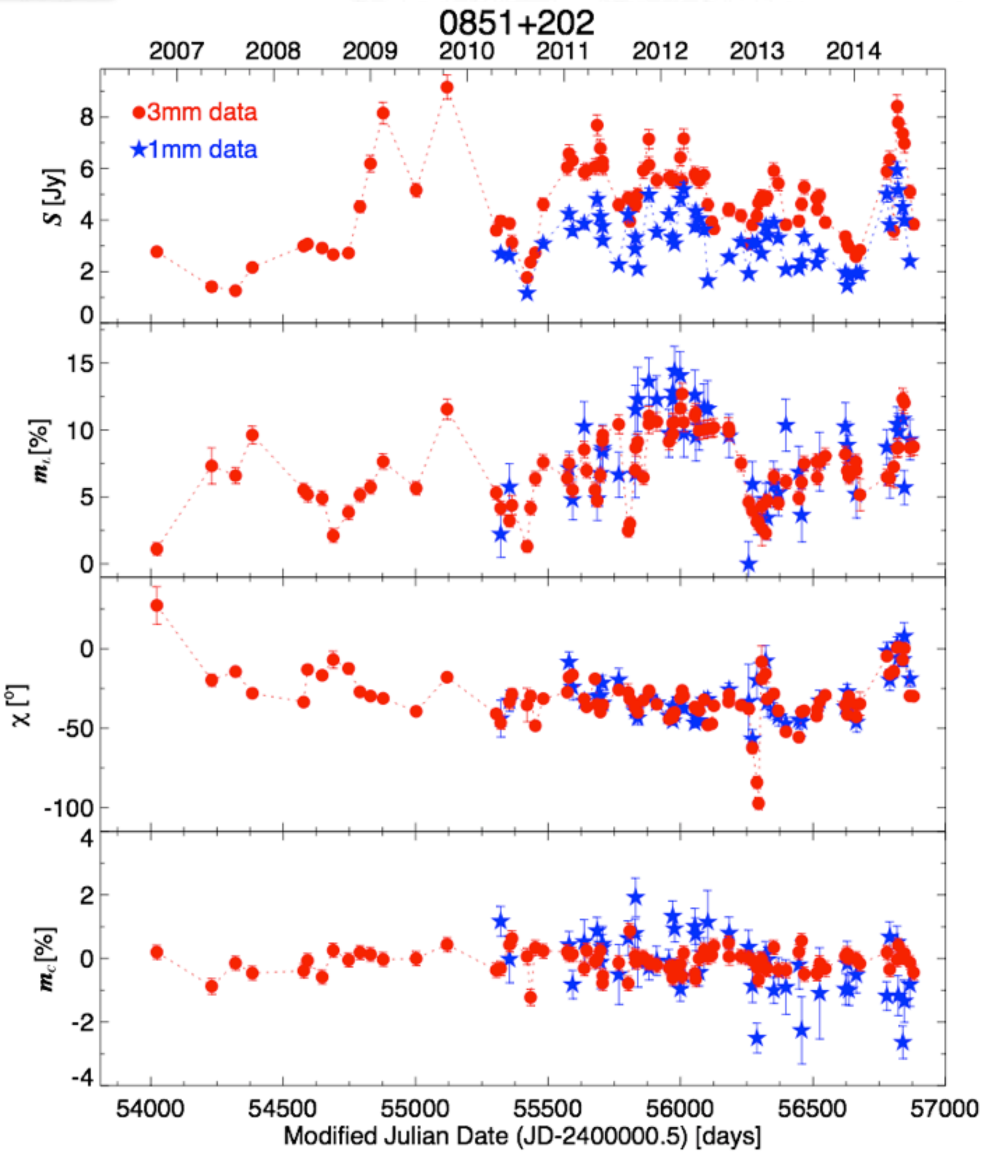

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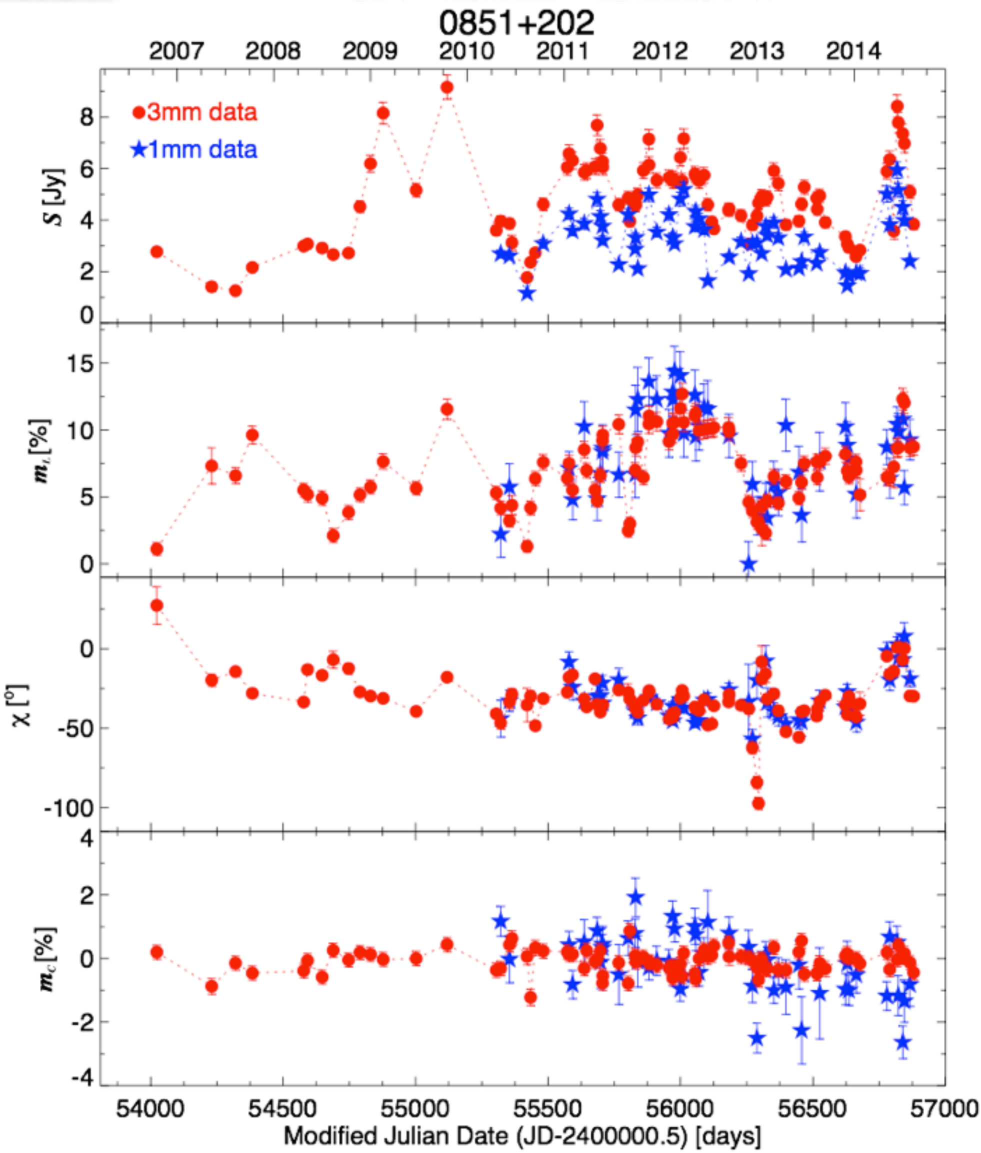

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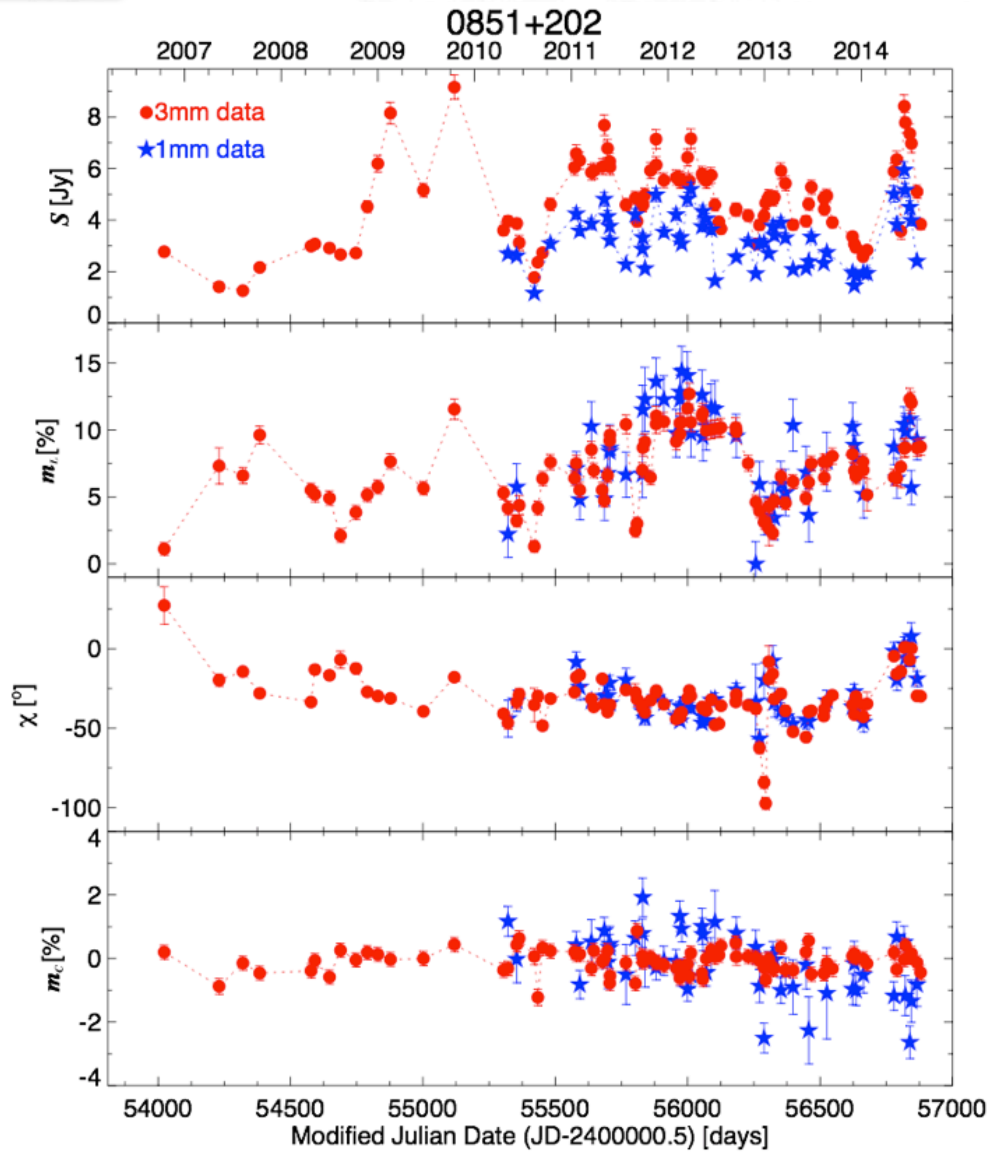
- Time scale of variability also significantly shorter at 1mm than at 3mm

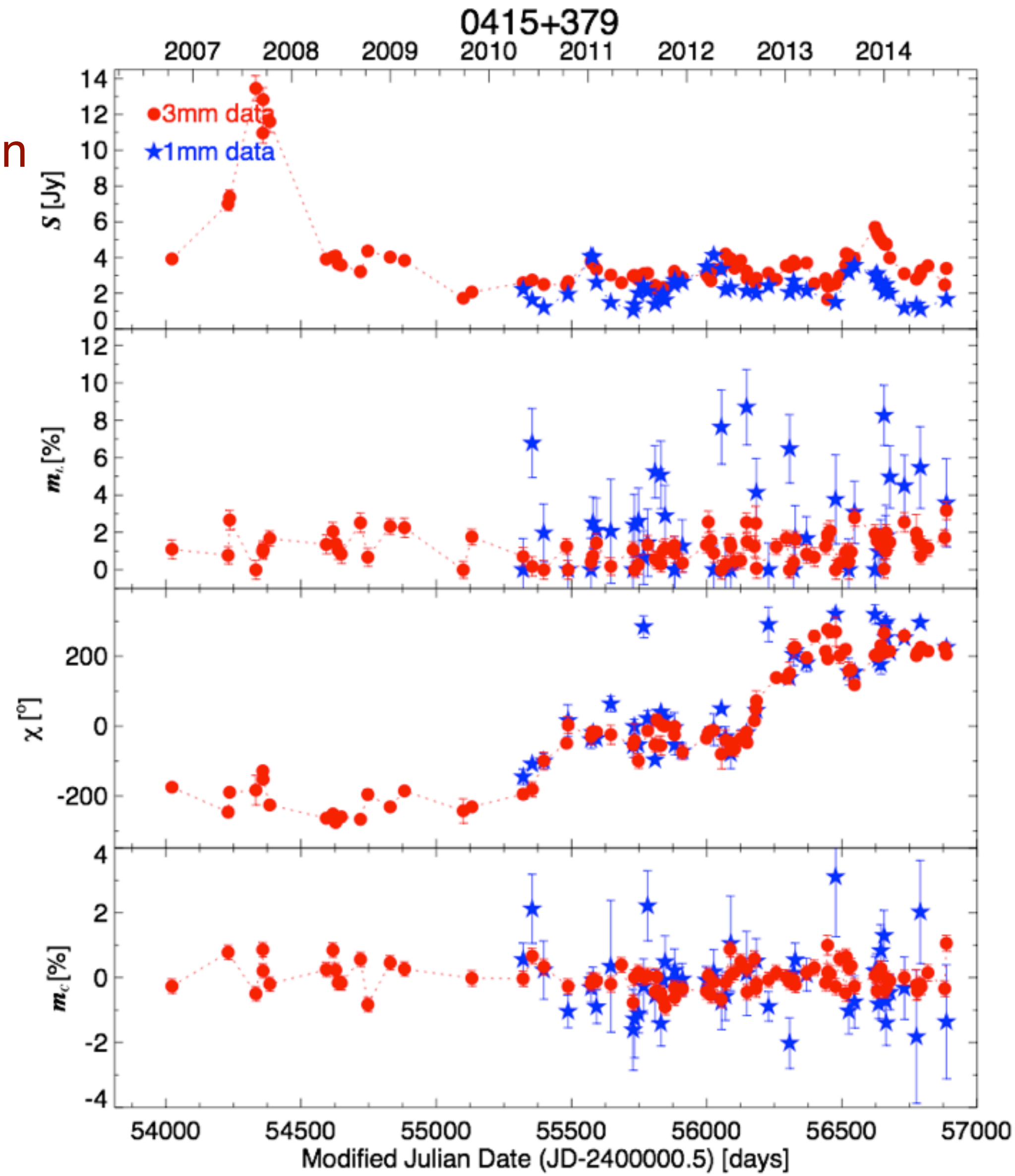
2) Consistent with shorter wavelength emission coming from smaller regions



POLAMI Paper III

Variability of linear polarization angle

- χ at 3 and 1mm also highly variable
- 21/36 sources at least a > 180° rotation
- Time scales from a few weeks to a year (typical 3-5 weeks)



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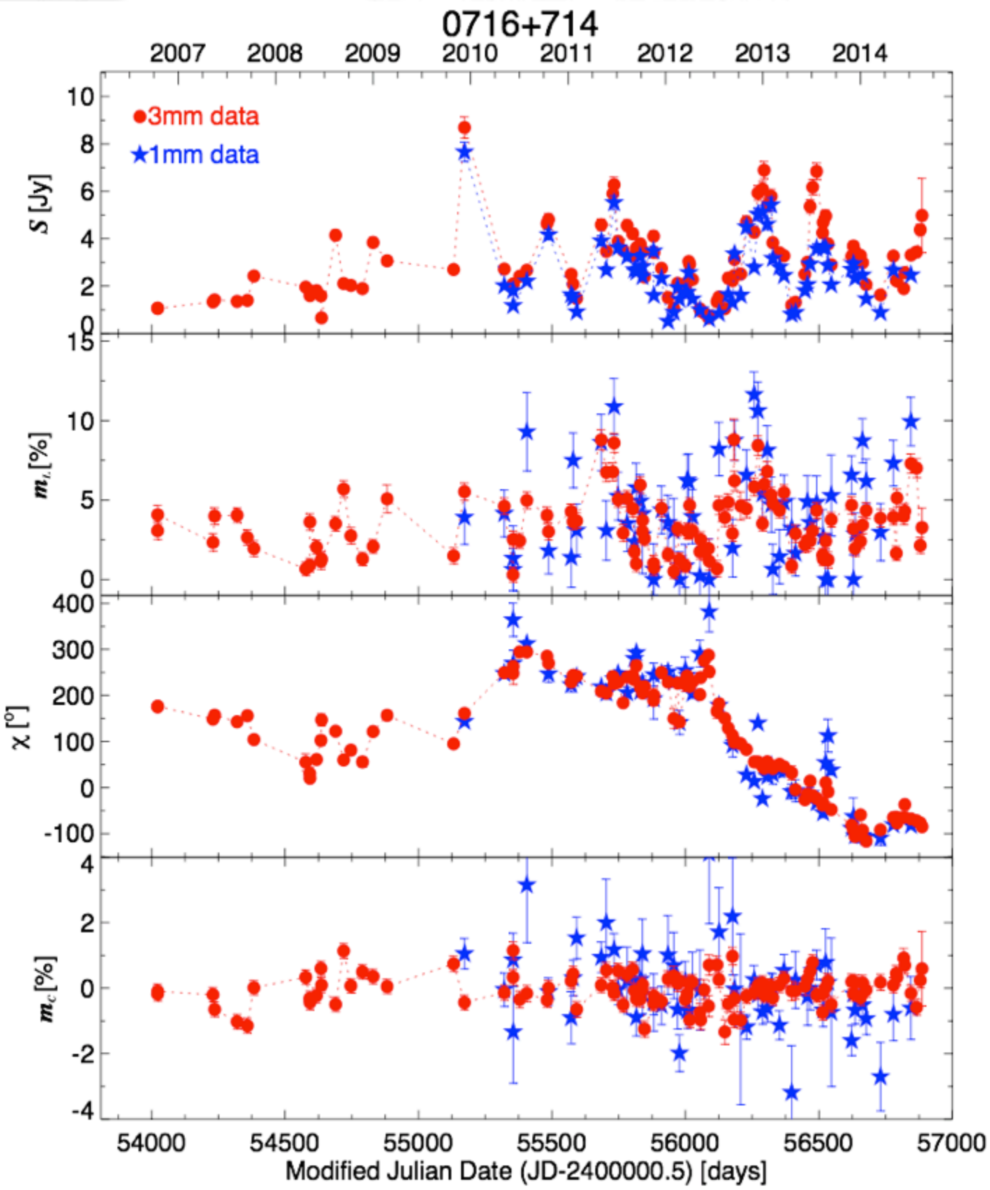

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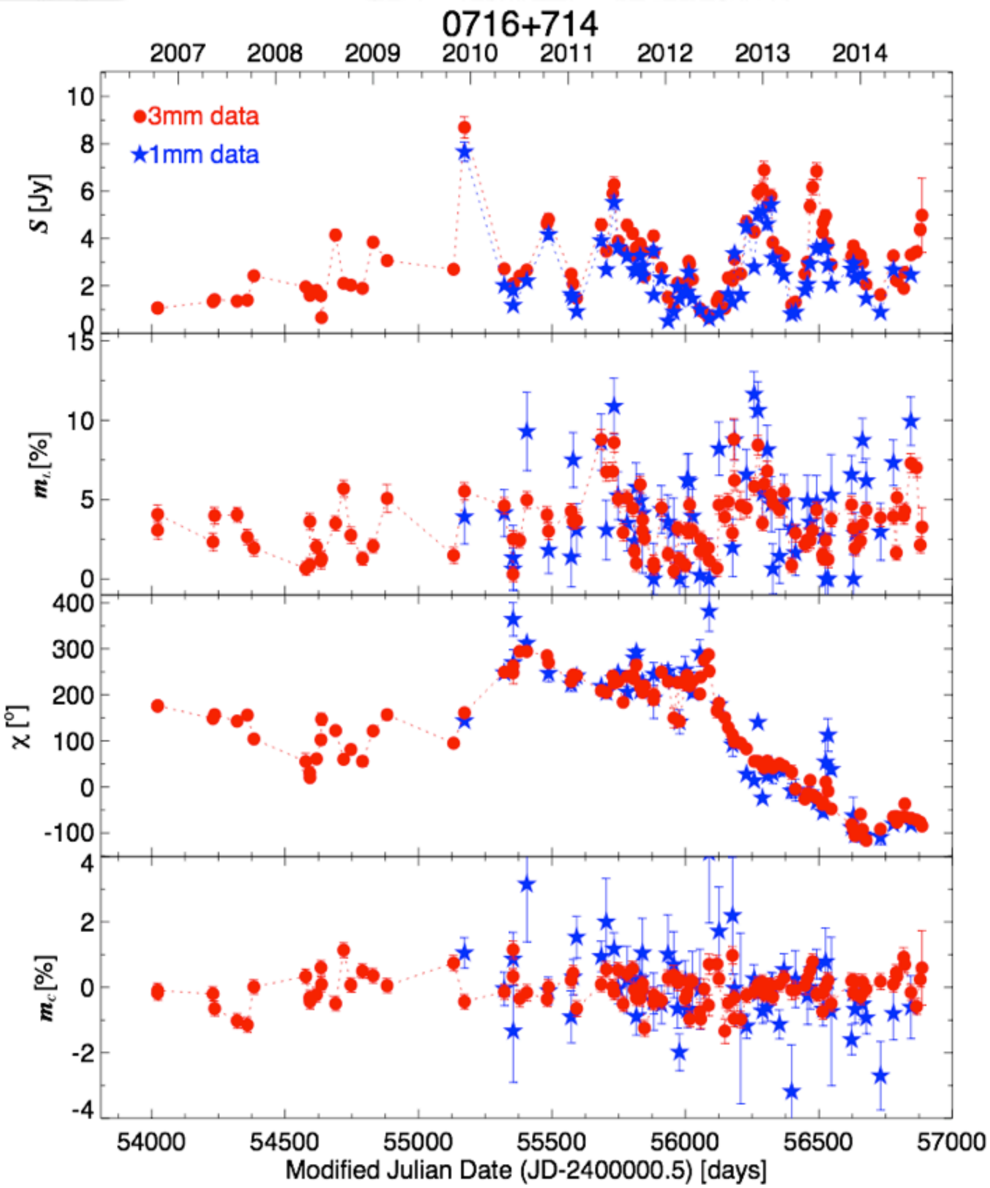
3) Excludes 1-zone models. Number of emission zones should probably be larger than two in some cases)



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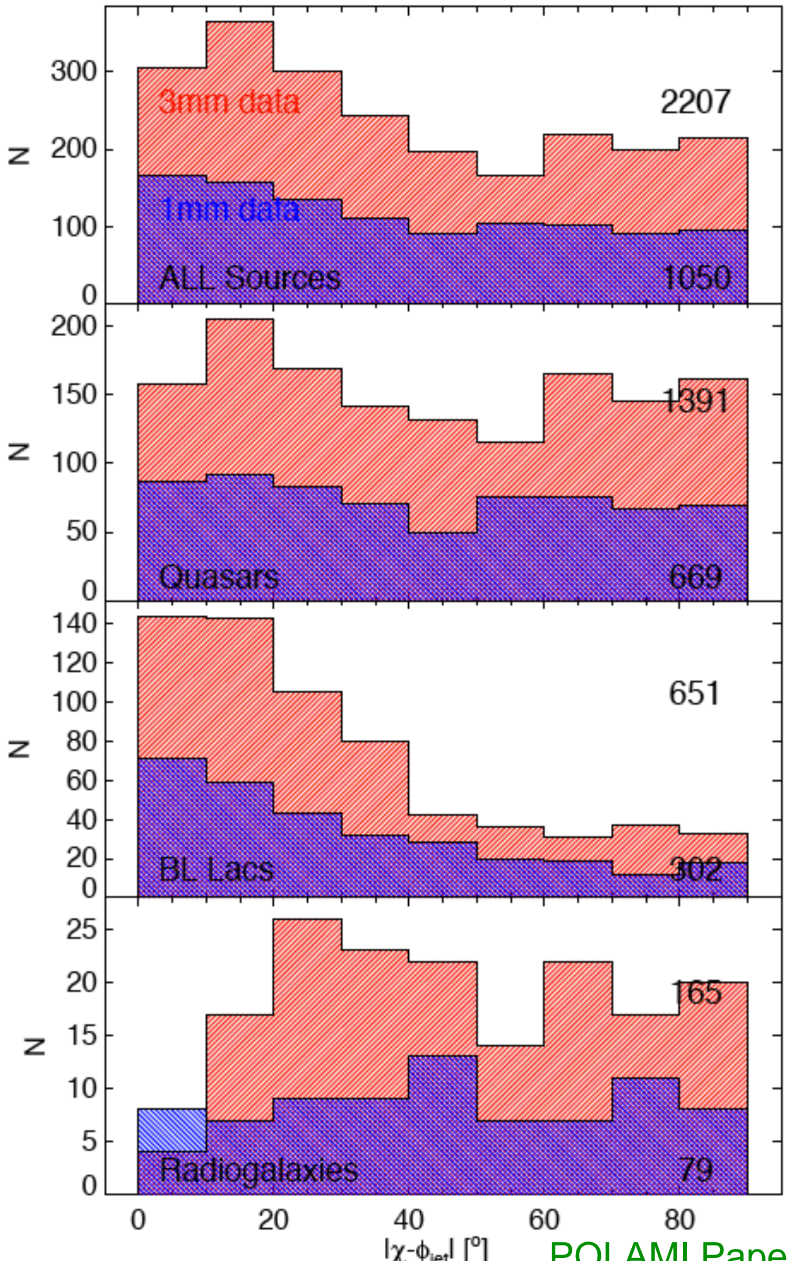
Linear polarization angle vs. jet position angle



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- Similar results found in Agudo et al. (2010, 2014), and Lister & Homan (2005)

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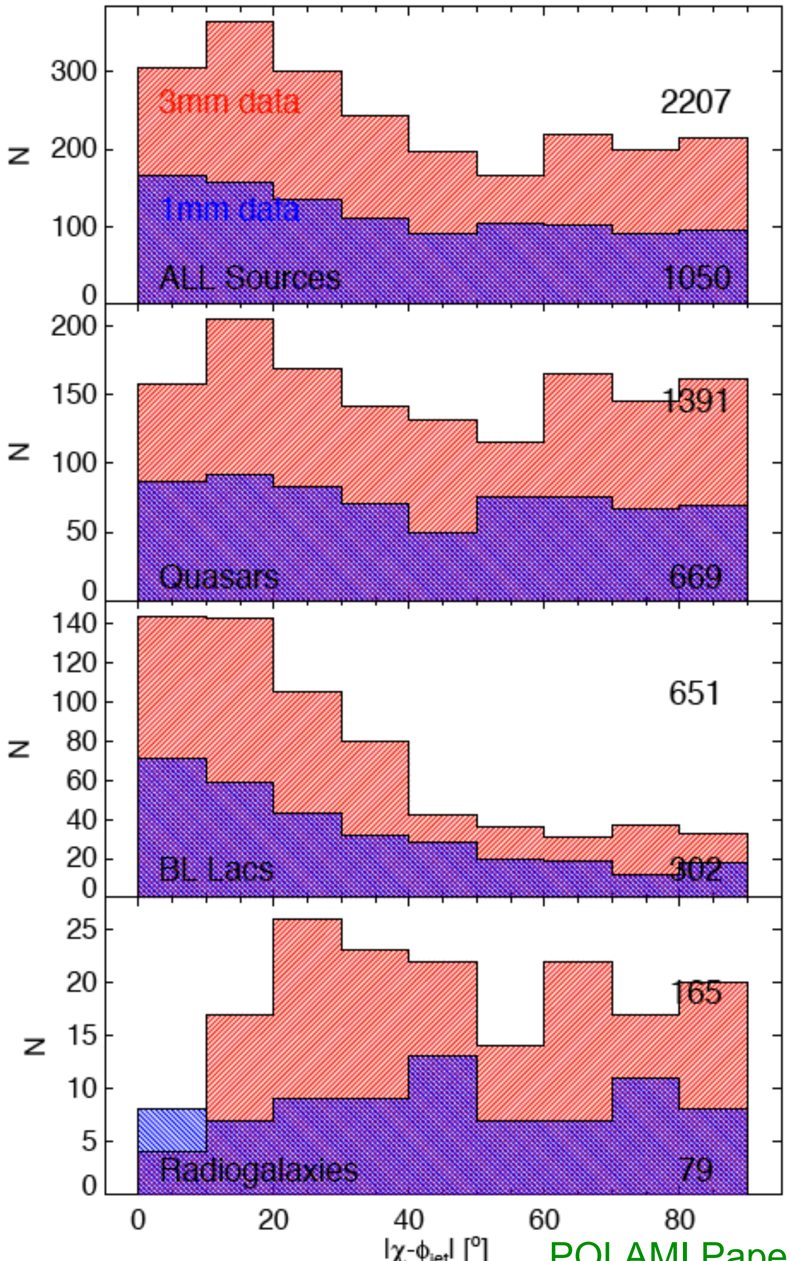

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- **What we get for most of the sources is the other way round!**
- **Although BL Lacs seem to tend to align their χ with the jet position angle**

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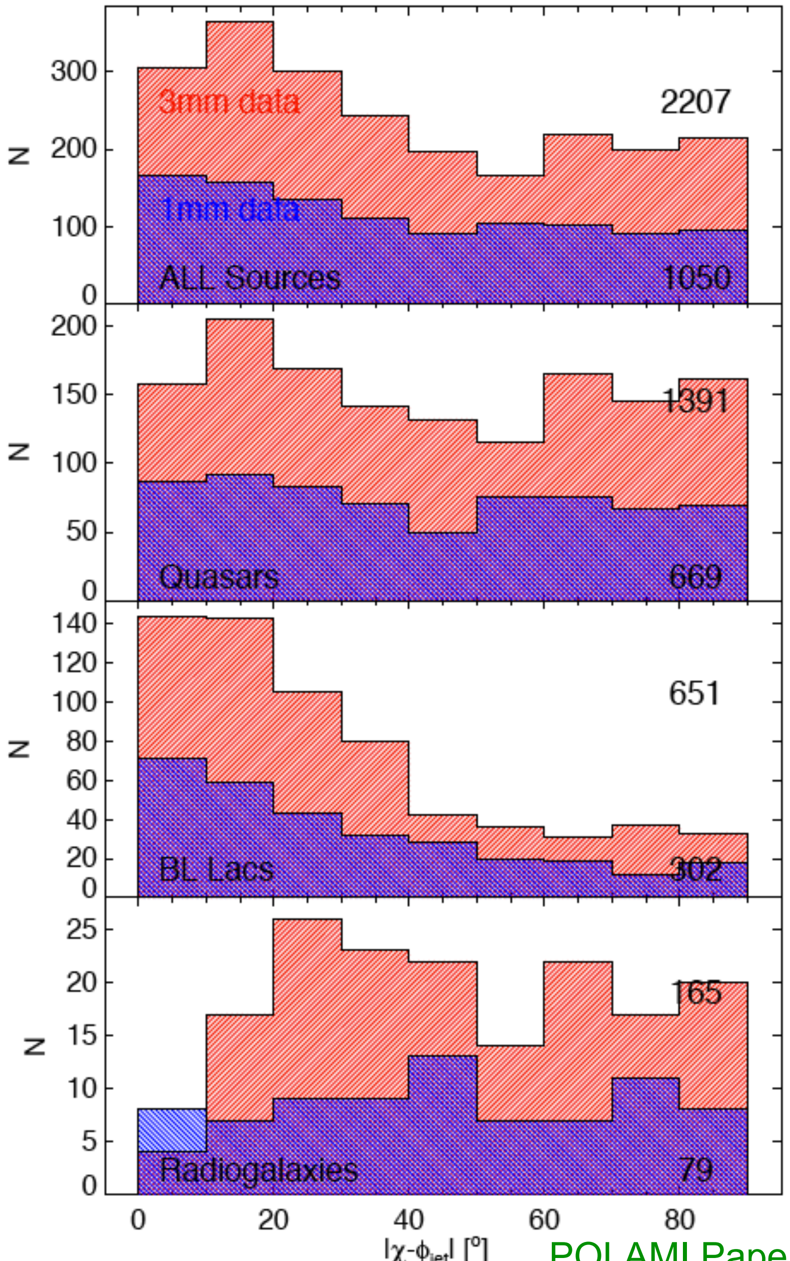

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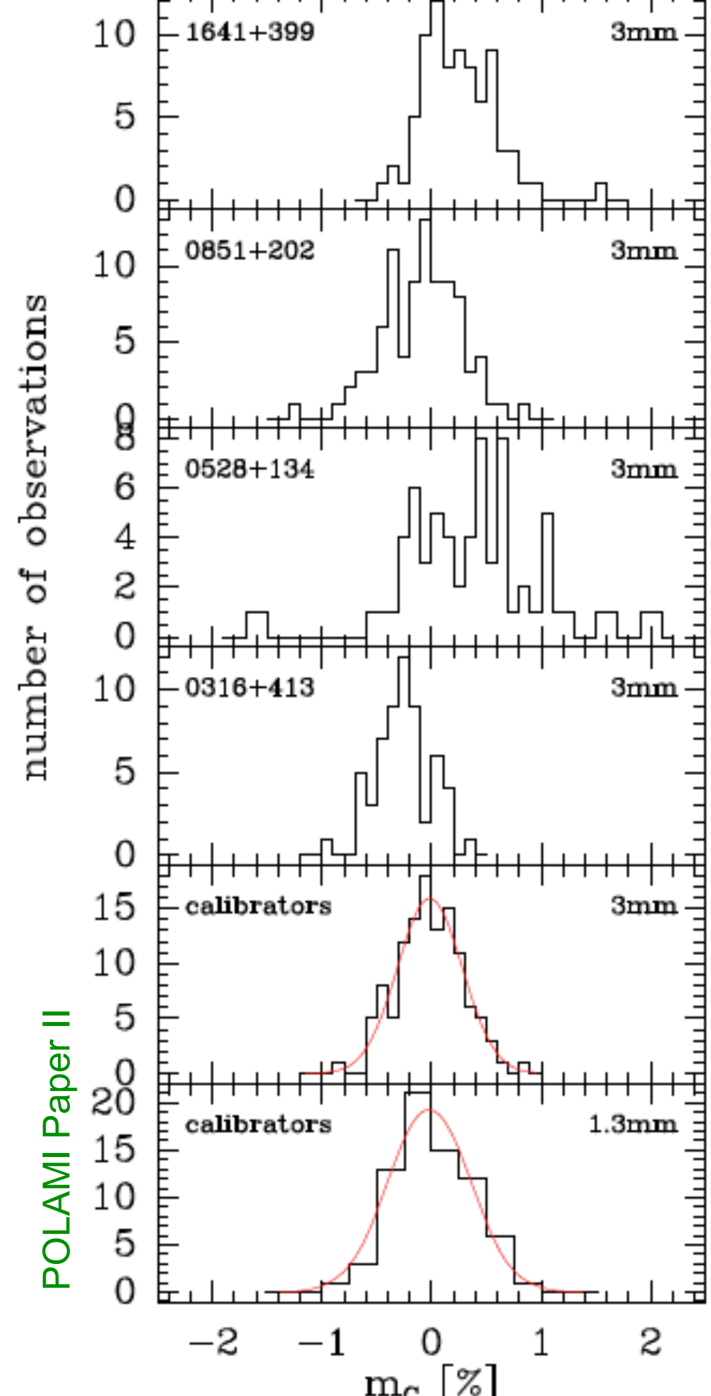
4) Blazar jets are not axisimmetric, at least on which regards to their polarization emission

Circular polarization

- Mars & Uranus (unpolarized), shows Gaussian profile with σ~0.3% (σ~0.5% at 1mm, all measurements together) and $<m_C>$=0.0%



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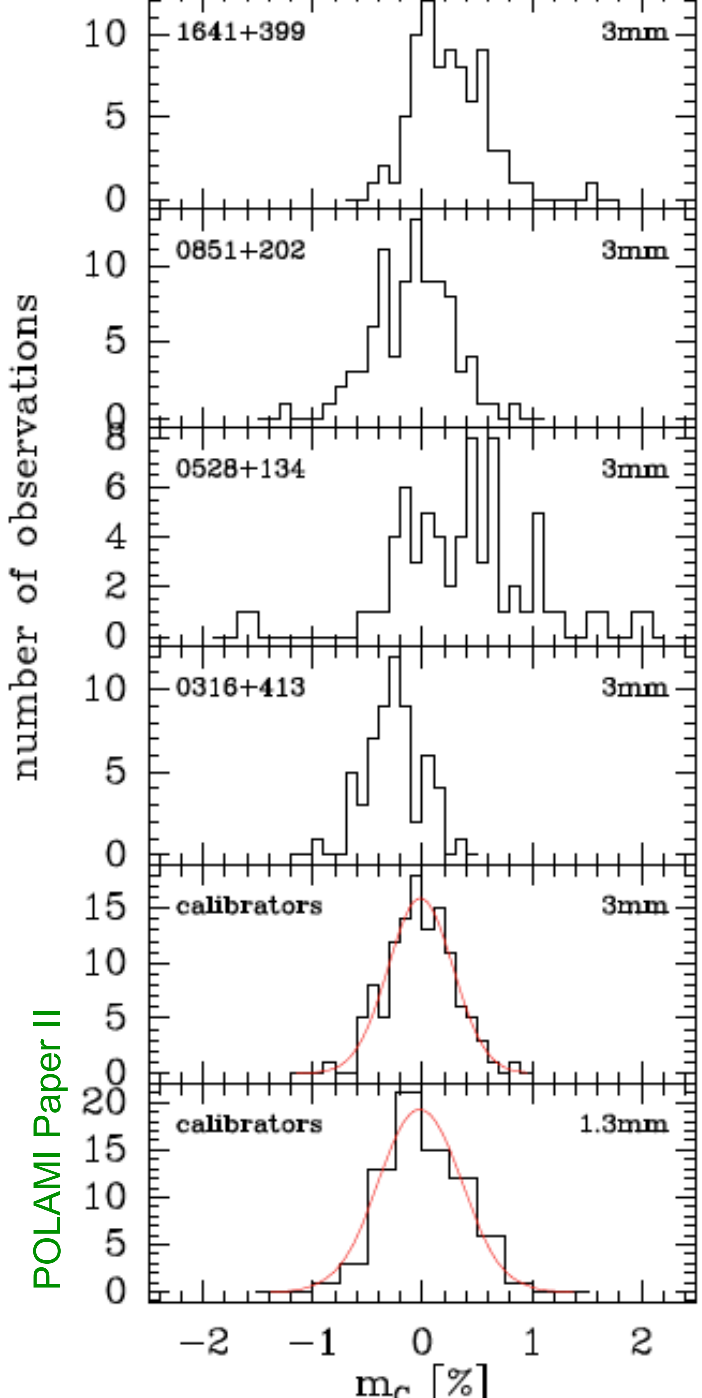
- Blazars show different distributions (>99.7% conf):
  - Broader m_C distributions, even double-peaked
  - Sometimes significantly shifted from 0.0%
  - Several detections >5σ up to ~1% (even ~2%)
  - CP is detected in all but one source, often more than once
  - A number of sources have CP detected always of the same sign



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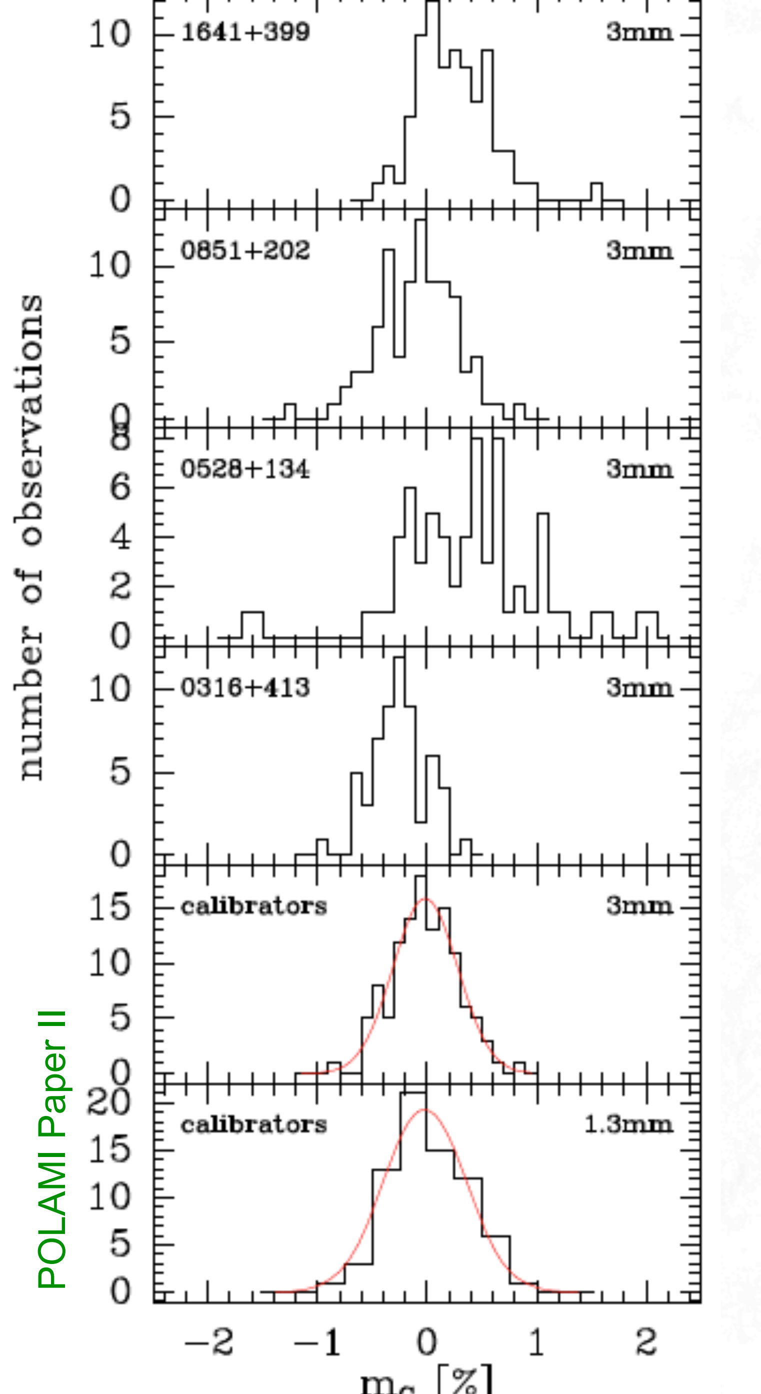
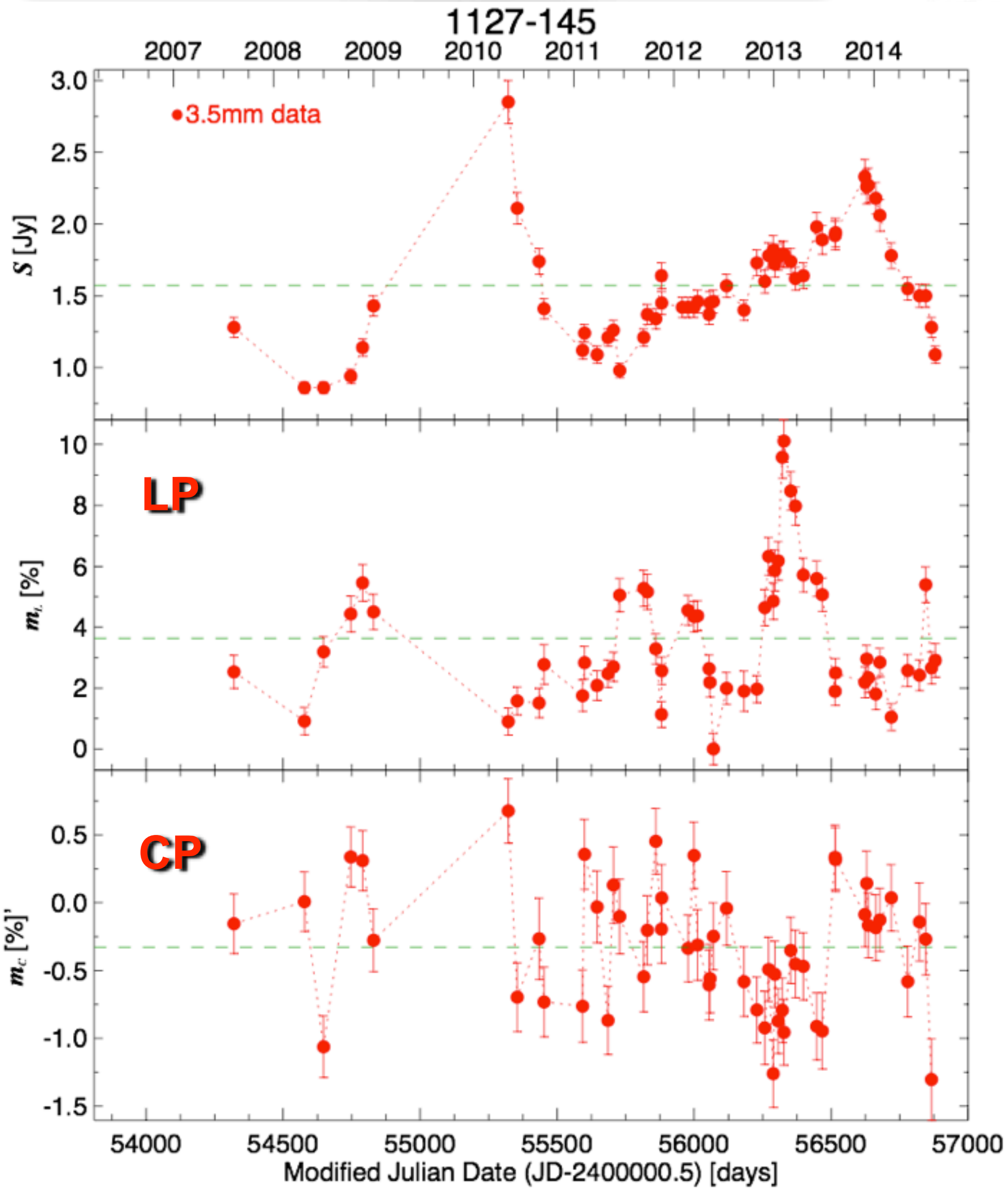
5) Circular polarization routinely detected at mm-λλ and as large as those reported at cm-λλ!



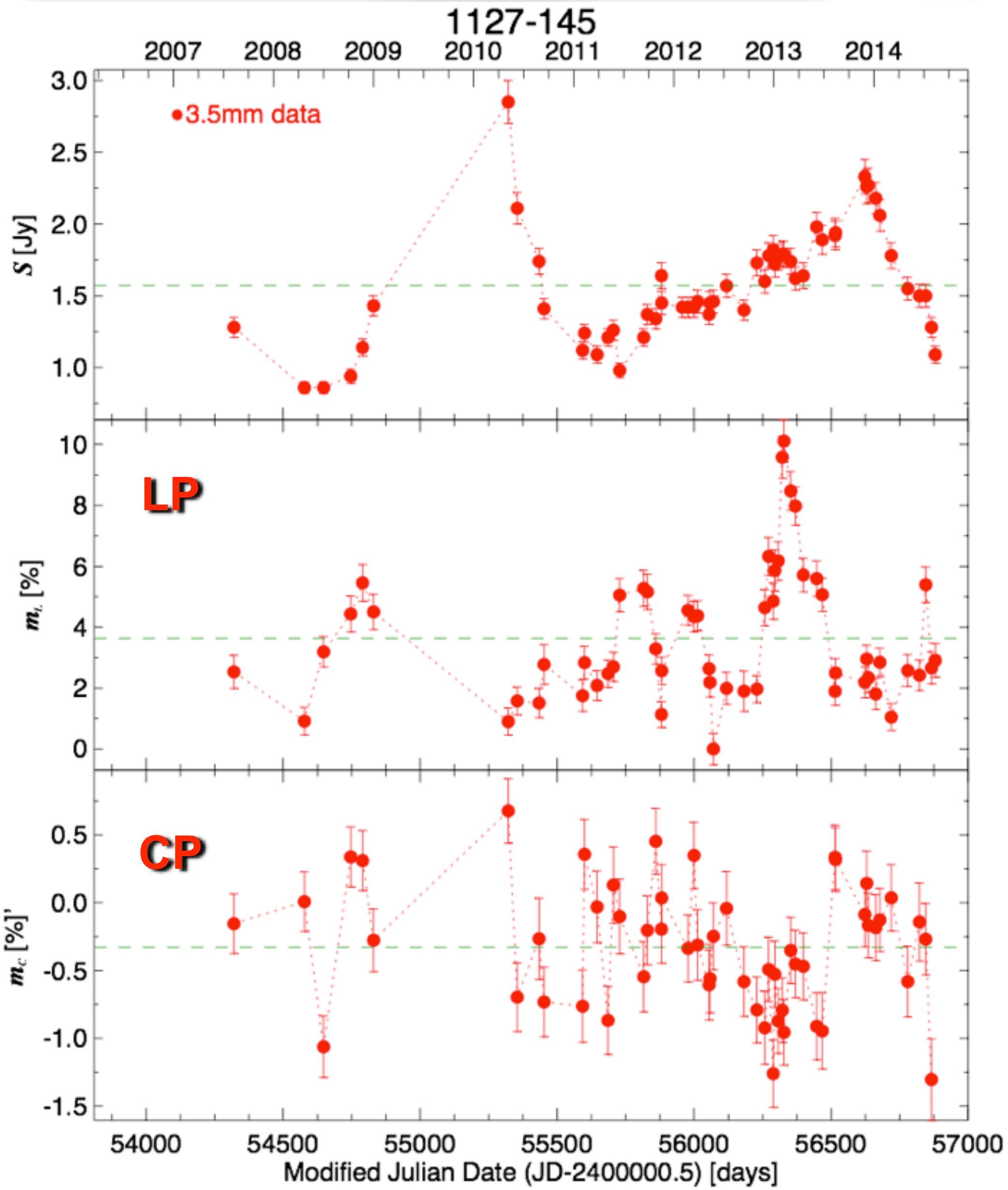
Circular polarization variability



POLAMI Paper II

- **CP time evolution show hints of:**
- Faster than LP and total flux
- Time scales of months
- Perhaps even much shorter time scales (~weeks)
- Frequent sign changes

Circular polarization variability



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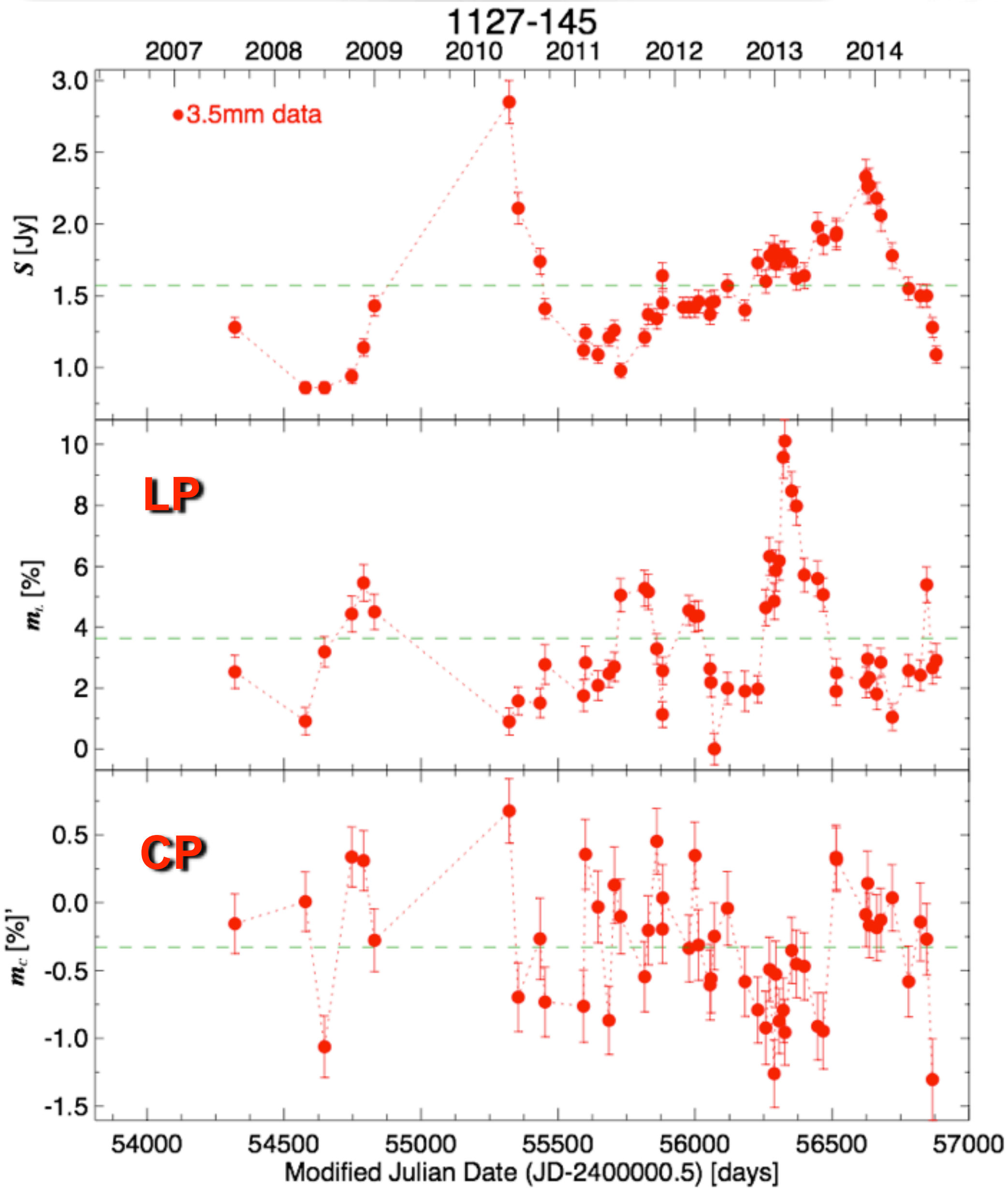
Circular polarization variability



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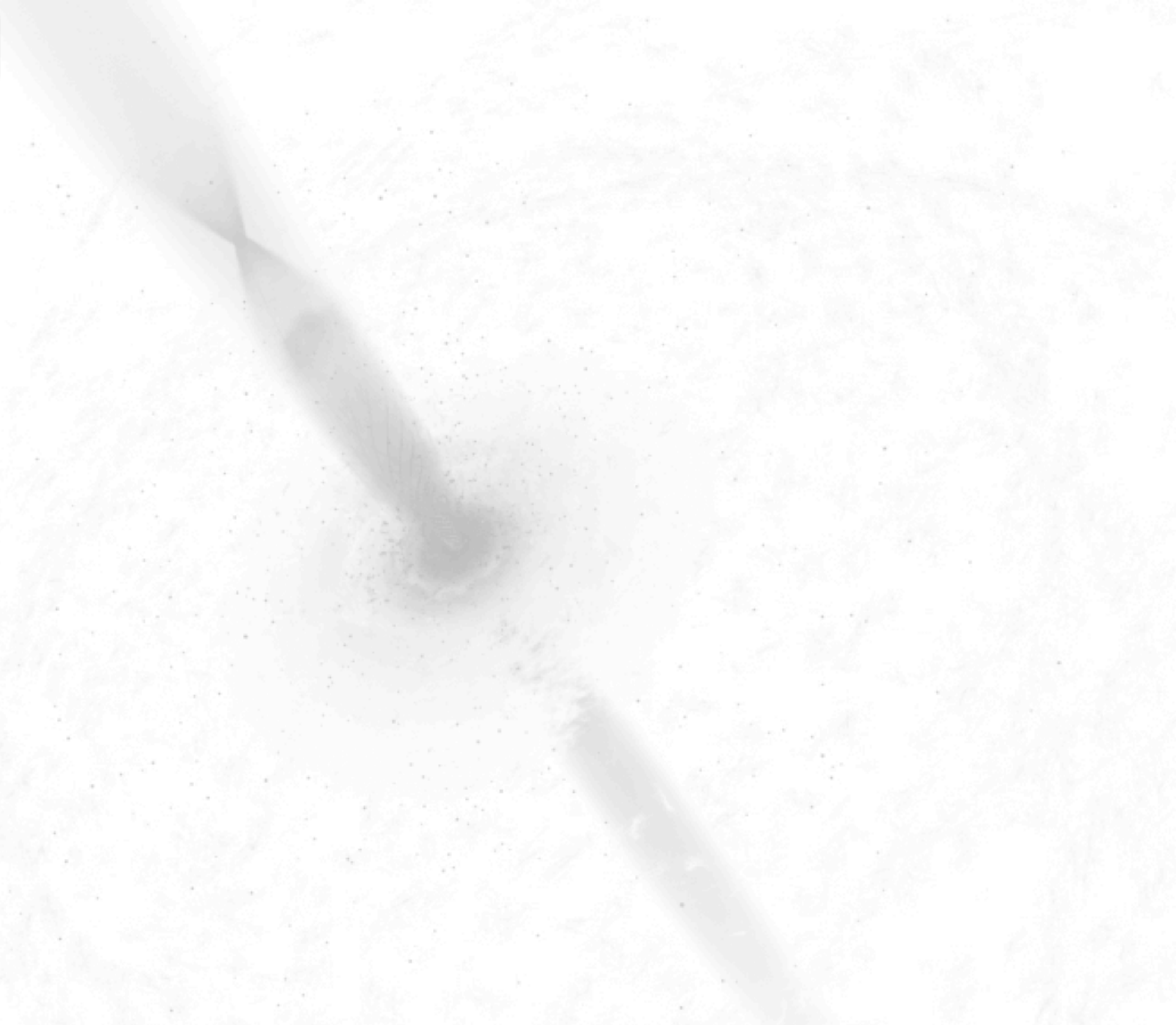
Data is compatible with Faraday conversion, e.g. in the presence of helical B field, but also production of intrinsic synchrotron CP

Summary



Summary

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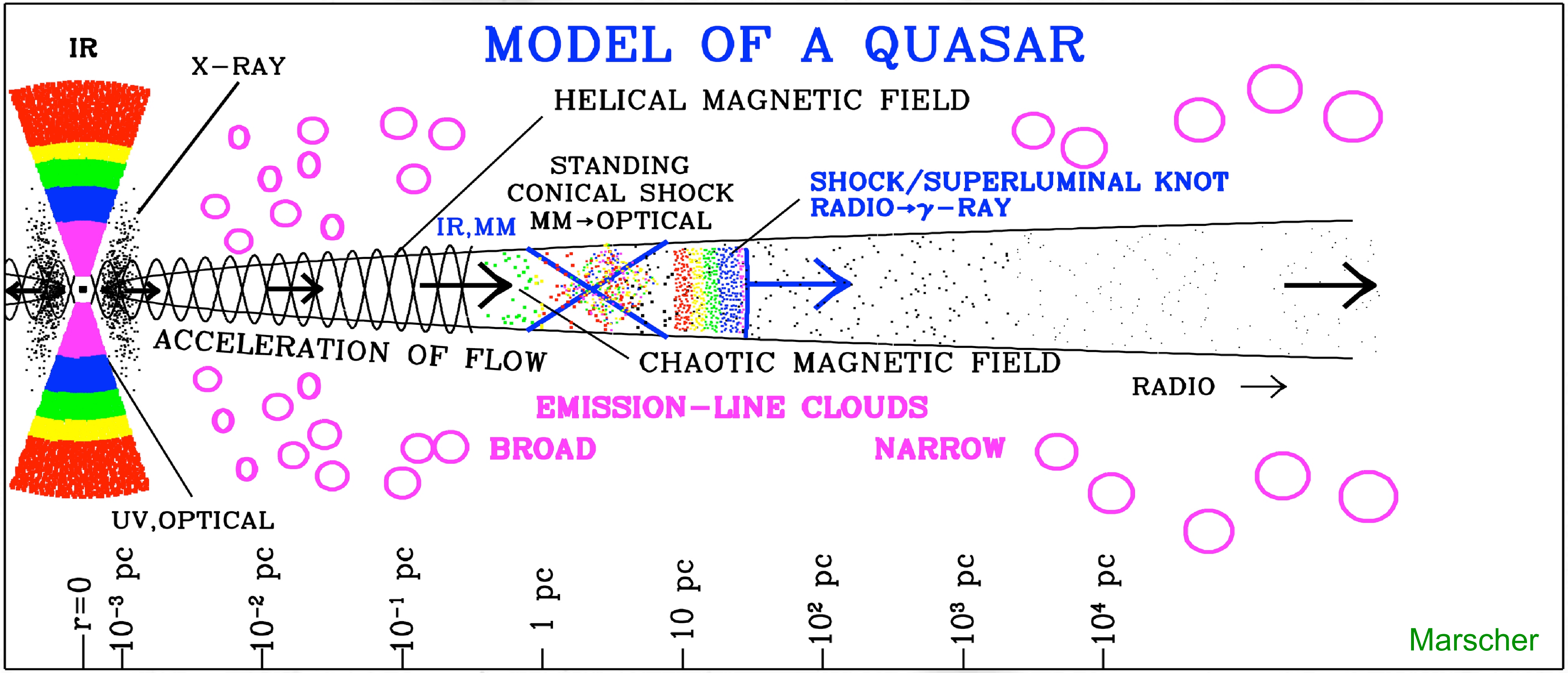
- Hints of fast CP variability and frequent sign changes

- Circular polarization seems to be present in blazars at mm wavelengths in general at levels ≲2%

- Faraday conversion of LP into CP from helical B field, inhomogeneous dynamic processes, and intrinsic CP production can explain our CP data

Conclusions



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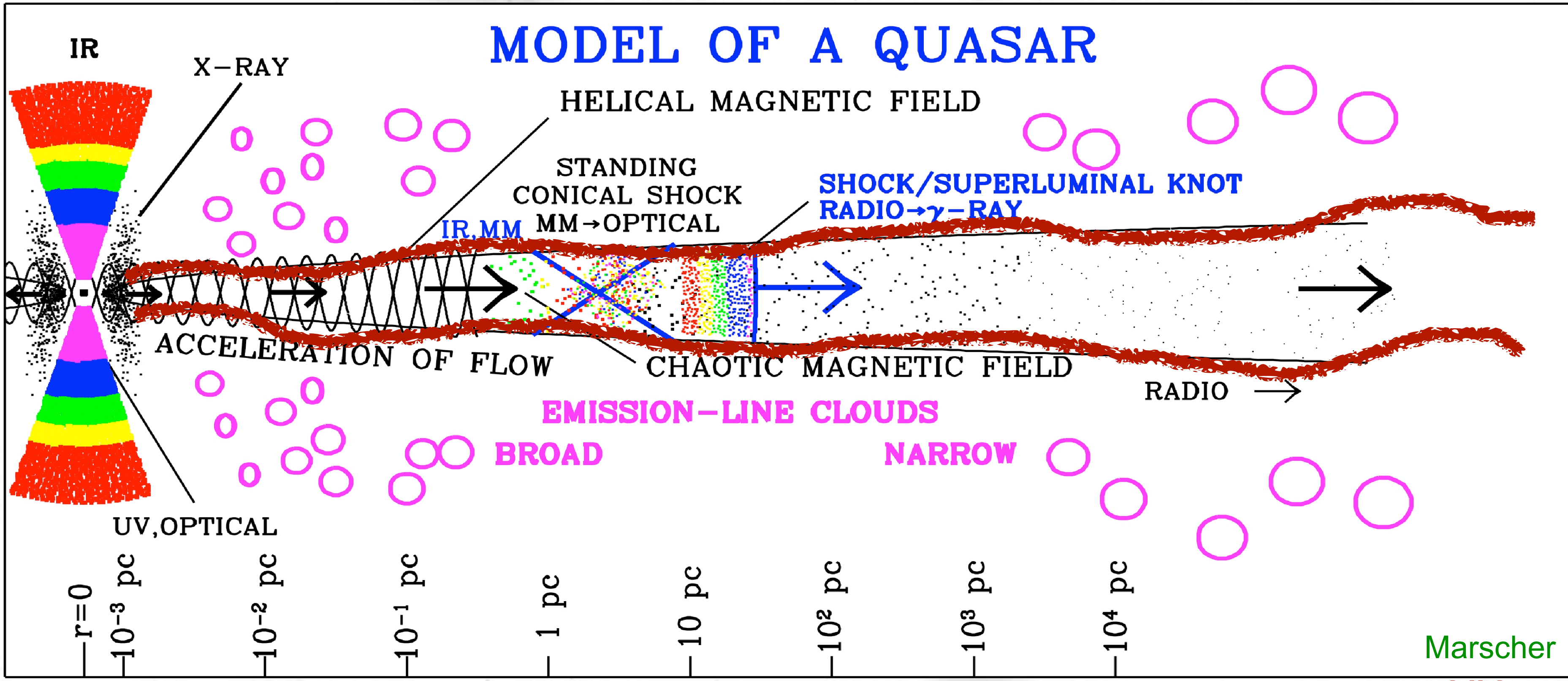

+ additions

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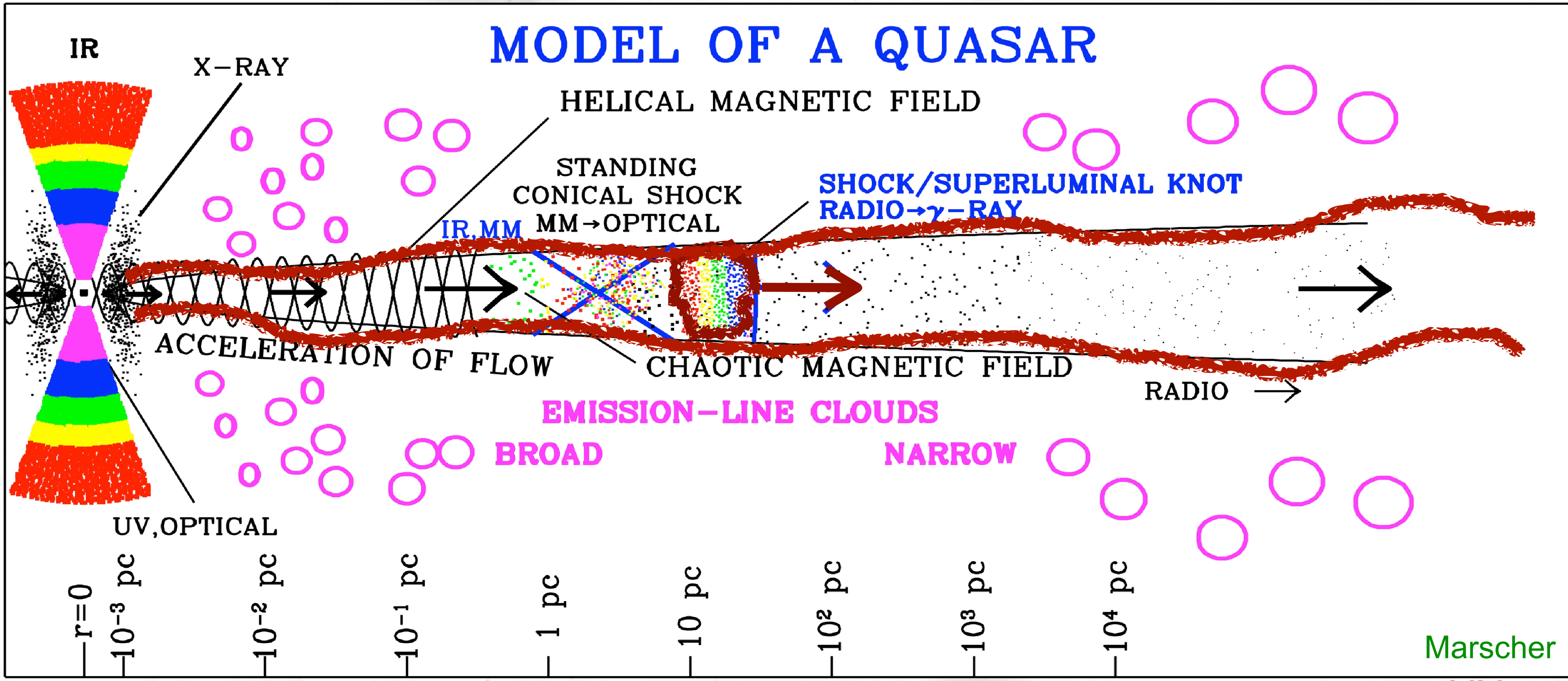

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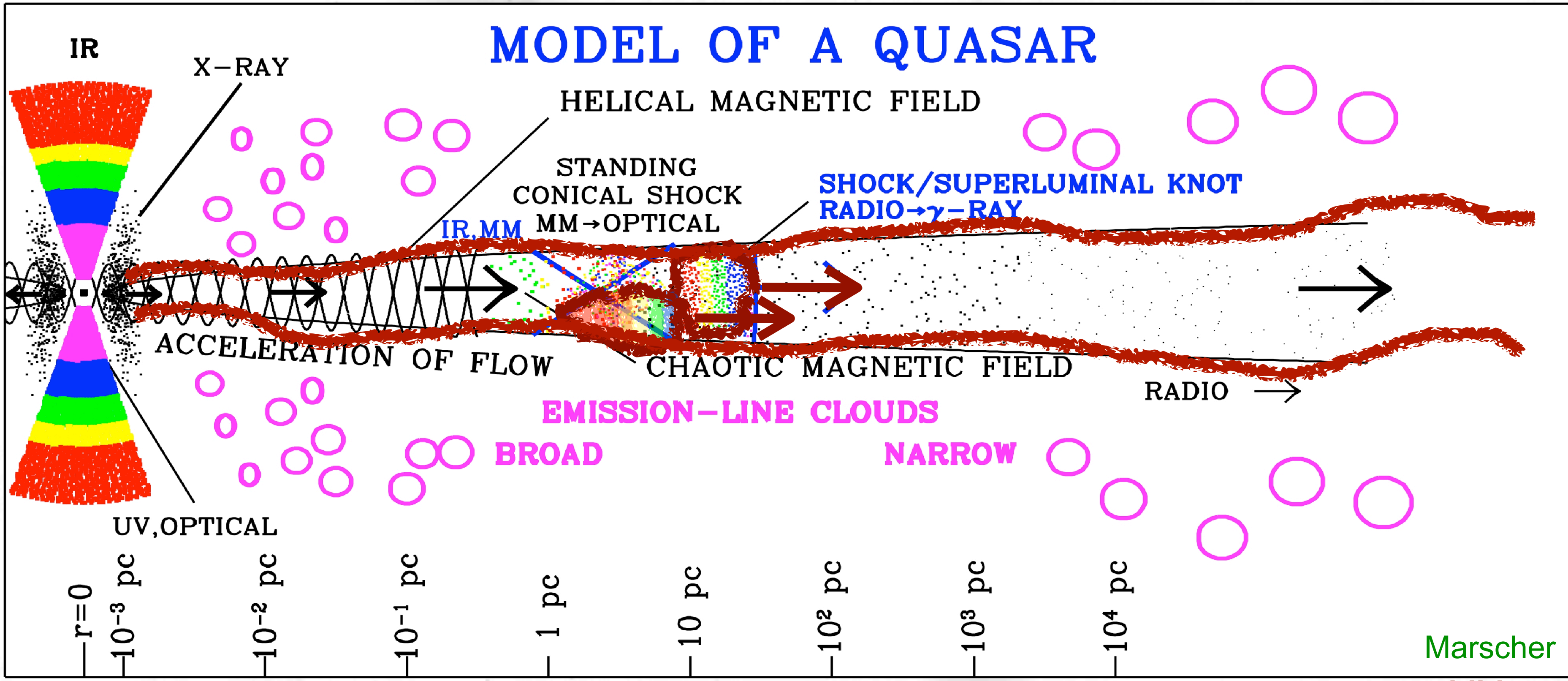

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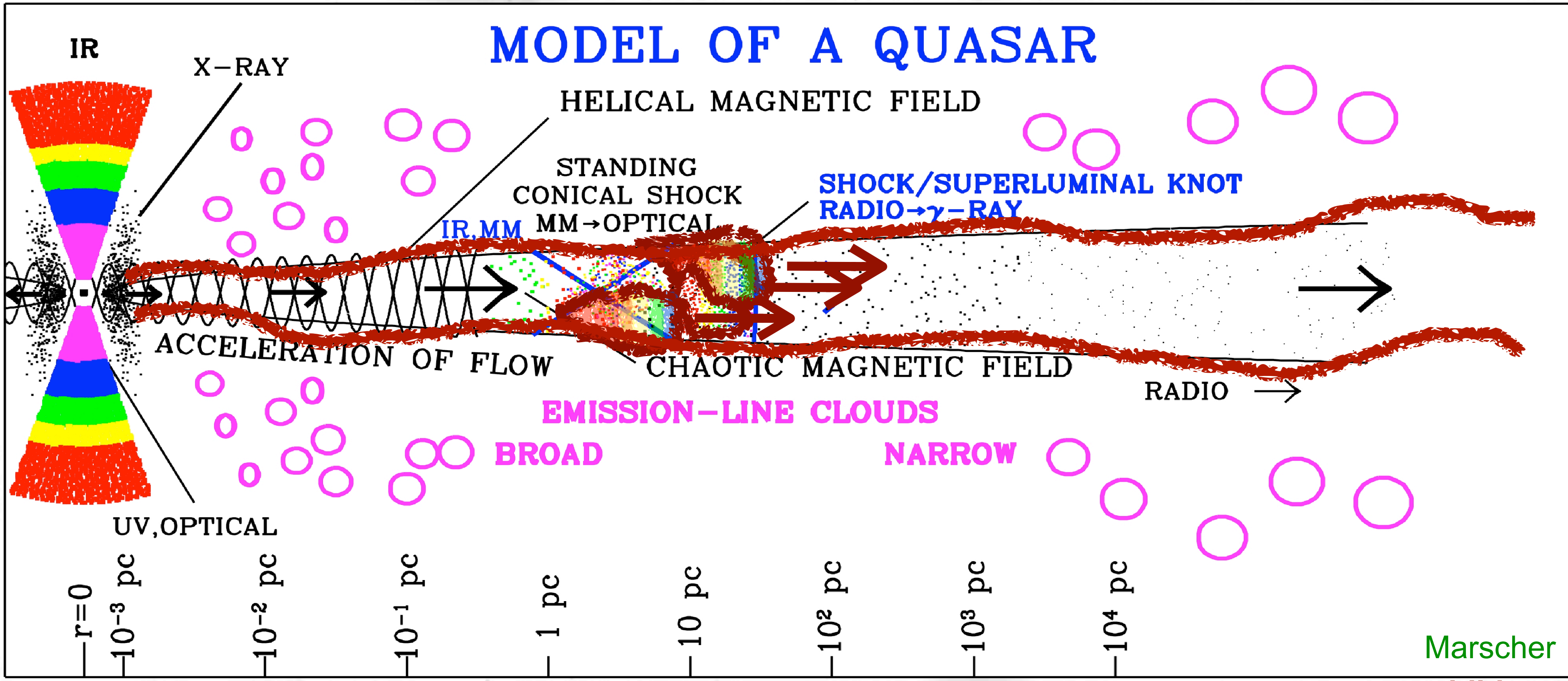

+ additions