Search for extreme Faraday Rotation in AGN jets

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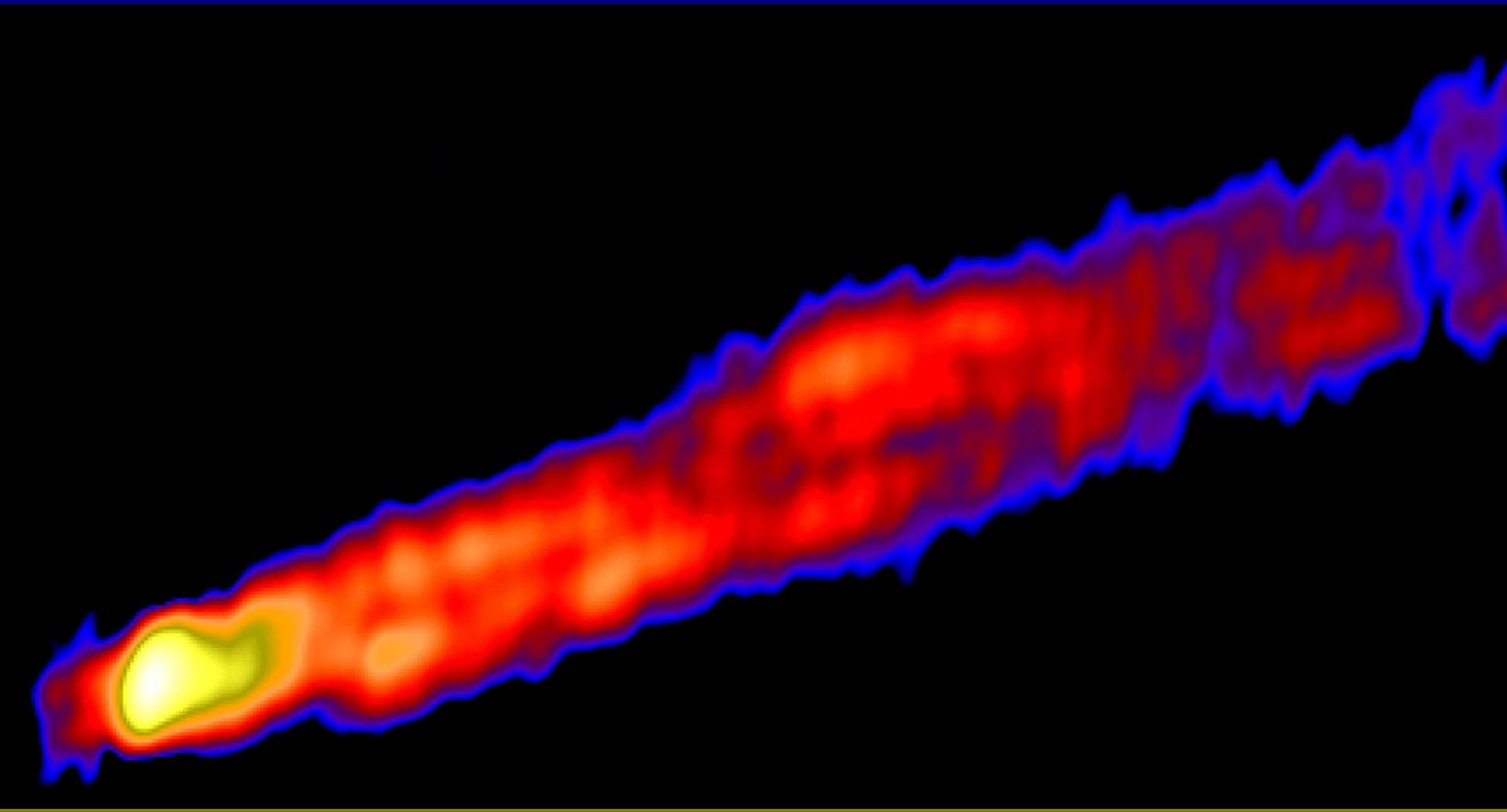

The team

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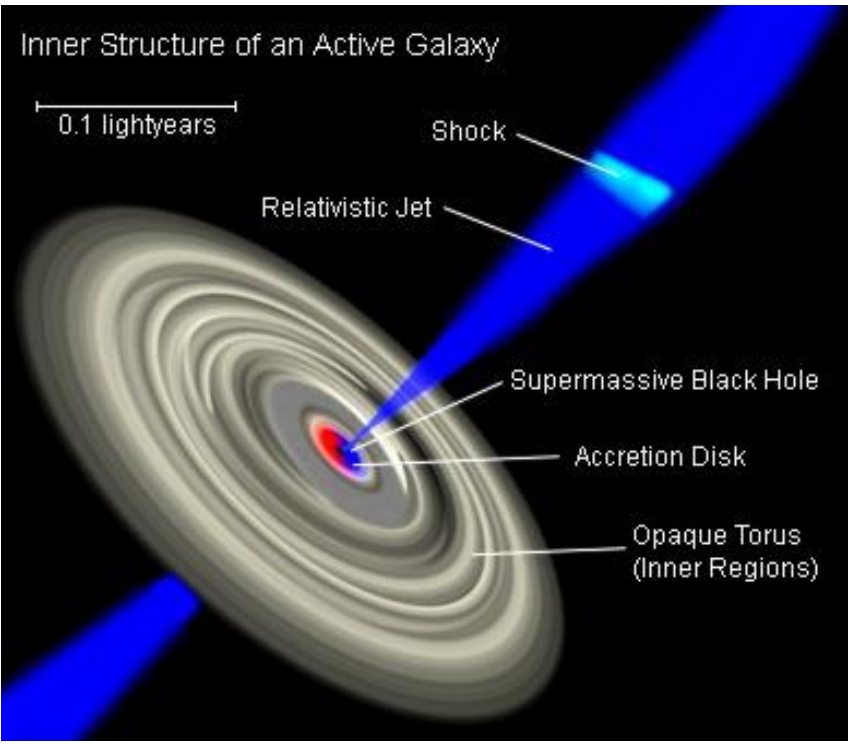
- **V. A. Soglasnov** *(ASC Lebedev)*

Outline

- **Grounds for Extreme Faraday rotation**
- **New method to search for extreme FRM**
- **Results from the first implementation of the method with the 100-m Green Bank Telescope**

Why (extreme) Faraday rotation?



WikipediA

- FRM: Probe thermal particle density and magnetic field.
- Extreme FRM: probe close to the central engine where relatively high magnetic field strength and/or particle density might be expected. Even no need to do VLBI since this is (I am simple minded) the only place which could produce such high RM.
- How much high? A million rad/m^2.
- Possible? Yes. Already observed somewhere? Yes. Sgr A*: half a million rad/m^2 (Marrone *et al.* 2007).

Very basic equations

Rotation measure:

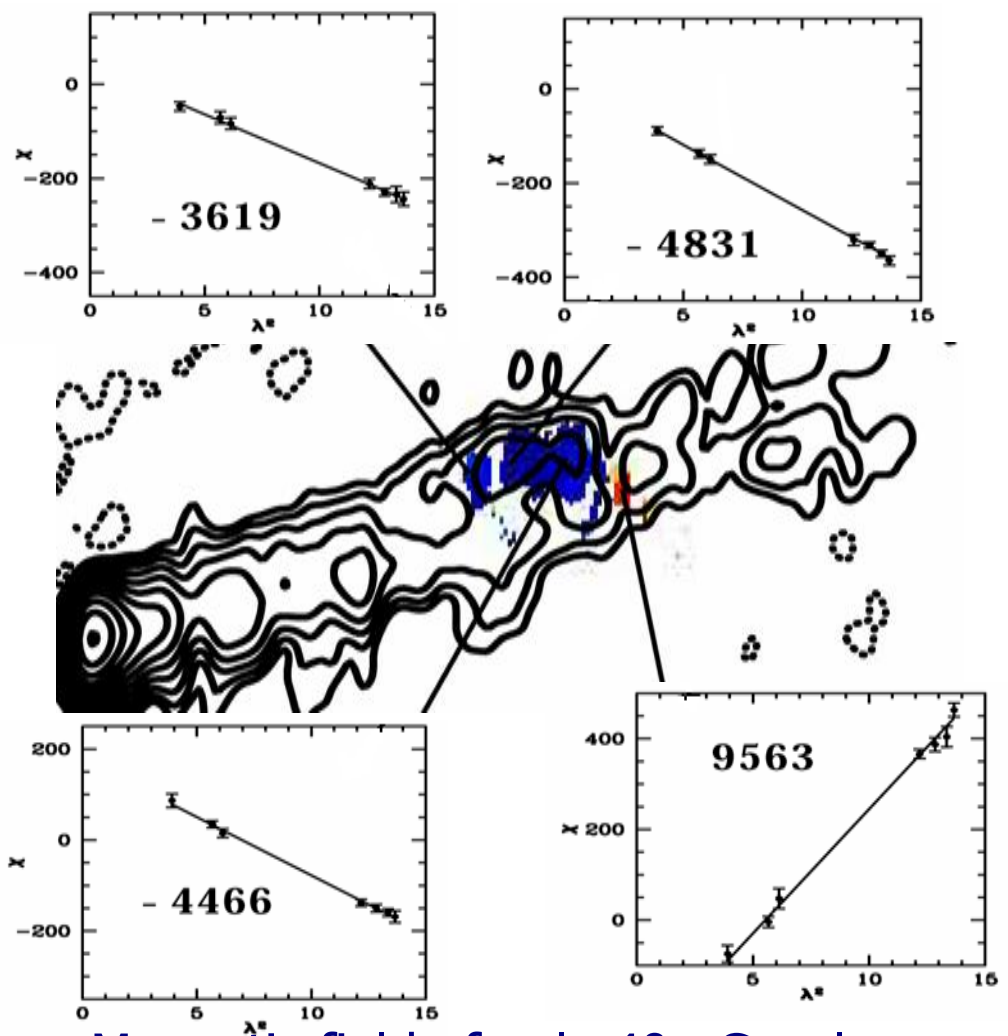
$$RM = 8{,}1 \cdot 10^5 \int n_{e[cm^{-3}]} B_{\parallel[G]} dl_{[pc]} \quad [rad/m^2]$$

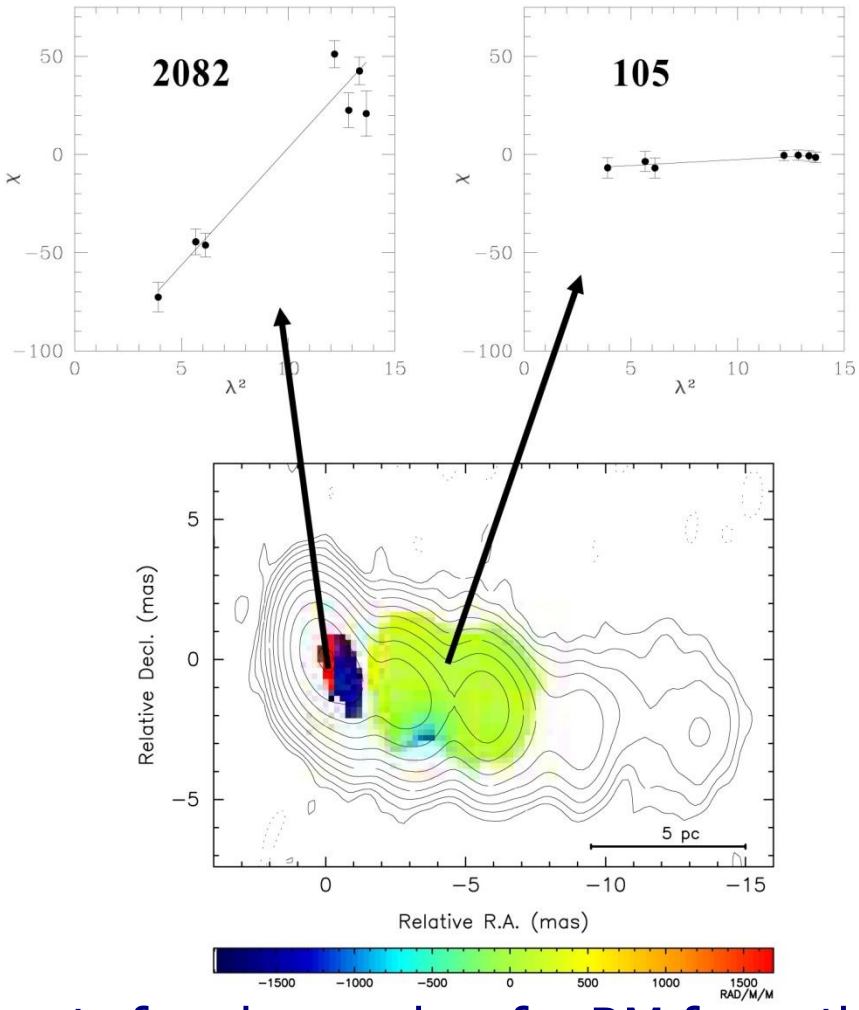
EVPA rotation:

$$\psi = RM \cdot \lambda^2_{[m]}$$

Faraday rotation in M87 & 3C120

Zavala & Taylor (2002)





Magnetic field of only 40 μG or less accounts for observed so far RM for path lengths through the Faraday rotating medium of 1 pc and electron densities 10^3-10^2 cm^{-2}.

Limitations of traditional methods

1. Limited angular resolution: in-beam depolarization, the Larry's "WRONG answer" problem.

2. The $n\bullet\pi$ polarization P.A. ambiguity.

3. Faraday rotation within a frequency channel: depolarization, upper limit on detectable RM versus sensitivity per frequency channel.

New method

The Faraday effect is caused by free electrons and can be characterized as a difference in the refractive index seen by the two circularly polarized propagation modes. Since this differences results in a different speed of propagation for the two circularly polarized modes, it obviously causes a delay between the modes. The later results in the rotation of the EVPA which is proportional to the λ^2 — the Faraday rotation.

We propose to directly measure the delay between right and left circular polarization.

Differential Faraday rotation within the recorded band can be corrected for by digital methods. This is similar to the pulsar de-dispersion technique.

The new method implementation

1. Record LCP and RCP signals (like you would do for VLBI) on your single-dish radio telescope

2. Compensate for a *known* Faraday rotation

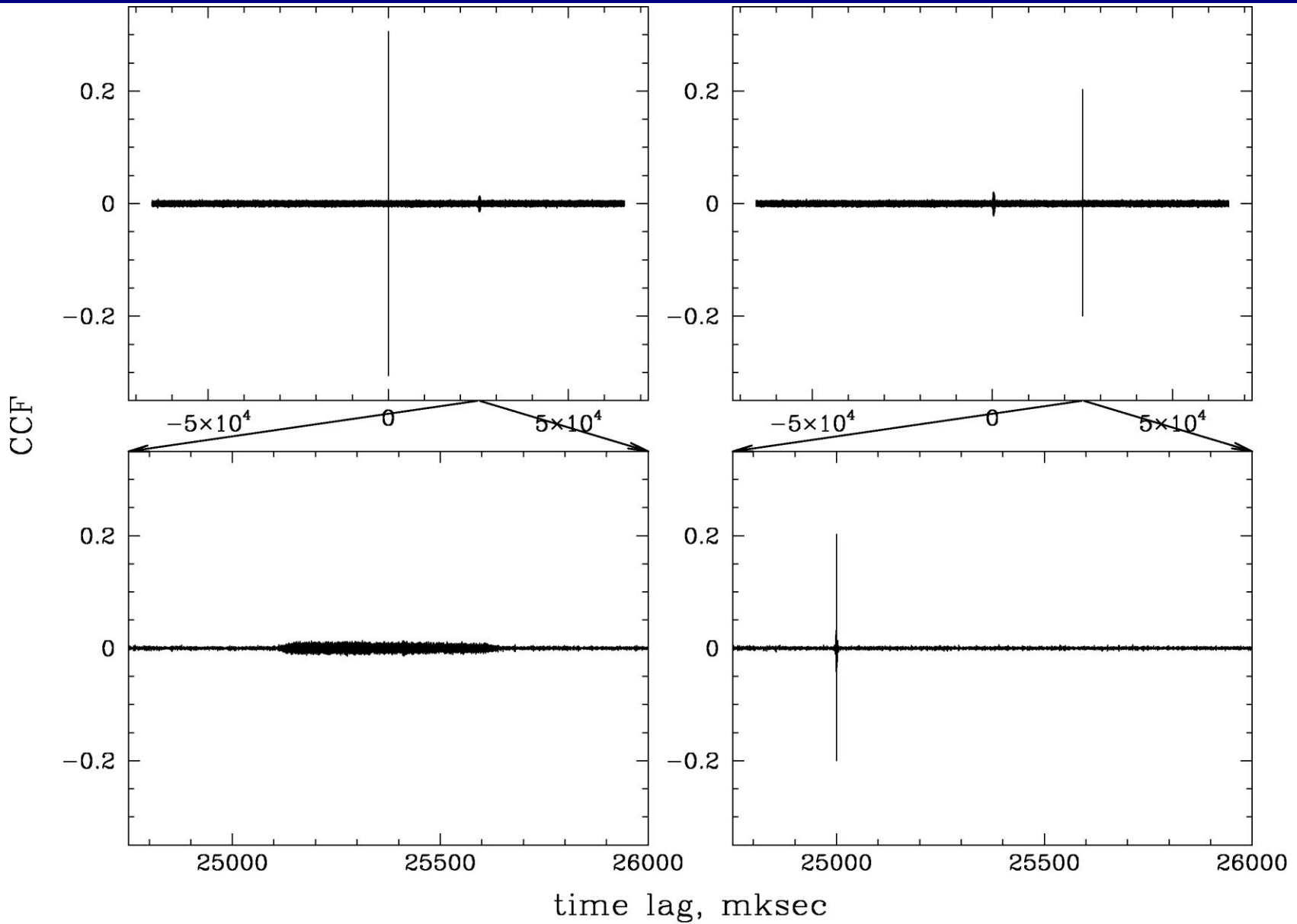
3. Correlate LCP with RCP

As a result, the cross-correlation function will show you a nice peak corresponding to a given Faraday delay (rotation).

<u>Realistic strategy:</u>

1. Preliminary correlation analysis in order to find peaks (hints) on a CCF.
2. Fine tuning the Faraday delay(s).

Computer modeling



Pros and Cons

Pros:

1. No FRM upper limit of the method.
2. No need for high angular resolution since different FRM components can be extracted independently
3. No need for multi-band observations

Cons:

1. High computing power requirements.
2. The method has a lower limit of detectable FRM.

Implementation – Robert C. Bird Green Bank Telescope

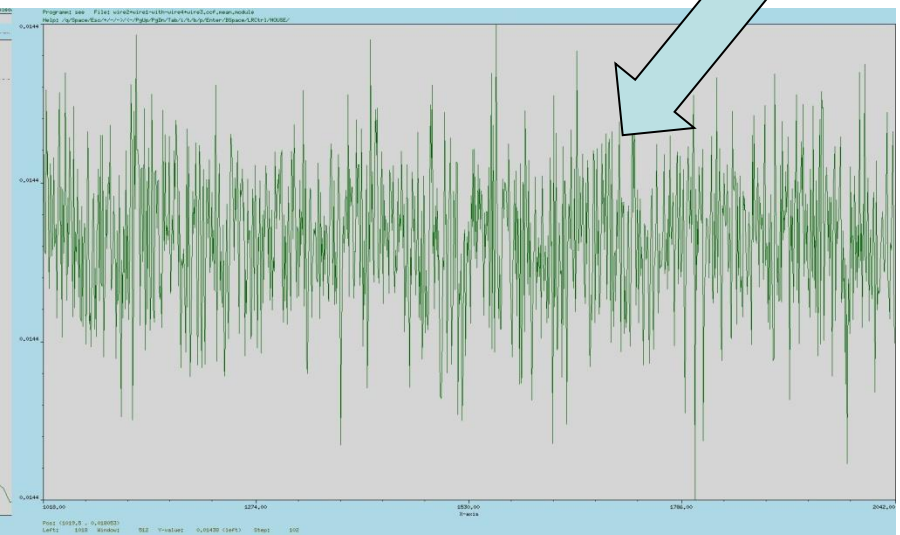
Setup

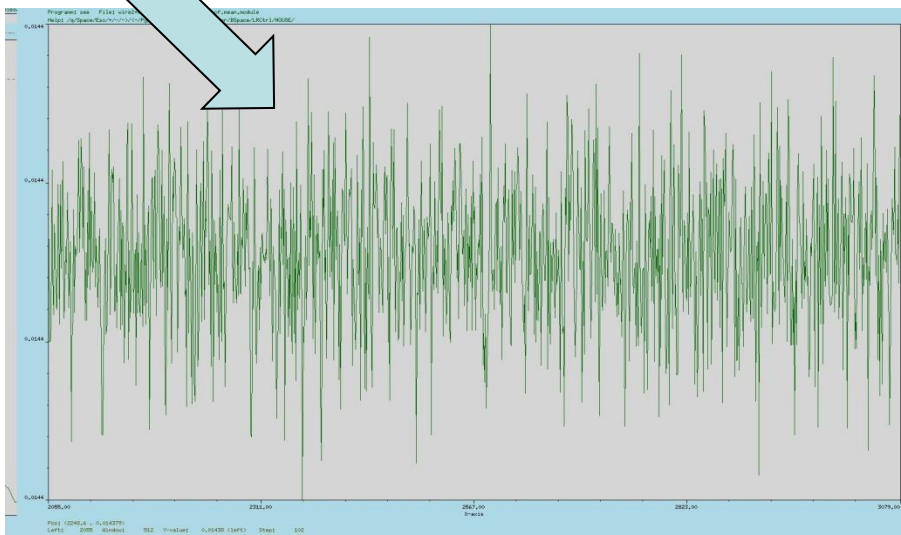
1. Telescope: GBT (unblocked aperture).
2. Observing bands: 2 and 8 GHz.
3. Bandwidth: 20 MHz.
4. Targets: NRAO530, 0716+714, 3C279, 3C273, M87.
5. Recorder: PFS (Portable Fast Sampler)
6. Type of observations: ON-OFF
7. Typical integration time: 15 min.
8. Typical sensitivity: 1 mJy.
9. Detectable RM: >200,000 rad/m^2 (2 GHz),
   >500,000 rad/m^2 (8 GHz).

Results

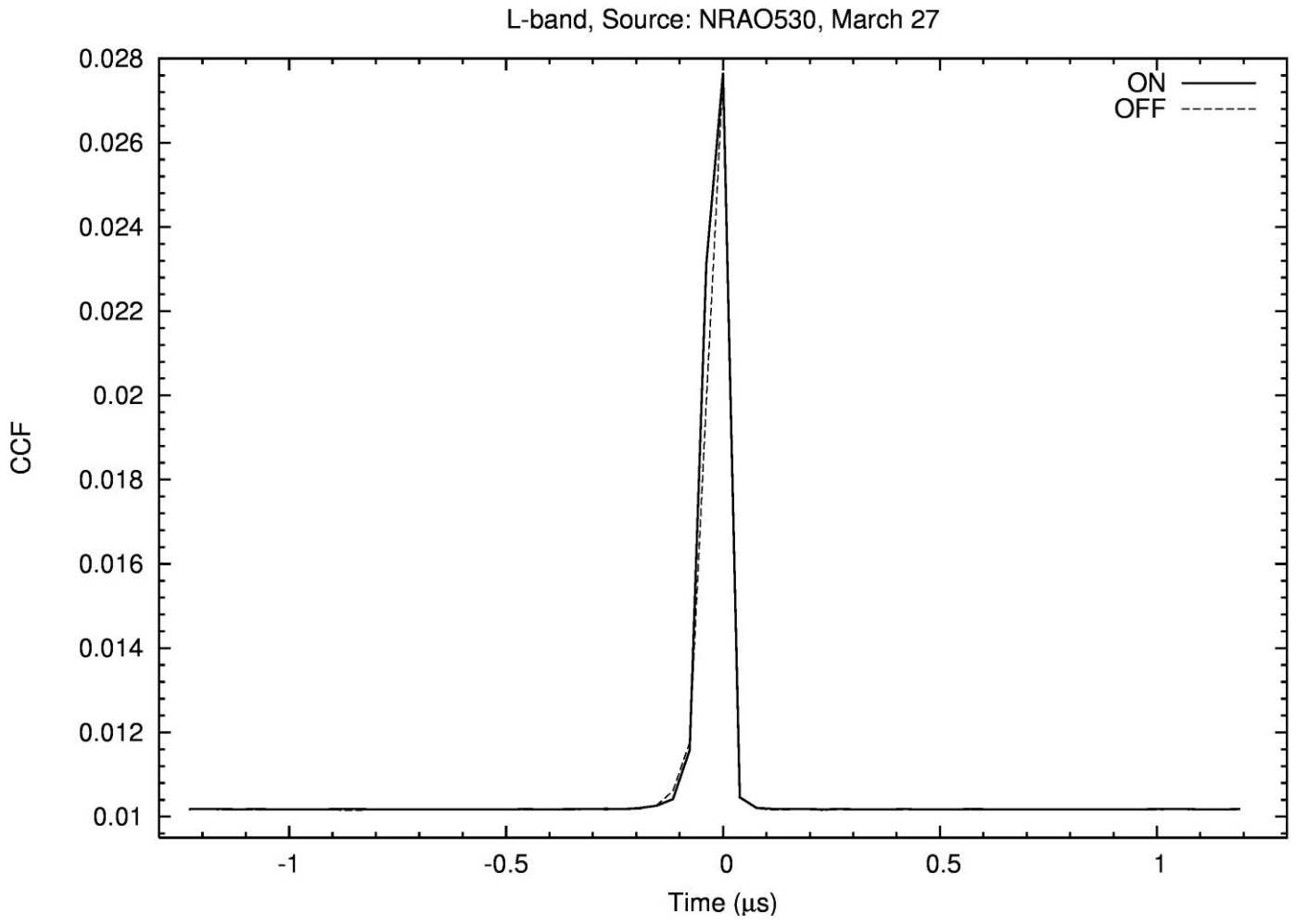
No detections so far.

3C279, 8 GHz

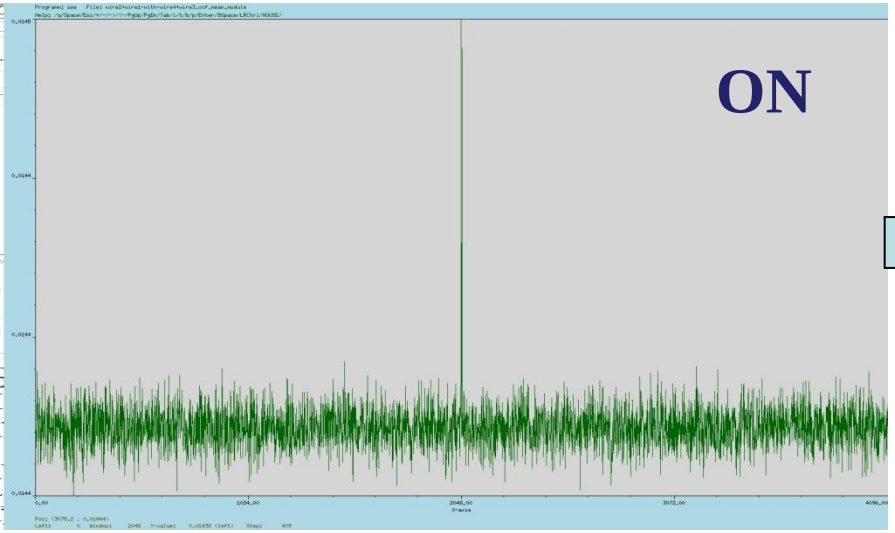


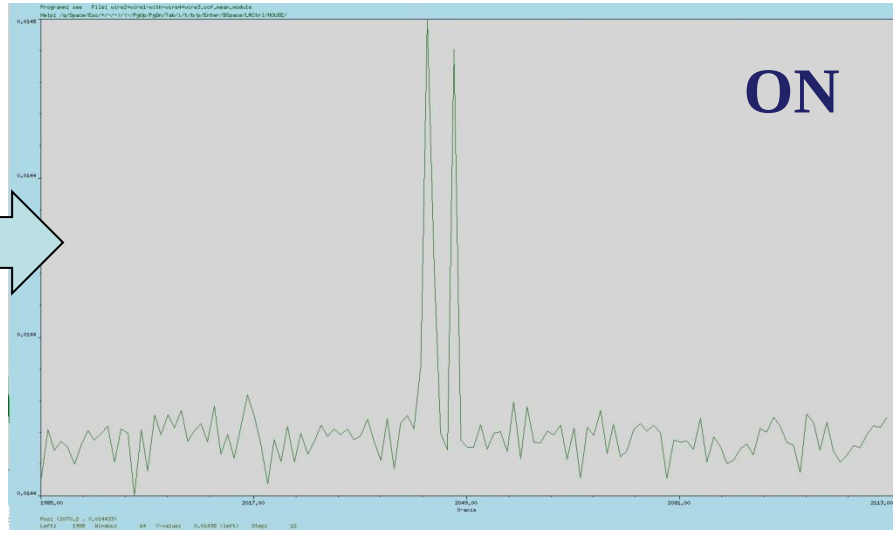


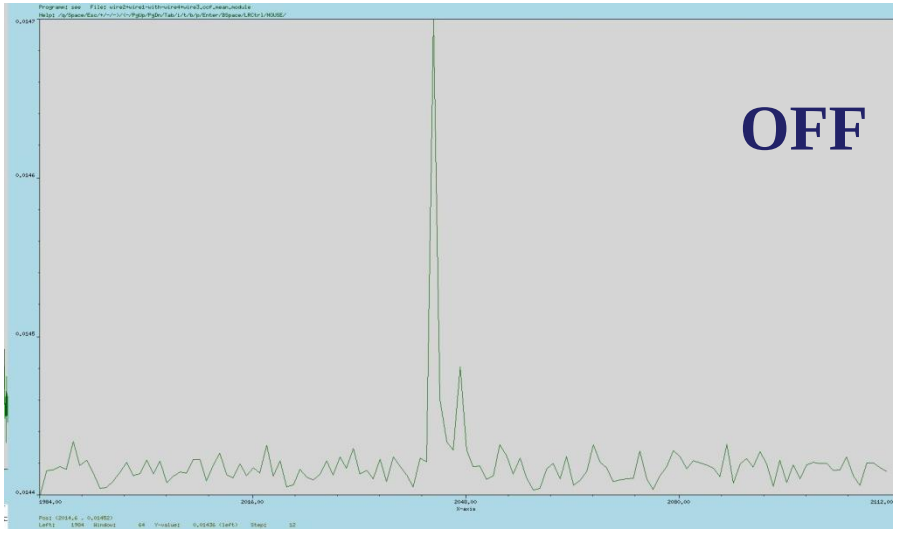
Results. NRAO530, 2.3 GHz



Results. 0716+714, 8 GHz







Possible reasons for not-detections. What to improve?

1. Not enough sensitivity.

Increase the bandwidth with Mark5C and digital BBCs.

2. Synchrotron opacity does not allow to probe inner regions with extreme FRM.

Go to higher frequencies.

3. Poor statistics.

Increase the number of sources observed.

4. Stupid or unlucky.

Extremely difficult to improve hear.

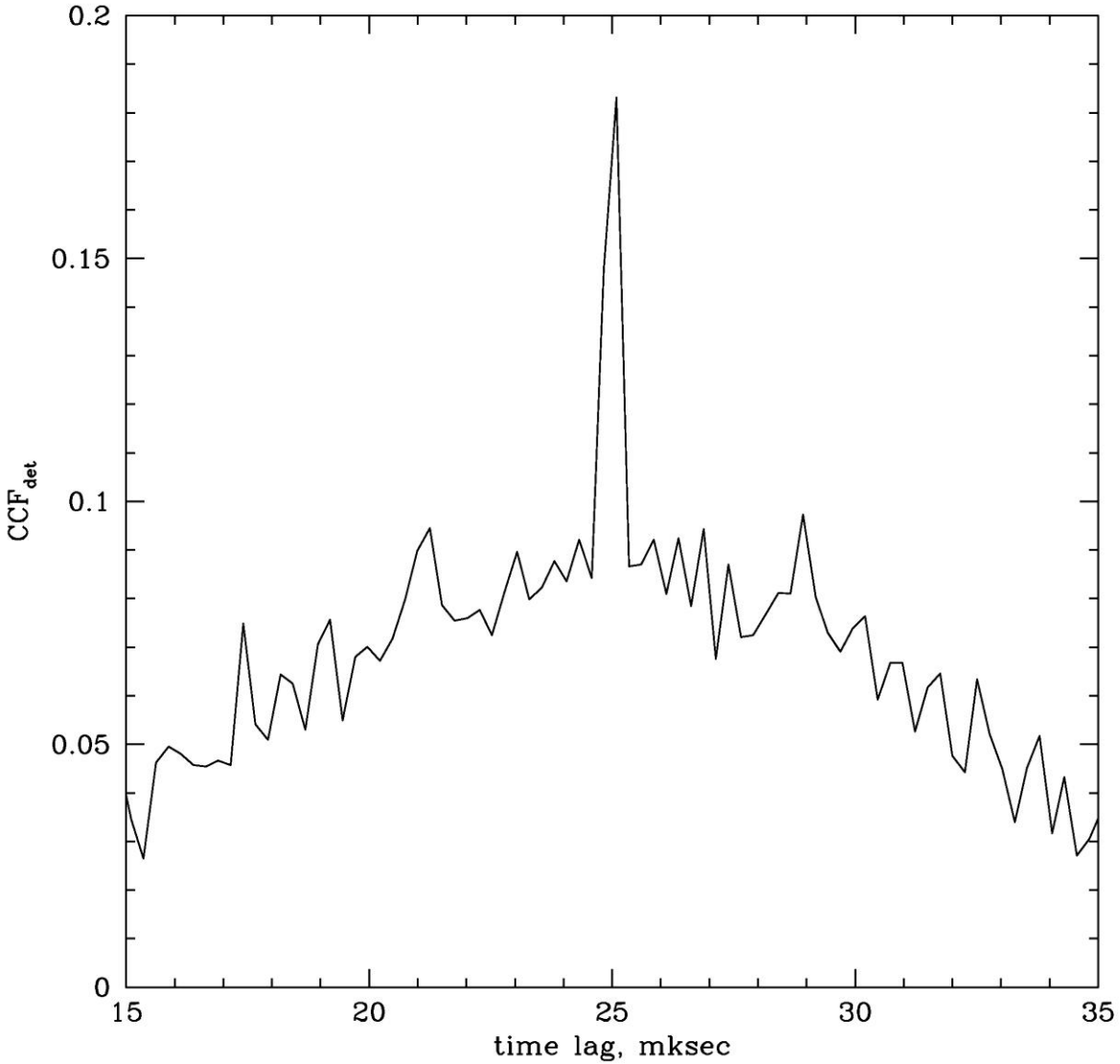
Summary

A new correlation method to detect the Faraday effect is proposed and implemented.

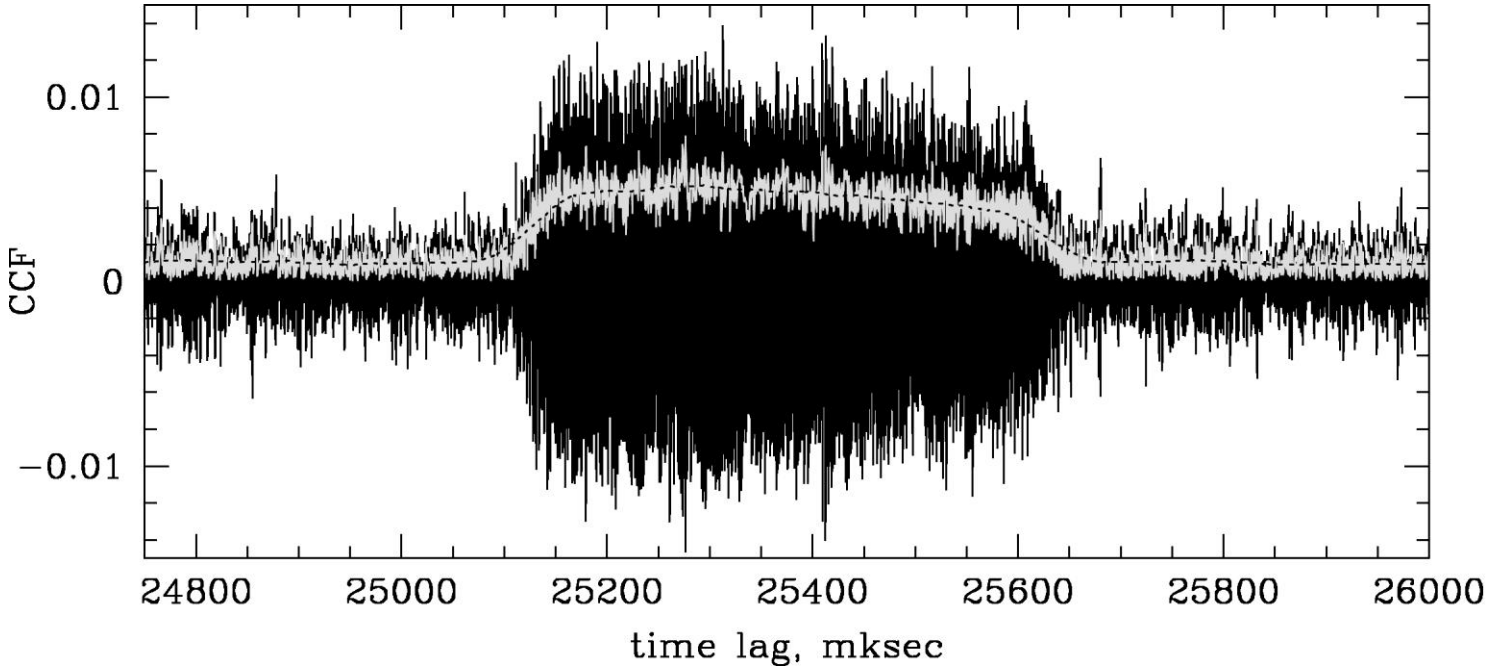
So far, it did not result in a discovery of extreme Faraday rotation.

Thank you

Extra1



Extra2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0
−0.01
CCF
24800
25000
25200
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25600
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26000
time lag, mksec