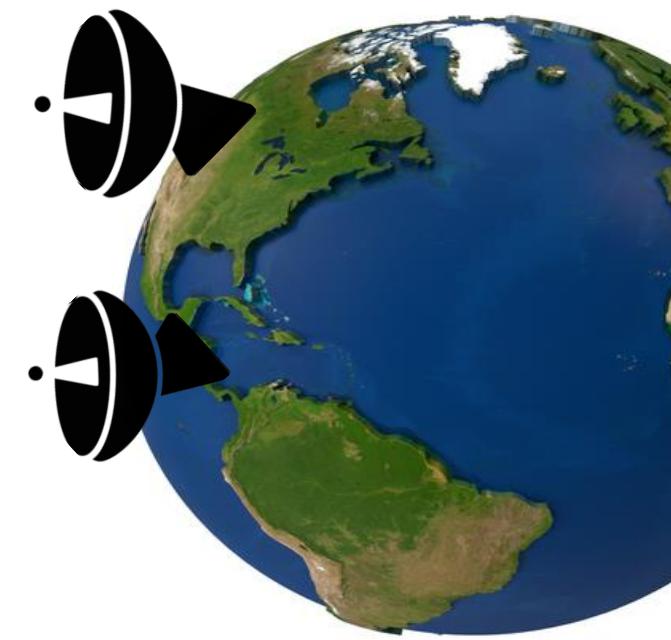
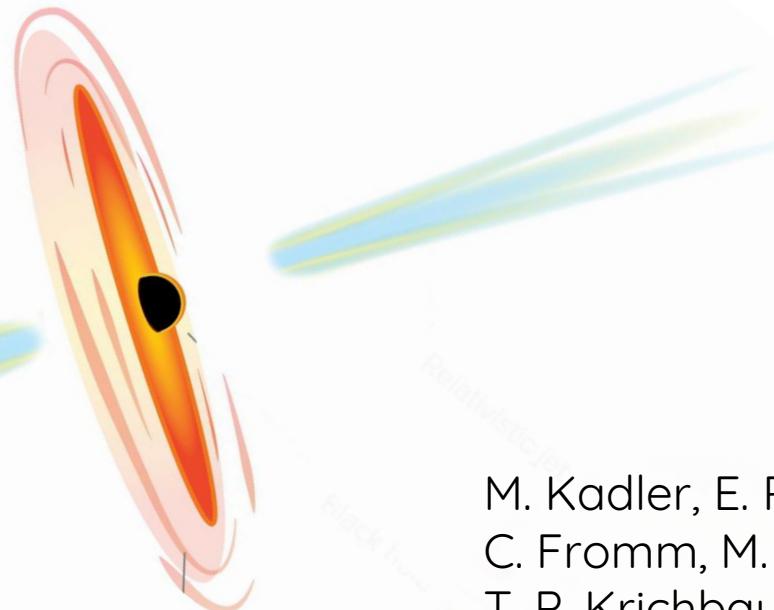


# VLBI Probes of Jet Physics in Neutrino-Candidate Blazars

## Florian Eppel

JMU Würzburg & MPIfR Bonn



M. Kadler, E. Ros, J. Heßdörfer, F. Rösch, P. Benke, B. Boccardi, S. Buson, P. Edwards, C. Fromm, M. Giroletti, A. Gokus, J. L. Gomez, S. Hämerich, D. Kirchner, Y. Y. Kovalev, T. P. Krichbaum, M. Lister, K. Mannheim, F. McBride, C. Nanci, R. Ojha, G. F. Paraschos, M. Perucho, A. Plavin, A. C. S. Readhead, J. Stevens, P. Weber, P. Torne

Credit: Sophia Dagnello, NRAO/AUI/NSF

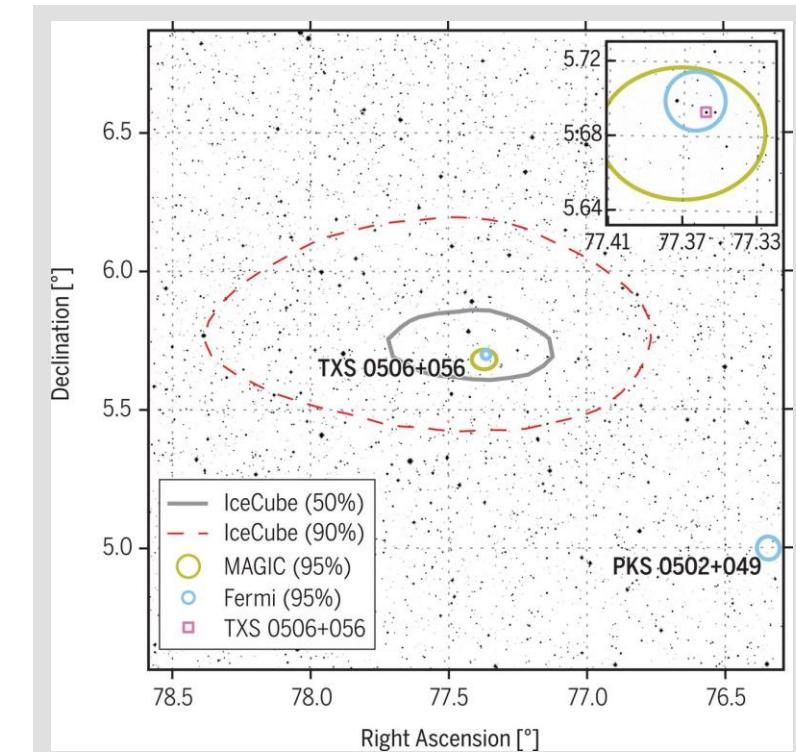
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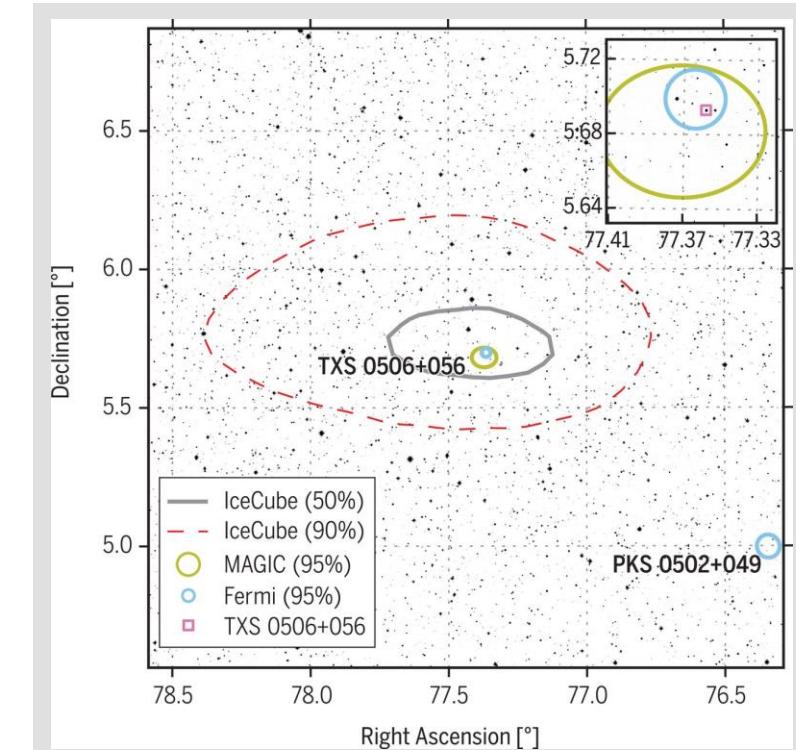
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Localization Region of IC170922A (IceCube Collaboration et al. 2018)

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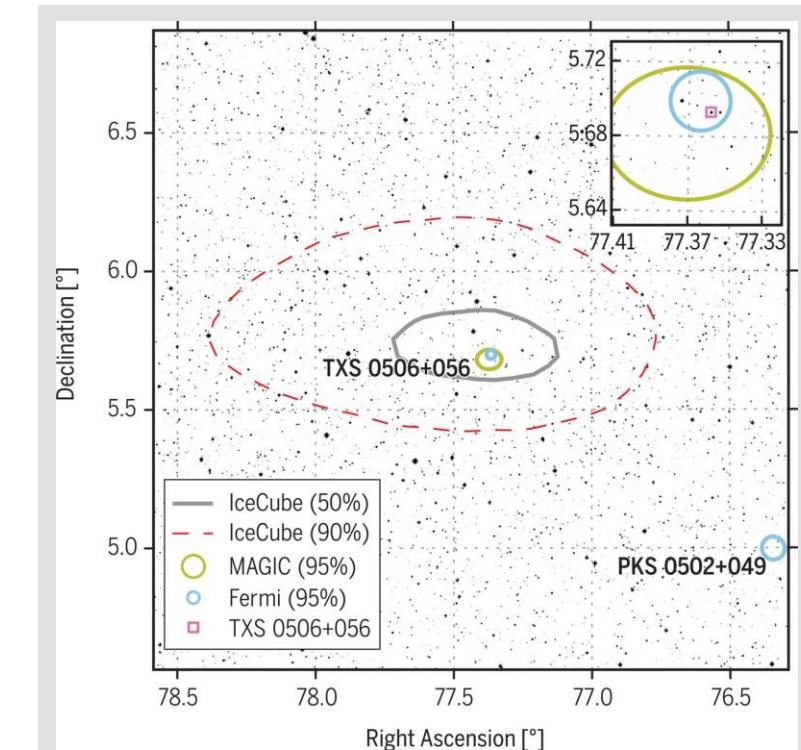
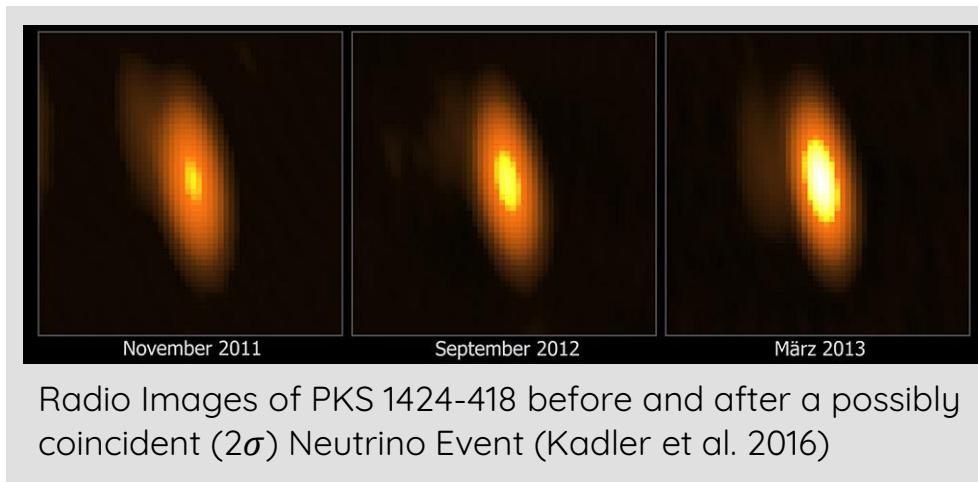
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This list is not complete and still keeps growing!

→ Need for more statistics  
and individual case-studies to  
understand the physics of neutrino  
production

# TELAMON

- TeV Effelsberg Long-term Agn MONitoring



© J. Heßdörfer

Effelsberg 100-m Telescope

Kadler et al. (2021, ICRC PoS),  
Eppel et al. (2023, in prep.)

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- High cadence monitoring observations
  - Every 2-4 weeks
  - From 5 GHz up to 45 GHz (45mm, 20mm, 14mm, 7mm)
- **Neutrino follow-up observations**



Effelsberg 100-m Telescope

Kadler et al. (2021, ICRC PoS),  
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## Main Goals (long term):

- correlation (especially with upcoming CTA)
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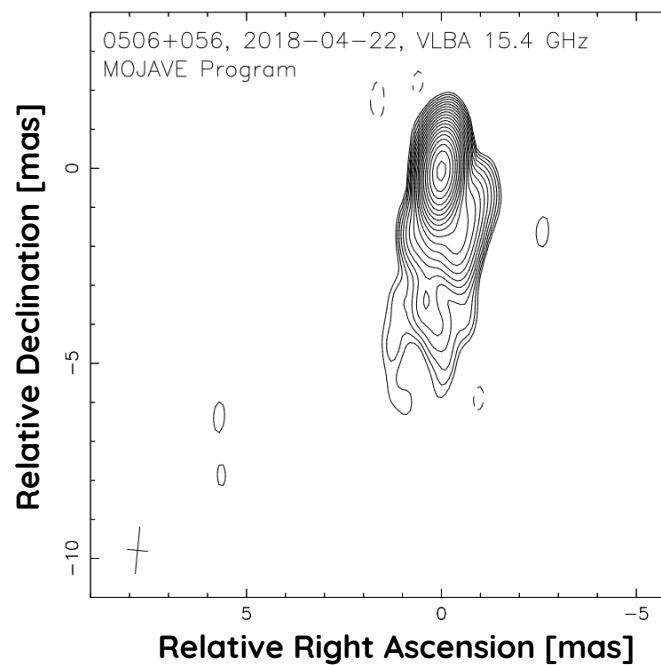
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Publicly available data distributed via website: <https://telamon.astro.uni-wuerzburg.de>



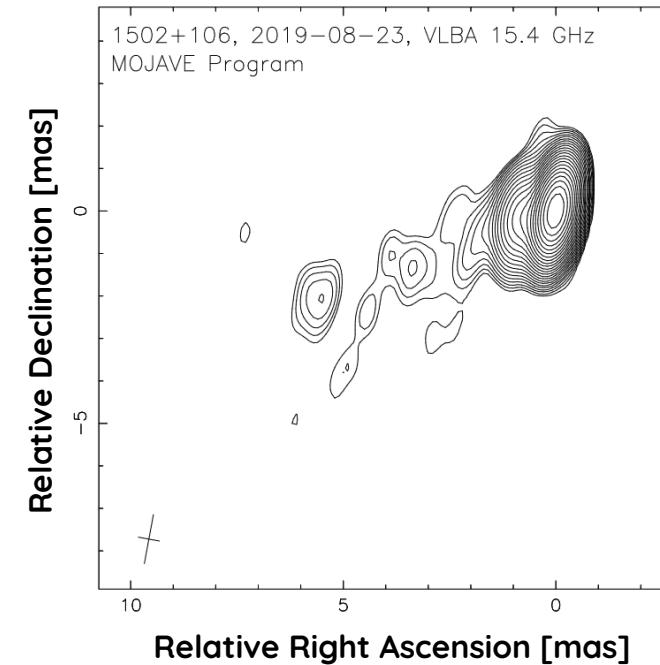
# Good Things Come In Threes

**TXS 0506+056**



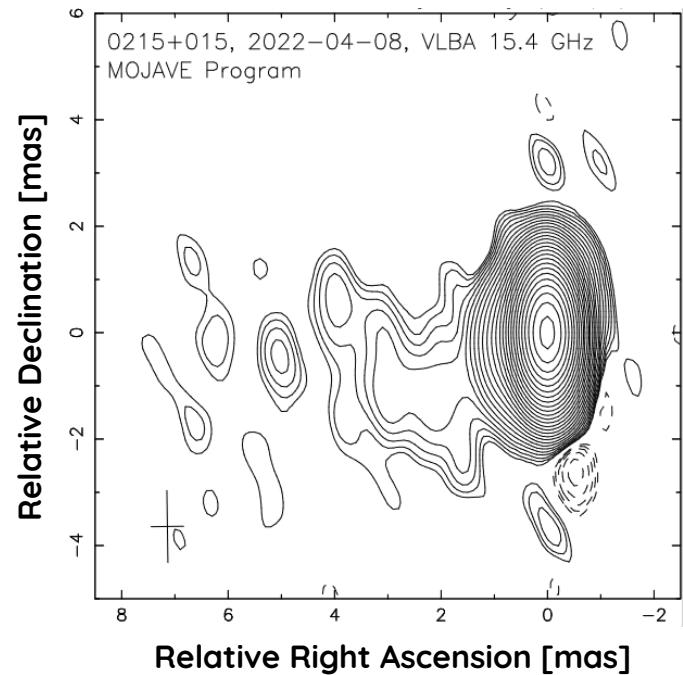
IC170922A

**PKS 1502+106**



IC190730A

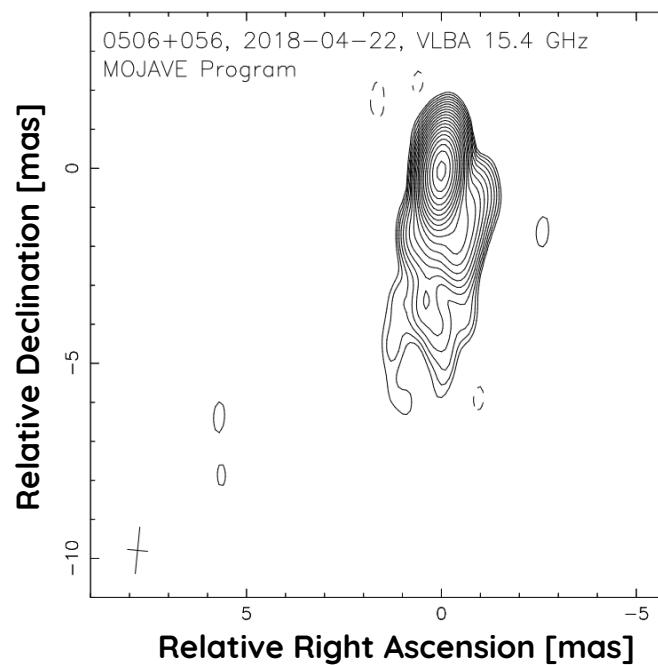
**PKS 0215+015**



IC220225A

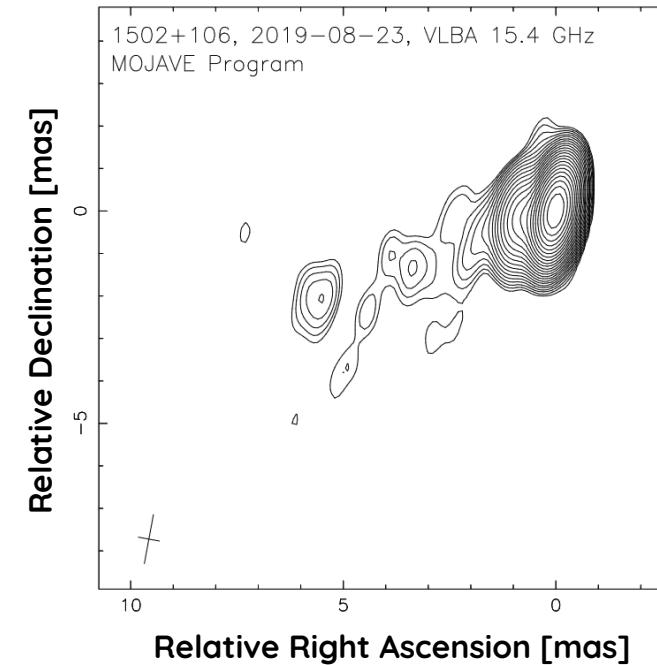
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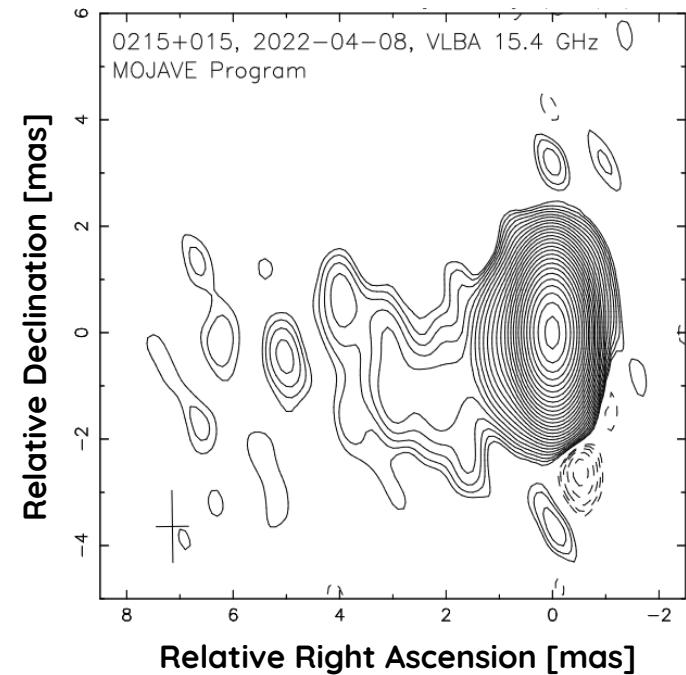
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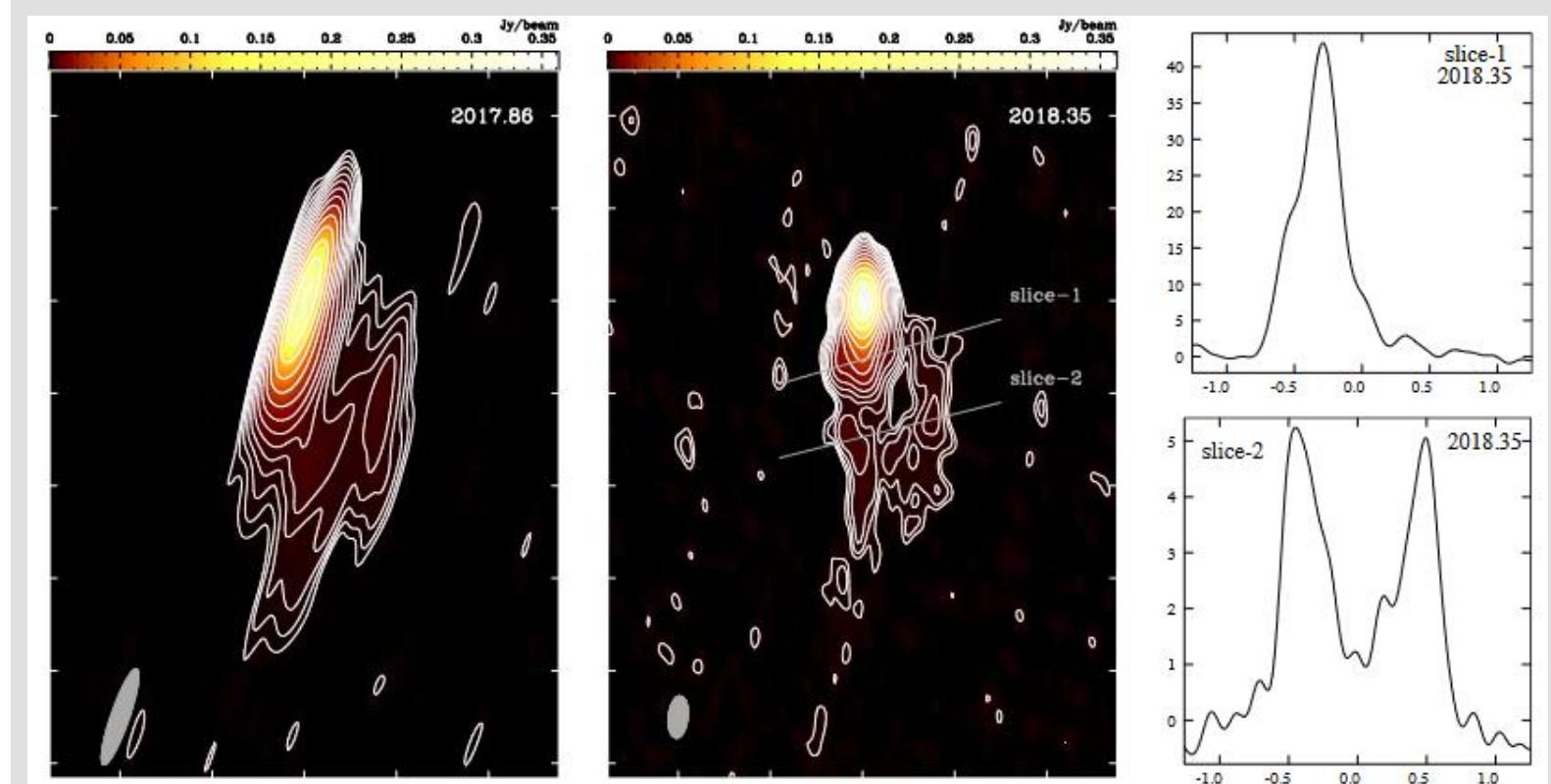


IC220225A

→ All radio-flaring at time of neutrino event and followed up with VLBI ToO observations

# TXS 0506+056 (IC170922A)

Multiwavelength-Flare associated  
with Neutrino Event IC170922A

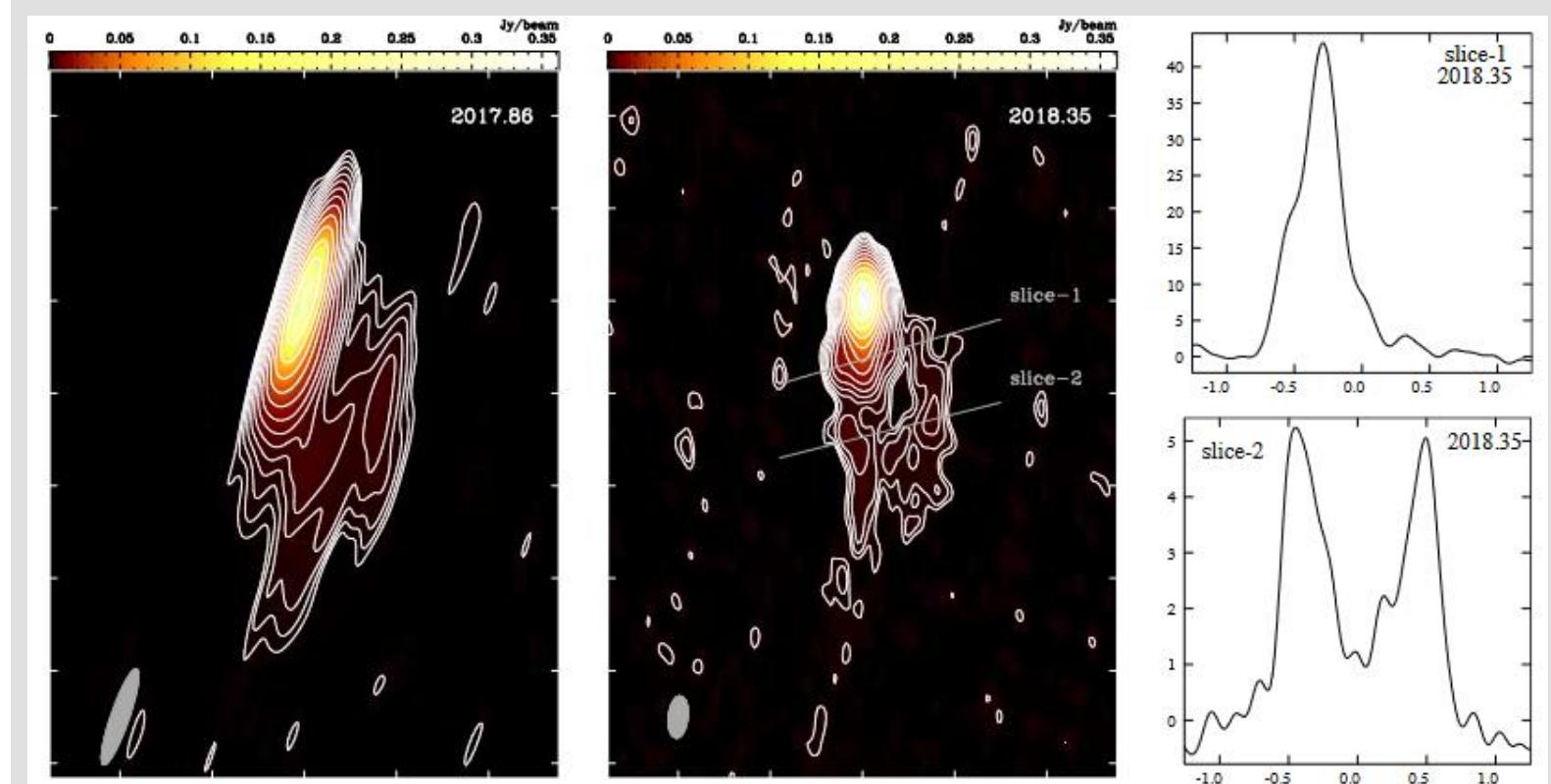


43 GHz VLBA images and surface brightness profiles of TXS 0506+056 after the associated neutrino event providing evidence of limb-brightening (Ros et al. 2020)

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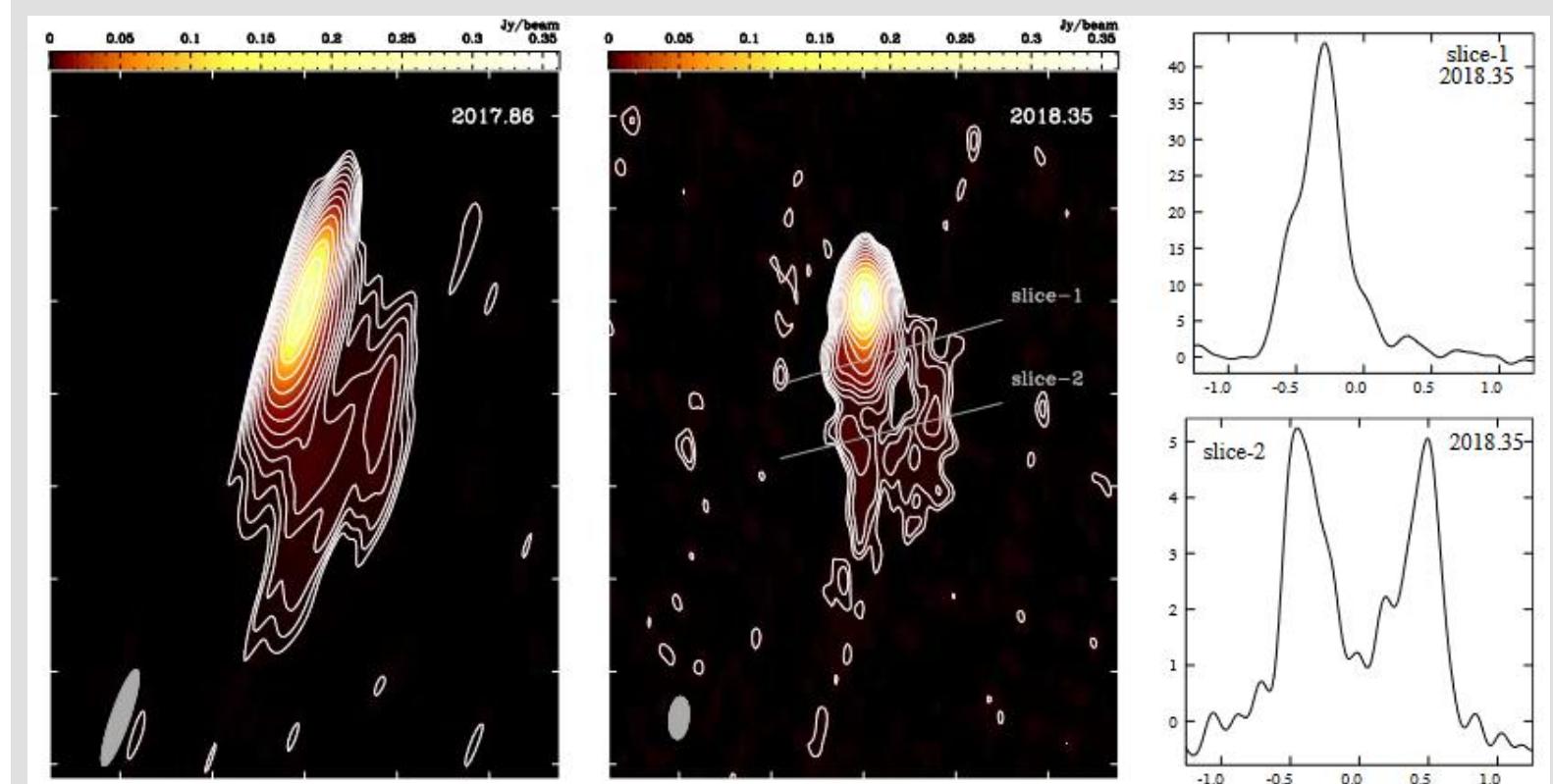


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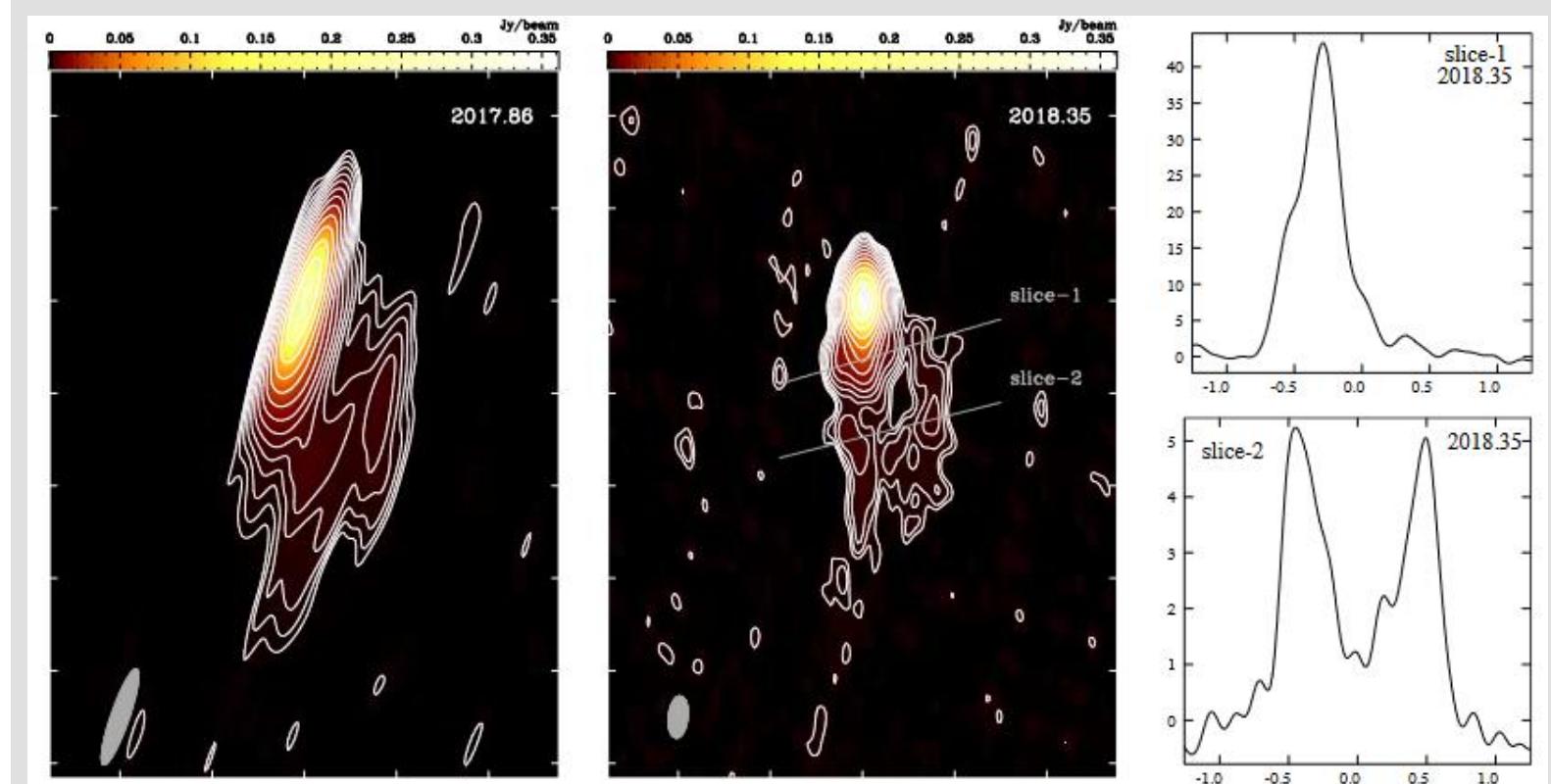


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# TXS 0506+056 (ongoing work)

## Main Goals

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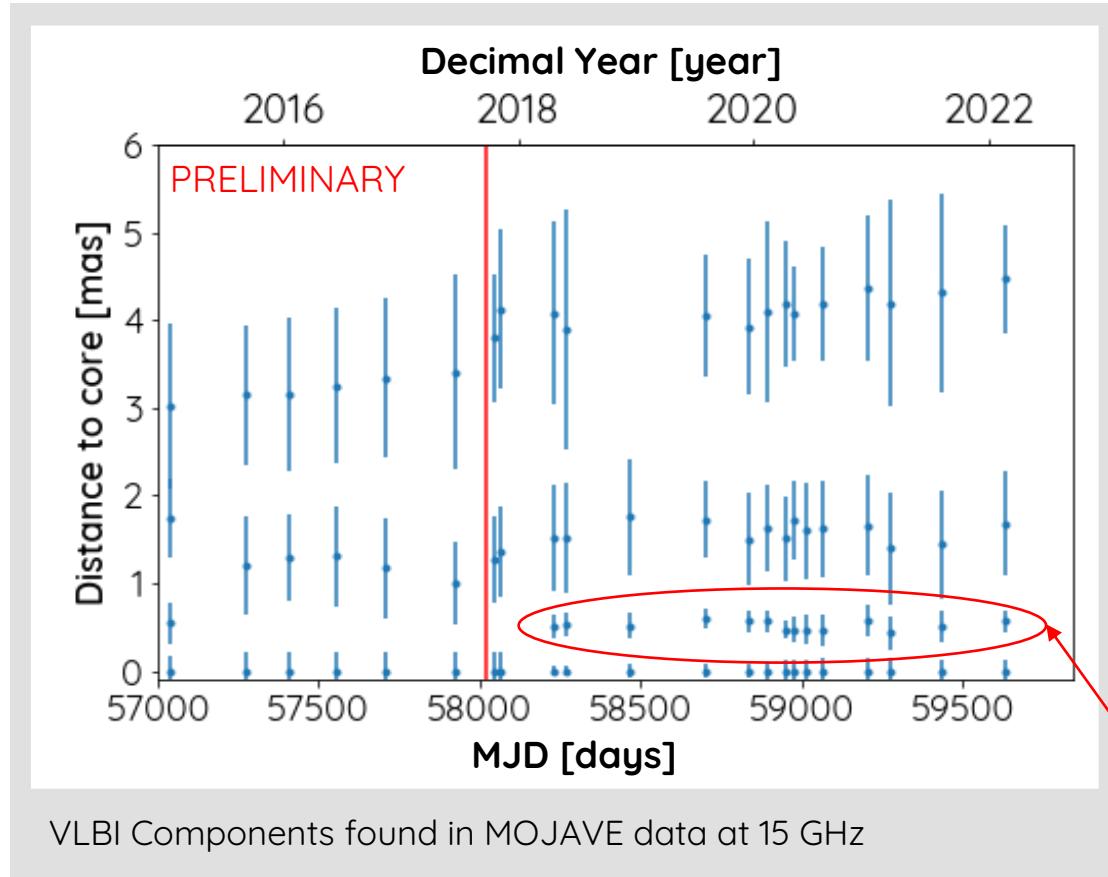
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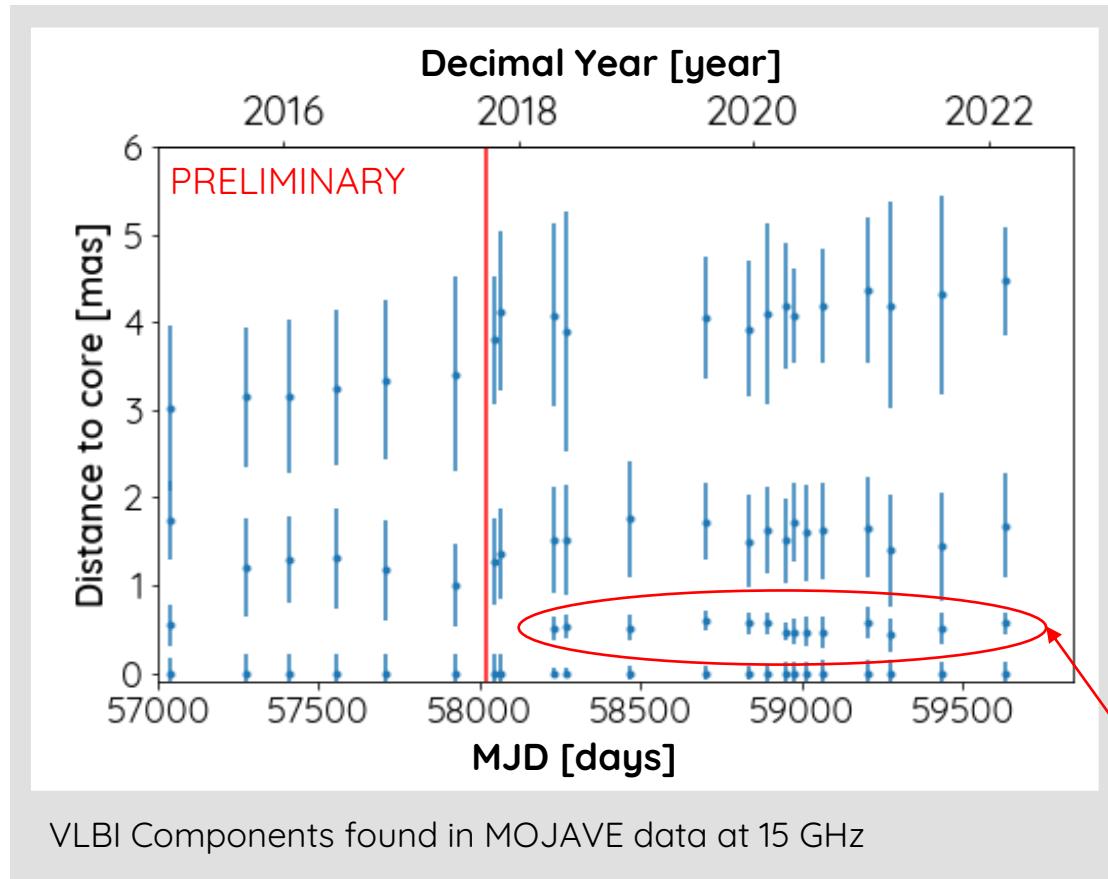
VLBI Components found in MOJAVE data at 15 GHz

Possible new jet component found

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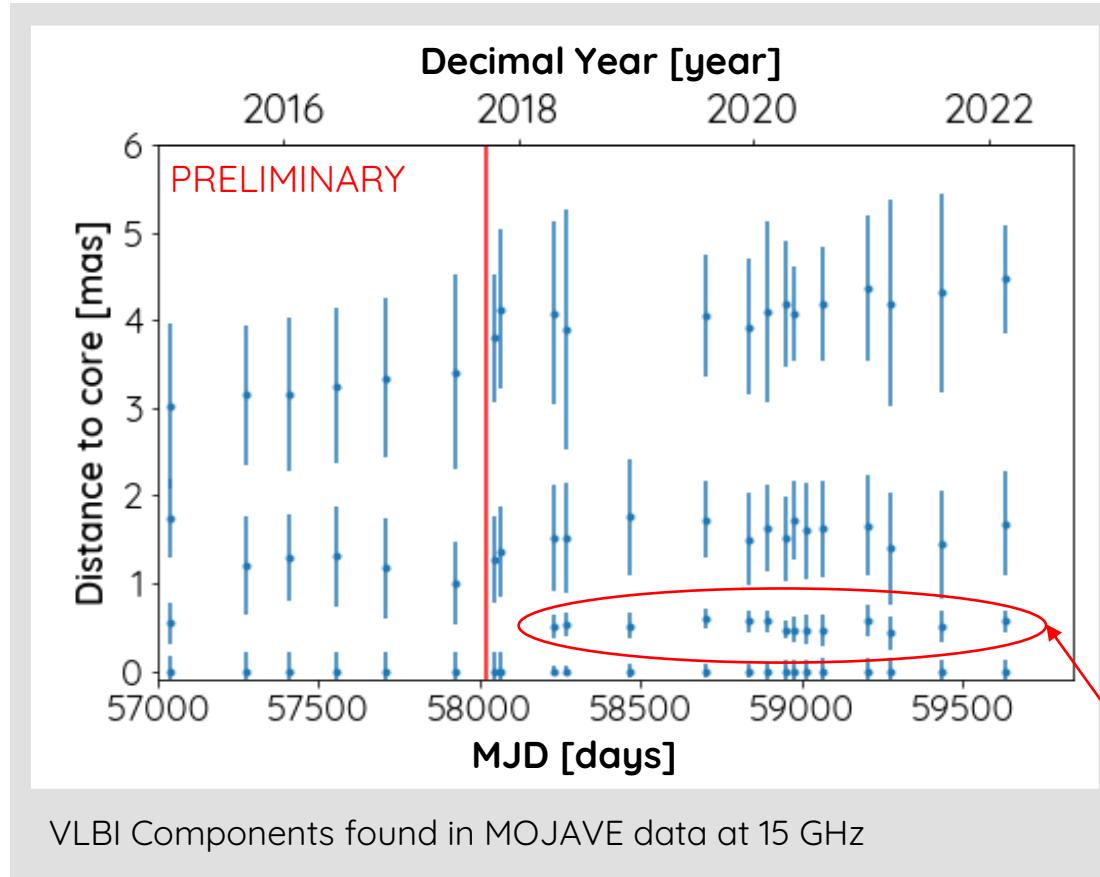
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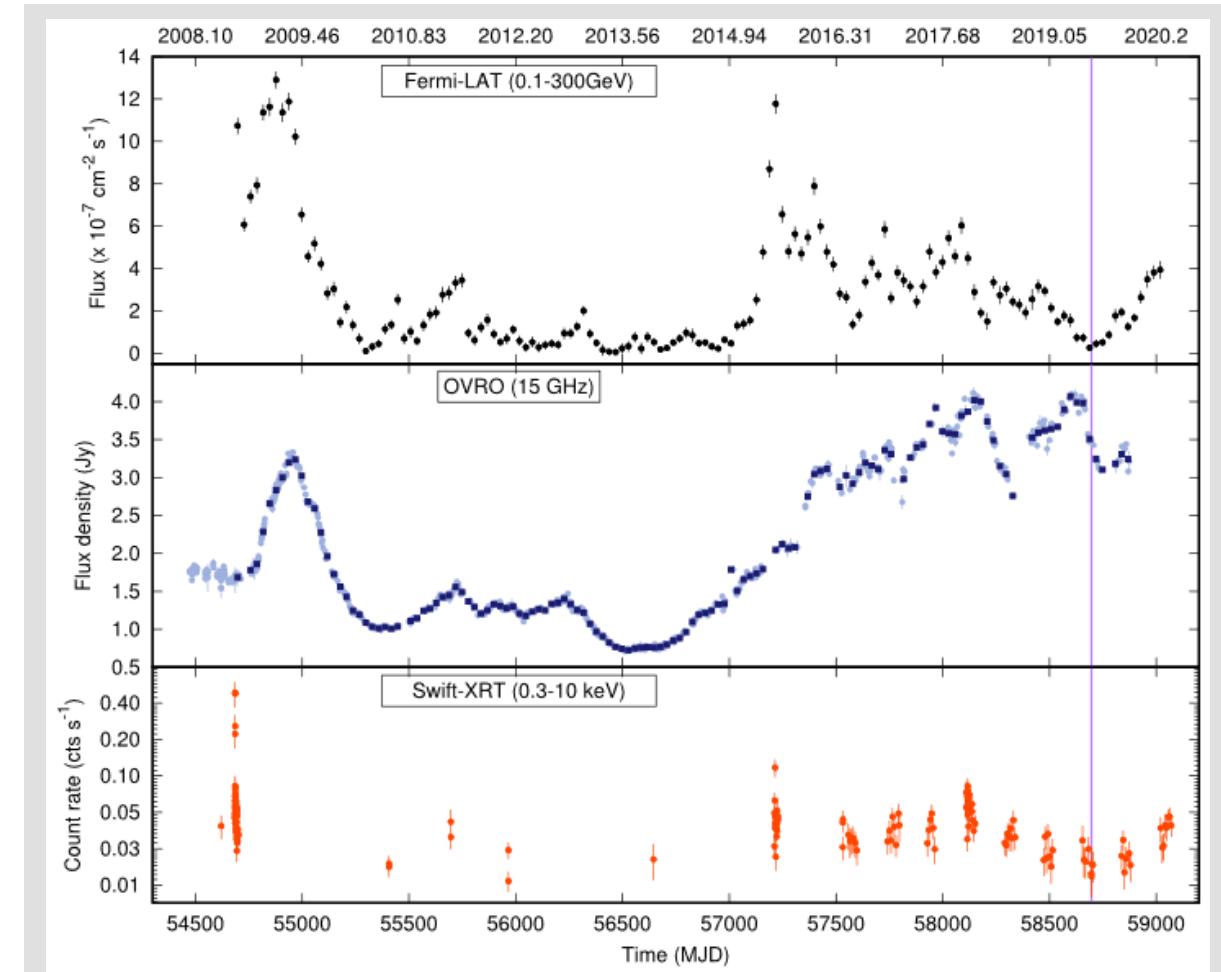
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- Investigate magnetic field and spine-sheath structure with polarization information

Possible new jet component found

# PKS 1502+106 (IC190730A)

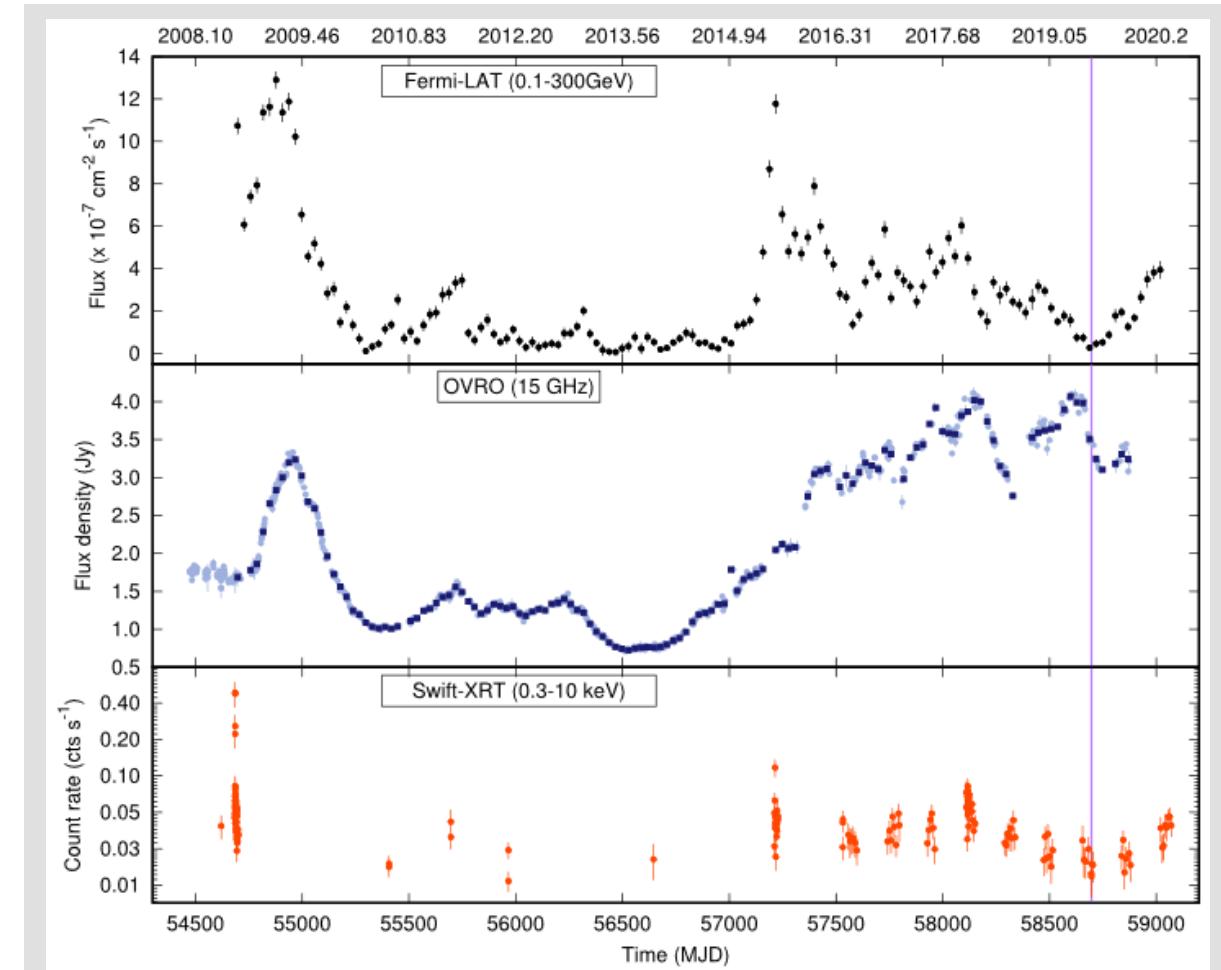
Kun et al. 2021



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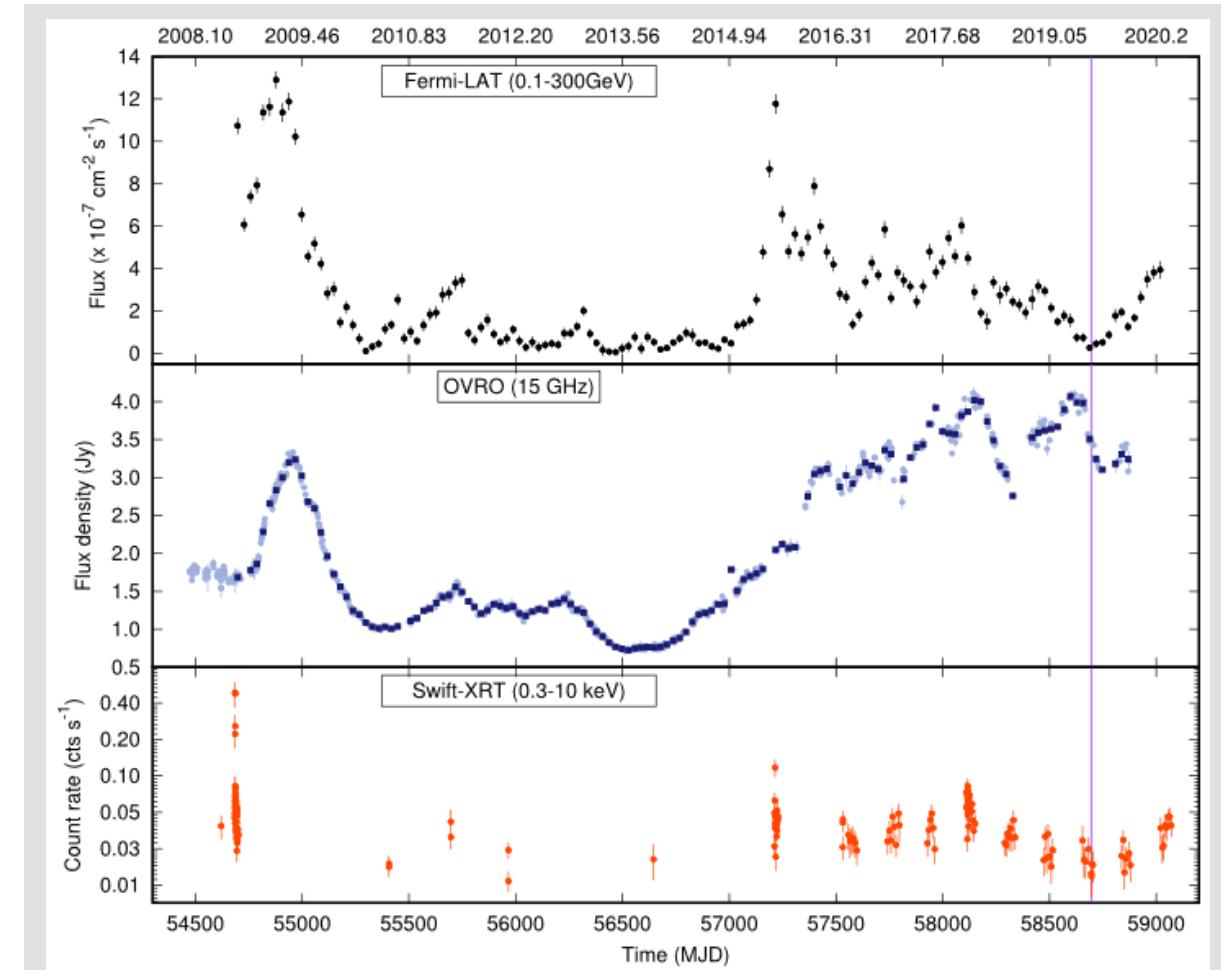


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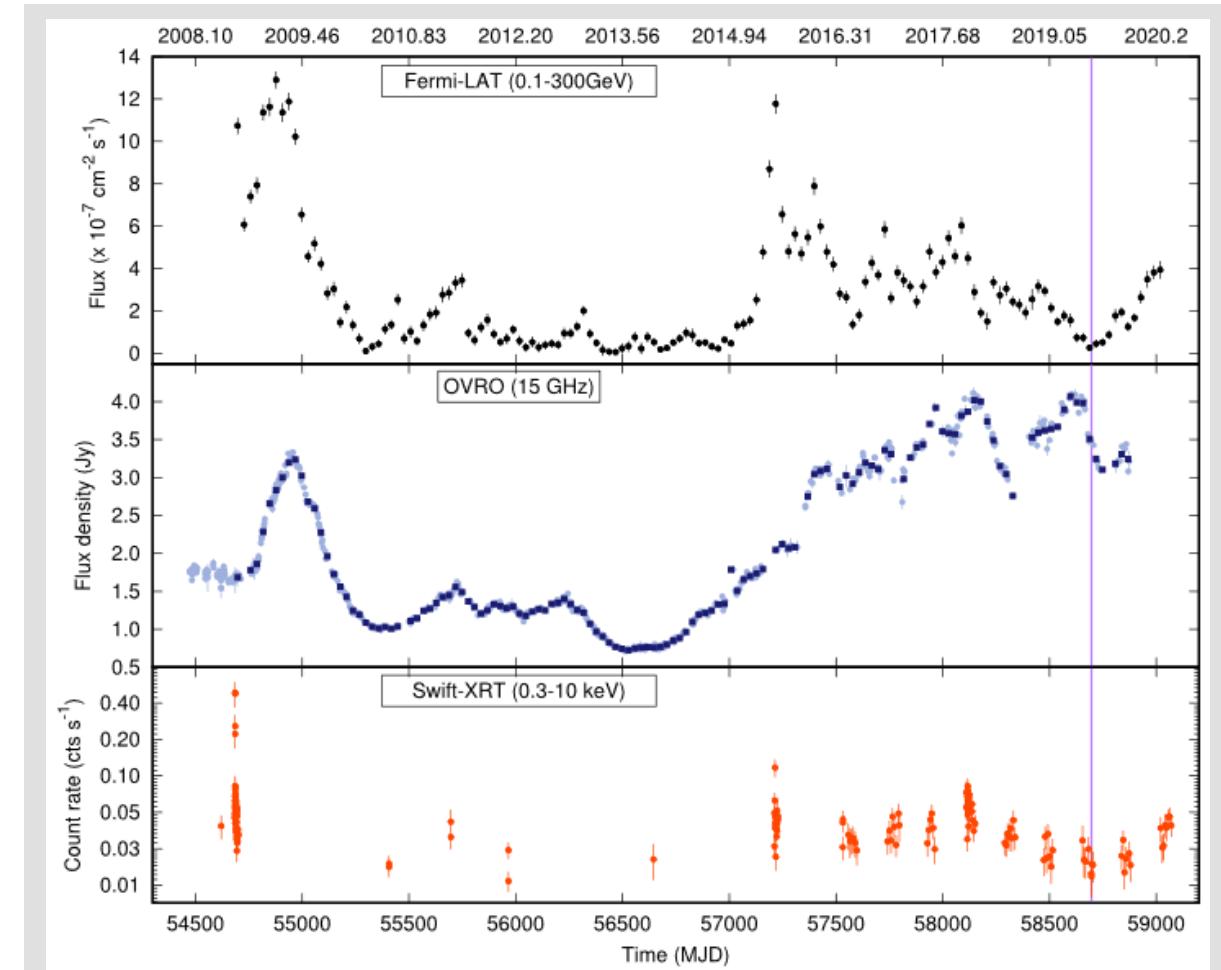


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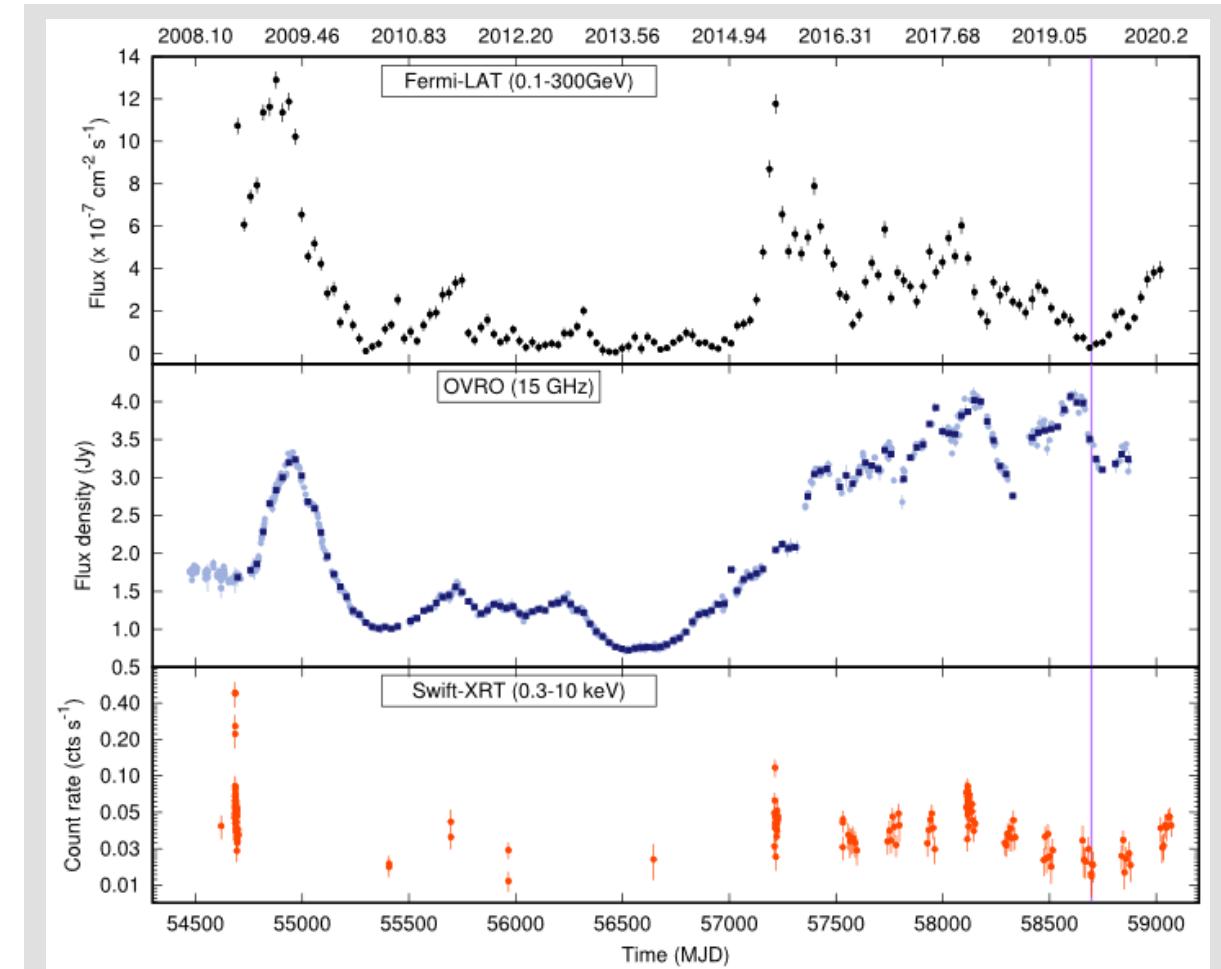


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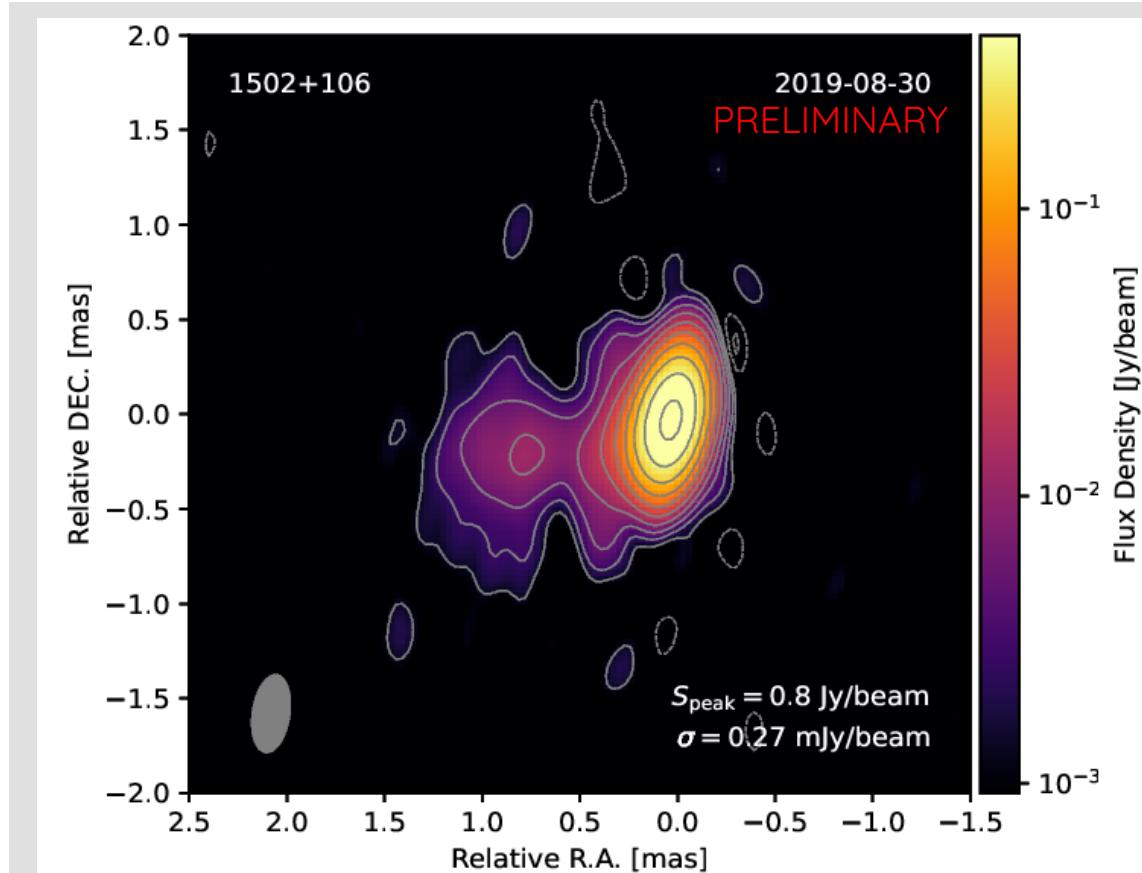
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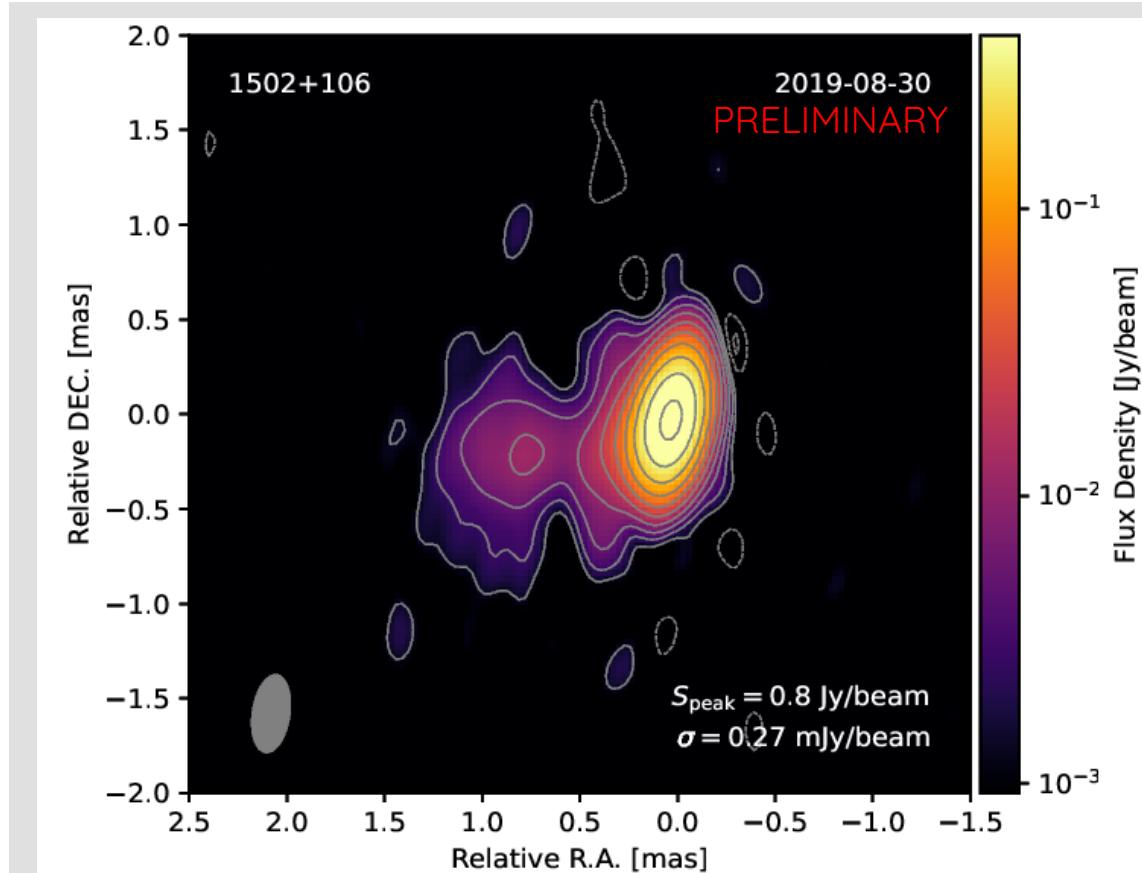
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43 GHz Image of PKS 1502+106 ~1 month after the Neutrino Event

## Main Goals

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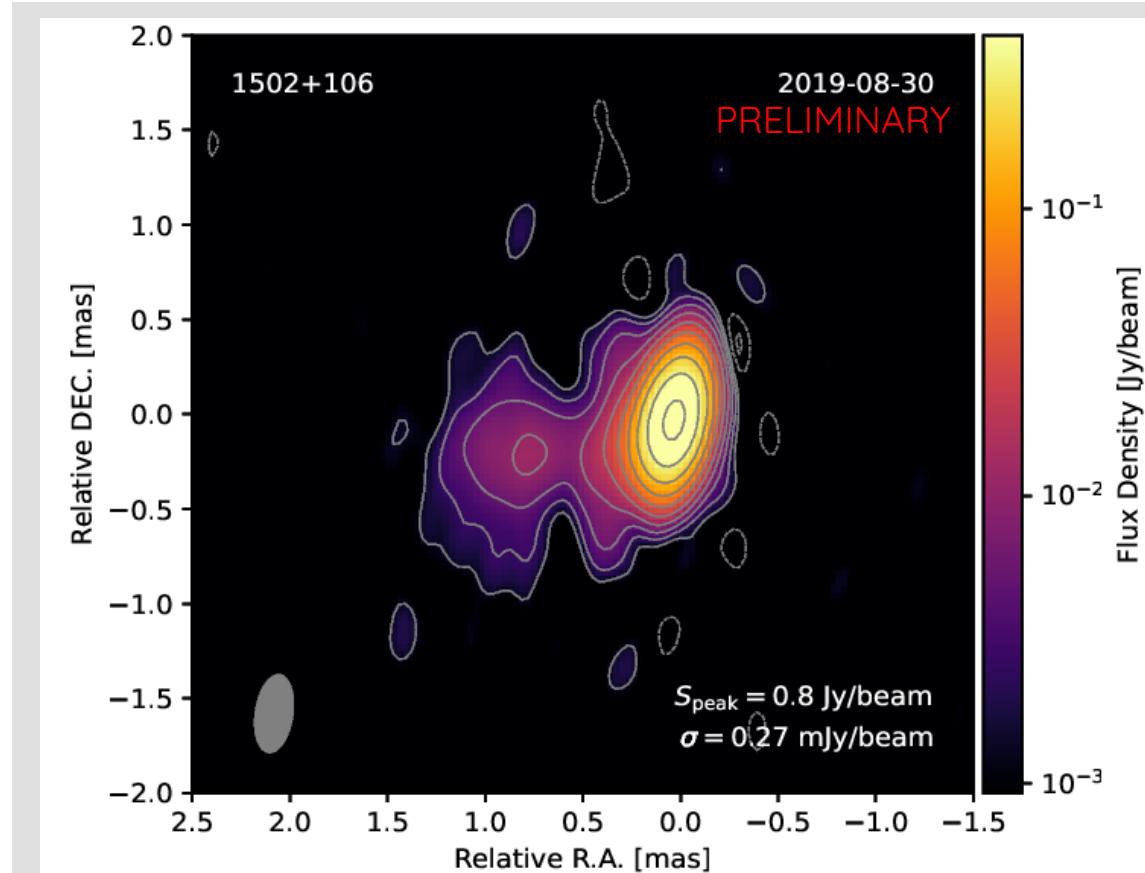


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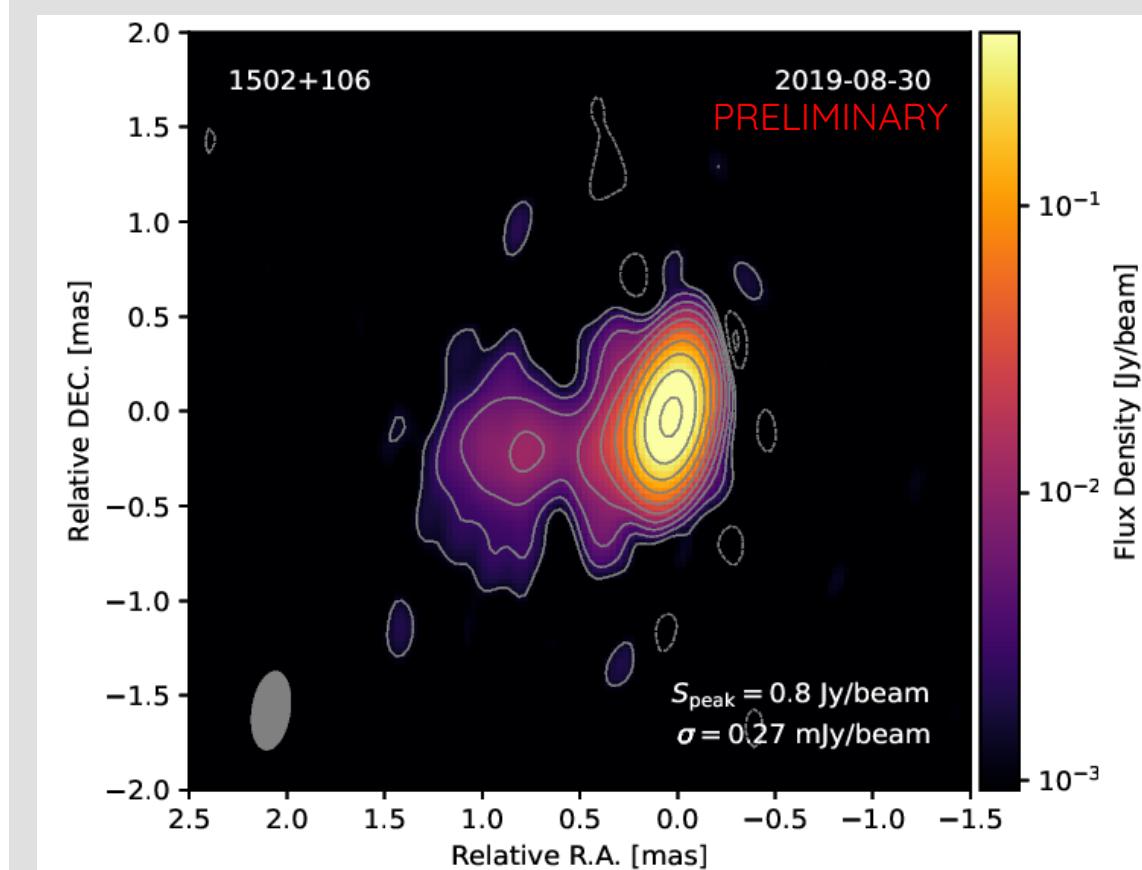


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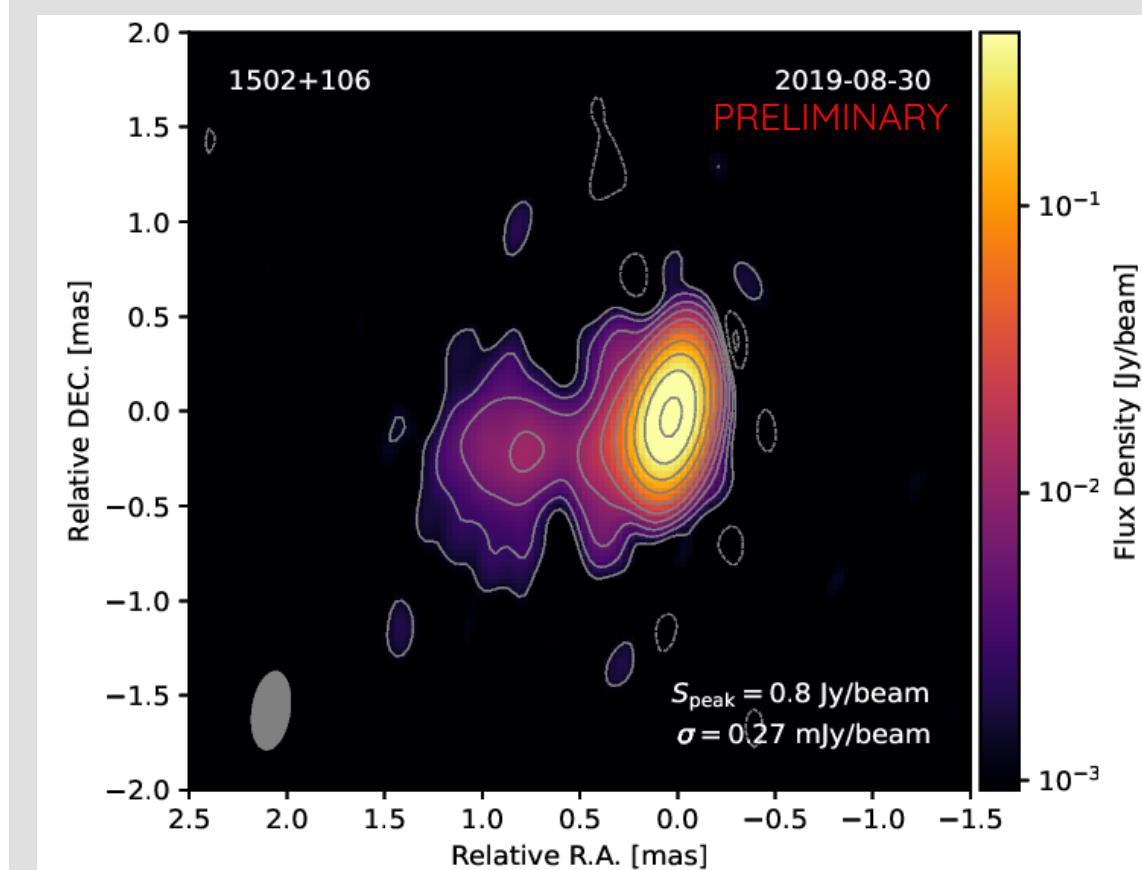


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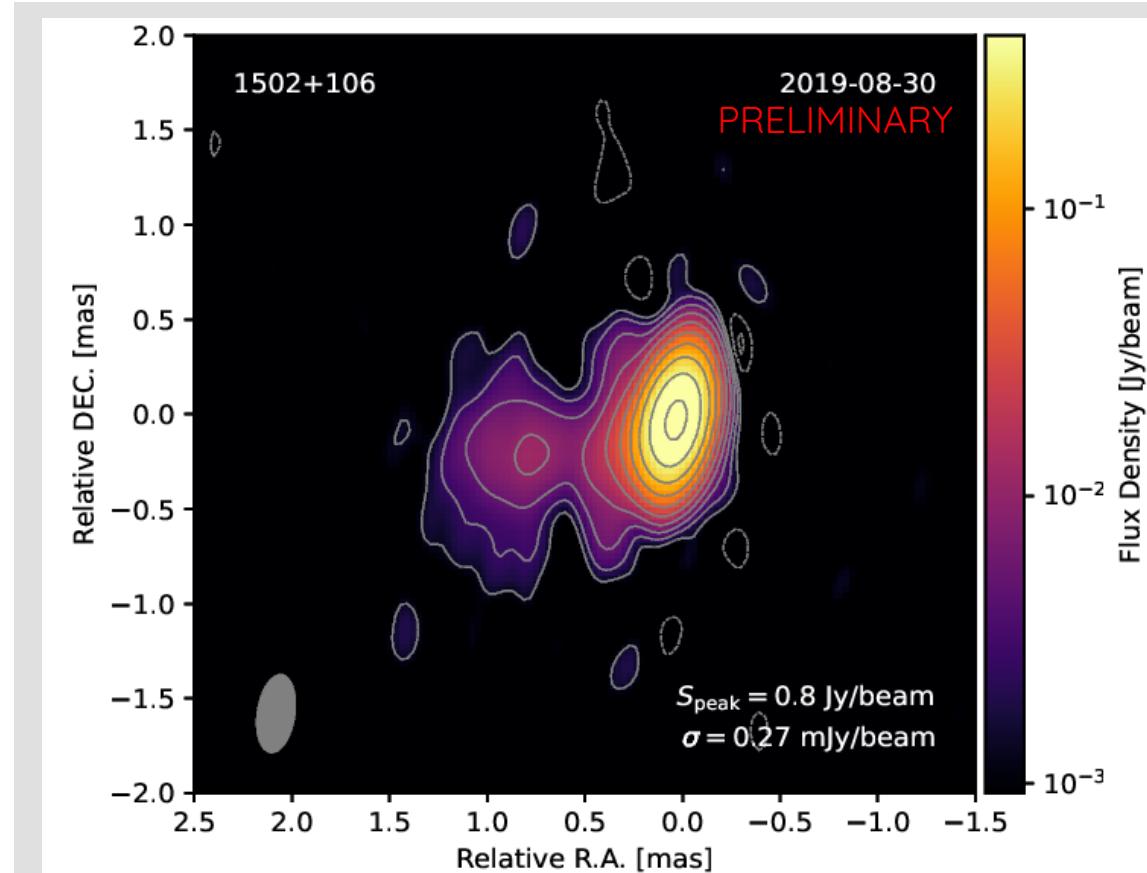


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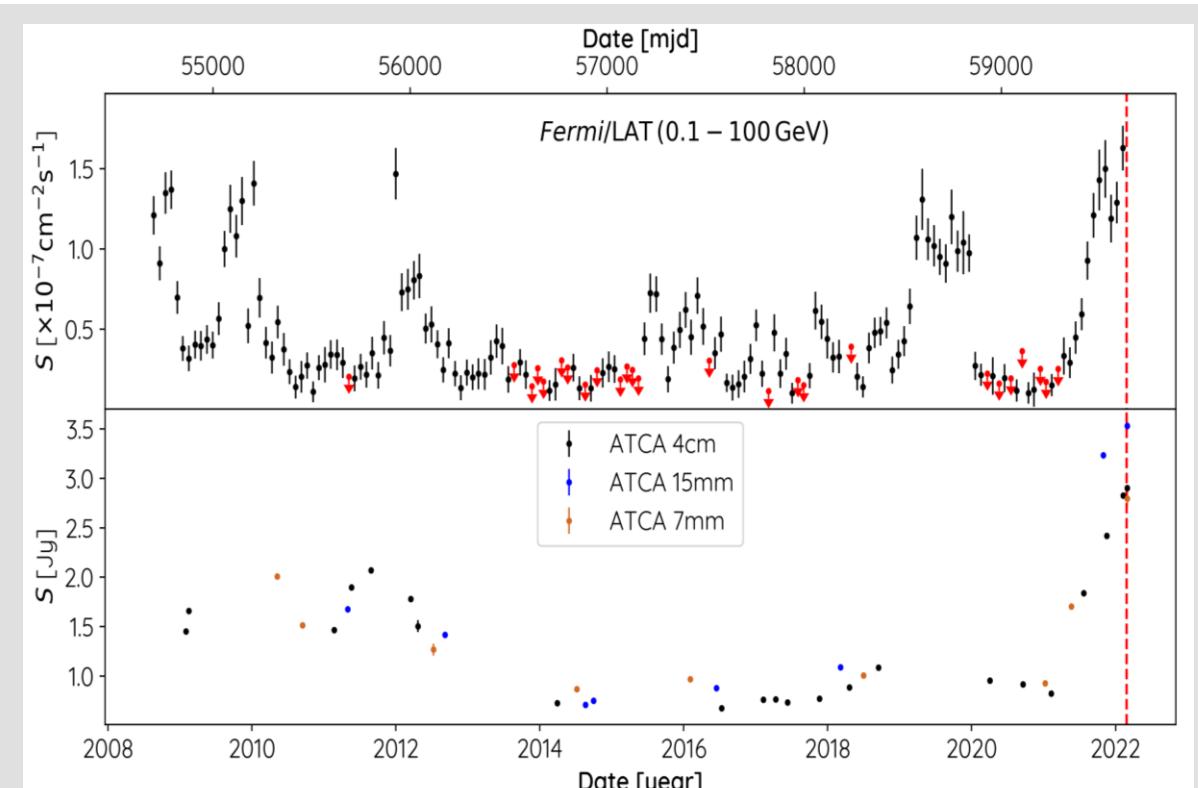
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- Investigate spine-sheath structure in combination with lepto-hadronic SED models

# PKS 0215+015: A New Neutrino Emitter?

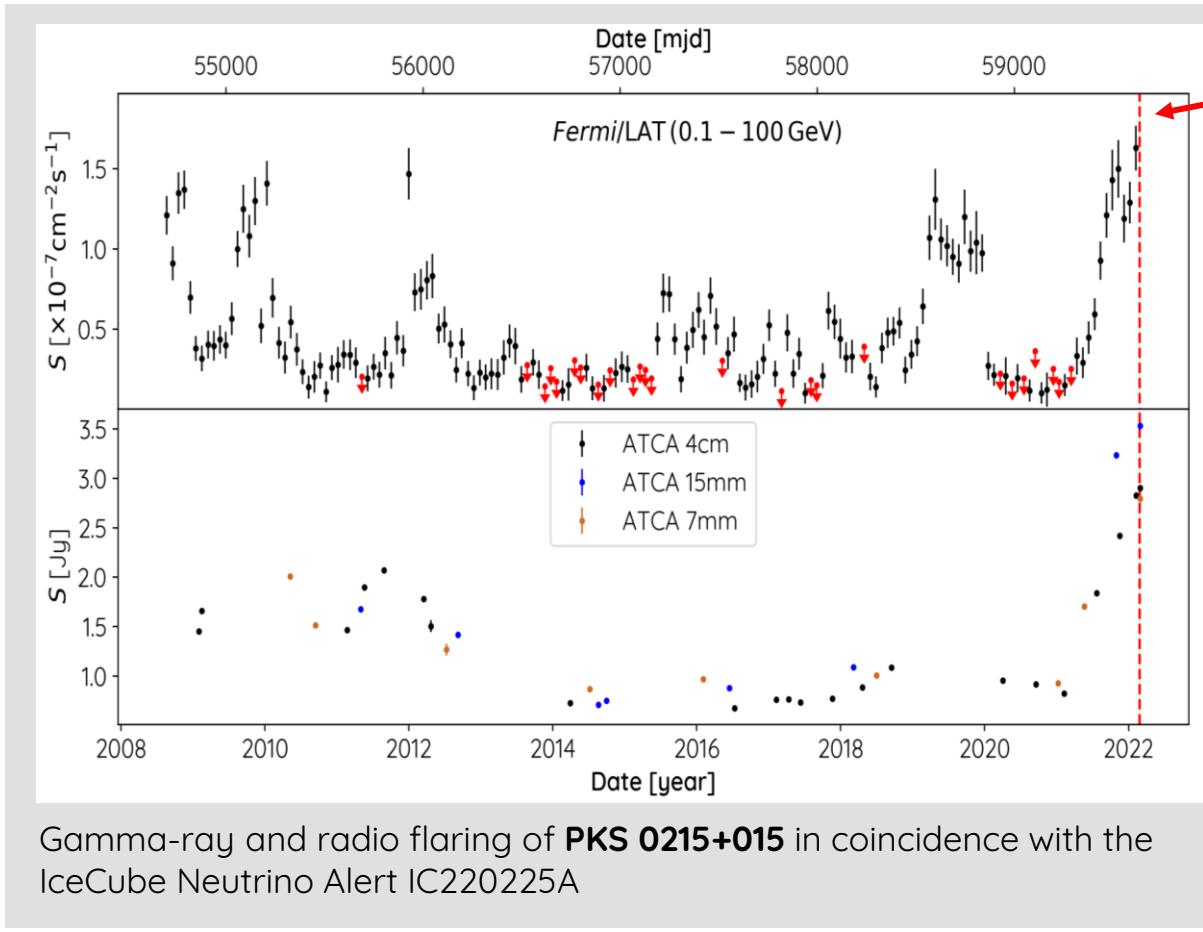
Eppel et al. 2023



Gamma-ray and radio flaring of **PKS 0215+015** in coincidence with the IceCube Neutrino Alert IC220225A

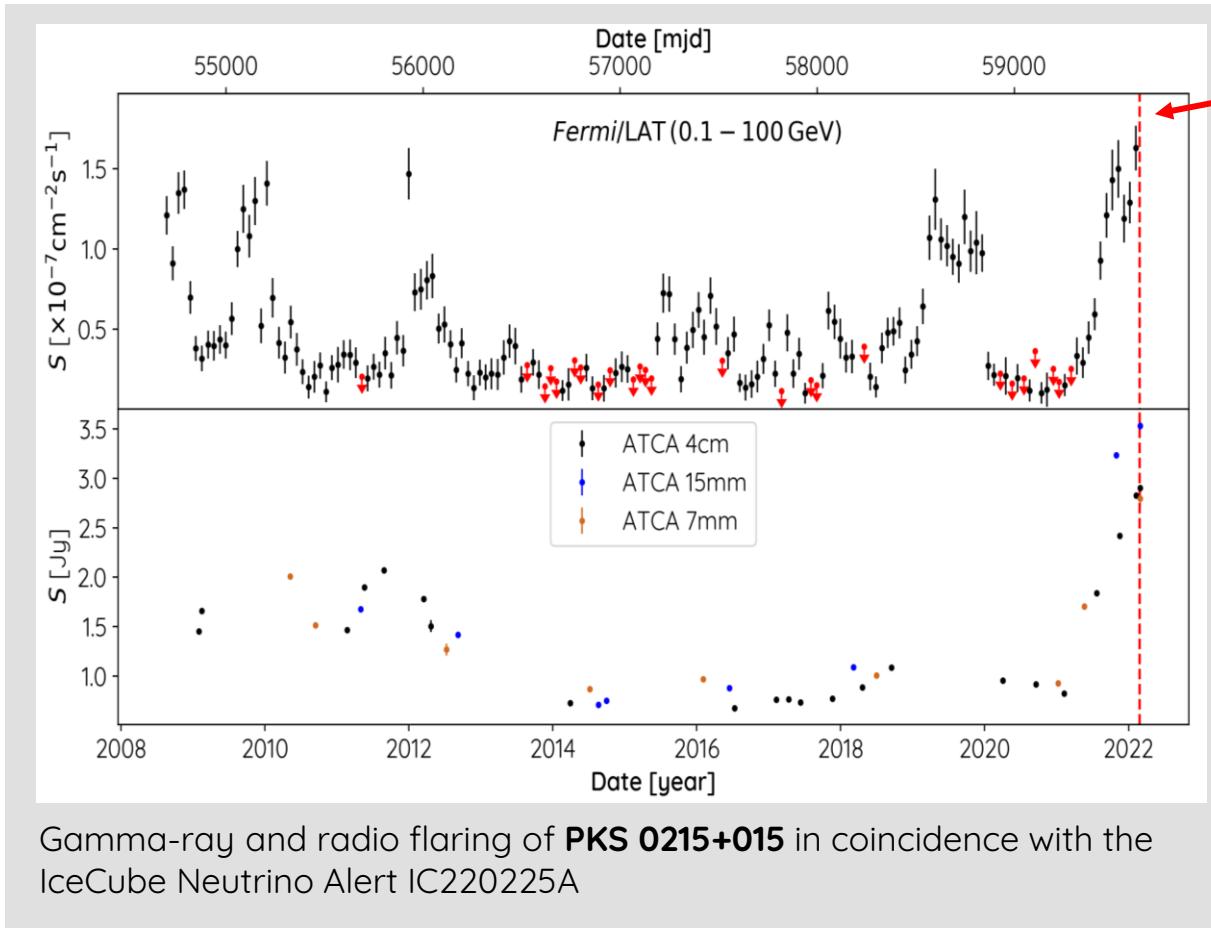
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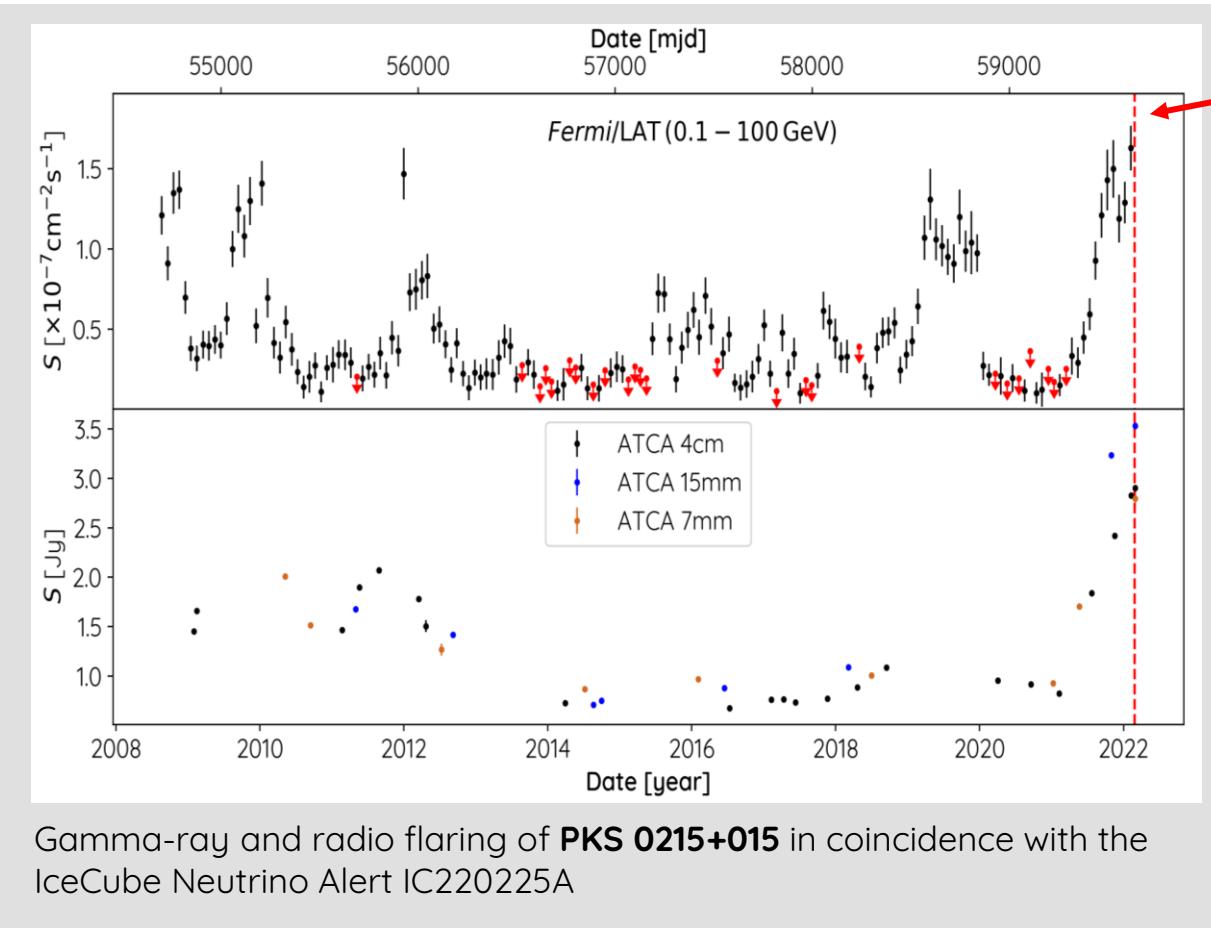


## VLBA ToO-Proposal

- Total of 6 epochs after the neutrino event (1 per month)

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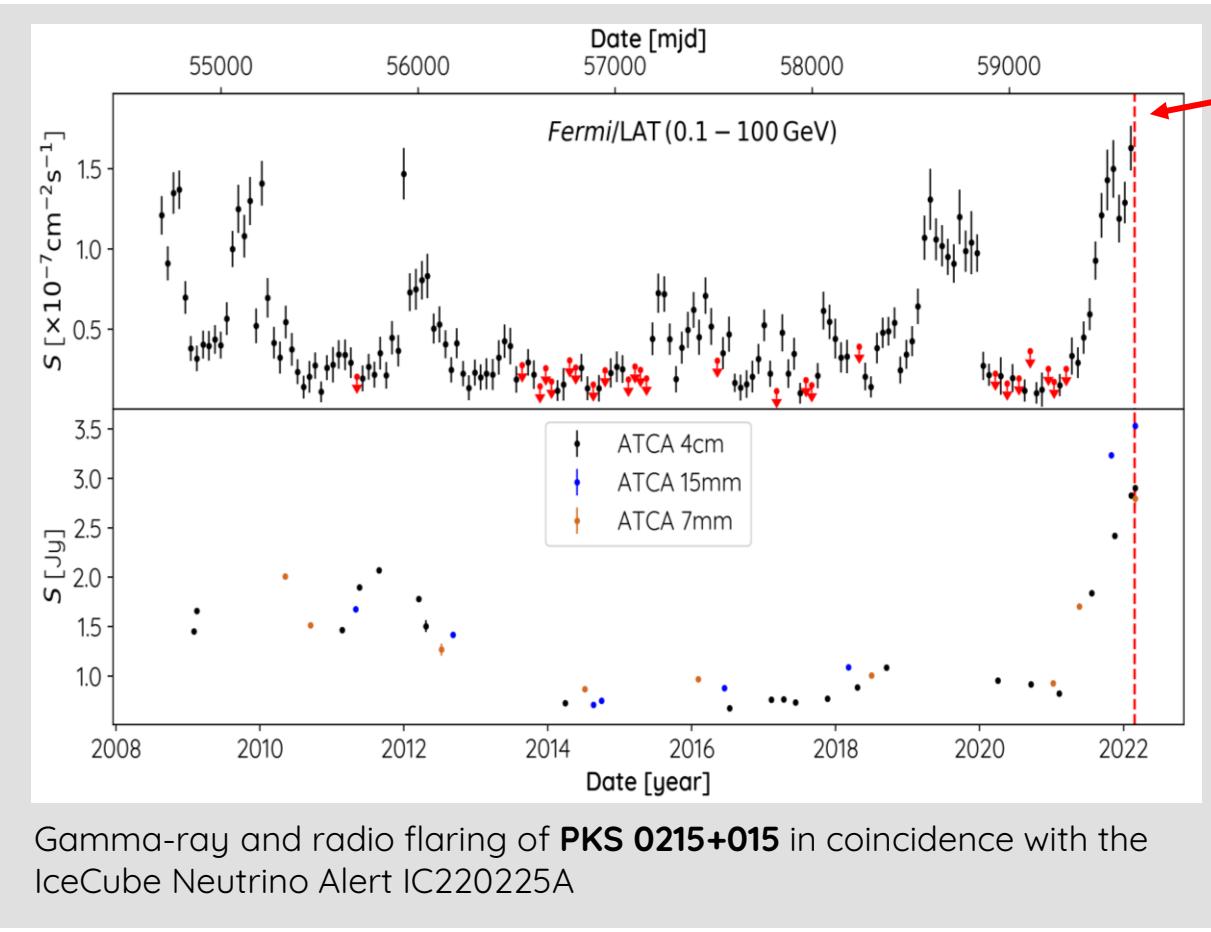


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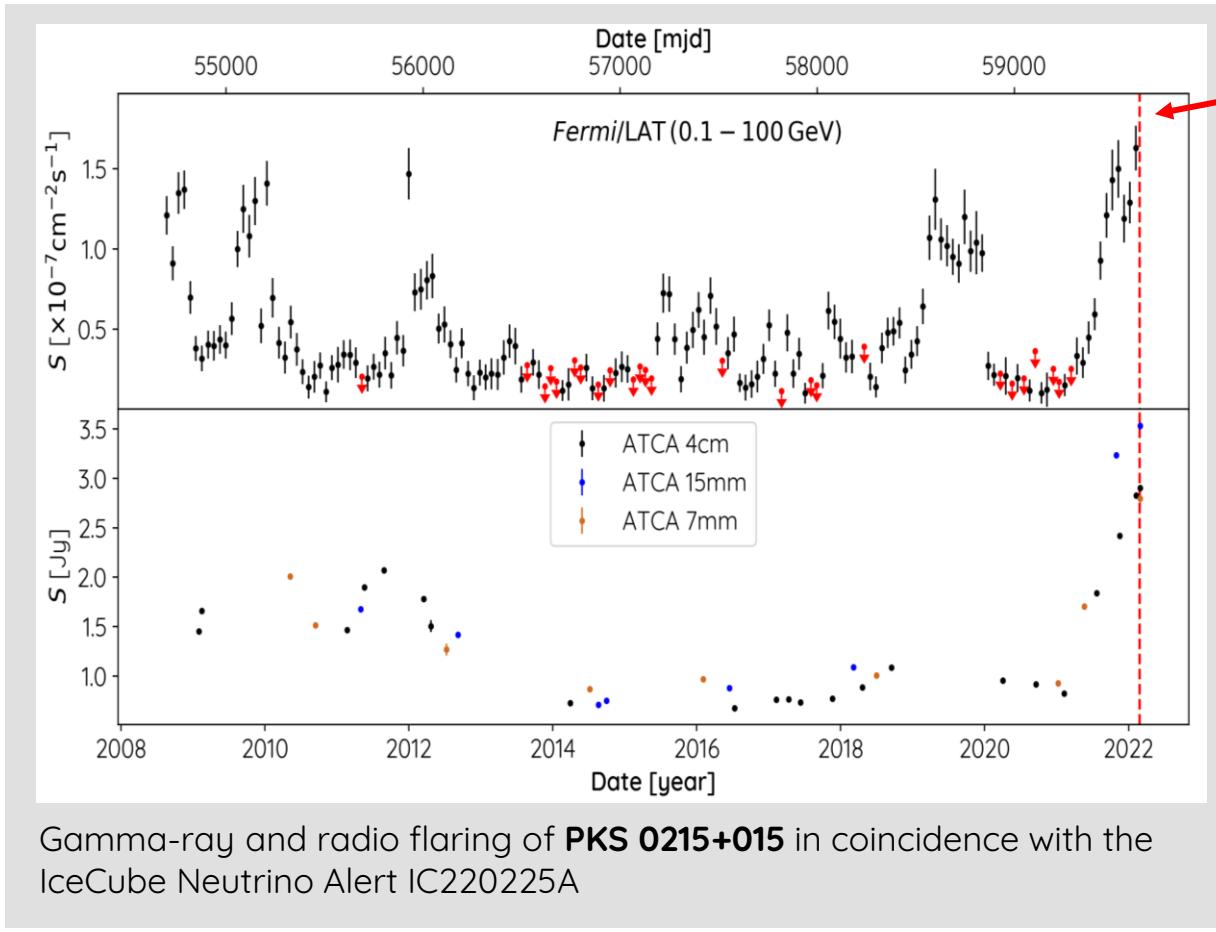


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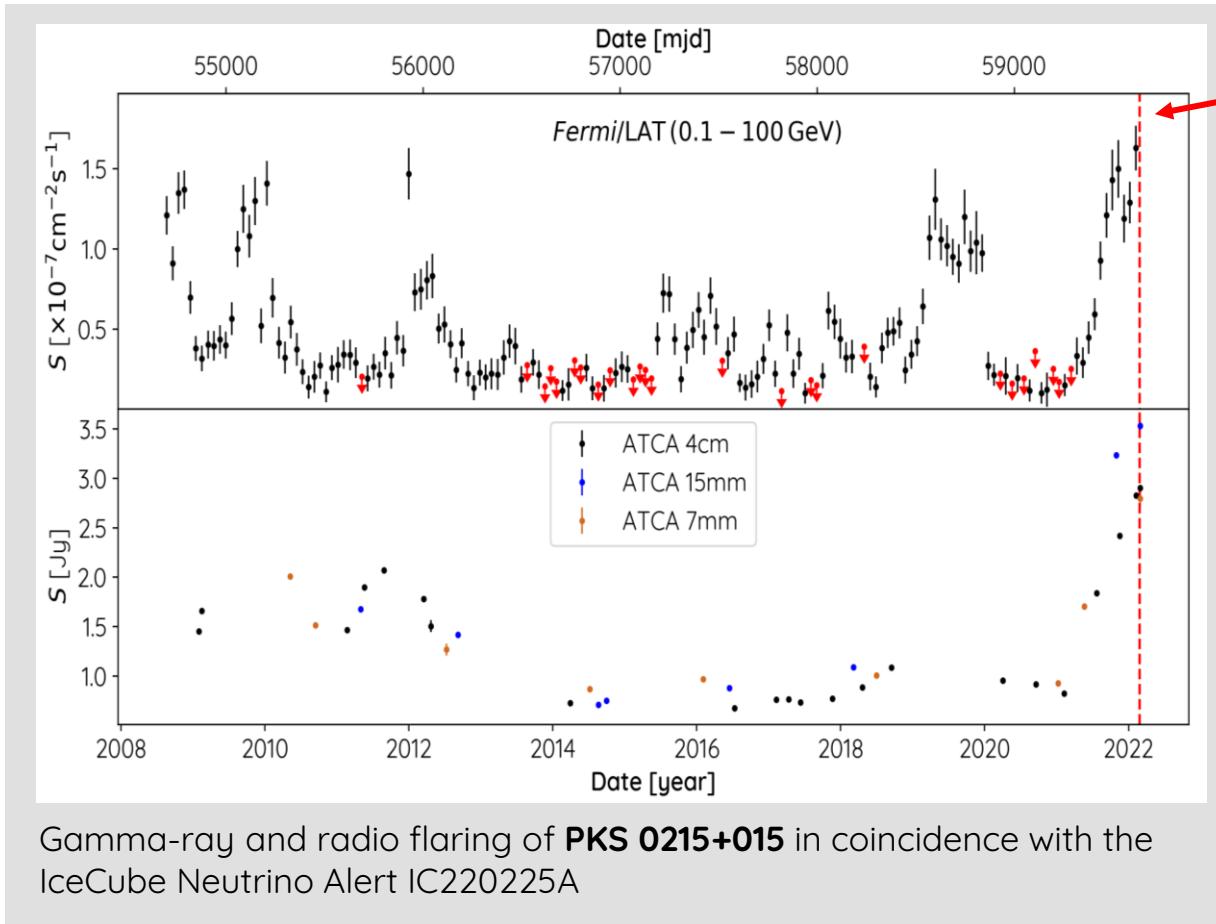


## VLBA ToO-Proposal

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- Probe jet kinematics
- Search for characteristic similarities to TXS 0506+056 and other candidate neutrino-emitting blazars

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Eppel et al. 2023

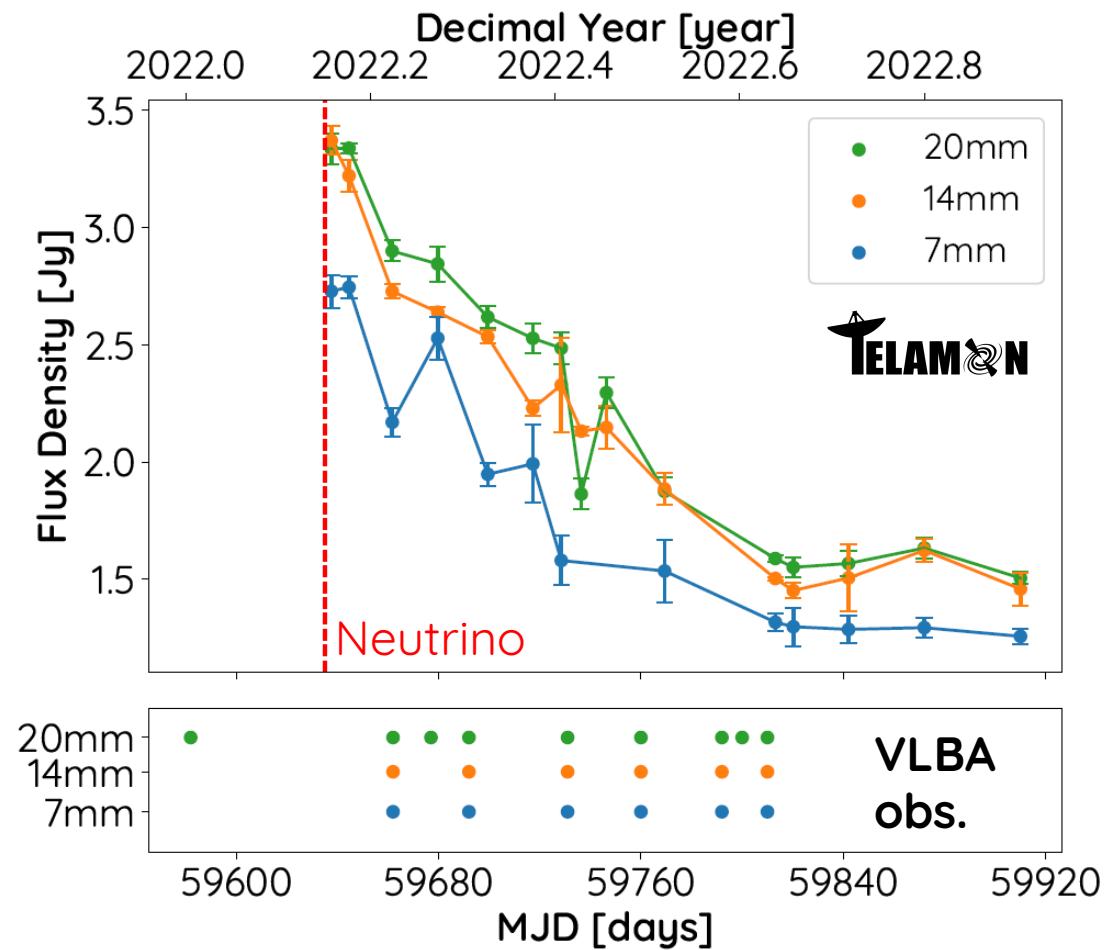


## VLBA ToO-Proposal

- Total of 6 epochs after the neutrino event (1 per month)
- Three-point spectral-index (20mm, 14mm, 7mm) and Faraday-rotation measurements
- Probe jet kinematics
- Search for characteristic similarities to TXS 0506+056 and other candidate neutrino-emitting blazars

→ First VLBA observation took place on **March 24, 2022** (total of 6 epochs)

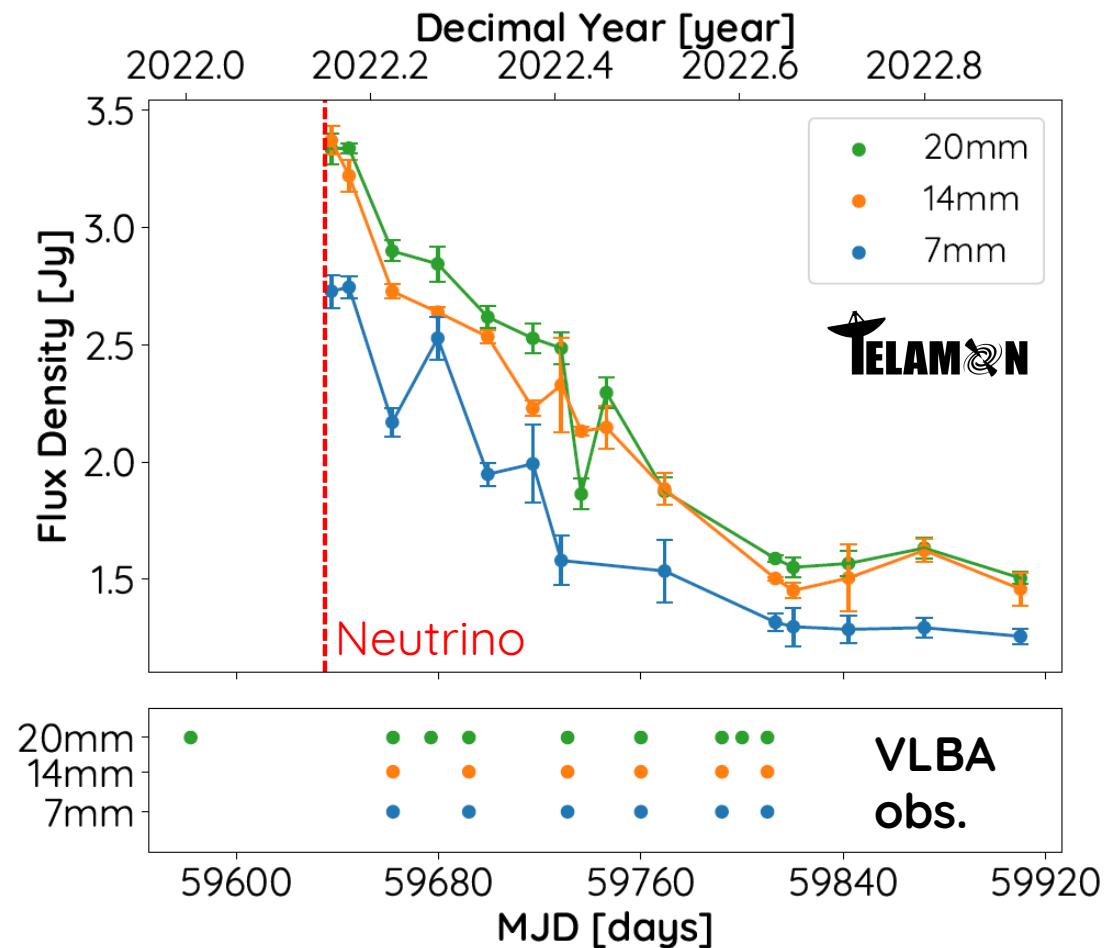
# PKS 0215+015: A New Neutrino Emitter?



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## VLBA observations:

- 6 epochs with 20 mm, 14 mm and 7 mm
- 3 additional MOJAVE epochs with only 20mm available



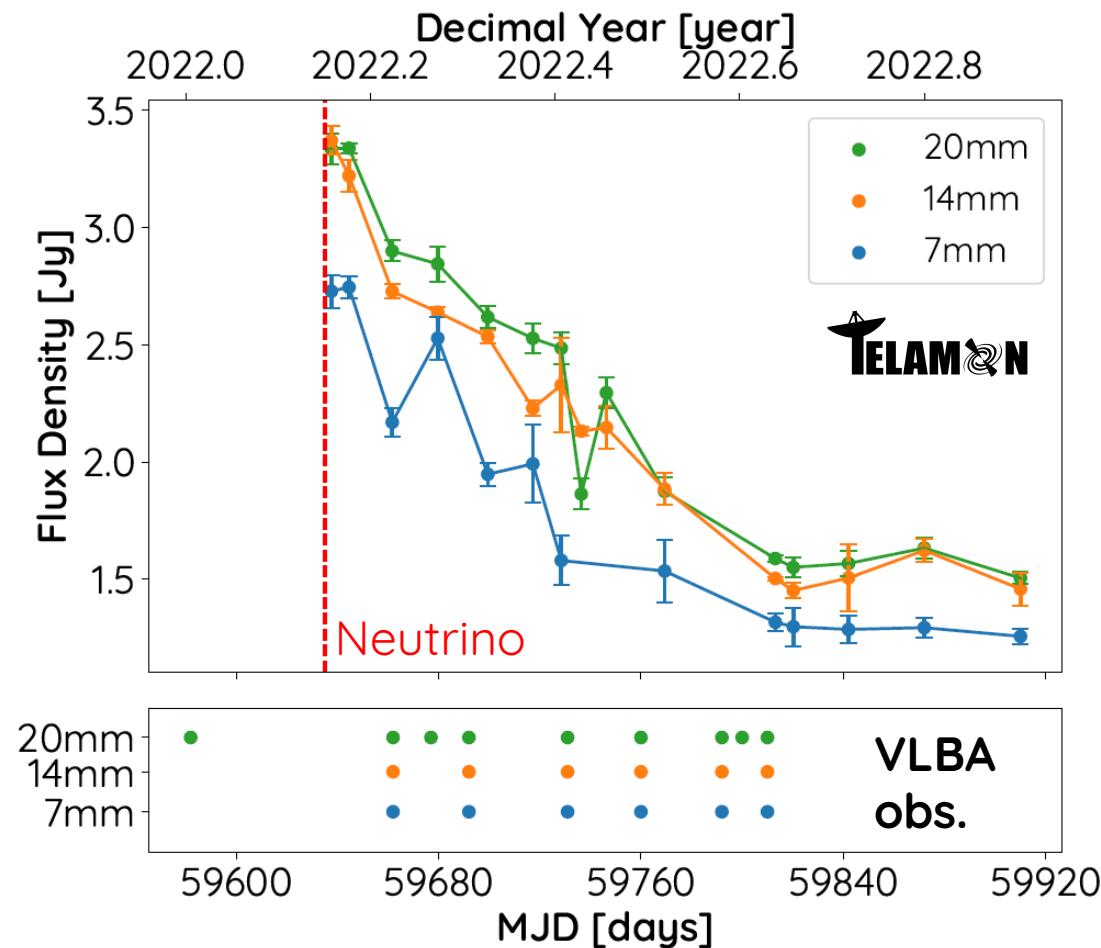
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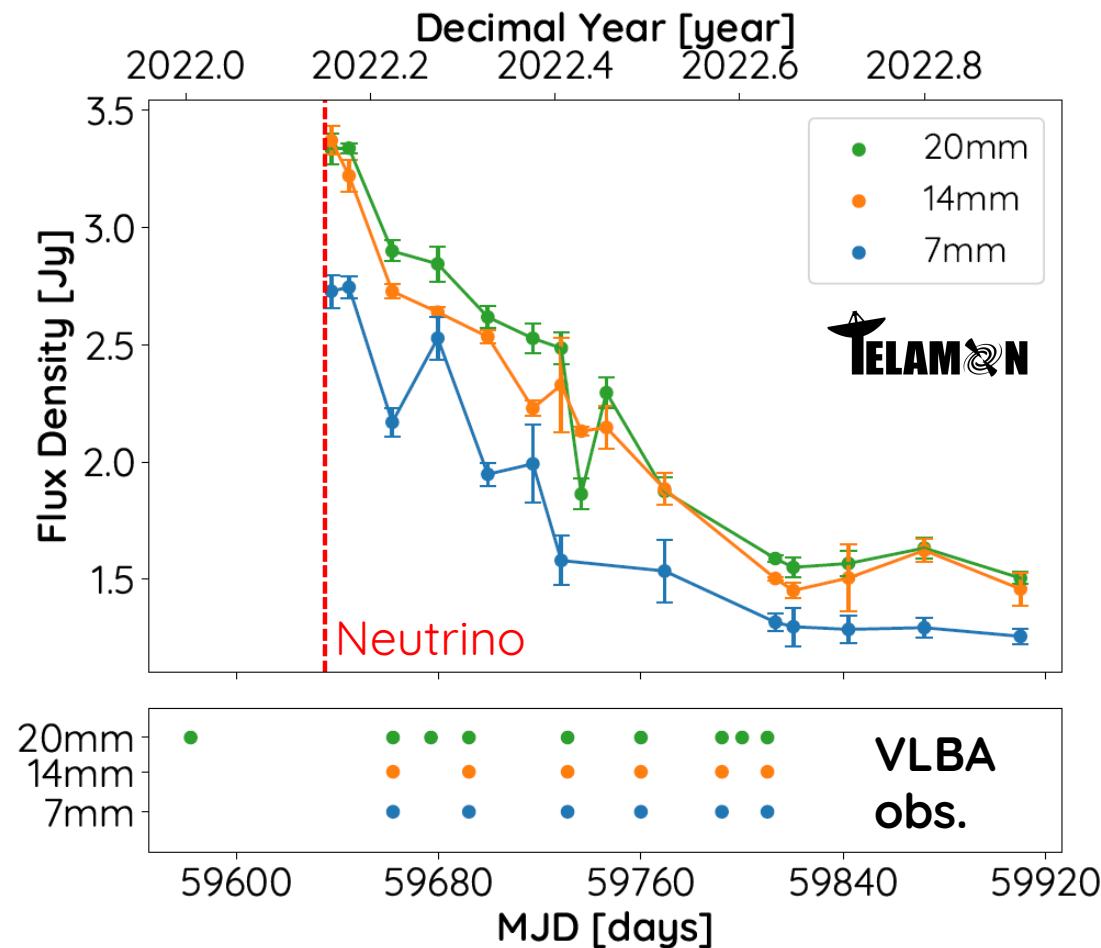
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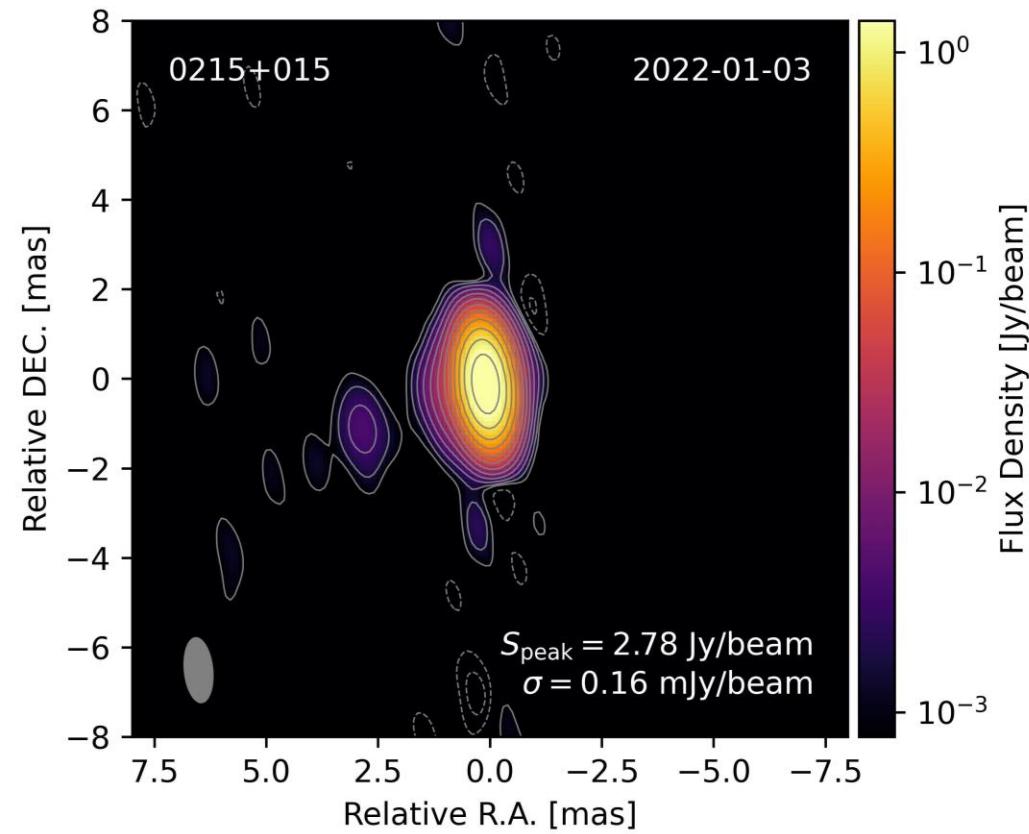
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## To Do:

- Consistency check of final images
- Model fitting
- Polarization calibration/imaging



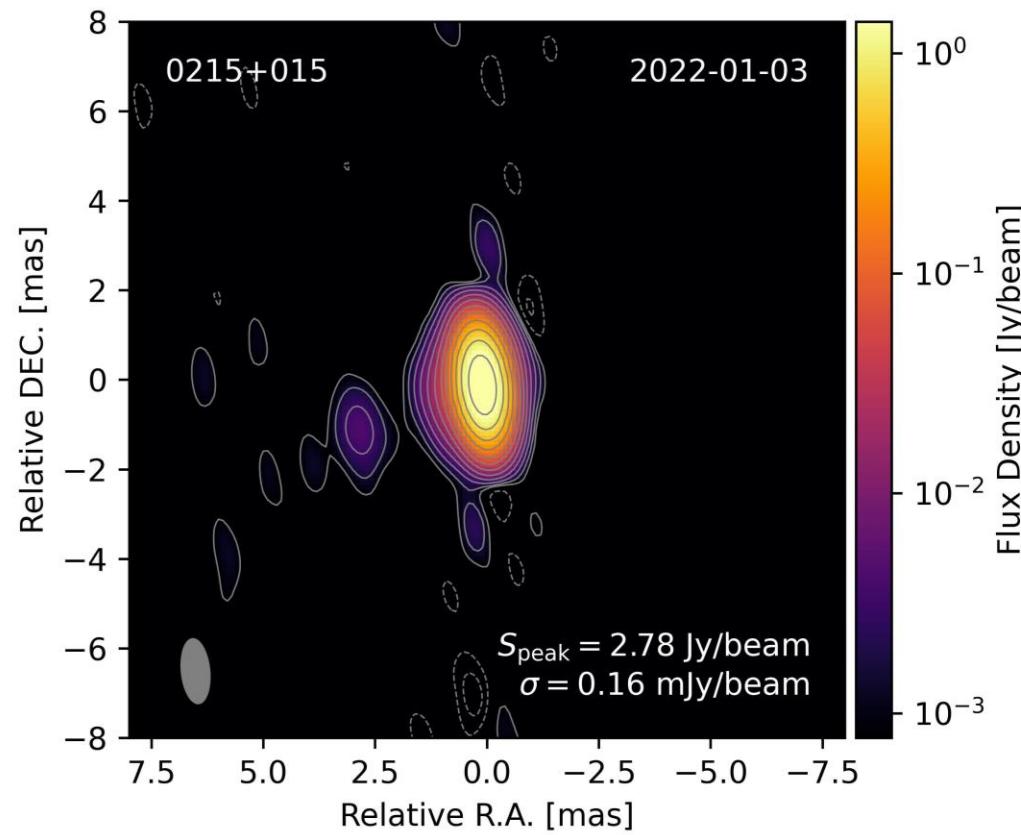
# PKS 0215+015: First Look at 15 GHz



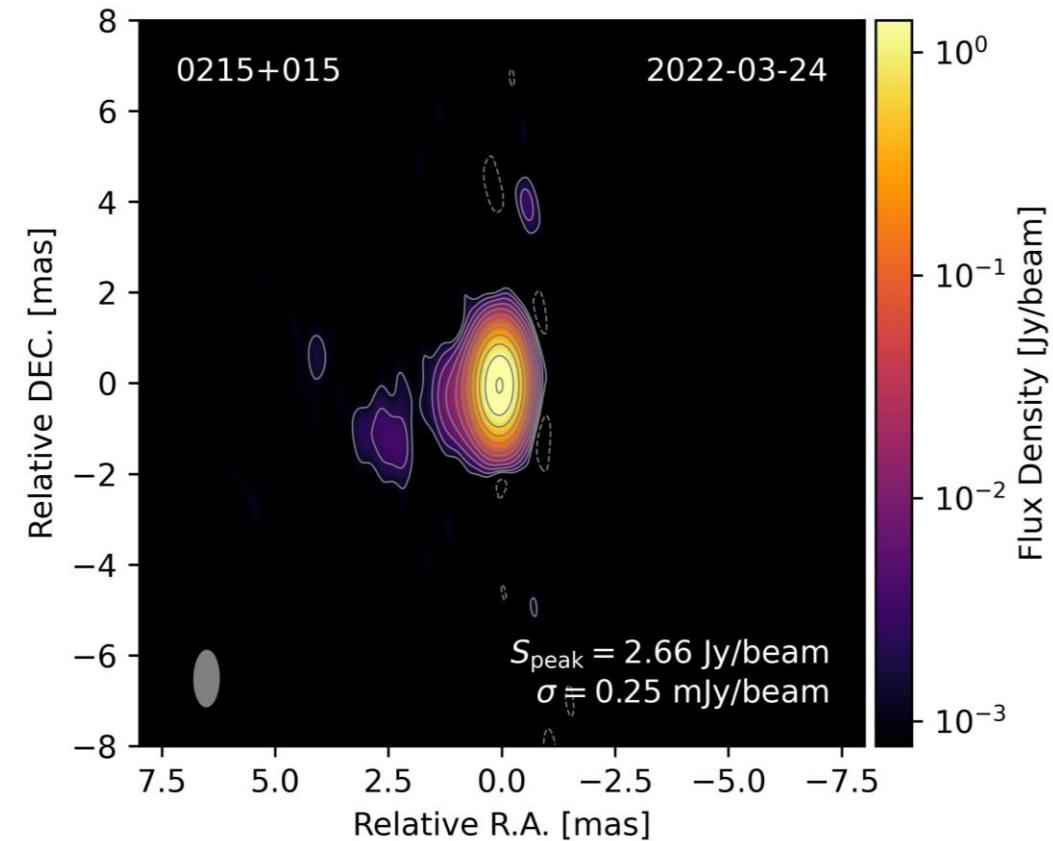
2022-01-03 (MOJAVE) - pre-neutrino

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PRELIMINARY



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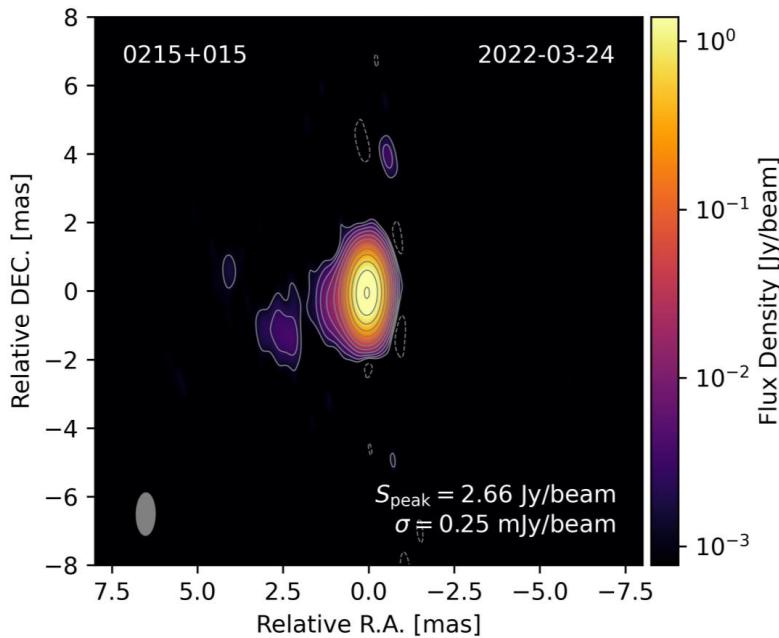


2022-03-24 - post-neutrino

# PKS 0215+015: First Look

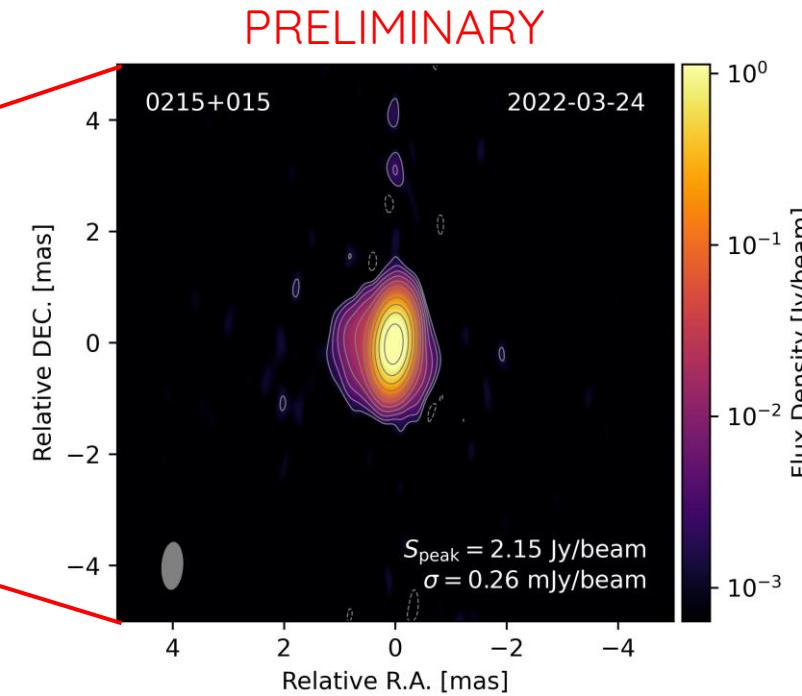
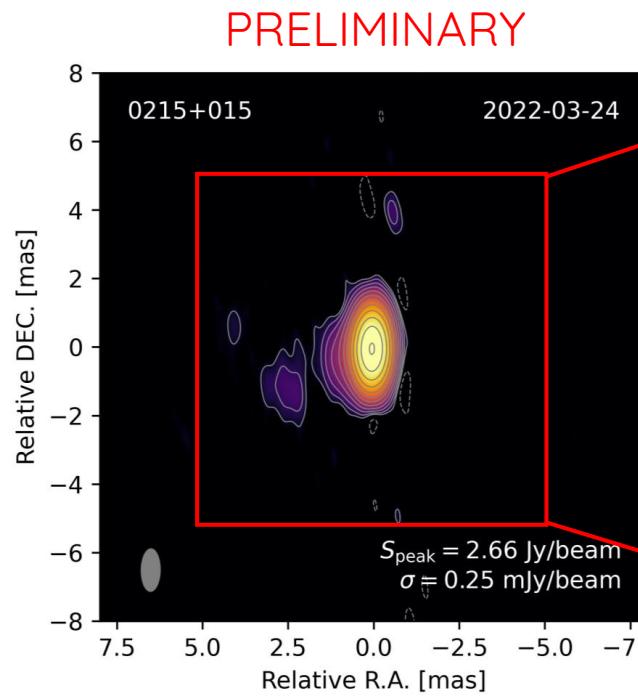
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PRELIMINARY



Ku-Band (15 GHz)

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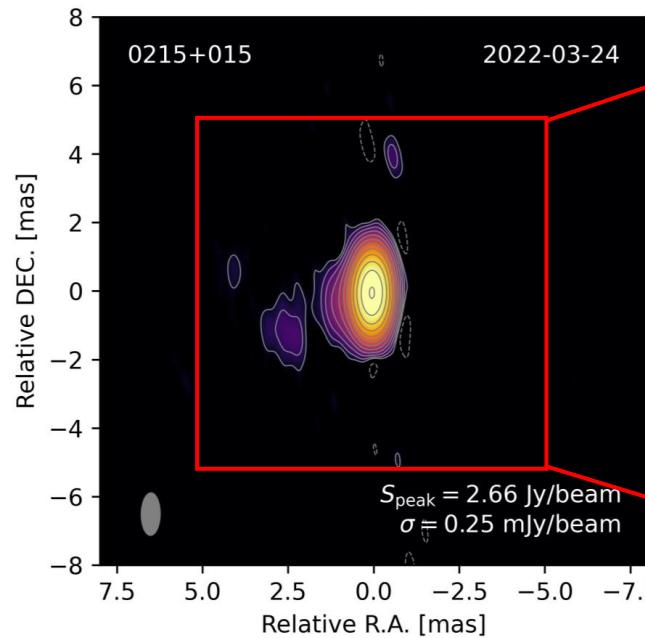


Ku-Band (15 GHz)

K-Band (23 GHz)

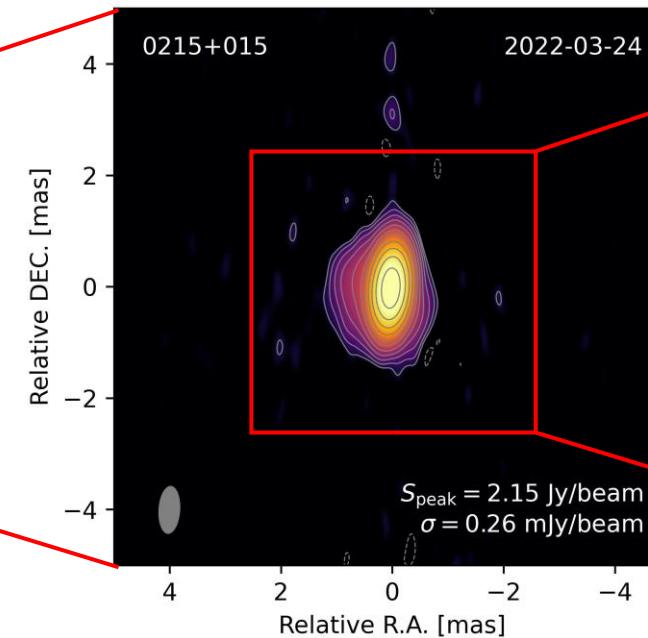
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PRELIMINARY



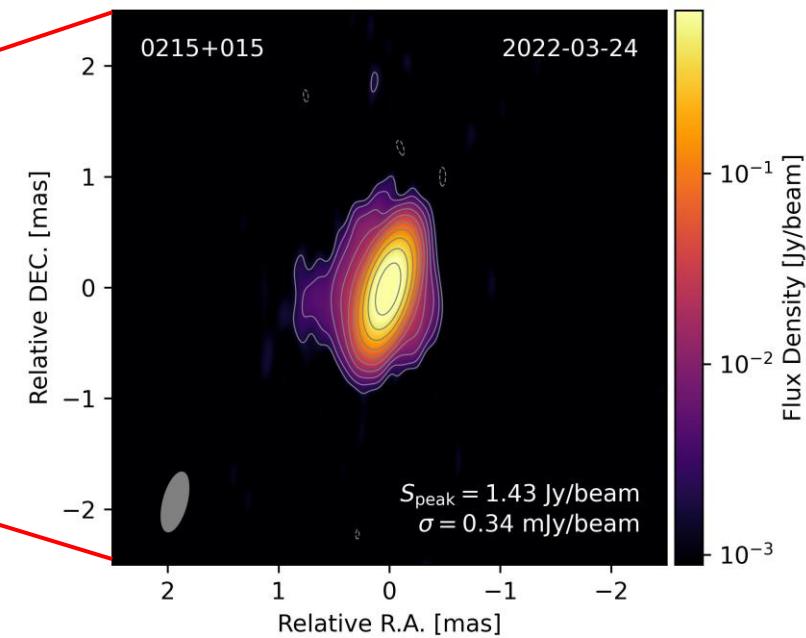
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PRELIMINARY



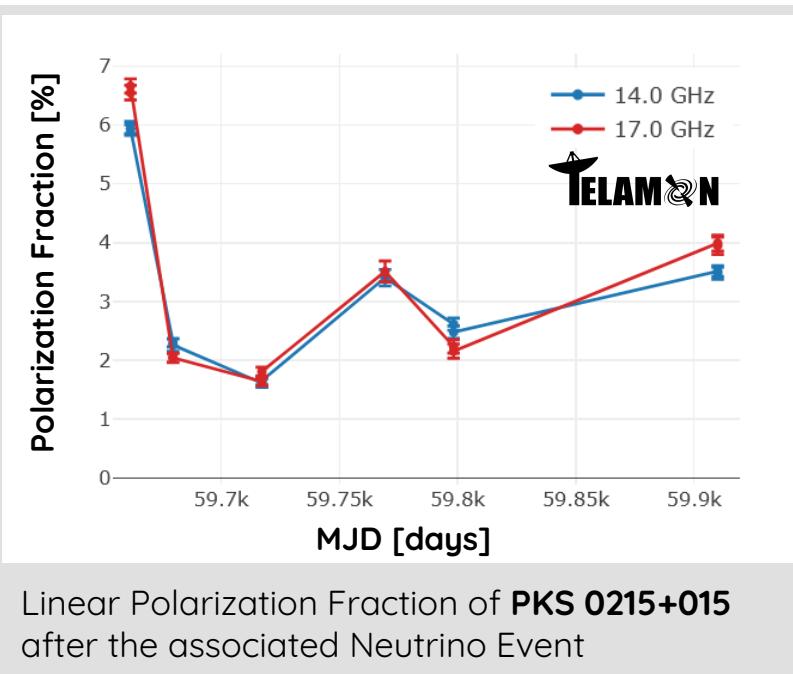
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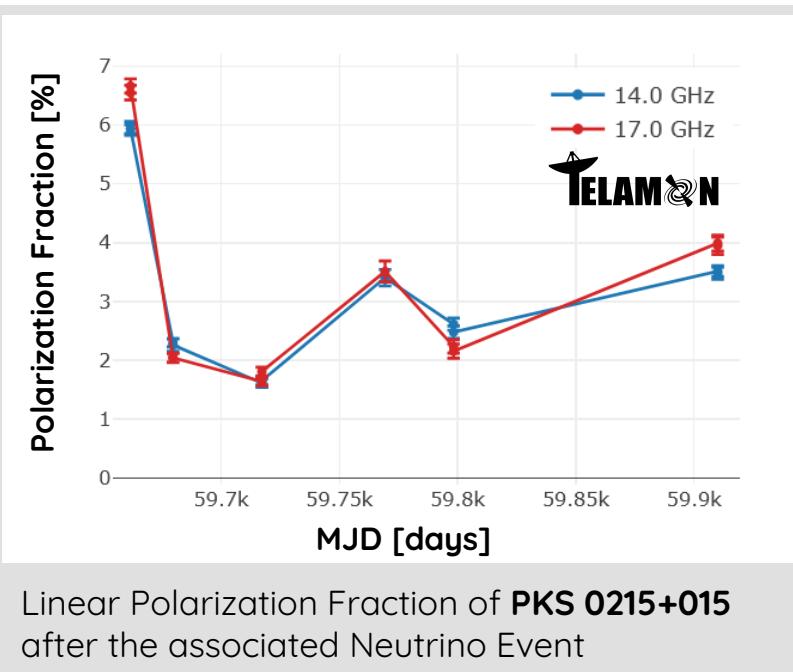


Q-Band (43 GHz)

# PKS 0215+015: First Look at Polarization

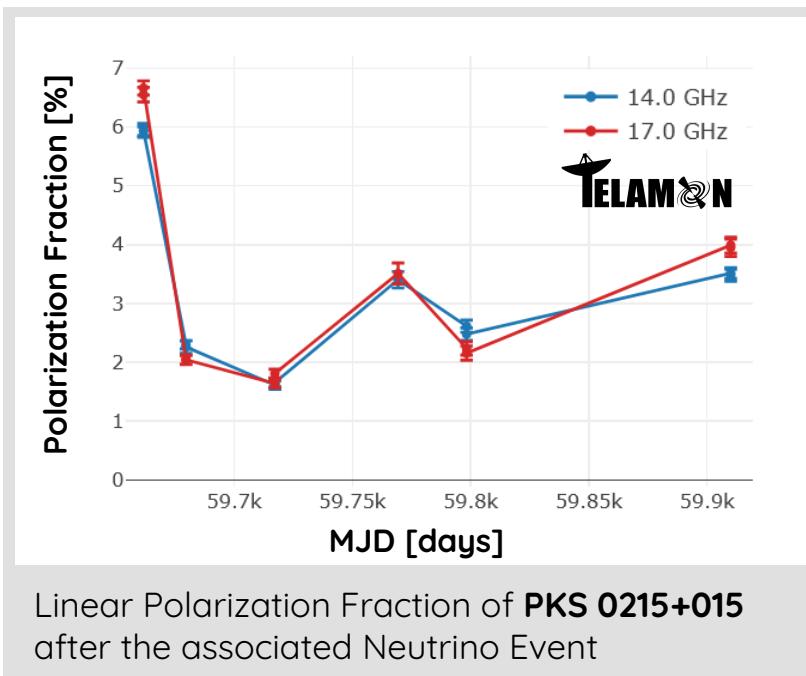


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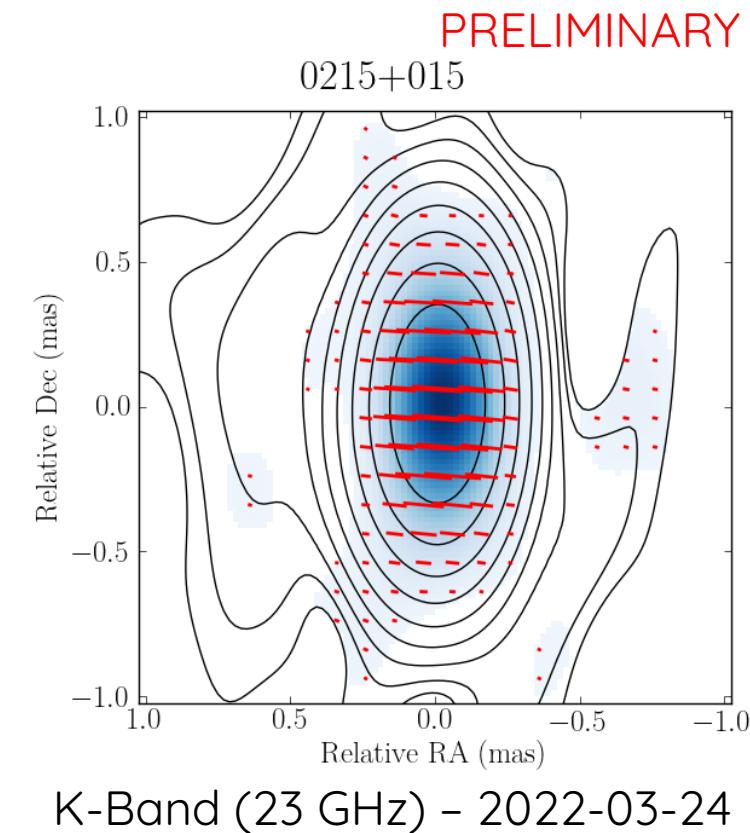


- TELAMON data shows elevated polarization state close to neutrino event

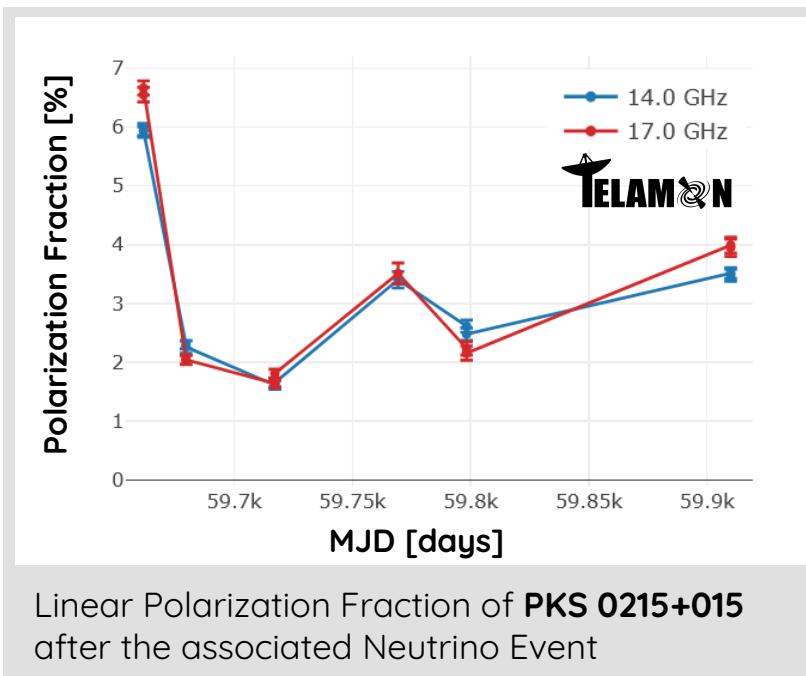
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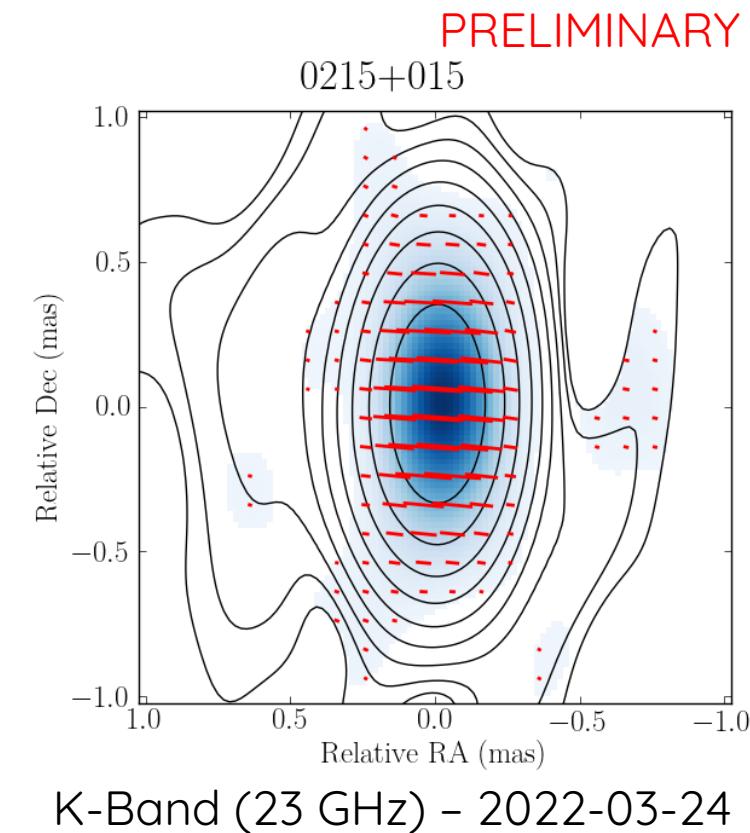
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# PKS 0215+015: First Look at Polarization



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- Preliminary VLBA polarization image produced in CASA with PolSolve (Marti-Vidal et al. 2020)
- Polarized emission core dominated



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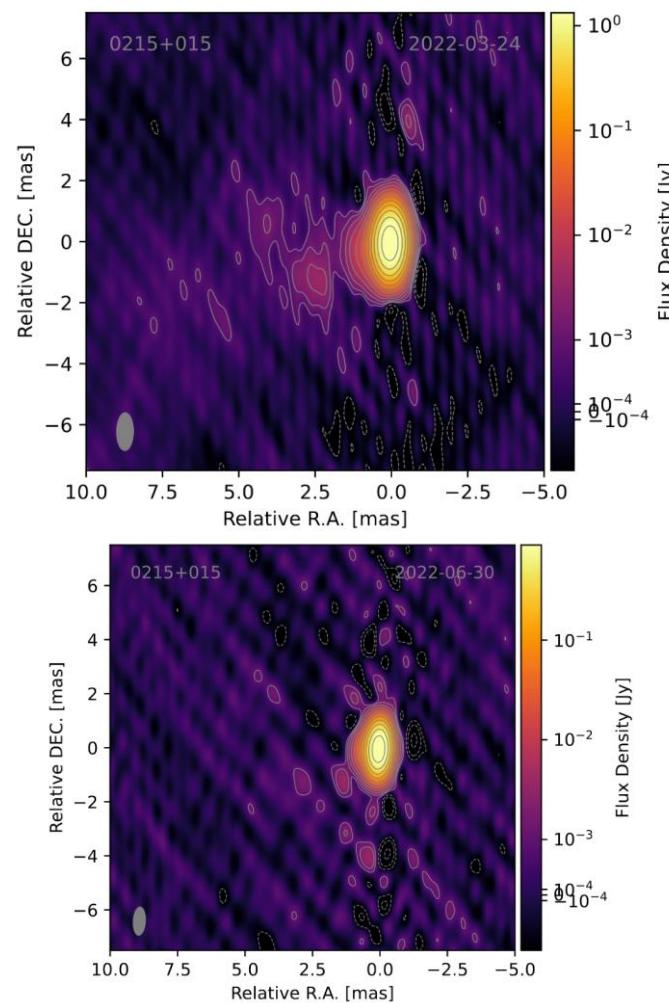
⇒ We now have a unique data set at hand to investigate neutrino emission mechanisms in blazars

# Thank you!

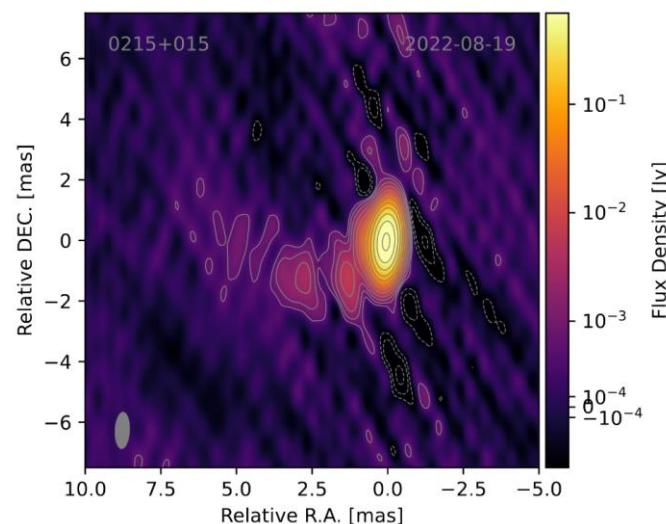
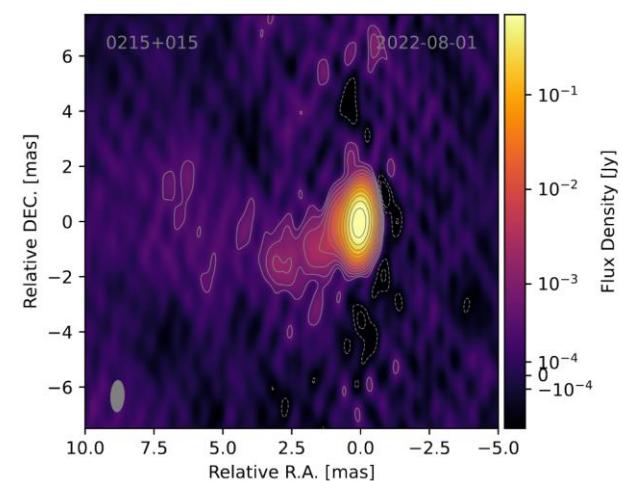
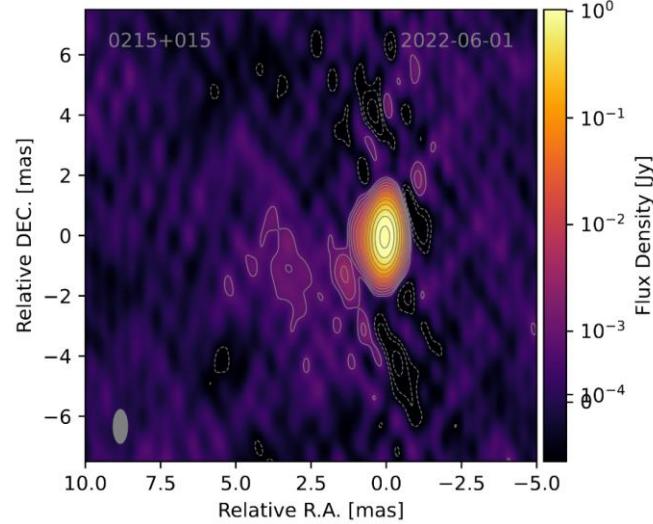
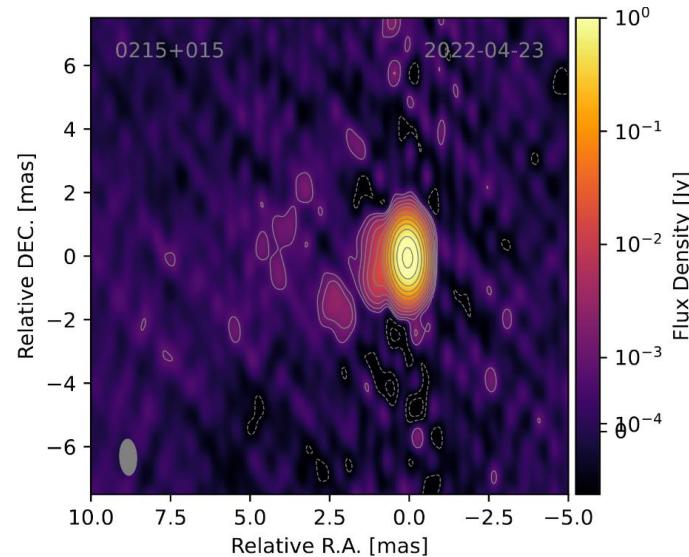
# Questions?



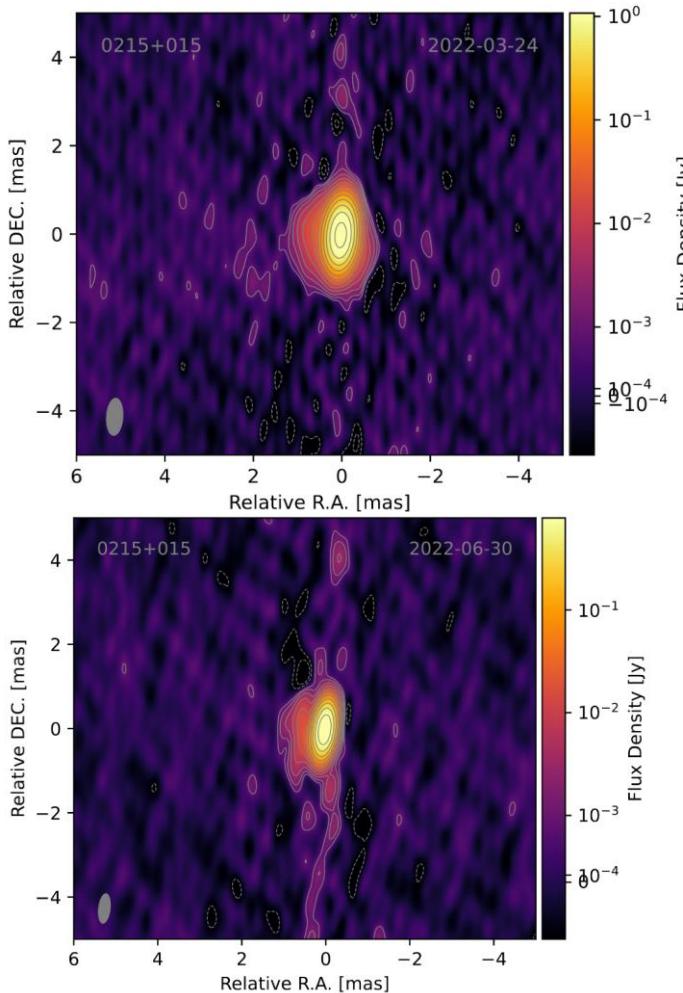
# Ku-Images



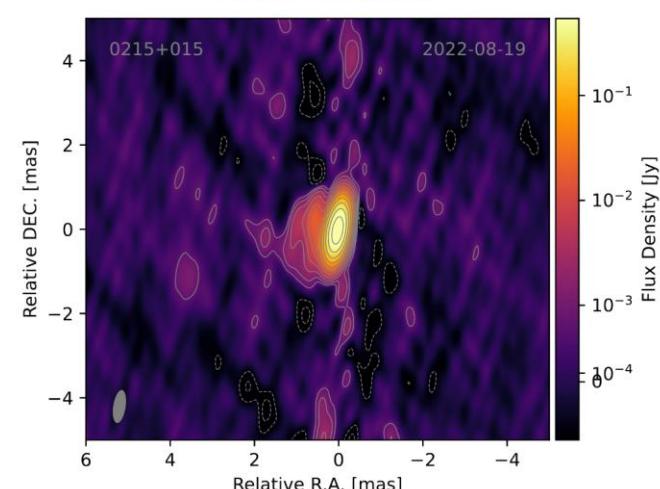
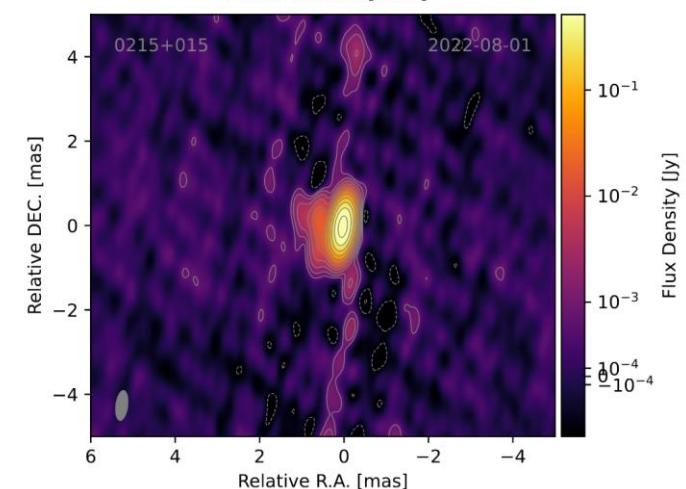
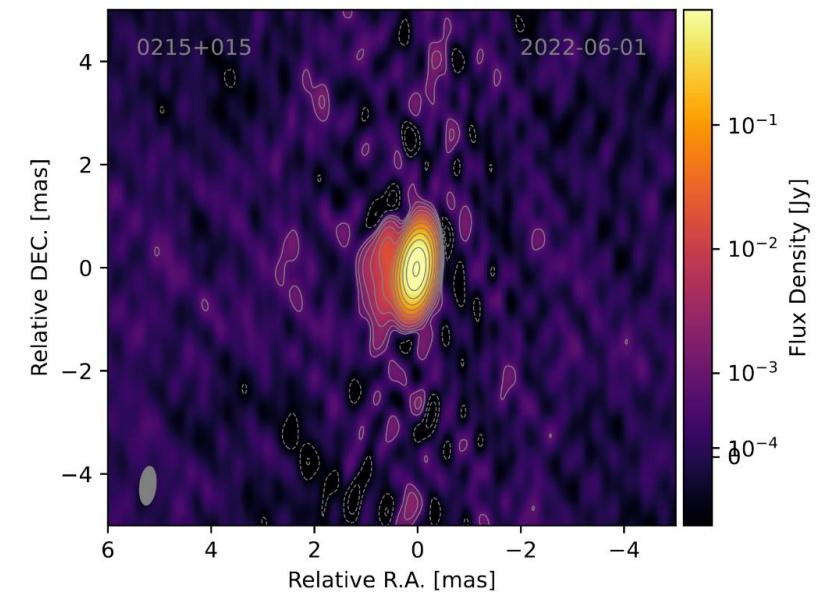
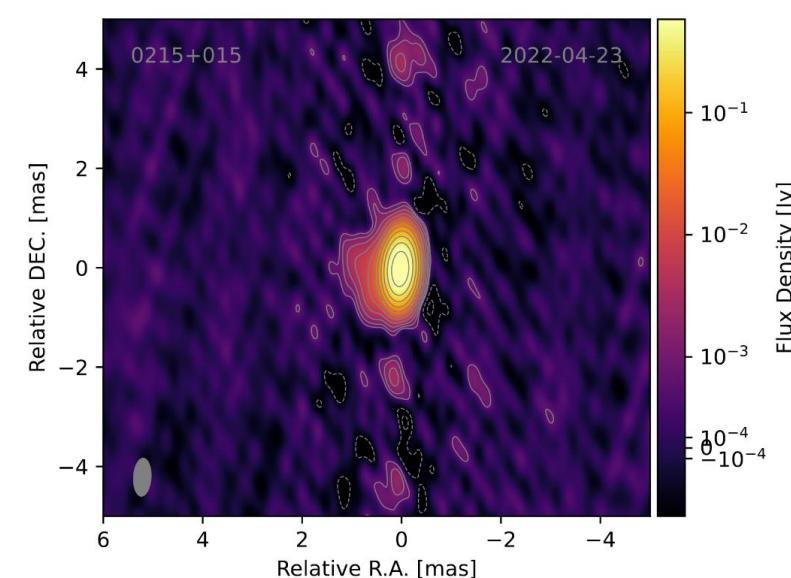
PRELIMINARY



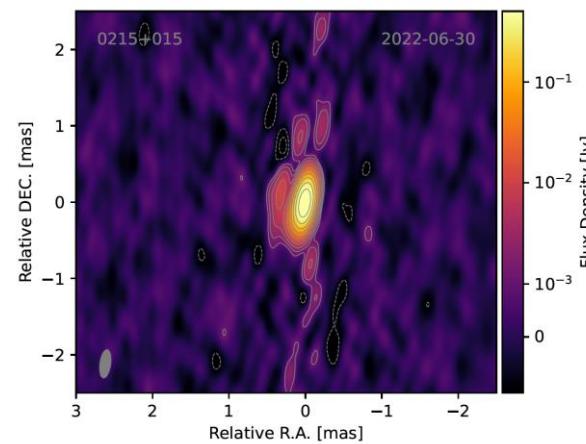
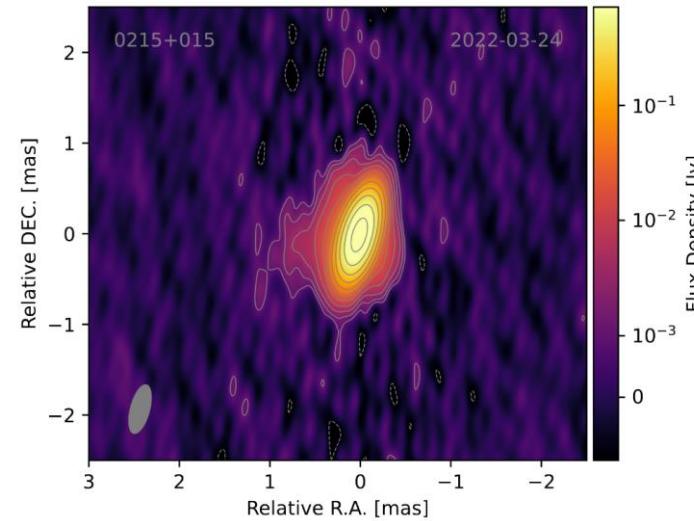
# K-Images



PRELIMINARY



# Q-Images



PRELIMINARY

