Tips for ALMA Proposal Preparation

2025 Jan 14

Jongho Park (Kyung Hee University)

How to write good proposals?

ALMA's guidelines for reviewers (https://almascience.nrao.edu/proposing/alma-proposal-review/guidelines-for-reviewers)

Reviewers should assess the scientific merit of the proposals to the best of their ability using the following criteria:

The overall scientific merit of the proposed investigation and its potential contribution to the advancement of scientific knowledge.

- Does the proposal clearly indicate which important, outstanding questions will be addressed?
- Will the proposed observations have a high scientific impact on this particular field and address the specific science goals of the proposal? ALMA encourages reviewers to give full consideration to well-designed high-risk/high-impact proposals even if there is no guarantee of a positive outcome or definite detection.
- Does the proposal clearly describe how the data will be analyzed in order to achieve the science goals?

The suitability of the observations to achieve the scientific goals.

- Is the choice of target (or targets) clearly described and well justified?
- Are the requested signal-to-noise ratio, angular resolution, largest angular scale, and spectral setup sufficient to achieve the science goals and well justified?
- Does the proposal justify why new observations are needed to achieve the science goals?
- For Joint Proposals (see the Proposer's Guide), does the proposal clearly describe why observations from multiple observatories are required to achieve the science goals?

In general, the scientific merit should be assessed solely on the content of the proposal, according to the above criteria. Proposals may contain references to published papers (including preprints) as per standard practice in the scientific literature. Consultation of those references should not, however, be required for a general understanding of the proposal.

How to write good proposals?

NRAO’s guidelines for reviewers (https://science.nrao.edu/observing/proposal-types/documentation/srp-review-instructions)

The purpose of the proposal-selection process for NRAO telescopes is to prioritize and recommend the proposals that potentially are most valuable for the advancement of scientific knowledge. This does not necessarily mean recommending only those proposals that will provide sure results; it also includes a careful consideration of well-reasoned proposals that may be unconventional but provide opportunities for new discoveries. In the evaluation of proposals, we ask that reviewers think about how best to exploit the full capability of the unique scientific instruments that NRAO operates on behalf of the community. In this context, we ask the reviewers to take a constructive approach.

How to write good proposals?

Something I learned when I reviewed NRAO proposals…

Proposal Code	Title	Normalized Scores		SRP Consensus			Status	
		Avg.	Stdev.	Score	PI & TAC Comments	TAC Only Comments		
GMVA/23B-067 PI: Jongho Park Type: Regular Hours: 28.00 Thesis: No	Peering into M87's black hole in multiple colors	1.76	0.31	1.76	Conflict	Conflict		Review
GMVA/23B-134 PI: Michael Janssen Type: Regular Hours: 8.00 Thesis: No	Precision astrometry of Sgr A* with 3mm VLBI observations of SiO stellar masers	2.50	0.54	2.50				Review
GMVA/23B-053 PI: Seiji Kameno Type: Regular Hours: 12.00 Thesis: No	Scanning the Molecular Torus in NGC 1052	3.07	2.04	3.07				Review
VLBA/23B-235 PI: Eileen Meyer Type: Regular Hours: 10.65 Thesis: No	Mrk 590 : The onset of jet activity in a changing-look AGN	3.69	1.63	3.69	Summary: This is a proposal to obtain C-, X-, and U-band continuum and polarimetry VLBA observations of the changing-look AGN (CL-AGN) Mrk 590 to continue monitoring the radio spectrum and evolution of the compact radio structure. This is a continuation of their previous VLBA monitoring program. Mrk 590 has changed its spectral state between type 1 and type 2 more than once over a period of decades and has shown an extreme variability in UV/optical luminosity and X-ray luminosity, which are believed to be caused by episodic accretion events. These events may be followed by the launch of relativistic jets and, indeed, VLBI observations in 2015 revealed a faint compact source interpreted as a nascent jet. Recent multi-frequency VLBA imaging (project VLBA/22B-261) confirm the presence of an extension at multiple bands. The primary goal of these new observations is to detect and characterize the radio jet proper motion, reveal changes in the elongation of the source or the ejection of a new component, and look for spectral changes with time. The specific science goals are to compare the new C and X band observations to previous ones to see if the extension is a jet and estimate its velocity, get more detailed jet structure with the U band, measure the spectral index more accurately with 3 bands, look for polarization in the ejection components (and maybe map the magnetic field), compare these observations with already approved Swift observations, and to select the best frequency for future long-term monitoring. If these observations show evolution of the radio structure, they will continue to follow the source. Strengths: A strong case is made that this is an opportune time to be observing Mrk 590 with the VLBA given the likely extension of a radio jet. Continued monitoring of this CL-AGN will continue to provide valuable information about the dynamic accretion physics near SMBHs. VLBI monitoring of this unique CL-AGN target is needed to build the connection between AGN activity and any jet launching and, possibly, on the mechanism triggering jet formation. The target has already been approved for near-simultaneous Swift XRT and UVOT observations, to be triggered upon observation with the VLBA. This additional data will also be very valuable and will allow the team to investigate the connection between radio and optical/UV/X-ray emission. The analysis plan for the new proposed data is well-described. The observing strategy and the amount of requested observing time are appropriate to reach the proposed goals. Weaknesses: A mention of what can already be deduced from the 2022 observations would have strengthened the proposal. The proposal could have discussed how this target compares with other CL-AGN sources and whether the results will provide general insights for this group of remarkable objects. Recommended time: The SRP does not recommend a change to the proposed time request. Technical issues affecting ranking or recommended time: None.			Review
GMVA/23B-212 PI: Loreto Barcos-Munoz Type: Regular Hours: 16.00 Thesis: No	Arp 220: AGN or not AGN?, that is the question...	4.20	0.84	4.20				Review

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Lessons Learned from Reviewing NRAO Proposals:

1. **Prepare Strong Science Cases**: This is always the most important aspect! Ensure that your proposal is compelling and well-supported by scientific rationale.
2. **Consider the Reviewers' Time Constraints**: Reviewers, particularly for ALMA proposals, have limited time. Make sure your proposal is:
   - Catchy and engaging
   - Easy to understand
   - Very clear and concise
3. **Use Visual Aids**: Schematic diagrams can be very helpful in conveying complex ideas quickly and effectively.
4. **Be Specific with Scientific Objectives**:
   - Avoid vague, broad scientific goals (e.g., "This observation will broaden our knowledge about star formation...").
   - Specify which models and aspects are important (e.g., simulations) and explain how the proposed observation can distinguish and constrain these models.

How to write good proposals?

Lessons Learned from Reviewing NRAO Proposals:

5. **Cater to Non-Experts**: Reviewers are often not specialists in your specific field, especially for ALMA proposals. Write in a way that is accessible and friendly to a broader scientific audience.
6. **Justify the Need for ALMA**: Clearly articulate why ALMA is necessary for your research. Could this be accomplished with other, less expensive telescopes?

List of Successful ALMA Proposals written as a P.I.

1. 2016.1.00112.S (Cycle 3, Ph. D. student)
   : Probing the Magnetic Fields in the Jet Base of the Gamma ray Bright Blazar PKS 1510-08 (3 hours, Band 4, 6, 7)
2. 2022.1.00750.V (Cycle 9, Postdoc)
   : A Multicolor View of the Black Hole Environment in M87 (16 hours, B3)
3. 2023.1.01086.V (Cycle 10, Scientific Staff)
   : Peering into M87’s Black Hole in Multiple Colors (16 hours, B1,3)
4. 2024.1.01311.V (Cycle 11, Professor)
   : Challenging the Structured Jet Paradigm of AGN with the Event Horizon Telescope (6.5 hours, B6)
5. 2023.A.00043.V (Cycle 10 DDT, Professor)
   : Peering into M87’s Black Hole in Multiple Colors (16 hours, B3,7)

Successful ALMA proposal: 2016.1.00112.S

Title: Probing the Magnetic Fields in the Jet Base of the Gamma-ray Bright Blazar PKS 1510-08.

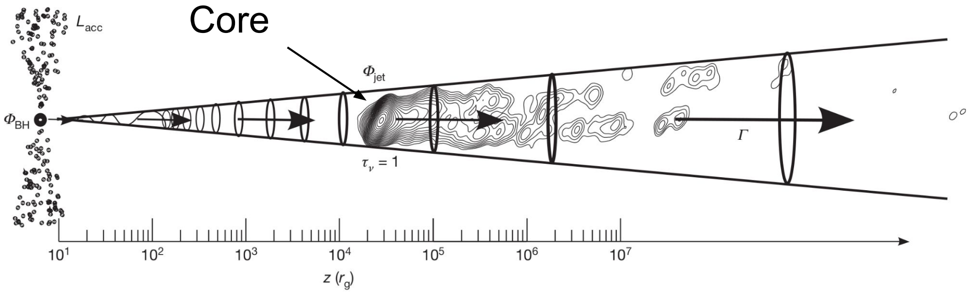
Requested time: 3 hours

Bands: 4 (150 GHz), 6 (230 GHz), 7 (345 GHz)

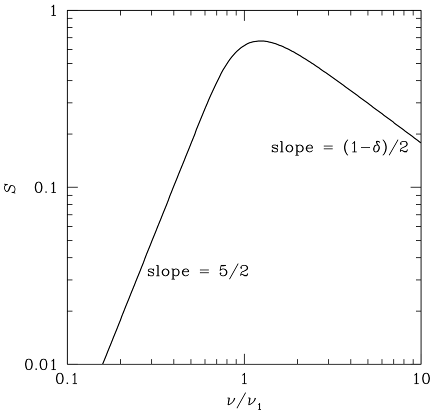
Special Requests: Polarimetry but standard mode, time constraints (multiple bands), student project

Successful ALMA proposal: 2016.1.00112.S

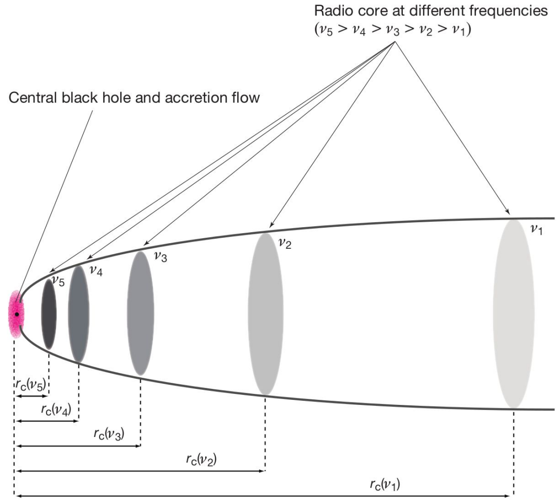
The "core-shift" effect in synchrotron emitting AGN jets.
Model 1: The radio cores are tau=1 surfaces?



Zamaninasab et al. (2014)



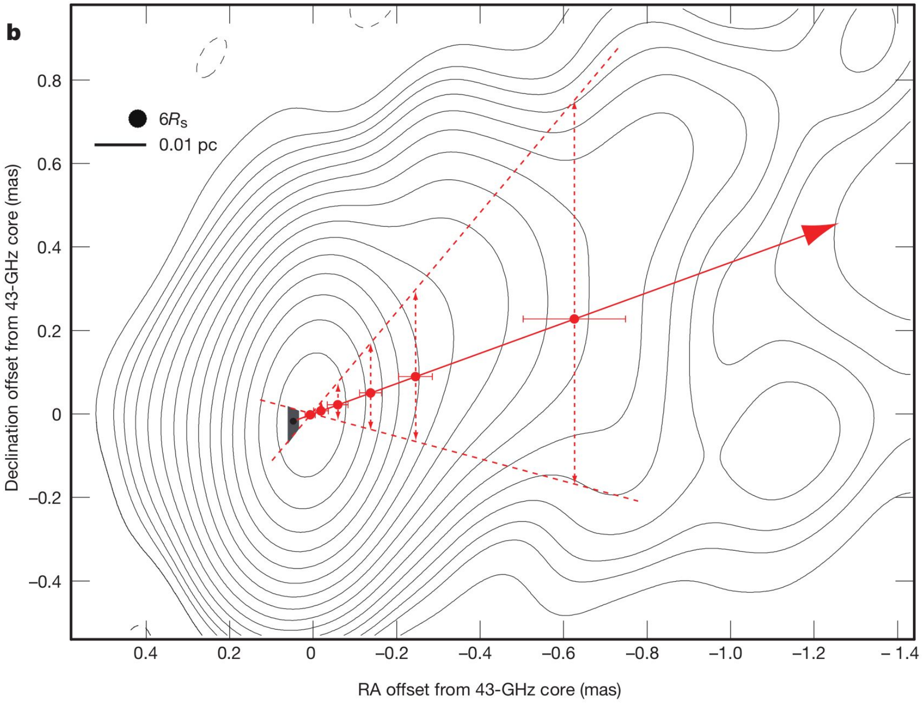
Synchrotron self-absorption
The location of the synchrotron peak frequency depends on the magnetic field strength and electron density.
(구본철, 김웅태 교수님 천체물리학)

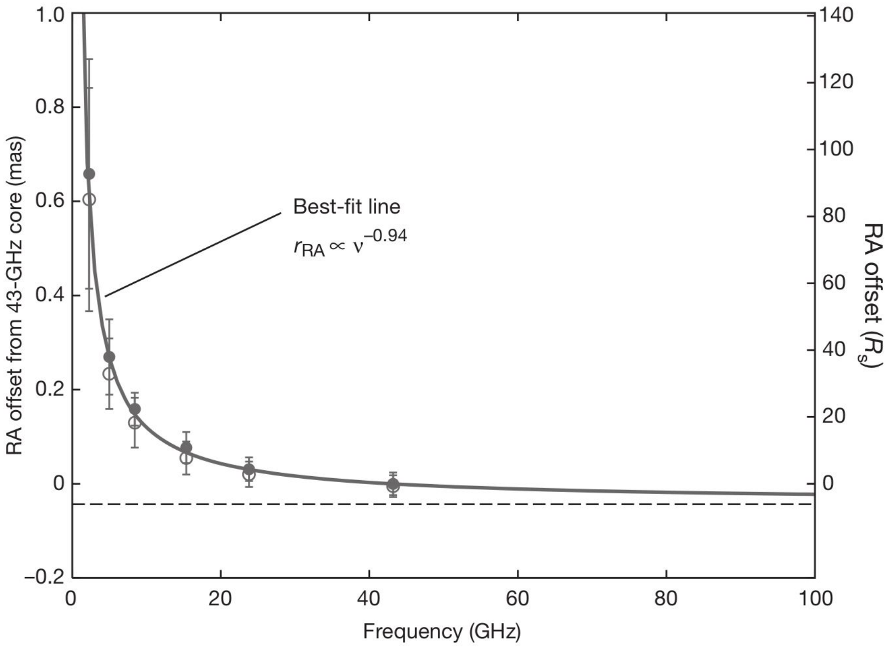


Hada et al. (2011)

Successful ALMA proposal: 2016.1.00112.S

The core-shift effect observed in the M87 jet using the VLBA.





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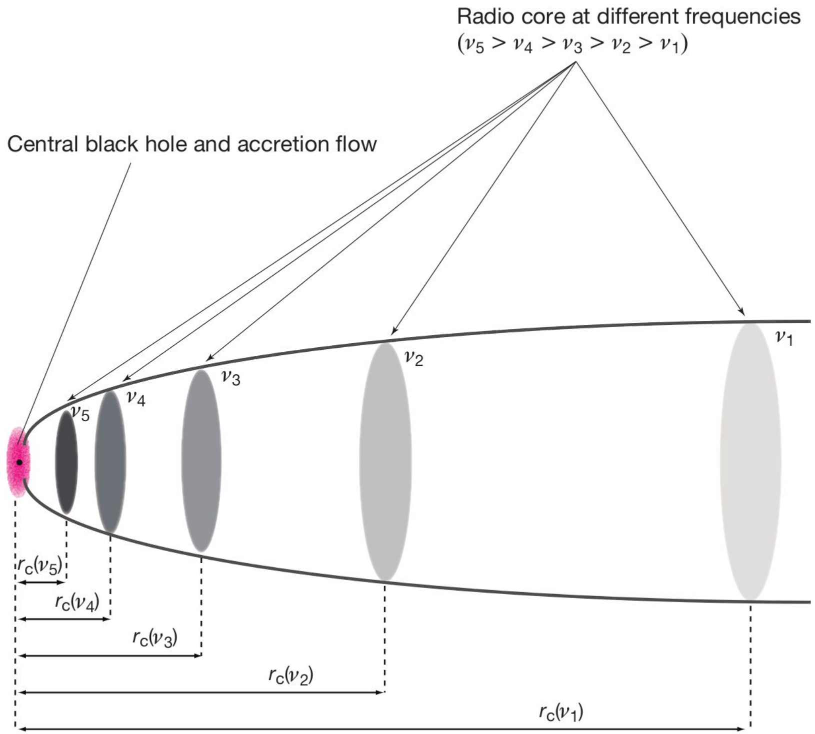


As we go to higher frequencies…

Higher $n_e \, B_{||}$ are expected.

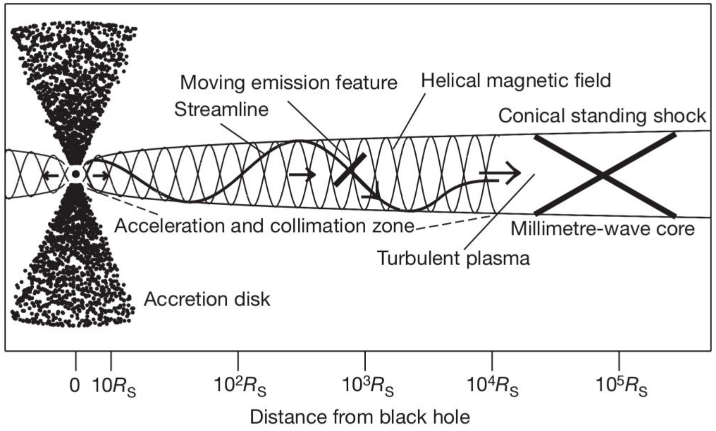
$$\mathrm{RM} \propto \int n_e B_{||} dl$$

$$\mathrm{RM} \propto \nu^a$$

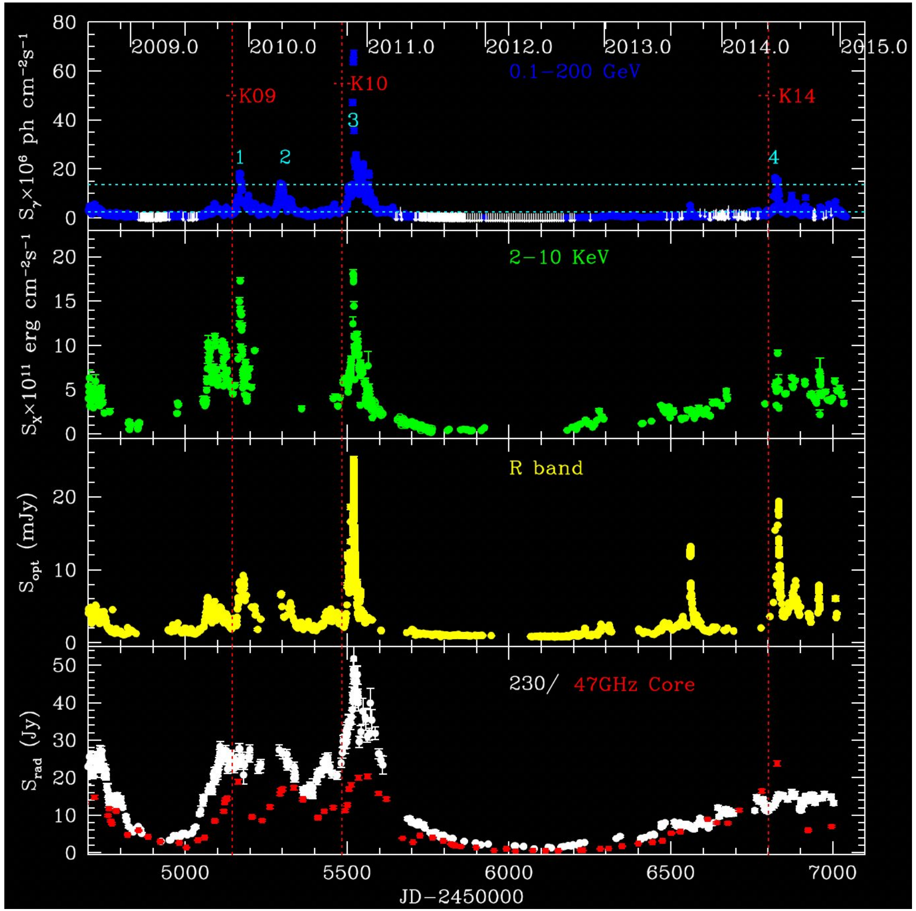
a depends on the jet geometry and magnetic field configuration.

Successful ALMA proposal: 2016.1.00112.S

Model 2: The radio cores are standing shocks?



Marscher+2008



Jorstad & Marscher (2016)

Successful ALMA proposal: 2016.1.00112.S

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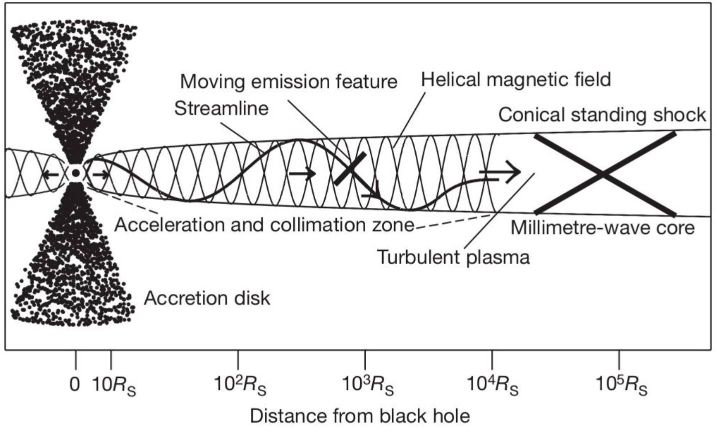

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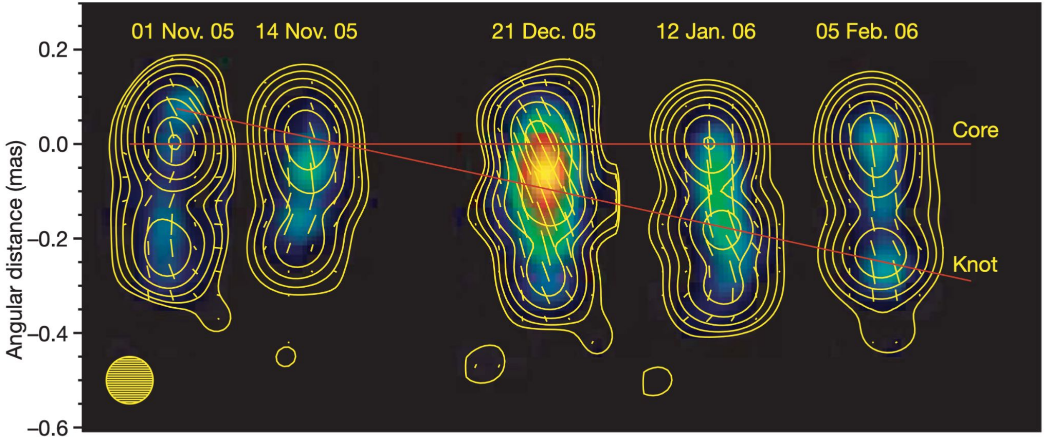


Marscher et al. (2008)

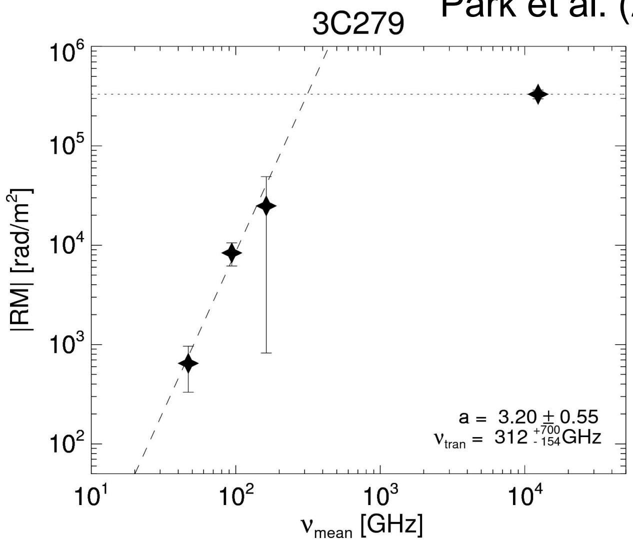
The linear polarization structure of the cores of some AGN jets are consistent with that of a recollimation shock.

Successful ALMA proposal: 2016.1.00112.S

Model 1: The radio cores are tau=1 surfaces?
-> RM is expected to increase with observing frequency.
Model 2: The radio cores are standing shocks?
-> RM is expected to be constant over frequency.

$$\mathrm{RM} \propto \int n_e B_{||} dl$$

Park et al. (2018)



- The core-shift effect is observed at frequencies lower than a few hundred GHz due to the opacity of the jet downstream the recollimation shock.
- At high enough frequencies (> a few hundreds GHz), no more frequency dependence of RM is expected as the emission from the recollimation shock is dominated.

Based on KVN 22/43/86 GHz observations + optical archival data

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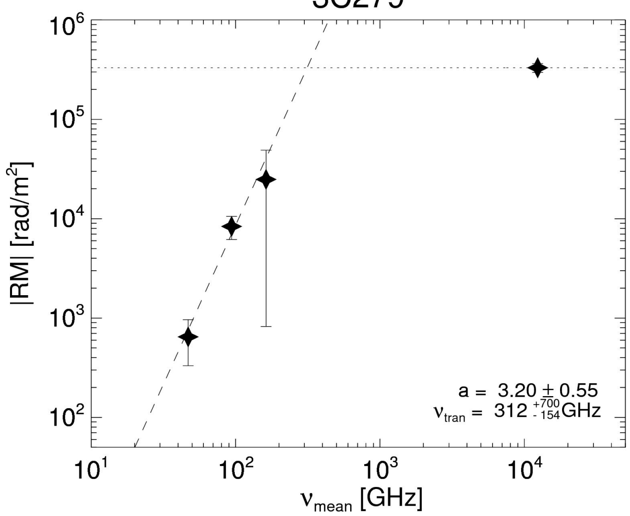
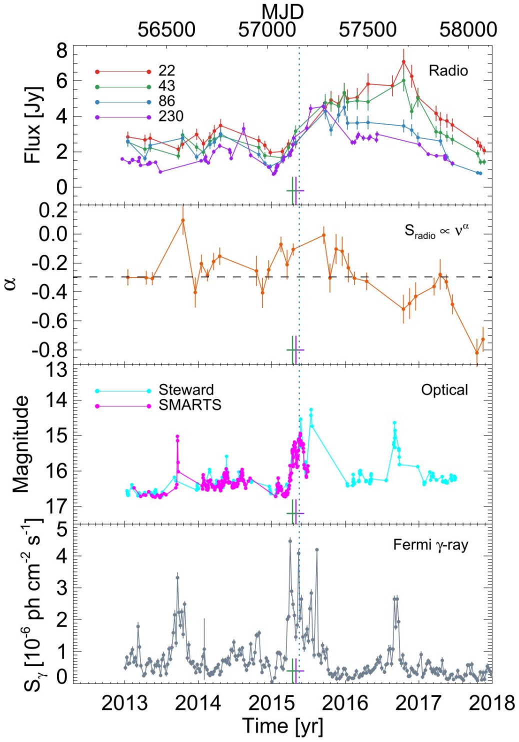


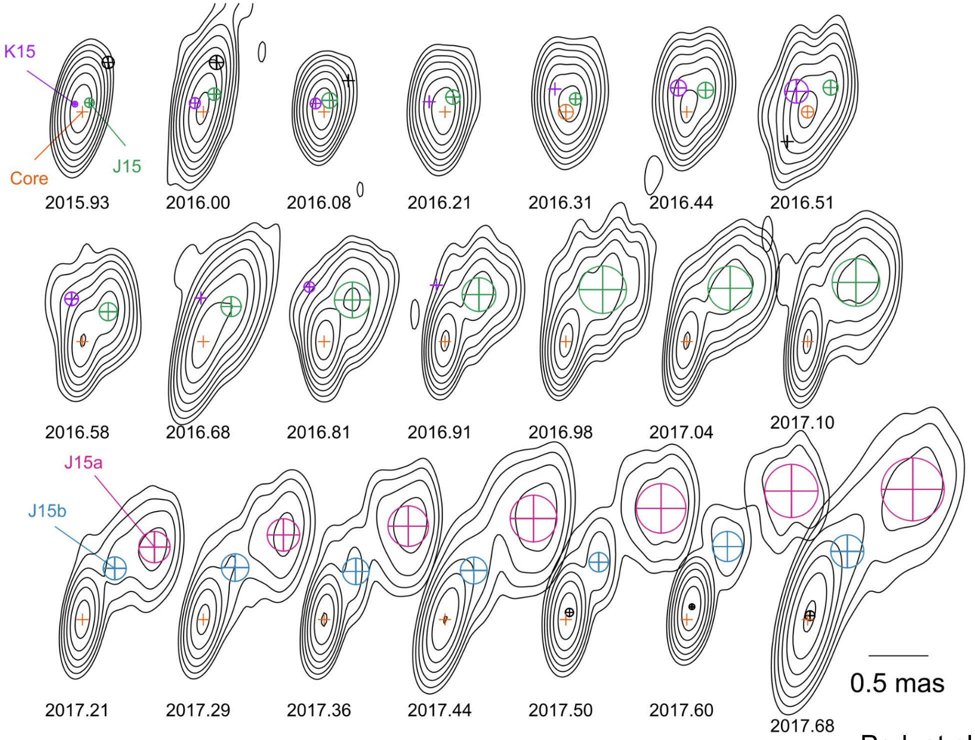
- The core-shift effect is observed at frequencies lower than a few hundred GHz due to the opacity of the jet downstream the recollimation shock.
- At high enough frequencies (> a few hundreds GHz), no more frequency dependence of RM is expected as the emission from the recollimation shock is dominated.
-> We will test this conjecture using ALMA.

Based on KVN 22/43/86 GHz observations + optical archival data

Successful ALMA proposal: 2016.1.00112.S

The target source PKS 1510-089: one of the brightest sources in the gamma-ray sky. Indication of the existence of a recollimation shock. Compact geometry (less confusion). Being monitored with the KVN.





Park et al. (2019)

Successful ALMA proposal: 2016.1.00112.S

The “Earth-rotation Polarimetry”

- We need multifrequency polarization observations of the target source at three bands (band 4,6,7)
- It takes about three hours to properly calibrate polarization of ALMA at each band -> too large amount of observing time.
- We instead proposed to use the Earth-rotation Polarimetry, which can be done with a much shorter integration time.

$$
\begin{aligned}
XX &= (I + Q_\psi) + U_\psi (d^*_{X_j} + d_{X_i}) \\
XY &= U_\psi + I(d^*_{Y_j} + d_{X_i}) + Q_\psi (d^*_{Y_j} - d_{X_i}) \\
YX &= U_\psi + I(d^*_{Y_i} + d_{X_j}) + Q_\psi (d^*_{Y_i} - d_{X_j}) \\
YY &= (I - Q_\psi) + U_\psi (d_{Y_i} + d^*_{Y_j})
\end{aligned}
$$

$$
\begin{aligned}
Q_\psi &= Q cos2\psi + U sin2\psi \\
U_\psi &= -Q sin2\psi + U cos2\psi
\end{aligned}
$$

$$
\begin{aligned}
\frac{XX-YY}{XX+YY} &= \frac{Q}{I} cos2\psi + \frac{U}{I} sin2\psi \\
&= \alpha\cos\theta + \beta\sin\theta \\
&= \sqrt{\alpha^2+\beta^2}\left(\frac{\alpha}{\sqrt{\alpha^2+\beta^2}}\cos\theta + \frac{\beta}{\sqrt{\alpha^2+\beta^2}}\sin\theta\right) \\
&= \sqrt{\alpha^2+\beta^2}\,(\cos\phi\cos\theta + \sin\phi\sin\theta) \\
&= m_L \cos(\phi - \theta) \\
&= m_L \cos[2(\chi - \psi)]
\end{aligned}
$$

$\alpha = Q/I$, $\beta = U/I$, $\theta = 2\psi$

$\tan\phi = \frac{\beta}{\alpha} = \frac{U}{Q}$

$\sqrt{\alpha^2+\beta^2} = \frac{\sqrt{Q^2+U^2}}{I} = m_L$

$\phi = 2\chi$, $\theta = 2\psi$

$$
q \equiv \frac{XX-YY}{XX+YY} = m_L \cos[2(\chi - \psi)]
$$

Successful ALMA proposal: 2016.1.00112.S

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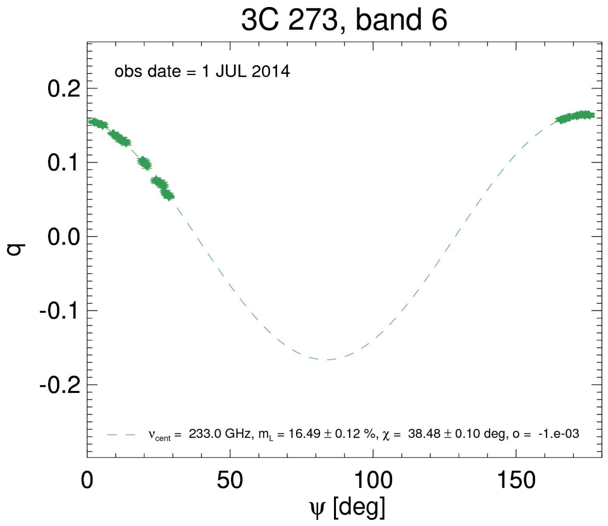

CrossM

ALMA SCIENCE VERIFICATION DATA: MILLIMETER CONTINUUM POLARIMETRY OF THE BRIGHT RADIO QUASAR 3C 286

H. Nagai[1], K. Nakanishi[1,2,3], R. Paladino[4], C. L. H. Hull[5,9], P. Cortes[3,6], G. Moellenbrock[7], E. Fomalont[3,6], K. Asada[8], and K. Hada[1]
[1] National Astronomical Observatory of Japan, Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan; hiroshi.nagai@nao.ac.jp
[2] The Graduate University for Advanced Studies (SOUKENDAI), Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan
[3] Joint ALMA Observatory, Alonso de Córdova 3107, Vitacura 763 0355, Santiago de Chile, Chile
[4] INAF-Osservatorio di Radioastronomia, Via P. Gobetti, 101 I-40129 Bologna, Italy
[5] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
[6] National Radio Astronomy Observatory, Charlottesville, VA 22903-2475, USA
[7] National Radio Astronomy Observatory, Socorro, NM 87801, USA
[8] The Academia Sinica Institute of Astronomy and Astrophysics, AS/NTU. No.1, Sec. 4, Roosevelt Rd, Taipei 10617, Taiwan, R.O.C
Received 2016 March 20; revised 2016 April 17; accepted 2016 April 29; published 2016 June 21

ABSTRACT

We present full-polarization observations of the compact, steep-spectrum radio quasar 3C 286 made with the Atacama Large Millimeter and Submillimeter Array (ALMA) at 1.3 mm. These are the first full-polarization ALMA observations, which were obtained in the framework of Science Verification. A bright core and a south–west component are detected in the total intensity image, similar to previous centimeter images. Polarized emission is also detected toward both components. The fractional polarization of the core is about 17%; this is higher than the fractional polarization at centimeter wavelengths, suggesting that the magnetic field is even more ordered in the millimeter radio core than it is further downstream in the jet. The observed polarization position angle (or electric vector position angle (EVPA)) in the core is ~39°, which confirms the trend that the EVPA slowly increases from centimeter to millimeter wavelengths. With the aid of multi-frequency VLBI observations, we argue that this EVPA change is associated with the frequency-dependent core position. We also report a serendipitous detection of a sub-mJy source in the field of view, which is likely to be a submillimeter galaxy.

Key words: galaxies: active – galaxies: jets – galaxies: individual (3C 286) – radio continuum: galaxies

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Band	S_ν (Jy)	$\sigma_{1\text{min}}$ (mJy)	$\Delta\chi$ for LST offset from transit [deg]			
			0 hour	1 hour	2 hour	3 hour
4	2.0	0.10	0.88	1.01	4.06	29.04
6	1.5	0.14	0.90	1.26	8.34	37.63
7	1.2	0.20	0.97	2.08	19.60	43.84

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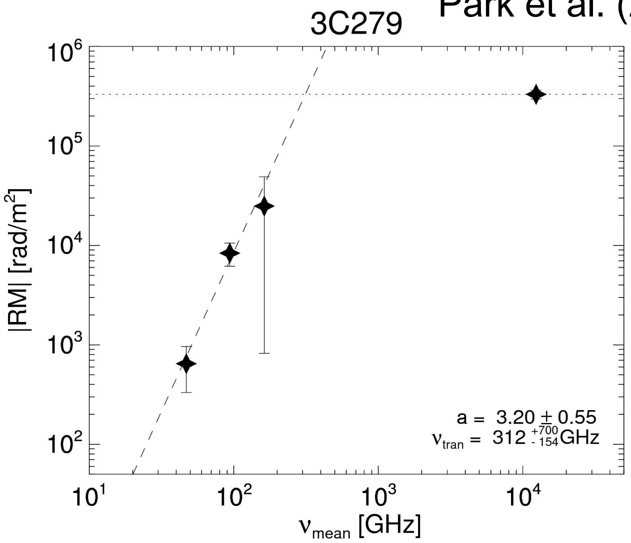

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Successful ALMA proposal: 2016.1.00112.S

The “Earth-rotation Polarimetry”
- We need multifrequency polarization observations of the target source at three bands (band 4,6,7)
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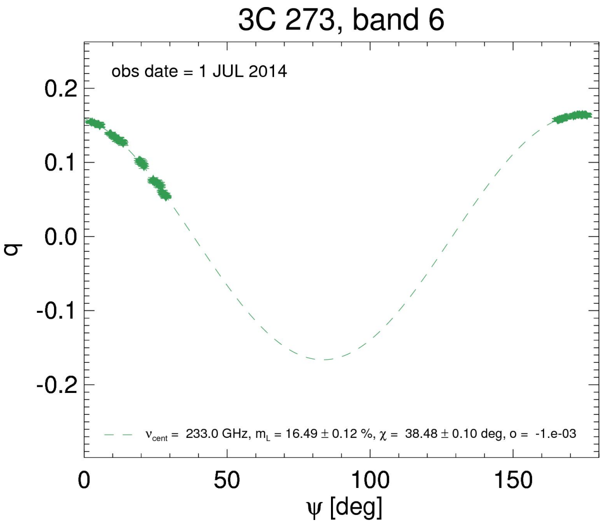

ALMA SCIENCE VERIFICATION DATA: MILLIMETER CONTINUUM POLARIMETRY OF THE BRIGHT RADIO QUASAR 3C 286

H. Nagai[1], K. Nakanishi[1,2,3], R. Paladino[4], C. L. H. Hull[5,9], P. Cortes[3,6], G. Moellenbrock[7], E. Fomalont[3,6], K. Asada[8], and K. Hada[1]

[1] National Astronomical Observatory of Japan, Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan; hiroshi.nagai@nao.ac.jp
[2] The Graduate University for Advanced Studies (SOUKENDAI), Osawa 2-21-1, Mitaka, Tokyo 181-8588, Japan
[3] Joint ALMA Observatory, Alonso de Córdova 3107, Vitacura 763 0355, Santiago de Chile, Chile
[4] INAF-Osservatorio di Radioastronomia, Via P. Gobetti, 101 I-40129 Bologna, Italy
[5] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
[6] National Radio Astronomy Observatory, Charlottesville, VA 22903-2475, USA
[7] National Radio Astronomy Observatory, Socorro, NM 87801, USA
[8] The Academia Sinica Institute of Astronomy and Astrophysics, AS/NTU. No.1, Sec. 4, Roosevelt Rd, Taipei 10617, Taiwan, R.O.C

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ABSTRACT

We present full-polarization observations of the compact, steep-spectrum radio quasar 3C 286 made with the Atacama Large Millimeter and Submillimeter Array (ALMA) at 1.3 mm. These are the first full-polarization ALMA observations, which were obtained in the framework of Science Verification. A bright core and a south–west component are detected in the total intensity image, similar to previous centimeter images. Polarized emission is also detected toward both components. The fractional polarization of the core is about 17%; this is higher than the fractional polarization at centimeter wavelengths, suggesting that the magnetic field is even more ordered in the millimeter radio core than it is further downstream in the jet. The observed polarization position angle (or electric vector position angle (EVPA)) in the core is ~39°, which confirms the trend that the EVPA slowly increases from centimeter to millimeter wavelengths. With the aid of multi-frequency VLBI observations, we argue that this EVPA change is associated with the frequency-dependent core position. We also report a serendipitous detection of a sub-mJy source in the field of view, which is likely to be a submillimeter galaxy.

Key words: galaxies: active – galaxies: jets – galaxies: individual (3C 286) – radio continuum: galaxies

How to write good proposals?

ALMA's guidelines for reviewers (https://almascience.nrao.edu/proposing/alma-proposal-review/guidelines-for-reviewers)

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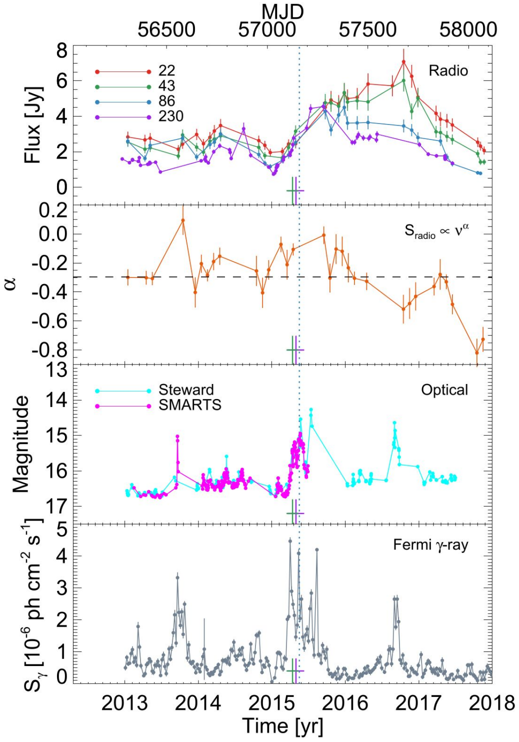
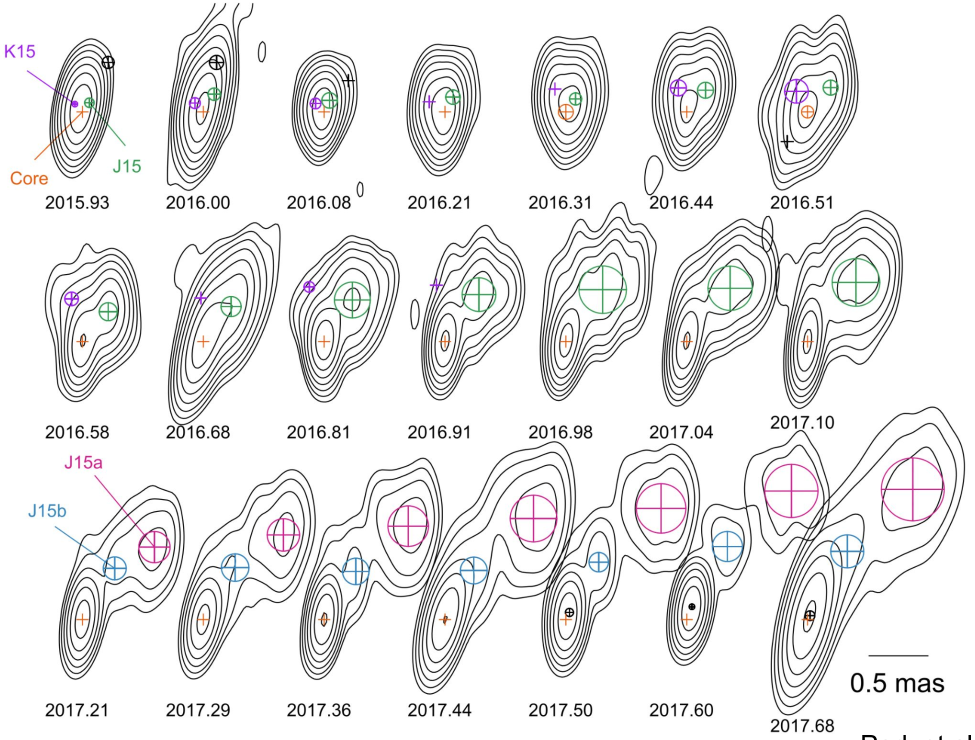
The target source PKS 1510-089: one of the brightest sources in the gamma-ray sky. Indication of the existence of a recollimation shock. Compact geometry (less confusion). Being monitored with the KVN.





Park et al. (2019)

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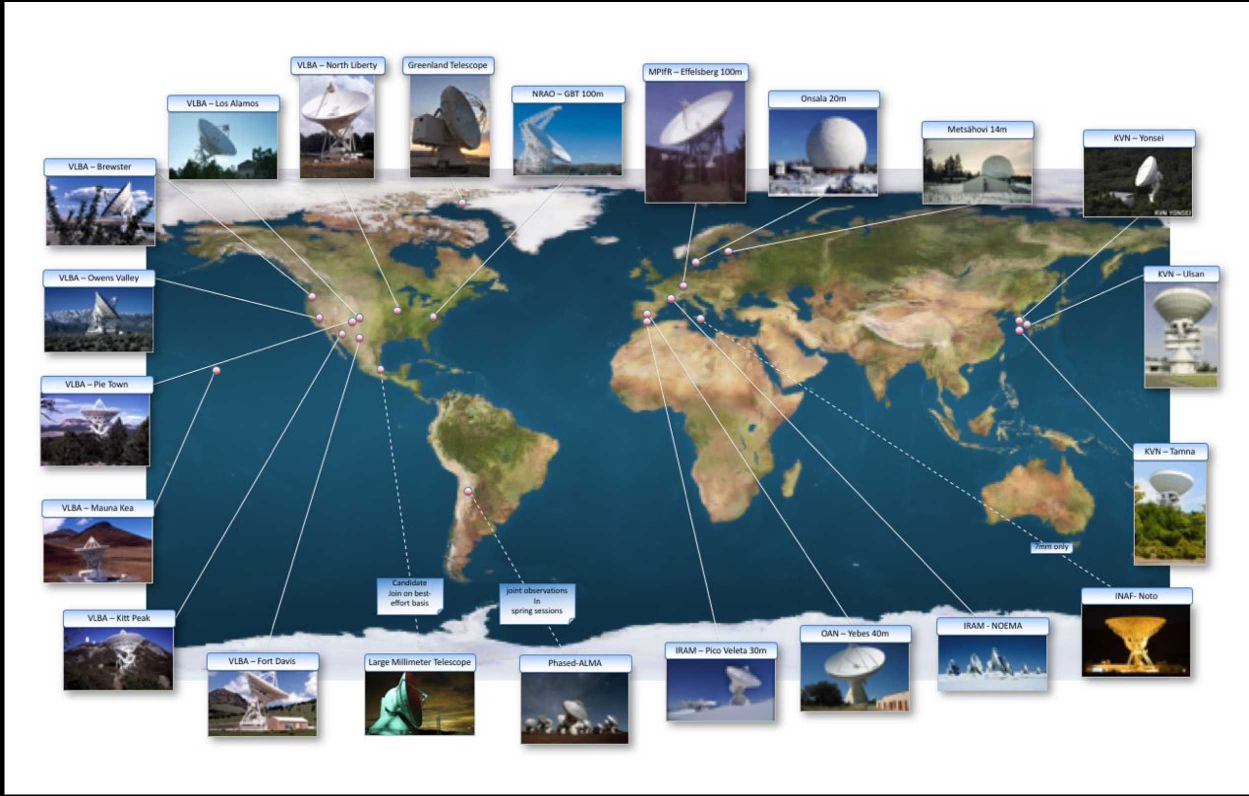
Band	S_ν (Jy)	$\sigma_{1\mathrm{min}}$ (mJy)	$\Delta\chi$ for LST offset from transit [deg]			
			0 hour	1 hour	2 hour	3 hour
4	2.0	0.10	0.88	1.01	4.06	29.04
6	1.5	0.14	0.90	1.26	8.34	37.63
7	1.2	0.20	0.97	2.08	19.60	43.84

Successful ALMA proposal: 2022.1.00750.V



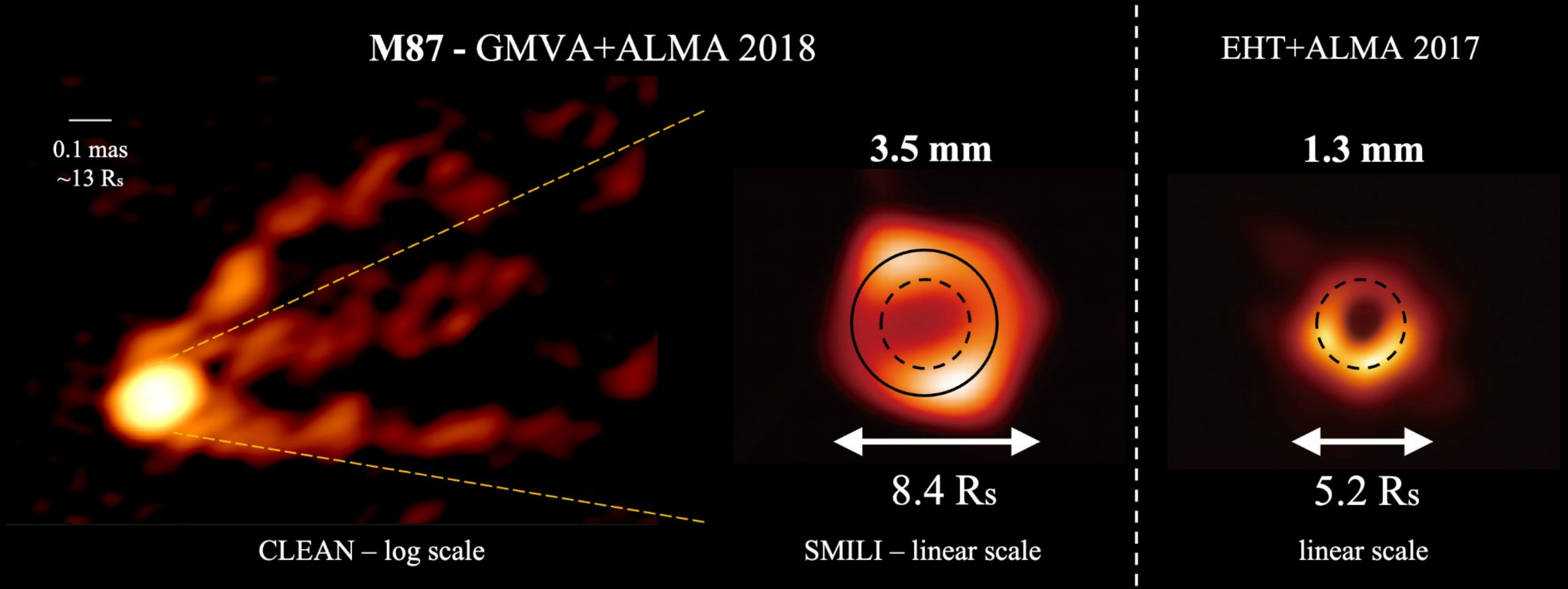
The Global Millimeter VLBI Array (GMVA)

wavelength: 3 mm
angular resolution: ~ 40 uas

ALMA recently joined the GMVA, providing super-sensitive very long North-South baselines.

Successful ALMA proposal: 2022.1.00750.V

Lu et al. (2023, Nature)



- The GMVA+ALMA image presents a limb-brightened jet that emerges from the core at a very wide opening angle.
- A ring-like structure is detected in the core for the first time.
- The ring size is ~50% larger than the EHT ring size.

Maximizing angular resolution through ALMA as a VLBI station

The first-ever image of a supermassive black hole revealed by the EHT.

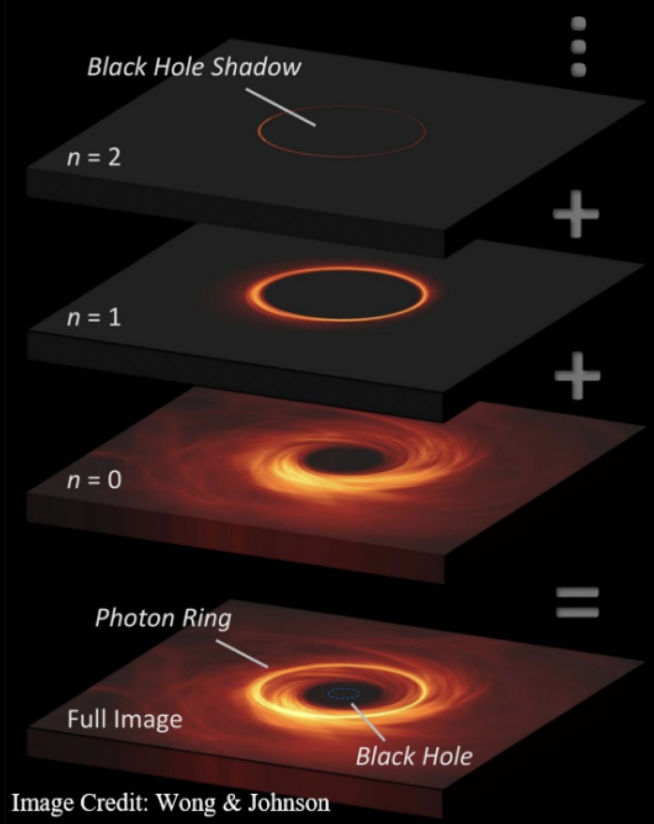
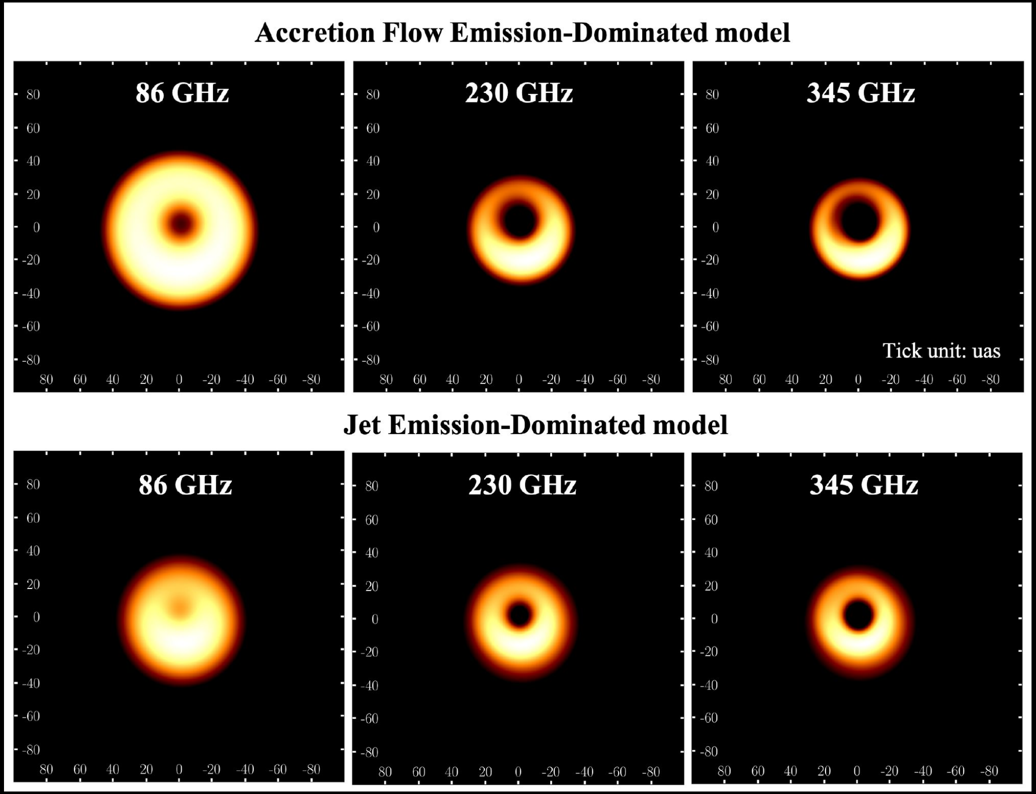


Image Credit: Wong & Johnson

Successful ALMA proposal: 2022.1.00750.V

Objective #1: a Multicolor View of the Black Hole Environment in M87



- What is the origin of the ring?
- If the ring emission is actually dominated by the photon ring at 230 GHz, then a similar structure is expected at 345 GHz.
- However, the ring at 86 GHz is expected to depend a lot on the physical conditions of the plasma in the accretion flows and jet.
- First-ever quasi-simultaneous observations of the ring-like structure at 86, 230, and 345 GHz.

Successful ALMA proposal: 2022.1.00750.V

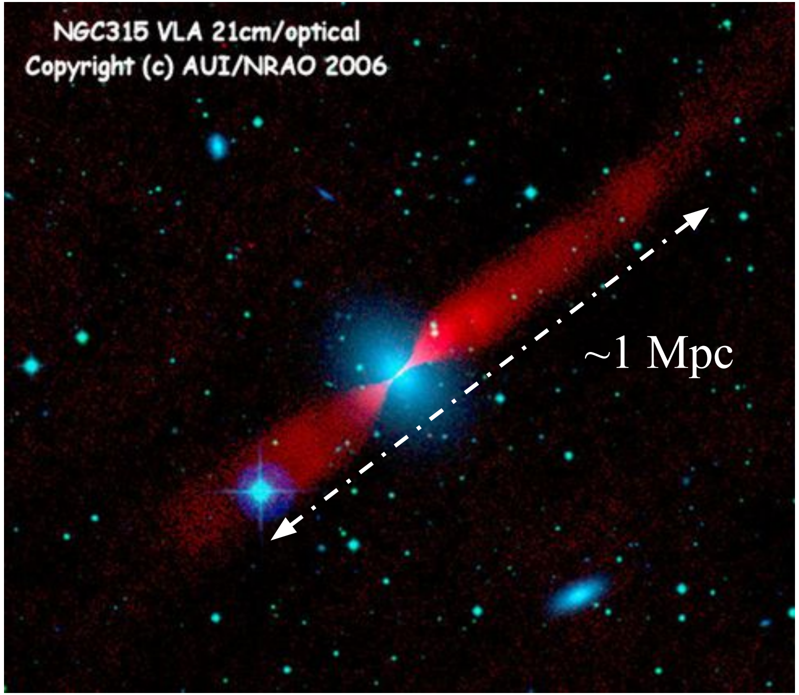
Description of Observations

- The Need for ALMA
  : We cannot resolve the ring at 86 GHz without ALMA
- Why Cycle 9?
  : ALMA-VLBI at band 7 (345 GHz) is available for the first time in Cycle 9.
- Scientific Impact
  : The first-ever triple color view of the M87 black hole.

Lessens Learnt from 2024.1.01311.V

Project: observing NGC 315 with global mm-VLBI including ALMA

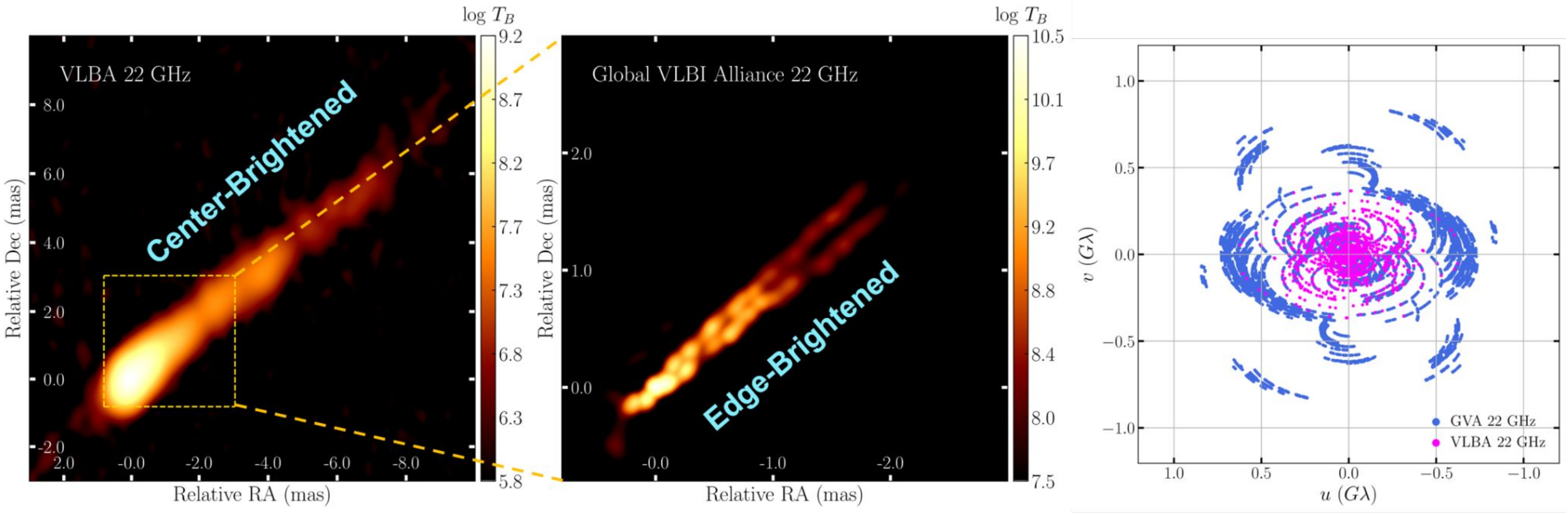
- 2021.1.00063.V (Cycle 8, rejected)
- 2022.1.01236.V (Cycle 9, rejected)
- 2023.1.01120.V (Cycle 10, rejected)
- 2024.1.01360.V (Cycle 11, accepted!)



The main scientific objective is to investigate the edge-brightening of the jets at the innermost scales.
→ Why were the proposal rejected three times but accepted in Cycle 11?

Lessens Learnt from 2024.1.01311.V

Park et al. (2024, ApJL)



If the edge-brightening phenomenon is observed in the jet base using EHT+ALMA, it would allow us to rule out the jet model that has been considered the standard in the field (cited over 500 times since 2005).

→ Potential to trigger a paradigm shift in our understanding of AGN jets.

How do I know if I wrote a good proposal or not?

I would suggest you to do the following before submission (Please keep in mind that there is no golden rule of thumb though).

1. Show your proposal to your colleagues and friends.
2. If it takes more than 10 minutes for them to read the proposal, then probably your proposal is not very strong.
3. If they could not understand the proposal very well and ask you questions regarding the basics of the proposal, then probably your proposal is not very strong.
4. If they think that your proposal is good but is not impressive, then probably your proposal is not very strong.

Please keep in mind that the oversubscription rate for ALMA is 7:1 (and 8:1)

Summary

- Just follow the guidelines provided by ALMA!
- Be friendly to anonymous and non-expert reviewers. The same applies to all kinds of applications (budget proposal, job application, and so on).
- Never give up!