Key Science Observation of AGNs with KaVA array

M. Kino (KASI) & B.W. Sohn (KASI)
on behalf of KaVA AGN sub-WG

Announcement from directors

(copy & paste of Honma-san's e-mail)

The way to the Large Project

From 2015, we would like to start the KaVA large project (upto ~150h/yr/WG), though it is still subject to change depending on the performance evaluation.

To start the large project from 2015, each sub-WG is asked to complete the following processes.

1) Make a presentation at KVN and VERA UM in 2014 on the draft plan of the large project, and call for collaborations from other people (to be open to the community)

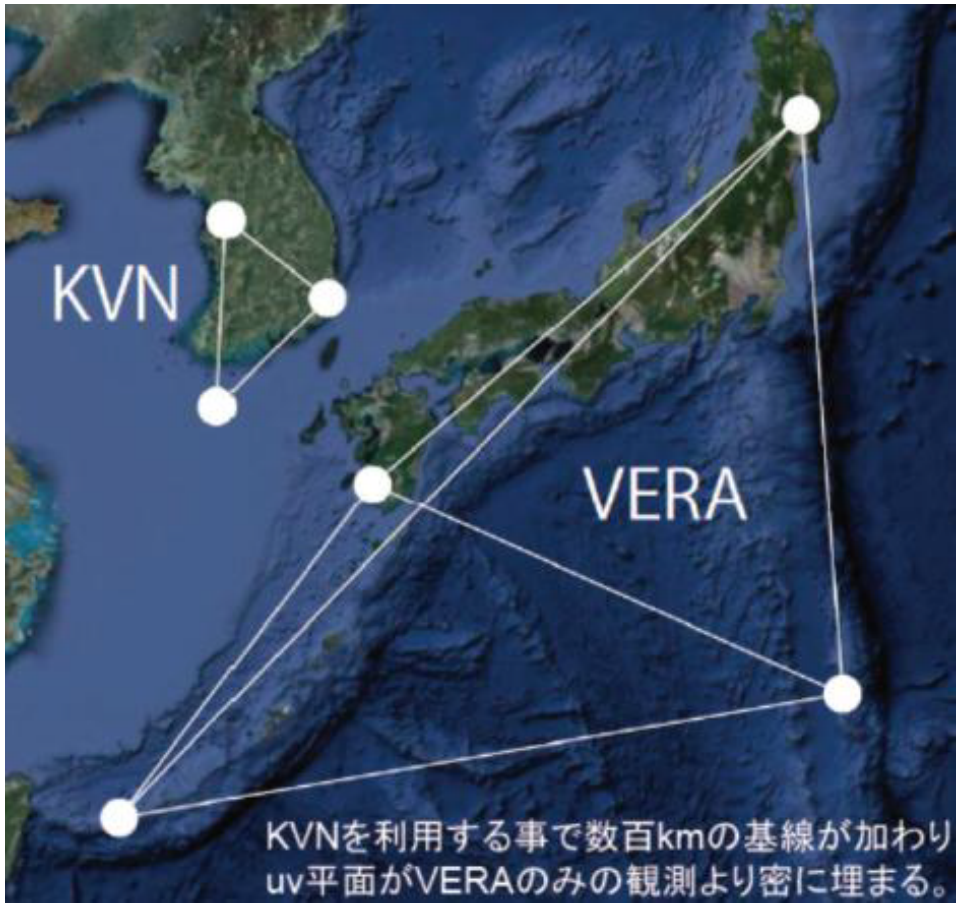
2) Submit a proposal to the DM by the end of 2014.
(cover sheets, 6 pages for science/technical justification
+ detailed source list)

3) Make a presentation on the proposal at the f2f Science WG meeting in 2015 Jan.

Scientific Motivations

- Understanding physical mechanism of AGN(BH) activities in the Universe.
  - testing "*B*-driven jet paradigm"
  - probing "real vicinity of BH"
  - exploring "universality & diversity of jets"

KaVA



KVN:

3 baselines

（300 – 500 km）

+

VERA:

6 baselines

（1000 - 2300 km）

=

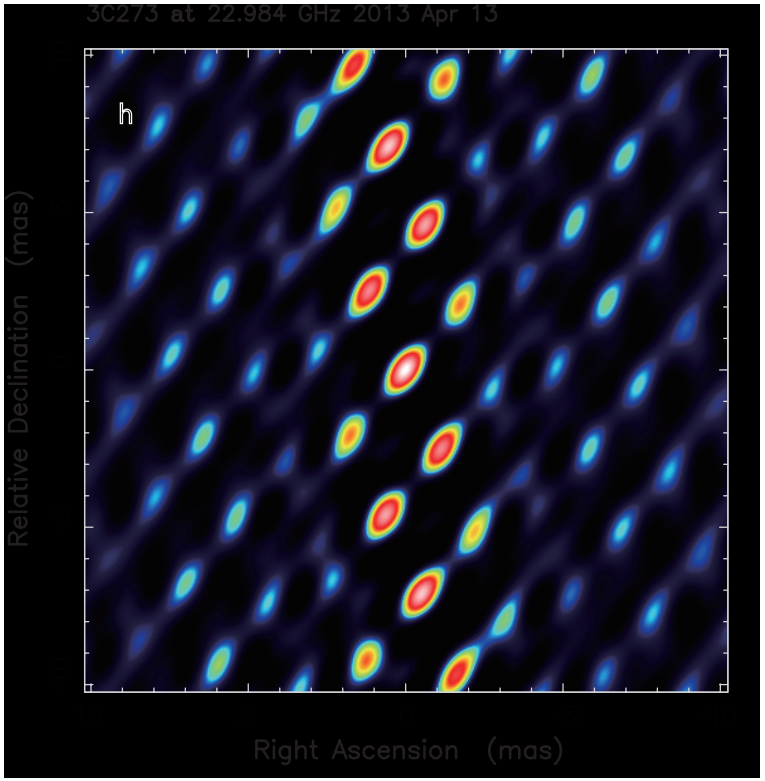
KaVA:

21 baselines

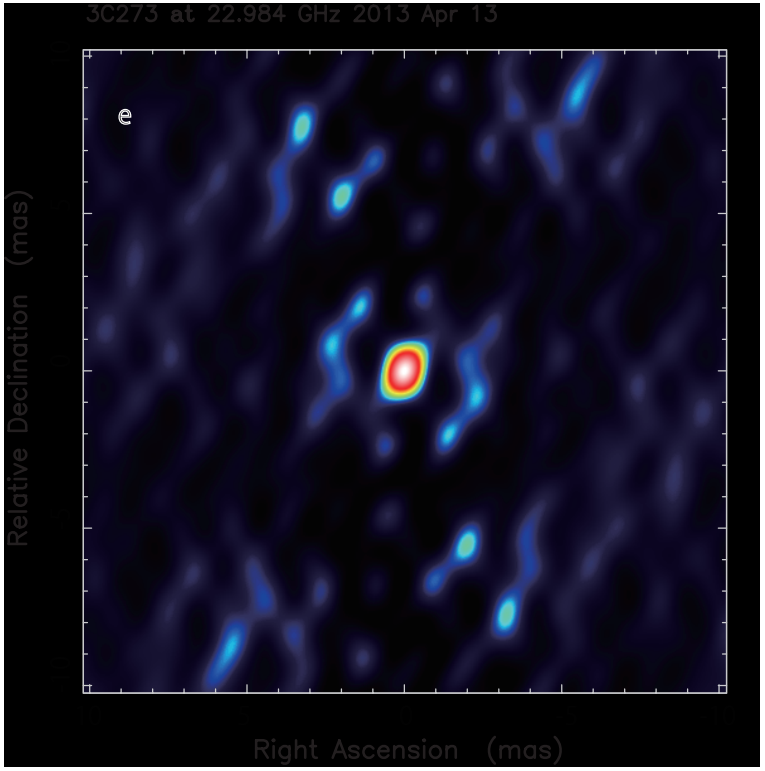
（300 – 2300 km）

Synthesized beam of VERA & KaVA

VERA



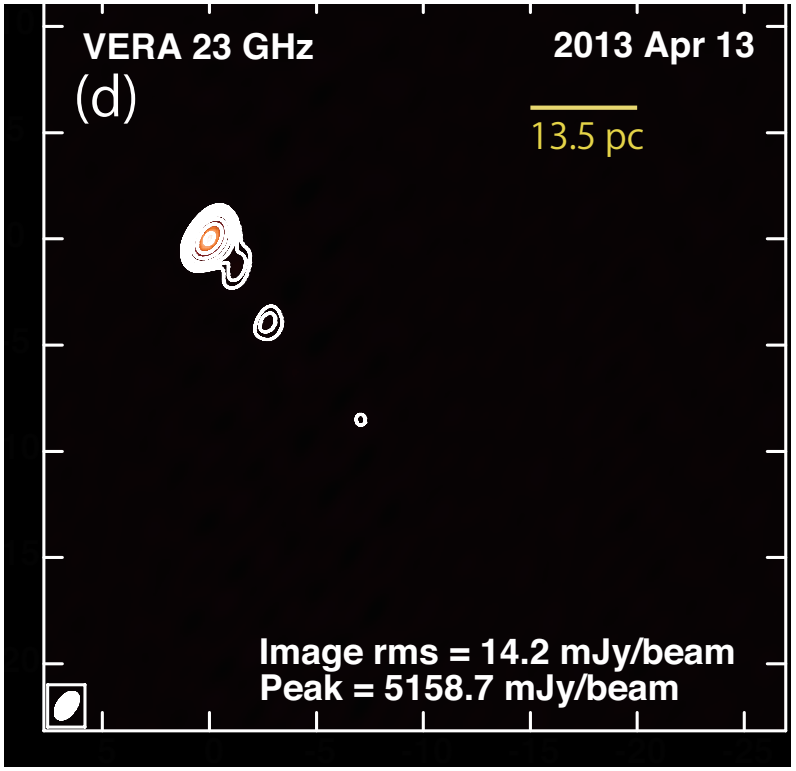
KaVA

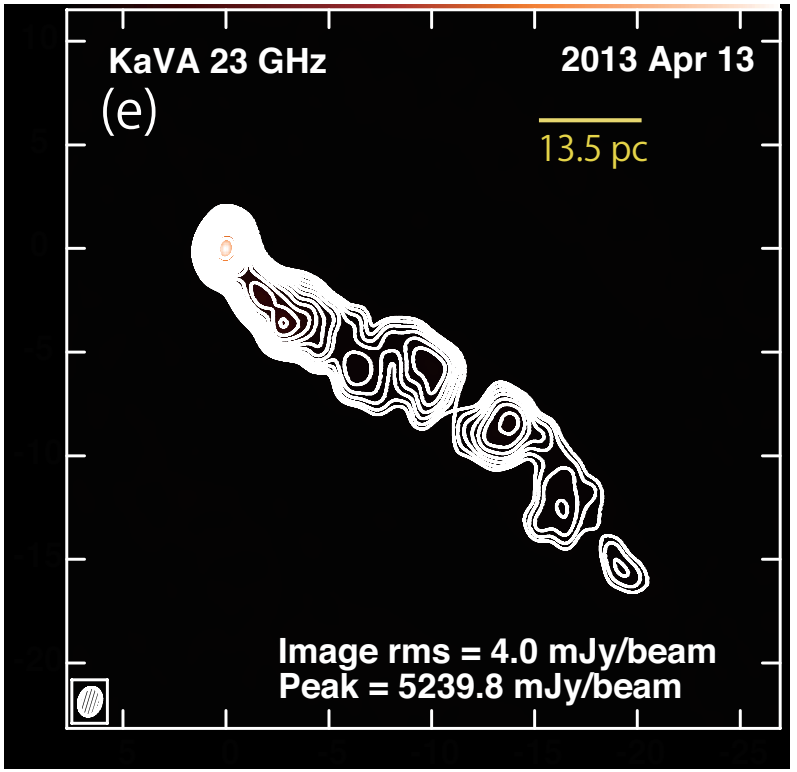


KaVA has a beautiful synthesized beam! It enables us to perform imaging analysis for extended-jet structure.

Imaging capability of KaVA

Niinuma, Lee+ (2014) in press (arXiv:1406.4356)





Dynamic Range is improved by a factor of 3.

VERA UM 2014

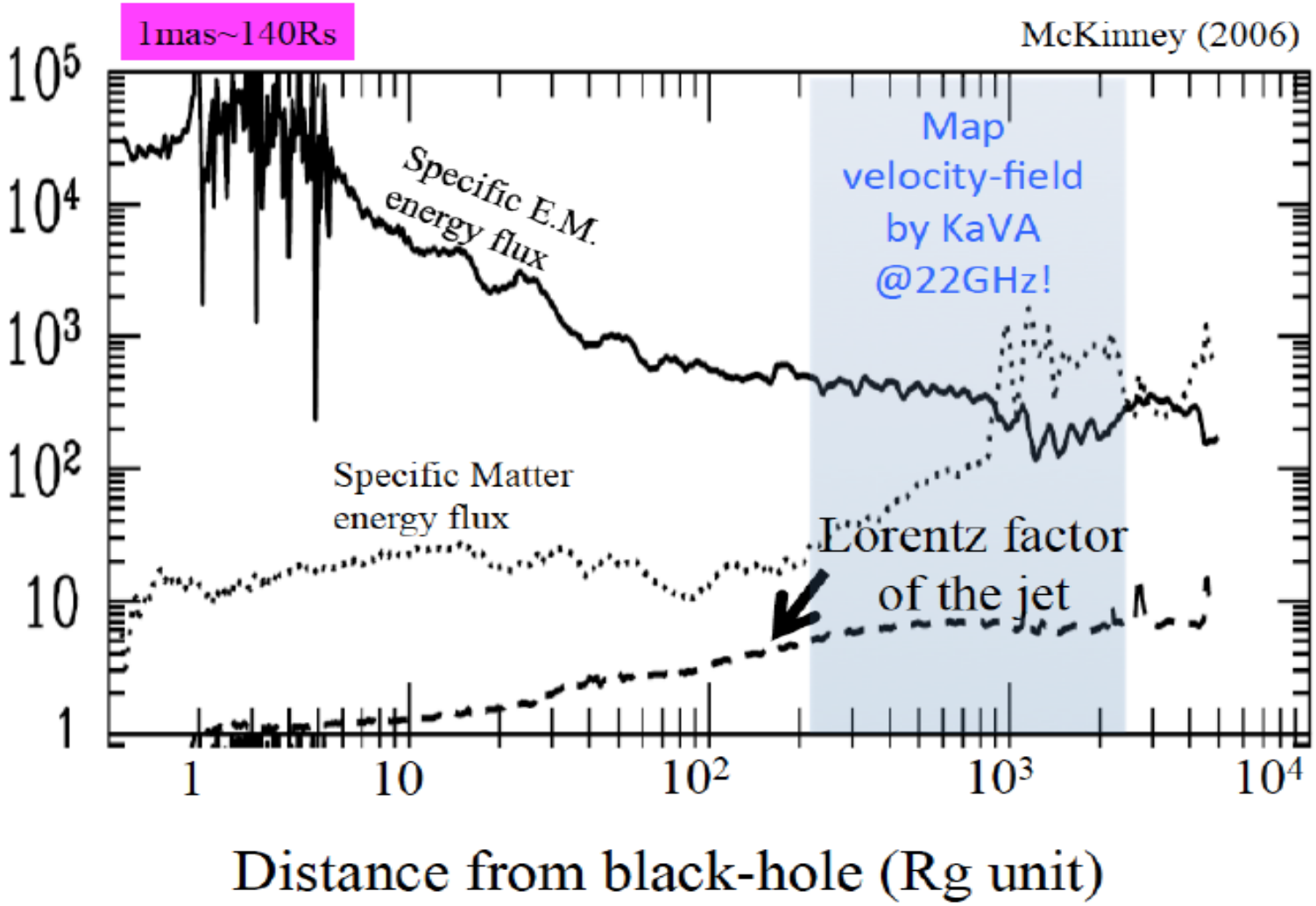
Key Science Program of AGN Sub-WG

M87 (1 mas = 140 Rs): testing *B*-driven jet paradigm

Sgr A*(1 mas = 100 Rs): probing real vicinity of SMBH

Testing "*B*-driven jet paradigm"(1/2)

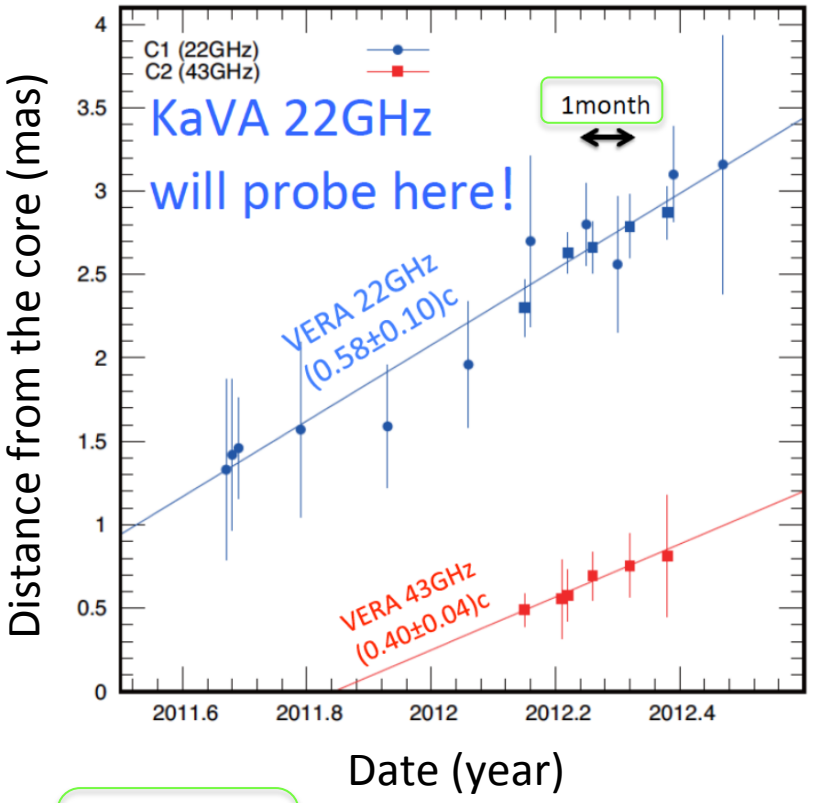
GRMHD Model predicts jet-acceleration around 100~1000 Rs.

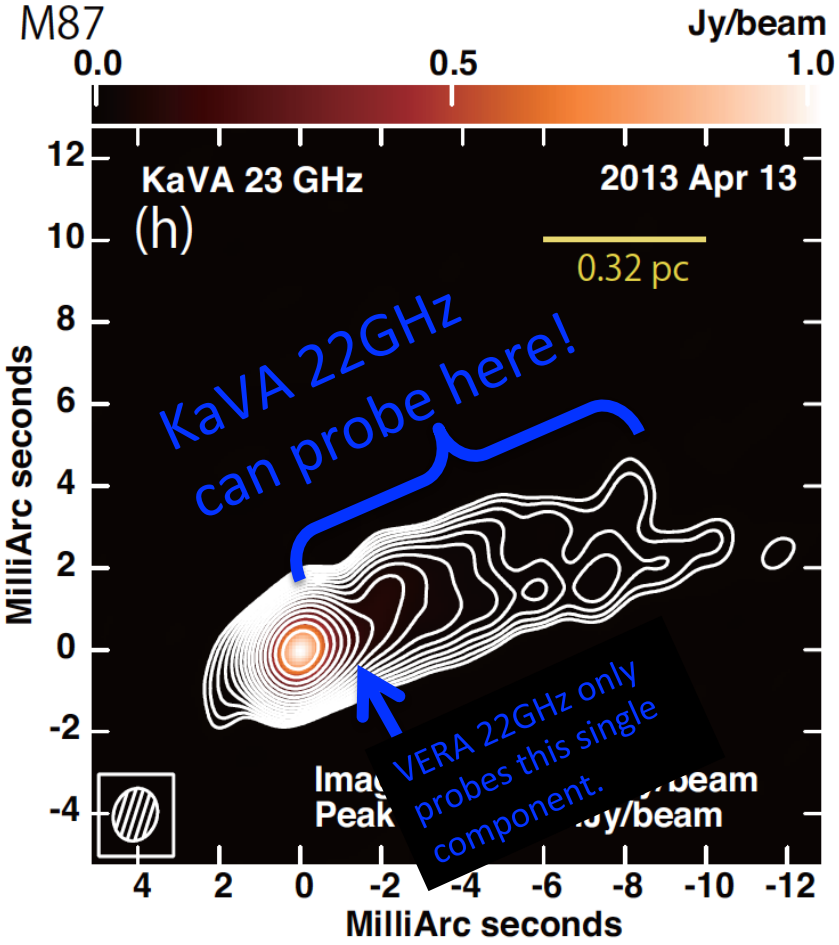


Testing B-driven jet paradigm (2/2):

KaVA can probe "acceleration"-zone!

Hada *(2014) finds a sign of acceleration at 1~3mas region with VERA.*



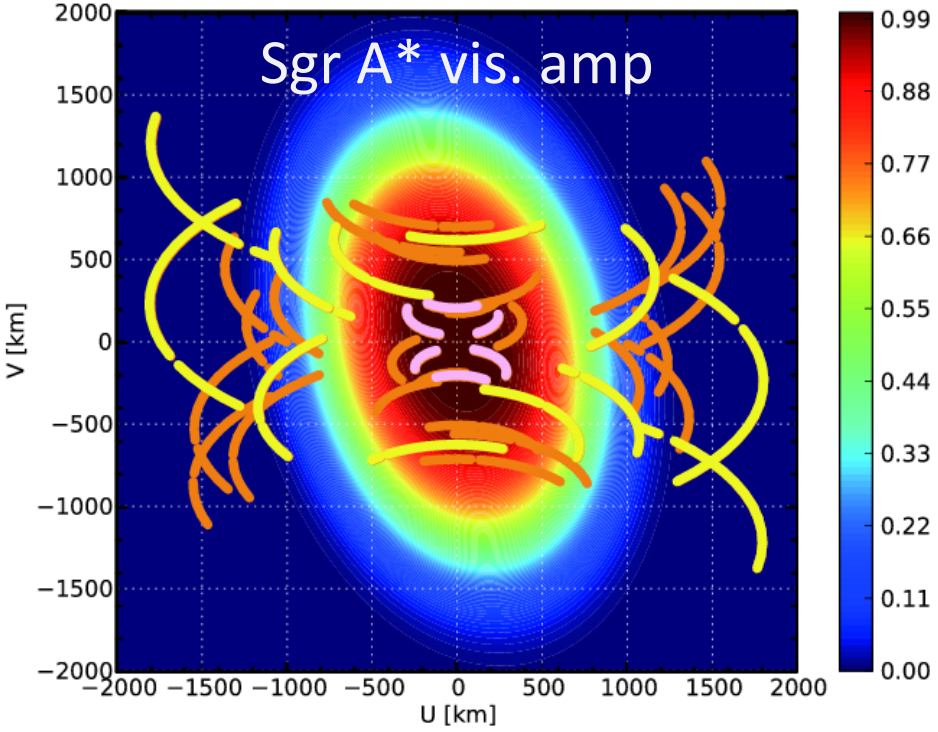


Monthly monitoring @1~10mas by KaVA is the requirement.

Proving real vicinity of BH (1/4):

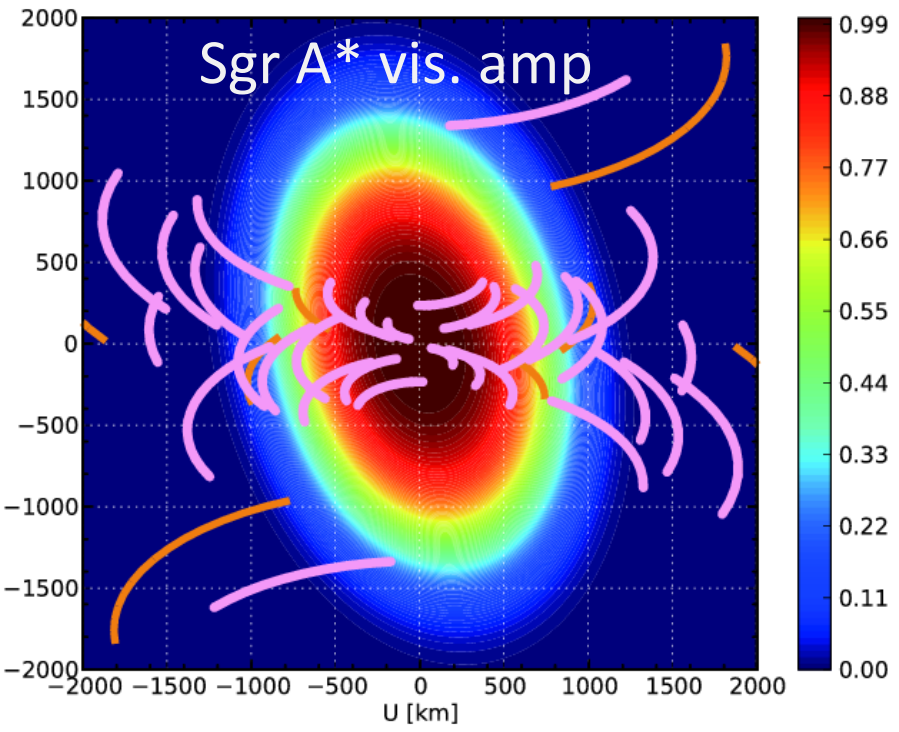
KVN+VERA has better (*u,v*) coverage than VLBA+GBT @ 43GHz.

KaVA



Pink: KVN only
Orange: KaVA
Yellow: VERA only

VLBA+GBT



Pink: VLBA+GBT
Orange: VLBA only

Proving real vicinity of BH (2/4)

With angular-size of the radio core ($\vartheta_{\rm obs}$), U_e/U_B is uniquely determined.

Kino et al. (2014) ApJ, 786, id.5

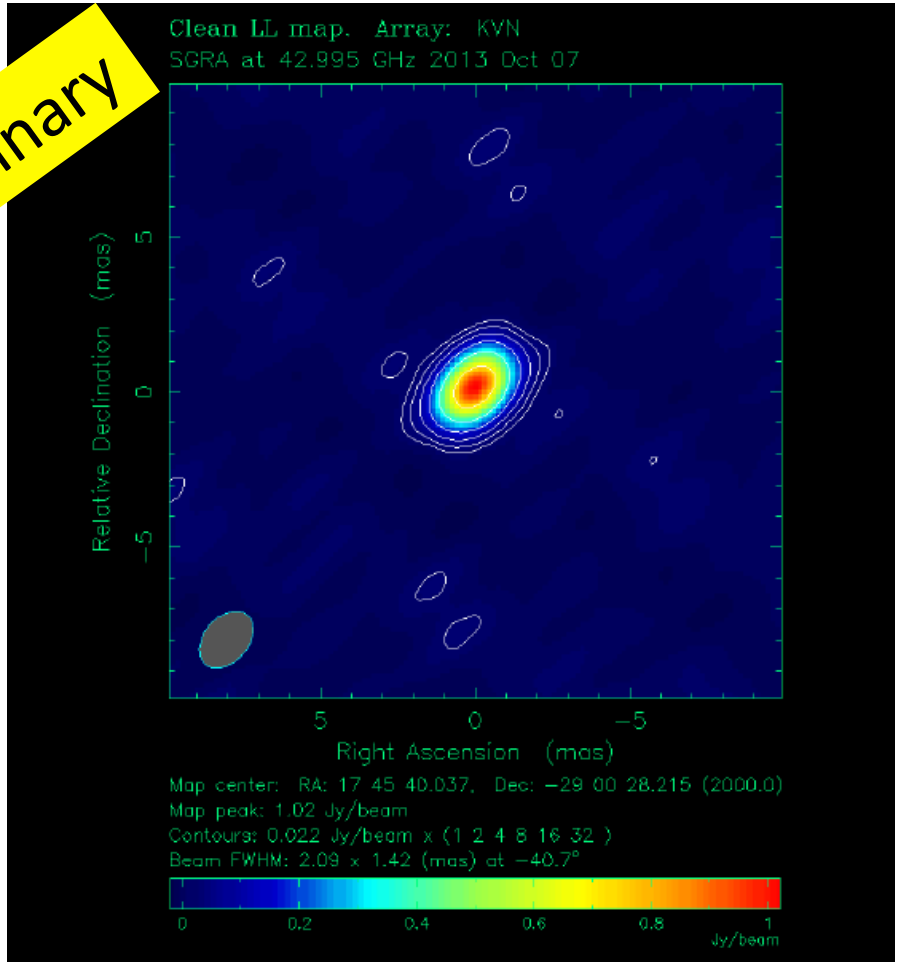
$$\frac{U_e}{U_B} = \frac{8\pi}{3b^2(p)} \frac{k(p) E_{e,\rm min}^{-p+2}}{(p-2)} \left(\frac{D_{\rm A}}{1\ {\rm Gpc}} \right)^{-1} \left(\frac{\nu_{\rm ssa,obs}}{1\ {\rm GHz}} \right)^{-2p-13} \times \left(\frac{\theta_{\rm obs}}{1\ {\rm mas}} \right)^{-2p-13} \left(\frac{S_{\nu_{\rm ssa},\rm obs}}{1\ {\rm Jy}} \right)^{p+6} \left(\frac{\delta}{1+z} \right)^{-p-5}$$

Since the radio core of Sgr A* is the SSA-thick surface, SSA turnover frequency is identical to the observing frequency itself.

Better measurements of $\vartheta_{\rm obs}$ by KaVA is critical because U_e/U_B has strong dependence on $\vartheta_{\rm obs}$.

Proving real vicinity of BH (3/4):

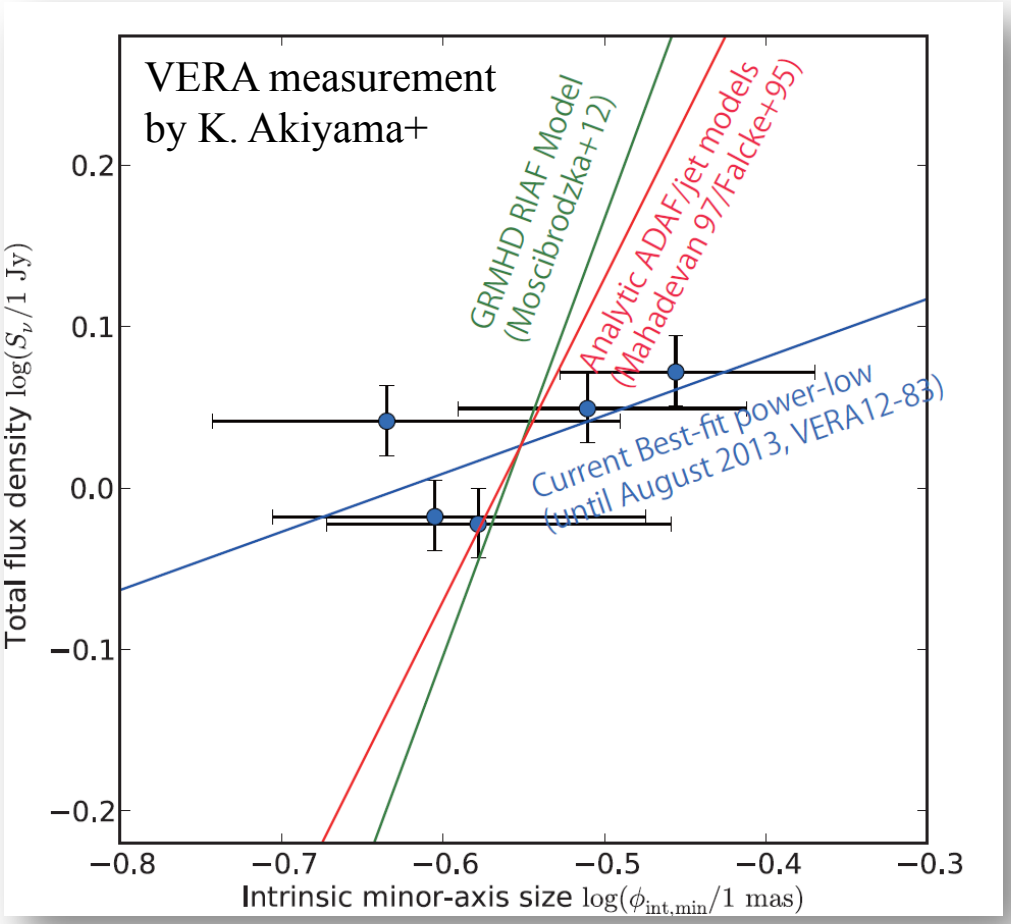
KaVA image of Sgr A*@43GHz, 2013 Oct 7 (by G. Zhao)



We are on the way of carefully checking of visibility data in details.

Proving real vicinity of BH (4/4):

"Large-When-Brighter?"



KaVA is able to get better measurements of θ_{obs}. Then, we will clarify the origin of the radio emission (RIAF? expanding plasma? jet?).

Assignment of data analysis in AGN SWG

(based on one's performance and wishes)

Sources	Team leaders	Team	Persons in charge of data analysis (*)	Comments
M87 @23GHz	M. Kino B.W. Sohn	AGN SWG	K. Hada K. Niinuma	KSP source
Sgr A* @43GHz	M. Kino B.W. Sohn	AGN SWG	K. Akiyama G. Zhao	KSP source
4C39.25 @23GHz	B.W. Sohn	Yonsei Univ.	Yonsei Univ. students	Beneficial Use of M87 slot@23GHz
3C279 (TBD) @23GHz	S-S Lee	iMOGABA	S. Kang, J-C Algaba, +	Beneficial Use of M87 slot@23GHz
4C21.35 @23GHz	S. Trippe	SNU	SNU students	Beneficial Use of M87 slot@23GHz

Inclusions of these AGN sources will tell us new insights on "universality & diversity of jets "(structural evolution/magnetism/radio/γ-connections).

Summary

1st paper showing KaVA imaging capability has been published (*Niinuma, Lee et al. 2014, PASJ, in press*). Now, we go ahead with AGN KSP.

- Towards understanding physical mechanism of AGN (BH) activities in the Universe, we will
  - test "*B*-driven jet paradigm" (M87)
  - probe "real vicinity of BH" (Sgr A*)
  - explore "universality & diversity of jets"

    (4C39.25, 4C21.35, 3C379, M87, Sgr A*)

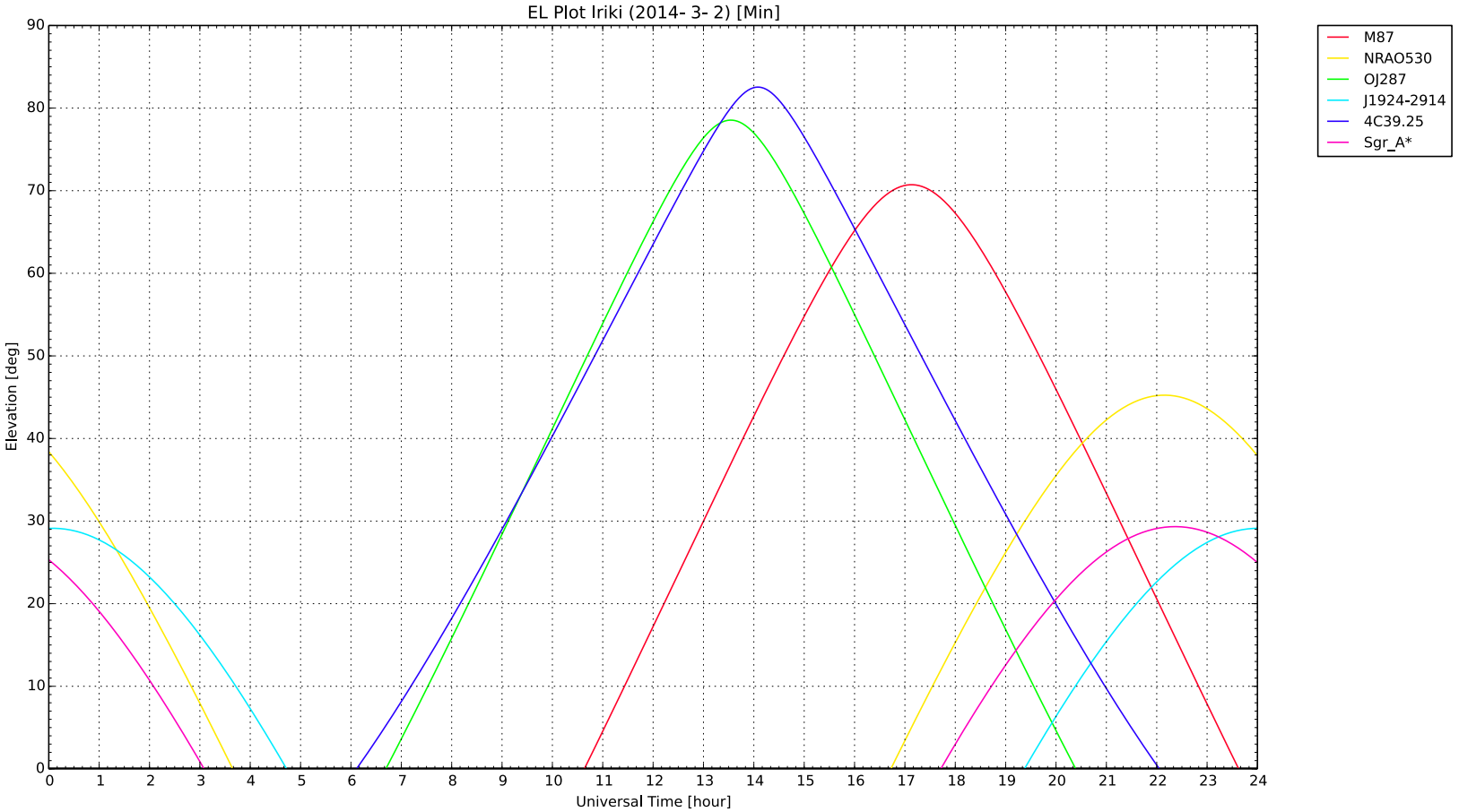
Appendix

Estimate of request time (~180 hr/yr)

We started AGN f2f meeting at Mizusawa in 2012 July and in this Sci. meeting we present the current version of of KaVA AGN KSP.

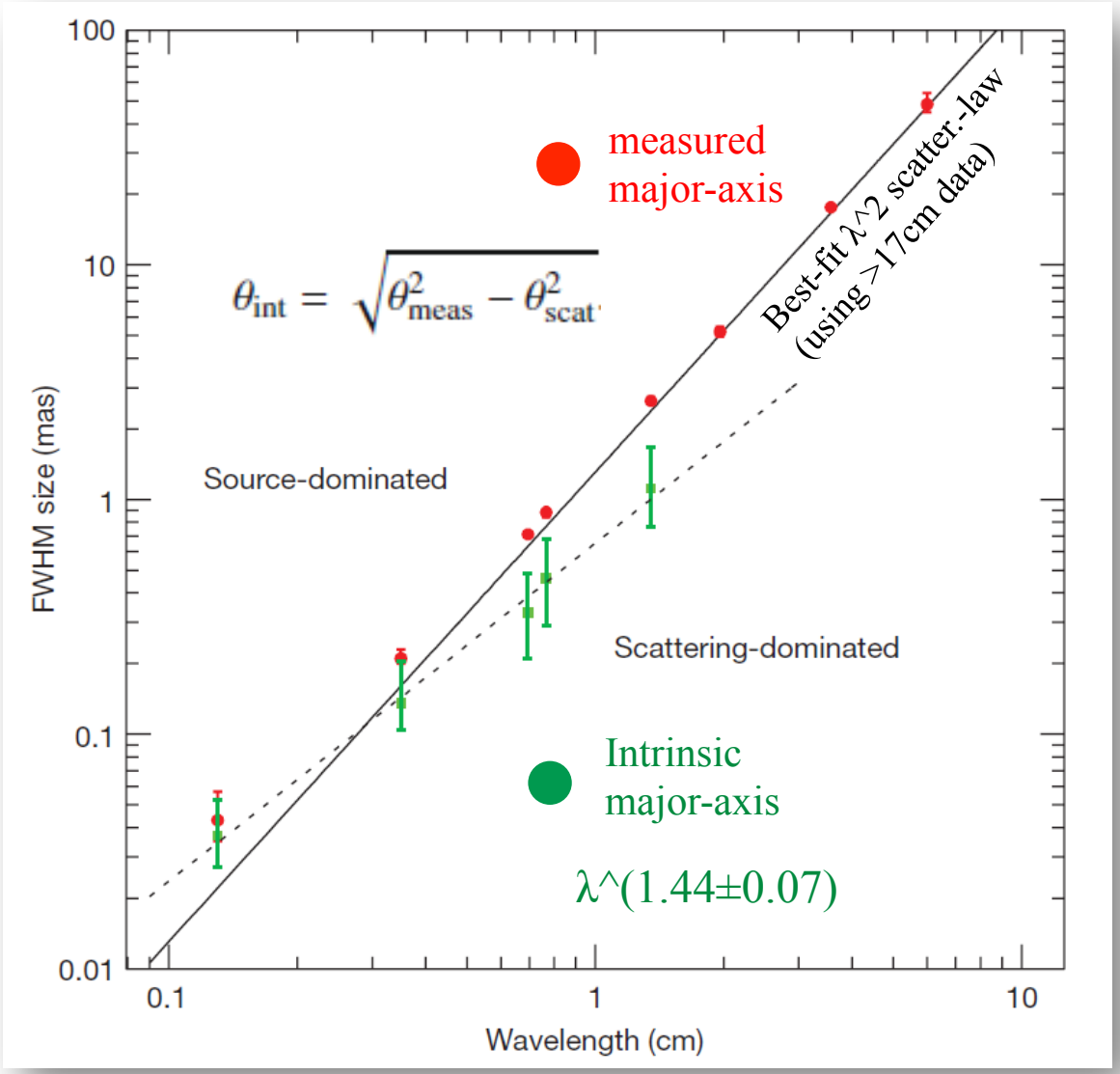
- M87@23GHz + three sources (80 hr/yr)
  - Monthly monitoring: 10epoch *8hr = 80 hr
- Sgr A*@43GHz (60hr/yr)
  - Monthly monitoring: 10epoch *6hr = 60 hr
- EHT campaign (40hr/yr)
  - Short monitoring (Spring): 5epoch *8hr = 40hr

Combination of M87 & Sgr A* observations might be economical. (This is the way indeed used in EHT observations.) comment by Akiyama



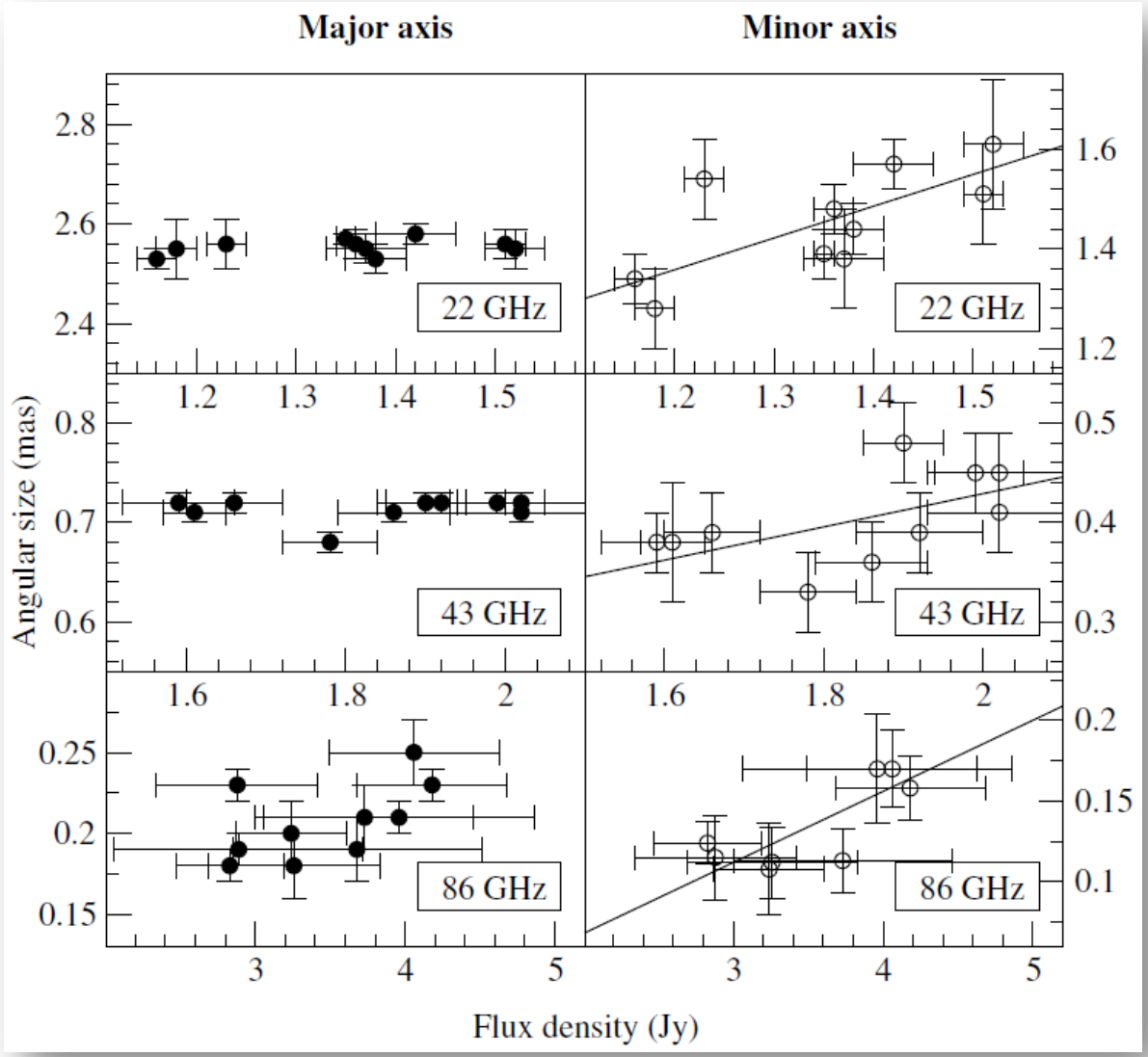
Doeleman et al. (2008), *Nature*

measured & intrinsic sizes of Sgr A*



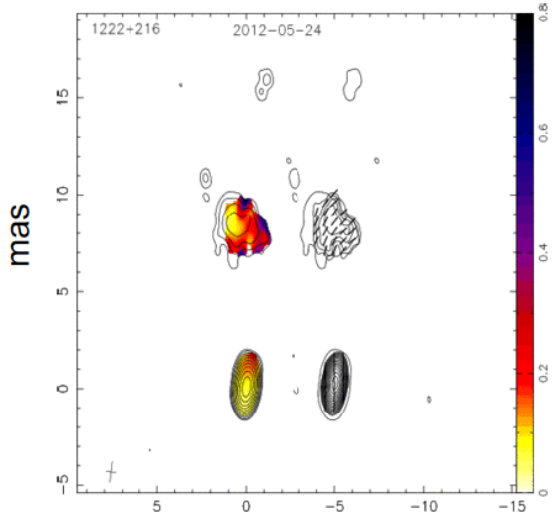
Lu et al. (2011) A&A

Size-variability of Sgr A* (~10% level at Q-band) has been claimed. "Larger-When-Brighter"

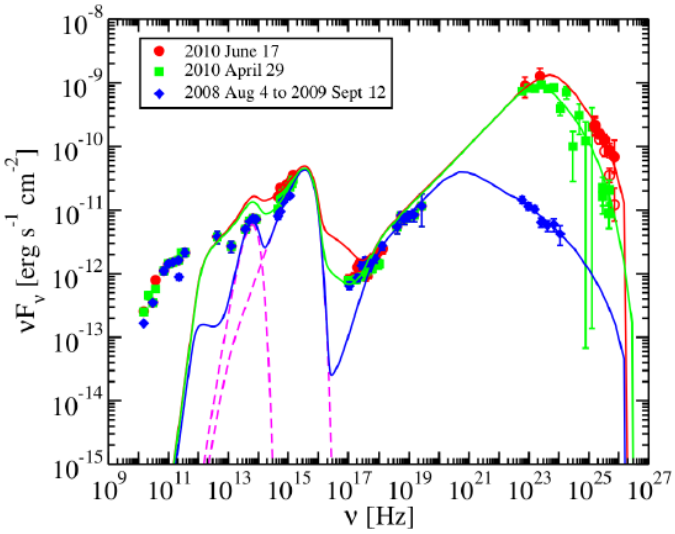


SNU team aims to prove "rapid structure evolution".

4C +21.35 (1222+216) ...



Intensity (contours), spectral index (color scale), and polarization (bars) 15-GHz maps in May 2012 (MOJAVE)

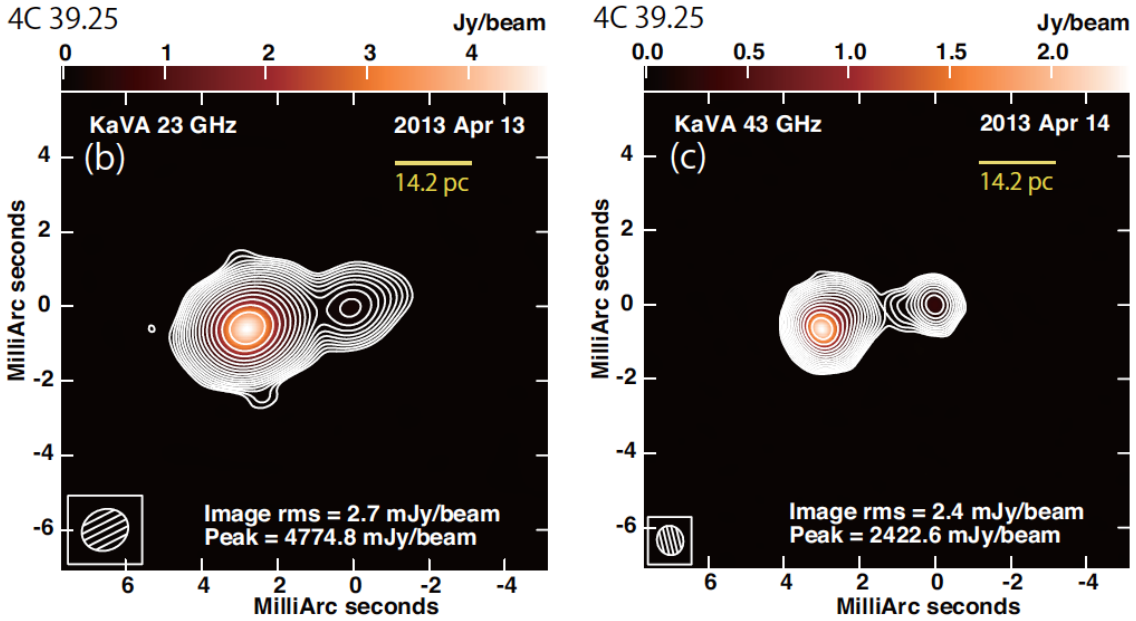


Spectral energy distributions at three observing dates, showing dramatic variability at the highest energies (Ackermann et al. 2014)

... is a flaring blazar known for puzzling hard, high energy, intense γ ray outbursts
... shows fast ($v/c > 10$) outflows with multiple components
... has become an intensely monitored test bench for "jet in a jet" models
... requires multi-epoch KaVA observations for tracing the rapid structural evolution

Selected references: Tavecchio+ 2011, A&A; Tanaka+ 2011, ApJ; Ackermann+ 2014, ApJ

Yonsei Univ. team aims to "Young Radio Source 4C39.25".



Long-term monitoring is by KaVA is essential since young sources shows year-scale evolutions.

(See also Chida-san's talk on year-scale monitoring of 3C84 by GENJI!)