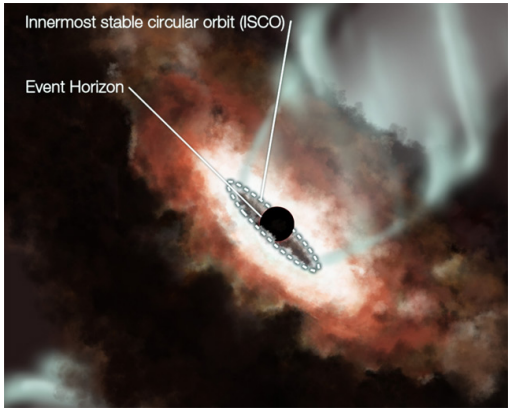
Key Science Observation of AGNs with KaVA array

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

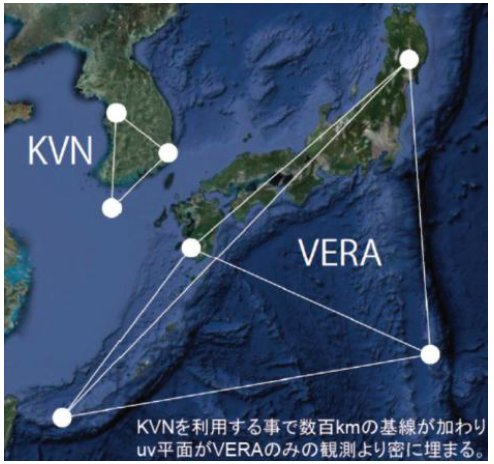
Scientific Motivations

- What happens at the edge of black holes (BHs)?



Scientific Motivations (contd)

- Especially, we aim to address key science issues w/ KaVA.
  - testing "*B*-driven jet paradigm"
  - probing "real vicinity of BH"
  - exploring "universality & diversity of AGN jets"



Announcement from KaVA directors

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.

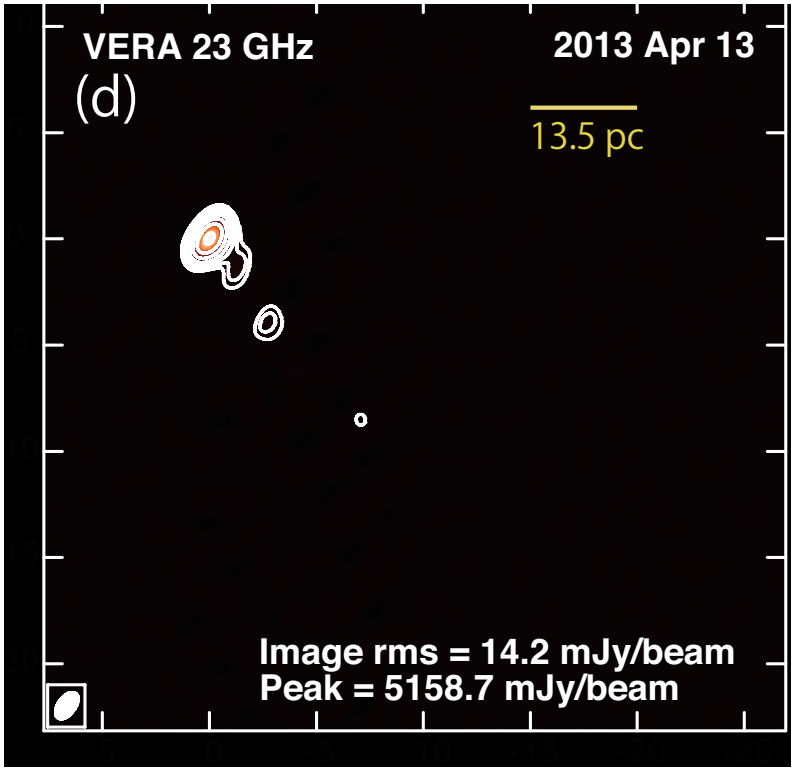
1) Make a presentation at KVN and VERA UM in 2014 on the draft plan of the large project, and call for collaborations from other people (to be open to the community)

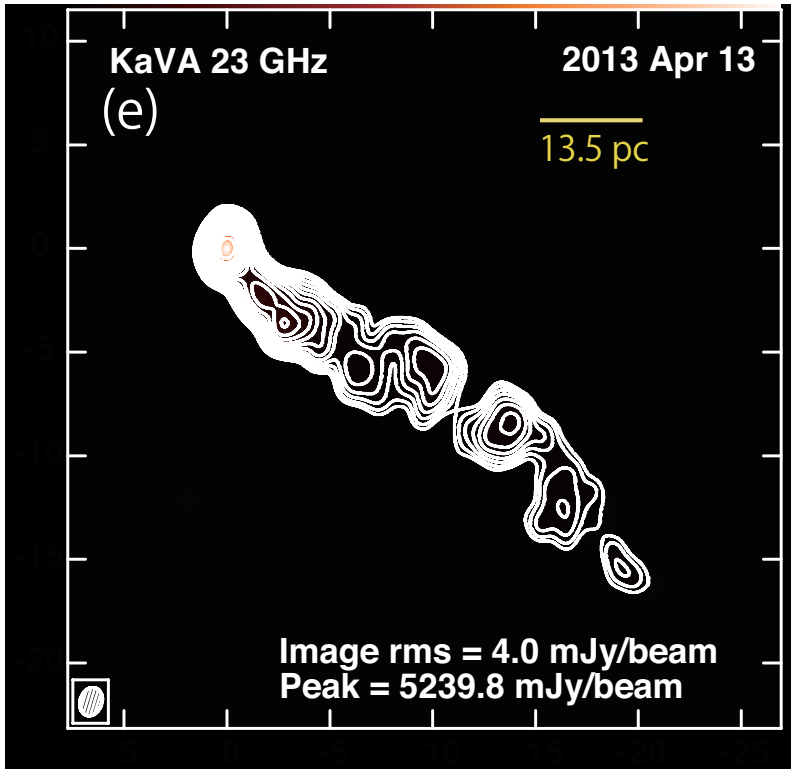
2) Submit a proposal to the DM by the end of 2014.
(cover sheets, 6 pages for science/technical justification
+ detailed source list)

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

AGN sub-WG ready to go Key Science Project (KSP).

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





KaVA (@23GHz) can investigate extended jet structures typically on ~10mas scale.

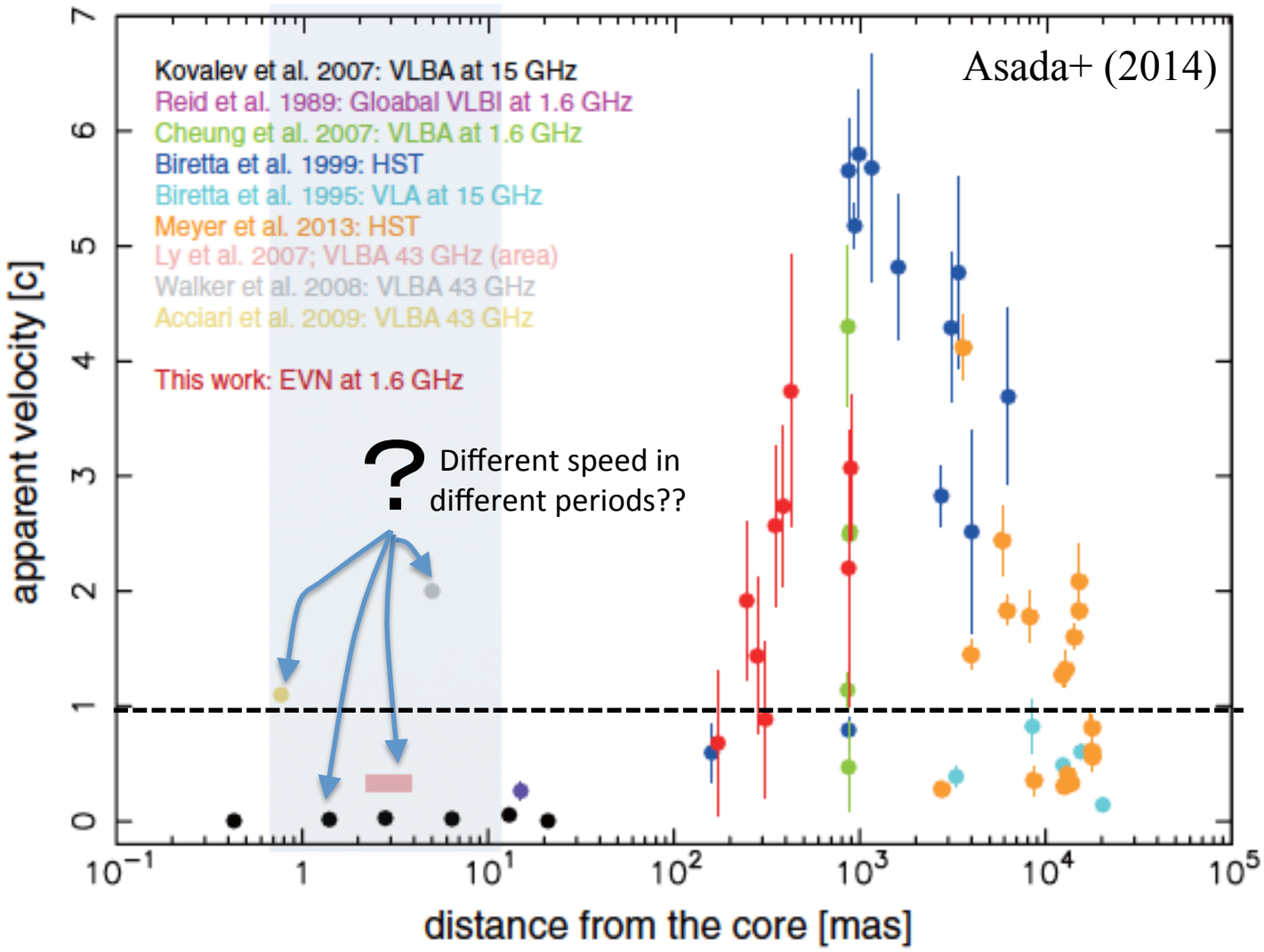
EATING VLBI 2014

Key Science Program of AGN Sub-WG

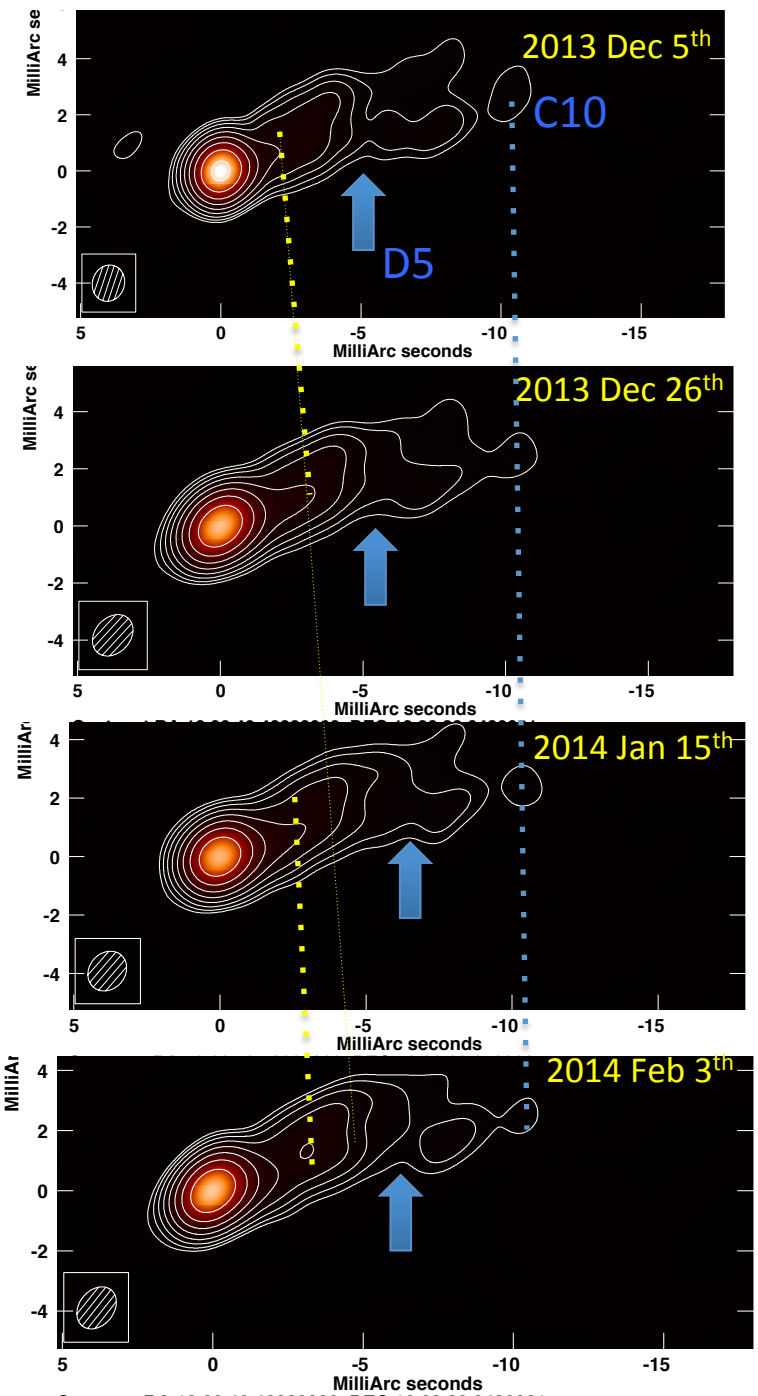
M87 (1 mas = 140 Rs): testing *B*-driven jet paradigm

β_app >1 or not? That is the question.

GRMHD models predict slow acceleration (e.g., Vlahakis 04; McKinney 06; Komissarov 07).



Mapping of v-field of M87 w/ KaVA. To measure β_{app} >1, dense monitoring is required.

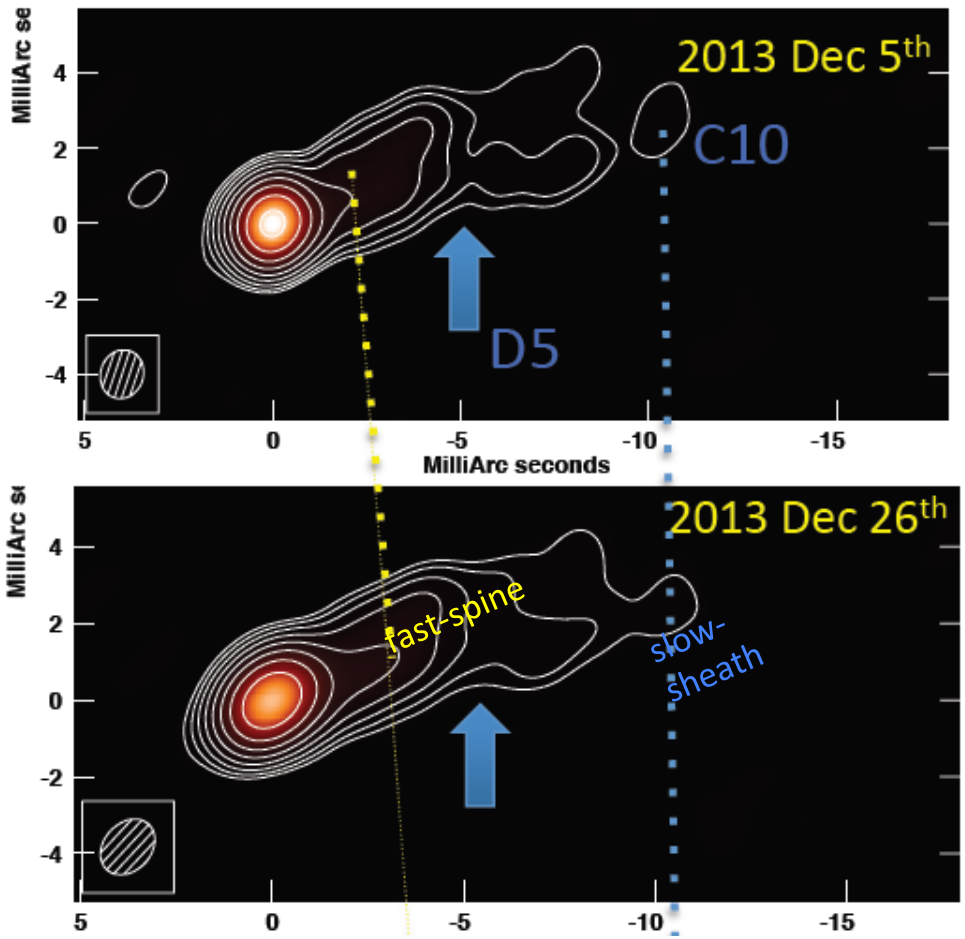


Preliminary Result during test obs

(lowest contour = 4mJy/beam.
Data analysis by Niinuma)

- Systematic motion(s) seen at the spine-part. It looks fast.
- The component at 10mas (hereafter C10) looks almost stationary.
- The dent (ammaccatura、へこみ) at ~5-7mas (hereafter D5) looks fluctuate.

Evidence of “fast-spine”?



- fast-spine:
  - 1mas/21 day～4c !?
  - short-lived?
  - identical to Walker’s component@43GHz?
- slow-sheath:
  - steady
  - long-lived?
  - identical to Kovalev’s components@15GHz

To confirm this, required interval may be 2~3 weeks.

EATING VLBI 2014

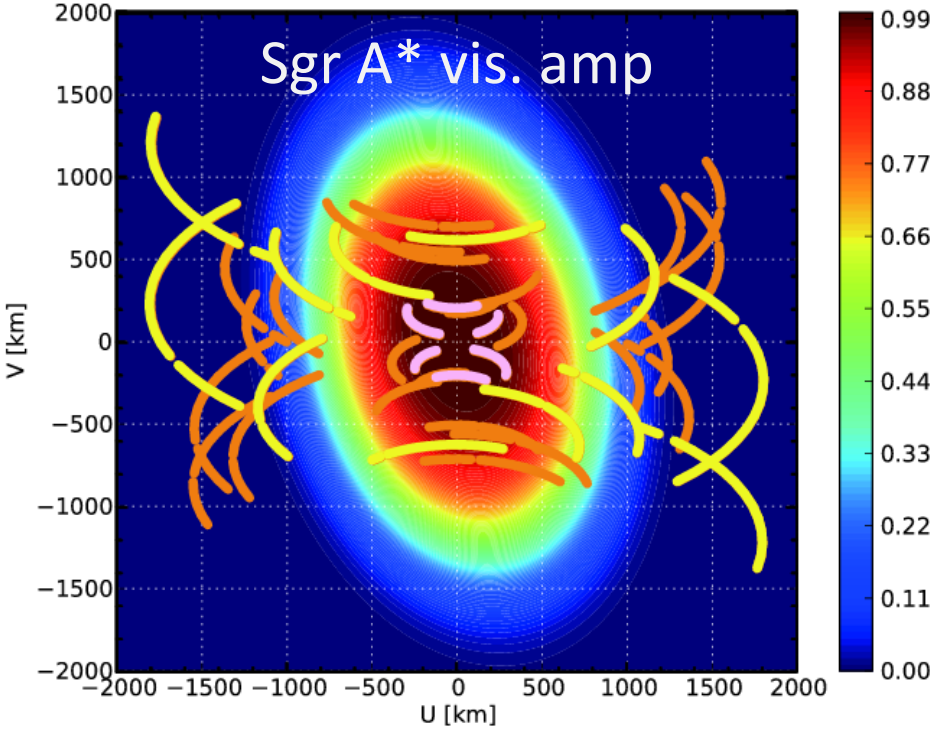
Key Science Program of AGN Sub-WG

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

Proving real vicinity of BH (1/4):

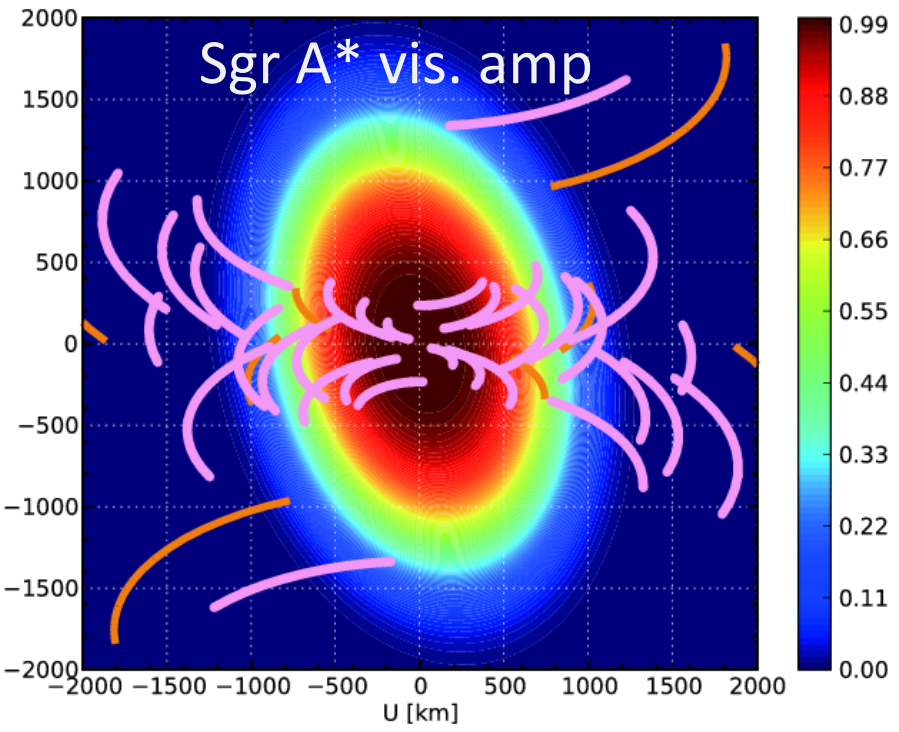
KVN+VERA has better (*u,v*) coverage than VLBA+GBT @ 43GHz.

KaVA



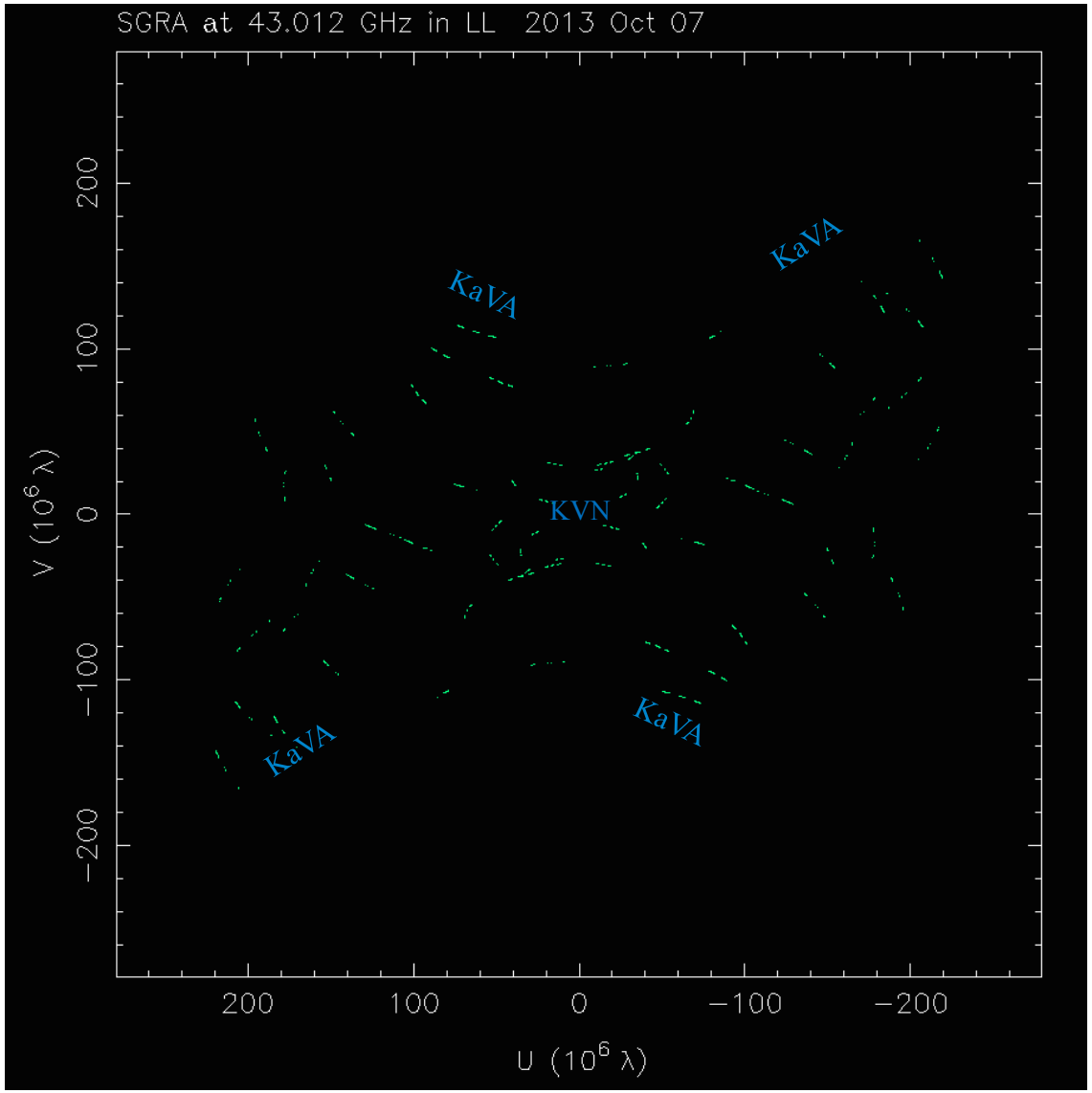
Pink: KVN only
Orange: KaVA
Yellow: VERA only

VLBA+GBT

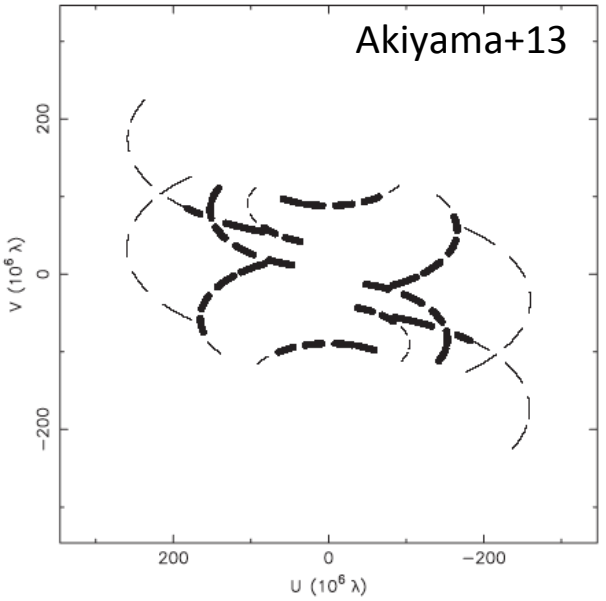


Pink: VLBA+GBT
Orange: VLBA only

Proving real vicinity of BH (2/4):
KaVA's *u,v* coverage for Sgr A*

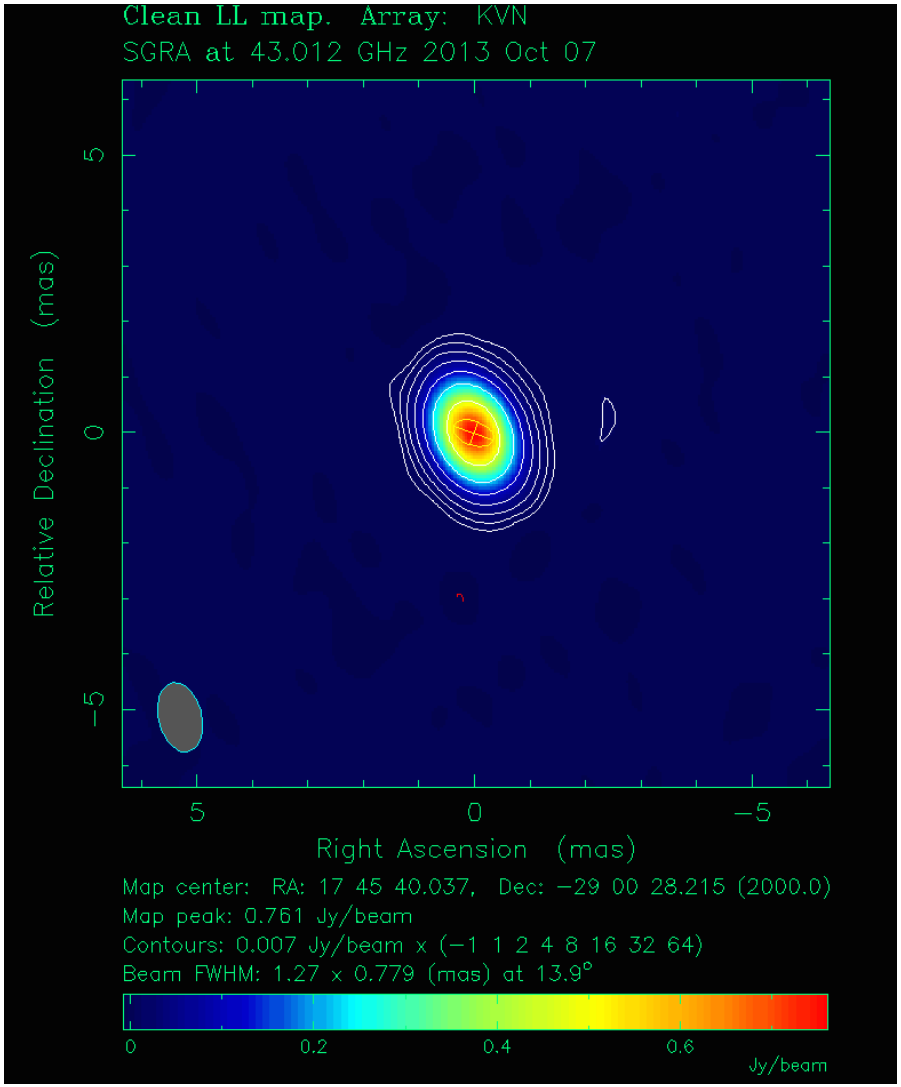


cf. VERA case



Proving real vicinity of BH (3/4):

1st epoch KaVA image of Sgr A*@43GHz, 2013 Oct 7 (by G. Zhao)



peak = 0.76 Jy/beam

S_tot = 1.1 Jy

major axis = 0.75 mas
= 75 Rs

minor axis = 0.43 mas
= 43 Rs

Proving real vicinity of BH (4/4)

Once we get the radio-core size $\vartheta_{\rm obs}$, 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 (i.e., 43GHz) itself.

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

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's 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, 3C279, M87, Sgr A*)