2017年 11月 03-04日
第15回 水沢VLBI観測所ユーザーズミーティング

KaVA PET Activities and New Observation Modes in the Open Use 2018A

杉山　孝一郎（国立天文台）

PETメンバー： Lee, Sang-Sung; Roh, Duk-Gyoo; 紀 基樹; 秦 和弘; 今井 裕; 坂井 伸行

EAVN Tiger Team から： 輪島 清昭

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第15回 水沢VLBI観測所ユーザーズミーティング

KaVA 性能評価チームの活動報告 と 共同利用2018A からの新観測モード

杉山　孝一郎（国立天文台）

PETメンバー： Lee, Sang-Sung; Roh, Duk-Gyoo; 紀 基樹; 秦 和弘; 今井 裕; 坂井 伸行

EAVN Tiger Team から： 輪島 清昭

KaVA PET Activities

0. 新体制 など

PET members in 2017 year

- 2017年度のPETメンバー （計8名）
  - Co-chairs : **Lee, Sang-Sung**; **杉山 孝一郎**
  - From each Science sub-Working Group（SWG）:
    - KJCC — **Roh, Duk-Gyoo**
    - AGN — **紀 基樹**; **秦 和弘**
    - Star Formation Region (SFR) — **杉山 孝一郎**
    - Evolved Star (EvS) — **今井 裕**
    - Galactic Astrometry (GA) — **坂井 伸行**
  - From EAVN Tiger Team : **輪島 清昭**
    - 性能評価項目・方法や、EAVNの共同利用観測公開へ向けた問題意識の共有を通じて、シナジーを加速

※ 新規・引継ぎメンバーを青色で表示

Framework of PET in 2017 year

Red : new members
* **Black**: current and continue
Gray : switch

Co-chairs:
Lee, Sang-Sung
Sugiyama, Koichiro
(Matsumoto, Naoko)

Contact person from EAVN TT:
Wajima, Kiyoaki

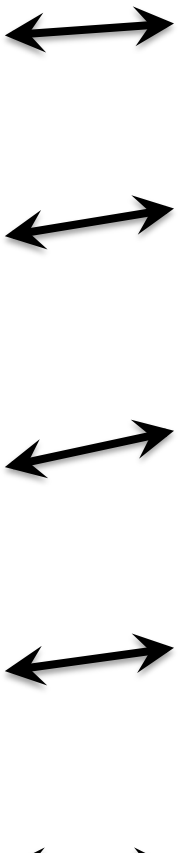
KJCC:
Roh, Duk-Gyoo

AGN SWG:
Kino, Motoki
Hada, Kazuhiro

SFR SWG:
Sugiyama, Koichiro
(Kim, Mikyoung)

EvS SWG:
Imai, Hiroshi

GA SWG:
Sakai, Nobuyuki
(Wu, Yuan Wei)



KJCC: Roh, Duk-Gyoo and members

AGN SWG:
Sohn, Bong Won
Kino, Motoki
and members

SFR SWG:
Kim, Kee-Tae
Hirota, Tomoya
and members

EvS SWG:
Cho, Se-Hyung
Imai, Hiroshi
and members

GA SWG:
Oh, Chungsik
Sakai, Nobuyuki
and members

Activities

- スカイプ会議 in 2017 year
  - 第1回: 6月08日
  - 第2回: 7月13日
  - 第3回: 8月31日
  - 第4回: 9月25日
  - 第5回: 10月19日
- 下記を議論
  - 各 SWG 担当の性能評価項目に関する進捗報告
  - EAVN Tiger Team とのシナジー
  - KaVA共同利用 2018A における新観測モード公開へ向けた性能評価報告・議論、およびステータスレポート執筆

Evaluation items : vol. 1
(based on a document by N. Matsumoto)

Modes	Evaluated by	2017 Sep. (2018A)	2018 Mar. (2018B)	2018 Sep. (2019A)	2019 Mar. (2019B)
C2	AGN	Decision			
C3	AGN				
C4	AGN	Already opened			
C4 high	EvS	* This mode would be already opened as “C4” ??			
2 Gbps	AGN				
Fast ant. nodding	GA	Already opened			
Dual-pol. (K: cont.)	AGN	New obs.			
Dual-pol. (Q: cont.)	AGN				
Hybrid	SFR, EvS	Already opened			
Multi-frequency					
K/Q simultaneous quasi-optics					
Wide-field imag.	SFR	Decision			
Multi-tracking	SFR		New obs.?		

Evaluation items : vol. 1
(based on a document by N. Matsumoto)

Modes	Evaluated by	2017 Sep. (2018A)	2018 Mar. (2018B)	2018 Sep. (2019A)	2019 Mar. (2019B)
C2	AGN	Decision			
C3	AGN				
C4	AGN	Already opened			
C4 high	EvS	* This mode would be already opened as "C4" ??			
2 Gbps	AGN				
Fast ant. nodding	GA	Already opened			
Dual-pol. (K: cont.)	AGN	New obs.			
Dual-pol. (Q: cont.)	AGN				
Hybrid	SFR, EvS	Already opened			
Multi-frequency					
K/Q simultaneous quasi-optics					
Wide-field imag.	SFR	Decision			
Multi-tracking	SFR		New obs.?		

Evaluation items : vol. 2
(based on a document by N. Matsumoto)

Modes	Evaluated by	2017 Sep. (2018A)	2018 Mar. (2018B)	2018 Sep. (2019A)	2019 Mar. (2019B)
Astrometry (Multi freq.)	EvS, AGN			* Depend on developments of K/Q simultaneous quasi-optics in VERA	
Astrometry (Absolute pos.)	GA, EvS	**New obs.**			
Astrometry (Parallax)	GA, AGN				
Nobeyama 45-m	AGN, EvS	* Finished the PET decision. Wait for 2 Gbps			

KaVA PET Activities

1. 共同利用2018A の新観測モード

KaVA PET Activities

1-1. C2

Evaluation for C2 mode

【相関処理モード】 **128** MHz x **2** IFs

– 既存モード : C4 (32MHz x 8IFs), C5 (16MHz x 16IFs)

【主目的】 各バンド端で顕著な振幅減衰の軽減

- AGN SWG が主体となり性能評価 （Hada+ talk）
  - テスト観測 : “DA55”（明るく、かつほぼ点源）
    - C2 : r16111a, r16112a, r17087a
    - C5 : r16110a, r17086a（※ 既にオープンされているモード）
  - 特に、絶対フラックス較正の比較・検討に注力
  - **Q-band のみ**オープン （K-band はテスト未観測のため、見送り）
- 観測時の Digital Filter Unit : VERA1S

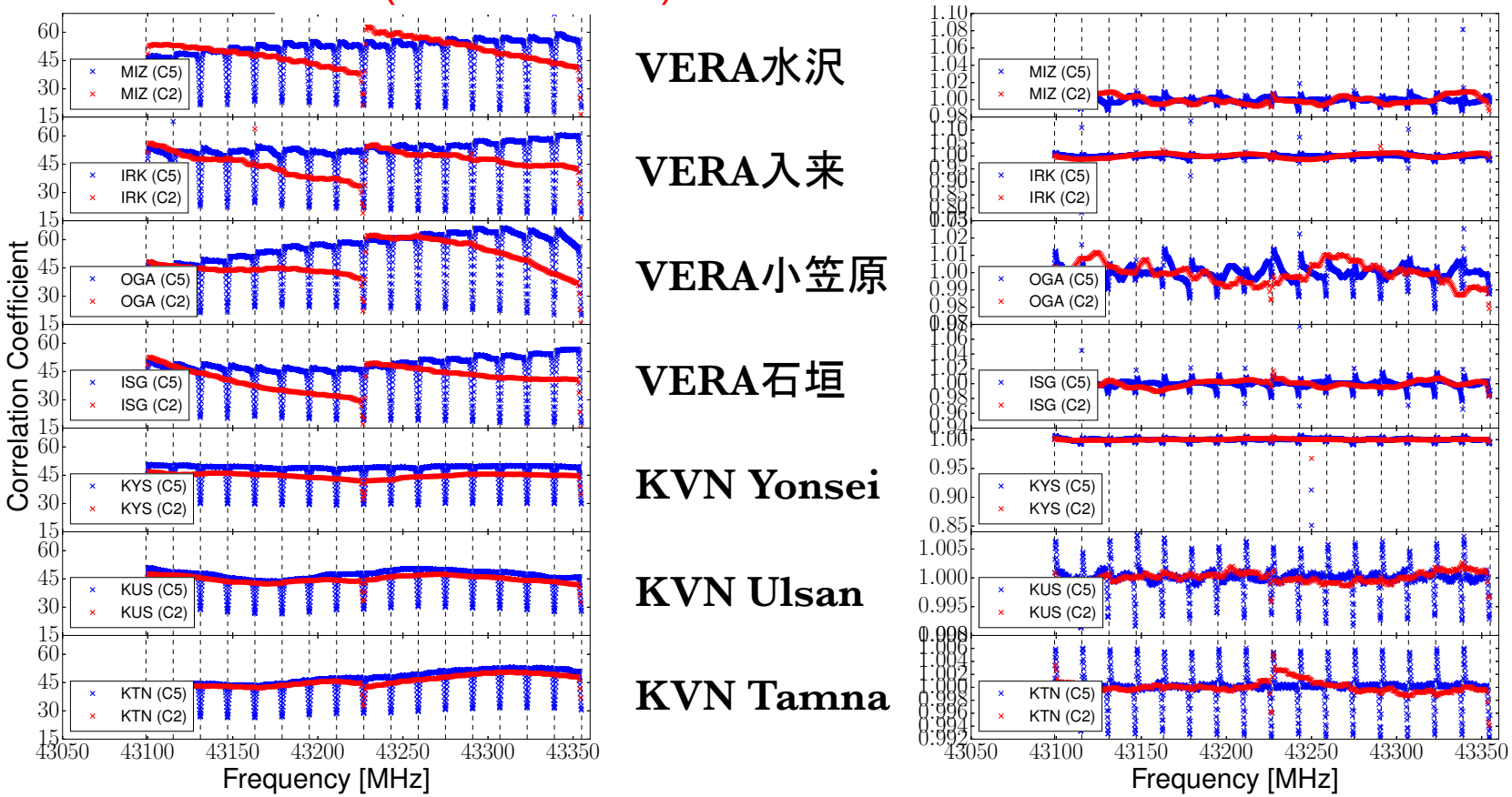
Evaluation: Amp. calibration

生データ

C5 (2017.03.27)

C2 (2017.03.28)

バンキャラ, 量子化損失較正後



VERA水沢

VERA入来

VERA小笠原

VERA石垣

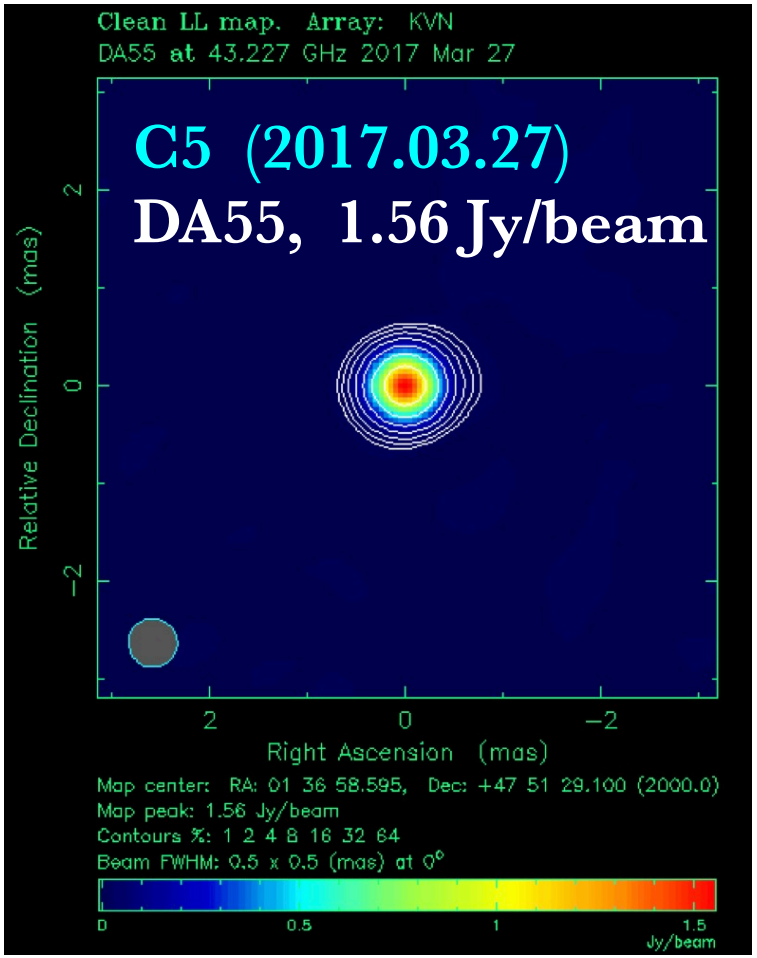
KVN Yonsei

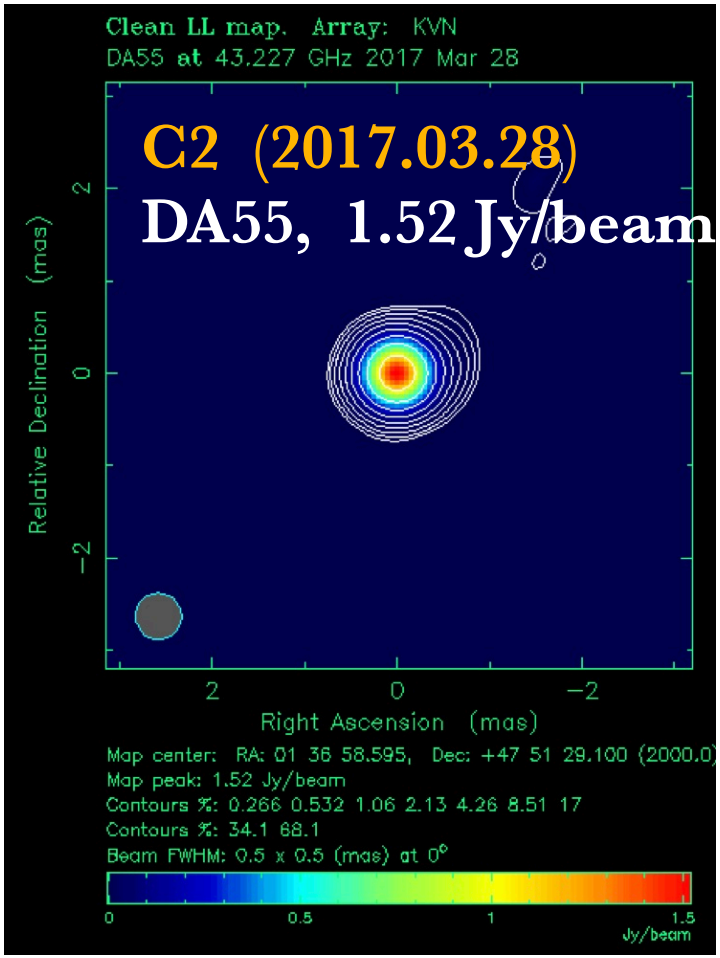
KVN Ulsan

KVN Tamna

Provided and Evaluated by I. Cho, M. Kino, G.-Y. Zhao, T. Jung, S. Sawada-Satoh, K. Niinuma, on behald of KaVA AGN SWG

Evaluation: Image comparison





Provided and Evaluated by I. Cho, M. Kino, G.-Y. Zhao, T. Jung,
S. Sawada-Satoh, K. Niinuma, on behald of KaVA AGN SWG

KaVA PET Activities

1-2. Wide-Field Imaging (WFI)

Evaluation for WFI mode

【相関処理モード】 accumulation period of **0.2048** sec

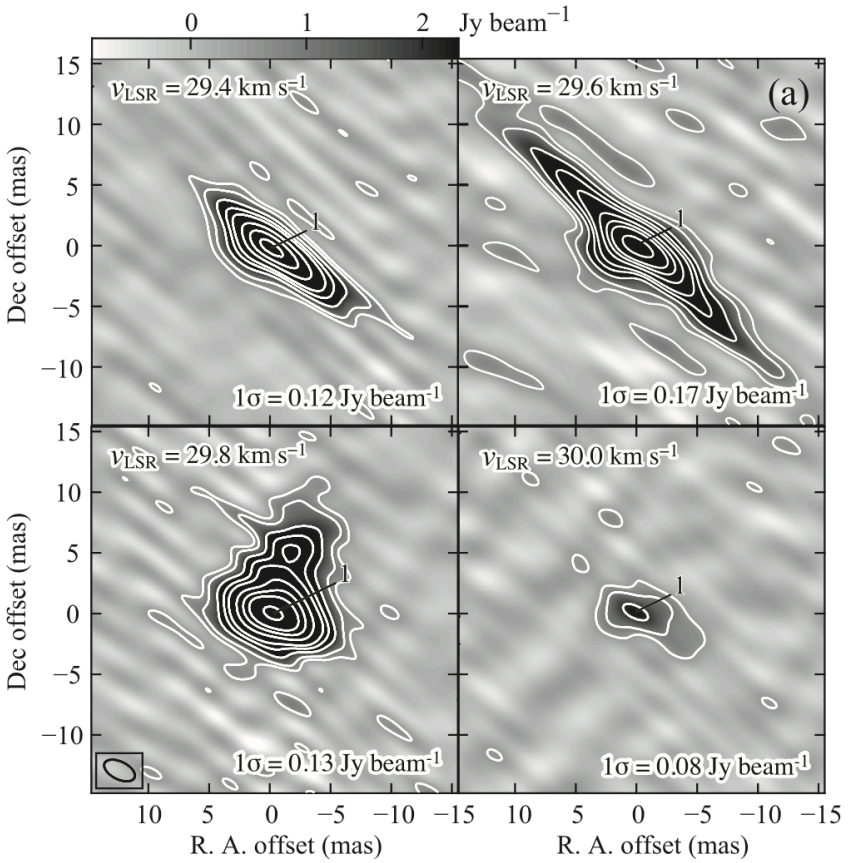
- 通常は 1.6384 sec

【主目的】 44.1 GHz メタノールメーザーを対象とした広視野イメージングの達成

- SFR SWG が主体となり性能評価
  - テスト観測： 2016年4月19日, 44.1 GHz メーザー in W51 E
  - C2 モード, 0.2048 sec periodの相関処理により、推定通りの広視野を達成出来ているかを、過去の干渉計観測結果などとの比較で評価

Advantage of KaVA for 44.1 GHz CH_3OH masers

- 主に KVN局で形成される短基線
- resolved out 軽減による広がったメーザー成分の検出性向上
- 44.1 GHz メタノールメーザーのVLBI初検出（Matsumoto+ 14）
- KaVA Large Proposal における多数天体でのVLBI検出 (Hirota+ talk)



First VLBI detection of 44.1 GHz CH_3OH maser in IRAS 18151-1208 (Matsumoto+ 2014)

Advantage of KaVA for 44.1 GHz CH_3OH masers

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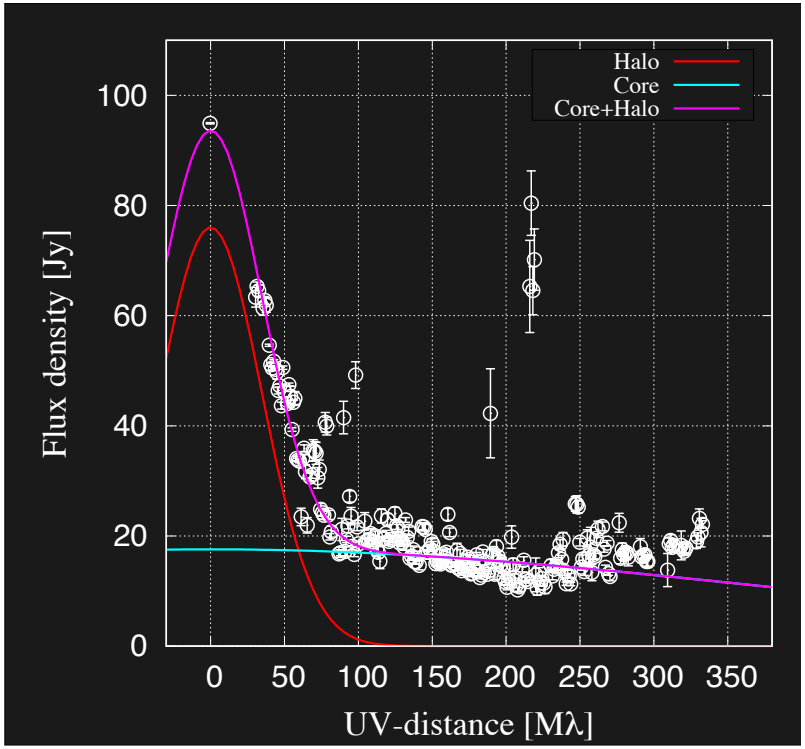
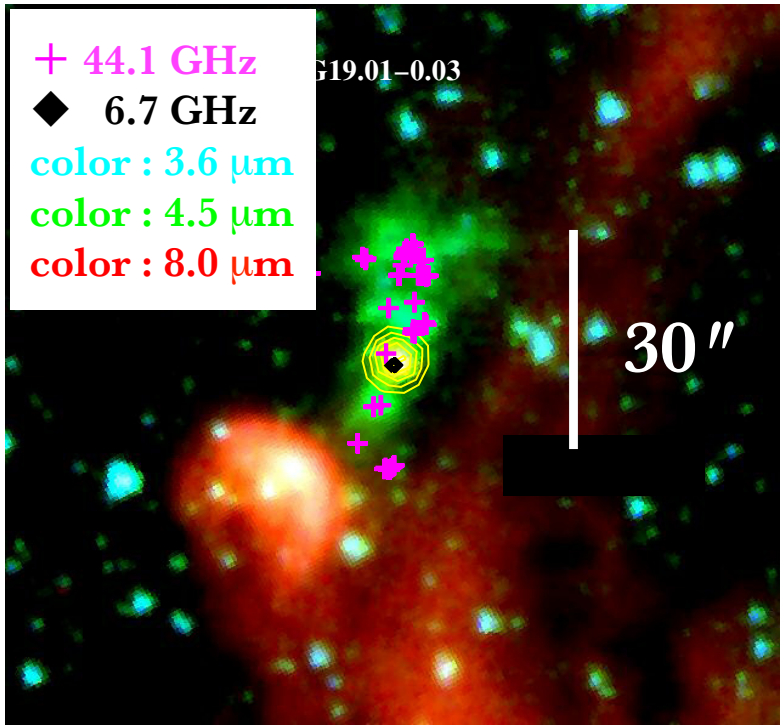


Size estimation of 44.1 GHz CH_3OH maser in G 010.32-00.26 in KaVA Large Proposal (by SFR SWG) and Spatial distribution etc. (by M. K. Kim)

Another issue : Time-smearing

- 44.1 GHz メタノールメーザーの空間分布スケール： ~**10-30″**
- Time-averaged smearing effect が顕著に影響
  - 長時間積分によるビジビリティ確度の不正確性とイメージの歪み
  - それによる振幅の減衰
  - 相関位相中心から外れているビジビリティデータで顕著



VLA observation of 6.7 and 44.1 GHz CH_3OH masers in G 019.01-00.03 (Cyganowski+ 2009)

※ 詳細は下記文献参照：

Proceedings from the 1988 synthesis imaging workshop, Astronomical Society of the Pacific as Volume 6 of their Conference Series

Formula for the loss of amp.

$$\textit{Loss} \sim (\alpha \pi^2 / 12) * \omega_e^2 * \tau^2 * (\theta / \theta_{FWHM})^2$$

$$\sim 1.22 * 10^{-9} * \tau^2 * (\theta / \theta_{FWHM})^2$$

α : 基線配置に伴う定数
ω_e: 地球の自転角速度
τ : accumulation period
θ : 位相中心からの距離
θ_{FWHM}: ガウス合成ビームの半値全幅

※ 詳細は下記文献参照 :

Proceedings from the 1988 synthesis imaging workshop, Astronomical Society of the Pacific as Volume 6 of their Conference Series

Formula for the loss of amp.

$$\textit{Loss} \sim (\alpha \pi^2 / 12) * \omega_e{}^2 * \tau^2 * (\theta / \theta_{FWHM})^2$$

$$\sim 1.22 * 10^{-9} * \tau^2 * (\theta / \theta_{FWHM})^2$$

Accumulation period (sec)	Amplitude loss 1.0% (arcsec)	5.0% (arcsec)	10.0% (arcsec)
0.2048	8.6	19.4	27.4
1.6384	1.1	2.4	3.4
3.2768	0.5	1.2	1.7

※ KaVA @Q-band の最長基線での空間分解能 0.6 mas を仮定

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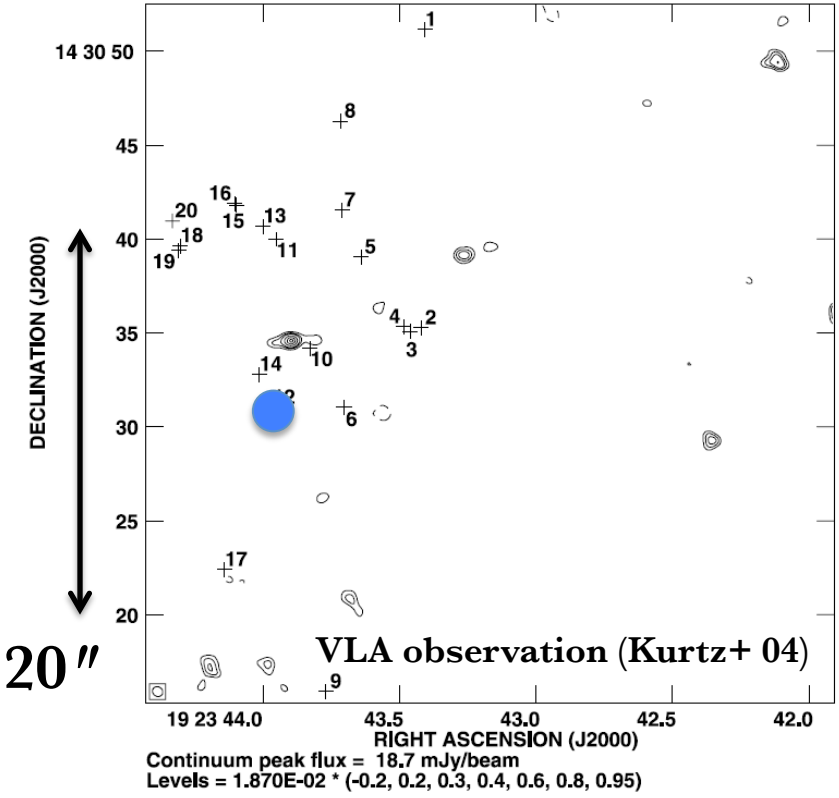
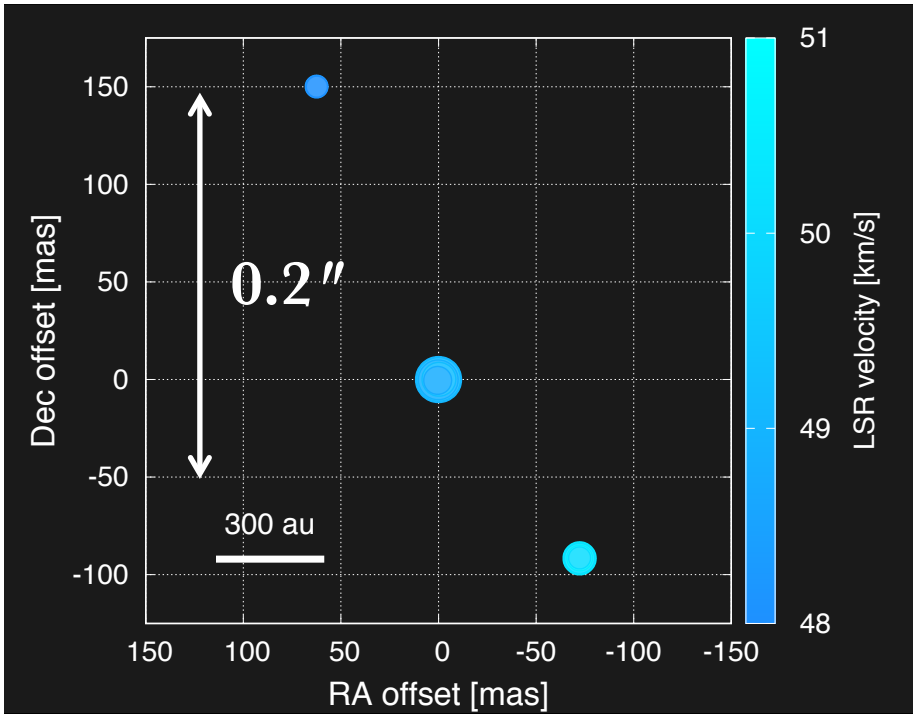
※ KaVA @Q-band の最長基線での空間分解能 0.6 mas を仮定

Channel map with 1.6 sec period

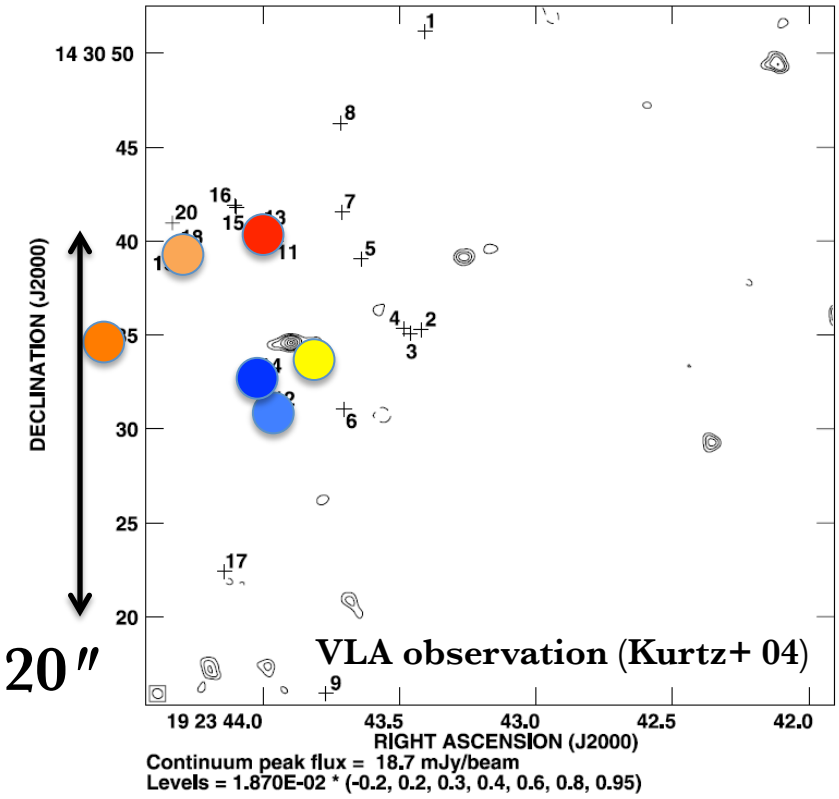


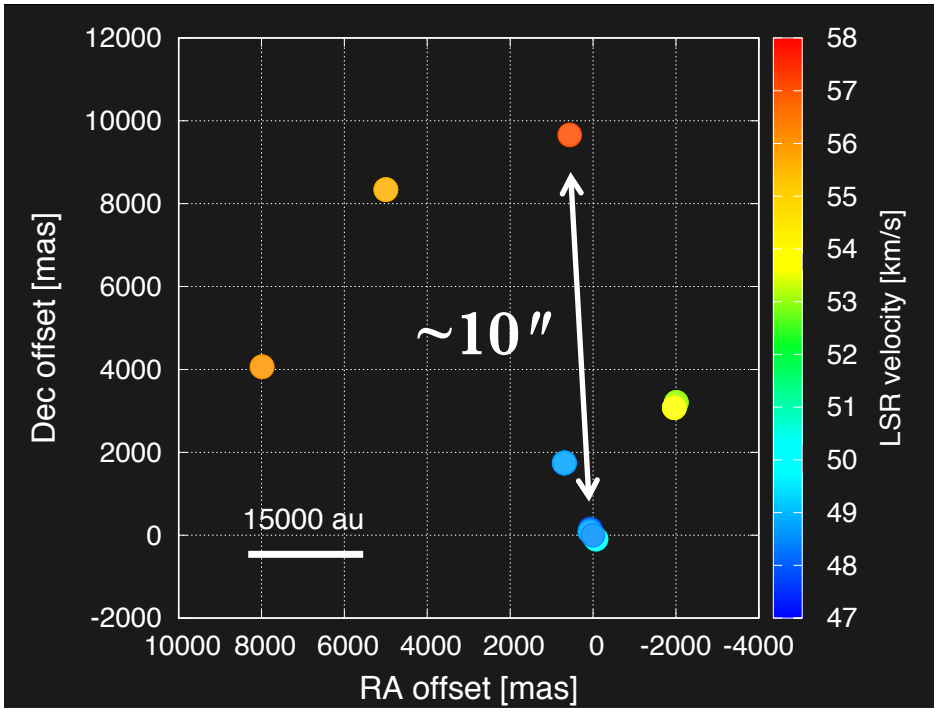


W51 E in KaVA Large Proposal with 1.6 sec period (by SFR SWG)

❖ 原点付近の一番明るい成分のみのVLBIイメージングに成功

Channel map with 0.2 sec period





W51 E in KaVA test obs. in 2016.04.19
with 0.2 sec period (by SFR SWG)

- ❖ 原点含め、合計6成分のVLBIイメージングに成功
- ❖ 最大で原点から ~9.6″ 離れた成分も検出 ☞ ~20″ の実効視野を確認

Status report : p.28, 29

New observation mode from 2018A

B New observation mode from 2018A

Two new observations modes are available from the 2018A semester; C2 mode and Wide-field imaging mode. Details are summarized in the following subsections.

B.1 C2 mode

KaVA has provided two correlation modes with 8 IFs × 32 MHz and 16 IFs × 16 MHz, called as the C4 and C5 modes, respectively. To obtain the accurate amplitude values across the all frequency channels, however, the number of basebands (or IFs in AIPS data handling) yielded by the digital filter unit (DFU) is better to be reduced because the amplitude losses mainly occur at the edges of each baseband. This reduction is especially helpful to observe continuum sources, such as active galactic nuclei (AGN). The C2 mode, which has 2 IFs × 128 MHz, therefore, is opened but at only Q-band in 2018A. Note the following two matters: there are some amplitude slopes mainly at VERA stations (Figures 12 and 13 in the VERA status report: http://veraserver.mtk.nao.ac.jp/restricted/CFP2018A/status18A.pdf), which must be corrected by all the gain calibration procedures (AIPS tasks ACCOR, BPASS, and APCAL); multiply the scaling factor to recover the quantization loss (1.3 for Daejeon correlator) [8].

B.2 Wide-field imaging mode

This mode is required to fully image 44 GHz methanol maser emissions associated with star-forming regions, which are generally distributed on the angular scale over 10 arcsec. The wide-field imaging (WFI) mode is achieved with an accumulation period shorter than the usual one of 1.6384 sec in Daejeon correlator at KJCC. Theoretically, the field of view (FoV) within an amplitude loss of 1%, 5%, and 10% is estimated on the basis of the time-average smearing effect due to a finite accumulation period [13]. The FoVs calculated for accumulation periods of 0.2048, 1.6384, and 3.2768 sec are summarized in Table 12, in the case of the highest angular resolution at Q-band of 0.6 mas with KaVA.

Table 12: FoV within a given amplitude loss in each accumulation period*.

Accumulation period (sec)	Amplitude loss 1.0% (arcsec)	5.0% (arcsec)	10.0% (arcsec)
0.2048	8.6	19.4	27.4
1.6384	1.1	2.4	3.4
3.2768	0.5	1.2	1.7

* Under an assumption of the highest angular resolution at Q-band of 0.6 mas with KaVA.

In the current available specification of Daejeon correlator, there is a trade-off between a shorter accumulation period and a larger number of IF channels to yield higher spectral resolution. The most highly recommended setup is the combination of C2 mode and an accumulation period of 0.2048 sec, in which both a sufficiently high velocity resolution (0.11 km s^{-1} for 44 GHz methanol masers) and a sufficiently wide FoV (10 arcsec or more) can be obtained. Thus the recommended set-up for WFI mode is summarized in Table 13.

Table 13: Recommended set-up for WFI mode in the current situation.

Correlation mode	Sampling rate	Bandwidth /IF	Accumulation period	Spectral channels/IF
C2	1024 Mbps	128 MHz	0.2048 sec	8,192

The evaluation for the WFI tests was done by the following two ways: comparing the data of an accumulation period of 0.1 sec produced in DiFX to those of 0.2048 sec in Daejeon correlator, and comparing the latter data to the same data but with averaging in 3.2768 sec. These ways provide us a chance to estimate whether such an isolated maser can be detected or not and how much rate of the amplitude loss occurs. The evaluation might be updated on the basis of a comparison between a short-accumulation period data and a multi-tracking center data in the near future.

If you would like to require this WFI mode, please describe your requests in the following two items:

- Requested setting parameters for WFI in the proposal cover sheet
- Reasons for requiring WFI mode in the scientific justification

Finally, note that the file size of correlated data for WFI is as huge as ∼600 GByte. We therefore recommend to check and improve the performance of your internet environment and personal computer as high as possible for comfortable data downloading and data processing, respectively. Please refer an example parameters in Table 14:

Table 14: Required performances of internet and personal computer.

Forward speed	$\geq$ 10 MByte s^{-1}
HDD/SSD volume	$\geq$ 1.5 TByte
RAM	$\geq$ 16 GByte

Here, the experiment to verify the time-average smearing effect due to a finite accumulation period has been done, however we will also verify the bandwidth smearing effect to KaVA observations in the near future.

KaVA PET Activities

2. まとめ

Summary

- 2017年度 KaVA PET
  - 計8名の新体制（PET 7名 ＋ EAVN-TT 1名）
  - 10月19日までに 計5回のスカイプ会議

- KaVA共同利用 2018A における新観測モード
  - C2 ： 128 MHz x 2 IFs
  - WFI： 0.2048 sec accumulation period, FoV ~20″

- 目下性能評価中
  - 2Gbps, Astrometry (absolute pos.), Nobeyama 45-m, Dual-polarization at K-band