Activities of Shanghai VLBI correlator

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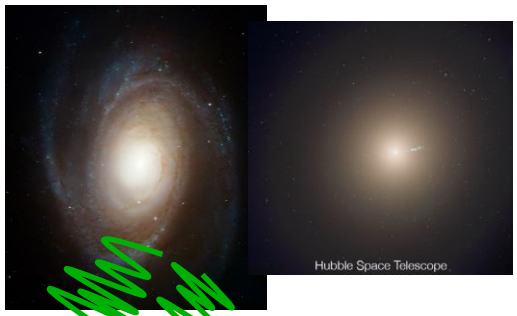
Introduction

- Correlator is the very important part of VLBI technology.



e-VLBI/diskpacks

ST1

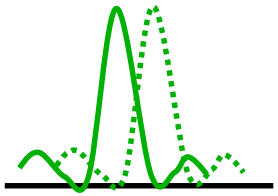
ST…

STn

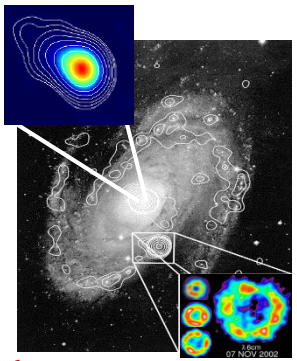
Hardware Corr

Correlator

Software Corr



Fringe!



TByte

GByte

MByte

Introduction

- **DiFX correlator** is developed by Adam Deller/Walter Brisken (2007) and maintained by a global correlator team. Widely and formally used at EHT, MPIfR, LBA, VLBA, RadioAstro, IVS etc. for both astrophysics and geodesy.

Introduction

SHAO's DiFX correlator platform

Build in Dec. 2014

3 Mark6 units (2019)

Introduction

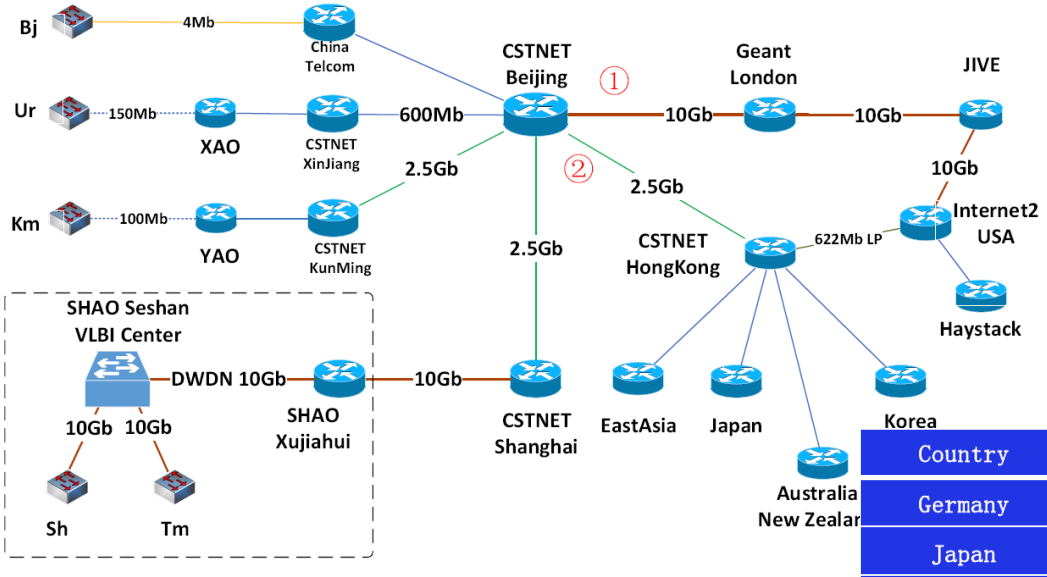
Deployment

Software	
	DiFX2.2/2.3/2.4.1***/2.5.2***, HOPS3.8/3.10/3.12/3.18***/3.20*** etc.
Hardware	
Head nodes	**2 head nodes**, *20 CPU, each head node manages 10 computing nodes*
Computing nodes	**400 cores**, *20 computing nodes, 20 CPU each node, Intel Xeon E5-2660 v3 2.6GHz, 64GB RAM.*
Networks	**56Gb infiniband** *network for cluster and RAID, 10Gb/1Gb Ethernet for cluster, RAID and Mark5.*
Storage system	**432 /1052 TB**, *RAID 6 and parallel file system.*
Mark5/6	**7 units**, *1 Mark5A, 2 Mark5B, 1Mark5B+, 3Mark6*

Achieve a speed of 10 stations, 1Gbps/station. More stations allowable at a relative low correlation speed.

Introduction

- Via CSTNET(Chinese Science&Technology Network, CAS)
- IPv6 supported in CVN



e-VLBI network conditions

Almost a real time connection.

Country	Institutes	Network B/W	To/From Shanghai
Germany	Bonn MPRiFR	900Mb/s	800Mb/s
Japan	NICT	10Gb/s	1Gb/s
Japan	GSI	10Gb/s	1Gb/s
South Korea	NGII	1Gb/s	800Mb/s
Italy	IRA	10Gb/s	800Mb/s
South Africa	Hartebeesthoek	10Gb/s	550Mb/s
Australia	University of Tasmania	10Gb/s	800Mb/s
New Zealand	Auckland University of Technology	10Gb/s	800Mb/s
Brazil	IPNE	1Gb/s	200Mb/s
Netherlands	JIVE	10Gb/s	1Gb+/s
Russia	IAA	1Gb/s	500Mb/s
USA	Haystack	1Gb/s	600Mb/s
Malaysia	University of Malaya	100Mb/s	90Mb/s

Operations and applications

1. Flexible: Support Mark4, Mark5B, VDIF format as input, provide Mark4 and FITS-IDI outputs.
2. Pulsar binning/gating, zoom maser line, multi-phase center correlation.
3. e-connected.

☐ Routine operations

1. **Astrophysics**, CVN observations, east Asia VLBI, joint observations.
2. **Geodesy**, serve as an IVS correlator since 2015. domestic geodetic observations and joint VLBI astrometry programs.
3. Other test experiments, **data exchange buffer** etc.

Operations and applications

CVN Chinese VLBI Network

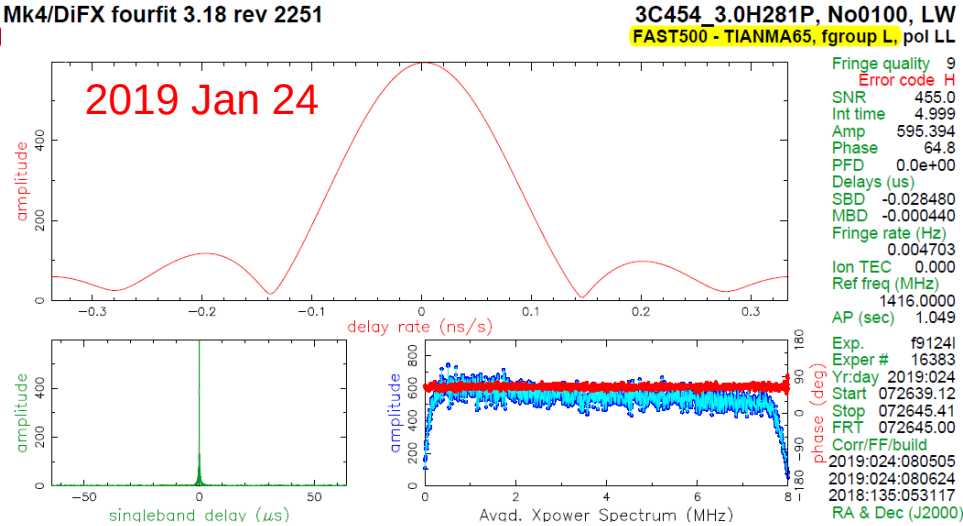
Observing Band:
- Bj S/X
- Km S/X, C
- Sh L, S/X, C(6cm)
- T6 L, S/X, C, X/Ka, K, Q
- Ur L, S/X, C(6cm), K

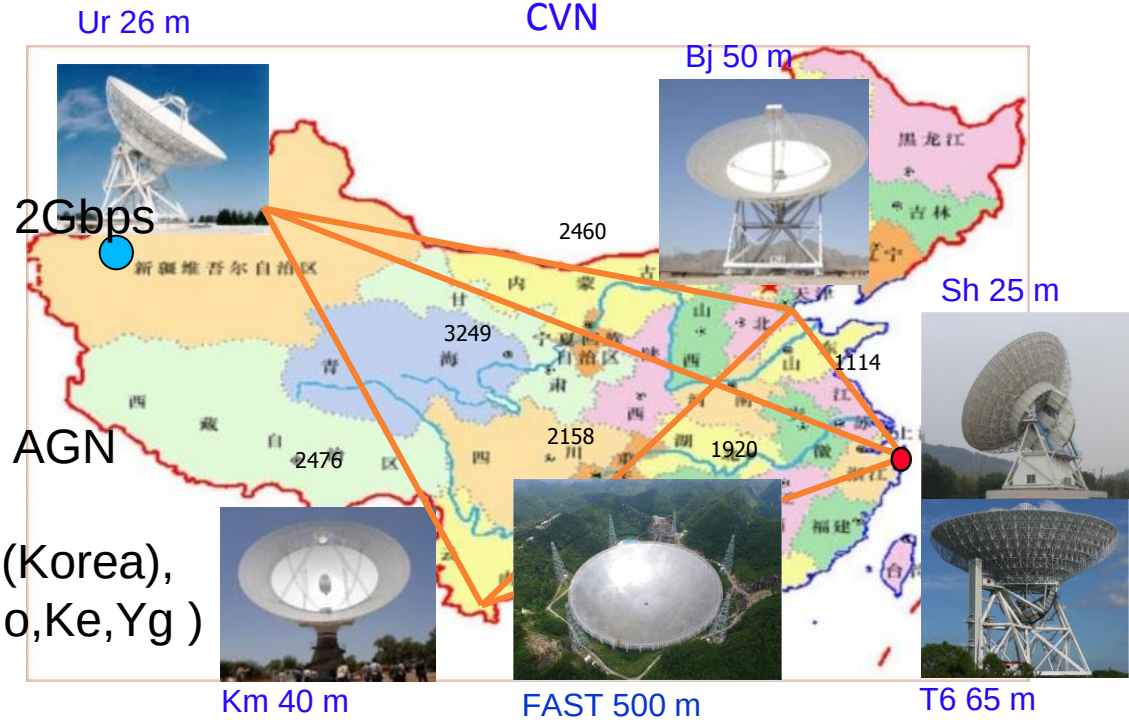
Backend:
- CDAS/DBBC, Mark5B, up to 2Gbps

Baseline Length:
- ~1100km-3250km

Scientific programs:
- Geodesy, astrometry, pulsar, AGN

Joint Observations:
- Kashima34 (Japan), Sejong (Korea),
- Australian telescopes (Hb,Ho,Ke,Yg)

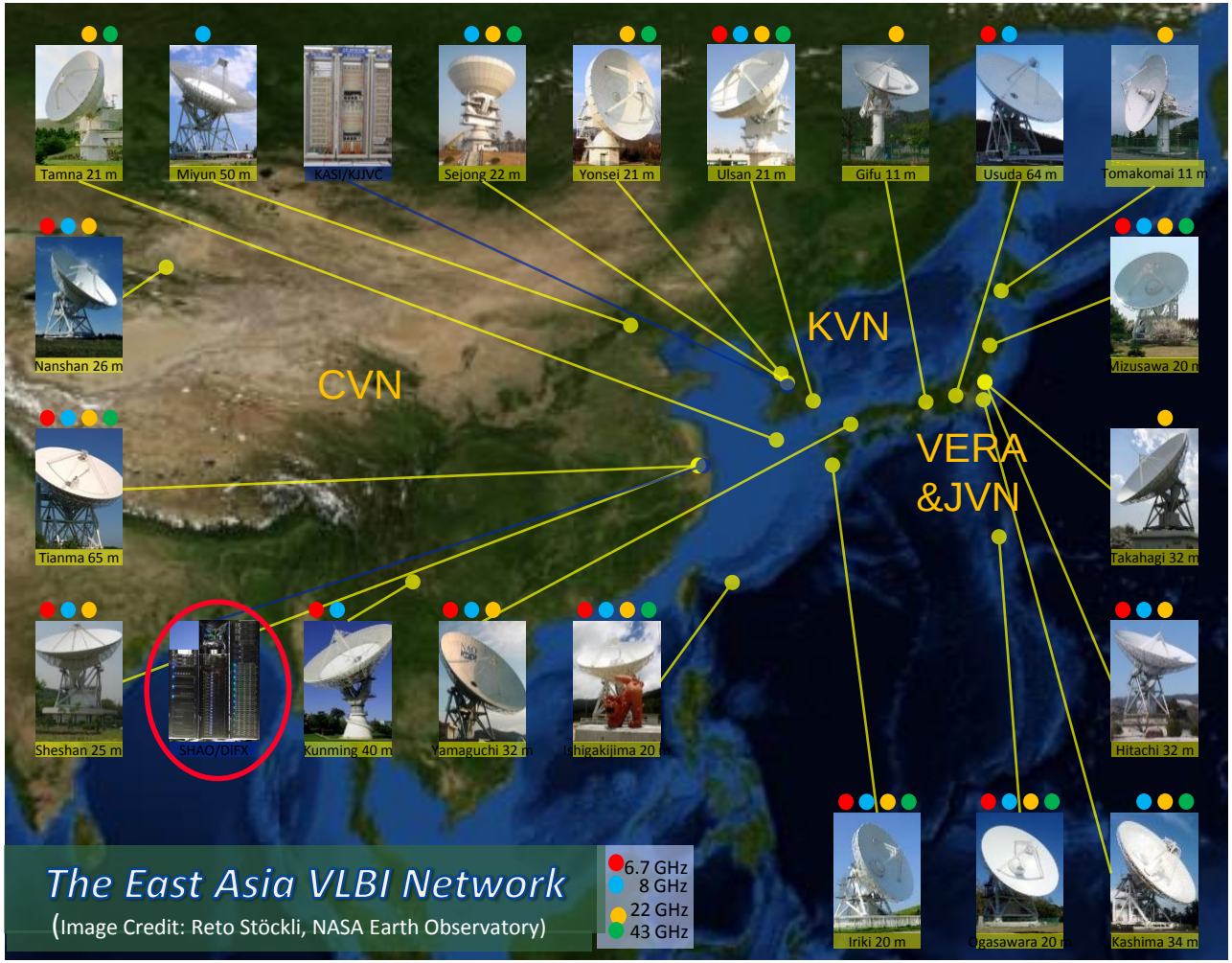




Operations and applications

EAVN

Observing Band:
C(6.7GHz), K, Q
Recording rate:
1Gbps
2Gbps(future)
Stations(common):
CVN(3),
KVN(3),
VERA(4)
Baseline Length:
~200km-5500km
Science work groups:
AGN
Astrometry
Evolved star
Star formation



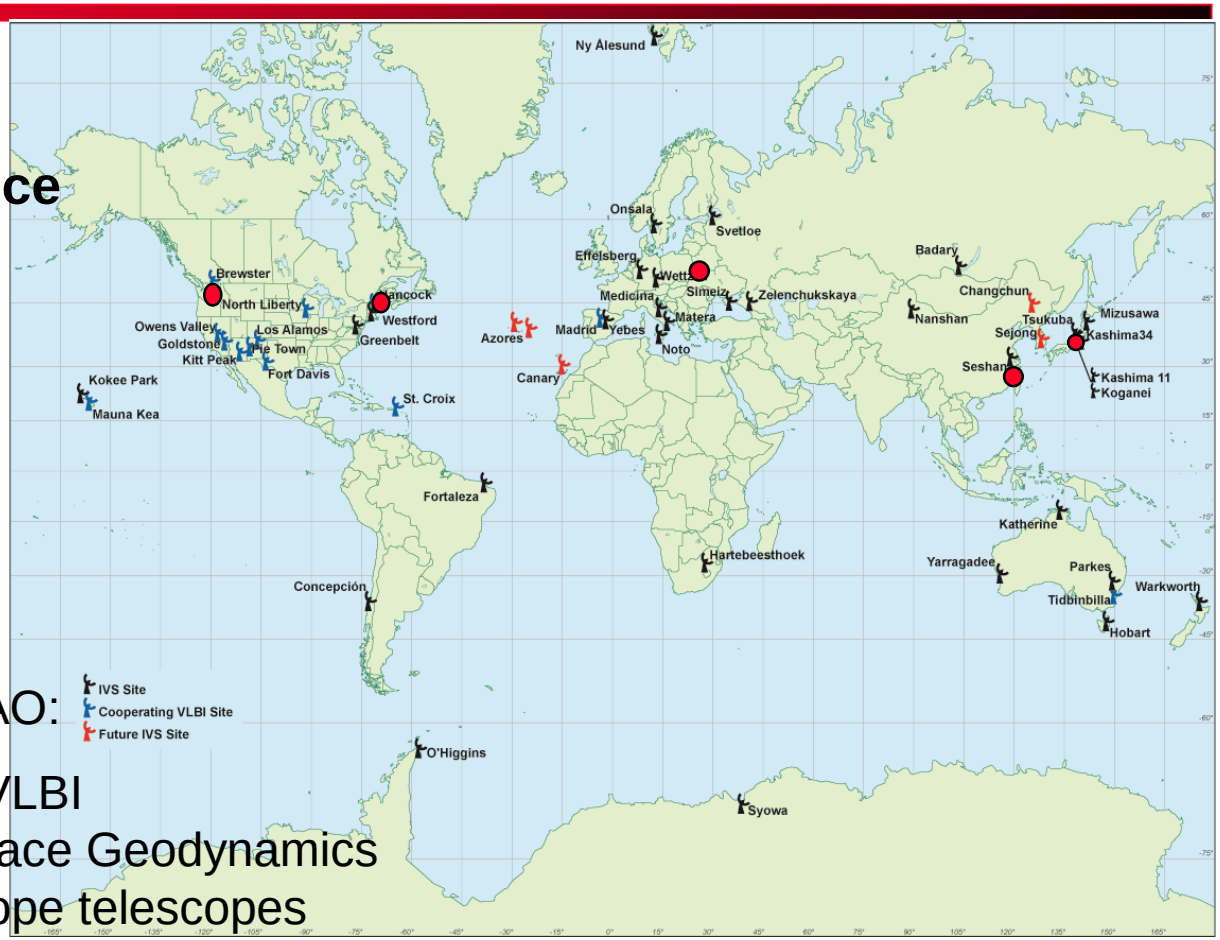
Early fringe tests for EAVN.
EAVN open-use started in 2018!

Operations and applications

IVS International VLBI service

1/5 of the main IVS correlator,

Bonn (German)
Haystack (USA)
GSI(Japan)
Shanghai(China)
Washington(USA)



Session series correlated at SHAO:

AOV	Asia Oceania VLBI
APSG	Asia-Pacific Space Geodynamics
AUA*	Austral AuScope telescopes
CRF	Celestial reference frame
CRDS	CRF deep-south
R&D	Research and development

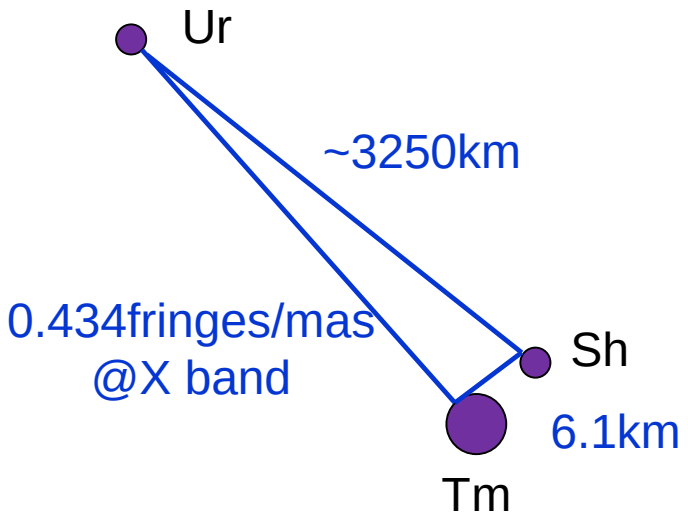
Operations and applications

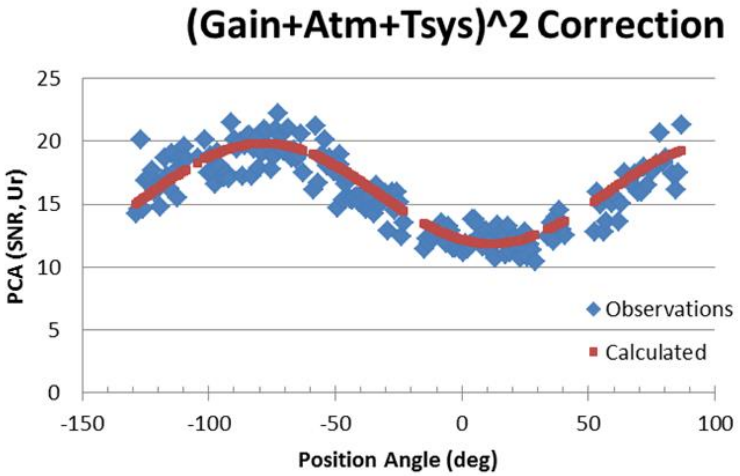
Routine operations

	CVN	Joint	IVS
2015	10 Continuum, Pulsar, Geodesy	10 EAVN(FT), Astrometry	10 AOV, APSG, CRF
2016	20 T6 Rx test, Continuum, Geodesy	8 EAVN(FT), FT, Astrometry	26 AOV, APSG, AUA, AUG, CRDS, CRF, R&D
2017	Astrometry, Geodesy, Pulsar	EAVN, FT	31 AOV, APSG, AUA, CRDS, CRF, R&D

Scientific Program

AGN





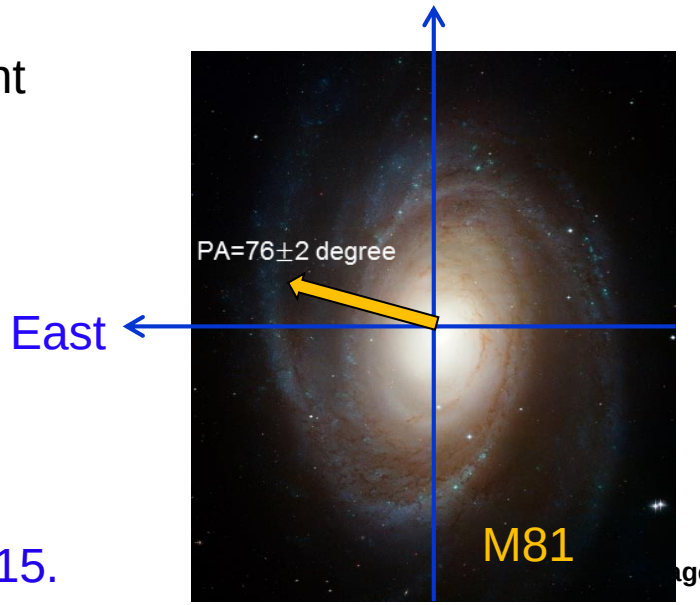
Pseudo Closure Amplitude(PCA) measurement

$$PCA_{Ur} = \frac{\rho_{SU} \bullet \rho_{TU}}{\rho_{ST}} \approx S_o \bullet r^2 \bullet S_{Ur}$$

So : Source Flux, S_{UR}: Station Sensitivity

small dish – calibration assistant

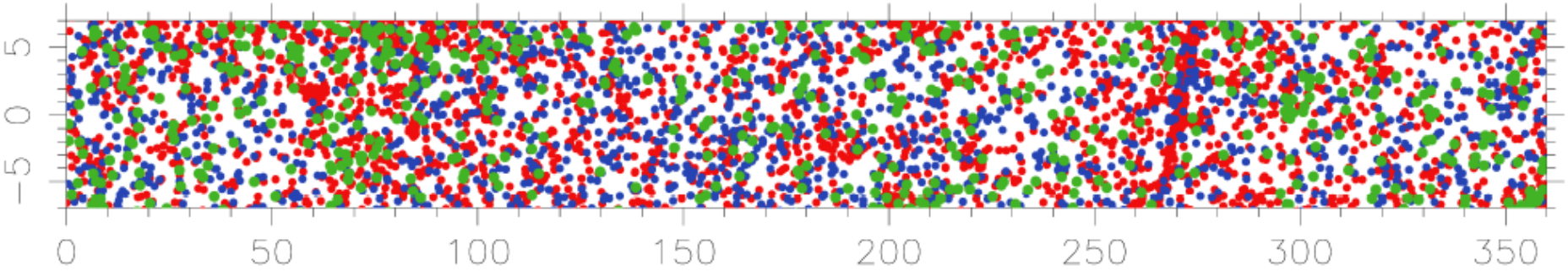
big dish – sensitivity booster

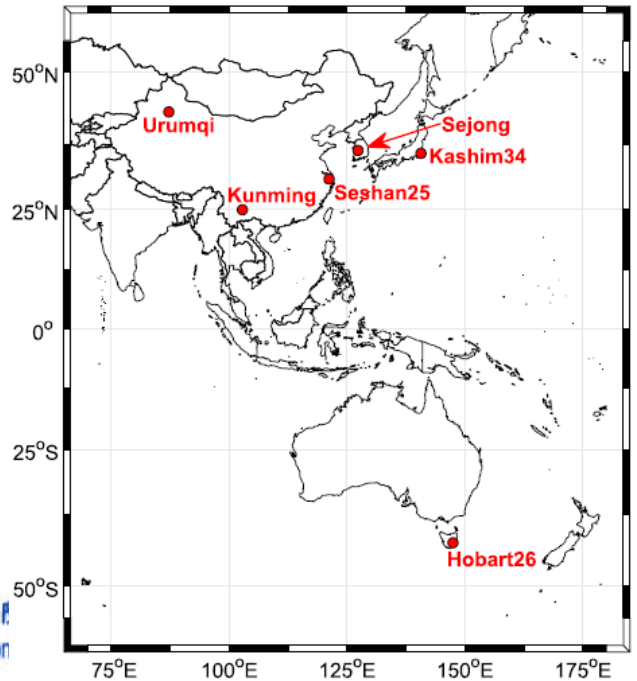


Kawaguchi et al. PASJ, 2015.

Ecliptic plane survey

Among 3321 sources (red+green), 556 sources detected (green). (Shu F C, session2-3)



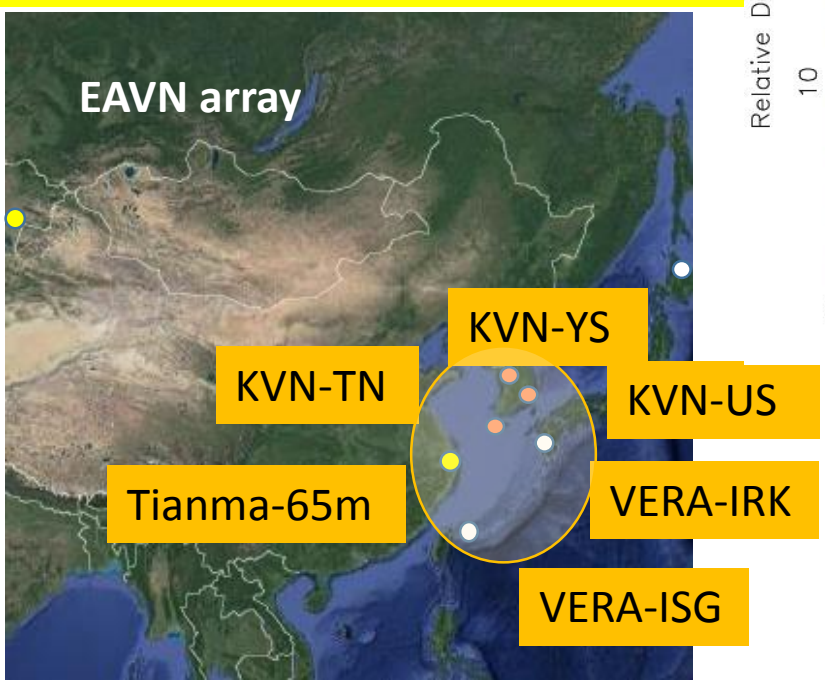


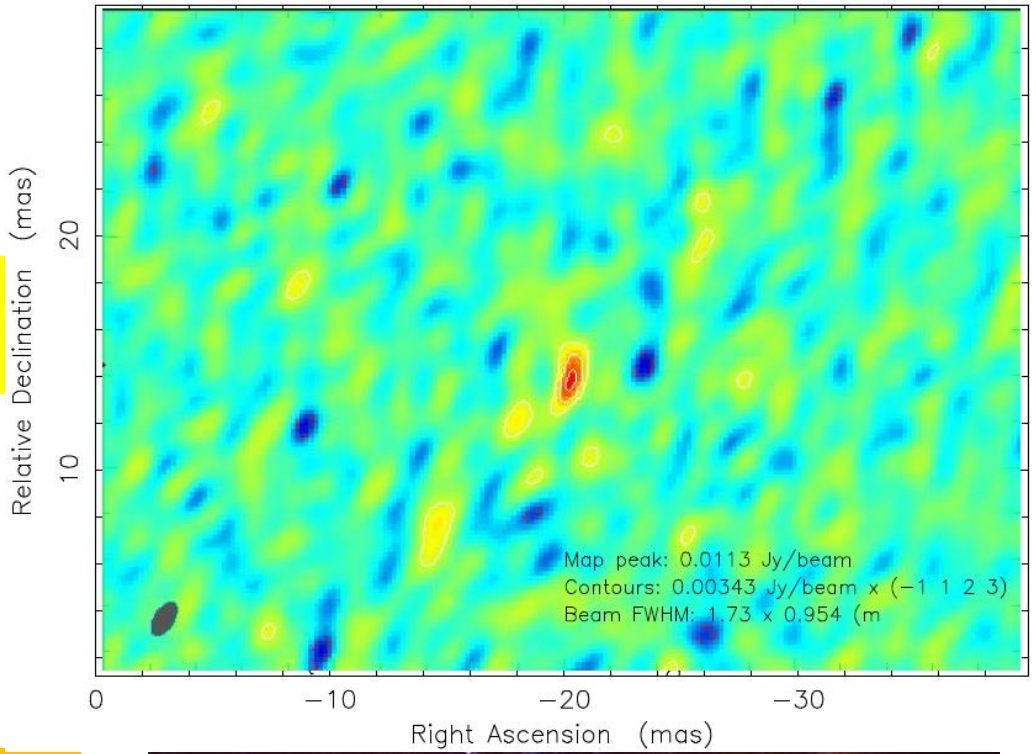
Hybrid recording and correlation

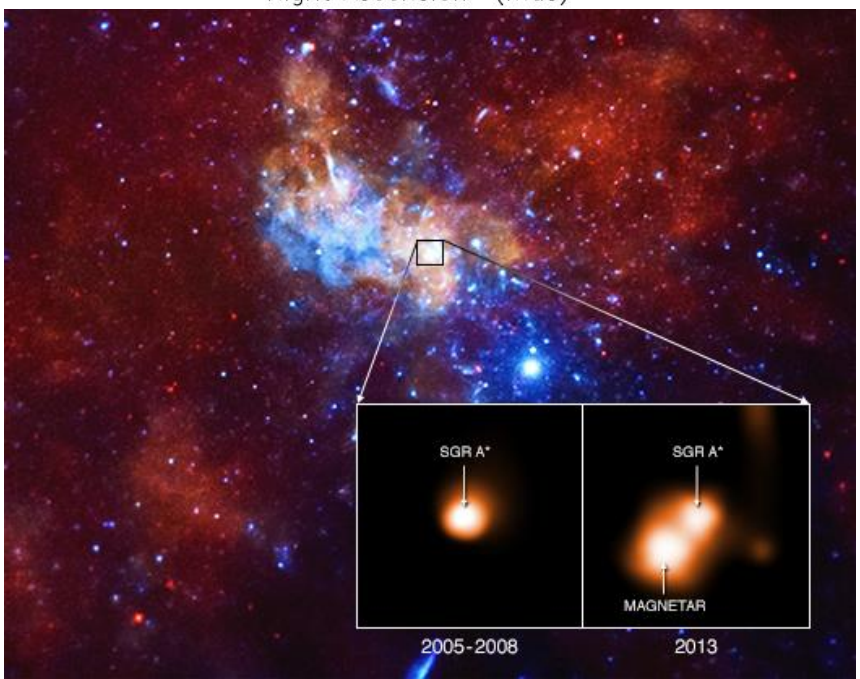
ShKbKmUr	16IF*32MHz*2bit = 2Gbps
Kv(Sejong)	16IF*32MHz*1bit = 1Gbps
Ho(Hobart26)	16IF*16MHz*2bit = 1Gbps

GC magnetar study

In beam (2.4 arcsec) phase-referencing imaging of magnetar



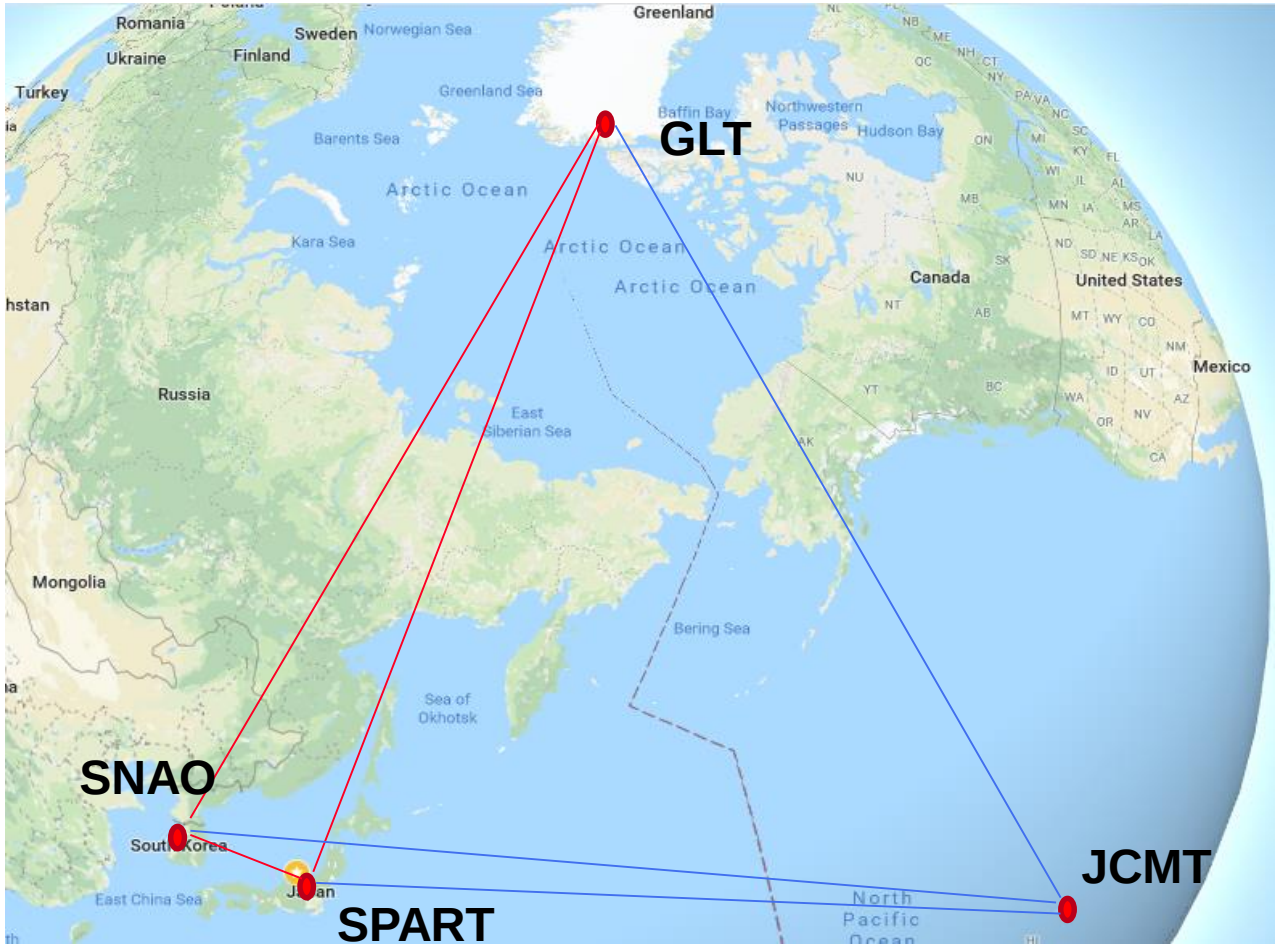




A 43G detection with EAVN, multi epoch observations in total on SgrA*/Magnetar with EAVN in 2017/2018/2019 EHT campaign.

EA 1mm VLBI

The **first EA 1mm VLBI** test observations (2019.03.17-19)! The data are collecting now.



Discussion: related to EAO Sub-mm Futures

The correlator at SHAO definitely can server for both test and scientific EA sub-mm VLBI observations!
Any requirements for the correlator?

For future sub-mm VLBI
More stations, higher frequency, new technology…
Science driven programs…
Connect to the outside region…

Thank you for your attention!

谢谢！