KVN Updates

Do-Young Byun (KASI)

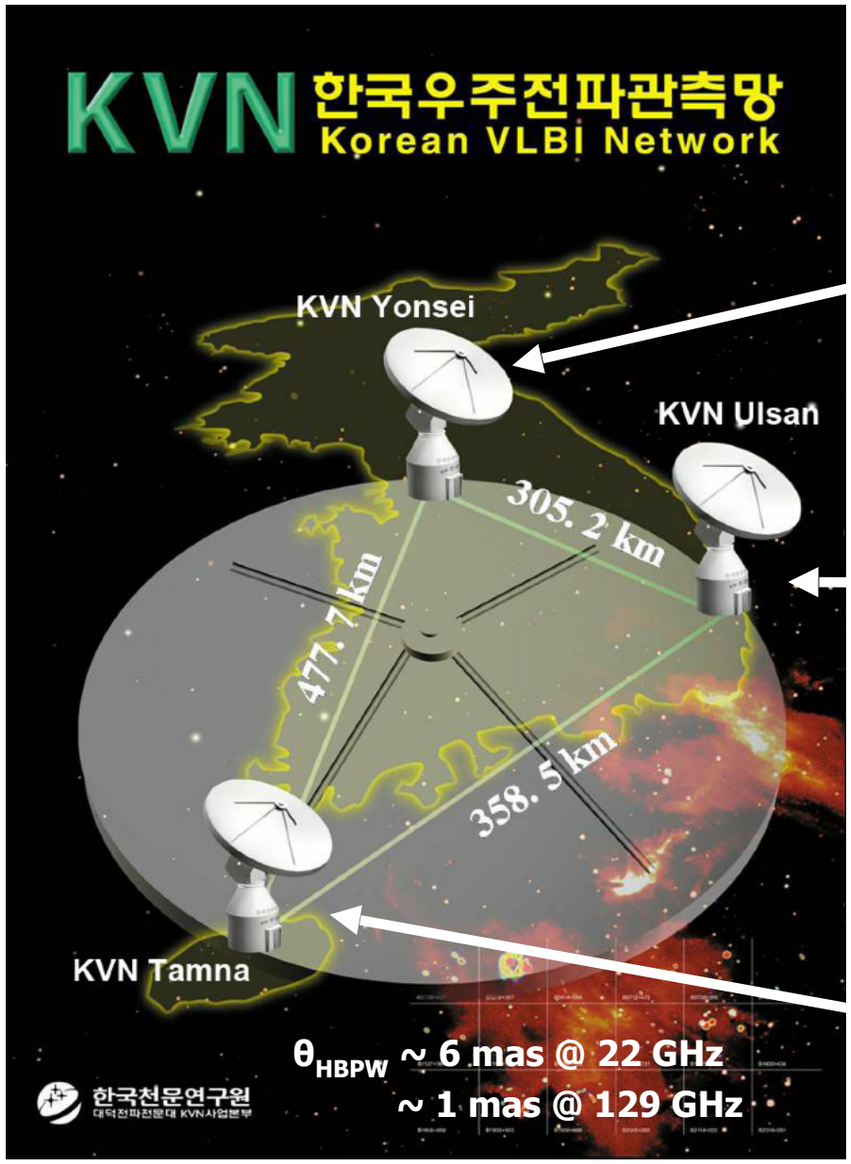
The 7th Survey Science Workshop

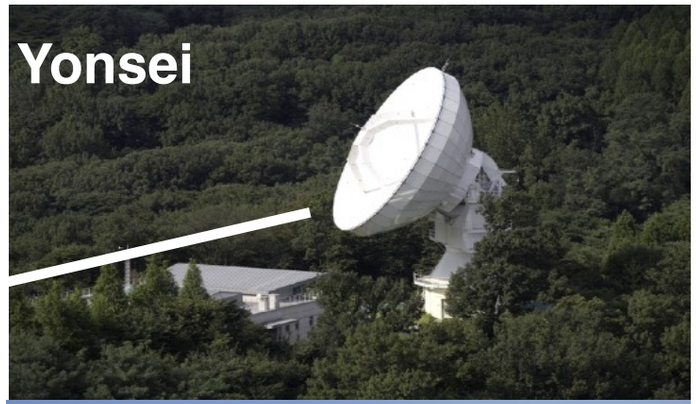
2018 Jan 15-17 @ High1

Outline

- Operation Status
- KVN Key Science Programs
- Upgrade Activities
  - Wideband Receiver / Backend
- Extended KVN project

Korean VLBI Network (KVN)





- 3 Telescopes (D = 21m)
- 22/43/86/129GHz
- 300 - 500 km
- Θ = 1 - 6 mas

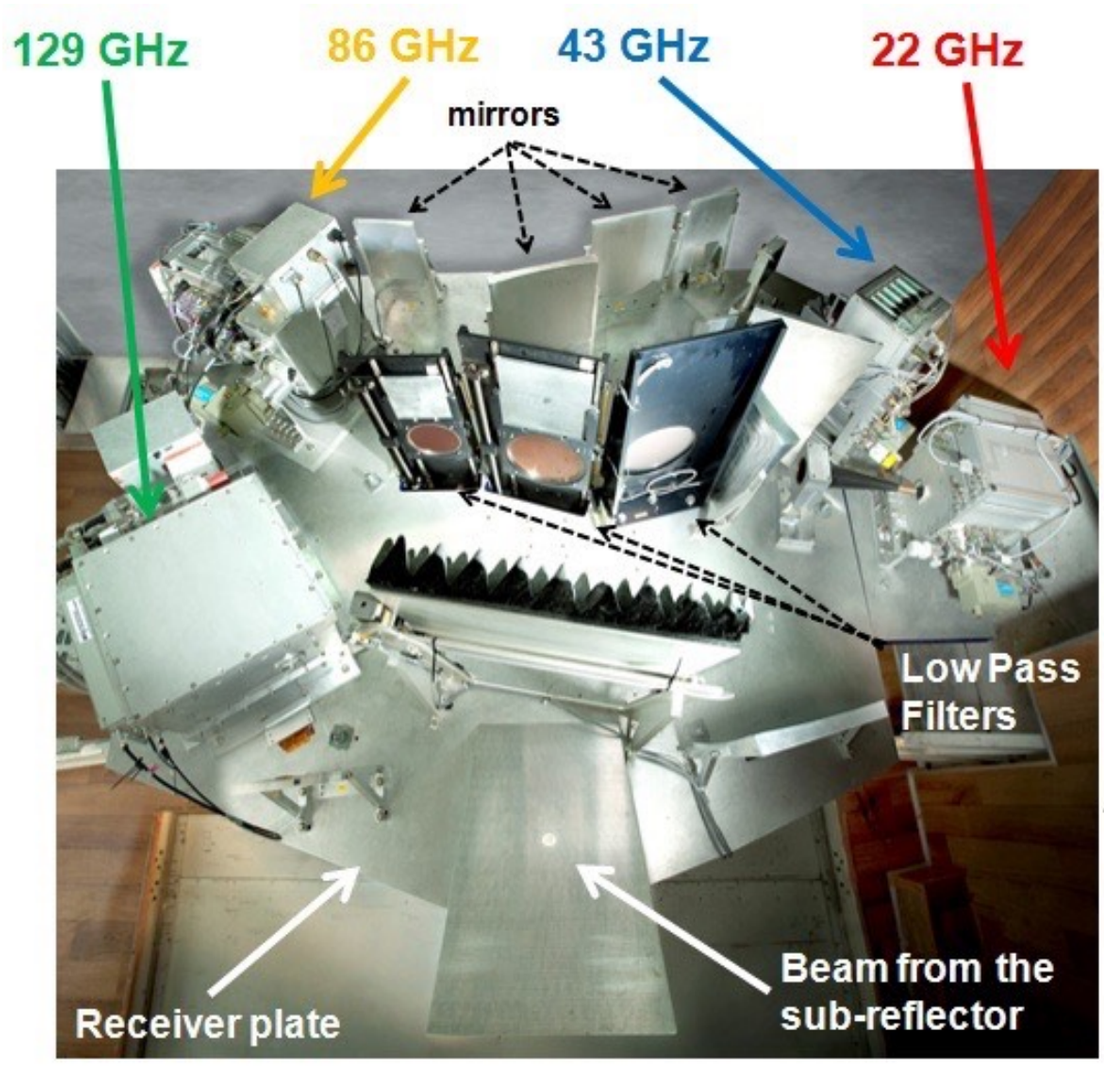
- Science Targets
  AGN/SF/Evolved Star
  + microquasar

Multi-Frequency Receiving System

- Simultaneous Multi-frequency Observation
  - @ 22/43/86/129GHz
  - Dual Pol : LCP & RCP

- (Source) Frequency Phase Transfer
  - Weak Source Detection
  - Chromatic Astrometry

- Multi-Frequency Observation
  - SED
  - Rotation Measure



Operation

- VLBI ~ 4000h/yr (+ SD ~ 500-1000 h/yr/site)
  - KVN Only : 2500h
  - KaVA (KVN and VERA Array) : 1000h
  - EAVN, EVN (22/43GHz), GMVA (86GHz) > 300h
  - KVN Key Science Projects : 1000h/yr
  - KaVA Large Programs : 500h/yr
  - Global Common Use : 1000h/yr
    - KVN : 500h/yr + KaVA : 500h/yr
- 16 SCI(E) papers/yr (half from VLBI observations)

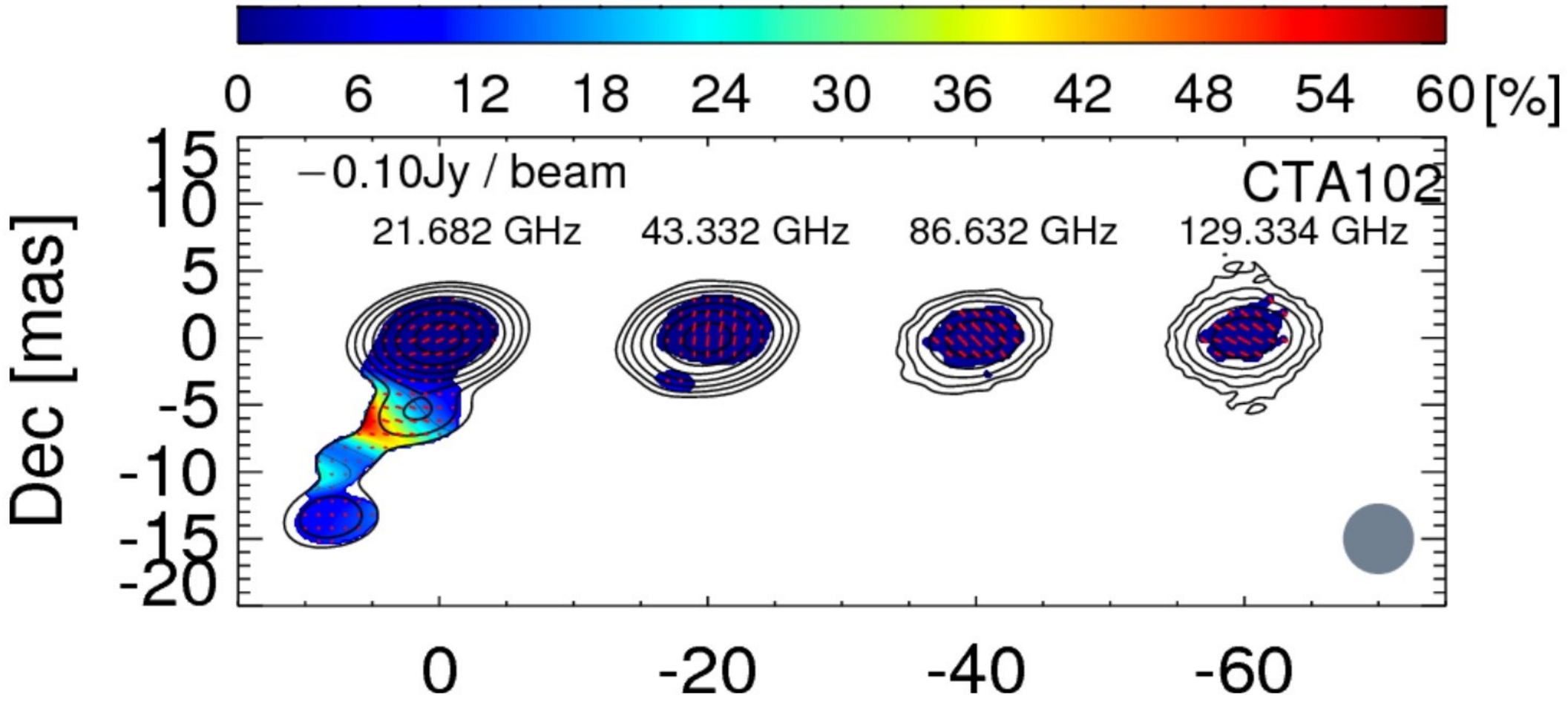
KVN Key Science Projects

1. Interferometric Monitoring of Gamma-Ray Bright AGN : iMOGABA (Sang-Sung Lee/KASI)
2. Simultaneous Monitoring of KVN 4 Bands towards Evolved Stars (Se-Hyung Cho/KASI)
3. The Plasma Physics of AGN with KVN : PaGAN (Sascha Trippe/SNU)

- Multi-Frequency AGN Survey with KVN : MASK (Taehyun Jung/KASI)

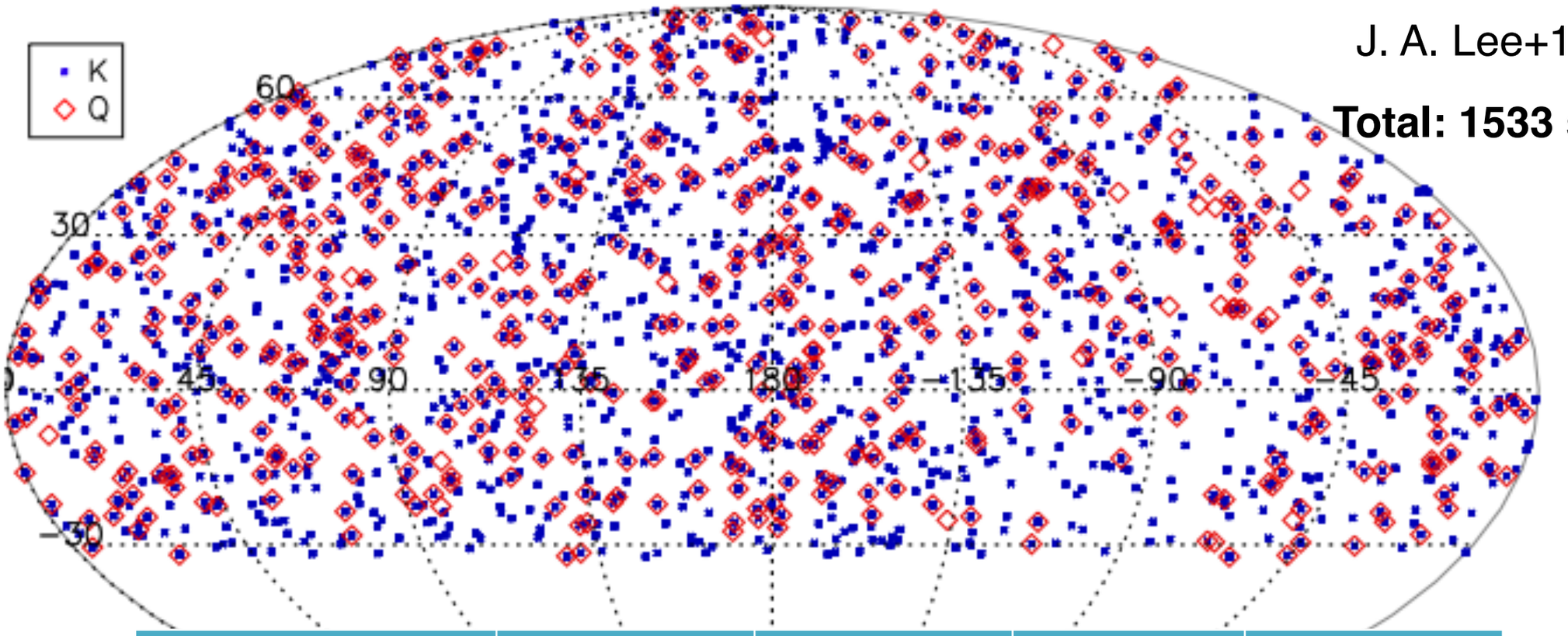
PaGAN: Multi-Frequency Polarization

- Geometry and Magnetic field structure of AGN Jets from ν-dependent Rotation Measure
- Polarization Monitoring of ~10 Bright AGNs
- Polarization Calibration up to 130GHz - JH Park (in prep)



Multifrequency AGN Survey with KVN

Goal : Constructing Multi-Frequency mm-VLBI Catalog of AGNs



J. A. Lee+17 ApJS

Total: 1533 sources

459 sources (30%)	K-band	FPT (K→Q)	FPT (K→W)	FPT (K→D)
Target Freq.	22GHz	43GHz	86GHz	130GHz
Detected	446	**401**	**325**	**246**
Detection Rate	97%	**87%**	**71%**	**54%**
5σ detection limit (mJy)	168	**20**	**40**	**55**

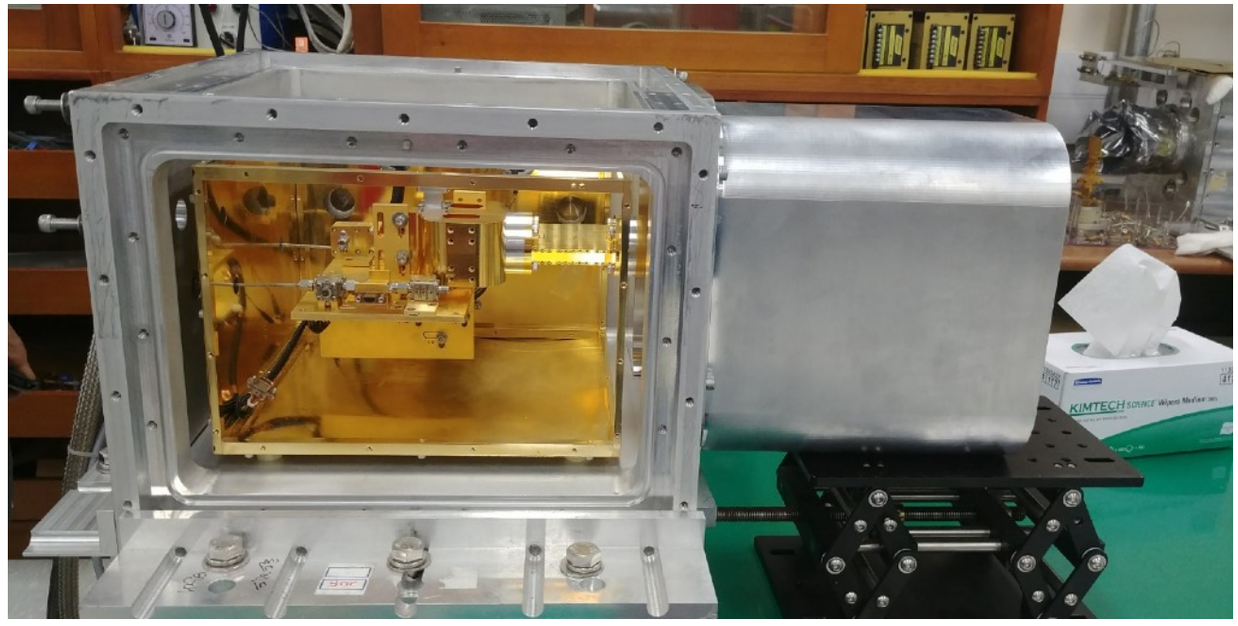
wideband Rx Project

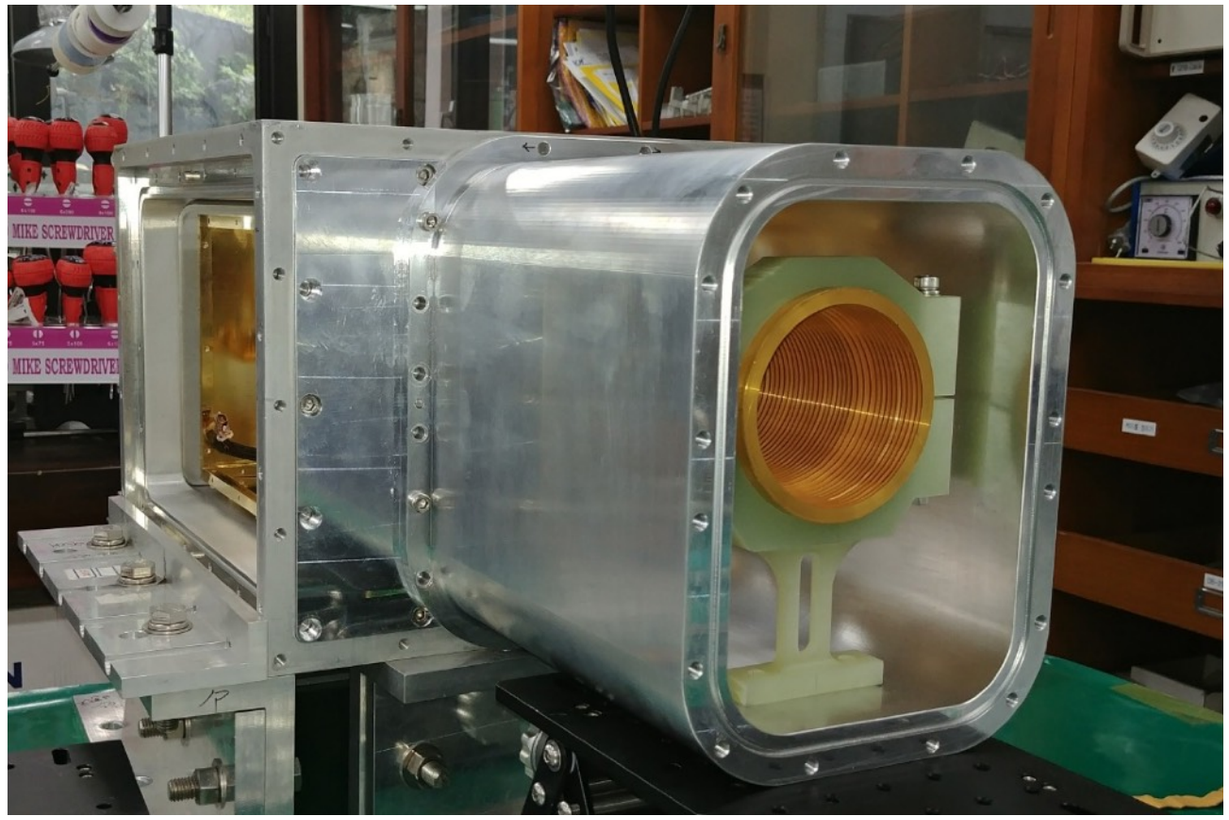
- Period : 2017 – 2020
- Upgrade current Rx by replacing narrow band components
  – LNA, Feed Horn, Polarizer, tunable LO etc
- Instantaneous Bandwidth = 8GHz

Band	Wide (GHz)	Trx(K)	Installation
K	16-26	< 40	2017 - 18
Q	35-50	< 50	2019 - 20
W	84-116	< 80	2018 - 19
D	125-172	< 60	2020

Upgraded 22GHz Rx for Yonsei

- RF 18 - 26.5GHz
- Compact Feed Horn
- Wideband Compact Polarizer
- New Low Noise Amp
- Trx ~ 25K (e.g old 50K)

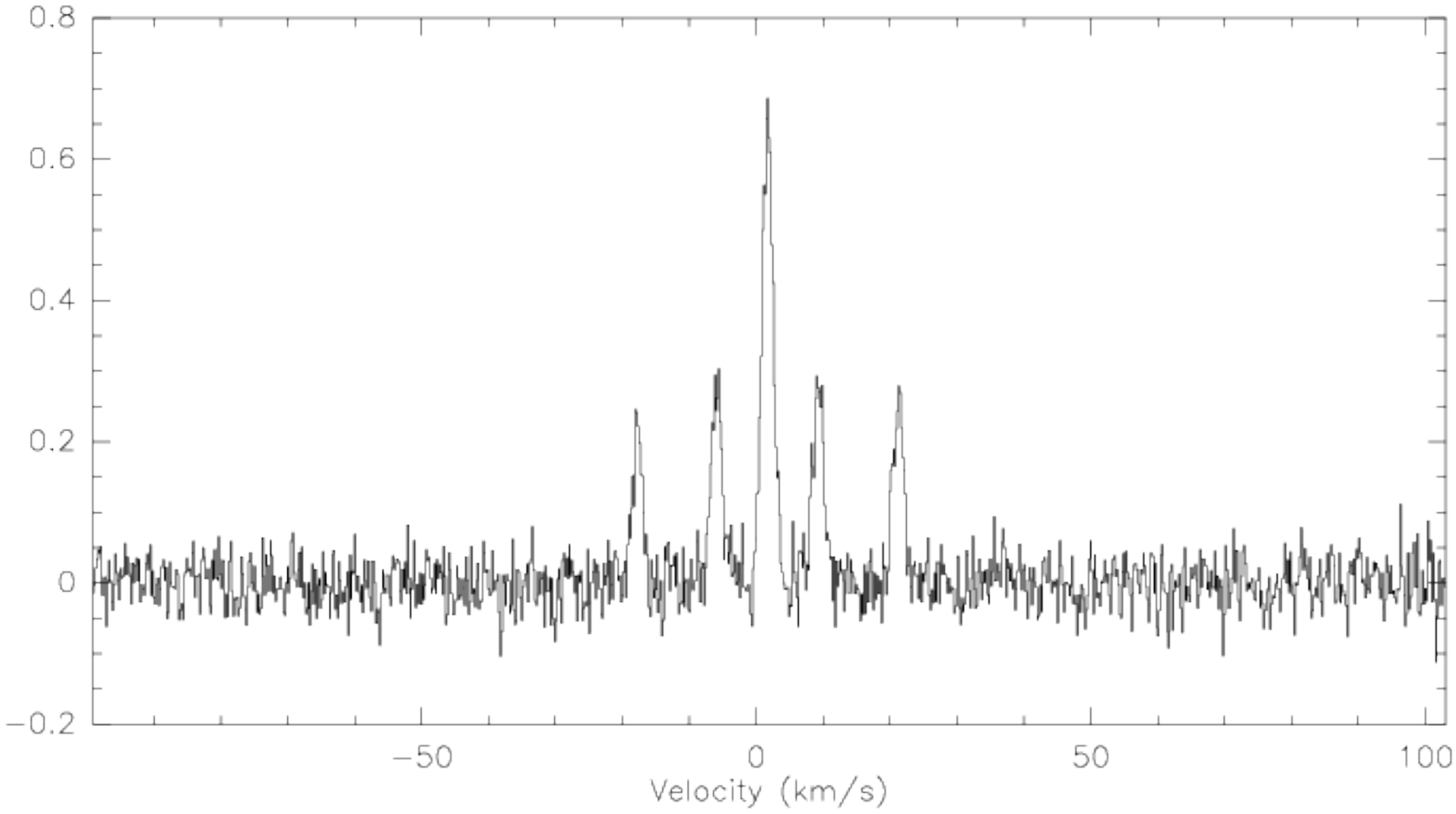




First Light with upgraded 22GHz Rx

88602; 2 HM20188+3928 23694 KYS21M22R 0:30-AUG-2017 R:30-AUG-2017
RA: 20:20:39.30 DEC: 39:37:52.0 Eq 2000.0 Offs: +0.0 +0.0
Unknown tau: 0.137 Tsys: 103. Time: 20. min El: 73.2
N: 1023 I0: 512.250 V0: 2.000 Dv: 0.1977 LSR
F0: 23694.5060 Df: -1.5625E-02 Fi: 41953.4940

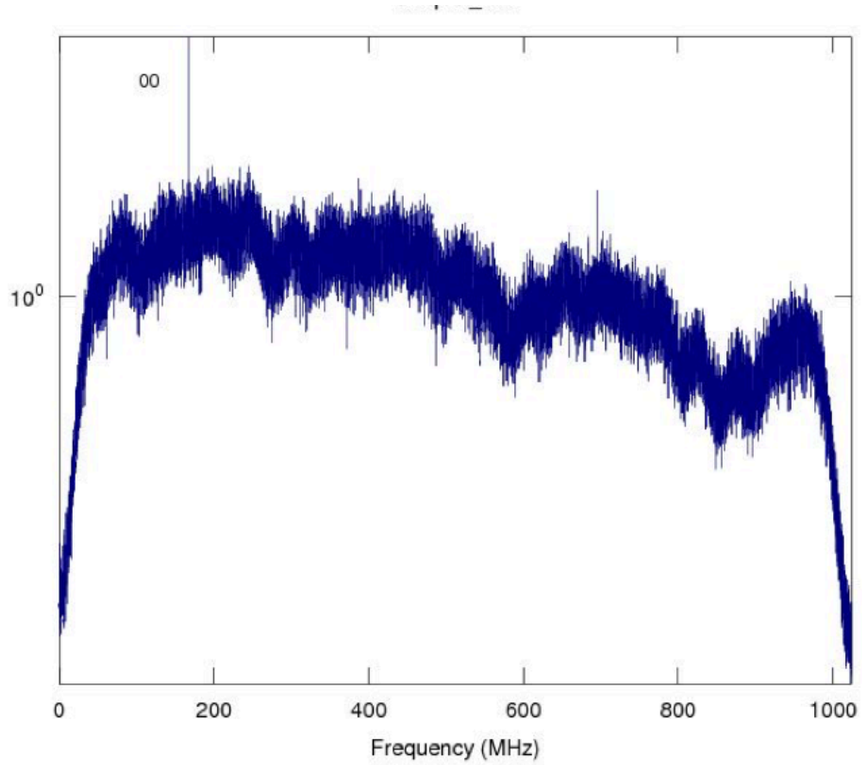
NH3 Line at 23.7GHz



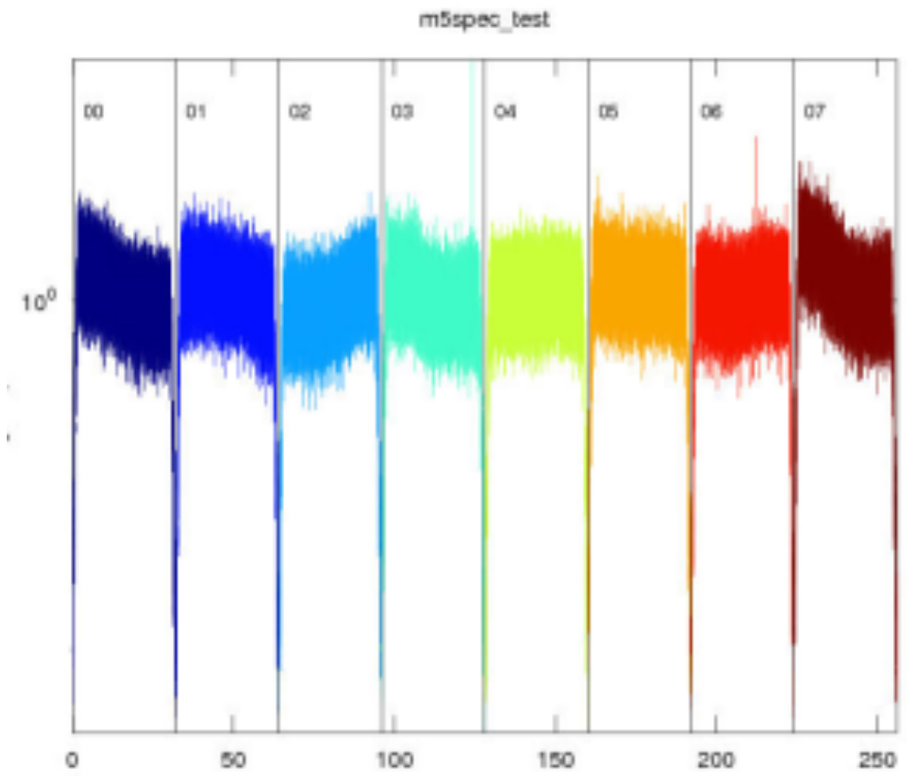
New Wideband Sampler: OCTAD

- 4 ADC (4 x 16Gsps) + DBBC(DFB)
  - 4 CH x 2GHz BW (max 32Gbps)
- Installed in 2017 August
- 32Gbps Modes (8GHz BW)
  - 4CH x 2GHz
  - 8CH x 1GHz
  - 16CH x 512MHz

Elecs co. (Japan)

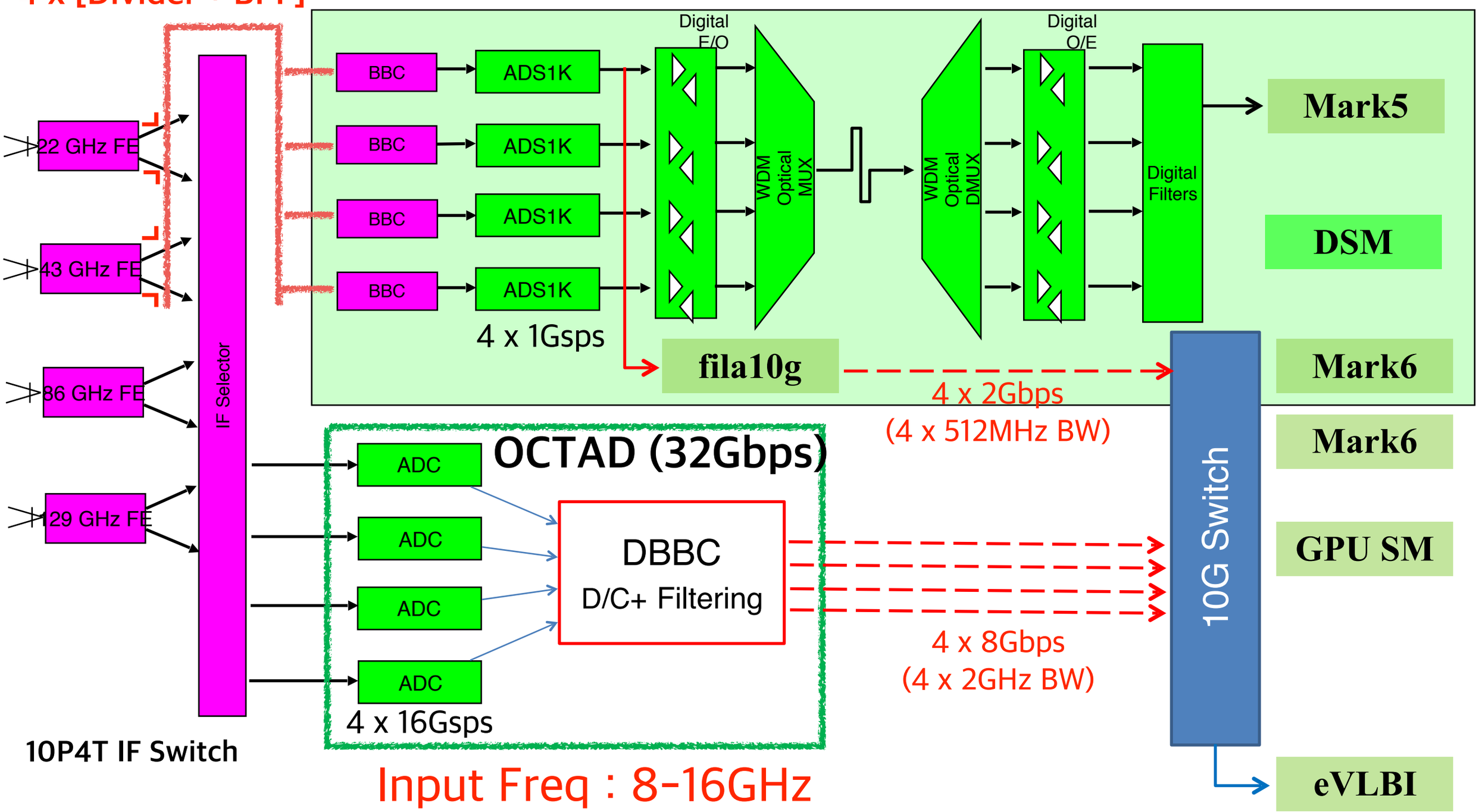


1GHz BW



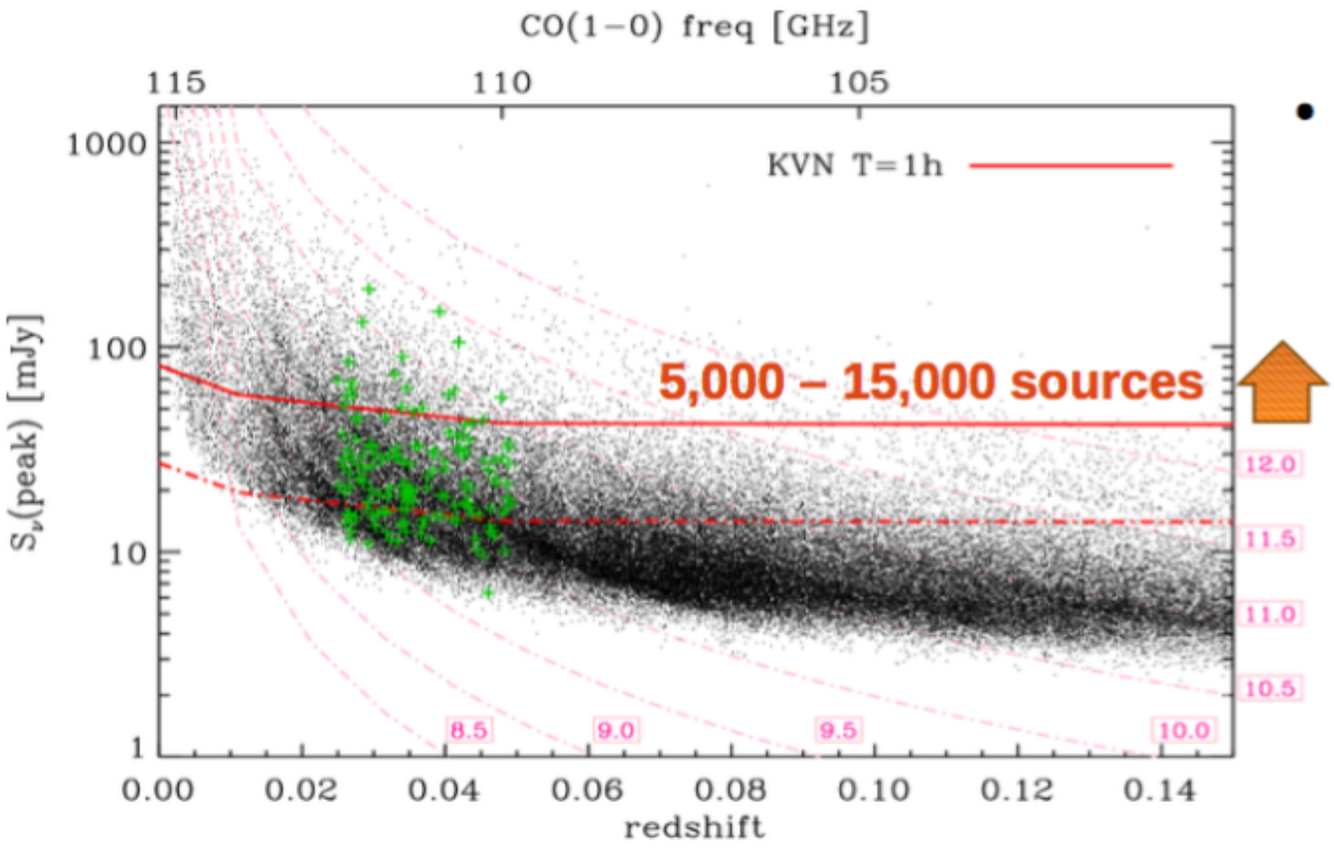
1Gbps (32MHz x 8 IF) Mode

Wideband Digital Backend (2018 -)



Single Dish

KVN CO Survey in Local Universe



- Largest CO survey so far:
  - COLD GASS (IRAM-30m)
  - 350 galaxies (goal = 1000)
  - *cf. ~100 detection at z>1 !!*

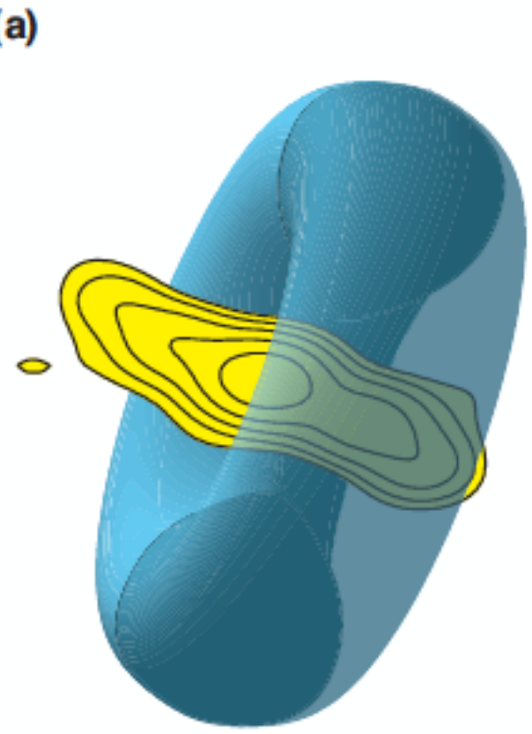
Alternative Targets
All WISE sources
All Herschel ULIRGs
SDSS QSOs

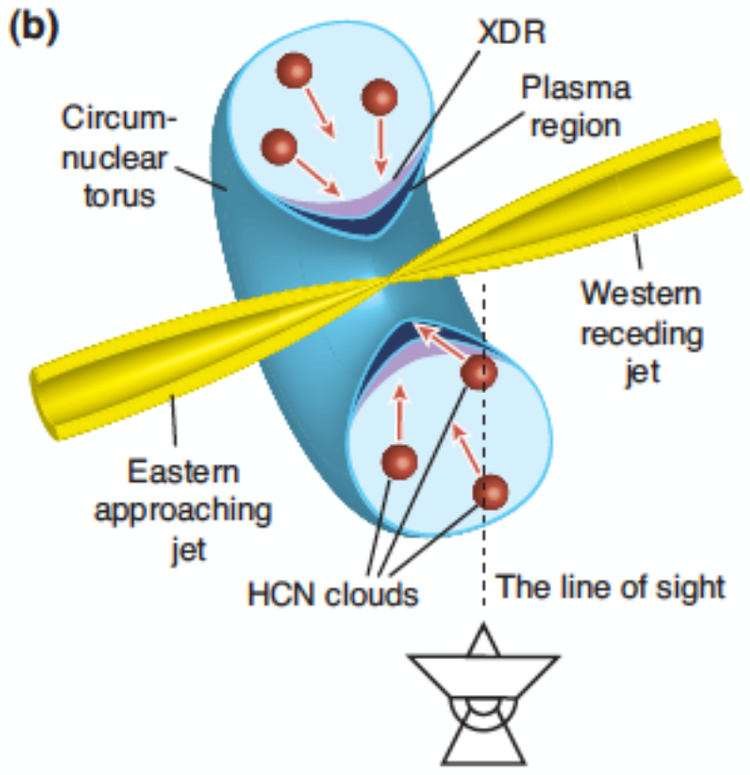
- Let's do **largest & definitive local CO survey** with KVN!
  - 5000 – 15000 SDSS galaxies
  - x(5 – 10) increase
  - Big optical-IFU surveys (e.g. MaNGA, SAMI) in progress
    Looking for HI or CO dataset to complement

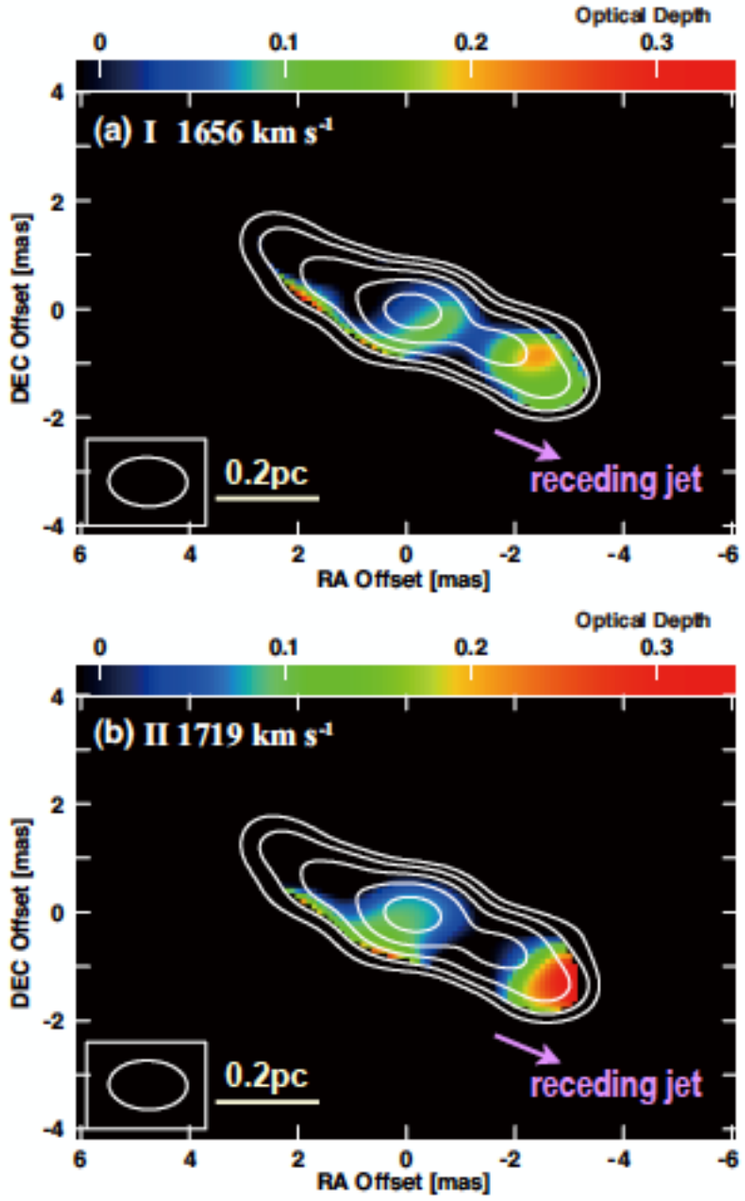
proposed by YJ Yang in Radio User's Meeting 2015

AGN Torus from Absorption Lines with KVN

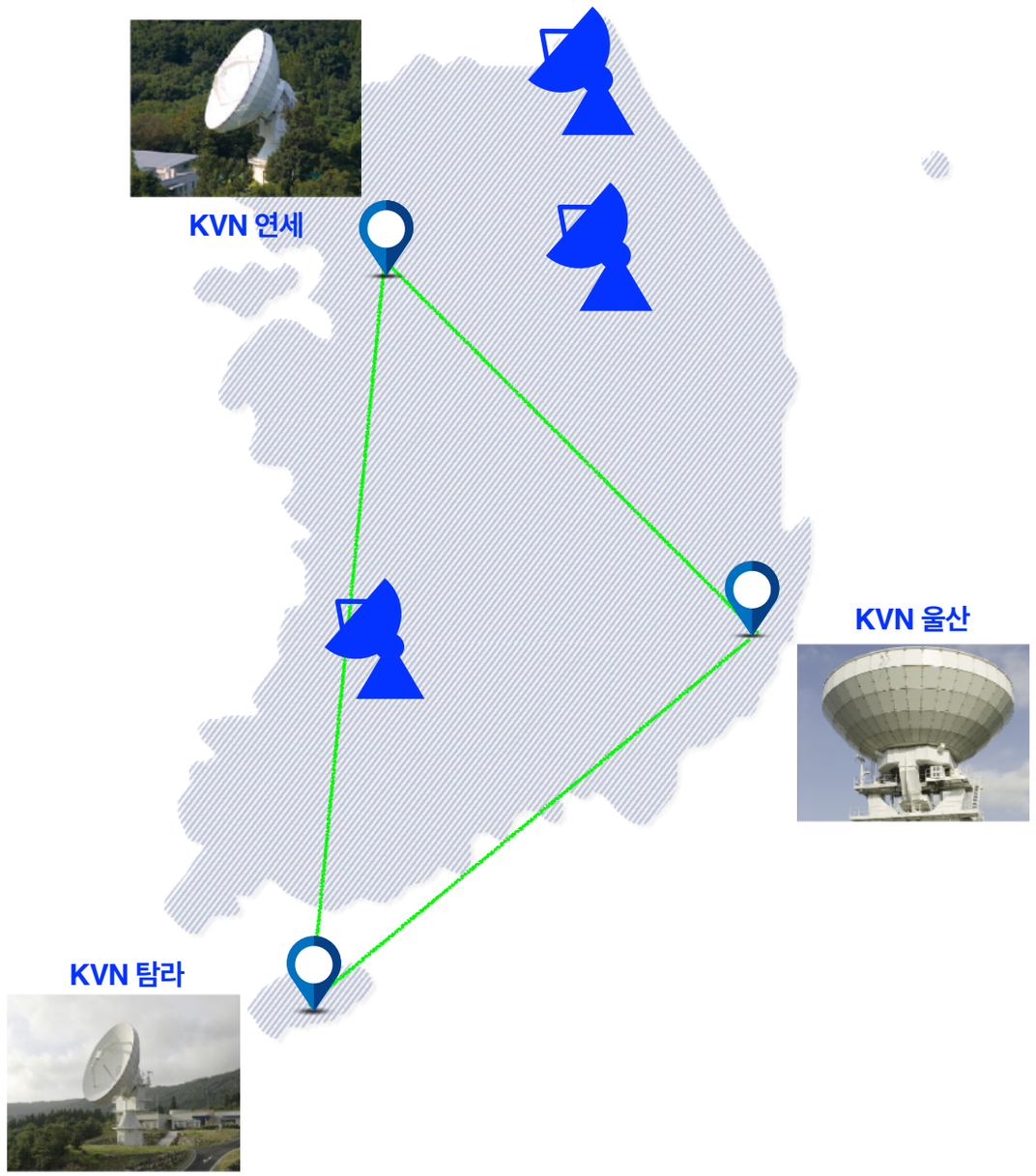
- HCN (1-0) associated with the AGN torus (Sawada-Satoh+ 16)
  - High opacity localized on the receding jet.
  - Ongoing infall of HCN clumps to SMBH.
  - Yielded physical properties of the torus.
    - $N(H_2)$: 10^{24}-10^{25} cm^{-2}
    - Infall rate : ~0.05-0.5 M_{sun}/yr







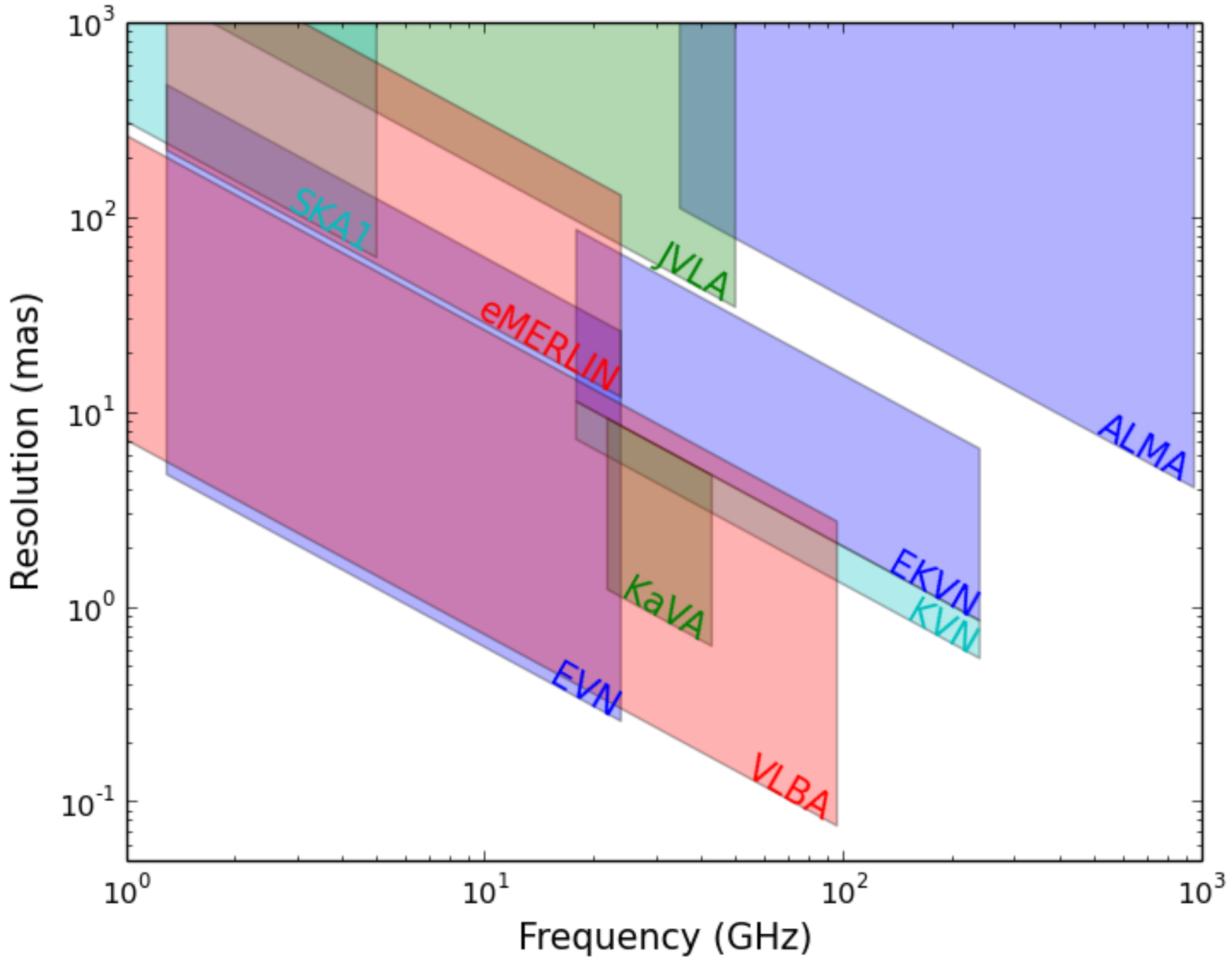
Extended KVN Project



- Why new KVN sites ?
  - 15 baselines
  - more than 5 times better imaging
  - Time Domain Astronomy & Rapid Response Science
- Unique baselines : 50 - 500 km

  * longer baselines (> 500km) from international collaborations
- Frequency : 18 - 172 (230)GHz
- 45M USD for 3 sites

Frequency & Angular Resolution



Summary

- KVN KSP + KaVA Large Program era
  - VLBI Operation ~ 4000 h/yr
  - Publications are increasing
  - International Collaboration ~ EAVN, EVN, GMVA
- Upgrade Activities
  - 130GHz Polarization are available
  - Wideband Receiver & Backend
- pre-study of Extended KVN Project
  - AGN/SF/Evolved Stars + microquasar + RSS
  - Any ideas and/or suggestions are welcome

Frequency Phase Transfer (FPT)

FAST SLOW

$$\Phi_{HIGH,OBS} = \Phi_{TRO} + \Phi_{GEO} + \Phi_{INSTR} + \Phi_{ION} + \Phi_{SOURCE}$$

$$- R\Phi_{LOW,OBS} = R(\Phi_{TRO} + \Phi_{GEO} + \Phi_{INSTR} + \Phi_{ION} + \Phi_{SOURCE})$$

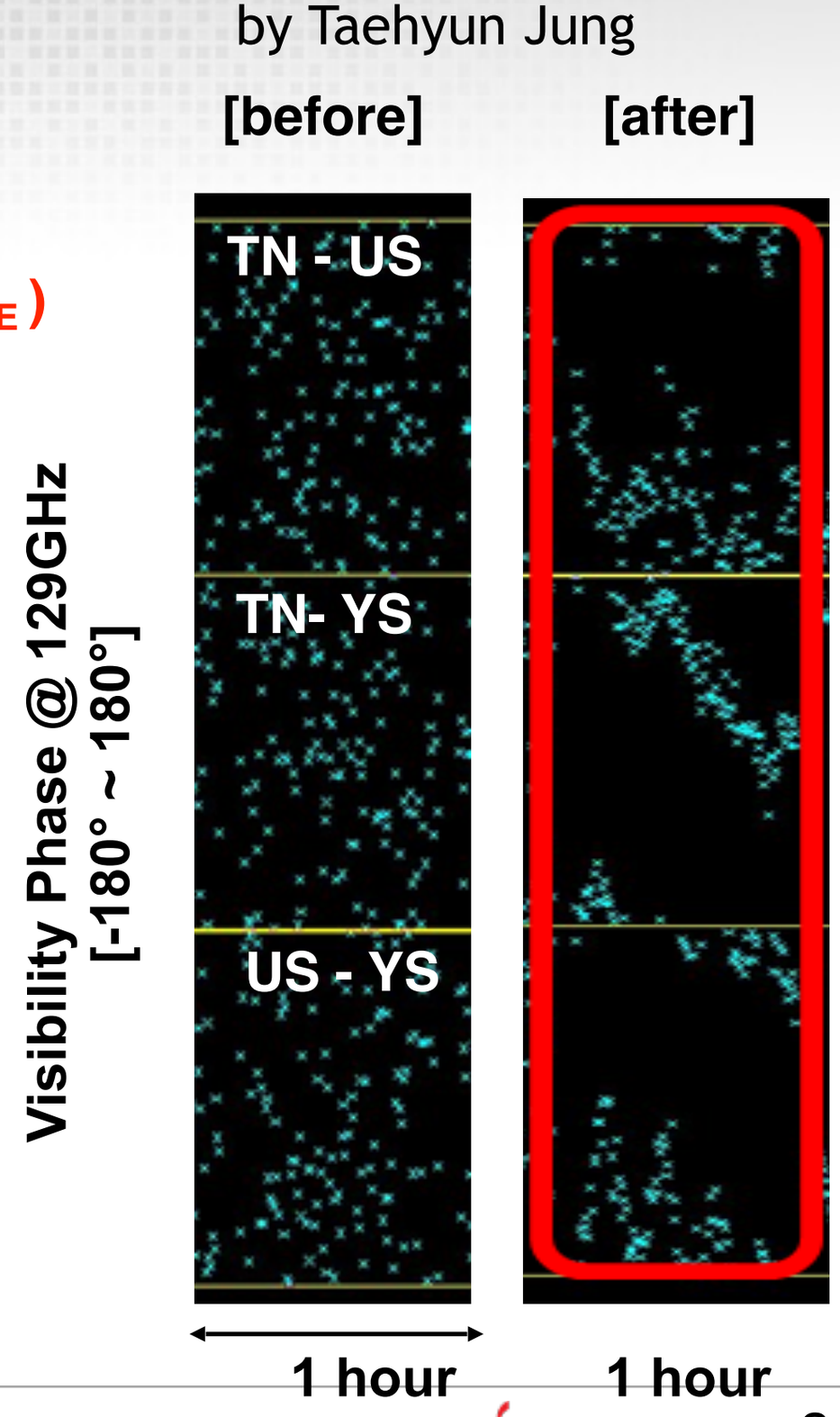
where $R = \nu_{HIGH} / \nu_{LOW}$

non-dispersive behavior of tropospheric phase

$$\Phi_{TRO} - (\nu_{HIGH} / \nu_{LOW})\, \Phi_{TRO} = 0$$

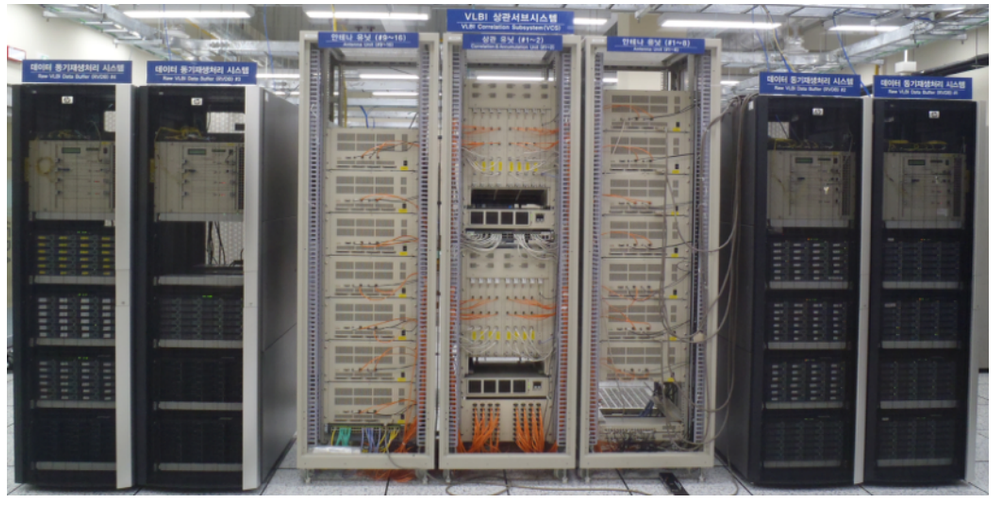
$$\Phi_{129,FPT} = \Phi_{129,OBS} - (\nu_{HIGH} / \nu_{LOW})\, \Phi_{22,OBS}$$

by Taehyun Jung



KaVA (KVN and VERA Array)

- 7 antennas (D ~ 20m)
- Baseline length 300 - 2300 km
- Frequency : 22/43(/86/129)GHz
- Beam Size : 1.2/0.6(/1.5/1.0) mas
- Baseline Sensitivity : 10/20 mJy



Daejeon Correlator
@Korea-Japan Correlation Center

KaVA Large

1. Expanded Study on Stellar Masers (ESTEMA)
   - P.I.: S.-H. Cho (KASI), Hiroshi Imai (Kagoshima Unv.)
2. Exploring the vicinity of supermassive blackhole with KaVA
   - P.I. : B.W. Sohn (KASI), Motoki Kino(Kogakuin Univ.)
3. Understanding high-mass star formation through KaVA observations of water and methanol masers
   - P.I. : K.-T. Kim (KASI), Tomoya Hirota (NAOJ)

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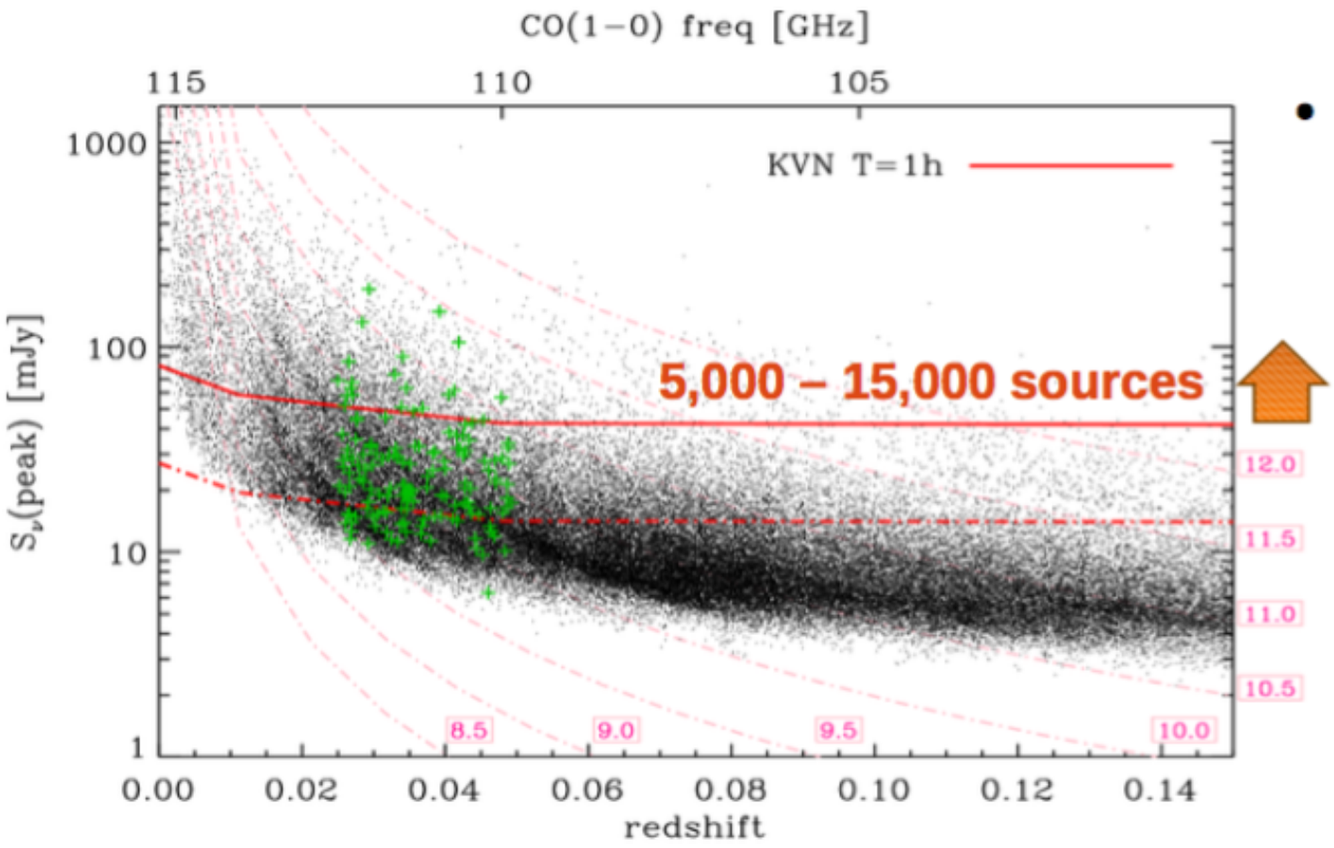

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Example: J0502+1338 KVN single dish flux at 22GHz ~ 0.3 Jy (No SD detection at 43GHz)

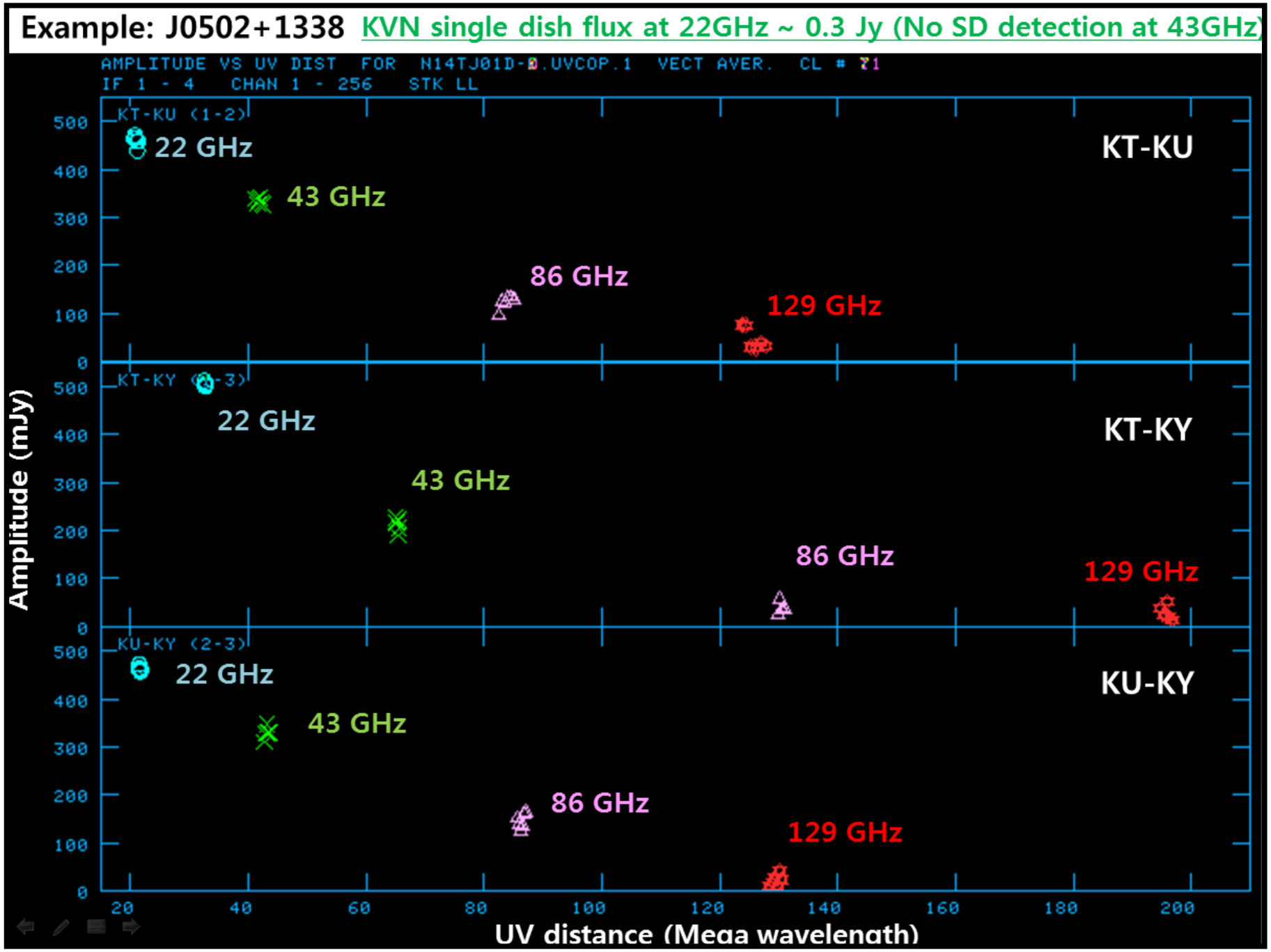
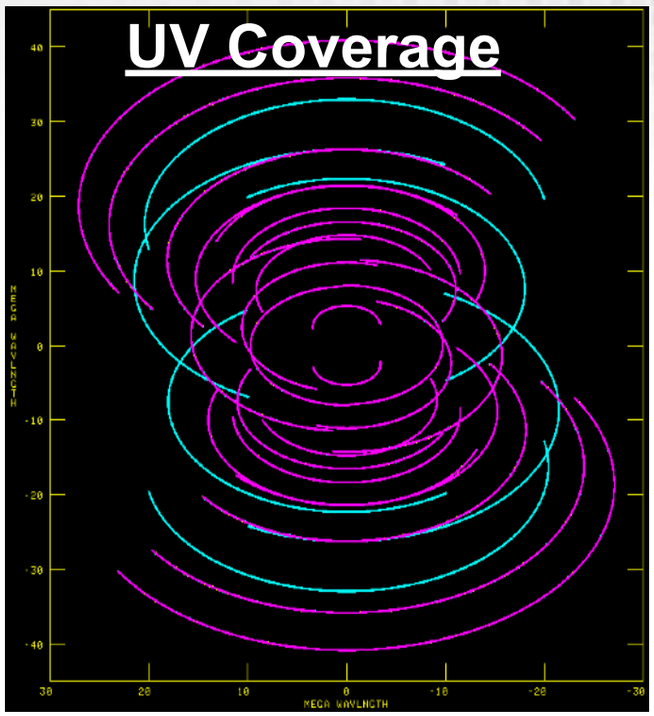
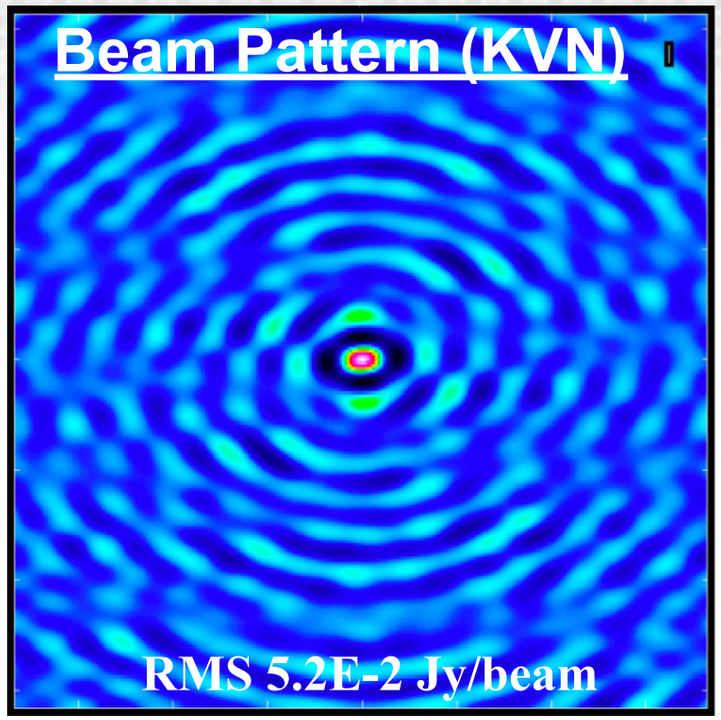
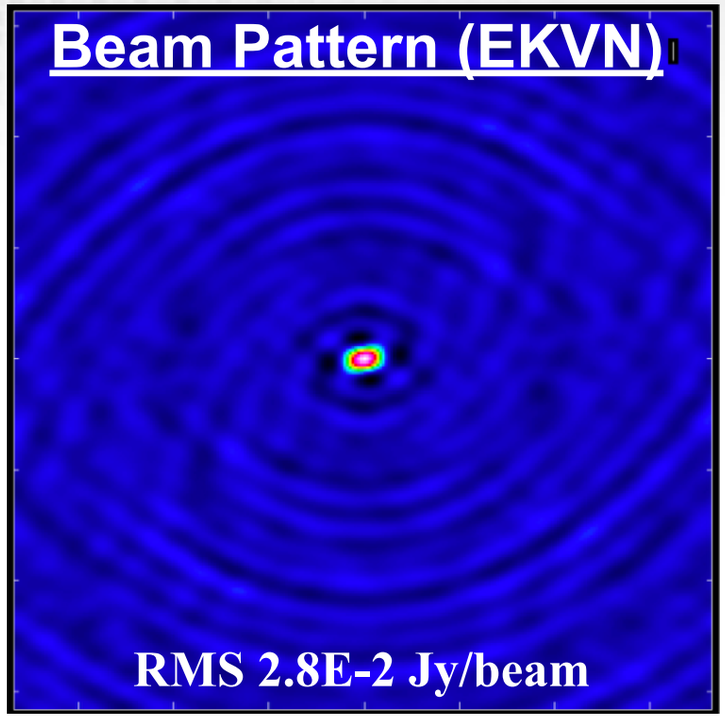


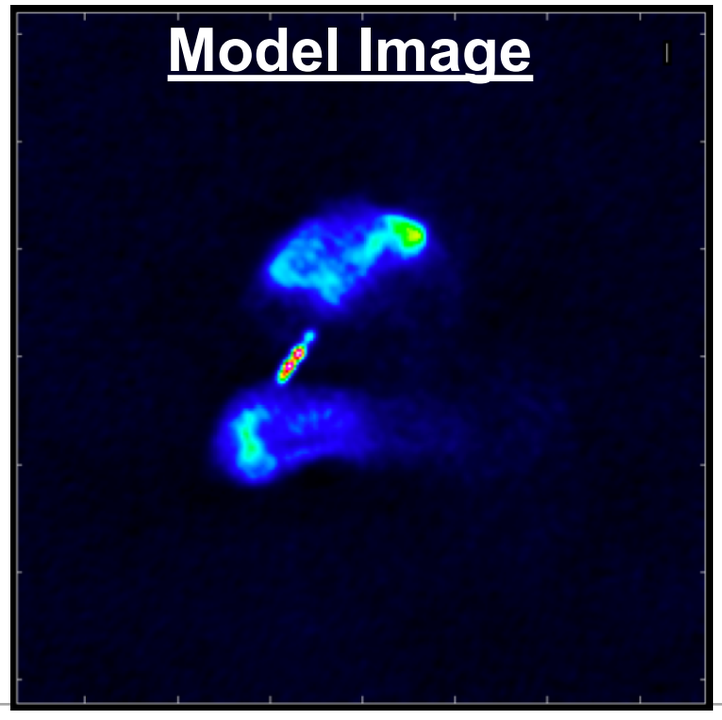
Image Simulation w/ EKVN 6

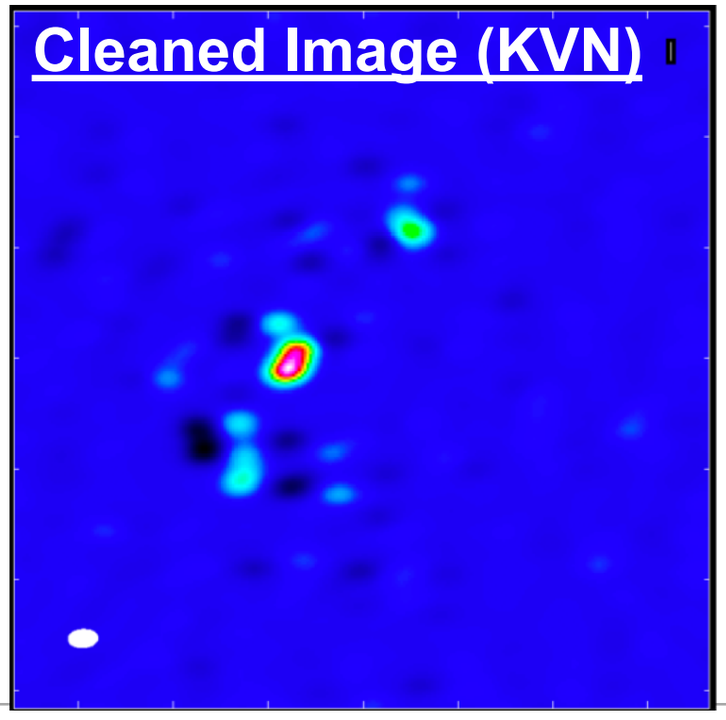
Poster AT-03 by Jung & Byun

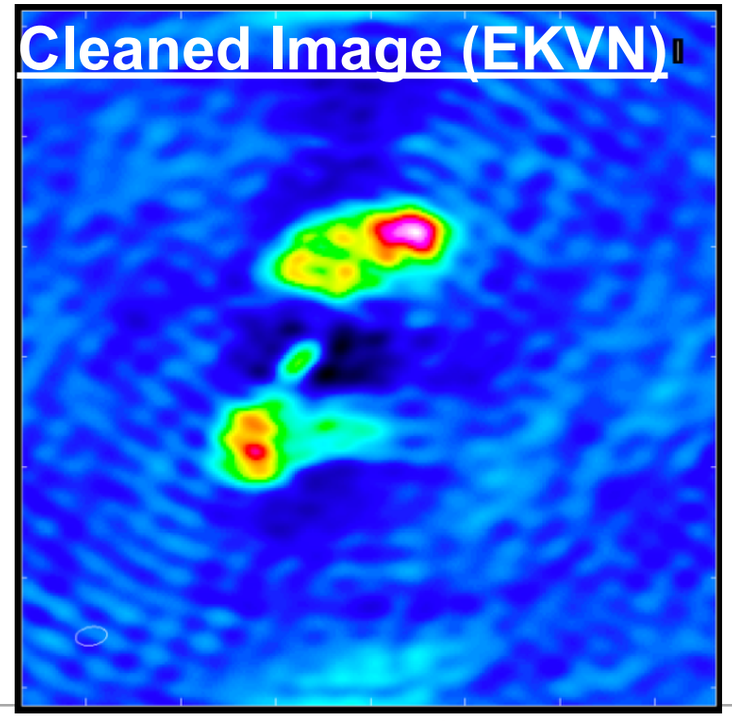












What considered as time domain astronomy?

◎ non-imaging (original definition)

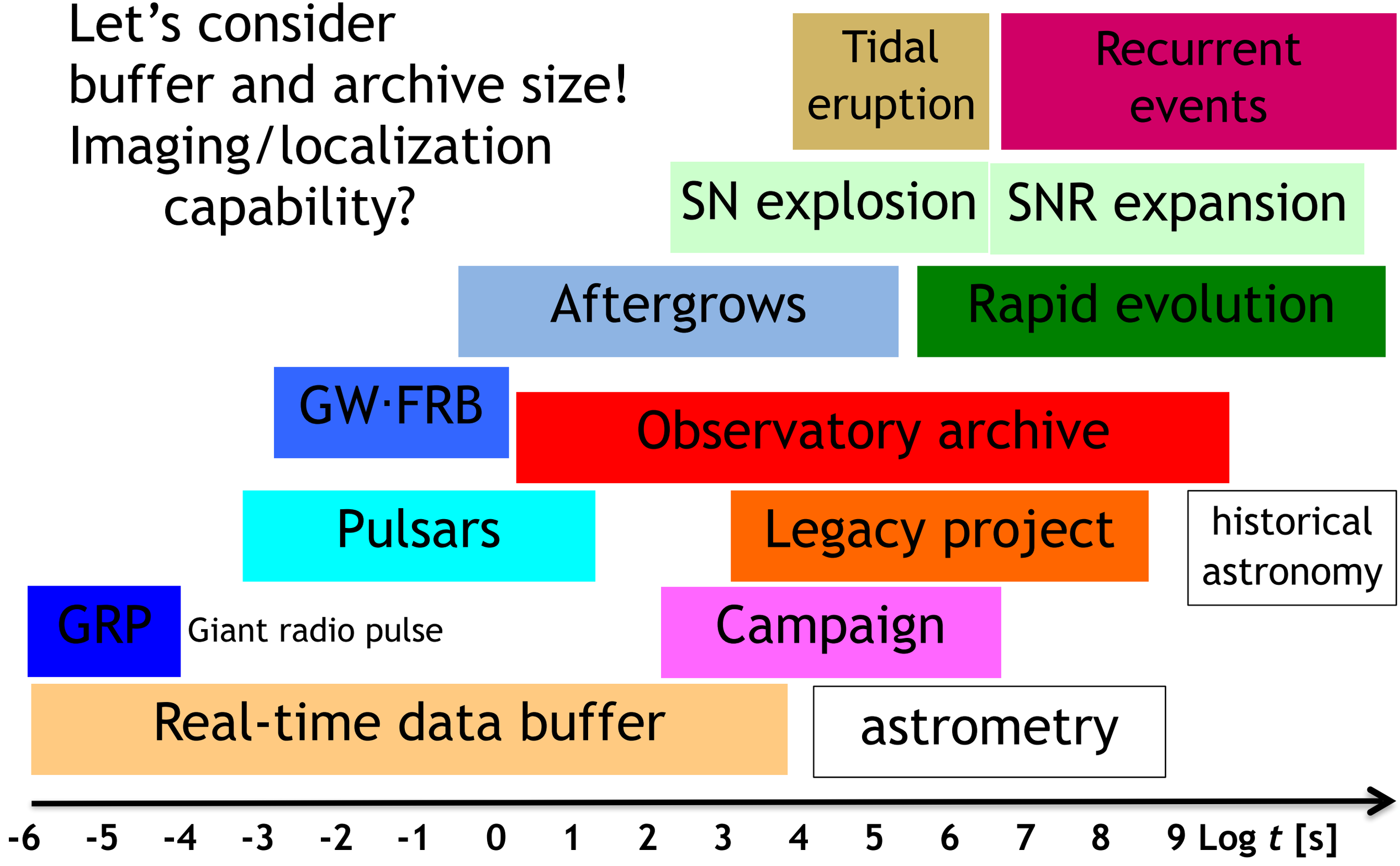
× Multi-epoch observations in a short period
  – e.g. proper motions, orbital motions, annual parallaxes of objects
  – Assuming stable or constant parameters
  – “known known”: known time variation from known objects:
  e.g. stellar pulsation with a known pulsation period and phase

○ Transients (quick events)
  – “Unknown known”: unpredictable time variation from known or identified objects:
  e.g. supernovae, tidal eruption events, FU Orionis-type outbursts
  – “unknown unknown”: unpredictable events from unknown objects:
  e.g. fast radio bursts

○ Evolution (slow events)
  – Very quick (for the object itself) and very slow (for human and observatory) evolution
  e.g. decadal evolution, recurrent events (nova, etc.)

Timescales of time domain astronomy

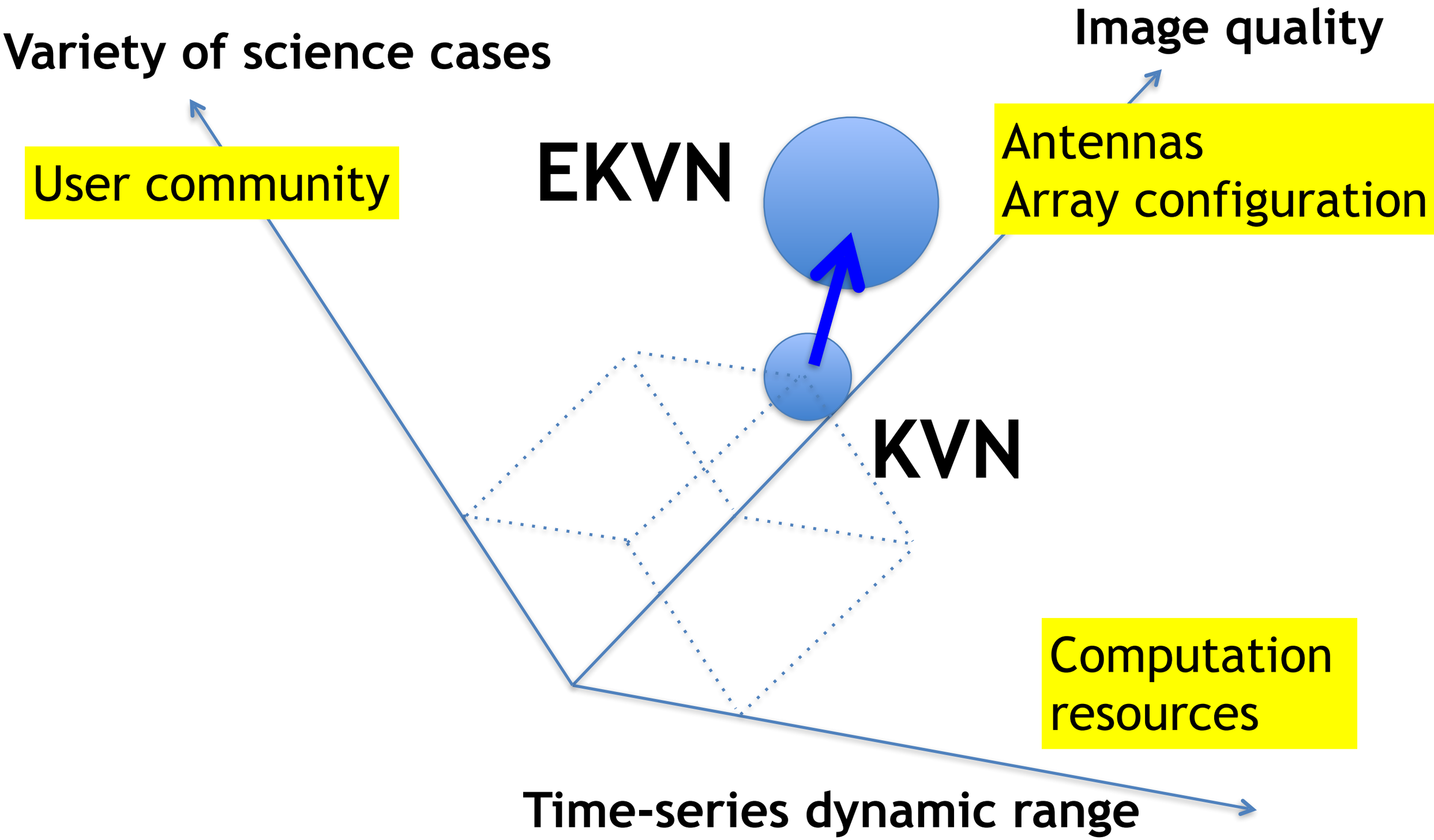
Let’s consider
buffer and archive size!
Imaging/localization
capability?



How to customize to time domain astronomy?

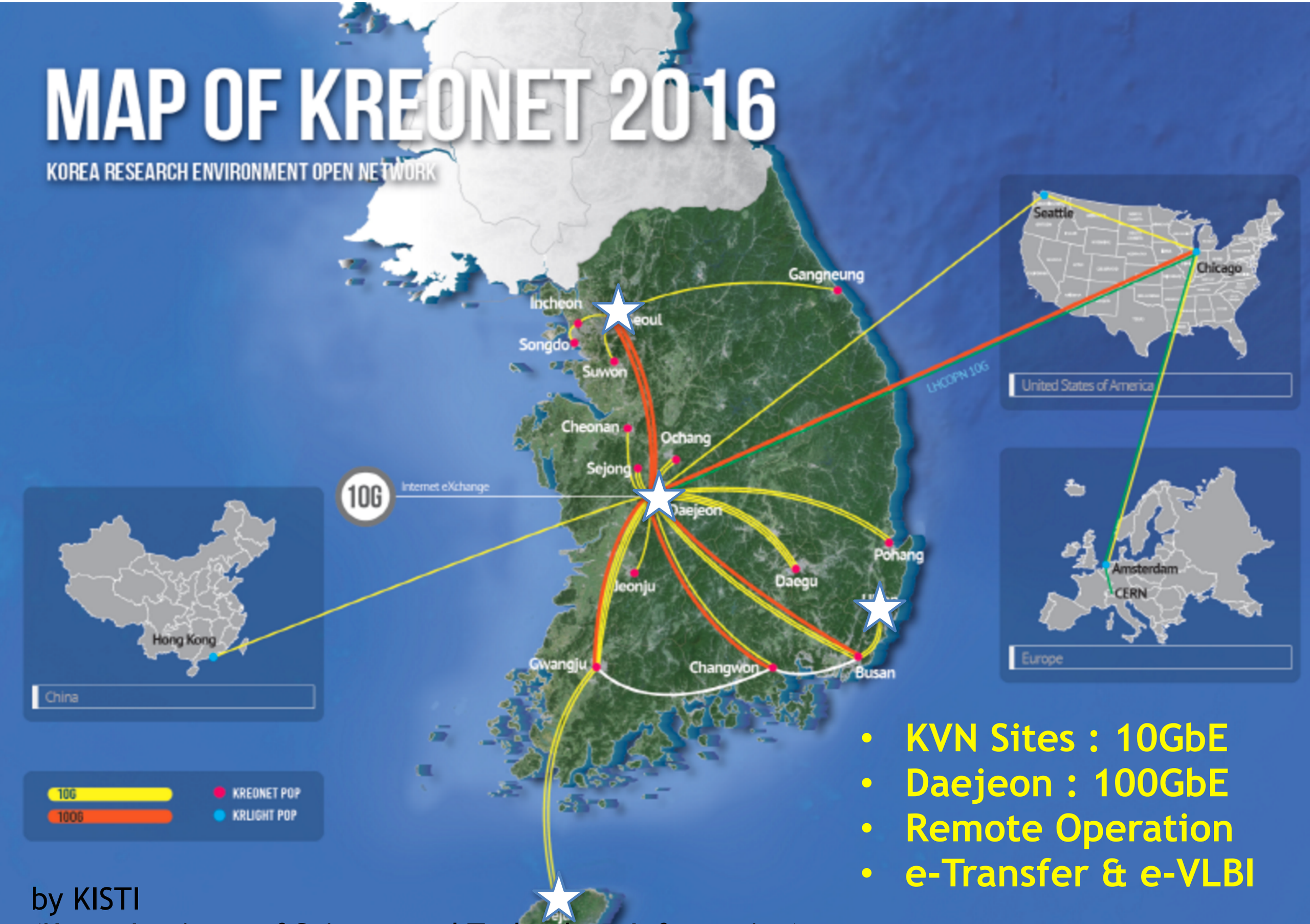
- Telescopes
  - Wide field of view: unlikely at higher frequency and larger dish
  - Quick driving (up to 10 degrees/s ?)
- Signal data buffers and data analysis
  - VLBI recording as buffer+ real-time processing (reduction)
  - Quick localization → automatic pipeline processing (<10^3 s ??)
- Operation
  - Observatory concept
    e.g. RadioAstron archive for repeated correlation processing
  - Dynamic time allocation (long-term)
  - Robotic operation (quick response)
- Software development
  - signal/RFI identification schemes
  - AI applications for source identification and pattern recognition

Where will EKVN go?



MAP OF KREONET 2016

KOREA RESEARCH ENVIRONMENT OPEN NETWORK



- KVN Sites : 10GbE
- Daejeon : 100GbE
- Remote Operation
- e-Transfer & e-VLBI

by KISTI
(Korea Institute of Science and Technology Information)