REPORT OF THE (KQW)-FPT TECHNICAL WORKING GROUP

Helge Rottmann

Max-Planck-Institut für Radioastronomie

FPT TECHNICAL WORKING GROUP

Workshop held in Bonn in 2022
"RADIO ASTRONOMY WITH MULTIBAND RECEIVERS AND FREQUENCY PHASE TRANSFER"

Great FPT work done by various groups already for a long time

…now FPT is turning global!

Science Working Group

- Report available: arXiv:2306.04516 (Dodson et al. 2022)

Technical Working Group

- Currently forming
- FPT-session during GMVA Technical Group (GTG) & EVN TOG joint meeting (Sep 2025)
- Interested persons/parties welcome to join (Email to Helge Rottmann, MPIfR)

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FPT TECHNICAL WORKING GROUP GOAL

Operational (!) goal:

Make KQW-FPT a standard VLBI mode for global mm-VLBI

- Define FPT observing mode(s)
- Work towards technical readiness of array/stations/correlator

FPT REASONING

Impact of troposphere on phase severe at high (mm/sub-mm) frequencies

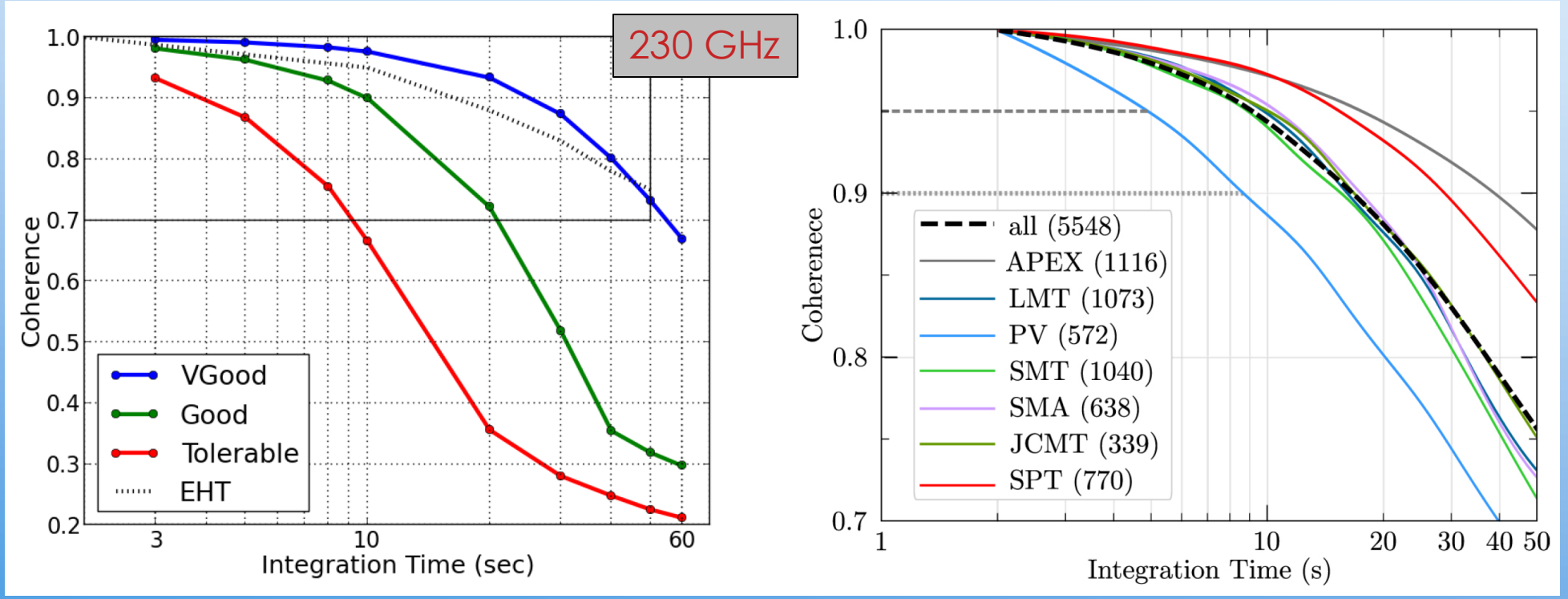
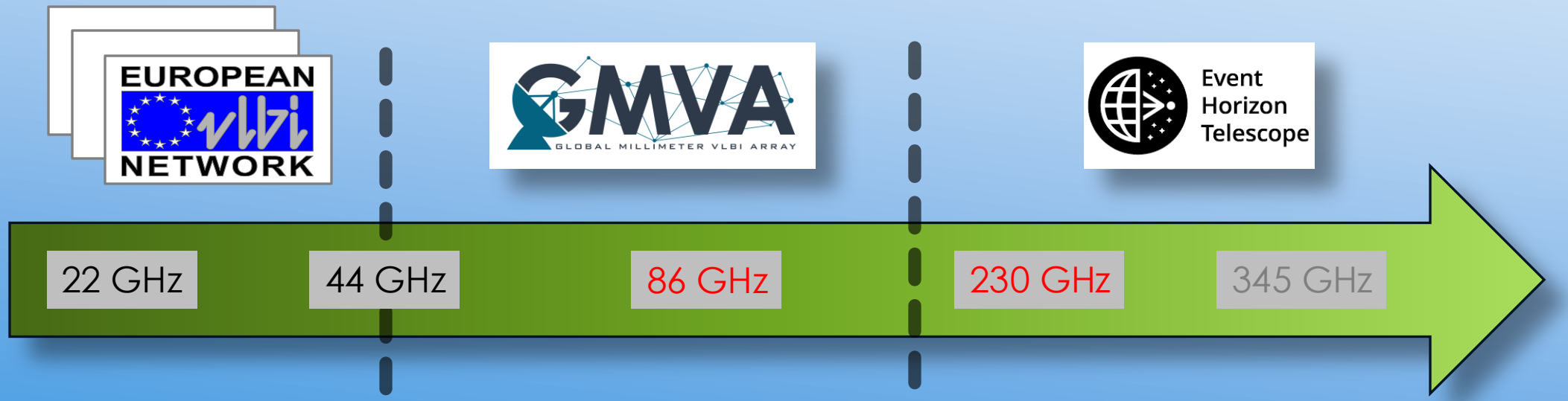


Figure from Rioja, Dodson, Asaki 2022 (https://doi.org/10.3390/galaxies11010016)

@230 GHz: even under ***very good*** conditions coherence times are < 1 min

FPT ACTIVITIES IN THE MM/SUB-MM REGIME

In the mm/sum regime FPT is the most promising approach to significantly increase the sensitivity (order of magnitude)



FPT ACTIVITIES IN THE MM/SUB-MM REGIME

EHT

230 GHz

Up to 11 stations

Event Horizon Telescope

ngEHT (planned)

86, 230, 345 GHz FPT

Telescopes need to be equipped with multi-band receivers

FPT activities

- Technical working group coordinated by S. Issaoun / D. Pesce (CfA)
- First tests carried out (86 => 230 GHz)

FPT ACTIVITIES IN THE MM/SUB-MM REGIME

GMVA

86 GHz & 43 GHz

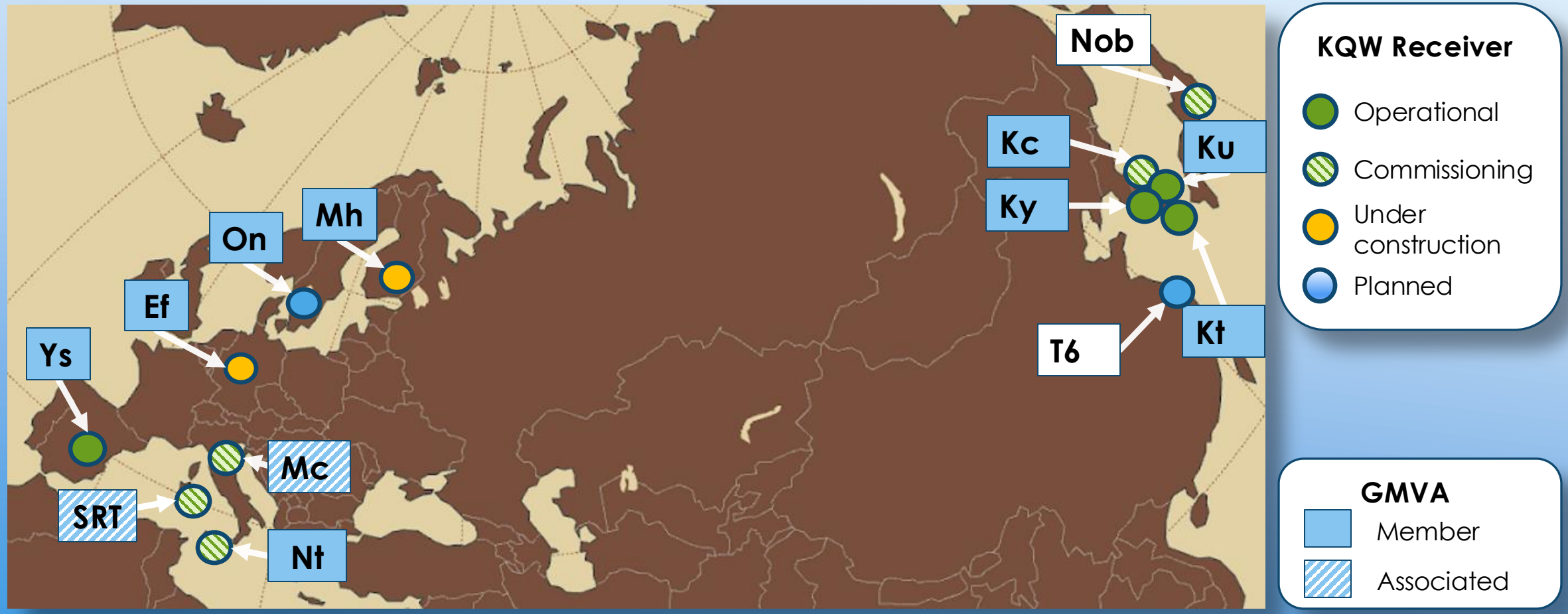
Up to 26 stations

Subset of telescopes are or will be equipped with KQW triple band receivers

FPT activities

- Coordinated by MPIfR
- Technical Working Group forming

KQW-RECEIVER ROADMAP



KQW(D)-RECEIVER TIMELINE

Table 1. Status of existing, planned, and potential future multiband SOP receivers

Antenna	Receiver Band				
	22 GHz	43 GHz	86 GHz	129 GHz	230 GHz
KVN: Yonsei	in operation	in operation	in operation	in operation	*planned*
KVN: Ulsan	in operation	in operation	in operation	in operation	
KVN: Tamna	in operation	in operation	in operation	in operation	
KVN: Pyeongchang	*in 2024/Q3*	*in 2024/Q3*	*in 2024/Q3*	*in 2024/Q3*	*in 2024/Q3*
Sejong	in operation	in operation	*possible*		
Yebes	in operation	in operation	in operation		
ATCA *	in operation	in operation	in operation		
Noto	*in 2023/Q4*	*in 2023/Q4*	*in 2023/Q4*		
SRT	*in 2023/Q4*	*in 2023/Q4*	*in 2023/Q4*		
Medicina	*in 2024/Q2*	*in 2024/Q2*	*in 2024/Q2*		
Effelsberg	*in 2024/Q2*	*in 2024/Q2*	*in 2024/Q2*		
Metsähovi	*In 2026/Q1*	*In 2026/Q1*	*In 2026/Q1*		
Onsala	*design*	*design*	*design*		
Tianma	*planned*	*planned*	*planned*		
Nobeyama	*under tests*	*under tests*	*under tests*		
Mopra	*planned*	*planned*	*planned*		
Pico Veleta	*possible*	*possible*	*under tests*	*possible*	*under tests*
NOEMA	*possible*	*possible*	*possible*	*possible*	*possible*
APEX	*possible*	*possible*	*possible*	*possible*	*possible*
Zelenchukskaya	*possible*	*possible*	*possible*		
Badary	*possible*	*possible*	*possible*		

* - limited frequency range, operating in the paired-antenna mode, using single-band receivers.

- Partially commissioned in 2025
- Commissioning expected to start in summer 2026
- Partially commissioned
- Commissioning starts in fall 2025
- Under construction; expected summer 2026
- Under construction; expected 2026
- Funding secured in Oct 2025

Table from Dodson et al. 2022 (arXiv:2306.04516)

KQW-FPT TIMELINE

Within 2026:
Likely up to 10 stations with working KQW systems

Europe: up to 5 stations (currently 1)
Asia: up to 5 stations (currently 3)

Test observations in 2026

- **Goal:** accommodate FPT tests within GMVA Session II (c262) in Sep. 2026
- Commissioning of European stations until summer 2026 crucial
- Feasibility to be continuously evaluated based on commission progress

TECHNICAL TASKS

Observing Strategy

- Ideally: Exact integer frequency multiples, e.g. 22/44/88 GHz
- Tuning capabilities at stations must be respected
- Avoid water vapor line at 22.24 GHz
- Band widths & polarizations

Station Technical Readiness

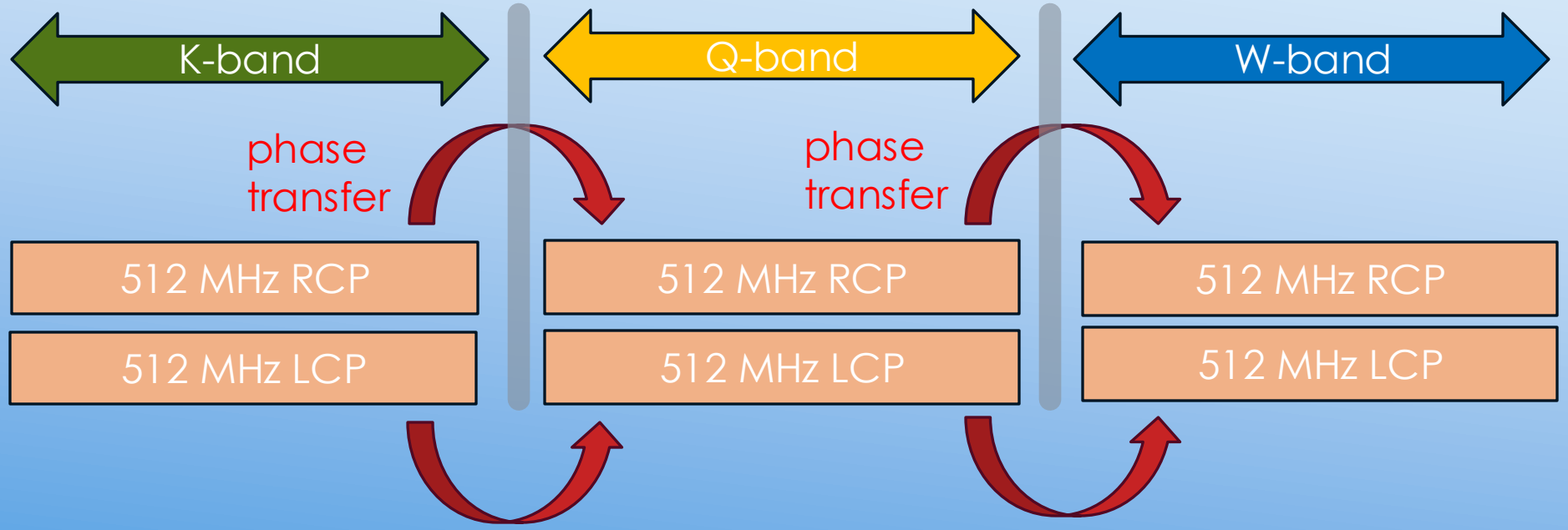
- Backends must support number of used IFs (e.g. KQW, dual pol = 6 IFs)
- Recording speed must match the produced data rates (e.g. 12 Gbps)
- Sufficient recording volume must be available (local storage or disk modules)

Correlator Technical Readiness

- Compute resources match increase in processing volume
- Available man power matches increase in correlation volume
- Sufficient storage volume must be available

PROPOSED OBSERVING STRATEGY

KQW dual-pol @ 12 Gbps



- Recording data rate = 12 Gbps
- Data volume = 130 Tbyte / 24 hrs / station
- Backend IFs = 6

NEXT STEPS

Formalize Technical Working Group

- Mailing list
- Regular meetings

Assess technical capabilities of array, stations & correlator, e.g.

- Frequency capabilities (RX, tuning, band widths)
- Backend capabilities
- Recorder capabilities
- Storage capabilities (stations, correlator)
- Commissioning status of KQW receivers
- ....

NEXT STEPS

Define standard mode for KQW-FPT observations with the GMVA

- Based on technical capabilities of array/stations/correlator
- Identify required technical upgrades at stations (e.g. backends, recorders)
- Coordinate upgrade procedure

Organize test observations

- Based on technical readiness of the array
- Define scheduling strategy
- Provide feedback loop between technical / analyst people

ADDITIONAL CHALLENGES

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Source Structure
- Strategies for source structure removal from phase calibration
- Large overlap with geodetic VLBI community

Proposal & Review
- e.g. NRAO not involved in FPT observations
- KQW spans frequency boundaries of existing arrays

Scheduling
- Sub-Arraying / Only subset of GMVA telescopes support FPT (separate FPT session ?)
- Find suitable sources and observing times with common visibility between Asia and Europe

…probably much more to think about

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Thank you !