Expanding the GMVA with Multi-Band Receivers

Eduardo Ros (MPIfR)

Towards high-performance mm-VLBI science operations with multi-band receivers
Bologna, 28 October 2025

MAX-PLANCK-INSTITUT
FÜR RADIOASTRONOMIE

GMVA officers

USA Scheduler:
Robert Minchin

Earlier: Mark Claussen

European Scheduler:
Eduardo Ros

Earlier: Richard Porcas

Correlator Manager:
Helge Rottmann

Earlier: Walter Alef

Operations Manager:
Thomas Krichbaum

Correlator Support Astronomer:
George Paraschos

Earlier: Yurii Pidopryhora

GMVA (est. 2004) – MPIfR supervising director

Anton Zensus (MPIfR director 1997-2026) at the APEX telescope for the GMVA 2024/II campaign, when the antenna joined the GMVA

Members:

- NRAO (VLBA8+GBT)
- IRAM (30m+NOEMA)
- MPIfR (Effelsberg+APEX)
- Chalmers (Onsala)
- Aalto (Metsähovi)
- KASI (KVN4)
- OAN (Yebes)
- CfA/ASIAA (GLT)
- Soon: IRA-INAF (SRT, Nt, Mc)

Agreement:

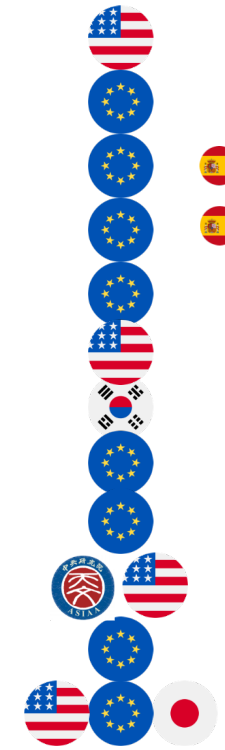
- JAO (ALMA37)

Non-members:

- CSIRO (ATCA+Mopra)
- MIT (Haystack)
- INAOE/UMass Amherst (LMT)
- EAO (JCMT)
- UArizona (KP12m)

GMVA
GLOBAL MILLIMETER VLBI ARRAY

Affiliation



Station name	Diameter [m]	T_{sys} [K]	Gain g_i [K/Jy]	η [%]	SEFD [Jy]
GBT	100	130	0.98	35	133
Effelsberg	80 (eff.)	140	0.14	7.7	1000
NOEMA (12×15 m)	52 (eff.)	70	0.42	70	163
Pico Veleta	30	100	0.15	60	654
Yebes	40	100	0.10	22	990
VLBA (8×25 m)	25	115	0.028	16	4100
KVN (4×21 m)	21	150	0.05	40	3000
Onsala	20	130	0.049	43	2650
Metsähovi	14	150	0.010	18	15000
GLT	12	170	0.032	78	5312
APEX (prelim)	12	170	0.032	78	5000
ALMA (37×12 m)	71 (eff.)	70	1.02	71	69
ARO (prelim)	12	170	0.032	78	5000
ATCA (6×22 m)	47 (eff.)	150	0.12	unk.	1450
Mopra	22	300	0.068	49	4400
LMT (prelim.)	50	200	0.39	55	513
Haystack	37	125	0.16	45	780
JCMT	15	170	0.038	0.60	4475

Equiv. diametre

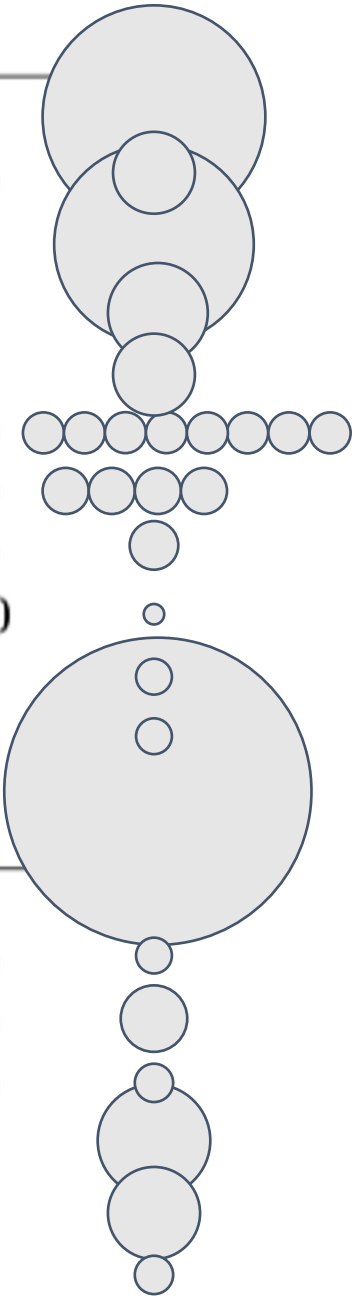


Table adapted from Ros et al. EVN 2024 Proc. pp. 159-168

Proceedings of the 16th European VLBI Network Symposium
Ros, E., Benke, P., Dzib, S., Rottmann, I., & Zensus, J.A. (eds.)
September 2nd-6th 2024, Bonn, Germany

The Global Millimetre VLBI Array

Current Capabilities and Future Enhancements

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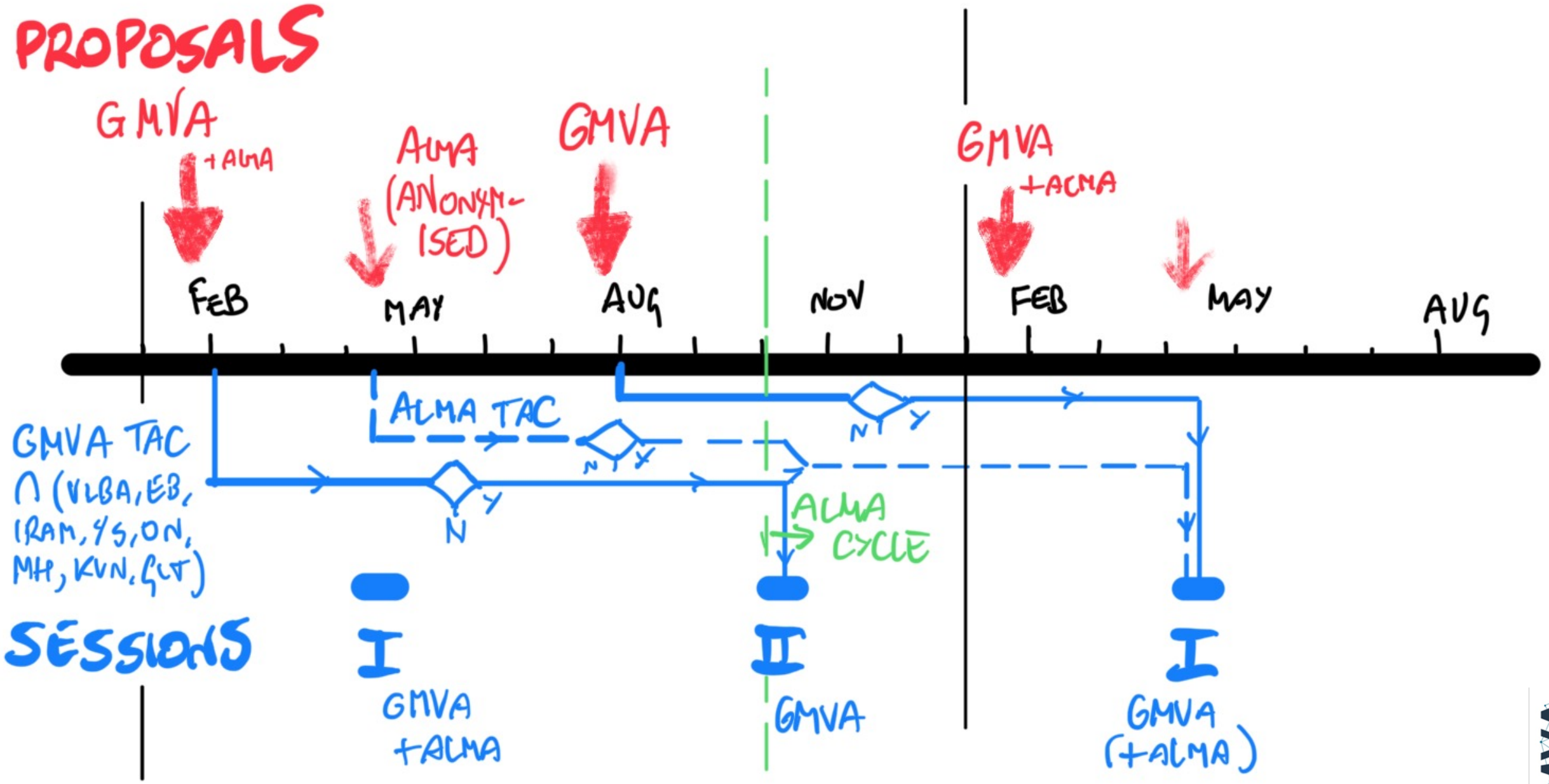
Abstract. The Global Millimetre VLBI Array (GMVA) is a high-resolution, high-sensitivity radio astronomical instrument operating at millimetre wavelengths. The GMVA, leveraging the phased ALMA and additional continental and global arrays, has recently achieved significant advancements in sensitivity and resolution. This paper presents the current capabilities of the GMVA, explores recent scientific achievements, and discusses ongoing enhancements to hardware and calibration techniques, aiming towards the next-generation very long baseline interferometry (VLBI) with the inclusion of future arrays such as the ngVLA.

Present status

- Operations based on a Memorandum of Understanding
  - 4 Gbps obs. at VLBA8+IRAM*+Eb+Mh+On*+Ys*+KVN4* + GBT (limited time) +GLT*+ALMA*+**APEX***
  - Temporary additions: LMT*, JCMT*, Haystack*, Mopra*, ATCA
  - Correlation at MPIfR

*: 16 Gbps available

- Open-sky policy, proposals via NRAO-PST (01feb, 01aug)
  - Proprietary period of 1yr, data archived at MPIfR and NRAO
- Two sessions per year (apr+oct)
- No dedicated funding, in-kind contribution by partners
  - Media provision, session planning, scheduling by MPIfR
- Moderated frequency agility (84-104 GHz) & 43 GHz interleaved (VLBA+Ys+Nt+*KVN4*), *also time agility, off-session VLBA+Eb, HSA, adhoc*


PROPOSALS
GMVA
+ALMA
ALMA
(ANONYM-
ISED)
GMVA
GMVA
+ACMA
FEB
MAY
AUG
NOV
FEB
MAY
AUG
GMVA TAC
∩ (VLBA, EB,
IRAM, YS, ON,
MH, KVN, GLT)
ALMA TAC
N
Y
N
Y
N
Y
ALMA
CYCLE
SESSIONS
I
II
I
GMVA
+ALMA
GMVA
GMVA
(+ALMA)

Some statistics of the last sessions

Boldface: ALMA requested

Call	Deadline	Submitted	GMVA rejected	GMVA accepted, ALMA rejected	Scheduled (all accepted)
23B	Feb23	13 = **8**+5	4 (31%)	**5** (38%)	**3**+1 (31%)
24A	Aug23	5	2 (40%)	---	3 (60%)
24B	Feb24	15 = **7**+8	4 (31%)	**5** (33%)	**2**+4 (40%)
25A	Aug24	4	1 (25%)	---	3 (75%)
25B	Feb25	19 = **10**+9	6 (32%)	**7** (37%)	**3**+3 (32%)
26A	*Aug25*	*7*			

Some statistics of the last sessions

Call	Deadline	GMVA rejected	GMVA accepted, ALMA rejected	Scheduled (all accepted)
23B	Feb23	102*/MB020, 112/MY001, 133/MR015, 247/MA012	**53/MK026, 134/MJ006, 212/MB022, 213/MR016, 237/MK029**	**67/MP010, 68/MT005, 152/MG010,** 167/MK027
24A	Aug23	224/MV005, 250/MK030	---	150/MX001, 297/MR017, 384/MW001
24B	Feb24	192/MB023, 198/MB025, 226/MK031, 317/ML013	**165/ML012, 321/MR029, 356/MB026, 376/MK032, 422/MB027**	43/MP012, **54/MJ008,** 138/MV007, **153/MP014,** 360/MN005, 371/MR020
25A	Aug24	193/MK003	---	145/MP015, 154/MH007, 194/MK034
25B	Feb25	226/MY002, 227/MY003, 296/MT009, 298/MH008, 312/MS006, 361/ML005	**76/MJ009**, **124/MT006**, **149/MM019**, **153/MR023**, **256/MB028**, **273/MS005**, **350/MY004**	17/MK035, **57/MK036**, **59/MK037**, 183/MR025, **200/ML014**, 348/ME001
26A	*Aug25*	*Under evaluation: 164/MM021, 228/MY008, 229/MY009, 318/MH009, 344/MC005, 450/ML016, 535/MS007*		

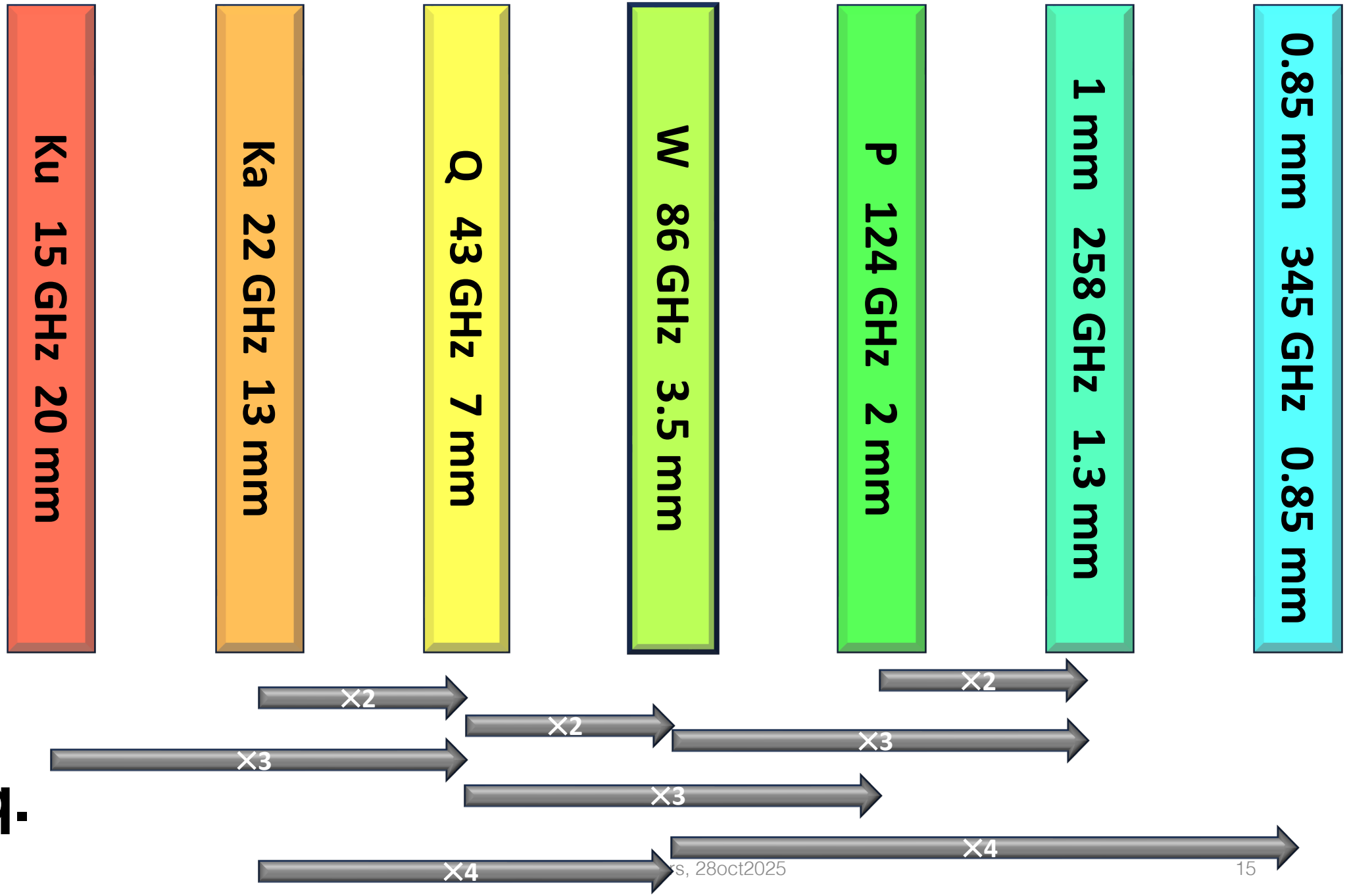
Boldface: ALMA requested

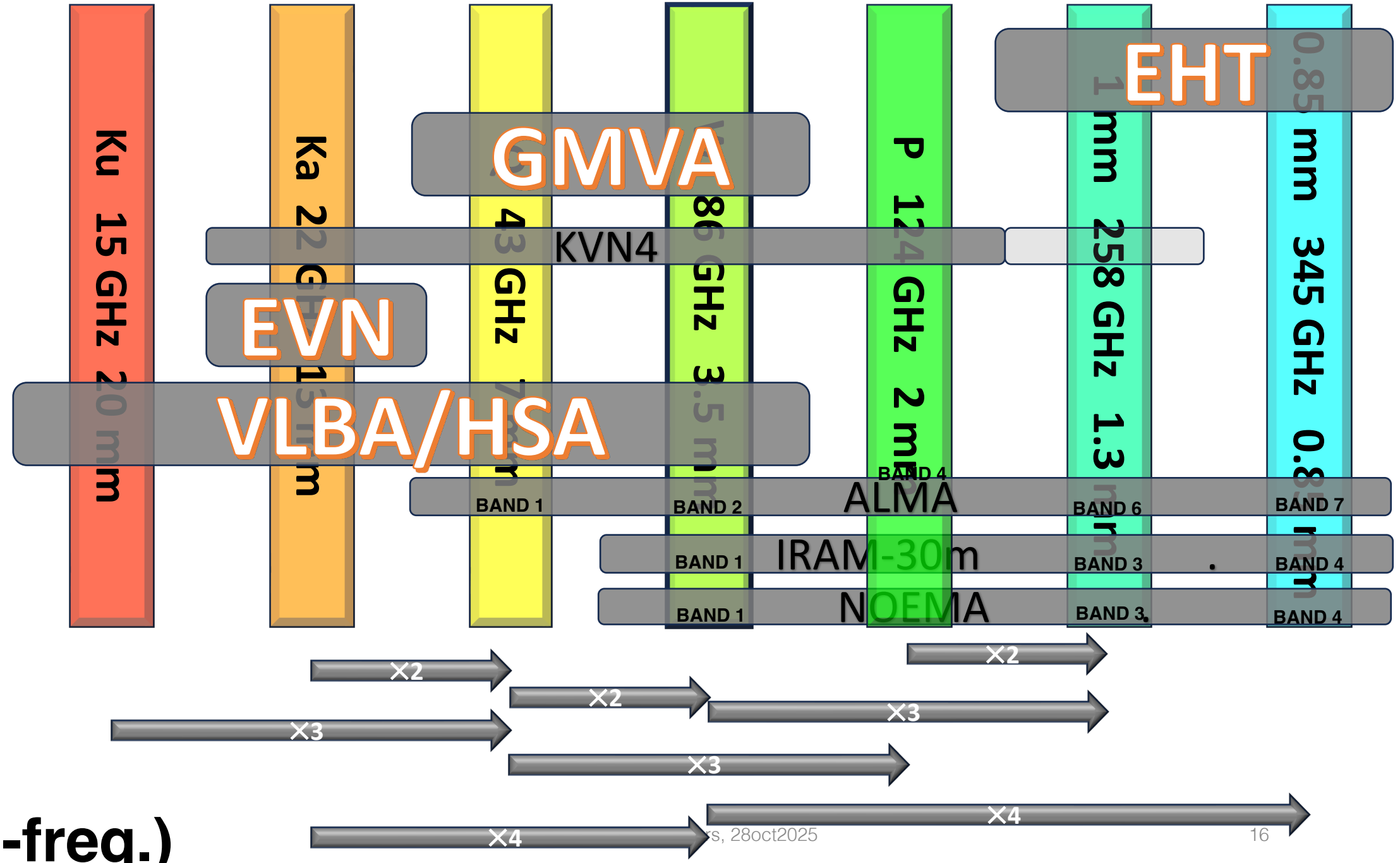
*: the full proposal code is GMVA-23B-102

Present progress

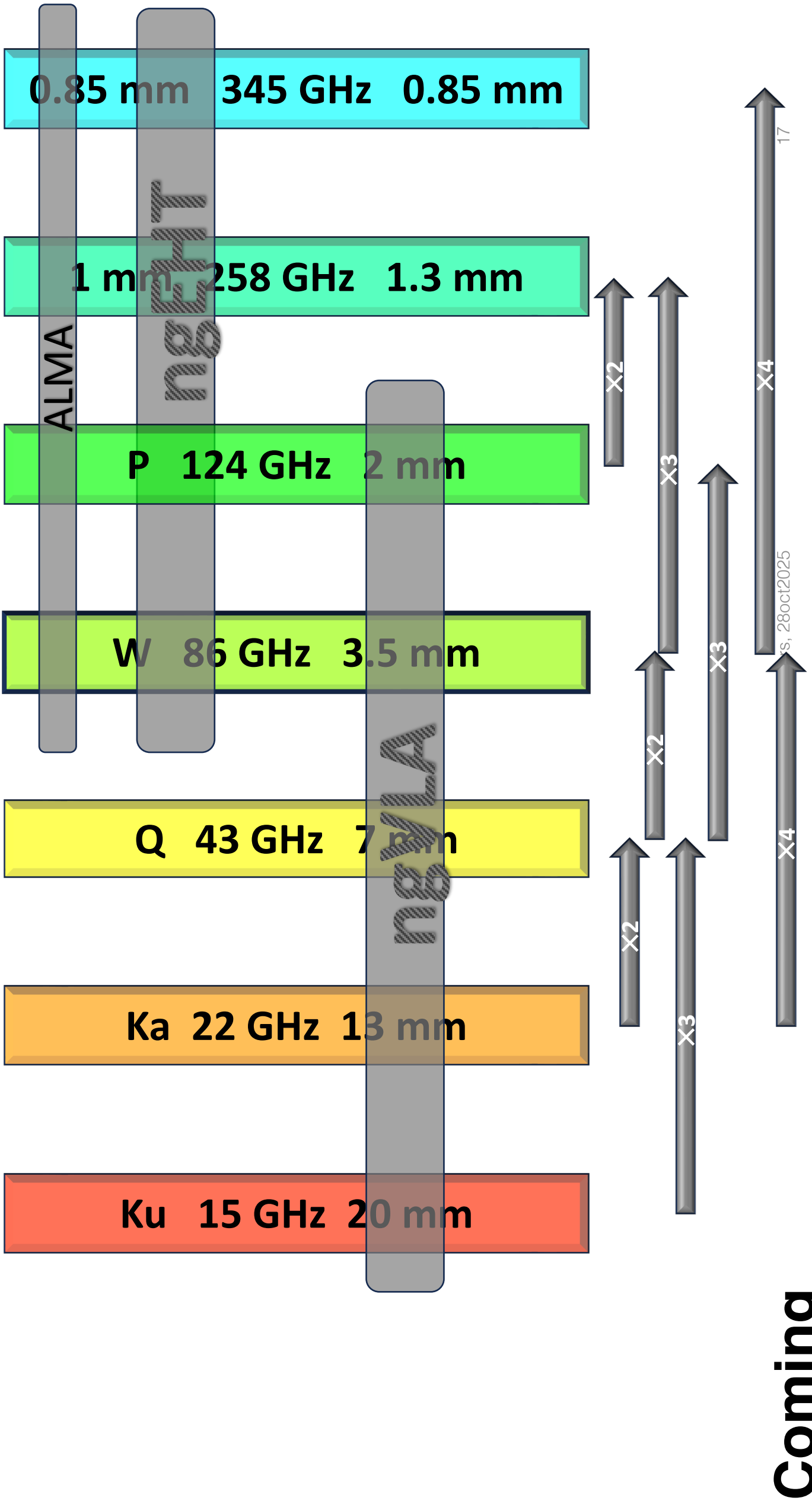
- GMVA smooth operations including phased ALMA (April sessions)
- New antennas joining GMVA (APEX, KVN-Py, Mopra, ATCA, LMT, Haystack, JCMT)
- GMVA at 4 Gbps with selected antennas 16 Gbps (cf. EHT 64 to 128 Gbps)
- Calibration and analysis enhancements: rPICARD, Bayesian imaging, etc.
- Promise of new antennas (Africa Millimeter Telescope, Tenerife EHT Antenna, Wetterstein Millimetre Telescope)
- GMVA FPT subarray: KVN; deployment of 3-band receivers at Effelsberg, Yebes, Onsala, Metsähovi, and IRA/INAF (SRT, Noto, Medicina)

High-freq. bands

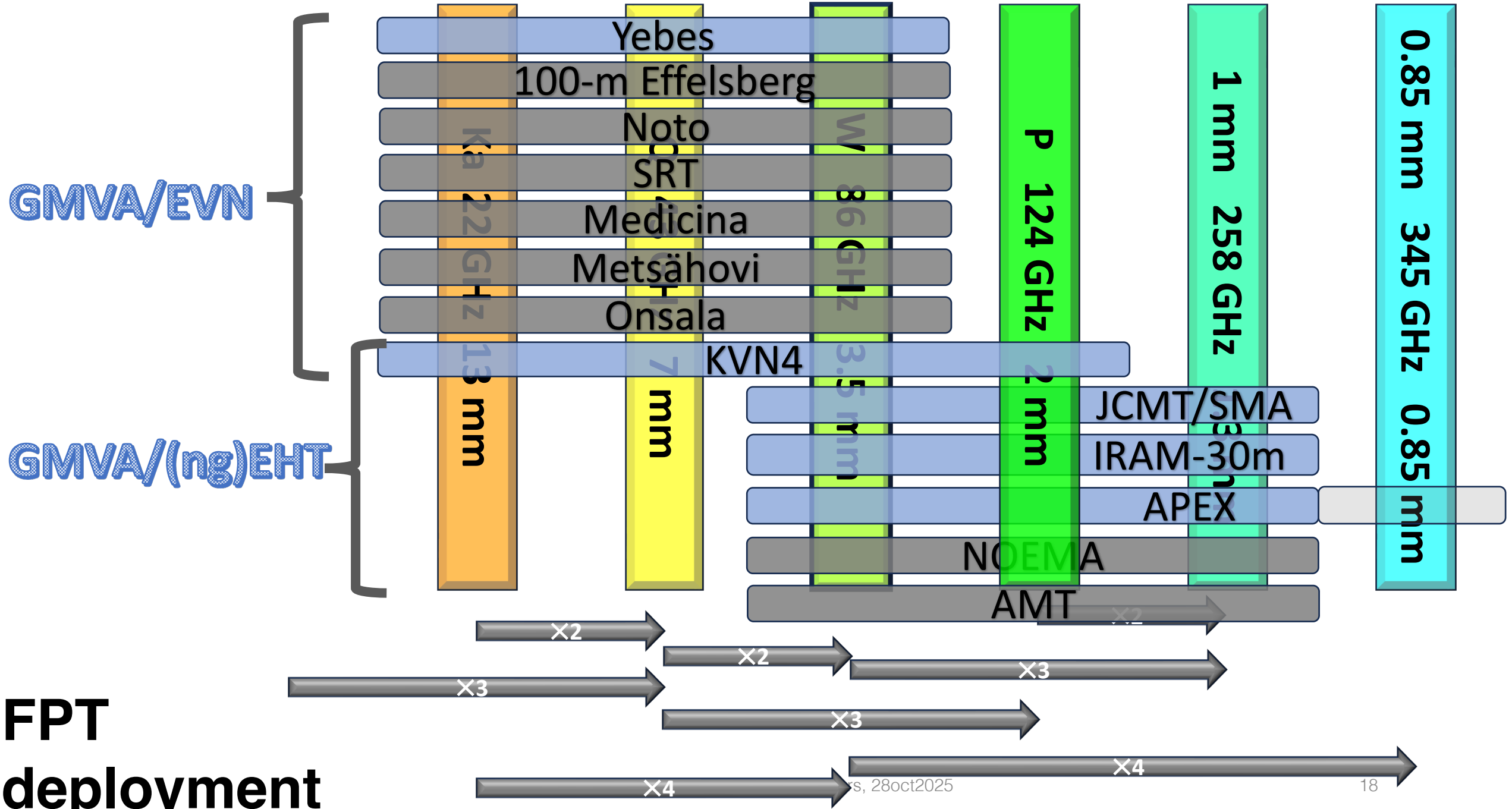




NOW
(single-freq.)


0.85 mm 345 GHz 0.85 mm
1 mm 258 GHz 1.3 mm
P 124 GHz 2 mm
W 86 GHz 3.5 mm
Q 43 GHz 7 mm
Ka 22 GHz 13 mm
Ku 15 GHz 20 mm
ALMA
n8HT
n8LA
X2
X3
X4
X2
X3
X4
X2
X3
17
s, 28oct2025
Coming

FPT deployment



Next steps to discuss

- Frequency definition
  - KQW at 4 Gbps each → 3 × 2 IF = 6 IF (512 MHz each, 2-bit, dual-pol, total 12 Gbps)
  - P at KVN potentially to be added (4 × 2 IF = 6 IF 8 IF, total 16 Gbps)
- GMVA:
  - Tuning the call for proposals for subarray, maybe also sessions
  - FPT-capable array tests at KQW with the enhanced Eurasian array for 2026/II or 2027/I sessions
- 86/258 GHz: further tests for observation plan enhancement
  - See Zhao's talk

Emerging science opportunities at mm-VLBI

- **Transient** phenomena and multi-messenger follow-ups
- Studies of **radio qui**et galaxies and galactic objects
- Precise **astrometric** measurements
- Investigations of **opacity** and **polarised** emissions close to jet bases
- Insights into the strength and orientation of **magnetic fields** near the event horizon
- Spectral line analysis, and much more…

Thank you!

Images created by ChatGPT with a prompt by Eduardo Ros