IRAM 30m Front-ends

Present and future

Carlos A. Durán // IRAM / Granada

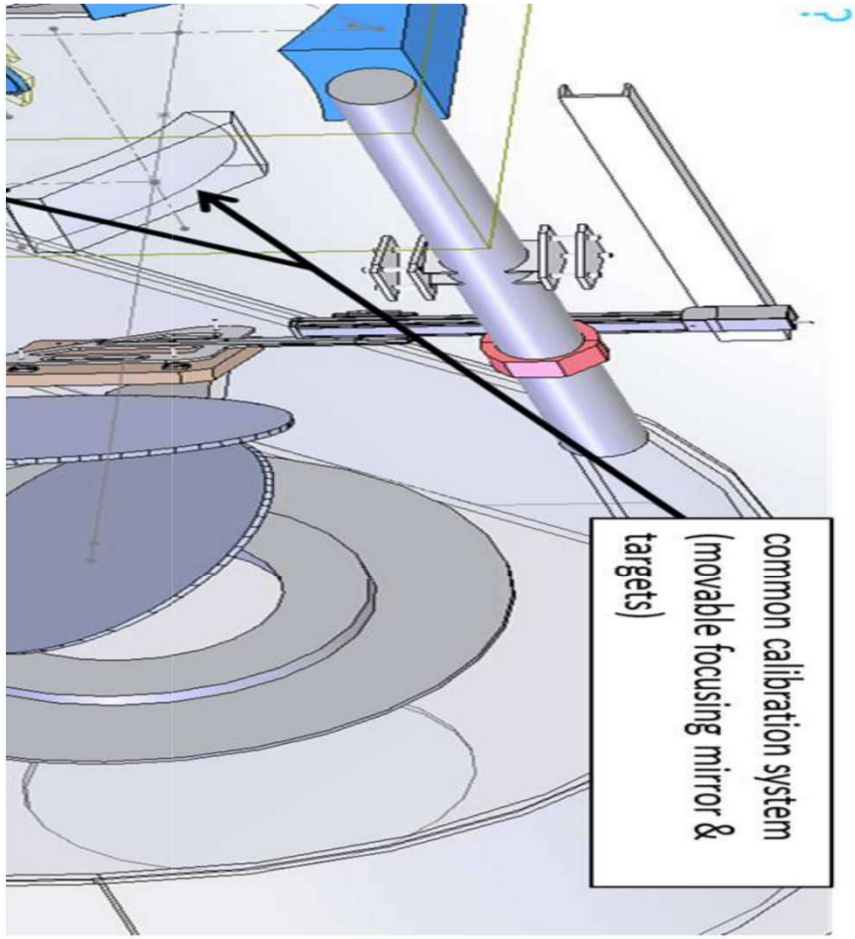
Current instrument configuration at 30m

There are two heterodyne receivers and one continuum camera installed at the 30m, in the RX cabin (Nasmyth focus – cabin remains static).

EMIR
Multicolor RX

HERA
Multipixel RX

NIKA2
Continuum camera



Cabin optics is mostly flat mirrors, with M3 corotating with Elevation of the telescope.

EMIR: the Eight MIxer Receiver

Four color single pixel dual pol 2SB RX.

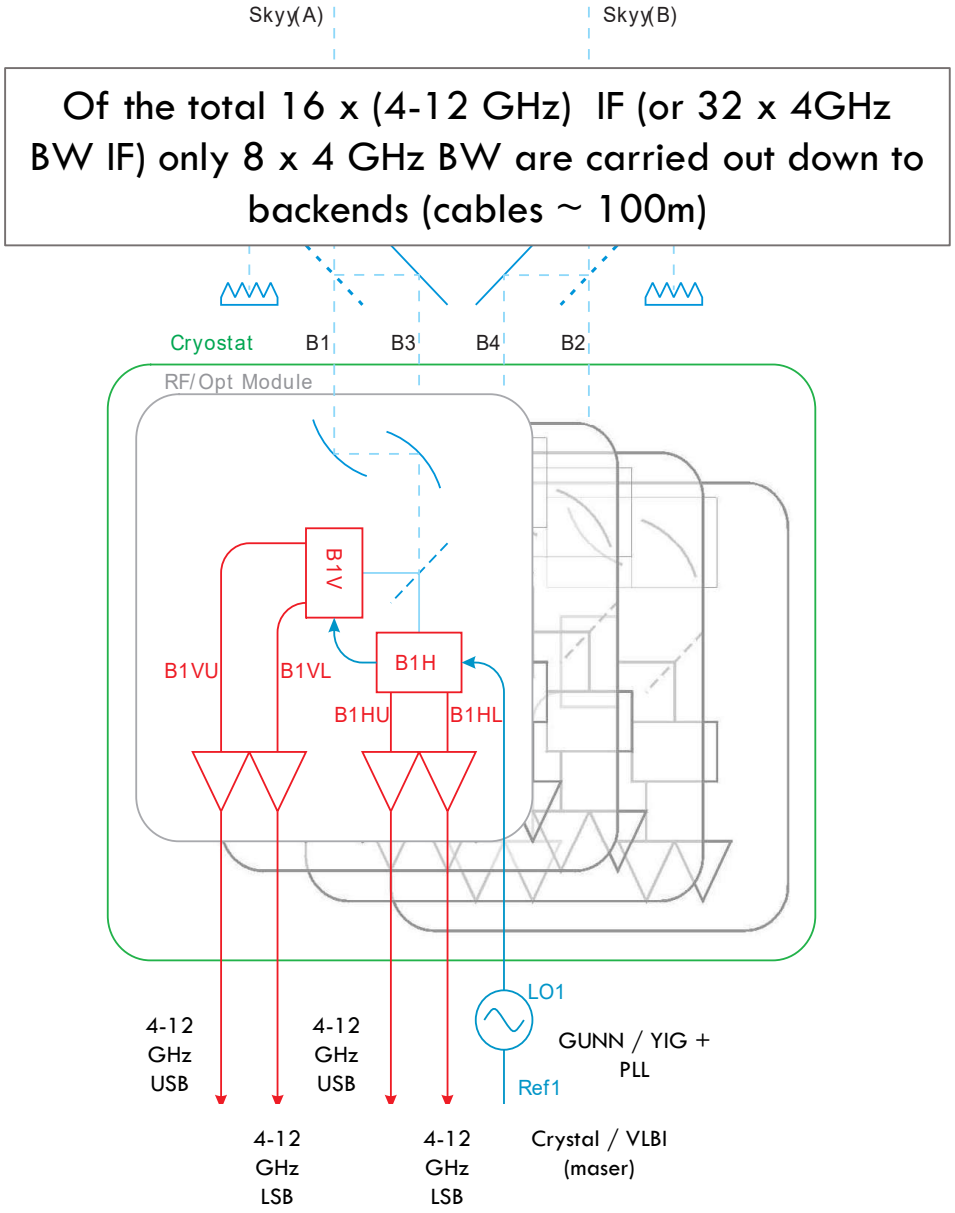
EMIR band	Alias	Sky Frequency GHz	Trx K	mixer type	Pol	IF width GHz	Image Rej. dB	Combinations			Trx K	LO type	Remarks
								E0/2	E1/3	E0/1			
E0 / E090	Band 1	**73-117** LSB: 73-97 (102) USB: 89-117	50	2SB	H/V	8	>10	X		X	65	GUNN + PLL	
E1 / E150	Band 2	**125-184** LSB: 125-168 USB: 141-184	50	2SB	H/V	8	>10		X	X	65	GUNN + PLL	
E2 E230	Band 3	**202-274** LSB: 202 (LO) - 263.5 (LI) USB: 217 (UI) - 274 (UO)	80	2SB	H/V	8	>10	X			95	GUNN + PLL	
E3 / E330	Band 4	**277-350 (375)** LSB: 277-335 USB: 293-350 (375)	80	2SB	H/V	8	>10		X		95	YIG + PLL	ALMA Band 7 mixer

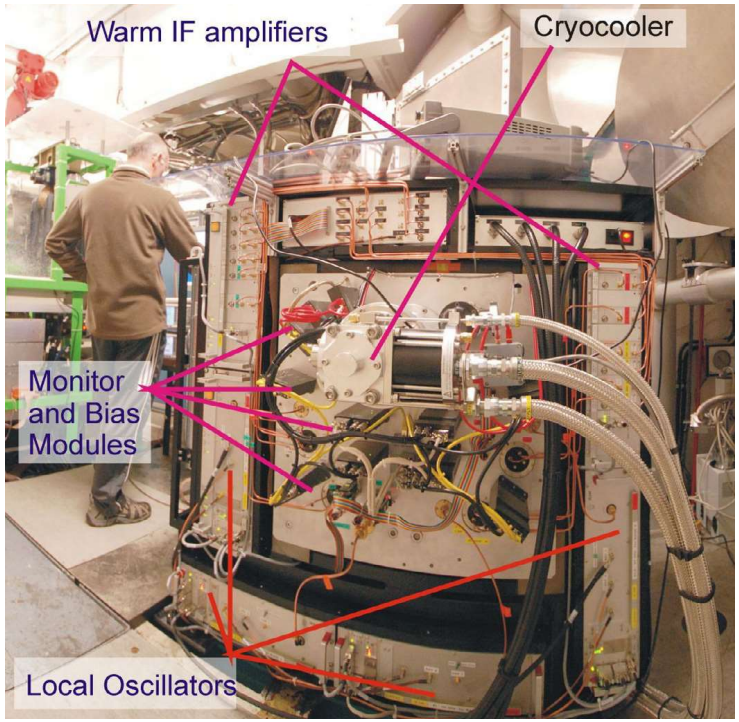
Full details: https://publicwiki.iram.es/EmirforAstronomers

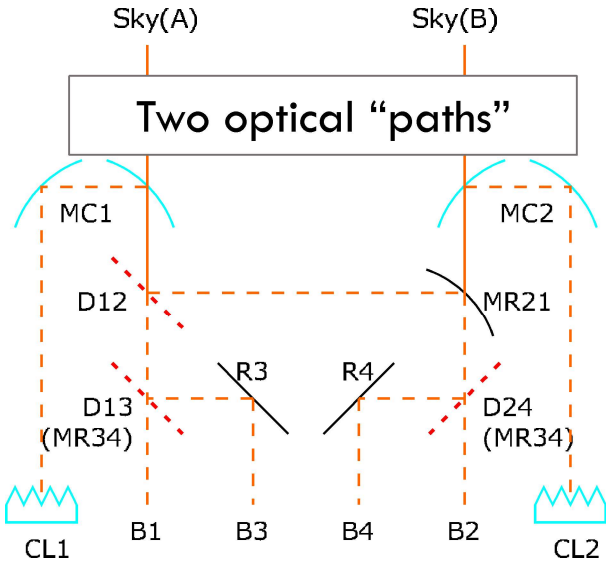
- EMIR is an IRAM workhorse.
- In continuous service since 2011* (with upgrades)
- There are plans for upgrades on EMIR key electronics, control computer and optics.

EMIR: the Eight MIxer Receiver

Four color single pixel dual pol 2SB RX.



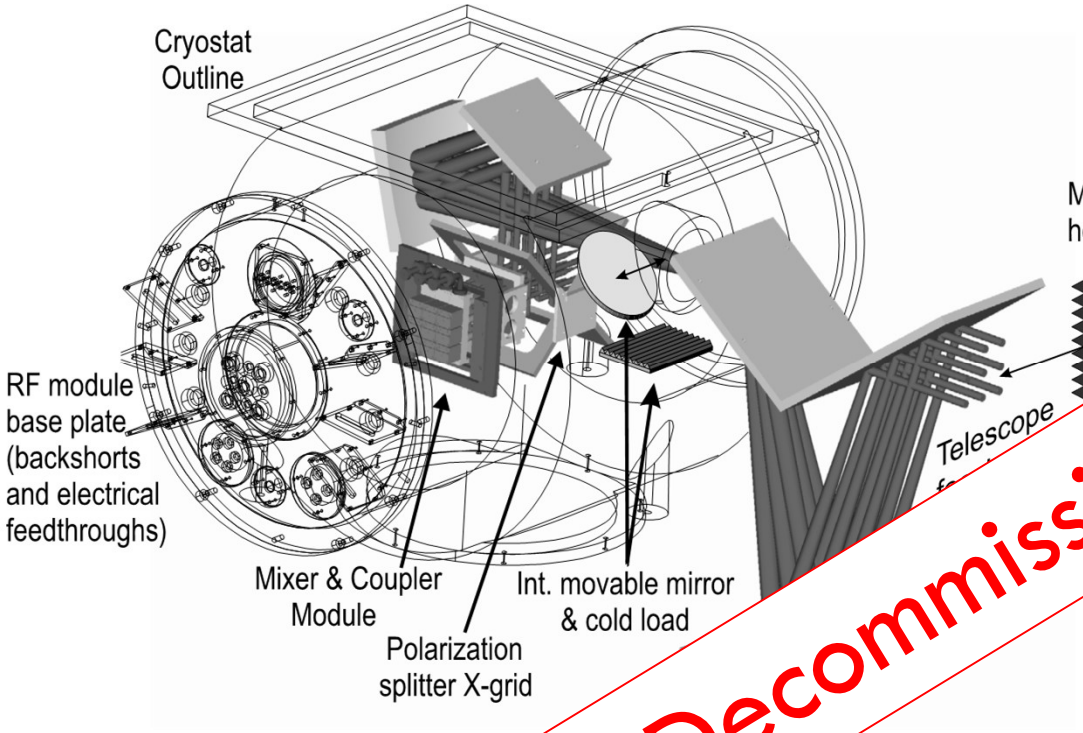


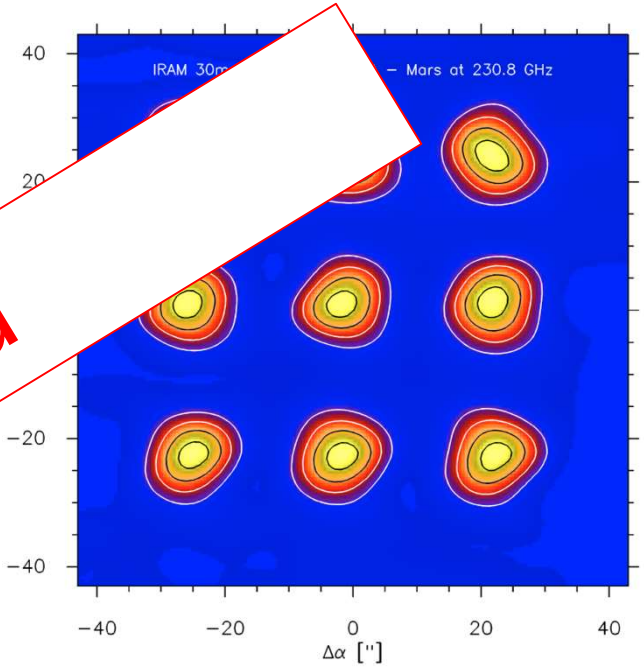


Optical combinations (table previous page)

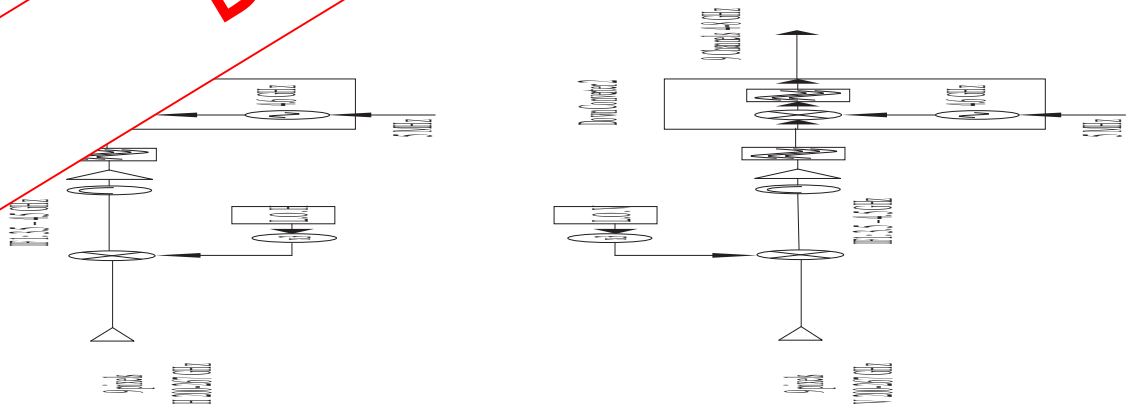
HERA: HEterodyne Receiver Array

9-pixel dual pol heterodyne RX at 230 GHz



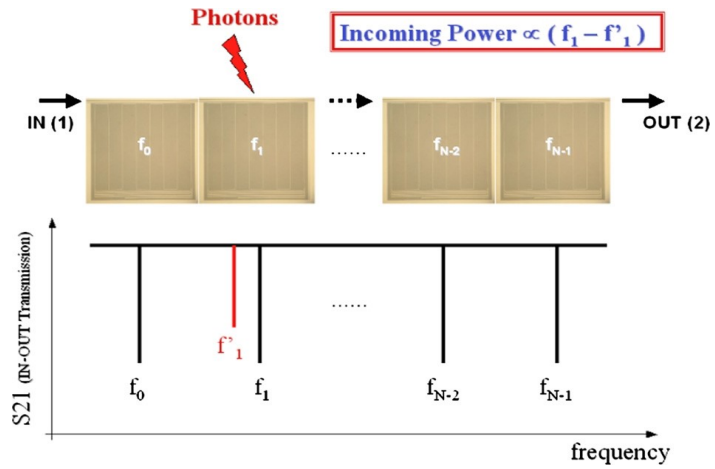


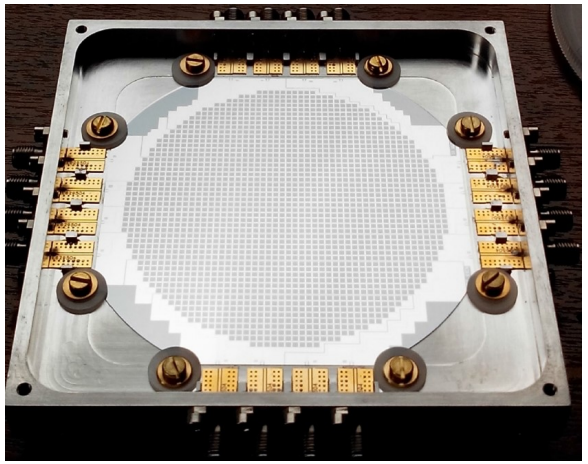
Decommissioned



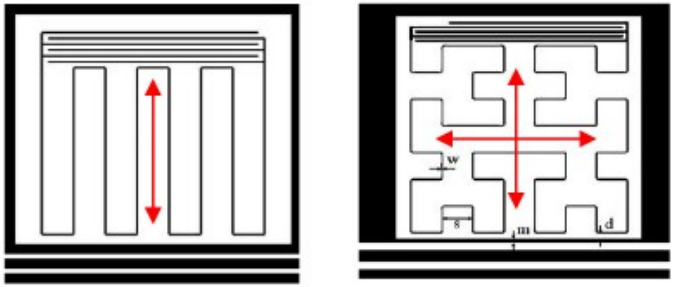
NIKA2: New IRAM KID Arrays 2

Multicolor Kinetic Inductance Detector based camera





1020 pixel array of NIKA2



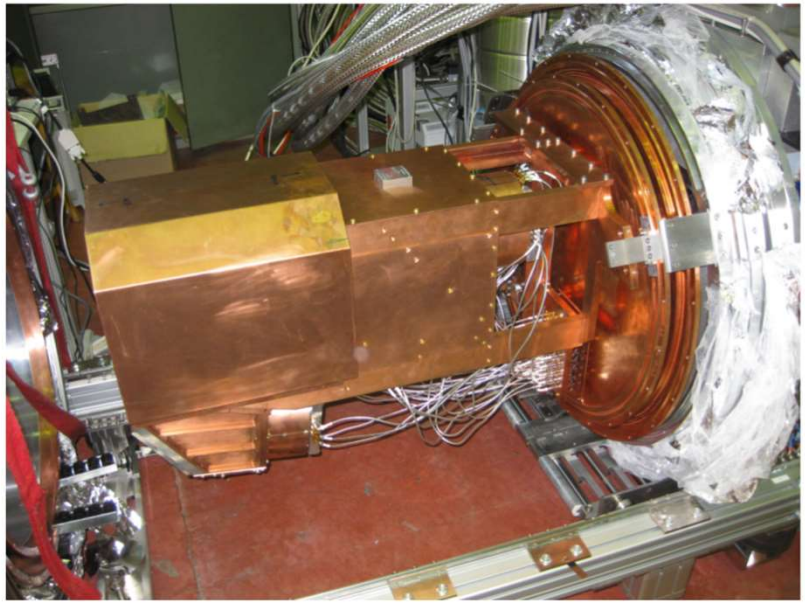
Standard LEKID Hilbert LEKID

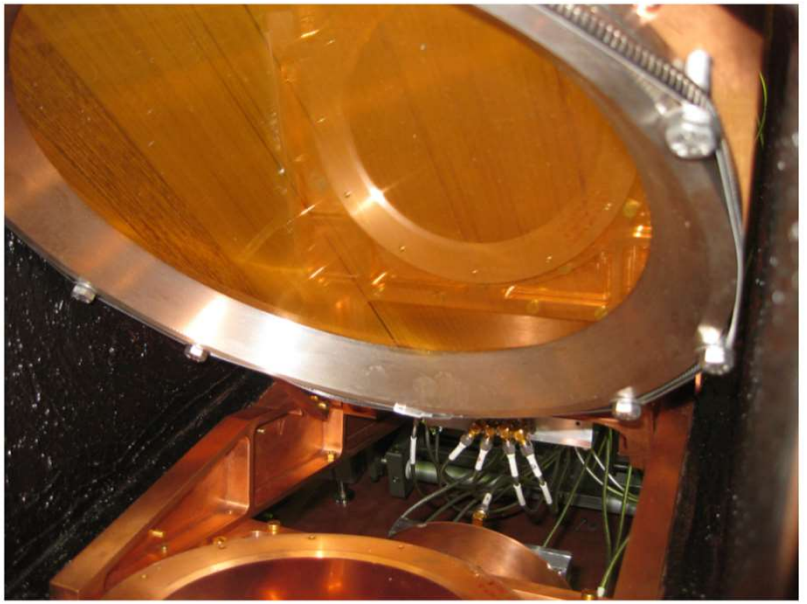
- KID: Resonant (R)LC networks
- NIKA2 is another workhorse, in operations since 2017
- Many upgrades have been implemented since → a good example of constant improvement of a system (next one for Feb-March 2024)

NIKA2: New IRAM KID Arrays 2

Multicolor Kinetic Inductance Detector based camera

~ 2,3 m





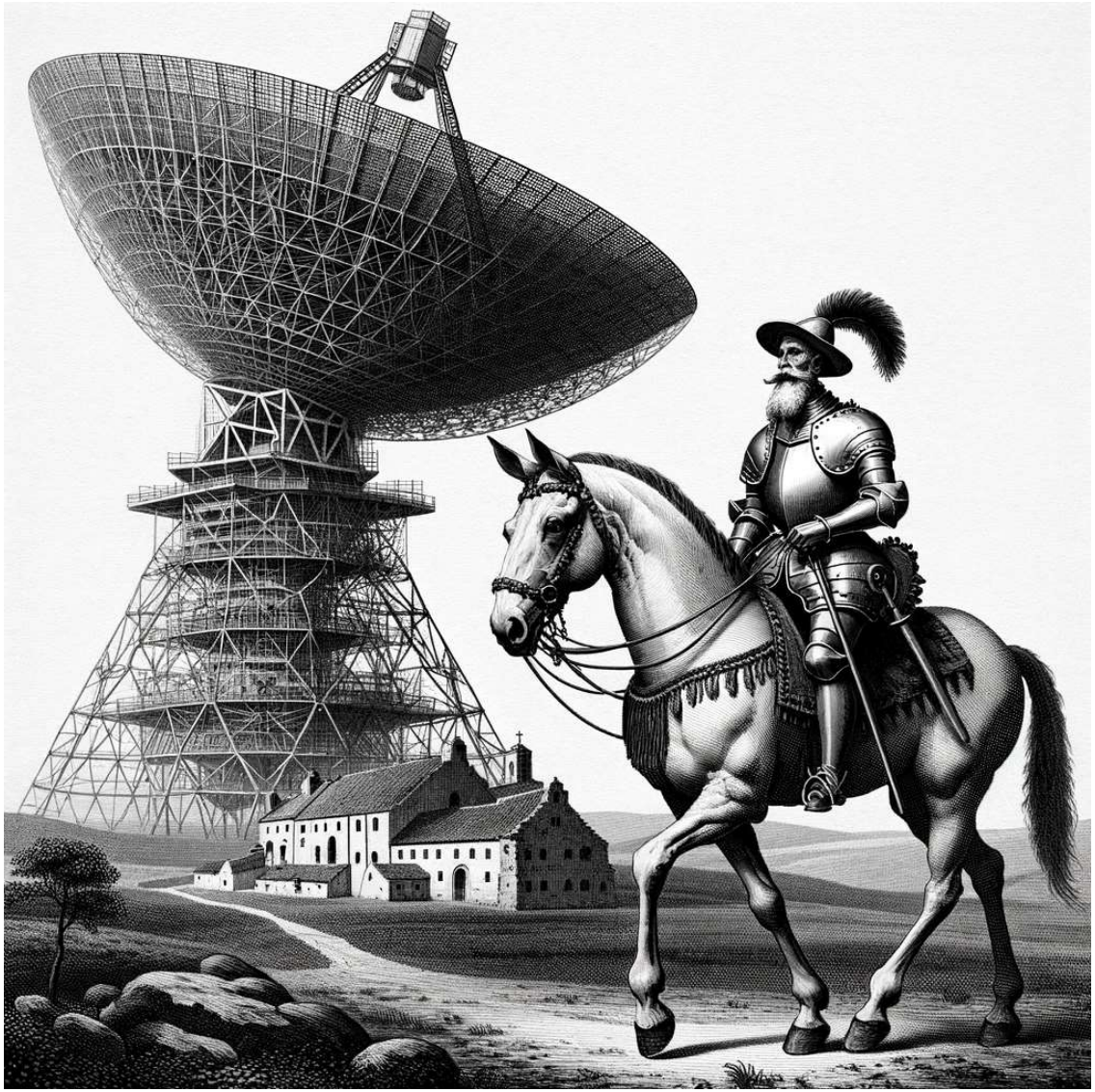
Wire grid polarizer for 1.15 mm band at 150mK

GHz
Pol /
0px

2 PT + He3/He4 dilution cooler

260 GHz / H-Pol / 1140px

What comes next?



The MRT (30m telescope) is a real pioneer of the radioastronomy

We have been discussing for a long time about making a major upgrade in the instrumentation.

In fact our telescope is being upgraded (more on M. Castillo and S. Sanchez presentations)

We envision long term plans for the whole observatory, on a coordinated effort:

IRAM30-30, IRAM30-40? (still to be discussed)

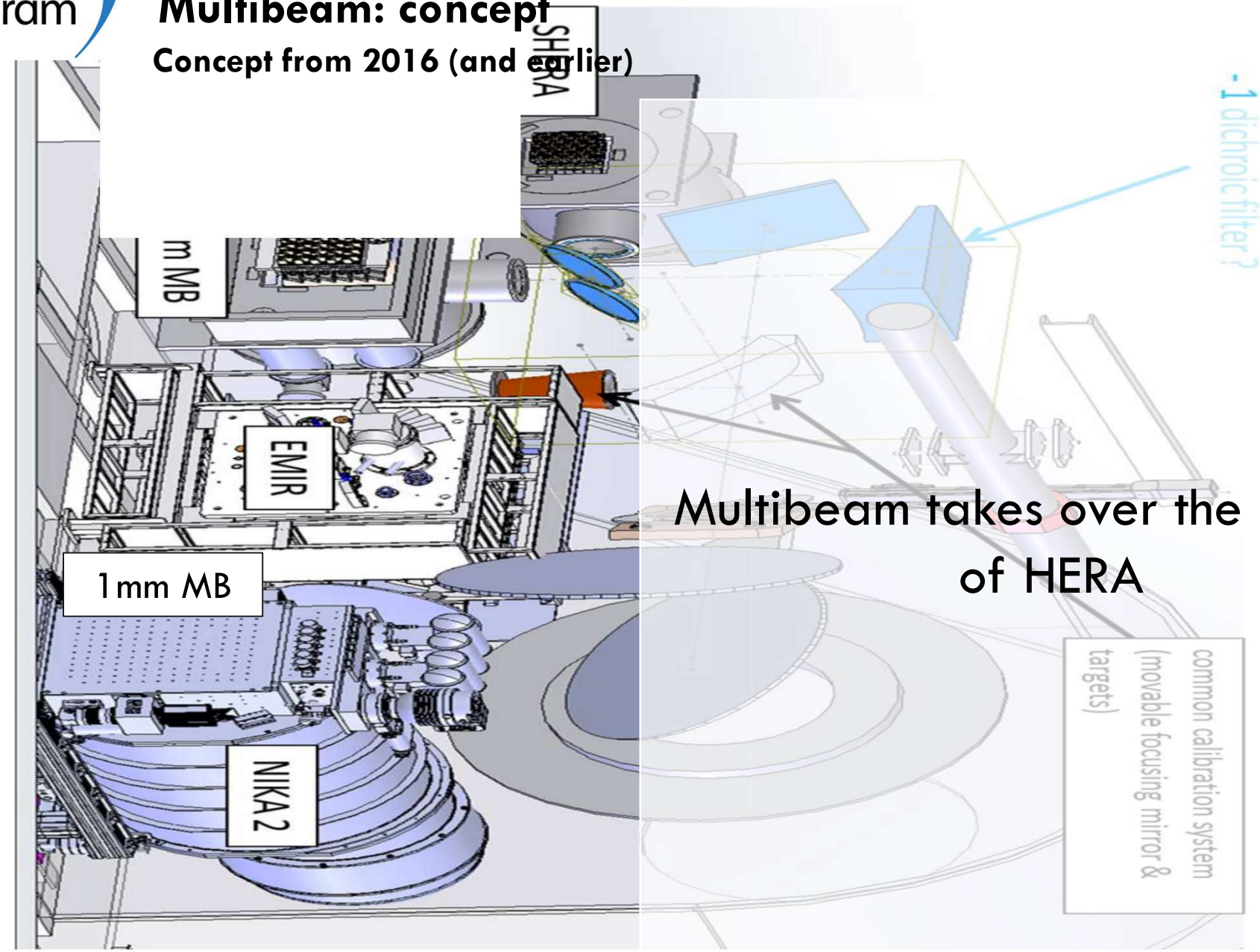
Future Multibeam: a very brief summary

High stability dual color dual pol 2SB extented IF coaligned multibeam with pixel derotation and high spectroscopic resolution…

- Long standing ambition / project (> 12 years)
- In the meantime, key required technology is being explored and developed, and "proofs of concepts" have been built.
- Resources have been focused on NOEMA instrumentation → direct sinergy

Multibeam: concept

Concept from 2016 (and earlier)



Multibeam takes over the position of HERA

Multibeam: Desgin key concepts to account for

Modular

- 2 cryostats with common warm optics. Central pixels coaligned : LFA & HFA.
- Common Hot / Cold loads (cold load @77K with Stirling cooler)
- Modular Bias and control electronics
- Modular mounting of mixers / HEMTs (blocks)
- (Warm) Optics as an assembly group with references.
- IF modules and backends (FFTs) in the telescope (even in the cabin)

De-rotation of pixels

- K-mirror close to Focal Plane and limited travel < 180 Deg phys.
- Compact / Removable / horizontal mounting
- **SW de-rotation?**

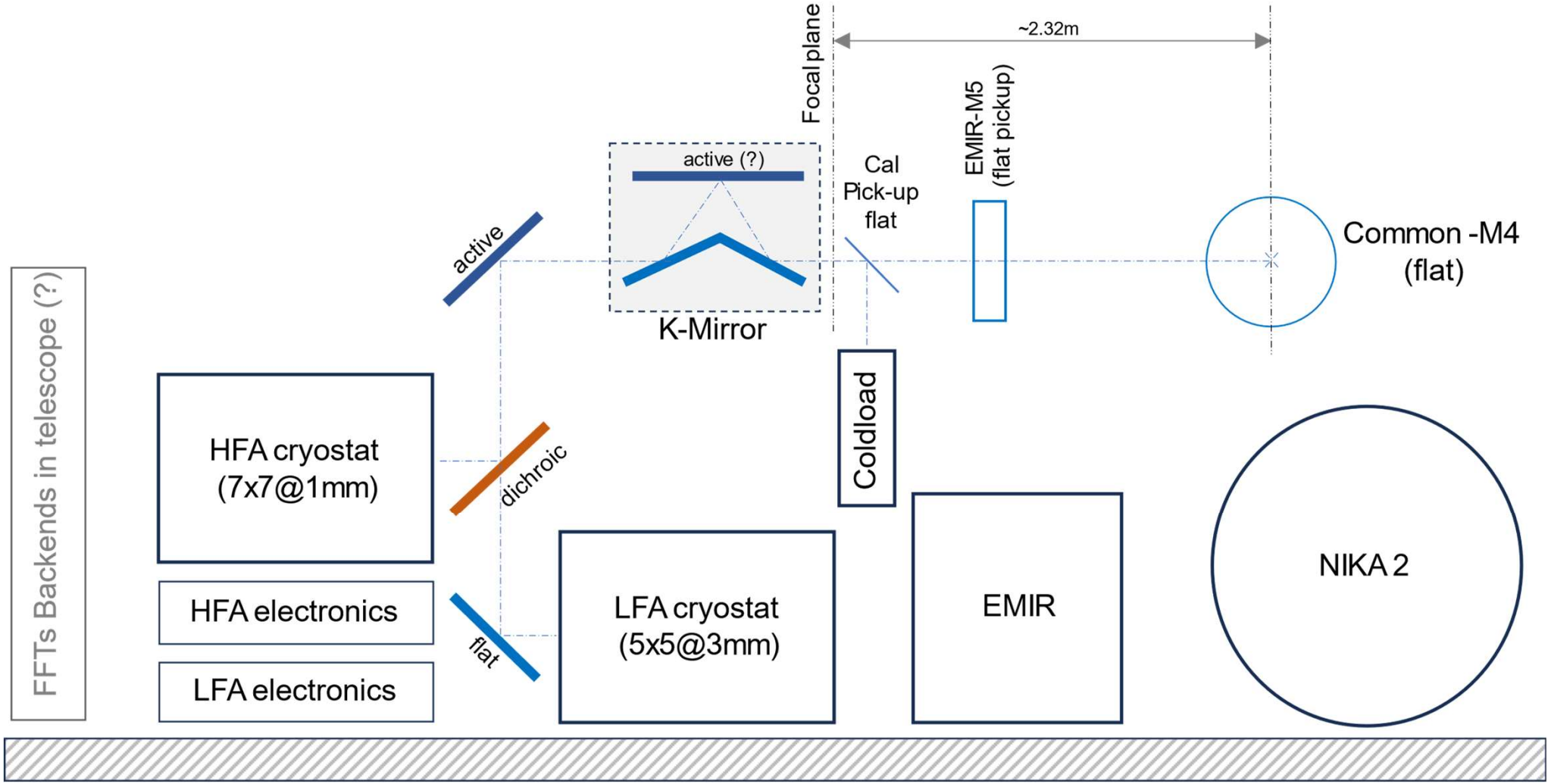
Easily maintainable

- Cryostats bolted to the floor on rails → optics and alingment
- Coldheads mounted vertically → removable with the crane
- Electronics mounted in subracks → replacement and upgrades

Flexible

- Being modular, means easier upgrades of electronics and control computer

Multibeam: updated concept



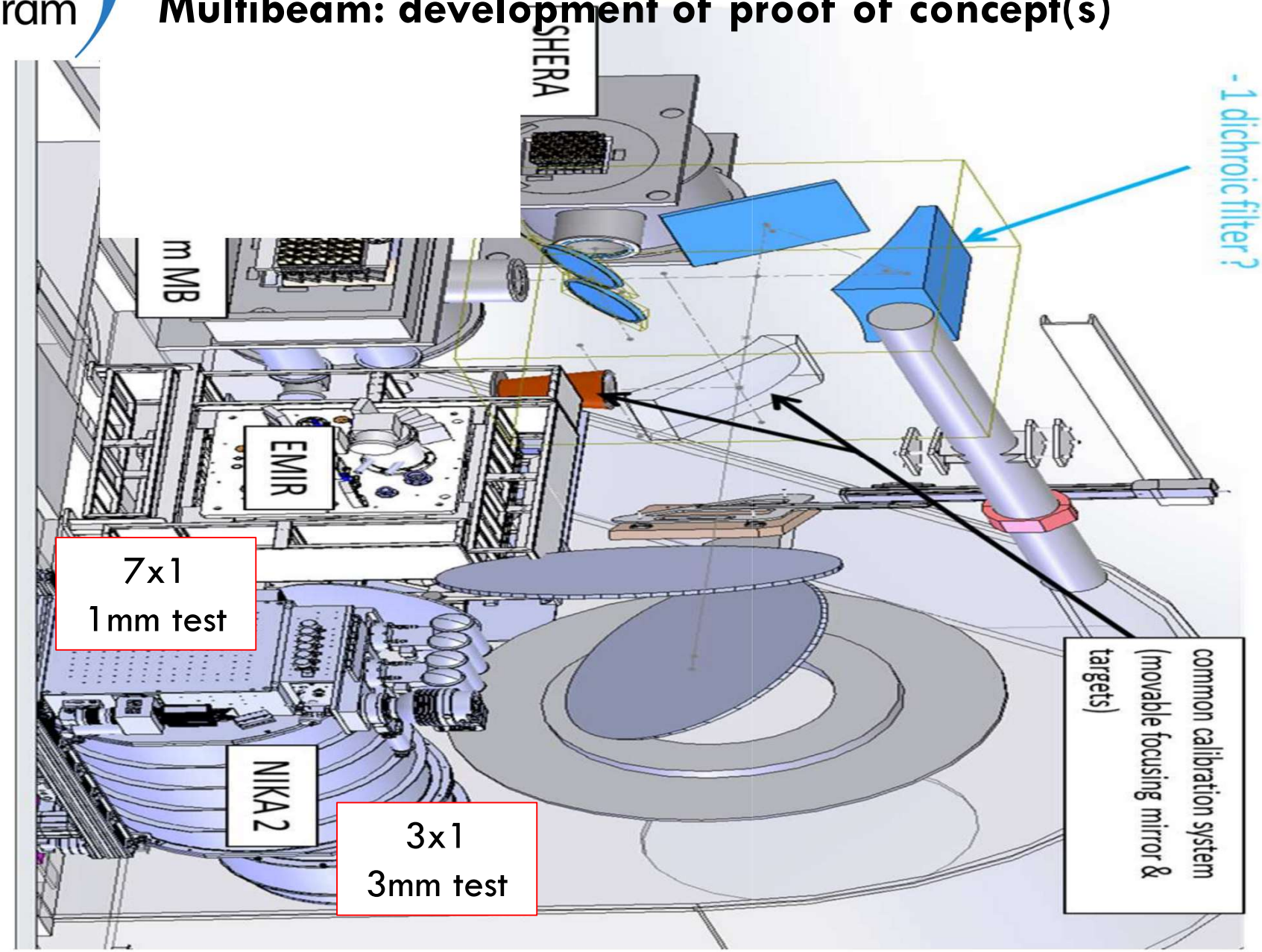
Based on the 2016 concept, a de-rotator can be included

Multibeam: some design challenges

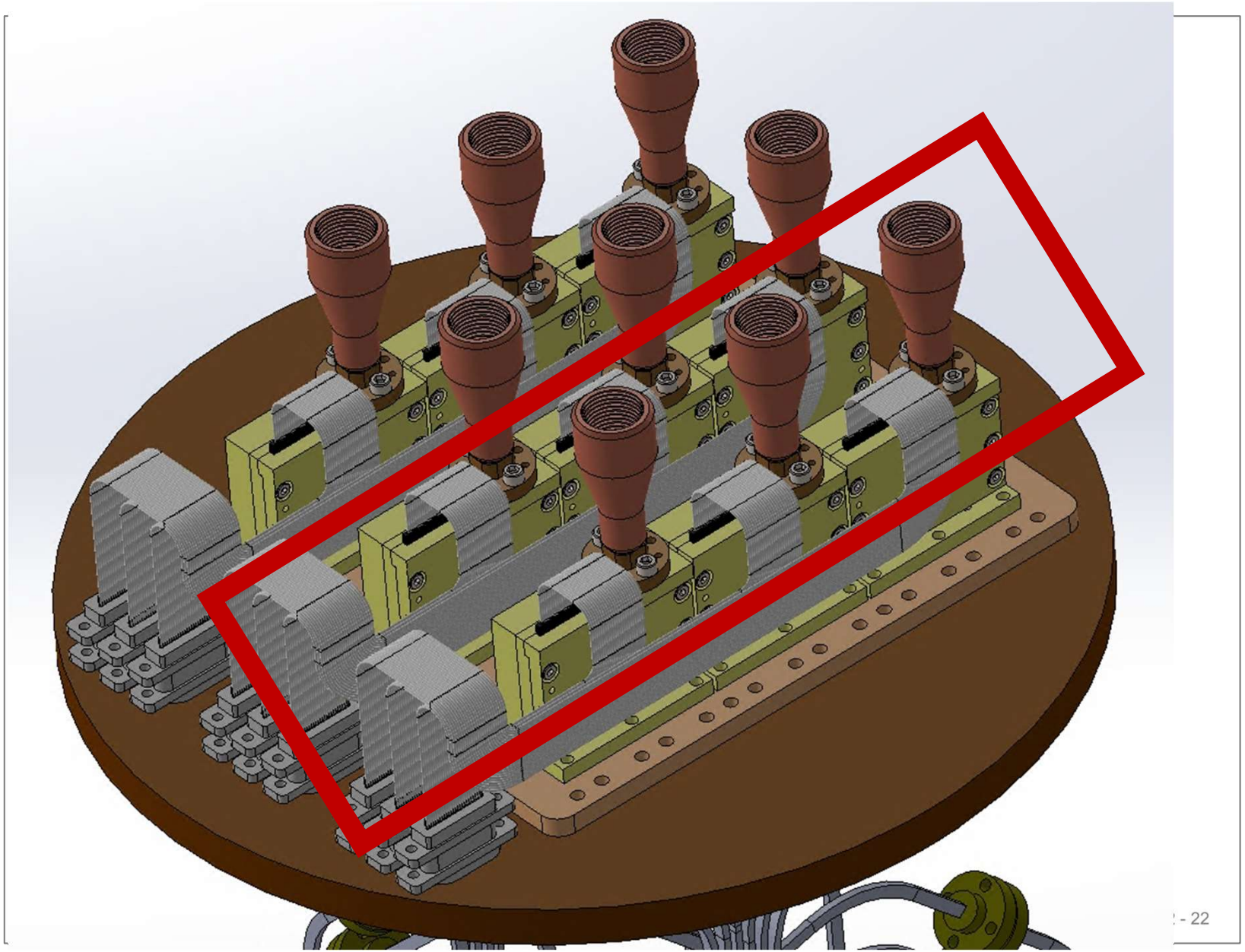
- Dual Pol + 2SB + Extended IF (>4-12)
- Development of HEMTs (?) and SIS (demonstrators experience)
- Development of OMTs
- LO power and distribution
  - Solid state chains with enough power + distribution modules
- Base synthesizers with YIG filters
- Heat dissipation (cryogenics)
  - Cryostat, cooling machine
  - windows / filters
- IF signals and sub-bands
- Type and amount of Backends to cover all sub-bands (FFTs?)
- Different operational modes : **LFA, HFA, LFA + HFA, LFAc + HFAc**
- FE control system
- Cabling and routing (→ *32GHz / pixel* or *8 x 4GHz BW / Pixel*)

- Coordination of different teams: IRAM-ES, IRAM-FR, Partners, Externals
- Short time scale → **target 3 years.**

Multibeam: development of proof of concept(s)

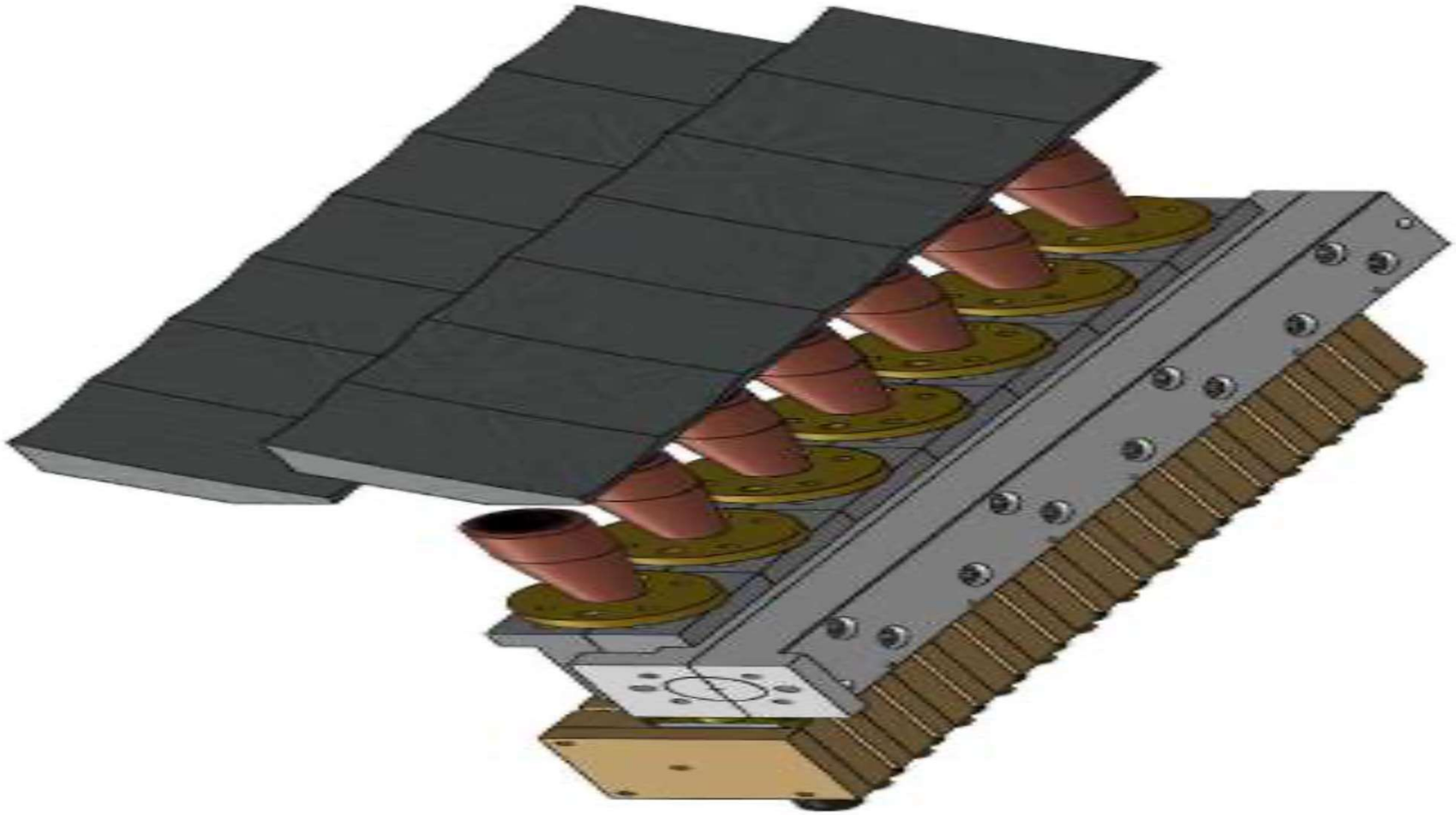


Functional Proofs of concepts (part of Aethra WP5.1)

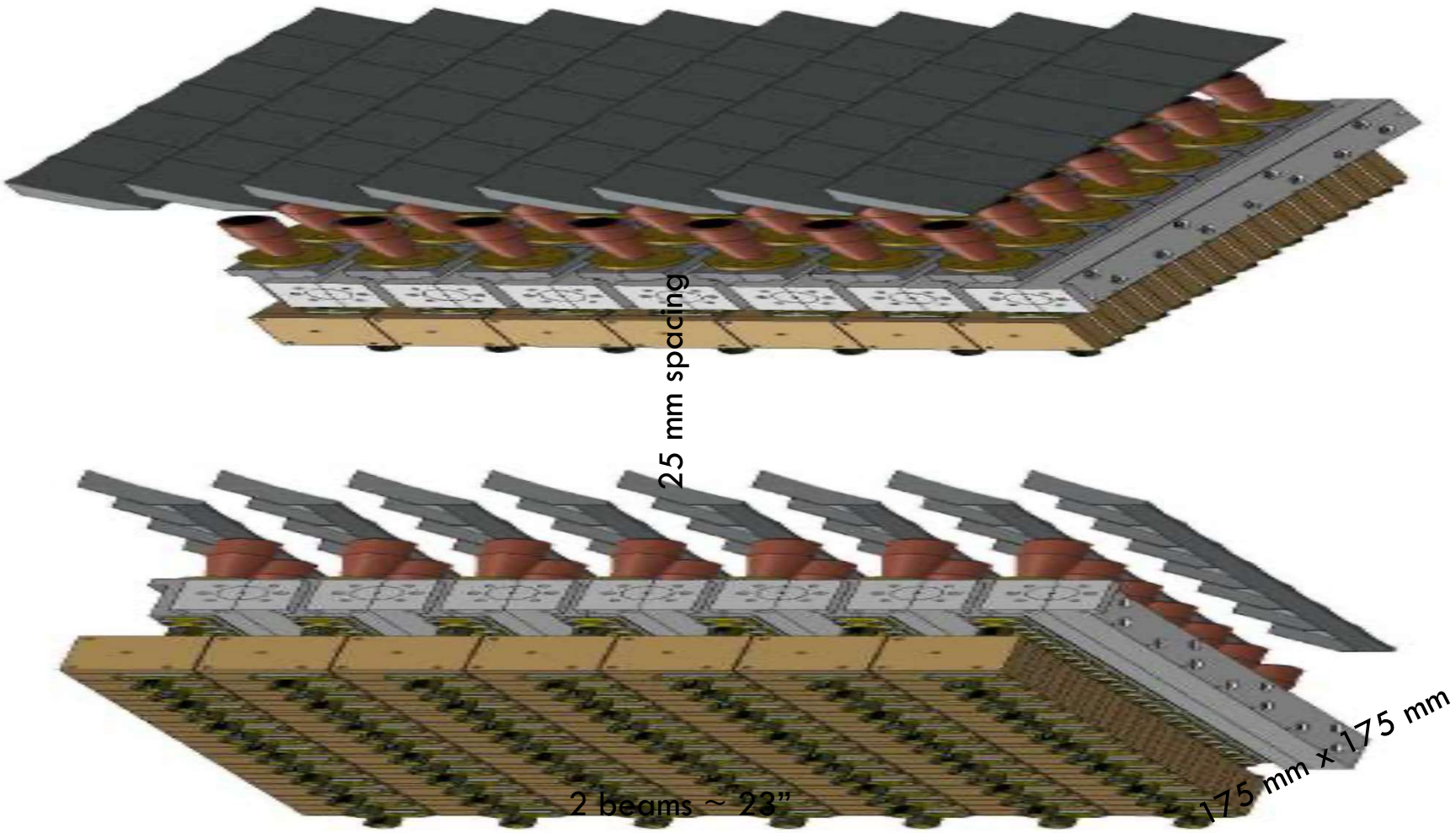


Functional Proofs of concepts (part of Aethra WP5.1)

Radionet projects

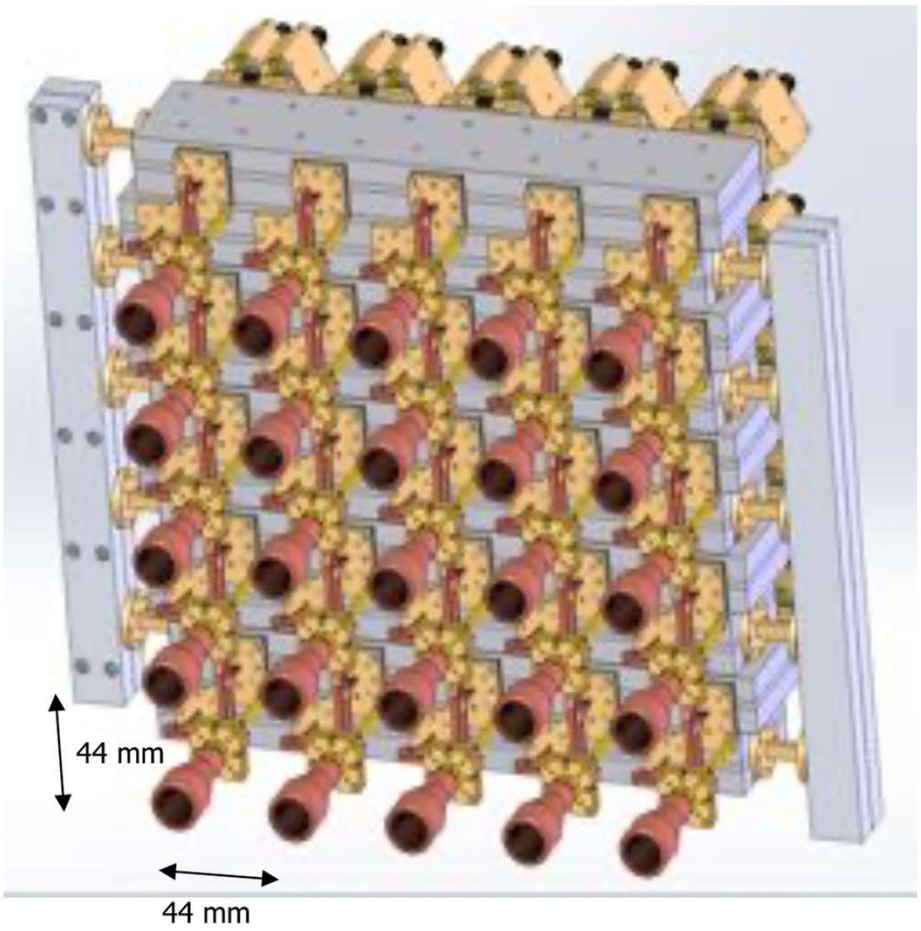


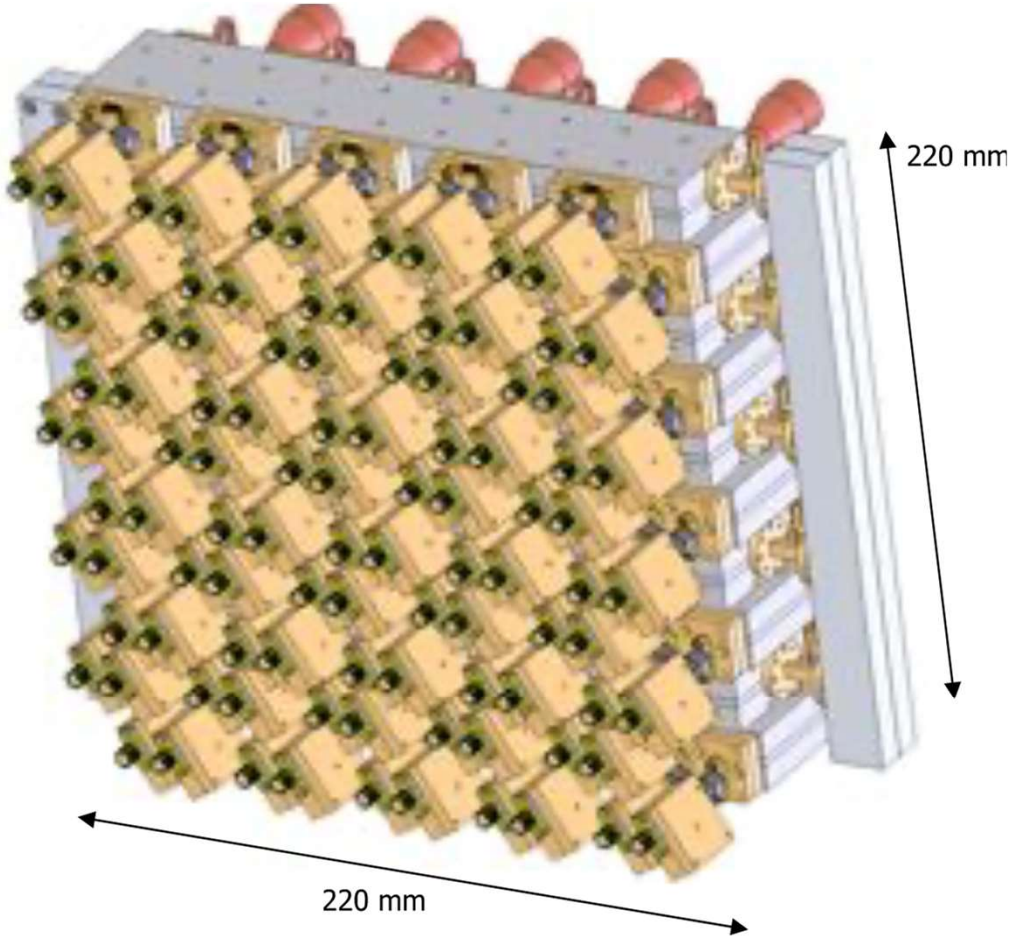
Multibeam: HFA based on concept 7x1 SIS demonstrator



Optics design by Anne-Laure Fontana – Mixer design by Doris Maier

Multibeam: LFA based on concept 3x1 HEMT demonstrator





Beam separation on the sky: ~ 2FWHM -> 48″

Optics design by Anne-Laure Fontana – Mixer design by Doris Maier

Multibeam: HFA + LFA based on demonstrators

Specs: goals and baseline

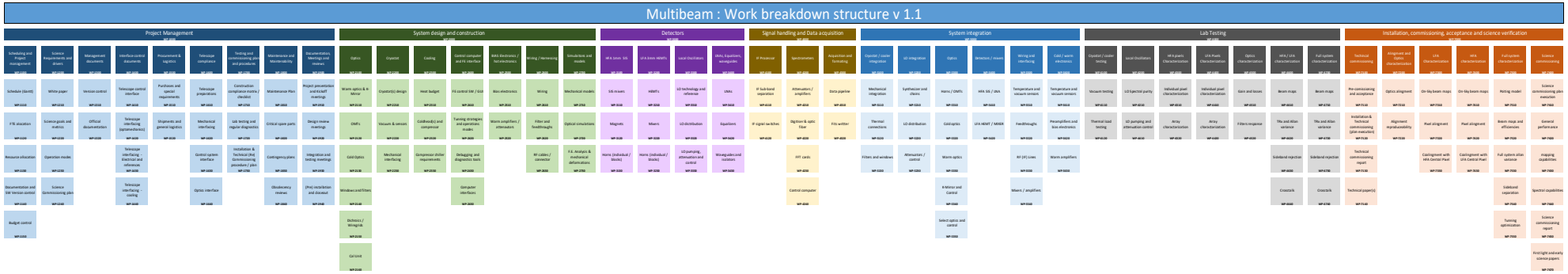
	HFA 1mm			LFA 3mm		
Feature	**Goal**	**Baseline**		**Goal**	**Baseline**	
Frequency range	**196 -- 280**	200 -- 276	GHz	**67 -- 117**	72 -- 116.5	GHz
LO range	**208 -- 268**	212 -- 264	GHz	**79 -- 105**	84 -- 104.5	GHz
IF range	**4 -- 12**	4 -- 12	GHz		4 -- 12	GHz
Mixer topology	**2SB Dual Pol**			**2SB Dual Pol**		
TRX for 80% of the RF band		≤ 83			50	K (SSB)
TRX at any frequency		≤ 138			≤ 70	K (SSB)
Spread in Trec between pixels (%)	**≤ 10**			**≤ 15**	≤ 30	%
Sideband ratio	**< -20**			**< -20**	< -10	dB
Spectroscopic stability with 1 MHz BW (Allan time)	**≥ 20**			**≥ 120**	≥ 100	s
Total power stability with 1 MHz BW (Allan time)			s	**≥ 20**	≥ 10	s
Total power stability for 4-12 GHz IF		**p 100s**		**4x10-7 A.V. up tp 100s**		
		up tp 300s		**3x10-6 A.V. up tp 300s**		
Backend resolution		≥ 64	KHz	**≥ 32**	≥ 64	KHz
Array layout	**7 x 7**			**5 x 5**		
Pixel separation (physical)		25	mm		44	mm
On-sky separation (@ lowest f		> 2	HPBW		> 2	HPBW
HPBW beam size (high	**9 -- 12**	9 -- 12	"	**21 --- 34**	21 --- 34	"
Edge taper	**14**	14	dB	**14**	14	dB
Alingment accuracy betw y)	**≤ 0.5**	≤ 1	"	**≤ 0.5**	≤ 1	"
Co-alingment between sub / pixels (on sky)	**≤ 1**	≤ 2	"	**≤ 1**	≤ 2	"
Co-alingment between sub-a ys for central pix (on sky)	**≤ 0.5**	≤ 1	"	**≤ 0.5**	≤ 1	"
Main beam efficiencies	**≥ 0.60**	≥ 0.53		**≥ 0.80**	≥ 0.75	
Aperture efficiency	**≥ 0.50**	≥ 0.41		**≥ 0.65**	≥ 0.60	
Forward efficiency	**≥ 0.95**	≥ 0.88		**≥ 0.98**	≥ 0.95	

A good approximation of final specs; to be defined soon → Workshop!

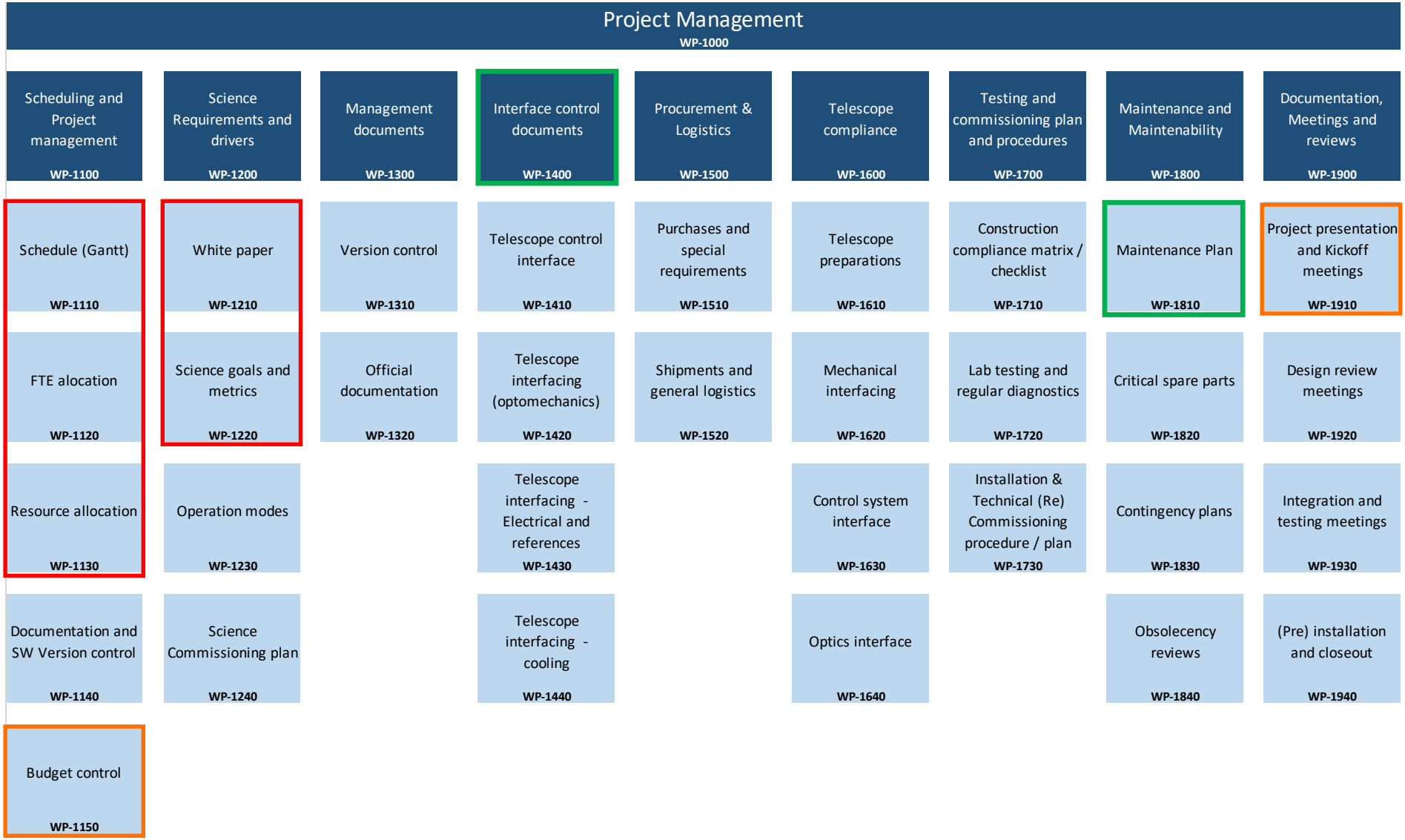
Multibeam: Work breakdown structure

Propossed workpackages for project development (work breakdown structure)

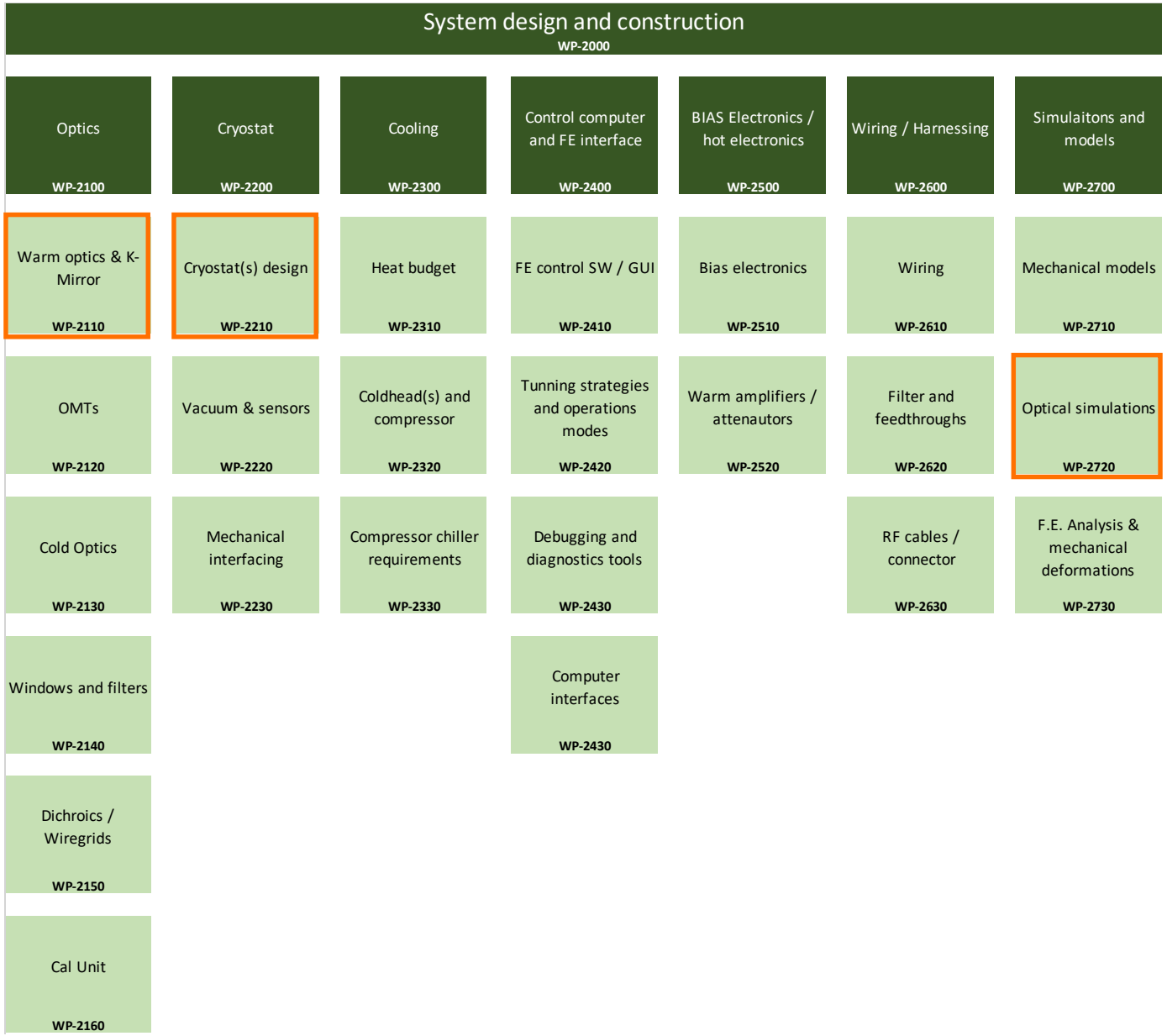
- Project management
- System design and construction
- Detectors
- Signal handling and data acquisition
- System integration
- Lab testing
- Installation, commissioning and science verification



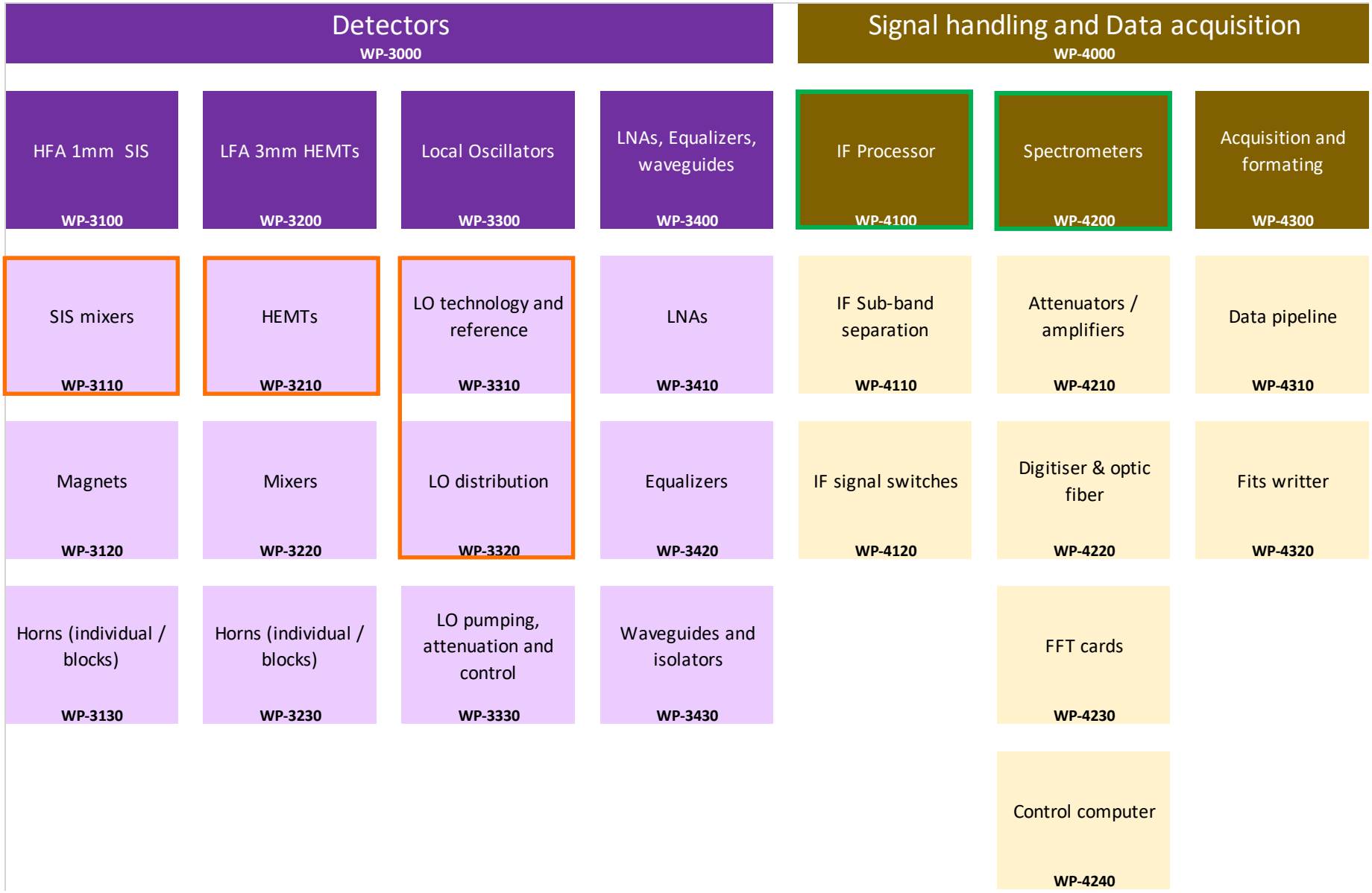
Multibeam: WBS : WP-1000



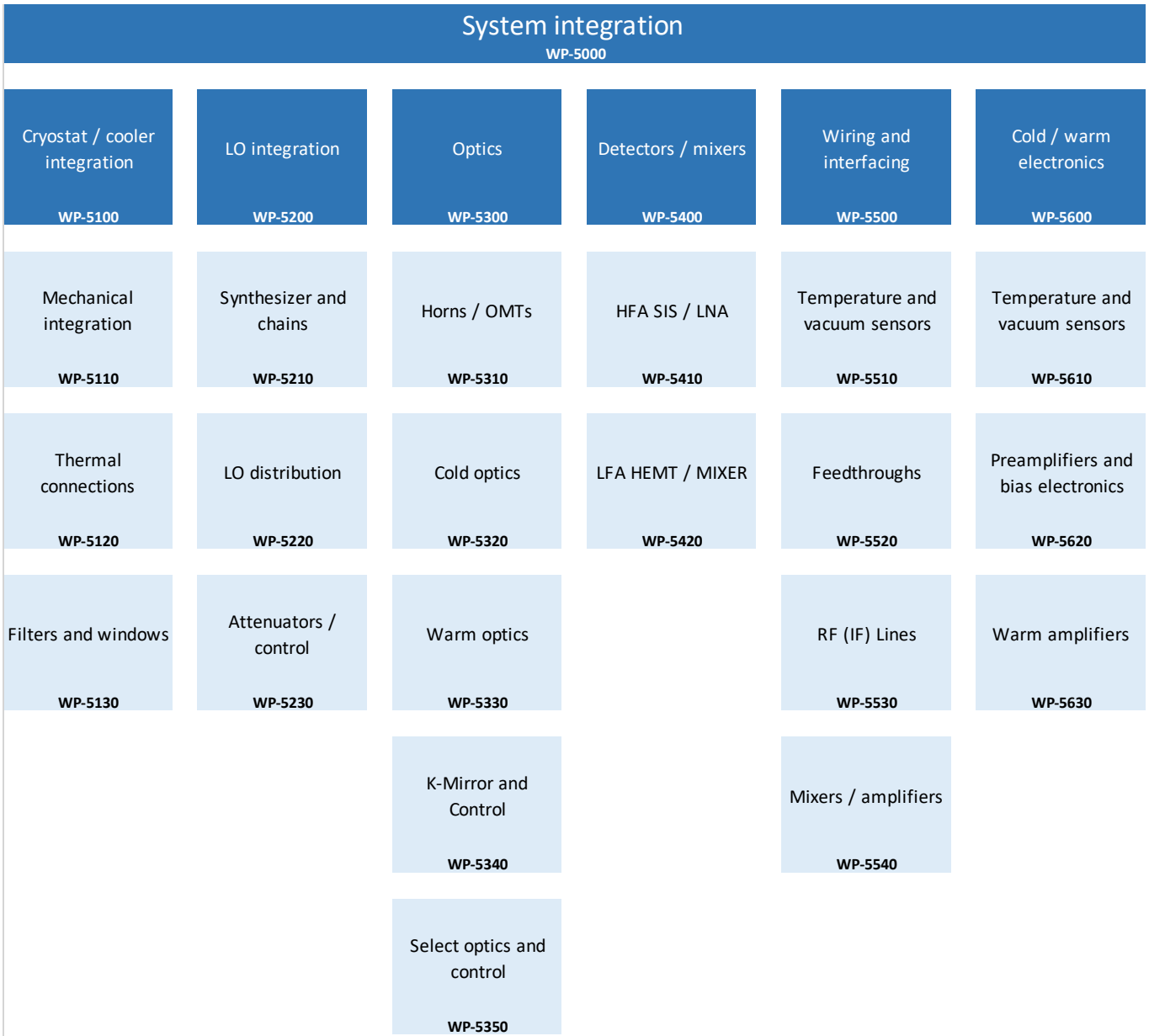
Multibeam: WBS : WP-2000



Multibeam: WBS : WP-3000 & WP-4000



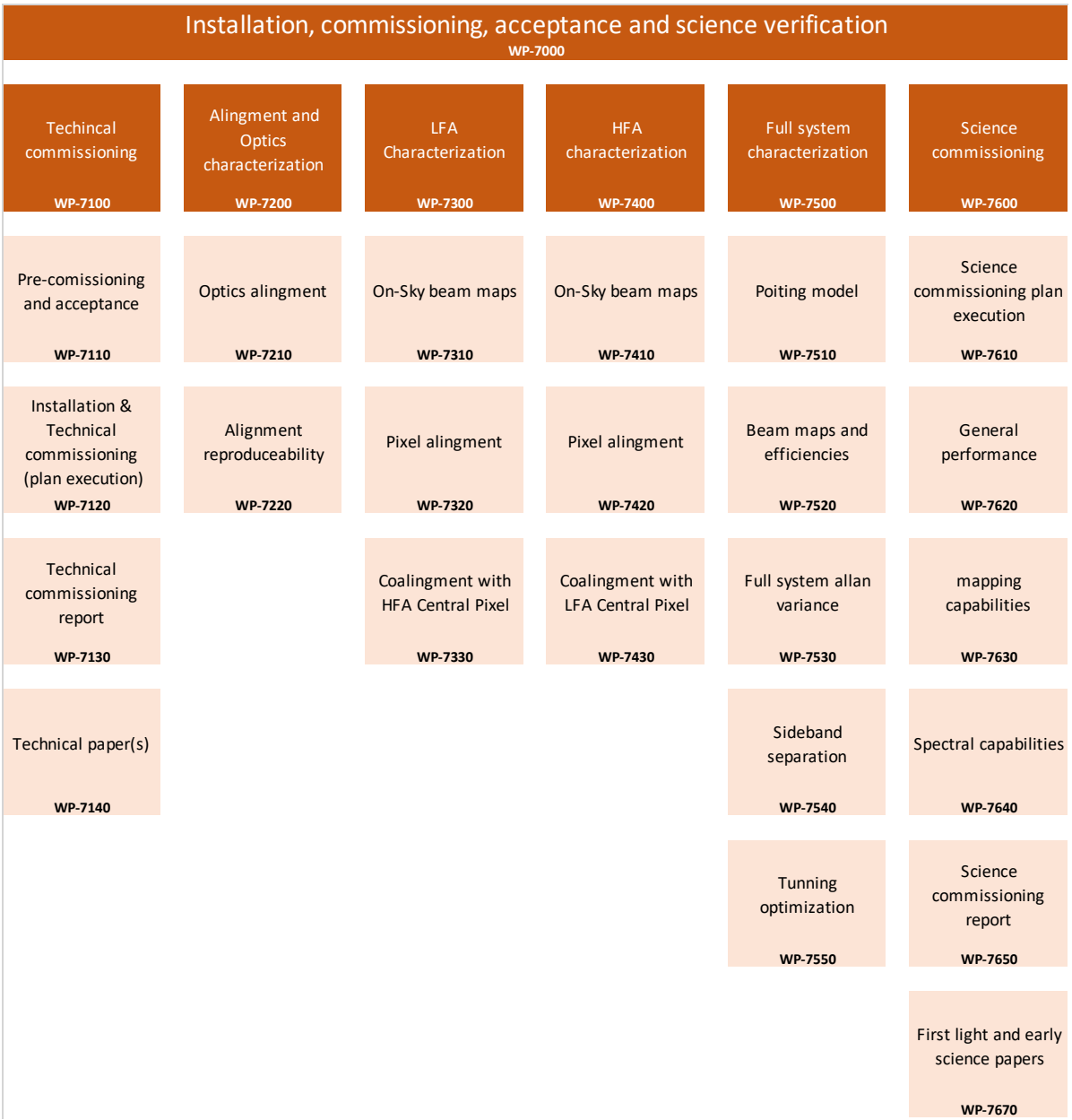
Multibeam: WBS : WP-5000



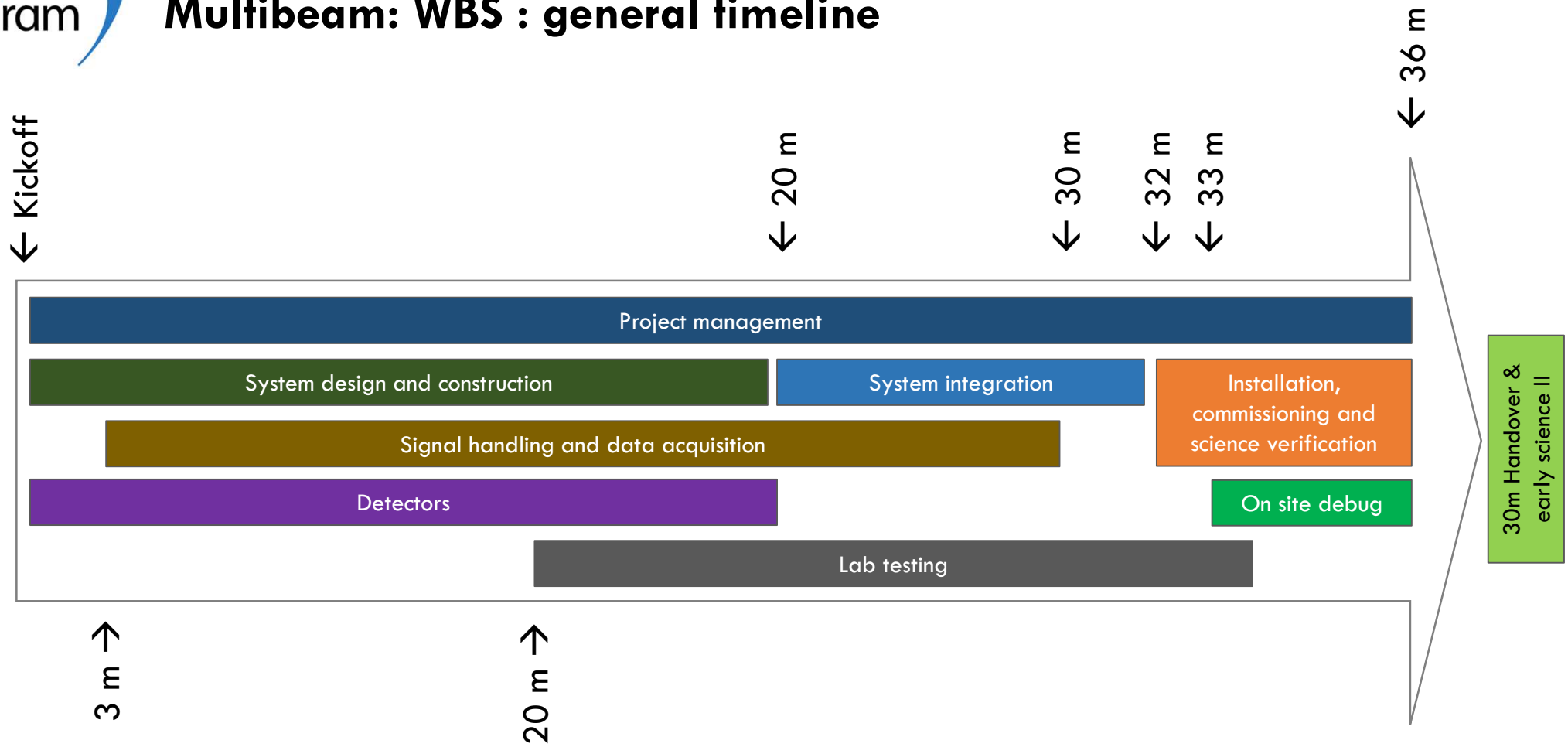
Multibeam: WBS : WP-6000

Lab Testing WP-6000						
Cryostat / cooler testing WP-6100	Local Oscillators WP-6200	HFA pixels Characterization WP-6300	LFA Pixels Characterization WP-6400	Optics characterization WP-6500	HFA / LFA characterization WP-6600	Full system characterization WP-6700
Vacuum testing WP-6110	LO Spectral purity WP-6210	Individual pixel characterization WP-6310	Individual pixel characterization WP-6410	Gain and losses WP-6510	Beam maps WP-6610	Beam maps WP-6710
Thermal load testing WP-6120	LO pumping and attenuation control WP-4410	Array charactarization WP-6320	Array charactarization WP-6420	Filters response WP-6520	TRx and Allan variance WP-6620	TRx and Allan variance WP-6720
					Sideband rejection WP-6630	Sideband rejection WP-6730
					Crosstalk WP-6640	Crosstalk WP-6740

Multibeam: WBS : WP-7000

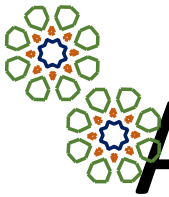


Multibeam: WBS : general timeline



- This short time scale (target 3 years) requires close coordination and collaboration between all parties: IRAM-ES, IRAM-FR, Partners and Externals (vendors and others).
- **Workshop being prepared for late 2023** → Kickoff to happen after that.

Multibeam: one last thing; A proper name for RX system.



Alhambra

Advanced **L**arge **H**eterodyne **A**rray for **M**illimeter **B**and **R**adio **A**stronomy