

VLBI with IRAM 30m & NOEMA

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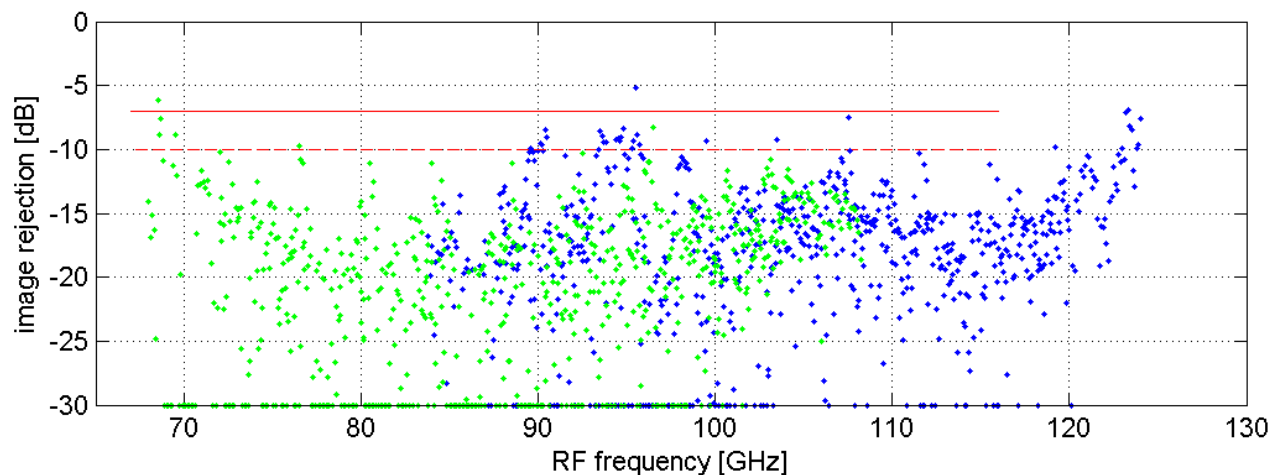
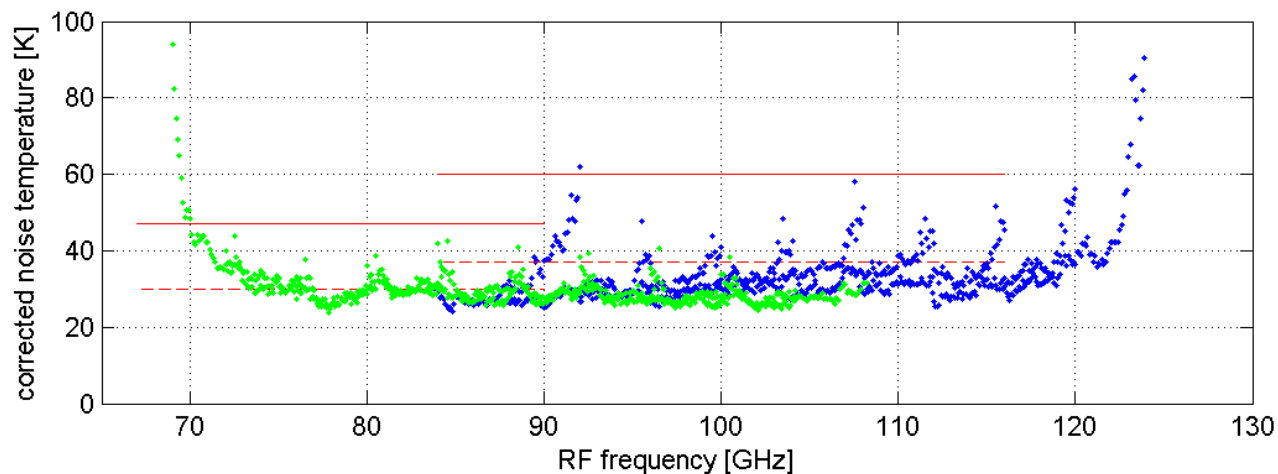


- IRAM is part of GMVA (2 sessions/yr @ 3mm since 2004)
- 1 mm experiments
- Strong collaboration with MPIfR
- Starting collaboration with BlackHoleCam



- EMIR – installed in 2009, upgrades in 2011, 2013, **2015**
- **All four bands are 2 polar x 2 sidebands x 8 GHz**

EMIR		
Band 1	3 mm	83-116 GHz → 70-116 GHz
Band 2	2 mm	124-184 GHz
Band 3	1.3 mm	202-274 GHz
Band 4	0.8 mm	277-375 GHz

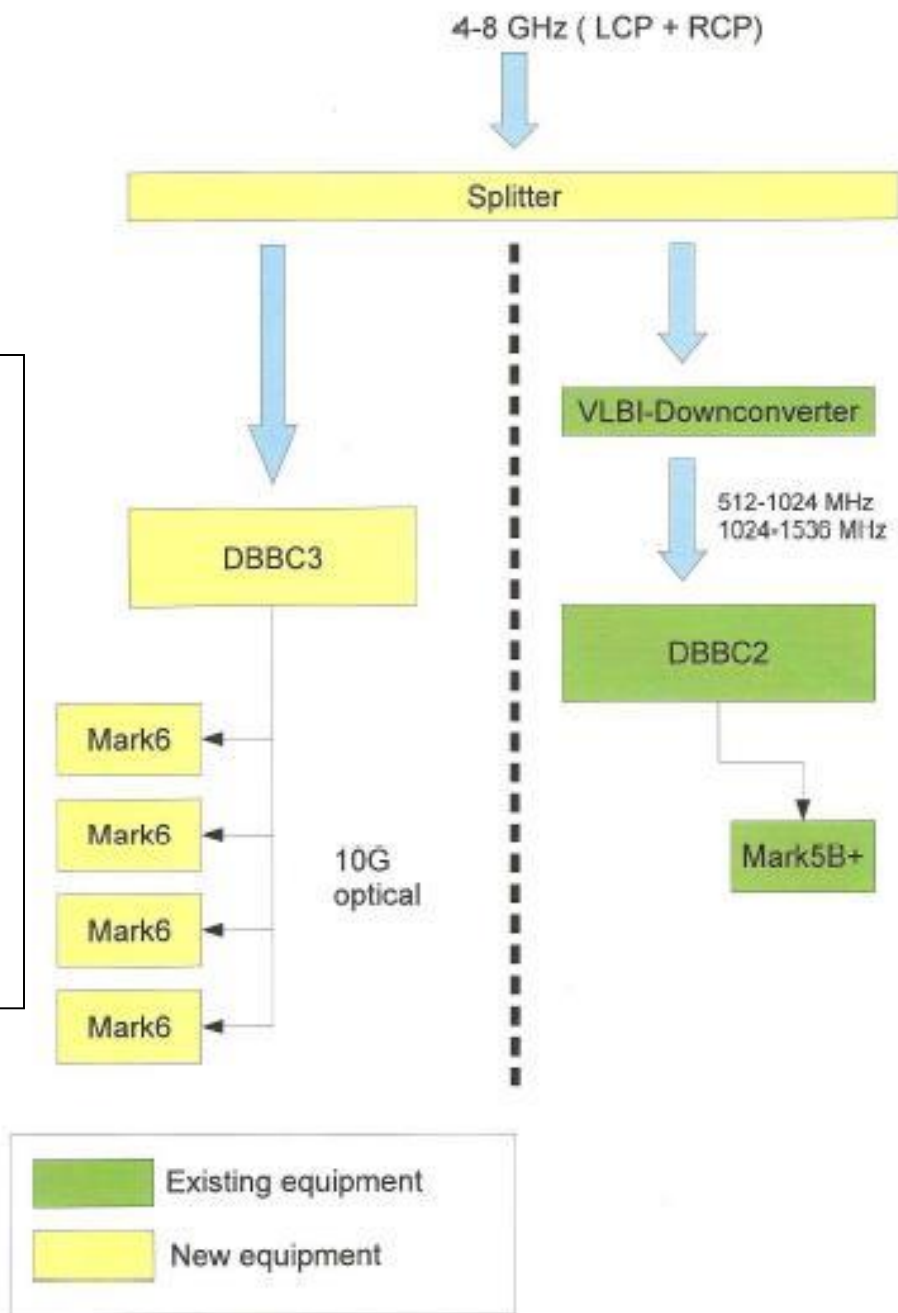


New EMIR Band 1 **70-120 GHz** (D.Maier et al.)

2015: DBBC3 + Mark 6

2 pol. x 4 GHz
32 Gbps

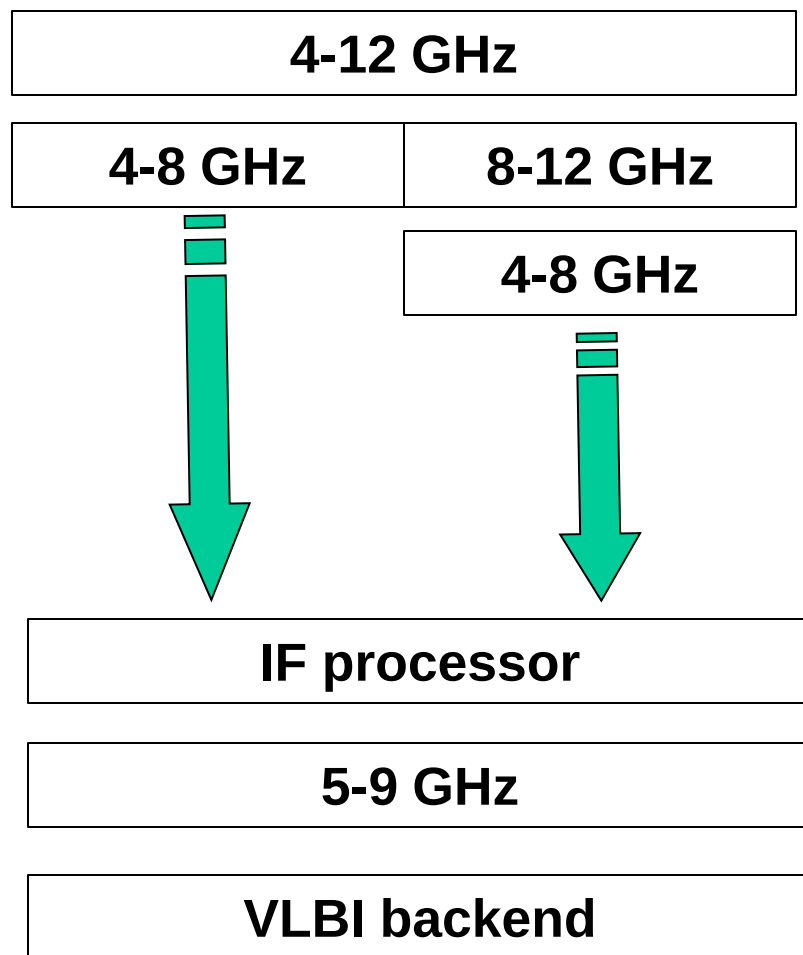
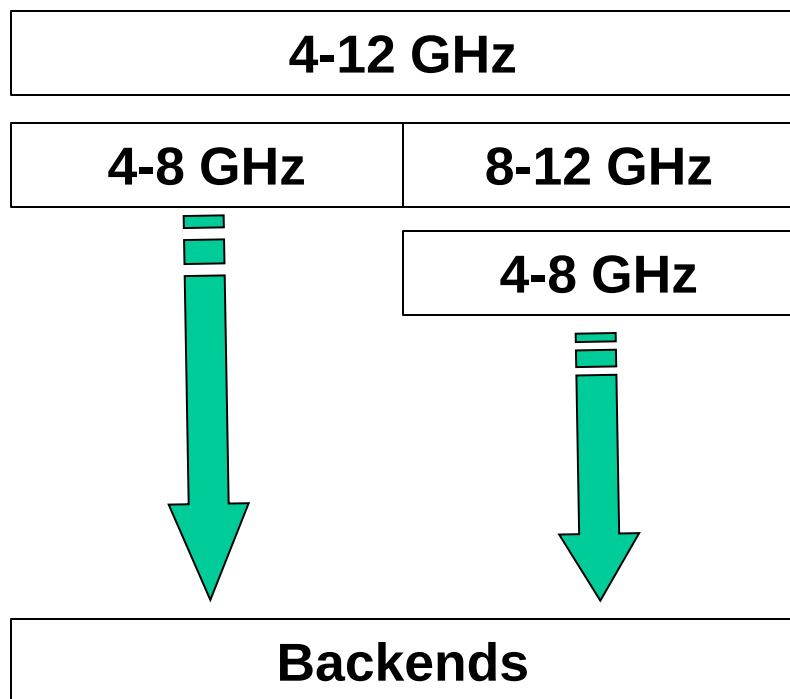
Plan = upgrade to
2 pol. x 8 GHz
64 Gbps
(four Mark 6
already in place)



DBBC2 + Mark 5C

2 pol. x 250 MHz
2 Gbps

- Data rates:
 - Receiver output = 2 pol x 2 sidebands x 8 GHz = 128 Gbps
- Future EHT/BHC experiments – some technical points to solve
 - @ **230 GHz**: IF=5-9 GHz?
 - 4-12 GHz band is split into 4-8 and 8-12 GHz
 - No 5-9 GHz signal
 - Needs specific IF processor
 - @ **345 GHz**: no $\lambda/4$ plate; maser stability?
 - **New maser?**
 - **VLBI press-button mode**





Northern Extended Millimeter Array Extension of the IRAM Plateau de Bure interferometer

- Double the number of 15 m antennas from 6 to 12
- New receivers: increase of IF bandwidth from 8 GHz to 32 GHz
- New correlator (FPGA technology)
- Extension of the baselines from 0.8 to 1.6 km



Collecting area

	Interferometry	Short spacings
ALMA/ACA	5655 m ²	914m ²
NOEMA/30m	2121 m ²	707m ²

Bandwidth per polarization

PdBI	4 GHz
ALMA	2 x 4 GHz
NOEMA/30m	2 x 8 GHz

Unique NOEMA features

Correlator provides full continuum **and** (up to) 128 spec. windows

Dual-band observations (two correlators)

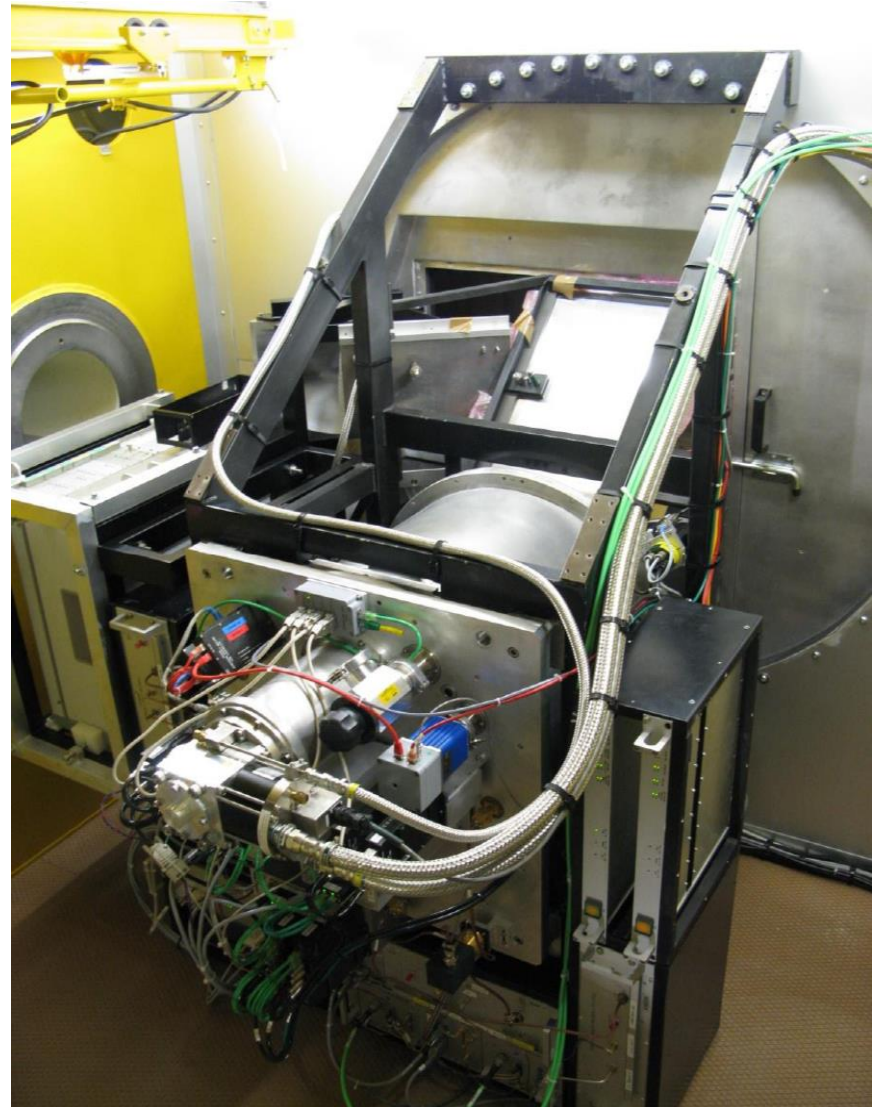
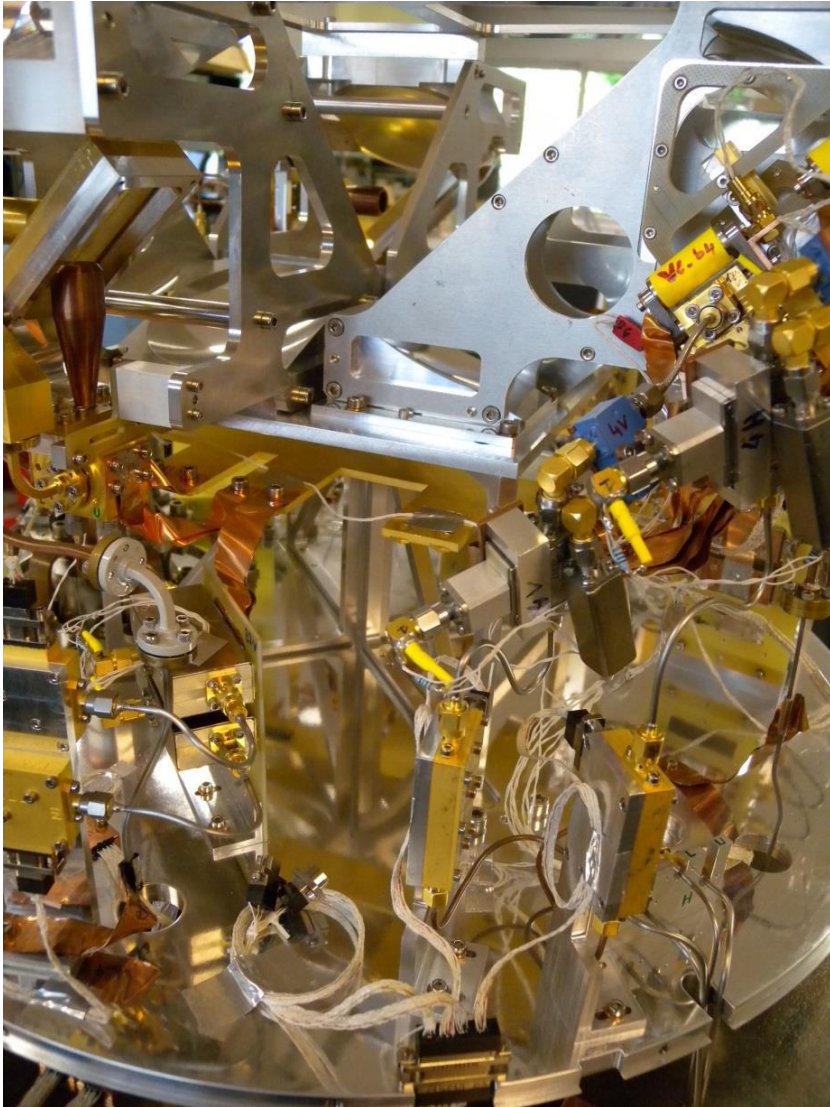


Antenna 7
22 Sept. 2014



Antenna 8
7 Jan. 2015

NOEMA receivers



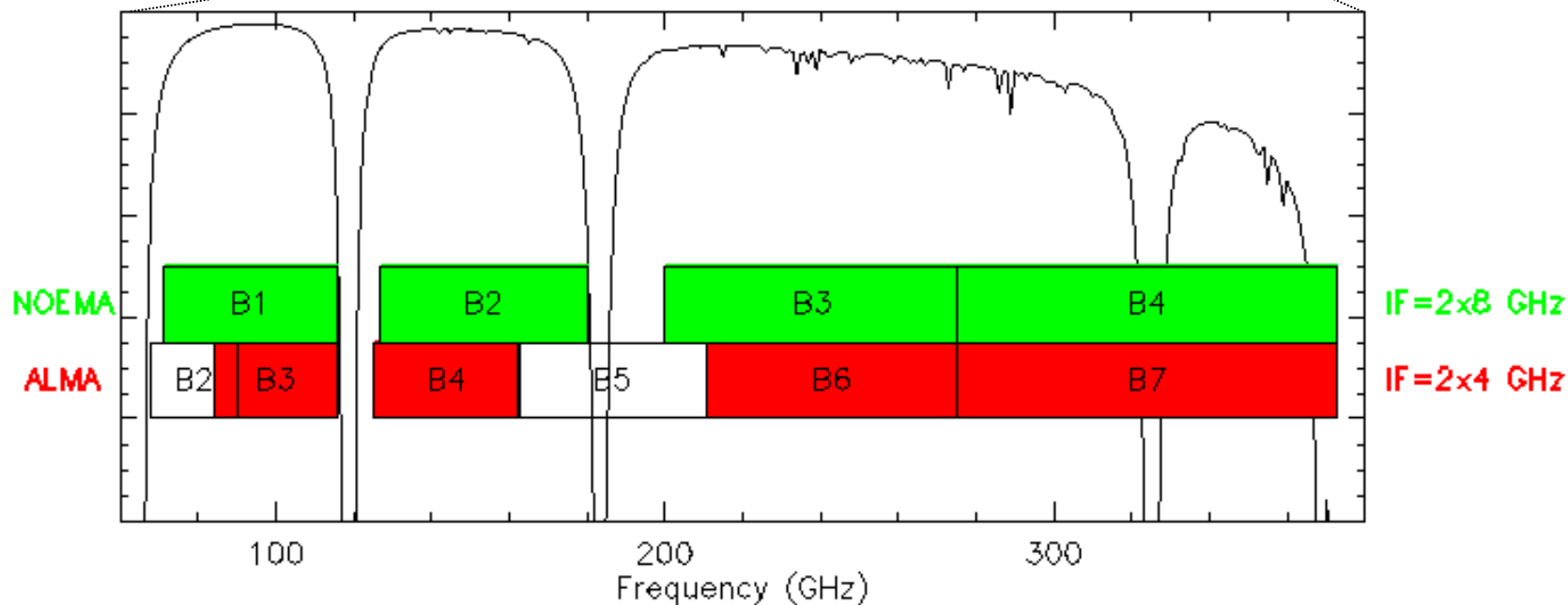
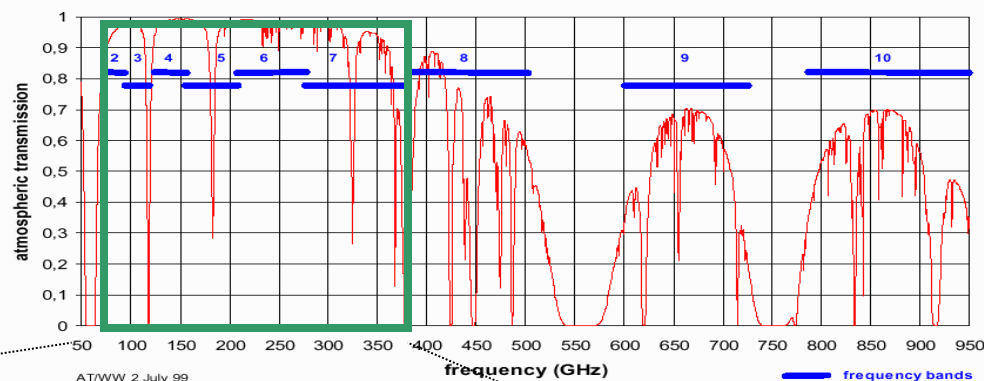
NOEMA receivers

- Bands 1+2+3 are **2 polar x 2 sidebands x 8 GHz**
- **Band 4** is 2 polar x 1 sideband x **4 GHz** on 7 antennas, to be upgraded later to 2 x 2 x 8 GHz / 12 ant.

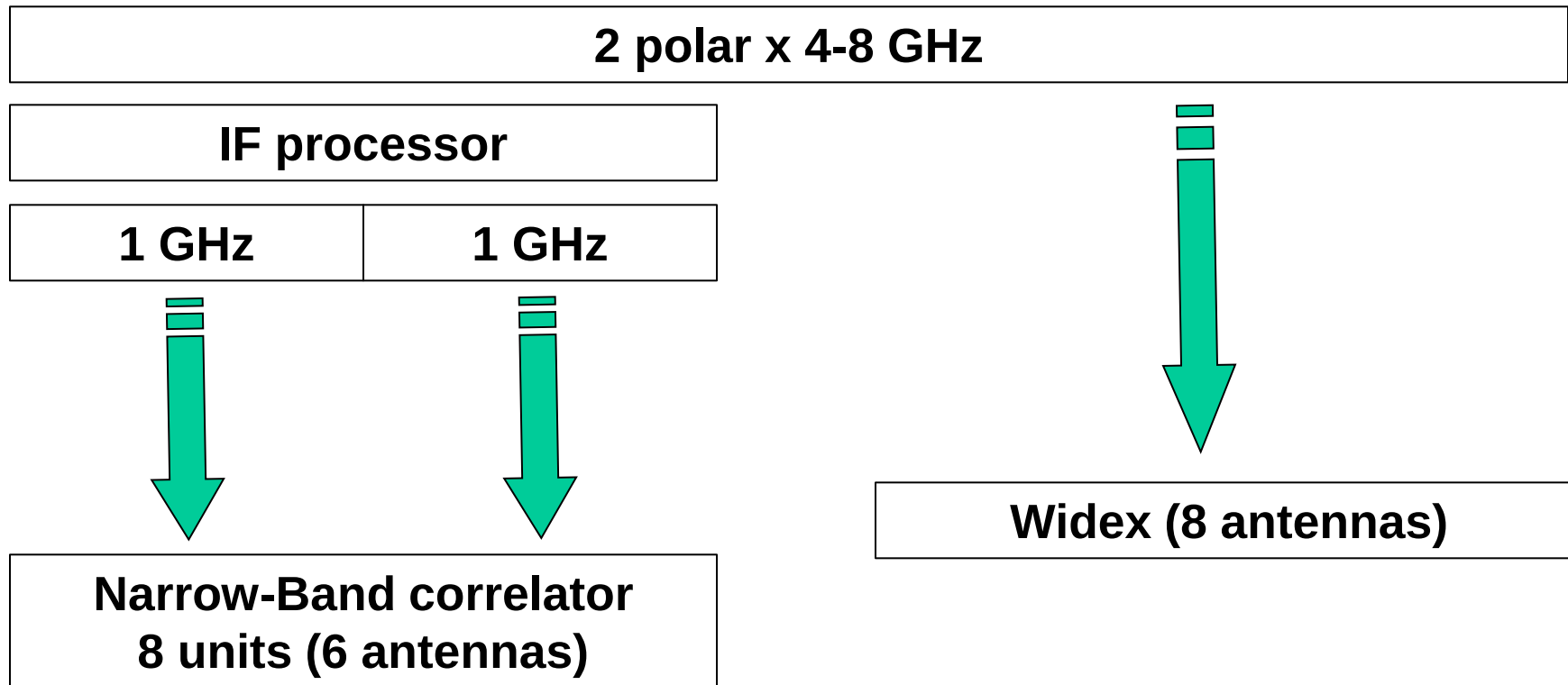
NOEMA receivers		
Band 1	3 mm	72-116 GHz
Band 2	2 mm	127-179 GHz
Band 3	1.3 mm	200-276 GHz
Band 4	0.8 mm	275-373 GHz

- IF = 3.8 to 11.8 GHz
- Mixers Band 4 → ALMA, Band 3 → APEX, Band 1 → OSO

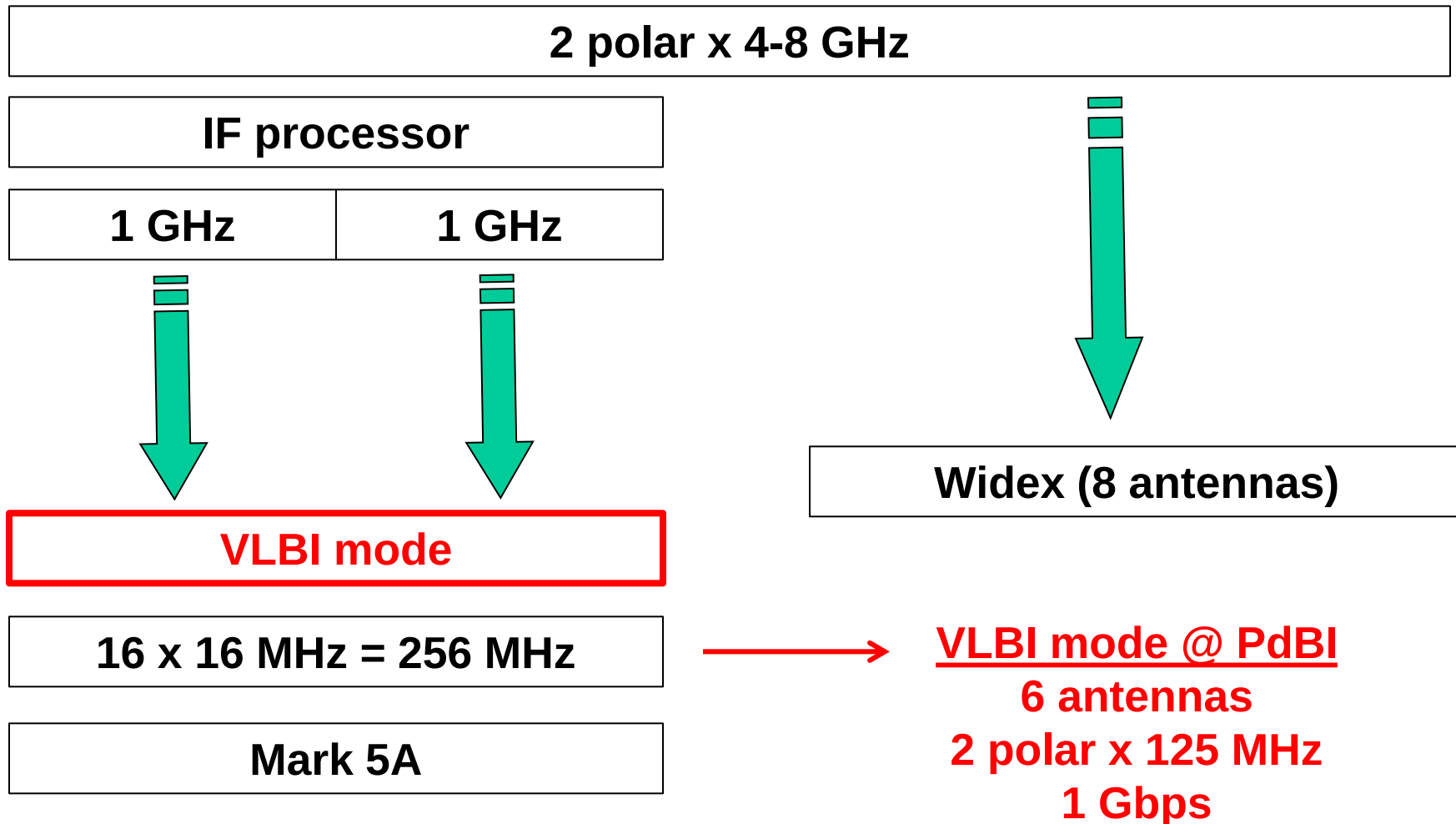
Atmospheric transmission at Chajnantor, $\text{pww} = 0.5 \text{ mm}$



Current backend



Current backend



NOEMA correlator: PolyFix

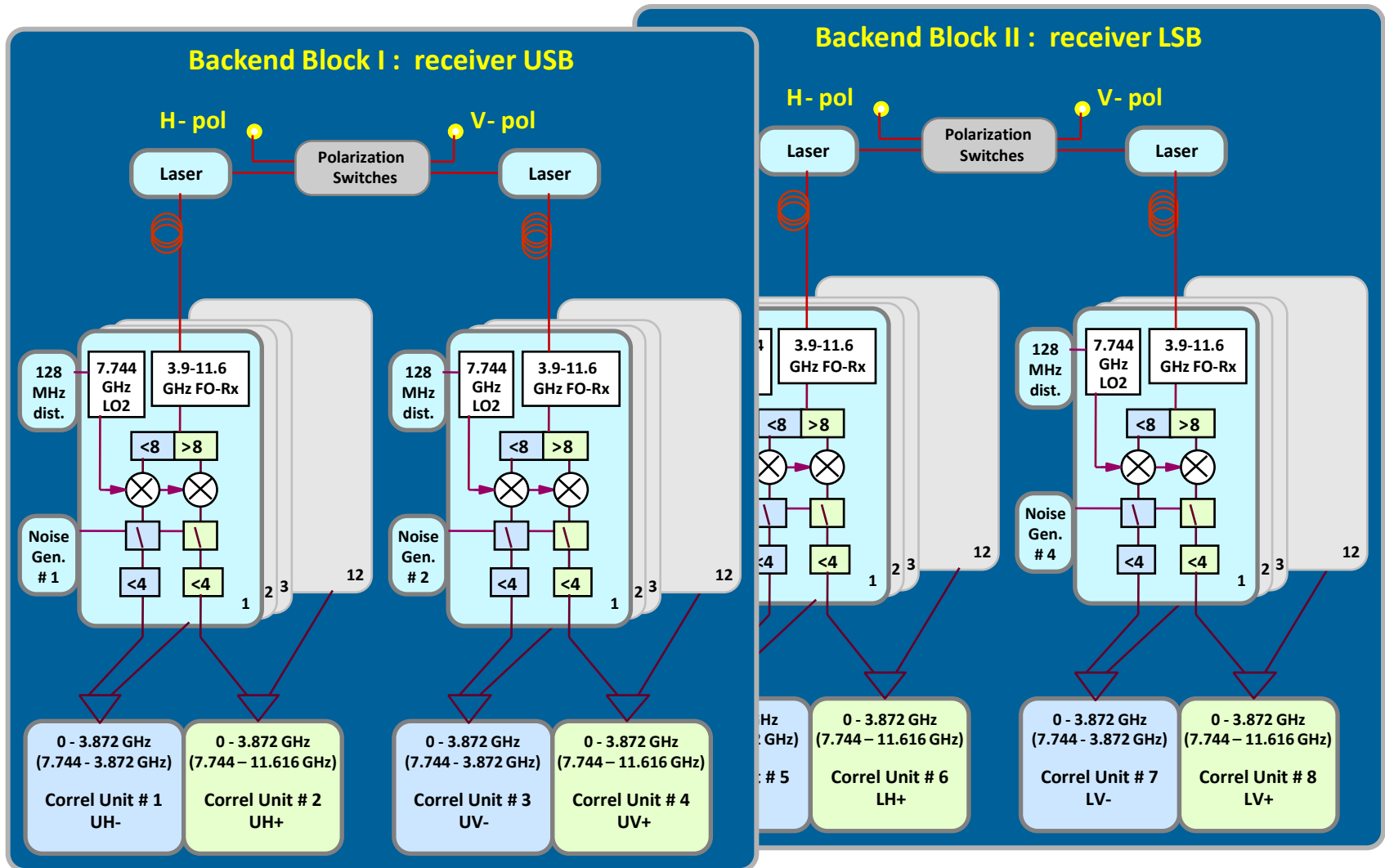
➤ Simultaneous continuum and line capabilities

- Up to 150000 spectral channels

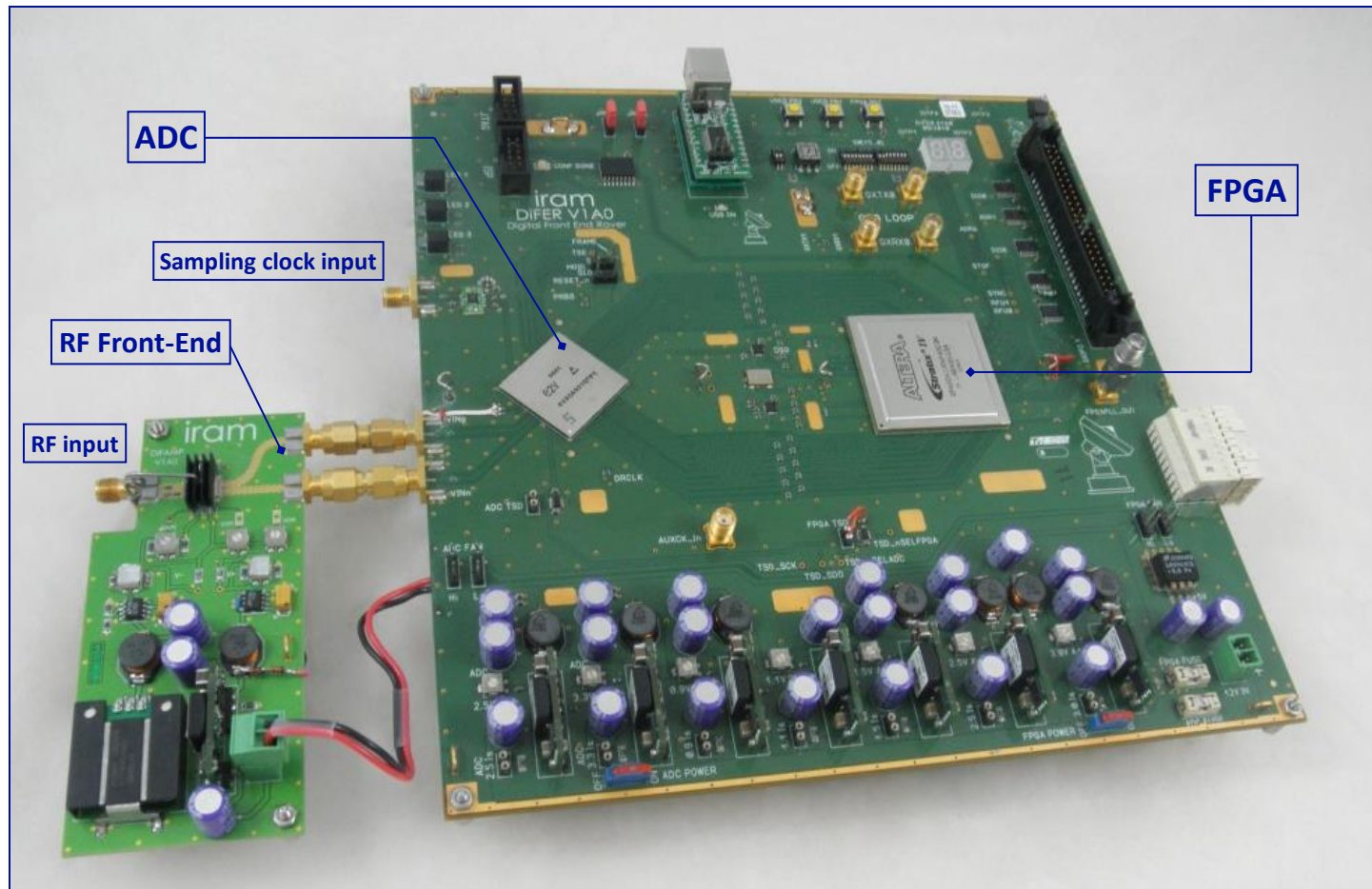
Mode 1 : continuum + lines	complete 16 GHz coverage in each polarization with 2 MHz channels
	AND
	128 windows of 64 MHz (= 8 GHz coverage) with 62.5 kHz channels, each window tunable individually in steps of 64 MHz*
Mode 2 : survey mode	complete 16 GHz coverage in each polarization with 250 kHz channels
Mode 3 : continuum + high-resolution lines	same as mode 1, but with 64/32/16** windows of 64 MHz with 32/15/8 kHz channels

* With the constrain of having 16 windows in each of the 8 4 GHz-wide correlator units

** Number of windows may eventually be lower



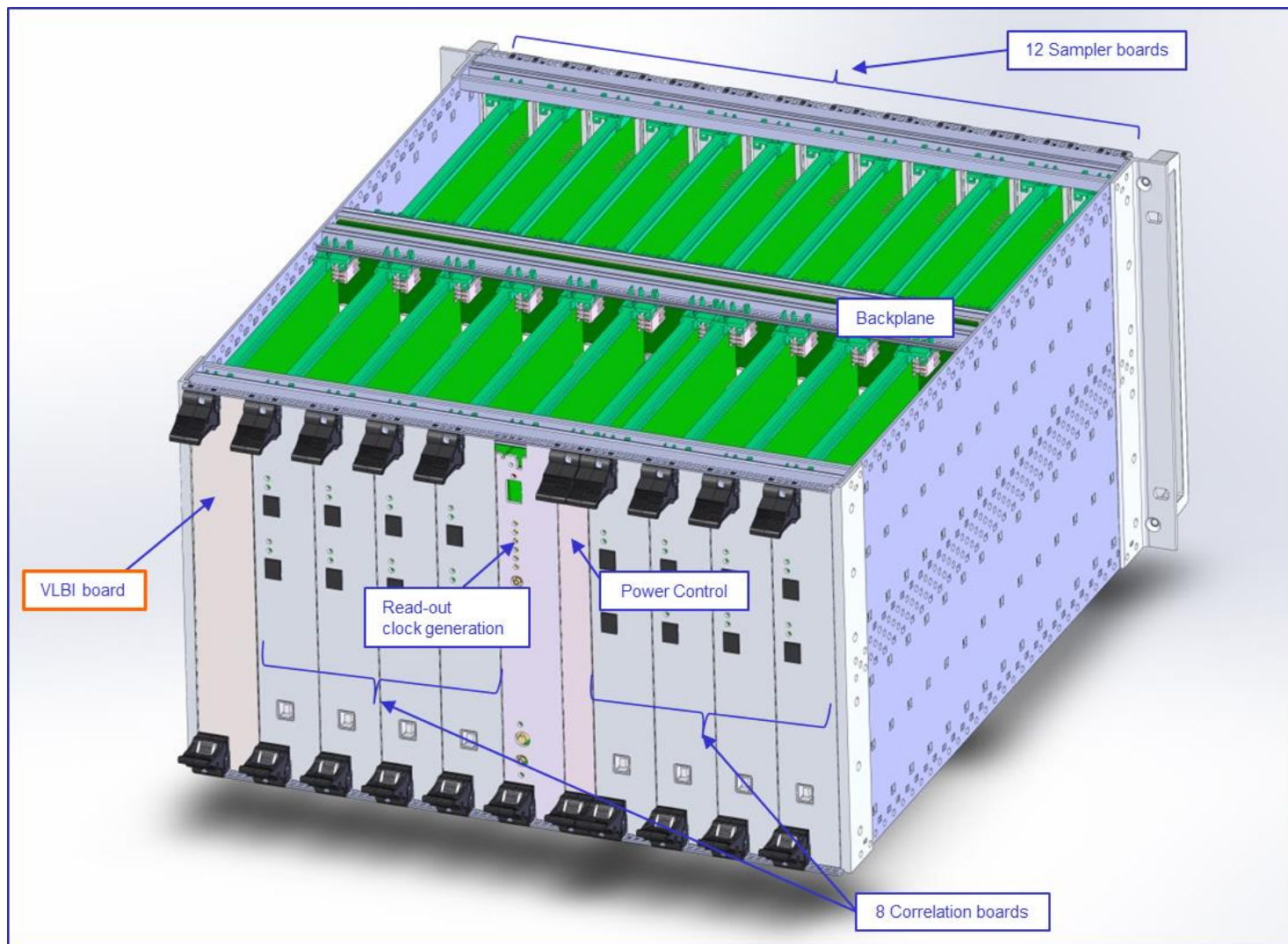
8 units processing 4 GHz each



DIFER (sampler prototype board)

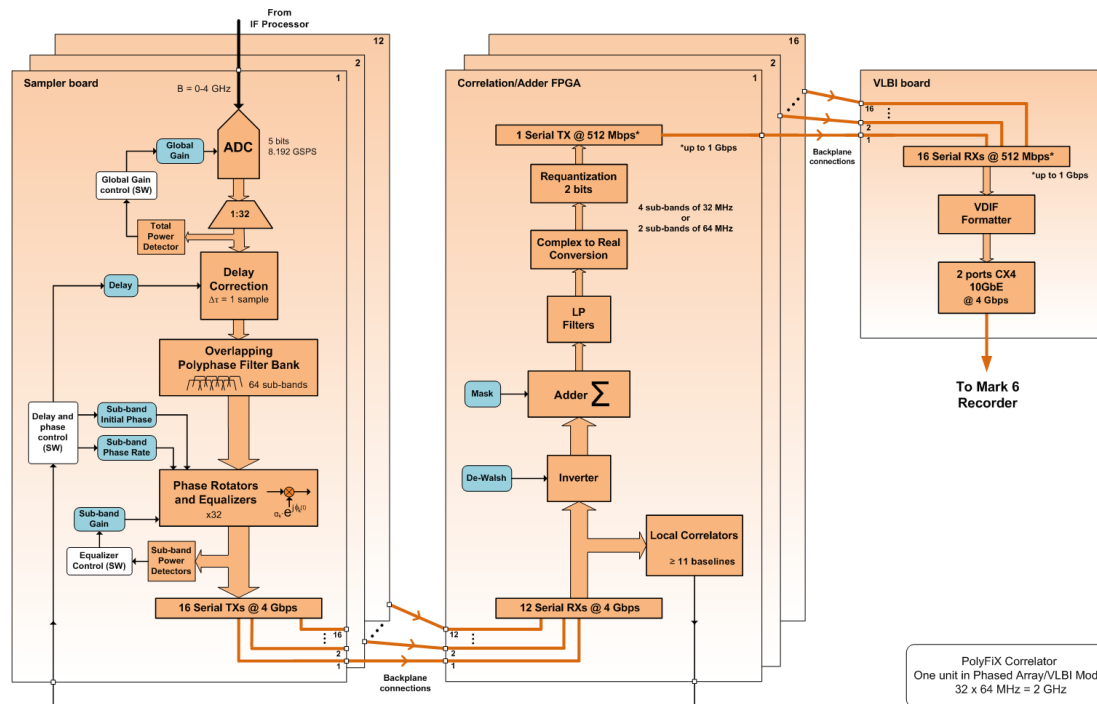


COMBO (correlation prototype board)



VLBI with NOEMA

- **Array phasing** = a new mode of the FPGA = software
 - Can include WVR phase correction + “local” correlator → beamformer
- **Interface card** to the VLBI recording system (Mark 6)



VLBI with NOEMA

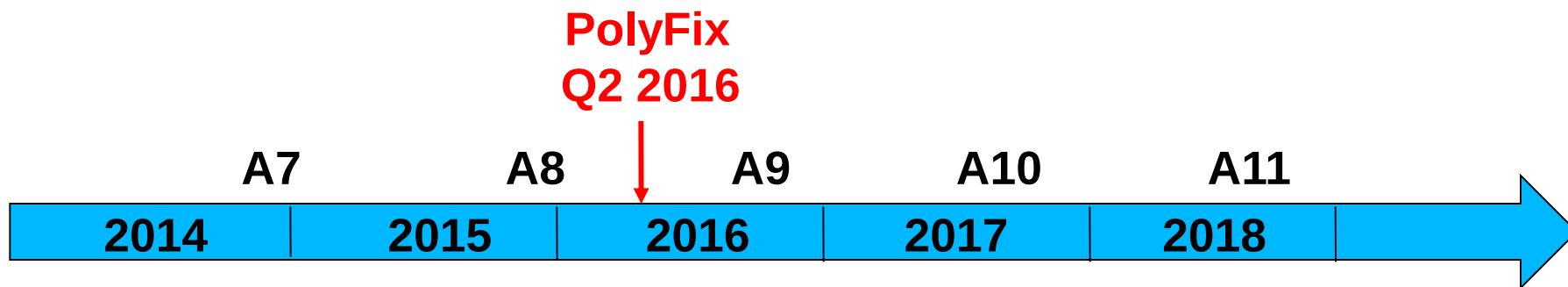
Mode	Recording rate	Polarization	Sideband	Band	IF range	# Correl/Beamformer units
2x2GHz	16 Gbps	Dual	Single	86/230/345 GHz	6-8 GHz	2 x 2 GHz
2x4GHz	32 Gbps	Dual	Single	86/230/345 GHz	6-10 GHz	4 x 2 GHz
2x2x4GHz	64 Gbps	Dual	Dual	230 GHz	5-9 GHz	4 x 1 GHz + 4 x 3 GHz
					6-10 GHz ?	8 x 2 GHz
				86/345 GHz	4-8 GHz	4 x 4 GHz*
2x2x8GHz	128 Gbps	Dual	Dual	86/230/345 GHz	4-12 GHz	8 x 4 GHz*

* Potential technical issues to be further discussed

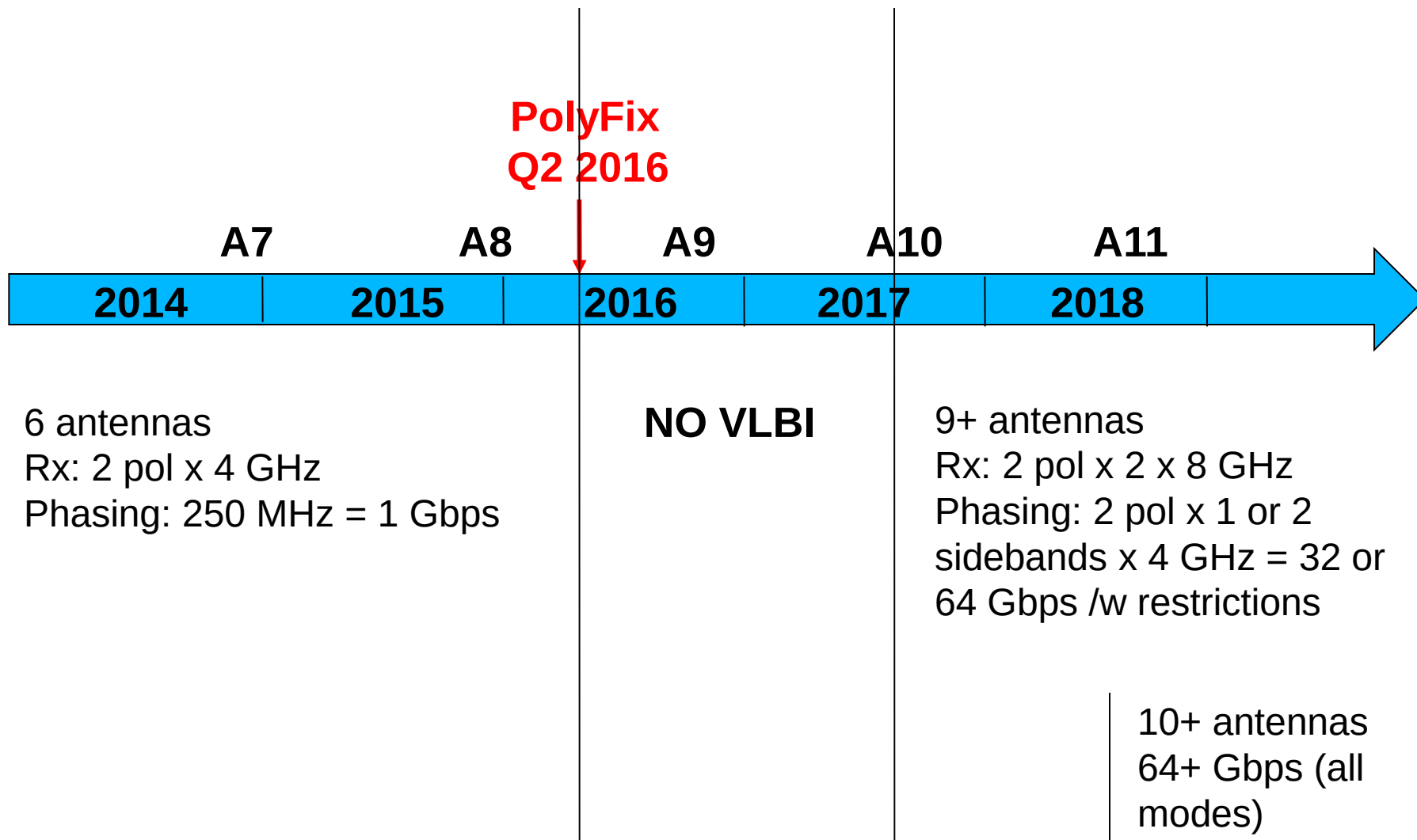
3 different firmware modes (FPGA core images) to be implemented:

- 2 GHz/unit
- 1 and 3 GHz/unit → for 5-9 GHz IF (EHT @ 230 GHz?)
- 4 GHz/unit → up to 128 Gbps

Timeline NOEMA



Timeline NOEMA



Timeline NOEMA

