



Forum della Ricerca Sperimentale e Tecnologica in INAF
Bologna, 22-24 giugno 2022

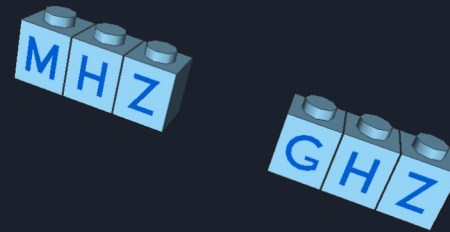
Expertise e sviluppo di sistemi riceventi all'IRA

Sessione: Elettronica e rivelatori
Speaker: Jader Monari

Istituto di Radioastronomia



Framework



- We cover from **few MHz to hundred GHz** a really tiny fraction of EM spectrum but a **very big difference in technology and methods**
- **INAF** has collected **long tradition and experience** in developing **RF/Microwave and mm-wave technology**, instruments, and experiments
- Through national facilities (Medicina, Noto, SRT) and involvement on World-wide state-of-the-art projects, **INAF personnel continuously improve their expertise**



2022 and beyond



- Requirements

- Large field of view
- High sensitivity
- High time resolution
- High spectral resolution

- Possible Solutions

- Aperture arrays
- Phased arrays
- Cryogenic focal plane arrays

- Cutting edge technologies

- Antenna's systems
- Beam forming techniques
- Multi-beam and -frequency systems
- RF and Power analog signals transportation over optical fibers
- Acquisition electronics
- Signal processing back-end
- Cryogenics

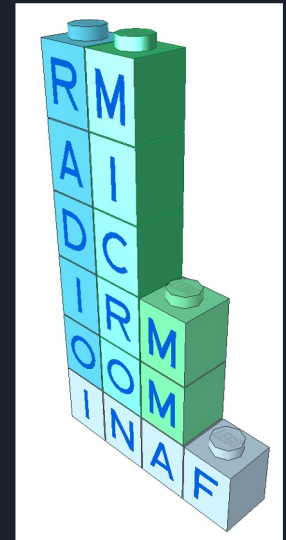
Lead Projects and facilities for Radio-/micro-/mm- wave

- Italian Radio Facilities

- **Sardinia Radio Telescope** (PON)
- **NOTO** radio telescope (PON)
- **MEDICINA** radio telescopes Northern Cross and 32m Dish (SST-FRB-PON)

- Square Kilometer Array (**SKA**)

- **LOFAR2** (station @ Medicina)



INAF Labs and Institutions - capabilities

- IRA Bologna, Medicina

- RF developments, tests, electronics, RX integration

- OAC Cagliari

- RF tests, cryogenics, support to SRT

- OAA Arcetri

- OEM design/test, RF tests on passive components and antennas

- OAS Bologna - Cryowaves

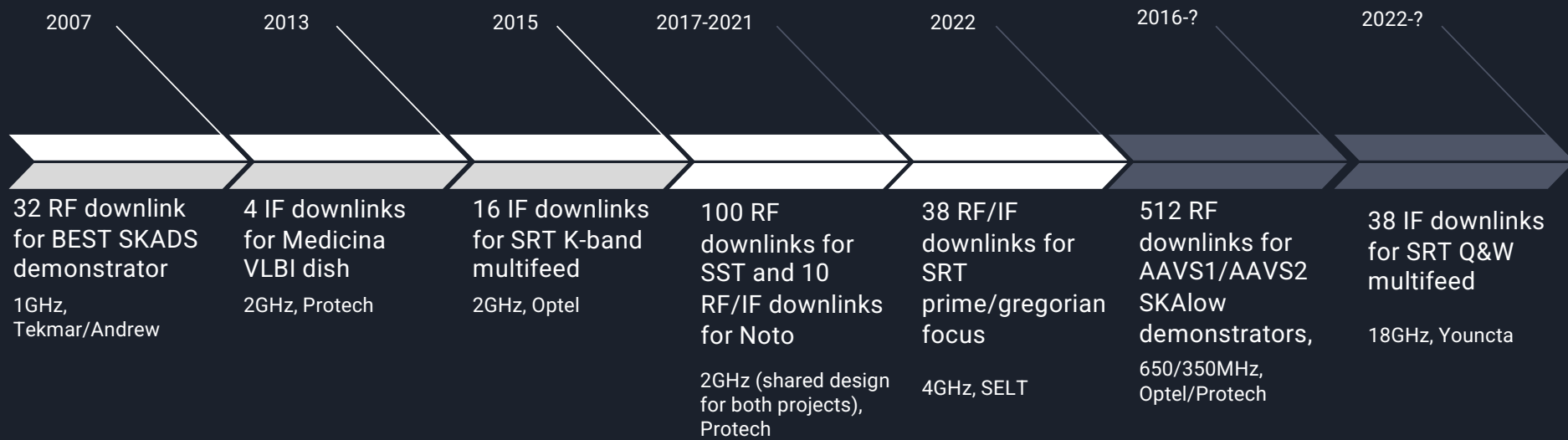
- Assembly integration and test, advanced cryogenics

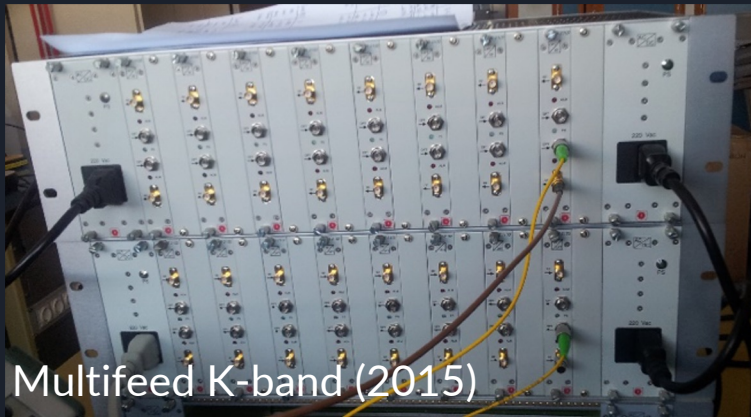
- OACt Catania

- Electronics



RFoF

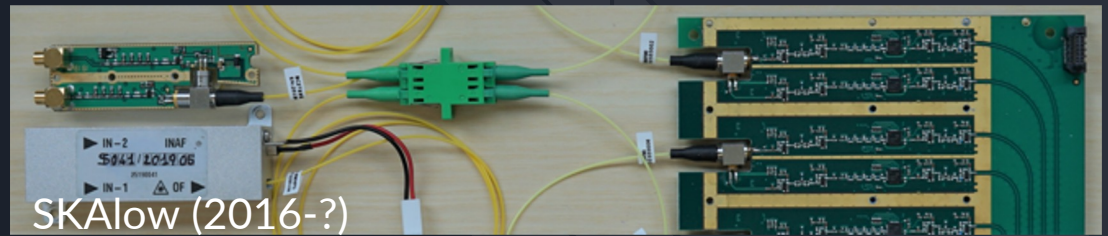




Multifeed K-band (2015)



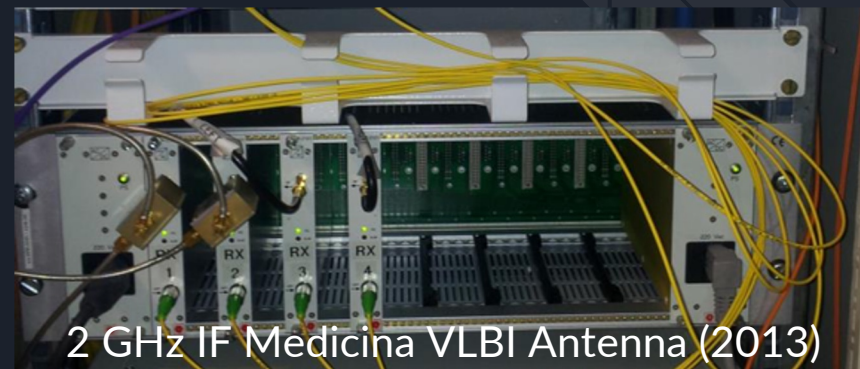
500MHz Northern Cross (2013)



SKALow (2016-?)



4GHz SRT (2022)



2 GHz IF Medicina VLBI Antenna (2013)

Italian radiotelescopes (dishes)



SRT 64m					
RX	RF Band [GHz]	Out Band [GHz]	Pixel per polarizzazione	polarizzazione	Stato
LP	0.305-0.410	0.305-0.410	1 x 2	H/V o L/R	Operativo
coassiale	1.3-1.8	1.3-1.8	1 x 2	H/V o L/R	Operativo
C ^{high}	5.7-7.7	0.1-2.1	1 x 2	L/R	Operativo
K	18-26.5	0.1-2.1	7 x 2	L/R	Operativo
X-ASI	8.2-8.6		1 x 1		Operativo
S	3-4.5	0.3-1.8	7 x 2	H/V	In costruzione
C ^{low}	4.2-5.6	0.1-1.5	1 x 2	L/R	In costruzione
Q	33-50	2-18	19 x 2	L/R	PON
W	75-116	4-12	16 x 2	H/V	PON
3-band	18-26	2-18	1 x 2	L/R	PON
	34-50	2-18	1 x 2	L/R	
	80-116	2-18	1 x 2	L/R	
W bolometro	80-115	/	400	/	PON

RICEVITORI AL SARDINIA RADIO TELESCOPE



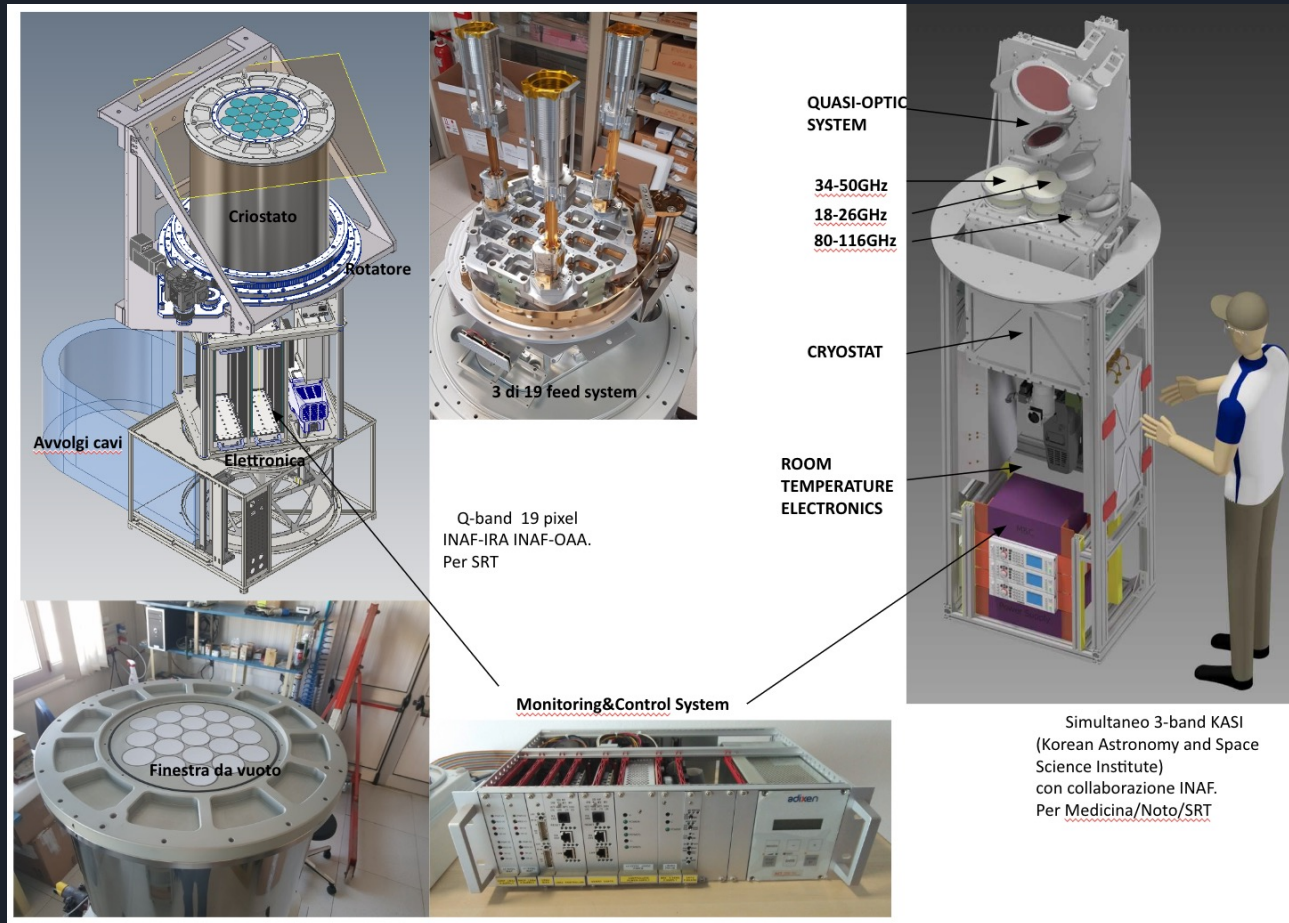
MEDICINA 32m					
RX	RF Band [GHz]	Out Band [GHz]	Pixel per pol.	Pol.	Stato
L	1.58-1.71	0.29-0.43	1 x 2	L/R	Operativo
	1.35-1.45	0.29-0.43	1 x 2	L/R	Operativo
SX coassiale	2.2-2.36	0.1-0.5	1 x 2	L/R	Operativo
	8.1-8.9	0.1-0.9	1 x 2	L/R	Operativo
C ^{low}	4.3-5.8	0.1-0.9	1 x 2	L/R	Operativo
C ^{high}	5.9-7.1	0.1-0.9	1 x 2	L/R	Operativo
K	18-26.5	0.1-2.1	2 x 2	L/R	Operativo
Ku	13.5-18	0.1-2.1	2 x 2	L/R	In costruzione
3-band	18-26	2-18	1 x 2	L/R	PON
	34-50	2-18	1 x 2	L/R	
	80-116	2-18	1 x 2	L/R	

RICEVITORI AL MEDICINA RADIO TELESCOPE

NOTO 32m					
RX	RF Band [GHz]	Out Band [GHz]	Pixel per pol.	Pol.	Stato
L	1.58-1.71	1.58-1.71	1 x 2	L/R	Operativo
	1.35-1.45	1.35-1.45	1 x 2	L/R	Operativo
SX coassiale	2.2-2.36	2.2-2.36	1 x 2	L/R	Operativo
	8.1-8.9	0.1-0.9	1 x 2	L/R	Operativo
C ^{low}	4.6-5.0	0.1-0.5	1 x 2	L/R	Operativo
C ^{high}	5.1-7.2	0.1-0.5	1 x 2	L/R	Operativo
K	21.5-23	0.1-0.6	1 x 2	L/R	Operativo
3-band	18-26	2-18	1 x 2	L/R	PON
	34-50	2-18	1 x 2	L/R	
	80-116	2-18	1 x 2	L/R	

RICEVITORI AL NOTO RADIO TELESCOPE

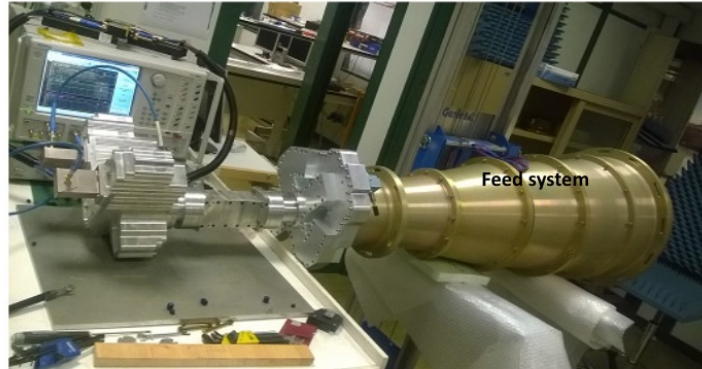
High frequency multi feed/frequency receivers



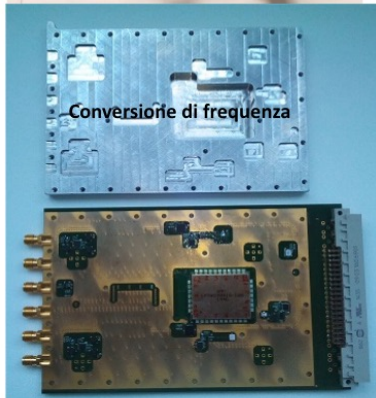
High frequency devices



Feed system



Feed system

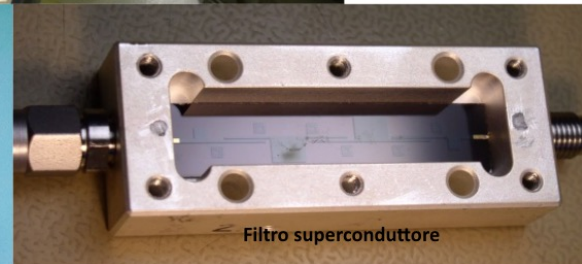


Conversione di frequenza

Ku per Medicina
INAF-IRA INAF-OAA



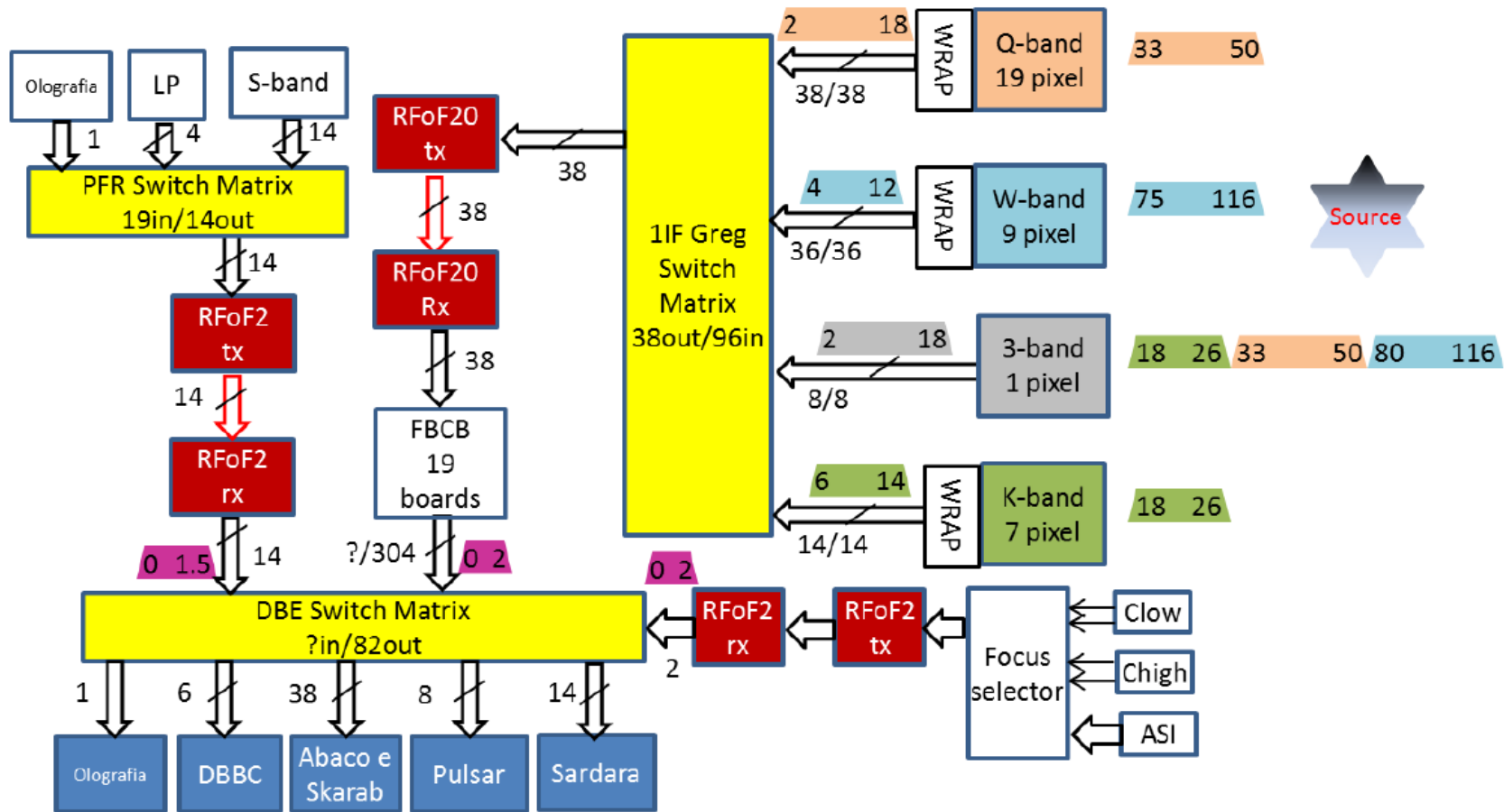
Conversione di frequenza



Filtro superconduttore

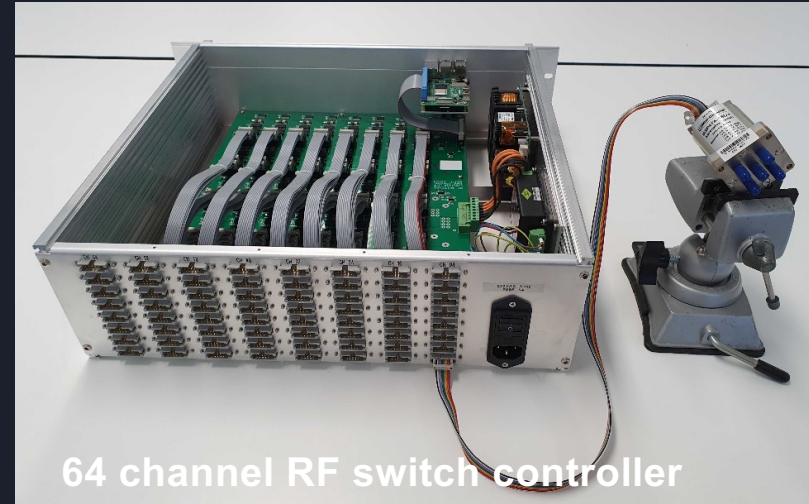
Clow per SRT
INAF-IRA INAF-OAA

Distribution systems

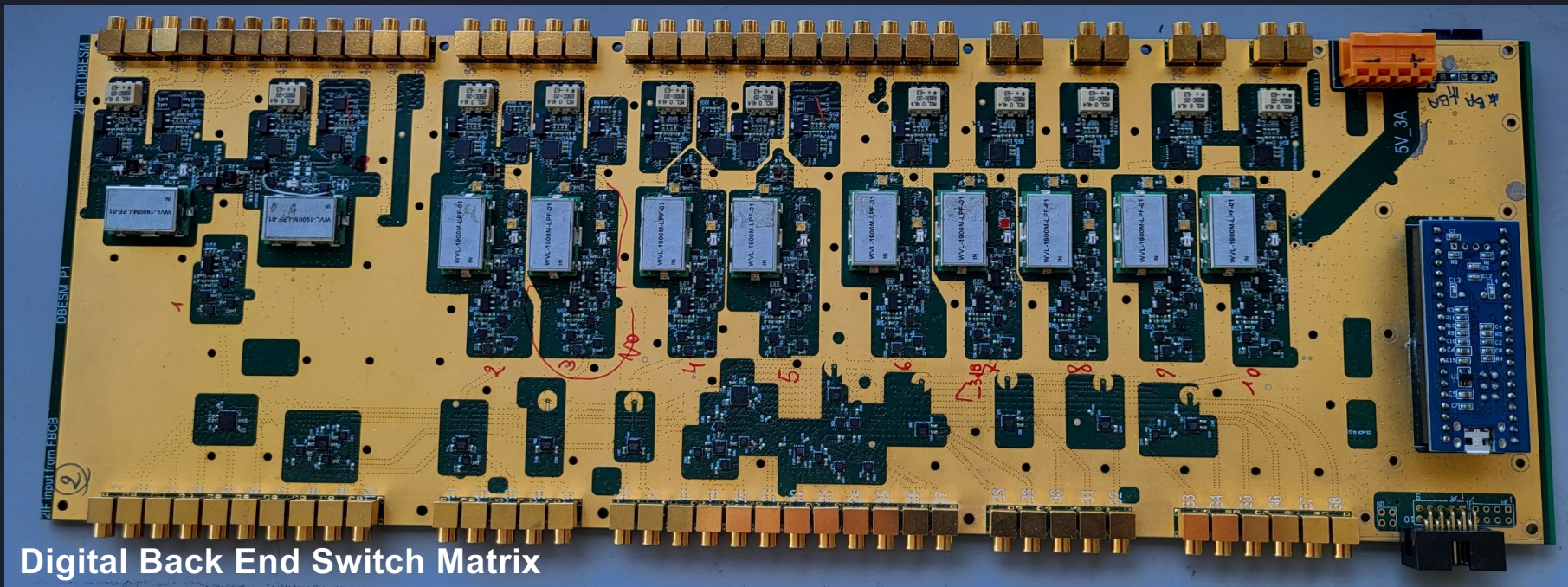




FCBC (Full Band conversion, Continuum Back-end)

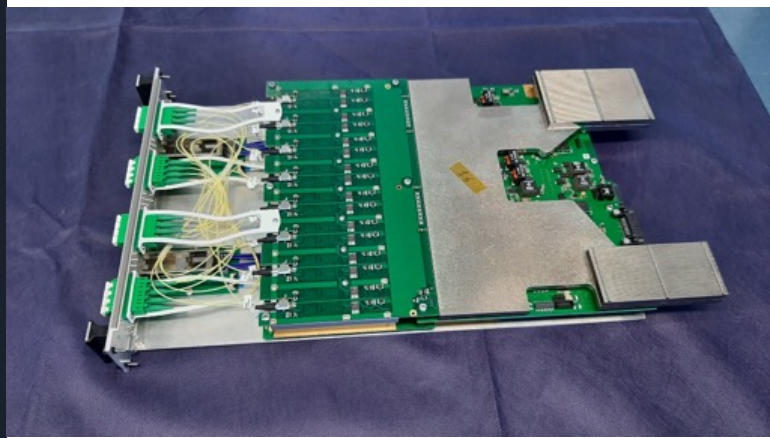
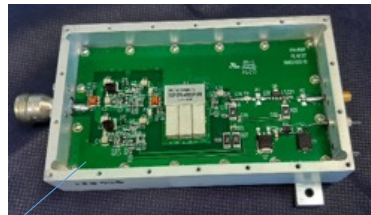
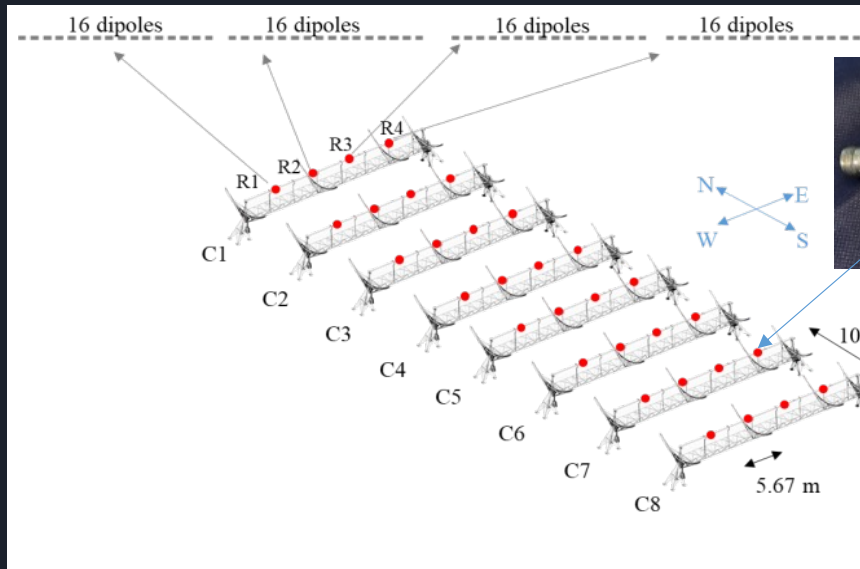


64 channel RF switch controller

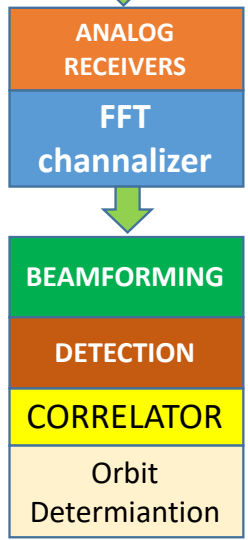


Digital Back End Switch Matrix

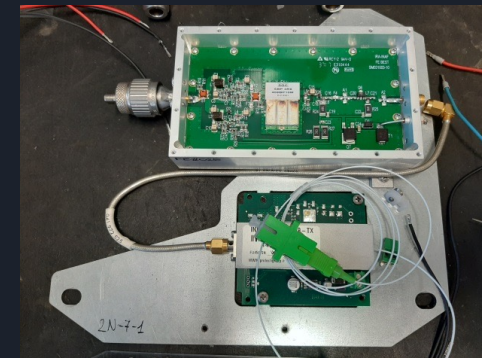
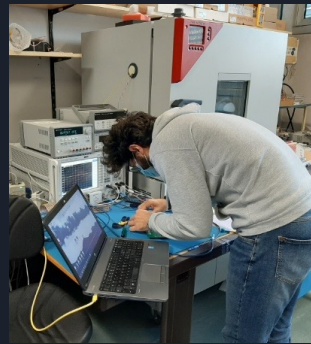




32 optical fibres

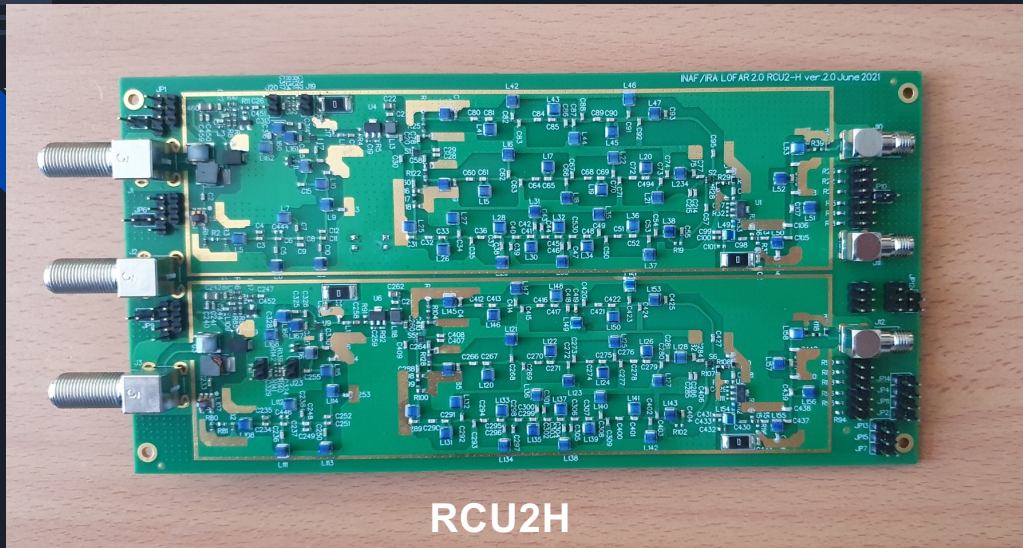


Design, development, test and installation of new receivers for NC

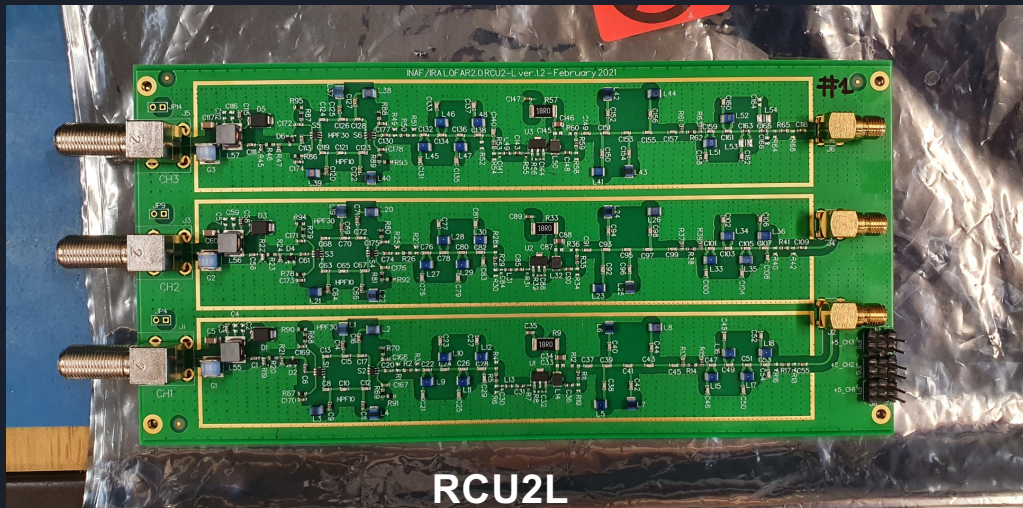




ASTRON

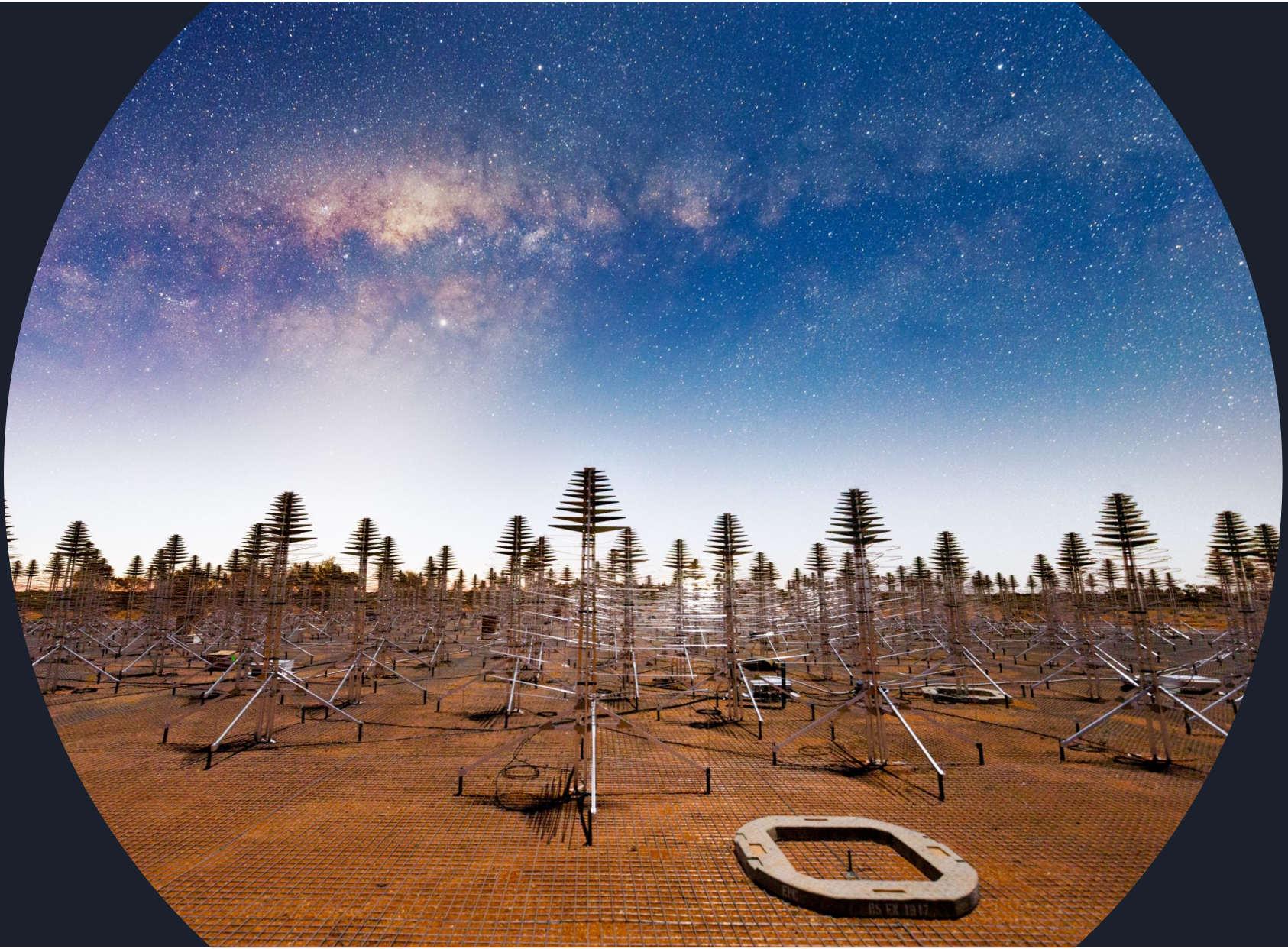


RCU2H



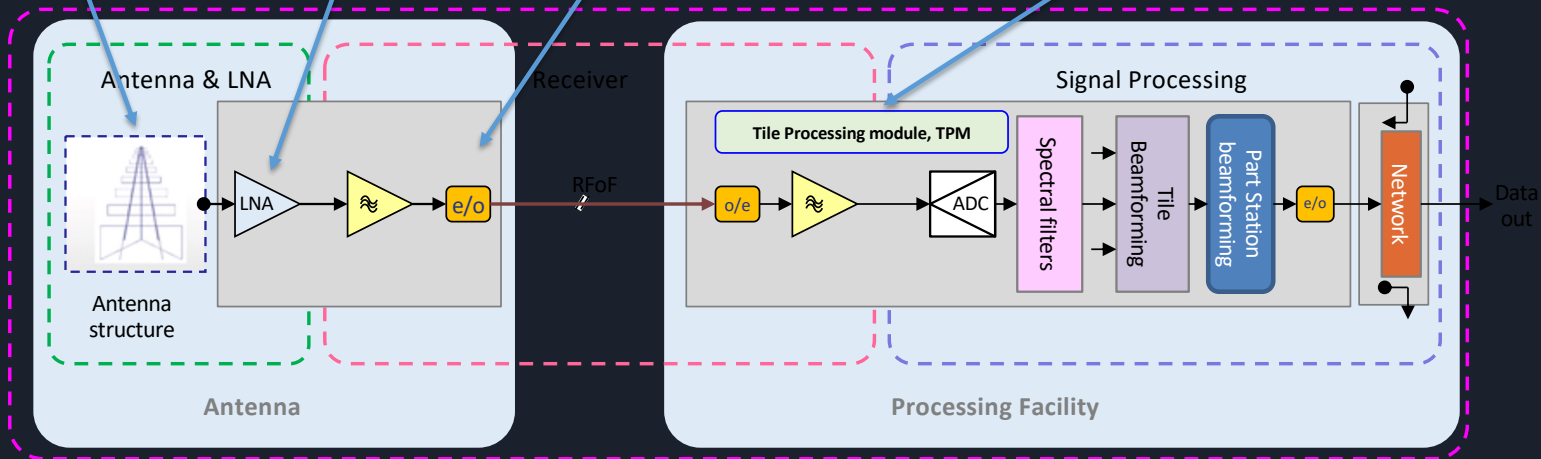
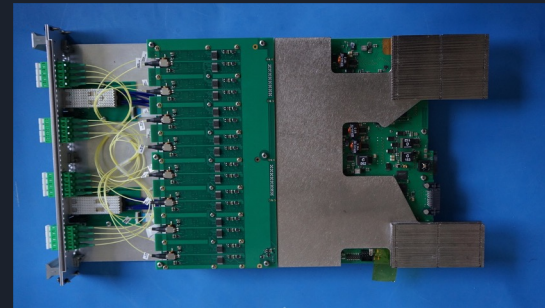
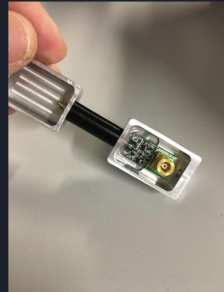
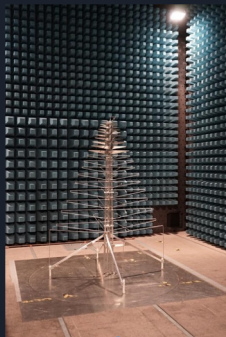
RCU2L







Receiver chain: technology made in Italy

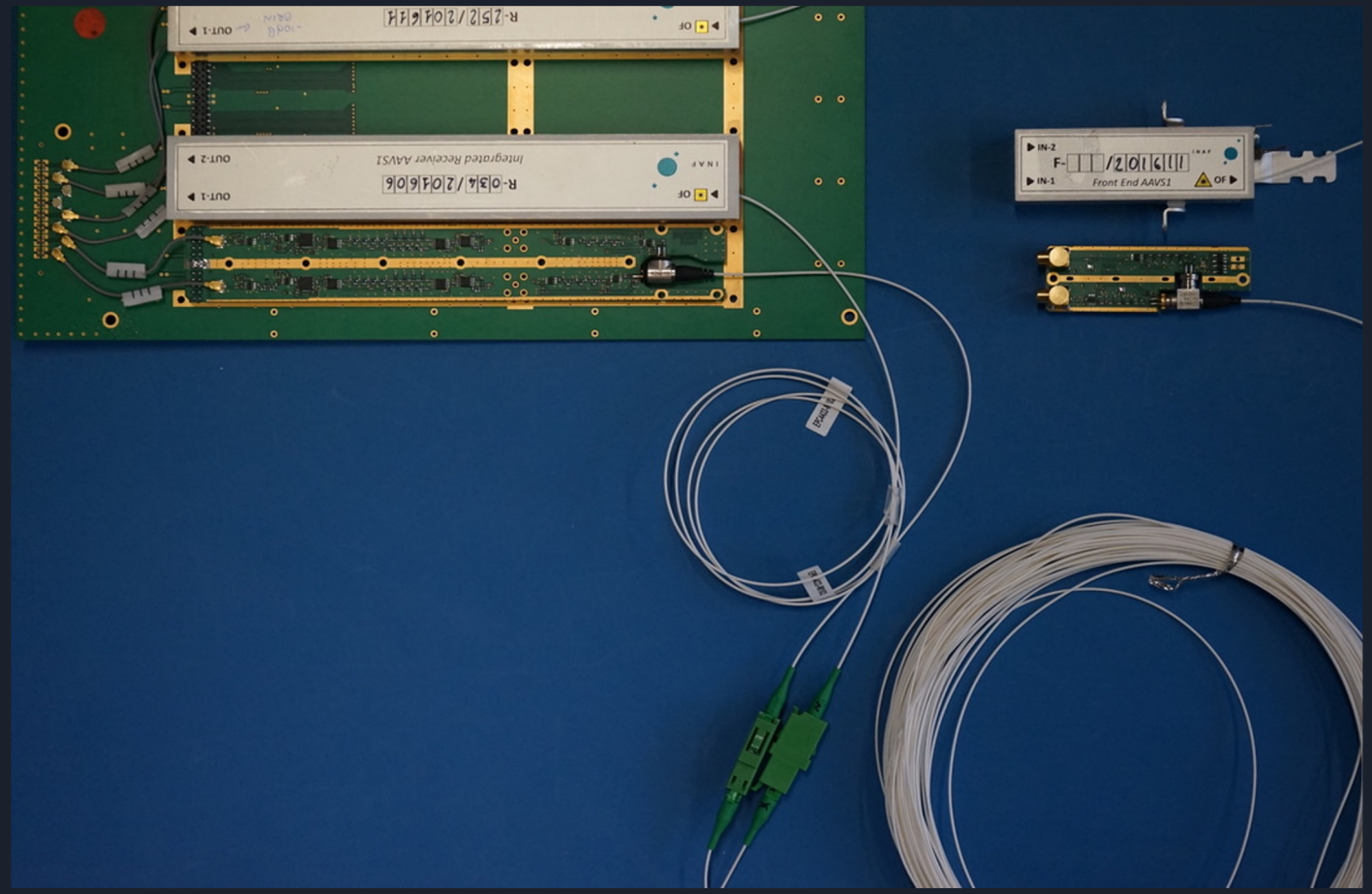
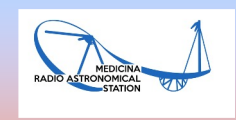


SKALA4.1AL Antenna

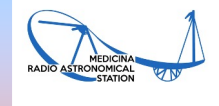
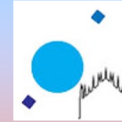
- Dual-polarized LPDA.
- 20 dipoles: 19 triangular-tooth plus 1 bow-tie at the bottom of the antenna.
- Solid dipoles on the high-frequency elements and wire dipoles on the low-frequency ones.
- 1-degree tilted boom.
- Aluminium-made.
- Electrical connection of the antenna to the ground plane.
- Antenna matched to a single-ended 50-ohm LNA.
- LNA encapsulated in the top-cap of the antenna and connected to a coaxial cable embedded in the antenna booms.



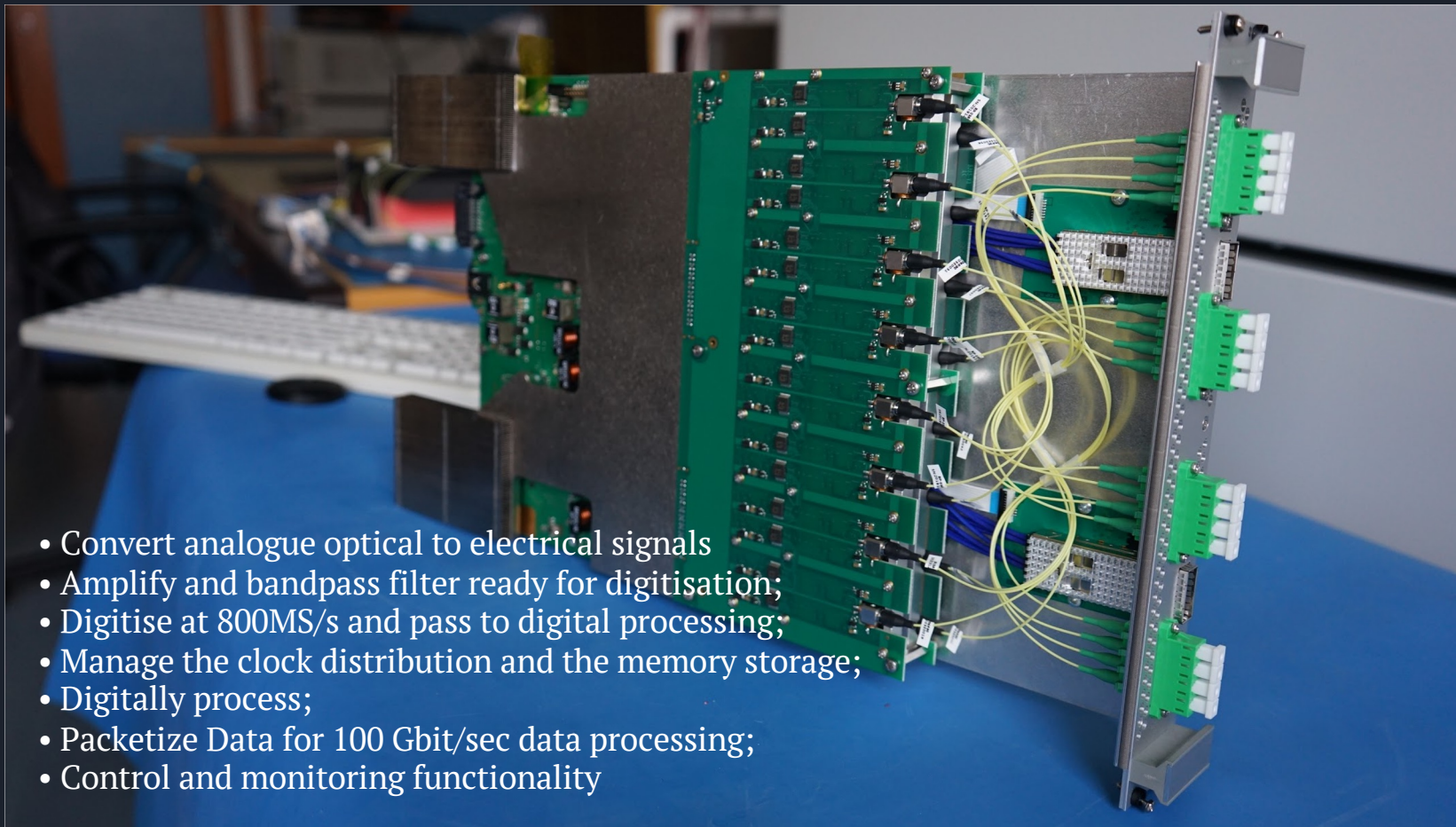
Analogue RFoF link



Tile Processing Module

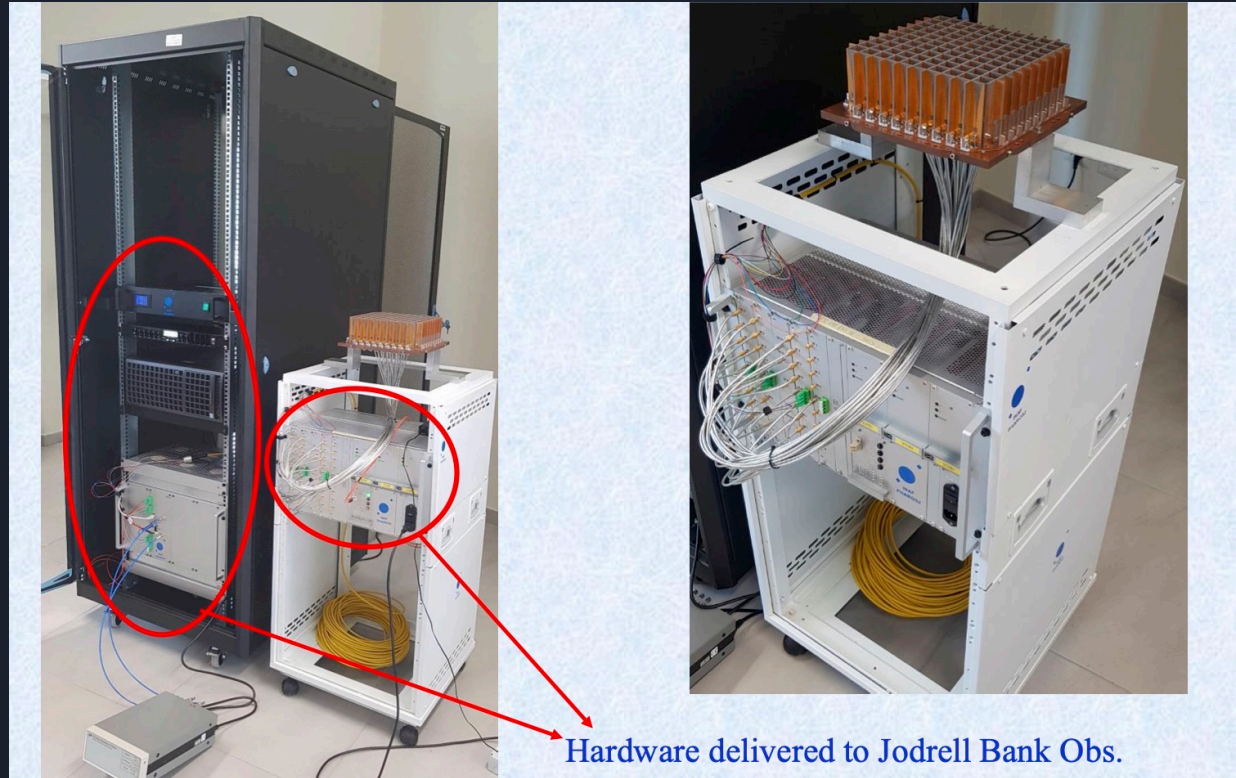
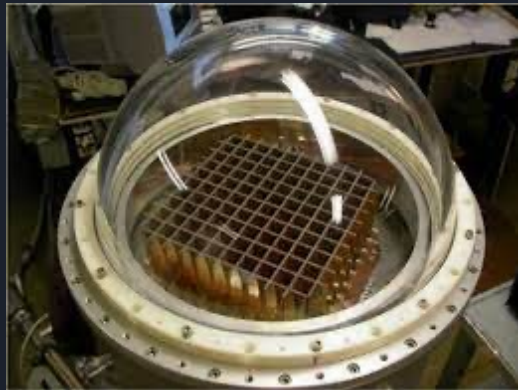


Sanitas^{EQ}
DIGITAL SYSTEMS, RESEARCH AND INNOVATION



- Convert analogue optical to electrical signals
- Amplify and bandpass filter ready for digitisation;
- Digitise at 800MS/s and pass to digital processing;
- Manage the clock distribution and the memory storage;
- Digitally process;
- Packetize Data for 100 Gbit/sec data processing;
- Control and monitoring functionality

Pharos2: Phased Array Feed (PAF)



Hardware delivered to Jodrell Bank Obs.





Grazie per l'attenzione

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