Managing hundreds of wideband receiving signals at the SRT (Sardinia Radio Telescope)

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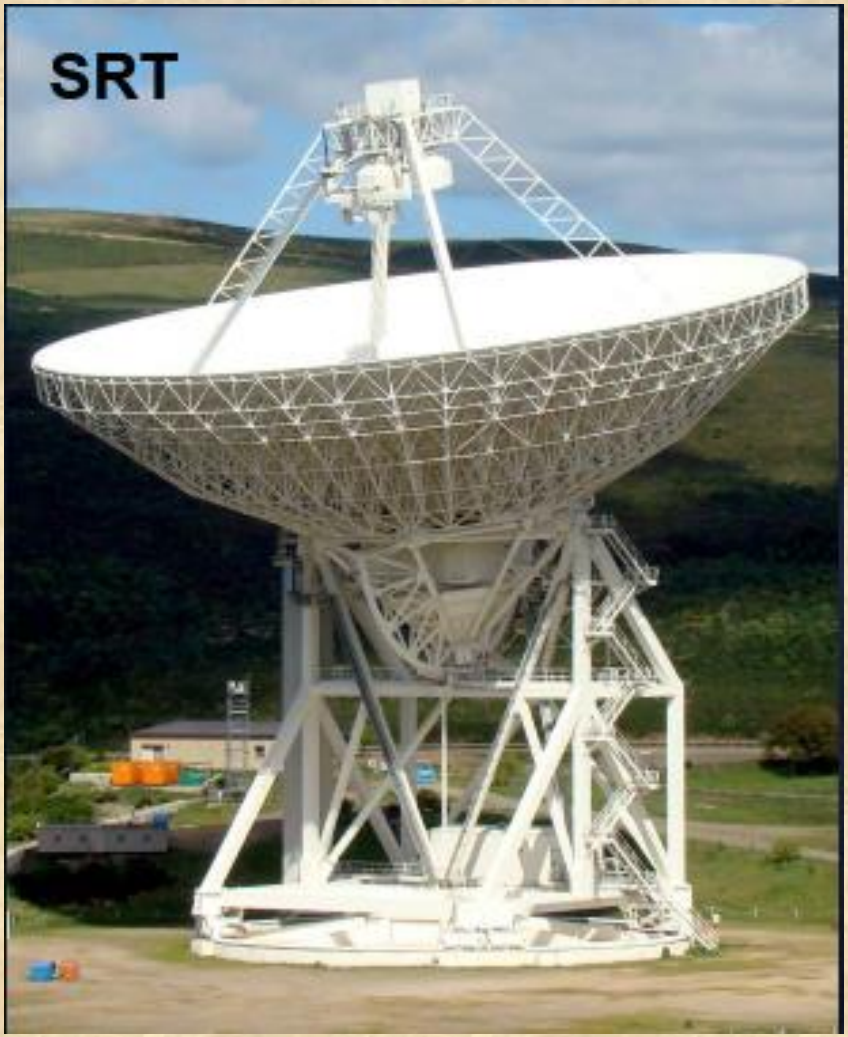
SARDINIA RADIO TELESCOPE (SRT)

- **Primary Mirror D=64 m; Secondary Mirror D=7.9 m**
- **Six focal positions:**
  Primary, Gregorian, Four Beam Wave Guide
- **Can host up to 20 dual polarization receivers:**
  mono feed, dual frequency, multibeam
  Swapped remotely and automatically
- **Aim 0.3-116 GHz frequency coverage**

PRIMARY FOCUS



INTRODUCTION

Feb-Jun 2018: INAF applies for getting funds from MIUR (Italian Ministry of University and Research)

*June 2019: in the framework of a wide national funding programme called **PON** (National Operative Plan) MIUR provides INAF*

18.6 M€

"SRT_HighFreq – Enhancing the Sardinia Radio Telescope for studying the Universe at high radio frequencies"

85% goes SRT, 15% goes Medicina and Noto

TIME FRAME: june 2019 TO february 2022

THE FRAMEWORK for SRT

9 WORK PACKAGES

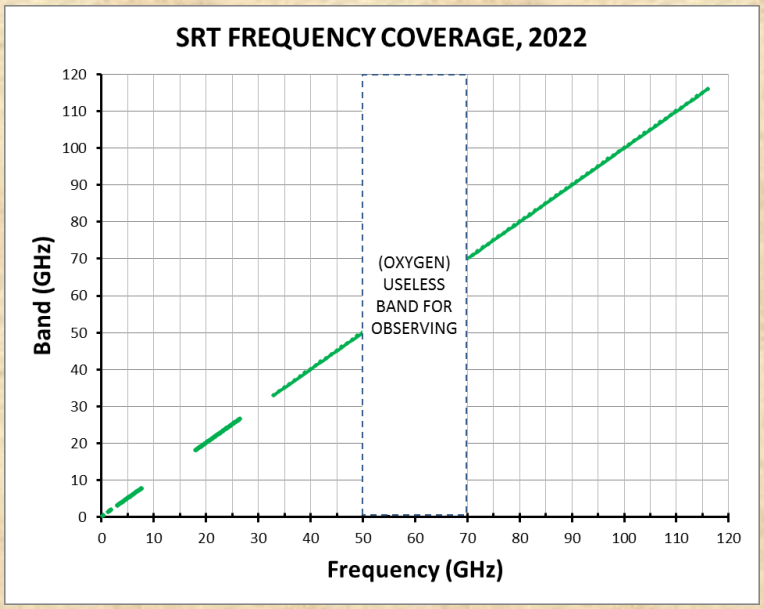
1. ***A MULTIFEED SYSTEM in the W-band, 70-116 GHz***
2. ***A MULTIFEED SYSTEM in the Q-band, 33-50 GHz***
3. ***A ~300 PIXEL BOLOMETER in the W-band, 80-116 GHz***
4. ***THREE SIMULTANEOUS RECEIVING SYSTEM in the K/Q/W bands (for SRT, Medicina and Noto)***
5. ***A METROLOGICAL SYSTEM FOR GETTING MAX ANTENNA GAIN UP TO 116 GHz***
6. ***NEW GENERATION DIGITAL BACK-ENDS***
7. ***ELECTRONIC and MECHANICAL INTERFACES for the INTEGRATION of the NEW OBSERVING SYSTEM***
8. ***HPC (HIGH PERFORMANCE COMPUTING) RESOURCES for STORAGE and MASSIVE PROCESSING of DATA***
9. ***STRENGTHENING of the INSTRUMENTATION in the MICROWAVE LAB***

RECEIVER SUITE: NOW and the INCOMING FUTURE

RX name	Focus	RF Band [GHz]	IF Band [GHz]	Feed per polarization	Delivered Band [GHz]	Status
LP coaxial	Primary	0.305-0.410	0.305-0.410	1 x 2	0.21	Operative
		1.3-1.8	1.3-1.8	1 x 2	1	Operative
C_{high}	BWG	5.7-7.7	0.1-2.1	1 x 2	4	Operative
K mfeed	Secondary	18-26	0.1-2.1	7 x 2	28	Operative
S	Primary	3-4.5	0.3-1.8	7 x 2	21	Parts under procurement
C_{low}	Secondary	4.2-5.6	0.1-1.5	1 x 2	2.8	To be assembled
K mfeed-extended	Secondary	18-26	4-12	7 x 2	**112**	PON TIME
Q mfeed	Secondary	33-50	2-18	19 x 2	**608**	PON
W mfeed	Secondary	70-116	4-12	16 x 2	**256**	PON
3-band simultaneous	Secondary	18-26	4-12	1 x 2	**16+32+64= 112**	PON
		34-50	2-18	1 x 2		
		80-116	2-18 x 2	1 x 2		
W bolometer	Secondary	80-116	/	300	/	PON

HUGE BANDWIDTH TO BE MANAGED

WHO MAKES RECEIVERS

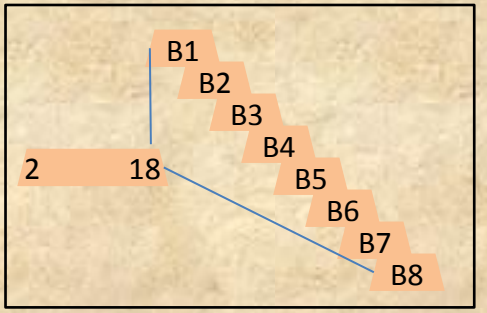


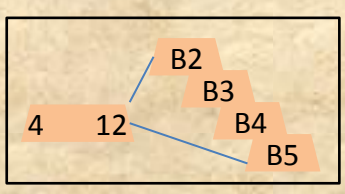
- ***W-MULTIFEED, 70-116 GHz: UKRI (UK RESEARCH and INNOVATION)***
- ***Q-MULTIFEED, 33-50 GHz: INAF***
- ***W-BOLOMETER, 80-116 GHz: U. LA SAPIENZA, Roma (De Bernardis group)***
- ***3-band SIMULTANEOUS 18-26/34-50/80-116 GHz: KASI (KOREA ASTRONOMY and SPACE SCIENCE INSTITUTE)***
- ***C_{low}, 4.2-5.6 GHz: INAF; all parts available. To be assembled***
- ***S-MULTIFEED, 3-4.5 GHz: INAF; parts under procurement***

THE SPECIFICATIONS of the INFRASTRUCTURE

1. INTEGRATE ALL RECEIVERS IN A COMMON INFRASTRUCTURE
2. SWITCH AMONG RECEIVERS TO BE SENT TO REMOTE BACK-ENDS
3. USE *2* AND *20* GHz *RFoF* TO SEND SIGNALS TO REMOTE BACK-ENDS
4. BREAK WIDER BANDS INTO SUB-BANDS 2GHz WIDE
5. SWITCH BANDS AND SUB-BANDS TO ONE or MORE BACK-ENDS
6. 2+4+5 $\Rightarrow$ OBSERVING SETUPS REQUESTED BY THE ASTRONOMERS

SUB-BANDS CREATION ⇒ INCREASING NUMBER OF SIGNALS

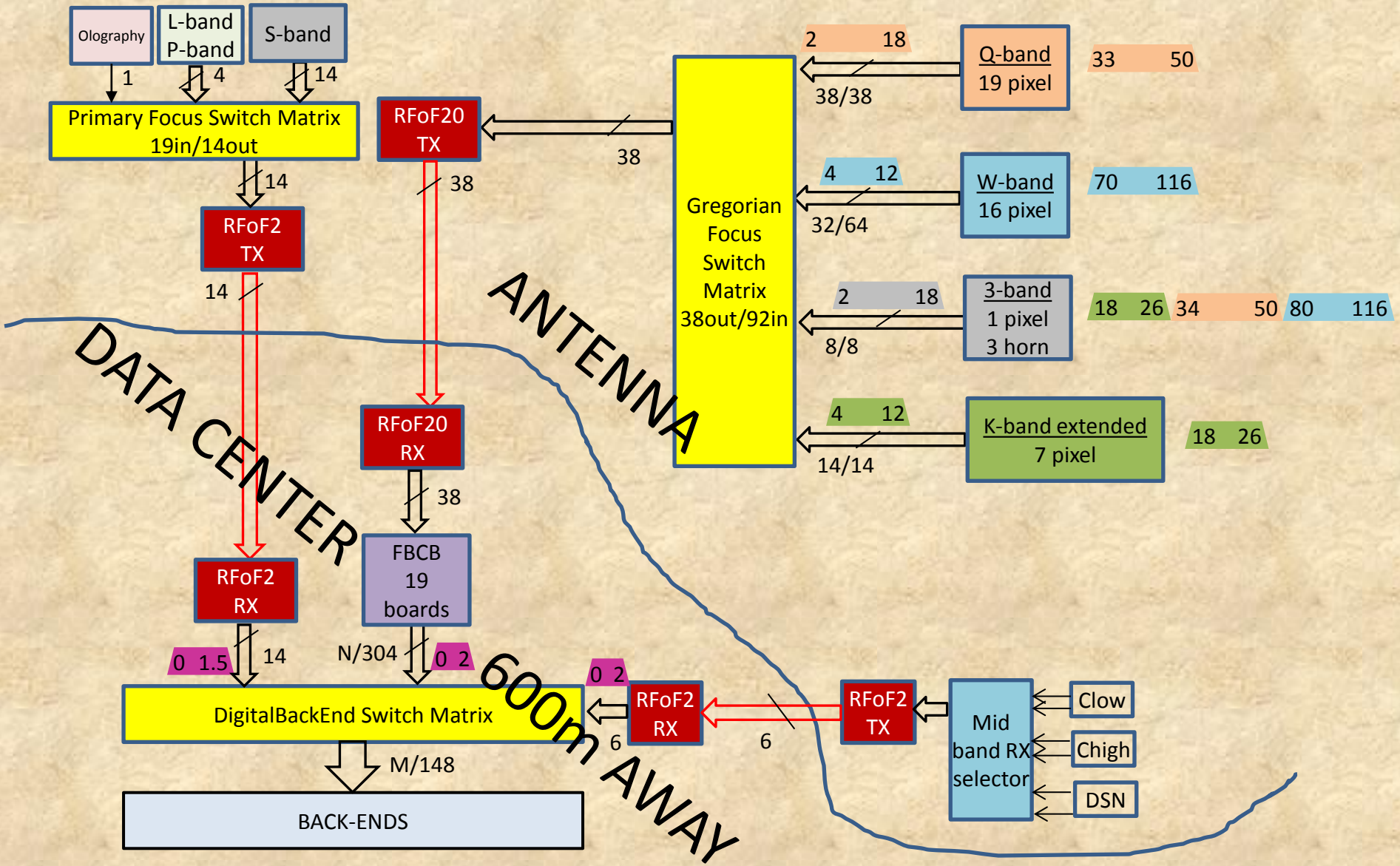




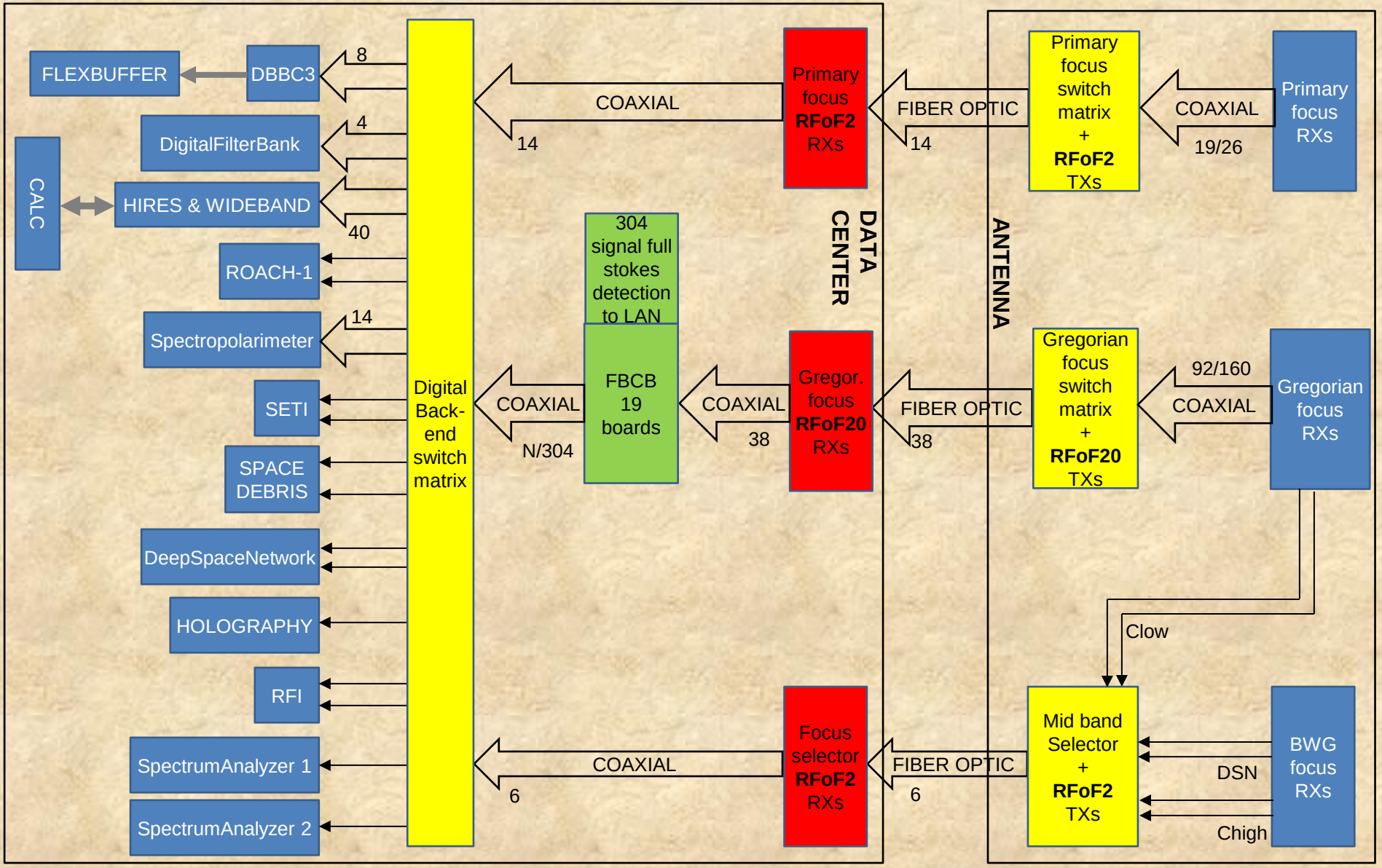
RX name	RF Band [GHz]	IF Bands	Number of signals
LP coaxial	0.305-0.410	RF	2
	1.3-1.8	RF	2
C_{high}	5.7-7.7	0.1-2.1	2
K mfeed	18-26	0.1-2.1	14
S	3-4.5	0.3-1.8	14
C_{low}	4.2-5.6	0.1-1.5	2
K mfeed extended	18-26	**B2 to B5**	**56**
Q mfeed	33-50	**B1 to B8**	**304**
W mfeed	70-116	**B2 to B5**	**128**
3-band simultaneous	18-26	**B2 to B5**	**8+16+32=56**
	34-50	**B1 to B8**	
	80-116	**B1 to B8**	

A LOT OF SIGNALS TO BE MANAGED

SWITCHING 100+ WIDEBAND SIGNALS



RECEIVERS TO BACK-ENDS INTERCONNECTION



THE MODULES FOR THE INTERCONNECTION

MODULE	TYPE	Module progress	System status
Primary Focus SM	Switches only	Designed	Under procurement
Secondary Focus SM	Switches only	Designed	Under procurement
Mid band RX Selector	Signal conditioning	In place	On antenna
RFoF2	Direct modulation	In place	On antenna
RFoF20	Indirect modulation	Specifications ready	Tender documentation
FBCB	Frequency conversion and signal conditioning	Designed	Under procurement
Digital Back-end SM	Switches and signal conditioning	Designed	Under procurement

PRIMARY and SECONDARY FOCUS SWITCH MATRIXES

ELECTRICAL CHARACTERISTICS	
LOSS (dB)	≤ 0.5
ISOLATION (dB)	≥ 90
BAND (GHz)	0 to 18
S_{11}, S_{22} (dB)	≤ -15
CONNECTORS	SMA-f
CONTROL SIGNAL V/mA	12/170
CONSUMPTION when active (W)	2.4
TERMINATION when NOT active	50 Ω

GENERAL CHARACTERISTICS	
TYPE	MECHANICAL
NUMBER of INPUTS	6 and 4
NUMBER of OUTPUTS	1
DIMENSIONS L x H x W (mm)	80 x 43 x 43
LIFETIME (cycles)	10,000,000
SWITCHING SPEED (ms)	20
QUANTITY for PRIMARY FOCUS	4
QUANTITY for SECONDARY FOCUS	37

RFoF20: RADIO FREQUENCY over FIBER 20GHz

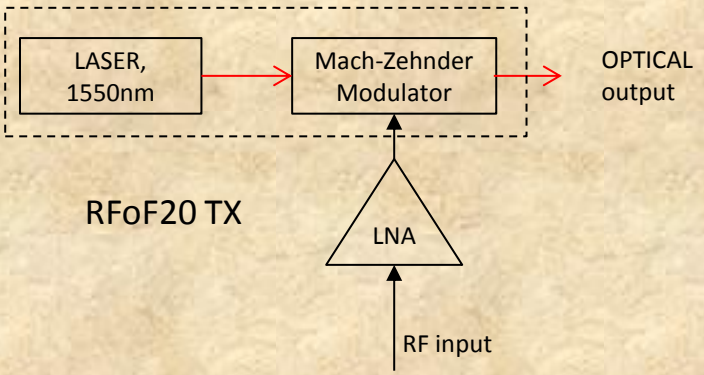
RF SPECIFICATIONS	
BAND (GHz)	1 to 18 (min)
GAIN (dB)	14 ± 2
GAIN SMOOTHNESS EVERY 2GHz	± 1
NF (dB)	< 6
S_{11}, S_{22} (dB)	≤ -12
INPUT P1dB (dBm)	≥ -6
GROUP DELAY	Linear phase
SSB PHASE NOISE at 10Hz OFFSET (dBc/Hz)	< -80
PHASE STABILITY (degree rms)	≤ 5 in 1 sec
ELECTRICAL CONNECTORS	SMA-f
RF IMPEDANCE (Ω)	50

OPTICAL SPECIFICATIONS	
WAVELENGTH (nm)	1550
CONNECTORS	FC-APC
SINGLE MODE FIBER	G652D

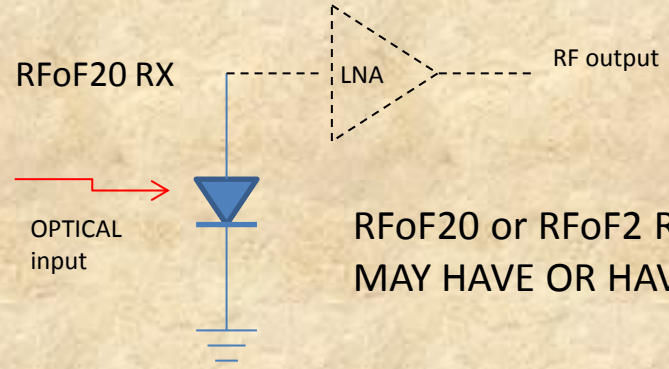
POWER SPECIFICATIONS	
MAIN SUPPLY (VAC/Hz)	230/50
CONSUMPTION 38 TXs (W)	≤ 350
CONSUMPTION 38 RXs (W)	≤ 100

MECHANICAL SPECIFICATIONS	
4 UNITs x 10 TXs	4 x 19"/3U
4 UNITs x 10 RXs	4 x 19"/3U
UNIT DEPTH (mm)	600

RFoF20 vs RFoF2 OPTICAL LINK



RFoF20 to RFoF2 COMPARISON		
	By M-Z Modulator	**By Direct Modulation**
BANDWIDTH (GHz)	UP TO 20	UP TO 4
NF (dB)	26	40
OIP3 (dBm)	10	35
COST FACTOR	~15	1
λ (nm)	1550	1300/1550



RFoF20 or RFoF2 RX IS A PHOTODIODE THAT MAY HAVE OR HAVE NOT AN RF AMPLIFIER

FBCB: FULL BAND CONVERSION/CONTINUUM BOARD/BACK-END

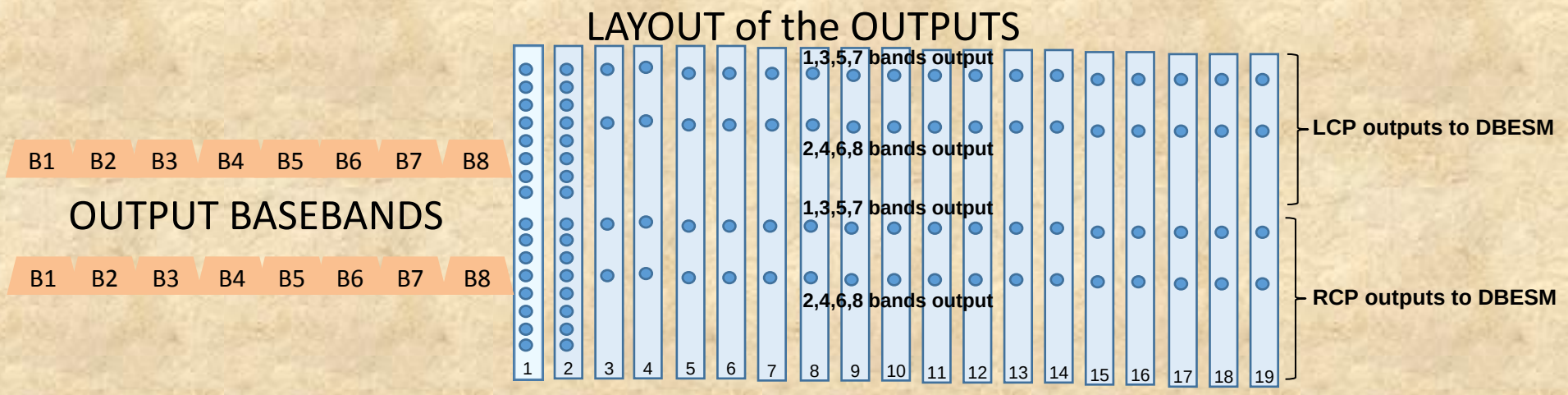
HITCH

✓ FULL CAPACITY (304 OUTPUTS) REQUIRES BOTH TOO MANY CABLES AND SWITCHING BOARDS FOR ROUTING

CAN A SUBSET OF OUTPUTS PROVIDE THE REQUESTED OBSERVING MODES FOR MULTIFEEDS ?

SOLUTION

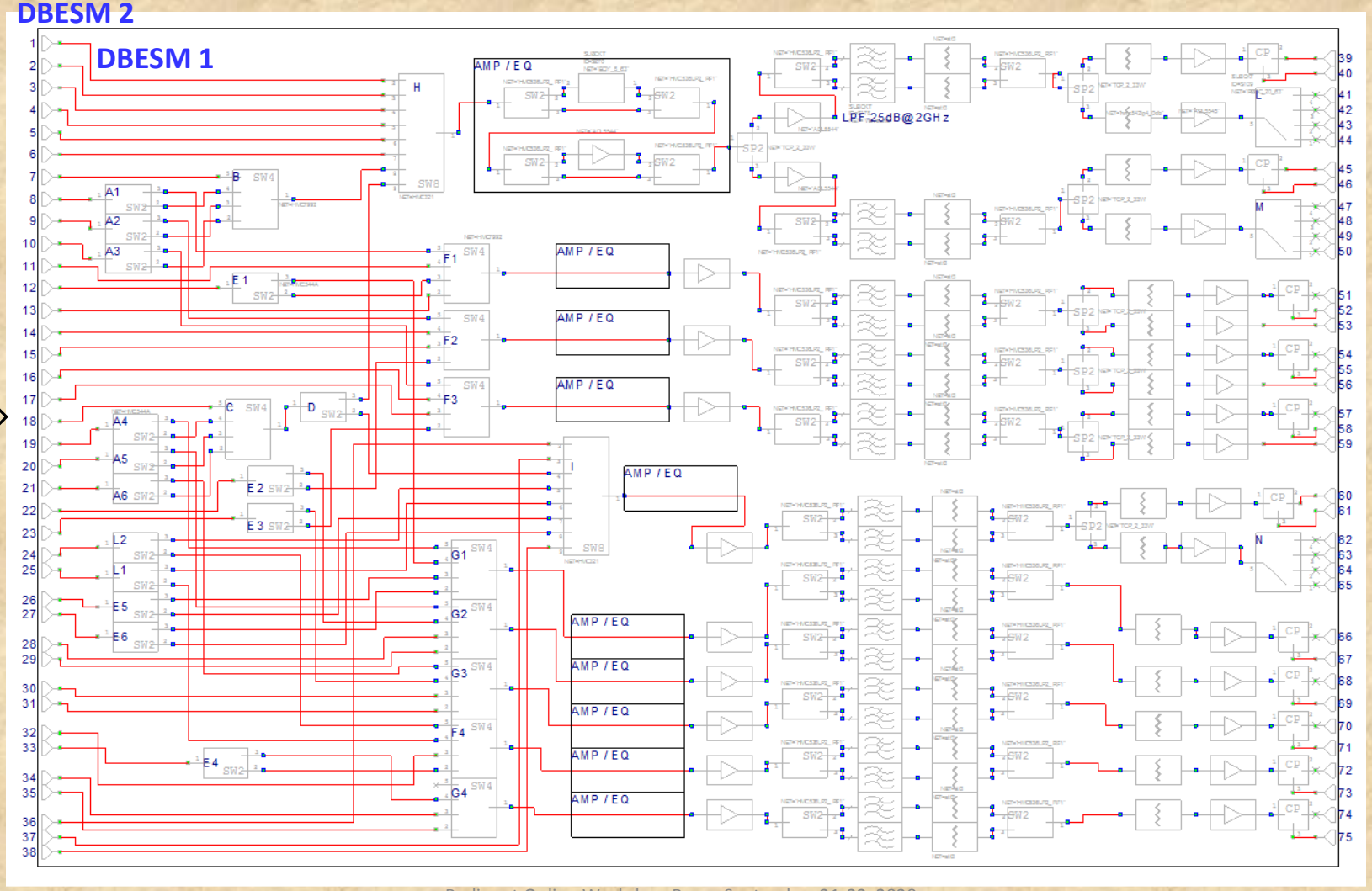
2 BOARDS FULL BASEBANDS + 17 BOARDS ODD and EVEN BASEBANDS (100 OUTPUTS)



DBESM: DIGITAL BACK-END SWITCH MATRIX

- 4 IDENTICAL BOARDS, 38 INPUTS and 37 OUTPUTS EACH
- ROUTING, AMPLIFYING, EQUALIZING, FILTERING, SETTING LEVEL

DBESM 4
DBESM 3
DBESM 2



CONCLUSIONS: CAPABILITIES of the INFRASTRUCTURE

- ✓ EVERY RX CAN BE REMOTELY/AUTOMATICALLY SELECTED
- ✓ RXs CAN BE ADDED IN THE FUTURE (e.g. 8-18GHz DUAL FEED)
- ✓ NEW and ALREADY IN PLACE RXs ARE MANAGED
- ✓ ANY RX CAN BE ROUTED TO ANY B-E
- ✓ UP TO 3 B-E AT THE SAME TIME CONNECTED TO A RX
- ✓ SPECTRUM ANALYZERS, RFI and SETI B-E TO ANY RX in MONITOR MODE
- ✓ B-E or INSTRUMENTS CAN BE ADDED
- ✓ ALL THE REQUESTED OBSERVING MODES ARE ALLOWED

THANK YOU !