

High Frequency Receivers

Stéphane Gauffre

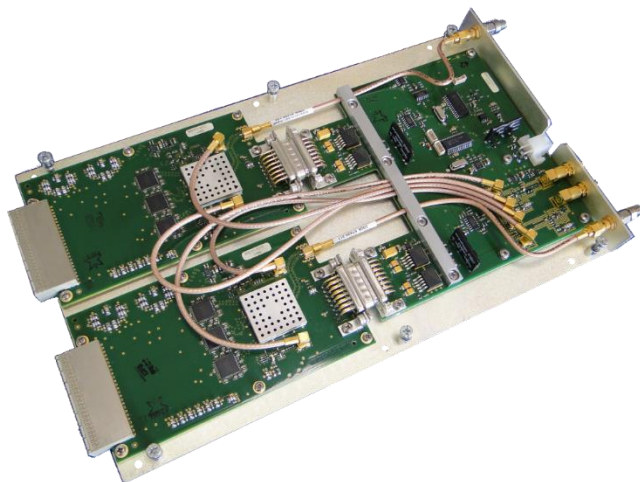




- ❑ **Electronic group**
- ❑ **Technical contribution in SKA**
- ❑ **High frequency Receivers**
 - **Dish Consortium**
 - **Work Breakdown Structure**
 - **SKA-MID Bands**
 - **SKA-MID Receivers**
 - **RXS45**
 - **Analog Digital Converter**
 - **First Digitizer Demonstrator**
 - **Digital Process Unit**
 - **Schedule**
 - **Industrial Partners and Funding**



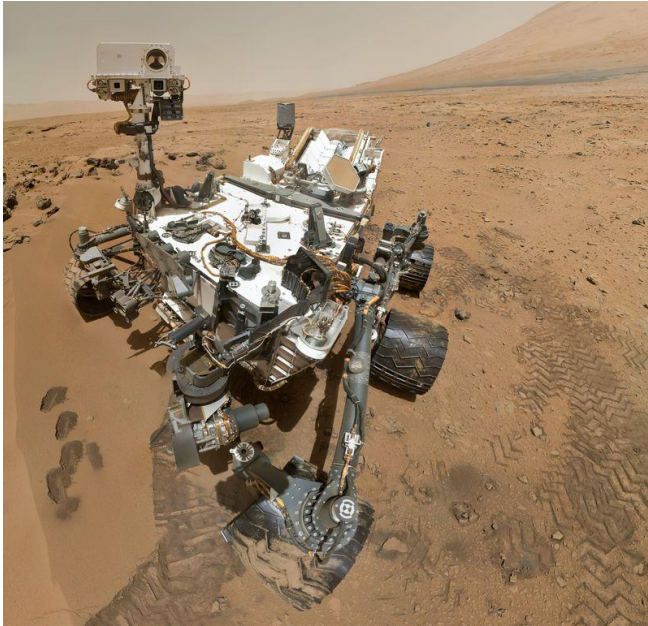
66 Antenna Interferometer in Chile



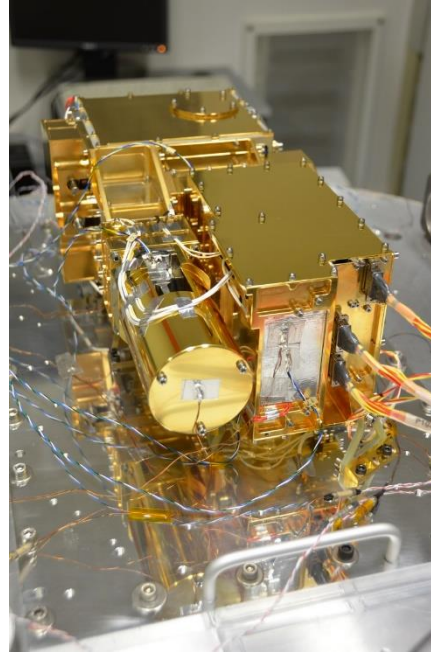
300 Digitizer modules



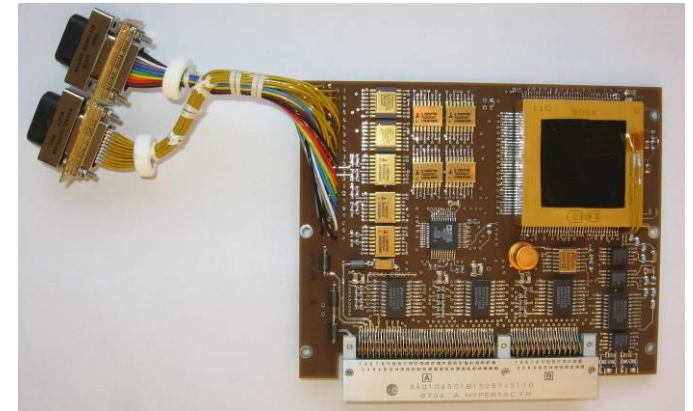
600 Tunable Filter Bank Cards



Curiosity Rover



**ChemCAM Instrument
(Mast Unit)**



Digital Process Unit Board

▪ **Full member of the AAMID consortium:**

- Involved in the receiver work package led by Nançay (Observatoire de Paris).



▪ **Member of DISH and WBSPF consortia**

- In charge of high frequency receiver developments (up to 25 GHz)



The DSH Consortium

The 14-member institution consortium brings with it a wealth of experience in every aspect of dish design, from low noise amplification, antenna design through to vast project management experience. The SKA Organisation have selected for all consortia the most accomplished teams on the planet to make the SKA a reality.

The consortium is led by **Roger Franzen** of CSIRO in Australia with 17 additional institutes around the world, these are:

- Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia
- RPC Technologies, Australia
- National Research Council, Canada
- Joint Laboratory for Radio Astronomy Technology (JLRAT), China
- Université de Bordeaux, France
- Max Planck Institute for Radio Astronomy (MPIfR), Germany
- Vertex Antennentechnik, Germany
- IAF Fraunhofer, Germany
- National Institute of Astrophysics (INAF), Italy
- European Industrial Engineering (EIE), Italy
- Società Aerospaziale Mediterranea (SAM), Italy
- University of Milano-Bicocca, Italy
- SKA South Africa, South Africa
- EM Software and Systems (EMSS), South Africa
- Universidad Pública de Navarra, Spain
- Universidad de Cantabria, Spain
- University of Oxford, UK
- Instituto Geográfico Nacional, Spain
- Chalmers University/Onsala Space Observatory, Sweden
- Omnisys Instruments AB, Sweden





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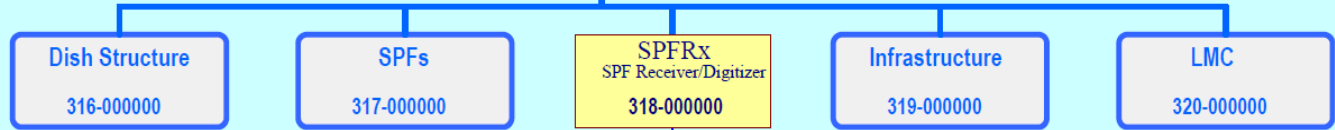




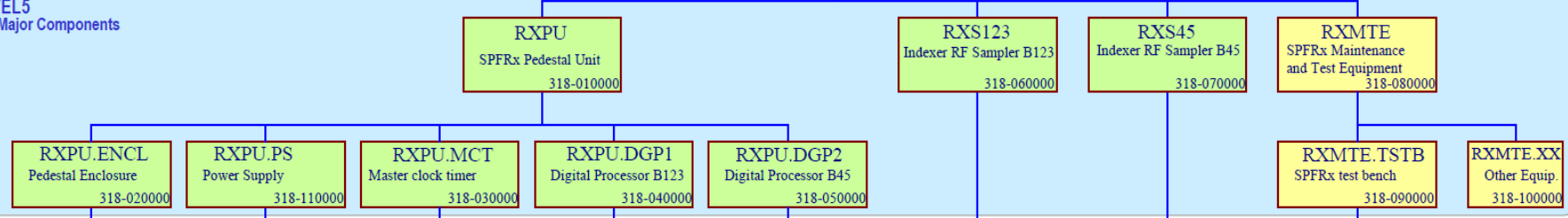
SKADC LEVEL3
Dish Element



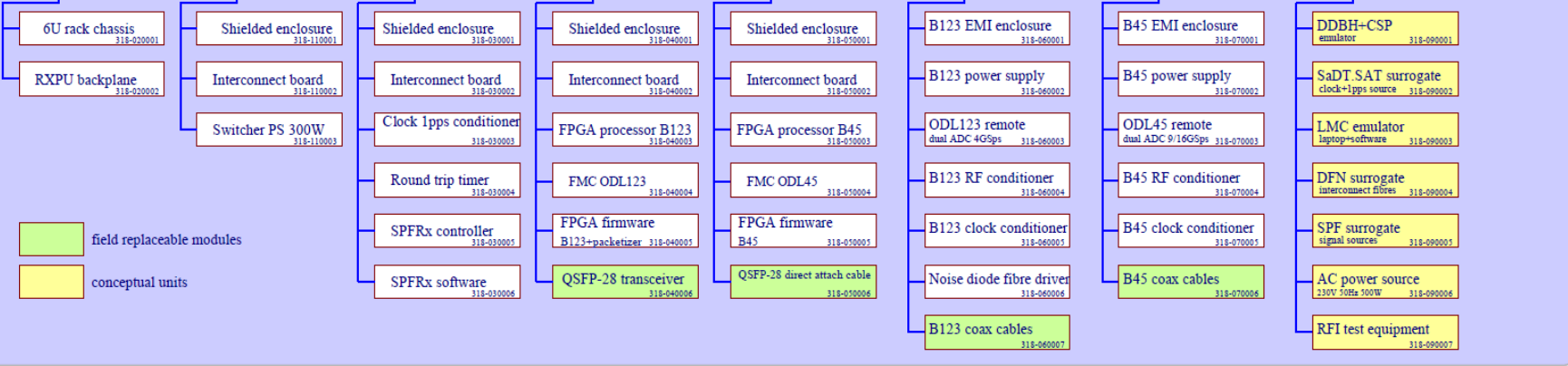
SKADC LEVEL4
Dish Sub-Elements



SKADC LEVEL5
Sub-Element Major Components



SKADC LEVEL6
Components

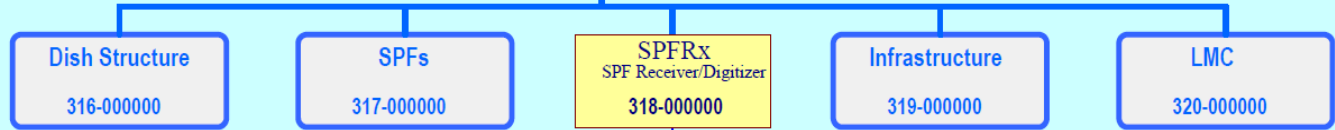




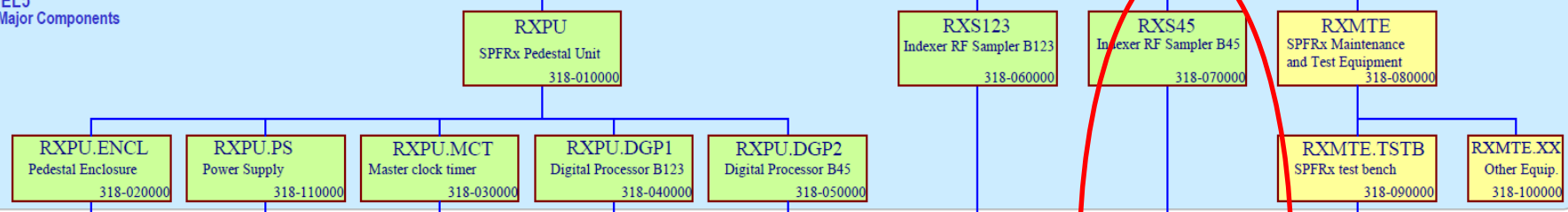
SKADC LEVEL3
Dish Element



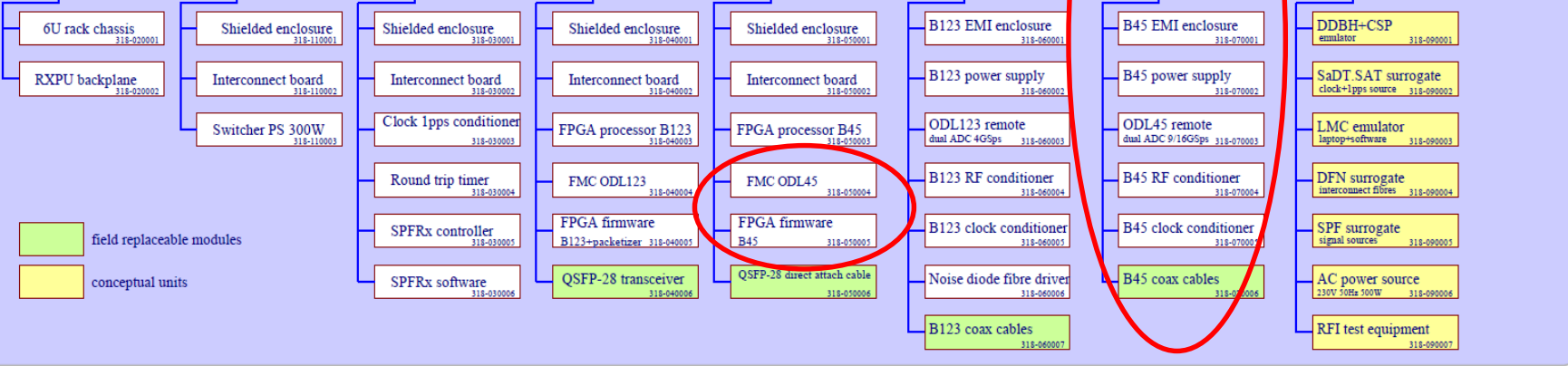
SKADC LEVEL4
Dish Sub-Elements



SKADC LEVEL5
Sub-Element Major Components



SKADC LEVEL6
Components



- Required bit depths and frequency ranges
- Bands 1, 2 and 5 deployed during SKA1

	RF frequency range (GHz)	RF Bandwidth (GHz)	ADC sampling rate (GSps)	Minimal ADC sampling bit depth	Transport sampling rate (GSps)	Transport bit depth
Band 1	0.35 – 1.05	0.70	4	8	4	8
Band 2	0.95 – 1.76	0.81	4	8	4	8
Band 3	1.65 – 3.05	1.40	3.2	6	3.2	8
Band 4	2.80 – 5.18	2.38	16	4	6	8
Band 5a	4.60 – 8.50	3.9	9	3	2x6	4
Band 5b	8.30 – 15.40	7.1	16	3	2x6	4



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- Bands 1, 2 and 5 deployed during SKA1

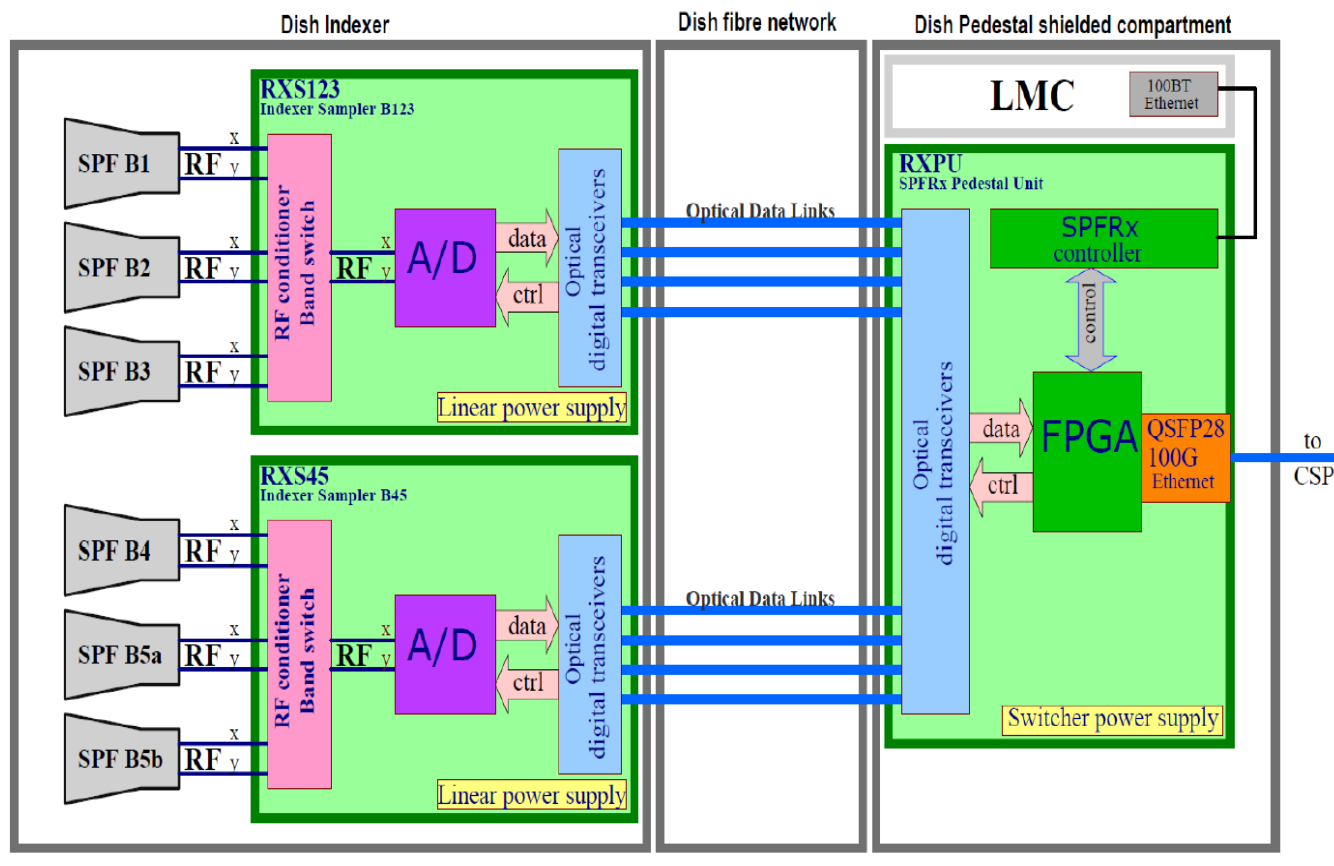
		RF frequency range (GHz)	RF Bandwidth (GHz)	ADC sampling rate (GSps)	Minimal ADC sampling bit depth	Transport sampling rate (GSps)	Transport bit depth
RXS123	Band 1	0.35 – 1.05	0.70	4	8	4	8
	Band 2	0.95 – 1.76	0.81	4	8	4	8
	Band 3	1.65 – 3.05	1.40	3.2	6	3.2	8
RXS45	Band 4	2.80 – 5.18	2.38	16	4	6	8
	Band 5a	4.60 – 8.50	3.9	9	3	2x6	4
	Band 5b	8.30 – 15.40	7.1	16	3	2x6	4

- Shared ADC
- RXS123 and RXS45 mechanically separate



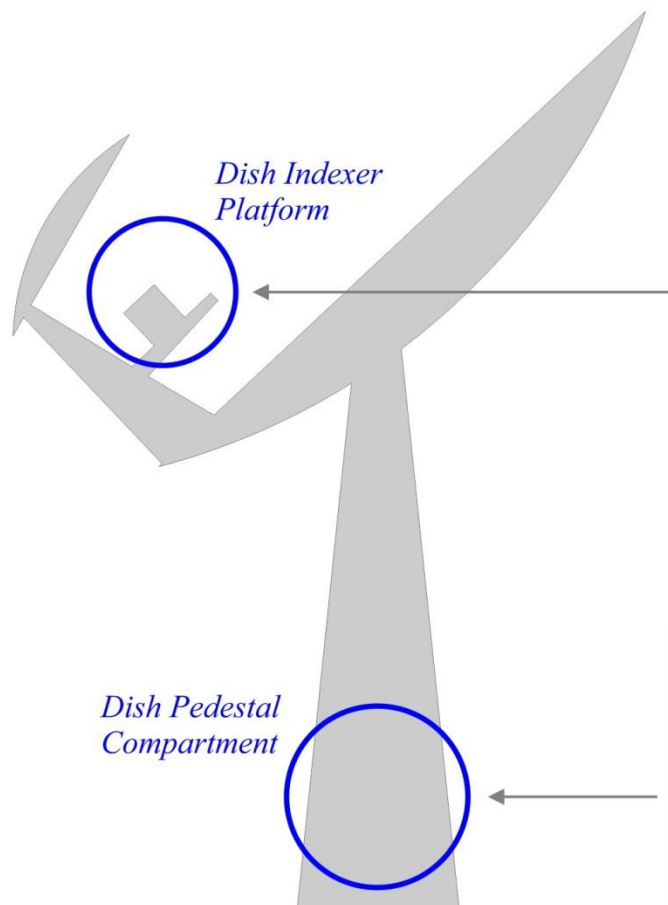
RF chain and Digitizer on feed indexer

- Aims to minimize EMI: galvanic isolation between RXS45 and digital process unit
- No switcher power circuit on indexer
- 4 GHz clock and 1PPS signal delivered to indexer with RFoF pair from RXPU



RF chain and Digitizer on feed indexer

- Custom built mechanical enclosures for indexer samplers RXS123 and RXS45
 - RF shielding
 - Thermal design
 - Build to withstand weather
- Customized VME enclosure for SPFRx Pedestal Unit
 - Height 6U
 - Horizontal slots for plugin modules
 - Front to back cooling air flow



SPFRx Indexer Sampler

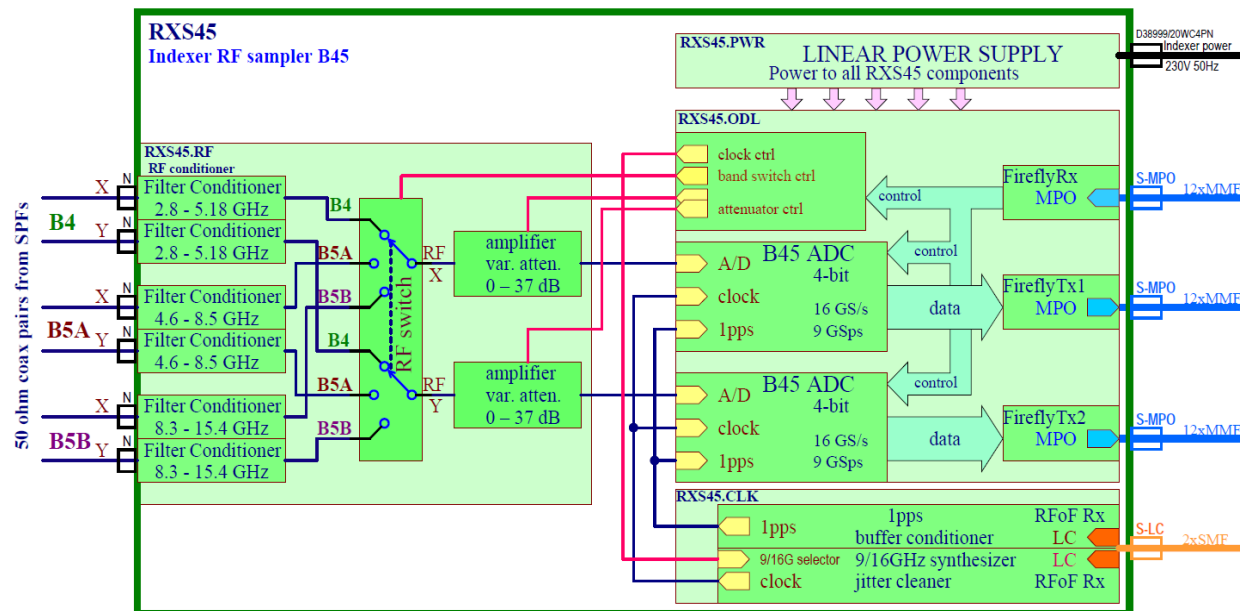


SPFRx Pedestal Unit



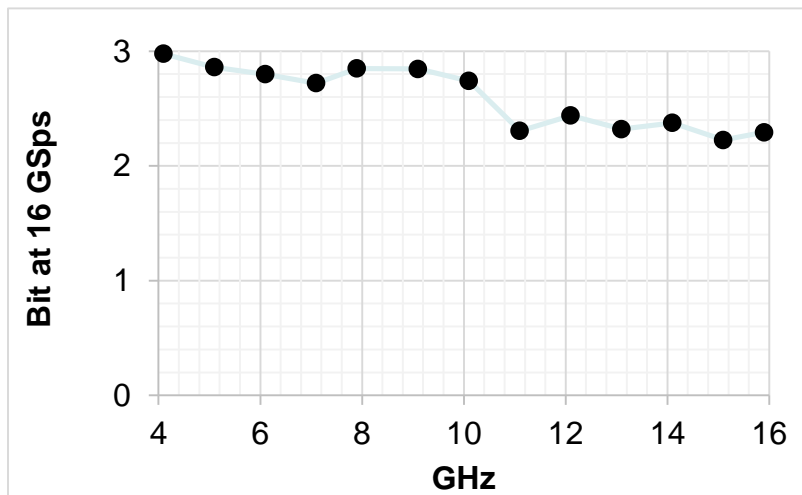
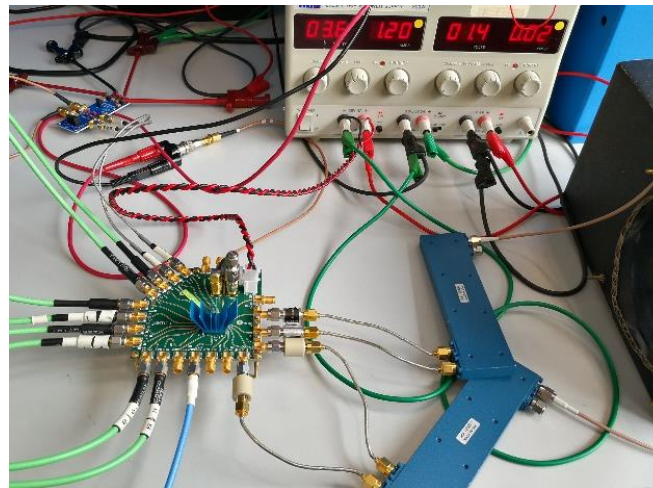
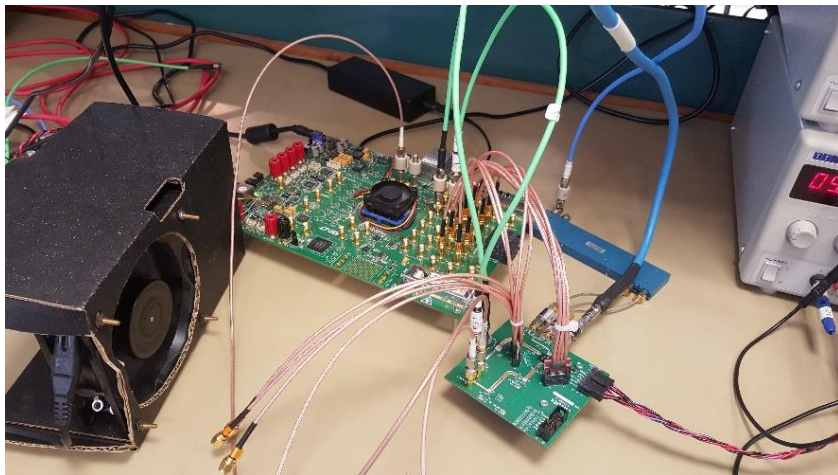
RF chain and Digitizer on feed indexer

- RF conditioner module
 - Band selection
 - Amplification
- Digitizer board
 - Wide band ADC
 - Optical transceivers
- Clock module
 - 16 GHz and 9 GHz
 - 1pps signal
- Power module
 - Wide band ADC
 - Optical transceivers



■ Critical component

- Two devices under evaluation: Hittite (10-level ADC) and Adsantec (4-bit ADC)

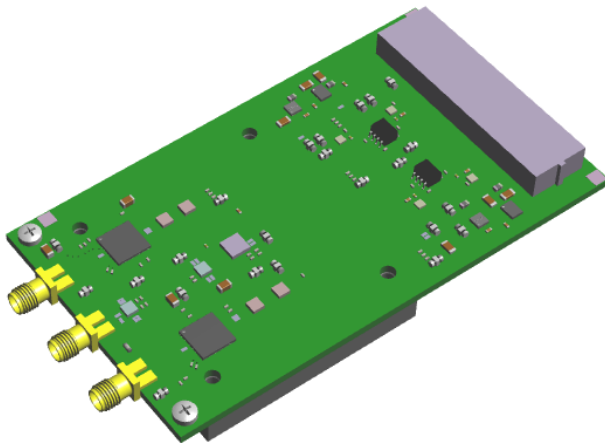


Fin (GHz)	ENOB at 8 GSps
3.1	3.35
5.9	3.26
11.9	3.26

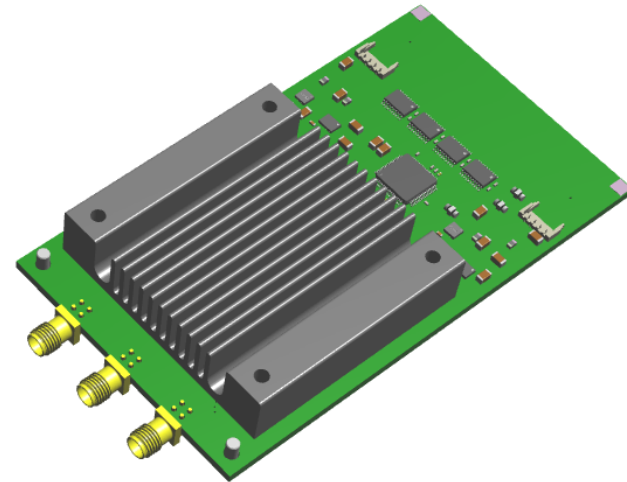


▪ Based on the HMCAD5831

- Single: Flash architecture
 - Used at 4 GSps in some VLA antennas
- Over-range bit:
 - The HMCAD5831 can be used as a ten-level (3.3 bits) ADC by combining the regular data outputs with the over-range bits. The strong RFI can be detected by using ADC histogram.



Bottom view

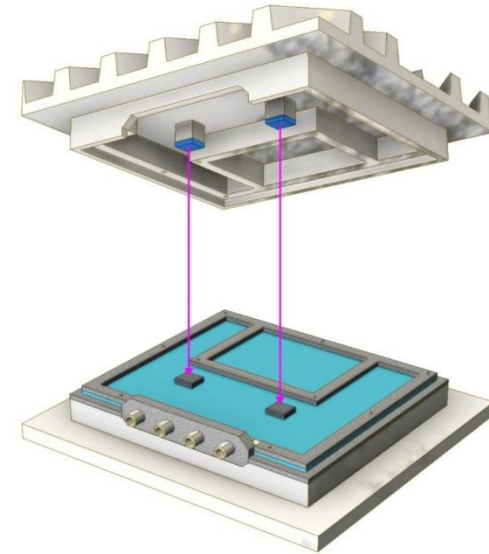
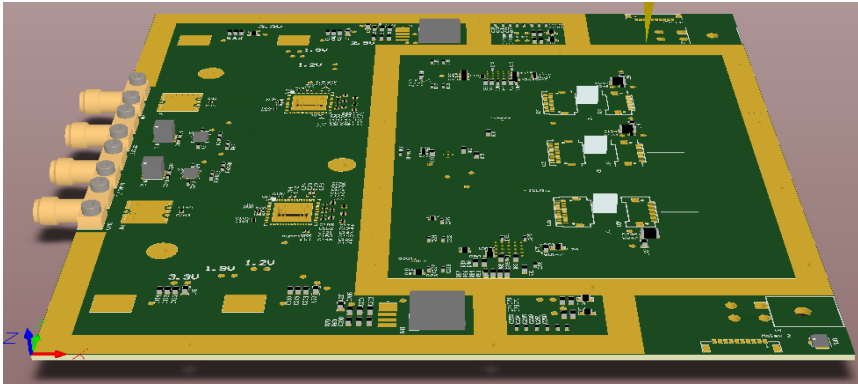


Top view



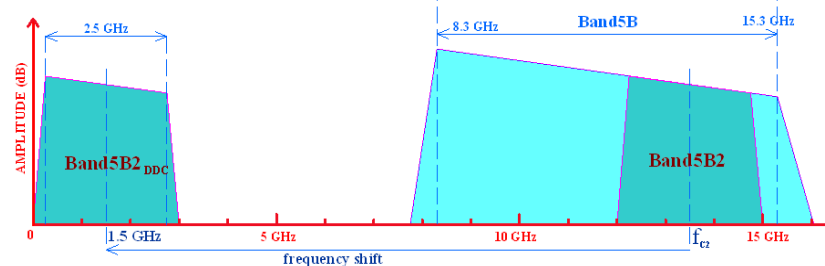
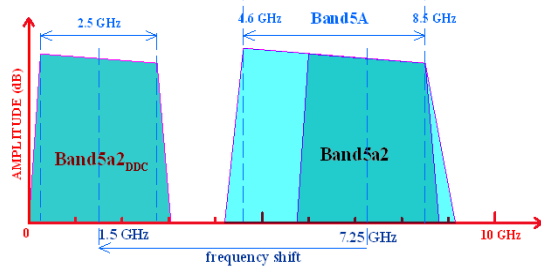
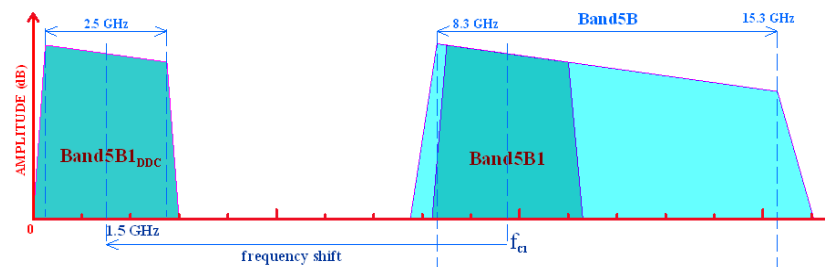
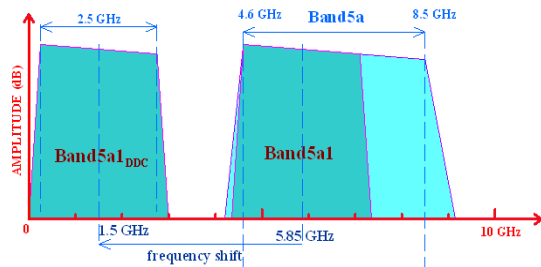
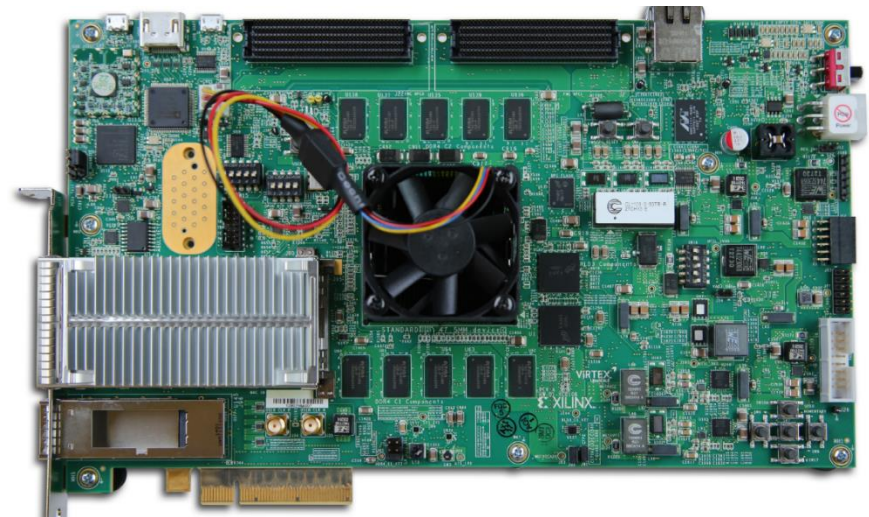
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■ VCU108

- Virtex Ultrascale XCVU095
- 768 DSP slices
- 537,600 LUTs
- one QSFP28 outlet
- one CFP2 outlet
- Two FMC sites to host ODL adapter

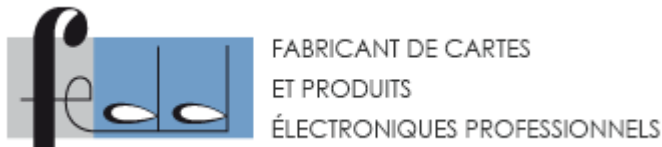




- **PDR** in July 2017 \Rightarrow Design report must be corrected before PDR closure
- The digitizer board prototype and the RF chain must be tested for **DDR** in March 2018
- The complete high frequency receiver must be tested for **CDR** in December 2018
- The receiver must be ready for production early 2019

■ Industrial Partners for prototyping:

- **FEDD**: for industrialisation support and for component assembly and testability
- **Atlantec**: for printed circuit board manufacturing



■ Funding

- University of Bordeaux
- INSU
- Nouvelle Aquitaine





Thank you!