



Next generation digitizers for MeerKAT

SAFARI CENTRE FOR ASTRONOMY

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Talk outline

- MeerKAT frequency bands
- L-band digitization
- UHF-band digitization
- S-band digitization
- X-band digitization options
- Available ADCs
- Conclusions

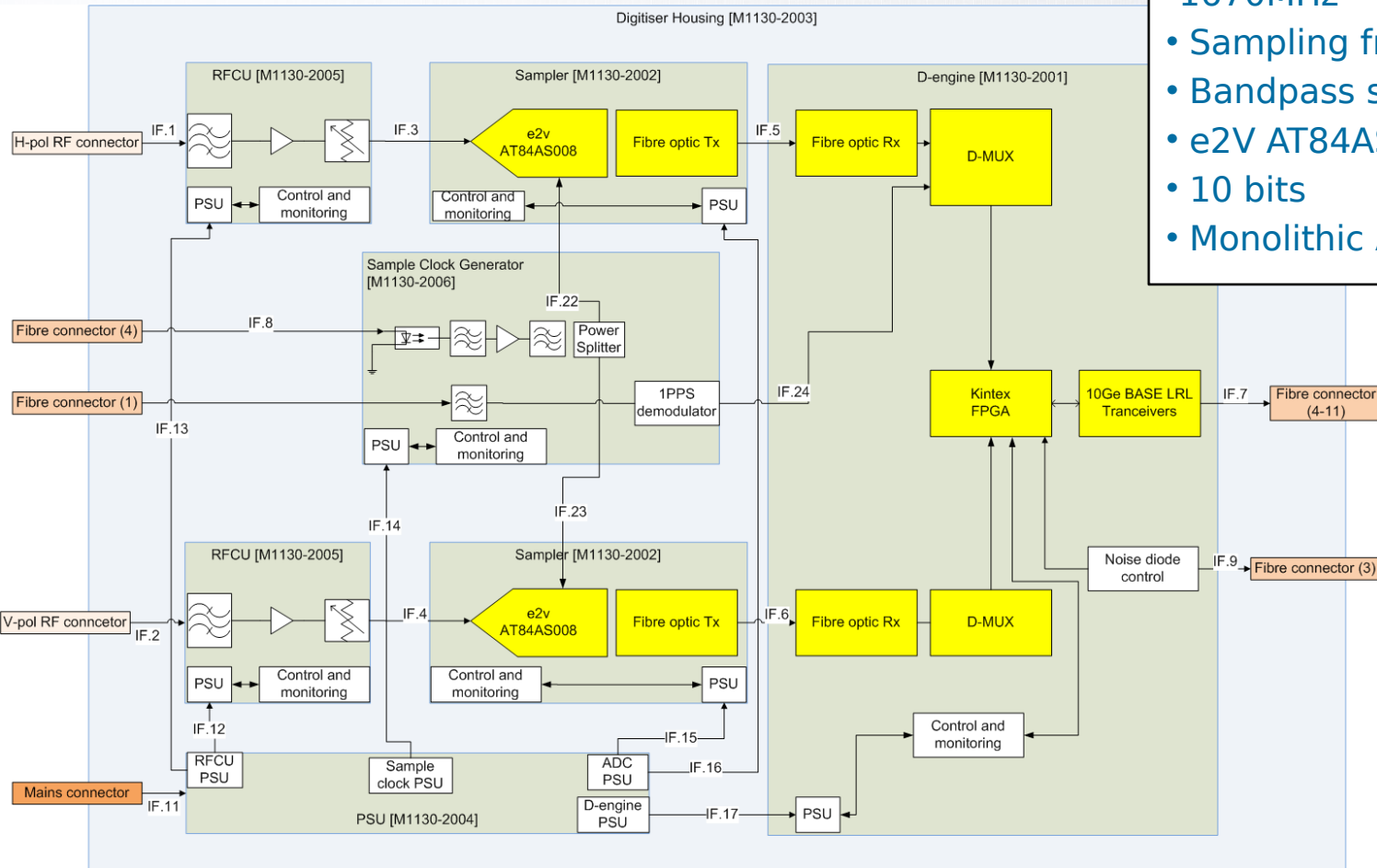
MeerKAT frequency bands

Band	Frequency range
L-band	900 – 1670 MHz
UHF-band	580 – 1010MHz
S-band	1750 – 3500 MHz
X-band	8 -14.5 GHz

L-band digitizer

Some key specifications

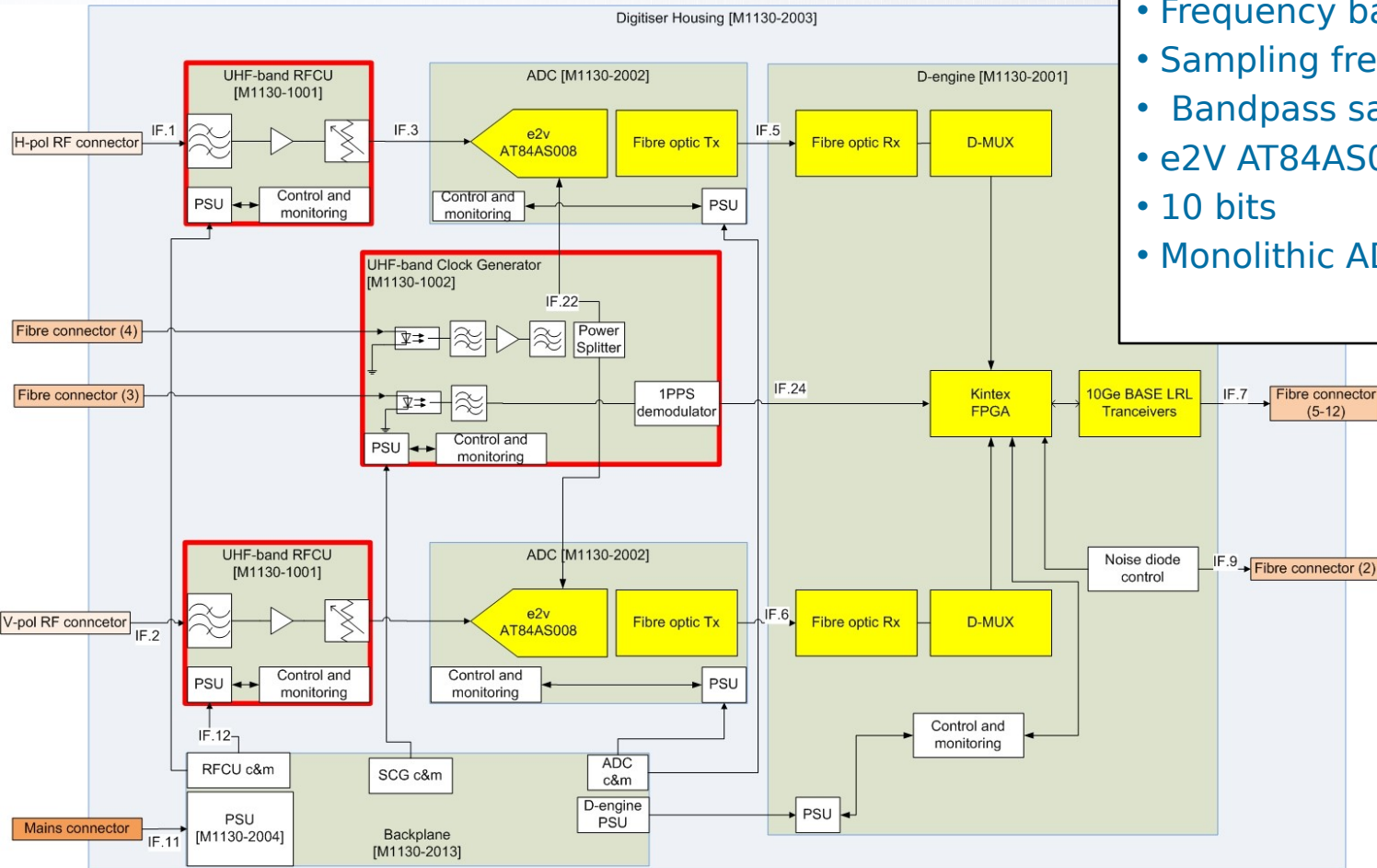
- Frequency band = 900 -1670MHz
- Sampling frequency =1712MHz
- Bandpass sampling
- e2V AT84AS008 ADC
- 10 bits
- Monolithic ADC



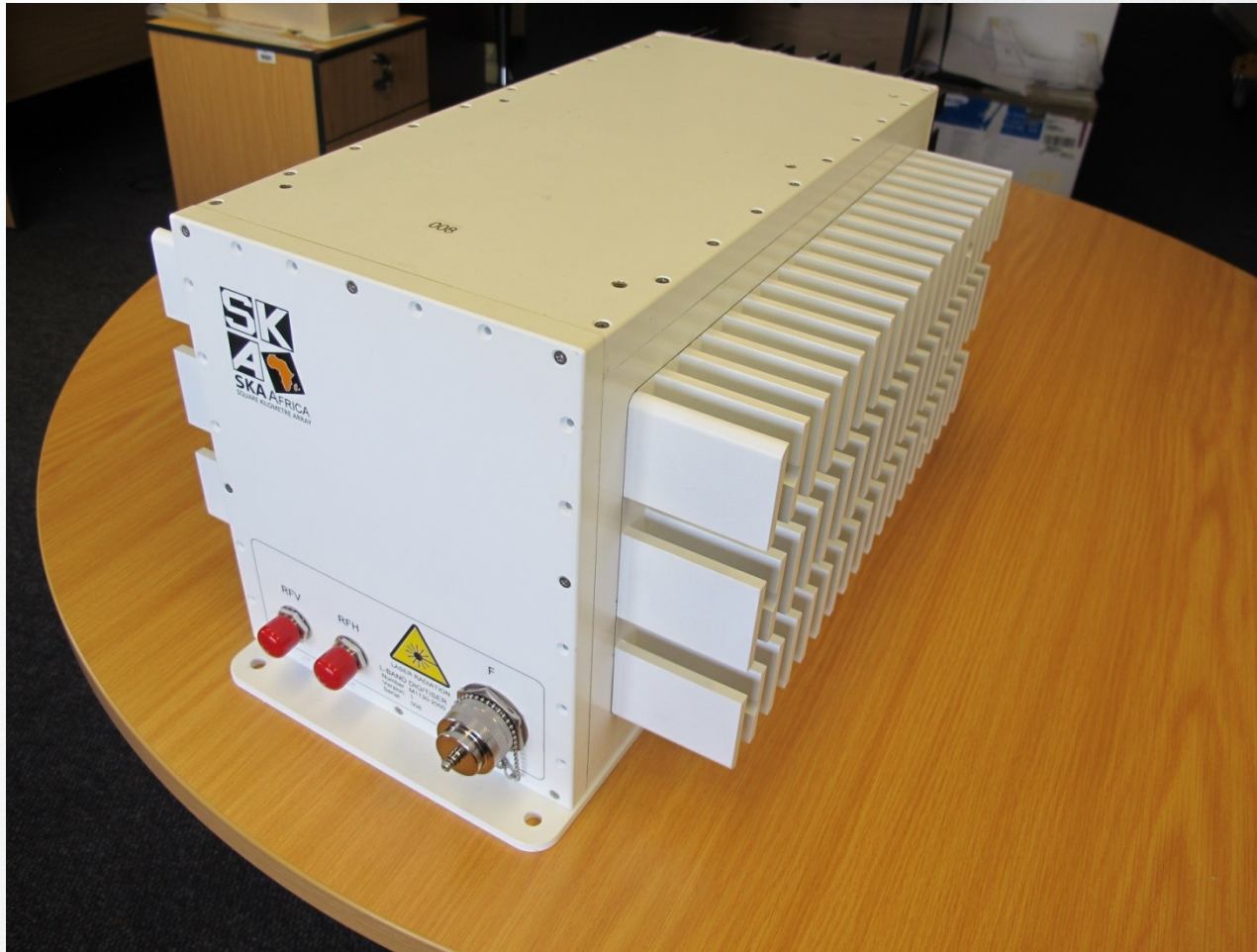
UHF-band digitizer

Some key specifications

- Frequency band = 580 -1010MHz
- Sampling frequency =1088MHz
- Bandpass sampling
- e2V AT84AS008 ADC
- 10 bits
- Monolithic ADC



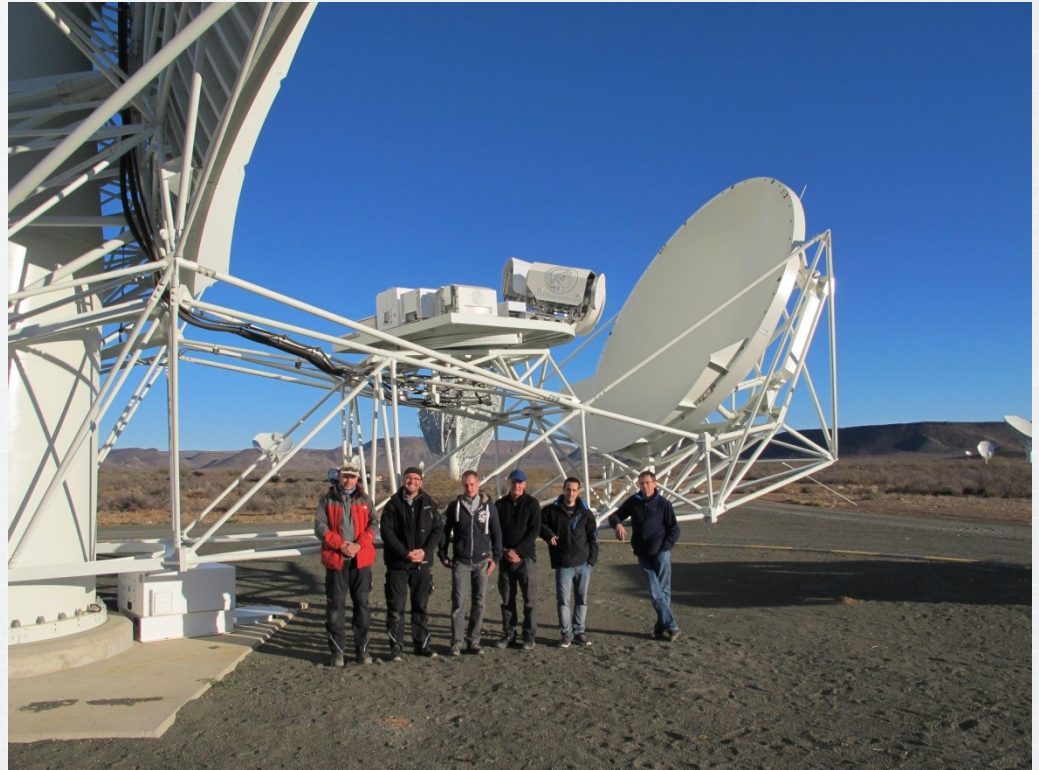
Physical implementation



S-band digitizer

Some key specifications

- System being designed and produced by MPIfR
- Receiver + digitizer + packetiser
- Frequency band = 1750 - 3500MHz
- Sampling frequency = 3500MHz
- Bandpass sampling
- TI ADC12J4000 ADC
- 12 bits



Digitization of MeerKAT X-band

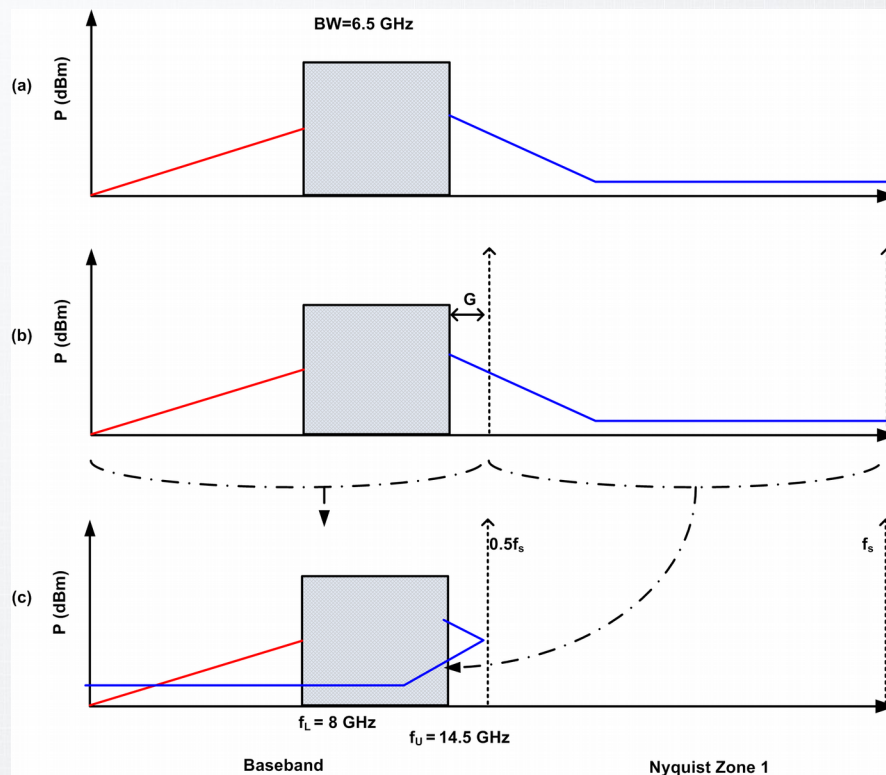
Frequency range: 8 – 14.5 GHz

Minimum processing bandwidth = 2.5GHz

Digitisation options:

1. Direct digitization using baseband sampling

- Require sampling rates of ≥ 29 Gsps
- No suitable ADCs



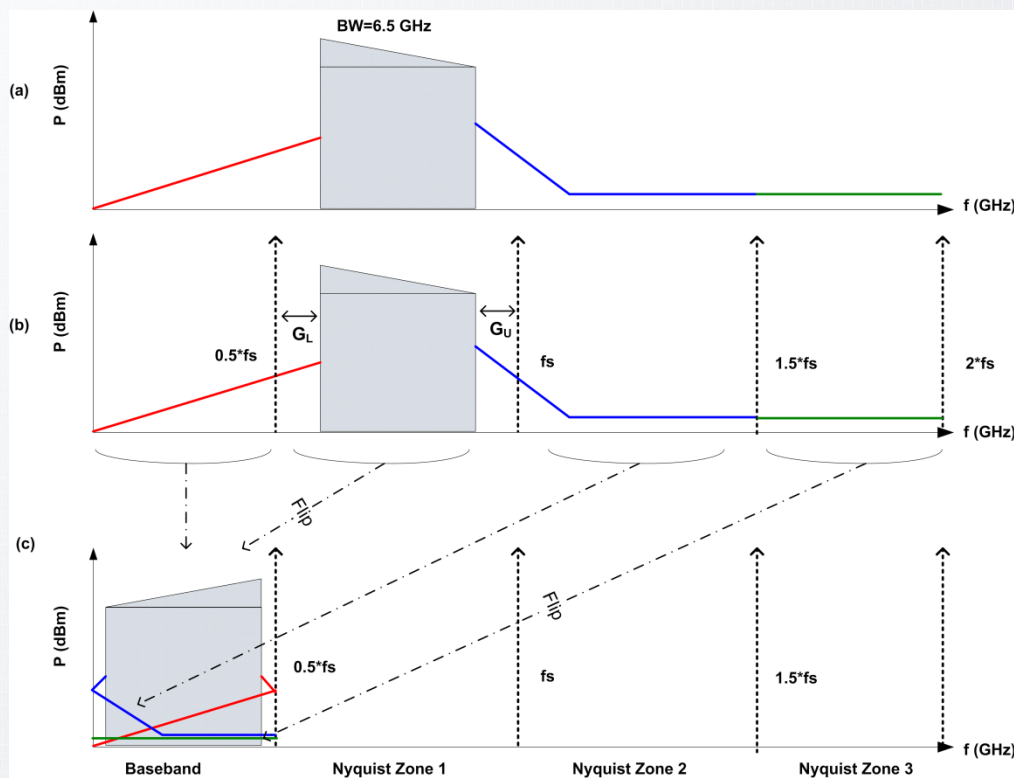
Digitization of MeerKAT X-band

2. Direct digitization using bandpass sampling

- Sampling rate (f_s) constrained by:

$$\frac{2f_H}{n} \leq f_s \leq \frac{2f_L}{n-1} \quad \text{and under sampling factor } n: \quad 1 \leq n \leq \left\lfloor \frac{f_H}{f_H - f_L} \right\rfloor$$

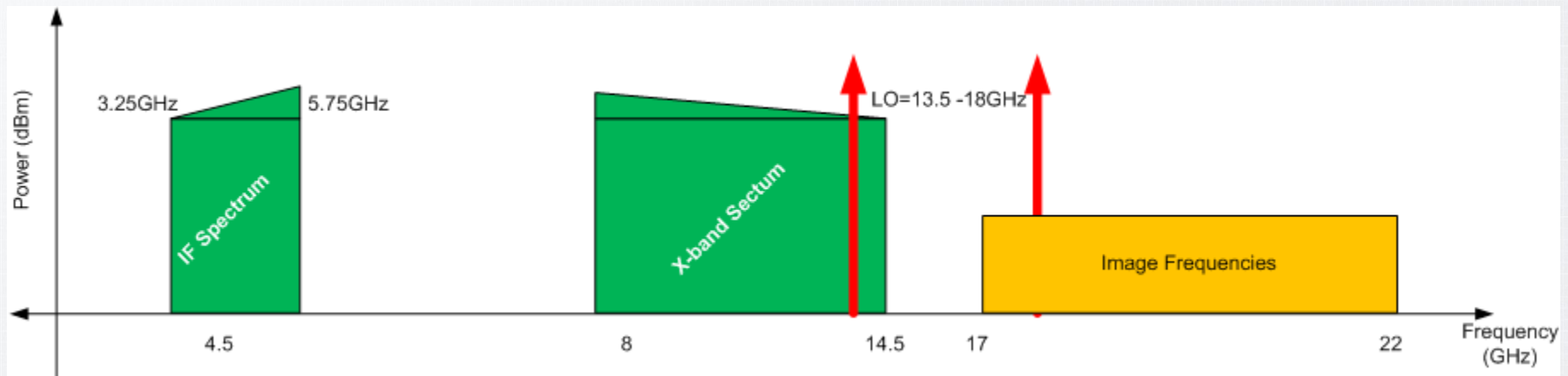
- Or $14.5 \leq f_s \leq 16$ Gsps if under sampled by 2



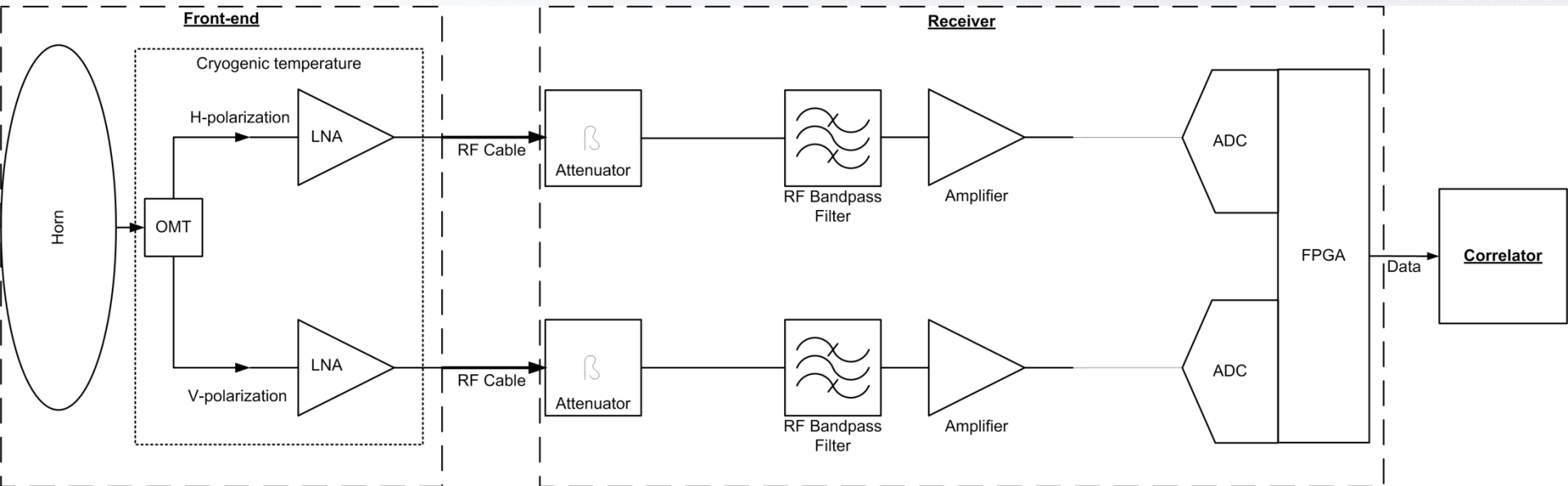
Digitization of MeerKAT X-band

3. Analogue downconversion prior to sampling (heterodyne architecture)

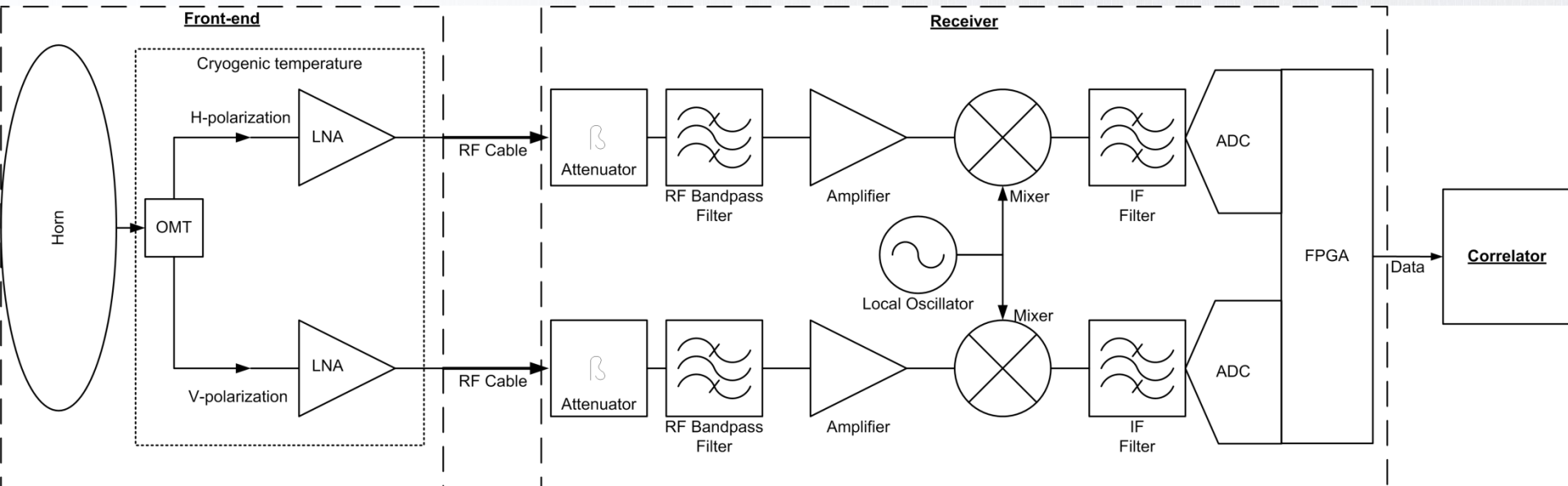
- Single stage block downconversion to IF
- IF BW = 2.5 GHz
- IF frequency = 4.5 GHz
- IF chosen such that image is outside the frequency band
- Use either baseband or bandpass sampling of IF signal
- Required sampling rate for baseband ≥ 12 Gsps
- Required sampling rate for bandpass sampling: $5.75 \leq f_s \leq 6.5$ Gsps



Bandpass sampling digitizer block diagram



Heterodyne digitizer block diagram



ADC options for direct digitization

Commercially available ADCs suitable for
MeerKAT environment

Parameter	Requirement	Specification		Comply	
		Hittite HMCAD5831	Adantec ASNT7122-KMA	Hittite	Adantec
Sampling rate	> 15 Gsps	26Gsps	15Gsps (TBC)	Y	Y
RF Bandwidth	> 15 GHz	20GHz	20GHz	Y	Y
ENOB	> 3	2.9 (fin=20GHz)	3.23 (fin=10GHz)	N	Maybe

ADC options for direct digitization

Commercially available ADCs suitable for MeerKAT environment

Parameter	Requirement	Specification		Comply	
		Hittite HMCAD5831	Adantec ASNT7122-KMA	Hittite	Adantec
Sampling rate	> 15 Gsps	26Gsps	15Gsps (TRC)	Y	Y
RF Bandwidth	> 15GHz	20GHz			
ENOB	3	2.9 (fin=20Gsps)			



ADC options for heterodyne architecture

Commercially available ADCs suitable for MeerKAT environment

Parameter	Requirement	Specification			Other ?
		TI ADC12DJ3200	Adsanterc ASNT7120-KMA	e2V	
Sampling rate	> 6 Gsps	6.4Gsps	6 Gsps	Possible future product	
RF Bandwidth	> 6GHz	8GHz	18GHz		
ENOB	>3	7.8	≥ 3		

Conclusion

- **Direct digitization architecture**
 - Preferred option based on simple architecture and wide instantaneous bandwidth
 - Learn from CASPER community regarding performance of Hittite and Adsantec ADCs
- **Heterodyne architecture**
 - More complicated architecture that require complex analogue modules
 - Mature suitable ADCs available
 - Prototype TI ADC12DJ3200
 - Possible mezzanine card for SKARAB



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SKA South Africa, a Business Unit of the National Research Foundation.

We are building the Square Kilometre Array radio telescope (SKA), located in South Africa and eight other African countries, with part in Australia. The SKA will be the largest radio telescope ever built and will produce science that changes our understanding of the universe

Contact information

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