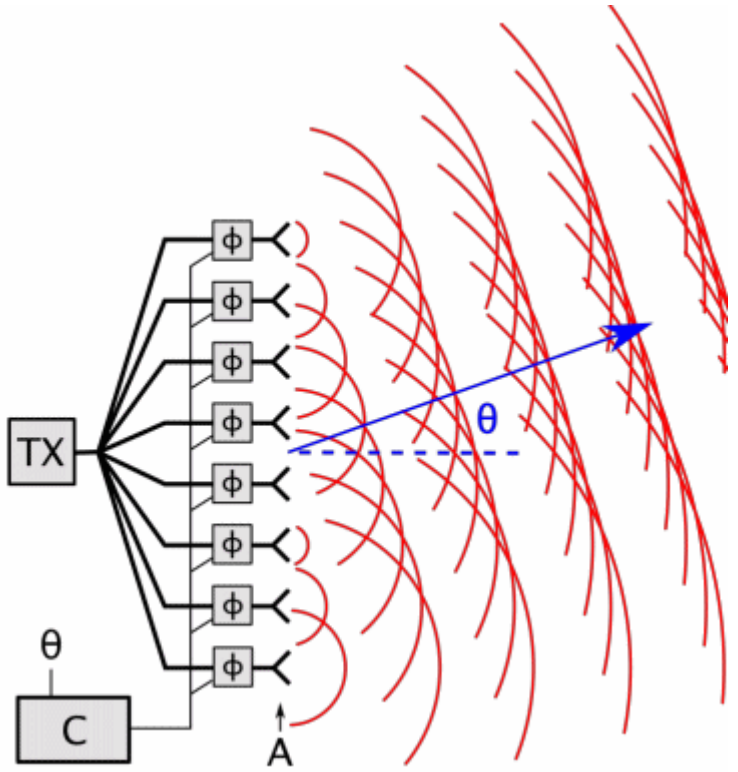
Development of Phased Array Feeds

Michael Keith

University of Manchester

Phased Array Feeds



PAF Development Activities at JBCA

PHAROS “C-band” 4-8 GHz

CSIRO MkII PAF 0.7-1.8 GHz

JBCA “S-band” PAF 2-4 GHz

PHAROS

4-8 GHz

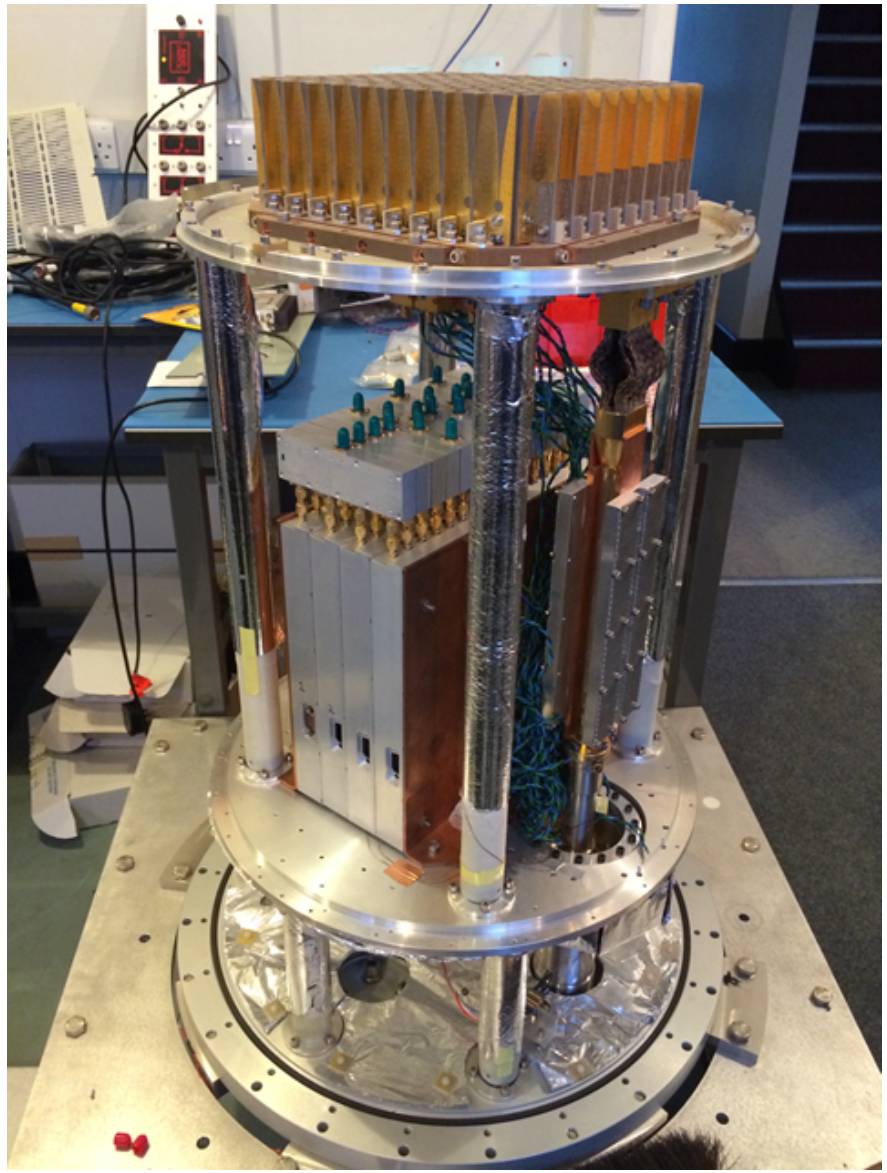
Cryogenic PAF

220 Vivaldi Elements

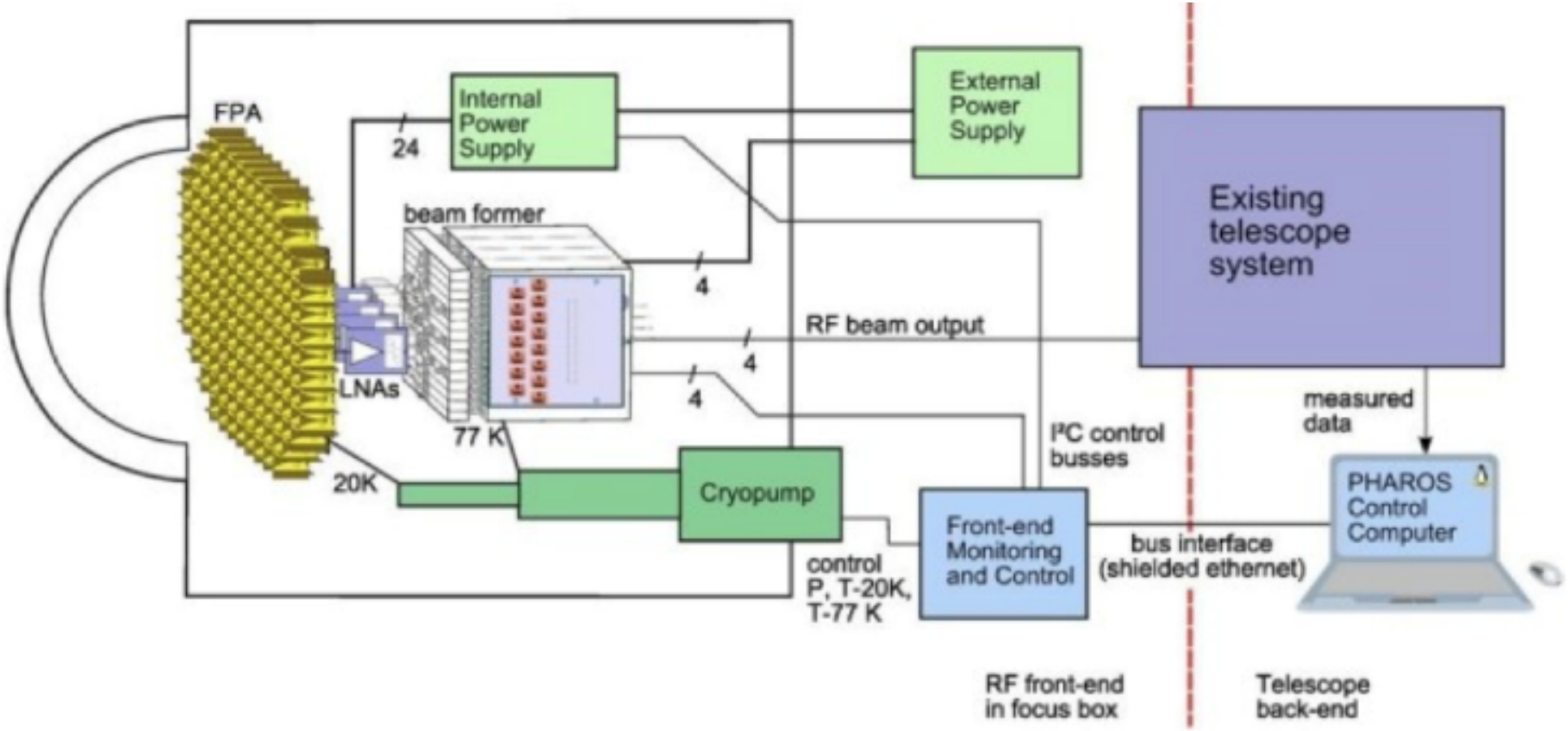
(only 24 active elements in prototype)

Analogue beamformer

(Upgrading to digital)



PHAROS design



Liu, L. & Grainge, K. 2017

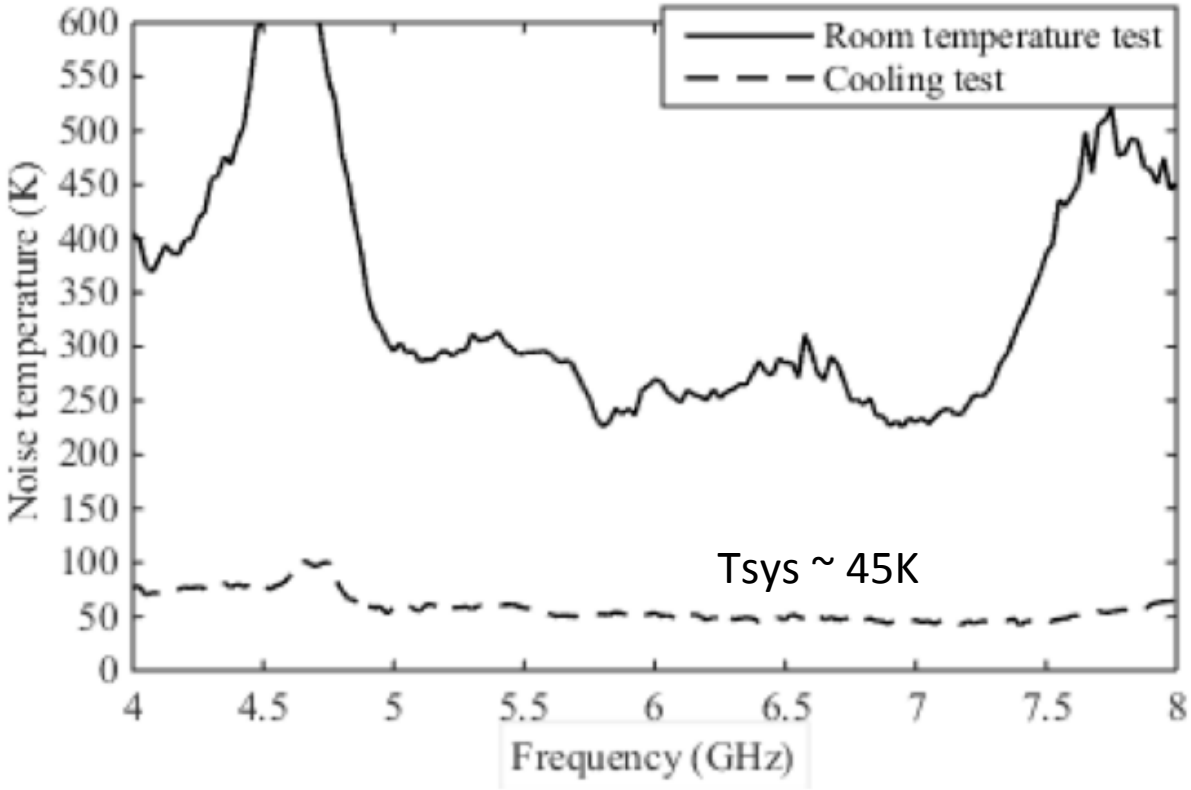
PHAROS

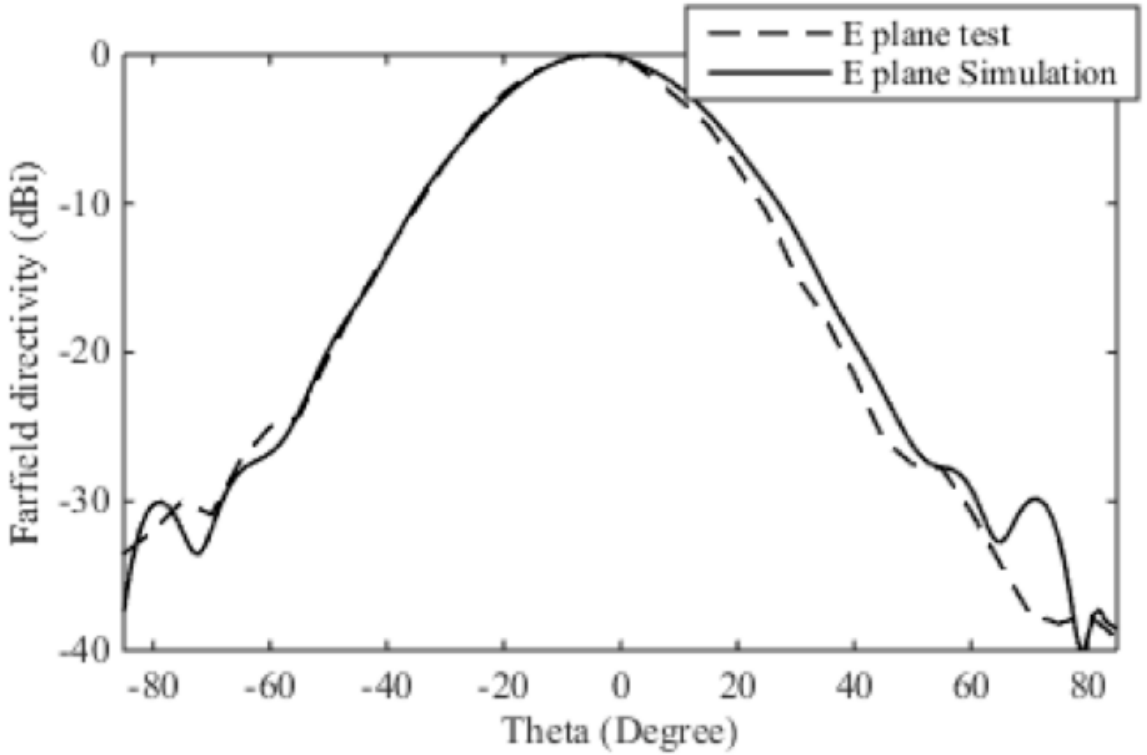
Lab tests complete

On-dish tests coming soon

Liu, L. & Grainge, K. 2017

PHAROS





Liu, L. & Grainge, K. 2017

PHAROS to PHAROS 2

New LNAs with substantially better performance across the band

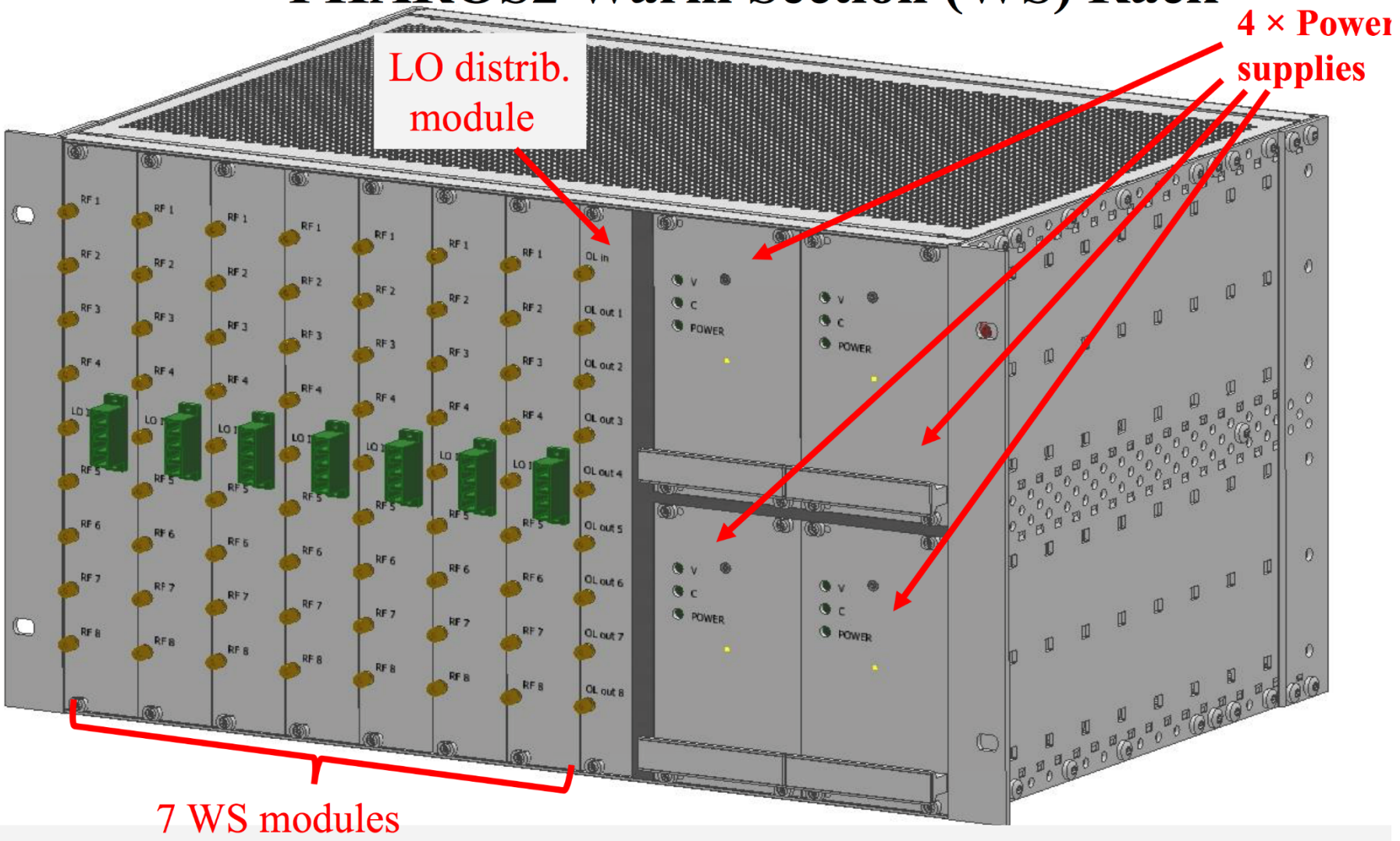
New IR filtering

Investigating new window technology

Digital beamforming

- New “warm rack” for downconversion and filtering
- Digital beamformer based on iTPM prototype for SKA1-Low

PHAROS2 Warm Section (WS) Rack



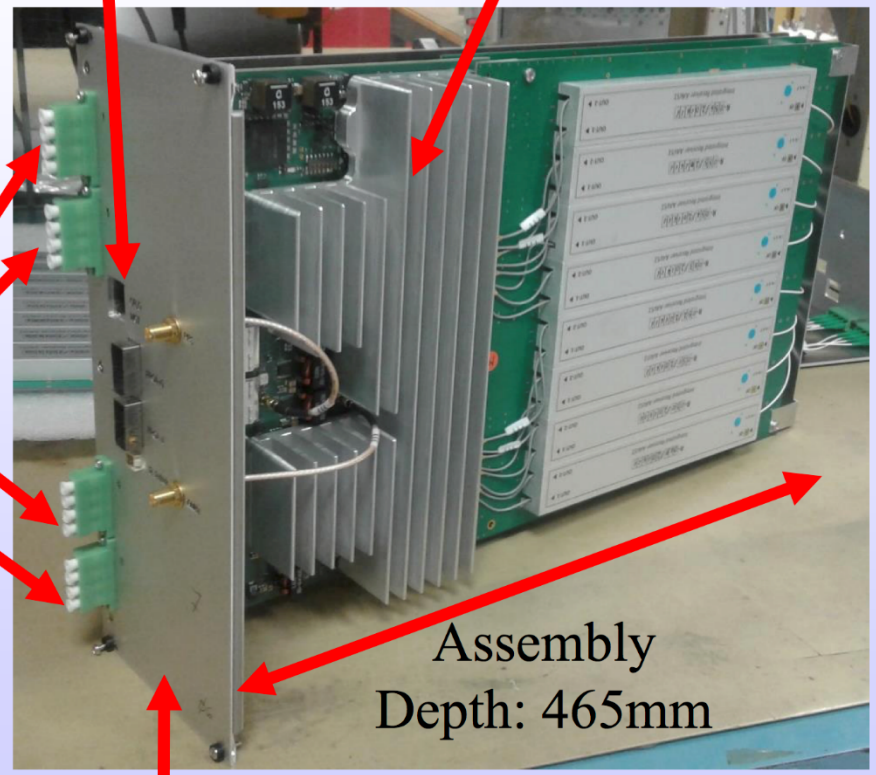
RF in 4-8 GHz
(on coax)

IF out 350-675 MHz
(on fibre)

- A 6U rack (19”) can contain 7 WS modules, 1 LO distribution module and 4 power supplies. It will be capable of handling up to 56 input signals;

iTPM overview

Designed for SKA1-Low



CSIRO MkII PAF

1.2-1.8 GHz (+ 0.7-1.1 GHz)

Room temperature electronics

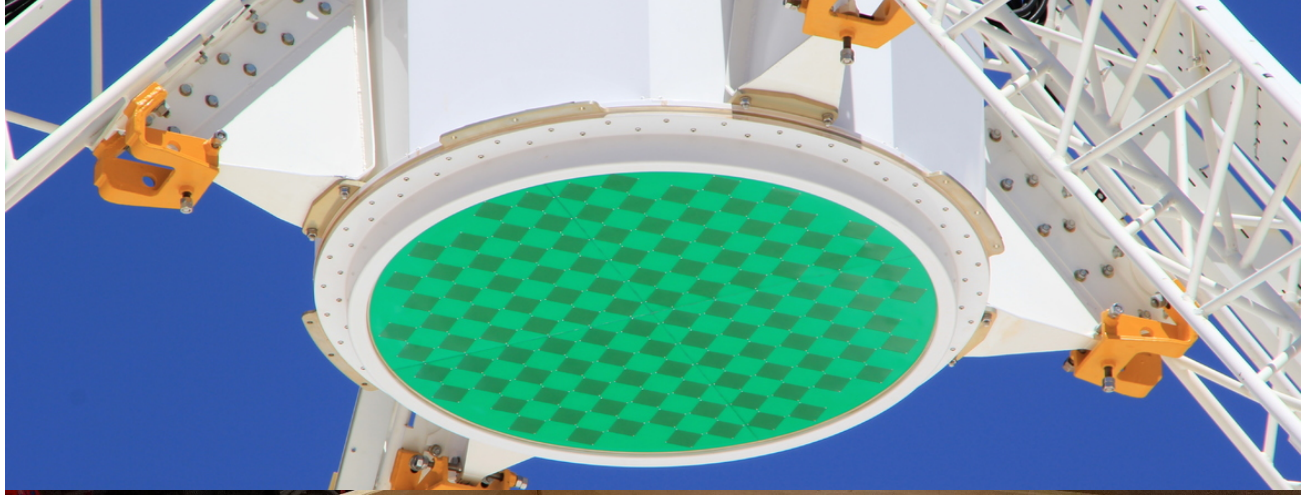
188 chequerboard elements

0.6 sq deg FoV

Digital beamfomer

Designed for ASKAP

We have purchased one for Lovell



CSIRO MkII PAF

Good progress on ASKAP-alike parts:

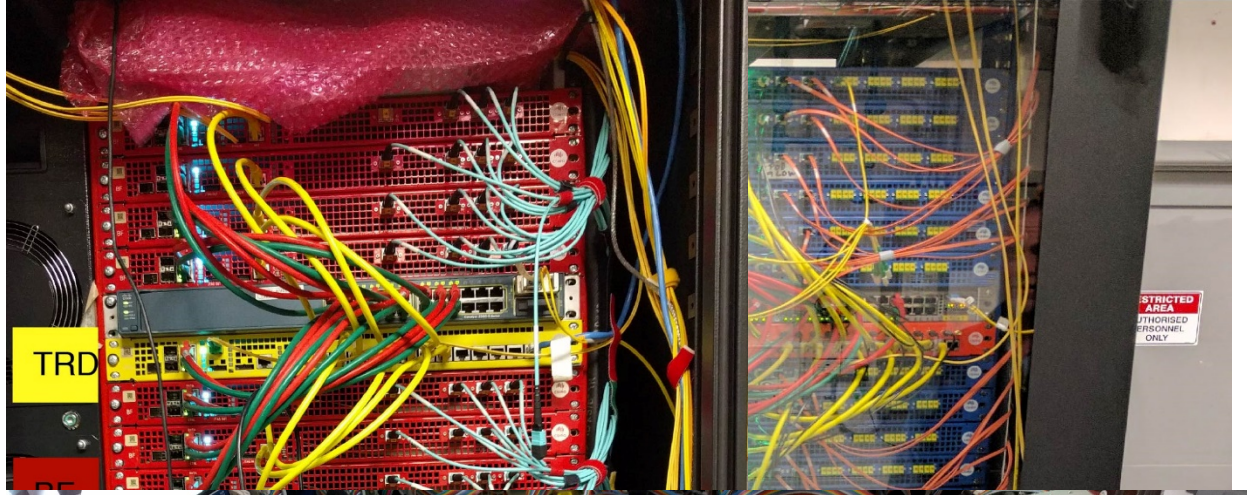
✓Construction of PAF unit

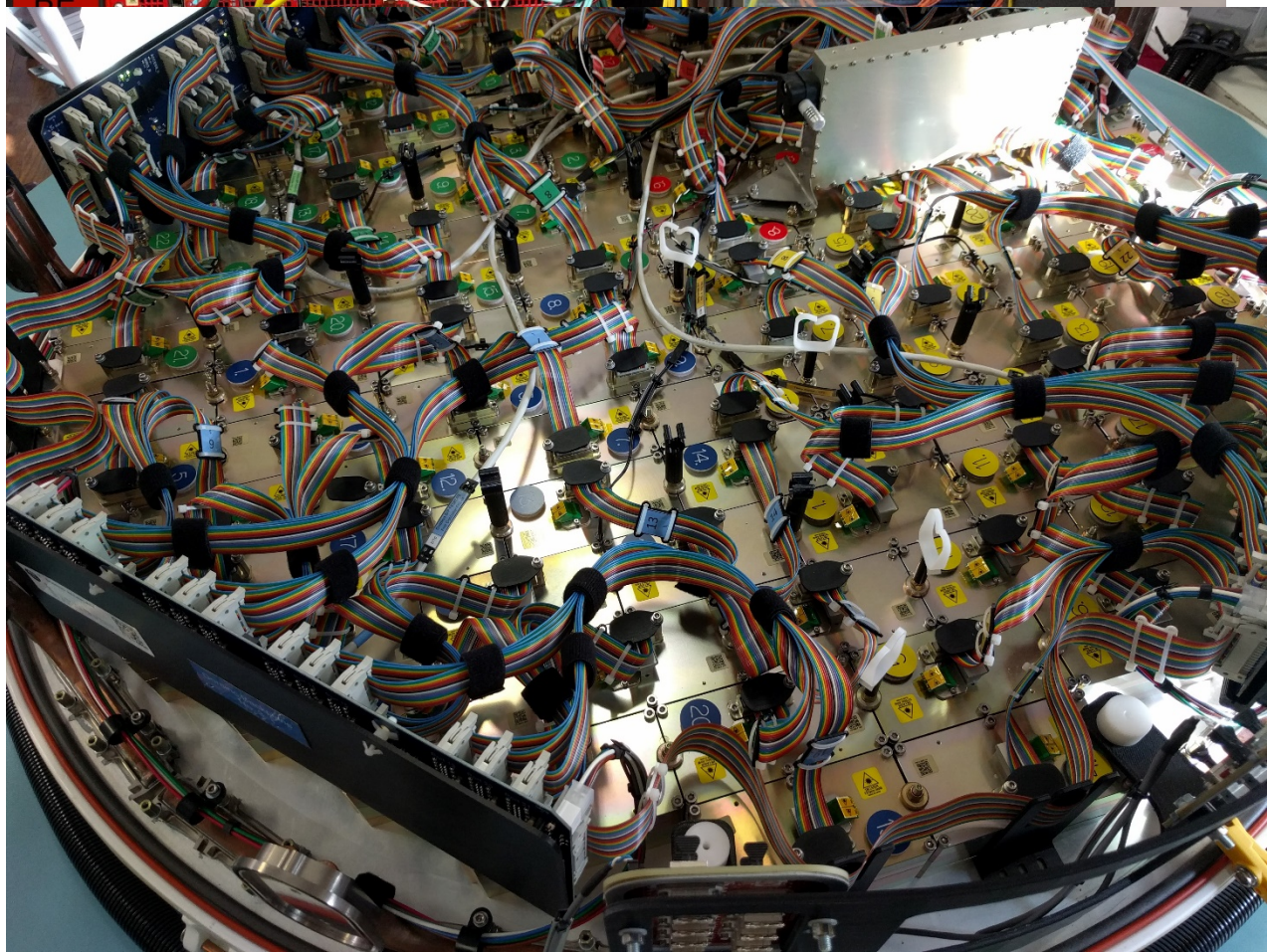
✓Construction of digital Rx

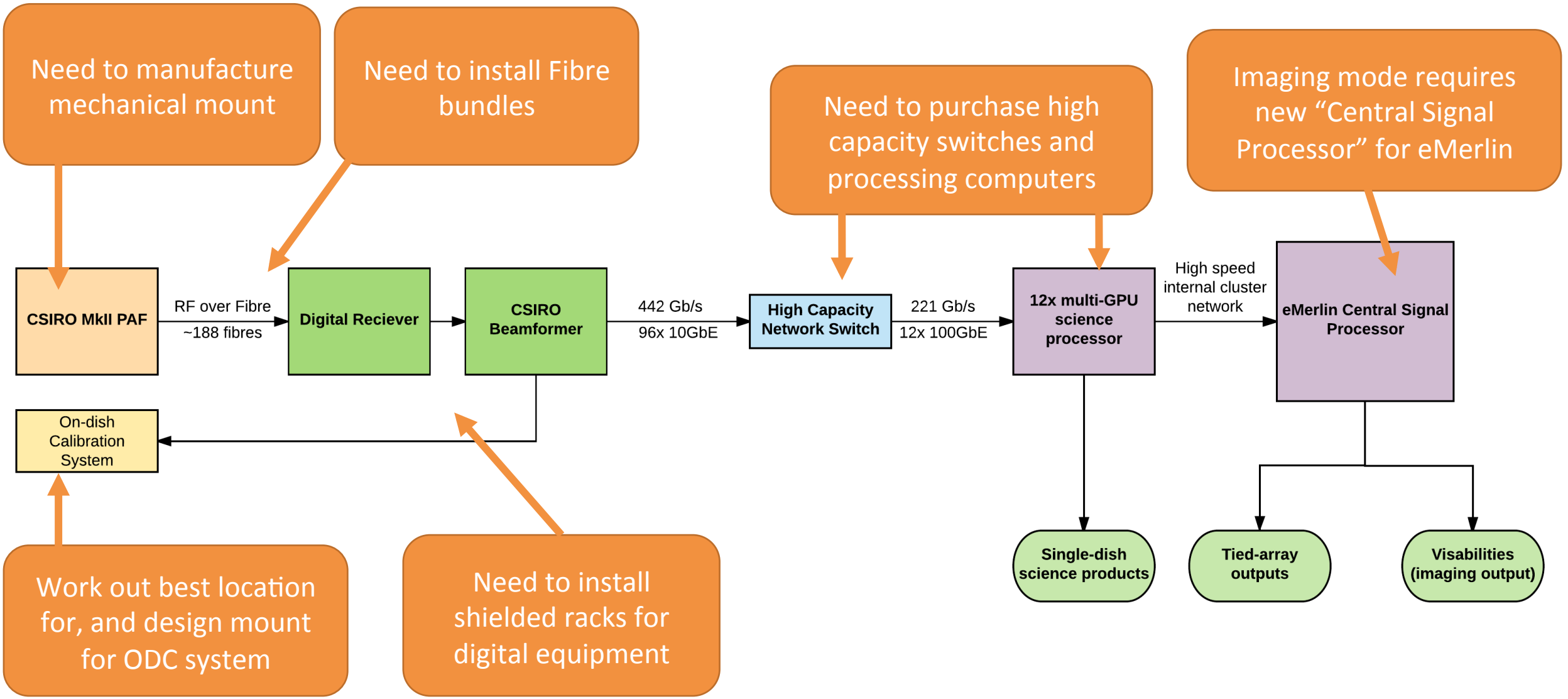
✓Construction of digital Beamformer

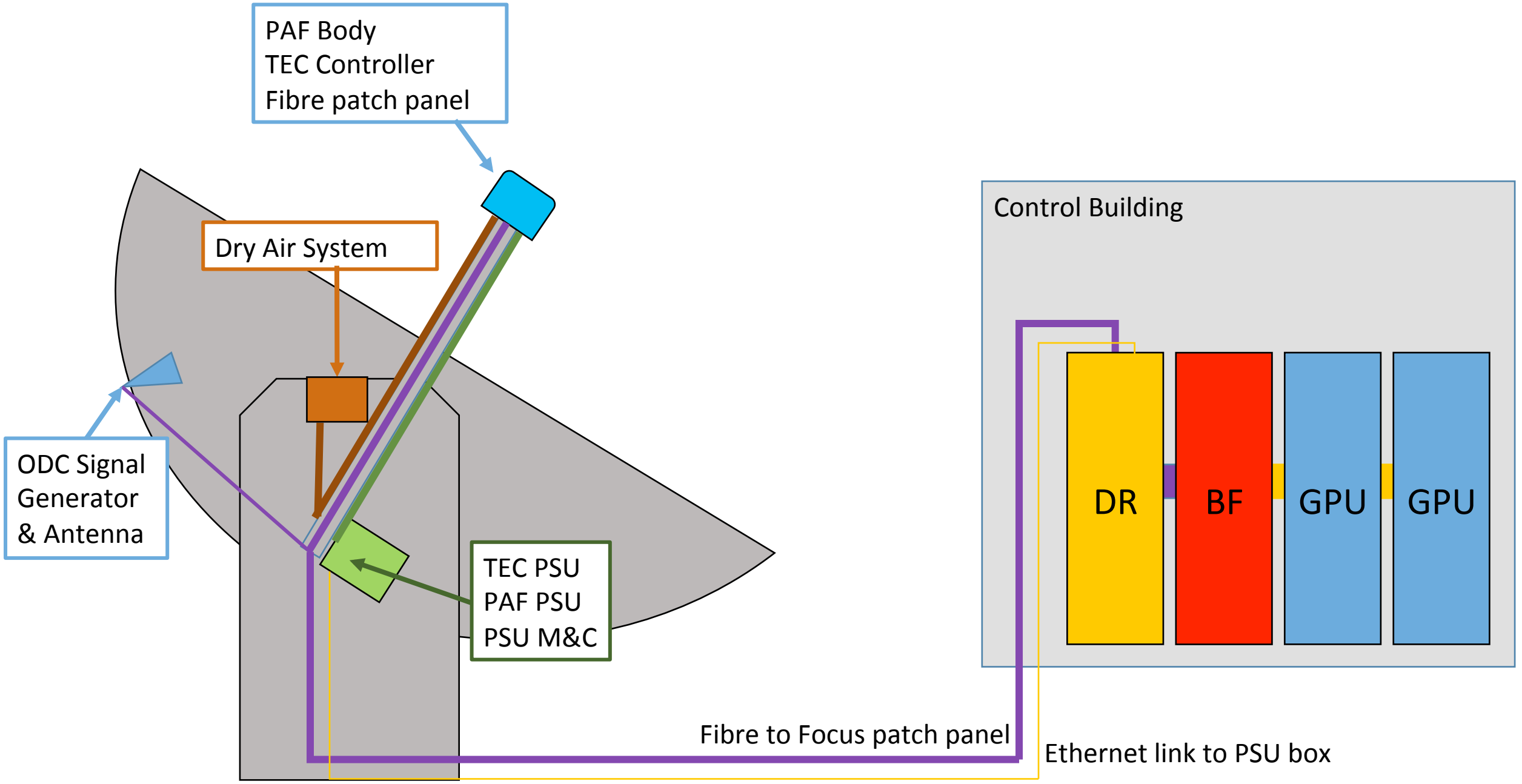
Bespoke components for JBO still under construction

- Timing interface
- PAF power supply





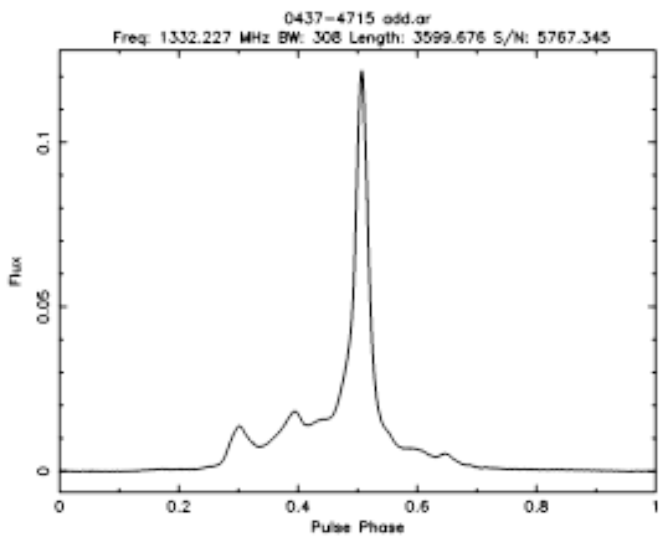

Need to manufacture mechanical mount
Need to install Fibre bundles
Need to purchase high capacity switches and processing computers
Imaging mode requires new “Central Signal Processor” for eMerlin
CSIRO MkII PAF
RF over Fibre
~188 fibres
Digital Reciever
CSIRO Beamformer
442 Gb/s
96x 10GbE
High Capacity Network Switch
221 Gb/s
12x 100GbE
12x multi-GPU science processor
High speed internal cluster network
eMerlin Central Signal Processor
On-dish Calibration System
Single-dish science products
Tied-array outputs
Visabilities (imaging output)
Work out best location for, and design mount for ODC system
Need to install shielded racks for digital equipment


PAF Body
TEC Controller
Fibre patch panel
Dry Air System
ODC Signal Generator & Antenna
TEC PSU
PAF PSU
PSU M&C
Control Building
DR
BF
GPU
GPU
Fibre to Focus patch panel
Ethernet link to PSU box

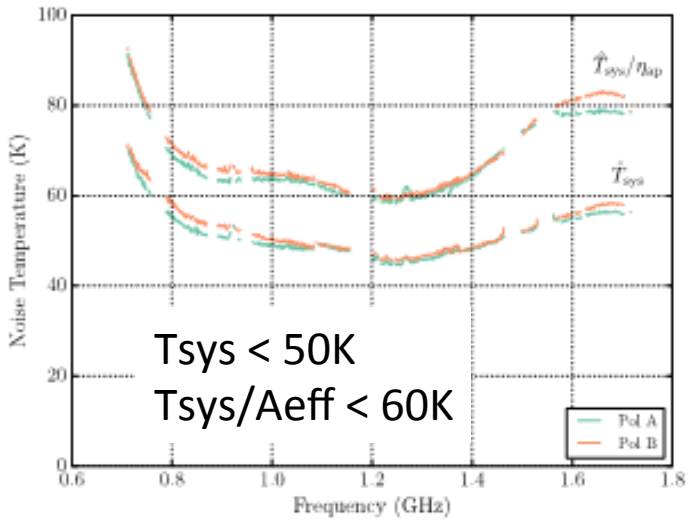
CSIRO MkII PAF

Delivery and installation anticipated early 2018

Same design PAF already tested at Parkes and Effelsberg



Successful Pulsar Observations



Tsys < 50K

Tsys/Aeff < 60K

JBCA “S-band” PAF

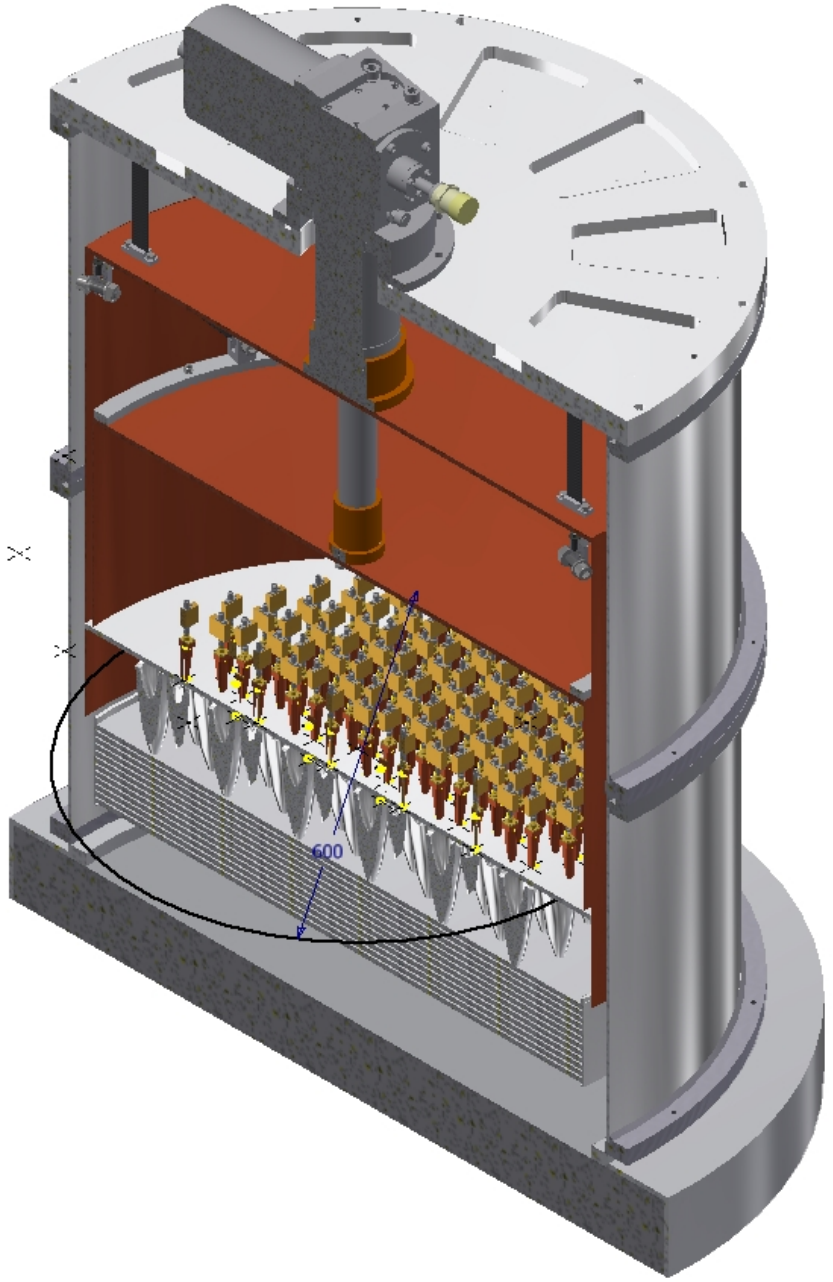
2-4 GHz (possibly also 1.5-2 GHz)

188 Elements

Fully Cryogenic

0.1 sq deg FoV

Utilise CSIRO receiver and beamformer.



Design work still continuing

Cryogenics

- Window technology
- IR filter technology
- Chiller selection

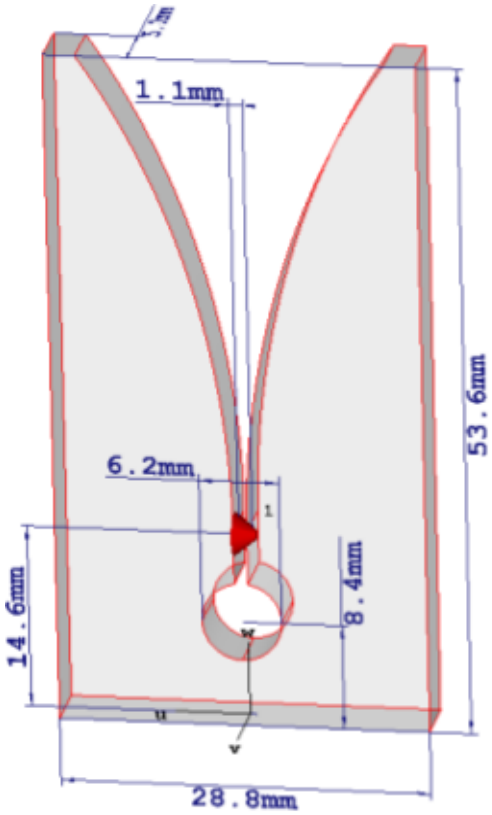
RFoF

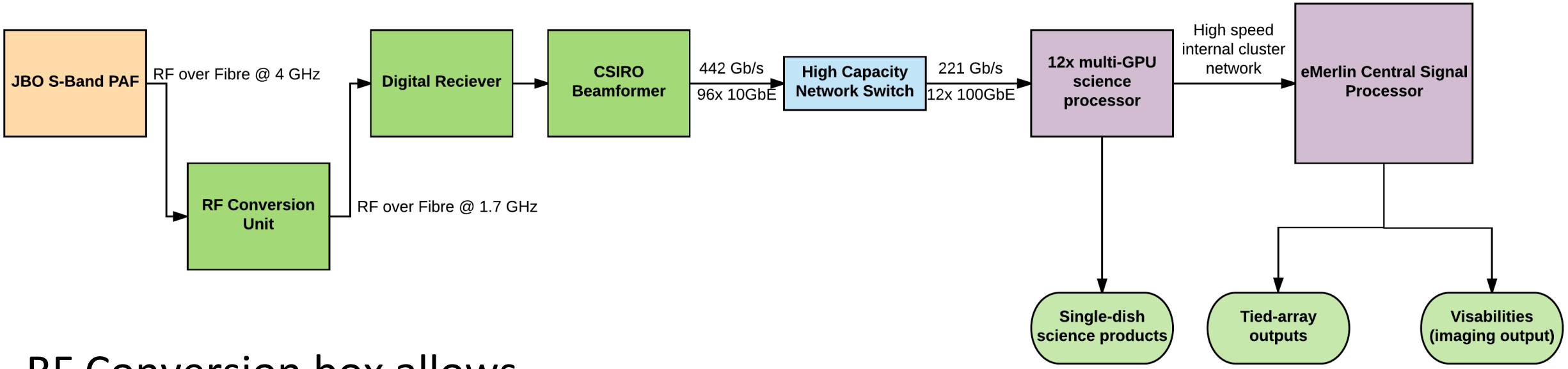
Likely direct conversion of 4GHz signal to Fibre

Investigating RFoF inside cryostat

RF element selection

Currently considering "thick" Vivaldi based on design presented by *Locke et al.* (2016) for the NRC "CryoPAF-4"

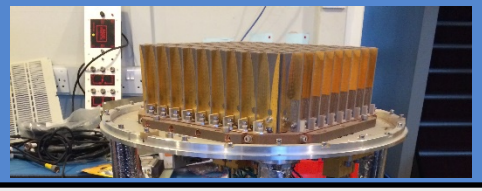
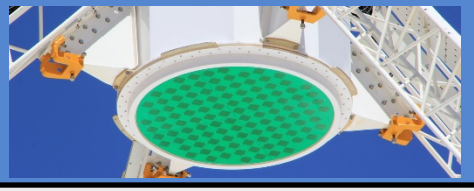
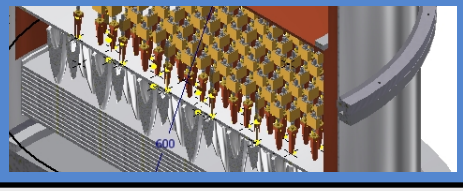




RF Conversion box allows re-use of entire digital chain and avoids re-work.

Likely sit adjacent to Digital Reciever.

Emulate CSIRO PAF.

	PHAROS / PHAROS2	CSIRO PAF	2-4 GHz Cryo PAF
			
Frequency	4-8 GHz	1.2-1.8 GHz (plus 0.70-1.1 GHz)	2-4 GHz (plus 1.4-1.8 option)
Cooling	Cryogenic	Room temperature	Cryogenic
Project status	Testing of prototype	Integration of production system	Design and prototyping
Number of elements	220 (24 in prototype)	188	188 (~24 in prototype)
Element technology	Vivaldi	Chequerboard	“Thick” Vivaldi?
Beamforming	Analogue (Upgrading to digital)	Digital CSIRO Beamformer	Digital CSIRO Beamformer
Future development in next round STFC funding request	N/A	Interface between beamformer and eMerlin systems	Development of full-scale instrument (+same interfaces as CSIRO PAF)