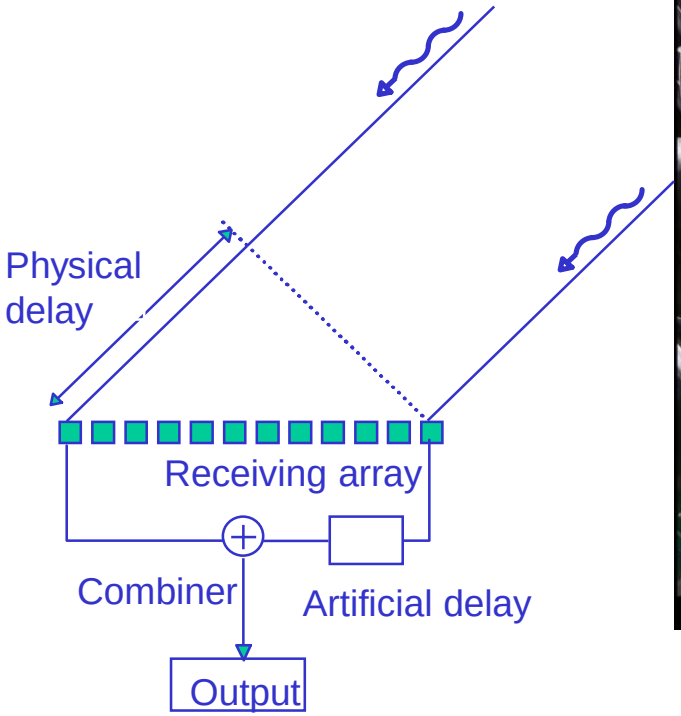
Mid freq Aperture Array Technology
The MFAA Element

Jan Geralt Bij de Vaate

Why MFAA?

- DRM 1.0, for SKA2, Survey Requirement
  - Speed 10^{10} $m^4 deg^2/K^2$
  - Large FoV 100 deg^2
  - Freq 450(350)-1450 MHz
- Processing advantages
- DRM -> System requirements for SKA2 ?

EMBRACE

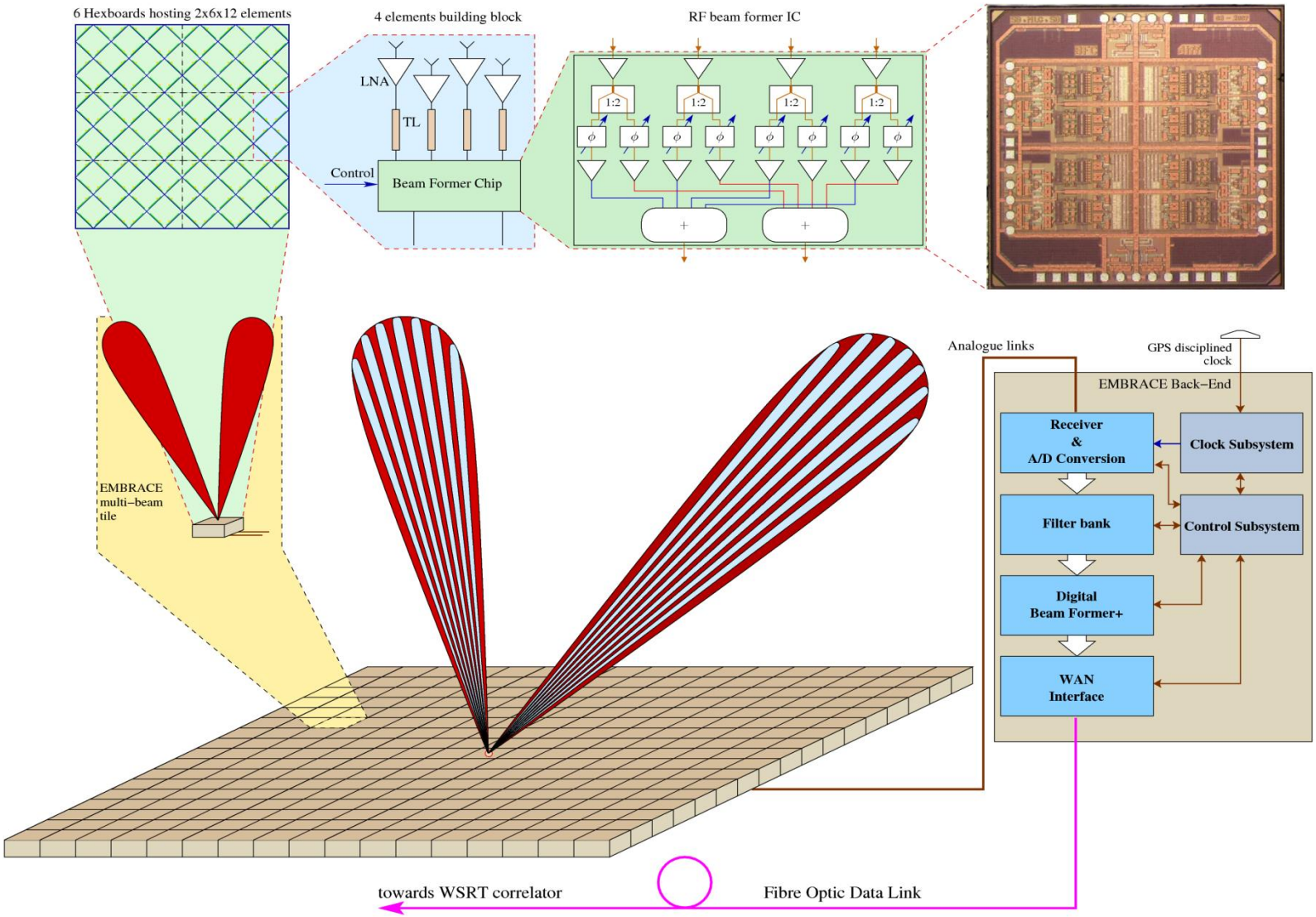



EMBRACE Aperture Array

EMBRACE design drivers

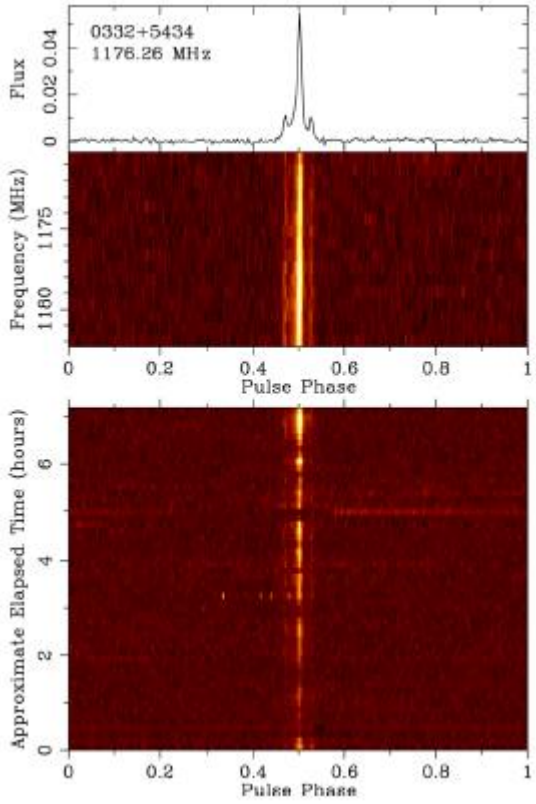
Frequency range	500-1500MHz
Area	150m^2 WSRT 80m^2 Nancay
Analogue beamforming	64 elements
Independent FoV	2
Digital beams	8

EMBRACE


6 Hexboards hosting 2x6x12 elements
4 elements building block
LNA
TL
Control
Beam Former Chip
RF beam former IC
1:2
EMBRACE
multi–beam
tile
Analogue links
GPS disciplined
clock
EMBRACE Back–End
Receiver
&
A/D Conversion
Clock Subsystem
Filter bank
Control Subsystem
Digital
Beam Former+
WAN
Interface
towards WSRT correlator
Fibre Optic Data Link

Observations with EMBRACE

- Pulsar B0329+54
  1175.6 MHz

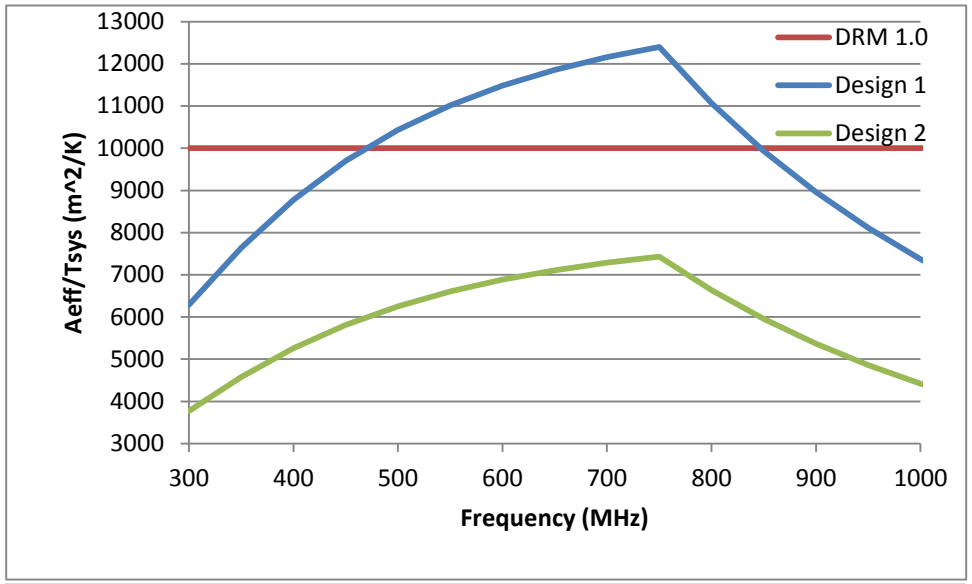


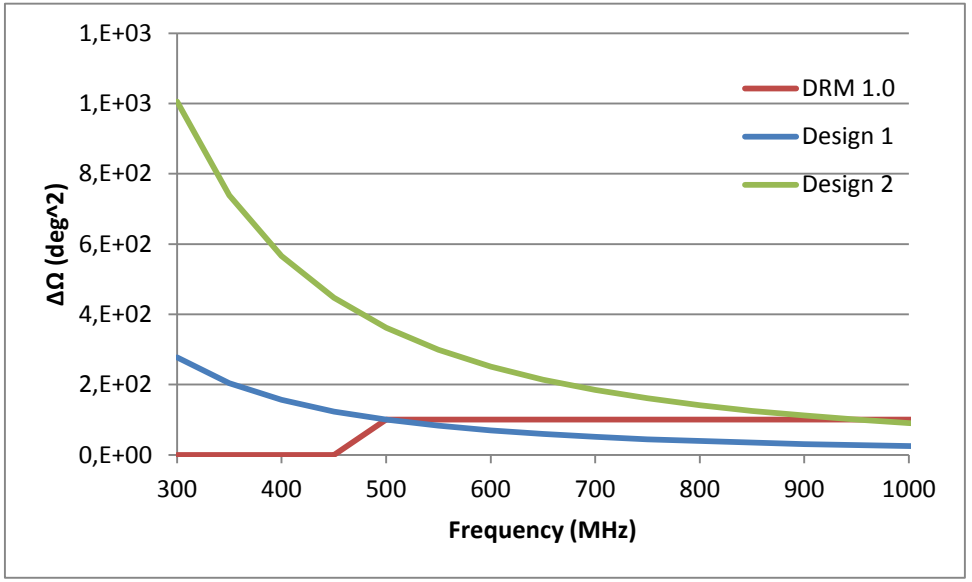
From EMBRACE to AERA^3 to SKA2

- Issues to be resolved;
  - Power consumption
  - Cost: 3000 -> €1000/m^2
  - Performance, calibratebility, T_{sys}

SKA System

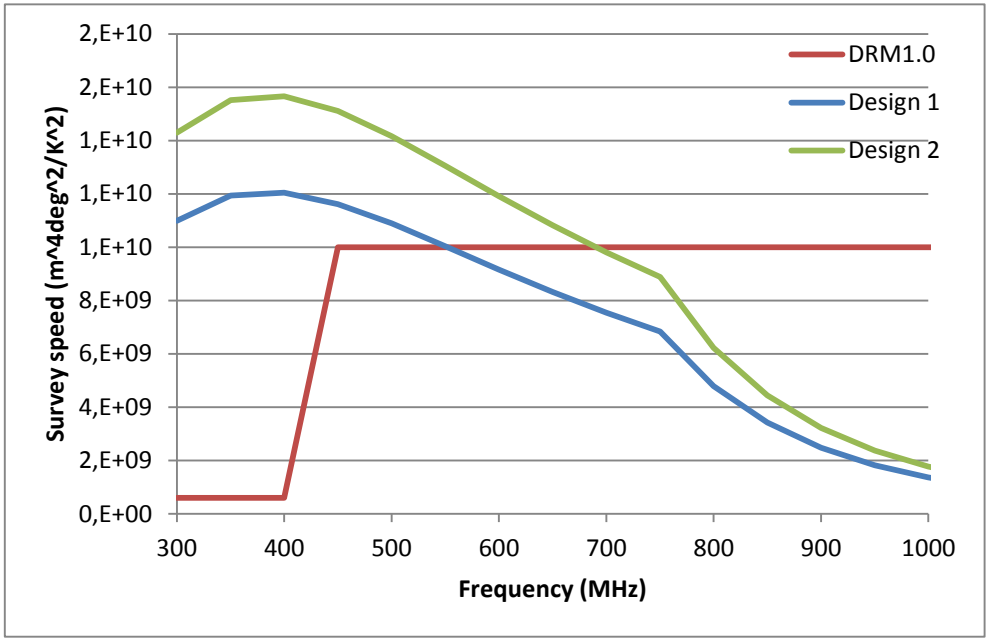
- Two options for AA-mid realization:
  - 1: Large Aeff
  - 2: Large processing backend
- Design1: 30/70%
  - Front-end / Backend
  - 2012 technology



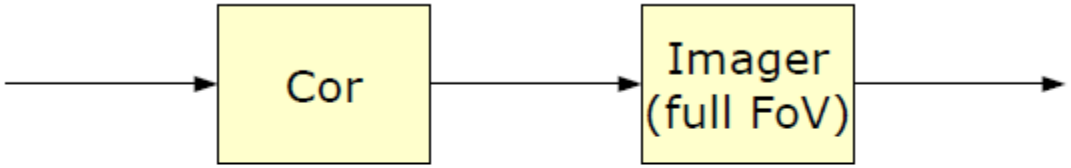


Performance

- Survey speed



Computing per 100MHz for full FoV



	Tbps	Pops	Tbps	Pops	power (MW)
SKA-dish	0.813	0.103	0.847	39.6	2.4
SKA-survey	11.1	0.531	4.49	204	12.8
AA-mid	4.10	0.131	0.204	**0.315**	**0.028**

- power is for processing only assuming 16 Gflops/W
- **Reasonable balance correlator – imager only for AA-mid**
- **AA-mid could significantly reduces costs of imaging**

- Ref Stefan Wijnholds, SKA Oct Eng meeting

MFAA Consortium

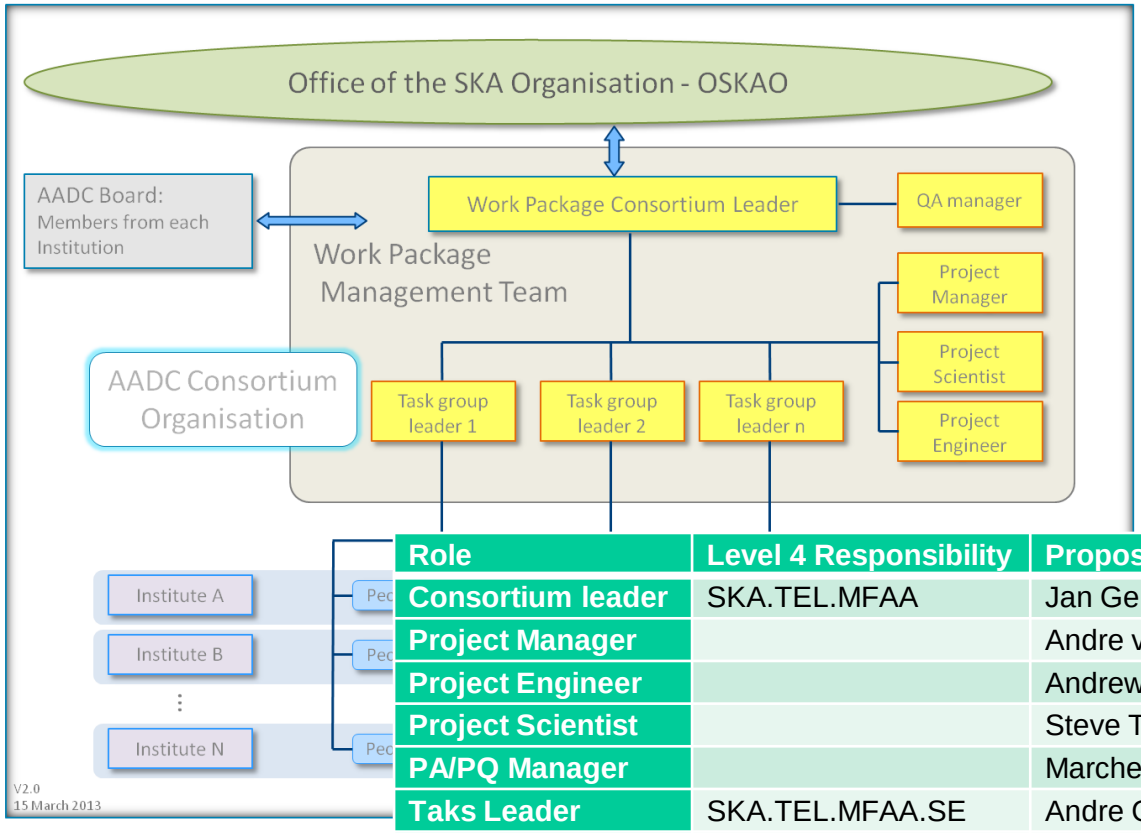
1. ASTRON	*Management, System, Prototyping*
2. Observatoire d'Paris	*Front-end Chips*
3. University of Bordeaux	*ADC*
4. University of Cambridge	*System*
5. University of Manchester	*ORA*
6. KLAASA (China)	*Industrial design, Prototyping*

7. Associate members:

– *Portugal, IT*	*Renewable energy, RFoF*
– *University of Malta*	
– *South Africa*	*Site, array design*
• *Stellenbosch University*	
– *Mauritius*	*array demonstration*

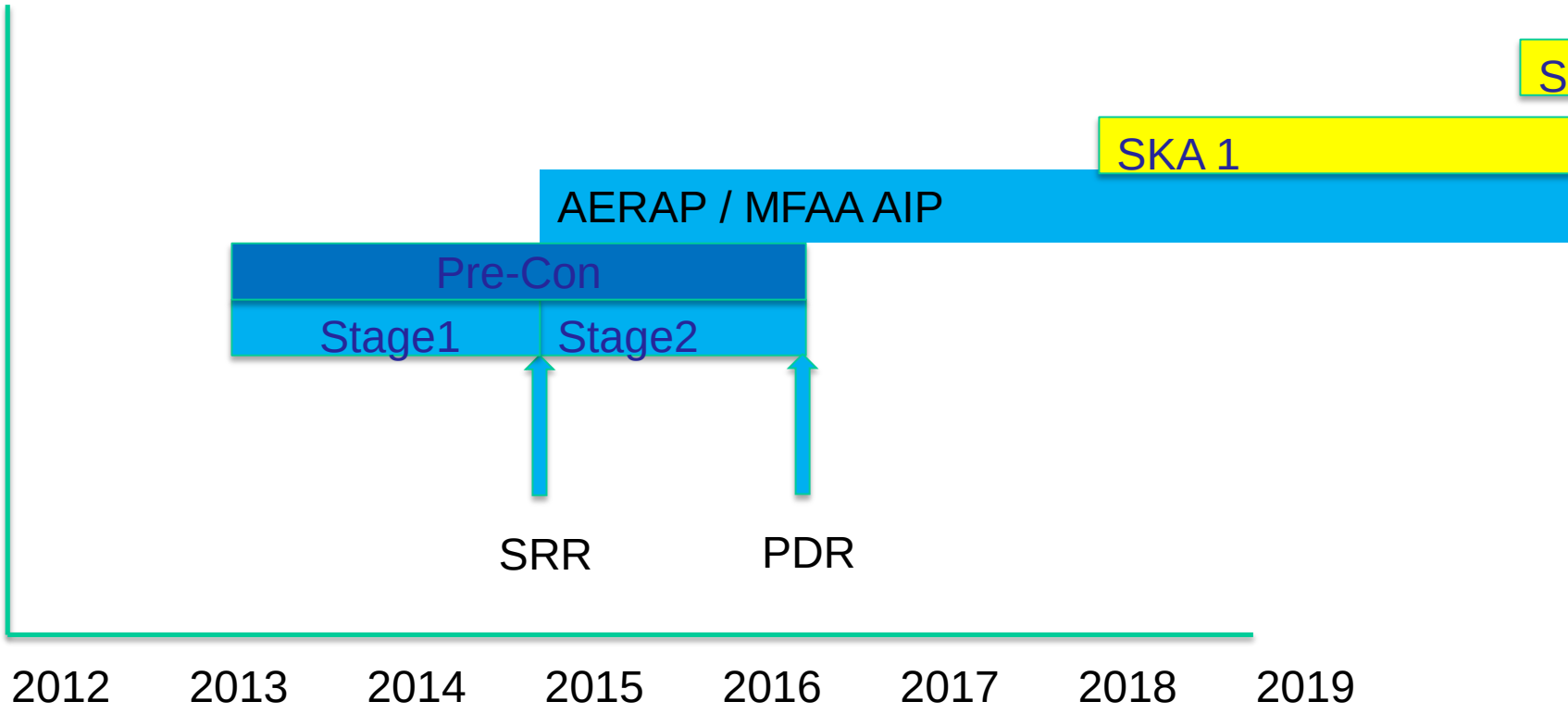
Focus on Front-end, LFAA will work on Digital Signal Processing

Consortium organogram



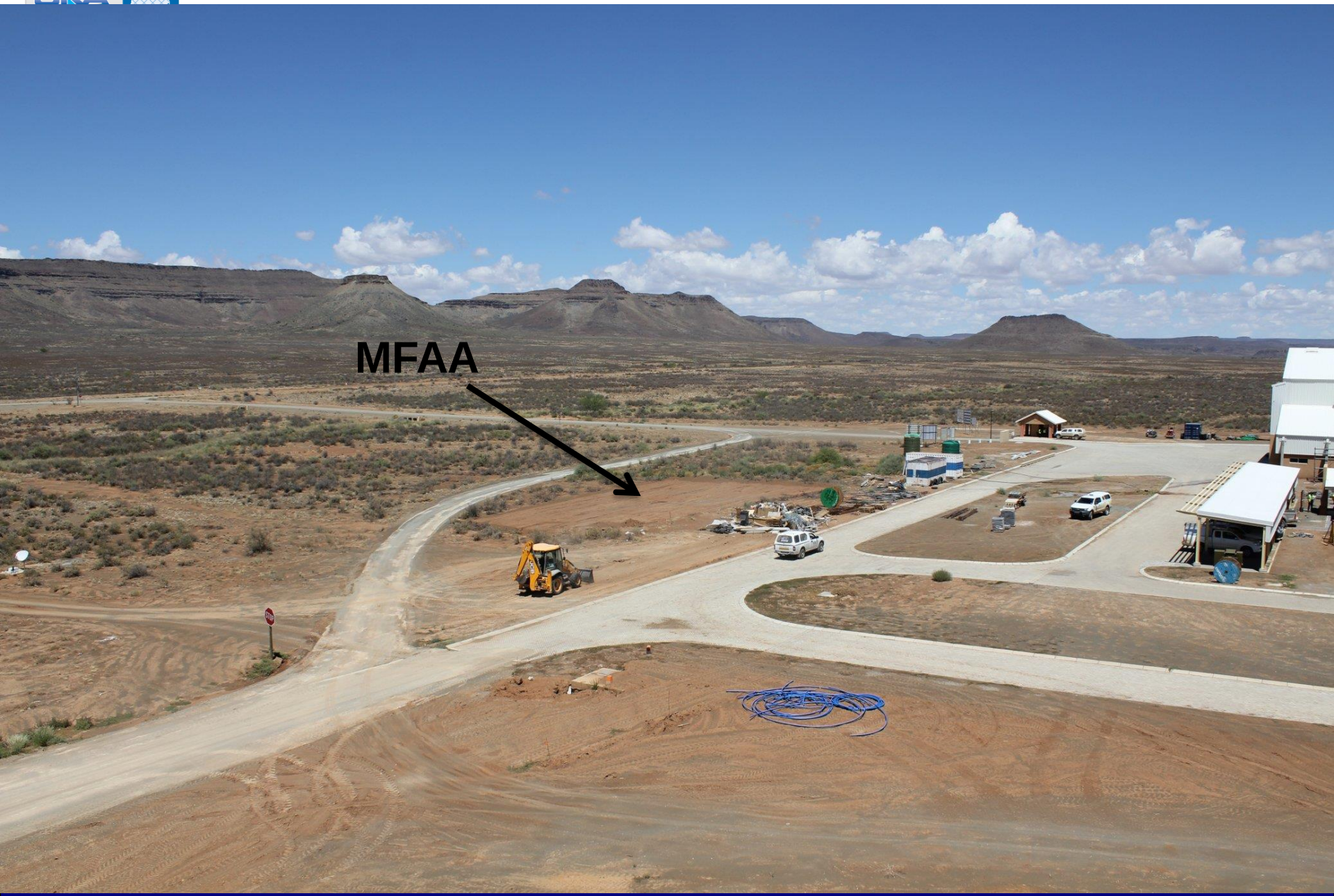
Role	Level 4 Responsibility	Proposed	Affiliation
Consortium leader	SKA.TEL.MFAA	Jan Geralt Bij de Vaate	ASTRON
Project Manager		Andre van Es	ASTRON
Project Engineer		Andrew Faulkner	UCAM
Project Scientist		Steve Torchinsky	OBSP
PA/PQ Manager		Marchel Gerbers	ASTRON
Taks Leader	SKA.TEL.MFAA.SE	Andre Gunst	ASTRON
Task Leader	SKA.TEL.MFAA.FED	David Zhang	UMAN
Task Leader	SKA.TEL.MFAA.RE	Guy Kenfack	OBSP
Task Leader	SKA.TEL.MFAA.SP	Kris Zarb-Adami	Malta
Task Leader	SKA.TEL.MFAA.PROT	Pieter Benthem	ASTRON

MFAA Schedule

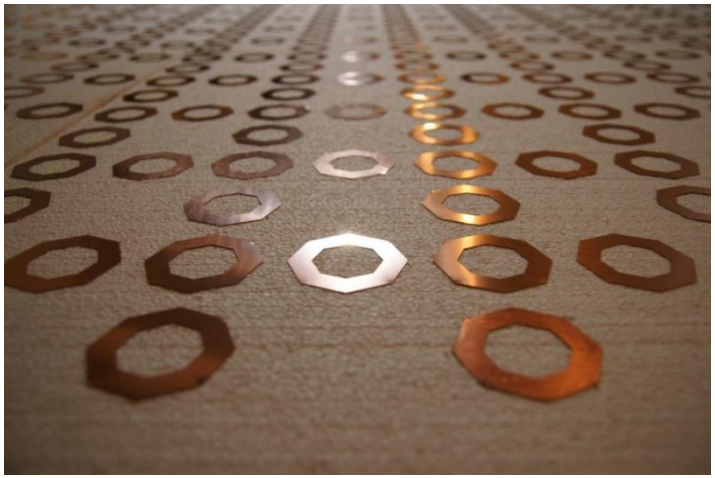


Front-end proto typing

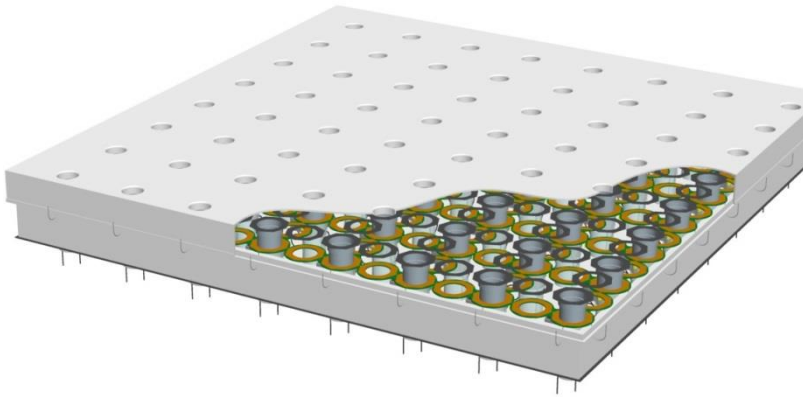
Front-end proto typing


MFAA

Octagonal Ring Antenna (ORA)

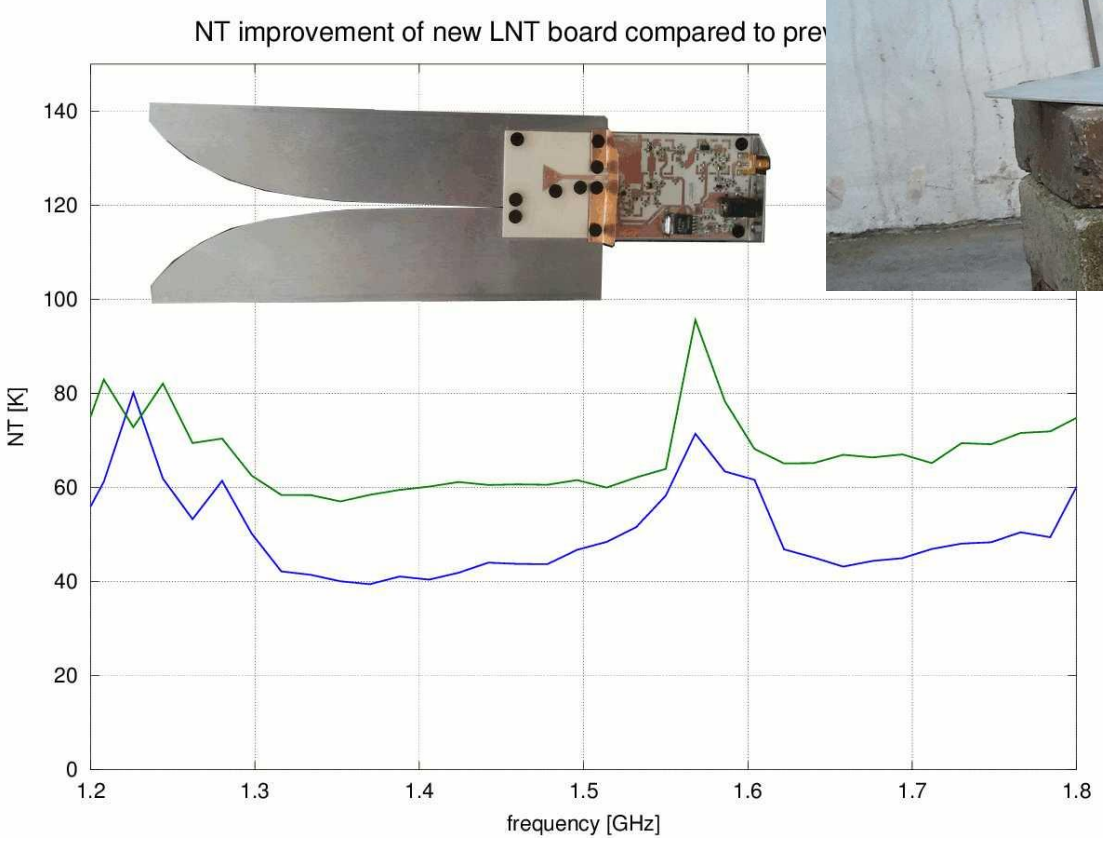


- Electromagnetic reception performance of basic ORA array has been verified
- Finite ORA array (1m^2 in area) integrated with LNAs has been measured with the lowest noise temperature of 39K

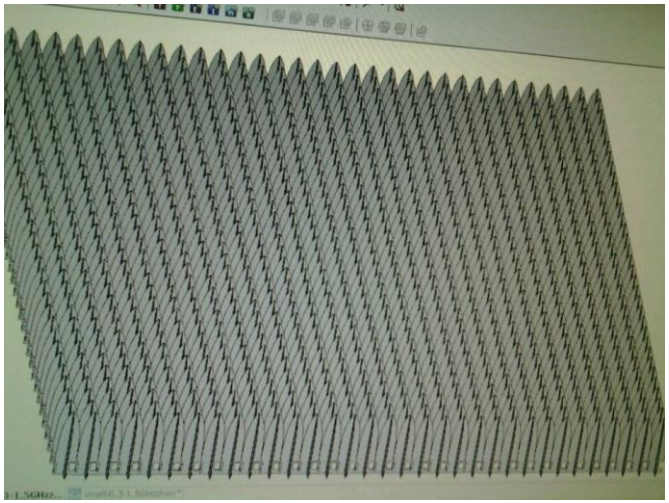


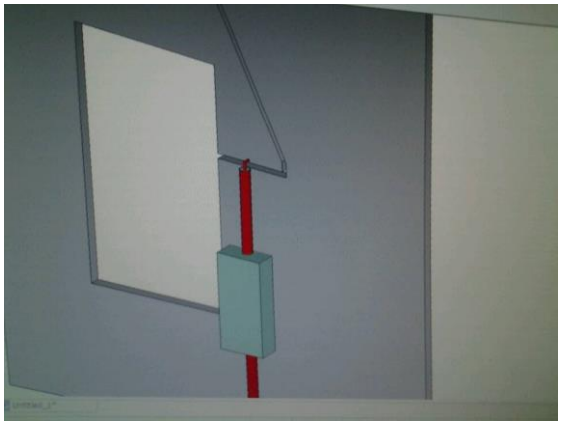
ORA with AVAGO MGA16116 simulated

Noise temp AAs



KLAASA Front-end prototyping





- Performance and cost of the Vivaldi Antenna arrays comparision in a metal array and a dielectric-slab
- Finite Metal Vivaldi Antenna array (9m^2 in area) integrated with LNAs
- Material and manufacturing method with low cost will

Next steps

- AERAP supported engineering work
  - Student exchange, MIDPREP, NWO-NRF exchange money
  - 3x3 m^2 arrays, Mauritius, Stellenbosch, Durban
  - New Tile evaluatio
  - Beamforming softw
  - Calibration, Imagir
- AERAP^3 -> Ilse

Transients

- No substitute for Field of View!

Freq range

• Transients	300-1000MHz (500-1500)
• Cosmology	400-800MHz (350-1200)
• HI continuem	300-1500MHz (don't bother)
• Cosmic Magnetism	300-1000MHz (750)
• Local HI	1100-1400MHz
• Pulsars	500-1500MHz
• Neutral gas	

Baseline

- Transients
- Cosmology 60m
- HI continuem 5km
- Cosmic Magnetism 300-1000m
- Local HI 1000m
- Pulsars
- Neutral gas

Field of View

- Transients 175 deg^2
- Cosmology 25 deg^2
- HI continuem
- Cosmic Magnetism
- Local HI 175deg^2
- Pulsars >50deg^2
- Neutral gas

Actions

- Update requirements and specifications
- Phasing MFAA -> AERAP -> SKA
  - Engineering demonstrator
  - Scientific demonstrator, AERA^3
  - Budget?
  - AERAP1 proposal
- Cost of (scientific) demonstrators
- System comparison: Dishes versus AAs
  - Compute power: beamforming, correlation, sensitivity
- SKA 2 vision

- MFAA All-hands meeting in Dwingeloo 1-3 April 2014