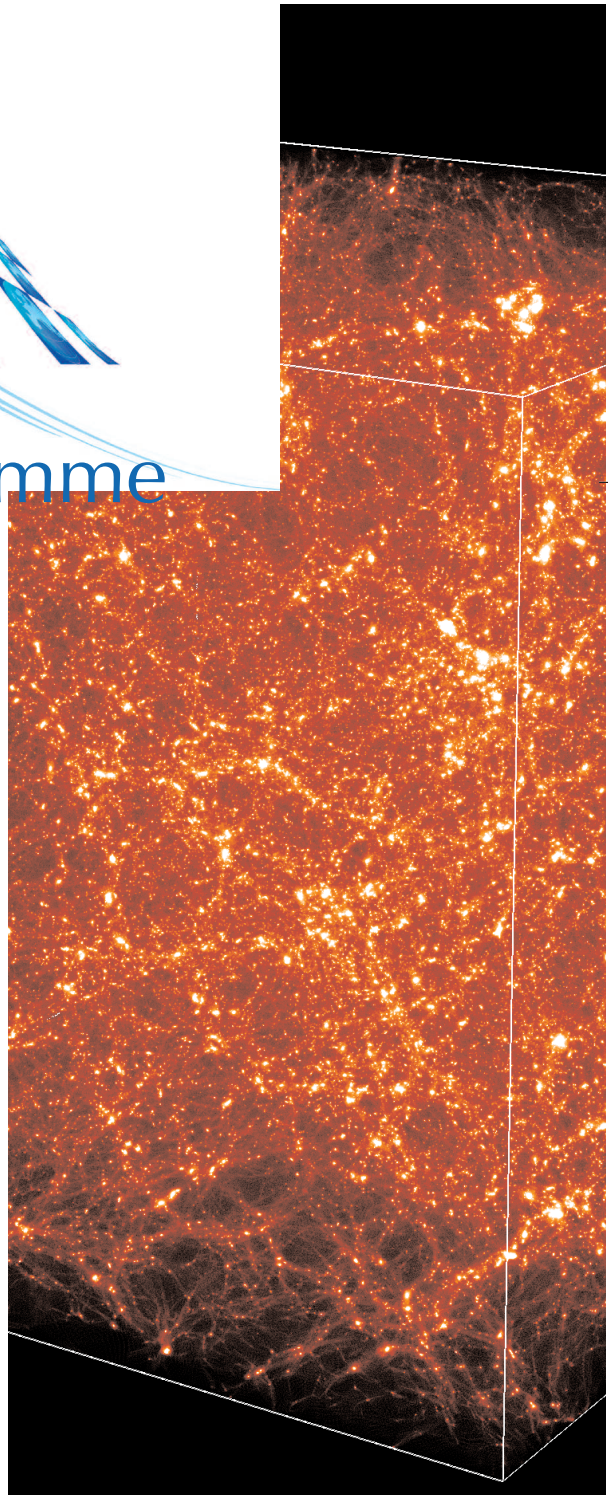
SKA-AAVP

Aperture Array Verification Programme

Aperture Array for low Frequencies- AAlo



Presented by Monari Jader
INAF-IRA
Radiotelescopio Croce del Nord
Email : j.monari@ira. inaf.it

Let's start the talk with some numbers……

Numbers for SKA Phase -1 (50 Aperture Arrays)

Each station has 11.200 elements:

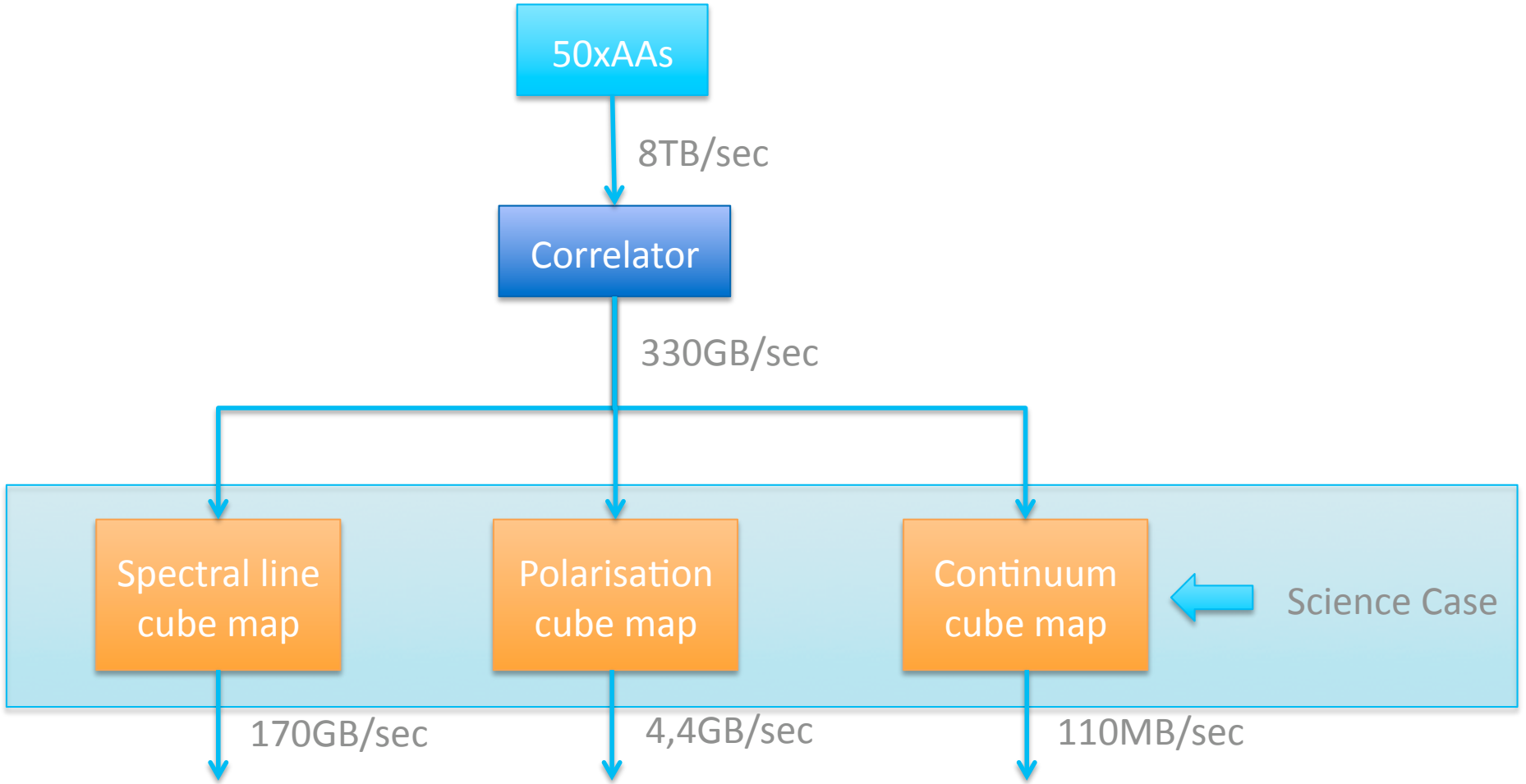
11.200X50=560.000 antennas

560.000X2=1.120.000

LNAs, FE, Optical Links, Acquisition system…

It is easier to understand that AAs are huge business for industry!

….more numbers…Data flows



….Storage and data after 1 year

330GB/sec X 31.536.000 =10,40X10^{18}=10,40EB !!!!

1 Blue Ray Disk =50GB about 1,2mm Thick

An enormous stack of Blue ray disk, high about 250 Km!!!

Try to imagine the same problem for the computation and power consumption!!!

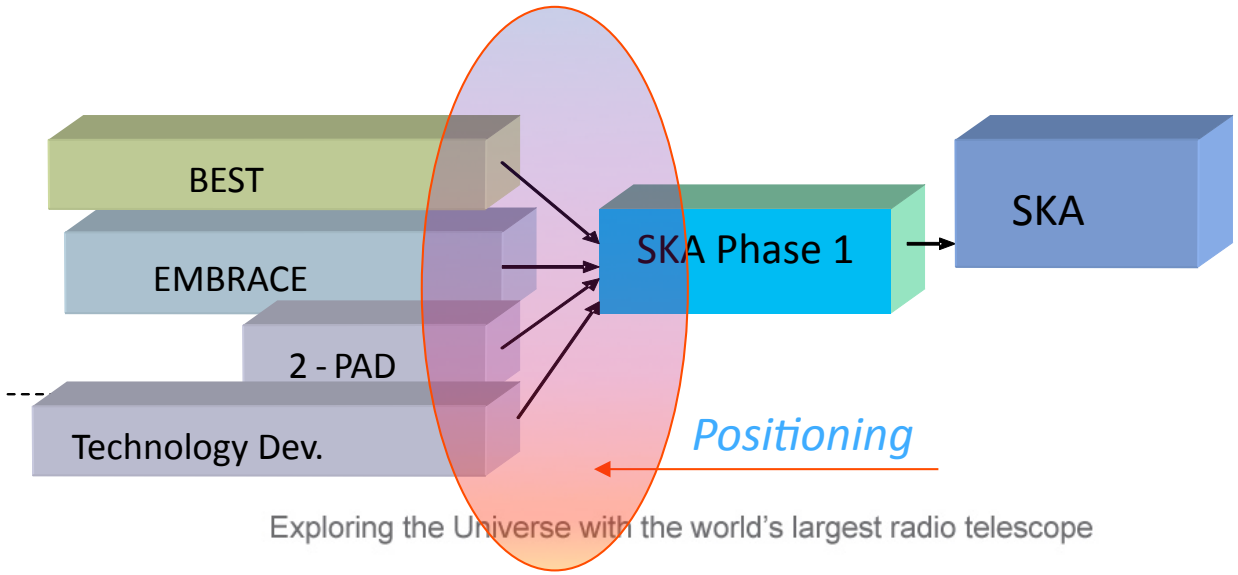
Aperture Array Verification Program

After SKADS;
Apertures arrays in the 2009-2012 period

Arnold van Ardenne

Project size:
~18-20M€
100+ FTE
42 month
15 institutes
9 European countries
+ Australia & SA

www.SKA-AAVP.eu
secretary@SKA-AAVP.eu
www.ska-aavp.eu/aavpwiki



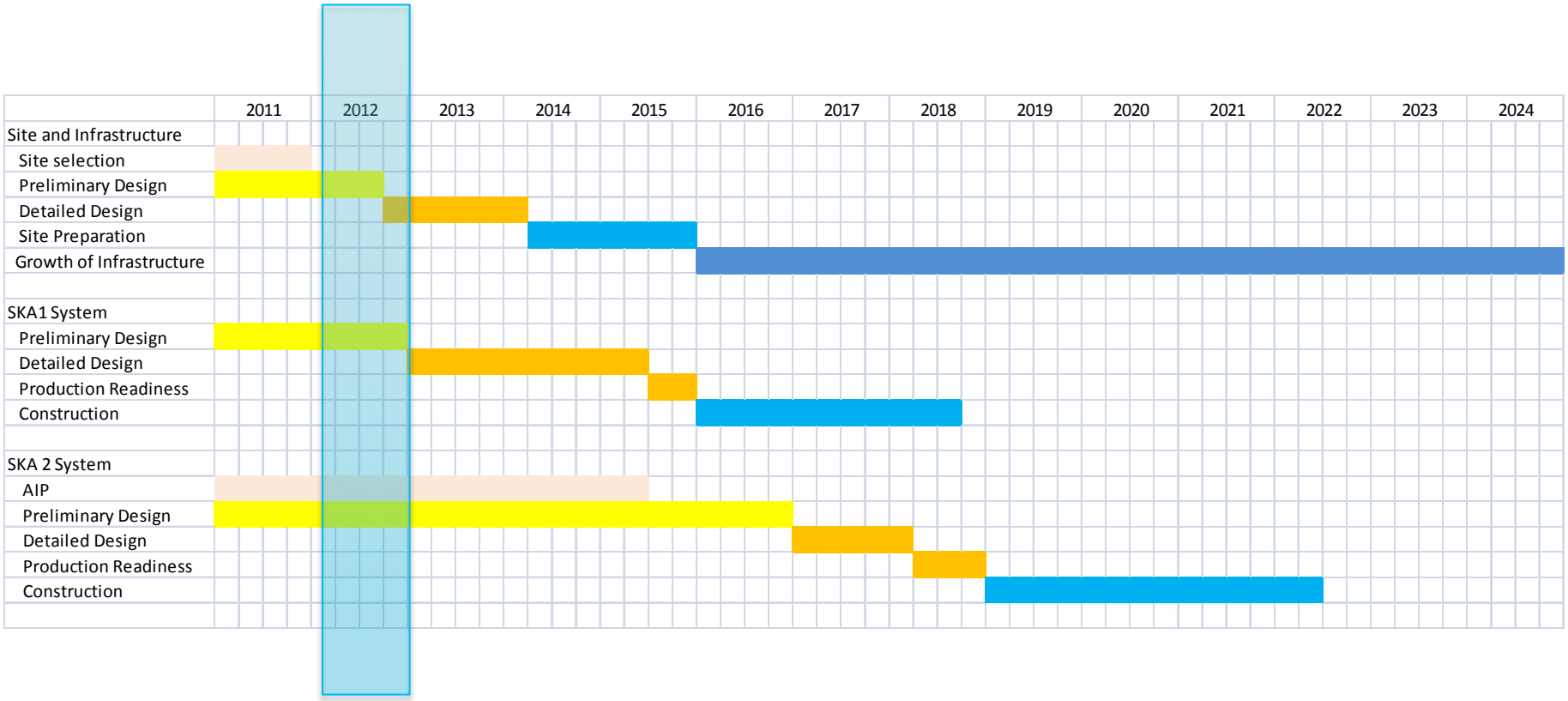
Kick off Meeting: Zaandam 2010

Consortium/Institute	Country
UK-PrepSKA	UK
ASTRON/Kapteyn Inst._RUG/Leiden Obs._Univ.Leiden	Nl
MPIfR	Germ.
Obs. De Paris/Obs. Bord./Ud'Orléans	Fr
INAF_IRA	It
OAN	Sp
OSO_ChTU	Sw
Torun Centre of Astronomy_UMK	Pol
JIVE	Europe
PRAC	Port
ICRAR	Aus
NRF	S.A.
SPDO/PrepSKA-WP2	

Note: US representative “only” through SPDO

Aperture Arrays for SKA

SKA Timeline



AA's in SKA phased planning

SKA_1

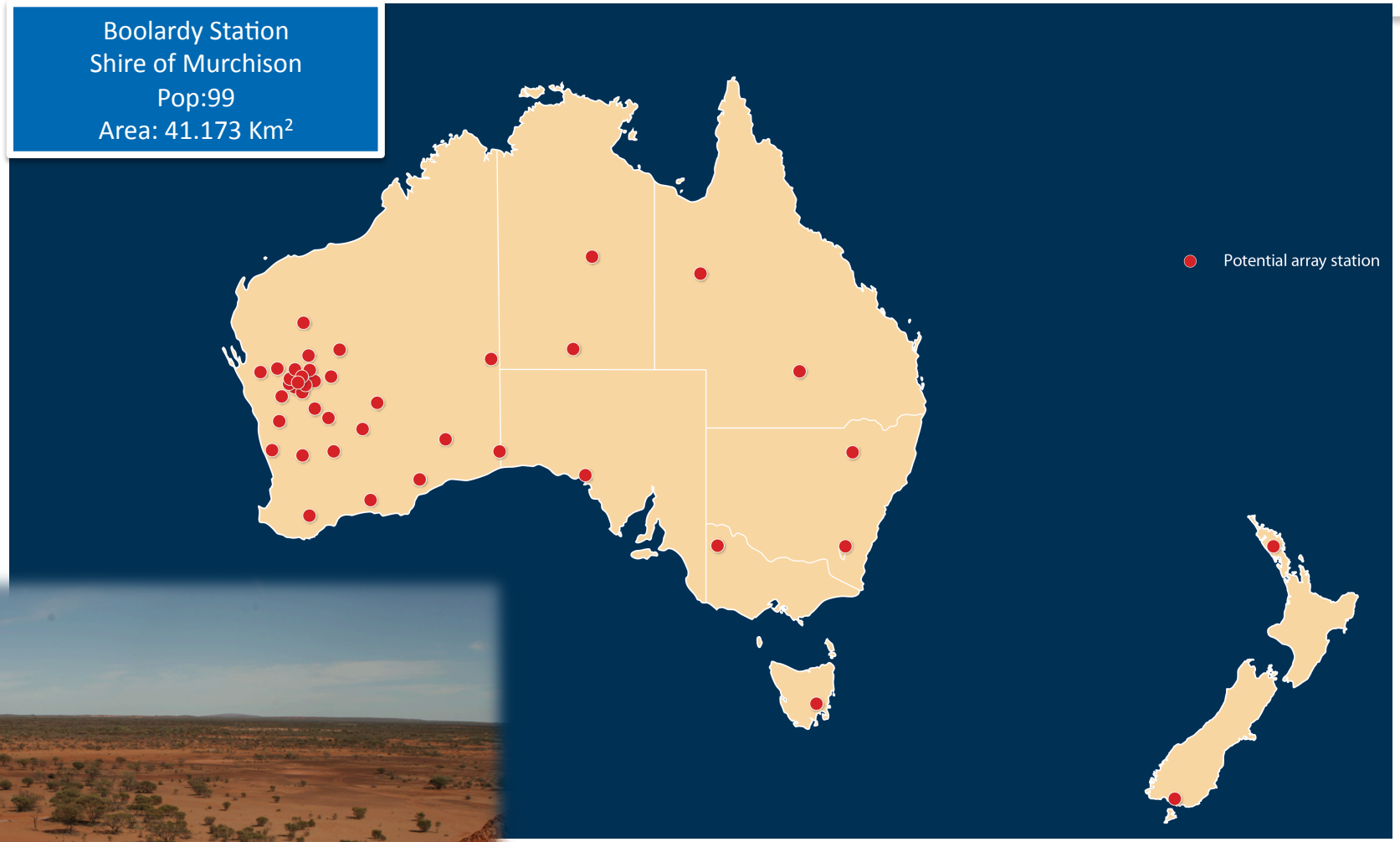
Freq. Range	Collector	Sensitivity	Number / size	Distribution
70 MHz to 450 MHz	**AA-low** Sparse AA	1,000 m^2/K at 100 MHz	50 array stations, Diameter 180 m	70% within 5 km dia., 30 % along 3 spiral arms out to 100 km radius
300 MHz to 3 GHz	Dishes with single pixel feed	1,000 m^2/K at 1.4 GHz	250 dishes Diameter 15 m	

SKA_2

Freq. Range	Collector	Sensitivity	Number / size	Distribution
70 MHz to 450 MHz	**AA-low** Sparse AA	4,000 m^2/K at 100 MHz	250 array stations, Diameter 180 m	66% within 5 km dia., 34% along 5 spiral arms out to 180 km radius
400 MHz to 1.45 GHz	**AA-mid** Dense AA	10,000 m^2/K at 800 MHz	250 array stations, Diameter 56 m	
300/1000 MHz to 10 GHz	Dishes with single pixel feed + PAF	10,000 m^2/K at 1.4 GHz	2000 – 3000 dishes Diameter 15 m	50% within 5 km dia, 30% 5km - 180 km 20% 180 km-3,000 km.

You go where the population is low…..

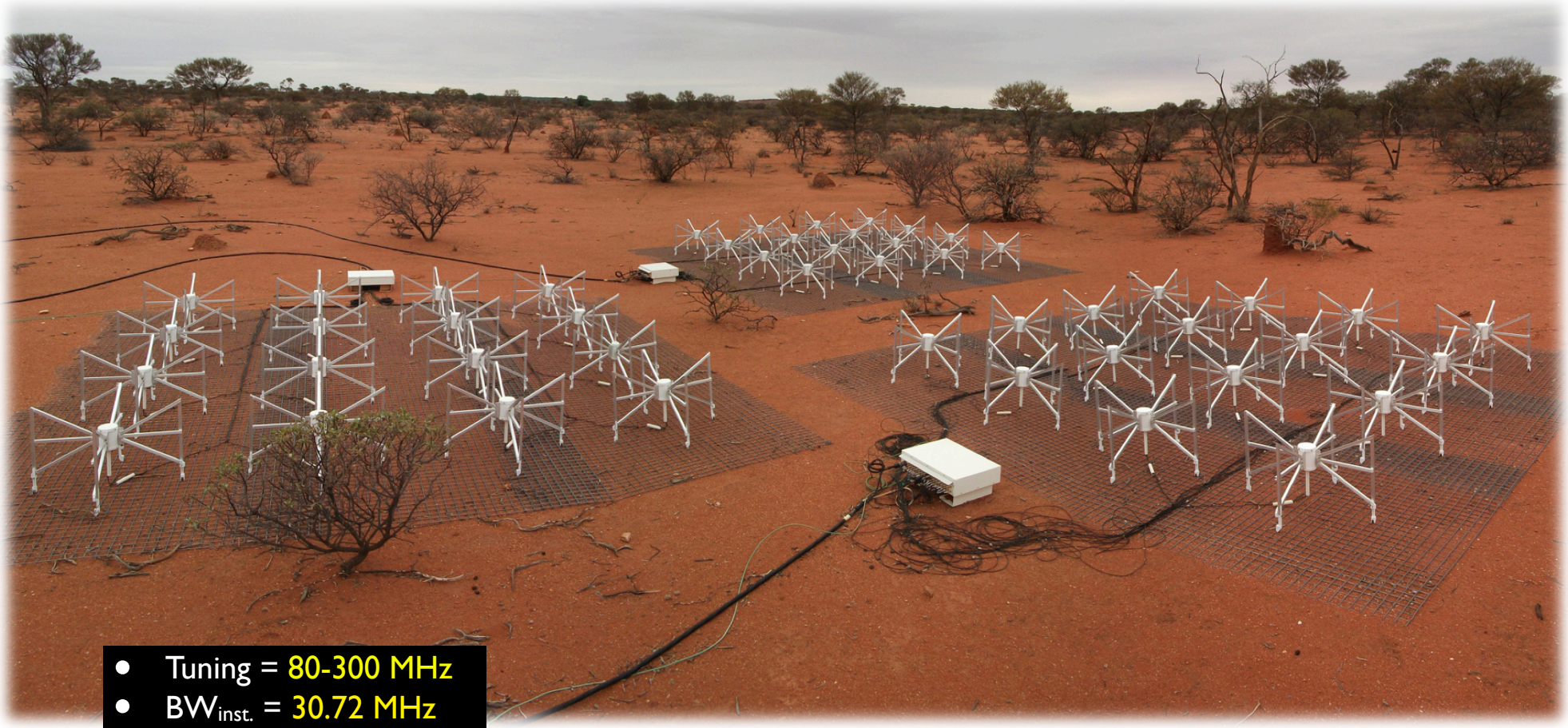
Boolardy Station
Shire of Murchison
Pop:99
Area: 41.173 Km^2



AAs Pathfinder

- Scientifically productive stepping stones to SKA-low
  - Includes LOFAR, , LWA, PAPER, ...
- Global investment of (much) more than €150 M
  - Critical to lever maximum return for SKA on investment

AAs precursor…. MWA
Murchison Widefield Array



- Tuning = 80-300 MHz
- $BW_{inst.}$ = 30.72 MHz
- $BsIn_{max}$ = 1.5 km
- FOV = 10 – 40° (x 1)
- Apertures = 512 tiles

Next Steps for AAVS program

		Array Scale	Site	Purpose & Comments
AAVS0 2011/2	AA-low	16 elements	Local	Prove electromagnetic performance in small array. Multiple arrays
AAVS1 2013/4	AA-low	256 elements	Selected SKA site strongly preferred.	Single station showing beam performance and the limits of analogue power requirements
AAVS2 2015/6	AA-low	,000's of elements in single or multiple arrays	Selected SKA site.	Multiple stations, similar to AAVS1, to show imaging performance. Final proving for SKA_2. Small numbers of beams for processing reasons. **NOT** a science instrument

AAVS2 science capable

Aperture Array Keys technologies

Frequency Coverage	50 – 450 MHz
Inst. Bandwidth	400MHz
Array Type	Sparse
Sky Coverage	±45°
Polarisations	2 linear

General Specifications

Italian Organization for AAVP

Jader Monari, Federico Perini, Germano Bianchi, Marco Schiaffino, Giovanni Naldi, Andrea Mattana

IRA-INAF Medicina

Stelio Montebugnoli

Giuseppe Virone, Pierluigi Debernardi, Augusto Oliveri

IEIIT Turin

COSPAL

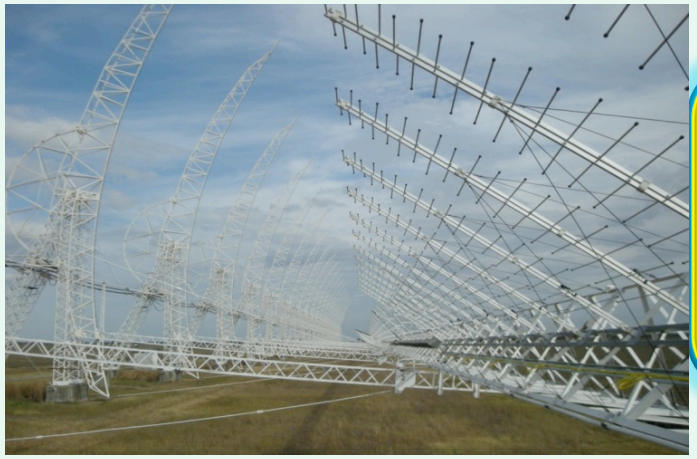
Andrea Lingua, Marco Piras, Paolo Maschio, Horea Bendea, Alberto Cima

POLITO

SGUINZI

From SKADS to AAVP

Experience from SKADS-BEST (UHF) (1400 sqm)

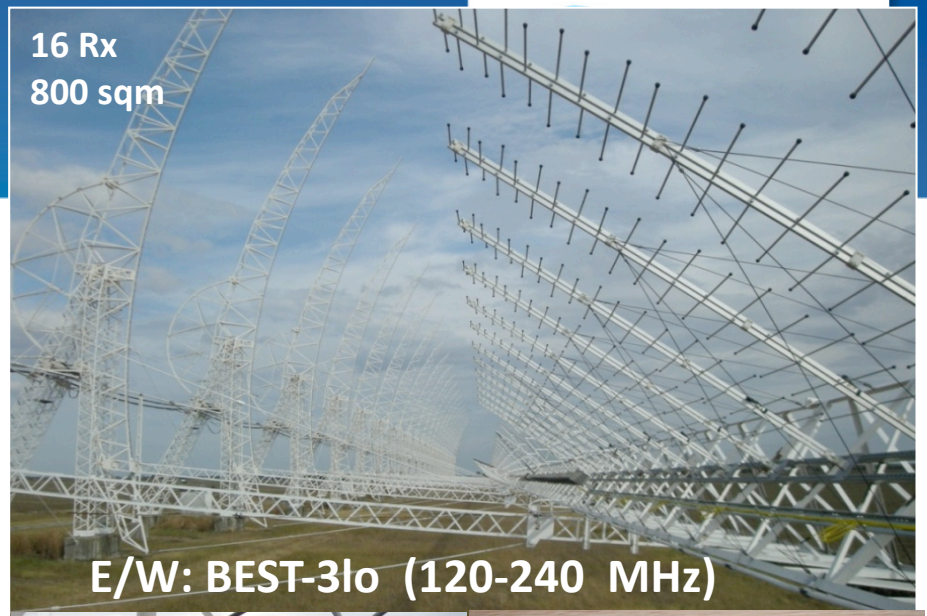


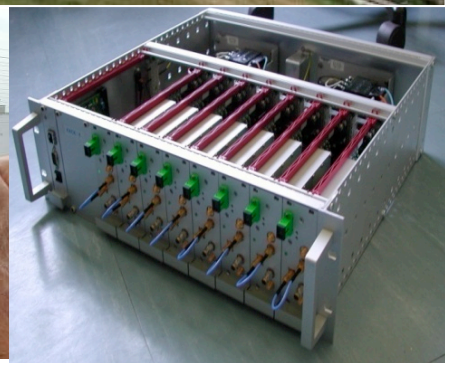
Experience from SKADS-BESTlo (VHF) (800 sqm)

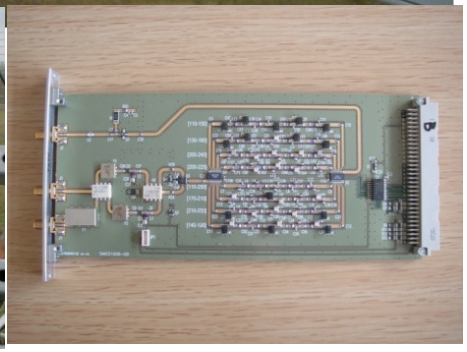
AAVP

This is the point we start from….

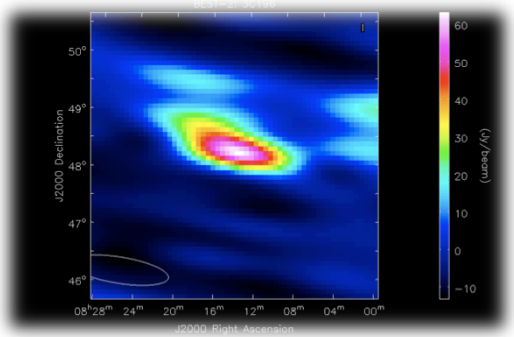

32 Rx
1400 sqm
N/S: BEST-2 (408 MHz 16 MHz Bw)


16 Rx
800 sqm
E/W: BEST-3lo (120-240 MHz)

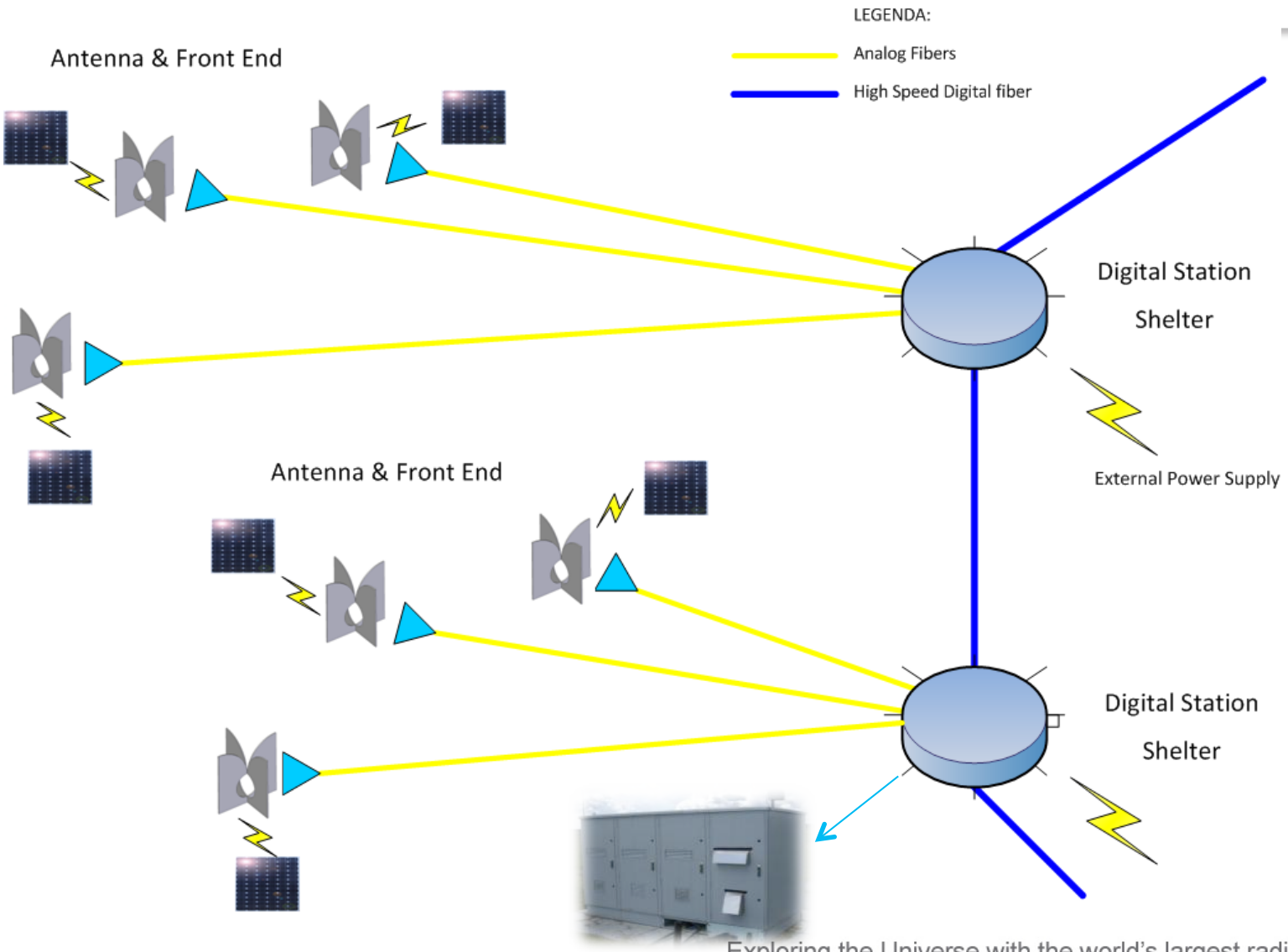




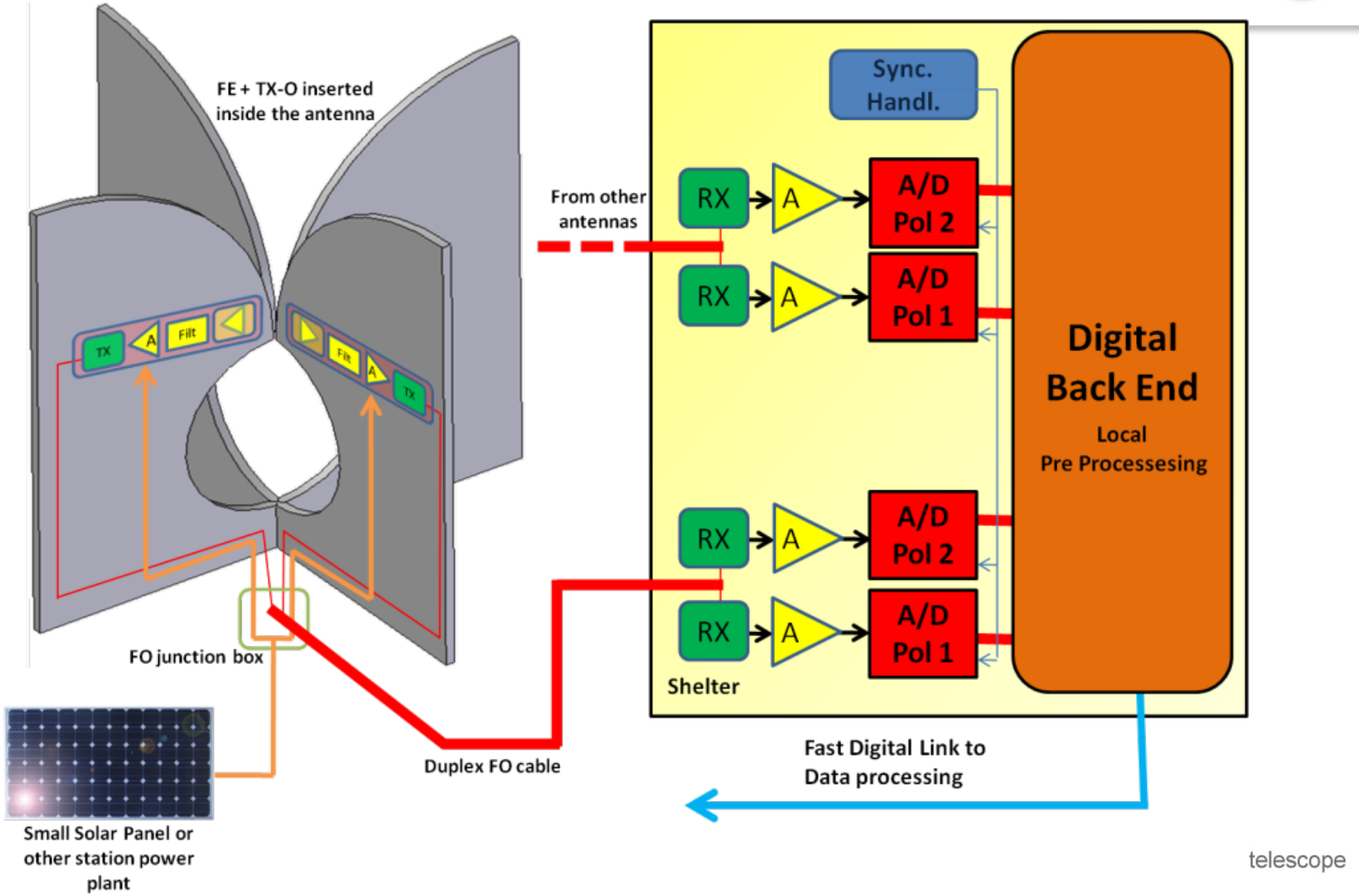
3C196 image


J2000 Declination
J2000 Right Ascension
(Jy/beam)

Aperture Array Architecture

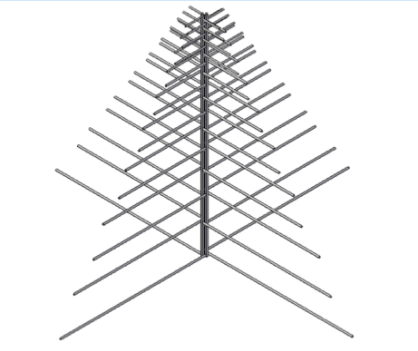
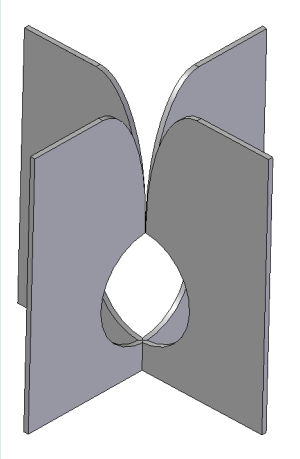
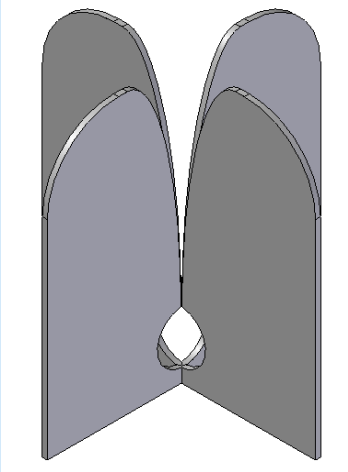
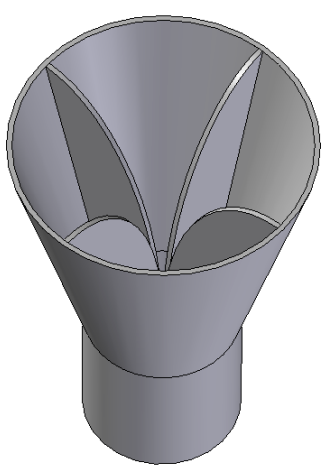


First Draft: Concept Description



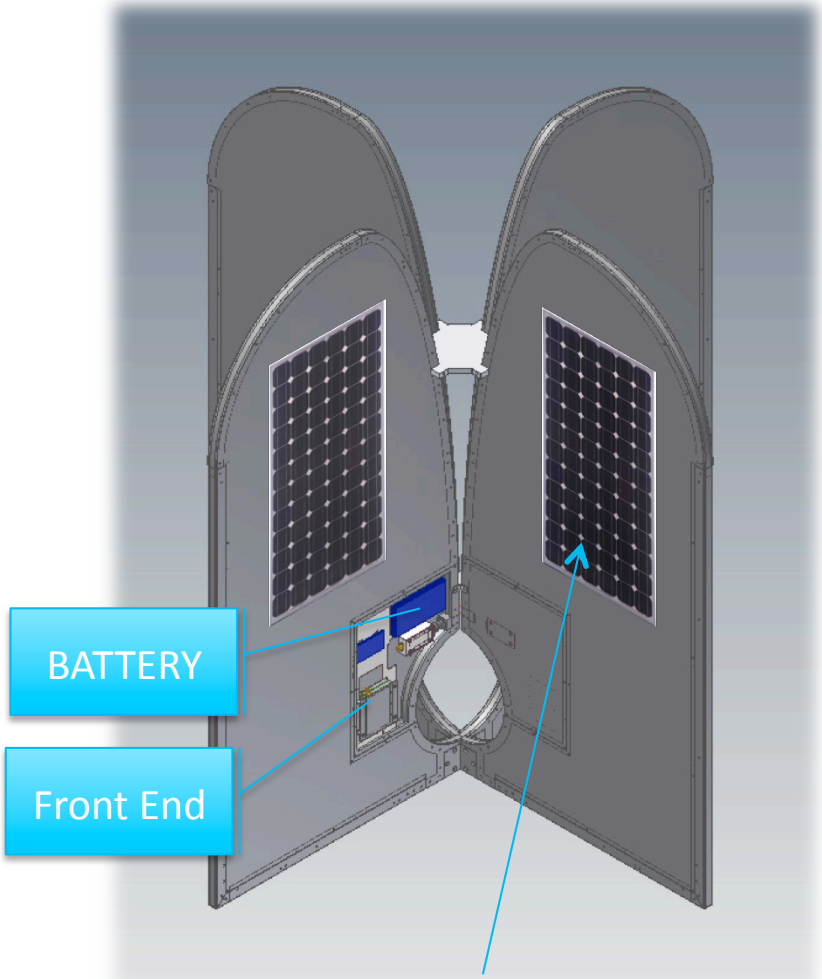
The final candidates……

Universe with the world's largest radio telescope

Dual-Pol Log-periodic	Dual-Pol Vivaldi version 1	Dual-Pol Vivaldi version 2	Quad-Ridge Horn
			
Pro - Well-known design - Simple manufacturing - Low-cost	Pro - Good reflection coefficient (50 Ohm) - High isolation between polarizations	Pro - Acceptable refl. Coeff. (50 Ohm) - High isolation between polarizations - Lower back lobe - Higher directivity at 45°	Pro - Very High directivity in the required sky coverage - Very Low back lobe - High isolation between polarizations
Cons - Very Poor Isolation between polarizations	Cons - High back lobe - Low directivity at 45°	Cons -Refl. Coeff is -4 dB at 120 MHz	Cons - Only suitable for split band solution - More complex manufacturing

All the configurations are metal-only and do not require a ground plane

Optical Self Powered Vivaldi



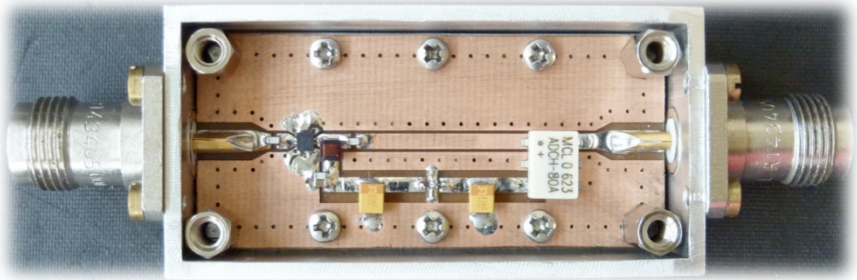
Thin film (amorphous silicon)

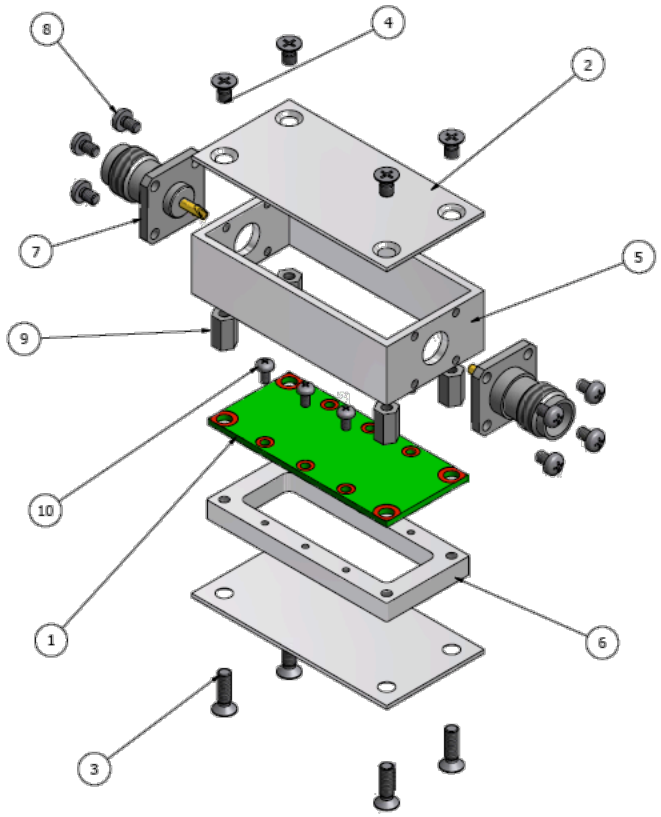
- Galvanic isolation between FE and DS
- more stable amplitude&phase Vs temperature
- RFI immunity (self-shielded)
- no Gain disequalization
- no Power Distribution → no DC power losses
- easy-deployable (no buried FO)

We have 0.15 m^2 maximum available area per arm.

That area could be sufficient, but we need more investigation and tests on the field.

LNA for Vivaldi





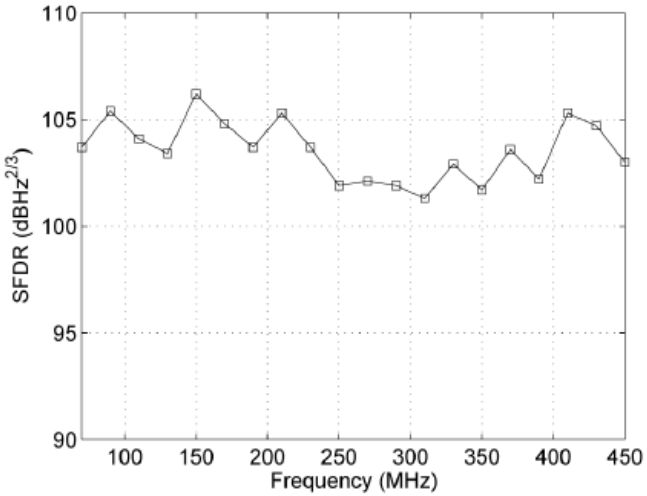
VCSEL optical link

- Collaboration with CNR – IEIIT (Turin):

U·L·M PHOTONICS

VERTILAS

CHALMERS

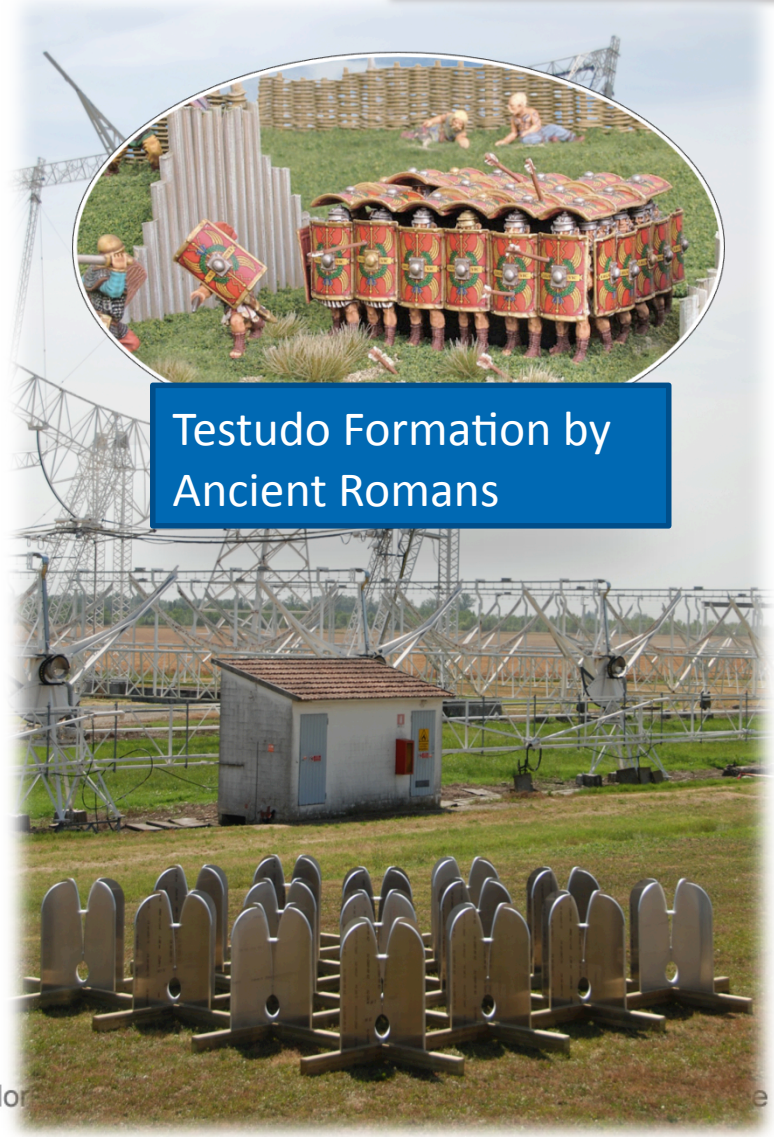


- 1.25, 2.5, 4.5 and 10Gbps COTS devices investigation:

Finisar
Advanced Optical Components Division

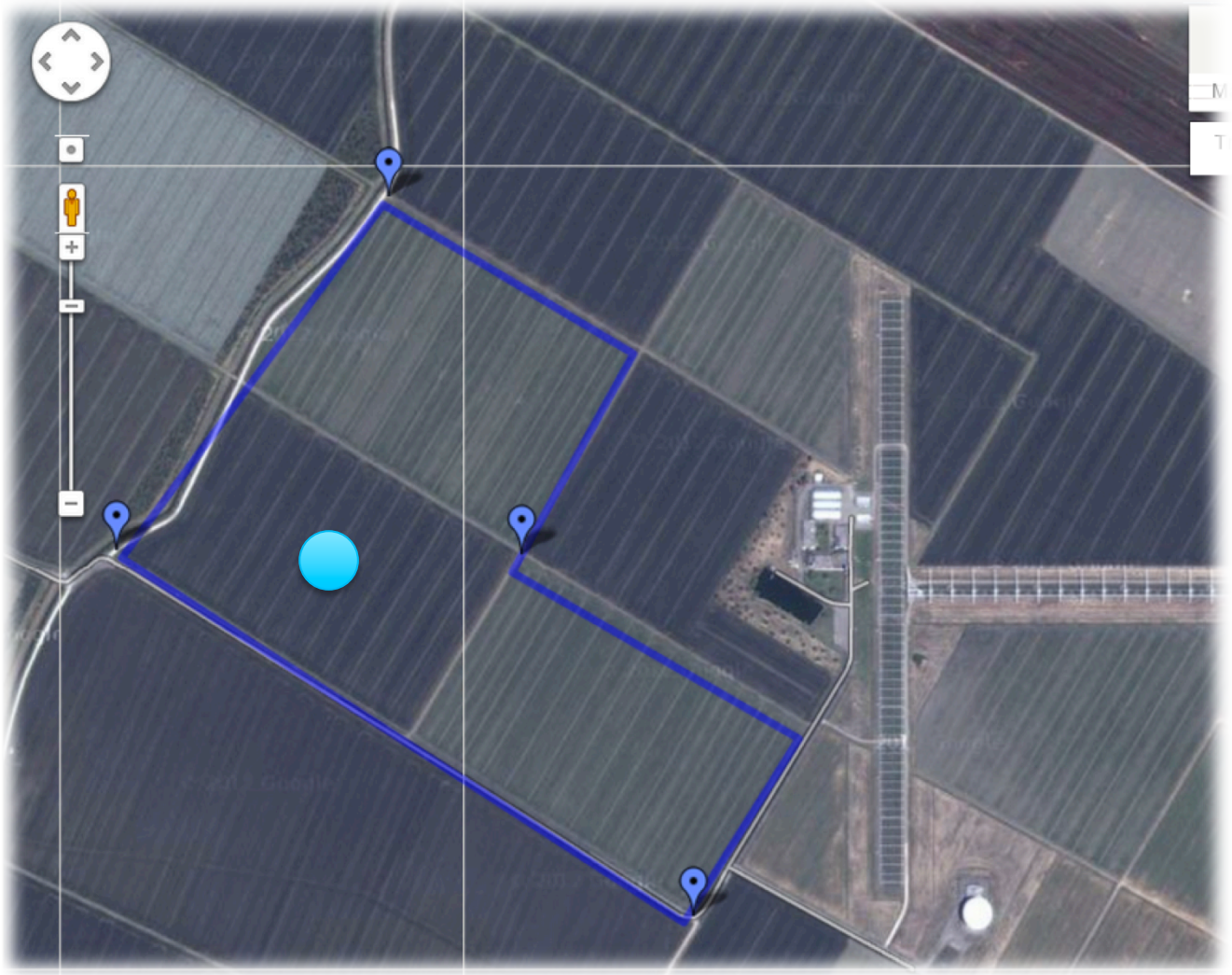
opto WELL

AAVS0 array based on Vivaldi



Testudo Formation by Ancient Romans

AAVS0 Medicina test site



AAVS0+ ??… first light using BEST2 back end

32 Optical fibres

Summary of the work done since 2010

- Kick Off meeting March 2010 Zaandam (NL)
- AAVP 2010 Congress Cambridge (UK)
- AAVP 2011 Congress Schipol (NL)
- 2012 Path to SKAlow Perth (AUS)
- 2012 Taking AAVP into SKA PEP Dwingeloo (NL)

- 2010 Medicina informal meeting for coordination
- 2011 Manchester informal meeting for Test
- 2012 Medicina informal meeting for Receivers

- Since the 2010 we had about 50 TELECON

- We produced 39 Documents

- ….lots of hardware……

CONCLUSIONS

The national industry has the opportunity to participate to SKA bidding, leading WPs and pushing Italian Concepts Technologies around the world inheriting the huge scientific works realized in the last years for AAVP.