Design, Environmental and Sustainability Constraints of new African Observatories: The example of the Mozambique Radio Astronomy Observatory (MRAO)

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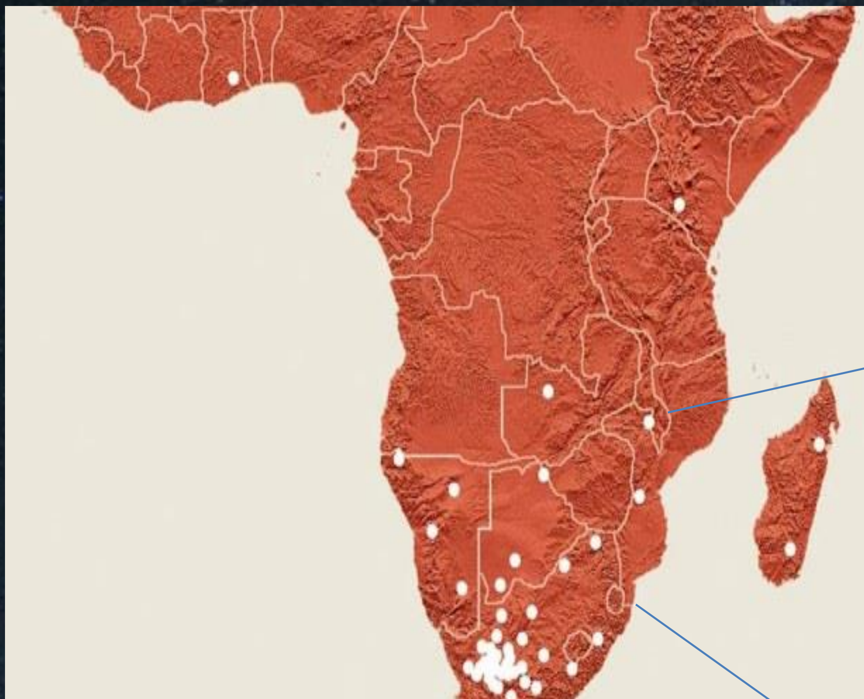
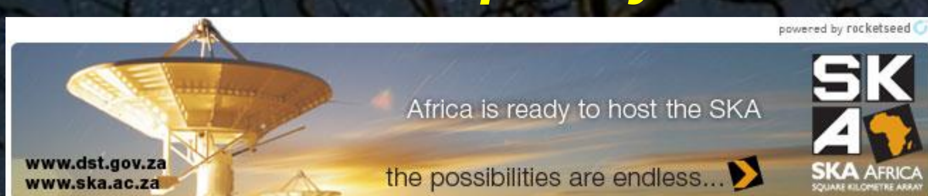
Radioastronomy in Africa: AVN + "Phase 2"

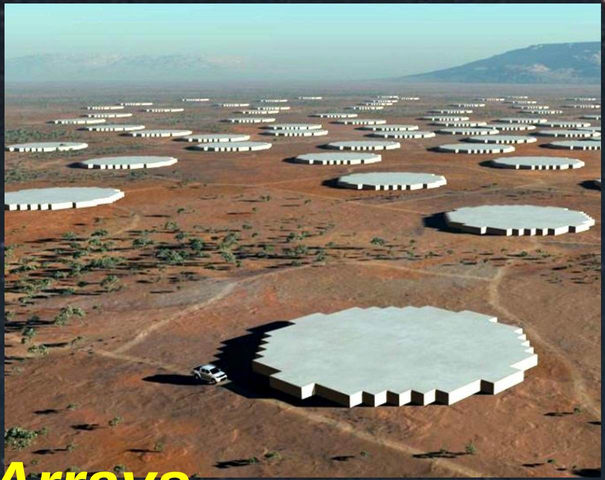


Differen t technologies

Need to build capacity!



Radioastronomy in Mozambique : Setting the scene from AVN to SKA



VLBI + Aperture Arrays

Need to build capacity!

Need to build training!
To maximise scientific +socio-economic impact

MRAO: Maluana -25.4°S / 32.64°E
50Km Maputo

Moçambique Astronomy Activities

DST / SKA-SA : TELKOM Antenna - similar to C-BASS Antenna (below)
(donated by DST-SA + antenna infrastructure Mz.)
Currently undergoing conversion

MRAO First Antenna:

Antenna Properties	
Primary Dish Diameter	7.6 m
Azimuth sky coverage:	-270 º to 270 º
Elevation sky Coverage:	0-90º
Operating Bands	S, C
half-power beamwidth at S-band	1.36 º (at 2000 MHz)
half-power beamwidth at upper C-band	0.41 º (at 6668MHz)
Drive speed:	Az: 10 deg/sec; El: 5 deg/sec

Environmental Constraints:

- Wind profile (check for cyclone history)
- Ground chemistry & acidity (attack on concrete)
- geotechnical characteristics of the site and geohydrology (especially depth of the water table)
- Soil Resistivity (-> earthing + lightning protection)
- Topography
- Infrastructure .Water+Power+ Data – 1Gps need for MRAO
- Preservation of mature trees
- Environmental Impact Assessment

The science operating modes for an Mz training radio telescope (being considered):

- 1 Radiometry with simple single-channel wideband radiometers
- 2 Radiometry with a multi-channel wideband radiometer
- 3 Pulsar timing with a multi-channel wideband timing system
- 4 Spectroscopy with a multi-channel narrow-band spectrometer
- 5 VLBI dropped (too expensive+ lack of sensitivity)

modes 2, 3 and 4 enabled by an FPGA-based instrument such as a ROACH board

Options for feed element of the antenna comprised:

- Substitute subreflector by ultra-wideband (UWB) feed at prime focus
- New subreflector, close to feed to permit mounting multi-frequency or UWB feed at secondary focus
- Using the existing feed as is, with retuning of filters

The feed / receiver solution proposed is (Gaylard, private comm.):

- Use all the available bandwidth of the S-band output for radiometry and pulsar timing
- Use the upper C-band retuned to include 6668 MHz for radiometry and spectroscopy
- Use the (circular) polarization outputs in each band to improve sensitivity
- Use uncooled LNAs with good noise figures as a compromise between sensitivity and maintainability - avoid cost+complexity

The science operating modes for an Mz training radio telescope (using as is):

S-band

- Pulsar Timing : Vela in Southern Africa monitored for glitches (HartRAO too busy…)
- Radiometry: follow slow variation of TauA and QSO 3C273
- RRLs very difficult (no spectrocoscopy)

C-band (filter retune 4926.5 - 5054.5 MHz)

- pulsars much weaker, since spectrum steeps with freq.
- Metanol Masers possible , after retune of filter for 6668.518 MHz – monitor long varion (from 19->100d); conjugate with large HartRAO for daily monitoring

Caveats: excision of potential RFI in either band would require multi-channel radiometry – actually, important training aspects

The proposed instrumentation fit is:

- Two single-input wideband radiometers, one per polarization.
- One FPGA-based dual input multi-channel instrument with software for multi-channel radiometry, multi-channel pulsar timing and narrow band multi-channel spectroscopy.
- To provide adequate pulse arrival time measurement accuracy, use a GPS-steered rubidium frequency standard or GPS-steered crystal oscillator?. It shall be possible to phase link Vela pulse arrival timing with that on other telescopes.
- To enable Doppler tracking of the methanol maser line, use a computer-controlled frequency synthesizer (signal generator) to provide one local oscillator (LO) source for the upper C-band band receiver. If a (fixed frequency) DRO is used for the first LO for this receiver, then an existing 3 GHz synthesizer can be used as the second LO.

The Observing Modes:

- Radiometry: drift scan
- Radiometery: crossed scan
- Radiometry & beam measurement – Point source tracking
- Spectroscopy of methanol masers
- Pulsar timing

CAVEATS:

Temperature control of receiver enclosure

Dry air system for feed and waveguide components

Antenna drive system + Observing Control System

Power Sustainability Investigations (long term potential for Solar Power):

MRAO: 415Vac three phase
50Hz at 40kW…

Example of an African Solar Power:
Cape Verde (5 MW) PV Ground Fixe structure (source. MARTIFER)


Workshop:
The Power Challenges of Mega-Science Infrastructures the example of SKA:
Moura, Portugal and Sevilla Spain
20th-21st June 2012
http://www.av.it.pt/workshops/pcska/index.html
Power Sustainability (potential for Solar Power):
a concern for science infrastructures

Power Sustainability: Photovoltaic Studies in 10 steps (ongoing)

STEP 1

- Define load, location, inclination
- Determine irradiation
- Calculate installed power to fulfill load
- Define number of modules
- Define system specs (battery, charge regulator, inverter)

STEP 2

- Choose worst irradiation month

STEP 3

- Determine irradiation – daily irradiation for the worst month

  Example:

  3.3 kWh/m2

  Calculate irradiation – PSH: Peak Sun Hours

  (hours@1000 W/m2 = kW/m2/day)

  Worst month: PSH=3.3 hours/day

STEP 4

- Define system configuration
  - *Off Grid requires battery*
  - *AC appliances requires inverter*

STEP 5

- Calculate installed power (P_{PV})

$$P_{PV} = \frac{Load}{\eta_{cable} \times \eta_{reg} \times \eta_{bat} \times \eta_{inv}}$$

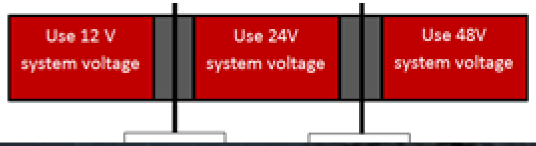
Typical: η_{inv} = 95% η_{bat} = 80% η_{reg} = 95% η_{cable} = 95

- Required Power $P_{peak} = \frac{P_{PV}}{PSH}$

STEP 6

- Choose operating voltage VDC

  (Typically multiple of 12V)



STEP 7

- Calculate string length and number of strings

  The total number of modules in series should take in account the charge regulator electrical specifications

Background for EU-AFR cooperation

Power Sustainability: Photovoltaic Studies in 10 steps (ongoing)

STEP 8

- Determine battery capacity

Choose autonomy (for example n=5 days)

$$C_B = \frac{n \times load}{depth\ of\ discharge}$$

Typical value for depth of discharge: 70%

STEP 9

- Choose charge regulator and the inverter

Relevant parameters:

- $V_{in} = V_{DC}$
- $I_{in} = P_{peak} / V_{DC}$
- P_{out}
- I_{out}

In off grid PV systems the inverter is chosen to be 20% higher than the rated power of the summation of AC loads.

STEP 10

- Measure RFI from components
- Shield
- Measure RFI from components
- Better if far away (ie shield by natural conditions – hills, vegetation.

A Great Oportunity to learn !
And study RFI mitigation from solar pla

- ***But dependent on economic reasoning...!!!***

Potential Background for EU-AFR cooperation

+ EU (FP7) : BIOSTIRLING-4SKA

Background for EU-AFR cooperation

EU-HOU

Further developments: potential cooperation - FOCUS proposal shortlisted

Assembly of the Antena and
1st teacher training in Portugal

instituto de telecomunicações

NUCLIO
Núcleo Interactivo de Astronomia

OBRIGADO; KANIMAMBO

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