

# Multi-frequency Astronomy & Cosmology at Wits



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# Outline

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- ✦ **Research Context** (National & International)
- ✦ **Research Strategy** Multi-w Astronomy & Cosmology @ Wits
  - ▣ Center for Multi-w Astrophysics & Cosmology (C-MAC)
- ✦ **Research Group**
  - ▣ Vision
  - ▣ Structure & Management
  - ▣ Research Outputs & Capacity
  - ▣ Human Capacity Development
  - ▣ Collaborations (National & International)
- ✦ **Future Strategies**
  - ▣ Short-term (1 yr) - Mid-term (3 yrs) - Long-term (> 5 yrs)
  - ▣ Integration with existing activities and projects
  - ▣ Challenges & Sustainability
- ✦ **A vision for future**
  - ▣ Integrate and Rationalize Research Activity and Capacity

# Astrophysics & Cosmology at

## Wits

### Research Context

SKA

MeerKAT

KAT-7

HESS-II

CTA

CTA Mini-Array

Planck

COrE

MILLIMETRON

RADIOASTRON

AGILE

DUAL

SKA SKA Chair activities  
SKA Africa Council

MeerKAT Mightee survey  
Fornax-A survey  
Transient survey

KAT-7 Diffuse radio source obs  
Gal.Clusters, Radiogalaxies,  
SNRs

HESS Extragalactic sources  
Dark Matter

CTA Extragalactic sources  
Dark Matter

MiniArray SNRs

Planck SZ effect  
Radiogalaxies & Blazars

COrE Extragalactic src.  
polarization

Millimetron Member of MISC and MMC  
SZ effect, RGs & BLZ, SNRs

Radioastron Member of RISC  
AGNs

AGILE BLZ, RGs, SNRs

DUAL  $\gamma$ -ray polarized sources



# Radio Astronomy (& AVN)

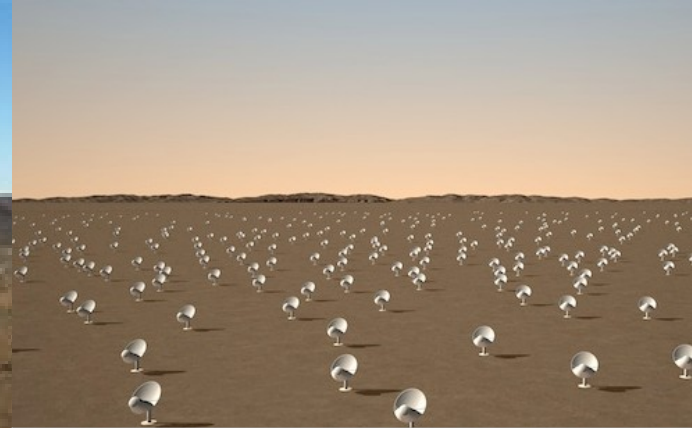
## KAT-7



## MeerKAT



## SKA



Diffuse radio emission in extended sources

- Galaxy clusters
- Giant radiogalaxies
- SNRs

Data analysis  
 Calibration  
 Interpretation  
 Modelling  
 Multi- $\nu$  follow-up

- Mightee Survey
- Fornax-A survey
- Transient survey
- Free time

Diffuse radio emission in extended sources

- Galaxy Clusters
- Giant Radiogalaxies
- SNRs

Multi- $\nu$  follow-up  
 Modelling

Key science cases

- AGNs and Radiogalaxies
- Galaxy evolution
- Clusters radio halos
- Magnetic fields in LSS
- Dark Matter search
- Physics of the Unknown

Data analysis  
 Modelling  
 Multi- $\nu$  follow-up

# African VLBI Network

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## Scientific involvement

- ✚ Blazars and Radiogalaxy jets [Jet sub-pc scale]
- ✚ Plasmoids in AGN jets [B-field physics at the extremes]
- ✚ VLBI and cosmological tests [Cosmology]

## From Africa to Europe



## HCD: The SKA Africa Council

- ✚ Radio Astronomy & Astrophysics in an African context





# SKA-CTA connection

**AGN jet**

Radio -  $\gamma$ -rays

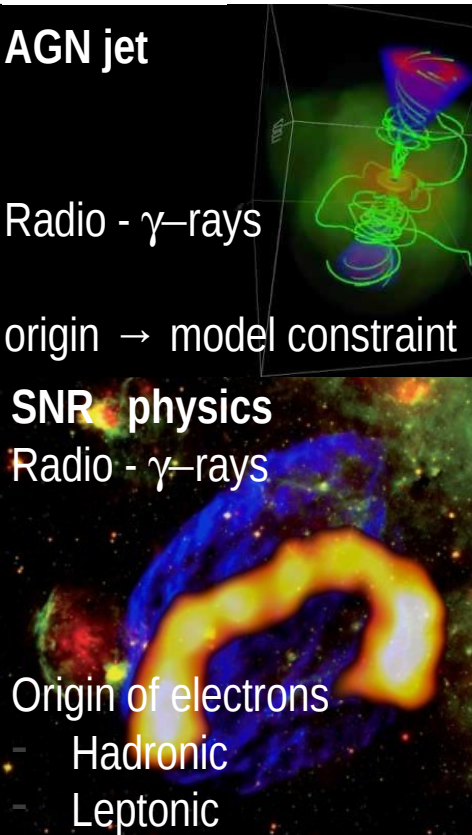
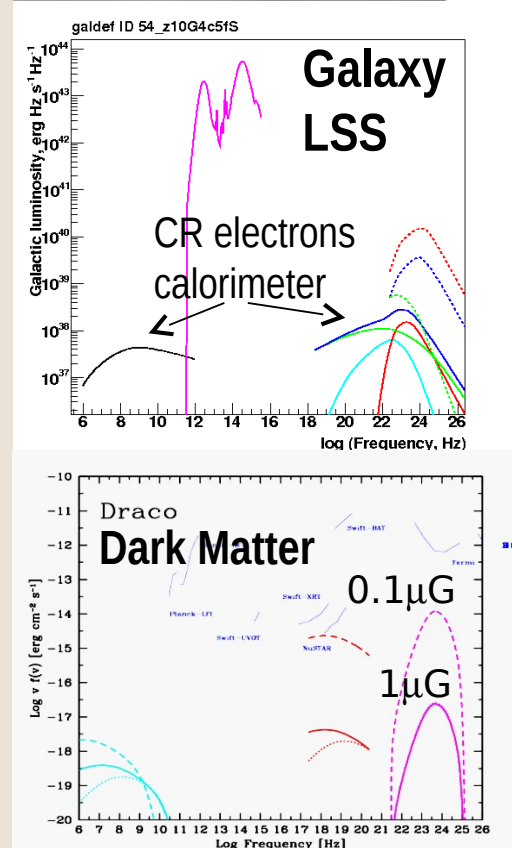
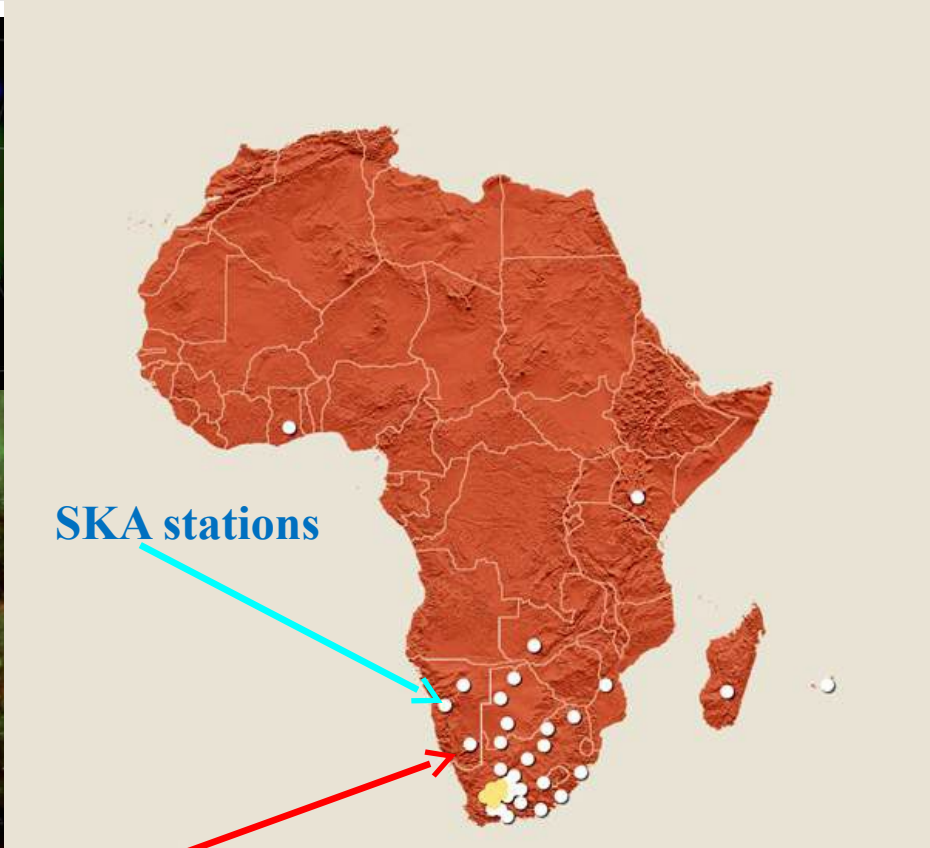
origin  $\rightarrow$  model constraint

**SNR physics**

Radio -  $\gamma$ -rays

Origin of electrons

- Hadronic
- Leptonic

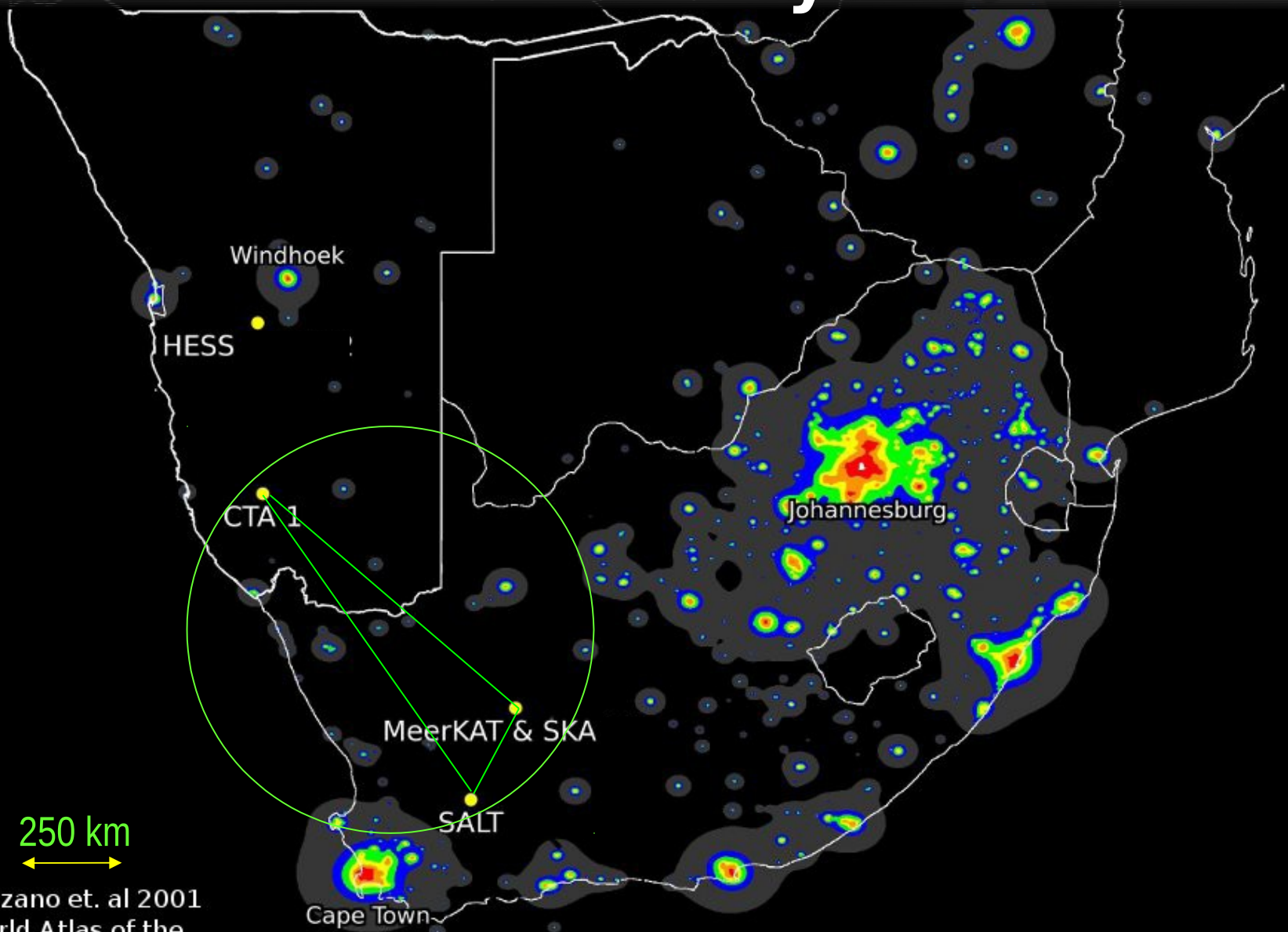



**CTA site: Aar**



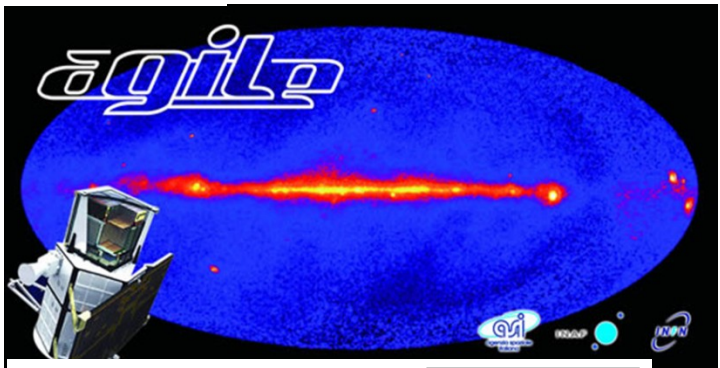


# The largest platform for multi- $\gamma$ Astronomy

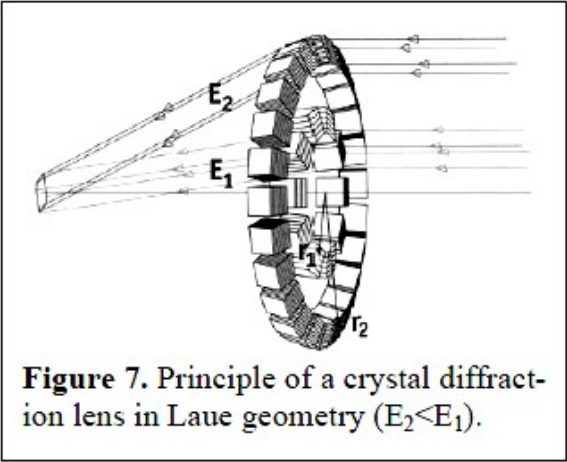
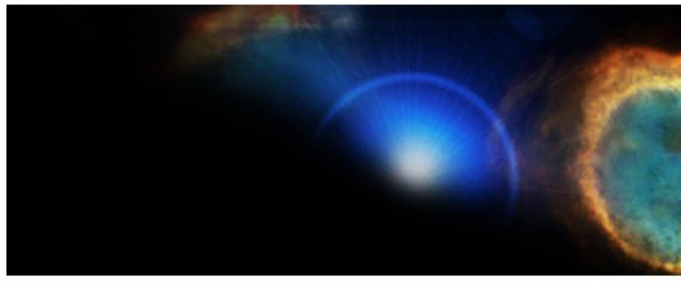
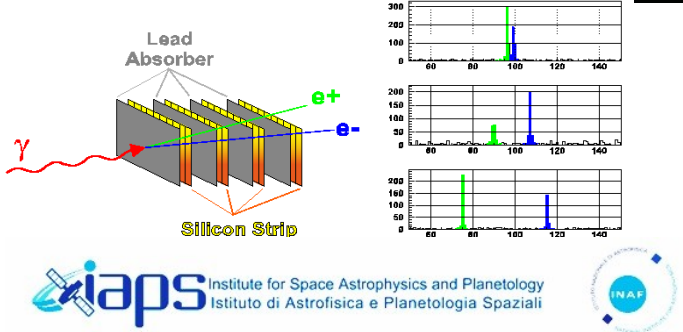


250 km  
Cinzano et. al 2001  
World Atlas of the  
Artificial Night Sky Brightness

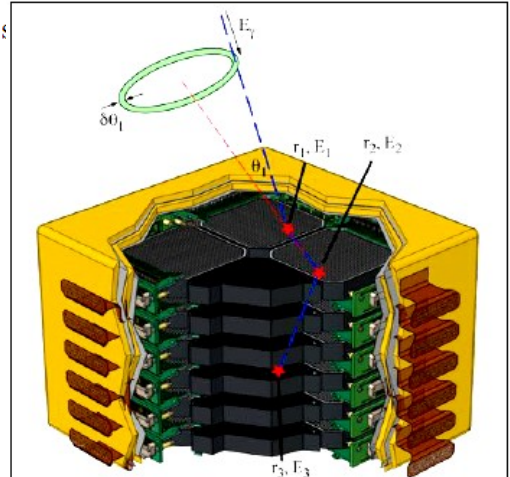




Parameter	target (LLT)	all sky (CAST)
Energy coverage	0.80-0.90 MeV	0.1-10 MeV
Line sensitivity ( $\Delta E/E=3\%$ )	$\sim 10^{-6}$ ph $\text{cm}^{-2}$ $\text{s}^{-1}$ in $10^6$ s	few $10^{-6}$ ph $\text{cm}^{-2}$ $\text{s}^{-1}$ in 2 y
Energy resolution (FWHM)	1%	1%
FoV	5'	$2\pi$ steradian
Angular resolution	1'	$\sim 1-2^\circ$



**Figure 7.** Principle of a crystal diffraction lens in Laue geometry ( $E_2 < E_1$ ).



**Figure 3.** Schematic of the WCT (GCT version). By measuring the position and energy of each photon interaction, the initial photon direction can be determined through the Compton scatter formula to within an annulus (event circle) on the sky. Dimensions are  $\sim (20 \text{ cm})^3$ .

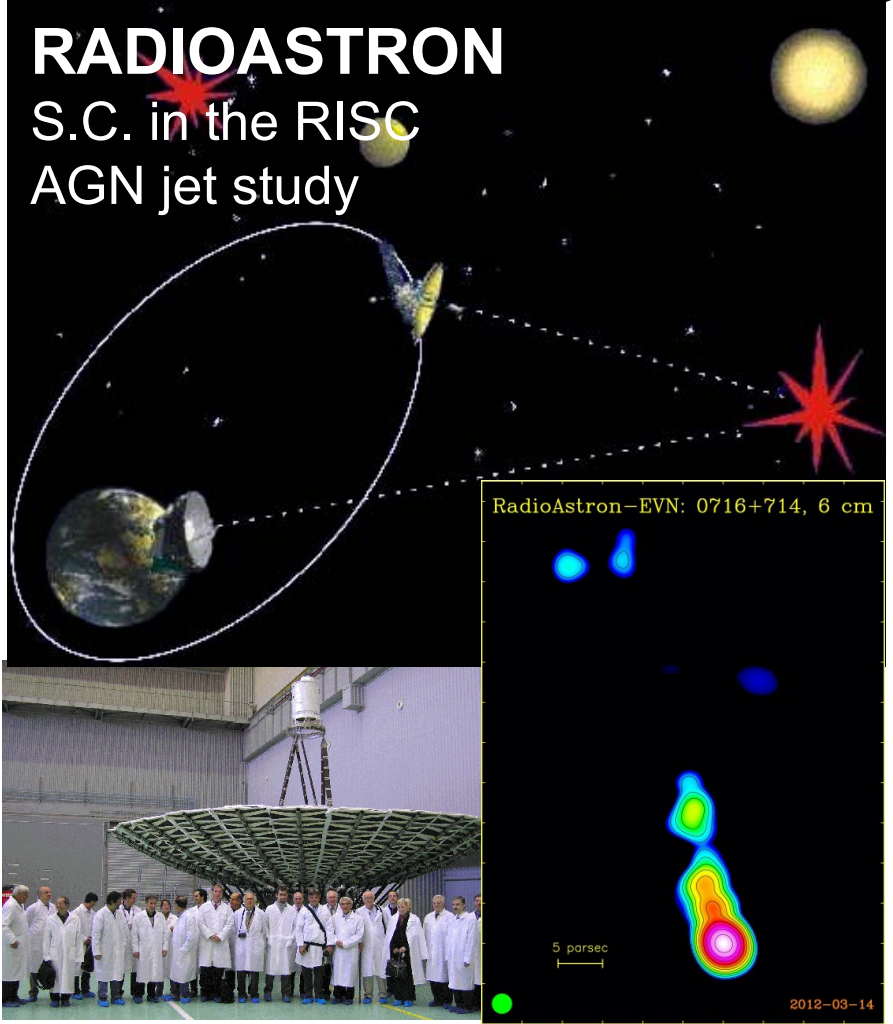
**Bruno Rossi Prize to Marco Tavani and the AGILE team**  
 January 10th, 2012 | Posted by [admin](#) in [All news](#) | [IAPS](#)



# RADIOASTRON MILLIMETRON

## RADIOASTRON

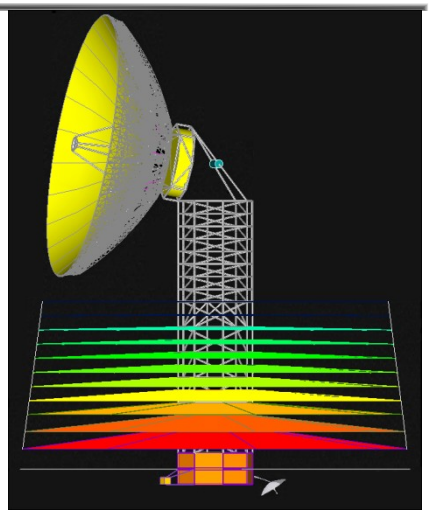
S.C. in the RISC  
AGN jet study



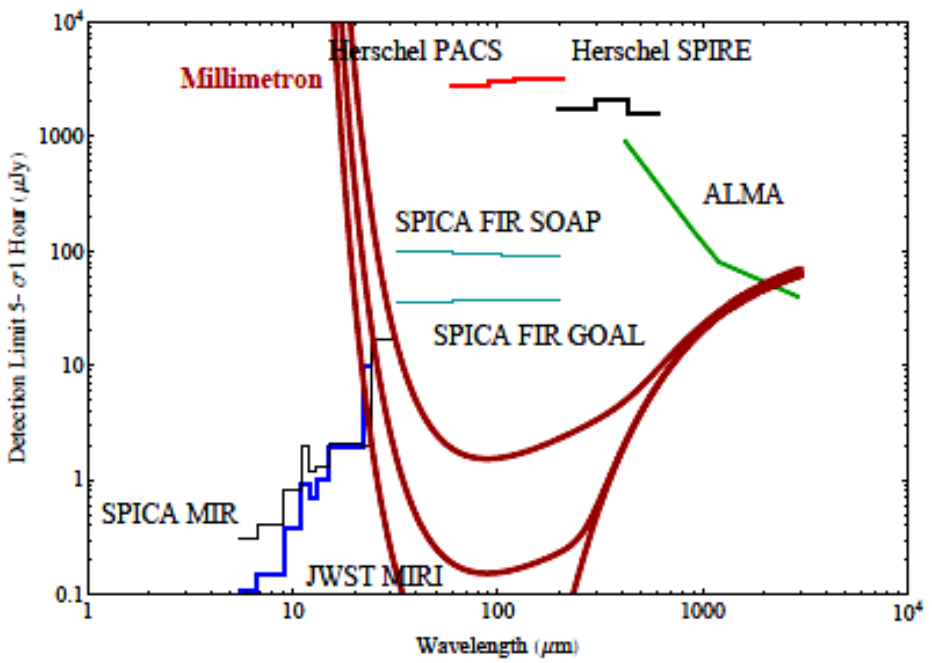
## MILLIMETRON

S.C. in MISC/MMC

- SZE
- AGNs
- SNRs
- Galaxy evolution



12 m central dish, 10 μm RMS, 4 K, R = 3



Data of about 24 hours of observations from about 10 largest ground radio telescopes from EU, Russia, China together with the 10-meter space Spektr-R were used in the analysis.

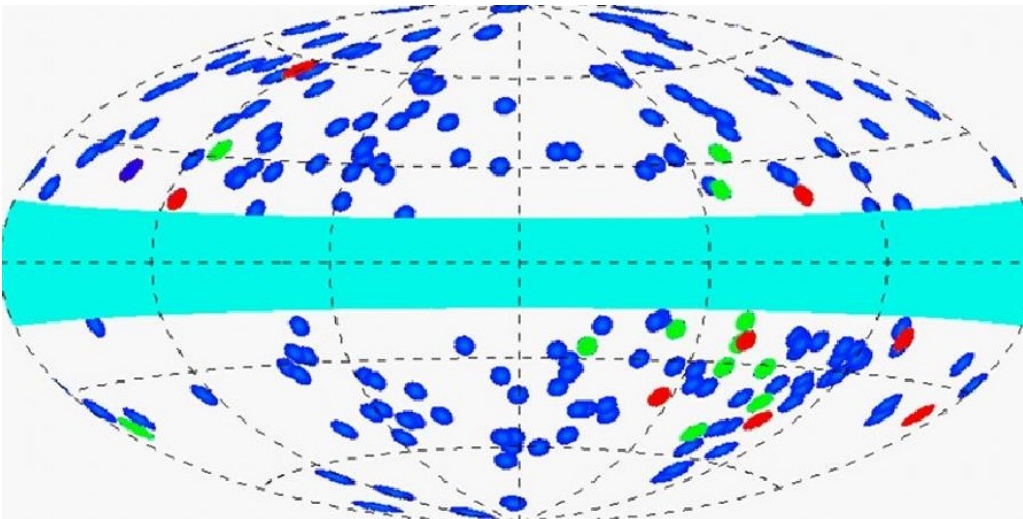
Correlated emission of 0716+714 detected up to 5.2 Earth diameters. Jet base width measured to be about



S.C. Planck member

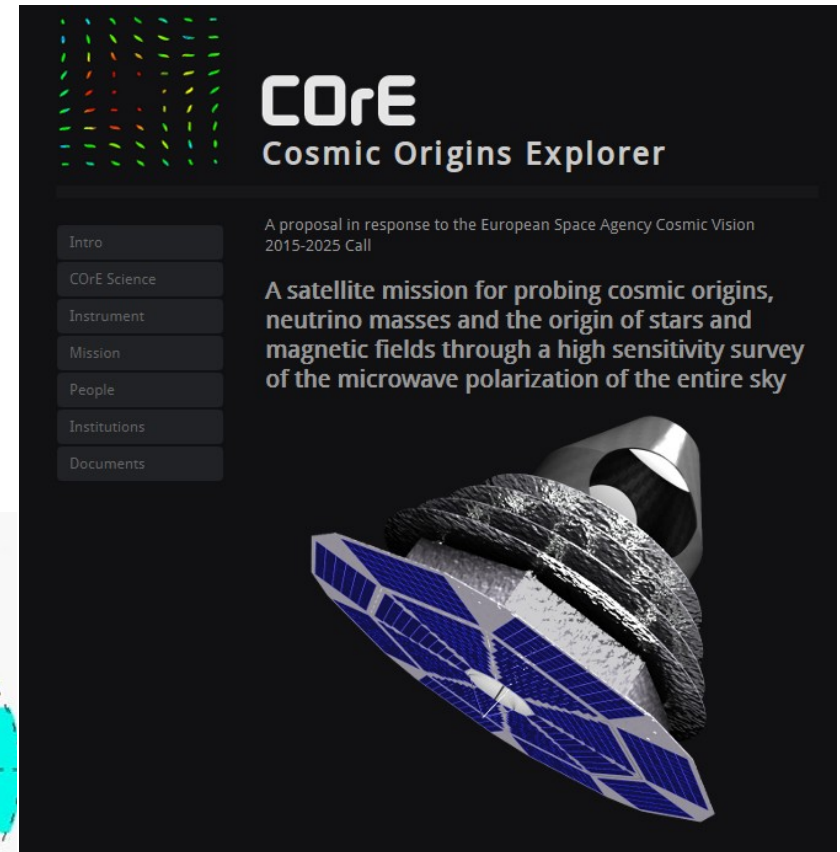
**WG5: SZE**

**WG6: Extragalactic**



All-sky distribution of all galaxy clusters and cluster candidates reported in the Early SZE sample.

Credit: ESA/Planck Collaboration.

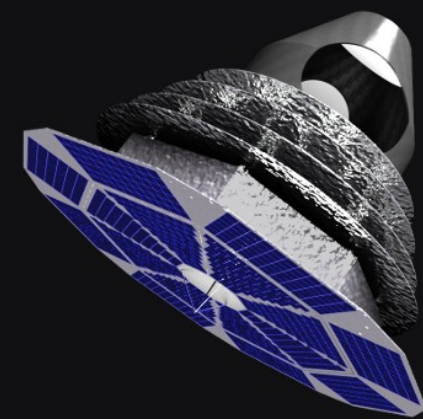


**COrE**  
Cosmic Origins Explorer

A proposal in response to the European Space Agency Cosmic Vision 2015-2025 Call

A satellite mission for probing cosmic origins, neutrino masses and the origin of stars and magnetic fields through a high sensitivity survey of the microwave polarization of the entire sky

- Intro
- COrE Science
- Instrument
- Mission
- People
- Institutions
- Documents



S.C. in the Team that proposed COrE to ESA call 2011





# Center for Multi- $\nu$ Astronomy & Cosmology

## Research Strategy

■ **Established in 2012**

■ **Members:** SKA group, J. Carter, E. Sideras-Haddad,  
■ A. Faltenbacher, F. Frescura, new staff,

■ **Activities:** Theory, Data Analysis, Simulations, ...

### ■ Motivations

■ Wits is an official member of SKA, MeerKAT, KAT-7

■ Wits is an official member of HESS-II and CTA

■ S.C. (Wits) is an official member of other projects:

- AGILE
- DUAL
- Planck
- CORe
- RADIOASTRON
- MILLIMETRON

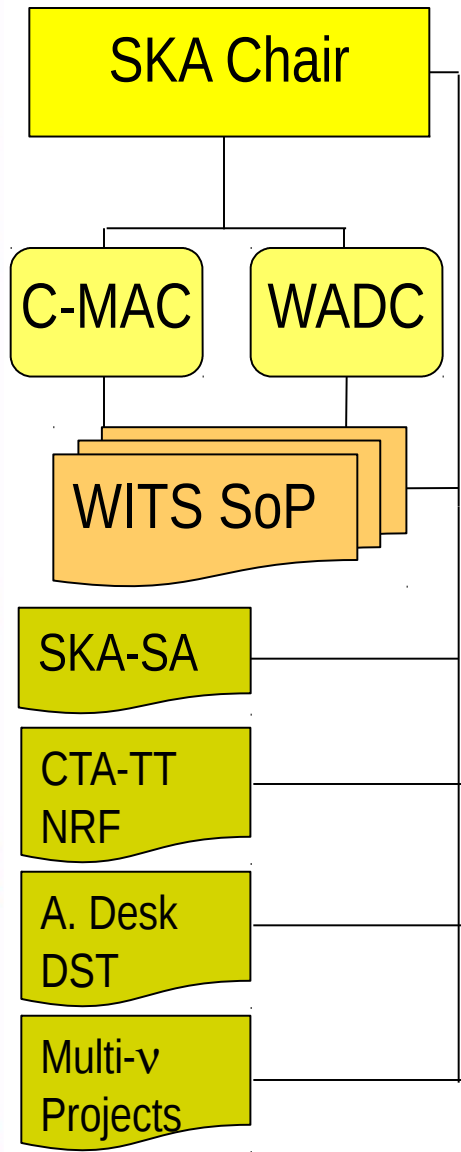
■ **Integration in a SA Multi- $\nu$  Astronomy Strategy**





# Group: Structure & Governance

Name	Nationality (race)	Level	SKA Chair budget	SKA free standing	Additional infos
<b>Hon students</b>					
3 students	SA (w)	Hon			F. Frescura's Group
<b>MSc students</b>					
P. Nicol	SA (w)	MSc 1yr	Yes		
N. Orford	SA (w)	MSc 2yr	Yes		
M. Emritte	Mauritius (c)	MSc 2yr		Yes	
<b>PhD students</b>					
A. Tailor	SA (c)	PhD 2yr	Yes		
N. Shafi	Ethiopia (b)	PhD last	Yes		
C. Paulo	Mozambique (b)	PhD 1yr		Yes	
G. Beck	SA (w)	PhD 1yr		Yes	
J. Tarrant	SA (w)	PhD 1yr		Yes	
R. Mekuria	Ethiopia (b)	PhD 1yr	Yes		
B. Asabere	Ghana (b)	PhD 3yr			guest (from UJ)
N. Padamphal	SA (c)	PhD 1yr			guest (from UWC)
P. Simphemba	Zambia (b)	MSc 1yr	Yes		Zambia 50% support
<b>Post Docs &amp; Researchers</b>					
N. Mhlahlo	SA (b)	Post Doc 2yr	Yes		
K. El Bouchefry	Morocco (w)	Post Doc 1yr			
P. Marchegiani	Italy (w)	Researcher 1yr	Yes		
N. Young (*)	UK (w)	Post Doc 2yr		Yes	(*) Trapum+Frescura+UK
P. Fallon	SA (w)	Post doc (PT)			Part Time
<b>Staff</b>					
Prof. S. Colafrancesco	Italy (SA)	SKA Research Chair	DST/NRF Chair		
Prof. F. Frescura	SA (Italy)	Ass. Prof.	Wits		
Dr. A. Faltenbacher	Germany	Senior Lect.	Wits		
Prof. J. Carter	UK (SA)	Prof. (HoS)	Wits		
Prof. E. Sideras-Haddad	SA (Greece)	Ass. Prof.	Wits		
Additional Position		Sen. Lect.	Wits		



Hon  
MSc  
3  
PhD  
7+2  
PD  
3+2  
Staff  
3+2  
+1  
+1

# Research Capacity

## Profile

- Hub of Radio Astronomy & Multi- $\nu$  Astronomy in SA
- Multi-disciplinary activity
- Multi-frequency approach
- Theory and Data Analysis support to various experiments
- Data analysis: multi-frequency platform (WADC)

## Publications (2011-2013)

- 72 total [37 in refereed journals]
- >15 in press [refereed journals]
- >10 submitted

R.A.	G.A.	Others
29	29	14
>5	>4	>6
>4	>3	>3

## Impact (2011-2013)

- 72 papers (total)
- 824 citations (total)
- $h=18$  (14+3+1)



# Human Capacity Development

## Post-grad students

<b>SKA</b>	Capacity	
4 PostDocs	6 (+ 50%)	
1 Researcher Contract		2 (+100%)
7 PhD + 2 Visiting PhD	10 (+ 50%)	
3 MSc	6 (+100%)	
1 Hon	3 (+300%)	
<b>HESS-II &amp; CTA</b>		
1(*) Post Doc	2 (+100%)	
0 PhD	2 (+∞)	

## Synergies

- WITS (School of Physics)
- SKA, SKA Africa Council, NRF CTA-TT, Astronomy Desk

## Teaching Intensive Coursework+Research Project in Multi-v Astronomy

- WITS (School of Physics) [diploma + MSc + practical (radio-)astronomy]
- Africa SKA Partner Countries student training
- NASSP modules

# Collaborations

## **South Africa**

- UKZN: mm Astronomy [Workshop Wits-UKZN (27 Feb, 2013)]
- NWU: HESS, CTA, ...
- UCT: Extragalactic Astrophysics, Astro-Particle Physics
- UWC: Cosmology
- SKA Africa Council: SKA, AVN, ...

## **International context**

- Namibia Politech. (HESS)
- Mauritius: MITRA
- RADIOASTRON & MILLIMETRO
- HESS Collaboration
- CTA Collaboration
- Italy (SKA, OLIMPO, AGILE, PLANCK, NuSTAR)
- Germany (Numerical Astrophysics, Plasma Physics)







# Future Plans Challenges/Sustainability

- Enhancing Research Capacity**
  - Enhancing publication rate and impact →
  - Project involvement (KAT-7, MeerKAT, SKA, HESS-II, CTA, MITRA, AVN, others)
  - The Wits Astro Data Center (WADC)
- Fund raising**
  - Publication income
  - Student graduation
  - National (\*) & International opportunities →
- Enhancing HCD & management**
  - Postgraduate Students →
  - Postdocs & Researchers
- Enhancing Collaborations**
  - National →
  - International
- Improve Research Space**
- Improve Infrastructures** →
- Improve Governance**

Staff goal	≥5 paper/yr
MSc goal	≥1 paper/yr
PhD goal	≥2 paper/yr
PostDoc goal	≥3 paper/yr

Local facility  
Web-oriented Sc. Apps

**Crucial**  
Available funding opportunity

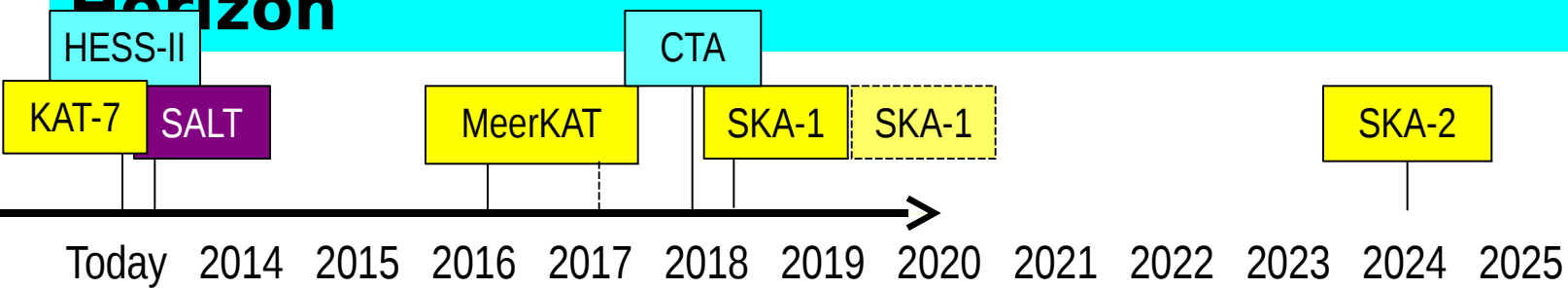
**Crucial**  
Group dynamical evolution

**Crucial**  
Profile & Visibility

**Important**  
Group hygienics

# Vision for future

**Enhance the research Profile of SA Astro community**  
**Tackle with challenges of Big Science at the Horizon**



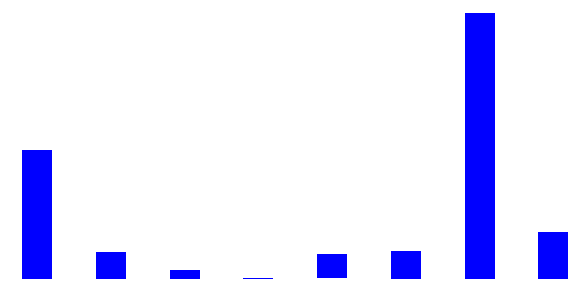
Follow the MWA on our Facebook page at:  
<http://www.facebook.com/Murchison.Widefield.Array>

## MWA

(2012-12-19) Announcement of Opportunity

First Announcement of Opportunity and call for Expressions of Interest as steps toward first Call for Proposals

## arXiv abstracts



**Integrate and Rationalize Research Activity & Capacity**



**Thanks  
for  
your attention**