Multi-frequency Astronomy & Cosmology at Wits

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Outline

Research Context (National & International)

Research Strategy Multi-ν Astronomy & Cosmology @ Wits
  Center for Multi-ν 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 Chair activities
SKA Africa Council

Mightee survey
Fornax-A survey
Transient survey

Diffuse radio source obs
Gal.Clusters, Radiogalaxies, SNRs

Extragalactic sources
Dark Matter

Extragalactic sources
Dark Matter

SNRs

SZ effect
Radiogalaxies & Blazars

Extragalactic src.
polarization

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

Member of RISC
AGNs

BLZ, RGs, SNRs

γ-ray polarized sources
# Radio Astronomy (& AVN)

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

## Data analysis
- Diffuse radio emission in extended sources
  - Galaxy clusters
  - Giant radiogalaxies
  - SNRs
- Data analysis
- Calibration
- Interpretation
- Modelling
- Multi-ν follow-up

## Multi-ν follow-up

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Survey/Case Studies</th>
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<tbody>
<tr>
<td>KAT-7</td>
<td>Mightee Survey&lt;br&gt; Fornax-A survey&lt;br&gt; Transient survey&lt;br&gt; Free time&lt;br&gt; Diffuse radio emission in extended sources&lt;br&gt; Galaxy Clusters&lt;br&gt; Giant Radiogalaxies&lt;br&gt; SNRs&lt;br&gt; Multi-ν follow-up Modelling</td>
</tr>
<tr>
<td>MeerKAT</td>
<td></td>
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<td>SKA</td>
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</table>

Data analysis Modelling Multi-ν follow-up
African VLBI Network

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
WITS is an official member from April 2012

WITS is an official member from December 2011
SKA-CTA connection

AGN jet

Radio - $\gamma$-rays

origin $\rightarrow$ model constraint

SNR physics

Radio - $\gamma$-rays

Origin of electrons
- Hadronic
- Leptonic

Galaxy

LSS

CR electrons calorimeter

SKA stations

CTA site: Aar

Dark Matter

0.1$\mu$G

1$\mu$G
The largest platform for multi-ν Astronomy

Cinzano et. al 2001
World Atlas of the Artificial Night Sky Brightness
<table>
<thead>
<tr>
<th>Parameter</th>
<th>target (LLT)</th>
<th>all sky (CAST)</th>
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<tbody>
<tr>
<td>Energy coverage</td>
<td>0.80-0.90 MeV</td>
<td>0.1-10 MeV</td>
</tr>
<tr>
<td>Line sensitivity (AE/E=3%)</td>
<td>~10^{-6} ph cm^{-2} s^{-1} in 10^6 s</td>
<td>few 10^{-6} ph cm^{-2} s^{-1} in 2 y</td>
</tr>
<tr>
<td>Energy resolution (FWHM)</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>FoV</td>
<td>5°</td>
<td>2π steradian</td>
</tr>
<tr>
<td>Angular resolution</td>
<td>1°</td>
<td>~1-2°</td>
</tr>
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</table>

**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 ~20 cm.

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

**Bruno Rossi Prize to Marco Tavani and the AGILE team**

January 15th, 2015. Posted by admin at IAPS. IAPS
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 70 microarcseconds or 0.3 parsec.
Planck

S.C. Planck member
WG5: SZE
WG6: Extragalactic

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

All-sky distribution of all galaxy clusters and cluster candidates reported in the Early SZE sample.
Credit: ESA/Planck Collaboration.
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-ν Astronomy Strategy
## Group: Structure & Governance

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

Profile

- Hub of Radio Astronomy & Multi-ν 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

Impact (2011-2013)
- 72 papers (total)
- 824 citations (total)
- h=18 (14+3+1)
### Human Capacity Development

#### Post-grad students

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

#### Synergies

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

#### Teaching

- Intensive Coursework+Research Project in Multi-ν 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**

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<table>
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<tr>
<th>Level</th>
<th>Goal</th>
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<tr>
<td>Staff</td>
<td>≥5 paper/yr</td>
</tr>
<tr>
<td>MSc</td>
<td>≥1 paper/yr</td>
</tr>
<tr>
<td>PhD</td>
<td>≥2 paper/yr</td>
</tr>
<tr>
<td>PostDoc</td>
<td>≥3 paper/yr</td>
</tr>
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- ** Crucial**
  - Available funding opportunity
  - Group dynamical evolution
  - Profile & Visibility
  - Group hygienics

- **Important**
  - Web-oriented Sc. Apps
Vision for future

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

Integrate and Rationalize Research Activity & Capacity

MWA
(2012-12-19) Announcement of Opportunity
First Announcement of Opportunity and call for Expressions of Interest as steps toward first Call for Proposals
Thanks for your attention