

Welcome to Namibia!





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Current Status and Future Impact of the Africa Millimetre Telescope

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University of Namibia,

Dept. of Physics, Chemistry & Material Science

North-West University,

Centre for Space Research

Oct 2022



Event Horizon Telescope

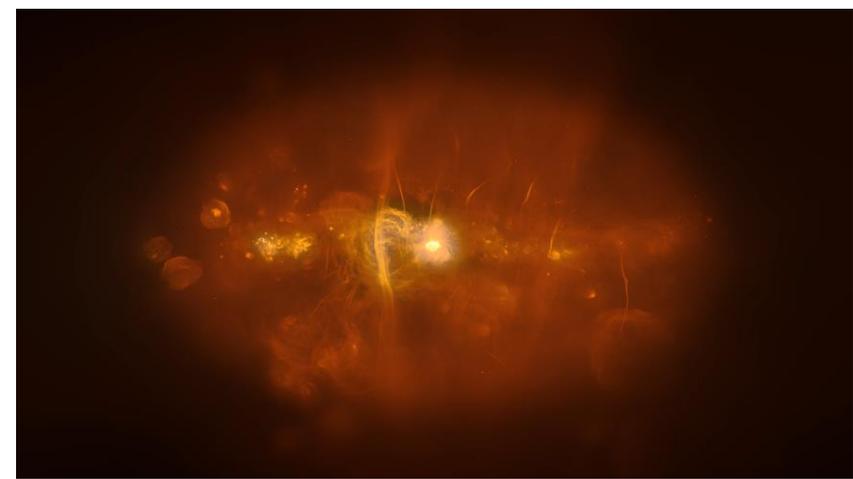
(also see SS13)

Event Horizon Telescope (EHT)

A Global Network of Radio Telescopes



EHT: M87* (2019)

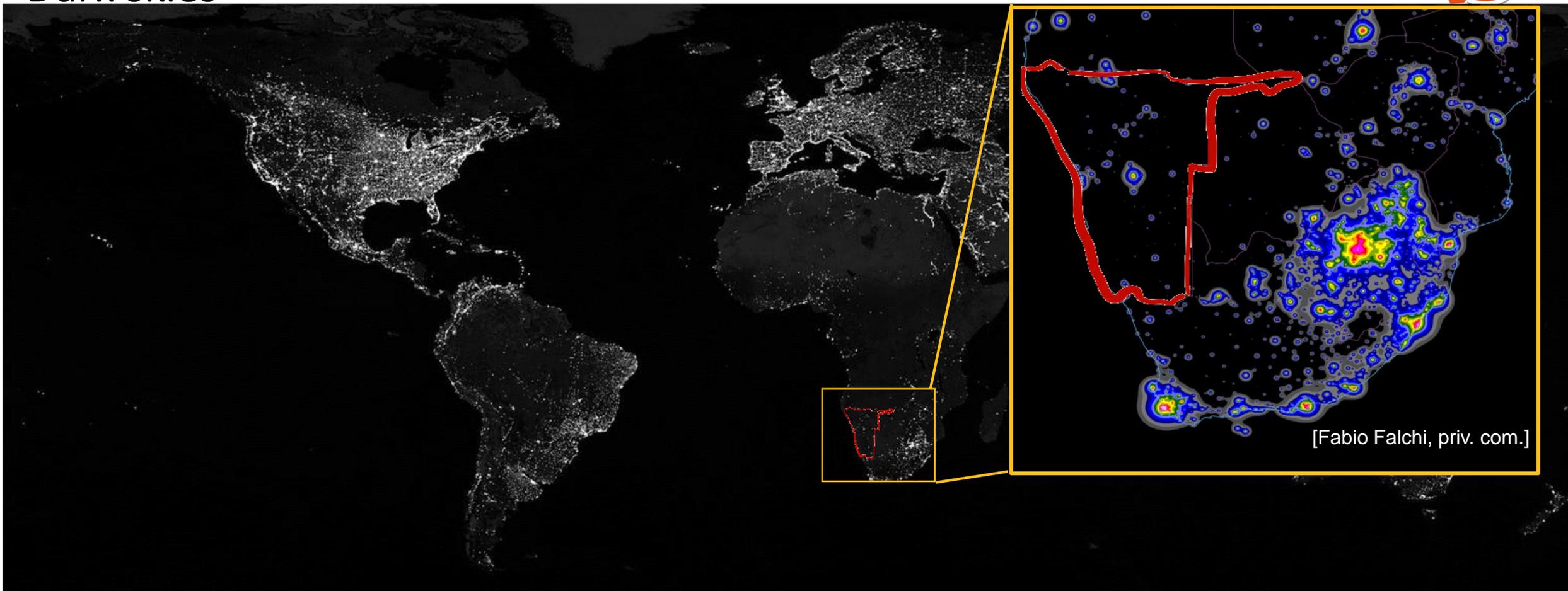


EHT: Sgr A* (2022)



Why Astronomy in Southern Africa?

Dark skies

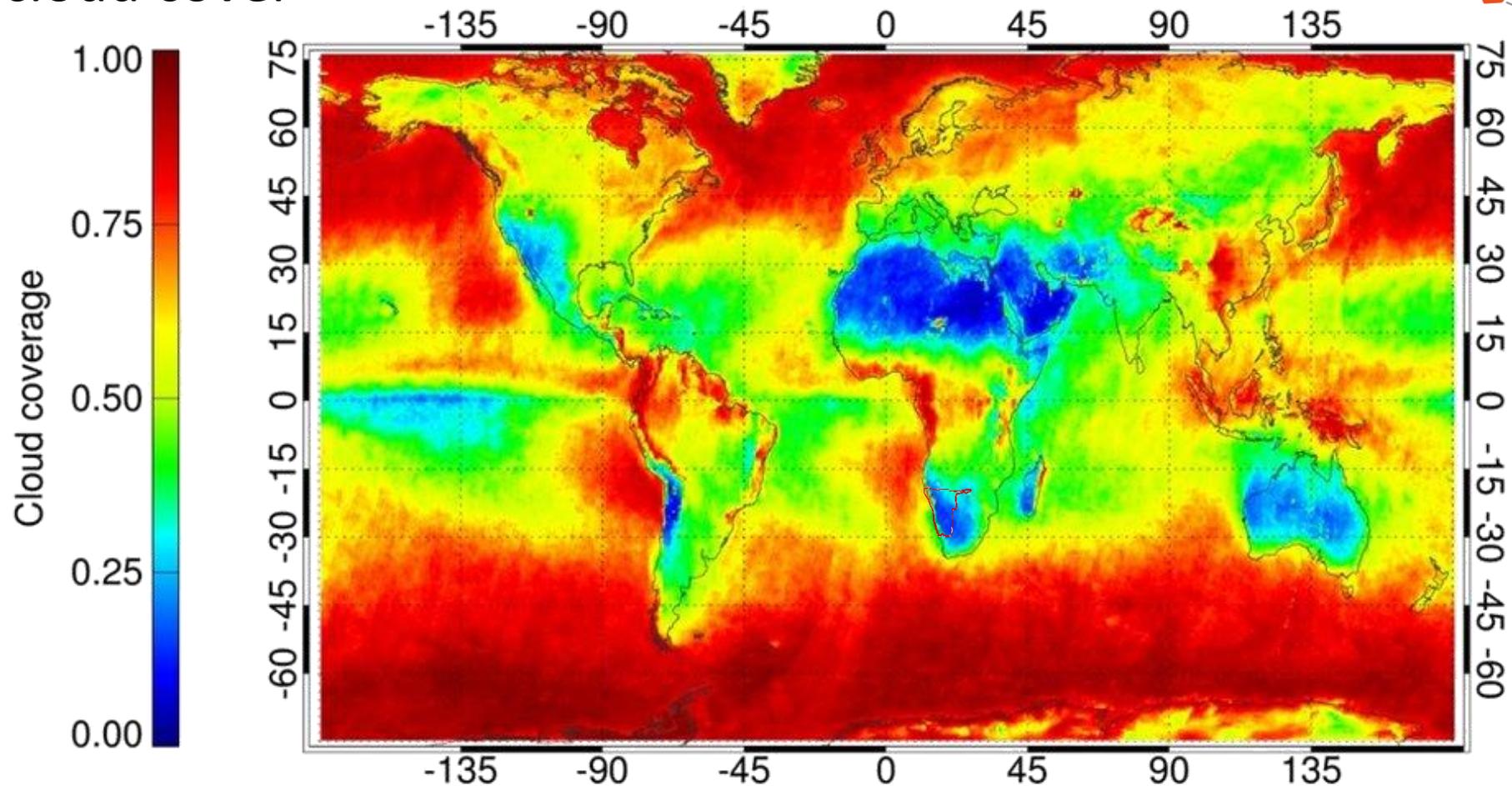


Credit: J. Stevens (NASA Earth Observatory), M. Román (NASA Goddard Space Flight Center), Suomi NPP VIIRS



Why Astronomy in Southern Africa?

Average annual cloud cover



[http://www.esa.int/spaceinimages/Images/2013/09/Cloud_cover]



Why Astronomy in Southern Africa?

“Astronomy is one such disciplines where Africa enjoys a considerable comparative advantage, due to the excellent conditions for observation on our continent. (...) We must exploit this geographic advantage for the maximum benefit of our people.”

Hon. Naledi Pandor

(then) Minister of Science and Technology (RSA)

Windhoek, 12 August 2014





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Astronomy in Southern Africa





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Mt. Gamsberg (2,347 m)



Mt. Gamsberg (2,347 m)



Africa Millimetre Telescope (AMT)

[Backes+ PoS(HEASA2016)029, Backes+ Galaxies 7(2019)66]

Radboud University
PI: Heino Falcke



UNAM
UNIVERSITY OF NAMIBIA
Co-PI: M. Backes



Director: Marc Klein Wolt

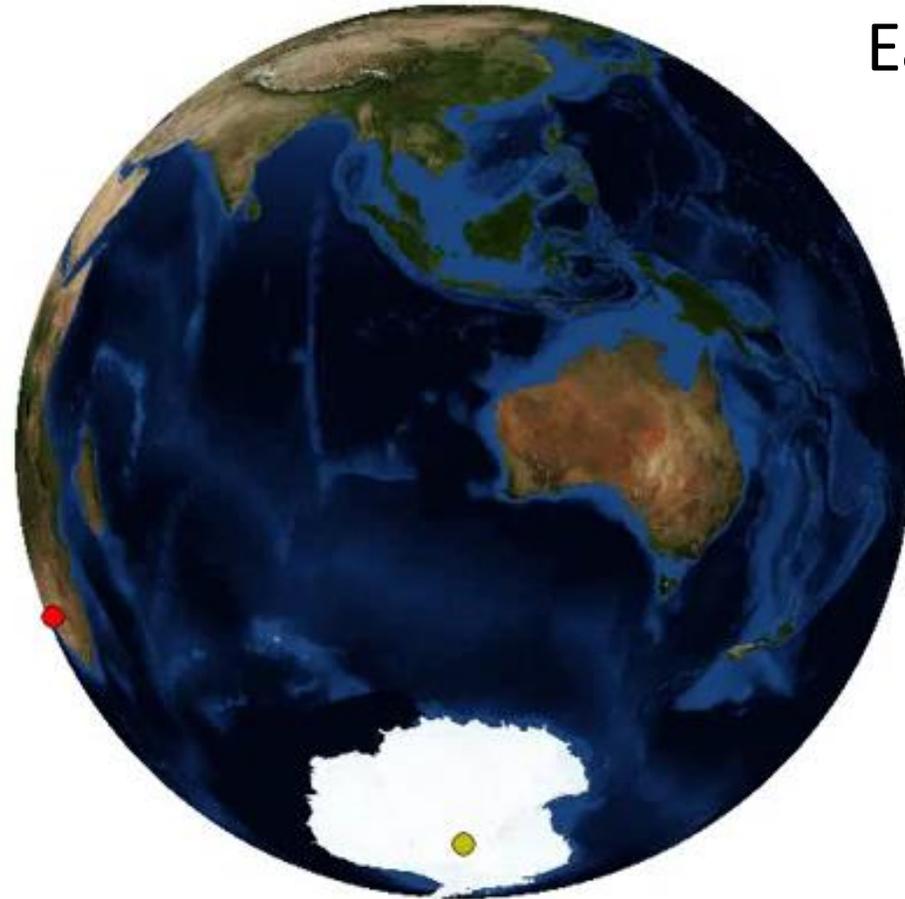
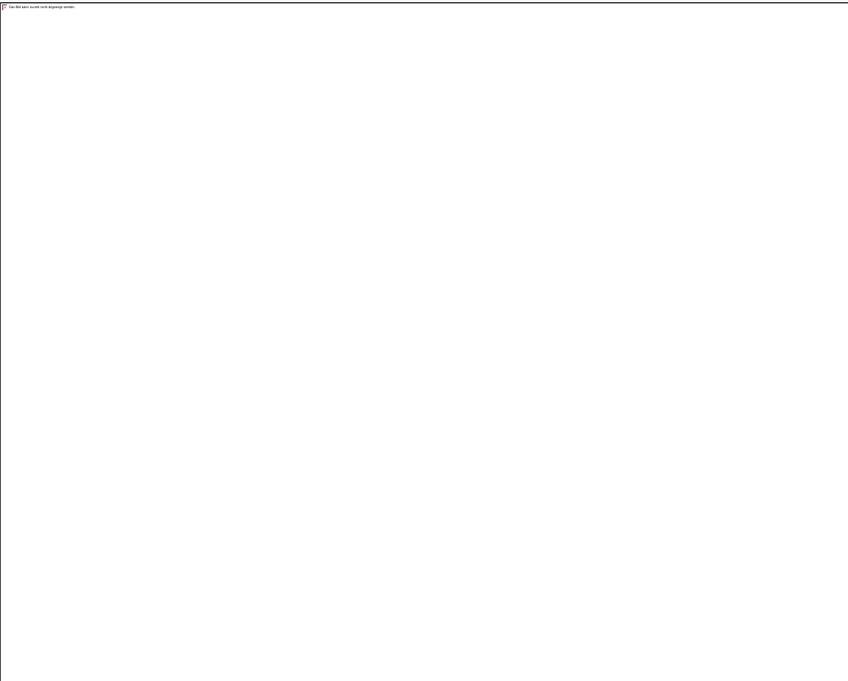


- Site quality being tested
- SEST to be refurbished (electronics, surface acc., sun avoidance, etc.)
- Preliminary Design Review passed in mid-2019
- Int. Science Committee formed (RU, UNAM, Wits, NWU, Metsähovi, Turku, Oxford, CEA, ASTRON, Grenoble Alpes, MIT, ...)



Africa Millimetre Telescope (AMT)

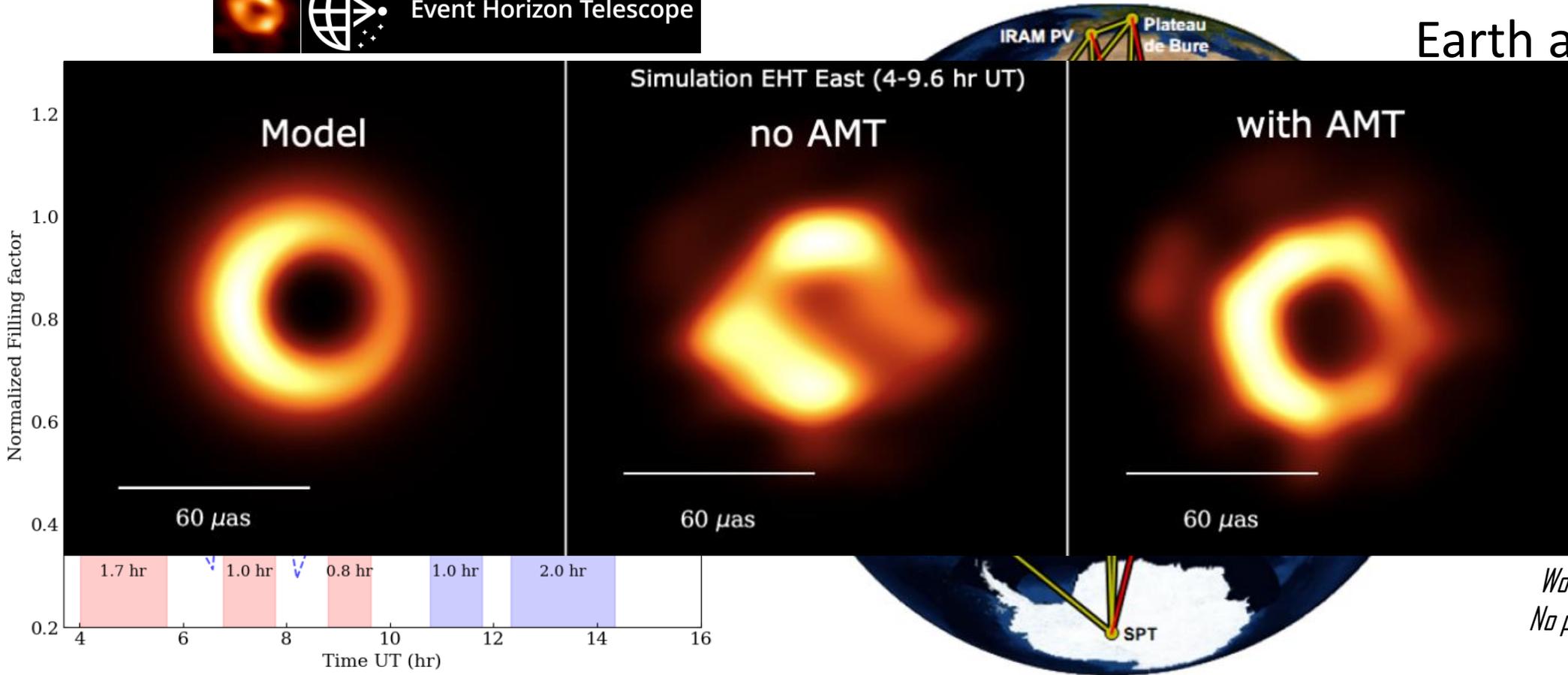
[Backes+ PoS(HEASA2016)029, Backes+ Galaxies 7(2019)66]



Earth as seen
from Sgr A*

EHT + AMT imaging

[Backes⁺ PoS(HEASA2016)029, Backes⁺ Galaxies 7(2019)66], [La Bella⁺ (2022), in prep.]



Earth as seen
Sgr A*



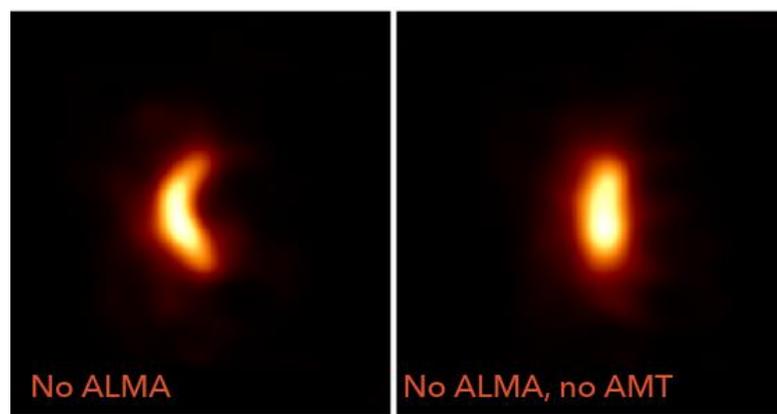
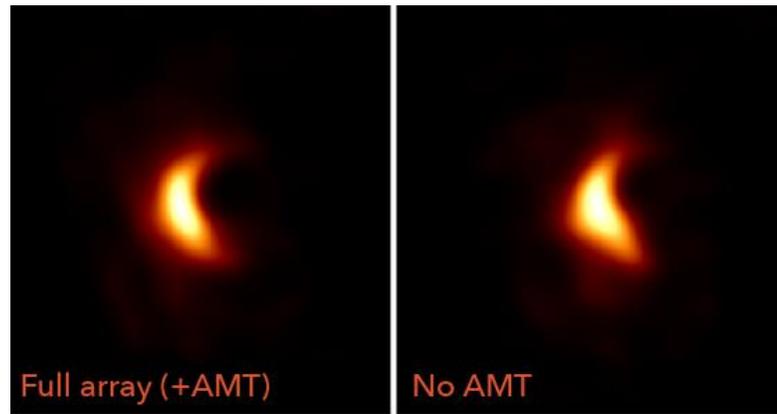
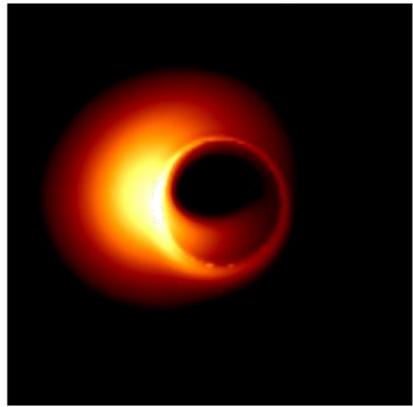
*Work in preparation.
No pictures, no tweets!*



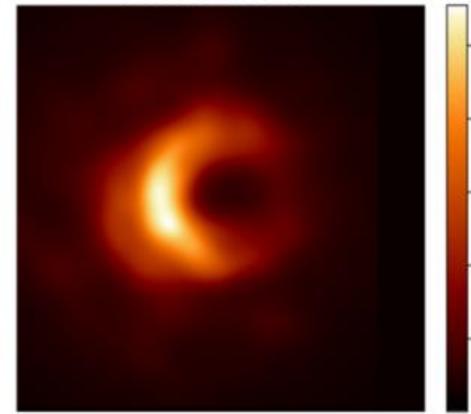
EHT + AMT imaging II

[Freek Roehlofs, Radboud Univ.]

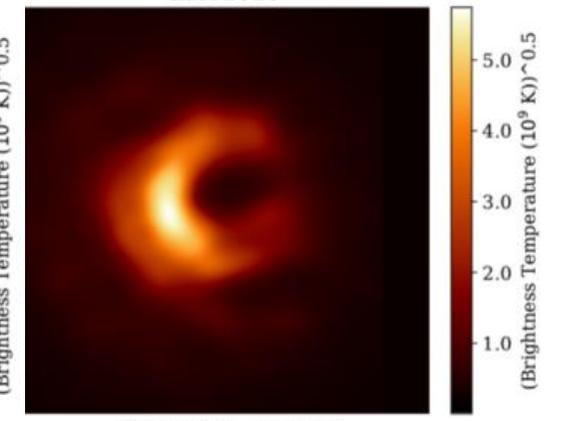
Model, time-averaged



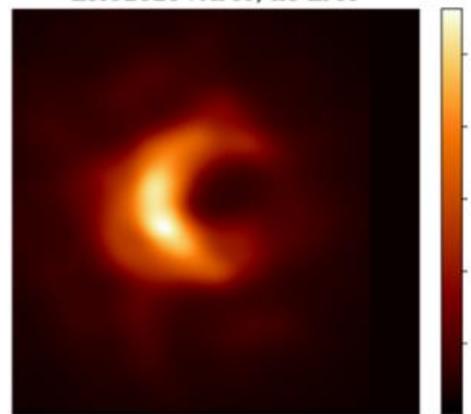
EHT2020+AMT



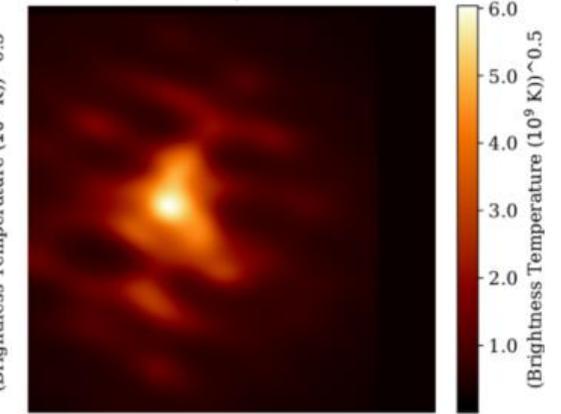
EHT2020



EHT2020+AMT, no LMT



EHT2020, no LMT

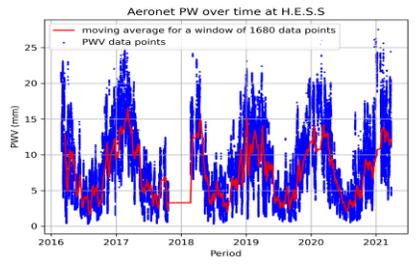


Precipitable Water Vapour I

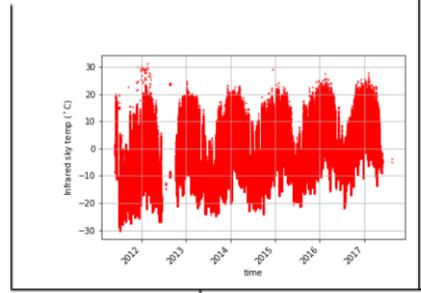
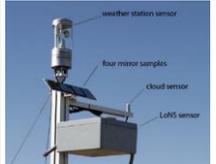
Lott Frans



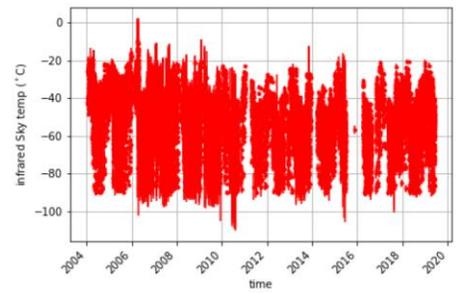
H.E.S.S. AERONET PWV (Day)



H.E.S.S. Atmoscope Sky temp (Day/Night)

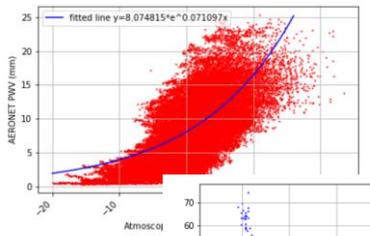


H.E.S.S. CT radiometers Sky temp (Night)

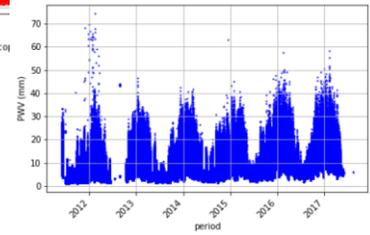
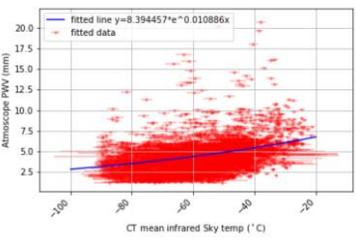


(A) Day PWV vs Day Sky temp

H.E.S.S. Atmoscope PWV (Day/Night)



(A) Night PWV vs Night sky temp



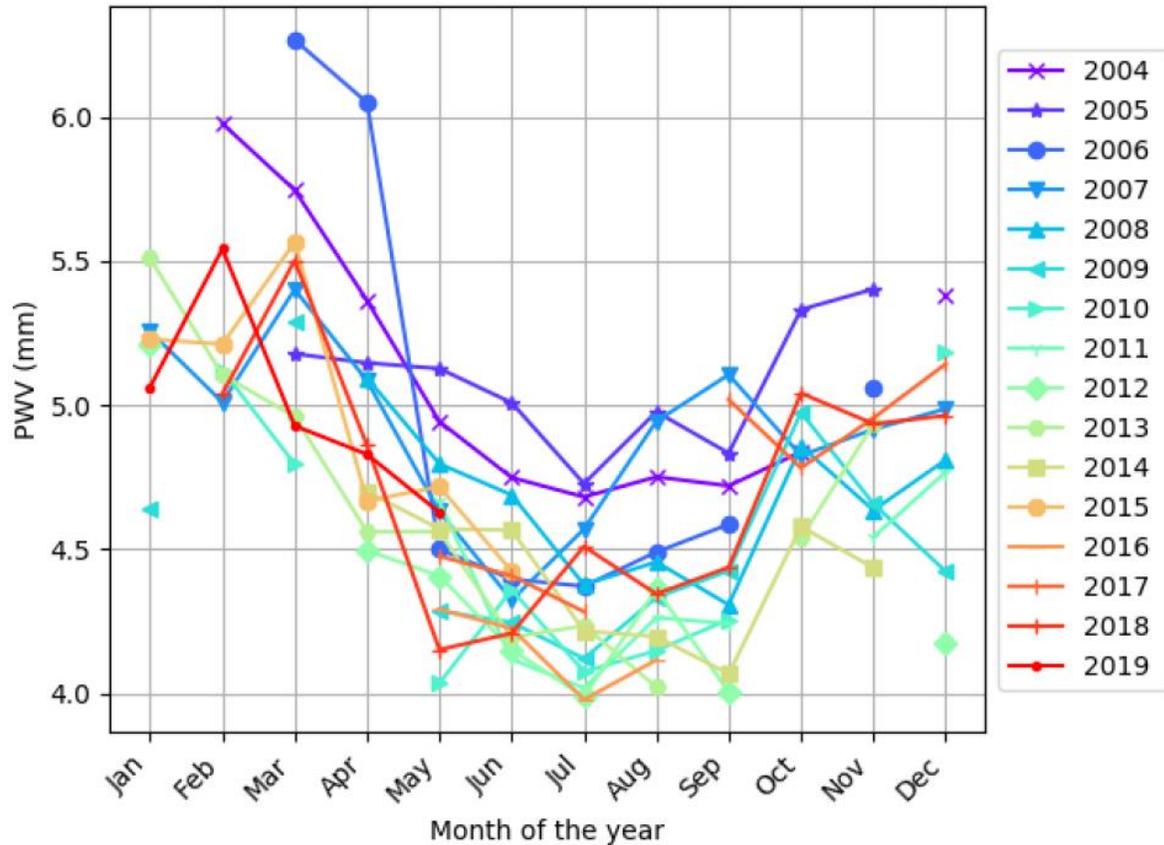
(B) H.E.S.S. CT PWV (Night PWV)

Scaled Mt Gamsberg (C) PWV (night)

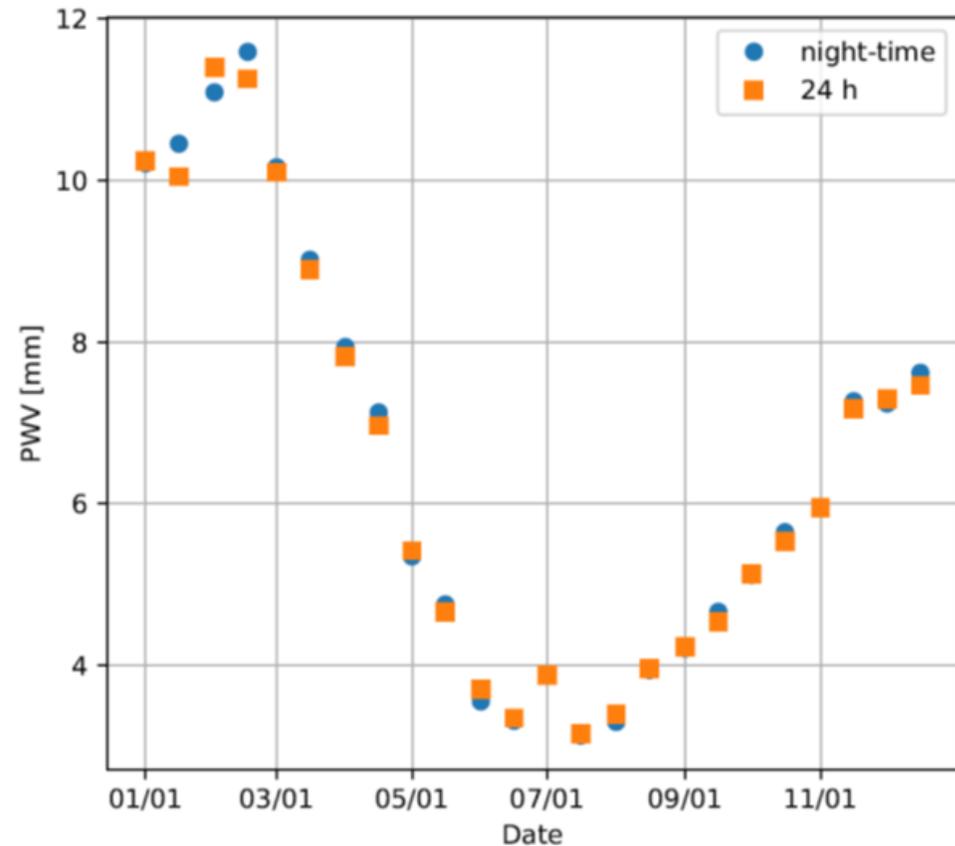
Precipitable Water Vapour II

Lott Frans

Indirect ground measurements



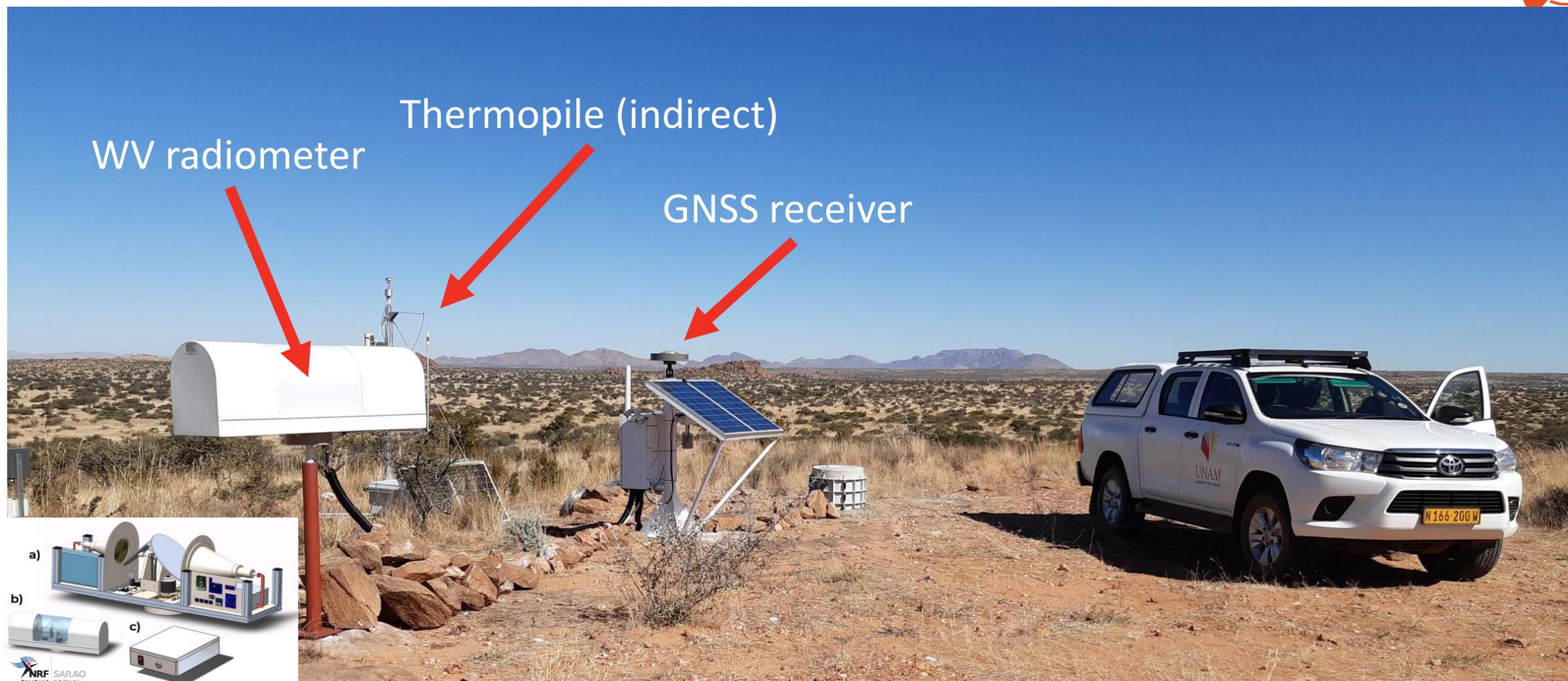
Scaled satellite-based model





Site Testing: Precipitable Water Vapour

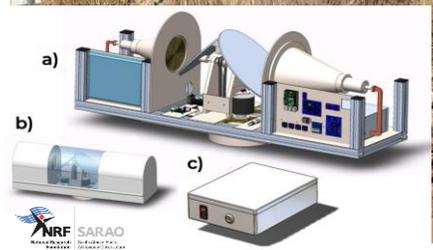
[L. Frans, MSc: <https://repository.unam.edu.na/handle/11070/2766>]



WV radiometer

Thermopile (indirect)

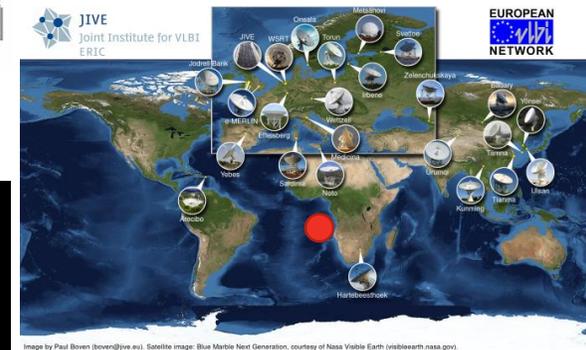
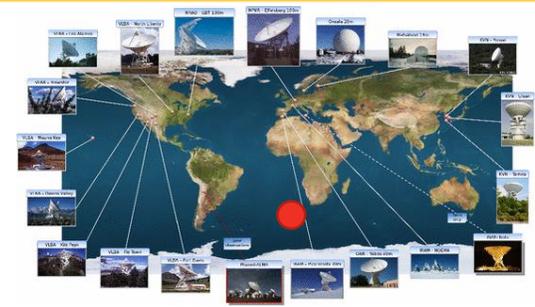
GNSS receiver



AMT Science Cases



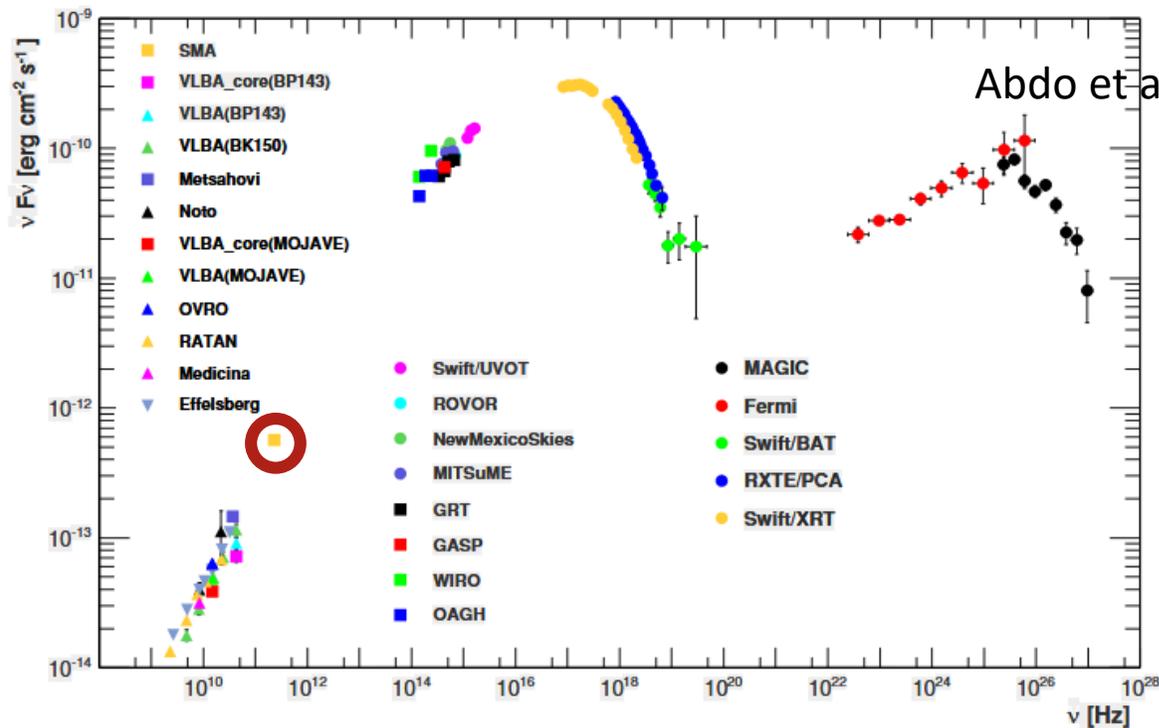
- VLBI
 - 1mm Event Horizon Telescope (EHT) VLBI
 - 3mm Global mm-VLBI Array (GMVA)
 - [7mm European VLBI Network (EVN)]
 - [6cm Africa VLBI Network (AVN)]
- Single dish
 - Monitoring of Active Galactic Nuclei
 - mm transients



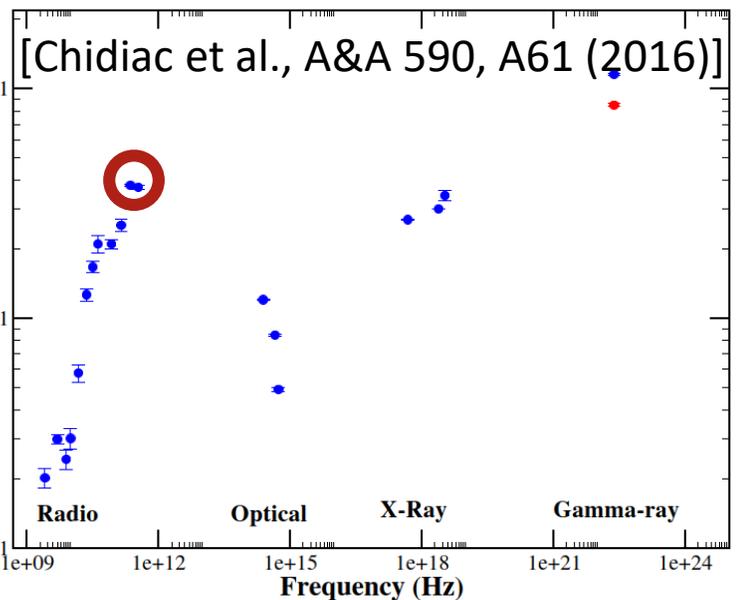
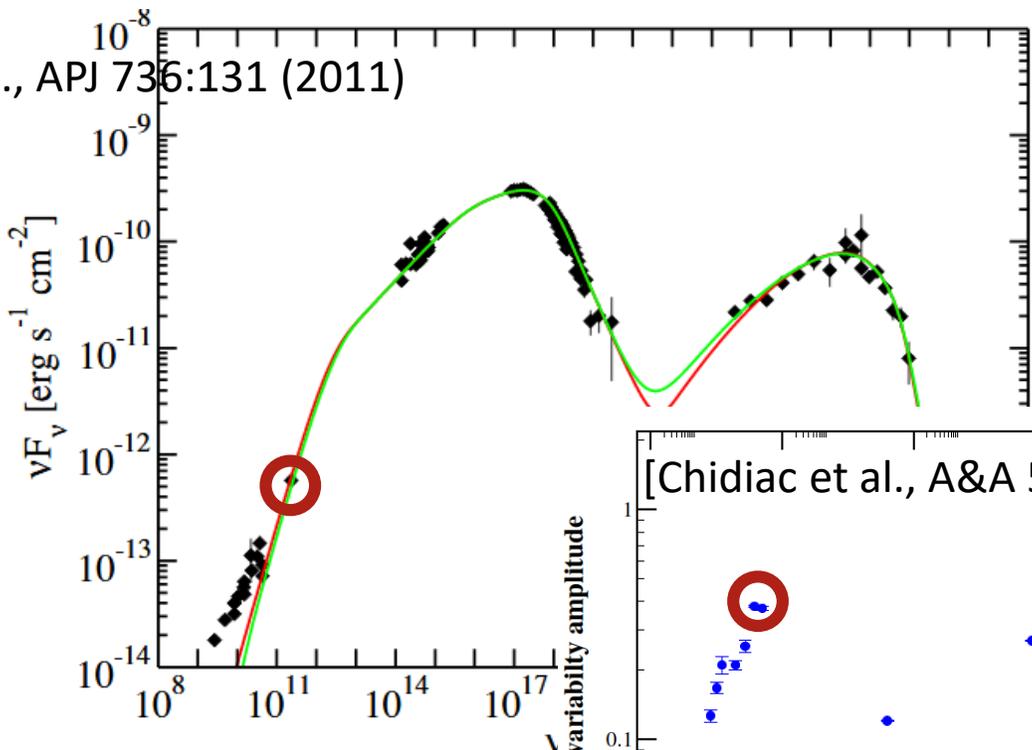
AMT Science Cases

- VLBI
 - 1mm Event Horizon Telescope (EHT) VLBI
 - 3mm Global mm-VLBI Array (GMVA)
 - [6cm Africa VLBI Network (AVN)]
- Single dish
 - Monitoring of Active Galactic Nuclei
 - mm transients

Monitoring of Blazars



Abdo et al., APJ 736:131 (2011)



[Chidiac et al., A&A 590, A61 (2016)]

- **Multi-wavelength monitoring with AMT** - mm-radio - Gamma Rays - Xray - nearIR (together with H.E.S.S., CTA, MAGIC, JWST, Chandra) at < weekly cadence over years to test detailed particle physics models + campaigns

AMT Science Cases

- VLBI
 - 1mm Event Horizon Telescope (EHT) VLBI
 - 3mm Global mm-VLBI Array (GMVA)
 - [6cm Africa VLBI Network (AVN)]
- **Single dish**
 - Monitoring of Active Galactic Nuclei
 - **mm transients**

mm transients

- **Unique mm-Transients facility:** single dish detection of few mJy within minutes at 3mm (submm leads cm radio!) can trigger SKA/VLBI/EHT, also the EHT/AMT can even image **XRBs** & Namibian node to the **AVN** and connection to **EVN**

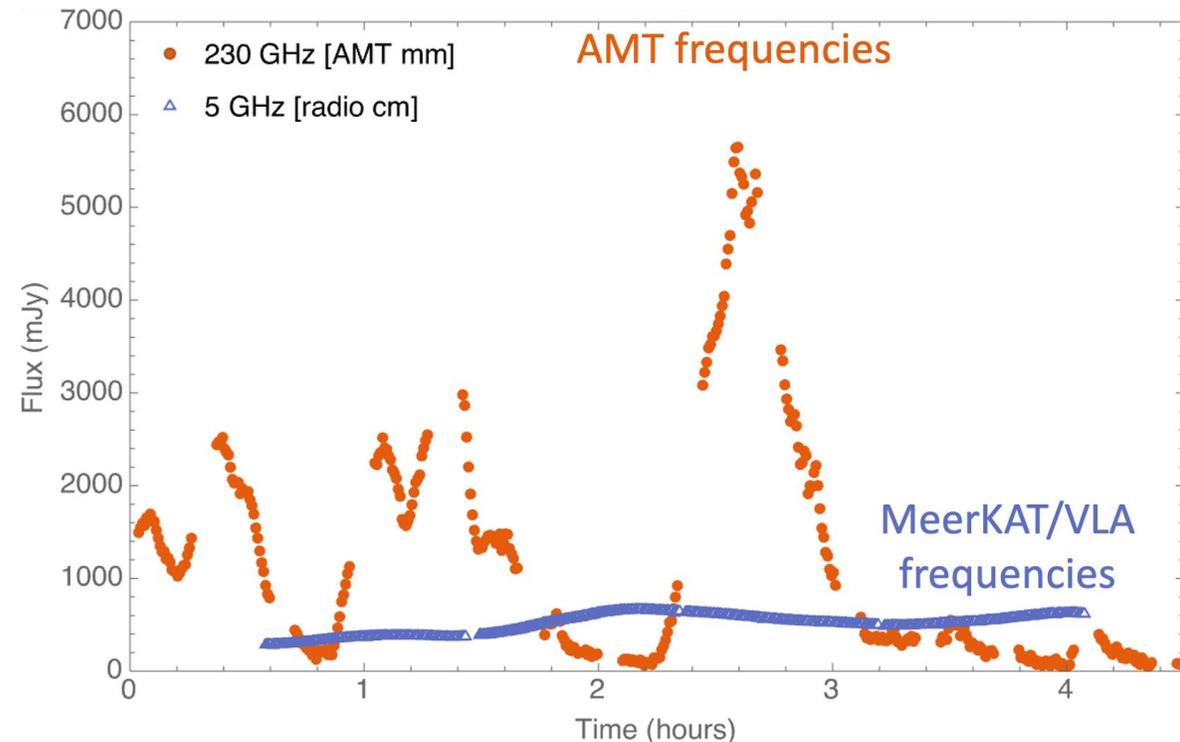


Figure 1: Comparison of mm-wave and cm-wave frequencies of the outburst in the X-ray binary V404 Cygni (R. Fender, based on Tetarenko, A. J. et al. 2017, MNRAS 469, p. 3141). Outbursts are much more pronounced at mm-waves.



mm transients detection rate for AMT

Table 1: Estimated number of transient sources detectable by the AMT for a 5 mJy limit, based on standard lightcurve evolution models from Eftekhari, T. et al. (2022, ApJ 935, p. 16).

| Class | Volumetric Rate ($\text{yr}^{-1} \text{Mpc}^{-3}$) | L_ν ($\text{erg s}^{-1} \text{Hz}^{-1}$) | Volume (Mpc) | Detection Rate (yr^{-1}) |
|-------------------------------|---|---|-----------------|--|
| Young core-collapse supernova | $R_{\text{CC}} = 10^{-4}$ [7] | $10^{27} - 10^{28}$ [8] | 13–41 | 0.4–11 |
| Interacting supernova | $0.1 \times R_{\text{CC}}$ [7] | $10^{27} - 10^{30}$ [9] | 10–400 | 0.04–1000 |
| Long-duration GRBs | $6 \times 10^{-6} \times R_{\text{CC}}$ | $10^{31} - 10^{32}$ [10] | 1300–4000 | 2–70 |
| On-axis jetted TDEs | $10^{-7} \times R_{\text{CC}}$ | 10^{32} [10] | 4000 | 1 |
| Low-luminosity GRBs | $0.01 \times R_{\text{CC}}$ | 10^{29} | 130 | 4 |
| AT2018cow | $0.001 \times R_{\text{CC}}$ | 10^{30} [11] | 410 | 11 |



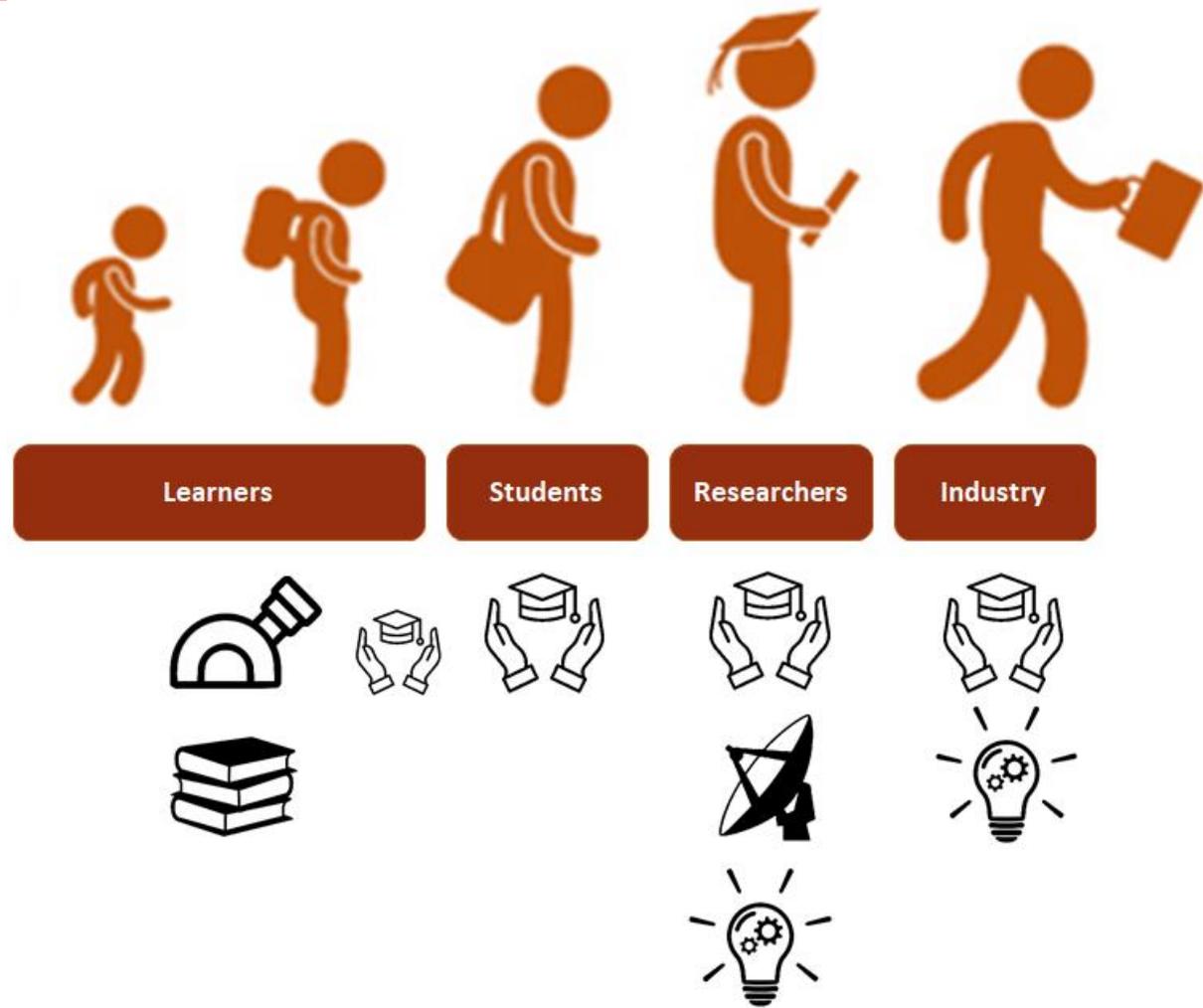
AMT: Social Impact programme I

**Physics/
Astronomy**

**Computer
Science**

**Green
Energy**

Engineering





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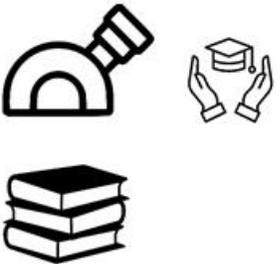
AMT: Social Impact programme II



- Mobile planetarium to every school in Namibia
- Training teachers in astronomy
- Providing low cost and durable astronomy resources to schools



Learners



AMT: Social Impact programme III



Researchers



Lott Frans

1st AMT PhD Fellowship (from 2022)

supported by

- Radboud University
- Univ. of Amsterdam
- INAF IRA
- JIVE
- Univ. of Namibia

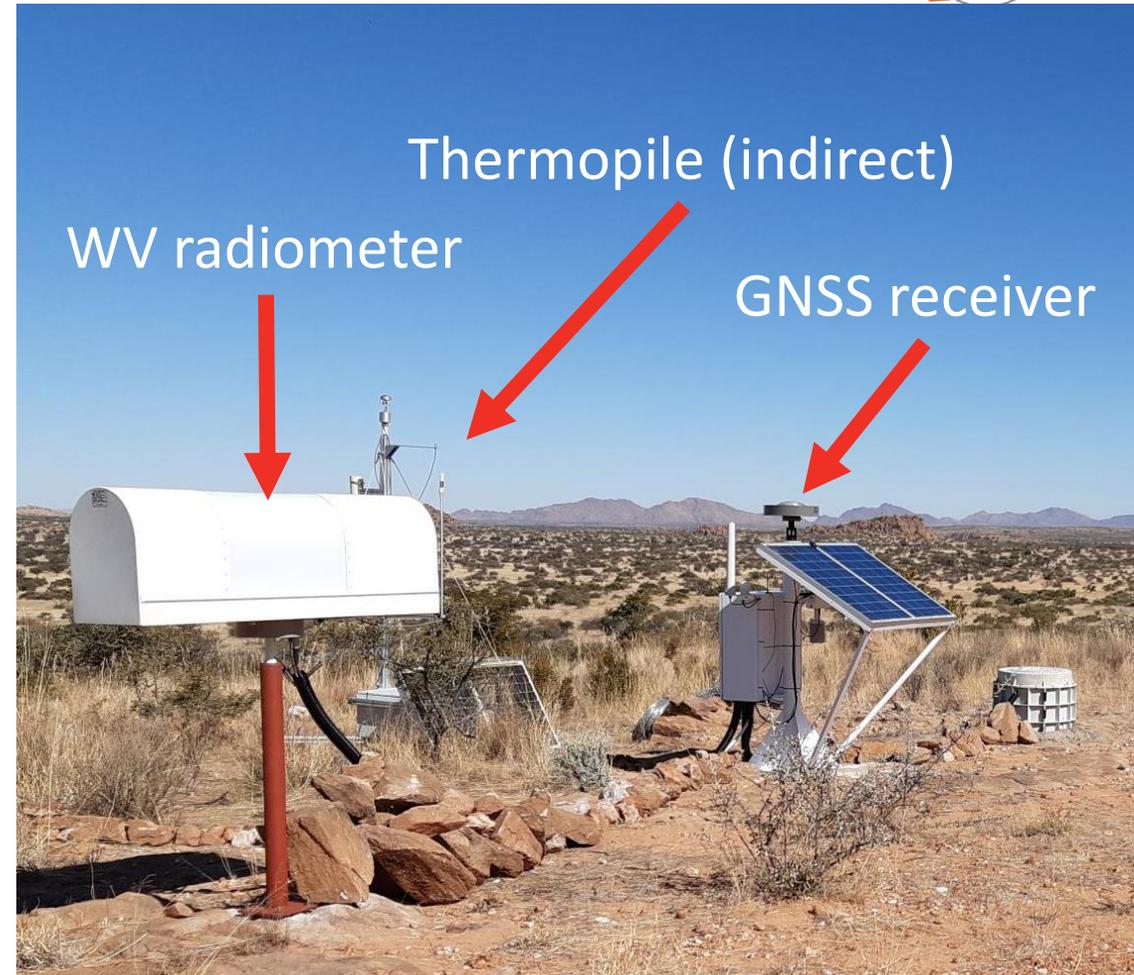
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AMT in the Media

<https://www.popsci.com/space/africa-millimeter-telescope-astronomy/>

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POPSCI 150

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NEWSLETTER SIGN-UP

With the arrival of Africa's next radio telescope, Namibia sees a new dawn in astronomy

The upcoming addition to the Event Horizon Telescope network will unlock cosmic secrets —and new doors for the next generation of Southern African astronomers.

BY TATYANA WOODALL | PUBLISHED MAY 11, 2022 9:09 AM

AMT in the Media

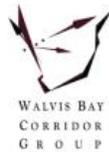
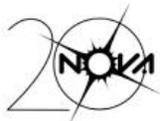


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Science - Education - Outreach - Technological Innovations



Radboud University



Further supported by members of



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Thank You