Estimating observation times for monitoring observations of radio galaxies using the Africa Millimetre Telescope

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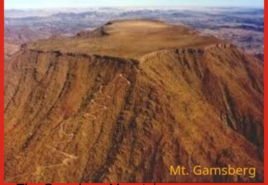
1. Objectives

Compare single-dish integration times at the H.E.S.S. site & the Gamsberg Mountain required to reach a target detection significance of 5σ at 86, 230, & 345 GHz for 324 AGN sources.

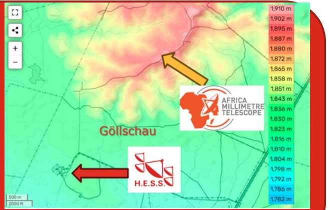

The Africa Millimetre Telescope



The Gamsberg Mountain

Scientific Motivation

Radio galaxies and blazars are jet-powered AGN. Monitoring at mm wavelengths (86/230/345 GHz) probes regions closer to the jet base and reduces synchrotron self-absorption compared to lower frequencies. This project is one of the single-dish science cases for the Africa Millimetre Telescope (AMT) [*Backes⁺ Galaxies (2019)*].



The H.E.S.S. telescopes and H.E.S.S. site

2. Methods & Pipeline

1. **Data Extraction:** Model fluxes at 86, 230, and 345 GHz from a 324-source leptohadronic SED catalogue of radio galaxies.
2. **Observability:** Applied a minimum elevation cut of >20° for culmination (reduction from 324 to 270 sources).
3. **Sensitivity:** Modelled using the flux-density form of the Radiometer Equation:

$$t_{\text{int}} \approx \left(\frac{\rho \cdot \text{SEFD}}{S_\nu \sqrt{n_{\text{pol}} \Delta\nu}} \right)^2$$

Where SEFD (System Equivalent Flux Density) relates instrument noise to flux units and $t(\nu) = e^{-\tau(\nu)}$ *defines atmospheric transmission.*

3. Site Characterization

Precipitable Water Vapour (PWV) is the main source of atmospheric attenuation at mm and sub-mm waves.

Median PWV:

H.E.S.S. (1,800 m):	14.27 mm
Mt. Gamsberg (2,347 m):	9.25 mm

Conclusion: Lower PWV at Mt. Gamsberg yields significantly higher transmission at 230 and 345 GHz, especially during winter months (June–August).

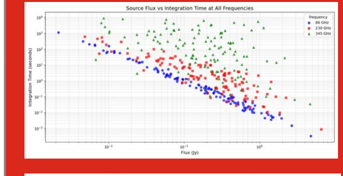
PWV data taken simultaneously by GNSS stations at the Gamsberg Mountain and the H.E.S.S. site. [*Frans⁺ MNRAS (2025)*]

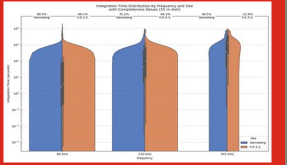
4. Results

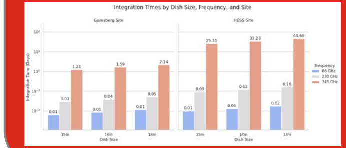
Observable sources at weekly cadence (15 m scenario):

Band	**H.E.S.S.**	**Gamsberg**
86 GHz	237 (88%)	239 (89%)
230 GHz	179 (66%)	203 (75%)
345 GHz	61 (23%)	104 (39%)

Efficiency: Simultaneous tri-band observing is dominated by the 345 GHz integration requirement. Mt. Gamsberg increases the high-frequency sample reach by about 70%.







Comparison of H.E.S.S. and Gamsberg sites.
Mt. Gamsberg consistently requires shorter integration times due to its lower atmospheric water vapour. [*Backes⁺ PoS (HEASA2025)010*)].

5. Conclusions & Next Steps

Observation-time estimation is a practical decision tool for AMT science operations. Both sites are suitable for 86/230 GHz, but Mt. Gamsberg is essential for routine monitoring at 345 GHz. Future steps involve post-commissioning calibration of receiver temperature T_{rec} and aperture efficiency models, dynamic atmospheric modeling, and validation against first-light data.