TANAMI: Milliarcsecond Resolution Observations of Extragalactic Gamma-ray Sources

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Summary: We present early results from the TANAMI (Tracking AGN with Austral Milliarcsecond Interferometry) program that monitors extragalactic gamma-ray sources in the southern hemisphere with parsec scale resolution.

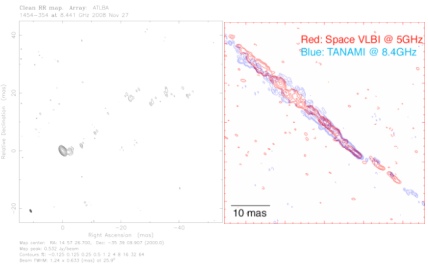
Background

- TANAMI provides parsec scale resolution monitoring of extragalactic gamma-ray sources south of -30 degrees declination at dual frequency (8.4 and 22 GHz) by making Very Long Baseline Interferometry (VLBI) observations with the Australian Long Baseline Array and associated telescopes at intervals of about 2 months.

- VLBI observations are complemented by arcsecond resolution monitoring across the radio spectrum with the Australia Telescope Compact Array (PI S. Tingay) and single-dish resolution with the Hobart and Ceduna telescopes of the Uni of Tasmania (PI: J. Lovell)

-The Ceduna Hobart Interferometer (CHI) provides a 1700km baseline for quick followup of Fermi detections

-The details of the TANAMI observing program (including sample composition) are described in the poster P1-51 (Mueller et al.)



Clockwise from above:

Fig 1: PKS 1454-354

Fig 3: Horiuchi et al 2005 and TANAMI images of Cen A overlaid

PKS 1454-354

- Flat-spectrum radio quasar (z=1.424)

- LAT detected gamma-ray flare (Sep 4th, 2008). Flux rise on timescale of hours, dropping over following 2 days

-TANAMI images part of first LAT AGN paper (Abdo et al. 2009 ApJ, 697, 934)

-Show (e.g. Fig 1) single-sided jet, activity confirmed, ongoing monitoring

Abstract

The TANAMI (Tracking AGN with Austral Milliarcsecond Interferometry) and associated programs provide comprehensive radio monitoring of extragalactic gamma-ray sources south of declination -30 degrees. Joint quasi-simultaneous observations between the Fermi Gamma-ray Space Telescope and ground based observatories allow us to discriminate between competing theoretical blazar emission models. High resolution VLBI observations are the only way to spatially resolve the sub-parsec level emission regions where the high-energy radiation originates. The gap from radio to gamma-ray energies is spanned with near simultaneous data from the Swift satellite and ground based optical observatories. We present early results from the TANAMI program in the context of this panchromatic suite of observations.

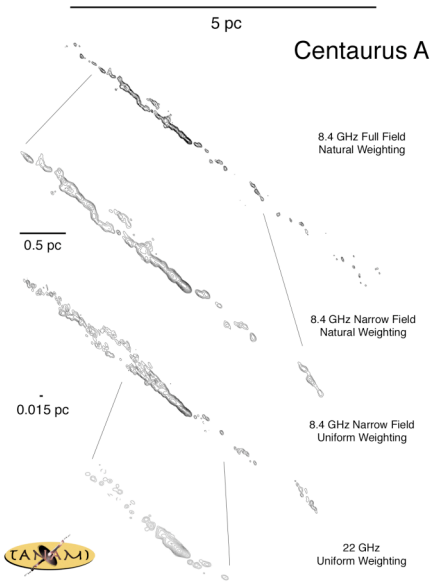


Fig 2: Centaurus A at phenomenal resolutions

Centaurus A

- Closest radio galaxy (3.4 Mpc) with bright jet and faint counter-jet. Subparsec scale analysis possible

- TANAMI images (Fig 2) **one of the highest resolution images of an AGN jet ever made**

- Beam of 0.68 x 0.41 mas is comparable to 0.8 x 0.7 mas resolution of Horiuchi et al. 2005 (previous highest resolution image; Fig 3). Though observations separated by 10 years structures remarkably similar (Fig 4) contrary to previous apparent velocity ~ 1.4 mas (Tingay et al. 2001. Detailed velocity information from TANAMI to investigate.

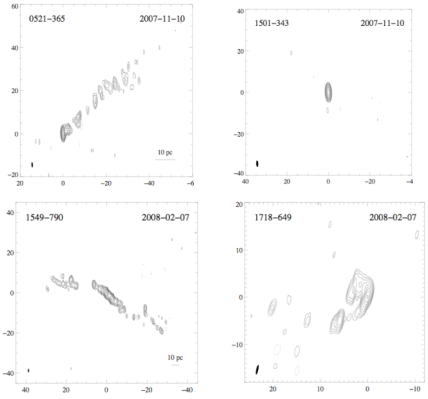


Fig 4: Example images for morphology classification (clockwise from above left): Single-sided (SS) - 36; Compact (C) - 1; Double-sided (DS) - 5; Irregular (Irr) - 1

First Epoch Results

- **Morphology** see Fig 4. After Kellermann et al. 1998.

- 45 of 65 TANAMI sources have associations with gamma-ray sources in the LAT team's 1-year catalog (for detailed discussion of gamma-ray properties see P1-23 (Boeck et al.)

- **Are opening angles correlated with gamma-luminosity?** 78% of LAT AGN Bright Sample (LBAS) sources have opening angle > 30 deg. Only 27% of non-LBAS sources do. (Caution: small numbers). So either (1) LBAS jets have smaller Lorentz factors (beaming cones ~ 1/Lorentz factor) or (2) LBAS jets are pointed closer to the line of sight.

- **Redshift distribution** of blazars in TANAMI sample similar to those for LBAS and EGRET blazars. No difference in the radio- and gamma-ray selected subsamples. None of the five most distant sources have been detected by Fermi

- No significant difference between LBAS and non-LBAS **luminosities.** None of the five most distant and luminous sources have been detected by Fermi. None of the nine most luminous jets are detected suggesting a possible counterintuitive anti-correlation between jet luminosity and gamma-brightness

- No significant difference in **brightness temperatures** of LBAS and non-LBAS. 13 below equipartition, 29 below inverse Compton limit, putting about a third above this limit

Coming Attractions

- Core and jet component spectra

- Proper motions

- SEDs !!!

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