e-VLBI observations of GHz-peaked spectrum radio sources in nearby galaxies from the AT20G survey

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ABSTRACT
Gigahertz-peaked spectrum (GPS) radio sources are thought to be young objects which later evolve into Fanaro–Riley type I (FR I) and FR II radio galaxies. We have used the Australia Telescope 20 GHz (AT20G) survey catalogue to select a uniform sample of GPS sources with spectral peaks above 5 GHz, which should represent the youngest members of this class. In this paper, we present e-VLBI observations of 10 such objects which are associated with nearby (z < 0.15) galaxies and so represent a new population of local, low-power GPS sources. Our e-VLBI observations were carried out at 4.8 GHz with the Australia Telescope Long Baseline Array (LBA) using a real-time software correlator. All 10 sources were detected, and were unresolved on scales of ~100 mas, implying that they are typically less than 100 pc in linear size.

Key words: instrumentation: interferometers – galaxies: active – galaxies: evolution – radio continuum: galaxies.

1 INTRODUCTION
Gigahertz-peaked spectrum (GPS) radio sources are characterized by a spectral peak and turnover at frequencies above 1 GHz. They were identified as early as 1966 (Kellerman 1966), and are thought to be the progenitors of large radio galaxies (O’Dea 1998). The spectral turnover is usually attributed to synchrotron self-absorption (SSA), although free–free absorption plays a role in some sources (Tingay & de Kool 2003; Vermeulen et al. 2003).

Interactions between the central active galactic nucleus (AGN) and its host galaxy are especially important in the younger sources, as the host ISM plays a large role in the evolution of the radio source. In the evolutionary scenario (Snellen et al. 2000), the peak of the radio spectrum progressively moves towards lower frequencies as the source evolves. Most current samples of GPS sources are dominated by sources which peak below 5 GHz, and so are either at large redshift or have moved beyond the earliest stages of evolution.

Recently, two very nearby (d ~ 19 Mpc) galaxies, NGC 1052 (Vermeulen et al. 2003) and IC 1459 (Tingay, Edwards & Tzioumis 2003) have been shown to be GPS radio sources. The turnover frequency of the overall spectrum is close to 2.5 GHz for IC 1459 and 10 GHz for NGC 1052. The radio sources within these galaxies are relatively low-powered (~10^22 W Hz^{-1} at 5 GHz) compared to the ensemble of known GPS sources, which have typical radio powers above 10^23 W Hz^{-1}.

Both NGC 1052 and IC 1459 (in common with the only other known GPS radio source within 100 Mpc, PKS 1718–649) show strong low-ionization nuclear emission region (LINER)-like emission lines in their optical spectra and have complex gas kinematics in their nuclear regions, which may suggest that the galaxy has undergone a recent interaction or gas accretion event. Franx & Illingworth (1988) note that IC 1459 has a counter-rotating stellar core, which is also postulated to have formed as the result of a galaxy merger.

The GPS radio sources in both NGC 1052 and IC 1459 are strongly jet-dominated on parsec scales, in contrast to the majority of more distant and luminous GPS radio galaxies where the radio emission is dominated by what appear to be the small-scale analogues of radio-galaxy hotspots. This raises the possibility that there exists a luminosity/morphology relationship in GPS radio galaxies, similar to that seen on much larger scales in FR I and FR II radio galaxies (Fanaroff & Riley 1974).

While the interpretation of NGC 1052 is unclear, since the radio source shows the presence of large-scale hotspots indicating that the radio source is not young, it could be classified as a restarted radio source. IC 1459, however, has no large-scale structure and could be interpreted as a young radio source. The apparently two-sided nature of the pc-scale jets in IC 1459 (Sokolova, Tingay & Edwards, in preparation) does not favour a highly aligned jet as an explanation for the lack of large-scale structure.

When investigating GPS radio sources, it is important to recognize the potential for contamination from variable sources whose peaked spectrum is not at all related to the evolution of young radio
galaxies. Less than 10 per cent of the quasi-stellar objects (QSOs) identified as GPS sources in the literature retain their classification when subjected to long term monitoring and simultaneous spectral measurements (Torniainen et al. 2005). Similarly selected galaxy type GPS samples are more reliable with ~40 per cent identified as genuine GPS sources (Torniainen et al. 2007). In each case, the contamination rate is seen to increase as the spectral peak shifts to higher frequencies.

To investigate the parsec-scale properties of GPS radio sources at the lowest luminosities further, we have used the high-frequency AT20G survey (Ricci et al. 2004; Sadler et al. 2006; Massardi et al. 2008) to construct a uniform sample of GPS sources with high-frequency (> 8 GHz) spectral turnovers, low redshift (z < 0.15) and low radio power ($P_3 < 10^{24.5}$ W/Hz). To avoid as much as possible the contamination from sources unrelated to the evolutionary scenario, we selected only sources that are identified with galaxies. The source names referred to in this paper are drawn from the AT20G survey. In this paper, we present observations from the Australian e-VLBI network at ~100 mas resolution as a first step in measuring the angular sizes and structures of these nearby high-frequency GPS sources.

We use the following cosmological values throughout this paper: $H_0 = 71$ km s$^{-1}$, $\Omega_m = 0.27$, and $\Omega_\Lambda = 0.73$.

2 TARGET SELECTION

2.1 Selecting high-frequency GPS sources

The AT20G full-sample data release (Murphy et al., in preparation) provides near-simultaneous flux-density measurements at 4.8, 8.6 and 20 GHz for most AT20G sources south of declination $-15^\circ$. This is important in allowing us to identify candidate GPS sources without the problem of variability giving a false spectral shape.

We selected our high-frequency GPS sample from the ~3800 AT20G sources which had good-quality data at all three frequencies, since this gives us enough spectral information to identify an inverted or peaked spectrum. All the AT20G sources observed at 5 and 8 GHz were detected at these frequencies, so there are no upper limits in the AT20G sample. AT20G sources whose radio spectrum peaked above 5 GHz or rose with frequency over the whole 5–20 GHz range were flagged as GPS candidates. This yielded a final list of 656 candidates high-frequency GPS sources with spectral peaks above 5 GHz (Hancock 2009). The 1.4 GHz NRAO VLA Sky Survey (NVSS, Condon et al. 1998) and 843 MHz Sydney University Molonglo Sky Survey (SUMSS, Mauch et al. 2003) catalogues were also used to search for low-frequency emission from the AT20G GPS sources.

2.2 Optical identification

We cross-matched our AT20G GPS sample with the optical SuperCOSMOS catalogue (Hambly et al. 2001) to search for optical counterparts. Roughly 70 per cent of our AT20G GPS sample (465/656) had an optical identification above the SuperCOSMOS plate limit. Of these 23 per cent were classified as galaxies by SuperCOSMOS and 77 per cent were stellar objects, which are expected to be QSOs. This is consistent with the finding of Stanghellini (2003) that GPS populations contain many flat-spectrum radio QSOs.

2.3 A complete sample of nearby GPS radio galaxies

Since our interest here is in the GPS radio sources associated with nearby galaxies, we considered only the ~100 AT20G GPS sources which were identified with SuperCOSMOS galaxies. A radio-optical identification was accepted if the two positions differed by less than 5 arcsec. Redshifts for these objects were obtained from the 6dF Galaxy Survey (6dFGS; Jones et al. 2004) and from the wider literature via the NASA/IPAC Extragalactic Data (NED) online data base.2

Only about 25 per cent of the AT20G GPS galaxies currently have redshift information, and further redshift measurements are in progress. Using the currently available redshift data, we identified a sample of 28 GPS radio sources which were associated with nearby (redshift $z < 0.15$) galaxies. All of these had 5 GHz radio powers below $10^{24.3}$ W Hz$^{-1}$. Ten of the galaxies from this sample (listed in Table 1) were observed in our 2008 March e-VLBI run. The low-frequency properties of these sources are summarized in Table 2.

3 OBSERVATIONS

The targets listed in Table 1 were observed using the new electronic-Very Long Baseline Interferometer (e-VLBI) capability of the Long Baseline Array (LBA; Tzioumis 1997) in 2008 March, at a frequency of 4.8 GHz. The LBA stations used were the Parkes observatory (64 m dish), Australia Telescope Compact Array (ATCA, six 22-m dishes as a tied array) and the Mopra antenna (22 m) of the Australia Telescope National Facility (ATNF). The data were correlated in real time at Parkes using a Distributed FX (DiFX) correlator developed by Deller et al. (2007).

The observations were arranged as a series of 5 min integrations per source, cycling through those sources that were above the horizon at any time. In this way, a typical ensemble of observations for an individual source consisted of approximately 10 × 5 min integrations, over a 12 h period. A typical $uv$ coverage is shown in Fig. 1. These data were reduced using standard VLBI data reduction and imaging techniques implemented in Astronomical Image Processing System (AIPS)3 and DIFMAP (Shepherd et al. 1994). The observations utilised phase-referencing techniques via observations of bright, compact calibration sources nearby to each target, for calibration of the interferometer phase, enhancing the coherence time of the visibilities and allowing the detection of fainter targets.

The typical 1σ image sensitivity derived from these data sets is approximately 1 mJy beam$^{-1}$. The angular resolution varies with source declination but is typically approximately 100 mas.

4 RESULTS

Fig. 2 shows a typical e-VLBI image of one of the sources in Table 1, all of which were unresolved on scales of 200 mas or less. Table 3 lists the maximum angular size of each source as measured from the images using the miraD task inPFT. An e-VLBI position is also listed for each source along with the 4.8 GHz flux density measured from the e-VLBI (~0.1 arcsec beam) and AT20G (~15 arcsec beam) images. The uncertainty in the e-VLBI positions is dominated by the phase referencing of the calibration source, and is typically 10 mas in RA and Dec. Note that the AT20G and e-VLBI

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1 Sadler et al. (2008) found that almost all AT20G sources with rising (‘inverted’) spectra at 5–20 GHz show a spectral turnover between 20 and 95 GHz, so we are confident that most of the ‘inverted-spectrum’ AT20G sources will be high-frequency peaking GPS objects.

2 http://nedwww.ipac.caltech.edu/

3 The AIPS was developed and is maintained by the National Radio Astronomy Observatory, which is operated by Associated Universities, Inc., under cooperative agreement with the National Science Foundation.
Table 1. AT20G sources observed in our e-VLBI run. Positions and flux densities are taken from the AT20G Final Data Release (Murphy et al., in preparation). Redshifts are from the Third Data Release (DR3) of the 6dF Galaxy Survey (Jones et al., in preparation) except for J074618–570258, J130031–441442 and J220916–471000 (both from de Vaucouleurs et al. 1991). Column 3 lists the total $K_s$-band magnitude from the Two-Micron All-Sky Survey (2MASS) Extended Source Catalogue (Jarrett et al. 2000). The frequency at which the radio spectrum peaks (Column 11) is estimated from the three quasi-simultaneous AT20G data points. The errors on the AT20G flux density measurements are typically ~5 per cent, giving typical uncertainties of ±0.15 in the radio spectral index $\alpha$.

| Name AT20G | AT20G position J2000 | $K_s$ (mag) | $z$ | $S_5$ (mJy) | $S_{20}$ (mJy) | $\alpha_5^0$ | $\alpha_{20}^0$ | log $P_S$ (WHz$^{-1}$) | $v_{peak}$ (GHz) | Alt. Name |
|------------|----------------------|------------|-----|-------------|---------------|-------------|-------------|----------------|----------------|-----------|
| J031010–573041 | 03 10 10.6 | −57 30 41.3 | 13.1 | 0.082 | 45 | 73 | 89 | +0.48 | 23.8 | ~20 |
| J051103–255450 | 05 11 03.8 | −25 54 51.0 | 12.2 | 0.092 | 92 | 113 | 122 | +0.35 | +0.20 | 24.2 | ~20 |
| J054828–331331 | 05 48 28.5 | −33 13 31.5 | 12.9 | 0.040 | 31 | 39 | 52 | +0.36 | 23.0 | ~20 |
| J074618–570258 | 07 46 18.7 | −57 02 58.6 | 0.130 | 47 | 63 | 94 | +0.49 | 24.2 | ~20 |
| J091856–243829 | 09 18 56.5 | −24 38 29.5 | 14.4 | 0.056 | 48 | 51 | 64 | +0.20 | 23.5 | >20 |
| J114503–325824 | 11 45 03.5 | −32 58 24.2 | 10.5 | 0.038 | 69 | 91 | 75 | +0.47 | 23.3 | ~10 |
| J130031–441442 | 13 00 31.1 | −44 14 42.6 | 10.5 | 0.032 | 68 | 104 | 77 | +0.95 | 23.2 | ~10 |
| J181857–550815 | 18 18 58.0 | −55 08 15.2 | 11.4 | 0.072 | 42 | 53 | 74 | +0.40 | 23.7 | >20 |
| J220916–471000 | 22 09 16.3 | −47 10 00.3 | 7.1 | 0.005 | 136 | 161 | 122 | +0.29 | −0.07 | 21.8 | ~10 |
| J224506–433157 | 22 45 06.0 | −43 31 57.3 | 13.0 | 0.068 | 74 | 90 | 84 | +0.33 | +0.09 | 23.9 | ~10 |

Flux-density measurements are not simultaneous and were made up to three years apart.

The mean flux ratio ($S_{\text{VLBI}}/S_{\text{AT20G}}$) is 0.90 with a standard deviation of 0.22. If we exclude the source J051103–255450, which appears to be variable (see Section 4.1.2), the mean flux ratio rises to 0.94 and the mean absolute deviation drops to 0.18. These results suggest that (i) the nearby AT20G GPS sources are compact, with ~90 per cent of their 4.8 GHz emission arising on scales smaller than 100–200 pc, and (ii) most of these sources show only modest variability at 4.8 GHz on time-scales of 1–3 yr.

4.1 Notes on individual sources

4.1.1 AT20G J031010–573041

The optical counterpart of this radio source is a member of a compact group of galaxies (Fig. 3). No redshift has been measured for the host galaxy (object A in Fig. 3), so we adopt the measured 6dFGS redshift of $z = 0.082$ for the companion galaxy as the redshift of the whole group. None of the other galaxies in this group has a redshift measurement.

![Figure 1](https://academic.oup.com/mnras/article-abstract/397/4/2030/998925/1)

**Figure 1.** Typical $u - v$ coverage for the e-VLBI observations of the sources within the sample. Each source has approximately $10 \times 5$ min integrations spanning a 12 h period.

4.1.2 AT20G J051103–255450

This source was detected in the Parkes–MIT–NRAO (PMN) survey (Griffith et al. 1994) with a flux density of 53±11 mJy in the 4 arcmicron Parkes beam at 4.8 GHz. This is significantly lower than the AT20G value of 92±4 mJy (in a 15 arcsec beam), suggesting that the source may be variable. The 6dFGS spectrum shows absorption lines typical of an early-type galaxy but no obvious optical emission lines.

4.1.3 AT20G J054828–331331

The 6dFGS spectrum shows absorption lines together with possible weak [O iii] emission. There is a faint NVSS source associated with this object (see Table 2), but it lies below the limit of the 843 MHz SUMSS catalogue.

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4.1.4 AT20G J074618−570258

This radio source has been identified by Saripalli et al. (2005) as the core of a ‘double–double’ Giant Radio Galaxy. Fig. 4 shows the optical SuperCOSMOS blue image overlaid with SUMSS radio contours at 843 MHz – the total extent of the SUMSS source is 5.5 arcmin, corresponding to a largest linear size of ∼750 kpc.

This source was classified as FR I by Saripalli et al. (2005) on the basis of the edge-darkened radio morphology in the SUMSS image. Saripalli et al. (2005) also obtained a higher resolution 1.4 GHz radio image of J074618−570258 with the ATCA (their fig. 9), which shows an inner pair of radio hotspots indicative of a core-jet morphology with the jet pointing towards the weaker (south-west) of the larger scale radio lobes. The component identified as the core by Saripalli et al. (2005), which is identified with a z = 0.13 galaxy, is also coincident with the AT20G source detected in our e-VLBI observation.

Saripalli et al. (2005) note that the optical spectrum of this galaxy (shown in their fig. 19) has stellar absorption lines but no obvious emission lines. They suggest that J074618−570258 may be an example of a restarting radio jet within relic lobes.

### Table 3. VLBI core positions and upper limits on angular and linear size for the AT20G sources in Table 1. Δ (Column 3) is the offset between the optical and e-VLBI positions. Columns 9 and 10 list the 4.8 GHz flux density measured from the AT20G (∼15 arcsec beam) and e-VLBI (∼0.1 arcsec beam) images. *Note that (as discussed in Section 4.1.5) this radio source may be a background QSO.

| Name AT20G (1) | e-VLBI position J2000 (arcsec) (2) | Δ (arcsec) (3) | z (4) | M_K (mag) (5) | Scale (kpc arcsec⁻¹) (6) | LAS (arcsec) (7) | LLS (pc) (8) | S_VLBI (mJy) (9) | S_AT20G (mJy) (10) | Flux ratio e-VLBI/AT20G (11) |
|---------------|-----------------------------------|----------------|------|-------------|--------------------------|----------------|-------------|----------------|----------------|-----------------------------|
| J031010−573041| 03 10 10.6 −57 30 41.68          | 0.1 0.082     | −24.7| 1.54        | <0.13                    | 200            | 36.5        | 45             | 0.81            |
| J051103−255450| 05 11 03.8 −25 54 49.96          | 0.5 0.092     | −25.9| 1.71        | <0.11                    | 188            | 47.2        | 92             | 0.51            |
| J054828−331331| 05 48 28.5 −33 13 30.00          | 1.1 0.040     | −23.3| 0.80        | <0.09                    | 72             | 24.5        | 31             | 0.79            |
| J074618−570258| 07 46 18.6 −57 02 58.21          | 0.0 0.130     | ... | 2.29        | <0.05                    | 114            | 62.2        | 47             | 1.32            |
| J091856−243829* | 09 18 56.5 −24 38 29.39         | 3.7 0.056     | −22.6| 1.07        | <0.06                    | 64             | 46.2        | 48             | 0.96            |
| J114503−325824* | 11 45 03.5 −32 58 23.48         | 0.3 0.038     | −25.6| 0.74        | <0.05                    | 37             | 62.9        | 69             | 0.91            |
| J130031−441442* | 13 00 31.0 −44 14 41.51         | 0.2 0.032     | −25.2| 0.63        | <0.06                    | 38             | 58.6        | 68             | 0.86            |
| J181857−550815* | 18 18 58.0 −55 08 15.30         | 0.3 0.072     | −26.1| 1.30        | <0.06                    | 81             | 47.9        | 42             | 1.14            |
| J220916−471000* | 22 09 16.2 −47 10 00.25         | 0.5 0.005     | −24.5| 0.10        | <0.15                    | 15             | 120.6       | 136            | 0.89            |
| J224506−433157* | 22 45 06.0 −43 31 57.44         | 0.1 0.068     | −24.4| 1.29        | <0.20                    | 258            | 56.5        | 74             | 0.76            |
Figure 4. J074618−570258 radio contours overlaid on a blue optical image. SUMSS contours (outer) are at 3, 6, 12 and 48 mJy beam$^{-1}$ with a beam of $54.3 \times 45$ arcsec$^2$. AT20G contours (inner) are at 6, 12 and 48 mJy beam$^{-1}$ with a beam of $12.7 \times 9.2$ arcsec$^2$.

Figure 5. SuperCOSMOS blue image with the galaxy pair AM 1257−435 identified. Galaxy A is the radio source and B the companion galaxy discussed in the text. AT20G 20 GHz contours are overlaid at 20, 40 and 80 mJy beam$^{-1}$.

4.1.7 AT20G J130031−441442

This object is associated with the brighter of the two objects in the galaxy pair AM 1257−435 (galaxy A in Fig. 5). Galaxy B, the second member of the pair, is 1.4 arcmin away. J130031−441442 (galaxy A) is listed as a shell galaxy in the catalogue of Malin & Carter (1983), who describe it as having 'shells north-west and south-east, two companions'. Such shells are generally attributed to a past merger of two gas-poor galaxies. J130031−441442 is also identified with the ultraviolet (UV) source FC-238 by Brosch et al. (2000), who list it as a SAB(s) peculiar galaxy with UV magnitude of 12.58 ± 0.61.

4.1.8 AT20G J181857−550815

The 6dFGS spectrum of this galaxy (marked as object A in Fig. 6) shows stellar absorption lines typical of early-type galaxies but no obvious optical emission lines. This galaxy lies between two SUMSS sources, as shown in Fig. 6. The AT20G source J181857−550815 is at the position of galaxy A near the centre of the image.

The most likely interpretation is that the AGN in galaxy A produces the extended radio lobes which are seen at 843 MHz. The radio observations at 5, 8 and 20 GHz from the AT20G show an inverted spectrum with spectral index $\alpha_{20}^{5} = +0.40$ centred on J181857−550815, which may mean that, like J074618−570258, J181857−550815 is a recently 'restarted' radio galaxy. The fact that the radio lobes are extended along the minor axis of the host galaxy is consistent with this scenario, and the 4.8 GHz AT20G image shows a jet-like feature extending roughly 1 arcmin from the nucleus.

A second galaxy, marked as B in Fig. 6 lies close to the centroid of the north-western lobe and may also be responsible for some of the radio emission seen in the SUMSS image. The total SUMSS flux density is 627.7 ± 21.2 mJy and the separation of the two SUMSS components is 1.1 arcmin, implying a largest linear size of at least 90 kpc.

5 DISCUSSION

5.1 Source sizes

As noted earlier, all 10 sources listed in Tables 1 and 2 were unresolved at $\sim$100 mas resolution in our e-VLBI observations. Fig. 7 shows that the radio emission detected by the AT20G survey on scales of 10−15 arcsec or larger is dominated by a central compact
component less than \( \sim 0.1 \) arcsec in size. The lack of any significant structure in the core on scales larger than 100 pc supports the idea that we are looking at young unevolved radio sources. Even for a very slowly evolving source with hot spot expansion velocities of 0.1c, a linear size of \(< 100 \) pc gives an age of \(< 3000 \) yr.

For powerful radio galaxies, it is well known that core and total radio power are related (Fabiano et al. 1984), and Slee et al. (1994) found \( P_c \propto P_t^{0.7 \pm 0.05} \) at 5 GHz for a sample of 140 galaxies ranging in radio power from \( 10^{29} \) to \( 10^{30} \) W Hz\(^{-1} \). Fig. 7 suggests that a similar relation applies for the nearby GPS galaxies in our sample.

5.2 Core spectral index

The distribution of the spectral indices \( \alpha_e^c \) listed in Table 1 is consistent with that of the medium-power sample studied by Slee et al. (1994). These authors attribute the inverted spectral indices of the galactic cores to a combination of SSA and free-free absorption (FFA) for sources smaller than \(~1\) mas. For SSA to be responsible for the spectral turnover, the magnetic fields must be either much stronger than previously thought or well below equipartition values, with the energy in relativistic electrons greatly exceeding that in magnetic fields. Orienti et al. (2008) find that equipartition does hold for high frequency peaking sources, requiring stronger magnetic fields than previously estimated by Slee et al. (2004). For sources larger than \(~1\) mas, SSA is no longer viable. Higher resolution observations of our GPS sample are needed to determine the angular size and structure of the central emission region.

5.3 Variability

GPS galaxies are the least variable class of compact radio sources (Rudnick & Jones 1982). GPS radio sources in general show a low incidence of variability (\(~10\) per cent, O’Dea 1998 and references therein), and many of the high frequency peaking sources are QSOs that show peaked spectrum only during outburst/flare events. This is supported by Torniainen et al. (2005) who find that nearly all quasar-type GPS sources are variable both in spectral shape and radio power with only a small fraction being ‘genuine’ GPS sources. As our sample of sources contains only galaxies, we might therefore expect very little variability to be present, but longer term monitoring is needed to test this. At least two objects in the sample, J051103–255450 and J220916–471000, already show some evidence of variability, as noted in Section 4.

5.4 Extended low-frequency radio emission

At least two of the sources in our sample, J074618–570258 and J181857–550815, show extended low-frequency radio emission on scales of 100 kpc or larger. These may be ‘restared’ radio galaxies in which the current phase of nuclear activity has been caught at an early stage.

It is particularly remarkable that our GPS sample, selected at 20 GHz, includes the giant radio galaxy J074618–570258 which was first identified by Saripalli et al. (2005) on the basis of its extended low surface-brightness radio emission at 843 MHz. When the redshift coverage of the AT20G GPS sample is completed, it should allow a more detailed study of the duty cycle of activity in nearby radio galaxies.

6 CONCLUSIONS AND FUTURE WORK

We have presented 6 cm e-VLBI observations of 10 low redshift, low radio power GPS galaxies selected from the AT20G survey. The angular resolution of the e-VLBI observations was sufficient to confirm the compact nature of the targets, but not high enough to differentiate between edge-brightened and jet dominated GPS sources. Such a differentiation is required to investigate the possibility of a luminosity–morphology relationship in radio galaxy progenitors, similar to the FR I/FR II relationship. The e-VLBI observations do allow us to devise follow-up VLBI observations using the full LBA at a higher observing frequency, to obtain higher angular resolution. The value of e-VLBI observations in this context is that fast feedback can be obtained regarding the detectability of the targets, allowing the rapid selection of a sample for more detailed follow-up observations.

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