TDP Calibration and Processing Group Memo. #7
Longitudinal study of dynamic range in interferometric images of 3C273

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ABSTRACT

This memo examines achieved interferometric dynamic range for the source 3C273 in a longitudinal study of observations reported over the period from 1975 to 2010. The goal of this study is to examine the evolution of achieved dynamic range in response to increased interferometric array sensitivity over time in order to inform related technical issues for the future Square Kilometer Array.

1. Data for longitudinal study

The Square Kilometer Array poses challenging continuum imaging dynamic range requirements. However given that it is technically very difficult to reliably predict precise achievable dynamic range from a specified system design alone it is instructive to examine current and past community experience in high dynamic range imaging as a complementary method of studying this issue (Chakraborty & Kemball 2009). The current memo extends our past work in this area to a longitudinal study of the evolution of dynamic range in interferometric images of 3C273 reported from 1975 to 2010 over a period of increasing interferometer array sensitivity. This individual source was chosen on the basis of its flux density and enduring scientific currency as a target of interferometric imaging studies.

This section is a compilation of the results for dynamic range of the images of 3C 273 synthesised over nearly the last three decades. These results appear in various forms in the literature over the years such as in the form of rms noise values, fractions of peak intensity, various polarisation modes or total intensity, or simply the dynamic range itself. A detailed compilation is made until 1993 by Conway et al., (1993) and we include their compilation along with later result(s) such as those reported by Jester, et al., (2005). These observations include the VLA and MERLIN telescopes in various configurations.

1.1. VLA

Foley et al., (1985) report observations of 3C 273 at 408 and 1666 MHz. Maps of the jet are made at these two frequencies with contour levels from 0.2 % of the peak to 80 % of the peak. Conway et al., (1993) describes various observations of 3C 273 made at different frequencies. Some

of these are VLA observations with different configurations. Figure 1a of Conway et al., (1993) is a 2 cm map of 3C 273 made with the VLA configuration (B+C) at a frequency 14.4 GHz and has the highest contour at 6000:1 and a noise/ lowest contour level at 3 mJy / beam. Figures 6 in Conway et al., (1993) shows intensity and polarisation maps of the jet at 6 cm in the VLA-B configuration. The intensity map at 4.84 GHz has a contour range of 2500:1 with noise/ lowest contour at 5 mJy / beam. Figure 7 in their paper is a map at 18 cm with VLA-A. The observing frequency is 1.67 GHz and contour range is 10,000:1 with lowest contour at 15 mJy / beam. Jester, et al., (2005) reports a dynamic range of 110000:1 in the VLA U-band at wavelength of 2 cm. Recent results (R. Perley, in preparation) suggest a dynamic range of 330000:1 at 8 GHz.

1.2. MERLIN

Davis et al., (1985) describes observations of 3C273 at 151 and 408 MHz using the MERLIN interferometer. The dynamic ranges reported at these frequencies are $4 \times 10^3 : 1$ and $10^4 : 1$, respectively. Conway et al., (1993) has maps at other frequencies in addition to these maps. Figure 3 in their paper has an intensity map of the jet of 3C 273 at 18 cm which has lowest contour at 10 mJy / beam and the highest contour at 12 Jy / beam. And polarisation maps have a highest contour level at 800:1. Figure 8 is a 73 cm map which has intensity contours at 8000:1 at 408 MHz with the lowest contour at 15 mJy / beam. A VLBI observation in Unwin, et al., (1994) includes a MERLIN alone map which has a dynamic range in excess of 50000:1.

2. Time Evolution of Dynamic Range

We study the time evolution of dynamic range over nearly three decades from 1970 to 2010. The combined data from the references cited above are summarized in Table 1. The data are diverse in terms of reported values relevant to dynamic range, as noted above. In cases where papers do not cite off-source noise levels explicitly, we assume the lowest contour to be at 5σ. In the Figure 1 below, we plot the time evolution of dynamic range. We plot the highest recorded dynamic range at any frequency in that year.

Our preliminary finding from these data, despite their uncertainties, is encouraging for future SKA. It shows broadly that achieved dynamic range broadly tracked increases in array sensitivity over time. This has unquestionably been accomplished by advances in both hardware performance and the sophistication of interferometric calibration and imaging algorithms.

Survey/Telescope	Frequency (MHz)	Year	Best dynamic range	Reference
Cavendish 5 Km telescope	5000	1975	78:1*	[1]
VLA-A	1665	1985	667:1	[2]
VLA-B	4835	1985	250:1	[2]
VLA-(B+C)	14435	1989	2571:1	[2]
MERLIN	408	1981	410:1	[3]
MERLIN	408	1984	80:1	[4]
MERLIN	408	1985	10,000:1	[3]
MERLIN	151	1985	4000:1	[3]
MERLIN (VLBI)	1666	1994	50,000:1	[5]
VLA U-band	$\sim$ 14,000	2005	110,000:1	[6]
VLA	8000	In preparation	330,000:1	[7]

Table 1: Dynamic range limits using various telescopes - The starred (*) values are using polarised flux density.

[1] Ryle et al., (1975)
[2] Conway et al., (1993)
[3] Davis et al., (1985)
[4] Thomasson et al., (1986)
[5] Unwin, et al., (1994)
[6] Jester, et al., (2005)
[7] Perley, in preparation

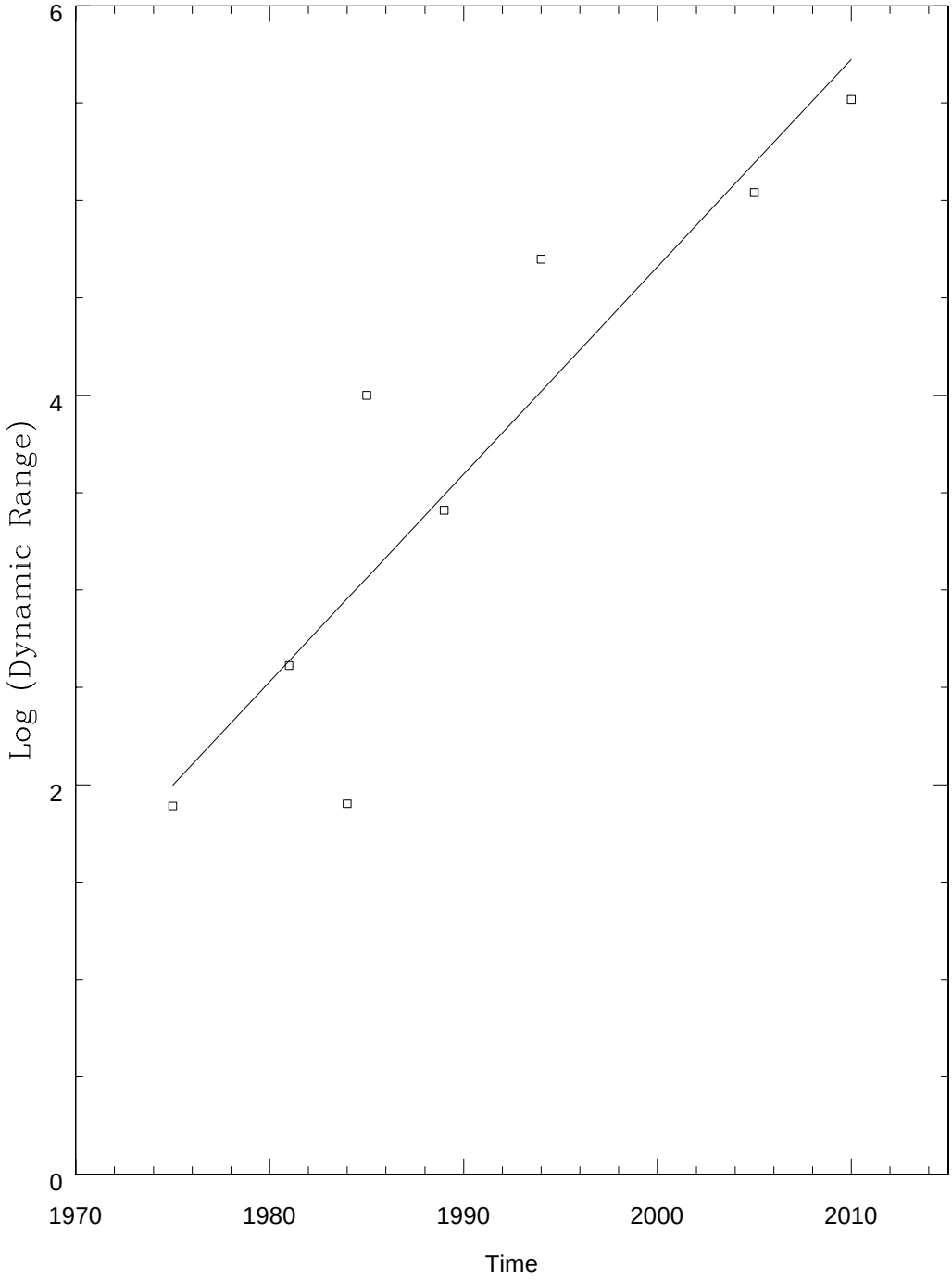

Fig. 1.— The above figure shows the highest imaging dynamic range obtained in a given year vs the year.

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