Possible science with a 6-dish xNTD

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Abstract

An early deployment of the xNTD could see 6 dishes with full focal plane array capability installed at the Mileura site by the end of 2008. The system would have a factor 4-5 less collecting area than the complete xNTD with resultant lower sensitivity by a factor of ∼20. I show here that unique H I science can be done with the early deployment instrument. For example, in excess of 1000 galaxies with M* detections to z∼0.13 can be achieved with modest integration time over a region of 30 square degrees. This goes significantly deeper than the Parkes HIPASS survey and detects more galaxies per unit area than the Arecibo AGES survey. Furthermore, obtaining the science will provide a complete shakedown of the system and allow better planning and characterisation of the eventual full-scale surveys.

1 Introduction

As an early step towards the installation of the full xNTD at the Mileura site, an early deployment is considered consisting of 6 antennas fully equipped with focal plane arrays.

H I science is one of the prime drivers of the full xNTD system. I have shown elsewhere that a minimum requirement for the xNTD survey is the detection of 500,000 galaxies across the entire sky with all M* galaxies detected up to at least z ∼0.1. This 'shallow' survey covers redshifts corresponding to the available 256 MHz of bandwidth. Such a survey would take up to one year of observing time. A precursor survey with the early deployment system could mimic this survey over a smaller field of view. This would already give an idea of the expectations for the large scale survey and do unique science in its own right.

Below, I will outline the hardware expectations and the science possible with the early deployment system.

2 Hardware expectations/assumptions

The early deployment system will consist of 6 antennas each of 15-m diameter. A focal plane array on each antenna will deliver a FoV no smaller than 30 square degrees at 1 GHz and will operate between at least 0.8 and 1.7 GHz. System temperature will be 50 K. Full beam-forming and correlator capacity (for a 15 baseline system) should be available. The necessary control and on-line software will allow data capture, with storage space and off-line imaging software on hand for data reduction.

The configuration of the antennas remains an issue (see below).

3 Science

The science case for observing H I is taken as a given. The early deployment system could mimic the survey of the full xNTD by observing a single pointing (30 square degrees) for about 15 days. This mini-survey would (a) detect in excess of 1000 galaxies, (b) find M* galaxies to z$\sim$0.13 and (c) exploit the full 256 MHz of bandwidth. Although the number of detections is only about one-quarter that of the HIPASS survey, the majority of the galaxies detected will be at distances larger than any of the HIPASS galaxies! A further useful comparison is with the Arecibo 'deep' (AGES) survey, which will cover 200 square degrees in about 45 days observing time. That survey will detect roughly 2000 galaxies but at lower red-shift than the mini-survey proposed here.

Small area surveys suffer from 'cosmic variance' issues. We could perhaps use this to our advantage by choosing a region known to be rich in H I galaxies. In any case, it will give some initial handle on the evolution of the gas between the present at z=0.1.

Note that this is an interferometric survey with all the advantages that has over the single dish surveys at Parkes and Arecibo (much less interference, reduction of standing waves, proper continuum subtraction etc).

This survey could be extended by increasing the survey area, with each further 15 days observing time gaining another 30 square degrees. Extensions to deeper redshift are not really viable with the low sensitivity; far better to wait for the full xNTD capability.

To obtain accurate positions and optical identifications, a minimum of $\sim$40 arcseconds would be useful, corresponding to a baseline of $\sim$1 km. Note that Arecibo, with its $\sim$3 arcmin beam finds it difficult to obtain optical IDs from H I detections.

Continuum science should not be neglected either. After 15 days observing, the 1-σ detection limit is $\sim$7μJy (assuming a 256 MHz bandwidth) over the field of view. Unless the baselines are sufficiently long, the survey will be confusion limited, at least in total intensity. Also, it's likely that the rather poor imaging quality with only 15 baselines will be an issue. The polarization properties of the focal plane array could be well tested in this observing scheme. Transient detection might be possible. In 12 hrs, the 10-σ detection limit is $\sim$400 μJy.

VLBI would also be possible at 1.6 GHz with east coast telescopes. This would be especially good if the optical fibre links were in place. Note also, VLBI with South Africa would be enhanced with a system in Mileura and might provide an early science collaboration point.

4 Discussion points

The entire system needs to be in working condition from front to back. Getting such a system fully working could obviously detract from the larger xNTD goal and could delay the implementation of the final system. However, having a science case gives focus and would allow some early kudos and publications.

Long baselines would be desirable to obtain good positions and avoid confusion. On the other hand, having one very short baseline might be useful to look at the effects of cross-talk between the feeds in different antennas. A fixed configuration with 6 elements is rather sparse. Is there any possibility of moving the antennas?

Correlator capacity. An early version of the correlator, able to cope with 15 baselines needs to be present. Is this likely?

Data storage. Extrapolating from Tim Cornwell's numbers, the data rate from the survey will be of order 200 Gbytes per hour. Even a 15 day survey will therefore require almost 100 Tbytes. This is a significant amount.

The on-line computing capability needs to be present and/or the data need to be stored and trucked out to a computer elsewhere.

5 Conclusions

We will not do killer science with a 6 element xNTD. However, we can devise useful experiments which will give interesting science results at the same time as providing a shake down of the system. Providing a science driver brings focus to the project and can allow for early establishment of the benefits of the xNTD (and Mileura) generally. The costs and time of getting a full 6 element system working needs to be weighed up against achieving the overall xNTD. A go/no-go decision on the whole scenario of dish + FPA could be taken at this point.