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Imaging Spectral-Line Deep Fields in the SKA-Era: insights from CHILES and DINGO

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Neutral hydrogen plays a central role in both driving and regulating star formation over the last 4.6Gyr. Observations show that the star formation rate has dropped by a factor of 3 over that range [1], with the larger galaxies forming most of their stars earlier and the smaller galaxies still forming stars today. The low mass galaxies have either not formed stars efficiently over their lifetime as compared to more massive galaxies, or they have acquired their reservoirs late. It is essential to have a complete unbiased survey of the HI mass of a large range of galaxy masses over a large range of redshifts. Thus there are a number of deep HI surveys planned and on-going that are attempting to answer these questions.

Deep Spectral Line imaging with SKA and the pathfinders, however, is one of the greatest challenges for the next generation instruments as the data volumes are too large to store the raw visibilities to be used for forming the final image. The current plans are for the instruments to have sufficient storage for one day of spectral line data; deep imaging will then be formed from many days of observations.

COSMOS HI Large Extragalactic Survey (CHILES) is a legacy survey on the ngVLA, and has now observed over 1000 hours over 5 epochs in B-array. These observations are made up of several hundred individual observing sessions. The total data volume from CHILES is about that of a single day of SKA observing. We have been using CHILES as a test dataset for Data Intensive Astronomy in designing an actual SKA-Scale data flow [2], using the innovative data manager DALiuGE. This has provided important inputs into the second HI survey we will discuss.

The Deep Investigations of Neutral Gas Origins (DINGO) survey has been allocated 2,500 hours for the deepest field, spread over some hundreds of days. We cannot store the full datasets, as these would be 30PB, so the initial proposal was to form daily images and average these together. The insights from CHILES underline that these would `bake-in' errors. We are actively developing an alternative data processing pipeline, in which we store the daily datasets as gridded data [3]. These grids are sparse, so can be stored efficiently. Gridding the data in this manner forms a product that is of the same scale as the image and applies to correct kernels, whilst maintaining the ability to flag, reweight or even recalibrate the data. Thus this approach addresses the greatest risk in the current strategy. We report on our progress in quantifying the numerical errors and any improvements in the standard processing approaches that will be required.

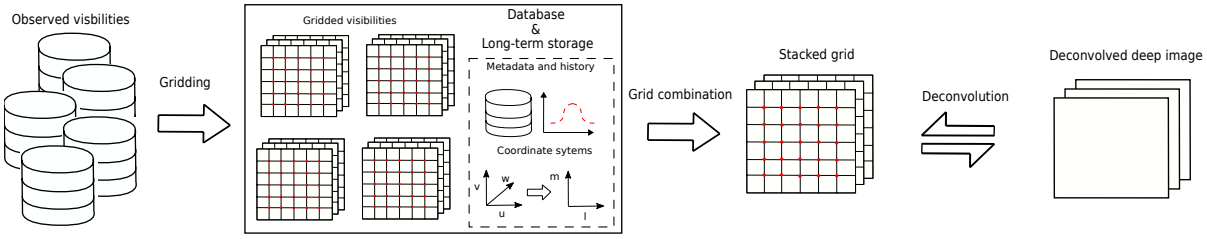

Fig 1.: *Deep imaging pipeline: Raw observed data is discarded after the gridding step and only sparse grids and associated metadata are stored in a dedicated database. After the preconditioning is applied the daily grids are stacked together. The deep image is formed via deconvolution in a minor- major-cycle fashion, applying further calibration on the gridded data if needed.*

References

[1] Hopkins & Beacom, 2006, "On the Normalization of the Cosmic Star Formation History", ApJ, 651, 142
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[3] Rozgonyi, K. 2021, "Deep interferometric spectral line imaging by gridded visibilities", PhD, UWA