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Extending REACH: A Scalable Backend for Multi-Receiver 21cm Observations

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1 Extended Abstract

The Radio Experiment for the Analysis of Cosmic Hydrogen (REACH) [1] is a pioneering instrument that aims to detect the 21cm global signal from the early Universe. We propose an extension to REACH that supports multiple receivers while maintaining a common backend. This enhancement aims to improve the ability to mitigate systematic effects in 21cm cosmology observations. The current REACH system employs a single-receiver configuration with a single dipole antenna. Our proposed extension introduces support for multiple receivers, each dedicated to a single antenna, while preserving the existing digital backend architecture.

Each receiver in the extended REACH system is described through configuration files using the YAML format. This approach allows for flexible and easily maintainable receiver setups. Similarly, all hardware components are described using YAML files, with each individual component assigned a unique ID. This ID system enables differentiation between identical devices in different receivers connected to the server, ensuring precise control and monitoring of the entire system.

The extended REACH system supports both calibration and on-sky observations with any subset of receivers enabled. This flexibility allows for targeted observations, system maintenance, and gradual scaling of the experiment without disrupting ongoing operations. Sky spectra from multiple receivers are synchronized to within the sampling time of the spectrometer. Such precise synchronization is not required for calibrator source spectra or S11 measurements.

The receiver monitoring and remote control systems have been upgraded to support multiple receivers. This enhancement enables centralized management of the instrument, allowing operators to monitor the status of all receivers in real-time and make adjustments as needed. The system provides comprehensive telemetry data and allows for individual or group control of receivers, facilitating efficient operation and troubleshooting.

These extensions to REACH's digital backend and control systems represent a significant advancement in global 21cm experiments. By leveraging multiple receivers with a common, flexible backend, we aim to enhance REACH's capabilities in probing the early Universe, potentially leading to groundbreaking insights into cosmic dawn and the epoch of reionization.

References

[1] E. de Lera Acedo et al., "The REACH radiometer for detecting the 21-cm hydrogen signal from redshift z ≈ 7.5–28," *Nature Astronomy*, **6**, September 2022, pp. 984–998, doi:10.1038/s41550-022-01709-9.