ELT-SKA Synergy: Detecting reionization using galaxy – 21 cm cross correlation

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Abstract

The cosmic 21-cm signal is our best bet to measure the Epoch of Reionization.

An early detection with the SKA will be hard to trust.

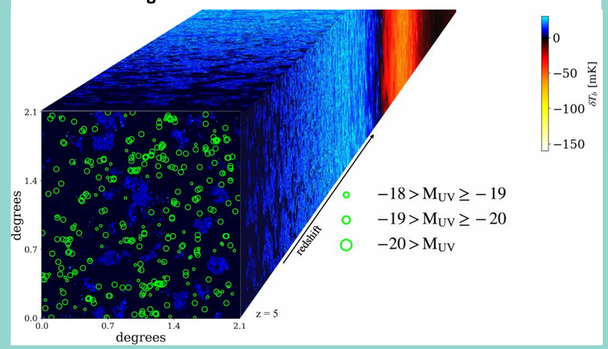
Galaxy cross-correlation is necessary.

ELT MOSAIC spectroscopy provides the sensitivity and redshift precision necessary to both confirm a 21-cm signal and probe the physics of reionization.

Methodology

- used 21cmFASTv4 to self-consistently simulate 1 Gpc³ volumes of 21-cm and galaxy fields.
- dark matter halo-galaxy connection via empirical scaling relations
- galaxy selection based on Lyman alpha in forecast
- forecasted galaxy—21-cm cross-power detectability using realistic noise model for SKA and redshift uncertainties in galaxy survey

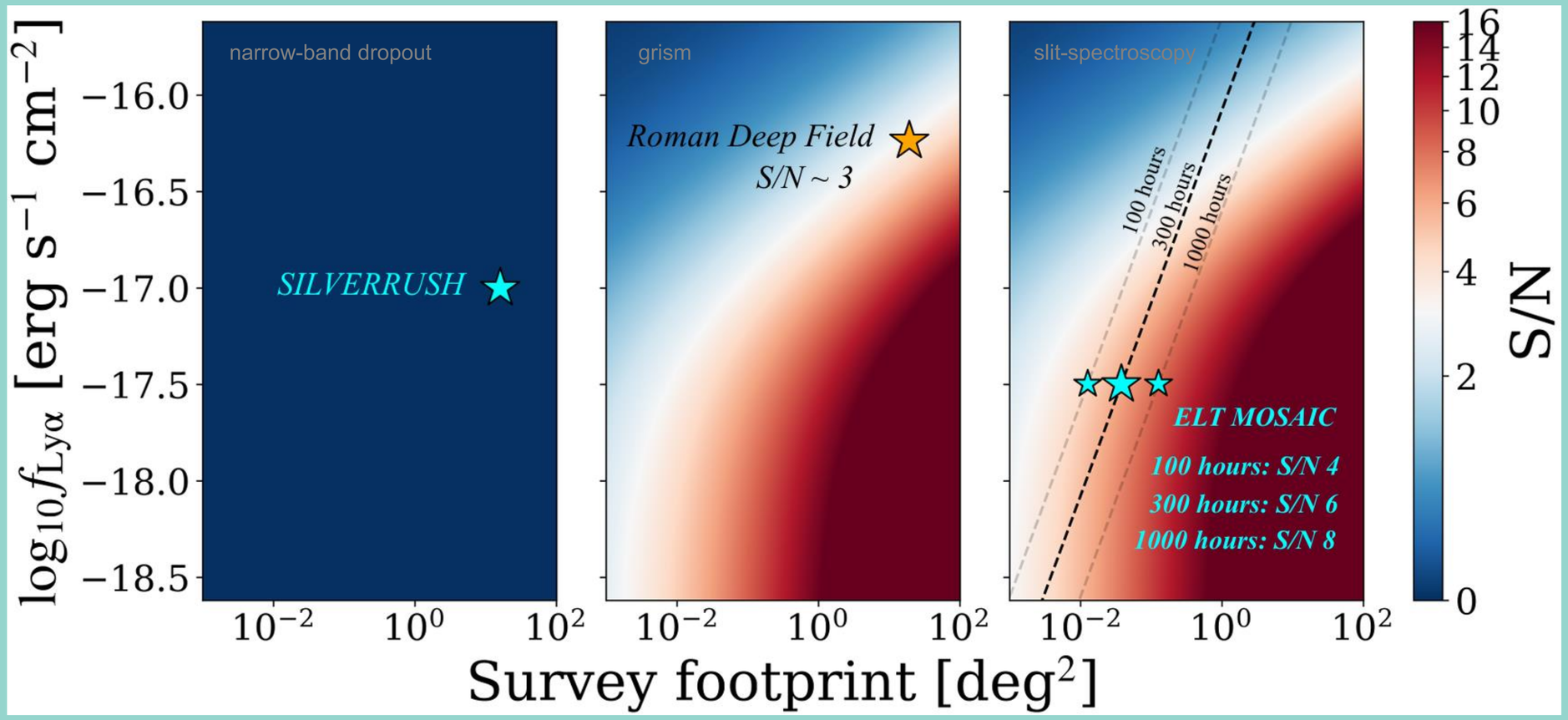
21-cm field and galaxies at z~5



Results

An **ELT MOSAIC** spectroscopic follow-up survey covering a contiguous field of **~80 arcmin2** can reach S/N~6 cross-power with an overlapping SKA-low 21-cm field in **~300 hours**.

- This detection, being deeper and over a smaller area than a prospective Roman-SKA cross-correlation, will be sensitive to different physical scales, and therefore **probe different physics**, than the SKA-Roman detection
- An opportunity for a unique European contribution to reionization science!



Conclusion

ELT MOSAIC is a perfect candidate to confirm a preliminary detection of the 21-cm signal made using the SKA.

This is an opportunity for ESO-SKA synergy and is a **primary science case** for the ELT instrument.

Italian-led efforts on ELT MOSAIC will be critical to EoR science in the 2030s, securing funding and prestige for decades to come.

Main Figure

This figure shows the signal-to-noise ratio (S/N) of a galaxy—21-cm cross-spectrum detection for three possible Lyman-alpha-selected survey types (left: narrow band dropout, middle: grism, right: slit spectroscopy) and for various configurations of angular survey area and limiting Lyman alpha flux.

The first panel shows that the existing SILVERRUSH survey sample produced by Subaru is insufficient to provide a detection of the cross-power spectrum due to large redshift uncertainties.

The second panel shows that Roman grism can provide a detection, but at low S/N.

The third panel shows that ELT MOSAIC spectroscopy can provide a **better detection** on a **smaller angular area** which probes **different physics** than the Roman detection.

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