Rejection of Tanh Models for the Global 21-cm Signal from Simulated Data: PART 2 *(ongoing work)*

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This document presents additional details about the computations described in Report #80 (`loco.lab.asu.edu/memos/`) entitled *'Rejection of Tanh Models for the Global 21-cm Signal from Simulated Data (ongoing work)'*.

Specifically, here we show the best-fit estimate for the amplitude of the Tanh template, $\hat{A}_{21}$, as well as its uncertainty, and *distance from the true value* normalized by the uncertainty, for the parameter space spanning $z_r = [12, 6.5]$ (equivalent to 110-190 MHz), and $\Delta z = [0, 2]$.

In Figures 1 and 2, the EDGES foreground model has 5 terms, and in Figures 3 and 4 it has 14 terms. For each foreground case (5 and 14 terms), three input cases are simulated: a baseline case with only noise added to the foreground power law, and 2 cases where a Tanh cosmological model has been added to the baseline noise.

In both foreground cases (5 and 14 terms), the injected Tanh signals fall, by construction, within the parameter region accessible for rejection ($2\sigma_{A_{21}} < 28$ mK, where 28 mK represents the true, input amplitude of the Tanh template). It is verified that the regions containing these Tanh signals are, correctly, NOT rejected when using the standard analysis approach. In this approach, the 95% rejection conditions are:

$$(2\sigma_{A_{21}} \geq 28 \ \ \text{mK}) \quad \text{OR} \quad (\hat{A}_{21} + 2\sigma_{A_{21}} \geq 28 \ \ \text{mK}). \tag{1}$$

In the case with 14 foreground terms, numerical problems arise when computing the covariance matrix, but only outside the accessible rejection region. In our implementation, no problems have appeared within the limits imposed by $2\sigma_{A_{21}} < 28 \ \ \text{mK}$.

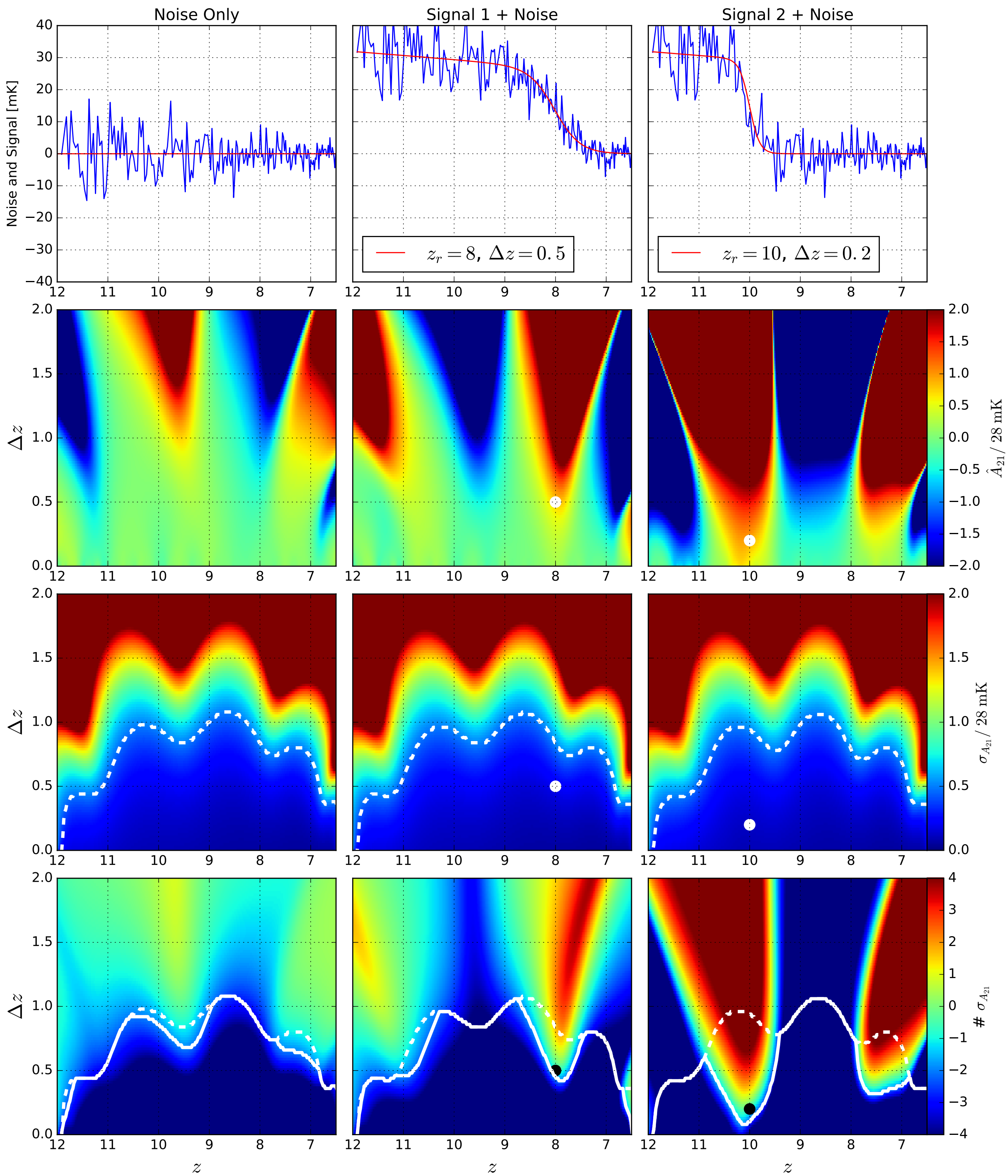

Figure 1: FIRST ROW: Noise and input Tanh signals. The noise realization is exactly the same in the three cases. SECOND ROW: Best-fit amplitude of the Tanh template, $\hat{A}_{21}$, for a foreground model with 5 terms. The color scale is normalized to 28 mK. White dots indicate the location of the input Tanh signals. THIRD ROW: Uncertainties for the amplitude of the Tanh template, $\sigma_{A_{21}}$, normalized to 28 mK. They are very similar in the three cases, since they are computed from the same measurement model. The small differences are due to the different RMS of the residuals across frequency. White dots indicate the location of the input Tanh signals. FOURTH ROW: 95% rejections (solid white lines) derived from the conditions of Equation 1. The locations of the input Tanh signals (shown as black dots) are, correctly, not rejected.

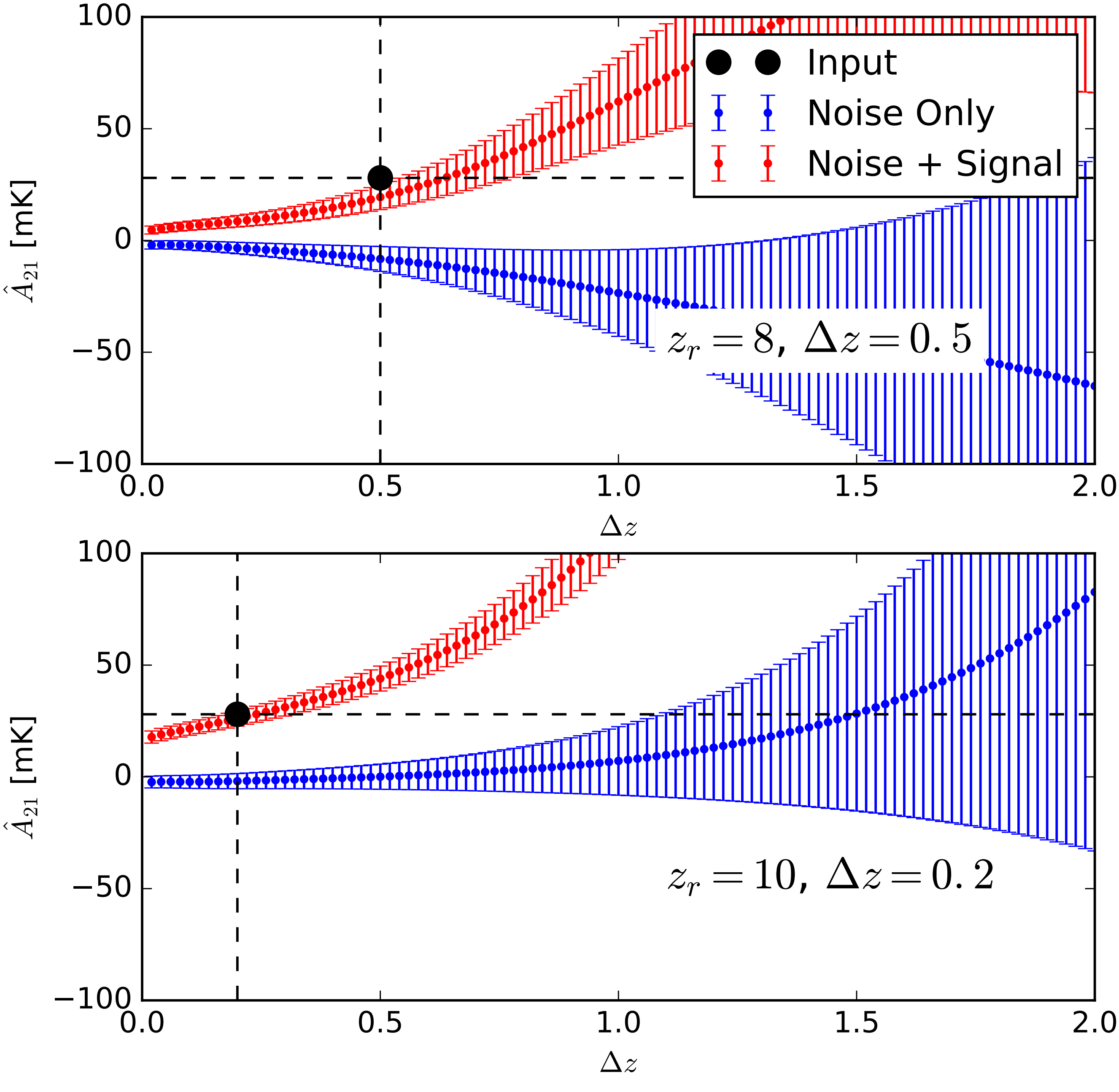

Figure 2: One cut across Δz for each input Tanh signal (in RED), as well as for the baseline Noise Only case (in BLUE), from Figure 1 (5 foreground terms). The cuts are done at the redshift corresponding to each input Tanh signal, i.e., at $z_r = 8$ (TOP) and at $z_r = 10$ (BOTTOM). To within the error bars, the estimates are consistent with the input signal when the signal is present (RED).

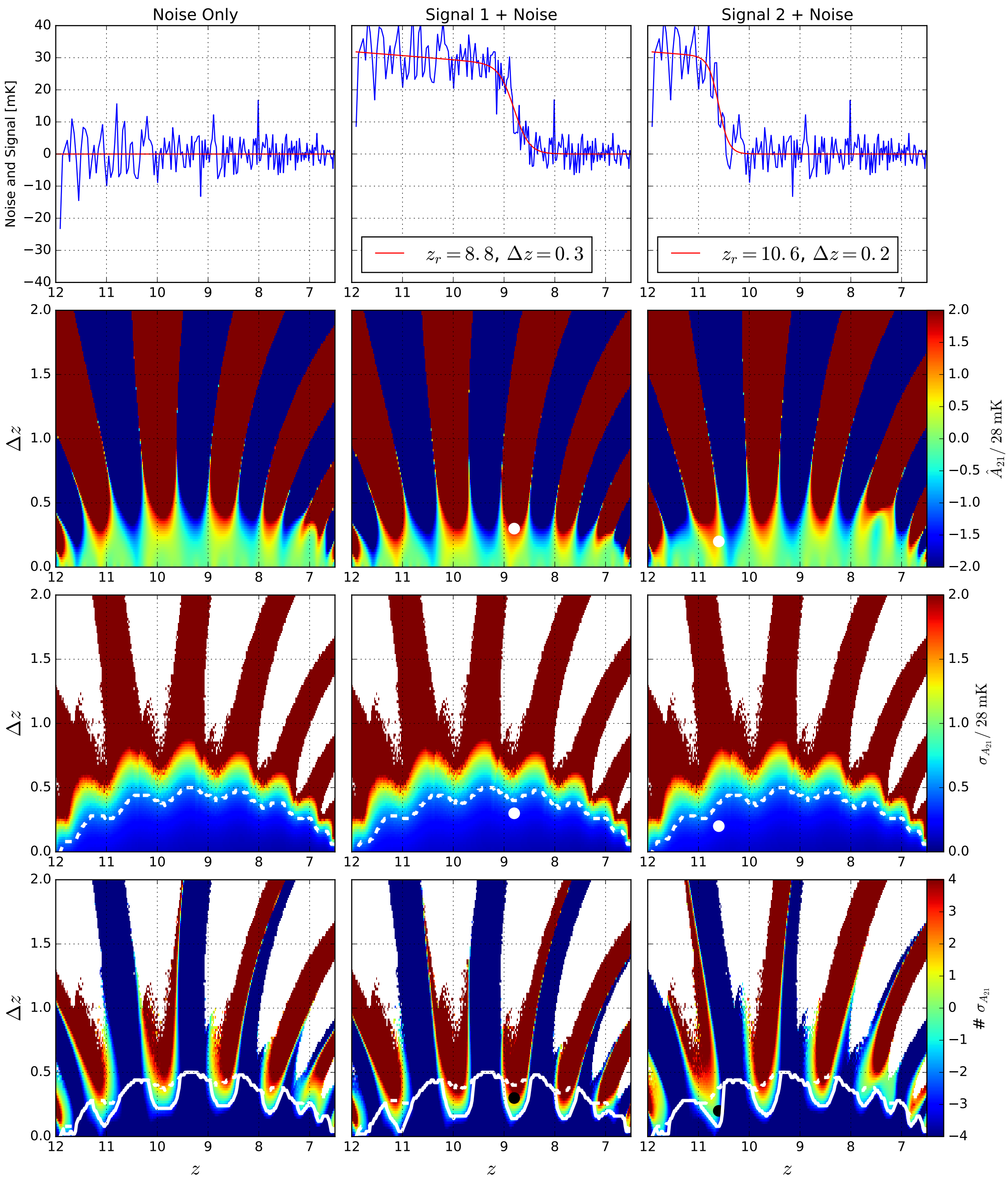

Figure 3: FIRST ROW: Noise and input Tanh signals. The noise realization is exactly the same in the three cases. SECOND ROW: Best-fit amplitude of the Tanh template, $\hat{A}_{21}$, for a foreground model with 14 terms. The color scale is normalized to 28 mK. White dots indicate the location of the input Tanh signals. THIRD ROW: Uncertainties for the amplitude of the Tanh template, $\sigma_{A_{21}}$, normalized to 28 mK. They are very similar in the three cases, since they are computed from the same measurement model. The small differences are due to the different RMS of the residuals across frequency. White dots indicate the location of the input Tanh signals. Numerical problems (large white regions) appear only outside the portion of parameter space accessible for rejection. FOURTH ROW: 95% rejections (solid white lines) derived from the conditions of Equation 1. The locations of the input Tanh signals (shown as black dots) are, correctly, not rejected.

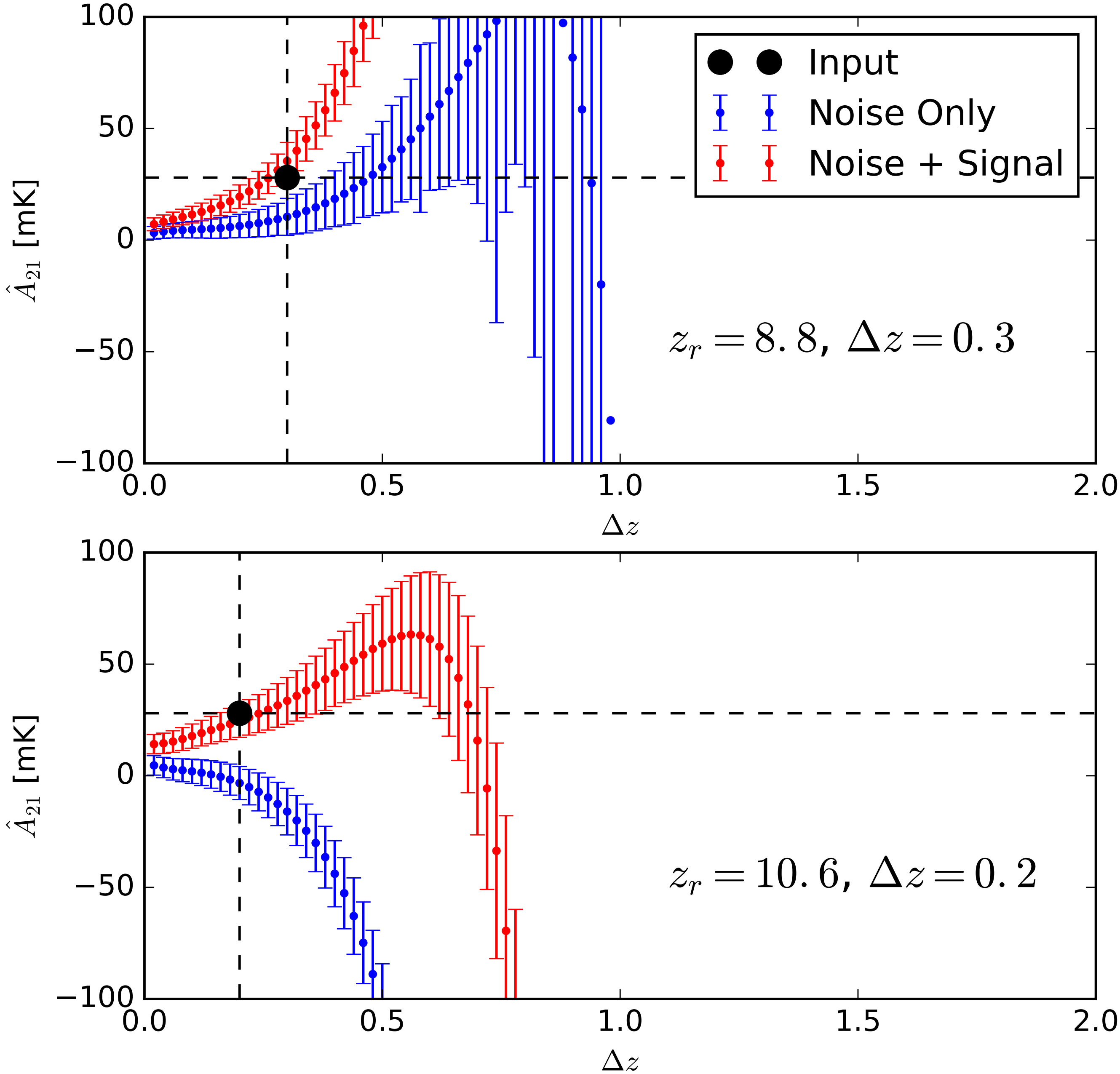

Figure 4: One cut across Δz for each input Tanh signal (in RED), as well as for the baseline Noise Only case (in BLUE), from Figure 2 (14 foreground terms). The cuts are done at the redshift corresponding to each input Tanh signal, i.e., at $z_r = 8.8$ (TOP) and at $z_r = 10.6$ (BOTTOM). To within the error bars, the estimates are consistent with the input signal when the signal is present (RED).