Parameter estimation of massive black hole binaries with aligned spins using eLISA

Sean T. McWilliams for Goddard/Princeton/UMD,*

(Dated: September 1, 2011)

We present results from our performance analysis of a redesigned LISA. We focus specifically on configuration 5, although we expect our conclusions will apply more generally. We performed a Fisher analysis on the aligned spin catalogs, using a waveform model that includes all available post-Newtonian corrections to the inspiral phase and amplitude, as well as a merger model which includes all relevant harmonic content. We do not include spin precession, so the relative amount of improvement due to higher harmonics (HHs) in the merger should be considered an upper limit. The uncertainty itself should also be considered an upper limit, meaning we expect that precession will generically make parameter uncertainties smaller despite the introduction of 4 extra parameters.

We can draw several conclusions from the uncertainty histograms. First, we note that our 4 link results without HHs should be comparable to the results using PhenomC mergers, which also lack HHs. It is interesting that HHs have as large an impact in log space as going from 4 to 6 links does for the distance determination, for both large and small seed catalogs. This seems to be due primarily to the determination of ι, which is the same with 4 links and HHs as it is for 6 links with HHs. Since the majority of the benefit from HHs comes from the very late inspiral and merger, we expect the improvement in distance determination we see to be more dramatic than results that include HHs in the inspiral, but not the merger. Codes with precession and HHs in the inspiral but not in the merger will see even less importance from HHs, as precession may break the same degeneracies that we see broken by HHs. We also see significant improvement in sky localization, with HHs improving latitude and longitude uncertainties by half an order of magnitude. However, this is much less than the improvement one would expect from 6 links, which yields an additional order-of-magnitude improvement beyond the inclusion of HHs. All angle parameters show improvement from HHs, as does the mass ratio, but the uncertainty in spin magnitude is unaffected by either HHs or 6 links.

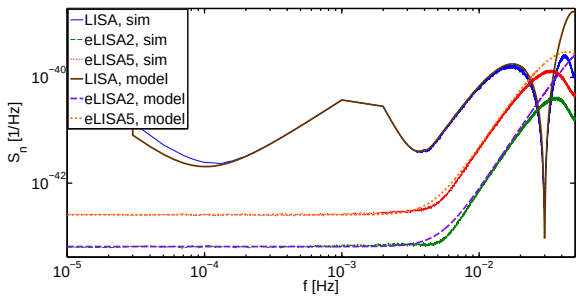

FIG. 1: Comparison of noise model with average of a 1000-case ensemble of noise realizations using SYNTHETIC LISA, for the A channel with classic LISA and configurations 2 and 5.

*Electronic address: stmcwill@princeton.edu

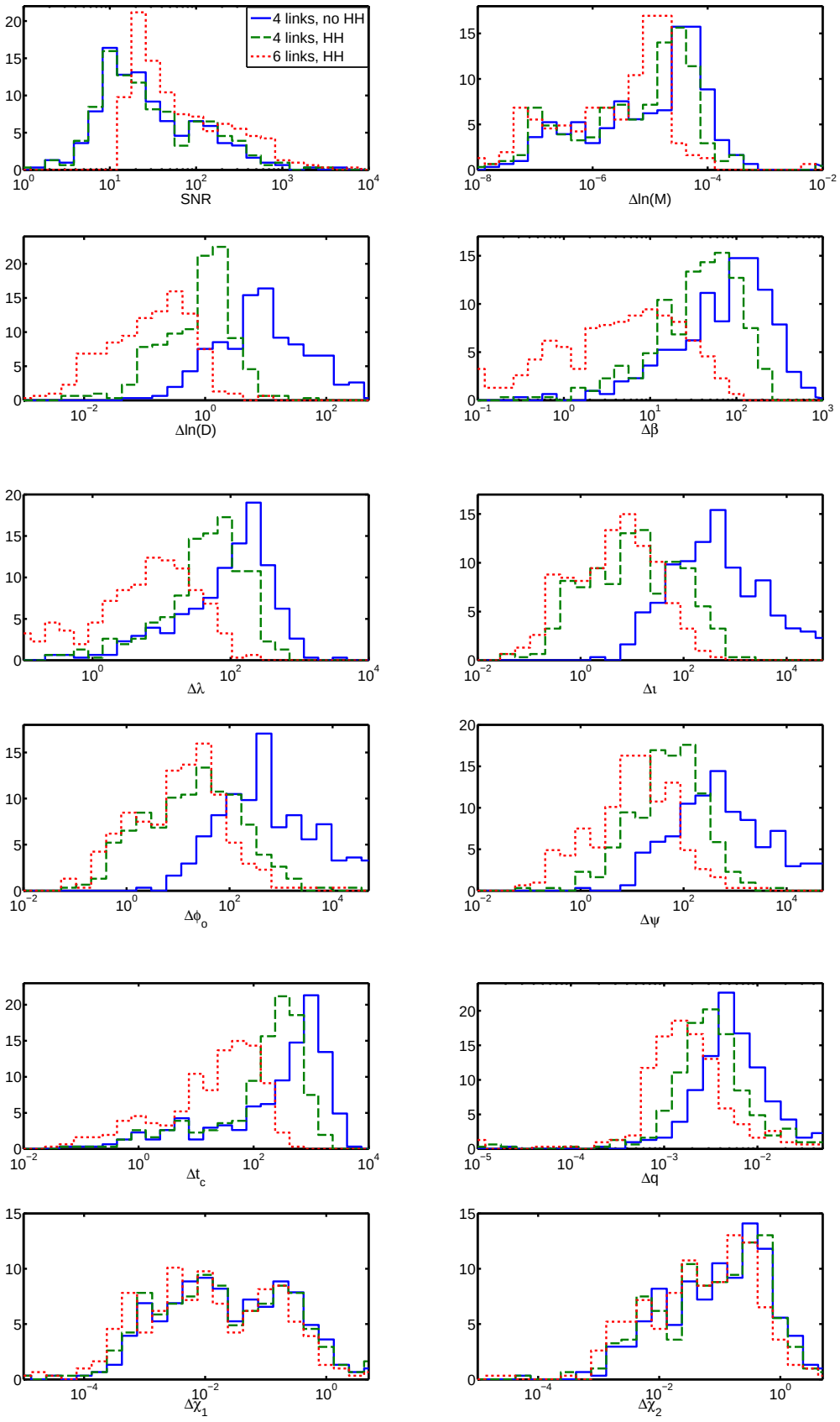

FIG. 2: Uncertainty histograms for the large seed, aligned spin catalog, using the configuration 5 LISA redesign. All angle uncertainties are in degrees, Δt_c is in seconds, and mass and distance errors are fractional. The catalog spin values are not used, but rather all cases are given dimensionless spins $\chi_{1,2} = S_{1,2}/M_{1,2}^2 = 0.5$ due to the limitations of our model for HHs.

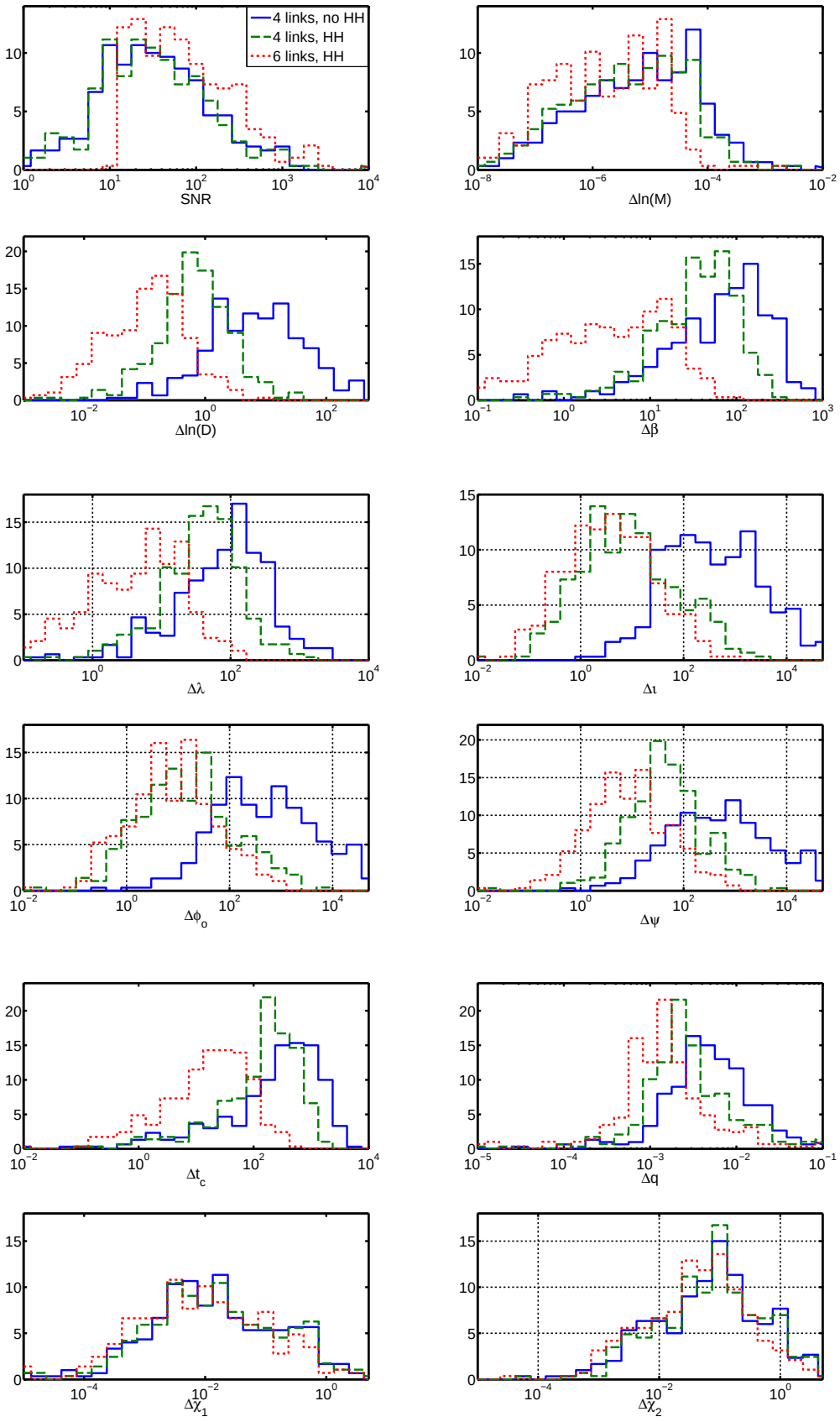

FIG. 3: Uncertainty histograms for the small seed, aligned spin catalog using configuration 5.