

of the left and right panels in that figure also shows that upper limits increase with the uncertainty on background and signal efficiency, as expected.

## V. MEASUREMENT OF THE SINGLE TOP QUARK CROSS SECTION

In this section, we demonstrate the computational feasibility of the methods described above by applying them to the recent measurement of the single top cross section by the D0 and CDF collaborations [22, 23]. Both collaborations use the same form of likelihood function — a product of Poisson distributions over multiple bins of a multivariate discriminant, the same form of evidence-based priors, namely truncated Gaussians, and flat priors for the cross section [24]. As a realistic example, we construct the reference prior for the cross section using one of the data channels considered by D0.

D0 partitioned their data into 24 channels, defined by lepton flavor (electron or muon), jet multiplicity (two, three, or four), number of  $b$ -tagged jets (one or two), and two data collection periods. The discriminant distribution is shown in Fig. 3 of Ref. [22]. Here we consider the electron, two-jet, single-tag channel from one of the data taking periods. The discriminant distribution contains about 500 counts spread over 50 bins, with a maximum bin count of about 40.

We model information about the effective integrated luminosity  $\epsilon$  and the background  $\mu$  for each bin with the help of the gamma priors of Eq. (17). These evidence-based priors describe the uncertainty due to the finite statistics of the Monte Carlo simulations. We do not include systematic uncertainties in this example. Figure 6(a) shows a comparison of the reference prior for the cross section using Methods 1 (the histogram) and 2 (the dashed curve). The jaggedness of the Method 1 prior reflects the fluctuations due to the Markov chain Monte Carlo [19] sampling of the parameters. The increased jaggedness at large  $\sigma$  is due to the fact that the numerical algorithm samples from the flat-prior posterior, whose density rapidly decreases in this region. It is noteworthy that the priors computed using the two methods are very similar for this particular example. This is also reflected in the similarity of the posterior densities, shown in Fig. 6(b). In principle fluctuations in the calculated posterior can be made arbitrarily small by increasing the size of the Monte Carlo sample. For reference, Fig. 6(b) also shows the posterior density using a flat prior for the cross section. An obvious conclusion can be drawn: when the dataset is large, here