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Overview of Bayesian methods for multiwavelength gamma-ray astronomy

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Bayesian data analysis (BDA) gets its name from Bayes's theorem, stating that posterior probabilities for hypotheses are proportional to the product of their prior probabilities and likelihoods (predictive probabilities for the observed data based on each hypothesis). It's tempting to view the Bayesian approach as merely using priors to "modulate" the familiar frequentist maximum likelihood approach. But BDA uses all of probability theory, not just Bayes's theorem. In particular, many Bayesian calculations use the law of total probability to compute probabilities for composite hypotheses (e.g., hypotheses with uncertain parameters). These computations average ("marginalize") the likelihood function, rather than maximize it. Many of the key capabilities of Bayesian methods follow from this key distinction—performing
computations that integrate rather than optimize over parameter space. I will highlight the role of marginalization in a variety of BDA methods relevant to multiwavelength gamma-ray astronomy: counterpart searches (cross-identification), accounting for systematics such as uncertain background rates, period searches using time-tagged event data, and population modeling accounting for measurement errors and selection effects in a hierarchical Bayesian framework.

Presenter: LOREDO, Tom

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