Improved GBM GRB localizations with BALROG

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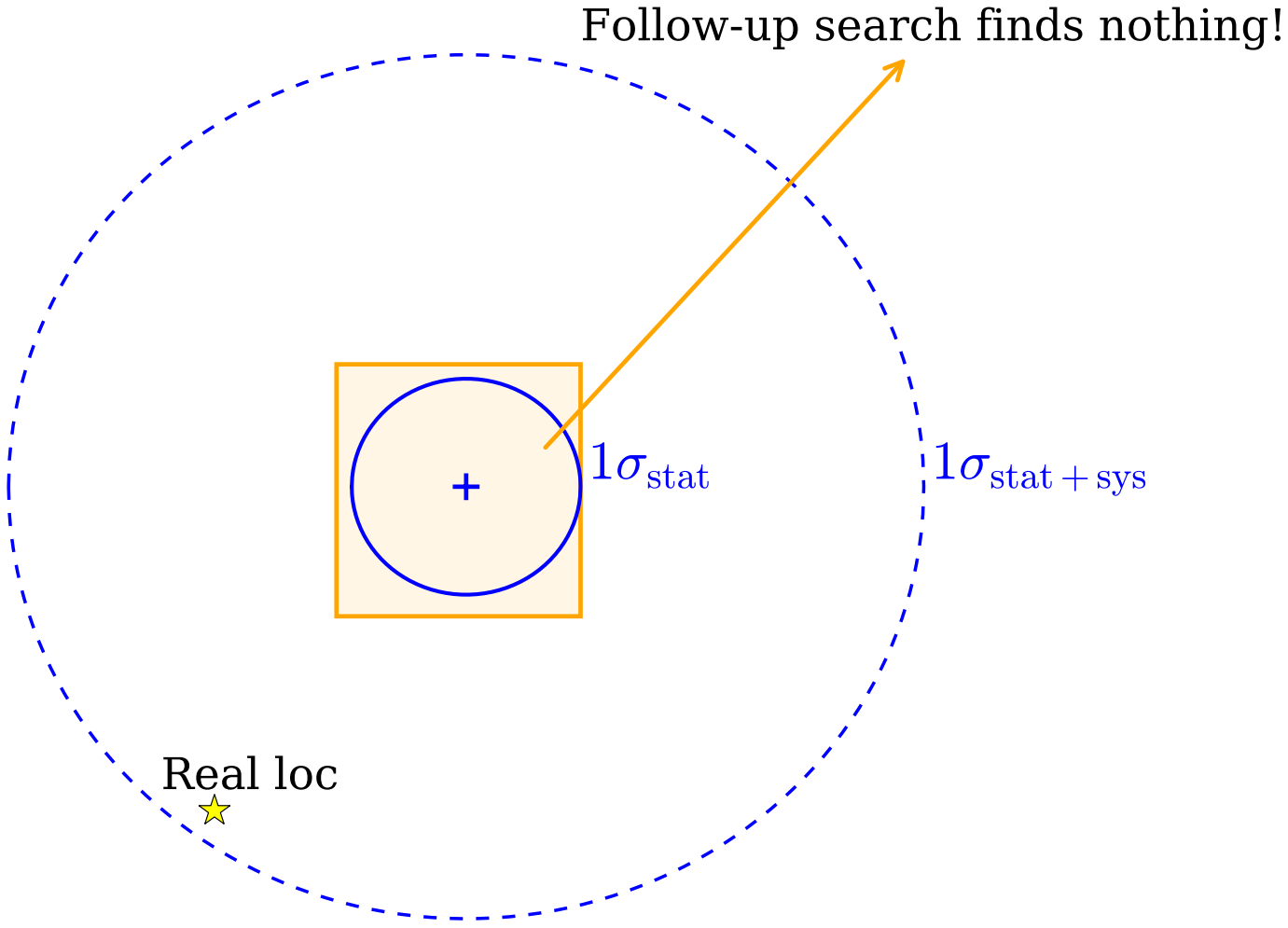
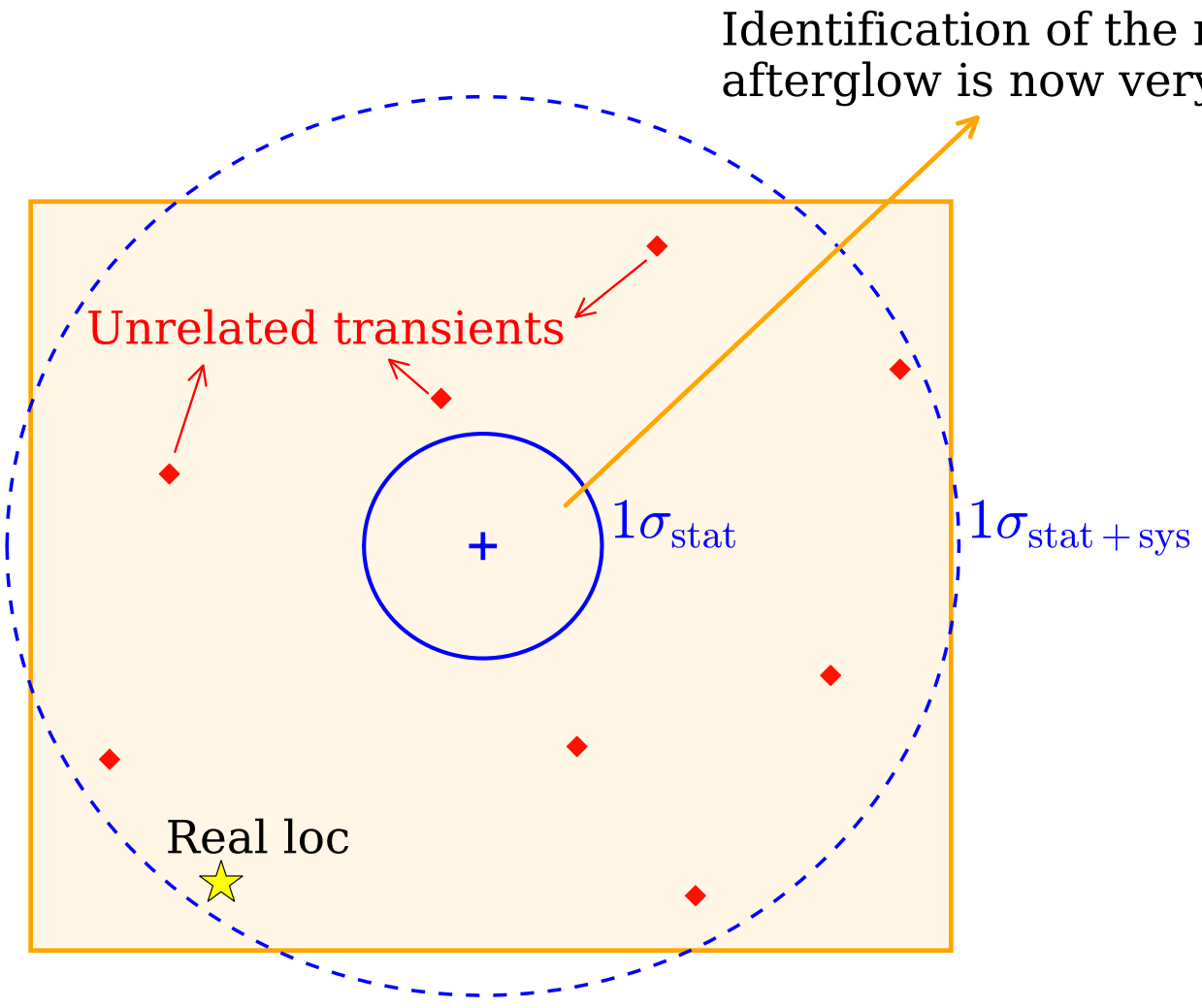
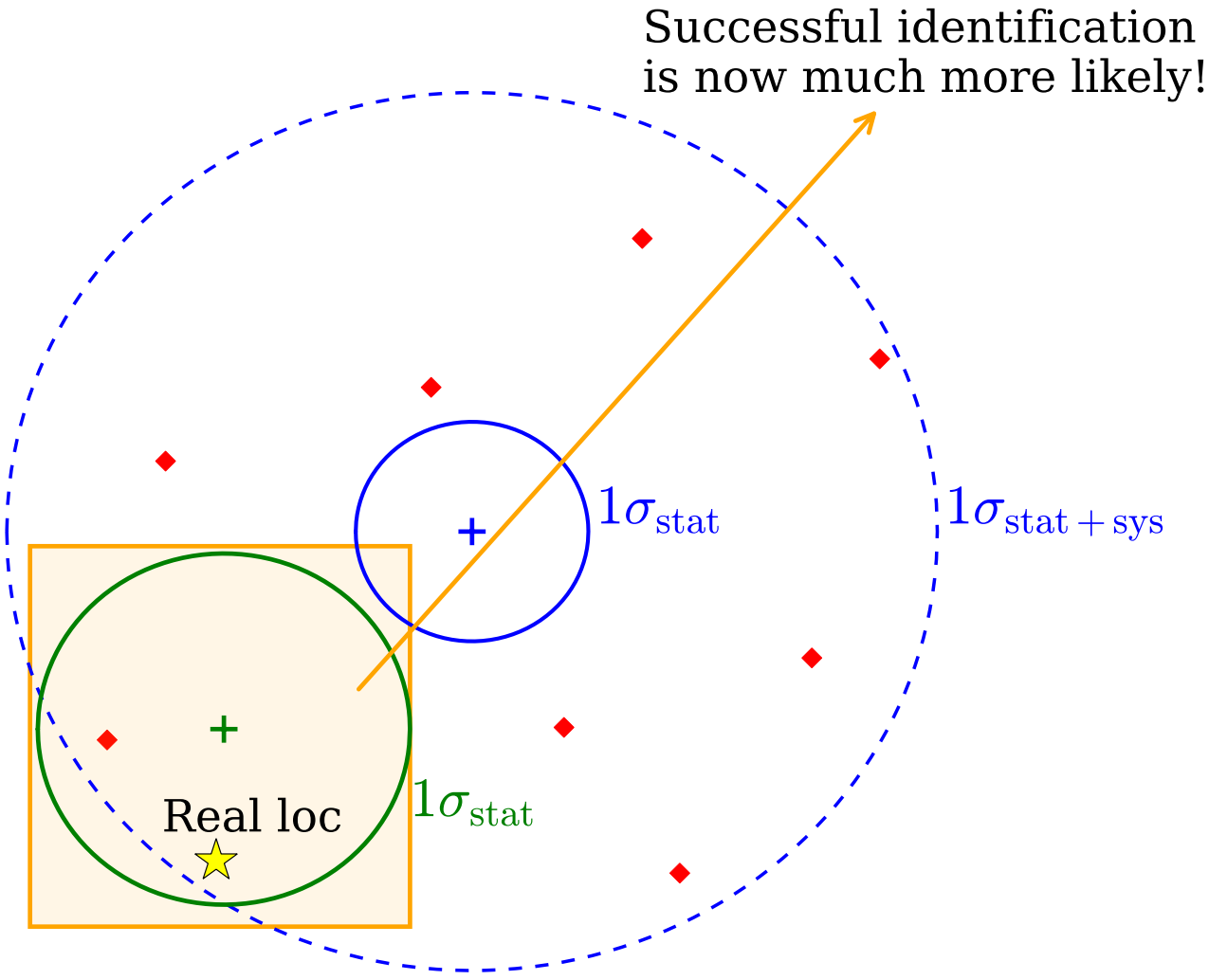
The current state of GBM localizations with DoL code



The current state of GBM DoL localizations with DoL code

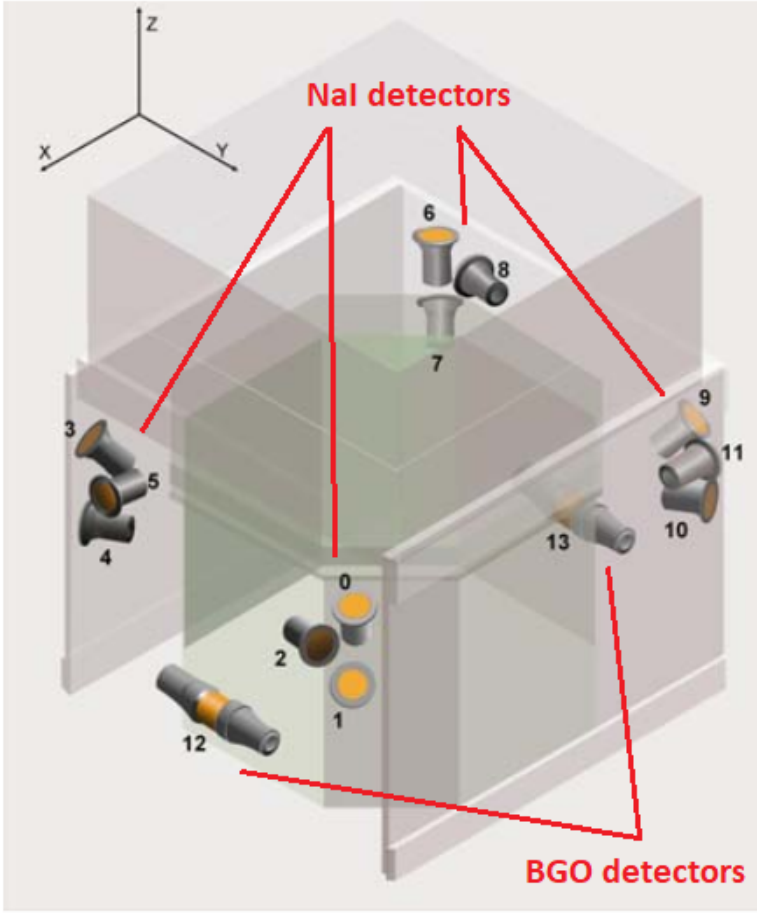


The current state of GBM's localizations with BALROG code



The Gamma-ray Burst Monitor

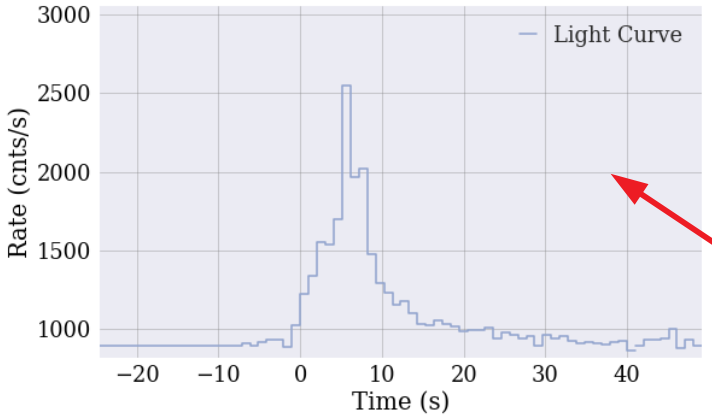
- The Gamma-ray Burst Monitor (GBM) on board the Fermi space telescope is an **array of 14 detectors** built to observe GRBs.
- Each detector is pointing in a different direction, so to provide an **all-sky field-of-view** to the instrument (except the region occulted by the Earth).

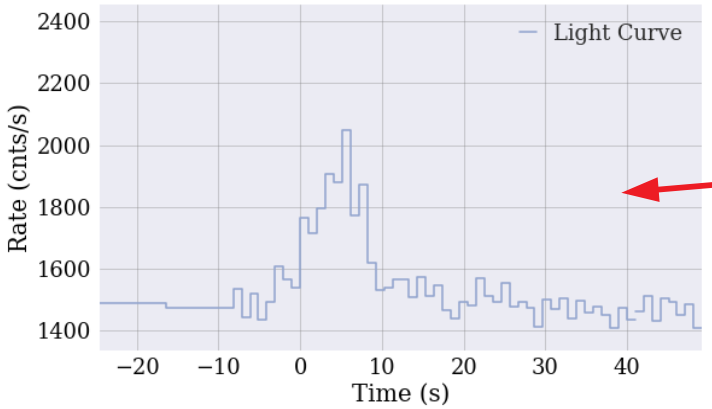


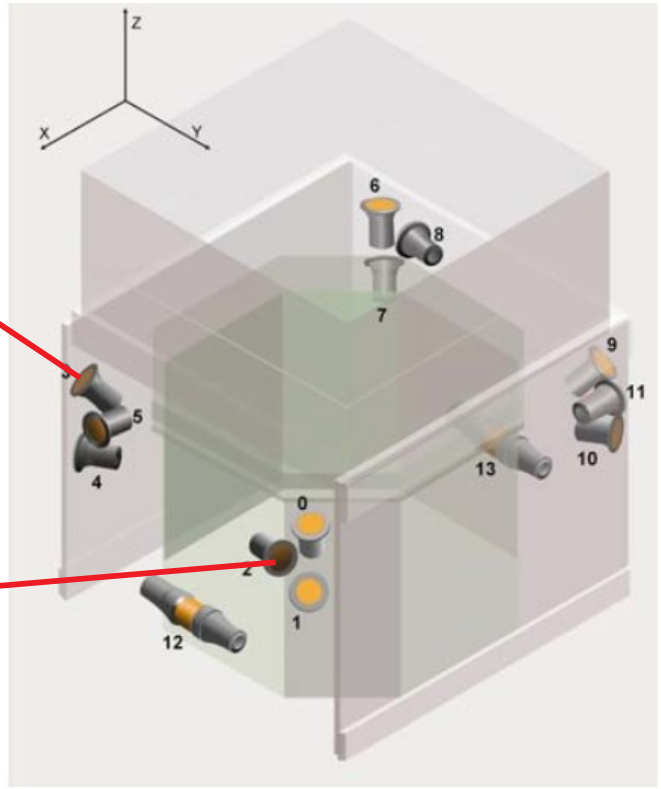
A schematic of the GBM detector array mounted on the Fermi spacecraft (original image from Meegan et al. 2009).

The Gamma-ray Burst Monitor

GBM is not an imaging instrument: only counts are measured!

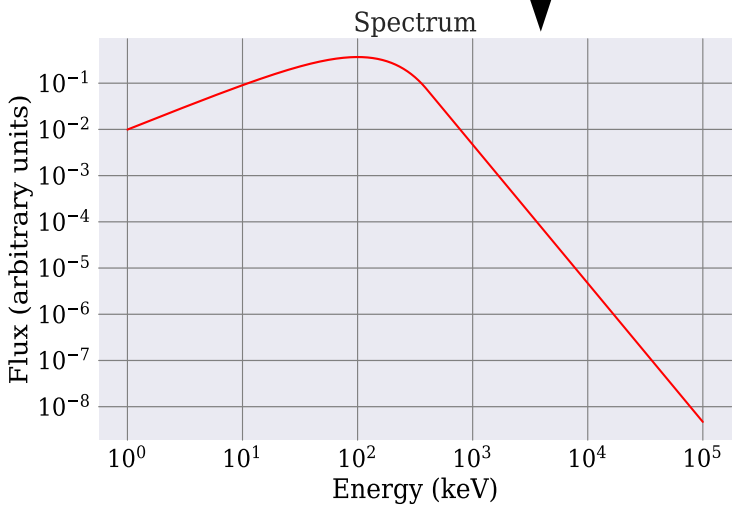




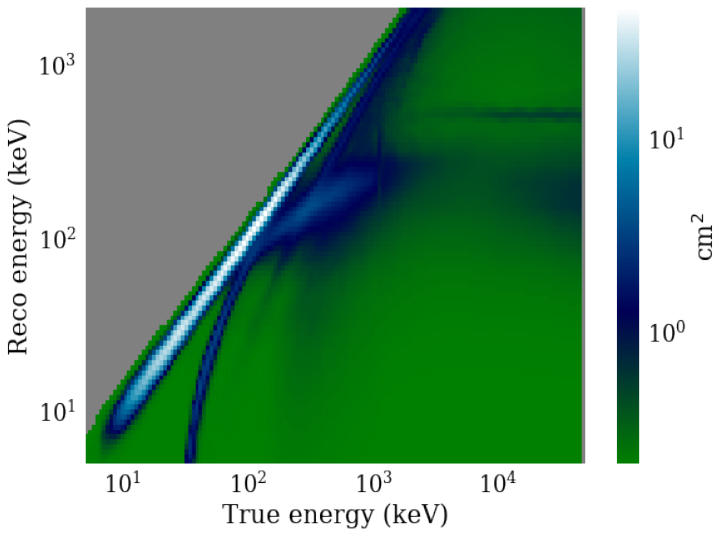


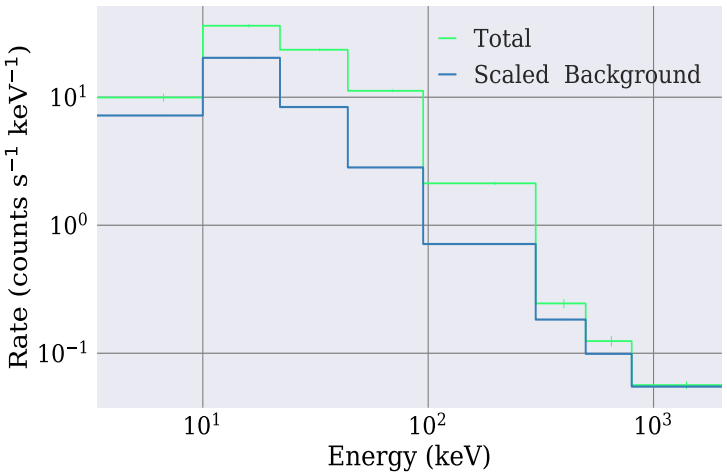
Forward folding

Position proposal



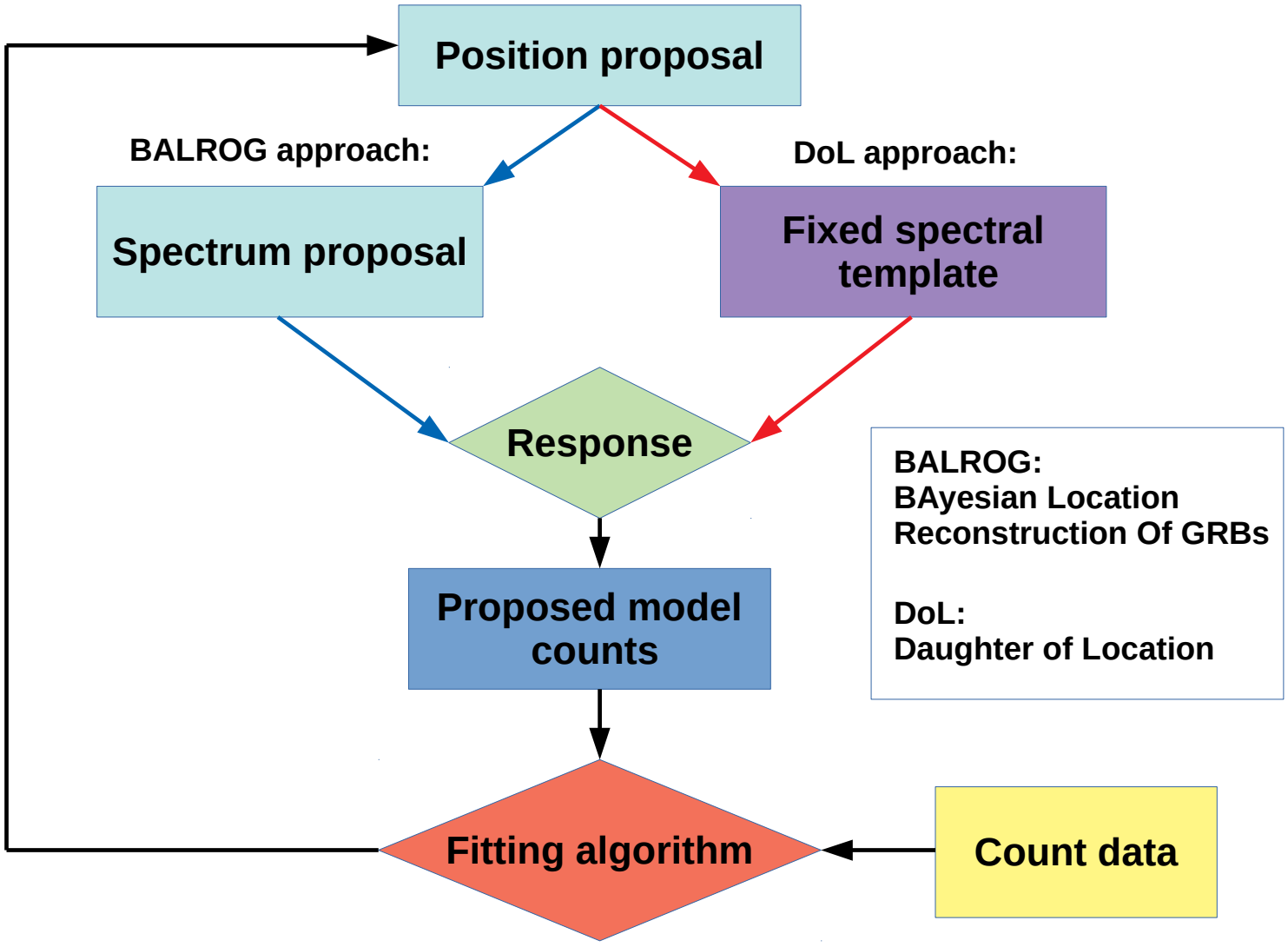
The spectrum is convolved through the response



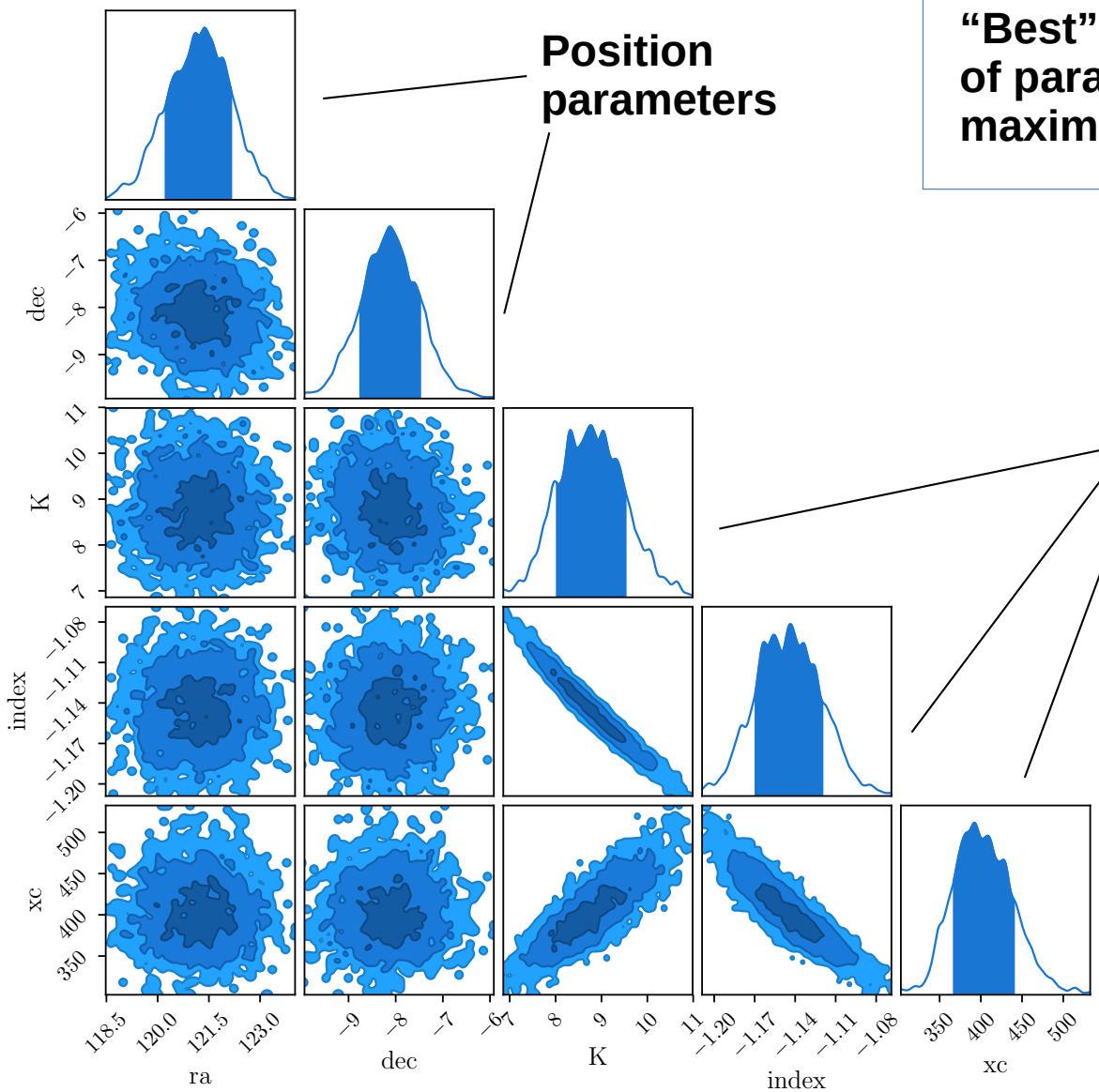


We fit by varying the spectral parameters, trying to match the measured counts

DoL and BALROG algorithms

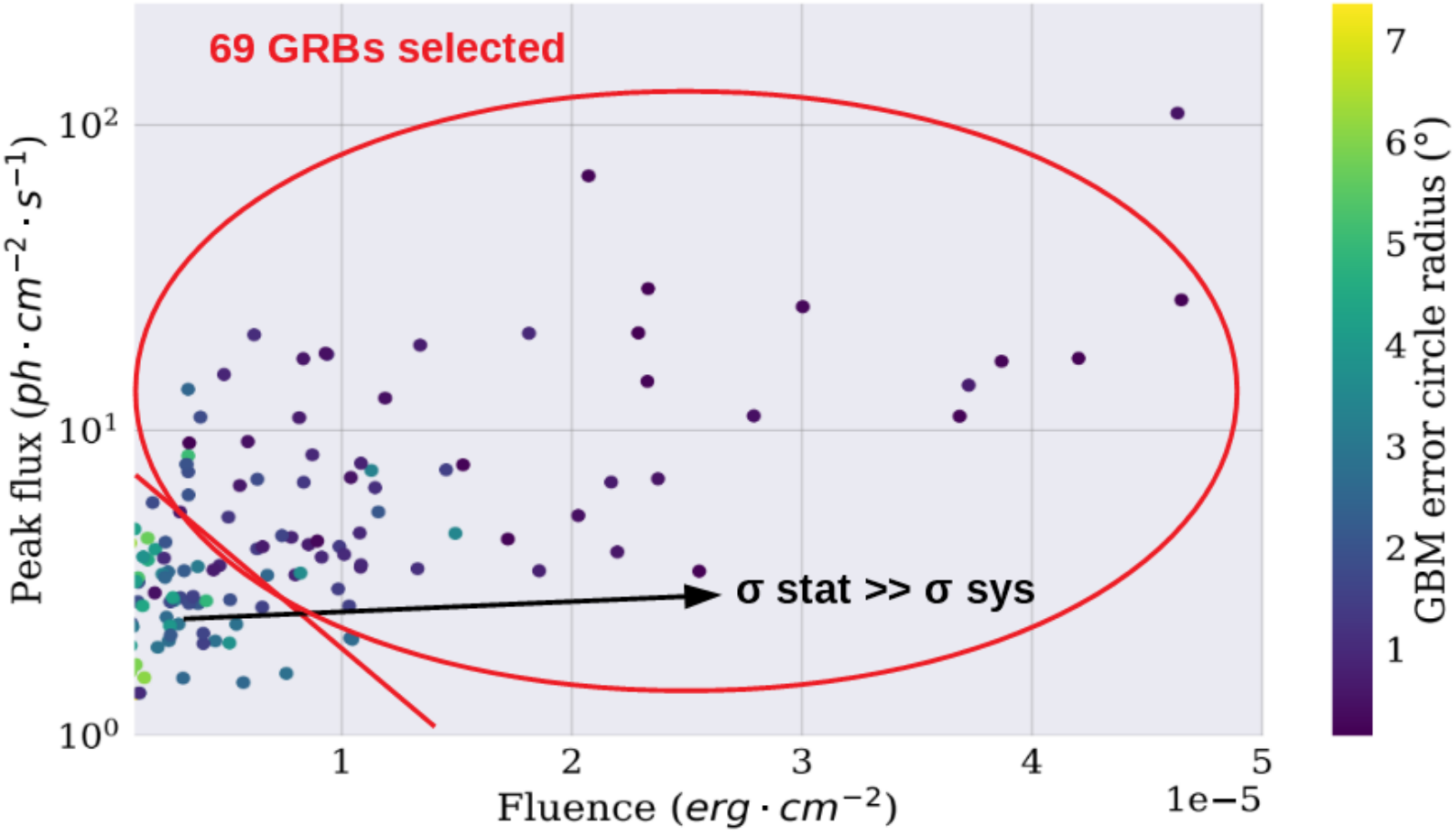


Posterior distribution



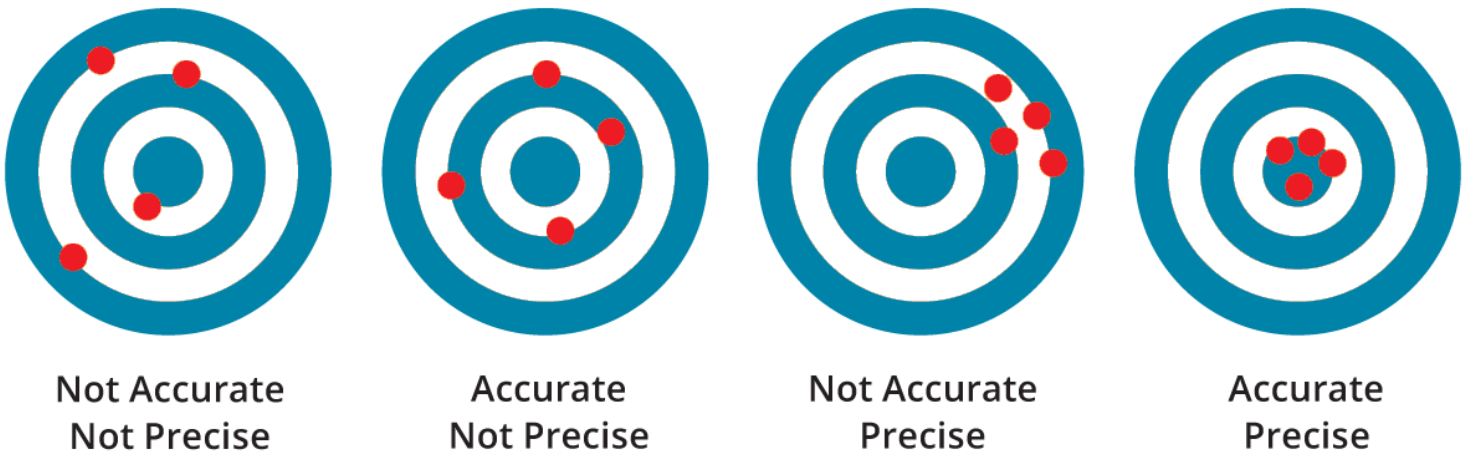
“Best” fit values = set of parameters which maximize the posterior

Sample selection



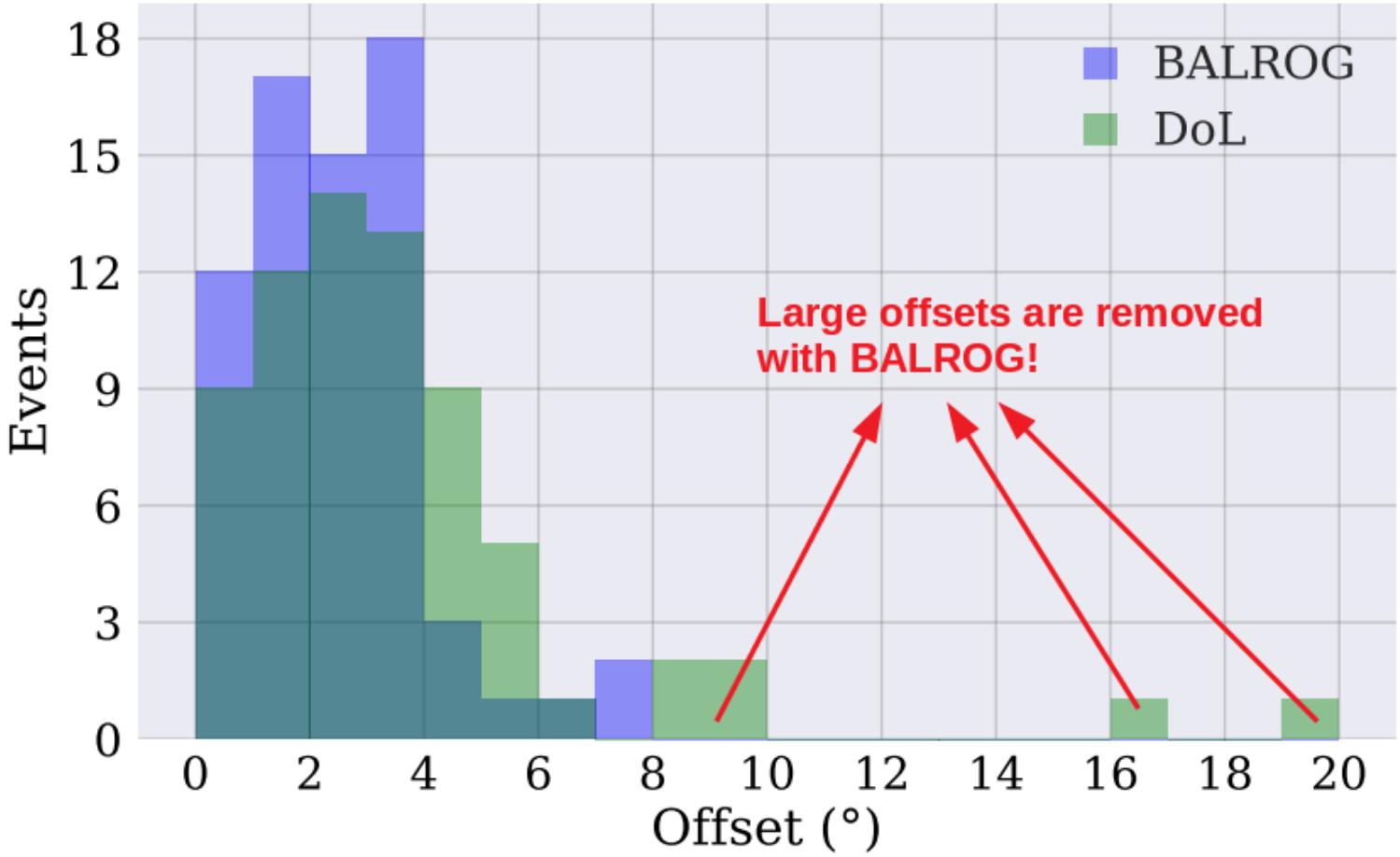
Precision and accuracy

- Precise = small spread of the measurements
- Accurate = ability of the uncertainties to capture the true value as often as they should



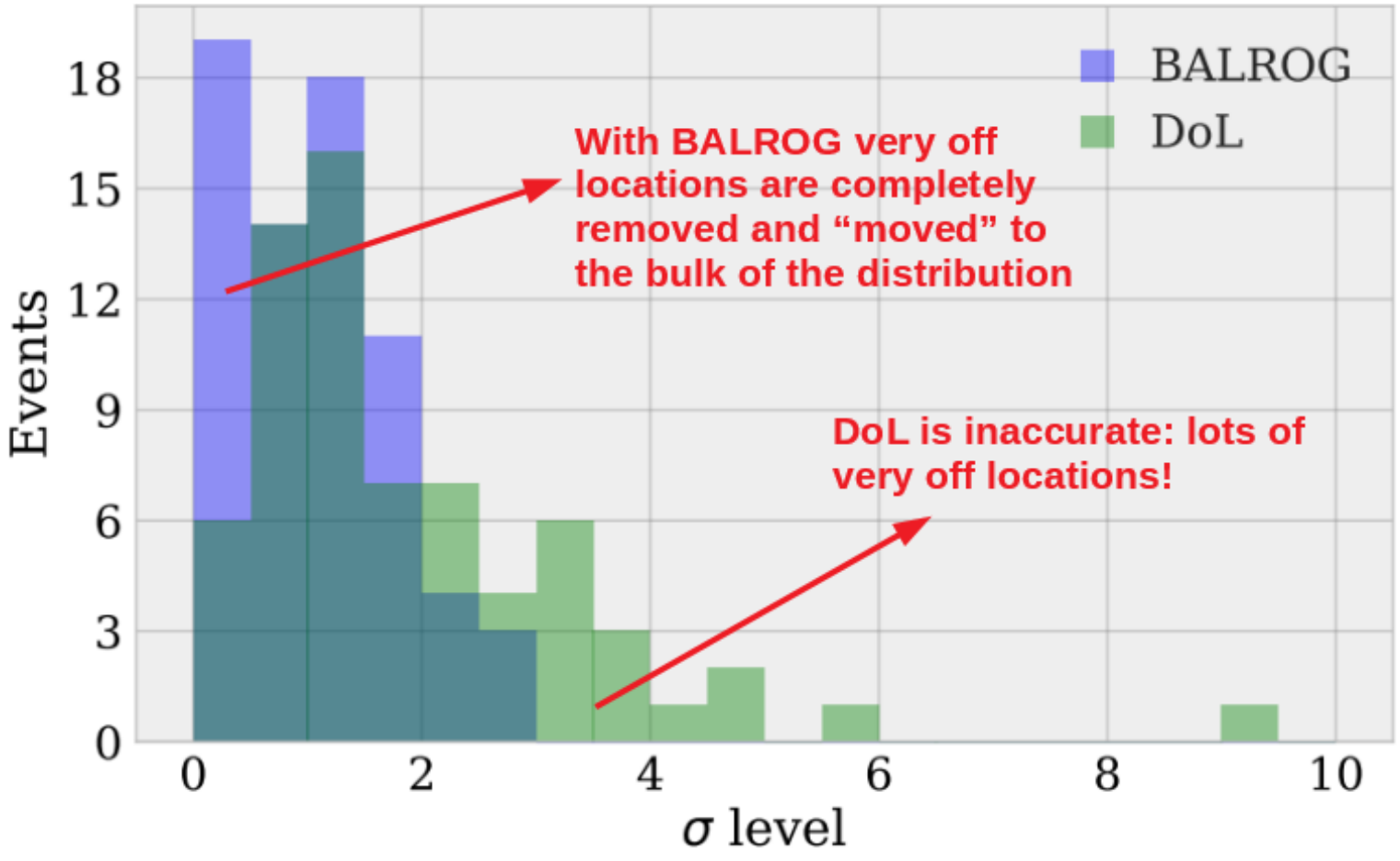
Offset comparison

By computing the offset (i.e. angular separation) between fitted and reference position for both BALROG and DoL a comparison in terms of the overall precision can be made for the two methods.



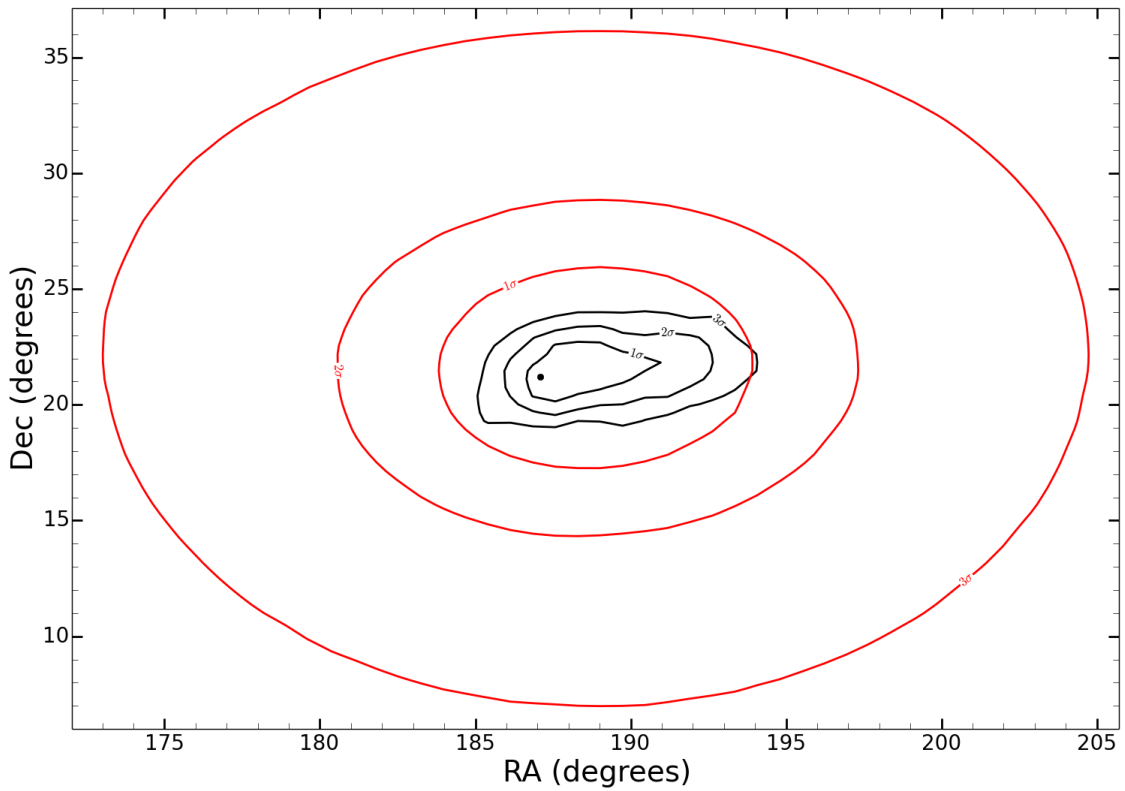
Accuracy comparison

We can compare BALROG and DoL accuracy by checking how many "error bars" away the fitted location is from the real location.



DoL and systematics

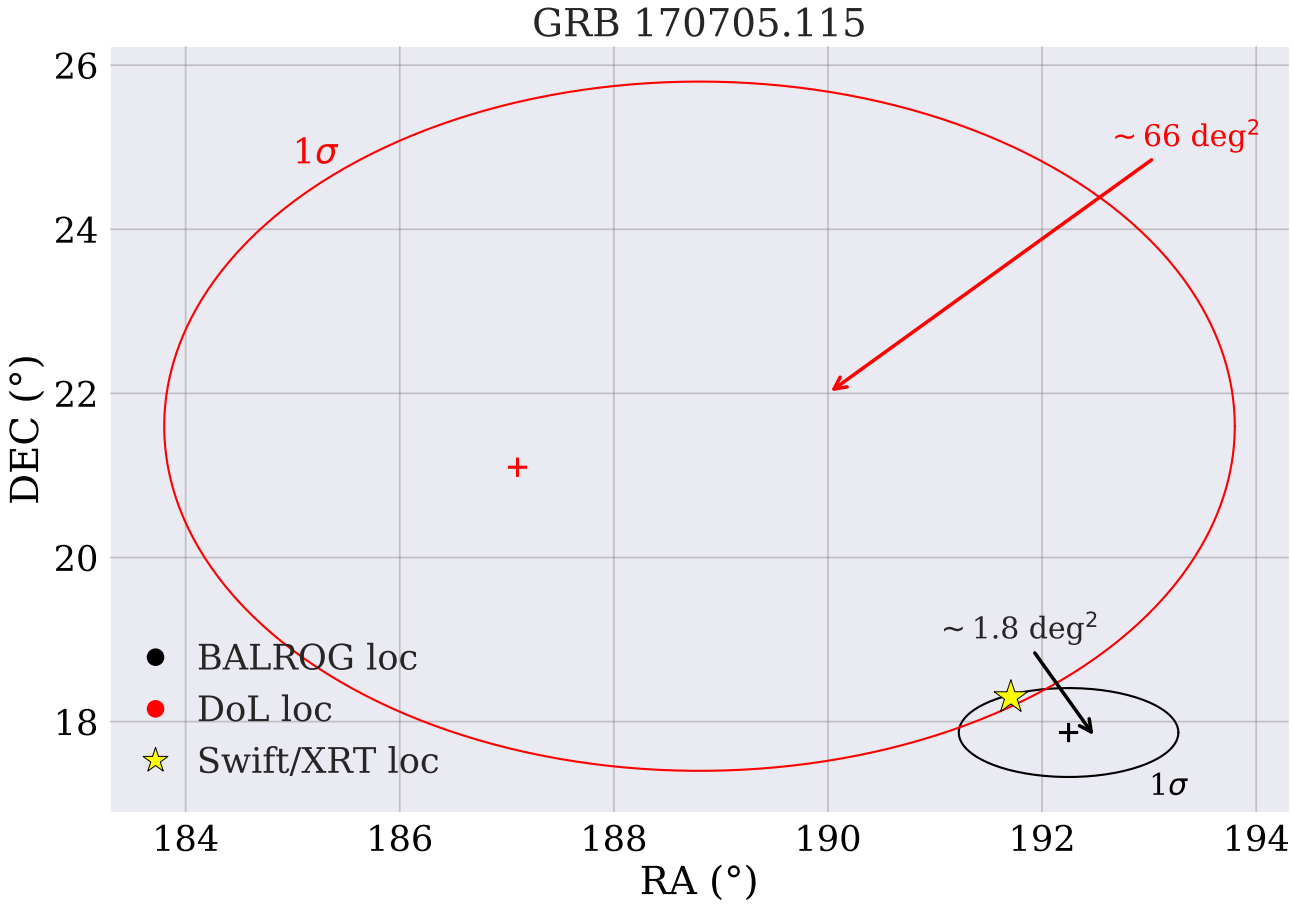
DoL tries to deal with the inaccuracy of the algorithm by convoluting the statistical error with a second, purely empirical distribution for the systematic error.



DoL 1,2,3 σ error contours for GRB 170705.115.

Systematics and error regions

This implies that some localizations will have excessively large error contours, making thus afterglow detection (or searches for gravitational waves or neutrinos) much harder.



In summary

- **Systematics primarily arise due to the use of spectral templates.**
- While making the uncertainties larger can improve the accuracy, this greatly lowers the instrument performance and does not solve the underlying problem.
- **BALROG** can make afterglow detection and multi-messenger searches **more effective and reliable** and should thus be preferred over DoL.

Thank you for your attention