

# Meet the BALROG: Bayesian Location Reconstruction of GRBs for Fermi-GBM

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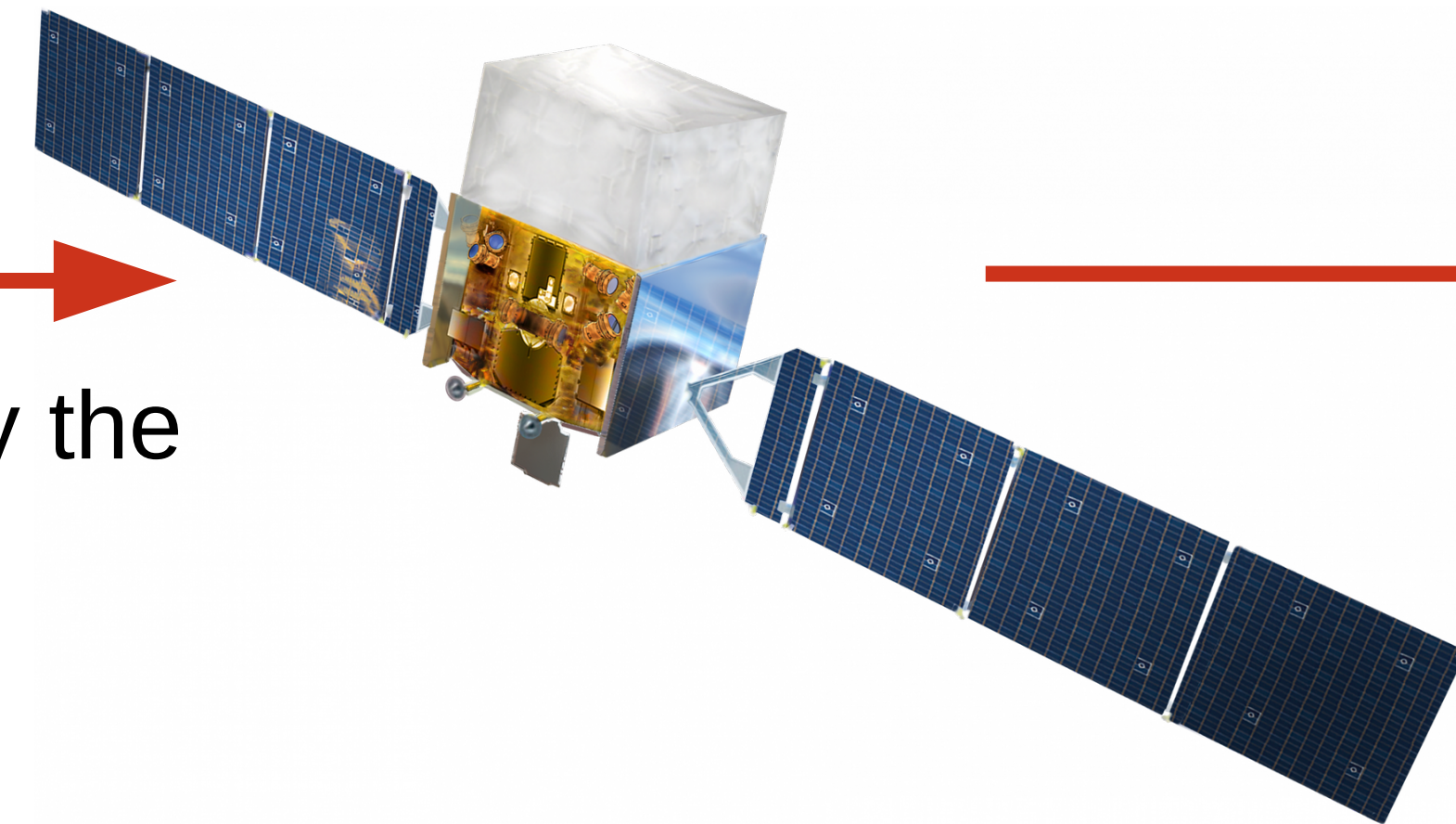


## Overview

GRB prompt emission

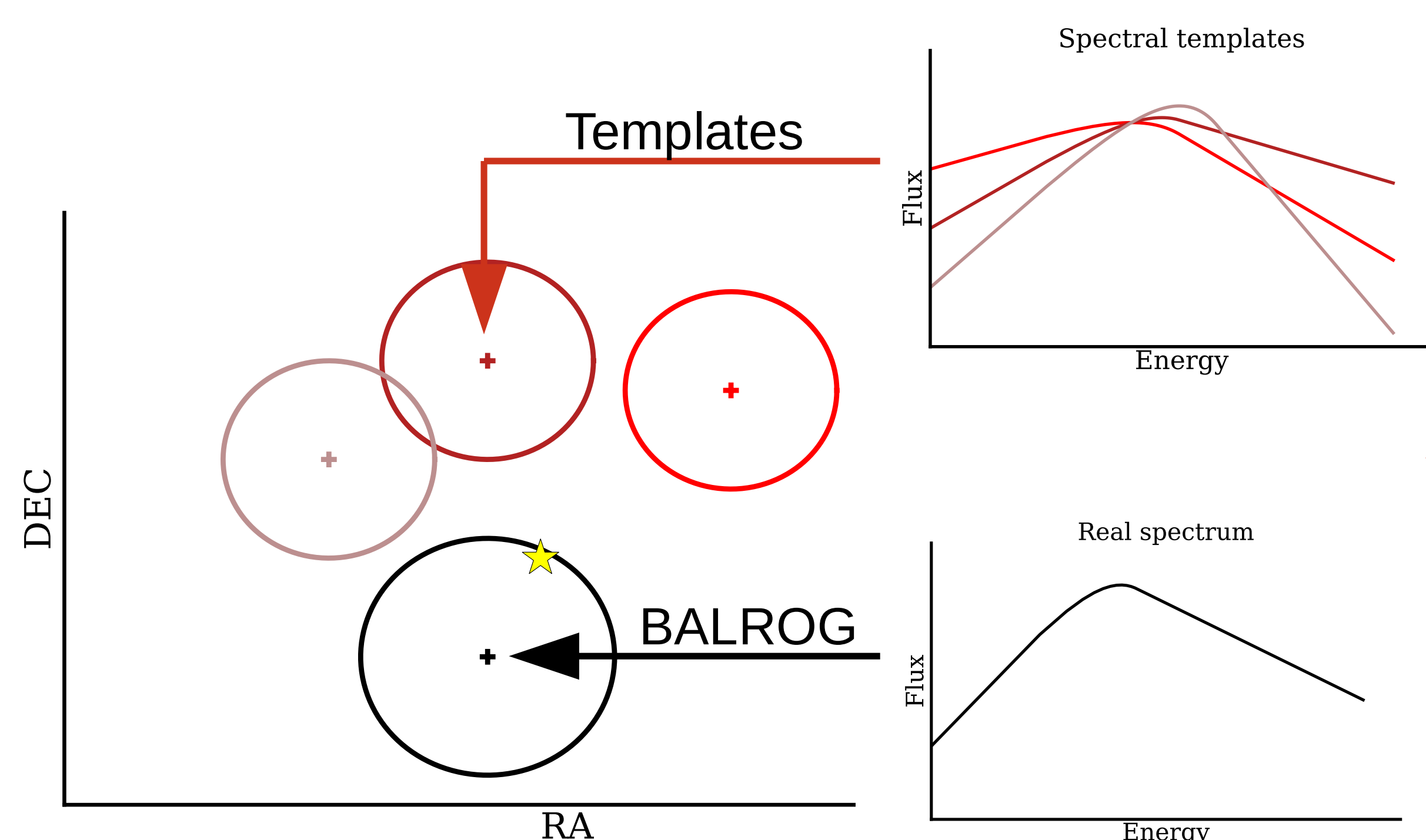


The gamma-ray photons are detected by the Fermi Gamma-ray Burst Monitor (GBM)



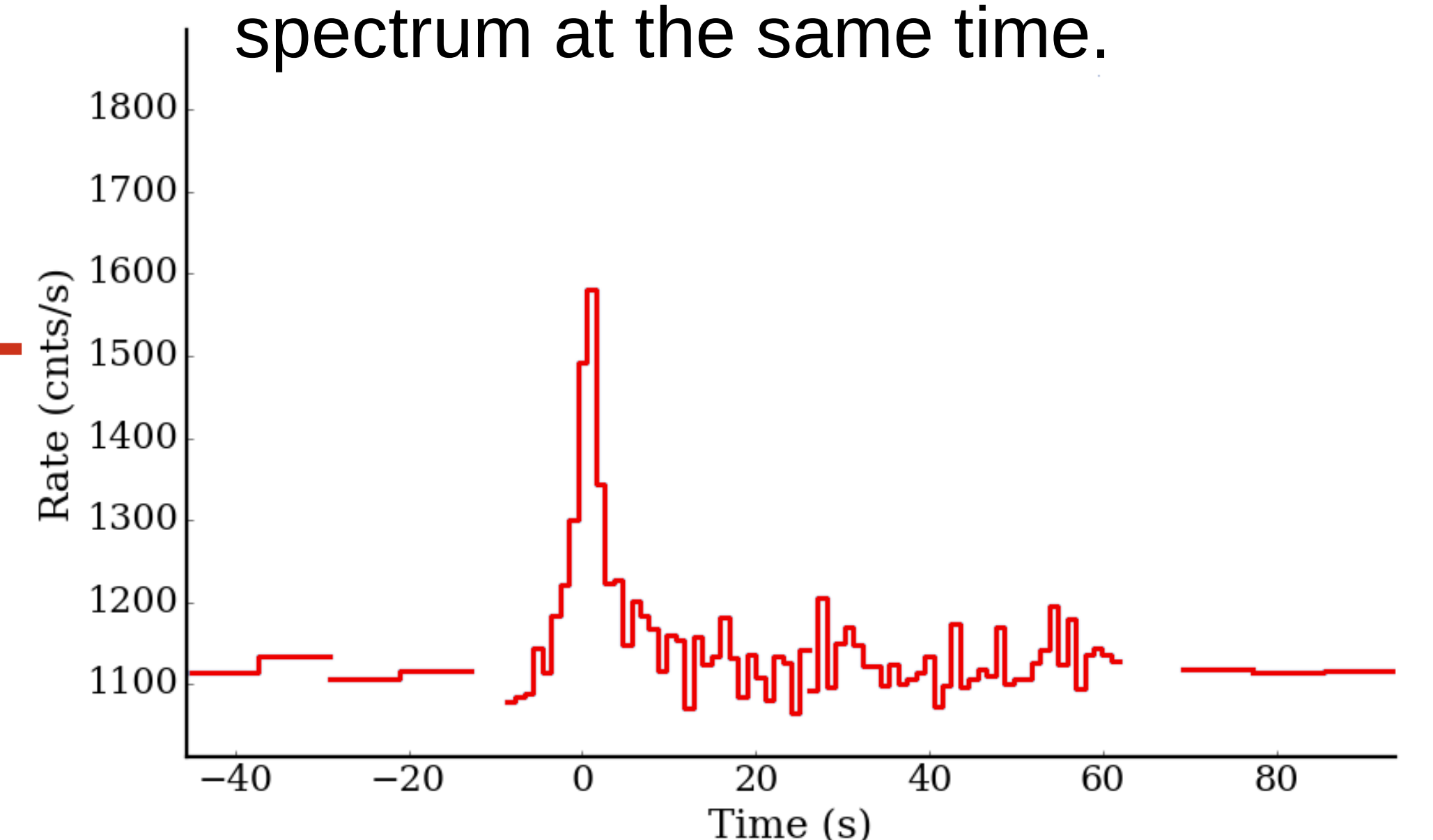
**Problem:** current locations are affected by systematics due to the use of spectral templates for fitting.

**Solution:** use the BALROG code to also simultaneously fit for spectrum and remove the systematics.



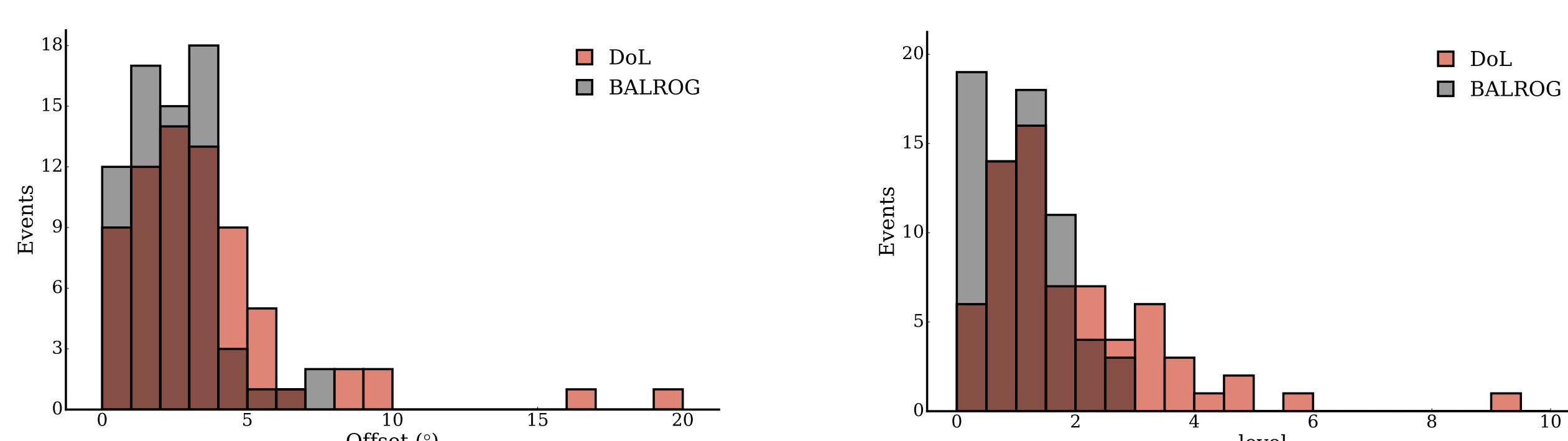
Fit the data for a location...but what kind of spectrum should we use?

**Count data:** GBM is not an imaging detector, it only measures counts, which depend both on the source position and spectrum at the same time.



## GBM locations and systematics

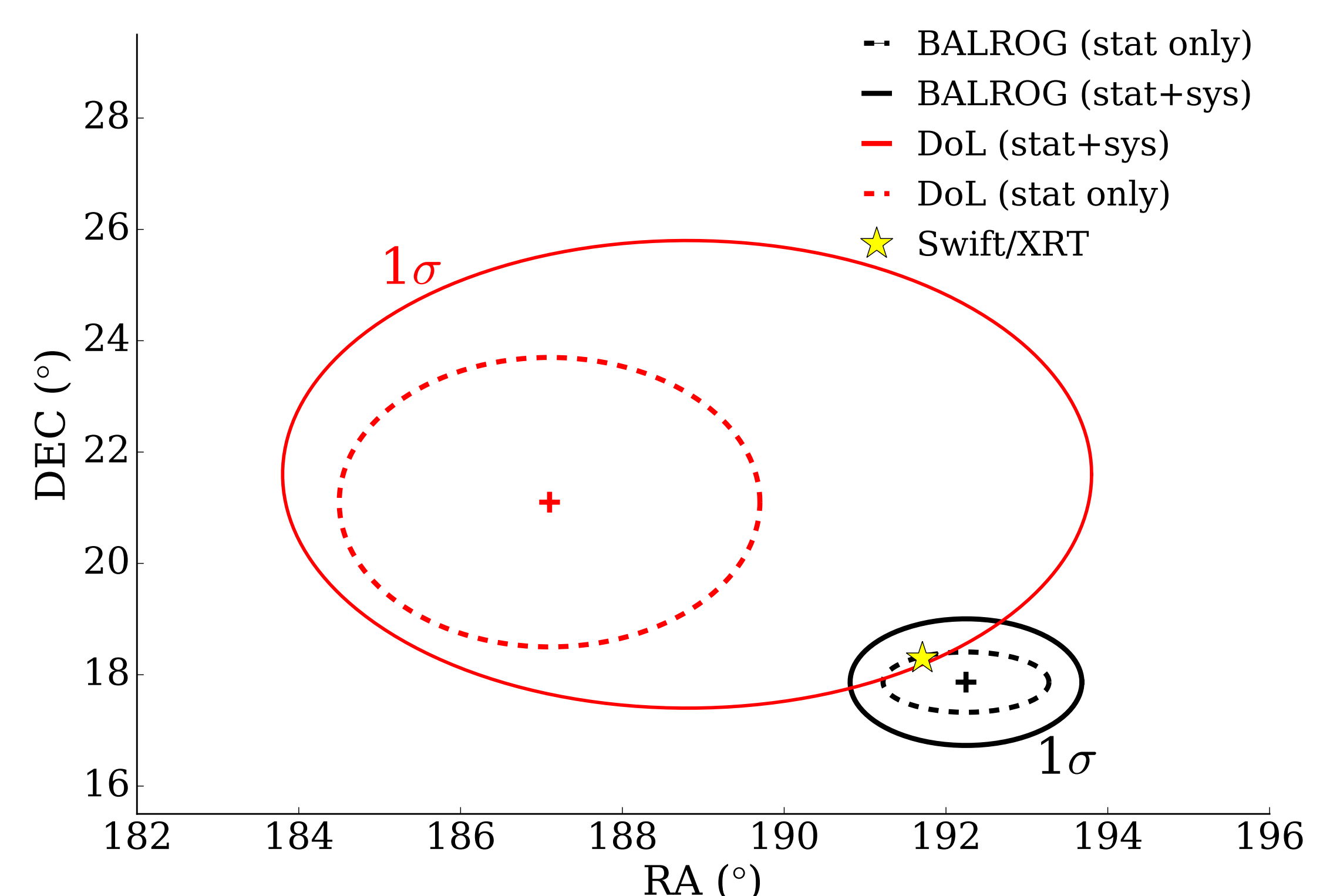
- Current GBM locations (DoL algorithm) are obtained through the use of three fixed spectral templates. Whenever they cannot match the real spectrum, systematics are being introduced in the localization (Burgess et al. 2016).
- The solution is to fit for both spectrum and location at the same time: this is made possible by the BALROG code.
- In Berlato et al. 2019 we perform a detailed study of the performance of BALROG. We find that we are able to remove all the very inaccurate positions still present with DoL.
- We also estimate a left-over systematic contribution of  $\sim 1 - 2^\circ$  compared to the original DoL  $3.7^\circ$  plus  $14.3^\circ$  (Connaughton et al. 2015).



**Figure 1:** A comparison between two methods for a sample of bright GRBs: separation from the real source position in terms of degrees and sigmas (i.e. error bars).

## Results

BALROG is able to improve GBM's localization performance by removing almost completely the previous systematics. This allows the locations to be both more accurate and more constraining, especially for bright GRBs.



**Figure 2:** A practical example of BALROG performance, GRB 170705A.

BALROG real time automated locations are available to the public at [grb.mpe.mpg.de](http://grb.mpe.mpg.de) and are also distributed through GCNs to subscribers. The BALROG code is open source and available at [github.com/mpe-heg](https://github.com/mpe-heg).



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