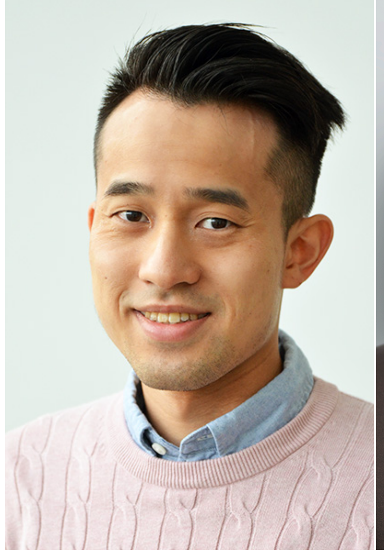
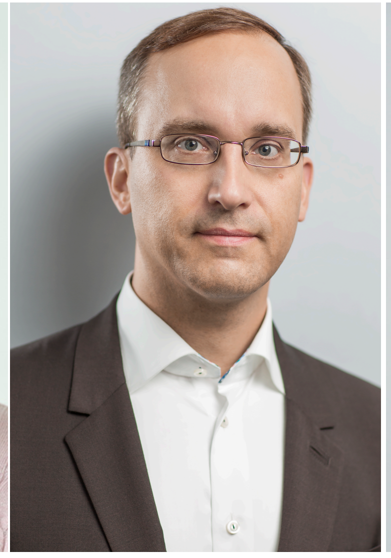
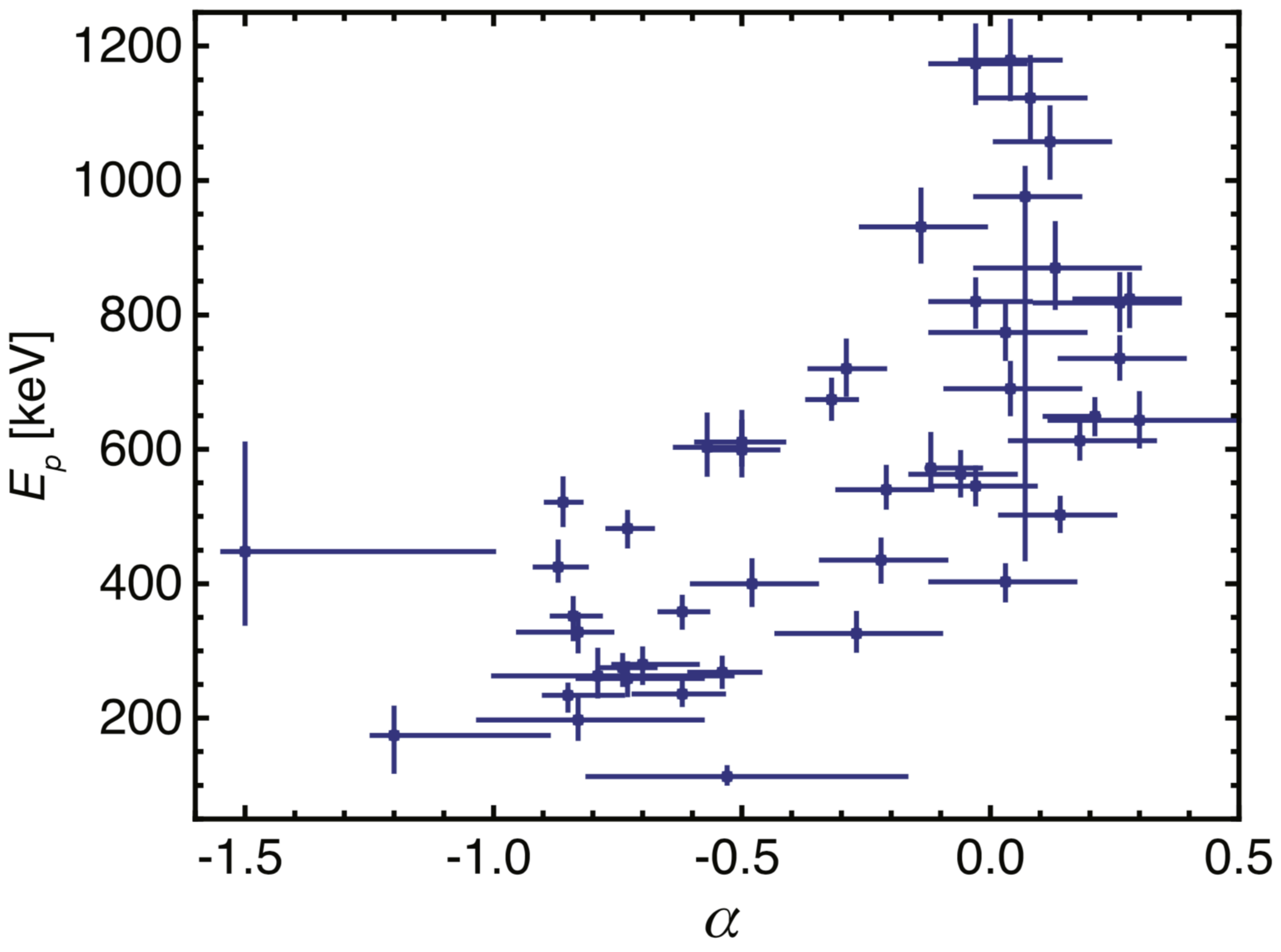




Hoi-Fung Yu[1,2], Felix Ryde[1,2], Hüsne Dereli[1,2]

[1]Department of Physics, KTH Royal Institute of Technology, Sweden
[2]The Oskar Klein Centre for Cosmoparticle Physics, Sweden

An Investigation on the GRB Peak Energy and Low-Energy Spectral Slope

The fit peak energy (parameterised as E_p) and low-energy spectral slope (α) of GRB prompt emission spectra may exhibit correlations (e.g., Lloyd-Ronning & Petrosian 2000, 2002; Ryde et al. 2011; Burgess, Ryde, & Yu 2015). We investigate this by performing time-resolved spectral analysis on the Fermi/GBM GRB data using 3ML (Vianello et al. 2015) and compare the results to thermal (e.g., sub-photospheric dissipation) and non-thermal (e.g., synchrotron radiation) emission models.

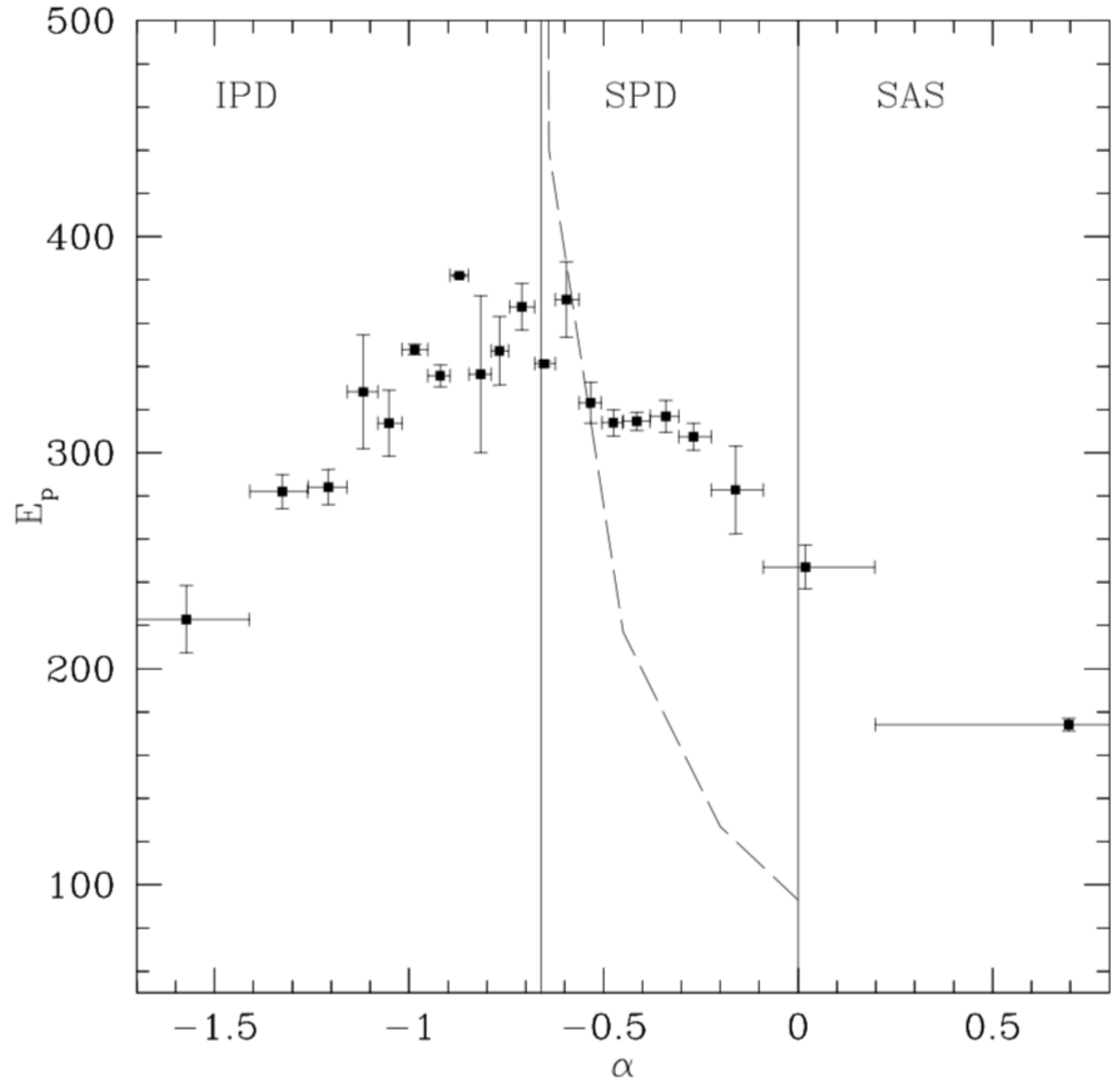


The observed E_p-α correlation in the GBM burst GRB090902B. The correlation could be explained by a sub-photospheric dissipative thermal emission model.

Ryde et al. (2011)

The observed E_p-α correlation in an example BATSE burst. The vertical lines separate different physical regimes. The dashed line shows the expected E_p-α trend for decreasing mean electron synchrotron pitch angle.

Lloyd-Ronning & Petrosian (2002)

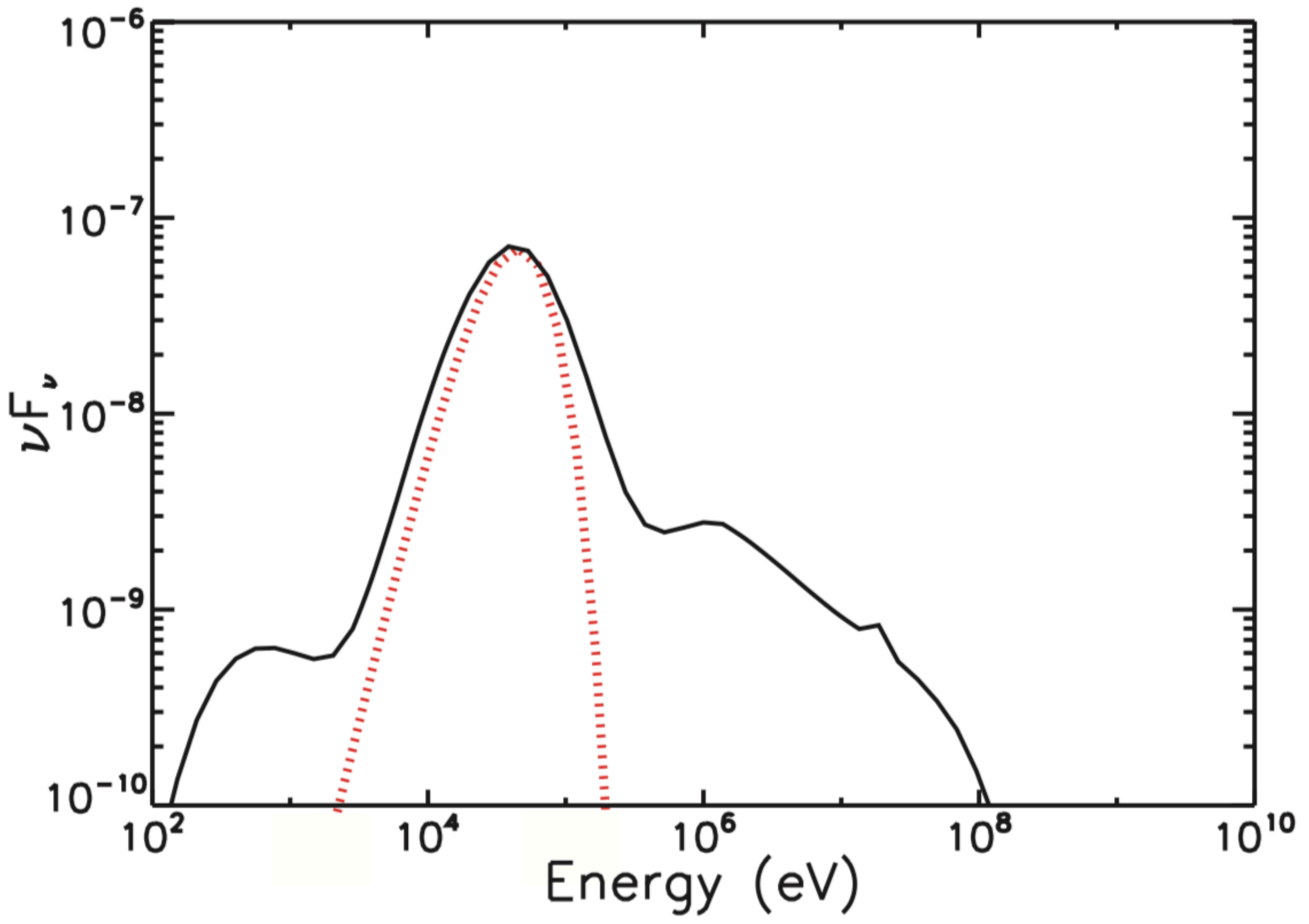


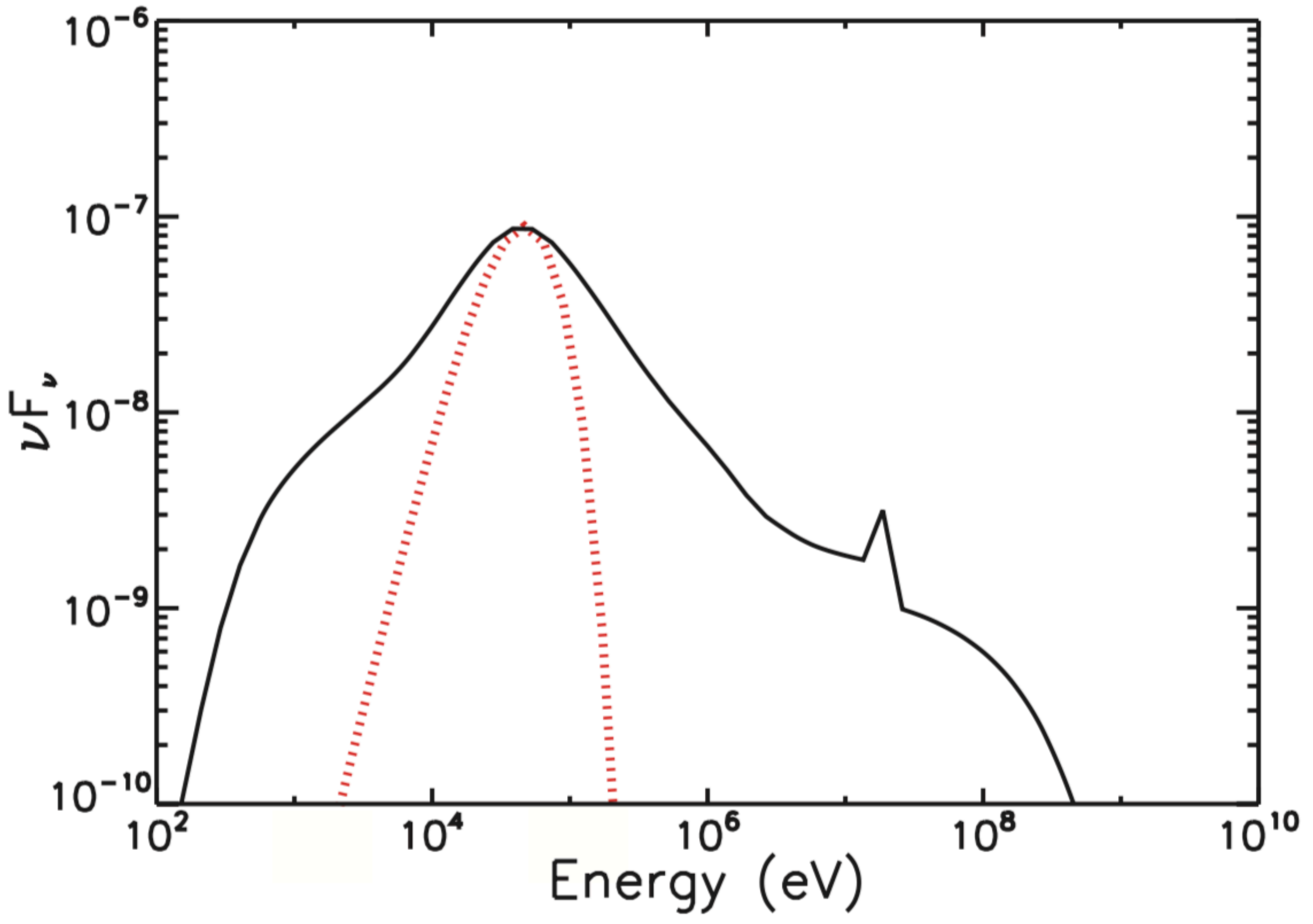
Motivation

(1) The E_p–α correlation could vary depending on the details of the underlying emission mechanism, which in turn can be used as an indicator for the mechanism(s) involved in GRBs.

(2) The conventional synchrotron hypothesis for GRBs has difficulty in explaining the "line-of-death problem" (Preece et al. 1998) and the sharpness angle problem (Yu, van Eerten, Greiner et al. 2015).

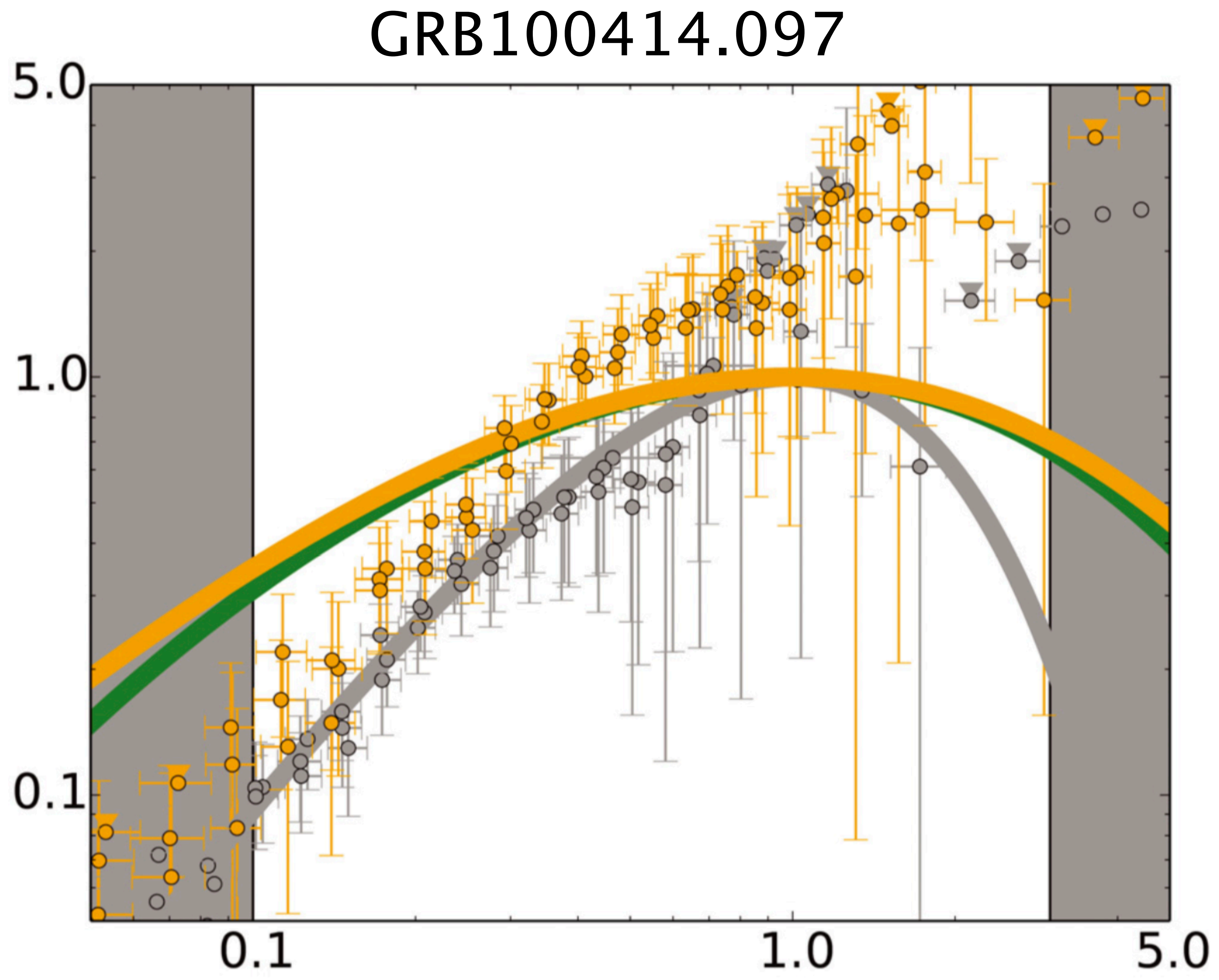
(3) The shape and evolution of the time-resolved spectra for some GRBs may be explained by thermal emission models (e.g., Ryde 2004, Pe'er & Ryde 2011; Ryde et al. 2011).





The evolution of GRB time-resolved spectra may be explained by thermal emission (red curves) followed by sub-photospheric dissipation (black curves), which causes a broadening effect.

Ryde et al. (2011)



The grey curve is the best-fit to the grey data points, convolved with the GBM detector responses, for a exponential cutoff model. The orange best-fit curve and convolved data points are obtained from a fit using a smoothly broken power law with parameters fixed to mimic the Maxwellian distributed synchrotron emission function (green). The plot is in log-log scale normalised to the peak energy.

Yu, van Eerten, Greiner et al. (2015)

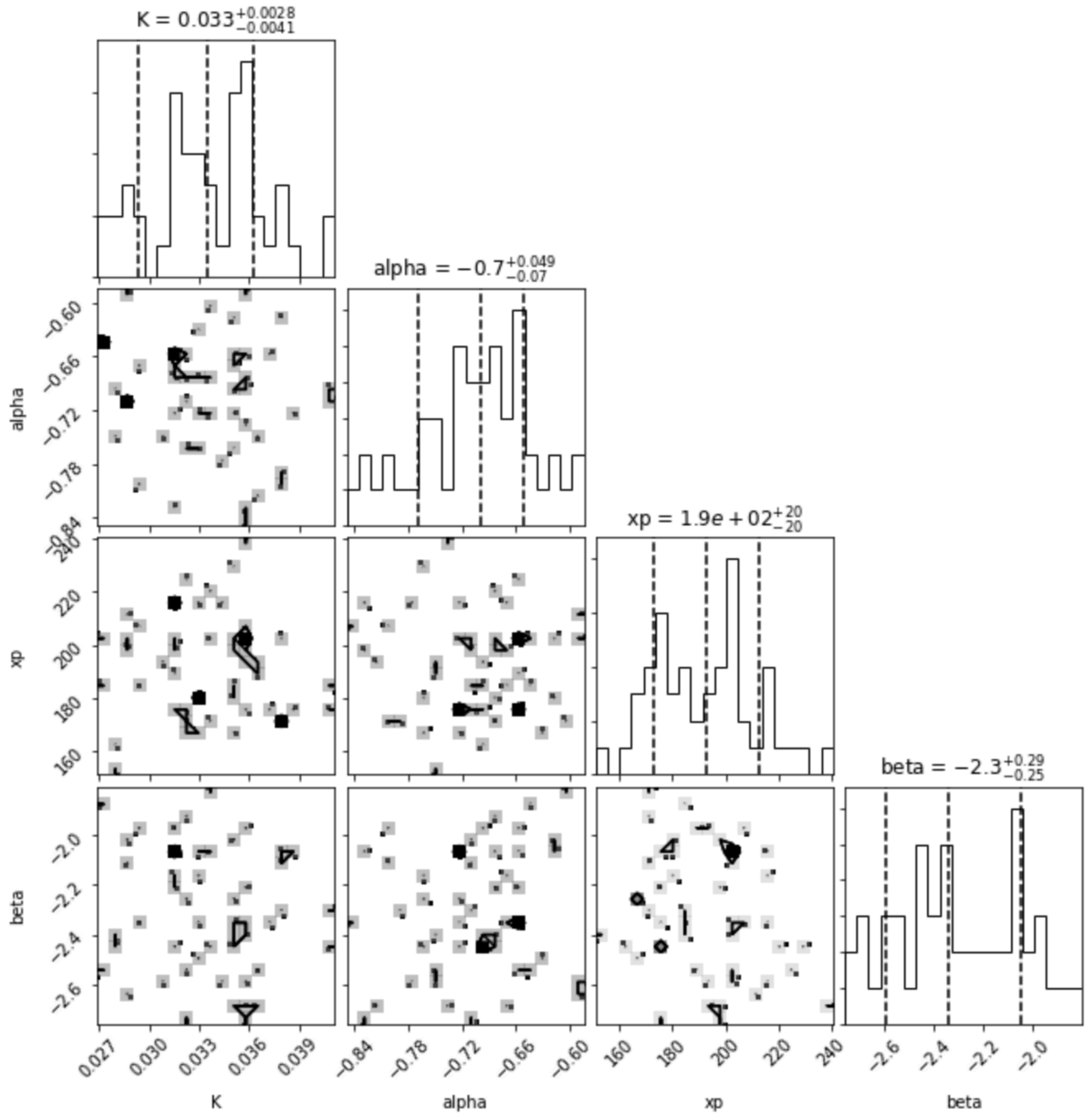
Method

We perform time-resolved spectral analysis on the GBM GRB data using 3ML (Vianello et al. 2015):

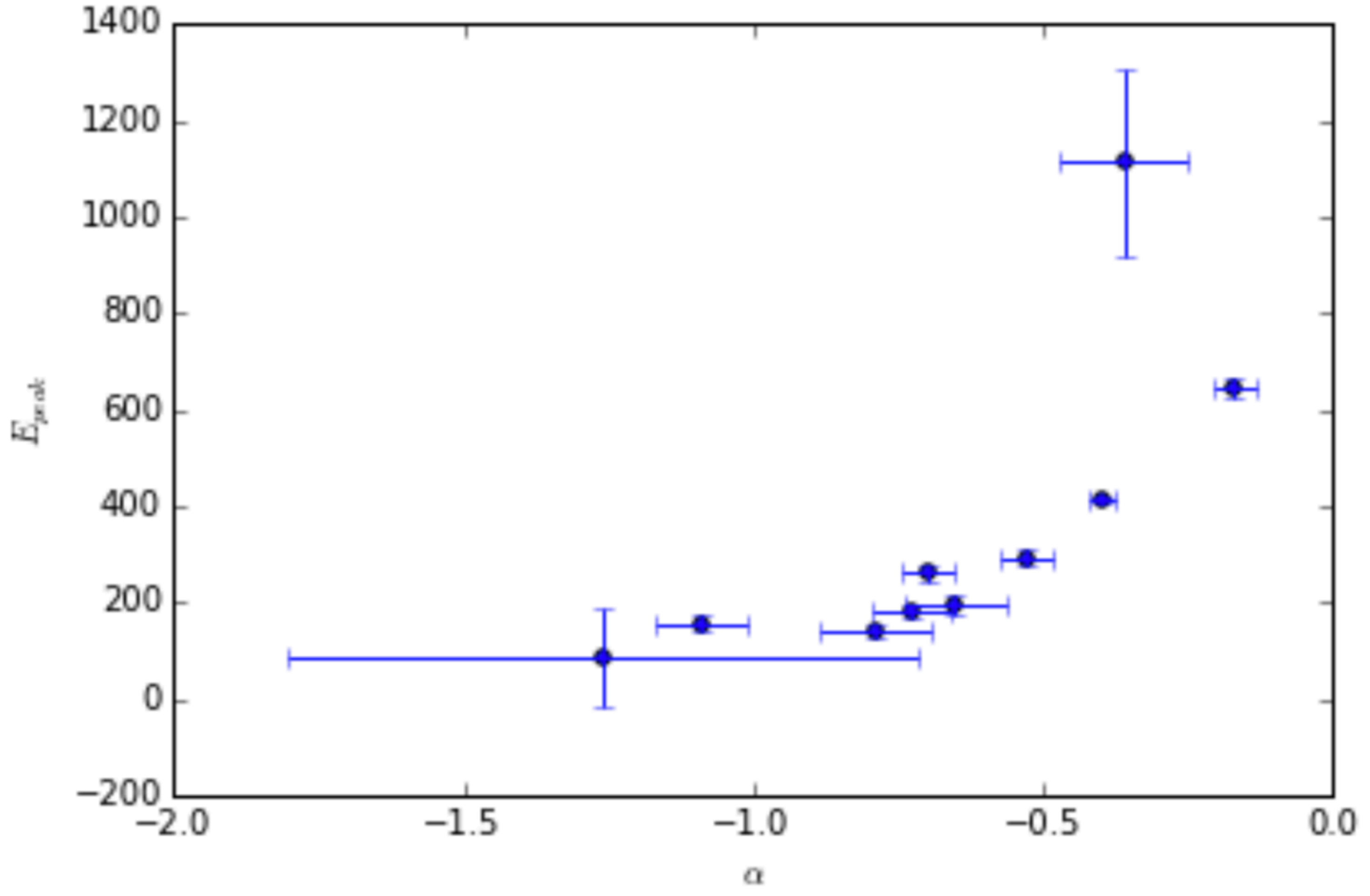
(1) Determine the temporal binning using the Bayesian blocks method (Burgess 2014);

(2) Bayesian fit the time-resolved spectra and obtain the model parameters E_p and α;

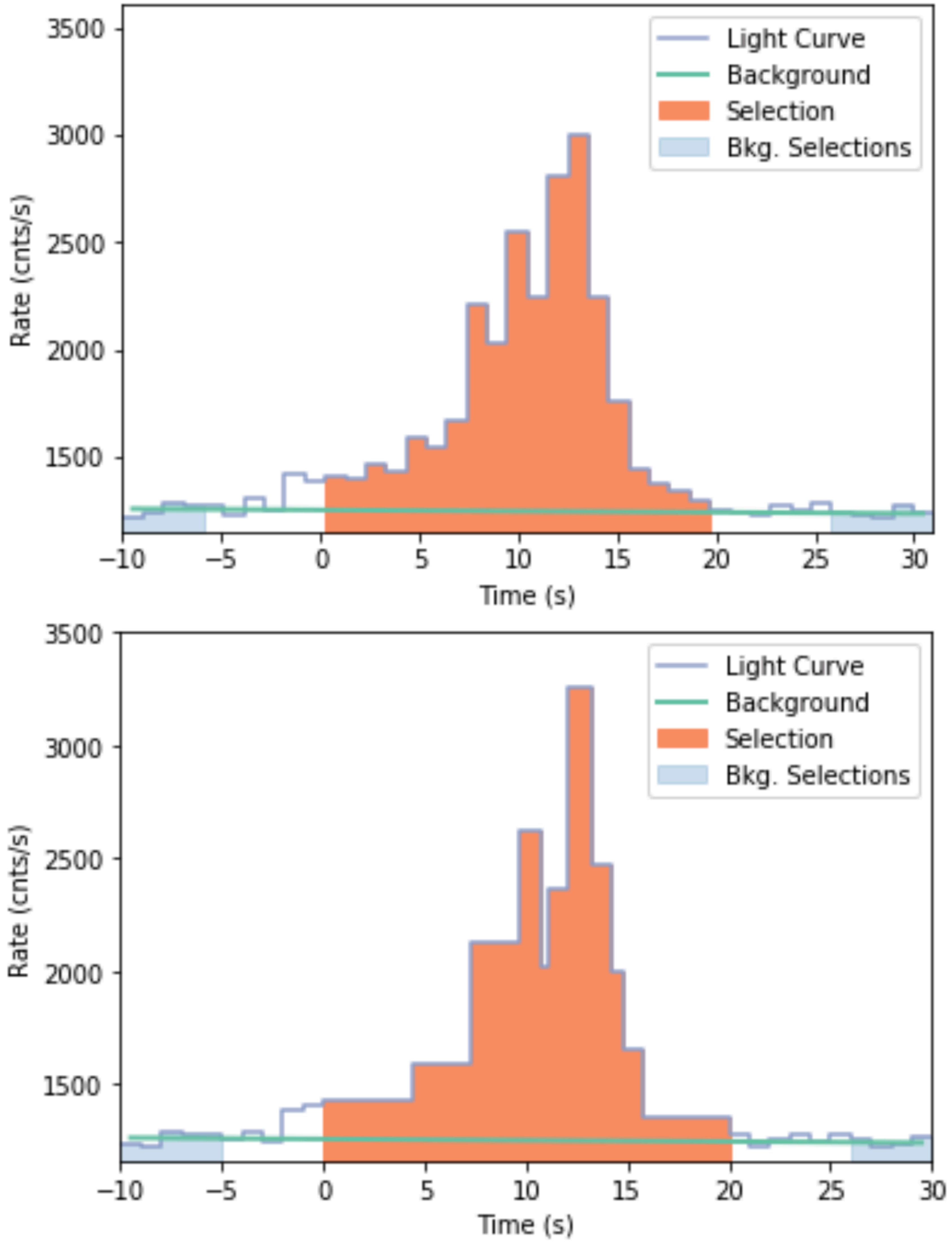
(3) Compare the E_p–α correlation with the predictions from various emission models.



Bayesian "corner plot" example obtained using 3ML.



The fit E_p–α correlation for an example GBM burst.



3ML plotted GBM light curve for GRB170308.221. Upper panel: constant bin width; Lower panel: Bayesian blocks.

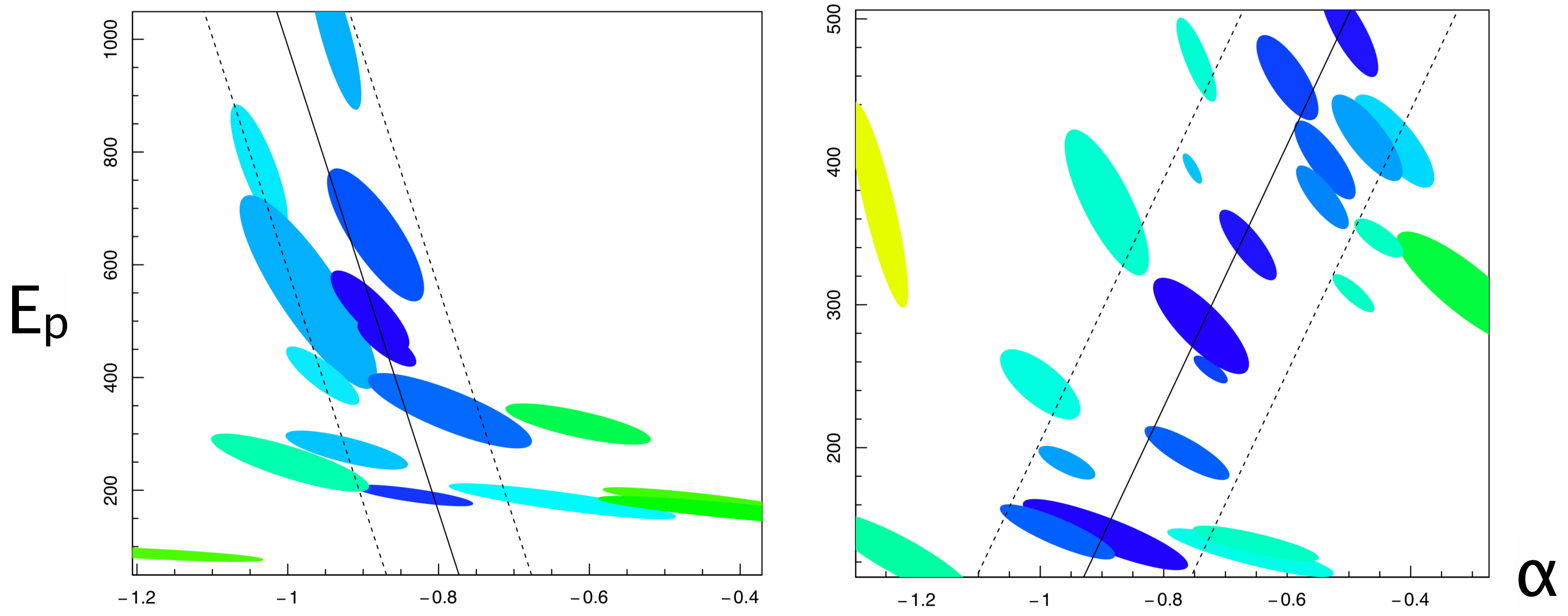
Validity

Simulations of various emission models will be done to produce artificial data, which are then convolved with the GBM detector responses. Then the simulated spectra will be analysed by the same analysis procedure, to understand:

(1) What are the sources of error in the study? E.g., the window effect due to the limited observing band?

(2) How reliable are the fit results, using the empirical fitting models?

(3) Are there imperfections in the GBM detector responses?



The E_p–α errors (coloured ellipses) for all bursts should always point to the same direction because of, e.g., the window effect, while the E_p–α correlation (black lines) for different bursts can have different directions for different emission mechanism and/or sources of uncertainties combined. Simulations help to understand and disentangle these effects.

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