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A Statistical Investigation of GRB X-ray and Optical Afterglows

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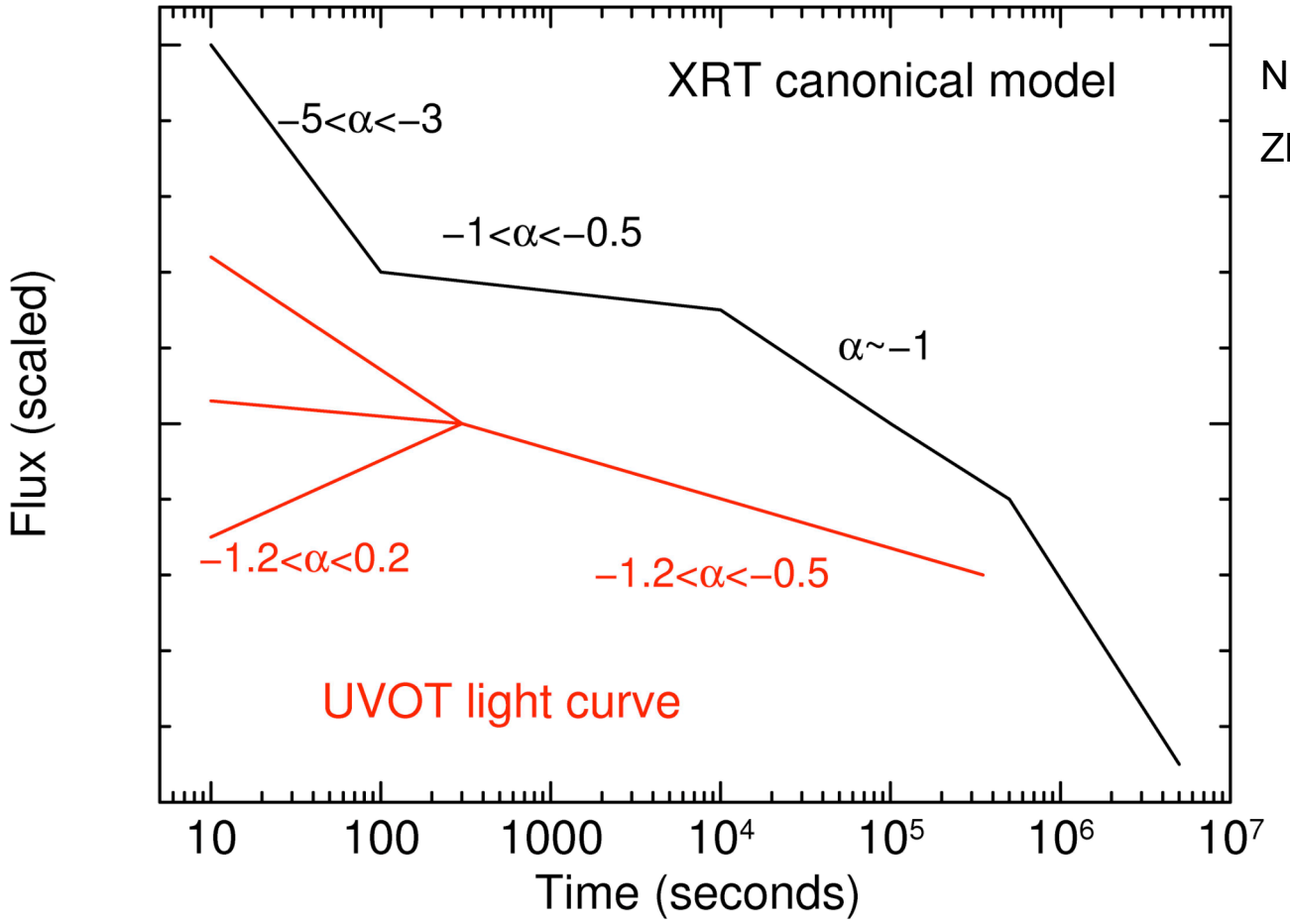
Comparison of the Average Optical/UV light curve with XRT canonical model



Nousek et al. 2006

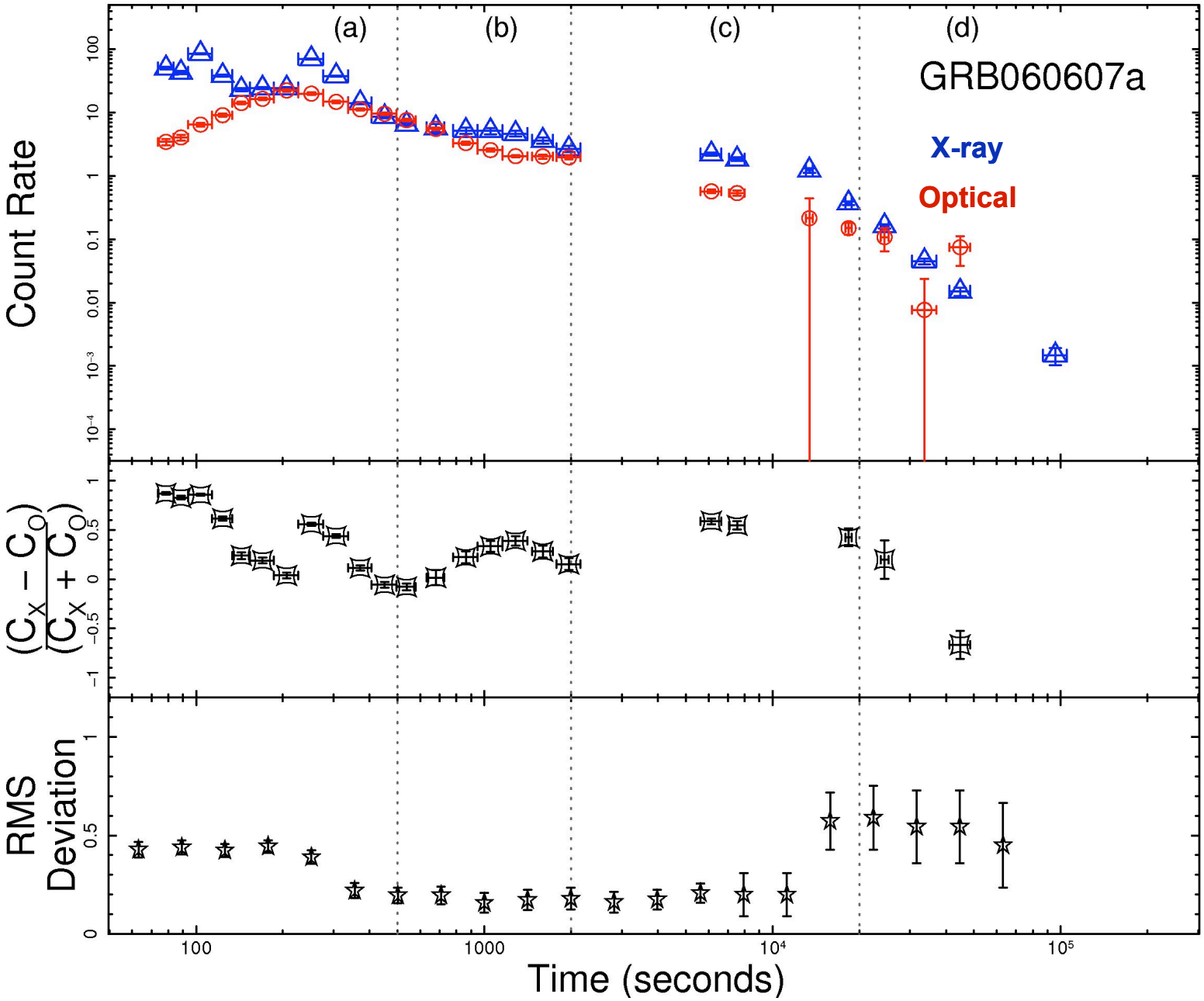
Zhang et al. 2006

Optical/UV afterglows do not follow the same behaviour as the X-ray afterglows, at least in the early afterglow.

Optical to X-ray Comparison

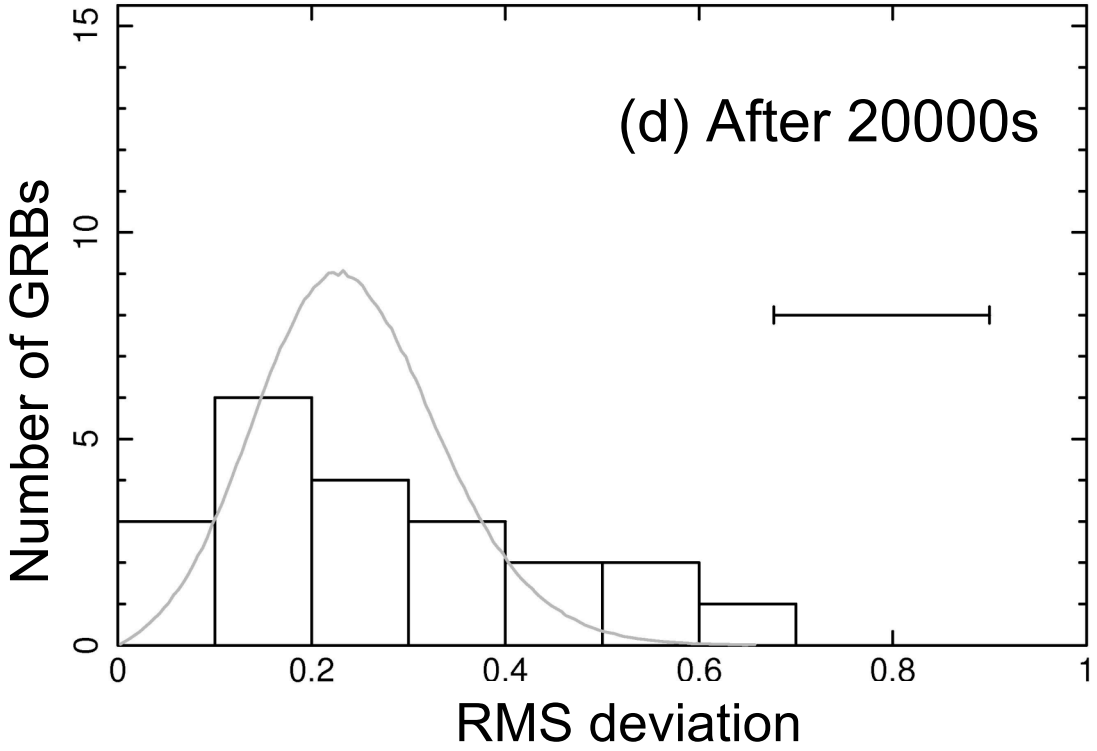
Using the sample of 26 GRBs from Oates et al. (2009):

- Optical to X-ray hardness ratio
  - Compares the individual data points
- Root Mean Square Deviation
  - Compares the small scale differences
    - Using a sliding window 1 dex wide (bottom panel)
    - Using data within 4 specific time periods (labeled (a),(b),(c),(d))
- Temporal Indices
  - Compare the overall behaviour of the X-ray and optical/UV light curves
    - (a) <500s, (b) 500s-2000s, (c) 2000s-20000s, (d) >20000s


(a)
(b)
(c)
(d)
GRB060607a
X-ray
Optical
Count Rate
$\frac{(C_X - C_O)}{(C_X + C_O)}$
RMS Deviation
Time (seconds)
100
1000
10^4
10^5

Mean Properties: RMS Deviation Distribution

- Distribution widens during last epoch



Monte Carlo simulation of data in 2000s-20000s epoch convolved with average error of >20000s epoch:

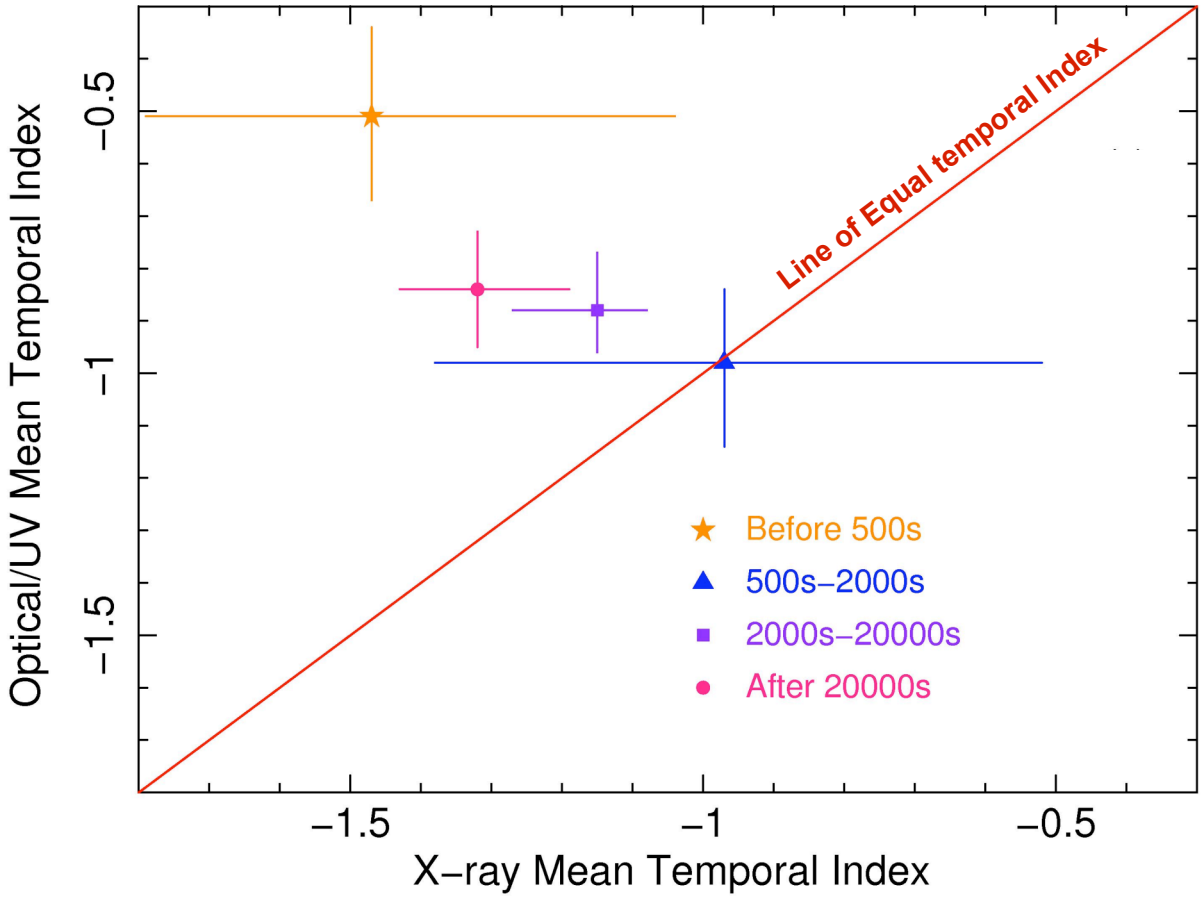
• >20000s is consistent with being wider due to larger data uncertainties.

Mean Temporal Indices

Average temporal indices residing above the line of equal temporal index imply: constant density medium.

After 500s, the temporal indices are consistent with closure relations for constant density medium with

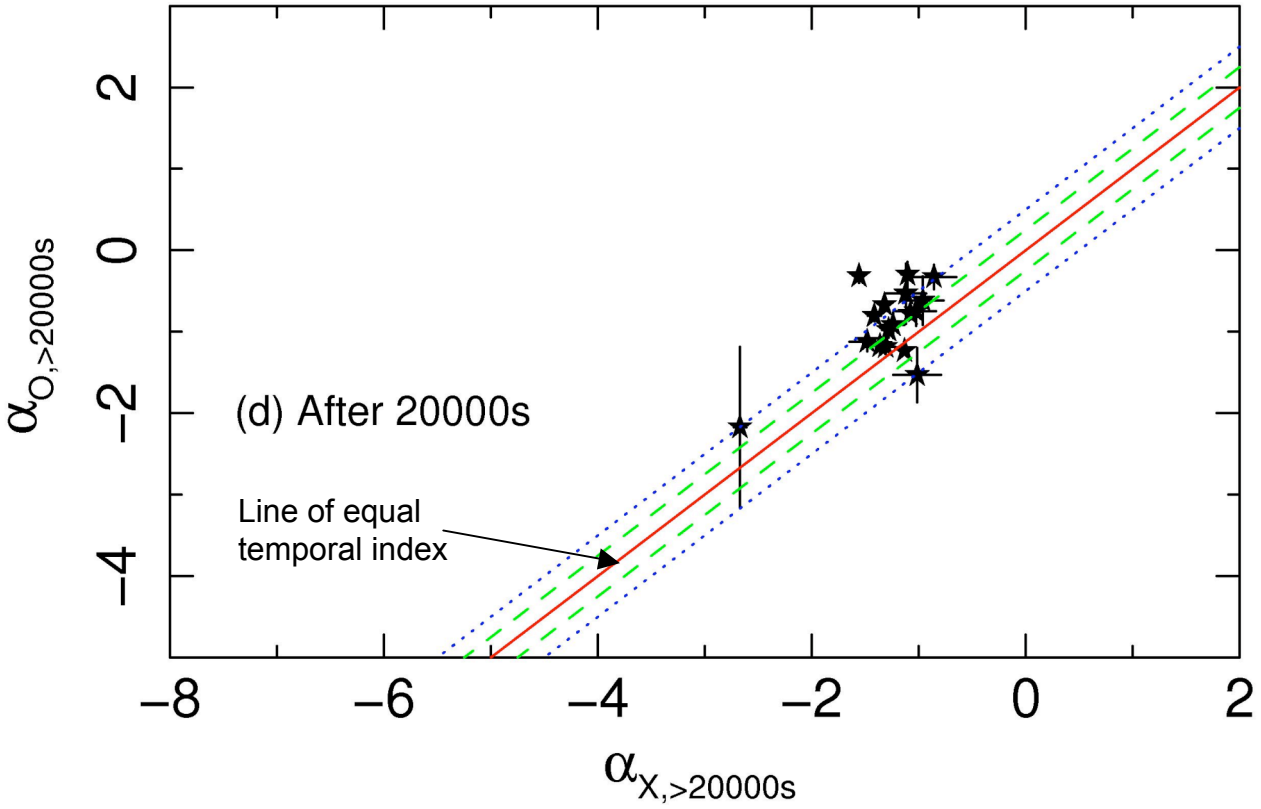
$\nu_m < \nu_o < \nu_c < \nu_x$



Can this apply to individual GRBs?

Individual GRBs: Temporal Indices, α

Optical and X-ray light curves behave similarly indicating similar production mechanism for both components.



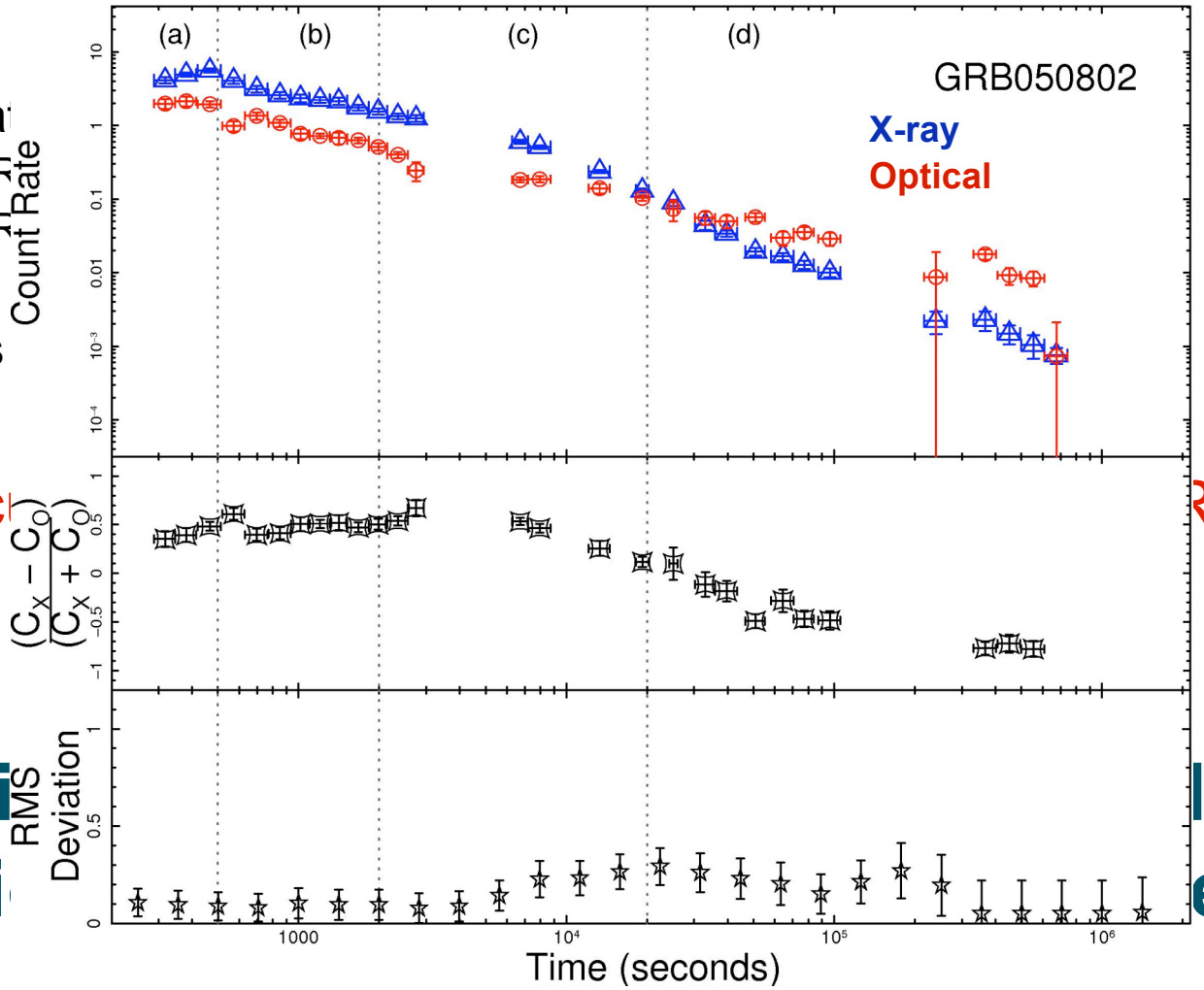
Constant density favoured, but energy injection appears to be required for some GRBs.

X-ray temporal indices are steeper

→Chromatic breaks ?

Temporal Changes in the Late time Afterglow

- Chroma
  - 3 GR
  - 4 GR
- 2 GRBs



Diffic RBs in

Requi litional emissi e GRBs

Conclusions

- X-ray and optical aftergows behave:
  - Most differently before 500s
  - Most similarly between 2000s and 20000s

- Mean properties indicate constant density medium is favoured with: $\nu_m < \nu_O < \nu_C < \nu_X$

- Individual properties: require additional energy injection

- Chromatic breaks: 3 GRBs (>12%), strong indication 4 GRBs.

- Complex jet structure and/or additional emission components required to explain at least a few of the GRBs in this sample.

  (e.g Peng et al. 2005, Ghisellini et al. 2007 Panaitescu et al 2008)