A Unified Model of Short & Long GRBs, X-Ray Rich GRBs, and X-Ray Flashes

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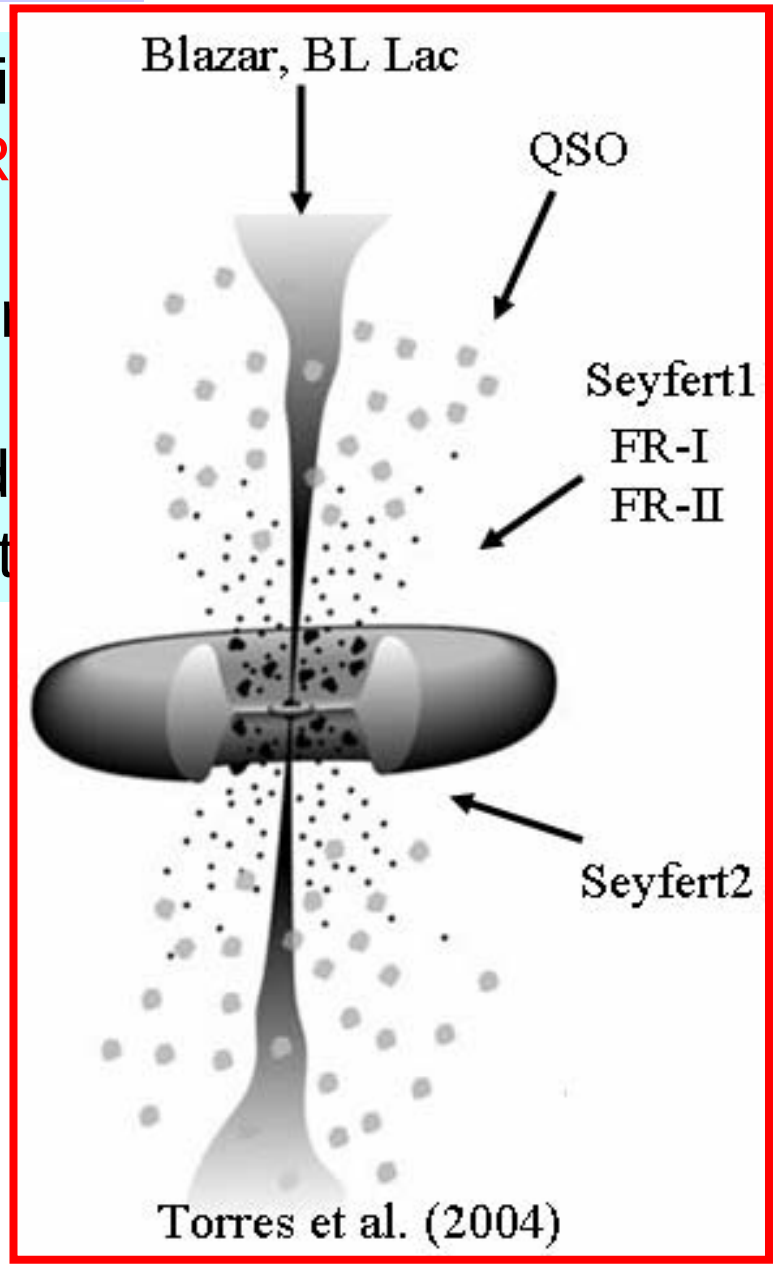
A Unified Model of GRBs ?

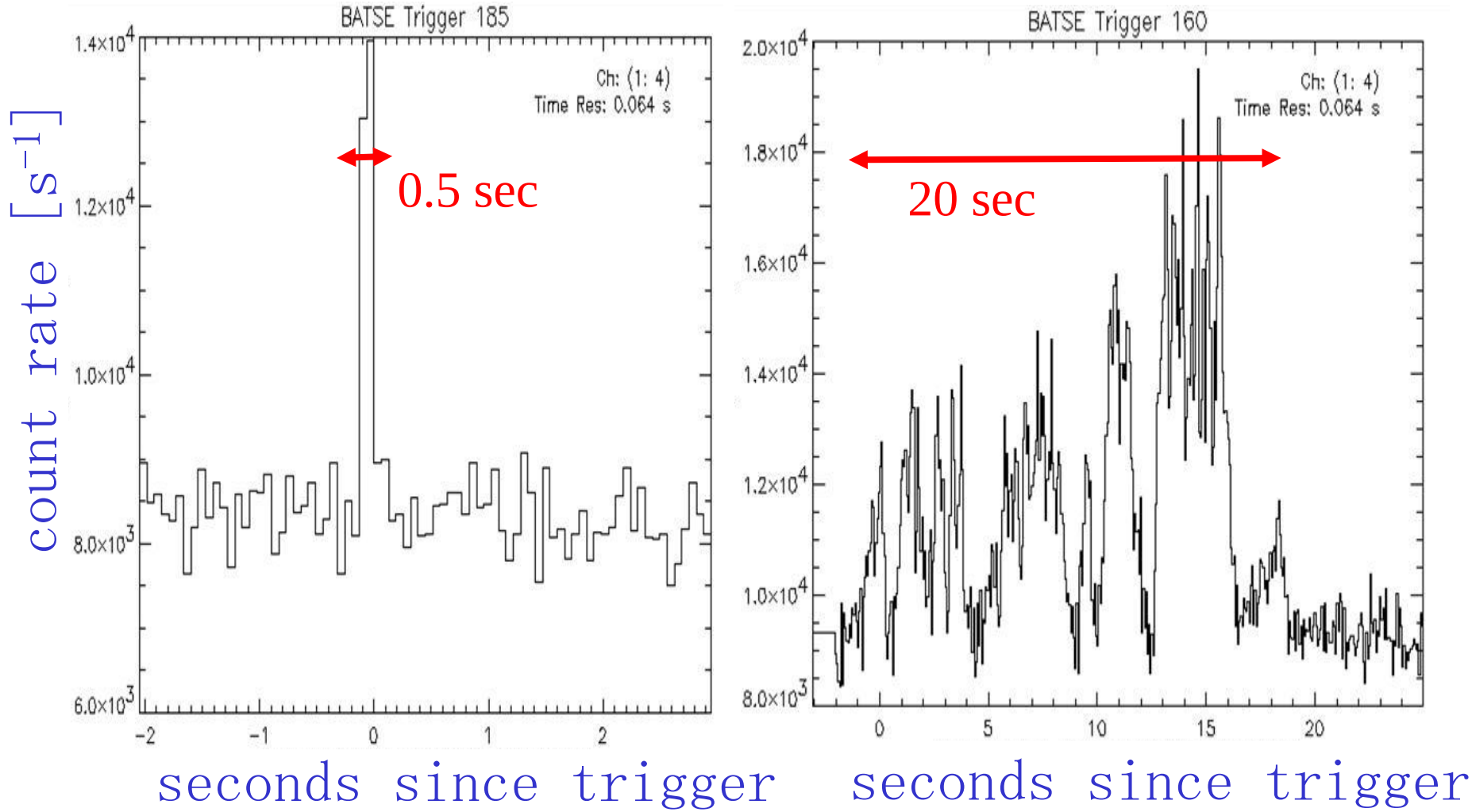
GRBs are observationally categorized i
Short GRBs, long GRBs, X-ray rich GR
however,

1. Short and Long GRBs have similar
   except for their durations.
2. Long GRBs, X-ray rich GRBs, and
   have similar properties except for t

Motivated by these observational facts, we construct a possible unified model of short and long GRBs, X-ray rich GRBs, and X-ray flashes, like a unified scenario of AGNs.



Short GRBs and Long GRBs

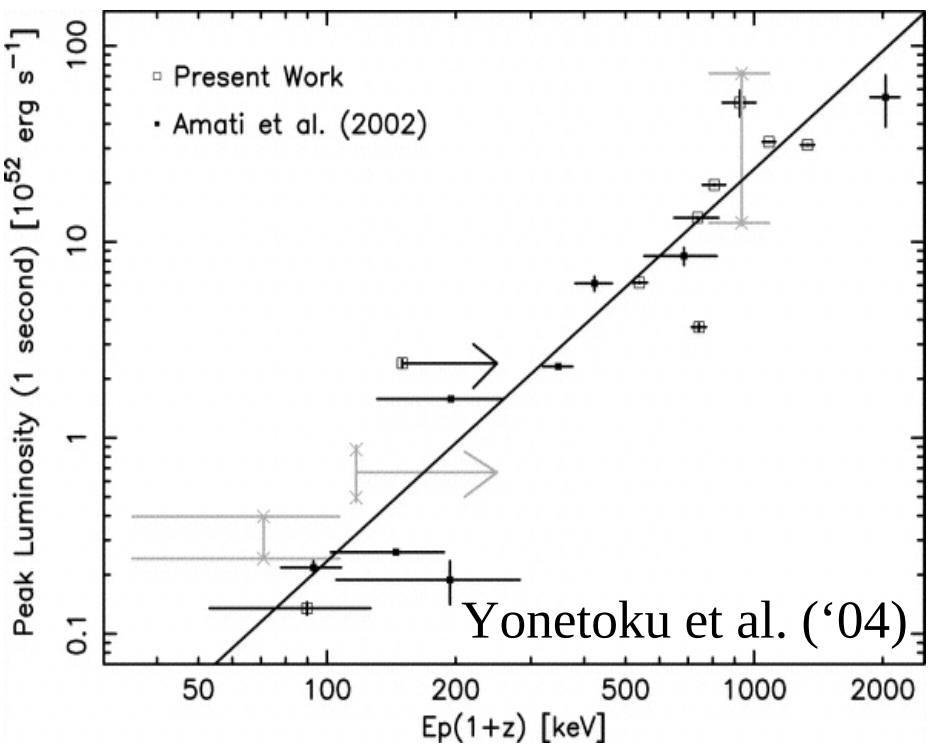


(From BATSE 4Br GRB catalog)

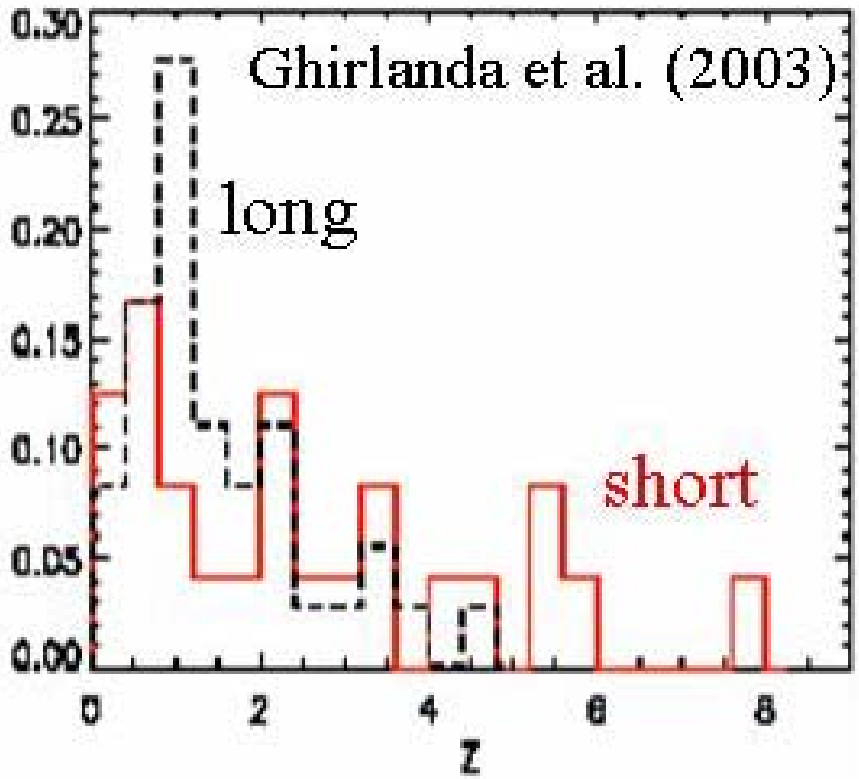
Similarity between short & long GRBs : 1

The distance scale of short GRB is similar to long GRB.

Luminosity indicator (Ep-L relation)

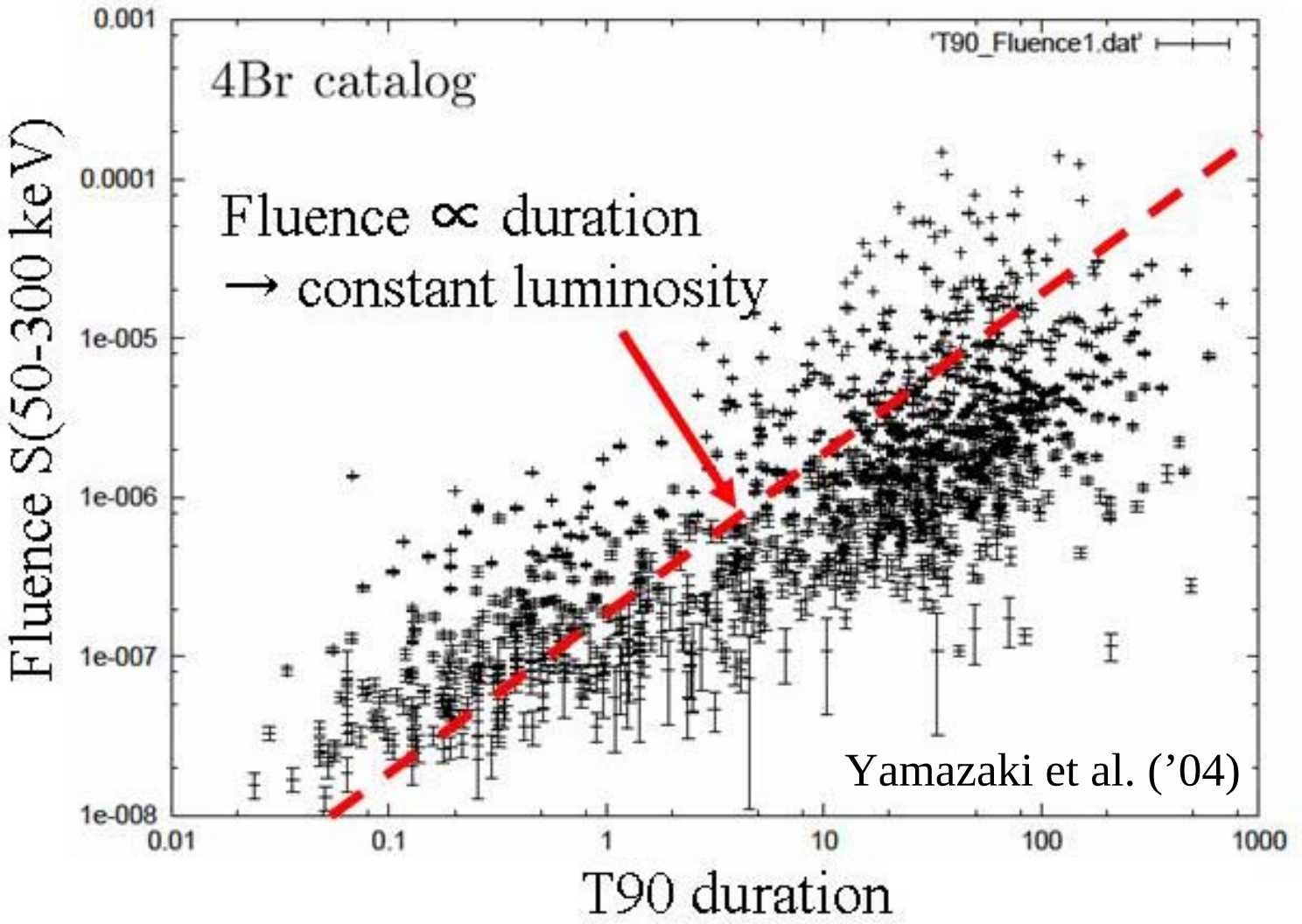


Redshift distribution



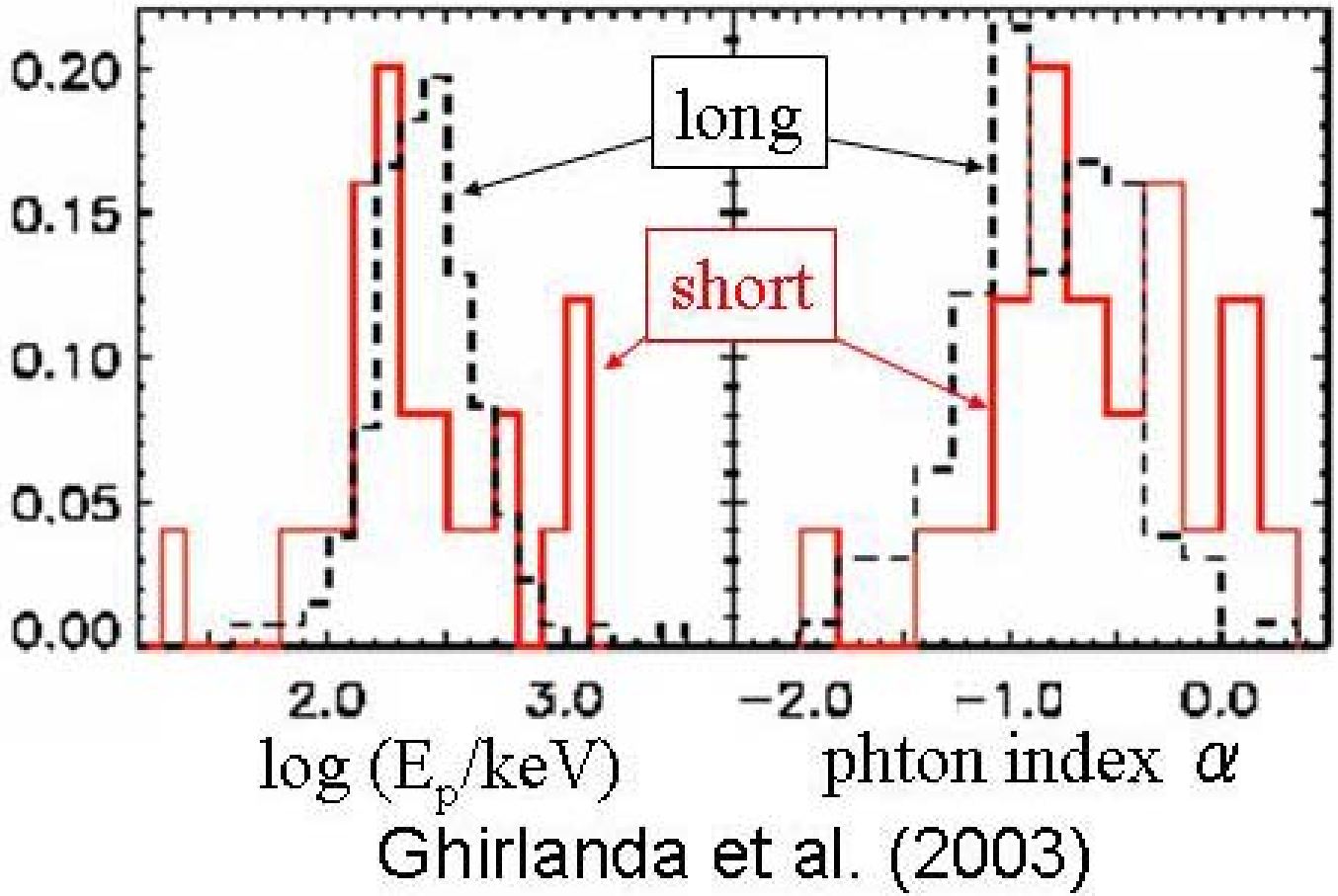
Similarity between short & long GRBs : 2

Luminosity of short GRB may be similar to long GRB.



Similarity between short & long GRBs : 3

The spectrum of short bursts may be similar to the first 1 sec of long GRBs.



Ghirlanda et al. (2003)

Origins of Short & Long GRB are…

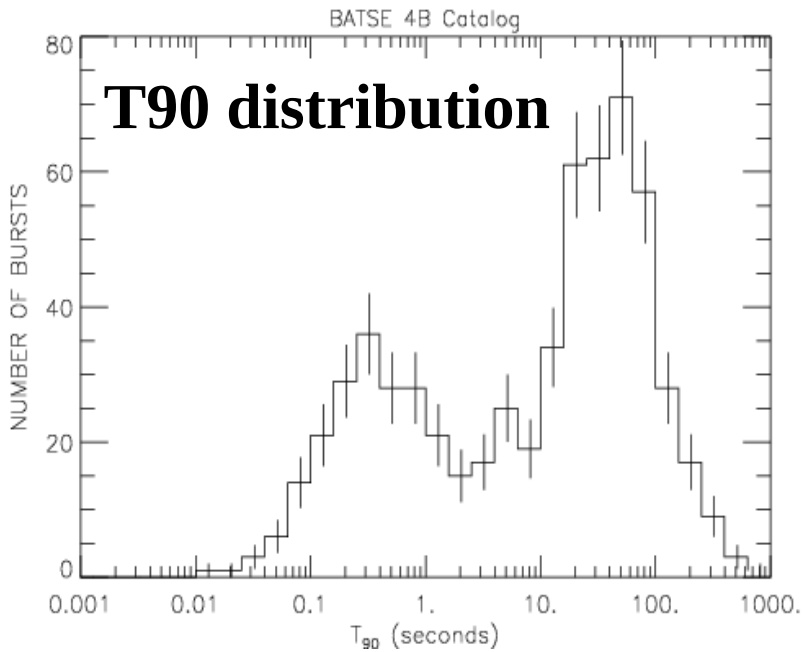
1. **Different:**

   short GRB = NS-NS merger

   long GRB = energetic SN

   Because

   T90 distribution is bimodal.



2. **Same:**

   Because

   i) Event rates are similar.

   ii) Short GRB is similar to the first 1 s of long GRB.

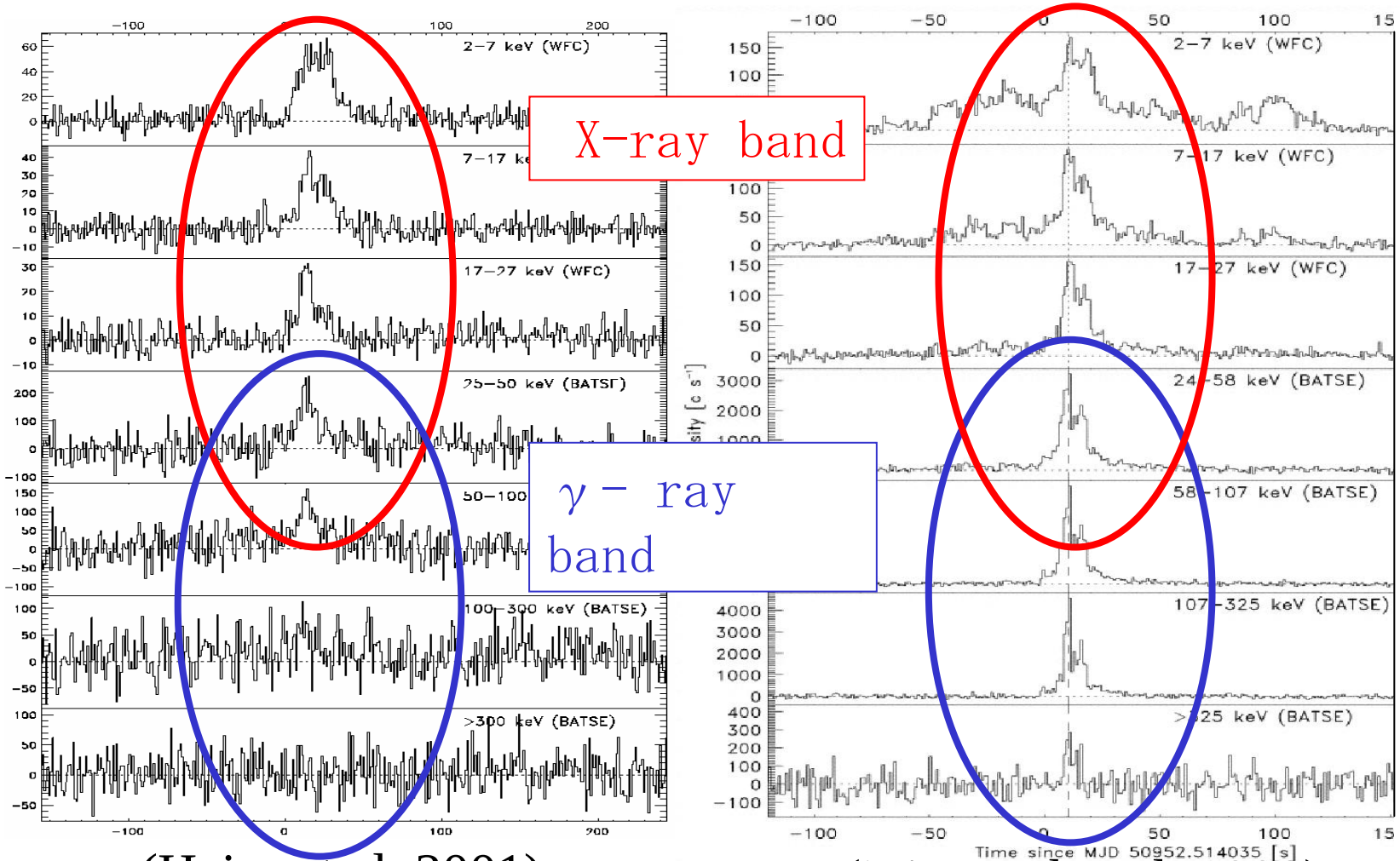
→ Properties of each pulse are the same.

→ The number of subjets (emission patches) along the LOS determines the observed properties of GRB population.

X-ray flashes and Normal (long) GRBs

X-ray flash (XRF)

γ-ray burst (GRB)



(Heise et al. 2001)

(in't Zand et al. 1999)

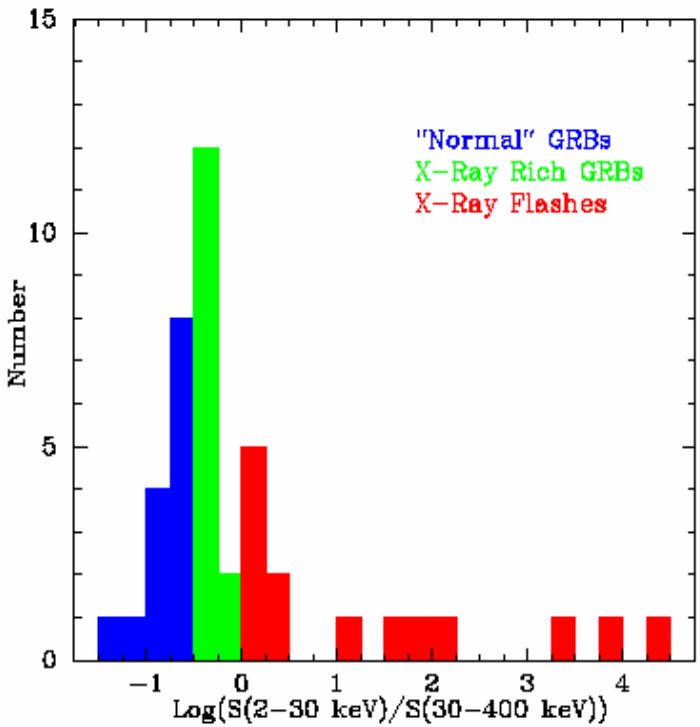
Origins of XRF & X-ray rich GRBs are…

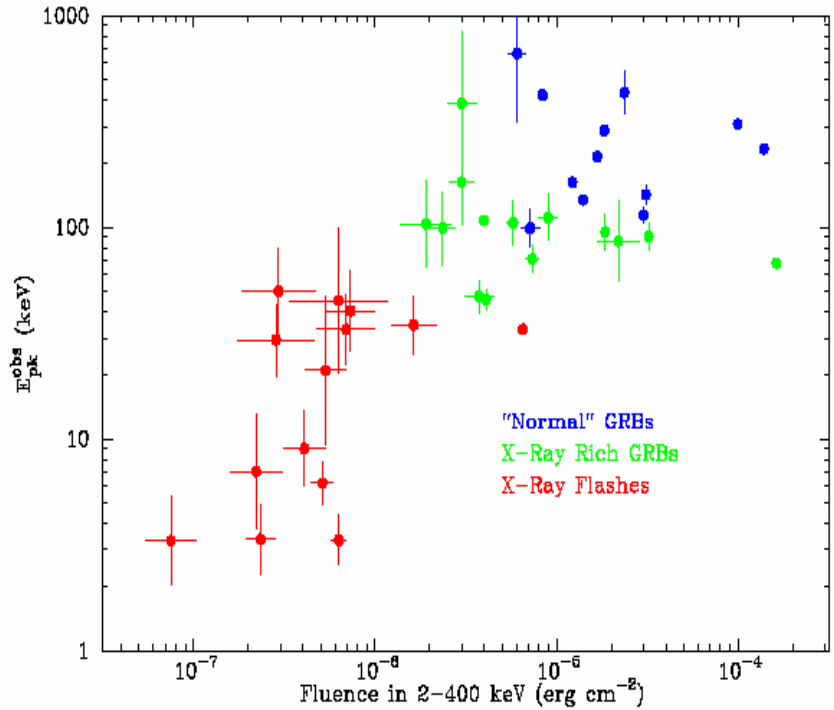
the same as long GRBs (by HETE-2).

Because

i) Event rates are similar.

ii) Long GRB, XRF, and XRR distribute continuously.



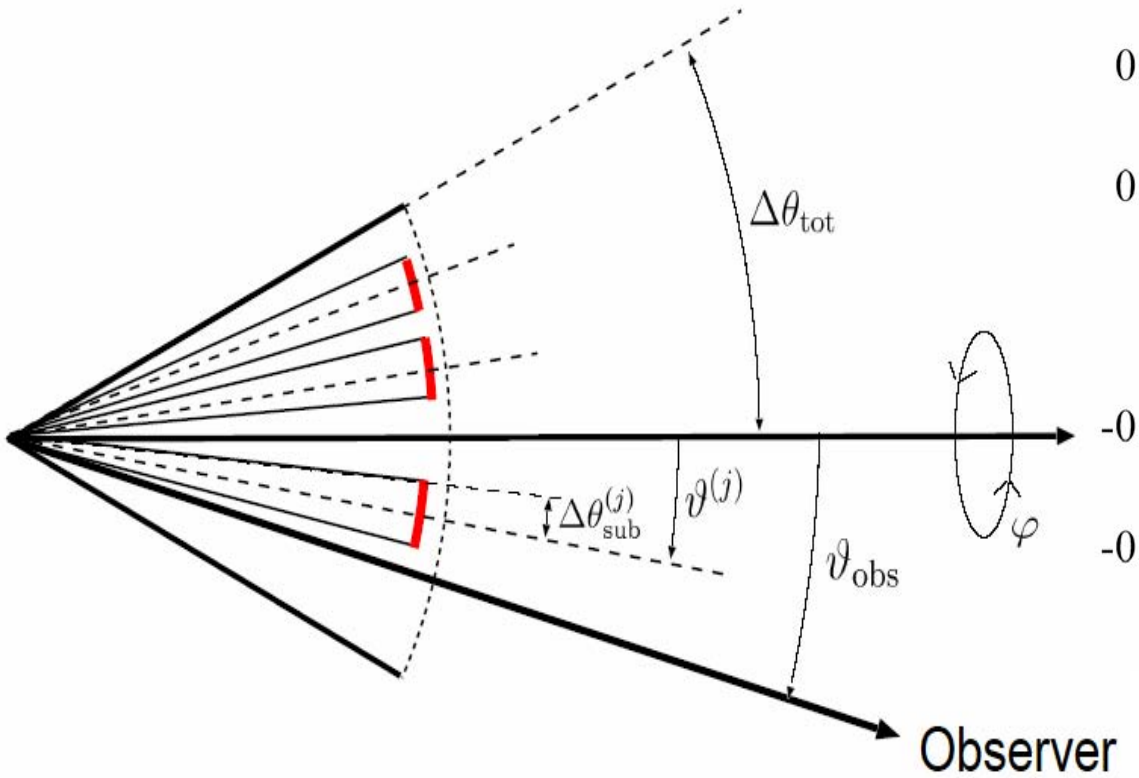


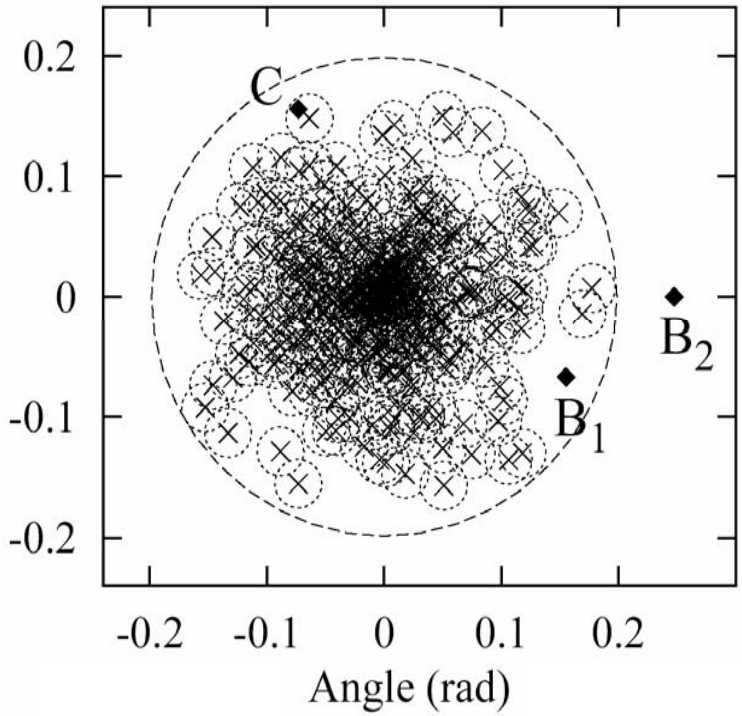
Lamb et al. (2003)

Multiple sub-jet model (Inhomogeneous Jet model)

Nakamura (2000), Kumar & Piran (2000)

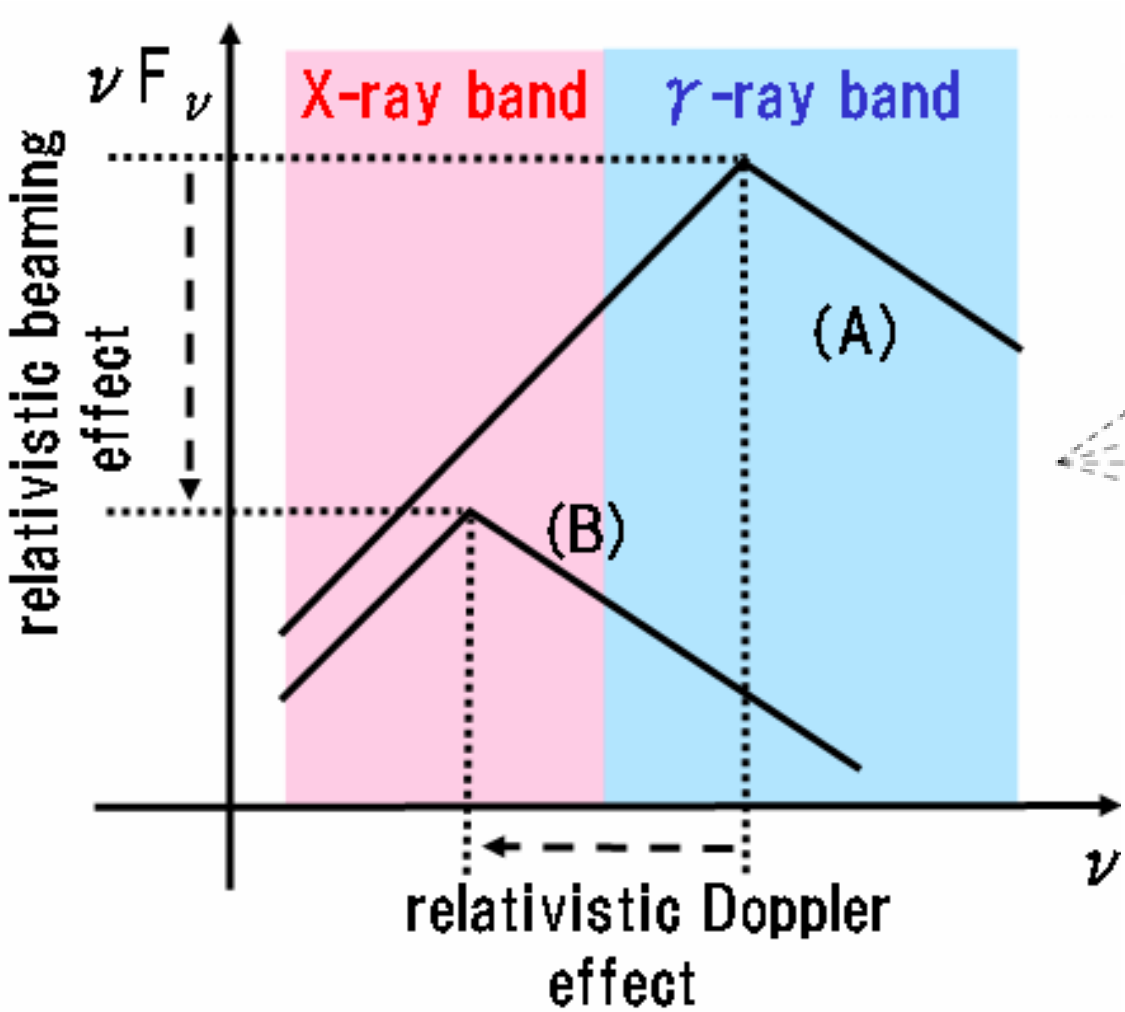
Many subjets (emission patches) are randomly launched (produced) by the central engine.

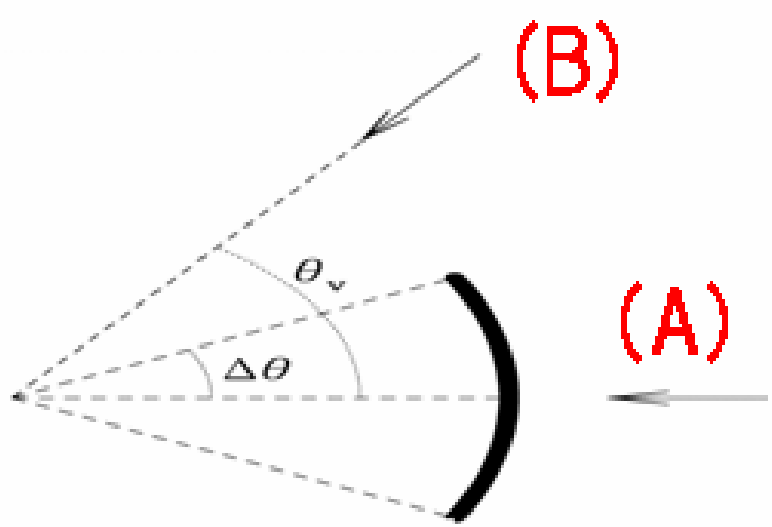




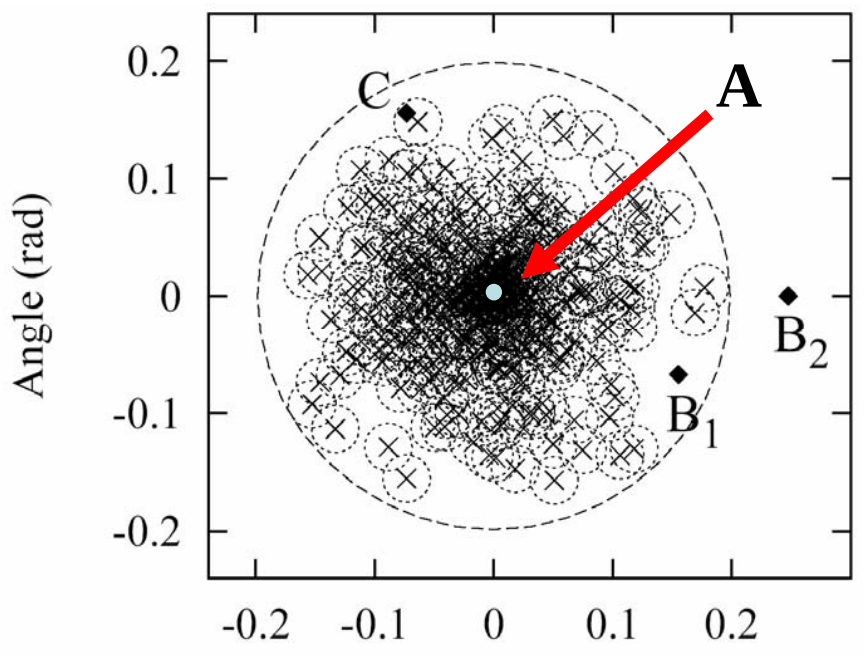
Angular distribution of subjet emissions

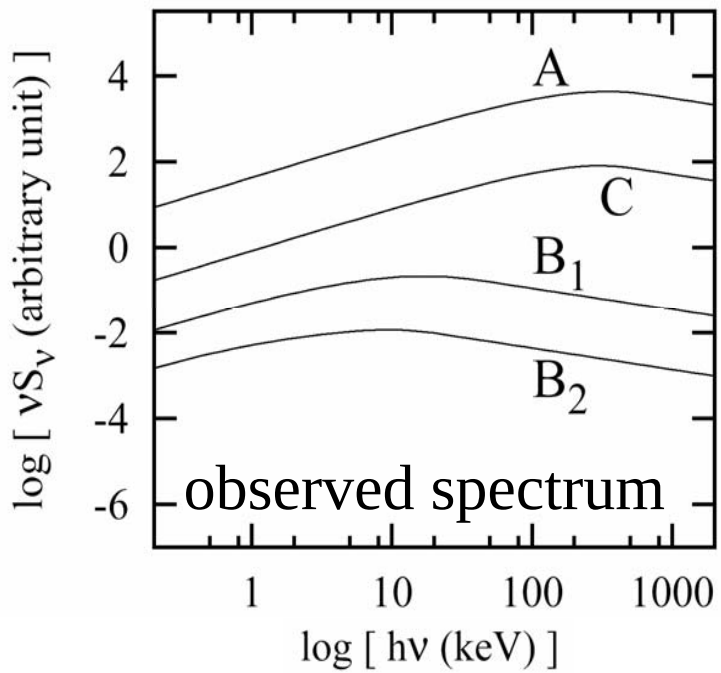
Relativistic Motion & Line of sight

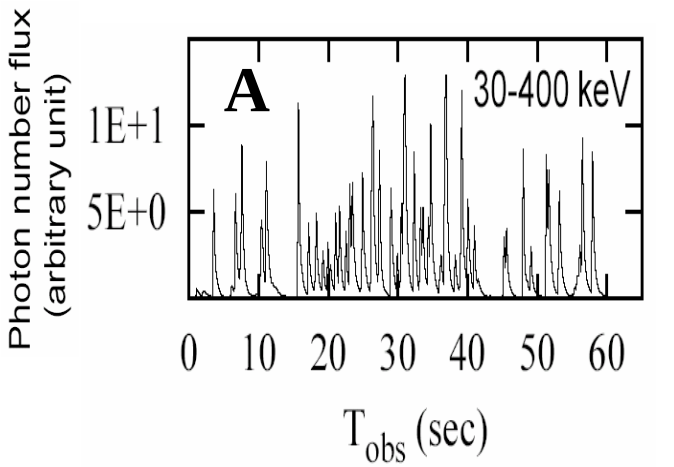




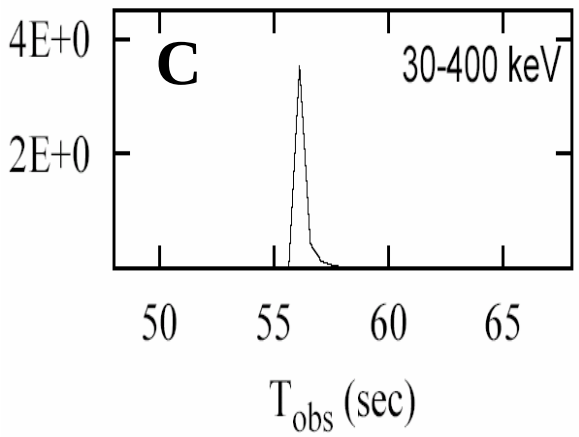
One Example (Yamazaki et al. 2004)



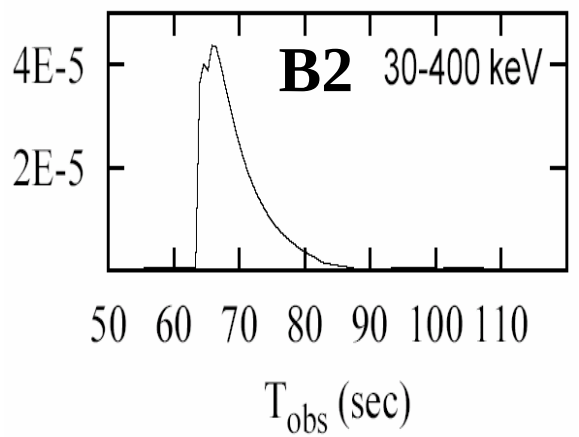




Long GRB



Short GRB

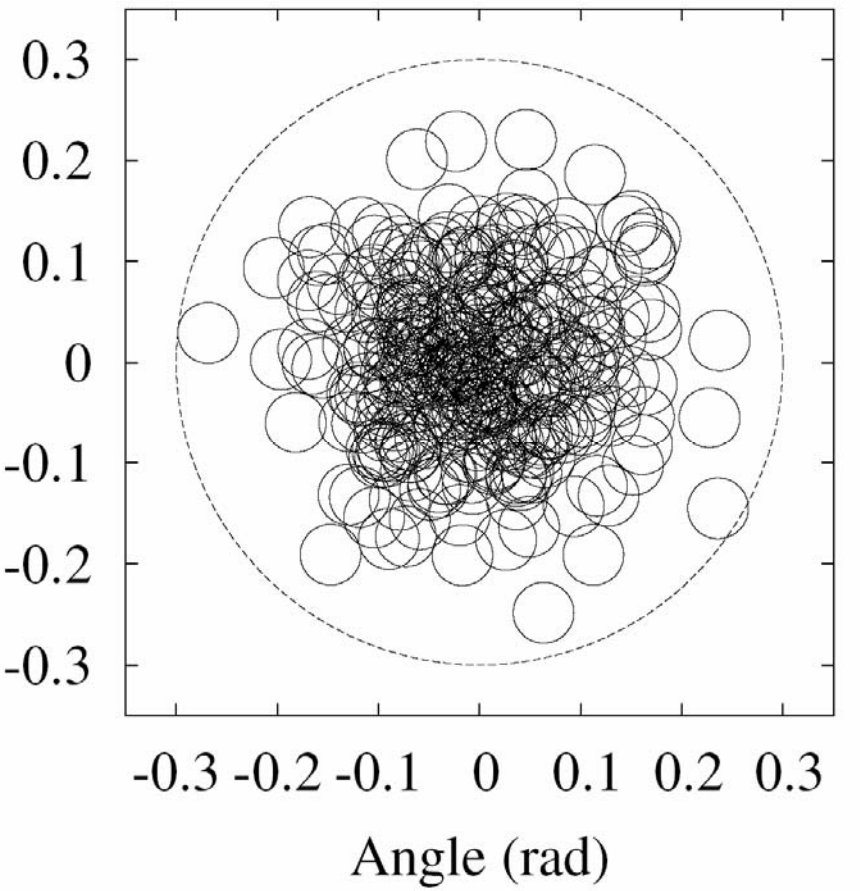


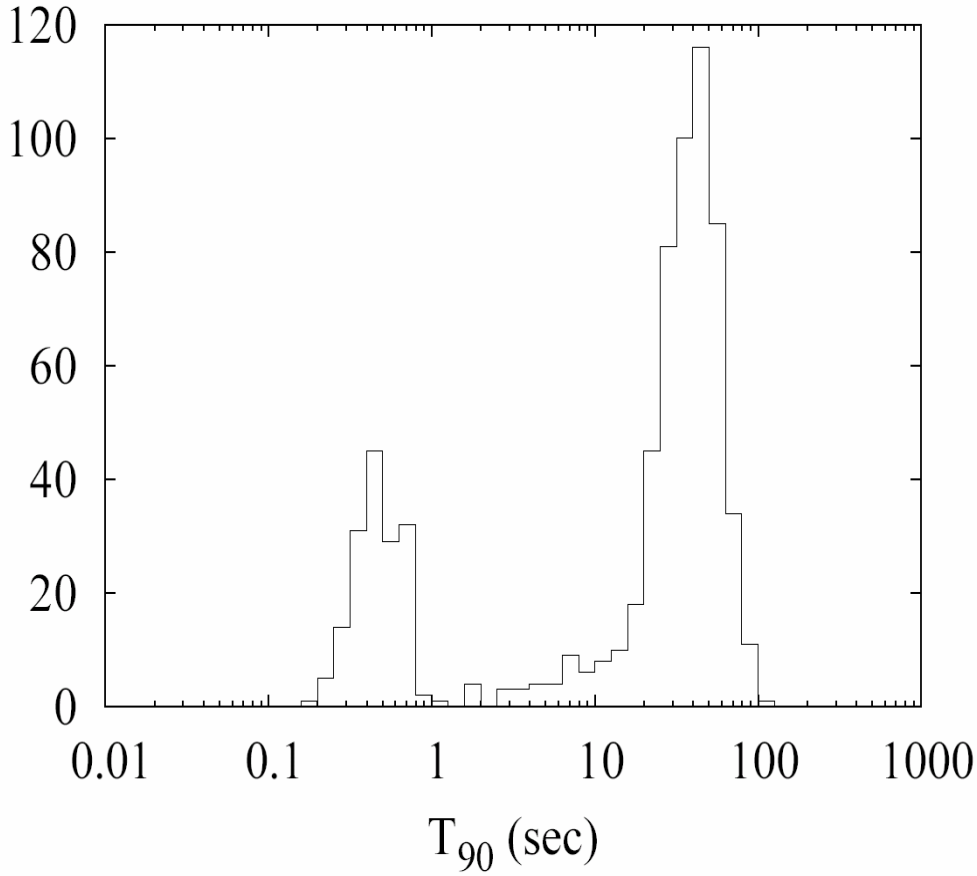
XRF/XRR

Bimodal distribution of T90 duration

Toma, Yamazaki, Nakamura (2004)

Bimodal T90 distribution can be reproduced.





Summary

n_s : the number of subjets along the line of sight

$n_s >> 1$ → long GRBs

$n_s = 1$ → short GRBs

$n_s = 0$ → X-ray rich GRBs or X-ray flashes

Observed event rates of long/short GRBs and XRFs may determine the geometry, i.e., the distribution of subjets.

Although we observe the same source, the different lines of sights produce different observed properties, as long/short GRBs, X-ray rich GRBs, and X-ray flashes.

Prediction of our model : All progenitors are massive-star origin. Short bursts and XRFs will be associated with SN signatures or star forming regions.