Probing mini black holes with astrophysical data

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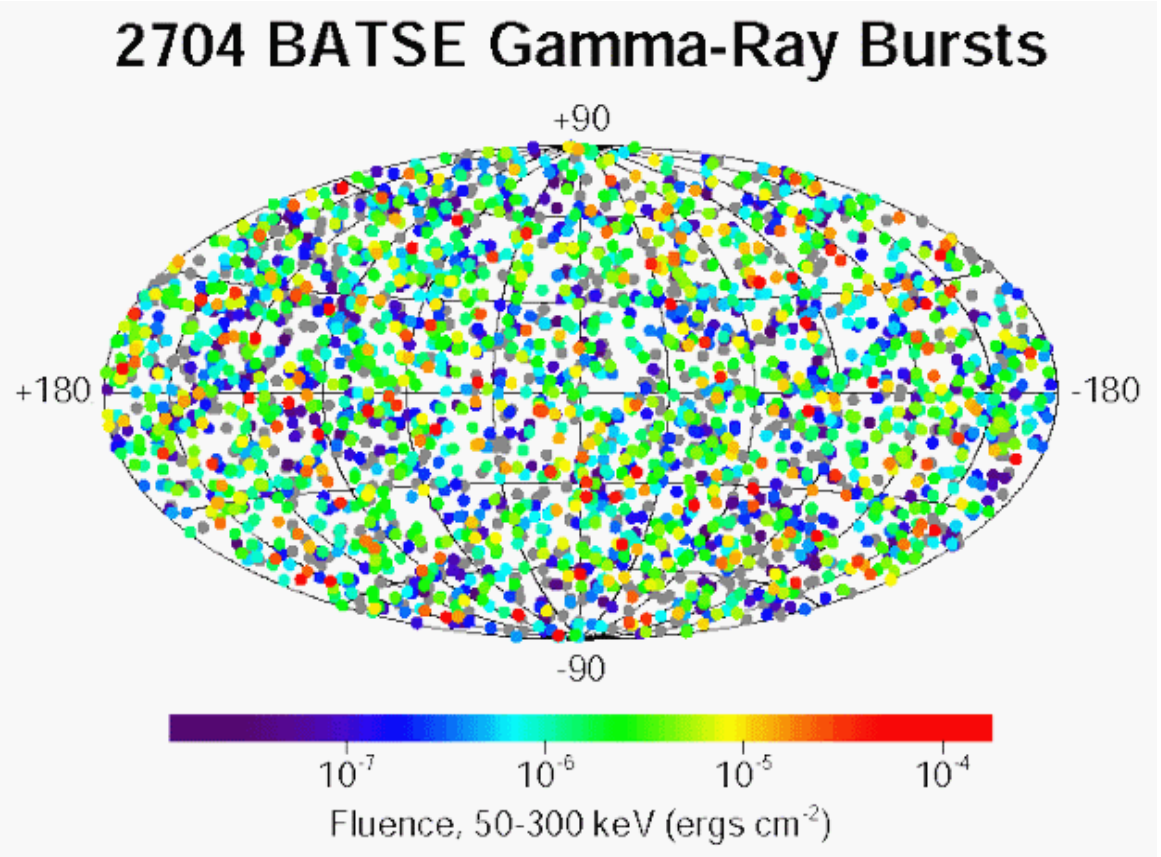
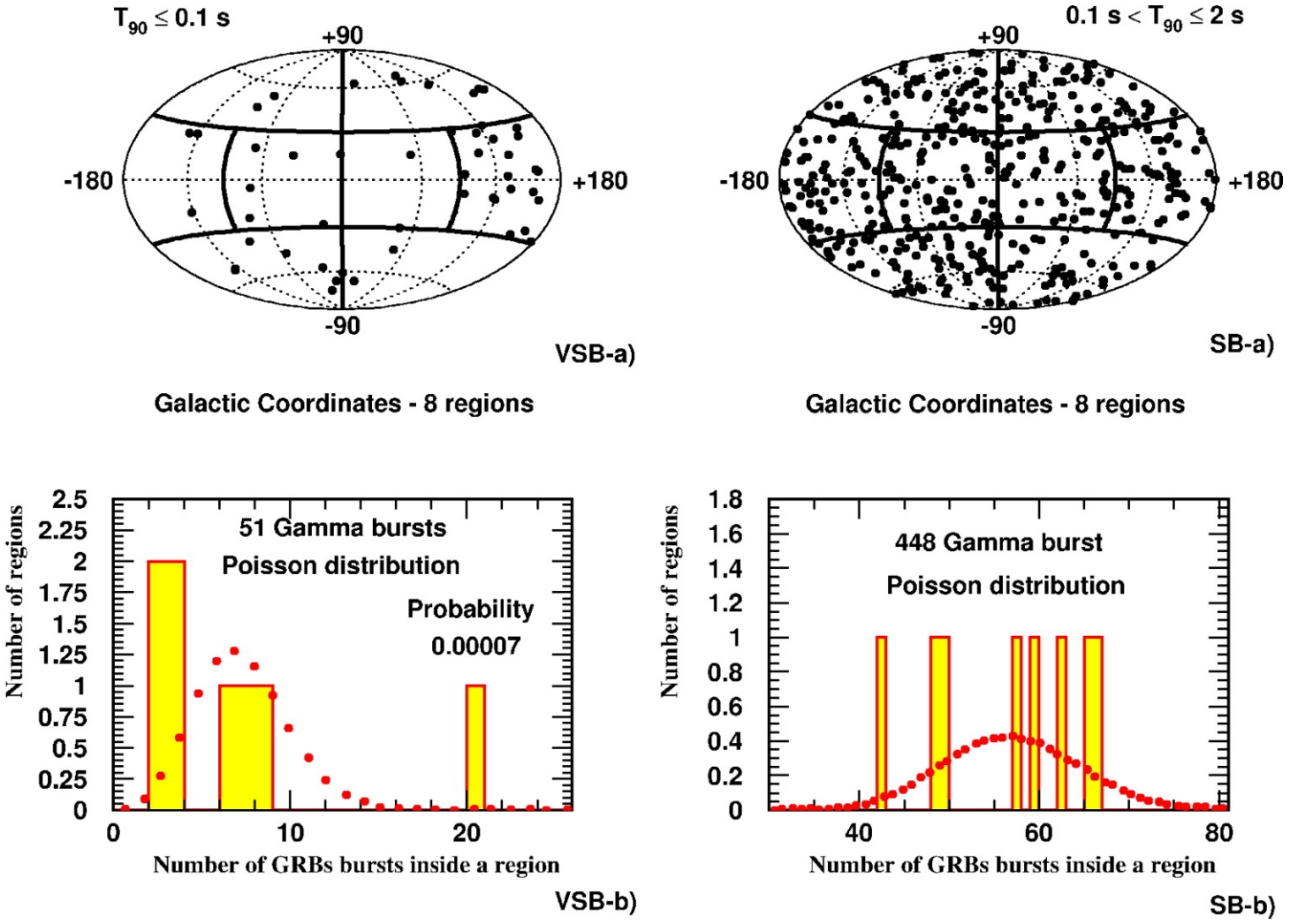
Some possible astrophysical manifestations of mini black holes

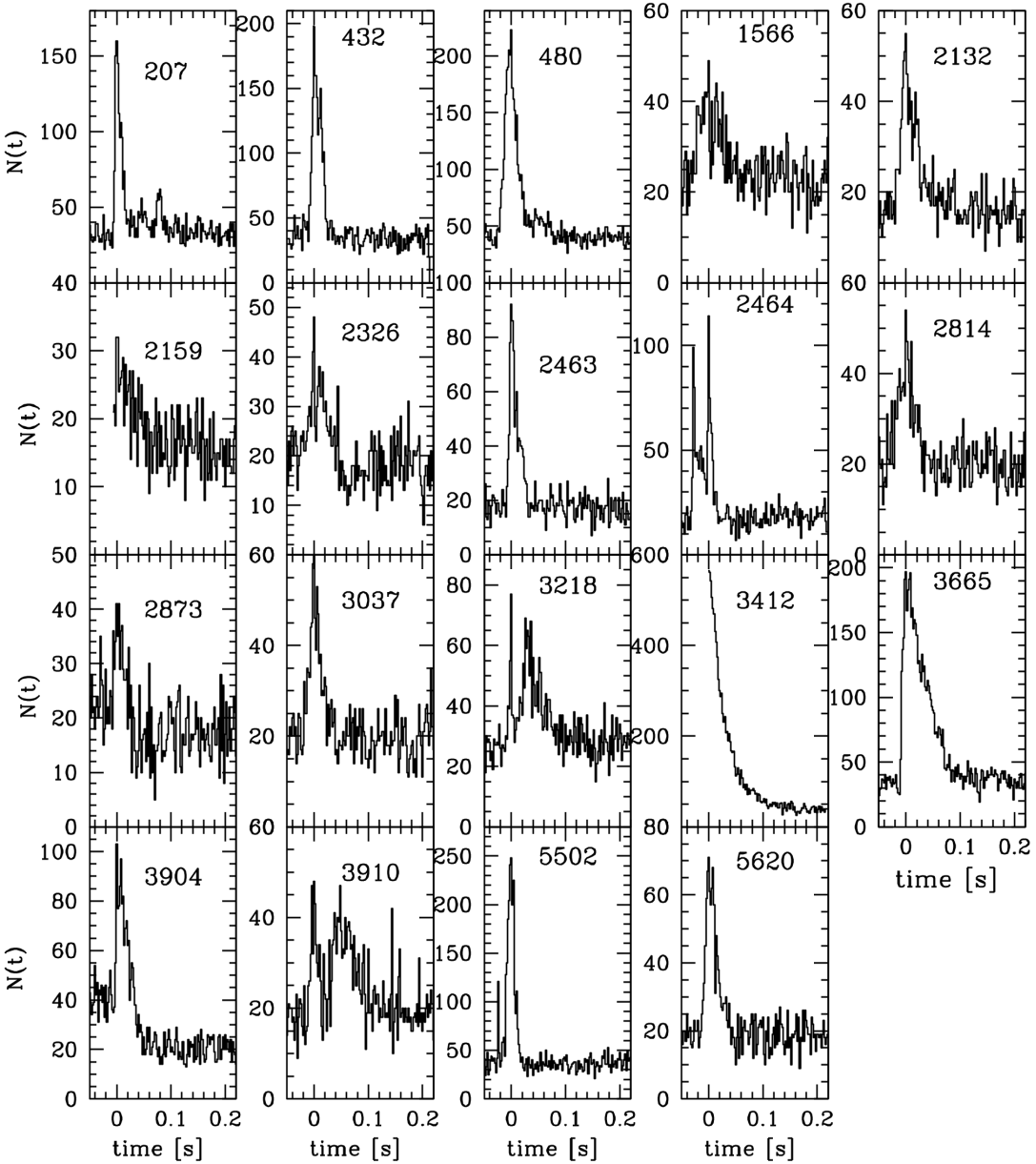
1. gamma ray bursts (e.g. This work)
2. encounters with stars in the Galaxy (e.g., Abramowicz et al. 2009)
3. dark energy (e.g Lacki & Beacom 2010)



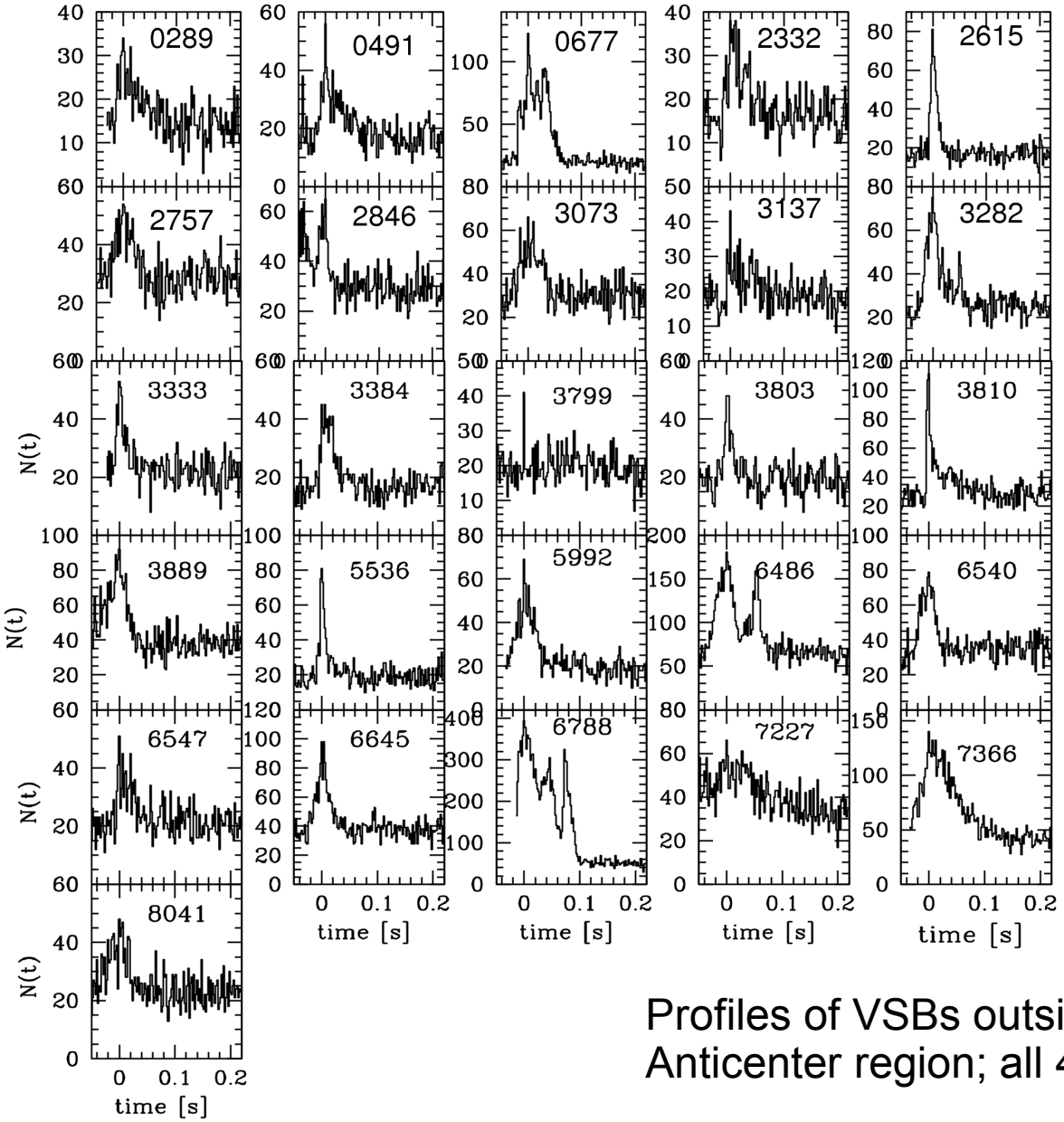
· Izotropic, no recurrence, up to several events/day
· uniformly distributed in space
· cosmological origin of long (T>2 s) and short (T<2 s) events



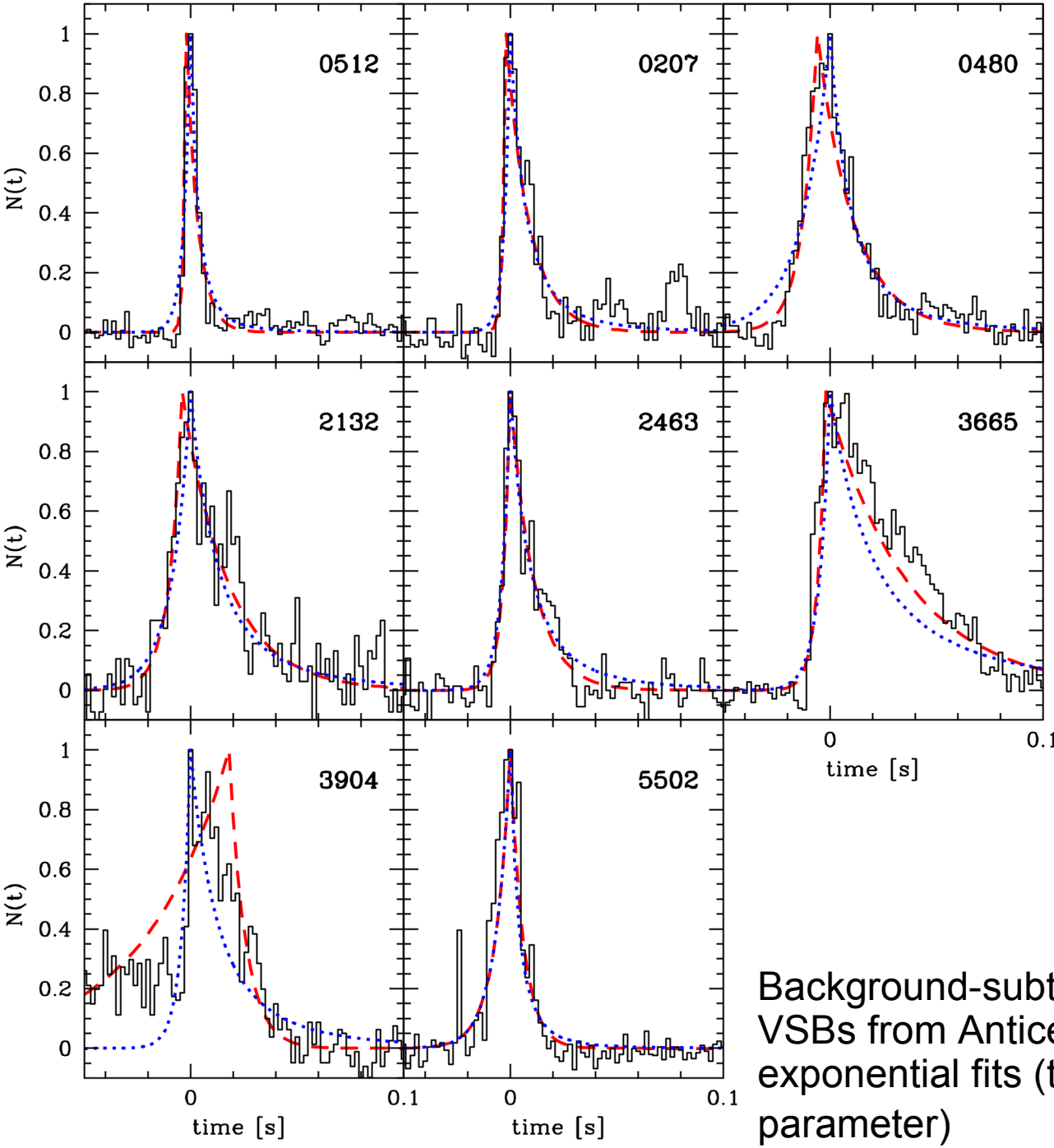
Angular distribution of BATSE short GRBs in Galactic coordinates; events from 1991 to 2000
(*Cline et al. 2005*)



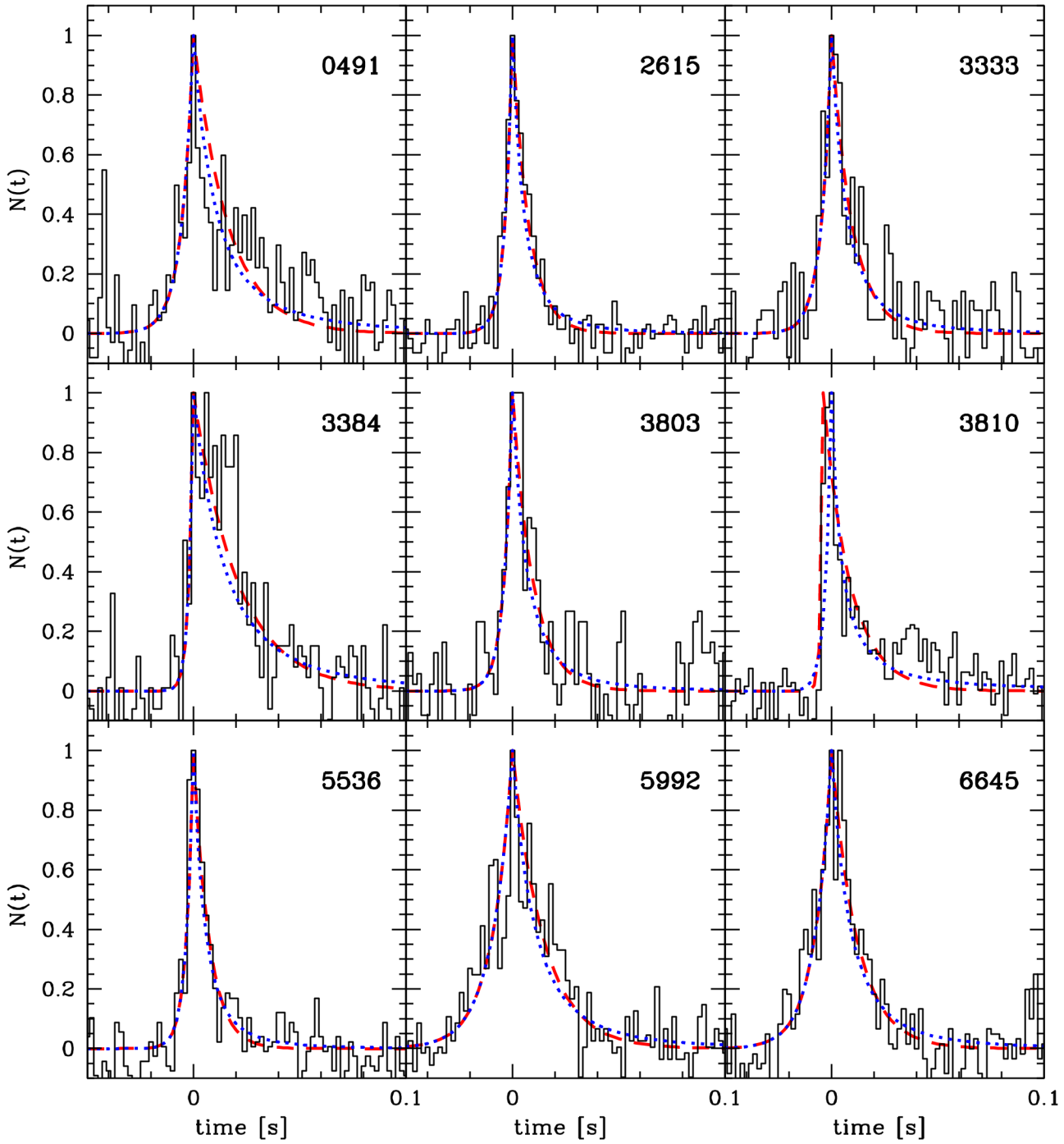
Profiles of VSBs from Galactic Anticenter region; all 4 BATSE channels (Czerny et al. 2010)



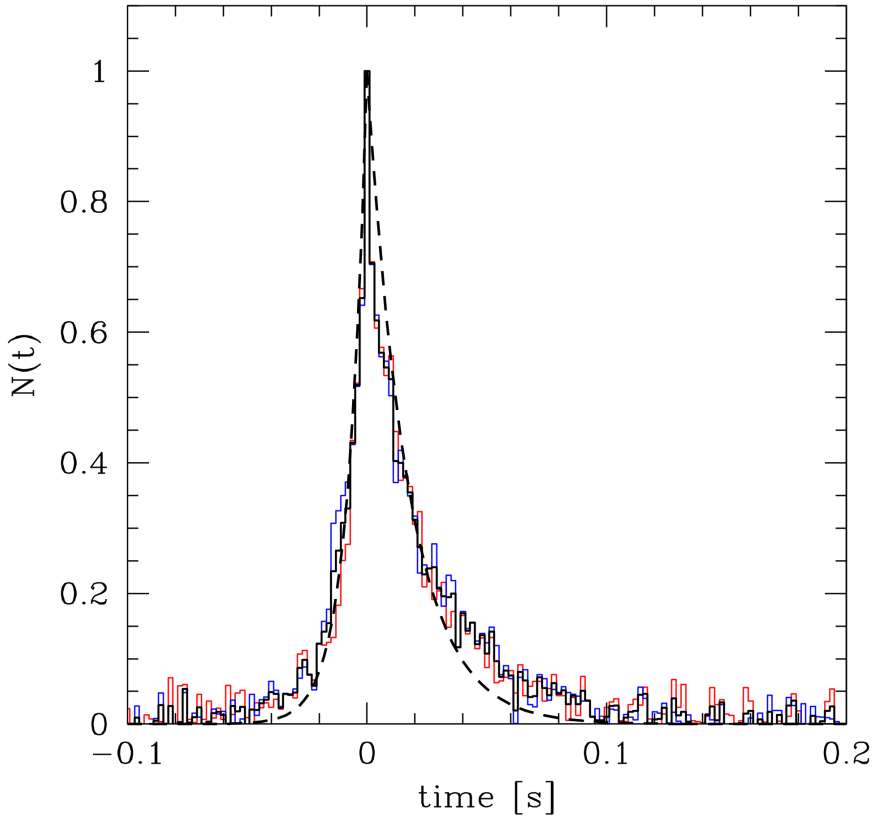
Profiles of VSBs outside the Galactic Anticenter region; all 4 BATSE channels

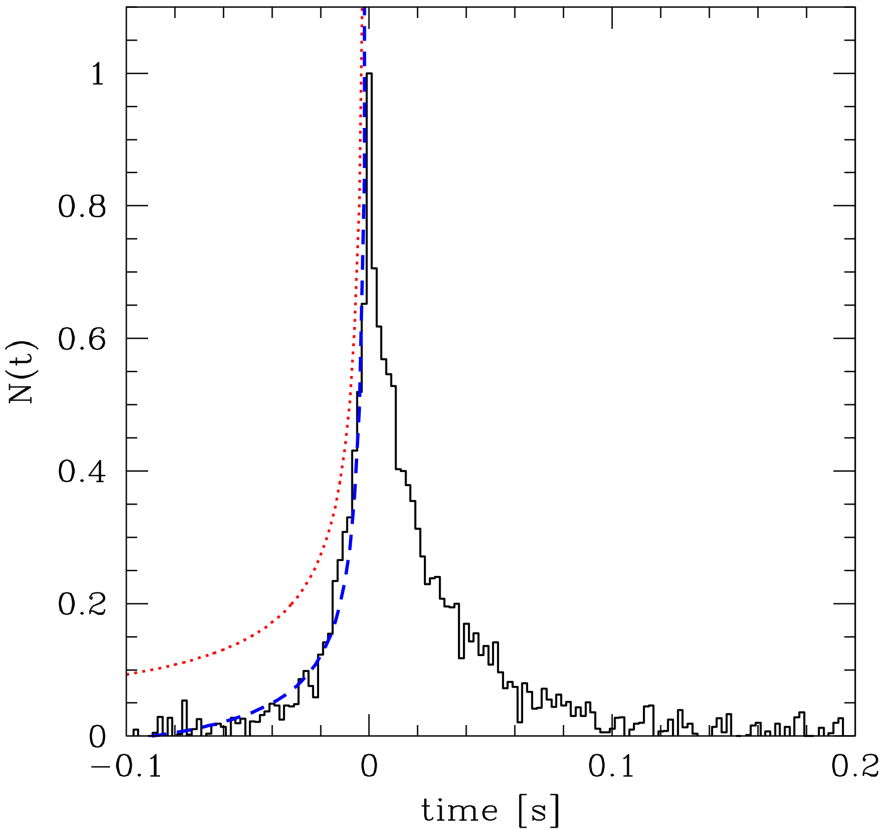


Background-subtracted profiles of selected VSBs from Anticenter region, with double-exponential fits (t_0 either fixed or free parameter)



Background-subtracted profiles of selected VSBs outside the Anticenter region, with double-exponential fits (t_0 either fixed or free parameter)





Composite profiles of VSBs with

- double exponential fit (left)
- bh evaporation profile (right), normalized to the luminosity integral or to the background level

Very Short Bursts:

- Distribution of the arrival times: uniform
- Profiles are typically asymmetric
- Some have two or more subpulses
- Much harder in energies than short bursts
- No significant time delays between the channels (> 2ms)
- Distribution in space more local than for short bursts, but might be a selection effect
- SWIFT VSB bursts are not located in the Anticenter region, but sample still very small

The Anticenter region:

- Rich star formation region
- Nucleosynthesis acivity indicated by COMPTEL Al^{26} survey
- Excess of the TeV cosmic rays
- Correlation of microwave background and diffuse gamma rays

Two mechanisms of origin discussed

- **Exceptionally short timescale binary merger**
  - Typically, NS-NS or NS-BH merger simulations give the timescales of 50-100 ms. The shortest VSB is 5.3 ms
  - Delayed hypermassive NS collapse with a hot magnetized torus (e.g. Shibata et al. 2006) give the shortest timescales

- **Evaporation of primordial black holes**
  - BH masses in the range 10^9 – 10^{14} g.
  - Mass evaporating now (during the final 0.1 s) is 6x 10^9 g; after a year is 4x 10^{11} g. The observed rate of VSBs (0.3 yr^{-1} pc^{-3}) gives the normalization to the mass distribution, $Omega_{PBH} \sim 10^{-9}$
  - Profiles are not identical: local fluctuations may be large if there is no thermalization at the beginning of the process and evaporation proceeds throug quark jets