

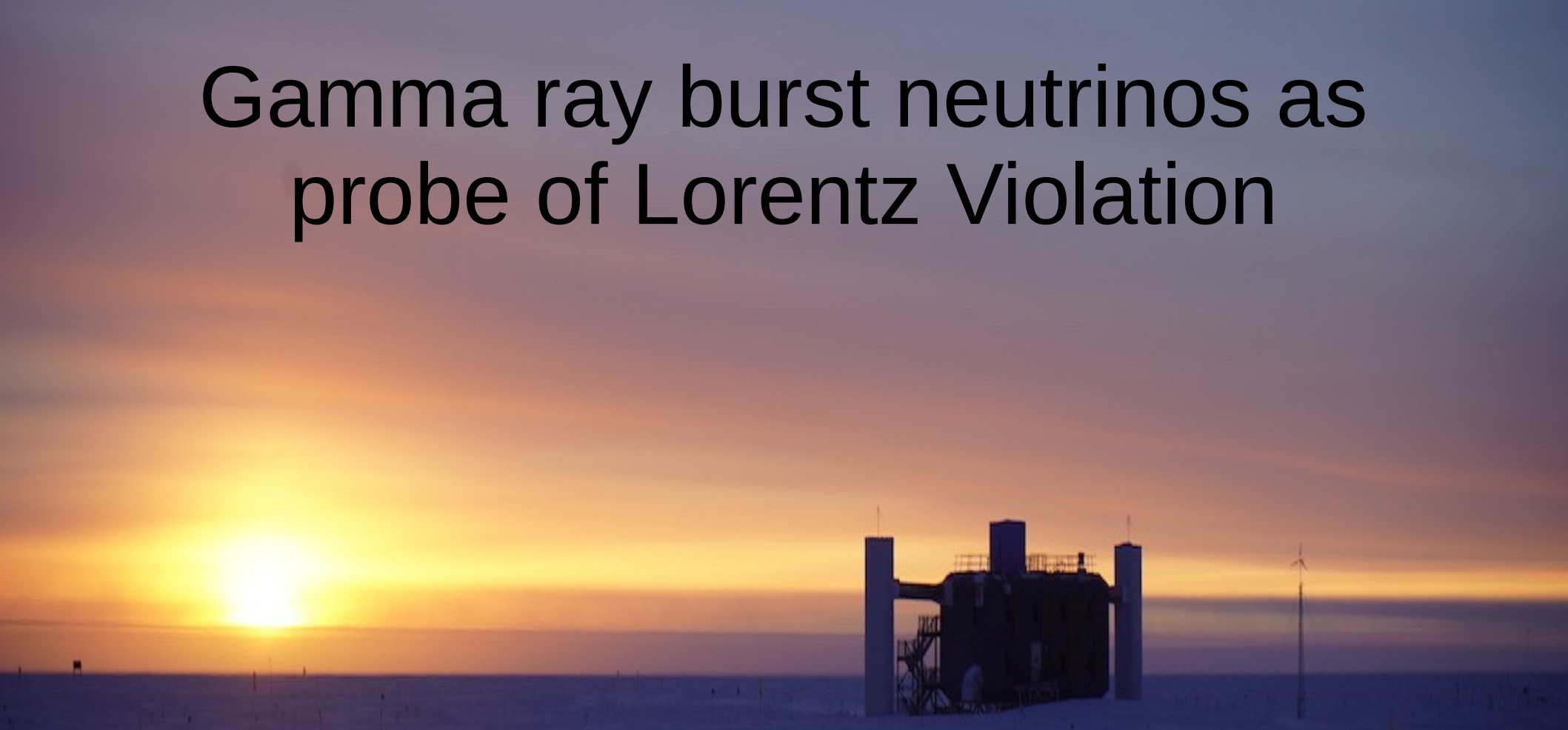
Gamma ray burst neutrinos as probe of Lorentz Violation



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Gamma ray burst neutrinos as probe of Lorentz Violation



We explore the possibilities of Lorentz Invariance Violations (LIV) in high energy cosmic neutrinos (Ellis, John et al (2019)). For this we use neutrinos from ICEcube data. When a neutrino interacts with the ice it forms charged particles, which in turn emit Cherenkov radiation that is detected by ICEcube. We combine this with data from the GCN and GRBweb to associate a neutrino with a gamma ray burst source. Next we look at the difference in arrival time of a photon and a neutrino from the same GRB source to be able to look at signs of LIV effects. (Schmid, Julia (2014), Antares colaboration (2016)).

We will make use of pseudo experiments in the near future to try to obtain statistically Feasible results and filter out for background effects.

Lorentz Invariance Violation

The LIV can be quantified by finding the shift in arrival time between photons and neutrinos. As we can see this shift depends on the energy of the neutrino, the distance to the source and the energy at which the symmetry is broken.

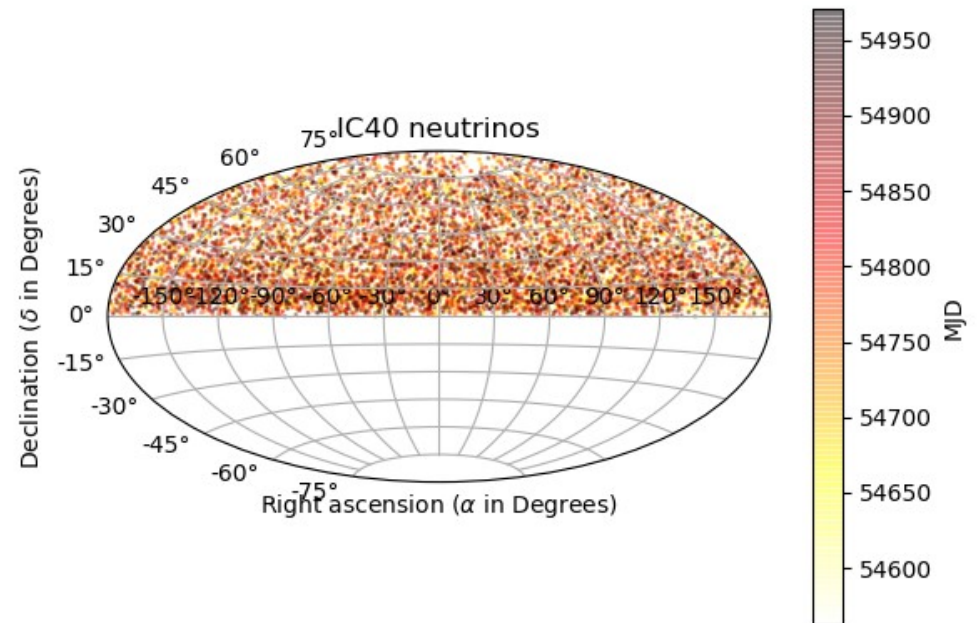
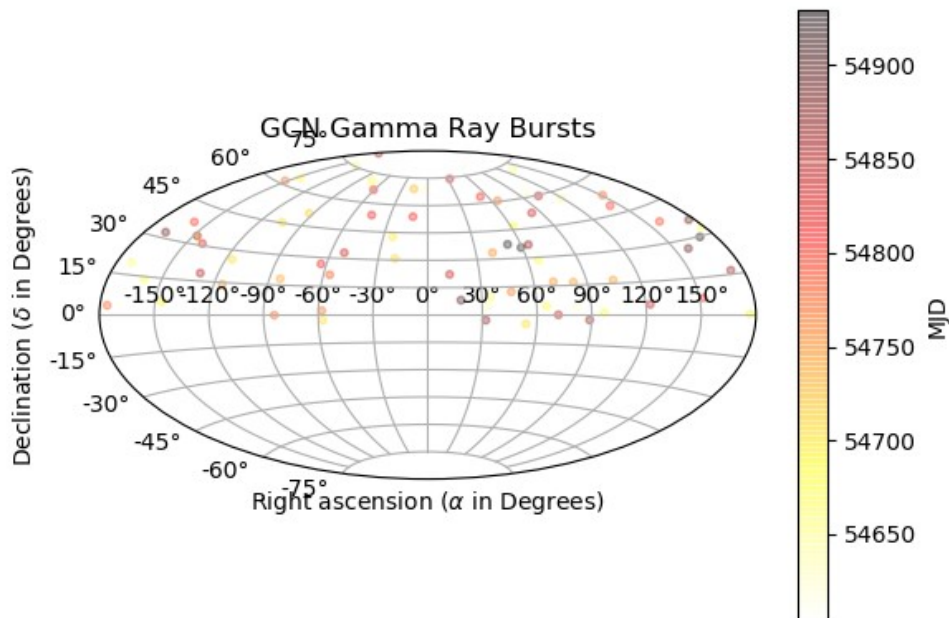
$$\Delta t_{\text{LIV}} = (\pm 1) \cdot E/M_{\text{LIV}} \cdot D(z)/c$$

Since we expect the time shifts due to LIV to be small we will probe this using stacked Distributions.

$$\tau_{\text{LIV}} = \frac{\tau}{E_{\text{est}} \cdot D(z)} \quad ; \quad D(z) = \frac{c}{H_0} \int_0^z \frac{(1+z') dz'}{\sqrt{\Omega_m(1+z')^3 + \Omega_\Lambda}}$$

Initial Data

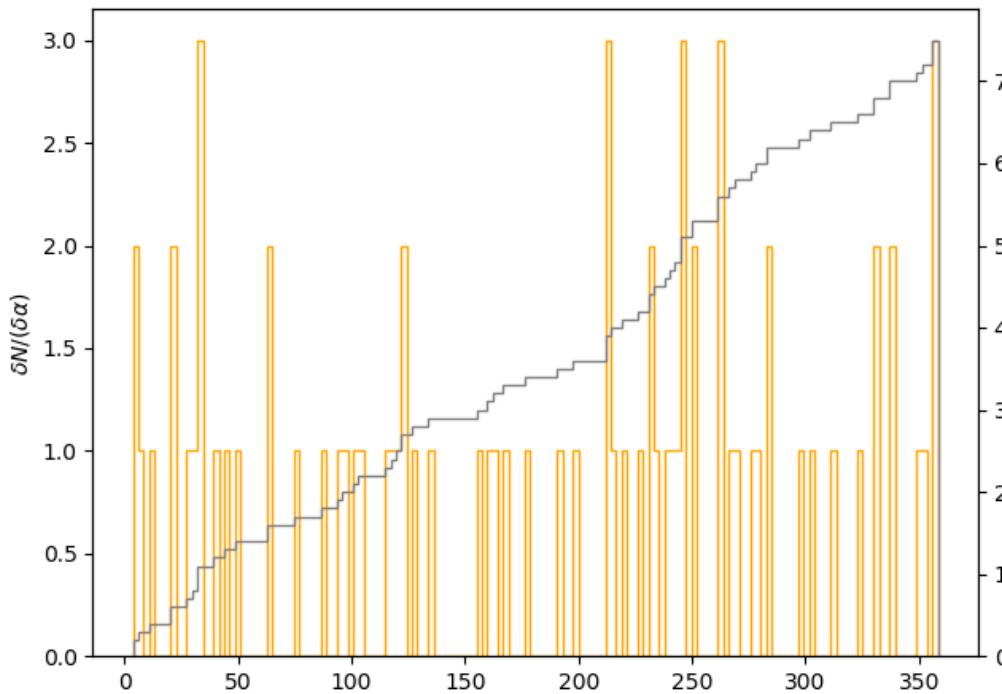
- 75 out of 1326 GCN GRB (GCN.nasa.gov)
- GRBweb2 (GRBweb)
- 12875 IC40 neutrinos ([R. Abbasi et al](#))
- Data period April 2008 may 2009



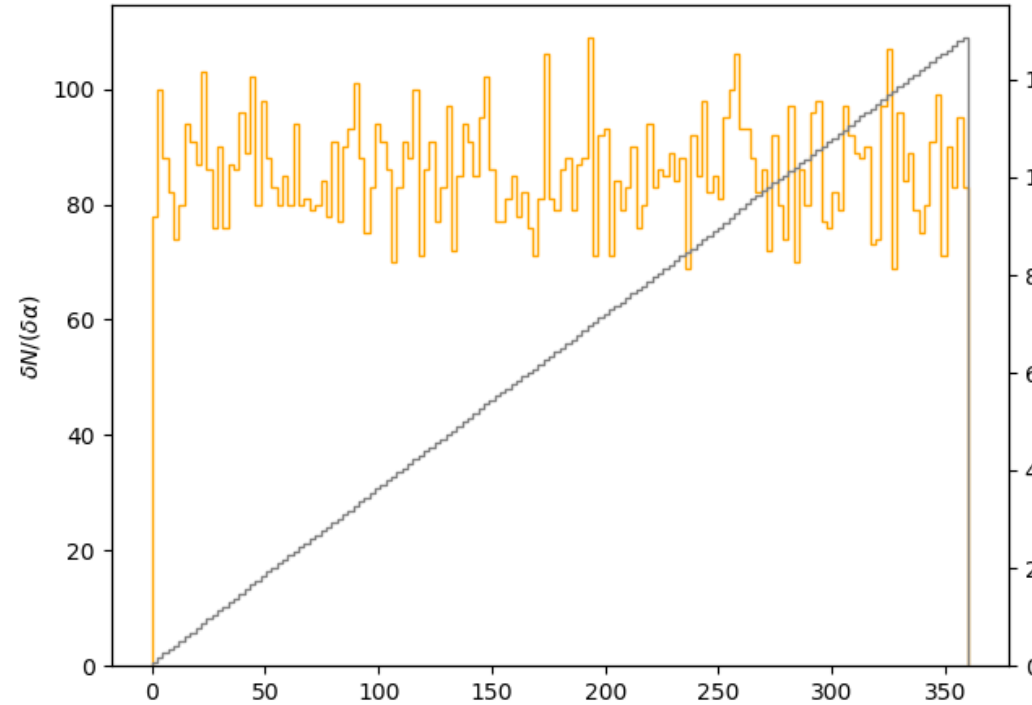
Initial data

- First selection error, location, moment of burst
- Randomly distributed

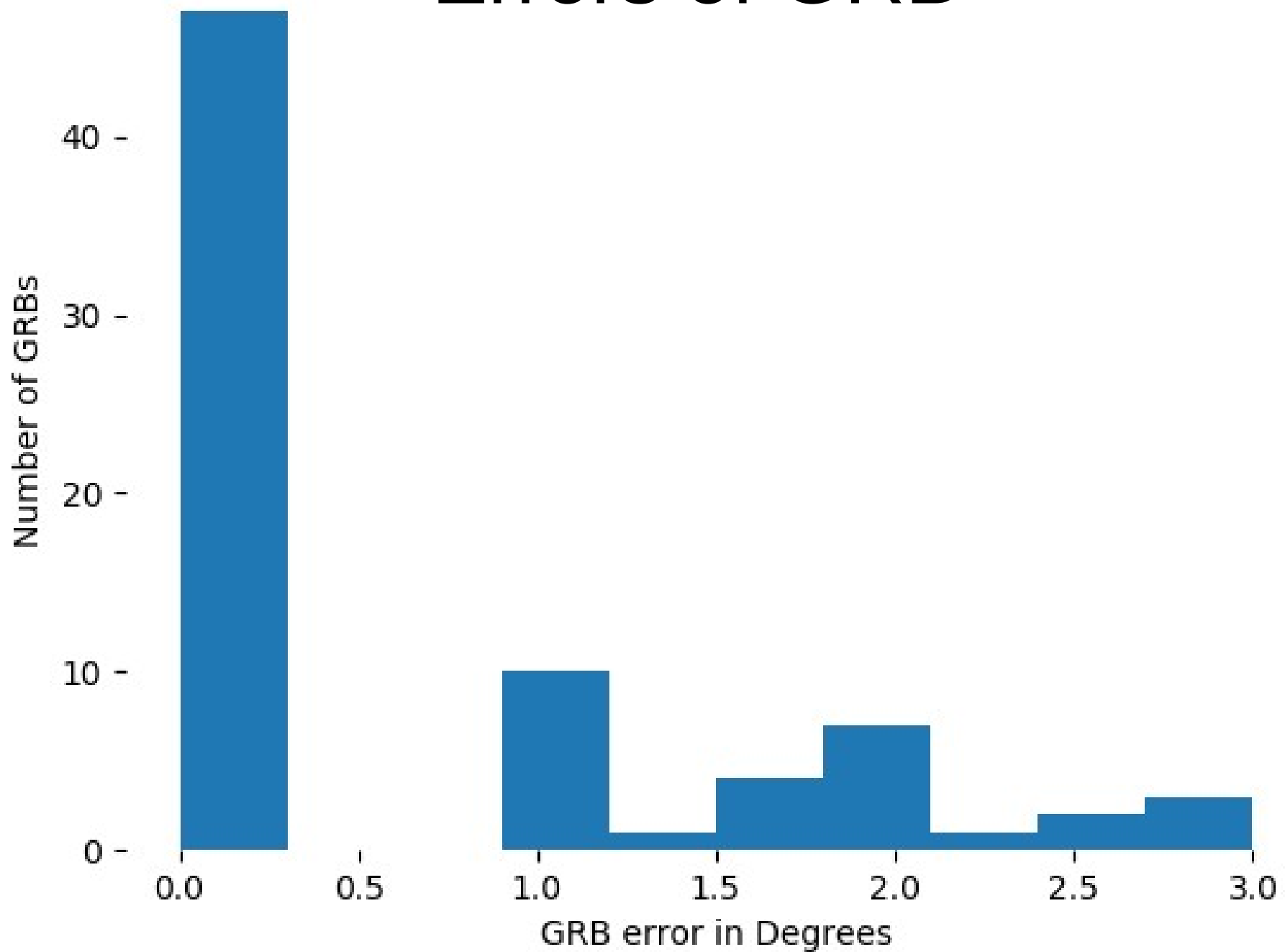
GCN GRB



IC40 neutrinos

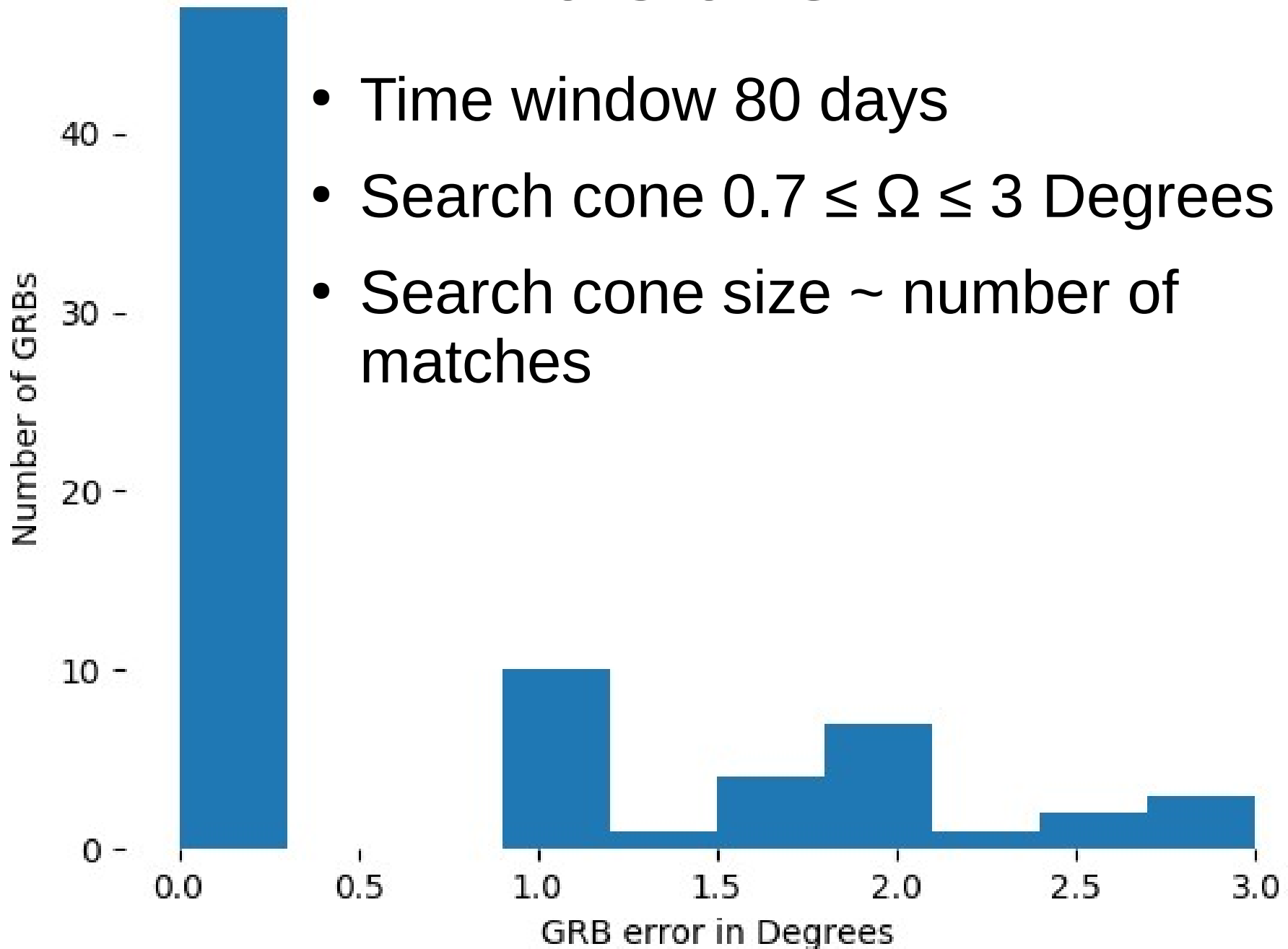


Errors of GRB



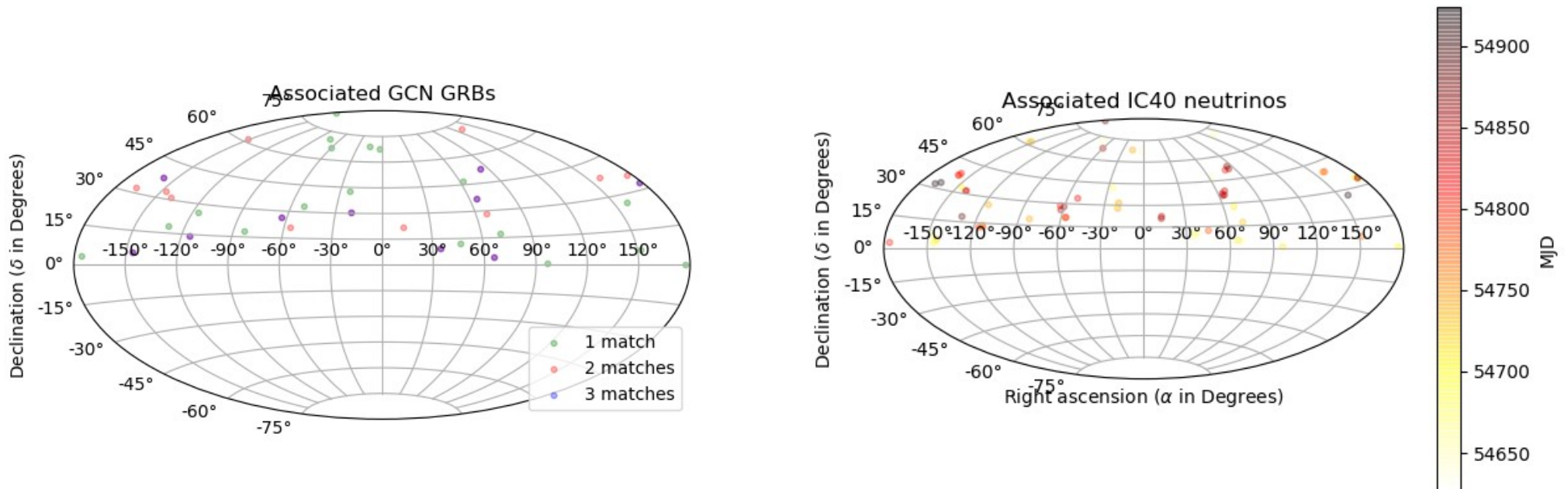
Errors of GRB

- Time window 80 days
- Search cone $0.7 \leq \Omega \leq 3$ Degrees
- Search cone size \sim number of matches



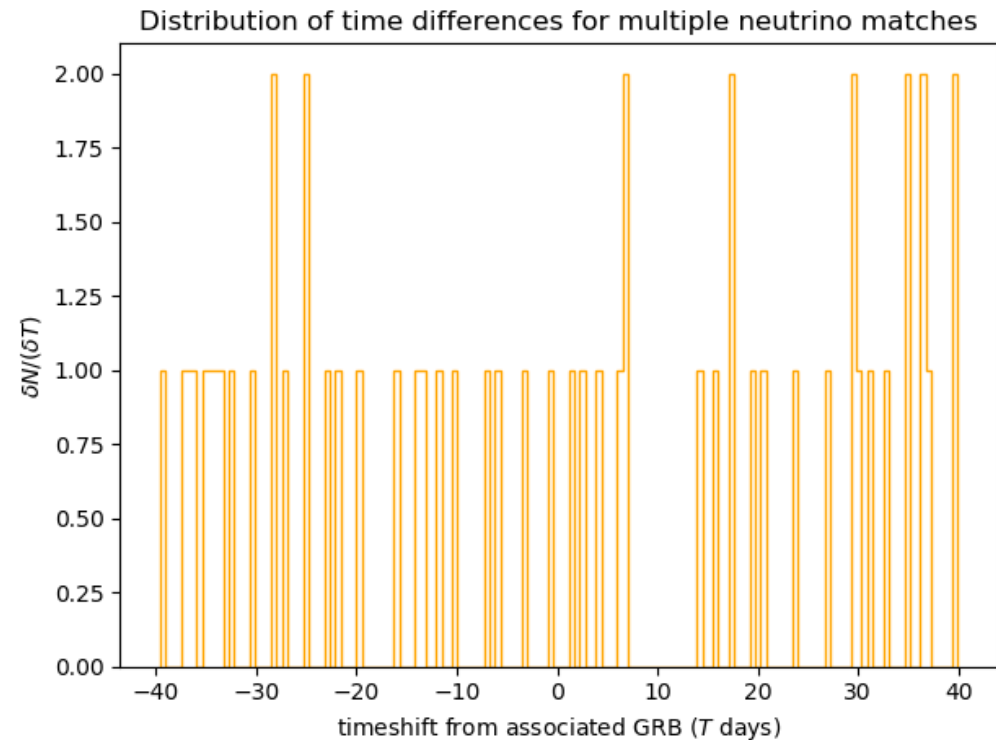
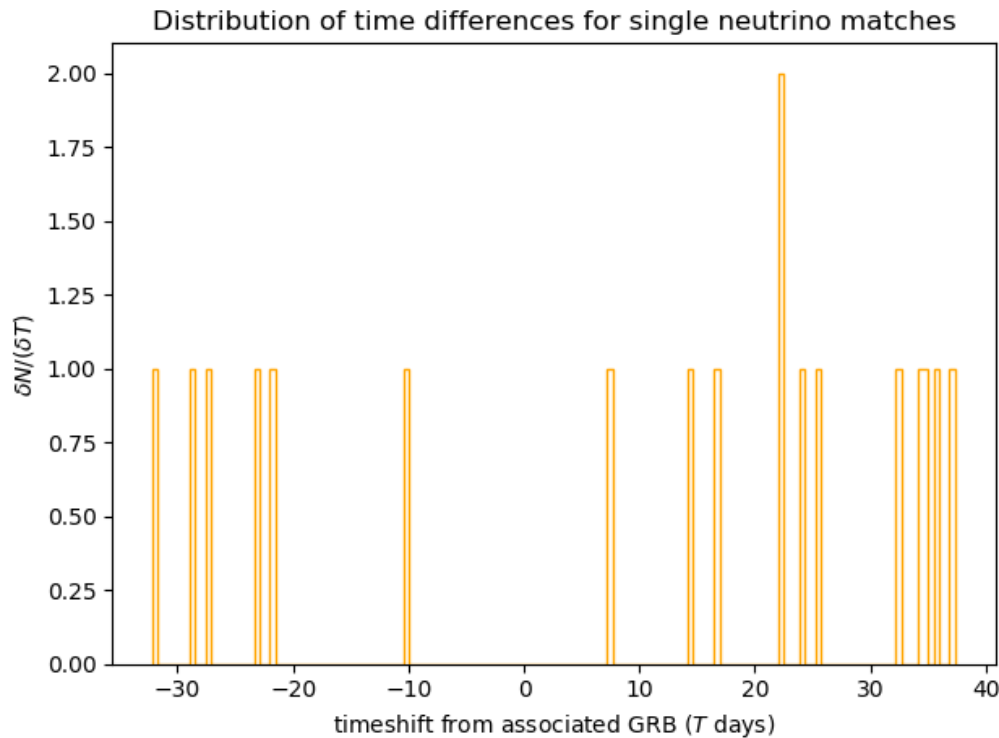
After matching

- GRB can match with multiple neutrinos
- Number of matches depends on search cone size \rightarrow positional error of GRB



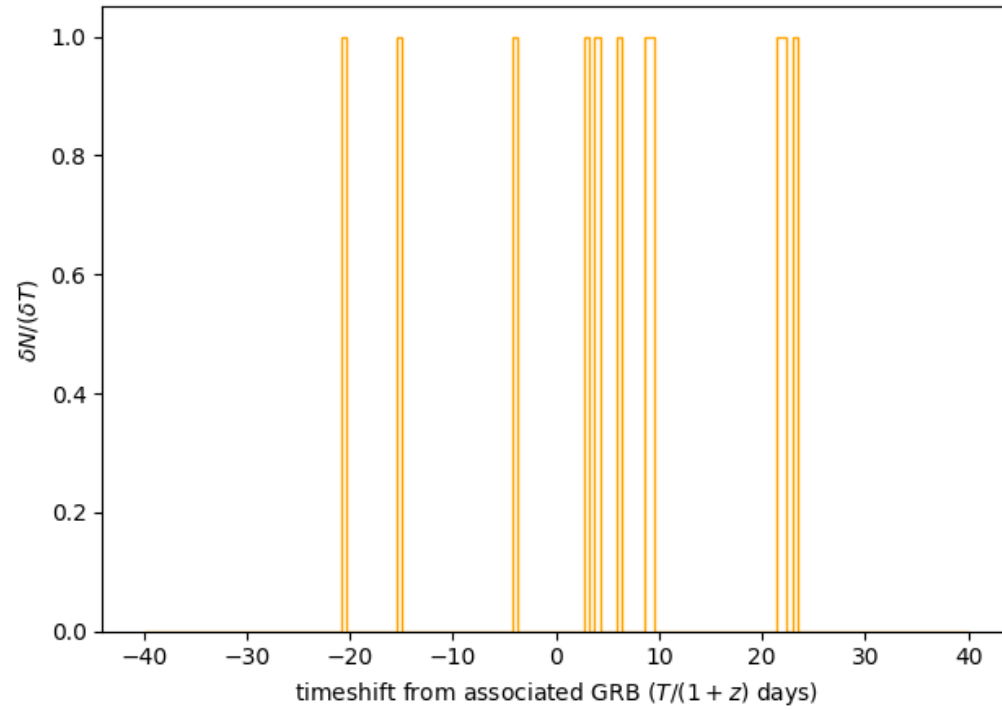
After matching

- Single: 6 vs 12 \rightarrow smaller search cone
- Multiple: 26 vs 27 \rightarrow bigger search cone

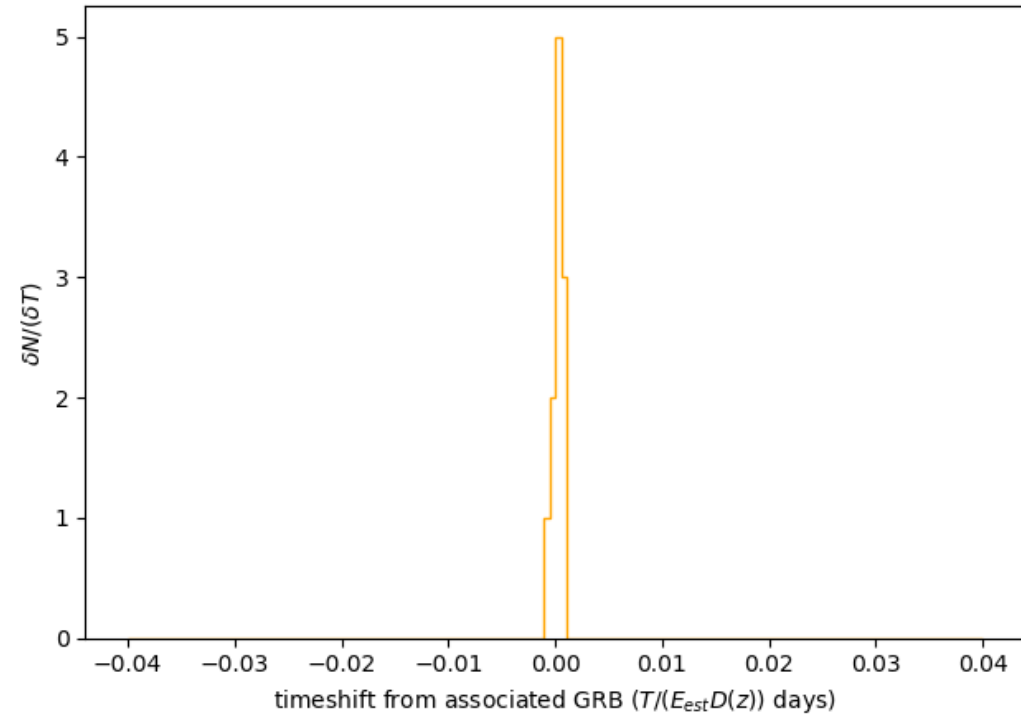


After matching

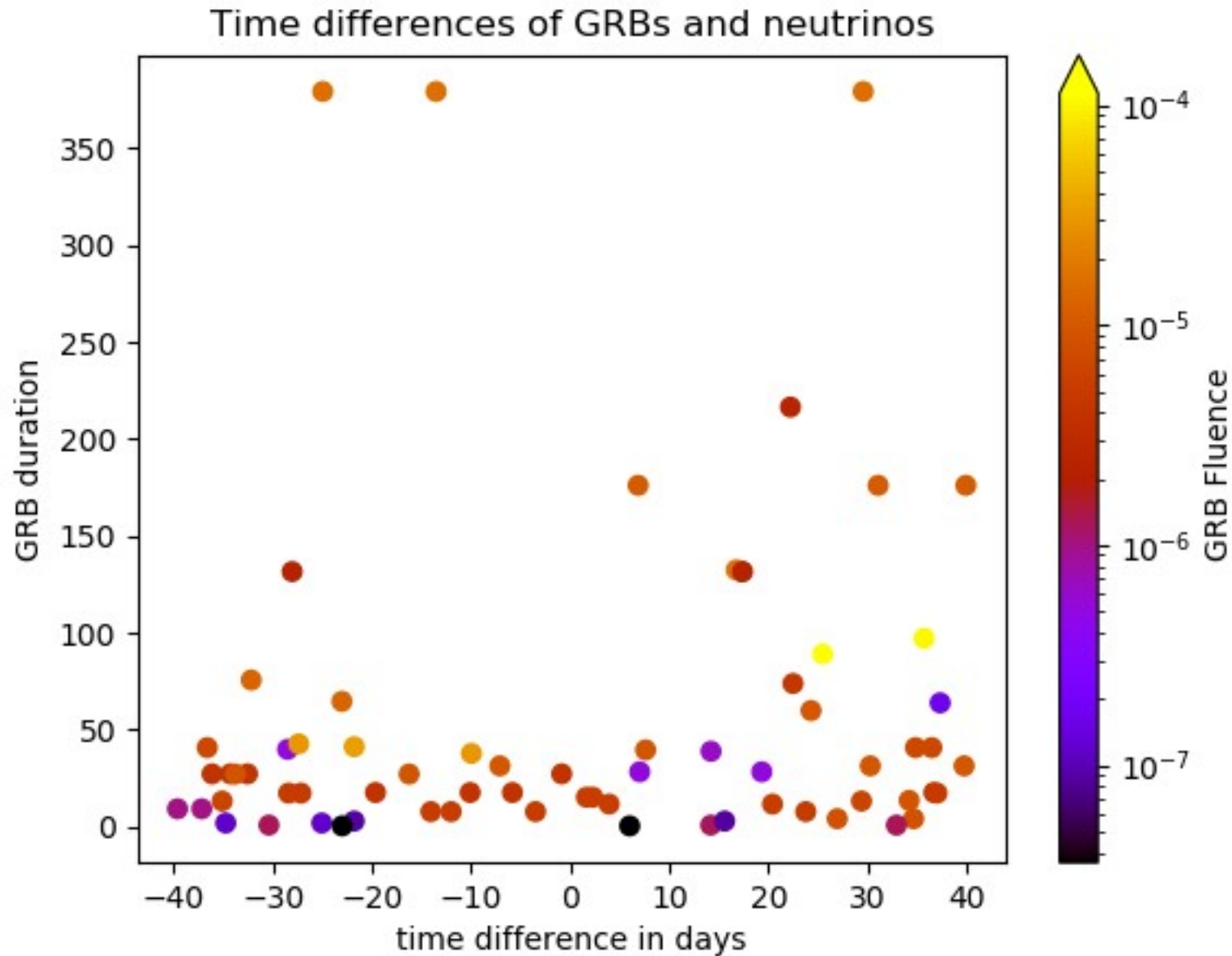
Distribution of time differences over redshift



Distribution of time differences over distance



After matching



Pseudo experiments

- Used to filter out accidental coincidences
- Scrambling order of neutrino MJD
- Correcting Right ascension for change in MJD

Thanks for your time!

References

- Schmid, Julia (2014)
- Ellis, John et al (2019)
- Antares colabration (2016)

Data

- R. Abbasi et al
- GCN.nasa.gov
- GRBweb2