Detection prospects for low-energy neutrinos from collisionally heated GRBs with current and future neutrino telescopes

Executive summary

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In this contribution, we present preliminary results on detection prospects of neutrinos produced in a Gamma-Ray Burst (GRB) model previously unexplored from the experimental point of view, the so-called *inelastic collisional model.* In such a model, the gamma-ray emission occurs close to the photosphere, namely right where the jet starts to be optically thin to the radiation. Thus, a freely expanding radiation-dominated outflow is responsible for the electromagnetic emission, which hence reproduces a Planck spectrum. However, as GRB spectra are typically observed with non-thermal extended tails, another component should contribute to the emission: this has been hypotized to be in the form of additional freely neutrons in the jet. In this framework, inelastic collisions between the emitted protons and neutrons produce charged pions that decay into positrons, electrons and neutrinos.

The novel aspect of this interpretation regards the energies at which neutrinos are expected to be produced (multi-GeV neutrinos), that are much lower with respect to the TeV-PeV range usually considered for GRB experimental studies. We here discuss detection prospects towards neutrino fluxes produced at inelastic collisions in GRBs of large volume Cherenkov neutrino telescopes. We present the case of the Southern hemisphere observatory IceCube and the under construction Northern hemisphere detector KM3NeT, both complemented with smaller detectors, designed for neutrino physics studies, which target neutrinos with energies down to 10 GeV: DeepCore and KM3NeT-ORCA, respectively.

We exploited detector performances at trigger level, with respect to muon neutrinos charged current interactions, in the upward going direction. To this aim, we simulated synthetic populations of both short and long GRBs emitting low-energy neutrinos. In particular, we built thousand populations of sources observable in half-sky in about 5 years, for different Lorentz factor values of the jet. As a result, we computed a median value of significance that each neutrino detector might be able to achieve. We also investigated the perspectives of combined analyses between low and high-energy detectors.

We obtain that (i) only a nearby and very energetic GRB (gamma-ray fluence values never observed so far) could produce a number of neutrino-induced events at least equal to one in DeepCore/IceCube and ORCA/ARCA; (ii) there is a good chance to detect multi-GeV neutrinos by stacking $\sim$900 long GRBs under the hypothesis that their prompt gamma-ray emission is explained by such a model.

Since no coincidence between neutrinos and GRBs has been observed so far, the detection of multi-GeV neutrino emission could be the key to clarify the composition of GRB jets, probing their hadronic nature. Furthermore, it could allow to discriminate among the various physical processes proposed to explain the origin of the gamma-ray emission in GRBs.