Fast Radio Bursts (FRBs) are one of the most intriguing transient radio sources discovered a decade ago. The origin of these FRBs is still a great mystery despite the growing observational efforts made by various multi-wavelength and multi-messenger facilities. So far, many theories have been proposed but no progenitors have been clearly identified and the radiative and particle acceleration processes at work are still unknown.

**Fast Radio Bursts**

**What is an FRB?**
- Short transient: 1-10 ms and very bright: 1-50 Jy ms (<10/ν ≈ 22)
  - The brightest: FRB 150807 reached S_{1.4GHz} = 128 Jy and S = 44.8 Jy ms!
- Detected in: GHz energy band (typically centered at 1.4 GHz in a narrow bandwidth)
- Frequency dependent delay: (νt) ~ DM × ν^2
  - Dispersion measure (DM): 266.5 ± 2.596.1 cm^3 pc
- Pulse broadening: W = ν^2 ms

**Constraints**
- Shorter duration: 2 ms, but not always detectable
- Peak brightness: ~10^20 W m^-2 Hz^-1

**Possible sources**
- Pulsars (magnetars)
- Neutron stars
- Massive stars
- Black holes
- Binary neutron star mergers
- Quasars
- Cosmological events: dark energy, cosmic strings, dark matter annihilation

**Search for high-energy neutrino signal from Fast Radio Bursts with the ANTARES telescope**

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**Selection of FRBs (2013-2017):**
- FRB position within ANTARES field of view at the time of the burst \(T_0\)
- Good and constant data quality in \([T_0-6h, T_0+6h]\)

\[\Rightarrow 12 \text{ FRBs selected (skymap in Fig. 1 and coordinates in Tab 1.)}\]

**Binned analysis:**
- Use data in \([T_0-6h, T_0+6h]\) for each FRB
- Select only ungrouped neutrino track candidates in a 2 degrees cone around the FRB position
- Optimization done on the reconstruction quality so that 1 event in time and space coincidence gives a 3 \(σ\) discovery.

\[\Rightarrow \text{No ongoing events spatially and temporally correlated with the 12 FRBs. This result is compatible with background rate (5 \times 10^6 events/s) fluctuations.}\]

**Upper limits at 90% Confidence Level (CL) on the neutrino fluence of the individual bursts (Fig. 2 and Tab. 2) assuming an energy spectrum for the neutrinos**

\[\Rightarrow E^2 \frac{d^2F_{ν}}{dEν dO} = \frac{d^2F_{ν}}{dEν dO} \times 10^{-2} \text{cm}^{-2} \text{sr}^{-1} \text{GeV}^{-1} \text{m}^{-2} \text{s}^{-1} \text{MeV}^{-1} \text{sr}^{-1} \text{GeV}^{-1}\]

Three spectral models are considered in the analysis: \(\gamma = 1.0, 2.0, 2.5\).

**Discussion**

- FRBs are probably explosive events associated to particle acceleration processes. If baryons are accelerated \(→\) productions of HE CR, γ-rays and HEN.

- No hadronic/neutrino model needed to FRB yet
- However, we can derive constraints on their origin from the non-observation of neutrino signatures.

**Discussion on the origin of the FRB**

- Different scenarios of FRB origin associated with a neutrino emission:
  - Short GRB progenitor (Zhang 2014)
  - Core-collapse supernova environment (Falcke & Rezzolla 2014)

- Detecting a neutrino signal from a single FRB seems difficult as most of the FRB hadronic model predictions remain orders of magnitude below the ANTARES neutrino detection threshold (Fig. 3). However, the expected large number of FRBs over the entire sky may contribute to a neutrino diffuse flux.

**Discussion on the contribution of the FRB on the diffuse neutrino flux**

\[E^2 \frac{d^2F_{ν}}{dEν dO} = \frac{1}{4π} \frac{\text{dΩ}}{\text{dE}ν \text{dO}} \times \frac{\text{d}^2F_{ν}}{\text{d}Eν \text{d}O} \text{GeV}^{-1} \text{cm}^{-2} \text{sr}^{-1} \text{MeV}^{-1} \text{sr}^{-1} \text{GeV}^{-1}\]

- Upper limits on the quasi diffuse flux normalised to \(Eν = 100 \text{ TeV}\): \(E^2 ν^2 < 0.5, 2.0\) and 3.0 \(10^8 \text{GeV cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \text{yr}^{-1}\) for \(E^2 ν^2\) and \(E^2 ν^2\) for \(E^2 ν^2\) and \(E^2 ν^2\) for \(E^2 ν^2\).

- Compared to IceCube astrophysical diffuse flux \(E^2 ν^2 < 10^8 \text{GeV cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \text{yr}^{-1}\) at 100 TeV and \(y = 2.46\)

- \(\Rightarrow 7300 \text{ above \(\Rightarrow \) rules out that all FRBs have a dominant hadronic emission}\)

- \(\Rightarrow E^2 ν^2 > 10^{-12} \text{TeV}^{-1} \text{cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \text{yr}^{-1}\) is less than \(1/2 \times 10^{-12} \text{TeV}^{-1} \text{cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \text{yr}^{-1}\) FrB could be neutrino emitters.

- \(\Rightarrow \) need more FRBs to test this scenario (UTMOST, SKA/ASKAP, CHIME, LoFAR will increase the sample).