KM3NeT Core Collapse Supernovae observation program in standalone and multi-messenger modes

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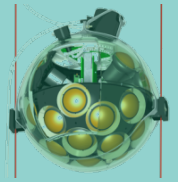
KM3NeT

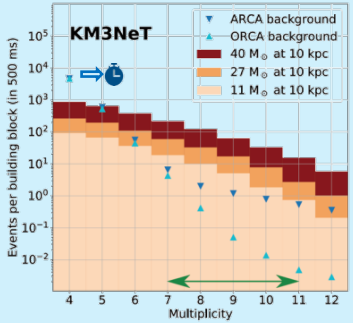
Two detectors in the Mediterranean sea are partially installed.
Main purpose is to detect GeV-PeV neutrinos for neutrino studies and astronomy.
Each detector is based on 3D array of Digital Optical modules (DOMs).

Each **DOM** is equipped with 31 3-inch PMT. MeV supernova neutrino interactions generate coincidences between PMTs of the same DOM. Several PMTs hit in one DOM produce an **event**. Number of hit PMTs – event **multiplicity**.

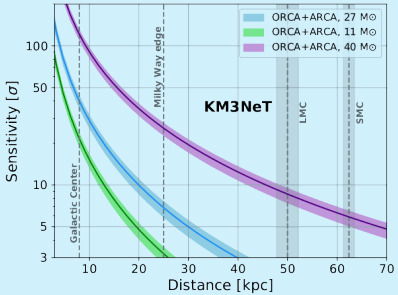


Backgrounds

- Radioactivity. Mainly 40K in seawater. Lower energy = lower multiplicities. Steady salinity = steady rates.
- Bioluminescence – one photon emission process. Random but predictably (down)scalable rates with growing multiplicity.
- Atmospheric down-going muons. Can be vetoed by checking if events are seen in nearby DOMs (compatible with the muon passage hypothesis) – simple veto. Also detected by the normal ARCA/ORCA neutrino search triggers – trigger veto.



Expected number of events for signal and background after muon rejection. One KM3NeT building block, 500 ms window.

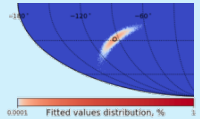


The best 5σ discovery horizon is obtained selecting the 7–11 multiplicity range.

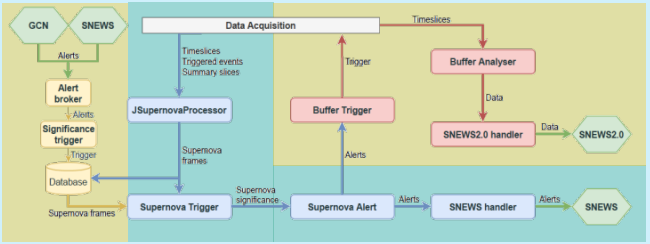
Discovery potential for 95% of Galactic CCSNe in the most conservative scenario. Eur. Phys. J. C81 (2021) 445

Thousands of events per detector block with multiplicity >=2:

- Neutrino light curve study (shock oscillations, halt due to black hole formation etc).
- Timing of the supernova emission for triangulation with other experiments.



- Standalone (exponential) rise search.
- Combination of the experimental lightcurves with other experiments Eur. Phys. J. C 80 (2020) 9 856



- Joint real-time trigger is running since early 2019.
- Sending alerts to SNEWS (1 fake alert per 8 days). KM3NeT is sensitive ~60% Galactic CCSN (<11 kpc) with running ARCA-6 DUs, ORCA-6DUs nowadays.

work in progress

- Quasi online analysis system with external alerts.
- *Semi automatic analysis of LIGO-Virgo unmodeled gravitational-wave burst alerts (GCN circulars #26249, #26751). For S200114f GW alert that was localized close to Betelgeuse (promising supernova progenitor) such nearby supernova was excluded by KM3NeT.*
- Providing "more than just an alert" data to SNEWS2.0: emission time, light-curves, energy estimation etc.