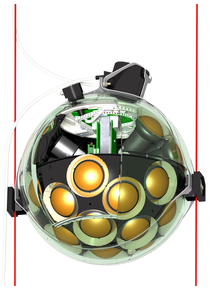
Monitoring the neutrino sky for the next Galactic Core-Collapse Supernova with KM3NeT

Godefroy Vannoye[1] on behalf on the KM3NeT collaboration

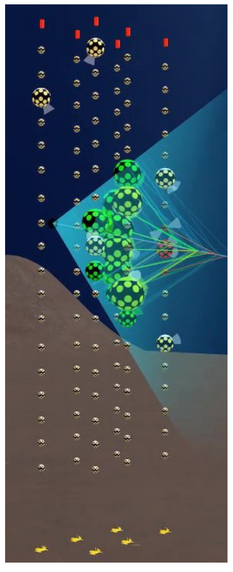
[1] Université Aix-Marseille, IN2P3/CNRS, CPPM

The KM3NeT detector

KM3NeT [2]
Water Cherenkov neutrino detector currently in construction at the bottom of the Mediterranean Sea.



Detection principle
Reconstruction of the neutrino properties from the light induced from secondary interaction products.



Two detectors
3D arrays of optical modules, each with 31 PMTs, attached to vertical lines.
ARCA: 2 arrays of 115 lines each. Scarsily instrumented volume, optimized for detection of TeV-PeV neutrinos.
ORCA: 1 array of 115 lines. Volume densely instrumented for detection of GeV-TeV neutrinos.

Beyond CCSN detection

Neutrino lightcurve
Loose event selection for higher statistics, useful for parameter estimation or model constraints.
Estimation of neutrino arrival time to triangulate the source and perform optical observation [3].

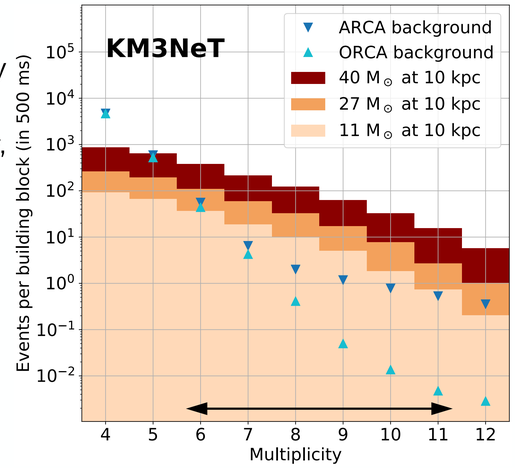
External alerts follow-up
See poster about search for neutrino counterparts from GW sources with KM3NeT/ORCA.

SNEWS2.0
Upgrade from SNEWS to provide more than alerts [4].

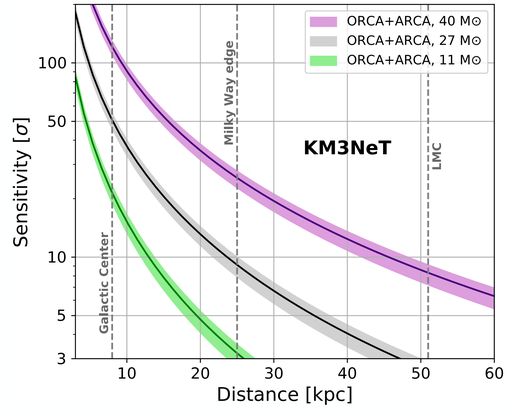
Detection of MeV CCSNe neutrinos

Core-Collapse SuperNovae
Explosive phenomena ending the life of massive stars with an enormous energy release.
99% of the energy is realeased as very low energy neutrinos (tens of MeV).
To this day, only 25 CCSN neutrinos have been detected (from SN 1987A).

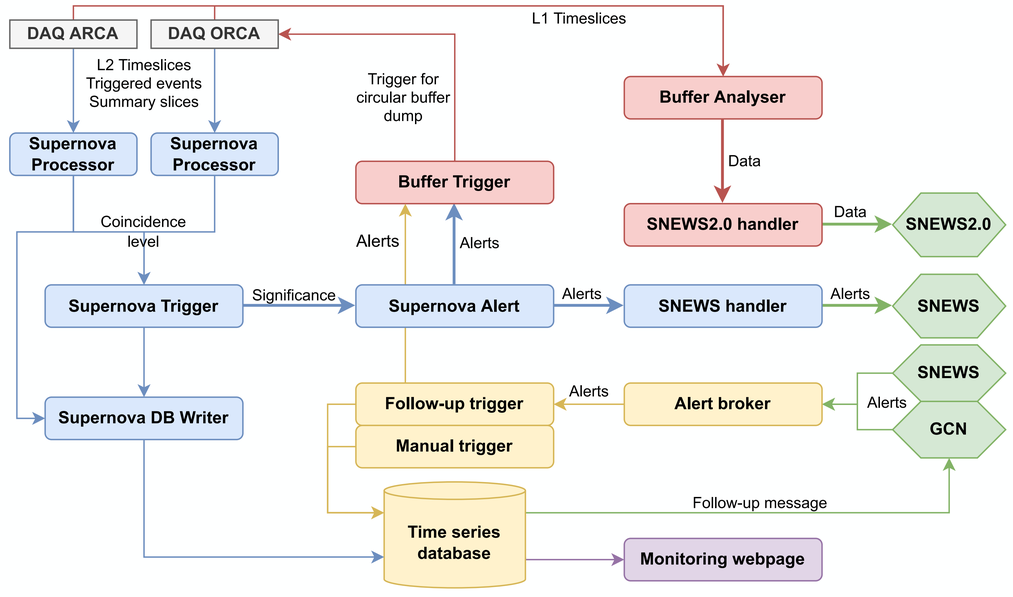
Detection
KM3NeT is sensitive to positrons induced by electron anti-neutrinos.
As they cannot be reconstructed individually, we search for an excess of hit coincidences between PMTs in single optical modules above the optical background (see figure on the right).
Alerts transmitted to the Supernova Early Warning System (SNEWS) [1].



Sensitivity
KM3NeT has a 5σ discovery potential [5] for Galactic and near-Galactic events (see figure below).
Expected rate for Galactic CCSN of 1.5 per century.



Implementation [6]



References

[1] Antonioli, P. *et al.* SNEWS: the SuperNova Early Warning System. *New J. Phys.* **6** 114 (2004)
[2] Adrián-Martínez, S. *et al.* Letter of intent for KM3NeT 2.0. *J. Phys. G: Nucl. Part. Phys.* **43** 084001 (2016)
[3] Coleiro, A. *et al.* Combining neutrino experimental light-curves for pointing to the next galactic core-collapse supernova. *Eur. Phys. J. C* **80**, 856 (2020)
[4] Al Kharusi, S. *et al.* SNEWS 2.0: a next-generation supernova early warning system for multi-messenger astronomy. *New J. Phys.* **23** 031201 (2021)
[5] Aiello, S. *et al.* The KM3NeT potential for the next core-collapse supernova observation with neutrinos. *Eur. Phys. J. C* **81**, 445 (2021)
[6] Aiello, S. *et al.* Implementation and first results of the KM3NeT real-time core-collapse supernova neutrino search. *Eur. Phys. J.* C **82**, 317

Neutrinos in the Multi-Messenger Era, Louvain-la-Neuve, Belgique, November 29, 2022 to December 2, 2022