KM3NeT core-collapse supernova & high energy neutrino alerts

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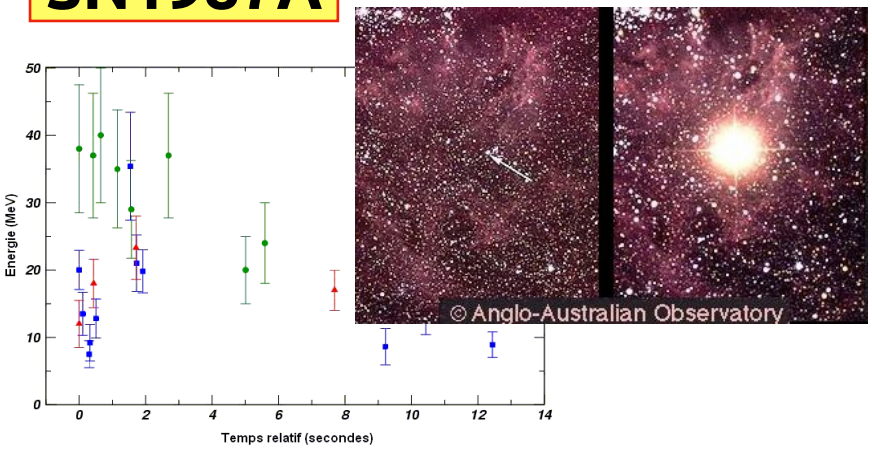
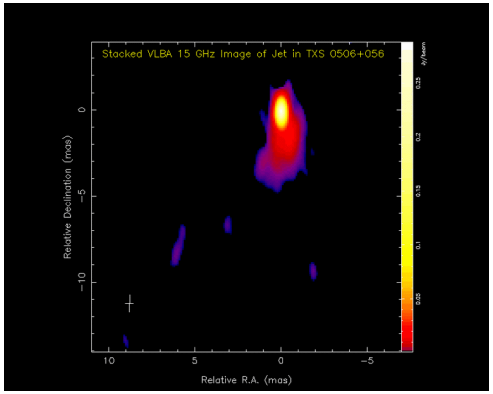
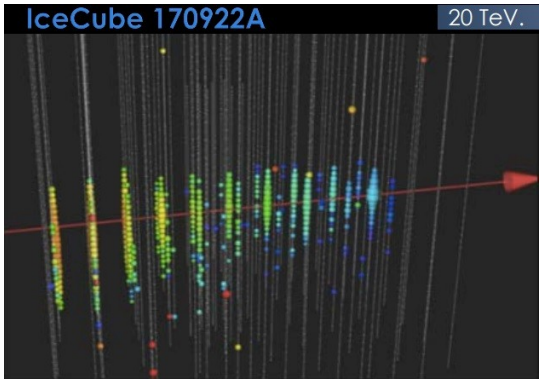
The multi-messenger astronomy era

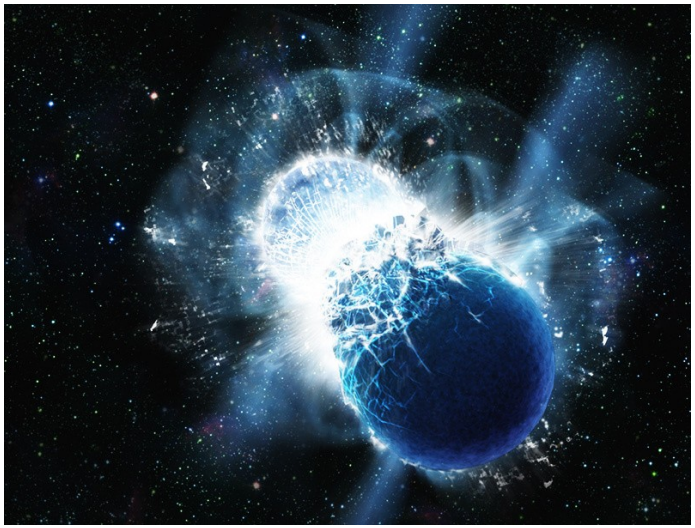
SN1987A



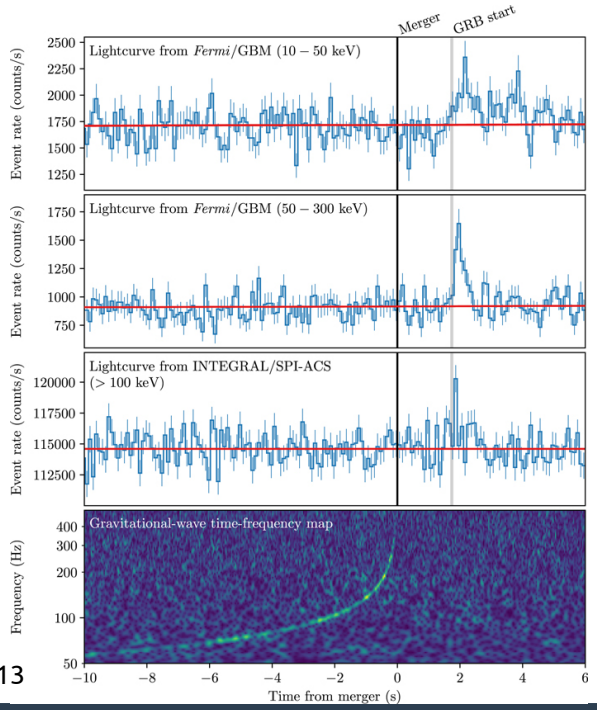
IC170922 / TXS 0506+056 ?







GW170817 / GRB170817



LIGO, Virgo, Fermi-GBM, INTEGRAL, Astrophys.J. 848 (2017) no.2, L13

KM3NeT and the neutrino universe

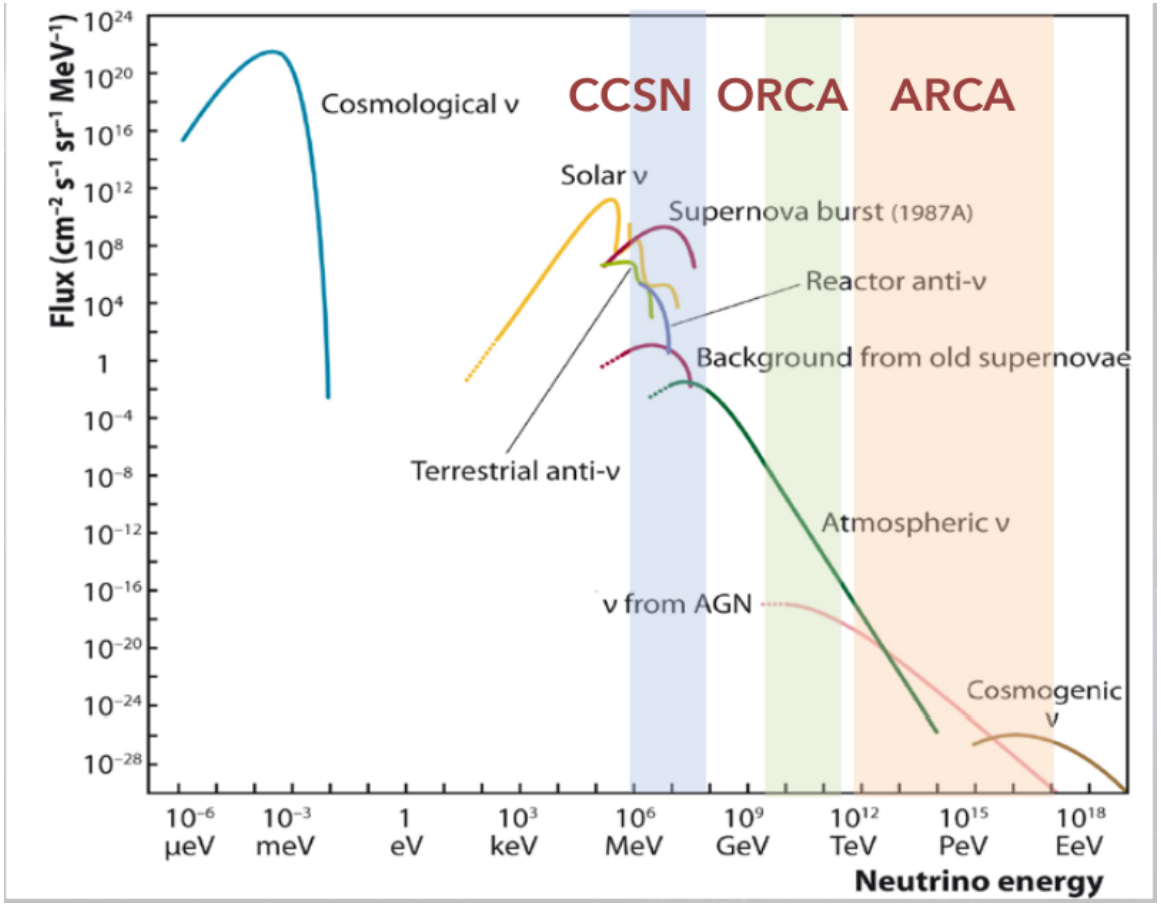
KM3NeT consists of two deep-sea Cherenkov detectors with differentiated physics potentials.

Neutrinos

Many **sources** spanning over several order of magnitudes of energy.

Candidate **messengers** for different kinds of violent hadronic astrophysical processes.

Rich **phenomenology** (oscillations, matter effects, supernova explosions etc.)!



Elaboration from Katz, U.F. et al. Prog.Part.Nucl.Phys. 67 (2012) 651-704 arXiv:1111.0507

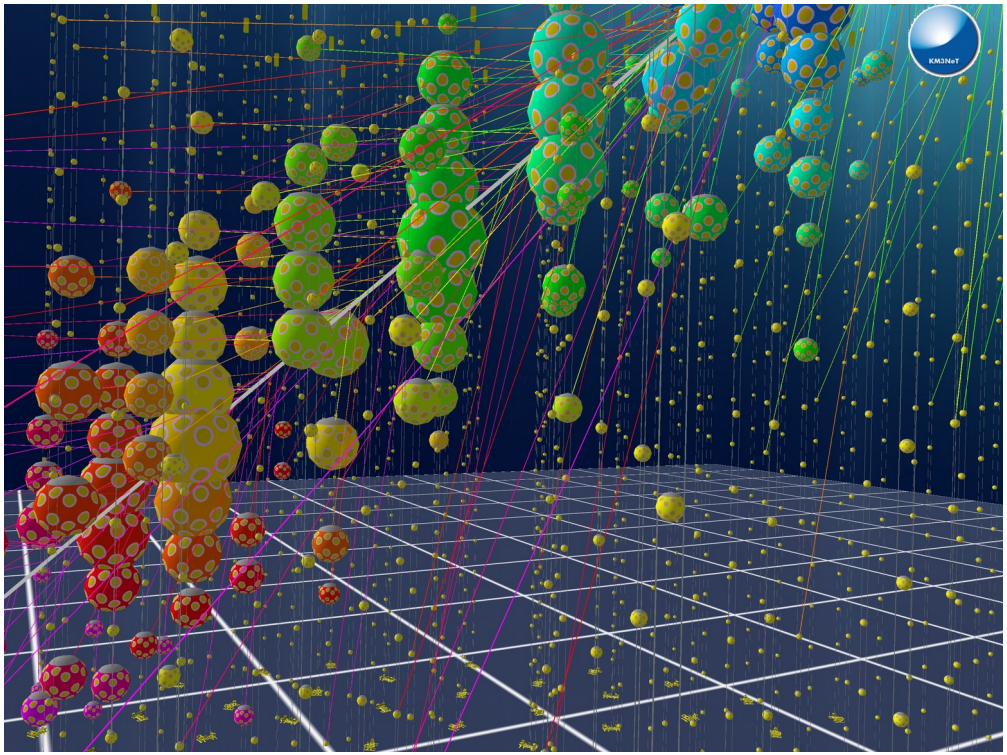
KM3NeT multi-messenger capabilities

KM3NeT detectors share a common multi-messenger strategy!

Real time full sky search!

High energy astrophysical neutrinos will be reconstructed on-line, sending directional information to the community.

Supernova neutrino burst detection relies on the observation of a collective increase in PMT rates.

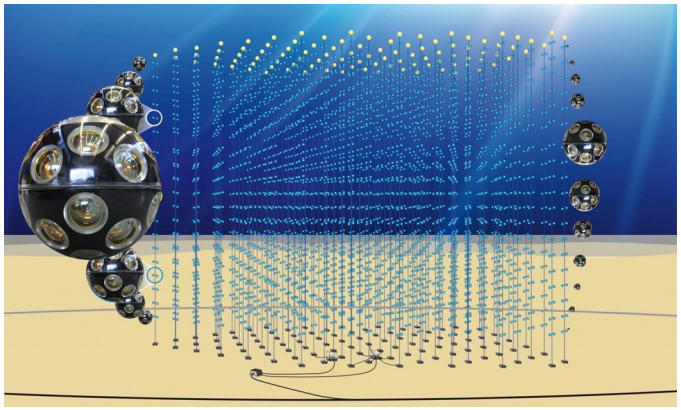


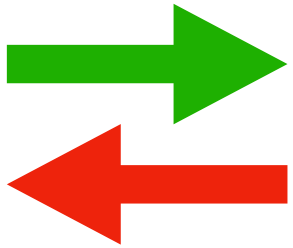
KM3NeT in the multi-messenger scenario

Follow-up of neutrino alerts

Joint sub-threshold analysis

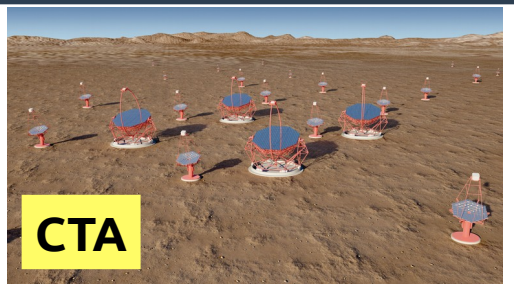
KM3NeT

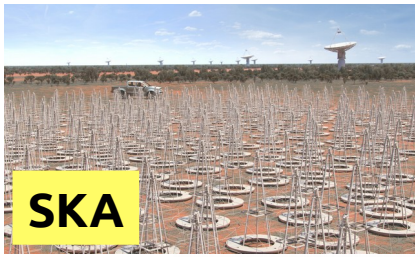


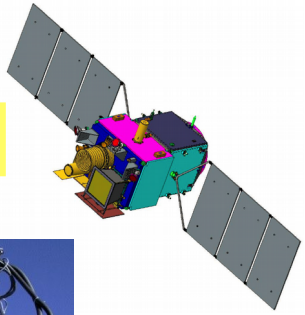


Follow-up of EM/GW alerts

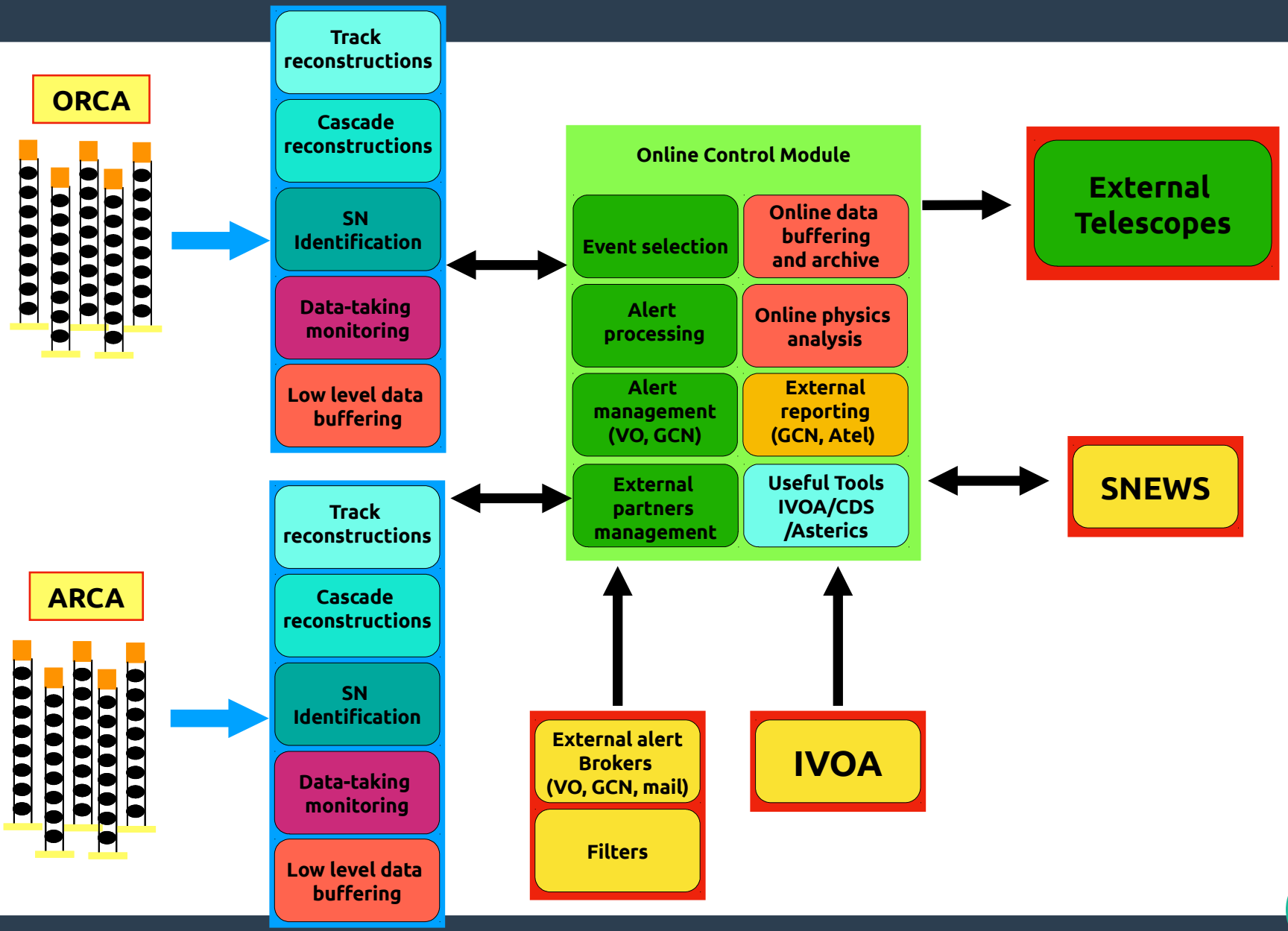
Offline time/space correlation search with catalogs (GRB, AGN, XRB, SN, FRB…)







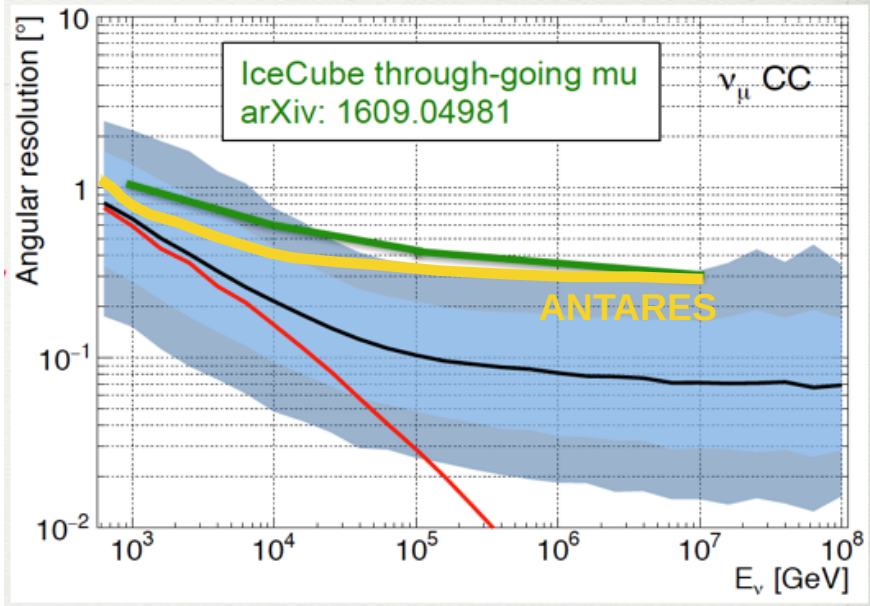
KM3NeT online framework



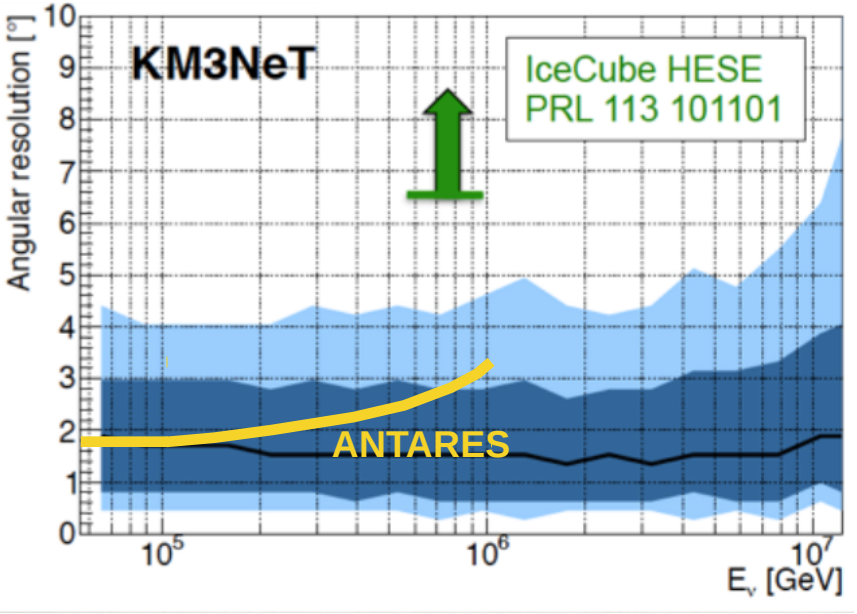
Online reconstruction of neutrino events

From offline to online: **aim to have matching performances**
Online calibration (charge, time, position)

Tracks



Cascades



Fast (< 1 min, goal ~ 10 s) alert sending with very good angular resolution especially for cascade-like events.

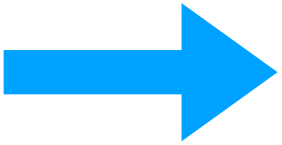
Towards a public alert system

ANTARES alert brokers:
* GCN socket: TAROT, ZADKO, MASTER, INTEGRAL
* VO Event: MWA, HESS, SVOM, AMON
* Mail: Swift

For **ANTARES**, all **neutrino information are private**. Need MoU with external partners.

Alert Message:
* ID
* Time,
* RA, DEC, error 50%
* Energy proxy
* Reconstruction quality
* probability neutrino
* Multiplicity, type of trigger

Only one real-time message



For **KM3NeT**: define a **standard VO event**:
* ID
* Time,
* RA, DEC, error 50%
* Energy proxy
* Reconstruction quality
* probability neutrino
* type of neutrino
* Multiplicity
* Type of trigger

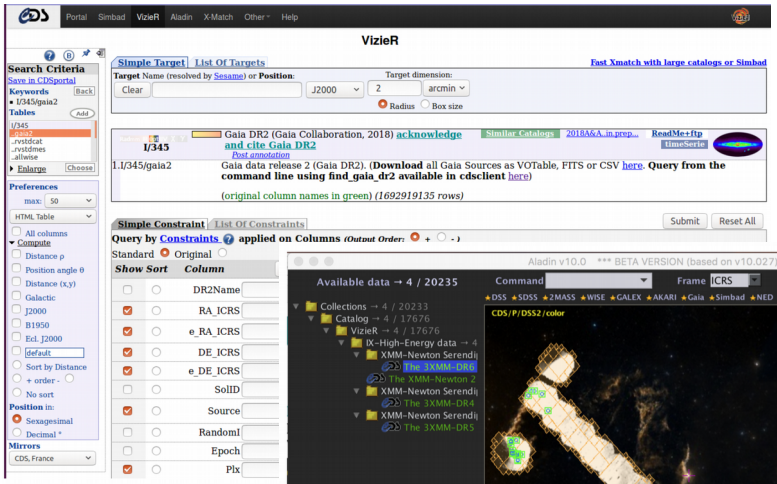
+ develop one alert brokers with different types of alerts

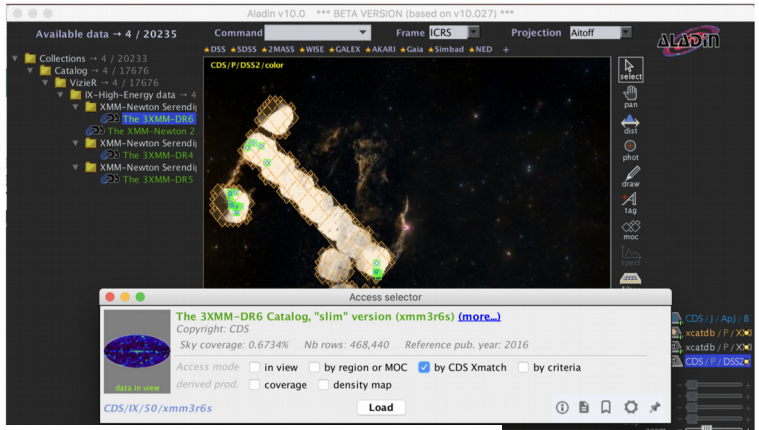
Data partners

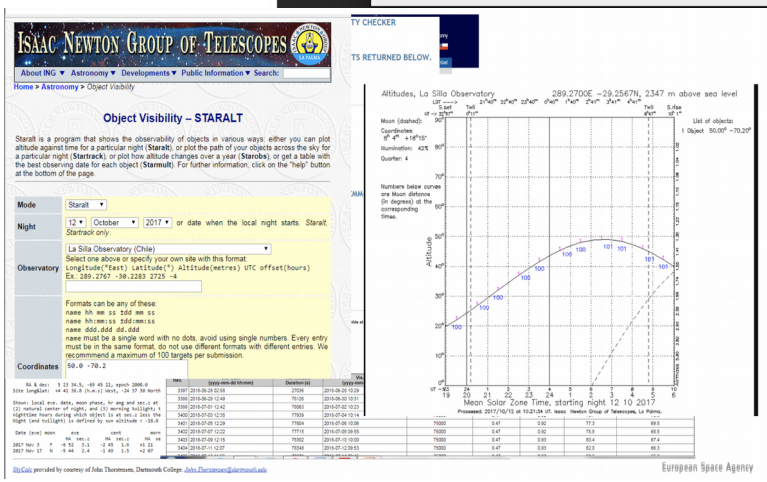
IVOA provides useful tools to format alert messages (**VO Event**), to set brokers (**Comet**) and some useful tools to planned observations (**STARALT, OVAP, OLAP**…)

CDS provides tools for source identification (**Simbad, Aladin, Aladin-Little, VizieR, Xmatch**…)

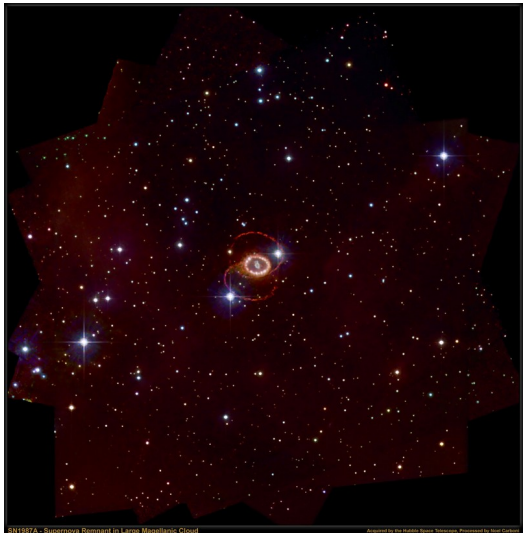
Asterics DADI: **ROAst** (to be verified)







Core-collapse supernova detection

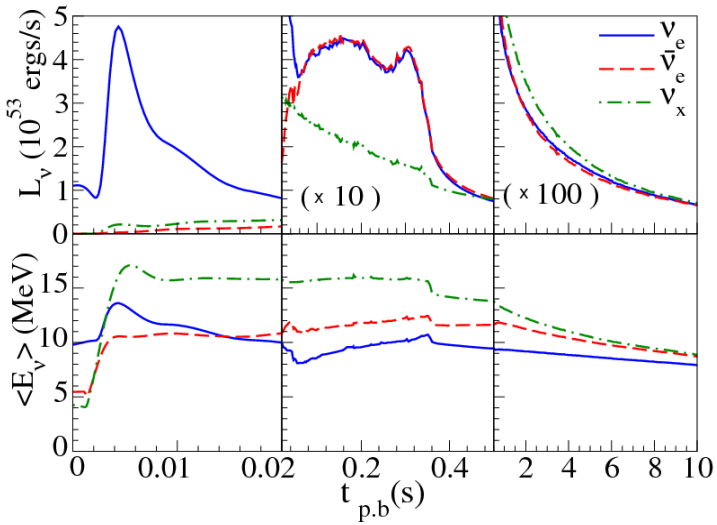


Supernova neutrinos reach the Earth few hours before optical observation is possible!

Very low energy for KM3NeT, no individual event reconstruction.

Monitoring of PMT single and **coincidence** rates for **collective increases**, signature of a SN neutrino burst.

Real-time **background rejection** (atm. muons) for improvement of the trigger performance.



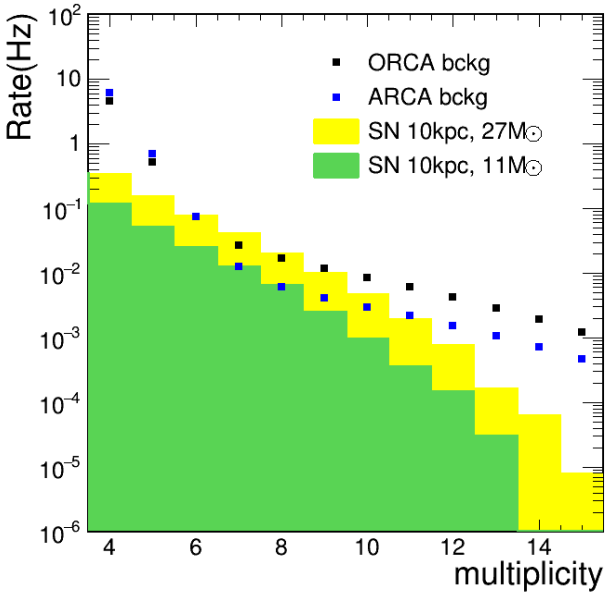
Chakraborty, Sovan et al. Phys.Rev. D89 (2014) no.1, 013011

KM3NeT
ORCA + ARCA

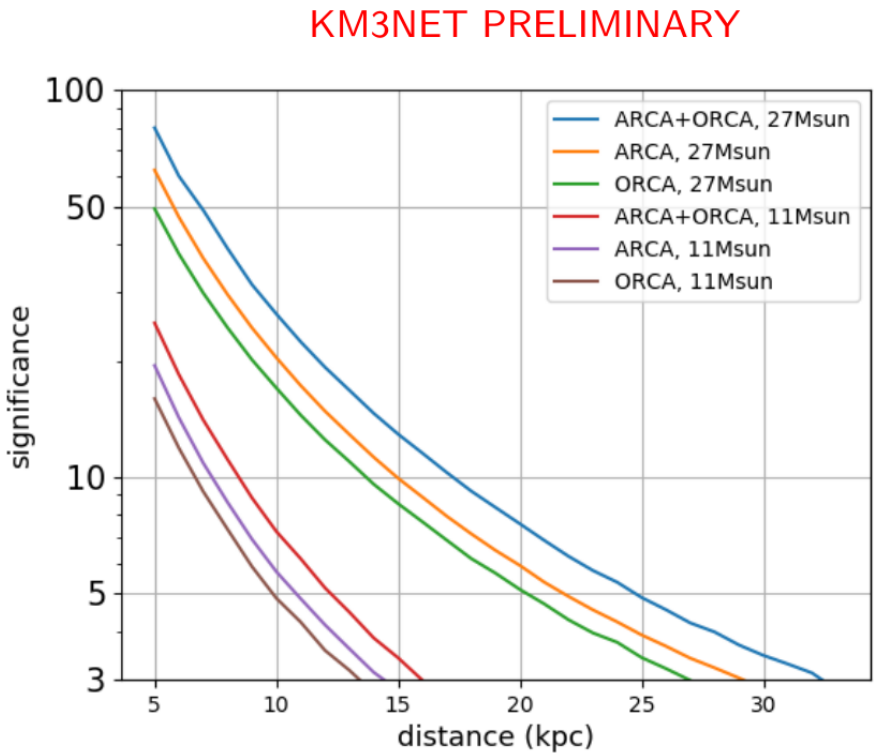
CCSN @ 10 kpc
Garching 27MSun

Single hits ~ **3x10^5**
Coincidences ~ **500**

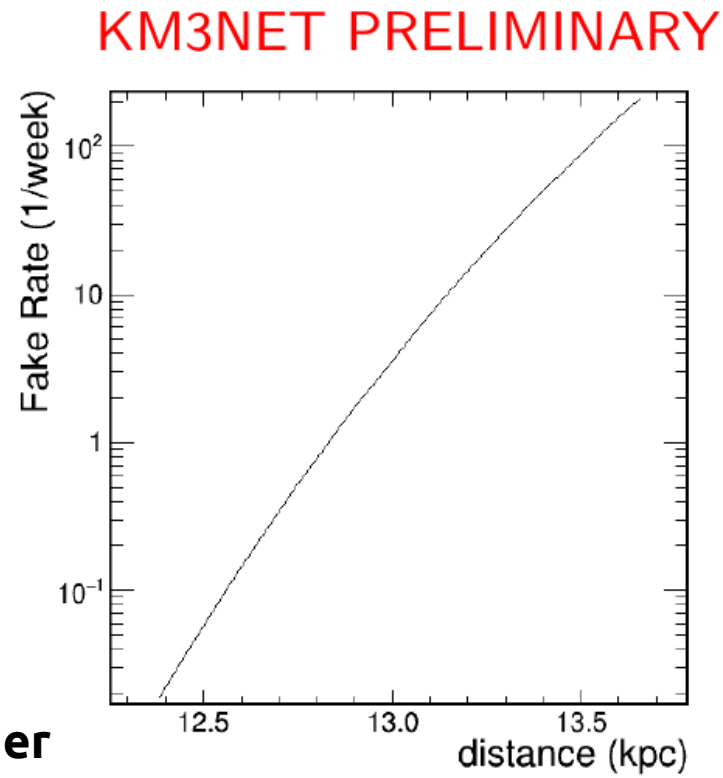
KM3NET PRELIMINARY



Supernova sensitivity and online trigger



Unknown onset time



Offline sensitivity (known onset time)

Room for improvement (optimization of ARCA muon veto, use of time-domain analysis methods)

Offline to online

10 Hz sampling of the background over a 0.5 s time window.

Online trigger

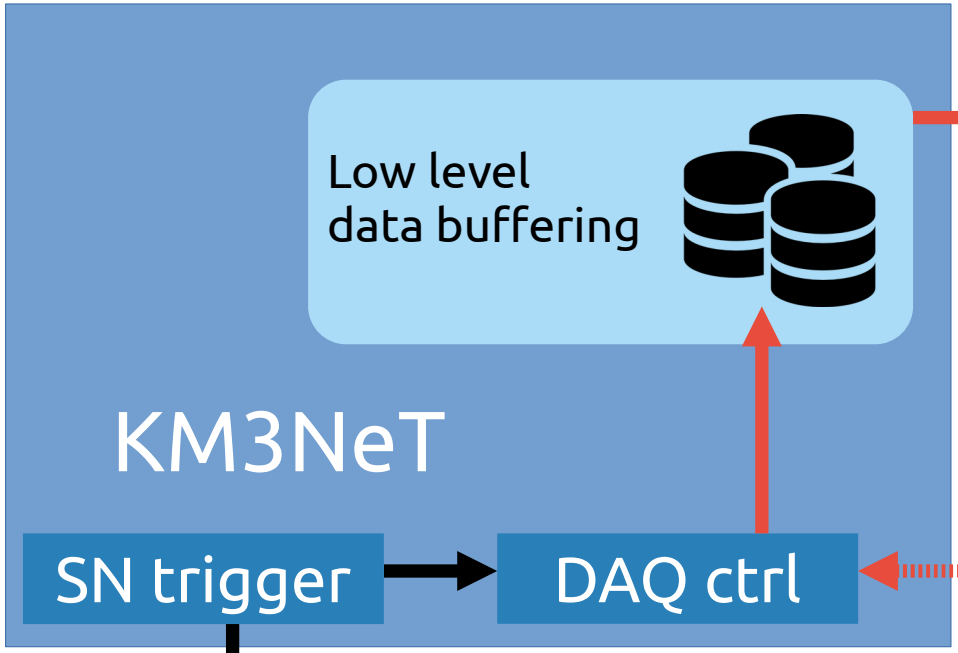
False rate	ORCA 10 lines	ORCA 1 block
1 / hour	8.9 kpc	13.6 kpc
1 / week (SNEWS)	8.2 kpc	12.8 kpc
1 / 1000 years	6.9 kpc	11.7 kpc

SN alerts and data buffering

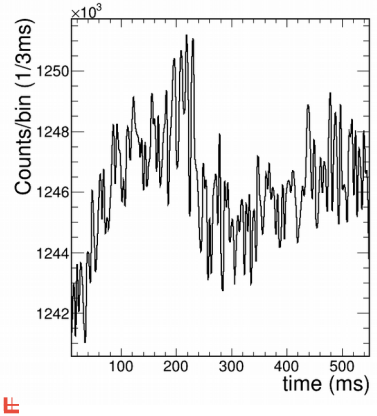
Trigger alerts

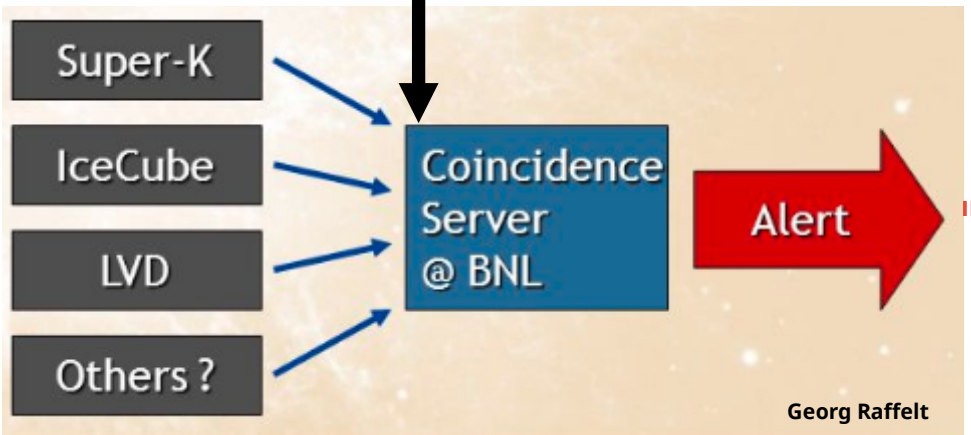
Internal self-testing
- high false rate

SNEWS global network
- 1 false alert / week



Offline
physics analyses
(light curve, etc.)





Conclusions

- Development of a **rich multi-messenger program** for the **KM3NeT** ORCA and ARCA neutrino telescopes.
- Towards an **open public alert** policy.
- Fast alerts for **high-energy** astrophysical neutrinos (with **directional information**) and for low-energy neutrino bursts from galactic **core-collapse supernovae**.
- Integration with several **data partners** and **alert networks**.