International Cosmic Ray Conference (ICRC2021)

Search for nuclearites with the KM3NeT detector

Alice - Mihaela PĂUN [1,2], Gabriela Emilia PĂVĂLAȘ [1], Vlad POPA [1]

On behalf of the KM3NeT Collaboration

[1] Institute of Space Science, 409, Atomiștilor Street, Măgurele, Ilfov, Romania

[2] Faculty of Physics, University of Bucharest, 405, Atomiștilor Street, Măgurele, Ilfov, Romania

KM3NeT detector

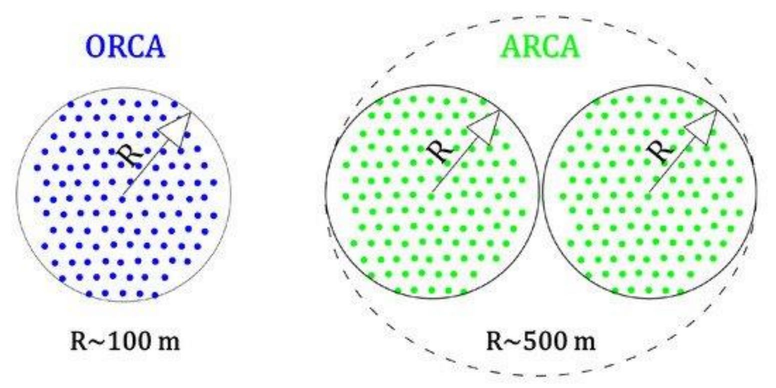
Oscillation Research with Cosmics in the Abyss

- Mediterranean Sea – France
- Atmospheric ν
- ν oscillation
- ν mass ordering determination

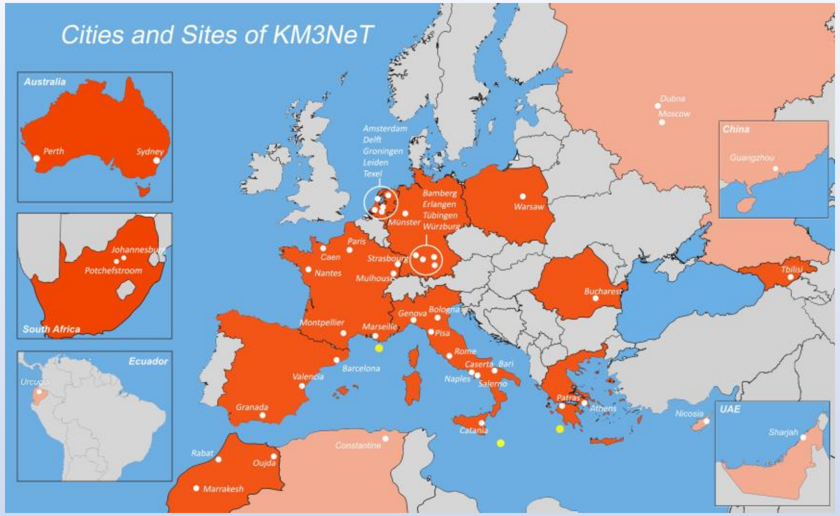
	ORCA	ARCA
Depth (m)	2475	3500
Height (m)	~ 200	~ 700
Radius (m)	~ 100	~ 500
No. of DUs	115	115
No. of DOMs/DU	18	18
No. Of PMTs/DOM	31	31
Distance between DUs (m)	23	95
Distance between DOMs (m)	9	36

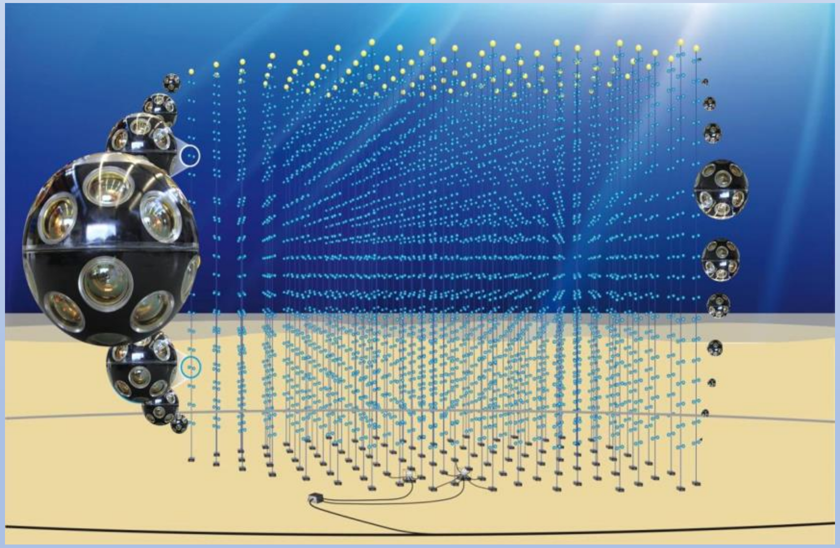
Astroparticle Research with Cosmics in the Abyss

- Mediterranean Sea – Italy
- High energy ν
- Identification/study of high energy cosmic ν sources
- Validation of the ν flux measured with IceCube



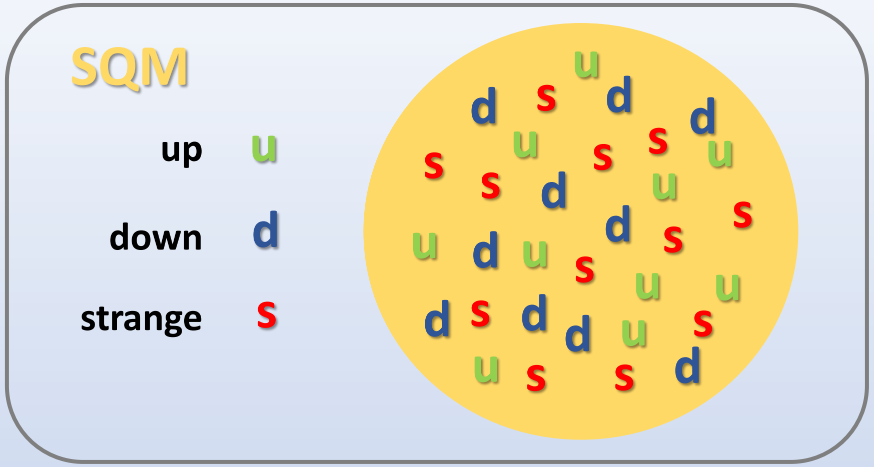
Sensors **2020**, *20*(18), 5116





https://www.km3net.org

Nuclearites



- Hypothetical objects (E. Witten 1984)
- Approximately equal quantities of up, down and strange quarks
- Non-relativistic particles
- Elastic and quasi-elastic collisions
- Blackbody radiation in visible

$$\frac{dE}{dx} = -\sigma \rho v^2$$

ρ – density of the medium
v – velocity of the nuclearite

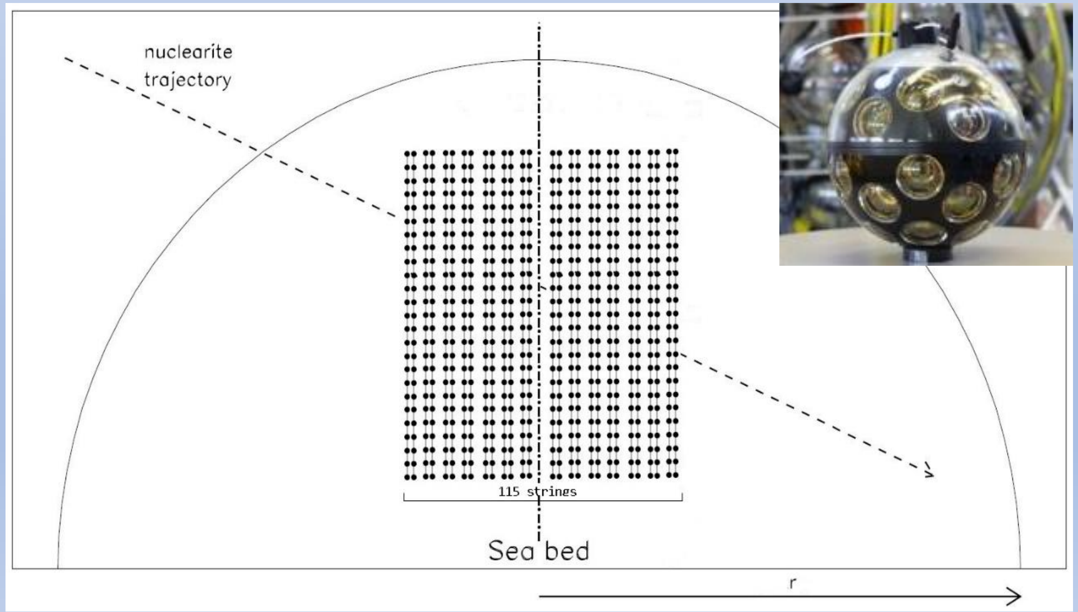
M – nuclearite mass
ρ_N – density of the nuclearite

$$\sigma = \begin{cases} \pi(3M/4\pi\rho_N)^{2/3} & \text{for } M \geq 8.4 \cdot 10^{14}\ \text{GeV} \\ \pi \cdot 10^{-16}\text{cm}^2 & \text{for lower masses.} \end{cases}$$

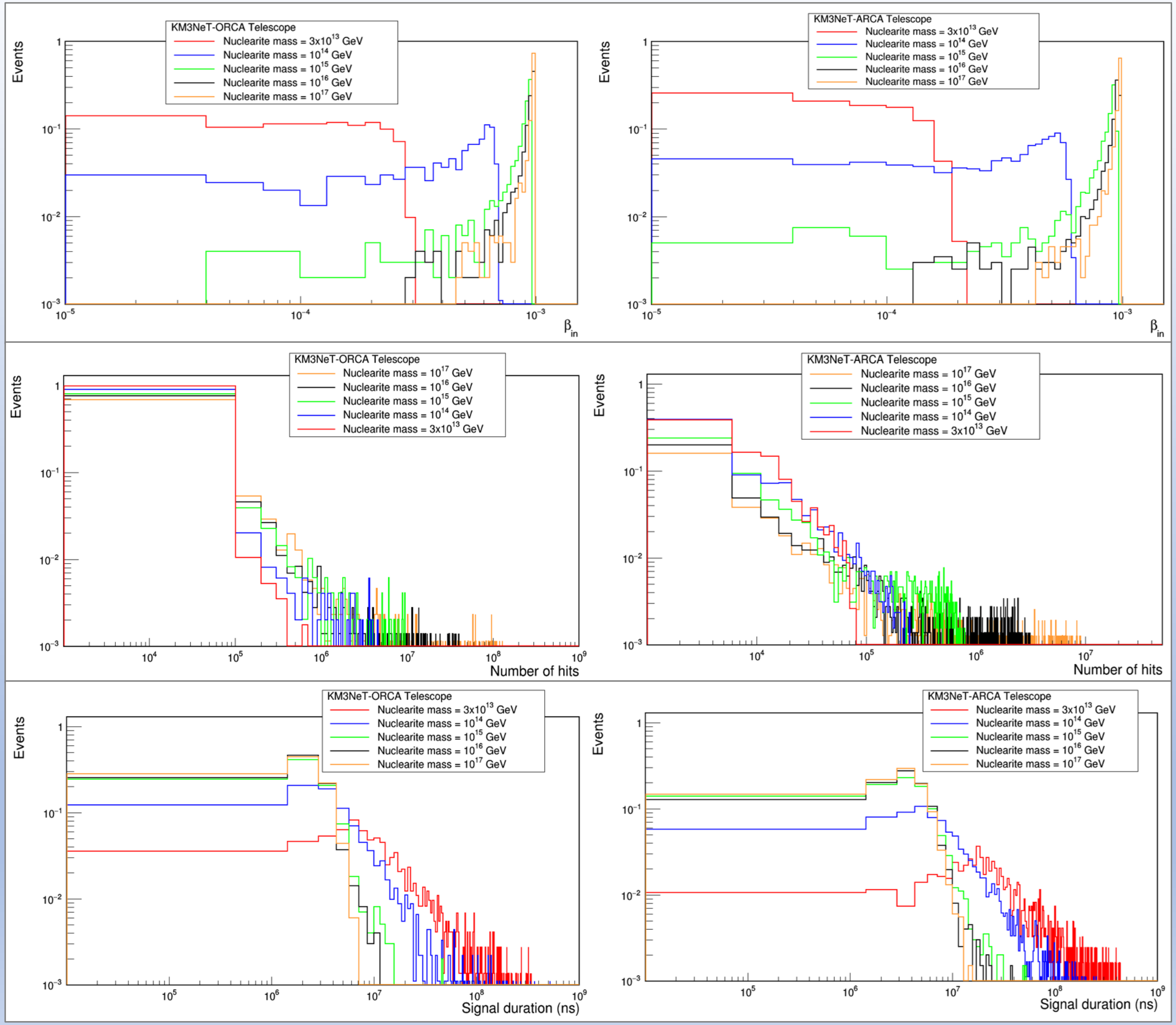
(A. De Rujula and S. L. Glashow, Nature 312 (1984) 734)

Nuclearite simulation – preliminary analysis

- Isotropic flux of downgoing nuclearites, uniformly distributed on the simulation hemisphere: $\theta \in [0,\pi/2]$, $\phi \in [0,2\pi]$
- The velocity at the entry in Earth's atmosphere $\beta_0 \approx 10^{-3}$ ($\beta_0 = v_{nucl}/c$)
- Light signal (> 0.3 pe) checked until the $E_{loss} < 3$ eV or the nuclearite leaves the simulation hemisphere
- **No ^{40}K and bioluminescence optical noises considered**



- Radius of simulation hemisphere: R_{hsf_ORCA}=548 m, R_{hsf_ARCA}=912 m
- Simulated nuclearite events in the mass range $3{\cdot}10^{13}$ – 10^{17} GeV, for ORCA and ARCA configurations
- Integration step of 50 ns
- Only events with non zero signal inside the detectors are considered



Results

- $\beta_0 \approx 10^{-3}$; β_{in} – at the entry in the simulation hemisphere
- $\beta(L) = \beta_0 \cdot e^{-\frac{\sigma}{M}\int_0^L \rho dx}$

- N_{hits} depends on the PMT density of the configuration
- N_{hits} increases with the nuclearite mass

- dt - the time interval between the first and the last hit
- The smaller nuclearite masses - larger span of the dt distribution inside the detector

Conclusions

- This is a preliminary study of the expected signal at the KM3NeT detector depths for downgoing massive nuclearites

- The distributions obtained show that nuclearites propagating through underwater neutrino telescopes, such as ANTARES and KM3NeT, will induce events that will be easily recognized due to the large number of hits and a large signal duration (>1 ms)