Neutrinos @ CPPM

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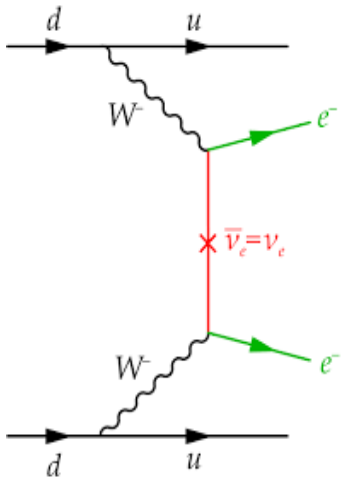
Overview

- Super NEMO — Jose Busto
- KM3NeT/ANTARES — Paschal Coyle
  - Neutrino astronomy — Damien Dornic
  - Dark Matter with neutrino — Vincent Bertin
  - Neutrino Oscillation — Jürgen Brunner, Paschal Coyle, Mathieu Perrin-Terrin
- P2O

Looking for neutrino nature : Dirac or Majorana

The neutrino is the only fundamental fermion for wich the nature is not know : Dirac / Majorana

Neutrinoless double beta decay $(\beta\beta)_{0\nu}$ is the best way to test the Majorana nature of neutrinos



Neutrinoless Double Beta Deca

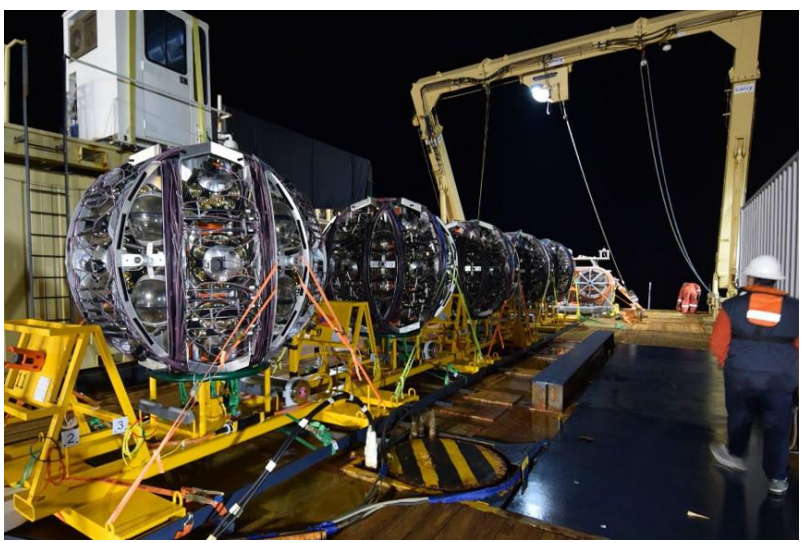
SuperNEMO demonstrator @ LSM

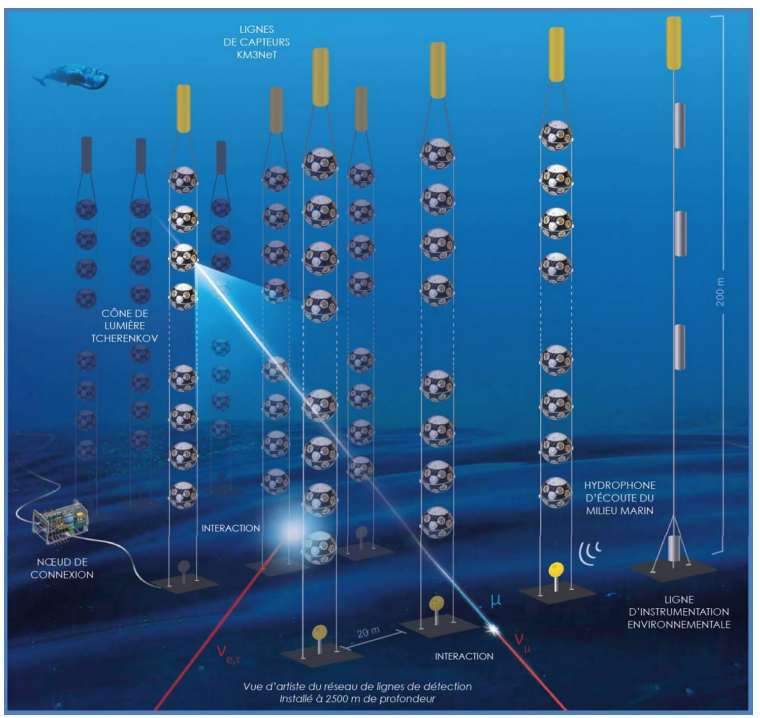
SuperNEMO uses a tracko-calorimeter technique to measure the full kinematics of $(\beta\beta)_{0\nu}$

SuperNEMO is a demonstrator for future tracko-calorimetric detectors capable of studying not only the nature of neutrinos but also the existence of new interactions (RHC).

KM3NeT and ANTARES

- CPPM pioneered very large neutrino telescopes using sea water
- ANTARES demonstrated the concept feasibility (>10years of operation)
- The next generation is under construction with the two detectors
  - ORCA [France] for to low energy (3-100GeV)
  - ARCA [Italy] for high energy (TeV-PeV)

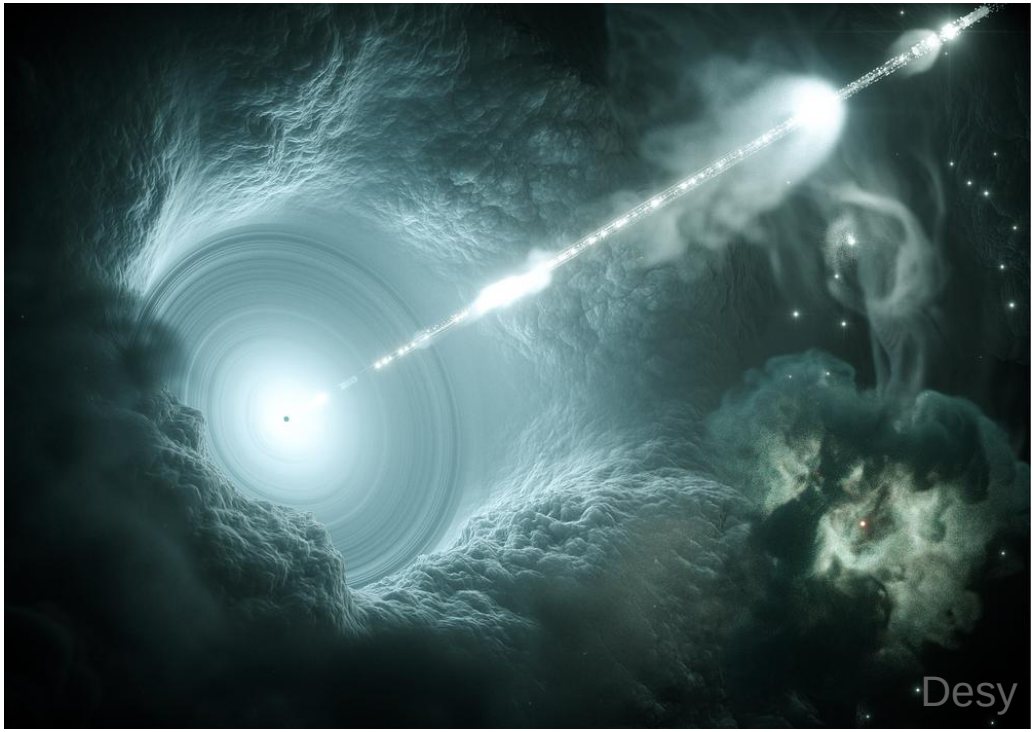




Neutrinos as cosmic messengers

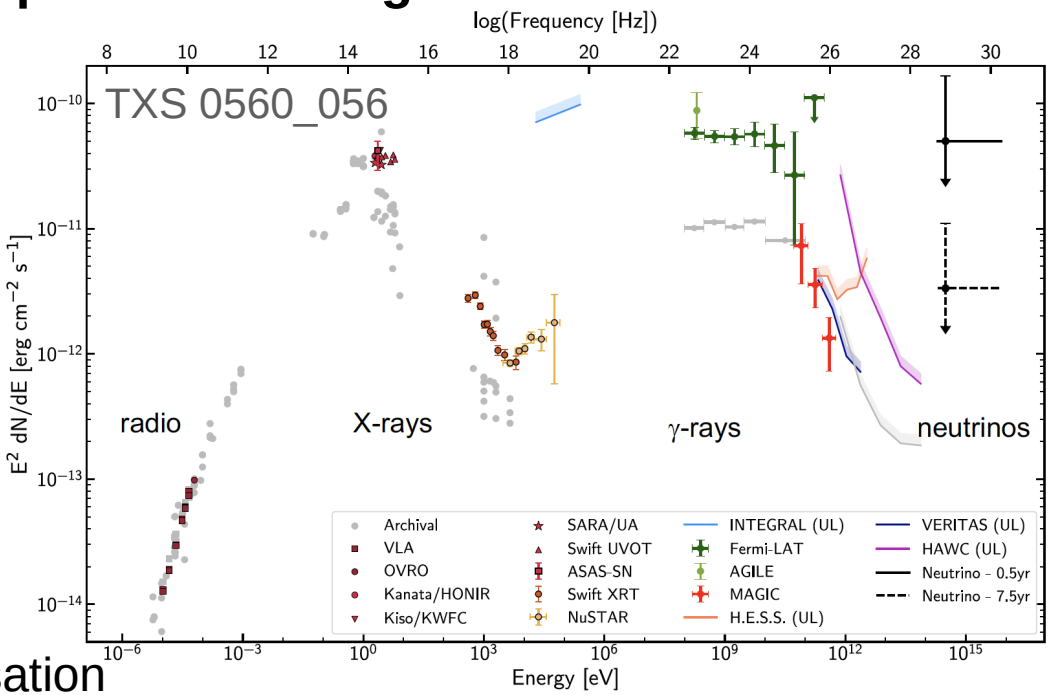
- **Neutrino astronomy**
  - link with CR production, acceleration, propagation)
- **Time-domain** astronomy
- **Multi-messenger** studies
- **Core-collapse** CCSN (MeV neutrinos, SNEWS)
- Link with **physics beyond LIV**

- Link with **ANTARES/KM3NeT, HESS/CTA, SVOM, COLIBRI, ZTF/LSST, LVKC**…



Neutrinos as cosmic messengers

- **Solid measurements of the diffuse high-energy ν flux by IceCube and ANTARES. We are touching the top of the iceberg of the ν sources.**
  - High gamma-ray activity (TXS 0506+056,PKS B1424-418, MG3 J225517+2409, 3C279)
  - High radio flux (PKS 1502+106 PKS B1424-418, 3C403)
  - High and hard X-ray activity (BZB J0955+3551 / 3HSP J095507.9+355101)
  - Tidal disruption events

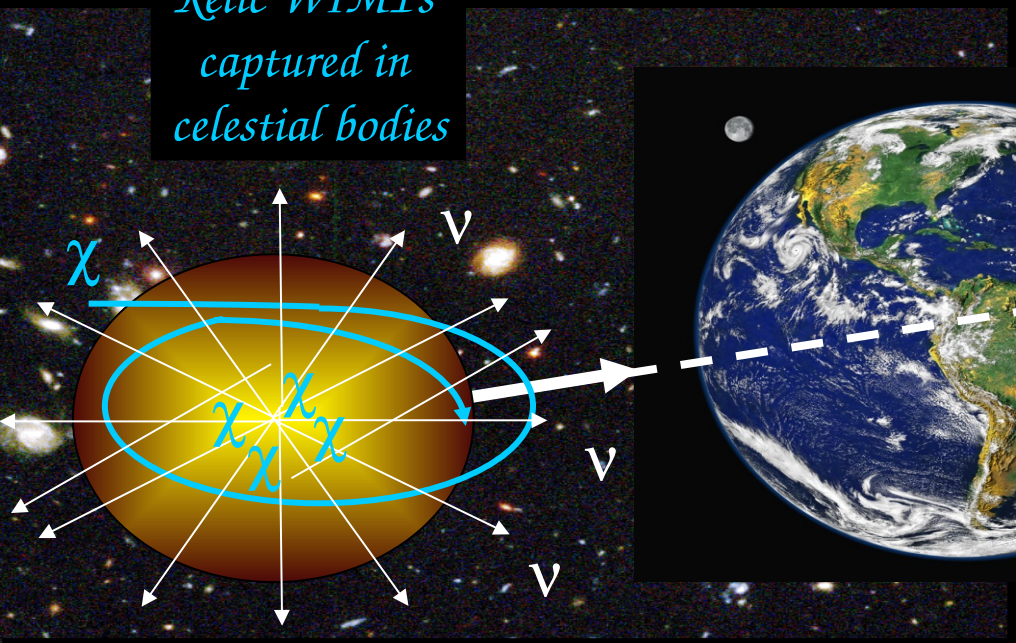


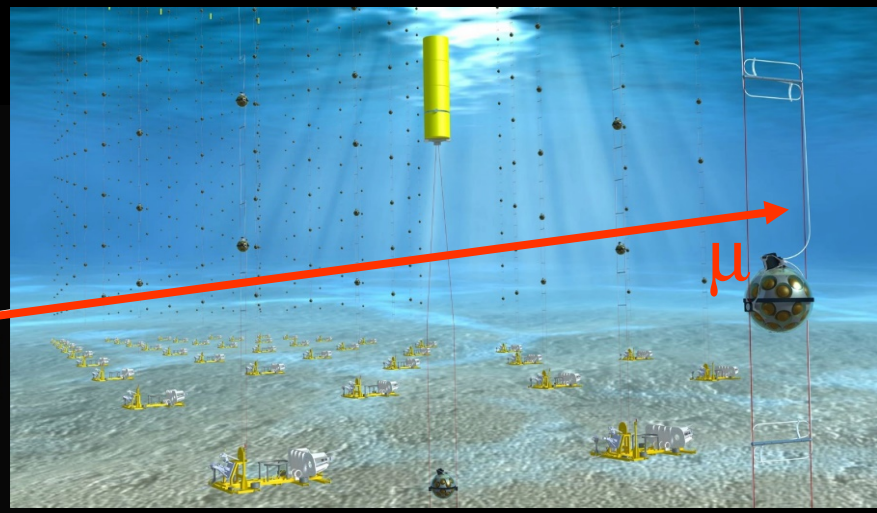
⟹ Difficulties for the MWL/MM modelisation

Simultaneous MWL/MM follow-up: key to resolve the ν sources (too few ν stat.)

Indirect detection of WIMPs in a neutrino telescope

Relic WIMPs captured in celestial bodies





χχ self-annihilations into c,b,t quarks, τ leptons or W,Z,H bosons can produce significant high-energy neutrinos flux

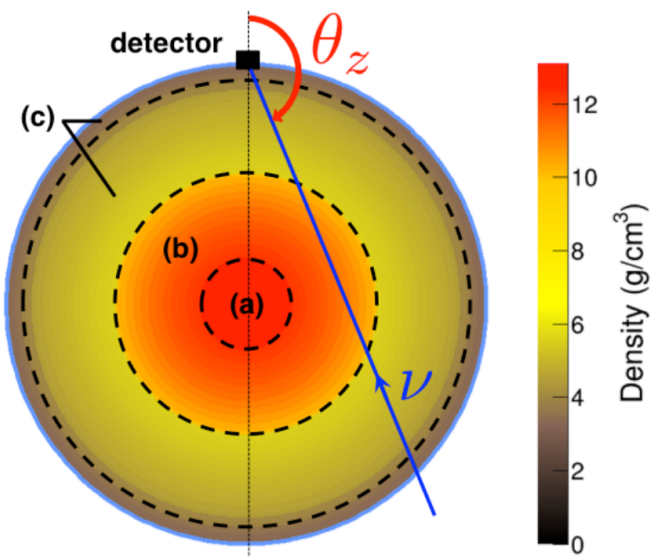
Potential χχ→ νν sources are Sun, Earth & Galactic Centre
Signal less affected by astrophysical uncertainties than γ-ray indirect detection

Complementary and competitive limits with ANTARES & KM3NeT for WIMP masses in [50, 3000] GeV (Sun) and > few TeV (GC)

Oscillation with Atmospheric ν

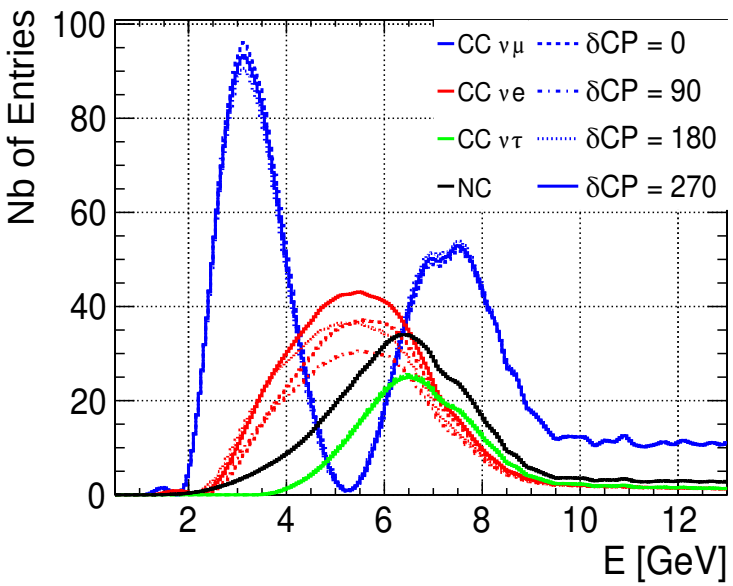
- Up-going ν covers a wide range of baselines, and are subject to very strong matter effects
  - neutrino mass ordering
  - PMS unitarity using νμ➔ντ appearance
  - Δm^2_{23}; θ_{23} measurment
  - Exotic (NSI, sterile etc...)

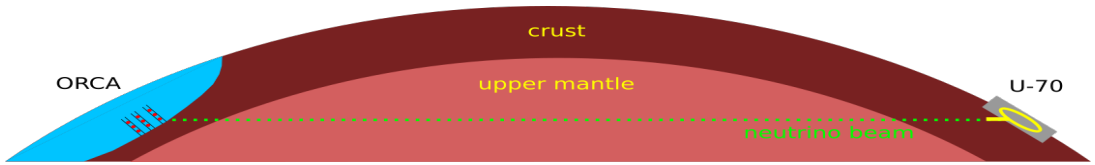
Results for ICRC-2021

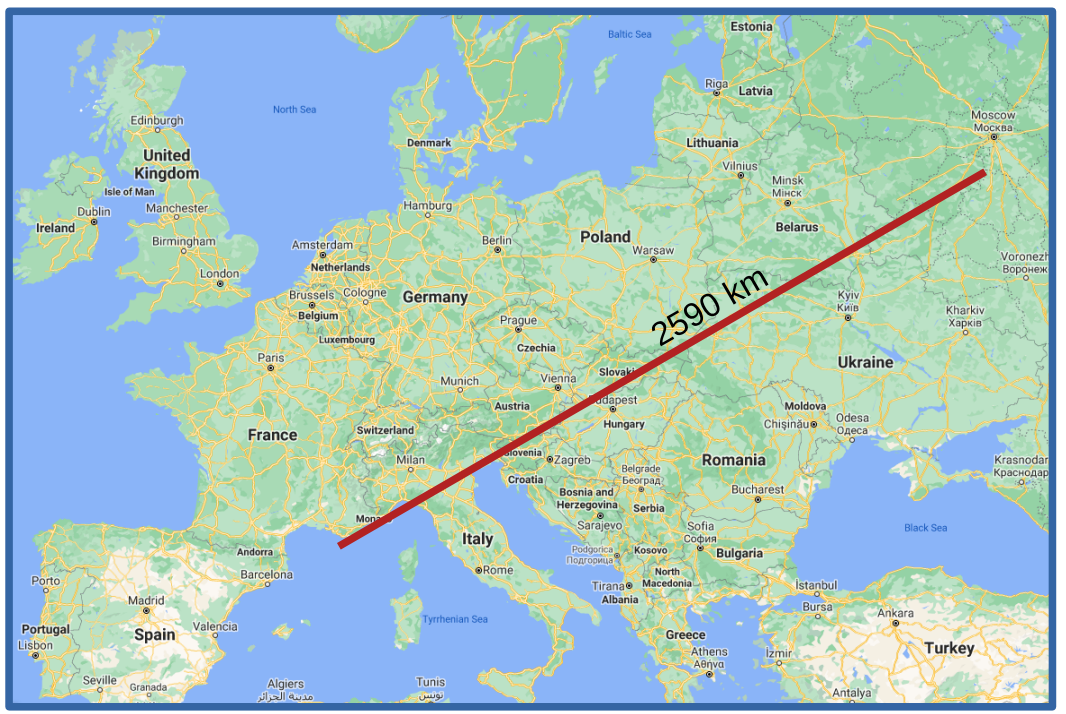


The next step: Protvino to ORCA – P2O

- Use **U70** accelerator in Protvino (Russia) to generate a **ν beam**
- Baseline is **~2600 km**
  ➜ 1st osc. max. is at 5 GeV
- Allows to measure δCP

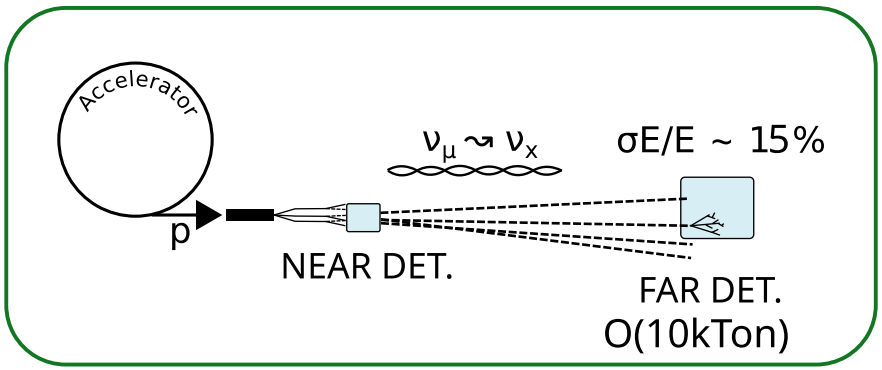


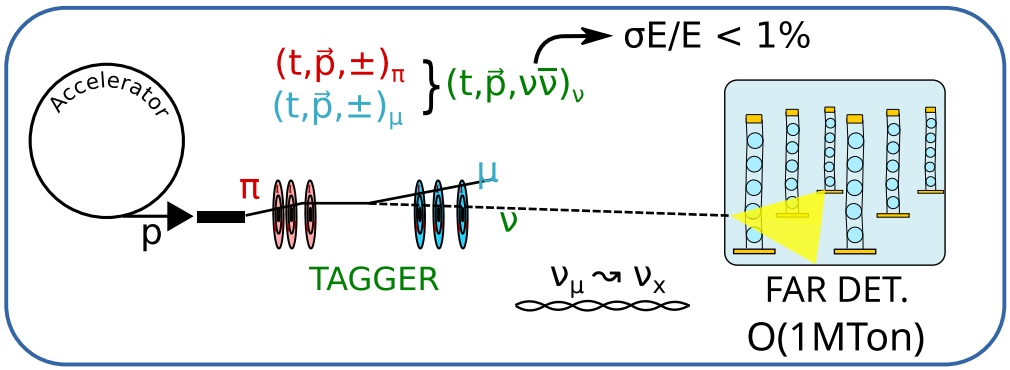




Neutrino tagging

- **P2O** offers an **alternative** to conventional LBL's





- ORCA **huge mass** (Mton) allows collect **large stat.** **with modest beam power**
- **beam line can be instrumented with trackers (TAGGER)**
  - ν properties precisely known from π➔μν kine. for each and all ν
  - one-to-one association between π➔μν and interacting ν

  } **no systematics**
- **ν followed from creation (tagger) to detection 2600km away**
  - any use in quantum mechanics?

Thanks for listening

ν at NA62

- **ν tagging implemented at NA62 (rare K decays)** as a by-product
- **Calorimeters act also as ν detectors** and with O($10^{12\text{-}13}$) K decays /y:

  ~1400ν/y from K➔μν + Kμ3 interact in Lkr+MUV (20 + 66 ton)

- K and μ properties (t,$\vec{p}$,±) precisely measured thanks to GTK (Si-Pixel) and STRAW trackers
- Dedicated **trigger line** will collect these events from July 2021