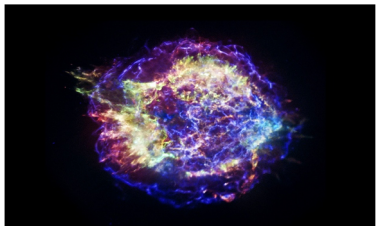
L2 activities within the Amaldi Research Center

Pia Astone, INFN Roma 1- for L2 group members

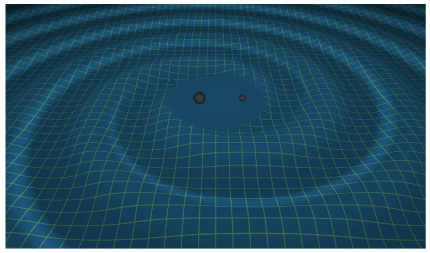
AMALDI RESEARCH CENTER

LIGO/Virgo/KAGRA gravitational wave (GW) data analysis



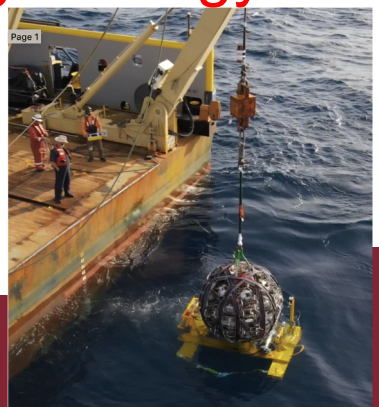
Supernova explosions

Isolated neutron stars

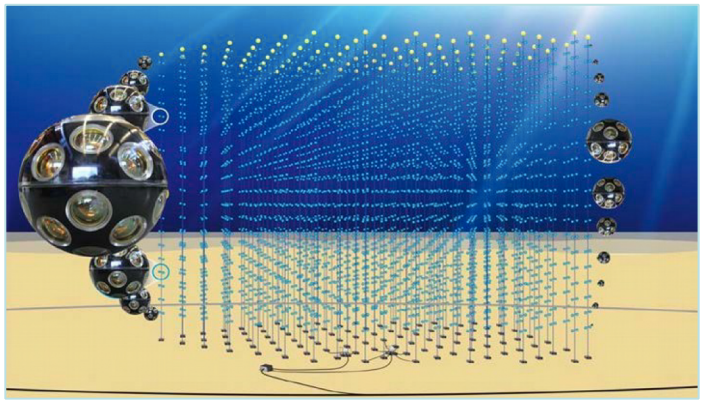


Compact binary coalescences

Multi-messenger astronomy (MMA): searches for dark matter (DM) and high-energy neutrinos



Deployment of a KM3NeT detection unit



KM3NeT: a neutrino telescope in the Mediterranean

LIGO/Virgo/KAGRA GW data analysis

Detector characterization studies for Virgo

Compact binary mergers (NS-BH, NS-NS), also in coincidence with short gamma-ray bursts

Continuous waves from neutron stars (NSs)

Bursts from Supernova (SN) explosions

Ultralight DM (boson clouds, dark photons effect on detectors)

MMA: searches for DM and high-energy neutrinos

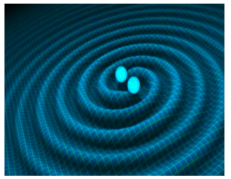
Analysis of Antares data (high energy neutrinos)

Contribution to the development of KM3NeT

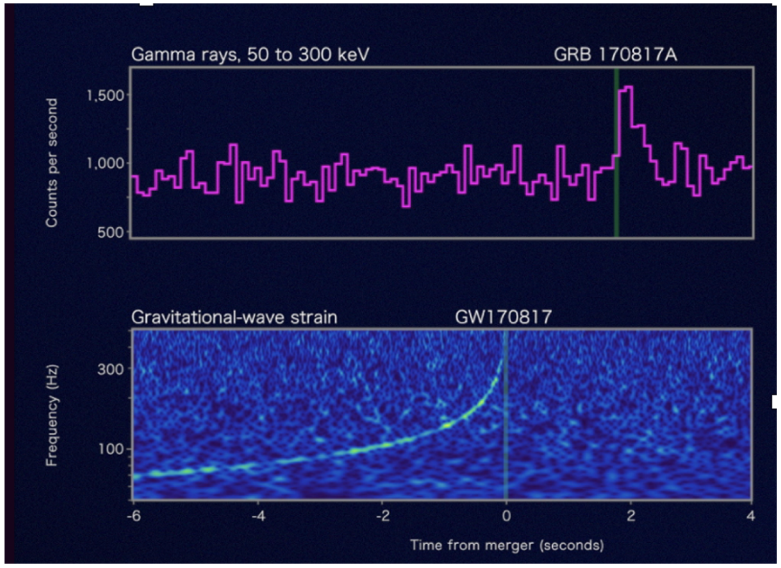
Novel detector concepts: Vertically-aligned carbon nanotubes as anisotropic target for light dark matter

Data analysis work, mainly algorithm testing and optimizations, has been carried out on the new ARC cluster, hosted and maintained at the SICR-INFN

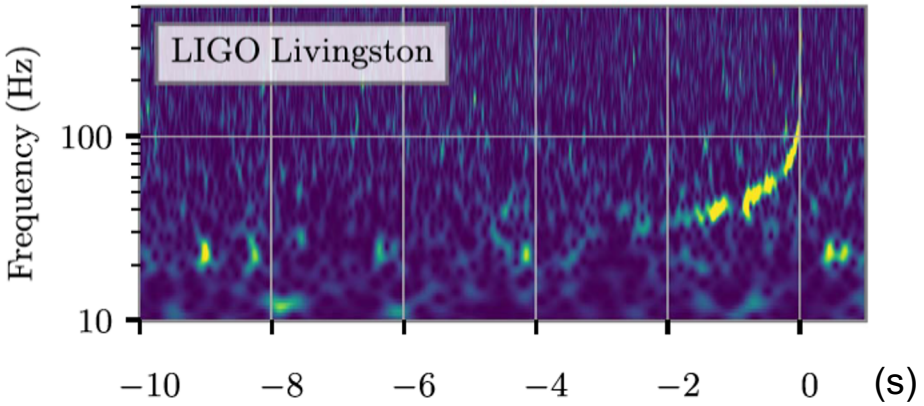
Compact Binary Searches, Waveform modelling and related



- Neutron star binary mergers: pipeline development and searches for mergers in coincidence with GRBs or FRBs in LIGO/Virgo data
- NS-NS and NS-BH waveform modelling
- Study of equilibrium properties of NSs containing mirror dark matter
- Assessing a fundamental test of General Relativity via the inference of the polarization content of transient GWs (*con.Scienze 2020 prize*)
- Machine learning applications to low-latency classification of compact binary source properties

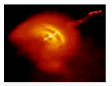


GW170817 and GRB 170817A

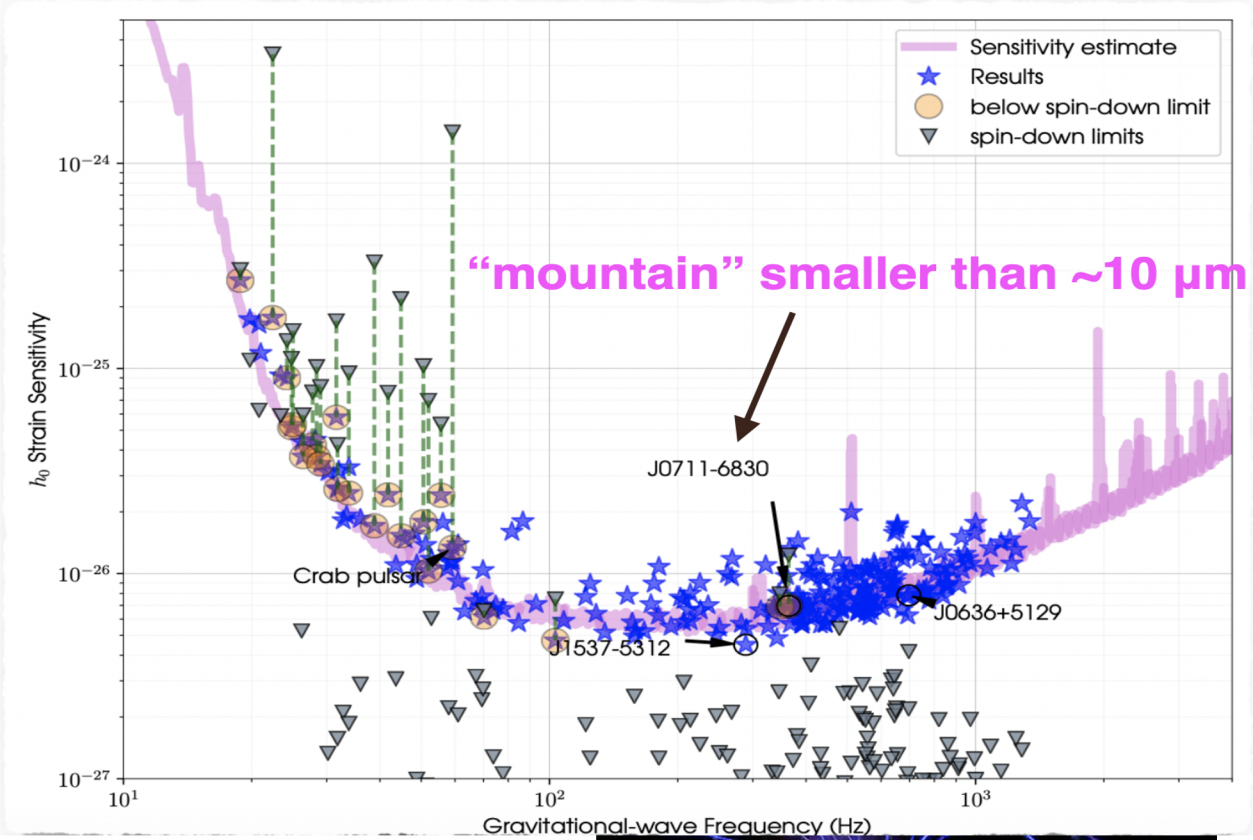


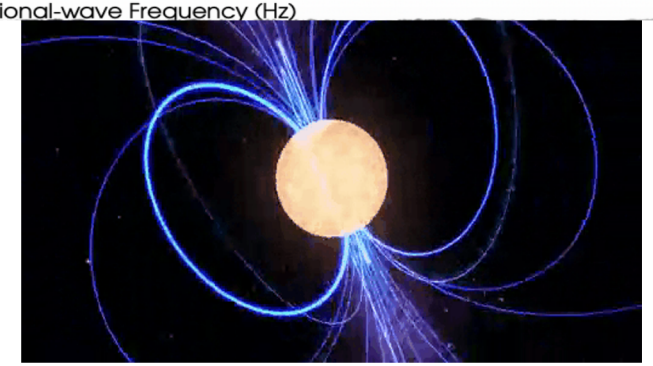
GW190814: GWs from the coalescence of a 23 Solar mass BH with a 2.6 Solar mass compact object

Continuous Waves and related searches



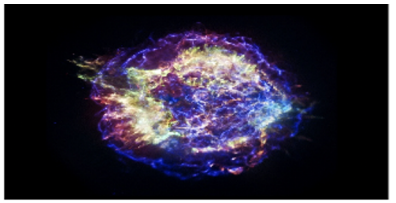
- Targeted & narrowband searches
- All-sky searches (isolated and binary NSs)
- Directed searches from young SN remnants and from the GC
- Long transient searches (magnetars)
- Ultra light dark matter searches (boson clouds around BHs, dark photons)
- Virgo noise characterization
- GPUs and exploration of machine learning techniques



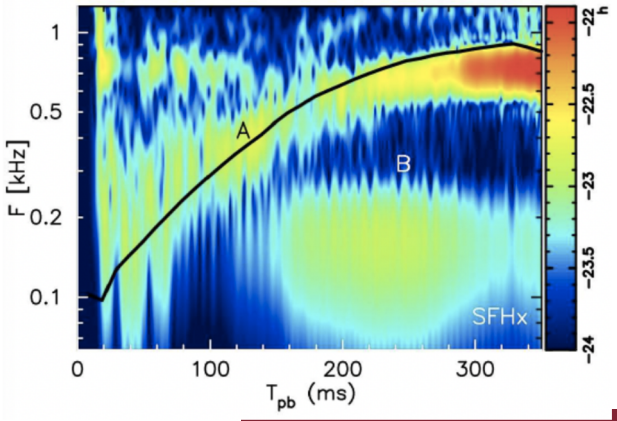


Expected sources: asymmetric neutron stars with respect to the axis of rotation, magnetar.
Bosonic clouds around BHs.
Direct interaction of dark matter and gravitational wave detectors

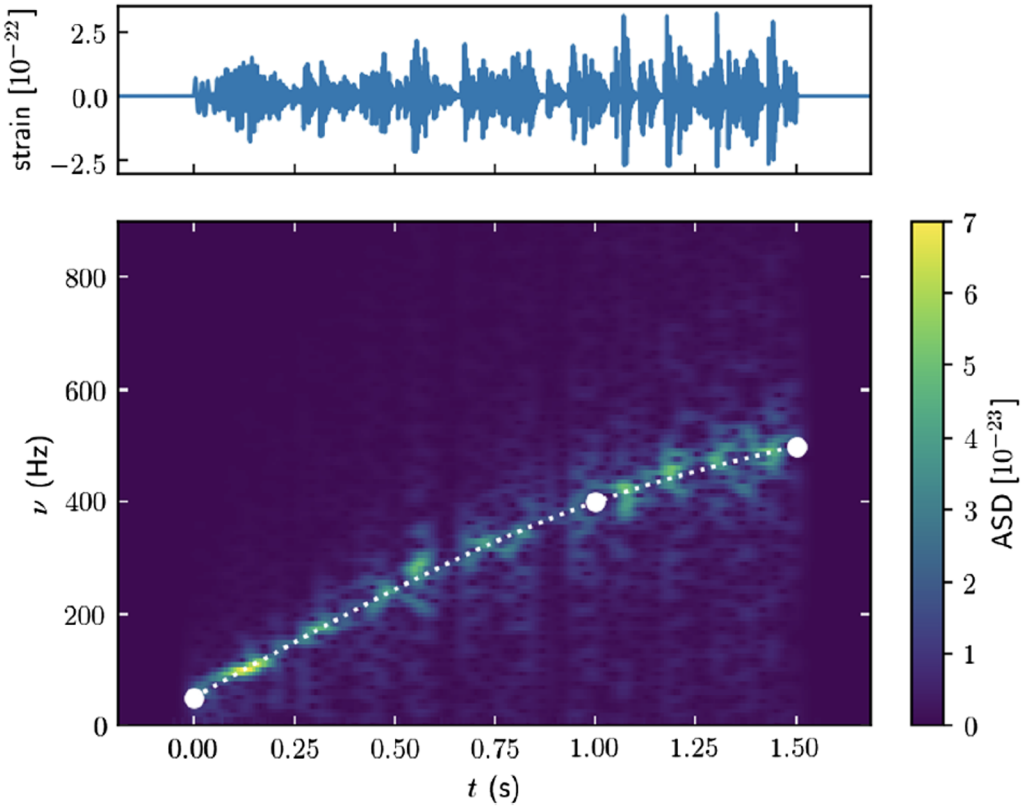
Burst (unmodeled signals) Searches



- Analysis and code optimizations for a wide class of transient signals
- LIGO/Virgo low-latency searches
- Waveform parameter estimation for unmodeled signals
- Analysis procedures for the science case of MMA with neutrinos and GWs for Supernova searches
- Machine learning algorithms for Core Collapse Supernovae



(Dimensionless) strain of the signal



Deep learning for multi-messenger core-collapse supernova detection

MMA with high energy neutrinos

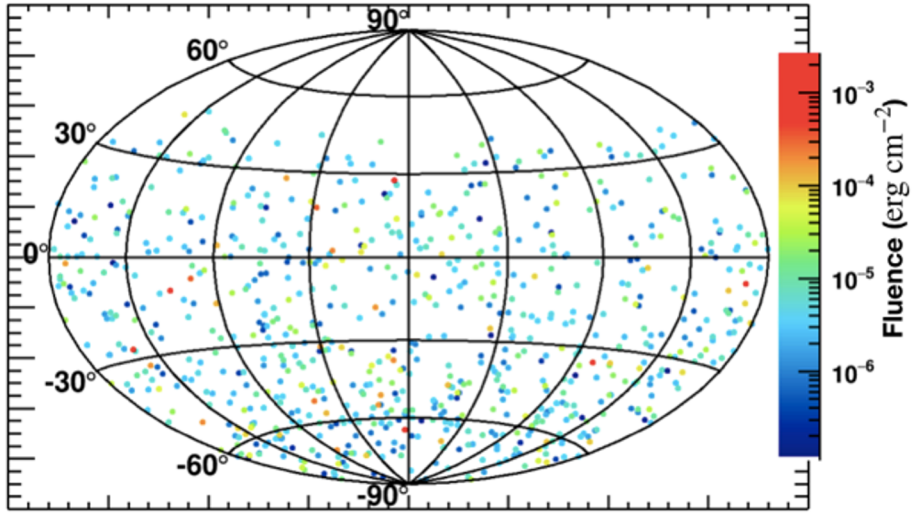
Short and Long Gamma-Ray Bursts and Fast transient Bursts (on-line pipeline development) with ANTARES and KM3NeT data.

Estimate of diffuse neutrino spectra from choked GRBs expected on Earth

Point-like neutrino sources: search from known gamma sources (HESS, MAGIC, LHAASO ...) and for statistical evidences over the full sky

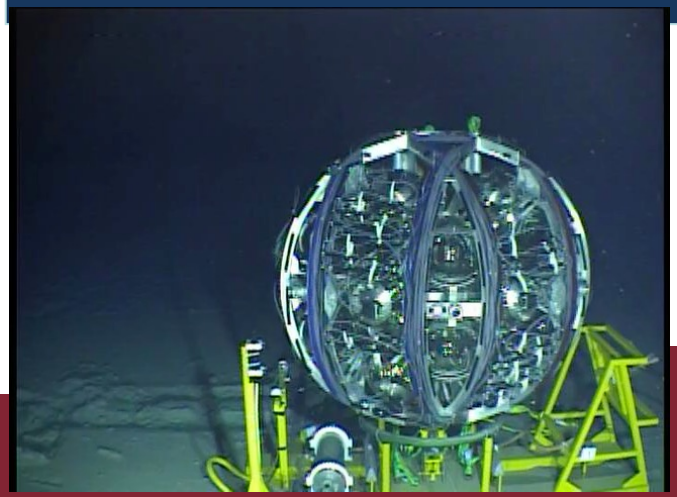
Design, implementation and production of the electronics for the KM3NeT experiment.

Detection prospects for low-energy neutrinos from collisionally heated GRBs with current and future neutrino telescopes



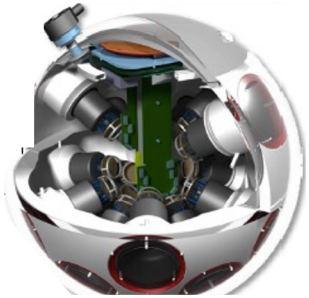
GRBs searches with ANTARES data

HE neutrinos offer the possibility to “observe” and study the properties of the most energetic and remote sources of Cosmic Rays



KM3NeT srotolamento della linea

42 cm

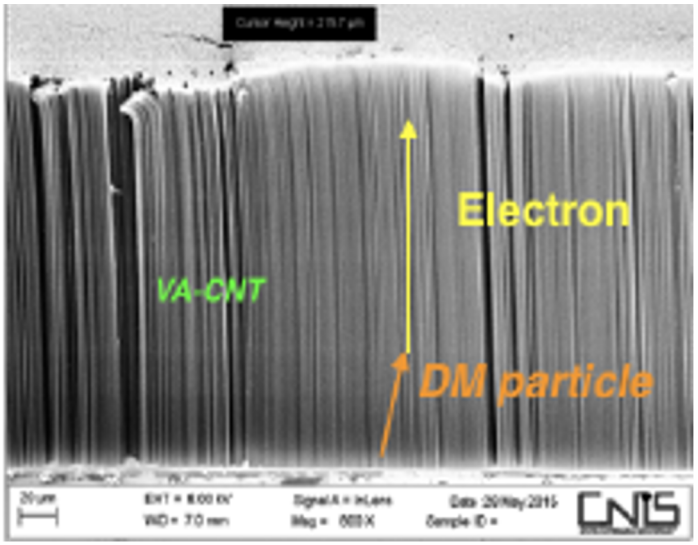


KM3NeT optical module

MMA: searches for dark matter and support to high-energy neutrino searches

Hydrogenation of carbon nanostructures is currently studied for future tritium-based neutrino experiments (relic neutrino background - **Ptolemy**)

Highly vertically-aligned CNT (VA-CNT) have been recently proposed as active cathode for a prototype sensor in the Dark Matter search (**Andromeda**)



Vertically aligned
multi-wall carbon nanotubes (CNTs)

No candidate as Dark Matter particles has been found yet.

The search requires new detectors in a very low background environment.

Project impact for L2 (goals reported by Prof. P. Mataloni)

Scientifico: “opening a new observing window on the Universe”

Formativo: “astrophysics of GW sources,” “gravitational physics,” “gravitational-wave astronomy”, “machine learning”

Tecnologico: “Machine Learning”

- **PhD course** “Advanced Data Analysis techniques” (2020/21 and 2021/22) - P. Astone, P. Leaci, C. Palomba - was supported by ARC.
- **PhD course** “High Energy Neutrino Astrophysics” (2020/21 and 2021/22) - A. Capone, I. Di Palma, S. Celli - was supported by ARC.
- **Course** for the **"percorso di eccellenza"** ``GW astronomy" ; F. Pannarale

*Strong benefit from the intense **visitors program** (see the posters)*

There is a lot of work ahead of us, and we are working to be ready for the exciting scientific scenario of the upcoming years