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LNS News

INFN - Laboratori Nazionali del Sud

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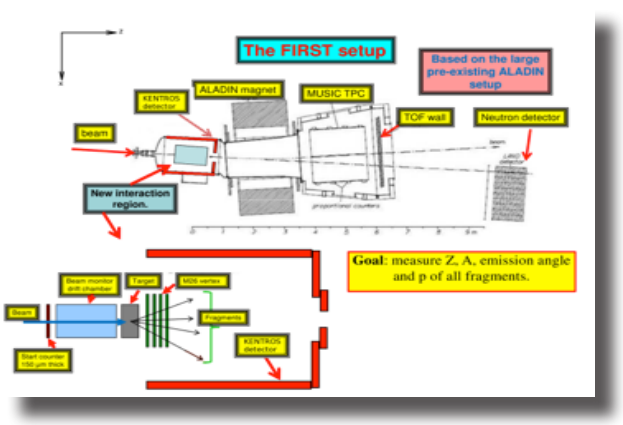
The scientific activity of the LNS is continuing with renewed efforts increasingly towards results of excellence, both in the field of nuclear physics and in the applications of nuclear properties. The experimental activity with the Superconducting Cyclotron is proceeding normally, whereas a lot of effort is dedicated to the maintenance of the Tandem after the last failure. In the last months LNS have got by the Minister "premiali funds" regarding a project of excellence in Nuclear Astrophysics. This project include also an important upgrade of the Tandem accelerator with the aim to allow a future and intense research activity, both with stable and unstable beams, as scheduled in the project. Ten years after their start the medical treatments of ocular tumors with proton beams successfully continue. This activity was the only one in Italy until the current year, when the experimental clinical activity has started also at CNAO of Pavia. A great activity is also devoted to the already started international project, ESS, ELI and Daedalus, for which LNS has an important scientific role. A new organization chart has been achieved 14 years after the previous one. The objective of this internal reorganization is to give a new impetus useful to the variety of activities going on at LNS. Professor Stefano Romano has been appointed to carry out management activities in support of the LNS Director. A new LNS User Committee has been newly elected and is formed by Antonio Capone, Silvio Cherubini, Enrico De Filippo, Nicolas Le Neindre and Vincenzo Patera.

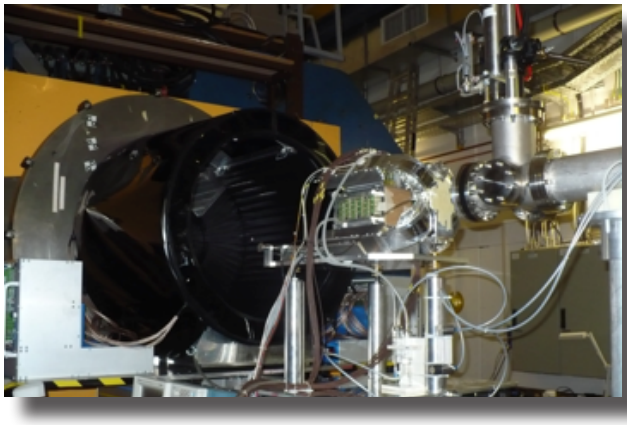
FIRST experiment: Fragmentation of Ions Relevants for Space and Therapy

Nuclear fragmentation processes are relevant in different fields of basic research and applied physics and are of particular interest for tumor therapy and for space radiation protection applications. The FIRST (Fragmentation of Ions Relevant for Space and Therapy) experiment, has been designed for the measurement of different ions fragmentation cross sections at different energies between 100 and 1000 MeV/nucleon.

The experiment is performed by an international collaboration made of institutions from Germany, France, Italy and Spain. The experimental apparatus is partly based on an already existing setup made of the ALADIN magnet, the MUSIC IV TPC, the LAND2 neutron detector and the TOFWALL scintillator TOF system, integrated with newly designed detectors in the interaction Region (IR) around the carbon removable target: a scintillator Start Counter, a Beam Monitor drift chamber, a silicon Vertex Detector and a Proton Tagger for detection of light fragments emitted at large angles.

The scientific program of the FIRST experiment, with the strong contribution of LNS, started at SIS accelerator of GSI laboratory in Darmstadt, on summer 2011 with the study of the 400 MeV/nucleon 12C beam fragmentation on thin (5mm) graphite target.



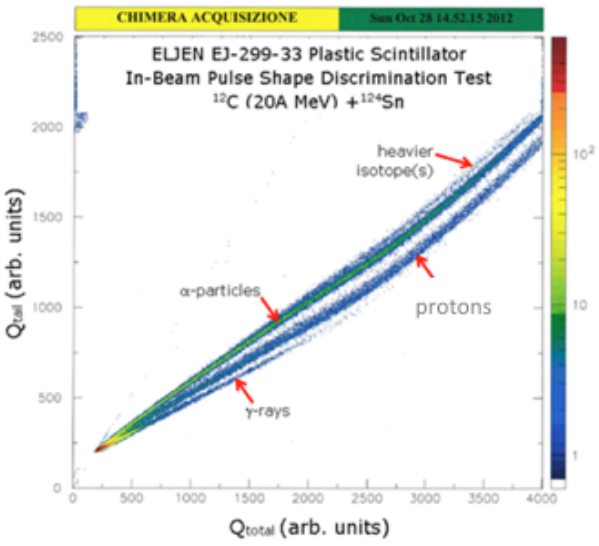


First time measurement of the $^{13}C(alfa, n)^{16}O$ cross section down to negative energies

The $^{13}C(\alpha, n)^{16}O$ reaction is the neutron source for the main component of the s-process, responsible of the production of most nuclei in the mass range 90 < A < 204. A recent measurement by Marco La Cognata et al. from LNS, published in Physical Review Letters, sheds light on the heavy element synthesis thanks to first-time measurement of a ^{17}O resonance lying 3 keV below the 13C+ α threshold. This resonance dominates the $^{13}C(\alpha, n)^{16}O$ cross section at the energies of astrophysical interest, 100 – 250 keV. Notwithstanding that it plays a crucial role in astrophysics, no direct measurements exist but only conflicting estimates. Extrapolations, e.g. through the R-matrix, and indirect techniques such as the asymptotic normalization coefficient (ANC) have yielded inconsistent results. The discrepancy amounts to a factor of 3 or more right at astrophysical energies.

The novelty of the LNS research work consists in the innovative approach using the Trojan Horse Method (THM), applied to the $^{13}C(^{6}Li,n\ ^{16}O)d$ quasi-free reaction, to deduce the ANC for the 6.356 MeV ^{17}O level responsible of the -3 keV resonance. Thanks to the fusion of THM and ANC approach, the n-partial width has been deduced as well, allowing to attain an unprecedented accuracy in the $^{13}C(\alpha, n)16O$ study.

Though a larger ANC for the 6.356 MeV level is measured than in the previous works, in the 100 – 250 keV energy interval the measured experimental cross section agrees with the most recent extrapolations in the literature and the accuracy has been greatly enhanced thanks to this novel approach.



A new neutron detector for the ASTERICS telescopes at LNS

The CECIL collaboration had another successful test experiment for the ASTERICS detector. This detector is a combination of an annular silicon detector made up of individual, double-sided Si-strip (300/400μ) ΔE/E detectors backed by plastic scintillation detectors read out with photomultipliers. The latter detector is intended to measure γ-rays, neutron and light charged particles. The object of the test run with a 20A-MeV ^{12}C beam on various targets was to test the capability of the plastic scintillator to distinguish different particle/γ species via pulse shape discrimination (PSD).

Protons are distinguished from neutrons via a combination of ΔE, time-of-flight and scintillator light output information (Q). The novel plastic scintillator with unusual pulse shape discrimination properties was developed by a team at Lawrence Livermore National Laboratory (N. Zaitseva et al., Nucl. Inst. Methods A 668, 88 (2012). The two-dimensional diagram plotting the a fractional integral (Q_{tail}) vs.the total light output (Q_{total}) indicate good PSD capability for γ-rays, protons and α-particles.

The LNS marine infrastructures: a science gateway opened into deep-sea abysses

In June 2012 the multidisciplinary observatory NEMO-SN1 (Fig. 1) has been re-deployed at over 2000 m water depth and connected through an electro-optical cable to the LNS on-shore station in the harbour of Catania and then in Internet through the link with the LNS. This new enterprise, following the successful campaigns of 2002-2003 (stand-alone mode) and 2005-2008 (cabled) (Favali et al., 2011), rewards the efforts of a team formed by researchers and technicians from INFN, INGV, CNR, CIBRA-Univ. Pavia and Tecnomare ENI.

The operation of NEMO-SN1 establishes the first cable node of EMSO (European Multidisciplinary Seafloor and water column Observatory, http://www.emso-eu.org) (Favali and Beranzoli, 2009) included among the large-scale European Research Infrastructures in the ESFRI Roadmap (European Strategy Forum on Research Infrastructures, http://cordis.europa.eu/esfri/roadmap.htm). The observatory is equipped with several sensors aiming at the monitoring of geophysical, oceanographic and environmental phenomena and at the study of acoustic sources in the sea (Favali et al., 2012). Some of the major goals of the detector are the test of a novel tsunami-early warning system (Chierici et al., 2012) and the search for cetaceans acoustic signatures and for other noise sources like vessels. All these activities are carried out in strong collaboration with the FIRB2008-SMO project (http://web.infn.it/SMO).

The data transmitted from the observatory are acquired, processed and distributed in real time over internet, thanks to the IT and computing infrastructure deployed by LNS and are available at the INGV database (http://moist.rm.ingv.it). Future plans foresee collaboration with the IGI (Italian Grid Initiative) in the aim of maximise the dissemination of results and knowledge provided by this unique facility.

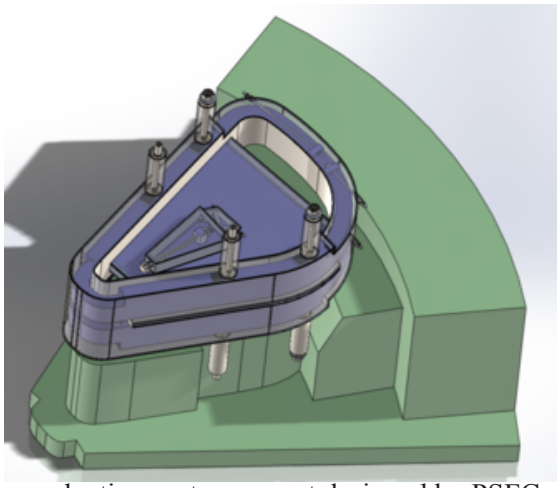
The NEMO-SN1 Observatory on board of the cable-ship Certamen (owned by Elettra Tlc SpA) before the deployment

High Intensity Cyclotron for Neutrino Experiments

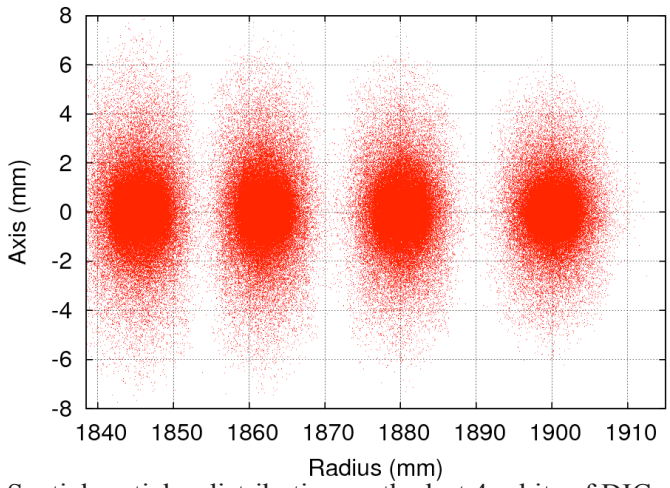
The annual DAEdALUS meeting was held in Erice from October 31st to November 3rd 2012. The new six sectors design for the 800 MeV DAEdALUS Superconducting Ring Cyclotron was presented along with the preliminary engineering design of the cryostat. The magnetic study of this machine was fulfilled at LNS by the DAEdALUS group. On the other hand, the preliminary study of the engineering design was developed by the PSFC, which is a MIT group with major expertise in superconducting magnets.

The Erice meeting was mainly focused on the DAEdALUS Cyclotron Injector (DIC) able to deliver a 10 mA proton beam @ 60 MeV. This machine matches the requirements for IsoDAR, that is an experiment to search sterile neutrinos proposed by DAEdALUS collaboration, Phys. Rev. Lett. 109, 141802. Other international research groups worked together with the LNS group to validate the results obtained on the DIC. In particular the LNS DIC magnetic design was used by coworkers of PSI to check the beam dynamics and the inter-turn separation at the extraction radius. The result was very good and demonstrated that, despite and thanks to the space charge effects, it is possible to accelerate and extract 5 mA of H2+ molecular beam from the DIC, to be published on NIM-A, http://www.sciencedirect.com/science/article/pii/S0168900212015835 .

Kamiokande researchers (laboratory board) expressed their intention to host the accelerator and the target, that has to be installed near the big water detector. The interest of Kamiokande lab has some drawbacks, too. The most critical is the narrow access tunnel that puts important mechanical constraints to the pieces' size. New options are under study by the LNS group to overcome these new blocking points. New versions of the DIC up to 35% smaller are under evaluation. The goal is to simplify the transport and the construction, which has to be done underground.



Superconducting sector magnet designed by PSFC of MIT



Spatial particles distribution on the last 4 orbits of DIC

Nuclear Physics First National Meeting

From November 12 to 14, the LNS have hosted the first "Incontro Nazionale di Fisica Nucleare" (INFN 2012). The meeting has been promoted by the INFN Scientific National Committees (CSN3 and CSN4) as an occasion to bring together the whole Italian Nuclear Physics community, involved both in theory and in experiments.

The aim of the Workshop was to consolidate existing collaborations and establish new ones, in order to develop useful synergies to face the new challenges of the Nuclear Physics domain. A wide spectrum of subjects, ranging from nuclear structure to reaction dynamics and nuclear astrophysics, from hadron physics to the quark- gluon plasma phenomenology, has been discussed. The talks were organized in plenary sessions, with general discussions involving all participants.

More than 150 participants made the initiative a big success. All the community looks forward a second edition that will take place in the near future.

ELIMED collaboration meeting at LNS

A pan-European task force has been established with the aim to realize the conceptual design of ELIMED (Medical application at Eli-Beamlines), which will be the first worldwide facility dedicated to the medical applications envisioned at the ELI-Beamlines project in Prague.

The cooperation agreement between international specialists has been the main outcome of the 2nd ELIMED Workshop and Panel which was held in Catania on 18th and 19th of October (2012) at Laboratori Nazionali del Sud.

The workshop gathered more than 60 experts in different disciplines like Physics, Biology, Chemistry and Medicine coming from Europe, Japan and US.

The ELIMED project has been promoted from the INFN researchers within the European project ELI (Extreme Light Infrastructure), selected by the European Strategy Forum for Research Infrastructures (ESFRI) to build three large research facilities dedicated to the development of new generation lasers. ELIMED main goal is to perform proof-of-principle experiments in order to demonstrate the feasibility of new approaches, based on laser-driven proton sources, for potential future applications in the field of hadrontherapy.