Terzo Incontro Nazionale di Fisica Nucleare INFN2016

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Laboratori Nazionali di Frascati

Book of Abstracts

Giovani ricercatori

Presentazioni

Sessione: Transizioni di fase e plasma di quark e gluoni

Lunedi 14 novembre 2016 12:05-12:50

Studio della produzione di materia (iper-)nucleare a LHC con l'esperimento ALICE

L'esperimento ALICE al Large Hadron Collider (LHC) ha permesso di caratterizzare il plasma di quark e gluoni prodotto nelle collisioni Pb-Pb in condizioni estreme di densità di energia e temperatura della materia nucleare. Nella presente comunicazione vengono riportati i risultati ottenuti dall'esperimento ALICE in merito alla produzione di (anti-)nuclei, ipernuclei e stati nucleari esotici. Si presentano in particolare gli spettri di produzione e il flusso ellittico dei nuclei leggeri come deutoni ed elio e i recenti risultati sulla misura dell'ipertrizio. Inoltre vengono illustrati i risultati della ricerca di un ipotetico stato legato LambdaN e del dibarione H in collisioni Pb-Pb. I risultati sono confrontati con le predizioni teoriche dei modelli termici (statistici) e con le predizioni dei modelli di coalescenza al fine di capire quale sia il meccanismo di produzione della materia (iper-)nucleare in collisioni ultrarelativistiche di ioni pesanti.

Speaker : PUCCIO, Maximiliano

Misura degli adroni composti da quark *leggeri* in funzione della molteplicita' con l'esperimento ALICE

Gli adroni composti da quark leggeri u, d e s sono importanti sonde per caratterizzare il mezzo creato nelle collisioni tra ioni pesanti ultra-relativistici, dando la possibilità di studiare i meccanismi di produzione di particelle. Recenti misure effettuate alle energie del Large Hadron Collider (LHC) in collisioni protone-protone (pp), protone-piombo (p–Pb) e piombo-piombo (Pb–Pb) suggeriscono l'esistenza di somiglianze - in parte inattese - tra i tre sistemi, giustificando lo studio approfondito della produzione di particelle in sistemi più piccoli rispetto al caso del Pb–Pb, come ad esempio pp e p–Pb. L'esperimento ALICE, sfruttando le ottime prestazioni del suo rivelatore per l'identificazione delle particelle, permette di misurarne la produzione su un ampio intervallo di momento trasverso (pT), nella regione a rapidità centrale. Le distribuzioni in pT di π, K, p, K0s, K*, Λ, Ξ e Ω, misurate in collisioni pp a $\sqrt{s}$ = 7 TeV, saranno mostrate in funzione della molteplicità di particelle cariche e, al fine di interpretare i risultati ottenuti, verranno confrontate sia con misure analoghe in collisioni p–Pb e Pb–Pb, che con le predizioni dei modelli Monte Carlo. Particolare attenzione sarà dedicata all'osservazione, in collisioni pp, di un incremento della produzione di adroni contenti quark s al crescere della molteplicità di particelle cariche.

Speaker : JACAZIO, Nicolò

Anisotropie v_n nello spazio degli impulsi e fluttuazioni di stato inziale nel plasma creato nelle collisioni ad energie ultra-relativistiche

Heavy Ion Collisions at ultra-relativistic energies represent the only possibility to explore the QCD phase diagram in laboratory. One of the most important observable which encode information about the matter created in these collisions is the elliptic flow v_2 which is a measure of the azimuthal anisotropy in momentum space. In recent years several analisys have been devoted to study more refined features of the particle distribution extending the study to the anisotropic flow coefficients to the n-th harmonic v_n. We discuss the build up of the anisotropic flows v_n for a fluid at fixed $\eta/s(T)$ in the framework of an event-by-event transport approach [1]. Such an approach, recovers the universal features of the ideal hydrodynamics. In particular, we discuss the role of the Equation of State and the effect of the η/s and its temperature dependence on the build up of the $v_n(p_T)$. We find that only in ultra-central collisions (0−0.2 %) the $v_n(p_T)$ have a stronger sensitivity to the T dependence of η/s in the QGP phase and this sensitivity increases with the order of the harmonic n. Moreover, the study of the correlations between the initial spatial anisotropies and the final flow coefficients reveals that at LHC energies there is much more correlation than at RHIC energies and the degree of correlation increases from peripheral to central collisions. In ultra-central collisions at LHC a linear correlation coefficent $C(n,n)\approx1$ for n=2,3,4 and 5 is found and entailing that the (v_n, v_m) correlations supply an image of the initial space correlations (ε_n,ε_m) between different harmonics in the eccentricities. Finally, we discuss in ultra-central collisions the structure of the integrated (v_n,n) plot and its relation with Equation of State and kinetic freeze out dynamics.

[1] S. Plumari, G. L. Guardo, F. Scardina, V. Greco, Phys.Rev. C92 (2015) no.5, 054902.
[2] S. Plumari, G. L. Guardo, V. Greco, J.-Y. Ollitrault, Nucl.Phys. A941 (2015)

Speaker : PLUMARI, Salvatore

Sessione: Astrofisica nucleare e reazioni a pochi corpi

Lunedi 14 novembre 2016 17:40-18:40

^{7}Be(n,α) and ^{7}Be(n,p) cross-section measurement for the cosmological Lithium problem at the n_TOF facility at CERN

One of the most important unresolved problems in Nuclear Astrophysics is the socalled “Cosmological Lithium problem” (CLiP). It refers to the large discrepancy (factor 3-5) between the abundance of primordial ^{7}Li predicted by the standard theory of Big Bang Nucleosynthesis (BBN) and the value inferred from the so-called ”Spite plateau” in halo stars. In the framework of Standard Model, a possible explanation for this longstanding puzzle is related to the incorrect estimation of the destruction rate of ^{7}Be. Indeed in the standard theory of BBN, 95% of primordial ^{7}Li is produced by the decay of ^{7}Be ($\tau_{1/2}$=53.2 days), relatively late after the Big Bang, when lower temperature of Universe allows electrons and nuclei to combine into atoms. Therefore, the abundance of ^{7}Li is essentially determined by the production and destruction of ^{7}Be. While charged-particle induced reactions responsible for the destruction of ^{7}Be have mostly been ruled out by recent measurements, data on the ^{7}Be(n,α) and ^{7}Be(n,p) reactions were so far scarce or completely missing, mainly due to experimental difficulties arising from ^{7}Be specific activity. Recently, (n, α) reaction cross-section has been measured at n_TOF (CERN) while (n,p) reaction cross-section measurement is in progress, taking advantage of state-of-art techniques for the production of high-purity radioactive samples at ISOLDE, of high performance detection systems and, especially, of the innovative features of the new measuring station (EAR2) particularly suited for challenging measurements on shortlived radioisotopes. The two measurements, performed with two different silicon detection systems, provide for the first time nuclear data on ^{7}Be(n, α) and ^{7}Be(n,p) cross-section in a wide neutron energy range, namely in the energy range of interest for Nuclear Astrophysics. The experimental setups and the results of the measurements will be here presented, together with the implications of the measurements in standard BBN theory.

Speaker : BARBAGALLO, Massimo

Study of the ^{2}H(p,γ)^{3}He reaction at the BBN energies at LUNA

The Big Bang Nucleosynthesis (BBN) describes the production of light nuclides in the first minutes of cosmic time. It started with deuterium accumulation when the Universe was cold enough to allow ^{2}H nuclei to be survived to photo-disintegration.

A primordial deuterium abundance evaluation $D/H=(2.65\pm0.07)\times10^{-5}$ is obtained by merging BBN calculations and CMB analysis obtained by the Planck collaboration. This value is in tension with the astronomical observations on metal-poor damped Lyman alpha systems, according to which $D/H=(2.53\pm0.04)\times10^{-5}$. The main source of uncertainty on standard BBN prediction of deuterium abundance is actually due to the radiative capture process ^{2}H(p,γ)^{3}He converting deuterium into helium, because of the poor knowledge of its S-factor at BBN energies. A measurement of this reaction cross section is thus desirable with a 3% accuracy in the energy range $10keV<E_{cm}<300keV$. Furthermore a precise measurement of the p+d reaction cross section is crucial for testing ab-initio calculations in theoretical nuclear physics. Thanks to the low background of the underground Gran Sasso Laboratories (LNGS) and to the experience accumulated in more than twenty years of scientific activity, LUNA (Laboratory for Underground Nuclear Astrophysics) [4][5] is now measuring the ^{2}H(p,γ)^{3}He fusion cross section in the energy range of interest.

The experimental procedure consists of two main phases characterized by two different set up. The former provides for a windowless gas target filled with deuterium at 0.3mbar pressure together with a 4π BGO detector. This high efficiency detector will be used for investigating the energy range between 30 keV and 260 keV, trying to find a continuation of the previous results obtained by the LUNA collaboration in [6], where the ^{2}H(p,γ)^{3}He cross section was studied in the Solar Gamow peak ($2.5\ keV<E_{cm}<22\ keV$).

The latter phase, instead, will cover the medium-high energies ($70\ keV<E_{cm}<260\ keV$) using a High Purity Germanium detector (HPGe). The HPGe high resolution allows the differential cross section of the reaction to be evaluated by using the peak shape analysis.

The aim of the present work is to describe the two experimental set up that will be used in the measurement campaign and to show the first preliminary results.

Speaker : MOSSA, Viviana

Absolute measurement of the $^7Be(p,\gamma)^8B$ cross section with the recoil separator ERNA

$^7Be(p,\gamma)^8B$ still represents one of the major uncertainties on the predicted high energy component of solar neutrinos. In fact, the discrepancy between existing data limits the precision of their extrapolation at astrophysical energy. Previous experiments producing data with useful precision were performed in direct kinematics, using an intense proton beam on a radioactive 7Be target. The complicated target stoichiometry and the deterioration under beam bombardment might possibly be the origin of these discrepancies. Inverse kinematics, i.e. a 7Be ion beam and a hydrogen target, would shed light on these systematic effects. Unfortunately, all attempts so far were limited by the low 7Be beam intensity. Recently, a new experiment started, exploiting a high intensity 7Be beam in combination with a windowless gas target and the recoil mass separator ERNA (European Recoil mass separator for Nuclear Astrophysics) at CIRCE (Center for Isotopic Research on Cultural and Environmental heritage), Caserta, Italy. Aim of the experiment is the measurement of the total reaction cross section by means of the direct detection of the ^8B recoils. The experiment will be discussed and the first results will be presented.

Speaker : BUOMPANE, Raffaele

Nuclear matter calculations with modern microscopic interactions

The energy per particle of symmetric nuclear matter and pure neutron matter is calculated using the many-body Brueckner-Hartree-Fock approach and employing the Chiral Next-to-next-to-next-to leading order (N3LO) nucleon-nucleon (NN) potential, supplemented with various parametrizations of the Chiral Nextto-next-to leading order (N2LO) three-nucleon interaction. Such combination is able to reproduce several observables of the physics of light nuclei for suitable choices of the parameters entering in the three-nucleon interaction. We find that some of these parametrizations provide a satisfactory saturation point of symmetric nuclear matter and values of the symmetry energy and its slope parameter L in very good agreement with those extracted from various nuclear experimental data. Thus, our results represent a significant step toward a unified description of few- and many-body nuclear systems starting from two- and three-nucleon interactions based on the symmetries of QCD.

Speaker : LOGOTETA, Domenico

Sessione: Struttura nucleare e dinamica delle reazioni

Martedi 15 novembre 2016 11:35-12:35

The NUMEN project: preliminary results from $^{116}Sn(^{18}O,^{18}Ne)^{116}Cd$ DCEX reaction at 270 MeV with MAGNEX

The knowledge of Nuclear Matrix Elements (NME), that enter in the expression of the half-life of the neutrinoless double beta decay (0vββ), is a key aspect for the extraction of the neutrino mass from these measurements. Relevant information on the NME can be obtained by measuring the cross sections of double charge exchange nuclear reactions (DCEX). The basic point is that the initial and final-state wave functions in the two processes are the same and the transition operators are similar. First pioneering experimental results for the $^{40}Ca(^{18}O,^{18}Ne)^{40}Ar$ reaction at 270 MeV Superconducting Cyclotron (K800) beam incident energy has been obtained at the INFN LNS laboratory in Catania using the MAGNEX large acceptance magnetic spectrometer, at zero degrees. On the basis of the above mentioned ground-breaking achievement, the NUMEN project has been proposed with the aim to go deep insight in the HI-DCE studies on nuclei of interest in 0vββ decay, looking forward at the 0vββ NME determination. In this work, some preliminary results achieved from the $^{116}Sn(^{18}O,^{18}F)^{116}In$ single charge exchange reaction and $^{116}Sn(^{18}O,^{18}Ne)^{116}Cd$ DCEX reaction at 270 MeV incident energy will be shown.

Speaker : SANTAGATI, Gianluca

Production of neutron-rich nuclei of the terra incognita

Multi-nucleon transfer reactions are the only known mean to produce neutron-rich nuclei of the Terra Incognita. In particular, the closed-shell region N=126 plays a central role for studying shell quenching in neutron-rich nuclei and for astrophysical interest being the last ”waiting-point” of the r-process. The choice of suitable reactions is challenging. A favorable case is the reaction $^{136}Xe+^{208}Pb$, around the Coulomb barrier, because the neutron shell-closures of ^{136}Xe and ^{208}Pb play a stabilizing role which favors the proton-transfer from lead to xenon leading to neutron-rich osmium fragments. TOF-TOF data were analyzed to reconstruct the mass-energy distribution of the primary fragments. The results of a recent experiment held at Laboratori Nazionali di Legnaro with the PRISMA setup, aimed at identifying the charge and the mass of the produced neutron-rich nuclei, will be shown. The production and study of heavy and super-heavy neutron-rich nuclei represent, nowadays, one of the most interesting challenges in nuclear physics and astrophysics. It is the only way to explore the unknown regions of the Segré map and to proceed towards the potential discover of the predicted Island of Stability centered at N = 184, Z = 114-120. Furthermore, quantities such as half-lives and masses (binding energies) are extremely important also for nuclear astrophysics investigations and for the understanding of the r-process: the last "waiting point" of the rapid neutron capture process, corresponding to the closed neutron shell N = 126, lies indeed deeply in the Terra Incognita. Aside from the astrophysical interest, the study of the structural properties of exotic neutron-rich nuclei would also contribute to the discussion of the quenching of shell effects in nuclei with large neutron excess. Concerning their production, heavy neutron-rich nuclei are obtained in fusion reactions with neutron-rich radioactive (exotic) nuclei, neutron capture or multinucleon transfer reactions at energies near the Coulomb barrier. The first two methods look unfeasible because of the low intensity of the currently available Radioactive Ion Beams (RIBs) and the insufficient neutron fluxes from existing working nuclear reactors. Multinucleon transfer reactions, along with the quasifission process, offer a more feasible ground for the production of neutron-rich nuclei in this scarcely known region of the nuclear map, by means of stable beams, even though the cross sections are of the order of mb or μb. Emblematic is the collision 136Xe + 208Pb at energies close to the Coulomb barrier. In this case, both nuclei have a closed neutron shell, N = 82 and N = 126; because of this, proton transfer from Pb to Xe might be favorable, allowing the exploration of the closed shell N = 126. Another advantage is the Q-value around zero for such transfer. Consequently, the products would be only slightly excited. In other words, the neutron shell closures plays a stabilizing role, which may increase the probability of proton transfers and fragment survival against neutron evaporation. Mass-TKE and angular distributions of the products can be measured using just kinematic analysis (TOF-TOF data). The results of a preliminary experiment [1] show a possible transfer up to about 20 nucleons. Furthermore, there is a good agreement with cross section calculations [2] in the region of interest (A ~ 200 and Qgg ~ 0) and the yield is even underestimated of up to a factor 2 in the region of superasymmetric fragments. The results of a recent experiment held at Laboratori Nazionali di Legnaro with the PRISMA setup, aimed at identifying the charge and the mass of the produced neutron-rich nuclei, will be shown.

[1] E.M. Kozulin, E. Vardaci et al., Phys. Rev. C86, 044611 (2012).
[2] V. Zagrebaev, W. Greiner, Phys. Rev. Lett. 101 (2008) 122701.

Speaker : QUERO, Daniele

Quadrupole Correlations in Neutron-Deficient Sn Isotopes via Lifetimes Measurements

The shell structure of nuclei with few nucleons outside the double-shell closure Z=N=50 has attracted a large interest. Several studies were performed in this region to examine the robustness of the proton shell closure when N=50 is approached. Experimental results such as the excitation energy of the first 2+ states and the reduced transition probabilities should provide a clear evidence of the shell evolution in this mass region. However, while the systematic of the first 2+ state excitation energy is well known and its behavior is rather constant along the whole Sn isotopic chain, the information on B(E2; 2+→0+) for the neutron-deficient Sn isotopes suffers from large experimental uncertainties which makes the interpretation of the shell evolution controversial. Recently the region in the vicinity of Z=N=50 has been investigated at GANIL in order to perform high precision measurement of the B(E2) values for the 4+→2+ and 2+→0+ transitions. The lifetime of the low-lying states in ^{106,108}Sn were measured with the Recoil Distance Doppler-Shift (RDDS) method, employing the differential Cologne plunger device. The γ rays were detected with 8 AGATA Triple Clusters, placed at backward angles, while the complete A and Z identification of the projectile-like fragments was done by the VAMOS++ spectrometer. The unique capabilities of AGATAVAMOS++ setup allowed a clear selection of the channels of interest and a proper event-by-event Doppler correction. The region of the neutron-deficient Sn isotopes has been studied mainly via relativistic Coulomb excitation reactions and the reduced transition probabilities have been indirectly obtained with a large experimental uncertainties. The AGATAVAMOS++ experiment represents the very first lifetime measurement in this neutrondeficient region and it will provide complementary information to the previous studies. In this contribution the status of the data analysis and the first results on lifetimes will be presented.

Speaker : SICILIANO, Marco

A self-consistent multiphonon approach to spectroscopic properties of even and odd nuclei

Several extensions of the random-phase approximation (RPA) have been adopted to study the fragmentation of the giant dipole resonance (GDR) and, in general, the anharmonic features of the nuclear spectra. Relativistic quasiparticle time blocking approximation (RTBA) [1], second RPA (SRPA) [2,3], and the quasiparticle phonon model (QPM) [4] are some of them. We have proposed an equation of motion phonon method (EMPM) [5,6] which de- rives and solves iteratively a set of equations of motion to generate an orthonormal basis of multiphonon states built of phonons obtained in particle-hole (p − h) TammDancoff approximation (TDA). Such a basis simplifies the structure of the Hamiltonian matrix and makes feasible its diagonalization in large configuration and phonon spaces. The di- agonalization produces at once the totality of eigenstates allowed by the dimensions of the multiphonon space. The formalism treats one-phonon as well as multiphonon states on the same footing, takes into account the Pauli principle, and holds for any Hamiltonian. The method was adopted mainly to investigate the dipole response in the heavy, neutron rich, ^{208}Pb [8,9] and ^{132}Sn [10]. Fully selfconsistent calculations using a Hamiltonian composed of an intrinsic kinetic term and an optimized chiral potential NNLOopt [7] have emphasized the crucial role of the two-phonon basis in enhancing greatly the fragmentation of the GDR and the density of low-lying levels associated to the pygmy dipole resonance (PDR), consistently with experiments. Recently, the method has been formulated in terms of quasiparticles and applied to the open shell neutron rich ^{20}O. A calculation using a Hartree-Fock-Bogoliubov basis derived from the same chiral Hamiltonian has shown that the low-lying spectrum can be repro- duced only once the two-phonon basis is included. The two phonons have an important quenching effect on the dipole response, necessary for reproducing semiquantitatively the experimental cross section in both GDR and PDR regions. The method has been extended, now, to odd nuclei with one particle external to a doubly magic core. An analogous set of equations is derived and solved iteratively to generate an orthonormal basis of states composed of a valence particle coupled to n phonons (n = 1,2,...n...) generated within the EMPM. A self-consistent calculation, using the same chiral potential in a space including up to two phonons and, under some simplifying assumptions, three phonons, has been performed for the A=17 nuclei. The multiphonon states enhance enormously the density of levels and compress the whole spectrum, consistently with the data. They contribute substan- tially to improve the agreement with the experimental moments and transitions strengths. Moreover, they exert a crucial quenching action on the dipole response, necessary for reproducing the cross section in GDR and PDR regions.

[1] E. Litvinova et al. 2008 Phys. Rev. C 78, 014312.
[2] P. Papakonstantinou et al. 2010 Phys Rev. C 81, 024317.

[3] D. Gambacurta et al. 2011 Phys. Rev. C 81, 054312.
[4] V. G. Soloviev, Theory of Atomic Nuclei Quasiparticles and Phonons (Institute of Physics Publishing, Bristol, Avon, 1992)
[5] F. Andreozzi et al. 2007 Phys. Rev. C 75 044312.
[6] D. Bianco et al. 2012 Phys. Rev. C 85 , 014313.
[7] A. Ekstr¨om et al. 2013 Phys. Rev. Lett.110 192502.
[8] D. Bianco et al. 2012 Phys. Rev. C 86, 044327.
[9] F. Knapp et al. 2015 Phys Rev. C 92, 054315.
[10] F. Knapp et al., 2014 Phys. Rev. C 90, 014310.

Speaker : DE GREGORIO, Giovanni

Sessione: *Dinamica dei quark e degli adroni e reazioni a molti corpi*

Martedi 15 novembre 2016 18:15-19:00

A Light-Front analysis of Nucleon 3D structure from double parton scattering

Double parton distribution functions (dPDF), accessible in high energy proton-proton and proton nucleus collisions, encode information on how partons inside a proton are correlated among each other and could represent a novle tool to explore the 3D proton structure. In order to evaluate the role of double correlations between two partons in a proton, dPDFs have been calculated by means of quark models [1, 2]. In a recent paper of ours, we have presented a dynamical calculation of the so called “effective cross section”, σ_{eff}, fundamental ingredient for the comprehension of the role of double parton scattering in proton-proton collisions. We have found an expression for σ_{eff} , suitable for this kind of analyses, in terms of standard PDFs and dPDFs. All these quantities have been previously calculated in a Light-Front, fully Poincar´e covariant approach, following Ref. [2]. In this talk, the results of the calculation of dPDFs and σ^{eff} will be discussed at the scale of the model and at higher energy scales, evaluating properly the pQCD evolution of the calculated dPDFs, both in the non-singlet and singlet sectors [3]. This procedure is fundamental to compare our results with the available experimental data for σ_{eff} . For the latter quantity, results show a strong x dependence in the valence region, a feature which could allow to obtain novel information on the three dimensional nucleon structure. The possibility to measure two-parton correlations in proton-proton scattering at the LHC, studying specific final states, will be addressed.

[1] M. Rinaldi, S. Scopetta and V. Vento, Phys. Rev. D 87, 114021 (2013)
[2] M. Rinaldi, S. Scopetta, M. Traini and V. Vento, JHEP 1412, 028 (2014) .
[3] M. Rinaldi, S. Scopetta, M. Traini and V. Vento, Phys. Lett. B 752, 40 (2016)

Speaker : RINALDI, Matteo

Hidden-charm pentaquarks as a meson-baryon molecule with coupled-channels for $\bar{D}^*\Lambda_c$ and $\bar{D}^*\Sigma^*_c$.

We study the hadronic molecules being realized as the coupled channel systems of $\bar{D}^*\Lambda_c$ and $\bar{D}^*\Sigma^*_c$. In this system, the coupled channels of $\bar{D}^*\Sigma^*_c$ are important due to the heavy quark spin symmetry. In addition, the couplings to the $\bar{D}^*\Lambda_c$ channels and to the states with nonzero orbital angular momentum are expected to provide an attraction. The full coupled channel analysis of $\bar{D}^*\Lambda_c$ and $\bar{D}^*\Sigma^*_c$ with large orbital angular momenta has never performed so far. By solving the coupled channel Schrodinger equations with the one meson exchange potential respecting to the heavy quark spin and chiral symmetries, we study the hidden-charm hadronic molecules with $I(J^P)=1/2(3/2^{\pm})$ and $1/2(5/2^{\pm})$. We conclude that the J^P assignment of the observed pentaquarks by LHCb collaboration is $3/2^+$ for $P_c(4380)$ and $5/2^-$ for $P_c(4450)$. In addition, we give predictions for the $J^P=3/2^{\pm}$ states.

Speaker : YAMAGUCHI, Yasuhiro

Investigating the low-energy K^- interactions in nuclear matter with AMADEUS

AMADEUS is dealing with the study of the low-energy K^- interactions with light nuclei, with the aim to shed light on fundamental open issues concerning the nonperturbative QCD regime in the strangeness sector with implications going from particle and nuclear physics, to astrophysics (equation of state of Neutron Stars). AMADEUS takes advantage of the DAΦNE collider at INFN Laboratori Nazionali di Frascati, which provides a unique source of monochromatic low-momentum kaons. In a first stage, the KLOE detector was used as an active target in order to obtain excellent acceptance and resolution data for K^- nuclear capture on H, ^{4}He, ^{9}Be and ^{12}C nuclei. The strength of the K^- binding in nuclei is currently under investigation through the study of the K^- multi-nucleon absorption processes in Λ/Σ - p,d,t channels, and the search for antikaon multi-nucleon bound states. We are also inquiring into the $\Sigma\pi^0$ channels to get information on the controversial $\Lambda(1405)$ resonance, and we are looking into the $\Lambda\pi^-$ channel to investigate the in medium properties of the $\Lambda(1405)$ and $\Sigma(1385)$ resonances. Future plans will also be discussed.

Speaker : DEL GRANDE, Raffaele

Sessione: Applicazioni della Fisica Nucleare

Mercoledi 16 novembre 2016 12:30-13:00

New Scintillator detectors for nuclear physics experiments

There is an intense R work on scintillator detectors as new high performing scintillating materials are being developed. Since some years ago the best scintillator detector was the NaI:Tl with an energy resolution of 6-7% at 662 keV. Nowadays several scintillator detectors, with energy resolution better that 5% are available. The most used is the LaBr3:Ce due to its excellent properties in term of energy (3% at 662 keV), time (< 500 ps) resolution and efficiency (density of 5.1 g/cm^3) for gamma ray detection. New materials are appearing, such as SrI2:Eu and CeBr3, they could compete with LaBr3:Ce. The development of new ceramic scintillator materials (such as GYGAG:Ce) offers the possibility to perform gamma-ray spectroscopy at low cost. In nuclear physics experiments, especially when using radioactive beams, there is a great interest in the possibility to identify gamma rays and neutrons and measure their energies. The scintillator Cs2LiYCl6:Ce (CLYC), that belong to the Elpasolite family, it is a new and important material for radiation detection because of its capability to measure gamma rays and neutrons simultaneously. CLYC scintillators are suitable for thermal neutrons detection, due to ^{6}Li ions and they can also be used as a fast neutron spectrometers, due to 35Cl ions. The gamma rays and neutrons can be discriminated by the pulse shape discrimination. In this work the performances of different scintillators detectors will be presented, pointing out the advantages and the disadvantages for nuclear physics experiments. The result of characterization measurements on a 2”x2” tapered SrI2:Eu sample, of a 2” x 3” CeBr3 sample, and of a 2” x 0.3” GYGAG:Ce sample will be discussed. In addition the properties of CLYC crystals(a 1”x 1” sample of a CLYC scintillator enriched by 6Li at 95%, a 1”x 1”and a 2” x 2” CLYC enriched with more than 99% of ^{7}Li) will be presented together with the response to fast monochromatic neutrons measured from 1.9 MeV up to 3.8 MeV at LNL (Italy). Moreover the possibility to measure continuous neutron spectra will be shown.

Speaker : Dr. GIAZ, Agnese

Cross section measurements of proton-induced nuclear reactions for the production of interesting radionuclides for nuclear medicine: A collaboration between INFN-LNL and ARRONAX facility

This work developed in the context of LARAMED project (Laboratory of Radionuclides for Medicine) at INFN-LNL and in collaboration with ARRONAX facility (Accelerator for Research in Radiochemistry and Oncology at Nantes Atlantique, France). These research centers are the only facilities in Europe equipped with a high performance proton cyclotron (dual beam extraction, 70 MeV): at INFN-LNL the Best 70p accelerator was installed in May 2015 and it is now under commissioning, at Arronax the multi-source IBA cyclotron is working since 2007. A scientific collaboration between such peculiar facilities started in 2010 and, among the most interesting topics included, the measurement of the cross section for the production of radionuclides with medical applications plays a key role. In fact, the knowledge of the excitation function is a fundamental ingredient in the optimization of irradiation parameters (e.g. proton beam energy, target thickness, duration and cooling time): the goal is maximize the production of the desired radionuclide and simultaneously minimizing the coproduction of contaminant isotopes that cannot be separated by applying a posteriori radiochemical process. Moreover, from a nuclear physics point of view, the measurement of unexamined or contradictory excitation functions can provide additional hints or missing information that are necessary to understand specific nuclear interactions and, consequently, optimize nuclear codes for each case of interest. Recently the measurement of an unexamined nuclear cross section for the production of ^{67}Cu developed at INFN-LNL in collaboration with Arronax facility. ^{67}Cu is the longest lived radionuclide of copper, with a half-life of 61.83 h, and it entirely decays to different excited states of ^{67}Zn (stable isotope), emitting β and γ radiation. ^{67}Cu is thus one of the few theranostic radionuclides, i.e. useful for both therapy and diagnostic applications, since the energy of β-particles is appropriate for the treatment of small-sized tumors (140 keV as mean energy), while the 185 keV photons are suitable for SPECT or SPECT/CT imaging studies. The main advantage of theranostic isotopes, such as ^{67}Cu, is the selection of patients prior therapy, by using the same radiopharmaceutical labelled with the same radionuclide to perform lower-dose imaging studies prior therapy. Moreover, ^{67}Cu can be used in pair with ^{67}Cu (β+ emitter) to perform low dose PET or PET/CT scans and obtain all the necessary pre-therapeutic information on effective tumor uptake, bio-distribution and dosimetry (limiting or critical organs or tissues, maximum tolerated dose, etc.). This innovative approach in nuclear medicine is a step towards the development of personalized treatments. In order to investigate the nuclear reaction induced by the 70 MeV proton beam, a stacked-foils target was used to obtain, during an unique irradiation run, the measurement of the desired cross section at several different proton energies, by inserting some aluminium foils as energy degraders. After the irradiation it was necessary to apply a dedicated chemical process to separate Cu from Ga isotopes. In fact, during the bombardment, it is also produced ^{67}Ga (3.2617 d half-life), a radionuclide that decays to ^{67}Zn, emitting the same γ-lines of ^{67}Cu. For this reason and considering the similar half-lives, it is not possible to distinguish among ^{67}Cu and ^{67}Ga activities with γ-spectroscopy. In this work the accurate experimental set-up and the chemical procedure aimed at the measurement of the nuclear cross section for ^{67}Cu production is described. Some considerations about the feasible future production of ^{67}Cu at INFN-LNL are also given. In the collaboration between INFN-LNL and Arronax facility the measurement of the cross section for the production of radionuclides for medical applications is a fundamental topic. In this work, the measurement of the nuclear cross section for the production of ^{67}Cu, an emerging theranostic radionuclide, is described. Experimental set-up, radiochemical procedure and future feasible production at INFN-LNL by using the new high performance cyclotron are discussed.

Speaker : Dr. PUPILLO, Gaia

Posters

Clustering effect in Ternary fission of super-heavy nuclear systems

Clusterization, i.e., the process of forming compact pieces of nuclear matter due to the shell effect inside the nucleus, plays an important role in true ternary fission of super-heavy nuclear systems [1]. Experimental investigations show that during the reaction between medium mass nuclei and heavy mass target, three body clusterization (ternary fission) occurs where preferable fragments are two heavy nuclei (doubly magic nuclei, i.e., ^{132}Sn, ^{208}Pb, etc.) and one light nucleus [2]. In ^{238}U + ^{238}U composite nuclear system, it is expected that triple cluster decay may occur possibly creating two Pb-like fragments (Z = 82 and N = 126) and a ^{60}Ca which is highly exotic. Using this concept, we have carried out a test experiment with the reaction between ^{238}U (with incident beam energy 6.2 MeV/u) and ^{238}U (target), in GANIL with the CORSET [3] setup by an international collaborations. The aim was to measure the mass and energy distributions of the fragments and their angular correlations by a TOF-TOF-E technique. The data indicate mainly binary decay of fission fragments. Besides, there are many events that can indicate ternary decays. For the confirmation of two Pb-like and one ^{60}Ca nuclei, we need more investigations that we are going to finalize soon.

[1] V. Zagrebaev, A. V. Karpov, W. Greiner, Phys. Rev. C, 81, 044608 (2010).
[2] I. M. Itkis et al., Phys. Rev. C, 83, 064613 (2011).
[3] E. M. Kozulin et al., Instruments and Experimental Techniques, 51, 44 (2008).

Presenter : ASHADUZZAMAN, Md

Isospin Symmetry Breaking in Mirror Nuclei ^{23}Mg – ^{23}Na

The differences between the excitation energy of analogue states, called mirror energy differences (MED), are an important signature of isospin symmetry breaking and constitute a very delicate probe of several nuclear structure properties. We present the results of an experiment performed in GANIL to study isospin symmetry breaking in mirror nuclei ^{23}Mg − ^{23}Na up to high spin. Experimental MED values are compared with state-of-the-art shell model calculations. This permits to enlighten several nuclear structure properties, such as the way in which the nucleons alignment proceeds, the radius variation with J, the role of the spin-orbit interaction and the importance of isospin symmetry breaking terms of nuclear origin.

Presenter : BOSO, Alberto

Quantum corrections to the stress-energy tensor at thermodynamic equilibrium with acceleration and rotation

The quark-gluon plasma created in relativistic heavy ion collisions is described as a relativistic fluid, with a formidably large value of initial acceleration (10^{30} g). We show that stress-energy tensor mean value have additional terms with respect to the ideal form which are quadratic in the acceleration and vorticity, of quantum origin and non-disspative, that is they do not increase entropy. We show how to obtain these corrections by using general equilibrium form with acceleration and vorticity and performing a perturbative expansion from homogeneous global equilibrium. The thermodynamic coefficients relevant to these corrections can be expressed in terms of correlators of the stress-energy tensor operator and the generators of the Lorentz group.

Presenter : BUZZEGOLI, Matteo

Sub-barrier fusion of Si+Si systems: does the deformation of ^{28}Si play a role?

This contribution reports on the results of measurements of near- and sub-barrier fusion cross sections in the system ^{30}Si + ^{30}Si performed at the Laboratori Nazionali di Legnaro of INFN. The ^{30}Si beam of the XTU Tandem accelerator in the range E_{lab}= 47-90 MeV, was delivered on a metallic ^{30}Si target (50μg/cm^2) enriched to 99.64% in mass 30, and using the beam electrostatic deflector for the detection of evaporation residues. The excitation function obtained for this symmetric system has been compared with the previous data on ^{28}Si + ^{28}Si and the Coupled Channels calculations performed using the M3Y+rep. potential, taking into account the low lying 2+ and 3− excitations. The ^{28}Si + ^{28}Si cross sections are largely underestimated at low energies. In a recent work a weak imaginary potential was found to be necessary to fit the data, probably simulating the oblate deformation of this nucleus. On the contrary, the data on ^{30}Si + ^{30}Si are nicely reproduced by the present calculations (^{30}Si has a spherical shape). The slopes of the excitation functions are below the LCS limit even at low measured energies, so that there is no evidence for hindrance. In this representation the cross section difference between the two cases is highlighted. Even above the barrier the two systems behave differently and this is best seen comparing the two barrier distributions where the high energy peak observed for ^{28}Si + ^{28}Si is not found for ^{30}Si + ^{30}Si. This is presumably due to the stronger couplings present in ^{28}Si and this is the object of further theoretical analysis.

Presenter : COLUCCI, Giulia

Studio della reazione ^{19}F(α,p)^{22}Ne ad energie di interesse astrofisico con il Trojan Horse Method

Comprendere vie di produzione e distruzione del ^{19}F è cruciale in ambienti AGB. L’abbondanza di fluoro, infatti, è utile in quanto tale elemento è fortemente connesso ai processi di mixing ed extra-mixing che hanno luogo in stelle AGB, le quali sono considerate essere i principali siti di produzione per tale elemento in ambiente galattico. Le abbondanze sperimentali sovrastimano grandemente tale quantità: si rendono perciò necessarie investigazioni più approfondite. Per tali ragioni abbiamo deciso di studiare la reazione ^{19}F(α,p)^{22}Ne, che rappresenta il canale di distruzione principale per stelle AGB in ambienti ricchi di elio, a temperature dell’ordine di $T \approx 2\cdot10^8$ K. Allo stato dell’arte attuale, tale reazione è stata studiata con metodi diretti tramite l’utilizzo di un fascio di particelle α di energia E_{beam}=792 keV (corrispondenti a EC.M. ≈ 660 keV), mentre la finestra di Gamow si trova tra 390 ÷ 800 keV, per cui al di sotto della barriera Coulombiana (3.81 MeV). È stato quindi condotto un esperimento al Rudjer Boskovic Institut (Zagabria), applicando il Trojan Horse Method; tramite tale approccio indiretto, siamo stati in grado di selezionare il contributo quasi libero proveniente dalla reazione $^{6}Li(^{19}F, p\ ^{22}Ne)^{2}H$, con E_{beam} = 6 MeV, ad angoli cinematicamente favorevoli. Si è potuta così misurare la sezione d'urto per la reazione in esame ad energie EC.M. ≈ 0 ÷ 0.9 MeV, ed è stato possibile inoltre fittare dati sperimentali usando un approccio R-Matrix. Nella regione attorno a 800 keV si è proceduto alla normalizzazione a misure dirette, con lo scopo di ottenere misure in unità assolute per la sezione d'urto. Infine si è estratto il fattore astrofisico per la reazione $^{19}F(\alpha, p)^{22}Ne$.

Presenter : D'AGATA, Giuseppe

Geant4 simulations of a Proton Recoil Telescope for the measurement of the n_TOF neutron flux between 100 and 1000 MeV

The $^{235}U(n,f)$ cross section is one of the most important cross-section standards for measurements of neutron-induced reaction cross-sections. At the n_TOF (neutron time of flight) facility at CERN, fission detectors equipped with a ^{235}U sample are used for the measurement of the neutron flux and the $^{235}U(n,f)$ cross section is used as a reference for all other fission cross section measurements. The $^{235}U(n,f)$ cross section is adopted as a standard at thermal neutron energy and between 0.15 MeV and 200 MeV. Despite the importance of the high-energy region, at present no data exist on neutron-induced fission above 200 MeV, and one has to rely on theoretical estimates. Therefore a measurement of the $^{235}U(n,f)$ cross section above 200 MeV would be highly desiderable. Thanks to its very wide neutron energy spectrum, which extends from thermal energies up to more than 1 GeV, the n_TOF facility offers the unique opportunity to perform such a measurement for the first time ever, relative to the n-p elastic scattering reaction. The prerequisite for this measurements is the availability of a Proton Recoil Telescope (PRT) for the detection of high-energy recoil protons. The PRT should have a fast time response and allow for good background rejection. The best configuration for the Proton Recoil Telescope (PRT) has been investigated by means of dedicated Monte Carlo simulations performed with the GEANT4 tool. The neutron-induced background of neutrons in the radiator (typically polyethilene) and in the PRT detector itself has been studied, together with the background related to multiple scattering of recoil protons inside the detector. Finally the efficiency of the PRT as a function of the energy of the neutron beam impinging on the radiator has been studied. The simulations demonstrate that the measurement is feasible at n_TOF, by using suitable detectors (fast scintillators) and analysis conditions. In this contribution, the results of the GEANT4 simulations will be compared with experimental data obtained from a test of the detector performance under the n_TOF neutron beam.

Presenter : DAMONE, Lucia Anna

NEDA: detecting neutrons in experiments with exotic nuclei at SPES facility

Exotic nuclei are expected to unveil new information on nuclear structure and new facilities for their production and study are being build worldwide. Production rates are however several order of magnitude smaller than the ones of stable nuclei. Consequently, the radiation detection arrays to be used in nuclear reaction experiments must be improved on the efficiency performance side. In reactions involving exotic nuclei beams, the neutron channel is very important, especially in the case of neutron rich nuclei to be produced at the SPES facility in construction at LNL. To increase the neutron detection efficiency, the new array NEDA was designed and is under development. The array is built on the replica of a single detector unit. With its relatively higher neutron multiplicity detection efficiency, NEDA will be used in forefront experiments at European accelerator facilities such as the soon to be SPES at LNL. The main characteristics of the prototype unit were evaluated through off-line analysis of the sampled signals from a 252Cf n-gamma source, with particular attention to the n-gamma discrimination power and timing. In this contribution, the application of a Neural Network concept for an on-line neutrongamma separation process is considered. The chart of nuclides maps all the nuclei that are known or that are predicted to exist by nuclear models. In nature only about 250 types of nuclides are available, however theories predict the existence of more than 7000 nuclei. New nuclides can be artificially produced and so far it was possible to synthesize about 3000 new species. Nuclei far from the line of stability are often called exotic nuclei as they possess structural properties that do not follow the systematics of stable nuclei. Because of this, in the last few years the scientific community found a rising interest toward the study of exotic nuclei whose useful results are expected to strengthen the actual nuclear models and to find ways to produce new isotopes. To produce exotic nuclei, nuclear reactions with very low cross sections, of the order of few mb , are exploited. These reactions often involve, as projectile, radioactive ion beams whose intensities are orders of magnitude lower than stable standard ion beams. Often, so called compound nuclei are formed by the fusion of the projectile and target nuclei. They are highly unstable and decay instantly emitting gamma-rays, charged particles and neutrons, in a process called evaporation. Fission of the nucleus is also possible. By detecting simultaneously light particles and γ -rays, it is possible to extract structural features of an excited nucleus. Arrays of high purity Germanium detectors (HPGe) are the most efficient tool for gamma-ray spectroscopy measurements. However, Germanium detectors alone don't allow the identification of the light particles that precede the discrete gamma-ray emission. For this purpose they are coupled with ancillary detectors able to detect evaporated particles. With stable heavy ions beams, proton rich nuclei, produced in fusionevaporation reactions induced by heavy ions, can be identified only through the selection of the decay channels in which the emission of multiple neutrons is observed. Cross sections of these channels are typically low (orders of tens of μb), thus a clear and efficient identification of the number of neutrons emitted is mandatory. Neutron detection is not a easy task. As neutrons carry no charge, they interact with matter only through nuclear force with relatively low cross sections that strongly depend on the energy of the neutron itself. Detectors based on organic liquid scintillator coupled with a photomultiplier tube (PMT) are widely used in neutron detection. In order to design an efficient detector array, various factors should be taken into account. Dimensions should be sufficient for the particle to lose all its energy inside the hit detector liquid without interacting with the surrounding detectors. At the same time dimensions of the detector should be limited in order to avoid scintillation light attenuation through the medium. Another problem with scintillation detectors is that they are also sensible to other kinds of radiation, such as gamma-rays and charged particles, and it is mandatory to develop algorithms that are capable of discriminating the kind of radiation that hits the detector. As different particles are characterized by different signal shapes, algorithms that exploits pulse shape discrimination are often used to fulfil this task. A new generation of neutron detector array, which is in the process of production, is NEDA (NEutron Detector Array). It will replace Neutron Wall and will be used in experiments with stable and radioactive beams at the European accelerator facilities such as SPES at the LNL. The use of the NEDA array, coupled with other particle and gamma detector arrays, in experiments with neutron-rich and proton-rich nuclei will allow the investigation of regions in the chart of the nuclides whose properties are predicted only by theoretical models. For example, the dependence of the effective interaction between the nucleons of exotic N/Z ratios could be investigated. Shell structure also changes as function of neutron excess and this evolution has consequences on the ground state properties (spin, parity, electromagnetic moments). Research of new magic numbers, predicted by new models, will be also performed. The collective motions of the nucleus could also be probed, with attention on particular nucleus structures like neutron halo and neutron skin. NEDA array will be composed by 300 scintillation detectors and was designed to achieve the highest possible neutron detection efficiency, excellent discrimination of neutron and gamma-rays and small neutron-scattering probability. Particularly, as the array will be involved in experiments with radioactive ions beams it will work in environment with high gamma-ray background, so it should grant the highest possible n-gamma discrimination efficiency. The NEDA detector unit consists in a hexagonal based prismatic cell. The cell is filled with a xilene based liquid scintillator and it is coupled to a PMT through a glass window. After the prototype was assembled an experiment was designed and performed in order to evaluate the main characteristics of the detector with particular attention in testing the neutron-gamma discrimination power. As comparison, the same analysis was performed with the same experimental set-up for a second detector which consisted in a 5”x5” cylindrical cell (the biggest that can be found on-shelf) coupled to the same PMT used for the prototype. Signals coming from a 252Cf radioactive source, which emits both neutrons and gamma, were sampled and analysed through a code specifically developed that implements various algorithms used in pulse-shape analysis. As first analysis the photo-electron yield (number of photo-electron measured at the photo-cathode of the PMT for unit of released energy) was measured. The obtained value shows that the detector has a good yield that grants good detection efficiencies at low energies. The results were compatible with the cylindrical detector. Then, an average of the shape of the sampled signal was performed. The average of the signals coming from a ^{137}Cs source (gamma source) and the average of the signals from the ^{252}Cf source (neutron-gamma source). As expected the two signals differs in the tail and this allow the use of pulse-shape discrimination algorithms in order to identify neutrons and gamma. Using the charge comparison (CC) and the integrated rise time (IRT) algorithms, the neutron-gamma discrimination power was measured at various energies. The figure of merit (FOM) has been chosen as quantitative parameter for the discrimination quality. Both discrimination methods gave the same results for the FOM, showing that the performed analysis is consistent and that there is no advantage in choosing one method over the other for n-gamma discrimination. FOM values obtained with the CC method were compared with the one obtained for the 5"x5" cell detector. Discrimination performances for this detector appear to be better by a factor 2. The cause of this discrepancy lays in the differences in geometry and dimension of the two detectors. Finally, a time of flight analysis was performed to achieve better n-gamma discrimination. It is shown that coupling the TOF and CC methods lowers the value of the neutron-gamma discrimination energy threshold from ~1.7 MeV to ~0.7 MeV. This is a very important achievement since the maximum in the neutron energy spectra, for the reactions of interest for the NEDA array, is usually located around 1 MeV. The presented analysis allowed to characterize the prototype cell that will be employed in the NEDA array in terms of photo-electron yield, timing and pulse shape analysis and was used by NEDA collaboration to better understand the properties of the prototype and to improve the detector. The development of Neural Network algorithms to achieve an automated and improved n-γ discrimination is under evaluation and preliminary work is in progress in order to choose the best approach strategy.

Presenter : DE CANDITIIS, Bartolomeo

Polarized ^{3}He target and final state interactions in SiDIS

At JLab12 is starting a wide program to study the neutron's structure, for instance by extracting the parton transverse-momentum distributions (TMDs) through polarized Semi-inclusive deep-inelastic scattering (SIDIS) experiments on ^{3}He, where a high-energy pion (or kaon) is detected in coincidence with the scattered electron. This will provide, togheter with proton and deuteron data, a sound flavor decomposition of the TMDs. Given the expected high statistical accuracy, it is crucial to disentangle nuclear and partonic degrees of freedom to get an accurate theoretical description of both initial and final states. In a recent paper [1,2], we have carried out a study of a SIDIS process on polarized ^{3}He where a spectator nucleon-pair in a deuteron state is detected. Within a non-relativistic framework, we have taken into account the very challenging issue of the final state interaction, between the observed deuteron and the remnant, through a distorted spin-dependent spectral function, based on a generalized eikonal approximation. The ^{3}He initial state was taken from the careful calculation with the AV18 NN interaction performed by the Pisa group. In this contribution, the extension to the standard SIDIS, where a pion (or a kaon) is detected, and the recoiling nucleon-pair can be in any state, will be presented [2] together with preliminary results illustrating the possibility of a reliable extraction of the neutron TMDs. This study will be very useful for the JLab experiments on ^{3}He target. In particular the derived distorted spectral function will be included in the MonteCarlo tools that will be used for the analysis of the forthcoming data.

[1] L. Kaptariet al., "Distorted spin-dependent spectral function of an A=3 nucleus and semi-inclusive deep-inelastic scattering processes", Phys. Rev. C 89, (2014) 035206.
[2] Emanuele Pace et al., "Light-Front Dynamics and the 3He Spectral Function" Few-Body Systems , 57, 601-606 (2016) DOI : 10.1007/s00601-016-1067-3
[3] A. Del Dotto et al., " Final state interactions in deep inelastic meson electroproduction off transversely polarized ^{3}He and the extraction of neutron single spin asymmetries", in preparation.

Presenter : DEL DOTTO, Alessio

Continuum-coupling effects in heavy meson spectroscopy and structure

Continuum coupling effects can play an important role in heavy meson spectroscopy and structure, especially in the case of mesons close to open- or hidden-flavor mesonmeson decay thresholds. I will discuss some of the most relevant cases, including the X(3872) [1,2], the $\chi_b(3P)$ system [2,3] and the $D_s^{0*}(2317)$ [4], and show how the presence of these thresholds can induce mass shifts with respect to naive QM predictions for the bare meson masses. I will also discuss how continuum coupling effects can be introduced in the QM formalism to calculate some of these mesons' main decay modes.

[1] J. Ferretti, G. Galatà and E. Santopinto, Phys. Rev. C 88, 015207 (2013).
[2] J. Ferretti, G. Galatà and E. Santopinto, Phys. Rev. D 90, 054010 (2014).

[3] J. Ferretti and E. Santopinto, Phys. Rev. D 90, 094022 (2014).
[4] J. Ferretti and E. Santopinto, arXiv: 1506.04415.

Presenter : FERRETTI, Jacopo

Development of a tracking detector to study the $^{12}C(\alpha,\gamma)^{16}O$ reaction

Stellar model calculations are extremely sensitive to the rate of $^{12}C(\alpha,\gamma)^{16}O$. Although great efforts were devoted to decrease the uncertainty in the extrapolations, more precise data are needed to provide a good input to the stellar models. The required precision for the rate of $^{12}C(\alpha,\gamma)^{16}O$ is about 10% [1]. The available data indicate that the cross section of $^{12}C(\alpha,\gamma)^{16}O$ at E_0 = 300 keV is dominated by E1 and E2 radiative capture processes into the 16O ground state, where the main contribution to the capture cross section is given by two subthreshold states with Jπ = 1− and 2+ at Elevel = 7.12 and 6.92 MeV, respectively. Since the measurement of Dyer and Barnes in 1974 [2], the E1 and E2 contributions have been determined by measuring the γ-rays from the $^{16\circ}$ recoils. Some of the experiments conducted to date performed coincidence between γ-rays and ^{16}O-recoils to reduce background. In one case [3] it was possible to measure the total cross section by the detection of recoils using the RMS (Recoil Mass Separator) ERNA (European Recoil mass separator for Nuclear Astrophysics). In the case of a RMS, an additional constrain to the γ-ray data can be the measurement of the angular distribution of the recoils. Monte Carlo simulations together with the simulation of the beam transport through ERNA have shown that it could be possible to determine the E1 and E2 contributions by the analyses of the angular distribution of the recoils at the end of the RMS. In order to achieve that, a two stage tracking detector is being developed. The first stage is a modification of the existing MCP detector [4], that will be made position sensitive. The second stage is a parallel grid position sensitive detector that will be placed inside of the existing Ionization Chamber Telescope [5]. The detector development will be described and the expected physics outcome presented.

[1] S. E. Woosley, A. Heger, T. Rauscher and R. D. Hoffman (2003). Nuclear data needs for the study of nucleosynthesis in massive stars. Nucl. Phys. A, 718:3c–12c.
[2] P. Dyer and C. A. Barnes (1974). The 12C(α,γ)16O reaction and stellar helium burning. Nucl. Phys. A, 233:495–520.
[3] D. Schürmann, A. Di Leva, L. Gialanella, et al. (2005). First direct measurement of the total cross-section of 12C(α,γ)16O. Eur. Phys. J. A, 26:301–305.
[4] A. Di Leva, M. De Cesare, D. Schürmann, et al. (2008). Recoil separator ERNA: Measurement of $^3He(\alpha,\gamma)^7Be$. Nucl. Instr. and Meth. in Physics Research A, 595:381–390.
[5] D. Rogalla, S. Theis, L. Campajola, et al. (1999). Recoil separator ERNA: ion beam purification. Nucl. Instr. and Methods in Physics Research A, 437:266–273.

Presenter : GARCIA DUARTE, Jeremias

Competizione tra i modi di decadimento ed influenza dell'isospin nei sistemi prodotti nelle collisioni $^{78,86}Kr+^{40,48}Ca$ a 10AMeV

Si presentano i risultati dello studio dei sistemi prodotti nelle collisioni $^{78}Kr+^{40}Ca$ e $^{86}Kr+^{48}Ca$ a 10 AMeV. L'esperimento è stato realizzato presso i Laboratori Nazionali del Sud dell'INFN con il multirivelatore CHIMERA. Oggetto di studio è l'influenza dell'isospin, e in particolare dell'arricchimento neutronico, sui modi di decadimento dei sistemi formati nelle suddette collisioni. L’analisi di spettri di velocità e delle variabili globali dei prodotti fornisce informazioni sulla dinamica dei processi, mostrando consistenti differenze nella competizione tra i diversi canali di reazione per i due sistemi. Confronti con modelli teorici di tipo statistico e dinamico sono presentati.

Presenter : GNOFFO, Brunilde

Studio della reazione $^{17}O(n,\alpha)^{14}C$: estensione del metodo del Cavallo di Troia alle reazioni indotte ad neutroni

La reazione $^{17}O(n,\alpha)^{14}C$ è di particolare interesse sia in ambito puramente nucleare che per le sue implicazioni astrofisiche. In particolare, questa reazione indotta da neutroni gioca un ruolo chiave in diversi scenari astrofisici quali la Nucleosintesi durante il Big Bang Inomogeneo o la produzione degli elementi pesanti durante la componente debole dei processi s [1,2]. Per superare le difficoltà legate alle misure dirette di sezioni d’urto di reazioni indotte da neutroni, si è applicato il Metodo del Cavallo di Troia (THM) selezionando opportunamente il contributo quasi-libero della reazione $^{2}H(^{17}O,\alpha^{14}C)p$ [3,4]. Tale metodologia ha permesso di utilizzare il deuterio come sorgente di neutroni virtuali e di studiare la reazione nella regione di interesse astrofisico evidenziando la presenza di molti livelli dell'18O già noti in letteratura (E*=8.213 MeV, $J_\pi=2^+$ and E*=8.282 MeV, $J_\pi=3^-$) [5]. Inoltre, il THM ha permesso di superare gli effetti dovuti alla presenza della barriera centrifuga, come dimostrato dall'evidenza della risonanza centrata a 75 KeV (E*=8.125 MeV, $J_\pi=5^-$, l=3), assente nelle misure dirette.

[1] J. H. Applegate et al., Ap.J. 329, 572 (1988).
[2] M. Pignatari et al., Ap.J. 710, 1557 (2010).
[3] C. Spitaleri et al., Phys. Rev. C 60, 55802 (1999).
[4] C. Spitaleri et al., Phys. Rev. C 69, 55806 (2004).
[5] M. Gulino et al., Phys. Rev. C 87, 12801(R) (2013).

Presenter : GUARDO, Giovanni Luca

Nuovi risultati sperimentali della reazione $^{19}F(p,\alpha)^{16}O$ ad energie di interesse astrofisico

La reazione $^{19}F(p,\alpha)^{16}O$ è il principale canale di distruzione del fluoro nelle stelle AGB [1]. A causa della barriera Coulombiana le misure in letteratura non hanno accesso alla regione di energia di interesse astrofisico, ovvero il picco di Gamow (E=38 keV). La sezione d’urto per il canale α_0 a tale energia è stata quindi misurata per mezzo del metodo indiretto del Trojan Horse, estraendo il contributo quasi-libero dalla reazione a tre corpi $^{2}H(^{19}F,\alpha^{16}O)n$. L'esperimento è stato realizzato presso i Laboratori Nazionali di Legnaro il cui Tandem ci ha fornito un fascio di ^{19}F ad un energia di 55 MeV che è stato fatto incidere su un target di CD_2 di ~100 μg/cm2. Il nuovo fattore astrofisico ottenuto è in accordo con la misura precedente [2] e presenta notevoli miglioramenti in risoluzione che hanno permesso di mettere in evidenza i contributi di strutture risonanti che contribuiscono significativamente ad un incremento del rate di reazione con importanti conseguenze per la nucleosintesi stellare.

[1] M. Lugaro et al., Ap. J. 615 (2004) 934
[2] M. La Cognata et al., Ap. J. 739 (2011) L54

Presenter : INDELICATO, Iolanda

Eccitazione Isoscalare della risonanza Pygmy nel ^{68}Ni

Negli ultimi anni molta attenzione è stata dedicata allo studio di stati collettivi in nuclei ricchi di neutroni. In particolare, è di notevole interesse lo studio della Risonanza di Dipolo Pygmy (PDR), presente in nuclei con eccesso neutronico e in particolar modo in nuclei lontani dalla valle di stabilità [1,2]. Come è possibile notare dallo studio della densità di transizione per nuclei neutron rich, tale risonanza può essere popolata sia con sonde isoscalari sia con sonde isovettoriali [3]. Diversi esperimenti, infatti, sono stati effettuati utilizzando entrambe le sonde su nuclei stabili; con due eccezioni per lo studio della risonanza Pygmy su nuclei instabili, tramite eccitazione Coulombiana [1,2]. Tuttavia, lo studio della risonanza Pygmy su nuclei instabili con sonde isoscalari è un'assoluta frontiera della Fisica Nucleare. Si riportano i risultati ottenuti con un esperimento, realizzato in cinematica inversa, utilizzando un proiettile instabile ed un target isoscalare. Tale esperimento è stato effettuato presso il LNS-INFN di Catania utilizzando un fascio di ^{68}Ni a 33 MeV/nucleone e un target di ^{12}C. Il fascio è stato prodotto tramite il metodo di frammentazione in volo, grazie all'apposita linea di trasporto In Fligth Radioactive Ion Beams (FRIBs). Per la rivelazione dei raggi γ e dei prodotti di reazione carichi sono stati utilizzati i multirivelatori CHIMERA [4] e FARCOS [5].

[1] D. Savran, T. Aumann and A. Zilges, Prog. Part. Nucl. Phys. 70, 210 (2013).
[2] A. Bracco, F.C. L. Crespi, and E. G. Lanza, Eur. Phys. J. A 51 (2015).
[3] E. G. Lanza et al., Phys. Rev. C 84, 064602 (2011).
[4] A.Pagano et al Nucl.Phys. A 734 (2004) 504.
[5] L. Acosta et al., EPJ Web of Conferences, 31 ,0035 (2012).

Presenter : MARTORANA, Nunzia Simona

FAMU: high precision measurement of the muonic hydrogen hyperfine splitting.

The precise measurement of the hyperfine splitting of the muonic-hydrogen atom ground state will be performed by exploiting the energy dependence of the transfer rate from hydrogen to heavier gases. The development of this tecnique, of the gas target and of the X-ray detection system will pave the way for new and innovative experiments based on muon spectroscopy which could lead to discover and study physics beyond the standard model. Preliminary results of the measurement of the transfer rate from hydrogen to heavier gases will be presented together with detectors and target characterization.

Presenter : Dr. MOCCHIUTTI, Emiliano

Nuclear physics and stellar MHD coupled together solve the puzzle of oxide grain composition

Oxide grains, enclosed in meteorites, give us very precise information about the stars in which they formed. Grains that belong to group 1 and 2 are characterized by values of

$^{17}O/^{16}O$ and $^{18}O/^{16}O$, inconsistent with explosive nucleosynthesis scenarios, and are then believed to form in red giant stars [1]. The measurements of the $^{14}N(p,\gamma)^{15}O$ and the $^{16}O(p,\gamma)^{17}F$ cross sections remarked that these grains condensate in the envelope of stars less massive than 2M8 [2,3]. Nevertheless, the high ^{18}O dilution and the large ^{26}Al abundance found in several grains remained unexplained, unless in precence of very deep mixing mechanisms coupled with nuclear burning [4,5]. The fine tuning of extra-mixing parameters and a new measurement of the ^{17}O+p reaction rates significantly improved the agreement between the grain oxygen isotopic mix and the model predictions. AGB stars with M>0.02). Recently, [8] have shown that the MHD equations allow for exact analytical solutions in the relevant layers of AGB stars. Applying this model of mixing driven by the buoyancy of magnetized materials, we find that the $^{17}O/^{16}O$, $^{18}O/^{16}O$ and $^{26}Al/^{27}Al$ ratios shown by group 1 and 2 grains are perfectly reproduced by a 1.2M8 AGB stars, without encountering any relevant energy feedback.

[1] L. R. Nittler, et al., The Astrophysical J. 483, 475 (1997)
[2] G. Imbriani, G., et al., Eur. Phys. J. A. 25, 455 (2005)
[3] C. Iliadis, et al., Phys. Rev. C 77, 045802 (2008).
[4] G. J. Wasserburg, et al., The Astrophysical J. 447, L37 (1995)
[5] K. M. Nollett, et al., The Astrophysical J. 582, 1036 (2003)
[6] S. Palmerini, et al., The Astrophysical J. 729, 3 (2011)
[7] S. Palmerini, et al., The Astrophysical J. 764, 128 (2013) and references therein
[8] M. C. Nucci, M. & M. Busso, The Astrophysical Journal 787, 141 (2014)
[9] O. Trippella O., et al., The Astrophysical Journal 818, 125 (2016).

Presenter : PALMERINI, Sara

Status of the direct cross section measurement of $^{18}O(p,\gamma)^{19}F$ at LUNA

The reaction $^{18}O(p,\gamma)^{19}F$ plays an important role in the context of Asymptotic Giant Branch (AGB) star evolution and nucleosynthesis. This reaction represents the bridge between CNO and other cycles, which are active during shell H burning. Moreover, the observed O isotope abundance in meteorites crucially depends on the precise knowledge of this rate at low energies. The low energy cross section of this reaction is influenced by the tails of higher energy broad states and by the presence of a state at 95 keV, which lies directly inside the energy window corresponding to the relevant stellar temperature range. In the context of the LUNA experiment we measured the low-energy cross section of this reaction, taking advantage of the low environmental background at the Gran Sasso underground laboratory. Two setups were used for the experimental campaign: measurements for the determination of the strength of the 95 keV resonance were done using a highefficiency 4π BGO detector, whereas gamma-ray branching measurements of the non-resonant low energy component and of higher-energy resonances utilized a highresolution HPGe detector. The experimental campaign was recently concluded. This talk will present the current status of the analysis.

Presenter : PANTALEO, Francesca Romana

Quark Deconfinement in Long γ-Ray Bursts

The late time activity observed after the prompt emission of several Gamma-Ray Bursts (GRBs) can be explained, in the context of the millisecond magnetar model, as the imprint of the energy injection from a newly born strongly magnetized Neutron Star in the form of a relativistic magnetically driven wind. Within this picture, however, it is not easy to reactivate the inner engine and therefore to describe late time bursts which are often found in the light curve of many long GRBs. Among the possible explanations it has been suggested that these events could be associated with the process of quark deconfinement. We will present here a study of the timescales and the energetic properties expected for such events based on the numerical modelization of the quasi-stationary spindown evolution for both Hadron and Quark stars. We will show how our results can be applied to the specific case of the double burst GRB 110709B.

Presenter : PILI, Antonio Graziano

Triggerless readout for silicon detectors at PANDA

PANDA is a key experiment of the future FAIR facility, under construction in Darmstadt, Germany. It will study the collisions between an antiproton beam with momenta between 1.5 GeV/c and 15 GeV/c and a fixed proton or nuclear target, allowing to study QCD at intermediate energies. The data acquisition concept of PANDA foresees a fully triggerless readout system and, together with the upgrade of LHCb, represents one of the first applications of a software-only triggering concept in a particle physics experiment. The triggerless architecture allows for the application of different filters on the same data sample, thus enabling the study of parallel physics topologies. The nominal collision rate, up to 20 MHz, poses significant challenges both on the detector readout electronics and on the data acquisition infrastructure. The Micro Vertex Detector (MVD) is the innermost part of the tracking system of the experiment and its main task is the precise spatial identification of primary and secondary vertices. The detector will be composed of four concentric barrels and six forward disks; the inner layers will be instrumented with silicon hybrid pixel detectors, while for the outer two barrels and for the outer part of the last two disks double-sided silicon microstrip detectors were chosen. Precise timestamp, signal amplitude capabilities, as well as low power consumption, a high dynamic range and radiation tolerance for both total ionising dose and single event effects, are common requests to the readout system of both parts. The readout of the pixel part uses the ToPix chip, which is a custom development in a 0.13 μm commercial CMOS technology. It will consist of a 116 × 110 pixel matrix arranged in 55 double columns and a Chip Control Unit (CCU) which multiplexes the data from the column controllers and sends them to the off-detector electronics via two 320 Mb/s serial links. In the pixel cell, the feedback capacitor of a preamplifier is discharged by a constant current. The preamplifier is followed by a comparator; a digital control unit detects the rising and falling edges of the comparator output and stores the respective timestamps. Due to the constant discharge of the integrating capacitor, the length of the comparator output is a linear measure of the integrated charge and therefore the difference between the trailing and leading edge timestamps provides a measure of the charge released by the particle in the detector; this approach is known as Time-overThreshold (ToT). Four prototypes have been realized; the latest features 640 full pixel cells divided into 8 columns. The functionality and the radiation hardness of the prototypes have been extensively tested, both in the laboratory and during beam tests. For the readout of the strip sensors of the MVD, the PASTA (PAnda STrip ASIC) chip has been developed. Its architecture is also based on the Time-over-Threshold technique and is inherited from TOFPET [1], a chip developed in the framework of the EndoTOFPET-US collaboration for the readout of Silicon Photomultipliers signals for a medical PET application. The analog frontend of PASTA consists of a preamplifier which can be connected to both n-type and p-type strips, and a second stage where a constant current discharges a feedback capacitance to extract a linear ToT information. The leading and trailing edges of the ToT signal are measured with time-to-digital converters with linear analog interpolators, providing a time resolution adjustable between 50 and 500 ps. The chip is designed to work with a clock of 160 MHz, with a maximum power consumption of 4 mW per channel. A 64 channel chip prototype has been submitted in a commercial 110 nm CMOS technology; the final prototype size is 3.4 x 4.5 mm^2. The evaluation of the prototype is currently ongoing. An overview of these systems and of their relevance to the triggerless acquisition at PANDA will be presented.

[1] M.D. Rolo et al. TOFPET ASIC for PET Applications, 2013 JINST 8 C02050

Presenter : Dr. QUAGLI, Tommaso

A supersonic jet target for the cross section measurement of the $^{12}C(\alpha;\gamma)^{16}O$ reaction with the recoil mass separator ERNA

$^{12}C(\alpha;\gamma)^{16}O$ plays a key-role in the determination of the C/O ratio at the end of stellar Carbon burning. Since stellar models predict an exceptional sensitivity of the following stellar evolution and nucleosynthesis on that parameter, the reaction cross section of $^{12}C(\alpha;\gamma)^{16}O$ must be determined with the precision of about 10% at the relevant Gamow energy of 300keV. The ERNA (European Recoil mass separator for Nuclear Astrophysics) collaboration could measure, for the fi rst time, the total cross section of $^{12}C(\alpha;\gamma)^{16}O$ by means of the direct detection of the ^{16}O ions produced in the reaction down to a an energy E_{cm} = 1.8 MeV. To extend the measurement at lower energy, it is necessary to limit the extension of the He gas target. This can be achieved using a supersonic jet, where the oblique shock waves and expansion fans formed at its boundaries confine the gas, that can be efficiently collected using a catcher. A test version of such system has been realized and experimentally characterized as a bench mark for a full numerical simulations using FV (Finite Volume) method. The results of the commissioning of the jet test version and the design of the new system that will be used in combination with ERNA are presented and discussed.

Presenter : RAPAGNANI, David

A beam line for production of a neutron beam using $D(d,n)^3He$ reaction at the 3MV Tandem accelerator

Two-body reactions are a convenient and powerful way to produce mono-energetic neutrons. Such a neutron beam can be basically used for scientific, technically and medical aims. The additional demand for reliable nuclear data, enhanced by the need of precise fast neutron data for fusion reactor development justifies the need of monoenergetic neutron beams. In most cases such neutron sources can be small-accelerator based. Given the availability of a 3 MV Tandem accelerator at the Department of Physics in Naples, we have developed a mono-energetic neutron beam facility by using the reaction $D(d,n)^{3}He$. The energy of the neutron is selected by measuring the energy of the associated 3He particle at fixed angles with respect to the primary deuteron beam. The neutron intensity can reach a maximum of 10^{5} neutron/s. The facility is ready for being used for different application.

Presenter : RATH, Prasanta Kumar