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Book of Abstracts

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New experimental measurement of the 24,25,26Mg neutron capture cross section at n_TOF

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The slow neutron capture process (s process) in stars is responsible for the production of about half of the elemental abundances beyond iron that we observe today. Most of the s-process isotopes between iron and strontium (60 < A < 90) are produced in massive stars (M > 10-12 Msun) where the 22Ne(alpha,n)25Mg reaction is the main neutron source. Beyond strontium, the s-process abundances are mostly produced in low mass Asymptotic Giant Branch stars (AGB stars, 1.2 Msun < M < 3 Msun), where the neutrons are provided by the 13C(alpha, n)16O reaction and by the partial activation of the 22Ne(alpha ,n)25Mg reaction. In stars with an initial metal content similar to solar, 25Mg is the most important neutron poison via neutron capture on 25Mg in competition with neutron capture on 56Fe that is the basic s-process seed for the production of the heavier isotopes. For this reason, a precise knowledge of the 25Mg(n, gamma)26Mg is required to properly simulate s-process nucleosynthesis in stars.

We will show the results from a combination of neutron total and capture cross section measurement on 25Mg in order to determine the resonance parameters and the Maxwellian averaged cross section.
Capture data come from a recent (n, gamma) measurement at the neutron time-of-flight facility n_TOF at CERN. On the other hand transmission data come from an experiment performed at the electron linear accelerator in Oak Ridge. These results constitute the only available neutron resonance data on Mg isotopes.

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Experimental Study of Energy Dependence of Proton Induced Fission Cross Sections for Heavy Nuclei in the Energy Range 200-1000 MeV.

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The need for information concerning fission reactions induced in heavy nuclei by intermediate energy projectiles (a main channel of decay of heavy nuclei) has been obvious for a long time. The interest in this process emerges from both fundamental and applied problems of nuclear physics. In spite of extensive experimental efforts, the fission process of nuclei induced by intermediate energy projectiles remains insufficiently understood in many aspects. The measurements of the energy dependence of total fission cross sections of heavy nuclei induced by intermediate energy protons may add to our understanding of the fission process in terms of nuclear properties of highly excited nuclei, such as temperature dependence of level density and fission barriers of excited nuclei. For physics applications the nuclear data are required for new energy production concepts with the help of accelerator driven systems (ADS), for nuclear waste transmutation technologies, for accelerator and cosmic device radiation shields as well as for applications in medicine and solid state investigations. Moreover, total fission cross section values are needed for the creation of monitoring standards for moderate energy proton beams. All the above mentioned problems require fission cross section data with high accuracy and reliability.
The results of the total fission cross sections measurements for natPb, 209Bi, 232Th, 233U, 235U, 238U, 237Np and 239Pu nuclei at the energy proton range 200-1000 MeV with step 100 MeV are presented. Experiments were carried out at 1 GeV synchrocyclotron of PNPI with the updated beam system that allows one to have proton beams with intensity up to 107 protons/s in all energy range. The measurement method is based on the registration in coincidence of both complementary fission fragments by two gas parallel plate avalanche counters, located at a short distance and opposite sides of investigated target. The insensitivity of parallel plate avalanche counters allowed us to place the counters together with target between immediately in the proton beam thereby providing a large solid angle acceptance for fission fragment registration and reliable identification of fission events. The proton flux on the target to be studied was determined by direct counting of protons by scintillation telescope and using secondary reaction of elastic proton scattering by CH2 target. Obtained results are compared with other experimental data and show that the fission cross sections do not depend strongly on the incident proton energy over this entire energy range.

Session 5: Current and Future Facilities / 6

Inelastic Neutron Scattering at nELBE

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At the superconducting electron linear accelerator ELBE at Forschungszentrum Dresden-Rossendorf the neutron time-of-flight facility nELBE has become operational.
Fast neutrons in the energy range from ca. 0.1 to 10 MeV are produced by the pulsed electron beam from ELBE impinging on a liquid lead circuit as a radiator.
The short beam pulses of ~10 ps provide the basis for an excellent time resolution for neutron time-of-flight experiments, giving an energy resolution of about < 1~\%
at 1 MeV with a short flight path of ~ 5 m.
The neutron intensity on target is ca. 4*10^4 n/s/cm^2 using an electron bunch charge of 77 pC and 203 kHz pulse repetition rate.
The energy range of the neutrons produced is well suited for neutron cross section measurements relevant for the development of Generation IV reactor systems and
for the transmutation of nuclear waste.
First measurements of inelastic scattering cross section on natural Fe have been performed using a double time-of-flight method.
The cross section for the first excited level of Fe-56 and Fe-54 could be determined.

Session 1: Nuclear Data Measurements (Part I) / 7

Am-241 neutron capture measurements at n_TOF

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The neutron capture cross section of Am-241 is being measured at n_TOF during 2010 experimental campaign. The measurement, which combines for the first time the 4pi Total Absorption Calorimeter with a pair of low neutron sensitivity C6D6 detectors, aims at providing high accuracy data from thermal up to 1 MeV neutron energy. The experimental set-up will be discussed and first data will be presented.

Session 4: Experimental Techniques / 8

Definition of a standard neutron field with the 7Li(p,n)7Be reaction

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The reaction 7Li(p,n)7Be has been widely used as neutron source in various experiments for astrophysical and technological applications. Since its neutron energy spectrum resembles a Maxwell-Boltzmann distribution around kT= 25 keV for incident proton energies of 1912 keV and for a proper irradiation geometry, it is specially suited for studying neutron capture reactions of interest for the astrophysical s-process. Moreover the 197Au(n,g) cross-section, which has been measured using this neutron spectrum, is used as a reference cross-section in several other experiments due to its small uncertainty of 1.4% [Ratynski and Kaeppeler, Phys. Rev. C 37, 595–604 (1988)]. For proper interpretation of these results, an accurate knowledge of the neutron spectrum itself is important. This motivated a new measurement of the neutron spectrum of the 7Li(p,n)7Be reaction in frame of EFNUDAT at PTB in Braunschweig, Germany. Pulsed protons of 1912 keV energy (1.5 ns in width), provided by the 3.75 MeV Van-de-Graaf accelerator of the Ion-Accelerator-Facility PIAF, were produced and bombarded onto a metallic Li target with a repetition rate of 625 kHz. The neutron time-of-flight spectrum was recorded by a moveable 6Li-glass detector for angles in steps of 5 deg. from 0 deg. to 65 deg. with respect to the proton beam. A long counter, mounted at an angle of 16 deg. and a distance of about 6 m, monitored the neutron flux for each run. The whole spectrum was measured for two flight paths of 35 and 70 cm, respectively. New results on this measurement will be presented and compared to previous measurements.

Session 4: Experimental Techniques / 9

Measurement of prompt fission gamma-rays with lanthanum halide scintillation detectors

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A challenging task within the modelling of new generation reactor neutron kinetics is the calculation of the gamma-heat deposition e.g. in steel and ceramics reflectors without UO2 blankets, which is required to be known with an uncertainty as low as 7.5%. A major difficulty in measuring the competition between neutron and gamma-ray emission during fission fragment de-excitation is the suppression of background gamma-rays induced by prompt fission neutrons in the gamma-detector. A common method is to distinguish between gamma-rays and neutrons by their respective different time-of-flight, which however is limited by the timing resolution of the detector (not better than 5 ns for NaI). A promising approach seems to be the use of recently developed cerium-doped lanthanum halide crystal scintillation detectors.

Recently we performed an experiment at the 10 MW research reactor at the Institute of Isotopes in Budapest, dedicated to the measurement of the fission-fragment mass and kinetic energy distribution as well as prompt fission gamma-rays from thermal (cold) neutrons on 235U. The gamma-rays were measured with three LaCl3:Ce detectors and one LaBr3:Ce detector. We report on the status of the data analysis and present experimental results from the experiments as obtained thus far.

Session 6: European Programs / 10

Transnational Access Activities and Euratom Framework programme feedback experience towards implementation of the European Research Area

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Euratom FP6 (2002-2006) and FP7 (2007-2011) instruments are making a significant contribution in establishing a common European view on scientific issues and towards integrating and establishing European Research Area (ERA) in nuclear science and technology: Networks of Excellence (NoE), Integrated Infrastructure Initiatives (III), Coordination and Support Actions (CSA), Actions to promote and develop human resources and mobility. They are implemented to reinforce Euratom R&D programme, to develop research infrastructures, to foster networking, transnational access and joint research activities.
This research effort is needed to retain and improve competences and know-how, to improve the efficiency and effectiveness of European research, and contributes to maintaining high levels of nuclear knowledge and industry competiveness in the nuclear field.

Establishment by the research community of technology platforms in sustainable nuclear energy, waste management and low dose research areas (www.snetp.eu , www.igdtp.eu , www.melodi-online.eu) are being capitalised. Mapping of the capacity of research centres and other research players that need more coordination across the European Union and beyond together with the implementation of European Sustainable Nuclear Industrial Initiative (ESNII) is also being performed. An overview of several projects will be given including a best practice analysis. The 'Euratom experience'with framework programmes (FPs) has been one of consistent success in pursuing excellence in research and facilitating pan-European collaborative efforts across a broad range of nuclear science and technologies and associated education and training activities.

Session 5: Current and Future Facilities / **11**

Measurements at the 175 MeV neutron beam at TSL

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During the past few years, an experimental programme has been run at the 175 MeV neutron beam of The Svedberg Laboratory, Uppsala, Sweden. Elastic scattering and light-ion production have been studied for a number of different target nuclei. We will present the neutron beam facility, the experimental methods and some preliminary results.

Session 5: Current and Future Facilities / **12**

Fast neutron facilities at the National Physical Laboratory, UK

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This paper describes the facilities at the UK's National Physical Laboratory for generating monoenergetic and broad-spectrum fast neutron fields.

Monoenergetic neutrons within the energy range 50 keV - 17 MeV are produced, via a variety of nuclear reactions, by directing charged particle beams from the Neutron Metrology Group's 3.5 MV Van de Graaff accelerator on to appropriate neutron-producing targets. The charged particle beam energy and energy spread are determined using a calibrated analysing magnet and the mean energy is defined to within ± 2 keV. The maximum useable beam current depends on the heat sensitivity of the target and varies from 3 - 20 microamps.

The targets are located at the centre of a low scatter facility, at a point at least 6 m from the walls, floor or ceiling of the room. Experiments are set up at the desired angle to the beam and distance from the target by means of lightly constructed detector supports accessed by low mass walkways. This arrangement minimises corrections for room- and air-scattered neutrons. In addition, a multi-energy facility is available, which makes use of the variation of neutron energy with angle to allow several irradiations to be carried out simultaneously at different energies.

Neutron fluences are measured using a well characterised long counter. Fluence uncertainties depend on the particular arrangements but are typically in the range 3 to 5%, and the instrumentation is subject to periodic international comparisons.

NPL has a wide range of isotopic neutron sources, including 252Cf, 241Am - Be, , 241Am - B, 241Am - F, and 241Am - Li. These may be mounted in the low-scatter area in place of the Van de Graaff neutron target for irradiations with a broad energy spectrum. The neutron output of all these sources has been measured to better than 1% in the NPL Manganese Bath facility, and their anisotropy characterised using a long counter. An accelerator-based broad-spectrum source has been constructed to simulate the neutron spectra typical of workplaces at pressurised water reactors and UK gas-cooled reactors.

Summary:

This paper describes the facilities at the UK's National Physical Laboratory for generating monoenergetic and broad-spectrum fast neutron fields.

Session 3: Data Evaluation & Theoretical Aspects of Nuclear Reactions / 13

Key issues of pre-equilibrium emission for consistent description of the nucleon-induced reactions

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The pre-equilibrium emission model inconsistencies found within attempts to describe unitary the nucleon-induced reaction cross sections up to 60 MeV, are still actual. Both global and local approaches have been used for a consistent analysis of the available activation data for all stable isotopes of medium-mass elements, available up to 50 MeV, and conclusions on particular model assumptions are obtained.

Session 4: Experimental Techniques / 14

VERDI –a double fission-fragment time-of flight spectrometer

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The investigation of correlated fission characteristics like fragment mass- and energy-distributions is usually based on the double-energy technique using twin Frisch-grid ionisation chambers (IC). Providing the existence of prompt-neutron emission data the pre-neutron fission fragment mass and energy distributions may be obtained in an iterative process. However, those input data do not exist for isotopes other than 233,235U and 239Pu at sufficient detail, and extrapolation methods have to be applied when analysing neighbouring compound nuclear systems. The double fission-fragment time-of-flight spectrometer VERDI aims at investigating the neutron-induced fission fragment characteristics. Measuring fragment velocity and kinetic energy for both fission fragments simultaneously allows obtaining mass and kinetic energy distributions without introducing apriori information about prompt neutron emission. In addition, the measurement of pre- and post-neutron fission-fragment data provide prompt neutron multiplicity data as a function of fragment mass and total kinetic energy. In order to achieve a mass resolution deltaA < 2, ultra-fast time pick-up detectors based on artificial diamond material are used.

The spectrometer in its present single (v, E) version was tested for the first time in an experiment performed at the Budapest Research Reactor. The results of this experiment, the performance of the diamond detectors with fission fragments, time-of flight spectra and post-neutron mass distributions will be presented.

Session 3: Data Evaluation & Theoretical Aspects of Nuclear Reactions / 15

A compilation of experimental total reaction cross sections

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The nucleon-nucleus and nucleus-nucleus total reaction cross sections are of importance in many different fields, both for a better theoretical understanding as well as for a number of applications. The total reaction cross section determines the mean free path when particles traverse nuclear matter, and the production cross sections for secondary particles are directly proportional to it. Many complex Monte Carlo codes use the total reaction cross sections for these purposes, and these observables become important in a number of different applications, including Accelerator Driven Systems, space radiation dosimetry. ion beam cancer treatment, and Single Event Effects (SEE) in digital electronics.

We have performed a comprehensive literature study in order to find all available experimental data on total reaction cross sections, interaction cross sections, and total charge changing cross sections for neutrons, protons, and all stable and exotic heavy ions. The data base extends earlier compilations with new data and data that has not been found in earlier searches. Excluded from the data base are measurements where the cross sections have been derived through model-dependent calculations from other kinds of measurements. The objective of the study is to identify where more measurements are needed in view of different applications, and to make the data easily available for model developers and experimentalists, as well as for the nuclear data bases such as EXFOR. We will present some examples from the study, which is in the stage of quality control of all the gathered data.

Session 2: Nuclear Data Measurements (Part II) / 16

Analysis of discrepancies in experimental data for Np-237 fission cross section

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Nuclear reaction data at fast neutron energies play a key role in the development of new nuclear reactor concepts and, in particular, of the Accelerator Driven Systems dedicated to waste transmutation. However, the evaluated cross sections for Np-237, one of the more abundant isotopes in the spent fuel, are discrepant and they do not provide the required accuracy required for practical applications.

This work is devoted to the analysis of available experimental data on the neutron-induced fission cross section for Np-237. We discuss the impact of the new data obtained at the n_TOF facility (CERN) which extend the energy range up to 1 GeV.

Session 2: Nuclear Data Measurements (Part II) / 17

On the corrections to the Th232(n,f) cross section measured with PPACs at n_TOF

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Recently, a renewed interested in the Th/U fuel cycle has emerged as a basis for safe and sustainable energy production, which presents the advantage, compared to the conventional U/Pu cycle presently used, of the reduced amount of produced transuranium elements. The development of fast reactors based on the Th/U cycle requires a good knowledge on the reactions involved in it, such as the neutron-induced fission of Th232. However, discrepancies exist among evaluated nuclear data libraries.

The neutron-induced fission cross section and the angular distribution of the fission fragments were measured at the CERN n_TOF facility for Th232 covering a continuous neutron energy range from threshold up to 1 GeV. For this purpose, a reaction chamber with PPAC detectors was used to detect the fission fragments in coincidence and to determine their trajectories, thanks to the stripped cathodes.

For an accurate determination of the fission cross sections, the knowledge of the angular distribution of the emitted fragments is required, since the detection efficiency of the PPACs is angle-dependent. In this work, a discussion on the corrections needed to obtain such a measurement is presented.

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Correlated cross-section calculations and the shape isomer in 235U

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For the development of future nuclear fission applications and for a responsible handling of nuclear waste the reliable a-priori assessment of fission-fragment yield and kinetic energy distributions relies on accurate experimental data and reaction cross-section modelling. In recent years a successful description of neutron-induced fission cross-sections was achieved for a series of actinide isotopes, e. g. 231,233Pa [1], 235,238U [2-5], 237Np [4] and 240Pu [6]. The model parameters as for example fission barrier penetrability and level densities have been chosen to best describing simultaneously total, elastic, inelastic, capture as well as fission cross-section data. In some cases even shape isomer data like the ground state energy [5] or the decay half life [6] were taken to improve consistency of the model parameters.

In this presentation we will discuss calculations for the reaction 234U(n, X), where X = tot, n, n', c and f, taking into account the half life of the recently identified shape isomer in 235U [7]. From those calculations we hope to be able to answer the question whether the fission barrier in 235U is double- or even triple-humped. The branching ratio between shape-isomeric fission and competing gamma-decay back to the normal ground state will be discussed as well as future experiments dedicated to the search of shape isomers in odd-A uranium isotopes.

[1] G. Vladuca et al., Nuclear Physics A740 (2004) 3-19
[2] G. Vladuca et al., Nuclear Physics A720 (2003) 274-292
[3] G. Vladuca et al., Ann. Nuclear Energy 27 (2000), pp. 995-1010
[4] F.-J. Hambsch et al., AIP Conf. Proc. "Int. Conf. on Nuclear Data for Science and Technology", Volume 769 (2005) 358-361; doi:10.1063/1.1945022
[5] A. Tudora et al., private communication (2009)
[6] M. Sin et al., Ann. Nuclear Energy 24 (1997) 1027-1033
[7] A. Oberstedt et al., Phys. Rev. Lett. 99, 042502 (2007) 1-4

Session 4: Experimental Techniques / 19

Characterization of fission ionization chambers using reference neutron beams

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At IRMM and PTB, several 235U and 238U parallel-plate fission ionization chambers are employed as reference instruments for measuring the spectral neutron fluence in monoenergetic as well as 'white' neutron beams with energies up to 200 MeV. Some of these instruments were already manufactured more than 20 years ago. Therefore a comparison exercise was organized at the PTB ion accelerator facility (PIAF) to check the stability of the fissile layers and to verify the efficiencies calculated from the measured properties of the deposits. Neutron fields with mean energies of 8.5 MeV and 15 MeV were produced using the D(d,n) and T(d,n) reactions. The 0° neutron yield was determined relative to the n-p scattering cross section using the PTB recoil telescope RPT1 and a well-characterized 2"x2" NE213 liquid scintillation detector (DD). The time-of-flight method was employed to discriminate the low-energy neutrons resulting from break-up reactions or target scattering. Two long counters

and a 3He detector covered with a PE cap were employed as monitors to relate the measurements with RPT1 and DD to those with the various fission ionization chambers under study. The present contribution reports on the actual results obtained for the different instruments and discusses the contribution to the uncertainty budgets as well as the minimum uncertainty which can realistically be achieved using neutrons beams to characterize fission ionization chambers. The models used so far to calculate the neutron detection efficiency as well as the scattering corrections are compared to more recent calculations.

Session 1: Nuclear Data Measurements (Part I) / 20

Analysis of radiative neutron capture data for nuclei in the A=90 region on the basis of new information about the electromagnetic dipole strength.

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Since decades photon strength functions have been extracted from photo-dissociation as well as from radiative capture and other nuclear reaction data. Both methods yield results for non-overlapping energy regimes and various proposals have been made for a unified parameterization covering the range from low lying single levels up to the isovector giant dipole resonance (GDR) energies. Photon scattering experiments allow to extract information on the electromagnetic strength for the intermediate range up to the nucleon binding energies, but until recently only scarce data were available. Novel experimental equipment allowed the accumulation of new data in a number of nuclei in the A=90 mass range and it appears to be difficult to find a unique parameterization covering the full energy range. To better understand possible discrepancies existing radiative neutron capture data from the literature have been reanalyzed taking into account the information from photon induced measurements. Average photon widths of neutron capture resonances resulting from such analysis will be presented as well as respective information for resonance capture cross sections and various coincidence data. Remaining uncertainties will be discussed with regard to future experimental possibilities.

Session 4: Experimental Techniques / 21

Level densities, Decay probabilities and Cross sections in the actinide region

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The first results from a new program of experiments to measure nuclear level densities in the actinide region will be presented. This series of measurements has three important goals: 1) To provide systematic level density information for improving cross section calculations where direct measurements are difficult or impossible. 2) The simultaneous measurements of compound nuclear decay probabilities using the surrogate method. 3) The exploration of fine structure in actinide level densities and strength functions, of particular interest for fundamental physics reasons.

Results will be presented from recent experiments carried out at the Oslo cyclotron using 232Th(d,x) and 232Th(3He,x) transfer reactions to populate several actinide nuclei. Level densities in 231,232,233Th up to the binding energy can be extracted using the Oslo method. In addition, compound nuclear decay probabilities for 230Ac, *232Pa*, 231Th*and 233Th* below fission thresholds have been measured using the surrogate method. For the case of 233Th*, the results can be compared with the 232Th(n,gamma) nTOF direct cross section measurements providing a good test of the validity of the surrogate method.

Session 4: Experimental Techniques / **22**

Neutron detection for DESPEC experiment at FAIR

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Improvement on nuclear data has received a special attention in the last decades within the framework of "Technology Advances in Fast Reactors and Accelerator Driven System for Actinides and Long-Lived Fission Products Transmutation". Neutron cross section (capture, fission, inelastic) data for minor actinides (MA), as well as delayed neutron data and decay heat data with improved accuracy have been requested within the WEPC (NEA-OECD) recommendations [1].

The improvement of the neutron detection systems and techniques contributes greatly to reduce the uncertainties in the nuclear data. Neutron spectroscopy by time-of-flight has been pointed out as one of the techniques to provide improved results in delayed neutron emission measurements. Such a technique can benefit from developments on digital signal processing techniques as well as from the use of appropriate scintillation material.

The characterization of the detectors in terms of time and energy resolution, light collection, detection threshold and n/g discrimination as well as the measurement of the response function at known irradiation fields is mandatory for the proper design of the spectrometer. The use of a digital DAQ system, based on digitizer will allow evaluating the performance of the digital signal techniques. A review of the design status of spectrometer and some preliminary results from the characterization measurements performed in lab and at the PIAF facility in PTB (Braunschweig) [2] will be presented in this work.

[1] http://www.nea.fr/html/science/wpec/
[2] http://www.ptb.de

Session 4: Experimental Techniques / **23**

Advances in the analysis of resonance cross section data

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In this contribution the efforts made to improve procedures for the analysis of cross section data in the resonance region, both resolved and unresolved, will be reported. The activities have been performed within the EFNUDAT project.
To improve the quality of the resonance parameters deduced from high resolution time-of-flight cross section data two new features have been implemented in the resonance shape analysis code REFIT:
- an algorithm to correct for the gamma-ray attenuation in the sample and for the impact of the resonance strength
- an algorithm to correct for sample inhomogeneities, such as the grain size of powder samples.
For the analysis of experimental observables in the unresolved resonance region a code has been developed which produces a full ENDF-6 compatible description of the average cross sections and includes full covariance information starting from the covariance matrix of experimental data. In addition a procedure to determine:
- the correction factor for transmission data due to the resonance structure in the total cross section; and
- the correction factor for capture data due to self-shielding and multiple scattering, has been developed. The procedure is based on Monte Carlo simulations using MCNP with a link to the resonance structure in terms of probability tables produced by NJOY.
The impact of these improvements will be discussed using the results of transmission and capture cross section measurements on 197Au.

Session 1: Nuclear Data Measurements (Part I) / 24

PGAA analysis of enriched samples

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Prompt Gamma Activation Analysis (PGAA) of samples is routinely used at our guided cold neutron beam facilities. Adaptation of this method for analyzing enriched samples required some modification of the data analyzing program as well as changing the prompt gamma ray library for each different sample. The advantage of the method is that it is completely nondestructive and it can be applied for encapsulated samples as well. Furthermore it provides bulk composition for almost the same conditions as it will be used in nuclear data experiments and it is sensitive for the same components that will give the biggest signals in measurements at other beams. This new method has been applied for enriched Ni, Fe, Zr and Hf samples.

Session 6: European Programs / 25

Status of the Transnational Access Activities within EFNUDAT

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The 9 institutes of the EFNUDAT consortium that are participating in the Transnational Access Activities (TAA) of the project are equipped with 14 neutron data facilities. The TAA within EFNUDAT promote the trans-national access to these facilities in order to endorse the neutron data requirements in the field of the management of radioactive waste or other fields of nuclear technologies and safety. It was the objective to offer within the project a total of 4015 supplementary data-taking hours to external users, spread over a minimum of 20 experiments.
In this talk we will give a general overview of the present status of the EFNUDAT TAA. An analysis will be made of some important aspects. Conclusions which could be of interest for future Transnational Access Activities within the consortium will be discussed in detail.

Session 1: Nuclear Data Measurements (Part I) / 26

Compound nuclear reactions induced by neutrons

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Neutron induced reaction cross sections are of major importance in a wide variety of research fields, ranging from stellar nucleosynthesis, neutron-induced symmetry breaking, and nuclear level density investigation, to applications of nuclear technology, including the transmutation of nuclear waste, accelerator driven systems and nuclear fuel cycle investigations.

In this presentation we will give an outline of neutron resonance spectroscopy, with a focus on neutron capture, and and overview of part of the related ongoing experimental activities.

Session 3: Data Evaluation & Theoretical Aspects of Nuclear Reactions / 27

The Full Bayesian Evaluation Technique - Properties and Developments

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The Full Bayesian Evaluation Technique has been developed for nuclear data evaluation and provides a consistent set of nuclear reaction cross sections and associated uncertainty information in form of covariance matrices. The technique is based on the concept of Bayesian statistics, which is the proper mathematical tool accounting simultaneously for the a-priori knowledge as well as for the gain of information by additional experimental data.

In this contribution we present the concept of the Full Bayesian Technique for nuclear data evaluation and current methods to determine its various components, i.e. the prior and the likelyhood function. The former accounts for the a-priori information and its proper determination is of particular importance for nuclear data evaluation beyond 20 MeV, where experimental data are scarce. Here, current developments on the prior will be presented. Emphasis will be given to specific features of the Bayesian technique, i.e. the role of systematic errors and the impact of cross channel correlations, which are discussed at the example of actually performed evaluations of Mn-55 and Pb-208 cross sections.

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Session 3: Data Evaluation & Theoretical Aspects of Nuclear Reactions / 28

Overview of the JRA1 activities at JRC-IRMM

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The Joint Research Activity 1 of EFNUDAT was dealing with the development of novel data acquisition techniques for nuclear data measurements based on wave-form digitization. JRC-IRMM was involved in the development of fast digital data acquisition systems as well as digital signal processing (DSP) routines for off-line treatment of the sampled signal wave-forms.
Two different digital data acquisition systems (DDA) are presently in use at JRC-IRMM. One is dedicated to the measurement of fission fragments as well as prompt fission gamma-rays and neutrons. The second DDA is used for investigating elastic scattering processes.

In the frame of the investigation of neutron-induced fission of 234U as a function of incident neutron energy both analogue and digital data acquisition systems are being compared, showing the beneficial application of DDA in terms of e. g. a highly efficient pile-up correction.
A Java based TCD-1.0 system is also in use for the measurement of elastic scattering angular distributions at the GELINA facility using different detector systems (e.g. the GAINS array as well as Ge-based elastic scattering detector with a 10B converter disk).

A Java based TCD-1.0 system is also in use for the measurement of elastic scattering angular distributions at the GELINA facility using different detector systems (e.g. the GAINS array as well as an array of 8 Li-glass and 8 liquid scintillation detectors).

The superiority of DDA in conjunction with the application of dedicated DSP routines will be discussed and a comparison with the traditional analogue technique presented.

Session 3: Data Evaluation & Theoretical Aspects of Nuclear Reactions / 29

Improved Full Bayesian Evaluation of Neutron-induced Reactions on Mn-55

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In spring 2010 a Full Bayesian Evaluation of neutron-induced reactions on Mn-55 in the energy range between 5 and 150 MeV was presented. This evaluation was based on a prior, which included the effect of parameter uncertainties and for the first time also model defects. It turned out that the latter have a remarkable impact on the final evaluation although only a first coarse approach has been implemented.

In this contribution we present recent refinements of the formulation of the model defects and their impact on the final evaluation of Mn-55 data. One major development concerns more realistic extrapolations of model defects into regions without experimental data. Thus some artefacts of the previous evaluation could be eliminated or at least reduced in size. In addition, the model space for parameter uncertainties has been increased in order to obtain more reliably estimated uncertainties for reactions responsible for gas production and thus for embrittlement of structural materials. The impact of these improvements on the evaluation of Mn-55 will be discussed.

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Session 2: Nuclear Data Measurements (Part II) / 30

Measurement of the 236U(n,f) cross-section at n_TOF

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Accurate knowledge of the U-236 neutron-induced fission cross-section is important for the development of accelerator-driven systems and fast reactors based on the Th-U cycle. The evaluated data presently stored in the nuclear data libraries rely on old measurements and show large discrepancies in the energy region between 1 keV and 100 keV. Recent measurements yielded results which are in disagreement with the literature for the resonance region and below 10 eV.
A new measurement of the 236U(n,f) cross-section was performed at the neutron Time-Of-Flight facility n_TOF at CERN, Geneva. A Fast Ionization Chamber has been used to determine the 236U(n,f) cross-section relative to the standard 235U(n,f) cross-section. Six resonance structures in the resonance and intermediate energy regions have been observed following the event reconstruction analysis, which included the subtraction of the 235U contamination in the sample together with the alpha-particle background, as well as the dead-time and detection efficiency corrections.
In this talk, a detailed report on the 236U(n,f) cross-section measurement at n_TOF will be given. The present high-resolution results point to several shortcomings in the current evaluations in the sub-threshold region and provide the basis for a re-evaluation of the cross-section.

Session 6: European Programs / 31

EU nuclear data projects for more sustainable nuclear energy and waste transmutation

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The EU is making a large R&D effort to improve sustainability of energy sources and its associated technologies following the SET plan. In particular, EURATOM supports a number of projects to evaluate and develop future nuclear fuel cycle and reactor concepts, including nuclear waste severe reduction by transmutation. In this framework, nuclear data projects had been financed by EU in the different Framework Programs. In this presentation, the last project of the 6th Framework Program (IP-EUROTRANS: NUDATRA) and the recently started project ANDES of the 7th FP will be presented.
The presentation will concentrate on the scientific objective of the projects, in reply of the nuclear data needs for the technological development of this cleaner nuclear energy, the results obtained in NUDATRA and the experiments planed within ANDES. Some remarks on the synergy of these nuclear data projects and the needs of basic nuclear physics and nuclear astrophysics will also be presented.

Session 1: Nuclear Data Measurements (Part I) / 32

EFNUDAT synergies in astrophysics

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About half of the abundances between Fe and Zr in Nature are produced by the slow neutron capture process (s process) in massive stars. These abundances are essentially determined by the (n,g) cross sections of the involved isotopes. In this context, recent (n, g) measurements benefit from the combination of activation and time-of-flight techniques, which were efficiently advanced by the EFNUDAT program. Experimental progress and innovative instrumental developments are illustrated at selected examples of measurements performed at CERN, Budapest, Braunschweig, Vienna, and Karlsruhe.

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Compound nuclear reactions induced by neutrons

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EFNUDAT synergies in astrophysics

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Analysis of radioactive neutron capture data for nuclei in the A= 90 region on the basis of new information about the electromagnetic dipole strength

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PGAA analysis of enriched samples

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Experimental Study of Energy Dependence of Proton Induced Fission Cross Sections for Heavy Nuclei in the Energy Range 200 - 1000 MeV

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Analysis of discrepancies in experimental data for Np-237 fission cross section

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On the corrections to the Th232 (n,f) cross section measured with PPACs at n_TOF

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Measurement of the 236U (n,f) cross-section at n_TOF

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Key issues of pre-equilibrium emission for consistent description of the nucleon-induced reactions

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A compilation of experimental total reaction cross sections

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Correlated cross-section calculations and the shape isomer in 235U

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The Full Bayesian Evaluation Technique - Properties and Developments

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Improved Full Bayesian Evaluation of Neutron-induced Reactions on Mn-55

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Definition of a standard neutron field with the 7Li(p,n)7Be reaction

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Measurement of prompt fission gamma-rays with lanthanum halide scintillation detectors

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VERDI - A double fission-fragment time-of flight spectrometer

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Characterization of fission ionization chambers using reference neutron beams

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Level densities, Decays probabilities and Cross sections in the actinide region

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Neutron detection for DESPEC experiment at FAIR

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n_TOF Facility at CERN

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Inelastic Neutron Scattering at nELBE

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Measurements at the 175 MeV neutron beam at TSL

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Fast neutron facilities at the National Physical Laboratory, UK

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NFS: A Neutron Facility at Spiral - 2

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Overview of the JRA1 activities at JRC-IRMM

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Conceptual design of ESS (European Spallation Source)

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Transnational Access Activities and Euratom Framework programme feedback experience towards implementation of the European Research Area

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Status of the Transnational Access Activities within EFNUDAT

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EU Nuclear data projects for more sustainable nuclear energy and waste transmutation

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Session 6: European Programs / 63

Integration of Nuclear Data facilities in Europe: the dawn of EFNUDAT and the rise of ERINDA

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Transnational Access Activities and Euratom Framework Programme feedback experience towards implementation of the European Research Area

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Integration of Nuclear Data facilities in Europe: the dawn of EFNUDAT and the rise of ERINDA

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Session 5: Current and Future Facilities / 68

Neutron time-of-flight measurements at GELINA

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The study of neutron induced reactions is of interest to various disciplines in science and technology. The neutron time-of-flight facility GELINA installed at the IRMM Geel (B) has been designed to study neutron-induced reactions in the resonance region. It is a multi-user facility, providing a pulsed white neutron source, with a neutron energy range between 10 meV and 20 MeV and a time resolution of 1 ns. The research program concentrates on cross section data needs for nuclear energy applications and cross section measurements. In this contribution the complementarity of GELINA and the nTOF facility and efforts made to improve the quality of the covariance data in the resonance region will be discussed.

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Neutron time-of-flight measurements at GELINA

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Session 6: European Programs / 70

Conceptual Design of ESS (European Spallation Source)

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The European Spallation Source

In 2003 the joint European effort to design a European Spallation Source (ESS) resulted in a set of reports and in May 2009 Lund was agreed to be the ESS site. The ESS Scandinavia office has since then worked on setting all the necessary legal and organizational matters in place so that the Design Update and construction can be started in collaboration with European partners. The design update phase is expected to end in 2012 and it will followed by a construction phase with first neutrons expected in 2018-2019.

I will in this talk give an overview of the physics case for ESS, the ESS organization and the plans for the Design Update and Construction projects. Some details for the accelerator will be presented.

Session 5: Current and Future Facilities / 71

n_TOF facility at CERN

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The neutron Time of Flight (n_TOF) facility at CERN is a source of high flux of neutrons obtained by the spallation process of 20 GeV/c protons onto a solid lead target and the remarkable beam intensity of the Proton Synchrotron (PS). From Nov 2008 the n_TOF facility resumed operation after a halt of 4 years due to radio-protection issues. It features a new lead spallation target, new cooling system, a separated moderator circuit, controlled primary zone ventilation system and a refurbished experimental area classified as Work Sector Type A permitting to measure highly radioactive targets with almost no restrictions from the radio-protection. The present paper will give an overview of the present state of the facility, the present experimental program as well the future objectives.

Session 5: Current and Future Facilities / 72

NFS : A neutron facility at SPIRAL-2

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The "Neutrons for Science"(NFS) will one of the SPIRAL-2 experimental areas. NFS, expected to be operational in 2012, will be composed of a pulsed neutron beam for in-flight measurements and an irradiation station for activation measurements and material studies.
The beams delivered by the high-power superconducting driver LINAC of the SPIRAL-2 facility will allow producing intense pulsed neutrons sources in the 100 keV-40 MeV energy range. Thick C and Be converters and deuteron beam will produce an continuous neutron spectrum while thin 7Li target and proton beam allow to generate quasi-mono-energetic neutrons.
NFS will be a very powerful tool for physics, fundamental research as well as applications like the transmutation of nuclear waste, design of future fission and fusion reactors, nuclear medicine or test and development of new detectors. Several "Day-one experiments"in these fields have already been evaluated by the scientific Advisory Committee of SPIRAL-2.
We will described the facility, give the characteristics and some examples of the first potential experiments