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POSTER SESSION

BOOK OF ABSTRACTS

Combined effect of BNCT, Boron Neutron Capture Therapy, with conventional high-energy radiotherapy

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Conventional high-energy (E>15MV) linear accelerators for radiotherapy produce fast secondary neutrons due to (γ, n) reaction with a mean energy of about 1 MeV [1]. This neutron flux, isotropically distributed, is considered as an undesired dose during the treatment. Considering the moderating effect of human body, a consistent thermal neutron flux (of about $1.55\ 10^{7}\ n_{th}\ cm^{-2}\ Gy^{-1}$) is localized in the tumour area [2].

The study analyses the possibility to employ this thermal neutron background for BNCT (Boron Neutron Capture Therapy, [3]) applications in order to enhance the radiotherapy effectiveness.

The previous work proves that the thermal neutron peak could be exploited for BNCT, delivering to the patient an additional therapeutic dose of about 4% (or more) to the photon dose [4]. It's now necessary to verify if this BNCT additional dose is more concentrated in the tumor tissue and much less in the healthy one. For this purpose, an anthropomorphic phantom has been exposed to a 18 MV photon beam, simulating a prostate radiotherapy treatment. By means of bubble dosimeters for thermal neutrons (BDT, [5]) placed inside the phantom, in holes corresponding to critical organs, thermal neutron doses have been measured during the treatment. The experimental results are in good agreement with the simulation data obtained by Monte Carlo simulations. From this investigation it's evident that a consistent flux of thermal neutrons is concentrated in the target volume and the BNCT effect is mainly present in the tumour tissue, while nearby organs are preserved (Fig.1).

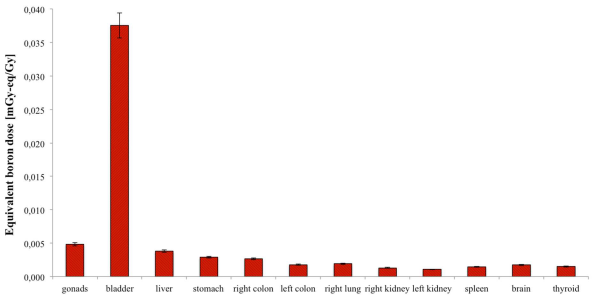

Fig.1 Equivalent boron dose due to BNCT for a thermal neutron flux in the treatment area of $2.88\ 10^{7}\ n\ cm^{-2}\ Gy^{-1}$. MCNP4B-GN simulation result. Boron concentration in the sick organ, bladder, is about one order of magnitude higher than nearby healthy ones: healthy tissues are preserved by BNCT effect.

Concluding, the undesirable thermal neutron component that affects the patient during a conventional high-energy treatment could be exploited to icrease the radiotherapy efficacy. The next work step will be focused on the study of a BNCT-dedicated treatment planning system, coupling the BNCT treatment to conventional radiotherapy.

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Polysiloxane based neutron detectors

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In the last decade, neutron detection has been attracting the attention of the scientific community for different reasons. On one side, the increase in the price of ^{3}He, employed in the most efficient and the most widely used neutron detectors. On the other side, the harmfulness of traditional xylene based liquid scintillators, used in extremely large volumes for the detection of fast neutrons. In addition, standard commercial plastic scintillators that could be regarded as another possible ^{3}He alternative, show at present some problem connected with their low radiation hardness and their pulse shape discrimination (PSD) capability. Polysiloxanes could help addressing some of the existing issues regarding neutron detection thanks to their unique properties like non-toxicity, low harmfulness, high radiation hardness, high molecule mobility.

For this reason, in this work, polysiloxane scintillators are developed and characterized, with a special attention to their optical properties and their time response. In particular, the scintillation performances of several different polysiloxane liquids are investigated. The results are connected with the optical properties of the material, in turns linked to its molecular structure, allowing to select the most suitable polysiloxane solvent for liquid scintillators. The timing properties of scintillating mixtures employing the best performing polysiloxane solvent are consequently analyzed as a function of the primary dye concentration, with a special focus to the pulse shape discrimination (PSD) capability of the material. PSD is indeed one of the most important characteristic of liquid scintillators, and one of the factors determining their widespread use.

Beside polysiloxane liquids, time response of radiation hard polysiloxane plastic scintillators was also investigated with the aim of studying their PSD capability. At the moment, indeed, only few examples of plastic scintillators capable of PSD exist, and also in those cases some criticalities emerged connected with stability issues and efficiency. Also in this regard, very good preliminary results are presented.

Probing the Structural Changes of Multifunctional Superparamagnetic Iron Oxide Nanocarriers

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Pluronic micelles have engendered the hope and promises to enhance therapeutic efficacy of hydrophobic drugs by improving solubility and blood circulation time [1]. In addition to the chemical nature of the Pluronic prodrugs, their pharmacokinetic behavior and cell internalization are functions of hydrophobicity, shape, size, and tendency towards aggregation [2]. Therefore, probing the Pluronic interaction with nanoparticles and drug in order to understand the mechanism of micellar structure variation is a necessary step before carrier can come into clinical setting. The present work aimed at studying structural changes of Pluronic block copolymer micelles after encapsulation of paclitaxel (PTX), doxorubicine (DOX), and superparamagnetic iron oxide (SION). The nuclear magnetic resonance (NMR) measurements demonstrated that PTX interacted with PPO in the micelle core whereas SION can be found in both blocks. Small angle neutron scattering (SANS) and cryogenic transmission electron microscopy (cryo-TEM) results highlighted that the interaction between micelles and PTX did not change the shape of the micelles. However, average core radius was increased in response to the higher concentration of Pluronic in aqueous solution (**Fig.1**). Results also showed that high PTX concentration leads to higher scattering intensity in the low-Q region, pointing that complex clusters of PTX and Pluronic were emerged in the samples. The effect of temperature on Pluronic and Pluronic-PTX was also explored using SANS. Results showed that increasing temperature from 310 to 323 K results in a transition in micelles' shape from sphere to cylinder. Furthermore, complementary cryo-TEM studies revealed that drug solubilization led to an increment of micellar size but the shape and size of micelles are dependent on the morphology of the SION or PTX nanocrystals.

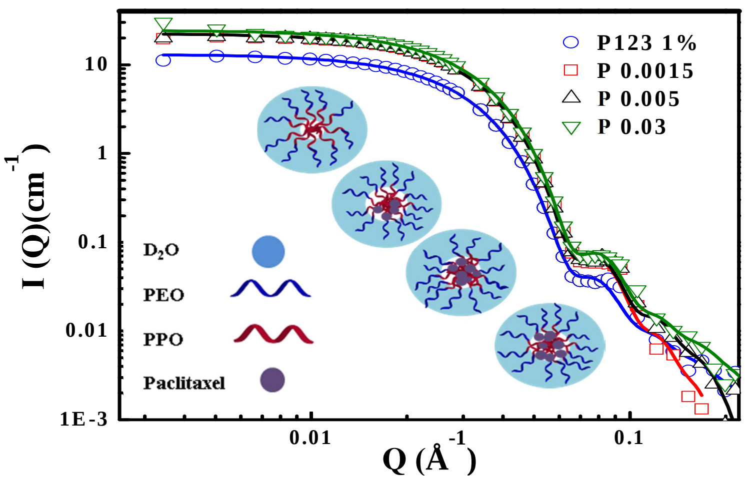

Fig. 1. SANS spectra of Pluronic P123 with increasing concentration of PTX in D_2O.

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Simulation of Background Radiation in Boron-10 Multi-Grid Neutron Detector with Monte Carlo Methods

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Instrumental advances are necessary to achieve better signal-to-background ratio at high intensity neutron sources. It is particularly relevant for neutron detectors, where developments are urgently needed owing to the helium-3 crisis. The new instrument designs necessitate advances in background reduction through the application of advanced modern techniques.

The current study focuses on the intrinsic detector background in the Ar/CO_2 gas-filled Multi-Grid neutron detectors with boron-carbide converter. Different sources of background radiation are investigated, as decay gamma and prompt gamma radiation originating from neutron activation of the counting gas and the structural components of the detector, and the scattered neutron background. MCNP6 and GEANT4 Monte Carlo codes are used for the simulation.

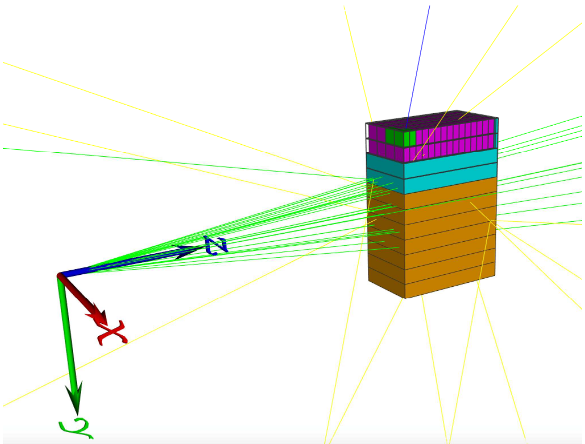

Fig. 1 GEANT4 simulation for neutron irradiation of a Multi-Grid Detector.

The goal of the reseach is to optimise the detector's signal-to-background ratio based on the detailed knowledge of the radiation background.

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Characterization of a Telescope Proton Recoil Spectrometer based on a YAP(Ce) scintillator to protons up to 80MeV

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In order to measure the response function of the telescope proton recoil (TPR) spectrometer for ChipIr [1-2], characterization of the spectrometer based on a 1"×1" YAP(Ce) crystal to protons up to 80MeV was performed at INFN-LNS. Two energies were chosen at 62 and 80 MeV from the Cyclotron accelerator, a plastic target was used for Rutherford scattering, and some aluminum foils were placed in front of the TPR spectrometer to select the proton energy on the YAP crystal. MCNP code and Pstar database were used to calculate the proton energy incident on the YAP crystal. It was shown that features of the spectrum include elastic scattering on C and H and inelastic reactions. Interaction with air and other materials (e.g. the collimator) contribute to the background. The capability of the system to discriminate charged products using the ΔE-E technique has been demonstrated.

The crystal has been calibrated with ^{137}Cs and ^{60}Co γ-ray sources. The relative light yield of protons with respect to gammas has been measured and is here reported to be in the range of 51.3%-83.5%, as shown in Fig.1.

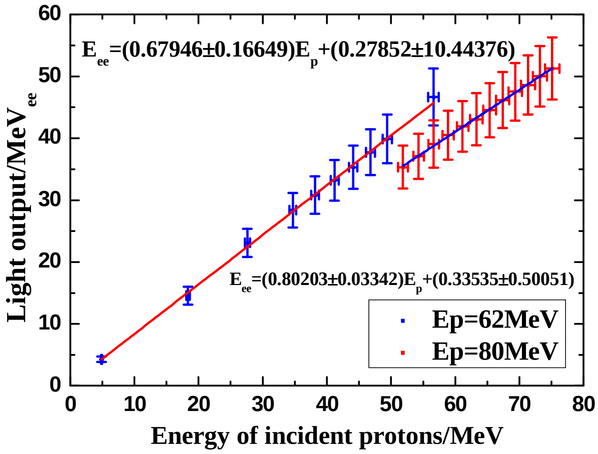

Fig. 1 Measured light output for YAP:Ce scintillator expressed in MeVee, as a function of the incoming proton energy

However, an instability in the PMT gain (causing systematic shifts in the measurements) was present. This is the reason why the accuracy on the light yield measurement was compromised and it is one of the main issues to be addressed anticipating the installation of the TPR on ChipIR. A revision of the TPR design was suggested, which could consist of changing the PMT or adding a monitor light source to correct for long term shifts. In the future a Geant4 model will be developed, allowing a higher flexibility in the selection of high proton energy data bases and the modified nuclei model for data files.

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Measurement of the natural neutron background underground with moderated ³He counters in the Dresden Felsenkeller

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A new underground ion accelerator with 5 MV acceleration potential will soon be installed in the Dresden Felsenkeller [1]. The site consists of nine mutually connected tunnels, shielded from cosmic radiation by a 45 m thick rock overburden. This poster reports on a measurement of the neutron flux in tunnel IV. There the neutron flux has been measured in three differently shielded laboratories using a set of seven polyethylene shielded ^{3}He tubes provided by the BELEN collaboration [2].

To determine the detector responses FLUKA [3, 4] simulations have been performed. The observed neutron count rates were unfolded using the MAXED [5] and GRAVEL [6] algorithms, and energy spectra have been derived.

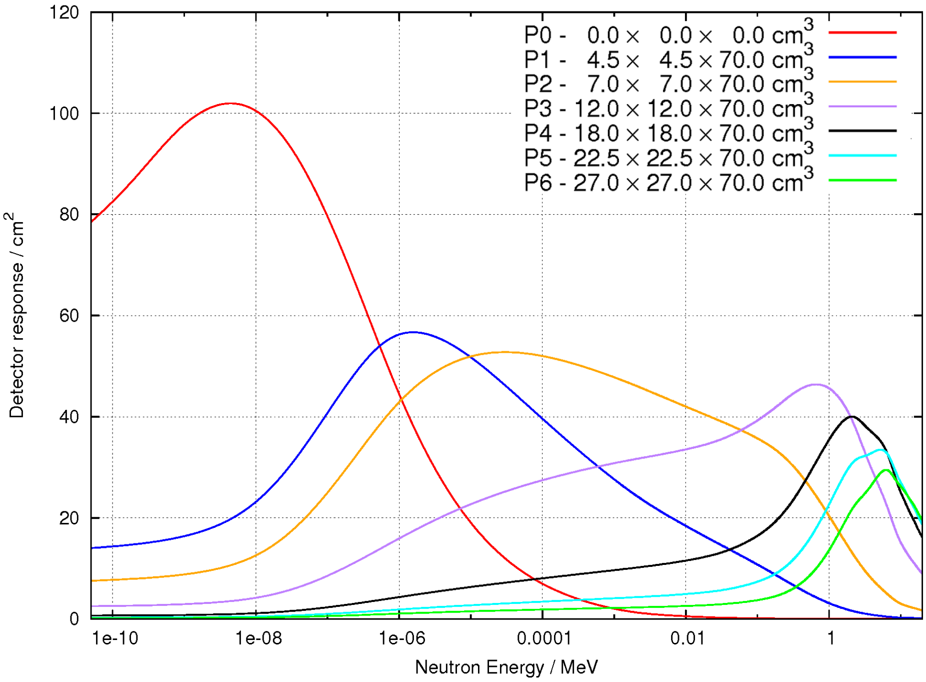

Fig. 1 Detector responses for the seven polyethylene shielded ^{3}He counter tubes calculated with FLUKA.

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Development of diamond film for application in neutron detectors

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This doctoral thesis work is framed in the field of basic materials science with the general aim of deepening the study of deposition and characterization of carbon based films for neutron detectors applications.

Due to its high band gap (5.4 eV), high radiation hardness, tissue-equivalent atomic number and high carrier mobility, diamond is an interesting material for semiconductor solid-state detectors [1]. Nevertheless, the production of synthetic diamond films remains a challenging task. Single-crystal diamond (SCd) shows a better crystalline quality than polycrystalline film (PCf) and this strongly affects the detection performance. However, the production of SCd is strongly linked to the choice of very few substrate materials showing lattice parameters very close to the natural diamond one. On the other side, PCf can be easily grown on electronic-relevant materials. Thus, the production and characterization of PCf with good crystalline quality is an interesting issue.

Different deposition techniques have been used to produce synthetic diamond films, but plasma-enhanced chemical vapor deposition (PECVD) is really promising since it is really flexible and cost effective [2]. Among the PECVD techniques, the micro-jet plasma attracts great attention: its possible applications ranges from synthesis of nanostructures to sterilization, detoxification and design of micro-scales patterns on materials [3, 4]. Moreover, its remarkable versatility with respect to plasma source and gas precursors, with an adequate choice of process parameters such as pressure, temperature and substrate material, permits to exploit it for the deposition of different carbon structures on small areas and with a high growth rate. For these unique features, this technique is particularly suitable for basic studies of materials science related to diamond growth.

In this framework, some preliminary results have been obtained [5] exploiting a direct-current micro-plasma technique for the deposition of carbon films and Raman and Scanning Electron Microscopy as main characterization tools. These studies have allowed to achieve a thermodynamic model able to predict the deposition of different kind of carbon structures with the direct-current micro-plasma technique.

Starting from these first results, in this work the dynamic evolution of the growth of diamond films is investigated. Samples are grown with increasing deposition times. As substrate materials, molybdenum is used due to its strong tendency in forming a carbide layer and thus helping diamond nucleation, while silicon for its interest in electronic applications. The deposited samples are characterized by means of multi-wavelength Raman Spectroscopy and Scanning Electron Microscopy. The evolution of the sp^3/sp^2 content in the samples is evaluated and an explanation of the structural and morphological processes leading to diamond deposition is provided.

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Characterization of Neutron beam Monitors for the European Spallation Source

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The European Spallation Source (ESS) in Sweden will be the world's leading neutron source for the studies of materials. The thermal neutron flux at ESS will be 30 times higher than the already existing facilities such as SNS and J-PARC. A unique feature of the ESS neutron production will be the long pulse spallation source (2.86 ms) with a repetition rate of 14 Hz. [1] At a spallation neutron source, the neutron intensity fluctuates with time depending on the characteristics of the proton beam to the neutron target. This requires a continuous beam monitoring with high precision [2]. Given the diversity of the instruments at ESS, different neutron beam monitors will be required.

Some beam monitors such as gas electron multiplier based on boron carbide will be realized for ESS [3]. Other types of beam monitors will be purchased from different companies. For this study seven neutron beam monitors, manufactured by different companies have been tested and characterized. Based on these measurements some of these beam monitors will be improved in order to match the ESS instrument requirements. In this work different types of neutron beam monitors from different suppliers have been characterized using the R2D2 beamline at IFE in Norway and using a Be-based neutron source. For the gamma sensitivity measurements different gamma sources have been used. The evaluation of these monitors includes the study of their efficiency, attenuation, uniformity, stability, and their sensitivity to gamma. In this work we report the results of this characterization. The specifications of these monitors are summarized in table I. These monitors could be categorized into two main categories position sensitive and non position sensitive. Using a stainless steel ^{3}He-tube as a reference we measured efficiency and attenuation of all the monitors at the R2D2 beamline at IFE, Norway. These results are also summarized in the last two rows of table I.

	MWPC from ORDELA	**MWPC from ORDELA**	**MWPC BM-100X50 from Mirroton**	**2D-MWPC from Mirroton**	**GEM from CDT**	**Scintillator from Quantum Detectors, UK**	**Fission chamber from LND**
Isotope used for neutron capture	^{3}He	^{14}N	^{3}He	^{3}He	^{10}B	^{6}Li	^{235}U
Gas pressure mbars	6,0795	81,06	6,5	1650	100	------	1013,2
Filled gas	^{3}He+^{4}He +CF_4	N+CF_4	^{3}He+CF_4	^{3}He+CF_4	Ar/CO_2	--------	P10
Active Area (mm^2)	114 x 51	114 x 51	100 x 50	100 x 50	Diameter 100 mm	28 x 42	Diameter 108.0 mm
Applied voltage (V)	850	850	1300	Anode at -3500V Drift at 1500V	-1000	650	300
Attenuation %	6.3	5.9	2.5	6.8	11.1	0.49	3.87
Efficiency %	0.21	3.3×10^{-3}	0.048	1.5×10^{-2}	2.7	0.052	0.01

Table I. Specifications and measurements of different neutron beam monitors with the measured efficiency and attenuation using the R2D2 beamline at 2.4 Å

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Usage of neutron detectors for the neutron lifetime experiment τSPECT

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The τSPECT experiment situated at the ultra-cold neutron source of the TRIGA Mainz research reactor [1] aims to measure the neutron lifetime τ with high precision. For this, highly efficient neutron detectors are required.

First, the ultra-cold neutrons are magnetically trapped. A detection of neutron losses during storage is needed for a determination of the systematic uncertainty. Various detector types will be used. Among others, CASCADE U-100 detectors are used, which are Gas Electron Multiplier (GEM) detectors with ^{10}B coating as neutron converter. Furthermore, τSPECT can be equipped with Si PIN diodes coated with ^{10}B.

Recently, a photomultiplier tube coupled to a plastic scintillator with 5 % ^{10}B doping has been commissioned for normalising the reactor pulse energy. In the coming months, τSPECT will be completed by introducing full magnetic storage using a Halbach multipole array [2]. Additionally, a measurement of the decay proton curve using a silicon drift detector (SDD) will allow for an accurate measurement of τ [3].

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Nuclear structure studies by photofission reactions at ELI-NP

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The possibility of photofission experiments at the Extreme Light Infrastructure – Nuclear Physics (ELI-NP) facility, an extensive experimental research facility will give us an opportunity to study g factors of short-lived ns isomers using the ELIADE detectors array. The neutron rich nuclei populated in their excited states via photofission reactions using actinide targets makes ELI-NP a unique facility for g-factor measurements of these nuclei. The importance of nuclear g-factor measurements is related to the fact that they provide information about the nuclear configurations. The presentation will discuss the results obtained from Geant4 simulations to study the feasibility of these measurements at ELI-NP, i.e. the production rates of fission fragments and their release efficiency from the actinide targets.

Spherical Penning Trap as a Small Fusion Neutron Source

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A solenoid Penning trap was previously explored as a potential fusion reactor.[1-3] We are studying by theory, simulation, and experiments whether a useful fusion output can be produced in a small (1 cm. radius) permanent magnet Penning trap. It has been shown theoretically that maintaining a throughput of electrons by injection and collection near the cylindrical center of the end cathodes can lead to a steady state with strong spherical convergence. Very low power can maintain such a state because electrons are sourced and collected at very low energy compared with the total well depth of the system. Additional theory arguments show that major instabilities are avoided provided that not too much of the space charge is neutralized by trapped ions and that low frequency ion/electron instabilities are also absent. Further, a moderate neutralization fraction leads to a reasonable ion density and temperature such that fusion output is expected. These favorable forecasts are being studied by a recently developed simulation model.

For experimental studies, we have built a permanent magnet system engineered to produce a uniform magnetic field (nonuniformity less than 10^{-3} over spherical volume) which can be varied from several hundred Gauss to nearly 2 kG by adding additional permanent magnets. A stainless steel mass spectrometer hyperbolic trap fitted with a hairpin filament electron source is mounted inside the magnet system in a room temperature vacuum chamber capable of a base pressure below 10^{-7} Torr. Following the previous work,[1] we have observed a sharp focus of electrons at the spherical center when the anode ring voltage is adjusted to a magnetic field dependent value. This focus forms a virtual cathode which can confine ions, and if the applied voltage is several kV, these ions may achieve a thermonuclear temperature, leading to controlled fusion reactions with a fractional energy gain.

In initial experiments, small differences between the theoretically predicted and experimentally observed electron trapping resonance are believed to be due to residual ferromagnetism of the machined 304SS electrodes which attenuates and distorts the field inside the trap. In addition, the mass spectrometer trap does not have a symmetric aspect ratio ($Ro \neq Zo$). We therefore built a new symmetric nonmagnetic titanium trap to circumvent these problems and observed an electron trapping resonance at the predicted anode potential. Future work will extend the magnetic field and anode potential to produce a potential well sufficient to effect nuclear fusion of injected deuterium nuclei.

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Test for a Liquid Neutron Detector for Spectroscopy with (^{3}He, n) Two Proton Stripping Reactions

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A liquid scintillator detector has been assembled at iThemba LABS, in South Africa. The detector is fabricated using an aluminum cylindrical housing of 1 m length and 0.073 m diameter. On each end of the pipe, attached, are the Hamamatsu R329 photomultiplier tubes (PMT). The PMT's were operated with a negative voltage of 1350 V and the signals from the anodes were collected to the data computer via a PIXIE16 electronics module. Figure 1 below shows the geometry of the detector assemble.

Figure 1: A photographic picture of the liquid scintillation detector setup.

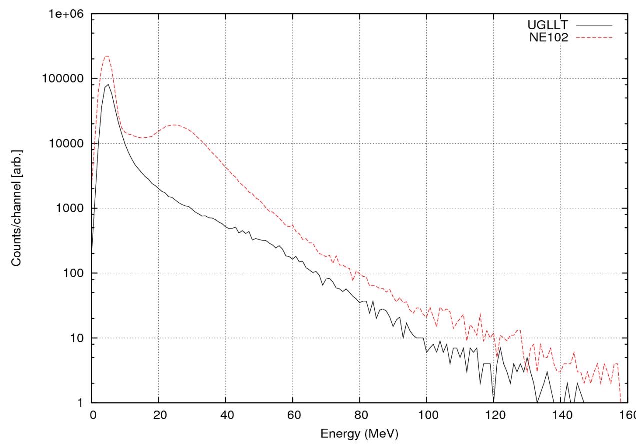

Figure 2: The calibrated energy spectra from the UGLLT (black) liquid scintillator and NE102 (red) plastic scintillator.

The inner surface of the cylinder is anodized with a reflective paint to reduce the amount of light lost by the pipe. The reflective paint makes scintillation photons scatter multiple times from the detector walls, which partially compensates for the relative poor PMT photo-cathode coverage. The detector was filled with the liquid scintillator, UGLLT (Ultima Gold Low Level Tritium) manufactured by Perkin-Elmer Inc. The main solvent in UGLLT scintillator is Di-Isopropyl-Naphthalene (DIN), which is a chemical compound that is characterized by its low toxicity, low vapour pressure and high ignition temperature. It is also degradable and safe in transportation and depository.

Tests were carried out to test for the performance of the new detector using cosmic-ray muons with energy of ~24 MeV. Figure 2 shows the muon spectra of signals captured by the 2 types of detectors, the UGLLT liquid scintillator (black) and NE102 plastic scintillator (red). The two diagrams show a marked difference with regards to the peak of interest, the muon peak. With the plastic scintillator, the muon peak is clearly visible with a pronounced bump at ~24 MeV when compared to the spectrum from the liquid scintillator. The liquid scintillator shows less sensitivity to the muons. Further investigations need to be done to ascertain the reason for this poor response by the liquid scintillator.

THE MULTI-BLADE ^{10}B-BASED NEUTRON DETECTOR

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The Multi-Blade is a ^{10}B-based detector conceived to face the arising challenge neutron reflectometry at the European Spallation Source (ESS). The instantaneous neutron flux on detectors at ESS will be without precedent and neutron reflectometers are amongst the most challenging instruments.

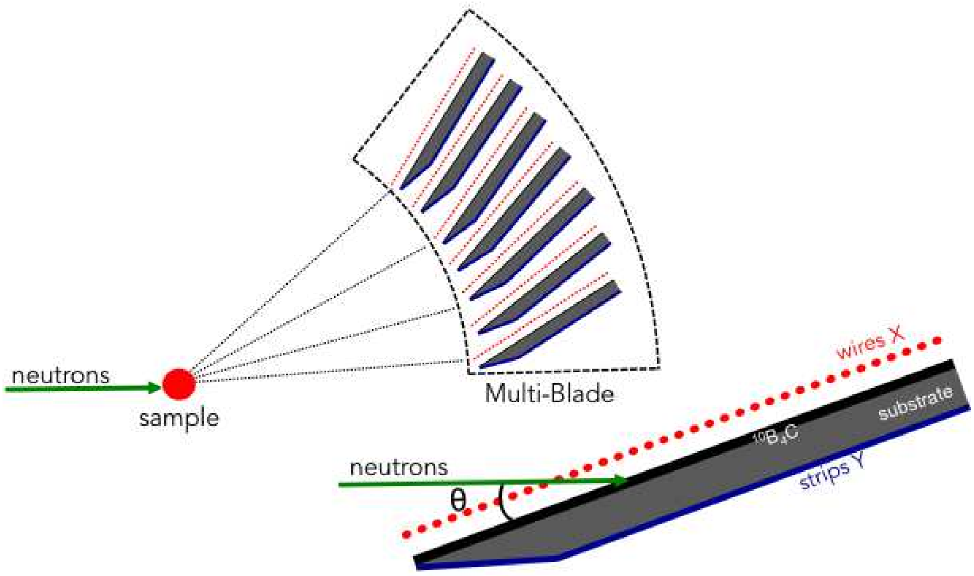

Fig. 1 Schematic view of the cross-section of the Multi-Blade detector made up of identical units (cassettes) arranged one after the other. Each cassette holds a $^{10}B_4C$-layer and the readout is performed through a plane of wires and a plane of strips.

The Multi-Blade detector is a stack of Multi Wire Proportional Chambers (MWPC) operated at atmospheric pressure with continuous gas flow (Ar/CO_2 80/20 mixture). The Multi-Blade is made up of identical units called cassettes. Each cassette holds a blade (a substrate coated with $^{10}B_4C$) and a two-dimensional readout system, which consists of a plane of wires and a plane of strips. Each $^{10}B_4C$-converter (blade) is inclined at 5 degrees with respect to the incoming neutron beam. Due to the inclined geometry, neutron conversion is more efficient, spatial resolution is improved and counting rate capability is increased.

A new prototype has recently been built. It has an active area of about 100×100 mm^2 with nine cassettes and each is equipped with 32 wires and 32 *4mm*-strips. It has been tested in beam at the Budapest Neutron Centre (BNC), a facility operated jointly by the Hungarian Centre for Energy Research and the Wigner Centre.

An overview of the test progress is presented.

Thermal neutron source based on medical electron Linac

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This work is focused on the installation of a thermal photo-neutron source based on a high energy electron Linac. The machine, an Elekta Precise 18 MV, commonly used in hospital for radiotherapy, is being installed in Turin at INFN in collaboration with the Physics Department at University of Turin.
A suitable photo-converter, coupled to the accelerator, has been designed and optimized to reach neutron fluxes of the order of $10^7 cm^{-2}\ s^{-1}$ inside a dedicated cavity [1].
In the photo-converter fast neutrons, with energy of about 700 keV, are produced via giant dipole resonance in a lead target and then slowed down to thermal energies with an appropriate moderator structure. The cavity geometry and materials have been chosen to guarantee a reasonable high quality of the thermal neutron field with respect to fast neutron and gamma contaminations. MCNP6 code has been exploited to simulate the source in order to find the best configuration.

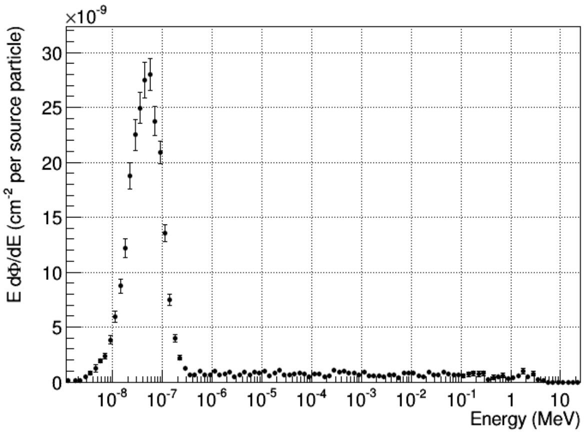

Fig. 1 Neutron energy spectrum inside the photo-converter cavity calculated by MCNP6 simulation. The thermal peak represents the 80% of the total flux, while the fast neutron component (above 0.2 keV) is below the 5%.

Both passive detectors, such as bubble dosimeters, and active diagnostics are used to evaluate the thermal and fast neutron flux in the cavity of a photo-converter prototype. In particular, new Thermal Neutron Rate Detectors (TNRD), based on solid state devices [2], are under development for the installation of a permanent monitor system of the neutron field in the photo-converter.

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Multilayer Thick-GEM geometries as 10B converters aiming thermal neutron detection

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One of the most relevant issues in neutron detection is the search for alternatives to Helium-3 as neutron converter. Its high absorption cross section for thermal neutrons used to make it the preferred absorber to build large area thermal neutron detectors. Its current unavailability triggered an intense research to find for alternatives, turning the attention of gaseous detectors developers back to Boron-10. Boron is in the solid state at NPT presenting an additional challenge in its deposition on surfaces, with reasonable thickness. Issues such as the self-absorption of the products of the nuclear reaction when the films are too thick are limiting the detection efficiency of the final detector.

The use of many layers is an interesting solution to overcome these issues. This has been tried in several geometries, such as Multi-grid [1], Inclined detector [2], Jalousie[3] and Cascade [4]. In this work, a solution based in the Cascade concept for the use of many thin boron layers is exploited, using a more cost effective Micropattern Gaseous Detector, the Thick-Gas Electron Multipliers (Thick-GEMs) as neutron converter and electron transporter, together with a standard GEM-based charge amplification stage.[5]

Results of the characterization of Thick-GEM prototypes produced in Brazil with hole pitch from 0.75 to 3 mm show that these devices already present a stable performance at low gains, also resulting in fair energy resolution, when cascaded with standard poliimide 50 μm GEMs. The first attempts of boron deposition with Ion Beam Assisted Deposition and on-going tests with Magnetron sputtering will be described as well as the experimental test setups in the Brazilian Research Reactor of the Nuclear and Energetic Research Institute (IPEN) in São Paulo, Brazil, foreseen for the near future.

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Soil moisture measurement by the Cosmic-Ray Neutron Sensing technique in Alpine regions

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Summary/Abstract

In recent years an increasing number of studies investigate the theory and the use of Cosmic Ray Neutron Sensing (CRNS) for soil moisture determination. This technique allows to get a space averaged information about the soil moisture content over a horizontal footprint with a radius of about ~300 m[1]–[4]. This means that the CRNS technique is of high importance for data retrieval in the meso-scale spatial range. The measurement is space-averaged and does not detect the high local variability of soil moisture within the footprint. However this scale range allows the validation of remote sensing data and implementation of hydro-geological models. This study aims at applying the CRNS in South-Tyrol and at locally calibrating the Cosmic Ray Neutron Probe (CRP), to obtain useful data for model implementation and calibrations.
In the first part of this research, a sensitivity analysis of the volumetric footprint will be performed using available software and models [2]. In the second part, the equipment will be set-up in an alpine meadow and two calibration methods will be used to correlate neutron counts with soil moisture content. Under these conditions the calibration will encounter for horizontal and vertical soil variability, air pressure and humidity and precipitation, while low changes in biomass amount will be considered as systematic biasing. In the third part of the project, the sensor will be set-up in a forest area and besides the two calibration methods, also basic data on temporal variation of biomass amount will be taken into account as the biomass is expected to affect the measurement up to 20%[1]. In both cases the obtained time-series will be integrated with meteorological data and hydro-geological models.
The two techniques used for the in-situ calibration will be the oven-drying method ant the punctual profiling of soil moisture with a wireless sensors network: the resulting soil moisture data will be used to calibrate the CRP with the calibration finction from *Desilets et al. 2010* [4]. The measurements with the wireless sensor network will be performed contemporary to the CRNS measurement for the whole duration of the campaigns. Besides the two core-measurement campaigns mentioned above, also a training campaign at the TA Siptenfelde site and TERENO observatory Harz/Central German Lowland was performed: a roving sensor was used to assess the effects of different ladn-use. The last measurement campaign will be held in a forest stand where a forest harvesting is planned: in this case the effects on changes in forest biomass will be investigated and quantified.
The expected results are the local calibration of the (CRP) with a better definition of the support volume of the footprint. The results of calibration and mesurements will be used for inter-calibration and validation of remote sensing data and hydro-geological models.
At the end of the project the opportunity to use CRNS in South-Tyrol will be assessed.

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Simulating the DESCANT Neutron Detection Array with the Geant4 Monte Carlo Toolkit

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The DEuterated SCintillator Array for Neutron Tagging (DESCANT) is a newly developed high-efficiency neutron detection array composed of 70 hexagonal deuterated scintillators. Due to the anisotropic nature of elastic neutron-deuteron (n,d) scattering, the pulse-height spectra of a deuterated scintillator contains a forward-peaked structure that can be used to determine the energy of the incident neutron without using traditional time-of-flight methods. Simulations of the array are crucial in order to interpret the DESCANT pulse heights, determine the efficiencies of the array, and examine its capabilities for conducting various nuclear decay experiments. To acheive this, we plan: (i) a verification of the low-energy hadronic physics packages in Geant4, (ii) a comparison of simulated spectra with data from a simple cynlindical "test can" detector geometry, (iii) expanding the simulated light response to a prototype DESCANT detector, and (iv) simulating the entire DESCANT array.

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BAND-GEM detectors for SANS measurements at the European Spallation Source

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Small Angle Neutron Scattering (SANS) will be among the first measurements to be performed at the European Spallation Source.
The expected high neutron fluxes, with associated high count rate requirements on the detectors, have been the main driver for developing a new type of neutron detector based on the Gas Electron Multiplier (GEM) technique.
The GEM technique is well established for charged particle measurements in high energy physics applications at CERN and elsewhere. The new development concerns the neutron conversion to charged particles.
It is well known that a single layer of ^{10}B can provide an efficiency that is <5% for thermal neutrons. In the BAND-GEM (Boron Array Neutron Detector GEM)) approach a 3D geometry for the neutron converter was developed that is expected to provide an average efficiency >50% in the wavelength of interest for SANS measurements, while meeting the spatial resolution requirements for SANS.
In the presentation the spatial resolution requirements for SANS will be reviewed and the BAND-GEM detection method will be described.
Furthermore, the steps required for the design of the lamellas setup and the final assembly, including electronic readout and packaging, are shown, as well as some photo of the real prototype to be tested in the beamline.

Modeling and Design of a Detector Used for Sensing Large Scale of Buried Explosives Based on Neutron Scattering

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There are various conventional methods for the detection of explosives buried underground and some of these methods are based on nuclear measurement techniques. Each method has its own difficulty for their applications and have their detection limits. Neutron scattering based explosive detection is one of the popular topics. Explosives contains hydrogen known as a good neutron moderator. Due to its high neutron scattering cross section, neutrons can scatter from the hydrogen content of explosive and can be detected. The difference between the scattering events with and without explosive buried underground, may provide a valuable information about the existence of explosives.

In this manner, we have planned to use a neutron generator as a source and to design a silicon photo-diode base neutron detector. Humidity in soil is one of the concerns to affect to detection limit. Other concerns are the burying depth and mass of the explosive. Our preliminary Monte Carlo studies showed that it was difficult to detect explosives less than 10 kg under the given circumstances. For that reason, we have concentrated on the detection of massive (greater than 100 kg) explosives buried under motorways.

Initial studies were conducted with Geant4 Monte Carlo tool to determine some parameters and to help design for building a low-risk detection system. Gun positions, detection angles, moderators, effect of humidity and burying depth were investigated with MC simulations. Detector geometry for distinguishing thermalized neutrons were also studied. Figure 1 shows spectrum of scattered thermal neutrons from massive explosive buried in soil. This Monte Carlo result was conducted with a 14 MeV neutron gun.

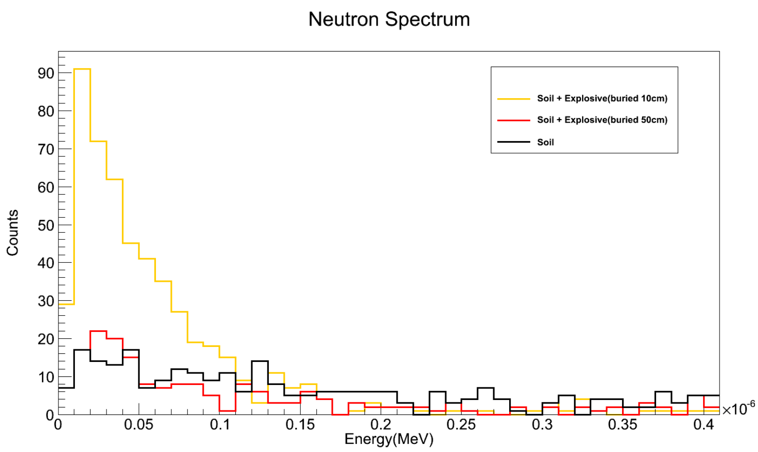

Fig. 1 Comparison of thermal neutron spectrum of a buried 1000 kg explosive for various burying depths in soil.