5th High Power Targetry Workshop

Tuesday 20 May 2014 - Friday 23 May 2014

Book of abstracts

Design and Thermal-Hydraulic Performance of a Helium Cooled Target for the Production of Medical Isotope 99mTc

HPTW Poster Session & Reception - Board: 101 - Tuesday 20 May 2014 17:30

Presenter: WOLOSHUN, Keith (Los Alamos National Lab)

99mTc, the daughter isotope of 99Mo, is the most commonly used radioisotope for nuclear medicine in the United States. Under the direction of the National Nuclear Security Administration (NNSA), Los Alamos National Laboratory (LANL) and Argonne National Laboratory (ANL) are partnering with NorthStar Medical Technologies to demonstrate the viability of large-scale 99Mo production using electron accelerators. In this process, 99Mo is produced in an enriched 100Mo target through the 100Mo(γ,n)99Mo reaction. This paper describes the design and performance (test results) of the helium-cooled Mo target to date. Modifications of the target size (diameter and length) continue toward an optimum configuration for isotope production maximization, but with volumetric heating as high as 33 kW/cc the cylindrical target has been segmented into disks to keep the peak heat flux under 1000 W/cm2. Changes in electron beam spot size and shape, also continually evolving toward an optimum for both production and cooling, impact of the design and performance of the target. The current design status and performance predictions are discussed.

CENF target thermo-mechanical study

HPTW Poster Session & Reception - Board: 102 - Tuesday 20 May 2014 17:30

Presenter: Ms. VENTURI, Valentina (CERN)

The design of the target assembly for the proposed CENF neutrino facility is a challenging task due to the very strict physics requirements. The material chosen for the target is graphite, while a beryllium double pipe configuration is foreseen for the external containing structure. The assembly must be supported in cantilever and has to fully fit inside a focusing horn featuring a very narrow neck (24 mm diameter). A helium cooling system has been designed to insure reasonably low temperatures for the external structures (350-400 K) and to keep the target at a temperature of around 700-800 K in order to minimize the modifications of the mechanical properties due to radiation damage. A second design, adapted for a possible larger horn neck of 30 mm diameter has also been studied in order to evaluate and improve the feasibility as well as the working conditions identified in the first design.

LBNE 1.2MW Target Conceptual Design

HPTW Poster Session & Reception - Board: 103 - Tuesday 20 May 2014 17:30

Presenter: HARTSELL, Brian (FNAL)

The Long Baseline Neutrino Experiment (LBNE) will utilize a proton beamline at Fermilab with 1.2MW power on target in the baseline configuration. A graphite target concept using a scaled version of the IHEP low energy target design was chosen to fulfill the design criteria. The proton beam was enlarged to a 1.7mm beam sigma compared to the 1.1mm beam sigma the IHEP LE target was originally designed for and target dimensions were scaled appropriately. Water cooling lines and target geometry have been optimized via thermal and structural beam heating simulations, and the final result is a target is predicted to operate successfully. The impact of scaling up the target on neutrino yield was shown to be minimal through detailed MARS15 simulations.

A Feasibility Experiment of a W-powder Target

HPTW Poster Session & Reception - Board: 104 - Tuesday 20 May 2014 17:30

Presenter: Dr. CHARITONIDIS, Nikolaos (CERN)

The development of high-power targets constitutes a key R activity for future facilities presently under study like the Neutrino Factory, the Muon Collider or the upgraded high-power super beams for long-baseline neutrino experiments. The choice of materials to sustain the proposed beam power ranging up to (Multi-) MW levels is not trivial. Granular solid targets have been proposed and are being studied as candidates for such high-power target systems. In the recently commissioned HiRadMat facility of CERN, a feasibility experiment of a tungsten powder target was performed. The experiment was designed to explore for first time the impact of a high-power proton beam on a static powder target in a thimble configuration. The instrumentation of the experiment was based on remote high-speed photography as well as on laser - doppler vibration measurements of the target containers. Highlights of the results from the experimental findings are presented in this paper.

Three tier blistering tolerant neutron target for iBNCT by using 80kW proton linac.

HPTW Poster Session & Reception - Board: 105 - Tuesday 20 May 2014 17:30

Presenter: Prof. KURIHARA, Toshikazu (High Energy Accelerator Research Organization (KEK))

An accelerator-based BNCT (Boron Neutron Capture Therapy) facility is being constructed at the Ibaraki Neutron Medical Research Center, Japan. It consists of a proton linac of 80kW beam power with 8 MeV energy and 10mA average current, a beryllium target, and a moderator system to provide an epi-thermal neutron flux enough for patient treatment. The technology choices for this present system were driven by the need to site the facility in a hospital and where low residual activity is essential. The maximum neutron energy produced from an 8 MeV-proton is 6 MeV, which is below the threshold energy of the main nuclear reactions which produce radioactive products. The down side of this technology choice is that it produces a high density heat load on the target so that cooling and hydrogen aniti-blistering amelioration prevent sever challenges requiring successful R progress. The precise in-situ observation using polarized long distance microscopy with proton beam irradiation presents the performance of hydrogen storage alloys. Diffusion bonding method of Be, hydrogen storage alloy, Cu is also developed. The nucleate boiling method is applied. This solid neutron target is manufacturing and will be installed in this summer shutdown period.
The latest design of the target and moderator system shows that a flux of 4×10^9 epi-thermal neutrons / cm2 / sec can be obtained. This is much higher than the flux from the existing nuclear reactor based BNCT facility at JAEA (JRR-4).

The Sinuous Target

HPTW Poster Session & Reception - Board: 106 - Tuesday 20 May 2014 17:30

Presenter: Dr. ZWASKA, Bob (Fermilab)

We present the concept for a target material comprised of a multitude of interlaced wires of small dimension. The wires will be made of a thermal-shock resistant material, but will not be subject to stress accumulation due to their small size. The intrinsic bends of the wires will allow them to absorb the strain of thermal shock with minimal stress. The bulk of this material will have a dramatically lower bulk modulus than the bare material, greatly improving its resistance to thermal shock. Furthermore, the interlaced nature of the wires provides containment of any segment that might become loose. The small feature size enhances the healing ability of the material. Some concepts for use will be presented, including fabrication and cooling techniques.

PNNL Beam Window and Target Analyses

HPTW Poster Session & Reception - Board: 107 - Tuesday 20 May 2014 17:30

Presenter: Mr. GATES, Robert (Pacific Northwest National Laboratory)

In this presentation, PNNLs work on structural analysis, material selection and fabrication issues associated with the energy deposition of proton beams in representative windows and targets will be explored. Strategies to improve the survival of beam window and target designs under challenging energy deposition rates will be discussed. High power beam parameters can induce very high thermal cycling, thermal shock and stress waves that in combination with material damage effects due to the irradiation may eventually exceed the available strength and ductility of the material. The energy deposition and resulting thermal response and induced stresses and strains are computed using the ANSYS finite element code. PNNLs extensive experience in the design of test trains successfully irradiated in the Advanced Test Reactor will be reviewed with a focus on available irradiated material properties, cooling methods, and novel fabrication strategies. The presentation will address optimal combinations of material properties, window and target configurations and beam parameters that should allow for greater utility of the components under the extreme demands of high energy proton beam applications.

Thermal Hydraulic Design of the Double-walled Mercury Target Vessel

HPTW Poster Session & Reception - Board: 108 - Tuesday 20 May 2014 17:30

Presenter: Mr. HAGA, Katsuhiro (Japan Atomic Energy Agency)

Cavitation damage of the target vessel wall which is caused by the pressure wave in mercury induced by the pulsed high power proton beam injection is the crucial issue for the development of the high power mercury target. Based on the analytical and experimental studies and also on the operational experiences of SNS, the effect of the rapid mercury flow to mitigate the cavitation damages seems obvious. In order to include this effect into the JSNS mercury target design, we applied doubled-walled structure to the beam window of the target vessel. The mercury flow velocity in the narrow channel between the double walls increases to almost 4 m/s, which should suppress the cavitation damages. In this presentation, the thermal hydraulic design of the double-walled target will be shown including the case of the failure of the inner wall.

High-power powder-flow target for radioactive ion beams production

HPTW Poster Session & Reception - Board: 109 - Tuesday 20 May 2014 17:30

Presenter: Dr. POPESCU, Lucia (SCK-CEN)

Worldwide several efforts are underway to increase the intensities of radioactive ion beams at an ISOL facility by several orders of magnitude. One of the approaches is based on increasing the power of the primary beam on target. For this, issues have to be solved on target design and target material, which should be capable of withstanding reliably high beam-power deposition over long periods of time. This becomes especially important at a facility such as ISOL@MYRRHA, since the scientific program of this envisaged facility is based exclusively on experiments requiring long periods of operation without interruption.

This presentation will discuss the concept developed at SCK•CEN for a high-power ISOL target for the production of radioactive ion beams at next-generation proton-based ISOL facilities. The concept is based on the flow of refractory-powder material under the continuous irradiation with a proton beam. Results of our feasibility study will be presented covering multiple aspects: particle-flow calculations, mass-flow rates, powder-density distribution, beam-power deposition, temperature profile, in-target production rates calculations, release-efficiency analysis, expected yields and overall expected performance of the system.

The main advantages of this concept, as concluded from the feasibility study, are: the possibility to increase the primary-beam power on target to unprecedented levels, faster release of the produced isotopes, the large variety of the produced RIBs since any refractory compounds can be used, and the expected long operation periods, increasing the overall RIB production at the facility and reducing the radioactive waste inventory.

EURISOL, with its high primary-beam intensities going to powers in the Megawatt range, is another interesting project to apply this target concept.

Design and test of a graphite target system for in-flight fragment separator

HPTW Poster Session & Reception - Board: 110 - Tuesday 20 May 2014 17:30

Presenter: Dr. KIM, Jong-Won (Institute for Basic Science)

A graphite target system to produce rare isotope beams using in-flight fragmentation method has been designed for the rare isotope science project in Korea. A main primary beam to bombard the target is 238U in the energy of 200 MeV/u with the maximum power of 400 kW, in which beam power deposit on the target amounts up to 100 kW. A multi-slice target concept was adopted to enhance the radiation cooling effect. A finite element program ANSYS was used to analyze thermo-mechanical behavior of single and multi-slice targets. To validate the design, electron beam at the energy of 50 keV was used to test a single slice target. A good agreement of hot spot temperature was achieved between simulation and measurement. Results of simulation and electron beam simulations will be presented along with a plan to test multi-slice targets.

Behaviors of transmutation elements Ca, Ti, Sc in ferritic-martensitic steel under mixed spectrum irradiation of high energy protons and spallation neutrons

HPTW Poster Session & Reception - Board: 201 - Tuesday 20 May 2014 17:30

Presenter: Dr. KUKSENKO, Viacheslav (Paul Scherrer Institute/University of Oxford)

Ferritic-martensitic steel F82H was irradiated in a mixed proton-neutron spectra in the Swiss spallation neutron source SINQ up to 20.3 dpa at 345°C. Atom Probe Tomography (APT) investigations were performed in order to study the atomic scale evolution of the microstructure of the F82H steel under irradiation.

The irradiation led to the production of about 370 appm of Ca, 90 appm of Sc and 800 appm of Ti. APT experiments revealed that regardless their low bulk concentrations, the spallation products are involved in the microstructural evolution of the steel under irradiation: formation of radiation-induced clusters, segregation at the dislocation loops and alteration of the microchemistry of carbides.

A quantitative description of the observed features will be presented and results will be compared with TEM data of the literature obtained on the same steel and under similar irradiation conditions.

Beryllium material tests: HiRadMat windows and NOvA fins

HPTW Poster Session & Reception - Board: 202 - Tuesday 20 May 2014 17:30

Presenter: ATHERTON, Andrew (STFC RAL); Dr. AMMIGAN, Kavin (Fermi National Accelerator Laboratory); HARTSELL, Brian (FNAL)

Beryllium is currently widely used in various accelerator beam lines and target facilities as material for beam windows, and to a lesser extent, particle production targets. With plans to increase beam intensities in future accelerator facilities, such as the PIP-II driven Long Baseline Neutrino Experiment (LBNE) at Fermilab, it is essential to take full advantage of the high temperature/strain rate plastic response of beryllium and identify material dynamic limits to avoid compromising particle production efficiency by limiting beam parameters. As a result, an experiment is being designed to investigate the failure mechanisms, limits and flow behavior of several commercial grades of beryllium exposed to intense pulsed proton beams at CERN's HiRadMat facility. The main objectives of this investigation, overview of the experimental set-up, and expected measurements and findings will be presented. A long term in-beam test of Beryllium is also planned using the NOvA MET-02 target. Preparations for inserting beryllium fins in the target will be presented including thermal and structural simulations of beam heating and physical testing using the MET-02 target components.

Materials in Extreme Environments at ELI-NP

HPTW Poster Session & Reception - Board: 203 - Tuesday 20 May 2014 17:30

Presenter: Dr. ASAVEI, Theodor (ELI-NP)

The ELI-NP (Extreme Light Infrastructure -Nuclear Physics) facility, currently under construction in Magurele, Romania, will make possible experiments with high power lasers with peak powers of 100 TW, 1PW and 10PW.
One of ELI-NP research direction will focus on the field of materials in high radiation fields, temperature and pressure conditions, taking advantage of the ultrashort time scales of secondary radiation pulses and the relatively broadband spectrum of radiation, complementary to the traditional nuclear physics research laboratories. Further specificity of the proposed experimental environment for tests at ELI-NP is that it simultaneously provides two or more types of radiation at the same time and on the same target. The planned radiation beams at the beginning at the ELI-NP operation will be: photon radiation (maximum energy of 19 MeV and maximum intensity 10^9 photon/pulse), laser driven electron beam (maximum energy 2 GeV and maximum intensity 10^8 e/pulse), laser driven proton and ion beams (maximum energy 100 MeV and maximum intensity 10^9 p/pulse) and laser driven neutron source (maximum energy 20 MeV and maximum intensity 10^7 n/pulse).
The study of materials behaviour in extreme environments will be a central topic, with a direct application to the development of accelerator components, understanding of structural materials degradation in next generation fusion and fission reactors or the shielding of equipment and human missions in deep space missions. Testing of novel materials for accelerator components at the future high–power facilities like FAIR, High Lumi-LHC, FRIB, neutrino factories and ESS in conditions of radiation, temperature and pressure reproducing operation scenarios would be possible by using "cocktails" of laser driven particles and laser induced shock waves. ELI-NP through experimental areas E5 (1PW at a repetition rate of 1Hz) and E4 (100TW at a repetition rate of 10Hz) offers an unique testing facility complementary to accelerator irradiation. The availability of two high-intensity short-pulse lasers would enable pump-probe experiments using laser based diagnostic enabling structural degradation studies during irradiation on a much finer time scale.

Nano-Indentation study of radiation damage induced by swift heavy ions in HOPG and polycrystalline graphite

HPTW Poster Session & Reception - Board: 204 - Tuesday 20 May 2014 17:30

Presenter: Mr. HUBERT, Christian (TU-Darmstadt / GSI Helmholtzzentrum für Schwerionenforschung)

Operation under intense radiation damage conditions and thermo-mechanical loads is common for both targets and beam protection components for high power particle accelerators like FAIR (Facility for Antiproton and Ion Research) which is currently under construction in Darmstadt, Germany. To ensure safe operation and less frequent maintenance shut-down's related to beam catchers and targets, optimized material and design solutions are needed. Due to its low atomic number combined with very good and stable thermo-physical properties and with its high radiation hardness, graphite and other carbon based materials are possible candidates for beam dumps and targets. We used nano-indentation to characterize the radiation induced embrittlement in carbon based materials. HOPG (highly oriented pyrolytic graphite) and high density isotropic graphite samples have been exposed to 3,6 MeV/u 197Au25+ and 4,8 MeV/u 238U29+ ion beams at the M-branch facility using fluxes of 5e8 ions/cm²s up to 2e10 ions/cm²s, at the UNILAC accelerator at GSI. Typical pulse lengths for 197Au25+ were 5ms @ 30Hz - 50Hz and 500µs @ 0,1JHz - 2Hz for 238U29+. Fluences between 1e11 ions/cm² and 5e13 ions/cm² were achieved. A general increase of young modulus and surface hardness with increasing ion-fluence can be observed for both HOPG and isotropic polycrystalline graphite samples.

Mu2e Target Station design and radiation levels

HPTW Poster Session & Reception - Board: 205 - Tuesday 20 May 2014 17:30

Presenter: Dr. PRONSKIKH, Vitaly (Fermilab)

One of the main parts of the Mu2e experimental setup is its Target Station in which negative pions are generated in interactions of the 8-GeV primary proton beam with a tungsten target; a large-aperture 5-T superconducting production solenoid (PS) enhances pion collection. The heat and radiation shield (HRS) is a 33 ton water-cooled bronze shield which protects the PS coils and the first TS coils from interactions from the production target located inside the PS.The HRS protects the PS and the first TS coils; the beam dump absorbs the spent beam. In order for the PS superconducting magnet to operate reliably the sophisticated HRS was designed and optimized for the performance and cost. The beam dump was designed to both accumulate the spent beam and keep its temperature and air activation in the hall at the allowable level. Comprehensive MARS15 simulations have been carried out to optimize all the parts while keeping the maximum muon yield. To determine the magnitude of the DPA damage effect on the residual resistivity ratio RRR) as well as the annealing cycle of PS, calculations have been done involving recent KEK measurements with Al and Cu samples. Prompt and residual radiation dose levels in and outside the Mu2e building are determined. MARS15 results on neutron fluxes and energy spectra are compared those from the MCNPX code. Results of simulations of critical radiation quantities and their implications on the overall Target Station design will be discussed.

Post-Irradiation Examination Capabilities at PNNL Relevant to Target and Window Materials

HPTW Poster Session & Reception - Board: 206 - Tuesday 20 May 2014 17:30

Presenter: Dr. SENOR, David (Pacific Northwest National Laboratory)

The Pacific Northwest National Laboratory has a number of facilities and capabilities that are relevant to post-irradiation examination of high power accelerator target and window materials such as graphite, beryllium, and Ti-base alloys. The Radiochemical Processing Laboratory contains a variety of shielded hot cell facilities routinely used for cask handling, experiment disassembly, visual inspection, gamma spectroscopy, metallographic sample preparation, chemical analysis, and thermal and mechanical property measurement. Small samples can be prepared in the hot cells to enable more specialized analyses in shielded gloveboxes and fume hoods including optical, scanning, and transmission electron microscopy, energy- and wavelength-dispersive x-ray spectroscopy, electron backscatter diffraction, x-ray diffraction, hydrogen and helium isotope assay, surface science such as Auger electron spectroscopy, x-ray photoelectron spectroscopy and Fourier transform infrared spectroscopy. Complementary radiological capabilities in the Materials Science and Technology Laboratory include additional scanning and transmission electron microscopes, a focused ion beam for micro-scale sample preparation, load frames for mechanical property measurements, immersion density apparatus, and autoclaves for corrosion testing. The poster will highlight relevant capabilities and provide examples of work from fission and fusion reactor materials irradiation experiments.

DPA Calculational Methodologies Used in Fission and Fusion Reactor Materials Applications

HPTW Poster Session & Reception - Board: 207 - Tuesday 20 May 2014 17:30

Presenter: Mr. WOOTAN, David (Pacific Northwest National Laboratory)

Well-developed methodologies have been extensively applied to predicting radiation damage in materials for the neutron irradiation environments typically encountered in reactor test irradiations. Decades of reactor experience have resulted in standardized methods. An example is the ASTM standard dpa cross section for iron based reactor materials based on the traditional NRT-dpa model. Folding of calculated neutron energy spectra with neutron damage cross sections derived from ENDF/B evaluations as a function of accumulated neutron fluence is a typical application in reactors. Various dpa methodologies have been proposed in an attempt to correlate reactor irradiations in various neutron spectra and with the much higher damage rates in charged particle irradiations. Methods applied for neutron irradiation of reactor materials will be compared to methods used for charged particle irradiations. The basics of these techniques will be described, along with some of the limitations of the methodologies for predicting material behavior. The use of MCNPX in calculating the radiation environments, dpa, and gas production in both nuclear reactor and charged particle irradiations will be described.

A LIFETIME ESTIMATION OF THE IFMIF LITHIUM TARGET BAYONET BACKPLATE BASED ON PSEUDO-TRANSIENT ANALYSIS OF IRRADIATION-INDUCED SWELLING EFFECT

HPTW Poster Session & Reception - Board: 208 - Tuesday 20 May 2014 17:30

Presenter: BERNARDI, Davide (ENEA)

In the framework of European fusion activities, a high flux neutron source is considered an essential device for testing candidate materials under irradiation conditions typical of future fusion power reactors. To this purpose, IFMIF (International Fusion Materials Irradiation Facility) project represents an important option to provide the fusion community with a source capable of irradiating materials samples at a rate of up to 20 dpa/fpy in a volume of 0.5 l. This is achieved by bombarding a high-speed liquid lithium target with a 10 MW double deuteron beam which yields a 14 MeV-peaked neutron spectrum. Within the engineering design work of the IFMIF/EVEDA project, which was concluded in half 2013, ENEA was in charge of the design of the lithium target system based on the so called bayonet backplate (BP) concept, which foresees the possibility to periodically replace only the most irradiated and thus critical component (i.e., the backplate) while continuing to operate the rest of the target for a longer period. With the objective of estimating the lifetime of the BP, a pseudo-transient calculation simulating one year of full-power operation has been performed by imposing a non-uniform neutron-induced volumetric swelling strain which evolves in time as a linear function of the accumulated displacement damage (dpa) according to available literature experimental correlations. Dpa damage distribution and time rate have been calculated by ENEA in the framework of an extensive neutronic analysis of the target system carried out through the MCNP transport code. The stress field evolution resulting from the increasing swelling deformation has been obtained through an uncoupled thermomechanical analysis carried out by the University of Palermo using a qualified finite-element code which takes into account all thermal and mechanical loads applied to the system during normal operation.

In this paper, the results of the above analysis are presented and an estimation of the BP lifetime due to swelling effect is given on the basis of ITER design rules criteria. It is found that, although the bulk structure of the BP is expected to survive several months of continuous irradiation, a further improvement of the system design is suggested in order to achieve an optimized configuration.

A Fusion Materials Irradiation Test Station at the Spallation Neutron Source

HPTW Poster Session & Reception - Board: 209 - Tuesday 20 May 2014 17:30

Presenter: Dr. MCCLINTOCK, David (Oak Ridge National Laboratory)

It has long been recognized by the nuclear materials research community that facilities suitable for irradiation studies relevant to envisioned fusion power systems are lacking. Therefore, efforts are underway at the Spallation Neutron Source (SNS) to design an irradiation facility at the beam entrance region of the SNS target module for materials science research in support of fusion energy technologies. The unique mixed spectrum of high-energy protons and spallation neutrons at the SNS permits exposure to several different irradiation parameters of interest to the fusion materials community. For example, since the He production rate is heavily dependent on the proton fluence, the He production rates can be customized for each experiment; with He gas production to displacement ratios ranging from 13-75 appm He/dpa for steel and 30-98 appm He/dpa for SiC. The current design of the Fusion Materials Irradiation Test Station (FMITS) consists of two specimen-containing tubes along the front of the SNS target module located above and below the vertical mid-plane. Each specimen tube contains an inner tube surrounded by a water-cooled jacket and an inner tube that is cooled by flowing mixed inert gases, which are used to establish and maintain the target irradiation temperature. Thermal analysis indicate maximum specimen temperatures ranging from 650°C to 1300°C could be achieved using the mixed-gas temperature control system. This poster describes some of the basic features of the FMITS irradiation assembly, including hardware configuration and achievable irradiation parameters.

Lead Bismuth Free Surface Target for High Intensity Proton Beam Application

HPTW Poster Session & Reception - Board: 301 - Tuesday 20 May 2014 17:30

Presenter: Ms. FETZER, Jana R. (Karlsruhe Institute of Technology (KIT))

A Lead-bismuth cooled accelerator driven system (ADS) is considered as a promising option for the transmutation of long lived nuclear waste into short lived or stable isotopes. In this type of reactor a subcritical core is used receiving the required neutrons for the nuclear reaction by spallation using a high power proton beam from an accelerator. At the entry point of the reactor pool where the beam impinges on the surface of the liquid metal, which simultaneously acts as the target material, special construction effort is indispensable to handle the high heat production.
In order to demonstrate the ADS concept, the Multi-purpose hybrid Research Reactor for High-tech Applications (MYRRHA) is currently under design at Mol/Belgium. One of the proposed targets for this reactor is a free surface target, based on a ring like liquid metal curtain, converging into a liquid metal jet by surface tension effects, and thus forming an inner and an outer free surface. The inner surface is then subjected to the 2.4MW proton beam, while the curtain maintains the separation between beam line and reactor pool.
A near full scale prototype of this target design has been set up and experimentally investigated at the Karlsruhe Liquid Metal Laboratory (KALLA) at the Karlsruhe Institute of Technology (KIT). Measurements at different flow rates of up to 30m^3/h show a stable surface in a wide range of operating conditions. In addition, the exact inner and outer shape of the conical surfaces were detected by image processing and depth of field information. Comparison with numerical precalculations using commercial CFD code Star-CD and Star-CCM+ show a very good agreement of experimental and numerical data.

G-2 ANSYS Mechanical Simulation for Lithium Lens

HPTW Poster Session & Reception - Board: 302 - Tuesday 20 May 2014 17:30

Presenter: SCHULTZ, Ryan (Fermilab)

Lithium Collection Lenses were used to collect anti-protons for decades during the Tevatron collider run at Fermilab. This investigation looks at using the same Lithium Lens design for future use for muon production during the g-2 experiment at Fermilab; where thermal loading is much less per pulse, but the repetition rate is much higher. A transient ANSYS analysis was performed comparing the two cases. Results and failure modes are presented along with some special operating conditions that are possible with the g-2 timeline.

Jet Flow Target Module Design, Analysis, and Testing

HPTW Poster Session & Reception - Board: 303 - Tuesday 20 May 2014 17:30

Presenter: Mr. WINDER, Drew (Oak Ridge National Laboratory)

The Spallation Neutron Source at the Oak Ridge National Laboratory produces neutrons by striking a target containing mercury with a pulsed proton beam. Examination of used targets shows that the innermost surface of the vessel where the proton beam strikes has a significant amount of damage due to mercury cavitation. The target also has an outer thin window flow channel which does not show significant cavitation damage. This lack of damage has two possible causes; the flow condition of the mercury and the thin width of the flow channel. Previous testing as LANSCE has also shown a link between flow condition and cavitation damage.
The target vessel design was modified to improve the flow condition on the inner surface of the vessel. A new design has been developed which diverts some of the bulk mercury flow into a wall jet which sweeps over the inner surface. Numerical simulations were used to develop a target design which balanced the jet flow and bulk mercury flow and provided a stable wall jet. The final design produces a flow condition across the inner surface of the target wall which mimics the near-wall velocity distribution in the channel where no significant damage has been found.
A test apparatus using water flowing in an acrylic vessel has been used to verify the predicted flow. Water allows for visual tracking of bubbles introduced into the flow. High speed videography of these bubbles has shown that the jet flow velocity agrees within 10% of the values predicted by simulation.

Simulations of Particle Impacts on Beam Intercepting Devices and Methods for an Experimental Characterization

HPTW Poster Session & Reception - Board: 304 - Tuesday 20 May 2014 17:30

Presenter: CARRA, Federico (CERN)

In recent years, state-of-the-art numerical methods, involving the use of Autodyn and LS-Dyna wave propagation codes, have been developed at CERN and at Politecnico di Torino in order to simulate the impact of a particle beam on solid accelerator devices such as collimators, windows, targets, dumps and absorbers. These methods were adopted by the authors in 2011 to analyze the consequences of an asynchronous beam abort on LHC Tungsten Collimators (TCT). In order to validate the material constitutive models, in 2012 and 2013 a vast characterization campaign has been launched, entailing advanced beam impact tests in the HiRadMat facility and high-speed mechanical measurements at Politecnico di Torino with the Hopkinson bar setup. The experiments confirmed the effectiveness of numerical methods to reliably predict beam-induced damages, also allowing to improve the material models. New simulations were then performed, adopting the refined material models and the updated accident scenarios; damage limits were also redefined, to identify the threshold of incipient plastic damage on the tungsten jaw.

Assessment of the beam–target interaction of IFMIF: A state of the art

HPTW Poster Session & Reception - Board: 305 - Tuesday 20 May 2014 17:30

Presenter: Dr. NITTI, Francesco Saverio (ENEA); Mr. MICCICHÈ, Gioacchino (ENEA); Dr. BERNARDI, Davide (ENEA); Dr. GROESCHEL, Friedrich (Karlsruher Institut fuer Technologie); Dr. IBARRA, Angel (CIEMAT)

The main requirement for an efficient and safe operation of the IFMIF plant is the stability of the Li jet. The stability is related to the thermohydraulic behaviour and can be affected by the beam–target interaction. The waviness of the jet must stay within rather narrow limits to protect the backwall from beam impact and to maintain stable irradiation conditions in the test modules. Thermal and momentum transfer of the beam may destabilize the flow structure, cause shock waves and increased evaporation or aerosol formation. Different aspects of beam interaction have been analyzed in the past, but a comprehensive assessment is still lacking. This contribution provides an overview of the IFMIF related beam–free lithium surface interaction studies including a description of the underlying basics. As it comes out from numerical analyses that the impact of thermal expansion and of the momentum transfer caused by the beam are still small enough to be ineffective for constructive interferences, beam–target interaction is not to be expected to have a critical impact on jet stability.

Uniform irradiation of an extended target by high power beam.

HPTW Poster Session & Reception - Board: 401 - Tuesday 20 May 2014 17:30

Presenter: Dr. TSOUPAS, Nicholaos (BNL)

As part of the Accelerator Driven Subcritical Reactor project at BNL, high power beams are crucial to increase the neutron production of the spallation target. To minimize the stresses on the target and on the vacuum window, which separates the optical elements of the beam delivery system from the target region, we propose to expand the beam and uniformly distribute it over the target area. In this talk we will present a well proven method which uses higher order beam optics to accomplish beam uniformity and also allows to control the beam halo along the delivery line.

SEM Grid Profile Monitors for Megawatt Proton Beams

HPTW Poster Session & Reception - Board: 402 - Tuesday 20 May 2014 17:30

Presenter: Mr. TASSOTTO, Gianni (FNAL)

Profile Monitors providing precision measurement of beam profile distributions are essential for transport and targeting of high intensity proton beams. We describe here the SEM grid monitors developed for the 0.4 – 0.7 MW NuMI proton beam, along with the development process leading to the current monitor design. We also provide details of their utilization in the NuMI beam, along with extensive performance results. Finally, we provide design and performance details to date for monitors which should work well in 2+ MW proton beams.

Machine Protection Strategy for the ESS Target Station

HPTW Poster Session & Reception - Board: 403 - Tuesday 20 May 2014 17:30

Presenter: SHEA, Thomas (ESS)

The ESS linear accelerator will deliver a 5 MW, low-emittance proton beam directly to the target station. To limit power density, a transport line expands this beam to centimetre scale and rasters this expanded beam across the target surface. This technique produces a reasonably uniform current density that enables a five year service life for the rotating tungsten target and a 6 month service life for the upstream proton beam window. Conversely, the beam's low emittance allows an errant spot size small enough to damage target station components within a single 2.86 millisecond pulse. A suite of instrumentation systems located within the target monolith and also upstream in the transport line will detect errant conditions and via the Beam Interlock System, suppress beam production. This presentation will introduce the primary causes of damaging beam properties, and describe the measurement techniques that will detect them promptly enough to mitigate component damage.

Operational Experience of a High-Intensity Accelerator-based Neutron Source Based on a Liquid-Lithium Target

HPTW Poster Session & Reception - Board: 501 - Tuesday 20 May 2014 17:30

Presenter: Dr. SILVERMAN, Ido (Soreq)

A prototype of a compact Liquid Lithium Target (LiLiT), able to constitute an intense accelerator-based neutron source was successfully tested for the first time with an intense 1.9 MeV, 1.3 mA (~2.5 kW) continuous-wave proton beam. The high-power liquid-lithium target is designed to produce neutrons through the 7Li(p,n)7Be reaction and to overcome the major problem of removing the thermal power generated by the proton beam at high intensity (1.91-2.5 MeV, >3 mA). Gold activation targets positioned in the forward direction show that the average neutron intensity during the experiment was ~2×1010 neutrons/s. The device will be used to assess the feasibility of accelerator-based Boron Neutron Capture Therapy (BNCT) with a lithium target and for research in stellar and Big-Bang nucleosynthesis and Accelerator Driven Systems (ADS) material cross section measurements.

The liquid-lithium jet acts both as neutron-producing target and as a beam dump, by removing with fast transport the thermal power generated by high-intensity proton beams. It has been designed to generate a stable lithium jet at high velocity on a concave supporting wall with free surface toward the incident proton beam (up to 10 kW). Of specific concern is the power densities created by the protons at the Bragg peak area, of the order of 1 MW/cm3 (volume power density), about 150 μm deep inside the lithium. Radiological risks due to the 7Be produced in the reaction will be handled though cold trap and appropriate shielding. Fire safety issues are taken care by multiple layers of passive and active safety devices.

Status of the FAIR pbar target and separator

HPTW Poster Session & Reception - Board: 502 - Tuesday 20 May 2014 17:30

Presenter: Dr. KNIE, Klaus (GSI)

In the future FAIR facility at GSI in Darmstadt, Germany, a multitude of experiments with an antiproton beam is foreseen. It is planned to produce these antiprotons in a collision of a primary proton beam with a metal target. A Ni rod will be bombarded with a pulsed beam of 29 GeV protons with an intensity of 2.5E13 ppp and a repetition rate of 0.2 Hz. Directely after the target the antiprotons will be focussed by a magnetic horn operated with an current of 400 kA. In the proceeding magnetic separator antiprotons with an energy of 3 GeV (+-3%) will be selected and transported to the collector ring for cooling. The setup of the target and separator area, including radiation protection issues, will be presented.

Radiation protection studies for the design of the CERN Neutrino Facility (CENF)

HPTW Poster Session & Reception - Board: 503 - Tuesday 20 May 2014 17:30

Presenter: Dr. STRABEL, Claudia (CERN)

A short-baseline CERN Neutrino Facility (CENF) has been proposed in which a high-intensity 100 GeV proton beam with a beam power of up to 200 kW will be directed to a new fixed target complex in the North Area of the CERN Prévessin site. The target complex will be located underground at a depth of 15 m and contains, in addition to the production target itself, a focusing system, a decay tunnel and a subsequent beam dump & hadron absorber. The produced neutrinos will then be measured with a near and far detector both located within CERN territory at 460m and 1600m from the target, respectively.
In order to respect the applicable CERN radiation protection legislation regarding doses to personnel as well as the environmental impact, a full radiological assessment of the CENF facility has been carried out. Studies include expected prompt and residual dose rates in the various accessible areas of CENF as well as the effect of the stray radiation on the surrounding experimental and public areas. Furthermore, the risk due to activated air and the consequence of its release into the environment has been evaluated. Finally, studies on ground activation, radioactive waste zoning and radiation exposure of equipment have also been conducted. All studies are based on simulations using the FLUKA Monte Carlo particle transport code.
The results of the radiological assessment, which allowed a careful optimization of the CENF design with regard to radiation protection, will be presented.

Target Station Design for Neutrino Superbeams

HPTW Poster Session & Reception - Board: 505 - Tuesday 20 May 2014 17:30

Presenter: Mr. WILCOX, Dan (RAL)

A conceptual design is presented for the target station and remote handling system of a multi-MW neutrino facility. This was originally developed for the EUROnu Super Beam study, which proposed a 4MW beam delivered to 4x 1MW pebble-bed targets operating in parallel. The target station was designed to cope with the unique demands of this 4 target arrangement, as well as challenges such as high activity and remote handling which are common to any high power facility. Although the EUROnu SB study has come to an end, many of the concepts developed here will be relevant to other current and proposed neutrino facilities.
EUROnu would have required construction of a completely new target station; this allowed every part of the facility to be designed and optimised from the ground up. The emphasis was on maximising uptime and ensuring safety, while minimising the costs of construction, operation and maintenance. The design concept was based on the target station of T2K, which was designed for comparable levels of beam power and activation and has been in operation for several years. The knowledge and practical experience gained from T2K were considered throughout the design process.

Mu2e Production Target Remote Handling

HPTW Poster Session & Reception - Board: 506 - Tuesday 20 May 2014 17:30

Presenter: Mr. CAMPBELL, Michael (FNAL)

The CD-2 conceptual design for the Mu2e production target remote handling system will be a robotic machine that is capable of performing the target exchange autonomously. After entering the target hall from the side through a sliding/shielded door, the robot is being designed to perform the following tasks: locate and remove the target access window from the end of the vacuum chamber, place that window into a radioactive storage cask, reach forward 12 feet to remove the target from inside the vacuum chamber, place that target into the cask, retrieve a new target and reach out 12 feet again to install it into the vacuum chamber, retrieve a new access window and install onto the end of the vacuum chamber, then exit the room. These tasks are to be accomplished using a machine-vision guidance system, along with several motorized and pneumatically operated motions. The presentation will provide a detailed description of the robotic system design and will include many pictures from the 3D CAD model.

A High-Power Target system for the Production of Intense Muon Beams

HPTW Poster Session & Reception - Board: 507 - Tuesday 20 May 2014 17:30

Presenter: Prof. MCDONALD, Kirk (Princeton University)

We describe a solenoid capture system suitable for producing an intense muon beam for eventual injection into either a neutrino factory storage ring or a muon collider ring. This arrangement allows for the capture and transport of muons of both charge states. An initial configuration featuring a low-Z solid target is envisioned for a 1-MW proton driver beam, while maintaining an upgrade path to 4-MW operation, perhaps with a liquid-jet target.

Radiological Calculations on the LBNE Neutrino Beamline

HPTW Poster Session & Reception - Board: 508 - Tuesday 20 May 2014 17:30

Presenter: Dr. REITZNER, Diane (FNAL)

The Long Baseline Neutrino Experiment (LBNE) will deliver a high intensity neutrino beam from Fermilab to a detector 1300 km away in South Dakota. The neutrino beam will be produced from the decays of pions and kaons generated from a 120 GeV proton beam incident on a 95 cm long graphite target.
To operate this facility over a twenty year period at a proposed 2.3 MW beam power requires extensive radiological calculations during the design process. Radioactivation and shielding calculations on the LBNE target hall and decay pipe facilities will be presented. The input to these calculations are based on results from a simulation using the MARS15 code.

Tritium Mitigation for the LBNE Beamline

HPTW Poster Session & Reception - Board: 509 - Tuesday 20 May 2014 17:30

Presenter: Dr. REITZNER, Diane (FNAL)

The production of tritium is a radiological concern in the operation of the Long Baseline Neutrino Experiment (LBNE) beamline. This experiment aims to send a high intensity neutrino beam from Fermilab to a detector located approximately 1300 km away in South Dakota. The high power 120 GeV proton beam incident on a 95 cm graphite target will produce significant amounts of tritium in and around the target hall facilities.
Although sufficient shielding can minimize the amount of tritium generated in the environment, tritium's mobility requires special care in designing the beamline facilities. Sufficient precautions can minimize the transfer to the enviroment of tritium generated in the concrete shielding.
Tritium which is either generated in or transfered to fluid or gasseous mediums needs to be either contained or released in a manner which will not violate any State or Federal environmental regulations.
Presented will be an overview of the predicted impact of tritium on the LBNE beamline and the methods that will be used to manage the exposure of the environment.

Proposals for ISIS Target Station 1 upgrade

HPTW Poster Session & Reception - Board: 510 - Tuesday 20 May 2014 17:30

Presenter: Mr. GALLIMORE, Stephen (Science and Technology Facilities Council); Mr. SOUZA, Colin (Science and Technology Facilities Council)

From the original vision over 30 years ago, ISIS has become one of the UK’s major scientific achievements. It is a world-leading centre for research in the physical and life sciences at the STFC Rutherford Appleton Laboratory near Oxford in the UK. The suite of neutron and muon instruments gives unique insights into the properties of materials on the atomic scale. ISIS supports a national and international community of more than 3000 scientists for research into subject ranging from clean energy and the environment, pharmaceuticals and healthcare, through to nanotechnology and materials engineering, catalysis and polymers and on to fundamental studies of materials.
With the knowledge and computational tools now available it is widely believed that the useful neutronic output of the ISIS First Target Station (TS1) can be significantly improved. There is a current project to assess the feasibility of this proposal. The overall aim is to have the implementation phase of the project complete by 2019.
This poster will cover some of the proposals and work carried out as part of the feasibility phase of this upgrade project.

New Sorgentina Fusion Source (NSFS) Experimental Facility Supporting Materials Research

HPTW Poster Session & Reception - Board: 511 - Tuesday 20 May 2014 17:30

Presenter: Mr. CONSOLE CAMPRINI, Patrizio (ENEA National Agency for New Technologies, Energy and Sustainable Economic Development)

Within the framework of fusion technology research and development, a neutron source has long been considered a key facility to perform irradiation tests aiming at populating materials engineering database – supporting DEMO reactor design and licensing. New Sorgentina Fusion Source (NSFS) has been proposed taking advantage of well-established D-T neutron generators technology, properly scaled in order to attain a bright source of some 1015 n/sec - with an actual 14 MeV neutron spectrum as relevant feature. Ion beams of 30 A are produced and accelerated up to some 200 keV energy. Present design envisages ion generators and extraction grid technology employed in neutral injectors currently utilized at large experimental tokamaks. Then deuterium and tritium ion beams are delivered to the target impinging on a hydride thin layer which is on-line D-T reloaded. Metal hydride is continuously re-deposited preventing layer from being sputtered and increasing installation load factor. Large and fast rotating target is conceived to enhance heat removal - coping with thermal transients and mechanical loads. Design features achieve high performances withstanding elevated heat flux of some tens kW/cm2 and significant thermal fatigue concerns. Main facility characteristics are provided, as well as target thermal and mechanical issues.