3rd CERN Baltic Conference (CBC 2023)

Monday, 9 October 2023 - Wednesday, 11 October 2023

Riga Technical University

Book of Abstracts

Contents

1

Analytical pencil beam dose and dose-rate engine development for FLASH therapy studies of heavy ion and very high energy electron beams

Author: Kristaps Palskis[1]

Co-authors: Joao Seco [2]; Mariusz Sapinski [3]; Maurizio Vretenar [4]; Toms Torims [5]

[1] *Riga Technical University (LV)*

[2] *German Cancer Research Center (DKFZ)*

[3] *Paul Scherrer Institute (CH)*

[4] *CERN*

[5] *Riga Technical University*

Corresponding Authors: mariusz.sapinski@cern.ch, toms.torims@rtu.lv, maurizio.vretenar@cern.ch, j.seco@dkfz.de, kristaps.palskis@rtu.lv

Background: With the growing interest of ultra-high dose rate therapy (FLASH-RT) different ionizing particle beams have been considered. With most of the experimental results acquired with electron or photon beams, knowledge on heavier ion use remains sparse.
Our previous work has developed a model for FLASH effect dose threshold estimation. Our results have suggested that, FLASH-RT could be more feasible with lighter ions such as lithium, helium and protons, as well as other low linear energy transfer (LET) particles –such as very high energy electrons (VHEE).
As our previous work has focused only single field irradiation modelling, multi-field treatment plan studies are of high clinical relevance, as well as characterization of dose rate parameters for technological delivery considerations is needed. Thus, necessity for a dose and dose-rate engine for the investigated particles is clearly indicated.
Aims: Primarily, to create an analytical pencil beam dose and dose-rate calculation engine for heavy ion and very high energy electron beams. Secondarily, to investigate and compare different analytical characterization approaches for different dosimetric parameters.
Methods: Monte Carlo simulations were performed in Geant4 environment to create an "experimental beam dataset"for protons, helium-3, helium-4, lithium-6, lithium-7 and carbon ions, as well as electrons for clinically relevant energies, as well as transmission-level energies. Analytical characterization was then performed on the acquired dataset of the pristine pencil beams. For integrated depth dose, different normalization options were investigated for efficient calculations. For lateral dose profile, various fitting functions were investigated and quality of fit was compared.
Physical implementation for a treatment planning system was then investigated, while focusing also on the different dose-rate definitions for FLASH-RT.
Conclusions: Depth normalization to dose maximum and practical range for ion and electron beams, respectively, proved to be most efficient integrated depth dose parametrization options. As for lateral dose profile - a sum of either three gaussian or two gaussian and one logistic function proved to be best approximations for ions, while a sum of double logistic and gaussian function –for VHEE.
The developed engine is sufficient and will be crucial for further comparison studies on ion FLASH-RT delivery methods.

Type of contribution:

Talk

2

Baltic particle therapy center initiative: status report, lessons learned and next steps

Authors: Diana Adliene[None]; Erika Korobeinikova[1]; Kristaps Palskis[2]; Maurizio Vretenar[3]; Toms Torims[4]

[1] *Lithuanian Society for Radiation Therapy / Lithuanian University of Health Sciences*

[2] *Riga Technical University (LV)*

[3] *CERN*

[4] *Riga Technical University*

Corresponding Authors: diana.adliene@ktu.lt, erikakorobeinikova@gmail.com, kristaps.palskis@rtu.lv, maurizio.vretenar@cern.ch, toms.torims@rtu.lv

Background: In the recent years, with the active work of CERN Baltic Group in close collaboration with scientists from Next Ion Medical Machine Study (NIMMS) group of the European Organization for Nuclear Research (CERN), an initiative has been started for an innovative particle therapy center in the Baltic States. To fulfill the initiative, a dedicated working group "Advanced Particle Therapy center for the Baltic States"was developed within the framework of CERN Baltic Group. Conceptual report for the proposed facility was developed in Spring of 2022, followed by active engagement with political, scientific and medical community stakeholders. At the end of 2022, bi-lateral meetings between the initiative working group and stakeholders were held at each of the Baltic States, highlighting the areas that need to be developed and explored in more detail, proposed as further steps in 2023.

Aims: Aim of this work is to present the current status of the initiative, focusing on reports on two key events –workshops –in 2023: "*Particle therapy - future for the Baltic States? State-of-play, synergies and challenges*"and "*Clinics and research: considerations to create a novel particle therapy center*". Key outcomes are to be indicated, while also proposing next steps of the initiative.

Contents: As indicated, work will focus on two workshops done in the framework of working group activities. Key facts, figures and considerations discussed within the events will be provided. Work will follow the multi-disciplinary principle of the workshops themselves, delving into topics of cancer statistics and medical case development, clinical indications, technological considerations, integration of nuclear medicine aspects and educational needs for personnel. Further insights from more educationally oriented "*Clinics and research: considerations to create a novel particle therapy center*"workshop will also be presented.
In conclusion, current key take-away messages after the events will be indicated, while discussing their role in future steps and planned activities of the initiative.

Type of contribution:

Talk

3

Comparison of different LINAC structures for injection into an ion therapy accelerator and parallel production of radioisotopes

Author: Lazar Nikitovic[1]

Co-authors: Maurizio Vretenar [2]; Toms Torims [3]

[1] *Riga Technical University (LV)*

[2] *CERN*

[3] *Riga Technical University*

Corresponding Authors: maurizio.vretenar@cern.ch, toms.torims@rtu.lv, lazar.nikitovic@cern.ch

In the scope of ongoing initiatives for the design of a new generation of synchrotron-based accelerators for cancer therapy with ion beams, an analysis of LINAC design has started. LINAC represents a critical element with a strong impact on the performance and cost of the accelerator complex. The goal is to identify alternatives at lower cost and a similar or possibly smaller footprint than the standard 217 MHz injector presently used in all carbon therapy facilities in Europe. As an additional feature, a new LINAC design can be tailored to produce radioisotopes for treatment and diagnostics in parallel with operation as a synchrotron injector. The possibility of moving to 352 MHz frequency has been studied. The design of Quasi-Alvarez Drift Tube LINAC (QA-DTL) as an injector LINAC for carbon ions at A/q=3 has been presented. At the same time, QA-DTL has been compared with Inter-Digital H-Mode DTL (IH-DTL) design. The option of a Separated-tank IH-DTL structure (S-IH-DTL) is also discussed, along with a standard IH-DTL, both at 352 MHz. Finally, a DTL design at 352 MHz for the injection of fully stripped helium ions into the synchrotron has been presented.

Type of contribution:

Poster

4

Mechanical design of the suspension system of superconducting elements subject to variable loads

Author: Luca Piacentini[1]

[1] *Riga Technical University (LV)*

Corresponding Author: luca.piacentini@cern.ch

This research outlines the recent progresses on the mechanical design and integration of the suspension system of superconducting elements subject to variable loads, with focus on the supports of superconducting dipoles for the rotating transfer line of a carbon ion therapy machine, the so-called gantry.
When designing suspension systems for superconducting elements subject to constant loads, the primary challenge is to strike a balance between limiting the heat load to the cold mass and ensuring proper mechanical resistance and/or stiffness of the system. This trade-off often leads engineers to choose from a limited set of materials and supporting architectures. In this presentation an overview of the different overall designs is presented.
The comprehensive design of a system that is able to withstand variable loads is of key importance for this application. Two suspension systems are proposed as viable solutions, the first being an adaptation of the eight-support architecture to rotating gantries, while the second is a novel architecture based on robotics. The methodology for the comparison of the two suspension systems is outlined. First results related to the heat-load, mechanical resistance and buckling are presented. The optimization of each of the two solutions by mean of genetic algorithm is explained and results with respect to initial manually optimized structures are shown. The performance against errors due to stiffness of components is compared as well as other advantages of one solution with respect to the other.

Type of contribution:

Poster

5

Laser Ablation of Silicon Nanoparticles for Enhanced UV Photon Sensing via Wavelength-shifting Properties

Author: Mindaugas Ilickas[1]

Co-authors: Dovilė Gimžauskaitė [2]; Liutauras Marcinauskas [3]; Mindaugas Alkas [2]; Brigita Abakevičienė [1]; Algirdas Lazauskas [1]

[1] *Kaunas University of Technology*

[2] *Lithuanian Energy Institute*

[3] *Lithuanian Energy Institute, Kaunas University of Technology*

Corresponding Authors: mindaugas.ilickas@ktu.edu, mindaugas.alkas@lei.lt, algirdas.lazauskas@ktu.lt, brigita.abakeviciene@ktu.lt, dovile.gimzauskaite@lei.lt, liutauras.marcinauskas@lei.lt

The detection of ultraviolet (UV) photons is becoming increasingly important in high energy particle physics experiments. Sensitivity to UV photons (wavelength range < 350 nm) is essential for detecting Cherenkov radiation in crystals as well as scintillation light in dark matter and neutrino experiments. Nowadays, scientists are looking for new materials for detectors that can directly detect UV photons and/or absorb them by emitting light in the visible spectrum, which can be measured using existing photon detectors without the need for an active cooling system. The materials must be thin to maintain calorimeter homogeneity, possess a significant surface area, and be impermeable to visible light to prevent the detection of scintillation light.
Silicon nanoparticles (SiNPs) are sensitive to UV light. Depending on the nanoparticle size, they absorb UV light and re-emit it at visible (>400 nm) wavelengths. The size of SiNPs can vary depending on the technological parameters of laser ablation. Therefore, it is essential to effectively control the laser ablation process in order to obtain nanoparticles of desired sizes.
We propose in this work to form colloidal solutions of SiNPs with varying sizes through silicon target laser ablation. These nanoparticles are then utilized as filters in charge-coupled device-based spectrometer configuration to enhance its sensitivity to the wavelengths <400 nm.

Type of contribution:

Poster

6

Relations between basis sets of fields in the renormalization procedure

Author: Simonas Draukšas[1]

[1] *Vilnius University (LT)*

Corresponding Author: simonas.drauksas@ff.stud.vu.lt

It seems that the literature suggests to go in two opposing directions simultaneously. On the one hand, many papers construct basis-independent quantities, since exactly these quantities appear in the expressions for observables. This means that the mixing angles such as $\tan\beta$ in the Two Higgs Doublet Model must drop out when calculating anything physical. On the other hand, there are many attempts to renormalize such mixing angles — this is in the opposite direction of basis-dependence. In terms of renormalization of mixing angles, the basis-dependent direction seems to be the far more popular one, despite the fact that there are no natural renormalization conditions and additional effort must be put in to take care of gauge-dependence and the singular degenerate mass limit. We give arguments for choosing the basis-independent direction beyond tree-level. In particular, we show that identifying bare mixing angles with the renormalized ones avoids inconsistencies, shows basis-independent features, naturally gets rid of unwanted gauge-dependence, and that the degenerate mass limit is non-singular.

Type of contribution:

Talk

7

Feasibility study of neutron spectra calculations for irradiation of materials using MCNPX in the NEAR station at CERN/n_TOF facility

Authors: Benjaminas Togobickij[1]; Gediminas Stankunas[None]

[1] *Lithuanian Energy Institute*

Corresponding Authors: gediminas.stankunas@lei.lt, benjaminas.togobickij@lei.lt

One of the few neutron spallation facilities in the world capable of delivering neutron spectra is the neutron time-of-flight facility (n_TOF). These spectra are primarily employed in conducting precise neutron-induced cross-section measurements using the time of flight technique. Since its operation began in 2001, the facility has continuously contributed to a diverse array of scientific pursuits, encompassing astrophysics, nuclear technologies, and medical applications. n_TOF produces neutrons through a 20 GeV pulsed proton beam, which is extracted from the proton synchrotron, impinging a pure lead target cooled down with nitrogen gas.

In 2021 the third irradiation area, the other two are n_TOF EAR1 and n_TOF EAR2, was constructed close to the n_TOF target, the NEAR station. The station is divided into two study locations. One of the locations is inside the shielding of the n_TOF target, which aim is to study irradiation damage of high dose (in the order of MGy) in materials. The other location, outside the shielding, which uses a collimator to convey the high-intensity neutrons to the outside area, has been incorporated to study irradiation of electronics.

In this work we introduce the capability of incorporation Monte Carlo N-particle (MCNPX) code to simulate the irradiation of materials in the NEAR station. Three locations were chosen to be irradiated in the NEAR station and neutron spectra were estimated for several moderator material compositions, which will be used during neutron capture cross section measurements by the activation method at the n_TOF NEAR Station in the upcoming years.

Type of contribution:

Poster

8

PF hadron calibration

Authors: Conrado Munoz Diaz[1]; Dace Osite[1]

[1] *Riga Technical University (LV)*

Corresponding Authors: dace.osite@cern.ch, conrado.munoz.diaz@cern.ch

To analyze high-energy collisions that occur in the CMS detector, the particles that come from these collision events need to be identified and reconstructed. This process is done by using the particle-flow (PF) reconstruction algorithm.

The energy response of the CMS detector to particles is non-linear. This effect is particularly prominent for PF hadrons. Hadrons are categorized into EH-hadrons that start their shower in the ECAL and H-hadrons starting to shower in the HCAL. In order to correct for the energy dependent effect, we define calibrated energy as functions of the energy deposited in each calorimeter corrected by an introduced parameter, as well as taking into account the true energy of the particles.

$E_{\text{calibrated}}|_{\text{EH-hadrons}} = a\ E_e + b\ E_h + 3.5\ \text{GeV}$

$E_{\text{calibrated}}|_{\text{H-hadrons}} = c\,E_h + 2.5\ \text{GeV}$

The calibration constants a, b and c are determined by an analytic χ^2 minimization, taking into account the true energy of the particles. These coefficients are obtained by simulating single pion events with the same detector conditions and low-level calibrations that are used for central collision event production in physics analyses.

Due to the calibrated energy dependence with pseudorapidity η, once the energy calibration has been done, we have to correct the residual η dependence as well. In both calibrations, it is necessary to take into account the different parts of the detector - barrel and endcap - and calibrate them separately.

Two different frameworks have been developed by the CMS collaboration to calculate the corrected energies: online and offline. Currently, they provide different results. The goal of this work is to achieve the same results for both frameworks. That is done by looking for the differences in both frameworks, and trying to make them as compatible as possible.

The calibration codes of both frameworks use some set of NTuples that contain all variables for the different events, and those NTuples seem to be different for the online and offline codes: there is a huge tail for low E_{true} when we represent the 2D histogram $(Ecal + Hcal)/E_{\text{true}}$ vs E_{true} in the case of online NTuples, that is not present for offline NTuples.

Type of contribution:

Poster

9

RTU Institute of Particle Physics and Accelerator Technologies activities in accelerator projects and additive manufacturing examination for accelerator applications

Author: Andris Ratkus[1]

[1] *Riga Technical University (LV)*

Corresponding Author: andris.ratkus@cern.ch

Riga Technical University Institute of Particle Physics and Accelerator Technology is involved in accelerator projects where our contributions are in accelerator technologies innovation and development as well as in accelerator medical applications. Our team contribute in Innovation Fostering in Accelerator Science and Technology, Heavy Ion Therapy Research and Integration plus and Next Ion Medical Machine Study projects.

Additive Manufacturing (AM) is already well-established for various manufacturing applications, providing many benefits such as design freedom, novel and complex cooling designs for the parts and different performance improvements, as well as significantly reducing the production time. All those advantages can be useful also for accelerator usage. Therefore, within the Innovation Fostering in Accelerator Science and Technology project, ongoing work is related to AM usage and evaluation for accelerator applications. Where tests were performed to ensure the Ultra High Vacuum (UHV) compatibility and the voltage holding capability of the surfaces.

UHV requirements were tested by helium leak tightness test at room temperature by using a high-sensitivity mass spectrometer for AM-built membranes. The leakage test showed that AM built 1mm wall thickness providing He leak tightness. Through this study, novel knowledge and results are provided for green laser source AM technology usage for applications for UHV accelerator components.

To characterize voltage holding capability for AM surfaces (as-built condition), a series of high electric field tests were performed on pure copper electrodes by using the CERN pulsed high-voltage

DC system. During the testing process, a high vacuum was maintained. Initial results prove the capability of AM electrodes to hold a high electric field (40 MV/m) while having low breakdown rates. These are crucial results for further AM technology usage for different AM pure-copper accelerator components.

Type of contribution:

Talk

10

Design of support structure for nozzle components in heavy ion therapy gantry

Author: Dairis Rihards Irbe[None]

Co-authors: Andris Ratkus [1]; Luca Piacentini [1]; Toms Torims [2]

[1] *Riga Technical University (LV)*

[2] *Riga Technical University*

Corresponding Authors: toms.torims@rtu.lv, dairis.rihards.irbe@cern.ch, andris.ratkus@cern.ch, luca.piacentini@cern.ch

Hadron therapy is a form of radiation therapy for cancer treatment. This cancer treatment approach shows multiple advantages to conventional radiotherapy such as higher precision, better effectiveness, minimal healthy tissue damage. Unfortunately, currently hadron therapy is hardly accessible due to complexity and high cost of infrastructure needed to accelerate and direct the beam of heavy particles. One of the most mechanically complex parts of this infrastructure, that may allow cost improvement, is machine called gantry. It allows tumor irradiation from multiple desired angles by supporting part of beam transfer line that rotates around patient. "HITRI plus"is a project with an aim to create hadron therapy more accessible. As a part of this project, this work proposes, the mechanical design of a gantry component called gantry nozzle. Topology optimization is used for an initial design followed by iterative manual optimization for final design proposals. Two possible solutions of nozzle design are developed and compared. The total of supported mass by the nozzle structure is estimated to be around 1.2t and the achieved mass of both proposals is lower than 1t while keeping transfer line component displacements within estimated required linear and angular tolerance of ± 0.2 mm and ±1 mrad respectively. In addition to that, a design workflow is developed that may be used to update nozzle structure designs due to ongoing development of the whole system.

Type of contribution:

Poster

11

Oblique corrections, when $m_W = m_Z \cos\theta_W$

Authors: Luis Lavoura[1]; Simonas Draukšas[2]; Vytautas Dudenas[2]

[1] *Lisbon, CFTP*

[2] *Vilnius University (LT)*

Corresponding Authors: simonas.drauksas@ff.stud.vu.lt, vytautas.dudenas@cern.ch

Oblique parameters, S, T, and U, are a popular way to parameterize Beyond the Standard Model (BSM) physics contributions to the observables of the electroweak sector. For this parametrization to work, however, one assumes that the BSM model preserves the custodial symmetry, i.e. it must have a tree-level relation $m_W = m_Z \cos\theta_W$, just as the Standard model. Inspired by the CDF collaboration's measurements of the W boson mass, we introduce an analogous parameterization that compares predictions of two models when both models violate custodial symmetry.

Type of contribution:

Talk

12

Research of surface post-treatment of additively manufactured pure copper parts using a laser beam

Author: Viesturs Lacis[1]

[1] *Riga Technical University (LV)*

Corresponding Author: viesturs.lacis@cern.ch

Additive manufacturing has allowed for production of high precision parts with sophisticated geometry and latest advances in technology has enabled production of parts also from pure copper that adds crucial electrical and electromagnetic properties to the produced parts. But main drawback of additive manufacturing is rough surface of produced parts. Effects on surface roughness by surface treatment of additively manufactured pure copper parts with laser beam is the main focus point of this research. This is research is part of larger effort to explore, how additive manufacturing can improve the way of manufacturing components with complex geometry for linear particle accelerators, although it is applicable to any industry where additively manufactured pure copper parts can be used. Reducing initial surface roughness is key issue and laser polishing is a promising way to improve surface characteristics. Research and planning was conducted to obtain initial laser parameters. Then a series of experiments were ran where additively manufacture pure copper samples were treated with laser beam and laser parameters were adjusted between the runs to try for the best possible surface roughness. As a result a set of laser parameters were obtained that allowed for 92,9% decrease of surface roughness from Ra 19,74 μm to Ra 1,40 μm. That means that treatment with laser beam can be successfuly used to reduce surface roughness of additively built pure copper parts. Further experiments are needed to investigate this process in more details.

Type of contribution:

Poster

13

Detector control and safety system for MIP Timing Detector

Author: Antra Gaile[1]

[1] *Riga Technical University (LV)*

Corresponding Author: antra.gaile@cern.ch

The Compact Muon Solenoid (CMS) experiment is one of four large experiments at the Large Hadron Collider (LHC) and significant upgrades are planned for all experiments and the accelerator facilities to get ready for the High Luminosity era (HL-LHC). As HL-LHC aims to significantly increase the

collision rates, thus providing more data for particle physics experiments, upgrades to handle the increased data rates and radiation levels are needed.
One solution is the introduction of a new detector sub-system in CMS that would work as a timing layer with a time resolution on the order of tens of picoseconds, the MIP Timing Detector (MTD where MIP stands for Minimum Ionizing Particle). It will consist of a barrel timing layer (BTL) situated between the outer tracker and the electromagnetic calorimeter and endcap timing layer (ETL) situated just in front of the high granularity calorimeter.
As the control of MTD should be compatible with all detector systems at CMS, the MTD will be controlled and monitored using detector control system (DCS), designed using centrally approved tools: WINCC OA, JCOP framework and CMS-made components. The primary purpose of a DCS is to ensure the safe and efficient operation of the detector, monitor and collect data on its performance, and respond to any issues that may arise during operation.
This contribution will outline the development of the DCS for the MTD sub-system at CMS, with a particular focus on the current single-tray prototype system implemented for the BTL test-bench at the Tracker Integration Facility (TIF) at CERN. Additionally, the detector safety system (DSS) and the associated hardware interlock system will be discussed. Finally, the early design on the final DCS, including the design of the Final State Machine (FSM) and the hardware components will be discussed.

Type of contribution:

Poster

14

Flavor-dependent (L5) MC truth jet energy corrections and flavor uncertainties in Run 2

Authors: Andris Potrebko[1]; Karlis Dreimanis[1]; Markus Seidel[1]

[1] *Riga Technical University (LV)*

Corresponding Authors: markus.seidel@cern.ch, andris.potrebko@cern.ch, karlis.dreimanis@cern.ch

Jet energy response depends on the jet flavor. Flavor-dependent (L5) jet energy corrections compensate for this factor while the flavor uncertainties estimate the mismodelling of individual flavors and propagate this to specific flavor mixes. We derive the L5 corrections for CMS run II on a dataset simulated with Pythia 8 and estimate the flavor uncertainties by comparing the Pythia 8 and Herwig 7 simulations. The new uncertainties provide enhanced overall results compared to those derived for the CMS run I while for bottom jets the uncertainty increases at large pt. Moreover, a similar framework is used to obtain the flavor/antiflavor uncertainty. This refined approach for flavor/antiflavor uncertainty helps to reduce the b vs bar uncertainty which represents the leading uncertainty source in the measurement of the top-antitop mass difference.

Type of contribution:

Talk

15

Mechanical properties of Y2SiO5-Lu2SiO5 solid solutions from ab initio calculations

Author: Alexander Platonenko[1]

Co-authors: Andrey Chesnokov [1]; Dmitry Bocharov ; Anatoli Popov [2]

[1] *Institute of Solid State Physics, University of Latvia*

[2] *University of Latvia (LV)*

Corresponding Authors: a.popov@cern.ch, bocharov@gmail.com, andrew.cesnokov@gmail.com, alexander.platonenko@gmail.com

Yttrium orthosilicate (Y_2Si2O_5 or YSO) is one of the scintillator materials that is successfully used in Compact Muon Solenoid (CMS) detectors in the Large Hadron Collider. This material can be chemically modified by substituting yttrium Y^{3+} metal ion(s) with lutetium Lu^{3+} ions, resulting in a range of compositions represented by the formula $Lu_xY_{(1-x)}SiO_5$, Lu_2SiO_5 (LSO). Additionally, cerium Ce^{3+} ions can be introduced as impurities into the crystalline lattice at varying concentrations. Oxy-orthosilicate materials exhibit the excellent radiation resistance and favourable luminescence properties.

In this work we study YSO-LSO solid solutions using group action theory for structure generation and *ab initio* approach for calculating equilibrium crystal structures and their corresponding elastic properties. The simulated solid solutions employed a 32-atom primitive cell featuring eight yttrium atoms. We explored nine compositions, varying the lutetium content from 0% to 100% in increments of 12.5%. A total of 74 symmetry-independent structures were generated and analyzed. For each composition, solutions with the lowest total energy were identified. Certain compositions displayed multiple energetically similar solutions, differing by only tens of milli-electron volts (meV) per primitive cell.

Our findings reveal that the volume of the crystallographic unit cell exhibits an almost linear decrease as the lutetium content increases. However, the composition with 37.5% Lu deviates significantly from this linear trend, warranting further in-depth analysis. The bulk modulus displays a distinct pattern, increasing from approximately 92 GPa for pure YSO to around 120 GPa for a 50% LYSO mixture, before slightly decreasing to about 115 GPa for pure LSO.

The results obtained are consistent with available structural data and contribute new insights into the mechanical properties of these materials. Such findings could be pivotal for future advancements in high-energy physics and related fields.

This research is supported by Latvian Research Program "High-energy physics and accelerator technologies"(Agreement No: VVPP-IZM-CERN-2022/1-0001).

Type of contribution:

Poster

16

Recent results from the CMS SMP-V group

Author: Markus Seidel[1]

[1] *Riga Technical University (LV)*

Corresponding Author: markus.seidel@cern.ch

We present recent results from the CMS Standard Model Physics - Vector boson (SMP-V) group. The heavy vector bosons W and Z are the carriers of the weak nuclear force and their properties are tightly coupled to those of other massive particles, such as the Higgs boson and top quark, via quantum corrections.
First, we discuss the experimental methods for vector boson measurements, such as the determination of luminosity, electron and muon reconstruction, their efficiencies, and energy scale calibration, as well as the estimate of neutrino momentum via the missing transverse momentum.
The dynamics of vector boson production are characterized by their cross sections which have been measured precisely at several center-of-mass energies during different runs of the LHC, both inclusively and differentially as a function of boson mass, transverse momentum, and rapidity.
The measurement of the invisible Z width allows to deduce a limit on the number of light neutrino

generations.
The study of angular observables in Z boson decays to taus is used to measure tau polarization and the electro-weak mixing angle.
Finally, searches for rare or forbidden decays of vector bosons into other Standard Model particles may reveal contributions from new physics interactions.

Type of contribution:

Talk

18

Studies of the Higgs boson production in association with top quarks in final states with electrons, muons, and hadronically decaying tau leptons at 13TeV with the CMS experiment

Author: The CMS collaboration[None]

Co-author: Nana Chychkalo [1]

[1] *Vilnius University (LT)*

Corresponding Author: nana.chychkalo@cern.ch

The Higgs boson production in association with a top quark-antiquark pair signal was firstly observed in 2018 with a significance of 5.2 standard deviations using proton-proton collisions recorded at center-of-mass energy of 13 TeV by the CMS experiment at the CERN LHC. In the final states containing electrons, muons or tau leptons decaying to hadrons and a neutrino the signal of 4.7 sigma significance is measured using the full LHC Run 2 data. No significant fractional CP-odd contributions, parameterized by the quantity |f^{Htt}*{CP}| are observed; the parameter is determined to be |f^{Htt}*{CP}| = 0.59 with an interval of (0.24, 0.81) at 68% confidence level. The further studies of differential signal distributions are ongoing.

Type of contribution:

Poster

20

Status of the MIP Timing Detector project for the CMS Phase-2 upgrade

Author: Karlis Dreimanis[1]

Co-author: CMS collaboration

[1] *Riga Technical University (LV)*

Corresponding Author: karlis.dreimanis@cern.ch

The Large Hadron Collider (LHC) and its associated experiments, including the Compact Muon Solenoid (CMS), are currently undertaking the Run 3 data collection period, set to end in 2025. This period will be followed by the Long Shutdown 3 (LS3) period (2026-2029), during which the High-Luminosity (HL-LHC) upgrade [1] of the LHC will be installed. In order to cope with the planned increase of the instantaneous luminosity delivered by the HL-LHC, CMS is undergoing an extensive

upgrade programme, called the Phase-2 upgrade, which will likewise be installed during LS3. As a part of Phase-2 upgrade, a wholly new sub-system, the MIP Timing Detector (MTD) [2], will be installed at CMS. MTD will allow the CMS experiment to retain the current primary vertex (PV) resolution ability in the greatly increased pile-up environment of the HL-LHC. This is made possible by the fact that the primary proton-proton interactions per bunch-crossing are dispersed in time with an RMS value of around 200 ps. This spread in time can be utilised to improve the particle track to PV matching at the experiment.
MTD will offer a track-time resolution of around 30 ps at the start of Run 4, with this parameter degrading to no more than 75 ps by the end-of-life of the detector, currently scheduled for 2041. The final system will consist of two distinct sub-systems, the Barrel Timing Layer (BTL) and the End-cap Timing Layer (ETL), which utilise different particle detection technologies due to vastly differing occupancy and radiation tolerance requirements.

In this contribution we will briefly cover the physics case and the overall design of the detector, with a particular focus on the BTL sub-system, before exploring discussing the current status of the detector development, including the latest milestones reached.

[1] https://cds.cern.ch/record/2749422
[2] https://cds.cern.ch/record/2667167

Type of contribution:

Talk

21

A Bayesian estimation of the Milky Way's circular velocity curve using Gaia DR3

Author: Sven Põder[1]

Co-authors: María Benito Castaño [2]; Joosep Pata [3]; Rain Kipper [4]; Heleri Ramler [4]; Gert Hütsi [1]; Indrek Kolka [4]; Guillaume F. Thomas [5]

[1] *National Institute of Chemical Physics and Biophysics (EE)*

[2] *Tartu Observatory, University of Tartu (EE), National Institute of Chemical Physics and Biophysics (EE)*

[3] *National Institute of Chemical Physics and Biophysics (EE)*

[4] *Tartu Observatory, University of Tartu (EE)*

[5] *Instituto de Astrofísica de Canarias (ES), Universidad de La Laguna (ES)*

Corresponding Authors: sven.poder@kbfi.ee, joosep.pata@cern.ch, mariabenitocst@gmail.com

The Milky Way is an excellent laboratory for studying dark matter as its spatial distribution can be inferred by tracing the dance of luminous celestial bodies. We use the Jeans equation to model the rotational velocities of stars measured by the Gaia satellite to constrain the Galactic circular velocity curve. In particular, we exploit the increase of volume and precision in data brought about by ongoing large-scale stellar surveys and use approximately 0.7 million Red Giant Branch stars from Gaia DR3. With the increasing precision of astrometry, a more careful accounting of the systematic uncertainties is required as they are propagated into the determination of the DM density profile and thus affect how we interpret results from searches of physics beyond the standard model. Motivated by this, we present a novel Bayesian inference approach to estimate the circular velocity curve of the Milky Way along with uncertainties that account for various sources of systematic uncertainty. Our methodology provides a self-consistent way to quantify uncertainties in the Sun's Galactocentric distance and the spatial-kinematic morphology of the tracer stars. Using this method, we estimate the circular velocity curve within a range of 5 to 14 kpc and we also infer the DM mass within 14 kpc and predict the local DM density.

Type of contribution:

Talk

22

Low-pT lepton SF measurements for lepton flavour universality (LFU) violation study in ttar decays in the CMS detector

Author: Normunds Ralfs Strautnieks[1]

Co-authors: Elina Pajuste [1]; Karlis Dreimanis [2]; Markus Seidel [2]

[1] *University of Latvia (LV)*

[2] *Riga Technical University (LV)*

Corresponding Authors: karlis.dreimanis@cern.ch, markus.seidel@cern.ch, elina.pajuste@cern.ch, normunds.ralfs.strautnieks@cern.ch

LFU studies has been on the forefront of HEP physics analyses in the recent years, due to the reported tension with SM predictions in LHCb measurements for R(μ/e) ratios. Some of the reported tension has been resolved, but a potential discrepancies could still be found in the R(τ/e) and R(τ/μ) ratios. To investigate these decay ratios, ttbar events have been chosen as a source of leptons for this analysis, as they provide a straight forward way to acquire unbiased set of events (t->W->τ/μ/e). To measure these ratios, there is need to identify the τ lepton, which is an unstable particle. This is done by searching for leptons that decay from τ particle in (τ->e) and (τ->μ) decay channels, where the resulting electrons and muons usually end up with lower pT and higher transverse displacement their counterparts from direct W boson decay. To distinguish these leptons coming from W(promt) and τ (non-promt), a 2D fit is performed in bins of pT and dxy. To increase the event statistics available, there is a need to use the low-pT leptons (<15 GeV), as significant part of electrons and muons coming from τ decay are in this pT region. There are many difficulties when working with low-pT leptons and one of them is the scale factor calculations, which are plagued by limited signal event statistics and high background contamination. To improve the existing scale factors and their uncertainties, a revised approach of using J/Ψ decays from various datasets is used with the goal of reducing the overall uncertainties in scale factor measurements.

Type of contribution:

Poster

23

Preliminary experimental evidence for the protrusion hypothesis on CuO forest

Author: Sven Oras[1]

[1] *University of Tartu*

Corresponding Author: sven.oras@ut.ee

Cu electrodes are widely used in accelerators, for example in CLIC [1]. One of the problems arising in such accelerators is the breakdown phenomenon [2] causing damage to the accelerating structures and disturbances in the accelerated beam. The cause of the vacuum breakdowns is still under investigation and the electrodes regularly investigated for clues. One possible explanation for the cause of breakdowns is the hypothesis stating the formation of nanoprotrusions in the electrodes. These protrusions can enhance the local electric field being a possible cause for breakdowns but up to this point no one has seen the protrusions in Cu surfaces.

In this study a forest of CuO nanowires (NW) was grown on a Cu substrate by heating the Cu in air. Field emission of the NWs was measured in a specialized system inside a scanning electron microscope. It consisted of a sample holder and a tip capable of approaching and going in contact to the sample. Voltage can be applied between tip and sample.
First field emission if thee CuO forest was measured until breakdown occurred. After breakdown a new Cu surface for created and it was found that the field emission on a smooth and fresh surface is much smaller than on the CuO forest. After deforming the Cu surface mechanically, increased field emission current was measured until breakdown occurred.

[1] Compact Linear Collider (CLIC), last accessed 08 Sep 2023, URL: http://clic.cern/
[2] A. Palaia et al. "Effects of rf breakdown on the beam in the Compact Linear Collider prototype accelerator structure", Physical Review Special Topics - Accelerators and Beams, 16, 8 (2013) 081004. 10.1103/PhysRevSTAB.16.081004

Type of contribution:

Talk

24

The Current Higgs-Boson Portrait by the CMS Experiment

Author: Aurelijus Rinkevicius[1]

[1] *Vilnius University (LT)*

Corresponding Author: aurelijus.rinkevicius@cern.ch

More than ten years have passed since the discovery of the Higgs boson by the ATLAS and CMS Collaborations at the CERN Large Hadron Collider at a mass of around 125 GeV. Since the discovery more than 30 times more Higgses were produced, thus enabling a further scrutiny of the Higgs-related processes, studying different Higgs production modes, its interactions to various bosons and fermions. Here we will overview the latest standard model Higgs boson studies done by the CMS experiment.

Type of contribution:

Talk

25

Investigation of Additively Manufactured Copper Synchrotron Radiation Absorber for the Future Circular Collider

Authors: Andris Ratkus[1]; Brigita Abakeviciene[None]; Kristupa Šeškauskaitė[None]; Sam Rorison[2]; Toms Torims[3]

[1] *Riga Technical University (LV)*

[2] *CERN*

[3] *Riga Technical University*

Corresponding Authors: brigita.abakeviciene@ktu.lt, samuel.rorison@cern.ch, andris.ratkus@cern.ch, kristupa.seskauskaite@ktu.e
toms.torims@rtu.lv

Future Circular Collider (FCC-ee) is a proposal for 92 km circumference double ring which would generate 50 MW/beam of synchrotron radiation (SR) power. Design studies call for the SR fan to be intercepted every ~5 m with localised absorbers. Compared to the continuous design (in which the synchrotron radiation absorber (SRA) channel is located all around the beam pipe), this layout is advantageous due to faster conditioning of the vacuum chambers, lower material and manufacturing costs. The proposed SRA design uses turbulent water flow to remove generated heat. The use of additive manufacturing (AM) was chosen due to the ability to achieve complex structures in shorter time and with lower material consumption, compared to traditional manufacturing techniques (such as extrusion or casting) making it ideal for SRA production. The 95 mm SRA prototype and specially made samples were produced and examined computed tomography (CT), 3D scans, roughness, tensile, density, hardness tests, scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX). The AM process produced a part, which, according to 3D scan inspection, reflects geometry within approximately 0.3 mm deviation from model, shrinkage was observed, this should be accounted for during blueprints preparation. CT scan verified the inner channel vein is approximately 0.5 mm in width. Copper tensile samples have yield strength of 100 MPa, which is below that required of initial design, and similar to 1/8 hardened copper, this is consistent with other mechanical characteristics and to the measured hardness of approximately 72 HV0.1 kgf. The piece exhibits high density >95%, which decreases the risks of mechanical failures during exploitation. Further tests, such as He leak testing and thermal transfer efficiency calculation, are necessary to validate the part and manufacturing method for use in accelerator.

Type of contribution:

Poster

26

MECHANICAL DESIGN OPTIMIZATION OF AN RFQ (PARTICLE) ACCELERATOR PROTOTYPE MADE BY ADDITIVE MANUFACTURING

Authors: Guntis Pikurs[1]; Maurizio Vretenar[2]; Toms Torims[3]

[1] *Riga Technical University (LV)*

[2] *CERN*

[3] *RTU*

Corresponding Authors: maurizio.vretenar@cern.ch, toms.torims@rtu.lv, guntis.pikurs@cern.ch

Additive manufacturing is a relatively new technology which is changing manufacturing paradigms. It is a more natural way of manufacturing with potential that has not yet been fully discovered in the accelerator community. Furthermore, it is a smarter and greener way of manufacturing where the material and energy are not wasted in extra material removal and chips. Compared to conventional techniques, AM allows the manufacturing high-complexity parts more efficiently in a shorter time and with a minimum number of technological steps. The technology allows design solutions which are entirely impossible and mindblowing for traditional approaches. The advantage opens the gateway to complex structure design improvements, achieving even higher efficiency for final products. This research covers AM RFQ cavity design and thermal system optimization solutions, allowing RFQ quality factor value improvement and thermal system upgrade. The research explicitly advances the PBF-LB/M/Cu-ETP process of manufacturing compact-size RFQ, a highly complex and intricate part of accelerators. The manufacturing process of HF-RFQ demands minimum ISO-286 fine machining tolerance grades and Ra0.4 surface quality due to stringent requirements for beam optics and cavity "skin layer"quality. The research results can serve as a valuable reference for the future advancements of AM technology in the context of RFQs and other critical accelerator components and encompass a comprehensive guide for the application of AM technology in functional RFQ development. Concluding with evaluating the geometrical shape and surface quality of the prototype through several types of tests represents a significant and valuable contribution to the H2020 I.FAST project, serving as an essential component of the deliverable for the I.FAST WP10 collaboration. Further, research has continued where the target is full-size functional RFQ.

Type of contribution:

Talk

27

CMS Phase-2 Inner Tracker Pixel Chip Prototype Tests

Author: Marijus Ambrozas[1]

[1] *Vilnius University (LT)*

Corresponding Author: marijus.ambrozas@cern.ch

The Compact Muon Solenoid (CMS) experiment is preparing for the Phase-2 upgrade to work with the High-Luminosity LHC. The upgraded CMS detector will feature a completely new tracker system. The CERN/RD53 Collaboration is in charge of developing the readout chip for the upgraded pixel detector (Inner Tracker).

Currently, the 2nd generation prototype chips RD53B CMS (also codenamed CROC_v1) are undergoing tests. We will present the latest test results for single chips with sensors. We will mainly focus on optimizing the chip's calibration process for realistic experiment conditions and testing the newest features of the currently developed DAQ system.

We will provide details on optimizing the signal detection threshold and signal gain, as well as studying the performance of various triggering options for single-chip tests, using both the internal calibration circuit and a radioactive X-ray source for these purposes.

Type of contribution:

Talk

28

LPBF of pure copper for particle accelerator applications

Authors: Andris Ratkus[1]; Maurizio Vedani[2]; Tobia Romano[3]; Toms Torims[1]

[1] *Riga Technical University*

[2] *Politecnico di Milano*

[3] *Politecnico di Milano, Riga Technical University*

Corresponding Authors: t.torims@cern.ch, tobia.romano@polimi.it, andris.ratkus@cern.ch, maurizio.vedani@polimi.it

Pure copper is largely used to manufacture particle accelerator components, such as vacuum devices and accelerating cavities, because it combines excellent electrical and thermal conductivity with good workability and solderability. These components often feature complex geometries, like connectors and internal cooling channels, that can only be manufactured following sophisticated routes that involve several brazing, machining, and heat treatment operations. These result in high production costs and long lead times.

In this work, laser powder bed fusion (LPBF) of pure copper is investigated for the manufacture of particle accelerator components, because it has the potential to create complex geometries that cannot be easily fabricated with conventional techniques. Also, it is particularly suited to manufacture prototypes and one-off parts with lower costs and lead times.

Commercial LPBF machines equipped with both infrared and green laser sources are used to fabricate pure copper samples and prototypes, like electrodes for high-voltage (HV) testing and thin membranes for helium leak testing. As-printed specimens are characterized in terms of chemical purity, surface roughness, microstructure, mechanical properties, and electrical and thermal conductivity.

LECO measurements reveal a similar oxygen content of about 0.04 wt.% for all specimens. As-printed parts exhibit rough external surfaces with a large amount of partially sintered particles. An anisotropic microstructure consisting of elongated grains oriented along the build direction was observed in all specimens. Occasional defects like unmelted particles and sub-surface porosity result in a relative density of about 99.3%. All printed parts show a similar microhardness of about 75 HV0.05. As regard the physical properties, specimens exhibit electrical conductivity and thermal diffusivity above 95% of the pure copper standards. Slightly lower electrical and thermal properties are measured in the transversal direction compared to the build direction due to the microstructural anisotropy.

Future developments include microscopy investigation of the electrodes after being subjected to vacuum arc breakdown testing to determine the surface features produced during breakdown. Also, thin membranes that failed tightness testing will be characterized to identify structural defects causing helium leakage.

Type of contribution:

Talk

29

The electric breakdown phenomena in accelerator design - numerical studies

Author: Veronika Zadin[1]

Co-authors: Andreas Kyritsakis ; Roni Koitermaa [2]; Sergei Vlassov ; Tauno Tiirats [3]

[1] *University of Tartu (EE)*

[2] *University of Helsinki*

[3] *University of Tartu*

Corresponding Authors: akyritsos1@gmail.com, roni.koitermaa@helsinki.fi, tauno.tiirats@ut.ee, veronika.zadin@ut.ee, serqent@gmail.com

Many high electric field applications, like as CERN's Compact Linear Collider, are severely hampered by the occurrence of electrical breakdowns. Electrical discharge arises in the presence of a sufficiently high applied electric field, even at ultra high vacuum circumstances, causing disturbances in the device's operating regime, material damage, and, in general, limiting the device's operation severely. The phenomenon itself has been known for a long time, but its precise initiation mechanisms remain a mystery. According to current hypotheses, electric field effect causes the creation of field augmenting nanoscale tips. This tip will cause large field emission currents, netural atom evaporation, plasma development, and, finally, full electrical breakdown. In this talk, we investigate the hypotheses of the initiation mechanisms of field emitters, through investigations conducted with nanoscale materials subjected to high fields utilizing the multi-physics-multi scale modeling framework FEMOCS calculations. We present the latest developments of FEMOCS and discuss fields of application in additional experiments like FCC.

Type of contribution:

Talk

30

Investigating the impact of high electric field on the surface of metals using artificial neural networks along with molecular dynamics

Author: Ehsan Moradpur-Tari[1]

Co-authors: Andreas Kyritsakis [1]; Veronika Zadin [1]; Ye Wang [1]

[1] *Institute of Technology, University of Tartu, Estonia*

Corresponding Authors: andreas.kyritsakis@ut.ee, veronika.zadin@ut.ee, ye.wang@ut.ee, e.moradpur.tari@gmail.com

The effect of high electric fields on the surface of metals can be severe and problematic leading to tip formation and vacuum breakdown. Since these effects relate to electric dipole and polarizability of the surface, they should be studied based on first-principle methods. On the other hand, these methods are computationally demanding and do not scale up to realistic times and dimensions. In this regard, Machine learning (ML) can establish a useful bridge between high-accuracy ab-initio calculations and high-efficient molecular dynamics. Since the effect of electric field is confined to only a few layers in the surface, a model based on artificial neural networks is proposed to calculate these surface effects, while the bulk of material is being treated classically by molecular dynamics. To make the surface interactions accurate, the input for training were prepared by density functional theory (DFT) and overall 500 frames were prepared for a 6-layer Tungsten slab between temperatures 0-2500 K. After training the deep neural network model, there was a good correlation between the forces predicted by ML and DFT. The model then coupled with LAMMPS code to predict surface effects simultaneously and feed them to classical force fields.

Type of contribution:

Poster

31

Latvia - CERN industry engagment

Author: Alise Pika-Ozola[1]

[1] *Industrial Liaison Officer for Latvia*

Corresponding Author: alise.pika-ozola@liaa.gov.lv

The primary task of the Industry Liaison Officer (ILO) in Latvia is to ignite the interest and to engage in procurement process a growing number of Latvian companies representing relevant-to-CERN industries. The role of ILO involves awareness-building, matchmaking and support to ensure that Latvian business community and wider society can leverage the opportunities presented by CERN's cutting-edge research and projects. The presentation will discuss the on-going work and planned activities of the new ILO in Latvia. **Industrial return aspects and industry mapping of 2021/2022/2023 will be discussed in detail.**

Type of contribution:

Talk

32

Laser Photodetchment Threshold Spectroscopy on Radioactive Negative Ions

Author: Uldis Berzins[1]

[1] *University of Latvia (LV)*

Corresponding Author: uldis.berzins@cern.ch

Laser Photodetchment Threshold Spectroscopy on
Radioactive Negative Ions
Uldis Bērziņš

Laboratory of Atomic Physics, Atmospheric Physics and Photochemistry,
Institute of Atomic Physics and Spectroscopy, University of Latvia.

Recently, the Laser Photodetachment Threshold Method was adapted for the measurements of radioactive negative ions. GANDALPH (Gothenburg ANion Detector for Affinity measurements by Laser PHotodetachment) apparatus was designed to study radioactive isotopes. And is placed at CERN at the ISOLDE [1] facility. The measurement of electron affinity of 128I− was a first demonstration of capacity to determine the isotope shift of iodine [2], and it was followed by Electron Affinity measurement in Astatine [3]. With implementation of ion trap MIRACLS (Multi Ion Reflection Apparatus for Collinear Laser Spectroscopy) [4] it opens up the opportunity for future studies of the fundamental properties of negatively charged radioactive isotope such as Chlorine [5] and Polonium as next.
Due to our expertise in isotope shift measurements in electron affinities of Chlorine [6] we were invited to join the MIRACLS group for trapping the Chlorine anions during summer 2022. Based on results of this collaboration I submitted application for funding at Latvian Council of Science. Our project is supported for next 3 years. In my presentation I'll report on our experimental facility, results of latest experiments and vision for next experiments in CERN and at University of Latvia.

Acknowledgments
Activities in CERN were supported by ERDF projects: No. 1.1.1.5/19/A/003: "Development of quantum optics and Photonics in University of Latvia"and ERDF project No. 1.1.1.1/19/A/144 "Technologic research for elaborating the next generation boron ion implantation apparatus with TRL level near to 4"

References
1. https://home.cern/science/experiments/isolde
2. Rothe S., et al (2017), J. Phys. G: Nucl. Part. Phys. 44 1040032
3. Leimbach, D., et al (2020),Nat Commun 11, 3824 (2020). https://doi.org/10.1038/s41467-020-17599-2
4. Sels S., et al (2020), Nucl.Instrum. Meth. B, Vol 463 310-314
5. E.Leistenschneider E., ⋯, Berzinsh U et al., (2022), 28th International Nuclear Physics Conference, in Cape Town, South Africa from 11-16 September 2022.
6. U. Berzinsh, et.al., (1995)., "Isotope shift in the electron affinity of chlorine,"Phys. Rev. A 51, 231)

Type of contribution:

Talk

33

Feasibility of OTIMA interferometry for antihydrogen gravity measurement

Author: Valts Krumins[1]

[1] *University of Latvia (LV)*

Corresponding Author: valts.krumins@cern.ch

Goal for the AEgIS collaboration is an antihydrogen free-fall measurement which would test one of cornerstones of General Relativity - Weak Equivalence Principle and might give insights about the baryonic asymmetry. The chosen method for this measurement is the moiré deflectometer.
Optical time-domain ionizing matter wave (OTIMA) interferometry has been established as a powerful tool in the field of high mass organic molecule interferometry and has been used for measurements using free fall of organic molecules. Using an OTIMA interferometer for antihydrogen free-fall measurement has multiple advantages compared to that of the moiré deflectometer. Grating periodicity is significantly smaller with optical gratings which allows for increased resolution or shorter measurement device, or both, and as the gratings are time based, the mechanical alignment is simplified due to position being determined by the timing of the laser pulses.
To study the feasibility of OTIMA interferometry for antihydrogen gravity measurement multiple simulations were developed - plane wave formalism simulation to determine fringe visibility, calculations of the solid angle and timing overlap to estimate the usable flux and Monte Carlo simulation to check the flux estimates.

Type of contribution:

Talk

34

Raman and FTIR spectra analysis of radiation effects on neutron-irradiated CVD diamond crystals

Author: Alise Podelinska[1]

Co-authors: Anatoli I. Popov [1]; Dmitry Bocharov [1]; Gaetano Aiello [2]; Georgijs Chikvaidze [1]; Jevgenijs Gabrusenoks [1]; Theo Andreas Scherer [2]

[1] *Institute of Solid State Physics, University of Latvia*

[2] *Karlsruhe Institute of Technology, Institute for Applied Materials*

Corresponding Authors: gaetano.aiello@kit.edu, georgijs.cikvaidze@cfi.lu.lv, gabrusen@cfi.lu.lv, popov@cfi.lu.lv, alisep@cfi.lu.lv, bocharov@cfi.lu.lv, theo.scherer@kit.edu

This study investigates the radiation response of Chemical Vapor Deposition (CVD) diamond, a crucial detector material at CERN. Utilizing Raman, Fourier Transformation Infrared (FTIR), and Luminescence Spectroscopy, we analyzed both non-irradiated and neutron-irradiated CVD diamond samples. The focus was on comparing spectral characteristics, specifically variations in band positions and intensities, to understand radiation-induced structural deformations and defects.

The research aims to decode the structural changes within CVD diamond due to irradiation. This is vital for gauging its radiation resistance, a key attribute for its application in CERN's demanding environment. We also performed a dose-dependent analysis, linking spectral attributes to neutron irradiation levels. This not only underscores the material's radiation sensitivity but also offers a quantitative framework for evaluating its structural changes under radiation exposure.

The study significantly enhances our understanding of CVD diamond's viability as a radiation-resistant detector in high-energy experiments. This has implications beyond CERN, including potential applications in fields requiring radiation-resistant materials, such as nuclear engineering and medical radiation therapy. Overall, the findings set a strong foundation for developing durable materials capable of withstanding extreme radiation conditions, thereby contributing to advances in both detector technology and material and medical sciences.
This research is supported by Latvian Research Program "High-energy physics and accelerator technologies"(Agreement No: VPP-IZM-CERN-2022/1-0001).

Type of contribution:

Talk

35

Experimental integral cross-sections of photonuclear reactions on proton-rich 113In and 114Sn nuclei for cosmic nucleosynthesis modelling

Authors: Anastasiia Chekhovska[None]; Daina Riekstiņa[1]; David Chvátil[2]; Igor Semisalov[3]; Ivana Krausova[2]; Tamara Krasta[1]; Vaclav Olšansky[2]; Yevgen Skakun[3]

[1] *Institute of Solid State Physics, University of Latvia*

[2] *Nuclear Physics Institute, Czech Academy of Sciences*

[3] *National Science Center "Kharkiv Institute of Physics and Technology"*

Corresponding Author: anastasiy101294@gmail.com

Photonuclear reactions play an essential role in nucleosynthesis taking place in all sites, e.g., stars, novae, and interstellar gas media. Especially important these reactions are for formation of isotopes heavier than iron. The proton-rich p-nuclei, such as ^{114}Sn, and ^{113}In, can be created only via a complex sequence of radiative processes, involving both emission and capture of γ-rays [1]. Correct modelling of cosmic nucleosynthesis processes requires a wealth of confident experimental data both about nuclear reactions, and nuclear structure of involved nuclei.
Presented work is a continuation of our earlier studies of photonuclear reactions involving p-nuclei [2]. Yields of the $^{114}Sn(\gamma,n)^{113}Sn$ photonuclear reaction were measured in the bremsstrahlung energy range from 11.5 to 14 MeV with a step of 0.5 MeV using Linear Electron Accelerator of the National Science Centre "Kharkiv Institute of Physics and Technology" (Ukraine). For $^{113}In(\gamma,n)^{112m}In$ and $^{113}In(\gamma,n)^{112g}In$ photonuclear reactions in the bremsstrahlung energy range from 7 to 23 MeV with a step of 2 MeV, the experiment was carried out using Microtron M-25 of the Institute of Nuclear Physics (Czech Republic). High-resolution gamma spectrometers based on HPGe detectors were used to measure induced activities in both experiments.
The results of experimental measurements are compared with the data available in the literature and with the nuclear reaction statistical model calculations obtained using TALYS 1.95 [3] computer codes.
1. M. Arnoud, S. Goriely. The p-process of stellar nucleosynthesis: astrophysics and nuclear physics status. Phys.Rep. 384 (2003) 1-84.
2. A.V. Chekhovska, et al. Stellar Nucleosynthesis: Experimental Yields of the $^{112}Sn(\gamma,n)^{111}Sn$ and $^{112}Sn(\gamma,p)^{111m,g}In$ Reactions for p-Nuclei Production Simulation. In "Nuclei in the Cosmos XV", Eds. A.Formicola et al. (Springer, 2019), p.301.
3. A. J. Koning, S. Hilaire and M. C. Duijvestijn. TALYS-1.0. Proc. of the Int. Conf. on Nuclear Data for Science and Technology. Nice: EDP Sciences, (2008), p.211.

Type of contribution:

Poster

36

CERN related activities by the group of Photoelectric Phenomena at Vilnius University

Author: Tomas Ceponis[1]

Co-authors: Eugenijus Gaubas [1]; Jevgenij Pavlov ; Laimonas Deveikis [2]; Vytautas Rumbauskas [2]

[1] *Vilnius University*

[2] *Vilnius University (LT)*

Corresponding Authors: eugenijus.gaubas@ff.vu.lt, tomas.ceponis@cern.ch, vytautas.rumbauskas@cern.ch, laimonas.deveikis@cern.ch, jevgenij.pavlov@tmi.vu.lt

The CERN related activities carried out by the group of Photoelectric Phenomena at Vilnius University will be presented

Type of contribution:

Talk

38

Scandium Thermal Release from Irradiated Titanium Foils: Implications for Enhanced Radionuclide Production

Author: Patricija Kalnina[1]

Co-authors: Alexandre Dorsival [2]; Bernard Crepieux [2]; Charlotte Duchemin [3]; Edgar Reis [4]; Edgars Mamis [1]; Elina Pajuste [1]; Laura Lambert [2]; Line Le [2]; Matthieu Deschamps [5]; Nadine Conan [2]; Sebastian Rothe [2]; Simon Thomas Stegemann [2]; Thierry Stora [2]; Valentina Berlin [2]

[1] *CERN, Institute of Chemical Physics of the University of Latvia*

[2] *CERN*

[3] *CERN SY/STI/RBS*

[4] *CERN, Fakültat für Ingenieurwissenschaften, University of Duisburg-Essen*

[5] *CERAP*

Corresponding Authors: charlotte.duchemin@cern.ch, patricija.kalnina@cern.ch, simon.thomas.stegemann@cern.ch, edgars.mamis@cern.ch

Certain radionuclides of the chemical element scandium are promising candidates to be used for radionuclide-targeted therapy and positron emission tomography (PET/CT). ^{44}Sc or ^{43}Sc can be used for diagnostic imaging purposes and monitoring therapy response and ^{47}Sc for therapeutic purposes or SPECT diagnostics. In terms of production cross section and cost natural titanium is an advantageous target material for producing ^{43,44g,44m,47}Sc radionuclides in sufficient amounts for clinical use. This is done to investigate isotope release and extraction for MEDICIS mass separation. This study is done in a MEDICIS target unit and is designed to undertake a comprehensive analysis of the release kinetics of scandium from irradiated titanium foils, with a specific focus on elucidating the intricate relationship between target material thickness and temperature conditions. By meticulously studying these factors, the project aims to uncover the underlying mechanisms governing scandium diffusion and effusion during ion implantation processes. This study aspires to contribute significant insights into the intricate interplay of target material thickness and temperature on scandium diffusion and effusion during ion implantation. By advancing the understanding of these mechanisms, the research outcomes are expected to pave the way for an optimized scandium implantation process.
In this study, natural titanium target material was irradiated at the CERN CHARM facility. Samples were parasitically irradiated during 5 days by taking advantage of the secondary flux procuced from a 24 GeV proton beam ipinging a thick target with an average intensity of 5E10 p/s. The titanium metal foils containing ^{46}Sc and ^{47}Sc were heated up inside the container of a target unit for time periods between 1 and 3 hours to temperatures between 1100 and 1550 ^{o}C in vacuum. Thus, the release properties of scandium from titanium under these conditions were studied by g-spectrometry means. From the experimental results, optimum release conditions are suggested.

Acknowledgments
This work was supported in part by Latvian Council of Science, grant number: lzp-2021/1-0539

"Novel and efficient approach of medical ^{43}Sc, ^{44}Sc and ^{47}Sc radionuclide separation and purification from irradiated metallic targets towards radiopharmaceutical development for theranostics"

Type of contribution:

Poster

Theory / 39

[cancelled] Ground state energy for a few-body systems in an algebraic framework

Corresponding Author: augustinas.stepsys@cern.ch

Theory / 40

A Bayesian estimation of the Milky Way's circular velocity curve using Gaia DR3

Corresponding Author: sven.poder@cern.ch

Theory / 41

Relations between basis sets of fields in the renormalization procedure

Corresponding Author: simonas.drauksas@cern.ch

Theory / 42

Oblique corrections, when $m_W = m_Z \cos\theta_W$

Corresponding Author: vytautas.dudenas@cern.ch

43

Automation and investigation of scandium separation from ionic contaminants using ion-exchange chromatography and electrochemical methods

Author: Rudolfs Janis Zabolockis[None]

Co-authors: Alexandre Dorsival [1]; Bernard Crepieux [1]; Charlotte Duchemin [2]; Edgars Mamis [3]; Elina Pajuste [4]; Laura Lambert [1]; Line Le [1]; Mathieu Bovigny [1]; Nadine Conan [1]; Thierry Stora [1]

[1] *CERN*

[2] *CERN SY/STI/RBS*

[3] *University of Latvia (LV)*

[4] *CERN, Institute of Chemical Physics of the University of Latvia*

Corresponding Authors: charlotte.duchemin@cern.ch, mathieu.bovigny@cern.ch, edgars.mamis@cern.ch, rudolfs.janis.zabolockis@

Scandium radioisotopes can be used to perform diagnostics (positron emission tomography and single-photon emission computer tomography) and therapy on patients (theranostics) due to low toxicity, short half-lives, and stable decay products. 43, 44Sc, and 47Sc can be produced from elements such as Ca, V, and Ti by proton, neutron, and gamma irradiation.
The CERN-MEDICIS facility uses target materials irradiated at ISOLDE with the 1.4 GeV proton beam delivered by the CERN Proton Synchrotron Booster, and subsequently proceed to the offline mass-separation of the produced mixture of radionuclides. Mass-separated isotopes which are collected on Al or Zn coated Au foils (alternatively –NaCl or KNO3-coated Al) still contain isobaric contaminants that must be separated by chemical methods.
In this study, the update of methods and results of scandium (stable and radioactive) separation from contaminants are reported including a novel method of removing impurities by aqueous electrolysis of Sc/impurity mixtures. Sample investigation has been conducted with ICP-MS PLASMAQUANT, XRF ThermoScientific Niton XL3t, and SEM-FIB Zeiss XB 540. Current, voltage, and temperature registration was carried out using Keithly 2000 multimeters. Radiation measurements were conducted with Canberra Cryo-Pulse 5 plus GX4020 gamma spectroscope and radiameter ThermoScientific FH 40G-L10.
A proposed schematic for an automized system is shown as well as tests for a semi-automated system have been successfully completed. The electrochemical separation method shows application in contaminant removal (in aqueous media). 47Sc separation recoverability (from NaCl coated Al) using ion-exchange DGA resin shows 81.4 ± 13.2 % for the 3 mm Diba Omnifit Benchmark Microbore column and 75.9 ± 11.8 % for the 5 mm Diba Omnifit EZ adjustable end-piece column. The actual radiochemical recoverability is estimated to be upwards of ~ 99.9 %.

Acknowledgments
This work was supported in part by Latvian Council of Science, grant number: lzp-2021/1-0539 "Novel and efficient approach of medical 43Sc, 44Sc and 47Sc radionuclide separation and purification from irradiated metallic targets towards radiopharmaceutical development for theranostics"as well as the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101008571 (PRISMAP –The European medical radionuclides programme).

Type of contribution:

Poster

Experiment / 44

Feasibility of OTIMA interferometry for antihydrogen gravity measurement

Corresponding Author: valts.krumins@cern.ch

Experiment / 45

Flavor-dependent (L5) MC truth jet energy corrections and flavor uncertainties in Run 2

Corresponding Author: andris.potrebko@cern.ch

Experiment / 46

The Current Higgs-Boson Portrait by the CMS Experiment

Corresponding Author: aurelijus.rinkevicius@cern.ch

Experiment / 47

Recent results from the CMS SMP-V group

Corresponding Author: markus.seidel@cern.ch

Experiment / 48

Laser Photodetchment Threshold Spectroscopy on Radioactive Negative Ions

Corresponding Author: uldis.berzins@cern.ch

Detectors / 49

Raman and FTIR spectra analysis of radiation effects on neutron-irradiated CVD diamond crystals

Corresponding Author: alisep@cfi.lu.lv

Detectors / 50

CERN related activities by the group of Photoelectric Phenomena at Vilnius University

Corresponding Author: tomas.ceponis@cern.ch

Detectors / 51

CMS Phase-2 Inner Tracker Pixel Chip Prototype Tests

Corresponding Author: marijus.ambrozas@cern.ch

Detectors / 52

Status of the MIP Timing Detector project for the CMS Phase-2 upgrade

Corresponding Author: karlis.dreimanis@cern.ch

Technologies I : Medicine and Computing / 53

Target developments for Sc radionuclide mass-separation at CERN-MEDICIS facility

Corresponding Author: edgars.mamis@cern.ch

Technologies I : Medicine and Computing / 54

Analytical pencil beam dose and dose-rate engine development for FLASH therapy studies of heavy ion and very high energy electron beams

Corresponding Author: kristaps.palskis@cern.ch

Technologies II: Accelerator Technologies / 55

RTU Institute of Particle Physics and Accelerator Technologies activities in accelerator projects and additive manufacturing examination for accelerator applications

Corresponding Author: andris.ratkus@cern.ch

Technologies II: Accelerator Technologies / 56

Preliminary experimental evidence for the protrusion hypothesis on CuO forest

Corresponding Author: sven.oras@ut.ee

Technologies II: Accelerator Technologies / 57

MECHANICAL DESIGN OPTIMIZATION OF AN RFQ (PARTICLE) ACCELERATOR PROTOTYPE MADE BY ADDITIVE MANUFACTURING

Corresponding Author: guntis.pikurs@cern.ch

Technologies II: Accelerator Technologies / 58

The electric breakdown phenomena in accelerator design - numerical studies

Corresponding Author: veronika.zadin@ut.ee

Technologies II: Accelerator Technologies / 59

LPBF of pure copper for particle accelerator applications

Corresponding Author: tobia.romano@polimi.it

Conference close / 60

Recap of CBC'23

Corresponding Authors: brigita.abakeviciene@ktu.lt, ants.koel@cern.ch

Conference close / 61

Final remarks & close

Corresponding Author: karlis.dreimanis@cern.ch

Conference Opening / 62

Welcome by the Chairman of the CERN Baltic Group

Corresponding Authors: brigita.abakeviciene@ktu.lt, ants.koel@cern.ch

Conference Opening / 63

Welcome by the Rector of Riga Technical University

Conference Opening / 64

Practicalities

Corresponding Author: karlis.dreimanis@cern.ch

Policy / 65

Address from Estonia: Dr Mario Kadastik, Member of Riigikogu

Policy / 66

Address from Lithuania: Ms Rasa Kulvietienė, Advisor to the Minister of Education, Science and Sport of Lithuania

Policy / 67

Address from Latvia: Ms Silvija Reinberga, Parliamentary Secretary of the Ministry of Education and Science

Policy / 68

Address from the Baltic Assembly: Mr Timo Suslov, President of the Baltic Assembly

Policy / 69

Representative of CERN

Baltic and National activities / 70

Baltic particle therapy center initiative: status report, lessons learned and next steps

Corresponding Authors: t.torims@cern.ch, kristaps.palskis@cern.ch

Baltic and National activities / 71

Development of a master's programme in HEP & HEP Instrumentation in the Baltics

Corresponding Author: karlis.dreimanis@cern.ch

Industry engagement / 72

Doing Business with CERN: ILO Report

Corresponding Authors: robert.aare@cern.ch, alise.pika-ozola@liaa.gov.lv

20+5

Industry engagement / 73

Industry representative #1

Industry engagement / 74

Industry representative #2

Poster session / 75

Poster session

Corresponding Authors: mindaugas.sarpis@cern.ch, viesturs.lacis@cern.ch, normunds.ralfs.strautnieks@cern.ch, nana.chychkalo@cern.ch, mindaugas.ilickas@ktu.edu, luca.piacentini@cern.ch, lazar.nikitovic@cern.ch, kristupa.seskauskaite@cern.ch, e.moradpur.tari@gmail.com, bocharov@cfi.lu.lv, dairis.rihards.irbe@cern.ch, dace.osite@cern.ch, conrado.munoz.diaz@cern.ch, benjaminas.togobickij@lei.lt, antra.gaile@cern.ch, andrew.cesnokov@gmail.com, anastasiy101294@gmail.com

76

LHCb Open Data Release

Author: Mindaugas Sarpis[1]

[1] *University of Bonn (DE)*

Corresponding Author: mindaugas.sarpis@cern.ch

LHCb collaboration is releasing research-quality data to the public for the very first time. A data sample amounting to 960TB was obtained in 2011 and 2012 during the Run I of the Large Hadron Collider. The data is obtained by the LHCb detector when recording the information of proton collisions in the LHC.

The data has undergone a preprocessing step where physics objects, such as the trajectories of charged particles, were reconstructed from the raw information delivered by the complex detector system. The data is filtered and classified according to 300 physical processes and decays. The data is made available in the same format as is used internally by the LHCb physicists and is accompanied by extensive metadata and documentation, as well as a Glossary explaining several hundred special terms used in the preprocessing. The data can be analyzed using dedicated LHCb software, which is open-source.

In this poster, the details of ongoing and future Open Data efforts in LHCb will be presented.

Type of contribution:

Poster

Baltic and National activities / 77

Riga Tech Girls

78

Federated HPC environment for distributed CERN CMS TIER2 computing

Author: Janis Irbe[1]

Co-author: Lauris Cikovskis [1]

[1] *Riga Technical University (LV)*

Corresponding Authors: lauris.cikovskis@rtu.lv, janis.irbe@cern.ch

The significant increase in CERN CMS computing requirements for the upcoming High-Luminosity Large Hadron Collider (HL-LHC) upgrade will initiate new challenges in pledged HPC computing infrastructure. Federated TIER2 deployment architecture is set to provide a scalable solution by utilizing Latvia's National Academic Network and distributed computing resources of several academic institutions involved in the project.

Type of contribution:

Talk

Conference keynote / 79

Hunting new-physics footprints: the SMEFT program for the LHC

Corresponding Author: ilaria.brivio@unibo.it

Over a decade after the discovery of the Higgs boson, the hunt for physics beyond the Standard Model faces the possibility that new particles might be too heavy to be seen at the LHC. In this case, they would only leave small non-resonant traces in the measured distributions, that could be detected in high-precision measurements. The theoretical framework that best describes these effects is the so-called Standard Model Effective Field Theory (SMEFT). After giving a pedagogical introduction to this theory, the talk will review the enormous theoretical and experimental progress made in the past decade towards enabling an "agnostic", SMEFT-based interpretation of experimental data, and it will discuss current limitations and future prospects.

Technologies I : Medicine and Computing / 80

Federated HPC environment for distributed CERN CMS TIER2 computing

Corresponding Author: janis.irbe@cern.ch

Conference Opening / 81

Welcome by the CERN Director for International Relations

Corresponding Author: charlotte.lindberg.warakaulle@cern.ch

Industry engagement / 82

Primekss Concrete R&D center collaboration with Institute of Chemical Physics at UoL: Tritiated water (HTO) and concrete interaction

Corresponding Authors: rolands.cepuritis@primekss.com, elina.pajuste@cern.ch

20+5

Type of contribution:

Industry engagement / 83

Latvian industry in CMS

Corresponding Author: guntis.pikurs@cern.ch

15+5

Theory / 84

Overview of Exotic Spectroscopy at LHCb

Corresponding Author: mindaugas.sarpis@cern.ch

[additional experimental talk]