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Talks

Trigger Rate Monitoring Tools at CMS

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Inside the Compact Muon Solenoid (CMS), a detector designed to further our understanding of fundamental physics, collisions occur at an approximate rate of 40 MHz. This is much more data than can possibly be stored, and the CMS detector uses two trigger systems to filter out uninteresting data, allowing only the more manageable 1kHz of relevant data to be stored. The two trigger systems are the hardware base Level-1 trigger (L1) and the software base High Level Trigger (HLT). Monitoring the trigger rates is of critical importance to the operations of the CMS detector these rates can help determine the performance of the trigger and give indications of issues in other systems in the detector. Software tools that can monitor, characterize, and visualize the trigger rates have been developed for both the runtime operations and the data analysis. This presentation will discuss the functionality of these tools and further development of these tools.

Using N-body simulations to study cosmological inflation and dark matter

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Cosmology is the study of the origin and evolution of the universe. While significant strides have been made in our understanding of the cosmos, many things still remain a mystery. How did the universe rapidly inflate in its early phases? What exactly is dark matter, which comprises most mass in the universe?

In this talk, I will give an overview on how the cosmological simulation, Gadget, is used to tackle these problems, focusing on models of “warm” inflation and “fuzzy” dark matter.

Ion Beam Analysis with St. Andre

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PIGE (particle-induced gamma emission) is a nuclear physics technique where target nuclei are excited to higher energy levels by bombardment with projectile particles. Since the level scheme for each nuclear isotope is unique, the energy of the gamma-rays emitted during relaxation to the ground state can be used to determine the isotopic composition of the target. Since each measurement is relatively fast (typically < 3 minutes), PIGE can be used as a rapid screening method to test large numbers of samples for the presence of contaminants. Exact identification may require more intensive chemical characterization, but PIGE can be used to rapidly screen for contaminants or to investigate fate and transport of contaminants.

New Worlds Around Ancient Stars: Exploring the History of Planet Formation with the SEAMSTRESS Survey

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The Search for Exoplanets Around Metal-poor Stars with T(r)ESS (SEAMSTRESS) Survey seeks to answer the question: “When and how did planet formation begin in the Universe?” To achieve this, we have conducted a large-scale search for transits of metal-poor stars in TESS light curves and discovered 48 previously unknown planet candidates around host stars in the metallicity range $-2.28 < [Fe/H] < -0.5$, eight of which have lower [Fe/H] than any known transiting planet hosts.

Cross section and reaction rate measurement of ^{24}Mg($\alpha, p\gamma$)^{27}Al with HAGRiD

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Alpha-induced reactions have been identified as playing an important role in various astrophysical phenomena, as well as in applications for the study of materials. Sensitivity studies have indicated the ^{24}Mg(α, p)^{27}Al reaction is important in understanding the energy generation in Type Ia X-ray bursts; therefore precise cross section measurements are needed. Data on the direct ^{24}Mg(α, p)^{27}Al reaction is scarce, with only a relative cross section known, and no data is available for the inelastic channels which may contribute to the reaction rate. Present ^{24}Mg(α, p)^{27}Al reaction rates rely exclusively on the inverse ^{27}Al(p, α)^{24}Mg cross section. The direct (α, p) and inverse (p, α) reactions have been performed at the University of Notre Dame's Nuclear Science Laboratory using the 5U Sta. ANA accelerator to produce a high-intensity beam with high energy resolution, providing new precision cross section measurements. The $LaBr_3$ Hybrid Array of Gamma Ray Detectors (HAGRiD) was utilized to span seven unique angles to detect the secondary γ rays in the inelastic channels. The cross sections, measured using secondary γ rays, and their effect on the reaction rate of ^{24}Mg(α, p)^{27}Al will be presented.

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AMS Development for Neutron Activated Actinide Measurements

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The next generation of nuclear reactors (Gen IV) will rely on more complete burning of the nuclear fuel rods. Due to the increased time within the reactor, the build-up of certain transuranic and minor actinides will be significant enough to affect reactor performance. Currently, measurements of the relevant neutron capture cross sections suffer from large uncertainties. Therefore, improved measurements will be crucial to properly assess future designs. The MANTRA (Measurement of Actinides Neutron TRAnsmutation) project involves a two step approach involving neutron irradiation and subsequent Accelerator Mass Spectrometry (AMS) measurements for a variety of actinide samples. In the Nuclear Science Lab (NSL), development towards expanding measurement capabilities to the actinide region are underway. Details of the MANTRA project as well as developmental efforts towards performing Actinide AMS measurements with the FN tandem accelerator will be presented.

Measurements of B($E2$) Electromagnetic Transitions in Light Nuclei and Comparisons to *Ab Initio* Calculations

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Precise measurements of electromagnetic transition strengths in light nuclei can provide stringent tests of nuclear *ab initio* calculations. *Ab initio* nuclear theory attempts to describe nuclear properties from the basics of nucleons and their interactions. In the A=7 isobars, specifically ^{7}Li and ^{7}Be, the B($E2$) transition strengths have been used to benchmark a variety of different *ab initio* calculations. While the ^{7}Li B($E2; 3/2^- \to 1/2^-$) has been previously measured, the ^{8}Li measured value has a large uncertainty and the ^{7}Be B($E2$) have never been measured. We have performed Coulomb excitation experiments to measure the B($E2; 2^+ \to 1^+$) transition strength in ^{8}Li and the B($E2; 3/2^- \to 1/2^-$) transition strength in ^{7}Be. Both the ^{8}Li and ^{7}Be were produced and separated with TwinSol and the Coulomb excitation cross sections were measured using particle-gamma coincidences. The final B($E2$) value of ^{7}Be and the preliminary B($E2$) value of ^{8}Li will be shown and compared to ab initio calculations. These calculations can give us insight into the structural changes from ^{7}Be to ^{7}Li to ^{8}Li due to change in isospin and neutron addition. The results of these experiments will also provide a test of the accuracy of available *ab initio* calculations in this light mass region.

Posters

Chiral Wobbling in ^{135}Pr

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Chirality and wobbling are the two unique signatures that help in the identification of the rare triaxial shape in nuclei. While both these modes have been separately established in a few limited regions of the nuclear chart, the coexistence of chirality and wobbling in a nucleus, a Chiral Wobbler, has never been observed so far. Using a high statistics Gammasphere experiment with the ^{123}Sb(^{16}O,4n)^{135}Pr reaction, the very first observation of a Chiral Wobbler in ^{135}Pr has been made. In addition to the previously established $n_\omega = 1$ and $n_\omega = 2$ wobbling bands, two chiral-partner bands with the configuration $\pi h_{11/2} \times \nu h_{11/2}^{-2}$ have been observed in this nucleus. Angular distribution analyses of the ΔI = 1 connecting transitions between the two chiral partners have revealed their characteristic M1/E2 nature. Preliminary calculations in the framework of the Particle Rotor Model (PRM) have been found to be in good agreement with the experiment.

Optimizing the Design of Magnet Filters through Simulations for fIREBall

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Measurement of conversion electrons is an important aspect of nuclear structure studies. A new fIREBall array is being constructed by building on the existing "ICEBall" mini-orange array of SiLi detectors. fIREBall will come into existence from the replacement of the current array of six mini-orange Si(Li) detectors of ICEBall with twelve new Si(Li) detectors and the optimization of the design of the magnetic filters. The magnetic elements are used to create a field that the electrons follow after being produced in nuclear reactions. The goal was to improve the efficiency of collecting the electrons with a redesign of the magnetic elements. Using a combination of FreeCAD, COMSOL and Geant4, we have created an efficient, working simulation to test numerous different shapes of magnets to use for the filters. We have identified several different magnet shapes that could potentially improve the current absolute efficiency of ICEBall (15% at 356 keV) by approximately twofold across a wider energy range. We report on the results of these simulations and will proceed to experimentally test the new magnet shapes.

Characterizing r-Process Sites through Actinide Production

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The astrophysical production site of the heaviest elements in the universe remains a mystery. Incorporating heavy element signatures of metal-poor, *r*-process enhanced stars into theoretical studies of *r*-process production can offer crucial constraints on the origin of heavy elements. We apply the "Actinide-Dilution with Matching" model to a variety of stellar groups ranging from actinide-deficient to actinide-enhanced to empirically characterize *r*-process ejecta mass as a function of electron fraction (Y_e). We find that actinide-boost stars do not indicate the need for a unique and separate *r*-process progenitor. Rather, small variations of neutron richness within the same type of *r*-process event can account for all observed levels of actinide enhancements. The very low-Y_e fission-cycling ejecta of an *r*-process event need only constitute 10–30% of the total ejecta mass to accommodate most actinide abundances of metal-poor stars. We find that our empirical Y_e distributions of ejecta are similar to those inferred from studies of GW170817 mass ejecta ratios, which is consistent with neutron-star mergers being a source of the heavy elements in metal-poor, *r*-process enhanced stars.

Posters

Implementing and evaluating modern nuclear models in the study of r-process nucleosynthesis

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The astrophysical *r*-process of nucleosynthesis produces the heaviest elements known to exist in the universe. Because the nuclei that participate in the *r* process are incredibly short-lived and neutron-rich, they can be difficult or impossible to study using modern experimental facilities. Our ability to understand the *r*-process, therefore, is directly tied to the success of theoretical nuclear models. Here, we examine how the well-quantified uncertainty of one modern nuclear model, UNEDF1, propagates to r-process simulations. We further describe a method for using the information contained in *r*-process observations to potentially help constrain UNEDF1 and related nuclear models.

The Slowly Fading Light Echo Around Type Ia Supernova 2009ig

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The light echo around Supernova 2009ig (SN2009ig) is the sixth known and most luminous around a type Ia supernova. Light echoes can provide information on the local environment around supernovae, which is particularly important for type Ias since they are used as standard candles. The presence of gas and dust in the local environment of a type Ia can affect the observed luminosity and could impact measurements of the Hubble constant. Using photometric data from the Large Binocular Telescope between 2010 and 2019, we present new observations of the SN2009ig light echo that confirm a slow fading of the echo over the past 6 years since its discovery in 2013. The fading is similar to that seen in the light echo of SN1991T and suggests that some of dust producing the echo may be local to the event.

Precision Magneto-optical Measurements of Magnetically Doped Mn$-$Pb$_{1-x}$Sn$_x$Se

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The search for topological semimetals is a major challenge in condensed matter physics. It has been proposed that Pb$_{1-x}$Sn$_x$Se, a topological crystalline insulator, can host a variety of relativistic fermionic phases. Through magnetic doping, we hope to realize a Weyl or a line node semimetal state using Pb$_{1-x}$Sn$_x$Se. This topological crystalline insulator is an ideal platform for searching for these exotic electronic states, as it contains a wide range of tunable parameters. In this work we study the magnetic and energetic properties of Mn-doped Pb$_{1-x}$Sn$_x$Se, with $x = 0$, to model the shift in energy levels found at low field.

Predictive modeling of plasma-induced DNA damage: A machine learning approach to plasma medicine

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Atmospheric pressure plasma (APP) is emerging as a potential and efficient candidate for cost-effective cancer therapy applications. One of the fundamental mechanisms that make them an ideal candidate for this purpose is the cell apoptosis arising from the DNA damage induced by the highly reactive oxygen and nitrogen species (RONS) present in the plasma. Since the plasma-induced DNA damage is highly dependent on the interaction of the DNA with various reactive species, the quantification of DNA damage is necessary to understand the reactive nature of plasma. This interaction can be controlled and tuned by numerous parameters such as plasma power, pulse frequency, feed gas flow, irradiation distance, and irradiation time. In this work, we are introducing a predictive model to quantify the DNA damage occurring at a given APP parameter, which would help us choose the desired plasma parameters for various applications, including plasma medicine. The predictive modeling was done with the help of a classic multi-layer perceptron (MLP) neural network model, which is a widely used and recognized machine learning model in data science.

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