WNPPC 2018

55th Winter Nuclear & Particle Physics Conference

Mont-Tremblant, Québec, 15-18 February 2018

Organised by Carleton University & TRIUMF

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Welcome!

On behalf of the Organizing Committee, I welcome you to the 55th Winter Nuclear & Particle Physics Conference. This year we have a record attendance! The program includes 6 plenary talks and 45 contributed talks, spanning a wide range of topics. Enjoy the talks, enjoy the venue, meet new and old colleagues. I wish you a fruitful and pleasant conference.

Alain Bellerive

Invited Speakers

- **Dr. Geoffrey Fathom Grinyer** (University of Regina) *ACTAR TPC: a novel detection system for nuclear physics experiments*
- **Dr. James Smallcombe** (TRIUMF) *Internal Conversion Electron Spectroscopy at TRIUMF-ISAC*
- **Prof. Marie-Cécile Piro** (University of Alberta) *Dark matter searches at SNOLAB*
- **Dr. Tamara Vazquez Schroeder** (McGill University) *Overview of the Higgs and Standard Model physics at ATLAS*
- **Prof. Aaron Vincent** (Queen's University) *Illuminating the dark sector with astrophysical neutrinos*
- **Dr. Mark Hartz** (University of Tokyo/TRIUMF) *From T2K to Hyper-K: Status and Prospects for Long Baseline Neutrino Physics in Japan*

Registration

Thursday 15 February, from 16:00 to 17:30 in the Mezzanine between the 1st and 2nd floors beside Grande Ascension.

Reception

The Reception will take place after the last talk on Saturday 17 February, starting at approximately 21:00, in the Chalet.

Others Meals & Breaks

Coffee breaks (am/pm) will be located in Grande Ascension (back of the meeting room). Breakfasts and lunches will be in Expedition 1. Attendees who pre-ordered a bagged lunch are requested to pick up their bagged lunch at lunchtime in the Expedition 1. All other attendees who have not purchased a meal package may explore food options within Mont-Tremblant at: **https://www.tremblant.ca/things-to-do/dining**. All participants need to plan their own evening dinner and return in time for the evening session.

WIFI Information

WIFI information for the Grande Ascension room is as follows:

Network: Tremblant-Guest
Password: cdc2016wifi

Talks

Presentations will be in Grande Ascension. Presenters are required to upload a PDF file of their talk on Indico at **https://meetings.triumf.ca**. Prizes will be awarded for the best student talks, funded by our sponsors.

Sponsors

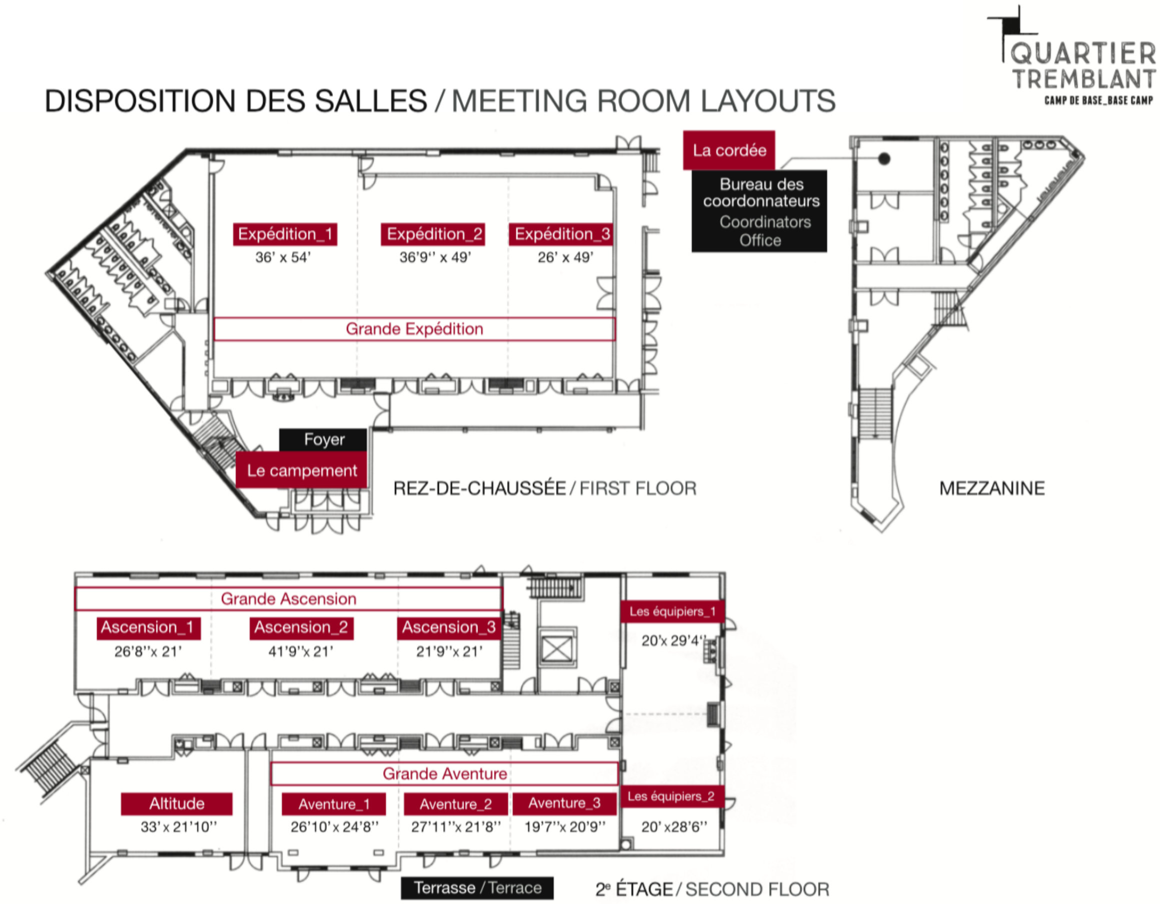
The support from our sponsors is gratefully acknowledged.

Main Sponsors

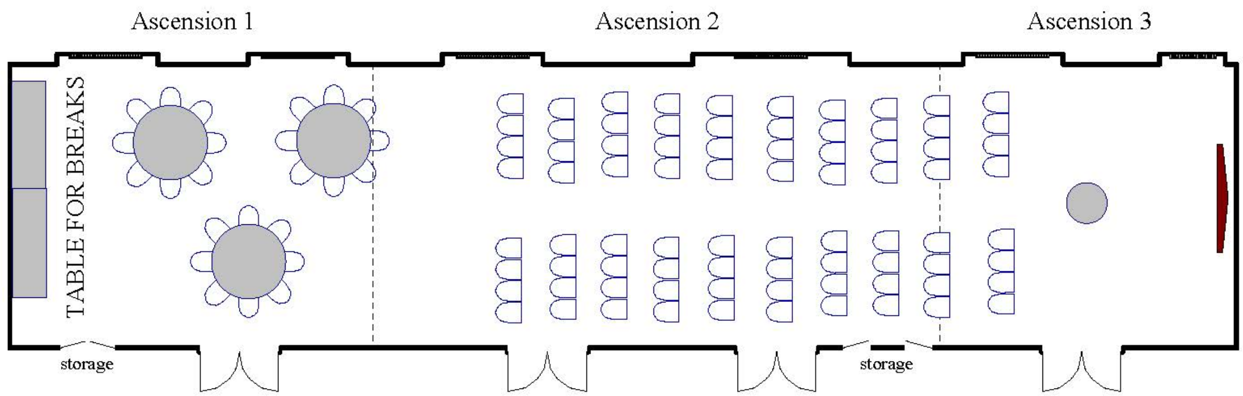
- Carleton University, Office of the Vice President, Research
- Carleton University, Office of the Dean of Science
- SNOLAB

Student Prizes Sponsors:

- CAP Division of Nuclear Physics (DNP)
- CAP Particle Physics Division (PPD)
- Canadian Institute of Nuclear Physics (CINP)
- Institute of Particle Physics (IPP)
- TRIUMF


QUARTIER
TREMBLANT
CAMP DE BASE_BASE CAMP
DISPOSITION DES SALLES / MEETING ROOM LAYOUTS
La cordée
Bureau des coordonnateurs
Coordinators Office
Expédition_1
36' x 54'
Expédition_2
36'9'' x 49'
Expédition_3
26' x 49'
Grande Expédition
Foyer
Le campement
REZ-DE-CHAUSSÉE / FIRST FLOOR
MEZZANINE
Grande Ascension
Ascension_1
26'8''x 21'
Ascension_2
41'9''x 21'
Ascension_3
21'9''x 21'
Les équipiers_1
20'x 29'4''
Grande Aventure
Altitude
33' x 21'10''
Aventure_1
26'10' x 24'8''
Aventure_2
27'11''x 21'8''
Aventure_3
19'7''x 20'9''
Les équipiers_2
20' x28'6''
Terrasse / Terrace
2e ÉTAGE / SECOND FLOOR

Ascension


Ascension 1
Ascension 2
Ascension 3
TABLE FOR BREAKS
storage
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Schedule Overview

Thursday 15 February

16:00 – 17:30	Registration (Mezzanine next to Ascension)
19:00 – 20:30	Session 1a
20:30 – 20:45	Coffee break
20:45 – 22:00	Session 1b

Friday 16 February

07:30 – 09:00	Breakfast & Registration
09:00 – 10:30	Session 2a
10:30 – 10:45	Coffee break
10:45 – 11:45	Session 2b
12:00 – 14:00	Lunch
Afternoon is free for other activities	
19:00 – 20:30	Session 3a
20:30 – 20:45	Coffee break
20:45 – 21:45	Session 3b

Saturday 17 February

07:30 – 09:00	Breakfast
09:00 – 10:30	Session 4a
10:30 – 10:45	Coffee break
10:45 – 12:00	Session 4b
12:00 – 14:00	Lunch
Afternoon is free for other activities	
19:00 – 21:00	Session 5
21:00 – 23:00	Reception Chalet

Sunday 18 February

07:30 – 09:00	Breakfast
09:00 – 10:30	Session 6a
10:30 – 10:45	Coffee break
10:45 – 11:45	Session 6b
12:00 – 14:00	Lunch

Detailed Schedule

Legend:

- **bold names** are the invited speakers
- ★ after the name are non-student talks
- all the others are student talks

Thursday 15 February, evening

Session 1a

19:00 – 19:15	Welcome – Introduction from Prof. Alain Bellerive
19:15 – 19:45	**Dr. Geoffrey Fathom Grinyer**, *ACTAR TPC: A Novel Detection System for Nuclear Physics Experiments*
19:45 – 20:00	Mr. Edward Thoeng, *Beta-SRF - A New Facility to Characterize SRF Materials Near Fundamental Limits*
20:00 – 20:15	Mr. Benjamin Tam, *SNO+ Calibration Systems*
20:15 – 20:30	Mr. Yan Liu, *AmBe Source Calibration in the SNO+ Water Phase*

20:30 – 20:45	Coffee Break

Session 1b

20:45 – 21:00	Mr. Richard Germond, *A Cryogenic Underground Test Facility (CUTE) for SuperCDMS*
21:00 – 21:15	Mr. Kevin Murray, *Design of a Multiple-Reflection Time-of-Flight Mass-Spectrometer for Barium-tagging with nEXO*
21:15 – 21:30	Mr. Alexandre Laurier, *Current State of ATLAS's New Small Wheel Simulation Software and Construction Effort of the Small Strip Thin Gap Chambers*
21:30 – 21:45	Mr. Alessandro Ambler, *Optimization Studies for the Upgraded Readout Electronics of the ATLAS Liquid Argon Calorimeter*
21:45 – 22:00	Mr. Konstantin Lehmann, *Electrical Isolation of ITk Strip Sensors*

Friday 16 February, morning

07:30 – 09:00 Breakfast & Registration

Session 2a

09:00 – 09:30 **Dr. James Smallcombe**, *Internal Conversion Electron Spectroscopy at TRIUMF-ISAC*
09:30 – 09:45 Badamsambuu Jigmeddorj, *High-Statistics β-decay Study of Collectivity in ^{122}Xe.*
09:45 – 10:00 Dr. Farnaz Ghazi Moradi★, *Decay Spectroscopy of ^{126}Xe*
10:00 – 10:15 Beau Greaves, *One-Neutron Transfer into 22Ne*
10:15 – 10:30 Prof. Viktor Zacek★, *Search for New Physics in Beryllium*

10:30 – 10:45 Coffee break

Session 2b

10:45 – 11:00 Mr. Yukiya Saito, *Decay Spectroscopy of Neutron-Rich ^{129}Cd with GRIFFIN Spectrometer*
11:00 – 11:15 Nikita Bernier, *Decay Spectroscopy of Neutron-Rich Cd Around the $N = 82$ Shell Closure*
11:15 – 11:30 Moushumi Das, *High-sensitivity Atomic Magnetometer for Neutron EDM*
11:30 – 11:45 Mr. Shomi Ahmed, *Compensation of Magnetic Fields at the TRIUMF nEDM Experiment*

12:00 – 14:00 Lunch

Friday 16 February, evening

Session 3a

19:00 – 19:30	**Prof. Marie-Cécile Piro**, *Dark Matter Searches at SNOLAB*
19:30 – 19:45	Mr. Daniel Durnford, *The NEWS-G Direct Dark Matter Search Experiment: First Results and Outlook*
19:45 – 20:00	Ms. Danika MacDonell, *Calibration of SuperCDMS* Dark Matter Detectors for Low-Mass WIMPs*
20:00 – 20:15	Mr. Andrew Erlandson, *The DEAP-3600 Muon Veto System*
20:15 – 20:30	Mr. Arthur Plante, *Dark Matter Search Results of the PICO experiment in the Effective Field Theory Context*

20:30 – 20:45	Coffee break

Session 3b

20:45 – 21:00	Mr. Frédéric Tardif, *Characterization of Superheated Fluids in PICO-0.1 Bubble Chamber for the Search of Dark Matter*
21:00 – 21:15	Clarke Hardy, *Improving the Optics and Fiducial Volume of the PICO Bubble Chamber Dark Matter Detector*
21:15 – 21:30	Mr. Mathieu Laurin★, *PICO-40, An Important Step Towards a Ton-Scale Spin-Dependent Dark Matter Search Experiment at SNOLAB*
21:30 – 21:45	Ms. Gevy Cao, *PICO-40L Calibration Simulation and Analysis Techniques using Machine Learning*

Saturday 17 February, morning

07:30 – 09:00 Breakfast

Session 4a

09:00 – 09:30 **Dr. Tamara Vazquez Schroeder**, *Overview of the Higgs and Standard Model Physics at ATLAS*

09:30 – 09:45 Mr. Tae Hyoun Park, *Determination of Jet Energy Resolution in Proton-Proton Collisions of the ATLAS Detector*

09:45 – 10:00 Mr. Stephen Weber, *Measurement of Z Bosons Produced in Association with Jets via Vector Boson Fusion at 13 TeV with the ATLAS Detector*

10:00 – 10:15 Mr. Benjamin Freund, *Search for Resonant WZ→lvl'l' Production in Proton-Proton Collisions at $\sqrt{s}$ = 13TeV with the ATLAS Detector*

10:15 – 10:30 Mr. Sebastien Prince, *First Measurement of Photon+b Production Cross Sections in pp Collisions Using the ATLAS Detector*

10:30 – 10:45 Coffee break

Session 4b

10:45 – 11:00 Robin Hayes, *Scale Factors for the ATLAS Muon Triggers*

11:00 – 11:15 Louis-Guillaume Gagnon, *Search for Production of Supersymmetric Particles in Final States with Missing Transverse Momentum and Multiple b-jets in 2015-2016 LHC p-p Collision Data with the ATLAS Detector*

11:15 – 11:30 Otilia Ducu★, *Search for Supersymmetry in Final States with Two Same-Sign or Three Leptons and Jets Using 13 TeV ATLAS Data*

11:30 – 11:45 Mr. Kays Haddad, *Sensitivity Study of a Search for a Charged Scalar Particle in $\sqrt{s} = 14$ TeV pp Collisions*

11:45 – 12:00 Ms. Shreya Saha, *Development of a New B-Physics Trigger for the ATLAS Detector at CERN*

12:00 – 14:00 Lunch

Saturday 17 February, evening

Session 5

19:00 – 19:30	**Prof. Aaron Vincent**, *Illuminating the Dark Sector with Astrophysical Neutrinos*
19:30 – 19:45	Dr. Carla Francisco, *Neutrinos, Dark Matter and the Standard Model*
19:45 – 20:00	Mrs. Fatemeh Najafi, *Neutrino Oscillation*
20:00 – 20:15	Mr. Ryan Plestid, *Prospects for Rare Neutrino Physics at the Iintensity Frontier*
20:15 – 20:30	Dr. Mohammad Hedayatipour★, *Quasi-Elastic Neutrino Reactions on Carbon and Lead Nuclei*
20:30 – 20:45	Mr. Özer Özdal, *Exploring the Supersymmetric U(1)$_{B-L}\times$ U(1)$_R$ Model with Dark Matter, Muon $g-2$ and Z' Mass Limits*
20:45 – 21:00	Mr. Tyrell Edward Umbach, *Equivalence and Classification of 4D Adinkras*
21:00 – 23:00	Social Event – Reception Chalet

Sunday 18 February, morning

07:30 – 09:00 Breakfast

Session 6a

09:00 – 09:30 **Dr. Mark Hartz**, *From T2K to Hyper-K: Status and Prospects for Long Baseline Neutrino Physics in Japan*
09:30 – 09:45 Ms. Hannah Wakeling, *Rare Decays with Missing Energy at the Belle II Detector*
09:45 – 10:00 Waleed Ahmed, *Material Studies for the Belle II experiment*
10:00 – 10:15 Ms. Satbir Kaur, *Determination of Proton Radii of Neutron Rich Oxygen Isotopes from Charge-Changing Cross Section Measurements.*
10:15 – 10:30 Leyla Atar★, *Quasi-Free Proton Knockout Reactions on the Oxygen Isotopic Chain*

10:30 – 10:45 Coffee break

Session 6b

10:45 – 11:00 Christina Burbadge, *Characterizing LaBr3(Ce) Detector Response for Proton Therapy Applications*
11:00 – 11:15 Ms. Eva Kasanda, *Detecting Fusion-Evaporation Reaction Products from Contrast Agents as a Range Verification Technique in Proton Therapy*
11:15 – 11:30 Closing Remarks & Prizes with Prof. Alain Bellerive

12:00 – 14:00 Lunch

ACTAR TPC: A NOVEL DETECTION SYSTEM FOR NUCLEAR PHYSICS EXPERIMENTS

Geoffrey Fathom Grinyer *
University of Regina

The Active Target and Time Projection Chamber (ACTAR TPC) is an ambitious European project whose goal is to design and construct a high-luminosity gas-filled detector to study reactions and decays of rare isotopes. The core detection system consists of a micro-pattern gaseous detector coupled to a highly pixelated pad plane with a pitch of only 2x2 mm2. Both the channel density (25 channels/cm2) and total number of channels (16384) are the highest that have been achieved by any nuclear physics detector to date. In this talk, I will provide an overview of the project, present new results from a recent commissioning experiment and describe the day one physics programs for ACTAR TPC when it goes online at the GANIL laboratory in France in 2018.

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BETA-SRF - A NEW FACILITY TO CHARACTERIZE SRF MATERIALS NEAR FUNDAMENTAL LIMITS

Edward Thoeng *

Ben Matheson, Gerald Morris, Norman Muller, Suresh Saminathan
TRIUMF

Arthur Chen
UBC

Tobias Junginger
University of Lancaster

Robert E. Laxdal
TRIUMF/University of Victoria

CW high-power LINACs require SRF cavities operating at the frontier of high accelerating gradient and low RF power dissipation, i.e. high quality factor (Q0). This requirement poses a challenge for standard surface treatment recipes of SRF cavities and new treatments including doping and layered structures are being developed and proposed. Understanding the fundamental mechanisms behind the success of Nb doping and the potential for new materials and layered structures to push beyond Nb is key for advancing the SRF field. At the TRIUMF beta NMR facility, a unique experimental apparatus, beta-SRF, is currently being developed to address these issues. This facility will enable studies of the local surface magnetic field through the London Penetration Depth (several nm) via β-decay detection of a low-energy radioactive ion-beam. This will allow depth-resolution and layer-by-layer measurement of magnetic field shielding effectiveness of doped materials, dirty/clean layers, coatings and new layered SRF materials at high-parallel field (up to 200 mT). Design and current development of this facility will be presented here, as well as measurement strategies for new SRF materials.

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SNO+ CALIBRATION SYSTEMS

Benjamin Tam *
Queen's University

The SNO+ experiment is a versatile multipurpose neutrino detector situated at SNOLAB. Though concentrated on the search for neutrinoless double beta decay in ^{130}Te, SNO+ is also capable of a vast array of physics goals including the observation of geoneutrinos, reactor antineutrinos, supernova neutrinos, and other exotic physics such as axion-like particles and invisible nucleon decay. Low background detectors for rare event physics such as the SNO+ detector require extensive calibration systems. The calibration hardware is designed to match the purity requirements of SNO+, be compatible with the liquid scintillator to be filled in SNO+, and be able to move sources in multiple orthogoal planes within the detector. As the detector is now fully operating in its first phase, extensive calibrations have been performed using optical and radioactive sources deployed within the detector. These calibrations are used to determine the PMT response, optical properties of the detector, the energy scale, energy resolution, linearity of response, detector asymmetries, and reconstruction efficiencies.

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AMBE SOURCE CALIBRATION IN THE SNO+ WATER PHASE

Yan Liu *

Queen's University

SNO+ is a kilo-tonne scale liquid scintillator experiment in search for neutrinoless double beta decay. SNO+ reuses the old SNO detector, which is currently filled with water. Physics topics including nucleon decay and antineutrino detection are explored during this water phase. In this talk I will discuss the importance of AmBe source calibration on both physics topics along with an overview of the progress we have made on the AmBe source calibration in the last few months.

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A CRYOGENIC UNDERGROUND TEST FACILITY (CUTE) FOR SUPER CDMS

Richard Germond *

Queen's University

Many astronomical and cosmological observations have led to the conclusion that approximately 85% of the mass content of the universe is composed of non-baryonic dark matter that interacts weakly with ordinary matter. The Super Cryogenic Dark Matter Search (SuperCDMS) experiment operates cryogenic semiconductor detectors to observe rare signals produced by dark matter particles colliding in the detector. Prior to the full deployment of SuperCDMS SNOLAB, the Cryogenic Underground TEst facility (CUTE) will provide a low background setting in SNOLAB for SuperCDMS to test and characterize detectors, study the internal and environmental backgrounds, and potentially obtain early dark matter search data.

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DESIGN OF A MULTIPLE-REFLECTION TIME-OF-FLIGHT MASS-SPECTROMETER FOR BARIUM-TAGGING WITH NEXO

Kevin Murray *

McGill University

The search for neutrinoless double beta decay requires increasingly advanced methods of background reduction. A bold strategy of solving this problem, in experiments using Xenon, is to extract the daughter Barium ion produced by double beta decay from the experiment vessel. The ion is then identified, which when combined with the corresponding energy deposit in the detector, allows for a virtually background free verification of the neutrinoless double beta decay signal. This is the process of Barium-tagging, in which the Multiple-Reflection Time-of-Flight Mass-Spectrometer (MR TOF) will perform systematic studies of the ion extraction technique, as well as provide further identification of the Barium ion. The MR TOF has been adapted such that it has a quickly adjustable mass-range and resolution. Simulations show that the mass-resolving power reaches a maximum of approximately 70000.

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CURRENT STATE OF ATLAS'S NEW SMALL WHEEL SIMULATION SOFTWARE AND CONSTRUCTION EFFORT OF THE SMALL STRIP THIN GAP CHAMBERS

Alexandre Laurier *

Carleton University

The ATLAS experiment is being improved in order to benefit from the increased performance provided by the next phase of CERN's large hadron collider upgrade plan. The Small Wheel will be replaced by the New Small Wheel, constructed from Micromega detectors and Small-strip Thin Gap Chambers (sTGC). The current state of the sTGC simulation software responsible for replicating hardware response and track reconstruction will be presented. The assembly and testing of sTGCs at Carleton University will also be introduced. The issues which arise when we attempt to consolidate both the hardware construction and the software efforts will be discussed in order to showcase some difficulties of building complex detectors.

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OPTIMIZATION STUDIES FOR THE UPGRADED READOUT ELECTRONICS OF THE ATLAS LIQUID ARGON CALORIMETER

Alessandro Ambler *

McGill University

Multiple analog and digital signal processing techniques are simulated to optimize the energy reconstruction performance of the upgraded readout electronics of the liquid argon hadronic endcap calorimeter in the ATLAS detector. The ATLAS detector is designed to record proton-proton collisions at the Large Hadron Collider (LHC). The detector will be upgraded in 2024-25 alongside the LHC's accelerator chain to cope with a factor 7 increase in luminosity. In this high luminosity environment, radiation will attain levels that the current detector readout electronics were not originally designed to sustain. The current readout electronics are also incompatible with the technical requirements introduced by the planned upgrade of the experiment's trigger system. Therefore, a complete overhaul of the readout electronics for the ATLAS liquid argon calorimeter system is required. In addition, the increased interaction rate will result in a degradation of the measured detector energy resolution. A detailed simulation of the hadronic endcap calorimeter readout electronics under the expected high luminosity conditions is used to optimize the various parameters of the analog and digital readout chain. The results of these optimization studies will be presented.

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ELECTRICAL ISOLATION OF ITK STRIP SENSORS

Konstantin Lehmann *

Simon Fraser Universtiy

Recording proton-proton collisions at the LHC requires cutting-edge detectors, custom- made for high energy physics applications. A new Inner Tracker (ITk) will be built for the ATLAS experiment to be able to resolve approximately 200 proton collisions simultaneously during the high-luminosity LHC phase. In order to minimize dead detector area, individual sensors need to be placed as close as possible while avoiding high voltage discharges between them. I will present a case study for the ITk strip detector investigating possible discharges between bordering sensors. Current-voltage characteristics will be used to define a threshold voltage. This threshold voltage can be graphed as a function of gap width to reproduce Paschen's law and determine whether gas discharges will be problematic for ITk. The influence of glue spills and other contaminants in the inter-sensor gap will also be summarized.

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INTERNAL CONVERSION ELECTRON SPECTROSCOPY AT TRIUMF-ISAC

James Smallcombe *

Michael Bowry, Greg Hackman, Adam Garnsworthy

TRIUMF

Internal conversion electron (ICE) spectroscopy is a key tool of nuclear structure research, particularly for the study of elusive electric monopole (E0) transitions. Such spectroscopy is less common than gamma-ray spectroscopy due to the technical challenges involved, however it provides crucial insight few other techniques can. The nuclear spectroscopy group at TRIUMF has two powerful detector arrays for studying competing internal conversion electrons and gamma rays. The SPectrometer for Internal Conversion Electrons (SPICE) is used with the TIGRESS HPGe array for studying nuclear structure in accelerated heavy ion experiments. The Pentagonal Array of Conversion Electron Spectrometers (PACES) is used with the GRIFFIN HPGe array for decay spectroscopy to study internal conversion electrons following beta decay. In this talk I will explain the details of ICE spectroscopy and E0 transitions as well as the equipment and techniques employed at TRIUMF. Results from recent studies of shape-coexistence in 70Se with SPICE, beta-decay studies of 72Ge and neutron deficient Hg isotopes with PACES and the development of electron-gamma angular correlation techniques with GRIFFIN will be presented.

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HIGH-STATISTICS β-DECAY STUDY OF COLLECTIVITY IN ^{122}XE

Badamsambuu Jigmeddorj[1] *

Corina Andreoiu[2], Gordon Ball[3], T Bruhn[2,3], David Cross[2], Adam Garnsworthy[3], Paul Garrett[1], Baharak Hadinia[1,4], Mohamad Moukaddam[3,5], Jason Patk[3,6,7], Jennifer Pore[2,8], Allison Radich[1], Mustafa Rajabali[3,9], Evan Rand[1,10], Usman Rizwan[2], Carl Svensson[1], Philip Voss[11], Zhimin Wang[1,3], John Wood[12], Steven Yates[13]

1. University of Guelph, 2. Simon Fraser University, 3. TRIUMF, 4. McMaster University, 5. University of Surrey, 6. Lund University, 7. University of British Columbia, 8. Lawrence Berkeley National Laboratory, 9. Tennessee Technological University, 10. Chalk River Laboratories, 11. Albion College, 12. Georgia Institute of Technology, 13. University of Kentucky

The evolution of the simple collective signature, the excited first 2^+ state energy, is extraordinarily smooth for the nuclei in the Z>50, N<82 region, which is expected to be an ideal region to test collectivity. The study of ^{122}Xe is a part of a systematic examination of the development of collectivity in the Xe isotopes which are located in the region. Detailed investigations of nuclear structure in the Xe isotopes reveal a pairing vibrational structure influenced by proton subshell gaps. In particular, the 0_3^+ states in $^{124-132}$Xe are very strongly populated in (^{3}He,n) reactions [1], suggesting a pairing vibrational structure. Recent work on ^{124}Xe [2] has established nearly identical quadrupole collectivity for the pairing vibrational 0_3^+ band and the ground state band. The collectivity of excited states in ^{122}Xe is not well characterized because of a general lack of spectroscopic data for low- and high-spin states, which provide measures of collective properties. The experiment to study ^{122}Xe with the β^+/EC decay of ^{122}Cs was performed at the TRIUMF-ISAC facility located in Vancouver, B.C., Canada. The data collected have enabled the observation of about 505 new transitions and about 250 new levels, including around 145 new high-spin states. The results on the establishment of the 2^+ band members of the 0_2^+ and 0_3^+ bands, observation of important, but previously unobserved, $2_2^+ \rightarrow 0_2^+$ and $2_3^+ \rightarrow 0_3^+$ transitions [3], and the confirmation of the spin of the 0_3^+ state [4] are reported. In addition, the present work is focused on newly observed high-spin states of ^{122}Xe. [1] W.P. Alford, $et.al.$, Nucl. Phys. A**323**, 339 (1979). [2] A.J. Radich $et.al.$, Phys. Rev. C**91**, 044320 (2015). [3] B. Jigmeddorj $et.al.$, Web of Conf. 107, 03014 (2016) [4] B. Jigmeddorj $et.al.$, Physics Procedia 90 (2017).

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DECAY SPECTROSCOPY OF ^{126}XE

Farnaz Ghazi Moradi *

Paul E. Garrett, Carl E. Svensson

University of Guelph

The low-spin excited states in the non-yrast bands of Xe nuclei in A=120-130 mass zone exhibit excitations built on both rotational and vibrational degrees of freedom.The precise branching ratio measurements of the often weak transitions that connect these low-lying collective states and the determination of their $B(E2)$ values play an important role in characterization of the excited states with low and medium angular momenta. This information is also essential in determination of the extent to which a certain dynamical symmetry is preserved or broken in the chain of even mass xenon isotopes which lie below $N = 82$ closed shell and approach the mid-shell at $N = 66$ [1,2]. Of particular interest in this regard are the appearance of the low-energy excited 0^+ states in even mass $^{124-130}$Xe isotopes with a population cross section of approximately 30% to that of the ground state [5]. In ^{124}Xe the 0^+_2 and the 0^+_3 excited states have been investigated and their structure is interpreted as proton-pairing vibrational states but for other stable even-even Xe isotopes in the mass range $A = 126 - 130$ this information is scarce [5]. The excited states in ^{126}Xe have been studied in β^+/EC decay spectroscopy of ^{126}Cs using 8π γ-ray spectrometer located in ISAC-I facility at TRIUMF in the past. Currently there are 29 γ-transitions that are reported in the Nuclear Data Sheet only by their energy and are not placed in the level scheme. The high statistics ^{126}Xe β^+ decay experiment allowed careful examination of these transitions in order to place them in the level scheme and also the measurement of their corresponding branching ratios. Some of the highlights of the $\gamma - \gamma$ coincidence and the angular correlation analyses presented here include: - The direct observation of the 326 Kev ($2^+_5 \rightarrow 0^+_3$) in-band transition and determining the absolute $B(E2; 2^+_5 \rightarrow 0^+_3)$ value for the first time. - Determining the multipolarity and the mixing ratios of transitions de-exciting the level energies at 2455 Kev, 2064 Kev and 1679 KeV in order to measure the $E2$ strength of mixed transitions which are previously reported as the upper limits only. The results presented here are preliminary as the coincidence and correlation analyses are currently under progress to assure that all observed new transitions are placed in the level scheme correctly and hence the best precision is obtained for the measurement of branching ratios. [1] L. Coquard et al., Phys. Rev. C, 044318 (2011). [2] G. Rainovski et al., Phys. Lett. B, 11-16 (2010). [3] W.P. Alford et al., Nucl. Phys. A, 339 (1979). [4] K. Heyde et al., Rev. Mod. Phys. 1467 (2011). [5] A.J. Radich et al., Phys. Rev. C, 044320 (2015). [6] J. Katakura et al., Nuclear Data Sheets, Issues 3-4 p765-926 (2002).

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ONE-NEUTRON TRANSFER INTO 22NE

Stephen Gillespie[2] * Beau Greaves[1] † Dennis Muecher[1] ‡

Christina Burbadge[1], Tom Drake[3], Greg Hackman[2], Devin Hymers[1], Eva Kasanda[1], Andrew Maclean[1], Tomer Rockman[1], Krzysztof Starosta[4], Carl Svensson[1], Joseph Turko[1]

1. University of Guelph, 2. TRIUMF, 3. University of Toronto, 4. Simon Fraser University

In this contribution, we present a preliminary look into a recent neutron transfer experiment done at TRIUMF in July 2017 studying the 22Ne nucleus. 22Ne plays an important role in the nucleosynthesis in asymptotic giant branch stars, with its synthesis competing with the production of 19F through the so called 'poisoning reaction', and the following transfer into 25Mg acting as one of the main neutron sources for the s-process. By using the high granularity of the TIGRESS high purity germanium detector array we can confirm the resonance energies, coupled to the SHARC highly segmented silicon detector we can determine the spins for these resonances, and using Doppler shift attenuation method we will constrain lifetimes of resonances down to femtoseconds, all allowing for the reaction rate of 22Ne production in AGB stars to be better defined, giving insight into the low abundance of 19F and a better understanding of nucleosynthesis through the s-process.

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SEARCH FOR NEW PHYSICS IN BERYLLIUM

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Nuclear transitions provide a means to probe light, weakly-coupled new physics and portals into the dark sector. Particularly promising are those transitions that can be accessed through excited nuclear states that are resonantly produced, providing a high-statistics laboratory to search for MeV-scale new physics. In this talk we will review the so-called 8Be - anomaly, which is a 6.8σ discrepancy reported by the ATOMKI group in the observation of the decays of excited 8Be -nuclei to their ground state via internal e+- e- pair creation. The anomaly can be explained by the emission of a neutral boson with a mass of 17 MeV. We discuss the ATOMKI experiment and present ideas about a possible follow-up experiment to confirm these results.

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DECAY SPECTROSCOPY OF NEUTRON-RICH ^{129}CD WITH GRIFFIN SPECTROMETER

Yukiya Saito *
Nikita Bernier
The University of British Columbia / TRIUMF
Iris Dillmann, Reiner Kruecken
TRIUMF

Nuclei around doubly magic ^{132}Sn are of particular interest in terms of nuclear structure as well as nuclear astrophysics. The properties of these nuclei provide important input parameters for the astrophysical r-process (rapid neutron-capture process) since they play a role as waiting-point nuclei and their shell structure and half-lives affect the shape of the second r-abundance peak at A$\sim$130. From the perspective of nuclear structure, the evolution of single-particle levels near shell closures is ideal for testing the current nuclear models far from stability. There has been two decay spectroscopies on ^{129}Cd, however, the level schemes of ^{129}In obtained from each measurement have large discrepancy [1,2]. Also, most of the spin assignments of the excited states of ^{129}In remain unclear. Therefore, to solve this discrepancy of level schemes and determine the properties of the energy states with high precision are the main purpose of this study. This experiment was performed at TRIUMF, Canada. New data of the decay of ^{129}Cd was collected with the high-purity germanium detector array GRIFFIN (Gamma-Ray Infrastructure For Fundamental Investigations of Nuclei), along with the auxiliary β-particle detector SCEPTAR, for about 13 hours with the beam intensity of $\sim$250 pps. This high statistics of the data and the high sensitivity of the detectors enabled us to perform detailed and precise spectroscopy, including β-γ-γ coincidence analysis and angular correlation analysis, which are essential for building the level scheme and assignment of the spins of each level. The new results from ongoing analysis, including 6 new excited states and 22 new transitions will be reported.
[1] J. Taprogge et al., Phys. Rev. C 91, 054324 (2015). [2] O. Arndt et al., Acta Physica Polonica B 40, 3 (2009). [3] R. Dunlop et al., Phys. Rev. C 93, 062801(R) (2016).

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DECAY SPECTROSCOPY OF NEUTRON-RICH CD AROUND THE $N = 82$ SHELL CLOSURE

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The neutron-rich Cadmium isotopes around the well-known magic numbers at $Z = 50$ and $N = 82$ are prime candidates to study the evolving shell structure observed in exotic nuclei. Additionally, the extra binding energy observed around the nearby doubly-magic ^{132}Sn has direct correlations in astrophysical models, leading to the second r-process abundance peak at $A \approx 130$ and the corresponding waiting-point nuclei around $N = 82$. The β-decay of the $N = 82$ isotope ^{130}Cd into ^{130}In was first studied a decade ago [1], but the information for states of the lighter indium isotope (^{128}In) is still limited. Detailed $\beta\gamma$-spectroscopy of ^{128}Cd was accomplished using the GRIFFIN [2] facility at TRIUMF, which is capable of performing spectroscopy down to rates of 0.1 pps. The ongoing analysis of the ^{128,131,132}Cd will be presented. Already in ^{128}Cd, 23 new transitions and 15 new states have been observed in addition to the 4 previously observed excited states [3]. These new results are compared with recent Shell Model calculations. For ^{131}Cd, results will be compared with the recent EURICA data. These data highlight the unique capabilities of GRIFFIN for decay spectroscopy on the most exotic, short-lived isotopes, and the necessity to re-investigate even ”well-known” decay schemes for missing transitions. [1] I. Dillmann et al., Phys. Rev. Let. 91, 162503 (2003) [2] C.E. Svensson and A.B. Garnsworthy, Hyperfine Int. 225, 127 (2014) [3] B. Fogelberg, Proc. Intern. Conf. Nuclear Data for Science and Technology, Mito, Japan, p.837 (1988)

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HIGH-SENSITIVITY ATOMIC MAGNETOMETER FOR NEUTRON EDM

Moushumi Das *

TUCAN collaboration

A non-zero neutron electric dipole moment (nEDM) would indicate time reversal and consequently charge-parity violation (T and CP). Many experiments are currently being conducted or planned to measure the nEDM. At present the experimental upper bound on the nEDM is 3.0×10^{-26} e-cm. Our collaboration is developing an experiment at TRIUMF to improve the sensitivity to the nEDM by over one order of magnitude (10^{-27}e-cm). I am proposed to develop a highly sensitive atomic magnetometer based on nonlinear magneto-optical rotation (NMOR). This is a crucial tool in the nEDM apparatus, for measurements of the stability and homogeneity of magnetic fields. The NMOR magnetometer is designed to serve in an array of such sensors to characterize the magnetic field in the experiment. An NMOR magnetometer has been developed and constructed at The University of Winnipeg. In this system an atomic vapour cell containing natural rubidium with stable isotopes Rb-87 and Rb-85 is used. An NMOR resonance occurs when the optical pumping is synchronous with Larmor precession. This causes the atomic vapor to become birefringent, so that subsequent probe light experiences polarization rotation modulated at the same frequency. Currently I am working on testing the performance of this NMOR magnetometer. I will report on latest experimental results on performance and of testing magnetic field stability, current source stability, temperature stability in our prototype magnetic field generation and shielding system.

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COMPENSATION OF MAGNETIC FIELDS AT THE TRIUMF NEDM EXPERIMENT

Shomi Ahmed *

U of Manitoba/ U of Winnipeg - for the TUCAN Collaboration

The existence of a non-zero neutron electric dipole moment (nEDM) would violate parity and time-reversal symmetry. Extensions to the Standard Model predict the nEDM to be 10^{-26} - 10^{-28} e-cm. The current best upper limit set by Sussex/RAL/ILL nEDM experiment is 3.0×10^{-26} e-cm. The nEDM experiment at TRIUMF is aiming at the 10^{-27} e-cm sensitivity level. We are developing the world's highest density source of UCN. The experiment requires a very stable ($<$ pT) and homogeneous ($<$ nT/m) magnetic field (B0) within the measurement cell. My involvement in the nEDM experiment is the development of active magnetic shielding to stabilize the external magnetic field by compensation coils. A prototype active magnetic shield has been tested at The University of Winnipeg. I will report on latest experimental results from this prototype and simulations conducted to understand the results. The magnetic environment at TRIUMF is more challenging than in our lab in Winnipeg, because of the closeness of the experiment to the TRIUMF cyclotron (B $\sim 350 - 400$ μT which is almost one order of magnitude larger than usual background fields) and the changing environment with iron. Studies of the implementation at TRIUMF will also be reported.

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DARK MATTER SEARCHES AT SNOLAB

Marie-Cécile Piro *

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Understanding the nature of Dark Matter is the Holy Grail for many physicists. While the answer to this fundamental question still eludes the scientific community, it could well result in unique proof of physics beyond the Standard Model. Direct detection searches are currently the most powerful way to solve this long lasting mystery. Over the last decade, dark matter detection techniques have been improving drastically, pushing the sensitivity to unprecedented levels. These great technical successes have brought new challenges. After giving an introduction of the evidences of dark matter, an overview of the diverse experimental detection techniques at SNOLAB and their current status will be presented.

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THE NEWS-G DIRECT DARK MATTER SEARCH EXPERIMENT: FIRST RESULTS AND OUTLOOK

Daniel Durnford *

Queen's University

The NEWS-G direct dark matter search experiment employs spherical proportional counters (SPCs) with light noble gases as target media to search for low-mass WIMPs. We report on the results of a 42 kg.day physics run with a 60 cm diameter SPC and a neon target, operated at the Laboratoire Souterrain de Modane. World leading constraints on the spin-independent WIMP-nucleon scattering cross section have been established at a mass of 0.5 GeV. Outlook for the next iteration of the experiment will also be presented; a 140 cm diameter SPC to be operated at the underground SNOLAB facility in Sudbury, Ontario. It will take advantage of neon and lighter targets such as helium and hydrogen, as well as improved shielding and radiopure construction materials, to improve sensitivity to low-mass WIMPs.

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CALIBRATION OF SUPERCDMS* DARK MATTER DETECTORS FOR LOW-MASS WIMPS

Danika MacDonell *

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Observational evidence indicates that ∼85% of all mass in the universe takes the form of non-baryonic dark matter. The Super Cryogenic Dark Matter Search (SuperCDMS) is a direct-detection dark matter experiment that searches primarily for a plausible dark matter candidate known as the weakly-interacting massive particle (WIMP). The experiment looks for an excess of nuclear recoil events in cryogenic solid-state detectors that could be attributed to WIMP-nucleon collisions. The most recent SuperCDMS run at the Soudan underground laboratory set a world-leading limit on the spin-independent WIMP-nucleon cross section for a WIMP mass as low as ∼2 GeV/c^2, and the next installation of the experiment at SNOLAB aims to be sensitive to WIMP masses below 1 GeV/c^2. To better understand the response of solid-state Ge detectors to low-mass WIMPs, ”photo-neutron” calibration data was taken at the Soudan laboratory by passing quasi-monoenergetic neutrons through SuperCDMS detectors. The observed nuclear recoil spectra will be compared with Geant4-simulated spectra to calibrate the nuclear recoil energy scale of the detectors. We expect to produce two or more calibration points in the approximate nuclear recoil energy range of 1 keV to 8 keV. Ionization yield results for Ge are to be extracted at the calibration points and compared with predictions from the Lindhard ionization yield model. The ongoing analysis of this energy scale calibration data will be presented. *Danika MacDonell, representing the SuperCDMS Collaboration

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THE DEAP-3600 MUON VETO SYSTEM

Andrew Erlandson *
Carleton University

DEAP-3600 is a single-phase liquid argon (LAr) dark matter detector located ∼2 km (∼6000 mwe) underground at SNOLAB near Sudbury, Ontario. Recently, DEAP-3600 published results on 4.44 live-days of data in which a leading limit on the spin-independent interaction cross section for 100 GeV/c Weakly Interacting Massive Particles (WIMPs) on ^{40}Ar was found. In order to achieve maximum sensitivity to the rare nuclear recoils of argon nuclei from WIMP interactions, detector systematics and backgrounds must be well known. One significant background in a WIMP dark matter search is neutrons resulting from interactions of cosmic ray muons with the surrounding rock and detector infrastructure. To mitigate this background, the DEAP-3600 detector is positioned at the center of a water Cerenkov veto tank which is viewed by 48 outward facing Hamamatsu R1408 8” PMTs. Muons that pass through the tank will produce Cerenkov light which is used to veto LAr events in a subsequent time window. The veto tank also serves to moderate neutrons produced from muons that do not interact with the water. The veto PMTs require thorough characterization such that the muon tagging efficiency can be both estimated and optimized. This presentation will provide an overview of the veto hardware and preliminary characterization analysis along with a crude estimate of the underground muon rate.

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DARK MATTER SEARCH RESULTS OF THE PICO EXPERIMENT IN THE EFFECTIVE FIELD THEORY CONTEXT

Arthur Plante *

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Dark matter direct detection experiments have been traditionally reporting their results in terms of limits on the spin-independent and spin-dependent cross sections. However, these two types of interactions are only a subset of possible interactions between WIMPs and nucleons. The full set of couplings can be derived in the effective field theory (EFT) framework. In this approach "new" interactions depend on nuclear properties such as the orbital angular momentum and spin-orbit interactions. The focal point of the talk will be the interpretation of limits set by the PICO experiment in this theoretical context and the complementarity of different dark matter experiments.

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CHARACTERIZATION OF SUPERHEATED FLUIDS IN PICO-0.1 BUBBLE CHAMBER FOR THE SEARCH OF DARK MATTER

Frédéric Tardif *

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Search for direct detection of dark matter has become more and more precise, and it is essential to understand perfectly how our detectors behave when interacting with ordinary matter, in order to potentially see interactions with dark matter. In the case of the PICO experiment, the behaviour of the superheated fluids used as active mass in the detectors is a key component of the search. This talk will present my work on two freons used in the PICO-0.1 calibration bubble chamber, and how we were able to detect proton recoils in this type of detector : first, I studied freon-r115 (C_2ClF_5) and the monoenergetic reaction ^{35}Cl $(n_{th}, p)^{35}$S, producing a 17 keV ^{35}S recoil and a 600 keV proton recoil, directly inside the detector; second, I studied freon-r134a ($C_2H_2F_4$) and the recoils of protons from collisions with fast neutrons.

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IMPROVING THE OPTICS AND FIDUCIAL VOLUME OF THE PICO BUBBLE CHAMBER DARK MATTER DETECTOR

Clarke Hardy *

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PICO is an ongoing experiment at SNOLAB, the underground laboratory at Vale's Creighton mine near Sudbury, Ontario. The purpose of PICO is to detect dark matter in the form of Weakly Interacting Massive Particles using superheated C3F8 in which bubbles form when sufficient energy is added in the form of a nuclear recoil. The active fluid is contained in a quartz jar within a larger pressure vessel filled with mineral oil. Cameras at the pressure vessel viewports are used for optical triggering. LED rings positioned around the cameras illuminate the pressure vessel and a retroreflector ensures adequate light returns to the cameras. PICO-60, the previous phase of the experiment, used bellows above a water interface to control the pressure of the active fluid. At the water interface and around the edges of the chamber, many background events were observed, limiting the fiducial volume of the detector. Poor optics due to the retroreflector geometry similarly limited the fiducial volume, in addition to the optical triggering efficiency. In PICO-40L, the next phase of the experiment, the collaboration aims to improve many of these issues by using a new retroreflector design. To this end, ray tracing was used to produce simulated images for a variety of retroreflector designs, and it was found that successive cone stages above the detection chamber resulted in the most uniform light intensity at the cameras. Experiments to measure the reflected light intensity with respect to the incident angle for various retroreflective materials showed that 3M 3290 retroreflective sheeting produced the highest image quality in the conditions under which PICO-40L will operate. A new retroreflector design based on these findings will be implemented in PICO-40L in mid-February. Once PICO-40L is operational, the new retroreflector design will serve as a proof-of-concept for PICO-500, the planned tonne-scale detector.

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PICO-40, AN IMPORTANT STEP TOWARDS A TON-SCALE SPIN-DEPENDENT DARK MATTER SEARCH EXPERIMENT AT SNOLAB

Mathieu Laurin *

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The PICO collaboration is one of the leaders in the field of dark matter searches. As of today, it has built several bubble chambers of increasing active mass and sensitivity, with PICO-60 being the largest of the series to date, containing 40 L of superheated C_3F_8. Despite the great success of PICO-60, some important design changes are needed in order to realize the next generation PICO-500 (500 L) experiment. In fact, the presence of dust in combination with the buffer fluid prevent us from scaling the current version. To test these modifications and improvements, an intermediate scale detector PICO-40 (40 L) is under construction. In this presentation, I will discuss some limitations of the PICO-60 technology and explain how to circumvent them with the so-called "right-side up" design of PICO-40. I will present an overview of the various systems and the current status of the detector fabrication, which should lead to the operation of the detector this spring. Finally, future plans for PICO-500 will also be presented.

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PICO-40L CALIBRATION SIMULATION AND ANALYSIS TECHNIQUES USING MACHINE LEARNING

Gevy Cao *

Queen's University

PICO is a dark matter experiment using superheated liquid to detect particle interactions. PICO-40L is a detector with a novel design of a Right-Side-Up chamber, placed inside a large pressure vessel, immersed in a water tank. Radioactive source calibrations are essential to identify background events. In the presentation, I will show the results from detector simulations for PICO-40L radioactive source calibration. I will also summarize the progress that has been made in the development of analysis strategies to identify different radioactive sources using machine learning techniques.

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OVERVIEW OF THE HIGGS AND STANDARD MODEL PHYSICS AT ATLAS

Tamara Vazquez Schroeder *

McGill University

This talk presents selected aspects of recent physics results from the ATLAS collaboration in the Standard Model and Higgs sectors, with a focus on the recent evidence for the associated production of the Higgs boson and a top quark pair.

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MEASUREMENT OF Z BOSONS PRODUCED IN ASSOCIATION WITH JETS VIA VECTOR BOSON FUSION AT 13 TEV WITH THE ATLAS DETECTOR

Stephen Weber *

Carleton University

At the large hadron collider, most Z bosons are produced in a qqZ vertex, sometimes in association with jets produced via the strong interaction. A more rare production mode for Z bosons is through a triple gauge coupling via a process called vector boson fusion (VBF). This VBF Z process is similar in nature to VBF Higgs production, which is of great interest and is being studied by large groups of physicists on the ATLAS and CMS experiments. VBF Z production is interesting in its own right as a probe for new physics via the triple gauge coupling. Measurements of the cross section and kinematic distributions of VBF Z production can also be used to constrain new physics scenarios, such as fits to an effective field theory extension of the Standard Model Lagrangian. An analysis of the standard model VBF Z process is ongoing, the general structure of the analysis will be discussed along with details of the systematic variations and pileup contamination of the Monte Carlo (MC) simulation. The VBF signal is measured by extrapolating between carefully chosen regions of phase space to best model signal and background distributions. Understanding the MC simulation is crucial to making an accurate final measure of the VBF Z cross section.

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SEARCH FOR RESONANT WZ→LVL'L' PRODUCTION IN PROTON-PROTON COLLISIONS AT $\sqrt{S}$ = 13TEV WITH THE ATLAS DETECTOR

Benjamin Freund *
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After the discovery of the Higgs boson at the LHC, it is important to test whether the Standard Model could be only an effective theory, and whether the Higgs sector could be extended to include theories with higher isospin multiplicity. This talk reports on a search for charged resonances produced by vector boson fusion and decaying via WZ→lvl'l', based on proton-proton collision data collected by the ATLAS experiment at the Large Hadron Collider at a centre-of-mass energy of 13 TeV and corresponding to an integrated luminosity of 36 fb^{-1}. Two kinds of resonances, either a heavy vector particle or a singly-charged Higgs of the Georgi-Machacek (GM) are tested.

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FIRST MEASUREMENT OF PHOTON+B PRODUCTION CROSS SECTIONS IN PP COLLISIONS USING THE ATLAS DETECTOR

Sebastien Prince *

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The production of a photon in association with a bottom quark in proton collisions is sensitive to the bottom quark content of the proton and to the modelling of b quarks in perturbative QCD calculations. A firm understanding of these aspects is required to properly describe background contributions to new physics interactions at high energies involving b quarks. Differential cross sections of this process in proton-proton collisions at sqrt(s)=8 TeV are measured with the ATLAS detector. The cross sections are differential in the photon transverse energy and are measured separately in two regions of absolute photon pseudorapidity. The total relative uncertainty in the measurements is of the order of 20% in most of the energy range. Ratios of the cross sections between the two regions are also measured as a way to reduce correlated systematic uncertainties. The measurements are compared to next-to-leading order predictions in perturbative QCD in two different calculation schemes. The predictions underestimate the data at the highest energies measured by up to a factor of two. These cross-section measurements mark the first time this process is measured in proton-proton collisions [Phys. Lett. B 776 (2018) 295].

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DETERMINATION OF JET ENERGY RESOLUTION IN PROTON-PROTON COLLISIONS OF THE ATLAS DETECTOR

Tae Hyoun Park *

Carleton University

The ATLAS detector at the Large Hadron Collider records high energy proton-proton collisions. These collisions can be used to test the Standard Model of particle physics that explain fundamental interactions of the universe. In these collisions, collimated sprays of hadronic particles, known as **jets**, are dominant final state object produced. They are key ingredients for most physics measurements and searches for new phenomena. Thus, an accurate understanding of the detector's jet energy measurements is an essential component of virtually every physics analysis in the experiment. I will present ongoing work to determine the jet energy resolution of the ATLAS detector using data collected from 2015 to 2017.

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SCALE FACTORS FOR THE ATLAS MUON TRIGGERS

Robin Hayes *
UBC/TRIUMF

Triggers are essential for data-taking in the high-rate environment of the ATLAS experiment at the Large Hadron Collider (LHC), where they make decisions at multiple stages about whether to flag a physics event. What is not flagged by the trigger is simply not recorded by ATLAS and not subject to further analysis. The trigger efficiency gives the fraction of events of interest that a trigger successfully catches and is an important measure of the trigger performance. Taking the ratio of trigger efficiency in data and Monte Carlo (MC) gives scale factors that are used by physics analyses to adjust MC predictions to match the data. For the ATLAS muon triggers, one of the biggest sources of systematic uncertainty in scale factors is their dependence on muon transverse momentum (pT). This talk presents an overview of the method of scale factor derivation for mid-pT (25-100 GeV) muon triggers using Z-¿dimuon samples, and presents a study of the pT dependence of the scale factors.

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SEARCH FOR PRODUCTION OF SUPERSYMMETRIC PARTICLES IN FINAL STATES WITH MISSING TRANSVERSE MOMENTUM AND MULTIPLE B-JETS IN 2015-2016 LHC P-P COLLISION DATA WITH THE ATLAS DETECTOR

Louis-Guillaume Gagnon *
Université de Montréal

Supersymmetry (SUSY), an hypothetical theory which associate new fundamental particles to each Standard Model (SM) particle, is one of the most well-motivated SM extensions and could solve some of its biggest outstanding problems. For example, if the lepton and baryon numbers are conserved, the lightest supersymmetric particle is stable and interacts only weakly providing a viable dark matter candidate. Moerover, if the supersymmetric partners of gluons and third generation quarks have masses near the weak scale, the hierarchy problem could also be solved. A search for supersymmetry involving the pair production of gluinos decaying via third-generation squarks to the lightest neutralino, a dark matter candidate, is reported. It uses LHC proton–proton collision data at a centre-of-mass energy of 13 TeV with an integrated luminosity of 36.1 fb^{-1} collected with the ATLAS detector in 2015 and 2016. The search is performed in events containing large missing transverse momentum and several energetic jets, at least three of which must be identified as originating from b-quarks. No excess is found above the predicted SM background. For neutralino masses below approximately 300 GeV, gluino masses of less than 1.97 (1.92) TeV are excluded at 95% CL in simplified models involving the pair production of gluinos that decay via top (bottom) squark. An interpretation of the limits in terms of the branching ratios of the gluinos into third generation squarks is also provided. These results significantly extend the exclusion limits obtained with the 3.2 fb^{-1} of data collected in 2015.

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SEARCH FOR SUPERSYMMETRY IN FINAL STATES WITH TWO SAME-SIGN OR THREE LEPTONS AND JETS USING 13 TEV ATLAS DATA

Otilia Ducu *

University of Montreal

A search for strongly produced supersymmetric particles using signatures involving multiple energetic jets and either two isolated same-sign leptons (e or μ), or at least three isolated leptons, is presented. The analysis relies on the identification of b-jets and high missing transverse momentum to achieve good sensitivity. A data sample of proton–proton collisions at sqrt s = 13 TeV recorded with the ATLAS detector at the Large Hadron Collider in 2015 and 2016, corresponding to a total integrated luminosity of 36.1 fb^{-1} , is used for the search. No significant excess over the Standard Model prediction is observed. The results are interpreted in several simplified supersymmetric models featuring R-parity conservation or R-parity violation, extending the exclusion limits from previous searches. In models considering gluino pair production, gluino masses are excluded up to 1.87 TeV at 95 % confidence level. When bottom squarks are pair-produced and decay to a chargino and a top quark, models with bottom squark masses below 700 GeV and light neutralinos are excluded at 95% confidence level.

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SENSITIVITY STUDY OF A SEARCH FOR A CHARGED SCALAR PARTICLE IN $\sqrt{S} = 14$ TEV PP COLLISIONS

Kays Haddad *

McGill University

Many models that extend the Standard Model Higgs sector predict the existence of at least one charged Higgs boson, in addition to the neutral Higgs boson expected from the Standard Model. While searches have been performed, a charged Higgs boson has not yet been observed. Using physics and detector simulations, the sensitivity of a search for a charged Higgs boson at the forthcoming High Luminosity LHC is being studied. Focusing on the process $pp \rightarrow H^+H^- \rightarrow (W^+\gamma)(W^-\gamma) \rightarrow (jj\gamma)(jj\gamma)$ with a charged Higgs mass greater than 100 GeV, expected upper limits on the production cross-section times branching ratio of this process, $\sigma(pp \rightarrow H^+H^-) \times BR(H \rightarrow W\gamma)^2$, are calculated.

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DEVELOPMENT OF A NEW B-PHYSICS TRIGGER FOR THE ATLAS DETECTOR AT CERN

Steven Robertson, *

Heather Russell, †

Shreya Saha ‡

McGill University

A novel B-Physics trigger for the ATLAS detector is being developed to enable lepton universality studies by selecting $B^0 \to K^* e^+ e^-$ events and complementing the existing $B^0 \to K^* \mu^+ \mu^-$ trigger. In the Standard Model, lepton universality refers to the fact that the electroweak couplings of the leptons to the gauge bosons is independent of the lepton flavour. A particular sensitive probe for studying lepton universality is by measuring the ratio ($R_{K^{*0}}$) of the branching fractions of $B^0 \to K^{*0} \mu^+ \mu^-$ and $B^0 \to K^{*0} e^+ e^-$ decay processes. The value of $R_{K^{*0}}$ is expected to be close to unity in the Standard Model. However, recent analyses have shown an intriguing deviation from the expected value of $R_{K^{*0}}$. The development of the $B^0 \to K^* e^+ e^-$ trigger is critical to the measurement of the ratio. Summary of ongoing work will be presented in the talk.

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ILLUMINATING THE DARK SECTOR WITH ASTROPHYSICAL NEUTRINOS

Aaron Vincent *

Queen's University

IceCube's observation of high-energy extra extraterrestrial neutrinos has signalled the dawn of neutrino astronomy. These events carry energies upward of a PeV and are isotropically distributed in the sky, and thus far their origin remains unknown. However, these data contain valuable information in their energy, flavour composition and arrival directions. I will demonstrate how these observables can already be used to learn about new physics, and specifically discuss the case of dark matter-neutrino interactions, which have long been studied in the low-energy limit of cosmology.

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NEUTRINOS, DARK MATTER AND THE STANDARD MODEL

Carla Francisco *
Thierry Duchesne
Laval University
Teresa Oliveira, Cleibson Almeida
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Luis Carlos Batista Santos
Brazilian Air Force

The Standard Model, was formulated in the beginning of the '70s but only became empirically establish in the '80s, although it has not been able to describe the gravitational interaction yet, it succeeded in describing the electromagnetic interaction, the weak interaction and strong interaction. The three different types of neutrinos that exist in the Universe are in the exact number predicted by the Standard Model of elementary particles. They are like "small children" capable of never seen incredible tricks such as transforming themselves into each other as they travel in space. Despite the various experiments performed to understand their behavior and interaction with the remaining particles, physicists keep up on their quest for the "sterile" neutrino. This fourth type of neutrino would explain a big set of question marks left in the air. It would be much more massive than the other remaining three types, which have very low masses, and it's interaction with matter would only be through the force of gravity, which would make it a strong candidate as the constituent of dark matter. This discovery would also be the first clear manifestation of physics beyond the Standard Model.

Although the Standard Model answer several questions of the structure of matter, it does not answer to all of them. Some discussion arise, about why we observe matter and nearly no antimatter, if we believe there is a symmetry between the two in the universe. Physicists have not yet found the answer to how does gravity interact in all of this and why the dark matter has a visible gravitational effect in the cosmos. They, do not know how is the observed pattern for particle masses explained and also why it's assumed that there are only three generations of leptons and quarks, as well as, if they are composed by even more fundamental particles, or if they themselves are fundamental particles.

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NEUTRINO OSCILLATION IN QUANTUM MECHANICS

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Neutrino oscillation is one of the most exciting subjects in elementary particle physics today. It was first confirmed in 1998 by the Super-Kamiokande group from their studies of atmospheric neutrinos. Experimental studies of neutrino oscillation have been rapidly progressing since then, and a number of oscillation results have been observed in atmospheric, solar, accelerator, and reactor neutrinos. The implication of the existence of neutrino oscillation is that neutrinos have finite masses and mixings, which are not accounted for in the framework of the standard model of elementary particles. Therefore, the standard model now must be extended to include the new information. Because the neutrino masses are extremely small, it is considered to be unnatural to be included in the standard model similar to the way quark and charged lepton masses are. Therefore, the neutrino oscillation is believed to provide an important new concept that will be a big step toward the unified understanding of elementary particle physics. In this document, we present studies for neutrino oscillation.

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PROSPECTS FOR RARE NEUTRINO PHYSICS AT THE INTENSITY FRONTIER

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Upcoming and ongoing neutrino experiments at the intensity frontier offer an unprecedented combination of high luminosity neutrino beams and state of the art detector technology. These include Fermilab's Short Baseline Neutrino Program (SBN) and Deep Underground Neutrino Experiment (DUNE), and CERN's Search for Hidden Particles (SHiP). The powerful combination of large signals and high quality detectors allows for the observation and discrimination of previously unseen neutrino physics, both within and beyond the Standard Model. In this talk I will focus on two signals: oppositely charged pairs of leptons, and single photons. In the case of charged leptons, I will describe how new detector technology enables the observation of, as of yet, unobserved Standard Model physics arising from neutrino trident production. I will then explain how these processes allow for the study of new particles beyond the Standard Model. Next I will explain how single photons can arise from beyond the Standard Model heavy neutral leptons, and present a phenomenological survey of a minimal model.

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QUASI-ELASTIC NEUTRINO REACTIONS ON CARBON AND LEAD NUCLEI

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We examine neutral-current quasi-elastic neutrino-nucleus reactions on ^{12}C and ^{208}Pb targets. We use the relativistic mean field theory approach to describe the nuclear dynamics. We compute the cross sections for the scattering of 150-MeV, 500-MeV and 1000-MeV neutrinos on a ^{12}C target and study the effect of the strange-quark content of the nucleon which appears in these reactions via the isoscalar weak current. We compare our results with the data of the MiniBooNE experiment for mineral oil (CH_2). We also calculate the cross section for the quasi-elastic neutron knockout reaction of 20 to 60-MeV neutrinos on a ^{208}Pb target which is relevant to plans to use Lead as a target material in future supernova neutrino detectors.

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EXPLORING THE SUPERSYMMETRIC U(1)$_{B-L}\times$ U(1)$_R$ MODEL WITH DARK MATTER, MUON $G-2$ AND Z' MASS LIMITS

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We study the low scale predictions of supersymmetric standard model extended by $U(1)_{B-L}\times U(1)_R$ symmetry, obtained from $SO(10)$ breaking via a left-right supersymmetric model, imposing universal boundary conditions. Two singlet Higgs fields are responsible for the radiative $U(1)_{B-L}\times U(1)_R$ symmetry breaking, and a singlet fermion S is introduced to generate neutrino masses through inverse seesaw mechanism. The lightest neutralino or sneutrino emerge as dark matter candidates, with different low scale implications. We find that the composition of the neutralino LSP changes considerably depending on the neutralino LSP mass, from roughly half $U(1)_R$ bino, half MSSM bino, to singlet higgsino, or completely dominated by MSSM higgsino. The sneutrino LSP is statistically much less likely, and when it occurs it is a 50-50 mixture of right-handed sneutrino and the scalar $\tilde{S}$. Most of the solutions consistent with the relic density constraint survive the XENON 1T exclusion curve for both LSP cases. We compare the two scenarios and investigate parameter space points and find consistency with the muon anomalous magnetic moment only at the edge of 2σ deviation from the measured value. However, we find that the sneutrino LSP solutions could be ruled out completely by strict reinforcement of the recent Z' mass bounds. We finally discuss collider prospects for testing the model.

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EQUIVALENCE AND CLASSIFICATION OF 4D ADINKRAS

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Adinkras are powerful and concise tools for the representation of complex supersymmetrical algebras as graphical objects. As these graphs can be seen as topologically equivalent to hypercubes of varying dimensions then these objects can be studied in terms of their underlying matrix structure. We have discovered a means of classifying all 4D Adinkra graphs in terms of attributes of their colour-sign superimposition matrices. Our efforts culminate in research towards the construction of a simple object for computing Adinkras using a minimum number of these matrix attributes. This result leads to a prediction of all possible solutions of topologies, with our focus upon the Chiral Supermultiplet.

Adinkras are a simple means of preserving supersymmetric algebraic and differential relationships between physically significant field theories and measurable operators. These graphs obey simple rules of composition, namely they are odd-dashed bipartite representations. These representations encode pertinent information pertaining to the super-partner relationships between the two fundamental forms of physical matter: bosons and fermions. All graphs begin with a bosonic node, which depending upon the specific energy level will produce some connected fabric of further boson-fermion super-partner networks. The three principle cases of Adinkra representation come from the Chiral, Vectorial, and Tensorial supermultiplets. These result in three distinct Adinkra topologies that can be represented in terms of a set of adjacency matrices, corresponding to each of the colour-coded edges given in the graphical representation. Each of these representations encodes specific properties and attributes of the underlying adjacency matrices, as well as important physical information concerning available energy levels. While Dr. Sylvester James Gates et al (**S.J. Gates, Jr., T. Grover, M.D. Miller-Dickson, B.A. Mondal, A. Oskoui, S. Regmi, E. Ross, and R. Shetty, A Lorentz Covariant Holoraumy-Induced "Gadget" From Minimal Off-Shell 4D, N = 1 Supermultiplets, Arxiv 1508.07546, 2015**) have developed a "gadget" tool which allows for some dimensional and topological analysis of Adinkras, the specific behaviour of this object remains somewhat elusive and it is unknown as to exactly what its ramifications are. Motivated by categorical and topological equivalences we have sought to construct a new "gadget" which enables one to compute equivalent classes of Adinkra topologies. Using the elementary properties of the adjacency matrices it is possible to encode the geometric striation of each super-adjacency matrix into a nine-digit identifier. This "Gadget" can further be compressed into a five-digit serial number, via a change of numerical base, which permits one to generate equivalence classes of Adinkra representations.

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FROM T2K TO HYPER-K: STATUS AND PROSPECTS FOR LONG BASELINE NEUTRINO PHYSICS IN JAPAN

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The T2K experiment is a long baseline neutrino experiment in Japan that detects neutrino oscillations over a 295 km baseline with the Super-Kamiokande detector. In 2013 T2K showed evidence for the oscillation of muon neutrinos into electron neutrinos. This measurement established the possiblility of CP violation in neutrino oscillations. Currently the T2K and NOvA experiments are operating with both neutrino and antineutrino beams to search for CP asymmetries in the oscillation probabilities. The next generation of long baseline experiments, Hyper-K and DUNE, will use even larger, more sensitive detectors to make searches for CP violation in neutrino oscillations and precision measurements of the parameters governing oscillations. I will review the status of the T2K experiment and discuss the prospects for the Hyper-K experiment. I also review important steps for systematic error reduction to achieve the full physics sensitivity of next generation neutrino oscillation experiments.

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RARE DECAYS WITH MISSING ENERGY AT THE BELLE II DETECTOR

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The Belle II detector is a competitive, perhaps unique, environment in which to study rare B decays with missing energy to a sensitivity that would exhibit indirect New Physics effects. From a B-$\bar{B}$ meson pair that has been produced in the SuperKEKB B-factory, one B meson can be can be fully reconstructed through powerful B-tagging, which in turn provides strong constraints for the other B meson. This is an ideal environment in which rare decays with missing energy can be measured. The possible missing energy decays will be examined with a focus on the decay $B \to \tau\nu$, which - with the full Belle II data set ($50\,\mathrm{ab}^{-1}$) - can be probed at unprecedented precision.

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MATERIAL STUDIES FOR THE BELLE II EXPERIMENT

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The Belle II experiment at the KEK laboratory is currently undergoing commissioning, with first physics data anticipated in 2018. Understanding the material distribution of detector components is of critical importance for precision e+e- collider experiments like Belle-II, as the density and distribution of this material impacts tracking and vertex reconstruction, as well as other aspects of detector performance. In the talk I will present a comparison of test beam experiments using high resolution tracking telescopes to obtain precise 2D images silicon vertex detector modules with the detector model implemented in the Belle-II simulation. I will also present detailed studies of material profiles of other components of the Belle II detector and compare these with the as-built detector

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DETERMINATION OF PROTON RADII OF NEUTRON RICH OXYGEN ISOTOPES FROM CHARGE-CHANGING CROSS SECTION MEASUREMENTS.

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Charge radius is an important bulk property of the nucleus for investigating nuclear structure. The nuclei lying close to the boundaries of the nuclear chart (the drip lines) have revealed new features like halo and skin. Another new phenomenon that has emerged in the neutron-rich region is the changing or vanishing of magic numbers [1,2]. The knowledge of proton radii is crucial for understanding the halo and skin formation and also the shell evolution in unstable nuclei. The systematic study of proton radii along an isotope chain, together with knowledge of the matter radii is important to deduce the neutron skin thickness in the neutron-rich nuclei. Furthermore, the proton radii are crucial to understand the spatial correlation between halo neutrons and its core nucleus. Proton radii also serve as a test of newly developed structure models including those based on $ab\ initio$ theory. Charge-changing cross section (σ_{cc}) is the total cross section for the change of the atomic number of the projectile nucleus. It is a unique method to extract the proton radii of neutron-rich nuclei using the Glauber model analysis. The proton radii of $^{12\text{-}17}$B [3] and $^{12\text{-}19}$C [4] have been successfully determined using the charge-changing cross section measurements. The neutron-rich oxygen isotopes are particularly interesting nuclei, with a new magic number (N=16) at the neutron drip line [5]. The proton radii of neutron-rich oxygen isotopes have not been measured till date. We, therefore, performed an experiment at Fragment Separator (FRS) in Germany using relativistic beams of $^{16\text{-}24}$O with energy around 900 MeV/u. In this talk, I will present the preliminary results of σ_{cc} measurements of $^{16\text{-}24}$O. References [1] A. Ozawa et al., Phys. Rev. Lett. 84, 5493 (2000). [2] R. Kanungo et al., Phys. Lett. B 528, 58 (2002). [3] A. Estrade et al., Phys. Rev. Let. 113, 132501 (2014). [4] R. Kanungo et al. Phys. Rev. Lett. 117, 102501 (2016). [5] C. R. Hoffman et al., Phys. Rev. Lett. 100, 152502 (2008).

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QUASI-FREE PROTON KNOCKOUT REACTIONS ON THE OXYGEN ISOTOPIC CHAIN

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According to the Independent Particle Model (IPM) single-particle (SP) states are fully occupied up to the Fermi energy with spectroscopic factors (SF) of one. However, it is well known from electron-induced proton knockout that the SP strength is reduced to about 60-70% for stable nuclei, which has been attributed to the presence of short-range and long-range correlations [1]. This finding has been confirmed by nuclear knockout reactions using stable and exotic beams, however, with a strong dependency on the proton-neutron asymmetry [2]. The observed strong reduction of SP cross sections for the deeply bound valence nucleons in asymmetric nuclei is theoretically not understood. To understand this dependency quantitatively a complementary approach, quasi-free knockout reactions, is introduced. Quasi-free knockout reactions in inverse kinematics at relativistic energies provide a direct way to investigate SP structure of stable and exotic nuclei [3]. We have performed a systematic study of spectroscopic strength of oxygen isotopes using quasi-free (p,2p) knockout reactions in complete kinematics at the R3B/LAND setup at GSI with secondary beams containing $^{13-24}$O. The oxygen isotopic chain covers a large variation of separation energies, which allow a systematic study of SF with respect to neutron-proton asymmetry. We will present results on the (p,2p) cross sections for the entire oxygen isotopic chain obtained from a single experiment. By comparison with the Eikonal reaction theory [4] the SF and reduction factors as a function of separation energy have been extracted and will be compared to existing data in literature. The results include total and partial cross sections extracted by means of gamma-coincidence measurements as well as momentum distributions. The latter are sensitive to the angular momentum of the knocked-out nucleon in the projectile. Finally, a brief report will be given on a pioneer experiment performed at RIKEN where the quasi-free (p,2p)-fission reaction was employed for the first time on 238U as a benchmark test for future applications to determine fission barriers of neutron-rich exotic nuclei near ^{208}Pb and ^{214}Bi. This work is supported by the GSI-TU Darmstadt co-operation agreement and the BMBF Verbundforschung under contract 05P15RDFN1. [1] L. Lapikas Nucl. Phys. A553, 297c (1993) [2] J. A. Tostevin, A. Gade Phys. Rev. C 90, 057602 (2014) [3] V. Panin et al. Phys. Letters B 753, 204-210 (2016) [4] T. Aumann, C. Bertulani, J. Ryckebusch Phsy. Rev. C 88, 064610 (2013)

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CHARACTERIZING LABR3(CE) DETECTOR RESPONSE FOR PROTON THERAPY APPLICATIONS

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In ion beam radiation therapy, charged particles are used to irradiate tumor cells for various malignant diseases, such as cancer. Charged particles deposit most their energy at the end of their range, producing a more sophisticated radiation profile while imparting a minimal dose to healthy tissue compared to standard photon-based radiation treatment. However, new complications emerge with ion beam therapy from the uncertainty in the stopping powers and overall range, making the dose verification for this technique rather difficult. If a certain isotope is delivered to the tumor, one could take advantage of the fusion-evaporation reactions between the ion beam and the isotope to reproduce the dose distribution administered to the patient. The well-understood mechanisms of fusion-evaporation reactions have been a work-horse in nuclear structure experiments for many decades, and can be applied to medical physics applications. With this experimental technique, the location of the beam in the patient and the dose distribution can be monitored online (during the treatment) instead of offline (post-treatment). Cerium-doped Lanthanum Bromide (LaBr3(Ce)) scintillators, which are typically used for electronic timing measurements in nuclear physics experiments, are also excellent candidates for measuring ion beam therapy reaction products due to their reasonable energy resolution and radiation hardness. A fast digitizer, such as the CAEN DPP-PSD, is also ideal for ion beam therapy applications as it can accept high count rates and allows to integrate the DAQ logic in a compact and cost-efficient way. The primary focus of this work will be to implement this setup at the proton therapy facility at TRIUMF, Canada's national laboratory for nuclear and particle physics, which is dedicated to treating eye melanomas. There are a number of applications in nuclear structure and nuclear astrophysics research for an auxiliary LaBr3(Ce) detector array coupled to fast-sampling digitizers at TRIUMF, such as fast-timing measurements with TIGRESS at ISAC-II and GRIFFIN and DRAGON at ISAC-I. Preliminary results will be shown, characterizing timing and energy resolution of LaBr3(Ce) detectors in high-rate applications for both fundamental nuclear structure research and medical physics applications.

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DETECTING FUSION-EVAPORATION REACTION PRODUCTS FROM CONTRAST AGENTS AS A RANGE VERIFICATION TECHNIQUE IN PROTON THERAPY

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Proton therapy is gaining popularity as a tumor irradiation method due to the superior dose distribution offered by heavy charged particles. The subject of range and dose verification has been approached from several angles and fields. Upon interaction with low-energy protons, certain nuclei undergo fusion-evaporation reactions. The resulting reaction products emit a cascade of characteristic gamma rays as they decay to their ground state. The product of these fusion-evaporation reactions is highly dependent on the energy of the incident proton. This means that the relative intensity of the competing fusion-evaporation channels can be correlated with the energy of the proton beam, and, by extension, its range. By administering an appropriate contrast agent to the tumor being irradiated, we are able to measure the intensity of characteristic prompt gamma rays resulting from fusion-evaporation reactions occurring inside the tumour. We propose to take advantage of the timing and energy resolutions of a fast scintillator detector to measure beam range and dose administered in proton radiation therapy. Fast scintillator detectors are used frequently in nuclear research due to their good timing resolution and reasonable energy resolution, and have begun to make their way into the medical field. Our Geant4 simulation results show that this technique would allow for accurate measurement of beam range relative to the position of the tumour within the body, as well as dose administered to the tumour. Additionally, the excited states resulting from the reactions of interest are very short-lived and as such this measurement is taken while the beam is online. This is advantageous because it allows for dose monitoring during the treatment as opposed to afterwards. The presented approach combines the unique expertise at TRIUMF in the fields of both gamma ray spectroscopy in nuclear physics research and proton therapy in order to strive towards improved cancer radiation therapy.

Geant4 simulations of fusion-evaporation reactions between a contrast agent and a proton beam show that we can accurately correlate the relative intensities of competing reaction channels to the range of the proton beam relative to the position of the contrast agent. This technique is applicable to range and dose verification in proton therapy.

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