Abstract Book

Joint APP and HEPP Annual Conference

26–28 March 2018
University of Bristol, Bristol, UK

Organised by the IOP Astroparticle Physics and High Energy Particle Physics Groups

http://appandhepp2018.iopconfs.org

IOP Institute of Physics

Joint APP and HEPP Annual Conference

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Programme

Monday, 26 March 2018

	Tyndall Lecture Theatre			
09:00–09:15	Welcome			
09:15–09:55	**Gravity & Light: Binary Neutron Star Mergers** Patrick Sutton, Cardiff University, UK			
09:55–10:25	**Gamma-ray astronomy: current status and future plans** Anthony Brown, University of Durham, UK			
10:25–10:55	**The status of dark matter searches** Chamkaur Ghag, University College London, UK			
11:00–11:30	Coffee Break (Enderby Room)			
	S1. Mott Theatre	**S2. Frank Theatre**	**S3. Room 3.34**	**S4. Berry Theatre (3.21)**
11:30–11:45	**Search for additional heavy neutral Higgs and gauge bosons decaying to di-tau in the ATLAS detector produced with 13 TeV proton-proton collisions at the LHC** Theodore Zorbas, University of Sheffield, UK	**Measurement of the CP violating phase, ϕs, in Run 2 using $B^{\circ}s \rightarrow J/\psi K^{+}K^{-}$** Konstantin Gizdov, University of Edinburgh, UK	**Vertex finding for pile-up mitigation in the Phase-2 upgrade of the Level-1 Trigger of CMS** Antoni Shtipliyski, Imperial College London, UK	**Measuring the Effective Longitudinal Electron Diffusion Coefficient at MicroBooNE** Adam Lister, Lancaster University, UK
11:45–12:00	**Search for exclusive Higgs and Z boson decays to $\phi\gamma$ and $\rho\gamma$ with the ATLAS detector** Rhys Edward Owen, University of Birmingham, UK	**Prospects for $K^{\pm}\pi\pi^{+}\mu^{+}\mu^{-}$ at the LHCb Experiment** Kristian Alexander Zarebski, University of Birmingham, UK	**Gaussian Processes for High Energy Physics** Adam Bozson, Royal Holloway, University of London, UK	**Calorimetric Energy Scale in the NOvA Detectors** Tyler Alion, University of Sussex, UK
12:00–12:15	**Search for boosted *ttH(H→bb)* with the ATLAS detector** Emma Winkels, University of Sussex, UK	**Status and prospects of the measurement of the pi+mu+mu- form factor with the NA62 experiment at CERN** Christopher John Parkinson, University of Birmingham, UK	**Perspectives for SUSY in light of current LHC constraints** Jonathan Costa, Imperial College London, UK	**MicroBooNE NC Delta Radiative Single-Photon Search** Robert Murrells, University of Manchester, UK
12:15–12:30	**Searching for decays of the Higgs boson to charm quarks at ATLAS** Elliot Reynolds, University of Birmingham, UK	**Measurement of the branching fractions and form factors of $K^{+} \rightarrow \pi^{\circ} l^{+} \nu$ decays** Stoyan Trilov, University of Bristol, UK	**QED Parton Distribution Functions** Ricky Nathvani, University College London, UK	**Latest muon neutrino disappearance results from the NOvA experiment** Diana Patricia Méndez, University of Sussex, UK
12:30–12:45	**Searches for additional neutral Higgs bosons in the di-tau final state with the CMS experiment** Daniel Winterbottom, Imperial College London, UK	**Measurement of the K+ -> pi+ gamma gamma decay at NA62** Maria Brigida Brunetti, University of Birmingham, UK	**Positivity Constraints on Self-Interacting Dark Matter** Scott Melville, Imperial College London, UK	**Comparison of Binned vs. Unbinned Likelihood Analyses for Neutrino Oscillation Measurements in NOvA** Sebastian Bending, University College London, UK
13:00–14:00	Lunch (Enderby Room)		**APP AGM** (Frank Theatre)	

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14:00–14:15	**Measurement of Z+bb kinematic variables with ATLAS** Chloe Gray, University of Glasgow, UK	**Search for the decay B → $p^+p^-\mu\nu$** Matthew James Tilley, Imperial College London, UK	**Sensor Characterisation and Readout for the LHCb VELO Upgrade** Vinicius Franco Lima, University of Liverpool, UK	**Overview of the ANITA experiment** Linda Cremonesi, University College London, UK
14:15–14:30	**Searching for invisible phenomena through measurement of events with jets and large missing transverse momentum in pp collisions at ATLAS** Rebecca Hayley Pickles, The University of Manchester, UK	**Measuring the WW Production Cross-Section at LHCb** Heather Mckenzie Wark, University of Liverpool, UK	**3D Printing Gaseous Radiation Detectors** Samuel Fargher, University of Sheffield, UK	**Hunting Axionlike Dark Matter by Searching for an Oscillating Neutron Electric Dipole Moment** Nick Ayres, University of Sussex, UK
14:30–14:45	**Measurements of boosted top-quark differential cross-sections in the lepton+jets channel at s=√13 TeV using pp collision data recorded with the ATLAS detector** Michael James Fenton, University of Glasgow, UK	**Search for B^c→DD decays with the LHCb detector** Alison Maria Tully, University of Cambridge, UK	**ATLAS inner detector decommissioning: Tolerance study of robotic components for use in high radiation environment** Alice Cryer, University of Sheffield, UK	**Search for New Physics in Astrophysical Flavor at IceCube** Shivesh Mandalia, Queen Mary University of London, UK
14:45–15:00	**Higgsinos and compressed sleptons: opening the soft lepton frontier for new physics at the LHC** Jesse Liu, University of Oxford, UK	**Searching for lepton universality violation and New Physics in rare decays of Lambda baryons at the LHCb** Ross John Glew, University of Southampton, UK	**The LHCb VELO Upgrade** Dutta Deepanwita, University of Manchester, UK	**Neutrino Interferometry for High-Precision Tests of Lorentz Symmetry with IceCube** Teppei Katori, Queen Mary University of London, UK
15:00–15:15	**Dark Matter Searches at CMS** Shane Davy Breeze, Imperial College London, UK	**Search for K+ to pi+ nu nu at NA62** Angela Romano, University of Birmingham, UK	**Bayesian optimisation of the SHiP muon shield** Oliver Lantwin, Imperial College London, UK	**Searching for WIMP dark matter with the LZ experiment** Ibles Olcina, Imperial College London, UK
15:15–15:30	**Search for single top production in association with a Z boson for the dilepton final state in pp collisions at √s = 13 TeV in the CMS detector** Corin James Keir Hoad, Brunel University, UK	**Search For Heavy Neutral Lepton Decays at NA62 Experiment at CERN** Lorenza Iacobuzio, University of Birmingham, UK	**Towards the highest precision detector at the LHC – The LHCb Upgrade VELO and its Performance** Chris Burr, University of Manchester, UK	
15:45–16:15	Coffee (Enderby Room)			
	Tyndall Lecture Theatre			
16:15–16:40	**Particle Beam Therapy in the UK** Michael Taylor, University of Manchester, UK			
16:40–17:05	**Promoting Physics in Developing Countries** Kate Shaw, International Centre for Theoretical Physics, Italy			
17:05–17:35	**ECR prize talk: Gravitational-wave astronomy and black hole astrophysics** Christopher Berry, University of Birmingham, UK			
17:35–18:15	**Status of Neutrino Physics** Frank Deppisch, University College London, UK			
18:15–19:30	Exhibition and poster reception (Enderby Room)			

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	Tyndall Lecture Theatre			
09:00–09:40	**Overview of experimental heavy flavour physics** Greig Cowan, University of Edinburgh, UK			
09:40–10:20	**Review of lepton flavor experiments** Phillip Litchfield, Imperial College London, UK			
10:20–11:00	**Who ordered that? Interpreting LFUV and other new physics signals from flavour** Alexander Lenz, IPPP Durham, UK			
11:00–11:30	Coffee (Enderby Room)			
	S5. Mott Theatre	**S6. Frank Theatre**	**S7. Room 3.34**	**S8. Berry Theatre (3.21)**
11:30–11:45	**Tagging boosted jets from top quarks and heavy vector bosons using jet substructure and multivariate techniques** Amal Vaidya, University College London, UK	**Relative branching fraction measurements of B→3h decays** Cayo Costa Sobral, University of Warwick, UK	**Optical Calibration of the Hyper-Kamiokande Detector with Test Data in Super-Kamiokande** Lauren Anthony, University of Liverpool, UK	**Status of the SuperNEMO double-beta decay experiment** Cheryl Patrick, University College London, UK
11:45–12:00	**Searches for Resonant and Non-Resonant Higgs Pair Production in the bbtautau Decay Channel with the ATLAS Detector** Emily Charlotte Graham, University of Liverpool, UK	**A search for the decay $\Lambda b \rightarrow pK\eta'$ using the LHCb Run I dataset** Timothy Williams, University of Birmingham, UK	**Gadolinium radiopurity assay programme for Super-Kamiokande** Matthew Thiesse, University of Sheffield, UK	**Recent Developments in the Spherical Proportional Counter for NEWS-G** Patrick Knights, University of Birmingham, UK
12:00–12:15	**Searches for heavy ZZ and ZW resonances in the llqq and $\nu\nu$qq final states at 13 TeV in the ATLAS detector** David Philip John Lack, University of Manchester, UK	**Anti-deuteron measurements at LHCb** Sophie Katherine Baker, Imperial College London, UK	**The Hyper-Kamiokande Outer-Detector : design, performance estimation of background rejection and physics potential** Stephane Alexandre Zsoldos, Queen Mary University of London, UK	**Sensitivity Studies and Development of the Gas Supply System for the SuperNEMO Experiment** Lauren Dawson, University College London, UK
12:15–12:30	**Measurements of Higgs boson cross sections and couplings in the diphoton decay channel with the CMS experiment** Edward Scott, Imperial College London, UK	**Searches for doubly charmed baryons at LHCb** Murdo Thomas Traill, University of Glasgow, UK	**Supernova Neutrino Simulations in Hyper-Kamiokande** Jost Migenda, University of Sheffield, UK	**Radon Background Mitigation Strategy for the SuperNEMO Experiment** Fang Xie, University College London, UK
12:30–12:45	**Higgs-to-Invisible Searches for the CMS experiment at the LHC** Riccardo Di Maria, Imperial College London, UK	**Angular analysis of the decay $\Lambda_b^0 \rightarrow \Lambda \mu^+ \mu^-$** Georgios Chatzikonstantinidis, University of Birmingham, UK	**Innovation and Non-Proliferation – Particle Physics for Nuclear Threat Reduction** Elisabeth Kneale, University of Sheffield, UK	**Search for light Dark Matter with NEWS-G** Konstantinos Nikolopoulos, University of Birmingham, UK
13:00–14:00	Lunch (Enderby Room)		**HEPP AGM** (Frank Theatre)	
	Tyndall Lecture Theatre			
14:00–14:30	**Standard Model Measurements at the LHC** Ulla Blumenschein, Queen Mary University of London, UK			
14:30–15:00	**Higgs Physics at the LHC** Nicholas Wardle, Imperial College London, UK			

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15:00–15:30	**New Physics Searches at the LHC** Jim Brooke, University of Bristol, UK
15:30–16:00	Coffee
16:00–18:00	**STFC Town Meeting**
19:00–23:00	Conference dinner (Bristol Museum and Art Gallery)

Wednesday, 28 March 2018

	Tyndall Lecture Theatre		
09:00–09:30	**Short-Baseline Neutrino Experiments** Andrzej Michal Szelc, The University of Manchester, UK		
09:30–10:00	**Long-Baseline Neutrino Experiments** Asher Kaboth, Royal Holloway, University of London, UK		
10:00–10:30	**Neutrinoless Double Beta Decay and Absolute Neutrino Mass** Elisabeth Falk, University of Sussex, UK		
10:35–11:00	Coffee (Enderby Room)		
	S9. Mott Theatre	**S10. Frank Theatre**	**S11. Berry Theatre (3.21)**
11:00–11:15	**Search for low mass dijet resonances in association with ISR in *pp* collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector** Andreas Sogaard, University of Edinburgh, UK	**Search for hidden sectors in kaon decays at the NA62 experiment at CERN** Viacheslav Duk, University of Birmingham, UK	**Commissioning of a Laser Calibration System for SNO+** Esther Turner, University of Oxford, UK
11:15–11:30	**ATLAS Measurement of the Dynamics of Single Proton Dissociation at the LHC** Andrew Geoffrey Foster, University of Birmingham, UK	**Charged Higgs Bosons in Naturally Aligned Two Higgs Doublet Models at the LHC** Emily Orgill, University of Manchester, UK	**The physics of SNO+** Edward Leming, University of Oxford, UK
11:30–11:45	**The Quest for New Physics, motivated with strong-supersymmetric models, in final states with many hadronic jets in 13 TeV *pp* collisions at the ATLAS detector** Michael Edward Nelson, University of Oxford, UK	**Constraining new physics with standard model measurements** David Yallup, University College London, UK	**Cosmic Muon Induced Neutrons in SNO+** Billy Liggins, Queen Mary University of London, UK
	Tyndall Lecture Theatre		
12:00–12:30	**IOP Prize Lecture: Charm Physics** Marco Gersabeck, The University of Manchester, UK		
12:30–13:00	**Collider Physics Beyond the LHC** Victoria Jane Martin, University of Edinburgh, UK		
13:00	Close of conference and depart		

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Poster programme

P1 Search for heavy neutral lepton decays at NA62 experiment at CERN
Lorenza Iacobuzio, University of Birmingham, UK

P2 Probing the light quark Yukawa couplings through rare exclusive Higgs boson decays
Govindraj Singh Virdee, University of Birmingham, UK

P3 IceCube DOM beamtest at the Fermilab Test Beam Facility (FTBF)
Shivesh Mandalia, Queen Mary University of London, UK

P4 Supernova burst observations with DUNE
Jost Migenda, University of Sheffield, UK

P5 Commissioning of a Laser Calibration System for SNO+
Esther Turner, University of Oxford, UK

P6 Monte carlo modelling of an optical calibration system for the Hyper-Kamiokande experiment
William Vinning, University of Warwick, UK

P7 Monitoring long-term performance of the Hyper-Kamiokande optical calibration system
Sam Jenkins, University of Sheffield, UK

P8 Measurement of the K+ -> pi+ gamma gamma decay at NA62
Maria Brigida Brunetti, University of Birmingham, UK

P9 Diffuser Research and Development for Optical Calibration Systems in Hyper-K
Sammy Valder, University of Warwick, UK

P10 The reconstruction and identification of electrons
Alix Fell, University of Sheffield, UK

P11 Cosmic muon induced neutrons in SNO+
Billy Liggins, Queen Mary University of London, UK

P12 Development of SF6 for use in a low pressure time projection chamber for dark matter detection applications
Callum Eldridge, University of Sheffield, UK

P13 Analysis with the ProtoDUNE single phase detector
Joshua Thompson, University of Sheffield, UK

P14 Prospects for Higgs measurements in the diphoton channel with the CMS experiment at the HL-LHC
Edward Scott, Imperial College London, UK

P15 Mirror Dark Matter Searches with LUX Electron Recoil Data
Elizabeth Leason, University of Edinburgh, UK

P16 Studying the Effect of Polarisation in Compton Scattering in the Undergraduate Laboratory
Patrick Knights, University of Birmingham, UK

P17 Simulations of gamma-ray background from rock for dark matter experiments
Andrew Naylor, University of Sheffield, UK

P18 Innovation and non-proliferation - Particle physics for nuclear threat reduction
Elisabeth Kneale, University of Sheffield, UK

P19 Adversarially trained neural network jet classifiers with ATLAS
Andreas Sogaard, University of Edinburgh, UK

P20 Higgs-to-Invisible Searches for the CMS experiment at the LHC
Riccardo Di Maria, Imperial College London, UK

P21 Bayesian optimisation of the SHiP muon shield
Oliver Lantwin, Imperial College London, UK

P22 The upgraded silicon detector characterisation facility of the University of Sheffield
Evangelos Kourlitis, University of Sheffield, UK

P23 X-PIPELINE: Gravitational-Wave Burst search applied to LIGO data
Elena Massera, University of Sheffield, UK

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Plenary and Invited

Gravity & light: Binary neutron star mergers

P Sutton

Cardiff University, UK

Gravitational waves -- ripples in the fabric of spacetime -- were one of the first major predictions of Einstein's theory of gravity, and are the last to be directly measured. These waves are produced by some of the most violent phenomena in the universe, such as collisions of black holes, the explosive deaths of massive stars, and the big bang itself. But they are so fantastically weak that they have only recently been observed, following decades of effort by a worldwide collaboration. The latest detection, from the merger of a pair of neutron stars, was observed not only in gravitational waves but also across the electromagnetic spectrum, from high-energy gamma rays, through visible light, to radio wavelengths. I will discuss how we are using this event to yield insights into astrophysics, cosmology, and the behaviour of matter under some of the most extreme conditions found in Nature.

Gamma-ray astronomy: Current status and future plans

A Brown

University of Durham, UK

Gamma-ray astronomy covers over 6 orders of magnitude in energy, from 100s of MeV to 100s of TeV. These exceptionally energetic photons allow us to probe particle acceleration in the most extreme objects in the universe, and to investigate fundamental physics questions such as the nature of dark matter and gravity. There has been considerable world-wide effort to develop and perfect detection methods gamma-rays using both space and earth based detectors. This effort has resulted in the current gamma-ray telescopes of Fermi-LAT, HESS, VERITAS and MAGIC producing a plethora of exciting results ranging from the electromagnetic counterpart of a gravitational wave event to indirect evidence of dark matter to cosmic-ray acceleration in relativistic jets. In this talk we review the current status of gamma-ray astronomy, and look at the future of the field in the form of the Cherenkov Telescope Array.

The status of dark matter searches

C Ghag

University College London, UK

The identification of the nature of the dark matter in the universe that constitutes 85% of its matter content is amongst the highest priorities in science. Discovery would elucidate both the missing mass problem and open Beyond the Standard Model physics. I shall present the status of current direct and collider searches for dark matter. Direct searches seek evidence of galactic dark matter particles scattering in terrestrial targets in low-background experiments operated deep underground. Collider searches are looking for evidence of dark matter through production mechanisms at the LHC. I shall discuss the prospects for these two complementary techniques in future searches.

Particle beam therapy in the UK

M Taylor

University of Manchester, UK

High-energy proton-beam therapy is coming to the UK ! The Department of Health has invested £250M in two new centres; one based at the Christie hospital in Manchester and other at University College London hospital. Of the two NHS centres the Manchester centre will be the first to treat patients in 2018. The centre will consist of three NHS treatment rooms with a fourth room being a dedicated research space. The research room will house a fixed beam line incorporating an engineering scanning nozzle which will provide the same pencil beam scanning technology as that available to the clinical service. Although proton therapy has many advantages over conventional x-ray radiotherapy there are still many aspects of treating with protons that need to be addressed in order achieve maximum effectiveness. A multidisciplinary research group has been established between the University of Manchester and the Christie NHS Foundation trust to address some of the key challenges associated with proton beam therapy. This presentation will give a brief overview of the Manchester centre and the research room which is being developed as a national facility highlight the major challenges in proton therapy and what research is being undertaken to address them.

Promoting physics in developing countries

K Shaw

International Centre for Theoretical Physics, Italy

There is a huge untapped potential of physicists that come from countries with low science capital and little or no physics research. University students often lack exposure to physics beyond the textbook, in particular to current research, they are often unaware of opportunities for further study, and governments and institutions may not fully recognise the importance of investing into the fundamental sciences. Promoting physics in developing countries can play a key role in promoting the growth and development of scientific culture, and our scientific community must support education and the development of research worldwide. The respective issues encountered by countries in the development of physics research are presented alongside programmes designed to address issues, and the various ways that we physicists can support physics students and departments in developing countries.

Gravitational-wave astronomy and black hole astrophysics

Christopher Berry

University of Birmingham, UK

Gravitational waves provide a revolutionary means of observing black holes. LIGO's first observation in September 2015 revealed a previously unknown population of binary black holes. Since then, we have made more detections, and we are starting to map out the family of stellar mass black holes. I will review our gravitational-wave observations to date, and explain how we infer the source properties from the signal. In the future, we will be able to use these measurements to constrain the formation of binary black holes and unravel the mysteries of binary stellar evolution, as well as test general relativity in the most extreme conditions.

Status of neutrino physics

F Deppisch

University College London, UK

I will discuss the current status and future prospects in neutrino physics, emphasizing the role of neutrino experiments on physics beyond the Standard Model. Oscillations give us a precise view of the flavour and CP structure of the lepton sector, whereas probes of absolute neutrino masses (Tritium decay, neutrinoless double beta decay and cosmological observations) give us an insight into the nature and origin of neutrinos. In either approach, experimental searches are also sensitive to exotic physics, either at low energies (for example in the form of sterile neutrinos) or at high energies (through effective interactions). I will motivate interesting theoretical scenarios and novel approaches of how neutrino experiments can be used to probe physics beyond the Standard Model.

Session 1

Search for additional heavy neutral Higgs and gauge bosons decaying to di-tau in the ATLAS detector produced with 13 TeV proton-proton collisions at the LHC

T Zorbas

University of Sheffield, UK

This (parallel) talk will present the current status of the ATLAS analysis searching for heavy neutral MSSM Higgs H/A and Z′ gauge bosons decaying to a di-tau lepton final state. The analysis team have recently had a paper accepted for publication [1] featuring the 2015 and 2016 LHC datasets, totalling 36 fb-1 of integrated luminosity delivered at 13 TeV center-of-mass energy of pp collisions. The results of this analysis have set record exclusion limits on the production cross-sections and model parameter spaces, as well as a significantly extended mass range. The talk will also focus on the event selection and background estimation techniques used by the analysis, where the student presenter is personally involved, as well as prospecting the future of the analysis with the upcoming 2017 and 2018 datasets, before closing the second run of the LHC.

[1] "Search for additional heavy neutral Higgs and gauge bosons in the ditau final state produced in 36 fb−1 of pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector", ATLAS Collaboration, CERN-EP-2017-199, arXiv:1709.07242 [hep-ex], accepted for publication in JHEP

Search for exclusive Higgs and Z boson decays to $\varphi\gamma$ and $\rho\gamma$ with the ATLAS detector

R Owen

University of Birmingham, UK

Following the discovery of a Standard Model-like Higgs boson, efforts are now focusing on the full characterisation of its properties. Despite the progress made, little is still known about the Higgs boson couplings to light fermions from the first and second generations. Direct measurements of the Higgs boson couplings to light quarks are plagued by small rates in the SM making them difficult to separate from the huge hadronic backgrounds. This talk will describe the recent ATLAS analysis which searched for such decays involving the φ and ρ mesons obtaining 95% confidence level limits on the branching fractions of 4.8×10^{-4} and 8.8×10^{-4} respectively.

Search for boosted $ttH(H\rightarrow bb)$ with the ATLAS detector

E Winkels

University of Sussex, UK

A search is conducted for the Standard Model (SM) Higgs boson produced in association with a top quark pair; *ttH*. We make use of 36.1 fb^{-1} of proton-proton collision data at a center-of-mass energy of $\sqrt{s}$ = 13 TeV, taken with the ATLAS detector in 2015 and 2016. The search targets the $H\rightarrow bb$ decay channel since it has the largest branching ratio in the SM.

The *ttH* production channel is a direct probe of the top-Higgs coupling. In the SM, the coupling of the Higgs boson to fermions has a coupling strength proportional to the fermion mass. Probing the coupling of the Higgs boson to the heaviest known fermion, the top quark, is hence very important for testing the SM and for constraining models of physics beyond the SM.

This analysis specifically targets high-pT (*boosted*) final states, and is combined for results with the orthogonal *resolved* selection. The boosted channel has different kinematics and thus contains extra information. The boosted events also have a simplified combinatorial background due to multiple jets in the final state.

We target events from the semileptonic decay channel in which the hadronically decaying top quark and the Higgs boson are produced at high-pT relative to their rest mass. To accomplish this, we select events where the decay products of these particles are produced close together in a large jet. Requirements are also set on the number of small jets and how likely these are to contain *b*-hadrons. Multivariate techniques are used to discriminate between signal and background events.

In combination with the resolved semileptonic and dileptonic decay channels, the ratio of the measured *ttH* signal cross-section to the SM expectation is found to be μ=0.84±0.6 for a Higgs mass of 125 GeV.

Searching for decays of the Higgs boson to charm quarks at ATLAS

E Reynolds and K Nikolopoulos

University of Birmingham, UK

In spite of the substantial progress made in the study of the Higgs sector, to-date the fermion-Higgs couplings for the first and second generation fermions remain elusive. These couplings are potentially susceptible to new physics effects. The first dedicated search for the Higgs boson decay to a pair of charm quarks is presented in the using 36.1 inverse-fb of proton-proton collision data collected during 2015 and 2016 at the ATLAS experiment. This analysis also pioneers the use of ATLAS' new Run II c-tagging algorithms. No excess in Z(ll)H(cc) production is observed, and a 95% CLs upper limit is set at 2.7 pb (107 times the SM expectation). Finally, the prospects of this analysis ranging from the immediate future to the HL-LHC are discussed.

Searches for additional neutral Higgs bosons in the di-tau final state with the CMS experiment

D Winterbottom

Imperial College London, UK

The standard model (SM) Higgs sector contains one Higgs doublet and consequently predicts the existence of one neutral Higgs boson. In 2012 the CMS and ATLAS experiments discovered such a Higgs boson and measurements of its properties to date have found it to be consistent with the SM predictions. Despite this success, many beyond the SM theories predict more complicated Higgs sectors which include additional Higgs bosons. An example of such a theory is supersymmetry, which in its minimal interpretation (MSSM) requires two Higgs doublets and consequently predicts the existence of three neutral and two charged Higgs bosons. The search for neutral Higgs bosons decaying into pairs of tau leptons at the LHC has emerged as a particularly interesting endeavour. This is due to the relatively good signal to background ratio and large branching fraction over much of the MSSM parameter space. This talk will present the latest results from the CMS experiment of the search for additional neutral Higgs bosons in the di-tau final state using 35.9 fb^{-1} of 13 TeV collision data collected during LHC Run 2. Result are presented in the form of both model-independent exclusion limits and model-dependent exclusion limits in the context of the MSSM.

Measurement of Z+bb kinematic variables with ATLAS

C Gray[1], A Buckley[1] and C Pollard[2]

[1]University of Glasgow, UK, [2]DESY, Germany

Following the Higgs discovery in 2012, it is crucial to understand the coupling of the Higgs to fermions, in particular to b-quarks. In ATLAS the main search mode for this is a Higgs decaying to bb, produced in association with a vector boson. The Standard Model V+bb process is the key background to this search and therefore must be well understood.

I will present a measurement of kinematic variable distributions in 36/fb of Z+bb events where the larger Run-2 energy collimates the bb pair into a single large-radius jet. The variables include distributions of the large-radius jet and its sub-jets corresponding to the b-quarks. As well as providing crucial input to the VH(H->bb) search, this process provides an important test of QCD and a constraint on its theory/modelling uncertainties for both the production and decay of bb pairs.

Searching for invisible phenomena through measurement of events with jets and large missing transverse momentum in pp collisions at ATLAS

R Pickles and D Price

The University of Manchester, UK

A search for dark matter and other invisible phenomena in pp collisions at a centre of mass energy of 13 TeV in final states with jets and missing transverse energy using the ATLAS experiment will be presented. The analysis utilises a measurement of the production cross-section ratio between the production of jets in association with missing transverse energy and the production of jets in association with an opposite-sign same-flavour lepton pair in order to provide powerful elimination of theoretical and experimental uncertainties.

The detector-corrected data ratio, measured differentially with respect to a number of kinematic properties of the hadronic system, allows competitive limits to be set on an array of dark matter models. As this measurement is presented corrected for detector effects and published alongside all necessary auxiliary data, this measurement can be used to constrain new-physics models beyond those presented in this talk without the need for detector simulation or modelling of Standard Model backgrounds.

Measurements of boosted top-quark differential cross-sections in the lepton+jets channel at s=√13 TeV using pp collision data recorded with the ATLAS detector

M Fenton

CERN, Switzerland / University of Glasgow, UK

As the heaviest known fundamental particle, the top quark has a unique place in understanding the limitations of, and helping to understand physics beyond, the Standard Model of Particle Physics. The measurement of the differential top-quark cross-section, particularly in the high momentum "boosted'' regime, provides a stringent test of advanced perturbative QCD calculations. Detailed measurements of those differential cross-sections, using pp collision data collected with the ATLAS detector at a centre-of-mass energy of 13 TeV, are presented.

Higgsinos and compressed sleptons: opening the soft lepton frontier for new physics at the LHC

J Liu

University of Oxford, UK

The smoking gun signals for new physics at the energy frontier elude us. What gaps remain under the lamppost? Where do we focus our next searches? I present the first hadron collider sensitivity to challenging scenarios of natural supersymmetry and dark matter, namely the sought-after Higgsinos and compressed sleptons. Dedicated efforts in the ATLAS Experiment, especially soft lepton reconstruction down to 4 GeV, were needed to surpass nearly two-decade old LEP limits. Untouched parameter space remains and will be the focus of 13 TeV LHC searches, opening tantalising prospects for discoveries at the weak scale.

Dark matter searches at CMS

S Breeze

Imperial College London, UK

The Standard Model (SM) of Particle Physics is a rigorous theory of fundamental particles and the interactions between them. However, an outstanding issue in the High Energy Physics community, and the most compelling argument for new physics, is the nature of Dark Matter (DM). There are many decades worth of astrophysical and cosmological measurements that motivates the existence of DM. The searches for a particle candidate for DM fall under three orthogonal and complementary methods: production at colliders, direct detection through DM scattering and indirect detection of DM annihilation. The focus here is on a DM search at a collider experiment. The phase space probed by these experiments are complementary to the other two search methods and also provide a wide range of sensitivity to different DM models: e.g. spin-dependent and spin-independent interactions.

DM searches at colliders is led by the Large Hadron Collider (LHC). At one of the LHC collision points resides the CMS detector: a multi-purpose hermetic detector allowing the full reconstruction of proton-proton collisions at unprecedented luminosities. A key signature for DM analyses is missing transverse momentum (MET) taken away by the undetected DM particles. To be able to trigger and tag events, the DM particles must recoil against observable particles. The largest cross-section are for jets recoiling against the DM particles. The alphaT search targets these topologies and provides powerful discrimination against the uncertain QCD multi-jet background providing limits on new physics.

Search for single top production in association with a Z boson for the dilepton final state in pp collisions at $\sqrt{s}$ = 13 TeV in the CMS detector

C Hoad

Brunel University, UK

A search for the rare standard model process in which a single top quark is produced in association with a Z boson and an additional jet in proton-proton collisions recorded by the CMS experiment at $\sqrt{s}$ = 13 TeV. Final states with two leptons (electrons and muons) from the leptonic decay of the Z boson in addition to at least one b jet are investigated. The effectiveness of multilayer perceptron and boosted decision tree classifiers to identify signal events is compared. In addition, a technique involving the training of two classifiers is explored, with a two-dimensional plane populated by the responses of each classifier. The performance of different strategies to reduce this two-dimensional plane to a one-dimensional histogram are examined with respect to their effect on the expected significance.

Session 2

Measurement of the CP violating phase, φ_s, in Run 2 using $B^0_s \rightarrow J/\psi K^+K^-$

K Gizdov and G Cowan

University of Edinburgh, UK

Precise measurements of CP violation provide stringent tests of the Standard Model as we search for signs of new physics. Using data collected by the LHCb detector during 2015 & 2016 LHC collisions at a centre-of-mass energy of 13TeV, I will present the latest measurement of the CP-violating phase, φ_s , using $B^0_s \rightarrow J/\psi\varphi$ decays. I will discuss the machine-learning based data selection, data-driven corrections to simulated event samples, and the control of systematic effects using control sample. The analysis is still blind but expected to yield a statistical precision for φ_s of 0.042 rad and 0.008 ps^{-1} for the decay width difference between the light and the heavy mass eigenstates in the B^0_s system, yielding the World's most precise determination of these quantities.

Prospects for $K^{\pm} \rightarrow \pi^{\pm}\mu^+\mu^-$ at the LHCb Experiment

K Zarebski

University of Birmingham, UK

A preliminary sensitivity study of the rare decay $K^{\pm} \rightarrow \pi^{\pm} \mu^+\mu^-$ at the LHCb experiment is presented using data from proton-proton collisions at Run II of the LHC with a centre of mass energy of 13TeV. This Flavour Changing Neutral Current decay is very sensitive to physics beyond the Standard Model. A blinded analysis into this decay is presented exploiting the $K^{\pm} \rightarrow \pi^{\pm} \pi^+\pi^-$ decay as a control and normalisation channel. Finally preliminary sensitivity studies and prospect are also presented.

Status and prospects of the measurement of the pi+mu+mu- form factor with the NA62 experiment at CERN

C J Parkinson

University of Birmingham, UK

I will discuss the status of the measurement of the K+ to pi+mu+mu- form factor at the NA62 experiment at CERN, based on data collected in 2016. I will then discuss future prospects for the measurement.

Measurement of the branching fractions and form factors of $K^+ \rightarrow \pi^0 l^+ \nu$ decays

S Trilov

University of Bristol, UK

The NA62 experiment at the CERN SPS is designed to measure the branching ratio of the decay, $K^+ \rightarrow \pi^+\nu\nu$. A key feature of the experiment is the identification of kaons, which comprise around 6% of the beam. This is achieved using the CEDAR (Cerenkov Differential counter with Achromatic Ring Focus). The radiator gas up to now has been nitrogen, however it might be desirable to use hydrogen, in order to reduce the amount of material the beam has to pass through. The preparations for the use of hydrogen, including upgrades to the detector hardware and its control system are discussed. NA62 provides unique opportunity to measure the branching fractions and form factors of the semileptonic kaon decays ($K_{l3} = K^+ \rightarrow \pi^0 l^+ \nu$, where l = e, μ) with world-beating precision. These values provide a

clean way to evaluate the CKM parameter V_{us}. The status of this analysis is presented, including event selection, and background evaluation.

Measurement of the K+ -> pi+ gamma gamma decay at NA62

M B Brunetti

University of Birmingham, UK

Radiative non-leptonic kaon decays are important tools to study the Chiral Perturbation Theory (ChPT), an effective field theory that describes the physics of hadrons in the low energy, non-perturbative QCD regime. The rare decay K+ -> pi+ gamma gamma is particularly interesting as its decay rate is determined in this framework by a single parameter. A past measurement of the branching ratio (BR) was performed by a combined analysis of data samples from the NA48/2 and NA62 2007 experiments. A higher precision measurement of the BR is possible using the currently available NA62 datasets. The status of a study of the K+ -> pi+ gamma gamma decay on NA62 2016 data is presented.

Search for the decay $B \rightarrow p^+p^-\mu\nu$

M Tilley, M Patel and M Smith

Imperial College London, UK

A test of lepton flavour universality (LFU) can be performed by measuring the ratio of branching fractions for semi-leptonic decays involving a τ lepton to the decays involving a μ lepton. The LFU ratios R(D), R(D*) are discrepant with the Standard Model at the level of 4σ. The LHCb experiment has contributed to the measurement of R(D*) along with a measurement of the ratio R(J/ψ). These ratios involve a $b \rightarrow c$ quark transition and the discrepancies may be due to a new physics process. It is interesting to investigate if a similar effect exists in an equivalent ratio with a $b \rightarrow u$ quark transition such as the decays $B \rightarrow p^+p^-l\nu$. The status of the search for the semi-leptonic decay $B \rightarrow p^+p^-\mu\nu$ will be presented. The progress of the measurement of the ratio with the tauonic mode will also be discussed.

Measuring the WW Production Cross-Section at LHCb

H Wark, T Shears and S Farry

University of Liverpool, UK

The LHCb experiment at CERN is a general-purpose detector in the forward region, capable of making very precise electoweak measurements used to test the Standard model – any deviation from theoretical prediction could point towards New Physics. The WW production cross-section is one of these measurements, being studied for the first time at LHCb thanks to the increased centre of mass energy of 13TeV in Run II. As well as being an important electroweak measurement in its own right, WW production is also a significant background in Top Physics investigations, a new area of study for the experiment. In this work, the feasibility of a WW cross-section measurement is assessed by attempting to identify candidates in the eμ channel using both Monte Carlo simulation and data driven methods.

Search for $B_c \rightarrow DD$ decays with the LHCb detector

A Tully

University of Cambridge, UK

CP violation has not yet been observed in the B_c^+ system. Decays of $B_c^+ \rightarrow D_{(s)}^+ D$ have been proposed to measure the Cabibbo-Kobayashi-Maskawa angle γ, which is the least well known parameter of the Unitarity Triangle. Presently, Presently, the most precise measurements of γ come from measurements of the CP asymmetry caused by the interference of b→u and b→c transitions in $B^+ \rightarrow DK^+$ decays. Due to the flavour structure of the B_c^+, much greater interference is expected, resulting in a larger CP asymmetry and sensitivity to γ. However, observing and using $B_c^+ \rightarrow D_{(s)}^+ D$ decays is experimentally very challenging. A search for $B_c^+ \rightarrow D_{(s)}^+ D$ decays with the run I dataset collected during 2011 and 2012 by the LHCb detector is presented.

Searching for lepton universality violation and New Physics in rare decays of Lambda baryons at the LHCb

R Glew

CERN / RAL / University of Southampton, UK

Due to lepton universality the standard model predicts the ratio between the branching fractions of the two rare decays $\Lambda \rightarrow pK\mu^+\mu^-$ and $\Lambda \rightarrow pKe^+e^-$, named R_pK to be unity. Recently the LHCb experiment at CERN measured similar ratios in the rare decays of B-mesons which showed deviations of 2.5σ and 2.6σ from the standard model predictions for the ratios named R_K*and R_K respectively. These observations could indicate the presence of new physics.

This analysis aims to measure the value of R_pK in the low dilepton mass squared region, which is well below all charmonium resonances, and search for any deviations from the standard model predictions. This measurement will provide a further test of lepton universality. The channels $\Lambda \rightarrow pKl^+l^-$ (where l=μ, e) are used as control channels. One measures the double ratio between the branching fractions of the rare decay channels and the control channels to cancel out many systematic uncertainties. The analysis uses 3.7fb-1 of Run2 data from the LHCb experiment taken during 2015-17 at $\sqrt{}$= 13TeV. A procedure for selection of signal candidates was developed, which involved implementing a multivariate classifier named BDT and applying selection criteria based on decay kinematics and identification of particles in the final states. The yield from the selection of each channel is used to calculate the corresponding branching fraction.

The analysis strategy, the event selection procedure and sources of uncertainty expected in this measurement will be described and the results obtained so far will be presented.

Search for K+ to pi+ nu nu at NA62

A Romano

University of Birmingham, UK

K->pinunu is one of the theoretically cleanest meson decay where to look for indirect effects of new physics complementary to LHC searches. The NA62 experiment at CERN SPS is designed to measure the branching ratio of the K+->pi+nunu decay with 10% precision. NA62 took data in 2015-2017; the analysis of a partial data set allows to reach the Standard Model sensitivity. The status of the experiments will be reviewed, and prospects will be presented.

Search For heavy neutral Lepton decays at NA62 experiment at CERN

L Iacobuzio

University of Birmingham, UK

The status of searches for heavy neutral lepton decays at the NA62 experiment at CERN is presented. The theoretical framework of this study is briefly discussed, together with the work carried out so far and the latest preliminary results.

Session 3

Vertex finding for pile-up mitigation in the Phase-2 upgrade of the Level-1 Trigger of CMS

A Shtipliyski

Imperial College London, UK

The High-Luminosity upgrade of LHC (HL-LHC) is expected to deliver a total luminosity of 3000 fb^-1 to the general purpose experiments. This will allow the measurement of Standard Model processes with unprecedented precision, and will significantly increase the reach of searches for new physics. Higher data rates and increased radiation levels will require substantial upgrades to the detectors and their trigger and data acquisition systems. The Phase-2 upgrade of CMS comprises a complete replacement of the silicon tracker that will for the first time provide tracking information to the Level-1 (L1) hardware trigger. The increased luminosity is expected to produce around 200 additional “pile-up” interactions per bunch crossing. This creates a challenging environment for efficient triggering, and the implementation of effective pile-up mitigation at L1 will be essential to keep trigger thresholds low to maintain sensitivity to important physics processes. The use of tracks in the L1 algorithms is essential for pile-up mitigation, as charged particle tracks can be matched to energy deposits in the calorimeter and tracks in the muon detectors to identify directly the particles originating from the primary interaction vertex of the hard scatter process. This talk will introduce the challenges involved in reconstructing the primary vertex at L1, describe the mechanisms for its use in pile-up mitigation, and highlight the architectural implications for the Phase-2 upgrade to the L1 Trigger.

Gaussian processes for High Energy Physics

A Bozson

Royal Holloway, University of London, UK

Gaussian Processes (GPs) are used as a powerful statistical tool in astrophysics, machine learning, climate science, and geostatistics. However they have not yet been widely adopted by the HEP community. In this talk I will give an introduction to GPs and their potential uses in HEP. GPs allow greater flexibility over rigid parameterised functions, and may be thought of as a distribution over the space of functions. A GP is entirely defined by its mean and kernel (covariance) functions. Useful properties of kernel functions will be discussed along with a demonstration of their impact on the sampled functions. Applications in generalised Bayesian inference and hyperparameter tuning, as well as links to machine learning, allow us to compare and contrast with methods currently used in HEP. I will present an example where a GP is used to model a smooth background in a dileptonic high-mass resonant search. Finally I will discuss the potential for GPs to be used in deconvolution in comparison to traditional unfolding methods.

Perspectives for SUSY in light of current LHC constraints

J Costa and E Bagnaschi

Imperial College London, UK

Low-energy data from flavour physics experiments, high precision electroweak observables as well as astrophysical data impose strong constraints on many new physics (NP) scenarios. In order to quantify the agreement of a particular NP model with the existing experimental measurements, a consistent set of theoretical predictions has to be provided. For that reason it is desirable to combine the different calculations into one common “MasterCode”. In this talk we present the current perspectives for SUSY at the LHC Run-II in the sub-GUT and in a phenomenological Minimal Supersymmetric Standard Model scenario with eleven parameters (pMSSM11). The results of this study show that today's experimental data already place tight constraints on the MSSM parameter space.

QED Parton Distribution Functions

R Nathvani, R Thorne and L Harland-Lang

University College London, UK

As the LHC ramps up in luminosity and experimental accuracy, equivalent increases in precision must be made on the phenomenological front. As an increasing number of processes are calculated at NNLO in QCD, the corrections to cross sections are anticipated to be similar, or perhaps even less than corrections due to QED. motivating the inclusion of the photon as an interacting parton in proton-proton collisions. I outline the latest approaches taken towards including QED effects in Parton Distribution Functions (PDFs), including the determination of the initial distribution of the photon from experimental data, the incorporation of QED effects in the so-called DGLAP evolution equation for PDFs, which determines their scaling with the centre of mass energy. I will also outline the effect of such inclusions on overall proton structure, and potential implications for LHC phenomenology.

Positivity constraints on self-interacting dark matter

S Melville

Imperial College London, UK

This talk will describe dark matter from an Effective Field Theory perspective, and show how various consistency conditions inherited from the underlying UV theory (such as causality and locality) limit the possible self-interaction between dark matter particles in the IR.

Dark matter self-interactions have recently received much attention because they may offer a resolution to several small-scale problems in simulations of Cold Dark Matter (cusp-core, missing satellite, too-big-to-fail, etc.). However, in order to completely smooth these problems, the self-interaction cross-section must be sufficiently large. This leads to tension with the UV consistency conditions.

Considering the explicit example of spin-2 dark matter, I will show that this tension between field theory axioms in the UV and experimental observations in the IR is enough to completely rule out this model. These UV constraints can therefore play an important role in our future dark matter model-building.

Sensor Characterisation and Readout for the LHCb VELO Upgrade

V Franco Lima

University of Liverpool, UK

The LHCb Experiment at the LHC will upgrade its detectors and move to a full software trigger during the LHC's second long shutdown in 2019-2020. This upgrade will allow LHCb to operate at a readout rate of 40MHz from the present 1MHz rate which in turn will allow higher luminosity, moving from an average of 1.8 collisions in LHCb to 7.6 collision in the LHCb Upgrade, while maintaining trigger and reconstruction efficiency. The Upgrade for LHCb Vertex Locator detector will be comprised of 52 modules, each carrying 4 pixelated silicon sensors, using by a bi-phase carbon dioxide flow through narrow channels in a silicon support structure. The sensors will be at a 5.2mm distance from the LHC beam during physics operation, thus being exposed to a very high non-uniform radiation flux. The design of sensors, cooling, readout chain and the extensive tests to characterise the prototypes will be discussed as well as the methods for testing the production sensors currently being designed.

3D Printing gaseous radiation detectors

S Fargher, L Thompson, C Steer and J Burns

University of Sheffield, UK

Additive Manufacturing (AM) techniques have been in development since the 1980s, however, only recent progress has been significant enough to allow Rapid Prototyping to become a cost-effective and fast manufacturing technique for complex designs, which require multiple build materials. As a result of the advancements made in this technology, Hohlmann produced a white paper[1] in 2013 posing a "grand challenge" to the HEP instrumentation community: develop a method of using AM techniques to produce particle detectors.

Fused Deposition Modelling (FDM), an AM technique, has been investigated as a possible production method of SWPCs. Acrylonitrile butadiene styrene (ABS) and Polylactic acid (PLA) were tested as possible thermoplastics to print a variety of different drift tube enclosure designs, varying many printing parameters to discover the ideal conditions to produce a working detector. Conductive filament, a composite thermoplastic, has also been investigated as a possible material for printing cathode structures.

Simple Iarocci-style SWPCs, without internal cathodes, have been produced, proving the concept that simple GRDs can be produced via AM techniques. These SWPCs are undergoing tests to measure the airtightness and the sustainability of operation. SWPCs containing cathodes, Multi-Wire Trackers and TPCs are currently being designed and printed to investigate whether AM techniques are viable production method for more complex detector designs. In this presentation, the results from the first operational tests and design progress will be discussed.

[1] Hohlmann M. Printing out Particle Detectors with 3D-Printers - a Potentially Transformational Advance for HEP Instrumentation. 2013

ATLAS inner detector decommissioning: Tolerance study of robotic components for use in high radiation environment

A Cryer, G Kapellmann, R French and H Marin-Reyes

University of Sheffield, UK

The Large Hadron Collider (LHC) at CERN in Geneva, Switzerland is the largest particle accelerator in the world. In 2024, the LHC will be upgraded to increase its luminosity by a factor of 10 (HL-LHC).
The ATLAS inner detector (ITk) will be upgraded at the same time. Over the course of its lifetime, it has suffered a high amount of radiation damage. Simulations estimate the detector will emit 1.1 mSv/h 10cm from the beamline at shutdown.

Such a high level of radiation makes it impossible for human engineers to decommission the detector, so robots will be used instead.

Identifying how robots are susceptible to radiation will improve robotic design for deployment in radiation environments, such as the ATLAS decommissioning and also for industrial nuclear decommissioning projects.
This poster will review the current status of the inner detector decommissioning, and present the results of the irradiation of a commercial CMOS camera and a robotic manipulator carried out at the Birmingham cyclotron.

The LHCb VELO Upgrade

D Deepanwita

University of Manchester, UK

The LHCb experiment is a forward spectrometer experiment dedicated primarily to study CP violation and rare decays of beauty and charm hadrons. The LHCb experiment will be upgraded to a trigger-less system reading out data at 40 MHz event rate. To cope with the higher data rates and increased occupancy, the detectors including the Vertex Locator (VELO) need to be upgraded. The VELO performs high precision track and vertex reconstruction. The upgraded detectors will be installed during the upcoming LHC long shutdown2 (LS2), currently scheduled to start at 2019-2020.

The upgraded VELO will be a hybrid pixel detector having pixels of dimensions 55 × 55 μm^2. Data from the pixel sensors will be read-out via VeloPix ASICs and transmitted through high speed serial links to the off-detector electronics. Low mass evaporative CO_2 cooling will be used with the coolant circulating within etched microchannels in the silicon substrate. The upgraded VELO will provide fast pattern recognition and track reconstruction to the software trigger. In this talk, I will discuss the design requirements, recent R&D results and the current status of the VELO upgrade.

Bayesian optimisation of the SHiP muon shield

O Lantwin

Imperial College London, UK

The SHiP experiment is new general purpose fixed target experiment designed to complement collider experiments in the search for new physics. A 400 GeV/c proton beam from the CERN SPS will be dumped on a dense target to accumulate 2×10^{20} pot in five years.

A crucial part of the experiment is the active muon shield, which allows the detector to operate at very high beam intensity while maintaining a zero-background environment for the search for new physics. In order to do this the

muon flux has to be reduced from 10^{11} muons per second by 6 orders of magnitude in the shortest distance possible.

This presentation will describe the concept of the active muon shield, the particular challenges of this optimisation problem, which necessitate the use of modern optimisation techniques, and how they are overcome with these techniques. Finally, recent results and their implications for the SHiP comprehensive design study and beyond are presented.

Towards the highest precision detector at the LHC - The LHCb Upgrade VELO and its Performance

C Burr

University of Manchester, UK

At the end of 2018 the LHC will begin Long Shutdown 2 and the LHCb detector will be the first LHC experiment to undergo a major upgrade. This will allow LHCb to increase its design luminosity by a factor of 10, while also dramatically improving its efficiency by the removal of the hardware trigger.

The current LHCb vertex locator (VELO) provides the highest precision vertexing at the LHC and needs to be replaced as part of the upgrade to allow for the increase in operating luminosity and new readout system. The upgrade VELO must be capable of maintaining or improving the physics performance of the detector so that LHCb can continue to exploit its unique position as the only specialised flavour physics experiment at the LHC.

This talk will give an overview of the LHCb upgrade followed by details on the design, status and expected performance of the new VELO.

Session 4

Measuring the effective longitudinal electron diffusion coefficient at MicroBooNE

A Lister

Lancaster University, UK

MicroBooNE is a Liquid Argon Time Projection Chamber (LArTPC) which has been running in the Booster Neutrino Beam since October 2015. As one of the first large-scale LArTPCs, one of the primary goals of MicroBooNE is to understand the performance of the LArTPC technology towards the development of future multi-kiloton detectors such as the Deep Underground Neutrino Experiment. In particular, understanding the diffusion of ionization electrons as they traverse the detector is vital to help determine the spatial, temporal and charge resolution of both MicroBooNE and future LArTPC experiments. This talk will outline the ongoing study to measure longitudinal diffusion at MicroBooNE.

Calorimetric energy scale in the NOvA detectors

T Alion

University of Sussex, UK

NOvA is a long-baseline neutrino oscillation experiment consisting of a near and far detector, both comprising layers of orthogonal scintillator-filled PVC extrusions. Reconstructing hits along the orthogonal views provides 3D tracks, and scintillation light provides calorimetry important for determining the visible hadronic energy of an interaction. Selecting muon tracks which stop inside the detector and choosing hits inside a sufficiently flat region around its

point of minimum ionization isolates a constant energy in the detectors. This energy is scaled by the path length of each hit, so additional quality cuts must be imposed to ensure accurate path lengths. Care must also be taken to avoid bias from electronic thresholds, which are meant to suppress noise hits but can also suppress low-energy muon hits far from the readout. After removing reconstruction and threshold biases, cosmic muon data provides a standard candle scintillation, while well-understood Monte Carlo simulation provides a standard candle energy, equipping NOvA analyses with a precise scale factor between observed light and desired energy measurements.

MicroBooNE NC Delta radiative single-photon search

R Murrells

University of Manchester, UK

MicroBooNE, an 85 metric ton (active mass) liquid argon time projection chamber (TPC), began studying neutrino interactions on the Fermilab Booster Neutrino Beamline (BNB) in October 2015. One of its primary physics goals is to investigate the Low Energy Excess of electromagnetic events observed in MiniBooNE. Neutral current resonant Delta baryon production, with subsequent radiative decay, is a standard model source of low energy single photons that could constitute the origin of this excess. This talk will describe the reconstruction and event selection scheme developed to identify neutral current Delta radiative events, with the intent to test the hypothesis that the MiniBooNE excess is caused by neutral current Delta baryon production. We also investigate MicroBooNE's ability to measure the rate of neutral current Delta baryon production and subsequent radiative decay.

Latest muon neutrino disappearance results from the NOvA experiment

D P Méndez

University of Sussex, UK

NOvA is a long-baseline neutrino oscillation experiment looking for muon neutrino disappearance and electron neutrino appearance. Having the longest baseline of any past or present accelerator experiment, NOvA uses the upgraded Neutrino Main Injector (NuMI) beam at Fermilab. The experiment measures oscillations within a muon neutrino beam using a 300 ton Near Detector and a 14 kiloton Far Detector placed 810 km away from each other, both located 14 milliradians off-axis. The energy spectra observed in this neutrino beam peaks at 2 GeV close to the oscillation maximum. NOvA being an oscillation experiment uses the Near Detector (ND) at Fermilab to measure the initial beam spectra and flavour composition. Then the spectra is extrapolated to the Far Detector (FD) at Ash River to search for oscillations.

NOvA's ν_μ Disappearance Analysis Group has increased its sensitivity, coming from a finner energy binning and hadronic energy fractions. The NOvA Collaboration has recently released a new ν_μ disappearance result using an exposure of 8.85×10^{20} protons-on-traget (POT). In conjuction with an upgraded analysis, this exposure has enabled us to set new limits to the allowed regions for the oscillation parameters Δm^2_{32} and $\sin^2\theta_{23}$ and make a measurement of Δm^2_{32} among the world's best. This talk will present the improvements to the muon neutrino disappearance analysis and its latest oscillation results.

Comparison of binned vs. unbinned likelihood analyses for neutrino oscillation measurements in NOvA

S Bending

University College London, UK

NOvA is a long-baseline neutrino experiment at Fermilab designed to make measurements of electron neutrino appearance and muon neutrino disappearance in the NuMI beamline. Through comparison of the beam composition at the NOvA near and far detectors, measurements of the parameters that govern neutrino oscillation are made, providing sensitivity to the neutrino mass ordering and the degree to which CP violation occurs in the neutrino sector.

In this talk, the methodology for performing unbinned likelihood analyses for ν_μ disappearance, ν_e appearance and combined data in NOvA is outlined, and the effects of unbinned analyses on experimental sensitivities compared with binned fitting methods utilised in the standard NOvA analyses.

Overview of the ANITA experiment

L Cremonesi

University College London, UK

The ANtarctic Impulsive Transient Antenna (ANITA) is a long-duration balloon payload funded by NASA, with an array of radio antennas. ANITA scans the Antarctic ice looking for Askaryan radio emission coming from ultra-high-energy (>E19 eV) neutrinos interactions. Extensive air showers coming from ultra-high-energy cosmic rays and hadronic showers from tau neutrinos can also be detected by ANITA via geomagnetic radio emission. This talk will present an overview of the ANITA simulation, the latest results of the third flight, and improvements towards future flights.

Hunting Axionlike dark matter by searching for an oscillating neutron electric dipole moment

N Ayres

University of Sussex, UK

Axions and axion-like particles (ALPs) are popular dark matter candidates. Ultralight axion and ALP cold dark matter would manifest as a classical field, oscillating coherently on a galactic scale. Through their couplings to gluons, this field would induce an oscillation in the measured value of the electric dipole moments of neutrons and other particles. We analyse datasets from the Sussex-RAL-ILL nEDM experiment and the current nEDM experiment at the Paul Scherrer Institute (2015-2016) to obtain limits on a potential oscillation in the value of the EDM.

While many experiments probe the axion-photon coupling, we set the first laboratory limits on the axion-gluon coupling, improving upon the previous indirect cosmological limits by up to 3 orders of magnitude. Additionally, we improve upon laboratory constraints on the axion coupling to nucleons by up to a factor of 40.

Paper: Phys. Rev. X 7, 041034 (2017)- Search for Axionlike Dark Matter through Nuclear Spin Precession in Electric and Magnetic Fields

Search for new physics in astrophysical flavor at IceCube

S Mandalia

Queen Mary University of London, UK

The astrophysical neutrino flavour is one of the most powerful tools to look for new physics in the neutrino sector. We use an effective operator framework related to terms in the Standard Model Extension to search for such new physics. The highest energy astrophysical neutrinos observed at the IceCube Neutrino Observatory are used to search for anomalous signals from neutrino oscillations. Here, we present the preliminary results using March 2018 data.

Neutrino interferometry for high-precision tests of Lorentz symmetry with IceCube

T Katori

Queen Mary University of London, UK

Lorentz symmetry is a fundamental space-time symmetry underlying the Standard Model of particle physics and gravity. However, unied theories, such as string theory, allow for violation of this symmetry. Thus, the discovery of Lorentz symmetry violation could be the first hint of these theories. Here, we use high-energy atmospheric neutrinos observed at the IceCube Neutrino Observatory to search for anomalous neutrino oscillations as signals of Lorentz violation. The large range of neutrino energies and propagation baselines, together with high statistics, let us perform the most precise test of space-time symmetry in the neutrino sector to date. We find no evidence for Lorentz violation. This allows us to constrain the size of the dimension-four operator in the Standard-Model Extension for Lorentz violation to the 1E-28 level and to set limits on higher dimensional operators of that theory. These are among the most stringent limits on Lorentz violation across all fields of physics.

Searching for WIMP dark matter with the LZ experiment

I Olcina

Imperial College London, UK

There is overwhelming evidence that suggests that there is an invisible and dominant mass component in the universe, known as dark matter. Weakly Interacting Massive Particles, or WIMPs, represent a well-motivated class of particle candidates. WIMPs could be directly detected on Earth via their scattering off atomic nuclei in underground, low energy threshold and ultra-low background detectors. The experiment LUX-ZEPLIN (LZ) is currently under construction and it will probe WIMP interactions practically as far as it is allowed by new backgrounds from astrophysical neutrinos. In this talk I will present the expected sensitivity of LZ to WIMP dark matter, and describe parameter inference tools developed specifically for this experiment.

Invited

Overview of experimental heavy flavour physics

G Cowan

University of Edinburgh, UK

The heavy quark sector is a wide field of study that encompasses searches for new states in the hadron spectrum, measurements of CP-violating observables and parameters of the Cabibbo-Kobayashi-Maskawa quark mixing matrix and searching for signs of beyond-the-Standard Model physics in rare flavour changing neutral current decays of b and c-hadrons. Recent high-profile examples have been the discovery of new heavy-baryons and hints of lepton flavour non-universality when comparing rates of $B0 \rightarrow K(*)\ \mu+\mu-$ and $B0 \rightarrow K(*)e+e-$ decays, the so-called RK and RK* ratios. Similar hints have also appeared in tree-level transitions of B mesons decaying semi-leptonically, using the ratio $R(D(*)) = BF(B0 \rightarrow D(*)\tau\nu)/BF(B0 \rightarrow D(*)\mu\nu)$. I will review recent measurements at the LHC and at the B factories in these areas. In addition I will discuss the status of the Belle-II experiment, the LHCb upgrade and the potential improvements in precision that are possible when operating a future LHCb upgrade-II during the high-luminosity LHC. Finally, I will show the status of the NA62 experiment at CERN that is aiming to measure the rare kaon decay processes, in particular $K \rightarrow \pi\nu\nu$, which are sensitive probes of new physics operators.

Review of lepton flavor experiments

P Litchfield

Imperial College London, UK

Lepton flavor experiments are entering a minor renaissance, with many experiments just starting up now or in the next decade. Both flavor-conserving and flavor-changing processes are in the spotlight, as experiments revisit old anomalies and tread new ground with the help of innovative secondary and tertiary beamlines. In this brief review I will cover recent results and the status of upcoming experiments.

Who ordered that? Interpreting LFUV and other new physics signals from flavour

A Lenz

IPPP Durham, UK

Intriguing hints for deviations of quark flavour observables from Standard Model expectations have been found by several experiments, in particular by LHCb. A rigorous understanding of hadronic contributions to these observables is of utmost importance for any interpretation as Beyond SM effects. We will give a more detailed insight in some of the SM predictions as well as an overview of possible BSM models that might explain the flavour anomalies.

Standard model measurements at the LHC

U Blumenschein

Queen Mary University of London, UK

This talk presents an overview of measurements of the strong and the electroweak force and of top quark production at the LHC experiments ATLAS, CMS and LHCb, comprising both an overview of the current status and highlights of recent measurements. The measurements are compared to state-of-the-art predictions and can be used in many cases to search for new physics in a model-independent way.

Higgs Physics at the LHC

N Wardle

Imperial College London, UK

The focus of Higgs physics at the LHC in Run-2 has been to characterize the Higgs sector, through precision measurements of the Higgs boson's properties, and through searches for additional Higgs bosons. I will outline the current status of the experimental program at the ATLAS and CMS experiments, and present recent results using the data from Run-2. I will also present a brief outlook on the future of Higgs physics at the LHC and future colliders.

New physics searches at the LHC

J Brooke

University of Bristol, UK

As we approach a decade since beams were first circulated in the LHC, the machine has delivered around 90/fb of proton-proton collisions at 13 TeV. I will review the status of searches for new physics in this data, covering results from the ATLAS, CMS and LHCb experiments.

Session 5

Tagging boosted jets from top quarks and heavy vector bosons using jet substructure and multivariate techniques

A Vaidya

University College London, UK

The identification of jets proceeded from the hadronic decays of heavy particles such as W, Z and higgs bosons and top quarks is important for a number of searches and measurements at the LHC. There is a large background of jets produced from gluons and light quarks that that make it very difficult to identify these interesting physics signals. Techniques that utilise the distribution of energy within a jet, its substructure, have been developed over the past decade in order to classify jets. This talk will discuss a evaluation of the performance of a number of substructure variables for jet identification at the ATLAS experiment, this includes the optimisation of a new tagging method known as shower deconstruction. It was shown that shower deconstruction is the best single variable top tagger. Additionally the use of machine learning methods to develop a classifier using substructure variables is also discussed. A deep neural network and a boosted decision tree were trained to identify W boson and top quark jets from a background of gluon and light quark jets. It was found that they outperformed each single variable and an optimised two variable tagger.

Searches for resonant and non-resonant Higgs pair production in the bbtautau decay channel with the ATLAS detector

E C Graham

University of Liverpool, UK

Searches for resonant and non-resonant Higgs pair-production decaying to a final state with two b-jets and two tau leptons are presented, concentrating on the semi-leptonic di-tau channel. The search uses 36.1 inverse femtobarns of proton-proton collision data with a 13 TeV centre-of-mass energy, as recorded by the ATLAS experiment at the LHC in 2015 and 2016. An observation of non-resonant di-Higgs production would allow for a measurement of the Higgs trilinear self-coupling and therefore provide a direct test of the Standard Model. The results for non-resonant di-Higgs production are compared to the Standard Model predictions. Resonant di-Higgs production would involve a beyond-the-Standard-Model particle decaying to a pair of Higgs bosons. The resonant search is interpreted in terms of constraints on a Randall-Sundrum Kaluza-Klein graviton model and a 2HDM extended Higgs sector.

Searches for heavy ZZ and ZW resonances in the llqq and ννqq final states at 13 TeV in the ATLAS detector

D P J Lack

University of Manchester, UK

Many extensions of the standard model predict the existence of new heavy resonances that can decay into a pair of electroweak bosons. The search for these new particles presented here uses data corresponding to an integrated luminosity of 36.1 fb-1 recorded with the ATLAS detector in 2015 and 2016 at the Large Hadron Collider. The production modes considered are gluon-gluon fusion, Drell-Yan and vector-boson fusion depending on the assumed model. These models are extensions to the Standard Model with additional Higgs bosons, a heavy vector triplet or Randall-Sundrum gravitons with warped extra dimensions. The searches are concerned with the final states in which one Z boson decays into either a pair of light charged leptons or a pair of neutrinos and the associated W or Z boson decays hadronically. No evidence of the production of heavy resonances is observed and upper bounds on the production cross sections of heavy resonances times their decay branching ratios to ZZ or ZW are derived in the mass range 300-5000 GeV.

Measurements of Higgs boson cross sections and couplings in the diphoton decay channel with the CMS experiment

E Scott

Imperial College London, UK

Since the discovery of the Higgs boson in 2012 by the ATLAS and CMS experiments at the CERN LHC, the focus of experimental Higgs physics has pivoted to precise characterisation of the boson and its properties. The diphoton decay has a small branching fraction but a clean final state with a narrow peak in the invariant mass distribution. The channel was consequently one of the most important for the discovery of the Higgs boson and remains one of the best to perform precision measurements during Run 2 of the LHC and beyond.

In this talk, cross sections and couplings of the Higgs boson using its diphoton decay are presented, including the signal strength relative to the standard model prediction, signal strength modifiers for different Higgs production modes, coupling modifiers to fermions and bosons, and effective coupling modifiers to photons and gluons. The analysis is based on 35.9 fb-1 of proton-proton collision data collected at a centre-of-mass energy of 13 TeV by the CMS experiment at the LHC in 2016.

Preliminary work and results for an updated analysis using 2017 data, including improved measurements within the Simplified Template Cross Section framework, are also presented.

Higgs-to-Invisible Searches for the CMS experiment at the LHC

R Di Maria

Imperial College London, UK

Although the observed 125 GeV boson is compatible with the SM Higgs boson, the existence of non-SM properties is not excluded due to the relatively large uncertainties. There is extensive evidence for the existence of dark matter. Invisible Higgs decay modes are realized in models allowing interactions between the Higgs boson and dark matter, for example "Higgs-portal" models. Searches for invisibly decaying Higgs bosons are possible through missing energy signatures, exploiting various production modes: gluon-gluon fusion, vector-boson fusion, and vector-boson associated production. A search focused on the vector-boson fusion (VBF) production mode, in which two quarks besides the Higgs boson are present in the final state, using the 13 TeV dataset collected by the CMS detector at the LHC in 2016 is presented. The combination with other relevant analyses to further improve the sensitivity to the Higgs to invisible branching fraction ($\mathcal{B}(H→ \text{inv.})$) is also presented.

Session 6

Relative branching fraction measurements of B→3h decays

C Costa Sobral

University of Warwick, UK

The three-body decays of B mesons to charged light mesons show interesting CP violation effects, originating from the rich dynamics between the different resonant contributions to these decays. Further understanding of such effects requires precise knowledge of the branching fractions and CP violation parameters of the contributing resonances. To this purpose, both amplitude analyses and improved measurements of the inclusive branching fractions of each mode are needed. A determination of the relative branching fractions of the modes $B^{\pm}\to K^{\pm}K^{+}K^{-}$, $B^{\pm}\to \pi^{\pm}K^{+}K^{-}$, $B^{\pm}\to K^{\pm}\pi^{+}\pi^{-}$, and $B^{\pm}\to \pi^{\pm}\pi^{+}\pi^{-}$ is presented using a data sample of proton-proton collisions collected by the LHCb experiment, corresponding to an integrated luminosity of 5 fb^{-1}.

A search for the decay Λ_b->pKη' using the LHCb Run I dataset

T Williams

University of Birmingham, UK

Before the collection of the Run I dataset by the LHCb experiment, opportunities to study charmless **Λ**b baryon decays were very limited. One particular area of charmless **Λ**b baryon decays which remains unexplored is those which involve an η or η'; the decay of a **Λ**b baryon to any final state involving an η or η' is still unobserved. A search for the decay **Λ**b -> pKη' using the LHCb Run I dataset is presented.

Anti-deuteron measurements at LHCb

S Baker, P Alvarez Cartelle and U Egede

Imperial College London, UK

Measurements of anti-deuterons in collider experiments can help to reduce systematic uncertainties in indirect searches for dark matter. Two predominant unknowns in these searches are the production of secondary anti-deuterons in the cosmos from spallation processes, and anti-deuteron production from annihilating dark matter.

LHCb is a forward spectrometer on the LHC ring, designed to measure b-hadron decays from high energy proton-proton collisions. With the detector's excellent particle identification capabilities, deuteron and anti-deuteron measurements at LHCb would help to parametrise the two cosmological processes.

Recent studies of (anti-)deuteron identification at LHCb and the prospects for measuring prompt (anti-)deuterons from pp-collisions will be presented, as well as a working analysis of b-baryrons decaying to deuterons.

Searches for doubly charmed baryons at LHCb

M Traill, P Spradlin and P Soler

University of Glasgow, UK

The Standard Model (SM) of particle physics is arguably one of the most successful theories in science, having predicted many of the sub-atomic particles found in high energy physics experiments to date. Yet SM is not without failures. It cannot explain the origins of dark matter or fully account for the in-balance of matter and anti-matter in the universe. Particles that have not been observed in experiment that SM predicts could constrain the current SM theory to help answer these important questions.

This talk discusses a class of such particles for which there was a lack of experimental evidence prior to 2017. They are known as doubly charmed baryons and are constructed from two charm quarks. The LHCb experiment at CERN is optimised to find particles containing charm quarks and as such is primed to look for these doubly charmed particles. In 2017, the LHCb collaboration announced the discovery of first ever doubly charmed baryon, the Xi-cc++, in data recorded from proton-proton collisions during 2012 and 2016. The analysis which led to this discovery will be presented and future work ongoing in this field of research will be discussed.

Angular analysis of the decay $\Lambda_b^0 \rightarrow \Lambda \mu^+\mu^-$

G Chatzikonstantinidis, T Blake, M Kreps, N Watson and C Everett

University of Birmingham, UK

An angular analysis of the rare baryon decay [1] of $\Lambda_b^0 \rightarrow (\rightarrow p\pi^-)\mu^+\mu^-$ is presented. The dataset that is used corresponds to an integrated luminosity of 5.0 fb^{-1} of pp - collision data collected at centre-of-mass energies between 7 and 13~TeV by the LHCb detector in the period 2011–2016. Taking into account the polarisation of the Λ_b^0 baryon, the angular distribution is extended to five dimensions [2] and the complete set of angular observables is measured for the first time. Due to large number of observables needed to describe the angular distribution and the small sample size, angular observables are determined using the method of moments.

[1] R.Aaij et al, JHEP **1506** (2015) 115.
[2] T.Gutsche, M.A.Ivanov, J.G. Körner, V.E. Lyubovitskij and P.Santorelli, Phys. Rev. **D.87.**074031.

Session 7

Optical calibration of the Hyper-Kamiokande detector with test data in Super-Kamiokande

L Anthony

University of Liverpool, UK

Hyper-Kamiokande will be the next generation of water Cherenkov detectors. As part of the UK's collaboration efforts, the calibration group has designed the optical calibration system for the Hyper-Kamiokande detector. Such a system will allow for the measurement of water scattering coefficients and absorption parameters; a measurement that can lead to reductions in the uncertainties of neutrino event reconstruction. In order to break the degeneracies between the scattering and absorption measurements, the system uses three plate mounted components; a bare fibre, a wide and a narrow angled diffuser; allowing for a control light input and the illumination of various sized regions of PMTs. These aspects propose an improvement on the current, well studied Super-Kamiokande water laser system; which alternatively uses a single optical fibre component. During R&D, the UK system has been tailored for the upcoming test deployment in Super-Kamiokande, due to take place in January 2018. Following the success of obtaining approval for full deployment of the UK system into SK-Gd, the equipment will be installed alongside the current system at several z positions in the the Super-Kamiokande tank during the tank open period, beginning in June 2018.

Gadolinium radiopurity assay programme for Super-Kamiokande

M Thiesse

University of Sheffield, UK

SK-Gd is an upgrade to the Super-Kamiokande experiment where a 0.1% concentration of gadolinium sulphate will be dissolved in the water. Because of gadolinium's extremely high neutron capture cross-section and energetic gamma cascade, thermal neutron tagging in the detector will be highly efficient (~80%). One of the possible benefits of gadolinium loading in the water Cherenkov detector is the separation of neutrino and anti-neutrino quasi-elastic interactions which will allow observation of CP violation in the lepton sector if it exists. Another benefit of neutron tagging in SK will be the efficient separation of low energy supernova relic neutrinos or proton decay events from radiological or cosmogenic backgrounds. To prevent accidental contamination of the ultra-pure SK water by natural radioactivity, the concentration of uranium and thorium chain isotopes in the supply of gadolinium sulphate is strictly limited. I will present the status of the screening programme by Sheffield at the Boulby Underground

Laboratory for assaying the radiopurity of gadolinium sulphate samples using low-background high purity germanium gamma spectrometry.

The Hyper-Kamiokande Outer-Detector : Design, performance estimation of background rejection and physics potential

S Zsoldos

Queen Mary University of London, UK

Hyper-Kamiokande is a next generation underground water Cherenkov detector, based on the highly successful Super-Kamiokande experiment. It will serve as a far detector, 295~km away, of a long baseline neutrino experiment for the upgraded J-PARC beam in Japan. It will also be a detector capable of observing --- far beyond the sensitivity of the Super-Kamiokande detector --- proton decay, atmospheric neutrinos, and neutrinos from astronomical sources.

An Outer Detector (OD) consisting of PMTs lying in the crown of the detector, but facing outwards will be able to detect interactions originating from particles outside of the detector. The OD is an essential element of Hyper-K that will serve as a highly granular instrument for identifying and removing background events.

The particles contributing to the background cover an energy range from a few-MeV (gammas) to hundreds of TeV (muons); An OD has to be defined considering its capability to detect and identify particles over six to eight orders of magnitude in energy, which is even more challenging considering the additional limitation lying within the OD segment with a reduced water thickness and cost constraints --- meaning a reduced amount of Cerenkov photons generated --- to maximize the fiducial volume's dimensions.

After introducing the Hyper-Kamiokande design and requirements to achieve the expected measurement of the remaining unknown δ_{CP} phase within a few years of data taking, I will describe the OD part and the different geometry designed to achieve the best background rejection thanks to improved PMTs performance. A few original setups have been studied to enhance the light collection by building "light traps" around the OD PMTs. Furthermore, the OD provides essential information for the event selection as I will show, and I will present how these original setups could improve the overall Hyper-Kamiokande analysis.

Supernova neutrino simulations in Hyper-Kamiokande

J Migenda

University of Sheffield, UK

Hyper-Kamiokande is a next-generation water Cherenkov detector that will search for nucleon decay, make precision measurements of neutrino oscillation parameters and look for astrophysical neutrinos. In preparation for the next galactic supernova, we are currently developing a software toolchain for supernova neutrino simulation and analysis.

This talk will give an overview of that toolchain. It will introduce a new event generator written specifically for supernova neutrino observations in water Cherenkov detectors, a Geant4-based package for simulating water Cherenkov detectors and ROOT scripts for event reconstruction and analysis.

This new suite of tools will improve Hyper-Kamiokande's ability to differentiate between supernova models when data arrives from the next supernova neutrino burst.

Innovation and Non-Proliferation - Particle Physics for Nuclear Threat Reduction

E Kneale

University of Sheffield, UK

The heat emission from a clandestine plutonium-production reactor can be masked by that of a larger, nearby power reactor. However, nuclear fission in just a small reactor produces in the order of 10^20 antineutrinos per second and this emission - impossible to shield - carries the signature of the core composition and location, which makes it possible to distinguish one reactor from another.

A kiloton-scale, gadolinium-doped water Cherenkov detector, WATCHMAN will demonstrate for the first time the feasibility of detecting the antineutrino signal from a hidden reactor within a 25km radius. The preferred site is the Boulby Mine in North Yorkshire, where the initial objective will be to detect the on/off cycle of the reactor 25km away at Hartlepool.

The presentation will describe WATCHMAN as a proof-of-concept detector and the first phase of the Advanced Instrumentation Testbed for technologies including water based scintillator, state-of-the-art photodetectors and directional detection. A WATCHMAN-style detector could be deployed for remote detection of reactors and also cooperative monitoring e.g. as part of the Iran nuclear deal. The programme also promises a unique opportunity to develop innovative detection technologies for non-proliferation and beyond.

Session 8

Status of the SuperNEMO double-beta decay experiment

C Patrick

University College London, UK

The demonstrator module for the SuperNEMO double-beta decay experiment is in the final stages of construction. Its tracker-calorimeter technology will provide us with a unique opportunity to distinguish between signal and background events. These ultra-low backgrounds allow it to be sensitive to a neutrinoless double-beta decay half-life of 6.5e24 years, with a proposed extended design having a sensitivity of up to 1e26 years for its initial isotope, selenium-82, corresponding to an effective Majorana neutrino mass of 50 - 100 meV.

I will introduce the SuperNEMO demonstrator and explain why it is such a good technology to look for neutrinoless double beta decay. I will also show our progress on construction and commissioning, in readiness for first data later this year.

Recent developments in the spherical proportional counter for NEWS-G

P Knights, K Nikolopoulos, I Giomataris and I Katsioulas

University of Birmingham, UK

The NEWS-G collaboration utilises the novel technology of the Spherical Proportional Counter (SPC) to conduct a direct search for low mass Dark Matter (DM) candidates. The SPC comprises a grounded metallic spherical vessel with a central spherical readout anode, referred to as the sensor. In the ideal geometry, the radial electric field within the detector varies as $1/r^2$, however, the details of the sensor support structure substantially influence its form. The understanding of the electric field is crucial to the successful operation of the detector, as it directly impacts the electron drift times and the uniformity of the detector gain. The detector will be presented, with an

emphasis on the developments in sensor design to improve electric field uniformity. Studies into the effect of geometry and bias voltage on the electric field will be discussed along with complementary experimental results.

Sensitivity studies and development of the gas supply system for the SuperNEMO experiment

L Dawson

University College London, UK

The SuperNEMO experiment will search for neutrinoless double-beta decay. It is a tracker-calorimeter detector, designed to reach a 0νββ half life sensitivity of $T_{1/2} > 10^{26}$ years, corresponding to an effective Majorana neutrino mass of 50 - 100 meV. Successful operation of the SuperNEMO tracker requires a precise mixture of gases to be supplied continuously to the detector volume. The purpose of the gas system is to control the fractions of gases, at a given flow rate. Improvements have been made to meet the basic requirements of a safe, radiopure, remotely monitored and controlled gas-delivery system.The SuperNEMO demonstrator module is the first phase of the experiment, with 7 kg of ^{82}Se. Construction of the module is well underway, with first data expected in 2018. In preparation for data taking sensitivity studies have been performed on simulated data. Results of the 0νββ half-life sensitivity for the demonstrator module will be presented here, along with studies of two key backgrounds, ^{208}Tl and ^{214}Bi. The enhancement of the gas system and integration with slow control will also be presented.

Radon background mitigation strategy for the SuperNEMO experiment

F Xie

University College London, UK

SuperNEMO is a neutrinoless double beta decay experiment using the tracker and calorimetry techniques, which has a designed capability reaching half-life sensitivity of $T_{1/2} > 10^{26}$ years, equivalent to an effective Majorana neutrino mass of < 40 - 100 meV. To achieve this sensitivity, SuperNEMO aims to be a zero background 0bb experiment in the first phase Demonstrator Module. This target placed challenging demands on the radiopurity of detector components and the gas within the tracker. All internal detector components are screened for radon emanation to minimise radon levels. Measurements of the potential radon contamination have allowed us to confirm that the tracker will meet our target radiopurity of 0.15mBq/m^3. The detector assembling and commissioning are ongoing and data-taking will start from 2018. One of most critical background, radon content inside the tracker will be measured by looking for e^--α delayed coincidence events from radon progeny. The results from detector components radon emanation and the radon content of the sub-tracker modules will be presented.

Search for light Dark Matter with NEWS-G

K Nikolopoulos

University of Birmingham, UK

The New Experiments With Spheres-Gas (NEWS-G) is dedicated to the direct search for Dark Matter candidates in the 0.1 – 10 GeV range. The experiment implements the novel Spherical Proportional Counter detector, which exhibits a number of key features including: a) low energy thresholds, few tens of eV, owing to low detector capacitance independently of the volume and high gain operation; b) small number of readout channels and potential for directionality; c) background rejection through pulse shape analysis; d) simplicity and use of highly radio-pure materials; e) variety of light target gases, including Hydrogen, Helium, and Neon, allowing optimisation of momentum transfers for low-mass particles in the GeV mass range, significantly increasing the sensitivity to sub-GeV candidates; and f) possibility to vary the operational pressure and high voltage, providing additional handles to

disentangle potential signals from unknown instrumental backgrounds. The first detector SEDINE, a 60cm diameter sphere already operated in the Underground Laboratory of Modane (France), while the full scale detector, with 140cm diameter, will be installed in SNOLab (Canada) later this year.

In this talk, the first NEWS-G results based on 9.7kg.days of exposure will be presented, and that status of the project and prospects for the future will be discussed.

Invited

Short-baseline neutrino experiments

A M Szelc

The University of Manchester, UK

The field of neutrino oscillations is an extremely exciting area of particle physics. Measurements using short oscillation baselines have been especially interesting in the last years, providing the first measurement of the theta_13 angle using anti-neutrinos from nuclear reactors. Short-baseline oscillations will also provide very exciting results in the near future because of their sensitivity to oscillations into a low-mass sterile neutrino. I will present the current state of short-baseline reactor and accelerator neutrino oscillation measurements as well as the prospects of searching for sterile neutrinos with near-future experiments.

Long-baseline neutrino experiments

A Kaboth

Royal Holloway, University of London, UK

Neutrino oscillation in long baseline accelerator experiments is giving new insight into matter-antimatter differences. This talk will review the current results from the T2K and NoVA experiments as well as updates and prospects from the upcoming DUNE and HyperK experiments.

Neutrinoless double beta decay and absolute neutrino mass

E Falk

University of Sussex, UK

Two of the fundamental open questions about the neutrino concern its nature – Dirac or Majorana particle – and its mass. Neutrinoless double beta decay, a lepton-number violating process, offers the best avenue to address both of these. The talk will give an overview of the current status of the field of neutrinoless double beta decay searches. There will be an emphasis on the SNO+ and SuperNEMO experiments, both of which have a significant UK involvement. The presentation will also touch upon complementary mass measurements from the single beta decay of tritium and from cosmology.

IoP prize lecture: Charm physics

M Gersabeck

University of Manchester, UK

Charm physics started in the early 1970s and has seen an increased focus on mixing and CP violation in the past decade, following the first observation of mixing in a combination of BaBar and Belle measurements in 2007. Neutral charm mesons are unique as they are the only weakly-decaying neutral mesons containing up-type quarks. This talk will review the history of the field and prospects for measurements at the future flavour factories Belle II and the LHCb upgrades, commenting also on theoretical challenges. Special attention will be given to the search for CP violation, which has been unsuccessful to date, making charm the only system of neutral mesons where CP violation remains to be discovered.

Collider physics beyond the LHC

V J Martin

University of Edinburgh, UK

Colliders have been at the forefront of discoveries in high-energy physics for the past 35 years. The latest discovery at a collider - the Higgs boson at the LHC - completed the Standard Model. So what now for collider physics? Are colliders still useful tools for particle physics research given the LHC hasn't observed any beyond-the-Standard-Model physics and when the current discrepancies all appear to be in the flavour sector? In this talk, I will introduce five options for new colliders beyond the LHC: the High-Energy-LHC (HE-LHC), the International Linear Collider (ILC), the Circular Electron-Positron Collider (CEPC), the Compact Linear Collider (CLIC) and the Future Circular Collider (FCC). I'll argue that colliders still have a vital role in furthering our understanding of nature at the smallest accessible scales, providing precise measurements of masses & cross sections and, hopefully, to act as discovery machines for an exciting new paradigm of particle physics.

Session 9

Search for low mass dijet resonances in association with ISR in *pp* collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector

A Sogaard

University of Edinburgh, UK

ATLAS searches for Dark Matter (DM) employ simplified models, where protons can collide to produce a mediator particle which can decay into DM particles or back to a quark pair. Limits on mediator masses, largely independent of the mass of the DM particle, are set down to 450 GeV by dijet searches, which are limited by the jet trigger thresholds from probing lower masses. Searches for mediator particles produced in associated with initial state radiation (ISR) used for triggering allows for probing even lower mediator masses. A search targeting mediator masses between m_Z and the current lowest ATLAS limit of 250 GeV is presented. In this regime, the decay of the mediator particle into a quark pair is reconstructed as a single, large-radius jet recoiling off the ISR object, either a jet or a photon. Using novel jet substructure techniques, a signal-enhanced sample is selected over the dominant QCD multi-jet background. The search is performed in 36 fb^{-1} of *pp* collision data at $\sqrt{s}$ = 13 TeV collected by the ATLAS detector and yields the lowest limits on DM mediator masses presented by ATLAS.

ATLAS measurement of the dynamics of single proton dissociation at the LHC

A Foster

University of Birmingham, UK

The ALFA Roman pot subdetectors, located ±240 m down the beampipe from the central ATLAS detector, are utilised to detect particles in the region ~1 cm from the beam at the LHC. This enables the tagging of protons, aiding the identification of single diffractive events (pp -> Xp).

The proton-proton single dissociative diffractive cross section is large yet not well constrained. The lack of measurement of this cross section has implications for the total proton-proton cross section as well as the understanding of proton structure and cosmic ray showering. Measurements and interpretation of the cross section differential in Mandelstam t and the fractional energy loss of the proton, ξ, are presented.

The quest for new physics, motivated with strong-supersymmetric models, in final states with many hadronic jets in 13 TeV pp collisions at the ATLAS detector

M Nelson

University of Oxford, UK

This talk summarises the latest iteration of a search for particles that decay producing a large jet multiplicity and invisible particles. The event selection applies a veto on the presence of isolated electrons or muons and additional requirements on the number of b-tagged jets and the scalar sum of masses of large-radius jets. Having explored the full ATLAS 2015-2016 dataset of LHC proton-proton collisions at centre-of-mass energy of 13 TeV, which corresponds to 36.1 fb^{-1} of integrated luminosity, no evidence is found for physics beyond the Standard Model. The results are interpreted in the context of simplified models inspired by R-parity-conserving and R-parity-violating supersymmetry, where gluinos are pair-produced. More generic models within the phenomenological minimal supersymmetric Standard Model are also considered. Within the context of these models, exclusion limits up to 1.8 TeV are set on the masses of strongly-produced gluinos.

This discussion is based on the work summarised in the paper JHEP12 (2017) 034 (https://link.springer.com/article/10.1007/JHEP12(2017)034) which is led by ATLAS analysis teams at the University of Oxford and the University of Geneva.

Session 10

Search for hidden sectors in kaon decays at the NA62 experiment at CERN

V Duk

University of Birmingham, UK

Kaon decays allow to probe "hidden sectors" by searching for new particles that can be weakly coupled to the Standard Model sectors via neutrino, vector and scalar portals. In this talk recent results and prospects of such searches at NA62 are presented. In particular, search for the heavy neutral lepton (N) production in K→mu N decay (neutrino portal) , dark photon (A') search in K→pi pi0, pi0→A' gamma (vector portal) and inflaton (S) search in K→pi S, S→mu+ mu- (scalar portal) are discussed.

Charged Higgs Bosons in naturally aligned two Higgs doublet models at the LHC

E Orgill, W Klemm, R Naranjo, Y Peter and A Pilaftsis

University of Manchester, UK

The Higgs boson was the last particle predicted by the Standard Model (SM) to be discovered. The SM is powerful, describing well much of visible matter, its properties and their interactions. However, there are many observations it cannot explain, such as baryon asymmetry and dark matter. Extensions to the SM attempt to answer these outstanding questions. The 2-Higgs-Doublet Model (2HDM) is a simple extension of the SM Higgs sector, useful for theories in supersymmetry. 2HDMs predict 5 Higgs bosons.

The focus of this phenomenological study are the charged Higgs bosons, H+ (H-), decaying to a top and a bottom quark, dominant when the H+ mass is larger than the top mass. The dilepton channel is considered, such that there are 4 b-quarks, 2 leptons and 2 neutrinos in the final state.

This final state is difficult to reconstruct for two reasons. The first is that the origin of particles is unknown at detector-level; hence, the permutation of jets to correctly reconstruct H+ is not simply determined. The second is that there are two neutrinos, which can only be recorded as a single missing energy variable. Machine learning, in the form of a boosted decision tree, and neutrino weighting are combined for the first time in a charged Higgs study to reconstruct these events and to separate from the SM background.

Constraining new physics with standard model measurements

D Yallup

University College London, UK

Constraints on New Theories Using Rivet (Contur), is a program designed to utilise precision detector corrected measurements of Standard Model processes at the LHC as a test for physics beyond the Standard Model. In this talk the methodology and design of Contur is introduced, alongside a brief review of the advantages and limitations of the process. Applications and future directions of the project will also be discussed.

Session 11

Commissioning of a Laser Calibration System for SNO+

E Turner and J Lidgard

University of Oxford, UK

SNO+ is a low energy neutrino experiment located 2km underground at SNOLAB, Canada, focusing on a neutrinoless double beta decay search in ^{130}Te. The detector is a 6m radius acrylic vessel containing the detection medium, suspended in an ultra-pure water filled cavity. Surrounding this vessel at a radius of 8.9m is a PMT support structure with approximately 9300 PMTs mounted on it. Currently the vessel is filled with ultra-pure water and the detector is taking data with the main aim being a nucleon decay search. This will be followed by a phase of pure scintillator before loading with Te. Optimising energy resolution and understanding the detector response is vital. For this purpose, a set of calibration tools have been built. This talk will focus on a laser calibration system (SMELLIE – Scattering Module for the Embedded LED/Laser Light Injection Entity) which is part of an *in-situ* continuous optical calibration system. It is designed to measure and characterise the scattering properties of the detection medium, such as a wavelength and angular dependence of the Rayleigh scattering length. SMELLIE is formed of 15 collimated fibres attached to the PMT support structure, connected to four fixed wavelength lasers and a supercontinuum laser. This enables many optical paths through the detector with a wavelength range of 375 – 700nm to be probed. Presented here is the commissioning of SMELLIE with water data. This commissioning is a necessary step in order to calibrate the internal variables of SMELLIE, in preparation for the scattering analysis. This has occurred at three intensity regions: low energy to characterise the beams, medium for a scattering length measurement and high to investigate high angle scattering.

The physics of SNO+

E Leming

University of Oxford, UK

SNO+ is a large liquid scintillator-based experiment located 2km underground at SNOLAB, Sudbury, Canada. It reuses the Sudbury Neutrino Observatory (SNO) detector, filling it's 12 m diameter acrylic vessel with approximately 780 tonnes of ultra-pure liquid scintillator. This talk will present an overview of the experiment's key physics goals, focusing on the search for neutrinoless double-beta decay ($0\nu\beta\beta$) of ^{130}Te. In Phase I, the detector will be loaded with 0.5 % natural Tellurium, which corresponds to approximately 1330 kg of ^{130}Te. The expected effective Majorana neutrino mass sensitivity will probe the boundary of the inverted mass hierarchy.

Cosmic Muon Induced Neutrons in SNO+

B Liggins

Queen Mary University of London, UK

SNO+, the successor to the noble prize winning SNO experiment is currently taking data with a detector full of water. In this first phase of data taking, external backgrounds will be analysed. We present an introduction and update on an analysis searching for cosmic muon induced neutrons. Being situated in SNOLAB at 6000 m.w.e, this analysis will be the first of its type at this depth. These neutrons are removed from other SNO+ analyses by means of time vetos based on the initial muon, but they could present a major background to dark matter experiments at these depths and this measurement will contribute to both the theoretical and experimental understanding of this background.

Posters

P1. Search For heavy neutral Lepton decays at NA62 experiment at CERN

L Iacobuzio

University of Birmingham, UK

The status of searches for heavy neutral lepton decays at the NA62 experiment at CERN is presented. The theoretical framework of this study is briefly discussed, together with the work carried out so far and the latest preliminary results.

P2. Probing the light quark Yukawa couplings through rare exclusive Higgs boson decays

K Nikolopoulos, A S Chisholm, R E Owen, E Long, E Zalyaeva and G S Virdee

University of Birmingham, UK

Following the discovery of a Higgs boson with a mass of about 125 GeV, subsequent measurements have confirmed its central role in the spontaneous breaking of electroweak symmetry. Currently, a wide-reaching programme of measurements is being proposed both for the HL-LHC and future electron-positron colliders to clarify the properties of the observed Higgs boson. Nevertheless, its role in the generation of fermion mass, in particular for the first and second generation, is still unclear. In the Standard Model (SM) this is implemented in an ad hoc manner through Yukawa interactions, and many beyond-the-SM theories offer rich phenomenology and exciting prospects for the discovery of New Physics in this sector.

The measurement of the rare exclusive decays H->Vγ, where V denotes a vector meson, is a unique probe of the Higgs boson coupling to light quarks, and provides sensitivity to a multitude of BSM scenarios. These measurements constitute a programme which is unique to hadron collider facilities due to the required large sample of Higgs bosons: a 100 TeV FCC-hh would be an ideal facility to measure these otherwise inaccessible quantities.
The sensitivity of a FCC-hh to probe these exclusive Higgs boson decays is assessed for the first time, and the potential to test the Standard Model and constrain new physics models is discussed.

P3. IceCube DOM beamtest at the Fermilab Test Beam Facility (FTBF)

S Mandalia and T Katori

Queen Mary University of London, UK

The IceCube Neutrino Observatory is a cubic-kilometer particle detector located at the South Pole. It consists of 5160 digital optical modules embedded in the ice, each containing a 10-inch photomultiplier tube. The infrastructure at the Fermilab Test Beam Facility (FTBF) gives us a precise knowledge of the particles which are contained in the beamline. Using this knowledge, we made precise measurements of the IceCube digital optical module response in water at the secondary beamline, known as MTest, at the 1-32 GeV configuration, with pions, muons and electrons. Such direct photon measurements from particles can be used to develop a new particle identification (PID) between MIPs and electrons and will be most applicable in water and ice Cherenkov detectors, such as PINGU, which is the proposed lower energy upgrade in the next generation of IceCube experiment. By analysing the data we have collected, we plan to see if PID between MIPs and electrons is possible by using the technique of waveform discrimination, which would allow for PID on an event-by-event level from a single hit.

P4. Supernova burst observations with DUNE

J Migenda

University of Sheffield, UK

The Deep Underground Neutrino Experiment (DUNE), a 40-kton underground liquid argon time-projection-chamber detector, will have unique sensitivity to the electron flavor component of a core-collapse supernova neutrino burst. We present expected capabilities of DUNE for measurements of neutrinos in the few-tens-of-MeV range relevant for supernova detection, and the corresponding sensitivities to neutrino physics and supernova astrophysics. Recent progress and some outstanding issues will be highlighted.

P5. Commissioning of a laser calibration system for SNO+

E Turner and J Lidgard

University of Oxford, UK

SNO+ is a low energy neutrino experiment located 2km underground at SNOLAB, Canada, focusing on a neutrinoless double beta decay search in ^{130}Te. The detector is a 6m radius acrylic vessel containing the detection medium, suspended in an ultra-pure water filled cavity. Surrounding this vessel at a radius of 8.9m is a PMT support structure with approximately 9300 PMTs mounted on it. Currently the vessel is filled with ultra-pure water and the detector is taking data with the main aim being a nucleon decay search. This will be followed by a phase of pure scintillator before loading with Te. Optimising energy resolution and understanding the detector response is vital. For this purpose, a set of calibration tools have been built. This poster will focus on a laser calibration system (SMELLIE – Scattering Module for the Embedded LED/Laser Light Injection Entity) which is part of an *in-situ* continuous optical calibration system. It is designed to measure and characterise the scattering properties of the detection medium, such as a wavelength and angular dependence of the Rayleigh scattering length. SMELLIE is formed of 15 collimated fibres attached to the PMT support structure, connected to four fixed wavelength lasers and a supercontinuum laser. This enables many optical paths through the detector with a wavelength range of 375 – 700nm to be probed. Presented here is the commissioning of SMELLIE with water data. This commissioning is a necessary step in order to calibrate the internal variables of SMELLIE, in preparation for the scattering analysis. This has occurred at three intensity regions: low energy to characterise the beams, medium for a scattering length measurement and high to investigate high angle scattering.

P6. Monte Carlo modelling of an optical calibration system for the Hyper-Kamiokande experiment

W Vinning and D Hadley

University of Warwick, UK

Among the next generation of long-baseline neutrino oscillation experiments, the water Cêrenkov Hyper-Kamiokande experiment calls for a sophisticated calibration system allowing for continuous monitoring of the detector. In order to calibrate the vast array of photo-sensors lining the detector chamber and measure water properties in situ, members of the UK Hyper-Kamiokande calibration group are currently undergoing joint R&D efforts to develop a light injection system deploying LED and laser light in the tank as a well-understood reference source.

Development and testing of hardware and corresponding simulation software on two separate components of the total system are under way. This includes optical diffusers, which will spread pulsed fibre injected LED and laser light uniformly in the detector volume as a source for PMT timing and charge calibration. Also in development is a collimation device, which will provide a narrow beam necessary for measurement of light scattering in the detector medium.

The accompanying software is a Monte Carlo photon transport package, allowing for rapid development of further prototype systems and for simulating behaviour of these systems in the large Hyper-Kamiokande tank. In this poster, we present findings from these software studies and their agreement with experiment.

P7. Monitoring long-term performance of the Hyper-Kamiokande optical calibration system

S Jenkins, L Thompson and M Thiesse

University of Sheffield, UK

Hyper-Kamiokande is a proposed next-generation water Cherenkov detector, to be situated in Japan. An order of magnitude larger than Super-Kamiokande, it will have a rich physics programme of neutrino physics, neutrino astrophysics, and nucleon decay. Hyper-K will also serve as the far detector for the J-PARC long-baseline neutrino beam, making precision measurements of neutrino parameters such as the mass hierarchy and the CP violating phase, δ_{CP}.

In order to fully exploit the increased statistics provided by Hyper-K, very low systematics (~2%) are required. To facilitate this, an LED light injection system is being developed for optical calibration, to soon be deployed for initial testing in Super-K. This system will be used to calibrate the gain and timing response of the photomultiplier tubes, alongside monitoring water quality and attenuation lengths in the detector.

To be able to properly calibrate PMTs, it is important to fully understand the long-term stability of the light injection system, and in turn the setup used to test it. This poster will present first results from the test bench setup, focusing particularly on the effect of environmental variables.

P8. Measurement of the K+ -> pi+ gamma gamma decay at NA62

M B Brunetti

University of Birmingham, UK

Radiative non-leptonic kaon decays are important tools to study the Chiral Perturbation Theory (ChPT), an effective field theory that describes the physics of hadrons in the low energy, non-perturbative QCD regime. The rare decay K+ -> pi+ gamma gamma is particularly interesting as its decay rate is determined in this framework by a single parameter. A past measurement of the branching ratio (BR) was performed by a combined analysis of data samples from the NA48/2 and NA62 2007 experiments. A higher precision measurement of the BR is possible using the currently available NA62 datasets. The status of a study of the K+ -> pi+ gamma gamma decay on NA62 2016 data is presented.

P9. Diffuser research and development for optical calibration systems in Hyper-K

S Valder, A Mitra, D Hadley, G Barker, S Boyd, K Jewkes and B Vinning

University of Warwick, UK

Proposed as part of the next generation of water Cherenkov detectors, Hyper-Kamiokande will have a vastly improved potential in determining leptonic CP violation in neutrino oscillations. At 187kT total mass Hyper-Kamiokande is approximately 8 times larger than its predecessor Super-Kamiokande. Surrounding the cylindrical tank, of dimensions 60m by 74m, will be in order of 40 000 high sensitivity photomultiplier tubes which all need calibration.

The Hypker-Kamiokande physics goals dictate that we understand the detector to the level of a few percent which can only be achieved with careful calibration systems. In particular, optical diffusers can be used to provide a well

understood light source for energy and timing calibration of surrounding photosensors, whilst also allowing for water attenuation and scattering length measurements to be made.

A hemispherical diffuser has been designed and manufactured out of PMMA with the intention of providing uniform light in the forward going direction. The diffuser, inside a specially designed stainless steel enclosure, is scheduled to undergo a sequence of calibration tests in Super-Kamiokande. This poster will give an overview of the research and development on optical diffusers for calibration, providing a summary of recent results and future objectives.

P10. The reconstruction and identification of electrons

A Fell and K Lohwasser

University of Sheffield, UK

The reconstruction and identification of electrons in the ATLAS detector is essential for analysing physics processes involving decays into prompt isolated electrons. The likelihood approach is used to improve electron identification efficiencies by considering discriminating variables from electromagnetic showers. Probability Density Functions (PDFs) are constructed and smoothed for the discriminating variables and then replaced by a kernel function, resulting in a likelihood discriminant. The likelihood recovers more of the tails of the discriminating variables than a hard-cut method. Training the likelihood against backgrounds, such as heavy flavour decays, can produce efficiencies which are validated by using the Z resonance.

P11. Cosmic muon induced neutrons in SNO+

B Liggins

Queen Mary University of London, UK

SNO+, the successor to the noble prize winning SNO experiment is currently taking data with a detector full of water. In this first phase of data taking, external backgrounds will be analysed. We present an introduction and update on an analysis searching for cosmic muon induced neutrons. Being situated in SNOLAB at 6000 m.w.e, this analysis will be the first of its type at this depth. These neutrons are removed from other SNO+ analyses by means of time vetos based on the initial muon, but they could present a major background to dark matter experiments at these depths and this measurement will contribute to both the theoretical and experimental understanding of this background.

P12. Development of SF6 for use in a low pressure time projection chamber for dark matter detection applications

C Eldridge

University of Sheffield, UK

Gas TPCs are limited in size by the diffusion of charge traversing the volume, this can somewhat alleviated by the use of a negative ion gas; one in which negative ions are drifted as opposed to free electrons. Sulpher hexaflouride (SF6) is a negative ion gas which has a number of properties which make it a desirable fill gas for large TPC's, this work was conducted to support the characterisation of the gas for TPC use. The head/tail effect is a phenomenon in which more ionisation occurs near the start of a nuclear recoil track, this enables a level of directionality to be determined. In order to investigate this a pair of small ThGEM's are used in a back to back configuration in low pressure SF6 with a number of neutron exposures from different angles acting as a recoil source.
This poster presents preliminary results on charge cloud asymmetry observed in SF6.

P13. Analysis with the ProtoDUNE single phase detector

J Thompson, C Booth and V Kudryatsev

University of Sheffield, UK

The ProtoDUNE-SP detector is a 1/20 scale prototype for the planned first module of the DUNE far detector, located at the CERN neutrino platform. Utilising a single phase liquid argon TPC detection mechanism and a charged particle test beam, ProtoDUNE-SP intends to validate the proposed far detector design in a large scale detector with near-final components prior to the start of production for the DUNE far detector, expected in 2020. LArSoft is a software package developed for use with liquid argon TPC experiments, including simulation, event reconstruction and analysis modules. The data collected from ProtoDUNE-SP will be analysed in order to improve the event reconstruction and particle identification algorithms for use in the final far detector, and to calibrate the simulation of events, while analysis of cosmic ray events in the detector will allow development of more efficient rejection algorithms. This poster covers recent developments in analysis of simulated events in ProtoDUNE-SP.

P14. Prospects for Higgs measurements in the diphoton channel with the CMS experiment at the HL-LHC

E Scott

Imperial College London, UK

The LHC at CERN has run successfully since its first proton-proton collisions in 2009. During Run 1 (2010-2012), record centre-of-mass energies were achieved (7 then 8 TeV) and the Higgs boson was discovered by the CMS and ATLAS collaborations. In Run 2 the energy has been further increased to 13 TeV, with the instantaneous luminosity reaching 2.06 x 10^{34} cm-2 s-1, twice its design value.

In order to maximise the physics potential of the LHC, a further luminosity increase is planned as part of the Phase 2 upgrades, to be installed after Run 3. The goal of the upgraded HL-LHC is to collect 3000fb-1 by the mid-2030s. In order to achieve this, the expected mean pileup per bunch crossing is expected to be between 140 and 200. The resulting environment will be highly challenging experimentally, and substantial improvements to the CMS detector are necessary to maintain performance and avoid radiation damage.

This poster presents the prospects for measurements of the Higgs boson decaying to two photons at the HL-LHC. Current CMS results are summarised, with recent inclusive and differential measurements. Extrapolations to higher luminosities, under various scenarios and different assumptions on systematic uncertainties, are presented. The results of upgrade studies are discussed, including the effect of the barrel calorimeter upgrade on photon resolution and the jet shape information provided by the endcap calorimeter upgrade.

P15. Mirror dark matter searches with LUX electron recoil data

E Leason

University of Edinburgh, UK

Despite compelling evidence for dark matter at large astrophysical scales, its physical nature remains unknown. Mirror dark matter is one of a number of models where dark matter is in a hidden sector that does not interact via Standard Model (SM) gauge boson forces. In this model, the hidden sector is isomorphic to the SM and contains mirror partners of SM particles. Mirror and SM particles can interact via kinetic mixing, allowing tests via electron recoil scattering events. Low threshold, low background, liquid xenon TPCs may have sensitivity to such events. The current status of the mirror dark matter search using electron recoil data from the Large Underground Xenon experiment will be presented.

P16. Studying the effect of polarisation in compton scattering in the undergraduate laboratory

P Knights, K Nikolopoulos, F Ryburn and G Tungate

University of Birmingham, UK

The study of Compton scattering has been an integral part of the undergraduate laboratory training program since the 1960s. However, experiments investigating polarisation effects at energies relevant to particle and nuclear physics are rarely found in the undergraduate laboratory. Two experiments for the undergraduate laboratory are presented that allow direct observation of the effect of photon polarisation on Compton scattering. In the first, an initially unpolarised beam of photons is polarised through Compton scattering, with a subsequent scattering used to analyse the polarisation. The other experiment measures angular correlations in the Compton scattering of entangled photons produced in electron-positron annihilations. In both experiments equipment typically available in the advanced undergraduate laboratory is employed. Potential geometry effects are studied through Geant4 simulations.

P17. Simulations of gamma-ray background from rock for dark matter experiments

A Naylor

University of Sheffield, UK

Identifying the constituents of dark matter still remains one of the most significant problems within science today. The Sanford Underground Research Facility (SURF) housed the LUX direct dark matter experiment and will house its successor, the LUX-ZEPLIN (LZ) experiment. The primary aim of both experiments is to search for Weakly Interacting Massive Particles (WIMPs), a promising candidate for dark matter. Understanding the effects of external backgrounds on detector sensitivity is crucial as these experiments are probing for rare physics events with high sensitivity. In this poster I will explore a key external background, gamma rays coming from the cavern rock walls at SURF. The results of Monte-Carlo simulations of cavern rock gamma rays impact on the LUX experiment will be presented. These results will be compared to a similar simulation performed for the LZ detector, illustrating the improved background rejection of the LZ detector.

P18. Innovation and non-proliferation - Particle physics for nuclear threat reduction

E Kneale

University of Sheffield, UK

The heat emission from a clandestine plutonium-production reactor can be masked by that of a larger, nearby power reactor. However, nuclear fission in just a small reactor produces in the order of 10^20 antineutrinos per second and this emission - impossible to shield - carries the signature of the core composition and location, which makes it possible to distinguish one reactor from another.

A kiloton-scale, gadolinium-doped water Cherenkov detector, WATCHMAN will demonstrate for the first time the feasibility of detecting the antineutrino signal from a hidden reactor within a 25km radius. The preferred site is the Boulby Mine in North Yorkshire, where the initial objective will be to detect the on/off cycle of the reactor 25km away at Hartlepool.

The presentation will describe WATCHMAN as a proof-of-concept detector and the first phase of the Advanced Instrumentation Testbed for technologies including water based scintillator, state-of-the-art photodetectors and directional detection.

A WATCHMAN-style detector could be deployed for remote detection of reactors and also cooperative monitoring e.g. as part of the Iran nuclear deal. The programme also promises a unique opportunity to develop innovative detection technologies for non-proliferation and beyond.

P19. Adversarially trained neural network jet classifiers with ATLAS

A Sogaard

University of Edinburgh, UK

Hadronically decaying resonances can be reconstructed as 'jets', collimated sprays of hadrons, in the ATLAS detector. Jet 'substructure' variables, computed from the kinematics of the jet constituents, can be used to distinguish jets initiated by hadronic decays of resonances (e.g. W/Z bosons; considered signal) from those initiated by continuum parton emissions ("QCD multijets"; considered background). Such variables can help to enhance sensitivity to new physics in final states with resonances coupling to quarks. Recently, machine learning techniques have been used to combine several substructure variables in a single classifier, providing improved separation between signal- and background jets. We present a novel tagging approach, using adversarial training of deep neural networks to construct powerful jet classifiers which are decorrelated from e.g. the jet mass, thereby avoiding sculpting effects and increasing sensitivity to new physics

P20. Higgs-to-invisible searches for the CMS experiment at the LHC

R Di Maria

Imperial College London, UK

Although the observed 125 GeV boson is compatible with the SM Higgs boson, the existence of non-SM properties is not excluded due to the relatively large uncertainties.

There is extensive evidence for the existence of dark matter. Invisible Higgs decay modes are realized in models allowing interactions between the Higgs boson and dark matter, for example "Higgs-portal" models.

Searches for invisibly decaying Higgs bosons are possible through missing energy signatures, exploiting various production modes: gluon-gluon fusion, vector-boson fusion, and vector-boson associated production.

A search focused on the vector-boson fusion (VBF) production mode, in which two quarks besides the Higgs boson are present in the final state, using the 13 TeV dataset collected by the CMS detector at the LHC in 2016 is presented.

The combination with other relevant analyses to further improve the sensitivity to the Higgs to invisible branching fraction ($\mathcal{B}(\mathrm{H} \rightarrow \mathrm{inv.})$) is also presented.

P21. Bayesian optimisation of the SHiP muon shield

O Lantwin

Imperial College London, UK

The SHiP experiment is new general purpose fixed target experiment designed to complement collider experiments in the search for new physics. A 400 GeV/c proton beam from the CERN SPS will be dumped on a dense target to accumulate 2×10^{20} pot in five years.

A crucial part of the experiment is the active muon shield, which allows the detector to operate at very high beam intensity while maintaining a zero-background environment for the search for new physics. In order to do this the

muon flux has to be reduced from 10^{11} muons per second by 6 orders of magnitude in the shortest distance possible.

This presentation will describe the concept of the active muon shield, the particular challenges of this optimisation problem, which necessitate the use of modern optimisation techniques, and how they are overcome with these techniques. Finally, recent results and their implications for the SHiP comprehensive design study and beyond are presented.

P22. The upgraded silicon detector characterisation facility of the University of Sheffield

E Kourlitis

University of Sheffield, UK

The ATLAS experiment at the LHC is planned to undergo a major upgrade to cope with the higher collision rate that will be provided by the HL-LHC. Major component of the upgraded detector is the Inner Tracker, an all-silicon detector featuring novel n^+-in-p micro-strip sensors. Miniature sensors of the latter design, are under radiation-tolerant testings at the upgraded characterisation facility of the University of Sheffield. After their irradiation, charge collection efficiency measurements, taken with the ALiBaVa system utilising β radiation, quantify their operational robustness. Previous experience and a review of the facility upgrade along with preliminary results are presented.

P23. X-PIPELINE: Gravitational-Wave Burst search applied to LIGO data

E Massera

University of Sheffield, UK

The rapid analysis of gravitational-wave data is not trivial for many reasons, such as the non- stationary nature of the background noise in gravitational-wave detectors and the lack of a definite and exhaustive waveform models, especially for gravitational-wave burst signals. One active research area is based on the use of X-PIPELINE [1], a software package designed for performing autonomous searches for un-modelled gravitational-wave bursts (GWBs). Functions in X-PIPELINE such as automated running, including background estimation, efficiency studies, unbiased optimal tuning of search thresholds and prediction of upper limits, are all performed automatically without requiring human intervention. X-PIPELINE has a novel approach based on spherical radiometry [2]. The core of our spherical radiometer pipeline is a set of fast cross-correlator codes written in C. This engine, called X-SPHRAD, transforms the problem of computing correlations between time series data streams into the spherical harmonic domain and allows correlation between detectors (in a network) to be performed quickly. X-SPHRAD is focused on optimising the sensitivity of the search.

[1] P.J. Sutton et al. New Journal of Physics 12 (2010)
[2] K. Cannon Physical Review D 75, 123003 (2007)

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