Abstracts

Target Simulations for Muon Production

Adriana Bungau
University of Huddersfield

We discuss possible designs for a high-intensity, stand-alone muon source dedicated to muSR studies. Considering the ISIS muon target as a reference, simulations have been performed to optimise the target parameters with respect to pion and muon production. Surface muon production obtained by firing an 800 MeV proton beam energy onto the target is simulated and potential improvements to the target material, geometry and angle orientation with respect to the incoming proton beam is presented. The study also focuses on the optimal energy of the proton deriver which will be of importance for the development of future muSR facilities.

Muon beamlines and target technologies at J-PARC

Naritoshi Kawamura
J-PARC/KEK

Muon facility in J-PARC (Muon Science Establishment; MUSE) has been operated since the first beam in 2008. Starting with a low beam power of a few tens of kW proton beam, the power reaches above 350 kW at present, and will reach the design value of 1 MW in the next fiscal year.

To produce a high intensity muon beam, a 2-cm thick graphite target was adopted, and this permits the extraction of four secondary muon beamlines. At present, three muon beamlines exist in MUSE; a decay muon beamline, an ultra-slow muon beam line and a surface muon beam line. Each of them has unique feature to answer the variety of users' demands. These beamlines are presented in the talk. In addition the new rotating target system with which the former fixed target system was replaced in the last summer.

HiMB – Towards a new High-intensity Muon Beam

Peter-Raymond Kettle - on behalf of the HiMB Project Team

Laboratory for Particle Physics LTP,
Paul Scherrer Institut PSI, Switzerland

The "Intensity Frontier" is a prerequisite for next generation lepton-flavour violation experiments such as that of MEG II and Mu3e, now under construction at PSI. To achieve their planned sensitivity goals in the range of 10^{-14} – 10^{-16}, high-intensity surface muon beams with intensities up to the GHz-range are required. Such beams could also offer new possibilities for the material sciences. Currently, PSI has the world's most intense DC muon beams, with intensities reaching $4 \cdot 10^{8}$ muons per sec. delivered by the 1.3MW HIPA proton accelerator complex.

The HiMB project – a feasibility study undertaken to investigate the possibilities of a new high-intensity muon beam for particle physics and materials science is currently in progress at PSI. An overview of the current status of the project will be presented in this talk.

Comparison between laser and conventional muon sources

Stephanie Ford
Imperial College London

The talk will cover the use of lasers instead of accelerator rings for accelerating the protons used to produce the pions which then decay into muons. I will talk briefly about the existing muon sources at ISIS and MuSIC, and compare the numbers from these facilities with the estimates for muon production using laser shockwave ion acceleration.

MuCool: Towards a much improved phase space slow positive muon beam

Andreas Knecht
Paul Scherrer Institut for the MuCool collaboration

Over the past decades meson production facilities have been providing powerful surface muon beams to experiments with intensities of up to several 10^8 μ^+/s. Due to the production process in dedicated targets and the limited time the phase space of these beams is generally poor.

We are developing a tertiary beamline to decrease the phase space of a mu+ beam by a factor of 10^{10} with an efficiency of 10^{-3}. The idea is to stop the MeV muon beam in helium gas at cryogenic temperatures and compress the muon swarm by means of a gas density gradient and electric and magnetic fields in longitudinal and transveral dimensions.

Muon production using a high power cyclotron

L. Calabretta
on behalf of DAEdALUS collaboration

The Daedalus collaboration has studied a two steps accelerator consisting of a cyclotron injector and of a Superconducting ring cyclotron booster able to deliver proton beam up to 800 MeV and peak power of 10 MW.

The injector cyclotron accelerates the H_2^+ molecular beam up to 60 MeV. Using first harmonic precession the inter-turn separation is increased up to 20 mm and an electrostatic deflector extracts the beam with efficiency as high as 100%. The beam is then injected into the superconducting ring and it is possible to extract the beam trough two different ports by stripper method.

This accelerator complex is quite flexible and can be used either in CW or also in pulsed mode (duty cycle 0.05, repetition rate 50 kHz) to drive a dedicated Muon source.

Details of the two accelerators will be presented.

Muons for condensed matter research

Tom Lancaster
Durham University

In recent years muon spectroscopy has emerged as a powerful and widely used tool in experimental condensed matter physics. I will describe the use of muons in solid state research, concentrating on the cases of magnetism and superconductivity, before briefly reviewing the muon spectroscopy of charge transport, semiconductors and chemistry. The talk will be illustrated with examples where muons have allowed us unique insights into the physics of condensed matter systems.

Local probe investigation of spin and charge dynamics in organic semiconductors

Dr. A. J. Drew, Queen Mary University of London
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Organic semiconductors fall into a class of materials that shows significant potential for future applications and as a result, the field is becoming extremely topical [1-5]. This is due to their ease of processing, low cost, highly tuneable electronic properties, favourable mechanical properties and long spin coherence times. However, many of the techniques extensively used to investigate traditional spintronic materials are proving challenging to apply to organic materials and as a consequence, there is an opportunity to develop novel techniques that can yield information on intrinsic spin and charge carrier dynamics in them.

I will start my talk by discussing the science that can be achieved with existing muon sources. I will introduce a number of recent results that involve using in avoided level crossing (ALC) resonances as a probe of dynamics in organic semiconductors, in particular the temperature dependent electron spin relaxation rates on a series of organic molecules of different morphology and molecular structure [4]. When combined with some more recent measurements of the mass-dependence of electron spin relaxation rates [5], I can offer some vital clues on an important underlying spin relaxation mechanism in organic semiconductors [1,2]. I will then go on to show how laser excited ALC spectroscopy (a technique currently being developed [6]) can offer unique insight into exciton dynamics and photochemical degradation in organic molecules [7]. Not only is this an important process in organic electronics and energy production, it also is fundamental to many biological processes, including photosynthesis, DNA repair and cell respiration. Finally, I will discuss possible future developments of the photo-μSR technique; those achievable within a reasonable timescale as well as those that we can only dream of.

[1] A. J. Drew et al., Nature Materials 8, 109 (2009)
[2] L. Schulz et al., Nature Materials 10, 39 (2011)
[3] A. J. Drew et al., Phys. Rev. Lett. 100, 116601 (2008)
[4] L. Schulz et al., Phys. Rev. B 84, 085209 (2011)
[5] L. Nuccio et al., Phys. Rev. Lett. 110, 216602 (2013)
[6] K. Yokoyama et al., Phys. Script., 88 068511 (2013)
[7] K. Wang et al., in preparation.

Low energy muons at PSI

Thomas Prokscha
PSI

At PSI we are using a moderation technique to generate epithermal positive muons with a mean energy of 15 eV and an energy width of about 20 eV FWHM. At the μE4 beam line energetic 4-MeV muons with a rate of $4.6\text{x}10^8$/s are sent on a cryogenic moderator: a 0.125-mm-thick Ag foil held at 10 K, with a ~300/10-nm-thick Ar/N_2 layer deposited on its downstream side. From the ~$1.9\text{x}10^8$ μ^+/s hitting the 3x3 cm^2 moderator area we obtain about 11000 moderated μ^+/s. These are electrostatically accelerated up to energy of 20 keV, and transported by electrostatic elements to a sample region, where low-energy μSR experiments are carried out. The implantation energy of the muons in the sample can be varied between 1 and 30 keV, corresponding to mean implantation depths of a few nm up to about 200 nm, thus allowing for depth resolved μSR investigations. In this talk we will give an overview of the low-energy μ^+ beam line with its μSR spectrometer (LEM facility), and about the current research program.

ISIS Facility update

Adrian Hillier
STFC-RAL

The ISIS muon facility has been operating for nearly 28 years. In this talk I will describe the current facilities and future directions together with some recent science highlights.

RIKEN Facility update

Philip King
STFC-RAL

The RIKEN-RAL muon facility is about to celebrate 20 years of operations at ISIS. I will briefly describe its current facilities and future plans, including condensed matter and molecular physics experiments, generation of low energy muons and measurement of the proton radius.

J-PARC Facility update

Naritoshi Kawamura
J-PARC/KEK

In the next fiscal year, we are planning to construct the fourth beam line in the muon facility in J-PARC. This new beamline is designed to have a large acceptance, and will provide the ability to tune the momentum, and use a kicker magnet and/or Wien filter.

This beamline will provide an intense beam for experiments that require high statistics and must occupy the experimental areas for a relatively long period. Namely, this beamline is dedicated to fundamental physics studies.

The frontend magnets were installed in 2012 and 2014, and the rest part will be constructed toward the first beam at the end of the next fiscal year.

The present status of this new beamline will be presented.

Muon tomography - monitoring carbon storage

Lee Thompson[1], Jon Gluyas[2], Dave Allen[3], Chris Benton[4], Paula Chadwick[3], Sam Clark[2], Max Coleman[5], Joel Klinger[1], Vitaly Kudryavtsev[1], Cathryn Mitchell[4], Sam Nolan[3], Sumnta Pal[1], Sean Paling[6], Neil Spooner[1], David Woodward[1]

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Humankind must reduce emissions of greenhouse gases if we are to slow climate change. However, fossil fuels are the mainstay energy source for the world's economy. Their replacement by renewable energy sources will not happen quickly and therefore in the interim we need to capture emitted carbon dioxide and store it deep beneath the earth in porous rocks.

Monitoring such carbon storage sites to ensure the distribution of injected carbon dioxide is known will form a critical part of the storage process. As of today the main methods available require active signal generation and are episodic. Muon tomography offers the opportunity of continuous passive monitoring. Signal generation is also free in muon tomography but expensive with other technologies.

Muon transport simulation has delivered results which indicated that injected carbon dioxide could be tracked at typical storage depths by placing detectors beneath storage sites. This requires that instruments be deployed in deep horizontal boreholes beneath injection sites where pore fluids may be at temperatures of around 70 ºC and highly saline.

We have built prototype detectors which could be deployed in such boreholes and are currently testing them within boreholes drilled into salt in the Boulby Deep Mine, Palmer Lab facility some 1km below the surface at Boulby in NE England. Successful deployment, detection of muons and retrieval here will lead to testing in a deep onshore borehole and ultimately an offshore setting in a true storage environment.

Demonstrated success could save the embryonic carbon capture and storage industry billions of dollars in monitoring costs around the globe.

Probing muon error effects using facility beams

Adrian Hillier
STFC-RAL

Cosmic rays generate radiation at ground level. The neutrons these cosmic create have been shown to be a major problem in electronic systems and devices. However, significant muons are also created. Back in 1979, it was predicted that transistors will become susceptible to muon ionisation when critical charge to cause an upset reduced to less than 0.5 fC. At the 20-nm technology node, it is believed that upset critical charge values are approaching this threshold. In this talk I will present some recent results from experiments to investigate the error induced by muon in the electronic devices.

Nuclear and Radiological Security and Safety

Now You See It: Unmasking Radiological, Nuclear and Explosive Threats as well as Narcotics and other Contraband

Billions of tons of goods move around the world through seaports, airports and land border crossings. Only a tiny fraction is inspected, allowing illicit transfer of goods ranging from undeclared or illegal items to weapons of mass destruction, resulting in financial losses and even worse, loss of life. A nuclear detonation would alter life as we know it. Trafficking of illicit nuclear materials, explosives, narcotics and other contraband are an ever-increasing threat to global security.

Decision Sciences has developed a revolutionary and disruptive security scanning technology that can safeguard ports of entry and border crossings from nuclear, radiological, explosive, narcotics and other contraband safely, quickly and passively, whether shielded or unshielded.

Originally researched by physicists at the U.S. Los Alamos National Laboratory (LANL), and developed into a real world solution by Decision Sciences (DSIC), the Multi-Mode Passive Detection System (MMPDS) detects, locates and identifies illicit materials and weapons of mass destruction. The technology makes use of the constant rain of background radiation, cosmic ray-generated charged particles (muons and electrons), to image the contents of vehicles, air and cargo containers and other large volumes. The technology applies no ionizing radiation and therefore has no health hazards or operational restrictions. It can perform scans in about a minute, providing a 100% scanning solution that does not impede the flow of commerce.

The underlying charged-particle imaging techniques applied to cosmic ray imaging can be adapted for active muon or other charged particle sources. Dr. Sossong will describe these techniques and discuss some potential low-dose charged-particle imaging applications.

DSIC Chief Physicist and Vice President of Research & Development was one of the original physicists developing the technology at LANL and continued his work at Decision Sciences to automate and commercialize the scanning system. Dr. Sossong will discuss the current state of security scanning technologies and the promise of this new disruptive technology to advance the safety and security of the global community.

Speaker BIO: Dr. Michael Sossong, Chief Physicist & Vice President of Research and Development

Dr. Michael Sossong has contributed greatly to the field of charged particle imaging, cargo security, nuclear nonproliferation and WMD detection. He joined Decision Sciences in April 2008, leading the development of its commercial Multi-Mode Passive Detection System as well as other exploratory applications and technologies. Prior to joining Decision Sciences, he was a key member of the development team for muon tomography (MT) at Los Alamos National Laboratory (LANL). Dr. Sossong was instrumental in the creation of full-physics simulation models for MT development, the application of tomographic algorithms to MT data, and the design and construction of a full-scale prototype.

Recipient of the 2011 prestigious Christopher Columbus Homeland Security Award, Dr. Sossong is published in several peer-reviewed scientific journals and has presented at domestic and international symposia and conferences. He holds several patents and copyrights. Dr. Sossong earned his Ph.D., Master's and Bachelor's degrees in Physics at the University of Illinois at Urbana-Champaign.