



International Society for μ SR Spectroscopy

Newsletter No. 2 - Summer 2004

Welcome from the President of ISMS, Robert Heffner

It is a pleasure to introduce our second μ SR eNewsletter. I hope you enjoy reading it. I would like to draw your attention to several important issues.

○ The first is the activation of the **Facilities Subcommittee** of the ISMS, which is to be chaired by Thomas Prokscha from PSI. This committee will help to satisfy one of the missions of the ISMS, as stated in Section 2.5 of our Constitution:

'Identify the needs of the μ SR community, including future requirements for instrumentation and sources and optimal access to these sources, and to represent these needs to the institutions operating μ SR facilities.'

Our Facilities not only provide muons for present research, they maintain and develop the expertise for the future of the μ SR technique. Thus, it is important to establish an active network among facility personnel to exchange technical information, share future plans, establish common or interchangeable data formats and encourage compatible software analysis codes, for example. The Facilities Subcommittee also should receive input from our scientific users, so please contact either Thomas Prokscha or your local committee member if you have ideas or concerns; the membership of the Committee is given on page 7. To further stimulate new facility development we are planning to have an international workshop on μ SR technologies by September, 2004.

○ The ISMS membership has overwhelmingly approved two **amendments to our Constitution**:
1) Extension of the terms of the ISMS Executive Council members from two years to three years, with elections to be held during the General Assembly at the International μ SR conferences; and 2) Selection of an auditor for the ISMS books by the Executive Council rather than by election by the general

membership. Prof. Roberto De Renzi (U. Parma, Italy) has kindly agreed to be the auditor for the ISMS.

○ Please nominate deserving scientists for the prestigious **Yamazaki Prize**, to be awarded at the upcoming μ SR Conference in 2005. We have moved up the deadline for nominations to February 28th, 2005. Further details can be found on page 6.

○ In addition, we have decided to give a **Young Researcher Award** to a student or postdoc at the 2005 μ SR Conference, based on a submitted paper. This entails receiving a request from the researcher to be considered for this Prize, together with a cover letter from the researcher's supervisor stating that the work being considered is primarily that of the potential recipient.

○ The **Journal of Physics: Condensed Matter topical issue**, edited by Prof. K. Nagamine and myself, is well underway. We are planning for a publication date sometime this summer.

○ You should be seeing posters in experimental data acquisition rooms and bulletin boards of our μ SR facilities urging new membership in the ISMS. If you don't find these, ask the facility to post them. Please encourage your students and postdoctoral fellows to sign up!

○ Finally, we have added a touch of science to this eNewsletter - see the 'Physics Corner' section.

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The International Society for μ SR Spectroscopy

c/o Philip King (Secretary), ISIS Facility, Rutherford Appleton Laboratory, Chilton, Oxfordshire, OX11 0QX, UK. email: isms@rl.ac.uk. Web: <http://musr.org/~isms/>

News from the regions . . .

. . . from the Vice President - N. and S. America

The future of μ SR in North America is looking increasingly bright. In order to ensure the provision of quality facilities for future μ SR researchers, Canadian users of TRIUMF's newly formed Centre for Molecular and Materials Science have been working collectively on major funding initiatives. The first of these is the proposed addition of two new state-of-the-art muon beam lines, briefly described in the previous *Newsletter*. The planning process for this proposal began way back in September 2002, at which time there was no guarantee that it would be included in TRIUMF's 2005-2010 plan. As it turns out, the proposed μ SR facility expansion was well received by both TRIUMF administration and external peer review committees. In particular, it was recognized that the μ SR User Facility supports a diverse and growing scientific community, and the technique itself has reached a level of maturity that warrants a major new investment in TRIUMF's muon facilities. In the end, both beam line upgrades were included in the final TRIUMF 5-year plan document, which in turn was presented to the National Research Council of Canada in Fall 2003. The presentation of TRIUMF's 5-year plan to the federal cabinet is to take place early this year. However, it may be some time before we know the outcome of this final stage in the 5-year planning process, and federal elections are likely to delay all decision-making on funding levels for new major project initiatives. Nevertheless, with the need for more μ SR facilities a top priority in TRIUMF's 5-year plan, there is a good reason for optimism.

Canadian users have also applied for an increase to the operating budget for μ SR at TRIUMF. For some years the Natural Sciences and Engineering Research Council (NSERC) of Canada has funded the μ SR User Facility through a Major Facility Access (MFA) grant. The MFA grant mainly funds personnel responsible for the daily operations of the facility. However, additional funds are now required to support the β -NMR facility at ISAC, and to hire instrument scientists for the proposed new muon beam lines. The application also includes a request to reduce user fees, long seen as a barrier to the wider scientific community.

Recently, members of the condensed matter community at Brookhaven National Laboratory (BNL) in the United States held a meeting to discuss the practicality of building a muon beam line at BNL for μ SR experiments. In attendance were μ SR experts Graeme Luke (Canada) and Tomo Uemura (USA). There is already a funded particle physics experiment

(Muon Electron CONversion) that will use the Alternating Gradient Synchrotron (AGS) operating at $\sim 10^{13}$ protons per cycle to produce a very intense pulsed negative muon beam ($\sim 10^{11}$ μ^- per second). To maximize the beam acceptance, the production target will be placed in a graded solenoid field. The MECO beam will have a muon spin polarization of 20-60 %, and hence is not ideal for μ SR. However, there was some discussion of building dedicated high-intensity positive muon beam lines suitable for time-integral μ SR and the generation of intense low-energy muons. An internal summary of the meeting is being prepared with the intent of looking further into the feasibility of μ SR at BNL.

Jeff Sonier.

. . . from the Vice President - Asia

KEK-MSL Facility Status and Operation

The Meson Science Laboratory is the original facility using a pulsed (50 ns pulse width, 20 Hz repetition) muon beam produced by a rapid-cycling 500 MeV proton synchrotron for basic and applied research. At present, there are three different channels producing muons for the Inter-University Experimental Program, including the Large Solid-Angle and Axial-Focusing Superconducting beam channel (Dai-Omega channel) which is now providing the world's strongest pulsed 4 MeV μ^+ beam and on which an advanced 128 channel two-fold segmented μ SR spectrometer was installed recently.

Anticipating the future Muon Science Laboratory at the Japanese high-intensity proton accelerator research complex, J-PARC.MSL, the ultra-slow μ^+ project at RIKEN-RAL is being upgraded. Slow muons are produced by resonant laser ionisation of thermal muonium generated from the surface of hot tungsten. New types of slow muon beam developments are also in progress at the Dai-Omega. In April 2004, at the time of reorganization of KEK from National Laboratory to Agency, the KEK-IMSS Meson Science Laboratory will become KEK-IMSS Muon Science Laboratory. The head of the Laboratory will be Professor Kusuo Nishiyama.

Construction of J-PARC.MSL

Design of the Muon Science Laboratory at the JAERI-KEK J-PARC Project, to be located upstream of the neutron facility, has now started, with construction to begin in 2004 after formal approval of the J-PARC.MSL construction budget. The neutron and muon centre will be known as the Material and Life Science Facility. First beam delivery will be in winter 2007. Because of budget limitations, the first phase of construction will produce a general purpose superconducting muon channel and part of the surface μ^+ channel.

In order to review the plan of J-PARC Muon Science Experimental Facility construction and the 1st phase experiments, an Advisory Committee (MUSAC) has been organized under the project director of J-PARC. The members of the committee are J. Akimitsu (Aoyama Gakuin U), R. H. Heffner (Los Alamos Lab.), S. Ikeda (KEK), Y. Ikeda (JAERI), M. Iwasaki (RIKEN), Y. Miyake (KEK), K. Nagamine (KEK, Secretary), N. Nishida (Tokyo Inst. Tech.), C. Petitjean (Paul Scherrer Inst.), L. I. Ponomarev (Kurchatov Inst.), J. M. Poutissou (TRIUMF, Chair), Y. Yamazaki and H. Yasuoka (JAERI). The second MUSAC meeting took place from 19-20 February 2004 and was asked to consider whether the design and plan of facility components is being done correctly, whether the financial plan is reasonably arranged and whether first-phase experimental proposals are sound and



Layout of the proposed Muon Science Facility at J-PARC Joint Project (March 2004).

technically feasible. The MUSAC was also asked to consider a proposed 'Core-User Plan' to attract researchers to take a leadership role in advanced muon science experiments at J-PARC.MSL and generate research funds from outside the J-PARC main budget. Successful applicants will have access to J-PARC.MSL beamtime and will possibly be given the post of Visiting Professor or Associate Professor. The J-PARC MUSAC will have responsibility for examining applications with the final decision to be made by the KEK-IMSS Executive Committee.

Highlights from the Inter-University Program

During the period from October 03 to February 04, 32 proposals of the Inter-University Program from 14 institutions received beam time. Some of the proposals had additional beam-time at RIKEN-RAL to obtain high-statistics data using the higher intensity pulsed muon beam. Also, complimentary to pulsed muon experiments at KEK-MSL, an experimental program with continuous muons is in progress at TRIUMF mainly using the decay μ^+/μ^- beam from the Japan-Canada superconducting muon channel built by our group. Highlight experiments include:

μ SR: Observation of strange superconducting state in $\text{Na}_{0.35}\text{CoO}_2 \cdot 1.3\text{H}_2\text{O}$, H. Higemoto, R. Kadono et al., KEK – U. Kyoto – NIMS;
Studies of proton-like transport in Nafion, J. Sugiyama et al., Toyota Cent. Lab., KEK.

Muon Catalyzed Fusion (μ CF) investigations:
Discovery of strange ^3He accumulation and diffusion in solid D-T, N. Kawamura, H. Imao, K. Ishida et al., KEK – RIKEN – JAERI – RAL.

Fundamental Physics: Successful generation of intense Mu and μ^- at Dai-Omega, M. Miyadera, K. Shimomura, K. Nagamine, et al., KEK.

Ken Nagamine.

. . . from the Vice President - Europe



ISIS is presently in a shut-down until mid-October 2004, but exciting things are happening during this period. On the machine side, new accelerating cavities are being added to the ISIS synchrotron and the ion source is also being upgraded. These developments will enable the proton beam current to be increased over the next year or so by 50%, generating

extra neutrons for the ISIS second neutron target station currently being built, plus more muons! During the shut-down we are also refurbishing the EMU and MuSR spectrometers, including doubling the detector complement on MuSR to give at least a factor of two increase in data rate. This upgraded instrument will also be equipped with a totally PC-based data acquisition and control system, very similar to that used on ISIS neutron instruments and giving additional experimental flexibility. These short-term developments will continue to provide for the varied science programme on the instruments. In the longer term, we continue to seek funds for more significant improvements in rate and applied field to give larger increases in scientific potential - very many thanks to all ISIS muon users who have recently written letters of support for our development plans. Finally, we will be running a training course in pulsed muon techniques for post-graduate and post-doctoral researchers in early 2005. This will be similar to the successful course run at the start of 2003, and will include both lectures on the technique together with practical sessions on the ISIS muon instruments. More details to come soon!

There are several new developments at [PSI muons](#). First, construction of the new surface-muon beam line at target E (former $\mu E4$) is almost complete. Commissioning of the new facility and first experimental tests with the new low energy muon instrument, LEM, will take place later this year. The new instrument will have an order of magnitude greater muon intensity at 15eV. The first element of the new beam line is an impressive, large acceptance, radiation hard double solenoid (see photo) which will collect the surface muons from the target station. Further major instrument upgrades are also planned. The May 2004 meeting of the PSI research commission approved the proposal to upgrade the

GPD (high energy decay-channel) muon spectrometer. The upgrade will essentially provide an entirely new spectrometer, with new detectors, new field coils (for fields up to 6.5 kG), and new cryostats (including a ^3He insert from Oxford



Instruments with base temperature 300 mK). Further developments in instrumentation include use of novel detectors based on avalanche photo diodes (APDs). First tests performed in late 2003 showed that APDs have the potential to replace PM tubes in the longer term. PSI is also currently developing new, fully-programmable constant fraction discriminators. A prototype was successfully tested last last year. The new CFDs will eventually replace the standard ORTEC CFDs.

[European researchers](#) have benefitted from 'Access' agreements that ISIS and PSI have had over recent years with the European Commission to provide beam fees and travel and subsistence funds for experiments. New Access agreements have recently been signed by both facilities to continue these programmes. Under the new arrangements, both ISIS and PSI muons are members of the EC Neutron and Muon Integrated Infrastructure Initiative (NMI3). This body includes 12 research facilities with neutron or muon sources, 14 countries, 23 partners and some 50 European research groups. In addition to Access funds, the NMI3 also provides money for technical networks, and ISIS and PSI muons, along with Oxford and Parma Universities, are members of a network to develop new techniques for muons. This will include exploring novel detector methods, creating simulation programmes for muon spectrometers and developing new techniques such as simultaneous AC-susceptibility measurements and novel pulsed methods. The NMI3 can also provide funds for workshops and collaboration on muon techniques, together with education and training - further details can be found at www.muon-eu.net.

Finally, it is hoped that an inaugural meeting of a committee of [national ISMS-Europe delegates](#) can be arranged to coincide with the autumn meeting of the joint NMI3/ENSA committees scheduled for October 2004 at PSI. Such a meeting will provide the European muon community with a forum to discuss common issues of muon science, instrumentation, facilities, funding and politics.

Bob Cywinski.

Physics Corner

When the Knight shift constant doesn't scale with the applied field!

A. Schenck, IPP ETH Zürich, CH-5232 Villigen PSI, Switzerland.

The Knight shift constant K is the fractional change in muon frequency due to the polarization of a material's electrons by an applied transverse magnetic field. Specifically, $K \propto (A^{dip} + A^{hyp})/X_{loc}$ is field-independent to the extent that the local susceptibility X_{loc} is not a function of field since the dipolar and contact coupling parameters $A^{dip} + A^{con}$ are usually field independent. Deviations from this conventional picture are of considerable interest since they signal the presence of new physics.

CeB₆ is a fascinating compound due to its complex phase diagram, which consists of a complicated antiferromagnetic phase below $T_N \approx 2.25$ K and an antiferroquadrupolar phase below $T_Q \approx 3.5$ K in zero field [1]. T_Q rises with the strength of an applied field.

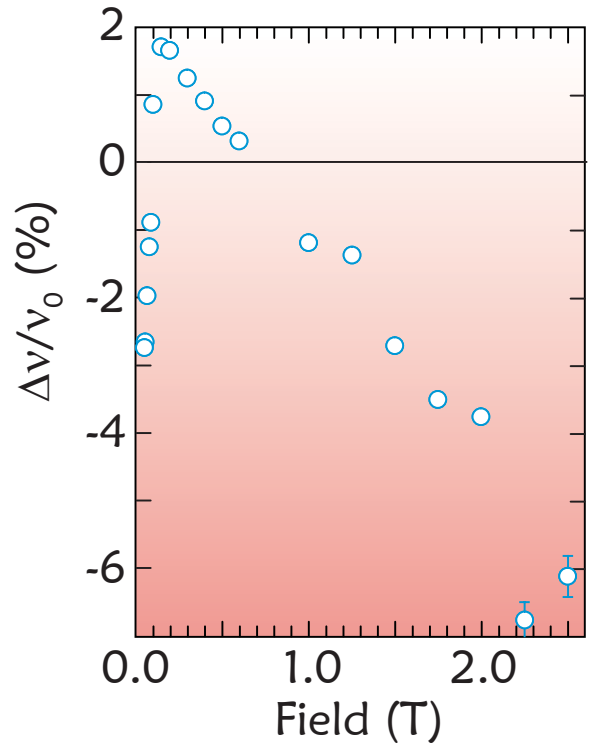
We initially measured the muon Knight shift K at 0.6 T [2] and arrived at conclusions which, in light of new neutron results [3], are no longer tenable. Motivated by Ref. [1] we measured K at other fields and found that it depends strongly on the applied field H_{ext} . We performed temperature scans for $H_{ext} = 0.6$ T, 1.5 T and 2.0 T for H_{ext} parallel to [0 0 1]. There are two muon frequencies ν_1 and ν_2 due to the presence of two magnetically inequivalent d -sites at which the μ^+ resides. Surprisingly K was found to depend strongly on H_{ext} . This is seen in Fig. 1 where $(\nu_2 - \nu_1) / (\gamma_\mu H_{ext})$ is plotted versus H_{ext} at 2.5 K. As can be seen $\Delta\nu/\nu_0$ changes sign twice.

$\Delta\nu/\nu_0$ can be expressed as

$$\Delta\nu/\nu_0 = \left[\frac{2}{3} A^{dip} + A^{con} \begin{pmatrix} 1 & 0 & 0 \\ 2 & & \end{pmatrix} - A^{con} \begin{pmatrix} 0 & 0 & 1 \\ 2 & & \end{pmatrix} \right] X$$

where A^{con} is different for the two inequivalent d -sites ($1/2 00$) and ($00 1/2$). X is the isotropic magnetic susceptibility of CeB₆. Since A^{dip} and X are field-independent, the field dependence of $\Delta\nu/\nu_0$ has to arise from the A^{con} . A^{con} is also temperature dependent. We emphasize that this behavior is restricted to temperatures below T_Q . Tentatively we attribute this unusual field dependence to a field-induced modification of the antiferroquadrupolar structure which affects the conduction electron spin polarization at the μ^+ through an anisotropic RKKY mechanism. Alternatively one may speculate that octupolar effects are involved.

Either way this opens the door to new explorations using muon Knight shifts!



Field dependence of the normalized field splitting $\Delta\nu/\nu_0 = (\nu_2 - \nu_1)/\nu_0$ at 2.5 K.

Thanks are due to my colleagues F. N. Gygax (IPP ETH, Zürich, Switzerland), S. Kunii (Tohoku University, Sendai, Japan) and O. Zaharko (LNS ETH Zürich, Switzerland).

- [1] M. Sera et al., Phys. Rev. Lett. 86, (2001) 1578
- [2] A. Schenck et al., Phys. Rev. Lett. 89, 037201 (2002).
- [3] F. Givord et al., J. Phys.: Condens. Matter 15, 3095 (2003).

山崎



**Professor Toshimitsu
Yamazaki**

was born in 1934 and graduated from the University of Tokyo.

His innovation and creativity have produced many new developments in intermediate-energy, nuclear-particle and condensed matter physics.

He pioneered the application of μ SR to solid-state physics, introducing in the late 1970's the zero-field relaxation technique, which is based upon the theoretical treatment of Kubo and Toyabe. This technique has become a distinguishing capability for μ SR and has revolutionized the role of μ SR in condensed matter studies. In addition, his influence has resulted in the spread of the μ SR technique to facilities in North America, Europe and, of course, Japan.

His research activities cover nuclear structure spectroscopy, meson exchange effects in magnetic moments, hypernucleus spectroscopy with stopped kaons, deeply bound pion spectroscopy in nuclear matter, and antiprotonic helium atom spectroscopy.



The Executive Committee of the
International Society for μ SR Spectroscopy
is pleased to announce the call for nominations for

THE 2005 ISMS YAMAZAKI PRIZE FOR μ SR SCIENCE

The \$3000 Toshimitsu Yamazaki prize is made available by ISMS every three years to any scientist for outstanding, sustained work in μ SR science with long-term impact on scientific and/or technical μ SR applications. The 2005 prize will be awarded at a special ceremony at the International Conference on μ SR, to be held in Oxford, UK.

Nominations for the prize will be considered by a Selection Committee which consists of the President and three Vice Presidents of the ISMS, together with authorities representing the major scientific disciplines to which μ SR contributes. The Committee includes acknowledged experts both inside and outside the μ SR community.

Nominations for the 2005 ISMS Toshimitsu Yamazaki Prize may be submitted by scientists as individuals or on behalf of a Group. To establish a high standard it is necessary that the Committee receive nominations that demonstrate a sustained, long-term impact on particular fields of science using μ SR and/or on substantial development of innovative μ SR-related techniques or technology. Nominations should include a cover letter describing the motivation for the award, a brief curriculum vitae of the nominee and a short list of major, relevant publications. At least two additional supporting letters of recommendation should be included. Nominations will be treated in confidence, and will be acknowledged, but no further communication from the Selection Committee will be sent.

Nominations should be sent before February 28th, 2005, to the Chairman of the Selection Committee:

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Other News and Information

μ SR 2005

The next **International Conference on Muon Spin Rotation, Relaxation and Resonance** will be held in Oxford at St. Anne's College, 7-13 August 2005. Information on the conference can be found at the conference web-site <http://musr05.physics.ox.ac.uk> as it becomes available. You can find information on St. Anne's College at www.st-annes.ox.ac.uk.

Muonium chemistry reaps prizes

Very many congratulations to Don Fleming (UBC, Canada), who has won the 2004 Glen T. Seaborg Award for Nuclear Chemistry of the American Chemical Society. This was announced in the January 5th issue of Chemical & Engineering News and on the web site of the ACS Nuclear Chemistry Division: <http://www.cofc.edu/~nuclear/>. The award recognizes Don's pioneering work in the applications of μ SR to physical chemistry and chemical physics. The prize was awarded at the ACS National Meeting, to be held in Anaheim, California, in the period 28 March to 1 April 2004. A one-day symposium in honour of Don Fleming was held on March 30 at Anaheim to celebrate Don's career and award.

This past year, the Undergraduate Awards Committee of the division of Nuclear Chemistry and Technology of the ACS named Michael Bridges the recipient of the 2003 Coryell Award. Michael is a student at the University of British Columbia, whose research at TRIUMF on muonium and muoniated free radical formation and radiation chemistry in sub- and supercritical carbon dioxide was done under the supervision of Don Fleming and Khashayar Ghandi.



Prize winners: Don Fleming (left) and Michael Bridges.

Comments on this newsletter?

The ISMS newsletter will be distributed twice per year, to inform the μ SR community of ISMS activities, and to provide other information and news of interest to community members. We would welcome comments and thoughts on the content and distribution method - please email the Secretary, Philip King, at isms@rl.ac.uk if you have suggestions.

ISMS Facilities Subcommittee

As described on the front page, a Facilities Subcommittee has been established to improve communication between muon facilities and represent the needs of users. The current permanent members of this committee are: Kusuo Nishiyama (KEK/JPARC), Philip King (ISIS), Dierk Herlach (PSI), Syd Kreitzman (TRIUMF). The rotating members are: Ryosuke Kadono, Wataru Higemoto and Masahiko Iwasaki (KEK/JPARC), Steve Cottrell (ISIS), Thomas Prokscha and Robert Scheuermann (PSI), Donald Arseneau (TRIUMF), Gerald Morris (Los Alamos). Do contact your local Committee member if you have comments on the technical aspects of a facility.

Facility Proposal Deadlines and Contact Details

ISIS

Deadlines: 2 per year - 16th April and 16th October
Contact: Philip King (philip.king@rl.ac.uk)
<http://www.isis.rl.ac.uk/muons/>

KEK

Deadline: 2 per year; contact Ken Nagamine
Contact: Ken Nagamine (kanetada.nagamine@kek.jp)
<http://msl-www.kek.jp>

PSI

Deadline: 1 per year - next one is November 2004
Contact: Dierk Herlach (dierk.herlach@psi.ch)
<http://lmu.web.psi.ch/>

TRIUMF

Deadline: please contact Syd Kreitzman
Contact: Syd Kreitzman (syd@triumf.ca)
<http://musr.triumf.ca/>