

RIKEN-RAL MUON FACILITY

SECOND INTERNATIONAL ADVISORY COMMITTEE REVIEW REPORT

4-5 NOVEMBER 2008

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1. Executive Summary

This second meeting of the RIKEN-RAL International Advisory Committee took place during 4-5 November 2008 at the RIKEN Nishina Centre, Wako, Japan. The aim of the second meeting, building on the scientific and technical findings from the first report, was to emphasise considerations relevant to the renewal of the RIKEN-RAL agreement. The Committee consisted of both International and Japanese experts appointed by Professor Yasushige Yano, the Director of the RIKEN Nishina Centre – Committee members are listed in Appendix 1.

The Committee heard a variety of reports on the activities of the Facility, together with documentary evidence relating to Facility work, including publications and annual reports. The Committee's agenda is given in Appendix 2. The following sections of this report give more detailed findings and recommendations for each of the various science areas covered by Facility activities. The broad findings and recommendations are summarised below.

1.1. Summary of First IAC Report

The overall conclusion of the first IAC report from November 2007 was as follows:

The international advisory committee is of the opinion that the RIKEN-RAL Facility provides unique instruments which serve a dynamic user community and produce excellent science at a competitive cost. The superb technical skills used to develop state of art equipment are matched by the competence and dedication of a strong physics team. RIKEN should be proud of such an achievement. The committee noted two areas that need further scientific guidance from the RIKEN PAC to optimise the use of the very precious beam time at RAL.

The Committee noted the world-class nature of the RIKEN-RAL Muon Facility and its unique and diverse capabilities, including the world's highest rate μ SR spectrometer and unrivalled μ CF facilities. The technical achievements were particularly impressive and were being undertaken by dedicated, enthusiastic and very able RIKEN-RAL staff members. The Committee was impressed by the strong publication output from the facility. The Committee noted the very successful programme in condensed matter physics, the strong opportunities provided by low energy muon development, and the opportunities for some programme areas, for example muonic X-ray studies and μ CF, to benefit from advice and guidance from the RIKEN advisory committees or external sources.

1.2. Findings and Recommendations of the Second IAC Meeting

General:

1. Following the first IAC report, the Committee were very pleased to note that responses have been made in line with its previous recommendations, and progress has been made in key areas. In particular:
 - the evidence for enhanced collaborative activity and user community development was particularly notable.

- further strong publications have been produced, including, for example, studies of the new pnictide superconductors
 - laser and pressure developments have been used in applied physics areas (e.g. spintronics; organic conductors; molecular ensembles)
 - a new advanced μ SR spectrometer has been developed
2. The Committee noted that the continued muon science studies performed at the RIKEN-RAL Muon Facility build on *a very rich Japanese scientific heritage* – both with respect to the achievements of the Nishina Centre, and the very significant contributions that Japanese scientists have made to muon research.
 3. The Committee noted the complementary place of *muon spectroscopy* within the techniques for condensed matter and molecular science investigations, and recognised its unique contribution for atomic and molecular-level studies across a wide variety of systems.
 4. The Committee considered *the unique place of the RIKEN-RAL muon facility* among the world muon facilities. It provides particular advantages as a pulsed muon source, and has capitalised on these advantages through low background measurements, development of pulsed stimuli and demonstration of a unique method of low energy muon production.
 5. The Committee recognised that the RIKEN-RAL Muon Facility provides a very successful and significant example of *international collaboration* for the RIKEN Institute, and leads the way as an example within RIKEN of international collaborative activity.
 6. The Committee considered that the RIKEN-RAL muon facility is *essential to the future success of the J-PARC muon facility*, through technique development, community expansion, and the training of Japanese and Asian researchers and development of expertise in the muon science area.

Specific science areas:

7. ***Condensed matter and molecular science.*** The Committee considered that this area is highly productive and successful for the RIKEN-RAL Muon Facility, and is going from strength to strength. It is generating significant (in number and quality) publications, and is a key example of the relevance of RIKEN-RAL science to societal benefit. It is an area which attracts researchers from throughout Japan, and has opportunities for significant community expansion in other Asian countries. This activity also maps strongly on to the primary research area of the ISIS facility as a whole, and so is a key area for development of further collaboration.

The Committee recommends that this area be prioritised as the first of two central pillars of the future RIKEN-RAL facility programme, and strongly recommends that it be given sufficient resources in terms of finances, manpower and leadership to enable its continued development.

8. ***Ultra-slow Muon source development.*** The Committee recognised the unique nature of the low energy muon source that has been developed at the RIKEN-RAL Facility, and considered it to be one of the most promising areas in muon science with high potential for a wide range of applications. These applications include a variety of

condensed matter and molecular physics areas. In addition, the recent development of ideas to use the low energy muon source for future g-2 measurements further strengthens the case for its development.

The Committee recommends that this area be prioritised as the second of two central pillars for the future RIKEN-RAL programme, and recommends that the strong and well focused R&D effort is continued to develop the world's best pulsed low energy muon source.

9. **Muon catalysed fusion.** The Committee recognised again the unique nature of the μ CF facilities and the first class results which have been produced to date. It also considered that future work will be technically challenging and will require significant investment of resources.

The Committee recommends that an expert review of this activity is undertaken before further resources are committed, in order to assess the ongoing likelihood of scientific reward compared with the two central pillars of RIKEN-RAL activity identified above.

10. **Muonic x-ray measurement.** The technical achievements of this activity were again noted by the Committee, together with the significant progress that has been made in demonstrating the method since the first IAC meeting. The Committee noted that further technical developments, requiring large resource investment, together with consideration of safety issues, would be necessary to fully realise the method for use with radioactive nuclei.

Again, the Committee recommends that an expert review of this activity is undertaken before further resources are committed, in order to assess the ongoing likelihood of scientific reward compared with the two central pillars of RIKEN-RAL activity identified above.

11. **Muon lifetime measurement.** The Committee recognise the technical achievement in this area, but note that it is presently not competitive with other muon lifetime measurement projects.

The Committee recommends that, with the resource constraints that the RIKEN-RAL Facility is under, and particularly given that this activity would compete for time with condensed matter and molecular studies, it is not taken further forward at the present time.

12. **Nuclear transmutation.** The Committee received a presentation on the possibility of using muons for nuclear transmutation. The ideas for this are still very much at an early stage.

The Committee recommends that further evaluation of the potential and technical practicality of this method is undertaken before bringing such ideas to the proposal phase.

1.3. Overall conclusions

The International Advisory Committee continues to endorse its summary conclusion from its first report, namely that

'The RIKEN-RAL Facility provides unique instruments which serve a dynamic user community and produce excellent science at a competitive cost. The superb technical skills used to develop state of art equipment are matched by the competence and dedication of a strong physics team. RIKEN should be proud of such an achievement.'

In order to deliver a balanced future programme which builds on recognised strengths, maximizes world-class science, strongly invests in only the most exciting and ambitious future plans and fosters increasing engagement with Japanese and international research communities together with the host facility, two key programme pillars were identified:

1. Condensed matter and molecular physics
2. Ultra-slow muon development

The committee are convinced that these two areas form a basis of core activity that will ensure a healthy balance between fostering *outstanding science now* and investing in *future science for tomorrow*. The Committee considers that it is necessary for RIKEN to provide adequate resources (manpower and financial commitment) to both of these areas to ensure continuing success.

To ensure development of RIKEN world-class science focusing on these two pillars, the Committee recommends an extension of the RIKEN-RAL agreement beyond 2010 by at least another 7½ years to 2018.

2. Findings in Detail: General

2.1. Muon research at the Nishina centre: a rich scientific tradition

The Nishina centre builds on an impressive history of Japanese world-class contributions in fundamental physics. This includes the groundbreaking work of Nishina himself (“The Father of Nuclear Science in Japan”), together with Tomonaga (Nobel Prize 1965), Yukawa (Nobel Prize 1949) and Sakata – a proud record of Japanese fundamental physics achievements further recognised by the 2008 Nobel Physics prize (awarded to Nambu, Maskawa and Kobayashi for their theoretical work).

This tradition and inheritance is one to be cherished, but there is an additional element to this intellectual heritage in which the RIKEN-RAL facility stands. This is the outstanding contribution that has been made by Japanese muon science, a contribution that has been pivotal in world μ SR research.

This tradition began in 1937 when Nishina and colleagues identified the muon in cosmic rays. Kubo (one of the fathers of non-equilibrium statistical mechanics) and Toyabe predicted the Kubo-Toyabe relaxation function in 1967 (as a hypothetical effect proposed for NMR) but it was only realised experimentally by work in Yamazaki’s group in 1979 who demonstrated it using muons. This study is one of the most cited papers in the μ SR literature. Nagamine’s group developed the pulsed muon source in 1980 and opened up a variety of innovative applications combined with pulsed extreme conditions taking the initiative over the world. His groups in KEK and RIKEN-RAL have originated many techniques in μ SR, and in particular the development of the laser ionization method for producing slow muons. Nagamine, Ishida and co-workers performed the first muon measurements in conducting polymers in 1984 in collaboration with Shirakawa (Nobel Prize 2000) and this work opened up a very fruitful area of later research. Uemura and co-workers made foundational progress on applying muons to spin glasses in 1985. Uemura devised what is now known as the “Uemura plot”, a diagram which has underpinned all subsequent studies of superconductivity using muons and has been of transformational importance in superconductivity research. Uemura was the first winner of the Yamazaki Prize in 2005, the main prize awarded by the muon community once every three years. The contributions of Matsuzaki and coworkers in muon-catalysed fusion also deserve special mention. There are many other achievements of Japanese muon science and the RIKEN-RAL facility is therefore ideally placed to continue to build on this tradition of excellence.

The committee agreed that RIKEN should be justly proud of these achievements from Japanese scientists and their role in supporting this research, and also that RIKEN should be excited about the future role they can play in building on this tradition.

2.2. The role of muons in condensed matter science

Muons are a unique probe in condensed matter and molecular studies. Their impact is distinct from, and complementary to, other techniques such as neutron scattering, x-rays and NMR. Specifically, the μ SR (muon spin rotation / relaxation / resonance) technique has particular strengths in studies of:

- weak and delicate magnetic states such as spin glasses, frustrated magnetism, spin liquids

- slow spin dynamics on MHz/GHz scale, thus bridging the gap between neutrons (THz timescales) and a.c. susceptibility measurements (kHz timescales)
- superfluid stiffness in superconductors, enabling measurement of penetration depth, gap symmetry, vortex dynamics
- probe-induced effects to extract charge dynamics and detailed information on hydrogen behaviour in materials – particularly relevant to studies of conducting polymers, defect states in semiconductors and chemical kinetics.

The significant contributions made by muons within these science areas are reflected in the strong publication output from muon facilities around the world including the RIKEN-RAL facility.

2.3. Characteristics of the RIKEN-RAL Muon Facility amongst other muon facilities

The RIKEN-RAL Muon Facility produced its first muons in 1994. The facility consists of a primary muon generation and transport beamline which allows production of both positive and negative muons with variable momentum. These can be fed at any one time to up to two of the four experimental areas: *Port 1* is used for muon catalysed fusion investigations; *Port 2* for condensed matter and molecular studies (ARGUS spectrometer); *Port 3* for development of a low-energy muon beam; and *Port 4* for development of muonic X-ray studies from unstable nuclei, alternating with a new, advanced spectrometer for condensed matter and molecular studies. The high muon intensity, together with the significant technology investment that has been made in the experimental infrastructure, mean that many of the studies performed are unique and that the RIKEN-RAL muon source is a world-class facility.

Specifically:

- The pulsed nature of the beam enables complementary studies to those performed at continuous sources such as PSI and TRIUMF.
- The pulsed beam means that very low measurement backgrounds can be achieved, for example in μ SR and μ CF studies.
- It also means that the facility is naturally suited to the application of pulsed stimuli to enhance investigations, for example the use of pulsed lasers or radio-frequency radiation.
- The ability to produce both positive and negative muons of variable momentum allows a very diverse range of fundamental and applied science to be undertaken.
- Significant investment in μ SR spectrometers has produced advanced instrumentation for high data rates at a pulsed beam facility, a trend that is continuing with the new spectrometer soon to be installed.
- An entirely unique method of low energy muon production suited to a pulsed source has been developed which gives a high quality (low emittance, small spot size, high timing resolution, high energy resolution) low-energy muon beam

2.4. Collaborative Activity at the RIKEN-RAL Muon Facility

The RIKEN-RAL Muon Facility is a very significant and successful international collaboration for the RIKEN Institute. It has been established under successive agreements between RIKEN and RAL, and it represents the largest research collaboration project between the UK and Japan. It is set in the context of over twenty years of successful partnership between the ISIS Facility at RAL and Japanese institutes on

neutron science and muon spectroscopy, including collaboration to build several ISIS neutron instruments.

There is strong collaboration within the RIKEN-RAL partnership. As well as the overall establishment of the muon facility, there is collaborative work on specific scientific projects, particularly in the condensed matter and molecular science area, as well as technical collaboration (such as the development of data acquisition and control systems for the ARGUS spectrometer, and provision of pressure and laser facilities for μ SR studies).

The establishment of the RIKEN-RAL Muon Facility has also led to significant collaborative activity within Japan, with over 40 Japanese groups being associated with RIKEN-RAL science and using RIKEN-RAL facilities. The Committee was impressed by the efforts being made to further develop the communities using RIKEN-RAL over the past year – particularly the outreach work to science groups within other Asian countries. There is continued high potential for further community development within this area.

2.5. Relationship between the RIKEN-RAL Muon Facility and J-PARC

The Committee consider that a successful RIKEN-RAL Muon Facility is essential to the development of a strong J-PARC Facility. Operating alongside J-PARC muons, the RIKEN-RAL Facility will continue to allow:

- development of new scientific and technical ideas which can be applied at J-PARC as J-PARC facilities grow.
- maintenance and development of the user community, both in Japan and more widely within Asia, which will be key to maximising the potential of J-PARC. As described above, links to Asian research groups are already being developed through the RIKEN-RAL facility and there is scope for this activity to grow.
- training of Japanese and Asian researchers in muon science in an international environment. Successful operation and development of J-PARC relies upon a body of scientists and technicians who are familiar with muon methods and their applications, and the RIKEN-RAL facility will continue to be a rich source of expertise in this area.

3. Findings in Detail: Specific Science Areas

3.1. Condensed matter and molecular physics

The committee judged that RIKEN-RAL has produced a highly productive and successful programme of research. There is a high demand for the unique facilities offered (these include the high data-rate, high pressure capabilities and the ability to measure small samples). The facility has an excellent publication record in condensed matter physics that has grown impressively even since the last meeting of the IAC. The committee noted several recent high-profile papers, including work on pnictide superconductors, frustrated magnetism and spin fluctuations in Mo-based superconductors. The committee noted that the societal benefit derived from condensed matter research was an important feature of this area and that it fitted well into the aims and mission of RIKEN. The committee felt that the condensed matter activity was the “jewel in the crown” of RIKEN-RAL and was continuing to go from strength to strength.

There is strong evidence of growing collaborations, more than fifty Japanese groups being involved, as well as an initiative for outreach to Asian scientists. This latter work has been carried out with great energy, enthusiasm and leadership by Dr Watanabe, and is essential work for the future. The panel commented on the inspiring leadership shown in this area.

The panel also noted the new science opportunities that are available with the laser and high pressure developments. The building of a new spectrometer for Port 4 will lead to expanded capability and capacity that the committee strongly welcomed. The committee were also enthusiastic about the detector technology developments. The committee also recognised that the facility plays a pivotal role in student training and this has an impact for future researchers in Japan, but also in Europe and Asia.

In conclusion, the panel saw a strong argument for continued support and expansion of the condensed matter activity and recommended that this programme, which is producing the most active and effective science output of the facility, be accorded a very high priority. Concerns were raised that insufficient resources were being directed to this activity. Request for additional staff support was enthusiastically supported by the committee. It is essential for the health of this core activity of the facility that more than one permanent staff member be strongly involved with the condensed matter activities. To provide user support, initiate and manage the technical developments, integrate and collaborate with the ISIS muon group and RAL technicians, and continue the outreach to users in Japan and elsewhere in Asia, is a major task. By identifying this activity as the first of two pillars of the RIKEN-RAL vision, the committee recommends that substantial resource and management responsibility be redirected to the condensed matter programme. It is important that the budget for the condensed matter programme be grown and is ring-fenced in order to maintain and enhance the world-class progress already made. It is an area that will richly repay investment from RIKEN and is an area in which RIKEN can be extremely proud.

3.2. Ultra-slow Muon source development

The RIKEN-RAL group has developed a pulsed ultraslow muon beamline with excellent beam quality by using the unique method of resonant ionization of thermal muonium in vacuum in a strong collaboration with the KEK muon science group.

The IAC reported last year that this facility was unique and could produce a pulsed muon beam with intensities comparable to those obtained at the continuous ultra-slow muon beam facility at PSI. The IAC encouraged further technical development to reach that goal based upon the motivation of condensed matter research in thin films, surface science and nanotechnology. The realisation that such a source would also produce the superb beam qualities needed in particle physics experiments (see muon $g-2$ section) have strengthened the case for improving upon the RIKEN-RAL pioneering effort.

Since the last meeting, a strong push has been instigated to produce much better laser ionization efficiencies (possibly by a factor of 100 improvement). A comprehensive program based upon the expertise of Dr. Wada's laser group is being mounted which shows extremely promising results already. All other aspects of muonium production, muon beam focalisation, spin control and ion optics are being considered for optimization.

The RIKEN-RAL facility is ideal for developing and testing all these ideas while in the longer term, the J-PARC muon source offers the prospect of producing the most intense pulsed ultra-slow muon source in the world. Combined with the possibility to simultaneously stimulate the samples using the laser facilities developed in a collaboration between several Japanese institutes (E Torikai, K Shimomura, K Nagamine) together with RIKEN-RAL staff, this will be an absolutely unique facility, which will attract leading scientists worldwide. This effort is capitalizing on effective collaborations between RIKEN, RAL, KEK, Japanese faculties and J-PARC.

This is one of the most promising areas in muon science with high potential for a wide range of applications. The committee recommends that the strong and well focused R&D effort is continued to develop the world's best pulse muon source in partnership with KEK, RAL, J-PARC and the potential users.

3.3. Muon $g-2$ presentation

The committee heard a presentation by Dr Iwasaki about the efforts by the RIKEN group together with the KEK group to develop a new proposal to measure the anomalous magnetic moment of the muon.

The physics motivation rests upon the 3.7 sigma discrepancy observed between the most recent measurement of the muon $g-2$ at the Brookhaven National Laboratory and the most up-to-date theoretical expectation from a pure Standard Model physics-based calculation. Although a 3.7 sigma discrepancy is not to be taken as evidence for physics beyond the standard model yet, it is important to continue to improve this test of a purely leptonic system for which very clean theoretical estimates can be made. An analysis of the experimental error budget indicates that the uncertainties related to the beam size and beam divergences in the BNL setup are a large contributor. The team has identified a possible way of doing the experiment at low energy with a very low divergence muon beam and very small phase space. This is very promising but a full detailed proposal is

still being worked out. In any case the required beam characteristics would be very demanding to achieve.

One way to achieve such muon beam qualities is to capitalize on the development of ultra-slow muon beams by the RIKEN-RAL team which is based upon laser ionization of muonium emitted from hot foils. Last year, the committee identified this development as the most important technological advance in muon beam production. This technique is particularly well suited for a pulsed beam and offers the most promising prospect for an intense slow muon beam at J-PARC in the future.

Based upon the additional requirements of the potential g-2 experiment in Japan, the RIKEN group has focused its excellent laser expertise on the development of high intensity lasers matched to the muonium ionization frequency. This decision is particularly welcomed as it will support both the motivation of ultra-slow muon beams for condensed matter research and a new motivation for a particle physics experiment of high visibility. The committee was impressed by the excellent work plan presented for achieving a major breakthrough in increasing the ionization efficiency currently obtained in the pioneering work at RIKEN-RAL.

3.4. Muon catalyzed fusion (μ CF)

This is a unique programme for which the RIKEN group has developed a state-of-the-art facility at RAL. The IAC commented last year on the achievements of this group. This is the only group that can carry out experiments on Deuterium-Tritium mixtures at a muon facility. They have established several scientific milestones in the recent years: measurement of the α -sticking probability; measurement in a wide range of different conditions of temperature, pressure, mixture; and they have established a dependence of the fusion rate on the ortho-para mixture in both D-D and D-T fusion.

These were first class results which do not yet have a complete theoretical understanding. Due to other commitments there was no new data taking since the last review. The group is preparing a new high pressure D_2 target to study density dependant effects as this seems to be the dominant factor in improving the fusion probability.

It is clear that the group ability to pursue this activity depends strongly on their competing commitments. The committee reiterates that the next step in this programme will involve challenging technological developments and would require considerable resources and theoretical support. It would be wise to undertake a comprehensive expert review of the field before committing such resources.

3.5. Muonic x-ray Measurement

The measurement of muonic x-rays in the transfer of negative muons (μ^-) from hydrogenic atoms to heavier atoms accumulated in a thin solid hydrogen film provides a unique possibility to develop muonic x-ray spectroscopy of unstable nuclei. The principle of this novel method and preliminary results using a few stable ions (Ar and Sr) have already been reported to the first IAC meeting in 2007. Since then, the experimental group have continued the efforts to demonstrate the validity of this method using several further stable atoms. The technology developments for these measurements were enormous and

impressive. The principle of the method can be now regarded as well established and a distinguished achievement of muon physics.

Preliminary experiments and their results using stable isotopes of Sr, Ba and Sm were presented this time. The transitions of $2p_{3/2} \rightarrow 1s_{1/2}$ and $2p_{1/2} \rightarrow 1s_{1/2}$ in ^{86}Sr , ^{87}Sr (new data) and ^{88}Sr show isomer shifts consistent with other experimental data. The same transitions were observed clearly in ^{138}Ba . The transition from spherical to deformed nuclei could be confirmed in ^{148}Sm and ^{152}Sm , where a quadrupole splitting was observed in the latter while a normal spectrum was seen in the former. All these data convinced the committee of the applicability of the method to nuclear parameter studies. On the other hand, however, the necessity for improving experiment efficiency such as the detector acceptance is apparent in the shown data.

The group presented the plan to proceed to long-lived radioactive isotopes (RI). As the first candidate, radium isotopes are suggested because the nuclear charge radii are desired to investigate the full atomic potential. In order to go further to radioactive isotopes, however, it is extremely important to check the physics case in detail for the most interesting and unique results. As was recommended in the last committee meeting it is essential to seek the view of the RIKEN Program Advisory Committee in nuclear and atomic physics.

There are also several technical issues to be solved in transferring to radioactive isotopes. Safe handling of RI in the system and the removal of RI after measurements are absolute safety requirements. The reduction of the μ/RI interaction volume and the improvement of detector acceptance will be prerequisites to realizing a spectroscopy with an adequate statistical significance. All these items will result in much higher costs and require larger manpower.

Given these boundary conditions, the committee regards that the overall contribution of muonic X-ray spectroscopy in the future should be a factor for consideration depending on the overall resources available to the RIKEN-RAL facility.

3.6. Muon lifetime measurement

The Muon lifetime experiment was not presented at this review, but the spin-off from these activities in terms of novel world-class instrumentation for especially solid state physics experiments was amply demonstrated in the scientific and instrumental presentations. Along the lines of previous recommendation, we concur with the decision by RIKEN-RAL not to pursue the muon lifetime measurements at this stage, and to further evaluate whether the limited available beam time should be invested in an experiment which at most will confirm the presently best known value for the muon lifetime, or rather be used for experiments where the RIKEN-RAL facilities are second to none.

3.7. Nuclear transmutation

One of the key questions for our society is to ensure sufficient energy without endangering the environment now or even in the far future. Nuclear power will be necessary to meet the demand – at least for a period of time. It is our duty as scientists to examine how we can contribute to a safer world and a cleaner environment. One key problem with nuclear power and its societal acceptance is the production of relatively small amounts of very

long-lived radioactive waste. Means to burn these long lived isotopes or convert them into short-lived isotopes are therefore highly relevant. New reactor types with different fuel cycles will probably be able to burn the major fraction of this waste, but accelerator driven systems generating fast neutrons or possibly other particles (e.g. muons) could be interesting concepts for waste transmutation. Before bringing such ideas to the proposal phase, we suggest further evaluation of the potential and technical practicality of this method.

Appendix 1: List of International Advisory Committee Members

Dr. Andrew Taylor (Chair)

Director, ISIS Facility
Science and Technology Facilities Council
Rutherford Appleton Laboratory,
Harwell Science and Innovation Campus,
Didcot, OX11 0QX United Kingdom
Tel: +44-1235-445383
e-mail: Andrew.Taylor@rl.ac.uk

Prof. Stephen J. Blundell

Leader of the Correlated Electron Systems Group, Department of Physics, University of Oxford
University of Oxford
Clarendon Laboratory
Department of Physics, Parks Road, Oxford OX1 3PU, UK
Tel: +44-1865-272347
e-mail: s.blundell@physics.ox.ac.uk

Dr. Kurt N. Clausen

Head of the Neutron and Muon Department, Paul Scherrer Institute
PSI
Paul Scherrer Institut
5232 Villigen PSI Switzerland
Tel: +41-56-310-21-11
e-mail: kurt.clausen@psi.ch

Dr. Jun Imazato

KEK
High Energy Accelerator Research Organization
Institute of Particle and Nuclear Studies
Ohho 1-1, Tsukuba-shi, Ibaraki-ken, 305-0801, Japan
Tel: +81-298-64-5418
e-mail: jun.imazato@kek.jp

Dr. Jean-Michel Poutissou

Associate Director
TRIUMF
4004 Wesbrook Mall, Vancouver, BC, Canada V6T2A3
Tel: +1-604-222-7351
e-mail: jmp@triumf.ca

Prof. Eiko Torikai

Interdisciplinary Graduate School of Medicine and Engineering,
University of Yamanashi
4-3-11 Takeda, Kofu, Yamanashi, 400-8511, Japan
Tel: +81-55-220-8681
e-mail: et@yamanashi.ac.jp

Appendix 2: Committee Agenda

Tuesday 4 November 2008

1. Opening address Y. Yano
2. Visit to the RIKEN Nishina Centre Radioactive Ion Beam Facility
3. Research Activity
 - Present status of the RIKEN-RAL Muon Facility T. Matsuzaki
 - Laser μ SR experiments at Port-2 K. Ishida
 - Ultra-slow muon beam production K. Ishida
 - μ SR results of the RIKEN group I. Watanabe
 - μ SR results of the UK group P. King
 - Randomness effect on spin dynamics in quantum spin systems T. Suzuki
 - High-pressure μ SR on organic materials Y. Ishii
 - Structural frustrations and spin dynamics T. Kawamata
 - Superconductivity and magnetism in Ce-based materials K. Ohishi
 - Electron conductivity in low-dimensional polymers Risidiana
 - Muon catalyzed fusion K. Ishida
 - Muonic X-ray measurements from Ba and Sm isotopes P. Strasser
 - Muon induced fission toward nuclear transmutation T. Matsuzaki
 - Muon beam density enhancement by capillary K. Ishida
 - New μ SR spectrometer at Port-4 D. Tomono
 - Collaboration with Indonesia on muon science I. Watanabe

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4. Future Plans
 - RIKEN Nishina Centre Y. Yano
 - ISIS Muon Facility at RAL P. King
 - The μ SR studies on Material Science I. Watanabe
 - The RIKEN-RAL Muon Facility T. Matsuzaki
 - RIKEN J-PARC Center project M. Iwasaki
 - High intensity laser for ultra slow muon production S. Wada
5. J-PARC Muon Facility K. Nishiyama
6. Suggestion from the Society of Muon and Meson Science of Japan N. Nishida
7. Closed discussion
8. Summary talk by International Advisory Committee Chairman A. Taylor