Report from the Muon Science Advisory Committee (KEK-IMSS) and Muon Advisory Committee (J-PARC Center)

April, 2011

Report from the Muon Science Advisory Committee
(and the 9th J-PARC Muon Advisory Committee)
Held on February 18 - 19th 2011
at J-PARC, Tokai

April, 2011

Table of Content

Executive Summary

The Muon Science Advisory Committee (MuSAC) met at J-PARC, Tokai on February 18th and 19th, 2011.

The committee congratulated MSL and all people involved at MUSE for the work done since November 2009 when MUSE became the world's most intense pulsed muon beam facility.

This achievement has been consolidated in 2010 with user operation at 200 kW (up from 120 kW in the previous year) and important technical developments along the way. In particular, MuSAC was very pleased to see the financial commitment by KEK to build the high intensity surface muon beam line (U-line) for innovative ultra-slow muon experiments.

The committee was charged to review and put forward recommendations on the following:

1) **User Operation of the MUSE facility.**

   In particular, to evaluate the equipment and user friendliness of the D1 and D2 experimental areas, and the quality of the scientific results obtained.

2) **Future plans.**

   Review the adequateness of the current plan and the progression of construction of the ultra-slow muon beam line.

3) **Expansion of the community.**

   Make recommendations on how to initiate domestic and international collaboration on the construction and operation of the muon beam lines, and on how the user community may be expanded.

MuSAC was impressed by the progress made in establishing D1 as a major user μSR facility of international quality. It is clear from the experiments carried out thus far, that D1 is performing well as a user instrument. There will be even greater progress when the sample environment suite is broadened, for example by the addition of a dilution refrigerator. This will make the facility far more versatile and valuable to a much wider range of applications.

It is evident from the data collected in the current run of experiments, that there may be some problems with the quality of the muon beam. It appears that there is a relatively large background signal possibly originating from material surrounding the sample, which may account for up to half of the observed asymmetry. This is problematic for a detailed analysis of the measured μSR signals. It is recommended that more instrument time be devoted to steering and focusing the beam in order to minimize the background contribution.

The committee considers optimization of D1 and D2 to be high priority, as these beams will generate all the competitive muon science for the next couple of years. Improving the performance of the spectrometer (e.g. increasing the solid angle) is essential to achieve this goal. The scientific program carried out so far is varied and timely, with significant problems in magnetism, superconductivity and other aspects of materials science being well represented. The data collected from these experiments is both interesting and informative. The committee congratulates the scientists responsible for this work.

The committee reinforces its recommendation that the ultra-slow muon beam line remain the top priority. MuSAC is very pleased to hear that significant progress was made in 2010 towards the construction of this beam line. In particular, the normal conducting capture solenoids that constitute the first section of the Super Omega muon beam line were installed. Now with the allocation of crucial funding,installation of the second section, namely the superconducting curved solenoids,will commence in July. The design of the last section of the Super Omega beam line, the axial focusing solenoids with positron separators, appears well underway. We are grateful to those responsible for providing the additional funding necessary to keep this project moving forward.

We recommend that enough time be allocated for detailed studies of the muon beam properties after each section of the Super Omega beam line is completed, in order to check compliance with the simulations. A detailed understanding of the transport properties of Super Omega will set precedent for the use of the ultra-slow muons beam line as a unique tool for novel experiments in nano science, life science and particle physics.

The highest remaining priority is to work out a scheme to secure funding for developing the moderator to be installed at the front end of the U-line and the low-energy muon experimental apparatus. Involvement of inter-university groups with expressed interest (e.g. via S-type proposals) and a comprehensive search for synergies should be pursued and intensified.

MuSAC is pleased to see the H-line users developing a common strategy, and that there is now a timeline in place for installation of both the S-line quadrupoles and the front end of the H-line (accepting up to 120 MeV/c muons) in the summer shutdown of 2012, before the activation levels in the target region becomes too high.

MuSAC most welcomes the news of another addition to the technical staff. However, the ambitions of the muon program will be difficult to realize at the current level of staffing and every avenue should be explored to secure sufficient manpower to complete the scientific and technical projects at hand. This could be achieved in the short term through the appointment of temporary contract staff. The balance between operational and staffing costs should be closely monitored and optimized.

MuSAC believes that some of the key ingredients necessary to attract users from the worldwide μSR community are already in place, namely a) reliable accelerator and efficient beam delivery, which has reached the 90-95 % level and is a remarkable achievement for a brand-new accelerator complex. b) Unique pulsed muon beams as well as c) the commitment and funding to build a world leading ultra-slow muon facility. The structure of the S-type interuniversity projects appears to be conducive to building up collaborations and to involve academia and national research centers in seeking funding for instrumentation. The g−2/DEEME/Muonium hyperfine structure collaborations which are coordinating their efforts to develop the H-line have already established international partners. However, the committee feels that a firm commitment from the host institution is needed to bring in international funding. The committee strongly believes that an investment in the implementation of refurbished state-of-the-art D1/D2 spectrometers will have a positive impact on developing new national and international collaborations.

Expansion of the user community via involvement of Asian countries such as Korea and China is recommended. The committee feels that advertising J-PARC MUSE at international conferences (e.g. at the upcoming μSR2011 conference in Mexico), establishing a training program for young scientists in μSR techniques, and involving the condensed matter physics and materials science communities (possibly in collaboration with the neutron and synchrotron facilities) via onsite workshops and seminars are necessary endeavours for expanding the user community.

Foreword

The enclosed report and the previously submitted executive report summary are based on the MuSAC meeting, which took place at J-PARC on February 18 and 19th. On March 11th an exceptional earthquake followed by a Tsunami wave of unprecedented violence hit the Japan East coast bringing death and destruction and severe damaging a nuclear power plant. J-PARC was not directly hit by the Tsunami wave and its distance from the epicenter somewhat alleviated the impact. Still the pictures we received from our Japanese friends and colleagues indicate the tremendous amount of work that has to be done to recover the status of before the quake.

MuSAC understands that the priorities and recommendations given in this report are at the moment overcome by much more urgent tasks dictated by the extraordinarily situation.

This report is not meant to ignore these difficulties, but it is expression of the deep conviction that the expertise, skills and diligence of the Japanese people will allow to master the present difficult circumstances. MuSAC is convinced that in a not too far future the exciting plans and prospects we heard in February will be again at the center of the activities and discussions at J-PARC and MSL.

We take the opportunity to express the deep regret for the occurrence of this catastrophe and manifest our most sincere sympathy and support to the Japanese muon community, to all collaborators of J-PARC and KEK and their families and to the entire Japanese people.

I. Overview Session

After the introduction and welcome address by Prof. Shimomura who presented the charge to the committee, Prof. S. Nagamiya gave an overview of the J-PARC activities, followed by status reports on the Material and Life Science experimental Facility by Dr. M. Arai and on the Muon Science Facility (MUSE) by Prof. Y. Miyake.

In his presentation Prof. Nagamiya showed that the beam power is steadily increasing; 200 kW for RSC are now available with the goal to increase to 300kW in the near future. MuSAC was very pleased to hear about the high beam availability of 90-95%. This is an important prerequisite for a successful user operation and is essential to fully exploit the beam intensity available now and in the future. The strengthening of the infrastructure such as the opening of the new dormitory and the collaboration meeting with Korean scientists which took place in 2010 are also important steps toward the expansion of an international user community. At the moment only one muon beam line is operational, and the committee strongly encourages continuing a concerted effort to find funding needed to complete and operate the other proposed muon beam lines. In this respect, MuSAC was very pleased to see the financial commitment by KEK to build the ultra-slow muon beam line.

Dr. Arai reviewed the activities at MLF. With respect to 2009 the cumulative beam power has further been increased. Also the number of proposal has increased with an important fraction represented by muon proposals, which is especially remarkable given that only one muon beam line is momentarily operational. Selected examples of scientific results obtained from muon and neutron experiments with 120 kW and 220 kW beam power, which was achieved in November 2010 were given.

As a consequence of troubles at the accumulator of the low temperature hydrogen circulation loop at the neutron source, the operation had to be stopped until May. Urgent action was taken and the whole system was replaced by a new one in August so that operation could be successfully restarted.

Prof. Miyake presented detailed status and plans of J-PARC MUSE including the muon target and the secondary muon beam lines.

A rotating target system is under fabrication and planed to be installed in the summer of 2012. It will be necessary when the power is increased to 1 MW and replace the present fixed edge-cooling graphite target which performed well at 200 kW.

The committee was informed about further key upgrades of the secondary D-line that have resulted in a world-class muon beam line for μSR applications.

Large aperture quadrupoles replaced old ones and a wide-gap separator with a new power supply was installed in replacement of an old Wien filter.

Prof. Miyake also reported about the development of a kicker device that will enable the simultaneous operation of the D1 and D2 legs of the D-line. At present only the D1 leg is equipped with a spectrometer and instrumentation for μSR experiments. The corresponding power supply has been delivered and installed and the kicker device itself will be installed in summer 2011. To realize the full scientific potential of the D-line, it is essential that this and the upgrade of the D-line spectrometer happen on time. Essential progress is reported concerning the U-line. The normal conducting capture solenoid after the muon target is already installed and the superconducting curving solenoid is planned to be installed in summer. The last elements of the beam line (axial focusing solenoids) are also funded and in stage of advanced design. This is a great achievement and MuSAC would like to thank the KEK director general for the essential contribution that allowed this to happen. With these elements the beam line will be able to deliver high flux surface muons to the ultra slow muon setup. For this part, application for additional funding is been sought in the framework of S-type projects.

MuSAC welcomes a new addition to the technical staff. The completion of the development program and the extension of the user program remains a challenge for the personal. The committee suggests that attempts should be made to secure sufficient manpower to complete the scientific and technical projects. This could be achieved in the short term through the appointment of temporary contract staff by optimizing the balance between operational and staffing cost.

II. MUSE Facility

Muon Production Target:

An overview of the performance of the current fixed muon target and the development of a rotating muon target were presented by Mr. S. Makimura. The fixed muon target made of isotropic graphite of 20 mm thickness and 70 mm diameter with the fixed edge-cooling method is reliably operating 2.5 years since the first muon beam generation in Sep. 2008. It recorded the world strongest pulsed muon intensity in Dec. 2010 in the 327 kW test operation of the accelerator, and is steadily delivering beams with continuous operation of 200 kW since Nov. 2010. However, the coming 1 MW proton beam irradiation will heat the target by 4 kW and will shorten its lifetime significantly down to half a year. For a stable long term operation of the target under the unprecedentedly high proton irradiation at 1 MW, the development of a rotating muon target is in progress. This development includes tests of the irradiation effects on thermal and mechanical properties using the prototype model. MuSAC recognizes the importance of the development and welcomes the synergetic efforts with PSI where a rotating target system is in operation at the high intensity accelerator. MuSAC is also impressed by the high level of engineering and the communication ability of the technical staff characterizing J-PARC as an international research center.

The Super-Omega Project:

Dr. Y. Ikedo (KEK) presented the developments and status of the Super-Omega Muon beam line. This is the second beam line currently under construction at MLF/J-PARC. It is a novel beam line with a high (400 msr) solid angle acceptance producing the highest intensity pulsed muon beam in the world. It will be capable of the simultaneous capture and transport of both μ^+ and μ^-, whilst also enabling experiments using μ^+ and μ^- at the same time. Of particular importance is that Super-Omega will provide the opportunity of delivering a high intensity, high luminosity source of ultra-slow muons in the energy range 0.3 eV to 30 keV.

Super-Omega consists of three solenoidal components: a normal conducting capture solenoid, and superconducting curved transport and axial focusing solenoids, giving a total length of 18 m. Installation of the normal conducting capture solenoid was completed in March 2009. It is intended that the superconducting transport solenoid, which has been modeled in detail using GEANT4 simulations, will be constructed by Toshiba during the summer of 2011, for installation in September. The first muon extraction should take place in October.

The conceptual design of the superconducting axial focusing solenoids will be shortly completed and fabrication will commence in March 2012.

MuSAC congratulates the Super-Omega team on their progress. Indeed the development and installation of the U-beam line is a major step towards providing the μSR community with a world-leading ultra-slow muon beam line capable of delivering new and exciting science. In this respect MuSAC recommends that completion and exploitation of Super-Omega should remain a high priority.

D1/D2 Beam Line Upgrade:

The infrastructure of the D-line with its two experimental areas, D1 and D2, was reviewed. At present, only the D1 area is equipped with a spectrometer for μSR experiments. The D2 area is open with no permanent instrumentation, and is consequently for interim general use. The committee considers optimization of the dual leg D-line to be a high priority. During construction of the U-line, H-line, and S-line, the D-line will be relied on to generate all of the internationally competitive muon science at J-PARC.

The replacement of 3 used beam line elements taken from KEK with new wider-bore elements (*i.e.* the DQ4 and DQ7 magnets, and Wien filter) this past summer, has increased the muon transmission rate through the D-line and greatly improved the muon beam spot profile.

This upgrade in beam optics has markedly improved both the quality of the μSR spectra that can be recorded and the data collection rate. Even so, the committee recommends that more time and resources be devoted to tuning the D-line. The μSR spectra taken thus far seem to have a larger background contribution than they should, and at present this appears to be a barrier for accessing the full ~ 20 μs time window. The longer 20 μs time range is one of the most appealing aspects of a pulsed muon source. For example, it allows μSR investigations of slower-relaxing phenomena (such as very weak magnetism) than what can be studied using a continuous muon source, like that at TRIUMF and PSI.

The planned installation of a beam kicker and septum magnets into the D-line in summer 2011 will provide separation of the double-bunched muon beam, diverting single pulses down both of the D1 and D2 legs. This will allow experiments in the D1 and D2 areas to operate simultaneously, which will essentially double the scientific throughput of the D-line. The committee considers this to be a significant upgrade to the D-line and an efficient use of the available muon beam.

A major limitation for current μSR experiments using the D1 leg is the second-hand spectrometer that came from KEK (*i.e.* DΩ1). The DΩ1 spectrometer has a limiting 5% solid angle, and undermines the advantages of having the world's most intense pulsed surface-muon beam line. It is vital that DΩ1 be replaced with a new state-of-the-art μSR spectrometer. The committee was pleased to hear that an effort is being made to upgrade the data acquisition system, and that there is some ongoing research and development of a new μSR spectrometer that utilizes semiconductor-based multi pixel photon counters (MPPC) in place of large, expensive phototubes. In addition, a used dilution refrigerator brought in from KEK is being refurbished to expand the sample environment possibilities to include ultra-low temperature. Still, a second μSR spectrometer is needed for D2, and funding must be found for further development and construction of both spectrometers. Moreover, the committee acknowledges a serious shortage of personnel to complete all of the tasks at hand.

III. Science at MUSE

Research Highlights in 2010:

Research highlights from μSR experiments carried out at J-PARC MUSE over the past year were reviewed. The committee recognizes that with only a single, functional, out-dated μSR spectrometer on the D1 leg of the D-line, there is a limit to the amount of high-profile science that can be done. Nevertheless, the committee was impressed by the progress in establishing D1 as a major μSR facility of international quality. There is high-quality science and good variety in both the experiments that have been done, and those that have been proposed. The scientific program carried out so far has addressed timely and significant problems in magnetism, superconductivity and other aspects of materials science. The data collected from these experiments is both interesting and informative. The committee congratulates the scientists responsible for this work.

There will be even greater progress when the sample environment suite is broadened, for example by the addition of a dilution refrigerator. This will increase the attractiveness of the facility by greatly expanding the materials science applications. For the near future, the D-line alone will produce all of the muon science at J-PARC, so it is essential that immediate attention be paid to bolstering the capabilities of the D1 and D2 experimental areas.

It is evident from the data collected from the current run of experiments, that there may be some problems with the quality of the muon beam. Based on the μSR spectra presented to the committee, it appears that there is a relatively large background signal. This may be coming from material surrounding the sample, and may be accounting for up to half of the observed asymmetry. This can cause problems with detailed analysis of the μSR spectrum and also distort the signal at late times. The experimental results shown to the committee did not exploit the long ~20 μs time range that is a unique feature of a pulsed muon source. As mentioned earlier, it is recommended that some instrument time be devoted in the next cycle to identify the source of this background problem.

Although beam time at J-PARC MUSE is at present greatly limited, it would still be of benefit to involve some external researchers in new experiments. Besides the obvious scientific advantages that stem from international collaboration, foreign scientists may help to alleviate human resource shortages in some areas or be used to leverage funding for equipment or operational expenses. Furthermore, their involvement at this early stage would begin laying the foundation for the broad user base that is envisioned for the future.

JAEA-KEK Project:

Dr. W. Higemoto described the scientific progress of a joint JAEA-KEK μSR research program focusing upon the novel properties of f-electron systems. The experiments were performed on the KEK spectrometer on the D1 beam line, on which short (~30 ns) muon pulses were shaped by an electrostatic beam slicer. Additionally a low background chamber has been introduced to allow samples to be mounted in a “fly-past” geometry thereby minimizing signal to noise. Unfortunately it has not been possible to entirely eliminate the background signal even in the absence of a sample. Sample environment was controlled with a new He-free cryogenic system.

The scientific problems that are being studied are extremely topical and of significant interest.

These include the investigation of high order multipole ordering in SmX_3, DyB_6 and related compounds; the symmetry of superconducting order parameters in $PrIr_2Zn_{20}$ and similar systems (although restricted to the normal state as a dilution refrigerator is required); competing ground states near a quantum critical point in YbPtSb etc.

In all cases the muon results have been extremely informative, providing evidence for novel magnetic ordering mechanisms and superconductivity in the respective compounds. MuSAC has been impressed with both the relevance and significance of the scientific program and with the quality of the data and its interpretation. It is clear that the muon facility of J-PARC is capable of maintaining a scientific research program of the highest international standard. The collaboration is to be commended on its work.

IV. Research Projects (S-Type Proposals)

Muon Anomalous g-factor:

MuSAC heard an update from Prof. N. Saito on the R and D being done towards a new muon g−2/EDM measurement proposed for the H beam line at MUSE. The goal of the experiment is to determine the muon anomalous magnetic moment a_μ to a statistical precision of 0.1 ppm. This is five times better than the current best experiment (BNL821) which established a 3.4σ deviation from the Standard Model prediction for a_μ. The novel approach proposed by a KEK/RIKEN led international collaboration of about 70 researchers will be able to confirm or disprove this discrepancy with the standard model in a systematically independent way and, in conjunction with anticipated new information from the LHC, identify possible solutions. Also in the same apparatus a new determination of the electric dipole moment of the muon can be made at a level that can shed some light on CP violation in the lepton sector, a key element for lepto-genesis.

As reported previously many challenges have to be met. The experiment requires i) a cold source of muonium, ii) ionization with high power pulse laser in the far UV range to produce 10^6 ultra slow muon (USM) per second with a reduced transverse momentum to less than 10^{-5} $\Delta p/p$, iii) a novel muon accelerator to 30 MeV, and iv) injection in a NMR type solenoid with a field precision of 0.3 ppm. All aspects are under development. Some recent successes were obtained in an experiment at TRIUMF that determined that Silica aerogel material is releasing muonium with good efficiencies at room temperature. A time evolution of the drifting muonium was obtained. In parallel a test of an improved laser is scheduled to take place at RIKEN-RAL in March 2011 which should demonstrate a factor 10 improvement over what was obtained in past at RIKEN-RAL (200 USM/sec). Design of the accelerator and specifications for the NMR magnet is underway . The experiment has been reviewed by the J-PARC IPNS PAC and has received encouragement to pursue the R/D phase of the experiment with vigor.

Synergies have been found with other proposals which would use the same front end in the MUSE H line: a muonium hyperfine splitting proposal is being developed that would also use the same muonium source and a prototype of the g−2 NMR magnet. A search for the muon to electron conversion (DEEME) could also be accommodated.

MuSAC is also very much aware of the importance of the above developments for research in material science. Should the test at RIKEN-RAL be successful in generating few hundred USM, it would allow a research program in surface science to be initiated before migrating back to MUSE when its USM source will be operational. Both g−2 and the IMSS researchers would benefit enormously from this learning experience with USM sources.

MuSAC congratulates the g−2 team for its strong R and D effort and for engaging other groups in the research of an optimum H1 line. Since this decision must be made soon to have the front end elements installed in an upcoming shutdown, MuSAC encourages KEK-IMMS to seek urgent funding for the construction of these elements.

Over the longer term, a significant amount of resources will be required (of the order of 50M$ for capital only) to mount the g−2 experiment as well as an extension to the MLF building. The time scale envisaged for start of data taking is FY 2015. A firm approval and commitment from J-PARC and KEK will be needed to attract foreign participation and associated funding.

μN-eN Rare Process:

The committee heard a presentation by Prof. M. Aoki on a proposal submitted to the J-PARC PAC to use a novel method to identify the flavor violating process: μ^- to e- conversion.

The idea is to use negative muons decaying in the surface layer of the production target itself and to identify delayed 105 MeV electrons using the beam line as a 100 MeV/c spectrometer followed by a good resolution electron spectrometer. The concept is novel and some preliminary tests in the D1 line have confirmed that delayed electrons can be identified with reasonable background levels. The concept may work but it is difficult to assess the sensitivity of the proposed detection scheme. Further simulations and validation of the background levels are necessary. For example, the momentum acceptance of the system is difficult to monitor experimentally. It is clear that a measurement in the D line would not be competitive. The level of sensitivity that could be achieved in the proposed new H line is an order of magnitude improvement better than the PSI measurement, but the estimates for background from delayed electrons produced by delayed proton and neutrons have very large uncertainties. It is not yet clear whether sufficient gain can be achieved to make the proposal viable. Further R/D is also needed on the beam line optimization and on the spectrometer. A rotating SiC target is also preferred and must be developed. The proposal is deferred by the PAC pending results from the R/D phase.

Nevertheless the group has worked with other potential users of the H line to come up with a compatible configuration which would be versatile and could also accommodate a wide class of experiments including g-2 with ultra slow muons and surface muon users. A final decision on the configuration of the H line must be made soon to allow for the installation of the front end components during the upcoming shutdown for the LINAC upgrade.

MuSAC recommends that KEK work with the potential users of the H-line to freeze its front end design in time for allowing construction and installation of the elements positioned in the Proton tunnel in the 2012 long shutdown .

Low Energy Negative Muon Generation:

Prof. N. Kawamura explained his proposal of S-type research project entitled “Fundamental study towards the generation of negative slow muon beam”. The proposed plan for producing an intense slow μ^- beam is very ambitious and its realization is expected to promote an important scientific progress in various research fields including interdisciplinary area. The muonic X-ray tomography and a CPT test using anti-muonium spectroscopy are typical examples of its application. It is, however, known that slowing down the μ^- beam is very difficult in comparison with a μ^+ one, and that there is no counterpart to the technique for producing an ultra-slow μ^+ beam using thermal muonium. This project aims at achieving a good quality of slow μ^- beam with an energy of ~10 keV by decelerating MeV negative muons using a technique of frictional cooling in combination with properly optimized moderation processes. Although the proposed technique is considered to be appropriate, it will be necessary to check carefully the efficiency of the designed apparatuses (a GEM detector, a moderator, a frictional cooling camber, etc.) by numerical simulations and various test experiments. MUSE has a potential to be a world-top facility regarding the research using negative muons, because of the availability of very high yield of negative muons due to the utilization of 3 GeV protons. The MuSAC thus suggests that this project should positively be supported in a middle- or long-term strategy of MUSE.

Muon-microscope:

Prof. E. Torikai presented an interesting and comprehensive overview of the continuing development of the ultra slow muon beam capabilities at J-PARC – the so-called Ultra Slow Muon Microscope, capable of exploring the near surface of materials with the additional advantage of microbeam provision for real space imaging of samples in the μg sample range. It is envisaged that the facility could be used for the study of spin transport and reactions in chemistry and the life sciences and of heterogeneous electron correlations at the surface-bulk boundary.

It is proposed that microbeam focusing will be achieved by the reacceleration of the ultra slow muons, leading to a reduction of beam size without any significant reduction of intensity. The expected ultra slow muon yield is 10^6/s compared with a surface muon yield of 10^8/s. It is anticipated that a 1μm beam with a penetration depth of 100 μm should be available by 2015.

There has been broad advisory support for the ultra slow muon beam line (from RIKEN-RAL, MuSAC, and IAC) with recommendation of prompt construction. In this respect the present MuSAC strongly endorses this support and is particularly grateful that KEK-Director Special Fund and the Government Supplementary Budget have been able to allocate a total of 7.9 OkuYen to the project in 2010. Additionally collaborative participation has been secured from the RIKEN surface science group and catalysis science group of Hokkaido University.

The presentation gave numerous topical examples of the application of the ultra slow muon microscope including the study and design of spintronics materials, superconducting systems, epitaxially grown complex systems, and surface metallicity. Finally, an overview was provided of how the ultra slow muon beam can be exploited in the g–2 experiment to quantify the discrepancy between theory and measurement which indicates new physics beyond the standard model.

Once again MuSAC is extremely supportive of this program, and rates it at a very high priority. It will provide J-PARC with a uniquely powerful muon facility on the world stage which has applications across many areas of materials science from physics and chemistry to biology and electrical engineering.

Electronic State of Supercritical Metals:

Prof. A. Koda has proposed to study the electronic state of supercritical metal under high-pressure and high-temperature by a new μSR technique. The goal is to explore new frontier of science, such as supercritical metal, by a local probe such as μSR. This is a challenging and interesting theme. The study needs to establish the μSR experimental technique under the extremely high-pressure and high-temperature. The spokesman has a good experience in high-pressure experiment and has presented the plan of a realistic new apparatus for high-pressure μSR. However, it appears that the design of the high-temperature part requires further improvement. Despite this, the proposal should continue as S-type proposal, since μSR experiments under extreme state conditions represent a key tool for reaching out new scientific frontiers.