1st J-PARC MuSAC committee meeting
Held at the KEK laboratory, Feb 7Th 2003

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April 14Th 2003

Executive Summary:

The Muon Science Experimental Facility Advisory Committee was set up to review the plans to produce a state of the art muon facility at J-PARC and to identify the flag ship experiments for the initial phase of the project.

One is proposing to develop a muon beam production facility on the 3 GeV , high intensity, proton beam from the booster Rapid Cycling Synchrotron at J-PARC. The muon facility is to be located in front of the 3GeV spallation neutron source and has to be operated in such a way as not impacting the neutron fluxes by more than 10%. The environment of the muon source dictates that the front end of all possible muon channels be installed in the pre-beam delivery period.

The J-PARC Muon sub-group has come up with a set of 4 muon channels of one production target that will cover the aspiration of the muon community. The committee reviewed the plan for the source and the front end channels ; it found that the plan is very good and takes into account the difficult environment in which they will operate. The engineering should be coordinated with that of the neutron source to optimize the overall area and minimize possible conflicts. Within the limited resources available, only one surface and decay muon channel will be develop at time zero but with a clear upgrade path to provide conventional surface muons, high energy muons and super-intense surface muons (Super-Omega) in the future. Amongst those muon facilities, the design of the Super–Omega channel is quite exciting since it will allow the development of ultra low energy beams and the possibility of micro muon beams in the future.The intensities of muon beams to be produced will be such that new instrumentation will be required to exploit them. The community is encouraged to do the Research and Development to define these new instruments and techniques at this time.

A program in condensed matter (with a potential large overlap with that of the neutron community) , a program in muon catalyzed fusion and a set of fundamental tests have been identified which will provide unique and important new data. Some effort to define the requirements of these “proto-experiments” must now take place to provide guidance to the accelerator developers and facility designers at an early stage.

The limited amount of funding will not allow for full shielding of the muon production target at initial operation. This issue must be addressed for the benefit of both the muon and neutron community.

MuSAC Report:

The first meeting of the Muon Science advisory committee (MuSAC) was held at KEK on February 7^{Th} to address the following mandate:

1. Review of the plan of J-PARC Muon Science Experimental Facility Construction
2. Review of the plan of the Flag-ship Experiments in the 1^{st} phase of Muon science Experimental Facility
3. Comment of the internationalization of the project.

The composition of the committee is given in appendice B) and the meeting agenda in appendice C)

The meeting coincided with a biannual Executive Council meeting of the International Society for MuSR Spectroscopy (ISMS) held at KEK and benefited from the presence of vice-presidents for Europe and North America who were invited to participate in the deliberation of the MUSAC committee.

The committee received some documentations prior to the meeting and these were supplemented by oral presentations. The J-PARC project director and the head of the Material and Life Science Facilities gave an overview of the planned facilities at J-PARC and the time table for their realization. This was followed by technical presentations of the muon science experimental facilities (Proton beamline ,Target and secondary channels) and by a set of presentations on the flag-ship experiments envisaged for such facilities.

The committee was impressed by the progress made in defining the core facility for muon science and in designing a state of art muon production facility within the constraints of the combined experimental area for both a muon source and the neutron spallation source, taking into account the aspiration of both communities. The committee agrees that the strategy of focusing the initial effort and spending in establishing the front end systems within the heavily shielded area is the right one since any later intervention in that location will required considerable remote handling manipulation with its associated extensive planning and dose management control requirements. Hence it is very crucial to make the right decisions at this time since one would have to live with those for the foreseeable future.

The conclusions and concerns of the committee were presented at an oral close-out session attended by the speakers and by the J-PARC project director. These are described in details in this report.

i) Muon facilities:

a) Proposed facility overview:

The slate of four secondary channels envisaged off the main muon production targets to be placed at the proton beam line in front of the spallation neutron facility covers well the aspirations of the currently identified user community and would allow a good balance between conventional decay/surface and surface muon beams (2 channels), very high flux surface muon beams (Super-Omega) with a possibility of developing a world class slow muon facility and a high energy (200 MeV/c) beamline.

b) Production target:

Key to this complex will be the muon production target which will receive the 3Gev 333 microamps beam from the Rapid Cycling Synchrotron accelerator and must limit the losses of proton to less than ten percent of the total beam intensity to the neutron source. The solution which is retained at the moment and for which much R/D work is being done consists of an edge cooled 2cm graphite target positioned perpendicularly to the main proton beam and viewed at 45 deg by the two conventional decay/surface and surface muon lines and at 60 degree by the Super-Omega and High-Energy muon channels. The fluxes of muons that could be obtained will position the muon facilities at J-PARC as the premier pulsed muon facility in the world by 2008 thereby creating a tremendous opportunity (as well as challenges) for the users of such intense muon beams.

The targetery design is well advanced and builds on previous experience at PSI and LAMPF while taking advantage of new technological development in the fabrication of the target cooling block assembly based upon hot isostatic press fitting and silver brazing. The simulations of the temperature profile and stresses seem comforting. However the committee would like to recommend that a validation of these calculations by a realistic beam test be considered at an early stage as some of the parameters are difficult to assess (Uniformity of the joints for example which may affect the thermal conductivity or the stress propagation.)

Safety considerations and analysis of abnormal events should continue to establish the parameters of safe operation and maintenance. The remote handling system associated with the target module is well advanced and should be coordinated with similar activities envisaged by the neutron target team.

c) Proton beamline and beam properties:

The considerations for the proton beam monitoring in particular for targeting on to the carbon target should take further development and the downstream scrapers should be instrumented to give beam position information via halo monitors.

Considerable work has been devoted to the air handling system in and around the target production area to minimize the corrosion due to Nox. Radiation fields due to radioactive gas generated in the proton beamline should also be considered in the design of the vacuum system and a window isolating the main proton beamline vacuum system from the secondary channel one will be needed.

The study of secondary beam optics and the examination of the experimental requirements should also indicate the proton beam quality requirements in term of beam spot size, stability and burst duration which will be asked for. Feed back to the accelerator team is essential.

d) Secondary channels:
Some muon flux determinations have been made. However optimization of both fluxes and brightness for the secondary muon beams should continue to assess the best orientation and configuration for the production target.

At the initial phase, only one channel will be available for users. The present KEK decay channel will be transferred to J-PARC and adapted. A new pion injection section will be built while the KEK solenoid will be modified. It is probably not necessary to boost the solenoidal field to 5 Tesla since it was observed at PSI that there is little if any gain above 3 Tesla.

When more funding will be made available the extraction part of the channel will be fitted with a septum and a kicker magnet to distribute the beam to two experimental stations. This is a cost effective proposition, which will provide an early opportunity to do physics and provide possibly the first publications of J-PARC.

Amongst the set of channels envisaged for phase 2, the design of a Super Omega channel is quite exciting and would provide a unique capability at J-PARC since it could be used to generate ultra slow muon beams with fluxes in the 10**6/sec opening the way for unique instruments and thin sample testing (e.g. micro probe beams could be developed opening a new vista in muon science). The committee considers this to be an outstanding development for J-PARC material science.

e) Timeline:
Due to the funding limitation, the initial set of muon beamlines will be very limited and even the shielding capability around the muon production target may be the limiting factor in delivering high intensity beams to the neutron source. It is important for all the front-end part of the facility around the muon-target to be completed before the delivery of the first beam from 3 GeV RCS to the neutron source. A compromise must be found that would solve this limitation and provide adequate shielding for the first year of operation so that science could be delivered at the very early stage of operation.

f) Instruments:
However superb the muon beams may be in terms of fluxes and brightness, the physics potential of the facility will only be realized if high quality instruments are provided for or by the user community. With the current funding directed mainly to the construction of the core facilities, it is imperative that the user community devote some effort to the design and development of new spectrometers focusing on the exploitation of the very high instantaneous rate of muons envisaged. Every effort should be mounted to gather

financial support at the University level in addition to KEK itself to conduct such development in parallel.

ii) Scientific program:

The muon facilities at J-PARC could be ushering a new area in muon science .The unprecedented fluxes of pulsed muons will position the J-PARC users at the forefront of material science. Together with the availability of pulsed neutrons, many users will want to use both probes for the characterization of their samples. As it has been demonstrated at the ISIS and PSI facilities, the availability of the muons and neutrons under a same roof will provide a unique synergy for material testing which shoud bring the two communities of users together around scientific issues. This is what J-PARC has been set up to do and the examples of ISIS and PSI indicate that it will happen here as well.

a) Muon Spin relaxation(Rotation, Resonance):

The J-PARC muon users will break new grounds and it is not expected that conventional MuSR experiments as being preformed today will be the norm. To exploit the huge instantaneous rate of the J-PARC muon facility new instruments and techniques will have to be developed. The science to be explored with the J-PARC muon beams will demand a strong R&D program in instrumentation with methods of stimulating polarization transfer, spin flip, spin echo , spin resonance etc becoming the norm. Although time integrated MuSR will be preferred initially, new way of doing time differential studies will have to be developed.

There is unique opportunity for the young generation of MuSR users (particularly in Japan) to provide a new set of powerful tools for the material science community.

b) Muon catalyzed fusion (MuCF):

The Japanese community has contributed greatly to this field of muon science with numerous interesting results leading to a basic understanding of the phenomena underlying the process of muon catalyzed fusion in H/D/T mixtures. Together with a strong theoretical effort one has been able to identify conditions allowing for a recycling of the muon by more than 100 times during its lifetime. However recent results have pointed out the ways of improving this recycling by going to higher temperatures and pressures for which high energy negative muon beams will be essential. The underlying physics is interesting in its own being a calculable three body interaction and allowing a study of nuclear reaction triggered by resonant molecular formation. Beyond this academic interest, the possibility of developing applications (for example intense 14 MeV neutron beams, breader reactor etc) have entered the realm of feasibility studies.

The high energy negative muon beam proposed for J-PARC will bring a unique tool for this important field of physics.

c) Fundamental studies with muons:

Studies of lifetimes for both positive and negative muon can be used to test CPT invariance. The current measurement of negative muon lifetime are hampered by uncertainties on the chemistry of atomic muonic hydrogen in liquid and studies in the gas phase are very difficult due to the low density and stringent purity requirements of the stopping target. However new information of the transition rate of the ortho-to-para muonic hydrogen molecule demand further study and challenge the theoretical interpretation of molecular dynamics.

The pulsed muon beam at JPARC will be ideal for such studies allowing for a study of the neutron emitted after muon capture over the span of several lifetime.

The determination of the induced pseudoscalar coupling gp from both ordinary and radiative muon capture in Hydrogen and the test of the prediction of the partially conserved axial-vector current (PCAC) hypothesis are critically dependant upon the knowledge of the ortho to para transition rate in muonic hydrogen molecule. J-PARC could make a valuable contribution to this field.

A new search for the lepton flavor violating process Muonium-Antimuonium conversion could be undertaken with a sensitivity 10 times larger than for the previous PSI experiment, placing constrains of extension of the standard model in particular when doubly charged Higgs would be present.

iii) Conclusions and recommendations:

The committee concluded that a rich physics potential exist for a program of muon science at J-PARC with modest investments and a great opportunity to train students. The Japanese community is very active in this field exploiting muon beams at home and abroad and could provide the world with a unique set of instruments which could attract in return a large segment of the current international community. The presence at our deliberation of the executive members of the recently created International Society for MuSR Spectroscopy is a testimony to the visibility of the J-PARC muon program and the interest for further collaboration at the world level.

The committee formulates the wish to see the J-PARC plan realized in a timely fashion. To that effect it recommends that the technical effort be concentrated on the design of the target until such time as the concept of a reliable and safe target has been validated by a test in a pulsed beam of similar power density. The design for the facility should also be reviewed in terms of the safe operation and maintenance activities at the early engineering level and in concert with other similar plans for the neutron target and even the other production targets at the 50 Gev machine.

[In general the committee noticed a need for better coordination of the engineering effort between the established facility groups to minimize duplication of effort and bring a higher level of standardization across the site.]

It recommends that the proposed initial channel using the refurbished KEK decay solenoid be actively implemented as the first user facility at J-PARC and that a solution to the lack of shielding be found to allow operation at time zero.

The committee recommends that the development of a Super Omega channel be actively pursued as it promises to be a unique contribution to the field of slow muon physics. The committee would welcome a more detailed report on the expected performance of such a channel at its next meeting.

The committed found that the initial slate of experiments envisaged for the muon facility is still very skechy and needs further refinements to the point that concrete letters of intent could be formulated and reviewed . This would provide valuable feed-back for the facility designers to tailor their plans to the user demands. The committee realizes that this is easier said than done in particular for the very dynamic field of material science where the horizon is quite short (typically of a yearly scale). Still it would be useful to develop a strategy for exploiting the unique beams of J-PARC and start an R&D program on instrumentation at the local universities while the J-PARC staff concentrates on the facility construction.

The committee congratulates the J-PARC team for its determination and enthusiasm and looks forward to a superb world class muon facility in the near future. It is convinced that the international community will also respond and want to join this exciting effort.

Appendix A

Composition of the committee

1st J-PARC MuSAC Member

J. Akimitsu	(Aoyama Gakuin U)	KEK-IMSS Exec.Comm. Member
S. Ikeda	(KEK)	KEK-IMSS Exec.Comm. Member
Y. Ikeda	(JAERI)	J-PARC MFLG Leader
M. Iwasaki	(RIKEN)	Muon Science Experiment Specialist
K. Nagamine	(KEK)	KEK-IMSS-MSL Head, , KEK-IMSS Exec.Comm. Member, ISMS Vice-president Asia and Australasia, ***(MuSAC secretary)*.**
N. Nishida	(Tokyo Inst. Tech.)	KEK-IMSS Exec.Comm. Member
Y. Miyake	(KEK)	J-PARC MLFG-Muon Sub-leader
Y. Yamazaki	(JAERI)	J-PARC Acc. Div. Leader
H. Yasuoka	(JAERI)	Condensed Matter Experiment Specialist
R. H. Heffner	(Los Alamos Lab.)	ISMS President, Muon Science Experiment Specialist
C. Petitjean	(Paul Scherrer Inst.)	J-PARC IAC Member
L. I. Ponomarev	(Kurchatov Inst.)	Muon Science Theory Specialist
J. M. Poutissou	(TRIUMF Lab.)	J-PARC IAC Member, ***(MuSAC Chair)***

Observers:

R. Cywinski (Leeds Uni.)	ISMS vice-president for Europe
J.Sonier (SFU)	MS vice-president for the Americas

Appendix B:

Agenda

The 1st J-PARC MuSAC MEETING

Japan - Proton Accelerator Research Complex
Muon Science Experimental Facility Advisory Committee

Date & Time	Feb. 7 (Fri) 11:00 – 17:15
Place	KEK, Bled.4, 2nd Floor, Conf. Room 1

I. Opening (11:00 – 11:45)

11:00 – 11:05	Chairman & Secretary Election	
11:05 – 11:25	Status of J-PARC Construction	S. Nagamiya
11:25 – 11:45	Status of MLF Construction	Y. Ikeda

II. Plan of Muon Science Experimental Facility; Presentation

11:45 – 12:00	(0) Overview	Y. Miyake
12:00 – 12:15	(1) Primary Line and Target	Y. Miyake, K. Nishiyama
12:15 – 12:30	(2) Muon Beam (Channel I' Phase)	K. Shimomura
12:30 – 12:45	(3) Muon Beam (Channel II' Phase)	K. Shimomura, K. Ishida, K. Nagamine

(12:45 – 13:30) Lunch

III. Plan of The 0 Phase Experimental Program; Presentation

13:30 – 13:50	(4) μSR	R. Kadono, W. Higemoto, K. Nishiyama
13:00 – 14:10	(5) μCF	N. Kawamura, K. Ishida,
14:10 – 14:30	(6) Fundamental Physics	S. N. Nakamura, K. Nagamine
14:30 – 15:00	Free Discussion	

IV. Committee Closed Session (15:00 – 17:00)

V. Chairman & Committee Report (17:00 – 17:15)

(18:00 – 20:00) Party

第１回ミュオン実験施設検討委員会（MuSAC）

2003 年２月７日に、第１回ミュオン科学実験施設委員会が開催され、以下の２点に関する評価についての諮問がなされた。

１）第 I 期ミュオン科学実験施設建設計画の事前評価。

２）第 I 期ミュオン科学実験施設における初期の代表的実験プログラム事前評価。

委員会のメンバーは、J. M. Poutissou（会議委員長；トライアムフ研究所）を始め、秋光純（青山学院大学）池田進（高エネルギー加速器研究機構)、池田裕二郎（日本原子力研究所)、岩崎雅彦（理化学研究所)、永嶺謙忠（高エネルギー加速器研究機構)、西田信彦（東京工業大学)、三宅康博（高エネルギー加速器研究機構)、山崎良成（日本原子力研究所)、安岡弘志（日本原子力研究所)、R. H. Heffner（ロスアラモス研究所、ISMS 会長）C. Petitjean（ポールシュラー研究所)、L. I. Ponomarev（クリチャトフ研究所）等国内外の物質科学、ミュオン科学、加速器の専門家である 13 名の方々であった。また、オブザーバーとして、ミュエスアール分光物性国際連組織 (ISMS) の北米地区副会長 J.Sonier（サイモンフレーザー大)、ヨーロッパ地区副会長 R. Cywinski（リーズ大)、及び横溝英明（日本原子力研究所）3 名のうち 2 名が参加された。

答申の骨子（Executive Summary）:（訳）

J-PARC で展開する最先端ミュオン施設を作り上げる建設計画を評価し、プロジェクト初期に旗頭になるような代表的な実験計画を選定する事を目的として、ミュオン科学実験施設検討委員会が発足した。

J-PARC ブースター RCS から得られる大強度 3GeV 陽子ビームを用いて、ミュオンビームを創り出すミュオン施設の構築が提案されている。ミュオン施設は、3GeV 中性子源の上流に位置し、中性子フラックスに 10% 以上の影響を与えない事を前提に運転される。ミュオン源周囲の放射線環境を考慮すると、標的近傍に位置するビームチャネルは可能な限りすべて、陽子ビームが打ち込まれる前の段階で設置されなければならない。

J-PARC ミュオンサブグループは、ミュオンコミュニティからの要望を満足させるために、一つの生成標的から 4 セットのミュオンビームラインを引き出す事を計画している。これを受けて、当委員会は、ミュオン源並びに標的近傍のビームチャネルの設計に関する評価を行った。結論として、本計画は非常によく検討されており、運転時に直面する難しい環境をも十分考慮して計画されている。ミュオン源の設置に当っては、中性子源の工学設計との調整を十分に行い、施設全体を最適化し、矛盾が生じないようにしなければならない。

限られた財源のなかで、当初は表面 / 崩壊ミュオンチャネルが唯一のビームラインとして建設される。しかし、旧来の表面ミュオン、高エネルギーミュオンビーム、超高強度表面ミュオン（スーパーオメガ）ビームなどを将来出せるような施設拡張の道筋も明瞭に示されている。

これらのミュオン施設の中でも、とりわけスーパーオメガビームチャネルの開発は極めて興味深く、将来、超低速ミュオンビームや、マイクロミュオンビームの実現にむけた道を切り拓くものである。得られるミュオンビーム強度を考えると、大強度に則した新しい装置の開発が肝要である。今こそ、新しい実験装置、並びに新しい測定手段を決定する為の開発研究を行うことをコミュニティに奨励すべきであろう。

ユニークで重要な新しい知見が得られる事が予測される物質科学（中性子コミュニティとの潜在的なオーバーラップが期待される）に関する研究計画、ミュオン触媒核融合に関する研究計画、基礎物理の検証に関する一連の研究計画が提示された。これらの “模範となる実験” を満たすために必要な要求項目を早急に決定し、加速器開発担当者のみならず施設の設計担当者に対して、指針を提示しなければならない。

限られた予算のなかでは、運転初期段階にミュオン生成標的周辺の遮蔽などの諸作業を十分保証することができない。この問題はミュオンだけでなく中性子のコミュニティの為にも指摘されるべきであろう。