JAEA-Review
2010-063

JAEA-Review

Proposed Plan for a JAEA Internationalization Initiative (JII)

(Contract Research)

Paul R. BOLTON, Jun'ichiro MIZUKI and Shunichi KAWANISHI

Photo-Medical Research Center

January 2011

Japan Atomic Energy Agency

日本原子力研究開発機構

独立行政法人日本原子力研究開発機構　研究技術情報部　研究技術情報課
〒319-1195　茨城県那珂郡東海村白方白根 2 番地 4
電話 029-282-6387, Fax 029-282-5920, E-mail:ird-support@jaea.go.jp

JAEA-Review 2010-063

Proposed Plan for a JAEA Internationalization Initiative (JII)

(Contract Research)

Paul R. BOLTON, Jun'ichiro MIZUKI+ and Shunichi KAWANISHI

Photo-Medical Research Center,
Japan Atomic Energy Agency
Kizugawa-shi, Kyoto

(Received October 29, 2010)

Concepts for a JAEA Internationalization Initiative, JII are presented. Following a general discussion of issues and recommendations for JII, a 'fast startup JII' is proposed in the form of fast start action items (FSAI). The FSAI represent a clear set of action items that can be implemented at the KPSI/PMRC site which would serve as a seed site for test and evaluation. A JAEA Internationalization Initiative that is guided by evaluation and tailored for JAEA as a whole can be established with appropriate oversight and tracking at each JAEA site by local JII teams. In addition to recommendations for the KPSI/PMRC seed site, the roles of the Quantum Beam Science Directorate (QuBS) leadership and the International Affairs Department (IAD) of JAEA are also discussed. Current KPSI/PMRC activities that are consistent with a JII are briefly presented.

Keywords: Internationalization, English Proficiency, Foreign Researchers, Foreign Collaboration, Global Relationships, Exchange Program, Magnet Facility, Cultural Diversity, KPSI/PMRC Seed Site, Initiative Evaluation

+ Quantum Beam Science Directorate

JAEA-Review　2010-063

JAEA 国際化戦略に関する提案

（受託研究）

日本原子力研究開発機構　光医療研究連携センター
Paul R. BOLTON, 水木　純一郎[+]、河西　俊一

（2010 年 10 月 29 日　受理）

日本原子力研究開発機構(JAEA)が世界に開かれた研究機構となるためには、JAEA が名実ともに国際化されなければならない。本レポートは、JAEA における国際化のあるべき姿を議論することによって現在の問題点を明らかにし、国際化のためにすぐに取り組める項目について提案する。最終目標は JAEA 全体の国際化を目指すものではあるが、試行拠点として木津の関西光科学研究所、光医療センターを選び、そこで現在行われている国際化のための活動、改善点、新しい試みを提案し実行する。これらの活動を支援するとともに評価するために拠点に国際化チームを組織することを提案する。また、国際化チームと量子ビーム応用研究部門、国際部との関係も提案する。

関西光科学研究所：〒619-0215　京都府木津川市梅美台 8-1-7
＋　量子ビーム応用研究部門

Contents

1. Introduction ---- 1
2. 'Precis' of Fundamental Concepts---- 2
3. Important Issues for JAEA Internationalization – General Concepts: ---- 3
3.1 Presence of Foreign Researchers---- 3
3.2 The KPSI/PMRC Site as a JII Seed:---- 4
3.3 QuBS/JAEA Oversight and the International Affairs Department:---- 9
4. Present KPSI/PMRC Activity---- 11
5. Proposal for a 'Fast Startup JAEA Internationalization Initiative' (JII):---- 12
6. Concluding Comments: ---- 17
Acknowledgement ---- 18

Appendix 1 Typical Routine Support Needed by Foreign Visitors During Their Stay---- 20
Appendix 2 Current KPSI Procedure for Inviting and Receiving Foreign Visitors---- 20
Appendix 3 Glossary of Abbreviations---- 22

目 次

1. 序論---- 1
2. 基本的概念の要約---- 2
3. JAEA 国際化のための重要なポイント：国際化とは？---- 3
3.1 外国人研究者数の増加---- 3
3.2 関西光科学研究所/光医療センターを例にして---- 4
3.3 量子ビーム応用研究部門/原子力機構全体と国際部との関係---- 9
4. 関西光科学研究所/光医療センターの現在の国際化に関する活動状況---- 11
5. 原子力機構の国際化のためにすぐに取り組める項目---- 12
6. 結論---- 17
謝辞 ---- 18

付録１ 外国人研究者が必要としている日常的な事柄---- 20
付録２ 関西光科学研究所における外国人研究受け入れに対する手続きに関する流れ---- 20
付録３ 短縮語の説明---- 22

This is a blank page.

1. Introduction

This effort and this document are timely. Following discussions with the QuBS leadership and researchers and in response to a request by JAEA Executive Director, S. Okada we offer this report and proposal draft which is aimed at launching a JAEA Internationalization Initiative (JII). We present this work as a fast start or seed for JAEA internationalization which we describe as an active process for all of JAEA. The 'process' viewpoint means that methodology, guided growth and adaptability are important in achieving the desired end result. With envisioned JII growth, choices in the process can be validated along our path by evaluated successes. We therefore mean internationalization to be an active process in which we cultivate and establish constructive global relationships that are further nurtured internally by a fostering and supportive micro-culture within JAEA.

In this new century we must understand JAEA in a global context and coordinate with a mosaic of worldwide activity. Global engagement in matters of science and technology is not only valuable and important, it is essential. The complexity and diversity of modern scientific and technology mandate a global attitude and a global agenda if we are to achieve and sustain state-of-the-art research. This means developing constructive international relationships that must also be appropriately coordinated and managed. Our future development cannot be isolated and our mindset cannot be insular. We should aggressively pursue the advancement of science and technology with a borderless attitude.

JII is proposed and recommended as a critical next step toward building these constructive, meaningful global relationships in parallel with the supportive micro-culture within JAEA. Inherent in the dynamics of JII activity is the flexibility or adaptability that is essential for its success. Also inherent is the necessary increased interaction with and presence of foreign researchers that are typically synonymous with increased use of spoken and written English. The JII effort will aim to guide, facilitate and coordinate increased foreign relationships and direct foreign involvement at JAEA. This document includes a first proposal for a 'fast startup JII' that can be understood and supported at many levels within JAEA.

In this work a 'foreign' researcher is considered to be one from a foreign country who does not speak or read/write the Japanese language. It is also understood that the abbreviations KPSI/PMRC include not only the Kansai Photon Science Institute and the Photo-Medical Research Center that was spawned from it but also the Harima site at Spring-8.

Following this introduction a précis of basic recurring concepts is given in section 2. Section 3 provides a detailed description of general concepts in three parts 1, 2 and 3. Present activity at

KPSI/PMRC that is consistent with JII is given briefly in section 4. It is section 5 that presents the proposed 'fast startup JII' in point form. These points are taken from the general discussion of section 3 and have been selected to define a clear 'fast startup JII' that can be easily understood and evaluated in order to 'tailor' a program to JAEA. Concluding comments are made in section 6. Appendices provide background information about basic activities where foreigners need routine help (appendix 1), what is currently done at KPSI to bring in foreign visitors (appendix 2) and a glossary of abbreviations (appendix 3). ***Thoughout this document key concepts, key recommendations and problematic issues that need to be addressed are highlighted in bold italic font.***

2. 'Precis' of Fundamental Concepts

Many key concepts recur in this document as linking threads for what is presented. The activities that comprise the proposed 'fast startup JII' are based on these few fundamental themes. Key among them is the need to engage with foreign researchers. This includes collaborations, exchanges, a foreign presence, recruiting, hosting international events and local support. Synonymous with foreign engagement is the enhanced use of the English language which would be manifested for example at meetings (with translators where needed), in seminars and colloquia, with website development and in publications. Foreign engagement brings cultural diversity and a global connectedness to the institution. Of course pursuing an internationalization initiative can require skilled coordination and management of multiple collaborations and agreements. Also it will be critical for us to have 'magnet' research facilities and programs for attracting foreign involvement in the first place.

The proposed 'fast startup JII' must be a clear, bold program of change that is also flexible in its implementation. Also key to this program is guided growth or evolution based on evaluation and a multi-site JAEA-wide effort that ultimately emerges from a 'seed' effort at KPSI/PMRC with appropriate oversight and efficiency.

In what follows all of these ideas are discussed in more detail.

3. Important Issues for JAEA Internationalization – General Concepts:

3.1 – Presence of Foreign Researchers

It will be essential for KPSI/PMRC to comprehensively and explicitly prepare for a future with a greater foreign presence. JII will mean an enhanced foreign presence in the form of collaborations, physical presence of foreign researchers and researcher exchange programs. The consequent broader use of the English language can play a major role in opening doors to a global, multicultural scientific research environment. For good examples we can look to other progressive institutions that have a significant and mandated foreign employee component. It is essential that we remove obstacles that can discourage and/or disable healthy scientific exchange with foreign researchers. This exchange is the lifeblood of internationalization. Therefore we must do our homework right and prepare accordingly. Getting the right foreign talent means first identifying and prioritizing site-wide scientific and technical areas where foreign expertise can be a significant benefit to us. It also means that we must advertize offered employment positions globally with international job search networks, well-known foreign websites and publications. It means that we need to establish 'magnet' facilities and research programs here that will attract desired foreign talent. Finally, we must be ready at KPSI/PMRC to host and support foreign visitors during their stay in Japan.

Of course there must be a lot of help going both ways. ***The foreign visitor needs much assistance from Japanese staff and much of it is about translation from Japanese to English.*** If this is not appropriately addressed the foreign visitor can rapidly become isolated. Appendix 1 lists typical examples of basic common tasks where this help is routinely needed. For these visitor needs KPSI/PMRC individuals can be assigned to provide this kind of support. It is particularly important for a high level senior foreign scientist who has significant responsibility at JAEA to have an assistant assigned to him or her for general daily translations, frequent assistance such as indicated in Appendix 1 and for carrying out higher level functions such as planning international meetings and visits. Furthermore for all foreign visitors we must continue to hire professional technical translators for important meetings and documents such as proposals and training courses. Where possible, it is also good for young foreign researchers to have an onsite mentor (such as a senior Japanese colleague with experience working abroad) to provide general advice, guidance and support during their time here.

In the case of senior foreign scientists it is good to consider accommodating various appointment types and arrangements. This could include for example sabbatical terms and also part-time or cross-appointments where the scientist shares his/her time between a home institution and JAEA. Such arrangements with other institutions (particularly academic) can be fertile ground for cooperative research programs, young researcher exchange and foreign hires.

Also in many cases young researchers might be more available to start in October and this should be made possible at JAEA. In general we need to be flexible and compatible with foreign academic and institutional calendars where April start dates are less likely.

Longer term career paths for foreign scientists can become an issue that results from our success with JII. In special cases the duration of stay can extend to years. In this case there needs to be a clear JAEA policy that allows for professional promotion and other career advancement of nonJapanese employees to higher leadership levels. Having foreign-born leadership at various levels can set a clear and powerful example of internationalization for JAEA and further expose JAEA to international thinking.

3.2 – The KPSI/PMRC Site as a JII Seed:

A 'fast startup JII' is proposed that begins with an appropriate seed site for initial test and evaluation aimed ultimately at the development of a JAEA – wide JII that is 'tailored' to this agency. ***The selected seed site is KPSI/PMRC where it is important to develop an environment of cultural diversity and English communication that facilitates the exchange and understanding of global viewpoints.*** This is fundamental to healthy scientific research here in this century if it is to be globally relevant. ***The broader use of English onsite is necessary.***

Use of English:

It is important for foreigners to access our websites to learn about who we are and what we are doing. We need to attract them to KPSI/PMRC. ***To this end it is necessary to review our English website development and to establish a single comprehensive plan for doing this as a coherent site-wide effort.*** This can later be extended to all of JAEA as JII grows. We need an inviting website where for example, we can advertize our laser capability at KPSI, Guest House accommodations and solicit foreign proposals for laser time (with contact information, etc). A coherent site-wide plan can also include the steps now being taken to create an English C-PhoST website and the ongoing development of the English PMRC website that reports the PMRC Colloquia and 'PMRC News'. In this plan it is also wise to consider an on online format for newsletters such as 'PMRC News'. In this way our English newsletters become dynamic allowing for continuous updates. This type of thinking also opens the door to other international newsletters that we might wish to develop. We cannot do this alone and must not try – one of the keys to

success with our English website development is discussion, consultation and planning with foreign visitors and foreign institutions that have successful, well-developed websites.

We know that the use of English onsite can be enhanced at many levels and in many ways. It is good to highlight some critical areas***. Training classes for safety and security for foreigners must be professionally translated.*** There can be a serious liability issue here; particularly if a foreign visitor is injured in the laboratory. Group meetings in which foreign researchers are expected to meaningfully participate should be conducted in English as much as possible. An English translation should be promptly available for important meetings that were not conducted in English. Meetings that foreigners are expected to attend should also be announced in English (such as seminars and all-hands meetings and whether it be by audio or email or both). The Photon Science and PMRC Joint Seminar can be made an English seminar series (as much as possible) that also provides a friendly setting for researchers to practice their oral conference presentations. In general we should expand the successful PMRC colloquium series to include all of KPSI where English presentation remains mandatory. This means it is important to resume the funding we enjoyed in previous years in order to attract speakers who are leaders in their field. As we know, this essential funding has been eliminated this year due to JFY2010 PMRC budget constraints.

Finally, proficiency with written English is critical for publication of KPSI/PMRC manuscripts in competitive international journals such as Science, Nature and Physical Review. It is important for KPSI to make a workable plan for this to happen in a seamless manner that minimizes burden to the foreigner and preserves intrinsic flexibility. Foreign researchers, junior and senior, should be asked to participate in an organized system of English writing consultation in which Japanese researchers directly get the help they often need to publish their work in these competitive international journals. For example a foreign researcher might agree to help with manuscript preparation for at least one identified KPSI/PMRC group with which he or she works closely. Members of that group can be made aware of this offer of help that would be made available at their request. Of course this help is available by default in cases where the foreign researcher is a co-author of a given manuscript. We can consider making this a mandatory activity for senior foreign hires and voluntary for junior foreign hires such as postdoctoral appointees. This is a critical matter that not only can boost our publication rate in world-class journals but it also helps foreign researchers to better understand our research efforts, increases the use of English on site, promotes open scientific discussion in a culturally diverse setting and enhances the cultural exchange overall.

It is also clear that for JII to succeed we need to hire support staff at KPSI/PMRC with strong English skills. This will become more obvious with the proposed 'fast startup JII'. We can also encourage and help interested employees to find English classes (web-based or otherwise).

Attracting Foreign Researchers:

Of course, we must first attract these foreigners. We need 'magnet' facilities and programs at KPSI/PMRC that will attract good foreign researchers that can help propel our agenda with a global attitude. This means upgrading our laser systems for use by external users. In addition to the laser system capability this must include upgraded laser operations, instrumentation capability and reliability for laser beam time. It is very helpful to allocate a fraction of laser time for foreign users (there is a 20 % quota at J-KAREN for external users but we need to encourage foreign external users). The KPSI committee that allocates laser time can be directed to make this happen. Our facility capabilities should also be advertized on an English website where we can solicit external proposals for laser beam time and invite feedback. A review of our laser capability (current and projected) and requirements for users needs to be conducted. Naturally it will be important and helpful to evaluate foreign user activity at KPSI and to seek feedback from users in order to improve as we proceed.

We can open our doors and bring many foreign scientists to KPSI/PMRC by hosting /organizing international events such as symposia and workshops. Of course, such activity serves JII in many ways. A good example of this is the Second International Symposium on Laser-Driven Relativistic Plasmas Applied to Science, Industry and Medicine that was hosted by KPSI/PMRC in January of 2009. We should examine our track record with this kind of global leadership activity and continue to promote it. Here are two excellent examples of co-hosting and co-organizing such events with foreign institutions: (i) in August 2010 PMRC (Paul Bolton) co-chaired (with David Neely, RAL and Fridtjof Nuesslin, TUM) a pioneering workshop in the UK that focused on instrumentation for diagnostics and control of laser-accelerated protons and (ii) next year PMRC (Bolton-san) will help launch a new Italian laser-acceleration program (PROMETHEUS) in Bologna by heading the International Advisory Board and assisting with program planning. It is worth noting that, at the request of its participants, the UK workshop will continue as an annual diagnostics event at various sites (in Paris for 2011, in Darmstadt for 2012, possibly in Munich for 2013, and hopefully one at KPSI/PMRC). We must pursue this level of leadership to maintain a vitality and visibility in our global relationships. Another good example for a future co-hosted/co-organized event would be an international symposium on applications (medical and nonmedical) of laser-accelerated ions which is currently under consideration.

Site-wide it is also very helpful for us to assess and prioritize our needs for foreign talent and expertise. In consultation with KPSI/PMRC group leaders and Deputy-Directors we can identify technical areas where this need is important and prioritize them. Eventually this can be done at many JAEA sites to compile a JAEA-wide prioritized assessment of requirements for foreign skills. Foreign hires should reflect these priorities in a coordinated manner. These needs can also be met in part if we have a funding program for KPSI/PMRC researchers to spend quality time conducting research abroad for several months. To date, this has been done only to a very limited extent. Sending our researchers abroad can help with English skills, with awareness of foreign programs and state-of-the-art technologies and also can promote a diverse attitude in our workforce.

If we are to succeed in attracting more foreign scientists then we must establish a healthy track record of local support. It is wise to establish organized procedures at KPSI/PMRC for supporting foreigner visits beyond the arrival. As mentioned in section 3 A, in the case of a senior foreign scientist an assistant should be officially assigned to him or her to address these needs and to support the high level work that is contractually mandated. Reference has also been made to Appendix 1 that lists examples of routine assistance typically needed by foreign visitors on a weekly (and even daily) basis. These menial items can be time consuming and it is wise for assigned staff to address them explicitly.

Opportunities for Foreign Collaborations:

We must encourage our group leaders at KPSI/PMRC to seek healthy collaborative relationships with foreign institutions and laboratories. These can become the basis for cooperative research programs, researcher exchanges and foreign hires. An excellent example of this is our development and promotion of a cooperative research agreement between PMRC and a Munich consortium that includes the Munich-Centre for Advanced Photonics (MAP), the Technische Universitat Munchen (TUM) and the Ludwig Maximilians Universitat Munchen (LMU). There is also great potential for research agreements and organized collaborative experimental campaigns with the LIBRA program in the UK and with the new PROMETHEUS program in Italy which will likely be funded. Cooperative efforts like this can significantly help all parties in many ways. It is very important to recognize that the coordination of collaborative research activity and foreign hires helps to avoid redundancy and to guarantee that our identified needs are being met effectively. Throughout all of this, we aim for a global standard.

It will be of great value to have an individual ('czar') at KPSI/PMRC for whom a key function is to be broadly and currently informed about funding opportunities with foreign programs that would include: funding schemes for fellowships for foreigners (also JSPS programs), researcher exchange programs, and details of grants made available by Japanese (eg. JSPS) and foreign agencies for international meetings and multi-institutional programs. This local 'czar' of foreign opportunities could thereby inform and assist KPSI/PMRC researchers and leaders through education, general dissemination of information (such as deadlines) and assistance with grant applications. Clearly this must be someone with adequate English skills. The local 'czar' might also be the right person to help KPSI/PMRC leaders recruit globally in appropriate international publications and websites for foreigner researchers to come to KPSI/PMRC. IAD can be involved in some way in this effort by the 'czar' to increase awareness of possible foreign opportunities. It is recommended that the 'czar' be a member of the local JII team that is introduced below.

As with foreign researchers we can also consider in the longer term allowing nonforeign (Japanese) researchers at KPSI/PMRC to have cross-appointments with other institutions and laboratories. With some KPSI researchers having other academic appointments it might be easier to establish foreign collaborations and research exchanges from which KPSI can benefit. There is potential here for enhanced flexibility.

A Local JII Team is Needed to Make JII Happen:

It will be necessary to have a local JII team in place at KPSI/PMRC to help with and oversee the startup JII plan, to track it and report about it to QuBS leadership and to IAD. This body can also verify that foreign visitors are getting the support they need. We recommend that this team consist of two or three people at KPSI/PMRC who speak English very well and have significant experience handling foreign visitors. The time commitment for team members would be very small. The team can be selected and lead by a senior foreign visitor such as Paul Bolton (who is happy to do this). This team leader would regularly report to QuBS leadership on JII progress. A member of this team (selected by the team leader) will also serve as a liaison or contact person to IAD who will provide information to IAD for a new JII link on the JAEA website that will highlight JII progress and events (discussed in section 3.3 below). The liaison member would also be the primary contact between IAD and the local JII team. Another team member would be the 'czar' recommended above.

As JII evolves we can anticipate that the sum of many such local JII teams from each relevant JAEA site can altogether comprise a 'JII Task Force'. A JAEA-wide task force like this can also include an IAD member. In fact, as JII grows it will be interesting to consider having the liaison members of each local JII team (at each JAEA site) become IAD employees. As mentioned below the local JII team can help to plan annual or semi-annual JII events (including an initial launch) jointly with IAD (and QuBS leadership) and also nominate recipients for a 'JII Award'. Although the local JII team will help to implement the fast startup JII, we anticipate that QuBS leadership would regularly conduct evaluations and make important decisions about JII to guide its growth. Figure 1 illustrates the proposed local JII team and JII Task Force relationships.

Getting Started and a JII Award:

Finally, to get started it will be essential at the beginning for QuBS and IAD leadership to educate KPSI/PMRC employees about the JII program and how it is to be implemented. This can be done through emailed material and all-hands presentations to the staff. For example, to initially launch the fast startup JII program we can consider an all-hands presentation by IAD in the main conference hall followed by a banquet to which all foreign visitors are invited. Following such a launch event IAD can continue this trend for another two or three years as needed, highlighting JII in follow-up annual or semi-annual events that can be short workshops about international issues/programs followed by a banquet. This type of visibility and activity is important to maintain the health of JII. The local JII team would assist with this planning and be the contact.

It is also constructive and encouraging to offer more official and visible recognition of KPSI/PMRC employees who make significant contributions to JII. This kind of encouragement can have lasting positive effects. We recommend consideration of a 'JII Award' that is well-recognized throughout JAEA and given by the JAEA President. The local JII team recommended above can provide nominations for this award.

3.3 - QuBS/JAEA Oversight and the International Affairs Department:

It will be essential for QuBS leadership and IAD to remain closely coupled to a JII effort at the KPSI/PMRC site; particularly in the early stages. This coupling and supervision would extend to other relevant JAEA sites as JII grows. We discuss here some clear ways to establish and maintain this coupling as well as the needed informed oversight. As has already been stated, we anticipate that the leader of the local JII team at KPSI/PMRC will report to QuBS leadership on JII progress and that QuBS leadership

will evaluate and make decisions to steer JII (as shown in figure 1). We recommend that JII become a regular agenda item for QuBS leadership meetings. Reporting to QuBS leadership by the local JII team leader can be done quarterly or semi-annually as needed or requested.

We have also recommended that a member of this local JII team at KPSI/PMRC be a liaison or contact person for IAD. This individual can be responsible for providing IAD with JII-related information (news, announcements, highlights, photos etc…) that can be posted to a new JII link (in English) on the JAEA website. IAD can manage this new JAEA website link to provide a continuously updated JII story for JAEA employees and foreigners. Of course, this new link can also feature other IAD activity. We have also stated how a JII Task Force for all of JAEA can be comprised of several such local JII teams – one from each JAEA site (see figure 1). This would develop as JII grows. We have already suggested that over time we can consider making the liaison team member (from each JAEA site) an IAD employee. We did recommend in previous sections that as JII grows some IAD employees can be officially assigned in some way to this multisite task force. In this way IAD remains aware of how JII is progressing first hand.

These ideas can represent an expanded role for IAD at JAEA. This would also facilitate discussion between IAD about how to simplify and expedite the process for inviting and receiving foreign visitors. Appendix B presents the current order of events pursued for this at KPSI/PMRC and it now spans about a two month interval. In the interest of flexibility and efficiency it will be good if we can reduce the overall time required for processing foreign visits down to one month or less.

In addition to the recommended all-hands meeting to get JII started, we have mentioned how follow-up events over the following few years can be held annually or semi-annually with a short banquet to which all foreign visitors would be invited. IAD (and possibly QuBS) can plan these events with local JII teams. This would represent a celebration/recognition for JII in the form of a brief afternoon workshop in which successful international programs (those worthy of example) can be described to JAEA employees highlighting the nature of and reasons for their success. Scientific, technical and administrative aspects of suitable programs can be described as motivation to other researchers. It can start at KPSI but as JII grows it can be held at other sites and can include more international efforts. At these meetings ‘JII Awards’ could be given.

It is a good exercise to explore how we can make use of our foreign offices to promote some of these ideas. For example in the countries where they are located might they be helpful in addressing opportunities for foreign bilateral proposals of collaboration, developing research agreements, promoting

JAEA openings for foreign researchers and researcher exchange programs and assistance with visas. Can we do more here and in a more official explicit way ? QuBS and IAD can consider this matter. Certainly all JAEA foreign offices need to be informed about JII.

It will be very helpful if the JAEA employee directory can be modified for easy use by foreign visitors. For example, results of foreign people searches are displayed in English but foreigners have no guidance on how to start a search. The initial display is all in Japanese. An English display for the directory will be quite valuable. In general the JAEA employee directory should be upgraded to be foreigner friendly.

It will clearly become necessary and appropriate for IAD to expand if JII grows as we recommend. As with almost everything we do, this raises budgetary issues. It is also advisable for QuBS to plan for budget requirements for enhanced foreign hire programs and 'magnet' facility upgrades that will be designed to attract the best foreign researchers.

4. Present KPSI/PMRC Activity

In response to the June request by JAEA Executive Director, S. Okada we make note here of current activities (extended over the past three years) at KPSI/PMRC that are consistent with (and possibly precursory to) a JII agenda.

Foreign hires have included one of us, Paul Bolton (in January 2008) to be the Scientist-in-Chief and Deputy-Director-General of PMRC as well as a Russian couple, Anatoly Faenov and Tania Pikuz who were visiting JAEA Fellows at KPSI for a three year term beginning in 2007. Brief researcher visits (three months) at KPSI have included experimentalist, Sergei Gasilov from Russia in late 2009 and laser physicist, Klaus Ertel from the UK in early 2009. Dr. H. Kiriyama of KPSI was funded in early 2008 by the JSPS ICHEDS program (at Osaka University) to visit the Central Laser Facility (STFC) of RAL.

In our efforts to connect with the global community KPSI/PMRC organized and hosted the "International Workshop on Laser-Driven Ion Sources Applied to Industry and Medicine" in March of 2008 and the "Second International Symposium on Laser-Driven Relativistic Plasmas Applied to Science, Industry and Medicine" in January of 2009. PMRC (Paul Bolton) also co-organized and co-chaired an international workshop in Abingdon, UK that focused on instrumentation for diagnostics and control of laser-accelerated proton (ion) beams. This was the first workshop of its kind on this timely subject matter

and will continue as an annual meeting. PMRC is also represented (by Paul Bolton) on a new international task force formed jointly by the International Committee for Future Accelerators (ICFA) and the International Committee on Ultra-High Intensity Lasers (ICUIL) to explore and highlight high power laser requirements for laser-driven particle accelerators. PMRC is now finalizing details of a cooperative research agreement with a consortium in Munich, Germany that consists of the Munich-Centre for Advanced Photonics (MAP), the Ludwig-Maximilians Universitat Muenchen (LMU) and the Technische Universitat Muenchen (TUM).

There are satellite efforts at KPSI/PMRC to connect with foreign colleagues and institutions through English websites. PMRC publishes a quarterly newsletter, 'PMRC News' that is posted to the English PMRC website as are the PMRC Colloquium presentations. PMRC Colloquia are presented in English by speakers who are typically foreign researchers who lead in various research fields. We also established the "Photon Science and PMRC Joint Seminar" which is less formal than the colloquia and occasionally delivered in English. The C-PhoST program is also developing an English website. There are also isolated individual examples of globally extending our 'scientific reach' at KPSI (Sergei Bulanov in particular).

The use of English at KPSI/PMRC needs further encouragement and development in the context of JII. A 'fast startup JII' will bring focus, organization, coordination and basic management to collaborative and all outreach efforts at KPSI/PMRC. These elements are essential for success. Furthermore, the previous and following sections show that there is much more that we can do and that the efficacy or our efforts can and should be evaluated.

5. Proposal for a 'Fast Startup JAEA Internationalization Initiative' (JII):

This section presents the bottom line of this document and a first basic goal of the JII program which is to define a clear, energetic plan of action for a 'fast startup JII'. The preceding discussion includes many items to think about. In an effort to define a quick and concrete start several items have been extracted from the above and are proposed as **'fast start action items' (FSAI)** to launch the JII. This section deals with these selected action items and a key word is **'Now'**. It is recommended that this launch include an initial test/evaluation phase for selected items to determine their efficacy and to 'tailor' the program to JAEA. The details of this can be established by QuBS leadership by determining the extent to

which test and evaluation of a specific activity (FSAI) at KPSI/PMRC is necessary prior to adopting it as part of the longer term JAEA-wide JII strategy.

This is consistent with JII as a dynamic process in which JII growth is guided by QuBS evaluation and decisions. It has been advocated in previous meetings on this subject matter, that selected FSAI must comply with the following basic four criteria: (i) they must be clear, concrete, positive and visible action items that can be easily discussed and understood, (ii) by their nature the FSAI must be an explicit seed or preliminary step for a larger, more permanent JII effort that evidences our JAEA-wide vision, (iii) the FSAI must be easily tracked, reported and evaluated and (iv) we must be able to apply the FSAI with flexibility (possibly site-dependent) where needed. The FSAI are numbered and listed in this section to simplify the plan presentation and to provide emphasis. Listed below are the FSAI chosen to constitute the 'fast startup JII' plan that is recommended at KPSI/PMRC as the local seed:

For the KPSI/PMRC Site (20 FSAI) *(items in italic font have either the potential for a small incremental cost in the future and/or have had more discussion at KPSI/PMRC)*

1. establish the local JII team at KPSI/PMRC (two or three people) to track, oversee and report (to QuBS leadership) on progress with the fast startup JII (Paul Bolton selects and leads this small team – it requires a very small time commitment from its members)
2. the liaison member of the local JII team will provide updated information to IAD for posting to a new JII link on the JAEA website (this link can be managed by IAD) and also be the primary contact between IAD and the local JII team
3. the 'czar' member of the local JII team will become well informed about grant opportunities (from Japan and abroad) for foreign activity that can include meetings, collaborations, coordinated research, hires, and exchanges; this individual will also
   be expected to educate KPSI researchers about all foreign opportunities and assist with applications
4. KPSI/PMRC and IAD jointly plan a kickoff for the 'fast start JII as an all-hands meeting/ workshop/banquet event
5. establish the first 'JII Award' to be given following the first year of JII (details of the award can be established later and after appropriate discussions)
6. further develop the 'PMRC News' newsletter (if PMRC is funded)

7. *expand the PMRC Colloquium (to include KPSI) and resume funding domestic travel for colloquium speakers*
8. English presentations as much as possible for the Photon Science and PMRC Joint Seminar
9. *acquire professional technical English translations of essential safety and security training courses for foreign hires and visitors (also critically needed to support foreign users of our laser facilities such as J-KAREN)*
10. *resume funding for professional translators for foreigners for important meetings and documents*
11. where possible announce and conduct meetings in English when foreign visitors are expected to participate
12. *longer term foreign scientists hired into high level positions must officially have assigned to them a KPSI/PMRC assistant with good English skills. It is understood that this would be one of the official duties of the KPSI/PMRC employee.*
13. establish the 'system of English writing consultation' program with foreign hires that is aimed at significantly enhancing our publication rate in English international journals of high ranking and at enhancing cultural exchange with foreigners
14. in order to open the door for international collaborations KPSI/PMRC makes a site-wide comprehensive plan for English website development that must include advertizing laser capability, soliciting beamtime requests from foreign users, Guest House accommodation, and special programs like PMRC and C-PHoST
15. *designate a portion of user beam time at our lasers (especially J-KAREN) to foreign users. For example this could be at least half of the 20 % beam time that is currently allocated to external users.*
16. to open our door and attract foreign users we need a clear plan (time and cost estimates etc…) for upgrading the J-KAREN laser facility (and possibly other laser systems at KPSI) to 'magnet' status for users. This should include for example state-of-the-art laser performance, instrumentation and operations, safety courses that are professionally translated into English, high reliability and promotional activity (website advertizing and soliciting). It is recognized that KPSI does not presently have such a plan and that KPSI would need to develop it.
17. request that each group leader consider foreign institutions or laboratories that can be viable candidates for extended collaborative and cooperative activity with the subject matter also

identified; as an excellent example finalize the cooperative research agreement between PMRC (if funded) and the Munich consortium (MAP)

18. exercise flexibility with start dates for foreign hires
19. work with IAD to assess and reduce the processing time for foreign visits (as outlined in appendix B) to one month or less
20. rigorously assess the following: technical subject areas or programs of research and development where foreign expertise is critical and prioritize them; foreign websites and key publications for advertizing openings at KPSI for foreign researchers; possible international events that we can co-host and co-organize jointly with foreign institutions for which a good example is an international symposium on applications for laser-accelerated ions co-chaired by Bolton-san with the Central Laser Facility at RAL.

For QuBS Leadership and IAD (9 FSAI)

1. QuBS leadership use results that are regularly reported by the local JII team leader at KPSI/PMRC to evaluate these items and steer JII as an ongoing part of their agenda
2. QuBS to determine which FSAI are to be initially tested and evaluated for the startup
3. make JAEA employee directory foreigner friendly
4. establish the 'JII Award' – determine award details with KPSI/PMRC
5. establish the new English JII link on the JAEA website for displaying JII progress (and other IAD activity) to the world; a designated IAD member is to coordinate with the local JII team at KPSI/PMRC (i.e. the liaison member of the team) for routinely acquiring this information
6. IAD is to jointly plan (with KPSI/PMRC) an all-hands kickoff event for the fast startup JII and some follow-up annual or semi-annual workshops/banquets to highlight progress and bring foreign visitors together.
7. expedite and simplify where possible the procedure (with KPSI/PMRC) for inviting and receiving foreign visitors for both short term and longer term cases, reducing the required time interval to one month or less (it currently about two months)
8. QuBS leadership and IAD to assess the suitable role for foreign offices concerning

global advertizing for foreign hires, foreign research exchange opportunities, research agreements with foreign institutions/laboratories and grant opportunities (bilateral or otherwise) with other countries

9. *IAD should anticipate and plan for growth in size and with new types of international activity as JII expands to include local JII teams at various JAEA sites;*
   the resultant JII Task Force (which is the sum of all local site teams) can have several IAD staff members on it (suggest one for each site)

The above points together comprise the recommended fast startup JII plan. Included as one of the FSAI is the role of QuBS in deciding at the beginning which FSAI are to be tested and evaluated prior to adopting them as components of the JII as a whole for JAEA. We suggest that evaluation periods for specific activities be 1-2 years at KPSI/PMRC. However, in order to remove any local biasing, we wish to emphasize the importance and convenience of testing some items at more than one JAEA site where possible (including for example the Takasaki and Harima sites).

Bolton is willing to cooperate closely with QuBS leadership by coordinating/leading this effort (which includes selecting and leading the local JII team) to guarantee the successful and clear fast start that is needed for JII. This is noteworthy because he is a foreign scientist at JAEA who can offer significant help that is consistent with the spirit and intention of JII. JII is proposed as a new and innovative venture for JAEA with built-in flexibility or adaptability for continued growth that will help provide the strength that will be much needed to succeed. This is because the JII plan is about bringing change (consistent with one of our PMRC logos) which can also bring challenges and even some associated discomfort. QuBS leadership and IAD are urged to consider the concepts of the proposed plan in their pure and fundamental form guided by vision and motivation for the future of JAEA and not limited or determined by budgetary concerns. This is also the spirit with which we were charged to address this matter by Okada-riji in his emailed message of June 16, 2010. Our thinking for this first step for JII should be guided by such vision in order to choose action items that establish the right direction, goals and character for the future of JAEA. To be successful the fast startup JII plan must also be guided by a **bold** optimism. It is clear that the discipline and constraints of budgetary considerations will be exercised in a subsequent step, ultimately determining what we do and when. Furthermore small costs associated with some of the listed FSAI are not immediate.

6. Concluding Comments:

Note that items included in this document that were not chosen for the listed fast startup JII plan in section 5 (and many others not mentioned in this document) can be considered for future JII growth. With this dynamic approach the growth of JII is interactive and adaptive. The current century mandates this kind of growth. Many colleagues at institutions around the globe continue to express an eagerness to work with us at KPSI/PMRC. We must learn to provide quick, intelligent and healthy responses to these important requests and in a coordinated manner.

The fast startup JII is unique because we have proposed clearly defined action items that have a directed momentum. They can be tracked and evaluated. With this modest and phased approach it will be clear that JAEA is doing something for all to observe, understand and support. We are mindful that by this action we also set an example in Japan for other agencies. It is also recommended that we now begin discussions with QuBS leadership aimed at pursuing the best ideas and at what we believe should the direction of JII. We have suggested in section 5 that this be done prior to any budgetary considerations which are certain to follow once we have agreed fundamentally on how to proceed.

JII is about change. What is proposed are many changes to what is currently being done at KPSI/PMRC. We recognize that this can be a challenge and we wish to applaud the vision of Okada-riji in requesting this document. For success it is important that JII be embraced by JAEA leadership and also by all JAEA employees. Appropriately informing JAEA employees about JII is critical. We will need JAEA support from all levels.

As we submit this report and JII proposal to the QuBS leadership we continue with optimism and proceed to the second point of Okada-riji's June 16 request. An active, energetic JII that accommodates guided growth can proceed in harmony with the fundamental nature of science itself, as the intellectual pursuit of physical knowledge and wisdom for the enlightenment and benefit of all. These are fundamentally global endeavours. There is no doubt that the JII effort is timely.

Acknowledgement:

We express our sincere thanks to A. Iwata for her valuable help with manuscript contributions, detailed discussions and final preparation of this document for publication. We are also happy to acknowledge the following individuals at KPSI/PMRC and are grateful to them for helpful discussions and valuable input to this document: S. Bulanov, J. Harries, I. Jarrige, M. Kando, T. Kawachi, H. Kiriyama, K. Nakaaki, A. Sugiyama, A. Yokoyama, and K. Yokoyama.

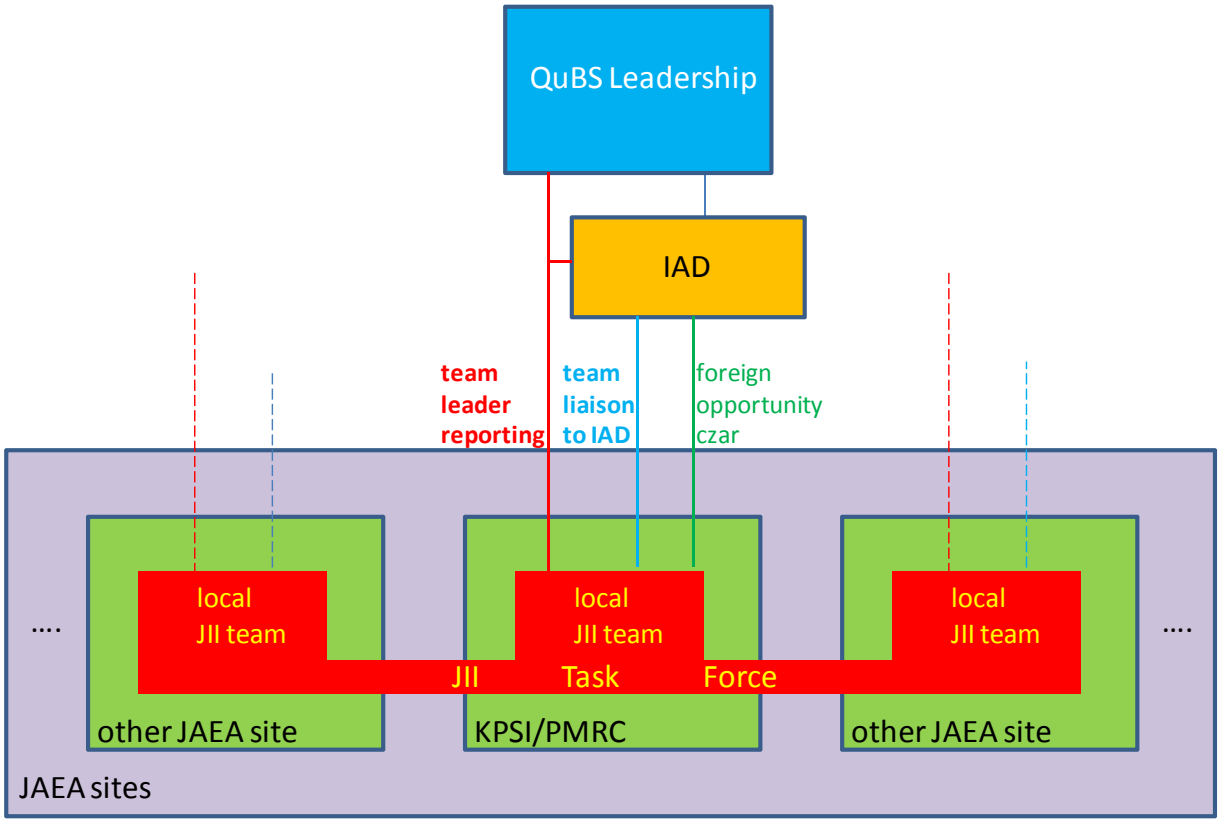

Fig. 1. Local JII teams (comprising the JII Task Force), QuBS leadership and IAD.

Appendix 1: Typical Routine Support Needed by Foreign Visitors During Their Stay

training courses – necessary safety and security training

travel - bus/train schedules, JAEA forms for planning and reporting travel

local resources – guides to supermarket, restaurants (making reservations, etc…)

e-learning – other courses as needed

notification of important upcoming meetings

translation (general) – Japanese email, necessary meetings, etc…

use of JAEA telephone directory (currently not easily used by foreigners)

monthly work day entry – Lysithea

regular password changes (these requests arrive as Japanese email)

setting up bank accounts and related activity

Alien registration card application at the Kizugawa City Hall (if appropriate)

automobile issues (translation is a main part here)

Appendix 2: Current KPSI Procedure for Inviting and Receiving Foreign Visitors

two months before visitor arrival:

I. (i) Request CV, passport copy, purpose and details of stay, and other basic information from visitor (birth date, address, telephone number, nationality, institutional affiliation and position etc…). Enquire if visitor will be conducting experiments at KPSI and whether or not a travel visa to Japan is necessary.

(ii) If visitor will conduct experiments at KPSI then submit a draft of the research agreement to IAD for approval and then send the approved draft to the visitor for signature by

foreign institution. This initial draft can be based on the language of former agreements. Iterations can be required before both parties establish and sign an acceptable agreement.

(iii) If a visa is necessary for the visitor's stay in Japan, prepare two supporting documents. First, an invitation letter in English to the visitor from KPSI/JAEA with the relevant KPSI leader signature. Second, an invitation document in Japanese for the Japanese Foreign Ministry with a KPSI leadership signature. Send these two documents to the visitor for use in the visa application.

(iv) Submit a visit plan document to IAD with the CV and passport copy based on response to I(i) above.

one month before visitor arrival:

II. (i) IAD approves the visit plan, issues air travel tickets, air tickets invoice and a cost calculation sheet for visitor costs. Air tickets are forwarded to the visitor.

(ii) KPSI (and IAD?) retains copy of signed research agreement

(iii) Using the cost calculation sheet from IAD prepare budgetary documents and have KPSI Accounting Division prepare to pay costs to visitor in cash on arrival.

(iv)Arrange for office space (if needed) and accommodation for duration of visit. For example this can include necessary approvals for use of laptop computer in the Guest House and the use of an office desktop computer

on visitor arrival:

III (i) KPSI Accounting Division pays travel costs to visitor in cash

(ii) Address other miscellaneous support issues as needed during the visit

(for example see appendix A)

Appendix 3: Glossary of Abbreviations

CLF	Central Laser Facility (in UK)
C-PHoST	Consortium for Photon Science and Technology
IAD	International Affairs Department (of JAEA)
ICHEDS	International Collaboration for High Energy Density Science
JAEA	Japan Atomic Energy Agency
JII	JAEA Internationalization Initiative
J-KAREN	JAEA Kansai Advanced Relativistic Engineering
JSPS	Japanese Society for Promotion of Science
KPSI	Kansai Photon Science Institute (of JAEA)
LMU	Ludwig Maximilians University (in Germany)
MAP	Munich Center for Advanced Photonics (in Germany)
PMRC	Photo-Medical Research Center (of JAEA)
QuBS	Quantum Beam Science Directorate (of JAEA)
RAL	Rutherford Appleton Laboratory (in UK)
STFC	Science and Technology Facilities Council (in UK)
TUM	Technical University of Munich (in Germany)

国際単位系（SI）

表１．SI 基本単位

基本量	SI 基本単位	
	名称	記号
長さ	メートル	m
質量	キログラム	kg
時間	秒	s
電流	アンペア	A
熱力学温度	ケルビン	K
物質量	モル	mol
光度	カンデラ	cd

表２．基本単位を用いて表されるSI組立単位の例

組立量	SI 基本単位	
	名称	記号
面積	平方メートル	m^2
体積	立法メートル	m^3
速さ，速度	メートル毎秒	m/s
加速度	メートル毎秒毎秒	m/s^2
波数	毎メートル	m^{-1}
密度，質量密度	キログラム毎立方メートル	kg/m^3
面積密度	キログラム毎平方メートル	kg/m^2
比体積	立方メートル毎キログラム	m^3/kg
電流密度	アンペア毎平方メートル	A/m^2
磁界の強さ	アンペア毎メートル	A/m
量濃度(a)，濃度	モル毎立方メートル	mol/m^3
質量濃度	キログラム毎立法メートル	kg/m^3
輝度	カンデラ毎平方メートル	cd/m^2
屈折率(b)	（数字の） 1	1
比透磁率(b)	（数字の） 1	1

(a) 量濃度（amount concentration）は臨床化学の分野では物質濃度（substance concentration）ともよばれる。
(b) これらは無次元量あるいは次元１をもつ量であるが、そのことを表す単位記号である数字の１は通常は表記しない。

表３．固有の名称と記号で表されるSI組立単位

組立量	SI 組立単位			
	名称	記号	他のSI単位による表し方	SI基本単位による表し方
平面角	ラジアン(b)	rad	1 (b)	m/m
立体角	ステラジアン(b)	sr(c)	1 (b)	m^2/m^2
周波数	ヘルツ(d)	Hz		s^{-1}
力	ニュートン	N		m kg s^{-2}
圧力，応力	パスカル	Pa	N/m^2	m^{-1} kg s^{-2}
エネルギー，仕事，熱量	ジュール	J	N m	m^2 kg s^{-2}
仕事率，工率，放射束	ワット	W	J/s	m^2 kg s^{-3}
電荷，電気量	クーロン	C		s A
電位差（電圧），起電力	ボルト	V	W/A	m^2 kg s^{-3} A^{-1}
静電容量	ファラド	F	C/V	m^{-2} kg^{-1} s^4 A^2
電気抵抗	オーム	Ω	V/A	m^2 kg s^{-3} A^{-2}
コンダクタンス	ジーメンス	S	A/V	m^{-2} kg^{-1} s^3 A^2
磁束	ウエーバ	Wb	Vs	m^2 kg s^{-2} A^{-1}
磁束密度	テスラ	T	Wb/m^2	kg s^{-2} A^{-1}
インダクタンス	ヘンリー	H	Wb/A	m^2 kg s^{-2} A^{-2}
セルシウス温度	セルシウス度(e)	℃		K
光束	ルーメン	lm	cd sr(c)	cd
照度	ルクス	lx	lm/m^2	m^{-2} cd
放射性核種の放射能(f)	ベクレル(d)	Bq		s^{-1}
吸収線量，比エネルギー分与，カーマ	グレイ	Gy	J/kg	m^2 s^{-2}
線量当量，周辺線量当量，方向性線量当量，個人線量当量	シーベルト(g)	Sv	J/kg	m^2 s^{-2}
酸素活性	カタール	kat		s^{-1} mol

(a)SI接頭語は固有の名称と記号を持つ組立単位と組み合わせても使用できる。しかし接頭語を付した単位はもはやコヒーレントではない。
(b)ラジアンとステラジアンは数字の１に対する単位の特別な名称で、量についての情報をつたえるために使われる。実際には、使用する時には記号rad及びsrが用いられるが、習慣として組立単位としての記号である数字の１は明示されない。
(c)測光学ではステラジアンという名称と記号srを単位の表し方の中に、そのまま維持している。
(d)ヘルツは周期現象についてのみ、ベクレルは放射性核種の統計的過程についてのみ使用される。
(e)セルシウス度はケルビンの特別な名称で、セルシウス温度を表すために使用される。セルシウス度とケルビンの単位の大きさは同一である。したがって、温度差や温度間隔を表す数値はどちらの単位で表しても同じである。
(f)放射性核種の放射能（activity referred to a radionuclide）は、しばしば誤った用語で"radioactivity"と記される。
(g)単位シーベルト（PV,2002,70,205）についてはCIPM勧告2（CI-2002）を参照。

表４．単位の中に固有の名称と記号を含むSI組立単位の例

組立量	SI 組立単位		
	名称	記号	SI 基本単位による表し方
粘度	パスカル秒	Pa s	m^{-1} kg s^{-1}
力のモーメント	ニュートンメートル	N m	m^2 kg s^{-2}
表面張力	ニュートン毎メートル	N/m	kg s^{-2}
角速度	ラジアン毎秒	rad/s	m m^{-1} s^{-1}=s^{-1}
角加速度	ラジアン毎秒毎秒	rad/s^2	m m^{-1} s^{-2}=s^{-2}
熱流密度，放射照度	ワット毎平方メートル	W/m^2	kg s^{-3}
熱容量，エントロピー	ジュール毎ケルビン	J/K	m^2 kg s^{-2} K^{-1}
比熱容量，比エントロピー	ジュール毎キログラム毎ケルビン	J/(kg K)	m^2 s^{-2} K^{-1}
比エネルギー	ジュール毎キログラム	J/kg	m^2 s^{-2}
熱伝導率	ワット毎メートル毎ケルビン	W/(m K)	m kg s^{-3} K^{-1}
体積エネルギー	ジュール毎立方メートル	J/m^3	m^{-1} kg s^{-2}
電界の強さ	ボルト毎メートル	V/m	m kg s^{-3} A^{-1}
電荷密度	クーロン毎立方メートル	C/m^3	m^{-3} sA
表面電荷	クーロン毎平方メートル	C/m^2	m^{-2} sA
電束密度，電気変位	クーロン毎平方メートル	C/m^2	m^{-2} sA
誘電率	ファラド毎メートル	F/m	m^{-3} kg^{-1} s^4 A^2
透磁率	ヘンリー毎メートル	H/m	m kg s^{-2} A^{-2}
モルエネルギー	ジュール毎モル	J/mol	m^2 kg s^{-2} mol^{-1}
モルエントロピー，モル熱容量	ジュール毎モル毎ケルビン	J/(mol K)	m^2 kg s^{-2} K^{-1} mol^{-1}
照射線量（X線及びγ線）	クーロン毎キログラム	C/kg	kg^{-1} sA
吸収線量率	グレイ毎秒	Gy/s	m^2 s^{-3}
放射強度	ワット毎ステラジアン	W/sr	m^4 m^{-2} kg s^{-3}=m^2 kg s^{-3}
放射輝度	ワット毎平方メートル毎ステラジアン	$W/(m^2 sr)$	m^2 m^{-2} kg s^{-3}=kg s^{-3}
酵素活性濃度	カタール毎立方メートル	kat/m^3	m^{-3} s^{-1} mol

表５．SI 接頭語

乗数	接頭語	記号	乗数	接頭語	記号
10^{24}	ヨタ	Y	10^{-1}	デシ	d
10^{21}	ゼタ	Z	10^{-2}	センチ	c
10^{18}	エクサ	E	10^{-3}	ミリ	m
10^{15}	ペタ	P	10^{-6}	マイクロ	μ
10^{12}	テラ	T	10^{-9}	ナノ	n
10^9	ギガ	G	10^{-12}	ピコ	p
10^6	メガ	M	10^{-15}	フェムト	f
10^3	キロ	k	10^{-18}	アト	a
10^2	ヘクト	h	10^{-21}	ゼプト	z
10^1	デカ	da	10^{-24}	ヨクト	y

表６．SIに属さないが、SIと併用される単位

名称	記号	SI 単位による値
分	min	1 min=60s
時	h	1h =60 min=3600 s
日	d	1 d=24 h=86 400 s
度	°	1°=(π/180) rad
分	’	1’=(1/60)°=(π/10800) rad
秒	”	1”=(1/60)’=(π/648000) rad
ヘクタール	ha	$1ha=1hm^2=10^4m^2$
リットル	L, l	$1L=11=1dm^3=10^3cm^3=10^{-3}m^3$
トン	t	$1t=10^3$ kg

表７．SIに属さないが、SIと併用される単位で、SI単位で表される数値が実験的に得られるもの

名称	記号	SI 単位で表される数値
電子ボルト	eV	$1eV=1.602\ 176\ 53(14)\times10^{-19}J$
ダルトン	Da	$1Da=1.660\ 538\ 86(28)\times10^{-27}kg$
統一原子質量単位	u	1u=1 Da
天文単位	ua	$1ua=1.495\ 978\ 706\ 91(6)\times10^{11}m$

表８．SIに属さないが、SIと併用されるその他の単位

名称	記号	SI 単位で表される数値
バール	bar	$1\ bar=0.1MPa=100kPa=10^5Pa$
水銀柱ミリメートル	mmHg	1mmHg=133.322Pa
オングストローム	Å	$1\ Å=0.1nm=100pm=10^{-10}m$
海里	M	1 M=1852m
バーン	b	$1\ b=100fm^2=(10^{-12}cm)2=10^{-28}m^2$
ノット	kn	1 kn=(1852/3600)m/s
ネーパ	Np	SI単位との数値的な関係は、対数量の定義に依存。
ベル	B	
デジベル	dB	

表９．固有の名称をもつCGS組立単位

名称	記号	SI 単位で表される数値
エルグ	erg	$1\ erg=10^{-7}$ J
ダイン	dyn	$1\ dyn=10^{-5}$N
ポアズ	P	1 P=1 dyn s cm^{-2}=0.1Pa s
ストークス	St	1 St =$1cm^2$ s^{-1}=$10^{-4}m^2$ s^{-1}
スチルブ	sb	1 sb =1cd cm^{-2}=10^4cd m^{-2}
フォト	ph	1 ph=1cd sr cm^{-2} 10^4lx
ガル	Gal	1 Gal =1cm s^{-2}=$10^{-2}ms^{-2}$
マクスウェル	Mx	1 Mx = 1G cm^2=10^{-8}Wb
ガウス	G	1 G =1Mx cm^{-2} =10^{-4}T
エルステッド(c)	Oe	1 Oe ≙ $(10^3/4\pi)$A m^{-1}

(c) ３元系のCGS単位系とSIでは直接比較できないため、等号「 ≙ 」は対応関係を示すものである。

表10．SIに属さないその他の単位の例

名称	記号	SI 単位で表される数値
キュリー	Ci	$1\ Ci=3.7\times10^{10}Bq$
レントゲン	R	$1\ R=2.58\times10^{-4}C/kg$
ラド	rad	$1\ rad=1cGy=10^{-2}Gy$
レム	rem	$1\ rem=1\ cSv=10^{-2}Sv$
ガンマ	γ	1γ=1 nT=10-9T
フェルミ		1フェルミ=1 fm=10-15m
メートル系カラット		1メートル系カラット = 200 mg = 2×10-4kg
トル	Torr	1 Torr = (101 325/760) Pa
標準大気圧	atm	1 atm = 101 325 Pa
カロリー	cal	1cal=4.1858J（「15℃」カロリー），4.1868J（「IT」カロリー）4.184J（「熱化学」カロリー）
ミクロン	μ	1 μ =1μm=10^{-6}m

（第8版，2006年改訂）

この印刷物は再生紙を使用しています