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**SHIELDING ASPECTS OF ACCELERATORS, TARGETS  
AND IRRADIATION FACILITIES - SATIF-7**

**Summary of the Seventh Meeting**

**17-18 May 2004  
Sacavém, Portugal**

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**English - Or. English**

*Seventh Meeting of the Expert Group on*  
**Shielding Aspects of Accelerators,  
Targets and Irradiation Facilities**

**SATIF-7**

17-18 May 2004  
Instituto Tecnológico e Nuclear (ITN)  
Estrada Nacional 10  
P-2686-953 Sacavém

*Jointly organised by*

Organisation of Economic Co-operation and Development Nuclear Energy Agency  
Instituto Tecnológico e Nuclear (ITN)  
Radiation Safety Information Computational Center (RSICC) and  
The Division of Radiation Science and Technology of Atomic Energy Society of Japan

## INTRODUCTION

Nuclear energy covers a field much wider than that of nuclear power. In fact, atomic and nuclear energy applications involve a large range of scientific and technological activities using a variety of machines and analysis techniques. Activities in this area have increased over the years and consequently the OECD/NEA Nuclear Science Committee sponsors an increasing amount of work in this domain.

One of these activities concerns “Shielding Aspects of Accelerators, Targets and Irradiation Facilities” (SATIF). A series of workshops have been held over the last decade: SATIF-1 was held on 28-29 April 1994 in Arlington, Texas; SATIF-2 on 12-13 October 1995 at CERN in Geneva, Switzerland; SATIF-3 on 12-13 May 1997 at Tohoku University in Sendai, Japan; SATIF-4 on 17-18 September 1998 in Knoxville, Tennessee; SATIF-5 on 17-21 July 2000 at OECD in Paris; France, SATIF-6 was held from 10-12 April 2002 at the Stanford Linear Accelerator Center (SLAC), Menlo Park, California, and SATIF-7 was held from 17-18 May 2004 at ITN, Sacavém, Portugal. SATIF-8 is planned for 22-24 May 2006 at the Pohang Accelerator Laboratory in the Republic of Korea.

SATIF-7 was jointly organised by the:

- OECD Nuclear Energy Agency;
- Instituto Tecnológico e Nuclear (ITN)
- Radiation Safety Information Computational Center (RSICC) and
- The Division of Radiation Science and Technology of Atomic Energy Society of Japan.

The current text provides a summary of the discussions, decisions and conclusions of the seventh SATIF meeting.

The full text of the proceedings, including all presentations made, will be published separately.

## **TABLE OF CONTENTS**

Introduction

Executive Summary

Annex I – SATIF-7 Programme

Annex II – List of Participants

## EXECUTIVE SUMMARY

### Scope

The Expert Group on Shielding of Accelerators, Targets and Irradiation Facilities (SATIF) deals with multiple aspects related to the modelling and design of accelerator shielding systems including electron accelerators, proton accelerators, ion accelerators, spallation sources and several different types of facilities, such as synchrotron radiation facilities, transmutation sources including accelerator driven systems, very-high-energy radiation facilities, free electron lasers, high power targets and dumps.

### Objectives

Objectives of the SATIF-7 meeting include:

- to promote the exchange of information among scientists in this particular field;
- to identify areas in which international co-operation could be fruitful;
- to carry on a programme of work in order to achieve progress in specific priority areas;

### Deliverables

Deliverables emerging from SATIF meetings include:

- assessment of needs in experimental data for the validation of models and codes;
- organisation of shielding experiments;
- collection and compilation of experimental data sets;
- assessment of models, computer codes, parametrisations and techniques available for accelerator shielding design purposes;
- validation of computer codes and models available to perform particle transport simulation and organisation of international benchmark and intercomparison exercises;
- organisation of workshops and co-organisation of conferences relevant in the area of its scope and computing radiation dosimetry;
- publication of workshop proceedings; and editing of an “Accelerator Shielding Handbook”;
- maintenance of the SATIF listserver and archive of technical discussion between members.

**Sponsors**

SATIF-7 was jointly organised by the:

- OECD Nuclear Energy Agency;
- Instituto Tecnológico e Nuclear (ITN)
- Radiation Safety Information Computational Center (RSICC);
- The Division of Radiation Science and Technology of Atomic Energy Society of Japan.

**Scientific Committee**

The members of the Scientific Committee of SATIF-7 were:

T. Gabriel (ORNL)	T. Nakamura (U. Tohoku, Vice Chair)
H. Hirayama (KEK)	S. Rokni (SLAC)
B. Kirk (RSICC)	E. Sartori (OECD/NEA, Secretary)
A. Leuschner (DESY)	M. Silari (CERN)
N. Mokhov (FNAL)	P. Vaz (ITN, Chair)

**Executive Committee**

The members of the Executive Committee, in charge of preparing the Technical Programme for SATIF-7 and submitting it to the Scientific Committee, were:

B. Kirk (RSICC)	M. Silari (CERN)
T. Nakamura (U. Tohoku, Vice Chair)	E. Sartori (OECD/NEA, Secretary)
S. Rokni (SLAC)	P. Vaz (ITN, Chair)

## SATIF-7 workshop

### Summary

The seventh SATIF workshop was hosted by the Instituto Tecnológico e Nuclear (ITN), Sacavém, Lisbon, Portugal. The objectives were to present and assess achievements on actions agreed upon at the previous meeting held at Stanford, California in 2002, and to discuss and recommend actions where a strong need is identified for further work in theoretical model development, experimental work and benchmarking for model validation.

The workshop was opened by Prof. Manuel Leite de Almeida, Vice-President of ITN who welcomed the participants, together with the General Chair, Pedro Vaz (ITN), who reminded participants of the history of SATIF and in particular that it was the 10<sup>th</sup> anniversary of the first SATIF meeting, held at Arlington, TX, then chaired by Dr. Shun-ichi Tanaka, now Vice-President of JAERI.

Enrico Sartori welcomed participants on behalf of the OECD/NEA and thanked ITN for hosting this workshop.

The workshop was attended by 36 participants from 9 countries, representing 24 organisations. Twenty-five presentations were made, organised into five topical sessions:

- source term and related data – electron, proton and ion accelerators and spallation source;
- measurements and calculations of induced radioactivity and activation data;
- benchmark experiments and calculations
- dose and related issues;
- status of computer codes, cross-sections and shielding data libraries;

The abstracts of the presentations are accessible via Internet:  
<http://www.nea.fr/html/science/meetings/SATIF-7/satif7-programme.html>.

The complete set of presentations was indexed and made available to participants on CD-ROM. The workshop proceedings are being edited and published in hard copy by OECD. Details about the programme and participants are provided in Annex I and II respectively.

Concerning future directions, the following topics were proposed for discussion:

The “visibility” of the SATIF group activities need to be enhanced through

- Book on “State-of-the-art on Accelerator Shielding”
- Publication in archival journals

New applications should be targeted such as:

- Medical radiation applications
- Dosimetry-related calculations for different applications
- Shielding of transmutation facilities
- Applications involving “high” energy radiations

An increased interaction with other groups should be implemented such as

- QUADOS-like (quality assurance and benchmarking)
- EURADOS (dosimetry)

During the Sessions VI and VII concerned with follow-up and future actions, and recommendations, Pedro Vaz, co-ordinator of the NEA/NSC activities in Radiation Shielding and Dosimetry, reported on the scheduled in-depth discussion that will take on the subject with emphasis on accelerators at the next NSC meeting (10 June 2004).

The mandate of this expert group had been extended in 2003 until 2005. As this group meets only every two years, a period judged appropriate for a consistent progress to be reported and as the mandate expires before the next meeting, a discussion as to justifications for continuing the SATIF activities was initiated.

Aspects for future studies were discussed then by all participants, the most important ones being:

1. Activation and dose rates estimation for facility maintenance planning is requested and it is particularly crucial if the targets are changed, to identify 'hot spots' and how to prevent them
2. Dismantling of facilities requires estimation of remnant dose for dose management, for the characterisation of waste to be able to declare it free from radiation. Lack of such a capability may lead to very expensive solutions.
3. Relevant data on activation and their evaluation was presented in several papers of SATIF-7 (induced radioactivity and remnant doses at CERN, production of radioactive isotopes at GT, an important and comprehensive set of experiments carried out within the ISTC programme in the Russian Federation by ITEP; also the HINDAS project has produced large sets of data at GSI, Darmstadt). This contributes to waste disposal and hazard classification of accelerators. The SINBAD database should be expanded to include such compilations, in particular, as EXFOR does not seem to be an adequate format for it. Also more basic data on mass distributions and spallation products are needed and should be integrated in the databases.
4. The activities of SATIF can provide reliable evaluated data and guidance for model selection; however, a strong support and stimulation for making data available should be provided; such experimental data should be presented at the SATIF meetings.
5. The Group does not just meet and hold workshops, it co-ordinates analysis, proposes action items; examples are the collaboration on attenuation length up to 10 GeV for which codes now agree. The consensus for certain parameters, reached through independent but co-ordinated work, is of high value.
6. Comparison between codes creates a challenge for code developers to show which ones perform better; this creates important insight for users and code developers.
7. For the energy region where it becomes difficult to distinguish phenomena such as fission and spallation requirements exist for additional development of models as the discrepancies are still very high. SATIF should devote efforts to resolving such issues by proposing experiments that help choosing the right model.

8. In accelerator shield design often simple codes are still used. This leads normally to overdesign. With today's state-of-the art methods only few safety factors need to be applied
9. Experimental databases and benchmarking are key elements for building confidence in data and codes used; this is an essential activity of SATIF that enforces objective comparison and facilitates access to the information needed. It is felt that official endorsement of benchmarks by NEA NSC is essential.
10. The discussions and exchange of views at SATIF relative to mechanisms that are not well understood, provide new ideas for designing experiments that lead to the solution of the problem.
11. The provision of a gamma-beam-line for nuclear physics and applications at the AURORA facility was reported. It was noted that there is lack of photonuclear data available for light elements and those available are for a limited range and often of poor quality. Data for production of d, t, and alphas with their spectra are required. Relevant work on photo-nuclear data is going to be presented and published at the "International Conference on Nuclear data for Science and Technology" (ND-2004), September 2004, Santa Fe, NM, USA., by A. Fassó. This could form the basis for identifying the needs for experiments to be carried out at this new facility. The availability of such a facility is most welcome.
12. Concerning computer programs it is essential that all responsible developers of the relevant codes contribute to the discussion and share their model; they should also generate a table describing the quality (good or bad) of their features. This should be presented and discussed by authors at SATIF-8. Also a session should be devoted to 'event generators' to facilitate common ways of solving problems. Release of standard routines and of tools for geometry conversion from one code input to others, to minimise benchmarking efforts and cost should be strongly encouraged.
13. A very valuable contribution is the 'Heavy Ion Handbook', presented at SATIF-7. Preparation of additional specialised handbooks should be encouraged.
14. At SATIF-6 it had been agreed that the know-how and experience gathered by the SATIF group over recent years should be synthesised into an "Accelerator Shielding Handbook" – for the benefit of an increasingly larger community of accelerator shielders. No current handbook exists on this subject and, a strong need for it being expressed, its production was agreed upon. The importance of this was underlined during SATIF-7 and a stronger co-ordination of the effort is required. The editors of the handbook were designated among those SATIF members having editing experience and having sufficient time available to realise the project; these are: Pedro Vaz and Nikolai Mokhov (co-ordinators and authors) and Takashi Nakamura, Stepan Mashnik, Phillip Ferguson and Franz Gallmeier (authors) as well as others who will confirm their availability. This should be prepared over the period of the next two years and be available in draft form for the next SATIF workshop. The chapters will cover: physics basics for accelerator shielding, facilities and their shielding and dosimetry approaches, simple fast methods for estimating orders of magnitude, existing state-of-the-art transport codes (MC and deterministic), data for accelerator shielding and experimental benchmark data.

15. It was noted that many of the actions agreed on in previous meetings have been carried out to the benefit of participants and the shielding community in general.

Members concluded that in view of the number of large accelerator facilities in planning and under construction within the OECD area, there is a growing need for extended and improved databases, methods and codes in accelerator and target shielding. The present scope and objectives of SATIF define well and represent current needs in this field and the deliverables such as experimental benchmarks, adequate computer codes and reports comparing them, preparation of special handbooks etc will be a major contribution to make progress in this area.

Over the last ten years, the radiation shielding community has benefited from the co-operation which takes place under the aegis of SATIF, and the group has established itself as the international forum for addressing priority issues in this area. SATIF will contribute shared research results to emerging priority areas and their members recommend that their mandate be extended for a period of two years until 2007.

B. Kirk presented the Technical Group in Computational Medical Physics (TGCoMP) recently set-up within the ANS for the promotion of the advancement of computational tools, experimental data, and enabling technologies which are applicable to problems in medical and health physics. The group concentrates on a multidisciplinary approach (nuclear engineering, medical physics and health physics) to the studies of radiation effects on human and animal life. The applications include computational benchmarks on phantoms and detectors, large scale optimization, deterministic and stochastic approaches to radiation therapy problems. This is well distinguished from the other two ANS divisions - Isotopes and Radiation, Biology and Medicine. She presented the proposed future activities. From the discussion which followed, it was clear that these activities are of interest for SATIF, who agreed to co-operate with this group.

Hee-Seock Lee introduced the Pohang Accelerator Laboratory (PAL) of the Republic of Korea, operated by the Pohang University of Science and Technology (POSTECH). PAL has a 3rd generation light source (PLS) 160 m long with a 2.5 GeV S-band PLS Linac. He briefly described the plans for construction of future facilities. The interests for accelerator radiation research is increasing in Korea and efforts are made to encourage young students to work in the field of nuclear science and accelerator radiation. PAL offers to host the NSC meeting on Shielding Aspects of Accelerators, Targets and Irradiation Facilities (SATIF-8) from 22-24 May 2006, in conjunction with the Synchrotron Radiation Instrumentation Conference that will held at Gyeongju the week after. Members of SATIF welcomed the offer in particular as it offers access and discussion with the experts at PAL.

*Annex I***SATIF-7 PROGRAMME**

*17-18 May 2004  
 Instituto Tecnológico e Nuclear (ITN)  
 Estrada Nacional 10  
 P-2686-953 Sacavém, Portugal*

***General Chair: Pedro Vaz • General Vice-chair: Takashi Nakamura***

**MONDAY, 17 May 2004**

Chair: Pedro VAZ

- Welcome (Introduction by Pedro Vaz)
  - Introduction of Participants (List of Participants)
  - Objectives of the Workshop (Viewgraphs by Enrico Sartori)
- 1.1 Source Term and Related data - Electron, Proton and Ion Accelerators and Spallation Sources (Chair: Hideo HIRAYAMA)
- Photo-neutron production
    - 10:30 - Hee-Seock Lee, Syuichi Ban, Toshiya Sanami, Kazutoshi Takahashi, Tatsuhiko Sato, Kazuo Shinand Chinwha Chung: Photo-Neutron Yields from Thin and Thick Targets Irradiated by 2.0 GeV Electrons [01]
    - 10:55 - Sergio Bartalucci, Vladimir Angelov, Krzysztof Drozdowicz, Grzegorz Tracz: A Linac-based Neutron Source for Time of Flight (TOF) Measurements [02]
  - Electron-photon production
    - 11:20 - J.L. Tain: A Gamma-ray Beam Line for Nuclear Physics and Applications at the Spanish Synchrotron ALBA [03]
    - 11:45 - J.E. Fernandez: Scattering in two targets with the vector code MCSHAPE [04]
- 1.2 Source Term and Related data - Electron, Proton and Ion Accelerators and Spallation Sources (Chair: Nolan HERTEL)
- High Energy Proton and Heavy Ion Machines
    - 12:10 - Nikolai Mokhov: Benchmarking Possibilities at Fermilab: Accelerators, Experiments and Irradiation Facilities [05]
    - 12:35 - T. Nakamura and L. Heilbronn: Handbook on secondary particle production and transport by heavy ions of energies above 100MeV/nucleon - general view and contents [06]
  - 13:00 - 14:15 - LUNCHEON

- Spallation Neutron Sources
  - 14:15 - K. Nünighoff, N. Bayer, W. Bernnat, V. Bollini, A. Bubak, H. Conrad, D. Filges, P.Ferguson, F.X. Gallmeier, F. Goldenbaum, H.-K. Hinssen, E.B.Iverson, R.-D. Neef, W. Ninaus, K. Pyzs, J. Keinert, S. Kulikov, B.Lensing, M. Mattes, Th. Matzerath, N. Paul, Ch. Pohl, H. Schaal, A. Smirnov, H. Soltner, H. Stelzer, H. Tietze-Jaensch, M. Wohlmuther, J. Wolters : Experimental Investigations of Advanced Cold Moderators at JESSICA at COSY-Jülich and Comparison with MCNPX Simulations [07]
- 2 Measurements and Calculations of Induced Radioactivity and Activation Data (Chair: Takashi NAKAMURA)
  - 14:40 - K. Kelley, M. Devlin, E. Pitcher, and S. Mashnik, N. E. Hertel: Gadolinium-148 Production Cross Sections Measurements for 600- and 800-MeV Protons [08]
  - 15:05 - V.Bollini, A.Bubak, D.Filges, F.Goldenbaum, P.Kulesa, H.Machner, K.Nünighoff, H.Ohm, N.Paul, K.Pysz, H.Schaal, R.Siudak, A.Heczko, L.Jarczyk, B.Kamys, St.Kistryn, A.Kowalczyk, A.Magiera, W.Migdal, B.Piskor-Ignatowicz, Z.Rudy, R.Sworst, M.Wojciechowski, A.Budzanowski, M.Kistryn, St.Kliczewski, J.Kisiel, E.Stephan, W.Zipper, R.Barna, D.DePasquale, A.Italiano, S.Förtsch, D.Steyn, T.Thovhogi, J.Cugnon, H.Hodde : Latest results of PISA - LCP and IMF cross sections in p+Ni at 1.9 GeV reactions [09]
  - 15:30 - Yu.E. Titarenko, V.F. Batyaev, V.M. Zhivun, R.D. Mulambetov, S.V. Mulambetova, K.A. Lipatov, S.L. Zaitsev, S.G. Mashnik: Experimental Study of Independent and Cumulative Product Yields in <sup>208</sup>, <sup>207</sup>, <sup>206</sup>, nat<sup>209</sup>Pb and <sup>209</sup>Bi Targets Irradiated with 0.04-2.6GeV Protons [10]
  - 15:55 - 16:15 - BREAK
- 3.1 Benchmark Experiments and Calculations (Chair: Bernadette KIRK)
  - Neutron attenuation length
    - 16:15 - Hideo Hirayama: Inter-comparison of Neutron Attenuation in Iron and Concrete (5) [11]
    - 16:40 - Takashi Nakamura: Summarized Experimental Results of Neutron Shielding and Attenuation Length [12]
- 3.2 Benchmark Experiments and Calculations (Chair: Albrecht LEUSCHNER)
  - Deep penetration
    - 17:05 - H. Nakashima, N. Matsuda, H. Nakano, Y. Iwamoto, K. Niita, T. Miura, M. Numajiri, N. Nakao: Benchmark calculation on neutron streaming of labyrinth at proton accelerator facilities [13]
    - 17:30 - Koji Oishi, Kazuaki Kosako, Yuki Kobayashi, Hiroshi Yamakawa, Takashi Nakamura: Measurement and Analysis on Radiation Shielding of 18 MeV Electron LINAC for Medical Use [14]
    - 17:55 - S. Taniguchi, M. Sasaki, T. Nunomiya, H. Iwase, S. Yonai, T. Nakamura, S.H. Rokni, J.C. Liu, S. Roesler, K. Kase: Measurement of Neutron Energy Spectra behind the Lateral Shield of the High Energy Electron Beam Dump [15]

**TUESDAY, 18 May 2004**

- 4 Dose and Related Issues (Chair: Sayed ROKNI)
- 09:45 - Wolfgang Dittrich, Werner Hofmann: Use of Iso-Dose-Rate Pictures for Shielding Design of a Proton Therapy Center [16]
  - 10:10 - M. Brugger, S. Mayer, S. Roesler, L. Ulrici, H. Khater, A. Prinz, H. Vincke : Measurement and Simulation of Induced Radioactivity and Remanent Dose Rates at the CERN-EU High Energy Reference Field Facility [17]
  - 10:35 - B. Mukherjee, E. Sartori: A Database on Health Physics and Radiological Safety of Cyclotrons 10-250 MeV [18]
  - 11:00 - 11:20 - BREAK
- 5 Status of Computer Codes, Cross Sections and Shielding Data Libraries (Chair: Nikolai MOKHOV)
- Status of Computer Codes, cross-sections and Data Libraries for
    - 11:20 - J.M. Galán, I. Kodeli: E. Sartori, and B.L. Kirk: Acquisition of Computer Codes, Cross-section Libraries and Accelerator Shielding Experiments - Status 2004 [19]
  - Accelerator Shielding Modeling
    - 11:45 - Ryuichi Tayama, Katsumi Hayashi, Hideo Hirayama, and Nobuo Ohtani: Development of Radiation Shielding Tool for Proton Accelerators Facilities (BULK-I) [20]
    - 12:10 - S.G. Mashnik, V.S. Pronskih, J. Adam, A. Balabekyan, V.S. Barashenkov, V.P. Filinova, A.A. Solnyshkin, V.M. Tsoupko-Sitnikov, R. Brandt, R. Odoj, A.J. Sierk, R.E. Prael, K.K. Gudima, M. I. Baznat: Analysis of the JINR p(660 MeV) +  $^{129}\text{I}$ ,  $^{237}\text{Np}$ , and  $^{241}\text{Am}$  Measurements with Eleven Different Models [21]
  - 13:00 - 14:15 - LUNCH
- 6 14:15 - Follow-up of past SATIF agreements and actions
- Yukio Sakamoto: Present Status of Data Collection on Dose Conversion Coefficients for High Energy Radiation [22]
- 7 15:15 - Discussion/Summary and Future Actions.
- E. Sartori – Review of Actions
  - B. Kirk: Technical Group on Computational Medical Physics (TGCoMP)
  - Hee-Seock Lee: Introduction of Pohang Accelerator Laboratory for SATIF-8
  - P. Vaz: Closing Remarks

**Annex II**

**SATIF7**

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