CONRAD WP 6:
Complex mixed radiation fields at workplaces

SG A: Further progress in the characterisation of complex radiation field fields

SPURNÝ František, SILARI Marco,
(Bartlett David)

CONRAD WP6/WG8

Complex mixed radiation fields at workplaces

Objectives. To coordinate research activities in two areas:

Sub-WG A (Chairman M. Silari)

1) the development of new techniques and the improvement of current techniques for the characterization of complex workplace fields (including high-energy fields and pulsed fields);

2) measurement and calculation of particle energy and direction distributions

Sub-WG B (Chairman P. Beck)

3) model improvements for dose assessment of solar particle events; in order to aid the research, increase the efficiency of resource utilization, and facilitate the technology transfer to practical application and for the development of standards

General overview of SG A activities

WG8, sub-group A members

P. Bilski, IFJ, Krakow, Poland

J. Blomgren, TSL/INF, Uppsala University, Sweden

F. d'Errico, DIMNP, Pisa, Italy

A. Esposito, INFN, Frascati, Italy

G. Fehrenbacher, GSI, Darmstadt, Germany

F. Fernàndez, UAB, Barcelona, Spain

A. Fuchs, PSI, Villigen, Switzerland

N. Golnik, IAE, Swierk, Poland

V. Lacoste, IRSN, Cadarache, France

A. Leuschner, DESY, Hamburg, Germany

S. Sandri, ENEA, Frascati, Italy

M. Silari, CERN, Geneva, Switzerland

F. Spurny, ASCR, Prague, Czech Republic

B. Wiegel, PTB, Braunschweig, Germany

P. Wright, RAL, Didcot, U.K

WP6 SGA deliverables

1. Report outlining research activities within the EU and Switzerland to develop new and improved methods and techniques for characterization of complex workplace fields.
2. Report on benchmark measurements in complex workplace fields – finally specified – GSI 400 MeV/amu C-ions;

   behind concrete shield

Progress report of sub-group A - 1

- First meeting in Brussels with sub-group B, 19-20 April 2005
- May 2005 – Dec 2005: preparation of report
- Second meeting at CERN, 31 Oct - 1 Nov 2005: revision of report, decision on time/place of benchmark exercise (with possible involvement of WP4 for MC calculations). Five potential sites
- Report (provisionally) approved as CERN Yellow Report in January 2006
- Restricted meeting to finalise report at HPA (AM 2006) on 25 January 2006

July 2006

90 pages

Complex workplace radiation fields at European high-energy accelerators and fusion facilities

- INTRODUCTION

- MONITORING OF MIXED RADIATION FIELDS
  - Neutron counting and spectrometry
  - Photon dosimetry and spectrometry
  - Pulsed fields and instrument response

- MONITORING AT EUROPEAN ACCELERATOR FACILITIES
  - RESEARCH INSTITUTES: CERN, GANIL, PSI, TSL, GSI, ELETTRA, LNF, RAL (ISIS and CLF), DL (SRS)
  - MEDICAL HADRON ACCELERATORS: ICPO Orsay, JINR Dubna, PROSCAN at PSI, Heidelberg Treatment Facility (HIT), CNAO in Pavia, Rinecker Proton Therapy Center (RPTC)

Complex workplace radiation fields at European high-energy accelerators and fusion facilities

➢ RADIATION PROTECTION AND MONITORING AT EUROPEAN THERMONUCLEAR FUSION FACILITIES: JET, ENEA Frascati, ITER

➢ DEVELOPMENT AND RESEARCH WORK IN INSTRUMENTATION AND DOSIMETRY:

- IRSN (TEPC, passive dosimetry, active and passive BSS)
- University of Barcelona (active and passive BSS)
- CERN (RAMSES for LHC, active and passive BSS)
- Institute of Atomic Energy, Poland (recombination chambers)
- INFN LNF (active and passive BSS, rem counters, TLD, CR39)
- PSI (CR39)
- Nuclear Physics Institute of the CAS (Si detectors, GM and scintillation counters, TLD, rem counters, bubbles, PADC, TEPC)
- PTB (BSS)

Complex workplace radiation fields at European high-energy accelerators and fusion facilities

CALIBRATION FIELDS AND CALIBRATION PROBLEMS

- Thermal neutron fields (PTB, ...)
- Monoenergetic or quasi-monoenergetic fields (PTB, TSL, UCL,...)
- Workplace fields (CERF)

RECOMMENDATIONS AND CONCLUSIONS

Progress report of sub-group A - 2

- March 2006–GSI & June 2006–Uppsala; program and organisation of benchmark
- GSI benchmark – July 18-24, 2006: Carbon beam 400 MeV/u), irradiations in the nights
- **Afterwards** – several meetings:

✓ AM 2007, Madrid, January 21-25 - the preparation of reports on results

✓ Vienna, March 14-16, - to review results of Monte Carlo calculations

✓ Frascati, May 9-10, Bonner spectrometer results

✓ Braunschweig, December 5-7, to finalise the content of three contributions to be published in the special volume of a journal

GSI benchmark participating institutions

ARC Seibersdorf, Austria
Bertold, Wildbad, Germany
CERN, Geneva, Switzerland
CESNEF, Milano, Italy
DESY, Hamburg, Germany
ENEA, Frascati, Italy
Helmholtz- M, Neuherberg, Germany
GSI, Darmstadt, Germany
IAE, Swierk, Poland
INFN, Frascati, Italy
IRSN, Cadarache & Fontenay-aux-Roses, France
NPI ASCR, Prague, Czech Republic
PSI, Villigen, Switzerland
PTB, Braunschweig, Germany
Strahlenbiol. Inst. München, Germany
UAB, Barcelona, Spain

Instruments for benchmark

List of instruments used by group members:

- Several BSS systems (NEMUS, active and passive detectors)
- Several TEPC equipments
- Several rem – counters (LINUS, WENDI, LB411, and LB411-Pb, MABX
- Rem2 recombination chambers
- MDU-Liulin energy deposition spectrometer
- Bubble detectors
- Track etch detectors
- TLD's

Frascati meeting - conclusions

A. GSI results – 2nd deliverable of SG A to be prepared as a three parts publication in single volume of a journal. Coordinators:

I. Monte Carlo Simulations (S. Rollet, ARCS)

II. Bonner Sphere Spectrometry (B. Wiegel, PTB)

III. Instrument Responses (M. Silari, CERN)

B. Journal chosen: Radiation Measurements

C. Preliminary discussions with Francesco d'Errico, two options:

- Special issue – purchasing of a number of copies expected (CONRAD funds 1-2 kEuros)
- Beginning of regular issue with a guest editorial

Part I.: Monte Carlo Simulations

- Introduction
- Description of the GSI cave A measurements site and measurements positions (OC/EM)
- Description of MC simulations, FLUKA and FLUKA MCNPX
- Spectra normalized per unit incident particle, provide one MC spectrum per position as input for the BSS unfolding
- Discussion on uncertainties, spectra differences
- Conclusions

Part I – Main conclusions

- The total ambient dose equivalent is dominated by the contribution of the neutrons which is between 90 and 95% for OC measurement positions. Protons do contribute between about 5 and 10% to the total dose equivalent, and photons roughly in the range of 1 to 2%
- The main peak shapes and heights are in satisfactory agreement
- The average standard deviation for all six simulated H*(10) values is about 20%. An average deviation of 16% between the measured and simulated ambient dose equivalent

Part II.: Bonner Sphere Spectrometry

- Introduction
- Description of the experimental set-up with short summary of beam monitoring, position used for the BSS measurements, measurements done over several shifts
- Discussion of unfolding problems and sensitivity analysis, limitations and analysis of BSS, two unfolding approaches, with and without MC a priori information
- Method: description of the various BSS, calculation of the response functions, calibration, data analysis and unfolding procedure: PTB, GSF, INFN-LNF, POL/CERN
- Measurements and results, one plot with all unfolded spectra per each position, discussion on comparison of results from various BSS for OC 11. Recommended conversion coefficients
- Reference neutron energy distributions per each position (if feasible)
- Conclusions
- Appendix: Numerical values of the “reference spectra”, one per each measurement position

Part II – Main conclusions

- A comparison of the spectra measured at the six positions outside Cave A shows that all spectra are very similar in shape. They consist of three major components: (a) thermal peak, (b) evaporation peak at about 2 MeV from neutrons evaporating from highly excited residual nuclei and (c) a peak around 100 MeV that is due to a broad minimum in the corresponding neutron cross-section at energies of about 100 MeV. On the other hand this finding is not very surprising since very similar models and a priori information were used to generate a default or start spectrum for the unfolding codes.
- The total fluence Φ, and total H*(10) measured with a BSS is usually a reliable quantity, the differences are lower than 10 %.

Part III: Instrument Response

- Introduction
- Beam Monitoring
- Method: Description of various instruments
- Measurement results and their intercomparison, table with results, one reference value from the BSS and one from the MC to be included
- Discussion
- Conclusions

Part III – Main conclusions

- There is good agreement amongst the various active detectors and passive dosemeters in the OC positions, whilst a much larger variability is observed in the results in the EM positions.

- Results show that:

i) of the various classes of instruments, the TEPCs are those that better agree amongst themselves,

ii) the TEPCs and the extended-range rem counters agree quite well with the “reference” BSS experimental values;

iii) the conventional rem counters underestimate by about 40% with respect to the BSS reference.

- The results discussed should hopefully contribute to a better understanding the radiation field one can encounter around a high-energy proton accelerator, in helping in the selection of survey dosimeters and deciding on the calibration. A subsequent important step would be to investigate the response of these same devices in pulsed radiation fields.

Detail results of GSI benchmark: next contribution of Marco Silari

Acknowledgements to:

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- GSI staff for their invaluable help for performing the experiments
- **To all you for the attention**