# Calculation Of The Pertubation of the Neutron Thermal Flux by a Sample in the Presence of a Moderator

Isabel F. Gonçalves, José Salgado, Eduardo Martinho

## Objectives

The presence of a sample in the neutron field of a nuclear reactor creates a perturbation of the local neutron fluxes. This perturbation was already studied for several cases, and now we are studying the case of the presence of a moderator. This work deals with the calculation of this perturbation factor.

Using the MCNP code this perturbation is being studied for spherical samples in water. First calculations were made in order to determine the neutron source that describes better the neutron flux around the sample. Different types of neutron sources were simulated (fission and thermal neutron sources). It was found that a spherical source with 5 cm of radius with a thermal energy distribution is a good approximation. This perturbation is obtained dividing the reaction rate in the sample by the reaction rate in a infinitely diluted sample. The diluted sample simulation arose the problem of the introduction of a void in the system. Preliminary results of the calculated perturbation factor for different (17) elements are shown in Fig.1. It can be seen that a universal curve can be adjusted to the calculated points.

Figure 2 compares de perturbation factor with the self-absorption factor (calculated without the presence of the moderator).

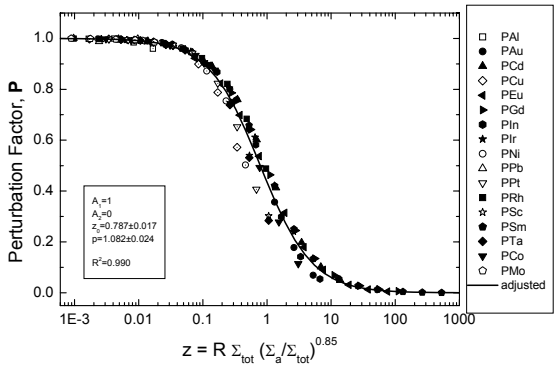



Fig. 1. Perturbation Factor

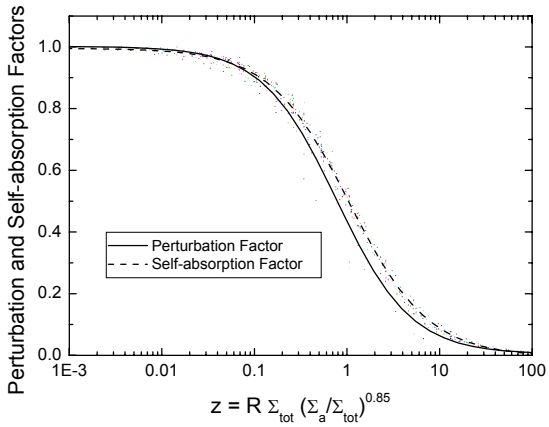



Fig. 2. Comparison of the perturbation factor with the self absorption factor

## Published, accepted or in press work

1. E. Martinho, J. Salgado, I. F. Gonçalves Universal curve of the thermal neutron self-shielding factor in foils, wires, spheres and cylinders *J. Radioanalytical and Nuclear Chemistry*, **261** (3), 637 (2004).

2. I. F. Gonçalves, E. Martinho, J. Salgado Extension to cylindrical samples of the universal curve of resonance neutron self-shielding factors, *Nucl. Inst. Meth.B***213** (2004) 186-188

# Neutron Capture Cross Section Analysis of $^{94}$Zr

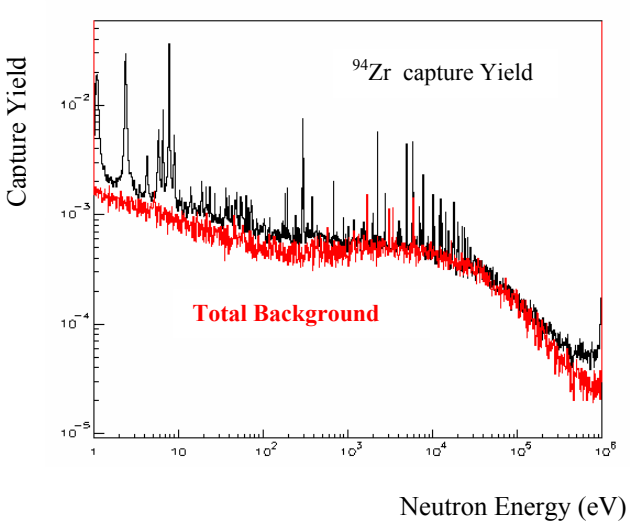
L. Marques, I.F. Gonçalves, P. Vaz, N. Collona[1]

## Objectives

The data acquisition of the $^{90,91,92,94,96}$Zr(n, γ) reactions is relative to the 2003 n_TOF experimental campaign. This work consisted in the $^{94}$Zr(n, γ) data analysis and was carried out together with the INFN of Bari-Italy (Instituto Nazionale di Fisica Nucleare), in the framework of the n_TOF Collaboration.

## Results

The summary of the analysis work performed is the following: data transfer (needed for the analysis) from the CERN computers; calibration of the $C_6D_6$ liquid scintillators; total background determination; capture yield determination for the isotopes $^{94}$Zr and $^{197}$Au (sample used to obtain the absolute normalization); resonance parameters analysis using the SAMMY code; comparison of the resonance parameters at n_TOF with those previously reported; estimate of the statistical and systematic uncertainties.
The preliminary results of the data analysis show capture resonances strengths systematically smaller than previously available data. This fact could be related to: the lower neutron sensitivity of the experimental setup used at n_TOF (in particular the $C_6D_6$ detectors used); a better estimate of the weighting functions.




## Published, accepted or in press work

1. L.M.C. Marques, Neutron Capture Cross Section Analysis of $^{94}$Zr at the CERN Neutron Time of Flight Facility (n_TOF), *College Graduation Thesis* in Physics Engineering at the Science University of Lisbon, Dec. 2004.
2. C. Moreau et al. (The n_TOF Collaboration), *Measurements of Capture Cross Sections of $^{90,91,92,94,96}$Zr at CERN n_TOF*, *Proceedings of ND2004 Conference*, Santa Fe, September 2004.
3. G. Tagliente et al. (The n_TOF Collaboration), *Measurement of the $^{90,91,92,94,96}$Zr(n, g) at n_TOF*, for publication at *Nucl. Phys.* A, accepted.

[1] Inst. Nazionale di Fisica Nucleare, Bari, Italy, (n_TOF Collaboration)

# Radiological Risk Assessment of a Storage Facility for Radioactive Sources

C. A. Carrapiço, A. D. Oliveira, I. F. Gonçalves, P. Vaz

## Objectives

A room with dimensions 4 m x 4 m x 3 m is used as a storage facility for radioactive sources. The bulk of the study concerned a 530 mCi source of $^{241}$Am-Be. Considering the radiological hazard of the neutrons from this source, this study was conducted to perform the risk assessment of the facility, which is contiguous to another room with a restricted access but classified as a non-controlled area.

## Results

The aim of this computational study consists on assessing the dose rates in the room and compare them with measurements performed using a Bonner-sphere based detector. The Monte Carlo code MCNPX was used to compute the equivalent doses at different locations above the ground level. The detailed geometry of the set-up has been implemented and a standard neutron energy spectrum has been used. The equivalent dose results obtained using different MCNPX tallies have been compared and their agreement has been tested. Considering the long flight path in the soil of neutrons contributing to the point dose in different locations inside the room, the importance of the soil composition has been investigated. The sensitivity of the obtained results to different soil compositions has been checked.A reasonable agreement between the computed and measured values has been obtained.

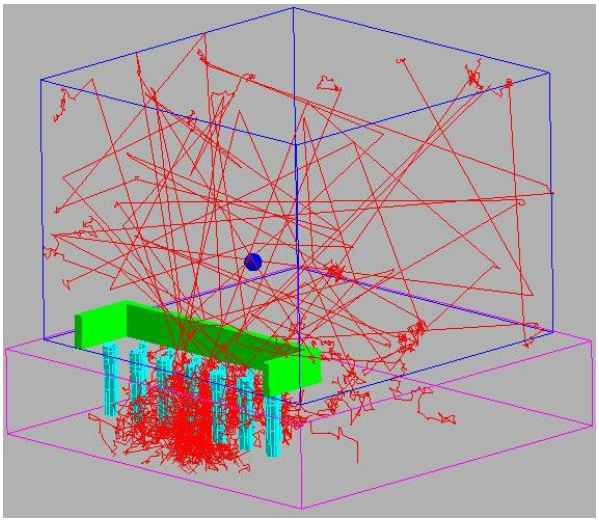


Fig. 1. Graphic of the behavior of the particles in the studied geometry.

## Published, accepted or in press work

1. C. A. Carrapiço, A. D. Oliveira, I. F. Gonçalves, P. Vaz “Radiological risk assessment of a storage facility for radioactive sources”, accepted for MC2005 Topical Conference, April 17-21, 2005, USA

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# Dose Assessment In A 650 Kev Electron Irradiator for Industrial Applications

A. Carrillo de Albornoz, L. Marques, A. D. Oliveira, I.F. Gonçalves, P. Vaz

## Objectives

This work using the Monte Carlo code MCNPX aims at obtaining the electron and photon flux distributions as well as the dose distribution inside and outside the chamber of an 650 keV irradiator for industrial applications.

## Results

The irradiator consists of an electron beam of 650 keV and a maximum current of 50 mA incident on a beam stopper of stainless steel with 4 mm thickness. This electron irradiator possesses a scanning system of 91.4 cm (60º) in order to irradiate electric cables which are rolled in cylinders. The setup is located inside a steel chamber with outer dimensions of 210×210×266 cm and wall thickness of 36 cm in the direction of the beam and 30 cm in the other directions. This work using the Monte Carlo code MCNPX aims at obtaining the electron and photon flux distributions as well as the dose distribution inside and outside the chamber. Variance reduction techniques have been used in order to reduce the computational time required for a detailed calculation of the dose distribution deep in the steel shield and outside the chamber. From the results obtained it was concluded that the dose rates outside the steel chamber are negligible, well bellow the limit of 0.50 μSv/h corresponding to an annual effective dose limit of 1 mSv/year for members of the public.

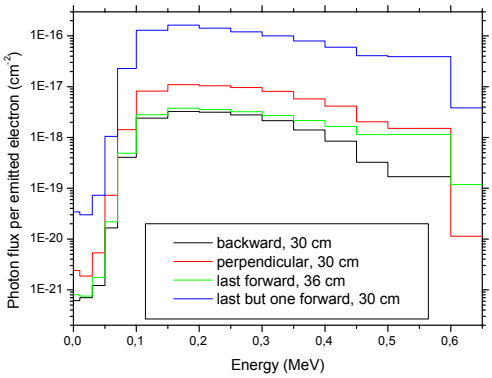


Fig. 1. Photon flux distribution per incident emitted electron ($cm^{-2}$) in different directions

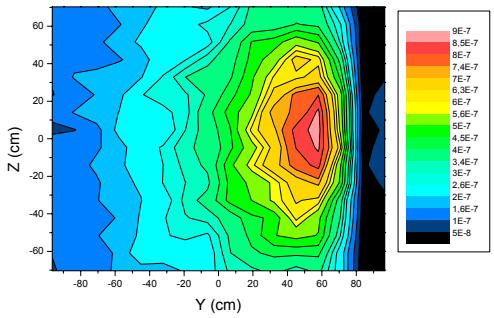


Fig. 2 - Photon flux impinging the lateral wall of the chamber, per incident electron

## Published, accepted or in press work

1. Carrillo De Albornoz, L. Marques, A. D. Oliveira, I.F. Gonçalves, P. Vaz, Dose Assessment In A 650 Kev Electron Irradiator For Industrial Applications" , accepted for MC2005 Topical Conference, April 17-21, 2005, USA

# Electrical Discharges on Environmental and Material Processing Applications

N.R. Pinhão

## Objectives

The main objective of this project is the study and application of cold plasmas. The activities developed extend from research on basic data to the development of applications. As both numerical modelling and experimental work are important in this field, the activities have continued to be directed to both areas. In the present framework of contraction of public financing on C&T the focus has been in consolidating and completing the work started on previous years.

### Results

*Numerical modelling*

1. The code developed for the solution of the steady-state electron Boltzmann equation in cold plasmas was extended to include the treatment of electron-electron collisions.
2. A software library to compute the chemical kinetics was expanded to include an extended treatment of the energy transferred in reactions.
3. In the framework of an international cooperation, the comparison between different kinetic calculation techniques for the analysis of electron swarm transport was completed with the analysis of the conditions of validity of the two-term approximation (figure 1).
4. The modelling of a plasma plume produced by laser ablation of graphite has progressed with the development of a fluid code.

*5. Experimental results*

6. A client-server application was developed to allow the remote control of a quadrupole mass spectrometer. In the near future and on the client side this application will be extended to do quantitative analysis of gas mixtures.
7. The decomposition on a chemical reactor of different plastics was studied using mass spectrometry.

## Published, accepted or in press work

1. N. R. Pinhão, Z. Donkó, D. Loffhagen M. Pinheiro, and E. A. Richley, Comparison of kinetic calculation techniques for the analysis of electron swarm transport at low to moderate E/N values, Plasma Sources Sci. Technol. **13** (2004), 719—728
2. N. Pinhão, T. Santos, and M. Silva, Automatic fitting of electron collision cross sections, Conference Proceedings, ESCAMPIG 17, (Constanta, Romania), September 2004, pp.57-58
3. N. Pinhão and H. Nowakowska, PLASMAKIN II: A chemical kinetics library for plasma physics modelling, Conference Proceedings, ESCAMPIG 17 (Constanta, Romania), September 2004, p. 260
4. L. Nemes, J. Marçalo, N. Pinhão, and A. Keszler, Optical spectroscopy and mass spectrometry of laser ablated carbon, Conference Proceedings, ESCAMPIG 17 (Constanta, Romania), September 2004, pp. 219-220.

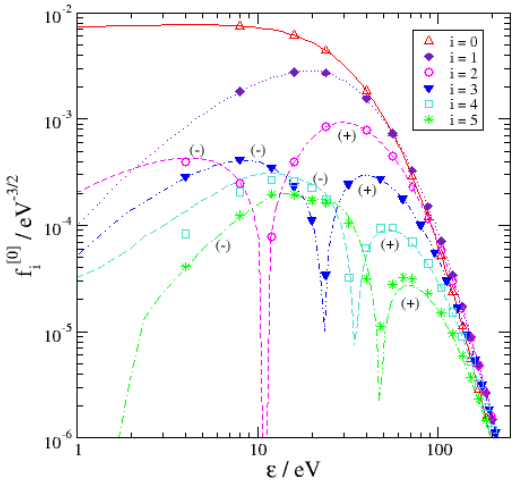


Fig.1. Legendre expansion coefficients for the electron velocity distribution function in neon at 500 Td: ITN (points), Loffhagen et al. (lines).

# Technical Assistance in the Field of Engineering Applications of Radiation and Radioisotopes

J. B. Manteigas, J. Neves, C. Cruz, F.G. Carvalho, J. Salgado

## Objectives

The main objectives are the development of equipment for internal groups, fabrication of equipment for specific applications and assistance to industrial companies and scientific institutions as well as technical consulting.

## Results

A summary of the more relevant work carried out is:

(i) Technical and scientific participation in the n-TOF (PS213) experiment at CERN.

(ii) Technical and scientific collaboration in testing equipment for the "CERN Large Hadron Collider" under contract agreement between ITN and VELAN.

(iii) Installation of the Robotized Detector Displacement System for the EPA Neutron Spectrometer and evaluation of the Electro-magnetic Compatibility of the DIDE Diffracto-meter at the RPI.

(iv) Development and maintenance of electronic equipment to RPI, Physics and Chemical Sectors.

Figure: Tension dividers for CERN Client.

**Summary of the more relevant services rendered in 2004**

| Activity | Quantity | Client | Price (Eur) |
|---|---|---|---|
| Laboratory equipment for the determination of radioactive element traces by electrodeposition | **1**<br>**1** | Gammadata (Suécia)<br>Station for Lab. & Scientific Equip. Trade (Jordânia) | 1289,00<br>1273,50 |
| Measuring and control of source activities | **27**<br>**1** | ABB/SOPORCEL<br>ABB/SOPORCEL | 2450,00<br>600,00 |
| Supply of Voltage Divisors | **45** | FCT/CERN (Suiça) | 14030,00* |
| Supply of RAD X 100 Dosemeters | **2**<br>**2** | FARMA APS<br>ITN/RPI | 850,00<br>760,00 |
| *Technical assistance to*<br>- RAD X 100 | **4**<br>**2**<br>**1** | Arsenal do Alfeite (NRP/Corte Real)<br>Marinha/Arsenal do Alfeite<br>ITN/Reactor | 265,00<br>185,00<br>125,00 |
| *Technical assistance to*<br>- Source Containers | **4**<br>**1** | PORTUCEL TEJO/V.V. Ródão<br>PORTUCEL TEJO/V.V. Ródão | 1140,00<br>400,00 |
| *Technical assistance to*<br>- Criogenic Valves | **130** | VELAN/CERN (Suiça) | 3000,00 |
| *Technical assistance to*<br>Capacitive sources | **2** | ISA | 510,00 |
| *Mechanical fabrication of metallic spare parts* | **3** | CRIOLAB | 950,00 |
| *Equipment: 1 Oscilloscope, 1PC, 2 Multi-channel PC cards | | **Total Amount (EUR):** | **27 827,50 €** |

PRICES DO NOT INCLUDE TAX (IVA )