
That´s just wonderful

Research and activities of the Group for Applied Physics with Accelerators

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Group for Applied Physics with Accelerators

Grupo de Físca Aplicada com Aceleradores

Instituto de Física USP

Dr. José Fernando D. Chubaci

Dr. Juan Carlos Acquadro (col)

Dr. Manfredo Harri Tabacniks

Dr. Marcel DL Barbosa (tec)

Dr. Márcia de Almeida Rizutto

Dr. Nemitala Added

Dr. Nilberto Hedder Medina (col)

Dr. Raphael Liguori Neto

students

- **Alessandro Alves da Silva - Dr**
- **Flor - Dr**
- **Márcia Regina Attie - Dr**
- **Jessica F. Curado - IC**
- **Jim Aburaya - Ms**
- **Regina Reiko - Dr**
- **Walter A. Santos Jr. - IC**
- **Viviane Silva Poli - MS**

main objectives

Provide and develope accelerator based techniques for science and industry.

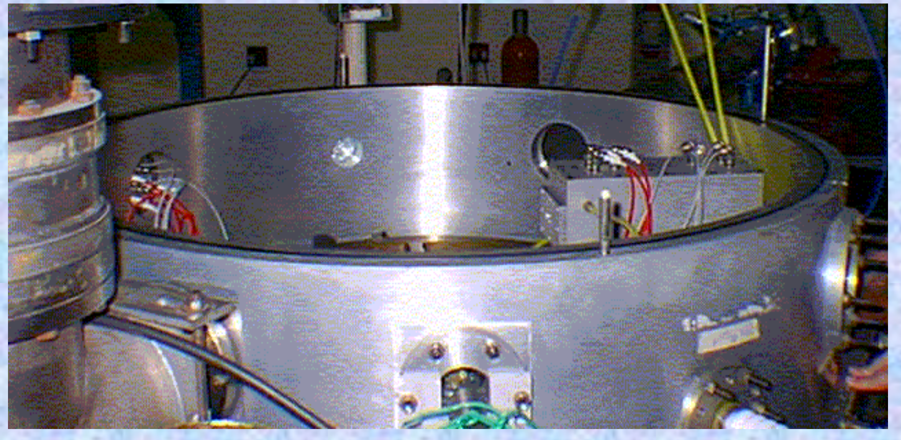
- Install, maintain, upgrade and provide accelerator based techniques for the analysis and modification of materials (equipment, softwares, databases..) and make them accessible to the scientific community including “non nuclear” scientists.

- Work for the development of these same techniques .

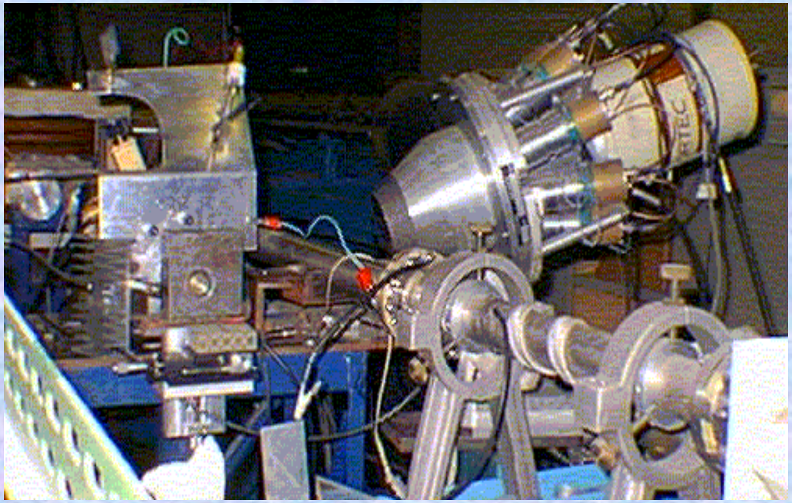
facilities - LAFN

Laboratório Aberto de Física Nuclear

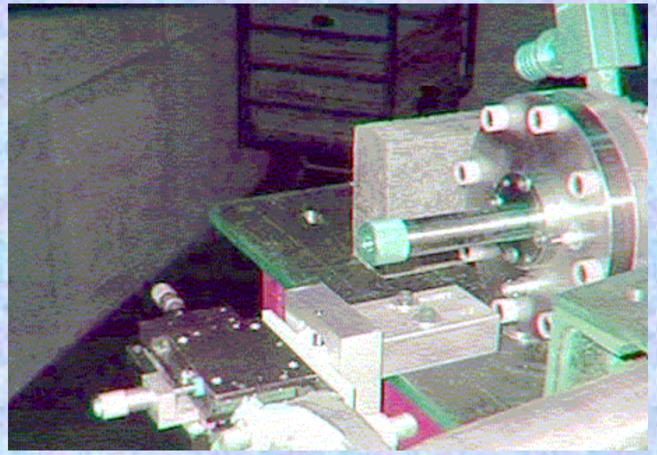
8.0 MV NEC Pelletron tandem accelerator with carbon foil stripper; 32-cathode SNICS ion source; duoplasmatron ion source.



Multi-use, 1m diameter vacuum chamber for HI-RBS and HI-EΔE-ERDA.



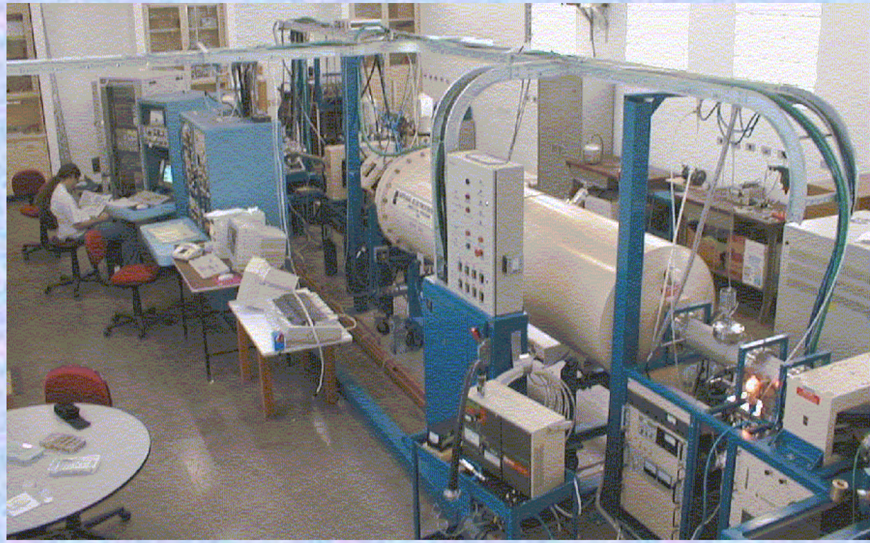
External beam PIXE-PIGE setup. 0.5mm Al exit window.

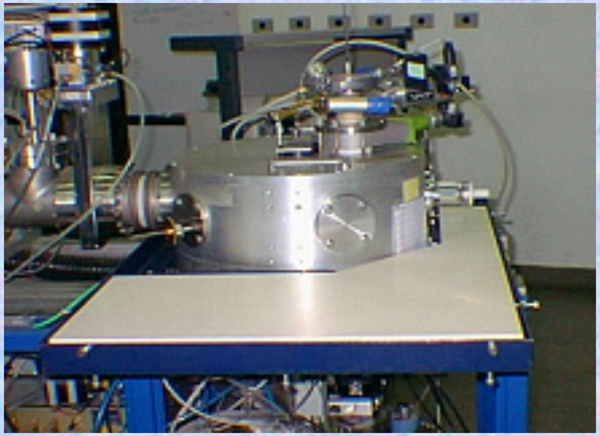


External beam setup for analysis and ion implantation of samples in air.

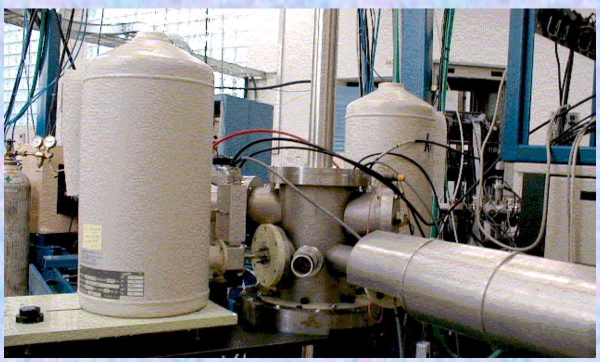
LAMFI Laboratório de Análise de Materiais por Feixes Iônicos

1.7 MV NEC (5SDH) Pelletron tandem accelerator with N_2 stripper; RF/Rb ion source He^- beam and a SNICS II source for H^-, Li^-, O^-, Si^-, and other beams .



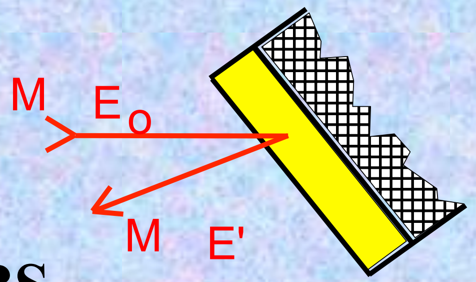


Multi use vacuum chamber for RBS, PIXE, channeling and ERDA analysis with optional external beam. 5DF goniometer computer based data acquisition and control system.



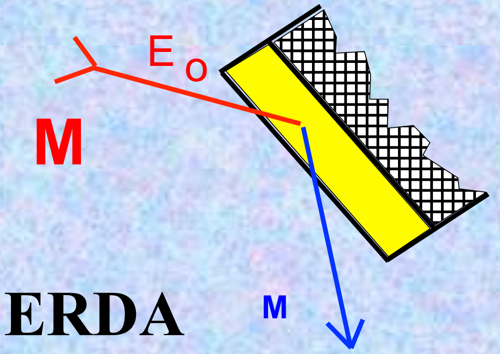
PIXE chamber optimized for air pollution analysis with 2 Si(Li) detectors, 18 position sample holder, computer based data acquisition and control system.

analytical techniques



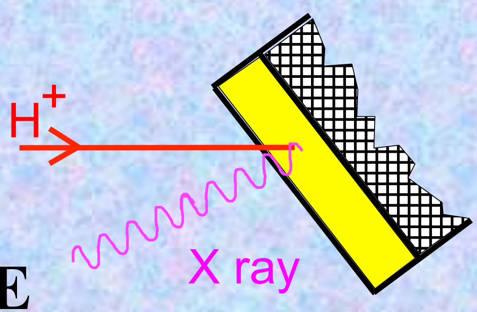
RBS

Rutherford Backscattering Spectrometry



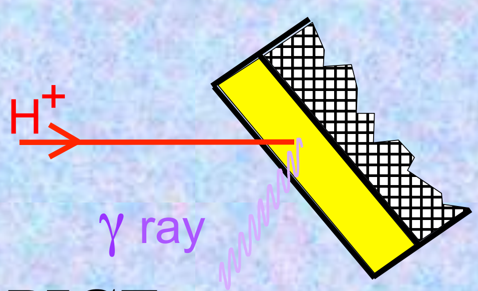
ERDA

Elastic Recoil Detection Analysis



PIXE

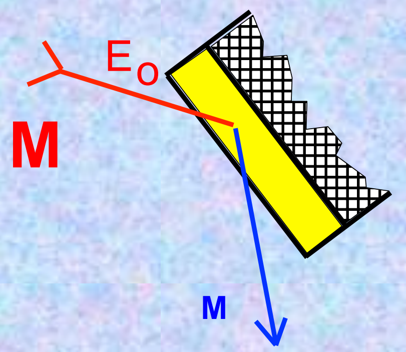
Particle Induced X ray Emission

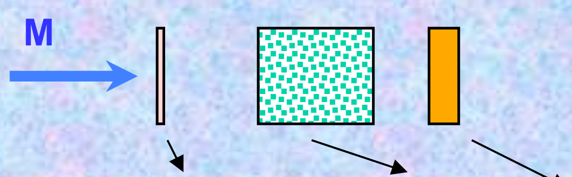


PIGE

Particle Induced Gamma ray Emission

analytical techniques





$$E_{tot} = \Delta E_{window} + \Delta E_{gas} + E_{res}$$

HI-EΔE-ERDA

Heavy Ion EΔE Elastic Recoil Detection Analysis

analytical techniques

for the analysis of all elements of the periodic table

RBS Rutherford Backscattering Spectrometry
ERDA Elastic Recoil Detection Analysis

absolute atomic concentration: atoms/cm^2
no need for calibration: first principles
depth profiles
high sensitivity: < 10^{12} Au/cm^2
quick: 10-20 min
sensitive to layer topography: ?

PIXE Particle Induced X ray Emission
PIGE Particle Induced Gamma ray Emission

absolute atomic concentration: atoms/cm^2
need calibration
high sensitivity: ppm
quick: 10-20 min

AMS Accelerator Mass Spectrometry

extremly high sensitivity: 1: 10^{14}
relative isotopic concentration
no need for calibration

External beam for non vacuum applications

LAMFI
main facility users

over 50 research projects / year

GEPA	Group for Air Pollution Studies, IFUSP. Coordinator: Prof. Dr. Paulo E. Artaxo (40%, ~1500 PIXE analysis / year)
LSI	Laboratory of Integrated Systems; Department of Electric Engineering, EPUSP. Coordinator: Prof. Dr. Nilton Itiro Morimoto (20%, ~400 RBS analysis / year)
LMM	Laboratory of Magnetic Materials, IFUSP. Coordinator: Prof. Dr. Frank P. Missell (20%, ~400 RBS analysis / year)
OTHERS	Calibration, tests and graduate and undergraduate courses. Other users from IFUSP and other research institutions. (20%, ~400 PIXE and RBS analysis / year)

Collaborations

Faculdade de Odontologia, USP
Instituto de Eletrotécnica, USP.
Instituto de Física Gleb Wataghin, UNICAMP
Instituto Nacional de Pesquisas Espaciais, INPE.
Instituto de pesquisas Energéticas e Nucleares, IPEN
Instituto de Geociências, USP
Museu de Arqueologia e Etnologia - USP

AMS project

Australian National University
Universidade Federal Fluminense, RJ
Universidade Estadual de Londrina

research projects

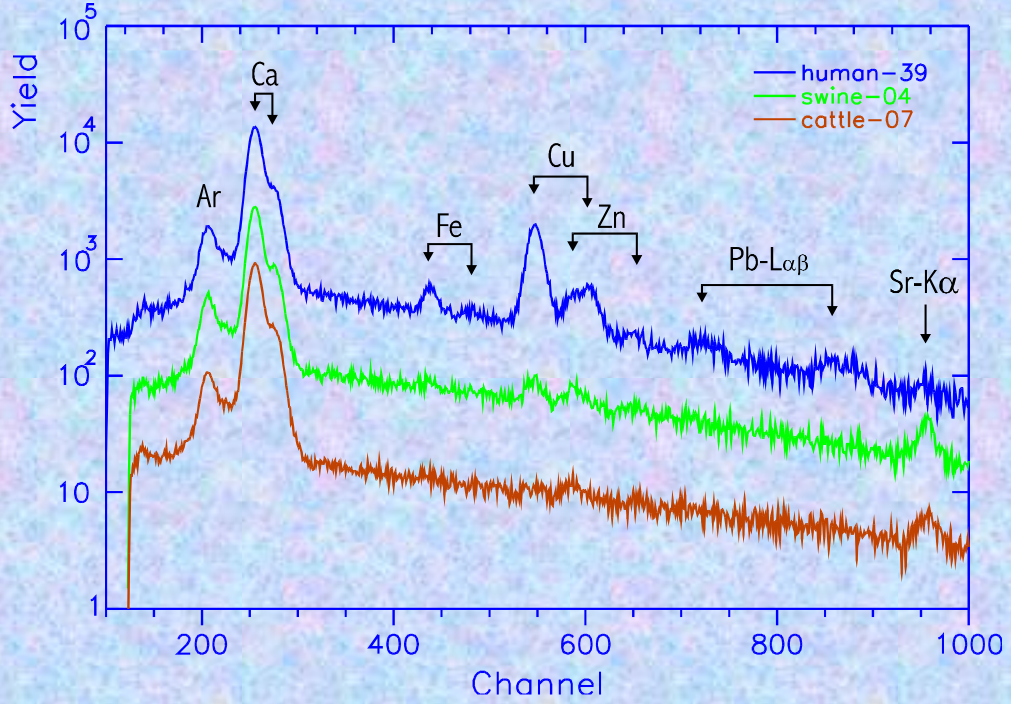
- Experimental curves for energy loss of ions in matter
- Effects of thin film roughness on RBS analysis
- Characterization of thin films containing Li atoms
- AMS of geological samples
- Elementary analysis of teeth enamel and dentine
- Standardization of thick target substrates for PIXE analysis
- Optimization of HI-ERDA parameters for the analysis of thin films
- Modification of Si devices by high energy proton implantation
- High energy ion induced defects in biological materials
- Production of ^{102}Ru radioctive sources
- Numerical simulation of E-ΔE ERDA spectra
- Sr/Ca in shells as an environmental temperature sensor
- Deep nitrogen profiling in steel samples
- RBS analysis with Li beam

External beam PIXE-PIGE analysis of teeth enamel

M.A. Rizzutto, M.H. Tabacniks, N. Added, R. Liguori Neto, J.C. Acquadro, *Institute of Physics, University of São Paulo, São Paulo, Brazil*

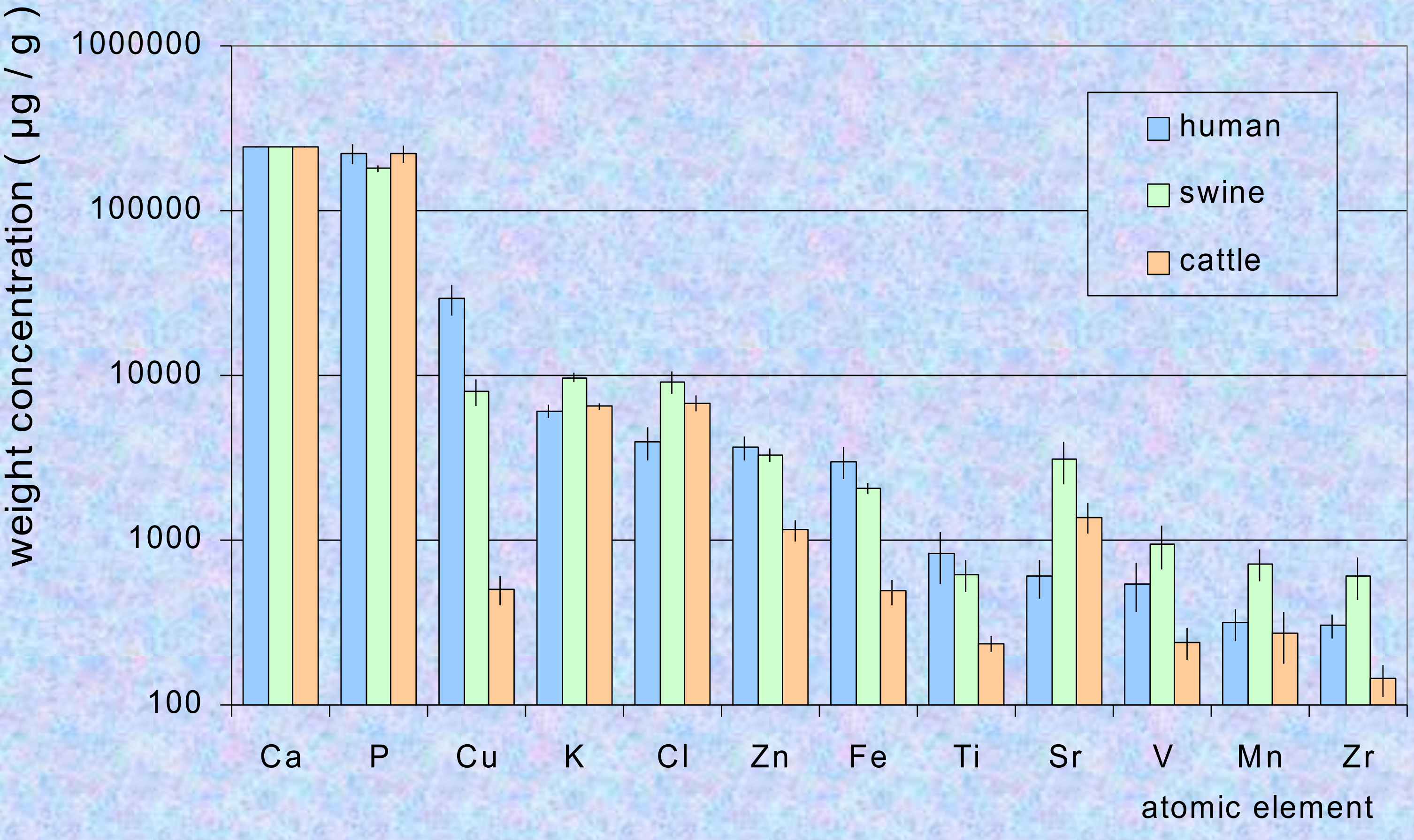
T.R.C.F. Oliveira, R.A. Markarian, M. Mori *Faculty of Dentistry, University of São Paulo, São Paulo, Brazil*

M. M. Vilela *Institute of Electrotechnique and Energy, University of São Paulo, São Paulo, Brazil*



Typical PIXE X-ray spectra for enamel from human, swine and cattle teeth, using 12 MeV external proton beam.

External beam PIXE-PIGE analysis of teeth enamel

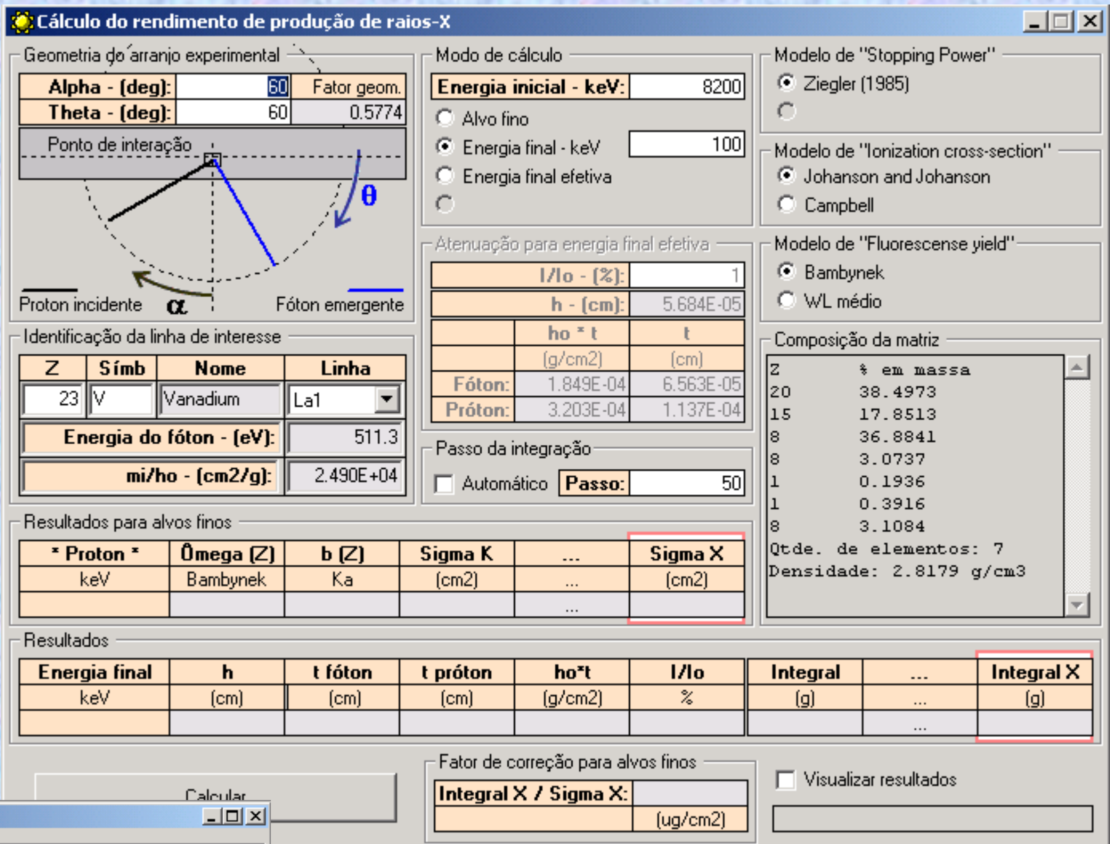


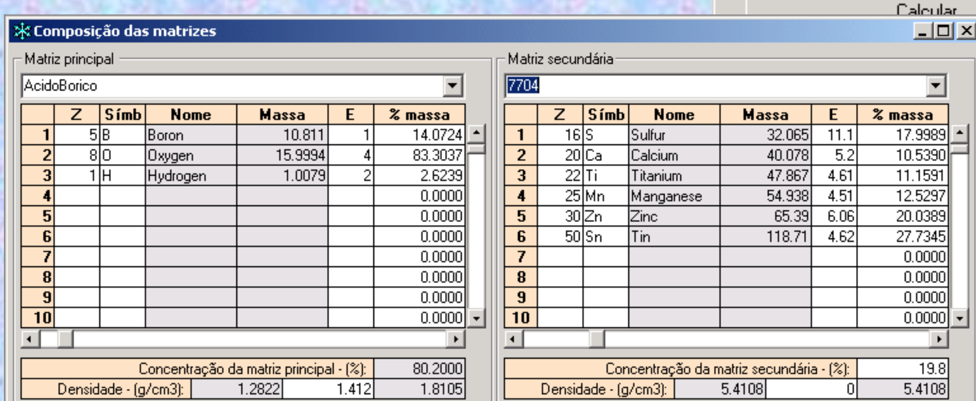
Trace element weight concentration (in ppm) in enamel of human, swine and cattle teeth. Lines on top of each bar indicate sample mean standard deviation. Data were normalized to Ca (24.4%) concentration in hidroxy-apatite with 0.4% water.

“*Padronização de matrizes para análise de amostras espessas pelo método PIXE*” Jim Heiji Aburaya

Desenvolver metodologia de diluição e padronização de amostras em pó para análises PIXE como amostra espessa sem os habituais problemas de elementos invisíveis (Z < 11).

$$N_i = \frac{\Omega}{4\pi}\varepsilon_i \frac{N_0}{A_i}\frac{Q}{q.e.\cos\alpha}\frac{\rho_i}{\rho}\int_{E_0}^{E}\frac{\sigma_{xi}(E).e^{-\frac{\mu\cos\alpha}{\rho\sin\theta}\int_{E_0}^{E}\frac{dE}{S(E)}}}{S(E)}dE$$

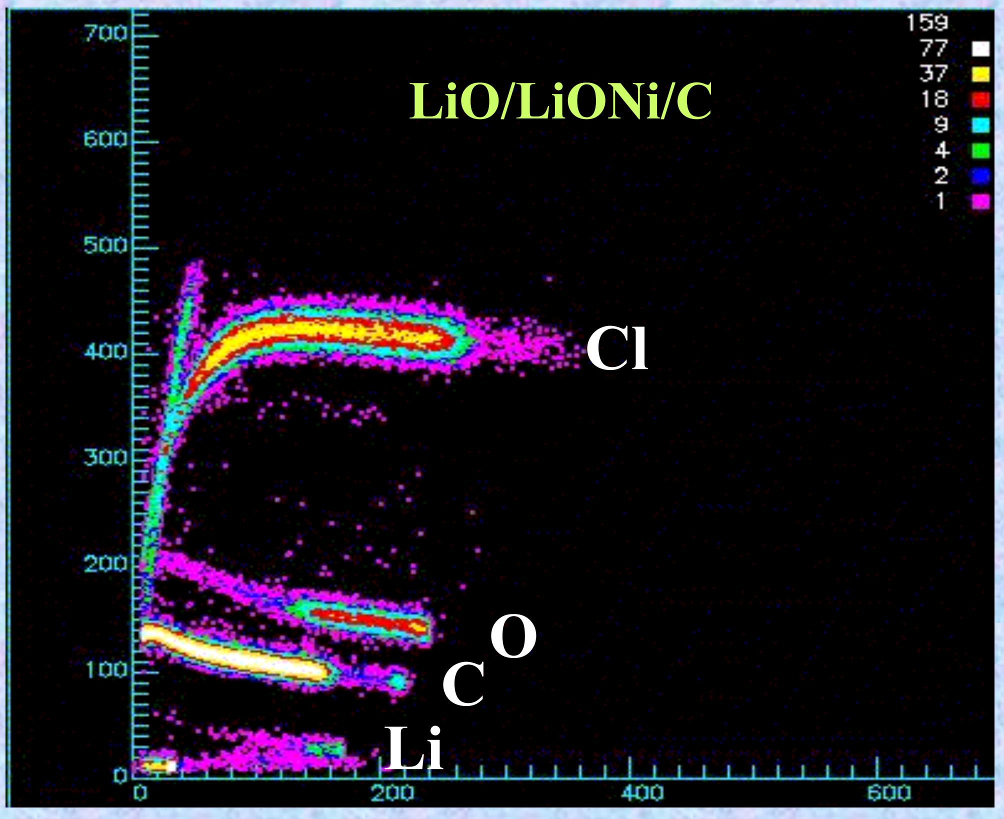




Diluição da amostra em ácido bórico, HBO_3 e calibração do PIXE por meio de fatores de correção de amostra espessa.

ERDA analysis of light elements in heavy matrices

N.Added, J.C. Acquadro, R. Liguori Neto, M.A. Rizutto, J.F. Chubaci, M.H. Tabacniks (IFUSP)



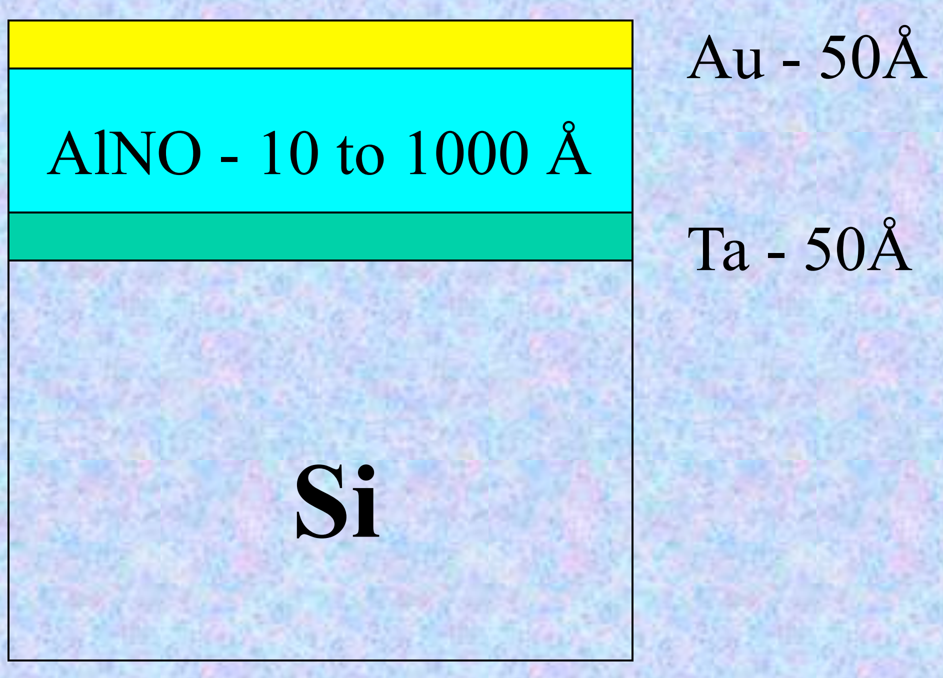
Biparametric ERDA spectra ΔE x E: LiO/LiONi on C using 58 MeV Cl beam.

(Sample from Alexandre Urbano, DFGW - UNICAMP)

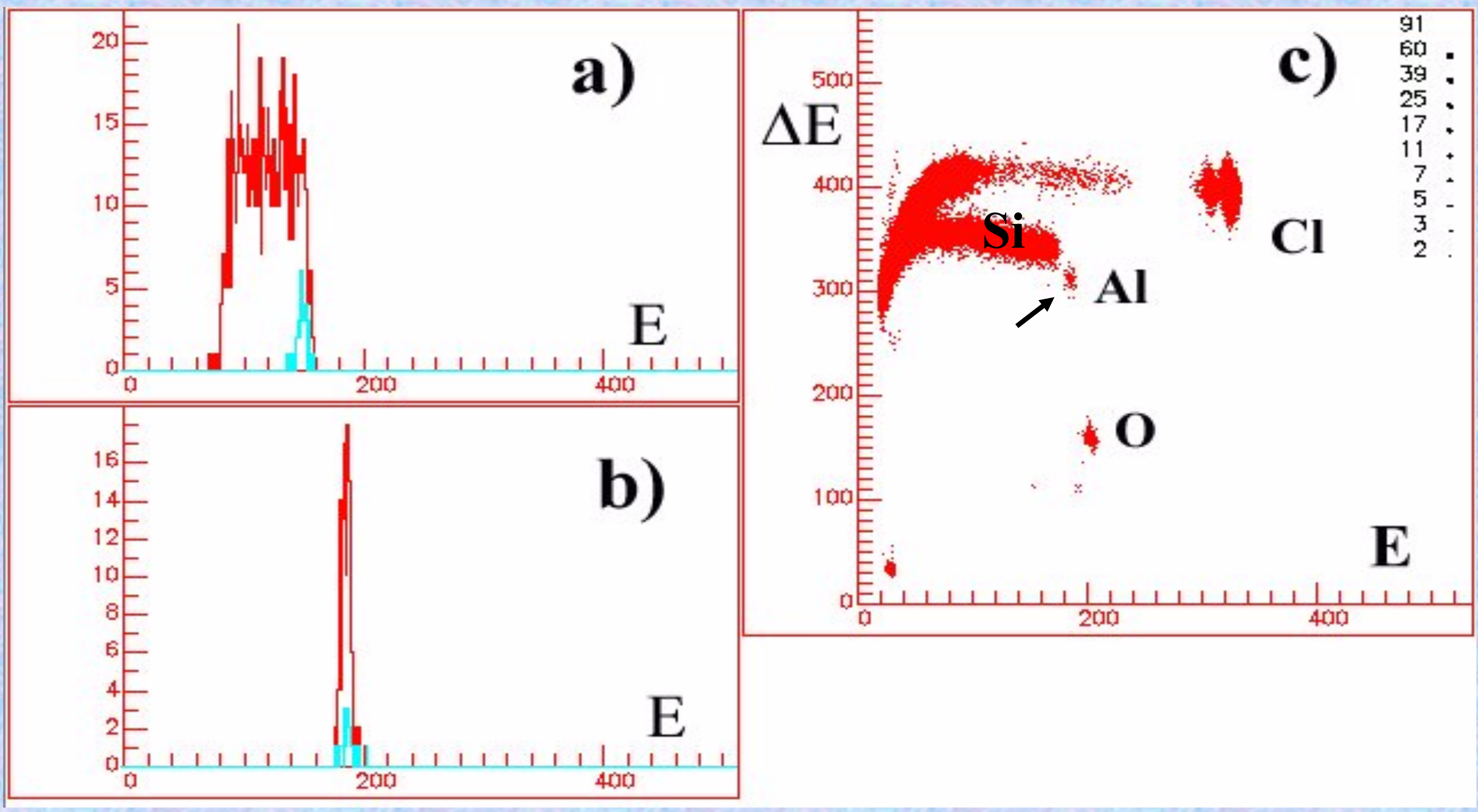
a)

Robin Round characterization of the thickness and composition of thin to ultra-thin AlNO films (Samples provided by Dr. Nuno Barradas, ITN - Portugal)

International Atomic Energy Agency Research Contract No, 11317/RO/Regular Budget Fund



Robin Round characterization of the thickness and composition of thin to ultra-thin AlNO films

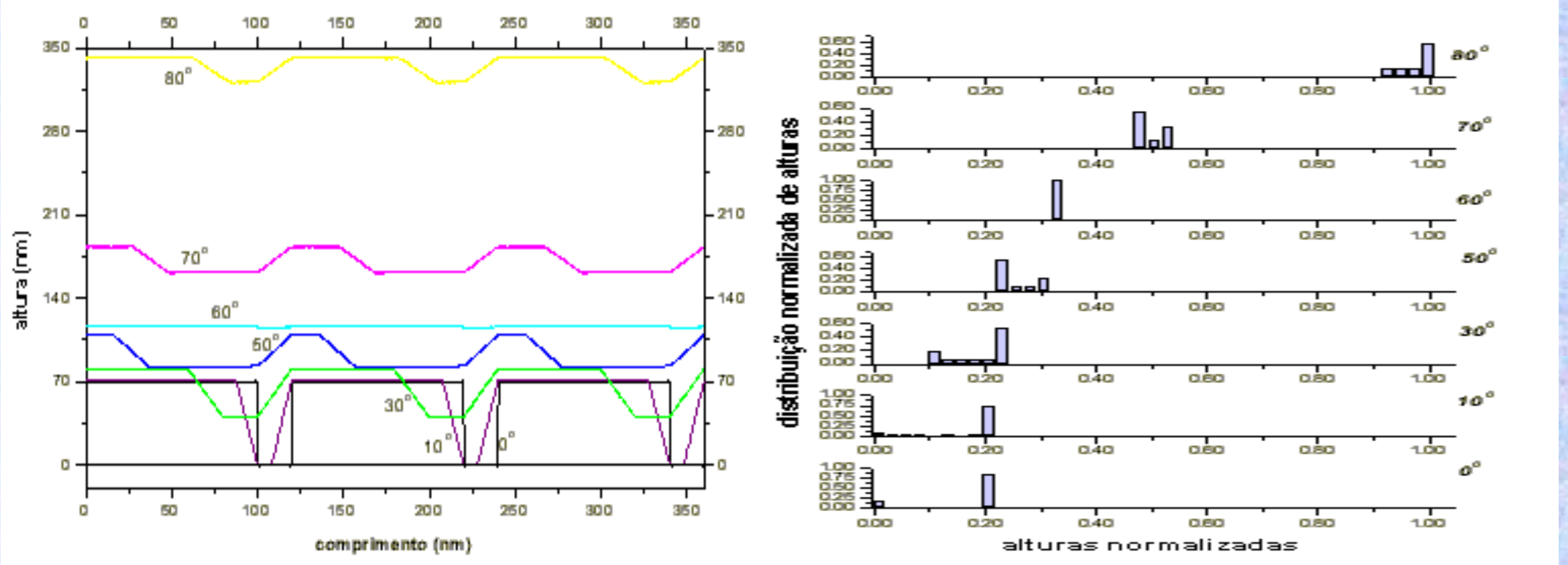


a) Energy spectrum for Al recoils from samples S5 and S6, nominally 1000 and 10 A thick;
b) Energy spectrum for Al recoils from samples S2 and S3, nominally 10 and 100 A thick;
c) Biparametric spectra ΔE x E for sample S3. (^{55}Cl beam, 50MeV)

Samples provided by ITN - Portugal.

Effects of thin film roughness on RBS spectra

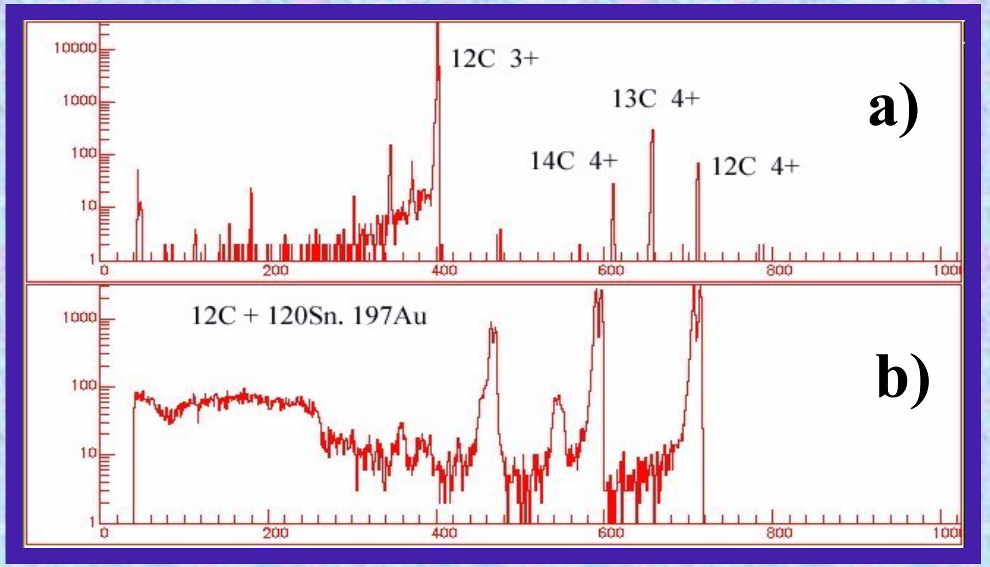
Alessandro A.da Silva, M.H. Tabacniks (IFUSP)



- By changing detection angle θ, the assumed relationship 1/cos(θ), for the film thickness, is not obeyed due to topographical effects
- Two detectors at different angles, measure different surfaces, thus different roughness, and different film thickness
- It might be possible to distinguish thin film diffusion effects from surface roughness just by tilting the sample or changing the detector angle

AMS analysis of geological and biological samples

N.Added, J.C. Acquadro, R. Liguori Neto, M.A. Rizutto (IFUSP) P.R.S. Gomes, R.M. dos Anjos (UFF), C.R. Appoloni, M.M. Coimbra (UEL), G.M.Santos, K. Fifield (ANU).



Typical AMS energy spectra

a) ^{14}C from sample and contaminants from setup.

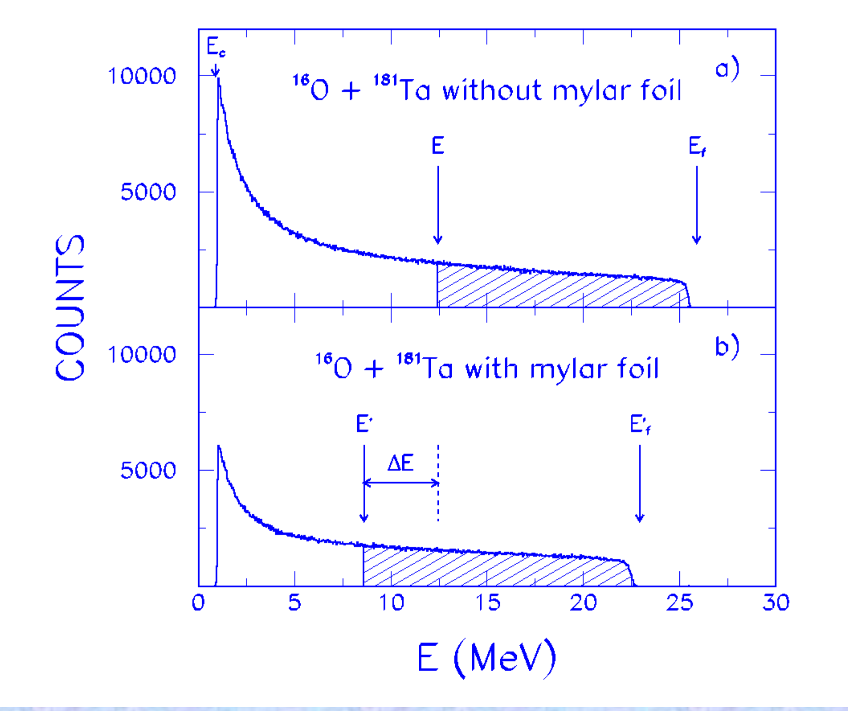
b) Energy calibration spectrum: three charge states of ^{12}C after bombarding a ^{120}Sn + ^{197}Au target.

Experimental curves for energy loss of ions in matter

R. Liguori Neto, N. Added, F.A.S. Coutinho (IFUSP)

$$\int_{E}^{E_f} f(E)\,dE = \int_{E'}^{E'_f} f'(E)\,dE$$

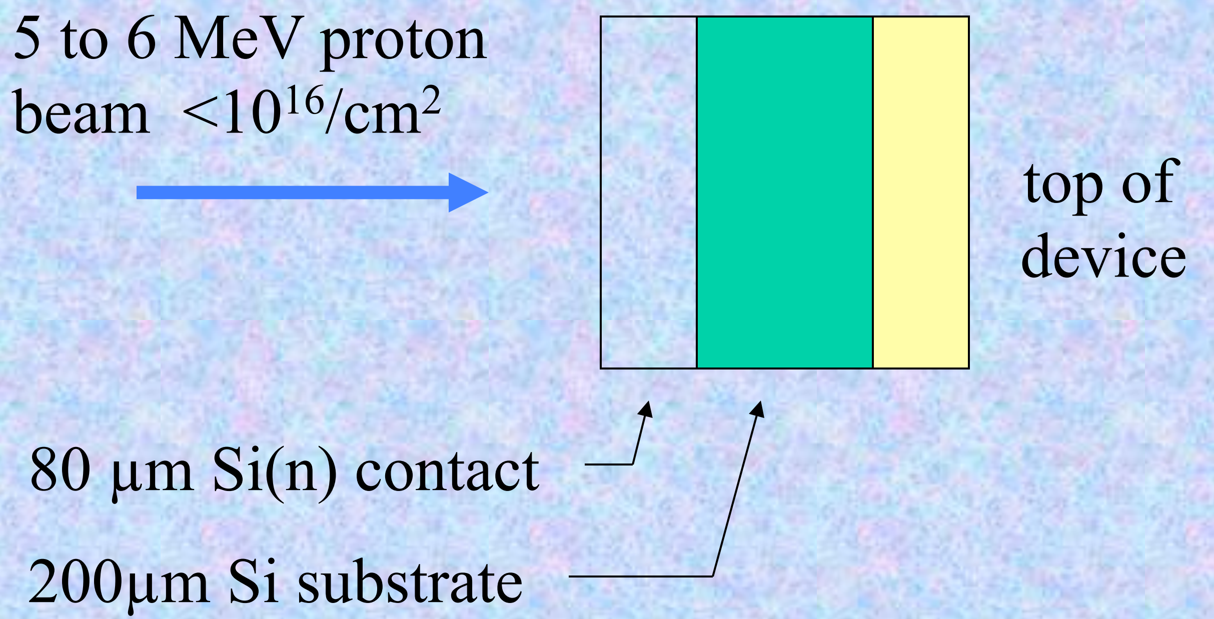
$$where\ \ E' = E - \Delta E(E)$$



Graphical example ilustrating the method
a) E_f and E without foil and
b) E_f' and E' with mylar foil.
Hatched area indicates the same number of particles in both spectra.

Modification of a Si device

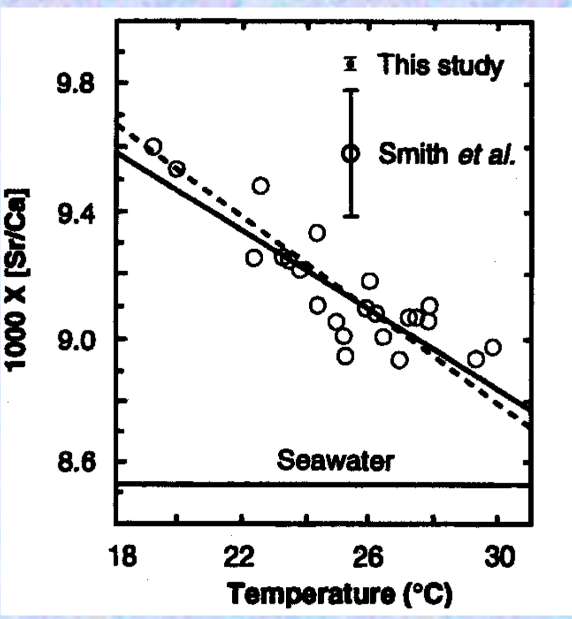
N.Added, M.H. Tabacniks (IFUSP)

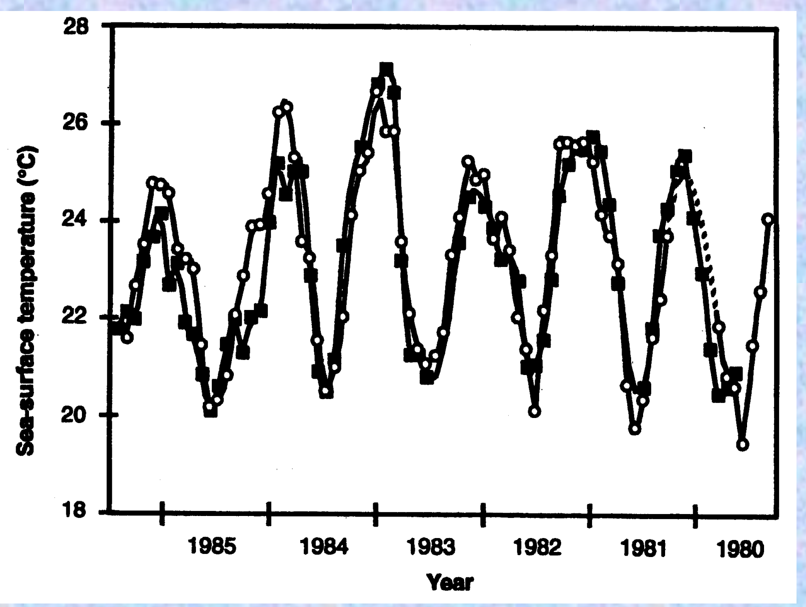


- high energy proton implantation in air
- defects in Si increase e^{-} mobility and device frequency
- during implantation device testing possible

Sr/Ca ratio in shells for a temperature sensor

Elisa Ferreira, M.A. Rizutto, N. Added, M.H. Tabacniks (IFUSP)

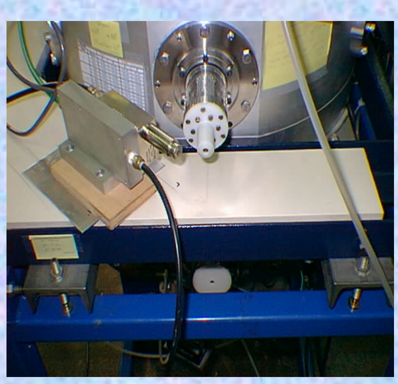
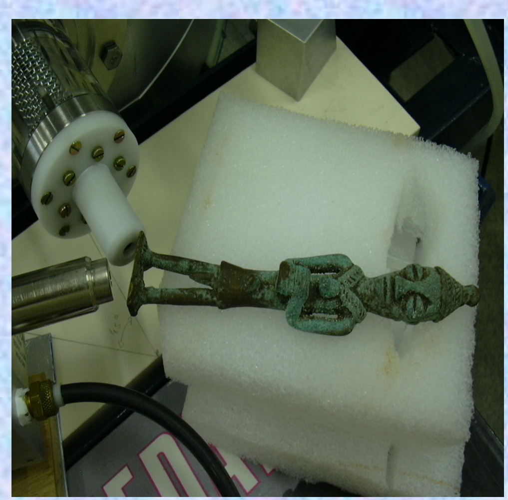
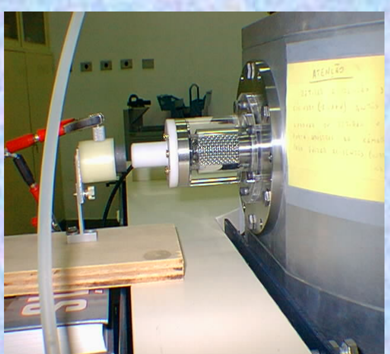
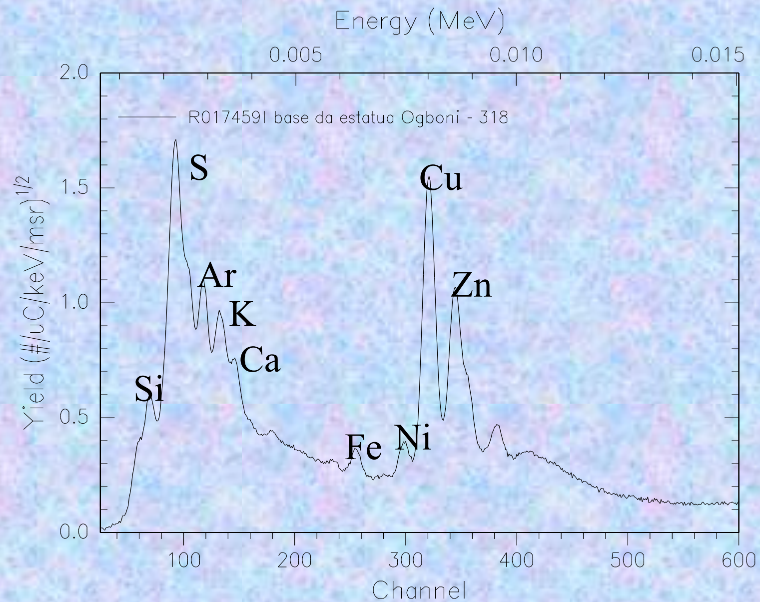




Shells collected at different sites with different temperatures
Sr and Ca measured by PIXE and PIGE

CARACTERIZAÇÃO ESPECTROSCÓPICA DE PRODUTOS DE CORROSÃO DE DUAS PEÇAS METÁLICAS DO MAE-USP

Carlos R. Appoloni, Paulo S. Parreira *Laboratório de Física Nuclear Aplicada, Departamento de Física, Universidade Estadual de Londina., Brasil*
Manfredo H. Tabacniks, Márcia A. Rizzutto, Nemitala Added, *Laboratório de Análise de Materiais por Feixes Iônicos, Instituto de Física, Universidade de São Paulo, Brasil*
Silvia Cunha Lima, *Laboratório de Conservação e Restauro, Museu de Arqueologia e Etnologia, Universidade de São Paulo, Brasil*
Hercílio G. de Melo, Augusto C. Neiva, Rocio P. Bendezú H. *Laboratório de Eletroquímica e Corrosão, Departamento de Engenharia Química, Escola Politécnica, Universidade de São Paulo, Brasil*

A primeira aplicação do arranjo experimental de feixe externo foi a análise de artefatos arqueológicos do MAE (Museu de Arqueologia e Etnologia da Universidade de São Paulo).

conclusions

(Nuclear) Applied physics can be part of the bridge connecting basic physics with the "real world" (Remember: It is a two way connection !)

Timing: Nuclear applied physics with accelerators started at IFUSP in 1980 with PIXE applied to air pollution research at the 8MeV Pelletron accelerator. 1992 started LAMFI. 2000 began the Group for Applied Physics with accelerators.

Do not do: " Given a solution (my accelerator), what is the problem?" Seek the right solutions to your problem.

Work in collaboration: Physicists don´t need to know everything, but avoid to be a "service" laboratory.

Facilities must work on a continuous basis. (Time is a working variable)

Thank you

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www.if.usp.br/LAMFI