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Authors

Gomes, P.R.S

Anjos, R.M

Acquadro, J.C

et al.

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Current status of the Brazilian AMS program

P.R.S. Gomes [a,*], R.M. Anjos [a], J.C. Acquadro [a], G.M. Santos [a,1], K.D. Macario [a,2], R. Liguori Neto [b], N. Added [b], M.M. Coimbra [c,2], C.R. Appoloni [c], N.V. de Castro Faria [d], S.D. Magalhães [d], R. Donangelo [d]

[a] *Instituto de Física, Universidade Federal Fluminense, Av. Litoranea s/n, Gragoatá, 24210-340 Niterói, R.J., Brazil*
[b] *Instituto de Física, Universidade de S. Paulo, C.P. 20516, S. Paulo 01498-970, Brazil*
[c] *Departamento de Física, Universidade Estadual de Londrina, Paraná, Brazil*
[d] *Instituto de Física, Universidade Federal do Rio de Janeiro, C.P. 68528, Rio de Janeiro 21945-970, R.J., Brazil*

Abstract

The status and the near future plans for the Brazilian AMS program are described. The 8 MV Tandem accelerator at the University of São Paulo (USP) is ready to measure standard AMS samples. A recently installed 1.7 MV Tandem at the University of Rio de Janeiro will have a ^{14}C AMS line. Together with external laboratories, we developed some projects on paleoclimatic and maritime geology. During these studies we have also learned sample preparation procedures.

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Keywords: Electrostatic accelerator; Mass spectrometry

1. Status of the AMS facility at the 8UD Pelletron Laboratory of São Paulo

The Brazilian AMS program was reported previously [1]. In this contribution, we report the main developments achieved since then, the status of the program and some of the plans for the near future.

At the Universidade de São Paulo (USP) 8UD Pelletron Laboratory, the single cathode ion source will soon be replaced by a NEC multicathode sputtering source for 32 samples. Improvements were made on the control system for the accelerator terminal voltage. Modifications of the generating voltmeter (GVM) control and the replacement of the current power supplies for the analyzing magnets are also under way. Stability tests have been performed and they have shown that the accelerator is ready to start AMS measurements. A computer controlled system for changing the accelerator parameters has been commissioned. Its main aim is to change periodically and simultaneously the terminal voltages

* Corresponding author. Tel.: +55-21-6206735; fax: +55-21-6203881.
E-mail address: paulogom@if.uff.br (P.R.S. Gomes).
[1] Present address: Department of Nuclear Physics, Australian National University, Canberra, Australia.
[2] Present address: PRIME Laboratory, Purdue University, West Indiana, IN, USA.

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and the focusing devices for a fast sequential injection.

A Bragg curve detector was built at the Universidade Federal Fluminense (UFF) and USP. For ^{36}Cl samples, the energy and charge resolutions achieved are 0.38% and 0.75%, respectively. The isobars ^{36}Cl and ^{36}S are cleanly separated. A detailed description of the detector and its performance is reported in another contribution to these proceedings [2]. Fig. 1 shows this detector placed at 0° in beam direction, and Fig. 2 shows results obtained for beams of the stable isotopes ^{37}Cl, ^{35}Cl and ^{36}S at São Paulo; their beam energies were 60.5, 64.0 and 62.4 MeV, respectively.

Standard ^{36}Cl and ^{14}C samples will be measured in order to test the reliability of the whole AMS system.

2. A new ^{14}C AMS facility at the 1.7 MV Tandem in Rio de Janeiro

In December 1998, a 1.7 MV Tandem (5SDH-NEC) was installed at the Universidade Federal do Rio de Janeiro (UFRJ), which is now under regular operation. This facility was purchased for basic research in atomic and solid-state physics. It has, originally, a single-cathode SNICS II ion source, GVM control, a gas stripper, magnetic quadrupoles, Wien filter, a 5° injection magnet and a switching magnet for ±15° beamlines.

This facility will be upgraded under the responsibility of the UFRJ and UFF AMS groups, in order to include a ^{14}C AMS line. We have already applied for the purchase of additional equipments required for this purpose, such as a multi-cathode (for 40 samples) ion source system, two mass analyzing magnets ($ME/Z^2 = 4$ and 12 MeV amu), one electrostatic deflector, Faraday cup assemblies including ultra low-noise linear current pre-amplifier, and some focusing and vacuum devices. A Bragg curve detector similar to the one developed for São Paulo will be built. Since the sequential beam injection system has been adopted, an automatic system for cyclic and periodic change of beams will be commissioned. Fig. 3 shows the schematic layout of the future facility.

3. Sample preparation

A fundamental and difficult task in the development of any AMS program is the sample

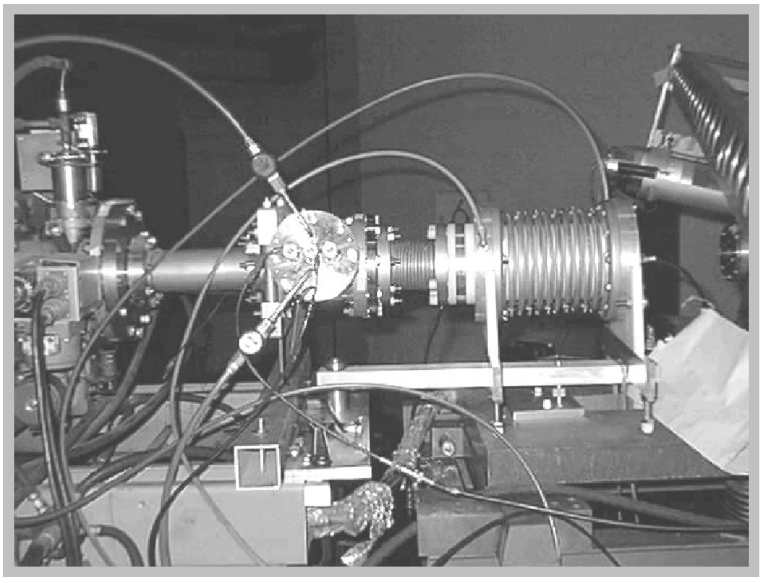

Fig. 1. The Brazilian Bragg detector, placed at 0° with the Pelletron beam direction.

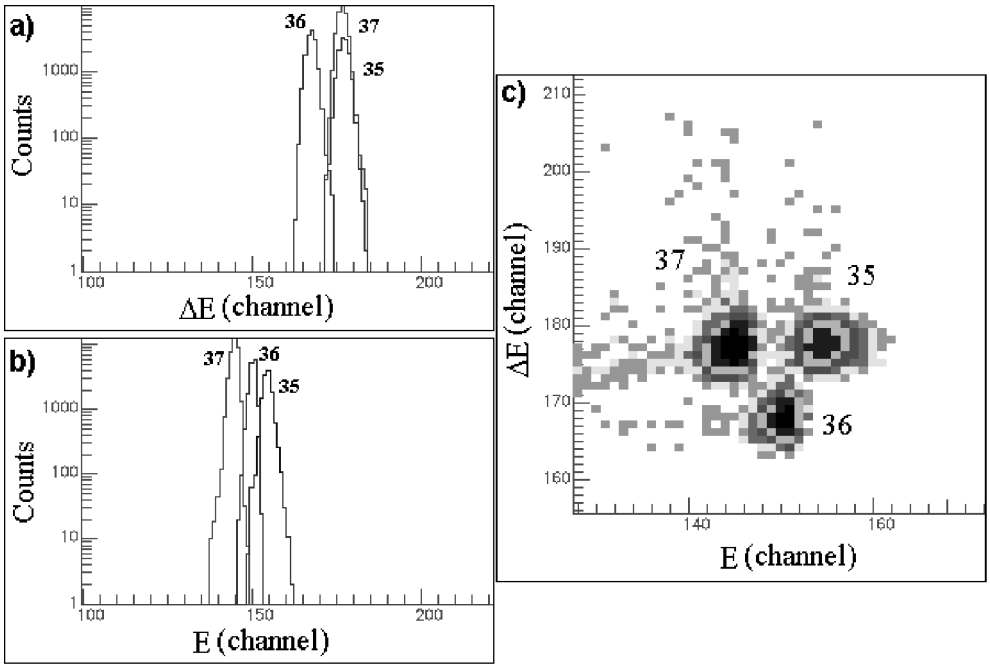

Fig. 2. Superposition of spectra of ^{35}Cl, ^{37}Cl and ^{36}S beams, taken with the Bragg detector at 0° with the beam direction and energies of 64.0, 60.5 and 62.4 MeV, respectively. (a) Projection of the energy with energy calibration of 0.34 MeV/channel. (b) Projection the energy loss spectra with energy calibration of 0.41 MeV/channel. (c) Two-dimensional E–E_r spectra.

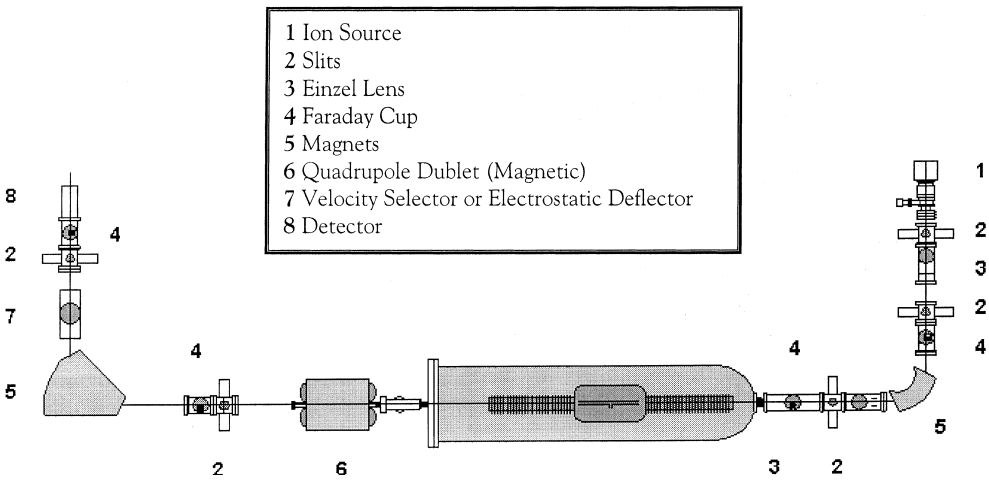

Fig. 3. Schematic view of the 1.7 MV Tandem at Rio de Janeiro with the main equipment which will be purchased and the ones already available.

preparation. We have sent Ph.D. students and post doctors (UFF and Universidade de Londrina, UEL) to the Australian National University (ANU) and PRIME Laboratory (Purdue University), in order to learn different aspects of the sample preparation technique. ^{14}C and ^{36}Cl samples have been prepared.

We have already applied for the purchase of a graphitization line, which will be installed at the Institute of Physics of UFF. The UFF's laboratory for ^{14}C sample preparation has the participation of physicists and chemists and also the collaboration of geochemists and geologists having experience in previous AMS projects and in the first steps of ^{14}C sample preparation.

4. Brazilian AMS research projects on paleoclimatic, maritime geology and biology studies

Within the already mentioned collaboration with ANU and PRIME Laboratory, some research projects concerning AMS radiocarbon dating and tracing were concluded and some are still under investigation. These projects were proposed by researchers from the geochemistry department, the maritime biology department and the maritime geology laboratory of the UFF and had the participation of physicists from the departments of physics of the UFF and UEL. One of the projects was proposed by the archaeological and ethnological museum of the USP.

At ANU, the occurrence of Holocene fires in the Amazon rain forest and the climatic changes that may have generated them were studied by dating charcoal fragments collected in soils from 0 to 100 cm depth [3]. The charcoal radiocarbon ages were found to vary mostly between 1000 and 1400 yr BP corresponding to one of the Holocene dry phases in this region. These results show that the fires have occurred more recently than expected by some authors, and that they have important regional dimensions and may be associated with regional climate changes.

At ANU, we will also investigate the black carbon of burned biomass, comparing the flux of atmospheric deposition of carbon particles with earlier fluxes of deposited carbon in lacustrine sediments in the Amazon region. The aim is to estimate the total flux of the atmospheric deposition which may be associated with the re-emission of Hg through forest fires, and to compare the ratios of Hg/(carbon atmospheric deposition) in pre-colonial (before 1500 AC), colonial and modern times (anthropogenic origin) in lacustrine sediments.

At the PRIME Laboratory, genesis and age of carbonate crusts collected offshore at the Campos Basin (Rio de Janeiro State, Brazil) were studied [4]. At 110 m water depth, the continental shelf at Campos basin presents a large carbonate platform complex with characteristic deposits of finely embedded pelagic limestone and uniform brown lime sand. It is completely different from other carbonate deposits found along the Brazilian continental shelf. This carbonate platform prevents downslope sediment transport via sheet flow. The radiocarbon ages of the carbonate laminae were determined to be from 1200 to 1100 yr BP at the bottom and from 1040 to 930 yr BP at the top of the deposit. The sedimentation rate was associated to productivity pulses related to upwelling and shelf edge current reworking.

In the PRIME Laboratory, we also determined the age and growth rates of stromatolite heads and crusts at the Salgada Lagoon (Rio de Janeiro State), as well as the age of the main episodes of changes in the internal structures of the stromatolite heads [5]. The ages of these changes are associated to other regional modifications of the lagoon's water column and to the local climatic variations during the last 3500 yr.

Other studies under investigation at the PRIME Laboratory are:

(i) The age and growth rates of the relict coral heads along the Victoria–Trindade submarine mountains chain (volcanic alignment of alkaline intrusions approaching the Brazilian continental margin). The samples were collected during an oceanographic cruise from the top of submarine peaks at depths from 60 to 90 m. In most samples, the coral heads are dead and covered by living red algae crusts, indicating that an important regional event was responsible for the death of the corals and the development of the red algae. The main aim of the project is to investigate the reasons for these regional changes, which might be related to changes in oceanic circulation patterns implying modifications in the water temperature or changes in water depth, which might be related to tectonic or isostatic subsidence of the submarine mountains or to variations of the sea-level.

(ii) An age and paleotemperature analysis from the middle slope at the boundary of Campos and Santos Basins (south-east of Brazil). The knowledge of the temperature variation of superficial and bottom waters that occurred through the Holocene are important in order to understand former marine currents, sea-level variations and water mass circulation. The objective of this study is to understand the intensity and frequency of the sea water temperature variations and to predict possible future tendencies. Samples of foraminifers (secret shells of pure calcium carbonate) will be studied, since they are found in the places where they lived, instead of being transported, like other groups of organisms.

(iii) An archaeological survey of the Lower Uaupés Basin (north-west Amazon region). The samples originate from a deeply stratified alluvial site from which two different occupation layers have already been dated by AMS to 3200 and 2600 yr BP. In between these layers, however, there are 60 cm of deposits with ceramic remains believed to represent different occupations. The aim of the project is to date these intermediate levels in order to assess whether this site has been occupied continuously from 3200 to 2500 BP. The assessment of this question will have implications for general debates in the Amazon anthropology due to the peculiar characteristics of the north-west Amazon, one of the most fragile ecosystems in the whole Amazon Basin.

Our goal is to collaborate and to keep in contact with the Brazilian research groups from different areas and to show them the applicability of AMS, in order to define the main directions of the Brazilian AMS program. While we are setting up the AMS facilities in Brazil, we work in collaboration with external laboratories and keep contact with the Brazilian AMS users.

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