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PRISMA - a magnetic spectrometer for heavy ions at LNL

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The heavy-ion magnetic spectrometer PRISMA was recently installed at Laboratori Naz. di Legnaro, in order to exploit the heavy-ion beams of the XTU Tandem-ALPI-PIAVE accelerator complex, with masses up to A$\simeq$200 at energies $\simeq$5-10 MeV MeV A.

1. The spectrometer

PRISMA is a magnetic spectrometer[1] installed at LNL, designed for the A=100-200, E = 5-10 MeV A heavy-ion beams of the XTU Tandem-ALPI-PIAVE accelerator complex and for the possibile use with the proposed radioactive beam facility SPES. PRISMA consists of a quadrupole singlet (30 cm diameter, 50 cm length) at 50 cm from the target, and of a dipole (20 cm gap, 1 m width, 1.2 m radius of curvature), 60 cm further away.

Its main features are large solid angle 80 msr ($\pm 6^0$ for θ and $\pm 11^0$ for ϕ), wide momentum acceptance$\pm$10%, mass resolution 1/300 via time-of-flight through the magnets, energy resolution up to 1/1000 and rotation in a large angular range -20^0+130^0. A picture of PRISMA can be seen in Fig. 1.

The large segmented ionization chamber IC at the focal plane consists of ten anodes in the same gas volume, each one subdivided into 4 sections for ΔE measurements, for a total surface of $\simeq$ 1 m^2. The Frisch-grid and anode planes are located at a distance of 13-16 cm from the cathode (Fig.2 was obtained very recently). A MWPPAC array is placed 60 cm upstream of the IC, consisting of 10 equal detector sections for a total area of 100 x 13 cm^2, with a three-electrode structure, i.e. a central cathode (polarized at high voltage) for the timing signals, and X and Y wire planes (at ground potential) for the position signals (X and Y resolutions 1 mm and 2 mm respectively), symmetrically placed on either side of the cathode and at a distance of 2.4 mm from it. The entrance detector is installed between the target and the quadrupole magnet. It is based on 80$\times$100

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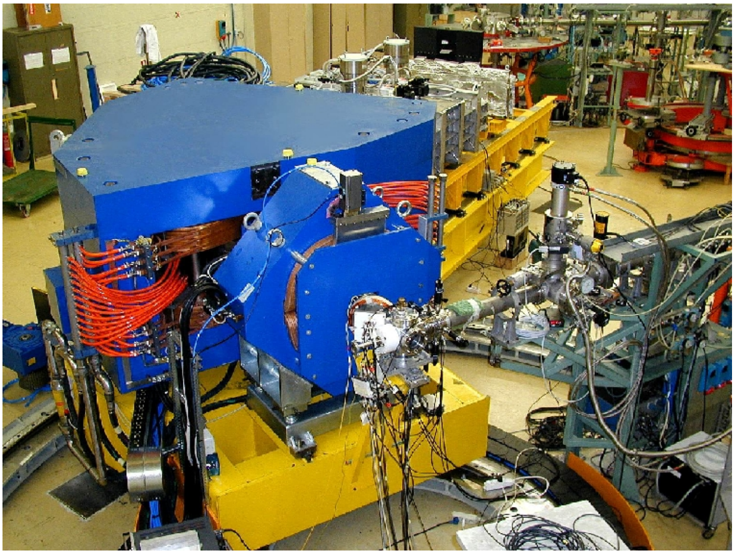

Figure 1. *The magnetic spectrometer PRISMA at LNL.*

cm^2 Micro-Channel Plates, and it gives time and X,Y position signals (1 mm resolution both), based on an anode with delay-line read-out. The overall resolution in the TOF measurement is typically 300 ps.

2. Recent results

The first experiments on heavy-ions grazing collisions were performed recently. The goals of the experiments were: 1) to investigate the population of neutron-rich nuclei in the A=50-60 mass region by means of multinucleon transfer reactions, and 2) to study the dynamics of such transfer processes. We used ^{54}Cr, ^{56}Fe and ^{64}Ni projectiles on a heavier and more neutron-rich target like ^{124}Sn, at incident energies corresponding to E/V_b=1.07-1.10 depending on the system. The beams were produced by the XTU Tandem accelerator of LNL at intensities in the range 2-10 pnA, using the double stripping technique. Angular distributions of the transfer reactions and of quasi-elastic scattering were measured in the range θ_{lab}= 65^o-105^o, and longer runs were taken around the grazing angle, in order to identify multinucleon transfer channels populated with small cross sections.

Various examples of mass spectra are reported in Figs. 3,4. Very good mass and Z resolutions were reached ($\Delta A/A$=1/280 routinely). The left spectrum in Fig.3 is obtained by selecting Z=24 events in the ionization chamber by ΔE-E identification, and various chromium isotopes are identified. The right spectrum is the A/q distribution of the pure neutron pick-up channels (+xn) leading to various neutron-rich iron isotopes (six-proton stripping and six-neutron pick-up channels were clearly observed). Population of ^{54}Ti

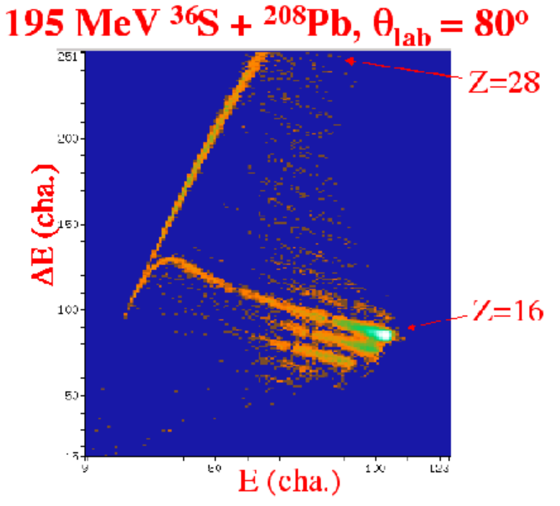

Figure 2. *ΔE-E spectrum from the ionization chamber of PRISMA.*

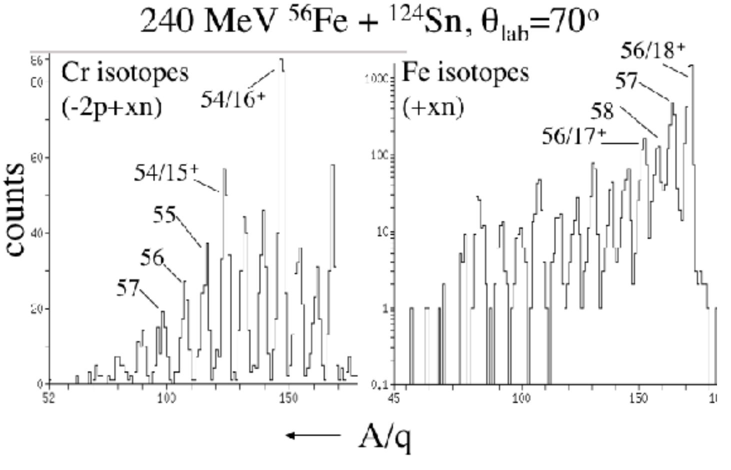

Figure 3. *A/q spectra measured with PRISMA during one of the recent runs.*

using a different reaction is shown in Fig.4. The analysis of all these data is in progress. In a separate run, the energy resolution of PRISMA was checked in the case of 235 MeV ^{40}Ca on ^{208}Pb, where true elastic scattering was clearly separated from inelastic excitations of 3^- states of both Ca and Pb.

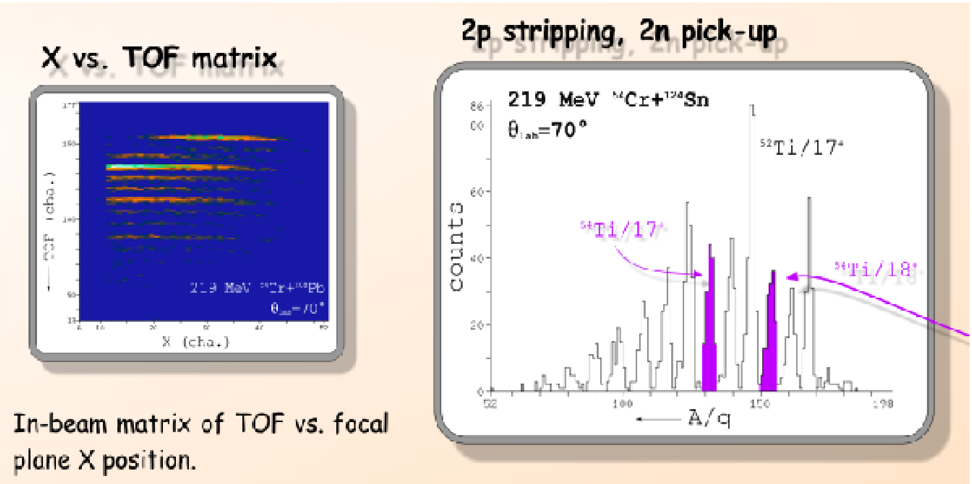

Figure 4. *Position X vs. TOF and A/q spectra of titanium isotopes.*

3. Combined operation with the Clover detector array CLARA

Coupling PRISMA with CLARA, the array of 25 Clover detectors [2] from the Euroball collaboration, is presently underway, and will soon allow to study the nuclear structure of moderately neutron-rich nuclei, populated at relatively high angular momentum, by means of binary reactions such as multinucleon transfer and deep inelastic. The project will largely benefit from the stable beams, at medium and high intensity, available from the PIAVE+ALPI complex. The entrance detector of PRISMA gives the direction of the ions with an uncertainty $\Delta\theta \leq 0.5^0$, so that Doppler broadening effects will mainly be due to the angular aperture of the Ge crystals. From the simulations we get the following features for CLARA: 1) total peak efficiency $\approx$3% for 1.3 MeV γ-rays; 2) peak/total ratio $\simeq$50%; 3) energy resolution 10 keV for v/c = 10 % at 1.3 MeV.

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