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The heavy-ion magnetic spectrometer PRISMA

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Abstract

PRISMA is a magnetic spectrometer for heavy ions under construction at Legnaro, with very large solid angle (80 msr), wide momentum acceptance (± 10%) and good mass resolution via TOF measurement; it will be dedicated to the study of nuclear dynamics and nuclear structure with stable and exotic ion beams. This is a review of its main features and of the present status of the project.

Keywords: Magnetic spectrometers; Detectors for heavy ions; Ion track reconstruction; Low-energy heavy-ion reactions; Exotic beams

PRISMA is a magnetic spectrometer for heavy ions [1], under construction at Legnaro, which will exploit the possibilities offered by the new positive-ion injector PIAVE of the ALPI linac [2], and by the future radioactive beams envisioned by the SPES [3] project for LNL. The most interesting features of PRISMA are its very large solid angle (80 msr) and momentum acceptance (±10%), good mass resolution (1/300) via TOF measurement and capability of rotation around the target in a wide angular range from $-30°$ to $130°$. The ion tracks will be reconstructed via software using the position, time and energy signals from the entrance and focal plane detectors, on the basis of the detailed knowledge of the magnetic field.

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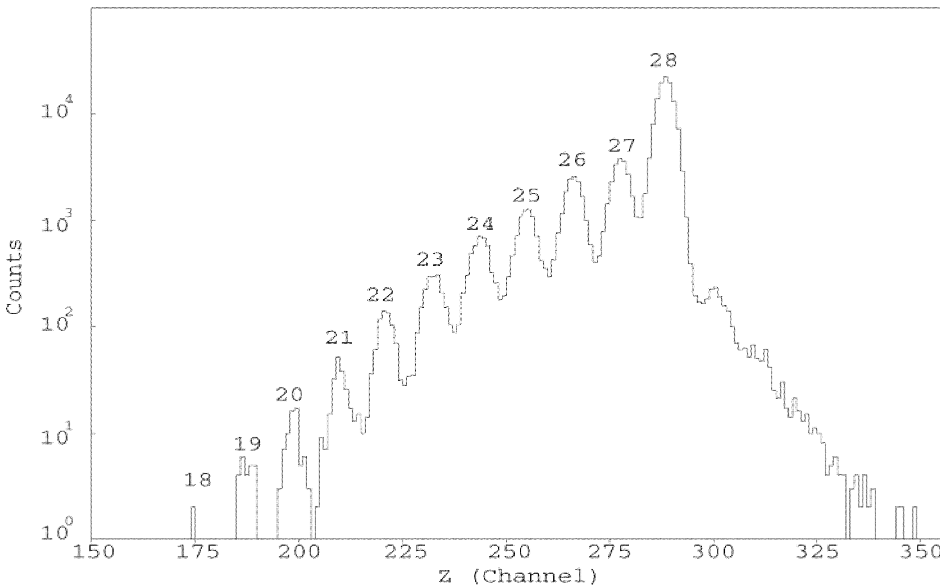

Fig. 1. Nuclear charge Z distribution from the reaction 347 MeV ^{58}Ni + ^{208}Pb recently studied at Legnaro.

Many interesting possibilities are offered by PRISMA both in the field of reaction dynamics and in nuclear structure studies, particularly for neutron-rich nuclei, when PRISMA will be used in a coupled operation with a large array of γ-detectors. Already with stable beams, yield measurements of exotic nuclei from multinucleon transfer, deep inelastic and fusion–fission reactions will be useful to complement the results from radioactive beam facilities. Fig. 1 is an example of this kind of studies that our group has undertaken in recent years, i.e. what we have obtained at LNL using the existent TOF magnetic spectrometer PISOLO [4] for the detection of light multinucleon transfer products in the reaction ^{58}Ni (beam) + ^{208}Pb at an energy (347 MeV) $\simeq$ 7% above the Coulomb barrier. The stripping of up to ten protons from ^{58}Ni was observed in a run (near the grazing angle) of $\simeq$ 12 hours; PRISMA will have a solid angle 30 times larger than PISOLO, and mass and energy resolutions around 3–4 and up to 10 times better, respectively.

The features of the PRISMA spectrometer are well suited also for detection of the reaction products in experiments with exotic beams where the complete kinematics of the events must be determined. In such experiments, PRISMA will be coupled with advantage to ancillary detector arrays for γ-rays and light reaction products. In this framework, the spectrometer could be used prior to the completion of the SPES project with light exotic beams produced in flight.

The optical design is very simple [1] and a sketch is shown in Fig. 2; we have a quadrupole singlet (diameter 30 cm, length 50 cm) at 50 cm from the target, focusing in the vertical plane, and a dipole (gap 20 cm, usable width 100 cm, radius of curvature 120 cm, deflection angle 60°) at 60 cm from each other. The effective field boundaries of the dipole are straight lines. The two magnets are being constructed by Danfysik

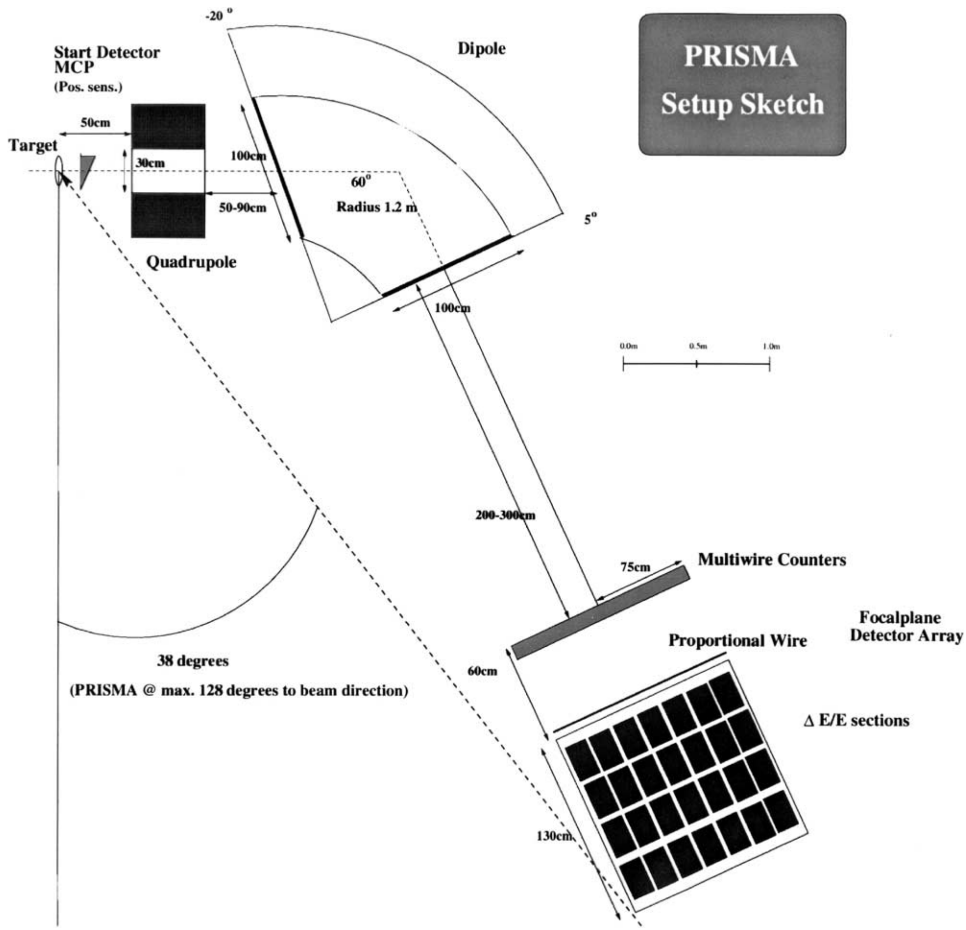

Fig. 2. Layout of the spectrometer PRISMA.

(Denmark) and should be delivered to LNL by end of May 2000. The mass energy product of the dipole is 70 MeV amu, the dispersion is 4 cm/%. The solid angle 80 msr corresponds to acceptances $\Delta\theta \simeq 12°$ in the dispersion plane (horizontal), and to $\Delta\phi \simeq 22°$ in the vertical plane. The total distance target–focal plane is near to 6 m. The magnets and all other parts of the spectrometer will lay on a rotating platform, whose design was completed at LNL during 1999 and which will be installed in May 2000.

The time and X, Y sensitive entrance detector [5] is based on rectangular microchannel plates 76×100 mm^2. It exploits an electrostatic field for the acceleration of secondary electrons from a thin Carbon foil ($\simeq 20$ µg/cm^2) onto the MCP assembly; a parallel magnetic field is applied [6]. Good position resolutions were obtained in the tests of the MCP detector prototype, on both X and Y axes (see Fig. 3); a fast induced signal is derived from the MCP face nearest to the anode, with good timing features ($\simeq 1.5$ ns rise-time).

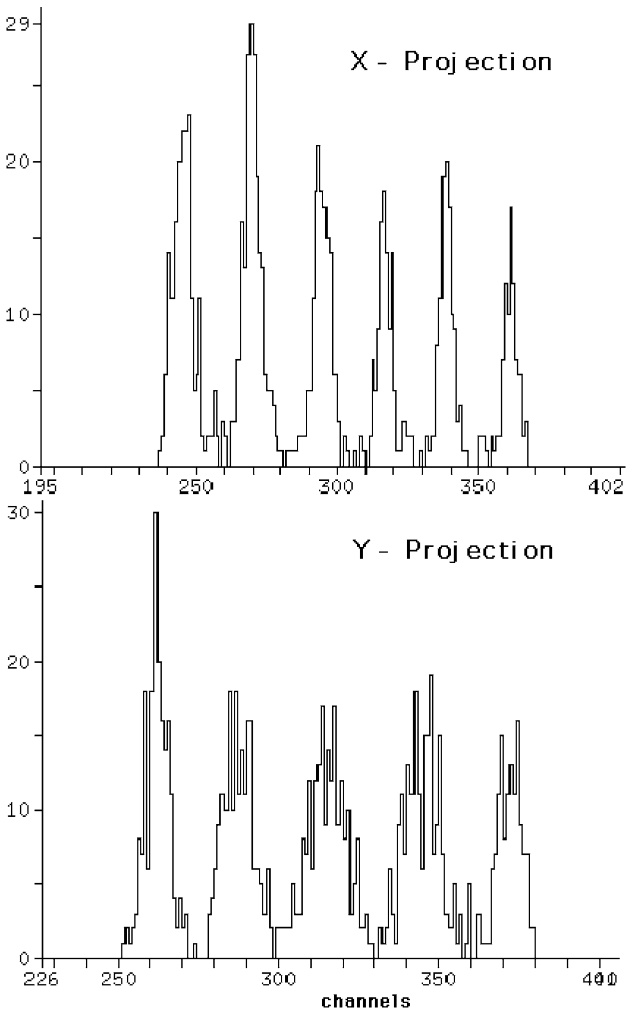

Fig. 3. X (up) and Y (down) position spectra from the entrance MCP detector. A mask with holes ($\phi = 3$ mm) 9 mm apart on the X-axis and 5 mm apart on the Y-axis was used in front of the detector. Intrinsic position resolutions are ΔX, $\Delta Y \approx 1.0$ mm.

The focal plane detector [7] (100×13 cm^2) consists of:

(1) a set of multiwire PPACs for time and X ($B\rho$), Y signals, followed by
(2) an array of split-anode ionization chambers with Y sensitivity and a proportional wire near the entrance window, to give a further X information.

The distance between the MWPPAC and the set of ionization chambers will be around 60 cm, so to measure the direction of the analyzed ions with sufficient accuracy (± 0.08 mrad in the dispersion plane). Low-cost preamplifiers for the ionization chambers have been successfully tested and produced. The entrance MCP and the focal plane detectors should be installed on PRISMA before the summer.

The acquisition system is presently being developed at LNL; here the main problems to be overcome are the very high event rate expected for PRISMA at forward angles (of the order of 200 kHz in a typical situation at $\theta \approx 20^{\circ}$), and the obvious need of a detailed on-line analysis which must produce, at least for a fraction of the events, mass and energy spectra for the various ion-charge states and for various combinations of measured parameters, using a detailed map of the magnetic field. This will be necessary in order to check the spectrometer performance in the set-up phase and during the experiments. Commissioning of PRISMA with beams should start within 2000. This would keep the original schedule, and will allow us to be ready for the first experiments with the PIAVE-ALPI facility in the second half of 2001.

References

[1] A.M. Stefanini et al., Report LNL-INFN(REP) 120/97, 1997.
[2] Annual Report 1999 of the Laboratori Nazionali di Legnaro, LNL-INFN(REP)-160/00, and references therein.
[3] SPES Project Study, LNL-INFN(REP) 145/99.
[4] G. Montagnoli et al., Nucl. Instrum. Methods A, in press.
[5] G. Montagnoli et al., in: Ref. [2], p. 160.
[6] O.H. Odland et al., Nucl. Instrum. Methods A 378 (1996) 149.
[7] S. Beghini et al., in: Ref. [2], p. 161.