First Results from the Fragment Mass Analyzer at ATLAS*

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Abstract. The Fragment Mass Analyzer (FMA) at the ATLAS accelerator has been operational for about one year. During that period a number of test runs and experiments have been run. The test runs have verified that the ion optics of the FMA are essentially as calculated. Experiments have been carried out on sub-Coulomb transfer reactions, alpha decay of neutron-deficient Pt isotopes, in-beam gamma rays from $^{202-204}$Rn, and the study of yrast isomers in ^{151}Yb. Recent results are presented, along with a brief facility description.

1. Introduction

The FMA[1,2] is an 8.2-meter-long recoil mass spectrometer installed at the ATLAS heavy-ion accelerator at Argonne National Laboratory. Figure 1 shows a schematic diagram of the FMA. The FMA separates reaction products from the primary heavy-ion beam and disperses them by M/q at the focal plane. The primary beam is stopped on the anode of the first electric dipole, and the two electric dipoles plus the bending magnet constitute an energy-dispersionless mass spectrometer. The two magnetic quadrupole doublets provide geometric focussing and control of M/q dispersion at the focal plane. The FMA has an energy acceptance of ±20%, a M/q acceptance of ±3.5%, a maximum solid angle of 8 msr, variable mass dispersion, and a M/q resolution of ≥300:1. The FMA

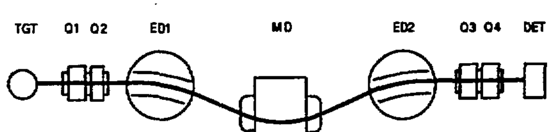

Fig. 1. Schematic diagram of the Fragment Mass Analyzer

can be positioned at angles between -5° and +45°, as well as at a variable distance from the target.

2. Early test runs

In test runs beginning in the summer of 1991, reactions induced by ^{32}S and ^{58}Ni beams on various targets were used to verify the ion-optical properties of the FMA. At the focal plane a 15 cm horizontal by 3 cm vertical parallel-plate avalanche counter (PPAC) was used to measure x- and y- position, time, and energy loss. This was followed by other detectors used to obtain the total energy, such as Si or Bragg curve detectors. With both A = 87 fusion products and target-like products from sub-Coulomb transfer reactions induced by ^{58}Ni on ^{154}Sm, a mass resolution of 350:1 was obtained at a solid angle acceptance of 5 msr. Because the FMA is a M/q spectrometer, unequal masses having different charge states can appear at the same focal-plane position. This M/q ambiguity can be resolved by using time-of-flight, as is shown in Figure 2 for the A $\simeq$ 154 recoils from the ^{58}Ni + ^{154}Sm experiment.

3. Early experiments

Test experiments were begun in late 1991. The first was a study of neutron-deficient Pt alpha-emitters produced by ^{32}S bombardment of ^{144}Sm. The reaction recoils were implanted in a Si detector located 25 cm behind the focal plane of the FMA. Further details of these measurements will be reported by Toth *et al.*[3].

The transit time of ions through the FMA is typically 0.5-1 μs, making it an ideal tool to study the decays of microsecond isomers at the focal plane. The ^{58}Ni on ^{96}Ru reaction was used to produce fusion products near mass 151, and delayed gamma-recoil and gamma-gamma coincidences were measured between the PPAC and three gamma detectors viewing a catcher foil just behind the focal plane. Besides known transitions resulting from the decay of high-spin isomers in ^{151}Tm and ^{152}Yb, two yrast isomers with half-lives of 2.6 ± 0.9 μs and 20 ± 1 μs were observed in ^{151}Yb. Figure 3 shows the gamma rays from these ^{151}Yb isomers.

The reaction ^{27}Al + ^{181}Ta was used to populate excited states in neutron-deficient $^{202\text{-}204}$Rn. Using four small Ge detectors at the target position, gamma spectra were taken in coincidence with recoils at the focal plane. The FMA provided extremely good suppression of the dominant fission, radioactivity, and

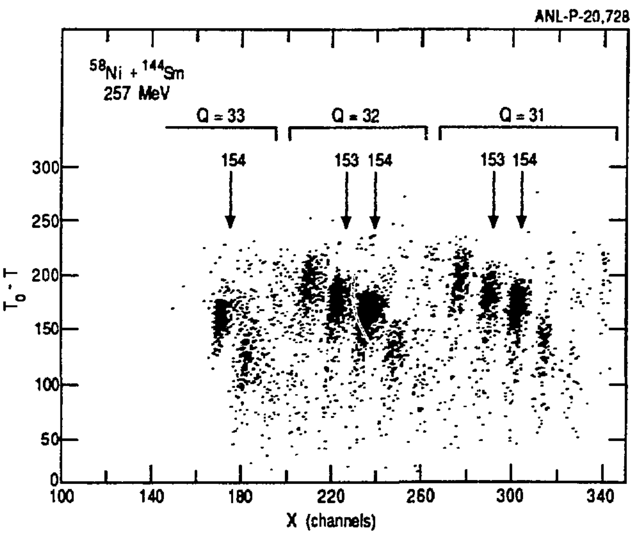

Fig. 2. Time-of-flight with respect to accelerator RF vs. M/q for target-like residues from the ^{58}Ni + ^{154}Sm reaction.

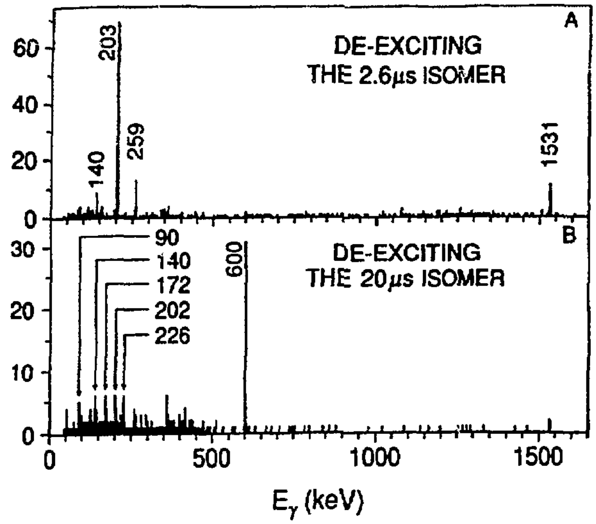

Fig. 3. Gamma rays from the decay of high-spin isomers in ^{151}Yb.

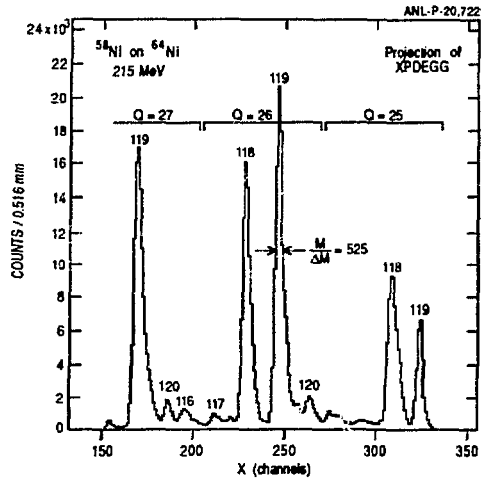

Fig. 4. M/q spectrum from the ^{58}Ni + ^{64}Ni reaction at 215 MeV.

Coulomb excitation backgrounds, allowing a number of transitions as well as characteristic x-rays to be observed for each nuclide.

4. Recent operational experience and future plans

The transmission and primary beam attenuation of the FMA were measured in a ^{58}Ni on ^{64}Ni experiment. For this symmetric case, a transmission of 24% was measured for the 2p2n evaporation product ^{118}Xe, and a primary beam rejection factor of $>10^8$ over the entire focal plane was obtained. Figure 4 shows the M/q spectrum, demonstrating a mass resolution of 525:1. The presence of up to three charge states of the same mass contributes to the high transmission. At present, development work is proceeding on new configurations of detectors for the focal plane, including highly segmented Si detectors for implantation studies. In addition, an array of ten Compton-suppressed Ge detectors is being installed around the target, to be used for in-beam gamma experiments.

References

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