To be published in
Physics Letters 1.4.1965

AR/Int. PSep./65-1
March 5th, 1965

The CERN Radio Frequency Particle Separator - First Operation

by

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The CERN microwave particle separator successfully completed its tests on 25th January 1965 by producing beams of K^- and K^+ at 10.12 GeV/c with adequate intensity and purity for bubble chamber experiments. The separator principles and basic design have been described by Bell et al(1); details of the "02" beam at CERN, in which the tests were made, are given by Keil and Neale(2).

The separated fluxes were measured with a threshold Čerenkov and scintillation counter system. To minimize errors due to counter saturation, the beam collimators for momentum and vertical angle selection were set to small openings and the corresponding two-dimensional phase space scanned in small elements or "bins". Since the beam was found to be very stable, the addition of the individual counts from each bin gave a reliable indication of the overall beam composition. The beam compositions and fluxes thus measured were 5×10^{11} circulating protons at 21.5 GeV/c:

		Positive beam	Negative beam
K flux per burst at bubble chamber:		7	6
Composition:	K	85 ± 4 %	64.7 ± 3 %
	p	8.6 ± 1 %	2.3 ± 0.5 %
	π	2.1 ± 0.3 %	10 ± 1 %
	μ	4.3 ± 1 %	23 ± 2 %

Since the threshold Čerenkov counters cannot distinguish between pions and muons, the π/μ ratios were deduced by an indirect method. The beam momentum of 10.12 GeV/c was chosen in conjunction with the RF separator parameters to eliminate protons and pions simultaneously at the beam stopper; consequently the protons and pions occupy the same region of transverse phase space throughout the system. In addition the ratios π^-/μ^- and π^+/μ^+ are equal; the ratio π^+/p^+ was determined from measurements with the unseparated beam and agrees with the results of Dekkers et al[4]. From these data and the counter measurements we deduced the separate μ and π contributions.

About 3000 photos were taken during the test run in the negative beam with the 1.52 metre British National Hydrogen Bubble Chamber. In order to limit the total number of tracks per photo to about 10 the intensity was reduced with the collimators, resulting in about 7 K^- per photo. The preliminary scanning of the photos gives results consistent with the counter measurements within the statistical errors.

The bin scanning procedure mentioned above brought to light some imperfections in the 02 beam as set up for RF separation. It was found, for example, that for optimum purity, the momentum collimator had to be set about 1°/o high for the positive beam and about 1°/o low for the negative beam. This effect may be due to a recent change in target position, made since the last complete setting-up of the beam optics. It should be noted in this context that, in the RF version of the 02 beam, 16 quadrupoles, 7 bending magnets and 9 adjustable collimators are in operation. Consequently we found that a few small adjustments of the type described above enabled satisfactory operation to be achieved much more rapidly than a complete systematic settinp-up procedure of the whole beam.

Different target positions, both radial and azimuthal, were used for the positive and negative beams, both targets being located in the magnetic field of the PS. The production angles were about 100 milliradian for the positive beam and 40 milliradian for the negative beam. This accounts for the somewhat lower flux of K^+ than K^-.

The RF separator requires a very short secondary beam burst of a few microseconds duration. The kicker magnet associated with the fast ejection system for the CERN-PS[3] was used tp produce a 2.1 microsecond burst. Since the fast kicker and the 02 beam target are separated by four betatron wavelengths in the beam direction, the kicked beam passes the target azimuth for the first time with zero displacement from the unperturbed orbit and has to make a further complete revolution of the PS in order to have the displacement necessary to strike the target, making in all 10¼ betatron oscillations.

The fast kicker and target operation took place at the end of each PS acceleration period, three other targets having already received their shares of the circulating beam earlier in the cycle. In order to protect the kicker magnet from excessive irradiation, three thick "dumping" targets were used in addition, the energy loss in these causing most of the residual beam to be consumed on the inner wall of the vacuum chamber within a quarter of a revolution. Despite the complication of this beam sharing arrangement, the stability of the PS enabled the operating conditions to be maintained during the run with only occasional minor adjustments.

No significant instabilities were observed in the separated beam. The setting-up procedure went smoothly and it can be expected that RF separated beams will be no more difficult to operate than those using conventional electrostatic separators.

Acknowledgements

The CERN RF separator, designed and constructed in Accelerator Research Division, was based on a proposal made by W.K.H. Panofsky at an informal meeting in CERN in 1959. The project was initiated and guided through its early stages successively by P. Lapostolle and H.G. Hereward. The basic design was developed by W. Schnell[5].

The success of the RF separator tests was the result of close co-operation between a number of groups and individuals. In particular we wish to thank W. Blum, C. Fischer, M. Jobes, E. Keppel, I. Lehraus, D.B. Miller, J.G. Rushbrooke and A. Ségar for the setting-up and running of the O2 beam. We are also indebted to L. Thorndahl for the separator timing system, W. Richter for the targetting arrangements, B. Kuiper and G. Plass with their group for the operation of the fast kicker, and the operational staff and services of MPS Division for the running of the Proton Synchrotron and the many services on which we depended.

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