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Catherine THIBAULT, Alain COC, Roger FERGEAU, Renaud LE GAC†, Michel de SAINT SIMON‡, François TOUCHARD†

CSNSM, Bât. 108, F-91405 CAMPUS ORSAY, France

Ernst HAEBEL, Heiner HERR, Robert KLAPISCH, Gérard LEBEE, Guido PETRUCCI, Giorgio STEFANINI

CERN, CH-1211 Genève 23, Switzerland

The radiofrequency mass spectrometer has been prepared in Orsay, and moved to CERN to be installed on-line with LEAR (PS189). The present and finally expected performances are given.

Presented at the "IX European Symposium on Antiproton-Proton Interactions and Fundamental Symmetries"

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1. INTRODUCTION

The principle of the radiofrequency mass spectrometer has already been explained many times[1,2]. The spectrometer has three main parts[3,4] :

-A 200 kV H^- ion source and a beam switching which allow to inject alternatively LEAR $\bar{p}$ and H^- ions into the same homogeneous magnetic field. The ratio of the cyclotron frequencies fo(≅ 2 MHz) in this field is thus related to the mass-to-charge ratio by $fo_{H^-}/fo_{\bar{p}} = q_{H^-}\, m_{\bar{p}} \,/\, m_{H^-}\, q_{\bar{p}}$.

-A RF (f ≅ 3 GHz) modulator which modulates and demodulates the energy in such a way that the energy remains unchanged only if $f = (n + 1/2)\ fo$

-Two electrostatic energy filters which select the ions for which the energy was unchanged and send them onto the detector : the resonance frequency is determined by recording the transmission of the spectrometer as a function of f.

2. EXPECTED ACCURACY

The accuracy of a single measurement including the recording of one $\bar{p}$ spectrum inbetween two H^- ones is given by :

$$\left[\frac{\sigma M}{M}\right]^2 = \left[\frac{1}{2.4\ R}\right]^2 \times \frac{1}{N} + \left[\frac{\sigma B}{B}\right]^2 .$$

The first term depends on the resolving power R of the apparatus and on the accumulated number of $\bar{p}$ (N). The second term reflects the fluctuations of

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†Present address CERN, CH1211 Genève 23, Switzerland
‡Presently CERN Associate, CERN, CH1211 Genève 23, Switzerland

the magnetic field B during the measurement. It is indeed expected to be negligible, compared to the first one.

The accumulation of $\mathcal{N}$ measurements will allow to improve these two terms by decreasing the statistical error and averaging the magnetic fluctuations so that both terms will decrease inversely proportional to $\mathcal{N}$.

2.1 Resolving power

The theoretical value of R is given[5] by:

$$R = M/dM = 2\pi\ n\ (T_m/T)\ (D\ R_0/w) = 2\pi \times 1500 \times 5\ 10^{-3} \times 6000/0.2 \cong 1.4\ 10^{6}$$

where n is the harmonic number (f/fo), T_m/T the relative amplitude of energy modulation and $D\ R_0/w$ the dispersive power of the energy filters.

In order to get more realistic values, we have performed Monte-Carlo simulations. For a dimensionless modulator the resulting value of R is $9\ 10^{5}$. When introducing the dimensions of the modulator, a value of $5\ 10^{5}$ is obtained which could be increased by adjusting the radial gradient of the magnetic field.

Actually, we have obtained R between 1 and $2\ 10^{5}$. This is due to a mismatching of about 10% between the modulation and demodulation amplitudes. The resolving power will be improved by using the definitive modulators in which it will be possible to equalize these amplitudes so that we expect to obtain the conservative value $R = 5\ 10^{5}$ or even a little better.

2.2 Antiproton counting rates

The main problem is to succeed to transmit a detectable amount of 20 MeV/c (200 keV) antiprotons throughout the spectrometer which has a much lower acceptance than the LEAR emittance : we need at least some tens of counts per measurement. A first approach -which will be tested at the end of november 88-, consists in degrading the antiproton momentum from 105 MeV/c down to 20 MeV/c. However the Monte-Carlo simulations of this process leave very little hope to be successful this way. Another possibility is now under study which would consist in decelerating the beam from 60 MeV/c down to 20 MeV/c by using a cyclotron. Such a scenario will certainly lead to much higher counting rates. However, even a very optimistic scenario will not predict a transmission better than 10^{-6} which would correspond to a counting rate of 1000/measurement if $10^{9}\ \bar{p}$ are ejected from LEAR in 100 ms.

2.3 Magnetic field stability

Stability tests have been performed by recording three successive H^{-} spectra and comparing the resonance frequency of the second one to the mean value of the two other ones. We obtained a variance of 10^{-7} for measurements lasting some seconds. This is sufficient for the next future but will have to be improved later on until some 10^{-8} by using a better stabilized magnet power supply.

3. CONCLUSIONS

The Table summarizes our expectations concerning the accuracy resulting from a single measurement and from one week of measurements assuming a repetition rate of 3 measurements per hour.

Resolving Power R	$\bar{p}$/spectrum in 100 ms	Accuracy	
		1 measurement	1 week
$2\ 10^{5}$	100 ?	$2\ 10^{-7}$	10^{-8}
$5\ 10^{5}$	20	$2\ 10^{-7}$	10^{-8}
$5\ 10^{5}$	100	$8\ 10^{-8}$	$4\ 10^{-9}$ ◄◄◄
$5\ 10^{5}$	1000	$3\ 10^{-8}$	$1.3\ 10^{-9}$

The scenario of the first line assumes the present performances of the spectrometer and a transmitted number of 100 $\bar{p}$/measurement. In the other lines are shown different scenarii of $\bar{p}$ counting rates using the expected value of R. Our challenge is shown by ◄◄◄..

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DISCUSSION

H. POTH (Institut für Kernphysik, KFK, Karlsruhe) : *Why don't you make use of electron cooling, which is now available in LEAR, in order to increase the antiproton beam phase space density before deceleration ?*
C. THIBAULT : *It is certainly very interesting if it is a routine item associated to LEAR, but it does not seem to be already the case.*