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Addendum to the proposal P54 presented to the ISOLDE Experiments Committee

Mass measurement of very short half-lived nuclei

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According to the minutes of the 9th meeting of the ISC (23th of august 1993), it appears that the physics motivation of our proposal is no more under discussion. Now, we have to answer to some specific questions, only some of them are mentioned in the minutes.

1. Separator emittance. The question is about the RFMS transmission we can obtain with the actual emittance of the separator and it was suggested doing measurements of the beam emittance. As a matter of fact, as the transmission is essentially determined by the transmission across the inlet slit of the spectrometer, it is the beam density in the waist which is relevant and, thus, the ion source emittance. Measurements of the emittance using a plasma ion source of ISOLDE have been carried out a few years ago by our colleagues of the ISOCELE Collaboration [1] with circular and rectangular exit slits at 40 kV. Among their data let's consider only the circular opening as the operation of rectangular slits is not conventional at ISOLDE. Taking into account, in order to be conservative, the highest emittance measured with the largest hole (2.5 mm in diameter) and doing the required correction for a 60 kV beam, our simulation of the RFMS provides a transmission of 4%. Such a result is better than the transmission of 1 % assumed in the proposal and doesn't rely upon the slit mode of the ion source. The emittance of the surface ionization source should be even better. With a transmission of 1 % and the yields measured at the SC, more than 100 nuclei with a half-life shorter than 1 second could be measured. Nevertheless, it could be valuable to check the emittance in the real situation using 2 beam scanners separated by a 0.5 m drift. The measurement has to be done preferably at the foreseen location of the spectrometer with a radioactive beam. One 8 hours shift is required for determination of the emittance in horizontal and vertical planes with a surface ionization source and 1 more shift for plasma ion source.

2. High Resolution Separator. Here, the question is referring to the transmission through the RFMS and to the stable beam availability.

For the first point, as it is mentioned above, the transmission of the RFMS is mainly related to the beam emittance and particularly to the beam density at the location of the inlet slit of the spectrometer. The beam density is determined by the ion source type and geometry and also by the setting-up of the ion source. These parameters are identical for HRS and GPS. Then, if there is a better emittance at the exit of the HRS, it corresponds to a lower transmission in this separator. As the resolving power of the RFMS is much larger than the HRS by a factor larger than 10 and the transmission is much lower, it is preferable to get the whole beam at the inlet slit in order to cut the trajectories at that location.

The second point is dealing with the greater availability of the stable beam from the HRS than from the GPS. This point is under the control of the ISOLDE Coordinator. But in order to lower the beam time request, it seems more convenient for ISOLDE and for the experiment that we produce our own stable beam as it will be explained below. **Thus, the HRS is not required to feed the RFMS.**

3. Stable beam requirement : need of an auxiliary ion source. The experiment needs stable beam for the initial setting-up of the spectrometer after installation and a few hours of stable beam at the beginning of each run for trajectory optimization in order to get the required transmission and resolving power. In addition, the experiment requires a beam used as reference mass during the whole process of mass measurement, it could be a stable or radioactive isotope, or a molecular ion providing excellent link to the ^{12}C which is considered as the standard reference mass. In addition, such a reference beam is also necessary for systematic errors investigation. Those beams except radioactive ones could be produce by a built-in ion source running at 60 kV providing stable alkali ions by surface ionization and molecular ions by electron impact ionization. The only constraint of such an equipment is the additional space required for the high voltage platform in the experimental area (figure 1). As a matter of comparison, this set-up will be much smaller than the existing high voltage equipment of experiment IS303 which is operated at 300 kV.

4. Voltage stepping. If we are allowed to install the auxiliary ion source as mentioned above, voltage stepping will probably not be required as ISOLDE will be operated at 60 kV and the auxiliary ion source at the right voltage to get both particles at the same momentum in order to make mass comparison. It could be used in the particular case of a radioactive reference mass to make a check of the systematic errors in this configuration. In this particular case, a duration of a few seconds to shift the ISOLDE voltage by 10 % could be acceptable. This duration has to be of the same order of magnitude as the time range corresponding to the fluctuations of the magnetic field which have to be lower than the mass accuracy we are aiming at. To get a final accuracy of 50 keV at A = 100 (0.5 ppm) with a stability of the power supply of 0.1 ppm/ 60 s which will be used, a duration of 5 s for voltage stepping is quite acceptable.

5. Systematic errors. As the RFMS has been fitted to the mass 1 for antiproton mass measurement, now it has to be adapted to the A = 10 / 250 mass range using a lower kinetic energy, a stronger magnetic field and a different frequency range. The last change implies a deep modification in the design of the RF modulator. About the systematic errors, they are related to the quality of the isochronism of the trajectories (homogeneity of the magnetic field), to the homogeneity of the RF field in the modulator and to the equality of modulation and demodulation amplitudes over the frequency range. A mapping of the magnetic field homogeneity at the higher field will be carried out. Then, we have to make a survey of systematic errors with the new type of wide band modulator in order to fight them.

6. Time table. Before to be able to start mass measurement with the radioactive beam, 3 steps have to be overcome : adaptation to the new mass range, construction of the auxiliary ion source and systematic errors investigation. For evident reasons (tight budget and efficiency) it is preferable to undertake them in Orsay leading to the following time table :

❶ RFMS move from LEAR/CERN to Orsay	february 1994
❷ RFMS installation	march 1994
❸ Magnetic field mapping	may 1994
❹ auxiliary ion source installation	july 1994
❺ fitting with new power supplies (magnetic field, RFpower)	november 1994
❻ setting-up and optimization	january 1995
❼ systematic errors survey	april 1995
❽ move and installation to ISOLDE	mai 1995

Of course, the experiment has to be approved so as the developments foreseeen in this time table could be funded.

7. Beam time request. The major consequence of the auxiliary ion source will be a strong reduction of the requested beam time : from 112 to 39 shifts. Nevertheless, systematic errors have to be checked also on the location of the experiment. For the first year of data taking after the installation, the request is the following :

Beam	Min.intensity	Target material	Ion source	Shifts	Programme
^{87}Rb-^{99}Rb	$\geq 4.\ 10^5$ /s	Thorium carbide	W surf. ion.	12	Technical tests
^{45}Ca-^{51}Ca	$\geq 1.\ 10^4$ /s	Tantalum powder	W surf. ion.	12	Systematic errors investigation
^{27}Na-^{35}Na	≥ 10 /s	Uranium carbide	W surf. ion.	15	Data taking

Reference : [1] Comparison between Nier-Bernas and Nielsen type ion sources for extracted ion-beam intensities in the mA range. J. C. Putaux, J. Obert, G. Boissier, P. Paris and the ISOCELE Collaboration. NIM B26 (1987)213-217.

Figure 1 : Proposal for the lay out of the RFMS equipped with an auxiliary ionionsource.