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Extending the mass "backbone" to short-lived nuclides with ISOLTRAP

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Abstract. New measurements performed with the Penning trap mass spectrometer ISOLTRAP extend the backbone to short-lived species. Recently obtained mass results are presented.

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In the Atomic Mass Evaluation [1], a backbone of very well known nuclides is distinguished (see fig. 1). For these nuclides the atomic-mass values are known with exceptionally high precision: their accuracy is below 1 keV. The precision now achieved with Penning traps allows also to improve the precision in our knowledge of atomic mass values of short-lived nuclides to extend the backbone.

ISOLTRAP [2] is a Penning trap mass spectrometer at the on-line mass separator ISOLDE, located at CERN, Geneva. It was designed for high-precision mass measurements of short-lived nuclides, based on the determination of the cyclotron frequency of ions stored in a Penning trap. The present relative mass uncertainty limit of ISOLTRAP is $8 \cdot 10^{-9}$ [3].

In an effort to extend the backbone, the masses of seven (six of them short-lived) nuclides were investigated (see table 1), almost all of them with an accuracy below than 4 keV. These high-precision mass values were included in the new Atomic Mass Evaluation 2003 [1]. All of them are in good agreement with the value recorded in the previous table [4] (see fig. 2).

The Atomic Mass Evaluation (AME) results from an evaluation of all available experimental data on mass measurements including decay and reaction energies, forming a linked network. The evaluation takes into account all measurements and achieved accuracy to produce a mass table. The new mean value can replace all the old ones and become the only one used, or the new one can be combined with old values to decrease the uncertainty. The

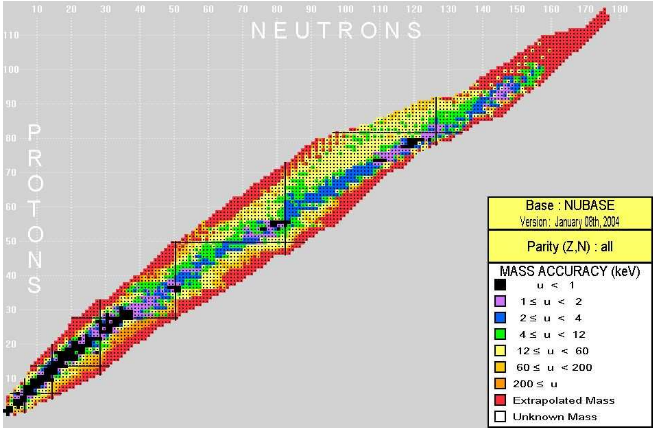

Fig. 1. Nuclear chart, where nuclides in black constitute the backbone. Their accuracy is below 1 keV (created by NUCLEUS-AMDC) [5].

Table 1. Comparison between previous [4], ISOLTRAP and new mass excess values [1]. All values are given in keV.

Isotopes	Previous Mass Excess	ISOLTRAP Mass Excess	New value from AME2003 table
^{56}Mn (2.6h)	−56905.6 (1.4)	−56910.3 (1.4)	−56909.7 (0.7)
^{57}Mn (85.4s)	−57485 (3)	−57486.4 (2.2)	−57486.8 (1.8)
^{82}Rb^{m} (6.5h)	−76121.1 (1.5)	−76118.8 (2.6)	−76119.1 (2.4)
^{92}Sr (2.7h)	−82875 (7)	−82865.2 (4.0)	−82868 (3)
^{124}Cs (30.9s)	−81743 (12)	−81745.5 (14.2)	−81731 (8)
^{127}Cs (6.2h)	−86240 (9)	−86244.0 (7.2)	−86240 (6)
^{130}Ba (Stable)	−87271 (7)	−87260.2 (3.2)	−87261.6 (2.8)

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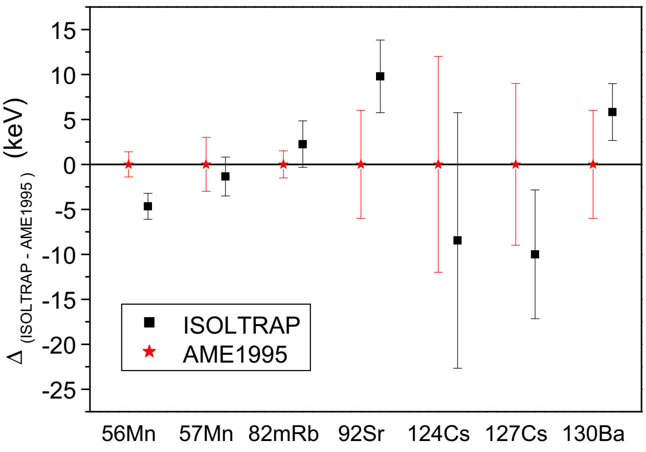

Fig. 2. Deviation of the ISOLTRAP measurements from the AME 1995 values [4].

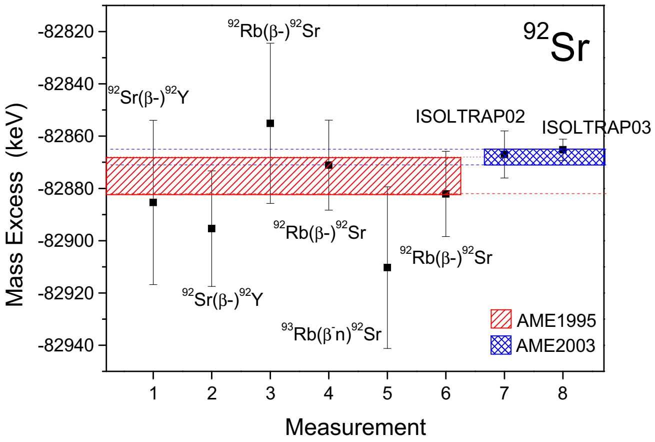

Fig. 3. ^{92}Sr measurements done with ^{92}Sr$(\beta^-)^{92}$Y [6,7], ^{92}Rb$(\beta^-)^{92}$Sr [7,8,9], ^{93}Rb$(\beta^- n)^{92}$Sr [10], the resulting value recorded in the AME 1995 [4], and ISOLTRAP values [11]. The final value in the AME 2003 table [1] has an uncertainty two times lower.

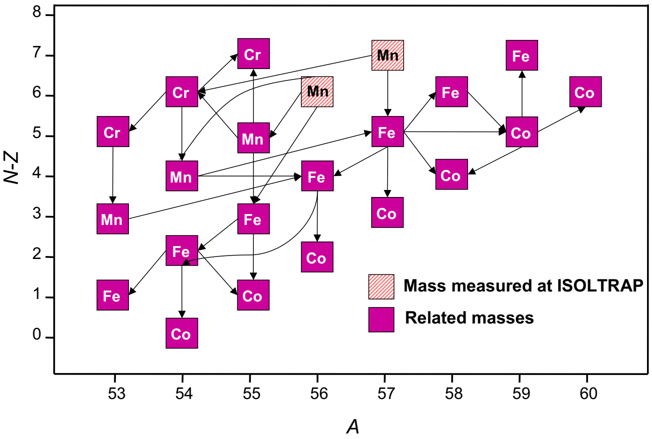

Fig. 4. Nuclides linked to the two manganese isotopes measured by ISOLTRAP.

case of ^{92}Sr can be taken as an example (see fig. 3). Six decay measurements were taken into account in the AME95 table [4]: ^{92}Sr$(\beta^-)^{92}$Y [6,7], ^{92}Rb$(\beta^-)^{92}$Sr [7,8,9] and ^{93}Rb$(\beta^- n)^{92}$Sr [10]. Since then, two measurements were done by ISOLTRAP: one in 2002 [11], and the other one presented in this work. The final precision of the mass value is increased by a factor of two, thanks to ISOLTRAP's measurements, but all the values are still taken into account: 88.64% from ISOLTRAP, 7.28% from ^{92}Rb$(\beta^-)^{92}$Sr, 2.89% from ^{92}Sr$(\beta^-)^{92}$Y, and 7.28% from ^{93}Rb$(\beta^- n)^{92}$Sr, according to the relative accuracy.

The linked network formed by the evaluation has an important role in the mass world. Links are built from measurements, but they also have an influence on measurements. For example, the SPEG [12] experiment needs calibration masses to deduce their mass of interest and has to add an extrapolation error. With a stronger, more accurate backbone, this error is decreased. The links between atomic mass values improved the accuracy of more than 20 nuclides of Cr, Mn, Fe, and Co, thanks to our high-precision measurements on manganese (see fig. 4). Some of these nuclides are now known with an accuracy below 1 keV, extending the backbone from the valley of stability.

In conclusion, a strong backbone is needed to increase our overall knowledge on atomic masses. The backbone is now extended by recent ISOLTRAP mass measurements as well as the ESR [13]. Further measurements also at other facilities are under progress [14,15,16,17] or planned for the near future [18].

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