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Addendum to proposal to the ISOLDE-Neutron-Time-of-flight-Committee (INTC)

Experiment IS418

Coulomb excitation of neutron deficient Sn-isotopes using REX-ISOLDE

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ABSTRACT

In our proposal to the INTC in 2003 we made the case to study the reduced transition probabilities, B(E2; 2+ → 0+), for neutron deficient Sn isotopes by Coulomb excitation in inverse kinematics using REX-ISOLDE and the MINIBALL detector array. The first beam time of this experiment was scheduled in 2004 and was followed by a new beam time in 2005. In this addendum we report on the so far largely successful experiment and motivate our request for extended beam time. In view of the newly measured yields we propose to continue the measurement series with ^{106}Sn as discussed in the original proposal.

1. Status and Motivation for Beam Time Extension

Experiment IS418 was allotted 19 shifts by the INTC in 2003 and the first run took place in the fall of 2004. This first beam time was largely successful from the experimental point of view. In particular the measured yield from the new LaC_x target was higher than expected. The yield of the isotope addressed at the beginning of the experiment, ^{110}Sn, was more than an order of magnitude higher compared to data from previous LaC_x targets (as quoted for the proposal). The full intensity available was thus not needed for the experiment. Instead the beam intensity was reduced in order to minimize data acquisition dead-time as well as random background radiation.

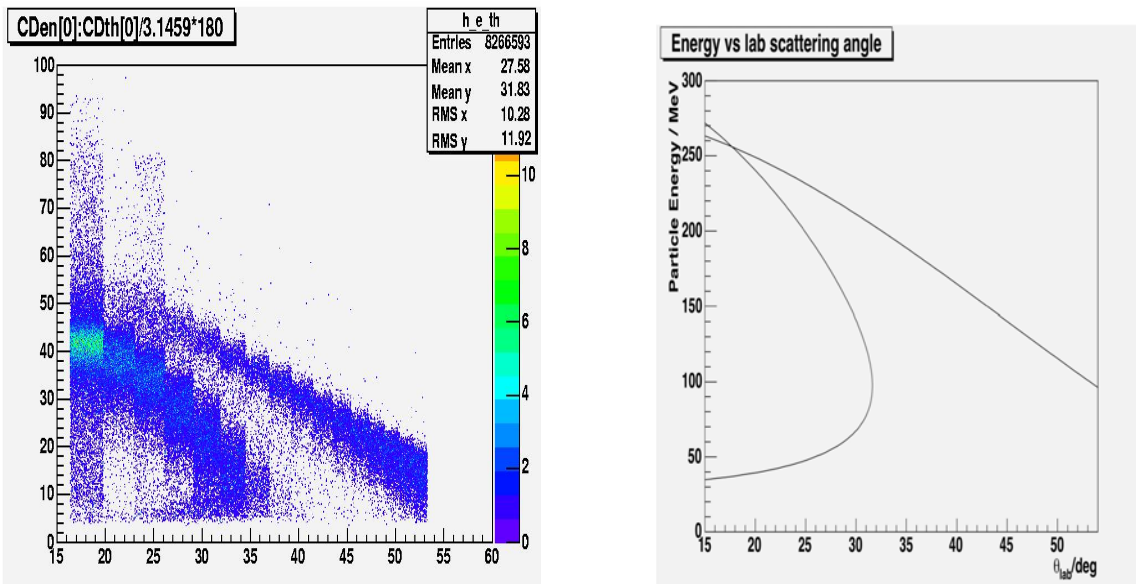

Fig. 1: Left panel: energy (in a.u) versus scattering angle measured with the Si-strip detector for ^{110}Sn on ^{58}Ni. The upper right branch corresponds to Ni recoils and the lower left branch to Sn beam particles. Right panel: calculated two-body kinematics for the same case (without target straggling). Data from 2004.

As can be seen in Figs. 1 & 2 an excellent data set was collected in 2004. However, some 6 shifts into the experiment (on October 31, 2004) the RF-amplifier of the so-called 9-gap resonator failed and further runs with radioactive beam could not be carried out that year. Nevertheless, enough data had been acquired to extract the B(E2; 2+ $\rightarrow$ 0+) value for ^{110}Sn which is the first isotope in the program we described in our proposal. On the positive side of the 2004 beam time was that we also established that the yield for ^{108}Sn was approximately an order of magnitude higher than previously measured from an LaC_x target. Furthermore, it was concluded during the 2004 run that an optimal beam current on the secondary target was ~2-3 pA. From the yield measurement it was predicted that such a current would be available also for ^{108}Sn (note that in both cases the available current was higher than this value). It was thus clear that it is possible to acquire a comparable data set for ^{108}Sn in approximately 6 shifts assuming the post-accelerator runs

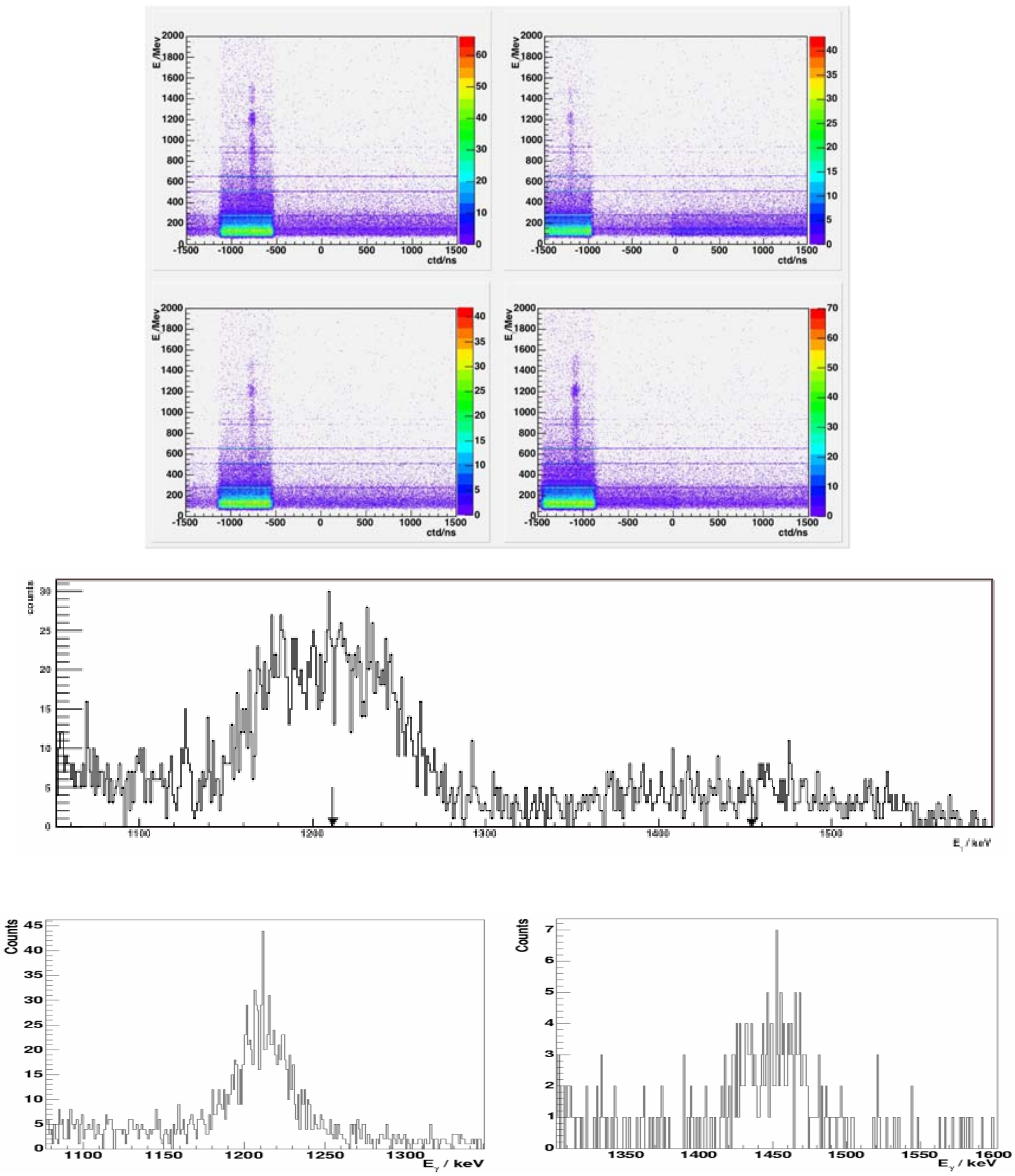

Fig 2: Top panel; gamma-ray energy (ordinate) detected in the MINIBALL Ge-detectors versus the time (abscissa) from EBIS-pulse release for detected particles in the Si-strip detector's 4 quadrants. The prompt peak is seen as a narrow line stretching up to ~1450 keV. This line corresponds to gamma-rays from Coulomb excitation of Sn beam particles and Ni target recoils. The photo peaks and the Compton distributions are clearly visible. Central panel; The non-Doppler corrected gamma-ray spectrum in the region of Sn and Ni gamma-ray emission after gating on prompt particles in the time spectrum. Bottom panel; Doppler corrected Sn and Ni gamma-rays. Data from the 2004 experiment.

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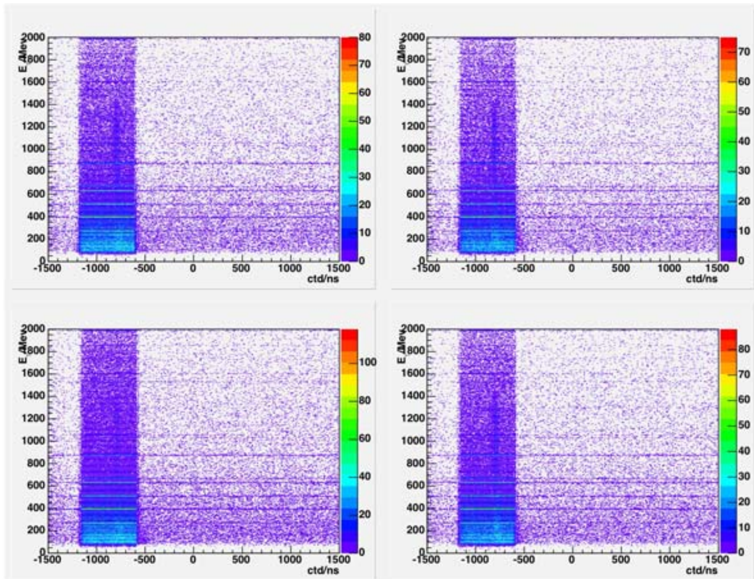

Fig 3: The plots for the 2005 data set corresponding to the top panel of Fig. 2 for the 2004 data set. Note that the total number of events in the prompt peak is not significantly smaller in this data set but that the overall background from random events is higher. It is also clear that the peak-to-background is better for some of the quadrants reflecting the fact that less events have been raised in these by scattered beam particles (misaligned beam). The effect is that the 2005 data set needs background subtraction in the gamma spectrum using a second time gate leading in turn to a larger error bar on the extracted B(E2) value. Experience from 2004 shows this to be unnecessary when the machine works according to specification.

in the same mode as in 2004.

The second beam time for IS418 was in August 2005. The yield for ^{108}Sn as measured in 2004 was confirmed during this beam time and the experiment ran with a current of ~2pA (corresponding to a reduction of the available beam current by a factor of ~10). Regrettably the RF-amplifier that caused the problems of the 2004 campaign was still not operating at its full duty cycle in 2005. The repetition frequency of the charge breeder was therefore set to 5 Hz instead of the 10 Hz used in 2004 in order to comply with the limitations of the RF amplifier. It should be noted here that the repetition frequency is normally determined by the time needed to breed the ions into the A/q range needed for the post-accelerator. The result of the lower repetition frequency was that in 2005 we were not limited by the normal performance of the machine but by a remaining deficiency in one of the components of the RF amplifier. In practice this meant that the active data collection time was reduced by a factor of 2 and consequently the number of events collected was half of what could have been expected. We add that the 2005 data set is still being analyzed. For the purpose of comparison of (machine) performance in

2004 and 2005 see Fig. 3.

Furthermore, a number of other factors were also less than optimal during the 2005 beam time. We need to mention that by mistake the separator was vented by a parasitic experiment at the GHM beam line during the preparations of the experiment. The end result of this event was the loss of set-up time and consequently a need to tune some of the experimental equipment using radioactive beam instead of stable beam (lost RI beam time). Luckily the target survived and the yield remained on the same level after the incident.

It was also noted that the quality of the beam spot on the secondary target was not as good in 2005 as in 2004. This effect lead to substantial beam-scattering into the detector elements and consequently to a higher random rate than in 2004 (Figs 2 & 3). It has been suggested that the alignment of the beam lines might have been affected by the recent removal of one of the walls in the experimental hall and that for this reason the beam was not on axis. That the beam was indeed off axis could be seen at the experiment by monitoring the beam position in the PPAC after the secondary target. Nevertheless, it was not possible to obtain a good position by beam steering. It also seems reasonable to believe that this effect is worse for cases where relatively intense beams are used and for cases where the 9 gap resonator is needed. We conclude that although the same beam current was available on the secondary target for ^{108}Sn in 2005 as for ^{110}Sn in 2004 the quality of the data was not as good and the number of collected events per shift was lower.

On the positive side we want to mention that similarly to what was the case for the yields of ^{110,108}Sn we have during the 2005 run confirmed a higher yield than predicted in the original proposal for ^{106}Sn. This fact now leads us to request shifts for measurements on this isotope.

2. Beam Time Request

With this addendum we would thus like to extend the beam time for IS418 in order to:

1) Finalize the run on ^{108}Sn with a properly working RF amplifier and a well aligned beam.

2) Continue our experiment with ^{106}Sn as discussed in the original proposal.

3) Perform the calibration using ^{112}Sn as described in the original proposal.

One can with the arguments above attempt to calculate the number of active shifts that have been used for ^{110,108}Sn in 2004 and 2005. We believe however that the rather complicated situation related to the RF amplifier that occurred during these two beam times better lends itself to re-establishing a firm number of shifts that can be scheduled

106Sn	108Sn	112Sn	REX set-up
10	5	2	2

Table 1: Suggested shift distribution for IS418. To finalize the ^{108}Sn measurement 6 shifts are needed for the experiment and the set-up. 3 more shifts are needed for calibration (^{112}Sn). To continue with the even more interesting isotope ^{106}Sn (see proposal) we suggest an allocation of 10 new shifts referring to the newly established yields. The continued use of the existing LaC_x target(s) is assumed.

e.g. during the 2006 campaign in order to finish this experiment and at the same time request new shifts for the measurement on ^{106}Sn (see Table 1) that can be scheduled concurrently.

We refer to the numbers given in the original proposal but note that the measured yield from the new LaC_x target is conservatively one order of magnitude higher than given there. We also note that there are now two LaCx targets that can be used for the continued effort in case new targets would not be built at this stage. With this in mind:

We first note that the 5 shifts approved for ^{110}Sn can be consider used in 2004 with a positive outcome.

We also suggest that of the 10 shifts approved for ^{108}Sn we have approximately used 5 in 2005 taking the arguments above into account. One shift is also needed to set up the ^{108}Sn beam.

Furthermore, the calibration using stable ^{112}Sn and the time to set up and retune the machine would require a total of at least 3 shifts. We believe that calibration should be performed as a verification of the result for the radioactive isotopes. This can possibly be done without use of the proton driver but with the RILIS.

Finally one can estimate that in 10 shifts we would be able to collect more than 100 events in the photo peak for ^{106}Sn which should be sufficient for this measurement. We point out that the Committee in its approval of the experiment put some emphasis on the lighter isotopes and that with the good yield from the new LaC_x target a measurement on ^{106}Sn is now within the limits of feasibility.

We thus ask the Committee to accept the use of 6 shifts, that we consider not actively used as argued above, to complete the ^{108}Sn case and to allow for 10 more shifts to continue the measurement series with ^{106}Sn in view of the new information on the yield. We also ask for 3 shifts for calibration. The latter may possibly be arranged without the need of the proton driver but with the use of the RILIS.