β and β-delayed proton decay of ^{31}Cl

L. Trache, A. Banu, J. C. Hardy, V. E. Iacob, M. McCleskey, B. T. Roeder, E. Simmons,
A. Spiridon, R. E. Tribble, A. Saastamoinen,[1] J. Aysto,[1] T. Davinson,[2]
G. Lotay,[2] and P. J. Woods[2]
[1]*University of Jyvaskyla, Jyvaskyla, Finland,*
[2]*University of Edinburgh, Edinburgh, United Kingdom*

In heavier nuclei close to the proton drip line, in the sd-shell region for example, the rates of radiative proton capture reactions on $_{Z}A$ nuclei are dominated by resonances. These resonances are excited states above the proton threshold in $_{Z+1}A$+1 nuclei. We aim at populating them by the beta-decay of their $_{Z+2}A$+1 isobars and study their further decay by proton or gamma emission. Such is the case with ^{23}Al and ^{31}Cl which we started to study in 2007 [1, 2]. We have extended the study of the decay of proton-rich ^{31}Cl with an experiment in November 2008 in which we aimed at:

a) decreasing the minimum of proton energies reached below 300 keV
b) increasing the statistics in the gamma-ray spectra.

We have produced and separated ^{31}Cl using MARS using the same (p,2n) reaction in inverse kinematics starting with a beam of ^{32}S @ 40 MeV from K500. We had similar rates and purity of the secondary beam

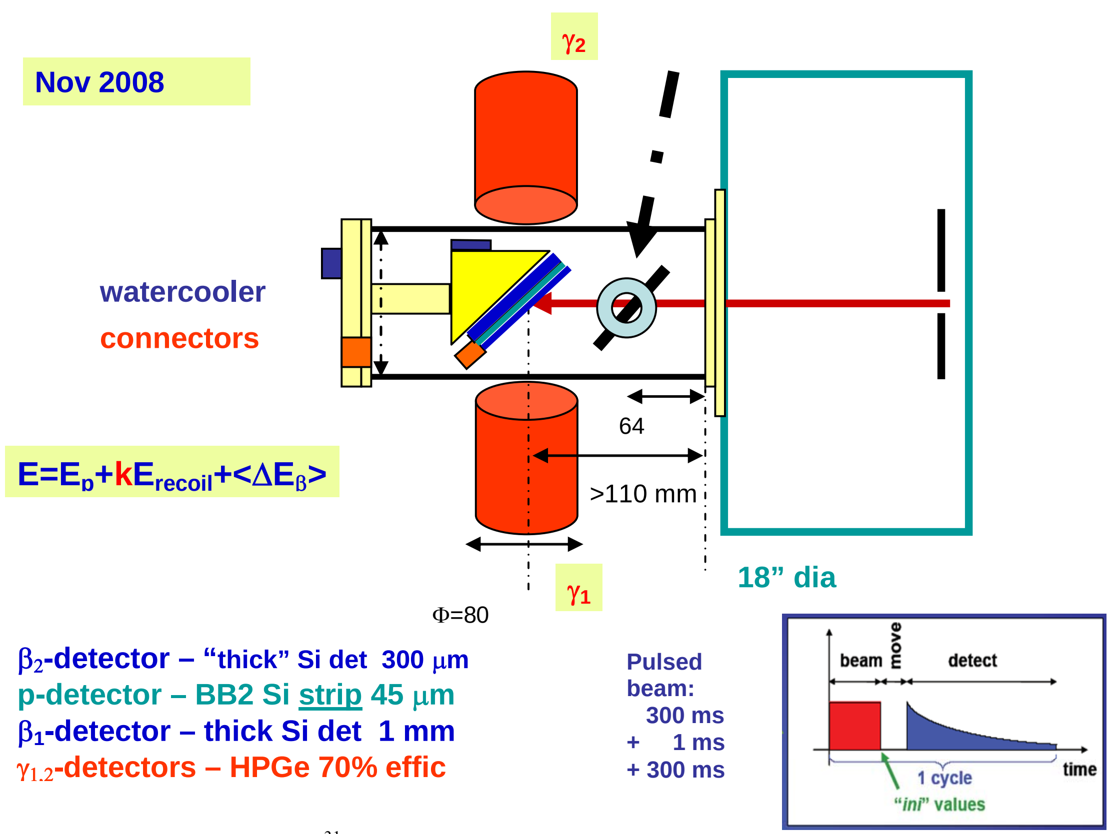

FIG. 1. The setup used for the ^{31}Cl run in Nov. 2008.

as the year before [2]: 3-4000 pps and 85% purity at the target detector. We used a setup as the one used before, except that we added now a second, identical, Ge detector.

The secondary beam was slowed down from about 34 MeV/u using the rotating Al degrader and was implanted in a thin detector (the "proton detector") in the middle of the Si telescope shown in Fig. 1. Two "beta detectors" were placed before and after it to detect the positrons emitted. We pulsed the beam from the cyclotron in cycles of 300 ms irradiation, 1 ms pause ("move") and 300 ms "detect" times. The measurements were only done off-beam in the last part of the cycle. To realize goal a) we replaced the W1-65 detector used previously with an even thinner detector and with narrower strips: a BB2-45 made by Micron Semiconductors Ltd., UK. To control the depth of the implantation distribution, and limit the rate impinging on the live detectors to <500 pps, we had to limit the momentum spread of the secondary beam to ± 0.27%. As expected, the background at low energies in the proton detector, due to the much more probable beta decay events not followed by the emission of a proton, was reduced very much. If in the previous detector we could see a large background below about 400 keV, in this case this background was pushed below 300 keV, or lower. In fact, at this point, the noise of the electronics was becoming the limiting factor. A proton spectrum is shown in the next report [3].

For the b) part of the experiment, we have removed the β_1 and the proton detector and replaced the latter with a 125 μm Al foil. The secondary beam was implanted in this thicker foil and we would open the momentum slits to obtain a larger rate. In each of the 70% HpGe detectors situated at 90° outside the chamber we obtained a statistics double from the one we had in Nov 2007. More recently, in spring of 2009, the lifetime of ^{31}Cl was measured with an accuracy <0.5% [4].

At this time, all data are still being analyzed.

[1] L. Trache *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2006-2007), p. I-29; http://cyclotron.tamu.edu/2007%20Progress%20Report/index.html; L. Trache et al., *Progress in Research*, Cyclotron Institute, Texas A&M University (2007-2008), p. I-9; http://cyclotron.tamu.edu/2008%20Progress%20Report/index.html

[2] L. Trache *et al.*, Proceedings of the 10th Symposium on Nuclei in the Cosmos Mackinac Island, Michigan, July 2008; http://pos.sissa.it//archive/conferences/053/163/NIC%20X_163.pdf and arXiv/0901.0330.

[3] E. Simmons *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2008-2009), p. I-8.

[4] V. E. Iacob *et al.*, (to be submitted).