Human Teeth Material - a Stable Biomarker for Neutron Exposure

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AMS measurements for a retrospective assessment of neutron doses of a-bomb survivors have been continued (see e.g. Ref. [1] for a review). The production rate of ^{41}Ca in human tooth material was proposed as a stable and characteristic signal of neutron exposure [2,3]. Tooth material from survivors of the a-bomb explosion in Hiroshima is available for a verification of this method. However, such an additional anthropogenic signal is of the order of typical natural background values. These ^{41}Ca amounts - measured as isotope ratio relative to the stable Ca isotopes, i.e. ^{41}Ca/Ca - are expected to be on the order of 10^{-14} for significantly exposed survivors. The quantitative measurement of isotope ratios at this level requires AMS as detection method, high particle energies for an effective background reduction, the use of CaH_2 as sputter material for isobar suppression and also high particle currents. Due to the closeness of expected signal to typical natural values, much effort has been put into a highly reproducible and low overall background level of the applied method. Therefore, the natural ^{41}Ca/Ca isotope ratio, typical for the area around Hiroshima, as well as the machine background have been investigated in detail. Fig. 1 shows the mean ratio of the overall ^{41}Ca/Ca background level during the various AMS beamtimes. Plotted is the cumulative mean isotope ratio obtained for tooth samples of several survivors from the Hiroshima region, which were not exposed significantly to a-bomb neutrons. During all beamtimes this background ratio, which consists of both, natural ^{41}Ca in the sample as well as the machine background itself, remained nearly constant at a low level of $\approx 2 \times 10^{-15}$. The dashed lines give the 1σ uncertainty of this background value ($\pm 0.5 \times 10^{-15}$). In addition, so-called chemical blanks have been measured, to o. They have been used either directly (commercially available CaH_2) or as compound material ($CaCO_3$). The latter underwent a similar chemical sample preparation process as the tooth samples.

Exposed samples are available for AMS measurements for survivors in Hiroshima with distances to the hypocenter between 892 m and 1153 m. Using the dosimtery system 1986 (DS86) [4], this distances correspond to calculated additional ^{41}Ca/Ca isotope ratios between 2×10^{-14} at 900 m and 3×10^{-15} at 1150 m distance to the hypocenter. Up to now tooth material has been measured via AMS for 12 exposed survivors. For 4 of those survivors material exists from two tooth samples of the same person. DS86 data for their individual neutron eye doses are available for 9 out of those 12 survivors, which provide the basic information for a detailed comparison of experimental and calculated data.

AMS-results on concentrations of ^{41}Ca in tooth samples for exposed survivors are shown in Fig.2. The symbols represent their isotope ratio ^{41}Ca/Ca versus distance of survivor to the hypocenter. The mean background value of 2×10^{-15} is subtracted from the measured value. Also shown is the expected isotope ratio (black line) using the neutron fluence distribution as predicted by DS86 one meter above ground, without any shielding corrections. 4 datapoints - as indicated with the rectangle in Fig. 2 - are found higher than their predicted value. In fact their γ-ray doses [5] show the same effect; i.e. measured γ-ray doses of these survivors obtained via ESR measurements on the same sample material, give also higher values than expected from DS86. Individual calculations for all survivors, which are investigated within this project are also underway now. And, using those data in comparison with our measurements, implications on the validity of the dosimetry system are investigated.

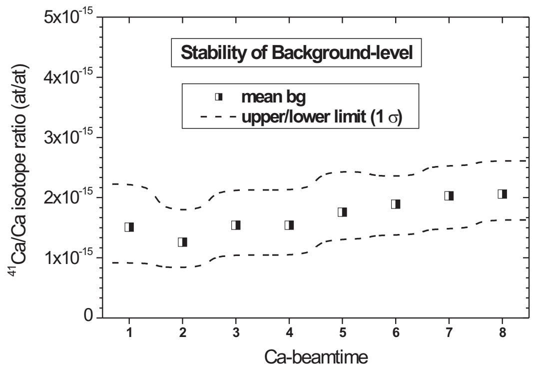

Fig. 1: Overall background level during various beam times

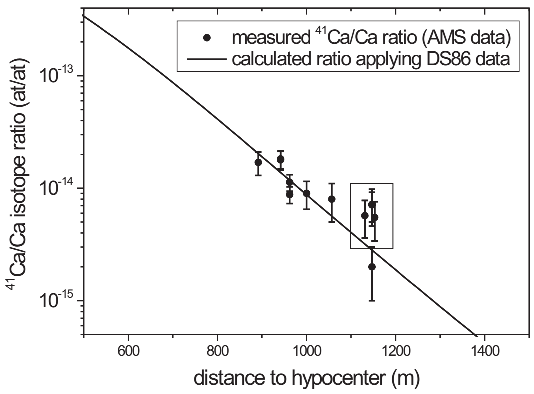

Fig. 2: AMS results on concentrations of ^{41}Ca in tooth samples for exposed survivors

References

[1] W. Rühm *et al.*, Radiation Environ. Biophys. **37** (1998) 293.
[2] A. Wallner *et al.*, Nucl. Instr. and Meth., accepted (2004) .
[3] A. Wallner *et al.*, Annual report 2002, p. 31.
[4] W.C. Roesch (ed.), U.S.-Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry in Hiroshima and Nagasaki, Final Report. Radiation Effects Research Foundation, Hiroshima (1987) .
[5] N. Nakamura and C. Miyazawa, J. Radiat. Res. **38** (1997) 173.