EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

**Status Report** to the ISOLDE and Neutron Time-of-Flight Committee

# IS478: Shape determination in Coulomb excitation of $^{72}$Kr

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## Abstract


The data obtained from the initial part of the experiment provided some evidence for the prolate shape of the $2_1^+$state in $^{72}$Kr, contradicting previous expectations and challenging theoretical models. The status report on this measurement is presented here. With the remaining shifts, we would like to carry out the Coulomb excitation of the 3.1 MeV/u $^{72}$Kr beam with an intensity of 800 pps impinging on $^{104}$Pd target as originally proposed.



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**Remaining shifts**: 13


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## 1. Motivation, experimental setup/technique

The motivation behind the present proposal, which is the same as that of the IS478 is briefly given here [1]. The measurement will also serve as an initial step towards realizing the plans presented in I152 [2].

Nuclei in the mass 70 region have relatively much larger ratio of valance to core numbers of particles compared to the heavier nuclei. Therefore, it is challenging for the theoretical models to explain phenomena such as shape co-existence in these nuclei. As a result this mass region provides a good testing ground for model calculations. Furthermore, the presence of oblate shapes, which is a rarity across the nuclear landscape, makes this region rather intriguing.

The Kr isotopic chain has been proven to be a good laboratory, in which a variety of shape dynamics are seen as a function of isospin and the spin, for example, see Refs. [3,4]. The proton rich $^{72}$Kr has been a challenging case for years [5,6]. Thanks to the efforts by the target team over a few years following the defense of the IS478, for the first time, the $^{72}$Kr of 500-1000 pps onto the MINIBALL target was possible [7]. This enabled us to carry out a Coulomb excitation study of $^{72}$Kr using the REX-ISOLDE facility in 2012 that resulted in our initial determination of its shape in the $2^+$ state. This result was valuable information for the theories, e.g., state of the art mean-field models in selecting the energy density functions [8,9]. A paper is currently under preparation [10].

In the original IS478 proposal, a 3.1 MeV/u $^{72}$Kr beam was assumed. However, the eventual measurement was carried out with 2.85 MeV/u. Only the $2^+$ to $0^+$ gamma decays in the target and the projectile were observed, indicating that inelastic excitations were significant only to the $2^+$ states and none of the higher lying levels were populated to any measurable extent. With the remaining shifts, we have the opportunity to perform our experiment at 3.1 MeV/u (just below the safe Coulomb barrier of 3.24 MeV/u). As a result, we will have better statistics for the prominent gamma decays observed in our initial experiment (cf. Fig.1) and for those from higher lying states that should further help us analyze shape coexistence features in this nucleus. In particular, there will be a possibility to obtain a larger set of matrix elements connecting the levels in $^{72}$Kr and will shed light on the validity of the mean-field models and the effects of various components of the effective nucleon-nucleon interaction used in the shell-models [9].

We request for the same setup used for the IS478 experiment, i.e. MINIBALL+CD, employing the Coulomb excitation technique.

# 2. Status Report

Fig. 1 shows the gamma ray spectrum detected by the MINIBALL in coincidence with the particles (both the projectiles and the target recoils) detected in the CD detector. This corresponds to the data obtained during the initial stage (May 2012) of our experiment.

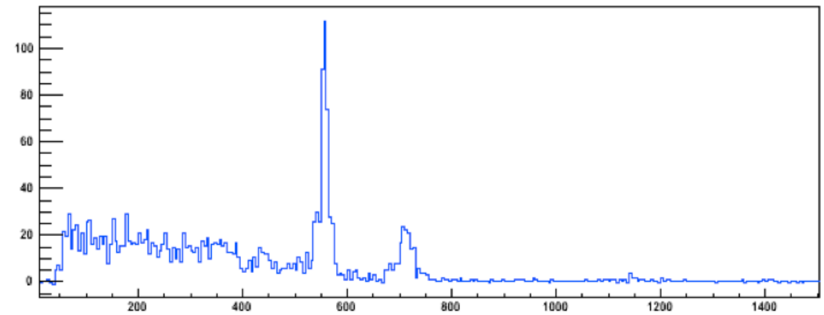


**Figure 1 The MINIBALL gamma ray spectrum in coincidence with the scattered particle. The two prominent lines correspond to the target ($^{104}$Pd, 0.56 MeV, 430 counts) and projectile ($^{72}$Kr, 0.71 MeV, 180 counts) excitations.**

An analysis of the target and projectile gamma-ray yields using the GOSIA code yielded a set of matrix elements shown in Fig.2

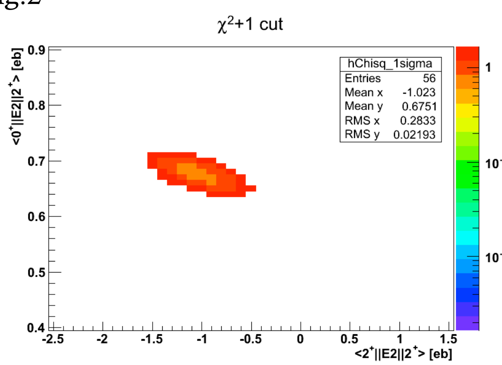


**Figure 2 A set of diagonal (<2$^+$||E2||2$^+$>) and transitional (<0$^+$||E2||2$^+$>) matrix elements obtained from the initial measurement.**

The negative sign for the diagonal matrix element (<2$^+$||E2||2$^+$>) implies a prolate shape for the 2$^+$ state in the $^{72}$Kr. The result is in contradiction with the previous expectations of oblate configurations for this state and provides a challenge to the theoretical models. New measurement with the remaining shifts will help us further confirm this result and will shed new light on the shape coexistence phenomena in this mass region. In particular, Observing gamma decays from the states located higher in energy than the $2_1^+$ state in $^{72}$Kr will further help us understand the nature of the ground $0_1^+$ and the first excited $0_2^+$ states that will be of a significant step forward in understanding the shape co-existence phenomena in the Kr isotopic chain and in general in the mass 70 region, providing critical tests to the models aiming at explaining oblate-prolate shape co-existence in this region.

### Accepted isotopes: $^{72}$Kr

### Performed studies: Coulomb excitation of $^{72}$Kr to determine its shape

## 3. Future plans

The measurement with the remaining shifts also serves as a bridge between the IS478 [1] and the letter of intent I152 [2], addressing shape co-existence in the region of mass 70 nuclei.

**Future plans with available shifts:**

(i) Envisaged measurements, beam energy, and requested isotopes

Coulomb excitation of $^{72}Kr$ using MINIBALL + CD setup, 3.1 MeV/u, $^{72}Kr$

(ii) Have these studies been performed in the meantime by another group?

No

(iii) Number of shifts (based on newest yields and latest REX-EBIs and REX-trap efficiencies) required for each isotope

| isotope | yield (/uC) | target – ion source | Shifts (8h) |
|---|---|---|---|
| $^{72}Kr$ | 5000pps/uC (800pps at Miniball target position) | Y203 - VADIS | 13 |

**Total shifts: 13**

## 4. References:


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10. B.S. Nara Singh *et al.,* to be submitted.