## Background

A recent experiment measuring the $\delta_c$ in $^{32}$Ar found the following value:

$$\delta_c^{exper} = (2.1 \pm 0.8)\%$$

This result is in agreement with the theoretical prediction, $\delta_c = (2.0 \pm 0.4)\%$; however, reducing the uncertainty will make it a more rigorous test of theory. One of the sources of uncertainty in $\delta_c$ was the $\gamma$ branching ratios from the decay measured by a set of 5 high-purity Germanium (HPGe) detectors. $^{32}$Cl is a decay product of $^{32}$Ar and has $\gamma$-rays which cover the same energy range; it could therefore be used as an in situ calibration source for the $\delta_c$ experiment. However, Detraz et al.\(^3\) last measured the $^{32}$Cl $\gamma$ and $\beta$ branching ratios over 35 years ago, and the uncertainties in their results contributed to the final uncertainty in $\delta_c$.

By measuring the $\gamma$-ray branching ratios in the $\beta^+$ decay of $^{32}$Cl, the detector efficiencies can be better determined, allowing for a more precise determination of $\delta_c$.

## Experimental Setup

- A beam of $^{32}$Ar was produced at the Texas A&M Cyclotron and purified in the MARS recoil spectrometer.
- A fast-tape transport system collected the $^{32}$Ar and was used to transfer the activity to a shielded counting position in $T_{\beta\beta}$ $= 0.2$ seconds.

The intensity of the gamma rays was measured in coincidence with beta particles. This HPGe was used because its absolute efficiency has been calibrated better than any other in the world.

### Calculations

**Data** was fit using a line-shape consisting of a Gaussian peak, low energy tail, and background. A variety of peak parameters were varied to obtain the best possible $\gamma$ value. All the peaks (except 2230 and 4770) had a reduced $\chi^2$ per d.o.f. less than 1.6, with most coming on 1.0 (example given to the right).

- Small gain variations can contribute to a non-Gaussian line shape when peaks are summed; fitting each line separately counters this effect. Doing this for the 2230 and 4770 peaks improved the $\gamma$ dramatically without changing the total fit area.
- If a potential $\gamma$ ray did not show a peak above background in our spectrum, we still fit the area to be able to set limits on the possible yield.

The data underwent various cuts to remove impurities and ensure a high signal-to-noise ratio:

- Cut on time after $T_{exp}$ to remove impurities with longer and shorter half-lives than $^{32}$Cl.
- By timing cut: to reduce random events that were not collected in coincidence with $\beta$ events.

### Results

Our preliminary results agree for the most part with Detraz’s work while maintaining a much higher degree of precision, though some strong inconsistencies remain.

$^{32}$S daughter level ($\text{keV}$)  | $^{32}$Detraz (%)  | This Work (%)\(^*\)
--- | --- | ---
2230.5 | 80.64 | 61.65 ± 0.17
3778.7 | 2.60 ± 0.48 | 1.90 ± 0.07
4281.3 | 3.16 ± 0.49 | 2.10 ± 0.07
4698.3 | 6.58 ± 0.9 | 4.12 ± 0.08
5548.4 | 6.16 ± 0.9 | 3.87 ± 0.07
6664.8 | 1.85 ± 0.2 | 2.02 ± 0.07
7095.5 | 20.5 ± 0.2 | 21.74 ± 0.13
7112 | 0.05 ± 0.1 | 0.59 ± 0.04
7161 | 0.59 ± 0.1 | 0.83 ± 0.04

\* Statistical uncertainty only

## Conclusions

Though these results are preliminary, their statistical precision for surpasses the previous measurements of the branching ratios of $^{32}$Cl. In addition, numerous new gamma peaks were seen. Systematic uncertainties, from the different timing cuts for example, still remain to be investigated. Even with systematic uncertainties yet to be included, the results promise to drastically increase the precision in $^{32}$Cl branching ratios. This will help improve the measurement of $\delta_c$ in $^{32}$Ar decay and ultimately better test theoretical calculations used to extract $\delta_c$.

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