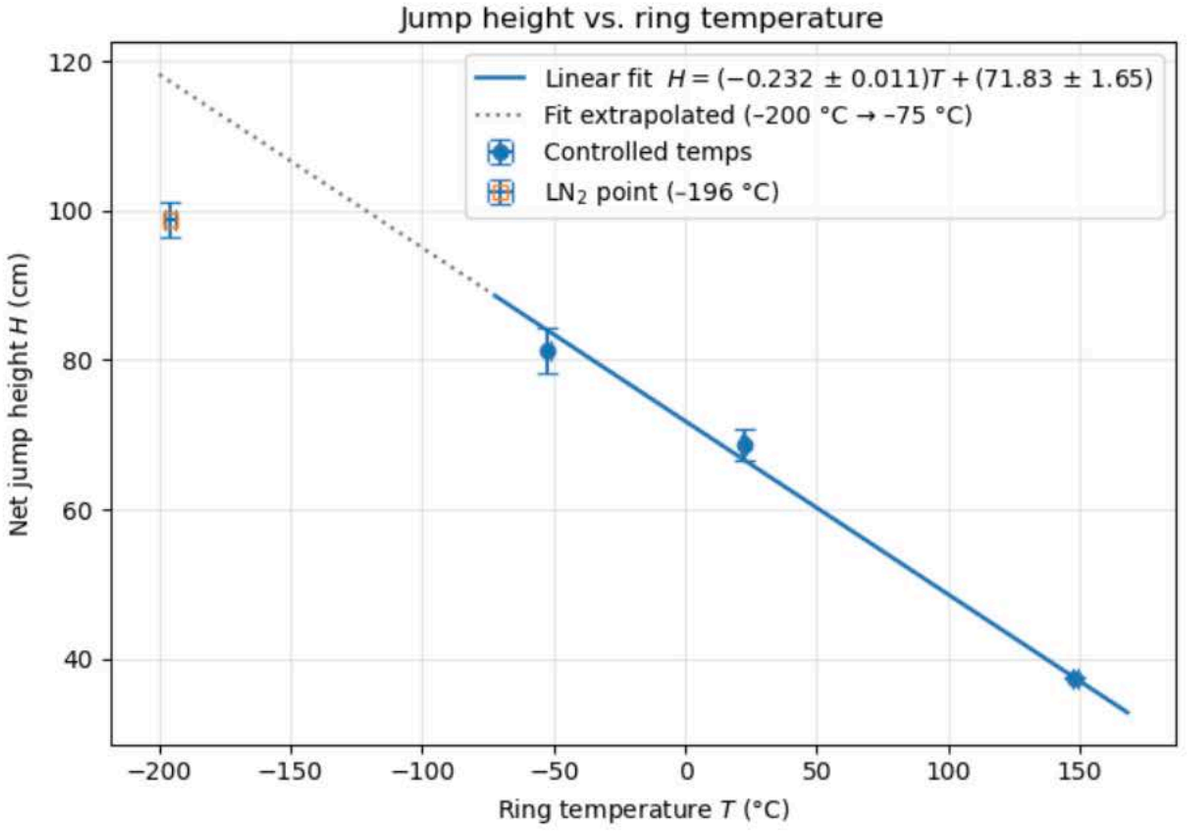

The plot suggests that the coldest ring was probably around -120°C

Uncertainty Analysis

To translate pixel measurements in Fiji to physical distances, I calibrated each frame with a wooden ruler: a 10 cm segment on the ruler was set equal to the corresponding pixel length, giving a conversion factor of $44 \pm 0.5, \mathrm{px\ cm^{-1}}$ in the high-resolution (3k @ 60 fps, portrait) videos and $11.5 \pm 0.5, \mathrm{px\ cm^{-1}}$ in the earlier landscape clips. The dominant systematic (scaling) error comes from the 1-px cursor placement uncertainty:

$$\{\pm 0.023, \mathrm{cm} \quad (\text{high-res})[4pt] \pm 0.087, \mathrm{cm} \quad (\text{low-res})$$

I adopt the more conservative $\pm 0.09, \mathrm{cm}$ for all heights. The camera timing jitter (60 fps $\Rightarrow \Delta t = 16.7, \mathrm{ms}$; observed frame-trigger variation $\pm 8, \mathrm{ms}$) is negligible: the ring's vertical velocity at the apex is ≈ 0, so shifting the peak by one frame changes height by $< 0.05, \mathrm{cm}$—well below σ_{scale}. The ring-centre selection (ring may tilt/translate in the frame) adds another $\pm 0.10, \mathrm{cm}$; combining this in quadrature with σ_{scale} gives a total single-measurement height uncertainty:

$$\sigma_H = \sqrt{0.09^2 + 0.10^2} \approx \pm 0.13, \mathrm{cm}$$

For each temperature, I recorded five trials; the statistical spread (sample standard deviation) at each T ranges from $0.6, \mathrm{cm}$ (hot ring) to $2.0, \mathrm{cm}$ (LN_2). Because these statistical errors exceed σ_H, they dominate the total uncertainty reported for the mean height:

$$\sigma_{\overline{H}} = \frac{s}{\sqrt{N}} \quad (N = 5)$$

Temperature uncertainties reflect the instruments used:

Room: $\pm 0.5, ^\circ\mathrm{C}$ (thermocamera, emissivity-corrected) Oven / Freezer: $\pm 2, ^\circ\mathrm{C}$ (thermocouple calibration) Liquid-nitrogen bath: $+5, ^\circ\mathrm{C} / -10, ^\circ\mathrm{C}$ (boiling LN_2 surface fluctuations and rapid warming during transfer)

These values are propagated into the x-error bars of the H vs T plot.