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Solid Hydrogen and High Vacuum – Nuclear Physics with IRIS at TRIUMF

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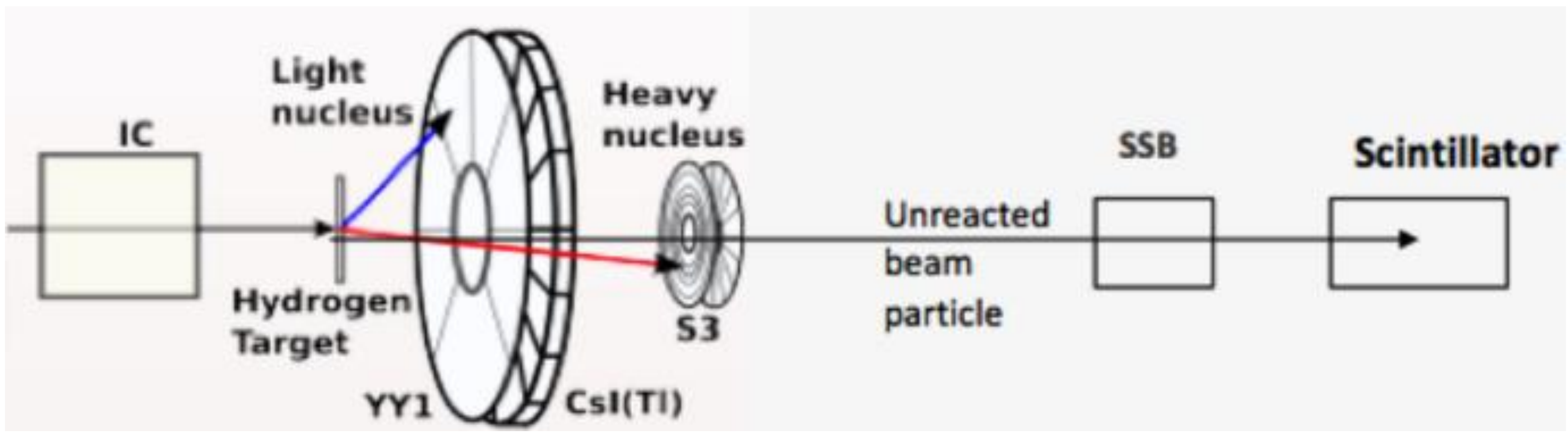
Experimental Setup



Schematic of the IRIS experiment. The beam passes through an Ionization Chamber (IC) for species identification before striking the target. Some of it is transmitted, the rest scatters and reacts, forming new nuclei. These products allow us to study exotic nuclear structure, probe *terra incognita* in the chart of nuclides, and explore potential three-nucleon forces vital for *ab initio* nuclear theory.

Problem:

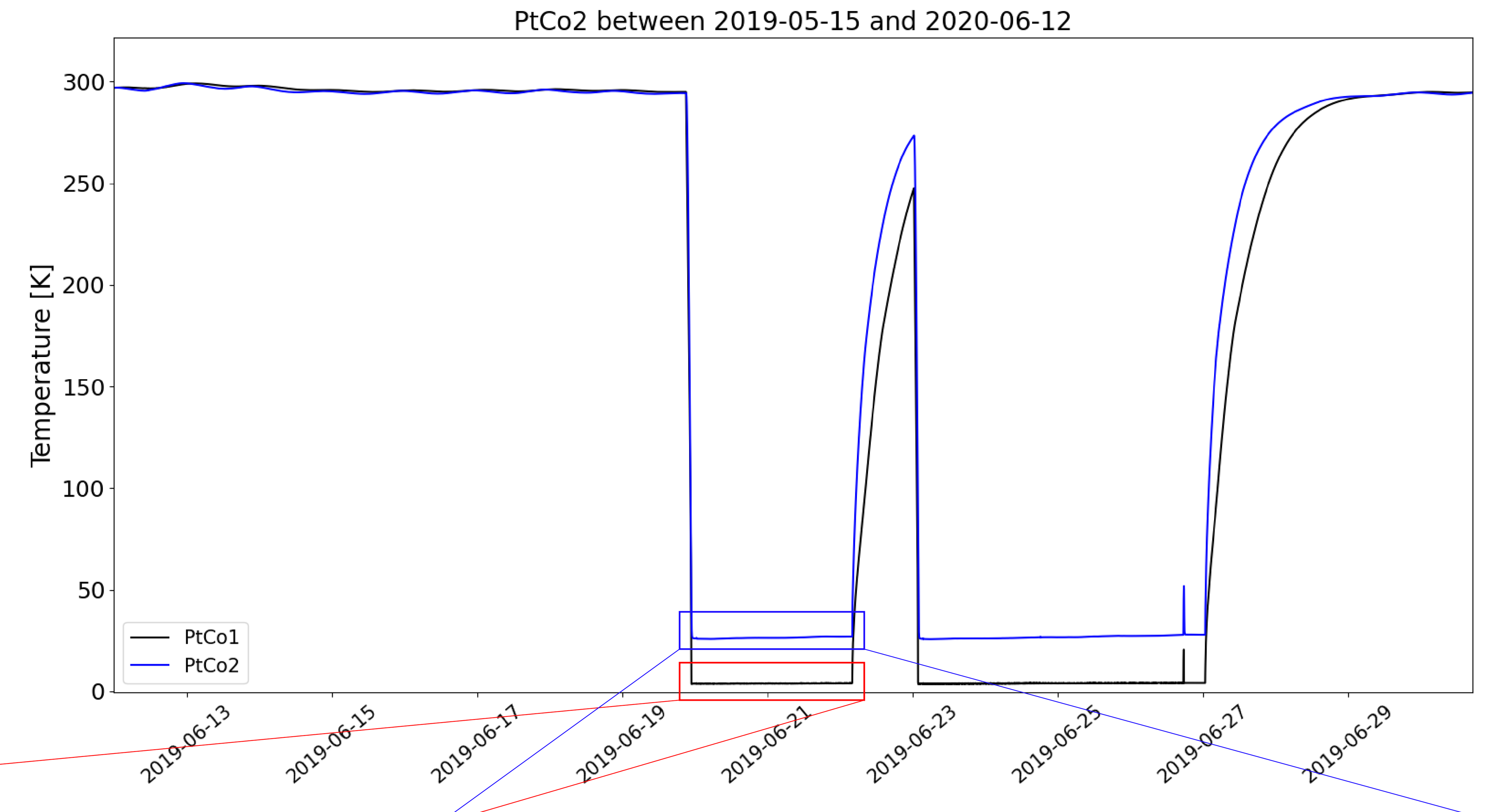
In January 2024, the target could not be formed- it would evaporate within a few seconds.

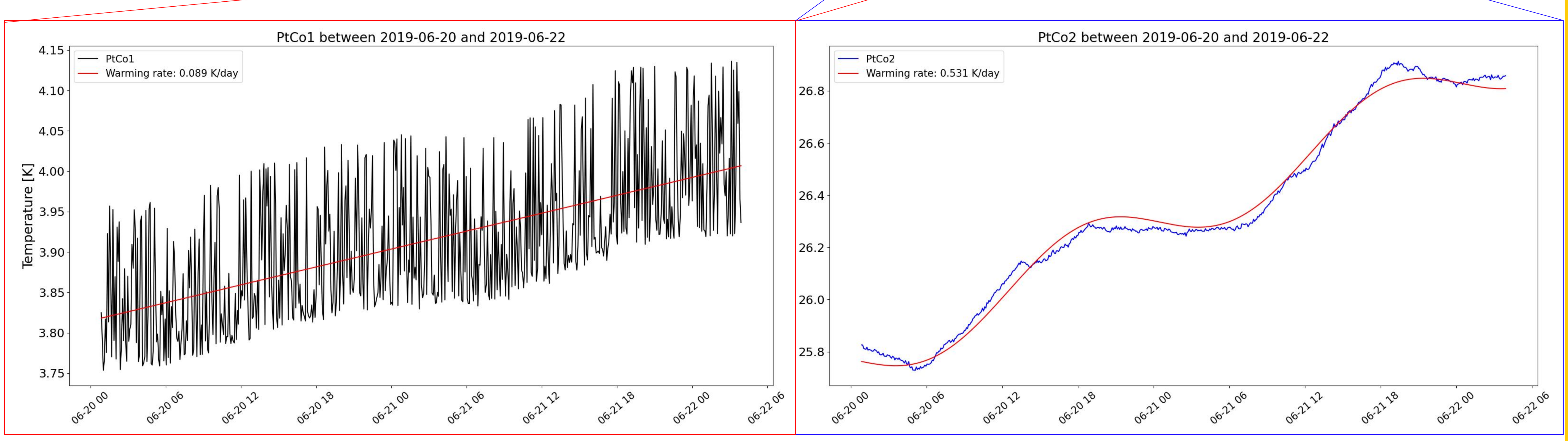
Target Cell In Situ

Above: The two halves of the target mask
Right: The maskless target cell, with the gas diffuser circled in red

Sample Cooling/Warming Curve

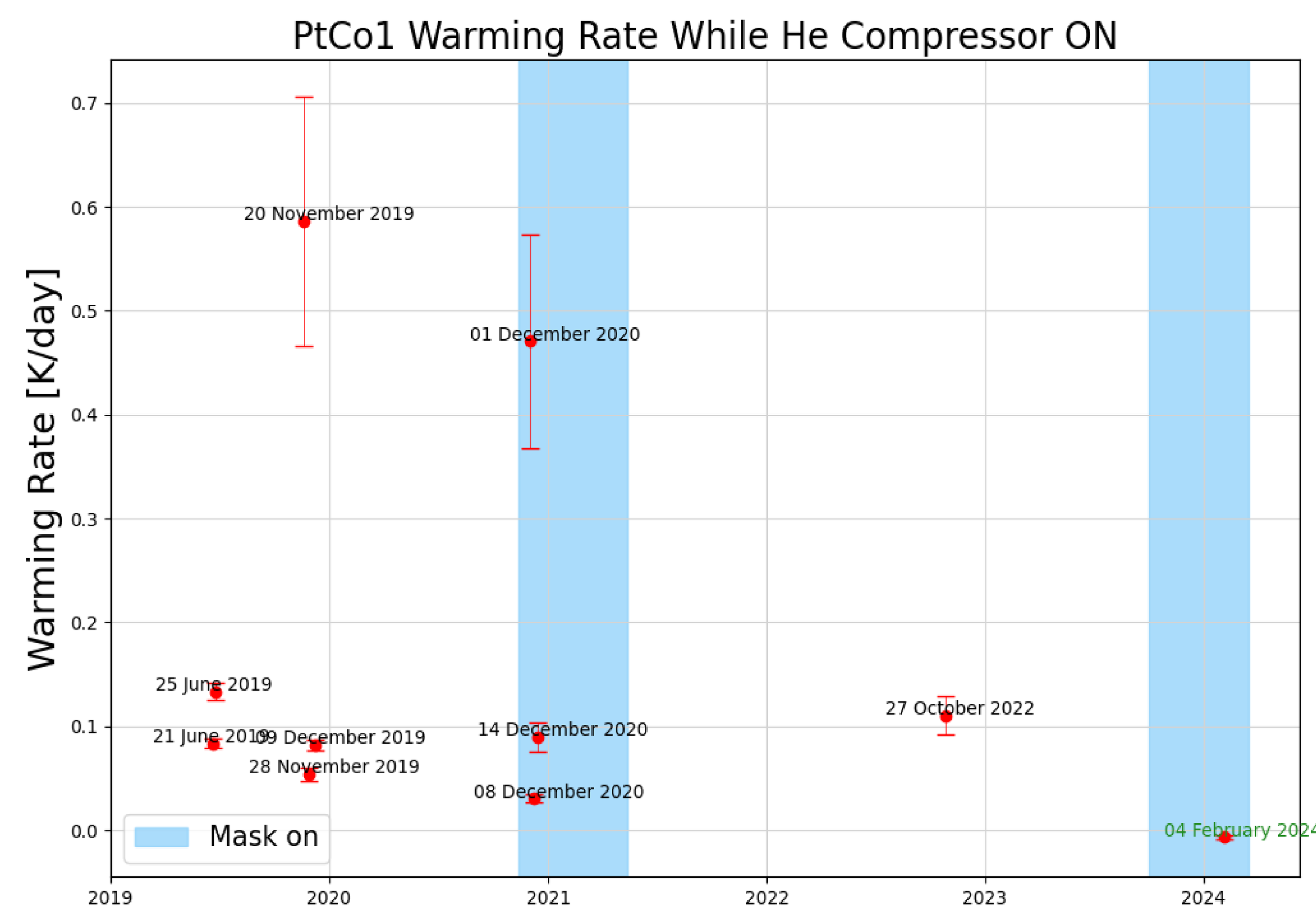
To form a target of solid hydrogen (or deuterium), a bed of silver foil 4.53 μm thick must be held at <4 K under high vacuum (~10^{-7} torr). Here, PtCo1 measures the target bed temperature, while PtCo2 measures the temperature of the heat shield.





Left: Snapshot of the target bed temperature increasing **despite being actively cooled by liquid He**, fit to $f(x) = ax + b$ as only the average warming rate was relevant.
Right: Heat shield temperature over the same window of time, fit to $f(x) = Ax + B + C\sin(\frac{x}{24h} + D)$, where the sinusoidal component accounts for the daily ambient temperature cycle.

My Work: Keeping it Cool



- Quantified warming causes and rates, using **Python for data analysis**
- **Improved thermal contact** by smoothing and applying low-temperature rated vacuum grease between target cell and mask
- Identified and resolved vacuum system leaks, **improving overall vacuum by a factor of 2.1**

Above: The warming rates of the target cell using historical data as a comparison. As of the most recent analysis in February, the warming rate is $-0.012 \pm 0.004\ K/day$, which (as it is near-zero) suggests that the target temperature is either remaining stable or even cooling further

Discovery, accelerated