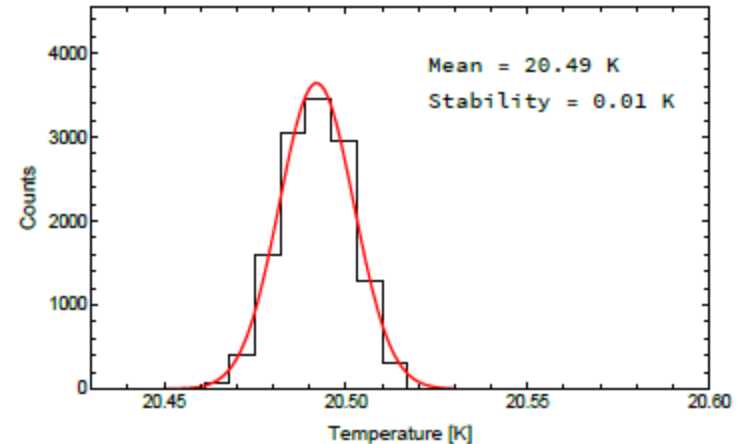
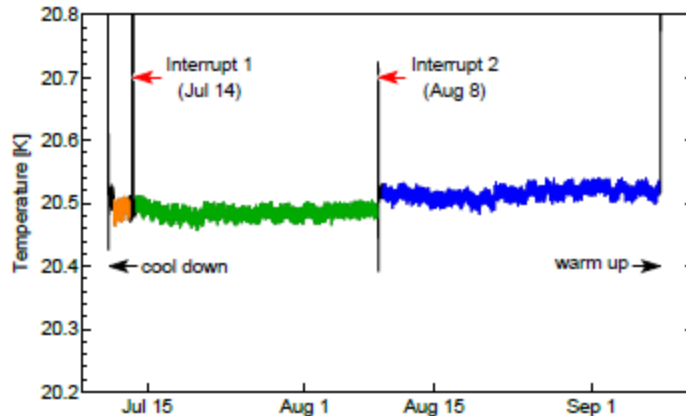


LH₂ Target Operation 2023

**Konrad Deiters
for the Muse Collaboration**

- MUSE Target was operated with LH₂ from early July to early September
- September 8, we filled the target with Ne to allow the operation of the SiPM detectors inside of the vacuum chamber. At this point a number of unusual circumstances led to the target cell heating well above room temperature and a subsequent small leak
- We replaced the cell for the December beamtime

Target Operation with LH₂ (10 Jul – 8 Sep, 2023)



- **Total LH₂ target uptime from 10 July – 8 Sep: 99.7%**
- **Interruption 1**
Jul 14, 2023: Due to unusually high temperatures in the PiM1 area we had to replace the compressor's air-cooled chiller with a water-cooled chiller from PSI
- **Interruption 2**
Aug, 8, 2023: there was a necessary adjustment to the slow control system clock to resolve a timing issue with the real time clock. The target temperature was stabilized at a slightly higher temperature after the change.
- **Warm up**
Sep 8, 2023: boiled off LH₂ to take STT straight through data simultaneously with the beam focus monitor, and filled with Ne (~27 K, >1 atm)) to switch back to LH₂ quickly

Target incident after warmup (8-9 Sep, 2023)

- Time line

- Sep 8 (9 pm): PSI-wide water-cooling failure => target system went into a safe mode as intended (compressor off, vent valves open)
- Sep 9 (9 am): PSI-wide water cooling restored => target was getting prepared for cool down (with Ne), which required to turn off the Lakeshore temp controller
- 9:45 am: probably due to a TCP/IP communication error with the turned off Lakeshore, the LabView slow control program partially froze; it stopped updating the target parameters (**temp** and **pressure**), but the vacuum pump values continued to update.
- 11:45 am: vacuum pump tripped (did not know why at the time, **now we know**).
- 1 pm: recognized partial freeze of slow control system and rebooted the computer.
- 1:15 pm: turned on Lakeshore again: saw that target cell temp was 45 C (and dropping). attempts to pressurize and leak check the target cell failed.

- Reason for failure

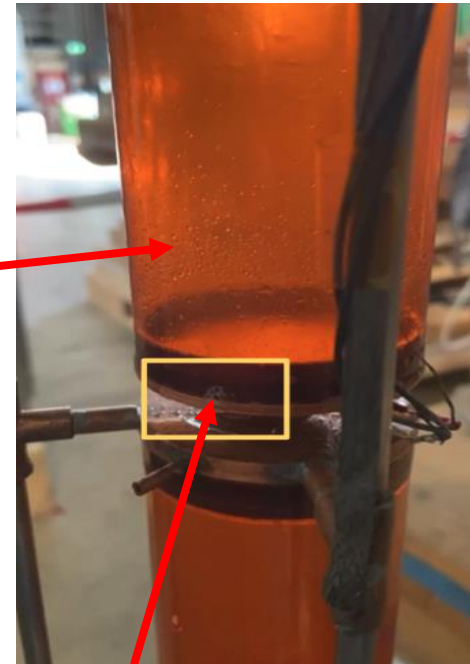
- **Note:** lack of target cell temp data **complicates interpretation**
- power for target cell heater must have stayed on when the LabView slow control froze => increased temp caused the epoxy on the copper endcaps to soften => creating a leak
- this leak was confirmed after removal and inspection of the target ladder failed.

two weeks of data-taking remained; replacing cell would take 1 week, affect alignment, risk of damaging other detectors; decided to take other calibration data for which a full LH2 cell was not needed.

Target incident after warmup (8-9 Sep, 2023)

- Comments

- this incident occurred when
 - there was no H₂ in the target system
 - the target system was above room temperature
- the target cell failed gently (no visible damage)
- there was never a safety issue; we have three layers of safety in place:
 - Overpressure valves
 - FPGA pressure and valve control
 - LabView RT program

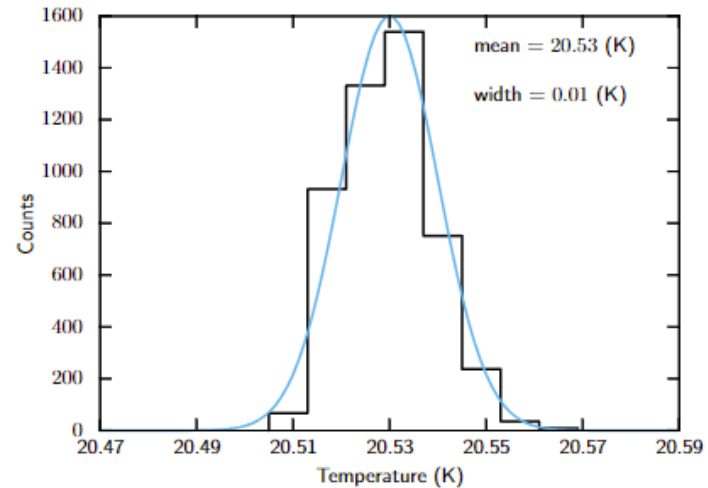
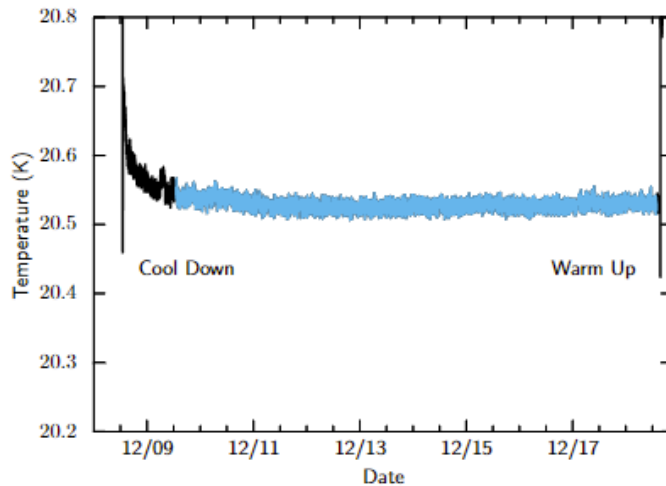


Leak location (soap bubbles visible)
no rupture of Kapton foil

- Extra layers of protection added

- modify written procedures to manually turn off the power to the target cell heater during regular operation
- power to the target cell heater is only turned on when a target expert is present (during fast warm up)
- open the target cell heater relay automatically by the LabView program
 - at the restart of the target slow control program
 - it needs a target expert on site to turn it back on
- install a heartbeat monitor on EPICS slow control to check if LabView slow control system is alive

Target Operation with LH₂ (9 – 19 Dec, 2023)



- **Total LH₂ target uptime from 9 – 19 Dec: 100%**
- ran with spare ladder installed very stably
- will use the currently installed ladder to run in 2024
- repair of the damaged target cell is in progress at U-M
- a 3rd target ladder will also be available