

Debugging the Thermocouple Readback Issues of the Neutral Particle Spectrometer

Aaron Brown, Mary Ann Antonioli, Peter Bonneau, Pablo Campero, Brian Eng, George Jacobs, Mindy Leffel,
 Tyler Lemon, Marc McMullen, and Amrit Yegneswaran
Physics Division, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606
 April 8, 2024

This note presents the outcome of debugging the thermocouple readback issues of the Neutral Particle Spectrometer (NPS).

The NPS crystal array has 112 thermocouples—the front and back sides each having 56 thermocouples, Fig. 1. The thermocouples (PN 201-301) are connected to four Keysight terminal blocks (PN 34921T) in the NPS, Table I, each of which is connected to a Keysight multiplexer (PN 34921A) installed in the Keysight mainframe (PN 34980A), via a Keysight D-sub cable (~10 ft.) connected to an in-house fabricated 60-ft. extension cable, Fig. 2.

During the physics run, temperature values of the thermocouples scanned by the thermal readback program were at times incomprehensible. Even though a terminal block was populated with at least 16 thermocouples, values shown for all the thermocouples of a terminal block would be -99000, an indicator of no connected sensors, or would be -0.0°C, Fig. 3.

Power cycling the Keysight mainframe sometimes resolved the issue, but was unreliable. Further, neither swapping the multiplexer with a working multiplexer nor replacing the in-house manufactured extension cable and manufacturer’s cable with spare cables solved the problem. Eventually, replacing the terminal block resolved the issue.

To date, terminal blocks #1, #2, and #3 have been replaced. The faulty terminal blocks will be tested using the Keysight test stand.

Thermocouple locations	Terminal block	Number of thermocouples
Crystal array back	1	40
	2	16
Crystal array front	3	40
	4	16

TABLE I. Thermocouple connections to terminal blocks.

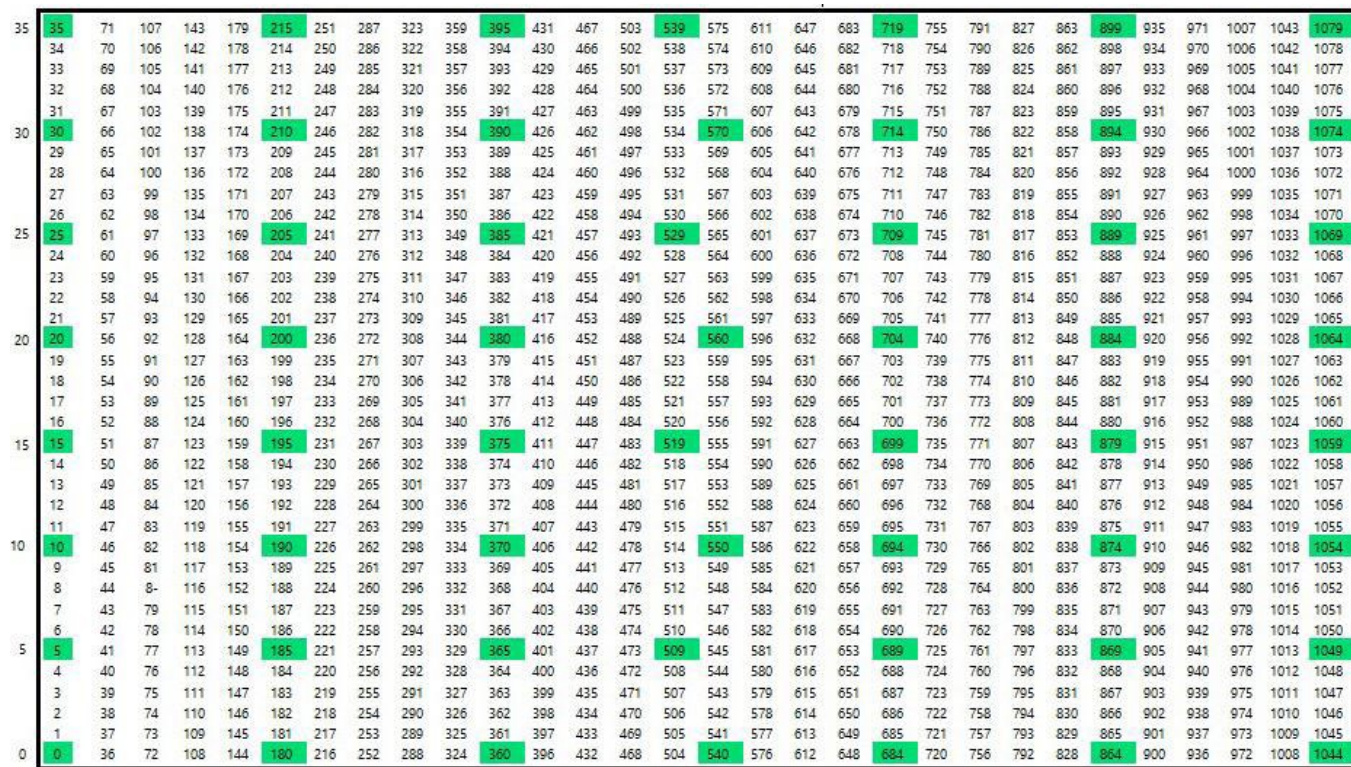


FIG. 1. Front crystal face with a thermocouple indicated in green. Backs of the same crystals have thermocouples as well.

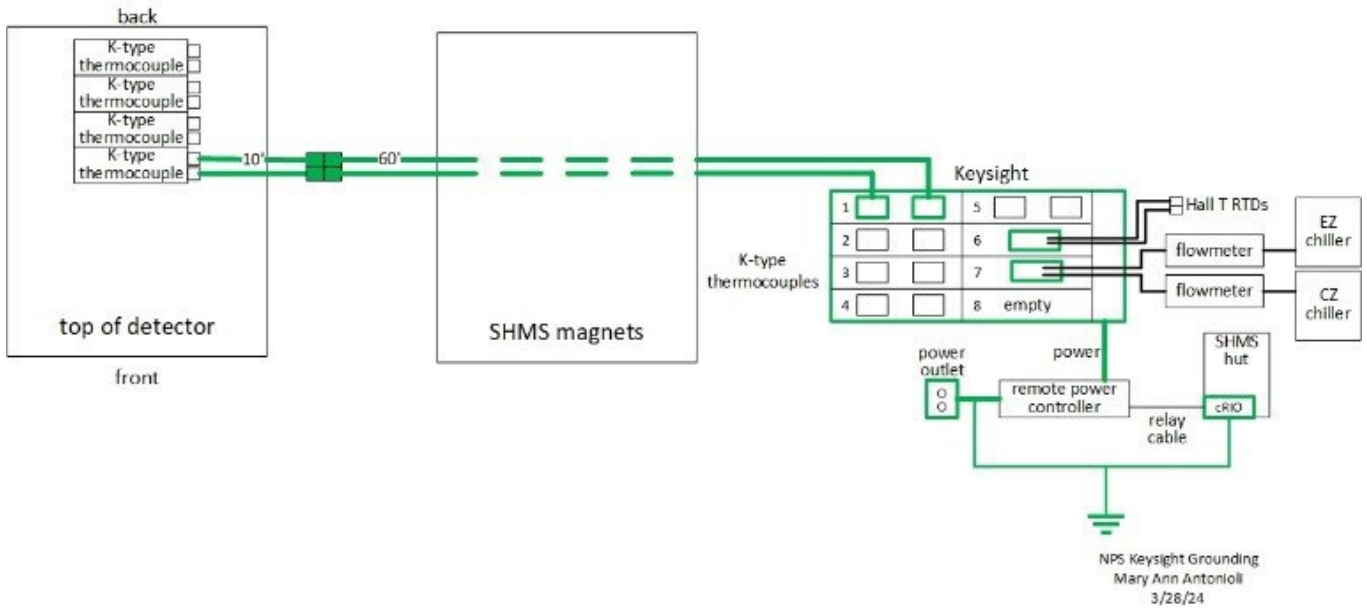


FIG. 2. Connection scheme of the NPS control and monitoring system. Green lines indicate grounding. Dashed green lines indicate cables under the magnets.

Monitoring											
Crystal	T [°C]	Avg [°C]	σ [°C]	Intlk status	Latch status	Crystal	T [°C]	Avg [°C]	σ [°C]	Intlk status	Latch status
0	-0.00	-0.00	0.00	OK	OK	540	18.78	18.81	0.02	OK	OK
5	-0.00	-0.00	0.00	OK	OK	550	26.71	26.74	0.02	OK	OK
10	28.67	28.67	0.03	OK	OK	560	28.21	28.23	0.02	OK	OK
15	28.15	28.18	0.02	OK	OK	570	21.89	21.88	0.02	OK	OK
20	27.67	27.67	0.02	OK	OK	684	18.41	18.40	0.02	OK	OK
25	27.37	27.40	0.02	OK	OK	689	21.82	21.83	0.02	OK	OK
30	27.09	27.12	0.02	OK	OK	694	28.05	28.07	0.02	OK	OK
35	27.70	27.71	0.02	OK	OK	699	25.13	25.16	0.02	OK	OK
180	27.96	27.97	0.02	OK	OK	704	22.52	22.52	0.01	OK	OK
185	28.66	28.66	0.03	OK	OK	709	20.33	20.34	0.02	OK	OK
190	28.34	28.34	0.02	OK	OK	714	19.22	19.23	0.02	OK	OK
195	25.97	25.98	0.02	OK	OK	719	20.23	20.22	0.02	OK	OK
200	24.13	24.14	0.01	OK	OK	864	-0.00	-0.00	0.00	OK	OK
205	22.64	22.65	0.01	OK	OK	869	-0.00	-0.00	0.00	OK	OK
210	21.59	21.61	0.02	OK	OK	874	-99000	-98999	946051	OK	OK
215	22.21	22.20	0.02	OK	OK	879	-99000	-98999	946051	OK	OK
360	24.18	24.18	0.02	OK	OK	884	-99000	-98999	946051	OK	OK
365	27.55	27.56	0.02	OK	OK	889	-99000	-98999	946051	OK	OK
370	28.02	28.06	0.02	OK	OK	894	-99000	-98999	946051	OK	OK
375	24.98	25.01	0.02	OK	OK	899	-99000	-98999	946051	OK	OK
380	22.16	22.14	0.02	OK	OK	044	-99000	-98999	946051	OK	OK
385	19.68	19.68	0.02	OK	OK	049	-99000	-98999	946051	OK	OK
390	18.72	18.80	1.35	OK	OK	054	-99000	-98999	946051	OK	OK
395	19.36	19.37	0.02	OK	OK	059	-99000	-98999	946051	OK	OK
509	22.02	22.03	0.02	OK	OK	064	-99000	-98999	946051	OK	OK
519	26.78	26.81	0.02	OK	OK	069	-99000	-98999	946051	OK	OK
529	24.77	24.78	0.02	OK	OK	074	-99000	-98999	946051	OK	OK

FIG. 3. Screenshot of Back Crystal Zone Temperatures Phoebus screen showing erroneous temperatures for multiplexer #2 (boxed in red).