Debugging the Thermocouple Readback Issues of the Neutral Particle Spectrometer

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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 <u>34921T</u>) in the NPS, Table I, each of which is connected to a Keysight multiplexer (PN <u>34921A</u>) installed in the Keysight mainframe (PN <u>34980A</u>), via a Keysight D-sub cable (~10 ft.) connected to an in-house fabricated 60-ft. extension cable, Fig. 2.

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

TABLE I. Thermocouple connections to terminal blocks.

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.

35	35	71	107	143	179	215	251	287	323	359	395	431	467	503	539	575	611	647	683	719	755	791	827	863	899	935	971	1007	1043	10
-5-52	34	70	106	142	178	214	250	286	322	358	394	430	466	502	538	574	610	646	682	718	754	790	826	862	898	934	970	1006	1042	10
_	33	69	105	141	177	213	249	285	321	357	393	429	465	501	537	573	609	645	681	717	753	789	825	861	897	933	969	1005	1041	10
_	32	68	104	140	176	212	248	284	320	356	392	428	464	500	536	572	608	644	680	716	752	788	824	860	896	932	968	1004	1040	107
- 1	31	67	103	139	175	211	247	283	319	355	391	427	463	499	535	571	607	643	679	715	751	787	823	859	895	931	967	1003	1039	107
30	30	66	102	138	174	210	246	282	318	354	390	426	462	498	534	570	606	642	678	714	750	786	822	858	894	930	966	1002	1038	107
100.000	29	65	101	137	173	209	245	281	317	353	389	425	461	497	533	569	605	641	677	713	749	785	821	857	893	929	965	1001	1037	107
	28	64	100	136	172	208	244	280	316	352	388	424	460	496	532	568	604	640	676	712	748	784	820	856	892	928	964	1000	1036	107
_ I	27	63	99	135	171	207	243	279	315	351	387	423	459	495	531	567	603	639	675	711	747	783	819	855	891	927	963	999	1035	107
	26	62	98	134	170	206	242	278	314	350	386	422	458	494	530	566	602	638	674	710	746	782	818	854	890	926	962	998	1034	107
25	25	61	97	133	169	205	241	277	313	349	385	421	457	493	529	565	601	637	673	709	745	781	817	853	889	925	961	997	1033	106
	24	60	96	132	168	204	240	276	312	348	384	420	456	492	528	564	600	636	672	708	744	780	816	852	888	924	960	996	1032	106
	23	59	95	131	167	203	239	275	311	347	383	419	455	491	527	563	599	635	671	707	743	779	815	851	887	923	959	995	1031	106
	22	58	94	130	166	202	238	274	310	346	382	418	454	490	526	562	598	634	670	706	742	778	814	850	886	922	958	994	1030	106
	21	57	93	129	165	201	237	273	309	345	381	417	453	489	525	561	597	633	669	705	741	777	813	849	885	921	957	993	1029	106
20	20	56	92	128	164	200	236	272	308	344	380	416	452	488	524	560	596	632	668	704	740	776	812	848	884	920	956	992	1028	1064
	19	55	91	127	163	199	235	271	307	343	379	415	451	487	523	559	595	631	667	703	739	775	811	847	883	919	955	991	1027	1063
	18	54	90	126	162	198	234	270	306	342	378	414	450	486	522	558	594	630	666	702	738	774	810	846	882	918	954	990	1026	1063
	17	53	89	125	161	197	233	269	305	341	377	413	449	485	521	557	593	629	665	701	737	773	809	845	881	917	953	989	1025	106
	16	52	88	124	160	196	232	268	304	340	376	412	448	484	520	556	592	628	664	700	736	772	808	844	880	916	952	988	1024	1060
15	15	51	87	123	159	195	231	267	303	339	375	411	447	483	519	555	591	627	663	699	735	771	807	843	879	915	951	987	1023	1059
	14	50	86	122	158	194	230	266	302	338	374	410	446	482	518	554	590	626	662	698	734	770	806	842	878	914	950	986	1022	1058
_	13	49	85	121	157	193	229	265	301	337	373	409	445	481	517	553	589	625	661	697	733	769	805	841	877	913	949	985	1021	105
	12	48	84	120	156	192	228	264	300	336	372	408	444	480	516	552	588	624	660	696	732	768	804	840	876	912	948	984	1020	1050
	11	47	83	119	155	191	227	263	299	335	371	407	443	479	515	551	587	623	659	695	731	767	803	839	875	911	947	983	1019	105
10	10	46	82	118	154	190	226	262	298	334	370	406	442	478	514	550	586	622	658	694	730	766	802	838	874	910	946	982	1018	105
	9	45	81	117	153	189	225	261	297	333	369	405	441	477	513	549	585	621	657	693	729	765	801	837	873	909	945	981	1017	105
	8	44	8-	116	152	188	224	260	296	332	368	404	440	476	512	548	584	620	656	692	728	764	800	836	872	908	944	980	1016	105.
	7	43	79	115	151	187	223	259	295	331	367	403	439	475	511	547	583	619	655	691	727	763	799	835	871	907	943	979	1015	105
2	6	42	78	114	150	186	222	258	294	330	366	402	438	474	510	546	582	618	654	690	726	762	798	834	870	905	942	978	1014	1050
2	5	41	11	113	149	185	221	257	293	329	305	401	437	473	509	545	581	617	053	689	725	/61	797	833	809	905	941	977	1013	1049
	4	40	/0	112	148	184	220	250	292	328	304	400	436	4/2	508	544	580	010	052	088	724	/60	/96	832	808	904	940	976	1012	104
	3	39	75	111	147	183	219	255	291	327	363	399	435	471	507	543	579	615	651	687	723	759	795	831	867	903	939	975	1011	104
	2	38	74	110	146	182	218	254	290	320	362	398	434	4/0	506	542	5/8	614	650	080	722	758	794	830	800	902	938	974	1010	104
	1	3/	73	109	145	181	21/	255	289	325	301	39/	435	409	505	541	577	013	649	085	721	757	793	829	805	901	93/	973	1009	104
U	10	30	72	108	144	180	210	252	288	524	300	390	432	468	504	540	5/0	012	048	084	120	/50	192	828	804	900	930	9/2	1008	184
	0										40					45					20					25				- 7

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.



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