LCLS-II 1.3GHz Prototype Cryomodule Instrumentation List

Table 1: LCLS 1.3GHz Prototype Cryomodule Instrumentation List

#	Sensor Description	Quantity & Location	Comments	Cryomodule Feed-Through Flange	Responsible/ Contact Person
1	Piezo Actuators (Fast Tuners)	32 Piezos – 4 piezos / fast-tuner x 1 fast-tuner/cavity x 8 cavities = 32 piezos	New tuner design similar to Saclay-1 lever tuner Voltage = -32V to +120V The fast tuner can be replaced through an access port. Each fast tuner comes wired with 60cm long Kapton insulated wires but connectors will need to be installed (CM internal pigtail connection): One 4-pin Hypertronic connector part number D01PB406MSUTH will be installed on each half-tuner for easy replacement. 2 wires/piezo x 2 piezos/half-tuner. The two mating 4-pin Hypertronic connectors part number D01PB406FSUTH (2 half-tuners) are terminated on the feed-through side with one 4-pair, 28 AWG stranded, shielded, Kapton insulated vacuum wire from Accu-Glass Products, Inc., Model: TYP3-8TW Note: Detoronics 12-pin connectors are hermetic glass to metal feed-through connectors with 304 SS shell. Note O-ring material must be radiation resistant. Two pins will be shorted on the vacuum side to provide	Flange A Feed-through: One 12-pin DT02H-14-12PN	Yuriy Pischalnikov

			an interlock for the piezo power supply.		
2	Stepper Motor Platinum RTD	8 Platinum RTDs: One RTD/stepper motor x 8 tuners	Will be used as an interlock to prevent the motor from overheating. The stepper motors come with embedded thermocouples installed by the manufacturer. It is proposed that Platinum RTDs are installed on the motor housing for consistency with the other Platinum RTD interlocks and readout electronics. One Platinum 100 Ohm RTD installed on the motor housing: European Standard DIN/IEC 60751. Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket.	Flange A Feed-through: One-third 19-pin Detoronics connector: DT02H-14-19PN (Shared with Main Coupler Platinum Interlock RTDs)	Yuriy Pischalnikov
3	Main Coupler Platinum RTDs	16 Main Coupler RTDs – 2 RTDs at each cavity x 8 cavities (1 at 12 o'clock & 1 at 10 o'clock).	These RTDs are used as interlocks so there is no need to read lower temperatures. Use platinum 100 Ohm, European Standard DIN/IEC 60751. Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket. Share a 19-pin feed-through connector with 1 stepper motor thermocouple.	Flange A Feed-through: Two-thirds 19-pin Detoronics connector: DT02H-14-19PN (Shared with Stepper Motor Platinum RTD)	Timergali Khabiboulline, Nikolay Solyak
4	Helium Vessel Cernox RTDs	16 Cernox RTDs – 2 sensors on each helium	Not required for cryogenic control but provides additional monitoring.	Flange A Feed-through:	Tom Peterson

		vessel (vacuum side) x 8 cavities: 1 sensor on top and 1 sensor on the bottom of each cavity.	Use Lakeshore Cernox bobbin mounted RTDs (CX-1030-CU-HT) to provide a local thermal anchor for the wire. 4 wires / Cernox RTD. Use one 19-pin feed-through connector. Will have 11 spare pins on each connector. Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket.	One-half 19-pin Detoronics connector: DT02H-14-19PN (Shared with Beam-tube Temperature and Beam Tube Temperature)	
5	Beam-tube Temperature	8 Cernox RTDs - 1 Cernox RTD on each cavity beam-tube	Use Cernox bobbin (CX-1030-CU-HT) mounted RTDs to provide a local thermal anchor for the wire. 4 wires / Cernox RTD. Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket.	<u>Flange A</u> Feed-throughs: One-fourth 19-pin Detoronics connectors: DT02H-14-19PN	Tom Peterson, Joshua Kaluzny
6	Magnetic Shield Temperature	8 Cernox RTDs - 1 Cernox RTD on each magnetic shield	Use Cernox bobbin (CX-1030-CU-HT) mounted RTDs to provide a local thermal anchor for the wire. 4 wires / Cernox RTD. Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket.	<u>Flange A</u> Feed-throughs: One-fourth 19-pin Detoronics connector: DT02H-14-19PN	Tom Peterson, Joshua Kaluzny
7	HOM Coupler Cernox RTDs	<u>32 Cernox RTDs</u> – Install 2 RTDs on each HOM coupler. This number will be reduced on	One RTD is mounted on each HOM can, alongside the two spots where the legs of the formteil are welded to the can.	<u>Flange A</u> Feed-through: One 19-pin Detoronics connector: DT02H-14-19PN	Timergali Khabiboulline, Nikolay Solyak

		the production CMs.	A second RTD will be installed on the copper feed-through via the copper clamp. Use a total of 4 Cernox 1030-HT-SD RTDs at each cavity. 4 wires / Cernox RTD. Use one 19-pin feed-through connectors. Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket.	(split between two connectors, but taking up one connector total)	
8	Stepper Motors	<u>8 Stepper Motors</u> – 8 slow tuners x 1 stepper motor / slow tuner	Manufacturer: Phytron Model #: VSS 52.200.2.5-4LP-5M-UHVC 200 Steps / Rev, 2.5A, 4 Leads Parallel. The slow tuner can be replaced through an access port. One 5-pin Hypertac connector part number HRM26F11-05PN will be installed on the slow tuner side (4 wires/stepper motor). A mating 5-pin Hypertac connector part number HRM24F11-05SN will be terminated with four twisted wires, 20 AWG stranded, Kapton insulated wire from Accu-Glass Products, Inc. Model: TYP12 One 8-pin Detoronics connector on flange A at each cavity.	<u>Flange B</u> Feed-through: One-half 8-pin Detoronics connector: DT02H-16-8PN (Shared with Tuner limit switches)	Yuriy Pischalnikov

9	Tuner limit switches	2 switches per tuner	Limit switches on tuner to prevent damage to cavity due to excessive tuner travel. Use 2 twisted-pair, 24 AWG, Kapton Insulated Wire from Accu-Glass, KAP-24AWG-TWIST-5	Flange B Feed-through: One-half 8-pin Detoronics connector: DT02H-16-8PN (Shared with Stepper Motor)	Yuriy Pischalnikov
10	Cavity Field Probes – Transmitted Power	8 Field Probes – 1 field probe / cavity x 8 cavities	Use Times Microwave Systems TFlex-402 RF cables for the cavity field probes (see description for HOMS below). The RF cable will be used in a vacuum and at 4K. See the technical specification. 3 m long cable terminated with SMA male connector on cavity end and N type male connector Flange B end.	Flange B Feed-throughs: One N-Type, H+S 34-N-50-0-3/133NE	Timergali Khabiboulline
11	HOM Field Probes – Transmitted Power	16 Field Probes – 1 on each HOM x 2 HOMs / cavity x 8 cavities	Use Times Microwave Systems TFlex-401 RF cables: 7-mm thick and copper core. Will have lower losses than that used for ILC CM-2. The RF cable will be used in a vacuum and at 4K. See the technical specification. Thermal anchor the RF cables by clamping directly to 5K pipe and 80K (35K) shield. Special semi-loops on cables will accommodate relative motion of cryomodule parts up to 20 mm. Note that the cavity feed-through (Sapphire) connector will also be thermally anchored to the 2K, 2-phase.	Flange B Feed-throughs: Two N-Types, H+S 34-N-50-0-3/133NE	Timergali Khabiboulline, Mohamed Hassan

			HOM1 (fundamental coupler side) length = 2.0 meter (CM-2 L=2.6m – 0.6m), HOM2 length = 3.0 meters (CM-2 L=3.6m – 0.6m). Both ends terminated with N type male connectors.		
12	Coupler Electron Pick-ups	24 e-Pickups – 3 Pick-ups /cavity x 8 cavities (1 is mounted on the cavity side of the Couple, 2nd is mounted on the wave guide side of the Coupler, and 3rd e-probe in air side of the coupler at each cavity).	Include on the Prototype CMs but may be decreased to 3 electron pick-ups on the production CMs. Use Times Microwave Systems TFlex-402 RF 1m cable. Both ends terminated with SMA male connectors. The cable will be used in a vacuum and at 4K. See technical specification. Alternative: Use H+S, K 03252-D06 RF cable (same as ILC CM-2 but will specify 316 SS). Two feedthroughs – third in air.	Flange B Feed-throughs: Two SMA-Type, H+S 34_SMA-50-0-3/111NE	Timergali Khabiboulline
13	Helium Vessel Heaters	1 Kapton Insulated Strip heaters on the bottom of each vessel = 8 heaters.	25 watt heater, Omega KH-112/10 (110 ohms, ~50VDC) 2 wires/heater x 1 heaters/vessel. Install 2 voltage sense wires on the air side. Use two 20 AWG twisted wires, Kapton Insulated Wire from Accu-Glass, Model: TYP12	Flange B Feed-through: One 4-pin BTC Electronics connector: 8673-14B-4PN-SP-M121 (FNAL drawing #C124809) Mil-C-26500	Tom Peterson, Tug Arkan, Josh Kaluzny

			Use one potted 4-pin feed-through connector/helium vessel.		
14	Split Quadrupole and Corrector Coil Voltage Taps for coil quench monitoring.	5 VT's /magnet x 3 magnets = 15 VT's.	Use three 8-pin "potted" feed-through connectors at Flange C. Use fifteen, 22 AWG, stranded, Kapton Insulated wires from Accu-Glass, TYP11. Wires to be bundled in groups of five for each magnet. The magnets will use passive quench protection (diodes) with energy extraction resistors.	Flange C Feed-through: Six potted 8-pin Detoronics connectors: DT02H-16-8PN	Vladimir Kashikhin
15	Split Quadrupole and Corrector Coil heater	1 Heater – 1 heater for the entire coil package.	The heater is used to stop persistent currents and magnet package tests. R(300 K) = 278 Ohms, Vmax = 400 V Use twisted 20 AWG stranded, Kapton insulated wire from Accu-Glass, Typ12 (or KAP-22AWG-TWIST-5) Use one 4-pin potted feed-through connector.	Flange C Feed-through: One potted 4-pin BTC Electronics connector: 8673-14B-4PN-SP-M121 (FNAL drawing #C124809) Mil-C-26500	Vladimir Kashikhin
16	Power Lead Voltage Taps for resistance monitoring.	24 Voltage Taps – 3 voltage taps / current lead x 2 leads /magnet x 3 magnets	Will use conduction cooled current leads. VT's are necessary for protection. Each lead is thermally anchored at two temperatures. The two pairs of voltage taps per lead are used to measure the two resistive segments	Flange D Feed-through: Three potted 8-pin Detoronics connector: DT02H-16-8PN	Vladimir Kashikhin

			There are 8 lead VTs per magnet. Use twenty-four, 22 AWG, stranded, Kapton Insulated wires from Accu-Glass, TYP11. Use three 8-pin "potted" feed-through connectors		
17	Beam Position Monitor (BPM)	1 BPM – 4 pick-ups Verify that BPM RTDs are not required (earlier TK note)	Mounting near to split quadrupole magnet? Use Times Microwave Systems TFlex-402 RF cable. The cable will be used in a vacuum and at 4K. See technical specification. The RF cable length is 2m. Both ends terminated with N type male connectors. Alternative: Use H+S, K 03252-D06 RF cable but will specify 316 SS). (same as e-pickups).	Flange D Feed-throughs: Four N-Types, H+S 34-N-50-0-3/133NE	Timergali Khabiboulline, Nikolay Solyak. Andrei Lunin
18	Fluxgate Sensors in Vacuum vessel	5 Fluxgate Sensors 1ea. in vacuum region near cavities 1,2,5/6, 7 and 8	1 outside of shield in region of cavities 1, 2, 7, 8, and between 5 & 6. Need to be insure the magnetic field inside the dressed cavity is <0.5µT Use Bartington Mag-F, single-axis cryogenic sensor rated for vacuum operation – 0.2mT (full field) Use 2 twisted 24 AWG pairs, Kapton Insulated Wires from Accu-Glass, KAP-24AWG-TWIST-5.	Flange D Feed-through: Two 19-pin Detoronics connector: DT02H-14-19PN	Curtis Crawford, Dmitri Sergatskov

19	Heater on Helium Cool Down Circuit	Kapton insulated strip heater	Use two potted 4-pin feed-through connector. 150 watt total heater power, Omega KH-112/10 (110 ohms, 3 in parallel, ~75VDC) Install 2 voltage sense wires/heater on the air side. Use two 20 AWG wires twisted, Kapton Insulated Wires from Accu-Glass, Model: TYP12	Flange D Feed-through: Two 4-pin BTC Electronics connector: 8673-14B-4PN-SP-M121 (FNAL drawing #C124809) Mil-C-26500	Tom Peterson, Joshua Kaluzny
20	Split Quadrupole and Corrector Coil cold mass temperature sensors	4 Silicon Diode Temperature Sensors – 1 sensor on the surface of each coil x 4 coils	Use Lakeshore DT-670 Band A-1 uncalibrated silicon diodes. 4 wires / Silicone Diodes. Use one 19-pin feed-through connectors. Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket.	Flange F Feed-through: One 19-pin Detoronics connector: DT02H-14-19PN	Vladimir Kashikhin
21	Split Quadrupole and Corrector Coil lead temperature sensors	12 Silicon Diode Temperature Sensors – 2/lead x 6 leads	Use Lakeshore DT-670 Band A-1 uncalibrated silicon diodes. 4 wires / Silicon Diode. Use three 19-pin feed-through connectors. Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket.	Flange F Feed-through: Three 19-pin Detoronics connector: DT02H-14-19PN	Vladimir Kashikhin
22	Cool Down Cernox Temperature Sensors	15 Cernox RTDs – mounted on: Line A: 1 Line B: 6 Line C: 1 Line D: 1 Line E: 1	Use Cernox bobbin (CX-1030-CU-HT) mounted RTDs to provide a local thermal anchor for the wire. 4 wires / Cernox RTD. Use four 19-pin feed-through	Flange K Feed-throughs: Four 19-pin Detoronics connectors: DT02H-14-19PN	Tom Peterson

		Line F: 1 HT Shield: 2 Cooldown heater: 2 (1 + redundant)	connectors. Will have 11 spare pins on one connector. Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket.		
23	Liquid Level Sensors	2 Liquid Level Sensors – 1 at each end of the cryomodule	Mounted inside each liquid level can. American Magnetics 2K level probe, radiation resistant, active Length = 12” Use 2 potted 6-pin connector, and 2 Ceramtec 6-pin connector. 2 feed-throughs/flange x 2 flanges = 4 feed-throughs Use two twisted pairs, 24 AWG, Kapton Insulated Wires from Accu-Glass, KAP-22AWG-TWIST-5	<u>One on Flange E & one on Flange L</u> Feed-through: Two 6-pin Detoronics connectors: DT02H-10-6PN Two 6-pin Ceramtec connectors: 18904-01-CF	Tom Peterson, Joshua Kaluzny
24	Cavity Helium Pressure	2 Pressure Transducers 1 – 0-100 Torr 1 – 0-100 psia	Pressure transducers will be in air 0-100 Torr, VCR 8 female MKS 230EA–00100BB 0-100 psia, VCR 8 female MKS 750C12PCE4GD [Check operation in radiation environment] (not inside vacuum vessel, accessible after installation)	<u>One on Flange E & one on Flange L</u> No feed-through, VCR 8 male Pressure tap on side of each flange extension	Tom Peterson, Joshua Kaluzny
25	Temperature Sensors in Helium Vessels	16 Cernox Sensors	Sensors are installed in helium vessels. One helium to guard helium feed-through per	<u>Cavities 5 and 8 on Flange E & Cavities 1 and 4 on Flange L</u> Feed-throughs:	Tom Peterson, Joshua Kaluzny

		4 RTDs in helium vessels 1,4,5, and 8	flange * 2 flanges = 2 feed-throughs Two guard helium to air feedthroughs per flange * 2 flanges = 4 feed-throughs Use quad-twisted Manganin wires with Polyimide ML insulation and Tefzel jacket.	Four 19-pin Detoronics connector: DT02H-14-19PN Two 32-pin Ceramtec connector: 24017-01-CF	
26	Fluxgate Sensors in Helium Vessels	8 Fluxgate Sensors 2 in helium vessel 1,4,5, and 8	Sensors are installed in helium vessels. Use Bartington Mag-F, single-axis cryogenic sensor – 0.2mT (full field) One helium to guard helium feed-through per flange * 2 flanges = 2 feed-throughs One guard helium to air feedthroughs per flange * 2 flanges = 2 feed-throughs Use 2 twisted 24 AWG pairs, Kapton Insulated Wires from Accu-Glass, KAP-24AWG-TWIST-5.	Cavities 5 and 8 on Flange E & Cavities 1 and 4 on Flange L Feed-throughs: Two 19-pin Detoronics connector: DT02H-14-19PN Two 19-pin Ceramtec connector: 18906-01-CF	Curtis Crawford, Dmitri Sergatskov
27	Heater in level can	1 cartridge heater	Mounted in well protruding into level can. Hotwatt HS50-5 (28.8 Ohms) Install 2 voltage sense wires on the air side. 50W, ~40VDC Use two twisted, 20 AWG, Kapton Insulated Wire from Accu-Glass, TYP12.	Flange K Feed-through: One 4-pin BTC Electronics connector: 8673-14B-4PN-SP-M121 (FNAL drawing #C124809) Mil-C-26500	Tom Peterson, Joshua Kaluzny
28	Coupler Tuner Motors	8 Stepper Motors, 16 Limit Switches, & 8	Purchase 2 sets (16 stepper motors, etc.) for tests before shipping the CM to	N/A External to the CM	Timergali Khabiboulline,

		Linear Potentiometers – 1 stepper motor, 2 Limit Switches, & 1 potentiometers for each main coupler x 8 main couplers. Purchase 2 sets: One set for FNAL and one for J-Lab	SLAC. One set for J-Lab and one set for Fermilab. Remove before shipping to SLAC. 12V, 0.54A, 2-Phase, stepper Motor External to the CM – no feed throughs or internal wiring.		Nikolay Solyak, Tug Arkan
29	PMTs & Quartz Windows will be used.	8 PMTs & 8 Quartz Windows – Purchase 2 sets: One set for FNAL and one for J-Lab	SLAC's vender will install the quartz windows on each cryomodule. Purchase two sets of PMTs (16 total) for tests before shipping the CM to SLAC. One set for J-Lab and one set for Fermilab. Remove before shipping to SLAC. A threaded port on the waveguide is available for connection of an infraRed temperature sensor head, which monitors the window temperature. One set for FNAL and one set for J-Lab External to the CM – no feed throughs or internal wiring.	N/A External to the CM	Timergali Khabiboulline, Nikolay Solyak, Tug Arkan
30	Infrared Temperature Sensors (see #29)	8 IR temp sensors One per threaded port	A threaded port on the waveguide is available for connection of an infraRed temperature sensor head, which monitors the window temperature.	N/A External to the CM	Nikolay Solyak, Tug Arkan
31	Photo diode Temperature Sensors (see #29)	8 photo diode sensors Outside warm window	Will be installed to compare with the IR sensor for monitoring the window temperature. Need to design a support.	N/A External to the CM	Elvin Harms

32	JT and Cooldown valves	One JT and One cooldown valve per Cryomodule	WEKA PM-TEV DN6/PN25 C-Po h=600 PM-TEV DN15/PN25 C-Po h=600	N/A External to the CM	Tom Peterson, Joshua Kaluzny