

K. Mattison #, M. Boyes, M. Cyterski, D. Fairley, C. Hovater, J. Kaluzny, B. Lam, A. Martinez  
SLAC National Accelerator Laboratory, Menlo Park, CA 94025 USA

## Abstract

LCLS-II is a superconducting upgrade to the existing Linear Coherent Light Source at SLAC. Construction is underway with a planned continuous wave beam rate of up to 1 MHz. Two cryogenic plants, a distribution system, and 37 cryomodules with superconducting cavities will operate with liquid helium at 2.2K. The process is controlled with networked PLC's and EPICS as an integrated system that work in concert for controlling valves, pressure, flow, and temperature. Interlocks and critical process information are communicated with the low level radio frequency, vacuum, and magnet systems. Engaging the controls community proved vital in advancing the controls architecture from a conventional design to a centralized, reliable, and cost-effective distributed platform.

## LCLS-II Parameters

Parameter	symbol	nominal	range	units
Electron Energy	$E_f$	4.0	2.0 - 4.5	GeV
Bunch Charge	$Q_b$	100	10 - 300	pC
Bunch Repetition Rate in Linac	$f_b$	0.62	0 - 0.93	MHz
Average $e^-$ current in linac	$I_{avg}$	0.062	0.0 - 0.3	mA
Avg. $e^-$ beam power at linac end	$P_{av}$	0.25	0 - 1.2	MW
Norm. rms slice emittance at undulator	$\gamma\epsilon_{rms}$	0.45	0.2 - 0.7	$\mu$ m
Final peak current (at undulator)	$I_{pk}$	1000	500 - 1500	A
Final slice E-spread (rms, w/heater)	$\sigma_{Es}$	500	125 - 1500	keV
RF frequency	$f_{RF}$	1.3	-	GHz
Avg. CW RF gradient (powered cavities)	$E_{acc}$	16	8 - 20	MV/m
Avg. Cavity Q0	$Q_0$	2.7e10	1.5 - 5e10	-
Photon energy range of SXR (SCRF)	$E_{phot}$	-	0.2 - 1.3	keV
Photon energy range of HXR (SCRF)	$E_{phot}$	-	1 - 5	keV

## Cryomodule Signals (~x37)

Instruments	Controllers	He Vessel	Couplers	Magnet	Vac Vessel	He Lines	He Level Cans	Total
Cernox	Lakeshore 240	4		2		2		8
Silicon Diode	Lakeshore 240		16	6		5		27
PT103	Lakeshore 240					3		3
Heater Control	Acopian PS	8		1		3	2	14
Pressure	MKS						2	2
Liquid Level	AMI						2	2
Voltage Taps	Conditioner				9			9
Flux (CMTF)	Bartington				*5			5
Valve Control	PS2				2			2
Total		12	16	18	7	13	6	72

## Distribution System Signals

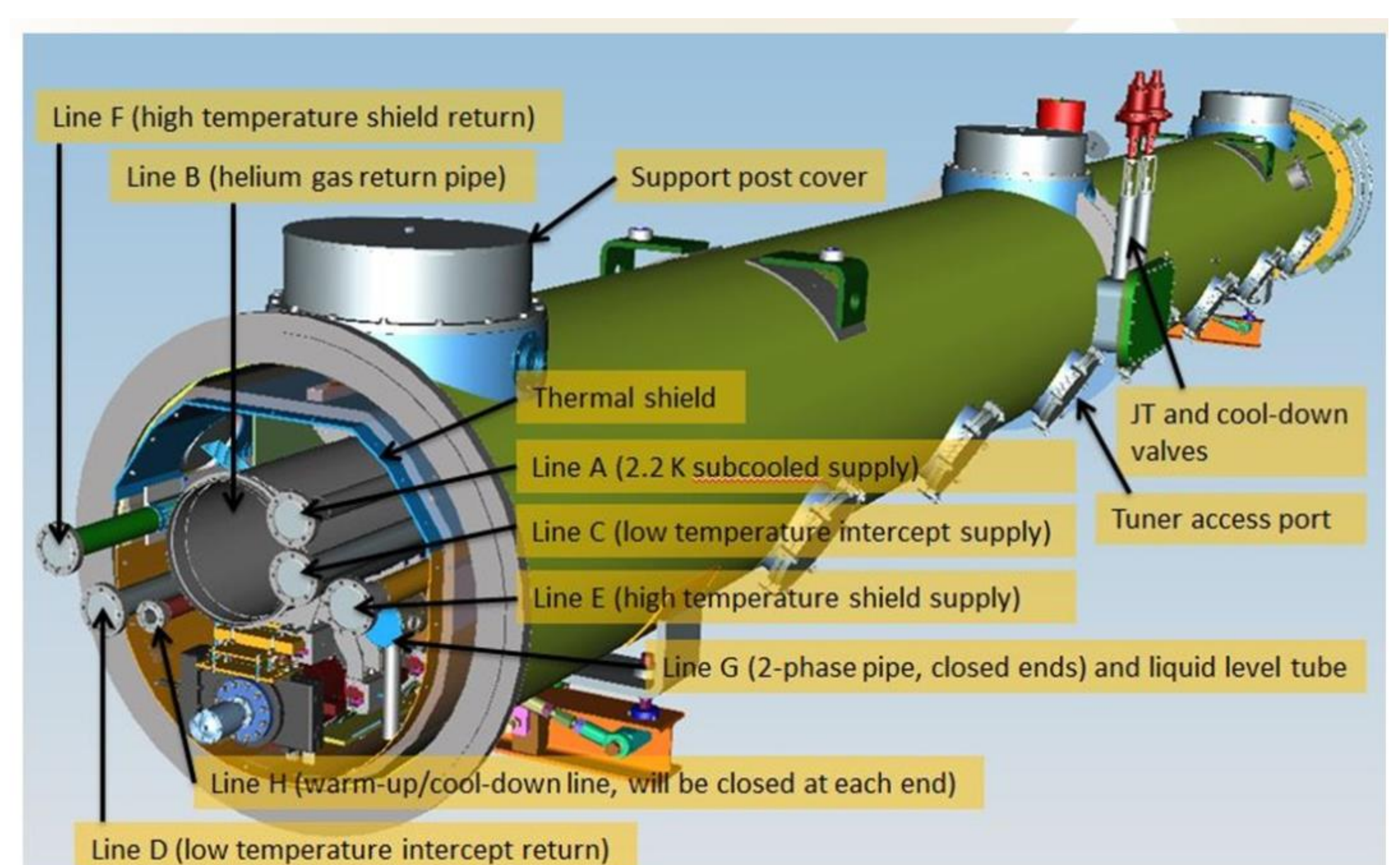
Instruments	Controllers	US DB	DS DB	FC1	FC2	FC3	FC4	FC5	FC6	US EC	DS EC	Total
Cernox	Lakeshore 240	19	19	10	9	9	9	9	9	8	9	110
PT103	Lakeshore 240	2	2									4
Heater Control	Acopian PS or EPOWER	2	2	1						1	2	8
Pressure	Strain Gauge on ECs	13	13							3	3	32
Vacuum	MKS	2	2	2	2	2	2	2	2			16
Valve Control	PS2 (caps) Samson (db)	5	5	1							1	12
Total		43	43	14	11	11	11	11	11	12	15	182

First Light 2020

Centralized, Redundant PLC Chassis

## What is a Cryomodule?

The LCLS-II cryomodule is 12 meters long and has 8 9-cell RF cavities. A total of thirty-five 1.3GHz and two 3.9 GHz cryomodules are being built and tested at FNAL and TJNAF. The JT Valve controls the amount of Helium into the tanks surrounding the cavities. Heaters under each cavity bath are used to offset the amount of heat generated by RF so the return pressure to the plant stays within expected parameters. The LCLS-II cryomodule is designed by FNAL and based on the previous designs with modifications to accommodate CW operation and LCLS-II beam parameters. The distribution equipment (6 feedcaps, 2 endcaps, 2 distribution boxes) are designed by FNAL.

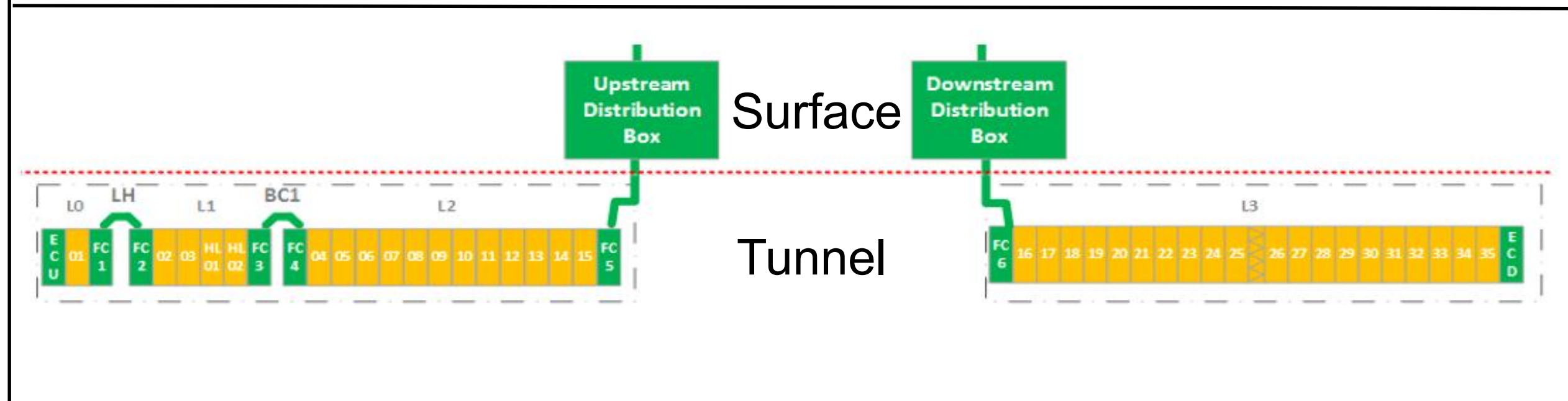


## Control System

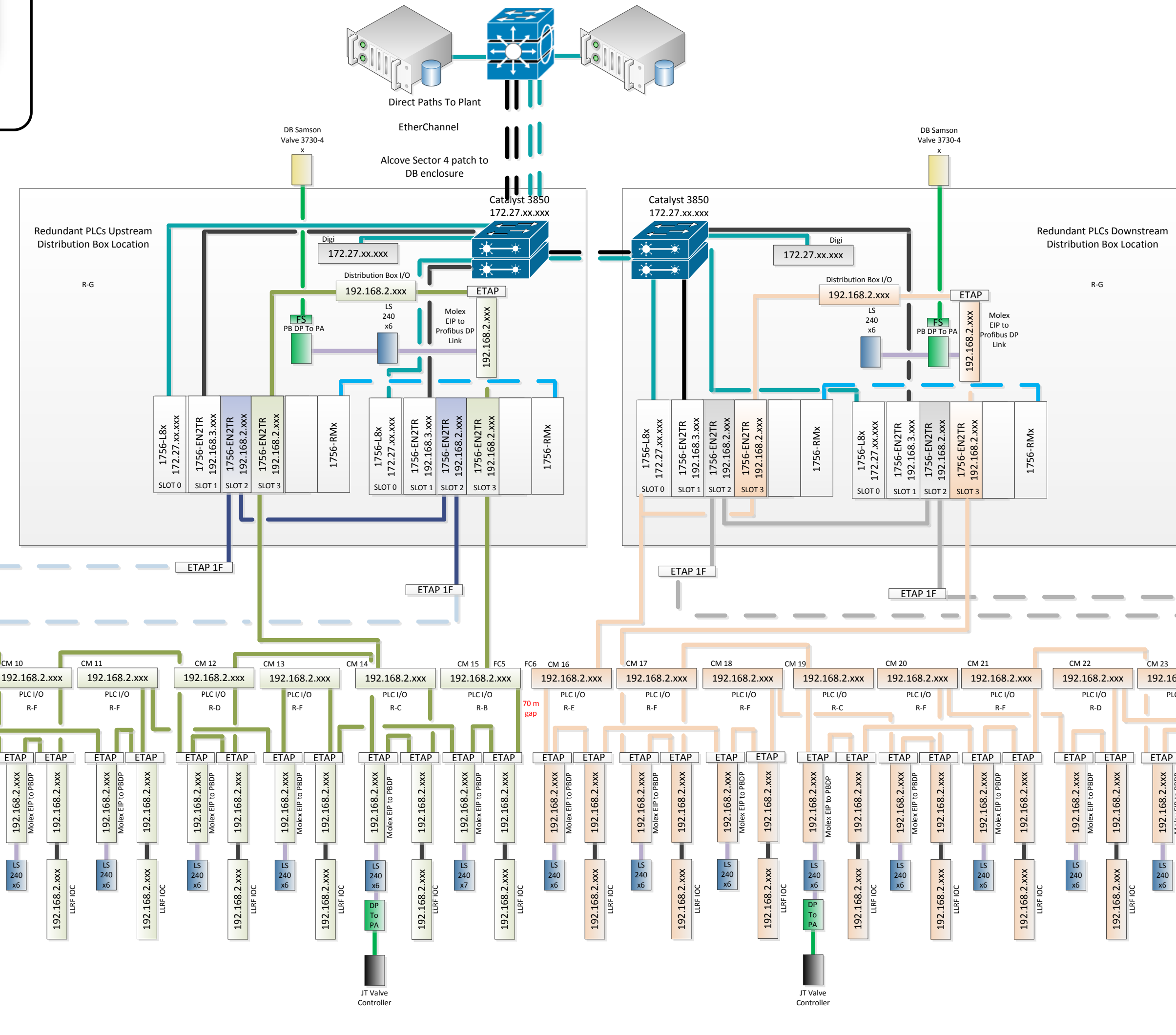
Two cryogenic plants, designed by TJNAF, supply helium to the LCLS-II Linac Cryogenic Control system. SLAC is responsible for the linac controls and EPICS integration to the plant. The controls design is set for first light in 2020 and includes:

- EPICS Supervisory Control of Plant, Distribution, and Cryomodules
- Subsystem PLC processors
- 2 sets of centralized, redundant PLC processors and EtherNet/IP modules for cryomodule and distribution System
- PLC 1GB/s interface to EPICS
- LLRF to cryo communications through Device Level Ring
- Device Level Ring communication with Distributed I/O and LLRF IOC Servers
- Profibus DP communication to temperature monitors
- Profibus PA communication to valve positioners
- Over 100 Devices on DLR
- Interfaced systems include: LLRF, Magnet, Vacuum
- Cryomodule and distribution control: cryogenic valves, pressure transmitters, liquid levels, and heaters

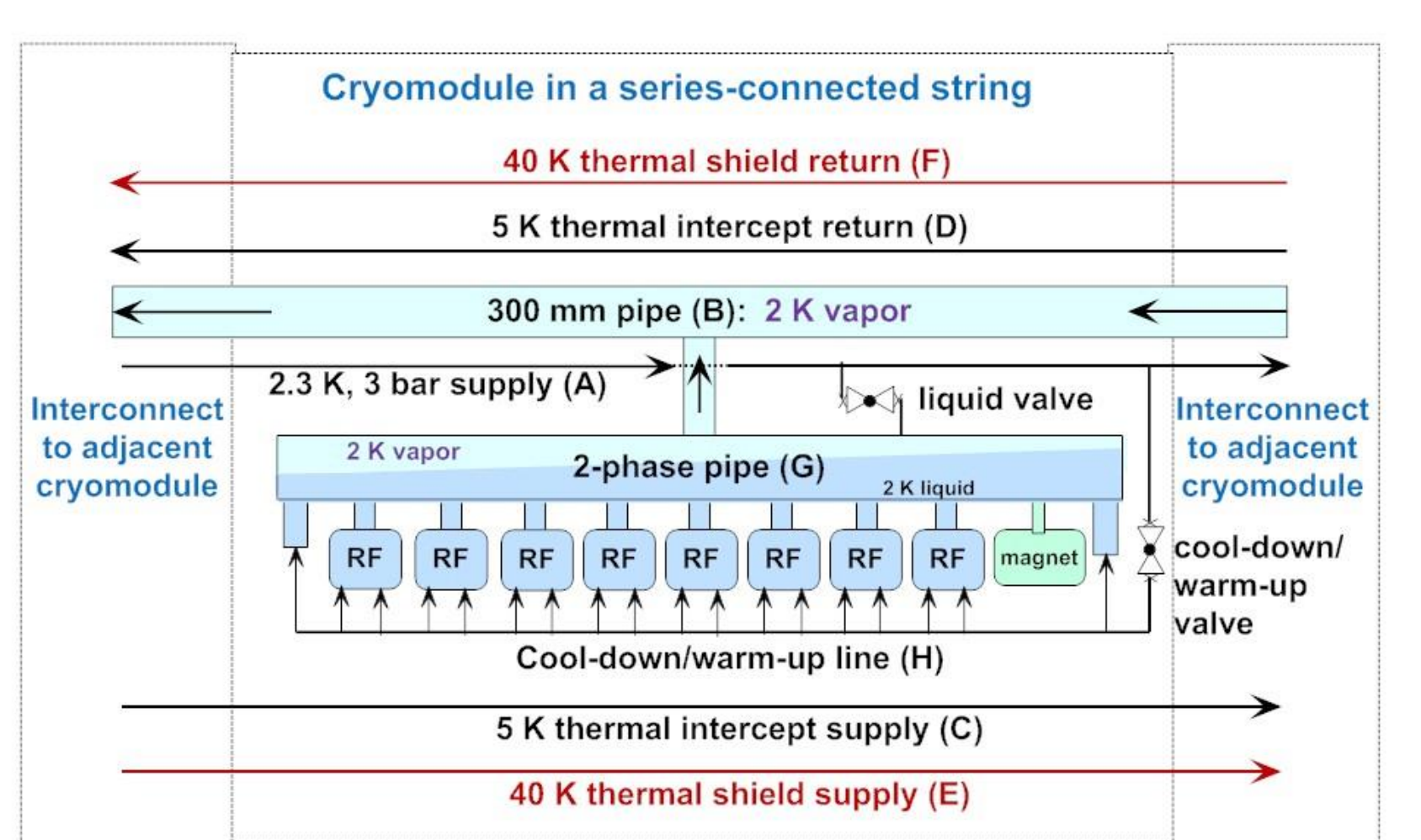
## Cryo Components Layout



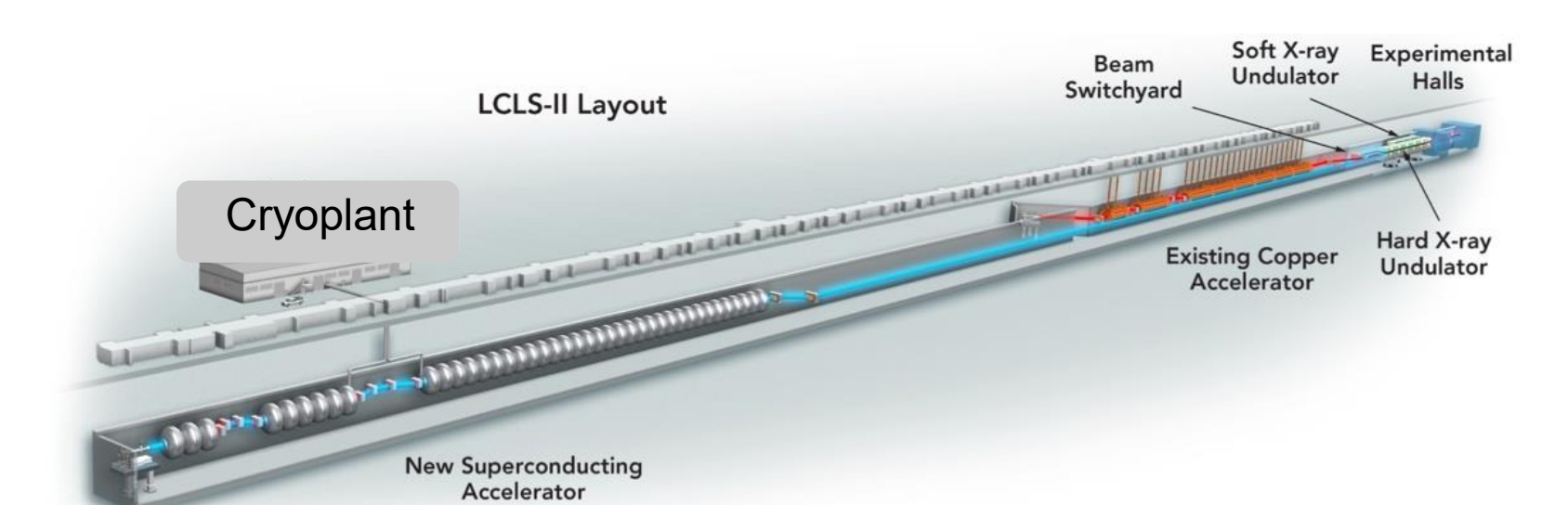
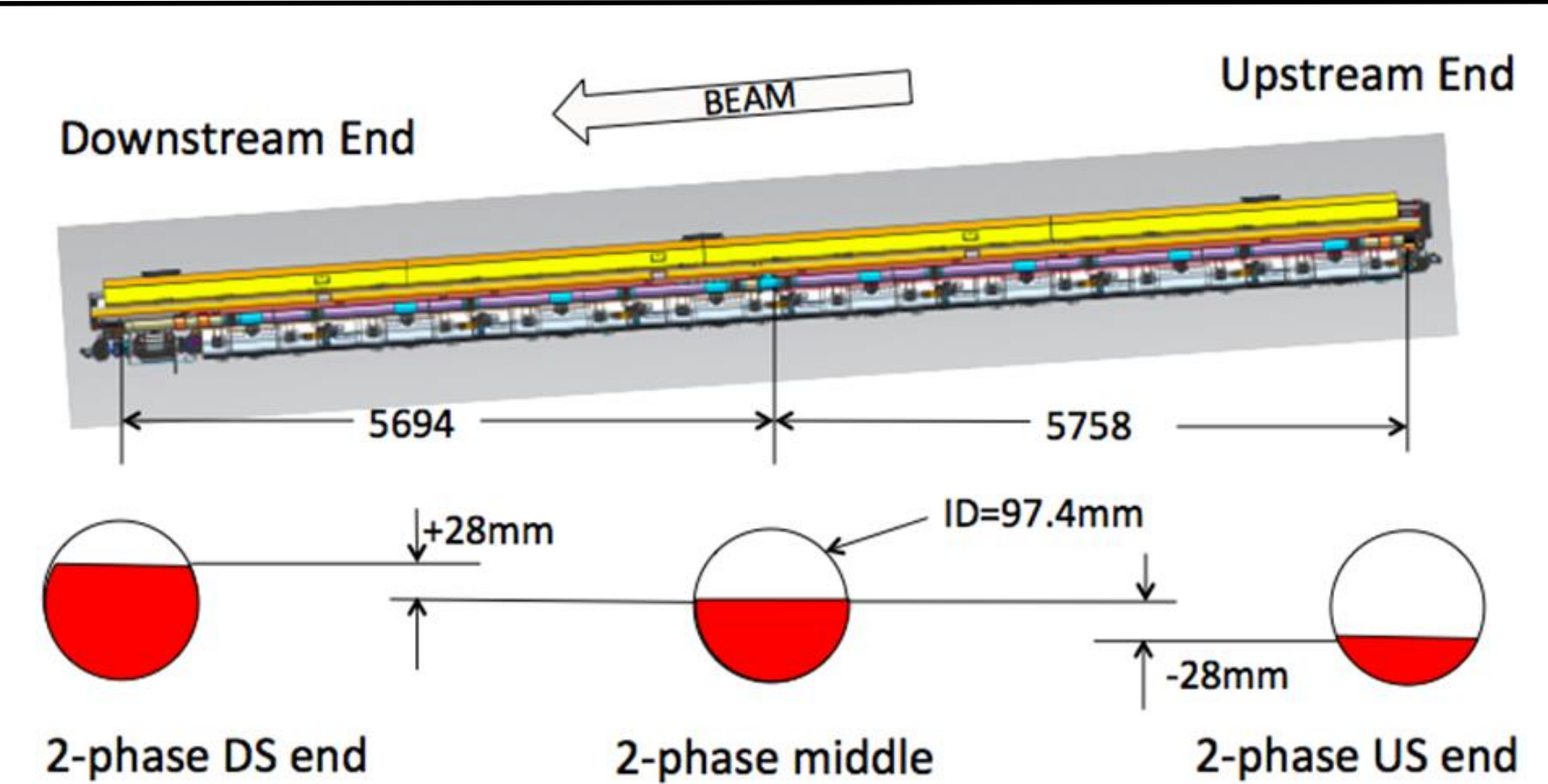
## EPICS Servers



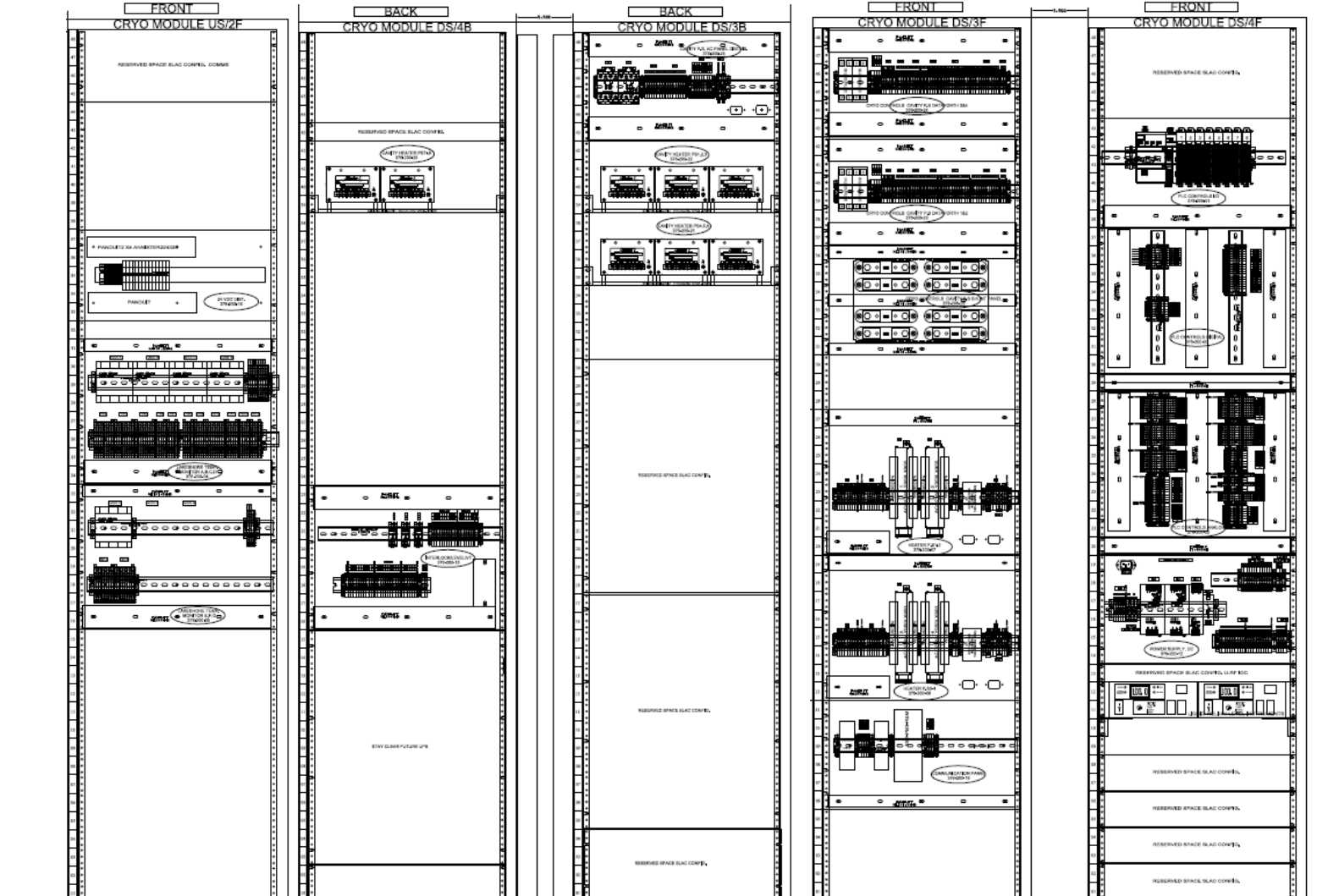
## Cryomodule Helium Management



## Liquid Helium Levels 0.5% slope



## Control Racks



## Device-Level Rings: I/O and Integrated Communications

