

## LCLS-II CRYOMODULES PRODUCTION AT FERMILAB\*

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The LCLS-II main linac 1.3 GHz cryomodule (CM) is based on the XFEL design, including TESLA-style superconducting accelerating cavities, with modifications to accommodate CW (continuous wave) operation and LCLS-II beam parameters. Two prototype cryomodules (pCM) were planned for assembly at Fermilab and JLab to confirm the design modifications. The 3.9 GHz CM assembly will follow the 1.3 GHz CMs, for efficiency. At Fermilab, the pCM was assembled at the Cryomodule Assembly Facility between September 2015 and June 2016. The pCM assembly was completed at the CAF in July 2016 and the module is currently undergoing test at the Cryomodule Test Stand (CMTS).

### CRYOMODULE ASSEMBLY FACILITY

The CAF consists of two assembly/production floors: CAF-MP9 and CAF-ICB. CAF-MP9 (see Fig. 1) houses the cleanroom which consists of a ~250 square meter cleanroom complex which has Class 10 (ISO 4), 100 (ISO 5) and 1000 (ISO 6) areas. There are two workstations (WS) setup in the cleanroom: WS0 is for coupler cold end assembly to the qualified dressed cavity and WS1 is for cavity string assembly. After the string is assembled, it is rolled to WS2 for cold mass assembly phase-I. CAF-ICB (see Fig. 2) houses the cold mass assembly work stations WS3, WS4, WS5 and WS6, i.e., all remaining assembly steps and preparation for shipment.

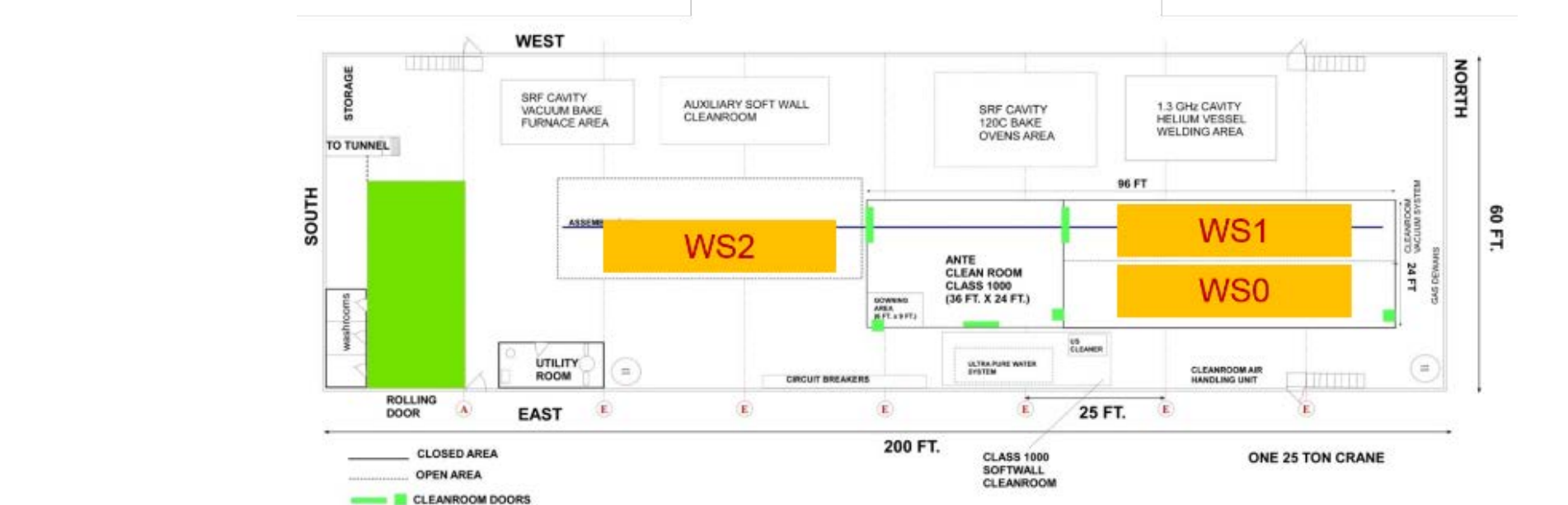


Figure 1: CAF-MP9 production floor

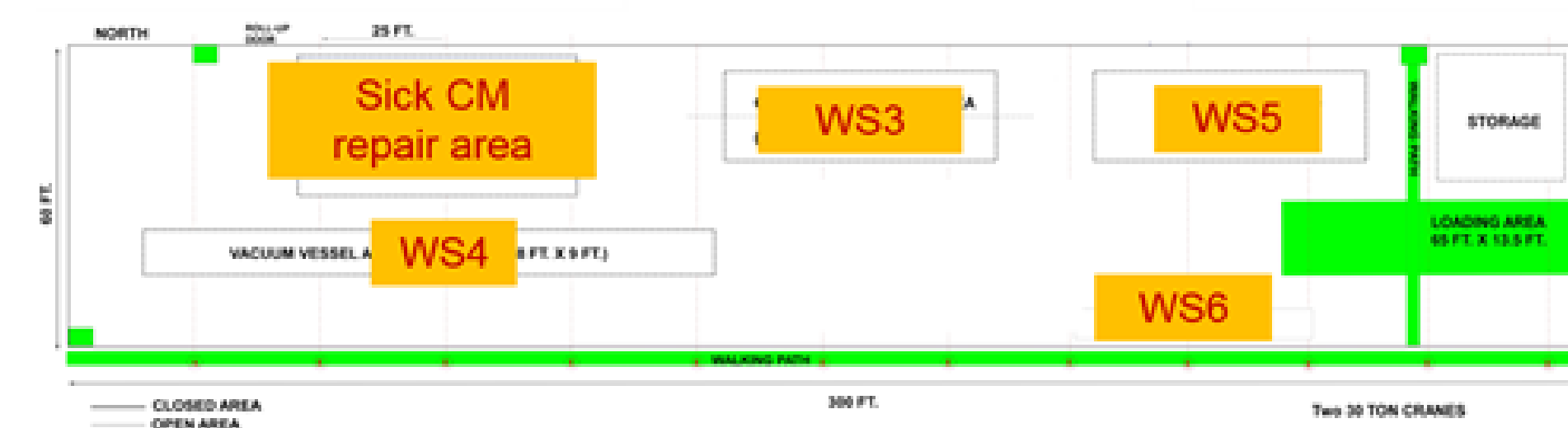


Figure 2: CAF-ICB production floor

### PROTOTYPE MODULE ASSEMBLY

WS0: Cold End Coupler Assembly [CAF-MP9]  
WS1: Cavity String Assembly [CAF-MP9]  
WS2: Cold Mass Assembly Phase-I [CAF-MP9]

- Split magnet installation
- 2-phase circuit pipe cutting and welding
- Instrumentation installation and checks
- Cavity magnetic shield installation
- Marry cold mass upper to the cavity string
- GHRP to 2-phase circuit welding
- Cool down lines to helium vessel welding
- Various leak checks of the helium circuit
- Various RF checks & HOM notch frequency tuning

WS3: Cold Mass Assembly Phase-II [CAF-ICB]

- Magnet & current leads thermal intercept installation
- Cavity string alignment to cold mass (laser tracker)
- End lever tuner system assembly
- Thermal intercept assembly
- Harnessing of the wires & RF cables
- Electrical & RF Checks

WS4: Vacuum Vessel Assembly [CAF-ICB]

- Installation/welding lower 50K aluminum shields
- Installation of 30 layers of MLI around cold mass
- Electrical & RF checks
- Vacuum vessel installation onto the cold mass
- Cold mass alignment to the vacuum vessel

WS5: Final Assembly [CAF-ICB]

- Weld JT/Cooldown valves
- Leak check, X-ray QC, and pressure tests
- Installation of coupler warm parts and waveguides
- Instrumentation flanges installation
- Installation of coupler pumping lines & leak check
- Beamline vacuum leak check
- Insulating vacuum pump down and leak check

### PRODUCTION ASSEMBLY READINESS

The pCM assembly has been very useful preparation for production assembly readiness. At this point, the CAF infrastructure is complete and ready. The pCM assembly travelers and parts kits are complete and ready. All discrepancy (non-conformance) reports have been closed. The production CM design drawings have been updated based on pCM experience, and the production CM components were ordered with the revised drawings. Lessons learned meetings were held with the assembly team, sub-systems leads, subject matter experts, process engineering. Meeting minutes resulted in action items which primarily addressed revisions for production cryomodule assembly travelers. The pCM task durations have been carefully analysed and considered for optimization during the production CM assembly. The first three production CM's will be assembled in pseudo-parallel mode during a ramp-up phase. The ramp-up phase will also be used to train additional contract mechanical technicians. The remaining thirteen cryomodules will be assembled with an assembly throughput of one CM per five weeks and a duration of ~12 weeks (60 days) (peak-rate). Excluding any sick modules that need to be reworked, there will be three modules in the production line at the same time to satisfy the required throughput. Since the tooling and assembly steps for the 3.9 GHz CMs are by design as similar as possible, after a brief preparation period, the 3.9 GHz CM assembly will proceed with similar throughput.



pCM Assembly Photos