LCLS-II Beamline Components: from Manufacturing to Particle Free Installation

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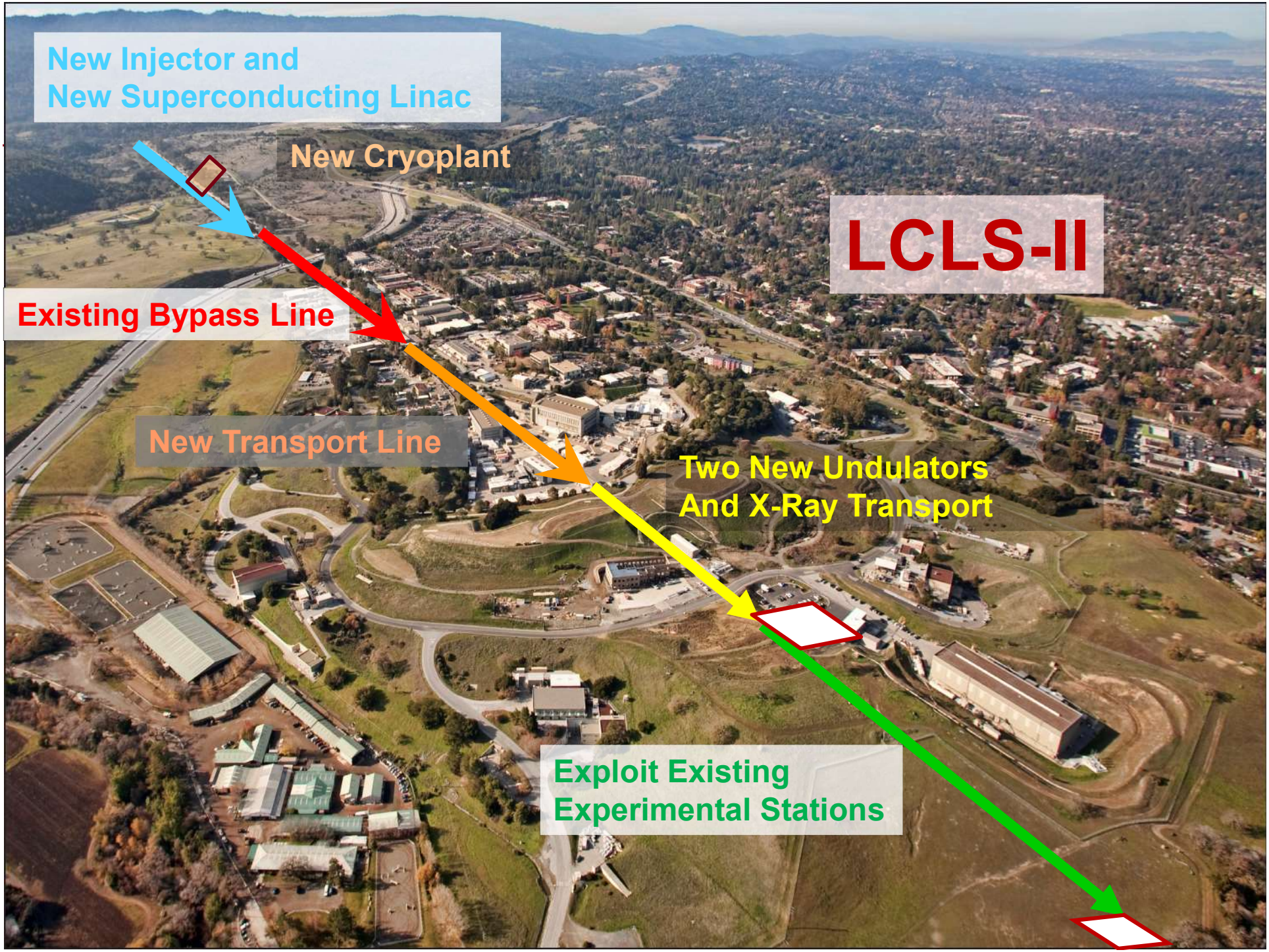
Outline

1. LCLS-II
2. Cryomodules: cryogenic vacuum system
3. RT vacuum system
   - UHV requirements
   - PF requirements
4. LCLS-II warm beamline modular design
   - Rafts assembly
   - Rafts installation
5. Summary

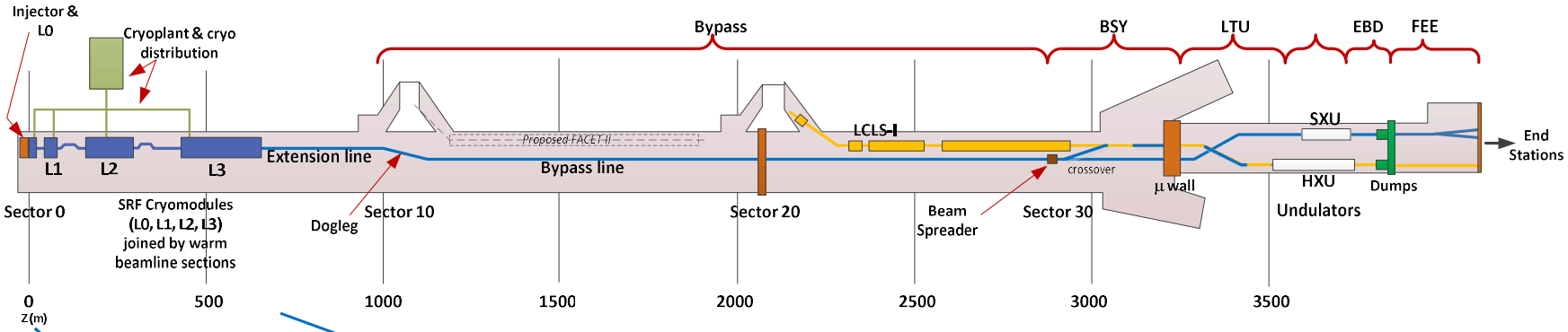

New Injector and
New Superconducting Linac
New Cryoplant
LCLS-II
Existing Bypass Line
New Transport Line
Two New Undulators
And X-Ray Transport
Exploit Existing
Experimental Stations

LCLS-II Project: European contribution and collaboration

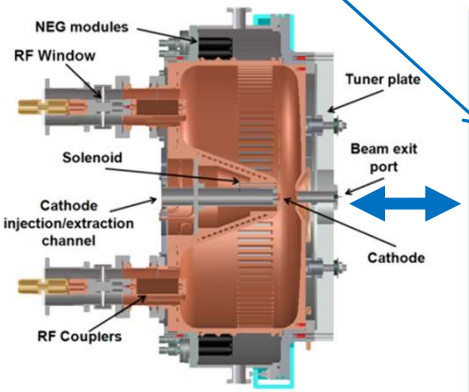
SLAC

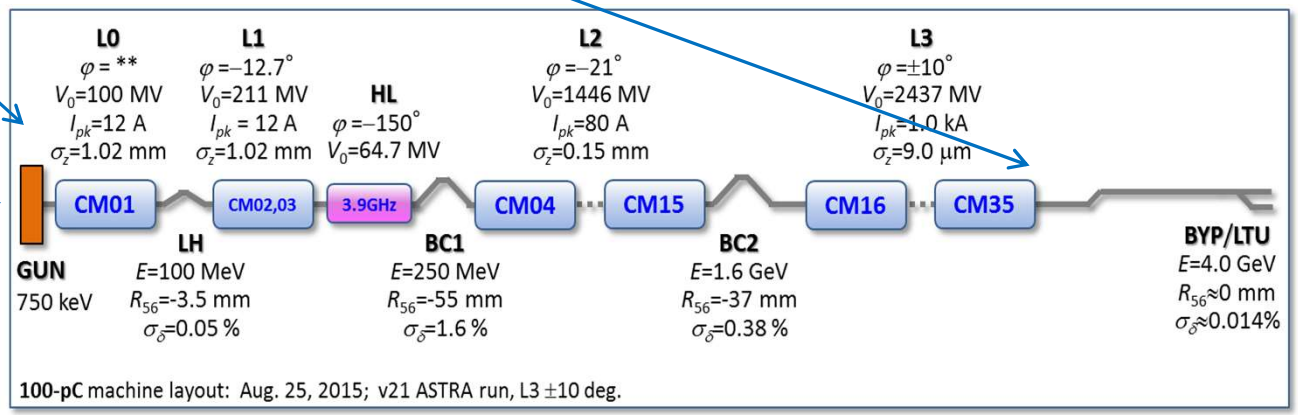
1. Numerous European engineers and scientists are involved in the project
2. Collaboration with the Superconducting RF accelerator group at LASA lead by Carlo Pagani
3. Collaboration with INFN Milano for the coating of the electron gun photocathode, Daniele Sertore and Laura Monaco.
4. Collaboration and exchange with the DESY/XFEL team
5. Multiple European suppliers

LCLS-II Project: Free Electron Laser

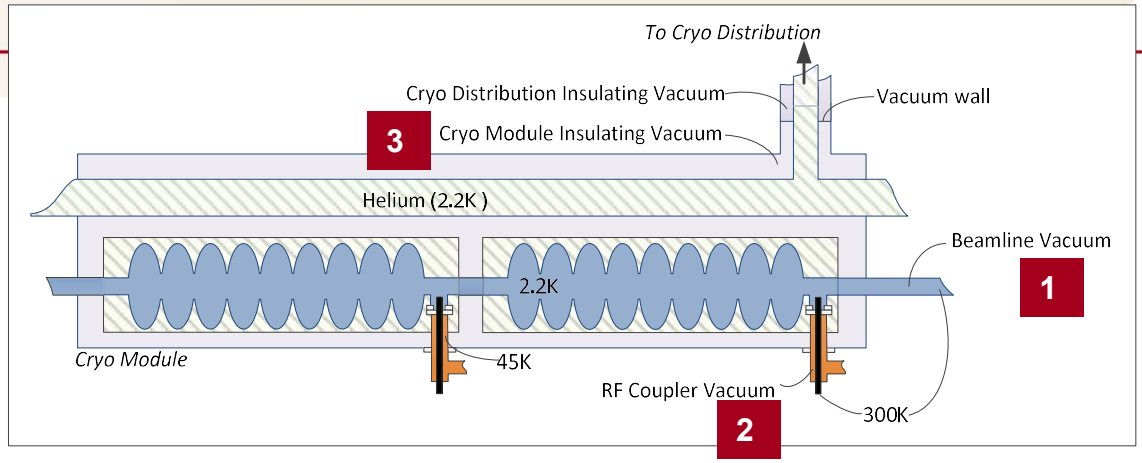


>3.5 km of beamline replaced or refurbished



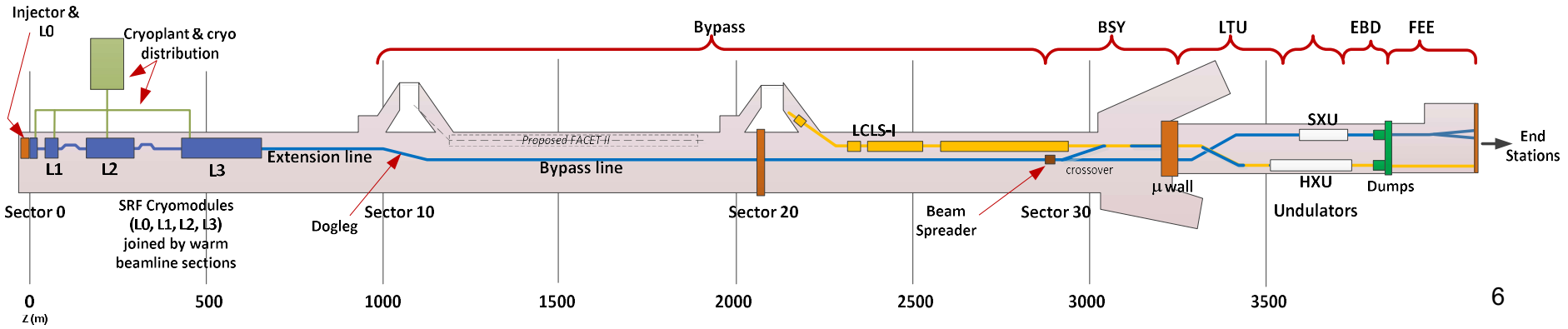


LCLS-II Beamline Vacuum Systems



LCSL-II Beamline Vacuum System is comprised of multiple environmental conditions:

- Room temperature, UHV (most of downstream beamline) ~ 10^{-7} ÷ 10^{-8} Torr
- Room temperature, UHV, particle-free (between cryomodules) ~ 10^{-8} Torr
- Cryo temperature, UHV, particle-free (cryomodules) ~ 10^{-8} Torr before cooling



CRYOMODULES

LCLS-II Cryomodules Production

LCLS-II Cryomodules

SLAC

3.9 GHz Cryo-Modules: x 2

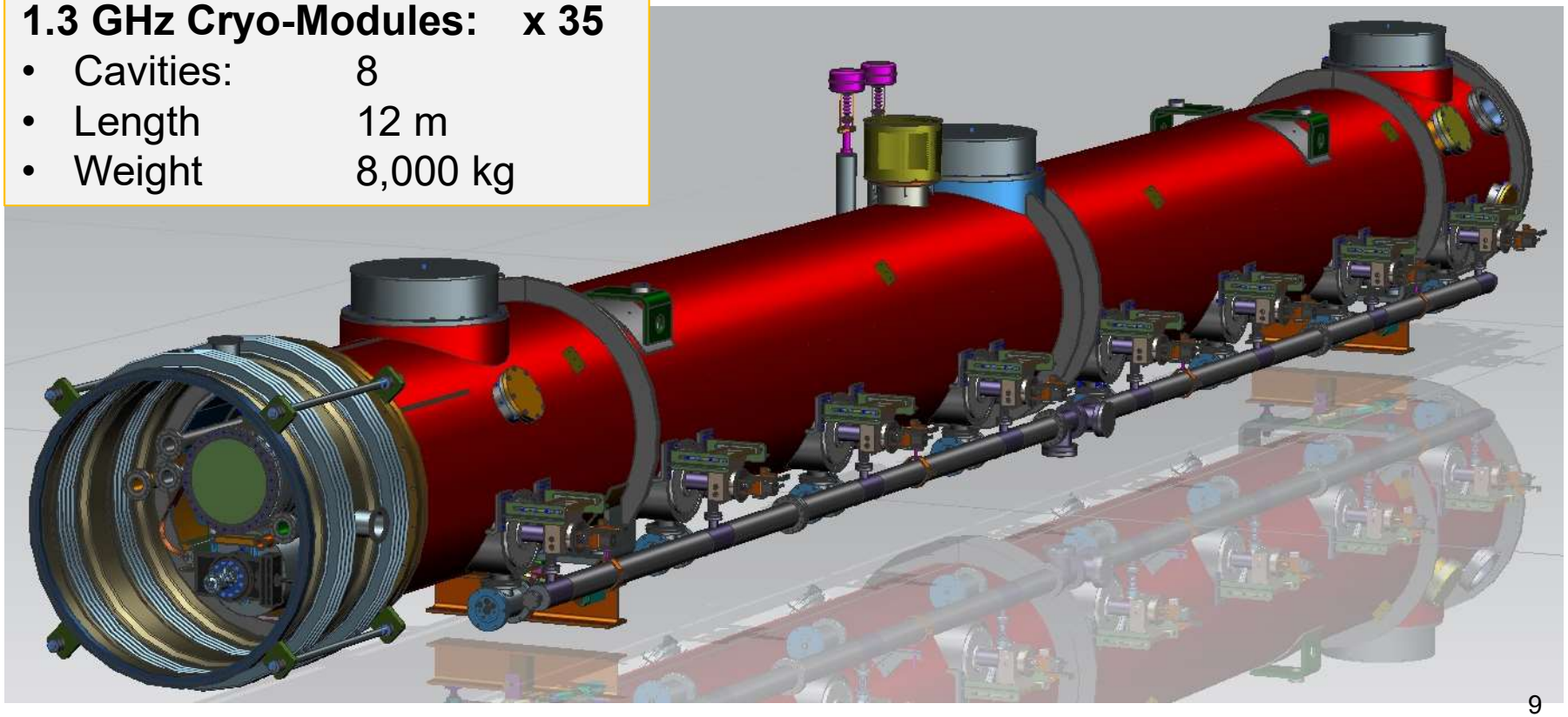
- Cavities: 8
- Length 6 m
- Weight 4,000 kg

1.3 GHz Cryo-Modules: x 35

- Cavities: 8
- Length 12 m
- Weight 8,000 kg

5 strings

30 interconnections



BEAM LINE VACUUM SYSTEM: SLAC MANUFACTURING – UHV and PARTICLE FREE REQUIREMENTS

SLAC UHV Acceptance Test Criteria

FP-202-631-14-REV8

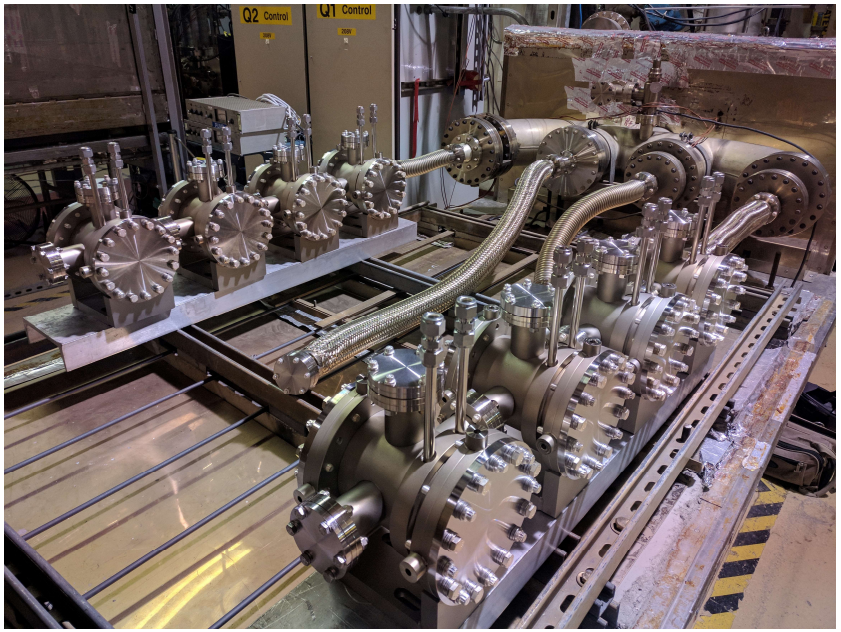
1. **Leak Tight:** Helium leakage rate of < 2×10^{-10} std. cc/sec helium.

2. **RGA Acceptance**: Mass spectrometer scan performed at 150°C on each lot of components in the same test chamber

Conditions/Criteria	Limits
	SLAC AD UHV
Temperature of entire vacuum system and RGA head ionizer	150°C
Ratio of partial pressures of water vapor, (18 AMU) to hydrogen (2 AMU)	$P_{18} < \frac{P_2}{2}$
Partial pressure from sum of all peaks >44 AMU	P < 1 x 10^{-11} Torr
Maximum single-peak partial pressure for >44 AMU	P < 5 x 10^{-12} Torr

3. **Total Outgassing:** As specified by component/assembly drawing, if present, otherwise a value < 2×10^{-12} Torr-L/sec-cm^2 of surface area exposed to vacuum shall be demonstrated (standard method like aperture or rate of raise method)

SLAC Bakeout Oven Stations



Example of Standard bakeout:

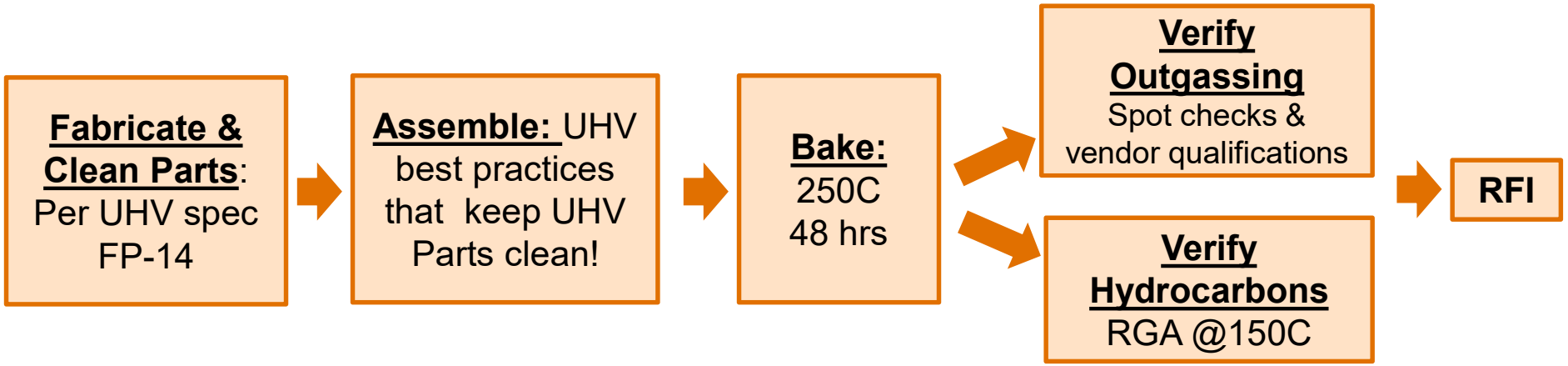
Electropolished 304 Stainless Steel baked at 250°C for 48h

grants an outgassing of < 2×10^{-12} Torr-L/sec-cm^2

Bakeout duration at 250°C is adjusted (> 48h) based on the cleanliness of the components

SLAC's Process for UHV Assembly and Verification

If executed properly, this sequence has many SLAC years' proof of success to achieve < $1x10^{-8}$ Torr levels.



For LCLS-II there won't be any beamline in-situ bakeout after installation

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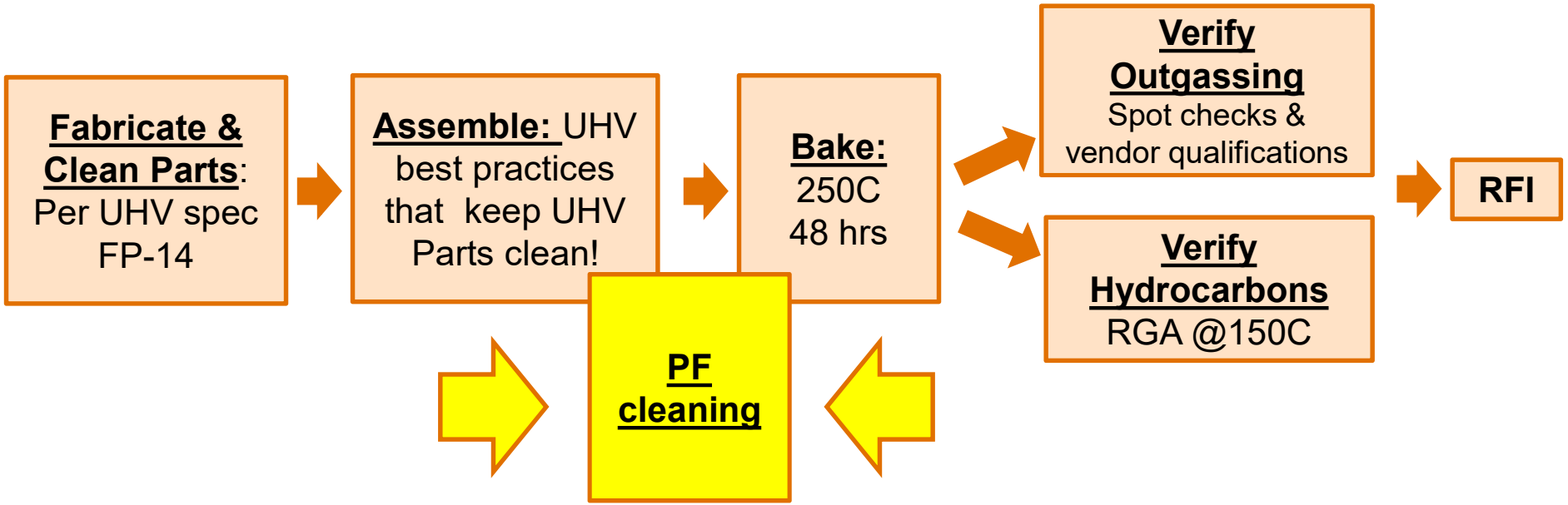

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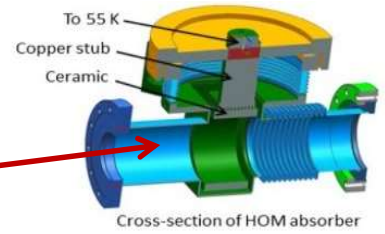
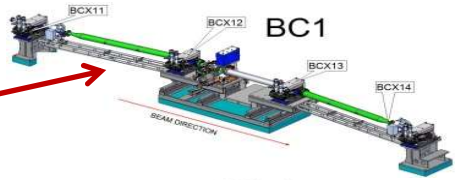
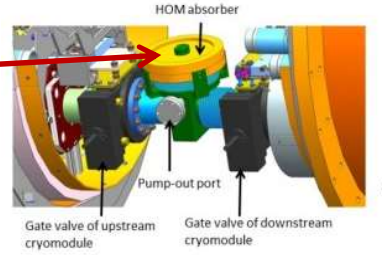
Particle Free: Definitions of Cleanliness Regions

LCLS-II Cleanliness Region	Description	Surface Contamination Level	Blow Off Testing (counts/ft³ of air at a minimum flow of 1 cfm)	Reference
A	**Cryo Beamline Vacuum Surfaces (Internal Surfaces)**	Level 1	0.3 µm bin ≤ 10 counts 0.5 µm bin ≤ 5 counts 1 µm bin 0 counts 3 µm bin 0 counts 5 µm bin 0 counts 10 µm bin 0 counts	LCLSII-4.5-ES-0055-R1
B	**Warm Beamline Vacuum Surfaces (Internal Surfaces)**	Level 10	0.3 µm bin ≤ 15 counts 0.5 µm bin ≤ 10 counts 1 µm bin ≤8 count 3 µm bin ≤5 counts 5 µm bin ≤3counts 10 µm bin ≤1 counts	
C	**Cryo Beamline Components, (External Surfaces)**	Level 25	Max 100 particles/ft³ sum of all bins 0.3 µm and larger	
C	**Warm Beamline Assembly parts and tools**	Level 25	Max 100 particles/ft³Sum of all bins 0.3 µm and larger	
C	**Cryo Beamline Assembly Jigs and Fixtures**	Level 25	Max 100 particles/ft³Sum of all bins 0.3 µm and larger	
D	**Warm Beamline Assembly Jigs and Fixtures**	Level 50	Max 200 particles/ft³ Sum of all bins 0.3 µm and larger	
E	**Warm Beamline Components and Assemblies, within clean zones during installation**	Level 100	Max 1000 particles/ft³ Sum of all bins 0.3 µm and larger	







Particle *Free ESD* Section 6.2.4

Particle Free: Definitions of Cleanliness Regions

LCLS-II Cleanliness Region	Description	Surface Contamination Level	Blow Off Testing (counts/ft³ of air at a minimum flow of 1 cfm)	Reference
A MFD connect	**Cryo Beamline Vacuum Surfaces (Internal Surfaces)**	Level 1	0.3 µm bin ≤ 10 counts 0.5 µm bin ≤ 5 counts 1 µm bin 0 counts 3 µm bin 0 counts 5 µm bin 0 counts 10 µm bin 0 counts	LCLSII-4.5-ES-0055-R1
MFD build, practices	**Warm Beamline Vacuum Surfaces (Internal Surfaces)**	Level 10	0.3 µm bin ≤ 15 counts 0.5 µm bin ≤ 10 counts 1 µm bin ≤8 count 3 µm bin ≤5 counts 5 µm bin ≤3counts 10 µm bin ≤1 counts	
C	**Cryo Beamline Components, (External Surfaces)**	Level 25	Max 100 particles/ft³ sum of all bins 0.3 µm and larger	
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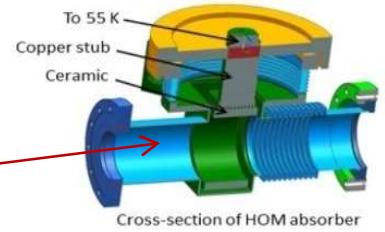
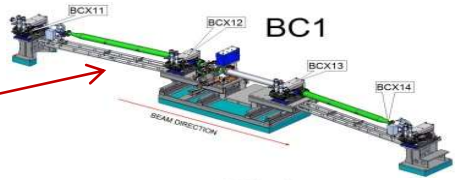
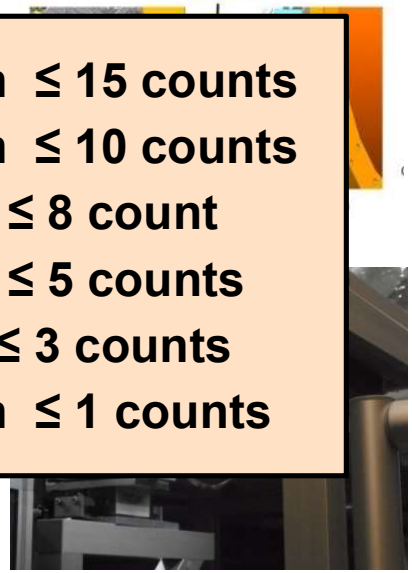






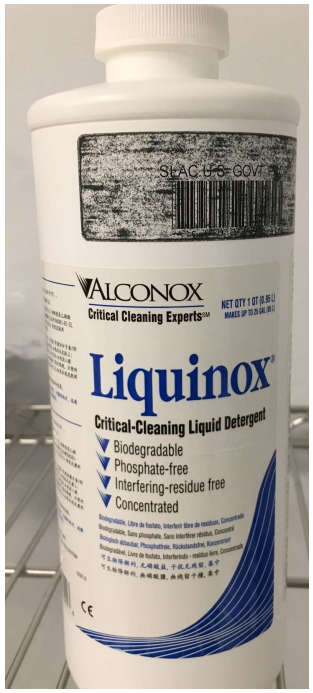
0.3 µm bin ≤ 15 counts
0.5 µm bin ≤ 10 counts
1 µm bin ≤ 8 count
3 µm bin ≤ 5 counts
5 µm bin ≤ 3 counts
10 µm bin ≤ 1 counts

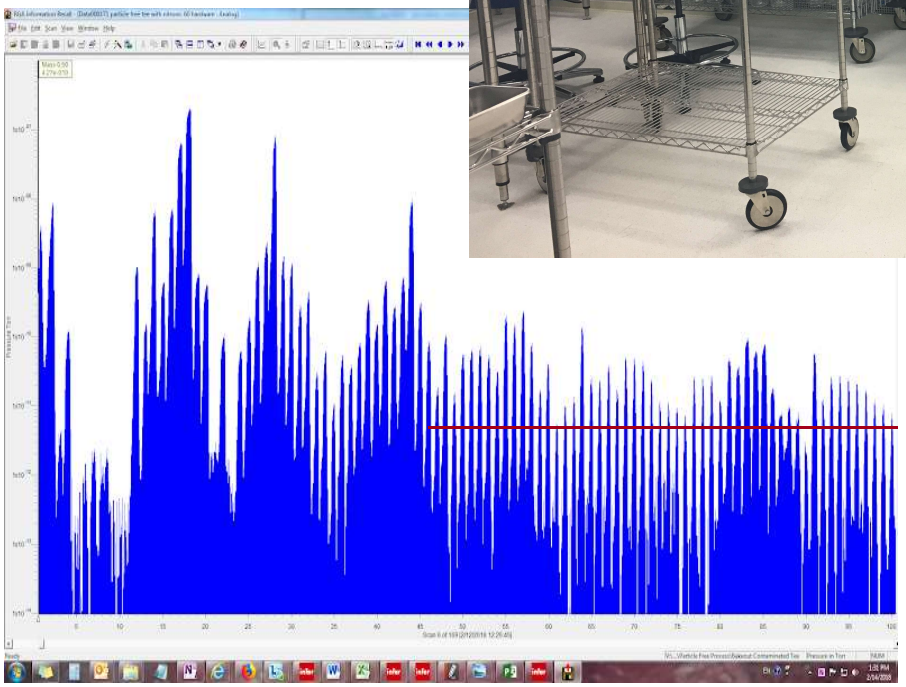
Particle *Free ESD* Section 6.2.4

SLAC Facilities for Particle Free Cleaning

- Cleaning station
- Rinsing station
- Clean storage of naked components

Cleaning solution has 1% of Liquinox



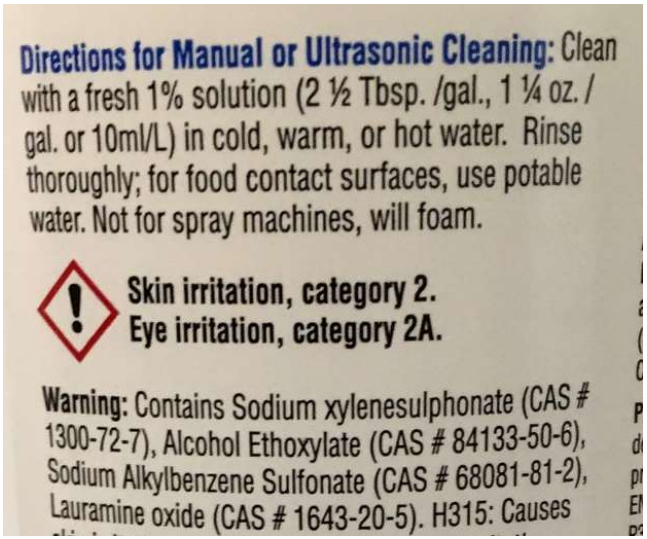


UHV clean parts cleaned with 1% of Liquinox shows hydrocarbon contamination after DI rinsing

SLAC Facilities for Particle Free Cleaning

Surfactants

- to facilitate wetting of surface so that the solution fully coats the parts.
- large hydrocarbon molecules.
- Adhesion to the part surface.



PF cleaning → **Bake:** 250C 48 hrs

Copper oxide during bakeout produce a huge amount of dust

- Nitrogen flow in furnace to reduce oxidation
- Silver plated gaskets

ANL collaboration for Particle Free cleaning

High pressure rinsing

- mechanical particles displacement
- No hydrocarbon contamination
- Needs a periodical check of the quality of the DI water

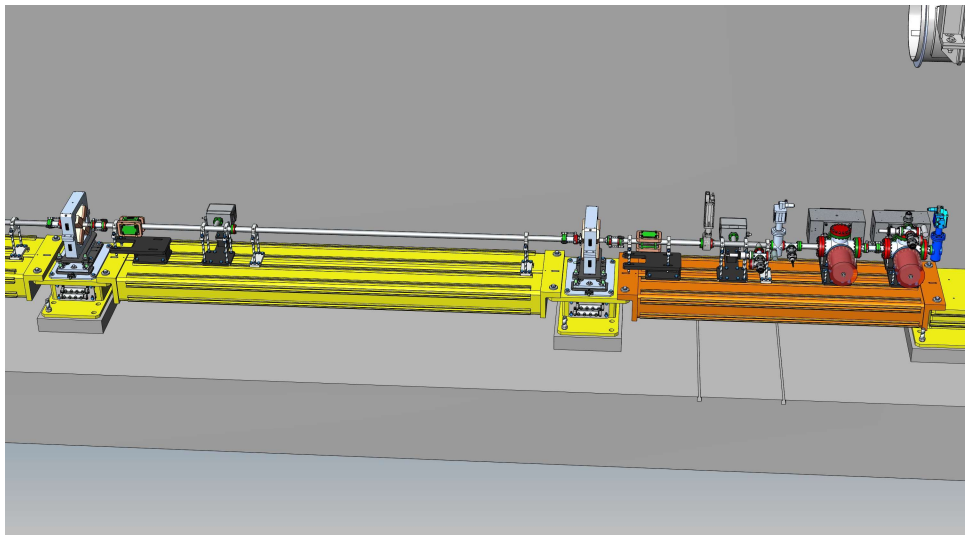
Bake:
250C
48 hrs

→

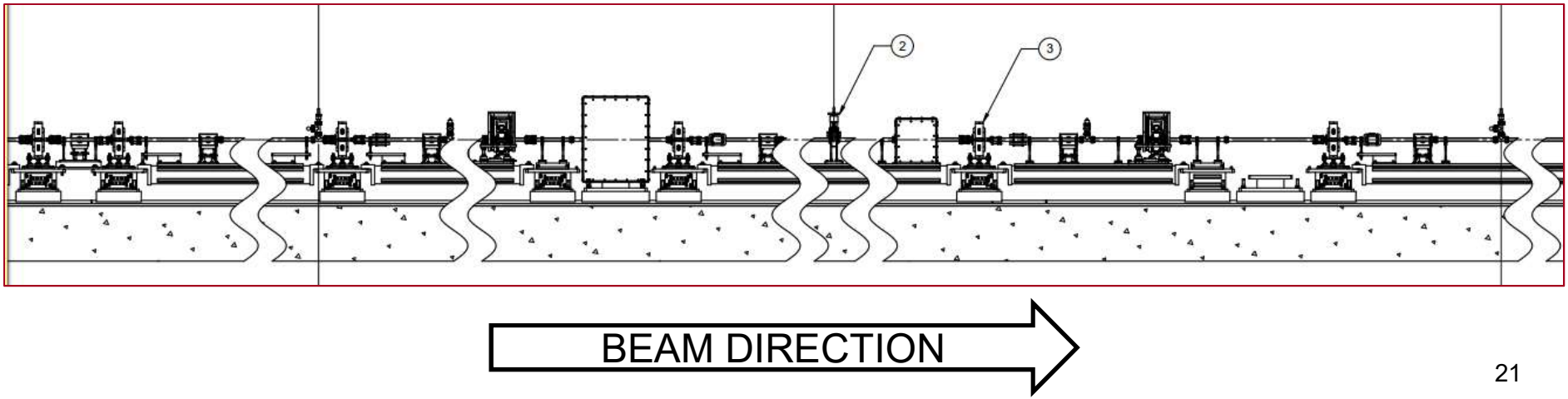
PF cleaning

BEAM LINE VACUUM SYSTEM: SLAC ASSEMBLY AND INSTALLATION

LCLS-II: Modular Beamline

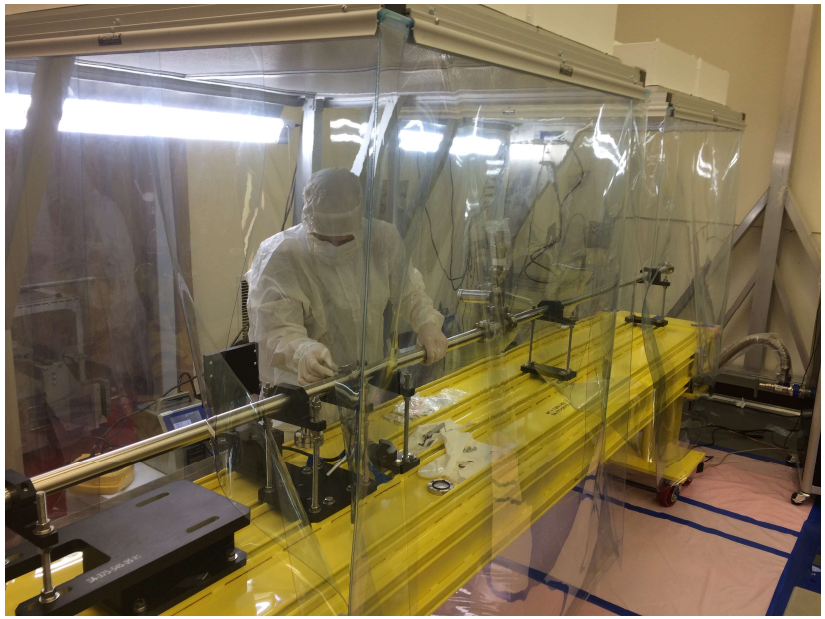


- ~ 160 rafts
- ~ 300 connections in situ
- The modular configuration reduces the amount of activity performed in the LCLS-II dusty tunnel



Rafts Assembly

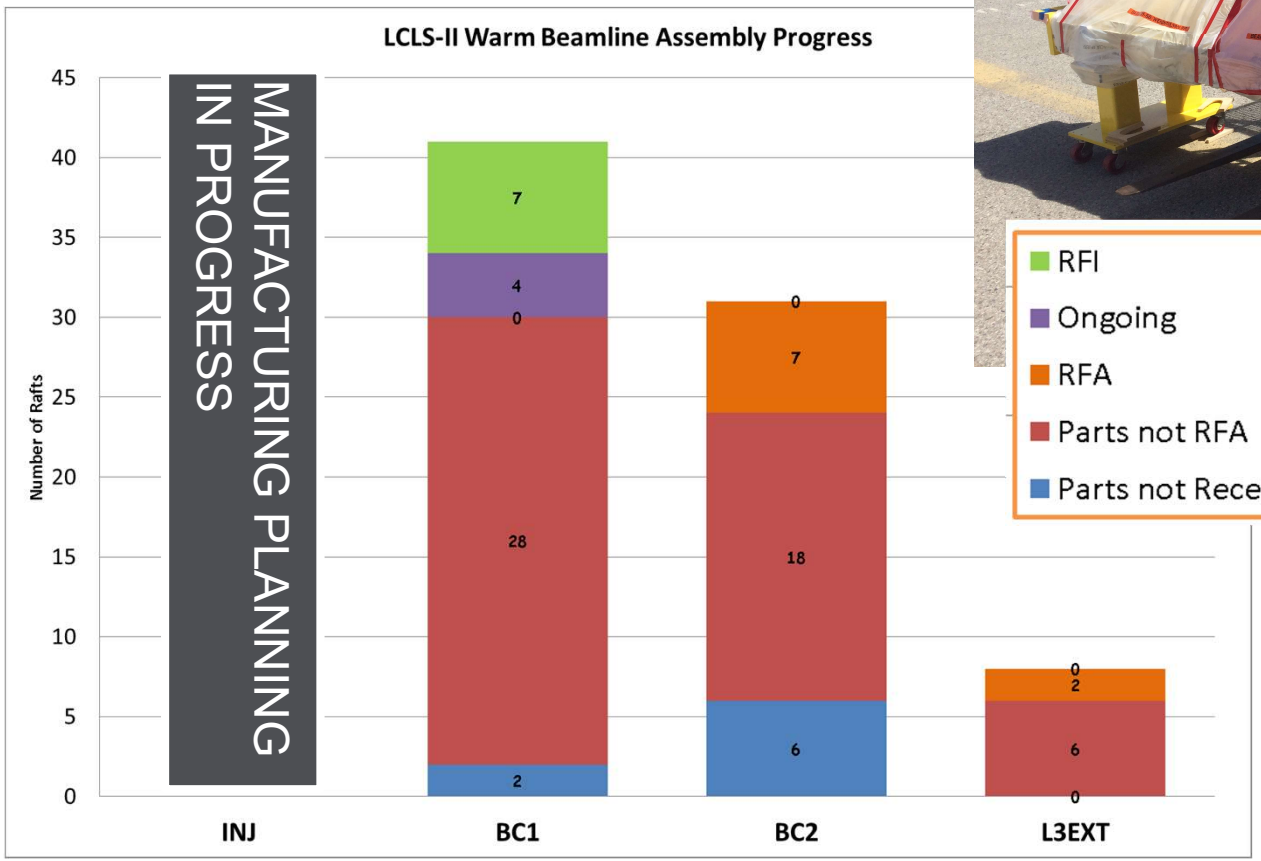
At the moment the LCLS-II are assembled in portable clean room class 100 placed in a cleanroom class 10,000



In the same building the construction of a new cleanroom of class 10,000 – 1,000 and 100 are ongoing and completion is foreseen by July 2018

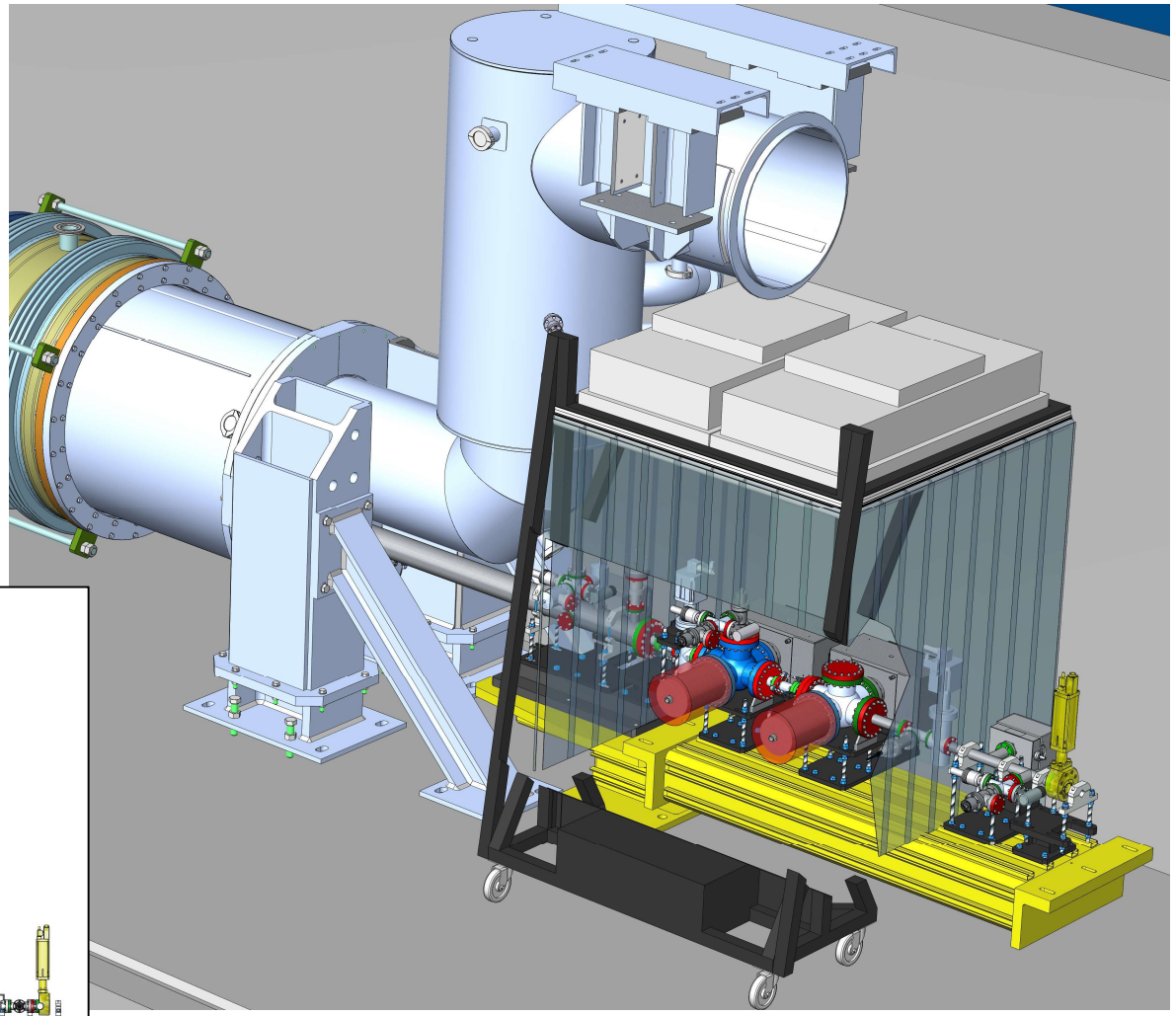
Rafts assembly progress

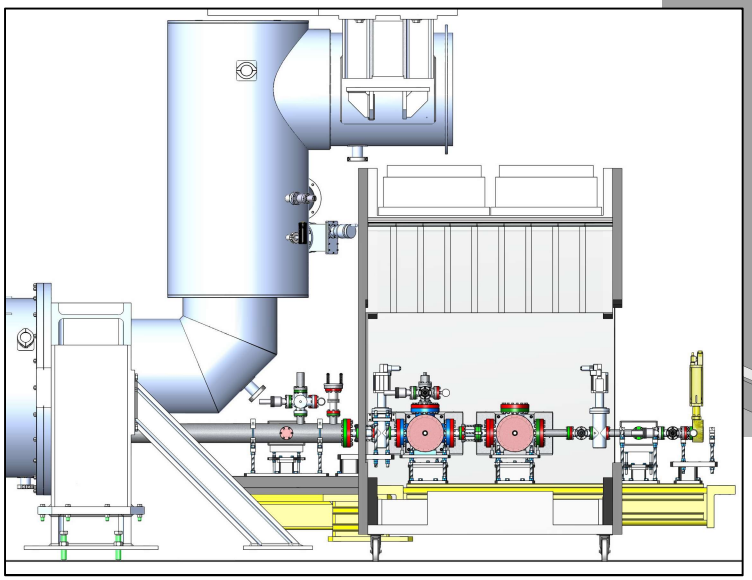
	INJ	BC1	BC2	L3 EXT
Total # of rafts	~70	41	31	8



LCLS-II Field Installation: Portable Overhead Clean Room

- Portable cleanrooms are used to connect the rafts.
- Estimated time for two adjacent connection is 2 days
- 3 days for additional pump down, leak check and venting (slow flow to avoid particle displacement)





Summary

- The SLAC Manufacturing Fabrication Department effort is focused on testing and processing all LCLS-II components so they meet UHV requirements
- Part of LCLS-II beamline has to be processed for Particle Free cleanliness. Procedures and facilities are in place to produce the best achievable result
- LCLS-II beamline will mainly be assembled in laboratory cleanrooms to reduce the activity in the tunnel
- Rafts will be transported in the tunnel and connected using portable overhead cleanrooms of class 100

Acknowledgment

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LCLS-II project

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AD-METSD - Mechanical Engineering Department

LCLS-II Field Installation: Portable BLA Clean Room