UCLA Breakdown & HG Research Updates

HG2022

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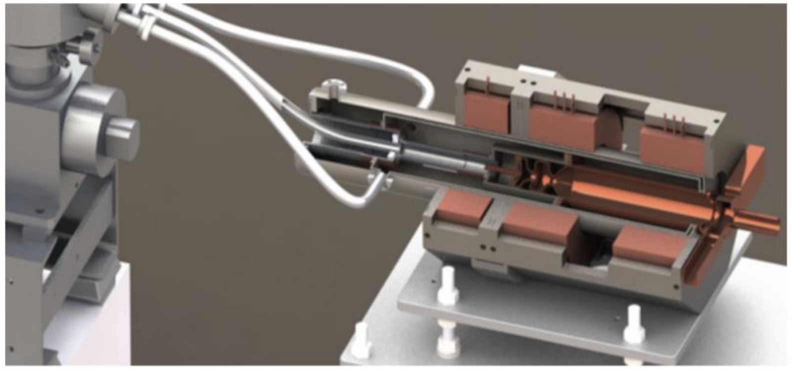
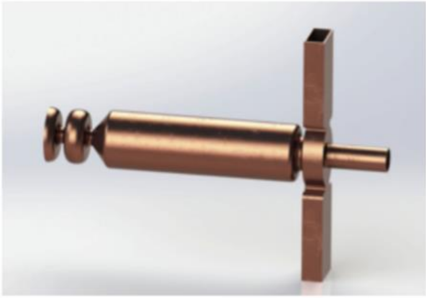
Outline of presentation

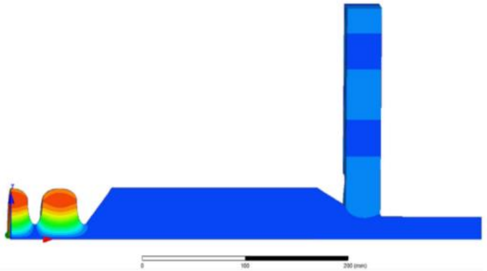
1. Background
2. Facilities overview
3. Experiment & Simulation
   a) LLRF
   b) High power C-band
   c) CYBORG Beamline
   d) UCXFEL photoinjector development
4. Conclusions

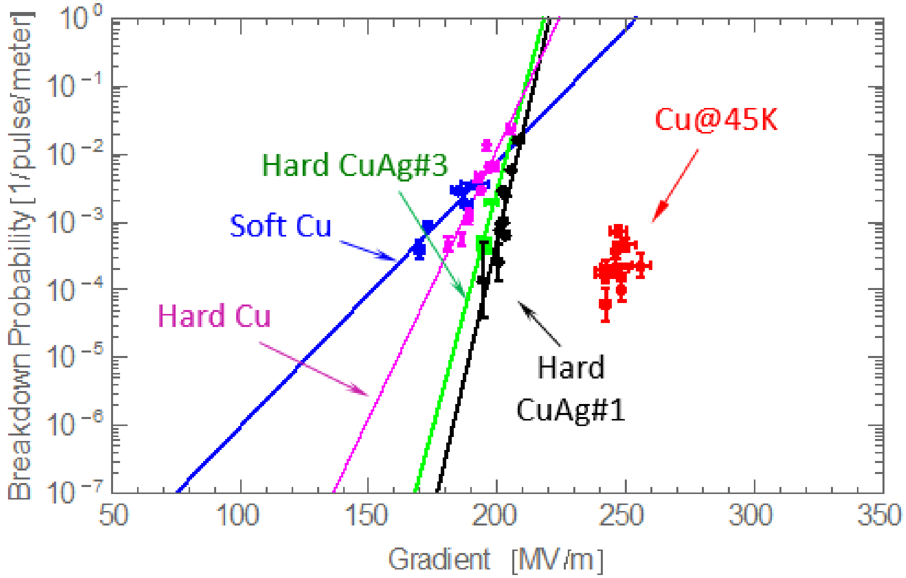
1) Background

- Significant focus photoinjector; wakefield; fundamental high field physics
- TopGun previous development in Sband
- Based on normal conducting cryogenic gradient improvements which we can





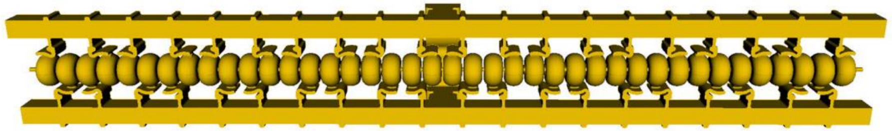


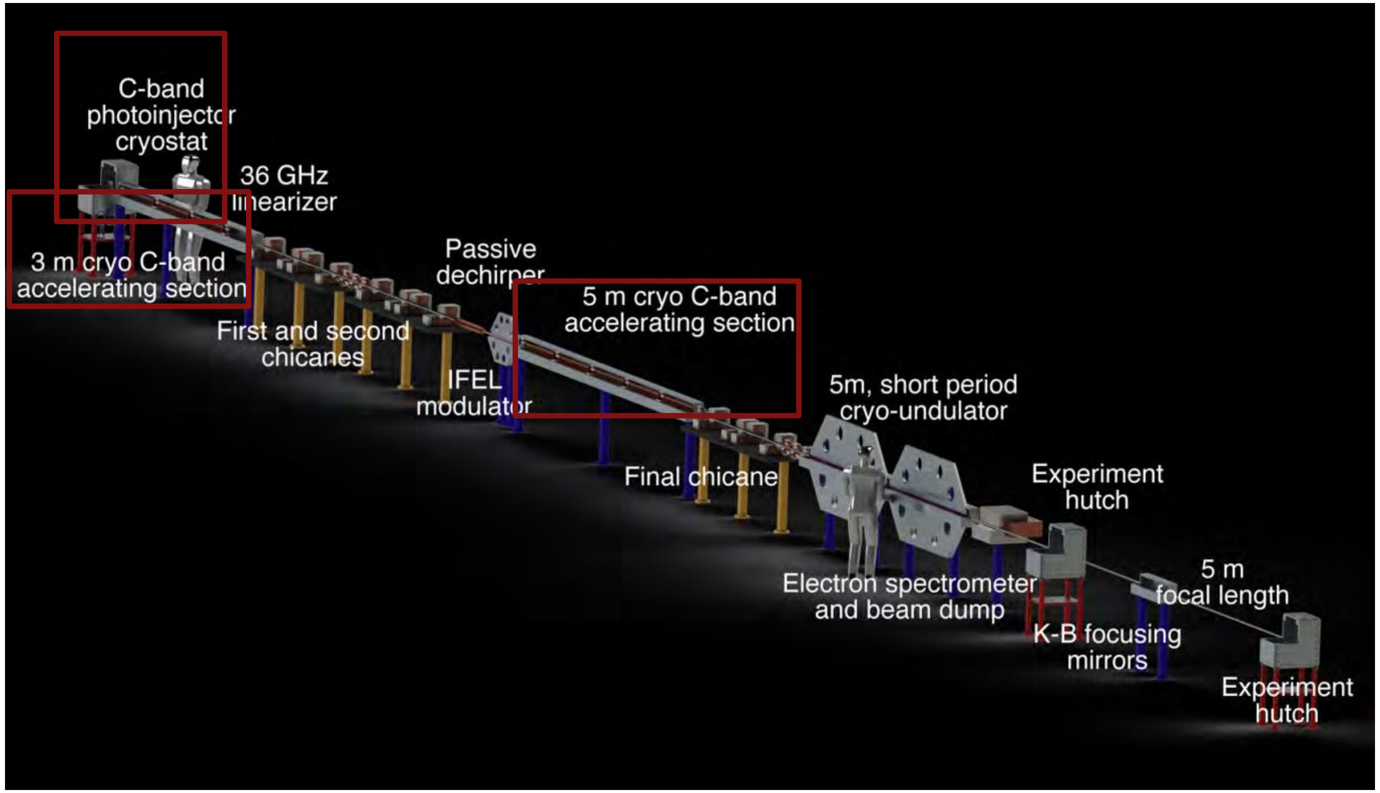


Next generation high brightness electron beams from ultrahigh field cryogenic rf photocathode sources
JB Rosenzweig, et al. - Physical Review Accelerators and Beams, 2019

1) Motivational Cases

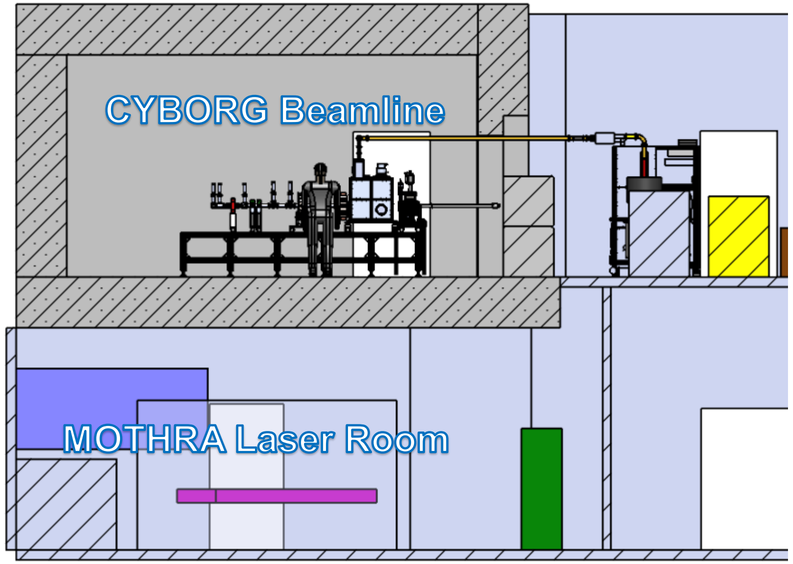
- Ultra-compact xray free electron laser (UCXFEL) concept, 40 m
- Multiple sections dependent on cryogenic operation
- Photoinjector and associated cryostat most relevant for now
- Cool Copper Collider (C^3) linac section (below)

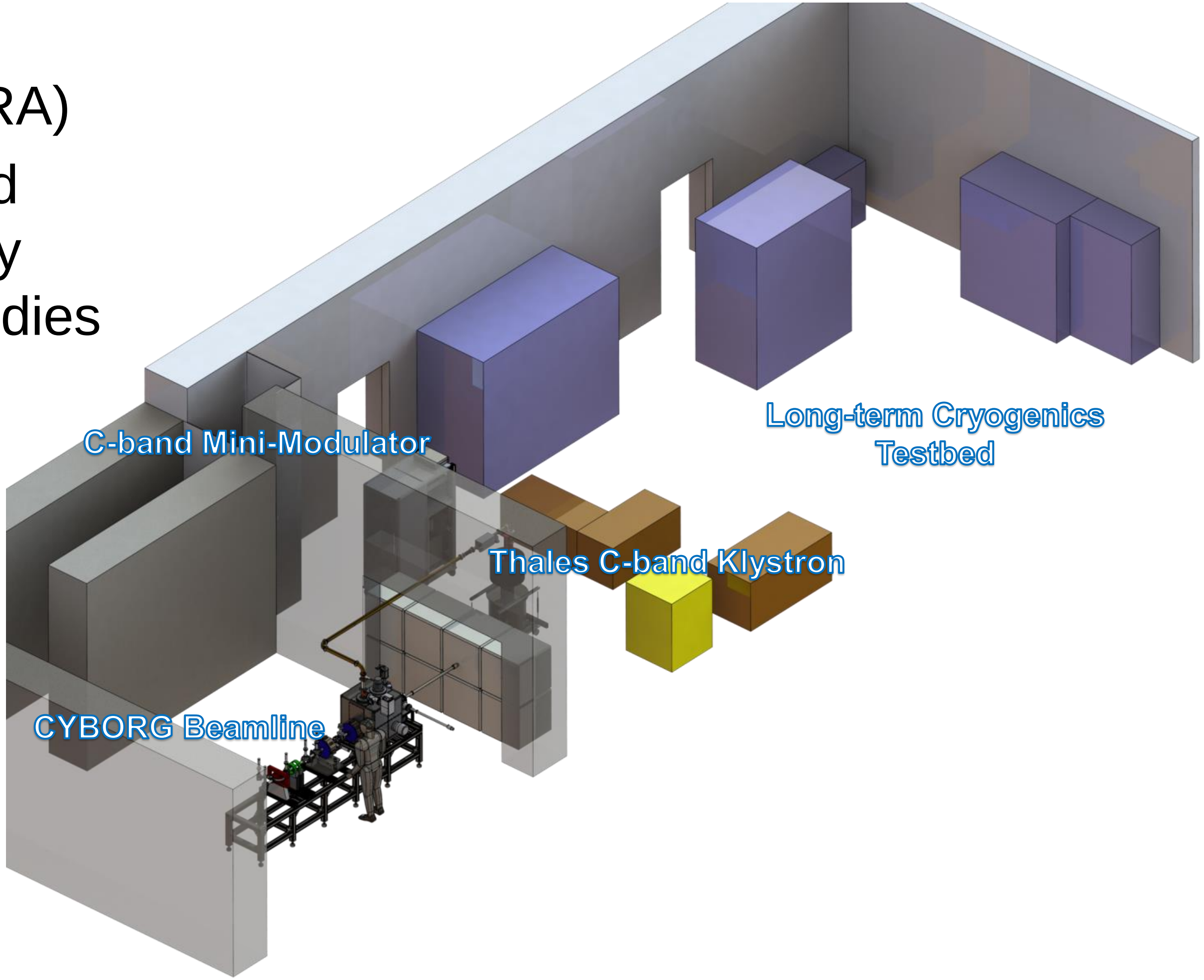




2) MOTHRA Lab

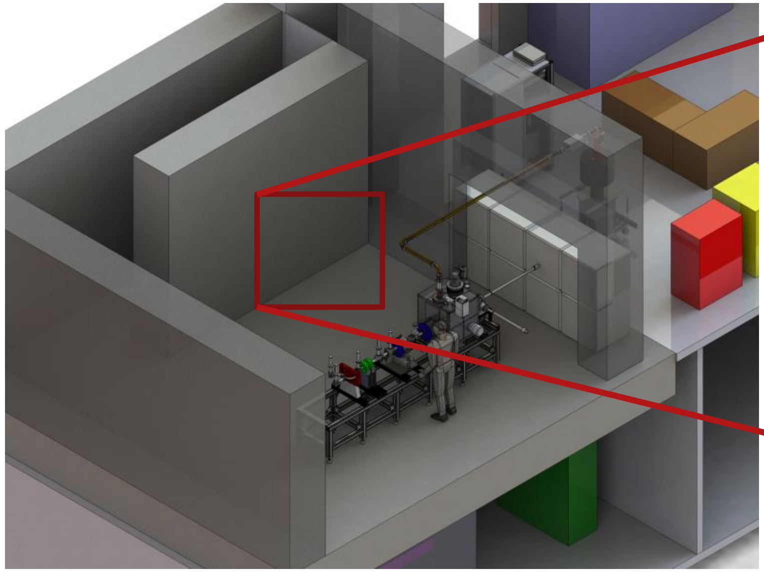
- Multi-Option Testing of High-field Radiofrequency Accelerators (MOTHRA)
- Suitable for cryogenics testing; C-band infrastructure development; low energy (single MeV) beamline for cathode studies

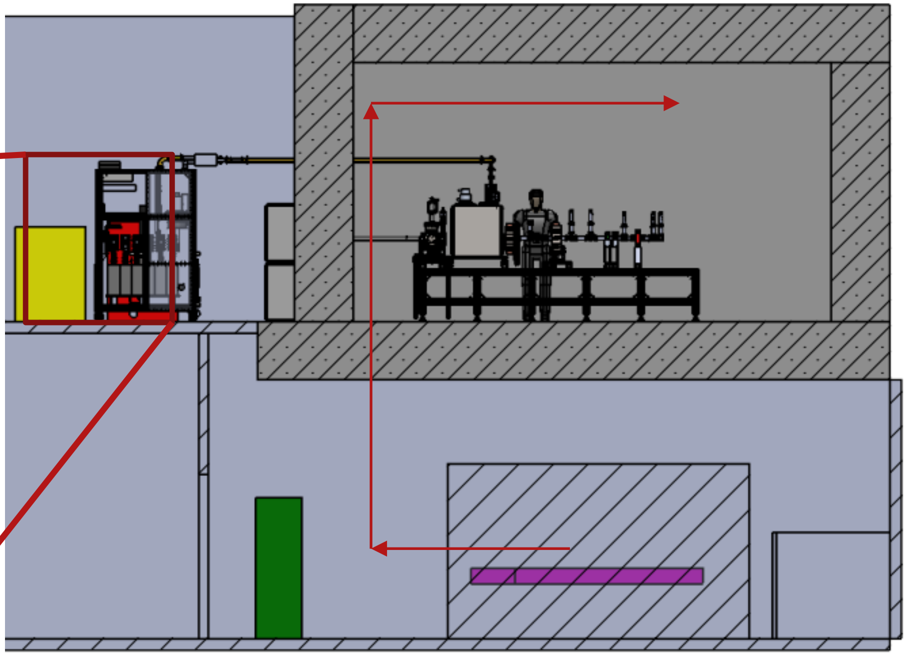




2) MOTHRA Lab

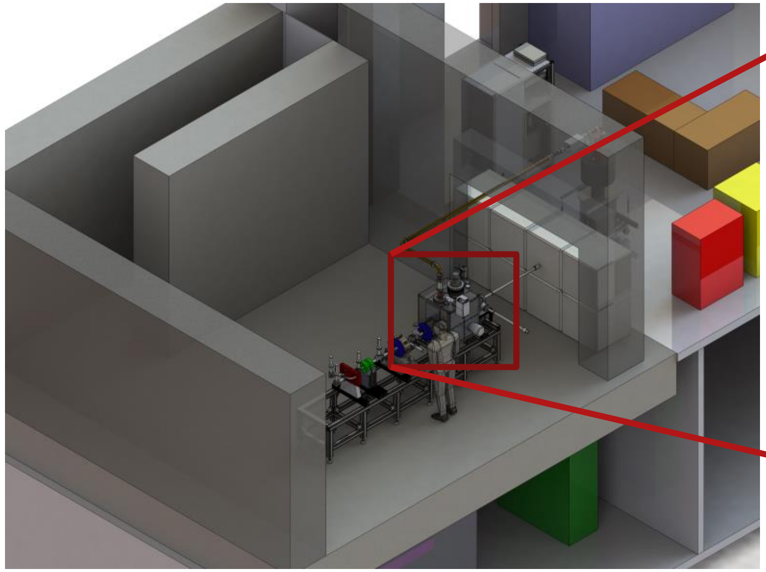
- Cryogenic cooling system development setup (cryostat v1, left)
- Conduction cooling setup for cost effectiveness and future miniaturization concerns

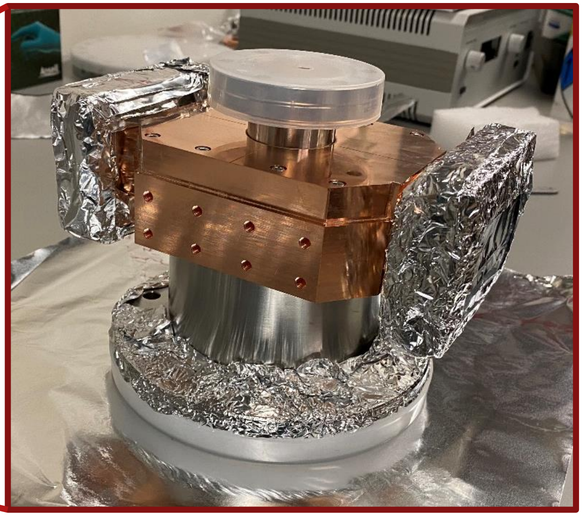




- C-band modulator construction (right)

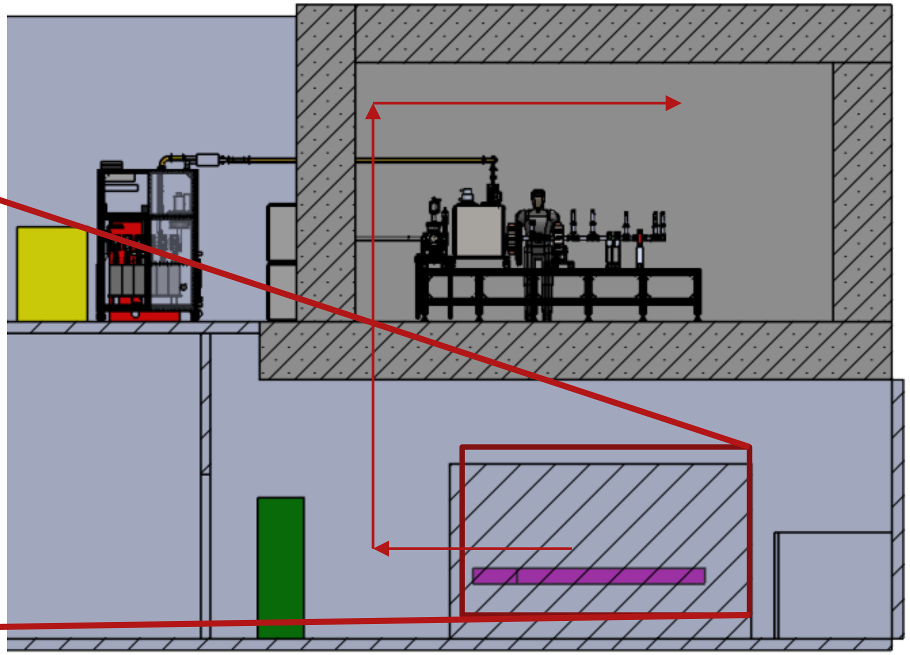
2) MOTHRA Lab





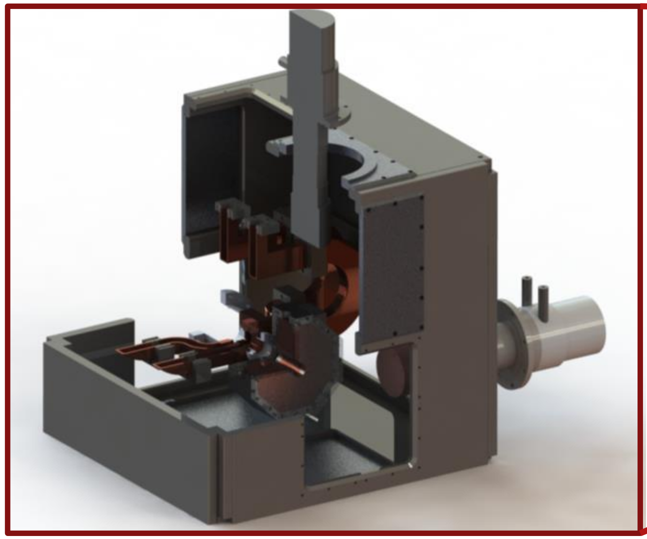
- Cryogenic cathode diagnostic test bed
- Using load lock-enabled ½ cell high gradient photogun (CYBORG, left)

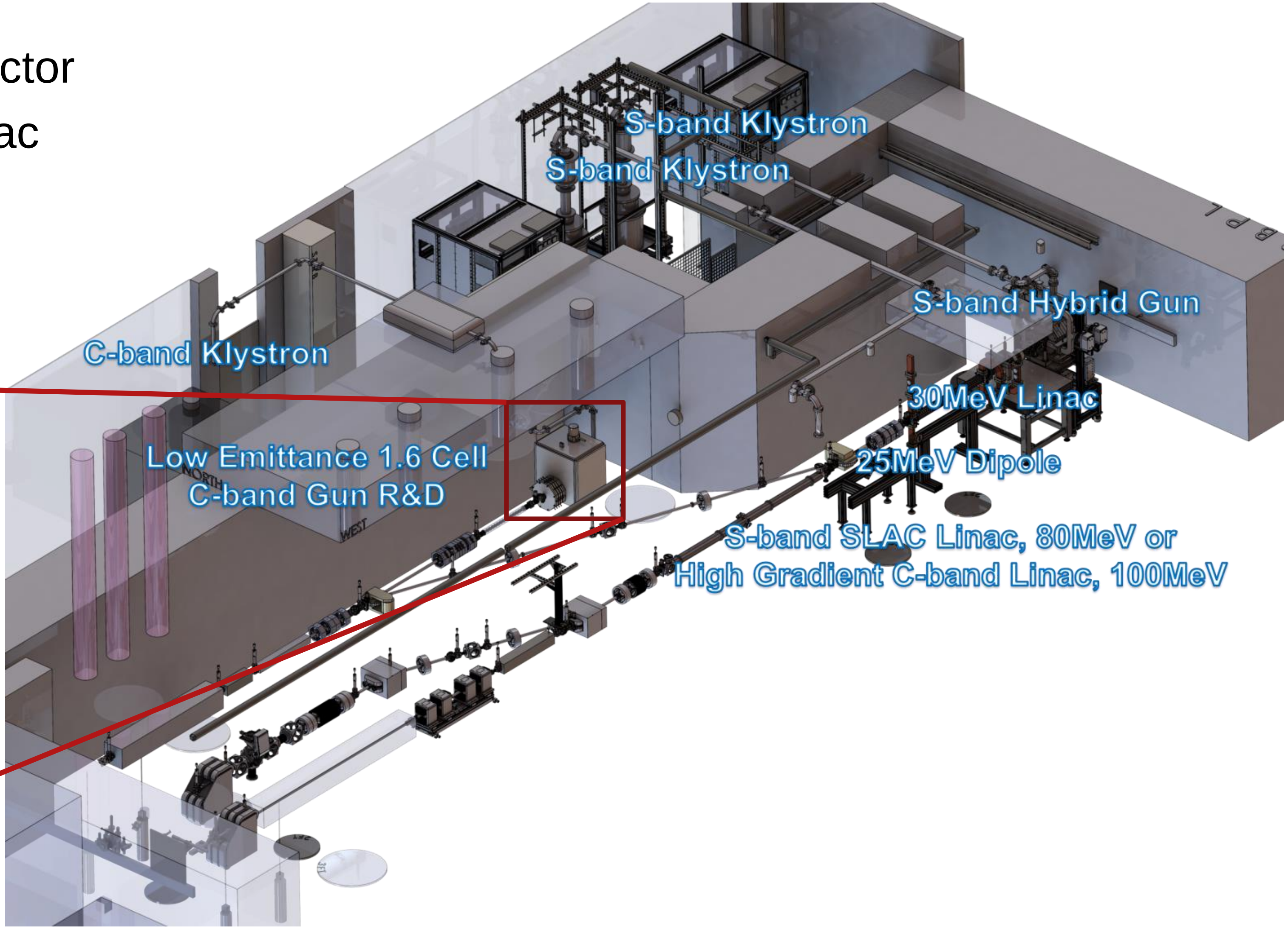
- Clean room for UV production using legacy SLAC GTF setup



2) SAMURAI Lab

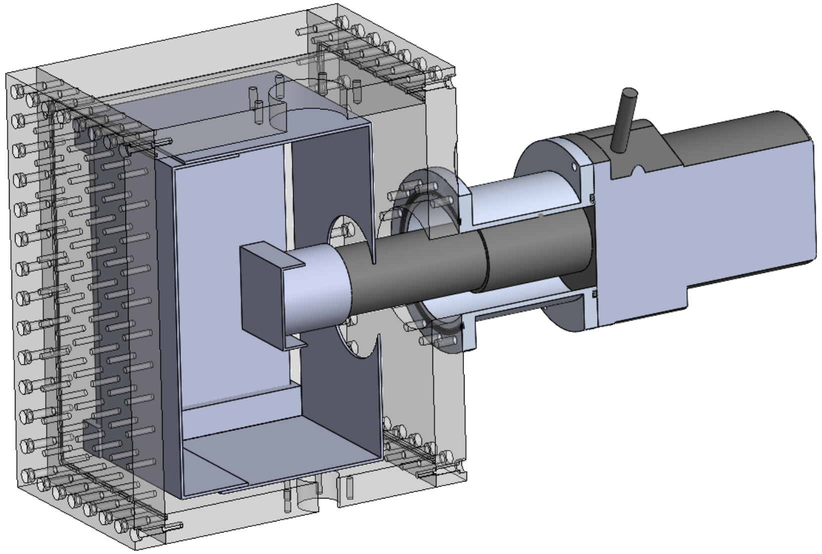
- Samurai lab & bunker space
- Operational with S-band hybrid photoinjector
- Suitable for high energy high gradient linac development (10s-100s MeV); UCXFEL demonstrators; C-band high gradient photoinjector research



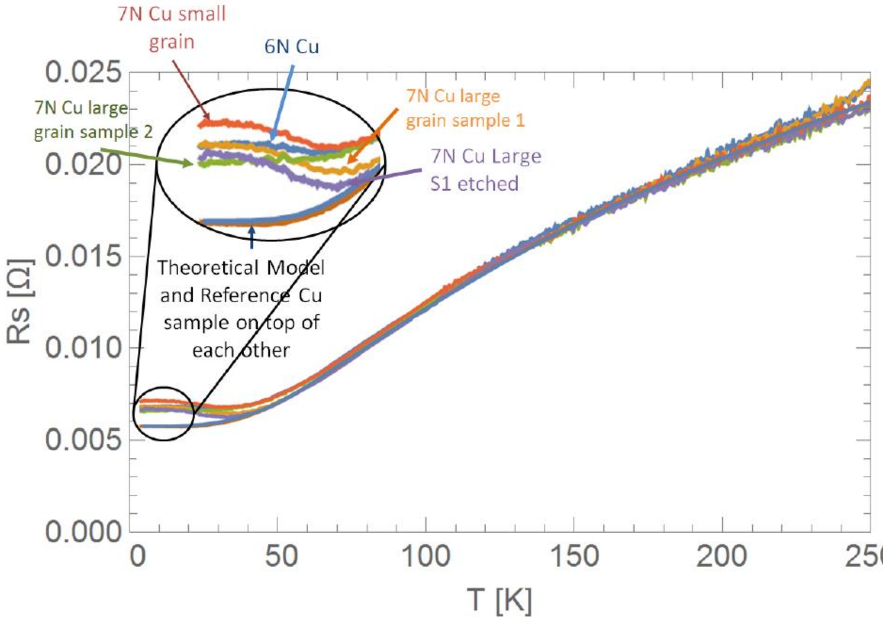


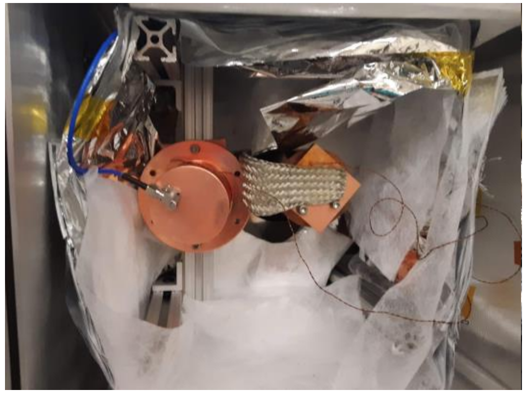
3a) Cryostat v1

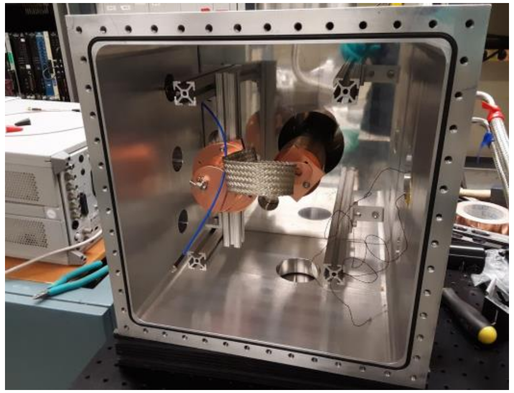
- Small test cryostat initial cryocooler commissioning; material property studies; and LLRF tests
- Small envelope, vacuum good enough for multi layer insulation



$$Q_0 = \frac{\Gamma}{R_s}$$

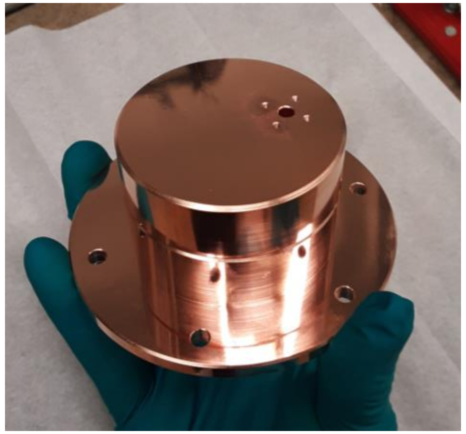


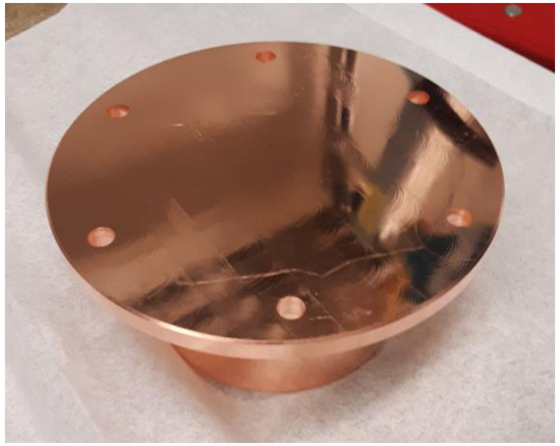




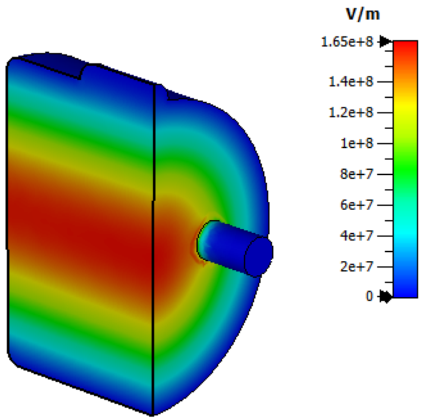
3a) LLRF Measurements

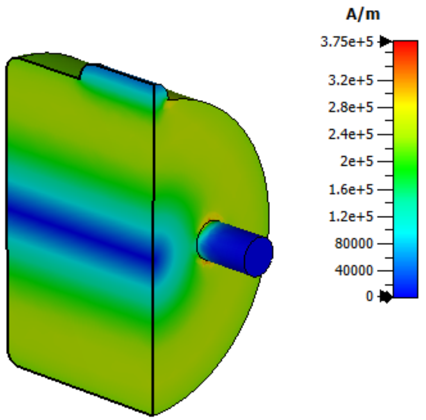
- Copper pillbox cavities used for Cband low level LLRF





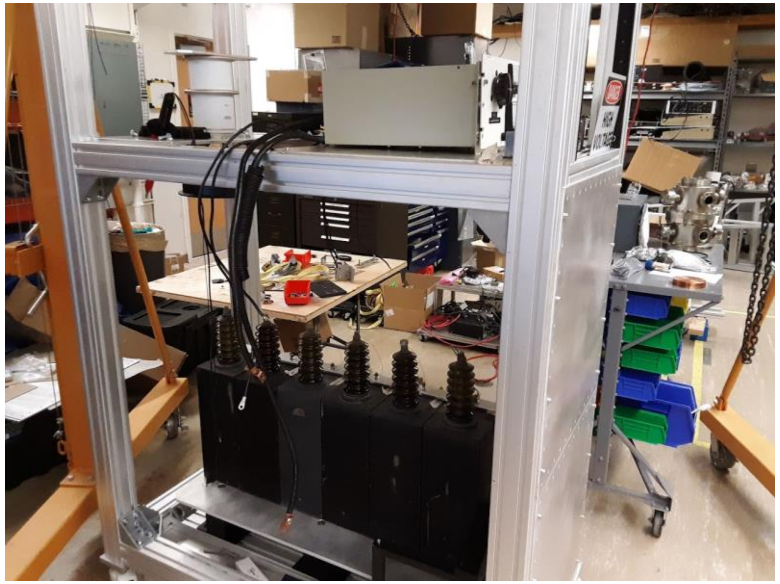

	Coupling	Q0
COMEB machining + brazing	0.58	12200
GZero machining + Scarrot brazing	0.55	7300
Simulation	0.5	12322





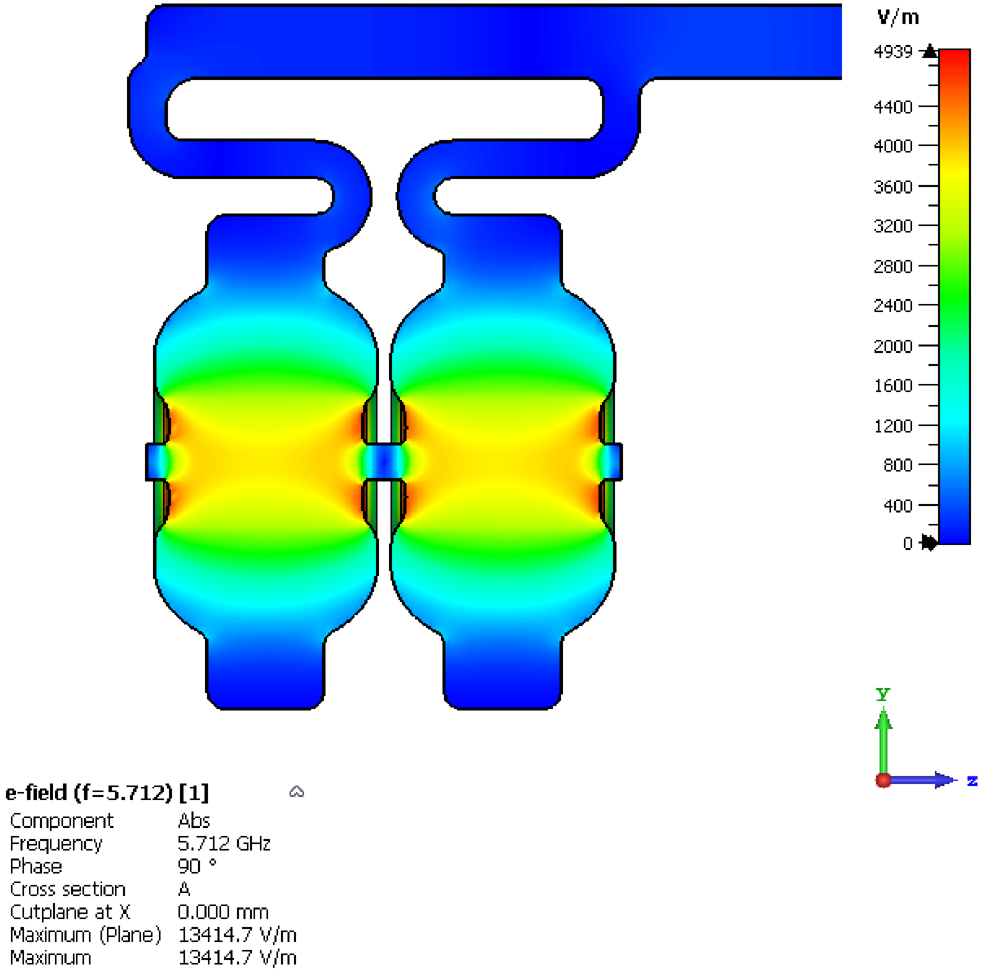
3b) Cband RF Power

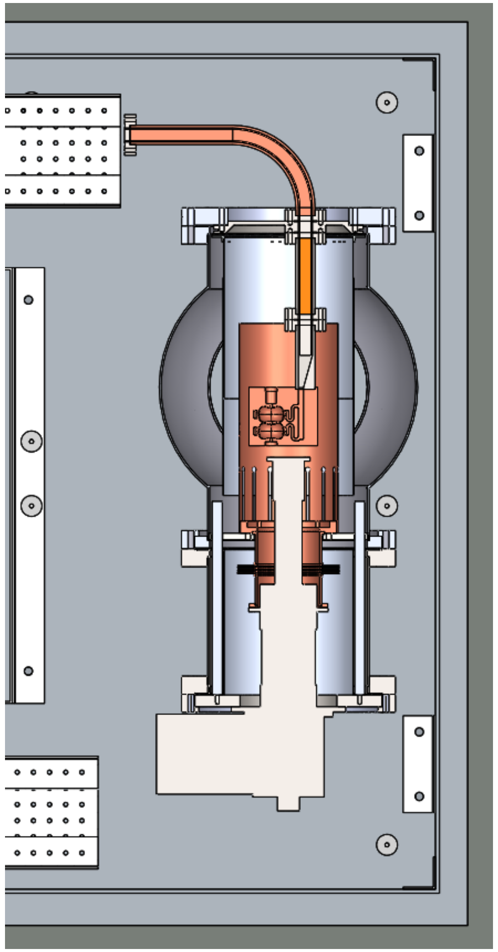
- Resurrected Thales C-band klystron to single MW power sufficient for 1st cryogenic beamline (right)
- Mini-modulator for C-band under construction (below)
- C-band SLED development in collaboration with Tantawi group at SLAC



3b) High Power Structure Collaboration

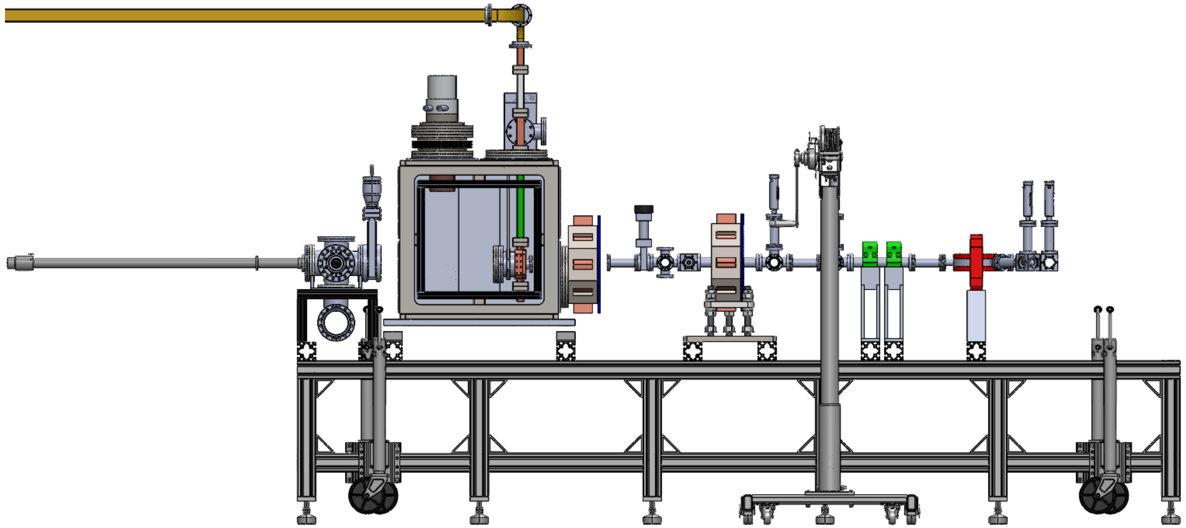
- Create test bed for hosting multiple different experiments into various structures and material alloys
  - Brazeless joint testing, copper-silver and more exotic alloys perhaps w/ Mo etc.
- Logic of cryogenics, assembly, and general diagnostics for actual experiments
- Example here using 2 cell distributed-coupling in Cband (to right)

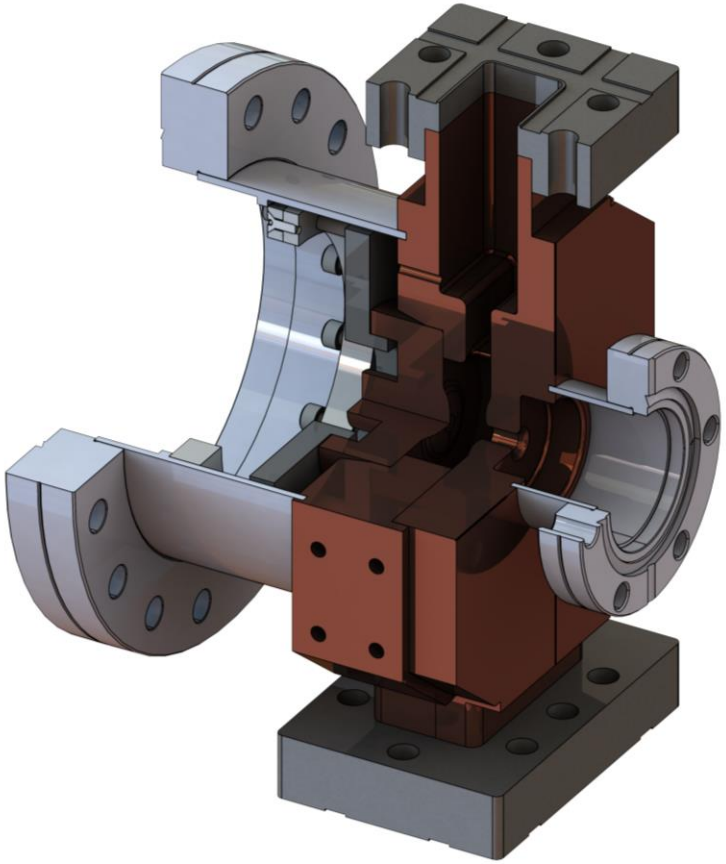




3c) CYBORG Beamline

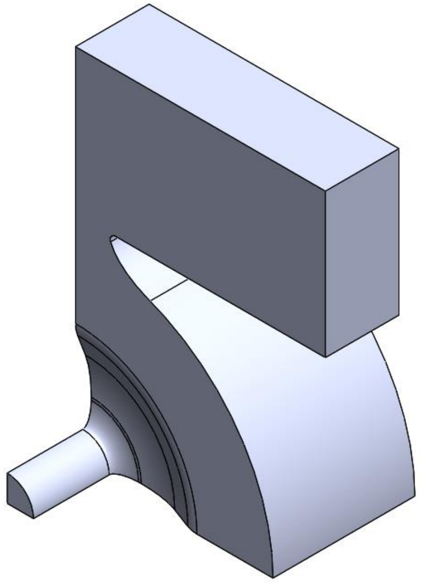
- Low energy beamline using CrYogenic Brightness-Optimized Radiofrequency Gun (CYBORG)
- Under construction in MOTHRA bunker
- Collaboration with NSF Center for Bright Beams
- Multi-phase setup + commissioning

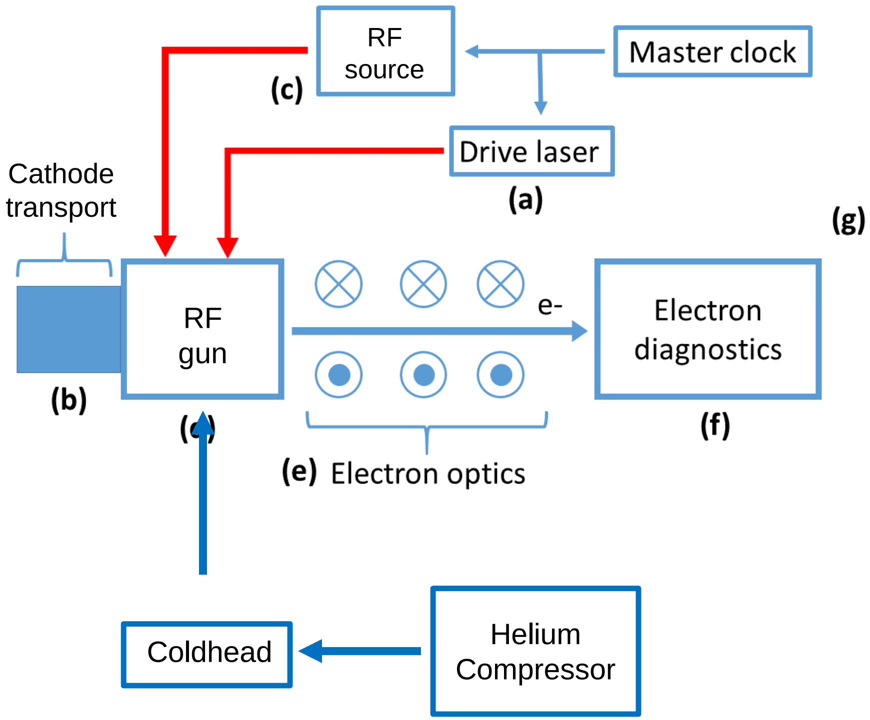


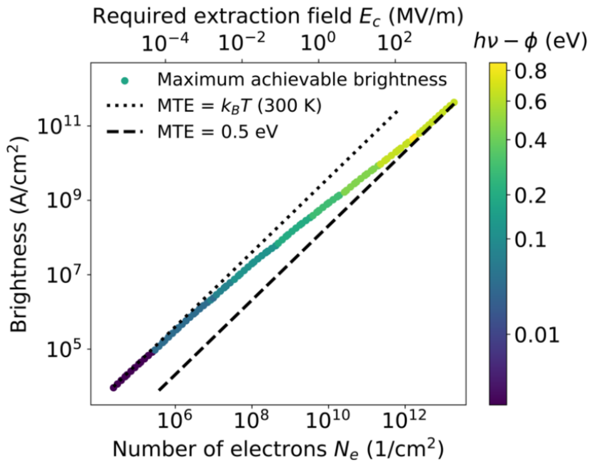


3c) CYBORG Functions

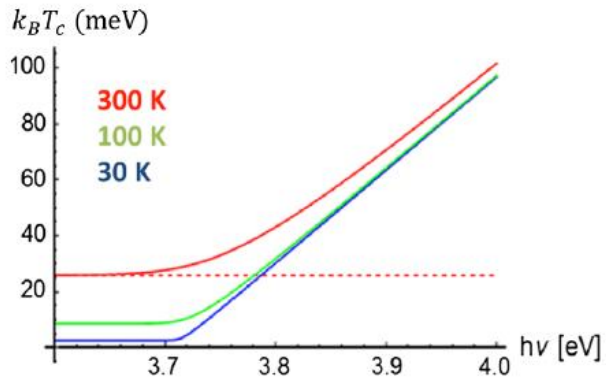
1. Cavity structure test
2. Infrastructure development
3. Low temperature emission/photocathode test bed





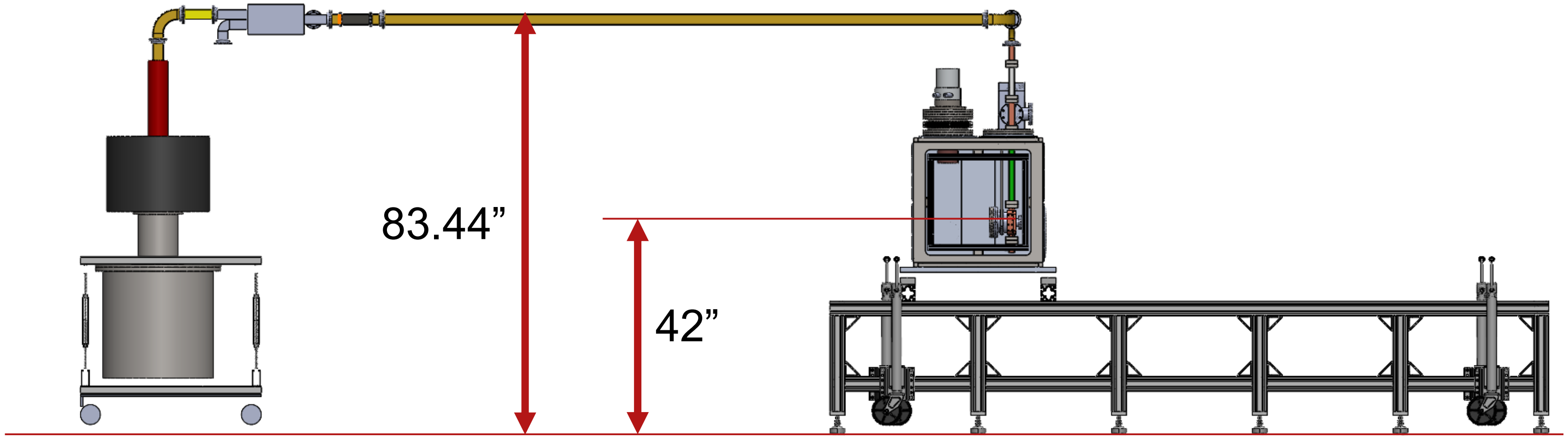


J. K. Bae, I. Bazarov, P. Musumeci, S. Karkare, H. Padmore, and J. Maxson, J. Appl. Phys. 124, 244903 (2018).



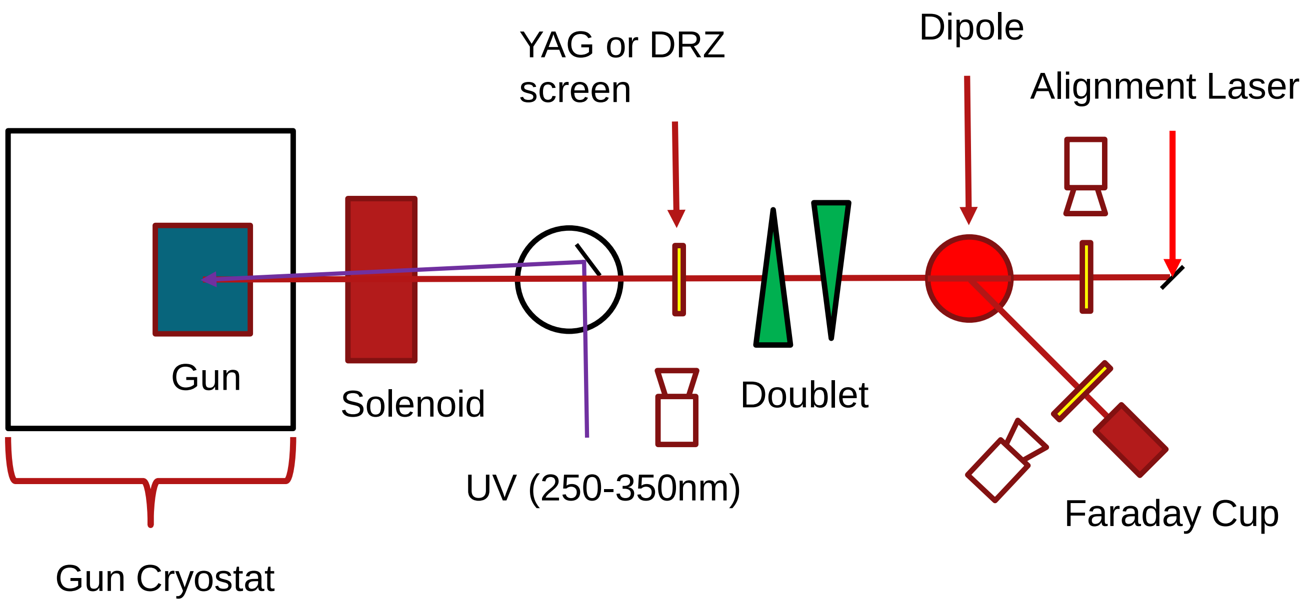
3c) Phase 1 Config 1

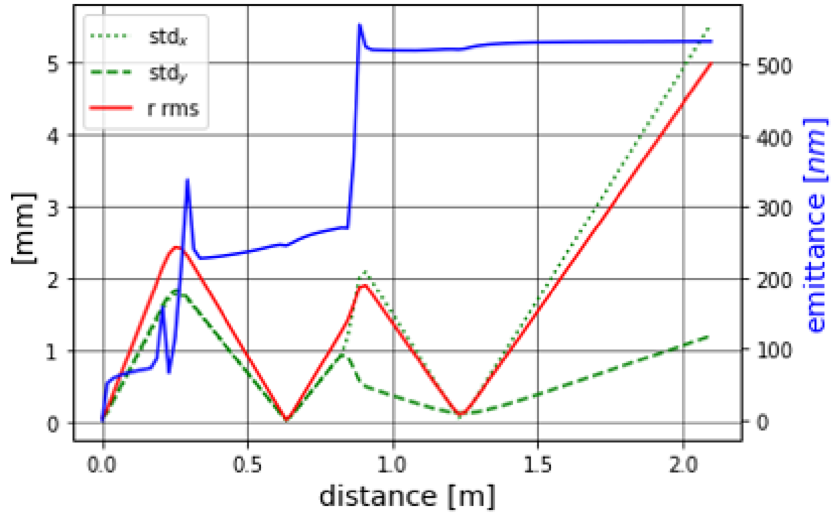
- Config 1 goals:
  - SHI vibration isolation
  - Waveguide setup
  - UHV
  - CYBORG cooldown & temperature stability
  - LL and high power RF tests
  - Optimize RF pulse heating + cooling



3c) Phase 1 Config 2

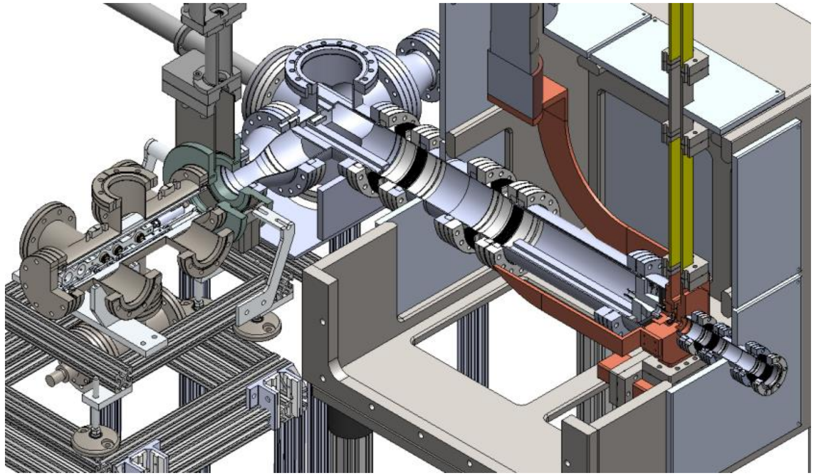
- Config 2 goals:
  - Cryogenic copper photoemission
  - Cryogenic QE
  - Low precision MTE measurement

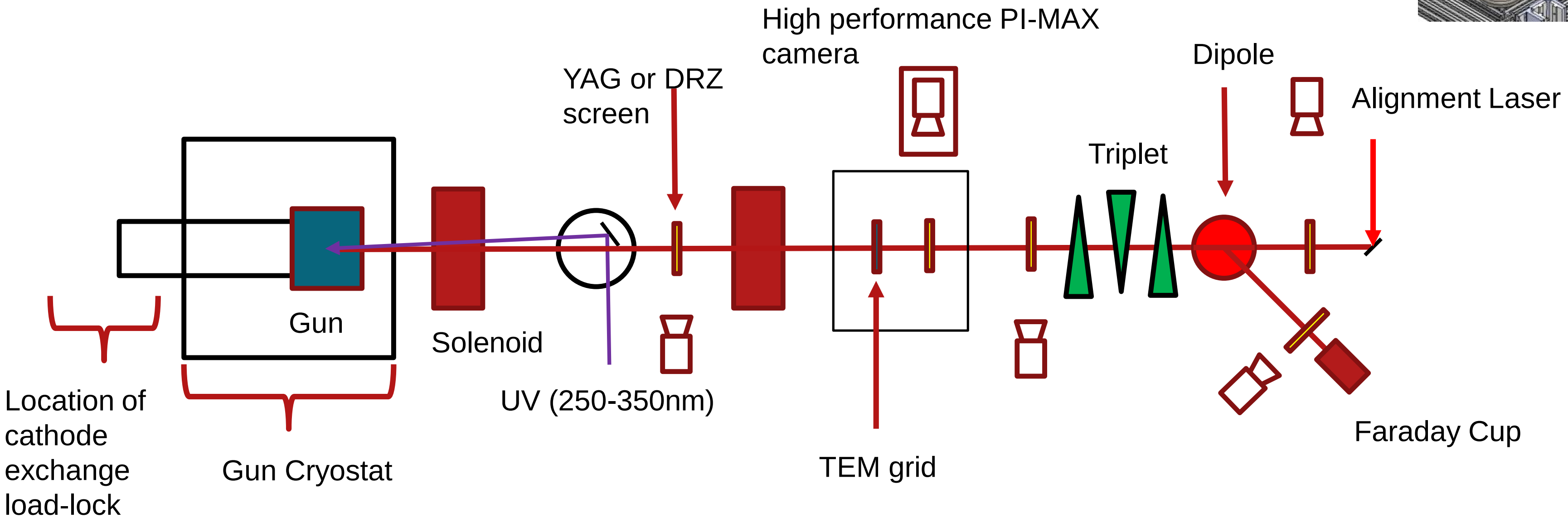




3c) Phase 2

- load lock and phase 2 diagnostics
- Test of back plane plug into reentrant small C-band cavity
- Cooling test with large additional heat leaks
- Completion condition: load lock plug QE measurement down to cryo temps

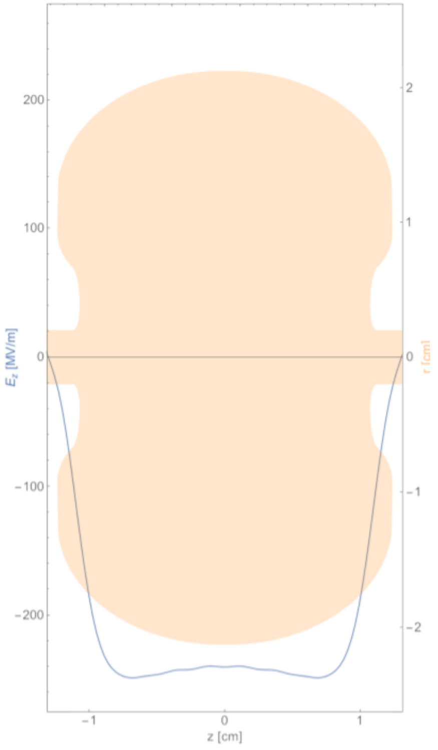




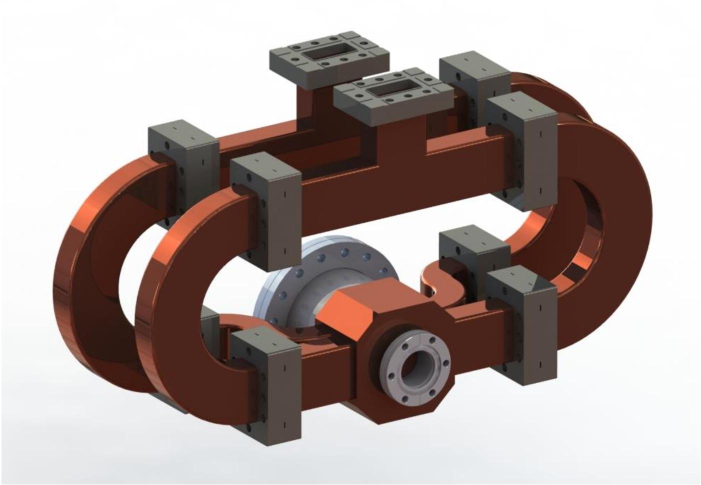
3d) UCXFEL Photoinjector Concept

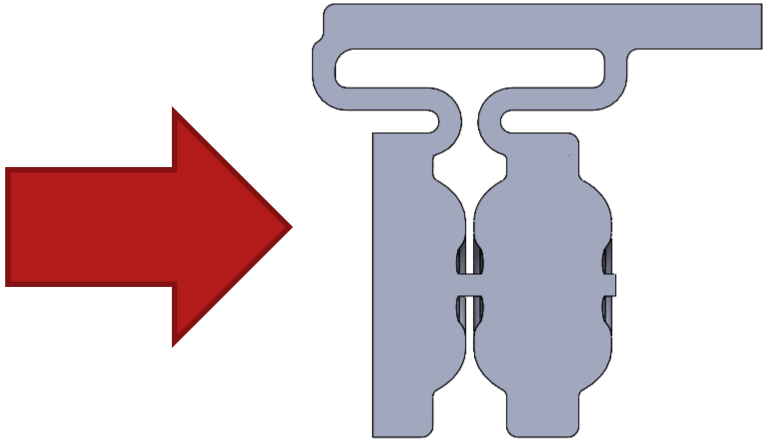
- 1.6 cell cavity w/ reentrant design
- Cryogenic solenoid in cryost
- Consideration of beam dynamics based on high spatial harmonic content
- introduction of strong second order focusing effects

- repetition rate of 100 Hz
- nominal 300 nsec RF pulses
- operating temperature of 27 K
- RF dissipation of 11 W, requiring over 0.5 kW cooling power
- Maximize shunt impedance and consequently efficiency



RR Robles et al. *Physical Review Accelerators and Beams* 24 (6), 063401





4): Conclusions

1. High gradient and breakdown research at UCLA multifaceted and located at multiple facilities
2. Focus on cryogenics surface physics and Cband RF development
3. Highly collaborative with bright beams research