Jlab Booster and Alternatives

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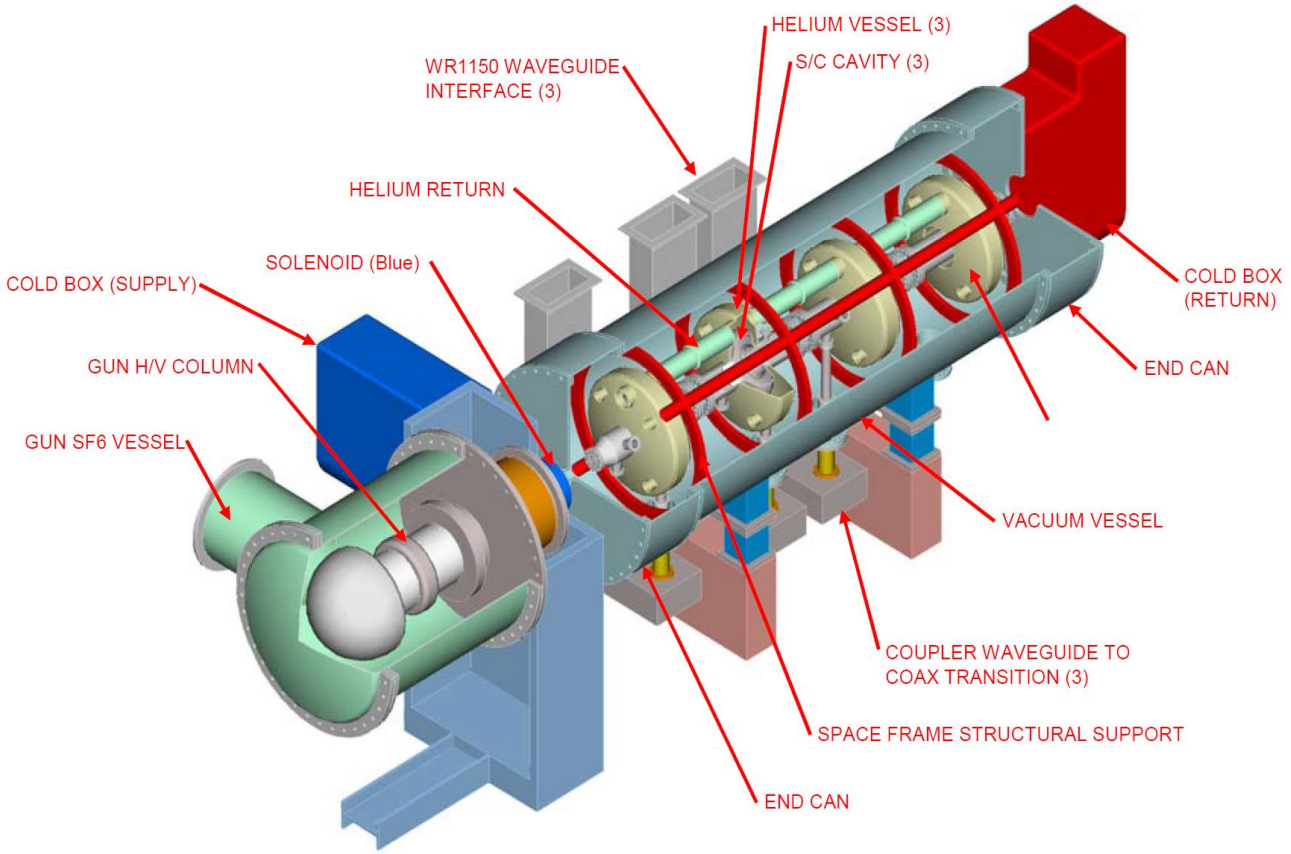
Outline

- Jlab/AES 748.5 MHz booster prototype
- Comparison of parameters
- Cavity Modifications needed
- Path forward
- JLEIC booster(s)
- EIC cooler booster
- Conclusions

Jlab booster

- A collaboration between JLab and Advanced Energy Systems, that began in 2002, had the goal to design, fabricate and test a prototype high-current electron beam injector for a 100kW free-electron laser (FEL)
- Module is based on SNS type cryostat
- 4 single-cell cavities with the same He tank
  - 1 third harmonic (not needed for PERLE?)
  - Replace with 802.5 MHz cavities
  - β-match to beam?
  - Salvage He tanks?
- SNS type couplers (FPC and HOM)
- Mated to DC gun similar to Alice gun
- Custom end cans to allow close proximity



A.Todd et al., “High-Power Electron Beam Injectors for 100 kW Free-Electron Lasers”, Proceedings of the 2003 Particle Accelerator Conference, p 997-999

J. Rathke et al., “Design and Fabrication of an FEL Injector Cryomodule”, Proceedings of 2005 Particle Accelerator Conference, p 3724-3726

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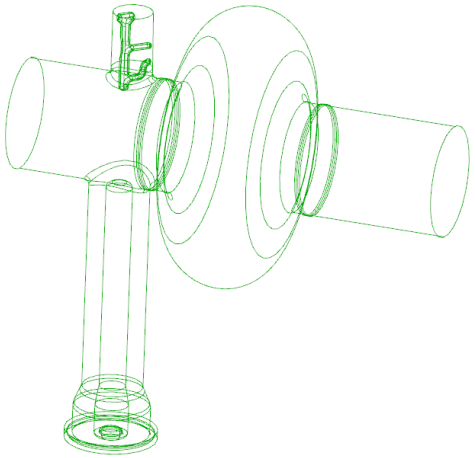
Jlab vs. PERLE comparison

Comparison of design parameters from the JLab/AES injector and PERLE

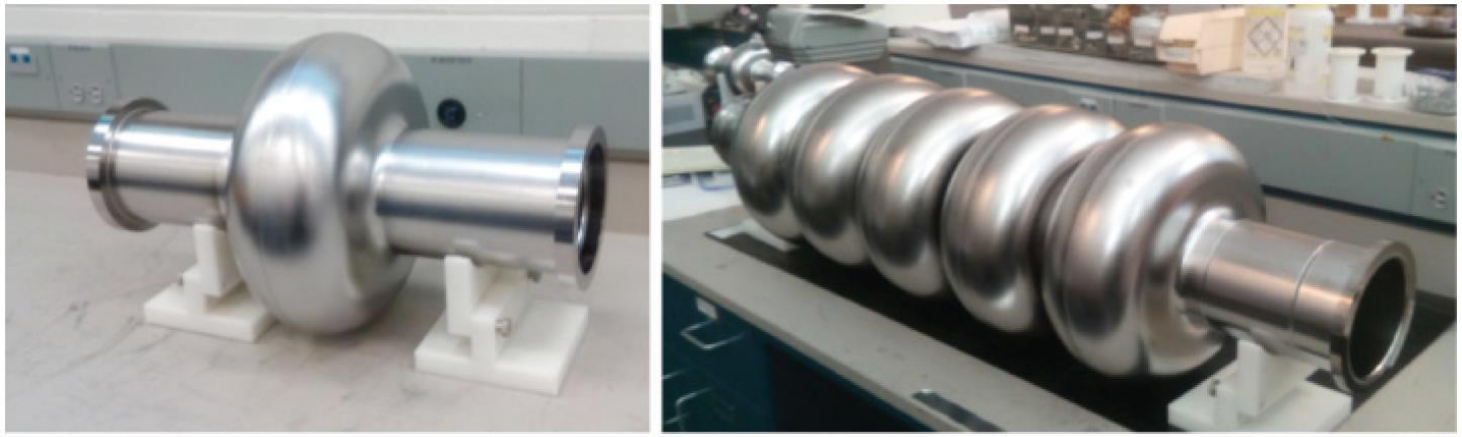
	JLab/AES Booster	PERLE
Booster exit energy	7MeV	7MeV
Bunch charge	133pC	500pC
Bunch repetition rate	748.5MHz	40.1MHz
Cavity Fundamental Frequency	748.5MHz	802MHz
Average current	100mA	20mA
RMS bunch length	3mm	3mm
Emittance	<5mm mrad	<6mm mrad
Uncorrelated energy spread		< 10keV

Jlab booster cavities

- The fundamental frequency cavities installed were scaled from SNS, as were the couplers and HOM dampers on either end of each cavity. Replace with 802.5 MHz.
- These components would be redesigned for PERLE, based upon recent advances in coupler design and cavity shapes for high current operation and HOM removal.
- It may be advantageous for beam performance to beta-match new cavities to improve capture efficiency and 6D emittance.

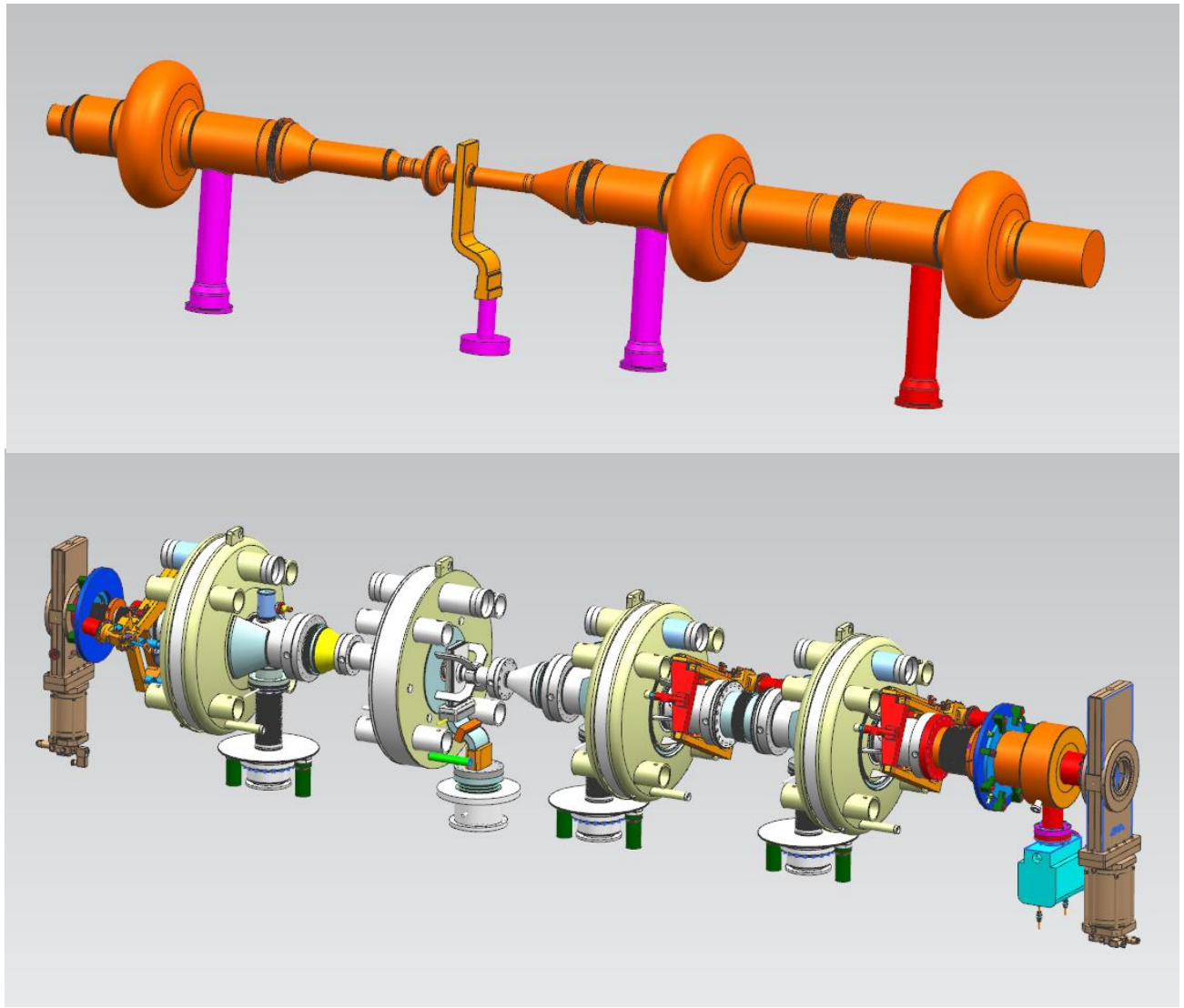


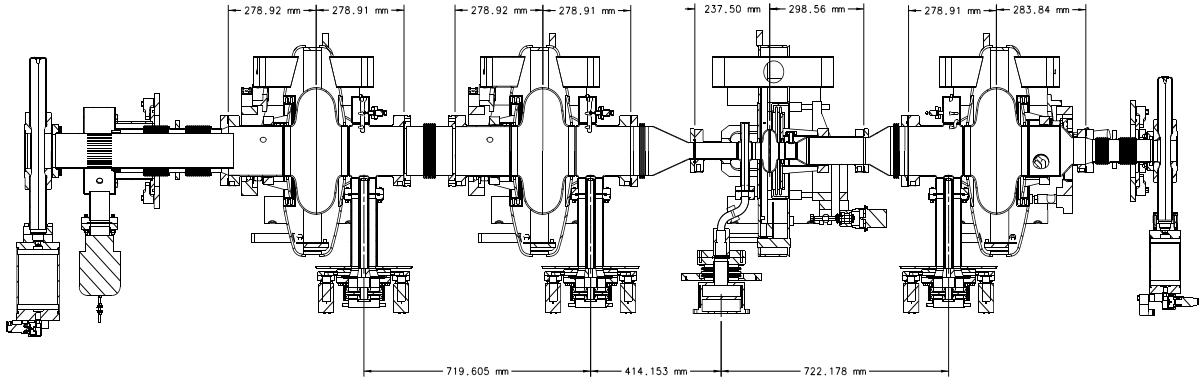
Wire drawing of the AES single cell cavity with coupler and HOM damper shown



802MHz Single cell and 5-cell cavities manufactured at JLab

JLab/AES booster cold mass





Booster path forward

The work associated with developing the booster to completion is estimated to take approximately three years. The expected high-level work packages are:

1) Perform beam dynamics simulations to verify that the key parameters of the PERLE injector can be met. Determine the cavity shape and whether a 3rd harmonic is required.

2) Cavity and power system design: simulate the cavity performance with HOM dampers and couplers scaled to 802MHz. Generate the mechanical model and drawings for manufacture.

3) Manufacture: Cavities, HOMs and couplers could be manufactured in-house at Jlab or procured from industry. Vertical testing of the cavities will be performed at this stage, prior to installation in the cryomodule.

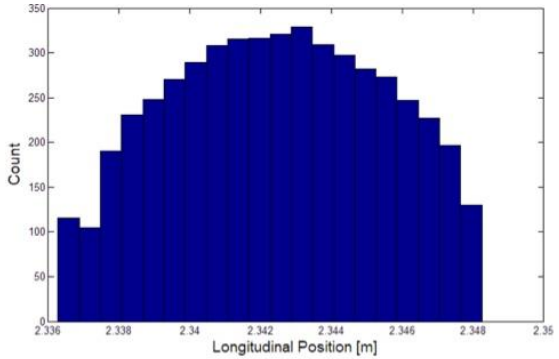
4) Cryomodule assembly: The 748.5MHz cavities string inside the module must first be removed before the new cavities can be installed. The new components are fitted and leak checked.

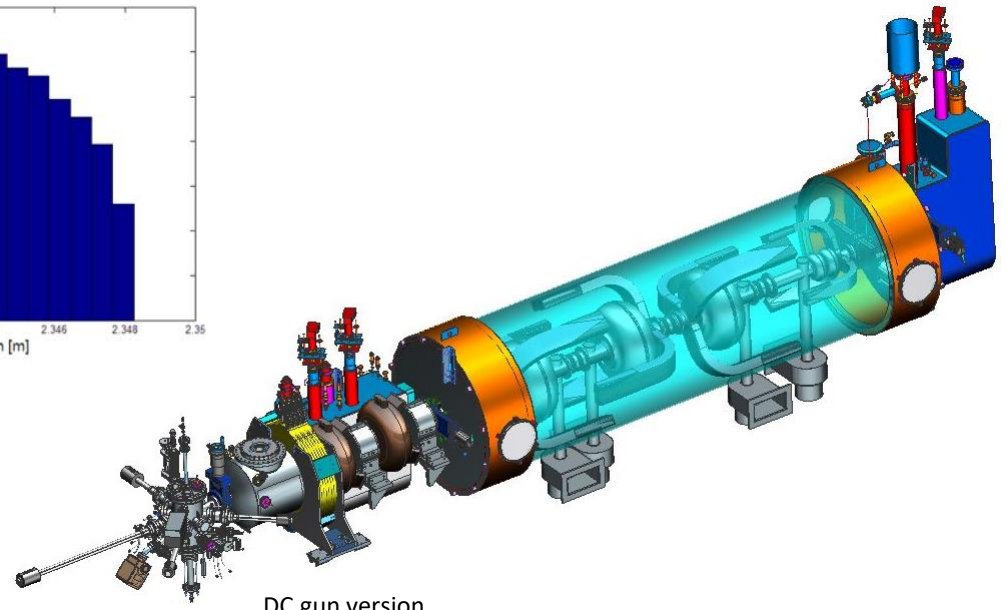
5) Testing: Horizontal RF conditioning and testing will be performed with the cryomodule test facility; a shielded bunker

JLEIC ERL injector(s)

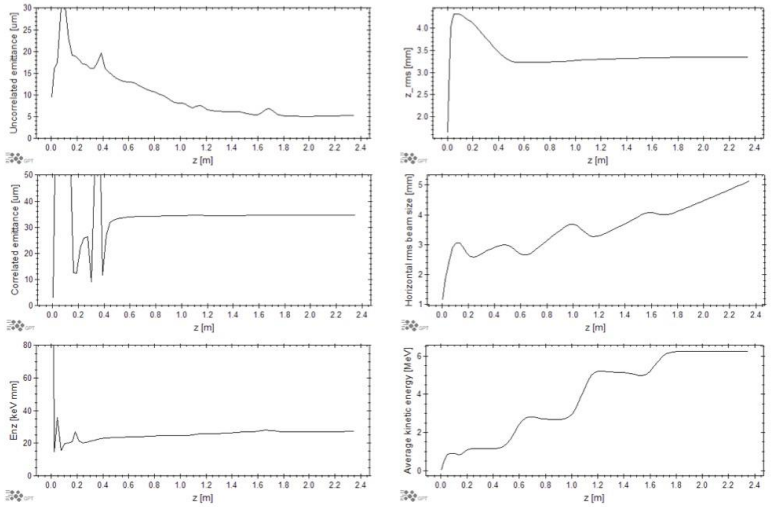
F. Hannon

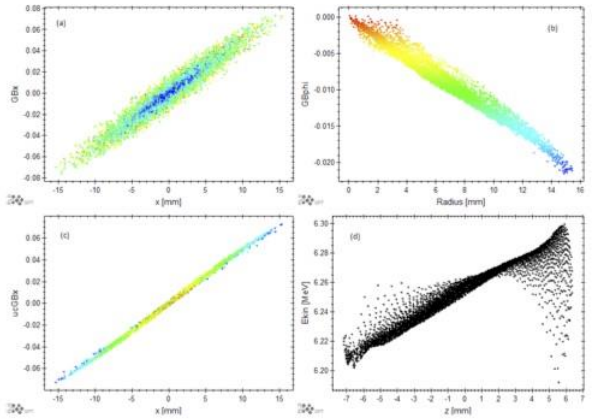
- Magnetized DC gun or RF gun
- NC capture and buncher
- 433 MHz SRF booster
- High-current non energy recovered
- 1299 MHz 3rd harmonic linearization

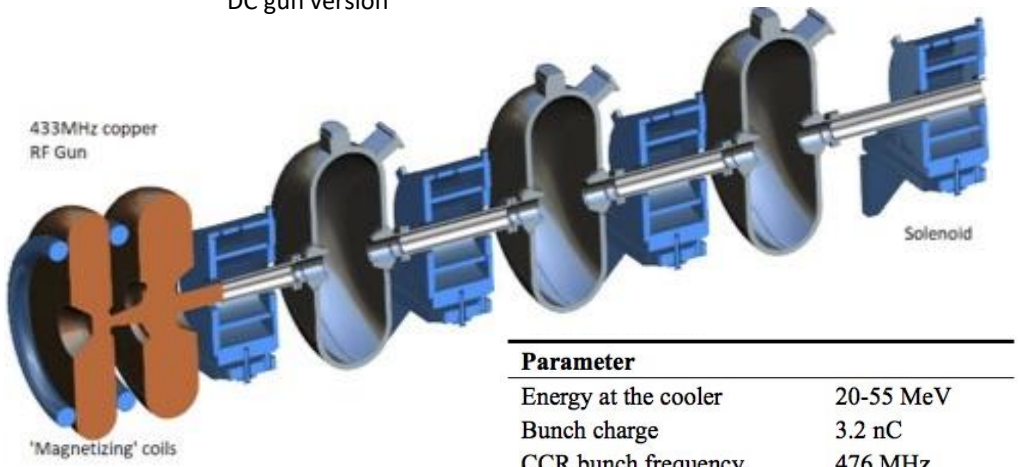




DC gun version







Parameter	
Energy at the cooler	20-55 MeV
Bunch charge	3.2 nC
CCR bunch frequency	476 MHz
Bunch length at cooler (full)	2 cm
Injector bunch frequency	43.3 MHz
Drift emittance	36 mm mrad

A Normal Conducting RF Gun as an Electron Source for JLEIC Cooling, F. Hannon, IPAC19, Melbourne

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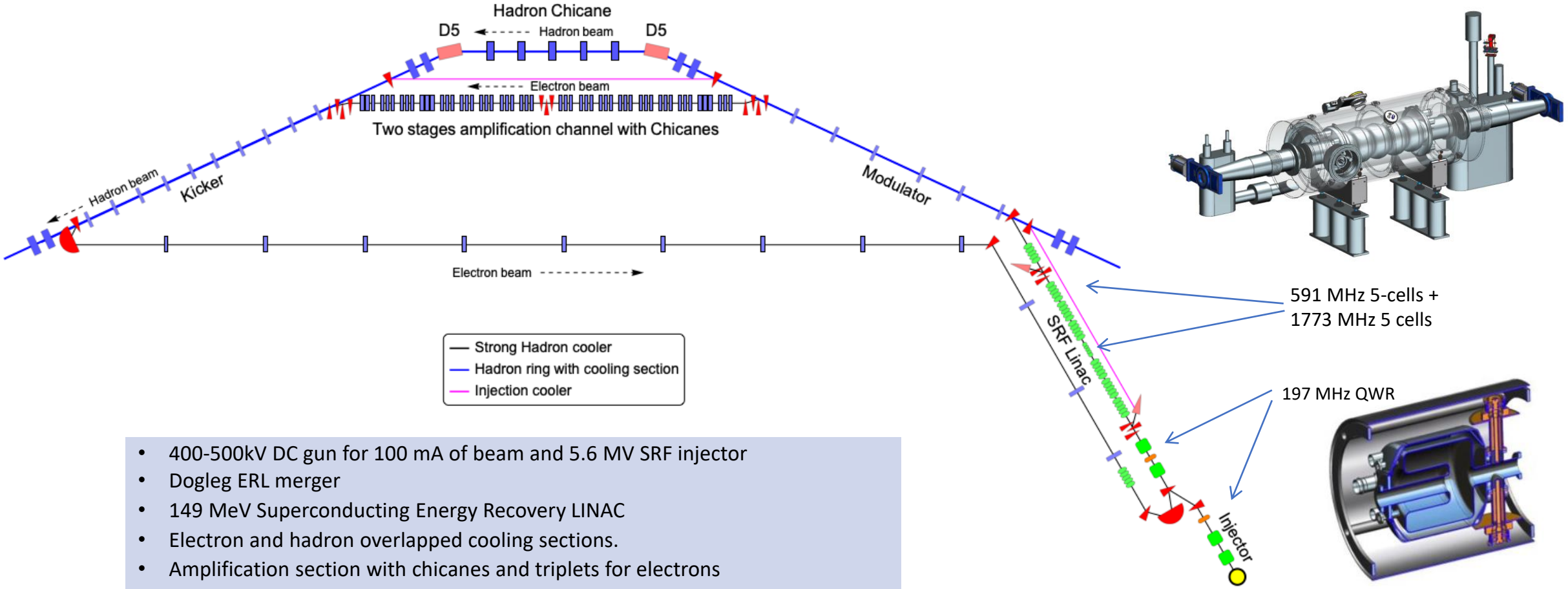
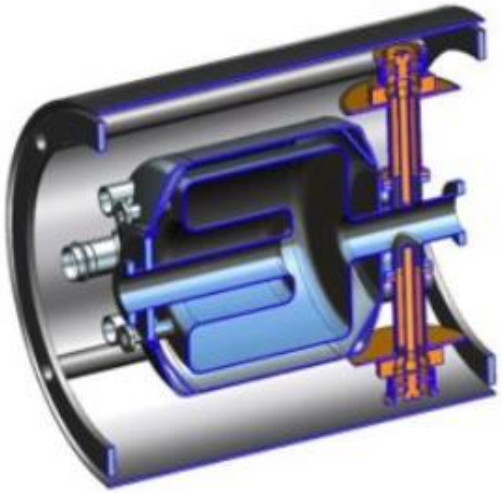
EIC Strong Hadron Cooler ERL layout



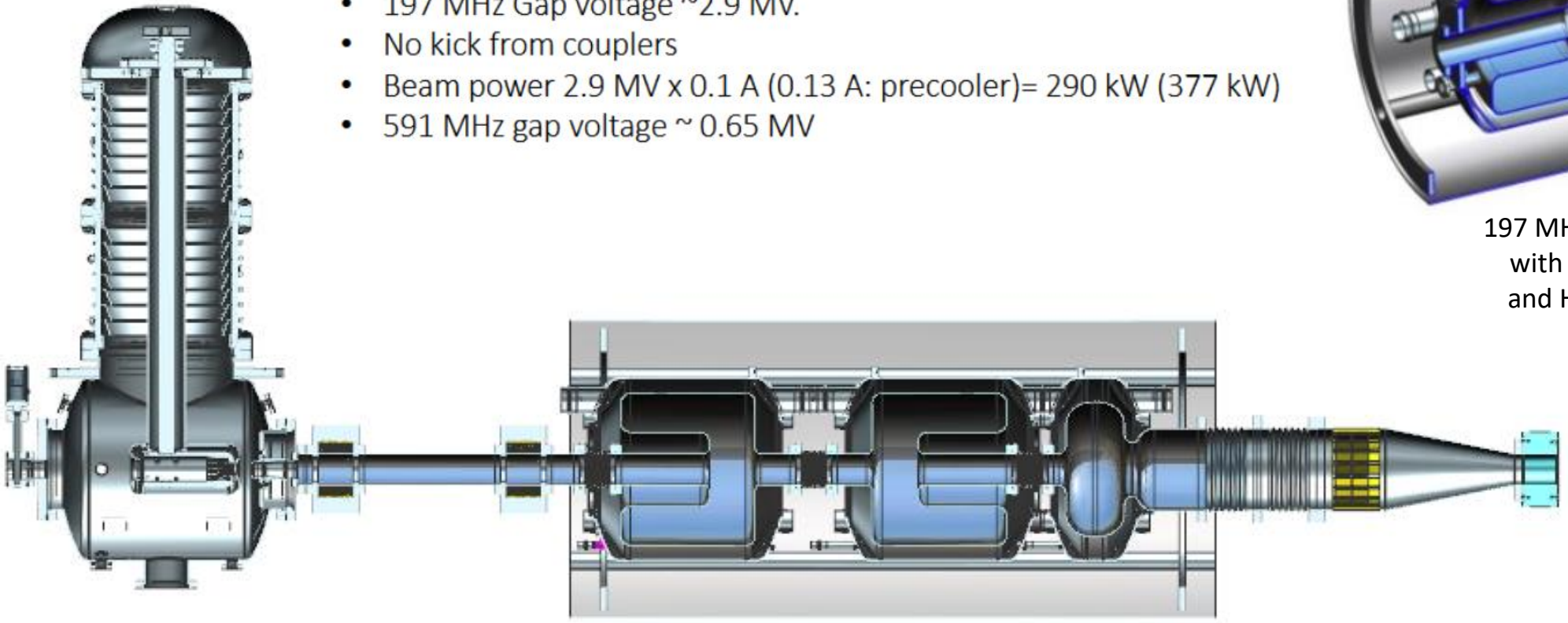
- 400-500kV DC gun for 100 mA of beam and 5.6 MV SRF injector
- Dogleg ERL merger
- 149 MeV Superconducting Energy Recovery LINAC
- Electron and hadron overlapped cooling sections.
- Amplification section with chicanes and triplets for electrons
- Hadron chicane path length matching & R_{56} adjust
- Return transport of electron beam to ERL
- Possibility to include injection pre-cooler in the same location

EIC cooler injector preliminary concept

- 197 MHz Gap voltage ~2.9 MV.
- No kick from couplers
- Beam power 2.9 MV x 0.1 A (0.13 A: precooler)= 290 kW (377 kW)
- 591 MHz gap voltage ~ 0.65 MV



197 MHz QWR with FPC's and HOMs



DC gun

197 MHz QWRs

591 MHz single cell

Conclusions

- JLab/AES FEL booster is still available
  - New cavities needed
  - 3 SNS type couplers may be OK
  - Labor to disassemble and reassemble
- JLEIC options were promising
  - DC gun with NC booster and SRF + 3rd harmonic
  - NCRF gun with SRF booster, no 3rd harmonic
  - Designs not completed
- EIC booster going for long bunches, low frequency
  - 197 MHz QWR's, 591 MHz 3rd harmonic
  - Similar requirements to PERLE except bunch length.