Advanced Energy Systems Photocathode Gun Development

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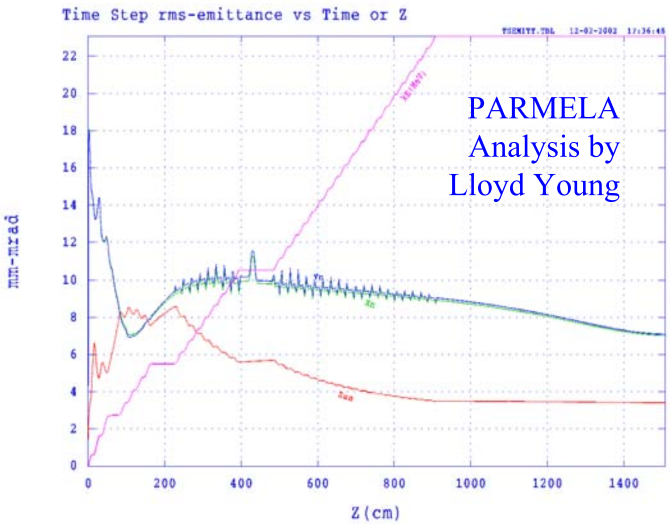
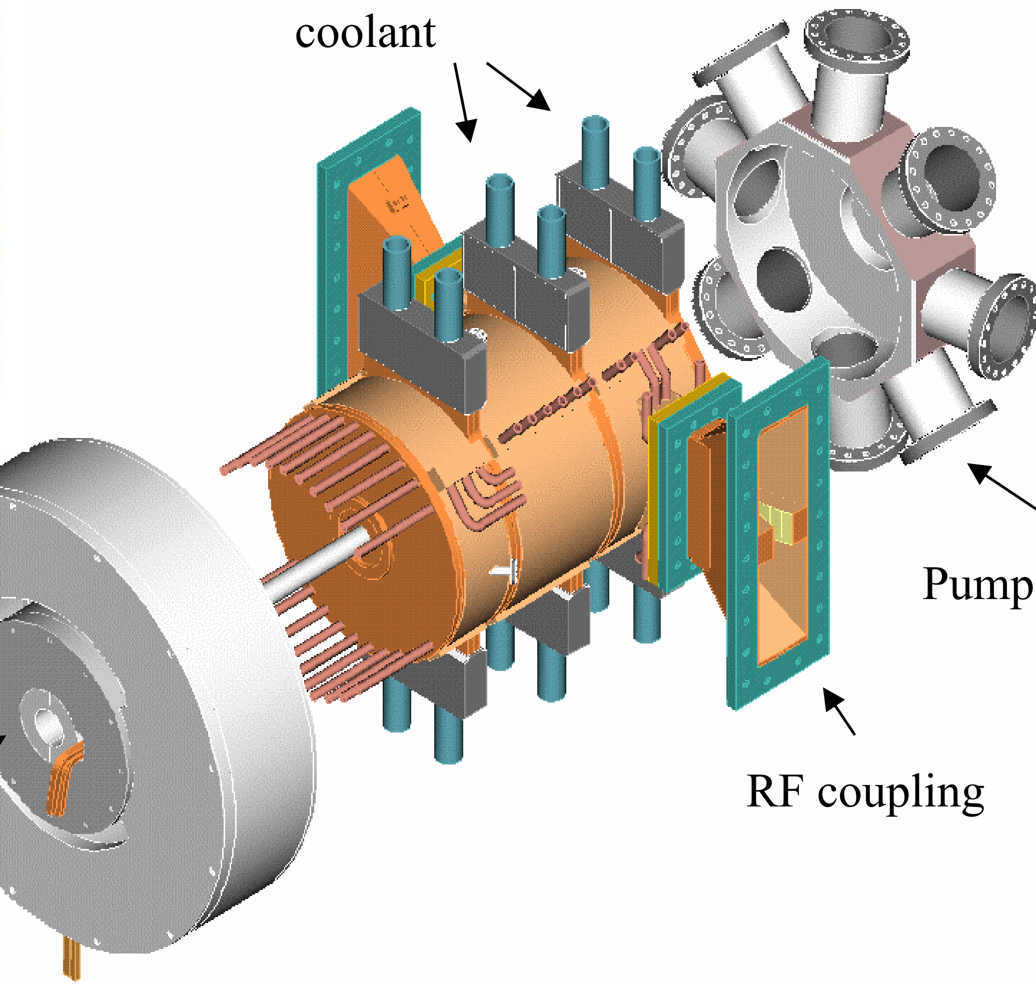
Gun/Injector Projects Overview

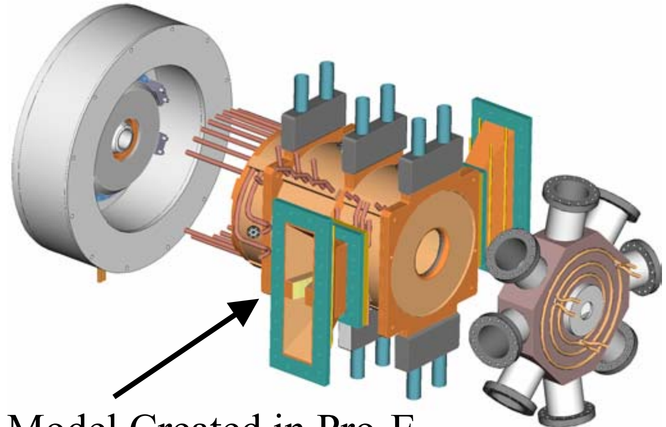
- DC gun based CW injector
  - DC gun matched into superconducting accelerating cavities
  - Working with JLab
- L-band CW gun
  - Working with LANL
- Standard S-band gun (BNL design)
- X-band axisymmetric gun
- All superconducting gun using the niobium as the photocathode

Los Alamos/AES Normal-Conducting CW RF Gun



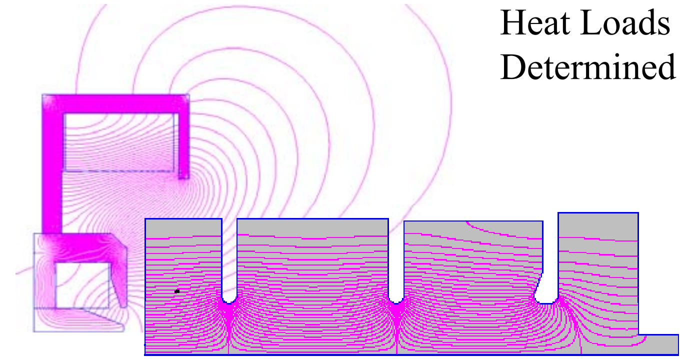


High-Average-Current RF Photoinjector



Solid Model Created in Pro-E

RF Analysis in SUPERFISH

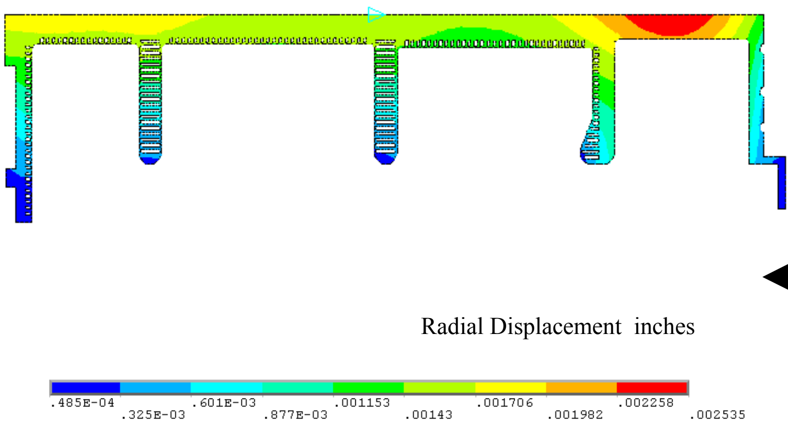


Heat Loads Determined

Iterate

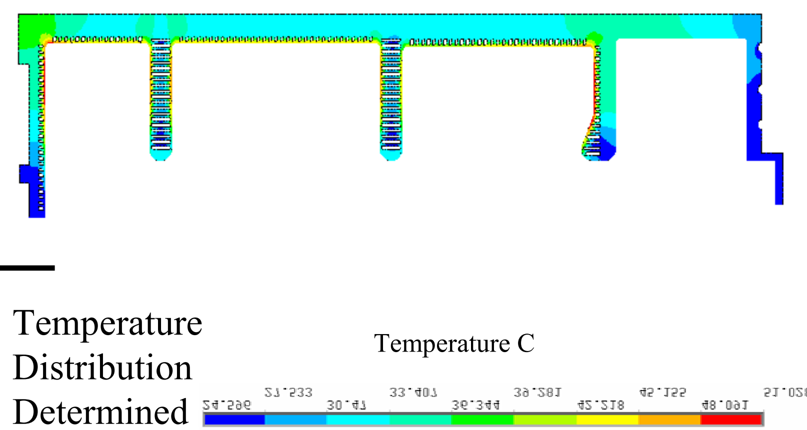
Frequency Shift

Structural Results Radial Displacements ANSYS



Radial Displacement inches

2-D Thermal Model ANSYS-Geometry from Pro-E



Temperature C

Temperature Distribution Determined

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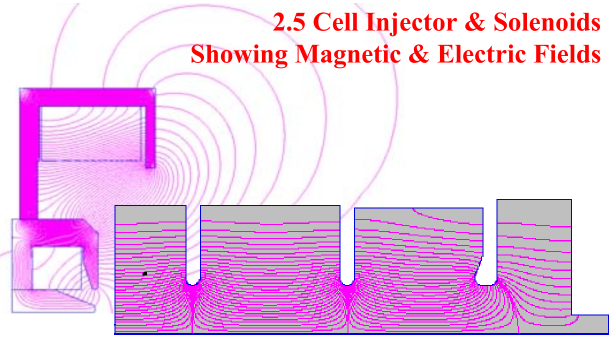
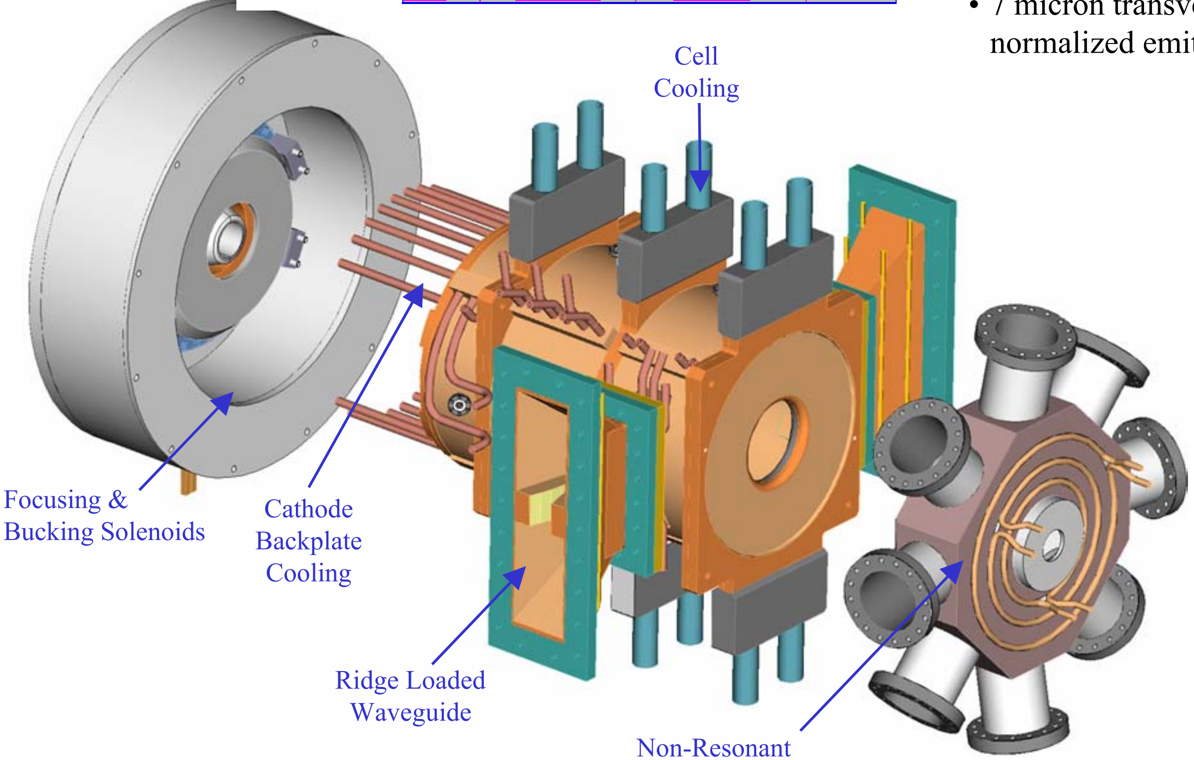
LANL-AES RF Gun Concept

2.5 Cell Injector & Solenoids
Showing Magnetic & Electric Fields

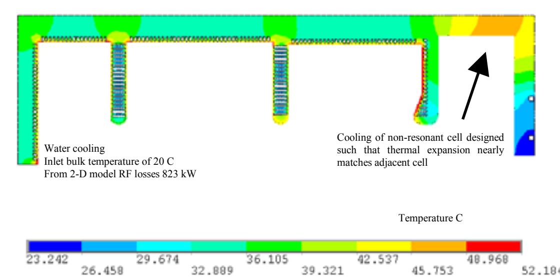




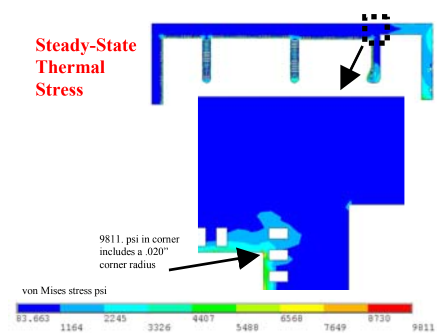
High-Power RF Injector Performance

- 2.5 Cell Photoinjector Linac, 700 MHz, 7 MV/m, 2.7 MeV
- Following 4 Cell Booster Linac, 4.5 MV/m, 5.5 MeV
- 3.0 nC per bunch
  100 mA CW @ 33.3 MHz: 1.05 A CW @ 350 MHz
- 7 micron transverse, 200 keV-psec longitudinal rms normalized emittance, < 1% energy spread

Steady-State Temperature Distribution



Steady-State Thermal Stress



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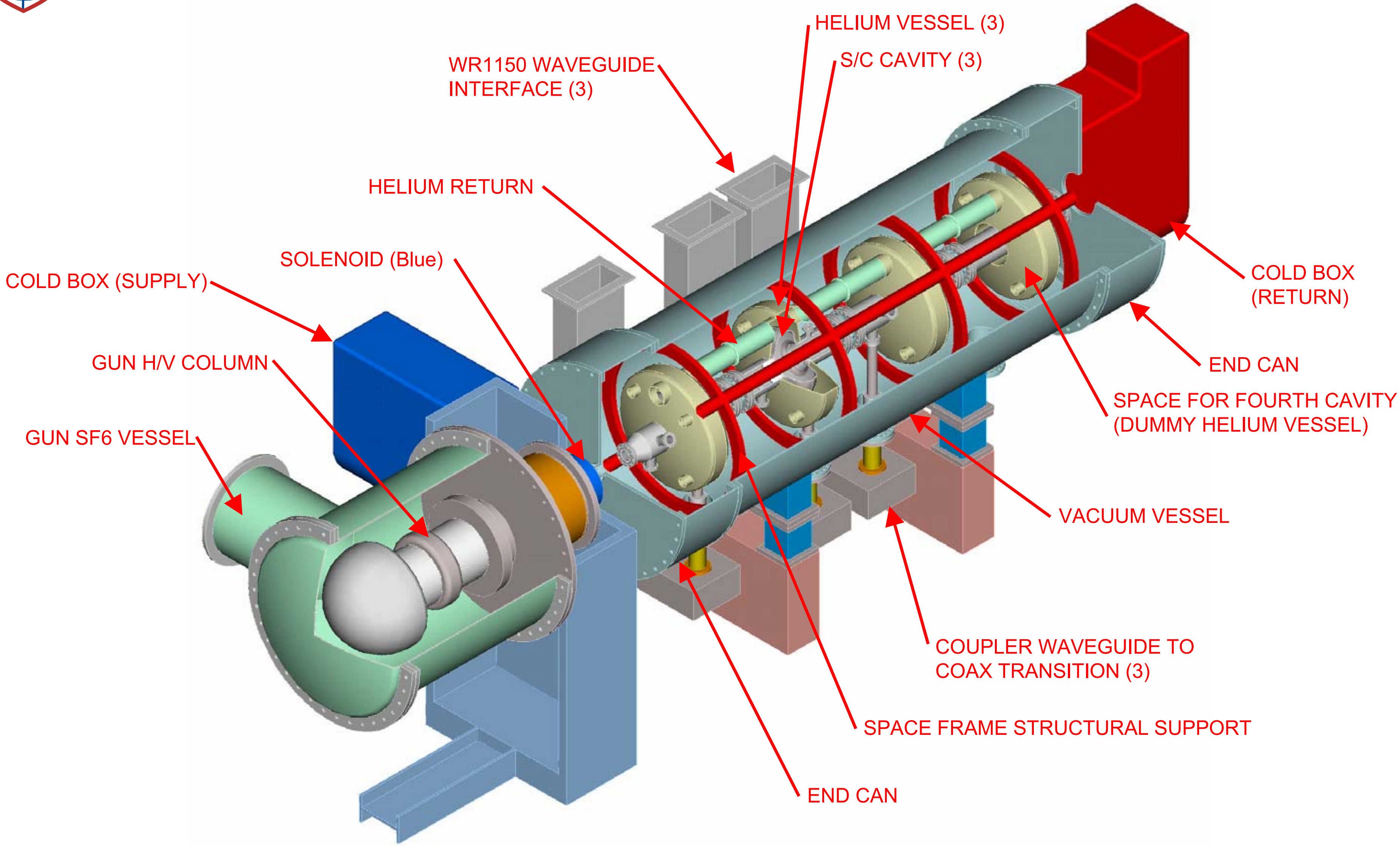
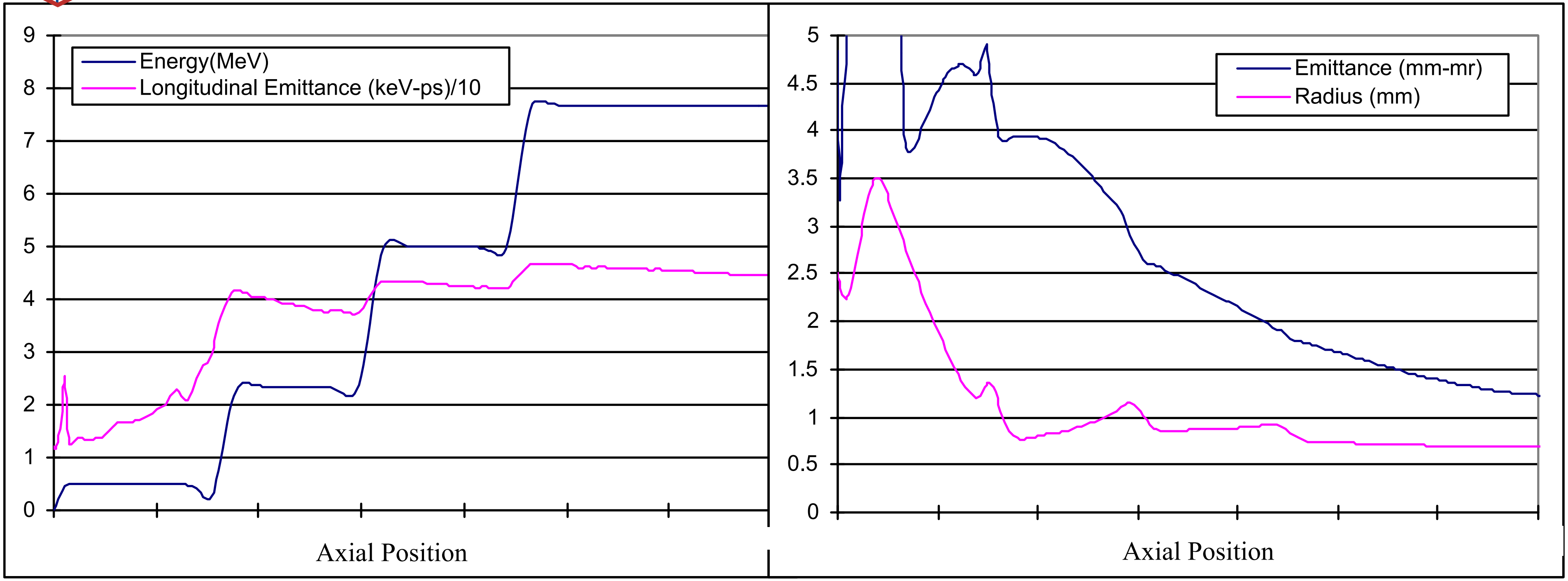
AES/JLAB 100 mA CW Injector



100 mA Injector Physics Design Performance



Parameter	Value Achieved	Specification	Units
Charge	133.3	> 133.0	pC
Beam Radius	0.69	N.A.	mm rms
Bunch Length	6.3	N.A.	psec rms
Emittance$_{xn}$	1.2	< 3.0	microns rms
Emittance$_{zn}$	44	< 100	keV-psec rms
Energy Spread	0.5	< 1.0	% rms
Energy	7.66	> 7.0	MeV

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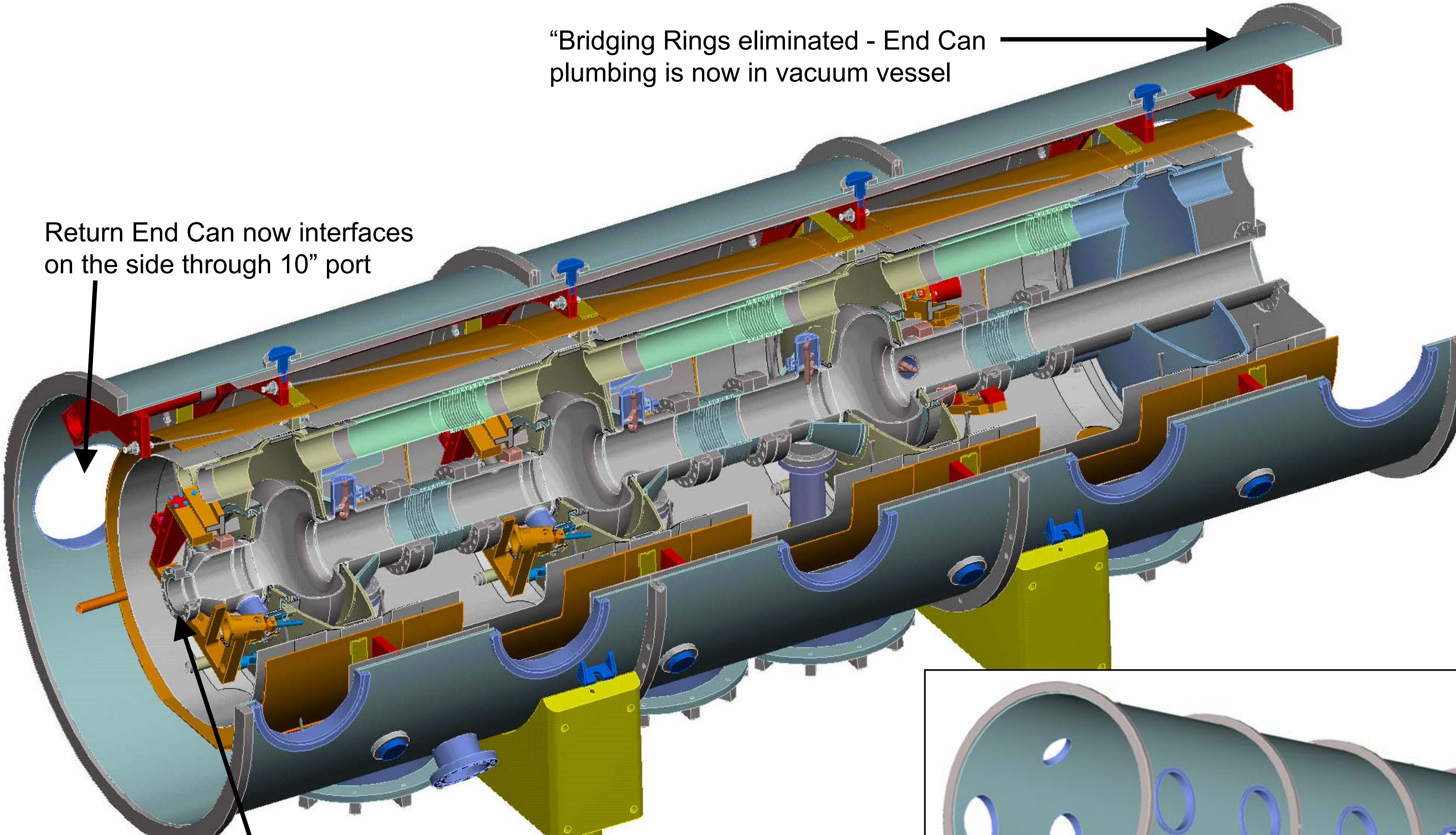
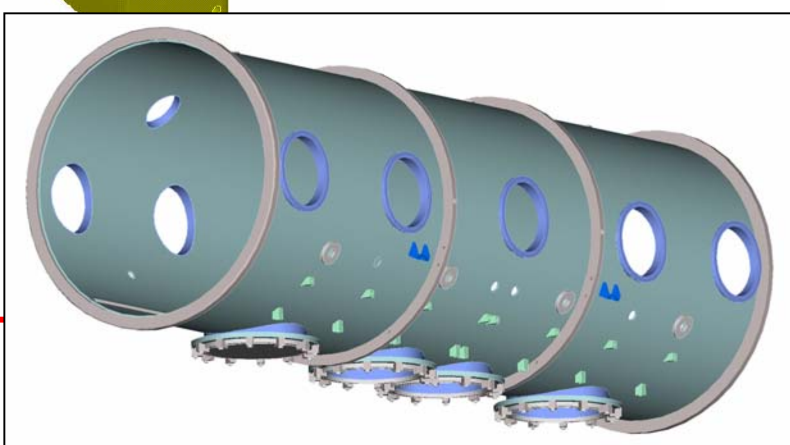
Cryomodule Cutaway - Revised Design

“Bridging Rings eliminated - End Can plumbing is now in vacuum vessel

Return End Can now interfaces on the side through 10” port

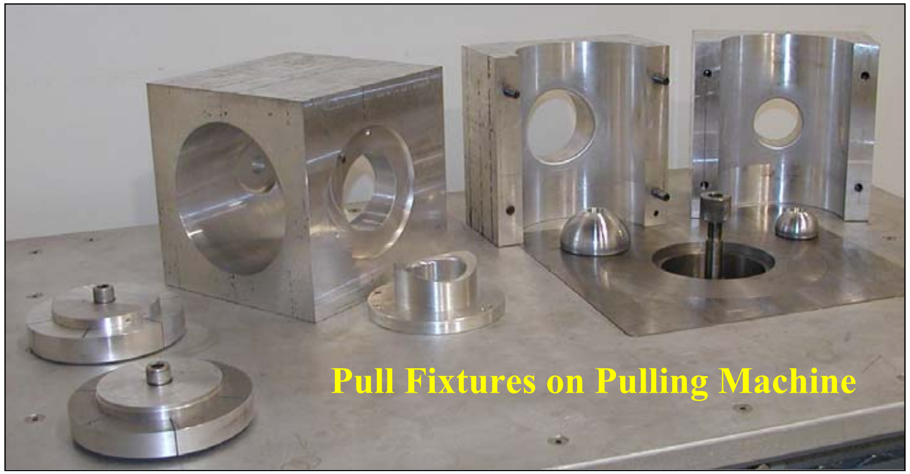


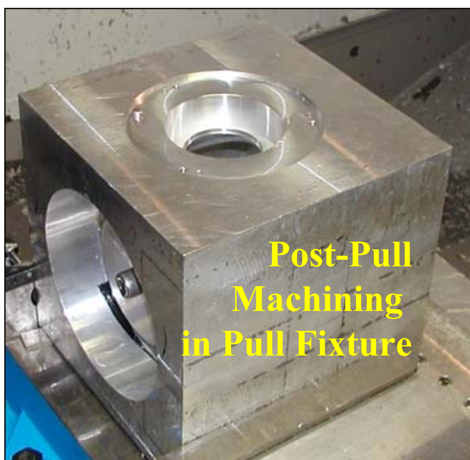
Cold Valves eliminated - Warm valves now used both ends

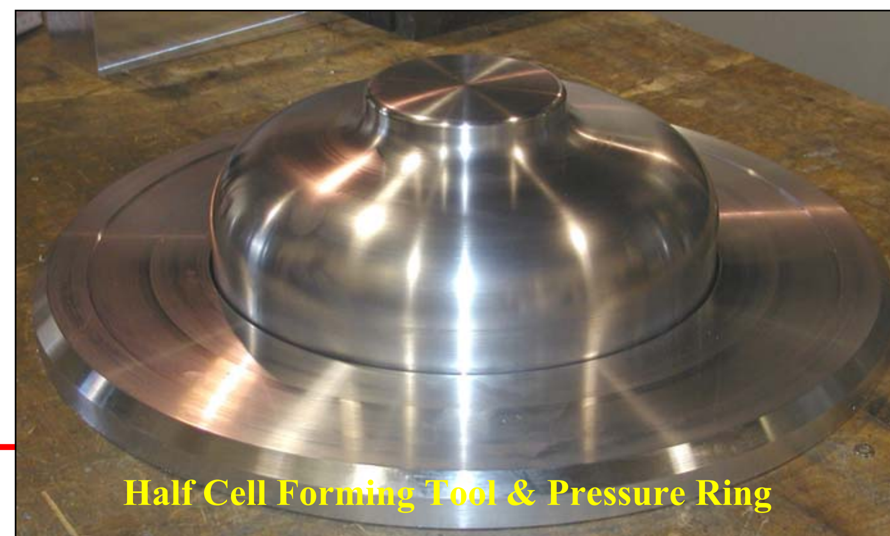


NAVSEA
NAVAL SEA SYSTEMS COMMAND

100 mA Injector Components







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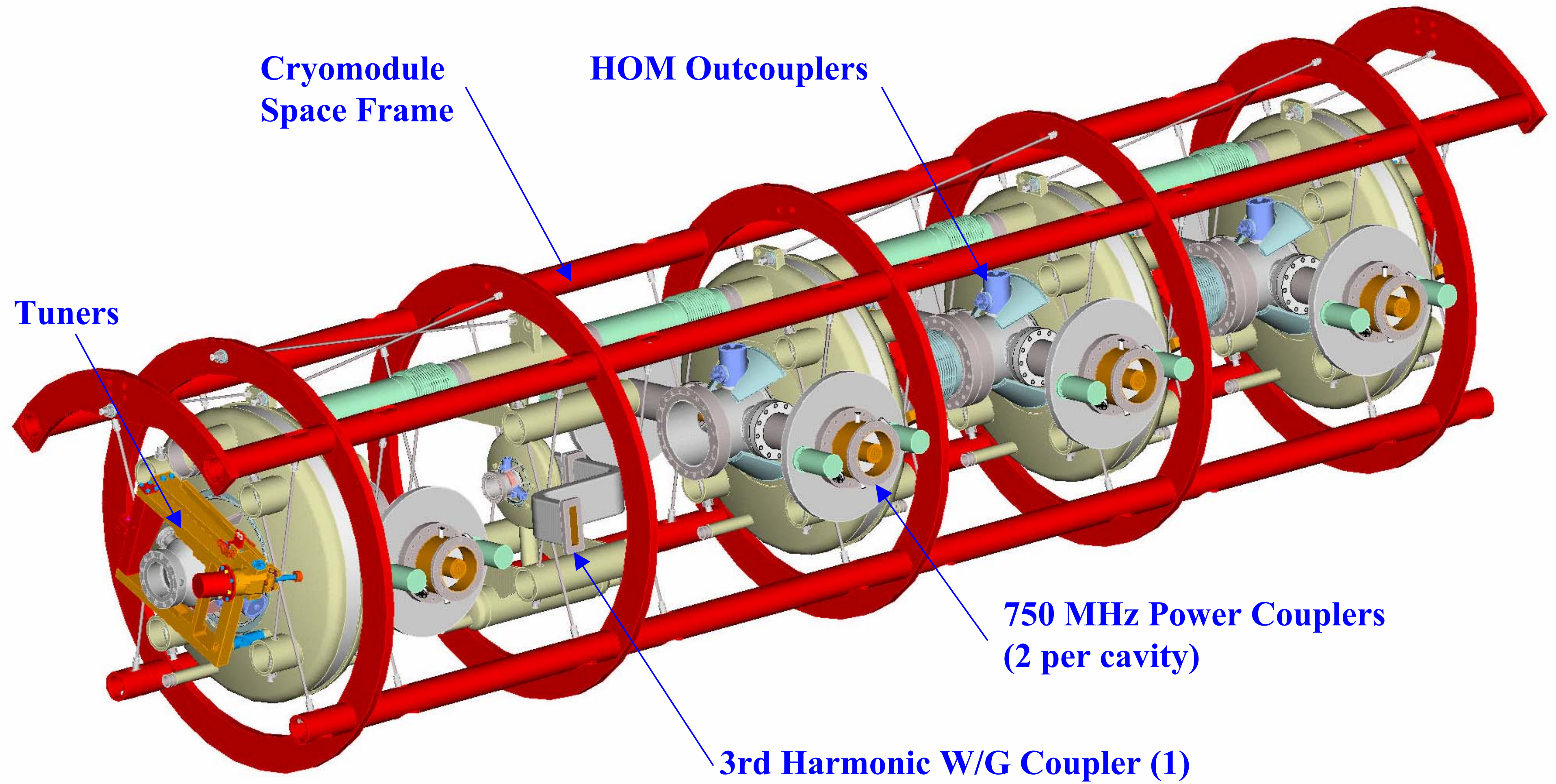
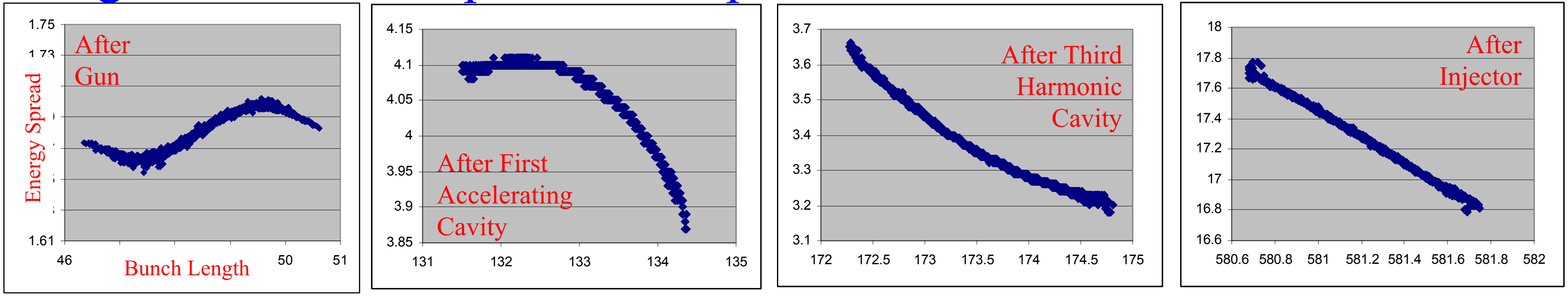
High-Power Cryomodule Components

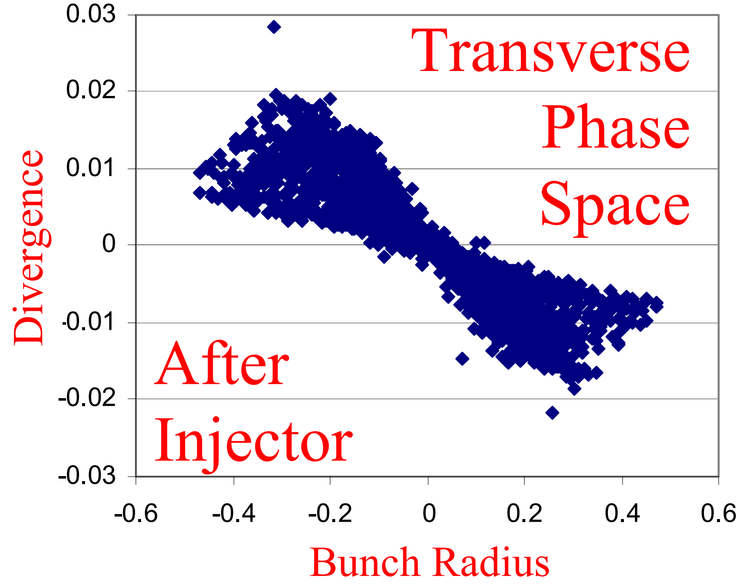


Injector Physics Design

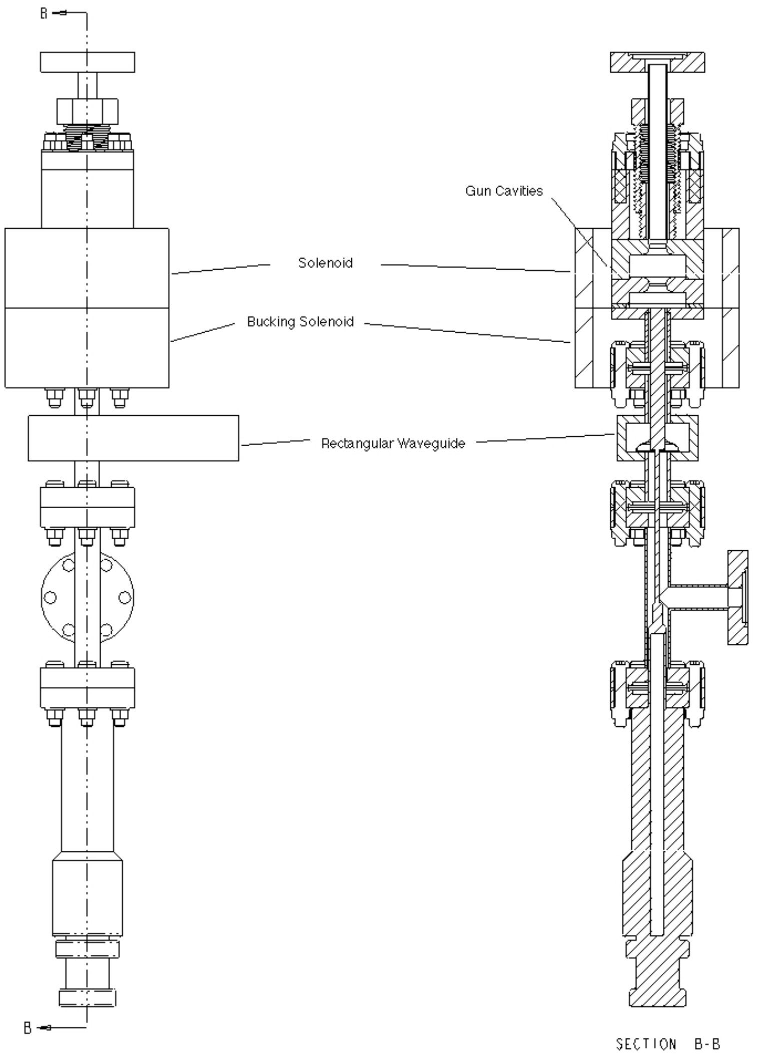
Longitudinal Phase Space Development



- Linearized longitudinal phase space permits maximum FEL gain due to short bunch length (= high peak current) and minimum energy spread
- Transverse phase space emittance compensation continues to evolve bowtie to ellipse for minimum FEL spot size (= high peak current & gain) and divergence in wiggler
- 1.1 nC per bunch, 750 MHz, 7 MeV
- Normalized rms emittance:
  4.7 microns transverse, 37 kev-psec longitudinal



Coaxial X-band Electron Gun



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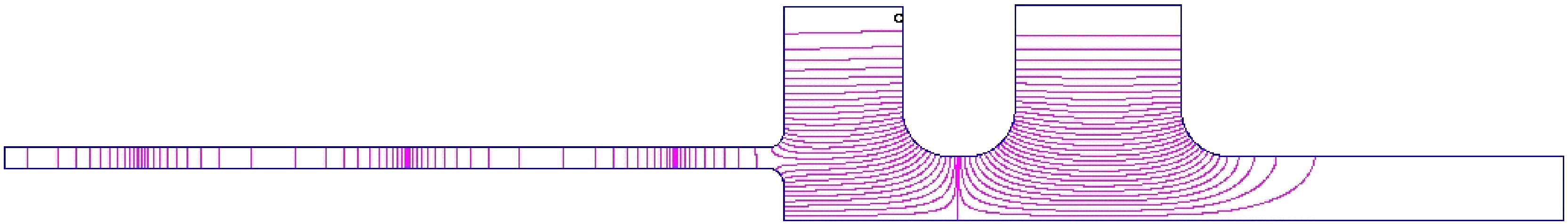

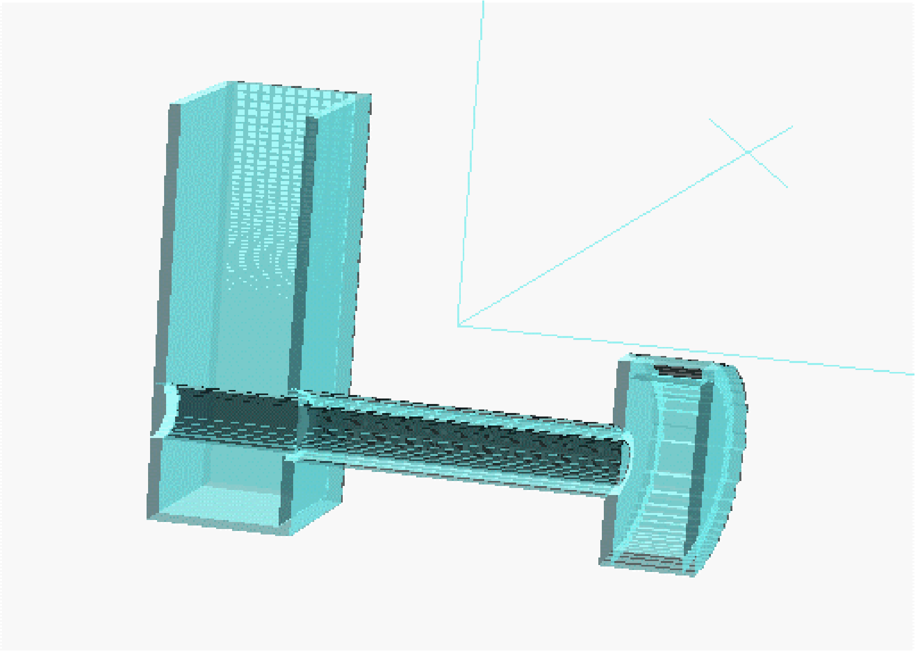

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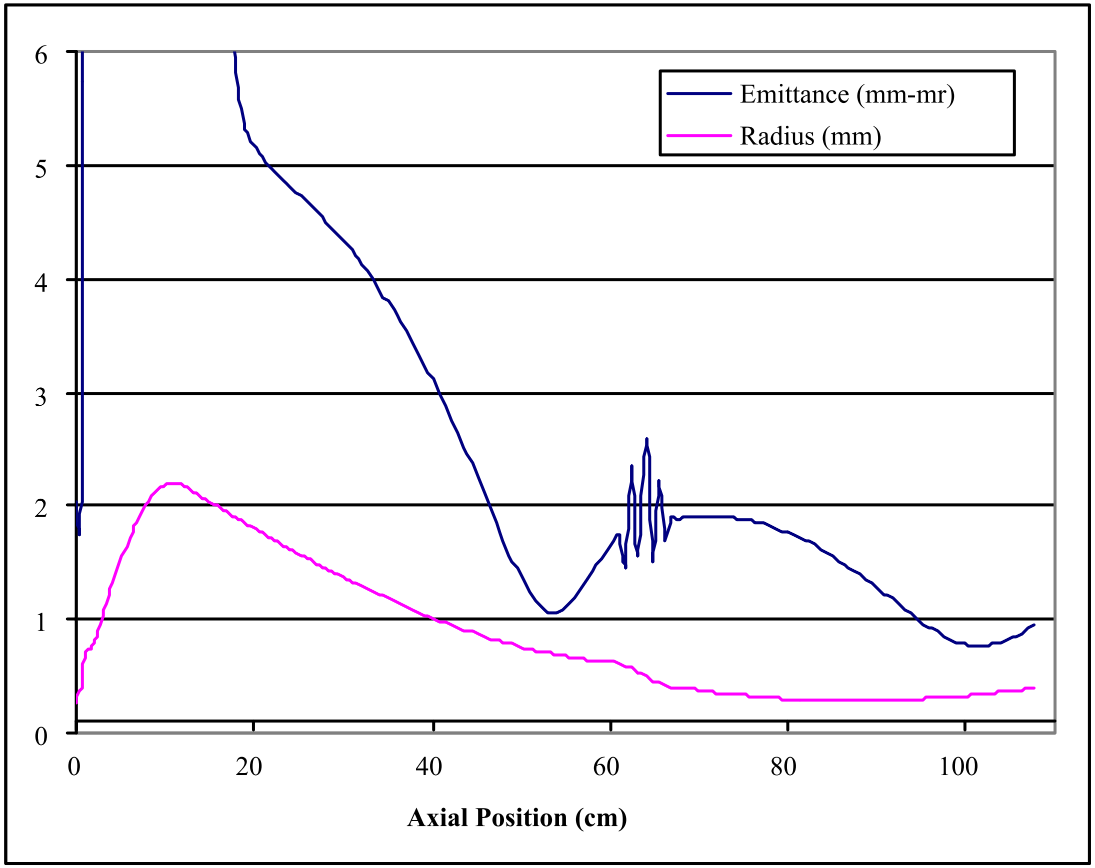

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Coaxial X-band Electron Gun

Parameter	Low Charge	High Charge (with short booster)	Units
Charge	0.10	1.0	nC
Beam Radius	0.28	0.34	mm rms
ε_{xn}	0.165	0.764	mm-mrad
Bunch Length	1.0	1.9	ps rms
Energy Spread	1.3	1.5	%
Energy	3.3	8.7	MeV

Summary

- AES has an active program in the design and fabrication of high-brightness electron photoinjectors
- Differing applications impose various constraints on the gun performance resulting in different solutions
- High duty factor/CW applications can be accommodated using either a DC gun closely coupled to SRF accelerating cavities or by a specially designed low frequency RF gun
    - A discriminator may be the vacuum requirements
- A gun with axial symmetry could, in principle, provide the lowest possible emittances