

High-power X-ray prototype source development using superconducting accelerator for radiological (Co-60) source replacement

FN24-SRF- X-Ray Source-PD2Ma

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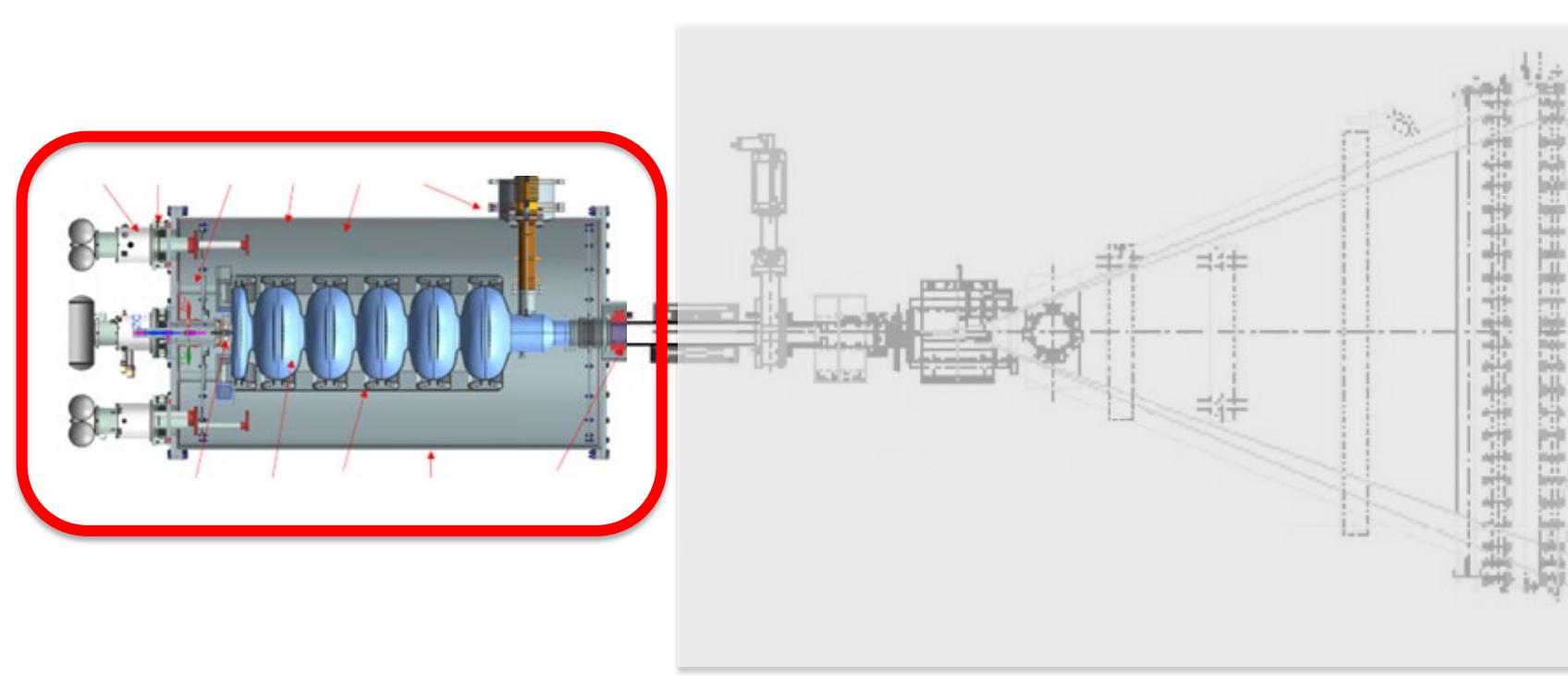
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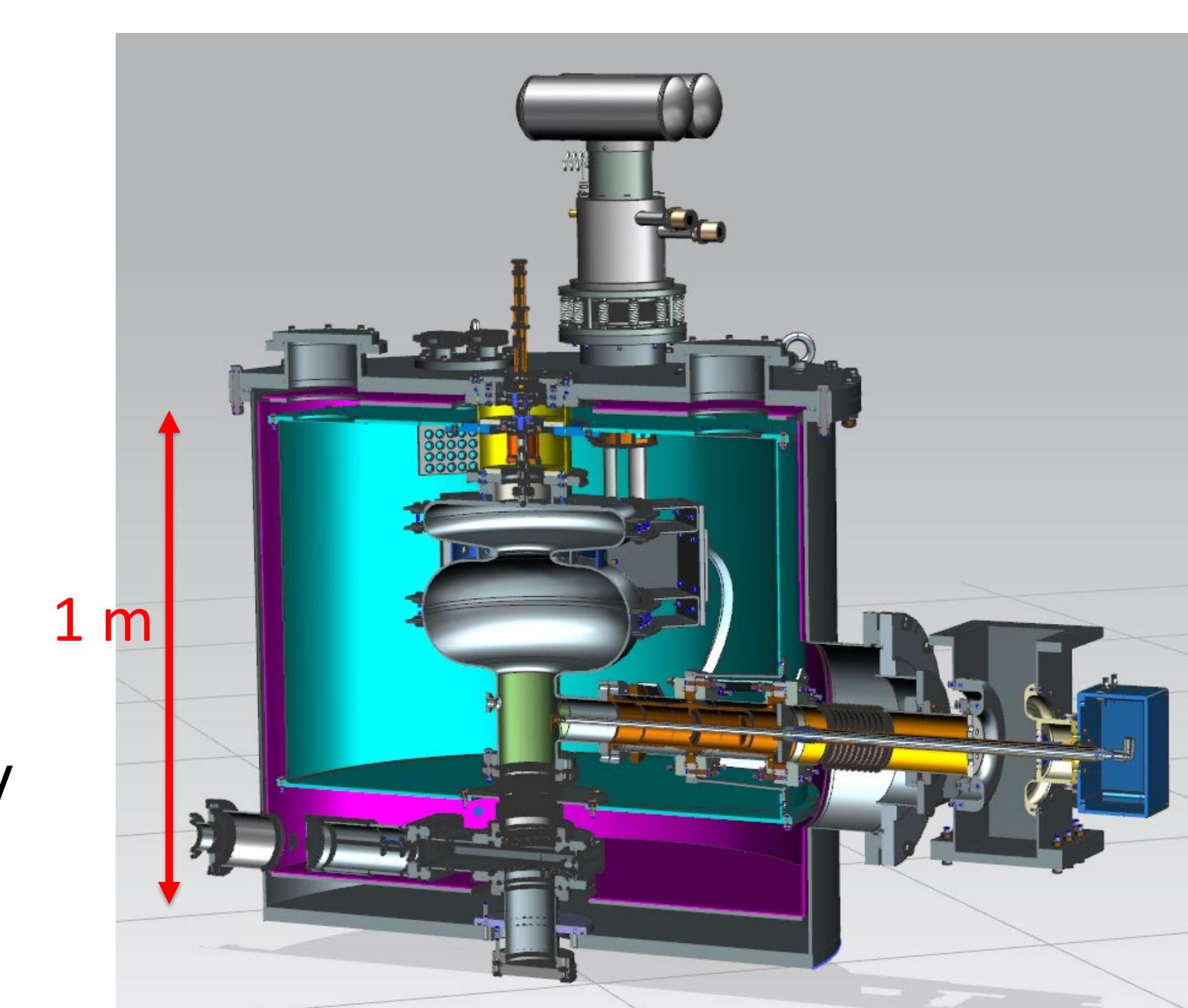
Goals and Objectives

- ▶ Demonstrate efficient, high-power, CW electron beams to enable economic x-ray production for medical device sterilization.
- ▶ Utilizing: Conduction-cooled superconducting RF (SRF) CW accelerating structures.
- ▶ Requirements:
 - 7.5 MeV
 - >200 kW (120 kW/MCi equiv.)



Introduction

- A large fraction (~45%) of single-use medical devices are sterilized using gamma rays from the decay of cobalt-60.
- The industry has been slow to adopt accelerator-based sources of radiation.
- X-rays provide an almost 1-1 alternative.
- Increased accelerator efficiency is required to compensate for the inefficiency of Bremsstrahlung.
- CW Superconducting RF and efficient RF sources provide the greatest system efficiency.



Render of complete prototype system.

Methods

- ▶ Assemble a 20 kW, 1.6 MeV prototype
- ▶ Conduction Cooling w/cryocoolers
 - Eliminates liquid cryogenic system
- ▶ Nb₃Sn coating
 - Puts operating temperature in cryocooler range
- ▶ Integrated electron source
 - Minimizes heat from ambient
- ▶ Low heat-leak RF coupler
 - Minimizes heat from ambient

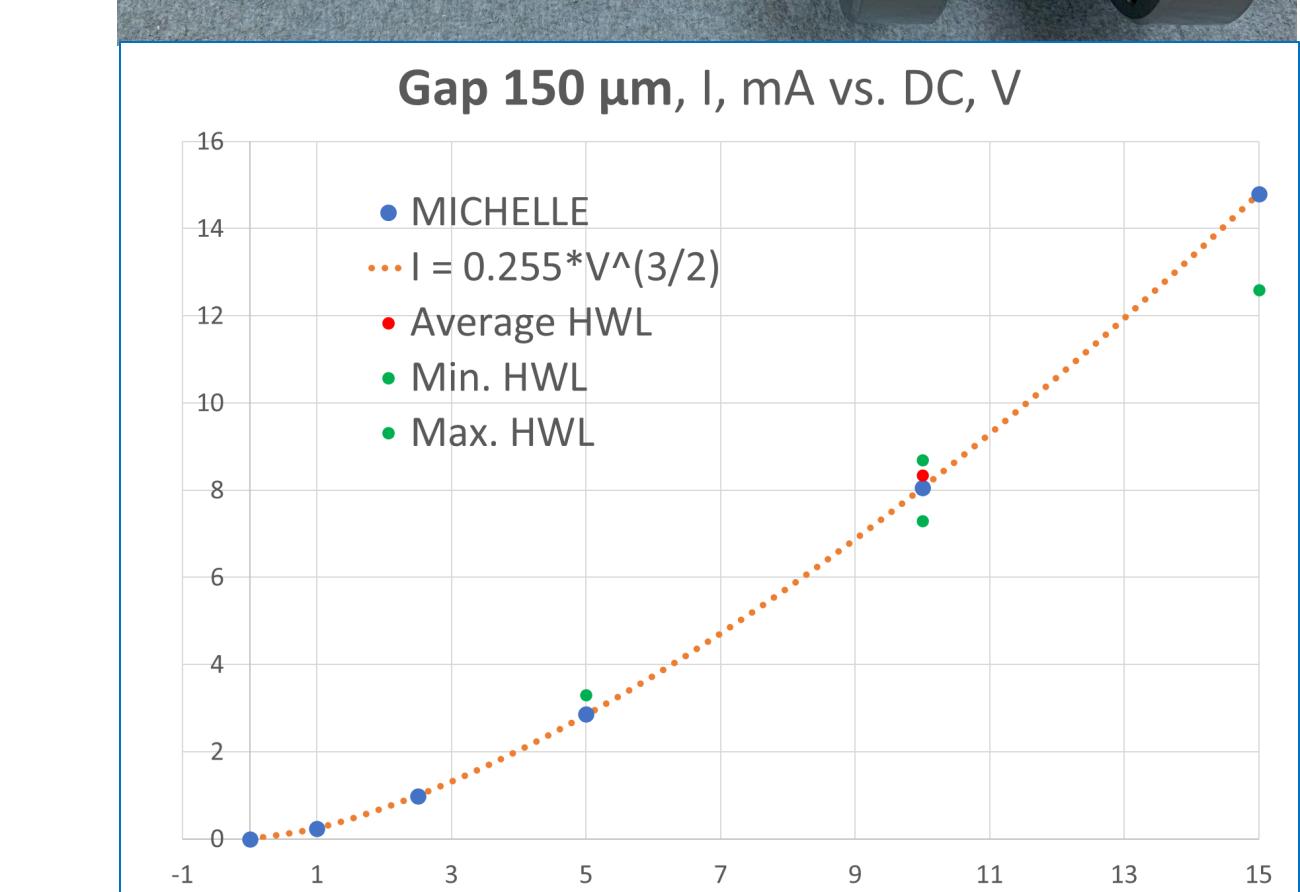
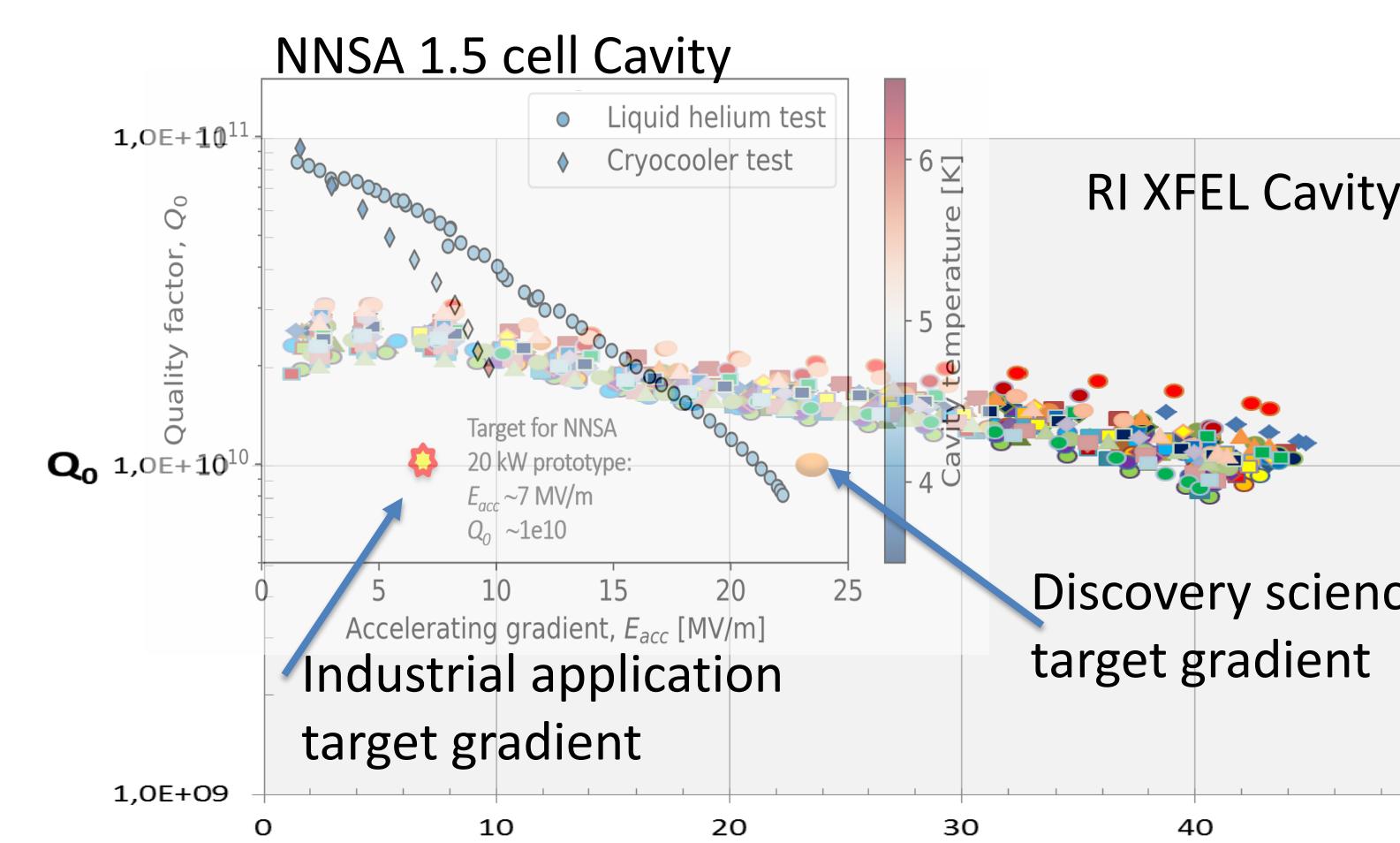
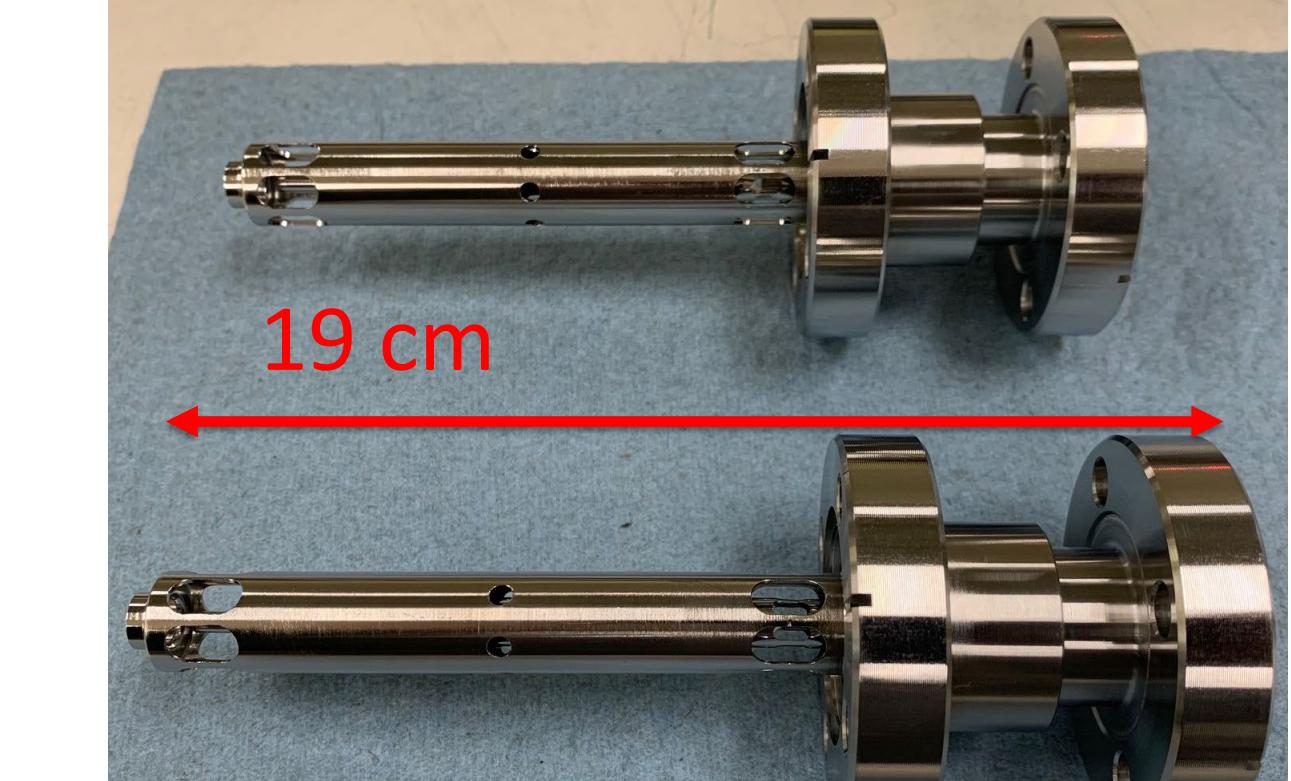
Heat load at ~5 Kelvin	Value [W]
RF dissipation in cavity (with Q ₀ = 1e10)	1.46
Gun static heat leak	0.08
Cathode radiation to cavity (temp = 1373 K)	0.22
Conduction through cavity supports	0.1
Conduction through outlet beam pipe	0.1
Thermal radiation to cavity from thermal shield	0.1
Thermal radiation to cavity through beam pipe window	0.24
Beam loss (1e-6 of 20 kW = 0.02 W)	0.02
Coupler static + dynamic at 20 kW cw	1.0
Total	3.5

- ▶ Demonstrate CW operation at 20 kW and within heat budget

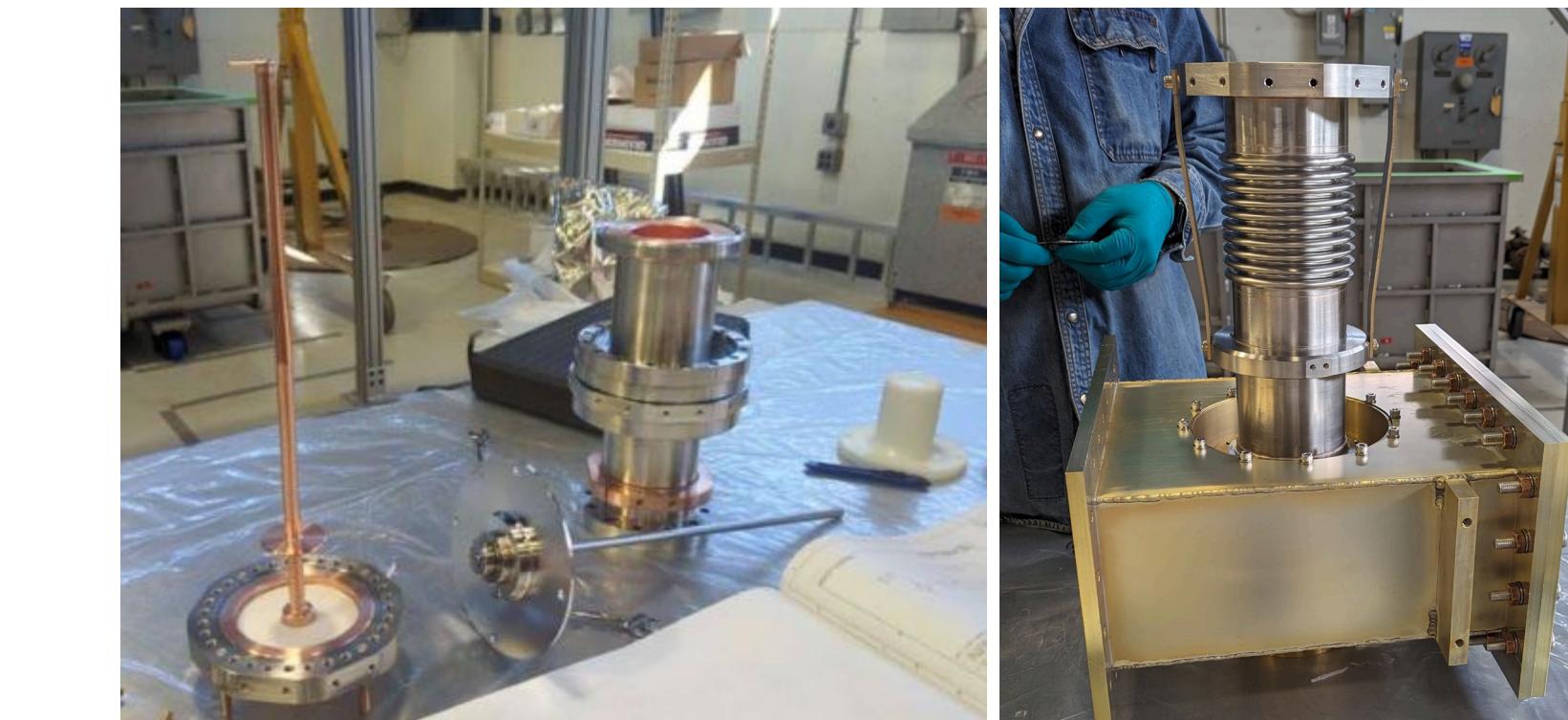
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Status

RF Electron Source/Cathode



RF Coupler Components



Electropolishing at Argonne



Unclassified

Next Steps

Prepare cavity

- ▶ Vertical test stand
- ▶ Surface processing
- ▶ Nb₃Sn coating
- ▶ Vertical test stand
- ▶ Assembly
- ▶ Commissioning
 - ▶ 1st Beam anticipated Q1 Y25
- ▶ Determine operating parameters
 - RF system
 - Electron source
 - RF coupler tuning
 - CW operation
- ▶ Document performance



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