DEMONSTRATION OF NIOBIUM TIN IN 218 MHZ LOW-BETA QUARTER WAVE ACCELERATOR CAVITY

Next generation SRF cavities for ion linacs

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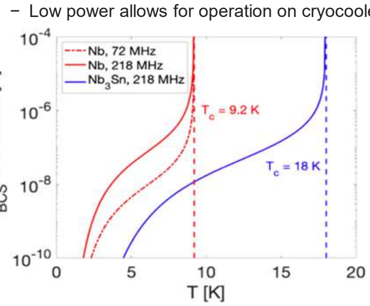
ABSTRACT

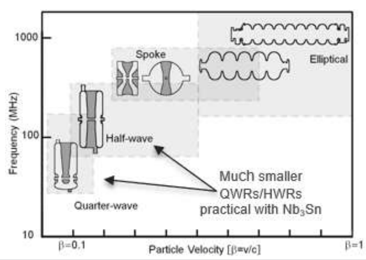
A 218 MHz quarter wave niobium cavity has been fabricated for the purpose of demonstrating Nb3Sn technology on a low-beta accelerator cavity. Niobium-tin has been established as a promising next generation SRF material, but development has focused primarily in high-beta elliptical cell cavities. This material has a significantly higher TC than niobium, allowing for design of higher frequency quarter wave cavities (that are subsequently smaller) as well as for significantly lowered cooling requirements (possibly leading to cryocooler based de-signs). The fabrication, initial cold testing, and Nb3Sn coating are discussed as well as test plans and details of future applications.

INTRODUCTION

Motivation for Nb_3Sn in low-beta cavities

- Demonstrate next generation SRF cavity material in low-beta cavity
- Higher T_c reduces R_{BCS}, which allows for both operation at higher frequency and lowered cryogenic power dissipation requirements
  - T_C of 18.3 K compared to 9.2 K for niobium
  - Reduces size of cavities and cryomodules
  - Low power allows for operation on cryocooler – no centralized helium cryoplant

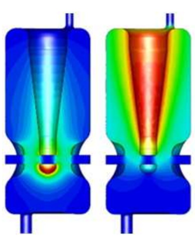




BCS surface resistance vs temperature plot (top left), accelerator cavity geometry regimes (bottom left), and example of physical scaling of cavity size vs frequency (right)

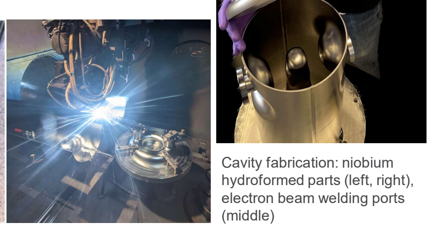
CAVITY DESIGN AND FABRICATION

- Design goal of ~200 MHz cavity with intention to run in ATLAS → 218.25 MHz
- Aim to demonstrate 60 mT peak magnetic field, modest Vacc



Parameter	Value	Unit
Frequency	218.25	MHz
Voltage	1.5	MV
R/Q	527	Ohm
G	45.6	Ohm
E_{PEAK}	58	MV/m
B_{PEAK}	56	mT
Aperture ϕ	2	cm
Diameter	22	cm
Length	56	cm

- Cavity parts fabricated through hydroforming process
  - Local vendor Stuecklen Mfg.
- E-beam welding performed at Sciaky Inc



Cavity fabrication: niobium hydroformed parts (left, right), electron beam welding ports (middle)

SURFACE PROCESSING AND CLEAN ASSEMBLY

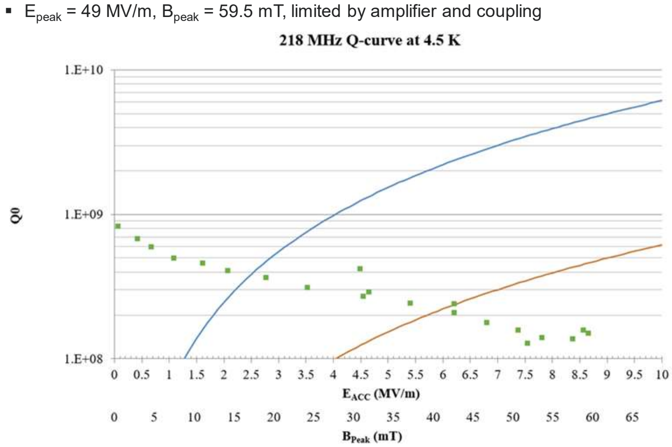
- 120 um electropolish
- Standard SRF cleaning processes
  - Ultrasonic cleaning
  - High pressure rinsing
- Used SS helium vessel designed for ANL TC3
  - Allowed for active pumping connection

Post-EP cavity surface finish

Photos of cavity ultrasonic and high pressure rinsing fixturing (left) and of the stainless steel helium vessel used for testing in Argonne's TC3

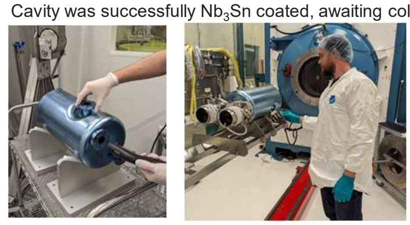
COLD RF TESTING

- Multipacting barrier at V_{acc} < 10 kV
- E_{peak} = 49 MV/m, B_{peak} = 59.5 mT, limited by amplifier and coupling

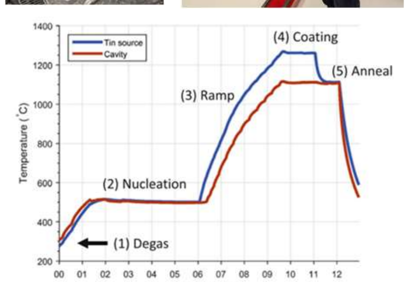


COATING PROCESS

- Cavity was successfully Nb_3Sn coated, awaiting cold test



Photos of cavity being anodized before coating process (left) and with Sn heater assemblies (right). A typical coating process temperature profile (bottom).



Cavity surface post coating

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