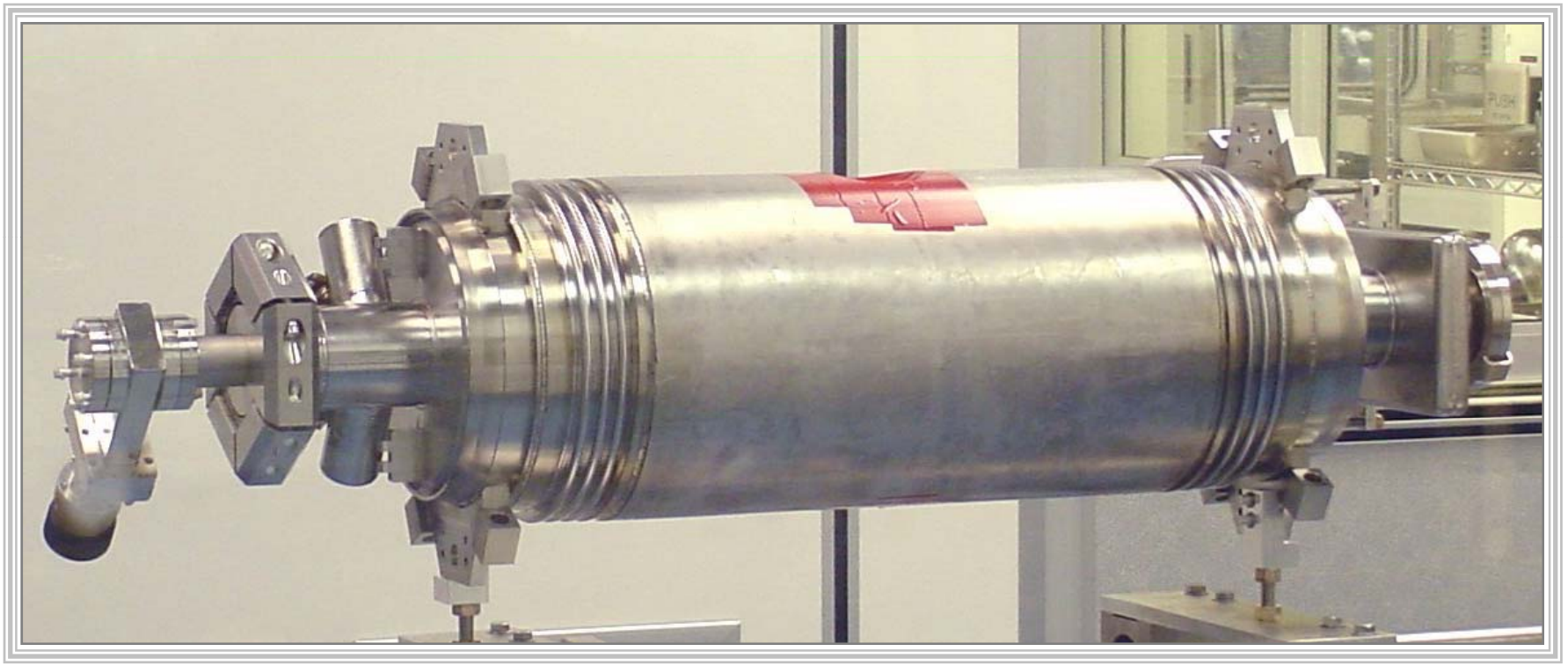
C100 Helium Vessel



Ed Daly for W. Robby Hicks

Outline

- Introduction
- Design verification
  - Show design satisfies requirements
- Design validation
  - Show design was validated through testing and prototype
- Fabrication
- Cost comparison
- Summary

Introduction to C100 Helium Vessel

- Design presented is part of 12 GeV Upgrade Project at JLAB
  - Requires 10 each 100 MV cryomodules (C100)
  - Requires 80 cavities (7 cell, 1497 MHz, CW)
  - Production schedule spans FY09,10 and 11.

- Original design used Titanium Helium Vessel
  - Two versions installed in three prototypes

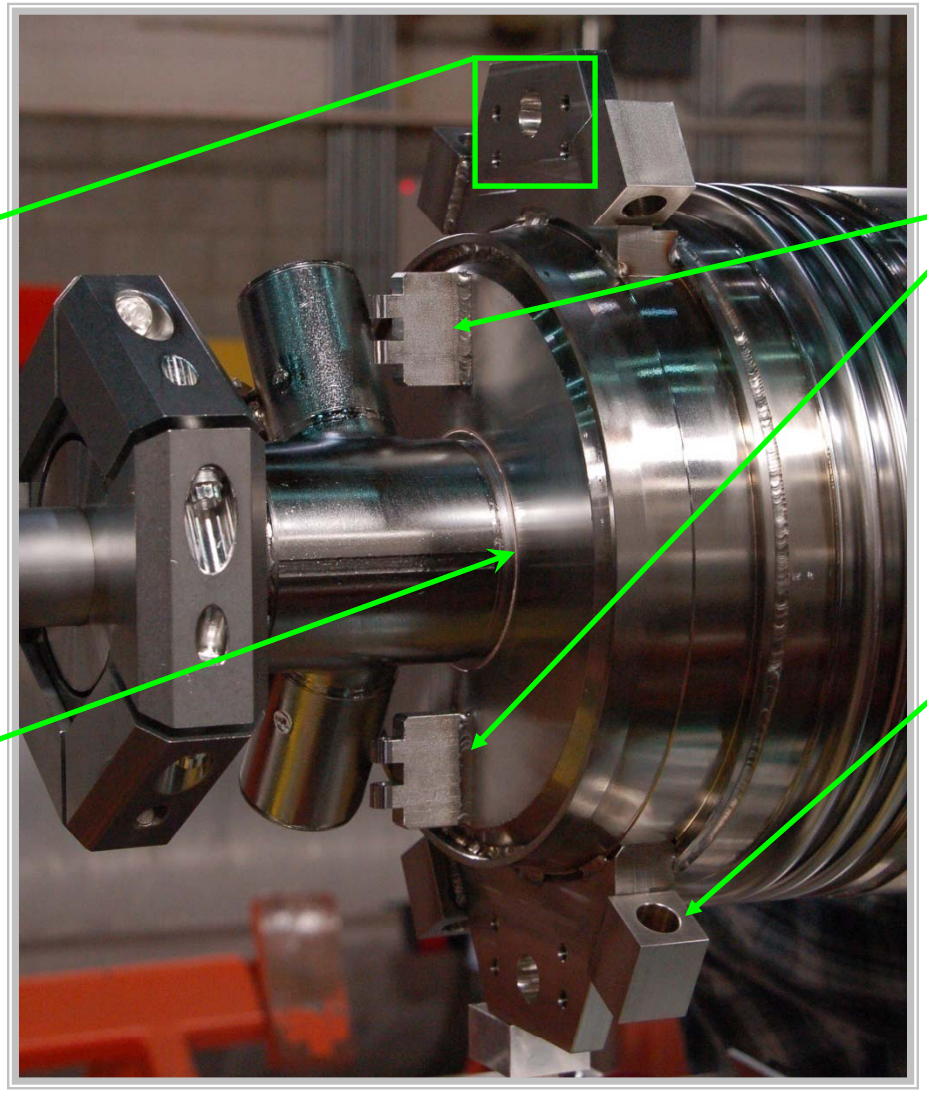
- New design uses Stainless Steel Helium Vessel
  - Motivation – reliability, cost, manufacturing

Requirements for C100 Helium Vessel

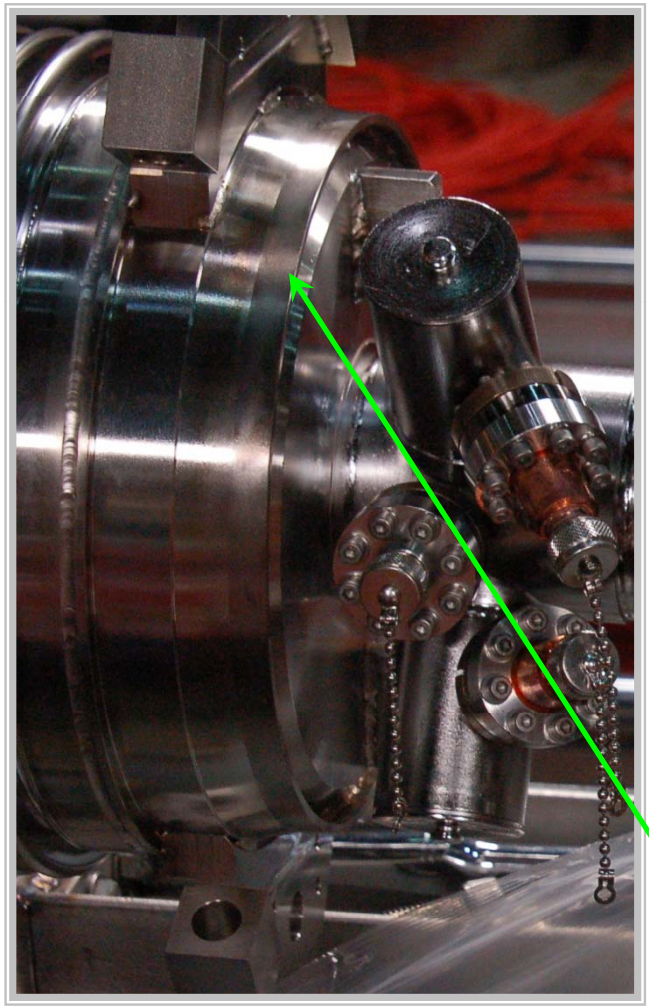
- Maintain interface for:
  - Tuner mechanism
  - Helium circuit
  - Assembly Tooling
  - Nitronic rod support system
- Incorporate a cavity alignment feature (with fabrication/assembly tolerance stack-up < .010” RSS)*
- Provide transition from Nb beam-line to SST helium circuit
- Transmit 820 lbf tuning force
- Support an internal pressure of 5 atm (@ 4.5K)
- Support an external pressure of 2 atm (@ 300K)

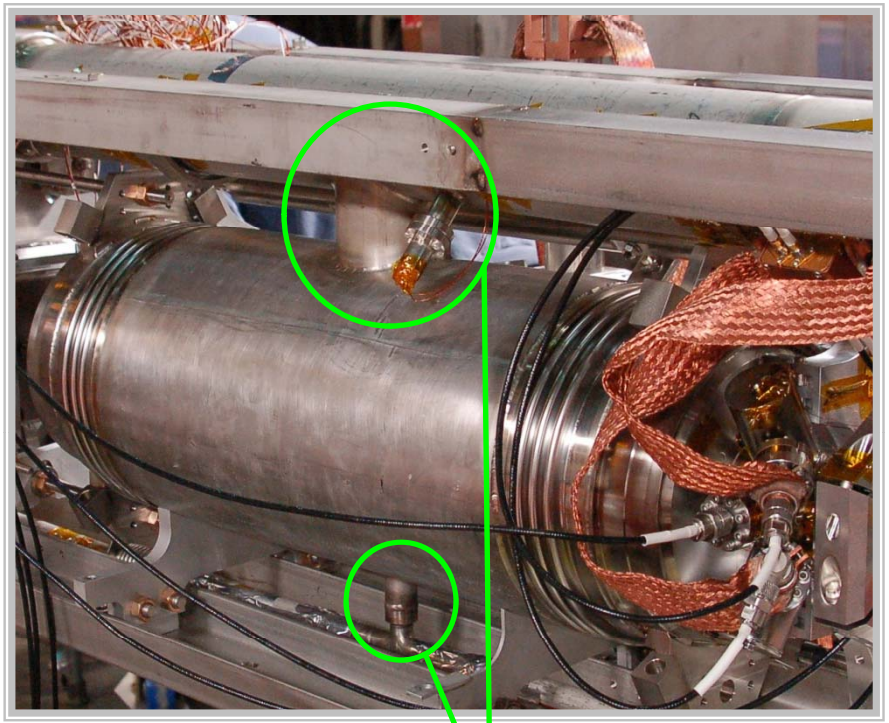
- Consistent with Cavity Processing Techniques

Design Verification



Design Verification

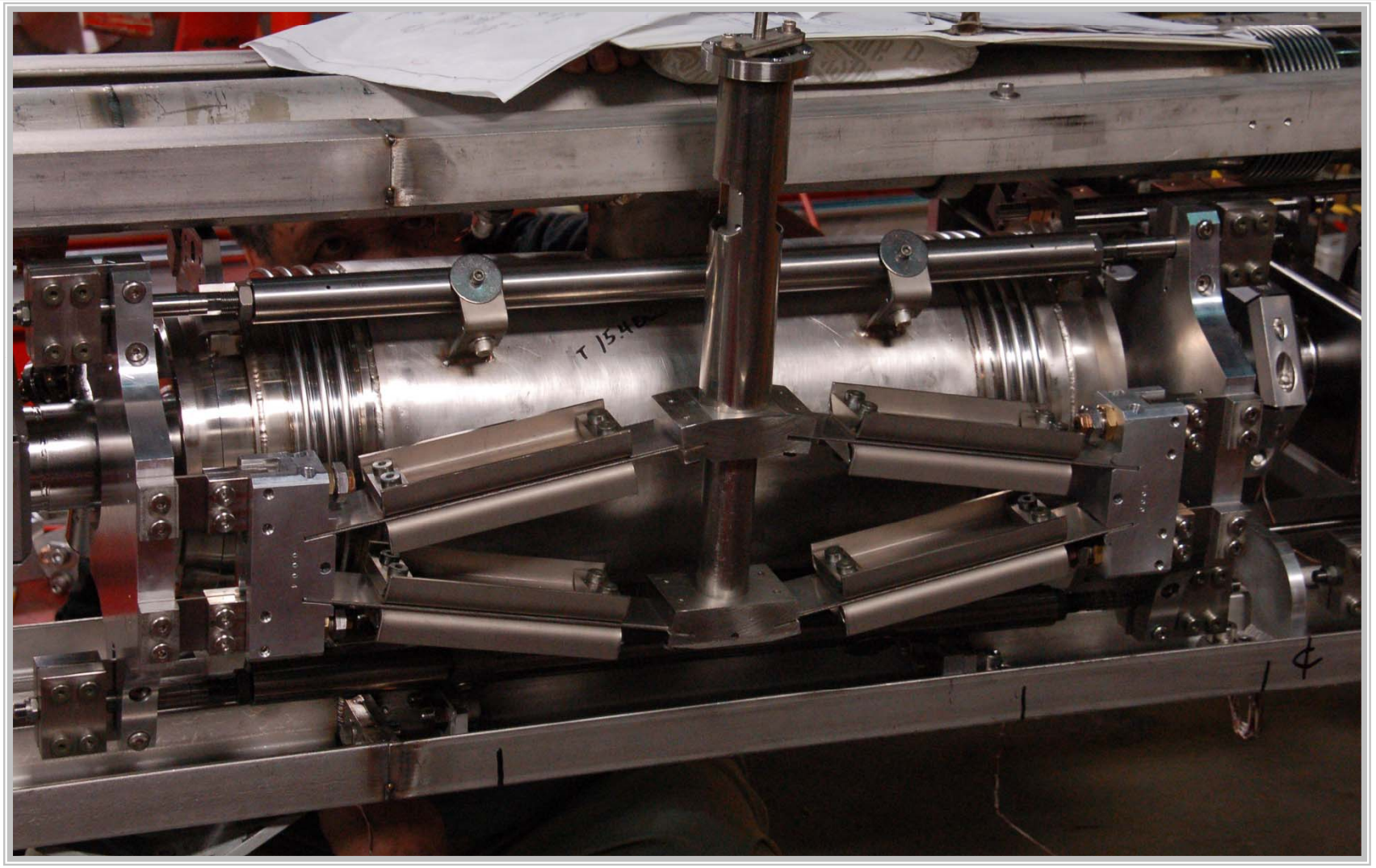




Helium circuit
inlet and outlet

Machined alignment feature
(fabrication/assembly tolerance stack-up ~.009” RSS)

Design Verification



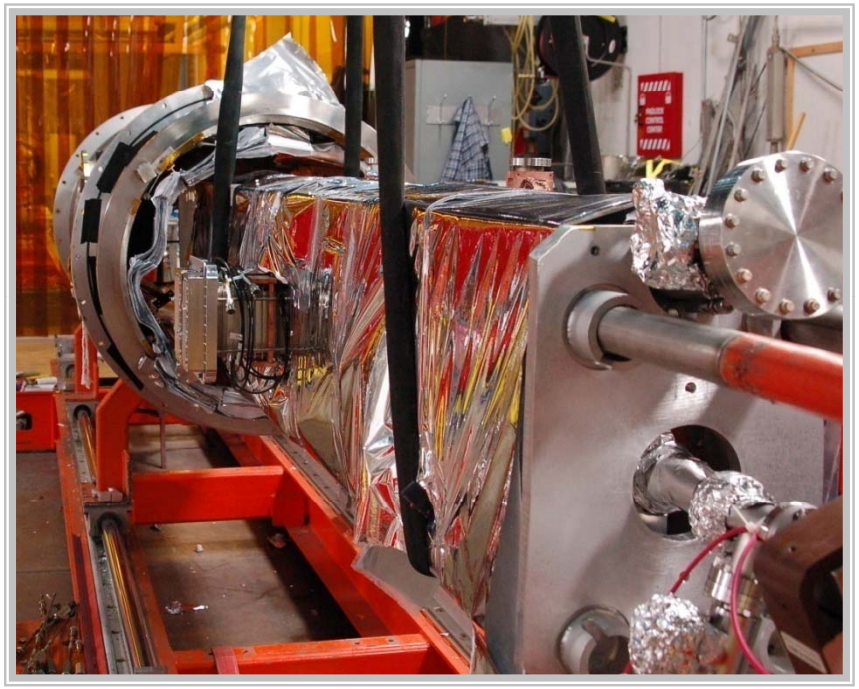
Tuner installed and successfully tested in HTB

Design Validation

Helium vessel design was validated by:

1. Thermal shock in liquid nitrogen & leak check of braze joint (x3/joint)
2. VTA cycle to 2K (x2/cav)
3. Thermal cycle to 2K in HTB (x1)
4. Functionally tested in HTB
5. Pressure test of “Helium Vessel Head Test Fixture”

Note : HTB is the Horizontal Test Bed – a facility for testing up to two cavities with cryomodule boundary conditions

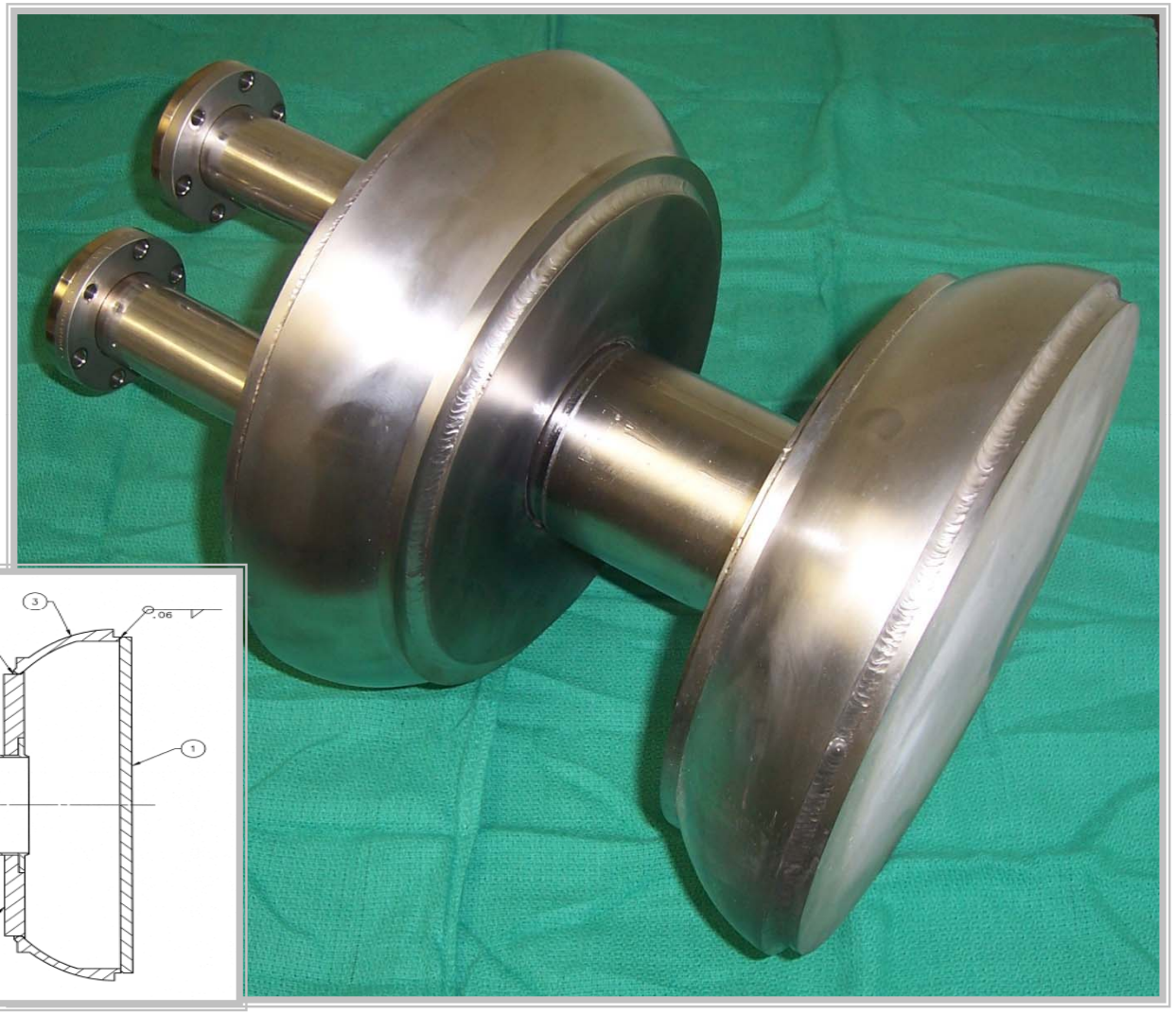


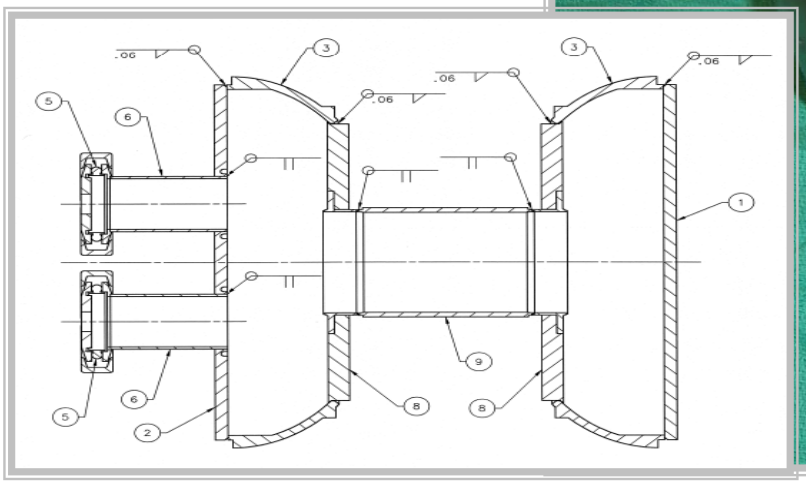
C100/HTB cavity string installation

Design Validation

Pressure Test:

- Design pressure is 75 psi
- Test fixture was pressurized to 82.5 psi* (110% of the design pressure)



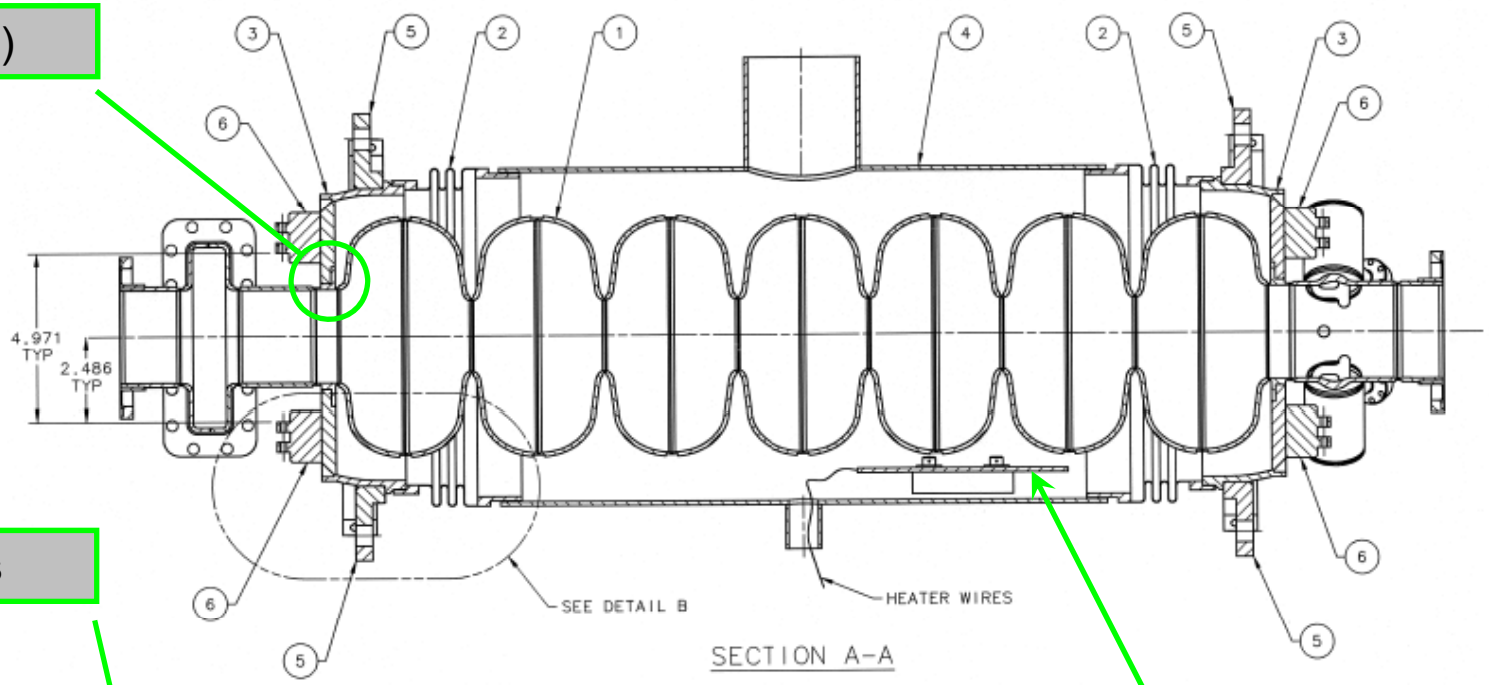


Helium Vessel Head Test Fixture

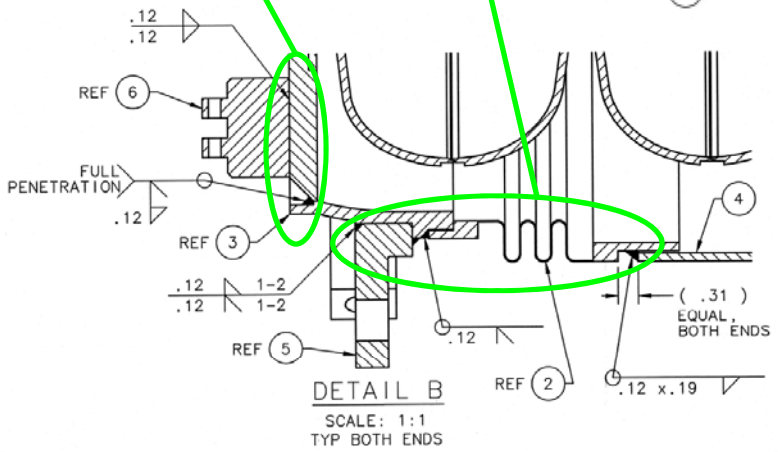
*TOSP A-06-021-T

Fabrication Process

1- Braze joints (x2)



3-SST TIG welds



2- Heater installation!

Stainless Steel Helium Vessel

Fabrication Process

Braze joint components:

1) Machine parts with proper joint clearances (.001”-.004” radial)
2) Transition plate outer features are post machined
3) Weld preps on Nb tee are post machined
4) Alloy is cut to shape (~.015 thk)

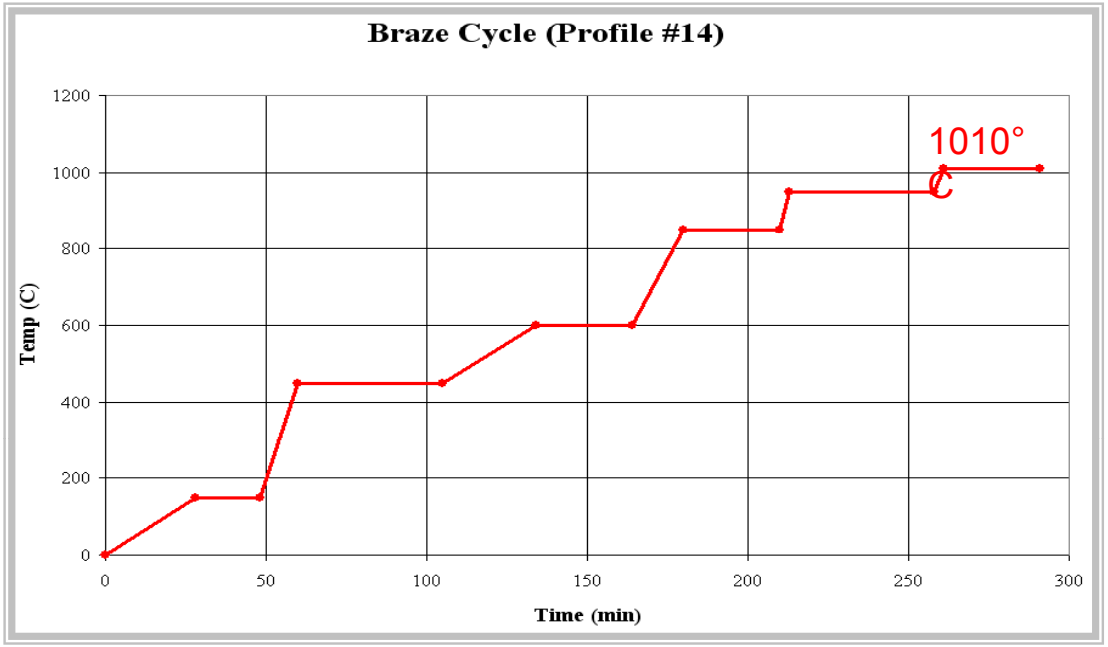
Parts prepped for brazing:

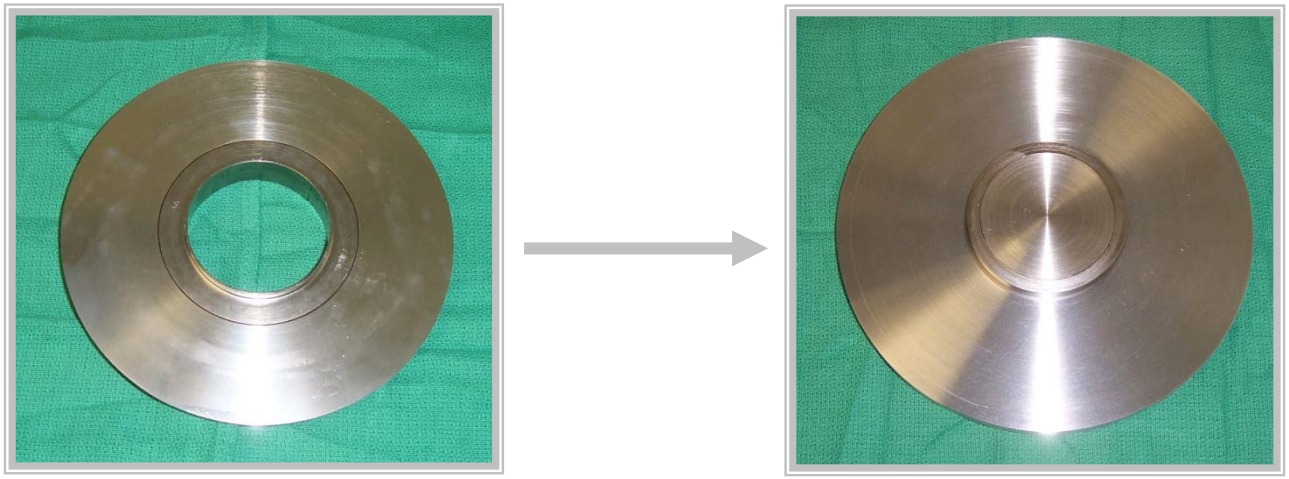
1) All parts cleaned in ultrasonics With Micro 90 and DI rinsed for 20 minutes
2) Parts are triple rinsed with pure DI water and dried with dry nitrogen
3) Stainless parts are etched (nitric 30%, hydrofluoric 4%, water 66%) for 1 hour
4) Nb parts are etched with BCP 1:1:1(nitric, phosphoric, hydrofluoric) for 1 minute
5) Parts are dried with dry nitrogen and sealed in clean nylon bags

Fabrication Process

Braze alloy

- 50/50 Au/Cu (Premabraze 402)
- liquidus 969°C/solidus 954°C
- Not affected by subsequent BCP
- ~0.015 thick foil and .060 wire





Cost Comparison

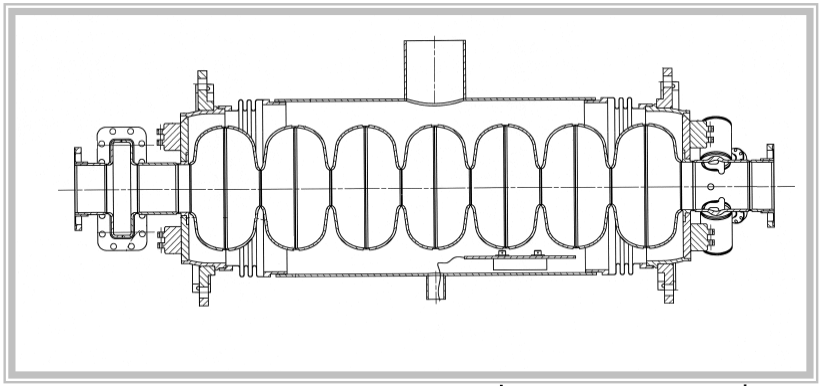
Based on:

- Price per pound for SST of $4.03 (2/07)
- Price per pound for Ti of $22.50 (2/07)
- Substituting historical prices for:
  - Explosion bonded joints (3/02)
  - Braze alloy (12/06)
  - Ti bellows (3/03)
  - SST bellows (11/06)

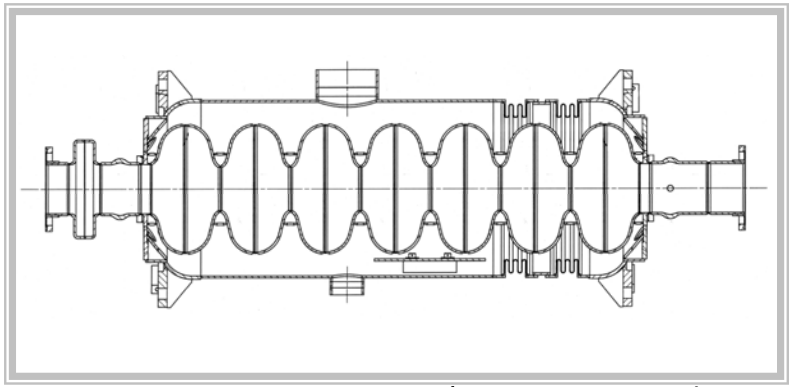
Cost savings = $2,050 ea.

For 80 helium vessels:

Total cost savings* = $164,000



SST He Vessel ≈ $2,280 ea.*



Ti He Vessel ≈ $4,330 ea.*

* Does not include labor

Summary

- HTB test verified that the design meets the requirements
- Design has been validated through HTB test and prototype testing
- The SST helium vessel is easily fabricated using standard machining, welding and brazing techniques
- The SST helium vessel has significant cost savings versus the Ti design

"The potential advantages of moving to a stainless steel helium vessel are significant both for the 12GeV upgrade and future machines. This effort is to be commended and should be continued."

Final Report, JLab 12 GeV Upgrade Cryomodule Review,

Belomestnykh, S., Walker, N., Weisand II, J.G.