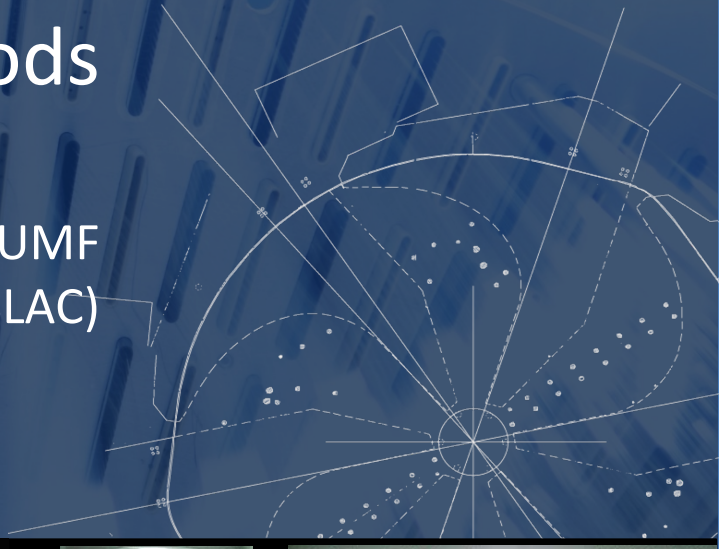
TRIUMF

Canada's national laboratory
for particle and nuclear physics
and accelerator-based science

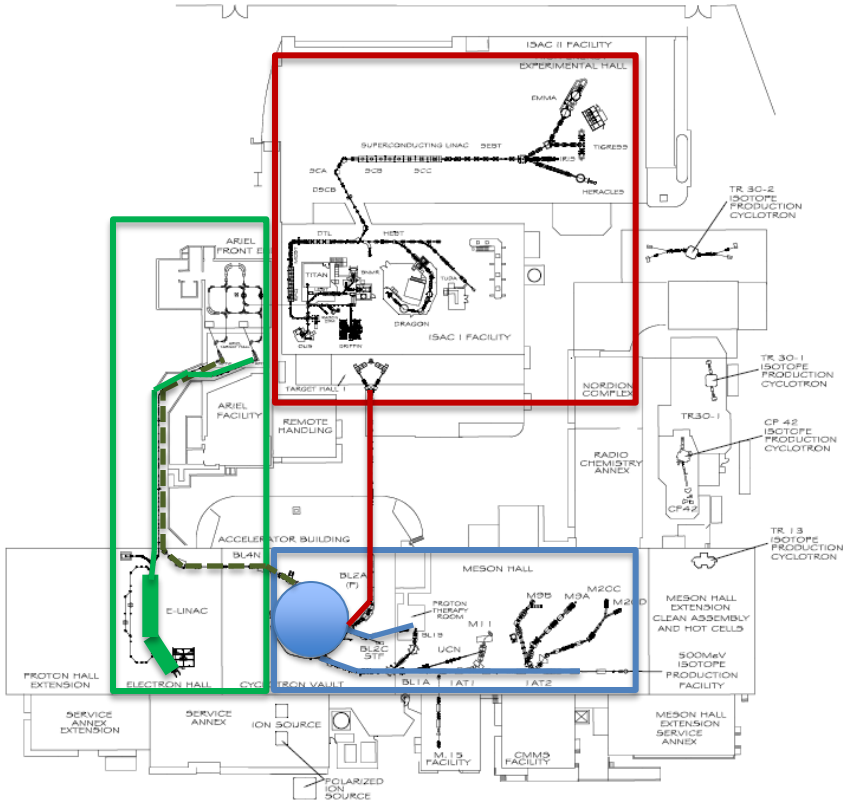
SRF Deflecting Cavity using Novel Fabrication Methods

Bob Laxdal, Zhongyuan Yao, TRIUMF
Doug Storey (now at SLAC)

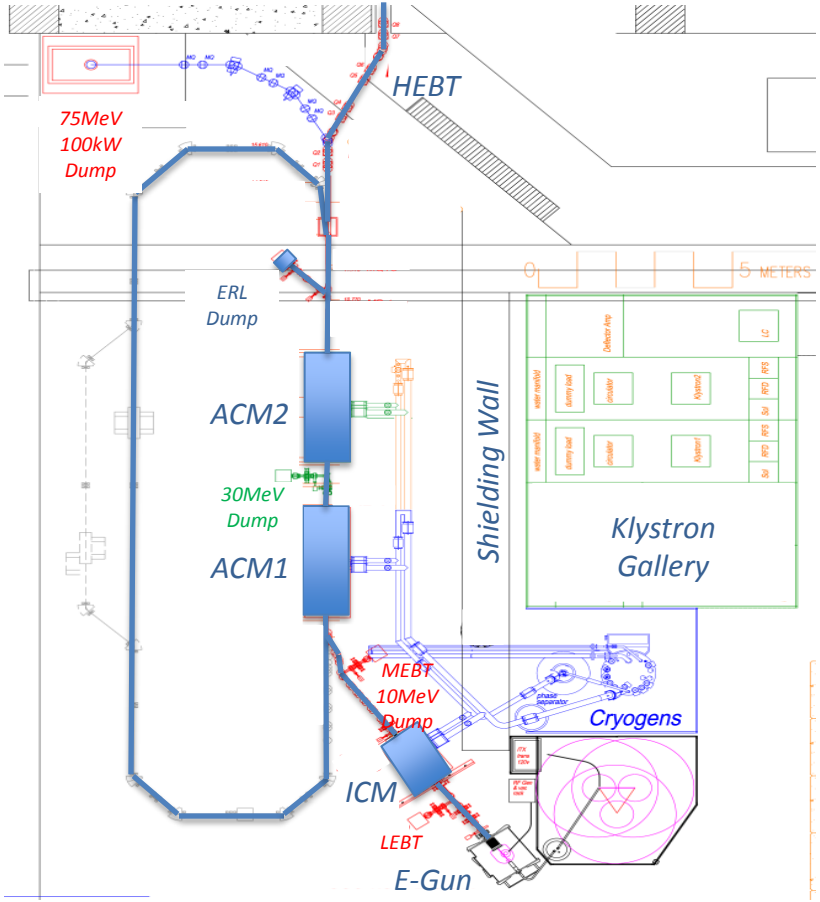


TESLA Technology Collaboration Meeting 26-29 June 2018

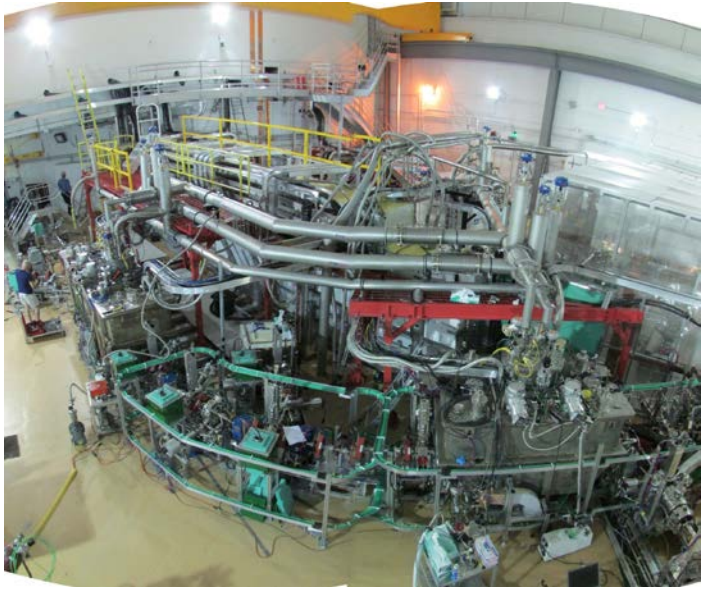
- 500MeV cyclotron since 1974
  - ~300μA distributed to multiple beamlines
- ISAC since 1995
  - Radioactive ion beam (RIB) facility
  - Driven by 500MeV protons from cyclotron
- ARIEL in progress (2010-2023)
  - e-Linac being commissioned – demonstrator beam in 2014
    - Will drive RIB production in new ARIEL target area (e-line in progress)
  - BL4N proton line
    - Will drive second ARIEL RIB production target



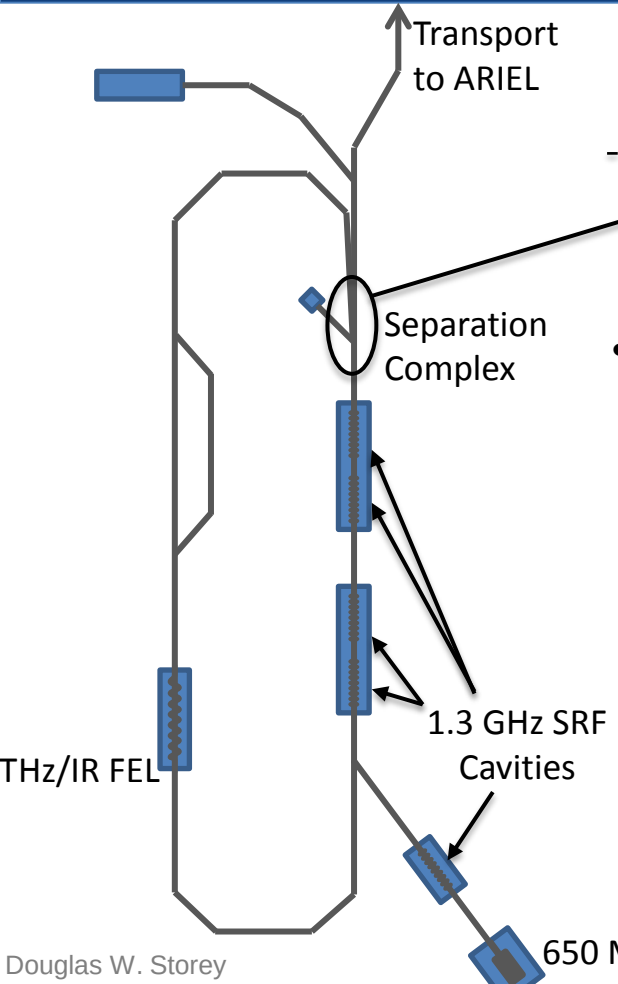
The ARIEL e-Linac as a recirculator



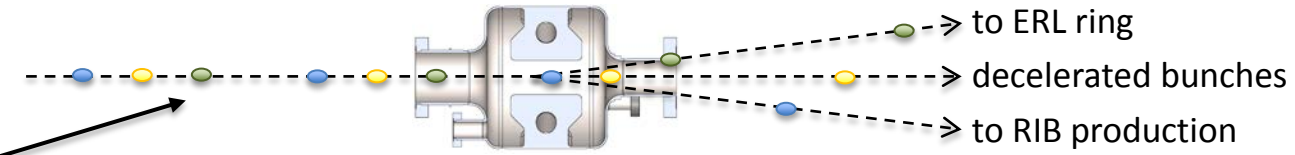
The ARIEL e-linac (50MeV, 10mA) is configured to allow future operation as an energy recovery linac (ERL) for accelerator studies and applications



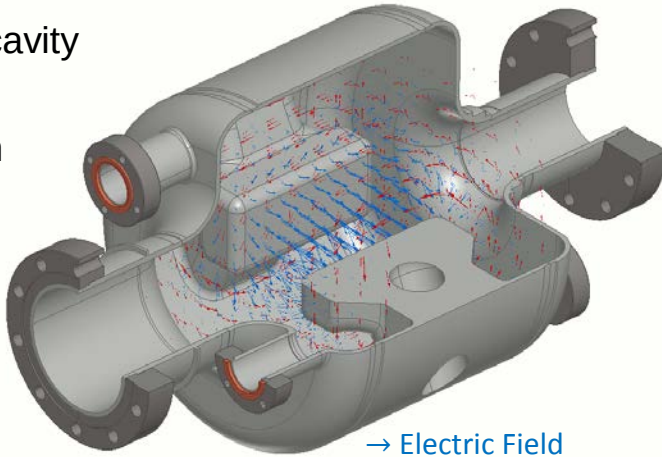
RF Separation of Interleaved Beams



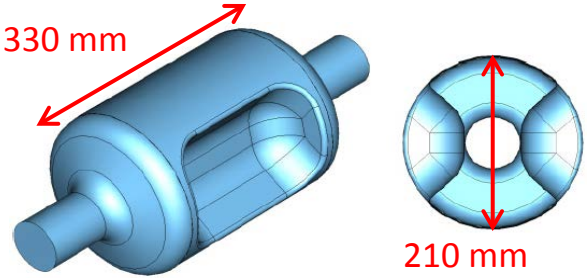
An RF cavity provides 3-way beam separation

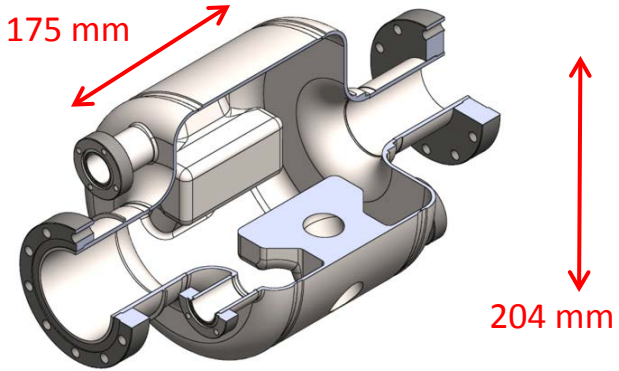


- Simultaneous beam delivery to both RIB production and an ERL/FEL requires RF separation of interleaved bunches
  - 650 MHz SRF deflecting mode cavity
  - Operates at 4 K
  - Provides 0.3 – 0.6 MV deflection
  - Shunt impedance of 625 Ω
  - Peak fields < 10 MV, 12 mT
  - 0.35 W power dissipation



Design – Post and Ridge – H-mode



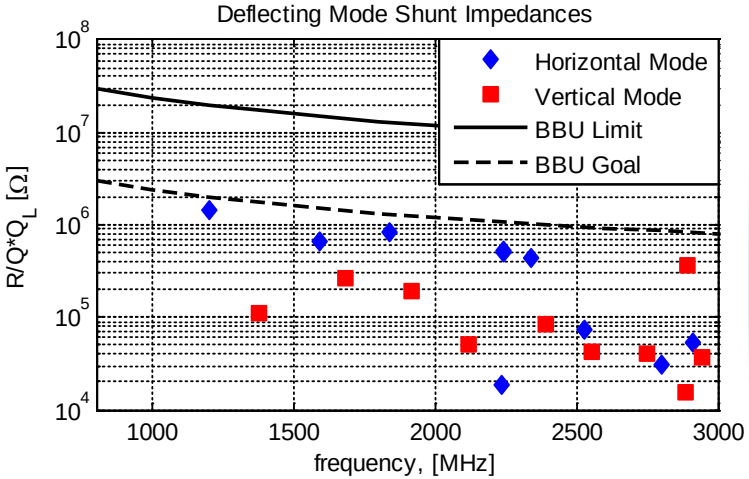


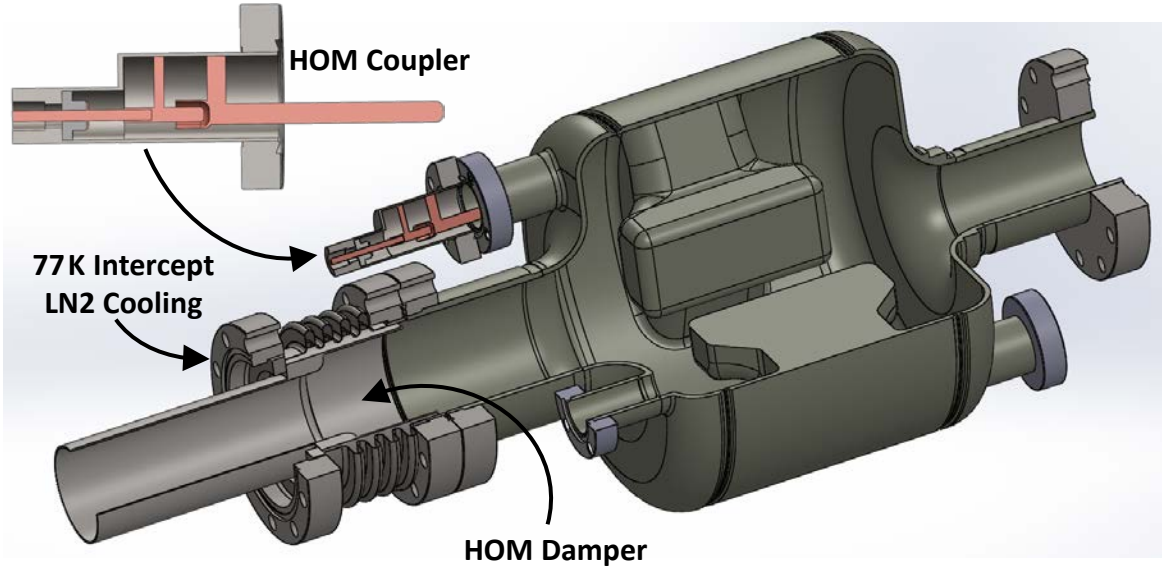
Specifications call for a relatively weak transverse voltage (0.3/0.6MV) so a post and ridge variant was chosen – reduces negative contibution from magnetic field increasing shunt impedance at the expense of peak surface fields

Parameter	RFD	Post and Ridge	Units
Frequency of the deflecting mode	650	650	MHz
First HOM frequency	1000	935	MHz
Cavity length	330	175	mm
Cavity diameter	210	204	mm
Inner ridge length	198	105	mm
Transverse deflecting voltage, $V_\perp$	0.3	0.3	MV
Geometry Factor, G	117	99	Ω
Transverse Shunt Impedance, $R_\perp/Q$	411	625	Ω
$R_\perp R_s$	48,000	62,000	Ω^2
Peak electric field at 0.3 MV, E_p	4.5	9.5	MV/m
Peak magnetic field at 0.3 MV, B_p	7.8	12	mT

HOM Damping Strategy

- Damping of Higher Order Modes is important due to high current CW beam
- Two types of HOM dampers used:
  - HOM Coupler: antenna with 650 MHz filter
  - HOM Damper: resistive coaxial beam pipe insert, cooled by LN2
- Modes damped to below goal imposed by multi-pass Beam Break-Up

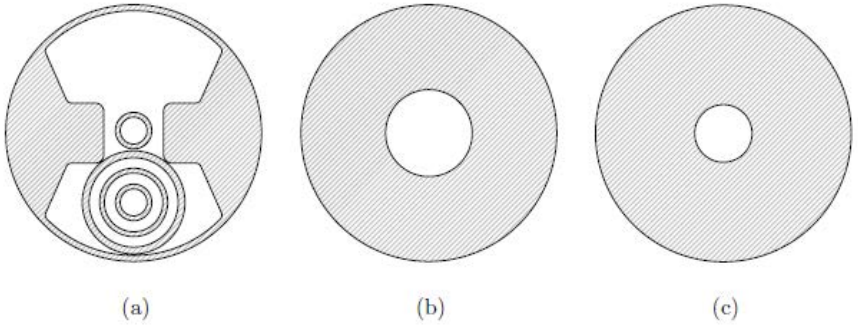


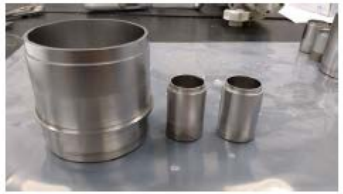


Fabrication

Novel (low cost) fabrication techniques were employed

- Reactor grade Nb (RRR-45) was used with machining from a solid block – EDM used to cut-out beam pipes and HOM and coupler ports
- Cu cavity fabricated to prove the machining

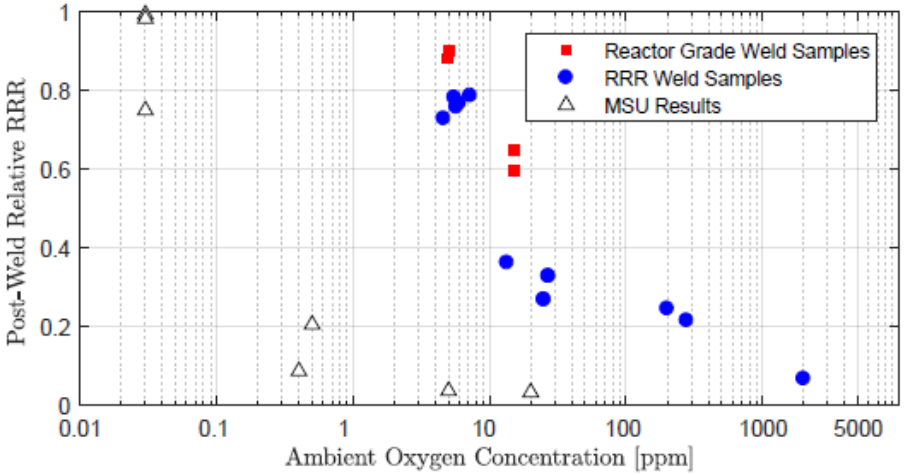


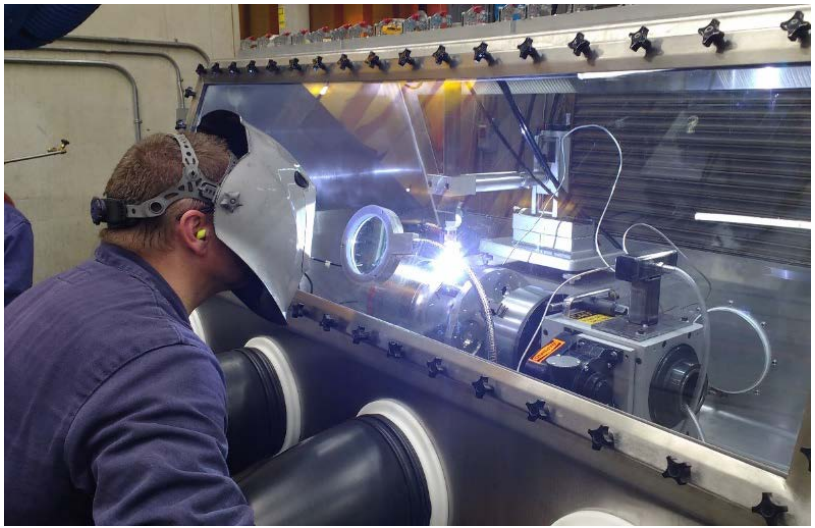


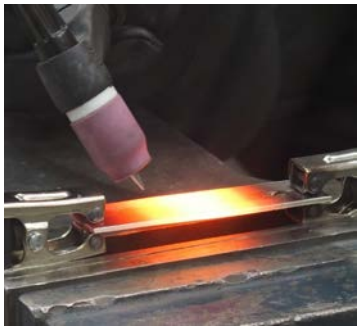
Fabrication

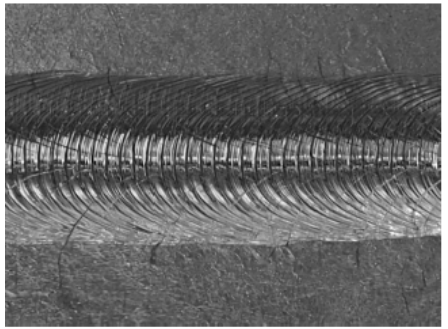
Novel (low cost) fabrication techniques were employed

- Tungsten Inert Gas (TIG) welding developed as an alternative to electron beam welding
- Samples were welded and RRR measured to qualify the process





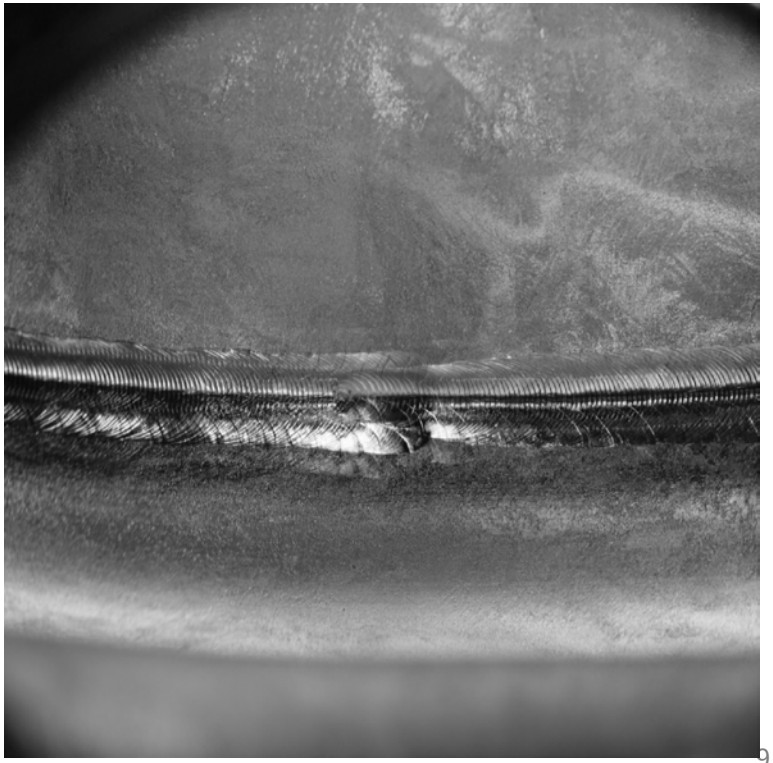




Completed Cavity

First cavity fabricated in the TRIUMF Machine Shop

Inner weld seam



Preparations for Cold Test

Etching…

Rinsing…

Assembling…

Ready to go!

Into the cryostat...

Surface finish

BCP on reactor grade material led to an uneven finish – cracks appeared on ridge

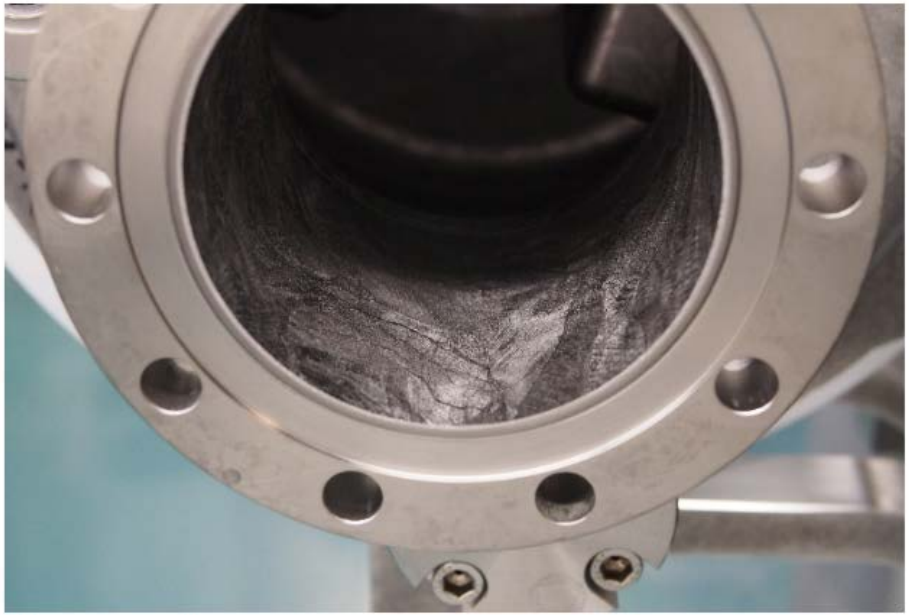


Figure 2: The surface appearance of the upstream beam pipe after the 120 μm etch.

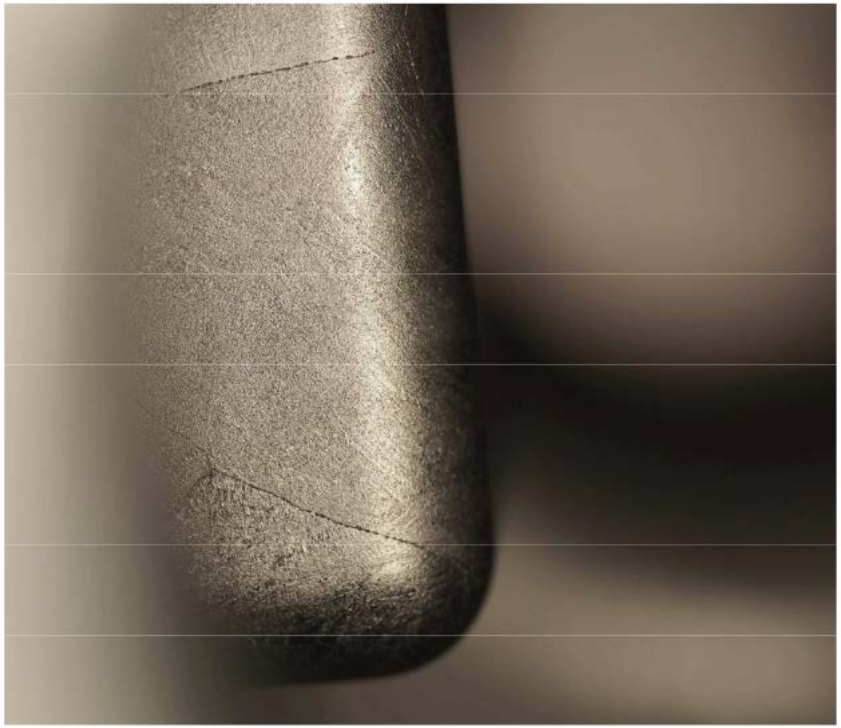
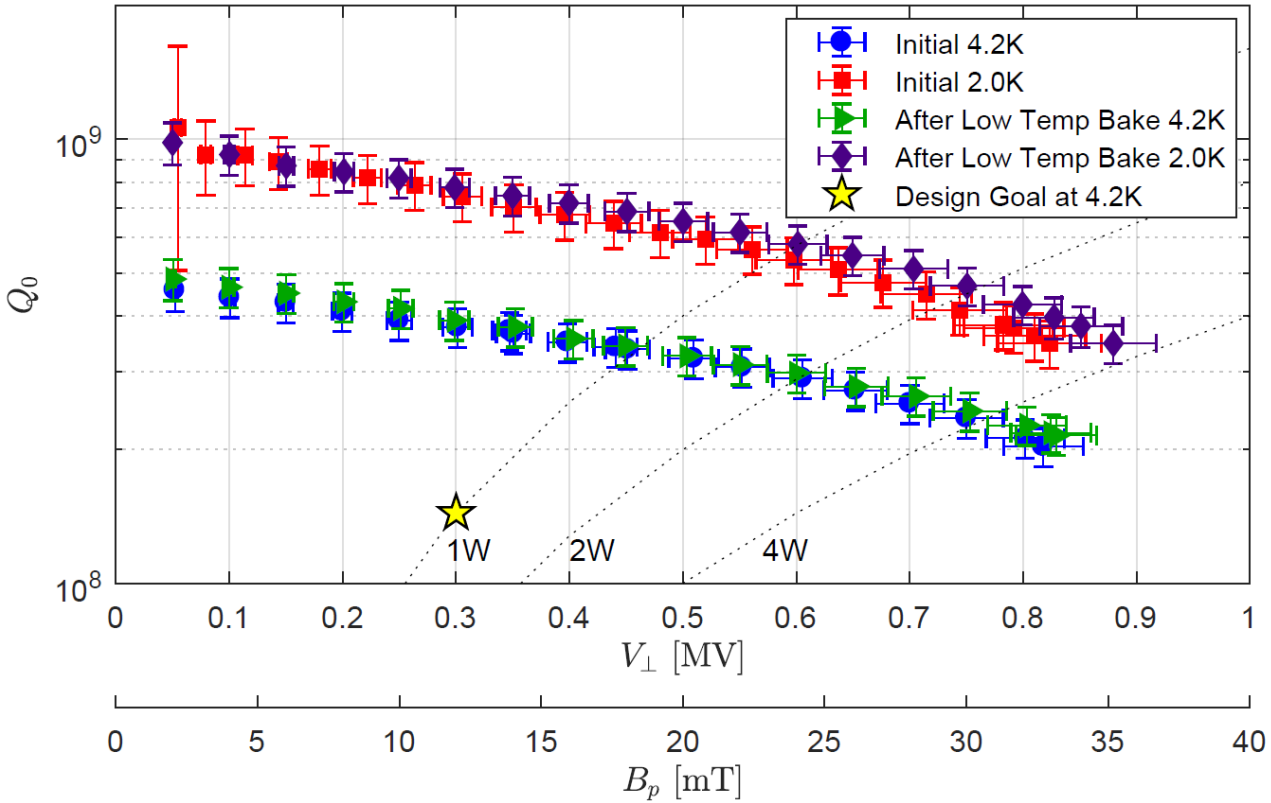


Figure 3: The surface appearance of the ridge showing the pitting after the 120 μm etch.

Cold Test Results

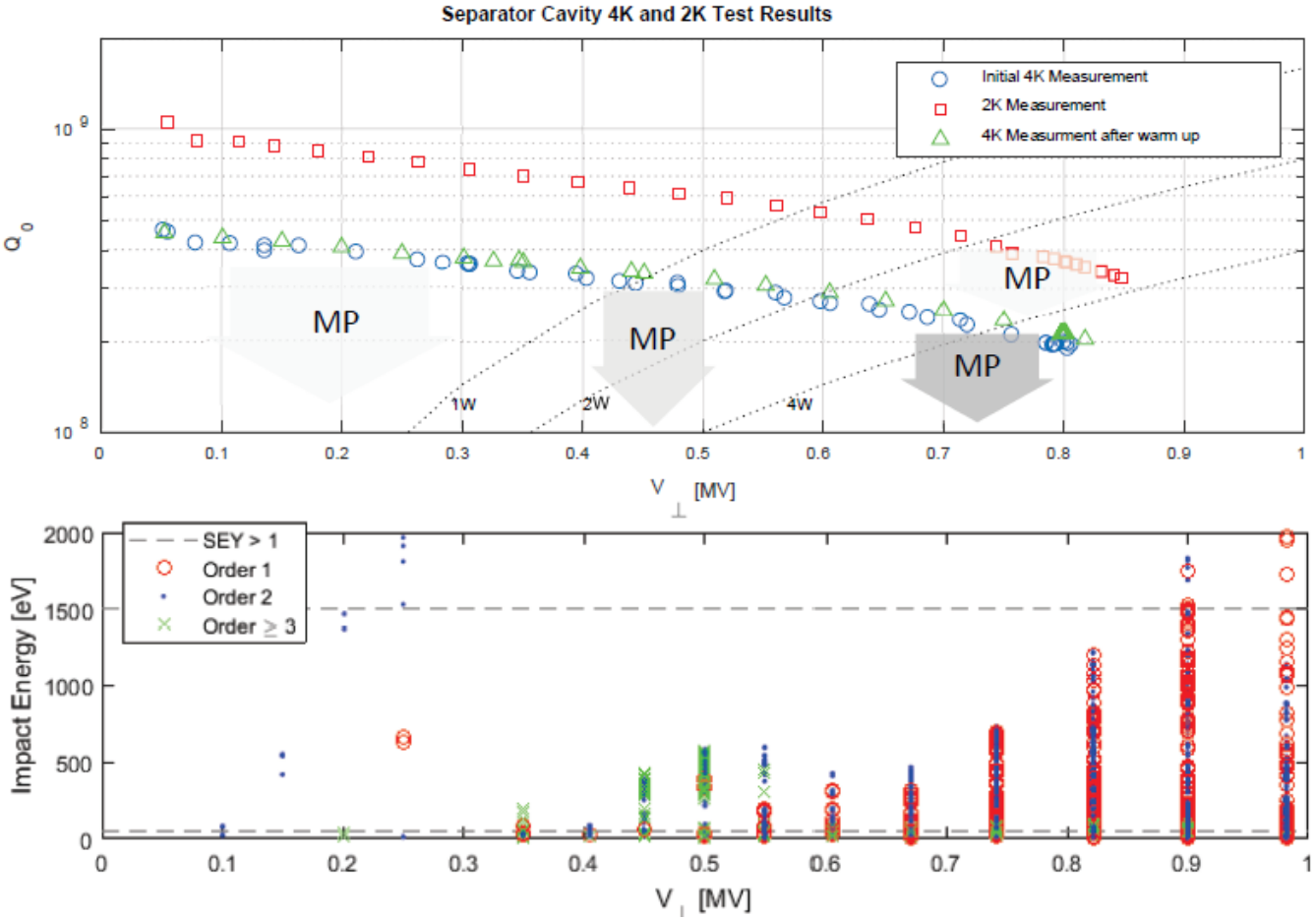


Main Results:

- Cavity surpassed design specification for voltage and quality factor
- TIG welds did not cause any issues
- No Q-disease from 100K soak
- Df/dp=9.7Hz/mbar

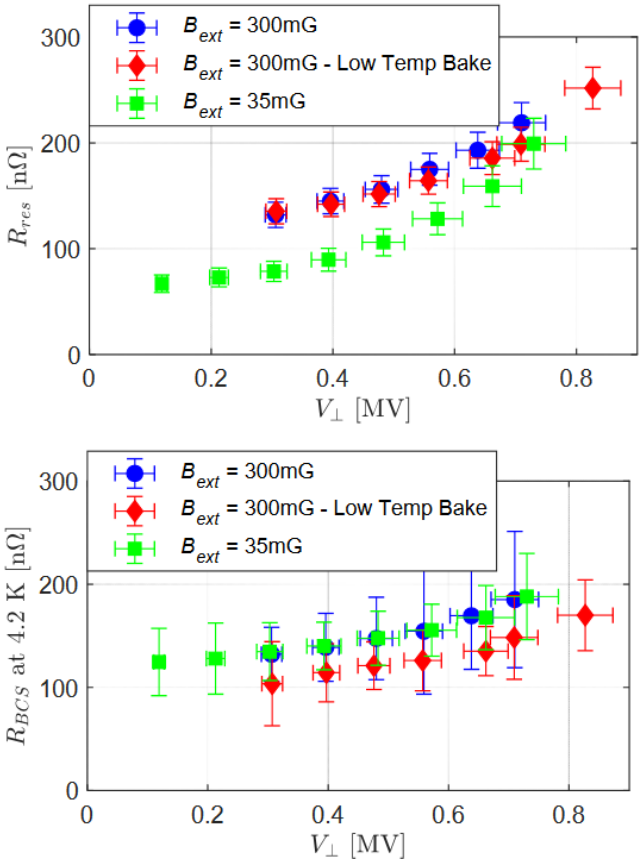
Multipacting

Several MP levels but all easy to condition after 5-10 minutes.



Surface resistance

- The cavity test was repeated several times – with and without bake and in high (300mG) and attenuated magnetic field (35mG)
- In general the residual resistance is high [Ro=(130,70)nΩ at B=(300, 35)mG] with significant Q-slope
- The BCS resistance at 4.2K is R_{BCS}=120n Ω without bake and 100nΩ with bake
- A test after a 100K soak showed the that cavity is insensitive to Q-disease



Acknowledgements

- Many thanks to:
  - Entire SRF group
  - Machine shop
  - CMMS
  - Cryogenics group
  - Design office, Targets group, Detector group, and more
  - Chris Compton (FRIB)

This Week:

- June 25: Hon. Kirsty Duncan (Minister of Science) announced $10M in funding for Canada's contribution to the High Luminosity Large Hardon Collider upgrade project - `Great scientists know that success lies in strong collaboration.'
- DOE is producing and qualifying 10 RFD crab cavities for HiLumi
- TRIUMF has just received funding to build the 5 RFD CMs