A New Electropolishing System For Low-β SC Cavities

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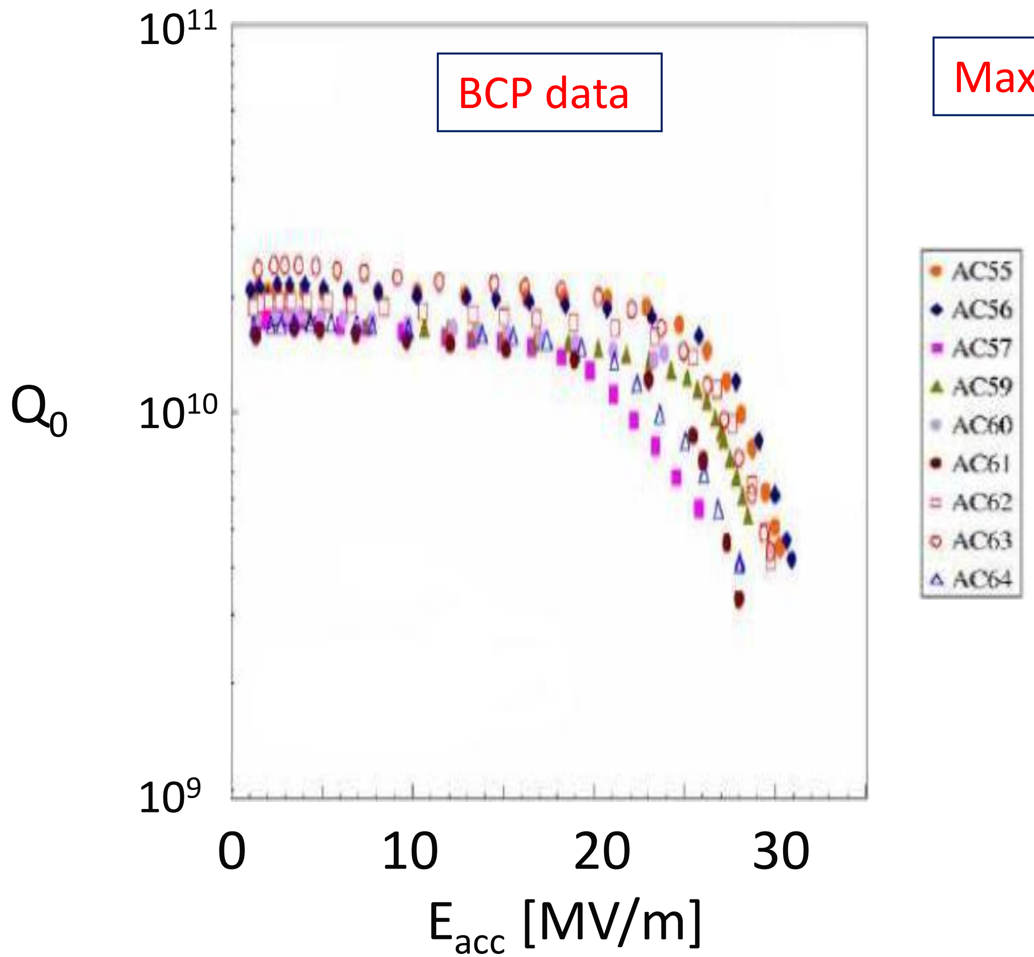
Outline

1. BCP or EP
2. Brief History of EP at ANL
3. New Low-β SC Cavity EP Tool
4. Summary

BCP or EP

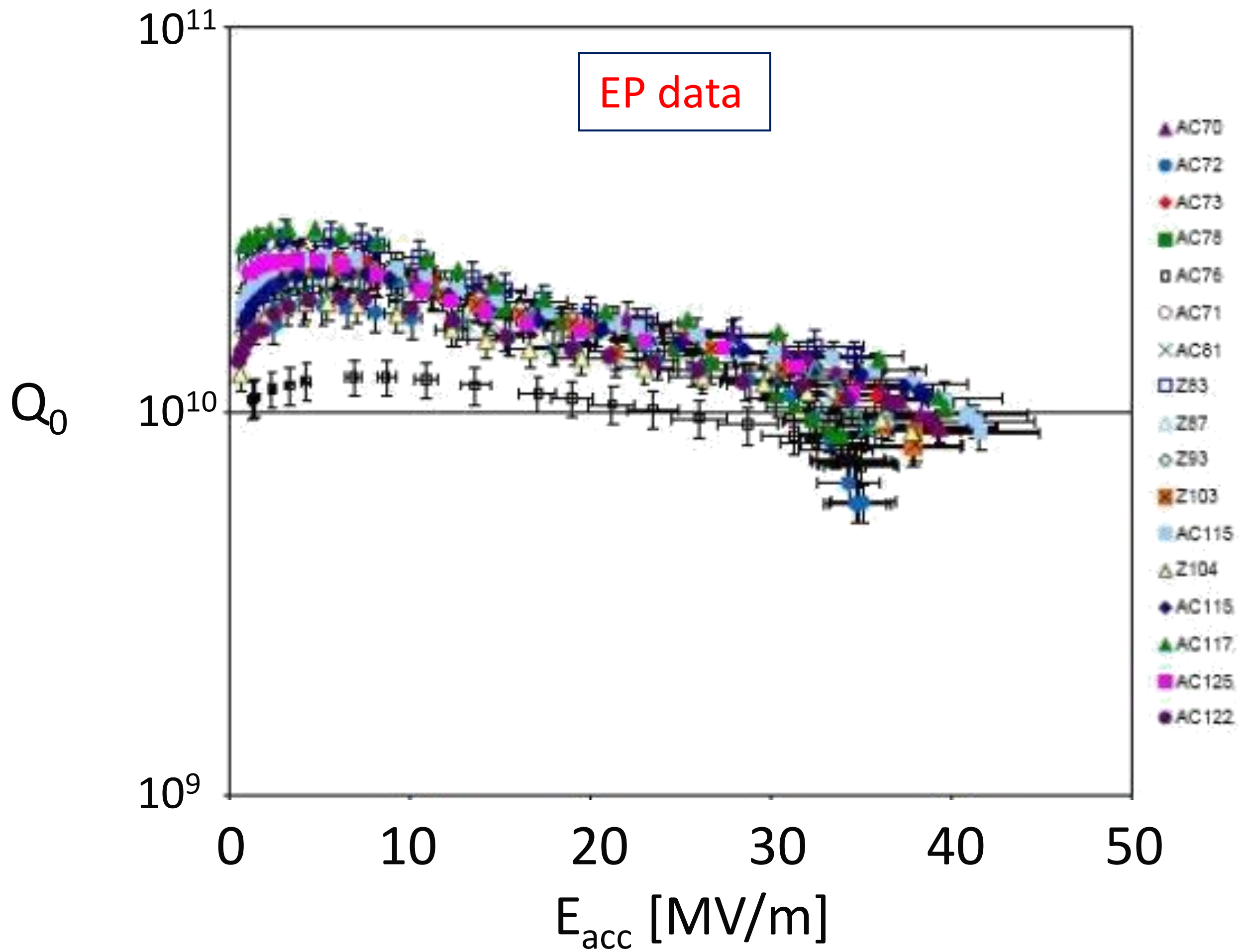


Max gradient ~ 25-30 MV/m

L. Lilje et al., DESY

BCP or EP

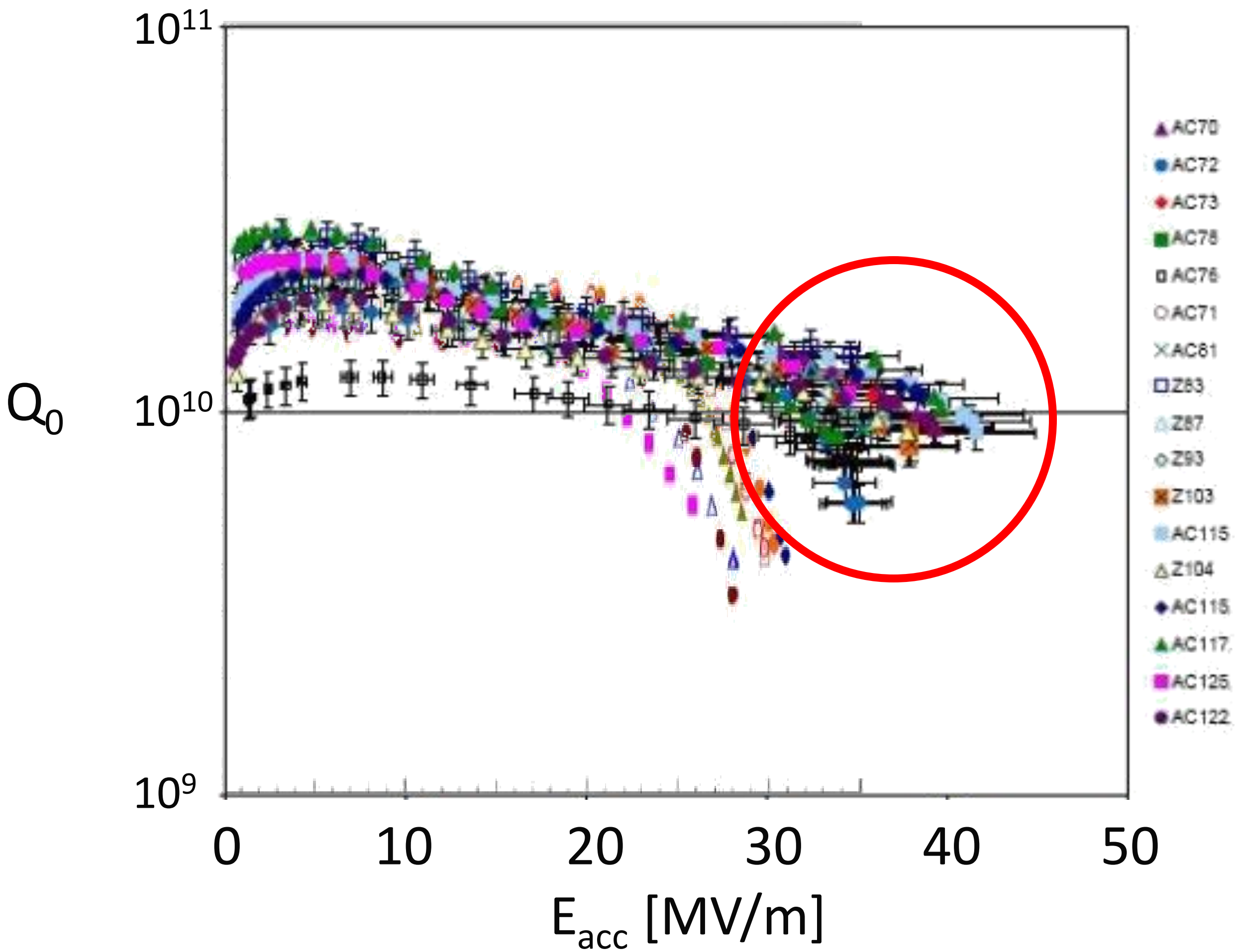
Max gradient ~ 35-40 MV/m



L. Lilje et al., DESY

BCP or EP

~20% higher than BCP

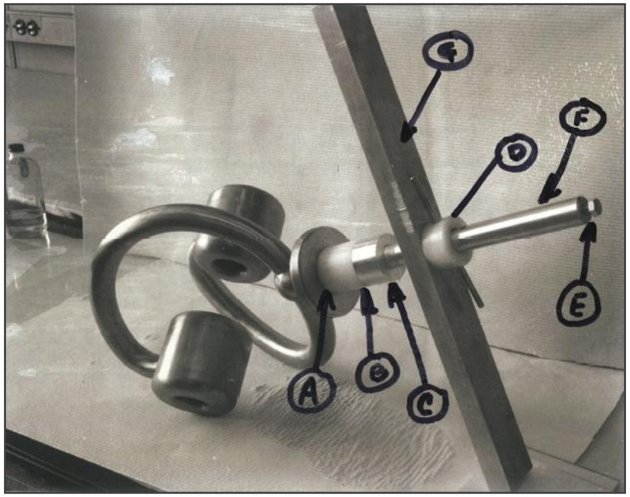


BCP or EP

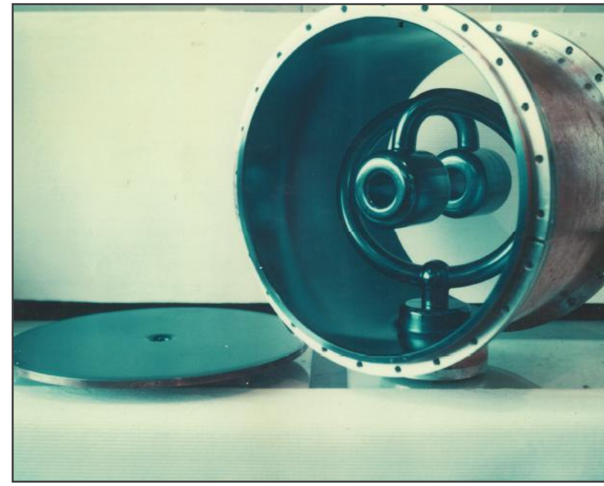
- EP produces higher average gradients than BCP in elliptical cell cavities
- The effect is likely fundamental and similar for low-β cavities
- Other benefits:
  - EP can be repeated without making surface progressively worse
  - Offers long term cost benefit for next generation machines by maximizing real estate gradient

D. Reschke – TUPO046
R.L. Geng – TUPO049
S. Aderhold – WEIOB05
J. Halbritter – THPO004
K. Saito – THPO013
A. Romanenko – THPO022
C. Xu – THPO046

EP at ANL



SPLIT RING – 1976



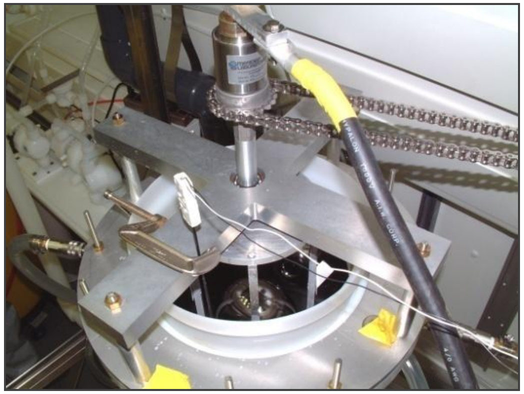
SPLIT RING - 1976

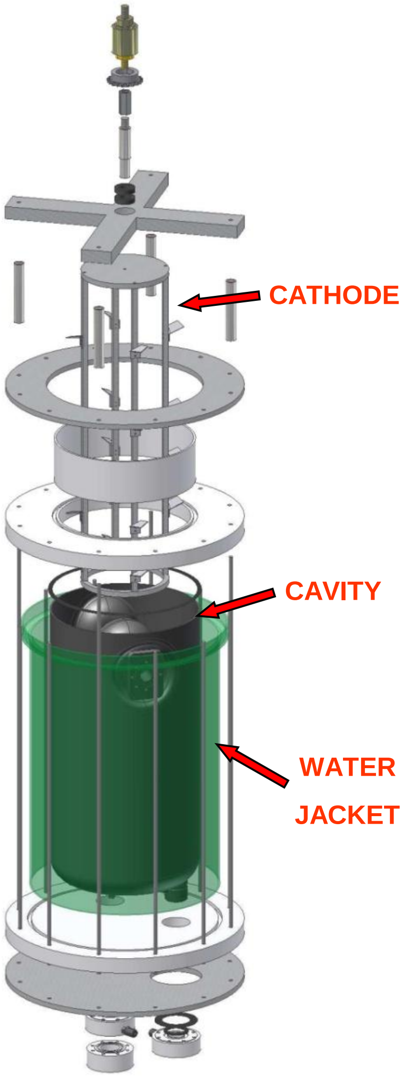
TRIPLE SPOKE – 2004

QUARTER-WAVE – 2004

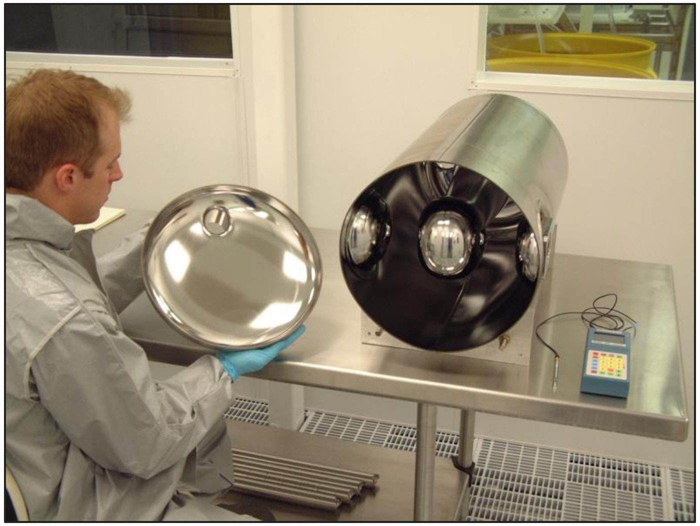
HALF-WAVE – 2004

EP at ANL – ATLAS Energy Upgrade

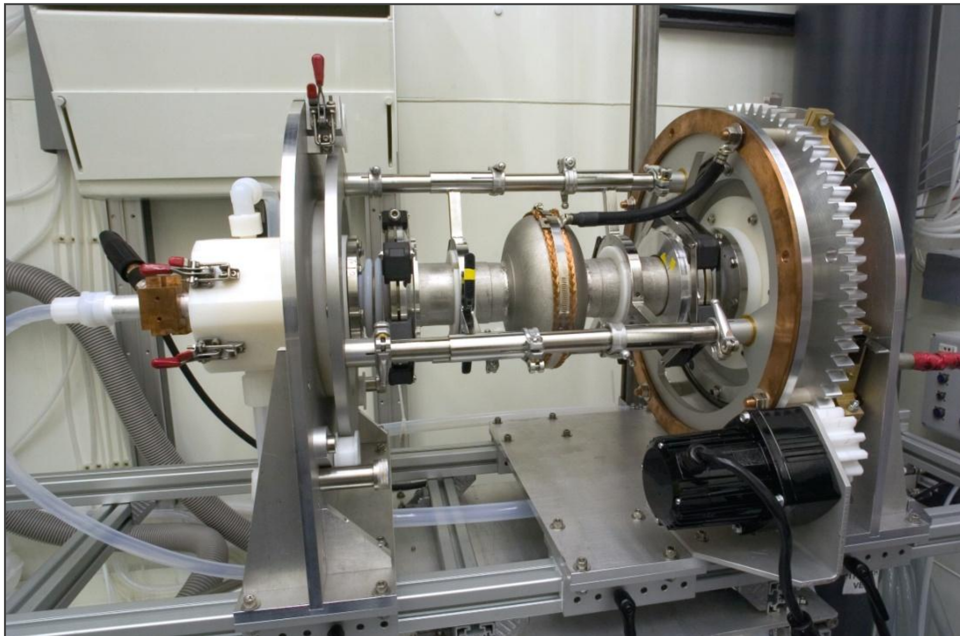




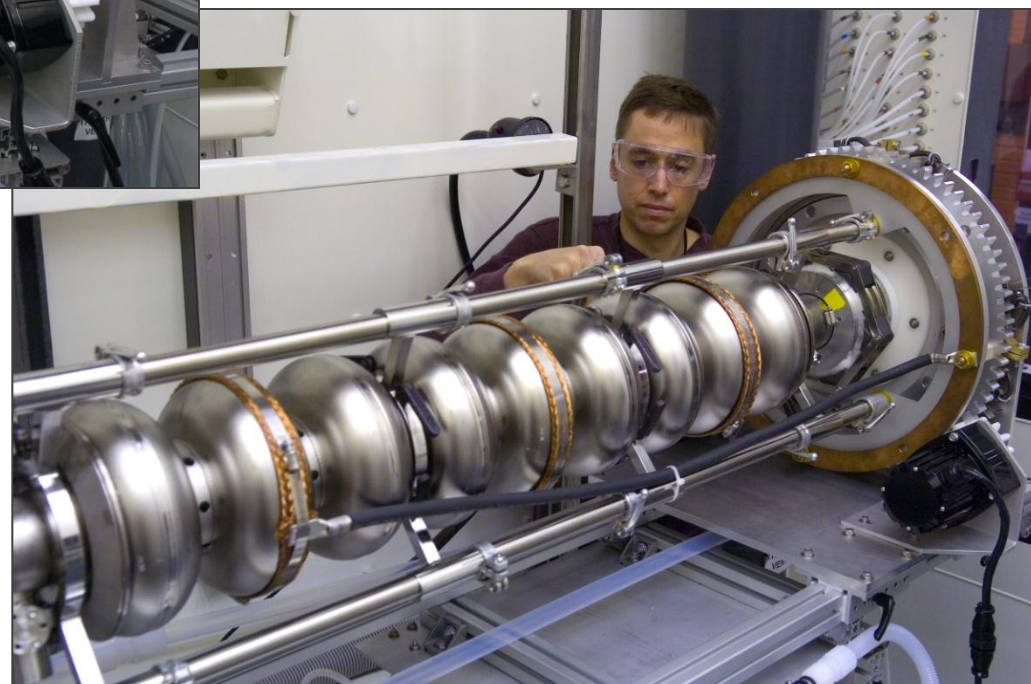
- Unique cathode design minimized EP to only two major assemblies
- Integrated direct water cooling
- Still needed one final E-beam closure weld followed by flash BCP



EP at ANL – Global ILC Effort

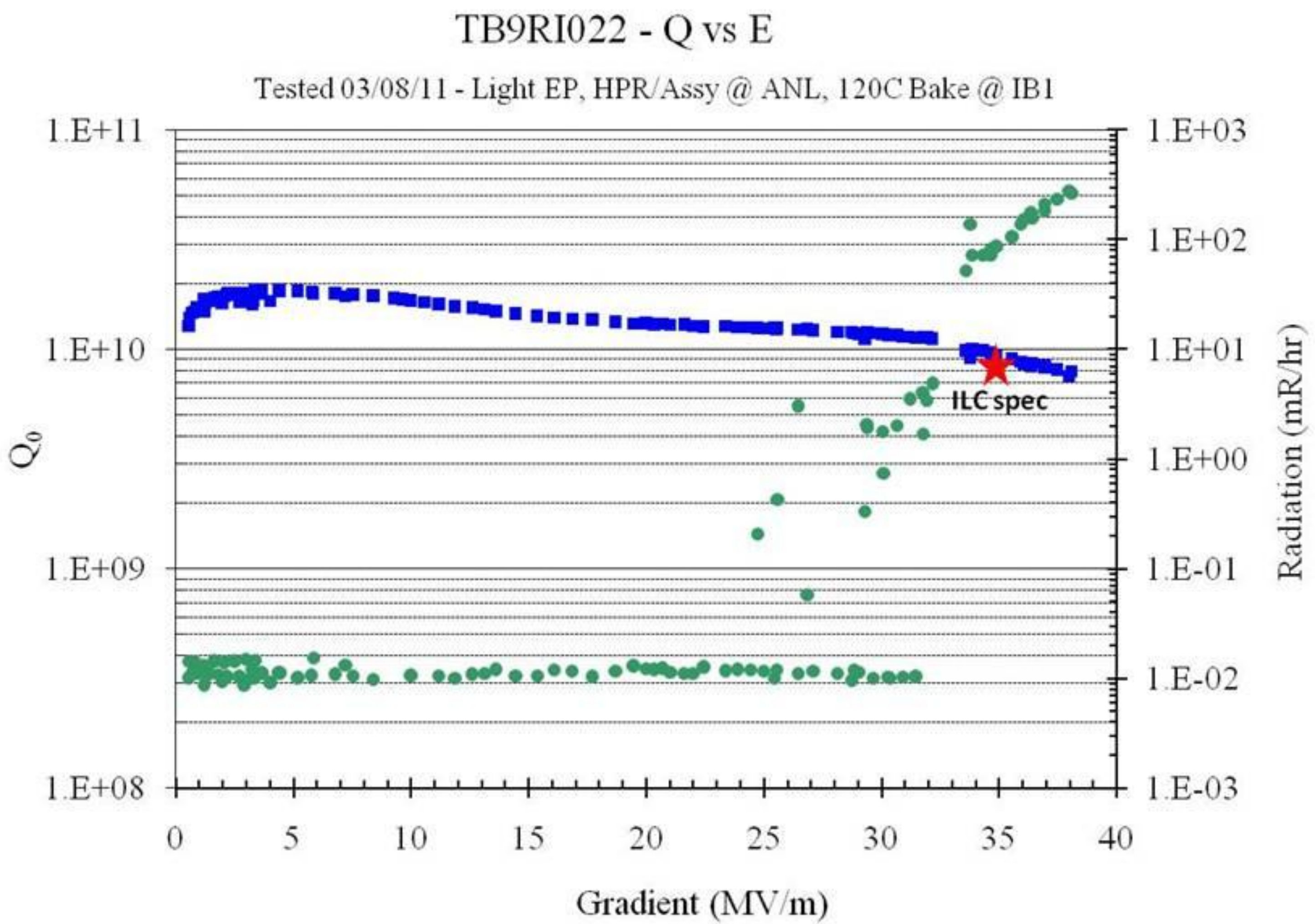


- Horizontal EP
- Teflon rotary lip seals
- Custom rotating copper/carbon brush electrical slip ring assembly
- Adjustable to allow EP of single to 9-cell cavities

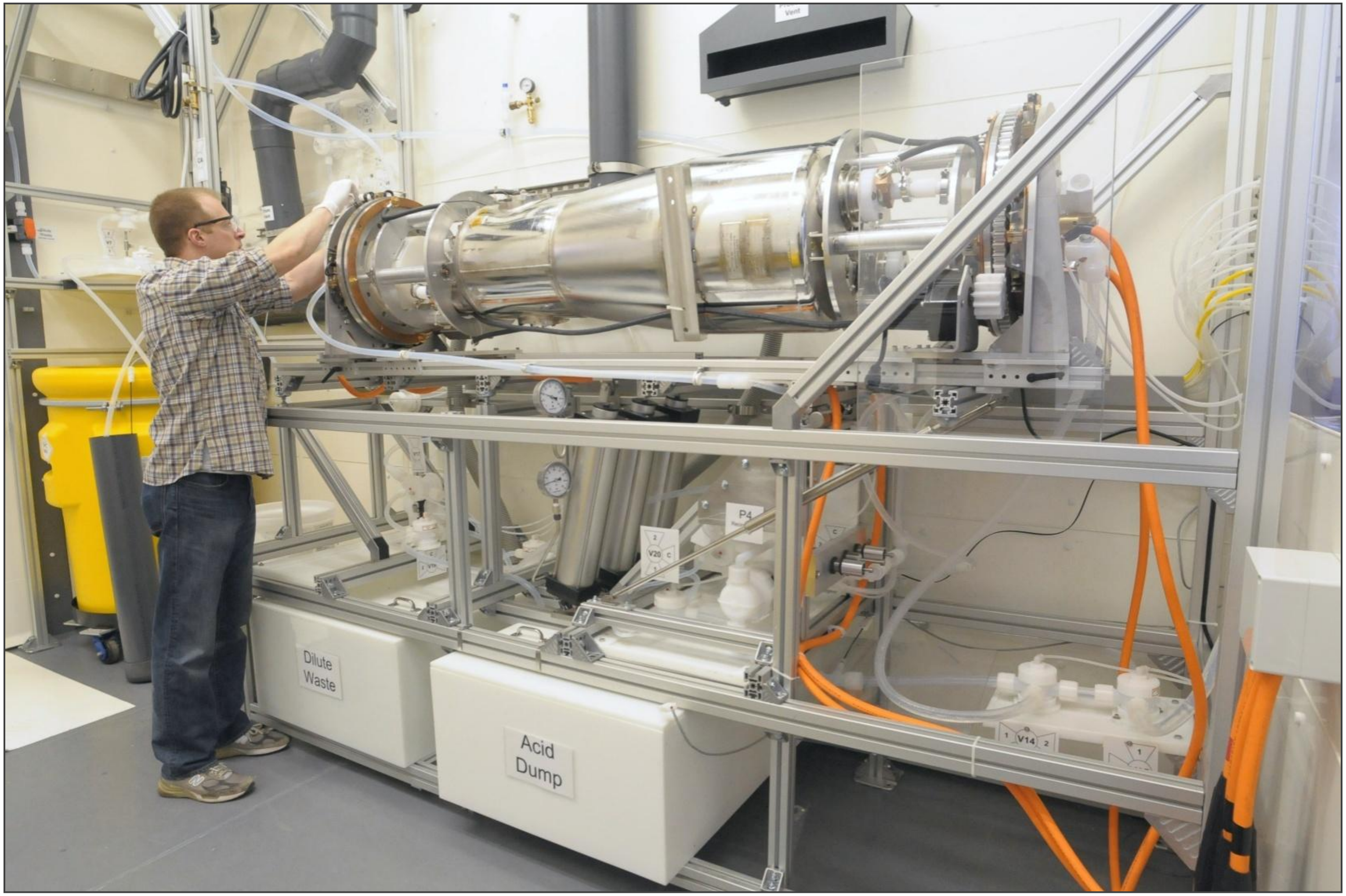


- Pivots to vertical position to drain acid and water rinse
- Continuous N_2 flow to evacuate hydrogen
- User friendly; short installation times
- Many good 9-cell cavities to date

EP at ANL – Global ILC Effort



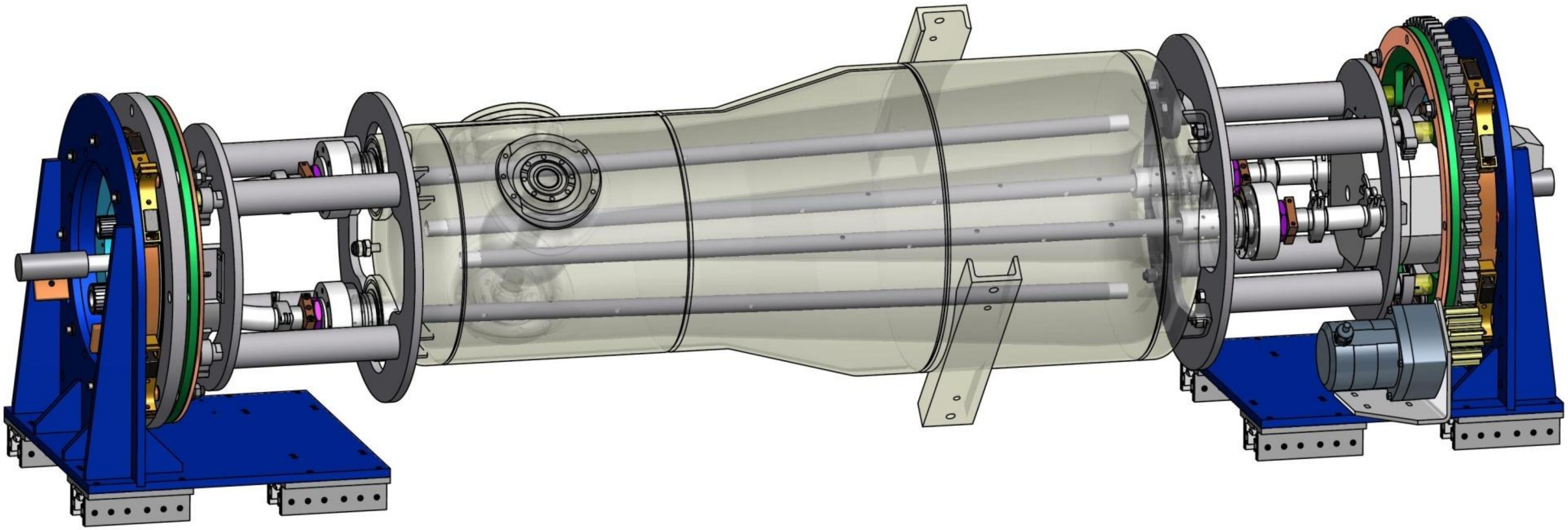
New Low-β SC Cavity EP Tool



New Low-β SC Cavity EP Tool Design Goals

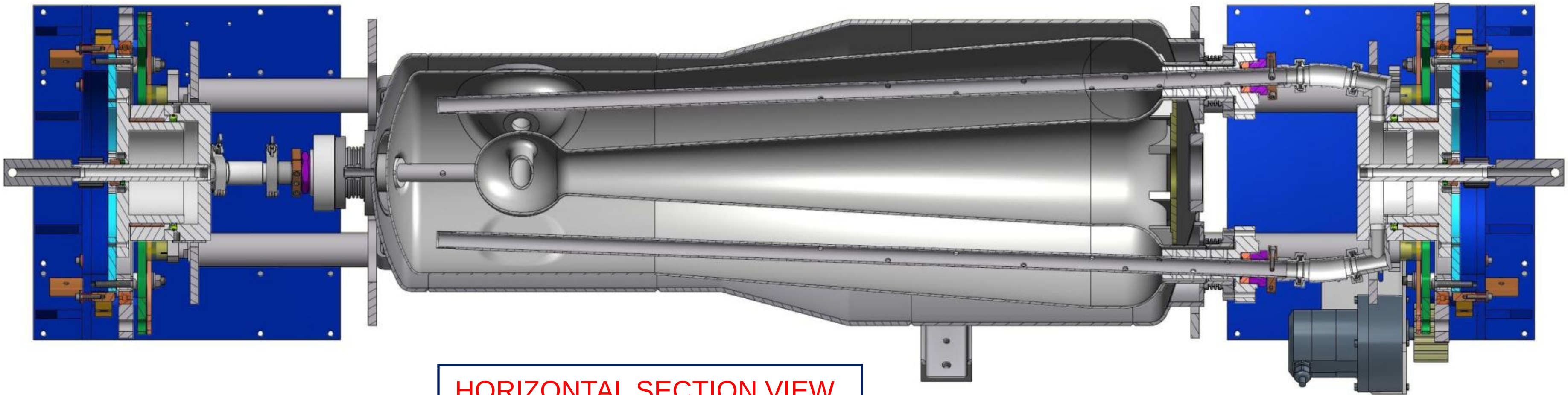
- Ability to EP a complete, fully jacketed cavity
- Direct water cooling through cavity LHe jacket (while cavity is rotating!)
- Two electrical slip ring assemblies to allow rotation of both anode and cathodes
- Enough cathodes to provide adequate polishing
- Cathode loading system to ensure correct cathode alignment inside cavity
- Ability to circulate acid during EP
- Nitrogen purge to evacuate hydrogen
- Within budget (yet still needs to work!)

New Low-β SC Cavity EP Tool

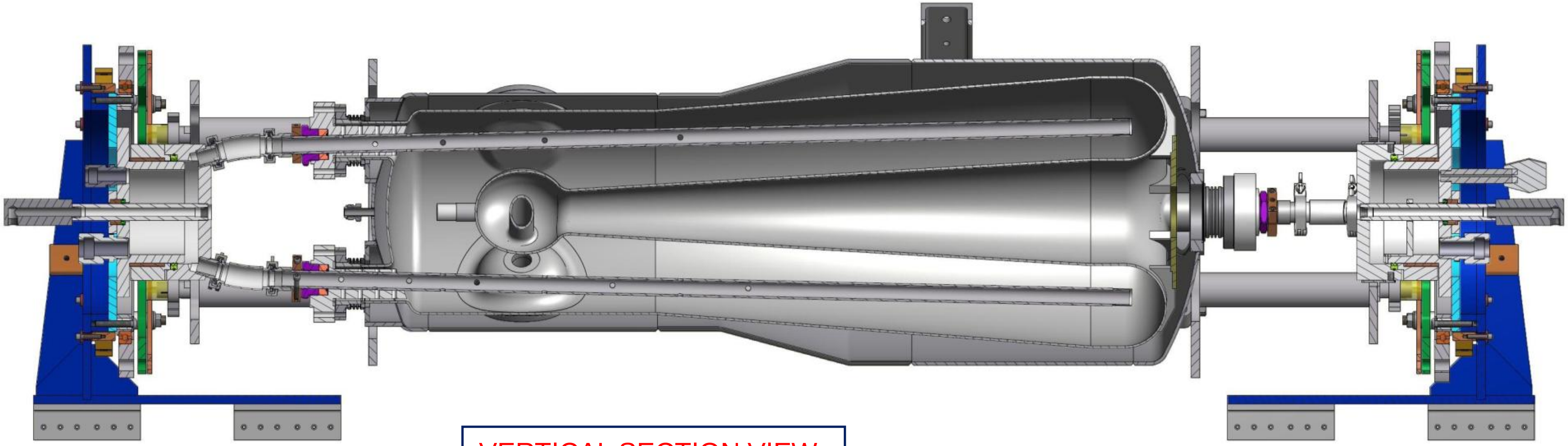


- Designed and built over 8 months for ~$95k and with 4 man-months effort
- Four cathodes which are used to flow both acid and N_2 to evacuate H_2
- Cathode loading done via plastic port flanges
- Direct water cooling achieved by using rotary water feedthroughs and Teflon lip seals
- Load/unload time is ~ 1 hour

New Low-β SC Cavity EP Tool



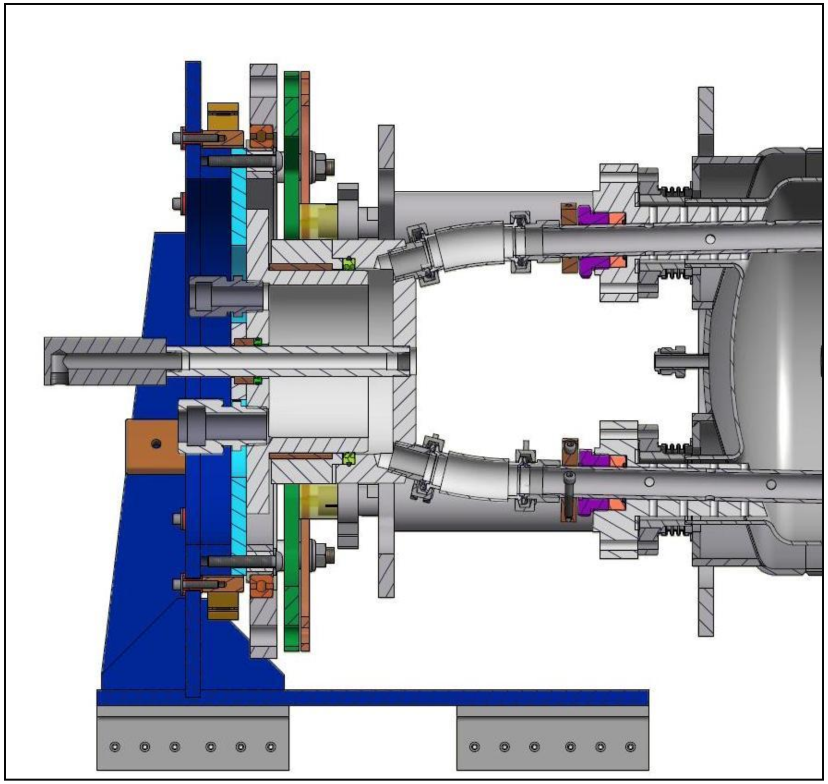
HORIZONTAL SECTION VIEW

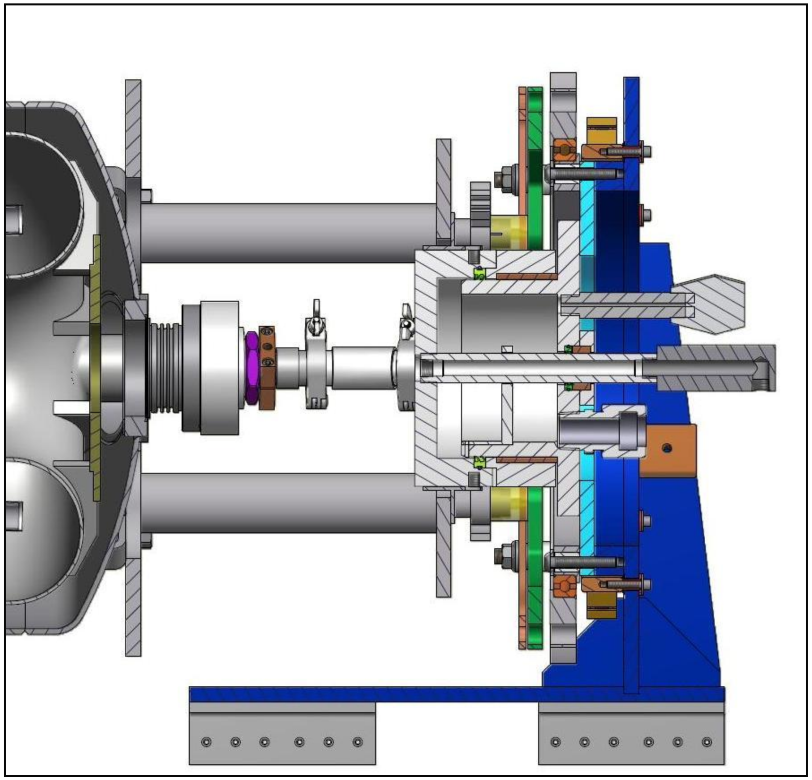


VERTICAL SECTION VIEW

New Low-β SC Cavity EP Tool

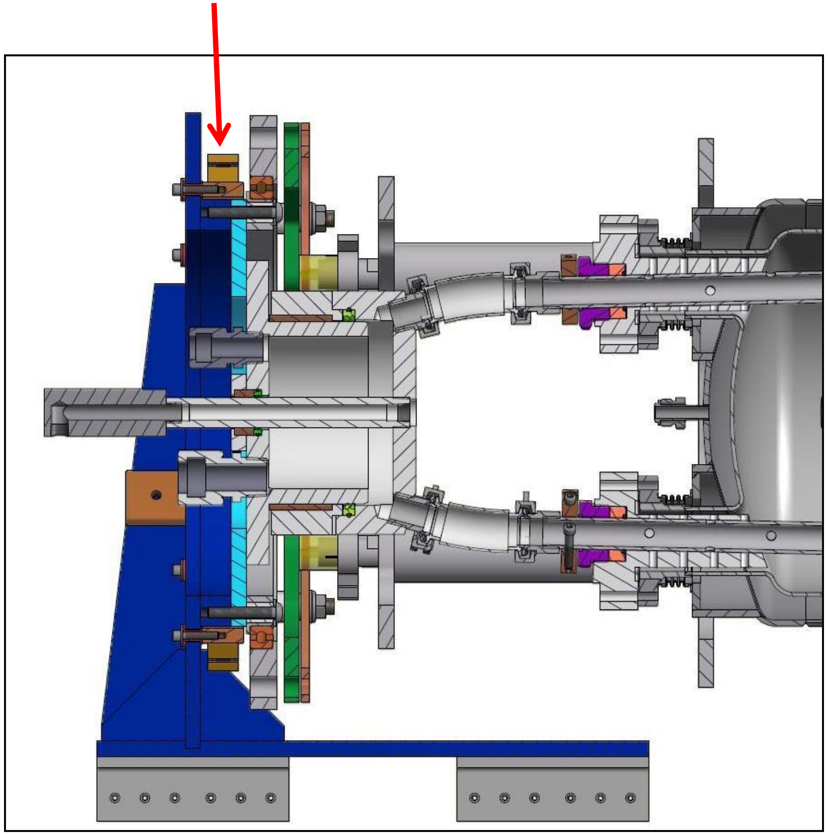
- All acid wetted parts are made from HDPE, UHMWPE, Teflon, Viton, and 3003 series aluminum
- "Bookends" and end groups share many of the same parts



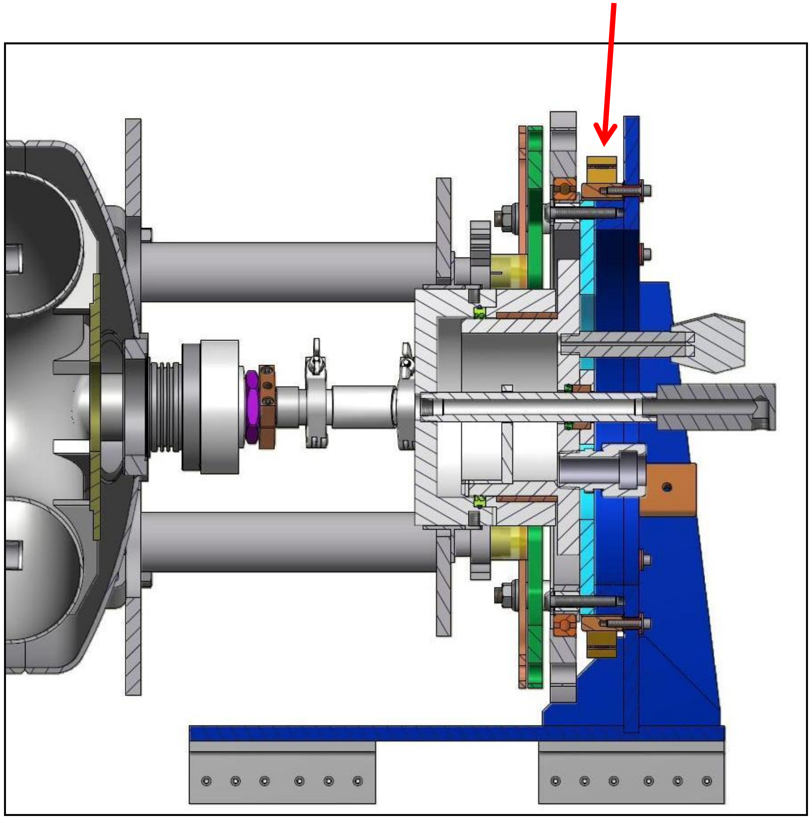


New Low-β SC Cavity EP Tool

ELECTRICAL SLIP RING

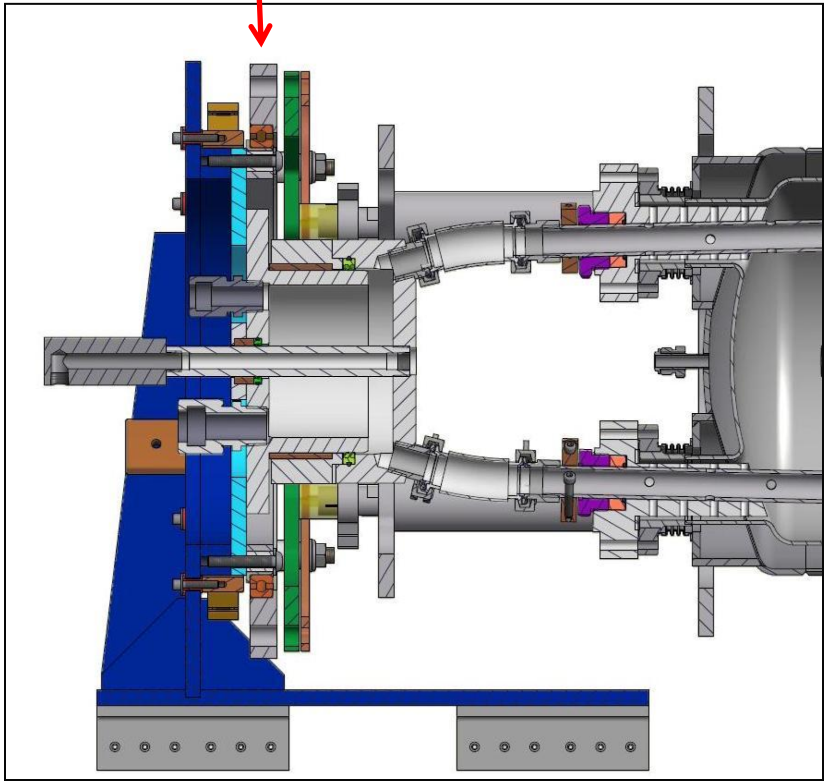


ELECTRICAL SLIP RING

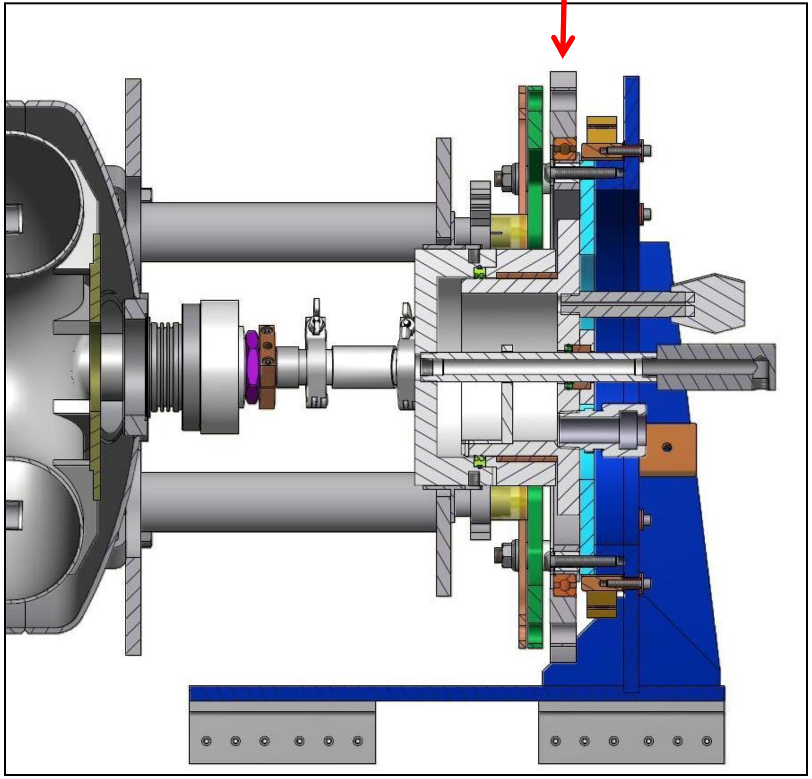


New Low-β SC Cavity EP Tool

BEARING ASSEMBLY



BEARING/GEAR ASSEMBLY



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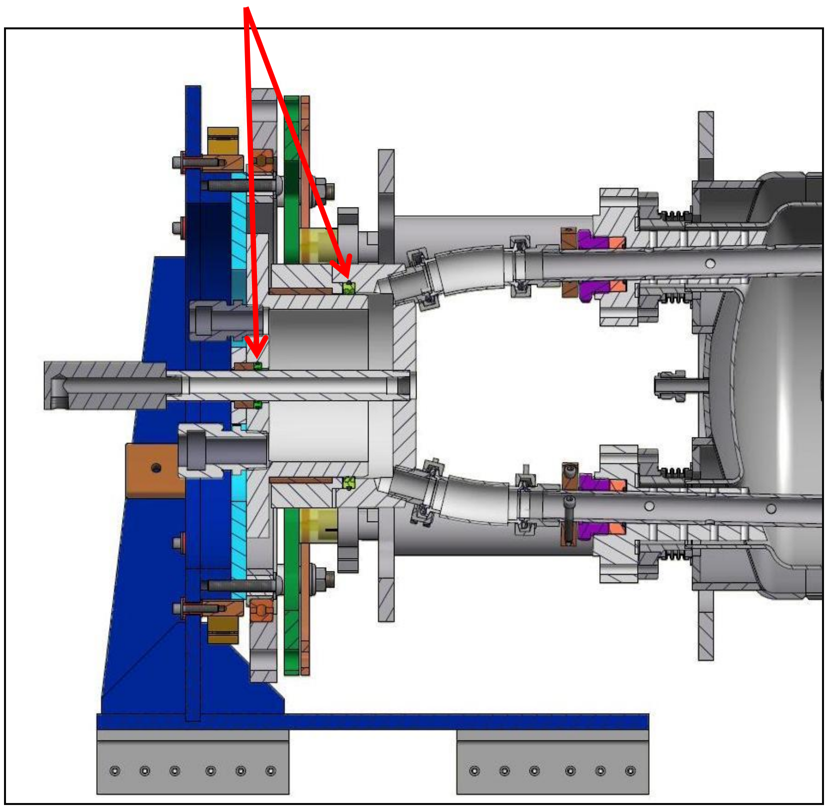
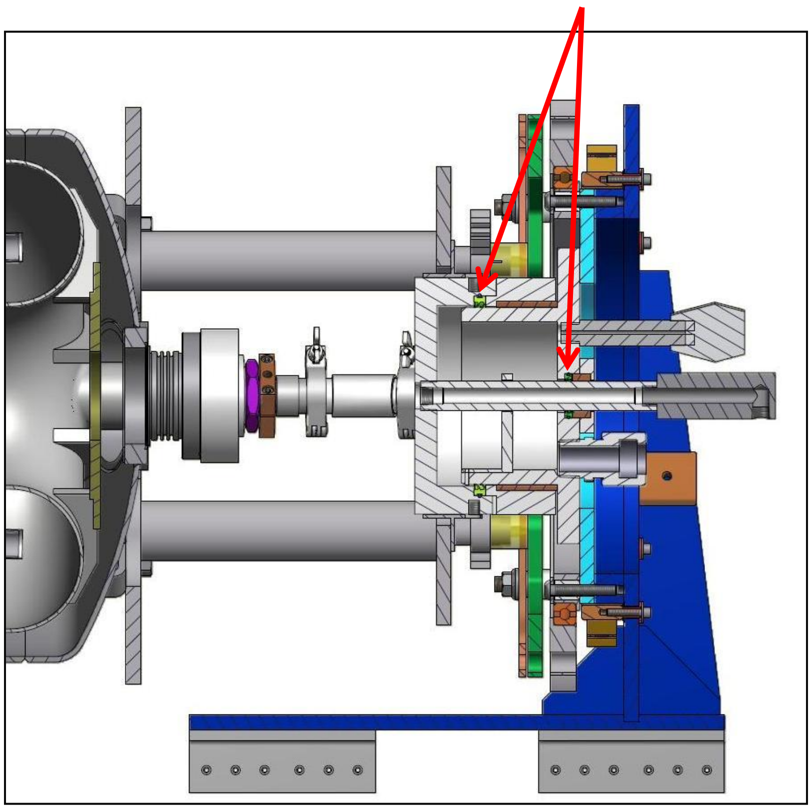
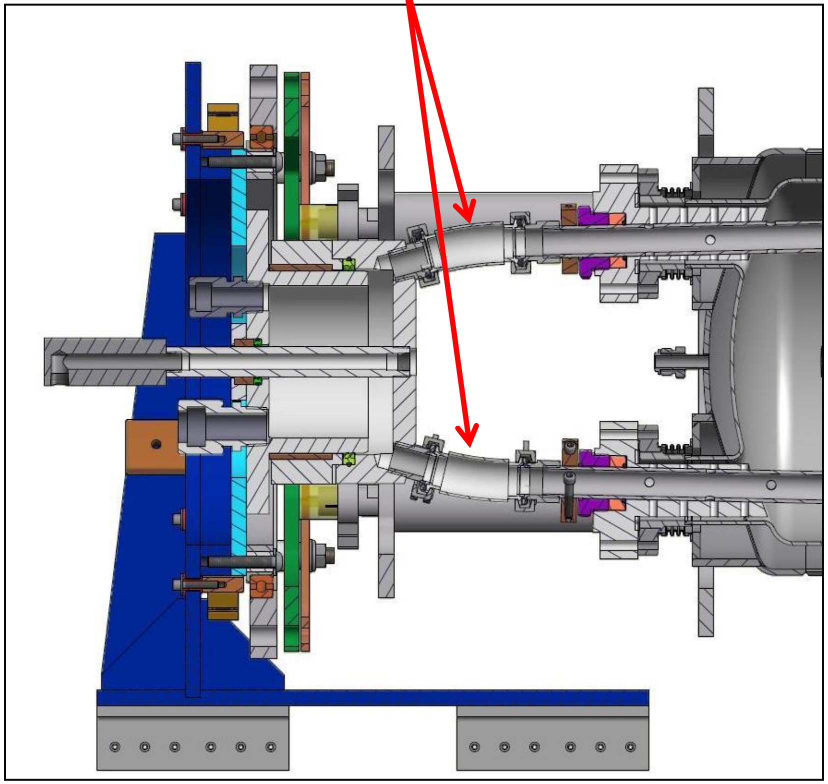




New Low-β SC Cavity EP Tool

TEFLON ISO-KF BELLOWS



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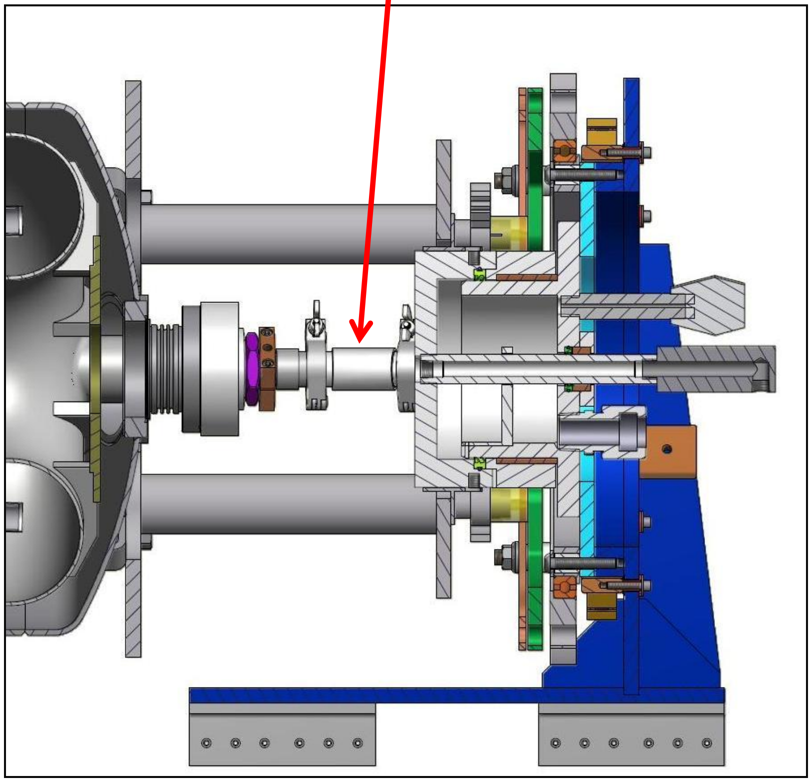

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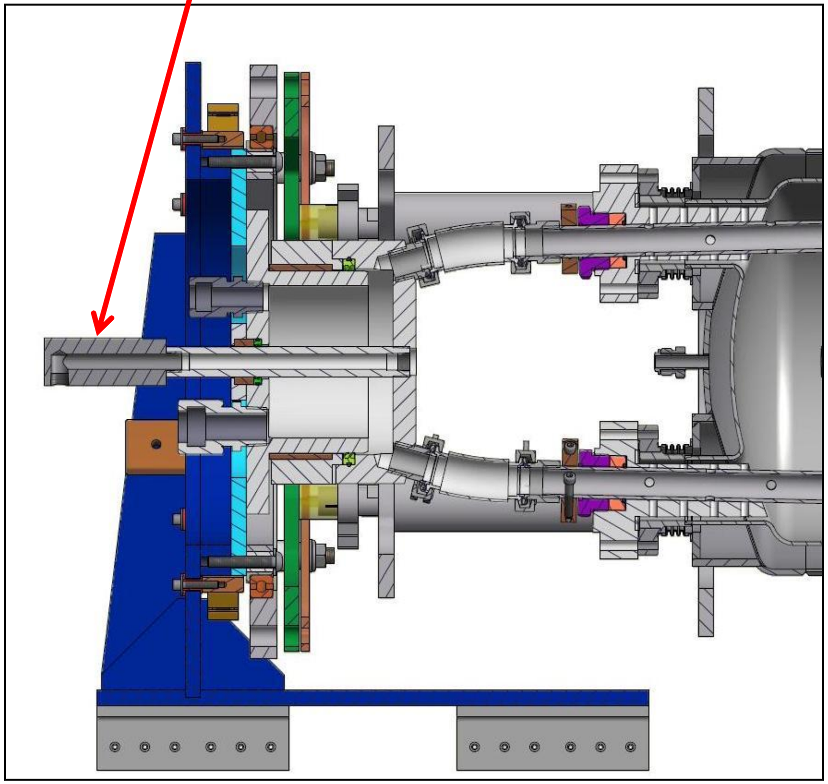

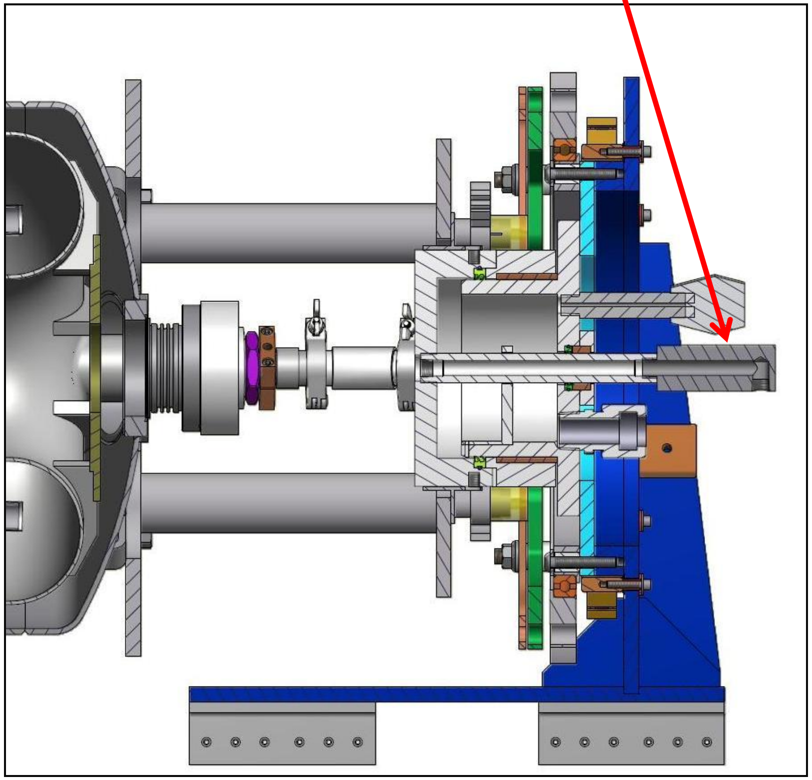

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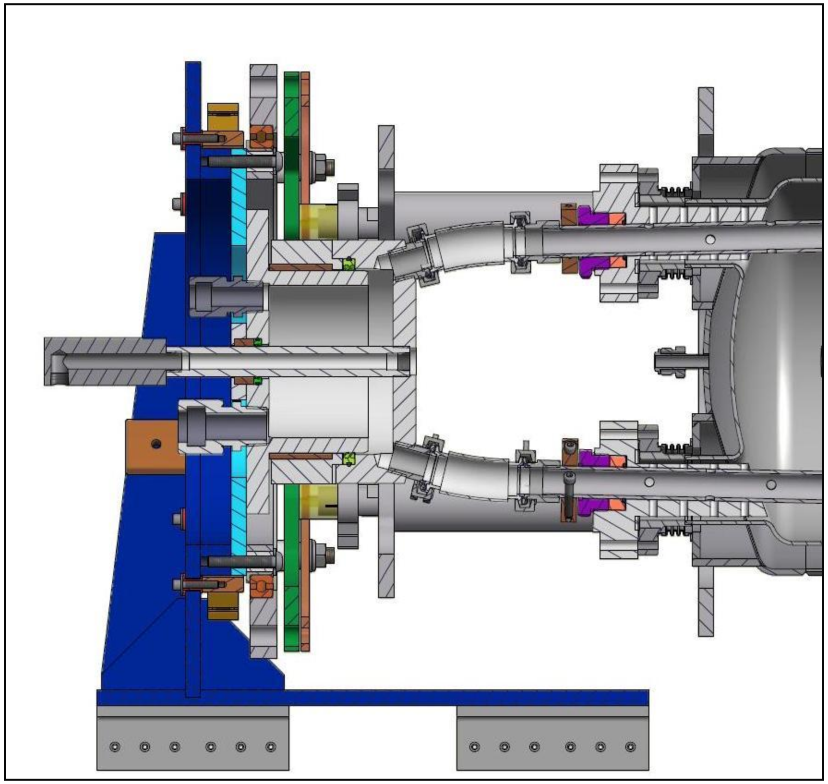
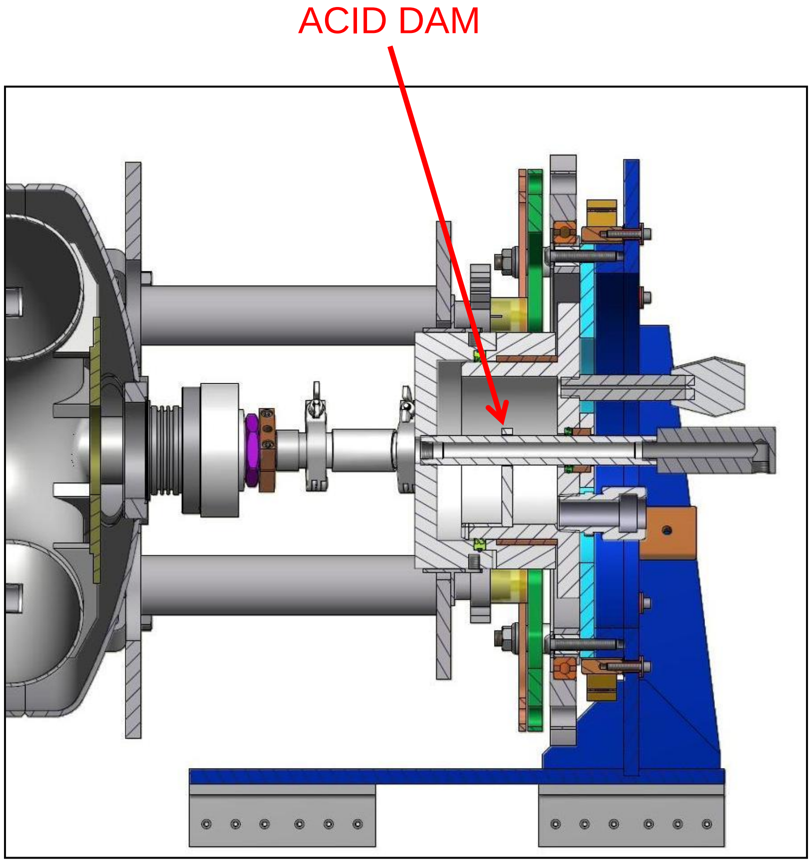
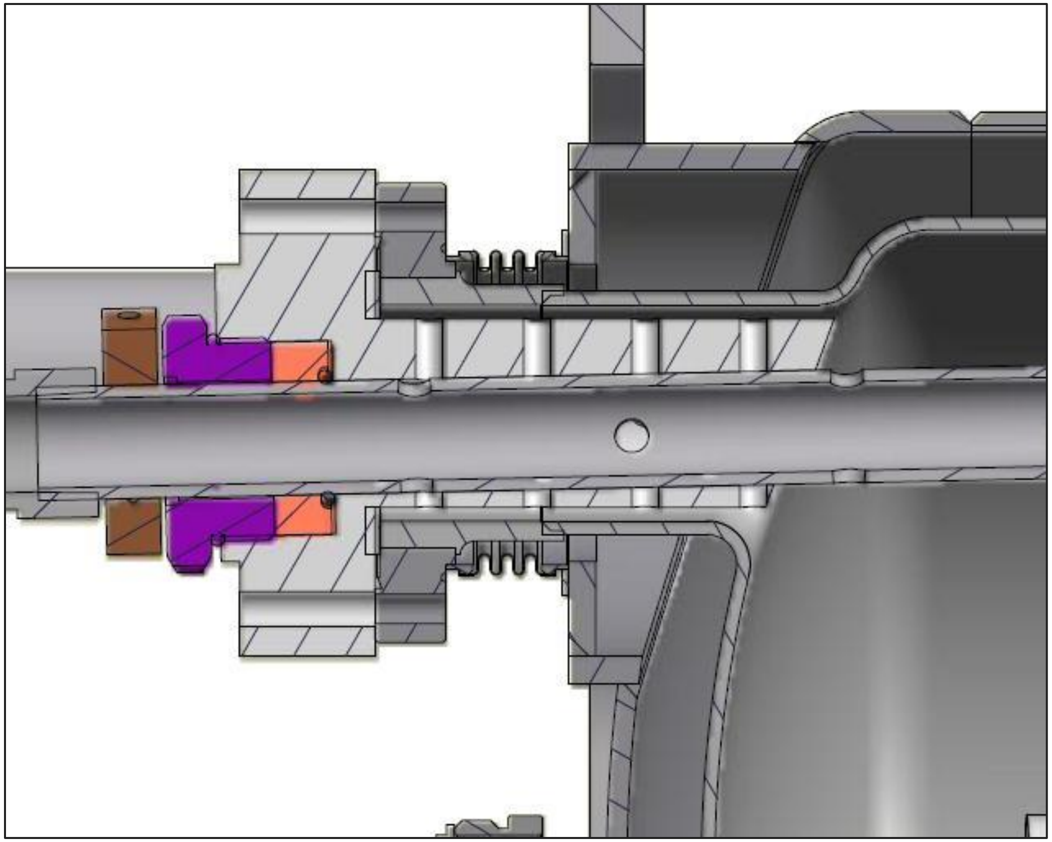




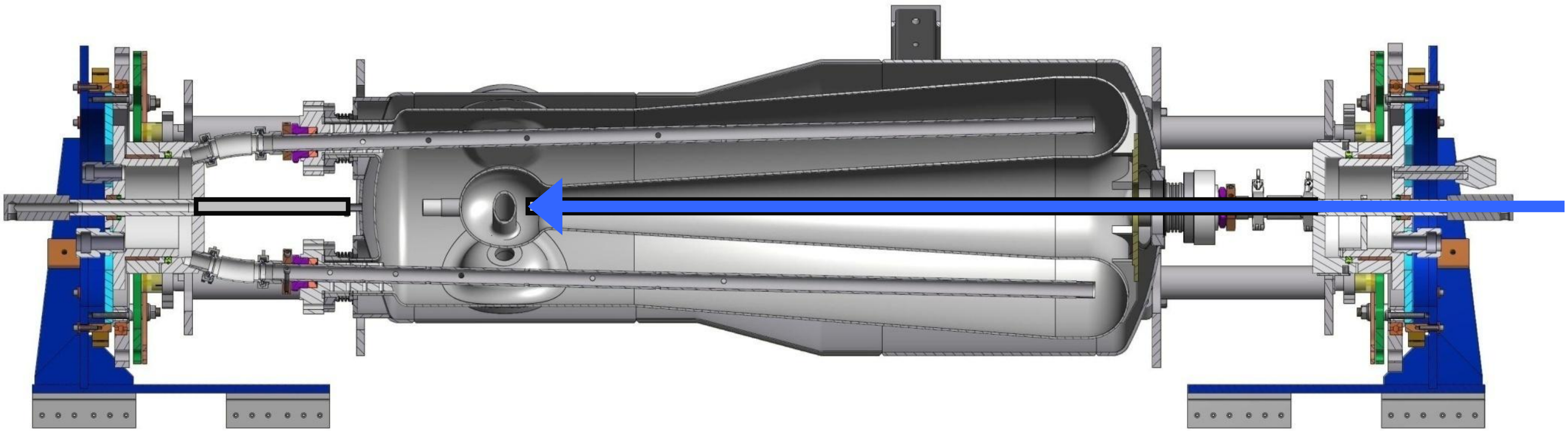
ACID HEIGHT IS ~ 60% CAVITY INNER DIAMETER

New Low-β SC Cavity EP Tool
Cathode Loading



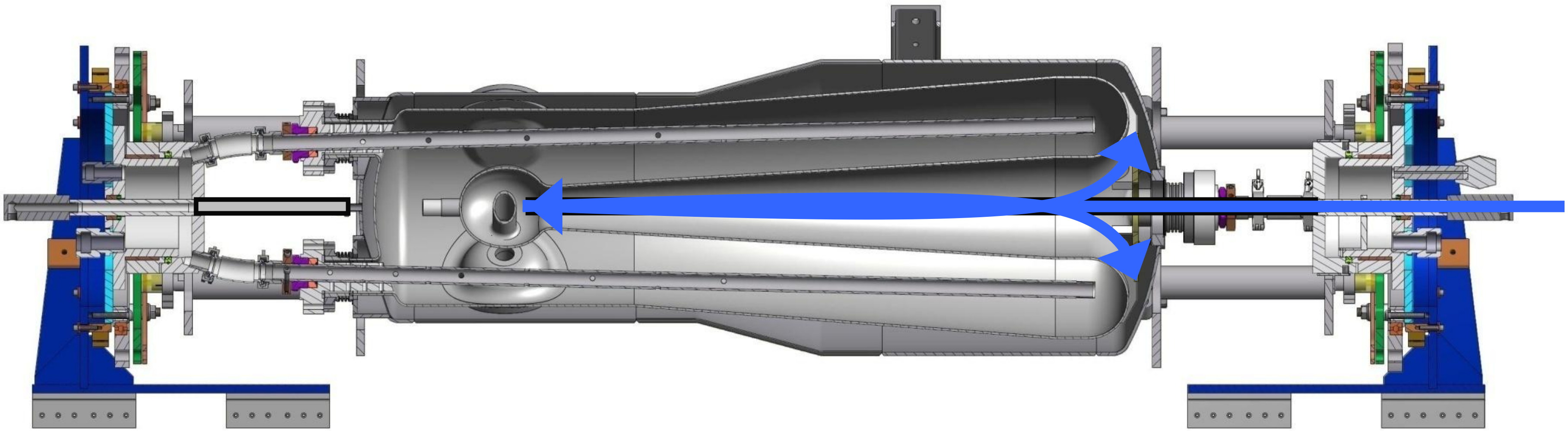
- Integrated cathode loading
- Precision HDPE port flanges allow cathode loading and set cathode angles inside cavity during EP
- Eliminates need for special cathode loading device when dealing with complex cavity geometries
- No cathode bag

New Low-β SC Cavity EP Tool
H_2O Flow



- Chilled water is circulated through the LHe space to control cavity temperature
- Offers an improvement over our elliptical cell EP setup which chills the acid in order to control temperature

New Low-β SC Cavity EP Tool
H_2O Flow



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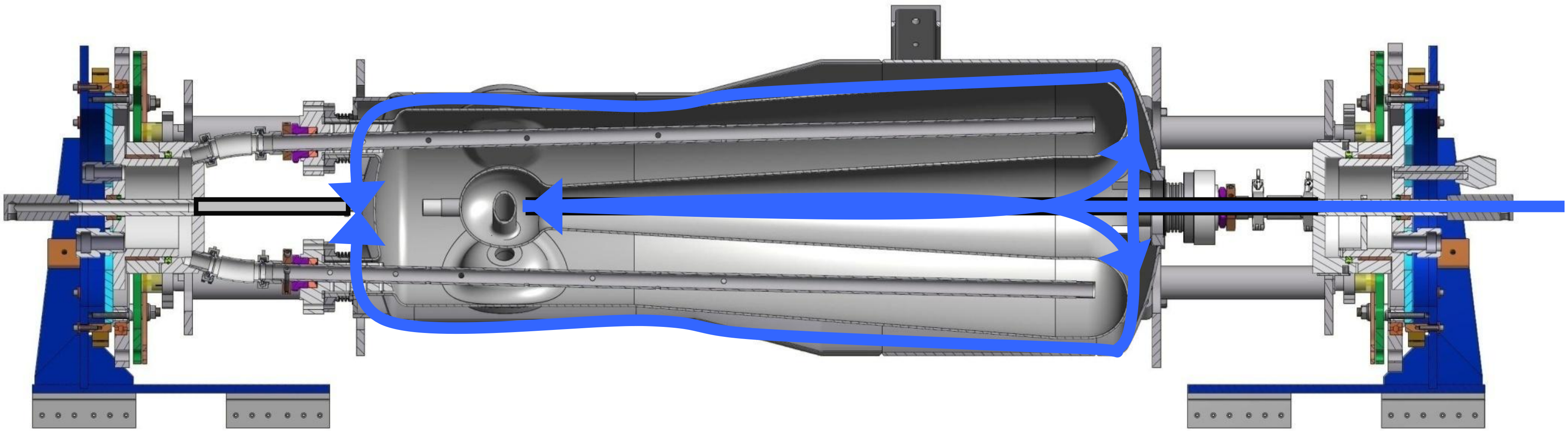

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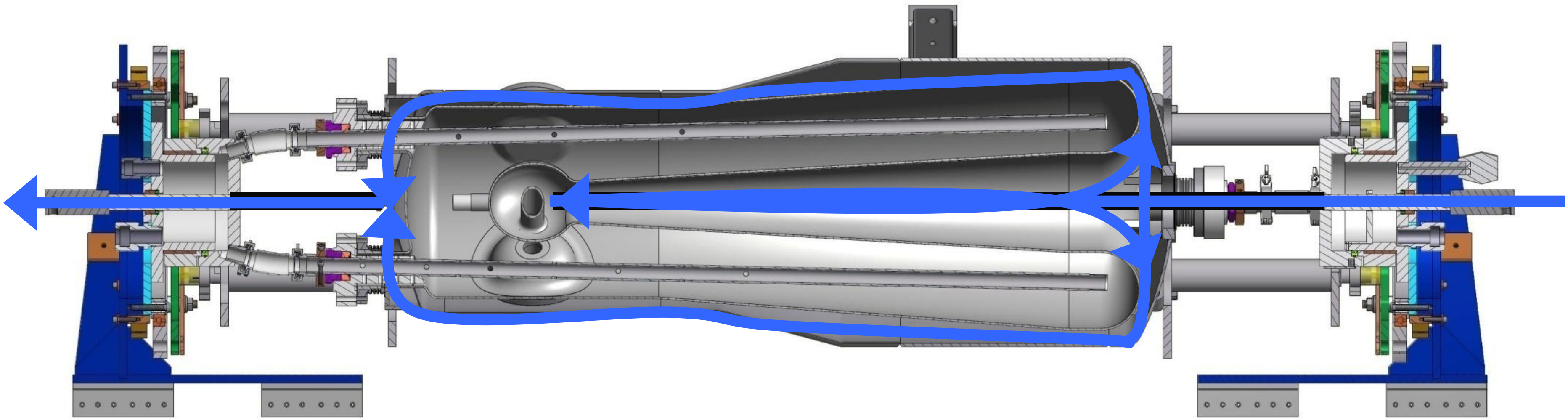

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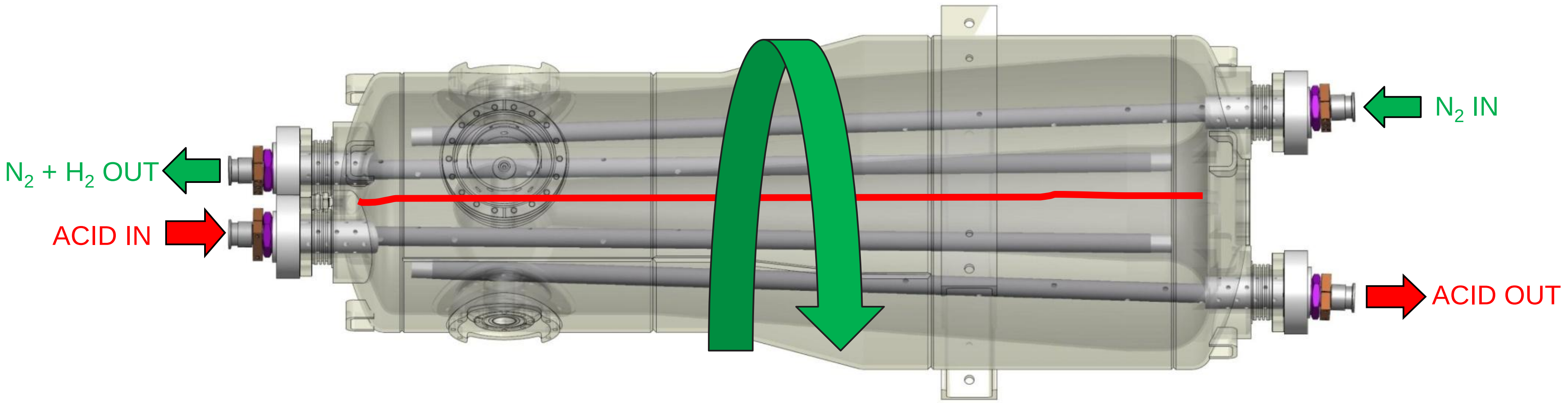
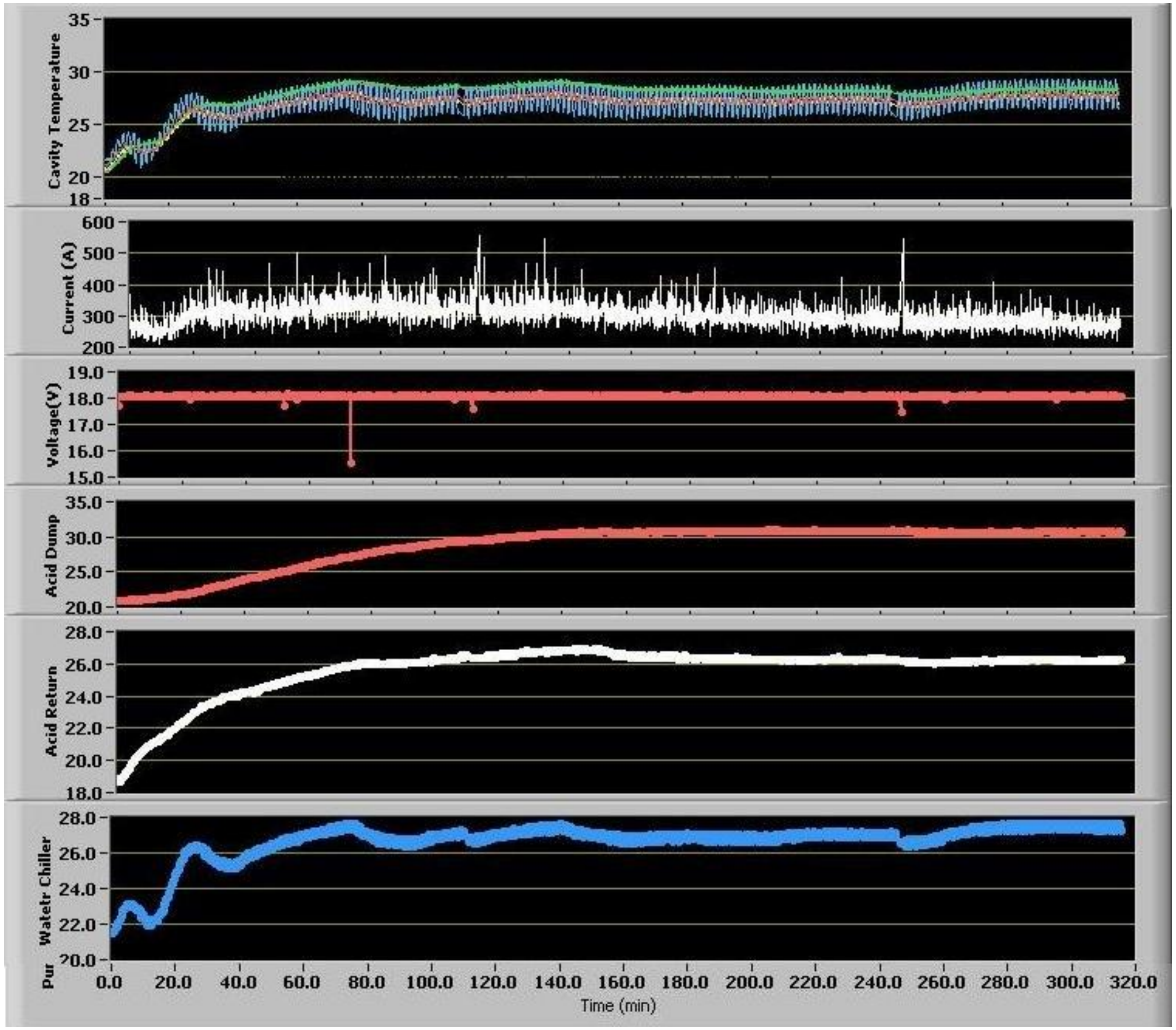
New Low-β SC Cavity EP Tool
Acid/N_2 Flow



- Low acid flow rate (0.19 LPM)
- Acid flow only needed to refresh acid, not to maintain temperature
- Rotates at 0.5 RPM

New Low-β SC Cavity EP Tool Operation Data for 72 MHz QWR EP



CAVITY TEMPS (C)

CURRENT (A)

OPERATING VOLTAGE (V)

ACID DUMP TANK TEMP (C)

ACID RETURN LINE TEMP (C)

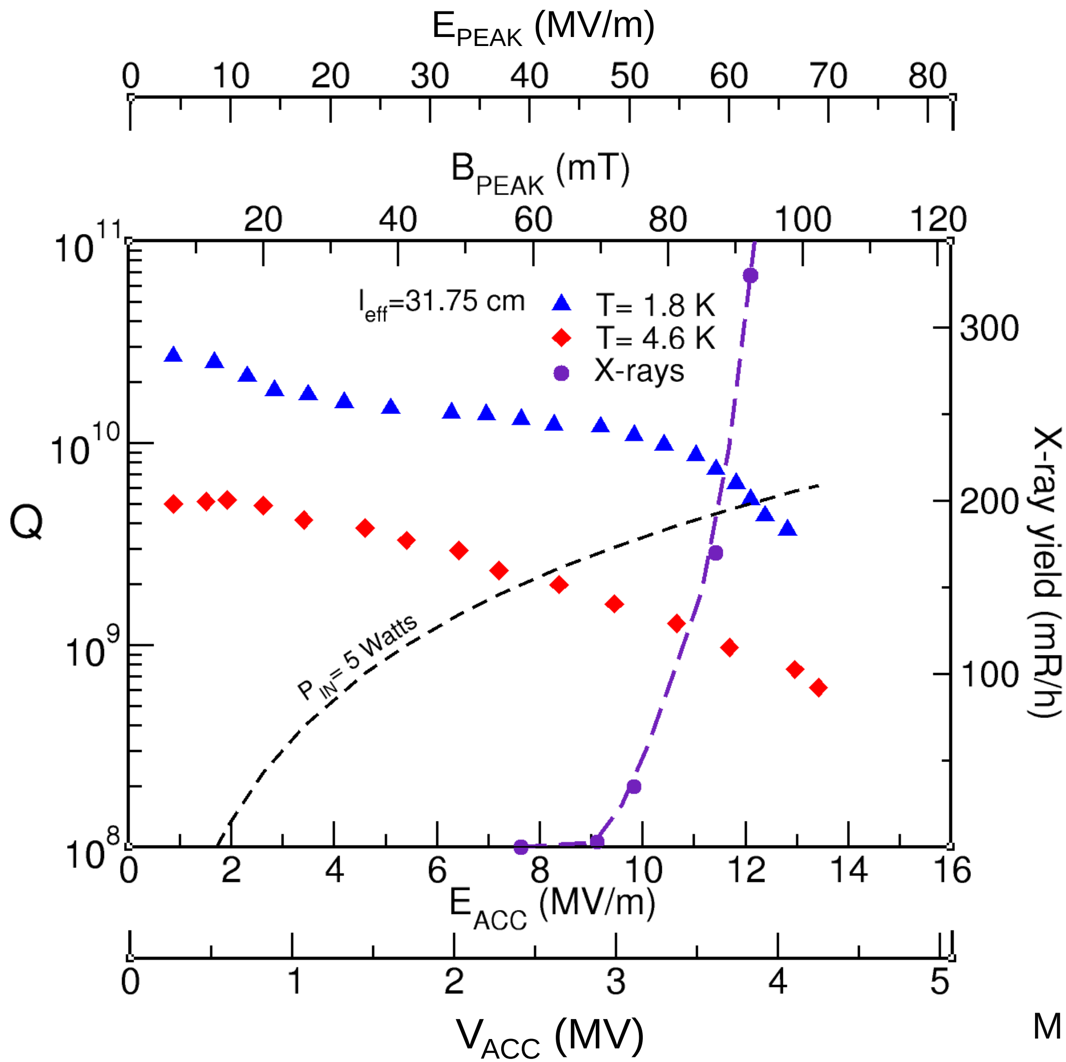
WATER RETURN TEMP (C)

New Low-β SC Cavity EP Tool
Before and After EP

BEFORE EP

AFTER 12HRS OF EP
150µm Nb REMOVED

New Low-β SC Cavity EP Tool Results



MIKE KELLY: THIOB04

Summary

- EP with this method is the ***final*** step in cavity fabrication
- Unlike BCP, EP can be repeated, if necessary, without degradation of surface
- Once the tool is built, EP with this method is simple to use and cost effective
- The EP tool is broadly useful for various cavity geometries, including any type of quarter-wave or half-wave cavity
- Our goal is to use this method of EP to maximize real estate gradient for ATLAS as well as the next generation of SC ion linacs