VERTICAL ELECTROPOLISHING OF 704MHz RESONATORS USING NINJA CATHODE: GRADIENTS OVER 40MV/m ACHIEVED ON ESS SINGLE-CELL CAVITY

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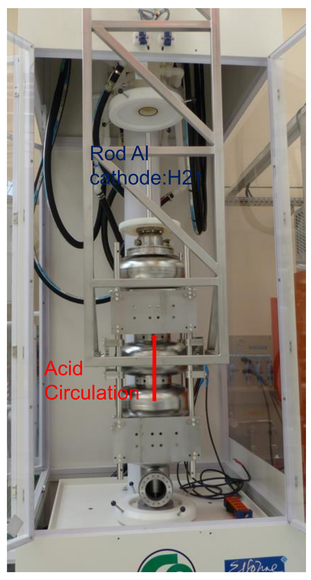
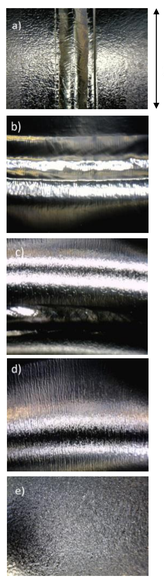
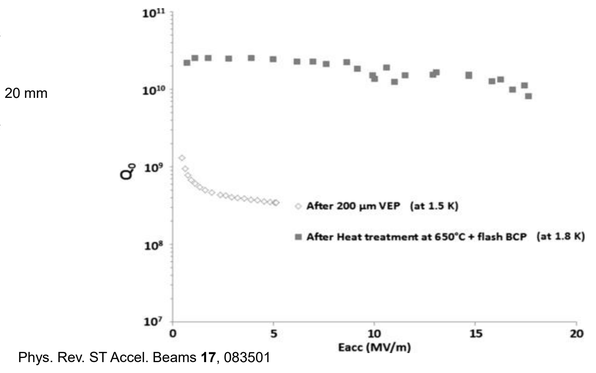
Introduction : Vertical Electro-Polishing (VEP) of elliptical cavities using rotating Ninja cathodes (Marui Company patented technology) has continually been improved since 2012 and successfully applied for 1300 MHz multi-cell ILC-type resonators. The goal of the presented study is to apply this technology to 704 MHz European Spallation Source (ESS)-type resonators with both better Q_0 and accelerating gradients in mind. We intend to demonstrate the superiority of VEP compared to standard Buffer Chemical Polishing (BCP), for possible applications.

PREVIOUS STUDY: VEP OF 704MHz β=1 SPL 5-CELL CAVITY (2014)





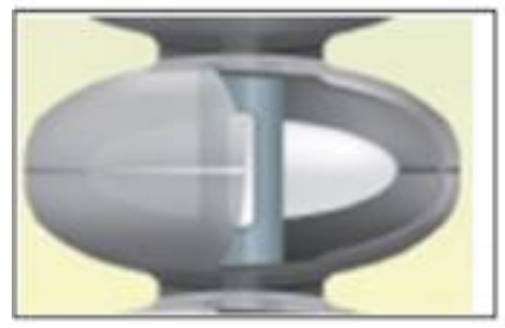
VEP Set-up at CEA Saclay. The cavity is electropolished using a circulating HF-H_2SO_4 acid injected from the bottom. A voltage is applied between the cavity (anode) and an aluminum rod cathode. The results achieved is limited by non-uniform EP conditions at the cavity surface, The weldings at a) equators, and b) irises are smooth. Bubbles stripes are observed at the proximity of irises c) and d). In the areas between equators and irises e) the surface is rougher.



Phys. Rev. ST Accel. Beams **17**, 083501

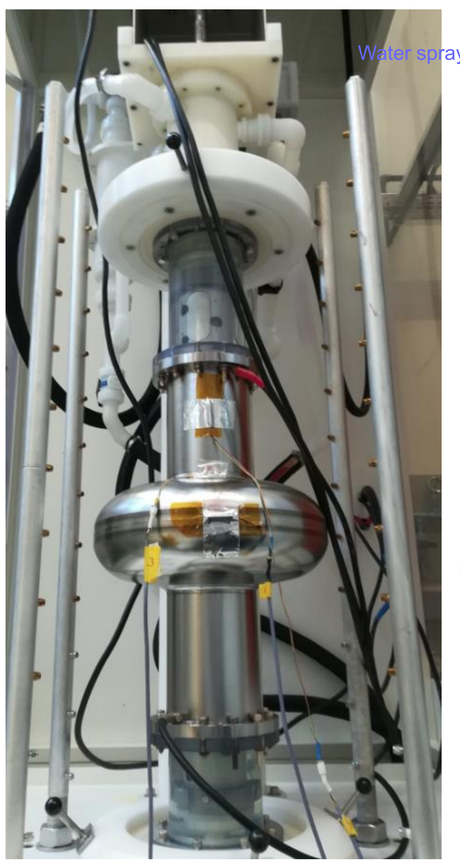
SPL cavity performance after 200µm VEP + Heat Treatment @650°Cx10h + 'flash' chemical treatment (5µm) Limited by field emission.

Non-uniform electropolishing conditions. Needs further improvement



- VEP USING ROTATING NINJA CATHODE
- TECHNOLOGY BY MARUI GALVANIZING CPNY
- ROTATING TEFLON WINGS FOR STIRRING
- EFFICIENT HYDROGEN REMOVAL

ELECTROPOLISHING OF ESS β=0.86 1-CELL CAVITY USING NINJA CATHODE



CAVITY DETAILS

Parameter	Value
R/Q [Ω] @β=0.86	113
G [Ω]	250
E_{pk}/E_{acc}	1.88
B_{pk}/E_{acc} [mT/(MV/m)]	3.86
Inner surface [m²]	0.55
Volume [l]	14.6

Cavity: manufactured by ZANON RI
Niobium: Tokyo Denkai Fine grain, RRR>300

CHEMISTRY

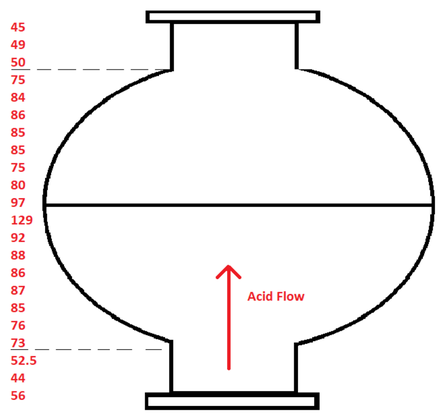
- HF(40%)-H_2SO_4(96%) acid mixture
- Anode: $2Nb + 5H_2O = Nb_2O_5 + 10H^+ + 10\ e^-$
- Cathode: $2H^+ + 2e^- = H_2\uparrow$
- HF: dissolution of Nb_2O_5 (diffusion limited)

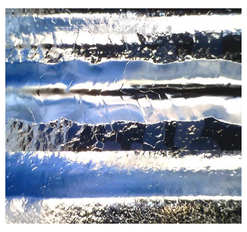
PROTOCOL

- 200µm Nb removal by VEP
- Heat Treatment 650°Cx10h
- 'Flash' VEP
- Ethanol Rinsing
- High Pressure Rinsing (ISO5 Cleanroom)
- Assembly (ISO5 Cleanroom)
- Test in Vertical Cryostat
- Baking at 120°Cx48h
- Test in Vertical Cryostat

PARAMETERS

- Large cathode area
- Rotation speed: 20rpm
- Voltage 19-20V
- Controlled temperature: cooled acid (T<15°C) + water spray
- Total Treatment time: 39h
- Removal rate 0.1µm/min
- Smooth equator area
- No stripes/nor pits at the surface
- Strong Sulphur odor → Ethanol Rinsing



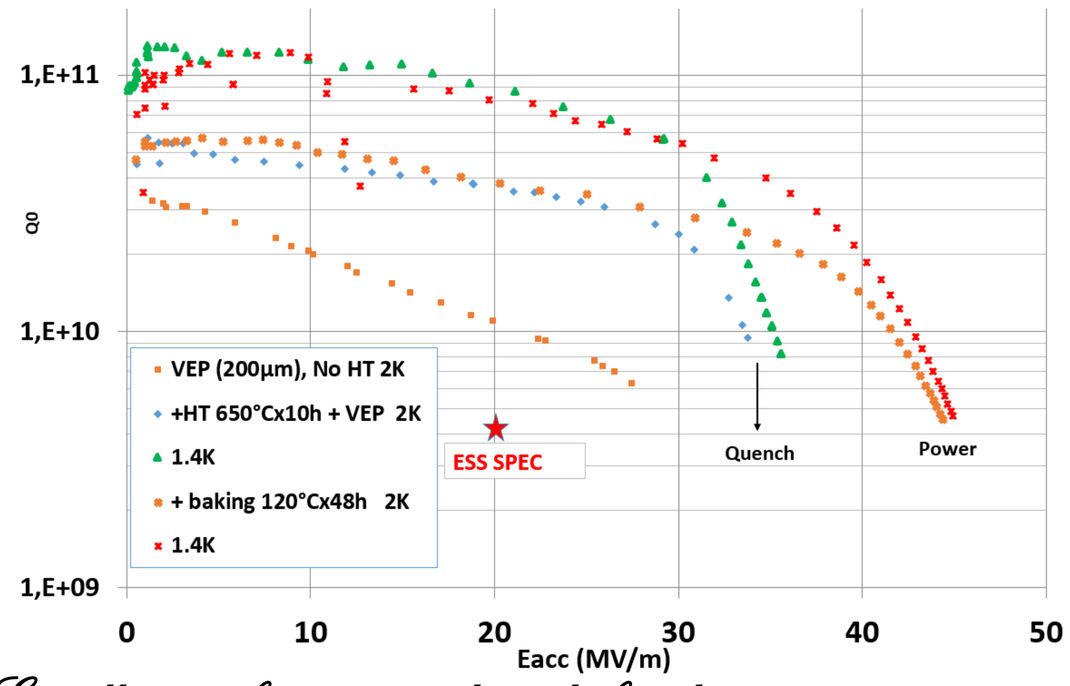


Ninja technology clearly suited to the treatment of 704 MHz cavities. Needs to be validated by RF-testing before/after heat treatments

Removal distribution in the cell after 80µm average VEP and surface at the equator

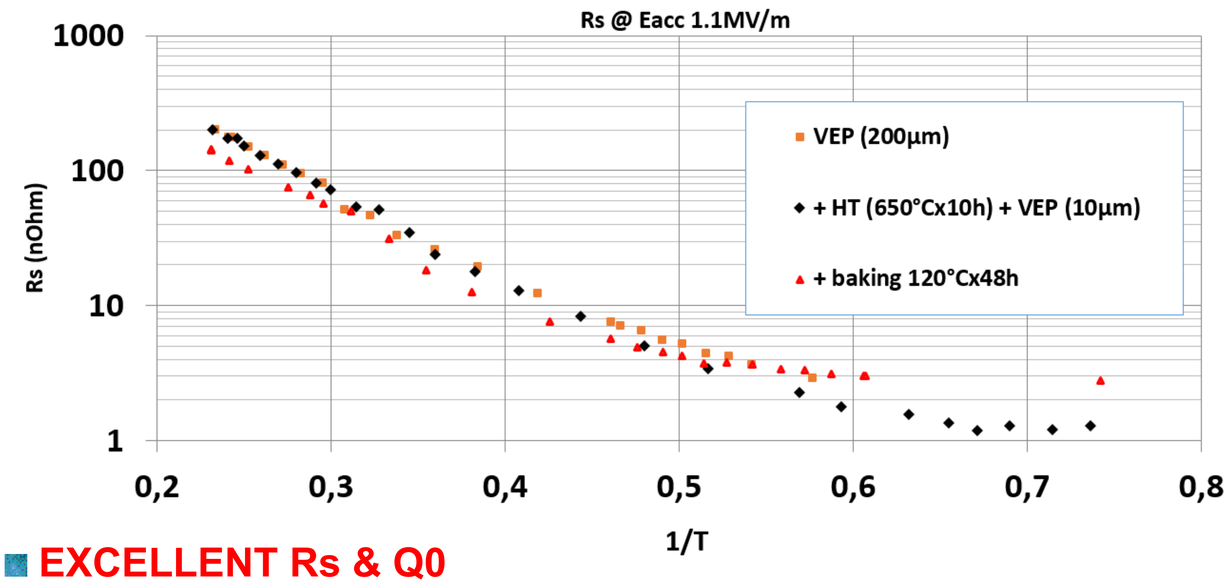
- UNIFORM Nb REMOVAL
- SURFACE ASPECT SUPERIOR TO BCP

TESTS IN VERTICAL CRYOSTAT before/after Thermal treatments

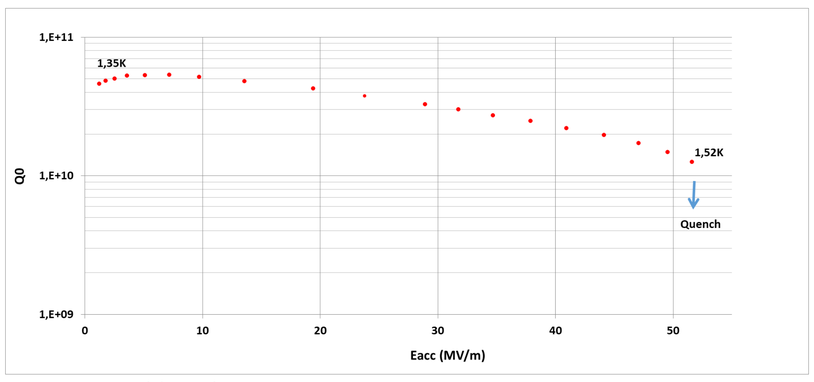


Excellent performance achieved after heat treatments.

Superiority vs standard BCP chemical process demonstrated



- EXCELLENT Rs & Q0
- GRADIENT >45MV/m, limited by power

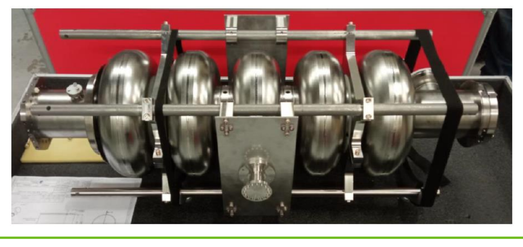


Eacc=52MV/m achieved after VEP followed by 2-step baking (75°C-120°C) (FERMILAB Recipe)

OUTLOOK:

- New VEP sequence on 1-Cell to remove Q-slope
- Investigate the 2-step baking (75°C-120°C) efficient on 1300MHz cavity after VEP
- Extrapolate the process to 5-Cell β=0.86 ESS Cavity (Cavity and cathode available)

CONCLUSION: Excellent results have been achieved after vertical electropolishing of a β = 0.86 single-cell ESS geometry cavity. Superiority of Electro-polishing Vs standard BCP treatment is demonstrated for this type of cavity. The process will finally be scaled to the 5-cell cavity case (ESS prototype cavity).



HB03 ESS-prototype cavity to be treated by VEP with dedicated cathode.