Development of new RFQs for J-PARC

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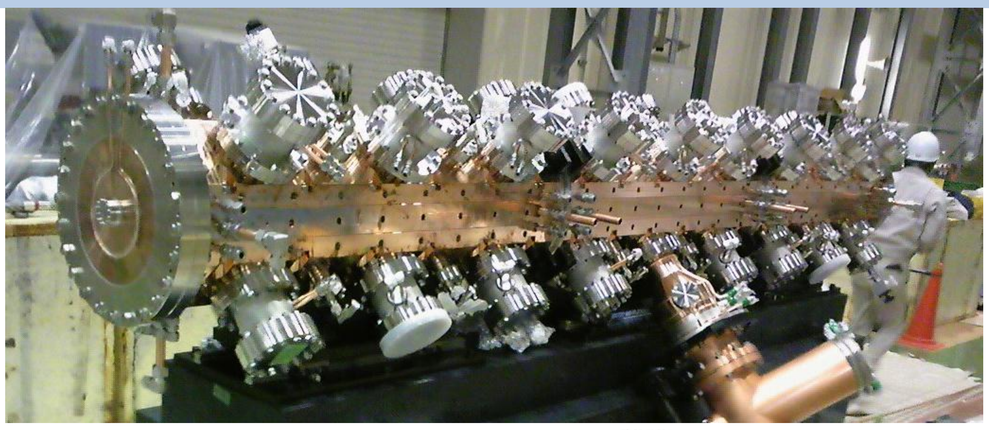
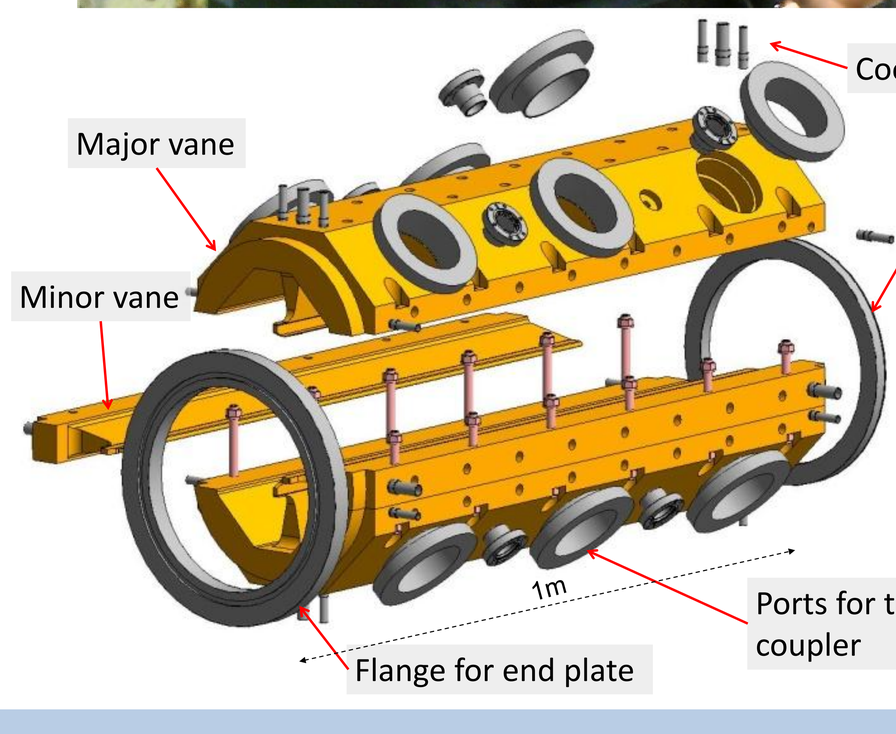
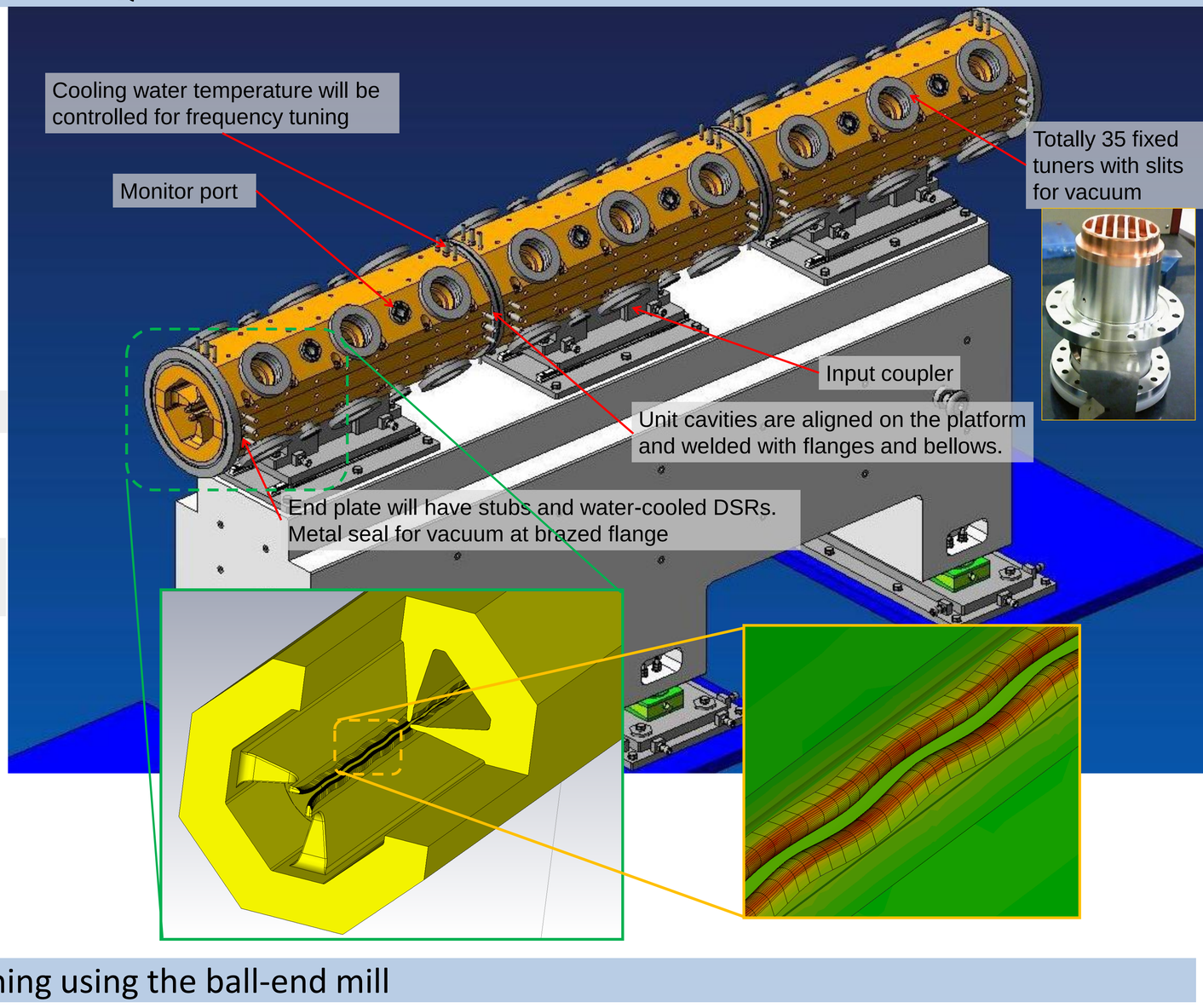
Parameters	RFQ I: operating	RFQ II: spare of RFQ I	RFQ III: in production
Beam current [mA]	30	←	50
Frequency [MHz]	324	←	←
Acceleration energy [MeV]	0.05 to 3	←	←
Vane length [m]	3.1	3.1	3.6
Inter-vane voltage[kV]	82.9	←	81
Max. surface field [MV/m]	31.6(1.77 Kilpatrick)	←	30.7(1.72 Kilpatrick)
Ave. bore radius [mm]	3.7	←	3.5
Vane-tip curvature [mm]	0.89r0 (3.293mm)	←	0.75r0(2.617mm)

Engineering design	RFQ I	RFQ II & III
Cavity material	OFC with 0.2% Ag	OFC + HIP(Hot Isostatic Pressing)
Joining method	Bolted with RF contactors in the vacuum chamber	Vanes, ports for vacuum, tuners, and flanges are brazed.
Vane machining	2D machining with wheel-shape formed bite	NC machining with conventional ball-end mill
Surface treatment	Acid wash	Chemical polishing

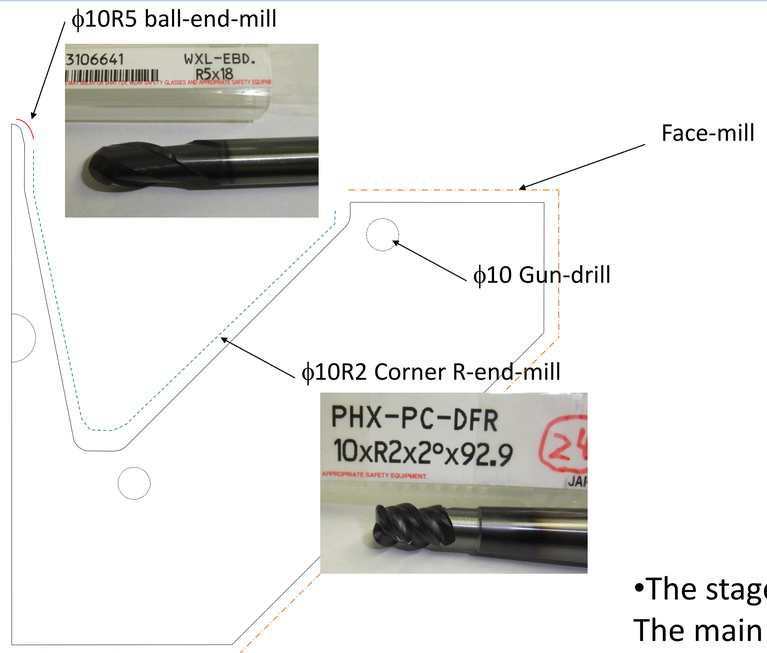
RFQ II

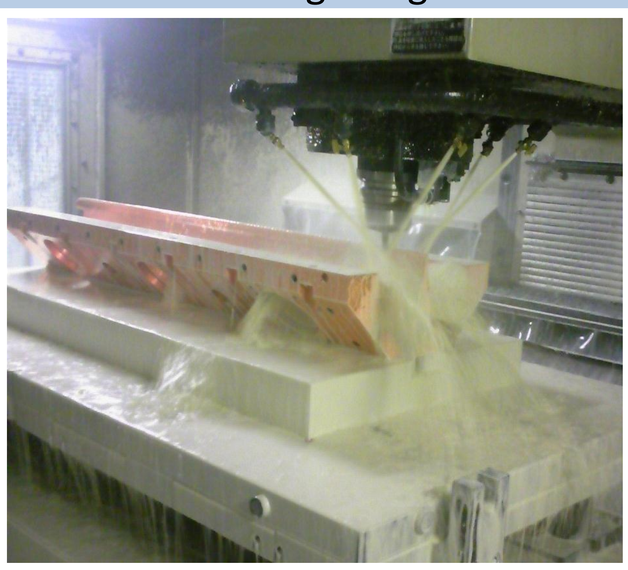






Vane machining using the ball-end mill

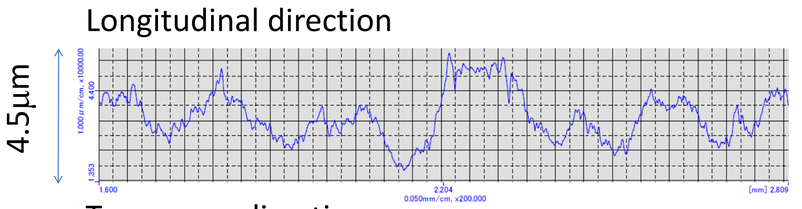




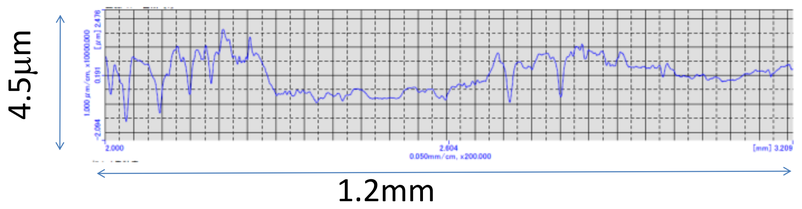
- The stage moves in a horizontal plane and the end-mill moves vertical. The main feed direction of the stage is the longitudinal direction.

Surface roughness

Longitudinal direction



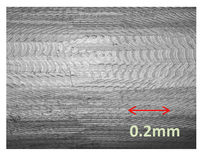
Transverse direction



- The surface roughness is typically 0.8 µm (Ra)
- The curvature of the ball-end mill is 5 mm.

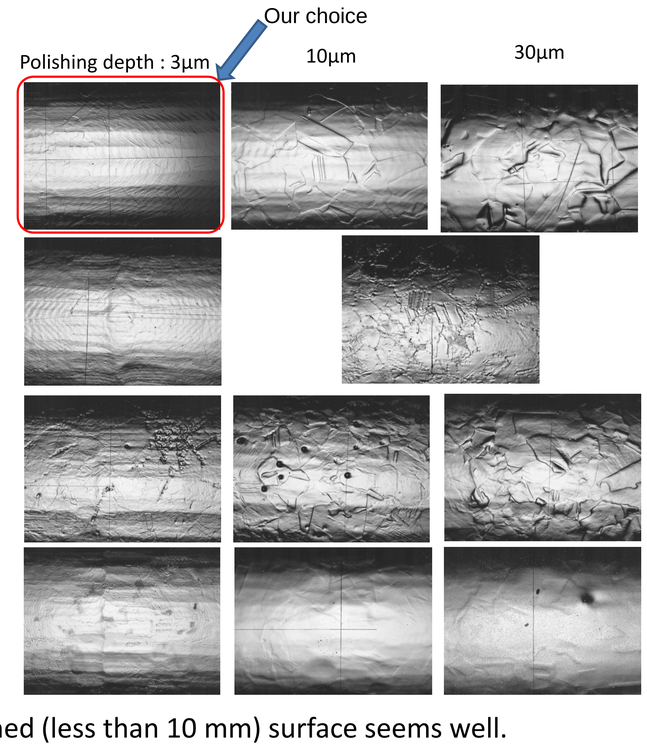
Surface treatment (chemical polishing)

process	Note	
Cleaning	Water, methyl alcohol, methyl ethyl ketone	Vane tip : running water Other : wiping
Masking	Taping, caulking	Screw holes, contact face between support for handling
Degreasing	Alkaline solution	Submerging
Acid wash	Sulfuric acid aqueous solution	Submerging
Chemical polishing	Nitric acid + Phosphoric acid + Surfactant	Submerging Polishing depth is controlled by temperature and time.
Acid wash	Sulfuric acid aqueous solution	Submerging
Anticorrosion	Chromate solution	Submerging
Cleaning /drying-out	Ultrapure water / drier	Running water Air blow



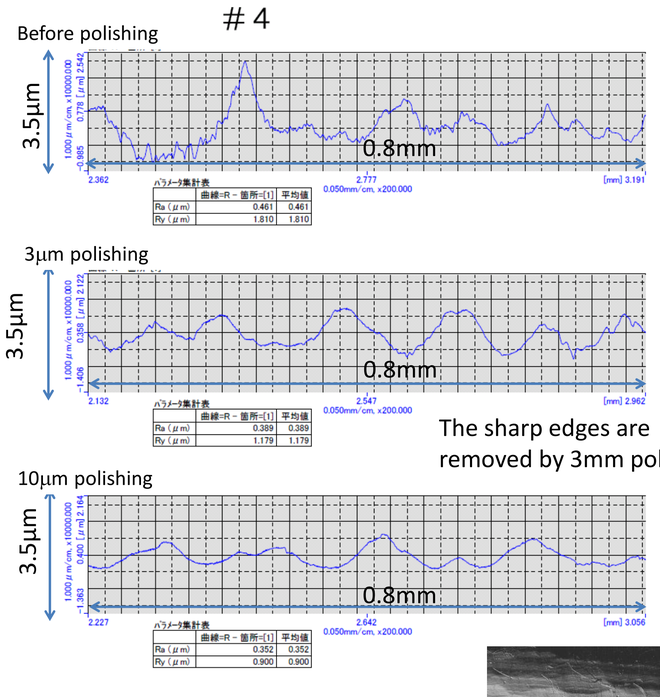
Before polishing

Tested four kinds of solutions



Lightly-polished (less than 10 mm) surface seems well.
Grain-boundary configuration appears at over-polished.

Surface roughness after chemical polishing # 4



The sharp edges are removed by 3mm polishing.

Outshoots are found only occasionally in the case of the solution #4.
Our choice is the solution #1 with 3µm polishing.