DESIGN AND FABRICATION UPDATE ON PSI/TRIESTE X-BAND PHASE-SPACE ROTATOR STRUCTURE

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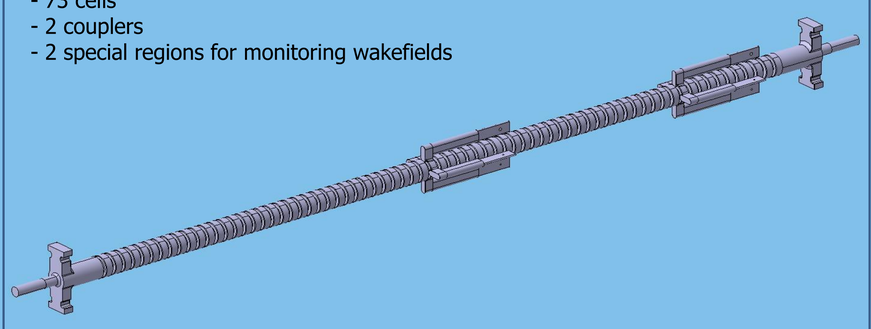
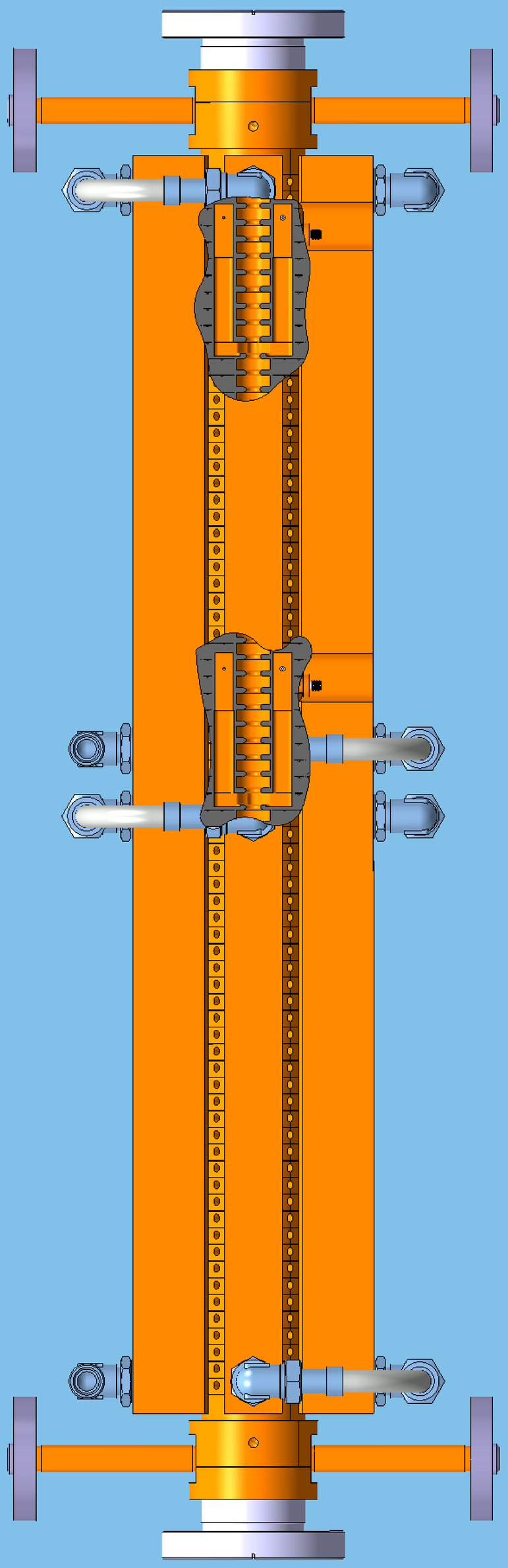
Abstract

Both FEL projects, SwissFEL and Fermi-Elettra each require an X-band RF accelerating structure for optimal bunch compression at the respective injectors [1]. As the CLIC project is pursuing a program for producing and testing the X-band high-gradient RF structures [2], a collaboration between PSI, Elettra and CERN has been established to build a multipurpose X-band accelerating structure. This paper focuses on its engineering design, which is based on the disked cells jointed together by diffusion bonding. Vacuum brazing and laser beam welding is used for auxiliary components. The accelerating structure consists of two coupler subassemblies, 73 disks and includes a wakefield monitor and diagnostic waveguides. The engineering study includes the external cooling system, consisting of two parallel cooling circuits and an RF tuning system, which allows phase advance tuning of the cell by deforming the outer wall. The engineering solution for the installation and sealing of the wake field monitor feed-through devices that are integrated in the accelerating structure are presented.

RF-design input

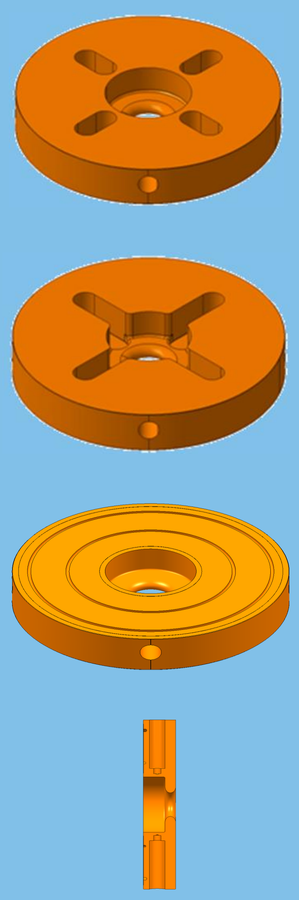
- 73 cells
- 2 couplers
- 2 special regions for monitoring wakefields

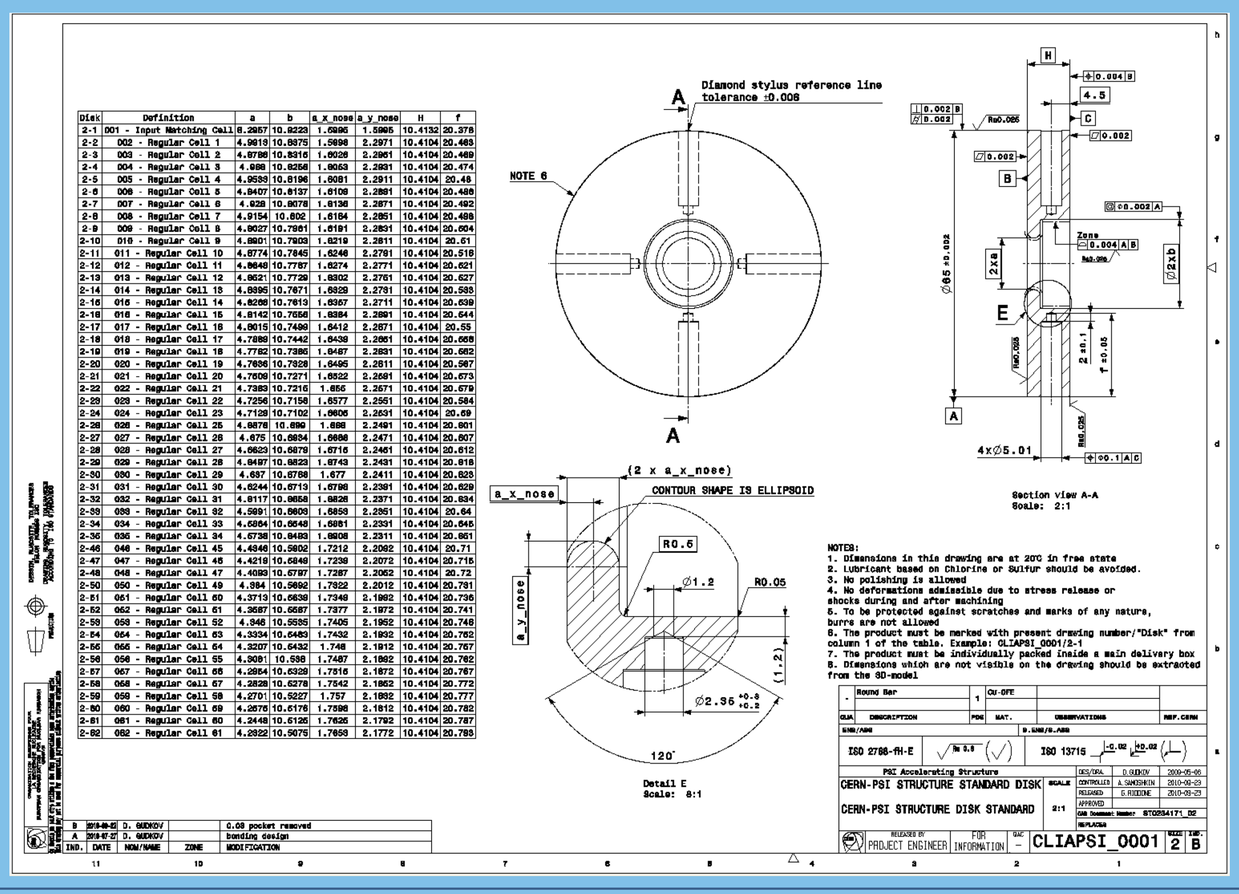




Mechanical Design of RF disks

- Thick cylindrical copper disks;
- Four radial holes;
- Slots and cavities for brazing material
- Cell shape accuracy 0.004 mm
- Flatness accuracy 0.002 mm
- Cell shape roughness Ra 0.025





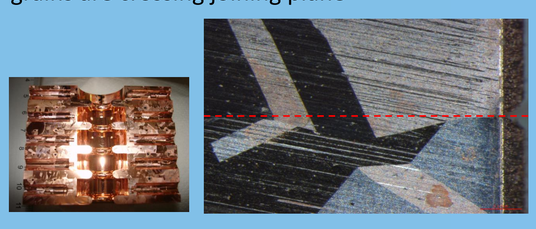
Disk	Definition	a	b	a_x_nose	a_y_nose	H	f
2-1	001 - Input Matching Cell	8.2957	10.8223	1.6995	1.5995	10.4132	20.378
2-2	002 - Regular Cell 1	4.9918	10.8375	1.5898	2.2971	10.4104	20.468
2-3	003 - Regular Cell 2	4.6788	10.8316	1.6026	2.2961	10.4104	20.469
2-4	004 - Regular Cell 3	4.988	10.8258	1.6053	2.2931	10.4104	20.474
2-5	005 - Regular Cell 4	4.9838	10.8196	1.6081	2.2911	10.4104	20.48
2-6	006 - Regular Cell 5	4.9407	10.8137	1.6108	2.2881	10.4104	20.488
2-7	007 - Regular Cell 6	4.828	10.8078	1.6136	2.2871	10.4104	20.492
2-8	008 - Regular Cell 7	4.9154	10.802	1.6164	2.2851	10.4104	20.498
2-9	009 - Regular Cell 8	4.8027	10.7961	1.6191	2.2831	10.4104	20.504
2-10	010 - Regular Cell 9	4.8901	10.7903	1.6219	2.2811	10.4104	20.51
2-11	011 - Regular Cell 10	4.8774	10.7845	1.6246	2.2791	10.4104	20.516
2-12	012 - Regular Cell 11	4.8648	10.7787	1.6274	2.2771	10.4104	20.521
2-13	013 - Regular Cell 12	4.8521	10.7729	1.6302	2.2761	10.4104	20.527
2-14	014 - Regular Cell 13	4.8395	10.7671	1.6329	2.2731	10.4104	20.533
2-15	015 - Regular Cell 14	4.8268	10.7613	1.6357	2.2711	10.4104	20.539
2-16	016 - Regular Cell 15	4.8142	10.7556	1.6384	2.2691	10.4104	20.544
2-17	017 - Regular Cell 16	4.8015	10.7498	1.6412	2.2671	10.4104	20.55
2-18	018 - Regular Cell 17	4.7889	10.7442	1.6439	2.2651	10.4104	20.556
2-19	019 - Regular Cell 18	4.7762	10.7386	1.6467	2.2631	10.4104	20.562
2-20	020 - Regular Cell 19	4.7636	10.7328	1.6495	2.2611	10.4104	20.567
2-21	021 - Regular Cell 20	4.7509	10.7271	1.6522	2.2591	10.4104	20.573
2-22	022 - Regular Cell 21	4.7383	10.7216	1.655	2.2571	10.4104	20.579
2-23	023 - Regular Cell 22	4.7256	10.7158	1.6577	2.2551	10.4104	20.584
2-24	024 - Regular Cell 23	4.7129	10.7102	1.6605	2.2531	10.4104	20.59
2-25	025 - Regular Cell 24	4.6878	10.699	1.666	2.2491	10.4104	20.601
2-27	027 - Regular Cell 26	4.675	10.6934	1.6688	2.2471	10.4104	20.607
2-28	028 - Regular Cell 27	4.6623	10.6879	1.6715	2.2451	10.4104	20.612
2-29	029 - Regular Cell 28	4.6497	10.6823	1.6743	2.2431	10.4104	20.618
2-30	030 - Regular Cell 29	4.637	10.6768	1.677	2.2411	10.4104	20.623
2-31	031 - Regular Cell 30	4.6244	10.6713	1.6798	2.2391	10.4104	20.629
2-32	032 - Regular Cell 31	4.6117	10.6658	1.6826	2.2371	10.4104	20.634
2-33	033 - Regular Cell 32	4.5991	10.6603	1.6853	2.2351	10.4104	20.64
2-34	034 - Regular Cell 33	4.5864	10.6548	1.6881	2.2331	10.4104	20.645
2-35	035 - Regular Cell 34	4.5738	10.6493	1.6908	2.2311	10.4104	20.651
2-46	046 - Regular Cell 45	4.4846	10.5902	1.7212	2.2092	10.4104	20.71
2-47	047 - Regular Cell 46	4.4219	10.5849	1.7239	2.2072	10.4104	20.715
2-48	048 - Regular Cell 47	4.4093	10.5797	1.7267	2.2052	10.4104	20.72
2-50	050 - Regular Cell 49	4.384	10.5692	1.7322	2.2012	10.4104	20.731
2-51	051 - Regular Cell 50	4.3713	10.5638	1.7349	2.1992	10.4104	20.736
2-52	052 - Regular Cell 51	4.3587	10.5587	1.7377	2.1972	10.4104	20.741
2-53	053 - Regular Cell 52	4.346	10.5535	1.7405	2.1952	10.4104	20.748
2-54	054 - Regular Cell 53	4.3334	10.5483	1.7432	2.1932	10.4104	20.752
2-55	055 - Regular Cell 54	4.3207	10.5432	1.748	2.1912	10.4104	20.757
2-56	056 - Regular Cell 55	4.3081	10.538	1.7487	2.1892	10.4104	20.762
2-57	057 - Regular Cell 56	4.2954	10.5329	1.7515	2.1872	10.4104	20.767
2-58	058 - Regular Cell 57	4.2828	10.5278	1.7542	2.1852	10.4104	20.772
2-59	059 - Regular Cell 58	4.2701	10.5227	1.757	2.1832	10.4104	20.777
2-80	080 - Regular Cell 69	4.2575	10.5176	1.7598	2.1812	10.4104	20.782
2-81	081 - Regular Cell 60	4.2448	10.5125	1.7625	2.1792	10.4104	20.787
2-82	082 - Regular Cell 61	4.2322	10.5075	1.7653	2.1772	10.4104	20.793

Assembly (bonding and brazing)

- Diffusion bonding of 3 stacks (24..25 disks each) of high-precision RF disks under H2 at about 1035°C
- Vacuum brazing of stacks together
- Vacuum brazing of special inserts for WFM feed-through connectors at about 800°C
- Vacuum brazing of couplers subassemblies at about 760°C

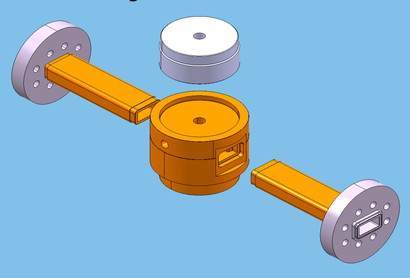
BONDING TEST

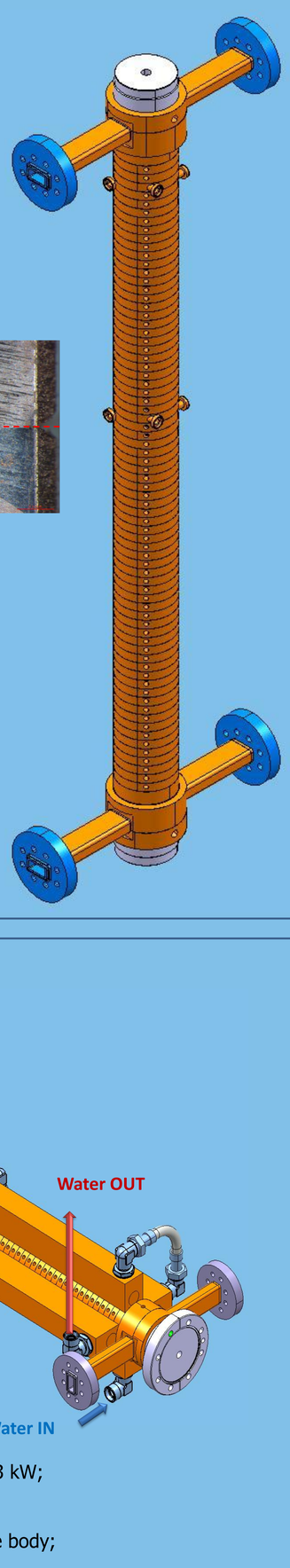
Metallographic observation shows that grains are crossing joining plane



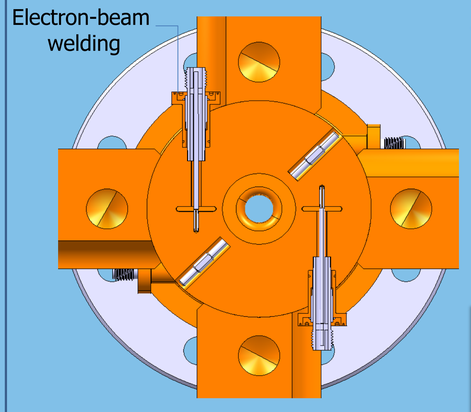
Assembly of Couplers

- Vacuum brazing of high-precision copper disks at about 800°C
- Vacuum brazing of other components: waveguides, stainless steel adapters and vacuum flanges at about 760°C





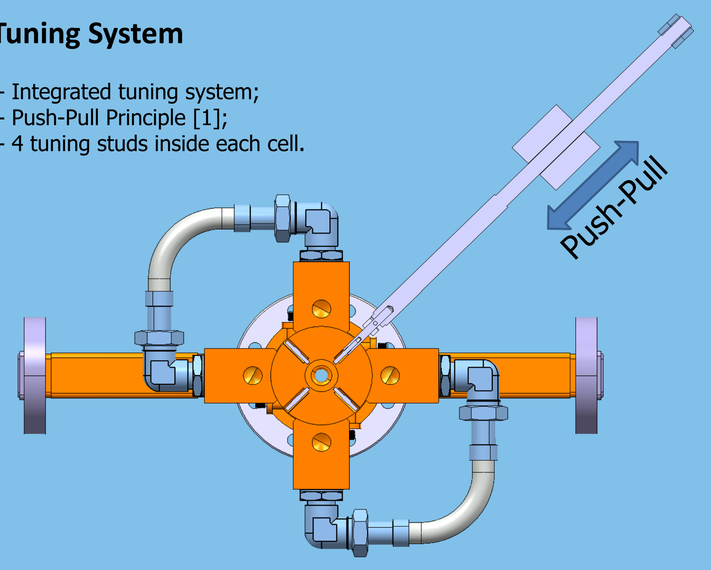
Design, Installation and Sealing of the WFM Feed-through Connectors



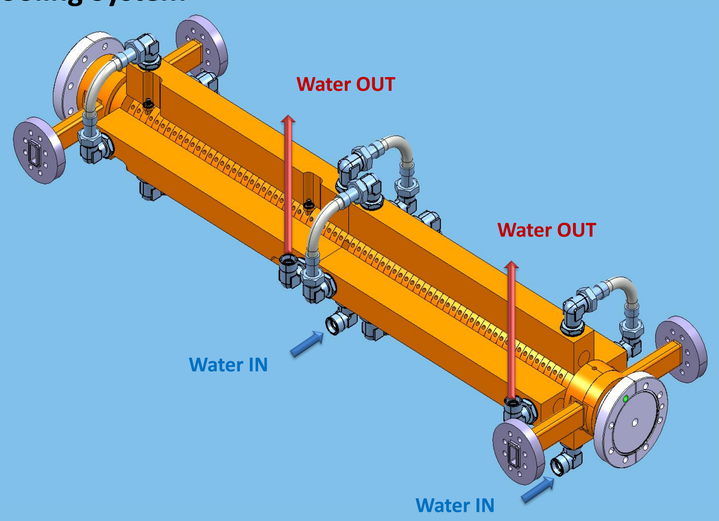
- Custom design. Produced by Orient Microwave Corp. [2]
- Special end of connector
- Specially designed adapter from the standard feed-through to the accelerating structure body
- The adapter is laser welded to the feed-through
- Final, vacuum tight connection of the feed-through assembly is made by electron beam welding

Tuning System

- Integrated tuning system;
- Push-Pull Principle [1];
- 4 tuning studs inside each cell.



Cooling System



- Power dissipation in the structure of about 0.3 kW;
- Two parallel cooling circuits;
- 8 cooling blocks each of 394 mm long;
- Brazed directly onto the accelerating structure body;
- Standard water connectors.

Fabrication strategy

Time/phase	July	August	September	October	November	December	January
Structure 1+2							
machining							
measurement							
cleaning+packaging							
ready for transport							
Structure 3+4							
machining							
measurement							
cleaning+packaging							
ready for transport							

REFERENCES

[1] Juwen W. Wang et al. “Fabrication Technologies of the High Gradient Accelerator Structures at 100MV/m Range”, paper presented at IPAC2010.

[2] http://www.orient-microwave.com/