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TITLE: HIGH ENERGY ACCELERATING STRUCTURES FOR HIGH GRADIENT PROTON LINAC APPLICATIONS

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program are shown in fig. 4. One can see that the part of the cavity close to the axis is very similar to the LAMPF cavity, and we have found that geometrical perturbations in that part of the cavity have approximately the same effects on the cavity parameters as they have in the case of the LAMPF cavity. Therefore, we used the data from our previous optimization of the LAMPF cavity and applied them to the DAW1.

The next step was to optimize the outer part of the cavity. The disk thickness t_2 and the radii R and R_1 have an effect on the shunt impedance and mode frequency. These parameters were optimized consistent with certain mechanical constraints. Then we calculated the effective shunt impedance for different β s at optimum gap factors α . The results are shown in Fig. 1, and one can see that the effective shunt impedance (ZT^2) of DAW1 is slightly below the data for the LAMPF cavity. The practical value of ZT^2 may be 5% lower than this theoretical value due to the losses on the washer supports. The other calculated parameters and dimensions of the optimized cavities for different β s are summarized in Table I.

TABLE I
GEOMETRY AND CAVITY PARAMETERS FOR DAW1

β	0.4	0.6	0.8	1.0
f_0 [MHz]	700	735	751	750
$f_{\pi/2}$ [MHz]	1350	1350	1350	1350
f_{π} [MHz]	1556	1631	1666	1668
Z [M Ω /m]	46	74	87	95
Q	19850	29554	27990	30400
T	0.831	0.83	0.823	0.805
ZT^2 [M Ω /m]	31	51	59	60.6
α	0.4	0.5	0.55	0.6
R [cm]	16	15.2	14.8	14.3
R_1 [cm]	11.3	10.85	10.5	10.2
R_2 [cm]	11.5	11.05	10.7	10.4
r_B [cm]	1.1	1.1	1.1	1.1
r_N [cm]	0.25	0.25	0.25	0.25
t_1 [cm]	0.7	0.7	0.7	0.7
t_2 [cm]	0.8	0.8	0.8	0.8
g [cm]	1.8	3.33	4.88	6.66
L [cm]	4.44	6.66	8.88	11.11
θ [°]	30	30	30	30

The advantages of the DAW1 structure are:

1. The high coupling coefficient ($\sim 60\%$) makes the structure less sensitive to beam loading effects at high current operation.
2. The high coupling coefficient makes the structure significantly less sensitive to manufacturing tolerances.
3. Manufacturing of DAW1 may be easier than the side-coupled structure.
4. The vacuum conductance of DAW1 is higher, thus the vacuum system might be less complicated.

Among the disadvantages of DAW1 one has to mention that the rf power is dissipated almost entirely on the washer, which means that it has to be water-cooled, since the heat conductivity to the outside wall is very poor. One can use the washer supports for water flow; however, this requires vacuum-water joints, a delicate thing from vacuum leak considerations. Another disadvantage of DAW1 is a lack of convenient locations for high power drive points. RF drive is almost restricted to be at the end plates of the cavity system.

We have been attracted by the properties of the disc and washer structure, and in our optimization studies, we tried to improve its ZT^2 and some other parameters. We shaped the washer to make it thicker so that mechanically it is improved, and the cooling is easier. The shaped cavity is shown in Fig. 5. The effective shunt impedance for this shaped washer structure is approximately the same as that for DAW1, as can be seen in Fig. 1. Other calculated parameters and dimensions of the optimized cavities for different β s are shown in Table II.

TABLE II
GEOMETRY AND CAVITY PARAMETERS FOR DAW2

β	0.4	0.6	0.8	1.0
f_0 [MHz]	705	800	866	930
$f_{\pi/2}$ [MHz]	1350	1350	1350	1350
f_{π} [MHz]	1532	1655	1724	1900
Z [M Ω /m]	48	77	90.1	95.2
Q	18841	25900	27990	30400
T	0.831	0.83	0.823	0.807
ZT^2 [M Ω /m]	32.5	53	61	62
α	0.4	0.5	0.55	0.6
R [cm]	16	13.8	12.5	11.6
R_1 [cm]	11.2	10	9.4	8.5
R_2 [cm]	11.4	10.2	9.6	8.7
r_B [cm]	1.1	1.1	1.1	1.1
r_N [cm]	0.25	0.25	0.25	0.25
r_2 [cm]	1.0	1.0	1.0	1.0
t_1 [cm]	0.7	0.7	0.7	0.7
t_2 [cm]	0.8	0.8	0.8	0.8
g_1 [cm]	1.80	3.33	4.88	6.66
g_2 [cm]	1.1	1.5	2.44	3.33
L [cm]	4.44	6.66	8.88	11.11
θ [°]	30	30	30	30

We found some other interesting features of this new configuration -- DAW2. It still has four mode frequencies (see Fig. 6), but one can see also the concentration of the field not only on the cavity axis but also around the second cone farther from the axis. The field separation became more pronounced in the $\pi/2$ mode which results in less perturbation due to the washer supports. The other improvement coming from the outer cone is that the accelerating and coupling mode frequencies are more independent; that is,

locations can be found where removing or adding material in the cavity affects either the mode or the other almost exclusively. This makes tuning much easier. Another effect is that the coupling mode becomes loaded by the cone's capacity; therefore, the cavity radius could be made smaller for the same resonant frequencies. Figure 7 shows the radii of all three structures as a function of β . The curve for the LASC corresponds to the radii of the main cell only, whereas the curves for the DAW structure corresponds to the entire structure.

We have calculated the rate of change of the two frequencies (e.g., "accelerating cell" frequency, f_{r2} , and "coupling" frequency, f_{r3}) due to perturbations of various physical dimensions in the range 1200 to 1500 MHz. The most important parameters for the tuning procedure for DAW2 with $\beta = 0.6$ are shown in Table III. One possible tuning strategy for the "coupling cavity" might be to trim a small amount of material from the corner of the "coupling cavity," represented by r_2 in Table II and in Fig. 5, which had purposefully been made a bit excessive during manufacture. This trimming can be done after the disk and washer are completed in a single unit. Thus, the best way to tune the coupling cell is to remove the material from the corner and/or from the outer cone. Either procedure has an almost negligible effect on the change of the "accelerating cell" frequency. The accelerating cell can be tuned by increasing its diameter or removing material from the cone on the cavity axis. Similarly, this has negligible effect on the frequency of the coupling cell.

TABLE III
TUNING EFFECTS OF PARAMETER CHANGES FOR DAW2

Parameter	f_{r2}	Rate [MHz/cm]	f_{r3}	Rate [MHz/cm]
$R_2 \uparrow$	+	120	-	-
$R \uparrow$	-	-	+	210
$R_1 \uparrow$	-	-	+	190
$t_1 \uparrow$	-	-	+	240
$r_2 \uparrow$	-	-	+	80
$g_2 \uparrow$	-	-	+	240
$g_1 \uparrow$	+	210	-	-

We have calculated also the power dissipation on the segments of the cavity surface to see how it is distributed along the cavity. In both cases, DAW1 and DAW2, there is a little power dissipated in the disk and on the outer wall of the cavity (10%). Almost all power is lost in the washer (90%). Total power for the whole cavity is around 900 W at 1 MV/m acceleration rate, as calculated by SUPERFISH. It is obvious that the washer has to be cooled. We propose four washer supports which can be made hollow for water transfer into the washer.

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Fig. 1. Effective shunt impedance of three considered structures as a function of β .

Fig. 2. Disk and washer structure -- DAW1.

a)

Fig. 3a. DAW1 segment
with the accel-
erating mode.

b)

Fig. 3b. DAW1 segment
with the coup-
ling mode.

$f_0 = 735 \text{ MHz}$

$f_\pi = 1631 \text{ MHz}$

$f_{\pi/2} = 1350 \text{ MHz}$

$f_{\pi/2} = 1350 \text{ MHz}$

Fig. 4. Field patterns in a quadrant of the DAWI cavity with the different boundaries. N marks the Neumann-type and D the Dirichlet-type boundaries ($\beta = 0.6$).

Fig. 5. Disk and washer structure, DAW2, with the shaped washer.

$f_0 = 800 \text{ MHz}$

$f_\pi = 1655 \text{ MHz}$

$f_{\pi/2} = 1350 \text{ MHz}$

$f_{\pi/2} = 1350 \text{ MHz}$

Fig. 6. Field patterns in a quadrant of the DAW2 cavity with Neumann (N) and Dirichlet (D) type boundaries ($\beta = 0.6$).

Fig. 7. Cavity radii for LASC, DAW1 and DAW2 versus β .