

MURA-468
UC-28 Particle Accelerator and
High-Voltage Machines
TID-4500 (15th Edition)

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COST OF A 10 BEV SCANNING FIELD AG SYNCHROTRON

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ABSTRACT

The cost of a 10 Bev SFAG Accelerator is estimated by comparison with either a high repetition rate AG synchrotron (MURA-467) or an FFAG accelerator (MURA-460). Both comparisons give the SFAG cost as approximately \$45 million.

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To build a high intensity high energy accelerator (e.g. 10 Bev, 1 -- 100 μ A average output) of the scanning field AG design is well within the feasibilities of modern technology. A rough cost estimate for a 10 Bev SFAG synchrotron is done with the design parameters shown in Table 1.

The cost estimate was based on the two standard examples previously estimated: high repetition AG (MURA-467) and FFAG (MURA-460). Figures from both examples are used directly or modified by simple factors because of the differences of machines. Figures for magnets, power supplies and RF system were independently estimated for the SFAG. The result is shown in Table II and III.

	<u>From AG data</u>	<u>From FFAG data</u>
Total	46.5 M\$	44.9 M\$

The total does not include "research and operating equipment," "escalation" and "contingency." The above results give the order of cost of the SFAG synchrotron.

TABLE I

Parameters

Type of machine	Separate type scanning field AG.
Energy	50 Mev \rightarrow 10 Bev
Field	504 Gauss \rightarrow 17 K Gauss
Mean radius	44 \rightarrow 46 m
Orbit shift	204 cm
Geometric index	$k = -77.3$
Focusing	$\left\{ \begin{array}{l} n_{dc} = -36 \\ n_{scan} = 51 \end{array} \right.$ $\left\{ \begin{array}{l} \nu_x = 6.8 \\ \nu_z = 5.8 \end{array} \right.$
Aperture	30 cm x 20 cm \longrightarrow 7 cm x 4 cm
Half relative aperture at injection	$\left\{ \begin{array}{l} x = 2.2 \times 10^{-3} \\ z = 3.4 \times 10^{-3} \end{array} \right.$
Maximum current at injection	~ 7 amp
Repetition rate	32 cps
Duty cycle of acceleration	90%
Average output	30 μ amp
Necessary acceleration	130 \rightarrow 390 kev/turn
RF stations	$\left\{ \begin{array}{l} \text{1st stage } 7 \\ \text{2nd state } 21 \end{array} \right.$
Harmonic number	28
Total RF power	1.5 Mw
Beam acceleration	300 kw

TABLE I
(continued)

dc magnet	
iron	3400 tons
copper	133 tons
power	2 Mw
Scanning magnet	
iron	500 tons
copper	20 tons
maximum field energy	3×10^4 joules
total energy in capacitor	3×10^5 joules

TABLE II

Cost Estimation Based on the 15 Bev AG Data (unit; million \$)

	<u>15 Bev</u> <u>AG</u>	<u>10 Bev</u> <u>SFAG</u>	
<u>Building</u>			
Tunnel, magnet foundation	1.5	1.9	(AG) x $\frac{46}{74}$ x 2
Linac building	1.5	.7	
Target building	6.0	6.0	
Shielding	2.5	2.5	
Office	1.5	1.5	
Water and piping	1.2	1.2	
Roads	.8	.8	
Engineering	2.0	2.0	
	<u>17.0</u>	<u>16.6</u>	
<u>Linac</u>			
	200 Mev	50 Mev	
	5.5	2.2	(Mark I, V)
<u>Magnet</u>			
{ Core	{ 3.2	dc { 3.0	.4 \$/lb.
{ Coil		scan { .7	.65 \$/lb.
Testing	.3	1.1	(AG) x $\frac{46}{74}$ x 6
Survey, erection	.3	.6	(AG) x $\frac{46}{74}$ x 3
	<u>6.0</u>	<u>7.0</u>	
<u>Magnet Power</u>			
	4.5	dc .3	150 \$/KW
		scan .3	1000 \$/KVA
		<u>.6</u>	
<u>Vacuum System</u>			
Chambers	.4	2.4	(Mark V) x $\frac{2}{3}$ x 2
Pumps	.2	.5	(Mark V) x $\frac{2}{3}$ x 1.5
Controls	.1	.1	
Special section	.1	.1	
	<u>.8</u>	<u>3.1</u>	
<u>RF</u>	3.5	3.0	
<u>Controls</u>	1.0	1.0	

TABLE II
(continued)

<u>Design and Development</u>	1.0	4.0	(AG) x 4
<u>Administration and Salaries</u>	6.0	9.0	(AG) x 1.5
Grand Total (Total 2)	<u>45.3</u>	<u>46.5</u>	

TABLE III

Cost Estimation Based on the FFAG Data (unit; million \$)

	<u>10 Bev Mark V</u>	<u>10 Bev SFAG</u>	
A. <u>Site, Utilities, DC Supplies, Buildings and Tunnels</u>			
Engineering, Design & Supervision	1.0	1.0	
Site Development	.1	.1	
Plant Utilities	.4	.4	
Accelerator Utilities	3.1	3.1	
Accelerator Tunnel & Beam Vaults	6.9	6.5	
Buildings	2.7	2.7	
Magnet and RF System DC Power	4.0	2.0	
	<u>18.2</u>	<u>15.8</u>	
B. <u>Accelerator Construction</u>			
Engineering, Design & Supervision	2.5	3.7	(Mark V) x 1.5
{ Magnet Core	{ 9.3	dc { 3.0	
{ Magnet Coils	{ 9.5		{ 1.1
		scan { .4	
		{ .5	
Magnet Accessories & Miscellaneous	.8	1.6	(Mark V) x 2
Vacuum Tanks & Accessories	2.3	2.5	
Vacuum Pumping System	.5	.5	(Mark V) x $\frac{2}{3}$ x 1.5
Injector	2.2	2.2	
Radio Frequency System	3.2	3.0	
Auxiliary Magnets & Power Supplies	1.0	1.0	
Instruments and Controls	.3	1.0	(AG)
	<u>31.6</u>	<u>20.5</u>	
C. <u>Accelerator Development</u>	<u>6.8</u>	<u>6.8</u>	
Total 1	56.6	43.1	
D. <u>Project Administration & Services</u>	1.0	.8	} Total 1
E. <u>Construction Management</u>	1.3	1.0	
Total	<u>58.9</u>	<u>44.9</u>	