RCG Note 92-11
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Establishment of Smear Counting Method for the HT1000

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In the course of establishing the operating parameters for the HT1000, I consulted a copy of "Radiological Safety Aspects of the Operation of Electron Linear Accelerators" (IAEA, 1979) to get an idea of what activation products can be expected around high energy electron accelerators. Tables XX, XXII, XXIV, XXV, and XXVIII were used to determine the common isotopes produced in various materials. From these tables, a list of the most likely activation products was compiled based on the listed saturation activities. This list is presented below as Table A.

Table A: Most Abundant Isotopes Produced in Materials

Material	Isotope	Emission Type	Max Energy (MeV)
Concrete	O^{15}	β^+	1.74
	Na^{22}	β^+	0.55
	Si^{27}	β^+	3.8
	K^{38}	β^+	2.7
Steel	Mn^{56}	β^-	2.85
	Cr^{51}	ϵ	
	Mn^{52}	β^+	0.58
	Mn^{54}	ϵ	
	V^{48}	β^+	0.70
	Fe^{59}	β^+	0.47
Natural Copper	Co^{60}	β^-	0.32
	Cu^{61}	β^+	1.22
	Cu^{62}	β^+	2.92
	Cu^{64}	β^-	0.57
	Cu^{64}	β^+	0.65

A perusal of the above table shows that the emissions of the most probably produced isotopes generally fall into two energy ranges: ~0.5 - 0.7 MeV and >1.2 MeV.

It is desirable that the HT1000 be set up using sources whose emission energies replicate as closely as possible the energies likely to be encountered when counting a sample. To this end I noted that the maximum energies of Sr^{90} and Y^{90} fall within the noted energy ranges of activation products of high energy electron accelerators (Sr^{90} β_{max}=0.544MeV; Y^{90} β_{max}=2.245MeV). It is therefore proposed that the HT1000 be calibrated with a strontium/yttrium source and an americium source using a low amplifier gain. This should provide an ample range for simultaneous counting of alpha and beta on normal smear samples.

The operating voltage of the HT1000 should be found by running a plateau using the 1" Sr^{90}/Y^{90} source and a low amplifier gain. Since the alpha plateau is still linear in the upper voltage regions of it's curve, the operating point for the beta plateau as found above will also dependably count any alpha present.

A program will be set up which incorporates the low amplifier gain, the corresponding operating voltage, simultaneous α/β counting, and 0% cross talk $\beta \rightarrow \alpha$. Calibration of the program for smear counting will be accomplished by using the 2" Sr^{90}/Y^{90} source and the 2" Am^{241} source. (It should be noted that since the strontium is in secular equilibrium with the yttrium, the stated activity of the source needs to be doubled for calibration purposes.) This method will correctly set up the HT1000 for counting smears with isotopes that approximate the energy distribution discussed above.

A test of this method was conducted on detector A1. The operating voltage was determined to be 1510 volts. The efficiencies for the strontium and americium sources were determined, and the 2" Sr^{90}/Y^{90}, C^{14}, and Am^{241} sources were then counted using the program SR90LOW. The report of the count is attached to this memo, and the results of the test are tabulated below.

Table B: Test Results

Source	Source Activity (nCi)	Measured Activity (nCi)
Am^{241}	53.46	53.7
Sr^{90}	105.7	106.
C^{14}	50.93	1.02

The measured activities for the Sr^{90} and Am^{241} are quite close to the certified source activities, but the measured C^{14} activity is very low. An efficiency for C^{14} was measured using the same operating voltage, and the resulting figure used to calculate the C^{14} activity from the test count data. The new measured activity was 53.14 nCi which is close to the actual activity.

The test verified that the proposed method is adequate for ordinary smear counting, but that if the only activity present consists of

very low energy beta emitters an alternate method must be used. This is due to the large variation of efficiency between the Sr^{90} (η=30.71%) and C^{14} (η=0.59%) sources.

It is thus recommended that smears be routinely counted on the HT1000 in a simultaneous alpha/beta mode using a low amplifier gain and an operating voltage derived from a plateau run with a Sr^{90} source and low amplifier gain. Smears having a high count rate and a low calculated activity should be recounted using a program appropriate to the counting of low energy beta emitters (ie. the C14 program). Similarly, smears showing a large degree of alpha into beta cross talk should be recounted using a program appropriate to the counting of alpha only (ie. the AM241 program).

CEBAF Radiation Control Office
Alpha/Beta Counting Report

August 26, 1992 03:08 pm

	High Voltage	Amp. Gain	Count Time
Drawer A:	1510	Low	120 sec.

Alpha:	Window	Efficiency	Background	Crosstalk
Det A/1	77.4-100%	0.0448	0	0

Beta:	Window	Efficiency	Background	Crosstalk
Det A/1	0 - 77.3%	0.3071	0	0

Det A/1	Sample:	active C^{14}	Aug 26, 1992 14:41:03			
Alpha	Gross:	0	Net:	0.00E+00	µCi:	0.00E+00 ±0
Beta	Gross:	1392	Net:	6.96E+02	µCi:	1.02E-03 ±5.4E-05
Det A/1	Sample:	AM	Aug 26, 1992 14:43:39			
Alpha	Gross:	10684	Net:	5.34E+03	µCi:	5.37E-02 ±0.00102
Beta	Gross:	4081	Net:	5.11E+01	µCi:	7.50E-05 ±5.7E-05
Det A/1	Sample:	SR	Aug 26, 1992 14:46:15			
Alpha	Gross:	1	Net:	5.00E-01	µCi:	5.03E-06 ±9.9E-06
Beta	Gross:	144464	Net:	7.22E+04	µCi:	1.06E-01 ±0.00055
Det A/1	Sample:	SRsmall	Aug 26, 1992 14:49:52			
Alpha	Gross:	1	Net:	5.00E-01	µCi:	5.03E-06 ±9.9E-06
Beta	Gross:	156987	Net:	7.85E+04	µCi:	1.15E-01 ±0.00057
Det A/1	Sample:	Csmall	Aug 26, 1992 14:52:53			
Alpha	Gross:	0	Net:	0.00E+00	µCi:	0.00E+00 ±0
Beta	Gross:	19426	Net:	9.71E+03	µCi:	1.42E-02 ±0.0002
Det A/1	Sample:	AMsmall	Aug 26, 1992 14:55:53			
Alpha	Gross:	93607	Net:	4.68E+04	µCi:	4.71E-01 ±0.00301
Beta	Gross:	20334	Net:	0.00E+00	µCi:	0.00E+00 ±0.00016