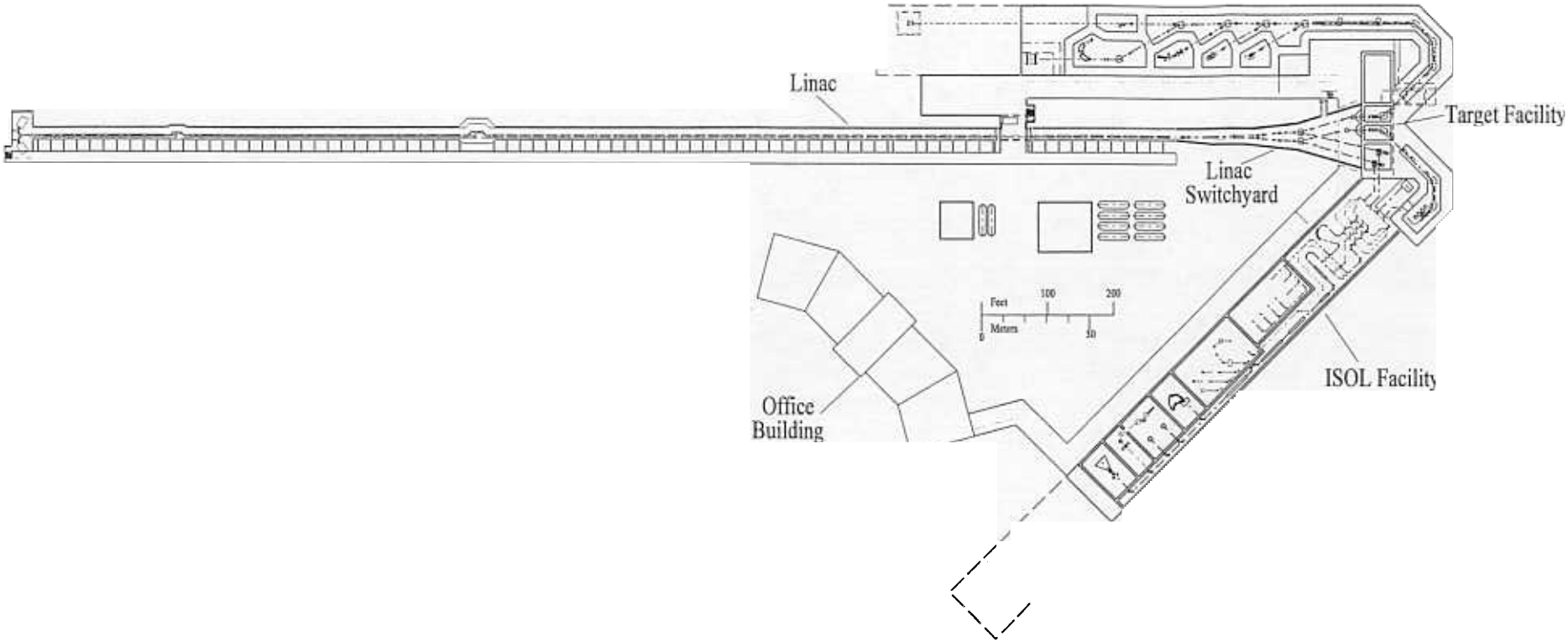
RIA Cost Estimate

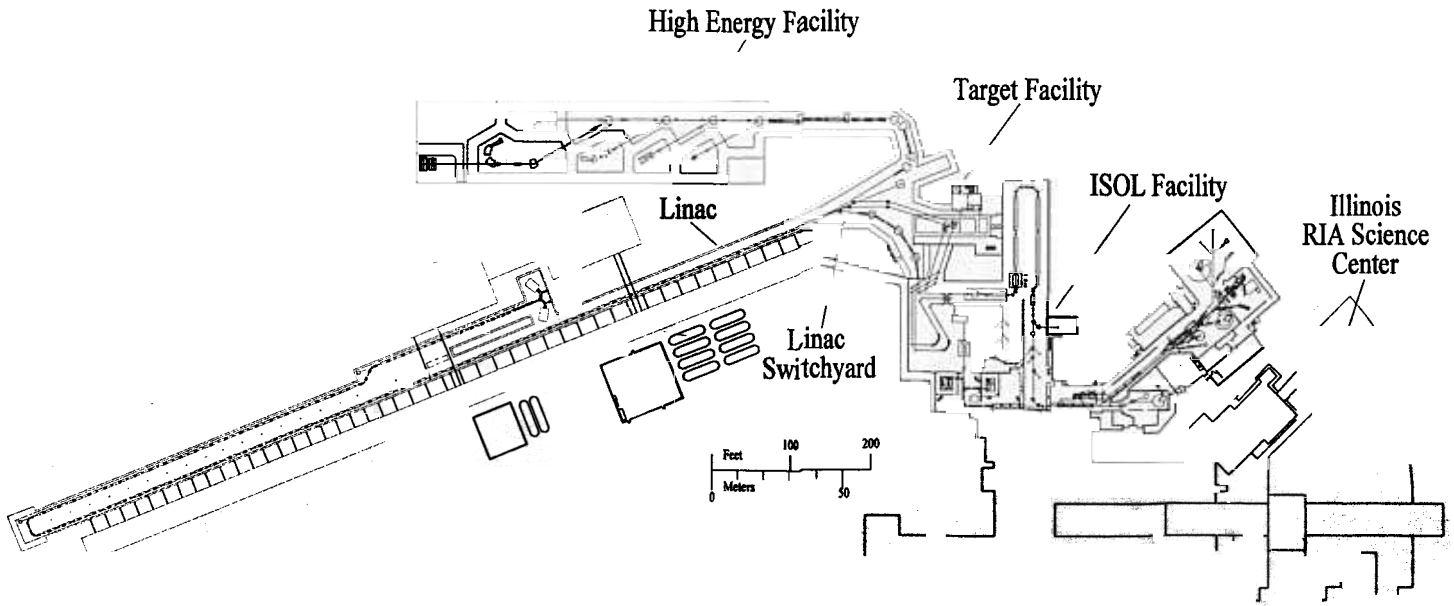
Cost Overview

				Experimental Facilities				
	Management, Computing, and Controls	Cryogenic Plant and Distribution	Driver	Exp. Safety and Control Systems	Target Systems	ISOL Facilities	High Energy Facilities	Total
Central Facilities	$44.3	$46.5						**$90.8**
Civil and Utilities	$28.1	$4.7	$27.0		$18.9	$26.2	$21.6	**$126.5**
Driver			$213.5					**$213.5**
Experimental Facilities				$9.6	$45.8	$124.3	$83.8	**$263.5**
MSU Total	**$72.5**	**$51.2**	**$240.4**	**$9.6**	**$64.6**	**$150.5**	**$105.4**	**$694.3**
- ANL Atlas						-$38.7		-38.7
- ANL Other (e.g. civil)								-15.6
ANL Total						**$111.8**		**$640.0**

Facility Layouts

High Energy Facility





Argonne Site

Driver Layout

RIA Driver Linac (805 MHz) - SC Resonator Configuration

(configured to compensate for energy loss in the second stripper)

(beta in = .01794c)

Beta	Type	RF Amp (KWS) Watts	Freq (MHz)	Length (cm)	Eacc (MV/m)	Voltage (MV)	Phase deg.	cav/cry (Vincent)	No. Cavities Injector	Middle	Final	Prototype	No. Cryostats (Vincent) Injector	Middle	Final	Cryomodule Cost k$	Total Cost k$
0.021	FORK	500	57.5	18	4	0.62	-30	8	2			1	1	0	0	1162	0
0.030	FORK	500	57.5	26	4	0.90	-30	8	5				-	0	0		
0.062	QWR	500	57.5	20	5	0.87	-30	8	32			1	4	0	0	892	2676
0.128	Split-ring	700	115.0	36	4	1.25	-30	8	40			1	5	0	0	1059	4236
0.190	Lollipop	1000	172.5	36	5	1.56	-30	8		72		1	0	9	0	1059	8472
0.380	Spoke	1000	345.0	36	5	1.56	-30	8		96		1	0	12	0	1052	11572
0.490	6 Cell	10000	805.0	55	8.28	3.93	-30	4			76	1	0	0	19	1197	21546
0.610	6 Cell	15000	805.0	68	10.22	6.04	-30	4			84	1	0	0	21	1197	23940
0.810	6 Cell	15000	805.0	91	12.56	9.85	-25	4			28	1	0	0	7	1197	7182
Total Cavities =			435		Section Cavities =				79	168	188		10	21	47		79624
Total Voltage =			1421	(MV)	Section Voltage =				77.6	261.9	1081.4						

K. W. Shepard ANL 6/8/00

SC DRIVER LINAC FOR A RARE ISOTOPE FACILITY

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Abstract

An ion linac formed of superconducting rf cavities can provide a multi-beam driver accelerator for the production of nuclei far from stability. A multi-beam driver supports a wide variety of production reactions and methods. This paper outlines a concept for a 1.3 GV linac capable of delivering several hundred kilowatts of uranium beam at an energy of 400 MeV per nucleon. The linac would accelerate the full mass range of ions, and provide higher velocities for the lighter ions, for example 730 MeV for protons. The accelerator will consist of an ECR ion source injecting a normally conducting RFQ and four short IH structures, then feeding an array of more than 400 superconducting cavities of six different types, which range in frequency from 58 to 700 MHz. A novel feature of the linac is the acceleration of beams containing more than one charge state through portions of the linac, in order to maximize beam current for the heavier ions. Such operation is made feasible by the large transverse and longitudinal acceptance provided by the large aperture and high gradient which are characteristic of superconducting rf cavities.

1 INTRODUCTION

For more than a decade there has been discussion and study in the North American nuclear physics community concerning the possibility of an advanced facility for generating intense beams of isotopes far from stability [1]. Several years ago, a design concept for such a facility, based on a multi-beam ion accelerator driver was put forward [2,3]. In late 1998, the Nuclear Science Advisory Committee (NuSAC) for the U.S. Department of Energy and the National Science Foundation recommended that construction of a rare-isotope accelerator (RIA) facility be given high priority [4]. More recently, a subcommittee of NuSAC has reviewed technical options for such a facility and recommended that the driver accelerator for such a facility be capable of providing beams of all ions from protons to uranium at energies of at least 400 MeV/nucleon. A further specification is that the driver should be capable of providing 100 kW of beam power initially, and be upgradeable to 400 kW for all ions [5]. This paper outlines a design for a heavy-ion linac capable of meeting these specifications.

2 OVERVIEW OF THE LINAC

Fig. 1 shows a block diagram of the proposed linac, with uranium as the benchmark beam. Parameters of the various sections are detailed in Table 1. For the first 10 MV of the linac normal-conducting accelerating structures can be used, since they can provide adequate performance and are somewhat more cost-effective at the lowest velocities. For the remaining 99% of the linac, however, superconducting (SC) structures have numerous advantages in addition to enabling cost-effective cw operation [6].

The independent phasing intrinsic to a SC cavity array allows the velocity profile to be varied, and enables higher energies for the lighter ions. The present design for a 400 MeV/nucleon uranium linac can also provide 730 MeV protons.

To obtain broad velocity acceptance, the accelerating cavities are necessarily short, allowing the linac to be configured with ample transverse focussing. Also, since SC structures provide high accelerating gradients, strong longitudinal focussing can be obtained by

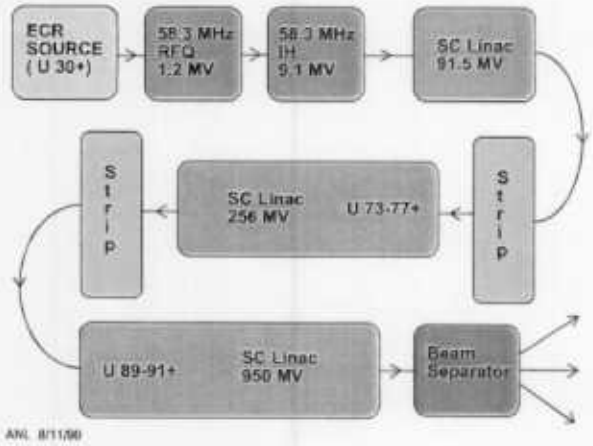

Figure 1: Elements of the proposed linac

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Table I: Accelerating elements of the benchmark RIA driver linac

Section	Element Type	Beta = v/c	Frequency (MHz)	Temp. (K)	Number of Elements	Section Voltage (MV)
Source	*ECR*	*(Ions from H^{1+} to $^{238}U^{30+}$)*			*2*	0.05
Injector	RFQ	.004 - .017	58.3	293	1	1.2
Injector	IH cavity	.017 - .05	58.3	293	4	9
Injector	2-gap cavity	.05 - .09	58.3	4.5	24	21
Injector	3-gap cavity	.09 - .16	116.6	4.5	57	71
1st Stripper	*Stripper*	*(Lithium film or carbon wheel)*				
Midsection	3-gap cavity	.16 - .3	175	4.5	72	111
Midsection	3-gap cavity	.3 - .4	350	4.5	96	150
2nd Stripper	*Stripper*	*(carbon wheel)*				
Endsection	6-cell cavity	.4 - .54	700	2	60	261
Endsection	6-cell cavity	.54 - .8	700	2	96	684

operating in a phase-focussing mode, such as the synchronous phase of –30 degrees assumed in this work. In this way the SC linac can be configured to provide very strong focussing, insuring that both transverse and longitudinal acceptances are large. For the case considered here, the longitudinal acceptance is ~250 times larger and the transverse acceptance is ~100 times larger than the input beam emittance, which is determined by the ion source and injector RFQ.

As is discussed below, such an immense margin for emittance growth makes entirely feasible a novel operating mode for the linac, in which the beam contains multiple charge-states [7]. By simultaneously accelerating several of the many charge states resulting from stripping the beam, the efficiency of charge stripping is greatly enhanced, since a much higher portion of the stripped beam can be utilized.

Multi-charge-state operation provides not only a substantial increase in the available beam current, typically a factor of four, but also enables the use of multiple strippers, which reduce the size of the linac required for 400 MeV/nucleon beams. An additional benefit of accelerating multiple charge states is a reduction in the amount of beam dumped during charge-state selection at the stripping points, which in turn reduces shielding requirements.

Taking uranium as an example, between the first stripper (12 MeV/n) and second stripper (85 MeV/n) the beam has an average charge state $q_0 = 75$. In this region we can accelerate 5 charge states, which encompass 80% of the incident beam. After the second stripper, 99% of the beam is in four charge states neighbouring q_0=90, all of which can be accelerated to the end of linac.

As discussed below, numerical simulations show such operation to be straightforward, with the consequent increase of longitudinal and transverse emittance well within the linac acceptance. By accelerating multiple-charge-state beams of the heavier ions, the linac described above would be capable of producing intense beams of virtually any stable ion.

3 SOURCE AND INJECTOR SECTIONS

3.1 ECR Ion Source

The heavy-ion driver for RIA begins with a high performance Electron Cyclotron Resonance (ECR) ion source. This type of source is well matched to the driver's requirements for a cw, high charge state ion source capable of ionizing a wide range of elements. The heaviest beam needed for the RIA driver is uranium, which is also the most demanding in terms of ion source performance. The RIA driver accelerator should produce at least 6×10^{12} pps of uranium at 400 MeV/nucleon. The target performance for the source is to produce U^{30+} at an intensity of 4×10^{13} for injection into the RFQ. This is about a factor of 6 greater than the current record intensities, which have been achieved with the AECR-U at Berkeley [8].

To reach these higher current levels will require R&D on a new high magnetic field high frequency

ECR ion source. A possible prototype for this RIA ECR is the VENUS ECR ion source currently under construction at the Berkeley Laboratory. It has superconducting solenoid and sextupole coils to enhance the plasma confinement and also sufficiently high fields to support ECR operation at 28 GHz. The coils are designed to generate a 4 T axial mirror field at injection and 3T at extraction and a radial sextupole field of 2.0 T at the plasma chamber wall.

3.2 Normally-conducting RFQ

A concept for an RFQ has been developed which can operate cw and can accelerate charge states as low as a U^{25+} beam from 5.25 keV/n to 150 keV/n. A frequency of 58.3 MHz matches the SC linac and insures adequate transverse acceptance, 1.25 π mm-mrad normalised (full), to accommodate the emittance expected from the ECR ion source [9].

The RFQ incorporates an internal kick buncher and drift, followed by a transition region prior to the acceleration section. The transition region produces a low longitudinal output (full) emittance, 1π keV/n-nsec. The low output emittance makes multiple-charge-state acceleration further on in the linac straightforward.

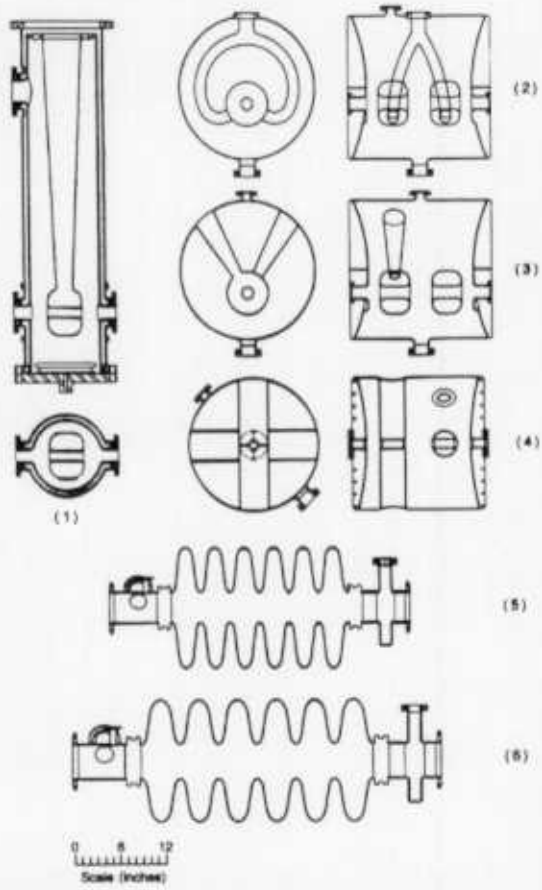

Figure 2: Six cavity types spanning the velocity range $0.04 < \beta = v/c < 1$.

The RFQ will be 4 meters long with an rf power requirement conservatively less than 60 kW. It will use a modified 4-vane configuration with field stabilisers which move the unwanted dipole modes far above the quadrupole mode frequency, reducing assembly tolerances. At 58.3 MHz, 100% duty-factor operation is practical, and the wall power loading is low.

3.3 Normally-conducting IH Section

For an ion energy range from 150 keV/n to about 1.5 MeV/n, inter-digital H-type (IH) structures may be the most cost-effective method for cw operation. Excellent performance in cw or high duty-cycle mode has been proven at several laboratories: Munich Technical Institute, GSI, KEK-Tanashi, and TRIUMF [10]. For IH structures in this velocity range, the optimum frequency is near 60 MHz at 150 keV/n with a higher frequency being desirable at the upper end of the range to increase shunt impedance.

We propose a linac section consisting of four IH tanks with SC solenoids between the tanks. The first two IH tanks would have a frequency is 175/3=58.33 MHz, and the last 2 IH tanks at 350/3=116.7 MHz, to match the following SC linac sections. The use of SC solenoids between the tanks for transverse focusing would maximize the transverse and longitudinal acceptance of this section. The RF power requirement of less than 20 kW/m, is very modest. Also, the solenoids provide a very short transverse focussing element, only 80 mm long for a 10 T field. This minimizes the phase-focussing required in the IH tanks, and helps to maximize the acceptance of this section of the linac.

4 SUPERCONDUCTING SECTIONS

Currently operating SC rf accelerators fall into two classes: velocity-of-light electron linacs, or heavy-ion linacs limited to energies at or below 20 MeV/nucleon. Fortunately for the present application, recent development work has demonstrated the feasibility of extending the velocity range of SC rf structures to cover the intermediate velocity range required by the RIA driver [11,12]. A possible set of SC accelerating structures for a RIA driver are shown in Figure 2. The principle parameters for these cavities are listed in Table 2.

It should be noted that while existing machines and recent development work clearly establish the feasibility of using such a set of cavities, important aspects of the RIA linac can be determined only through prototyping. This must include tests of complete cryomodules to determine, for example, the magnitude of vibration effects and the optimum methods for tuning and phase control. The long lead

Table 2: Parameters for six types of superconducting accelerating structure

Optimum Beta	0.062	0.128	0.19	0.38	0.488	0.64
Type	2 Gap	3 Gap	3 Gap	3 Gap	6 Cell	6 Cell
Frequency (MHz)	58.3	116.7	175	350	700	700
Active Length (cm)	20	36	36	36	63	82
Peak Electric Field - Ep/Ea	4	4.2	4.2	3.8	3.2	2.5
Peak Magnetic Field - Bp/Ea	100	150	150	110	77	62
Geometric Factor QRs	18	28	25	75	120	160
RF Energy (mJ @ 1 MV/m)	120	170	170	170	657	589
Accel. Gradient (MV/m)	5	4	5	5	8	10
Effective Voltage (MV/cavity)	0.87	1.25	1.56	1.56	4.35	7.13
Operating Temp	4.5	4.5	4.5	4.5	2	2

time required, more than two years, makes this activity a critical path in determining the construction schedule for a RIA facility.

4.1 Low-β Accelerator Section

Existing low-β SC drift-tube structures, which for the most part have parameters similar to cavities that are currently used in several SC ion linacs, can be employed for ion velocities up to 0.4 – 0.5 c [13]. For our benchmark RIA driver, four different types of drift-tube structure suffice to cover the velocity range from 0.05 c up to the second stripping point at .4 c or 85 MeV/nucleon. In sequence of velocity, as shown in Figure 2 and Table 2, these cavities are:

1. A 58 MHz, single drift-tube, coaxial quarter-wave cavity with parameters similar to those employed in several existing linacs. Recently-built, well-maintained cavities achieve on-line the 5 MV/m gradients we assume.

2. A 116 MHz, two drift tube split-ring cavity. This class of cavity has somewhat higher surface magnetic fields than the coaxial quarter-wave, leading to a slightly lower projected gradient., but with two drift tubes provides more voltage per cavity.

3. A 175 MHz, two drift-tube structure that is a hybrid between a half-wave and split-ring structure. This will have a lower surface magnetic field than a split-ring cavity at this frequency. The frequency is, however, somewhat higher than has been employed in two-drift tube structures up to the present time (150 MHz). In order to establish the projected accelerating gradient, 5 MV/m, an early prototype of this cavity type would be prudent.

4. A two-cell, 350 MHz spoke-loaded cavity. Spoke-loaded niobium cavities are well-suited to the velocity range from 0.3 to 0.4 c [13]. The projected gradient has recently been obtained in single-cell cavities of this class [14].

The low-β section of the RIA SC driver linac could be comprised of an array of 248 these four different types of SC niobium cavities. These would be distributed in 31 cryostat modules, with each module containing 8 SC cavities. Transverse focussing would be provided by 10 T, 30 mm bore SC solenoids. The basic linac cell or focussing period would be two cavities followed by a solenoid. Such an array, with the cavities operated at a synchronous phase $\phi = -30°$, would provide strong transverse and longitudinal focussing.

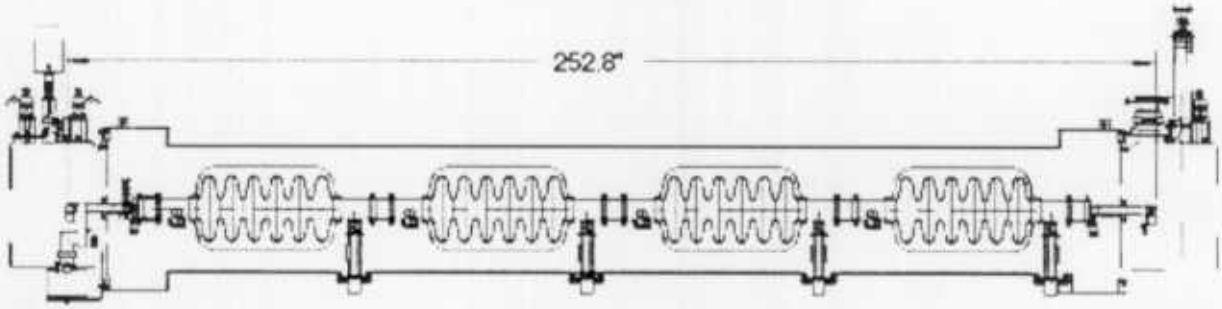

Figure 3: Cryomodule for beta .65 elliptical 6-cell cavities

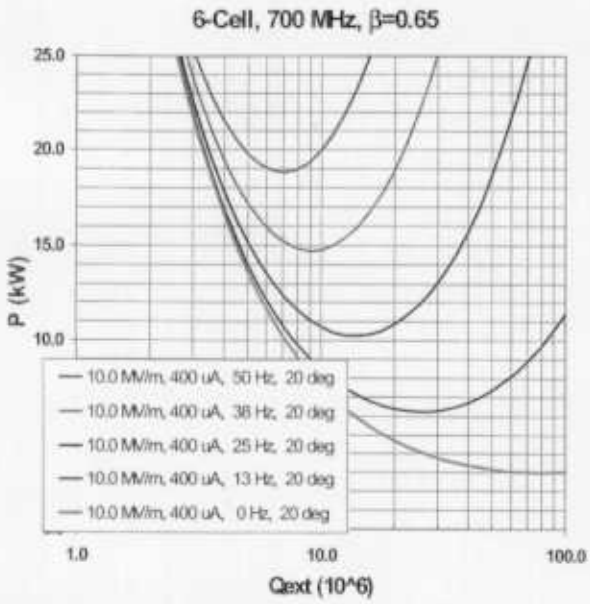

Figure 4: RF power required for phase control in the presence of microphonic frequency noise.

The frequency of all the cavities in the low-β section would be ≤ 350 MHz. In this frequency range the SC surface resistance is sufficiently low to permit economic operation at 4.5 K.

4.2 High-β Accelerator Section

For ion velocities from 0.5 c up, the driver linac would make use of the class of foreshortened elliptical-cell cavities recently tested at JLAB, LANL, and most notably at Saclay, which recently reported accelerating gradients above 20 MV/m in a β = .64, 700 MHz niobium cavity [15]. Note that nearly three-quarters of the total driver voltage is supplied by similar cavities.

The high-β section would consist of 156 SC cavities of two different types, distributed in 39 cryomodules. Each cryomodule would contain 4 SC cavities, and transverse focussing elements would be placed exterior to the cryostats, in the form either of normal-conducting quad triplets or SC solenoids. Both high-β elliptical-cell cavity types will operate at 700 MHz, and thus require 2 K operation.

Because of the relatively low current that will be accelerated, the rf power required to drive the cavities will be dominated by the maximum amount of detuning that will need to be accommodated by the rf control system. This includes both the average frequency offset and the maximum excursion due to microphonics. Figure 4 shows, as a function of external Q, the rf power required to operate and control the b=0.65 cavity at a gradient of 10 MV/m and accelerating 400mA with a phase offset of 20°, with detuning as a parameter, ranging from 0 to 50 Hz.

When the rf power requirement is dominated by microphonics, it increases quadratically with gradient. This makes operation at higher gradients less cost effective, even though the cavities might be capable of such high-gradient operation. For this reason, it may be cost-efficient to limit the assumed operating gradient to 10 MV/m. Even at this gradient, achieving economic performance will require particular attention to the mechanical design of the cavity and the cryostat to limit microphonics to no more than a few Hz rms.

5 PERFORMANCE

5.1 Operation with multiple charge state beams

Operation of the linac with multiple charge state beams is made possible both by the large acceptance of the linac and also by the fact that beams of the heaviest ions are at rather high charge states, so that the fractional difference in charge between neighboring charge states is small. If, for example, we tune the linac for a uranium 75+ beam at a synchronous phase of -30°, then a uranium ion of charge state 76+ can be accelerated simultaneously, with the same velocity profile, at a phase of –31.3°. This small phase shift represents a time difference of only a few picoseconds, so that both charge states easily fit within the stable, linear region of longitudinal phase space throughout the linac.

Such operation has been simulated numerically, using full 3D particle tracking, to study the dynamics of

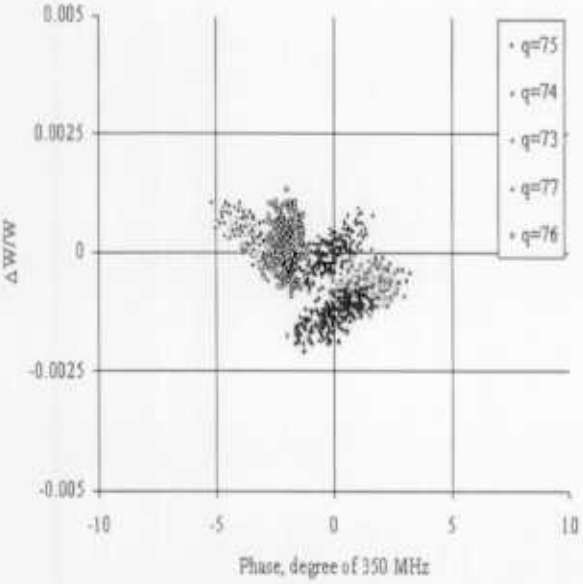

Figure 5: Phase space of a five charge-state uranium beam at 85 MeV/u, just prior to the second stripper.

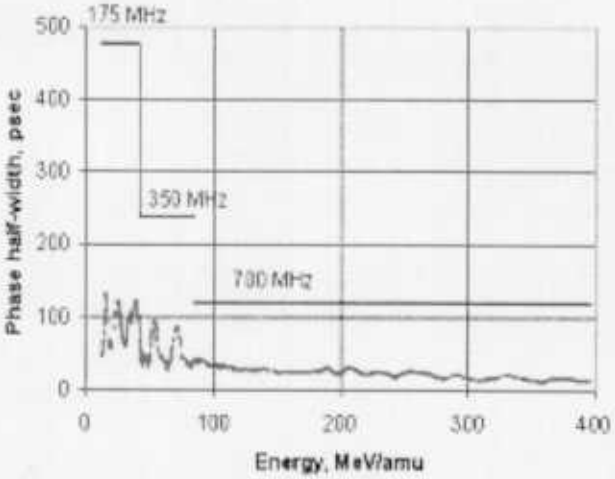

Figure 6: Beam envelope (longitudinal) through the linac for a multiple charge state uranium beam. The beam is shown in red, the linac acceptance in blue.

multiple charge state beams through the proposed RIA driver linac. Some of the results are shown in Figure 5, which details the longitudinal phase space of a uranium beam resulting from acceleration of 5 charge states from the first stripper up to the point just prior to the final stripper, at 85 MeV/nucleon. The phase ellipse for each charge state is clearly discernible, and all five fit within a larger ellipse which represents an effective emittance which is appreciably larger than for a single charge state, but still well within the longitudinal acceptance of the linac.

Figure 6 shows the longitudinal beam envelope for a multiple charge state uranium beam through the entire linac. The beam consists of 5 charge states from the first to the second stripper, and 3 charge states from the second stripper on. The entire beam is at all points well within the longitudinal acceptance, indicating that operation with multiple charge state beams will be straightforward.

5.2 Performance for various ions

Table 3 shows some parameters for beams of various ions from the RIA driver linac. We assume the linac to have sufficient RF power for a 400 kW beam. The stripped charge states are chosen to maximize the output beam current, and the linac is tuned to maximize the energy for each beam. For ions of mass greater than 90, current ECR source performance will not provide sufficient current in a single charge state for 400 kW output beam. For these ions we assume multiple charge state beams from the first stripper on.

Even with the limit of present ECR performance, several hundred kilowatts of beam would be available for nearly all ions: sufficient power to simultaneously feed several production targets. CW beams could be provided to multiple targets by several mechanisms. In the case of beams of several charge states, the different charge states could be separated magnetically. A more general and versatile method would be to use one or more rf beam separators at the linac output.

6 CONCLUSIONS

Current state-of-the-art superconducting cavities can form a highly flexible superconducting linac capable of producing 100 kW, 400 MeV/nucleon beams of any stable isotope from hydrogen to uranium. Such a linac could be the basis for a Rare-Isotope Accelerator (RIA) facility that could provide unprecedented beams of a large, diverse range of nuclei. A modest research and development effort over the next two to three years could significantly impact the cost and performance of cavities and cryomodules for this machine.

7 ACKNOWLEDGEMENTS

Many people have contributed to the development of the concepts described in this paper. The authors would like particularly to thank Hermann Grunder

Table 3: Output beam energies and power for various ions

A	I source	Qout	I out	Energy (MeV/A)	Energy (MeV/A) after $N\beta = .65$ cavities			Beam Power
	pμA		pμA	At 2nd stripper	N = 0	N = 48	N = 96	kW
1	548*	1	548	227.9	317.2	575.2	730.8	400
3	218*	2	218	172.5	273.4	474.5	612.2	400
2	379*	1	379	140.4	239.7	402.6	528.1	400
18	54*	8	45	125.4	222.9	369.8	490.9	400
40	24*	18	20	124.6	223.3	371.9	493.8	400
86	10	36	8.5	112.9	209.9	347.6	459.8	336
136	5	54†	3.4	103.7	198.0	326.3	445.3	206
238	1.5	90†	1.0	86.7	172.2	280.9	402.8	100

* Limited by RF power available, † Mean value of multiple charge states

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WBS Level 1
Systems

RIA Systems (WBS Level 1)

	Description	System (M$)	Purchases (M$)	FTE (150k$) (M$)
1	Central Facilities and Services	90.8	23.5	67.3
2	Civil and Utilities	126.5	126.5	0.0
3	Driver Accelerator	213.5	207.9	5.6
4	Experimental Facilities	263.5	187.6	75.9
	Total	694.3	545.4	148.9

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WBS Level 2 Components

RIA Central Facilities and Services (WBS Level 2)

Index	Description	System	Purchases	FTE (150k$)		
1		(M$)	(M$)	(M$)	Cost Basis	Lab
1.0	**Project Management & Support**	**21.9**				
1.1	Personel		0.9	21.0	=28 FTE/yr for 5 years	ANL/NSCL
2.0	**Facility Controls and Computing**	**11.0**				
2.1	Personel			9.0	=12 FTE/yr for 5 years	NSCL
2.2	Equipment		2.0		450 computers + nets, services	NSCL
3.0	**Cryogenic Plant & Distribution**	**34.4**				
3.1	Equipment		14.5	19.1	Eng. Est.	Jlab
3.2	Commisioning/Calibration			0.8	Eng. Est.	Jlab
	Sub-Total	**67.3**	**17.4**	**49.9**		
	Contingency (35%)	**23.5**	**6.1**	**17.5**		
	Total	**90.8**	**23.5**	**67.3**		
	12/18/2000 11:44					

RIA Civil and Utilities (WBS Level 2)

RIA Civil and Utilities

Index	Description	System	Purchases	FTE (150k$)		
2		(M$)	(M$)	(M$)	Cost Basis	Lab
1.0	**Site**	11.7				
1.1			11.7		Eng. Est.	NSCL
2.0	**Central Facilities**	11.8				
2.1	Control Room, Offices, Labs, Shops		11.8		Eng. Est.	NSCL
3.0	**Driver Accelerator Facilities**	22.5				
3.1	Linac Tunnel		12.0		Eng. Est.	NSCL
3.2	Klystron Gallery		6.4		Eng. Est.	NSCL
3.3	Linac BSY		4.0		Eng. Est.	NSCL
4.0	**Target Facilities**	15.7				
			15.7		Eng. Est.	NSCL
5.0	**ISOL Experimental Facilities**	21.8				
5.1	Fragment Seperator		6.8		Eng. Est.	NSCL
5.2	High Bay		15.0			
6.0	**High Energy Experimental Facilities**	18.0				
6.1	Fragment Seperator		4.9		Eng. Est.	NSCL
6.2	High Bay		13.1			
7.0	**Cryogenics**	3.9				
7.1	Building		3.9		Eng. Est.	NSCL
	Sub-Total	105.4	105.4			
	Contingency (20%)	21.1	21.1			
	Total	126.5	126.5			

12/18/2000 11:44

RIA Driver Accelerator (WBS Level 2)

Index	Description	System	Purchases	FTE (150k$)	Cost	
3		(M$)	(M$)	(M$)	Basis	Person
1.0	**Front End (source, RFQ, IH)**	9.3				
1.1	ECR		3.1		Eng. Est.	ANL/P.O.
1.2	High Voltage Platform		0.3		Eng. Est.	ANL/P.O.
1.3	LEBT		1.0		Eng. Est.	ANL/P.O.
1.4	RFQ		4.1		Eng. Est.	ANL/P.O.
1.5	MEBT		0.9		Eng. Est.	ANL/P.O.
2.0	**Injector and Low Beta Linac (31 CM)**	34.7				
2.1	Beta = 0.021 and 0.030 (1 CM, 7 CAV)		1.2		Eng. Est.	ANL/K.S.
2.2	Beta = 0.062 (4 CM, 32 CAV)		3.9		Eng. Est.	ANL/K.S.
2.3	Beta= 0.128 (5 CM, 40 CAV)		5.2		Eng. Est.	ANL/K.S.
2.4	Beta =0.19 (9 CM, 72 CAV)		9.4		Eng. Est.	ANL/K.S.
2.5	Beta = 0.38 (12 CM, 96 CAV)		12.7		Eng. Est.	ANL/K.S.
2.6	Magnets, Power Supplies, Other.		1.0		Allowance	NSCL
2.7	Design/Eng			1.0	Eng. Est.	ANL/K.S.
2.8	Installation and Checkout			0.4	Eng. Est.	ANL/K.S.
3.0	**High Beta Accelerator (47 CM)**	58.8				
3.1	Beta = 0.49 (19 CM, 76 CAV)		22.8		Eng. Est.	Jlab
3.2	Beta = 0.61 (21 CM, 84 CAV)		25.6		Eng. Est.	Jlab
3.3	Beta = 0.81 (7 CM, 28 CAV)		9.4		Eng. Est.	Jlab
3.4	Magnets, Power Supplies, Other.		1.0		Allowance	NSCL
4.0	**RF (RIA DRIVER)**	39.8				
4.1	_Signal Source		0.2		Eng. Est.	ANL/APS
4.2	_(RFQ(One System)		0.9		Eng. Est.	ANL/P.O.
4.3	_(Buncher (2 Systems)		0.4		Eng. Est.	ANL/APS
4.4	SC Linac Injection Section (79 Systems)		4.7		Eng. Est.	ANL/APS
4.5	SC Linac Mid Section (168 Systems)		9.4		Eng. Est.	ANL/APS
4.6	SC Linac Final Section (188 Systems)		24.3		Eng. Est.	ANL/APS
5.0	**Linac Control Interface**	7.9				
5.1	Linac IOC's and Software Setup		3.4		Eng. Est.	NSCL
5.2	Diagnostic Systems		4.5		Allowance	ANL/Atlas
6.0	**Stripping Systems**	3.0				
6.1	First		1.0		Eng. Est.	ANL/P.O.
6.2	Second		2.0		Eng. Est.	ANL/P.O.
7.0	**Linac BSY**	4.6				
7.1	RF Switch		0.2	0.3	Allowance	NSCL
7.2	Magnetic Elements		1.6	2.5	Eng. Est.	NSCL
	Sub-Total	**158.1**	**154.0**	**4.2**		
	Contingency (35%)	**55.3**	**53.9**	**1.5**		
	Total	**213.5**	**207.9**	**5.6**		

12/18/2000 11:45

RIA Experimental Facilities (WBS Level 2)

Index	Description	System	Purchases	FTE (150k$)	Cost Basis	Lab
4		(M$)	(M$)	(M$)		
1.0	**Safety Systems**	**$3.6**	$1.3	$2.4	Allowance	NSCL
2.0	**Control Systems**	**$3.5**	$1.0	$2.5	Allowance	NSCL
3.0	**Target Systems**	**$33.9**				
3.1	High Energy Target		$2.9	$4.3	Eng. Est.	NSCL
3.2	Gas Stopping Target		$2.5	$4.1	Eng. Est.	NSCL
3.3	2 ISOL Targets		$4.0	$4.4	Eng. Est.	NSCL/ISAC/SNS
3.4	Shared Target Services		$3.0	$8.8	Eng. Est.	NSCL/ISAC/SNS
4.0	**ISOL Systems**	**$57.2**				
4.1	Gas Cell TGT Area Transport		$3.0	$1.6	Eng. Est.	NSCL
4.2	Gas Cell Fragment Seperator		$2.8	$4.2	Eng. Est.	NSCL
4.3	Gas Cell System		$0.6		Eng. Est.	ANL/Atlas
4.4	Low Energy Static Switchyards		$2.0	$4.0	Allowance	ANL/Atlas
4.4.1	Isobar Entrance Switchyards					
4.4.2	Isobar Exit Switchyards					
4.4.3	Stopped Beam Vaults Switchyard					
4.4.4	Astrophysics 1 Mev/u Switchyard		$1.3		Eng. Est.	ANL/Ostromov
4.4.5	7 Mev/u Switchyard		$0.9		Eng. Est.	ANL/Ostromov
4.5	100 keV Isobar Sperators					
4.5.1	Two High Res		$0.6	$1.4	Allowance	ANL/Atlas
4.6	Post Accelerators					
4.6.1	RFQ's, HV platforms, bunchers		$2.6		Eng. Est.	ANL/Atlas
4.6.2	Helium and carbon strippers		$0.7		Eng. Est.	ANL/Atlas
4.6.3	SC to 2 MeV/u Linac		$11.8		(64 cav, 8 CM)	ANL/Atlas
4.6.4	SC to 7 MeV/u Linac (ATLAS)		$9.0		(42 cav., 4 rebunchers, 7 CM)	ANL/Atlas
4.6.5	RF Electronics/Amplifiers		$4.8		Eng. Est.	ANL/Atlas
4.6.6	Cryodistribution		$2.0		Eng. Est.	ANL/Atlas
4.6.7	Design			3.0	Eng. Est.	ANL/Atlas
4.6.8	Magnets, Power Supplies, Controls		$1.0		Allowance	NSCL
5.0	**High Energy Systems**	**$27.5**				
5.1	High Energy TGT Area Transport		$3.1	$1.6	Eng. Est.	NSCL
5.2	High Energy Fragment Seperator		$7.4	$11.6	Eng. Est.	NSCL
5.3	Beam Transport to Vaults		$1.4	$2.4	Eng. Est.	NSCL
6.0	**Detectors**	**$93.8**				
6.1	**Fragmentation Facilities**		**$29.3**			
6.1.1	High Res. Spectrograph		$14.3		SOFFBRIA, NSCL, 3/2000, pp 80	
6.1.2	Sweeper Magnet		$5.0		SOFFBRIA, NSCL, 3/2000, pp 80	
6.1.3	Large Area Neutron Detector		$2.0		SOFFBRIA, NSCL, 3/2000, pp 80	
6.1.4	Large Area Si-array		$3.0		SOFFBRIA, NSCL, 3/2000, pp 80	
6.1.5	Implantation Station		$1.0		SOFFBRIA, NSCL, 3/2000, pp 80	
6.1.6	Time Projection Chamber		$4.0		SOFFBRIA, NSCL, 3/2000, pp 80	
6.2	**ISOL Facilities Detectors**		**$29.7**		LBNL-43460, 3/99, pp4	
6.2.1	Recoil Seperators		$9.8			
6.2.2	Magnetic Spectrographs		$3.6			
6.2.3	Particle Detectors		$1.9			
6.2.4	Non Accelerated Beams		$12.7			
6.2.5	Special Targets		$1.8			
6.3	**Common Shared Detectors**		**$34.8**			
6.3.1	Position Sensitive Ge-array		$10.0		SOFFBRIA, NSCL, 3/2000, pp 80	
6.3.2	Gamma Ray Detectors		$24.8		LBNL-43460, 3/99, pp4	
	Sub-Total	**$125.7**	**$69.5**	**$56.2**		
	Contingency (35%)	**$44.0**	**$24.3**	**$19.7**		
	Detector Allowance	**$93.8**	**$93.8**	**$0.0**		
	Total	**$263.5**	**$187.6**	**$75.9**		
	12/5/2000 10:31					

WBS Level 3 Elements

WBS Level 1.3
Cryo. Plant & Dist.

RIA SYSTEM FOR 71 MODULES, 31@4.5 K 40 @ 2.1 K(REV 1)

SHEET 1 0F 2 | Summary on Sheet one

Costs:	Per Year		FINAL DRAFT		W.C. CHRONIS
Engineeer	$	96,600		Started	8.26.99
Design	$	85,200		Revised	12.02.99
Tech	$	58,420			

RIA SYSTEM, 31 MODULES @4.5 K, 40 MODULES @ 2.1 K

SUMMARY OF COSTS

MATERIAL		
COMPRESSOR SYSTEM	$ 2,560,192	
OIL SYSTEM	$ 260,006	
CONTROLS	$ 1,333,660	
300 TO 80 K BOX	$ 635,428	
80 K TO 4.5 K BOX	$ 2,101,414	
ANCILLARY EQUIPMENT	$ 1,483,242	
2K COLD BOX	$ 3,592,310	
TRANSFER LINE/BARE PIPE	$ 2,188,890	
PROJECT MANAGEMENT	$ 387,044	
LABOR FOR FABRICATION	$ 19,059,924	
TOTAL COST =	$ 33,602,110	
COLD BOXES PORTION ($$)		
CALIBRATION	$ 465,730	Estimate On Sheet #2
START-UP	$ 357,857	Estimate On Sheet #2
TOTAL COST=	$ 34,425,697	

#########################		
####	MAN-MONTHS	
####	Technician	Engineering
####		
####	474.00	170.35
####		
####	DESIGNER	
####		
####	49.45	
####		
####		
#########################		

COMPRESSOR SYSTEM

MATERIAL | LABOR

 # = Price checked

DESCRIPTION	QTY	COST PER	TOTAL COST	Eng Man	Eng Mo	Des Man	Des Mo	Mec Tec	MT MM	I&C Tec	I&C MM	Tec Tot	Des Tot	Eng Tot	Tech $$	E/D $$	Des $$
1st stage compressor #	4	$ 64,408	$ 257,632	1.0	0.3	1.00	1.0	2.0	1.5	2.0	0.2	3.40	1.00	0.30	$ 66,209	$ 2,415	$ 7,100
Helium HX's	4	$ 42,000	$ 168,000	1.0	0.5	1.00	0.1	2.0	0.5	0.0	0.0	1.00	0.10	0.50	$ 4,868	$ 4,025	$ 710
Oil HX's	4	$ 48,000	$ 192,000	1.0	0.5	1.00	0.1	2.0	0.5	0.0	0.0	1.00	0.10	0.50	$ 4,868	$ 4,025	$ 710
Oil Pumps	4	$ 16,000	$ 64,000	1.0	0.3	1.00	0.1	1.0	0.3	1.0	0.3	0.60	0.10	0.25	$ 2,921	$ 2,013	$ 710
Oil injection Valve	4	$ 8,000	$ 32,000	1.0	0.3	1.00	0.0	2.0	0.3	1.2	0.0	0.60	0.00	0.25	$ 2,921	$ 2,013	$ -
Shut Off Valves, Oil	16	$ 300	$ 4,800	1.0	0.3	1.00	0.1	1.0	0.3	0.0	0.0	0.30	0.10	0.25	$ 1,461	$ 2,013	$ 710
Flex hoses	28	$ 600	$ 16,800	1.0	0.2	1.00	0.1	1.0	0.1	0.0	0.0	0.10	0.10	0.20	$ 487	$ 1,610	$ 710
Motors, 600 HP,1.15 SF #	4	$ 40,000	$ 160,000	1.0	0.1	1.00	0.1	2.0	0.5	2.0	0.5	2.00	0.10	0.10	$ 9,737	$ 805	$ 710
Couplings	4	$ 1,300	$ 5,200	1.0	0.1	1.00	0.0	2.0	0.1	0.0	0.0	0.20	0.00	0.10	$ 974	$ 805	$ -
Spool valves	4	$ 700	$ 2,800	1.0	0.1	1.00	0.0	1.0	0.5	0.0	0.0	0.50	0.00	0.10	$ 2,434	$ 805	$ -
2nd Stage Compressor #	6	$ 66,560	$ 399,360	1.0	0.3	1.00	1.0	2.0	1.5	2.0	0.2	3.40	1.00	0.30	$ 66,209	$ 2,415	$ 7,100
He HX's	6	$ 45,000	$ 270,000	1.0	0.5	1.00	0.1	2.0	0.5	0.0	0.0	1.00	0.10	0.50	$ 4,868	$ 4,025	$ 710
Oil HX's	6	$ 55,000	$ 330,000	1.0	0.5	1.00	0.1	2.0	0.5	0.0	0.0	1.00	0.10	0.50	$ 4,868	$ 4,025	$ 710
Oil Pumps	6	$ 16,000	$ 96,000	1.0	0.3	1.00	0.1	1.0	0.3	1.0	0.3	0.60	0.10	0.25	$ 2,921	$ 2,013	$ 710
Oil injection Valve	6	$ 6,000	$ 36,000	1.0	0.3	1.00	0.0	2.0	0.3	1.2	0.0	0.60	0.00	0.25	$ 2,921	$ 2,013	$ -
Shut Off Valves, Oil	24	$ 300	$ 7,200	1.0	0.3	1.00	0.1	1.0	0.3	0.0	0.0	0.30	0.10	0.25	$ 1,461	$ 2,013	$ 710
Flex hoses	42	$ 600	$ 25,200	1.0	0.2	1.00	0.1	1.0	0.1	0.0	0.0	0.10	0.10	0.20	$ 487	$ 1,610	$ 710
Motors, 2500 HP, 1.15 SF #	6	$ 65,000	$ 390,000	1.0	0.1	1.00	0.1	2.0	0.5	2.0	0.5	2.00	0.10	0.10	$ 9,737	$ 805	$ 710
Couplings	6	$ 1,500	$ 9,000	2.0	0.1	1.00	0.0	2.0	0.1	0.0	0.0	0.20	0.00	0.20	$ 974	$ 1,610	$ -
Spool valves	6	$ 700	$ 4,200	1.0	0.1	1.00	0.0	1.0	0.5	0.0	0.0	0.50	0.00	0.10	$ 2,434	$ 805	$ -
Skid Design	2	$ -	$ -	1.0	1.0	1.00	1.0	0.0	0.0	0.0	0.0	0.00	1.00	1.00	$ -	$ 8,050	$ 7,100
Skid Fabrication	6	$ 15,000	$ 90,000	1.0	0.5	1.00	0.5	3.0	2.0	2.0	1.5	9.00	0.50	0.50	$ 43,815	$ 4,025	$ 3,550
										MM	=	28.4	4.7	6.7			$ 33,370
	Total Cost Mat'l		$ 2,560,192								Per Skid Subtotal				$ 237,575	$ 53,935	$ 66,740
									OUTSIDE LABOR								
	Labor/ 10 Skids		$ 10,738,052							Loading Overhead					$ 772,118	$ 134,838	$ 166,850
		Total Cost=	$ 13,298,244														

OVERHEAD FACTORS FOR ALL OUTSIDE LABOR

E&D	2.50	150%	JLAB LABOR 1.47
TECHS	3.25	250%	

OIL REMOVAL SYSTEM

MATERIAL

LABOR

= Price checked

DESCRIPTION	QTY	COST PER	TOTAL COST	Eng Man	Eng MM	Des Man	Des MM	Mec Tech	MT MM	I&C Tech	I&C MM	Tec Tot	Des Tot	Eng Tot	Tech $$	E/D $$	Des $$
Vessels/Charcoal/oil,2sets#	2	$ 53,400	$ 106,800	1.0	0.5	1.0	0.5	0.0	0.0	0.0	0.0	0.00	0.50	0.50	$ -	$ 4,025	$ 3,550
Coalescer Elements #	9	$ 10,000	$ 90,000	1.0	0.3	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.25	$ -	$ 2,013	$ -
Warm Valves	4	$ 4,500	$ 18,000	1.0	0.5	1.0	0.2	0.0	0.0	0.0	0.0	0.00	0.20	0.50	$ -	$ 4,025	$ 1,420
Flow meters #	4	$ 2,860	$ 11,440	1.0	0.3	1.0	0.1	0.0	0.0	0.0	0.0	0.00	0.10	0.25	$ -	$ 2,013	$ 710
Pipe/Flanges etc	1	$ 8,000	$ 8,000	1.0	0.3	1.0	0.4	0.0	0.0	0.0	0.0	0.00	0.40	0.30	$ -	$ 2,415	$ 2,840
Mount Vessels				1.0	0.1	1.0		2.0	0.3	0.0	0.0	0.50	0.00	0.05	$ 2,434	$ 403	$ -
Install Coalescers				1.0	0.2	1.0		2.0	0.4	0.0	0.0	0.80	0.00	0.20	$ 3,895	$ 1,610	$ -
Pipe warm valves				1.0	0.3	1.0		2.0	0.8	0.0	0.0	1.50	0.00	0.30	$ 7,303	$ 2,415	$ -
Install I&C				1.0	0.5	1.0		0.0	0.0	2.0	1.3	2.50	0.00	0.50	$ 12,171	$ 4,025	$ -
Fab Skid				1.0	0.8	1.0		2.0	2.0	0.0	0.0	4.00	0.00	0.75	$ 19,473	$ 6,038	$ -
Design Time				1.0	1.5	1.0		0.0	0.0	0.0	0.0	0.00	0.00	1.50	$ -	$ 12,075	$ -
Engineer Time				1.0	0.5	1.0		0.0	0.0	0.0	0.0	0.00	0.00	0.50	$ -	$ 4,025	$ -
	Total Material=		$ 234,240							Man Mont		9.30	1.20	5.60			
	Shipping all Mat'l=		$ 14,054														
										Labc	Totals=				$ 45,276	$ 45,080	$ 8,520
Add 5% Structual material=			$ 11,712							OUTSIDE LABOR							
										Loading Overhead					$ 147,145	$ 112,700	$ 21,300
		Total mat'l	$ 260,006														
		Total Labor	$ 281,145														
		Total Cost=	$ 541,152														

			SYSTEM CONTROLS (BSB)																
# = Price checked		MATERIAL								LABOR/INSTALL									
				Eng	Eng	Des	Des	Mec	MT	I&C	I&C	Tec	Des	Eng	Tech		E/D		Des
DESCRIPTION #	QTY	COST PER	TOTAL COST	Man	MM	Man	MM	Tech	MM	Tech	MM	Tot	Tot	Tot	$$		$$		$$
Pressure Instruments	1	$37,000	$ 37,000	1.0	1.5	1.0	0	1.0	1.0	2.0	2.0	5.00	0.00	1.50	$	24,342	$	12,075	$ -
TD's	40	$400	$ 16,000	1.0	1.5	1.0	0	1.0	1.0	2.0	2.0	5.00	0.00	1.50	$	24,342	$	12,075	$ -
TP's	20	$250	$ 5,000	1.0	0.5	1.0	0	1.0	0.5	2.0	2.0	4.50	0.00	0.50	$	21,908	$	4,025	$ -
Flowmeters	1	$2,000	$ 2,000	1.0	0.8	1.0	0	2.0	1.5	2.0	1.5	6.00	0.00	0.75	$	29,210	$	6,038	$ -
Unix Workststion,HPb180L	1	$7,460	$ 7,460	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
C pkg	1	$700	$ 700	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
C++ pkg	1	$750	$ 750	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VxWorks Development Licen:	1	$5,000	$ 5,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
Color Printer (HP 1600CM)	1	$3,000	$ 3,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
X- Terminal	3	$ 3,000	$ 9,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME crate	5	$3,000	$ 15,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
ioc (mv167/32MB)	5	$6,900	$ 34,500	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VxWorks Target License	5	$150	$ 750	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME ADC (32ch, 12bit)	11	$1,500	$ 16,500	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME DAC (16ch, 12bit)	7	$1,400	$ 9,800	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME LVDT Scanner(8 ch)	14	$2,800	$ 39,200	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME Digital Input (64ch)	7	$1,700	$ 11,900	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME Digital Output (32ch)	5	$1,200	$ 6,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME Diode Scanner (16ch)	15	$2,600	$ 39,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
Procurement Managment			$ -	2.0	6.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	12.0	$	-	$	96,600	$ -
VME crate	18	$3,000	$ 54,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
ioc (mv167/32MB)	18	$6,900	$ 124,200	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VxWorks Target License	18	$150	$ 2,700	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME ADC (32ch, 12bit)	18	$1,500	$ 27,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME Diode Scanner (16ch)	36	$2,600	$ 93,600	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME LVDT Scanner (8ch)	52	$2,800	$ 145,600	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME Pulse Generator (8ch)	52	$2,000	$ 104,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
VME LL Scanner	18	$3,000	$ 54,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
EV Actuator	160	$2,000	$ 320,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
Cables, connectors, etc.	1	$150,000	$ 150,000	0.0	0.0	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	$	-	$	-	$ -
Cable Installation			$ -	1.0	3.0	1.0	0	0.0	0.0	5.0	4.0	20.0	0.00	3.00	$	97,367	$	24,150	$ -
Programming/ Sys Design			$ -	3.0	6.0	1.0	0	0.0	0.0	0.0	0.0	0.0	0.00	18.0	$	-	$	144,900	$ -
		Total Materia	$ 1,333,660						Man-Months=			40.5	0.0	37.3			$	299,863	$ -
		Total Labor	$ 1,171,432								Labor totals=					$197,168		$599,725	$ -
		Total Cost=	$ 2,505,092								JLAB LABOR								
											Overheads					$ 289,836		$ 881,596	$ -

80 K COLD BOX (300 K to 80 K Box)

Spare included

DESCRIPTION	QTY	MATERIAL COST PER	TOTAL COST	Eng Man	Eng MM	Des Man	Des MM	Mec Tech	MT MM	I&C Tech	LABOR I&C MM	Tec Tot	Des Tot	E/D Tot	Tech $$	E/D $$	Des $$
COLD BOX																	
Turbines##	1	$ 230,000	$ 230,000	1.0	1.5	1.0	0.2	2.0	0.8	2.0	0.8	3.00	0.20	1.50	$ 14,605	$ 12,075	$ 1,420
Piping	1	$ 15,000	$ 15,000	1.0	0.7	1.0	1.2	2.0	2.5	2.0	1.3	7.50	1.20	0.70	$ 36,513	$ 5,635	$ 8,520
Heat Exchangers, 3 Pass	1	$ 95,000	$ 95,000	1.0	0.7	1.0	1.0	2.0	0.5	1.0	0.3	1.30	1.00	0.70	$ 6,329	$ 5,635	$ 7,100
Heat Exchanger, GN2/GHe	1	$ 20,000	$ 20,000	1.0	0.8	1.0	0.8	2.0	1.0	1.0	0.5	2.50	0.80	0.75	$ 12,171	$ 6,038	$ 5,680
Instruments	1	$ 10,000	$ 10,000	1.0	0.5	1.0	0.2	0.0	0.0	2.0	0.5	1.00	0.20	0.50	$ 4,868	$ 4,025	$ 1,420
Frame	1	$ 20,000	$ 20,000	1.0	1.0	1.0	0.2	3.0	1.3	0.0	0.0	3.75	0.20	1.00	$ 18,256	$ 8,050	$ 1,420
Spares, Required Set	1		$ -	1.0		1.0						0.00	0.00	0.00	$ -	$ -	$ -
Cold Box Vessel #	1	$ 120,000	$ 120,000	1.0	3.0	1.0	0.8	3.0	2.3	2.0	1.0	8.75	0.80	3.00	$ 42,598	$ 24,150	$ 5,680
Valves Manual, Cold #	10	$ 6,200	$ 62,000	1.0	1.5	1.0	0.2	2.0	1.3	2.0	1.5	5.50	0.20	1.50	$ 26,776	$ 12,075	$ 1,420
Valves, Warm	15	$ 3,500	$ 52,500	1.0	1.0	1.0	0.1	2.0	1.0	2.0	1.3	4.50	0.10	1.00	$ 21,908	$ 8,050	$ 710
			$ -									0.00	0.00	0.00	$ -	$ -	$ -
Transistions, Bi-Braze			$ -									0.00	0.00	0.00	$ -	$ -	$ -
8"	2	$ 1,488	$ 2,976									0.00	0.00	0.00	$ -	$ -	$ -
6"	4	$ 852	$ 3,408									0.00	0.00	0.00	$ -	$ -	$ -
2"	2	$ 270	$ 540									0.00	0.00	0.00	$ -	$ -	$ -
10"	2	$ 2,002	$ 4,004									0.00	0.00	0.00	$ -	$ -	$ -
			$ -									0.00	0.00	0.00	$ -	$ -	$ -
									Man-Months=			37.8	4.7	10.7			
		Total Materia	$ 635,428								Labor totals=				$ 184,023	$ 85,733	$ 33,370
											OUTSIDE LABOR						
		Total Labor	$ 895,831								Overheads				$ 598,075	$ 214,331	$ 83,425
		Total Cost=	$ 1,531,259														

80 K to 4.5 K Cold Box

## Spare Included		MATERIAL										LABOR						
DESCRIPTION	QTY	COST PER	TOTAL COST	Eng Man	E/D MM	Des Man	Des MM	Mec Tech	MT MM	I&C Tech	I&C MM	Tec Tot	Des Tot	E/D Tot	Tech $$	E/D $$	Des $$
Turbines ##	3	$ 230,000	$ 690,000	1.0	2.0	1.0	0.3	2.0	1.0	2.0	1.0	4.00	0.30	2.00	$ 19,473	$ 16,100	$ 2,130
Turbine Duty, 4.5 %			$ 31,050	1.0		1.0							0.00				$ -
Heat Exchangers	11	$ 65,000	$ 715,000	1.0	2.0	1.0	0.5	2.0	2.0	2.0	1.0	6.00	0.50	2.00	$ 29,210	$ 16,100	$ 3,550
Piping, Internal	1	$ 50,000	$ 50,000	1.0	3.0	1.0	1.5	4.0	2.0	2.0	2.0	12.0	1.50	3.00	$ 58,420	$ 24,150	$ 10,650
Shipping Pipe, 6 %			$ 3,000	1.0		1.0							0.00				$ -
Vessel	1	$ 200,000	$ 200,000	1.0	2.0	1.0	0.8	2.0	1.0	2.0	1.0	4.00	0.80	2.00	$ 19,473	$ 16,100	$ 5,680
Shipping costs, 6 %			$ 12,000	1.0		1.0							0.00				$ -
Warm valves	20	$ 4,250	$ 85,000	1.0	1.0	1.0	0.3	2.0	0.4	2.0	0.4	1.50	0.30	1.00	$ 7,303	$ 8,050	$ 2,130
Diffusion Pump #	1	$ 10,000	$ 10,000	1.0	0.1	1.0	0.1	2.0	0.2	2.0	0.2	0.60	0.10	0.10	$ 2,921	$ 805	$ 710
Mech Pump #	1	$ 6,428	$ 6,428	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	0.20	0.10	0.10	$ 974	$ 805	$ 710
Vac Instruments #	1	$ 1,500	$ 1,500	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	0.15	0.10	0.05	$ 730	$ 403	$ 710
Adsorber Vessels, 80/20K	3	$ 8,000	$ 24,000	1.0	0.2	1.0	0.5	2.0	1.0	0.0	0.0	2.00	0.50	0.20	$ 9,737	$ 1,610	$ 3,550
Cryo-valves #	20	$ 8,073	$ 161,460	1.0	0.4	1.0	0.3	2.0	1.0	2.0	1.0	4.00	0.30	0.35	$ 19,473	$ 2,818	$ 2,130
Piping, External	1	$ 25,000	$ 25,000	1.0	0.4	1.0	0.8	2.0	2.0	2.0	1.0	6.00	0.80	0.35	$ 29,210	$ 2,818	$ 5,680
Shipping 6 %			$ 1,500	1.0		1.0							0.00				$ -
Load Heater	1	$ 11,000	$ 11,000	1.0	0.2	1.0	0.1	2.0	0.1	2.0	0.3	0.80	0.10	0.15	$ 3,895	$ 1,208	$ 710
Super Insulation	1	$ 10,000	$ 10,000	1.0	0.2	1.0		2.0	0.5	0.0	0.0	1.00	0.00	0.20	$ 4,868	$ 1,610	$ -
Design engineer			$ -	1.0	2.5	1.0		0.0	0.0	0.0	0.0	0.00	0.00	2.50	$ -	$ 20,125	$ -
Designer			$ -	1.0	2.5	1.0		0.0	0.0	0.0	0.0	0.00	0.00	2.50	$ -	$ 20,125	$ -
Bi-Braze, Labor			$ -	1.0		1.0	0.8	2.0	1.0	0.0	0.0	2.00	0.75	0.75	$ 9,737	$ 6,038	$ 5,325
8"	16	$ 1,488	$ 23,808														
6 "	8	$ 852	$ 6,816							Man Mont		44.3	6.2	17.3			
4"	6	$ 462	$ 2,772														
2"	4	$ 270	$ 1,080														
		Material	$ 2,071,414								Labc	Totals=			$ 215,424	$ 138,863	$ 43,665
		Structual	$ 30,000								OUTSIDE LABOR						
		Total Mat'l	$ 2,101,414								Overhead				$ 700,127	$ 347,156	$ 109,163
		Total Labor	$ 1,156,446														
		Total Cost=	$ 3,257,860														

2K COLD BOX

= Price Checked

DESCRIPTION	QTY	MATERIAL COST PER	MATERIAL TOTAL COST	LABOR Eng Man	Eng MM	Des Man	Des MM	Mec Tech	MT MM	I&C Tech	I&C MM	Tec Tot	Des Tot	Eng Tot	Tech $$	E/D $$	Des $$
Cold Compressors	4	$ 797,112	$ 3,188,448	1.0	0.8	1.0	1.0	2.0	1.5	2.0	1.5	6.00	1.00	0.80	$ 29,210	$ 6,440	$ 7,100
S2M/Refu included	4	$ -	$ -	1.0	1.0	1.0	0.5	0.0	0.0	2.0	1.2	2.40	0.50	1.00	$ 11,684	$ 8,050	$ 3,550
Duty/Shipping, 4.5 %			$ 143,480	1.0	0.0	0.0	0.5	0.0	0.0	2.0	1.2	2.40	0.00	0.00	$ 11,684	$ -	$ -
Piping	1	$ 25,000	$ 25,000	1.0	0.7	1.0	1.0	3.0	3.0	2.0	2.0	13.0	1.00	0.70	$ 63,288	$ 5,635	$ 7,100
Vessel #	1	$ 120,000	$ 120,000	1.0	0.5	1.0	0.4	0.0	0.0	0.0	0.0	0.00	0.40	0.50	$ -	$ 4,025	$ 2,840
Headers/supply/return	1	$ 50,000	$ 50,000	1.0	1.2	1.0	1.5	3.0	3.0	2.0	1.0	11.0	1.50	1.20	$ 53,552	$ 9,660	$ 10,650
Structural/Internal	1	$ 30,000	$ 30,000	1.0	0.6	1.0	0.5	2.0	1.0	0.0	0.0	2.00	0.50	0.60	$ 9,737	$ 4,830	$ 3,550
Structural/External	1	$ 20,000	$ 20,000	1.0	0.6	1.0	0.8	2.0	1.5	0.0	0.0	3.00	0.80	0.60	$ 14,605	$ 4,830	$ 5,680
Design Engineer			$ -	1.0	1.5	1.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	1.50	$ -	$ 12,075	$ -
Designer			$ -	1.0	0.0	1.0	3.0	0.0	0.0	0.0	0.0	0.00	3.00	0.00	$ -	$ -	$ 21,300
Bi-Braze Labor				1.3	1.0	1.0	0.2	2.0	0.8	0.0	0.0	1.50	0.20	1.25	$ 7,303	$ 10,063	$ 1,420
4" #	7	$ 462	$ 3,234									0.00	0.00	0.00	$ -	$ -	$ -
10" #	2	$ 2,002	$ 4,004									0.00	0.00	0.00	$ -	$ -	$ -
Various Sizes	10	$ 414	$ 4,140									0.00	0.00	0.00	$ -	$ -	$ -
10" #	2	$ 2,002	$ 4,004														
										Man Mont		41.3	8.9	8.2			
		Material	$ 3,592,310								Labc	Totals=			$ 201,062	$ 65,608	$ 63,190
											OUTSIDE LABOR						
		Total Labor	$ 975,446								Overhead				$ 653,452	$ 164,019	$ 157,975
		Total Cost=	$ 4,567,756														

MISCELLANEOUS EQUIPMENT

# = Price Checked		MATERIAL		LABOR														
DESCRIPTION	QTY	COST PER	TOTAL COST	Eng Man	Eng MM	Des Man	Des MM	Mec Tech	MT MM	I&C Tech	I&C MM	Tec Tot	Des Tot	E/D Tot	Tech $$	E/D $$	Des $$
LN2 Dewar,60000 Gallons #	1	$ 426,819	$ 426,819	1.0	0.5	1.0	0.5	2.0	0.5	2.0	0.2	1.30	0.50	0.50	$ 6,329	$ 4,025	$ 3,550
LHe Dewar, 20000 Gallons	1	$ 397,923	$ 397,923	1.0	0.5	1.0	0.5	2.0	0.5	2.0	0.2	1.30	0.50	0.50	$ 6,329	$ 4,025	$ 3,550
80K Purifiers, External	2	$ 70,000	$ 140,000	1.0	0.5	1.0	1	2.0	2.0	2.0	1.0	6.00	1.00	0.50	$ 29,210	$ 4,025	$ 7,100
Purifier Compressors #	2	$ 18,000	$ 36,000	1.0	0.2	1.0		2.0	0.8	2.0	0.5	2.50	0.00	0.20	$ 12,171	$ 1,610	$ -
Skid Fabrication	2	$ 15,000	$ 30,000	1.0	0.5	1.0		2.0	2.0	2.0	0.5	5.00	0.00	0.50	$ 24,342	$ 4,025	$ -
Controls	1	$ 2,500	$ 2,500	1.0	0.2	1.0		0.0	0.0	2.0	0.8	1.50	0.00	0.20	$ 7,303	$ 1,610	$ -
Storage Tanks, 30k gallon	8	$ 40,000	$ 320,000	1.0	0.3	1.0	0.5	2.0	1.0	2.0	0.2	2.30	0.50	0.30	$ 11,197	$ 2,415	$ 3,550
External Piping	1	$ 15,000	$ 15,000	1.0	0.5	1.0	0.5	2.0	0.8	2.0	0.2	1.90	0.50	0.50	$ 9,250	$ 4,025	$ 3,550
Design Engineer				1.0	0.6	1.0	0	0.0	0.0	0.0	0.0	0.00	0.00	0.60	$ -	$ 4,830	$ -
Designer				1.0	2.3	1.0	1	0.0	0.0	0.0	0.0	0.00	1.00	2.25	$ -	$ 18,113	$ 7,100
Arc Cell #	1	$ 15,000	$ 15,000	1.0	8.0	1.0	0	0.5	0.1	1.0	0.3	0.35	0.00	8.00	$ 1,704	$ 64,400	$ -
Hydrometer #	1	$ 10,000	$ 10,000	1.0	0.1	1.0	0	0.0	0.0	1.0	0.1	0.10	0.00	0.10	$ 487	$ 805	$ -
	0		$ -			0.0						0.00	0.00	0.00	$ -	$ -	$ -
	0		$ -			0.0						0.00	0.00	0.00	$ -	$ -	$ -
Inst Air Compressor #	2	$ 5,000	$ 10,000	1.0	0.2	1.0	0.2	2.0	0.2	2.0	0.2	0.80	0.20	0.20	$ 3,895	$ 1,610	$ 1,420
Local Control Room (1)	1		$ -	1.0	0.9	1.0	0.8					0.00	0.80	0.90	$ -	$ 7,245	$ 5,680
Adsorber Regen Skid	1	80000	$ 80,000	1.0	1.0	1.0	1	2.0	2.5	2.0	1.5	8.00	1.00	1.00	$ 38,947	$ 8,050	$ 7,100
										Man	Mont	31.1	6.0	16.3			
		Material	$ 1,483,242								Labc	Totals=			$ 151,162	$ 130,813	$ 42,600
											OUTSIDE LABOR						
		Total Labor	$ 924,807								Overhead				$ 491,276	$ 327,031	$ 106,500
		Total Cost=	$ 2,408,049														

(1) Designed by Cryo, Facilities to Bulid

TRANSFER LINE/BARE PIPE

		MATERIAL							LABOR								
# = Price Checked																	
	QTY			Eng	Eng	Des	Des	ME	MT	I&C	I&C	Tec	Des	Eng	Tech	E/D	Des
DESCRIPTION #	Ft(1)	$$ per ft	TOTAL COST	Man	MM	Man	MM	Tech	MM	Tech	MM	Tot	Tot	Tot	$$	$$	$$
2K Branch(40 meters)	160	$118	$ 18,880	1.0	0.5	1.0	1.2	5.0	6.0	1.0	0.3	30.3	1.20	4.50	$146,735	$39,494	$ 8,520
2K Linac(280m)	920	$113	$ 103,960	1.0	0.5	1.0	1.2	5.0	6.0	1.0	0.3	30.3	1.20	4.50	$146,735	$39,494	$ 8,520
4.5K branch(170m)	560	$306	$ 171,360	1.0	0.5	1.0	1.2	5.0	7.0	1.0	0.3	35.3	1.20	4.50	$170,949	$39,494	$ 8,520
4.5 K Linac (193 m)	640	$184	$ 117,760	1.0	0.5	1.0	1.2	5.0	7.0	1.0	0.3	35.3	1.20	4.50	$170,949	$39,494	$ 8,520
H P GHe,2"513 m	1680	$3	$ 5,040	1.0	0.5	1.0	1.0	5.0	1.5			7.50	1.00	4.00	$36,321	$35,106	$ 7,100
Cooldown Line, 4"(513 m)	1680	$6	$ 10,080	1.0	0.5	1.0	1.0	5.0	1.5			7.50	1.00	4.00	$36,321	$35,106	$ 7,100
Grd Vacuum Line,6"(320m)	1080	$11	$ 11,880	1.0	0.5	1.0	1.0	5.0	1.5			7.50	1.00	4.00	$36,321	$35,106	$ 7,100
GN2 Vent, 4"(213m)	720	$6	$ 4,320	1.0	0.5	1.0	1.0	5.0	1.5			7.50	1.00	4.00	$36,321	$35,106	$ 7,100
Supply line Anchor,	36	$6,250	$ 225,000	1.0	0.5	1.0	1.6	5.0	3.3			16.3	1.60	6.50	$78,695	$57,047	$ 11,360
Supply line Expansion	36	$9,540	$ 343,440	1.0	0.5	1.0	1.6	5.0	3.3			16.3	1.60	6.50	$78,695	$57,047	$ 11,360
Return Line Anchor,	36	$12,560	$ 452,160	1.0	0.5	1.0	1.6	5.0	3.3			16.3	1.60	6.50	$78,695	$57,047	$ 11,360
Return Line Expansion	36	$16,250	$ 585,000	1.0	0.5	1.0	1.6	5.0	3.3			16.3	1.60	6.50	$78,695	$57,047	$ 11,360
Linac expansion/in line Ac	2	$21,450	$ 42,900	1.0	0.5	1.0	1.6	4.0	3.3			13.0	1.60	6.50	$62,956	$57,047	$ 11,360
Jigs/ Fixtures, one lot	1	$25,000	$ 25,000	1.0	0.5	1.0	1.0	2.0	1.0			2.00	1.00	2.00	$9,686	$17,553	$ 7,100
									Man-Months=			241	17.8	68.5			

(1) ROUNDED LENGTHS	Material	$2,116,780	Labor Totals =	$1,168,074	$601,188	$ 126,380
Assume 40 ' sections	6% Shipping	$72,110	JLAB LABOR			
	Total Materia	$2,188,890	Overhead	$1,717,069	$ 883,746	$ 315,950
	Total Labor	$2,916,765				
	Total Cost=	$5,105,655				

Project Managent		
Base Pay	$105,318	
1.47 fring	$154,817	
W/overhd	$387,044	150% OH

##

WBS 2.0
Civil

	Description	MSU Sq. Ft.	Cost Sq. Ft.	MSU $M
1	Site			$11.7
2	Support, Lab/Shop	60,000	$196	$11.8
3	Driver			
	Tunnel	36,800	$326	$12.0
	Klystron Building	31,700	$203	$6.4
	Linac BSY	12,400	$326	$4.0
4	Target Facilities	41,500	$379	$15.7
5	ISOL Facility			
	Fragment Seperator	11,700	$580	$6.8
	High Bay	63,400	$237	$15.0
6	High Energy Facility			
	Fragment Seperator	8,500	$580	$4.9
	High Bay	54,000	$242	$13.1
7	Cryogenic Building(s)	9,100	$432	$3.9
	Totals	**329,100**		**$105.4**
	Contingency - 20%			**$126.5**

Item	Unit	Cost/Unit	Description	Item Cost	Total Cost
Site Preparation	Acre	$ 90,000.00	Extensive clear and grub, demolition	6.00	$ 540,000.00
Car Parking	Ncars	$ 3,000.00	90 degree, 4" bitum paving, 8" gravel base	500	$ 1,500,000.00
Roadway	LF Road	$ 200.00	8" Asphalt, 24' wide	1000	$ 200,000.00
Sidewalks	LF Sidewall	$ 13.20	4" conc paving, 4" gravel, 4' width	2301	$ 30,373.20
Site Development	Acre	$ 6,000.00	Average site development	2.71	$ 16,260.00
Landscaping	LS	$ 410,000.00	Average: topsoil, sod, some trees/shrubs	1	$ 410,000.00
Fence	LF	$ 60.00	Chain link vinyl fence & gate ??	3000	$ 180,000.00
Water Supply & Dist	LF Utilities	$ 36.00	8" ductile iron class 250, excav & backfill	3600	$ 129,600.00
Water Supply & Dist	LF Utilities	$ 32.00	6" fire loop, 3 hydrants	1200	$ 38,400.00
Water Supply & Dist	LS	$ 30,000.00	Water treatment ??	1	$ 30,000.00
Storm Drainage Syst	LF Utilities	$ 50.00	15" clay	1000	$ 50,000.00
Sanitary Sewer system	LF Utilities	$ 150.00	18" concrete pipe, tie to existing line at	7920	$ 1,188,000.00
Elect. & Communications	LF Distribution	$ 200.00	Elect. & communication ductbank & man	1000	$ 200,000.00
Gas Dist. System	LF Utilities	$ 35.00	4" steel	1000	$ 35,000.00
Electric Dist System	LF Utilities	$ 70.00	Underground elect. cable on site	1000	$ 70,000.00
Telephone Dist Sys	LS	$ 5,000.00	Telephone support	1	$ 5,000.00
Site Lighting Syst	SF Lighting	$ 0.70	5 fc.20' high, high press sod 400 w fix, incl.	100000	$ 70,000.00
Elect. Dist. To Site	LF Distribution	$ 7,000,000.00		1	$ 7,000,000.00
					$ 11,692,633.20

WBS 3.1
Front End

			WBS 3.1				
				$K Total Procurement Cost	$K Total Labor Cost	$K Total Labor + Procurements	$K Total Without Contingency
			Preliminary Cost Estimate for RFQ for Rare Isotope Accerator Facility				
			58.3 Mhz RFQ for Full Energy Linac				
2			RFQ Construction				4100.00
	1		Mechanical Systems				
		1	RFQ Vane Subassemblies	140.00	640.00	780.00	
		3	Vacuum Chamber and Structural Enclosure	100.00	370.00	470.00	
		4	Vacuum Pumping and Diagnostics	260.00	55.00	315.00	
		5	Mechanical Subsystems	160.00	120.00	280.00	
		5	Performance verification of mechanical subsystems	0.00	60.00	60.00	
		6	RF Subsystems	145.00	0.00	145.00	
			Mechanical Construction Subtotal				2050.00
		7	Mechanical Systems EDI		2050.00	2050.00	

WBS 3.2
Inj/Low Beta Linac

Component estimates for the Drift Tube section of the Driver Linac

						kS	
1.2.3 Final Design							
	1.2.3.1 Driver Accelerator Systems						
		1.2.3.1.4 Drift Tube Linac Section				1000	(preliminary engineering design additional $0.6M)
						kS	
1.3.2 Drift Tube Linac Section						32696	Bottoms-up costing by AES.
	1.3.2.1 Box Cryomodules					5040	
		1.3.2.1.1 Cryomodule #1 (0.021 & 0.03 b Fork Cavities)			1178		
			1.3.2.1.1.1 Cavities			772	
			1.3.2.1.1.2 Cryostats			152	
			1.3.2.1.1.3 Internal Cryogenics			19	
			1.3.2.1.1.4 Focusing Magnets			99	
			1.3.2.1.1.5 Vacuum Systems			51	
			1.3.2.1.1.6 Cavity Processing & Cryostat Assembly			85	
		1.3.2.1.2 Cryomodule #2-5 (0.062 b QWR Cavities)			3862		
			1.3.2.1.2.1 Cavities			2564	
			1.3.2.1.2.2 Cryostats			607	
			1.3.2.1.2.3 Internal Cryogenics			76	
			1.3.2.1.2.4 Focusing Magnets			66	
			1.3.2.1.2.5 Vacuum Systems			204	
			1.3.2.1.2.6 Cavity Processing & Cryostat Assembly			345	
	1.3.2.2 Circular Cryomodules					27264	
		1.3.2.2.1 Cryomodule #6-10 (0.128 b Cavities)			5212		
			1.3.2.2.1.1 Cavities			2692	
			1.3.2.2.1.2 Cryostats			1212	
			1.3.2.2.1.3 Internal Cryogenics			210	
			1.3.2.2.1.4 Focusing Magnets			175	
			1.3.2.2.1.5 Vacuum Systems			430	
			1.3.2.2.1.6 Cavity Processing & Cryostat Assembly			492	
		1.3.2.2.2 Cryomodule #11-19 (0.190 b Cavities)			9381		
			1.3.2.2.2.1 Cavities			4846	
			1.3.2.2.2.2 Cryostats			2182	
			1.3.2.2.2.3 Internal Cryogenics			378	
			1.3.2.2.2.4 Focusing Magnets			315	
			1.3.2.2.2.5 Vacuum Systems			774	
			1.3.2.2.2.6 Cavity Processing & Cryostat Assembly			886	
		1.3.2.2.3 Cryomodule #20-31 (0.38 b Cavities)			12671		
			1.3.2.2.3.1 Cavities			6625	
			1.3.2.2.3.2 Cryostats			2909	
			1.3.2.2.3.3 Internal Cryogenics			504	
			1.3.2.2.3.4 Focusing Magnets			420	
			1.3.2.2.3.5 Vacuum Systems			1032	
			1.3.2.2.3.6 Cavity Processing & Cryostat Assembly			1182	
	1.3.2.3 Inter-cryomodule Beam Transport Sections				31		
	1.3.2.4 Cryomodule Installation & Checkout in Tunnel				361		
1.3.4 Beam Stripper & Charge State Selection Systems (2 units)						3000	See K.W.S. spread sheet

WBS 3.3
High Beta Accel.

$\beta = 0.48$

	ASSUMPTIONS:		Number of drawings comparable to current design											
04-Jan-01	20 MHRS/drawing		40% Engineering		Cost of Current Design			CEBAF escalated to today's prices						
RIA4M.xls	Prototype +30%		1840 Mhrs/yr					cost of engineering $ X k/year =		150000				
	Frequency (MHz) =		1497	Gradient (MV/m) =		5		Cost			# of CM's	MeV	meters	
	Cryomodules cost approximately =					$1,390,891		$26,426,933	Fabrication		19	845	169	
	Active meters per cryomodule =					4		$1,402,826	Design/Engr		k$/MV =	$31.27		
	Cost is about per active meter currently =					$347,723		$27,829,759	Total					
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prodt'n	# Req'd CU	Fab Cost Proto	Prot Cost CU	# Req'd CM	Prod Cost CM		
CAVITY														
Cavities	100	2000	800	$163,043	$65,217	$228,261	$30,000	2	$41,057	$82,114	8	$328,457	Cavities	
Nobium							$6,000	2	$8,211	$16,423	8	$65,691	Nobium	
HOM	5	100	40	$8,152	$3,261	$11,413	$800	4	$1,095	$4,379	16	$17,518	HOM	
Window	5	100	40	$8,152	$3,261	$11,413	$2,500	2	$3,421	$6,843	8	$27,371	Window	
Pair Parts	10	200	80	$16,304	$6,522	$22,826	$7,000	2	$9,580	$19,160	8	$76,640	Pair Parts	
													$9,797,860	
CRYOUNIT														
Tuners	50	1000	400	$81,522	$32,609	$114,130	$2,700	2	$3,695	$7,390	8	$29,561	Tuners	
Rotary Fdthru	2	40	16	$3,261	$1,304	$4,565	$625	4	$855	$3,421	16	$13,686	Rotary Fdthru	
He Vessel	33	660	264	$53,804	$21,522	$75,326	$8,000	1	$10,949	$10,949	4	$43,794	He Vessel	
Vacuum Tk	56	1120	448	$91,304	$36,522	$127,826	$15,500	1	$21,213	$21,213	4	$84,851	Vacuum Tk	
Magntic Shd	10	200	80	$16,304	$6,522	$22,826	$2,000	1	$2,737	$2,737	4	$10,949	Magntic Shd	
Wiring	10	200	80	$16,304	$6,522	$22,826	$2,000	2	$2,737	$5,474	8	$21,897	Wiring	
Fd Thrus	5	100	40	$8,152	$3,261	$11,413	$300	4	$411	$1,642	16	$6,569	Fd Thrus	
Indium Seals	10	200	80	$16,304	$6,522	$22,826	$400	1	$547	$547	4	$2,190	Indium Seals	
Top Hats	45	900	360	$73,370	$29,348	$102,717	$6,400	1	$8,759	$8,759	4	$35,035	Top Hats	
Waveguides	15	300	120	$24,457	$9,783	$34,239	$1,600	2	$2,190	$4,379	8	$17,518	Waveguides	
													$5,054,947	
CRYOMODULE														
End Cans	100	2000	800	$97,826	$65,217	$163,043	$55,000	1	$75,271	$75,271	1	$75,271	End Cans	
Bridging	35	700	280	$34,239	$22,826	$57,065	$14,000	1	$19,160	$19,160	1	$19,160	Bridging	
Stands	40	800	320	$39,130	$26,087	$65,217	$4,800	2	$6,569	$13,138	1	$6,569	Stands	
													$1,919,008	
VACUUM														
Pumpdrops	5	100	40	$4,891	$3,261	$8,152	$1,200	2	$1,642	$3,285	2	$3,285	Pumpdrops	
Connections	5	100	40	$4,891	$3,261	$8,152	$900	2	$1,232	$2,463	4	$4,927	Connections	
Girders	12	240	96	$11,739	$7,826	$19,565	$1,000	1	$1,369	$1,369	1	$1,369	Girders	
Fast Valve	27	540	216	$26,413	$17,609	$44,022	$3,000	1	$4,106	$4,106	1	$4,106	Fast Valve	
Slow Valves	2	40	16	$1,957	$1,304	$3,261	$1,000	2	$1,369	$2,737	2	$2,737	Slow Valves	
20 l/s Pumps	2	40	16	$1,957	$1,304	$3,261	$700	1	$958	$958	4	$3,832	20 l/s Pumps	
30 l/s Pumps	2	40	16	$1,957	$1,304	$3,261	$900	1	$1,232	$1,232	2	$2,463	30 l/s Pumps	
4" Vac Valves	2	40	16	$1,957	$1,304	$3,261	$900	1	$1,232	$1,232	1	$1,232	4" Vac Valves	
													$455,049	
INTERFACE														
Assembly	20	400	160	$19,565	$13,043	$32,609	$112,500	1	$112,500	$112,500	4	$450,000	Assembly	
													$8,580,000	
ELECTRICAL														
Interlocks	100	2000	800	$97,826	$65,217	$163,043	$20,000	1	$27,371	$27,371	1	$27,371	Interlocks	
Instrumentation	10	200	80	$9,783	$6,522	$16,304	$5,000	1	$6,843	$6,843	1	$6,843	Instrumentation	
													$650,070	
LABOR # / MHRS		8	4											
TOTALS	718	14360	7241	$934,565	$468,261	$1,402,826	$306,725	1	$376,310	$617,086	1	$1,390,891	TOTALS	
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod CU	Number Req'd	Fab Cost Proto	Tot Cost per CU	Number Req'd	Cost per CM	$26,426,933	

	ASSUMPTIONS:		Number of drawings comparable to current design							MEDIUM BETA PRODUCTION				
04-Jan-01	20 MHRS/drawing		40% Engineering		Cost of Current Design based upon CEBAF and DESY					cost of engineering $ X k/year =		150000		
RIA4M.XLS	Prototype +30%		1840 Mhrs/yr		Beta =	0.49		Cost			#CM's	MeV	meters	WBS
	Frequency (MHz) =		805	Gradient (MV/m) =		6.26		$21,810,860	Fabrication		19	286.68	40.28	
	Cryomodules cost approximately =					$1,147,940		$964,402	Design/Engr					
	Active meters per cryomodule =					2.12		$22,775,262	Total		k$/MV =	73.02		
	Cost is about per active meter currently =					$541,481								
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prodt'n	# Req'd section	Fab Cost Production	Tot Cost Production	# Req'd per CM	Prod Cost per CM		
CAVITY													CAVITY	
Cavity Assy	50	1000	400	$81,522	$32,609	$114,130	$45,000	1	$45,000	$45,000	4	$180,000	Cavities	1.11.1.1.1.1
Niobium Mat'l							$18,860	1	$18,860	$18,860	4	$75,440	Niobium	1.11.1.1.1.2

Coupler Assy	7.5	150	60	$12,228	$4,891	$17,120	$17,000	1	$17,000	$17,000	4	$68,000	Coupler Assy	1.11.1.1.1.3
Misc Cavity Parts	5	100	40	$8,152	$3,261	$11,413	$2,000	1	$2,000	$2,000	4	$8,000	Misc Cavity Pts	1.11.1.1.1.4
HOM Assy	2.5	50	20	$4,076	$1,630	$5,707	$7,000	2	$7,000	$14,000	4	$56,000	HOM Assy	1.11.1.1.1.5
													$7,361,360	1.11.1.1.1.
HV ASS'Y													HV ASS'Y	
He Vessel	16.5	330	132	$26,902	$10,761	$37,663	$7,000	1	$7,000	$7,000	4	$28,000	He Vessel	1.11.1.1.2.1
Wiring	5	100	40	$8,152	$3,261	$11,413	$2,500	1	$2,500	$2,500	4	$10,000	Wiring	1.11.1.1.2.4
Fd Thrus	2.5	50	20	$4,076	$1,630	$5,707	$400	4	$400	$1,600	4	$6,400	Fd Thrus	1.11.1.1.2.5
													$843,600	1.11.1.1.2
SPACE FRAME													SPACE FRAME	
Tuners	25	500	200	$40,761	$16,304	$57,065	$7,000	1	$7,000	$7,000	4	$28,000	Tuners	1.11.1.2.1
Headers S&R	2.5	50	20	$4,076	$1,630	$5,707	$3,200	1	$3,200	$3,200	4	$12,800	Headers S&R	1.11.1.2.2
Magnetic Shd	5	100	40	$8,152	$3,261	$11,413	$2,500	1	$2,500	$2,500	4	$10,000	Magnetic Shd	1.11.1.2.4
Thermal Shield	22.5	450	180	$36,685	$14,674	$51,359	$8,400	1	$8,400	$8,400	4	$33,600	Thermal Shield	1.11.1.2.6
Seals/Misc Hardwa	5	100	40	$8,152	$3,261	$11,413	$1,000	1	$1,000	$1,000	4	$4,000	Seals/Misc Hdw	1.11.1.2.7
Space Frame	28	560	224	$45,652	$18,261	$63,913	$10,000	1	$10,000	$10,000	4	$40,000	Space Frame	1.11.1.2.8
													$2,439,600	1.11.1.2
CRYOMODULE													CRYOMODULE	
Vacuum Tk	28	560	224	$45,652	$18,261	$63,913	$10,000	1	$10,000	$10,000	4	$40,000	Vacuum Tk	1.11.1.3.2
End Cans	100	2000	800	$163,043	$65,217	$228,261	$90,000	1	$90,000	$90,000	1	$90,000	End Cans	1.11.1.3.3
heat exchanger	17.5	350	140	$28,533	$11,413	$39,946	$10,000	1	$10,000	$10,000	1	$10,000	Heat Exchanger	1.11.1.3.2
Stands	20	400	160	$32,609	$13,043	$45,652	$6,000	2	$6,000	$12,000	1	$12,000	Stands	1.11.1.3.5
													$2,888,000	1.11.1.3.
VACUUM													VACUUM	
Pumpdrops	2.5	50	20	$4,076	$1,630	$5,707	$1,500	2	$1,500	$3,000	1	$3,000	Pumpdrops	1.11.1.3.1
Connections	2.5	50	20	$4,076	$1,630	$5,707	$1,200	2	$1,200	$2,400	1	$2,400	Connections	1.11.1.3.4
Girders	6	120	48	$9,783	$3,913	$13,696	$1,300	1	$1,300	$1,300	1	$1,300	Girders	
Slow Valves	1	20	8	$1,630	$652	$2,283	$2,300	2	$2,300	$4,600	1	$4,600	Slow Valves	1.11.1.3.2
Coupler Inst	1	20	8	$1,630	$652	$2,283	$2,500	3	$2,500	$7,500	1	$7,500	Coupler Inst	1.11.1.3.5
40 l/s Pumps	1	20	8	$1,630	$652	$2,283	$3,000	2	$3,000	$6,000	1	$6,000	40 l/s Pumps	1.11.1.3.3
4" Vac Valves	1	20	8	$1,630	$652	$2,283	$2,200	2	$2,200	$4,400	1	$4,400	4" Vac Valves	1.11.1.3.2
													$554,800	1.11.1.3
INTERFACE													INTERFACE	
Assembly	10	200	80	$16,304	$6,522	$22,826	$90,000	1	$90,000	$90,000	4	$360,000	Assembly	1.11.1.4
test,install							$15,000	1	$15,000	$15,000	1	$15,000	Installation	1.11.1.6.1
													$7,125,000	1.11.1.6
ELECTRICAL													ELECTRICAL	
Interlocks	50	1000	400	$81,522	$32,609	$114,130	$25,000	1	$25,000	$25,000	1	$25,000	Interlocks	1.11.1.7.2.2
Instrumentation	5	100	40	$8,152	$3,261	$11,413	$6,500	1	$6,500	$6,500	1	$6,500	Instrumentation	1.11.1.7.2.2
													$598,500	1.11.1.7.
TOTALS		5	2										TOTAL	
LABOR # / MHRS	423	8450	3380	$688,859	$275,543	$964,402	$398,360	1	$398,360	$427,760	1	$1,147,940	$21,810,860	1.11.1
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Production	Number Req'd	Fab Cost Production	Tot Cost per CU	Number Req'd	Cost per CM	TOTALS	
	ASSUMPTIONS:		Number of drawings comparable to current design											
04-Jan-01	20 MHRS/drawing		40% Engineering		Cost factor of 1.3 added					MEDIUM BETA PROTOTYPE				
RIA4MR&D.XLS	Prototype +30%		1840 Mhrs/yr		Beta =	0.49				cost of engineering $ X k/year =		150000		
	Frequency (MHz) =		805	Gradient (MV/m) =		8.28		Cost			# of CM's	MeV	meters	
	Cryomodules cost approximately =					$1,492,322		$1,492,322	Fabrication		1	15.72	2.12	
	Active meters per cryomodule =					2.12		$1,928,804	Design/Engr			k$/MV =	94.93	
	Cost is about per active meter currently =					$703,925		$3,421,126	Total					
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod'n	# Req'd section	Fab Cost Prototype	Tot Cost Prototype	# Req'd per CM	Prot Cost per CM		
CAVITY													CAVITY	
Cavity Assy	100	2000	800	$163,043	$65,217	$228,261	$45,000	1	$58,500	$58,500	4	$234,000	Cavities	1.11.1.1.1.1
Niobium Mat'l							$18,860	1	$24,518	$24,518	4	$98,072	Niobium	1.11.1.1.1.2
Coupler Assy	15	300	120	$24,457	$9,783	$34,239	$17,000	1	$22,100	$22,100	4	$88,400	Coupler Assy	1.11.1.1.1.3
Misc Cavity Parts	10	200	80	$16,304	$6,522	$22,826	$2,000	1	$2,600	$2,600	4	$10,400	Misc Cavity Pts	1.11.1.1.1.4
HOM Assy	5	100	40	$8,152	$3,261	$11,413	$7,000	2	$9,100	$18,200	4	$72,800	HOM Assy	1.11.1.1.1.5
													$503,672	1.11.1.1.1.
HV ASS'Y													HV ASS'Y	
He Vessel	33	660	264	$53,804	$21,522	$75,326	$7,000	1	$9,100	$9,100	4	$36,400	He Vessel	1.11.1.1.2.1
Wiring	10	200	80	$16,304	$6,522	$22,826	$2,500	1	$3,250	$3,250	4	$13,000	Wiring	1.11.1.1.2.4
Fd Thrus	5	100	40	$8,152	$3,261	$11,413	$400	4	$520	$2,080	4	$8,320	Fd Thrus	1.11.1.1.2.5
													$57,720	1.11.1.1.2
SPACE FRAME													SPACE FRAME	
Tuners	50	1000	400	$81,522	$32,609	$114,130	$7,000	1	$9,100	$9,100	4	$36,400	Tuners	1.11.1.2.1

Headers S&R	5	100	40	$8,152	$3,261	$11,413	$3,200	1	$4,160	$4,160	4	$16,640	Headers S&R	1.11.1.2.2
Magntic Shd	10	200	80	$16,304	$6,522	$22,826	$2,500	1	$3,250	$3,250	4	$13,000	Magntic Shd	1.11.1.2.4
Thermal Shield	45	900	360	$73,370	$29,348	$102,717	$8,400	1	$10,920	$10,920	4	$43,680	Thermal Shield	1.11.1.2.6
Seals/Misc Hardwe	10	200	80	$16,304	$6,522	$22,826	$1,000	1	$1,300	$1,300	4	$5,200	Seals/Misc Hdw	1.11.1.2.7
Space Frame	56	1120	448	$91,304	$36,522	$127,826	$10,000	1	$13,000	$13,000	4	$52,000	Space Frame	1.11.1.2.8
													$166,920	1.11.1.2
CRYOMODULE													CRYOMODULE	
Vacuum Tk	56	1120	448	$91,304	$36,522	$127,826	$10,000	1	$13,000	$13,000	4	$52,000	Vacuum Tk	1.11.1.3.2
End Cans	200	4000	1600	$326,087	$130,435	$456,522	$90,000	1	$117,000	$117,000	1	$117,000	End Cans	1.11.1.3.3
heat exchanger	35	700	280	$57,065	$22,826	$79,891	$10,000	1	$13,000	$13,000	1	$13,000	heat exchanger	1.11.1.3.2
Stands	40	800	320	$65,217	$26,087	$91,304	$6,000	2	$7,800	$15,600	1	$15,600	Stands	1.11.1.3.8
													$197,600	1.11.1.3.
VACUUM													VACUUM	
Pumpdrops	5	100	40	$8,152	$3,261	$11,413	$1,500	2	$1,950	$3,900	1	$3,900	Pumpdrops	1.11.1.3.1
Connections	5	100	40	$8,152	$3,261	$11,413	$1,200	2	$1,560	$3,120	1	$3,120	Connections	1.11.1.3.4
Girders	12	240	96	$19,565	$7,826	$27,391	$1,300	1	$1,690	$1,690	1	$1,690	Girders	
Slow Valves	2	40	16	$3,261	$1,304	$4,565	$2,300	2	$2,990	$5,980	1	$5,980	Slow Valves	1.11.1.3.2
Coupler Inst	2	40	16	$3,261	$1,304	$4,565	$2,500	3	$3,250	$9,750	1	$9,750	Coupler Inst	1.11.1.3.5
40 l/s Pumps	2	40	16	$3,261	$1,304	$4,565	$3,000	2	$3,900	$7,800	1	$7,800	40 l/s Pumps	1.11.1.3.3
4" Vac Valves	2	40	16	$3,261	$1,304	$4,565	$2,200	2	$2,860	$5,720	1	$5,720	4" Vac Valves	1.11.1.3.2
													$37,960	1.11.1.3
INTERFACE													INTERFACE	
Assembly	20	400	160	$32,609	$13,043	$45,652	$90,000	1	$117,000	$117,000	4	$468,000	Assembly	1.11.1.4
test,install							$15,000	1	$19,500	$19,500	1	$19,500	Installation	1.11.1.6.1
													$487,500	1.11.1.6
ELECTRICAL													ELECTRICAL	
Interlocks	100	2000	800	$163,043	$65,217	$228,261	$25,000	1	$32,500	$32,500	1	$32,500	Interlocks	1.11.1.7.2.2
Instrumentation	10	200	80	$16,304	$6,522	$22,826	$6,500	1	$8,450	$8,450	1	$8,450	Instrumentation	1.11.1.7.2.2
													$40,950	1.11.1.7.
TOTALS		9	4										TOTAL	
LABOR # / MHRS	645	16900	6760	$1,377,717	$551,087	$1,928,804	$398,360	1	$517,868	$556,088	1	$1,492,322	$1,492,322	1.11.1
							Production	Req'd	Prototype	proto sect	Req'd	per CM		

$\beta = 0.61$

	ASSUMPTIONS:		Number of drawings comparable to current design											
04-Jan-01	20 MHRS/drawing		40% Engineering		Cost of Current Design			CEBAF escalated to today's prices						
RIASM.xls	Prototype +30%		1840 Mhrs/yr					cost of engineering $ X k/year		150000				
	Frequency (MHz) =		1497	Gradient (MV/m) =		5		Cost			# of CM's	MeV	meters	
	Cryomodules cost approximately =					$1,390,891		$29,208,716	Fabrication		21	845	169	
	Active meters per cryomodule =					4		$1,638,913	Design/Engr					
	Cost is about per active meter currently =					$347,723		$30,847,629	Total		K$/MV =	34.57		
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod'n	# Req'd CU	Fab Cost Proto	Prot Cost CU	# Req'd CM	Prod Cost CM		
CAVITY														
Cavities	100	2000	800	$163,043	$65,217	$228,261	$30,000	2	$41,057	$82,114	8	$328,457	Cavities	
Nobium							$6,000	2	$8,211	$16,423	8	$65,691	Nobium	
HOM	5	100	40	$8,152	$3,261	$11,413	$800	4	$1,095	$4,379	16	$17,518	HOM	
Window	5	100	40	$8,152	$3,261	$11,413	$2,500	2	$3,421	$6,843	8	$27,371	Window	
Pair Parts	10	200	80	$16,304	$6,522	$22,826	$7,000	2	$9,580	$19,160	8	$76,640	Pair Parts	
													$10,829,213	
CRYOUNIT														
Tuners	50	1000	400	$81,522	$32,609	$114,130	$2,700	2	$3,695	$7,390	8	$29,561	Tuners	
Rotary Fdthru	2	40	16	$3,261	$1,304	$4,565	$625	4	$855	$3,421	16	$13,686	Rotary Fdthru	
He Vessel	33	660	264	$53,804	$21,522	$75,326	$8,000	1	$10,949	$10,949	4	$43,794	He Vessel	
Vacuum Tk	56	1120	448	$91,304	$36,522	$127,826	$15,500	1	$21,213	$21,213	4	$84,851	Vacuum Tk	
Magntic Shd	10	200	80	$16,304	$6,522	$22,826	$2,000	1	$2,737	$2,737	4	$10,949	Magntic Shd	
Wiring	10	200	80	$16,304	$6,522	$22,826	$2,000	2	$2,737	$5,474	8	$21,897	Wiring	
Fd Thrus	5	100	40	$8,152	$3,261	$11,413	$300	4	$411	$1,642	16	$6,569	Fd Thrus	
Indium Seals	10	200	80	$16,304	$6,522	$22,826	$400	1	$547	$547	4	$2,190	Indium Seals	
Top Hats	45	900	360	$73,370	$29,348	$102,717	$6,400	1	$8,759	$8,759	4	$35,035	Top Hats	
Waveguides	15	300	120	$24,457	$9,783	$34,239	$1,600	2	$2,190	$4,379	8	$17,518	Waveguides	
													$5,587,046	
CRYOMODULE														
End Cans	100	2000	800	$163,043	$65,217	$228,261	$55,000	1	$75,271	$75,271	1	$75,271	End Cans	
Bridging	35	700	280	$57,065	$22,826	$79,891	$14,000	1	$19,160	$19,160	1	$19,160	Bridging	
Stands	40	800	320	$65,217	$26,087	$91,304	$4,800	2	$6,569	$13,138	1	$6,569	Stands	
													$2,121,008	
VACUUM														
Pumpdrops	5	100	40	$8,152	$3,261	$11,413	$1,200	2	$1,642	$3,285	2	$3,285	Pumpdrops	
Connections	5	100	40	$8,152	$3,261	$11,413	$900	2	$1,232	$2,463	4	$4,927	Connections	
Girders	12	240	96	$19,565	$7,826	$27,391	$1,000	1	$1,369	$1,369	1	$1,369	Girders	
Fast Valve	27	540	216	$44,022	$17,609	$61,630	$3,000	1	$4,106	$4,106	1	$4,106	Fast Valve	
Slow Valves	2	40	16	$3,261	$1,304	$4,565	$1,000	2	$1,369	$2,737	2	$2,737	Slow Valves	
20 l/s Pumps	2	40	16	$3,261	$1,304	$4,565	$700	1	$958	$958	4	$3,832	20 l/s Pumps	
30 l/s Pumps	2	40	16	$3,261	$1,304	$4,565	$900	1	$1,232	$1,232	2	$2,463	30 l/s Pumps	
4" Vac Valves	2	40	16	$3,261	$1,304	$4,565	$900	1	$1,232	$1,232	1	$1,232	4" Vac Valves	
													$502,949	
INTERFACE														
Assembly	20	400	160	$32,609	$13,043	$45,652	$112,500	1	$112,500	$112,500	4	$450,000	Assembly	
													$9,450,000	
ELECTRICAL														
Interlocks	100	2000	800	$163,043	$65,217	$228,261	$20,000	1	$27,371	$27,371	1	$27,371	Interlocks	
Instrumentation	10	200	80	$16,304	$6,522	$22,826	$5,000	1	$6,843	$6,843	1	$6,843	Instrumentation	
													$718,499	
LABOR # / MHRS		8	4											
TOTALS	718	14360	7241	$1,170,652	$468,261	$1,638,913	$306,725	1	$378,310	$617,096	1	$1,390,891	TOTALS	
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod CU	Number Req'd	Fab Cost Proto	Tot Cost per CU	Number Req'd	Cost per CM	$29,208,716	

	ASSUMPTIONS		Number of drawings comparable to current design							MEDIUM BETA PRODUCTION				
04-Jan-01	20 MHRS/drawing		40% Engineering		Cost of Current Design based upon CEBAF and DESY					Engineering cost $ X k/year		150000		
RIASM.XLS	Prototype +30%		1840 Mhrs/yr		Beta =	0.61		Cost			#CM's	MeV	meters	WBS
	Frequency (MHz) =		805	Gradient (MV/m) =		10.22		$24,664,080	Fabrication		21	$07.36	57.288	
	Cryomodules cost approximately =					$1,174,480		$964,402	Design/Engr					
	Active meters per cryomodule =					2.728		$25,628,482	Total			K$/MV =	48.61	
	Cost is about per active meter currently =					$430,528								
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod'n	# Req'd section	Fab Cost Production	Tot Cost Production	# Req'd per CM	Prod Cost per CM		
CAVITY													CAVITY	
Cavity Assy	50	1000	400	$81,522	$32,609	$114,130	$45,000	1	$45,000	$45,000	4	$180,000	Cavities	1.11.1.1.1.1
Niobium Mat'l							$24,395	1	$24,395	$24,395	4	$97,580	Nobium	1.11.1.1.1.2

Coupler Assy	7.5	150	60	$12,228	$4,891	$17,120	$17,000	1	$17,000	$17,000	4	$68,000	Coupler Assy	1.11.1.1.1.3
Misc Cavity Parts	5	100	40	$8,152	$3,261	$11,413	$2,000	1	$2,000	$2,000	4	$8,000	Misc Cavity Pts	1.11.1.1.1.4
HOM Assy	2.5	50	20	$4,076	$1,630	$5,707	$7,000	2	$7,000	$14,000	4	$56,000	HOM Assy	1.11.1.1.1.5
													$8,601,180	1.11.1.1.1.
HV ASS'Y													HV ASS'Y	
He Vessel	16.5	330	132	$26,902	$10,761	$37,663	$8,000	1	$8,000	$8,000	4	$32,000	He Vessel	1.11.1.1.2.1
Wiring	5	100	40	$8,152	$3,261	$11,413	$2,500	1	$2,500	$2,500	4	$10,000	Wiring	1.11.1.1.2.4
Fd Thrus	2.5	50	20	$4,076	$1,630	$5,707	$400	4	$400	$1,600	4	$6,400	Fd Thrus	1.11.1.1.2.5
													$1,016,400	1.11.1.1.2
SPACE FRAME													SPACE FRAME	
Tuners	25	500	200	$40,761	$16,304	$57,065	$7,000	1	$7,000	$7,000	4	$28,000	Tuners	1.11.1.2.1
Headers S&R	2.5	50	20	$4,076	$1,630	$5,707	$3,200	1	$3,200	$3,200	4	$12,800	Headers S&R	1.11.1.2.2
Magntic Shd	5	100	40	$8,152	$3,261	$11,413	$2,500	1	$2,500	$2,500	4	$10,000	Magntic Shd	1.11.1.2.4
Thermal Shield	22.5	450	180	$36,685	$14,674	$51,359	$8,400	1	$8,400	$8,400	4	$33,600	Thermal Shield	1.11.1.2.6
Seals/Misc Hardwa	5	100	40	$8,152	$3,261	$11,413	$1,000	1	$1,000	$1,000	4	$4,000	Seals/Misc Hdw	1.11.1.2.7
Space Frame	28	560	224	$45,652	$18,261	$63,913	$10,000	1	$10,000	$10,000	4	$40,000	Space Frame	1.11.1.2.8
													$2,696,400	1.11.1.2
CRYOMODULE													CRYOMODULE	
Vacuum Tk	28	560	224	$45,652	$18,261	$63,913	$10,000	1	$10,000	$10,000	4	$40,000	Vacuum Tk	1.11.1.3.2
End Cans	100	2000	800	$163,043	$65,217	$228,261	$90,000	1	$90,000	$90,000	1	$90,000	End Cans	1.11.1.3.3
heat exchanger	17.5	350	140	$28,533	$11,413	$39,946	$10,000	1	$10,000	$10,000	1	$10,000	Heat Exchanger	1.11.1.3.2
Stands	20	400	160	$32,609	$13,043	$45,652	$6,000	2	$6,000	$12,000	1	$12,000	Stands	1.11.1.3.5
													$3,192,000	1.11.1.3.
VACUUM													VACUUM	
Pumpdrops	2.5	50	20	$4,076	$1,630	$5,707	$1,500	2	$1,500	$3,000	1	$3,000	Pumpdrops	1.11.1.3.1
Connections	2.5	50	20	$4,076	$1,630	$5,707	$1,200	2	$1,200	$2,400	1	$2,400	Connections	1.11.1.3.4
Girders	6	120	48	$9,783	$3,913	$13,696	$1,300	1	$1,300	$1,300	1	$1,300	Girders	
Slow Valves	1	20	8	$1,630	$652	$2,283	$2,500	2	$2,500	$5,000	1	$5,000	Slow Valves	1.11.1.3.2
coupler instr	1	20	8	$1,630	$652	$2,283	$2,500	3	$2,500	$7,500	1	$7,500	coupler instr	1.11.1.3.5
40 l/s Pumps	1	20	8	$1,630	$652	$2,283	$3,000	2	$3,000	$6,000	1	$6,000	40 l/s Pumps	1.11.1.3.3
4" Vac Valves	1	20	8	$1,630	$652	$2,283	$2,200	2	$2,200	$4,400	1	$4,400	4" Vac Valves	1.11.1.3.2
													$621,600	1.11.1.3
INTERFACE													INTERFACE	
Assembly	10	200	80	$16,304	$6,522	$22,826	$90,000	1	$90,000	$90,000	4	$360,000	Assembly	1.11.1.4
test,install							$15,000	1	$15,000	$15,000	1	$15,000	installation	1.11.1.6.1
													$7,875,000	1.11.1.6
ELECTRICAL													ELECTRICAL	
Interlocks	50	1000	400	$81,522	$32,609	$114,130	$25,000	1	$25,000	$25,000	1	$25,000	Interlocks	1.11.1.7.2.2
Instrumentation	5	100	40	$8,152	$3,261	$11,413	$6,500	1	$6,500	$6,500	1	$6,500	Instrumentation	1.11.1.7.2.2
													$661,500	1.11.1.7.
TOTALS		5	2										TOTAL	
LABOR # / MHRS	423	8450	3380	$688,859	$275,543	$964,402	$405,095	1	$405,095	$434,695	1	$1,174,480	$24,664,080	1.11.1
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Production	Number Req'd	Fab Cost Production	Tot Cost per CU	Number Req'd	Cost per CM	TOTALS	
	ASSUMPTIONS:		Number of drawings comparable to current design											
04-Jan-01	20 MHRS/drawing		40% Engineering		Cost factor of 1.3 added					MEDIUM BETA PROTOTYPE				
R:\ASMR&D.XLS	Prototype +30%		1840 MHrs/yr		Beta =	0.61				Engineering cost $ X k/year		150000		
	Frequency (MHz) =		805	Gradient (MV/m) =		10.22		Cost			# of CM's	MeV	meters	
	Cryomodules cost approximately =					$1,526,304		$1,526,304	Fabrication		1	24.16	2.728	
	Active meters per cryomodule =					2.728		$1,928,804	Design/Engr			K$/MV =	$3.17	
	Cost is about per active meter currently =					$559,496		$3,455,108	Total					
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prodt'n	# Req'd section	Fab Cost Prototype	Tot Cost Prototype	# Req'd per CM	Prot Cost per CM		
CAVITY													CAVITY	
Cavity Assy	100	2000	800	$163,043	$65,217	$228,261	$45,000	1	$58,500	$58,500	4	$234,000	Cavities	1.11.1.1.1.1
Niobium Mat'l							$24,395	1	$31,714	$31,714	4	$126,854	Niobium	1.11.1.1.1.2
Coupler Assy	15	300	120	$24,457	$9,783	$34,239	$17,000	1	$22,100	$22,100	4	$88,400	Coupler Assy	1.11.1.1.1.3
Misc Cavity Parts	10	200	80	$16,304	$6,522	$22,826	$2,000	1	$2,600	$2,600	4	$10,400	Misc Cavity Pts	1.11.1.1.1.4
HOM Assy	5	100	40	$8,152	$3,261	$11,413	$7,000	2	$9,100	$18,200	4	$72,800	HOM Assy	1.11.1.1.1.5
													$532,454	1.11.1.1.1.
HV ASS'Y													HV ASS'Y	
He Vessel	33	660	264	$53,804	$21,522	$75,326	$8,000	1	$10,400	$10,400	4	$41,600	He Vessel	1.11.1.1.2.1
Wiring	10	200	80	$16,304	$6,522	$22,826	$2,500	1	$3,250	$3,250	4	$13,000	Wiring	1.11.1.1.2.4
Fd Thrus	5	100	40	$8,152	$3,261	$11,413	$400	4	$520	$2,080	4	$8,320	Fd Thrus	1.11.1.1.2.5
													$62,920	1.11.1.1.2
SPACE FRAME													SPACE FRAME	
Tuners	50	1000	400	$81,522	$32,609	$114,130	$7,000	1	$9,100	$9,100	4	$36,400	Tuners	1.11.1.2.1

Headers S&R	5	100	40	$8,152	$3,261	$11,413	$3,200	1	$4,160	$4,160	4	$16,640	Headers S&R	1.11.1.2.2
Magnetic Shd	10	200	80	$16,304	$6,522	$22,826	$2,500	1	$3,250	$3,250	4	$13,000	Magnetic Shd	1.11.1.2.4
Thermal Shield	45	900	360	$73,370	$29,348	$102,717	$8,400	1	$10,920	$10,920	4	$43,680	Thermal Shield	1.11.1.2.6
Seals/Misc Hardwe	10	200	80	$16,304	$6,522	$22,826	$1,000	1	$1,300	$1,300	4	$5,200	Seals/Misc Hdw	1.11.1.2.7
Space Frame	56	1120	448	$91,304	$36,522	$127,826	$10,000	1	$13,000	$13,000	4	$52,000	Space Frame	1.11.1.2.8
													$166,920	1.11.1.2
CRYOMODULE													CRYOMODULE	
Vacuum Tk	56	1120	448	$91,304	$36,522	$127,826	$10,000	1	$13,000	$13,000	4	$52,000	Vacuum Tk	1.11.1.3.2
End Cans	200	4000	1600	$326,087	$130,435	$456,522	$90,000	1	$117,000	$117,000	1	$117,000	End Cans	1.11.1.3.3
heat exchanger	35	700	280	$57,065	$22,826	$79,891	$10,000	1	$13,000	$13,000	1	$13,000	heat exchanger	1.11.1.3.2
Stands	40	800	320	$65,217	$26,087	$91,304	$6,000	2	$7,800	$15,600	1	$15,600	Stands	1.11.1.3.5
													$197,600	1.11.1.3.
VACUUM													VACUUM	
Pumpdrops	5	100	40	$8,152	$3,261	$11,413	$1,500	2	$1,950	$3,900	1	$3,900	Pumpdrops	1.11.1.3.1
Connections	5	100	40	$8,152	$3,261	$11,413	$1,200	2	$1,560	$3,120	1	$3,120	Connections	1.11.1.3.4
Girders	12	240	96	$19,565	$7,826	$27,391	$1,300	1	$1,690	$1,690	1	$1,690	Girders	
Slow Valves	2	40	16	$3,261	$1,304	$4,565	$2,300	2	$2,990	$5,980	1	$5,980	Slow Valves	1.11.1.3.2
coupler instr	2	40	16	$3,261	$1,304	$4,565	$2,500	3	$3,250	$9,750	1	$9,750	coupler instr	1.11.1.3.5
40 l/s Pumps	2	40	16	$3,261	$1,304	$4,565	$3,000	2	$3,900	$7,800	1	$7,800	40 l/s Pumps	1.11.1.3.3
4" Vac Valves	2	40	16	$3,261	$1,304	$4,565	$2,200	2	$2,860	$5,720	1	$5,720	4" Vac Valves	1.11.1.3.2
													$37,960	1.11.1.3
INTERFACE													INTERFACE	
Assembly	20	400	160	$32,609	$13,043	$45,652	$90,000	1	$117,000	$117,000	4	$468,000	Assembly	1.11.1.4
test,install							$15,000	1	$19,500	$19,500	1	$19,500	Installation	1.11.1.6.1
													$487,500	1.11.1.6
ELECTRICAL													ELECTRICAL	
Interlocks	100	2000	800	$163,043	$65,217	$228,261	$25,000	1	$32,500	$32,500	1	$32,500	Interlocks	1.11.1.7.2.2
Instrumentation	10	200	80	$16,304	$6,522	$22,826	$6,500	1	$8,450	$8,450	1	$8,450	Instrumentation	1.11.1.7.2.2
													$40,950	1.11.1.7.
TOTALS		9	4										TOTAL	
LABOR # / MHRS	845	16900	6760	$1,377,717	$551,087	$1,928,804	$404,895	1	$526,364	$564,584	1	$1,526,304	$1,526,304	1.11.1
							Production	Req'd	Prototype	proto sect	Req'd	per CM		

$\beta = 0.81$

	ASSUMPTIONS		Number of drawings comparable to current design											
04-Jan-01	20 MHRS/drawing		40% Engineering		Cost of Current Design			CEBAF escalated to today's prices						
RIA06M.xls	Prototype +30%		1840 Mhrs/yr					cost of engineering $ X k/year		150000				
	Frequency (MHz) =		1497	Gradient (MV/m) =		5		Cost			# of CM's	MeV	meters	
	Cryomodules cost approximately =					$1,390,891		$9,736,239	Fabrication		7	845	169	
	Active meters per cryomodule =					4		$1,638,913	Design/Engr		K$/MV =	$11.52		
	Cost is about per active meter currently =					$347,723		$11,375,152	Total					
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod'n	# Req'd CU	Fab Cost Proto	Prod Cost CU	# Req'd CM	Prod Cost CM		
CAVITY														
Cavities	100	2000	800	$163,043	$65,217	$228,261	$30,000	2	$41,057	$82,114	8	$328,457	Cavities	
Nobium							$6,000	2	$8,211	$16,423	8	$65,691	Nobium	
HOM	5	100	40	$8,152	$3,261	$11,413	$800	4	$1,095	$4,379	16	$17,518	HOM	
Window	5	100	40	$8,152	$3,261	$11,413	$2,500	2	$3,421	$6,843	8	$27,371	Window	
Pair Parts	10	200	80	$16,304	$6,522	$22,826	$7,000	2	$9,580	$19,160	8	$76,640	Pair Parts	
														$3,609,736
CRYOUNIT														
Tuners	50	1000	400	$81,522	$32,609	$114,130	$2,700	2	$3,695	$7,390	8	$29,561	Tuners	
Rotary Fdthru	2	40	16	$3,261	$1,304	$4,565	$625	4	$855	$3,421	16	$13,686	Rotary Fdthru	
He Vessel	33	660	264	$53,804	$21,522	$75,326	$8,000	1	$10,949	$10,949	4	$43,794	He Vessel	
Vacuum Tk	56	1120	448	$91,304	$36,522	$127,826	$15,500	1	$21,213	$21,213	4	$84,851	Vacuum Tk	
Magntic Shd	10	200	80	$16,304	$6,522	$22,826	$2,000	1	$2,737	$2,737	4	$10,949	Magntic Shd	
Wiring	10	200	80	$16,304	$6,522	$22,826	$2,000	2	$2,737	$5,474	8	$21,897	Wiring	
Fd Thrus	5	100	40	$8,152	$3,261	$11,413	$300	4	$411	$1,642	16	$6,569	Fd Thrus	
Indium Seals	10	200	80	$16,304	$6,522	$22,826	$400	1	$547	$547	4	$2,190	Indium Seals	
Top Hats	45	900	360	$73,370	$29,348	$102,717	$6,400	1	$8,759	$8,759	4	$35,035	Top Hats	
Waveguides	15	300	120	$24,457	$9,783	$34,239	$1,600	2	$2,190	$4,379	8	$17,518	Waveguides	
														$1,862,349
CRYOMODULE														
End Cans	100	2000	800	$163,043	$65,217	$228,261	$55,000	1	$75,271	$75,271	1	$75,271	End Cans	
Bridging	35	700	280	$57,065	$22,826	$79,891	$14,000	1	$19,160	$19,160	1	$19,160	Bridging	
Stands	40	800	320	$65,217	$26,087	$91,304	$4,800	2	$6,569	$13,138	1	$6,569	Stands	
														$707,003
VACUUM														
Pumpdrops	5	100	40	$8,152	$3,261	$11,413	$1,200	2	$1,642	$3,285	2	$3,285	Pumpdrops	
Connections	5	100	40	$8,152	$3,261	$11,413	$900	2	$1,232	$2,463	4	$4,927	Connections	
Girders	12	240	96	$19,565	$7,826	$27,391	$1,000	1	$1,369	$1,369	1	$1,369	Girders	
Fast Valve	27	540	216	$44,022	$17,609	$61,630	$3,000	1	$4,106	$4,106	1	$4,106	Fast Valve	
Slow Valves	2	40	16	$3,261	$1,304	$4,565	$1,000	2	$1,369	$2,737	2	$2,737	Slow Valves	
20 l/s Pumps	2	40	16	$3,261	$1,304	$4,565	$700	1	$958	$958	4	$3,832	20 l/s Pumps	
30 l/s Pumps	2	40	16	$3,261	$1,304	$4,565	$900	1	$1,232	$1,232	2	$2,463	30 l/s Pumps	
4" Vac Valves	2	40	16	$3,261	$1,304	$4,565	$900	1	$1,232	$1,232	1	$1,232	4" Vac Valves	
														$167,650
INTERFACE														
Assembly	20	400	160	$32,609	$13,043	$45,652	$112,500	1	$112,500	$112,500	4	$450,000	Assembly	
														$3,150,000
ELECTRICAL														
Interlocks	100	2000	800	$163,043	$65,217	$228,261	$20,000	1	$27,371	$27,371	1	$27,371	Interlocks	
Instrumentation	10	200	80	$16,304	$6,522	$22,826	$5,000	1	$6,843	$6,843	1	$6,843	Instrumentation	
														$239,500
LABOR # / MHRS		8	4											
TOTALS	718	14360	7241	$1,170,652	$468,261	$1,638,913	$306,725	1	$378,310	$617,086	1	$1,390,891	TOTALS	
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod CU	Number Req'd	Fab Cost Proto	Tot Cost per CU	Number Req'd	Cost per CM	$9,736,239	
										HIGH BETA PRODUCTION				
	ASSUMPTIONS		Number of drawings comparable to current design											
04-Jan-01	20 MHRS/drawing		40% Engineering		Cost of Current Design based upon CEBAF and DESY					Engineering cost $ X k/year		150000		
RIA06M.XLS	Prototype +30%		1840 Mhrs/yr		Beta =	0.81		Cost			#CM's	MeV	meters	WBS
	Frequency (MHz) =		805	Gradient (MV/m) =		12.56		$8,436,960	Fabrication		7	275.8	23.772	
	Cryomodules cost approximately =					$1,205,280		$964,402	Design/Engr					
	Active meters per cryomodule =					3.396		$9,401,362	Total			K$/MV =	$30.59	
	Cost is about per active meter currently =					$354,912								
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod'n	# Req'd section	Fab Cost Production	Tot Cost Production	# Req'd per CM	Prod Cost per CM		
CAVITY													CAVITY	
Cavity Assy	50	1000	400	$81,522	$32,609	$114,130	$45,000	1	$45,000	$45,000	4	$180,000	Cavities	1.11.1.1.1.1
Niobium Mat'l							$29,520	1	$29,520	$29,520	4	$118,080	Nobium	1.11.1.1.1.2

Coupler Assy	7.5	150	60	$12,228	$4,891	$17,120	$17,000	1	$17,000	$17,000	4	$68,000	Coupler Assy	1.11.1.1.1.3
Misc Cavity Parts	5	100	40	$8,152	$3,261	$11,413	$2,000	1	$2,000	$2,000	4	$8,000	Misc Cavity Pts	1.11.1.1.1.4
HOM Assy	2.5	50	20	$4,076	$1,630	$5,707	$7,000	2	$7,000	$14,000	4	$56,000	HOM Assy	1.11.1.1.1.5
													$3,010,560	1.11.1.1.1.
HV ASS'Y													HV ASS'Y	
He Vessel	16.5	330	132	$26,902	$10,761	$37,663	$9,000	1	$9,000	$9,000	4	$36,000	He Vessel	1.11.1.1.2.1
Wiring	5	100	40	$8,152	$3,261	$11,413	$2,500	1	$2,500	$2,500	4	$10,000	Wiring	1.11.1.1.2.4
Fd Thrus	2.5	50	20	$4,076	$1,630	$5,707	$400	4	$400	$1,600	8	$12,800	Fd Thrus	1.11.1.1.2.5
													$411,600	1.11.1.1.2
SPACE FRAME													SPACE FRAME	
Tuners	25	500	200	$40,761	$16,304	$57,065	$7,000	1	$7,000	$7,000	4	$28,000	Tuners	1.11.1.2.1
Headers S&R	2.5	50	20	$4,076	$1,630	$5,707	$3,200	1	$3,200	$3,200	4	$12,800	Headers S&R	1.11.1.2.2
Magnetic Shd	5	100	40	$8,152	$3,261	$11,413	$2,500	1	$2,500	$2,500	4	$10,000	Magnetic Shd	1.11.1.2.4
Thermal Shield	22.5	450	180	$36,685	$14,674	$51,359	$8,400	1	$8,400	$8,400	4	$33,600	Thermal Shield	1.11.1.2.6
Seals/Misc Hardw	5	100	40	$8,152	$3,261	$11,413	$1,000	1	$1,000	$1,000	4	$4,000	Seals/Misc Hdw	1.11.1.2.7
Space Frame	28	560	224	$45,652	$18,261	$63,913	$10,000	1	$10,000	$10,000	4	$40,000	Space Frame	1.11.1.2.8
													$898,800	1.11.1.2
CRYOMODULE													CRYOMODULE	
Vacuum Tk	28	560	224	$45,652	$18,261	$63,913	$10,000	1	$10,000	$10,000	4	$40,000	Vacuum Tk	1.11.1.3.2
End Cans	100	2000	800	$163,043	$65,217	$228,261	$90,000	1	$90,000	$90,000	1	$90,000	End Cans	1.11.1.3.3
heat exchanger	17.5	350	140	$28,533	$11,413	$39,946	$10,000	1	$10,000	$10,000	1	$10,000	heat exchangar	1.11.1.3.2
Stands	20	400	160	$32,609	$13,043	$45,652	$6,000	2	$6,000	$12,000	1	$12,000	Stands	1.11.1.3.5
													$1,064,000	1.11.1.3.
VACUUM													VACUUM	
Pumpdrops	2.5	50	20	$4,076	$1,630	$5,707	$1,500	2	$1,500	$3,000	1	$3,000	Pumpdrops	1.11.1.3.1
Connections	2.5	50	20	$4,076	$1,630	$5,707	$1,200	2	$1,200	$2,400	1	$2,400	Connections	1.11.1.3.4
Girders	6	120	48	$9,783	$3,913	$13,696	$1,300	1	$1,300	$1,300	1	$1,300	Girders	
Slow Valves	1	20	8	$1,630	$652	$2,283	$2,300	2	$2,300	$4,600	1	$4,600	Slow Valves	1.11.1.3.2
coupler instr	1	20	8	$1,630	$652	$2,283	$2,500	4	$2,500	$10,000	1	$10,000	coupler instr	1.11.1.3.5
40 l/s Pumps	1	20	8	$1,630	$652	$2,283	$3,000	2	$3,000	$6,000	1	$6,000	40 l/s Pumps	1.11.1.3.3
4" Vac Valves	1	20	8	$1,630	$652	$2,283	$2,200	1	$2,200	$2,200	1	$2,200	4" Vac Valves	1.11.1.3.2
													$206,500	1.11.1.3
INTERFACE													INTERFACE	
Assembly	10	200	80	$16,304	$6,522	$22,826	$90,000	1	$90,000	$90,000	4	$360,000	Assembly	1.11.1.4
test,install							$15,000	1	$15,000	$15,000	1	$15,000	Installation	1.11.1.6.1
													$2,625,000	1.11.1.6
ELECTRICAL													ELECTRICAL	
Interlocks	50	1000	400	$81,522	$32,609	$114,130	$25,000	1	$25,000	$25,000	1	$25,000	Interlocks	1.11.1.7.2.2
Instrumentation	5	100	40	$8,152	$3,261	$11,413	$6,500	1	$6,500	$6,500	1	$6,500	Instrumentation	1.11.1.7.2.2
													$220,500	1.11.1.7.
TOTALS		5	2										TOTAL	
LABOR # / MHRS	423	8450	3380	$688,859	$275,543	$964,402	$411,020	1	$411,020	$440,720	1	$1,205,280	$8,436,960	1.11.1
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Production	Number Req'd	Fab Cost Production	Tot Cost per CU	Number Req'd	Cost per CM	TOTALS	
	ASSUMPTIONS		Number of drawings comparable to current design							HIGH BETA PROTOTYPE				
04-Jan-01	20 MHRS/drawing		40% Engineering		Cost factor of 1.3 added									
RIA08MR&D.XLS	Prototype +30%		1840 Mhrs/yr		Beta =	0.81				Engineering cost $ X k/year		150000		
	Frequency (MHz) =		805	Gradient (MV/m) =		12.56		Cost			# of CM's	MeV	meters	
	Cryomodules cost approximately =					$1,552,564		$1,552,564	Fabrication		1	39.4	3.396	
	Active meters per cryomodule =					3.396		$1,928,804	Design/Eng					
	Cost is about per active meter currently =					$457,174		$3,481,368	Total			K$/MV =	$39.41	
ACTIVITY	DRAWINGS	DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod'n	# Req'd section	Fab Cost Prototype	Tot Cost Prototype	# Req'd per CM	Prot Cost per CM		
CAVITY													CAVITY	
Cavity Assy	100	2000	800	$163,043	$65,217	$228,261	$45,000	1	$58,500	$58,500	4	$234,000	Cavities	1.11.1.1.1.1
Niobium Mat'l							$29,520	1	$38,376	$38,376	4	$153,504	Niobium	1.11.1.1.1.2
Coupler Assy	15	300	120	$24,457	$9,783	$34,239	$17,000	1	$22,100	$22,100	4	$88,400	Coupler Assy	1.11.1.1.1.3
Misc Cavity Parts	10	200	80	$16,304	$6,522	$22,826	$2,000	1	$2,600	$2,600	4	$10,400	Misc Cavity Pts	1.11.1.1.1.4
HOM Assy	5	100	40	$8,152	$3,261	$11,413	$7,000	2	$9,100	$18,200	4	$72,800	HOM Assy	1.11.1.1.1.5
													$559,104	1.11.1.1.1.
HV ASS'Y													HV ASS'Y	
He Vessel	33	660	264	$53,804	$21,522	$75,326	$7,000	1	$9,100	$9,100	4	$36,400	He Vessel	1.11.1.1.2.1
Wiring	10	200	80	$16,304	$6,522	$22,826	$2,500	1	$3,250	$3,250	4	$13,000	Wiring	1.11.1.1.2.4
Fd Thrus	5	100	40	$8,152	$3,261	$11,413	$400	4	$520	$2,080	8	$16,640	Fd Thrus	1.11.1.1.2.5
													$66,040	1.11.1.1.2
SPACE FRAME													SPACE FRAME	
Tuners	50	1000	400	$81,522	$32,609	$114,130	$7,000	1	$9,100	$9,100	4	$36,400	Tuners	1.11.1.2.1

Headers S&R	5	100	40	$8,152	$3,261	$11,413	$3,200	1	$4,160	$4,160	4	$16,640	Headers S&R	1.11.1.2.2
Magnitic Shd	10	200	80	$16,304	$6,522	$22,826	$2,900	1	$3,250	$3,250	4	$13,000	Magnitic Shd	1.11.1.2.4
Thermal Shield	45	900	360	$73,370	$29,348	$102,717	$8,400	1	$10,920	$10,920	4	$43,680	Thermal Shield	1.11.1.2.6
Seals/Misc Hardw	10	200	80	$16,304	$6,522	$22,826	$1,000	1	$1,300	$1,300	4	$5,200	Seals/Misc Hdw	1.11.1.2.7
Space Frame	56	1120	448	$91,304	$36,522	$127,826	$10,000	1	$13,000	$13,000	4	$52,000	Space Frame	1.11.1.2.8
													$166,920	1.11.1.2
CRYOMODULE													CRYOMODULE	
Vacuum Tk	56	1120	448	$91,304	$36,522	$127,826	$10,000	1	$13,000	$13,000	4	$52,000	Vacuum Tk	1.11.1.3.2
End Cans	200	4000	1600	$326,087	$130,435	$456,522	$90,000	1	$117,000	$117,000	1	$117,000	End Cans	1.11.1.3.3
heat exchanger	35	700	280	$57,065	$22,826	$79,891	$10,000	1	$13,000	$13,000	1	$13,000	heat exchanger	1.11.1.3.2
Stands	40	800	320	$65,217	$26,087	$91,304	$6,000	2	$7,800	$15,600	1	$15,600	Stands	1.11.1.3.5
													$197,600	1.11.1.3.
VACUUM													VACUUM	
Pumpdrops	5	100	40	$8,152	$3,261	$11,413	$1,500	2	$1,950	$3,900	1	$3,900	Pumpdrops	1.11.1.3.1
Connections	5	100	40	$8,152	$3,261	$11,413	$1,200	2	$1,560	$3,120	1	$3,120	Connections	1.11.1.3.4
Girders	12	240	96	$19,565	$7,826	$27,391	$1,300	1	$1,690	$1,690	1	$1,690	Girders	
Slow Valves	2	40	16	$3,261	$1,304	$4,565	$1,300	2	$1,690	$3,380	1	$3,380	Slow Valves	1.11.1.3.2
60 l/s Pumps	2	40	16	$3,261	$1,304	$4,565	$2,500	4	$3,250	$13,000	1	$13,000	60 l/s Pumps	1.11.1.3.5
40 l/s Pumps	2	40	16	$3,261	$1,304	$4,565	$3,000	2	$3,900	$7,800	1	$7,800	40 l/s Pumps	1.11.1.3.3
4" Vac Valves	2	40	16	$3,261	$1,304	$4,565	$1,200	1	$1,560	$1,560	1	$1,560	4" Vac Valves	1.11.1.3.2
													$34,450	1.11.1.3
INTERFACE													INTERFACE	
Assembly	20	400	160	$32,608	$13,043	$45,652	$90,000	1	$117,000	$117,000	4	$468,000	Assembly	1.11.1.4
test,install							$15,000	1	$19,500	$19,500	1	$19,500	Installation	1.11.1.6.1
													$487,500	1.11.1.6
ELECTRICAL													ELECTRICAL	
Interlocks	100	2000	800	$163,043	$65,217	$228,261	$25,000	1	$32,500	$32,500	1	$32,500	Interlocks	1.11.1.7.2.2
Instrumentation	10	200	80	$16,304	$6,522	$22,826	$6,500	1	$8,450	$8,450	1	$8,450	Instrumentation	1.11.1.7.2.2
													$40,950	1.11.1.7.
TOTALS		9	4										TOTAL	
LABOR # / MHRS	845	16900	6760	$1,377,717	$551,087	$1,928,804	$407,020	1	$529,126	$566,436	1	$1,552,564	$1,552,564	1.11.1
							Production	Req'd	Prototype	proto sect	Req'd	per CM		

WBS 3.4
RF (RIA Driver)

RIA DRIVER		
		K$
SIGNAL SOURCE		
Frequency Generation		$ 43.80
Transmission		$ 148.00
Miscellaneous Hardware		$ 10.00
TOTAI		**$ 201.80**
RFQ (1 System)		
High Level RF Power		$ 198.00
Low Level RF		$ 39.00
Miscellaneous Hardware		$ 39.00
TOTAL		**$ 276.00**
BUNCHER (2 Systems)		
High Level RF Power		$ 190.00
Low Level RF		$ 84.00
Miscellaneous Hardware		$ 80.00
TOTAL		**$ 354.00**
SC LINAC INJECTION SECTION (79 System		
High Level RF Power		$ 879.12
Low Level RF		$ 3,081.00
Miscellaneous Hardware		$ 729.19
TOTAL		**$ 4,689.31**
SC LINAC MID SECTION (168 SYSTEMS)		
High Level RF Power		$ 3,150.03
Low Level RF		$ 4,676
Miscellaneous Hardware		$ 1,538.41
TOTAL		**$ 9,364.84**
SC LINAC FINAL SECTION (188 SYSTEMS)		
High Level RF Power		$ 17,108
Low Level RF		$ 4,089
Miscellaneous Hardware		$ 3,064
TOTAL		**$ 24,261.40**
SYSTEM TOTAL		**$ 39,147.35**

Work Sheet (Notes)

INJECTION SECTION	INJECTION RF AMP	VENDOR QUOTES			
	57.5MHz - 500W Amp	$8K			
	115MHz - 700W Amp	$10.2K			
	Engineering Judgement	$8K			
	Energy Onix	$5K			
	QEI	$7.795K			
	Selected Cost	$8K			
					SUB
		HIGH LEVEL RF	LOW LEVEL RF	MISCELLANEOUS	TOTAL
		$879	$3,081	$ 729.19	$ 4,689.31
MID SECTION	MID RF AMP	VENDOR QUOTES			
	1kW @ 172.5MHz	$216K			
	1kW @ 345MHz	$480K			
	Engineering Judgement	$16.25K			
	Energy Onix(-circ)	$15.5K			
	QEI 172.5(-circ)	$12.5K			
	QEI 345(-circ)	$23.7K			
	SNS Quote	$20k			
	Selected Cost	$16.25K			
		HIGH LEVEL RF	LOW LEVEL RF	MISCELLANEOUS	SUB TOTAL
		$ 3,150.03	$ 4,676.40	$ 1,538.41	$ 9,364.84
FINAL SECTION	FINAL RF AMP	VENDOR QUOTES			
	RF Power @ 805MHz	$20K			
	Engineering Judgement	$77.25K			
	IGOR	$35K			
	Energy Onix	$200K			
	Continental	$162K			
		HIGH LEVEL RF	LOW LEVEL RF	MISCELLANEOUS	SUB TOTAL
		$ 17,108.00	$ 4,089.00	$ 3,064.40	$ 24,261.40
	TOTAL	$ 21,137.15	$ 11,846.40	$ 5,332.00	$ 38,315.55

INJECTION SECTION RIA DRIVER

		ENGINEERING JUDGEMENT			INSTALLATION AND COMMISSIONING				
	HIGH-LEVEL RF	COMPONENTS	TECH. LABOR	SUB		DAVIS BACON	TECH. LABOR	SUB	
QTY.	57.5MHz/115/MHz		at $68/MH	TOTAL	TASK	at $55/MH	at $68/MH	TOTAL	TOTAL
39	500W amp, 57MHz	$8		$ 312.00	RQ Racks	$20		$ 20.00	
40	700W amp, 115MHz	$10		$ 408.00	Cable Tray	$20		$ 20.00	
					Cable Pulls	$20		$ 20.00	
					Burn-in Test		$5.50	$ 5.50	
					Installation		$5.50	$ 5.50	
					Cavity Test		$88.12	$ 88.12	
	Total each RF amp = 8.4K			**$ 720.00**	**Total Installation each = $2K**			**$ 159.12**	**$ 879.12**
	LOW-LEVEL RF								
79	Fast Tuners	$5		$ 395.00					
79	Slow Tuners Controls Crate	$5		$ 395.00					
79	CPU	$6.50		$ 513.50					
79	a/d Boards	$2		$ 158.00					
79	d/a Boards	$2		$ 158.00					
79	I/o Boards	$2		$ 158.00					
79	Tuners (Fast & Slow)	$4		$ 316.00			711	$ 711.00	
79	Interlock Boards	$2		$ 158.00					
79	Interface Boards	$1		$ 79.00					
79	Pre-made Cables	$0.50		$ 39.50					
	Total each LLRF System = 26.8K			**$ 2,370.00**	**Total Installation each = 9K**			**$ 711.00**	**$ 3,081.00**
	MISC. HARDWARE								
79	Equipment Racks	$2K		$158					
79	Cable Tray	$1.5K		$118.50					
79	RF Cables	$1K		$79					
79	Tuner Cables	$1.5K		$118.50	EQ Racks &				
79	Ctrl/Inst. Cables	$1K		$79	Cable Tray	$139.K		$139	
1	2430' Heliax			$10	Cable Pulls	$20K		$20	
1	158 Heliax Conn.			$7					
	Total each Misc. Hardware = 7.13K			**$ 570.19**	**Total Installation each = 2K**			**$ 159.00**	**$ 729.19**
	TOTAL								**$ 4,689.31**

MID SECTION RIA DRIVER

	HIGH-LEVEL RF	ENGINEERING JUDGEMENT			INSTALLATION AND COMMISSIONING				
	POWER 175MHz and 345MHz	COMPONENTS	TECH. LABOR	SUB		DAVIS BACON	TECH. LABOR	SUB	
QTY.	Triode or Tetrode		at $68/MH	TOTAL	TASK	at $55/MH	at $68/MH	TOTAL	TOTAL
72	RF Amp, 1kW @ 172.5MHz	$4.00	$95.04	$ 383.04	Rigging	$5.70		$ 5.70	
96	RF Amp, 1kW @ 345MHz	$5.00	$146.88	$ 626.88	Water	$88.63		$ 88.63	
168	HVPS	$1.50	$276.60	$ 528.60	Electrical	$37.86		$ 37.86	
168	Controls	$1.00	$276.60	$ 444.60	Load Test		$22.80	$ 22.80	
96	Water System	$1.00	$49.50	$ 145.50	Install		$11.42	$ 11.42	
168	Misc. Hardware	$1.00	$85	$ 253.00	Cav. Test		$182	$ 182.00	
168	350MHz Circ.	$2.50		$ 420.00					
	Total each RF amp = 16.25			$ 2,801.62	Total Installation each = $2K			$ 348.41	$ 3,150.03
	LOW-LEVEL RF								
72	Fast Tuners	$5.00		$ 360.00			$9	$ 1,512.00	
72	Slow Tuners & Control Crate	$5.00		$ 360.00					
84	CPU	$6.50		$ 546.00					
168	a/d Boards	$2.00		$ 336.00					
168	d/a Boards	$2.00		$ 336.00					
168	I/o Boards	$2.00		$ 336.00					
72	Tuners (Fast & Slow)	$4.20		$ 302.40					
168	Interlock Boards	$2.00		$ 336.00					
168	Interface Boards	$1.00		$ 168.00					
168	Pre-made Cables	$0.50		$ 84.00					
	Total each LLRF System = 18.75			$ 3,164.40	Total Installation each = 9K			$ 1,512.00	$ 4,676.40
	MISC. HARDWARE								
168	EQ Racks	$2		$ 336.00					
168	Cable Tray	$1.50		$ 252.00					
168	RF Cables	$1		$ 168.00					
168	Tuner Cables	$1.50		$ 252.00	Cable Tray				
168	Control/Inst. Cable	$1		$ 168.00	& EQ Racks	$295.63		$ 295.63	
1	6560', 7/8 Heliax	$ 25.50		$ 25.50	Cable Pulls	$18.48		$ 18.48	
1	328 Heliax Conn.	$ 22.80		$ 22.80					
	Total each Misc. Hardware = 7.46			$ 1,224.30	otal Installation each = 1.86			$ 314.11	$ 1,538.41
	TOTAL								$ 9,364.84

FINAL SECTION RIA DRIVER

		ENGINEERING JUDGEMENT			INSTALLATION AND COMMISSIONING				
	HIGH-LEVEL RF	COMPONENTS	TECH. LABOR	SUB		DAVIS BACON	TECH. LABOR	SUB	
QTY.	POWER @805MHz		at $68/MH	TOTAL	TASK	at $55/MH	at $68/MH	TOTAL	TOTAL
	(Klystron based)								
188	RF Amp	20	3.5	$ 4,418.00	Rigging	188 (1K)		$ 188.00	
188	HVPS	20	3.5	$ 4,418.00	Water	225.6 (1.2K)		$ 225.60	
188	Controls	4	3.5	$ 1,410.00	Electrical	338.4 (1.8K)		$ 338.40	
188	Cabinets	3	2.25	$ 987.00	Load Test		413.6 (2.2K)	$ 413.60	
188	Water System	5	2.25	$ 1,363.00	Install		817.6 (4.35K)	$ 817.80	
188	Misc. Hardware	5	2.25	$ 1,363.00	Cav. Test		601.6 (3.2K)	$ 601.60	
188	Circulators & Loads	3		$ 564.00					
	Total each RF amp = 77.25K			**$ 14,523.00**				**$ 2,585.00**	**$ 17,108.00**
	LOW-LEVEL RF								
94	CPU	6.5		$ 611.00					
188	a/d Boards	2		$ 376.00					
188	d/a Boards	2		$ 376.00					
188	i/o Boards	2		$ 376.00					
188	Interlock Boards	2		$ 376.00					
188	Interface Boards	1		$ 188.00					
188	Premade Cables	0.5		$ 94.00			9	$ 1,692.00	
	Total each LLRF System = 12.25K			**$ 2,397.00**	**Total Installation each = 9K**			**$ 1,692.00**	**$ 4,089.00**
	MISC. HARDWARE								
188	Equipment Racks	2		$ 376.00					
188	Cable Tray	0.5		$ 94.00					
188	RF Cables	1		$ 188.00					
188	Ctrl/Interlock Cabes	2.5		$ 470.00	Cable Tray				
					& EQ Racks	1.8		$ 338.40	
188	3 1/8" Hardline	3.5		$ 658.00	Install Hardline	5		$ 940.00	
	Total each Misc. Hardware = 9.5K			**$ 1,786.00**	**Total Installation each = 6.8K**			**$ 1,278.40**	**$ 3,064.40**
	TOTAL								**$ 24,261.40**

WBS 3.5
Linac Control Inter.

Labor Cost ($/hr)	$75						
WBS	Description	Quantity	Total k$	Item M$	Hours	K$ Purchasing	Basis
1.1	Cryomodule I/O Crate	78	$2,106.0	$27.0	160.0	$15.0	NCS (analog in + out, digital, serial)
1.2	Networking	1	$40.0	$40.0	200.0	$25.0	Allowance
1.3	Central Control Aspects	1	$850.0	$850.0	10000.0	$100.0	Allowance (= 2 FTE for 5 years)
	Total		$2,996.0				

1.1 12,000*78 = 936,000
1.2 15,000 15,000
1.3 1*750,000 750,000
1,701,000

WBS 3.7
Linac BSY

Labor Cost ($/hr)	$75					
WBS	Description	Total M$	Item M$	kHours	M$ Purchasing	Basis
1	**RF Switches**	**$0.5**	$0.5	4.1	$0.2	Allowance
			$0.5	**$0.3**	**$0.2**	
2	**Linac Switchyard**	**$4.1**				
2.1	dipole (5)		$0.2	8.0	$0.2	scaled A1900 dipoles 15/30 degree
2.2	quads (19 doub)		$0.7	16.9	$0.7	scaled S800 doublets
2.3	septum magnets (2)		$0.1	0.2	$0.2	guess/scale from A1900
2.4	corr magnets (10V 10H)		$0.0	0.8	$0.0	10% dipole
2.5	power supplies		$0.3	2.0	$0.3	15% magnets
2.6	vac and controls		$0.1	2.2	$0.1	10% quad and dipole
2.7	boxes, det, etc		$0.0	3.3	$0.0	10% quad and dipole
			$4.1	**$2.5**	**$1.6**	

WBS 4.3
Target Systems

Fragment Separator Radiation Safety (RIA-MSU Estimates)

System	Item	Purchases					Labor		Notes
		Quantity	Cost Each	$K Total	Basis	$K System Total	Hours	Basis	
Target	Fragmentation Target	1	1,300,000	1,300	wag				
	Remote Handling	1	300,000	300	wag				
	Water Cooling Package	1	66,000	66	ISAC	1,666	51,000	wag	
Shielding	Target, local, steel	1	5,333	5	Ronningen				
	Dump, Concrete	1	260,000	260	Ronningen				
	Dump, steel	1	-	-	Ronningen/Nolen				
	Target + Dump, steel shipping	1	720,530	721	Nolen	986	1,834	ISAC	
Vacuum	Decay Storage Tanks	2	6,600	13	ISAC				
	High Vacuum Gauges	8	1,320	11	ISAC				
	Rough Vacuum Guages	5	132	1	ISAC				
	Extended Control Cables (lot)	1	3,300	3	ISAC				
	Mechanical Vacuum Pumps	3	1,980	6	ISAC				
	Operating Storage Tanks	2	1,980	4	ISAC				
	Turbo Pumps	12	13,200	158	ISAC				
	Rad Hard Valves	2	13,200	26	ISAC				
	Small Vacuum Valves	25	330	8	ISAC				
	Vacuum Exhaust Plumbing (Lot)	1	3,300	3	ISAC	234	4,000	wag	
				Total =		$2,886	56,834		
				Total$		$2,886	$4,263		
				Total		$7,148			

Gas Stopping Target Radiation Safety (RIA-MSU Estimates)

System	Item	Purchases					Labor		Notes
		Quantity	Cost Each	$K Total	Basis	$K System Total	Hours	Basis	
Target	Target Module	1	1,000,000	1,000	wag				
	Remote Handling	1	300,000	300	wag				
						1,300	51,000	wag	
Shielding	Local, steel	1	5,333	5	Ronningen	986	1,834	ISAC	
	Steel dump shield	1	-	-					
	Concrete dump shield	1	260,000	260	Ronningen				
	Target + Dump, steel shipping	1	720,530	721	Nolen				
Vacuum	Decay Storage Tanks	2	6,600	13	ISAC				
	High Vacuum Gauges	8	1,320	11	ISAC				
	Rough Vacuum Guages	5	132	1	ISAC				
	Extended Control Cables (lot)	1	3,300	3	ISAC				
	Mechanical Vacuum Pumps	3	1,980	6	ISAC				
	Operating Storage Tanks	2	1,980	4	ISAC				
	Turbo Pumps	12	13,200	158	ISAC				
	Rad Hard Valves	2	13,200	26	ISAC				
	Small Vacuum Valves	25	330	8	ISAC				
	Vacuum Exhaust Plumbing (Lot)	1	3,300	3	ISAC	234	2,000	wag	
				Total =		$2,520	54,834		
				TotalS		$2,520	$4,113		
				Total		$6,632			

ISOL Radiation Safety (RIA-MSU Estimates)

System	Item	Purchases					Labor		Notes
		Quantity	Cost Each	$K Total	Basis	$K System Total	Hours	Basis	
Target	Target Dump Module	2	47,520	95	ISAC				
	Target Entrance Module	2	30,202	60	ISAC				
	Target Exit (1 and 2) Modules	4	102,300	409	ISAC				
	Target Module	4	100,320	401	ISAC				
	Target Station High Voltage System	2	118,008	236	ISAC				
	Target Vacuum Tanks	4	47,586	190	ISAC				
	Water Cooling Package	2	66,000	132	ISAC	1,524	51,000	ISAC	
Shielding	Target, Concrete-fixed	2	260,000	520	Ronningen				
	Target, Concrete-removable high density	2	6,082	12	ISAC				
	Target, steel from ORNL	2	-	-	Ronningen/Nolen				
	Target, steel shipping from ORNL	2	720,530	1,441	Nolen	1,973	3,700	ISAC	
Vacuum	Decay Storage Tanks	4	6,600	26	ISAC				
	High Vacuum Gauges	16	1,320	21	ISAC				
	Rough Vacuum Guages	10	132	1	ISAC				
	Extended Control Cables (lot)	2	3,300	7	ISAC				
	Mechanical Vacuum Pumps	6	1,980	12	ISAC				
	Operating Storage Tanks	4	1,980	8	ISAC				
	Turbo Pumps	24	13,200	317	ISAC				
	Rad Hard Valves	4	13,200	53	ISAC				
	Small Vacuum Valves	50	330	17	ISAC				
	Vacuum Exhaust Plumbing (Lot)	2	3,300	7	ISAC	468	4,000	wag	
				Total =		$3,965	58,700		
				Total$		$3,965	$4,403		
				Total		$8,368			

System	Services (RIA-MSU Estimates) Item	Purchases Quantity	ISAC Cost Each	Scaled up Cost (x1.5)	$K Total	Basis	$K System Total	Labor Hours	Basis	Notes
Hot Cell	Hot Cell	2	66,000	99,000	99	ISAC				
	Access Door	2	9,900	14,850	15	ISAC				
	Roof and Concrete Fill	2	80,520	120,780	121	ISAC				
	Windows, Installation	2	114,510	171,765	172	ISAC				
	Manipulators	4	58,740	88,110	88	ISAC				
	Scissor Lift Tables	2	4,620	6,930	7	ISAC				
	Target Alignment Optics	1	40,920	61,380	61	ISAC				
	Turntables	1	10,890	16,335	16	ISAC	579	23,550	ISAC	Scaled up
				-	-					
				-	-					
				-	-					
Crane	20T overhead crane with 3T aux.	1	145,378	218,067	218	ISAC				
	Crane remote console and controls	1	75,900	113,850	114	ISAC	332	500	wag	
				-	-					
				-	-					
Decontamination	Decontamination Room	1	33,000	49,500	50	ISAC	50	300	wag	
				-	-					
				-	-					
Storage Pit	Decontamination Tank	1	5,014	7,521	8	ISAC				
	Storage Silos	6	13,860	20,790	21	ISAC				
	Target Alignment Frame	1	1,320	1,980	2	ISAC	30	1,000	wag	
				-	-					
				-	-					
Target Storage	Spent Target Storage Vault Shielding	1	58,080	87,120	87	ISAC				
	STSV Electrical Controls	1	1,320	1,980	2	ISAC				
	STSV Mechanical Components	1	16,500	24,750	25	ISAC	114	1,000	wag	
				-	-					
				-	-					
Services	Secondary Water System (low-active)	1	33,000	49,500	50	ISAC				
	Nuclear Exhaust System	1	330,000	495,000	495	ISAC				
	Tertiary Water System (raw water)	1	19,800	29,700	30	ISAC	574	6,000	wag	
				-	-					
				-	-					
Safety Monitoring, System	Safety and Computing Sytems	1	708,089	708,089	708	NISOL		7,488	NISOL	
	Target Hall Safety System (lockout)	2	8,316	8,316	8	ISAC				
	Neutron	30	10,000	10,000	10	Ronningen		300	wag	
	alpha, beta, gamma	30	10,000	10,000	10	Ronningen		300	wag	
	Water sump monitoring	1	200,000	200,000	200	Ronningen		1,500	wag	
	Air stack monitoring	1	200,000	200,000	200	Ronningen		1,500	wag	
	(particulate, iodine, noble, tritium)			-	-					
	Waste Monitoring	1	100,000	100,000	100	Ronningen		500	wag	
	Portal (monitor+access control) (4)	4	80,000	80,000	80	Ronningen	1,316	1,000	wag	
				-	-					
				-	-					
Project Support	Management & Administration			-	-	NISOL				
	Systems Design/Integration			-	-	NISOL				
	Safety			-	-	NISOL				
	Environmental and WM Planning			-	-	NISOL				
	QA			-	-	NISOL				
	Regulatory Compliance			-	-	NISOL		71,867	NISOL	
				-						
				-	Total =		$2,995	116,805		
					Total$		$2,995	$8,760		
					Total		$11,756			

2/3 of these hrs.

WBS 4.4
ISOL Systems

Labor Cost ($/hr)	$75					
WBS	Description	Total M$	Item K$	kHours	K$ Purchasing	Basis
1	**Gas Cell TGT Area Transport**	**$4.6**				
1.1	dipoles (1)		$1.7	15.0	$0.6	scaled A1900 X ~2
1.2	quad doublet (1)		$0.5	4.0	$0.2	scaled S800 quad X 2
1.3	quad triplets (1)		$2.5	22.0	$0.8	scaled A1900 X 3
			$4.6	**$3.0**	**$1.6**	
2	**Gas Cell fragment Seperator**	**$7.1**				
2.1	dipoles (2)		$1,200.6	10.4	$417.6	
2.2	quads (6)		$4,287.7	37.7	$1,460.2	
2.3	corr magnets (4V 4H)		$158.8	1.6	$41.8	
2.4	power supplies		$774.6	3.6	$504.4	
2.5	vacuum &controls		$540.4	4.0	$240.2	
2.6	boxes, det, etc		$122.2	0.4	$94.0	
			$6,999.4	**$4,241.3**	**$2,758.1**	
3	**Gas Cell System**	**$0.58**				
3.1	Gas Cell		$180.0			
3.2	Roots Blower		$80.0			
3.3	RF Cooler		$20.0			
3.4	Vacuum Pumps		$30.0			
3.5	Gas Recirculation		$50.0			
3.6	High Voltage Platform		$150.0			
3.7	Mechanical Support		$30.0			
3.8	Electronics		$40.0			

Low Energy RIB System

• Isobar Separator Systems	$2,000k
• Transport of unaccelerated RIBs	$5,900k
• RFQ High-Voltage Platform	$200k
• Buncher	$100k
• RFQ Tanks (3)	$1800k
• 8 Resonator Cryomodule (8)	$11,800k
• Rebuncher	$500k
• Helium gas strippers	$700k
• Diagnostics, Controls & Software	$800k
• Beam Transport	$1,311k
• Total (w/o cont.)	$25,111K

ATLAS equivalent RIB LINAC System

• Design	$3.8M
• Cryodistribution	$2.5M
• RF and cavities	$5.6M
• Cryostats	$2.6M
• Control system	$2.2M
• Beamlines	$0.9M
• Rebunchers	$0.4M
• Total (w/o cont.)	$18.0M

WBS 4.5
High Energy Systems

Labor Cost ($/hr)	$75					
WBS	Description	Total M$	Item M$	kHours	M$ Purchasing	Basis
1	**Production TGT Area Transport**	**$4.8**				
1.1	dipoles (1)		$1.7	15.0	$0.6	scaled A1900 X ~2
1.2	quad doublet (1)		$0.6	5.2	$0.2	scaled S800 quad X 2
1.3	quad triplets (1)		$2.5	22.0	$0.8	scaled A1900 X 3
				$3.1	**$1.6**	
1	**HE fragment Seperator**	**$19.2**				
1.1	dipoles (3)		$3.0	26.1	$1.0	scaled A1900 magnets
1.2	quads (12trip 1 5Q)		$10.0	87.7	$3.4	scaled A1900 magnets
1.3	Wein filters (2)		$2.3	20.0	$0.8	guess
1.4	corr magnets (10V 10H)		$0.5	5.3	$0.1	10% of dipole cost
1.5	power supplies		$1.8	8.6	$1.2	15% of magnet cost (A1900)
1.6	vacuum &controls		$1.3	9.5	$0.6	10% of magnet cost (A1900)
1.8	boxes, det, etc		$0.3	0.9	$0.2	10% of quad-dipole cost (A1900)
			$19.0	**$11.6**	**$7.4**	
2	**Beam Transport to Vaults**	**$3.9**				
2.1	dipoles (5)		$1.0	9.7	$0.3	scaled A1900 magnets(30degrees)
2.2	quads (21 doub)		$1.9	16.2	$0.6	scaled S800 magnets
2.3	corr magnets (20V 20H)		$0.1	0.8	$0.0	
2.4	power supplies		$0.3	1.2	$0.2	
2.5	vacuum &controls		$0.3	2.0	$0.2	
2.6	boxes, det, etc		$0.3	3.1	$0.1	
			$3.8	**$2.4**	**$1.4**	

WBS 4.6
Dectectors

FTE (K$/y)	$150							
				Construction				
WBS	Description	Total M$	Item M$	FTE	Years	M$ Purchasing	Basis	EAC by looking @ following pgs.
2	**Gamma Ray Detectors**	**$24.8**					LBNL-4360, pp 4	
2.1	class 2 (TRACKING)		$24.8	8	4	$20.0		450
3	**Recoil Seperators**	**$9.8**					LBNL-4360, pp 4	
3.1	Low Energy		$3.6	2	2	$3.0		990
3.2	High Energy		$4.1	2	2	$3.5		900
3.3	Gas Filled Seperator		$2.1	2	2	$1.5		225
4	**Magnetic Spectrographs**	**$3.6**					LBNL-4360, pp 4	
4.1	Conventional		$3.6	2	2	$3.0		825
4.2	Large Acceptance		$0.0					935
5	**Particle Detectors**	**$1.9**					LBNL-4360, pp 4	750
5.1	light charge particle - CsI		$0.4	1	1	$0.3		
5.2	light charged particle- Si		$0.8	1	2	$0.5		
5.3	neutron		$0.7	1	1	$0.5		
6	**Non Accelerated Beams**	**$12.7**					LBNL-4360, pp 4	2500
6.1	laser atom trap		$2.9	4	3	$1.1		
6.2	ion trap		$4.3	10	2	$1.3		
6.3	nuclear orientation		$0.9	2	1.5	$0.5		
6.4	beta-NMR		$1.0	3	1.5	$0.4		
6.5	decay spectroscopy		$2.5	5	2	$1.0		
6.6	electron-beam ion trap		$1.1	2	2	$0.5		
7	**Special Targets**	**$1.8**					LBNL-4360, pp 4	
7.1	gas		$0.7	1	1	$0.5		75
7.2	radioactive targets		$1.1	2	2	$0.5		110
	Total	**$54.5**						

Gamma-Ray Detector System

• Ge detectors (40)	$12000k
• Processing electronics	$3160k
• Data acquisition	$2200k
• LN2 filling system	$200k
• Mechanical system/ Annealing stations	$260k
• Digital design	3.0 my
• Installation/calibration	1.5 my
• Total (w design, w/o cont.)	$18.1M

Low-Energy Recoil Separator

• Magnets (dipoles, quads)	$350k
• Electric dipoles	$250k
• Power supplies	$240k
• Vacuum vessels	$290k
• Mechanical supports	$40k
• Vacuum equipment	$270k
• Focal plane detectors	$60k
• Controls/electronics	$280k
• Shielding/interlocks	$60k
• Engineering	3.0 my
• Design	3.6 my
• Installation	0.8 my
• Total (w design, w/o cont.)	$1.93M

High-Energy Recoil Separator

• Magnets (dipoles, quads)	$500k
• Electric dipoles	$330k
• Power supplies	$260k
• Vacuum vessels	$290k
• RF resonator	$300k
• Mechanical supports	$120k
• Vacuum equipment	$380k
• Focal plane detectors	$90k
• Controls/electronics	$200k
• Shielding/interlocks	$60k
• Engineering	3.0 my
• Design	3.6 my
• Installation	0.8 my
• Total (w design, w/o cont.)	$2.62M

Gas-Filled Magnet

• Magnets	$540k
• Power supplies	$180k
• Vacuum/gas control	$300k
• Support structure	$50k
• Focal plane detectors	$100k
• Target/control systems	$50k
• Design	1.5 my
• Installation	0.5 my
• Total (w design, w/o cont.)	$1.28M

High-Resolution Spectrograph

• Magnets (dipoles, quads)	$1200k
• Power supplies	$260k
• Carriage/Vacuum chamber	$510k
• Vacuum equipment	$190k
• detector/electronics	$200k
• Engineering	3.0 my
• Design	2.5 my
• Field mapping/Installation	1.0 my
• Total (w design, w/o cont.)	$2.48M

Silicon Particle Detector Systems

• Detector costs	$460k
• Readout chips costs	$55k
• Hardware for assembly	$530k
• Electronics/DAQ/cables	$325k
• Mechanical assembly	$50k
• Development of readout chips	5.0 my

Associated Detectors

• CsI upgrade	$250k
• Neutron detectors	$170k
• Electronics	$340k
• Total (w/o cont.)	$2.18M

Stopped Beam Area

• Laser farm	$900k
• Magneto-optical trap	$550k
• Ion-trap beam handler	$590k
• Mass spectrometer	$880k
• Dilution refrigerator	$450k
• NMR equipment	$50k
• Absorption spectrometer	$550k
• EBIT trap	$450k
• detectors/electronics	$410k
• Spectroscopy systems	$60k
• Mechanical systems	$290k
• Installation	3.0 my
• Total (w design,w/o cont.)	$5.5M

Gas Target

• Roots blowers	$90k
• Vacuum pumps	$95k
• Vacuum gauges	$40k
• Control system	$15k
• Mechanical systems	$35k
• Recovery system	$25k
• Design	0.5 my
• Installation	0.5 my
• Total (w design, w/o cont.)	$361k

Labor Cost ($/hr)	$75					
WBS	Description	Total M$	Item M$	kHours	M$ Purchasing	Basis
1	**High Res. Spectrograph**	**$14.3**				
1.1	dipoles (2)		$7.8	67.7	$2.7	scaled from S800 1275k
1.2	quads (1 doub)		$1.7	14.4	$0.6	scaled from S800 275
1.3	det, vac, cryo, track, etc		$4.8	42.0	$1.7	scaled from S800 725

Radioactive Target System

- Radiochemical laboratory $500k
- Total (w/o cont.) $500k