8 GeV Linac CD-0 Parameter List

Working Version V.8

With Reference Parameters from Spallation Neutron Source Parameter List Rev.6 (Oct 2000)

NOTE 1: Initial 0.5 MW Parameters are Baseline, Ultimate {2 MW} Parameters are in Braces { }

Both Initial and Ultimate parameter sets support 2 MW beam power at 30-120 GeV from Main Injector.

NOTE 2: Two Exclusive Technical Options (Spoke Resonators or Elliptical Cavities) are listed between 110 and 400 MeV

The Spoke Option is highlighted in Violet and the Elliptical Option is in Blue.

NOTE 3: Items in Red are placeholders containing probable rubbish

8 GeV Linac CD-0 Parameters V.8

7 March 2004

PRIMARY PARAMETERS	8 GeV Initial 0.5 MW {Ultimate 2MW in Brackets}			Spallation Neutron Source		
Linac beam kinetic energy	8	GeV		**1**	**GeV**	
Linac Particle Types	H - ions		Baseline Mission	**H -**		
	Protons		via foil stripping in transfer line			
	Electrons		Possible w/upgrade of Phase Shifters & Injector			
Linac Stand-Alone Beam power	0.5 {2.0}	MW	8 GeV beam power available directly from linac	**1.56**	**MW**	
Linac Pulse repetition rate	2.5 {10}	Hz		**60**	**Hz**	
Linac macropulse width	3.0 {1.0}	ms		1	ms	
Linac current (avg. in macropulse)	8.7 {26}	mA		26	mA	
Linac current (peak in macropulse)	9.3 {28}	mA		**38.2**	**mA**	
Linac Beam Chopping factor in macropulse	94	%	For adiabatic capture with 700ns abort gap.	**68**	**%**	chopped to fill RF bucket
Linac Particles per macropulse	1.56E+14			1.56E+14	H-	
Linac Charge per macropulse	26	uC		26	uC	
Linac Energy per macropulse	208	kJ		26	kJ	
Linac average beam current	0.07 {0.26}	mA		**1.56**	**mA**	1.4 mA on target
Linac beam macropulse duty factor	0.75 {1.0}	%		**6**	**%**	
Linac RF duty factor	1.00 {1.3}	%		**7.6**	**%**	
Linac Active Length including Front End	614	m	Excludes possible expansion length	**258**	**m**	Excludes space for 9 more cryomoc
Linac Beam-floor distance	0.69	m =27 in.	same as Fermilab Main Injector	1.27	m	50.0 in
Linac Depth Below Grade	9	m	same as Fermilab Main Injector			
Transfer Line Length to Ring	972	m	for MI-10 Injection point	170	m	
Transfer Line Total Bend	40	deg	two 20-degree collimation arcs	90	deg	
Ring circumference	3319.4	m	Fermilab Main Injector	**248**	**m**	SNS accumulator ring
Ring Beam Energy	8-120	GeV	MI cycle time varies with energy	**1**	**GeV**	
Ring Beam Power on Target	2	MW	~ independent of MI Beam Energy	**1.4**	**MW**	
Ring Circulating Current	2.3	A		**29.0**	**A**	
Ring cycle time	0.2-1.5	sec	depends on MI beam energy & flat-top	**60**	**Hz**	
Ring Protons per Pulse on Target	1.50E+14	protons		1.50E+14	protons	
Ring Charge per pulse on target	25	uC		24	uC	
Ring Energy per pulse on target	200-3000	kJ	at 8-120 GeV	24	kJ	
Ring Proton pulse length on target	10	us	1 turn, or longer with resonant extraction	**0.695**	**us**	
Linac Wall Power	5.5 {12.5}	MW	approx 3 MW Standby + 1MW / Hz			

LINAC SEGMENT LENGTHS

	8 GeV Linac					Spallation Neutron Source			
	Length	Eout	# Modules			Length (m)	Eout (MeV)	# Modules	
Ion Source (H- and P)	~0.1 m	0.065 MeV				0.0 m	0.065		
Low-Energy Beam Transport (LEBT)	~0.1 m	0.065 MeV				0.1 m	0.065		
Radio-Frequency Quad (RFQ)	~4.0 m	3.0 MeV	TBD	RFQ modules		3.8 m	2.5	4	RFQ modules
Medium-Energy Beam Transport (MEBT)	3.6 m	3.0 MeV	2	Rebuncher Cavities		3.6 m	2.5	4	Rebuncher Cavities
Room Temperature Front End	10.4 m	15.8 MeV	21	Room Temp 3-Spoke Resonators		10.2 m	23.4	2	DTL Tanks 1-2
SCRF Single-Spoke Resonator	12.5 m	33 MeV	1	Cryomodules		26.4 m	86.8	3	DTL tanks 3-5
SCRF Double-Spoke Resonator	17.2 m	110 MeV	2	Cryomodules					
SCRF Triple-Spoke Resonator(OPTION)	64.0 m	400 MeV	6	Cryomodules	Either 3-Spoke or Elliptical for 110-400 MeV				
Low Beta=0.47 elliptical cavity (OPTION)	18.8 m	175 MeV	2	Cryomodules		**55.1 m**	**186**	**4**	**Warm CCL Modules**
Medium Beta=0.61 elliptical (OPTION)	38.5 m	400 MeV	4	Cryomodules		**64.2 m**	**391**	**11**	**cryomodules**
High Beta=0.81 SCRF	70.1 m	1203 MeV	6	Cryomodules		**94.7 m**	**1000**	**12**	**cryomodules**
Beta=1 SCRF	438.3 m	8000 MeV	36	Cryomodules					
LINAC ACTIVE LENGTH *	**613.6 m**	**8000 MeV**				**258 m**	**1000 MeV**		
Transfer Line to Ring	972.5 m	8000 MeV	47	half-cells (quads)		**170 m**			
Tunnel to Front End Equipment Drop	20.0 m			TBD					
TUNNEL TOTAL LENGTH *	**1606.0 m**					**428 m**			

*** These Segment Length totals are for Elliptical Cell Option; also have option of 3-spoke SCRF Resonators in range ~110-400 MeV**

LINAC SEGMENT DETAILS

Open Technical Choice: 3-spoke or Elliptical

	RFQ	Room Temp TSR	SRF 1-spoke	SRF 2-spoke	Spoke Option 3-spoke	Elliptical Option Low	Elliptical Option Medium	High	TESLA
Frequency, MHz	325	325	325	325	325	1300	1300	1300	1300
Energy Range, MeV	0.065-3	3-15	15-33	33-110	110-400	110-175	175-400	400-1200	1200-8000
Beta geometrical	-	0.08 to 0.18	0.21	0.4	0.61	0.47	0.61	0.81	1.00
Number of cavities or resonators	4	21	16	28	42	16	32	48	288
Number of accelerating gaps / cavity	-	4	2	3	4	6	6	8	9
Epeak, MV/m	32.1	TBD	32	32	32	52	52	52	52
Eacc, MV/m	-	2.3 to 3.7	10.67	10.67	10.67	15.2	19.2	23.7	26
Cavity effective length, cm	-	15 to 32	13	36.9	85.8	32.5	42.2	74.8	103.8
Synchronous phase, deg (typ.)	-	-40 to -30	-30	-30	-30 to -20	-30	-25	-20	-16
Length of Segment, m	~4	10.4	12.5	17.2	64	18.8	38.5	70.1	438.3
Number of Cryomodules	-	-	1	2	6	2	4	6	36
Cavities per Cryomodule	-	-	16	14	7	8	8	8	8
Magnetic Focusing Type	-	Solenoid	Solenoid	Solenoid	Quad	Quad	Quad	Quad	Quad
Coupler Power Initial {Ultimate}, kW	125	40 {54}	9 {26}	34 {102}	80 {238}	42 {125}	72 {214}	133 {398}	220 {660}
Cavities per Klystron Initial {Ultimate}	72 {36}				42 {14}	48 {24}		48 {24}	36 {12}
Number of Klystrons Initial {Ultimate}	1 {2}				1 {3}	1 {2}		1 {3}	8 {24}

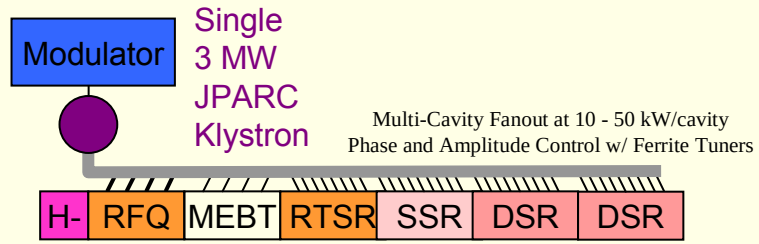
0.5 MW Initial 8 GeV Linac

11 Klystrons (2 types)
449 Cavities
51 Cryomodules

"PULSED RIA"

Front End Linac

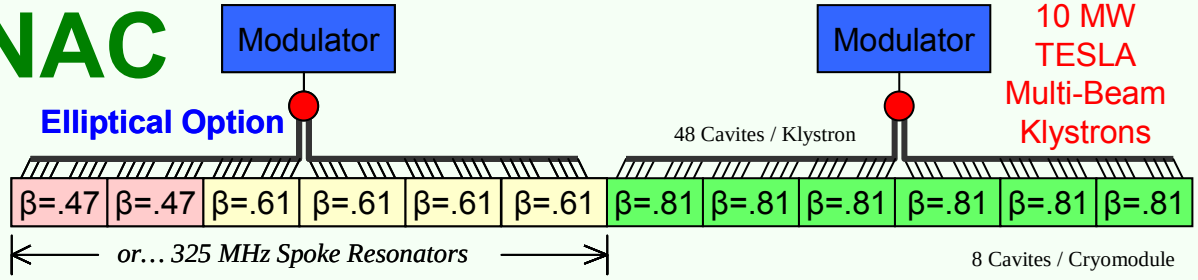
325 MHz
0-110 MeV



β<1 TESLA LINAC

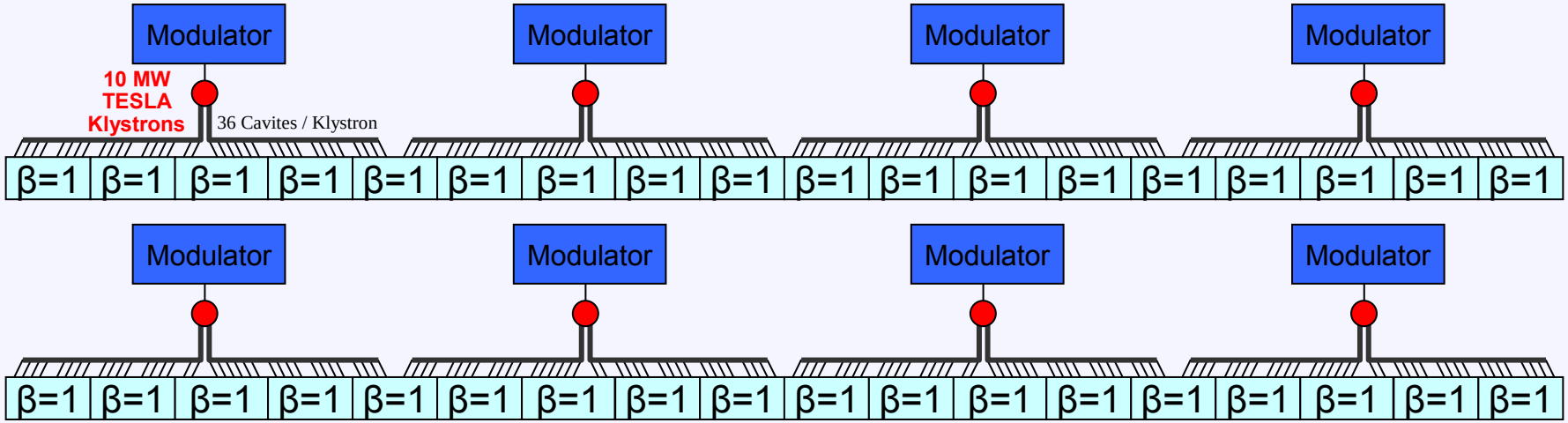
1300 MHz 0.1-1.2 GeV

2 Klystrons
96 Elliptical Cavities
12 Cryomodules



TESLA LINAC 1300 MHz β=1

8 Klystrons
288 Cavities in 36 Cryomodules



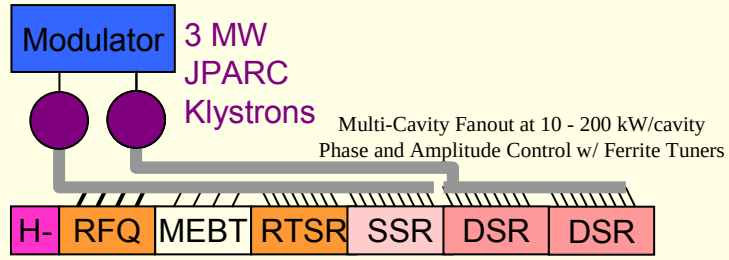
2 MW Ultimate 8 GeV Linac

32 Klystrons (2 types)
449 Cavities
51 Cryomodules

"PULSED RIA"

Front End Linac

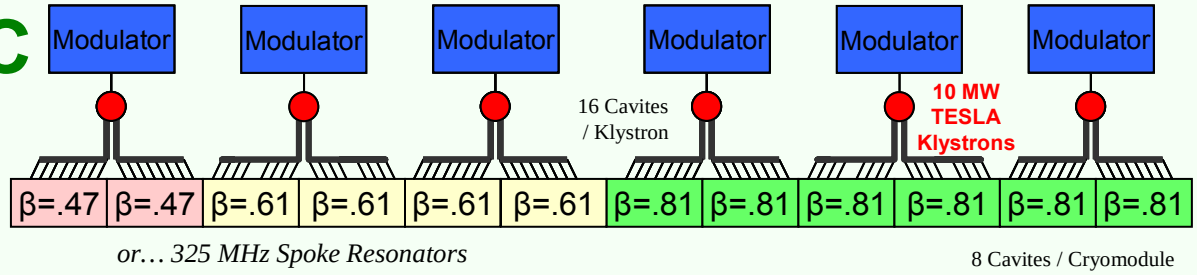
325 MHz
0-110 MeV



β<1 TESLA LINAC

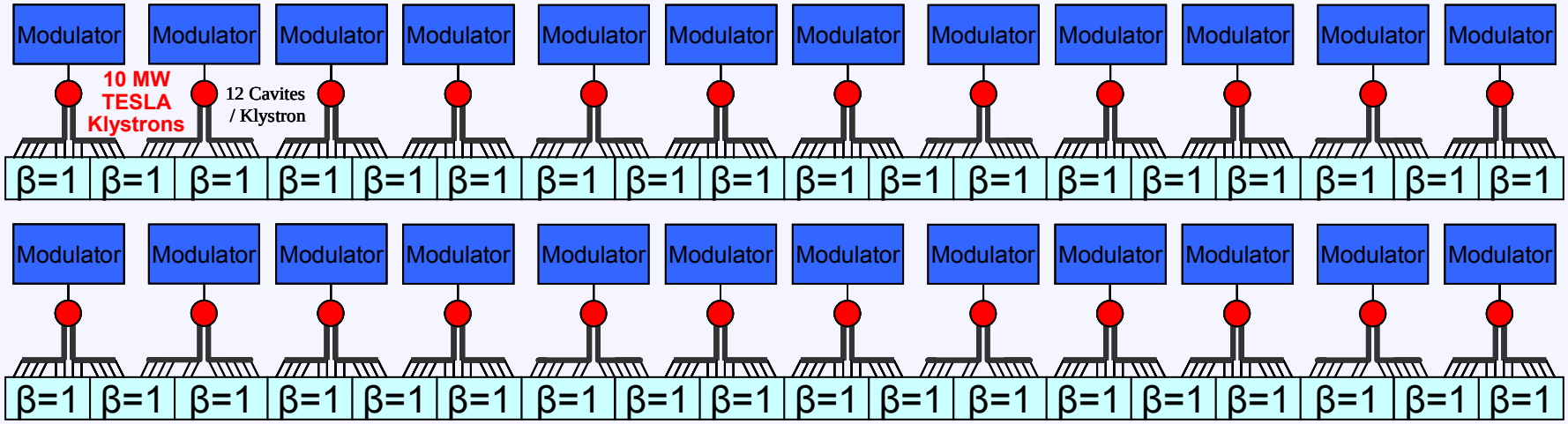
1300 MHz 0.1-1.2 GeV

6 Klystrons
96 Elliptical Cavities
12 Cryomodules



TESLA LINAC 1300 MHz β=1

24 Klystrons
288 Cavities in 36 Cryomodules

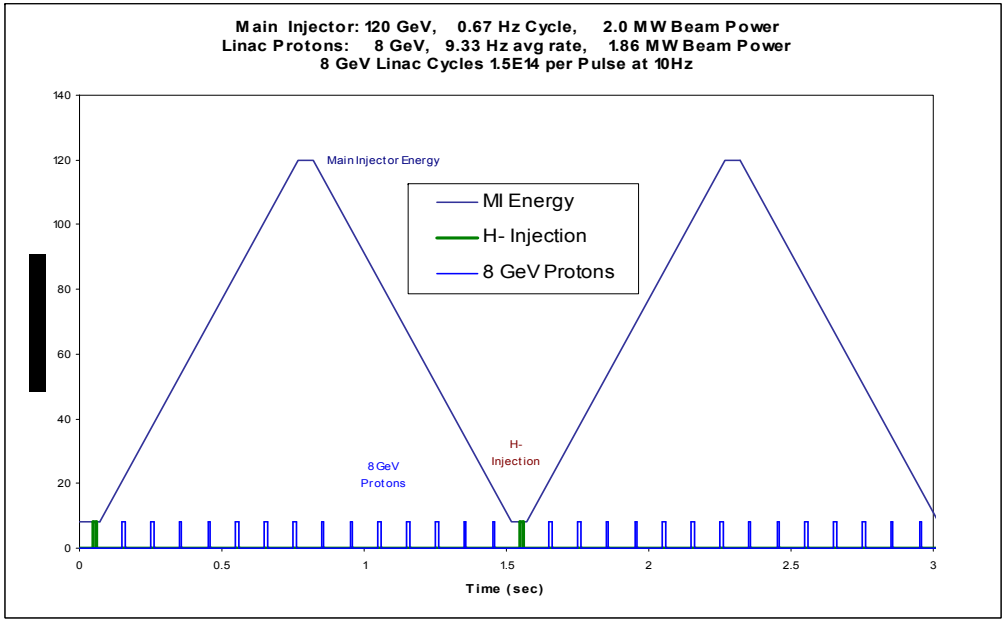


Main Injector Cycles Supported — 8 GeV Linac Initial 0.5 MW {Ultimate 2.0 MW in Curly Brackets}

	Typical User	Cycle Time	Spill Time (typ)	Beam Power in Main Injector	8 GeV Linac Beam power
120 GeV Standard Main Injector Cycle	NOVA / FT	1.5	0.01-100ms	2 MW	0.37 {1.87} MW
60 GeV Rapid Cycle	60 GeV nu	0.8 sec	10us - 50ms	2 MW	0.25 {1.75} MW
30 GeV Rapid Cycle	30 GeV nu	0.4 sec	10us - 50ms	2 MW	0 {1.5} MW
8 GeV Long Pulse Directly From Linac	e+/- or n	0.4 {0.1} sec	3 {1} msec	negotiable	0.5 {2.0} MW
8 GeV Accumulation (MI or Recycler)	BooNe	0.4 {0.1} sec	10 usec	negotiable	0.5 {2.0} MW
8 GeV Continuous Spill (MI or Recycler)	8 GeV FT	0.1-100 sec	0.1-100 sec	negotiable	0.5 {2.0} MW
150 GeV Tevatron Injection	1 Tev FT	1.8	10 usec	2 MW	> 1.95 MW
150 GeV Collider Injection	BTeV/VLHC	1.5	10 usec	40kW	> 1.95 MW

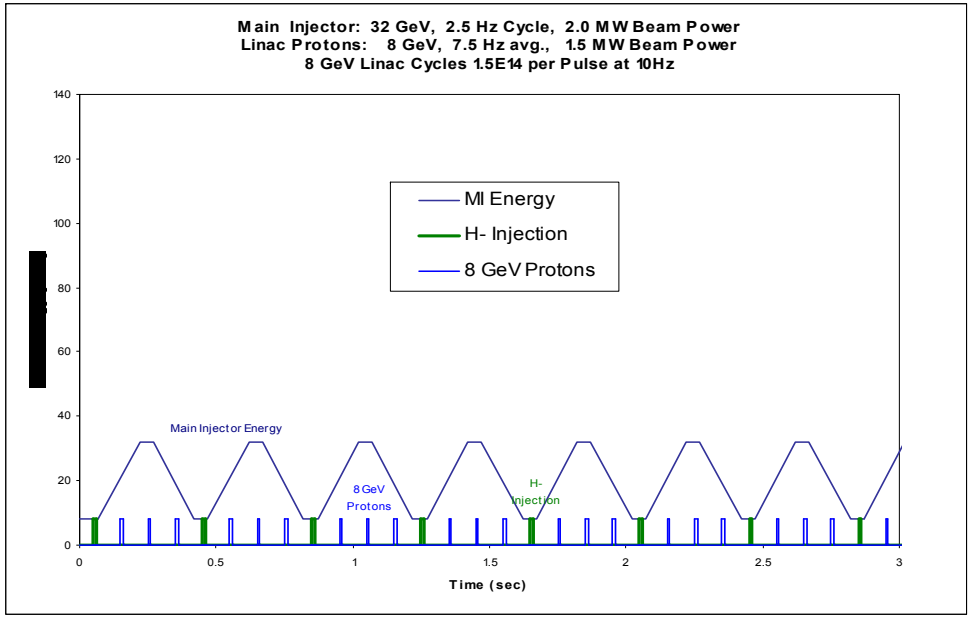
120 GeV Main Injector Cycle

With Interleaved 8 GeV Protons/H-



30 GeV Main Injector Rapid Cycle

With Interleaved 8 GeV Protons/H-



FRONT END (H-)	8 GeV Initial {Ultimate}		Spallation Neutron Source		
Ion type	H-minus		H minus		
Pulse Rate	2.5 {10} Hz		**60 Hz**		
Pulse Width	3.0 {1.0} ms		1 ms		
Output energy	3 MeV	RFQ output	2.5 MeV		RFQ output
Length	6.47 m (TBD)	From Ion Source outlet flange first RTSR	7.52 m		From IS outlet flange to DTL
Output peak current	9.3 {28} mA		**38 mA**		
ION SOURCE AND LEBT					
Output energy	65 keV		65 keV		
LEBT length	0.1 m		0.12 m		
Output peak current	12.7 {38} mA	Assuming 80% front end transmission	**48 mA**		Assuming 80% front end transmissi
Ion source type	RF volume	Multicusp Cs-enhanced	RF volume		Multicusp Cs-enhanced
Electron suppression	magnetic	Interception at low energy	magnetic		Interception at low energy
LEBT focusing type	electrostatic		electrostatic		
Estimated output rms norm H & V emit.	0.2 pmm-mrad		0.2 pmm-mrad		
Ion source lifetime	72 weeks	?? Scale by pulse rate from SNS ??	**3 weeks**		Maintenance cycle
Ion source replacement time	2 hours	With conditioned replacement ion source	2 hours		With conditioned replacement ion s
LEBT CHOPPER					
Type	LBL/SNS		LBL/SNS		
Purpose	Establish 700ns abort kicker rise time gap in ring		Assist MEBT Chopper		
Deflection	transverse	uses split focusing electrodes in LEBT	transverse		uses split focusing electrodes in LE
Output peak current	9.3 {28} mA		**38 mA**		
ON/OFF beam current ratio	5E+03	TBD			
Rise, Fall Time	< 20 ns	1% - 99%	< 20 ns		1% - 99%
Operating energy	< 65 keV		< 65 keV		
Operating Voltage	10 kV	TBD	~10? kV		
RFQ ACCELERATOR					
Output energy	3 MeV		2.5 MeV		
Length	~4 m		3.76 m		4 modules, incl. LEBT diagnostic pl
Output peak current	9.3 (28) mA		**38 mA**		
RF frequency	325 MHz	RF Split from main Klystron, with ferrite tuner	402.5 MHz		
Nominal aperture radius	3.7 mm		3.5 mm		
Peak surface field during macropulse	1.85 Kilpatrick		1.85 Kilpatrick		
Macropulse structure power	630 kW	Assumes 67% of Cu Q	630 kW		Assumes 67% of Cu Q
Expected output rms norm H & V emit.	0.21 pi mm-mrad		0.21 pi mm-mrad		
Expected output rms L emittance	0.1 pi MeV-deg	At 325 MHz	0.1 pi MeV-deg		At 402.5 MHz

FRONT END (Electron Option)	8 GeV Linac		Spallation Neutron Source
Comparable Model	TTF2 Photoinjector		
Repetition Rate (max)	10 Hz		
Macropulse Length	1 msec		
Average Current During Macropulse	8.7 {26} mA		
Beam Merging with H- Linac	after Beta=0.81 Cryomodules (TBD)		
Proton Beam Energy at merging	1200 MeV	Requires 2-4 "TESLA" Cryomodules in e- beamline	

MEBT *(Medium-Energy Beam Transport)*	**8 GeV Initial {Ultimate}**		**Spallation Neutron Source**	
Ion type	H-minus		H minus	
Output energy	3 MeV		2.5 MeV	
Length	2.2 m		3.64 m	
Output peak current	9.3 {28} mA		38 mA	
Number of focusing magnets	2	solenoids (& possibly 2-4 trim quads-TBD)	14	quadrupoles
Number of magnet Power Supplies	4		11	two symmetric triplets wired in serie
Magnet clear bore diameter	32 mm		32 & 42 mm	Quads 1-4&11-14 small; 5-10 larger
Focusing Magnet Strength	4 T	Solenoid Peak Field	2.4/1.9 T	Quad Integrated Gradient
Number of two-plane beam steerers	4	X & Y steering trims in each solenoid	6	Quad poletip windings
Number of steerer PS	4		12	
Number of rebuncher cavities	2		4	
Rebuncher cavity frequency	325 MHz	RF Split from main Klystron, with ferrite tuner	402.5 MHz	
Rebuncher effective voltage	150 kV		120 kV	
H & V norm output emittance w/errs	0.27 pi mm-mrad	TBD	0.27 pi mm-mrad	
L norm output emittance w/errs	0.13 pi MeV-deg	At 325 MHz	0.13 pi MeV-deg	At 402.5 MHz
Expected max quad rms gradient error	<1 %		<1 %	
Max quad rms position error on sub-raft	0.025 mm	TBD	0.025 mm	
Max sub-raft rms pos. err on major support	0.04 mm	TBD	0.04 mm	
Quad rms Roll error expected max	0.06 mrad	TBD	0.06 mrad	
Quad rms Yaw error expected max	0.06 mrad	TBD	0.06 mrad	
Quad rms Pitch error expected max	0.6 mrad	TBD	0.6 mrad	
MEBT RF SYSTEM				
RF frequency	325 MHz	RF Split from Klystron, with ferrite tuners	402.5 MHz	
RF power	2 kW	(or can be solid-state amp)	20-40 kW	20, 20, 20, 40 kW
RF amplitude rms error	2 %		2 %	
RF phase rms error	1 degree		1 degree	
MEBT TRAVELING WAVE CHOPPERS				
Number of choppers	1	Antichopper unnecessary	2	Chopper and antichopper
Chopper length	0.45 m		0.35 m	Each active structure
Beam-on duty factor for Extraction Kicker	94 %	Baseline: slow once-per-turn chopping	68 %	
Beam duty factor for bunch-by-bunch choppin	80 % TBD	Option: to Chop away ~ every 7th bunch		
Rises between bunches	TBD	Only needed for bunch-by-bunch chopping	no	
Full rise/fall time	2.5 ns (TBD)	can be slower if only 800ns abort gap needed	10 ns	
Gap	18 mm		18 mm	
Total deflection voltage	+/- 1800 V	Lower than SNS due to longer structure	+/- 2350 V	18 mrad deflection
Post chopper off/on beam-current ratio	0.0001	TBD	1.00E-04	
MEBT DIAGNOSTICS				
Number of beam current monitors	1		2	
Number of beam profile monitors	2	Two dual-plane monitors (laser wires?)	5	Includes one dual-plane laser wire
Number of two-plane stripline BPMs	2	Near solenoids, include phase measurement	6	Inside quads, incl. phase measurem
Number of emittance scanners	1 TBD		1	

WARM FRONT-END LINAC	8 GeV Linac			Spallation Neutron Source		
Linac Type	Room-Temp. Triple Spoke Resonator (RT TSR) with Solenoidal Focusing			Drift-Tube Linac (DTL) Driven by one Klystron per Tank		
Input energy	3	MeV	RFQ Output Energy	2.5	MeV	RFQ Output Energy
Output energy	15.8	MeV	Feeds SCRF Spoke Linac	86.8	MeV	Feeds Warm Coupled-Cavity Linac
Duty Cycle (beam)	1	%		6	%	
Length	10.4	m		36.569	m	Tank 1 entry plane to tank 6 exit pla
RF frequency	325	MHz	RF Split from main Klystron, with ferrite tuners	402.5	MHz	
Average synchronous phase	-35 to -25	degrees	TBD	-37 to -26		Phase ramped
Number of tanks	21		Warm 3-spoke Resonators	6		DTL tanks
Maximum field	TBD	MV/m		1.3	Kilpatrick	At tank 1
Bore radius	8	mm		12.5	mm	
Focusing Magnet Type	Warm-Bore Superconducting Solenoid			permanent magnet quads inside Drift Tubes		
Focusing structure	Solenoids between each 3-spoke warm tank			FFODDO		
Number of focusing magnets	21	solenoids		147	quadrupoles	
Focusing period	~6	beta-lambda (Independently phased resonators)		6	beta-lambda	
Focusing Strength	4.0-6.0	T		1.295	T	Integrated focusing strength
Number of steering dipoles	42		two per solenoid - # powered TBD	24		
Average operating vacuum pressure	1.80E-07	Torr	TBD	1.80E-07	Torr	
Length of differential pumping section	TBD	m	use cryopumping of SC Solenoids in RT-TSR?	2.35	m	CCL to SRF distance

Spoke Resonator SRF Linac	Med-Beta = Elliptical	Med-Beta = Spoke		
Linac Option Chosen for Medium Beta:				
Input energy	15 MeV	15 MeV	from warm spokes	
Output energy for Spoke Cryomodules	110 MeV	400 MeV	start of 1300 MHz Elliptical Cavities	
Length of Spoke Section	40.1 m	104.1 m		
Number of Spoke Resonators	65	107	including warm resonators	
Number of Spoke Cryomodules	3	9		
Number of Spoke Cryomodule Designs	2	3		
Number of 325 MHz Klystrons (initial)	1	2		
Cryomodule Type (Beta)	RT-TSR	1-Spoke	2-Spoke	3-Spoke Option
Operating Temperature	WARM	4.5K	4.5K	4.5K
Geometrical Beta of Sections	**.008-.018**	**0.21**	**0.40**	**0.61**
RF frequency (MHz)	325 MHz	325 MHz	325 MHz	325 MHz
Input Energy of each section (MeV)	3 MeV	15 MeV	33 MeV	110 MeV
Epeak	TBD	32 MV/m	32 MV/m	32 MV/m
Eacc	3 MV/m	11 MV/m	11 MV/m	11 MV/m
Number of Cryomodules for each Beta	n/a	1	2	6
Length of Cryomodule slot for each Beta	n/a	12.5 m	8.6 m	10.67 m
Total Length for each Beta	10.4 m	12.5 m	17.2 m	64.0 m
Number of Spokes Per Resonator	3	1	2	3
Number of Resonators Per Cryomodule	n/a	16	14	7
Number of Magnets Per Cryomodule	n/a	16	7	7

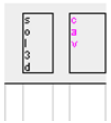
SPOKE RESONATOR CELL LAYOUTS

Room temperature triple spoke resonators. RT TSR

D | S | D | C

D – drift, 3.5 cm
S – solenoid, 18 cm
C – TSR, 15-32.3 cm
Period – 40-57 cm
21 periods
Total – 10.4 m

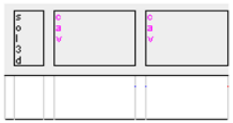
SC single spoke resonators. SSR



D | S | D | C

D – drift, 10.5 cm
S – solenoid, 18 cm
C – SSR, 21 cm
Period – 60 cm
16 periods
Total - 12.5 m

SC double spoke resonators. DSR



D | S | D | C | D | C

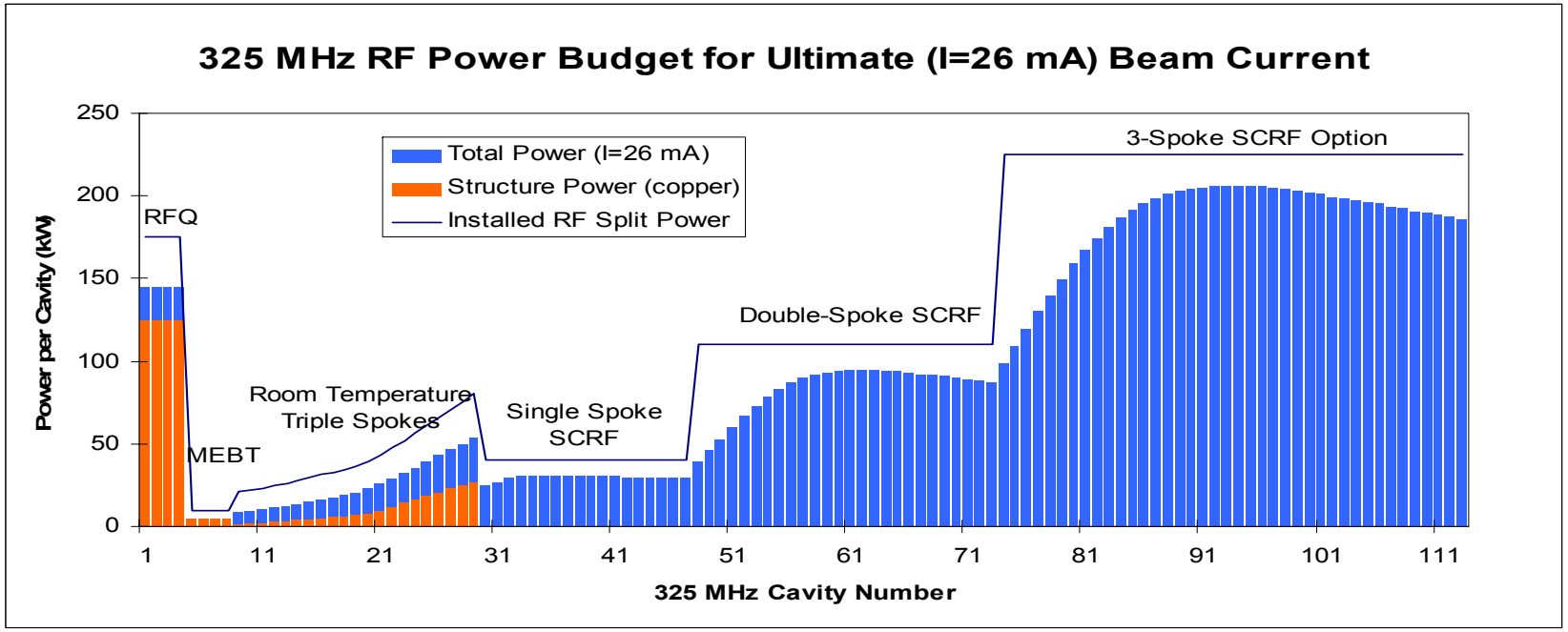
D – drift, 6 cm
S – solenoid, 18 cm
C – DSR, 50 cm
Period – 136 cm
14 periods
Total – 17.2 m

SC Triple-Spoke Option, TSR

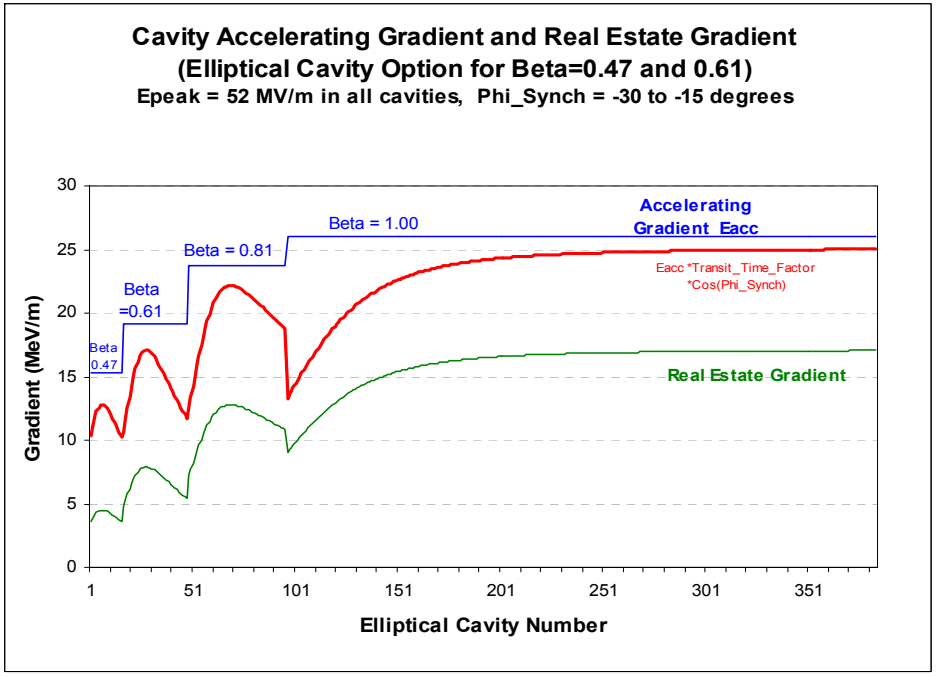
D | +Q | D | C | D | -Q | D | C

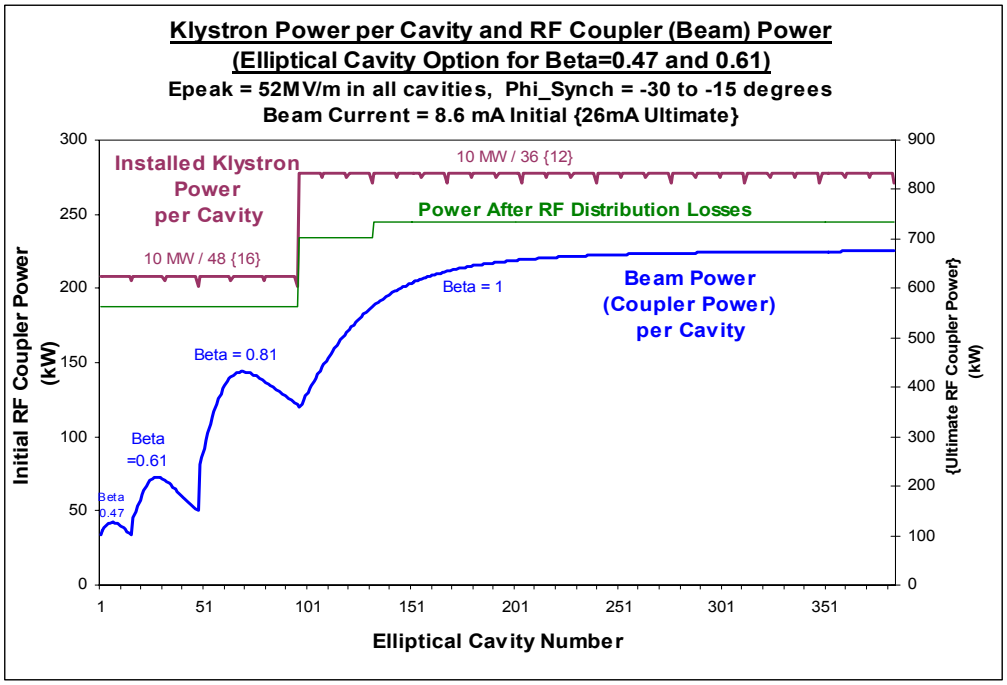
D – drift, 6 cm
Q – quadrupole, 28 cm
C – TSR, 110 cm
Period – 300 cm
21 periods
Total – 64 m

Elliptical-Cell SRF LINAC	8 GeV Initial {Ultimate}					Spallation Neutron Source		
Output energy	8000 MeV					1000 MeV		
Input energy	110 MeV		(~400 MeV if triple-spoke resonators used)			190 MeV		
Length of Elliptical-Cell Linac Section	565.6 m		(~ 508 m if triple-spoke resonators used)			157.321 m		23 cryomodules + 22 warm spaces
Number of Elliptical Cryomodules	48		(42 if triple-spoke resonators used)			23		
Cryomodule Style	TESLA (TTF3)		no warm spaces between cryomods			CEBAF		warm space between every cryomo
Number of Cavities	384		(336 if triple-spoke resonators used)			81		
RF frequency	1300 MHz					805 MHz		
Cavity Maximum Field Epeak	52 MV/m		TESLA(500)=47, TESLA(800)=70 MV/m			37 MV/m		
Cavity Accelerating Field Eacc	13-23 MV/m		varies along length - see graph					
Cavity Voltage Profile	Constant Gradient					Constant Gradient		
Number of Beta Sections	4		(2 if triple-spoke resonators used)			2		
	Elliptical Cavity Option							
Cryomodule Type (Beta)	LOW	MEDIUM	HIGH	"TESLA"		MEDIUM	HIGH	
Geometrical Beta of Sections	0.47	0.61	0.81	1.00		0.61	0.81	
Input Energy of each section (MeV)	110 MeV	175 MeV	400 MeV	1200 MeV		185.6	391.4	MeV
Number of Elliptical Cryomodules	2	4	6	36	42 (48) total	11	12	
Length of Cryomodule slot for each Beta	9.40 m	9.62 m	11.68 m	12.2 m		5.839 m	7.891 m	
Total Cryomodule Length for each Beta	18.8 m	38.5 m	70.1 m	438.3 m	**565.6 m tot.**	64.229 m	94.692 m	
Number of Cells Per Cavity	6	6	8	9		6	6	
Number of Cavities Per Cryomodule	8	8	8	8		3	4	
Number of Cavities per Klystron	48 {16}	48 {16}	48 {16}	36 {12}		1	1	
Number of Quads Per Cryomodule	9	5	3	1		2	2	warm doublet outside cryomodule
Quad + BPM Assembly Lengths	0.42 m	0.42 m	0.86 m	0.86 m				
Space between cryomodule valves	0.5 m		TBD - cold beam pipe with profile monitor			1.6 m		Warm Space between gate valves
Length for additional cryomodules	TBD m					71.019 m		nine additional high beta
Number of Klystrons	11 {31}		+1 for optional Debuncher Cavity			81		one Klystron per cavity
Klystron Total Peak Power	110 {310} MW					44.6 MW		
Peak Beam Power	65 {200} MW					18 MW		
Warm beam pipe vacuum	N/A Torr					1.00E-09 Torr		



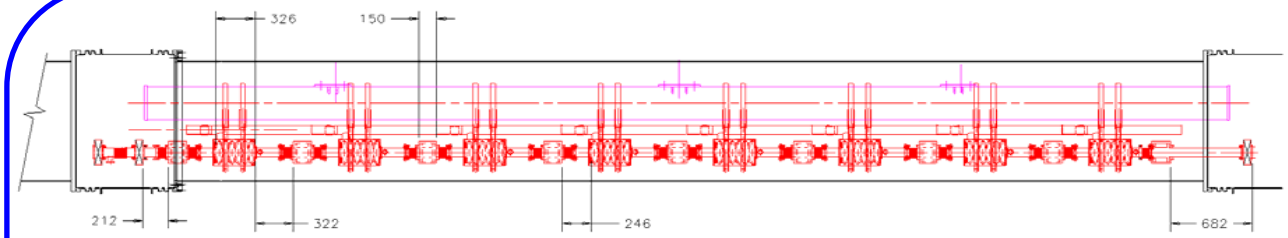
1300 MHz ELLIPTICAL CAVITY GRADIENTS AND RF POWER BUDGET





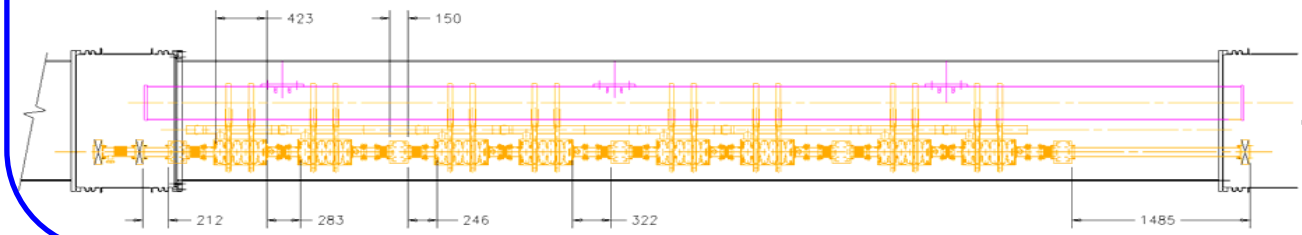
SRF ELLIPTICAL CAVITIES	8 GeV Linac					Spallation Neutron Source		
Number of Cavities in Linac	392		including 8 in debuncher cryomodule					
Cavity type	elliptical					elliptical		
Cavity operating mode	pi					pi		
Cavity material	Niobium					Niobium		
Cavity material thickness	4 mm		3.8 mm after processing			4 mm		3.8 mm after processing
Cavity final processing	electropolish							
Cavity stiffeners	yes					yes		
Allowed frequency swing due to Lorentz force	470 Hz		(maybe more--depends on Beta)			470 Hz		
Frequency swing after Piezo Feed-Forward	TBD Hz							
Microphonic amplitude limit	+/- 60 Hz		Six sigma TBD			+/- 100 Hz		Six sigma
Cavity operating temperature	~1.9 K					2.1 K		
Cryomodule Type (Beta)	**LOW**	**MEDIUM**	**HIGH**	**TESLA**		**MEDIUM**	**HIGH**	
Geometrical Beta of Sections	**0.47**	**0.61**	**0.81**	**1.00**		**0.61**	**0.81**	
RF frequency (MHz)	1300	1300	1300	1300	MHz	805	805	MHz
Cavity Type	Scaled RIA	Scaled SNS	FNAL	TESLA (TTF)		SNS061	SNS081	
Number of Cells Per Cavity	6	6	8	9		6	6	
Cell-to-Cell Coupling Constant	1.50%	1.61%	1.80%	1.87%		1.61%	1.61%	
Unloaded Qo	>5E9	>5E9	>5E9	>1E10		>5E9	>5E9	
External Q	7.5E+05	7.3E+05	7.0E+05	1.5E+06		7.3E+05	7.0E+05	
External Q Variation	+/- 20%	+/- 20%	+/- 20%	+/- 20%	Adjustable	+/- 20%	+/- 20%	
R/Qo (function of beam velocity)	160	220-440	170-570	1036	Ohms	220-440	170-570	
Typical band width FWHM=f0/(2Qex)	867 Hz	890 Hz	929 Hz	433 Hz		550 Hz	575 Hz	
Cavity Active Length (geometrical)	0.325 m	0.422 m	0.747 m	1.038 m		0.682 m	0.906 m	
Cavity Total Length incl. Couplers	0.545 m	0.642 m	0.967 m	1.258 m		1.067 m	1.290 m	
Cavity Slot Length incl. avg. Bellows	0.610 m	0.707 m	1.032 m	1.323 m		1.158 m	1.381 m	
Iris Diameter	47.8 mm	47.7	60.0	70 mm		77 mm	77 mm	
Beam pipe Diameteter	TBD	TBD	78 mm	78 mm				
ID at Equator	203.8 mm	204 mm	199 mm	206 mm		329 mm	329 mm	
Epeak (max)	52	52	58.6	52	MV/m	**27.5**	**35.0**	MV/m
Bpeak/Eacc	6.92	5.73	4.33	4.26	mT/(MV/m)			
Bpeak	105.5	109.9	102.8	110.76	mT			
Epeak/Eacc	3.41	2.71	2.47	2.00				
Eacc (max, on crest for Beta-design)	15.2	19.2	23.7	26.0	MV/m	52.0 - 63.5	58.9 - 80.3	mT
Synchronous Phase Phi (typ)	-30	-25	-20	-15	deg			
Eacc*Cos(Phi)	13.2	17.4	22.3	25.1	MV/m			
Energy Gain Per Cavity (max)	4.3	7.3	16.7	26.1	MV			
Coupler Power (max) for 25mA Beam	107	183	417	652	kW			
Cold Mass of Dressed Cavity					kg			

1300 MHz ELLIPTICAL CAVITY CRYOMODULES: 2-4 TYPES

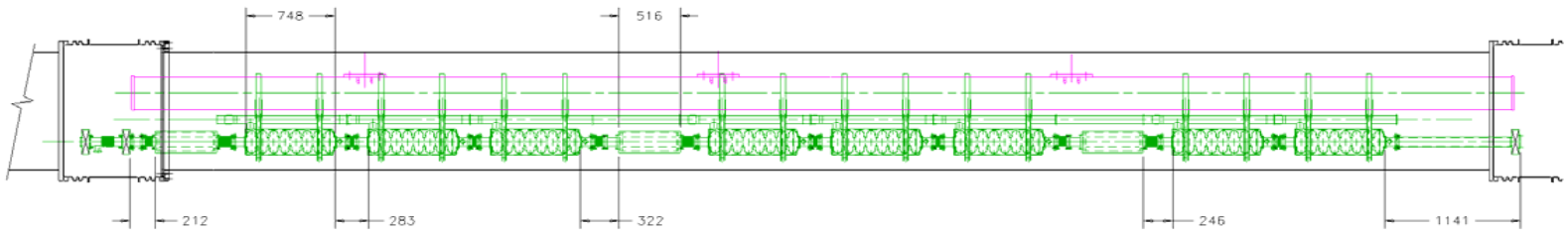


Beta = 0.47
2 Cryomodules
16 Cavities

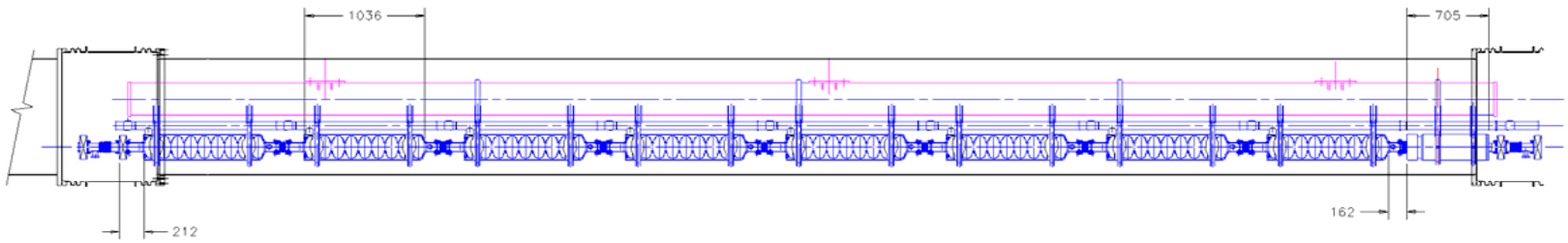
OPTION OF ELLIPTICAL MEDIUM-BETA CAVITES 110 - 400 MeV



Beta = 0.61
4 Cryomodules
32 Cavities



Beta = 0.81
6 Cryomodules
48 Cavities



Beta = 1.00
36 Cryomods
288 Cavities

Elliptical Cavity Cryomodules	8 GeV Linac (Elliptical Cavity Section)		Spallation Neutron Source	
Number of Cryomodules	48	(42 if 3-Spoke Option Chosen)		
Cryomodule Style	TESLA (TTF3)	Beta<1 have modified lengths and quads	CEBAF	
Warm-Cold Beam Pipe Transitions	No		Yes	
Bayonet Cryo Disconnects & cold box	No		Yes	
Quadrupole Type	Cold	runs at 2K	Warm Doublet	
Cryostat Pipe Diameter (OD)	38 in. 965 mm			
Cryostat Material	Low Carbon Steel	de-Gaussed *in situ*	Stainless	
Magnetic field at cryomodules from rebar	< 0.005 Tesla	low-carbon steel cryostat provides shielding	0.0001 Tesla	
Magnetic Shield Material around Cavities	cryoperm foil?			
Radiation Hardness	1.0E+08 Rads	TBD		
Cavity alignment tolerance WRT Cryomod	+/-1 mm	TBD	+/-1 mm	Maximum
Cavity tilt tolerance relative to cryomodule	+/-1 mrad	TBD	+/-1 mrad	Maximum
Cryomodule transverse alignment tolerance	+/-1 mm	TBD	+/-1 mm	Maximum
Quad Alignment Tolerance WRT Cryomod	+/-0.5 mm	TBD	N/A	
Transportation Distance from Factory	2 km	FNAL IB2 to Front-End Bldg.	800 km	TJNAF to ORNL

ELLIPTICAL CRYOMODULE TYPES	LOW	MEDIUM	HIGH	TESLA (TTF3)		MEDIUM	HIGH	
Cryomodule Geometrical Beta of Cavities	**0.47**	**0.61**	**0.81**	**1.00**		**0.61**	**0.81**	
Number Elliptical Cryomodules in Linac	2	4	6	36	48	11	12	
Spare Cryomodules	1	1	2	4				
Length of Cryomodule slot for each Beta	9.396 m	9.615 m	11.682 m	12.175 m		5.839m	7.891m	
Number of Cavities Per Cryomodule	8	8	8	8		3	4	
Number of Quads Per Cryomodule	9	5	3	1		2	2	warm doublet outside cryomodule
Slot Lengths (approx)								
Cavity Slot Length incl. avg. Bellows	0.607 m	0.707 m	1.032 m	1.323 m		1.158	1.381	
Quad Assy Slot Lengths	0.437 m	0.437 m	0.727 m	0.727 m				
Beam Profile Monitor Slot Length	0.066 m	0.066 m	0.066 m	0.066 m	1/cryomod			
Cryostat Interconnect Length*	0.541 m	1.708 m	1.178 m	0.800 m	*tweaked			
Cold Mass								
Cold Mass of Quad/BPM Assy	14 kg	14 kg	33 kg	33 kg	see quad sect			
Total 2K Cold Mass per Cryomodule	752 kg	769 kg	935 kg	974 kg	rough est.			
Total 5K Cold Mass per Cryomodule	47 kg	48 kg	58 kg	61 kg	rough est.			
Total 50K Cold Mass per Cryomodule	141 kg	144 kg	175 kg	183 kg	rough est.			
Heat Loads (1.5% RF Duty Factor)					**Linac Total**			
2 K static heat load per Cryomodule	4 W	4 W	4 W	4 W	**198 W**			
2 K total heat load per Cryomodule	16 W	16 W	16 W	16 W	**789 W**			
5K Static Heat Load per Cryomod	13 W	13 W	13 W	13 W	**637 W**			
5K Total Heat Load per Cryomod	21 W	21 W	21 W	21 W	**1009 W**			
40K static heat load per Cryomodule	90 W	90 W	90 W	90 W	**4410 W**			
40K total heat load per Cryomodule	234 W	234 W	234 W	234 W	**11466 W**			
RF Coupler Type	TTF	TTF	TTF	TTF		SNS/KEK	SNS/KEK	
Coupler LHe consumption / cryomodule	0	0	0	0	cond. cooled	0.225	0.3	g/s

SRF POWER COUPLERS	8 GeV Initial {Ultimate}			Spallation Neutron Source
Cavities per Power Coupler	1			1
RF Frequency	325 MHz	1300 MHz	MHz	805
Power coupler design	RIA	TESLA		KEK-B
Number of Couplers	69	384	depends on 3-spoke vs. elliptical medium-beta	81
Maximum power through coupler	79 {238}	217 {652}	kW	550 kW
Tested power of coupler	TBD	TBD	kW	
Coax Impedance	50	50	Ohm	50 Ohm
Bias Voltage on Center Conductor	0 V	+/-2.5kV	Bias not needed at TTF after conditioning	+/-2.5kV
Input Waveguide	Heliax	WR-650		WR975
Separate Power coupler vacuum	none	YES		none Single RF Window Design
Liq. Helium Consumption per Coupler	none	none	conductive cooling w/6K & 50K intercept	0.075 g/s vapor cooled
Static Heat Load at 2K	n/a	0.10 W		0.7 W
Total Heat Load at 2K	n/a	0.11 W		0.8 W
Static Heat Load at 6-8K	TBD	0.26 W	(these heat loads are for	
Total Heat Load at 6-8K	TBD	0.41 W	ultimate coupler power,	
Static Heat Load at 50K	TBD	2.69 W	with maximum beam loading)	
Total Heat Load at 50K	TBD	10.11 W		
Power Coupler Water Cooling	No	No	not needed for 10Hz operation	yes, center conductor of coax
HOM COUPLERS				
HOM couplers per cavity	TBD	2		2
Number of HOM couplers	TBD	2 x 384		2 x 81
HOM coupler design	TBD	TTF	preserve option of running e+/- in beta=1 linac	TTF (scaled to 805MHz)

HOM HEAT LOADS	2K	6K	50K	
per coupler	0.34 W	0.87 W	4.69 W	estimated
per cryomodule	2.7 W	6.9 W	37.5 W	
linac total	133 W	340 W	1838 W	

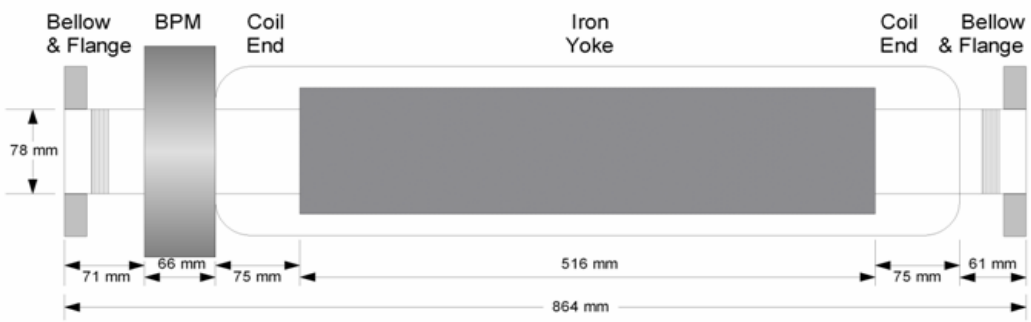
CAVITY TUNERS	325 MHz	1300 MHz		
Number of tuners	69	384	depends on 3-spoke vs. elliptical medium-beta	81
Mechanical Tuner Range	TBD	+/-100	kHz TBD	+/-100 kHz
Mechanical Tuner Slew Rate	TBD	3000	Hz/min TBD	3000 Hz/min
Mechanical Tuner Actuator	Pneumatic	cold stepping motor in insulating vacuum		cold stepping motor in insulating vacuum
Cavity Spring Constant	TBD	~200	kgf/mm	
Fast Piezo Fine Tuners Included	TBD	yes		yes

SC SOLENOIDS IN LINAC	8 GeV Linac					Spallation Neutron Source
Number of Solenoids	53					
Number of Solenoid Types	2		warm & cold bore			
Focusing structure	FOFO					
Solenoid type	Superconducting					
Operating Temperature	4.5K					
SteeringTrims Inside Solenoids	both H & V each magnet					
	MEBT	**RT TSR**	**1-Spoke**	**2-Spoke**		
Number of Solenoids Per Module	1	1	16	7		
Number of Solenoids per Section of Linac	2	21	16	14		
Solenoid Bore Type	**WARM BORE**		**COLD BORE**			
Solenoid Slot Length	0.210 m		0.240 m			
Solenoid Magnetic Length	0.180 m		0.180 m			
Solenoid Peak Field	6.0 T		8.0 T			
Stray Field at Cavites (during cooldown)	no spec		< 1 uT			
Stray Field at Cavites (after cooldown)	< 1 T		< 10 mT			
Solenoid Clear Bore (radius)	15mm		15mm			
H-minus Stripping Field at max energy						
Beam Radius for Stripping						
SRF Solenoid Design Details						
Amps	10 A		0 A			
Amp-Turns						
Number of Windings						
Inductance						
Stored Energy (approx)						
Quench Protection	Passive (TBD)		Passive (TBD)			
SC Strand Diameter (including Insulation)						
SC Coil Radial Thickness						
Outer Radius						
Approximate Weight						
SRF Solenoid Current Leads						
Number of Leads per Solenoid	4		4		2+Dipole trims	
Current Lead Type	HTS (BSCCO)		HTS (BSCCO)			
Lead Cooling	vapor		Conductive, 50K Intercept			
Heat Leak per Lead to 4.5K	0.003 W / Lead		Scaled per Amp from TESLA TDR			
Heat Leak per Lead to 50K	0.361 W / Lead		Scaled per Amp from TESLA TDR			

SRF LINAC QUADRUPOLES	8 GeV Linac					Spallation Neutron Source	
Number of Quadrupoles in Cryomodules	92		depends on 3-spoke vs. elliptical medium-beta			64	Includes doublets for unoccupied sp
Focusing structure	FODO					Doublet	
Quadrupole type	Cold Superferric Quads inside cryomodules (MSU/TRASCO & TTF)					Warm Copper Electromagnets between Cryomodules	
Trim Dipole Windings Inside Quads	both H & V each quad					both H & V each quad	32 Powered
Trim Dipole Downstream Orbit Deflection	+/-1 cm		typical, varies along lattice				
Stray Field at Cavites (quads unpowered)	1 uT		during cavity cooldown				
Stray Field at Cavites (quads powered)	10 uT		after cavites are SC				
Cryomodule Type (Beta)	3-Spoke	LOW	MEDIUM	HIGH	TESLA		
Number of Quads Per Cryomodule	7	9	5	3	1	2	
Number of Quadrupoles	42	18	20	18	36		
Quad + BPM Slot Length	0.423 m	0.423 m	0.423 m	0.864 m	0.864 m	0.39 m	
Quad Magnetic Length	0.150 m	0.150 m	0.150 m	0.516 m	0.516 m		
Quad Integrated Strength (at max energy)	2.50 T	2.39 T	2.39 T	2.70 T	1.5 T		
Quad Gradient at max energy	16.7 T/m	15.9 T/m	15.9 T/m	5.2 T/m	2.9 T/m	7.2 T/m typ	
Quad Aperture Radius	20 mm	40 mm	40 mm	40 mm	40 mm	40 mm	
Quad Pole Tip Field at max energy	0.33 T	0.64 T	0.64 T	0.21 T	0.12 T		
H-minus Stripping Field at max energy	5.62 T	1.35 T	0.58 T	0.27 T	0.06 T		
Beam Radius for Stripping (at max energy)	337 mm	85 mm	37 mm	52 mm	21 mm		
SRF Quadrupole Design Details							
Amps	10 A	10 A	10 A	10 A	10 A		
Amp-Turns per pole	2,653	10,122	10,122	3,326	3,326		
Turns/pole	265	1012	1012	333	333		
Stored Energy (approx)	8 J	112 J	112 J	41 J	13 J		
Inductance (scaled from RHIC corrector)	0.15 H	2.23 H	2.23 H	0.83 H	0.26 H		
Charge/discharge time w/ +/-50V supply	DC	DC	DC	DC	0.05 sec		
SC Strand Diameter (including Insulation)	0.50 mm	0.50 mm	0.50 mm	0.50 mm	0.50 mm		
SC Coil Area (pole winding)	66 mm^2	253 mm^2	253 mm^2	83 mm^2	83 mm^2		
SC Coil Azimuthal Thickness	8 mm	16 mm	16 mm	9 mm	9 mm		
SC Coil Radial Thickness	8 mm	16 mm	16 mm	9 mm	9 mm		
SC Coil Inner Radius	25 mm	45 mm	45 mm	45 mm	45 mm		
Lamination Return Leg Thickness	10 mm	13 mm	13 mm	10 mm	10 mm		
Lamination Outer Radius	43 mm	74 mm	74 mm	64 mm	64 mm		
Approximate Weight	6 kg	14 kg	14 kg	33 kg	33 kg		
SRF Quadrupole Current Leads							
Number of Leads per quad	4	4	4	4	4		
Number of Leads per Cryomodule	28	36	20	12	4		
Number of Leads per Cryomodule Type	168	72	80	72	144		
2K Heat Load per cryomodule from Leads	0.08W(4K)	0.10 W	0.06 W	0.03 W	0.01 W		
50K Heat Load per cryomodule from Leads	10.11 W	13.00 W	7.22 W	4.33 W	1.44 W		
Current Lead Type	HTS (BSCCO) conductively cooled with 50K Intercept						
Heat Leak per Lead to 2K	0.003 W / Lead		Scaled per Amp from TESLA TDR				
Heat Leak per Lead to 50K	0.361 W / Lead		Scaled per Amp from TESLA TDR				

Magnet & Beam Position Monitor Slot Lengths

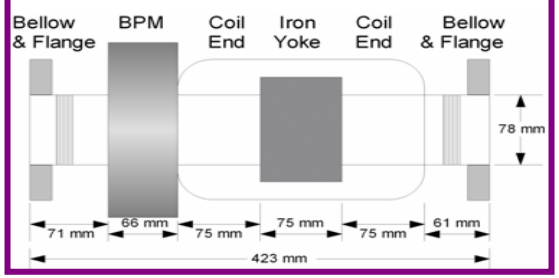
Quad/BPM Slot Length for Beta=1.00 & beta=0.81 Cryomodules



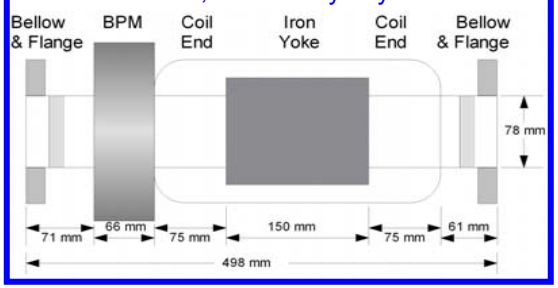
Warm-Bore Solenoids
For 325 MHz Linac

Cold-Bore Solenoids
For 325 MHz Linac

Quad/BPM Slot Lengths for
Triple - Spoke Resonator Option



Quad/BPM Slot Lengths for Elliptical
Beta=0.47,0.61 Cavity Crymodules

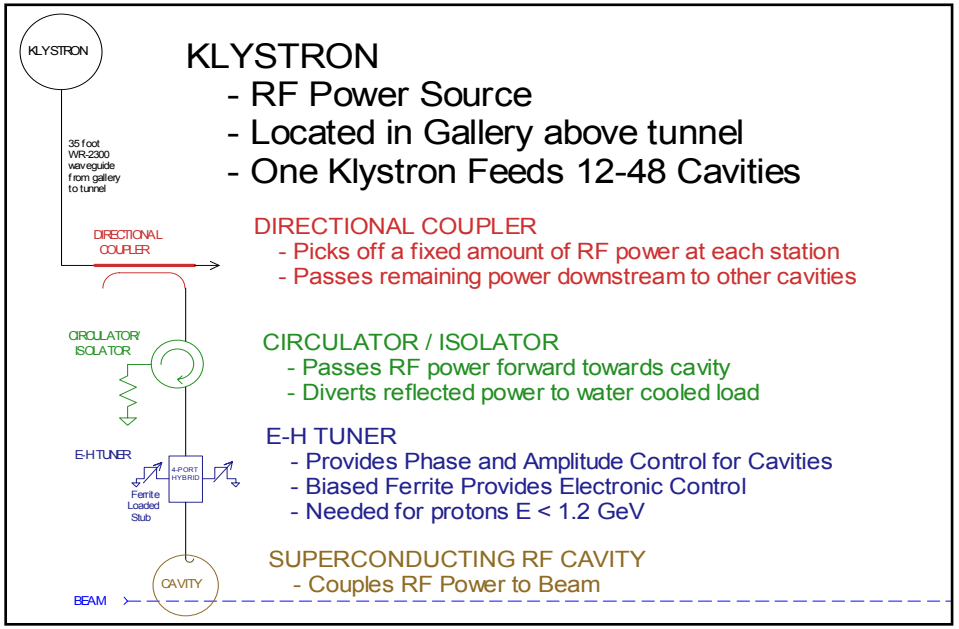


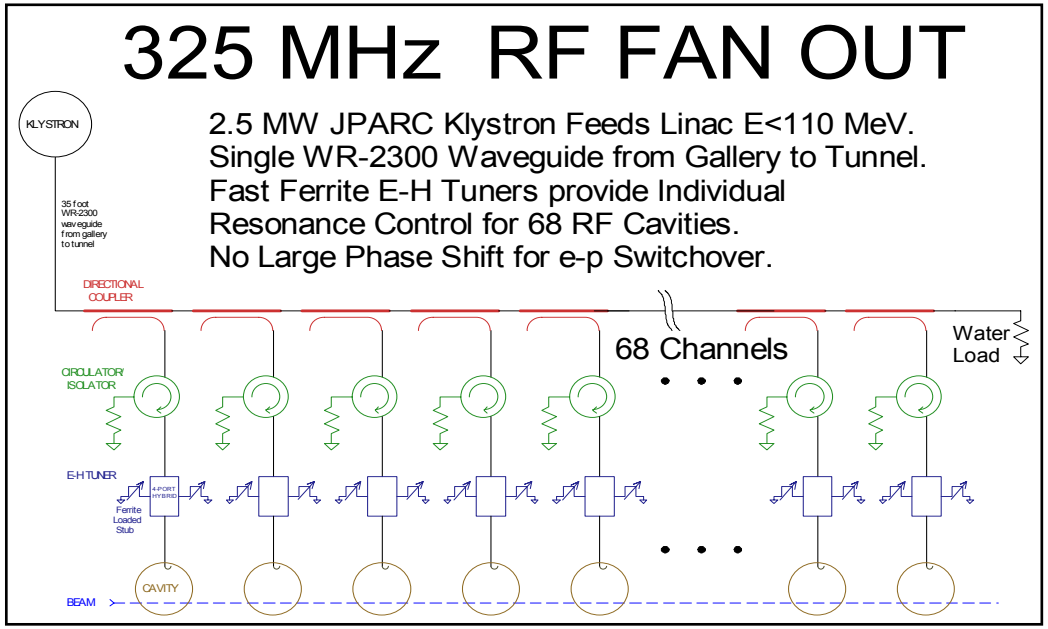
CRYOGENIC SYSTEM	8 GeV Linac					Spallation Neutron Source	
Nominal Refrigeration Power	5.21	kW of 4.5K	Equiv. Refrigeration				
Nominal Compressor Wall Power	1.37	MW	at 10 Hz operation			at 10 Hz Operation	
Installed Compressor Power	2.06	MW	includes overcapacity for cool down, etc.				
Electrical Service Required @Cryoplant	3	MW					
Number of Indep. Cryogenic Segments	1+1		4.5K upstream & 2K Downstream			23	(each cryomodule has indep cooldown & 2K coldl
Cryomodule Replacement Time	48	hrs	Target, TBD			8-12	hours
Warm-up or Cool Down time	18	hrs	Prelim. Est.			~4?	hours for a single cryomodule
Distance between Vacuum Breaks	50	m	TBD			6-8	m each cryomodule
Inventory Control							
Helium Inventory	1800	kg He	100%	rough est.			
Liquid Storage	2500	kg He	139%	one 20,000 gal LHe dewar			
Gas Storage	2000	kg He	111%	eight 30,000 gal gas tanks			
Warm Gas Return Header for Cooldown	600	m	6" IPS SS pipe in tunnel (if needed)				
Cryogenic Transfer Lines							
Cryoplant to Linac	60	m TBD	Across the street				
Linac to Debuncher	0	m	Not needed: Room-Temp Debuncher Used				
Cryomodule Test Stand	20	m TBD	Assume Test Stands near cryo building				
CRYO LOADS (SPOKE OPTION)	**2K**	**4K**	**6K**	**50K**			
Predicted Static Heat Load [W]	182	1,154	616	5,429			
Predicted Operating Heat Load [W]	687	1,271	935	11,506			
Static to Total Ratio	26%	91%	66%	47%			
Heat Uncertainty Factor	1.3	1.3	1.3	1.3			
Nominal Operating Load [W]	893	1,652	1,216	14,958			
Overcapacity Factor	1.5	1.5	1.5	1.5			
Installed Capacity [W]	1,340	2,478	1,823	22,437			
4.5K Equivalent Heat Load [W @4.5K]	1,982	1,496	771	960	**5,209 W @4.5K**		
COP, [W/W]	588	240	168	17			
Nominal Operating Power [kW]	599	256	231	285	**1371 kW total**		
Installed Operating Power [kW]	899	384	347	428	**2057 kW total**		

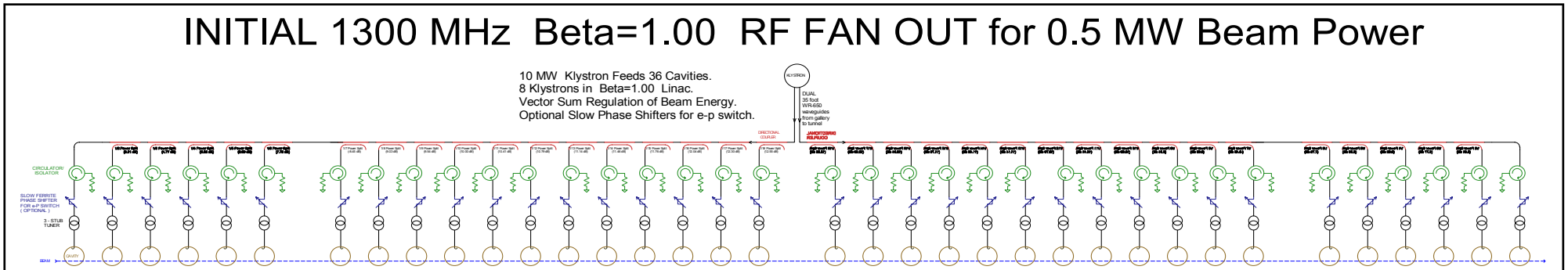
KLYSTRONS	8 GeV Initial {Ultimate}			Spallation Neutron Source			
Number of Klystrons	12 {33}		linac(11) {32} + debuncher(1)				
Number of Klystron Types	2		325 MHz (JPARC) and 1300 MHz (TESLA)				
Number of Modulators	12 {31}		linac(11) {31} + debuncher(1)				
Location of Klystrons & Modulators	Linac Gallery						
Klystron Individual Details	**325 MHz**	**1300 MHz**		**402.5 MHz**	**805 MHz**	**805 MHz**	
Number of Klystrons (main linac)	1 {2}	10 {30}	(elliptical option)	7	5	81	93 total Klystrons
Number of Klystrons (debuncher)	0	1	1 for Debuncher				
Number of Klystrons (test stands)	1	1	2 pre-project				
Klystron System Loads	RFQ,MEBT, RT-TSR & Spokes	Elliptical SCRF Linac & Debuncher					
Klystron Peak Power	2.5 MW	10 MW		2.5 MW	5.00 MW	0.55 MW	
Klystron Test Power	3.0 MW	10 MW					
Klystron Type	JPARC	TESLA MBK					
Klystron Reference Manufacturer	Toshiba	Thales*	* Three vendors for Multi-beam Klystron:				
Klystron Reference Model #	E3740A	TH-1801	Thales, CPI #VKL-8301, or Toshiba #E3736				
Klystron RF Pulse Width [msec]	4.2 {1.4}	4.2 {1.4}					
Klystron Repetition Rate [Hz]	2.5 {10}	2.5 {10}					
Klystron RF Duty Cycle (%)	1.1 {1.4}	1.1 {1.4}					
Klystron Average Power [kW]	26 {35}	105 {140}		150 kW	300 kW	33 kW	
Klystron Rated Average Power [kW]	93	150		0 kW	0 kW	0 kW	
Klystron Rated Efficiency	55%	65%					
Klystron Assumed Efficiency	50%	60%	system design assumes efficiency below spec				
Klystron Beam Voltage	110 kV	117 kV					
Klystron Beam Current	45 A	142 A					
Klystron Number of Beams	1	7					
Klystron Perveance (Amps per V^3/2)	1.2E-06	3.6E-06					
Klystron Gain	50 dB	40 dB					
Klystron Bandwidth (1dB)	~0.7 MHz?	3 MHz	Bandwidth of Toshiba eyeballed from curve				
Klystron Number of Internal Cavities	5	6					
Klystron Filament Voltage	15 V	9 V					
Klystron Filament Current	26 A	50 A					
Klystron Solenoid Power	9.8 kW	5 kW					
Klystron Mounting Orientation	horizontal	vertical					
Klystron HV Connection	SNS Cable	Oil Socket					
Klystron Length	15 ft	8.2 ft					

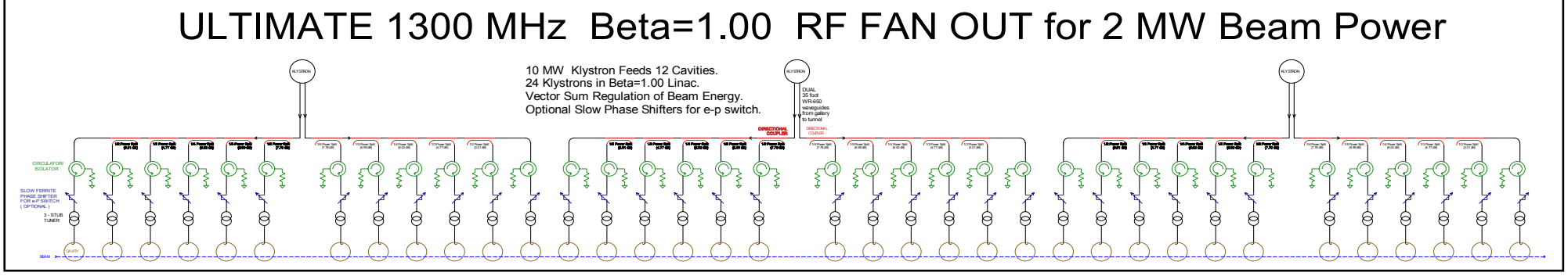
MODULATORS	8 GeV Initial {Ultimate}			Spallation Neutron Source		
Number of Modulators Initial {Ultimate}	12 {33}	total	linac + debuncher			
Modulator Types	1	type	drives both 1300MHz and 325MHz Klystrons			
Modulator Peak Power Required	17-20	MW	depending on location in linac			
Modulator Maximum Average Power	275	kW	typ.			
Modulator Specified Max Pulse Width	4.5 {1.5}	msec	must hold flat top tolerance within this time			
Modulator Expected Max Pulse Width	4.2 {1.3}	msec	expected RF pulse width			
Modulator Output Voltage	10	kV	before step-up from pulse transformer			
Modulator Rep Rate	2.5 {10}	Hz				
Modulator type	IGBT	bouncer		IGBT switcher		
Modulator Flat Top Accuracy	+/- 0.5	%	maybe negotiable			
Modulator RMS Pulse-to-Pulse variation	+/- 0.2	% RMS	maybe negotiable			
Modulator Spark Protection for Klystron	Redundant IGBT switch					
Modulator Max Fault Energy into Klystron(s)	20	J	including capacitance for 2 ganged klystrons			
Modulator Supply Voltage	480 VAC, 60 Hz, 3 Phase					
Modulator Charging Supply Type	SCR phase control with output filter and Power Factor Correction					
Modulator Power Factor Correction	meeting FNAL standards for large installations					
Modulator Size (W x D x H)	28 x 6 x 8	ft	{14 x 6 x 8 ft}			
Modulator Individual Details	**325 MHz**	**1300 MHz**				
Number of Modulators	1 {2}	11 {31}	including Debuncher			
Number of klystrons per modulator	1 {2}	1				
Modulator Voltage	110	117	kV			
Modulator Current	45	142	A			
Modulator Peak Power	5 {10}	17	MW			
Modulator Average Output Power [kW]	58 {120}	192	kW			
Modulator HV Pulse Width (flat top) [ms]	4.5 {1.5}	4.5 {1.5}	msec			
Modulator Switch Conduction Time [ms]	4.6 {1.6}	4.6 {1.6}	msec			
Modulator Switch Duty Cycle [%]	1.2 {1.6}	1.2 {1.6}	%			
Modulator Efficiency incl. Charging Supply	85%	85%				
Modulator Wall Power (max)	68 {140}	225	kW	varies along linac		
Modulator Cooling Water (LCW) Flow	2.6	8.5	GPM	15 degC temperature rise		
Total Modulator Wall Power	0.07 {0.17}	2.48 {6.97}	MW	tot. installed		
Modulator Pulse Transformers	**Initial**	**Ultimate**				
Pulse Width at Flat Top	4.5	1.5	msec			
Number Required	11	11+20	initial transformers reused in ultimate config.			
Tank Size (L x W x H)	8' x 6' x 5'	7' x 5' x 5'	new transformers for Ultimate are smaller			
Transformer Ratio	1:12	1:12				
Tank Weight including Transformer(s)	TBD	TBD				
Tank Oil Inventory (approx)	4 k-liters	3 k-liters				
Tank Avg Power Dissipation	3	3	kW	from TESLA TDR fig 8.5.3		
Transformer Cooling Water (LCW) Flow	0.8	0.8	GPM	15 degC temperature rise		
Modulator-to-Klystron Interface	**325 MHz**	**1300 MHz**		**402.5 MHz**	**805 MHz**	**805 MHz**
Number of Tubes per Transformer	1 {2}	1		1	1	6
Filament Transformers per tank	1 {2}	1	Separate Filament Transformers			
Height needed to remove Klystron	N/A (horiz.)	12 ft	Vertical liftout of Solenoid & MBK as unit			
Tank Moved for Klystron Replacement	NO	MAYBE				
Oil Purification Method	Travelling cart					

RF Distribution	8 GeV Initial {Ultimate}				Spallation Neutron Source	
RF Distribution System	**325 MHz**	**1300 MHz**			**402.5 MHz**	**805 MHz**
Peak Power from Klystron	2.5 MW	10.0 MW			2.5 MW	0.55 MW
Cavities per Klystron (typ)	72 {48}	36 (12)			1	1
RF Distribution Efficiency (see below)	79%	83%	including Ferrite Phase shifter losses			
Power at Cavity (typical)	27 (72)	232 (715)	kW			
Power at Cavity (max)	0.30 MW	0.60 MW	worst-case cavity in each grp.			
Excess RF Power Available after losses	8988%	38519%	TESLA ~6%			
Waveguide	**325 MHz**	**1300 MHz**				
Waveguide Type (in long chase & fanout)	WR-2300	WR-650				
Number of Output Waveguides per Klystron	1	2				
Rated Waveguide Power @freq.	600 MW	85 MW	No SF6			
Max Power in Waveguide (at Klystron)	2.5 MW	5 MW				
Average Power in Waveguide (at Klystron)	2875 kW	5750 kW				
Waveguide Temperature Rise Above Ambient	TBD	TBD				
RF Distribution Losses	**325 MHz**	**1300 MHz**				
Average Waveguide Length	100 ft	95 ft {65 ft}	50ft from Klystron to nearest Cavity			
Nominal Attenuation dB/100ft @freq.	0.05 db/cft	0.25 db/cft				
Waveguide Attenuation Losses	0.05 db	0.24 db				
Power Splitter Directivity Losses	0.10 db	0.05 db				
Circulator Losses	0.20 db	0.10 db	0.08 meas. at TTF			
Ferrite Tuner Internal Losses	0.20 db	0.20 db	prototype measurements & spec from AFT			
Ferrite Tuner Setpoint Losses	0.50 db	0.20 db	estimate - needs simulation			
Overall Losses (avg)	1.05 db	0.79 db				
percent power losses	21%	17% *	* 9% for cavities without tuners (> 1.7 GeV)			
RF Phase and Amplitude Tuners	**325 MHz**	**1300 MHz (Fast)**	**1300 MHz (Slow) ***	*** Slow Tuners are option needed for alternating electrons & H-**		
Included in Baseline	Yes	Yes	**NO**		LLRF control per Klystron	
Phase / Amplitude Tuner Type	Coax	Waveguide	Waveguide			
Ferrite	YIG	YIG	YIG	Perpendicular Biased		
Phase / Amplitude Tuner Locations	1/cavity	1 / cavity	1 / cavity			
Number of Phase / Amplitude Tuners	73 or 115*	132 or 84*	252	* for 3-spoke or ellip. med-beta		
Phase Tuner Adjustment Range (deg)	90 deg	90 deg	360 deg		360 degree	
Phase Tuner Settling Time (within 1 deg)	100 usec	100 usec	0.1 second			
Phase Tuner Slew Rate	1 deg/usec	1 deg/usec	N/A			
Amplitude Tuner Attenuation Range	6.0 db	6.0 db	none			
Amplitude Tuner settling time (1% F.S)	100 us	100 us	N/A	needs simulation		
Tuner Peak Power	0.30 MW	0.60 MW	0.60 MW	worst case for ultimate scenario		
Tuner Insertion Loss	0.2 db	0.2 db	0.2 db	Measured on Protos,&AFT Quote		
Tuner Avg. RF Power Dissipation	71 W	142 W	142 W	worst case for ultimate scenario		
Tuner Coil Average Power Dissipation	25 W	40 W	40 W	target for 1.5% RF Duty Factor		
Static RF amplitude error	+/-1%	+/-1%		TBD needs simulation	+/-1 %	
Static RF phase error	+/-1 deg.	+/-1 deg.		TBD needs simulation	+/-1 degree	
Dynamic RF amplitude error	+/-0.5%	+/-0.5%		TBD needs simulation	+/-0.5 %	
Dynamic RF phase error	+/-0.5 deg.	+/-0.5 deg.		TBD needs simulation	+/-0.5 degree	


KLYSTRON
35 foot WR-2300 waveguide from gallery to tunnel
DIRECTIONAL COUPLER
CIRCULATOR/ ISOLATOR
E-H TUNER
4-PORT HYBRID
Ferrite Loaded Stub
CAVITY
BEAM
KLYSTRON
- RF Power Source
- Located in Gallery above tunnel
- One Klystron Feeds 12-48 Cavities
DIRECTIONAL COUPLER
- Picks off a fixed amount of RF power at each station
- Passes remaining power downstream to other cavities
CIRCULATOR / ISOLATOR
- Passes RF power forward towards cavity
- Diverts reflected power to water cooled load
E-H TUNER
- Provides Phase and Amplitude Control for Cavities
- Biased Ferrite Provides Electronic Control
- Needed for protons E < 1.2 GeV
SUPERCONDUCTING RF CAVITY
- Couples RF Power to Beam


325 MHz RF FAN OUT
KLYSTRON
2.5 MW JPARC Klystron Feeds Linac E<110 MeV.
Single WR-2300 Waveguide from Gallery to Tunnel.
Fast Ferrite E-H Tuners provide Individual
Resonance Control for 68 RF Cavities.
No Large Phase Shift for e-p Switchover.
35 foot WR-2300 waveguide from gallery to tunnel
DIRECTIONAL COUPLER
68 Channels
Water Load
CIRCULATOR/ ISOLATOR
E-H TUNER
4-PORT HYBRID
Ferrite Loaded Stub
CAVITY
BEAM


INITIAL 1300 MHz Beta=1.00 RF FAN OUT for 0.5 MW Beam Power
10 MW Klystron Feeds 36 Cavities.
8 Klystrons in Beta=1.00 Linac.
Vector Sum Regulation of Beam Energy.
Optional Slow Phase Shifters for e-p switch.
KLYSTRON
DUAL 35 foot WR-650 waveguides from gallery to tunnel
DIRECTIONAL COUPLER
CIRCULATOR/ ISOLATOR
SLOW FERRITE PHASE SHIFTER FOR e-P SWITCH (OPTIONAL)
3 - STUB TUNER
CAVITY
BEAM


ULTIMATE 1300 MHz Beta=1.00 RF FAN OUT for 2 MW Beam Power
10 MW Klystron Feeds 12 Cavities.
24 Klystrons in Beta=1.00 Linac.
Vector Sum Regulation of Beam Energy.
Optional Slow Phase Shifters for e-p switch.
KLYSTRON
DUAL 35 foot WR-650 waveguides from gallery to tunnel
DIRECTIONAL COUPLER
CIRCULATOR/ ISOLATOR
SLOW FERRITE PHASE SHIFTER FOR e-P SWITCH (OPTIONAL)
3 - STUB TUNER
CAVITY
BEAM

SRF INSTRUMENTATION	8 GeV Linac (Preliminary Estimate)			Spallation Neutron Source	
CHANELS IN SRF LINAC	**16,131**				
Channels per Each CAVITY	per cavity	per linac	**498 total cavities per Linac**		
Forward & Reverse Power Monitors	4	1992	2 @ Power Split & Input Coupler		
Coupler Spark Detector	2	996	Appears SNS has this many?		
Coupler IR detector	1	498	PIN diode		
Circulator / Isolator Spark Detector	2	996	on circulator and load		
Cavity Resonance Pickup	1	498			
Secondary Emission Pickup	1	498			
HOM Signals	2	996	Used for BPM's & cavity alignment check		
Step Motor Tuner Drive	1	498			
Step Motor Tuner Readback	1	498			
Step Motor Tuner Limit Switches	2	996			
Piezo Tuner Drive	2	996			
LCW Flow Meters	1	498	one water ckt. per cavilty: circulator, load, tuner		
Misc. Temperatures	5	2490	TBD		
Total Channels Per CAVITY	**25**	**12450**			
Channels per Each QUAD LOCATION	Per Quad	per linac	**145 (quad+solenoid) locations**		
BPM and phase monitors	2	290		34	2 in CCL-SCL transition
Magnet / Lead Protection	2	290			
Alignment Readouts	2	290	TBD		
Total Channels per QUAD LOCATION	**6**	**870**			
Channels per Each FERRITE TUNER	per Tuner	per linac	**195 total tuners per Linac**		
Ferrite Tuner Drive Amp	2	390	Assume Tuners for E<2.2 GeV only		
Ferrite Tuner Current Monitor	2	390	Inside Power Supply (upstairs)		
Ferrite Stub RF Power Monitors	2	390	in addition to power monitors per cavity		
Ferrite Tuner Temperature Monitor	2	390	?use B-H saturation point to measure Temp?		
Total Channels Per TUNER	**8**	**1560**	including debuncher and 2 test stands		
Channels per Each CRYOMODULE	per CM	per linac	**51 total Cryomodules per Linac**		
Beam loss monitors	1	51		59	1 in CCL-SCL transition
Beam Profile scanners	1	51	TBD--maybe laser windows	33	1 in CCL-SCL transition; 17 connec
Number of Cryo Temp Sensors	8	408			
Insulating Vacuum TC gages	1	51			
Coupler Vacuum Ion Pump	1	51			
Coupler Vacuum TC gage	1	51			
Alignment Readouts	4	204	TBD		
Total Channels per Cryomodule	**17**	**867**			

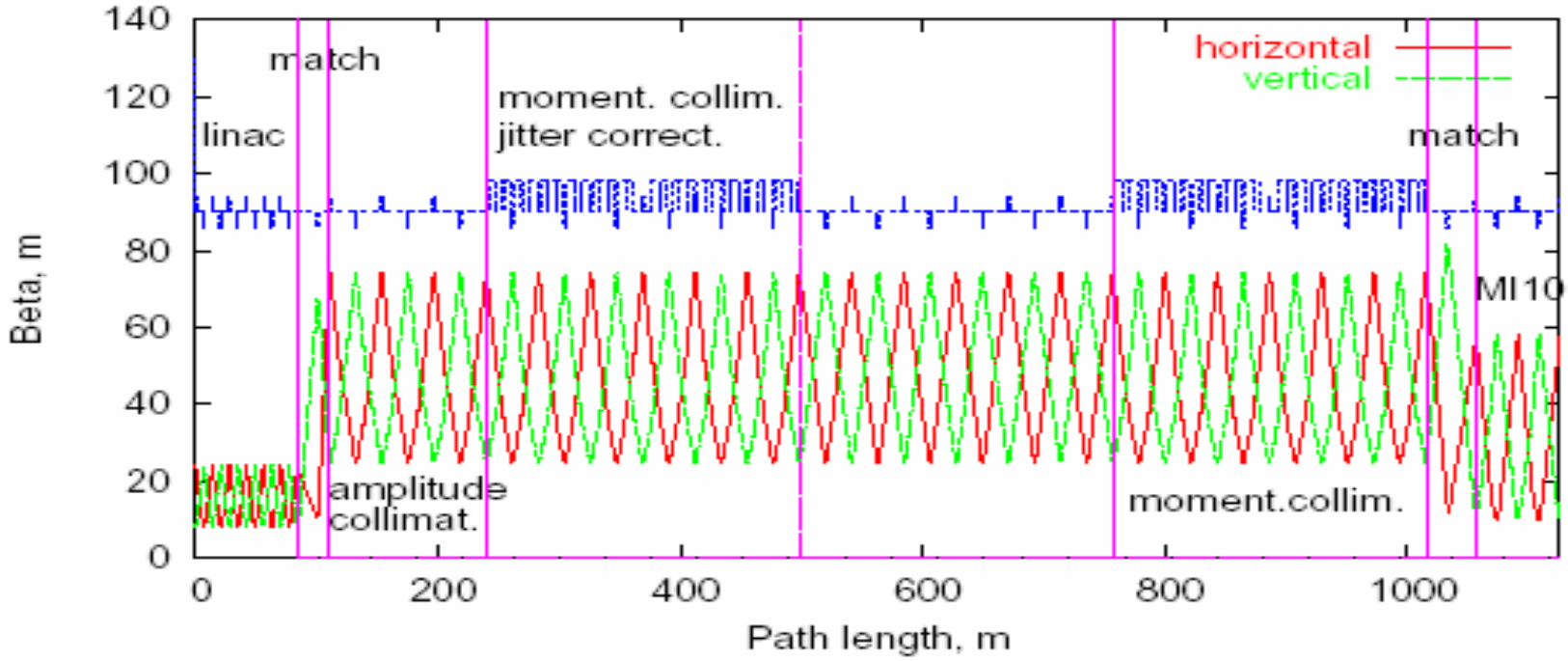
SRF Instrumentation (cont'd)	8 GeV Linac		
Channels per Each KLYSTRON (initial)	per Klystron	per linac	**12 Klystrons (initial) incl. debuncher**
Vacuum	3	36	Readback, Interlock, Ion Gauge
Water Flow	3	36	Body, Collector, Solenoid
Solenoid Power Supply	3	36	PS control, PS Readback, Ground Fault
Filament	3	36	Control, Voltage Readback, Current Readback
Forward & Reverse RF Power Monitors	4	48	in addition to power monitors per cavity
Ion Pump Power Supply	1	12	
Waveguide Pressure	2	24	
Pulse Transformer	4	48	Temperature (2+Interlock), Oil Level
Pulse Transformer Bias Supply	2	24	Control & Readback
RF Leak Detector	3	36	
Gun Voltage and Current	2	24	Voltage divider & Current Transformer
RF Power (Directional Coupler)	2	24	Forward & Reverse power at Klystron
Total Channels per Klystron	**32**	**384**	including debuncher and 2 test stands

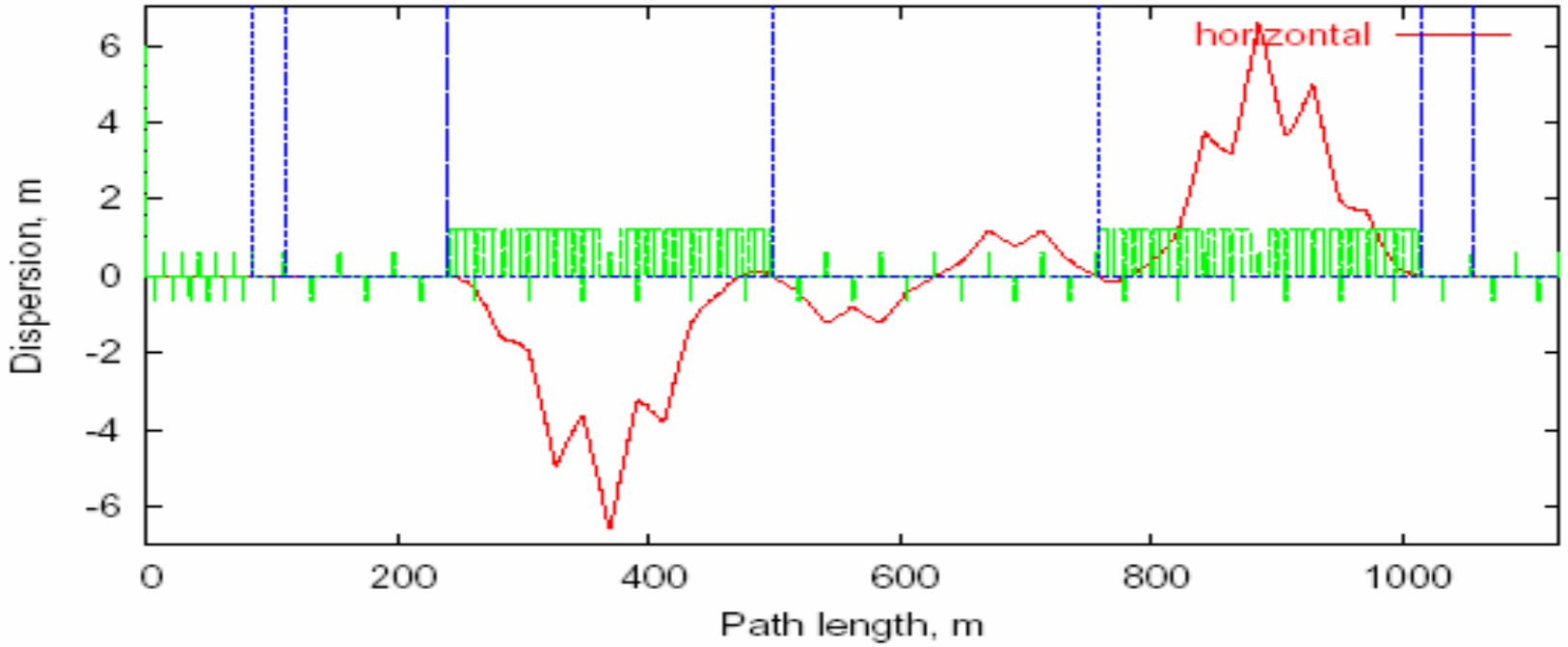
Waveguide/Cable Chases	8 GeV Linac			Spallation Neutron Source
Number of Waveguide Chases	31	one per Klystron in Ultimate config		
Typical Spacing between Chases	60 ft	2/3 are used only for cables in initial configuration		
Number of Waveguides per Chase	2	(only one waveguide for 325 MHz Chases)		
Number of Cables per Chase	430	average	~80 of these are 3/8" Heliax	
Total Number of Cables in Chases	13317	approx		

WARM VACUUM	8 GeV Linac	
VACUUM INSTRUMENTATION		
Vacuum sectors in Transfer Line	24	1/2 arcs, straights, collimators, etc
Ion Pumps	146	One per dipole, quad, special
TC gauges	24	One per vacuum sector
gate valves	25	at boundaries of each vacuum sector
Klystron Ion Pump Power Supplies	12 {33}	one per klystron

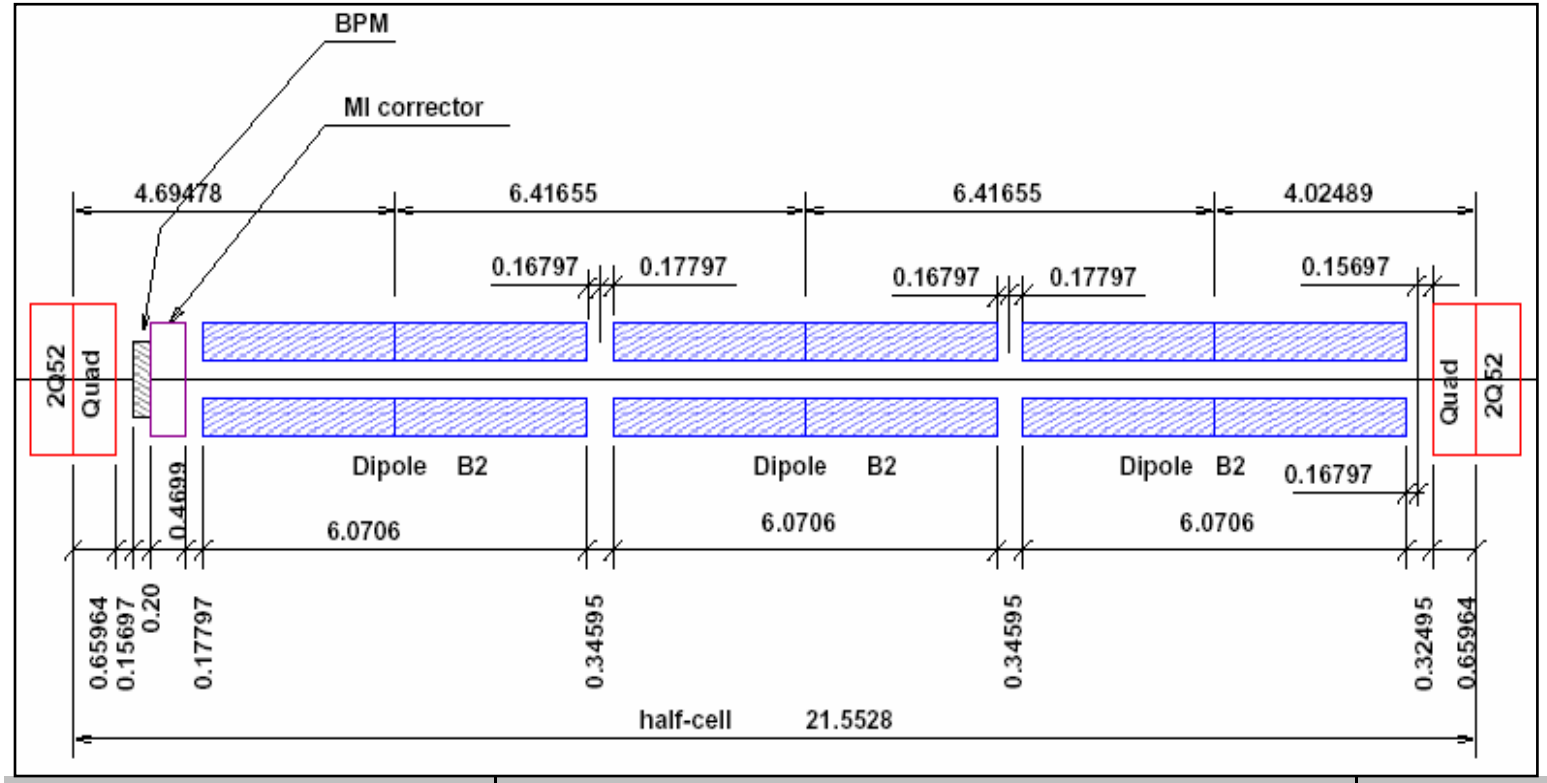
TRANSFER LINE TO RING	8 GeV Linac			Spallation Neutron Source
Transfer Line Length to Ring	972.456	m	incl. momentum collimation bend	170 m
Injection Point to Main Injector	MI-10		baseline design; others possible	SNS Accumulator Ring Straight Section
Quad Focusing	FODO			
Phase Advance per cell	60	degrees		
Number of half-cells (quads)	47			
half-cells in matching section from linac	2		non-standard cell	
half-cells in collimation straight	6		standard cells	
half cells in right bend	12		standard cells	
half cells in positioning straight	12		standard cells	
half cells in left bend	12		standard cells	
half cells in match to Main Injector	3		non-standard cell	
Half-cell length, standard	21.553	m	3 B2's per half-cell	
Half-cell length, linac match	13.28	m		
Half-cell length, MI match	13.56	m		
Beta-Max (H & V)	77	m		
Beta-Min (H & V)	20	m		
Number of Bend half-cells	24			
Transfer Line Total Bend	2 x 20	deg	two achromatic arcs	90 deg
Dispersion at entrance and exit	0	m		
Dispersion Max (at momentum collimation)	8.85	m		
Vacuum Required	1E-07	torr	TBD for < 1e-4 beam loss from stripping	
QUADRUPOLES in transfer line	**47**			
Quad Length	1.308	m	New Construction	
Quad Gradient	1.06	T/m		
DIPOLES in transfer line	**68**			
C magnets in first half cell	3		New design	
B2 dipoles in standard cell	3			
Missing dipoles in arc centers	4			
Total B2 dipoles	65			
Dipole Field	0.05	Tesla	limited from H-minus stripping at 10 GeV	
Dipole Length	6.07	m	Main Ring B2 @125A	
Horizontal Trims in transfer line	24		at every F-quad	
Vertical Trims in transfer line	23		at every D-quad	

8 GeV Transfer Line Optics with Betatron and Momentum Collimation





TRANSFER LINE BEND CELL GEOMETRY



Magnets & Power Supplies	8 GeV Linac				
	Number	Volts/mag	Current	Power/mag	Total Power
Power Supply Total	**449**			**83W. Avg**	**37 kW**
MEBT matching Quads	4	10 V	10 A	100 W	400 W
SC Solenoids (non-ramped) in 325 Linac	56	2 V	10 A	20 W	1120 W
SC Solenoid steering trims(unramped)	112	+/- 2 V	2 A	4 W	448 W
SC Quadrupoles (unramped in beta<1)	60	+/- 25 V	10 A	20 W avg.	1200 W
SC Quad steering trims(unramped)	120	+/- 25 V	2 A	4 W avg.	480 W
SC Quadrupoles (ramped in beta=1)	36	+/- 25 V	25 A	50 W avg.	1800 W
Transfer Line Dipole Bus	1	0.84 V	125 A	105 W	6805 W
C-magnets on Transfer Line Dipole Bus	1	1.68 V	125 A	209 W	628 W
C-magnets on Transfer Line Dipole Bus	1	0.89 V	150 A	134 W	134 W
Transferline Main Quad Bus (41 quads)	1	9.43 V	41 A	387 W	15852 W
Transferline Matching Quad Supplies	6	11.50 V	50 A	575 W	3450 W
Transferline Vertical Correctors	23	+/- 20 V	5 A	100 W	2300 W
Transferline Horizontal Correctors	24	+/- 20 V	5 A	100 W	2400 W
Orbit Bump Painting supplies (1ms pulsed)	4	275 V	75 A	21 W Avg.	83 W Avg.

Collimation in Transfer Line	8 GeV Linac			Spallation Neutron Source
BETATRON COLLIMATION IN TRANSFER LINE				
Collimation Type	H-minus halo stripping foils followed by magnets & Dump (like SNS)			
Location	first 3 cells of transferline downstream of Linac			
Number of collimators	12		+/-X, +/-Y at 3 locations each	
Phase advance between stations	60	degrees		
Beta Functions at collimation	76.9	m	scrape at Beta-max in each coord	
Beam Size at Collimators (sigma)	2.0	mm		
Nominal Collimator settings	4.0	sigma	TBD	
	8.0	mm	radial from beam center	
Disposal of Collimated Particles	downstream absorber			
MOMENTUM COLLIMATION IN TRANSFER LINE				
Number of stations	2			
Location	midpoint of each arc (dispersion max)			
Dispersion at Collimation Point	8.85	m		
Collimation Type	H-minus halo stripping foils followed by magnets & collimators			
Number of collimators per station	2		+/-X	
Beta Function (X) at collimators	76.9	m		
Betatron Beam Size at Collimators (sigma)	2.0	mm	same in X and Y	
Nominal Collimator settings (betatron)	5.0	sigma	TBD	
	10.1	mm	from beam center	
Nominal dP/P acceptance of Collimation	+/-0.11	%	for no betatron amplitude	
dP/P acceptance of Main Injector ring	+/-0.75	%	measured, at injection	
dP/P acceptance for MI Transition Crossing	+/-0.20	%	0.7 eV-S per 19ns bucket	

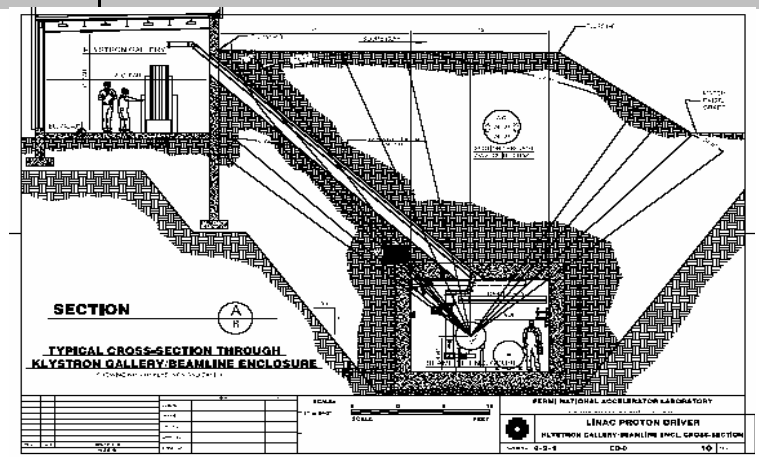
DEBUNCHER	8 GeV Linac				Spallation Neutron Source
Status	INCLUDED IN BASELINE DESIGN & COST				REMOVED FROM BASELINE?
Location (Distance from end of linac)	640	m			
Number of Cavities	16				
Cavity Type	Room-Temperature Copper TESLA cavities				
Frequency	1300	MHz			
Cooling	LCW		Already there for Klystron		
Beam Energy (kinetic)	8	GeV	gamma=	9.51	
Gamma-T of transport line from linac	38		eta=	0.010363037	
Maximum dP/P for correction w/o feedback	0.4%		40	MeV	
Phase Err at Debuncher from max dP/P	41	deg	1300 MHz sine is adequately linear		
Voltage required for 100% energy correction	61	MV	7.6	MV/cavity	
Dispersion at Debuncher cavity	<0.5	m	DPx also small		
Feedback	optional		debuncher can run open loop during the pulse		
Resonance Control	vector sum of 16 copper cavities				
Energy Spreader Cavity	none		modulate linac LLRF if necessary		REMOVED FROM BASELINE?

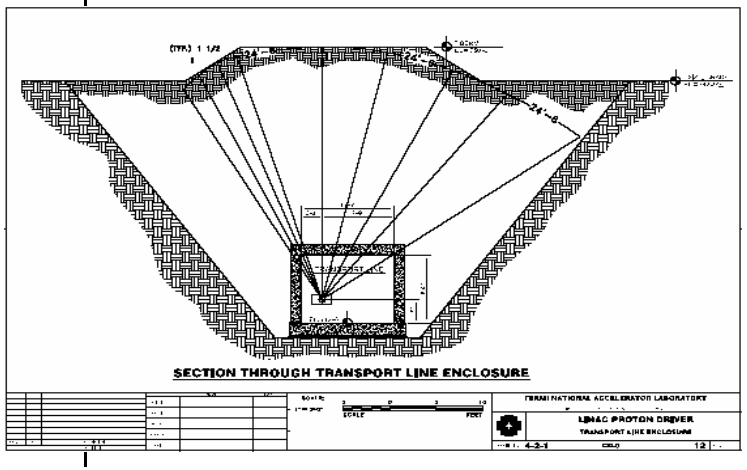
LINAC BEAM STOP	8 GeV Linac					Spallation Neutron Source
Model for Cost Estimate	Main Injector Beam Dump					
Location	Straight downstream of Linac, outside of transferline bend					
Beam Energy	8	GeV	electrons, H-, or (stripped) Protons			
Average Total Beam Power (max)	2	MW				
Core Material	graphite/aluminum					
Shielding Material	steel/cement					
Cooling	RAW, heat exchaged with Tunnel LCW in beam stop enclosure					
RAW Circulation Flow at Full Beam Power	1500	liters/min	396	GPM	(Peak Demand)	
RAW Delta-T	20	deg C	36	deg F		
LCW Flow	549	liters/min	145	GPM		
LCW Delta-T	10	deg C	18	deg F		

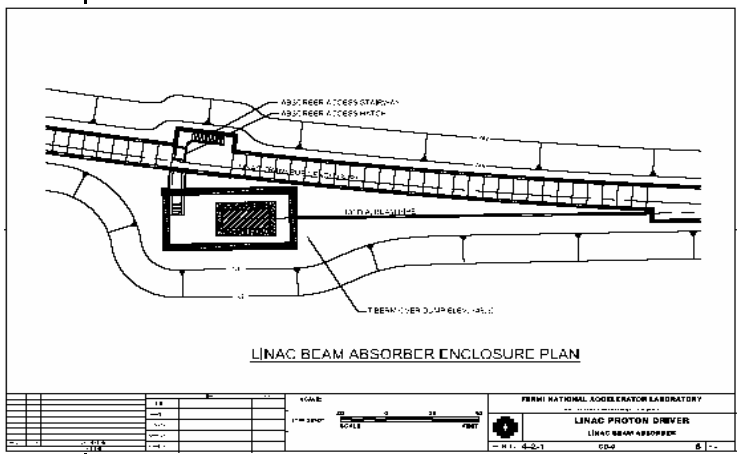
H- INJECTION TO RING	8 GeV Linac			Spallation Neutron Source		
Injection Point	MI-10 Quad Location (F)					
Injection Bend	Vertical					
Injection Method	Foil Stripping					
Number of turns	270 (90)					
Injection Painting Method	uncorrelated					
Foil Material	Diamond					
Foil Thickness	1	micron				
Peak Temperature of Foil	2500	degK	TBD			

Emittances & Alignment	8 GeV Linac			Spallation Neutron Source		
Output H & V rms emit. w/errs, w/o jitter		pi mm-mrad		0.41	pi mm-mrad	
Output transverse centroid jitter		mm		+/- 0.25	mm	
Output H & V rms emit. w/errs & jitter		pi mm-mrad		0.45	pi mm-mrad	
Output L rms emit. w/errs		pi MeV-deg	At 1300 MHz; 99.99%	0.6	pi MeV-deg	At 805 MHz
Output rms energy spread		MeV		0.33	MeV	
Maximum output energy jitter		MeV	99.99%	+/- 1.5	MeV	99.99%
Maximum phase centroid jitter		deg	At 1300 MHz; 99.99%	+/- 3.7	deg	At 805 MHz; 99.99%
Beam halo outside 5 sigma transv.				< 1x10-4		
Beam residual inside chopper gap				< 1x10-4		
Quad gradient err rms max		%	Limit +/- 0.25 %	0.14	%	Limit +/- 0.25 %
Quad transverse err rms max		mm	Limit +/- 0.13 mm	0.07	mm	Limit +/- 0.13 mm
Quad roll rms max expected		mrad	Limit +/- 5 mrad	3	mrad	Limit +/- 5 mrad
Quad tilt rms max expected		mrad	Limit +/- 10 mrad	6	mrad	Limit +/- 10 mrad

Underground Construction	8 GeV Linac		
LINAC BEAM LINE TUNNEL			
Comparable Tunnels(s)	SNS Beam Line Tunnel & Main Injector MI-60 RF Straight Section		
Width (inside)	15.00 ft	4.57 m	1' wider than SNS, same width as MI-60
Height (inside)	11.00 ft	3.35 m	1' taller than SNS, 2' taller than MI-60
Length (total)	**2369 ft**	**722 m**	
Drop Hatch & Front-end Bldg	98 ft	30 m	
Front End & Warm Linac	138 ft	42 m	
SCRF Main Linac	2133 ft	650 m	
Location	Inside Main Ring		
Altitude of floor above sea level	713.5 ft	217 m	Main Injector Depth
Floor Depth Below Grade	29 ft	8.8 m	In plane of Main Injector
Berm Height above Grade	4 ft	1.22 m	unnecessary for first 250m of linac
Number of Microwave Chases	31		one per "Ultimate" Klystron location
Stairwell spacing for Personnel Egress (typ.)	500 ft	152 m	8 total Including Transfer line & Buildings
Bend	none		
Equipment Drop Hatch	one, 20m long for possible 17m Cyromodules, downstream end of linac		
BEAM TRANSFER LINE TUNNEL			
Comparable Model	Main Injector MI-8 Transfer Line Tunnel		
Width (inside)	10.00 ft	3.05 m	same as MI-8 Tunnel
Height (inside)	8.00 ft	2.44 m	same as MI-8 Tunnel
Length (total)	**3190 ft**	**972 m**	
Matching Straight	87 ft	27 m	Downstream of linac
Collimation & Analysis Straight	424 ft	129 m	
First Collimation Bend	849 ft	259 m	20-degree Right bend at 700m radius
Debuncher Straight Section	849 ft	259 m	Straight Section upstream of Debuncher
Second Collimation Bend	849 ft	259 m	20-degree Left bend at 700m radius
Matching Straight	133 ft	41 m	Matching section into MI-10 injection point
Location	Between Linac and MI-10 Straight Section		
Altitude of floor above sea level	713.5 ft	217 m	Main Injector Depth
Floor Depth Below Grade	29 ft	8.8 m	Main Injector Depth
Berm Height above Grade (typ)	4 ft	1.22 m	Provides 26' minimum earth equiv. shielding
Stairwell spacing for Personnel Egress	500 ft	152 m	3 total (TBD)
Beam Line Elevation Above Floor	2.25 ft	0.69 m	Same as Main Injector
Beam Line Distance out from wall	2.25 ft	0.69 m	Same as MI-8 Line
Equipment Drop Hatch	shared with Linac, at downstream end of linac tunnel		
BEAM STOP ENCLOSURE			
Comparable Model	Main Injector Beam Stop Enclosure		
Height	18.30 ft	5.58 m	
Width	23.00 ft	7.01 m	
Length	52 ft	160 m	
Altitude of floor above sea level	705.00 ft	214.88 m	9 ft. below Tunnel Floor, same as MI dump
Floor Depth Below Grade	38.00 ft	11.58 m	
Beam Line Height above Floor	7.00 ft	2.13 m	
Personnel Egress	(1) exit to beam transport line tunel (same as MI)		
Drop Hatch	TBD		







Above Ground Construction	8 GeV Linac		
FRONT-END BUILDING			
Comparable Model	Main Injector E-cool Service Building (MI-31)		
Location	at head of Linac		
Length (along Beam Line Direction)	125.00 ft	38.10 m	TBD -smaller if no major eqpt drop
Width (perp. To Beam Line)	50.00 ft	15.24 m	TBD -smaller if no major eqpt drop
Height (overall)	30.00 ft	9.14 m	smaller over office space
Height (crane hook height)	23.00 ft	7.01 m	needed for Klystron Replacement
Area with Crane Coverage	50 x 75ft		no coverage over office area
Garage Door height for Equipment	15 ft	4.57 m	
Equipment Drop Size	TBD		cryomodules droped from downstream end
Crane Payload	20 tons		
Freight Elevator	like MI-60		
Floor altitude above sea level	742.0 ft	226.2 m	same as Klystron gallery
Personnel Doors for Egress	4		
Parking Lot	paved for 10 cars; unpaved for ~40		
KLYSTRON GALLERY			
Comparable Model	MI-30 Service bulding, stretched to length of linac		
Width (inside)	**18.00 ft**	**5.49 m**	8ft aisle +6ft modulator +4ft back aisle
Aisle Width	8.00 ft	2.44 m	
Modulator Width	6.00 ft	1.83 m	modulator is bigger than klystron or rack
Back Side Aisle Width	4.00 ft	1.22 m	permits modulator chassis door opening
Height (inside, clear, typical)	12.00 ft	3.66 m	to bottom edge of roof joists
Height (inside, immediately above Klystrons)	13.00 ft	3.96 m	needed for replacing 1300 MHz Klystron
Length (total)	2461 ft	750 m	Front-End Bldg. to end of Linac
Floor altitude above sea level	742 ft	226.2 m	2' above "100 Year Flood Level"
Door Spacing for Personnel Egress	500 ft	152.40 m	6 total (shared with beamline enclosure)
Crane Coverage	none		Klystron Service w/ fixture like existing linac
WATER PUMP BUILDING			
Comparable Model	Main Injector MI-60 Pump Room		
Location	Attached to downstream end of Klystron Gallery		
Length (along Beam Line Direction)	50.00 ft	15.24 m	
Width (perp. To Beam Line)	50.00 ft	15.24 m	
Height (overall)	14.00 ft	4.27 m	
Height (inside clear)	12.00 ft	3.66 m	
Garage Door height for Equipment	12 ft	3.66 m	
Floor altitude above sea level	742.00 ft	226.16 m	not critical
Parking Lot	paved for 6 cars		
Power Transformers installed Nearby	1MW		

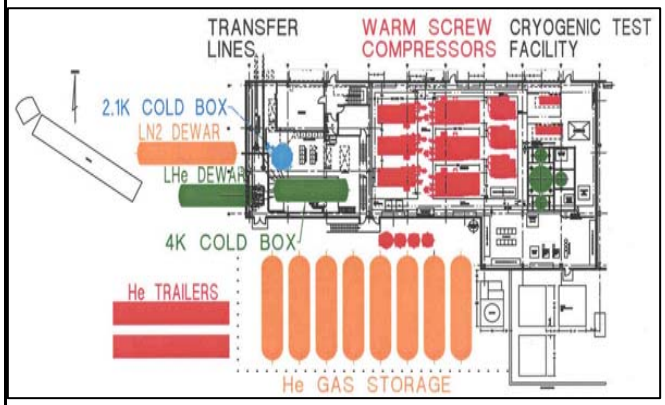
Front-End Building
Plan View

Above Ground Construction	8 GeV Linac		
TRANSPORT LINE SERVICE BUILDING			
Comparable Model	MI Power Supply Building		
Location	~1/3 of the way along transfer line		
Length (along Beam Line Direction)	40.00 ft	12.19 m	
Width (perp. To Beam Line)	40.00 ft	12.19 m	
Height (inside clear)	10.00 ft	3.05 m	
Area with Crane Coverage	none		
Area for Office Space	none		
Garage Door height for Equipment	10 ft	3.05 m	
Floor altitude above sea level	742.00 ft	226.16 m	not critical
Personnel Doors for Egress	2		
Parking Lot	paved for 4 cars		
Power Transformers installed Nearby	<1 MW		
DEBUNCHER SERVICE BUILDING			
Comparable Model	MI Power Supply Building		
Location	Near Debuncher (~2/3 of the way along transferline)		
Length (along Beam Line Direction)	50.00 ft	15.24 m	
Width (perp. To Beam Line)	50.00 ft	15.24 m	
Height (overall)	14.00 ft	4.27 m	needed for changing out 1300 MHz Klystron
Area with Crane Coverage	none		special crane for Klystron change
Area for Office Space	none		
Garage Door height for Equipment	12 ft	3.66 m	
Floor altitude above sea level	742.00 ft	226.16 m	not critical
Personnel Doors for Egress	2		
Parking Lot	paved for 4 cars		
Power Transformers installed Nearby	1 MW		modulator is 300 kW
CRYOPLANT BUILDING			
Comparable Model	SNS Cryoplant Bldg (Metal sided building w/crane) (use for cost)		
Location	At break between 4K / 325MHz Spokes and 2K Ellipticals		
Length (along Beam Line Direction)	125.00 ft	38.10 m	
Width (perp. To Beam Line)	50.00 ft	15.24 m	
Height (overall)	30.00 ft	9.14 m	
Height (crane hook height)	20.00 ft	6.10 m	
Area with Crane Coverage	TBD		
Area for Office Space	TBD		
Garage Door height for Equipment	15 ft	4.57 m	
Floor altitude above sea level	742.00 ft	226.16 m	not critical
Personnel Doors for Egress	3 - 4		
Parking Lot	paved for 15 cars + 2 Gas Trucks		
Power Transformers installed Nearby	4MW		~2MW cryo + 0.5MW water pumps + spare
Gas Storage Tanks Outside	~8		
Liquid He Storage Tank	TBD gal		
Liquid N2 Storage Tank	TBD gal		
Transferline to Tunnel			

Transport Line
SERVICE BLDG
Plan View

Debuncher
SERVICE BLDG
Plan View

SNS CRYOPLANT BUILDING



GALLERY LCW LOADS	8 GeV Linac Initial {multiply GPM x3 for ULTIMATE}				
325 MHz RF STATIONS					
Modulator Chassis	10 kW	9.7 l/m	2.6 GPM	15 degC	
Pulse Transformer	3 kW	2.9 l/m	0.8 GPM	15 degC	
Number of Klystrons/modulator	1				{2 Ultimate}
Klystron Collector	26 kW	113.6 l/m	30.0 GPM	3 degC	Toshiba
Klystron Body	8 kW	9.1 l/m	2.4 GPM	15 degC	Toshiba
Klystron Solenoids	10 kW	10.0 l/m	2.6 GPM	15 degC	Toshiba
325 MHz RF Station Total	*57 kW*	145.19 l/m	*38.4 GPM*	*15 degC*	
Number of 325 MHz Rf Stations	1				
Total all 325 MHz RF Stations In Gallery	**57 kW**	**145.2 l/m**	**38.4 GPM**	**5.6 degC**	
1300 MHz RF STATIONS					
Modulator Chassis	34 kW	32.3 l/m	8.5 GPM	15 degC	
Pulse Transformer	3 kW	2.9 l/m	0.8 GPM	15 degC	TESLA TDR
Klystron Collector	103 kW	250.0 l/m	66.1 GPM	6 degC	Thales
Klystron Body	8 kW	10.0 l/m	2.6 GPM	11 degC	Thales
Klystron Solenoid	5 kW	10.0 l/m	2.6 GPM	7 degC	Thales
1300 MHz RF Station Total	*153 kW*	*305.2 l/m*	*80.6 GPM*	*7.2 degC*	
Number of RF Stations	11		Linac+debuncher		{31 Ultimate}
Total all 1300 MHz RF Stations	**1681 kW**	**3357.0 l/m**	**887 GPM**	**7.2 degC**	

TUNNEL LCW LOADS	8 GeV Linac Initial {multiply GPM x3 for ULTIMATE}			
RFQ+DTL+SPOKE RF LCW Loads	**26 kW**	**25 l/m**	**7 GPM**	**15.0 degC**
1300 MHz Cavity LCW Loads	One Circuit for (Circulator + Ferrite Tuner +Water Load Absorber) in series			
Number of Cavity RF Stations in Tunnel	392	assume all stations are equal to worst case (pessimistic)		
Circulator	0.2 kW			
Ferrite Tuners	0.4 kW	sum of 2 tuners with 0.2dB total losses		
Water Load	3.6 kW			
Total per Cavity	*4.1 kW*	*4.0 l/m*	*1.0 GPM*	*15 degC*
Total for all Cavity Stations in Tunnel	**1623 kW**	**1550.5 l/m**	**409.6 GPM**	**15.0 degC**
BEAM DUMP RAW System (Initial)	**575 kW**	**549 l/m**	**145 GPM**	**15 degC**
Beam Stop Location	Along Transfer Line to Ring			
Pump & Heat Exchanger Location	In Beam Dump Enclosure			
Beam Heat Load (nominal)	0.5 MW	{2 MW Ultimate}		
Beam Heat Load (design)	2 MW	design for Ultimate		
Beam Heat Load (typical)	<10 kW	typical during running		
RAW Pump Heat Load	75 kW	100 HP WAG		
Heat Exchanger	With Downstream LCW flow in tunnel			

LCW SYSTEM TOTALS	Heat Load (worst-case)	FLOW		Delta-T
Klystron Gallery Header Totals (initial)	1738 kW	3502 l/m	925 GPM	7.1 degC
Linac Tunnel Header Totals (initial)	1649 kW	1576 l/m	416 GPM	15.0 degC
Test Stand LCW Totals (initial)	210 kW	450 l/m	119 GPM	6.7 degC
RAW HTX Header Total (initial)	575 kW	549 l/m	145 GPM	15.0 degC
INITIAL LCW SYSTEM	**3597 kW***	**6077 l/m**	**1606 GPM**	**8.5 degC**
ULTIMATE LCW SYSTEM	**10372 kW***	**16233 l/m**	**4289 GPM**	**9.2 degC**
LCW Supply Temperature (nominal)	32 degC	90 degF		
LCW Max. Temp (anywhere in system)	47 degC	117 degF		

** note: Worst-Case Heat Load of entire LCW system is less than the sum of the individual worst cases.*

Wall Power Summary

8 GeV Linac

Spallation Neutron Source

	INITIAL (0.5 MW Beam)		ULTIMATE (2.0 MW Beam)	
	Nominal [MW]	Installed [MVA]	Nominal [MW]	Installed [MVA]
RF Stations	2.700	6.000	10.000	18.000
Cryogenics	1.371	2.057	1.070	1.682
LCW Pump Power	0.300	0.471	0.400	0.471
Beamline Technical	0.082	0.219	0.082	0.219
Conventional Power @600 W/m *	1.044	1.228	1.264	1.448
TOTAL	**5.5 MW**	10.0 MW	**12.8 MW**	21.8 MW

*Note: The 600 watts/meter is a Fermilab average for (Tunnel+gallery) conventional power including instrumentation