Accelerator Laboratory, KEK

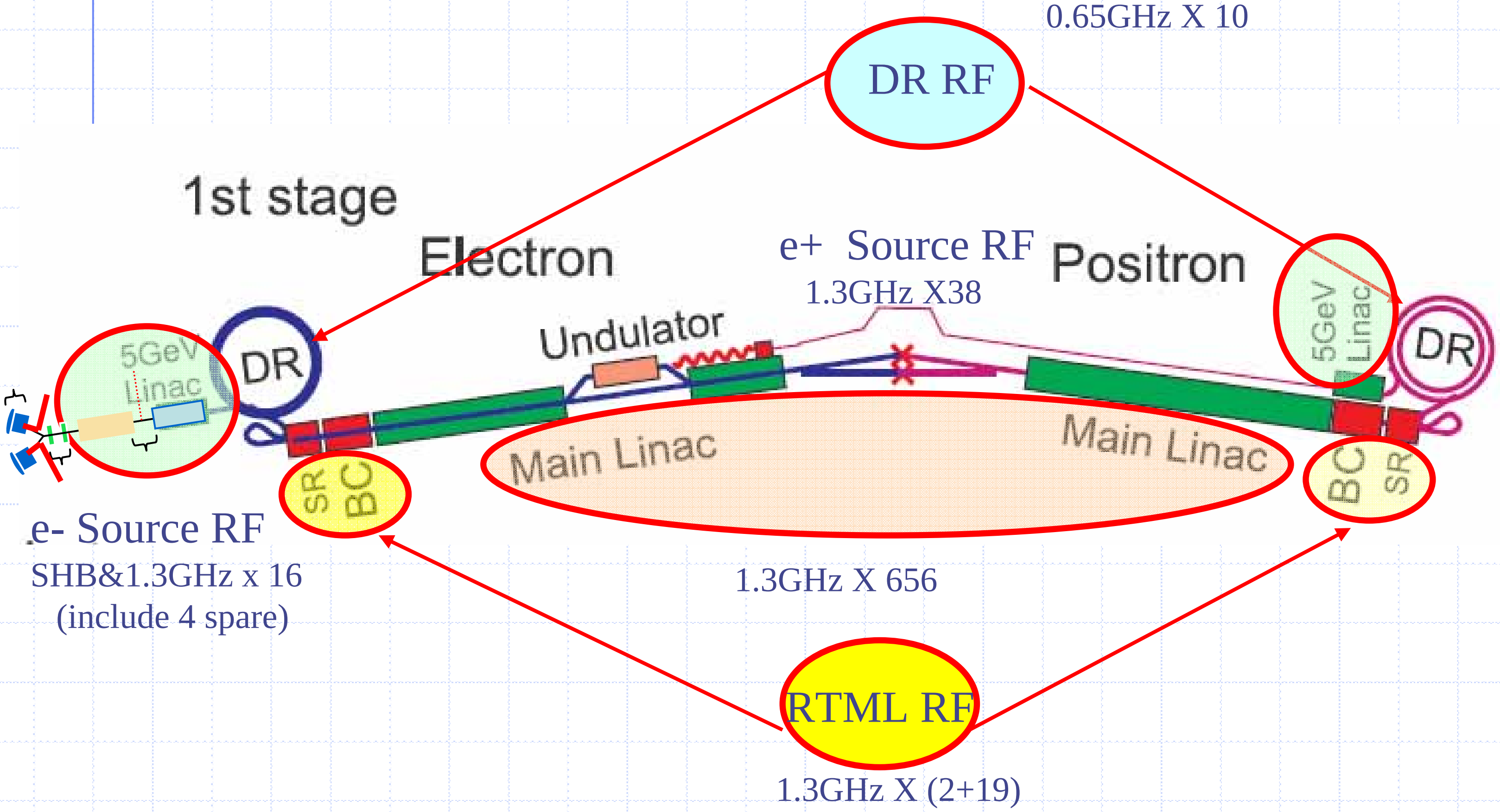
RF Power Technical Systems

S.Fukuda(KEK), R. Larsen(SLAC)

Content

Accelerator Laboratory, KEK

ILC General Layout and RF System



POC of ILC RF Technical System

General contact person: Shigeki Fukuda

Area Systems	e-Sources	e+Sources	Main Linacs	Damping Rings	Beam Delivery	RTML
	A. Brachman	J. Sheppard	C. Adolphsen	S. Guiducci	A. Seryi	P. Tennenbaum
RF Power TS	S. Fukuda	S. Fukuda	S. Fukuda	S. Fukuda		S. Fukuda
Systems Integration	R. Larsen	R. Larsen	R. Larsen	R. Larsen		R. Larsen
Klystrons	C. Adolphsen	C. Adolphsen	C. Adolphsen	S. Fukuda		C. Adolphsen
Modulators	C. Jensen	C. Jensen	C. Jensen	KEKB		C. Jensen
RF Distribution	C. Nantista	C. Nantista	C. Nantista	KEKB		C. Nantista
Diag-Intlk-Controls	R. Cassel	R. Cassel	R. Cassel	SLAC		R. Cassel
Safety Systems	SLAC	SLAC	SLAC	SLAC		SLAC
Cost Integration	M. Neubauer	M. Neubauer	M. Neubauer	M. Neubauer		M. Neubauer

- Still lacking Points of Contact from Europe

	Area	Component	US	Asia	Europe
Contact Person			**Ray Larsen**	**Shigeki Fukuda**	**?**
	ML	**Moduilator**	**Chris Jensen**	**Nam SangH**	**?**
				M. Akemoto	**?**
		Klystron	**C. Adolpsen**	**Shigeki Fukuda**	**?**
		PDS	**C. Nantista**	**S. Kazakov**	**?**
		Diagnosis, C,P	**R. Carssel**	**T. Shidara**	**?**
	RTML		↑	↑	**?**
	e-		↑	↑	**?**
	e+		↑	↑	**?**
	DR		***PEP-II***	**KEKB-RF**	**?**
			R. Larsen		

- It is necessary to share the documents among the regions for drawing, table, and CAD.
- Regular Meeting

ML RF

Progress from the FNAL meeting

- Confirmation of the ML RF System specification based on the BCD. Specifying the changing issues from TESLA BCD.

- Tunnel Layout and the Configuration of RF System are progressed.

Re-design the parts of the modulator, klystron assembly, and waveguide distribution in the service tunnel. Sub-unit Rack systems were listed up.

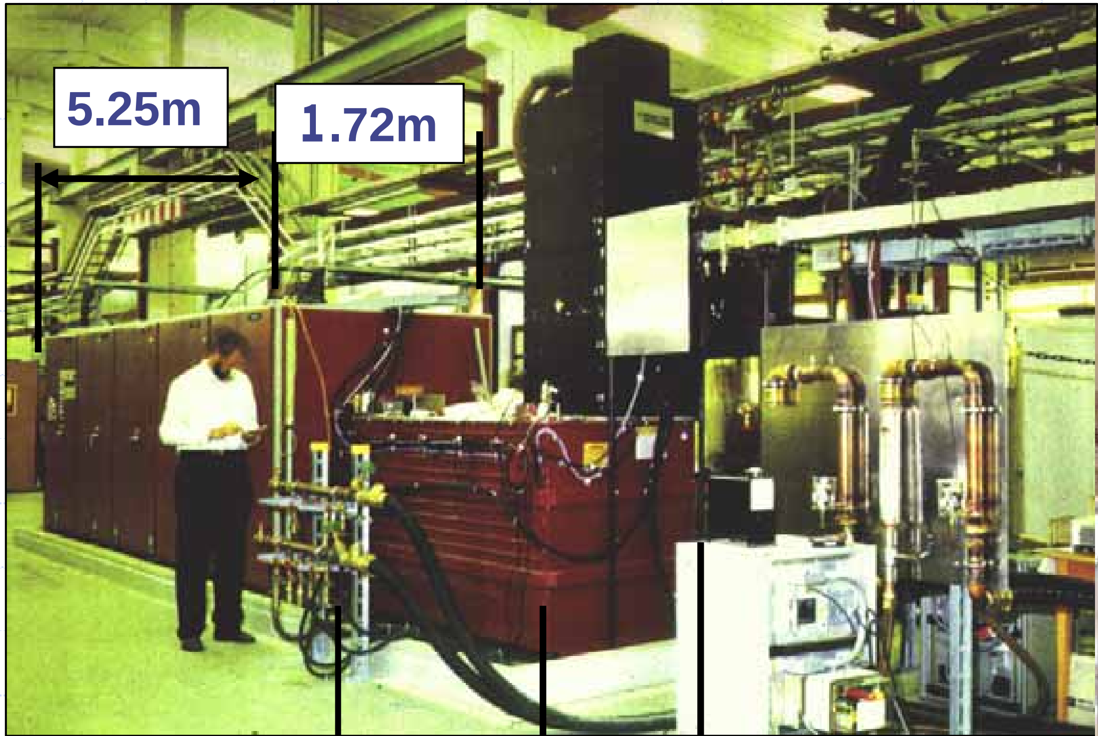
- Water and Air requirement related to the RF System were listed up.

Accelerator Laboratory, KEK

BCD System for ML RF Power Source (excluding LLRF)

Klystron	10MW with double WG ports, 1.3 GHz,
	117kV, 1.5ms(RF),5 Hz Repetition
	Horizontal mounting
Modulator	Solid State SW, 1.7ms(voltage)
	1:12 Pulse Trans. With Bouncer
Power Distribution	10MW is divided into 3 cryomodules of 8 Cavities each.
Total Unit	328 x 2=656 (5% overhead)
Tunnel	Assuming Two Tunnel

BCD Klystron & Modulator Assembly

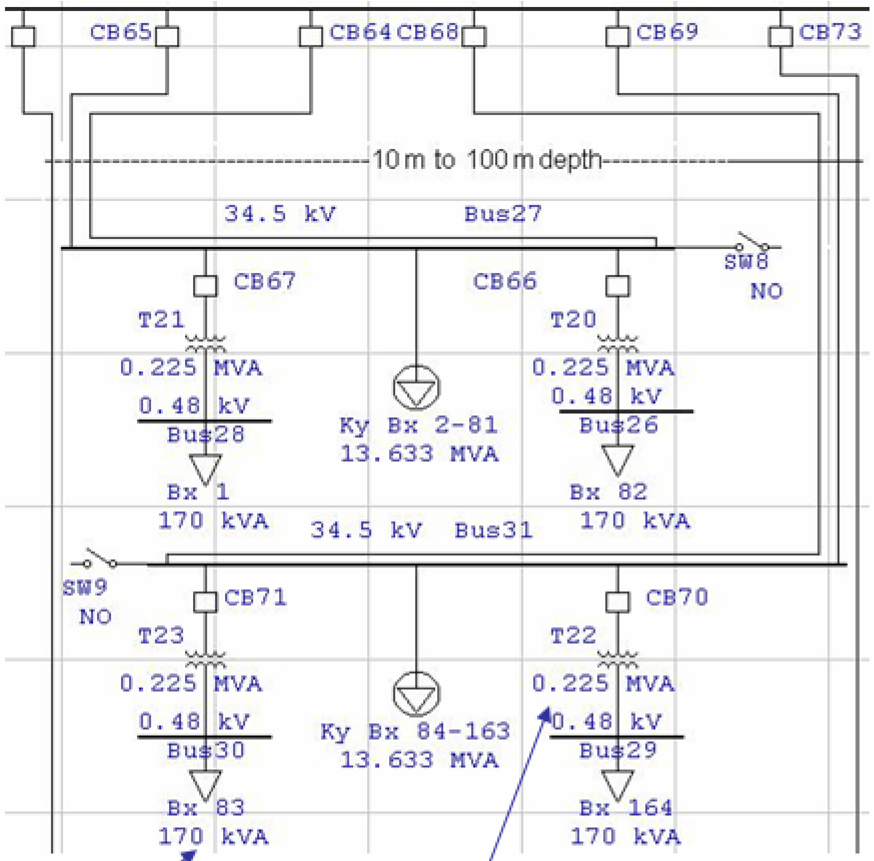


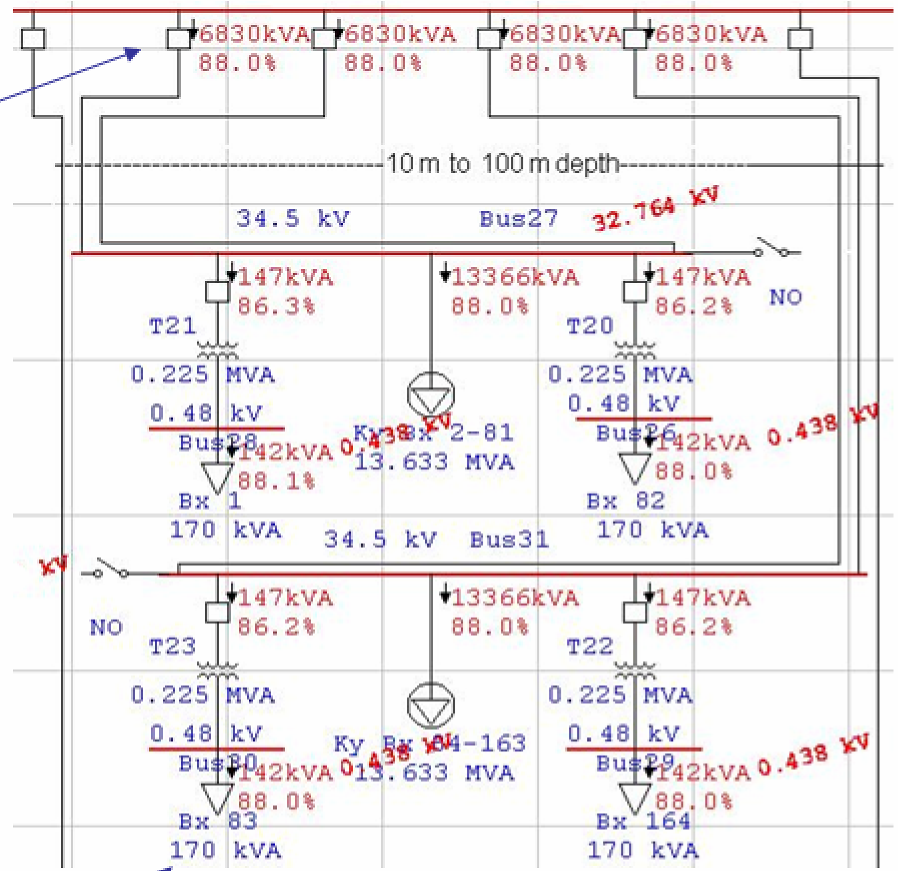
Photos courtesy S. Choraba, DESY

ML
Tunnel Issues

- Tunnel Diameter, which is one of the cost driver, was intensively discussed relating with installing and replacement of the RF components .
- Space consideration for the installing and transporting the biggest component and aisle space consideration were made.
- Modulator components were re-configured and the charging transformer, the single widest components, were re-designed.

AC RF System Power Flow - 164 RF Units





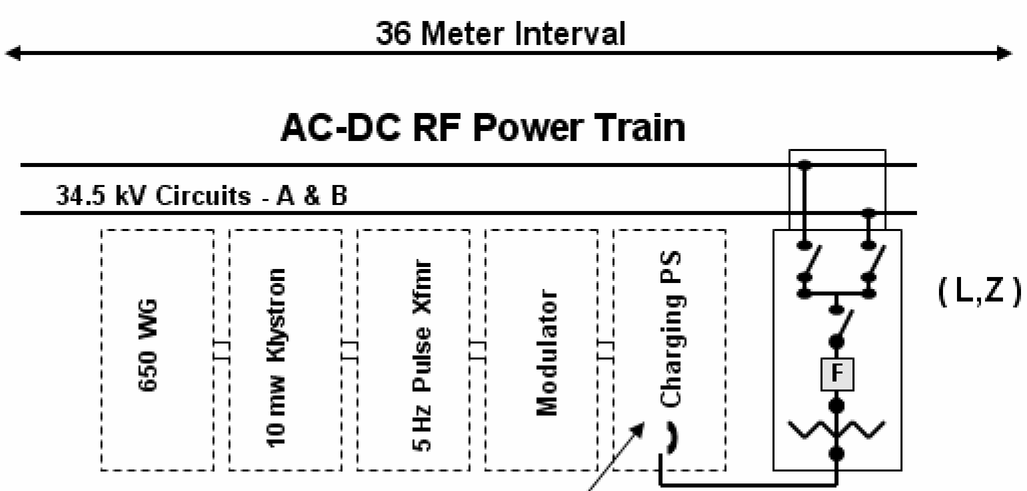
Charging PS:
150kw @ .88 pf Control Regulator Firing Angle = 170 kva
Regulator Control Range Assumed to be 0.85 to 0.90

AC RF Power Transformer:
225 kva FL Rating, 180 kva (80%) Allowed per NEC
%Z= 7.25, X/R= 3.09, @ 225 kva Base

Charging PS:
-8.75% Voltage Excursion @ 438 Volts on 480 Volt Base

34.5 kV Distribution System:
6830 kva (120A) Load @ 32.764 kV on 34.5 kV Base

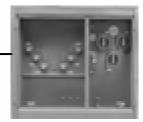
Support Tunnel AC-DC-RF Power System Layout



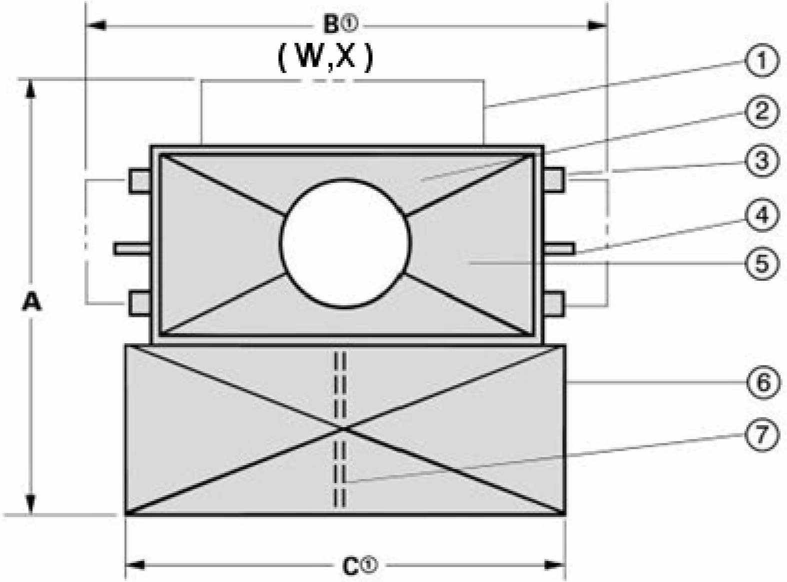
Rack Mounted PS
Double Rack
0.8W x 1.6L x 2.0H m

Power Factor
Passive PFC 0.85 min

Efficiency
Better than 85%



http://www.ppmpower.co.uk/product58.htm

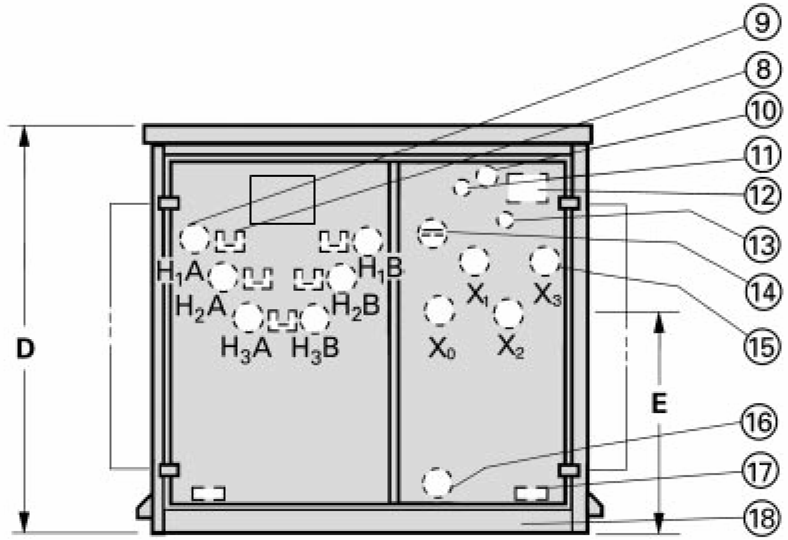


Dimensions in Inches (mm)				
A (L,Z)	B (W,X)	C	D (H,Y)	E
59 (1499)	57 (1448)	53.25 (1353)	49 (1245)	25 (635)

Dimensions in Inches (mm)			Liquid Gal. (Lt)	Approx. Total Wt. With Oil lbs. (kg.)
F	G	H		
29.00 (737)	18.50 (470)	21 (533)	168 (635)	3300 (1497)

Subject to ± 7.5% variation.

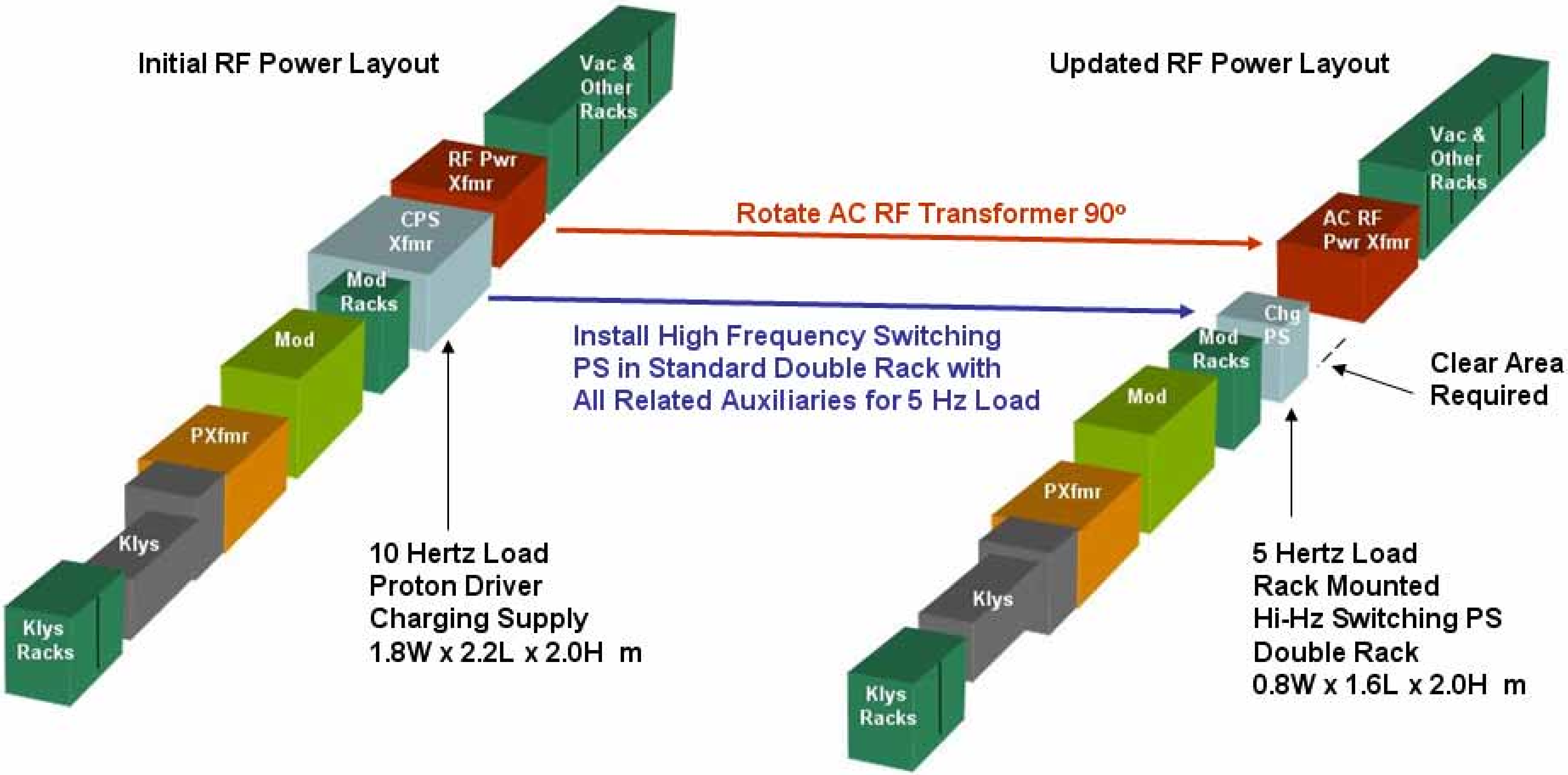
(H,Y)



Dead Front Loop Feed

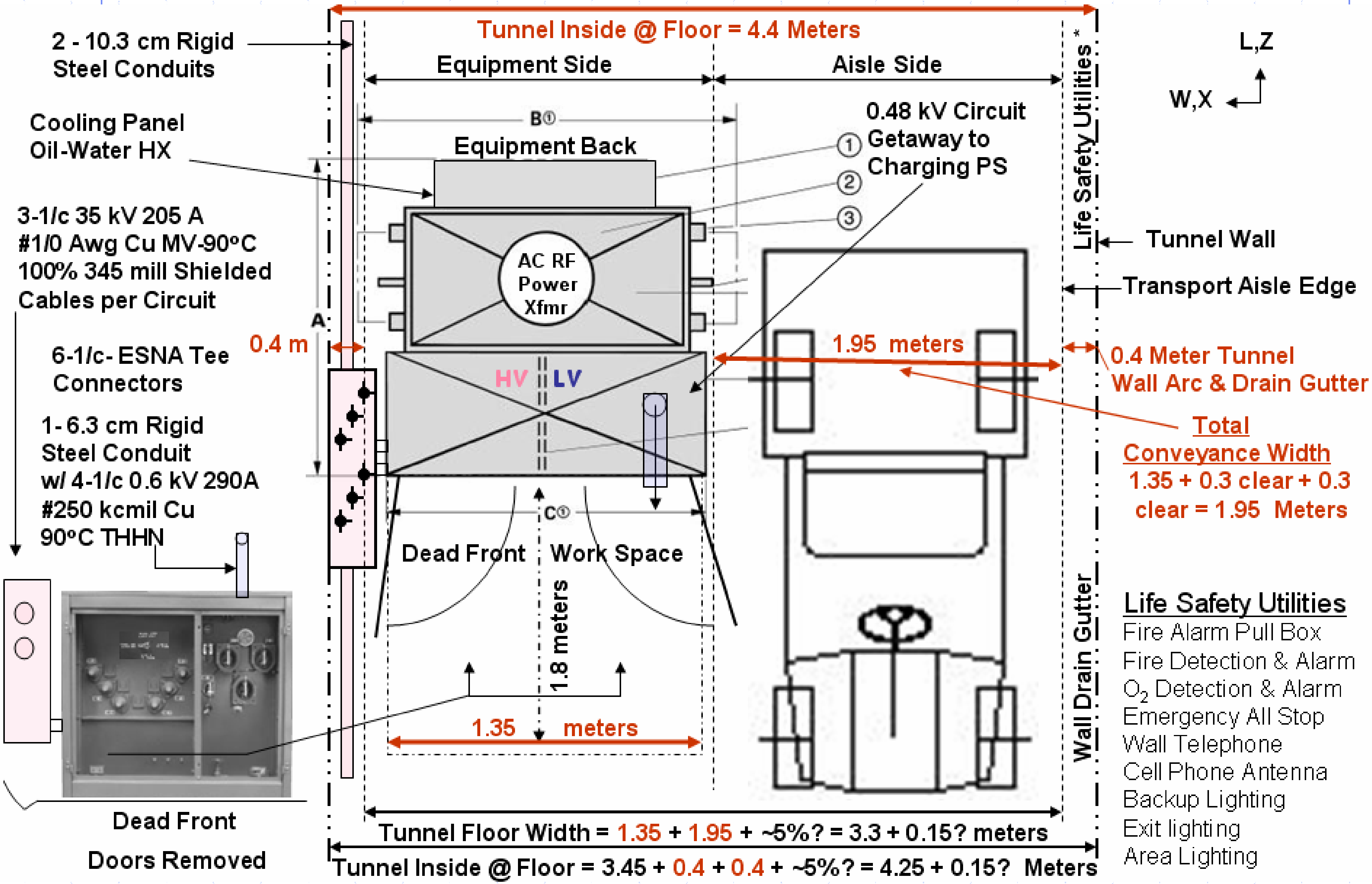
RF Sub-System Design Development

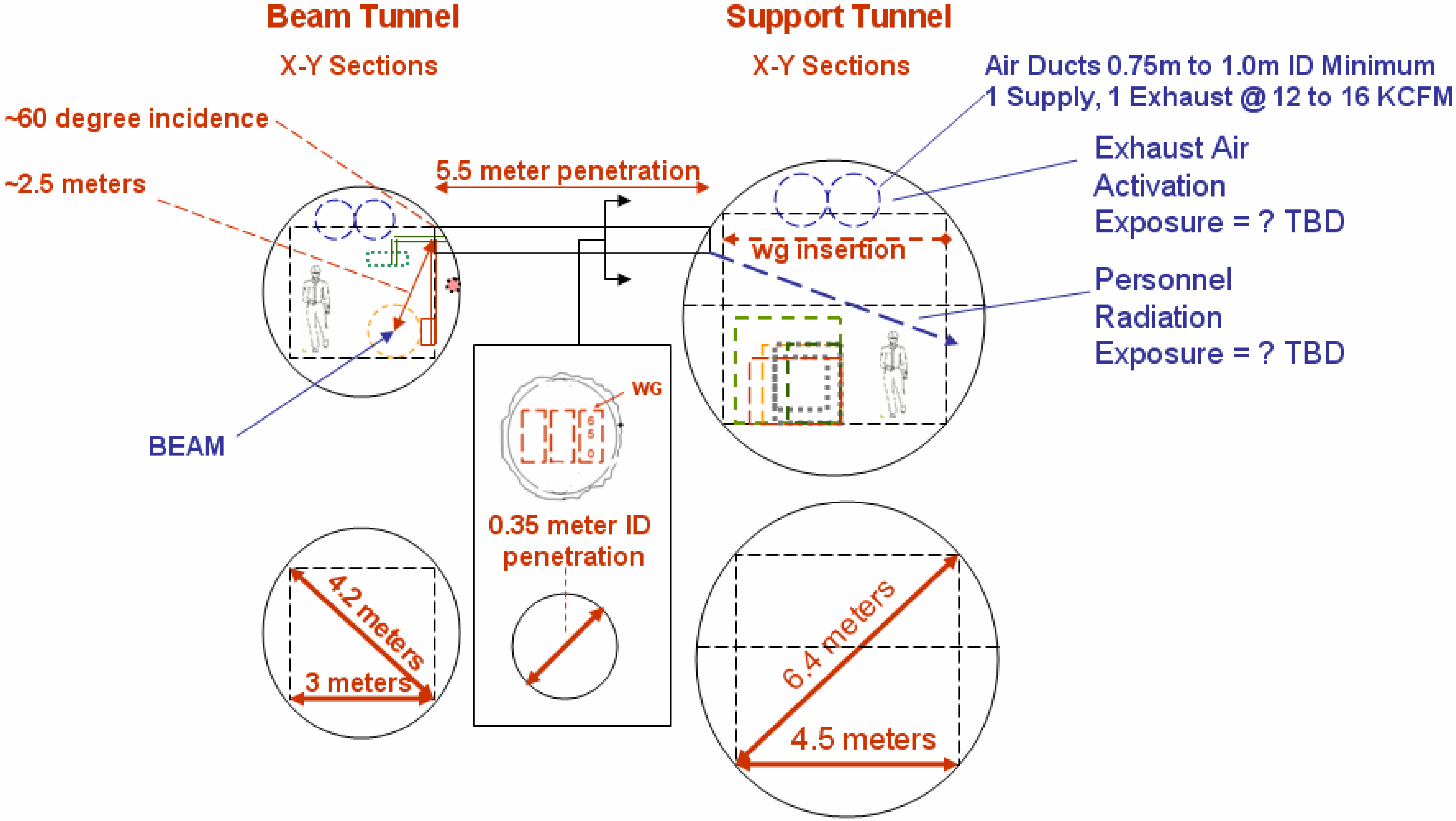
Support Tunnel AC-DC-RF Power System Layout



RF Sub-System Design Development

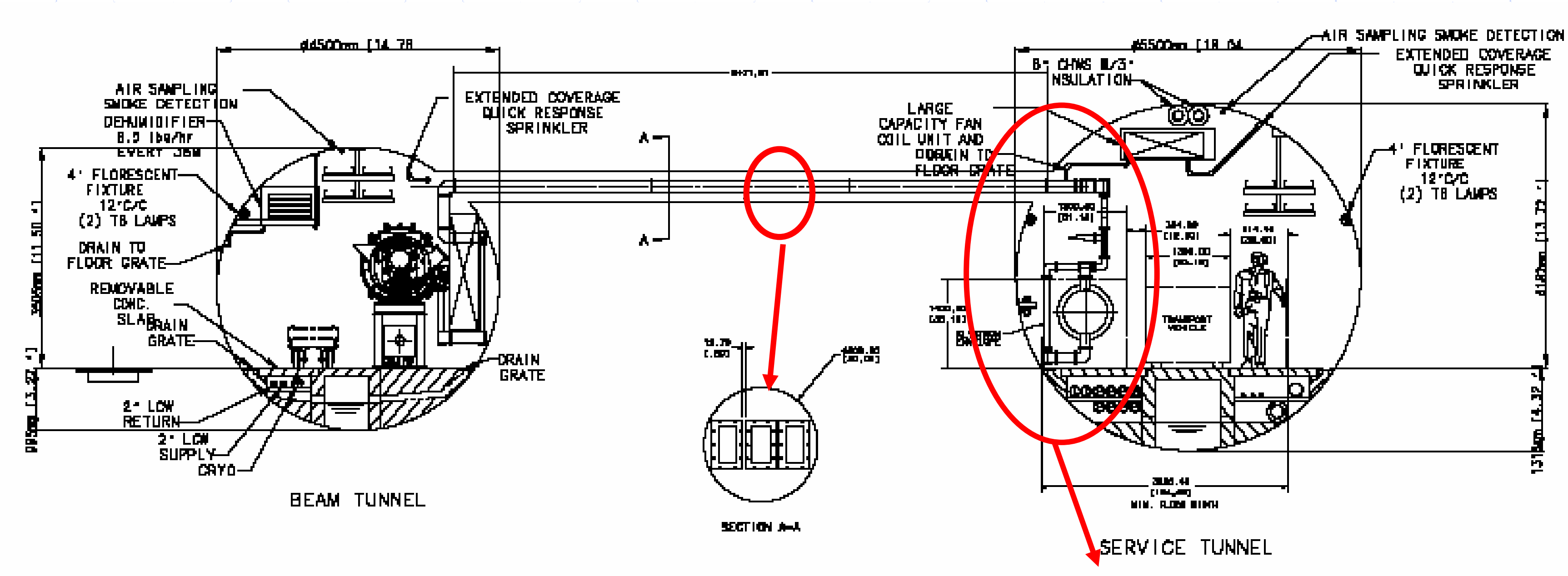
Support Tunnel AC RF Power Transformer

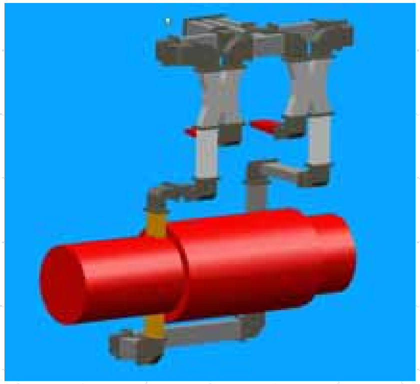




Support Tunnel Inside @ Floor ~ 4.4 Meters w/o
A One meter Personnel Egress Allowance for Equipment Conveyance Obstruction

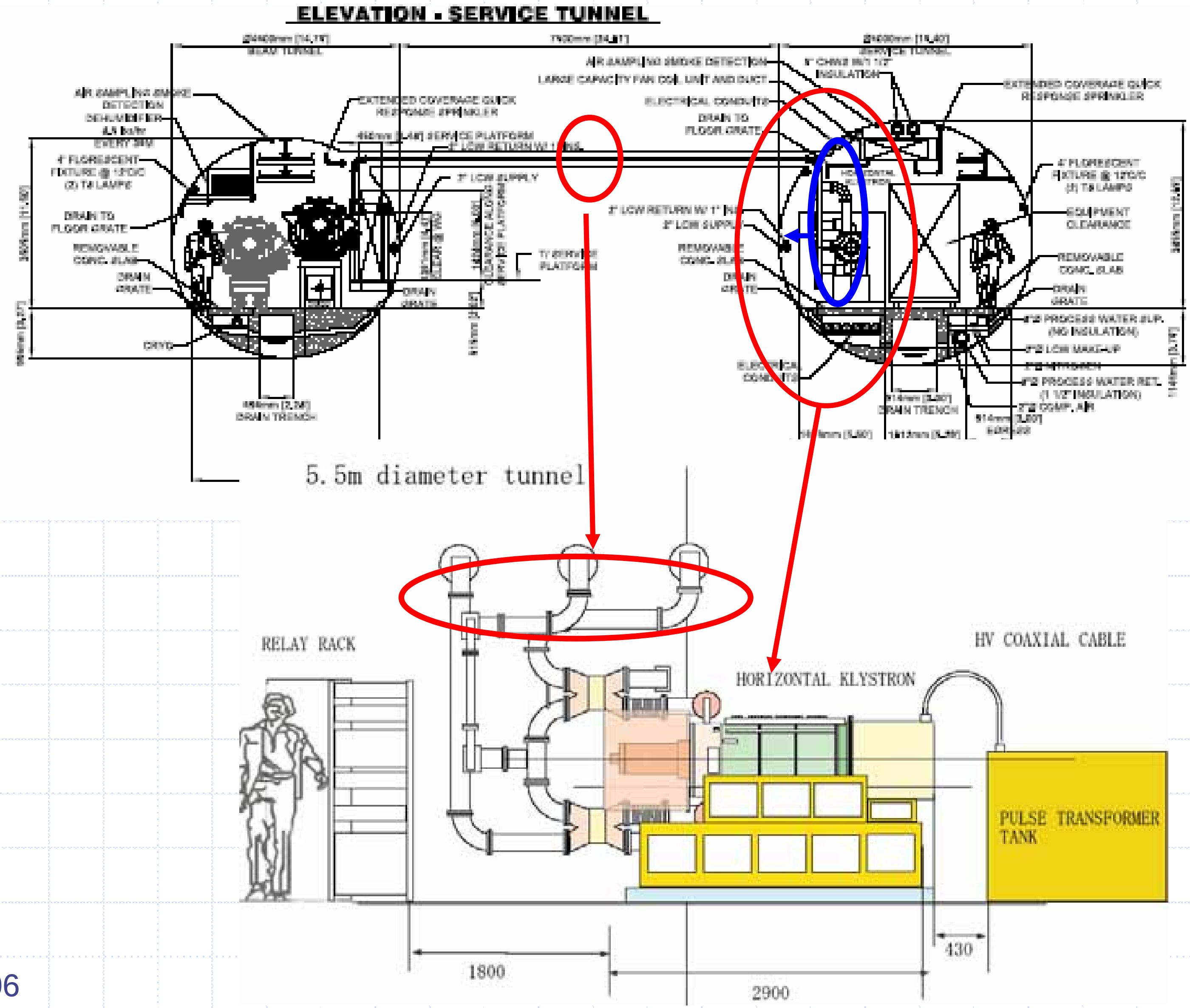
Klystron and Waveguide Layout





Accelerator Laboratory, KEK

Klystron and Waveguide Layout (alt.)



Who will determine the tunnel size?

- Tunnel should meet all Technical System critical requirements.
- RF TS feels that maximum flat floor without buried infrastructure is far preferable and may be comparable in cost to any other design.
- CFE is responsible for design and final selection.

Accelerator Laboratory, KEK

ML
Water requirement for one RF unit

Component	Sub components	piece	Place	Power Dissipation (Av) ends up in the air		Power Dissipation (AV) ends up in water (Nom)		Power Dissipation (AV) ends up in water (Worst)	Flow rat	Pressure	Pressure drop	*Vendor	Source of Data
Unit						kW		kW	liter/min	bar			
Modulator	Charging P/S	1	Klystron Tunnel		*3	5.0		-	15			FNAL	C.Jensen
	Modulator	1	Klystron Tunnel	7.5	*3	7.5		-	15			FNAL	C.Jensen
Pulse Transformer		1	Klystron Tunnel		*3	7.5		-	15			FNAL (Stangenes?)	C.Jensen
MB-Klystron	*1 Collector	1	Klystron Tunnel		*4	63	*8	127.08	250	6.5>	2	Thales	Thales CA1801
	*1 Body/Window	1	Klystron Tunnel		*5	11		-	10	6.5>	5	Thales	Thales CA1801
	*1 Focus Coil		Klystron Tunnel			8.4		-	10	6.5>	1.5	Thales	Thales TH20584
	*1 Collector		Klystron Tunnel			(63)		-	(170)	1 0>	0.3	Toshiba	Toshiba Hayashi
	*1 Body/Window		Klystron Tunnel			(15)		-	(10)	1 0>	1	Toshiba	Toshiba Hayashi
	*1 Focus Coil	1	Klystron Tunnel			(3.5)		-	(10)	1 0>	1	Toshiba	Toshiba Hayashi
	*1 Collector		Klystron Tunnel			-		-	(?)	?		CPI	Not available now
	*1 Body/Window		Klystron Tunnel			-		-	(?)	?		CPI	Not available now
	*1 Focus Coil		Klystron Tunnel			-		-	(?)	?		CPI	Not available now
Power Distribution	Circulator(5MW/85kW)	2	Klystron Tunnel		*6	(1.37)			10> 10	6>		Ferite	WFHI3-2/Thec. Sheet
	Circulator Dummy	1	Klystron Tunnel		*6	(0.32)	*9	66.56	60> 10	6>		Ferite	WFHI3-2/Thec. Sheet
	Waveguide in service tu	3	Acc. Tunnel /Penetration	2.00	*7								
	Variable Attenuator	3	Klystron Tunnel						?	?	?		?
	Circulator(0.4MW/8kW)	24	Acc. Tunnel	20.33	*7				168 120	6>		Ferite	WFHI3-4/Thec. Sheet
	*2 Waveguide in tunnel		Acc. Tunnel	2.00	*7								Not Water Cooled
Total (K..Tunnel)				9.50		102.4			335				
Total (L..Tunnel)				24.33		20.33			120				

Accelerator Laboratory, KEK

ML

Summary of Heat Load for One RF Unit

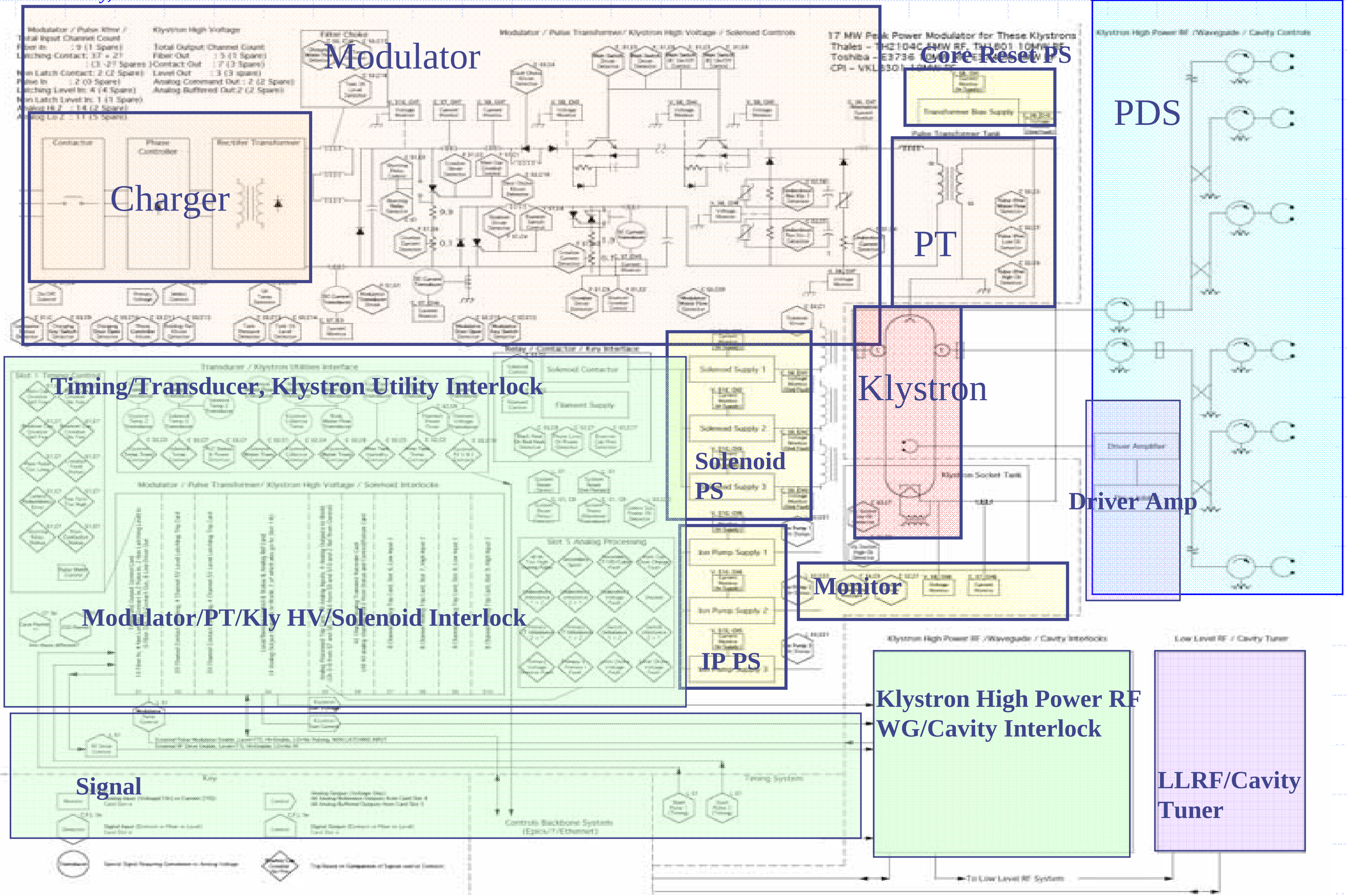
ILC (March 12006)
HEAT LOAD FOR ONE RF UNIT (every 36 meter)

			To Deionized Water					To Air	
	Location	Total Heat Load (KW)	Heat Load to Water (KW)	Supply Temp (C)	Return Temp (C)	Typical (water) pressure drop	Acceptable Temp Variation	Heat Load to Air (KW)	Max Space Temp (C)
Transformer 34.5Kv to 480V (by Clay?)	Service Tunnel	by CFS?							27
Pulse Transformer	Service Tunnel	15.00	7.50					7.5	
Klystron Focusing Coil	Service Tunnel	8.40	8.40	*30>				0	
Modulator	Service Tunnel	15.00	7.50					7.5	
Klystron Collector	Service Tunnel	61.00	61.00	*35>		2		0	
Klystron Body	Service Tunnel	10.00	10.00	*35>		5	+-0.2 deg.	0	
Klystron Windows	Service Tunnel	0.50	0.50	*35>		1		0	
Relay Racks	Service Tunnel	13.25	0.00	N/A	N/A	N/A		13.25	
Charging Supply	Service Tunnel	7.50	7.50					0	
Circulators and Dummy Load	Accelerator Tunnel	24.30	24.30	20-40				0	N/A
Waveguide	Accelerator Tunnel	4.00	0.00	N/A	N/A	N/A		4.00	
Other components?????	????								N/A
Total		158.95	126.70					32.25	

Accelerator Laboratory, KEK

Modulator Control developed

by C. Jensen



ML Sub-Rack List

First estimation

S. Fukuda & H. Hayano

Sub-unit rack

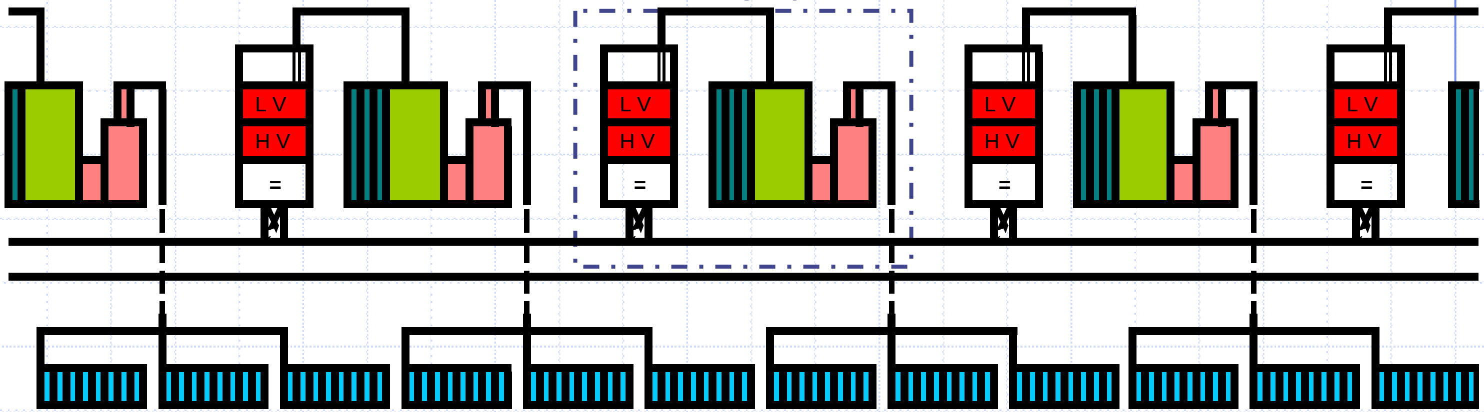
Module	Sub-module	V(Load)	I(Load)	Power (Load)	VA	Comment	Required(VA)	Power ends up in air	Cooling
Modulator control rack (S.Fukuda)									
	PLC								
	Communication								
	Fiber Link						2000	2000	Air Cooling
	NIM or CAMAC BIN								
	BNC Box								
	Relay Sequence Box								
Klystron Support Rack 1 (S.Fukuda)									
	Ion Pomp Power Supply	5kV	5mAMax		100VA	Thales		50	
	Digital Meter Relay				100VA			100	
	Wave Monitor				150VA			150	
	NIM or CAMAC BIN				150VA		4500	150	Air Cooling
	Heater Power Supply	9.5V	43.5A	413VA	600VA	Thales		180	
	DC Core Reset Power	300V	5AMax	1500VA	3000VA	KEK PT		1000	
Klystron Support Rack2 (S.Fukuda)									
	Magnet P/S Controller				300VA			300	
	Magnet power Supply	50V	70A	3500VA	4000VA	Thales	7000	500	Air Cooling
	RF fault detectors/arc detectors				200VA			50	
	interlocks connecting to modulator				200VA			50	
LLRF (S. Michizono)									
	ATCA				500VA			500	
	Piezo Driver				0		3000		Air Cooling
	RF Amplifier				1000VA			300	
	Power Supply for ATAC				750VA			750	
Motor Controller (H. Hayano/02272006)									
	pulse motor controller for ATT/Stub-tuner				2100VA			2100	
	timing reference line/controller/distributer				500VA		4000	200	Air Cooling
	High Power Attenuator Motor				1000VA			300	
Cavity (H. Hayano/02272006)									
	pulse motor controller for input coupler/tuner				1350VA	24ch+24ch		400	
	Piezo tuner controller				1600VA	48ch	3000	550	Air Cooling
	HOM monitor cables				0	48ch			
cryogenics (H. Hayano/02272006)									
Vacuum	cryogenics monitors (temp, pressure, liquid level, etc)				1000VA	24cg+24ch		300	
	Pump PS/controller				900VA	9ch	1500	300	Air Cooling
	gauges				200VA	9ch		200	
BPM (H. Hayano/02272006)									
control	BPM signal process electronics with CPU/LAN				1000VA	3ch		1000	
	interface-bus unit with CPU/LAN				500VA			500	
	acc. Safty & MPS interface unit with optical link				500VA			500	
Magnet (H. Hayano/02272006)							5000		Air Cooling
	Q-mag PS				1000VA	6U		200	
	corrector PS				2000VA	6U+6U=12		600	
							30000	13230	

RF Sub-System Design Development (SLAC)

RF Support Tunnel Layout – BCD Model

DESY RF Support Tunnel

← Iso-graphic View



328 Disconnects (1 per)
328 RF Pwr Transformers
984 Control Racks (dbl)
328 DESY Modulators
328 10 MW Klystrons
328 Primary RF Switch
2 Primary Power Loops

984 8 Cavity Cryomodules (3 per cluster)

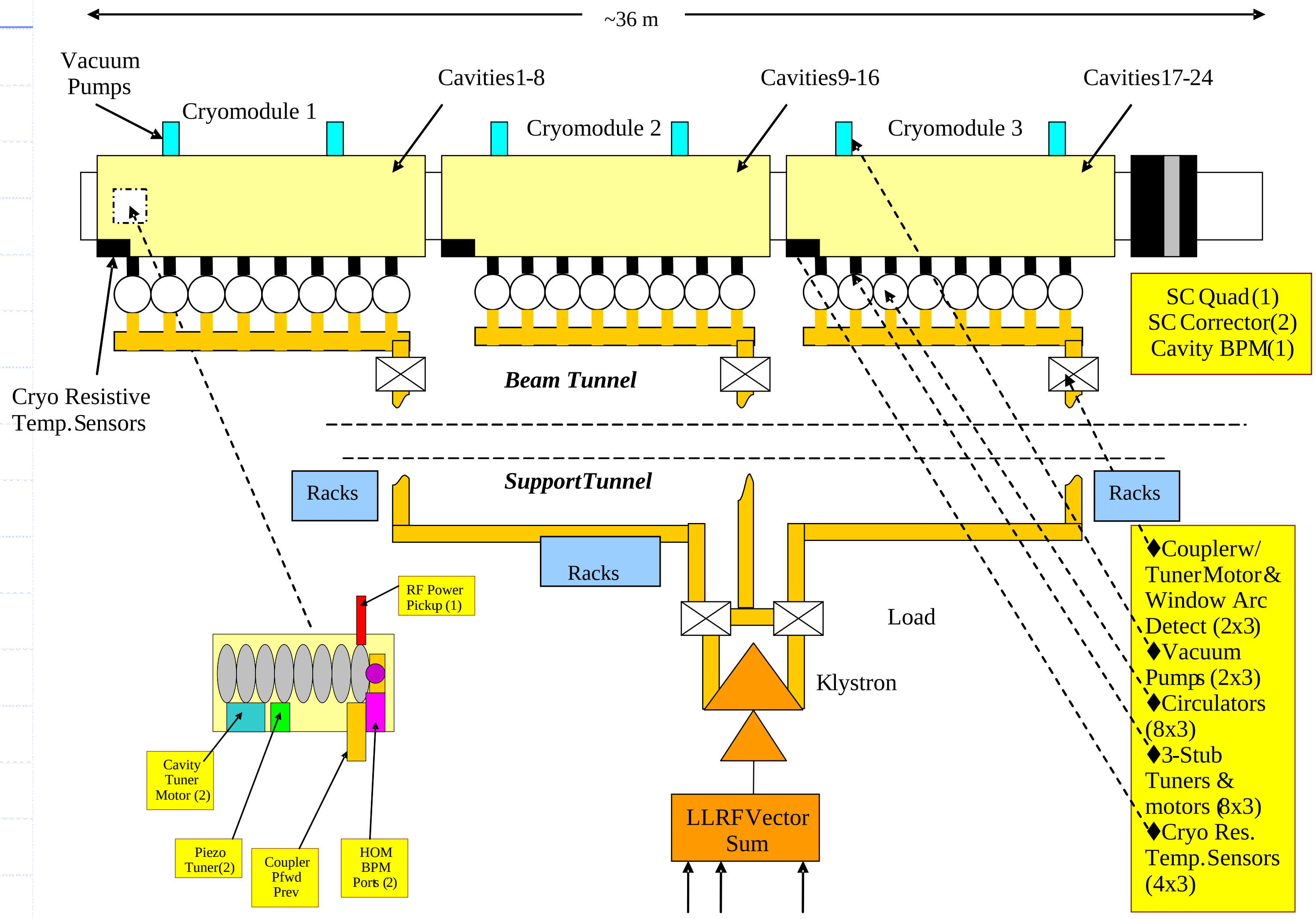
3 x 12 meters = 36 meters | 3 x 12 meters = 36 meters | 3 x 12 meters = 36 meters | 3 x 12 meters = 36 meters

82	RF Power Unit	RF Power Unit = 144 meters
1	RF Power System	Total 250 GeV Linac RF Length: 82 x 144 meters = 11,808 meters
2	Cryo Refrigerators	Total 250 GeV Linac Cryo Refrigerator Length: 11,808 / 2 = 5,904 meters
24	Cryo Maint. Units	Total 250 GeV Linac Cryo Maintenance Unit Length: 11,808 / 24 = 492 meters
20.5	Cryo Maint. Units	Total 250 GeV Linac Cryo Maintenance Unit Length: 11,808 / 20.5 = 576 meters = 16 x 36 meters
	RF Pwr Units per Cryo Maintnenance Unit	RF Power Units per Cryo Maintenance Units: 576 meters / 144 meters = 4

By C. Corvin, SLAC per data from S. Choroba, DESY

Accelerator Laboratory, KEK

ML
Cryo Section Block Diagram

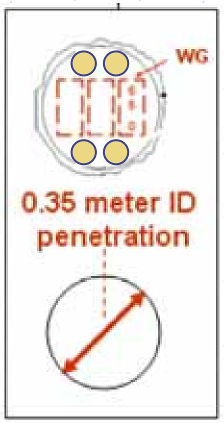


Accelerator Laboratory, KEK

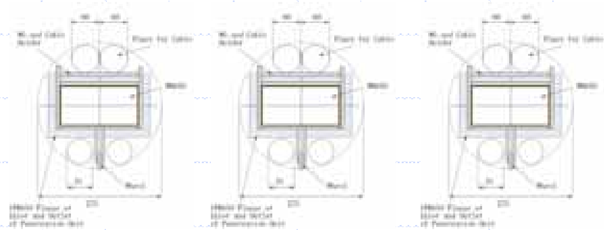
Instrumentation Cables per CM

Cryo Section Controls Instrumentation													
Item	**#/Cavity**	**#/Module**	**#/Klystron**	**#Cables**	**Cable Type**	**#10AWG**	**6 Cond**	**12 Cond**	**16 Cond**	**TC Cond**	**RG58**	**RG214**	**Type C**
3-Stub Tuner Motors, Readback	8	24	72	24	12 cond shld'd			24					
Cavity Tuner Motor	2	16	48	48	6 cond shld'd		48						
Cavity Piezo Tuner Dirver	2	16	48	48	Coax RG58						48		
RF Power Pickup Readout	1	8	24	24	Coax RG214							24	
HOM BPM Readout Channels	2	16	48	48	Coax RG214							48	
RF Load Thermocouples	2	16	48	48	TC 2 cond					48			
Coupler Tuner Motors, Readback		1	3	3	6 cond shld'd		3						
Coupler Arc Detectors		1	3	3	Coax RG214							3	
Vacuum Pumps HV		2	6	6	Coax Type C								6
Cryo Resistive Temp readout		4	12	3	8 Pr shld'd				3				
SC Quad Power Supply			1	1	2 Cond #10	2							
SC X-Y Corrector Power Supply			2	1	4 Cond #10	4							
SC Cavity BPM Readout Channels			1	2	Coax RG214							2	
Quad Mover Motor, Readback			3	1	6 cond shld'd		1						
Total Cables Cryo Modules				255									
Cables/ Penetration (3)				85									
Total Cables by Type				264		6	52	24	3	48	48	77	6

Three WGs and cable pipes in one penetration hole.



Three holes with a WG and cable pipes



Three holes with a WG, power cables and electric cables Dedicated respectively.

Accelerator Laboratory, KEK

Parts Count Table

It is the time to refine the each part count.

	A	B	C	D	E	F	G	H	I	J
1	Number (both linacs)	Component	Sub-Component	Quantity per Cavity	Quantity per Cryomodule	Quantity per 3 CM's	Motors/ Pwr / 3 CM	Instrument Ch. Per 3 CM	Total Machine Motors/ Pwr	Total Machine Instrumentation
2										
3	2034	Cryomodules	Tesla Cavities	1	8	24				
4			HOM Ports	2	16	48		48		32544
5			TTF3 Couplers + Vac System	1	8	24				
6			Blade Tuners + Shields			24				
7			Piezo Tuners	2	16	48	48		32544	
8			~ 8 Bellows		8	24				
9			Gate Values			2				
10			Beamline HOM Absorber		1	3				
11			Beampipe Vac Port / Pump		2	6	6	6	4068	4068
12			Insulating Vac / Port Pump		2	6	6	6	4068	4068
13			Cold Mass Assembly			1				2034
14		Cryo-Strings	Cryo-String Ends		4	12		12		8136
15	43	Cryo-Segments	Insulating / Beam Vac Isolation		1	3				2034
16	678	Quad Package	Quad Magnet			1	1	1	678	678
17			Cavity BPM			1		1		678
18			X&Y Corrector			2	2	2	1356	1356
19			Lead Assemblies			1				678
20	678	RF System Hardware	Modulator			1				678
21			10 MW Klystron			1			678	678
22			~ 60 m WR650 WG			1				678
23			FE/RE couplers			2			1356	
24			Hi Pwr Attenuators		1	3			2034	
25			Splitters / Loads		8	24			16272	
26			Circulators / Loads		8	24			16272	
27			Remote Phase/Qext Tuner E-H		8	24	48		32544	
28	678	Front End Electronics	Kly/Mod/WG Monitor / Interlocks			1		1		678
29			Cryogenic Monitors			3		3		2034
30			LLRF Modulator & Amplifier			1				678
31			LLRF Signal Processing			1				678
32			RF Fault Detectors / Interlocks			1				678
33			100 A Magnet PS			3				2034
34			BPM Processing Electonics			1				678
35			Vac PS and Monitors			6				4068
36			123 Motor Controllers				123		83394	
37			24 Piezo Controllers		24		24		16272	
38	6	Emittance Stations	4 2D Laser Wires							
39	2	Energy Stations	4 Magnet Chicanes / Coll / Dump							
40	8	Refrigerators	25 kW eqv at 4.2 K (50 MW AC)							
41	1	Water Cooling System	~ 100 MW Capacity at 35 degC							

Other 1.3GHz RF Systems

Electron Source RF: 1.3GHz 10MW Systems

Positron Source RF: 1.3GHz 10MW Systems

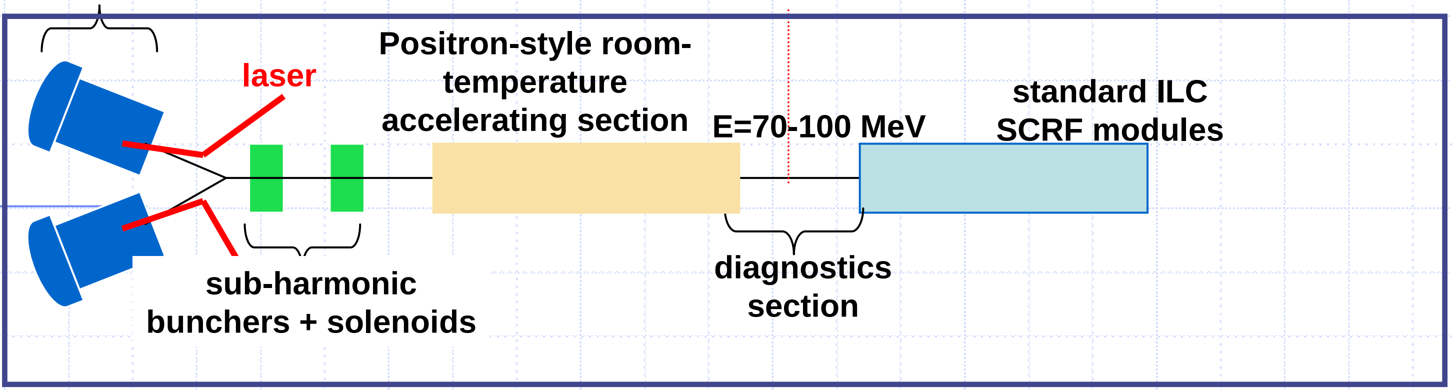
→ **Normal conducting RF is not same.**
High Density Layout
SC RF is similar as ML

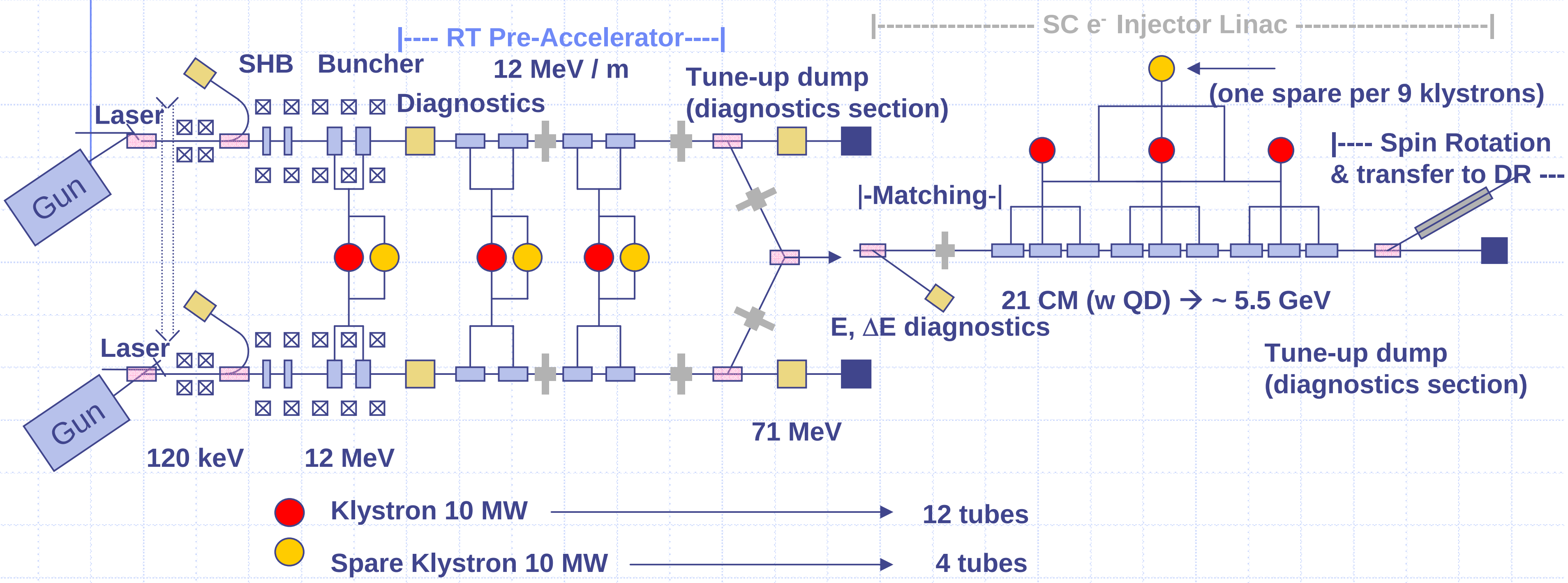
RTML RF: Two + Nineteen 1.3GHz 10MW Systems

→ **Requirement for the phase and amplitude are different from ML.**
Tunnel Configuration is not yet determined.

Accelerator Laboratory, KEK

E- Source BCD (A. Brachmann)





ILC Positron System Beamlines

Accelerator Laboratory, KEK

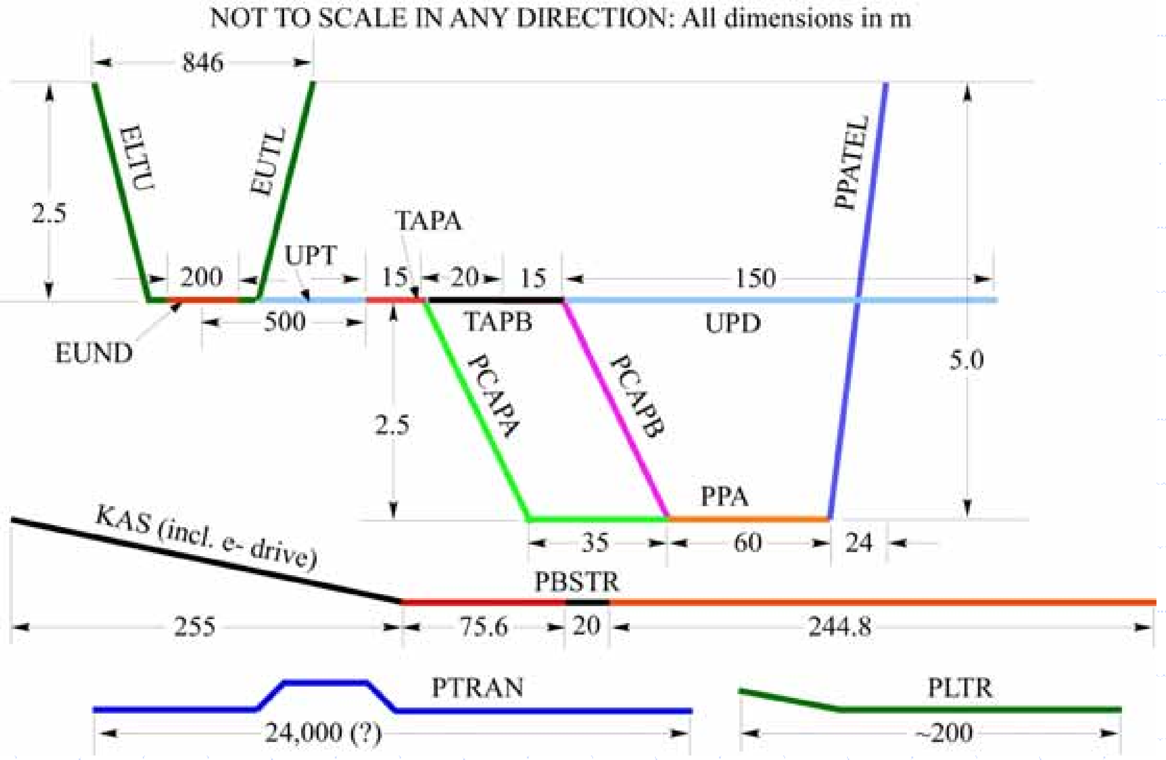
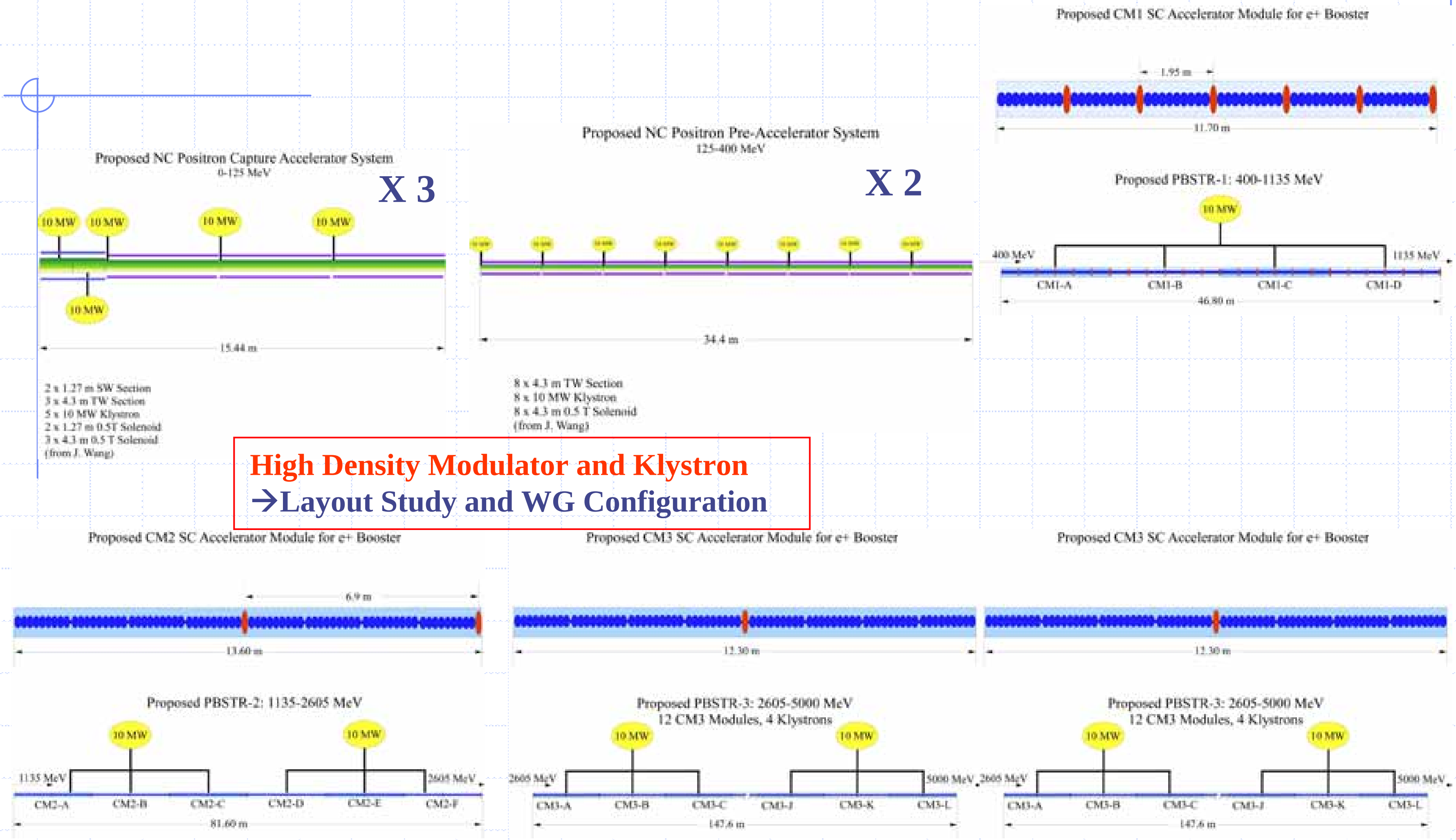


Table 1: ILC Positron Linac Systems, layout

Location	Energy Range	Structure	Klystrons
	MeV		
TAPA	1-125	2x1.27 m SW, RT+3x4.3 m TW, RT	5x10 MW
TAPB	1-125	2x1.27 m SW, RT+3x4.3 m TW, RT	5x10 MW
KAS TAP	1-125	2x1.27 m SW, RT+3x4.3 m TW, RT	5x10 MW
PPA	125-400	8x4.3 m TW, RT	8x10 MW
KAS PPA	125-400	8x4.3 m TW, RT	8x10 MW
PBSTR	400-1135	4xCM1, SC	1x10MW
PBSTR	1135-2605	6xCM2, SC	2x10 MW
PBSTR	2605-5000	12xCM3, SC	4x10 MW

Positron Injector RF System



High Density Modulator and Klystron
→Layout Study and WG Configuration

Accelerator Laboratory, KEK

RTML BC RF Systems

- BC1 has 3 cryomodules, 1 klystron, plus one s klystron with waveguide switch
- BC2 has 57 cryomodules, 19 klystrons, of whic klystron + 3 cryomodules are spare
- Gradients modestly lower than 31.5 MV/m nee
- Stations operate far from RF crest
  - **Need to change klystron amplitude and phase during train to compensate beam loading**
  - **Larger average power goes to RF loads than in main linac stations**
- **Phase and amplitude tolerances are tight**
  - Phase jitter < 0.1 ° ➔ 2% loss of integrated luminosity from longitudinal jitter of collision point
- Most promising bunch length monitor requires crab cavity
  - Based on system prototyped at SPPS and TTF2
  - Might need crab cavities for bunch length measurement, depending on downselect of BLM technology

RF Components in Bunch Compressors

Region	Cavities	Modules	Klystrons
BC1	32	4	1? 2?
BC2	456	57	19
Total	488	61	20? 21?

Need specification from RTML Area System

↓

Type of phase shifter

Layout in the tunnel from RLMT Area System

↓

Waveguide layout

LLRF/Global System

Accelerator Laboratory, KEK

DR BCD RF

From BCD (Wiki)

- **RF frequency**
- The choice of RF frequency is strongly coupled to the choice of bunch train length:
- the flexibility in the number of bunches in a train depends to some extent on the RF frequency.
- **Baseline**
- The damping rings RF systems should use an RF frequency of 500 MHz. This is a standard technology; other options would require R&D.
- **Options**
- An RF frequency of 500 MHz is a common choice for synchrotron light source storage rings. It is possible to consider other choices, for example **650 MHz**.
- **Description**
- **Issues**
- **Cost (Significance: A)**
- 500 MHz RF systems are standard, and will therefore be lower cost. A **650 MHz system** would need to be designed from scratch.
- **Bunch length (Significance: B)**
- A higher frequency makes it possible to achieve the desired bunch length at a lower voltage. A reduction in voltage has advantages in saving cost; but in the case of the options considered here, the cost savings of the lower voltage of the 650 MHz system compared to the 500 MHz system would be outweighed by the required R&D.
- **Phase locking with linac RF (Significance: C)**
- The damping ring RF must be phase locked to the linac RF, to ensure that bunches extracted from the damping ring arrive at the correct phase of the main linac RF. **An RF frequency of 650 MHz is a simple subharmonic (1/2) of the main linac RF frequency of 1.3 GHz.** A 500 MHz RF system is at a more complex subharmonic (5/13). However, either frequency can easily be locked to the main linac RF.

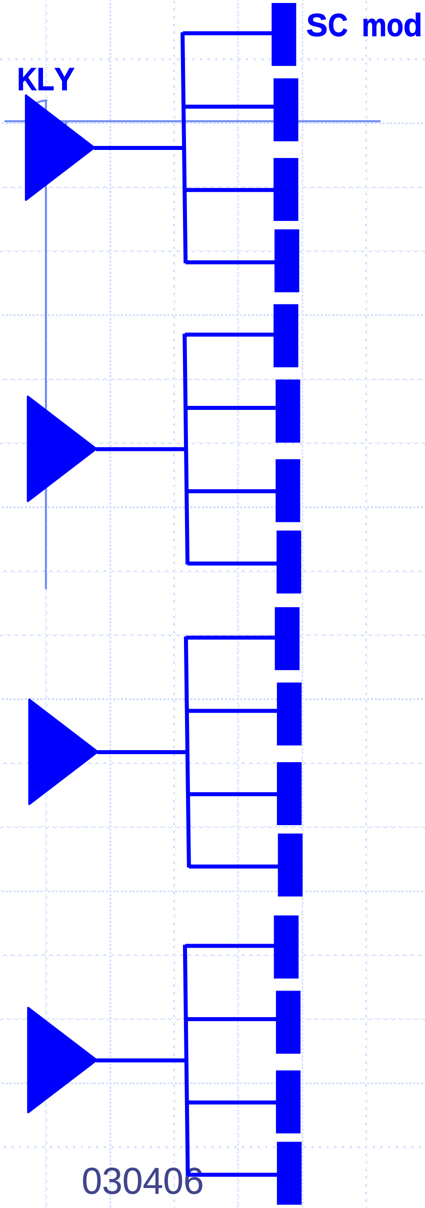
Accelerator Laboratory, KEK

DR BCD RF

- Basically choice of 650 MHz has no difficult technical problems for RF Power.
- Evaluation of the klystron is recommended by manufacturing a proto-type. **Horizontally mounting klystron** should be developed to install in the DR tunnel.
- ->confirmation of the specification and cost extraction
- Layout of the RF system in the tunnel should be shown by DR Area System. Spare klystron or necessary redundancy should be discussed by area system.
- *Specification of the rf source, such as the output power from the klystron, how many rf sources required, stability, and operation mode, should be shown by DR Area System.*
- *->proposal was given in this WS.*

ILC Damping Ring RDR Progresses-RF-4

(INFN, R. Boni)



ELECTRON RING

16 CRYO-MODULES

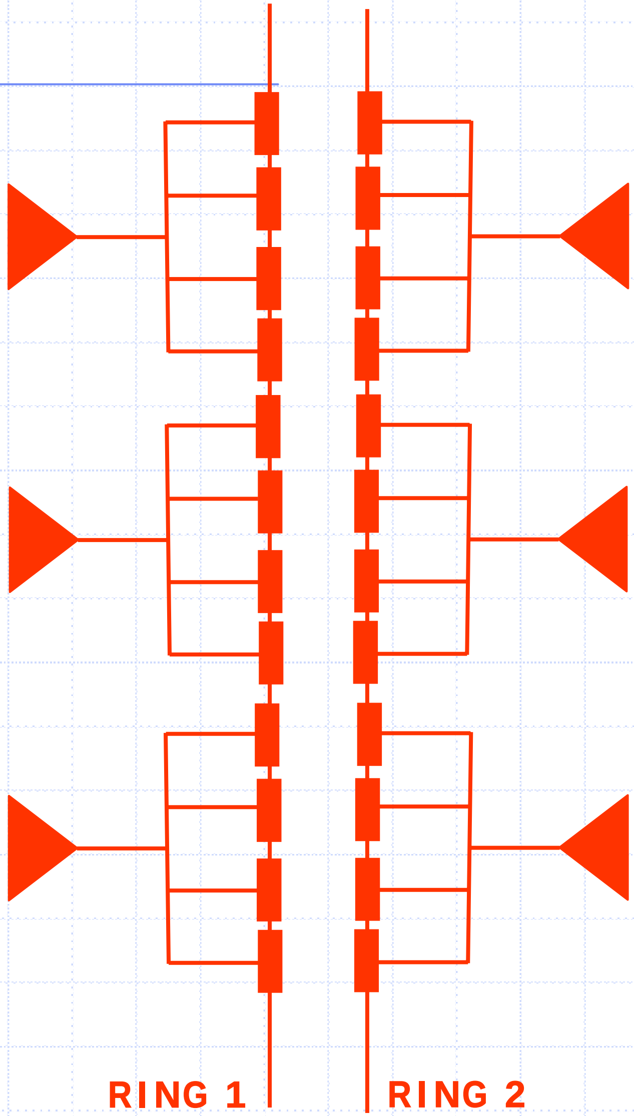
237 kW - 5.5 MV/m per SC cavity

4 KLYSTRONS

650 MHz - 1 MW

ILC Damping Ring RDR Progresses-RF-5

(INFN, R. Boni)



POSITRON RINGS

12 + 12 CRYO-MODULES

160 kW - 7 MV/m per SC cavity

6 KLYSTRONS

650 MHz - 1 MW

First Draft Proposal of RF WBS

Accelerator Laboratory, KEK

1.5.1.1 RF System - Main Linacs

1.5.1.1.1 Klystron
- 1.5.1.1.1.1 Solenoid
- 1.5.1.1.1.2 Socket, wiring
- 1.5.1.1.1.3 Vacuum pumps, instrumentaion
- 1.5.1.1.1.4 Power supplies Solenoid, Filament
- 1.5.1.1.1.5 RF Pre-driver
- 1.5.1.1.1.6 Local Diagnostics-Controls-Protection

1.5.1.1.2 Modulator
- 1.5.1.1.2.1 Pulser Forming Unit
- 1.5.1.1.2.2 Charging Supply
- 1.5.1.1.2.3 HV Cable Plant
- 1.5.1.1.2.4 Pulse Transformer
- 1.5.1.1.2.5 Local Diagnostics-Controls-Protection

1.5.1.1.3 RF Distribution
- 1.5.1.1.3.1 Waveguide distribution
- 1.5.1.1.3.2 Cavity Coupler Matching tuners
- 1.5.1.1.3.3 Hybrids and Loads
- 1.5.1.1.2.4 Motor drivers
- 1.5.1.1.2.5 Gas & Vacuum Systems
- 1.5.1.1.2.6 Local Diagnostics-Controls-Protection

1.5.1.1.4 Integrated Controls-Diagnostics- Interlocks-Protection-PPS
- 1.5.1.1.4.1 Klystron
- 1.5.1.1.4.2 Modulator
- 1.5.1.1.4.3 RF Distribution
- 1.5.1.1.4.4 LLRF, Feedback & Tuning

1.5.1.1.5 Infrastructure
- 1.5.1.1.5.1 Instrument Racks & Cabling
- 1.5.1.1.5.2 Cable Trays
- 1.5.1.1.5.3 Electrical Distribution - Primary, secondary
- 1.5.1.1.5.4 Cooling water system

1.5.1.1.6 RF Integrated Safety Systems

1.5.1.2 RF Systems - Sources

1.5.1.2.1 Electron Sources
- 1.5.1.2.1.1 10MW RF Stations Warm Structures(Rollup)
- 1.5.1.2.1.2 10 MW RF Stations - 5 GeV Linac (Rollup)
- 1.5.1.2.1.3 Bunch Compressor RF Systems
  - 1.5.1.2.1.2.1 Solid State Amplifier System
  - 1.5.1.2.1.2.2 LLRF System
  - 1.5.1.2.1.2.3 Infrastructure
- 1.5.1.2.1.4 RF Integrated Safety Systems

1.5.1.2.2 Positron Source
- 1.5.1.2.2.1 10MW RF Stations Warm Structures(Rollup)
- 1.5.1.2.2.2 10 MW RF Stations - 5 GeV Linac (Rollup)
- 1.5.1.2.2.3 Bunch Compressor RF Systems
  - 1.5.1.2.2.2.1 Solid State Amplifier System
  - 1.5.1.2.2.2.2 LLRF System
  - 1.5.1.2.2.2.3 Infrastructure
- 1.5.1.2.2.3 RF Integrated Safety Systems

1.5.1.3 RF Systems - Damping Rings

1.5.1.3.1 Electron Damping Rings

1.5.1.3.1.1 CW RF Stations
- 1.5.1.3.1.1 Klystrons
- 1.5.1.3.1.1 Waveguide
- 1.5.1.3.1.1 Cavities
- 1.5.1.3.1.1 Tuners
- 1.5.1.3.1.1 LLRF
- 1.5.1.3.1.1 Infrastructure
- 1.5.1.3.1.1 RF Integrated Safety Systems

1.5.1.3.2 Positron Damping Rings

1.5.1.3.2.1 CW RF Stations
- 1.5.1.3.2.1 Klystrons
- 1.5.1.3.2.1 Waveguide
- 1.5.1.3.2.1 Cavities
- 1.5.1.3.2.1 Tuners
- 1.5.1.3.2.1 LLRF
- 1.5.1.3.2.1 Infrastructure
- 1.5.1.3.2.1 RF Integrated Safety Systems

1.5.1.4 Ring to Main Linac (RTML)

1.5.1.4.1 Electron RTML Systems
- 1.5.1.4.1.1 10MW RF Stations
- 1.5.1.4.1.2 High Performance LLRF
- 1.5.1.4.1.3 Infrastructure
- 1.5.1.4.1.4 RF Integrated Safety Systems

1.5.1.4.2 Positron RTMLSystems
- 1.5.1.4.2.1 10MW RF Stations
- 1.5.1.4.2.2 High Performance LLRF
- 1.5.1.4.2.3 Infrastructure
- 1.5.1.4.2.4 RF Integrated Safety Systems

HLRF WBS Organization - RSL030806

RF Power TS Information Status 060311

	e-Source	e+Source	DR	RTML	ML	BDS	DCB	GlobalSys
Dialog - Contacts	●	●	●	●	●		●	●
Prelim Reqmts	●	●	●	●	●			
Prelim Parts List	●	●		●	●			
Sketches - Layouts	●	●			●			
Treaty Pts AS, TS								
Cost Model					●			
WBS Draft	●	●	●	●	●			
Cost Schedule								
Resource Analysis								

Another issues important for cost estimation:

Manufacturing facility of klystrons (in vendor's site or in ILC site)

- Klystron is the special component among the ILC components.

(1) It is necessary to have an acceptance test in the ILC test facility before installing.

(2) It is necessary to procure and test the klystron even after the construction is over.

(Numerical example)

If the construction period is 7 years, net period of klystron manufacturing is 5 years. Roughly 700 tubes manufactured for 5 years goes to **140 tubes per year**. If 3 regions share equal amount of production, **47 tube /year/region.**

If the life time of the klystron is 50,000 hrs, and average operation hours of ILC for 1 year is 5,000 hrs, **60-70 tubes are replaced in every year.**

Accelerator Laboratory, KEK

Possible Model for Klystron Manufacturing Model

- For one tube production, 2 weeks baking in the furnace and 2.5 weeks processing are required.-> 2 furnaces and 3 modulators must be equipped in each region. It costs $ 5 million excluding operation cost. ($ 15 million total). ILC site needs the 2-3 modulators for acceptance test ($2-3 million).

Model(1) All expenses are covered by vendor's and such extra cost is included in the klystron price. (Each vendor has 2-3 extra modulators after construction).**$20 million basis**.

Model(2) ILC facility has a test facility with 6-8 modulators, and vendor's processes using this facility. After construction, the test facility keeps 2 modulators for test facility and others are installed in regular position in ILC linac.

Model(3) ILC covers all extra facilities including the backing furnace.

This is discussed by DCB. RF tech. System informs manufacturing cost model.

Accelerator Laboratory, KEK

Summary

- Since the FNAL GDE meeting, tunnel size problem was intensely discussed and basic layout in ML service tunnel was proposed.
  From the RF tech. system, tunnel diameter of 5.5m is the comfortable size for installing and maintenance.
- Reducing the size of the modulator has progressed.
- WG Layout from horizontally mounted klystron to penetration was planned.
- Water and air-conditioning requirement are progressed. Sub-rack basic plan is presented. Cabling requirement are also summarized.
- ML RF has started detailed WBS, ready to begin costing.
- RF system of Sources, DR's & RTML included in WBS rollup.
- For DR RF, it is necessary to have a prototype study including the horizontally mounting design.
- Cost study for manufacturing the klystron during the construction and after the construction is needed.