Review of the International Linear Collider (ILC) Electrical and Mechanical System Design to be held at CERN on 21 March, 2012

The purpose of the Review is consider specified performance criteria and evaluate how the mechanical and electrical technical design solutions formulated by the ILC team address these. The ILC design is under development in parallel in each of three global regions. Conventional facilities (electrical and mechanical) design work from two of these, Asia (Japan) and Americas (US) will be presented. It is not the intention of the review to directly compare and contrast these two with each other. At the review, representatives from the Asian Region will present the Mechanical and Electrical Designs that have been developed using the Asian Region High Level RF (HLRF) system suitable for a mountain site in Japan and representatives from the Americas Region will present the Mechanical and Electrical Designs that have been developed using the Klystron Cluster RF system suitable for the Americas Sample Site.

Ample time will be available in the agenda for open discussion among all participants. The Review Panel will produce a report to the GDE Project Management that records panel impression and comments of the designs presented as well as conclusions reached during discussion periods.

The ILC high – power superconducting linac presents new and interesting technical challenges that are sure to be interesting.

(A separate meeting – 22 to 23 March, also listed on the indico page, but is not to be confused with the Review).

Review of the International Linear Collider (ILC) Electrical and Mechanical System Design to be held at CERN on 21 March, 2012

The review panel will consist of:

Marc Ross (Fermilab – ILC) Chair
Vic Kuchler (Fermilab – ILC)
John Osborne (CERN – ILC) Host
Atsushi Enomoto (KEK – ILC)
Philippe Lebrun (CERN)
Mauro Nonis (CERN)
Francois Duval (CERN)

ILC Utilities – Electrical / Mechanical

- ILC has six regions:
  1/2. Sources (electron / positron)
  3. Damping Rings
  4. Ring to Linac
  5. SC Linac → Power critical
  6. Beam Delivery

- But… Superconductivity means "low resistance"…

Power Loads:

- (Reference Design – 2006)

TABLE 4.3-1

Estimated nominal power loads (MW) for 500 GeV centre-of-mass operation

Area System	RF Power	Conventional Power				Em[illegible]er Power	Total (by area)
		Co[illegible]	NC Magnets	Wate[illegible] Sys[illegible]ems	Cryo		
Sources e–	1.05	1.19	0.73	1.27	[illegible].46	0.06	4.76
Sources e+	4.1[illegible]	7.32	8.90	1.27	[illegible].46	0.21	22.27
DR	14.[illegible]	1.71	7.92	0.66	1.76	0.23	26.29
RTML	7.1[illegible]	3.78	4.74	1.34	[illegible].[illegible]	0.15	17.14
Main Linac	75.72	13.54	0.78	9.86	3[illegible].[illegible]	0.4	134.21
BDS	0.[illegible]	1.11	2.57	3.51	[illegible].33	0.20	7.72
Dumps	0.[illegible]	3.83	0.0	0.0	[illegible]0.0	0.12	3.95
Totals (by system)	102.[illegible]	32.5	25.6	17.9	[illegible]6.9	1.4	216.3

- Beam Power (500 GeV): 22 MW

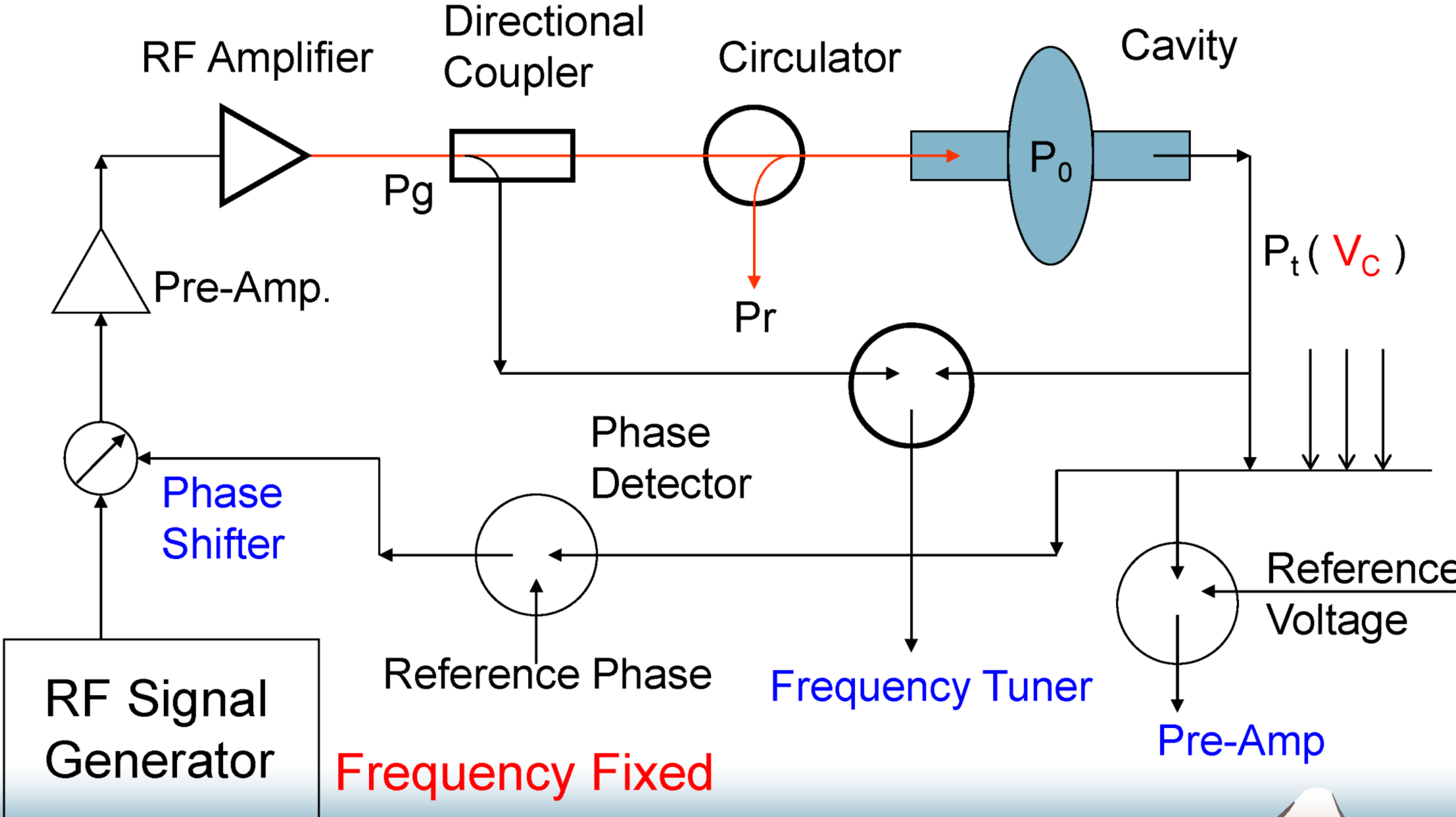
Heat Loads:

TABLE 4.5-1

Summary of heat loads broken down by Area System

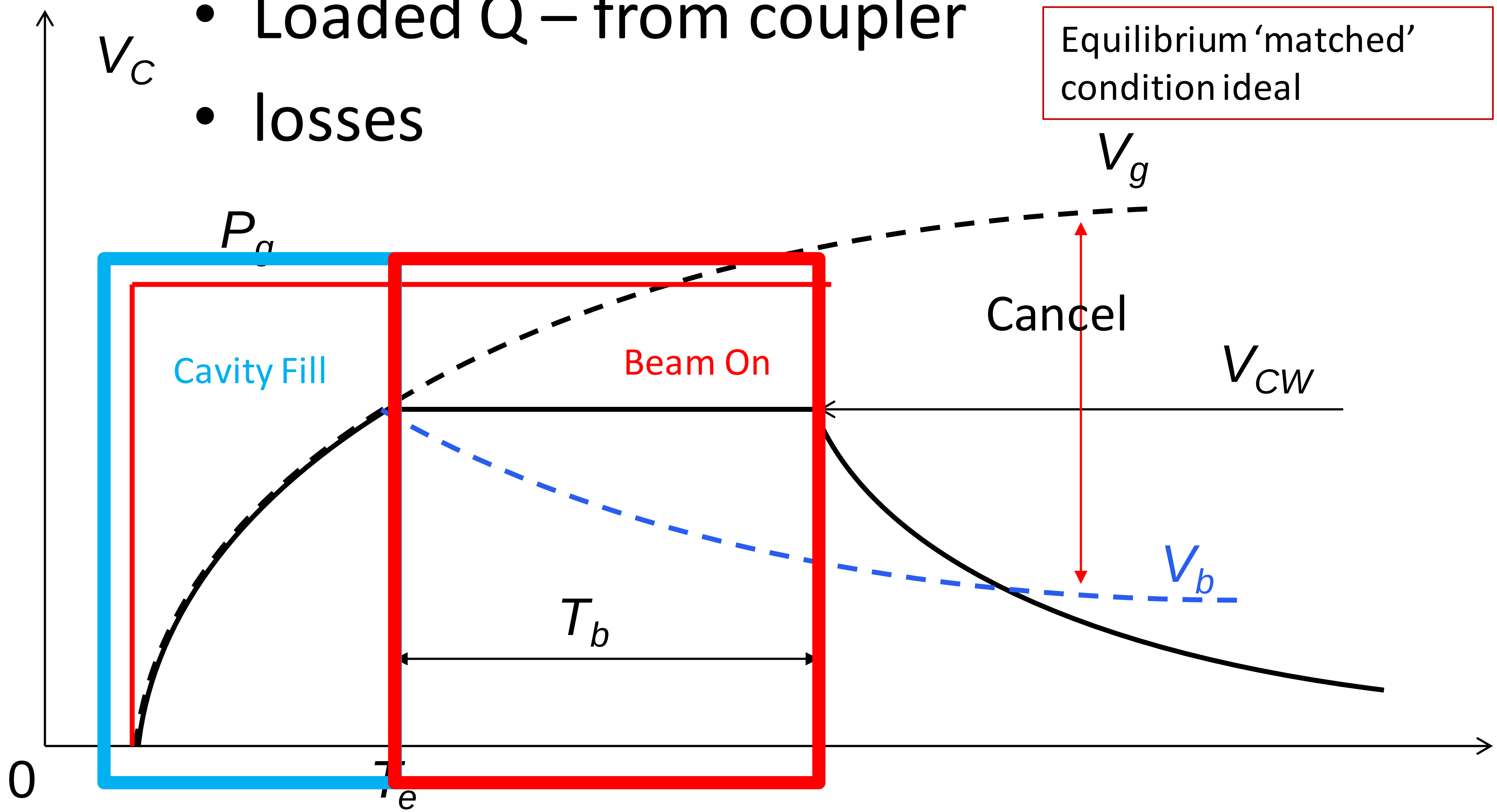
Area System	LCW (MW)	Chilled Water (MW)	Total (MW)
Sources e^-	2.880	1.420	4.300
Sources e^+	17.480	5.330	22.810
DR e^-	8.838	0.924	9.762
DR e^+	8.838	0.924	9.762
RTML	9.254	1.335	10.589
Main Linac	56.000	21.056	77.056
BDS	10.290	0.982	11.272
Dumps	36.000	0.000	36.000
Total Heat Load (MW)			182

RF Acceleration System

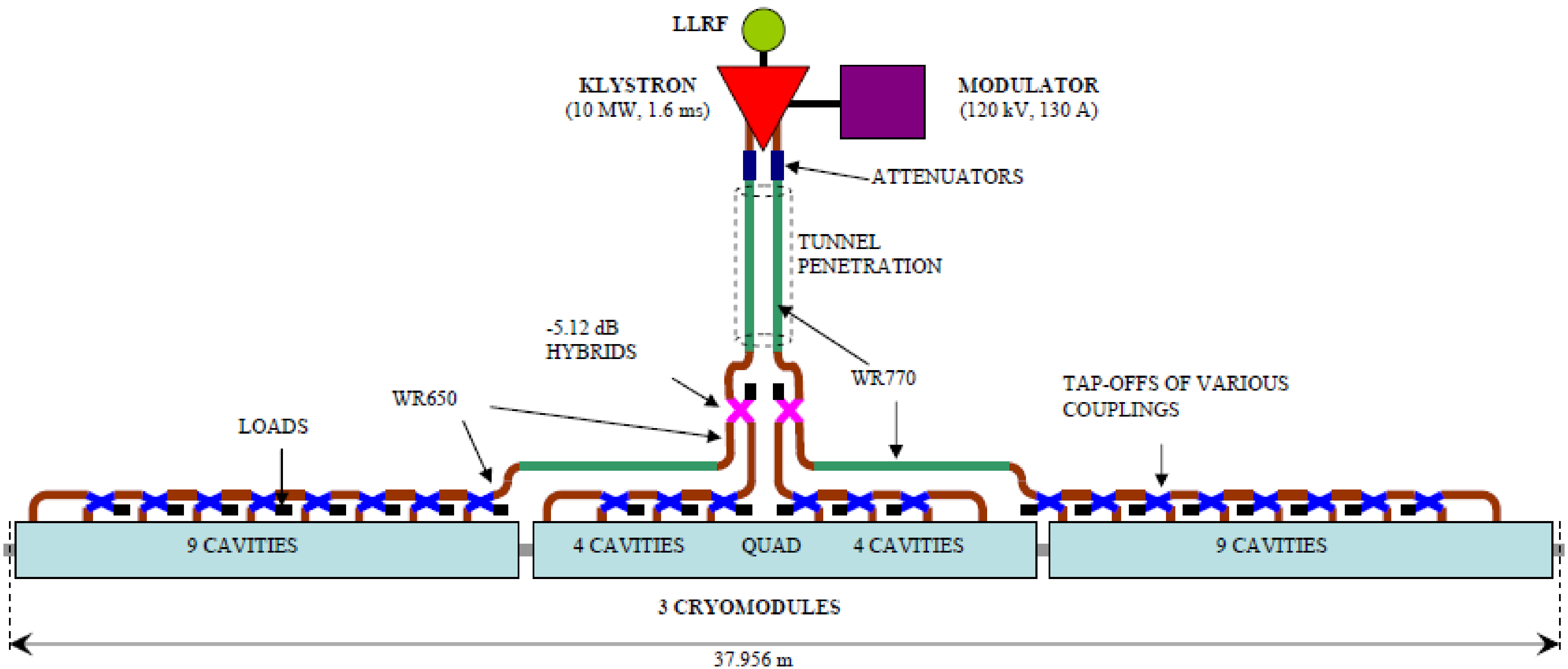


Superconducting resonators

- Typical resonator intrinsic Q
- Loaded Q – from coupler
- losses



Old RDR Power Distribution System

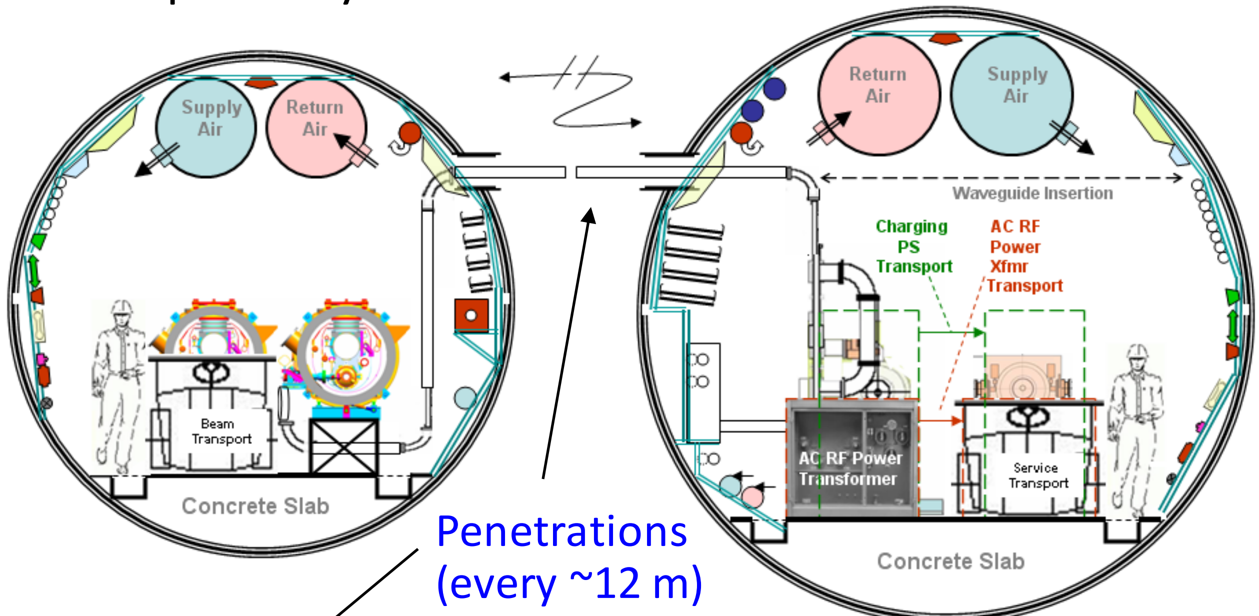


Baseline Tunnel Layout

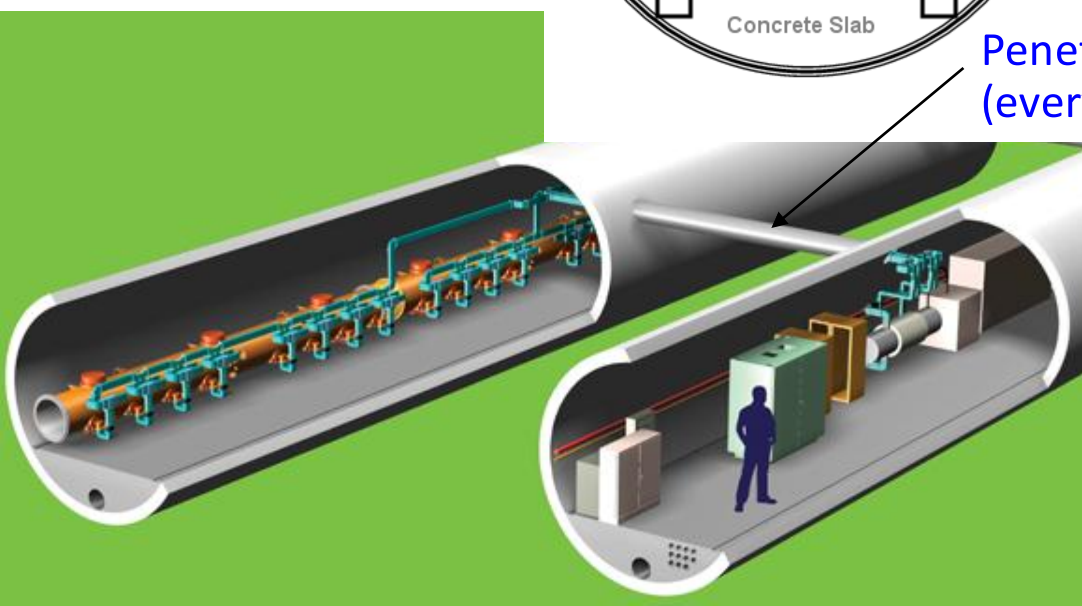
Two 4-5 m diameter tunnels spaced by ~7 m.

Accelerator Tunnel

Waveguides
Cryomodules



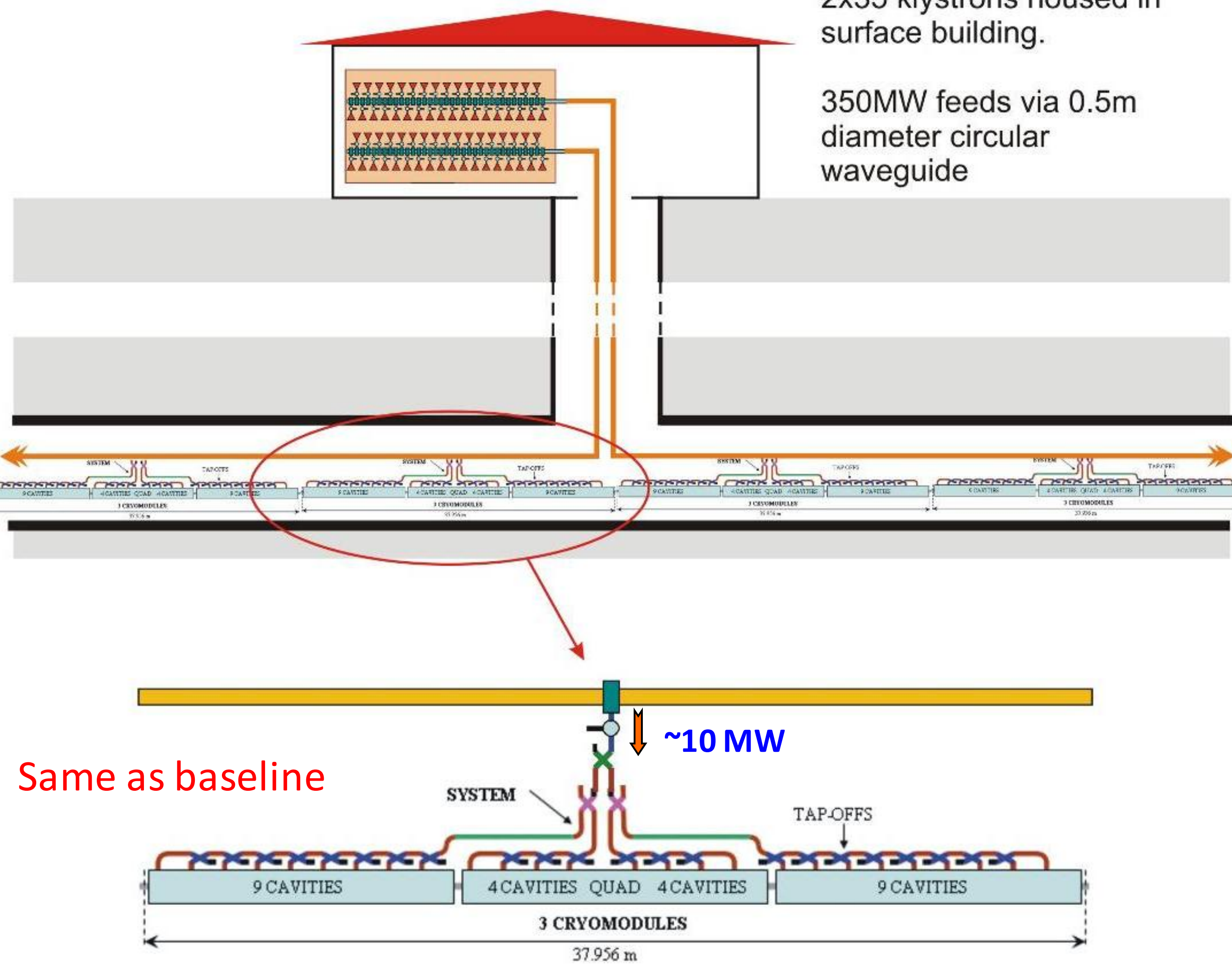
Penetrations (every ~12 m)



Service Tunnel

Modulators
Klystrons Electrical
Dist Cooling System

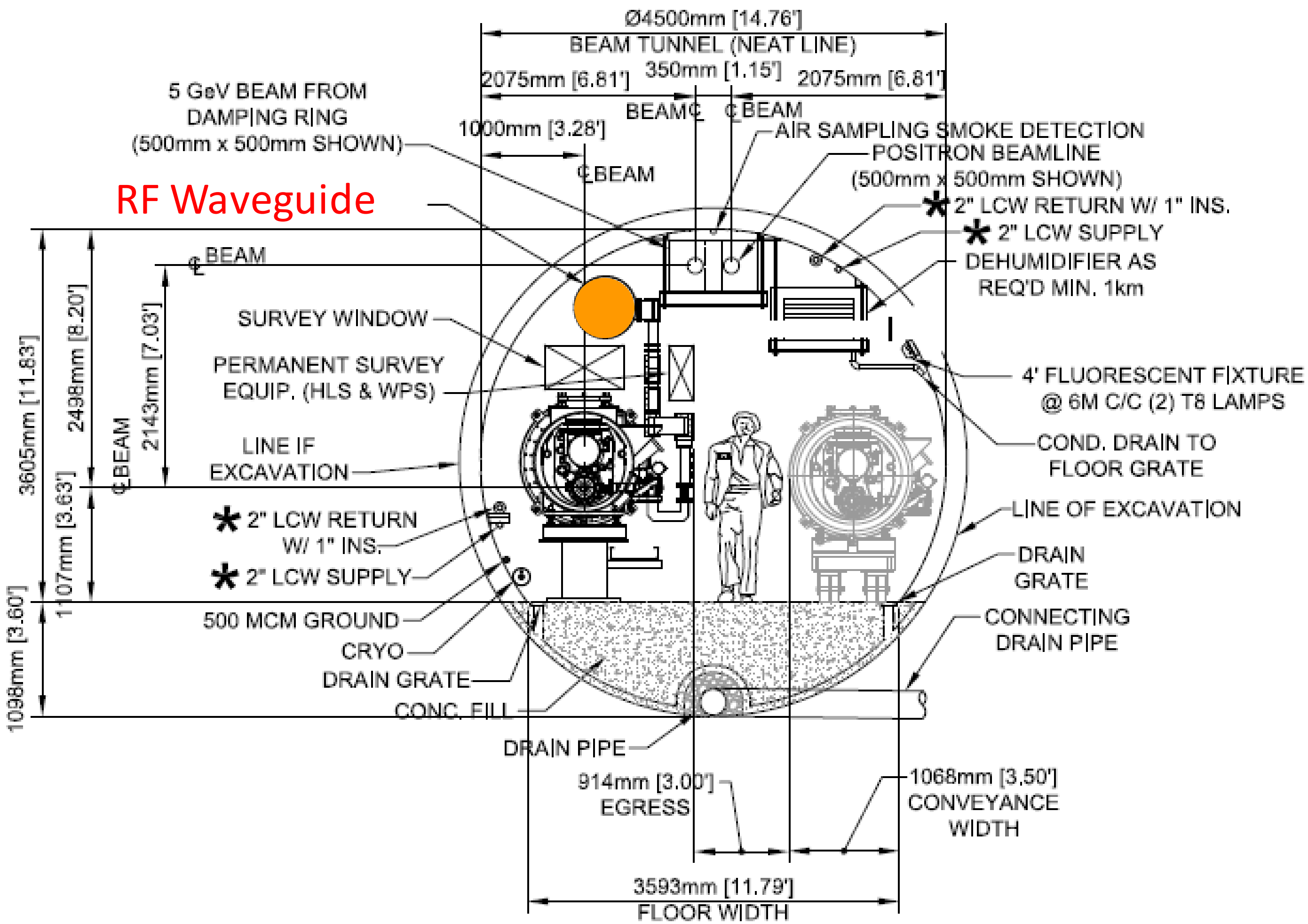
Klystron Cluster Concept



Each tap-off from the main waveguide feeds 10 MW through a high power window and probably a circulator or switch to a local PDS for a 3 cryomodule, 26 cavity RF unit (RDR baseline).

- RF power “piped” into accelerator tunnel every 2.5 km
- Service tunnel eliminated
- Electrical and cooling systems simplified
- Concerns: power handling, LLRF control coarseness

First Pass at New Tunnel Layout



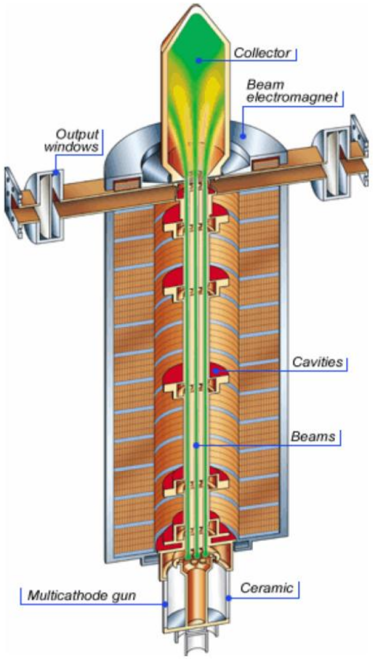
TYPICAL MAIN LINAC SECTION

DRAFT FOR REVIEW

Multi Beam Klystron THALES TH1801 (1)

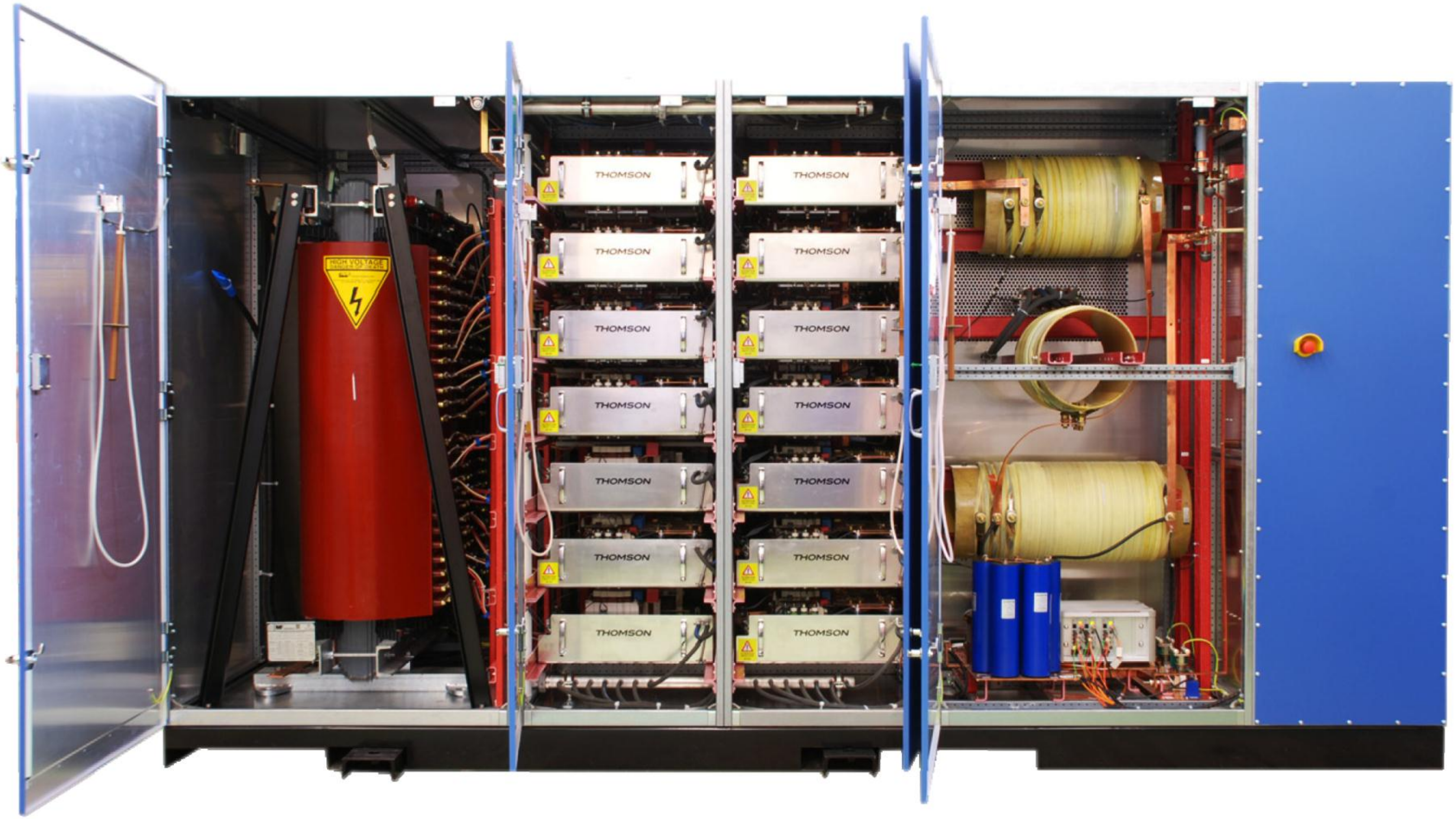
Measured performance

Operation Frequency:	1.3GHz
Cathode Voltage: 117kV	
Beam Current:	131A
mperveance:	3.27
Number of Beams:	7
Cathode loading: 5.5A/cm^2	
Max. RF Peak Power:	10MW
RF Pulse Duration:	1.5ms
Repetition Rate:	10Hz
RF Average Power:	150kW
Efficiency:	65%
Gain:	48.2dB
Solenoid Power:	6kW
Length:	2.5m
Lifetime (goal):	~40000h

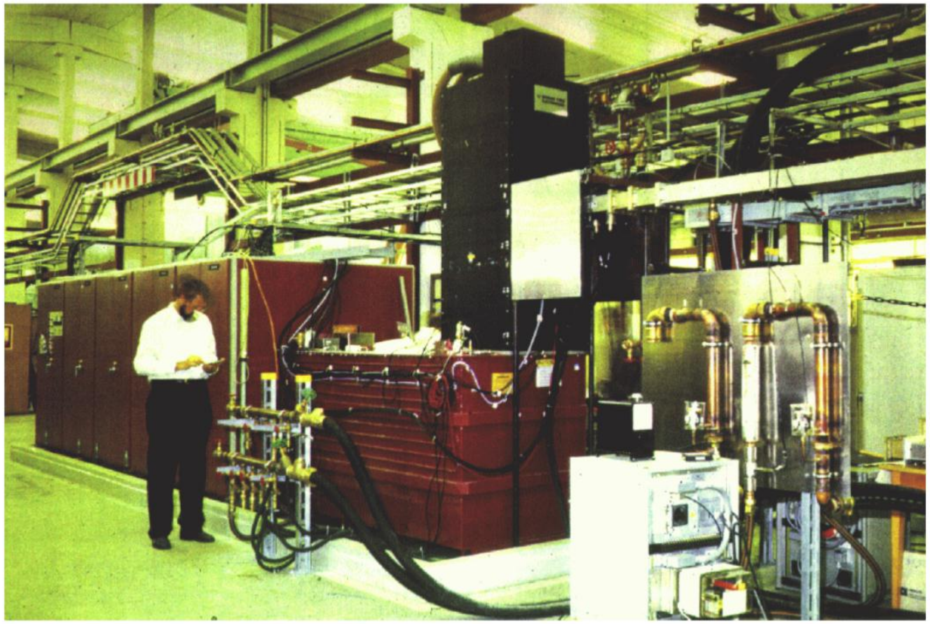


Klystron Modulator:

- 150 KW (10/.6=17 MW peak) (XFEL 410KW)
- Few % losses



BCD Klystron & Modulator Assembly



Photos courtesy S. Choraba, DESY

Installing an 8-cavity cryomodule:

- ~15 each made and tested DESY, Fermilab, KEK
- (125 more now under construction)

SC Linac power feed

BCD RF Waveguide Components

3 Stub Tuner (IHEP, Bejing, China)

Changing phase, degree	±60
Impedance matching range	1/3Z_w ÷ 3Z_w
Max power, MW	2

* Z_w – waveguide impedance

E and H Bends (Spinner)

Circulator (Ferrite)

Type	WFHI 3-4
Peak input power, MW	0.4
Average power, kW	8
Min isolation at 1.3 GHz, dB	>30
Max insertion loss at 1.3 GHz, dB	≤0.08
Input SWR at 1.3 GHz (for full reflection)	1.1

Hybrid Coupler (RFT, Spinner)

Directivity, dB	>30
Return loss, dB	>35
Coupling factor, dB (due to tolerance overlapping only 13 different coupling factors instead 18 are necessary)	12.5; 12.0; 11.4; 10.7; 10.1; 9.6; 9.1; 8.5; 7.8; 7.0; 6.0; 4.8; 3.0
Accuracy of coupling factor, dB	±0.2

RF Load (Ferrite)

Type	WFHLL 3-1
Peak input power, MW	1.0
Average power, kW	0.2
Min return loss at 1.3GHz, dB	32÷40
Max VSWR at 1.3 GHz	≤1.05

RF Load (Ferrite)

Type	WFHL 3-1	WFHL 3-5
Peak input power, MW	2.0	5.0
Average power, kW	10	100
Min return loss at 1.3 GHz, dB	32÷40	32÷40
Max VSWR at 1.3 GHz	<1.05	<1.05
Max surface temperature, ΔT °C (for full average power)	20	30
Physical length, mm	385	850

MAIN LINAC KCS

Mar 23 2011

Component	Group	Quantity	Average Heat Load (KW)	Heat Load to LCW Water (KW)	Max Allowable Temperature (c)	Supply Temp (C)	Delta Temperature (C delta)	Water Flow (l / min)	gpm	Delta Temperature (F delta)	Maximum Allowable Pressure (Bar)	Typical (water) pressure drop Bar	Acceptable Temp Variation delta C	Racks Heat Load (KW)	Heat Load to Air (KW)	Max Space Temp (C)
				To Low Conductivity Water										to CHW?	To AIR	
RF Components x (692)																
RF Charging Supply	Power Supplies	692/ML	3.03	2.1		40	10.7	2.84	0.75	19.3	18	5	10	NA	0.9	104 F (a)
Switching power supply	Power Supplies	692/ML	7.0	4.2		35	7.94	7.6	2.008	14.28	13	5	10	NA	2.8	
Pulse Transformer	Power Supplies	692/ML	1.0	0.7	60	35	0.50	20	5.283	0.905		1	n/a	NA	0.3	
Modulator		692/ML	6.3	3.8		35	2.73	20	5.283	4.916	10	5	n/a	NA	2.5	
Klystrn Scket Tank / Gun	Klystron Wvgud	692/ML	1.0	0.8	60	35	1.15	10	2.642	2.068	15	1	n/a	NA	0.2	
Focusing Coil (Solenoid)	Klystron Wvgud	692/ML	1.7	1.6	80	55	2	10	2.642	4.182	15	1	n/a	NA	0.1	
Klystron Collector		692/ML	42.13	37.5	87	38 (inlet temp 25 to 63)	15	37	9.774	26.19	15	0.3	n/a	NA	1.3	
Klystron Body & Windows		692/ML		3.4	40	25 to 40C	5	10	2.642	8.711	15	4.5	+ - 2.5 C	NA		
CTOs & combining Loads/circulator		2/Klstrn	10.50	8.4			6.04	19.99	5.28	10.86		(80 psid)	?		2.1	
Relay Racks (Instrument Racks)		TBD	3.0	0	N/A	N/A	N/A		0	N/A	N/A	N/A	None	3	0.0	
SUBTOTAL				62.51		Total surface RF (excluding Racks) =					72.74			3.0	10.2	
COMPONENTS IN THE TUNNEL (listed as per RF)																
RF Components (x 584)																
RF Pipe in Shaft (shaft & bends)		584/ML	1.31	1.18			10	1.693	0.447	18		(80 psid)	?		0.1	
Relay Racks (Instrument Racks)		TBD	5	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	None	5	0.0	
Main tunnel Wvgde & local wvgd		584/ML	8.47	8.05			12	9.628	2.544	21.6		(80 psid)			0.4	??
Distribution Edn Loads & Cavity Reflection loads		TBD	30.21	27			20	19.52	5.157	36		(80 psid)	+ - 2.5 C / + - 2.5 C	0	3	
Subtotal Tunnel RF& NonRF unit Only (for 1 RF)				36.41		Total tunnel RF (excluding Racks) =					39.99			5.0	3.6	
Power to Beam =37KW per RF		Total (for 1 RF)		98.9		total RF heat loss less racks =					112.73	KW/RF		8	13.8	

Top 3 load types

- Klystron/modulator localized 60%
- Waveguide distributed 15% ←to be regulated
- Cryomodule distributed 25%

Most of the heat load to water does not require tight temperature regulation

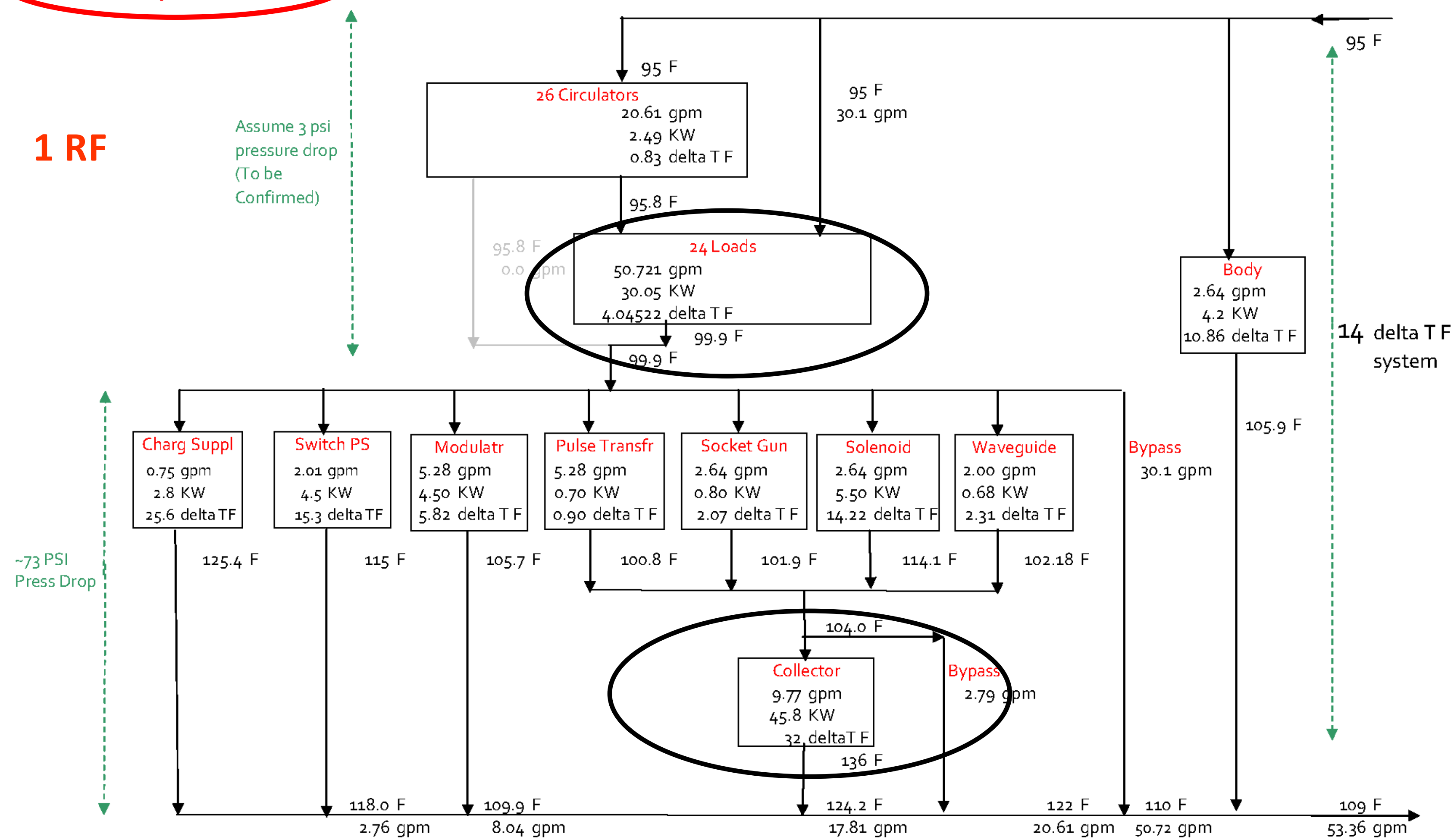
Klystron Collector	38.0%	38.0%
Cavity load	27.3%	65.3%
Waveguide distribution - surface	8.5%	73.8%
Waveguide distribution - undergro	8.2%	82.0%
Switching PS	4.3%	86.2%
Modulator	3.8%	90.1%
Klystron - other	3.4%	93.5%
	2.1%	95.7%
	1.6%	97.3%
	1.2%	98.5%
	0.8%	99.3%
	0.7%	100.0%

Stacking of Loads / High Delta T

MAIN LINAC RF WATER SYSTEM (based on incomplete heat table dated Oct 31 2007), excluding Transformer

8 liter /min per load flow

e. huedem 11/15/2007



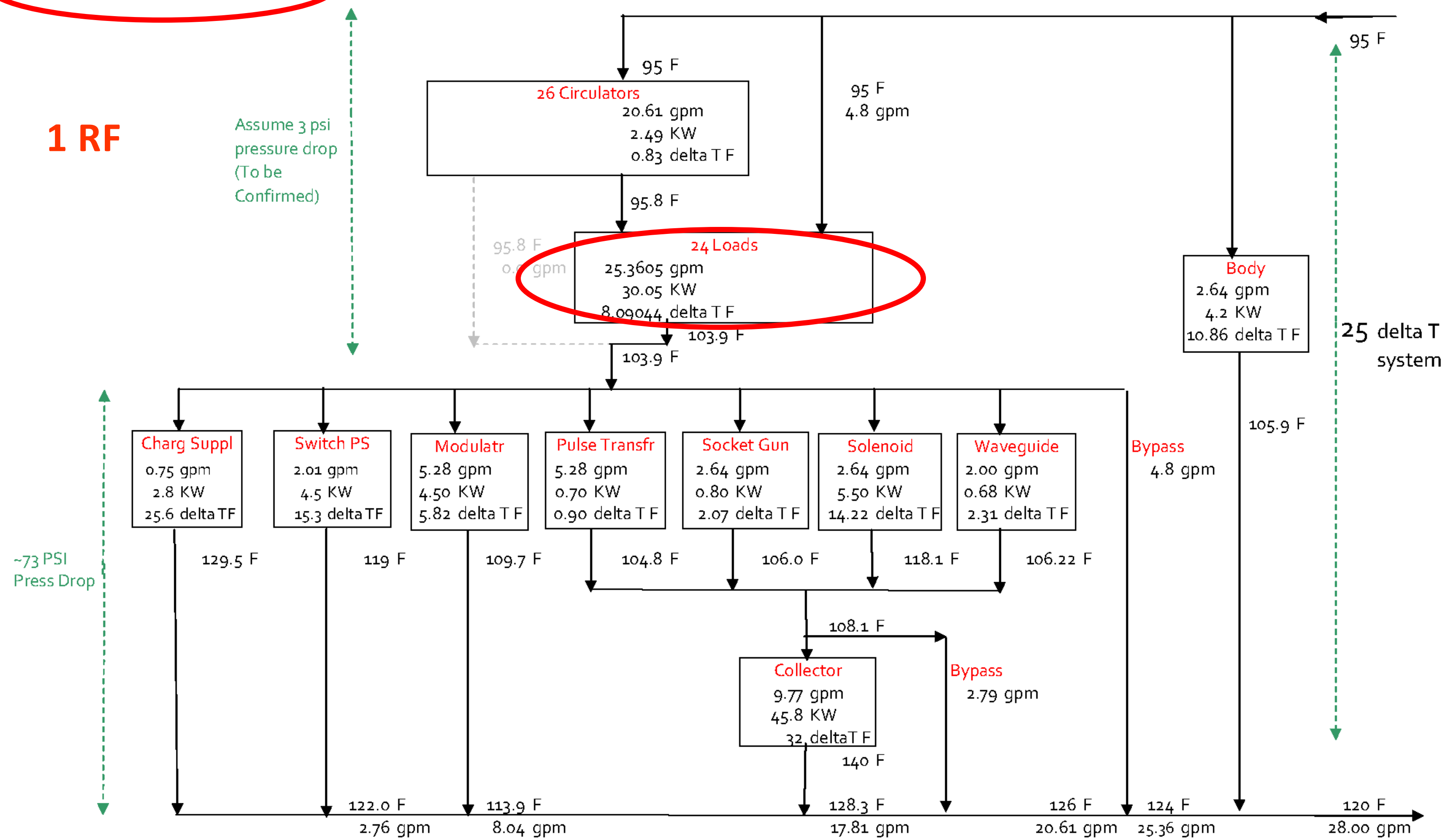
Stacking of Loads / High Delta T

MAIN LINAC RF WATER SYSTEM (based on incomplete heat table dated Oct 31 2007), excluding Transformer

4 liter /min per load flow

e. huedem 11/15/2007

1 RF

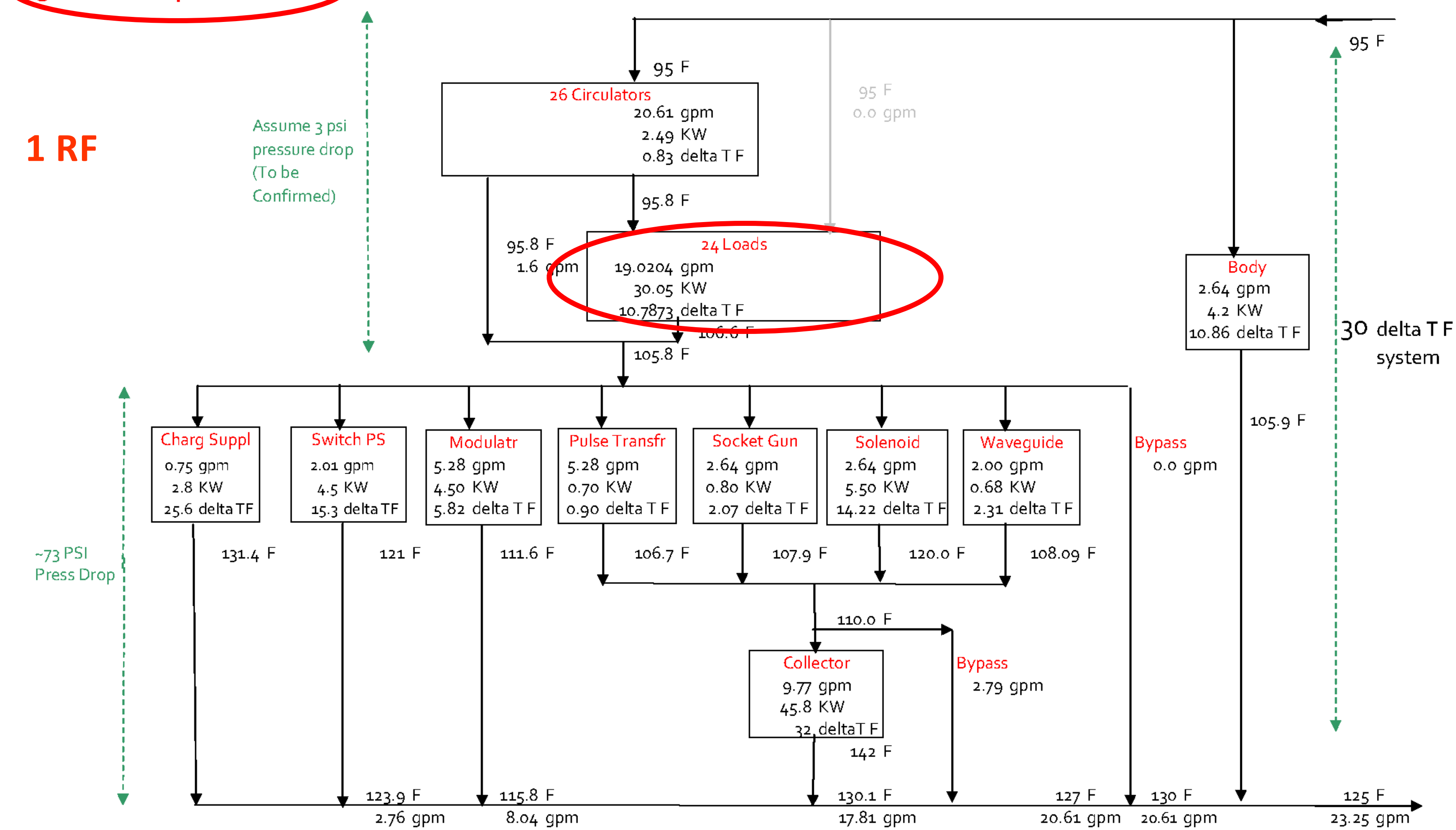


Stacking of Loads / High Delta T

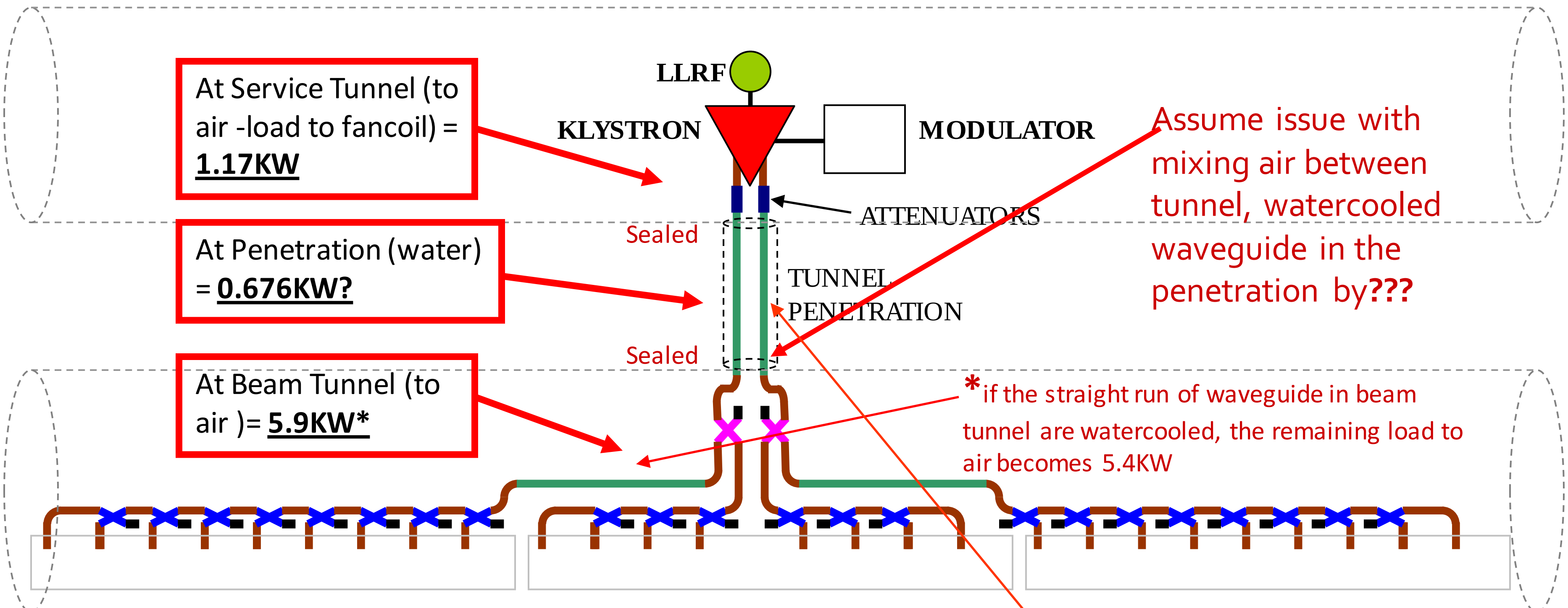
MAIN LINAC RF WATER SYSTEM (based on incomplete heat table dated Oct 31 2007), excluding Transformer

3 liter /min per load flow

e. huedem 11/15/2007



Waveguide Heat of ONE RF UNIT (Oct 4 2007)



Heat Loss from Cryo ~5w/m (T.Peterson) ~(-0.18KW)

Heat Loss from RockWall ignored

Heat Loss (Air) ~38 w/m ~(-1.3 KW)
*15F delta T air at 2.5Km

Heat Gain (Waveguide) = 5.9 KW ~ +5.9 KW

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NET LOAD to AIR (beam tunnel) **+ 4.42 KW**

See HVAC slides later, for option of aircooled wavgd at penetration & about rock contrbtion

Reviewer Questions:

- Criteria (functional requirements) understood?
- Designs address the criteria?
- Designs optimum?
- Overheads / Margins reasonable?
- Special systems (e.g. emergency power) OK?
- Unusual or notable conditions?