

ILC Mechanical & Electrical Review

Conventional **MECHANICAL** System Design Summary

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INTRODUCTION

- Process cooling water, ventilations, and sump system
- Cryogenic system is not included but only it's final heat rejection (cooling towers)
- Sizing (&costing) for full power first (adjustment to lower power-baseline will be done later)
- **Criteria/Load tables used was before July 2011.** Many changes since
- Parsons did the concept & costing for both KCS-ML and DRFS-ML. Only KCS is considered in this review
- Costed each system-bottoms up, per shaft, per system (in RDR scaled from shaft 7)
- Some items just have cost (\$/m fire suppression, \$ target ventilation, \$laser room HVAC, \$compressed air from RDR)

WBS

- Follows the RDR WBS system
- Specific wbs only

1.7.3 AIR TREATMENT (HVAC)	
1.7.3.1	Engineering, study work and documentation
1.7.3.1.1	In-house Engineering
1.7.3.1.2	Outsourced Consultancy Services
1.7.3.2	HVAC Equipment
1.7.3.2.1	Ventilation Units - MUA
1.7.3.2.2	Tunnel Fancoils / air handler
1.7.3.2.3	Air-conditioning for General Areas
1.7.3.2.4	Alcoves / Caverns HVAC
1.7.3.2.5	HVAC surface racks
1.7.3.2.6	Surface RF equipment Ventilations
1.7.4 PIPED UTILITIES	
1.7.4.1	Engineering, study work and documentation
1.7.4.1.1	In-house Engineering
1.7.4.1.2	Outsourced Consultancy Services
1.7.4.2	Plumbing
1.7.4.2.1	Potable Water
1.7.4.2.2	Sanitary System
1.7.4.2.3	Sump Systems
1.7.4.2.4	GroundWater Lift Systems
1.7.4.3	Fire Suppression
1.7.4.4	Fuel System Distribution
1.7.5 PROCESS COOLING WATER	
1.7.5.1	Engineering, study work and documentation
1.7.5.1.1	In-house engineering
1.7.5.1.2	Outsourced Consultancy Services
1.7.5.2	Primary Stations
1.7.5.2.1	Cooling Towers & Pumping Stations
1.7.5.2.2	Primary Stations and Piping
1.7.5.3	Secondary Stations
1.7.5.3.1	Demineralized Water Stations and Distribution Piping
1.7.5.3.2	Chilled Water Stations and Distribution Piping
1.7.5.3.3	Water Stations and Distribution Piping
1.7.5.3.4	Compressed Air
1.7.5.3.5	Process Water Distribution

1.7.5 PROCESS (COOLING) WATER	
1.7.5.1	Engineering, study work and documentation
1.7.5.1.1	In-house engineering
1.7.5.1.2	Outsourced Consultancy Services
1.7.5.2	Primary Stations
1.7.5.2.1	Cooling Towers & Pumping Stations
1.7.5.2.1.1	Cooling Towers for Process Water
1.7.5.2.1.2	Cooling Towers for Chiller Water
1.7.5.2.1.3	Tower Pump & Accessories for Process Water
1.7.5.2.1.4	Tower Pump & Accessories for Chiller Water
1.7.5.2.1.5	Chilled Water Pumps
1.7.5.2.1.6	Controls
1.7.5.2.1.7	Heat Exchanger for RF Water system
1.7.5.2.1.8	reserved
1.7.5.2.2	Primary Stations and Piping
1.7.5.2.2.1	Chillers
1.7.5.2.2.2	Tower piping for Process Water (surface)
1.7.5.2.2.3	Tower piping for Chilled Water (surface)
1.7.5.2.2.4	Tower piping for Process Water (shaft)
1.7.5.2.2.5	Chilled Water Piping (surface)
1.7.5.2.2.6	Chilled Water Piping (Shaft)
1.7.5.2.2.7	reserved
1.7.5.3	Secondary Stations
1.7.5.3.1	LCW Systems
1.7.5.3.1.1	LCW Skid (Pumps & Heat Exchangers)
1.7.5.3.1.2	LCW Pumps - Surface
1.7.5.3.1.3	LCW Piping - Surface
1.7.5.3.1.4	LCW Piping - Tunnel
1.7.5.3.1.5	LCW Piping Connections
1.7.5.3.1.6	MISC LCW (DI processing / LCW Controls etc)
1.7.5.3.2	Chilled Water Stations and Distribution Piping
1.7.5.3.2.1	Heat Exchanger (Cavern)
1.7.5.3.2.2	Distribution Pumps (Cavern)
1.7.5.3.2.3	Piping (Cavern)
1.7.5.3.2.4	Piping (Tunnel)
1.7.5.3.2.5	Piping Connections to End Equipment
1.7.5.3.2.6	reserved
1.7.5.3.3	Water Stations and Distribution Piping
1.7.5.3.3.1	Water Stations and Distribution Piping
1.7.5.3.3.2	reserved
1.7.5.3.4	Compressed Air
1.7.5.3.5	Process Water Distribution
1.7.5.3.2.1	Heat Exchanger (Cavern)
1.7.5.3.2.2	Distribution Pumps (Cavern)
1.7.5.3.2.3	Piping (Cavern)
1.7.5.3.2.4	Piping (Tunnel)
1.7.5.3.2.5	Piping Connections to End Equipment
1.7.5.3.2.6	reserved

Load Table progress – Basis for current Concept design

	Load Tables		
	starting point	use by Parsons	latest
electron source		just a single KW #	Mar 02 2012 (statement only)
positron source	Aug 27 2010	Feb 25 2011	Mar 02 2012
damping ring	Aug 2 2010	Jun 17 2011	Feb 28 2012
rml	Sep 7 2010	Sep 7 2010	Mar 14 2012
main linac-KCS	Dec 8 2010	Mar 23 2011	Mar 01 2012
main linac-DRFS		Jul/Aug 2011	N/A
ML-rdr style	N/A	N/A	
BDS	Sep 27 2010	Sep 27 2010	Mar 02 2012
IR	Sep 20 2007	Sep 2007 & Jun 30 2010	Mar 09 2012
dumps			Feb 14 2012
Cryo		Feb 8 2011	Mar 07 2012
Laser			Feb 14 2012

RECENT CHANGES ARE
NOT INCLUDED HERE

CRITERIA / TECHNICAL LOADS

AREAS	MW load	%
electron source (e-)	4.3	2%
positron source (e+)	7.4	4%
damping ring (dr)	17.3	8%
ring-to-main-linac (rtml)	8.6	4%
main linac (ml)	123.8	59%
beam delivery system (bds)	10.8	5%
major dumps	36	17%
interaction region (ir)	1.9	1%
	210	

In Central Region

ML loads comes from RF system & racks
For KCS, more than 60% of ML loads are in the surface

Some key criteria/input

Various area system heat load tables (except e-)

Various delta T per users

Machine design to run all year or anytime in a year

DR & BDS has tight space (air) stability

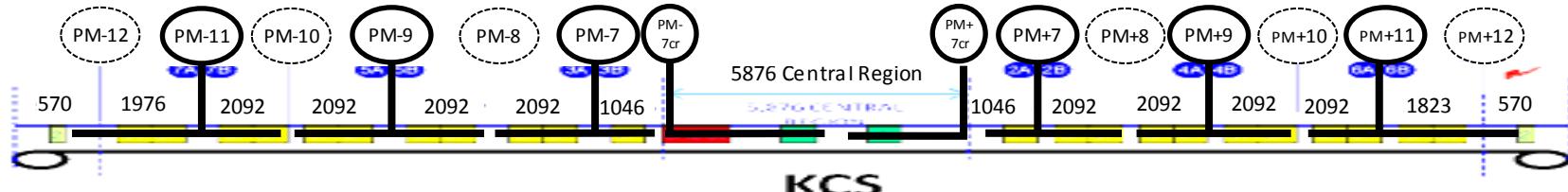
Lcw/process water supply stability not critical

150 gpm per mile inflow for groundwater

RECENT CHANGES ARE NOT INCLUDED HERE

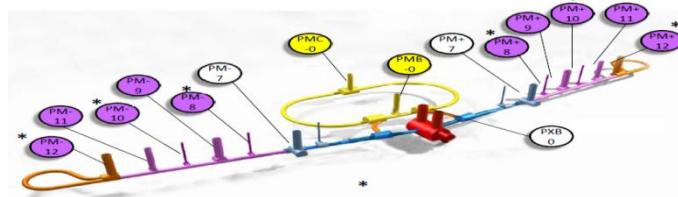
PROCESS WATER PLANT LOCATIONS & LOADS-KCS

(Technical components only shown)



(sample load distribution) *EXCLUDING non-technical components

New Shaft Nos	PM-12	PM-11	PM-10	PM-9	PM-8	PM-7	PMC-0	PMB-0	PXB-0	PXB-0	PM+7	PM+8	PM+9	PM+10	PM+11	PM+12	TOTAL MW (cooling)*
Old Shaft Nos	Shaft 11	Shaft 7	Shaft 14	Shaft 5	Shaft 15	Shaft 3	Shaft 13	Shaft 12	Shaft 1.1	Shaft 1.2	Shaft 2	Shaft 16	Shaft 4	Shaft 17	Shaft 6	Shaft 10	
						(central region)				near this shaft	(central region)						
	2.1	21.0	4.85	17.3	4.85	16.54	11.9	14.5	2.8	2.3	36	9.9	16.54	4.85	17.3	4.85	210
RTML		45% rtml 3.87					5% 0.43				5% 0.43				45% rtml 3.87		8.61
ML(surface)	28 RF 2.12	64 RF 4.85	64 RF 4.85	64 RF 4.85	64 RF 4.85	64 RF 4.85					64RF 4.85	64RF 4.85	64RF 4.85	64 RF 4.85	64 RF 4.85	24 RF 1.82	79.59
ML(tunnel)**		105 RF 4.91		108 RF 5.04		81 RF 3.74					81 RF 3.74		108 RF 5.04		101 RF 4.73		
e+						100% 6.22											6.22
e-											100% 4.3						4.30
BDS						50% 5.20					50% 5.20						10.4
DR							85% 11.97	15% 2.84									14.81
Dumps									36								36.00
CRYO (surface)		7.37		7.37		7.96	2.52	0	1.730		7.96		7.37		7.37		49.63
IR									0.576								0.576
** includes 0.914 KW nc magnet over 5 plants																	210
* excluding conventional non-technical components (By Parsons)																	



RECENT CHANGES ARE
NOT INCLUDED HERE

DRAFT
7/19/2011
E.Huedem

ML-KCS Process water System

ML-KCS [MAIN LINAC - Klystron Cluster Scheme] DESIGN CRITERIA FOR CFS														
KLY CLUSTER SCHEME, MAIN LINAC "Power, Water & Air Heat Load" per RF (3-cryomodule section)														
COMPONENTS IN THE SURFACE (listed as per RF)														
	Quantity	Average Heat Load (kW)	Heat Load to LCW Water (kW)	Max Allowable Temperature (°C)	Supply Temp (°C)	Delta Temperature (F delta)	Water Flow (l/min)	gpm	Delta Temperature (F delta)	Maximum Allowable Pressure (Bar)	Typical (water) pressure drop Bar	Acceptable Temp Variation delta C	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
Switching power supply		692/ML	7.0	4.2		35	7.94	7.6	2.008	14.28	13	5	10	NA
Pulse Transformer		692/ML	1.0	0.7	60	35	0.50	20	5.283	0.905		1	n/a	NA
Modulator		692/ML	6.3	3.8		35	2.73	20	5.283	4.916	10	5	n/a	NA
Klystron Scket Tank / Gun	Klystron	692/ML	1.0	0.8	60	35	1.15	10	2.642	2.068	15	1	n/a	NA
Focusing Coil (Solenoid)	Weight	692/ML	1.7	1.6	80	55	2	10	2.642	4.182	15	1	n/a	NA
Klystron Collector		692/ML	42.13	37.5		87	15	37	9.774	26.19	15	0.3	n/a	NA
Klystron Body & Windows		692/ML		3.4	40	25 to 40C	5	10	2.642	14	15	4.5	+ - 2.5 C	NA
CTOs & combining Loads/circulators	z/Klystron	10.50	8.4				6.04	1.99	5.28	10.86		(80 psid)	?	
Relay Racks (Instrument Racks)		TBD	3.0	0	N/A	N/A	N/A		0	N/A	N/A	N/A	None	1.1
SUBTOTAL			62.51							Total surface RF (excluding Racks) =	72.74			3.0
														10.2

SURFACE (per RF)

~62.5 kW to LCW

3 kW to CRAC

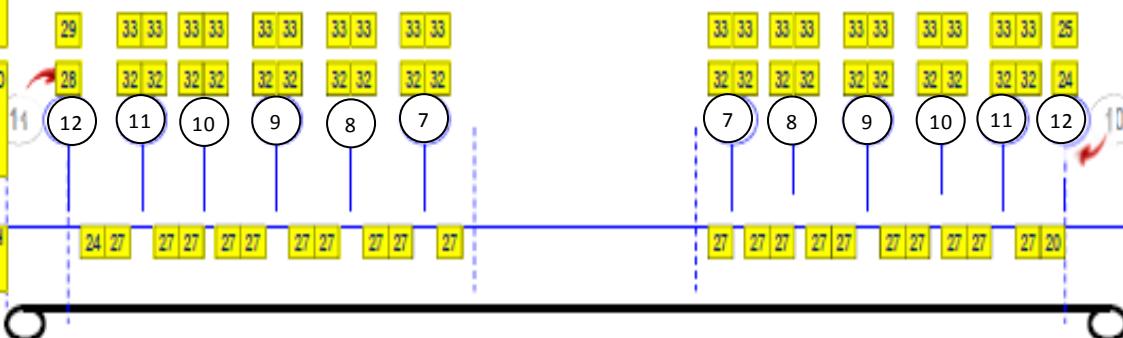
~10.2 kW to air (ventilation)

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	0	3
Subtotal Tunnel RF & NonRF unit Only (for 1 RF)		36.41								Total tunnel RF (excluding Racks) =	39.99			5.0
														3.6

Total No of Klystron in surface = 714

Total No of POWERED Klystron in surface = 692

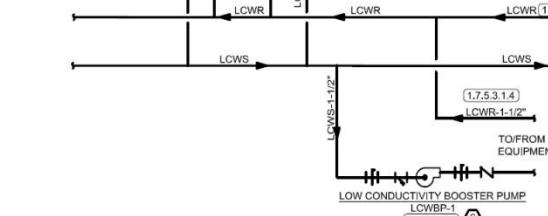
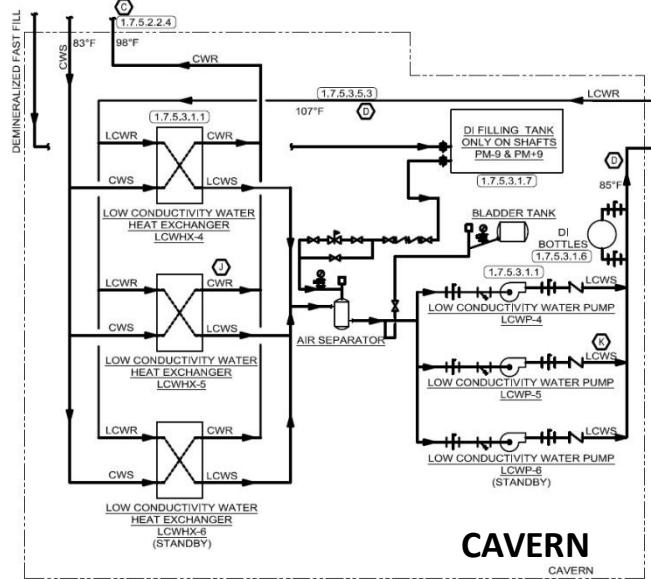
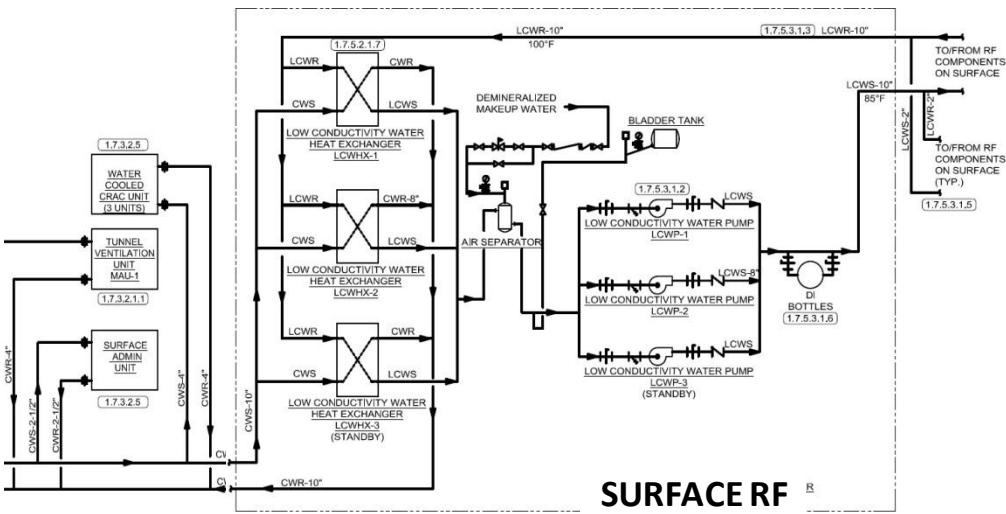
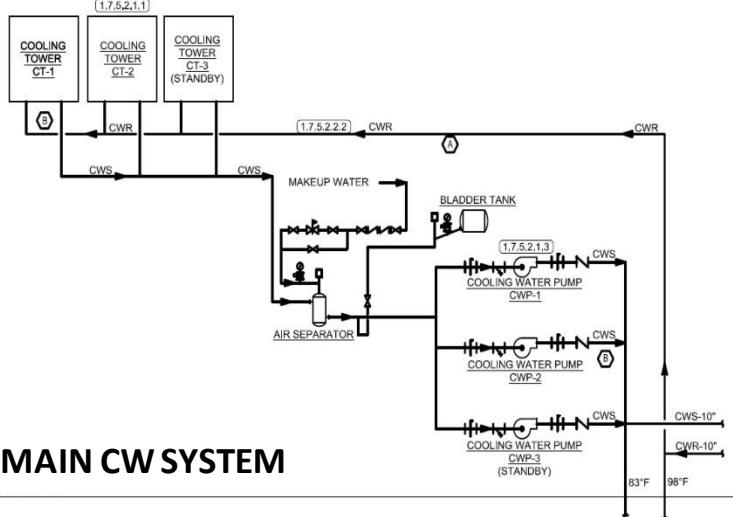
Total No in the tunnel = 584*



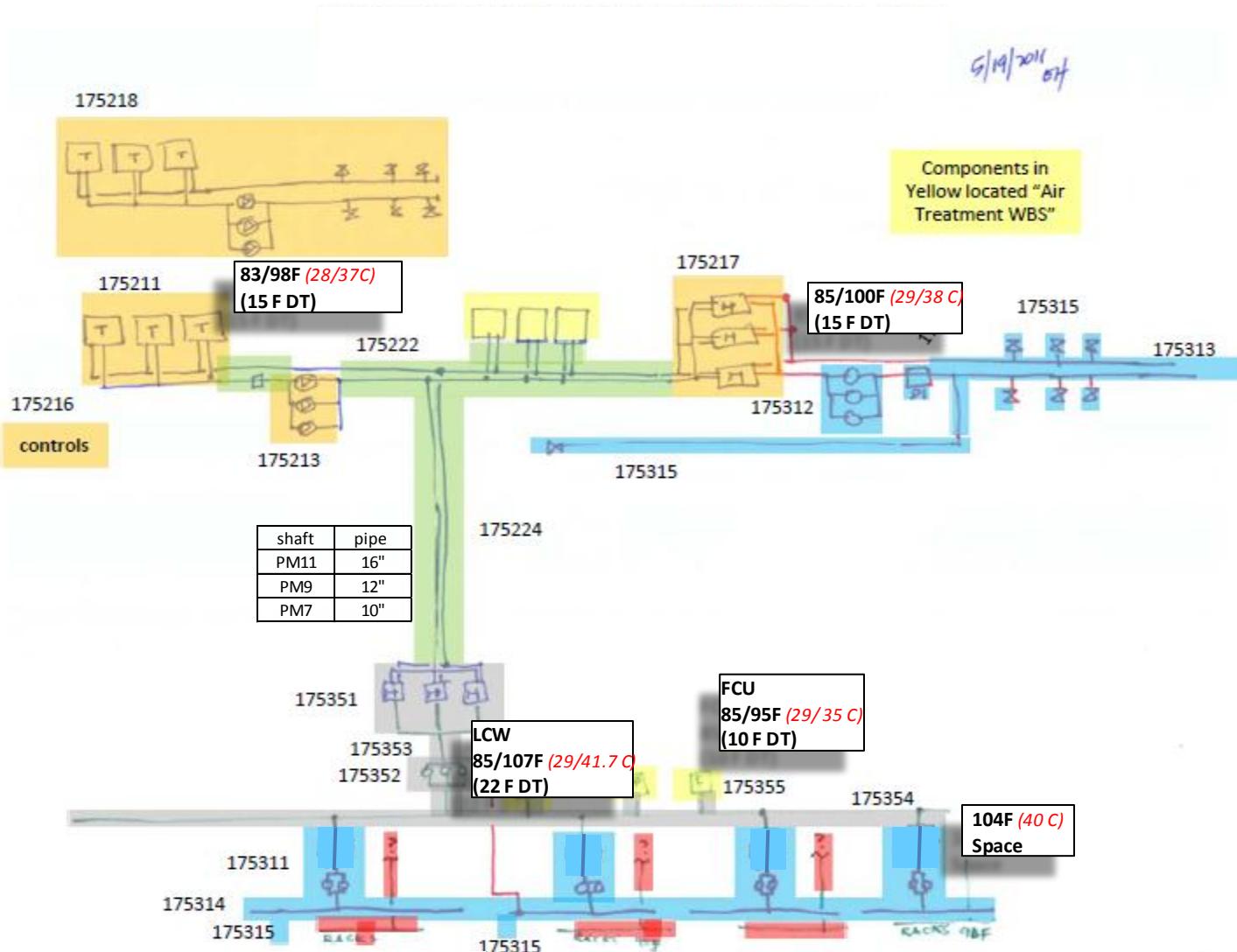
A. FULL POWER

RECENT CHANGES ARE NOT INCLUDED HERE

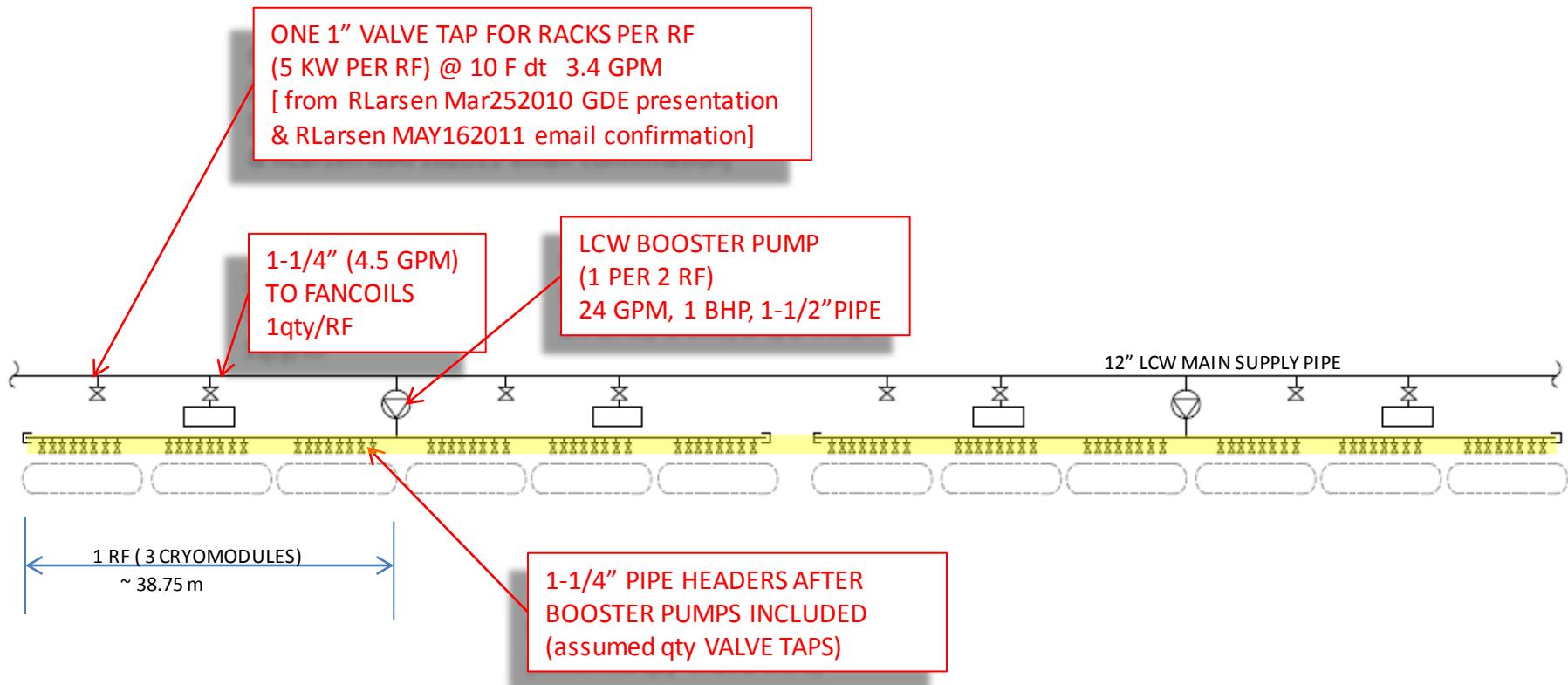
ML-KCS Process water System



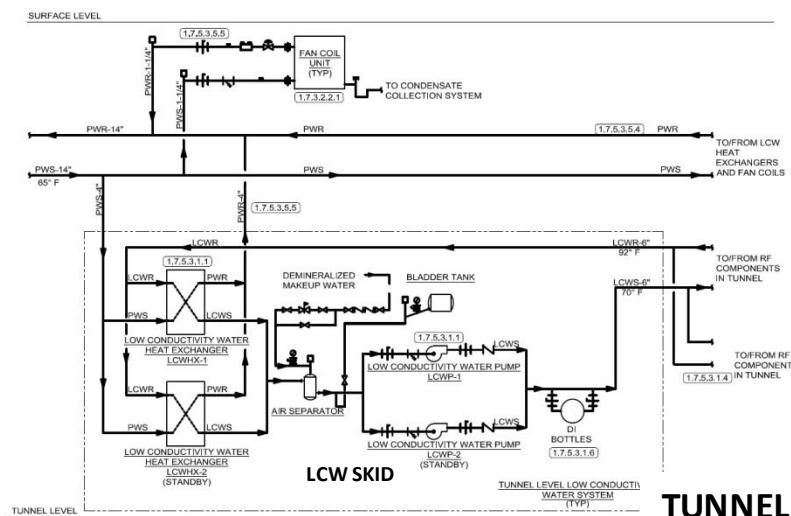
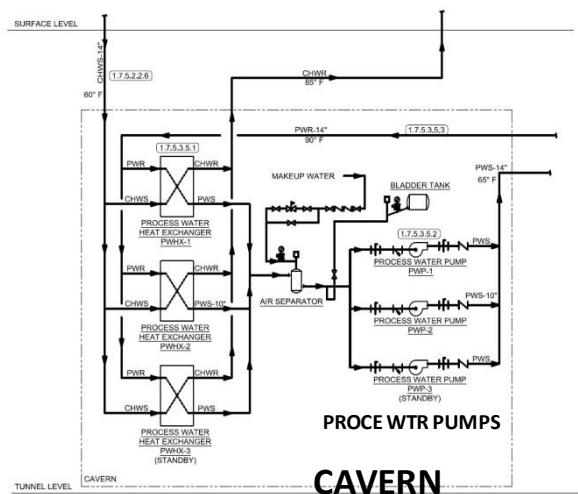
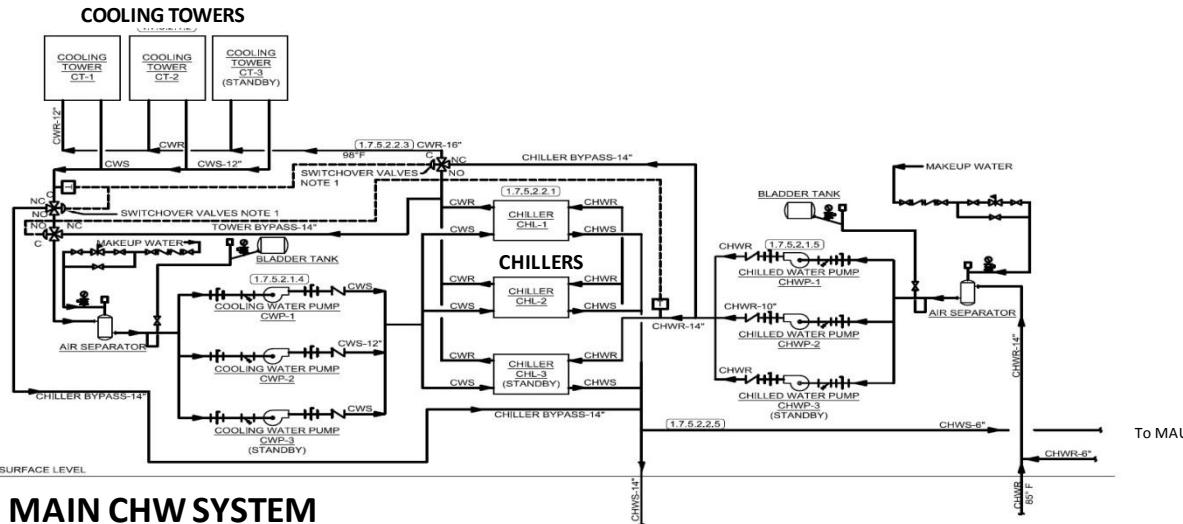
ML-KCS Process water System (simplified)



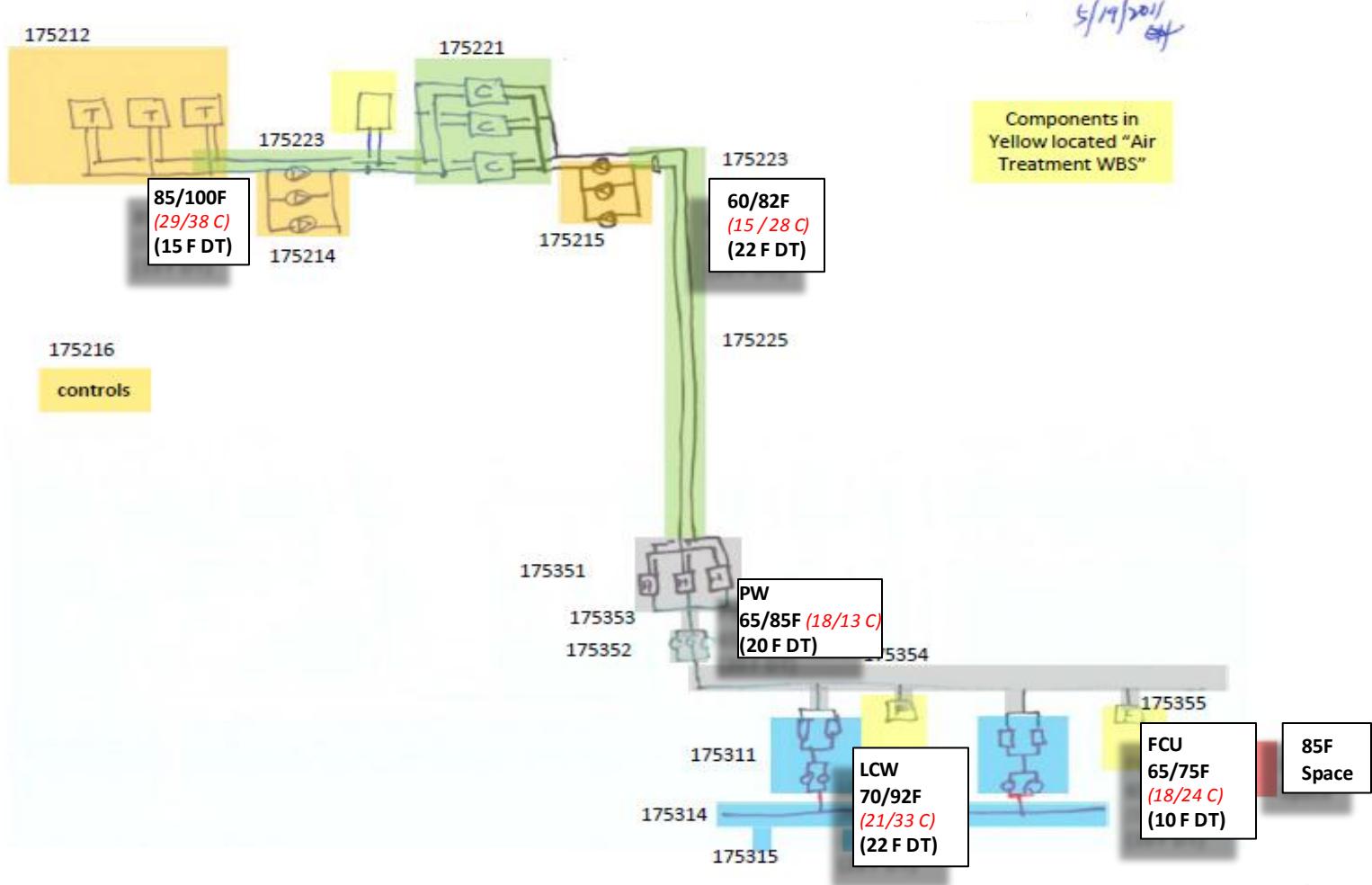
INTERFACE (KCS) (ONLY THE SUPPLY PIPE ARE SHOWN FOR CLARITY)



Central Region Process water System

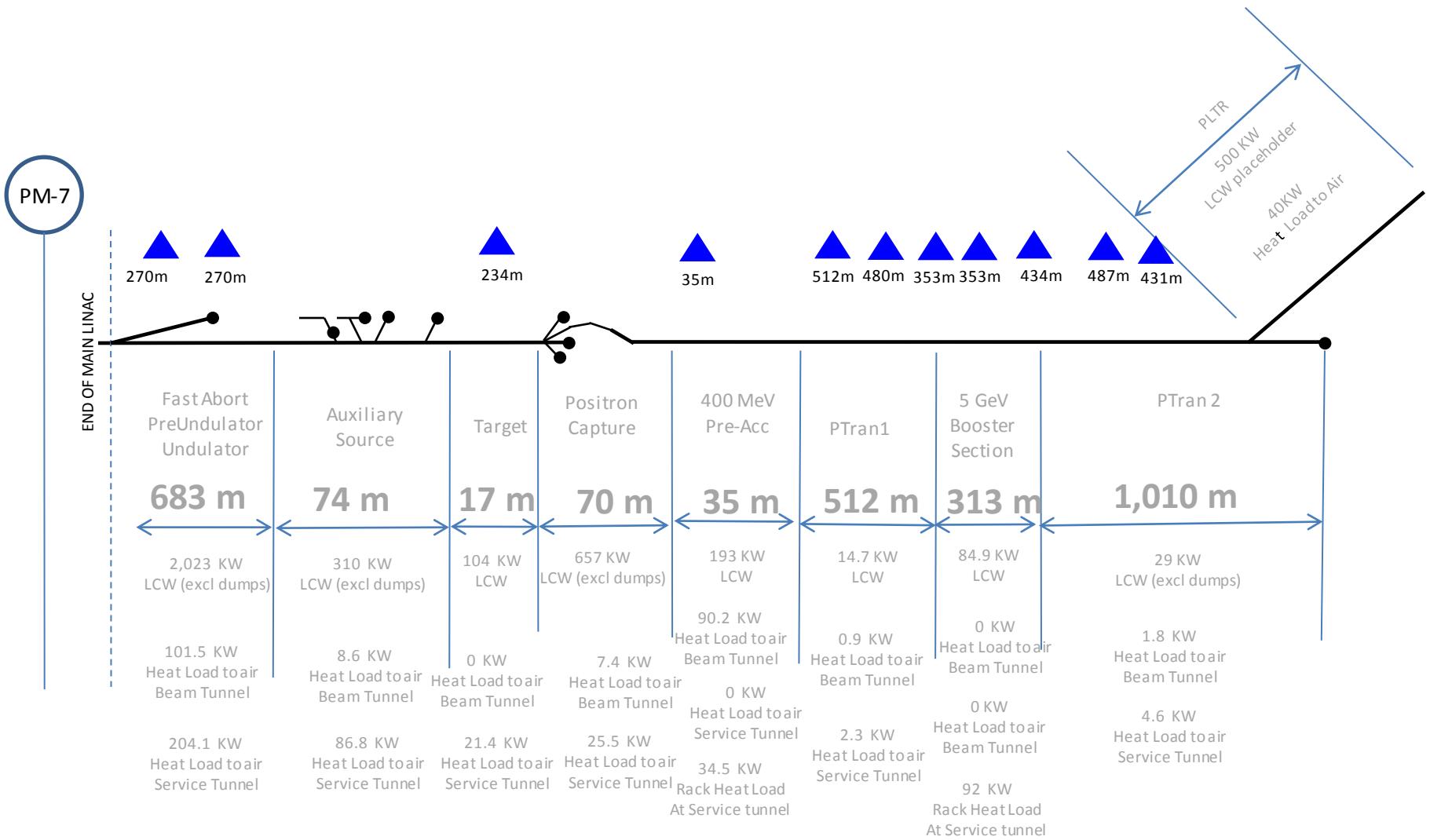


Central Region Process water System (simplified)

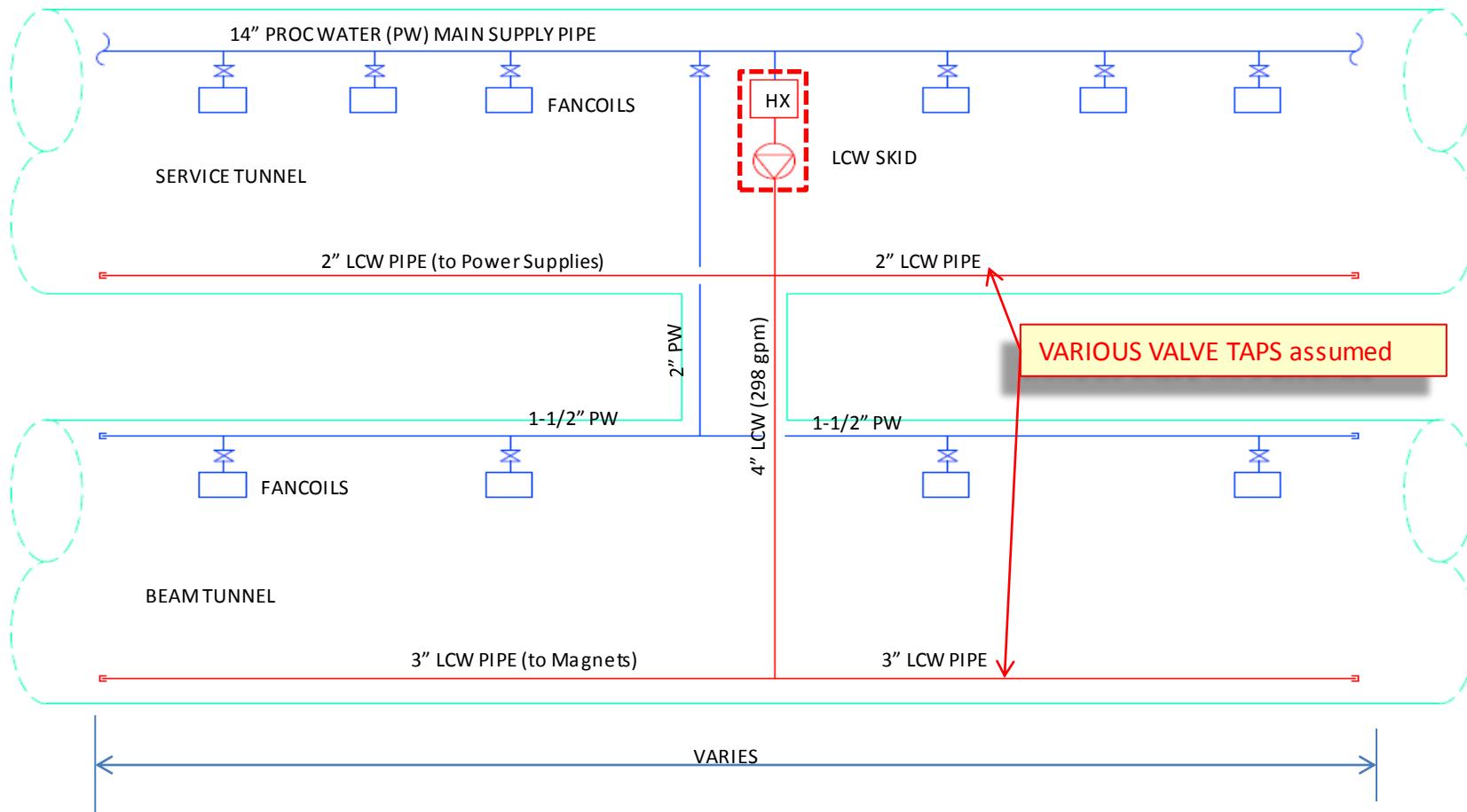


▲ Central Region LCW SKID LOCATIONS & FEED

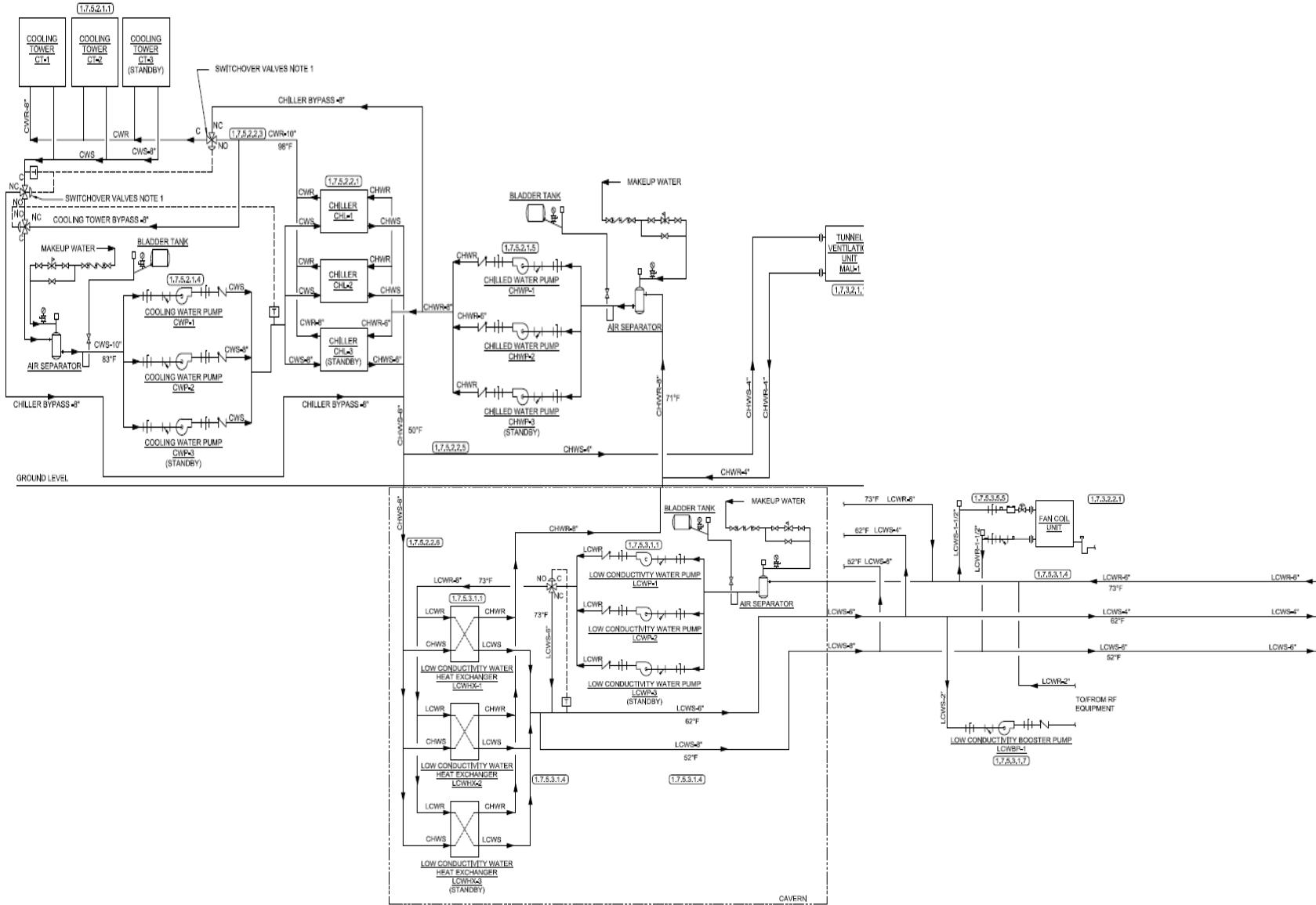
Length shown are approximate for process water distribution purposes only & doesn't reflect the actual beamlength



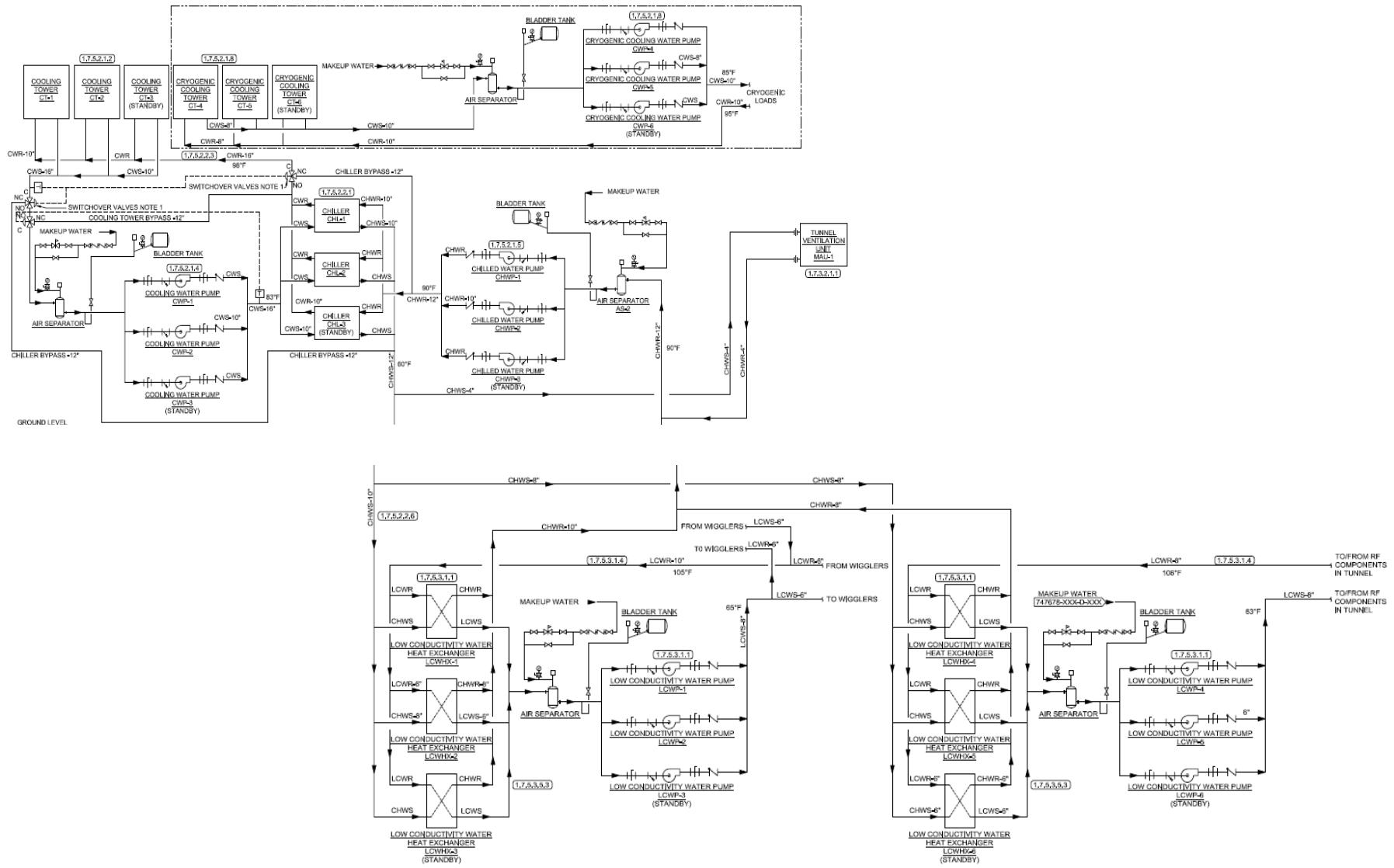
INTERFACE (Central Region) (ONLY THE SUPPLY PIPE ARE SHOWN FOR CLARITY)



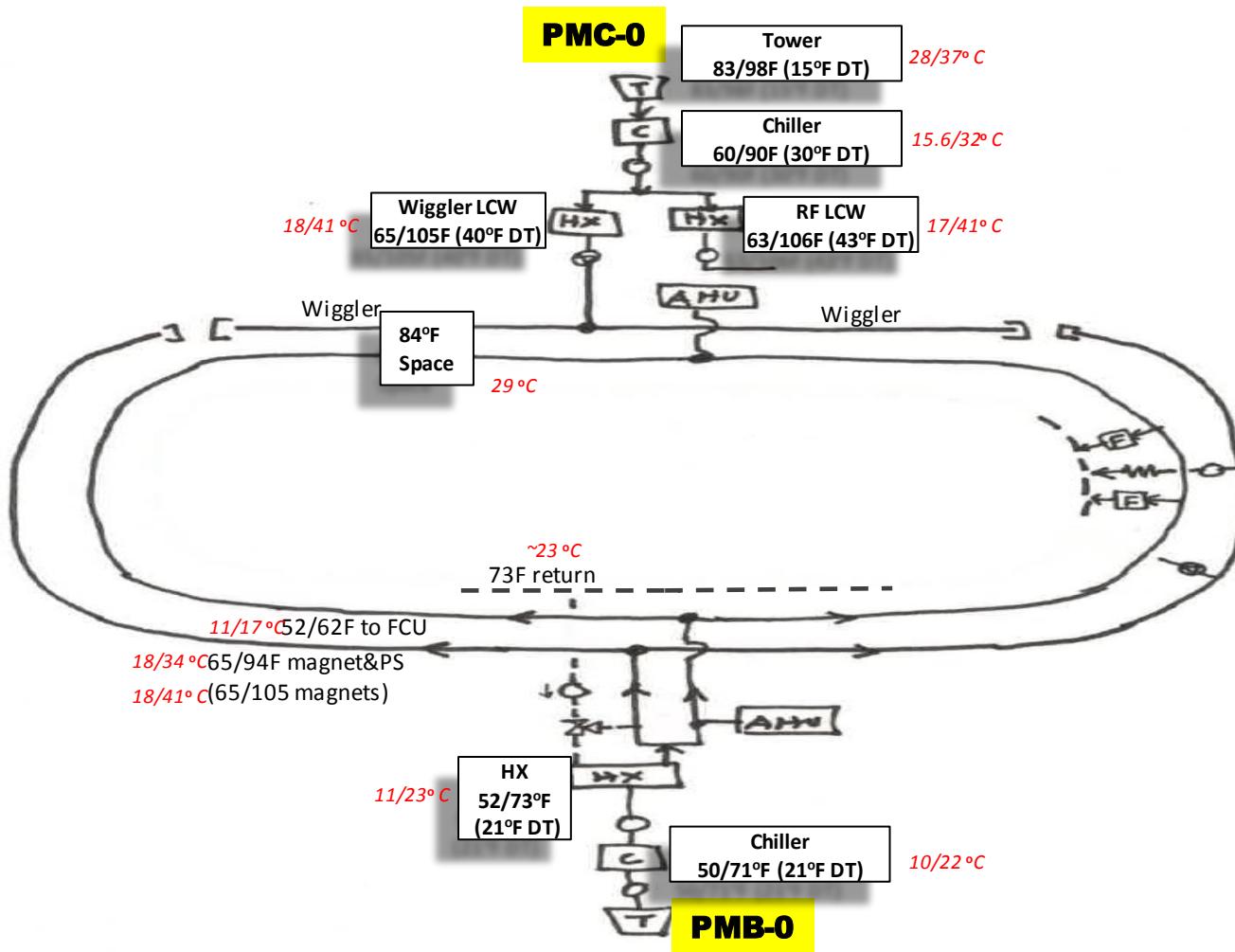
Damping Ring Process water System (PMB shaft)



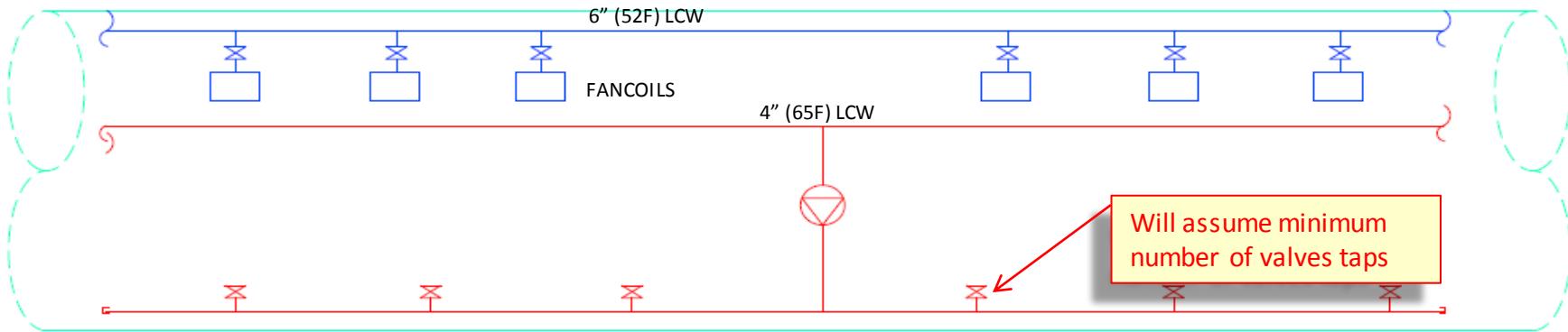
Damping Ring Process water System (PMC shaft)



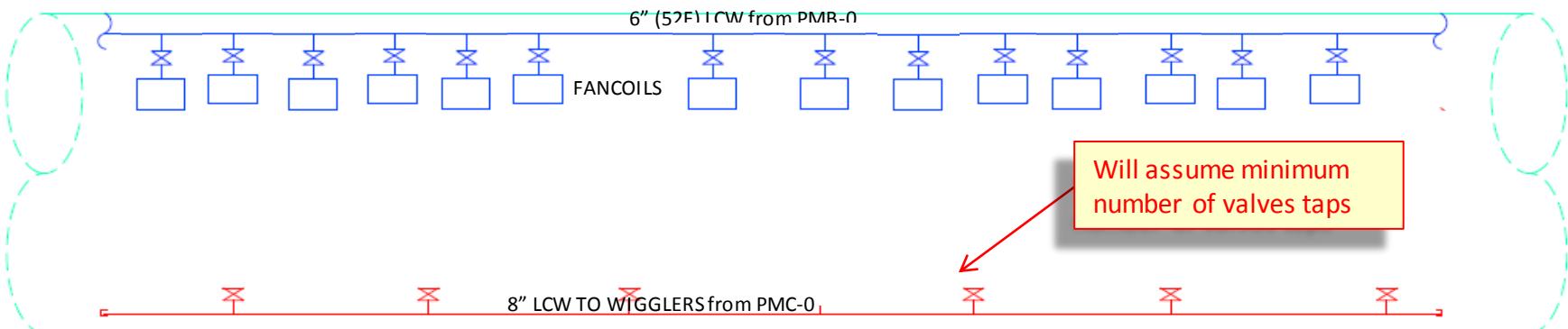
Damping Ring Process water System (Simplified)



INTERFACE (Damping Ring) (ONLY THE SUPPLY PIPE ARE SHOWN FOR CLARITY)

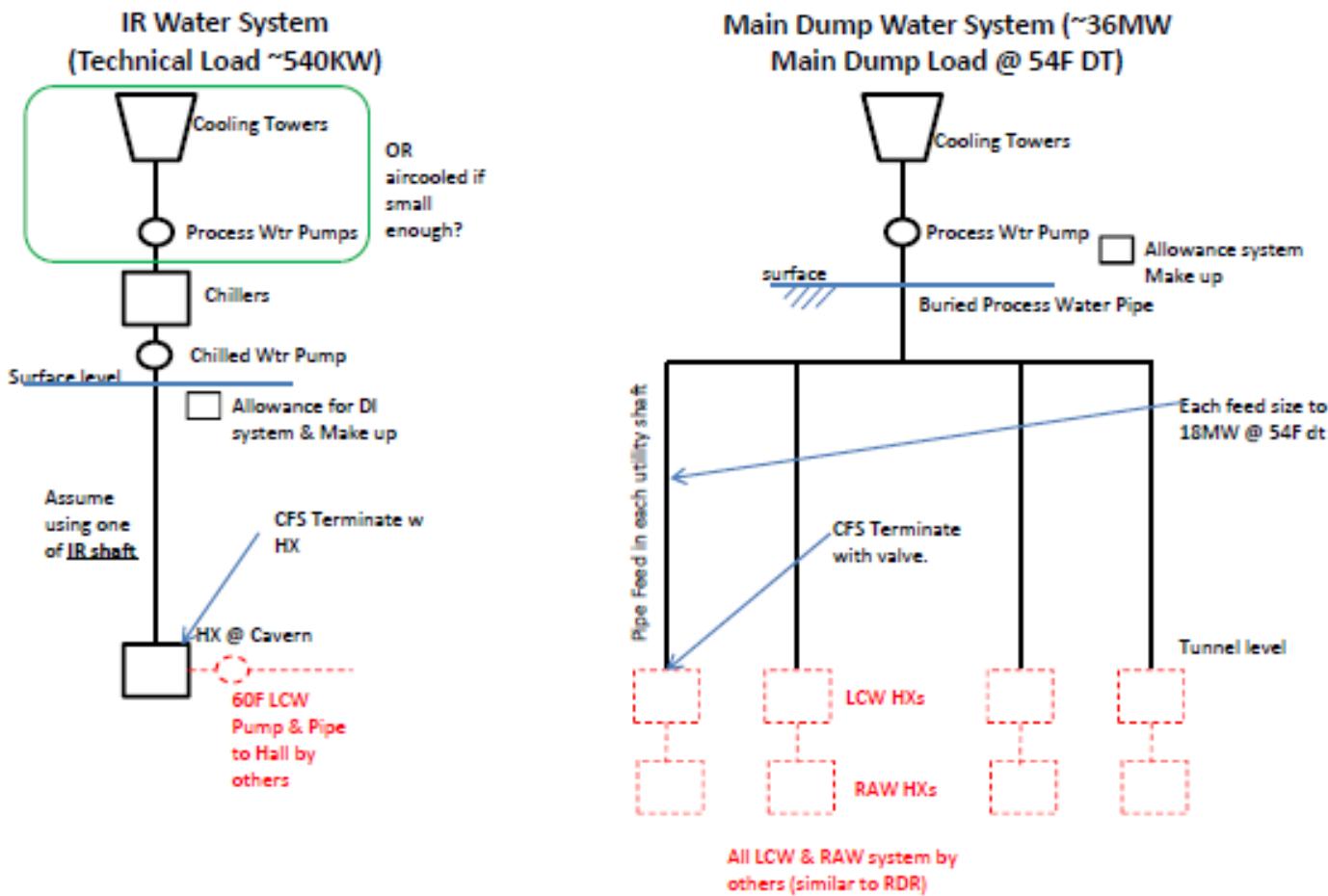


Feed from PMB-0 to beam tunnel (approx 1.3 Km)

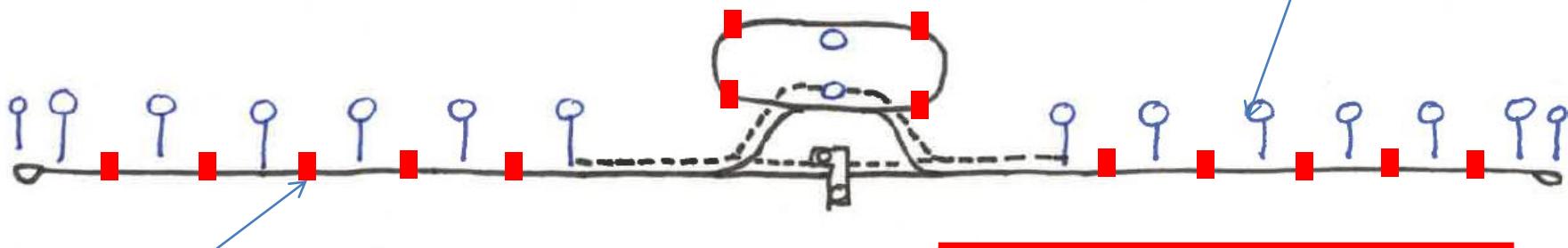
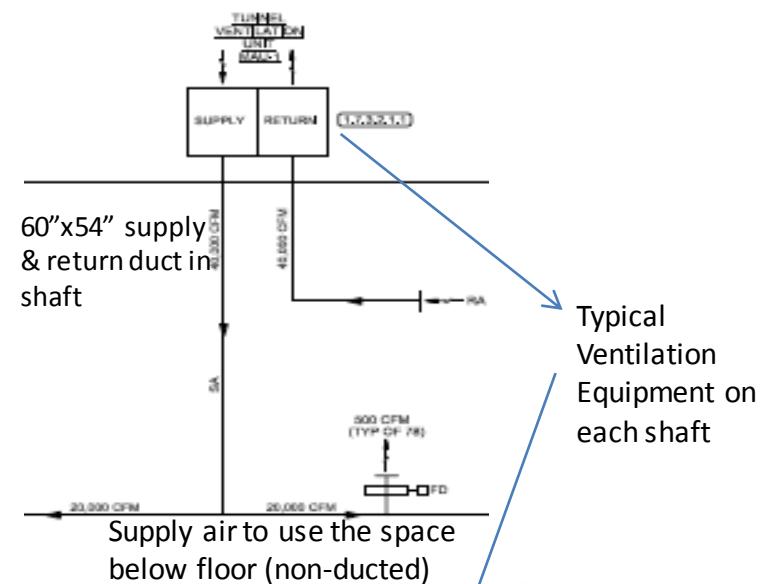
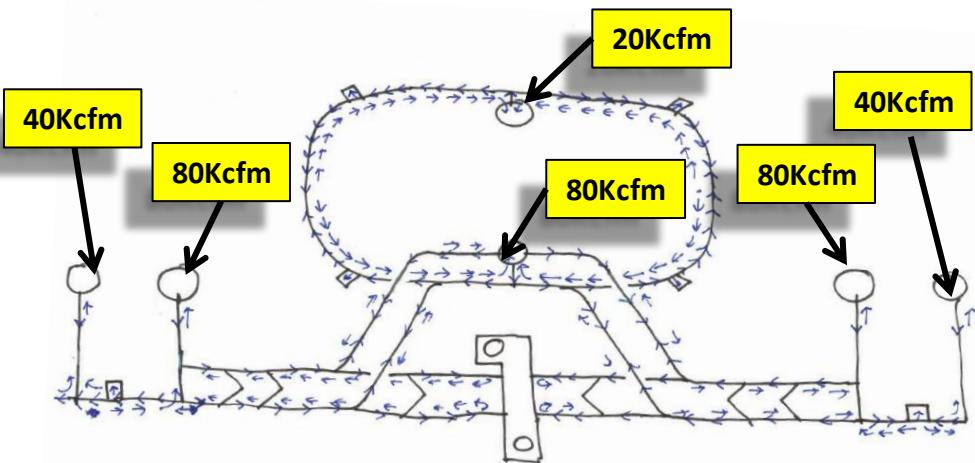


Feed from PMC-0 to wiggler area (approx 204m x 2)

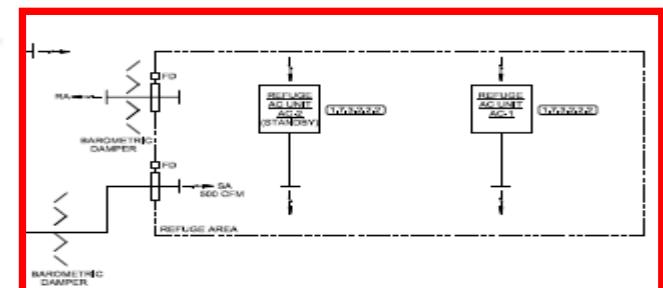
IR & Main Dump Process water System (simplified)



AIR TREATMENT SCHEME



- ~1mph airspeed (~2 ac/hr)



PLUMBING SCHEME

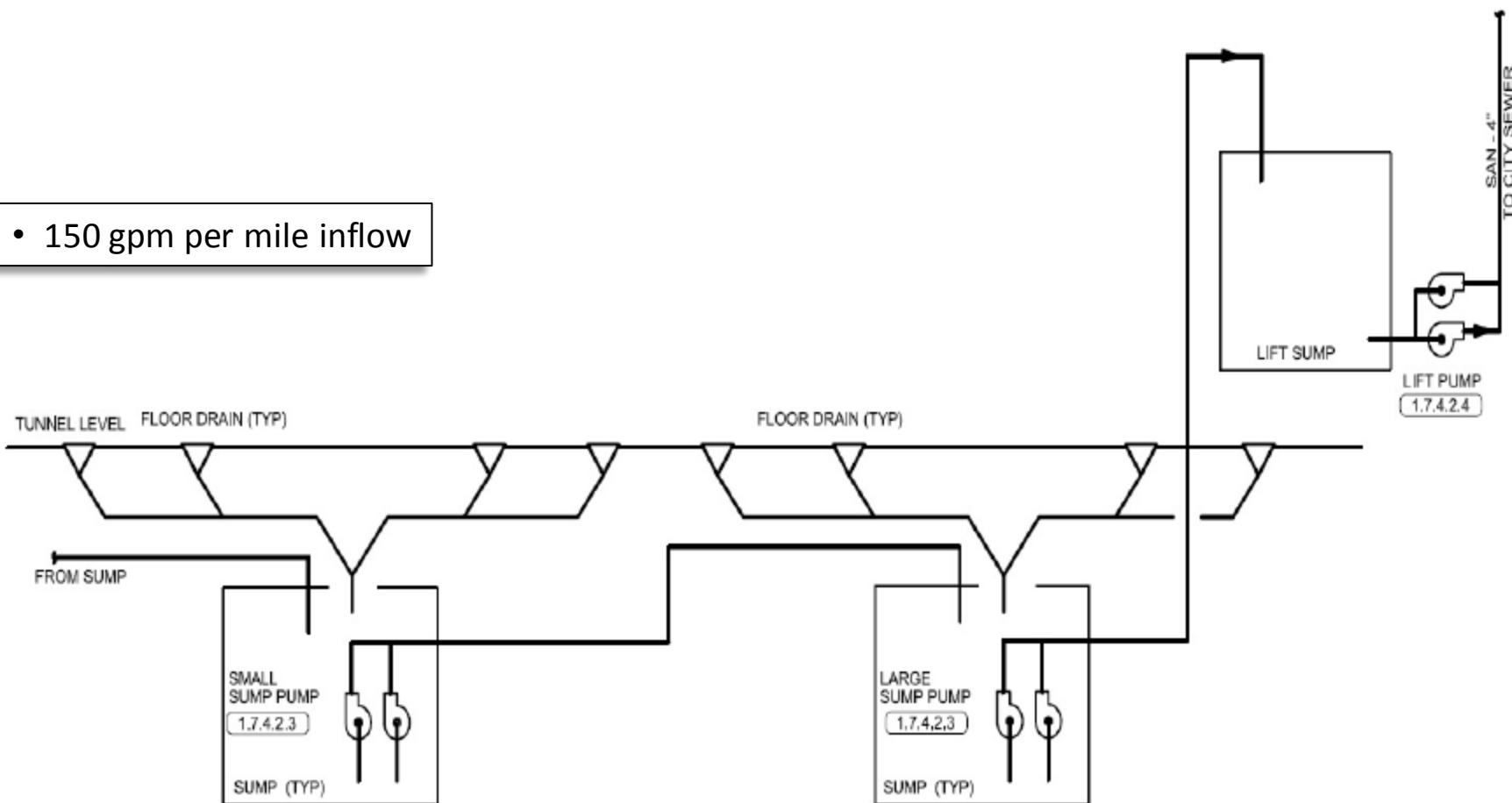


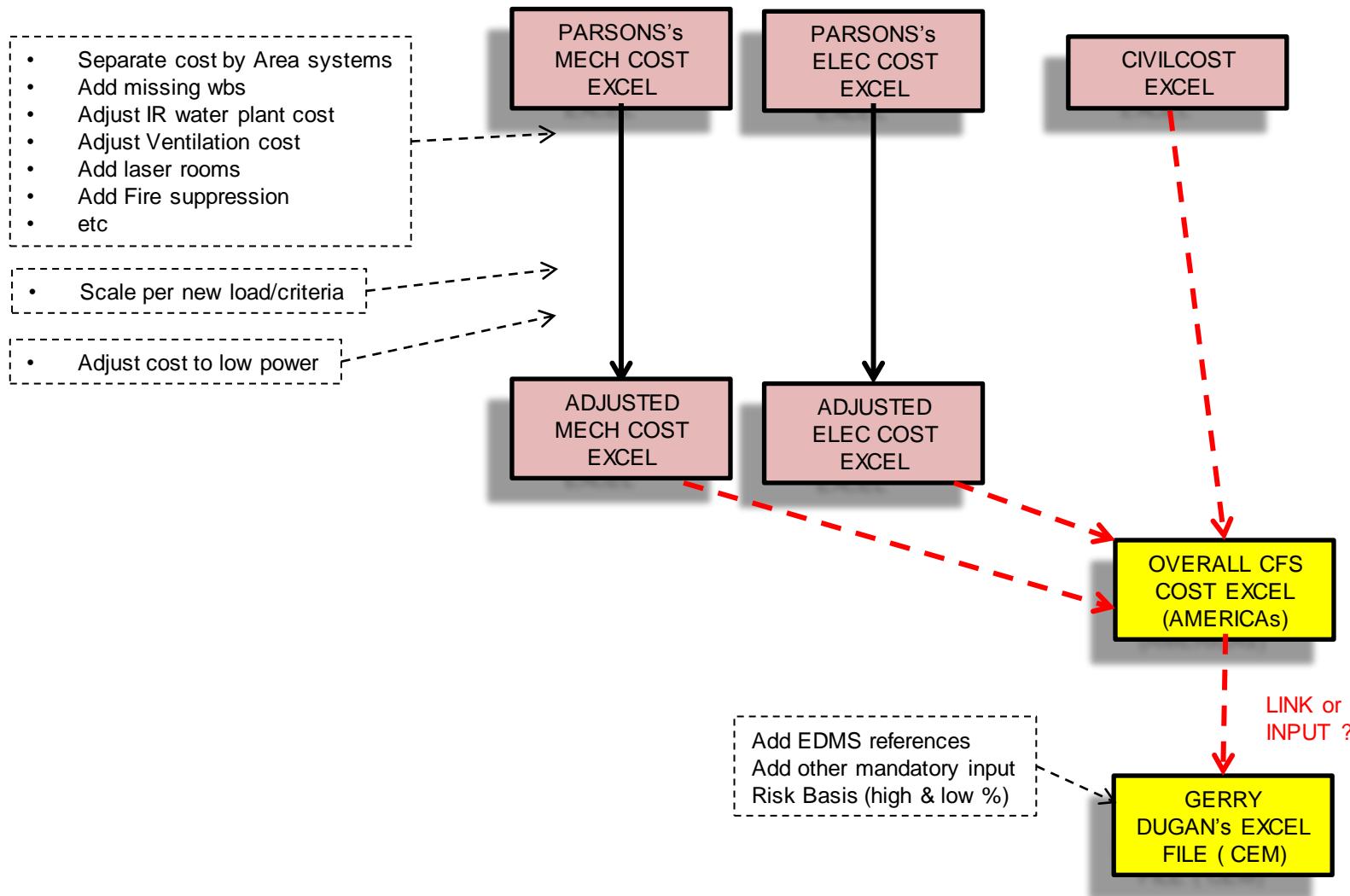
Figure 2-8: Typical Below Grade Drainage Diagram

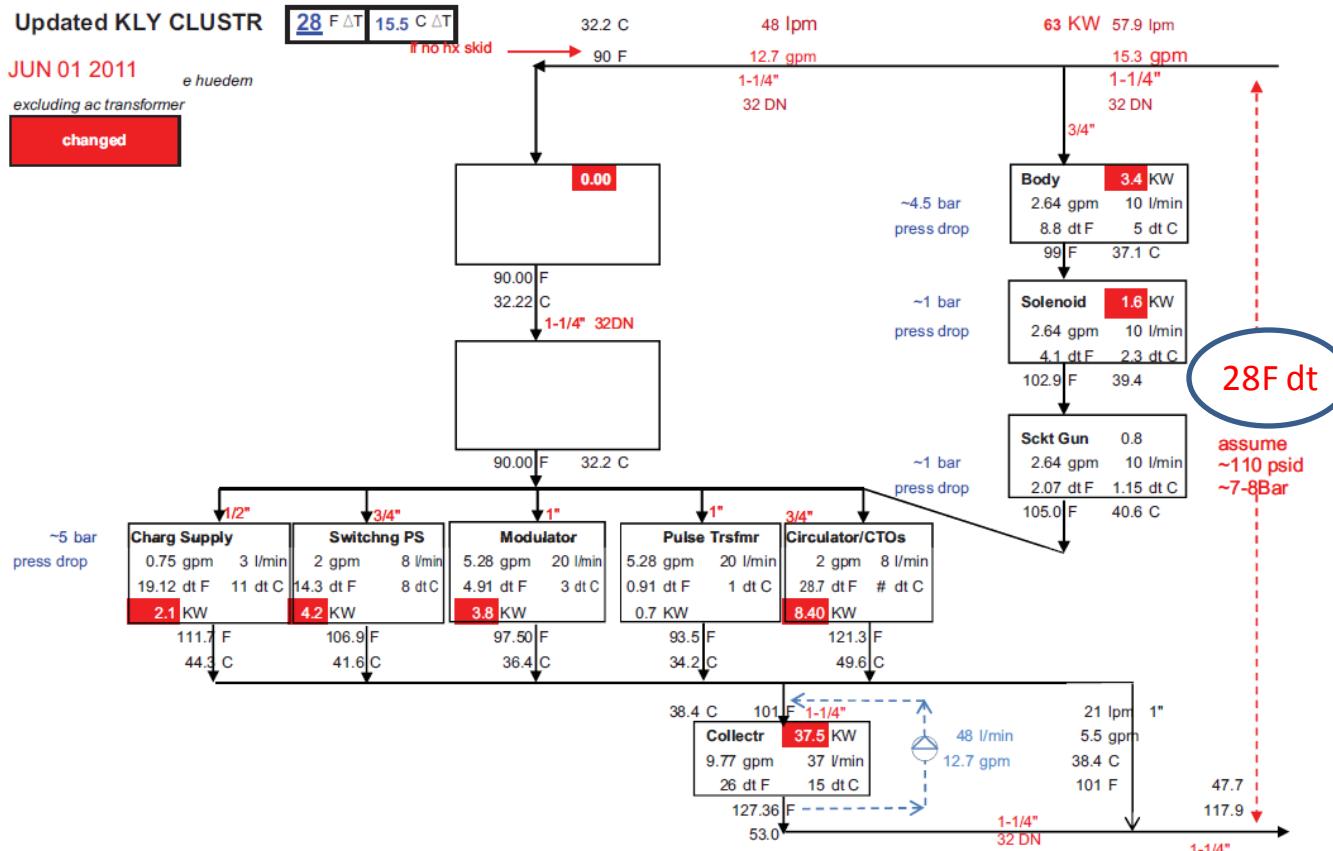
Conventional Mechanical Equipment QUANTITIES (n+1)																March 19 2012			
Location		PM-12	PM-11	PM-10	PM-9	PM-8	PM-7	PM-7cr	PMC	PMB	PXA	PXB	PM+7cr	PM+7	PM+8	PM+9	PM+10	PM+11	PM+12
surface area	chiller							2+1	2+1	2+1	2+1		2+1						
	chilled pump							2+1	2+1	2+1	2+1		2+1						
	cooling tower-process	3+1	2+1	3+1	2+1	3+1	2+1	2+1	2+1	2+1	2+1	2+1	2+1	2+1	3+1	2+1	3+1		
	cooling tower-cryo		2+1		2+1		2+1		2+1					2+1		2+1		2+1	
	cooling twr pump-process	3+1	2+1	3+1	2+1	3+1	2+1	2+1	2+1	2+1	2+1	2+1	2+1	3+1	2+1	3+1	2+1	3+1	
	cooling twr pump-cryo		2+1		2+1		2+1		2+1		2+1			2+1		2+1		2+1	
	computer ac for racks	2+1	2+1	2+1	2+1	2+1	2+1							2+1	2+1	2+1	2+1	2+1	
	ventilation for RF	4	4	4	4	4	4							4	4	4	4	4	
	DI Tank				1					1						1			
	Heat Exchanger	2+1	2+1	2+1	2+1	2+1	2+1							2+1	2+1	2+1	2+1	2+1	
	lcw pump	2+1	2+1	2+1	2+1	2+1	2+1							2+1	2+1	2+1	2+1	2+1	
tunnel	Make up air-supply	1	1	1	1	1	1	1	1				1	1	1	1	1	1	
	Make up air-return	1	1	1	1	1	1	1	1				1	1	1	1	1	1	
	hvac unit for admin space	1	1	1	1	1	1						1	1	1	1	1	1	
	process pump							2+1					2+1						
	proc wtr heat exchanger							2+1					2+1						
	LCW Heat Exchanger		2+1		2+1		2+1	11(2+1)	2(2+1)	2+1	2+1		11(2+1)	2+1		2+1		2+1	
	lcw pumps		2+1		2+1		2+1	11(1+1)	2(2+1)	2+1			11(1+1)	2+1		2+1		2+1	
	fancoils	100		102		102	147		103				147	102		102		100	
	booster pump	54		54		54			20				54		54		54		
	rml fancoils	3															3		
	rml booster pump	1+1															1+1		
	sump duplex pumps	11	11	11	11	11	11	60	16	16	1		60	11	11	11	11	11	
	grndwtr lift pumps	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1			1+1	1+1	1+1	1+1	1+1	1+1	
	refuge area hvac		1+1		1+1		1+1		2(1+1)	2(1+1)			1+1		1+1		1+1		

OVERHEAD (full power loads)

PEAK RUNNING KW -(BHP to KW)																	March 19 2012				
HEAT REJECTION- related Mech Equip																					
Locatid	equipment	tag	PM-12	PM-11	PM-10	PM-9	PM-8	PM-7	PM-7cr	PMC	PMB	PXA	PXB	PM+7cr	PM+7	PM+8	PM+9	PM+10	PM+11	PM+12	
S u r f a c e	chiller	CHL-1							854	785	232	37		854							2762
	chiller	CHL-2							854	785	232	37		854							2762
	chilled pump	CHWP-1							46	35	15	3		46							145
	chilled pump	CHWP-2							46	35	15	3		46							145
	cooling tower	CT-1	22	37	22	37	22	37	37	22	11	37	37	37	22	37	22	37	22	535	
	cooling tower	CT-2	22	37	22	37	22	37	37	22	11	37	37	37	22	37	22	37	22	535	
	cooling tower	CT-3	22		22		22										22		22	22	132
	cooling tower	CT-4cryo		30		30		30		11					30		30		30		191
	cooling tower	CT-5cryo		30		30		30		11					30		30		30		191
	cooling twr pump	CWP-1	6	91	13	61	13	61	60	32	12	3	52	60	61	13	61	13	91	6	709
	cooling twr pump	CWP-2	6	91	13	61	13	61	60	32	12	3	52	60	61	13	61	13	91	6	709
	cooling twr pump	CWP-3	6		13		13										13		13	6	64
	cooling twr pump	CWP-4cryo		69		41		41		9		7			41		41		69		318
	cooling twr pump	CWP-5cryo		69		41		41		9		7			41		41		69		318
	computer ac	CRAC-1	67	67	67	67	67	67							67	67	67	67	67	67	804
	computer ac	CRAC-2	67	67	67	67	67	67							67	67	67	67	67	67	804
	ventilation	Surf Ventil	67	67	67	67	67	67							67	67	67	67	67	67	804
	ventilation	Surf Ventil	33	33	33	33	33	33							33	33	33	33	33	33	396
	lcw pump	LCWP-1	24	67	54	54	54	54							54	54	54	54	67	24	614
	lcw pump	LCWP-2	24	67	54	54	54	54							54	54	54	54	67	24	614
t u n n e l	process pump	PWP-1							290					290							580
	process pump	PWP-2							290					290							580
	lcw pump	LCWP-1							198					198							396
	lcw pump	LCWP1-dr tunl								31	39										70
	lcw pump	LCWP2-dr tunl								31	39										70
	lcw pump	LCWP-4		125		70		70		23					70		70		125		553
	lcw pump	LCWP-5		125		70		70		23					70		70		125		553
	fancoils	FCU		25		25		25	52		52			52		25		25			306
	booster pump	LCWBP		60		60		60		23					60		60		60		383
	rmtl fancoils	ARU-rtml		55														55		110	tunnel
	rmtl booster pump	RWBP rtml		56														56		112	3713
			366	1268	447	905	447	905	2824	1926	715	122	178	2824	905	447	905	447	1268	366	17265
	technl load used		2.1	21	4.85	17.3	4.85	16.54	11.9	15.1	2.2	2.3	36	9.9	16.54	4.85	17.3	4.85	20.8	1.8	210.18
	w/w peak	0.15	0.06	0.08	0.05	0.08	0.05	0.19	0.11	0.25	0.05	0.005	0.22	0.05	0.08	0.05	0.08	0.05	0.08	0.06	0.17
	w/w	0.17	0.06	0.09	0.05	0.09	0.05	0.24	0.13	0.33	0.05	0.00	0.29	0.05	0.09	0.05	0.09	0.05	0.06	0.20	0.08
		366	1268	447	905	447	905	996	292	227	42	178	996	905	447	905	447	1268	366	0.05	

ADJUSTMENT TO FINAL NUMBERS





- Stacking of loads in surface RF considered but not used
- Not much first cost savings, (10" to 8" pipe mains) vs effect of high space temperature

Chiller vs w/out chiller on DR

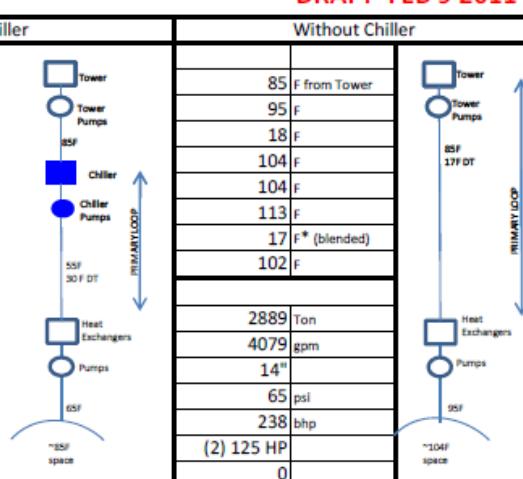
"QUICK and DIRTY" ANALYSIS - Chilled vs Process Water System (DR)

Prepared by E. Huedem 2/9/2011 (CFS)

Checked by L.Hammond 2/9/2011 (CFS)

DRAFT FEB 9 2011

		With C	
user reqmnt (77-85F space, 0.1C + -)			
Supply Water Temperature Primary Loop		55	F from Chiller
Supply Water Temperature LCW		65	F
Magnet Water Delta T		40	F
Mean water Temperature		85	F
Tunnel Space temperature		85	F
Magnet Return Water Temperature		105	F
Overall System Water Temperature Delta T		30	F* (blended)
Primary Water Return Temperature		85	F
SHAFT 12			
Cooling Tower Size Shaft 12		2889	Ton
Flow		2311	gpm
Pipe Size		10"	
Assume pump head		40	psi
Tower Pump Shaft 12		83	bhp
Use	(2)	50 HP	
Chiller Size Shaft 12		2889	Ton



With Chiller

Pros

- Will meet user reqmnt for air temperature
- meet metrology(survey) temperature requirement
- Better controllability of air "tight" stability
- Longer life of equipment (due to space temperature)
- water system can run @ high water DT
- Chiller only runs about 7-8 months /Yr*

Without Chiller

Pros

Less 'First cost' between <\$2M to <\$5M

Less operating cost

Cons

More 'first cost' between <\$2M to <\$5M
more operating cost

Cons

- Will **NOT** meet user reqmnt (air temperature)
- Will **NOT** meet metrology/survey reqmnt (temp/rate)
- Metrology said laser tracker won't operate reliably above 90F
- More difficult to maintain air "tight" stability
- Shortened equipment life (high space temperature)
- Workers temperature maintenance issue
- lower water system delta T

POST RDR

DESCRIPTIONS & "color" legend (DRAFT Dec 18 2007)		With a detailed effort description
High Priority may result in some savings, but not much. (not much cost savings)		Green
Medium Priority may result in savings. Will be evaluated? (potential cost savings TBA)		Yellow
Low Priority - less likely to have impact		Red
Not Sure		Grey
Provide one high efficiency oxygen power / cooling plant on site and distribute power and 33 degree F chilled water throughout the facility, remove the power generation and chilling cost from the project cost		Green
Eliminate one piping system by using process water as primary rejection for the chilled water system w/ tank, (integrated heat pump on tanks) and elevations chillers (for racks)		Green
Decentralize power systems by using process water as primary rejection for chilled water system w/ tank, (integrated heat pump on tanks) and elevations chillers (for racks)		Green
Decrease the delta T in Wtr's CW and CHW by using rejection coil 30 degrees instead of 28 degrees (reduce 300kW plus more)		Green
Add a chiller on the process water side w/t		Green
Lower the temperature in the tunnel to 65 or 70 degrees to increase operating efficiency, extend equipment life, and lower energy costs		Green
Consider use of renewable energy source for use with oxygen system w/t		Green
Provide a cost analysis for reducing the overall cooling load by 5% and 10% w/t		Green
Centralize the cooling system		Green
Provide distributed oxygen power / cryo. trailer to #2 & 3		Green
Decentralize the 345 KV substation function w/ 18, 20, 28, & 30		Tracy
Electrically engineer the distribution system to optimize and reduce cost w/t		Tracy
Provide connection to electrical utility system at all shafts (w/ 90)		Tracy
Optimize substation spacing w/t		Tracy
Let the electrical utility construct substations and don't include that cost in the project construction cost w/t		Tracy
Centralize the HVAC and reconfigure air flow from the ends		Lee
Pipe two chilled water coils in series, chilled water intake, size one for 30 degree delta T w/t		Larry
Decrease the operating temperature to 30 degrees (statting at 33 degrees) and add 300kW to the system to 30 degrees (which would not consider investment cost for major equipment replacement)		Green
Water current temperature (T) 100 degrees at end (lower power OCPH requirement ref.)		Green
Provide air conditioned suits for personnel working in tunnel and let the temp go higher than OSHA requirements		Karen
Consider overrating electrical cables and transformers to reduce heat		Karen
Reduce the RF noise for more efficient process water flow		Green
Modify top shaft HVAC to only process make up air, add blowers down shaft for recirculation		Lee
Reduce lighting level to green limits		Tracy
Replace water pressure drop across components, minimize head pressure		Green
Examine possibility of going to 2 condenser water loops instead of 3 as presently planned		Green
Centralized cooling system to central main station w/ 300kW chilled water central for your tunnel system		Green
Allow the use of other potential HVAC (PAC, VAV, MPP) methods other than central PSC who has no experience with		Green
Consider replacing the fan coil units with a chilled water beam (radiant cooling)		Green
Put the water piping in the concrete slab, eliminate pipe supports		Tracy
Use water cooled wavyguide in the accelerator tunnel in lieu of air cooling		Green
Provide passive convection tunnel using cooling shafts during colder months		Lee
Provide multiple modes of operation dependent on outdoor temperatures		Lee
Develop loads that do not require low conductively water		Pokaboo
Use the in-situ pipe insulation system for cooling the waveguide (flow-cooled gas inside the waveguide)		Green
Push the power source for selected loads when not being used		Tracy
Use pressure regulators to control the hydrostatic pressure in the collectors		John
Define the maximum hydrostatic pressure for the collectors		Mike
Consider expandability of systems - modular vs centralized		Tracy
Recognize the loss changeout or maintenance power supplies		Green
Plan for a 4 month downtime during the summer		Rick
Utilize the operation of the system to 72 degree wet bulb		Rick
Use CO2 based monitoring and limit the intake of outside air to what is necessary to maintain a safe environment		Lee
Use a dehumidifier to dehumidify ventilation air		Lee
Evaluate each load individually to determine requirements		Green
Detailed power budget for the relay racks (4400 W / RF = 10% of power supplies)		Green
Provide power supply that will work with excess water if necessary (quasi militarized)		Karen
Use on site ponds for make up water		Green
Consider using cooling ponds in lieu of cooling towers		Green
Give or sell them chiller to neighboring communities		Green
Install the most efficient chiller for LCW		Green
Use vapor phase cooling on the collectors to generate electricity from excess energy		Green
Use the lowest KVA transformer to reduce heat load		Green
Consider use of geothermal cooling		Green
Use the Fox river for once thru primary cooling, eliminate the cooling towers		Green
Use modular systems for all equipment		Green
Replace Rack, Skid and replace with Juul pump		Tony/Karen
Eliminate one piping system by using chilled water only as primary rejection, eliminate process water distribution		Green

- About 50+ list from V.E. in Nov 2007, List from value engineering sessions in Nov 2007. Some appear to have real good cost reduction potentials.

- Project focus on “first-cost” reduction

- Talks located in

<http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=2328>

- Description of each list, but no detailed evaluation

- Specific items selected by project to be evaluated in 2008

- **Elimination of centralized chilled in ML**
- Higher RF water delta T
- **Warmer tunnel temperature during operation and local cooling during maintenance**
- Other pipe materials

- **discussions during this effort effort**

- **Centralized LCW vs processwtr/skid**
- **Tunnel booster pump footprint=2/rf**
- **(stacking of loads) Surface RF High delta T 28 Fdt vs 15F = not much cost savng**
- **Surface RF ventilate or part of rack**
- **DR chilled water or not**

BACKUP SLIDES

some LOAD TABLES

MAIN LINAC KCS

Mar 23 2011

Mar 23 2011		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	to CHW?	To AIR	Max Space Temp (C)
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		692/ML	7.0	4.2		35	7.94	7.6	2.008	14.28	13	5	10	NA	2.8	
Pulse Transformer		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	
Klystron Scket Tank / Gun	Klystron Wgt	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 Wgt	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/circulators	2/Klystrn	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	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	

POSITRON SOURCE (1 of 3)

Positron (e+)Source Heat and Power load

Load to Water - LCW

Load to Air Chilled Wtr Beam Tunnel Temperature

DRAFT AUG 27 2010

	Total kW	Rough location	Quantity	Distribution Assumption	kW heat load	LCW supply temperature (F)	Delta T (F)	Flow (gpm)	kW Heat load			Notes
1) Pre-Undulator												
Magnets	785.6	Beam Tunnel	52	individual	785.6	Depends on tunnel space temperature. Initial basis is 95F	18	298		Follows BDS reqmnt ?	25 Mattison Magnets omitted - no info (Norbert 8-27-2010) Includes Rack figures (Norbert 8-27-2010) 7 Freestanding Racks + 13 Rackmounted PSUs (Norbert 8-27-2010) 1 gpm per collimator - 30°C delta T (Norbert 8-27-2010)	
Cables	85.5	Beam Tunnel		individual					85.5			
Power Supplies	122.9	Cavern	20	Cavern Cluster	87.6		18	33.2	35.4			
Racks	0	Cavern	10	Cavern Cluster								
Collimator	30	Beam Tunnel	3	individual	30		54	3.8				
2) Fast Abort Dump												
Magnets	633.2	Beam Tunnel	38	individual	633.2	Depends on tunnel space temperature. Initial basis is 95F	18	240.2		Follows BDS reqmnt	Includes Rack figures (Norbert 8-27-2010)	
Cables	15	Beam Tunnel		individual					15			
Power Supplies	97.2	Cavern	10	Cavern Cluster	23.1		18	8.8	74.2			
Dumps	240	Beam Tunnel	1	individual	240		54	30.3				
3) Undulator Section												
Magnets	8.4	Beam Tunnel	22		8.4	Depends on tunnel space temperature. Initial basis is 95F	18	3.2		Follows BDS reqmnt	Includes 63 PSU for 21 Undulator Strings in service tunnel (Norbert 8-27-2010) Cryocooler can be in Service tunnel. Yellow boxes require info (Norbert 8-27-2010)	
Cables	1	Beam Tunnel	1	String					1			
Power Supplies	108.7	Service Tunnel	64	individual	14.2				94.5			
Cryocooler	441	Service Tunnel	63	individual	441		45	66.9				
4) AUX Source												
Magnets	1	Beam Tunnel	33	individual	1	Depends on	18	0.4			Info for Bunchers from e- Source (Norbert 8-27-2010) SW Accel info included in RF (Norbert 8-27-2010)	
Cables	7.4	Beam Tunnel		individual					7.4			
Power Supplies	11	Service Tunnel	24						11			

POSITRON SOURCE (2 of 3)

Positron (e+)Source Heat and Power load					Load to Water - LCW			Load to Air	Chilled Wtr	Beam Tunnel Temperature	DRAFT AUG 27 2010
	Total kW	Rough location	Quantity	Distribution Assumption	kW heat load	LCW supply temperature (F)	Delta T (F)	Flow (gpm)	kW Heat load		Notes
RF	249.8	Service Tunnel	2	30% in Beam Tunnel	207	Depends on tunnel space temperature. Initial basis is 95F	45	31.4	42.8	Follows BDS reqmnt	2 Superconducting Cryomodules + 2 Standing Wave Accelerators (ML info used)- (Norbert 8-27-2010, Emil use MLRF high delta T data)
Bunchers	135	Service Tunnel	3	30% in Beam Tunnel	102		32.4	21.5	33		PSU, Solenoid and RF included (Norbert 8-27-2010)
Dumps	78.5	Beam Tunnel	4	individual	78.5		54	9.9			
Thermionic Gun	1.2	Beam Tunnel	1	individual					1.2		incl. 150kV PSU with 0.2kW heatload into Service Tunnel (Norbert 8-27-2010)
5) Target Area											
RF	124.9	Service Tunnel	1	30% in Beam Tunnel	103.5	Depends on tunnel space temperature. Initial	45	15.7	21.4	Follows BDS reqmnt	3 Travelling Wave Accelerators (Norbert 8-27-2010, Emil use MLRF high delta T data)
Target Stations	0	Beam Tunnel	0								
6) Capture Area											
Magnets	657	Beam Tunnel	62	String	657	Depends on tunnel space temperature. Initial basis is 95F	18	249		Follows BDS reqmnt	
Cables	7.4	Beam Tunnel							7.4		
Power Supplies	25.5	Service Tunnel	7	String					25.5		
Dumps	327	Beam Tunnel	3	individual	327		54	41.3			Assumed 301kW for Photon Dump and 13kW for Electron Dump (x2)-(Norbert 8-27-2010)
7) 400 MeV Pre-Accelerator											
Magnets	166.5	Beam Tunnel	8	individual	166.5	Depends on tunnel space temperature. Initial basis is 95F	64.4	17.7		Follows BDS reqmnt	Estimate (Norbert 8-27-2010)
Cables	90.15	Beam Tunnel		individual					90.15		Estimate (Norbert 8-27-2010)
Power Supplies (HV)	26.4	Service Tunnel	3		26.4		45	4.0			Estimate (Norbert 8-27-2010)
Racks	34.5	Service Tunnel	3		0						Estimate (Norbert 8-27-2010)
8) Positron Transport Line 1											

POSITRON SOURCE (3 of 3)

Positron (e+)Source Heat and Power load

Load to Water - LCW

Load to Air

Chilled Wtr

Beam Tunnel Temperature

DRAFT AUG 27 2010

	Total kW	Rough location	Quantity	Distribution Assumption	kW heat load	LCW supply temperature (F)	Delta T (F)	Flow (gpm)	kW Heat load			Notes
Magnets	14.7	Beam Tunnel	62	String	14.7	Depends on tunnel space temperature. Initial basis is 95F	18	5.6		Follows BDS reqmnt	Estimate (Norbert 8-27-2010)	
Cables	0.9	Beam Tunnel							0.9			
Power Supplies	2.3	Service Tunnel	1						2.3			
9) 5 GeV Booster Section												
Magnets	2.1	Beam Tunnel	8	individual	2.1	Depends on tunnel space temperature. Initial basis is 95F	18	0.8		Follows BDS reqmnt	No info for Coldbox available - not included (Norbert 8-27-2010)	
RF	828	Service Tunnel	8	30% in Beam Tunnel	828		45	125.6			Info from ML 9-8-9 RDR Water and Air Heat Load 31/10/2007 spread sheet	
Racks	92	Service Tunnel	8		0				92			
10) Positron Transport Line 2												
Magnets	29	Beam Tunnel	122	String	29	Depends on tunnel space temperature. Initial basis is 95F	18	11.0		Follows BDS reqmnt		
Cables	1.8	Beam Tunnel							1.8			
Power Supplies	4.6	Service Tunnel	2	String					4.6			
Dumps	226	Beam Tunnel	1	individual	226		54	29				
11) Positron Line Transfer to Damping Ring (PLTR)												
PLACEHOLDER	540	Beam Tunnel	???	uniformly	500	Depends on tunnel	18	189.7	40	Follows BDS reqmnt	PLACEHOLDER (Norbert / Emil 8-27-2010)	
	6253				5532				595		127	
Misc components												
AC Power Transformers			??									
Emergency Transformer			cavern									
Fancoils			beam									
Dehumidifier			beam									
Water Pumps			cavern									
Lighting			beam									
	0				0				0			

Updates recently Added

~200KW

New totals = 6460

	Total KW	rough location	Qty	Distribution Assumption	KW heat load	LCW supply temperature (F)	Delta T (F)	or Flow (gpm)	KW heat load	Beam Tunnel	Service Tunnel	Notes
BDS components (excluding Major DUMPS)												
Magnets	129.9	Post Undulator Dogleg	92	equally distributed	129.9	depend on space temperature discussion	20	44	0	80-85	~85	Norbert Email Sep 27 2010
	2746	e-e+ common - beam tunnel		equally distributed	2746		20	937	0			Total KW From Paul Bellomo List May 9 2007
	5604	e-e+ 14 mr - beam tunnel		equally distributed	5604		20	1913	0			Total KW From Paul Bellomo List May 9 2007
Cables	3.9	Post Undulator Dogleg		assume at beam tunnel	0	depend on space temperature discussion	N/A	N/A	3.9	80-85	~85	Norbert Email Sep 27 2010
	186	e-e+ common - beam tunnel		equally distributed (assume 50% to beam tunnel and 50% to svc tunnel)	0		N/A	N/A	186			Total KW From Paul Bellomo List May 9 2007
	398	e-e+ 14 mr - beam tunnel		equally distributed (assume 50% to beam tunnel and 50% to svc tunnel)	0		N/A	N/A	398			Total KW From Paul Bellomo List May 9 2007
Power supplies	20.1	Post Undulator Dogleg	58	assume at service tunnel	0	depend on space temperature discussion	N/A	N/A	20	80-85	~85	Norbert Email Sep 27 2010
	440	e-e+ common - service tunnel	27	equally distributed	168		12	96	272			Quantity from Paul Bellomo List May 9 2007
	900	e-e+ 14 mr - service tunnel	179	equally distributed?	552		12	314	348			Quantity from Paul Bellomo List May 9 2007
RF	0	beam	0	N/A	0	depend on space temperature discussion	N/A	N/A	0	80-85	~85	
Racks	0	beam	0	N/A	0		N/A	N/A	0			
Dumps	0	beam	0	N/A	0		N/A	N/A	0			There are (4) 10MW major dumps served by dedicated water plant
	10427.9	KW (Total)			9200	KW (water)			1228	KW (air)		
Misc components (LATER)												
AC Power Transformers										104		
Emergency Transformer												
Fancoils		beam										
Dehumidifier												
Water Pumps												
Lighting												
	0				0				0			

RTML (Ring-To-Main-Linac)

RTML Heat and Power Load (Totals RTML shown)

draft SEP 7 2010

CFS

for total (2) RTML

	Total KW	rough location	Qty	Distribution Assumption	Load to water-LCW				Load to Air	Beam tunnel Temperature		Notes
RTML components												
Magnets	2931	beam	4000	equally distributed in RTML area? & negligible in ML from DR area	2931	95	20	1001	0	104F (40C)	Qty and KW from P.Bellomo 5/9/2007. [SEP 3 2010, scale qty by ratio of 4000/4334]	
Cables	942	beam		equally distributed?	0	95	N/A	N/A	942		KW from P.Bellomo 5/9/2007	
Power supplies	618	??	3832	equally distributed?	8	95	N/A	N/A	610		P.Bellomo 5/9/2007	
RF	3570	svc			3570	95	45	542	0		Jul 14 2009 Nikolai & Marc (50% from RDR)	
Racks	550	beam			0	95	N/A	N/A	550		Old Table Oct 2006	
Dumps	* 0	beam		one location (in each rtml) =(2)	0	95	56	0	0		{RDR showed 250 KW each AL ball dump with 30 gpm] Jul 14 2009 Nikolai & Marc (50% from RDR)	
	* 0	beam		one location each (near DT-LTR) =(2)	0	95	56	0	0		from dump list 2009 - not used?	
	8611	*	(4) 220 KW dump are not used all the time		6509				2102			

Misc components												
AC Power Transformers		??										
Emergency Transformer		cavern										
Fancoils		beam										
Dehumidifier		beam										
Water Pumps		cavern										
Lighting		beam										
	0				0				0			

DR (DAMPING RING)

draft Jun 17 2011

CFS

DR Heat Load (Totals DR shown) for "5 HZ -2652 bunches - 3 rings - upgrade from SB2009 (CFS FACILITIES BASELINE)"

for total DR

Items highlighted in yellow=new items added or items that changed as compared to the previous Jan 05 2011 power table

	Total KW Heat Load	rough location	Qty	Distribution Assumption	Load to water-LCW				Load to Air	Beam tunnel Temper- ature (F)	Notes
					KW heat load	LCW supply temperature (F)	Delta T (F)	or Flow (gpm)			
DR components (surface)											
Cryo	2520	surface		one location	2520	85 to 90F (tower water)	10	1721		*ventilated space	Jan 28 2011 Tom Peterson Meeting; Jun 2, 2011, MP confirmed located in one shaft

DR components (tunnels and caverns)

Magnets	1628	tunnel		equally distributed	1553	65 F if using chiller, 95F if using just towers	40	265	75	77F to 87 F	(07/22/09) reduce to 70% from RDR, Susana email 7/15/09, due to decrease in circumf to 3.2 KM. [06/02/2011] reduce heat load to air, distributed power supplies to be watercooled
Cables (watercooled bus)	240	tunnel		equally distributed	229		20	78	11		
Power supplies (distributed)/ Rack style	184	tunnel	350?	equally distributed in tunnels	175		10	119	9		
Power supplies (Bulk style)- 480V	20	cavern & alcoves	?	2 in cavern, 1 each in alcove	20		18	8	1		
RF in Cavern (Klystron, Modulator, Power supply etc)- High Power CFS feed - 13.8KV	5540	in cavern		RF (base value)	4432		45	672	1108		
RF Racks (assumed 1% of RF base value total)	60	in cavern	12?		57		10	39	3		
RF in tunnel (waveguide?)	140	beam tunnel		RF (peak overhead)	0		N/A	N/A	140		
Radiation (from RF)- mostly Wigglers	7000	(mostly wiggler)		12% total radiation load in two arc; 88% of radiation load in two wiggler area; 1km straight section has stable load	6650		40		350		
Totals for tunnel/cavern DR components	14812				13116				1697		

Misc components

AC Power /Emerg Transformers											
Fancoils		beam									
Water Pumps											
Lighting											
	0				0				0		

SEP 21 2011, check of Parsons data by emil hueDEM

large difference (mine vs parsons)- TO BE CHECKED

Parsons corrected via email or to be corrected

Guess

emil check

Data from Parsons

load to air

central region

Damping Ring

Damping Ring

Main Dump

IR

SHAFT LOCATIONS →

PM-7 (7)

PMB-0 (12)

PMC-0 (13)

near PXB

PXAB(1)

SURFACE LOADS

MAU 30,000 cfm each

380

281

281

0

0

Miscellaneous Building Load (20 Ton) - none shown

0

0

0

0

0

TUNNEL Loads

RTML (kw assume all water)

430

0

0

0

0

e+ (Lcw Water - Beam Tunnel)

4105

0

0

0

0

e+ (Lcw Water - Service Tunnel)

1553.35

0

0

0

0

e+ (Air - Beam Tunnel) **Fancoils**

256.77

0

0

0

0

e+ (Air - Service Tunnel) **Fancoils**

338.28

0

0

0

0

BDS (Lcw Water - Beam Tunnel) - half load of bds from this shaft

4239.95

0

0

0

0

BDS (Lcw Water - Service Tunnel)- half load of bds from this shaft

360

0

0

0

0

BDS (Air - Beam Tunnel) **Fancoils**- half load of bds from this shaft

147.95

0

0

0

0

BDS (Air - Service Tunnel) **Fancoils**- half load of bds from this shaft

466

0

0

0

0

DR Magnets (LCW)

1553

0

0

0

0

DR cables (LCW)

229

0

0

0

0

DR Magnets/cables (air)

95

0

0

0

0

DR Power Supplies (LCW)

195

0

0

0

0

DR Wigglers (LCW)

0

6650

0

0

0

DR Wigglers (air)

350

0

0

0

0

RF in tunnel (air)

140

0

0

0

0

RF in cavern (air)

280

0

0

0

0

RF (LCW)

0

5263

0

0

0

Racks (LCW)

0

57

0

0

0

Main Dumps (2 running at all time out of 4)

36000

0

0

IR load

540

TOTAL tunnel from technical load

11897

2842

11970

36000

540

Heat Pump for Area of refuge (?) needed? **NOT INCLUDED IN TOWER SIZING?**

559

485

0

0

0

Misc heat load from Conventional (138 tons for PMB)

12456

3327

11970

36000

540

SEP 14 2011, check of Parsons data by emil huedem

Ventilation load only	large difference (mine vs parsons)						
Data from Parsons	emil check						
SHAFT LOCATIONS	PM-12 (11)	PM-11 (7)	PM-10 (14)	PM-09 (5)	PM-08 (15)	PM-07 (3)	PM+12 (10)
surface RF qty	28	64	64	64	64	64	24
tunnel RF qty		105		108		81	
SURFACE LOADS-KW							
rf surface LCW cooled (62.51 KW/RF)	1750	4001	4001	4001	4001	4001	1500
rf surface racks (3 KW/RF)	84	192	192	192	192	192	72
Rf to air (10.2 KW/RF)	286	653	653	653	653	653	245
MAU (4000cfm) used 175gpm@10Fdt	256	256	256	256	256	256	256
Miscellaneous Building Load (20 Ton)	70	70	70	70	70	70	70
TUNNEL Loads							
RF (36.41 Kw/RF)		36.41		36.41		36.41	
Magnets (914 KW / 584 RF)=1.565 KW/RF		1.57		1.57		1.57	
Racks (5 KW / RF)		5		5		5	
RF to air-Fancoils (3.6 KW to air per rf)		3.6		3.6		3.6	
Heat Pump for Area of refuge (?) needed? NOT INCLUDED IN TOWER SIZING?							
Misc heat load from Conventional (?)		255		255		255	
TOTAL tunnel tech equip only	0	4890	0	5030	0	3773	0
TOTAL tunnel tech equip + conv	0	5145	0	5285	0	4028	0