ILC-250 AC Power Re-estimation

originated by NW-BL,

and

adjustment suggested by AY

A. Yamamoto and S. Michizono

Provided for discussions at TCMB

Updated: 190604

ILC250 AC Plug-Power Estimates to be updated,

AY-190602

re-estimated by NW/BL (190531)

	500 (DKS)	250A-Base L. 5Hz, 1312 L= 1.35E34	250A' (RD) 5Hz, 1312 L = 1.35E34	250A 5Hz, 2625 L=2.7E34	500 @ 250 10Hz, 2625 L= 5.4E34	500 5Hz, 2625 L = ?
Gradient	31.5	31.5	35	31.5	14.7	31.5
Qo	1E10	1E10	1.6E10	1E10	1E10	1E10
ML-Egain	470	220	220	220	220	470
E. Ratio	1	0.47	0.47	0.47	0.47	1
ML	104.1	48.0	47.3	61.1	100.4	130.6
e- Source	4.87	5.6	5.6	5.6	5.6	5.6
e+ Source	9.32	10.2	10.2	10.2	10.2	10.2
DR	15.72	13.6	13.6	21.5	30.3	21.5
RTML	10.40	10.4	10.4	13.9	13.9	13.9
BDS	12.38	9.3	9.3	9.3	9.3	12.4
Dumps	1.21	1.2	1.2	1.2	1.2	1.2
IR	5.76	5.8	5.8	5.8	5.8	5.8
Main Campus						
General Margin						
Total	163.8	104.0	103.3	128.5	178.6	201.1

Excel Reference: ILC TDR AC Power Scaling CR018-b (190602)

ILC250 AC Plug-Power Estimates to be updated

AY-190603

Adjustment suggested by AY, refering Re-estimate by NW/BL (190602)

	500 (DKS)	250A-Base L. 5Hz, 1312 L= 1.35E34	250A' (RD) 5Hz, 1312 L = 1.35E34	250A 5Hz, 2625 L=2.7E34	500 @ 250 10Hz, 2625 L= 5.4E34	500 5Hz, 2625 L = ?
Gradient	31.5	31.5	35	31.5	14.7	31.5
Qo	1E10	1E10	1.6E10	1E10	1E10	1E10
ML-Egain	470	220	220	220	220	470
E. Ratio	1	0.47	0.47	0.47	0.47	1
ML	104.1	**49.4**	**48.5**	**62,6**	**103.0**	**133.8**
e- Source	4.87	5.6	**4.8**	5.6	5.6	5.6
e+ Source	9.32	10.2	**9.6**	10.2	10.2	10.2
DR	15.72	13.6	13.6	21.5	30.3	21.5
RTML	10.40	10.4	8.4	13.9	13.9	13.9
BDS	12.38	9.3	9.3	9.3	9.3	12.4
Dumps	1.21	1.2	1.2	1.2	1.2	1.2
IR	5.76	5.8	5.8	5.8	5.8	5.8
Main Campus		**2.7**	**2.7**	**2.7**	**2.7**	**2.7**
General Margin		**3.3**	**3.1**	**4.0**	**5.4**	**6.2**
Total	163.8	**111.5**	**106.9**	**136.7**	**184.5**	**213.2**

Excel Reference: ILC TDR AC Power Scaling CR018-b (190602)

Appendix

- TDR information

- Previous Study for ILC250A and A'
  - Focusing on Cryogenics

ILC500: TDR-DKS AC Power Balance

ILC-TDR-V3-II, Table 11.6

Table 11.6
Estimated DKS power loads (MW) at 500 GeV centre-of-mass operation. 'Conventional' refers to power used for the utilities themselves. This includes water pumps and heating, ventilation and air conditioning, (HVAC). 'Emergency' power feeds utilities that must remain operational when main power is lost.

Accelerator section	RF Power	Racks	NC magnets	Cryo	Conventional		Total
					Normal	Emergency	
e^- sources	1.28	0.09	0.73	0.80	1.47	0.50	4.87
e^+ sources	1.39	0.09	4.94	0.59	1.83	0.48	9.32
DR	8.67		2.97	1.45	1.93	0.70	15.72
RTML	4.76	0.32	1.26		1.19	0.87	8.40
Main Linac	52.13	4.66	0.91	32.00	12.10	4.30	106.10
BDS			10.43	0.41	1.34	0.20	12.38
Dumps					0.00	1.21	1.21
IR			1.16	2.65	0.90	0.96	5.67
TOTALS	68.2	5.2	22.4	37.9	20.8	9.2	164

Tom Peterson's study in 2012

ILCCryoTDR-140ct2012BN.xls, CryoPowerTotal-28June2012s.xls

Tom Peterson ILC Cryogenic Power Estimates
26-Jun-12
This sheet: TDR Power DKS
1 standard cryogenic unit with DKS arrangement into cryo strings and cryo
Heat loads per attached CM_HeatLoad sheet (sheet 1)
Module length based on Module-9-8-9-21Nov06.xls approxim

Total operating power for one cryo unit based on predicted heat (MW)	3.24	Operating
Total operating power for one cryo unit including uncertainty factor (MW)	3.57	Operating
Total installed power for one cryo unit (MW)	4.16	22.01
Total installed 4.5 K equivalent power for one cryo unit (kW)	19.01	
Fraction of largest practical cryoplant per cryogenic unit	0.76	

Tom Peterson Full heat loads, static plus dynamic
28-Jun-12 Update for TDR
Using latest revised heat loads, per ILCcryoTDP26June2012.xls
and DampingRingCryo-17May2012.xls
Operating power based on predicted heat load and Fo = 1.2

Area	Number of plants	Installed plant size (each)	Installed total power	Operating power (each)	Operating total power	
		(MW)	(MW)	(MW)	(MW)	
Main Linac + RTML KC	12	3.37	40.44	2.63	31.56	
Main Linac + RTML DK	10	4.16	41.60	3.24	32.40	
e+ 5 GeV linac	1	0.65	0.65	0.35	0.35	
e- 5 GeV linac	1	0.70	0.70	0.48	0.48	
Damping Rings	1	1.45	1.45	1.13	1.13	
BDS	*1*	*0.41*	*0.41*	*0.33*	*0.33*	*still just the old RDR number*
Experiments	*1*	*1.00*	*1.00*	*0.70*	*0.70*	*1 kW at 4.5 K from Tom Markiewicz*
TOTAL with KCS			**45.81**		**35.39**	
TOTAL with DKS			**44.65**		**34.55**	
Total central campus compr pow		3.80		2.66		assume BDS+DR+Sources

Consideration on A Cryogenic-Plant Layout for Cost-saving associated with SRF R&D

Akira Yamamoto

To be discussed, 19 July, 2017
Updated, 23 July, 2017

A New Approach for the ILC Cryogenics Cost-reduction at the Staging-250 (Option-C)

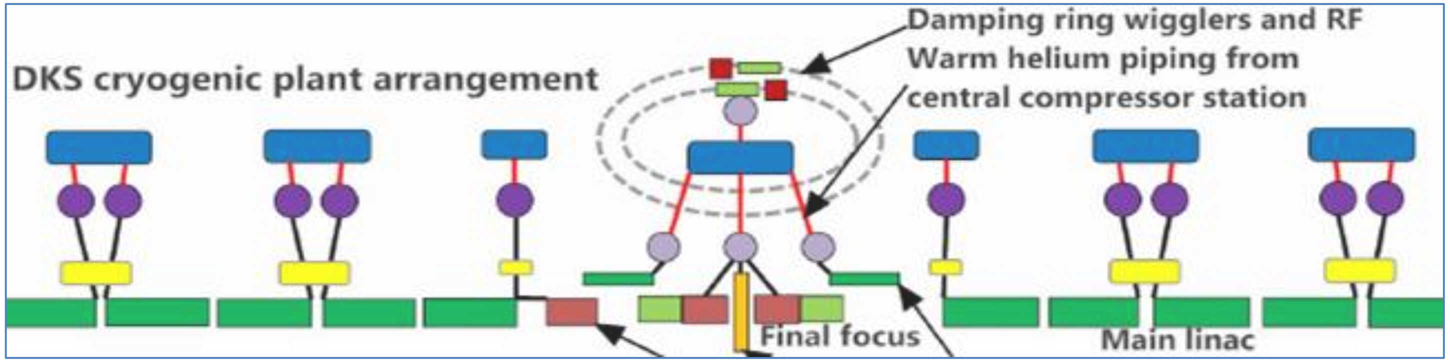
- A model / Assumption:
  - SRF high-Q and high-G R&D successful,
    - Gradient: 31.5 MV/m to 35 MV/m
      - # ML-CMs down to ~ 90 %
    - Q: 1E10 (31.5 MV/m) to 1.6E10 (35 MV/
      - Cooling power requirement down to 70 % (still to be checked)
        - » (taking both static and dynamic thermal load effect).
  - Plan to keep the Cryogenics System unit scale (19 kW at 4.5 K) to be kept (for simplicity for cost estimate),
    - Cryogenics system to be merged, and
      - # Cryogenic systems to be reduced from 5.5 systems (BC, ML, Booster) to 2 systems (with some additional cost for Booster Cryogenics with long distribution line).

Additional Cryogenics System Cost Reduction at Staging-250 (Option-C)

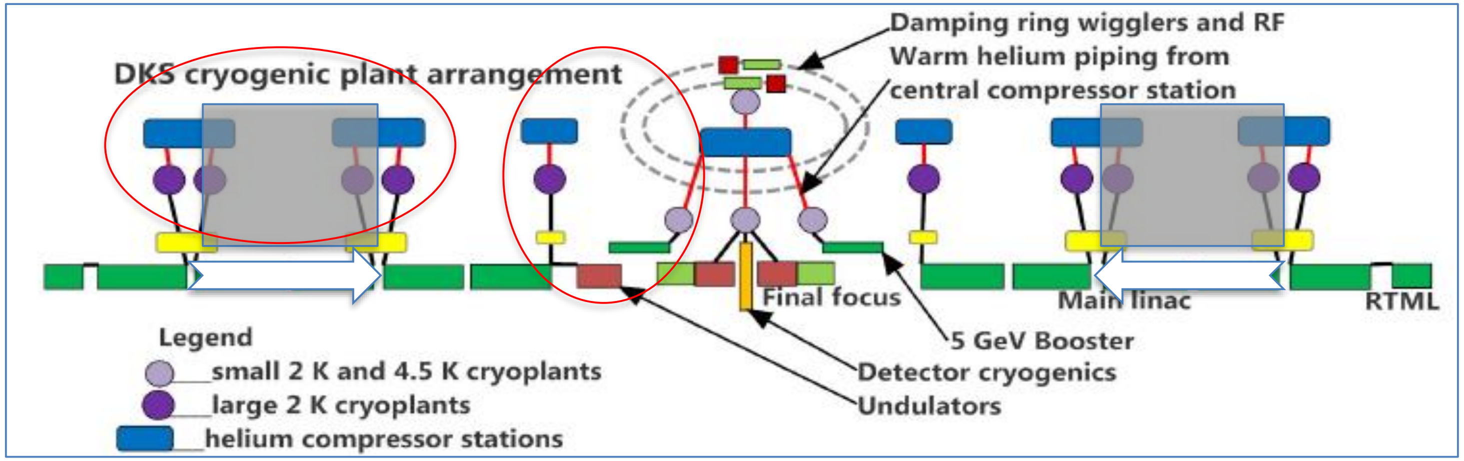
- Previous approach
  - Cooling power requirement down to 70 %
    - Cryogenics System cost down to 0.7 ^0.6 = 0.81 (→81%)
    - Effect in the simple staging option c (31.5 MV/m, 1E10) :
      - Cost for 3.5 sub-system →198 MILCU / one side of ILC linacs
        - » Down to **160.4** w/ simply reduce the cryogenics power capacity
- A new approach
  - Cooling power requirement down to 70 % (same)
  - Keeping the plant power of 19 kW at 4.5 K
  - Merge the cryogenics systems from 3.5 to 2 systems.
    - RTML-BC + ML-CM (upstream), and
    - ML-CM (down-streadm) + Booster (even though cryo-line to be added)
      - Cost for 2 sub system: 2 x 58.5 + ~ 13 = **130** MILCU / one-side
        - » Cost for RTML-BC → 0, Cost for e; source only for long distribution line (13 MILCU / booster)
  - Additional cost saving : ~ 2 x 30 MILC per two-sides (to be further checked).

ILC Cryog. Configuration to be staged at 250 GeV

Option D (ML installed, downstream)



TDR-2013 Configuration at 500 GeV
- 5 plants/linac

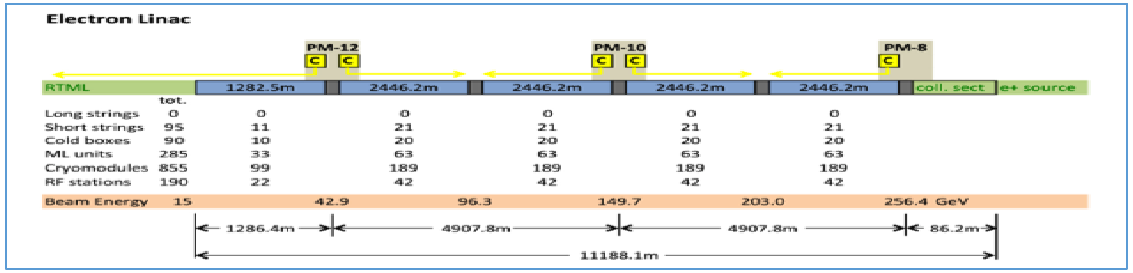


Staging at 250 GeV : 3 plants/linac, although the cooling power requirements to be reduced down to ~70 %.

Updated: 170724

Staging (250 GeV) effects on the SRF Cryogenic Systems

	MILC	%
e-, 2+	2 x 32.5	2 x 4.8
DR	26.0	3.9
RTML (unit)	38.1 19.1	5.6 (2.8)
ML (unit)	526.9 (58.54)	78.1 (8.6)
BDS	18.4	2.7
Sum	674.6	100



E = 31.5 MV/m, and L-eff = 1.0385 m
+V/cavity = 32.7 MV

+V/st-Cryogenics) = 3 x 21 x 0.8505 = 53.6 GeV
+V/short-string = 2.55 GeV
+V/MLU = 32.71 x 26 = 850.5 MV
Cryogenics unit (short string) length (3 MLU)
= 3 x 37.956+2.5 = 116.368
RF unit (4.5 CM) length = 56.934 m
MLU blength (→3 CM) = 3 x 12.652 = 37.956 m
CM length = 12.652 m (pitch)

		RTM L-BC	ML-CM	PM -12 -u	PM -12 -d	ML-CM		PM -10 -u	PM -10 -d	ML-CM		PM -8 -u	PM -8 -d	e+ Booster	Sum	Cost Down
TDR-500	Cryo-Cost	**19.05 + 29.27**			**58.54**		**58.54**		**58.54**		**58.54**		**32.54***		**315.02**	**n/a**
	# C-Plant	**~ 0.2 + 0.5 = 0.7 → 1**			**1**		**1**		**1**		**1**		**> ~ 0.55***		**5.5 systems**	
	CP-Power	(19 kW @ 4.5 K)			19 kW @ 4.5 K		19 kW @ 4.5 K		19 kW @ 4.5 K		19 kW @ 4.5 K					
	# CM	**51**	**99**			**189**	**189**			**189**	**189**			**24**	**930**	
	E. Sum	10	28.1			53.6	53.6			53.6	53.6			5	257.5	

		RTM L-BC	ML-CM	PM -10 -u	PM -d			PM -u	PM -10 -d	ML-CM		PM -8 -u	PM -8 -d	e+ Booster	Sum	
	Cryo-Cost	**19.05 + 29.27**			**---**		**---**		**58.54**		**58.54**		**32.54***		**197.94**	**0**
Stage - 250	# Cryo-P.	**~0.2 + 0.5 = 0.7 → 1**			**---**		**---**		**1**		**1**		**~ 0.55**		**3.5 systems**	
	# CM	**51**	**45**		**---**	**---**	**---**	**---**		**189**	**189**			**24**	**498**	
31.5MV/m 1E10	E. Sum	10	12.8		---	---	---	---		53.6	53.6			5	135.0	
Stage - 250 +SRF R&D	Cryo-Cost	**58.54**									**58.54 + 13 (for long distribution)**				**130**	**- 68**
	# C-Plant	**0.7 x (0.2 + 0.05 + 1) = 0.88 → 1** **(TL reduction model: relatively lowered to ~ 70%, because of high-Q)**									**0.7 x (1+0.13) + x= 0.79 + ~0.x → 1**				**2 systems**	
	# CM & (relative TL)	**51**	**4.5**		**---**	**---**	**---**	**---**		**189 (132)**	**189 (132)**			**24 (17)**	**457.5**	
35MV/m 1.6E10	E. Sum	10	1.28		---	---	---	---		59.56	59.56			5	135.4	