LINEAR COLLIDER COLLABORATION
Designing the world's next great particle accelerator

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Radiation safety study for conventional facility and siting pre-project phase of International Linear Collider

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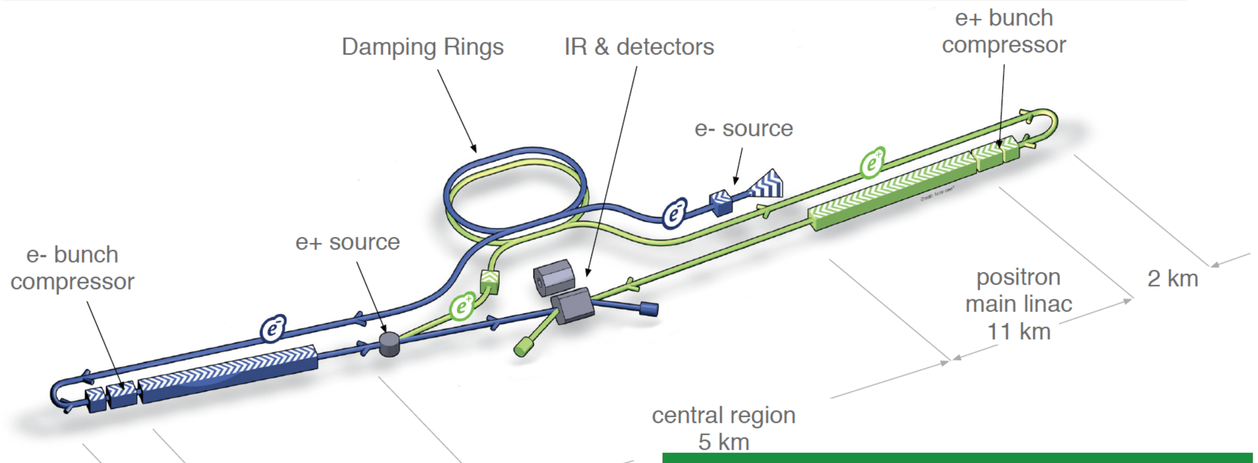
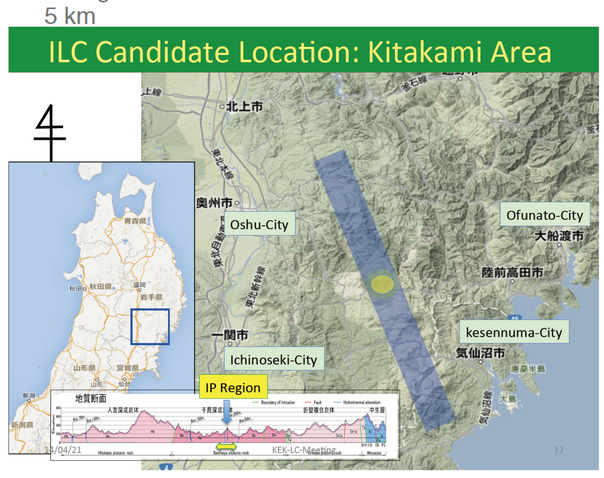
1. The International Linear Collider



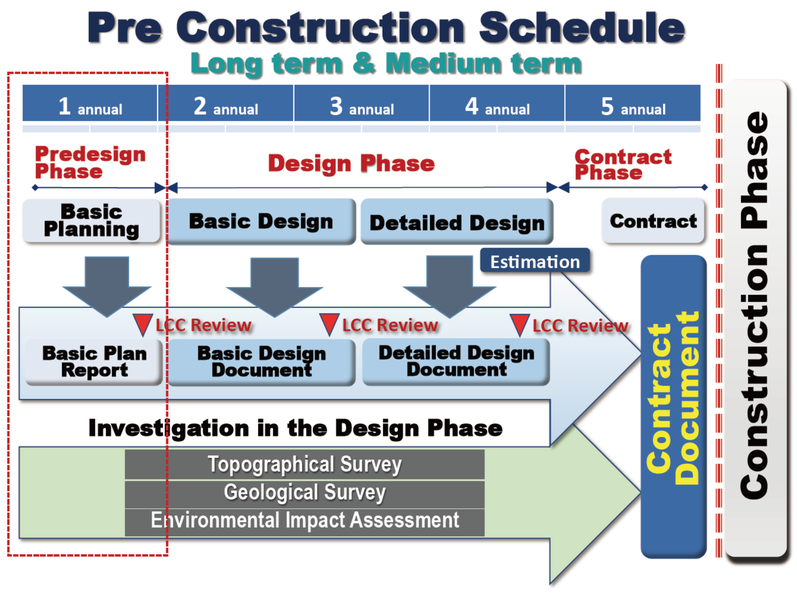
Centre-of-mass energy	E_{CM}	GeV	Baseline 500 GeV Machine			1st Stage	L Upgrade	E_{CM} Upgrade	
			250	350	500	250	500	A 1000	B 1000
Collision rate	f_{rep}	Hz	5	5	5	5	5	4	4
Electron linac rate	f_{linac}	Hz	10	5	5	10	5	4	4
Number of bunches	n_b		1312	1312	1312	1312	2625	2450	2450
Bunch population	N	$\times 10^{10}$	2.0	2.0	2.0	2.0	2.0	1.74	1.74
Bunch separation	Δt_b	ns	554	554	554	554	366	366	366
Pulse current	I_{beam}	mA	5.8	5.8	5.8	5.8	8.8	7.6	7.6
Main linac average gradient	G_a	MV m^{-1}	14.7	21.4	31.5	31.5	31.5	38.2	39.2
Average total beam power	P_{beam}	MW	5.9	7.3	10.5	5.9	21.0	27.2	27.2
Estimated AC power	P_{AC}	MW	122	121	163	129	204	300	300
RMS bunch length	σ_z	mm	0.3	0.3	0.3	0.3	0.3	0.250	0.225
Electron RMS energy spread	$\Delta p/p$	%	0.190	0.158	0.124	0.190	0.124	0.083	0.085
Positron RMS energy spread	$\Delta p/p$	%	0.152	0.100	0.070	0.152	0.070	0.043	0.047
Electron polarisation	P_-	%	80	80	80	80	80	80	80
Positron polarisation	P_+	%	30	30	30	30	30	20	20
Horizontal emittance	$\gamma\epsilon_x$	μm	10	10	10	10	10	10	10
Vertical emittance	$\gamma\epsilon_y$	nm	35	35	35	35	35	30	30
IP horizontal beta function	β_x^*	mm	13.0	16.0	11.0	13.0	11.0	22.6	11.0
IP vertical beta function	β_y^*	mm	0.41	0.34	0.48	0.41	0.48	0.25	0.23
IP RMS horizontal beam size	σ_x^*	nm	729.0	683.5	474	729	474	481	335
IP RMS veritcal beam size	σ_y^*	nm	7.7	5.9	5.9	7.7	5.9	2.8	2.7
Luminosity	L	$\times 10^{34}$ cm^{-2}s^{-1}	0.75	1.0	1.8	0.75	3.6	3.6	4.9
Fraction of luminosity in top 1%	$L_{0.01}/L$		87.1%	77.4%	58.3%	87.1%	58.3%	59.2%	44.5%
Average energy loss	δ_{BS}		0.97%	1.9%	4.5%	0.97%	4.5%	5.6%	10.5%
Number of pairs per bunch crossing	N_{pairs}	$\times 10^3$	62.4	93.6	139.0	62.4	139.0	200.5	382.6
Total pair energy per bunch crossing	E_{pairs}	TeV	46.5	115.0	344.1	46.5	344.1	1338.0	3441.0



The International Linear Collider is a proposed high energy collider which consist of two liner accelerators, two dumping rings, electron and positron source, and single colliding hall with two detectors. The total length and CMS energy of ILC reach 31 km and 500 GeV, respectively (50 km with 1 TeV for future upgrade).

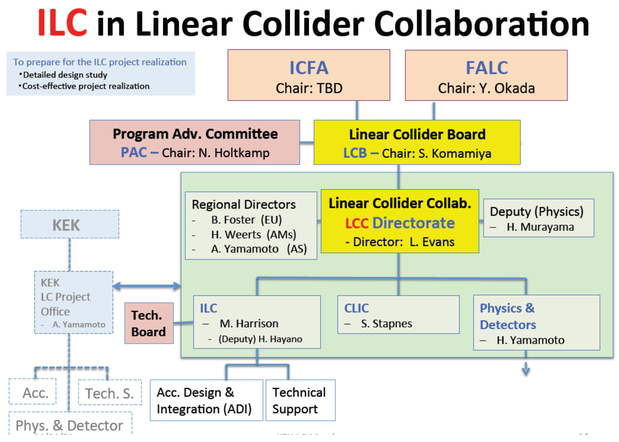
In 2013, Technical research document (TDR) of ILC was published and Japanese candidate of ILC site was determined at Kitakami.

2. CFS pre-project phase



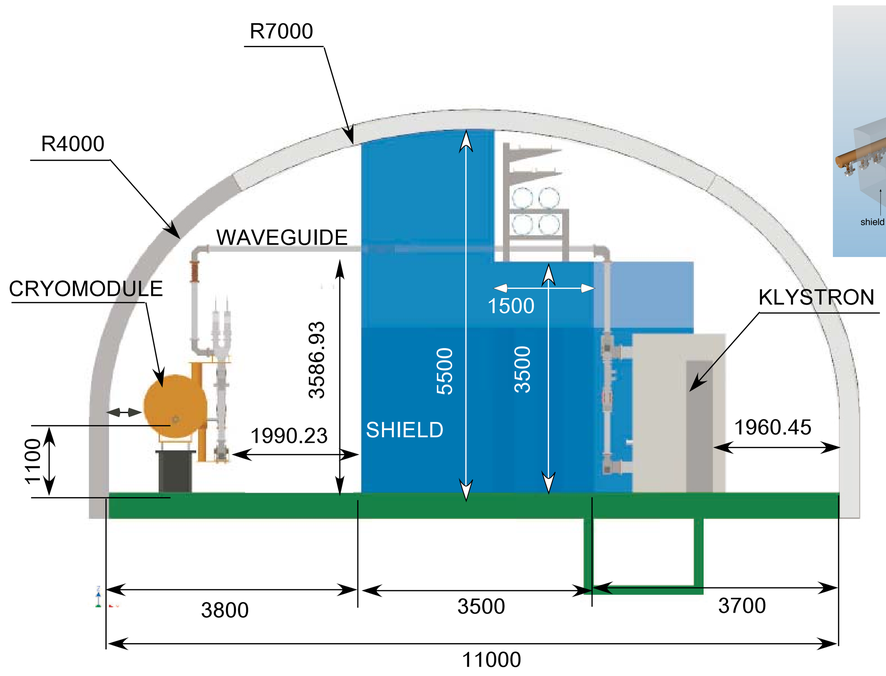
Now, the design phase move to pre-project which includes accelerator detailed design, R&Ds for cost-effective production, site study, conventional facility and siting(CFS) designs.

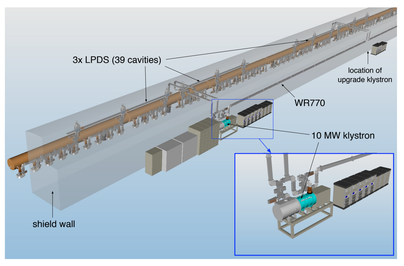
The CFS design in pre-project intends to determine not only actual design of accelerator tunnel and related infrastructure but also to design tunnel structure, beam dump housing, ventilation, cooling water circulation and drainage.



LCC-ILC will organize ADI and technical support group to fix technical design parameters to be optimized, and reflect them to CFS design optimization within a few years.

3. The separation shield





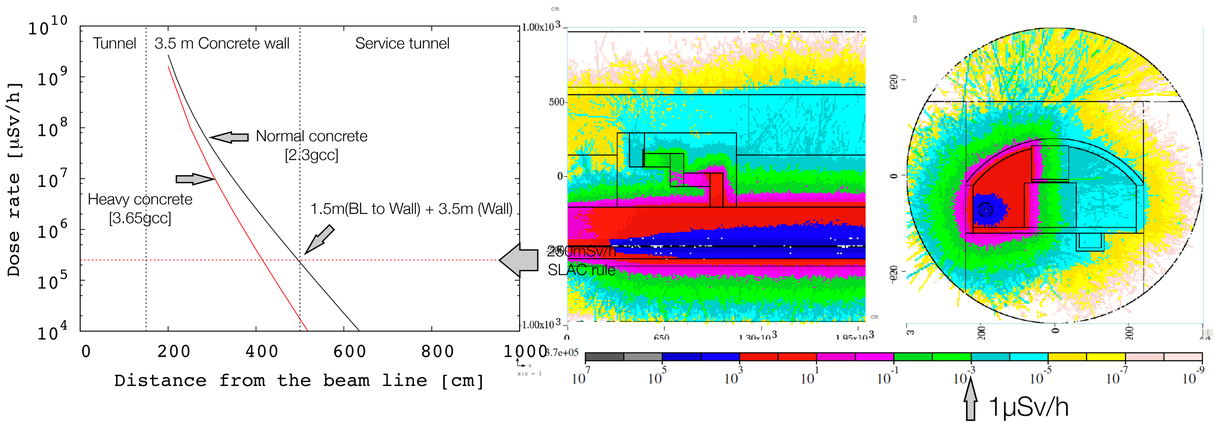


TABLE 2.9-2
Maximum allowable radiation levels and doses.

(*a*) Radiation Protection Instructions, DESY, June 2004.
(*b*) Radiation Safety Instructions, KEK, in Japanese, June 2004.
(*c*) Radiation Safety System, SLAC, April, 2006.
(*d*) Fermilab Radiological Control Manual, FNAL, July, 2004.

	DESY (*a*)	TESLA	KEK (*b*)	SLAC (*c*)	FNAL (*d*)
Standard	20 mSv/yr	1.5 mSv/yr	20 mSv/yr		50 mSv/yr
Fertile women	2 mSv/month	1.5 mSv/yr	6 mSv/yr 2 mSv/3months		
Pregnant women	1 mSv /pregnancy	1.5 mSv/yr	1 mSv /pregnancy		5 mSv /pregnancy
Operating conditions					
Normal			20 μSv/hr (1mSv/week)	5 μSv/hr (10 mSv/year)	
Mis-steering			20 mSv/event (20 mSv/year)	4 mSv/hr	
System failure			20 mSv/event (20 mSv/year)	250 mSv/hr for max. credible beam (30 mSv/event)	

Since large difference between beam power (18MW) and normal loss (less than few W), thickness of the separation shield was determined from system failure scenario, at this moment.

Beam loss and failure scenario based on actual machine operation are required to update this design.

How many system failure should be assumed per year? What happen if beam hits duct or accelerator tube? How robust device can we obtain to terminate failure beam? We have to define reasonable guide line for radiation safety design.

4. Conclusion

Radiation safety design is ongoing with pessimistic assumptions. The assumptions should be replaced approved values based on information on existing and future machines.

First draft of total radiation safety design for entire facility will be required soon, for CFS basic planning, thus go through entire accelerator structure to find issues should be addressed before fixing CFS design.

Experience and knowledge of shielding design and radiation control operational work in other lab. is required.