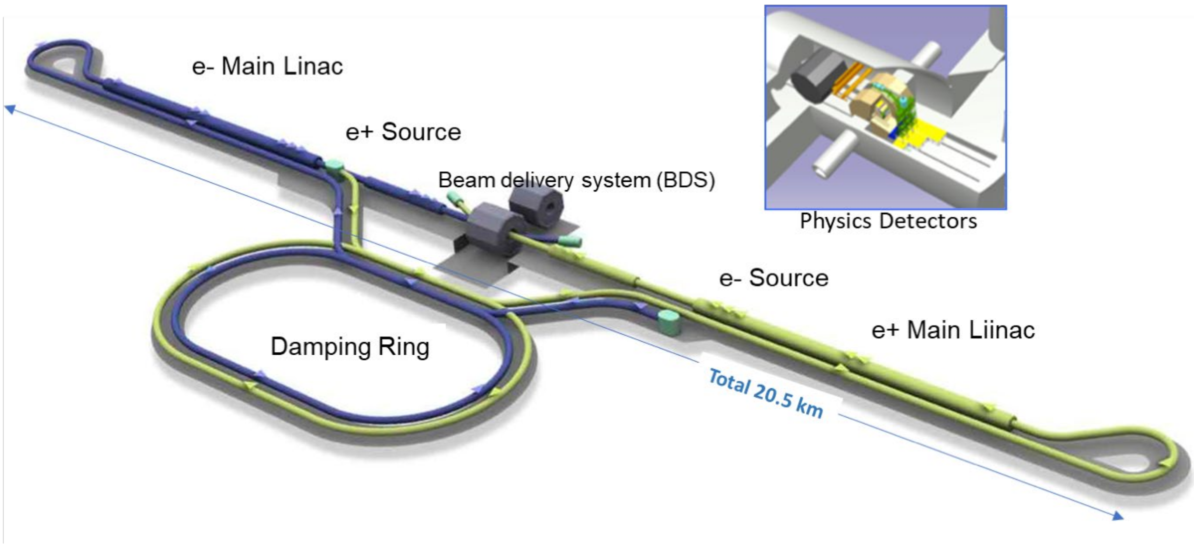
ILC Accelerator Systems:

Technical Preparation and Work Packages (WPs) during ILC Pre-lab

Outline :

The International Linear Collider (ILC) is an electron–positron collider with a total length of approximately 20 km. The ILC consists of the following components: electron and positron sources, damping rings (DR) to reduce the emittance (a value corresponding to the spread of the beam) of the e-/e+ beams, beam transportation from the damping rings to the main linear accelerators (RTML), the main linear accelerators (ML) including bunch compressors (to compress the beam bunch length) to accelerate the e-/e+ beams using superconducting RF technology, beam delivery and final focusing system (BDS) to focus and adjust the final beam to increase the luminosity, and the beam interaction region for machine and detector interface (MDI) where detectors are installed. After passing through the interaction region, the beams go to the beam dumps (DUMP).



The technical preparation plan defines all activities necessary during the main Preparation Phase to prepare for the construction phase of the ILC. The technical preparation plan will be conducted by the ILC Pre-Lab. The plan assumes that most of the preparation tasks will be carried out with international collaborations, based on agreement (MOU) between laboratories/institutions. The technical preparation work packages have been discussed and defined by IDT-WG2.

The work packages include:

- ML and SRF: Cavity and Cryomodule (CM) production readiness, based on global cavity fabrication of ~ 3 x 40 cavities and the required RF performance achievement with the ≥ 90 % successful, and on global CM fabrication of 3 x 2 CMs using 40 % of the cavities fabricated,
- The global CM transfer program to be conducted to practice to simulate all the process of

the CM fabrication satisfying the high-pressure regulation, safe transport across oceans, and qualification of the CM performance after shipping from Europe and Americas to Japan on surface across oceans. One of two CMs in each region to be used for this purpose,

- Positron source: The final design selection either with undulator-driven or electron driven option and technology readiness to be demonstrated,
- DR and BDS: Readiness of nanobeam technology (ATF3 and related) based on DR and BDS subsystems to be demonstrated in particular for fast kicker and feedback controls, and
- Beam dump: system design to be established including beam window handling, cooling water circulation, and safety assurance.

Total 18 (3 SRF, 8 Sources, 3 DR, 2 BDS and 2 Dumps) are proposed.
Each work package includes:

- technical readiness evaluation (listed in each technical proposal)
- EDR documentation with cost estimate confirmation for the ILC construction

Timeline (example of SCRF and positron)

Four-year preparation period is assumed. In case of SCRF and positron, the following schedule is considered.

1st year:

- Extend SRF cost reduction R&D, and start a pre-series SCRF cavity production for industrialization readiness, and
- Continue positron source technology survey and evaluation.

2nd year:

- Select positron scheme (so essential preparation for positron selection assumed to be finished by 1st year)
- Complete SRF cost-reduction R&D, and start the work for assembly of the cavities with CMs,

3rd year:

- Demonstrate "Global CM transfer, including legal process for high-press-gas equipment, shipment, and SRF QA test after surface shipment across the ocean,
- Mature ILC Lab. planning and prepare the lab. including the management and site,
- Complete prototyping of critical items (such as positron target)
- Prepare for the Engineering Design Report (EDR) and proceed the EDR cost-review,

4th year:

- Evaluate CM performance based on CM shipment, and prepare for Hub Lab. functioning
- Progress prototyping of critical items (such as positron target)
- Publish the EDR, and
- Prepare for large procurement process, in particular for civil engineering and SRF.

Description of each work package ……

Appendix

Following work packages are listed in this technical proposal.

Area system	Work package	Items
SRF1 (+ Infra.)	Cavity Industrial-Production Readiness	Cavity production, partly incl. cavities w/ He tank+mag. shield for CM, high pressure gas regulation, EP/HT/Clean work, partly 2nd pass, incl. VT, pre-tuning
		Plug-compatibility, surface treatment, Nb material to be reconfirmed/decided
		Cavity Production Success yield
		Tuner baseline design to be frozen (decided)
		Infrastructure for EP, HT, VT, pre-tuning, etc. (with each regional responsibility)
SRF2 (+ Infra.)	Cryomodule (CM) Transport and Performance Assurance	Coupler production incl. preparation/RF processing readiness ~~(not incl. klystron, baking furnace, clean room)~~
		Infrastructure for klystron, baking furnace, and coupler conditioning, and associated environment (with regional responsibility)
		Tuner production readiness
		SCM (Q-D combined) production readiness
		CM production incl. high pressure gas, v. vessel, cold-mass, and assembly (cavity-string, coupler/tuner, SCM etc.)
		CM test and degradation mitigation (in 2-CM joint work) at production site for the readiness in the acc. tunnel work,
		CM Transportation cage and shock damper preparation
		Mockup-CM ground transportation practice
		Real-CM ground transportation test
		Global CM transfer with sea shipment (with attention for longer CM than that at E-XFEL)
		Performance assurance test after global CM tansfer
		Returning transport back to home country (by sea shipment)
		Hub-lab Infrastructure for the CM production, assembly, and test (with regional responsibility and/or each lab.)
SRF3	Crab Cavity (CC)	Decision of installation location in accelerator tunnel, combined with cryogenics and RF utility locations.
		Design and development of prototype cavity/coupler/tune/CM include. beam extraction line
		CC production readiness (incl. EP/HT/Clean work), and CM assembly with coupler/tuner
		CC , coupler, and tuner test, incl. preparation work
		CC-CM prototype assembly and test incl. harmonized operation with two cavities
		Infrastructure for CC (and CM) development and test (w/ corresponding lab.)
Sources		
e- source		
Sour1	Electron Source	Cathode, High voltage, Laser
e+ undulator scheme		
Sour2	Undulator	Simulation (field,errors, alignment)
Sour3	Rotating target	Design finalization

		Wheel
		Magnetic bearings
Sour4	Magnetic focusing system	Design finalization,Wheel
		Magnetic bearings
		Full wheel prototype
e+ e-driven scheme		
Sour5	Rotating target	Stress calculation
		Vacuum seal test
		Target module
Sour6	Magnetic focusing system	Flux concentrator conductor
		Power source
		transmission line
		System prototype
Sour7	Capture cavity, linac	APS cavity design
		APS cavity prototype
		Transient beam loading
		Operation and tuning (incl. multiple bunches)
		L-band Klystron
		Power unit prototype
		solenoid
		fast position monitor (separate e+ and e-)
Sour8	target replacement	Target replacement system
Damping Ring		
DR1	System design of ILC damping ring	System design : Optics optimization with magnet model
		Simulation : Dynamic Aperture with magnet model
		Normal Magnet Magnet : Magnet design
		Permanent Magnet : Magnet design
		Permanent Magnet : Prototype (?)
DR2	Evaluation of the collective effect in the ILC damping ring	Simulation : Electron Cloud Instability
		Simulation : Ion trapping Instability
		Simulation : Fast Ion Instability
		System design : Orbit FB for Fast Ion Instability
		Beam test : Orbit FB for Fast Ion Instability
DR3	System design of ILC DR Injection/extraction kickers	Fast kicker: System design; DR and LTR/RTL optics optimization
		Fast kicker: Hardware preparation; based on FID pulser
		Fast kicker: System design & Prototyping ; based on induction kicker
		Fast kicker: Long-term stability test at ATF
		E-driven kicker: System design, include the induction kicker development
BDS		
BDS1	System design of the ILC final focus beamline	System design : beam optics and hardware optimization
		Simulation : Intensity dependence evaluation and correction
		Beam test : 2nd order optics correction
		Beam test : Intensity dependence correction
		Beam test : Long-term stability test of IP beam size and position at ATF
BDS2	System design of the FD magnet package	System design (include the anti-solenoid)
		Vibration test
Beam Dump		
Dump1	System design of the main beam dump	Engineering design of water flow system
		Engineering design and prototyping of components; vortex flow in the dump vessel, heat exchanger, hydrogen recombiner
		Engineering design and prototyping of window sealing and remote exchange
		Design of the countermeasure for failures / safety system

Dump2	System design of the photon dump for undulator positron source	System design and component test of water curtain dump System design and component test of graphite dump

ILC parameters:

Parameter	Unit	Requirement	Design	Achieved	Facility
Electron Source					
Bunch Charge	nC	3.2	4.8	8	SLAC -SLC
Average Beam current	mA	21	42	1000	JLAB
Beam current in pulse	mA	5.8	11.6	60	Cornell U.
Polarization	%	80	80	90	Nagoya, SLAC, KEK
Quantum Efficiency	%	0.5	0.5	2.2	Nagoya
Drive Laser (in pulse)	W	1.8	10	>10	Commercially available
Positron Source					
Bunch Charge	nC	3.2	4.8	8	SLAC SLC (E-Driven)
Undulator scheme					
Undulator pitch	mm	11.5	11.5	2.5	SLAC E166
Positron Polarization (optional)	%	30	30	80	SLAC E166
Ti alloy Target Heat Load (PEDD)	J/g		61	160	Estimated from physics constant table
QWT peak field	T	1		2.3	KEK
Target radius	mm	500			
Target weight	kg	50			
Target tangential velocity	m/s	100			
Target rotation	rpm	2000			
Beam heat load	kw	2			
Vacuum pressure	Pa	10^-6			
E-driven scheme					
W-Re Target Heat Load (PEDD*)	J/g		34	70	SLAC SLC (E-Driven)
Flux Concentrator Peak field	T	5		10	BINP
Target radius	mm	250			
Target weight	kg	65			
Target tangential velocity	m/s	5			
Target rotation	rpm	200			
Beam heat load	kw	20			
Vacuum pressure	Pa	10^-6			
APS cavity					
SCRF					
Module gradient	MV/m	31.5 (+/- 20%)		~31.5	DESY, FNAL, JLab, Cornell, KEK,
Cavity Q value (Q0)		10^10		~10^10	
Cavity gradient	MV/m	35 (±20%)		33.4 MV/m	
Cavity production yield	%	90			
Beam current	mA	5.8		> 5.8	DESY, KEK
Number of bunches		1312		1312	DESY
Bunch charge	nC	3.2		3	
Bunch interval	ns	554		333	
Beam pulse width	μs	730		800	DESY, KEK
RF pulse width	ms	1.65		1.65	DESY, KEK, FNAL
Repetition	Hz	5		10	DESY
DR					
Horizontal Emittance(ε_x)	nm	0.4	0.4	0.34	MAX-IV
Vertical Emittance (ε_y)	pm	2	2	<2	SLS, Australian LS, Diamond LS
Normalized Emittance($\gamma\varepsilon$_x/ $\gamma\varepsilon$_y)	μm/nm	4/20	4/20	4/15	ATF
Fast Ion instability					SuperKEKB
Electron Cloud Instability					SuperKEKB/CesrTA
Kicker Rise Time	ns	< 6.15	< 3.07	2.2	ATF
Kicker Voltage	kV	±10	±10	±10	ATF
Kicker Voltage stability		0.0007	0.0007	0.00035	ATF
Kicker Frequency	MHz	1.8	2.7	3.25	ATF
Fast Kicker extraction test					ATF
BDS					
ATF2 beam size (σ_y^*)	nm	37		≤41	ATF2
ILC beam size	nm	7.7			ATF2
Feedback position stability	% of beam	12	10	4	ATF2
Feedback latency	ns	< 554	< 366	133	ATF2
Beam Dump					
ILC 250GeV	MW	2.6	17	-	Designed for 500GeV beam
SLAC 2mile LINAC	MW	-	2.2	0.75	ILC beam dump prototype