6^{th} meeting of SRF subgroup in IDT/WG2

- ✓ Introduction
- ✓ Discussions on budget request
- ✓ Others (if any)

Attendees: A. Yamamoto, S. Michizono, H. Hayano, N. C. Lasheras, D. Delikaris, S. Posen, R. Rimmer, M. Liepe, P. McIntosh, B. Laxdal, E. Cenni, L. Monaco, M. Ross, S. Stapnes, H. Weise, Kirk

https://agenda.linearcollider.org/category/256/

Kirk

Minor changes in task list for technical preparation

SRF → Main linac and SCRF

※Based on TDR

- ◆ Cavity and cryomodule production
- ◆ Cryomodule transport (“Global CM transfer”)

→

- ◆ Cavity Industrial-production Readiness
- ◆ Cryomodule transport and Performance assurance
- ◆ Crab Cavity
- ◆ Bunch compressor and others (not only SRF)
- ◆ Engineering design report

※Hub-lab. Infrastructure added in CM and crab

Reconfirmation of cost unit in ILC

- **ILCU** (ILC unit) has been used as the cost unit for ILC since GDE era
- Based on US dollars as of January 2012 (1 ILCU = $1)

TDR Vol.3 II

15.4.2.4 ILCU Definition in terms of PPP Indices

For the TDR, the ILCU will be defined as equal to the USD on January 1, 2012. Conversions of estimates obtained in currencies other than USD to ILCU will be based on PPP indices (as of January 1, 2012) relating those currencies to the USD. The only exception to this rule is for the superconducting material for the cavities. There is only one supplier of RRR-niobium raw material in the world. Thus, it is appropriate to consider this cost element to be a commodity which must be purchased on the international market. In preparing the Value estimate, conversions from currencies other than USD to ILCU for this cost element have been based on exchange rates as of January, 2012. The PPP indices of four regional[6] currencies, relative to the USD, together with exchange rates, are shown in Fig. 15.2. Numerical values of the PPP indices and exchange rates for January, 2012, which are used in the Value estimate, are given in Table 15.2.

Table 15.2. Currency conversion factors between ILCU and national currencies (January, 2012). To convert a cost element from ILCU to the indicated currency, multiply by the factor appropriate for the type of cost element.

Cost element type	ILCU→USD	ILCU→Euro	ILCU→Yen	ILCU→CHF
Civil construction (PPP)	1	0.939	109.3	1.303
Machinery and equipment (PPP)	1	0.923	127.3	1.480
Superconducting material (EX)	1	0.776	76.9	0.939

FTE-yr estimated in ILC Action Plan 2016

ML and SCRF has 224 (Japan) and 74 (abroad)

KEK ILC Action Plan 2016

Appendix 5. Breakdown of the Human Resource Plan (see: Table 3 in the main text)

Category	Subject		pp	P1	P2	P3	P4	Int.-FTE
Grand-Sum		**Sum =JP+Abr.**		**118** = **80**+38	**161** = **105**+56	**222** = **138**+84	**282** = **171**+111	**783** = **494**+289
Acc-Sum		**Sum =JP**+Abr.		**82** = **54**+ 28	**115** = **74**+41	**163** = **98**+65	**211** = **122**+89	**571** = **348**+223
Accelerator (FTE)	Tech. coordination	**JP** abroad		**1** 2	**1** 2	**1** 2	**1** 2	**4** 8
	ADI	**JP** abroad		**3** 6	**4** 8	**6** 12	**8** 16	**21** 42
	SRF (& ML)	**JP** abroad		**38** 8	**50** 12	**62** 22	**74** 32	**224** 74
	Nanobeam (& DR, BDS)	**JP** abroad		**6** 6	**9** 9	**15** 15	**21** 21	**51** 51
	Sources (e-, e+)	**JP** abroad		**3** 3	**4** 4	**5** 5	**6** 6	**18** 18
	Others (RTML, Dump etc.)	**JP** abroad		**3** 3	**6** 6	**9** 9	**12** 12	**30** 30

Schedule of SRF (incl. crab) subgroup meeting in IDT/WG2

Meeting #	Date	Contents
1	29/Sep/2020	introduction, member list, schedule/work items in technical preparation, discussions
2	13/Oct/2020	New member, discussions on how many cavities/CMs to be produced, AWLC2020
	19~22/Oct/2020	**AWLC2020 on virtual**
3	27/Oct/2020	Brief report of KEK-DOE mtg and AWLC, discussions on main items in technical preparation
4	10/Nov/2020	Reports from US labs., introduction to Michizono-san's report, discussions on cost down R&D, crab cavity, high pressure gas, etc.
	24/Nov/2020	Crab kick-off meeting
5	24/Nov/2020	To be fixed task list in technical preparation period
	30/Nov/2020	2nd Crab cavity meeting (after this, SRF subgroup leads to the discussions on crab cavity)
6	8/Dec/2020	**Discussions on the budget request for SRF technical preparation**
7	22/Dec/2020	Discussions on draft of sharing work items in technical preparation period
	25/Dec/2020	Submission of budget request to EB
?	12/Jan/2021?	
?	19/Jan/2021	
	19~21/Jan/2021	**TTC meeting 2021 on virtual**
?	26/Jan/2021	
	Feb/2021	First draft of budget request in each region/lab., Submission to WG1/EB
		Preparation for MOU between/among laboratories
	Jun~Jul/2021	Submission of budget request to MEXT, in case of Japan
	28/Jun~2/Jul/2021	**SRF 2021 on virtual**

Questions/Discussions/Comments (memorandum) @6th meeting

Translation by Kirk

- Budget request
  - Cost of cavity production includes everything from production to cavity string excluding infrastructure as hub-laboratory
    - Helium tank, magnetic shield, surface treatment, clean room work, high pressure gas regulation, VT (after 2nd pass)
      - Additional lecture/meeting is necessary for high pressure gas regulation of Japan (not this year, but needs to be hurried)
    - Unit cost is preferable?
      - Cavity and coupler cost looks valid
  - Coupler production includes preparation work, waveguide system to connect between two couplers for RF processing at test bench excluding klystron/modulator
  - Number of CM in abroad
    - In US, as we already presented in the previous subgroup meeting, totally four CMs will be produced (FNAL/J-LAB), the number is increased
    - The number of abroad production needs to be discussed well in Europe
  - Remaining cavities (not used for CM production) and bad performance cavities
    - If the performance is good and HPG is satisfied, those cavities can be in stock for ILC (may be not used in technical preparation period)
    - If the performance is bad and HPG is satisfied, those cavities can be repeatedly surface-treated and tested to achieve the good performance
    - If the performance is bad and HPG is not satisfied, those cavities can be used for the other purpose
    - If a cavity with poor performance appears, it is necessary to discuss in advance whether or not the cavity equips a helium tank in production
  - Additional infrastructure
    - If you need some additional items, you can put them into hub-lab. infrastructure in ML-SRF-2
      - ex) klystron/modulator, CM test cave, coupler test area, clean room, pre-tuning machine, EP facility, vacuum furnace for heat treatment, etc.
    - UK team needs the CM test area (cave?) as the additionally necessary infrastructure for crab cavity
  - Crab cavity
    - Japan may/can not control the management for this, because too many labs. have strong interest
      - Candidate labs: UK, FNAL, J-LAB, TRIUMF, CERN?
    - In the current budget request, only abroad has some number in budget/FTE-yr
  - CM transportation
    - Simulation and support from DESY are necessary
    - Cost of cage/shock damper looks reasonable
    - Cost of ground transportation to be checked
    - Cost of sea shipment may be increased, if a special container is necessary (because CM length for ILC is longer than E-XFEL)
      - KEK will have the meeting with a transportation company this month
  - Breakdown is necessary for each quantity and FTE-yr for abroad
  - FTE-yr
    - EDR needs some people, then we put 10 FTE-yr for each
  - Release
    - If you keep this sheet confidentially, we can release → already done

References

- KEK homepage
  - https://www2.kek.jp/ilc/en/
- Technical Design Report
  - https://ilchome.web.cern.ch/publications/ilc-technical-design-report
  - https://www2.kek.jp/ilc/en/docs/
- The International Linear Collider Progress Report 2015
  - https://www2.kek.jp/ilc/en/docs/
- The International Linear Collider – A Global Project
  - Submitted to European Particle Physics Strategy Update, 2020.
  - https://indico.cern.ch/event/765096/contributions/3295702/
- ILC Action Plan
  - https://www.kek.jp/ja/newsroom/2016/01/06/1400/
  - https://www.kek.jp/ja/newsroom/2018/04/24/1200/
- Recommendations on ILC Project Implementation
  - https://www.kek.jp/ja/newsroom/attic/20191001_%20ILC%20Project.pdf

Backup slides

IDT-WG2 organization

Bi-weekly *Tuesday* meeting: Sep.22, Oct. 6, 20,…

IDT WG2
Shin Michizono (Chair)
Benno List (Deputy)

https://agenda.linearcollider.org/category/256/

SRF

Bi-weekly Tuesday Oct.13,27,…

Yasuchika Yamamoto	***KEK***
Nuria Catalan	CERN
Enrico Cenni	CEA
Dimitri Delikaris	CERN
Rongli Geng	JLAB
Hitoshi Hayano	KEK
Bob Laxdal	Triumf
Matthias Liepe	Cornell
Peter McIntosh	STFC
Laura Monaco	INFN Milano
Olivier Napoly	CEA
Sam Posen	FNAL
Robert Rimmer	JLAB
Marc C. Ross	SLAC
Luis Garcia Tabares	CIEMAT
Hans Weise	DESY
Akira Yamamoto	KEK

DR/BDS/Dump

Bi-weekly Tuesday Oct.13,27,…

Toshiyuki Okugi	***KEK***
Karsten Buesser	DESY
Philip Burrows	U. Oxford
Angeles Faus-Golfe	LAL
Jenny List	DESY
Thomas Markiewicz	SLAC
Brett Parker	BNL
David L. Rubin	Cornell
Nikolay Solyak	FANL
Nobuhiro Terunuma	KEK
Glen White	SLAC
Kaoru Yokoya	KEK
Mikhail Zobov	INFN LNF

Ivan Podadera ivan.podadera@ciemat.es

Charges of Sub-groups

- Discuss and coordinate the topics for
  - technical preparation (remaining topics) at Pre-lab
  - preparation for mass production at Pre-lab
  - possible schedule at Pre-lab
  - international sharing candidates of these activities
- Report to the IDT-WG2

All members belong to some sub-group(s).

Sources

Bi-weekly Monday Oct.12,26,..

Kaoru Yokoya	***KEK***
Jim Clarke	STFC
Steffen Doebert	CERN
Joe Grames	JLAB
Hitoshi Hayano	KEK
Masao Kuriki	U. Hiroshima
Benno List	DESY
Gudrid Moortgat-Pick	U. Hamburg

Peter Sievers Peter.Sievers@cern.ch
Sabine Riemann<sabine.riemann@desy.de>

Civil engineering

Nobuhiro Terunuma	***KEK***
John Andrew Osborne	CERN
Tomoyuki Sanuki	U. Tohoku

2pm UTC (6am US Pacific, 8am US Central, 2pm U.K., 3pm Geneva, 11pm Japan)

Main tasks in technical preparation period based on "Recommendations on ILC Project Implementation"

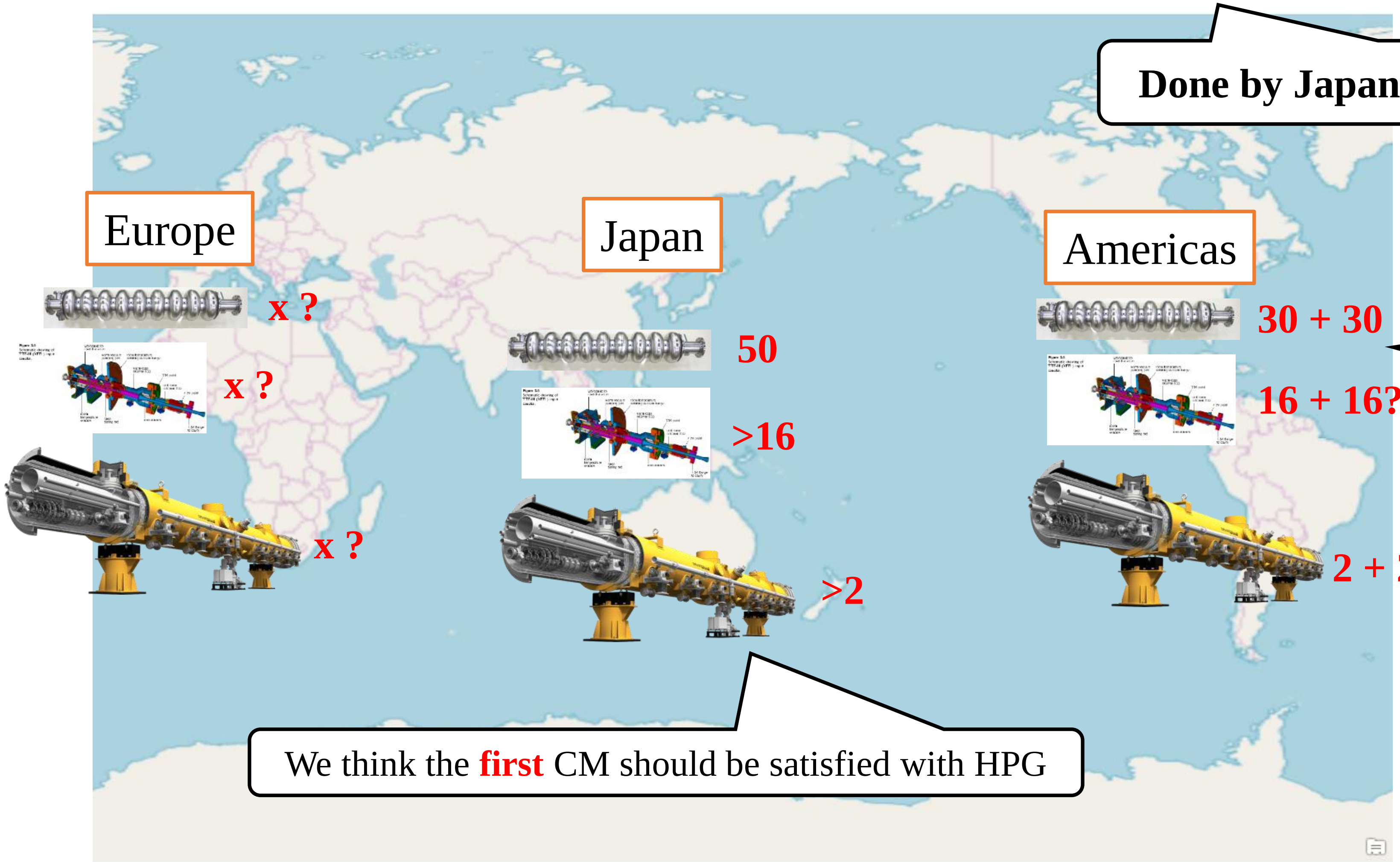
- Cavity and cryomodule production
  - 100 cavities produced in preparation for mass production
    - ~1% of full production
    - Japan: 50 cavities, other regions/countries: 50 cavities
  - By new cost-effective production method
  - Plug-compatibility re-confirmed/re-established
  - Surface preparation recipe baseline/guideline to be re-established
  - To be checked RF performance/success yield
  - High pressure gas regulation in Japan (cavity/cryomodule production)
  - Coupler/Tuner improved/produced/assembled/tested
  - Superconducting magnet (quad.+dipole combined) in CM to sustain under dark current irradiation from high-gradient SRF linac
  - Cryomodule (CM) production/test
- Cryomodule transport ("Global Cryomodule transfer")
  - Shipment/transport incl. inspection
  - RF performance rechecked after transport

Crab cavity is listed additionally **as third issue**

Update of # of cavity/cryomodule produced in technical preparation period

Before this production starts, tuner design should be fixed!!

Done by Japan-U.S. collaboration



From Matthias's report

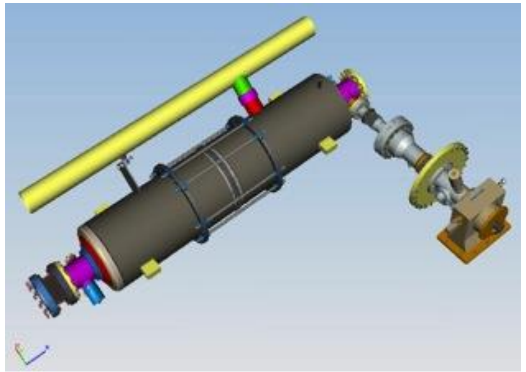
We think the **first** CM should be satisfied with HPG

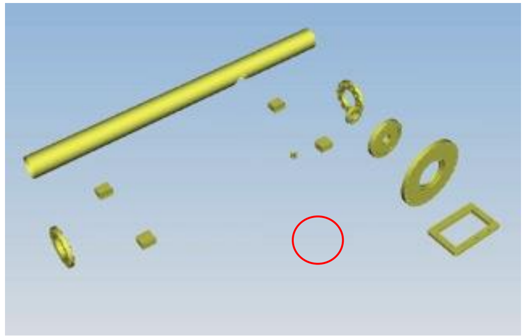
In the both plans of Japan and Americas, upgrade of infrastructure as function of hub-laboratory is also included!

Plug-compatible Conditions in TDR

SRF-Report at ILC-PAC
12/05/14, 12/12/13

Interface and Process established, in TDR, 2013



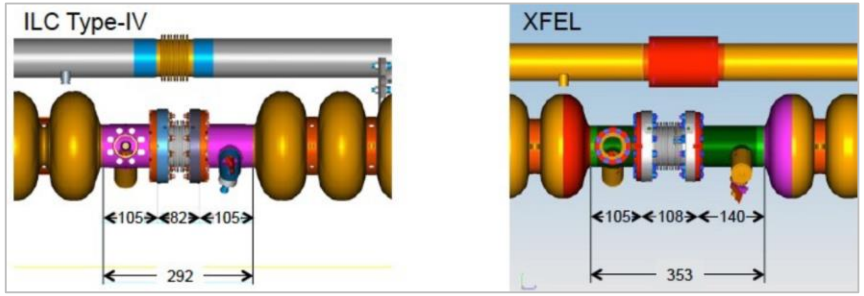


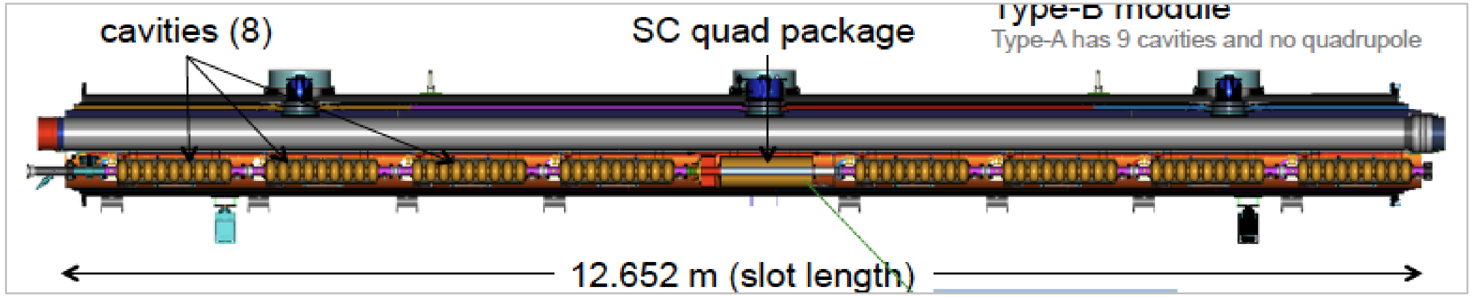
Item	TDR Baseline
Cavity shape	TESLA
Length	Fixed, L = 1,247 mm (61 mm shorter than XFEL)
Beam pipe flange	Fixed
Suspension pitch	Fixed
Tuner	Blade
Coupler flange (cold end)	40 mm
Coupler pitch	Fixed
He –in-line joint	Fixed

Twice allowed

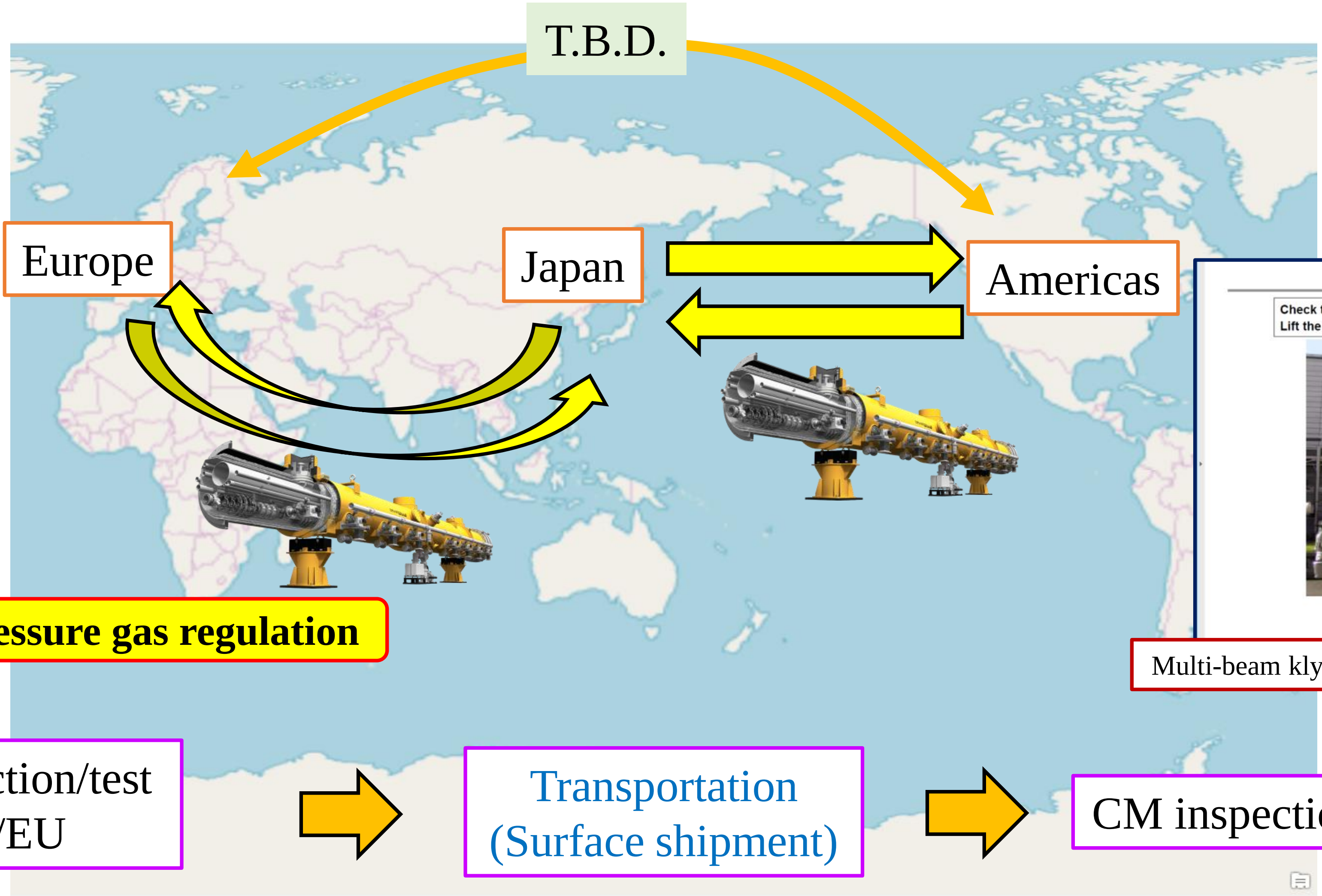
	Standard Fabrication/Process
Fabrication	Nb-sheet purchasing
	Component Fabrication
	Cavity manufacturing with **EBW**
Process	**EP-1 (~150um)**
	Ultrasonic degreasing with detergent, or ethanol rinse
	High-pressure pure-water rinsing
	Hydrogen degassing at > 600 C
	Field flatness tuning
	EP-2 (~20um)
	Ultrasonic degreasing or ethanol (or EP 5 um with fresh acid)
	High-pressure pure-water rinsing **(HPR)**
	Antenna Assembly
	Baking at 120 C
Cold Test (vertical test)	Performance Test with temperature and mode measurement

12/05/14 **KEK-LC-Meeting**





Global cryomodule transfer in technical preparation period



Multi-beam klystron transportation from Japan to EU

conforming to high-pressure gas regulation

New CM production/test @America/EU → Transportation (Surface shipment) → CM inspection/test @Japan

Note: Returning the CMs to Europe/Americas for redundant confirmations, to be discussed.

Preparation for task list/budget request

Michizono-san and Kirk are preparing for document and task list including budget request for the technical preparation period.
We will submit the preliminary version to EB early December.
Then, the SRF subgroup has to fix the task list until the end of this month.

Budget request will be added

Table 4.3: Accelerator-related technical preparation tasks and possible partners for international collaboration as envisioned by KEK.

Component	Issue	Summary of tasks	Candidates for collaboration
SCRF Cavity	Mass production incl. automation	Performance statistics, mass production technology	France, Germany, US
	Cryomodule transport	Performance assurance after transport	France, Germany, US
	Rotating target	Exchanging target, ...sign	CERN, France, Germany, ... + industry-academia effort
		...esign	France, Ger...
		...esign	CERN, Ger...
... Ring		...g-term stability, ... design	CERN, Italy
	Feedback	Test at SuperKEKB	Italy
Interaction ...	Beam ...	...	...
Beam Dump	Beam window, cooling water circulation	Durability, exchangeability, earthquake-resistance	CERN, US + industry-academia efforts

Name of laboratories will be added

Component	Issue	Task	Candidates
CM SCQ(+D)	Sustainability against SRF dark current	Absorb heating and not causing quench	US and Spain
Tuner	Design not fixed	Reconfirmation Wider range piezo	Japan and US

Crab cavity is listed additionally **as third issue**

If you don’t have any other input, we can fix these two (plus one) tasks as the list of SRF

High pressure gas regulation and schedule of cavity/CM production

Regarding high pressure gas (HPG) regulation, KEK is currently trying to launch a task force.
Recently, **cavities and cryomodule components produced in Europe have been delivered to Rokkasho for IFMIF project**.
After the delivery, every part including cavity string is assembled at Rokkasho (under prgress).
I think we can learn a lot from this experience.
Mr. Kasugai replied that he may provide his presentation reviewing his effort for IFMIF, and possibly at LCWS2021.
We will have a first meeting about HPG between KEK and QST on 25/Nov.

As a proposal, since it is **impossible to manufacture cavities compatible with HPG in the first year of the technical preparation period**, we will **manufacture 10 cavities that are not compatible only in the first year**. If we decide to manufacture a cavity compatible with HPG from the next fiscal year and later, it will open the way for the ILC to be **used as spare cavities**, which will be an effective utilization measure.

For construction of CM, we think that the "global transfer" cryomodule program shall start from the beginning of the technical preparation period, in order to properly satisfy the HPG regulation process in Japan.

There are two different types of rules (general rule and cryoplant rule (cryo-plant in refrigeration mode with closed gas-flow circuit)) in HPG in Japan. We think cryoplant rule is preferable for ILC.
It is necessary to discuss/consider this matter more with many experts.

Linac and CM in IFMIF
(courtesy of Kasugai-san)

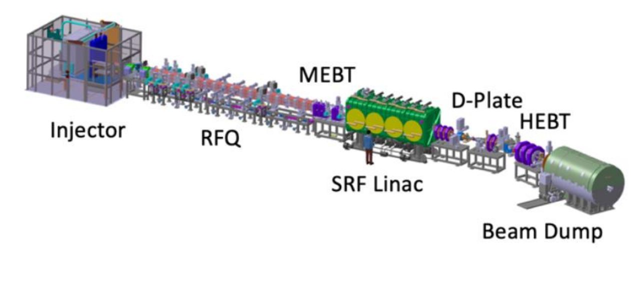


Fig. 1 Configuration of an IFMIF prototype accelerator (LIPAc).

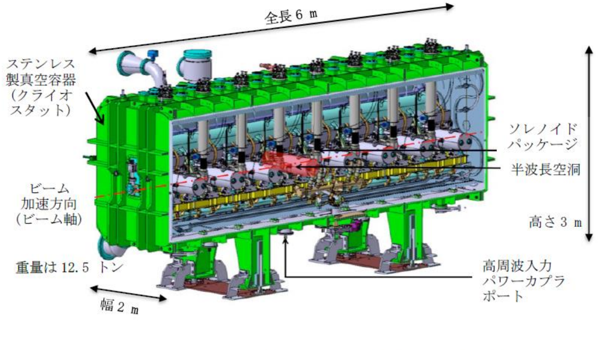


Fig. 2 Internal view of a cryomodule for the LIPAc.

Brief view of High-Pressure Gas Regulation

- Step 1 (discussion)
  - Before cavity/CM production, we need to discuss with KHK (authority of HPG in Japan)
  - KHK requests to submit necessary documentations (material certificate, EBW method, simulation results related to mainly mechanical crush, etc.)
  - KHK may request Charpy impact test for Nb material
  - KHK may request TIG welding test between cavity and helium tank

- Step 2 (production)
  - Cavity/Cryomodule production satisfying high pressure gas regulation
  - KHK may stand by during production

- Step 3 (inspection)
  - Must undergo completion inspection for cavity

Required number of cavities, and performance improvement by recent surface treatment for ILC

Recently, some ideas for improving cavity performance (mainly Q_0 value) have been tested.
Even if these attempts of cost down R&D are successful, we will **not reduce the number of cavities required for the ILC-250** presented after TDR.
The performance improvement achieved after TDR is considered as an additional **margin (insurance)**.
And, it will be positioned as a technology for more efficient and appropriate upgrades in the future.
The performance of the cavities manufactured during the preparation period shall also satisfy the specifications of TDR.

Further, for the purpose of improving the cavity performance, the number of recent surface treatments has been increasing, but it is also a factor of cost increase.
In the first place, it is necessary to consider cost effective improvement while maintaining the spirit of cost reduction.
The selection of niobium material and surface treatment method can be finally selected in each country or each laboratory.
Similarly, it is necessary to agree that each country or each laboratory is responsible for the cost increase associated with it.

We plan to **hold a session at LCWS2021 (around spring in 2021) to discuss cost reduction R&D, and which is the best method**. Probably also in TTC meeting 2021.

Accelerator activities at ILC Pre-lab phase

Presented by S. Michizono in IDT-EB meeting

Technical preparations /performance & cost R&D [shared across regions]

- SRF performance R&D, quality testing of a large number of cavities (~100), fabrication and shipping of cryomodules from North America and Europe (for validating shipping)
- Positron source final design and verification
- Nanobeams (ATF3 and related): Interaction region: beam focus, control; and Damping ring: fast kicker, feedback
- Beam dump: system design, beam window, cooling water circulation
- Other technical developments considered performance critical

Technical preparation

Final technical design and documentation [central project office in Japan and possibly regional project offices]

- Engineering design and documentation, WBS
- Cost confirmation/estimates, tender and purchase preparation, transport planning, mass-production planning and QA plans, schedule follow up and construction schedule preparation
- Site planning including environmental studies, CE, safety and infrastructure (see below for details)
- Review office
- Resource follow up and planning (including human resources)

Engineering Design Report (EDR)

Preparation and planning of deliverables [distributed across regions, liaising with the central project office and/or its satellites]

- Prototyping and qualification in local industries and laboratories, from SRF production lines to individual WBS items
- Local infrastructure development including preparation for the construction phase (including Hub.Lab)
- Financial follow up, planning and strategies for these activities

Planning and preparation of Hub lab.

Civil engineering, local infrastructure and site [host country assisted by selected partners]

- Engineering design including cost confirmation/estimate
- Environmental impact assessment and land access
- Specification update of the underground areas including the experimental hall
- Specification update for the surface building for technical scientific and administrative needs

Civil engineering

Assumed Pre-lab timeline

Presented by S. Michizono in IDT-EB meeting

For Engineering design

1st year: Work on TDR-based cost-estimate confirmation, started by an international team centered on the Pre-lab.
2nd year: Complete the cost-estimate confirmation, and an internal review in the latter half of the 2nd year.
The review also reports on the progress of technical issues during the preparation period.
3rd year: Conduct an external review and completed scrutiny of costs and risks.
Complete the draft of Engineering Design Report (EDR).
4th year: Publish EDR (in first half yr), report progress on technical issues,and prepare each large bid.

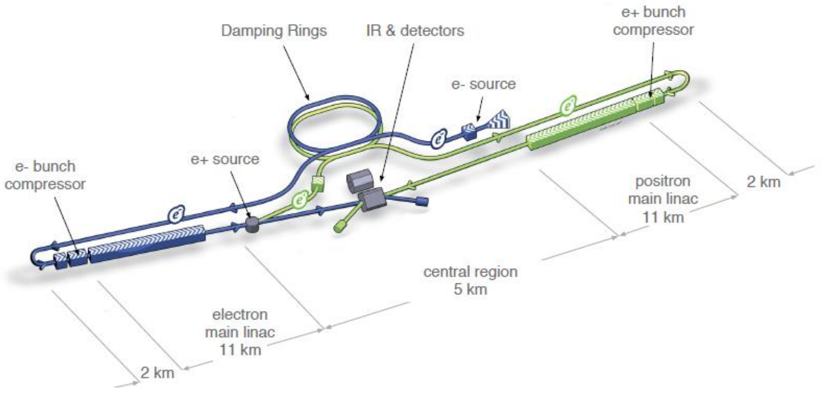
For technical preparation (example of SCRF and positron)

1st year: Extend SCRF cost reduction R&D, Start a pre-series SCRF cavities production preparing for industrialization
Continue positron survey
2nd year: Complete SCRF cost-reduction R&D, and extend the work to assemble the cavities with cryomodule (CM),
Select positron scheme
3rd year: Demonstrate "Global CM transfer, aiming at HPG legal-process, shipment, and SRF QA test after transport
Mature Lab. planning and preparation
Prototyping of critical items (such as positron target)
4th year: Evaluate CM performance based on CM shipment, and prepare for Hub Lab. functioning
Progress prototyping of critical items (such as positron target)

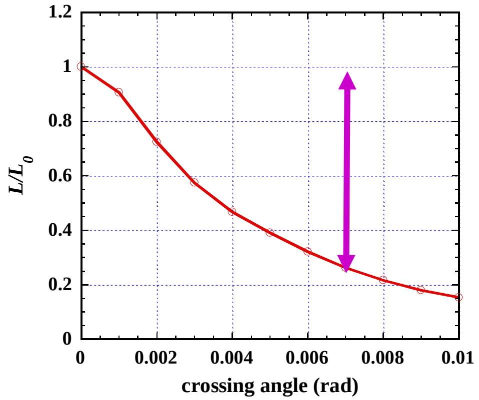
Kick-off meeting for crab cavity

- Crab cavity system is essential for ILC
- No progress after TDR
- Prototype CM is necessary (Nomura Research Institute, Ltd. considered not-matured technology)
- Kick-off meeting will be held 30 min earlier before next SRF subgroup meeting on 24/Nov
- Expected attendees: SRF subgroup, BDS subgroup, UK members related to crab cavity R&D in TDR, Crab cavity members for HL-LHC (?)
- Discussion items: Work list in technical preparation period, Cavity design, Responsible laboratories, etc.

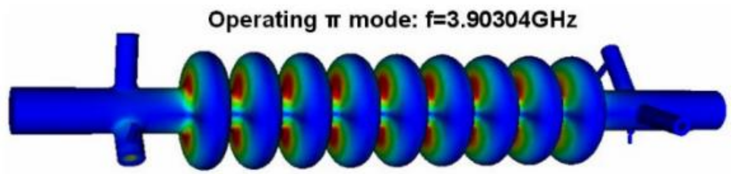
For higher luminosity



ILC RDR parameter, by CAIN simulation



Cavity design presented in TDR



Not using crab cavities reduces luminosity by 80%!

Pre-Lab schedule (translated into table)

	Technical preparation period (Fiscal year)							
Items	**1**		**2**		**3**		**4**	
Cost down R&D								
Cost estimation based on TDR								
Review				Internal	External			
Engineering design report	Writing					Draft	Publish	
Prototyping of critical items								
Preparation for mass-production technology								

We have to fit the SRF schedule to this overall schedule!

Brief view of cavity production by cost-effective method, and the best recipe

- Step 1 (production)
  - Cavity production by cost-effective method incl. selection of Nb material
  - Reconfirmation of plug-compatibility (only flanges)
  - Not necessary for satisfying high pressure gas regulation of Japan
  - Not necessary for helium tank

Technical workshop is necessary

- Step 2 (decision of surface/heat treatment methods)

Technical workshop is necessary

  - Cold temp. EP or standard EP?
  - N-dope, N-inf, Low temp. baking, Mid temp. baking, etc.?
- Step 3 (RF performance check)
  - VT1, but if not successful, VT2 done (after VT3, to be discussed)
- Step 4 (success yield)
  - Estimate success yield for 1st pass and 2nd pass (after 3rd pass, to be discussed)

How many cavities are produced for mass production?

Discussion item

We can refer Volume 3 Part 1 in TDR.

At that time, **16** 9-cell cavities (out of > 50 cavities, **recognized as identical in fabrication and surface process**) were used to evaluate cavity performance.

In the preparation phase, **at least ~ 20 or much more cavities are necessary** to evaluate recent surface treatment method including fabrication method much advanced since TDR.

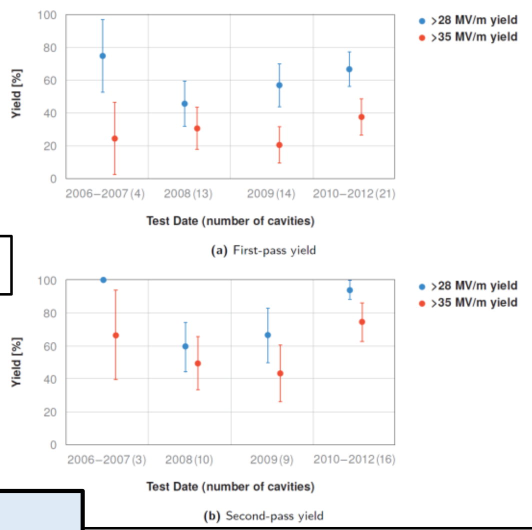
Not only surface treatment method but also what type of Nb material/fabrication method is used has to be discussed.

Table 2.6
Processing and handling of high-purity niobium cavities

Treatment method in TDR

Light BCP etching (10 µm)
Heavy EP (100-120 µm)
Post-heavy-EP cleaning
Vacuum-furnace outgassing (800 °C for 2 h)
RF tuning by no-touch bead-pull
Light EP (25 µm)
Post-light-EP cleaning
First HPR 3 passes (~ 6 h)
First clean room assembly
Final HPR 3 passes (~ 6 h)
Final clean-room assembly
Leak checking
In-situ baking at 120 °C for 48 h

Figure 2.19
Cavity yield for two gradient thresholds as a function of years, based on the global ILC cavity database updated as of October 2012 [67, 68]. Numbers in parentheses refer to cavity sample size. The cavities received standard treatment and were provided by established vendors.



History of cavity performance

When we evaluate success yield of cavity performance,
each region/lab. has to select one method of fabrication and surface process.
But, we don't need world-unified method of fabrication and surface process.

Helium tank/tuner are not necessary for this evaluation

# of cavities	**Japan (/Asia)**	**Americas**	**Europe**
w/o helium tank/tuner	20	20	20
w/ helium tank/tuner			

At least 20 cavities are produced

Brief view of "Global CM transfer"

- Step 1 (production)
  - Cavity/Cryomodule production satisfying high pressure gas regulation

- Step 2 (performance check)
  - Checking RF performance and success yield in each region

- Step 3 (transport)
  - Designing/developing cage and shock damper
  - Inspecting vacuum pressure and mechanical damage after transport

- Step 4 (performance re-check)
  - Re-checking RF performance and success yield in Japan (maybe in others)

How many cryomodules are produced for mass production?

Discussion item

ILC needs two types of cryomodules; Type A and Type B.
Any laboratory has never produced same types of CM as ILC.
High pressure gas regulation of Japan should be also satisfied for ILC.

As first step, each region produces **one prototype CM** (not necessary for conforming high pressure gas regulation).
Type B is preferred, as it includes systems of SC-Q magnet/cold BPM.
Prototype CM is produced and tested in each region.

As second step, each region produces **at least one CM conforming high pressure gas regulation of Japan**.
That CM (Type B is preferred) is produced and tested in each region.
If possible, Type A can be also produced.

As final step, each region carries out **global CM transfer to Japan**.
CM produced in second step is available.

Table 3.1
Summary of key numbers for the SCRF Main Linacs for 500 GeV centre-of-mass-energy operation. Where parameters for positron and electron linacs differ, the electron parameters are given in parenthesis.

Cavity (nine-cell TESLA elliptical shape)		
Average accelerating gradient	31.5	MV/m
Quality factor Q_0	10^{10}	
Effective length	1.038	m
R/Q	1036	Ω
Accepted operational gradient spread	±20%	
Cryomodule		
Total slot length	12.652	m
Type A	9 cavities	
Type B	8 cavities	1 SC quad package
ML unit (half FODO cell)	282 (285)	units
(Type A - Type B - Type A)		
Total component counts		
Cryomodule Type A	564 (570)	
Cryomodule Type B	282 (285)	
Nine-cell cavities	7332 (7410)	
SC quadrupole package	282 (285)	
Total linac length – flat top.	11027 (11141)	m
Total linac length – mountain top.	11072 (11188)	m
Effective average accelerating gradient	21.3	MV/m
RF requirements (for average gradient)		
Beam current	5.8	mA
beam (peak) power per cavity	190	kW
Matched loaded Q (Q_L)	5.4×10^6	
Cavity fill time	924	μs
Beam pulse length	727	μs
Total RF pulse length	1650	μs
RF–beam power efficiency	44%	

# of cavities/couplers/CMs	Japan (/Asia)	Americas	Europe
Cavity	16 + spare	16 + spare	16 + spare
Power coupler	16 + spare	16 + spare	16 + spare
Cryomodule	2	2	2

Brief report of KEK-DOE meeting

- The meeting done at 7:00~8:22 on 27/Oct (JST)

- Organized by A. Lankford

- 35 people attended
  - Japan: S. Michizono, A. Yamamoto, K. Yokoya, N. Terunuma, Kirk
  - Members of SRF subgroup in Americas: R. Rimmer, M. Liepe, R. Laxdal, R. Geng, S. Posen

- Michizono-san presented ILC overview, IDT, technical preparation, budget request from KEK, Recommendations on ILC Project Implementation, SCRF, positron source, damping ring, final focus system, beam dump, potential US accelerator contribution, and so on.

- A lot of discussions/questions/comments

Brief report of SRF session in AWLC2020

- 20 impressive presentations incl. three large-scale operating/on-going projects
- Presentation time was too short! Necessary to be considered in next LCWS
- Each topic:
  - E-XFEL by Nick; Four degraded cavities during operation, Stable RF availability, Piezo has impact on beam dynamics
  - LCLS-II-HE by Mattia; 2/0 doping was chosen as standard recipe, Cold temperature (<13℃) EP used, Higher Q_0/E_{acc} than LCLS-II was already achieved in CM test
  - PIP-II by Genfa; Two CMs (HWR and SSR1) constructed/tested and testing, common design of 325/650 MHz CMs
  - Tuner by Yuriy; LCLS-II tuner is strong candidate for to ILC (no design changes required), piezo study is necessary
  - Power coupler by Denis; 776 couplers operated stably, 4 couplers had no conditioning and overheating, Much higher power operation is necessary for ILC
  - Robotics by Stephane; Robotics study is under progress using ESS cavities, Goes to assembly of flange/coupler in future

Mission of SRF subgroup in IDT/WG2

- List work items in ILC preparation period
  - Plug-compatibility of design to be re-confirmed/re-established
  - Mass production
  - Global CM transfer
  - Any other?
- List technical concerns (if any)
  - Although E-XFEL has been successfully constructed and operated (and LCLS-II also in progress), are there any concerns for ILC to be constructed in Japan?
  - High pressure gas (HPG) regulation to be globally handled
    - In Japan, IFMIF (@Rokkasho) requested CM construction to EU (satisfied with HPG regulation)
  - Contents specialized in Japan?
- List human resources/budget/schedule for each work item and in each region/lab.
  - Necessary to discuss how to share each work item for each region/lab.

Pre-lab schedule

1st year: TDR-based estimate confirmation work started by an international team centered on the Pre-lab.

2nd year: Estimate tabulation work, internal review in the latter half of the 2nd year. The review also reports on the progress of technical issues during the preparation period.

3rd year: Conducted an external review and completed scrutiny of costs and risks (this is the end of incorporating cost reduction R & D). Completion of draft of engineering design report (EDR). Prototyping of critical items. Preparing mass-production line.

4th year: EDR publishing (first half), report on progress on technical issues, preparation work for each large bid. Prototyping of critical items. Preparing mass-production line.

IDT WG2 timeline

Example (towards Pre-lab)

Time

- 2022 April: Pre-Lab starts
- 2021 Dec.: IDT ends
- 2021 Feb.: First draft of budget request (each region/lab.)
- 2020 Dec.: Draft of sharing remaining technical preparation/pre-lab preparation (each region/lab.)
- 2020 Oct.: AWLC
- 2020 Oct.: Information sharing about technical preparation and updating the list
- 2020 Sep.: List of Pre-lab acc. activities/ Human resources/ budget/ schedule

2021, Submission of budget request in each region/lab,
(**2021**, early Summer: Submission of budget request to MEXT, in case of Japan)

Materials for Pre-lab human resources, budget, technical preparation

- KEK ILC action plan (Jan. 2018, KEK)

https://www.kek.jp/en/newsroom/KEK-ILC_ActionPlan_Addendum-EN%20%281%29.pdf

- "Recommendations on ILC Project Implementation" (Oct. 2019, KEK) https://www.kek.jp/en/newsroom/2019/10/02/1000/

* Both materials are based on KEK estimate.

In case of Japan (KEK)…

Demonstration of beam acceleration satisfied with ILC spec.

STF

Infrastructure upgrade for hub-lab. is mandatory!

COI

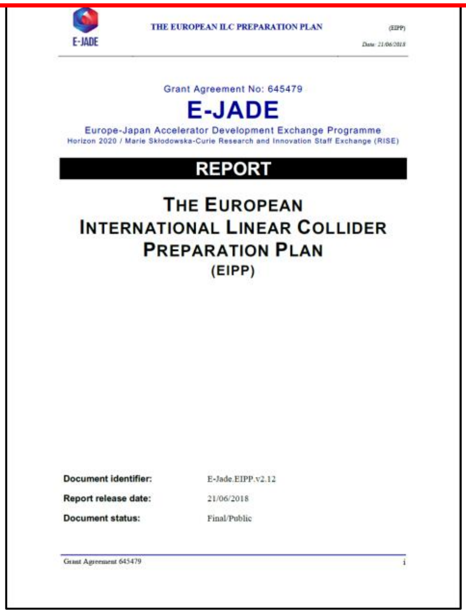
Mass production of CM

CFF

Mass production of cavity

Contribution from each lab. (case of E-JADE)

Kirk will make template table after discussion with Michizono-san and Akira Yamamoto-sensei. Please wait a minute!


THE EUROPEAN ILC PREPARATION PLAN (EIPP)

Date: 21/06/2018

Grant Agreement No: 645479

E-JADE

Europe-Japan Accelerator Development Exchange Programme

Horizon 2020 / Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE)

REPORT

THE EUROPEAN INTERNATIONAL LINEAR COLLIDER PREPARATION PLAN (EIPP)

Document identifier: E-Jade.EIPP.v2.12

Report release date: 21/06/2018

Document status: Final/Public

Grant Agreement 645479

Item/topic	Brief description	CERN	France Cl	Germany D	Time line
SCRF	Cavity fabrication including forming and EBW technology,	✓			2017-18
	Cavity surface process: High-Q &–G with N-infusion to be demonstrated with statics, using High-G cavities available (# > 10) and fundamental surface research		✓	✓	2017-18
	Power input-coupler: plug compatible coupler with new ceramic window requiring no-coating	✓			2017-19
	Tuner: Cost-effective tuner w/ lever-arm tuner design	✓	✓		2017-19
	Cavity-string assembly: clean robotic-work for QA/QC.		✓		2017-19
Cryogenics	Design study: optimum layout, emergency/failure mode analysis, He inventory, and cryogenics safety management.	✓			2017-18
HLRF	Klystron: high-efficiency in both RF power and solenoid using HTS	✓			2017- (longer)
CFS	Civil engineering and layout optimization, including Tunnel Optimization Tool (TOT) development, and general safety management.	✓			2017-18
Beam dump	18 MW main beam dump: design study and R&D to seek for an optimum and reliable system including robotic work	✓			2017- (longer)
Positron source	Targetry simulation through undulator driven approach			✓	2017-19
Rad. safety	Radiation safety and control reflected to the tunnel/wall design	✓			2017 – (longer)

Table 1: Current common studies between European institutions and Japan relevant for ILC.

- SRF sub-groups need to make similar table for each region (Asia, America).
- Addition to these items, some new contents need to be added to the table.
  - CM transportation, automation, etc.
- And, budget, human resources…

KEK starts development of automation technique

	Germany	France		Italy	Poland			Russia	Spain
	DESY	CEA Saclay	LAL	INFN Milan	IFJ PAN	WUT	NCBJ	BINP	CIEMAT
Linac									
Cryomodules	✓	✓		✓					
SCRF Cavities	✓			✓					
Power Couplers	✓		✓						
HOM Couplers							✓		
Frequency Tuners	✓								
Cold Vacuum	✓							✓	
Cavity String Assembly	✓	✓							
SC Magnets	✓				✓				✓
Infrastructure									
AMTF	✓				✓	✓		✓	
Cryogenics	✓								
Sites & Buildings									
AMTF hall	✓								

Table 2: Responsibility matrix for cryomodule production and testing for the European XFEL

	Germany	France		Italy		Poland	Spain	Sweden		UK
	DESY	CEA	IPNO	Elettra	INFN-LASA	IFJ-PAN	ESS Bilbao	ESS	Uppsala	STFC
RF systems				✓			✓	✓		
LLRF									✓	
Cryomodules		✓	✓							
SCRF Cavities		✓	✓		✓					✓
Power Couplers		✓	✓							
HOM couplers										
Frequency Tuners		✓	✓							
Cold Vacuum		✓	✓					✓		
Cavity String Assembly		✓	✓							
RF Tests (Cavites)	✓									✓
RF Tests (Cryomodules)		✓	✓			✓		✓	✓	

Table 3: Responsibility matrix for the cryomodule production and testing for the ESS.

Work packages of SRF at ILC (it's too early!)

Item	Brief description
1.3 GHz Cavities	Order/fabrication, preparation , surface treatment, VT
1.3 GHz cavities for positron beamline	T.B.D., Not necessary for many cavities, Order/fabrication, preparation , surface treatment, VT
Power couplers	Order/fabrication, preparation, assembly, high power test
HOM couplers	Order/fabrication, tuning
Frequency tuners incl. piezo	Order/fabrication,
Cavity string assembly	Overall works in clean room
Cryomodules	Order/fabrication, assembly incl. waveguide system (preparation by HLRF), cold test
Cold vacuum incl. HOM damper	Beamline connection of CM-to-CM, Pumping systems, Open/close gate valves
SC Q/D-magnet + BPM Systems	Order/fabrication, test
Alignment	Cavity-to-cavity, Cavity-to-CM, CM-to-CM
3.9 GHz Cavity System	For bunch compression in injector, Same type as E-XFEL/LCLS-II
650 MHz Cavity System	For damping ring, KEKB type?
Crab Cavity System	For head-on collision, Design not fixed, Discussion is necessary with BDS group
High Level RF System	Klystron, modulator, waveguide, dummy load, variable hybrid, phase shifter, circulator?
Low Level RF System	Construction of control systems incl. feed-forward/feed-back (closed-loop operation)
Cryogenics	For VT and module test, He/N_2 line connection in tunnel
Global CM transfer	CM transfer to Japan by ship
High pressure gas regulation	To satisfy Japanese law
Installation	CM installed into accelerator tunnel
Machine protection (?)	Performance degradation, dark current, radiation security, possible quench of SCQ-magnet, etc.

Questions/Discussions/Comments (memorandum) @5th meeting

Translation by Kirk

- Plug-compatibility
  - One design should be selected. More than two types, we need two jigs, and will experience complicated situation.
  - We can decide only flanges of cavity and CM, it dose not mean two types are used
- Relation between surface treatment and cost increase
  - We think selection of surface treatment is flexible, but we also need to think about the cost increase related to the selected method
- The words of “mass production” may be misunderstood, it’s much better to use the other ones
- SCQ is included in CM production?
  - Yes, Spain is added as the new contributor
- Steiner will organize the meeting in Europe to discuss cavity/CM production and test, how shared, how proceeding
  - Crab cavity is unknown to discuss
- Budget request
  - Local or global to be submitted?
  - How much precise is the draft?
  - In Japanese case, we need to submit by August of the previous fiscal year. We need to complete the draft by the end of this year, discuss it with EB, and go to each lab. for consultation.
  - In Americas and Europe, it will be a different process. At least, the process will be slower than in Japan.
  - In Europe, we need to hold a meeting because we have to discuss the proposal first
  - The SRF budget request does not include the cost of infrastructure as function of hub-lab, but FNAL and J-LAB plan to construct new experimental facilities. If it is built during the technical preparation period, the new experimental facility will be available only around the final fiscal year, and there will not be enough time to demonstrate its function as a facility.
    - There are various approaches in each lab and each region, and it is difficult to unify all of them. Of course, it may be behind the expected plan, so you don't have to think so seriously.
- The SRF subgroup concluded that there are three main tasks (cavity/CM production, global CM transfer, crab cavity) during the technical preparation period
  - If there is more input from Europe and Americas, we think it can be added later
- How about the SRF subgroup meeting on 22/Dec?
  - CERN and Spain are on Christmas holidays
  - Americas has no problem

Questions/Discussions/Comments (memorandum) @4th meeting

Translation by Kirk

- Reports from U.S.
  - M. Liepe presented the schedule/task list
    - There are two stages of cavity production; yield study (1) and yield study (2), totally 60 new 9-cell cavities produced
      - To be discussed yield study (2)
        - Really necessary? By new vendor in US? By new recipe?
    - Global CM transfer done in 4th year of technical preparation period. It's also to be discussed.
  - S. Posen presented the infrastructure of CM assembly in FNAL
    - Two lines of cavity string assembly available in clean room enlarged for PIP-II
    - In CM test area, one CM test available. For second, space of klystron to be checked
    - Test stand of power coupler to be discussed/checked
  - B. Rimmer presented the present infrastructure of CM assembly/test, and upgraded plan for ILC in J-LAB
    - Three assembly lines of CM and one cave for CM test at present for CEBAF, LCLS-II-HE, and SNS
    - Possibly additional clean room, and test cave to be constructed in the same building
  - Requests from Akira and Kirk
    - **Tuner should be put to the list, and we need to discuss the final design between Japan and U.S. before the technical preparation period**
    - Please consider the preparation area/test stand of power coupler in U.S. labs. (one klystron maybe available for both CM test and power coupler test)
- **Task list to be fixed in the next SRF subgroup meeting on 24/Nov**
  - **Any other than cavity/cryomodule production, and cryomodule transport recommended in ILC project implementation?**
- Cost down R&D
  - **Think about the balance between cost increase and performance improvement**
  - In LCLS-II-HE, EP x 3 and HT x 2 (In TDR, EP x 2 and HT x 1), but may be reduced the number in future
  - In TDR, the number of final EP was limited to up to twice to evaluate the success yield
  - In TDR, 10 % margin in RF power
  - For higher gradient operation than TDR (above 35 MV/m @CM operation), piezo should be improved for wider frequency range
  - **We should not change number of cavity/CM/klystron from TDR**
  - To be discussed in the next LCWS, and TTC meeting 2021, and to be reconfirmed
- Crab cavity
  - **Kick-off meeting held on 24/Nov 30 min earlier the SRF subgroup meeting, organized by Okugi-san (as the leader of BDS Gr.) and Kirk**
  - Design of cavity, coupler, tuner, CM to be discussed, establishment of collaborators, possible schedule, what we can do before technical preparation period
  - Every member of SRF and BDS subgroup can join, and Kirk will send the invitation to G. Burt and R. Calaga
  - If you know any other candidate person, please tell me before the next meeting
- High pressure gas regulation
  - Kirk explained very shortly (the time is over)
  - Necessary for longer time to discuss in the future meetings
  - Before cavity/CM production in Japan, we have to visit to KHK (authority) and discuss with them; need to pass each by each step (too complicated processes)
  - CEA has the experiences for HPG of Japan, and U.S. labs. have different situation (DG in each lab. can make a decision for HPG)

Questions/Discussions/Comments (memorandum) @3rd meeting

Translation by Kirk

- 50 cavities satisfied with HPG? Or not? Cost should be effectively used. Cavities w/o helium tank is used for only estimation of success yield
  - 10 cavities w/o tank in 1st year, 10 cavities w/ tank satisfying with HPG in 2nd year…
- Necessary for learning impact on high pressure gas regulation of Japan
- How much is one cavity estimated?
- Flexibility in surface treatment is necessary, to be discussed
  - To be decided in technical workshop
- International workshop is necessary to review material/fabrication/surface treatment methods
  - plug-compatibility reconfirmed
  - To be held after TTC meeting 2021 or next LCWS2021?
- New vendors in US
  - Important to find cavity fabrication vendor, in not only US but the other countries
  - To be checked qualification, learning curve expected, capability of large number production, etc.
- In GDE, cost estimation has been done by some vendors, but one vendor was dominant
- Reexamine lesson/learned from what GDE have done
- After E-XFEL construction, cavity fabrication cost is not changed, or a little changed
  - Cost of power coupler increased
- Laboratory-vendor collaboration in cavity fabrication is also necessary
  - KEK has already done
- Year and year plan is necessary in each region for technical preparation period
- Americas laboratory proposals in next meeting
  - Kirk requests responsible persons in each lab.

Questions/Discussions/Comments (memorandum) @2nd meeting

Translation by Kirk

- CM production
  - Existing CM or New CM?
  - In Japan, before production, we have to discuss with KHK (authority of high pressure gas in Japan)
    - During production, inspection by KHK is necessary
- CM transfer
  - Shipping/High pressure gas regulation can be separated
  - Also rechecking cavity performance after shipping
- No cavity vendor in U.S., but same process as LCLS-II can be used
- How many cavities are produced? 20 at minimum. It depends on budget.
- Fabrication (incl. Nb material)/surface treatment to be discussed
- In TDR, second pass was available. How many times in surface treatment is available? It also depends on cost, and to be discussed.
  - Reliability
  - Cost-effectiveness
- Same method of fabrication and surface treatment as technical preparation period has to be used in construction of ILC
- Global CM transfer among Japan/U.S./EU to be discussed (Japan → U.S./EU?)
  - For fair international collaboration
- There are strict rules in high pressure gas regulation of Japan
  - It may take longer time to solve this
- How many prototypes do we need?
  - No prototype CM in LCLS-II → The construction started immediately (some of existing cavities are used)
  - Three prototype CMs in E-XFEL (PXFEL series)

Questions/Discussions/Comments (memorandum) @1st meeting

Translation by Kirk

- Surface treatment
  - Which surface treatment method (EP, HT) is selected in mass production?
    - Surface treatment method is flexible, rather, plug-compatible design of cavity package should be fixed
    - To investigate yield rate, same method should be used. One method in each region (Japan, US, EU)?
    - Always think about which method is used in mass production (performance, cost effective)
    - Choice as advanced technology should be left, even though new method does not work well at present
- Power coupler
  - Power coupler needs a lot of improvements for ILC
  - D. Kostin will present those issues and some suggestions in AWLC2020
- CM transportation
  - 13 CMs will be transferred from EU to US by plane in PIP-II (2023-2024?)
  - CM of ILC needs very large cage for marine transportation. After arrival at Japan, the cage may be sent back.
  - Cost of aerial transportation is much higher than marine
  - Cost of marine transportation is included into budget of each region
  - Design of cage and supporting jigs is necessary
  - "CM transportation" is not appropriate, then "Global CM transfer" is better?
- Necessary to fix design of tuner/coupler until second year of technical preparation phase when technical review is done
- Additional membership (Michizono-san discussed with Andy and Steiner)
- Budget request of SRF including technical preparation
  - Budget request of subgroup → WG1 → each laboratory → Conclusion of MOU
  - Mass production and Global CM transfer should be summarized to one page for each until end of this year
  - Preparation for conclusion of MOU after Feb/2021
- Introduction of activity of SRF subgroup will be presented in AWLC2020
- Request to upload meeting slide on INDICO