

# 5<sup>th</sup> meeting of SRF subgroup in IDT/WG2

- ✓ New members of SRF subgroup
- ✓ Reconfirmation/determination of task list
  - ✓ Update of # of cavity/cryomodule in technical preparation period
  - ✓ Plug-compatibility
  - ✓ Global CM transfer
- ✓ Preparation for draft of budget request
- ✓ Discussions on high pressure gas, cost down R&D, etc.
- ✓ Others (if any)

Attendees: A. Yamamoto, S. Michizono, H. Hayano, N. C. Lasheras, S. Posen, R. Rimmer, R. Geng, M. Liepe, P. McIntosh, B. List, B. Laxdal, E. Cenni, L. Monaco, L.G. Tabares, O. Napoly, N. Solyak, Kirk

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

# 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,...

DR/BDS/Dump **Bi-weekly Tuesday**  
 Oct.13,27,...

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

<b>Toshiyuki Okugi</b>	<b>KEK</b>
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
<b>Mikhail Zobov</b>	<b>INFN LNF</b>

Ivan Podadera [ivan.podadera@ciemat.es](mailto: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,...

<b>Kaoru Yokoya</b>	<b>KEK</b>
Jim Clarke	STFC
Steffen Doebert	CERN
Joe Games	JLAB
Hitoshi Hayano	KEK
Masao Kuriki	U. Hiroshima
Benno List	DESY
Gudrid Moortgat-Pick	U. Hamburg

Peter Sievers [Peter.Sievers@cern.ch](mailto:Peter.Sievers@cern.ch)

Sabine Riemann<[sabine.riemann@desy.de](mailto:sabine.riemann@desy.de)>

Civil engineering

<b>Nobuhiro Terunuma</b>	<b>KEK</b>
John Andrew Osborne	CERN
Tomoyuki Sanuki	U. Tohoku

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

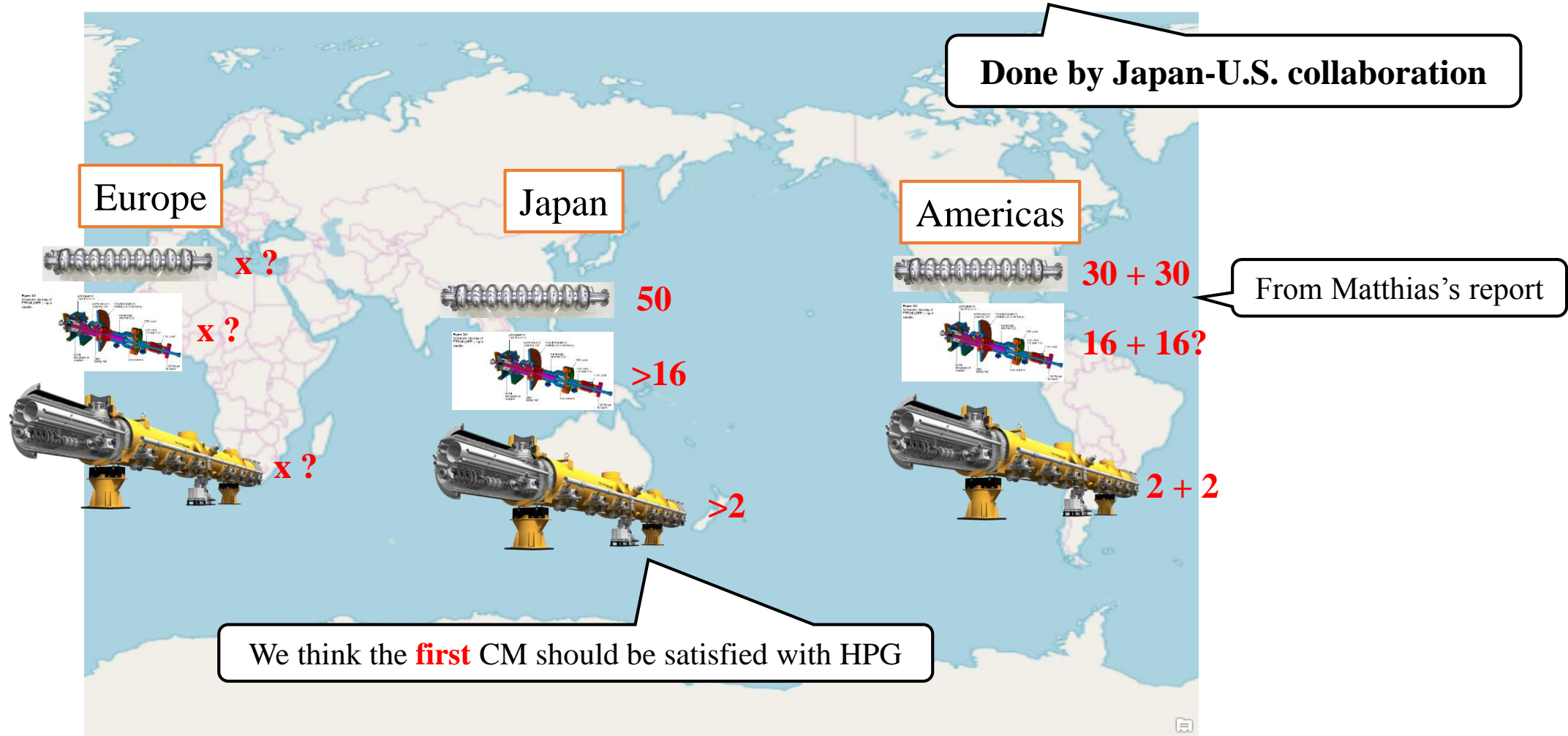
# Main tasks in technical preparation period based on “Recommendations on ILC Project Implementation”

- ◆ 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**

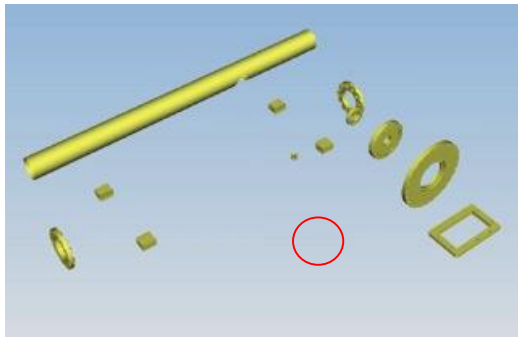
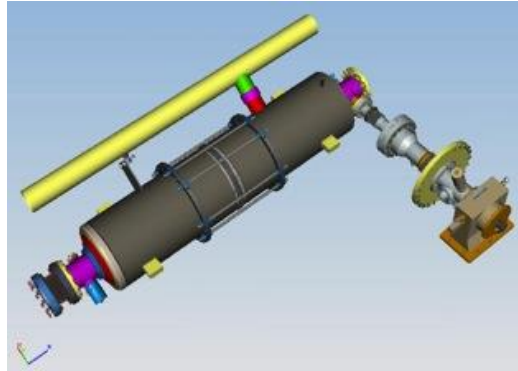
# Update of # of cavity/cryomodule produced in technical preparation period

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



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

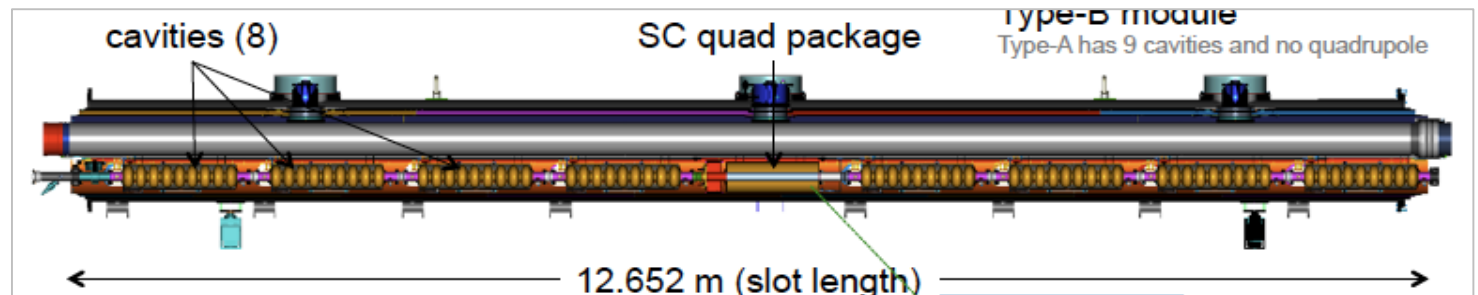
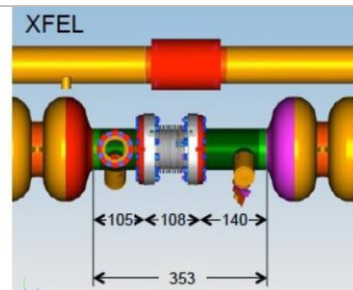
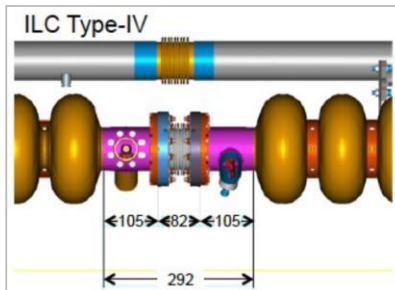
Interface and Process established, in TDR, 2013



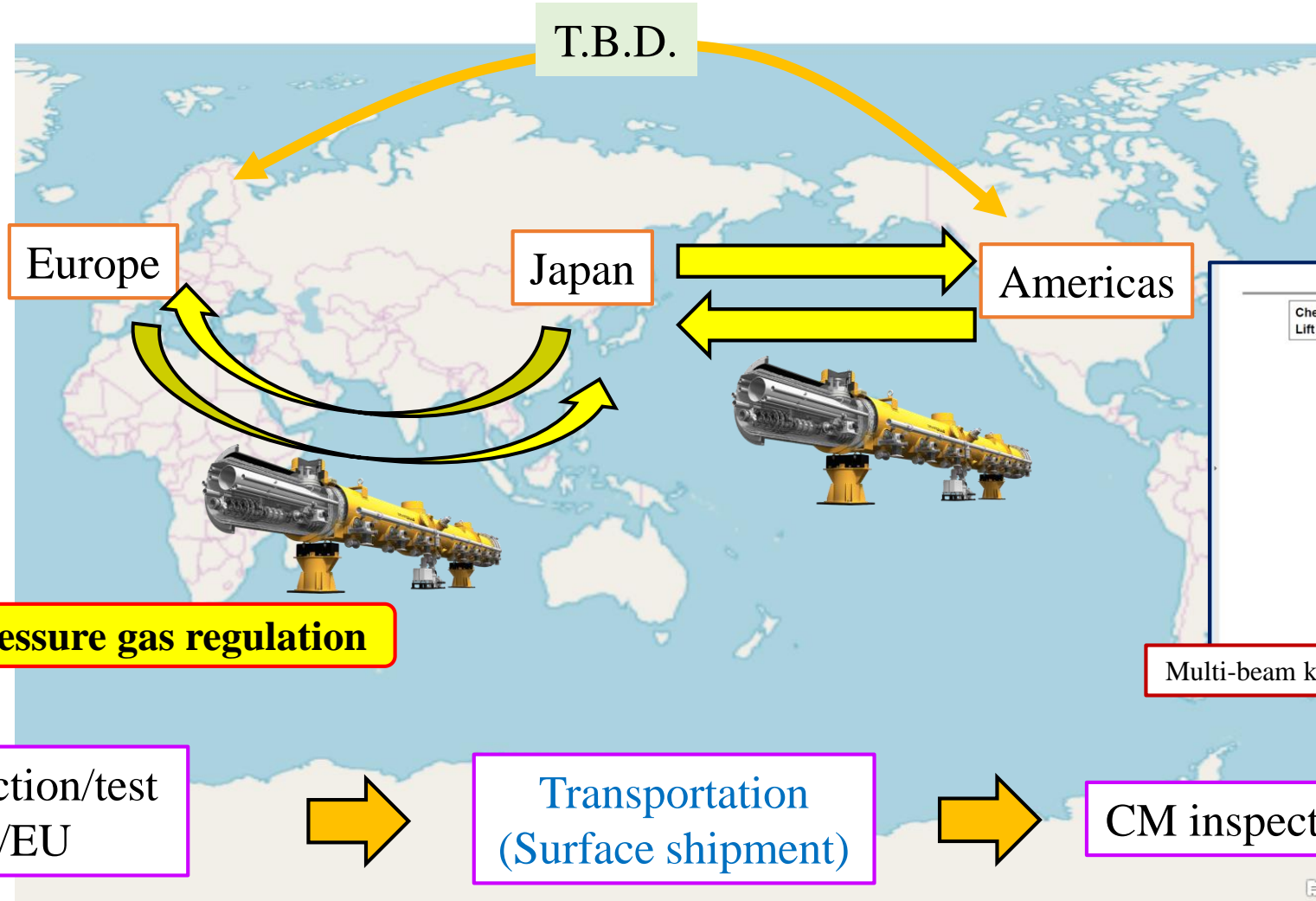
Item	TDR Baseline
Cavity shape	TESLA
Length	Fixed, L = 1,247 mm (61 mm shorter than XFEL)
Beam pipe flange	Fixed
Suspension pitch	Fixed
Tuner	Blade
Coupler flange (cold end)	40 mm
Coupler pitch	Fixed
He -in-line joint	Fixed

	Standard Fabrication/Process
Fabrication	Nb-sheet purchasing
	Component Fabrication
	Cavity manufacturing with <b>EBW</b>
Process	<b>EP-1 (~150um)</b>
	Ultrasonic degreasing with detergent, or ethanol rinse
	High-pressure pure-water rinsing
	Hydrogen degassing at > 600 C
	Field flatness tuning
	<b>EP-2 (~20um)</b>
	Ultrasonic degreasing or ethanol (or EP 5 um with fresh acid)
	High-pressure pure-water rinsing ( <b>HPR</b> )
	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



# 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.

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, design		CERN, France, Germany, US + industry-academia efforts
	Design		France, Germany, Russia
Tuner	Design not fixed	Reconfirmation	CERN, Germany
	Wider range piezo	Long-term stability, design	CERN, Italy
Ring	Feedback	Test at SuperKEKB	Italy
	Beam Interaction	Test at SuperKEKB	CERN, UK
Beam Dump	Beam window, cooling water circulation	Durability, exchangeability, earthquake-resistance	CERN, US + industry-academia efforts

Budget request will be added

Name of laboratories will be added

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

# Schedule of SRF 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
	<b>19~22/Oct/2020</b>	<b>AWLC2020 on virtual</b>
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.
5	24/Nov/2020	<b>To be fixed task list in technical preparation period</b>
6	8/Dec/2020	To be checked draft for budget request
7	22/Dec/2020	<b>Are you convenient (Christmas holiday)?</b> Draft of sharing work items in technical preparation period
?	12/Jan/2021?	
?	19/Jan/2021	
	<b>19~21/Jan/2021</b>	<b>TTC meeting 2021 on virtual</b>
?	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



# 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 progress).

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.**

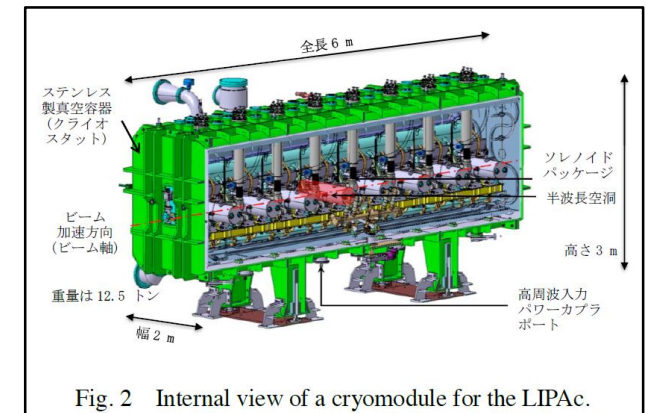
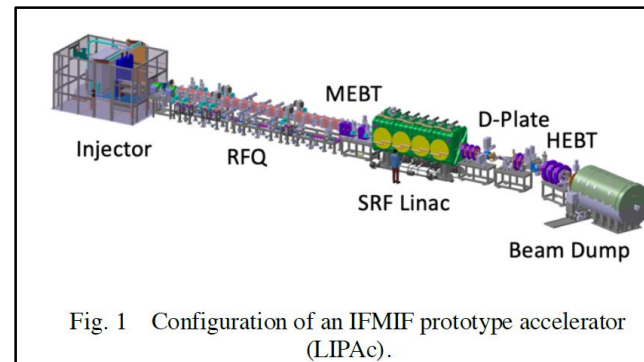
As a proposal, since it is **impossible to manufacture cavities compatible with HPG in the first year of the technical preparation period**, we will **manufacture 10 cavities that are not compatible only in the first year**. If we decide to manufacture a cavity compatible with HPG from the next fiscal 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)



# 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.

# Questions/Discussions/Comments (memorandum) @5<sup>th</sup> 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

# 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](https://www.kek.jp/ja/newsroom/attic/20191001_%20ILC%20Project.pdf)

# Backup slides

# 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

## **For Engineering design**

- 1<sup>st</sup> year:** Work on TDR-based **cost-estimate confirmation**, started by an international team centered on the Pre-lab.
- 2<sup>nd</sup> 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.
- 3<sup>rd</sup> year:** Conduct an **external review** and completed scrutiny of costs and risks.  
Complete the **draft of Engineering Design Report (EDR)**.
- 4<sup>th</sup> 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)**

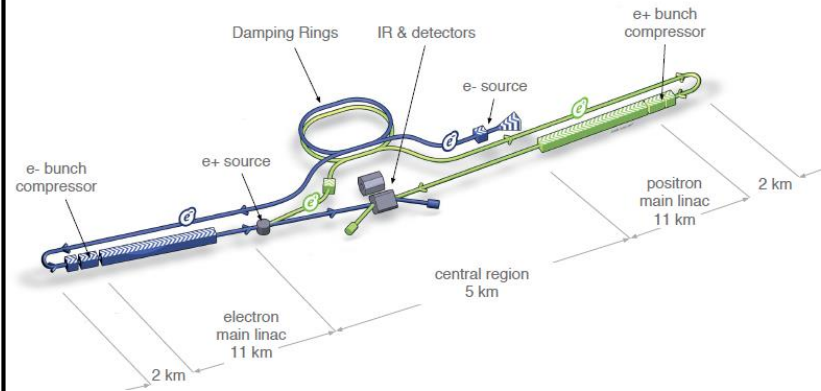
- 1<sup>st</sup> year:** Extend SCRF cost reduction R&D, Start a pre-series SCRF cavities production preparing for industrialization  
Continue positron survey
- 2<sup>nd</sup> year:** Complete SCRF cost-reduction R&D, and extend the work to assemble the cavities with cryomodule (CM),  
Select positron scheme
- 3<sup>rd</sup> 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)
- 4<sup>th</sup> year:** Evaluate CM performance based on CM shipment, and prepare for Hub Lab. functioning  
Progress prototyping of critical items (such as positron target)



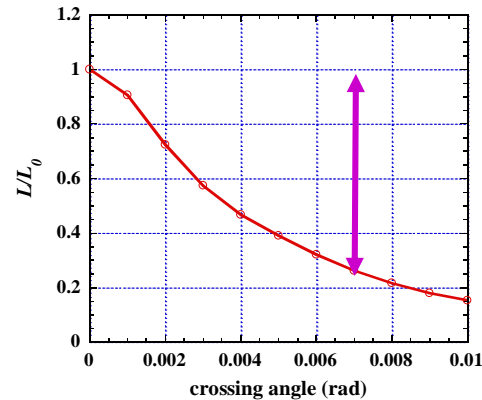
# Kick-off meeting for crab cavity

- ◆ 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.

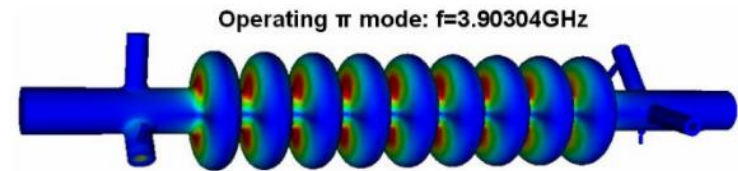
For higher luminosity



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)

- ◆ Cold temp. EP or standard EP?
- ◆ N-dope, N-inf, Low temp. baking, Mid temp. baking, etc.?

Technical workshop is necessary

## ◆ 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 1<sup>st</sup> pass and 2<sup>nd</sup> pass (after 3<sup>rd</sup> pass, to be discussed)

# How many cavities are produced for mass production?

Discussion item

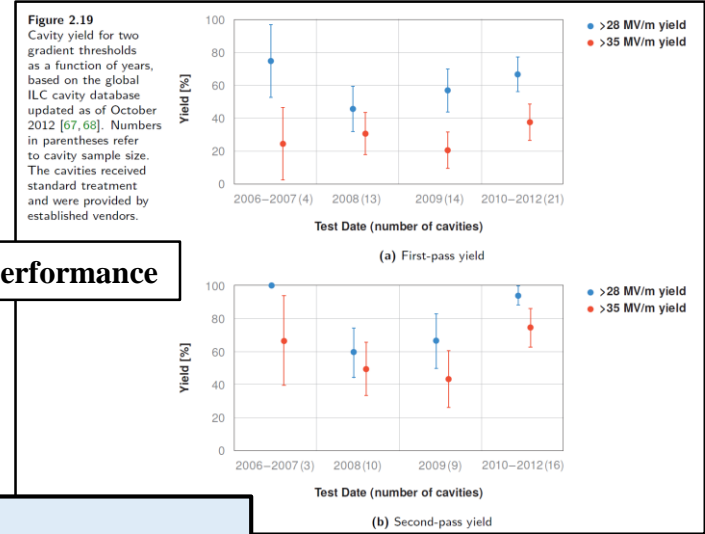
We can refer Volume 3 Part 1 in TDR.

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



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?

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.

Discussion item

**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.

<i>Cavity (nine-cell TESLA elliptical shape)</i>		
Average accelerating gradient	31.5	MV/m
Quality factor $Q_0$	$10^{10}$	
Effective length	1.038	m
R/Q	1036	$\Omega$
Accepted operational gradient spread	$\pm 20\%$	
<i>Cryomodule</i>		
Total slot length	12.652	m
Type A	9 cavities	
Type B	8 cavities	1 SC quad package
<i>ML unit (half FODO cell)</i>		
(Type A - Type B - Type A)	282 (285)	units
<i>Total component counts</i>		
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
<i>RF requirements (for average gradient)</i>		
Beam current	5.8	mA
beam (peak) power per cavity	190	kW
Matched loaded $Q$ ( $Q_L$ )	$5.4 \times 10^6$	
Cavity fill time	924	$\mu\text{s}$
Beam pulse length	727	$\mu\text{s}$
Total RF pulse length	1650	$\mu\text{s}$
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

# IDT-WG2 organization

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

SRF

DR/BDS/Dump

<b>Yasuchika Yamamoto</b>	<b>KEK</b>	<b>Toshiyuki Okugi</b>	<b>KEK</b>
Nuria Catalan	CERN	Karsten Buesser	DESY
Dimitri Delikaris	CERN	Philip Burrows	U. Oxford
Rongli Geng	JLAB	Angeles Faus-Golfe	LAL
Hitoshi Hayano	KEK	Jenny List	DESY
Bob Laxdal	Triumpf	Thomas Markiewicz	SLAC
Matthias Liepe	Cornell	Brett Parker	BNL
Peter McIntosh	STFC	David L. Rubin	Cornell
Olivier Napoly	CEA	Nikolay Solyak	FANL
Sam Posen	FNAL	Luis Garcia Tabares	CIEMAT
Robert Rimmer	JLAB	Nobuhiro Terunuma	KEK
Marc C. Ross	SLAC	Glen White	SLAC
Akira Yamamoto	KEK	Kaoru Yokoya	KEK

## **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

<b>Kaoru Yokoya</b>	<b>KEK</b>
Joe Grames	JLAB
Hitoshi Hayano	KEK
Masao Kuriki	U. Hiroshima
Benno List	DESY
Gudrid	U. Hamburg
Moortgat-Pick	

Civil engineering

<b>Nobuhiro Terunuma</b>	<b>KEK</b>
John Andrew Osborne	CERN
Tomoyuki Sanuki	U. Tohoku

# 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 ( $<13^{\circ}\text{C}$ ) EP used, Higher  $Q_0/E_{\text{acc}}$  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.

# Technical preparation of SRF (only 4 years!)

- ❑ Mass production satisfied with the ILC spec.
  - ❑ 9-cell cavity production by cost effective method (to be discussed true number)
    - ❑ Production to be demonstrated during the Preparation Phase (Japan: 50 cavities, Others: 50 cavities)
    - ❑ RF performance, and success yield to be evaluated, under plug-compatible fabrication conditions
    - ❑ Surface treatment to be discussed (see next slide)
  - ❑ Ancillaries production (power coupler, tuner, HOM antenna, etc.)
  - ❑ Cryomodule (CM) production (Prototype, Type A, Type B)
- ❑ Global CM transfer
  - ❑ After surface (sea/marine) transportation, CM test to be done to confirm legal process in high-pressure code and RF performance in Japan (maybe in others)
  - ❑ After CM test, CM may return to home country

## In case of Japan;

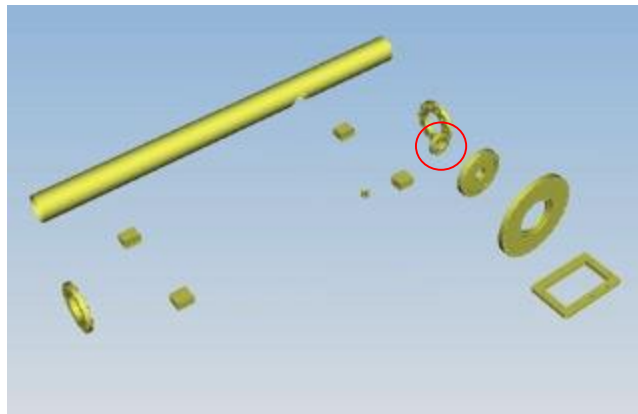
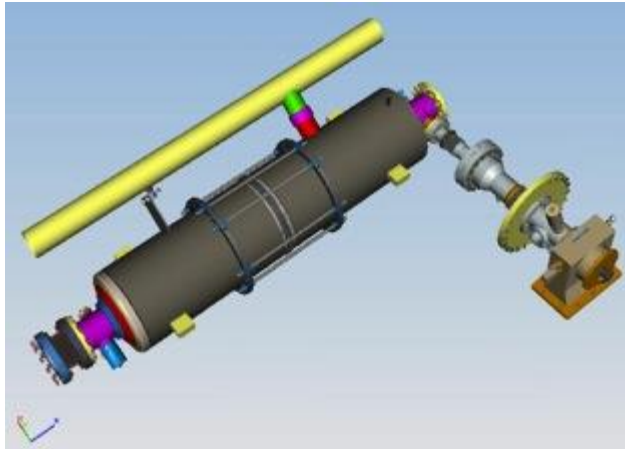
- ❑ Construction of hub-laboratory for mass production
- ❑ Demonstration of beam acceleration satisfied with ILC spec.

**Any other items?**

Remarks:

- Necessary cost should be considered **based on TDR**.
- Another important point is that new technology (fabrication/surface treatment) is **reliable**.

# Plug-compatible Conditions



Item	Variation	TDR Baseline
Cavity shape	TESLA / LL	TESLA
Length		Fixed
Beam pipe flange		Fixed
Suspension pitch		Fixed
Tuner	Blade/ Slide-Jack	Blade
Coupler flange (cold end)	40 or 60	40 mm
Coupler pitch		Fixed
He -in-line joint		Fixed

**Plug-compatible interface established, in TDR, 2013**

# Accelerator activities at ILC Pre-lab phase

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

- SRF performance R&D
- 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 with the help of regional project offices (satellites)]**

- Engineering design and documentation, WBS
- Cost confirmation/estimates, tender and purchase preparation, transport planning, mass
- 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) follow up

## **Preparation and planning of deliverables [distributed across regions, liaising with 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

Mass-production

## **CE, 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

# Pre-lab schedule

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

**2<sup>nd</sup> 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.

**3<sup>rd</sup> 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**.

**4<sup>th</sup> 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)

- 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](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)...

STF



Demonstration of beam acceleration satisfied with ILC spec.

**Infrastructure upgrade for hub-lab. is mandatory!**

COI



**Mass production of CM**

CFF

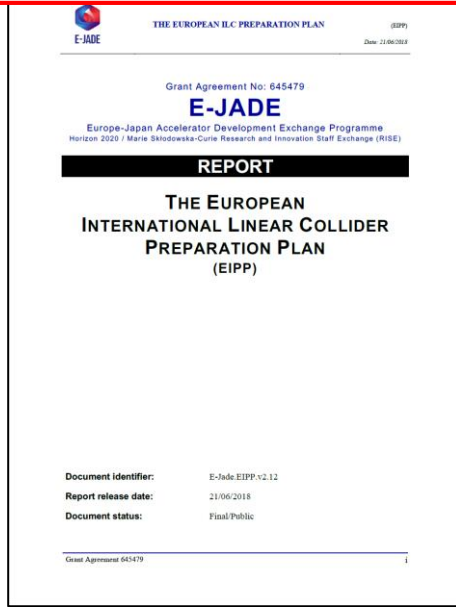


**Mass production of cavity**



# 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!**



Item/topic	Brief description	CERN	France C	Germany E	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)

- 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**

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

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

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

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

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
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 <sub>2</sub> 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) @4<sup>th</sup> 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 4<sup>th</sup> 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) @ 3<sup>rd</sup> 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 1<sup>st</sup> year, 10 cavities w/ tank satisfying with HPG in 2<sup>nd</sup> 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) @ 2<sup>nd</sup> 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) @ 1<sup>st</sup> 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