

International Development Team

Activities in IDT WG2 (Accelerator Design)

Benno List, DESY

European ILC Community Meeting

4.11.2020

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,...

Yasuchika Yamamoto	KEK	Toshiyuki Okugi	KEK
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	Triumf	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

Hans Weise DESY

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

Civil engineering

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

Note: Summer to Winter time transition will be specially considered at next sub-group meeting.

1pm (->2pm) UTC (6am US Pacific, 8am US Central, 2pm U.K., 3pm Geneva, 10pm (->11pm) Japan)

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

- 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)

- Develop R&D plan for budget request to MEXT
- Timeline:
 - Feb 2021: Submit plan
 - Aug 2021: Budget decision
 - Apr 2022: Start of Japanese FY
-> Pre-lab funding available

Main discussion items based on
“Recommendations on ILC Project Implementation”

AWLC2020

◆ 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
- ◆ To be checked RF performance/success yield
- ◆ High pressure gas regulation in Japan (cavity/cryomodule production)
- ◆ Coupler/tuner improved/produced/assembled/tested
- ◆ Cryomodule production/test

◆ Cryomodule transport (“Global Cryomodule transfer”)

- ◆ Shipment/transport incl. inspection
- ◆ RF performance rechecked after transport

SRF

e-Driven scheme		IDT period		Preparation period (4 years)			Tunnel construction period	
Subcomponent	Study Item (WP)			Effort	Human resource	cost (MJPY)	possible partners	
Electron driver	Target	Target stress calculation	FEM calculation	Engineering design				
		Vacuum seal	confirm the longterm seal performance, prototype	FEM calculation				
		Target module	Conceptual design	Engineering design, Prototyping, Operation				
Capture device (FC)	Flux concentrator conductor	cooling design including the radiation	Engineering design	Omori	2			
	Power source	Conceptual Design	Engineering design	KEKB	2			
	Transmission line	Conceptual Design	Engineering design	KEKB	1			
Capture linac	system prototyping	none	Prototyping and operation	KEKB, Omori	100	J-lab		
	L-band APS cavity	Engineering design	Prototyping	Kuriki, Hayano	20			
	Transient Beamloading and its compensation	Construct the model	none	Kuriki	0	CERN, J-Lab		
Booster linac	Power unit prototype	Engineering design	Prototyping	Omori	100			
	fast position monitor (separate e+ and e-)	rely on KECB	Prototyping	Hayano	4			
	L-band TW accelerator	Conceptual design	Engineering design	KEKB	1	J-lab		
Shield	S-band TW accelerator	Conceptual design	Engineering design	KEKB	1	J-lab		
	CFS	Conceptual design	Engineering design	Hayano, Kuriki, Omori	2			
	Maintenance system	Conceptual Design, Estimate Radiation environment	Engineering design	Myamoto, Sanami, Kuriki	2			

Sources

	Grade	Items	Technical Preparation	human resources (FTE)	budget [kUS\$]	candidate collaboration	Presenter	Date
Damping Ring	A	Fast kicker	Long-term stability test					
	A		Feedback : system design					2020/10/27
	A	Fast Ion Instability	Feedback : damping time test					2020/10/27
	B		Evaluation by simulation					2020/10/27
	B	Electron Cloud	Evaluation by simulation					2020/10/27
	B (?)	Permanent Magnet	System design					
	B (?)	Injection kicker for e-driven P-source	System design					
		RF system	Prototype test	N/A	N/A	N/A	N/A	
		Wiggler Magnet	Prototype test	N/A	N/A	N/A	N/A	
BDS, MDI	A	ATF3	Long-term stability test			ATF (ATF3) collaboration	Angeles Faus-Golfe	
	B	Final doublet (incl. Anti-solenoid)	System design (include the anti-solenoid)				Brett Parker	
	B		Vibration test				Brett Parker	
	B (?)	Crab cavity	System design				Yasuchika Yamamoto	
		Anti-solenoid	System design and vibration test				Karsten Buesser	2020/10/27
Beam Dump	A	17MW main dump	System design of water flow system				Nobuhiro Terunuma	2020/10/13
	A		System design of window sealing and remote exchange				Nobuhiro Terunuma	2020/10/13
	A		System design of countermeasure for failure				Nobuhiro Terunuma	2020/10/13
	A/B (?)		Robustness test of window				Nobuhiro Terunuma	2020/10/13
	B	300kV photon dump	System design				Nobuhiro Terunuma	2020/10/13
Rank	A	Technical preparation, which is recommended by KEK ILC International WG						
	B	Technical preparation, which is necessary to write EDR						

BDS/Dump/DR

Europe Regional Report: *SRF technology developments relevant to the ILC*

Olivier Napoly
CEA

Olivier Napoly's excellent overview at AWLC 2020:
<https://agenda.linearcollider.org/event/8622/contributions/46392/>
Please have a look

IDT European has strong broad a SRF technology base



Crab-cavity CM for HL-LHC

Double Quarter Wave
• Vertical crossing for Atlas
• SPS test in 2018

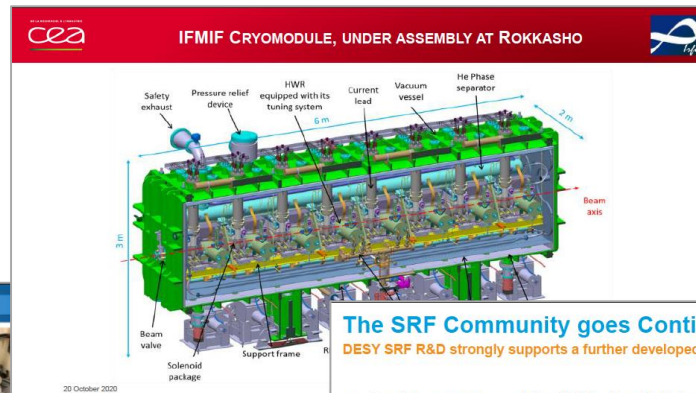
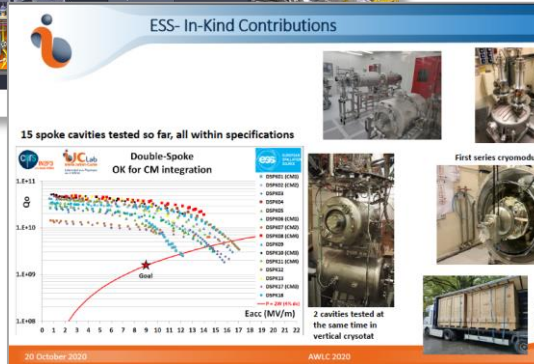
RF Dipole
• Horizontal crossing for CMS
• First vertical test in Feb. 2020
• SPS test in 2021

2 types of Crab cavities

Voltage	3.4 MV/cavity
E_{peak}	40 MV/m
B_{peak}	70 mT
Frequency	400.79 MHz
Q_0	10^{10}
Q_{ext}	5×10^3
Cavity tuning	± 100 KHz
Temperature	2.0 K

DQW@SPS: the first bulk Nb cavity operating on a machine at CERN

20 October 2020



Please refer to full talk for details

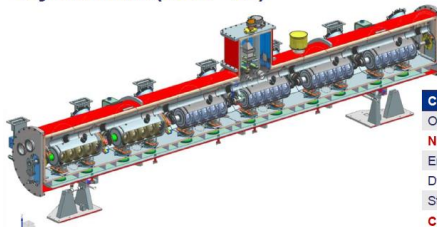
The SRF Community goes Continuous Wave

DESY SRF R&D strongly supports a further developed TESLA technology

- Continuous wave mode is THE final goal of all superconducting accelerators
- If affordable (cryogenic wise), keep RF on for ever... and offer the users of your facility highest flexibility regarding beam time structure
- The European XFEL R&D efforts aim for technology development
- The DESY Accelerator Research and Development (ARD) program clearly advertises more fundamental questions related to SRF CW performance
- DESY activities include
 - SRF gun development / CW injectors
 - CW linac design: Niobium material / cavities / RF power couplers / module design & operation
 - Assembly of 1+ accelerator module per year



SRF Cryomodule Activities – PIP-II High Beta Cryomodule (2019 - 25)



Cryomodule (CM)	PIP-II
Operating Temperature (K)	2
Number of Cavities	6
Energy Gain (MeV)	~110
Dynamic Load (W)	130
Static Load (W)	32
CM Length (m)	9.8
Number of Cryomodules	3



AWLC 2020

FREIA Laboratory

Facility for Research Instrumentation and Accelerator Development

Funded by KAWS, Government, Uppsala Univ.

State-of-the-art Equipment

- cryogenics
- liquid helium
- liquid nitrogen
- control room
- equipment controls
- data acquisition

Competent and motivated staff

collaboration of physics (IFA) and engineering (Teknikum)

3 bunkers with test stands

vertical cryostat

radio-frequency (RF) power sources

horizontal cryostat

20 October 2020

AWLC 2020

ESS LINAC Work Matrix

	EU	Germany	France	Italy		Poland	Spain	Sweden	UK	
	ESS-Lund	DESY	CEA	CNRS	Elettra	INFN	IFJ-PAN	ESS-Bilbao	Uppsala	STFC
Linac Components										
RF systems	✓				✓			✓		
LLRF									✓	
Cryomodules			✓	✓						
SRF cavities			✓	✓		✓				✓
Powers Couplers			✓	✓						
Frequency Tuners			✓	✓						
Cold vacuum	✓		✓	✓						
Module Assembly			✓	✓						
Test Infrastructures										
RF cavities/ couplers		✓	✓	✓						✓
RF cryomodules	✓		✓	✓			✓		✓	

20 October 2020

ANL/C 2020

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HL-LHC-Crab/EU Work Matrix



DGW cryomodules (5)	RFD cryomodules (5)	Solid State RF Systems (20)
Cavities + processing + helium vessels by Research Instruments (DE) under CERN	Bare cavities by Zanon (IT) under US-AP	High power solid state amplifiers by BINP-Russia collaboration
Cold magnetic shields: UK	Processing + cold magnetic shield + helium vessel + HOM couplers + antennas + cold tests by US-AP	First step, one amplifier prototype for qualification of SSPA technology
HOM couplers + antennas: MEPHI-Russia & CERN		
4 CM: UK (STFC) & 1 CM: CERN, with some components by CERN	5 CM by TRIUMF-Canada with some components by CERN	
All cavities & CM cold validation tests at CERN (and a few at Uppsala-Sweden)	CM cold validation tests at CERN	

20 October 2020

ANL/C 2020

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PIP-II LINAC Work Matrix / EU

Fermilab is leading and hosting the project, for LBNF/DUNE.

Four DAE (India) labs are major contributors for cavities, couplers, cryomodules, RF amplifiers, etc.

Legend:
✓ Prototypes

	France		Italy	Poland	UK
	CEA	CNRS	INFN	WUSt	STFC
Linac Components					
Cryogenics				✓	
Cryomodules	✓				✓
SRF cavities		✓	✓		✓
Powers Couplers	✓	✓			
Frequency Tuners		✓			✓
Cold vacuum	✓				✓
Module Assembly	✓				✓
Test infrastructures					
RF cavities/ couplers		✓			✓

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 CEA	Germany DESY	Time line
SCRF	Cavity fabrication including forming and EBW technology	✓	✓	✓	2012-18
	Cavity surface process: High-Q & G with N-injection to be demonstrated with static, using High-Q cavities available (N = 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
Cryogenics	Cavity string assembly: clean robotic work for QA/QC	✓	✓	✓	2017-18
	Design: double optimum layout, emergency/failure mode analysis, the inventory, and cryogenics safety management	✓	✓	✓	2017-18
HLRF	Optimize high efficiency in both RF power and acoustics using HTS	✓	✓	✓	2017-18
CRS	Cold engineering and thermal 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	✓	✓	✓	2017-19
Positron source	Targetry simulation through undulator driven approach	✓	✓	✓	2017-19
Rel. safety	Radiation safety and control reflected to the tunnel/hall design	✓	✓	✓	2017-19

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 DESY	France CEA	Italy INFN	Poland IFJ-PAN	Spain ESS-Bilbao	Sweden ESS	UK STFC
Linac							
Cryomodules	✓	✓	✓	✓	✓	✓	✓
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

13/Oct/2020

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

2nd meeting of SRF subgroup in IDT/WG2

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- SRF subgroup plan for R&D during Prelab phase
 - Produce ~100 cavities: 50% Japan, 50% abroad -> 25 cavities in Europe?
 - Produce ~2 cryo modules per region, verify transport
 - Resolve high pressure regulation issues
- BDS/Dump/DR subgroup:
 - Finalize Dump design(s)
 - ATF3 project
- Sources subgroup: Prepare for a concept downselect in 2022
- Aim: Fund prelab with ~200M€ over 4 years (2022-25), 2/3 Japan, 1/3 Foreign
-> naïve scaling: $200\text{M€} * 1/3 * 1/2 \text{ over 4 years} \Rightarrow \sim 8\text{M€/year from Europe}$
- AWLC discussions indicate interest by DOE and U.S. and Canadian labs
- Accelerator design will be finalized during years 1-2 (2022/23):
cavity fabrication recipe, positron source concept etc
- Strong European Participation in IDT WG2 and its subgroups