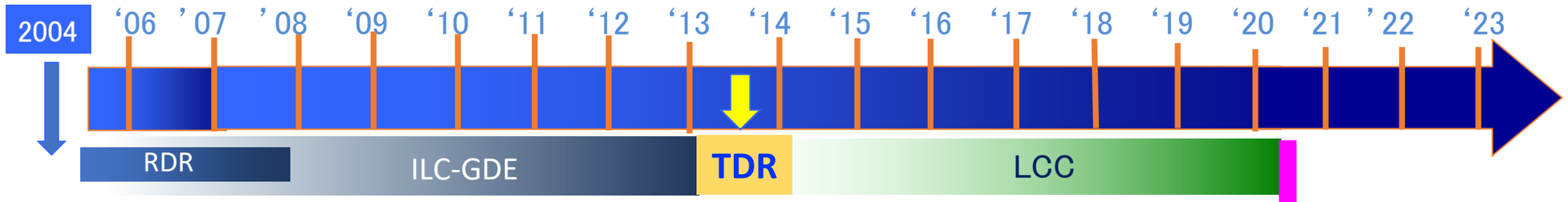
Status of the ILC and the ITN

Yoshinori Enomoto (KEK)

History of ILC collaboration



Technology selection

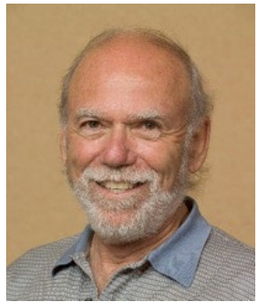
ILC technical design

TDR:
49 countries
392 institutions
>2400 researchers

ILC-250

International
Development
Team

Tatsuya Nakada (EPFL)
IDT chair



Barry Barish
GDE director
(the Nobel Prize winnerin 2017)

Lyn Evans
LCC director
(former LHC project manager)

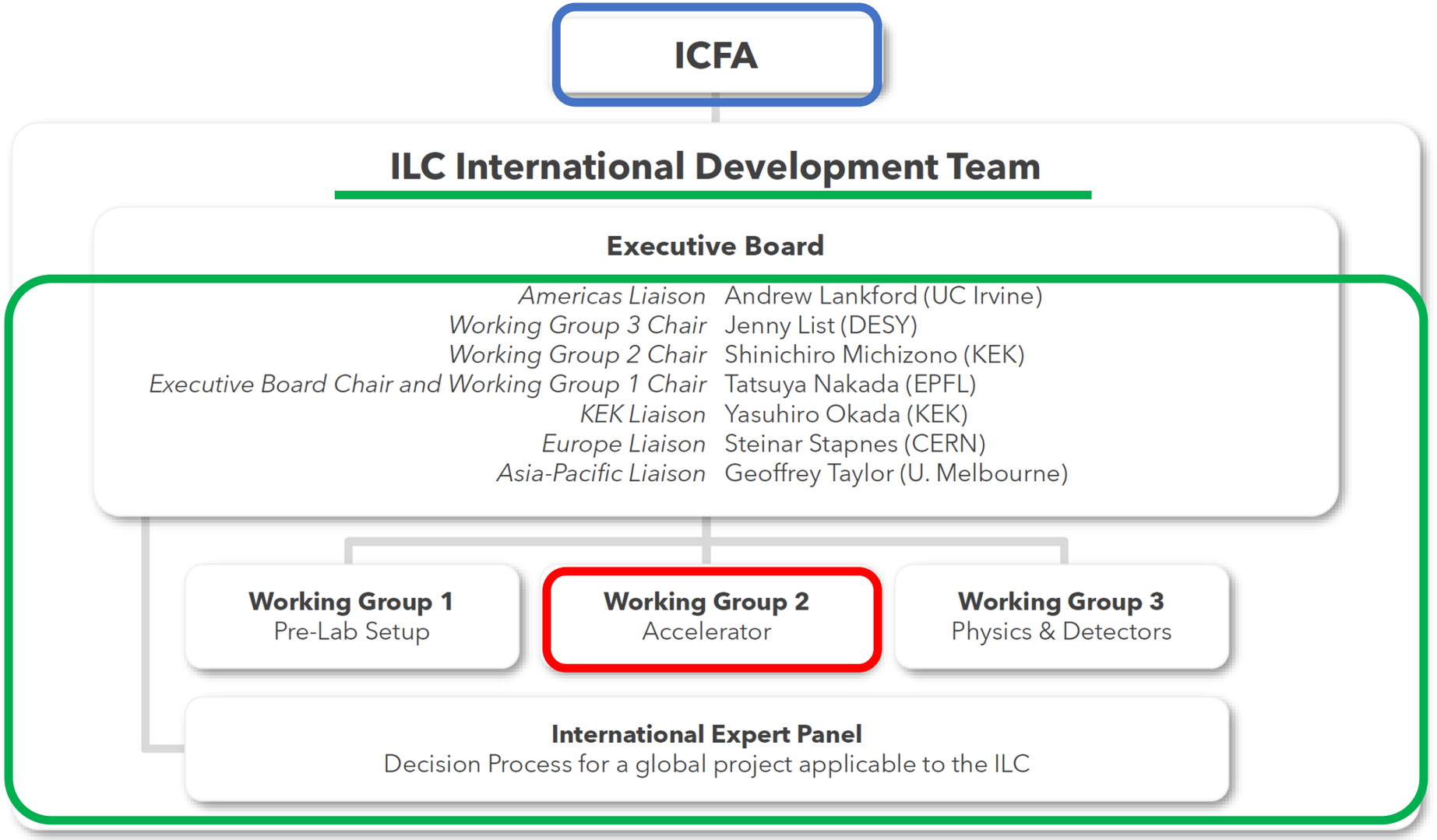
LHC

European XFEL

LCLS-II

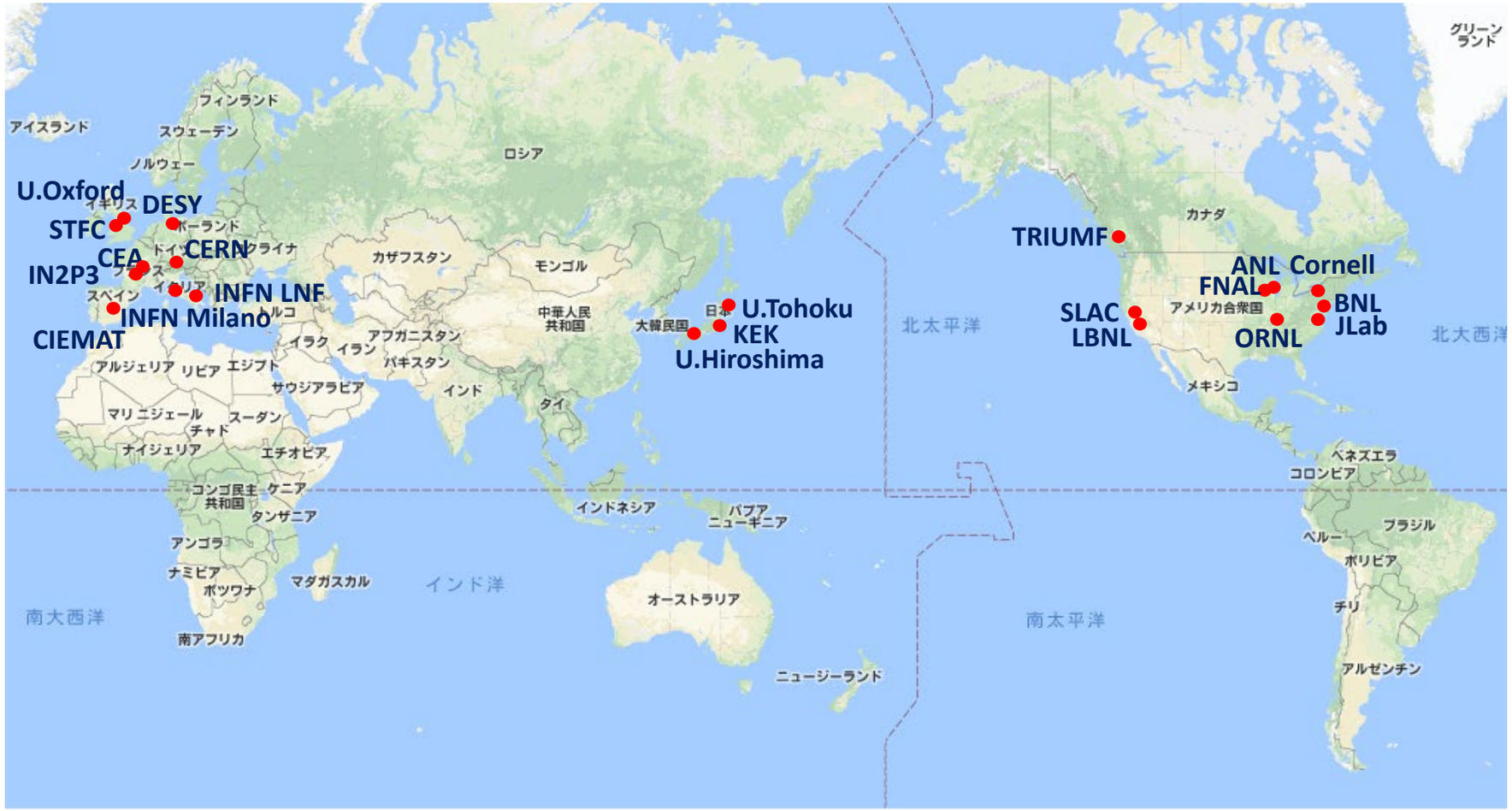
SRF technology matureared after European XFEL/LCLS-II

IDT organization



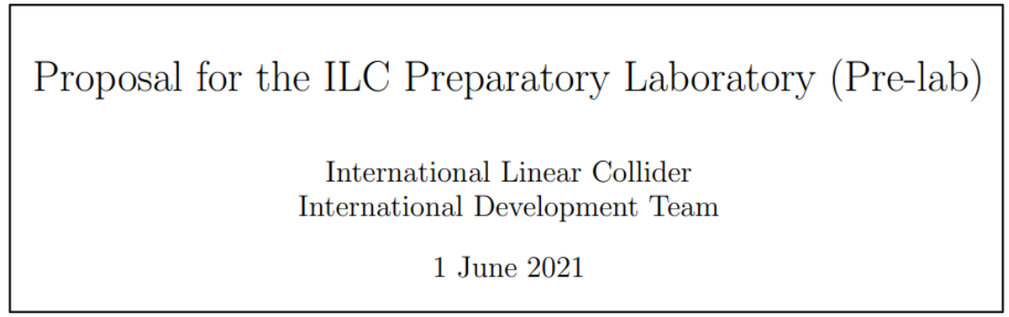
IDT-WG2

IDT-WG2 has about 50 accelerator researchers from around the world participating in discussions on ILC accelerator development research.



Recent topics

- 2021/6 pre-lab proposal from IDT
- 2021/7～2022/1 Advisory panel was set up under MEXT (Ministry of education, culture, sports, science and technology)
- 2022/2 report from the panel
- 2023 ITN (International Technology Network) starts
- 2023 5-years grant from MEXT for accelerator R&D



Proposal for the ILC Preparatory Laboratory (Pre-lab)

International Linear Collider
International Development Team

1 June 2021

文部科学省 MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

会見・報道・お知らせ | 政策・審議会

トップ > 政策・審議会 > 審議会情報 > 調査研究協力者会議等（研究振興） > 国際リニアコライダー（ILC）に関する有識者会議（第2期） > 国際リニアコ

国際リニアコライダー（ILC）計画の諸課題に関する議論のまとめ

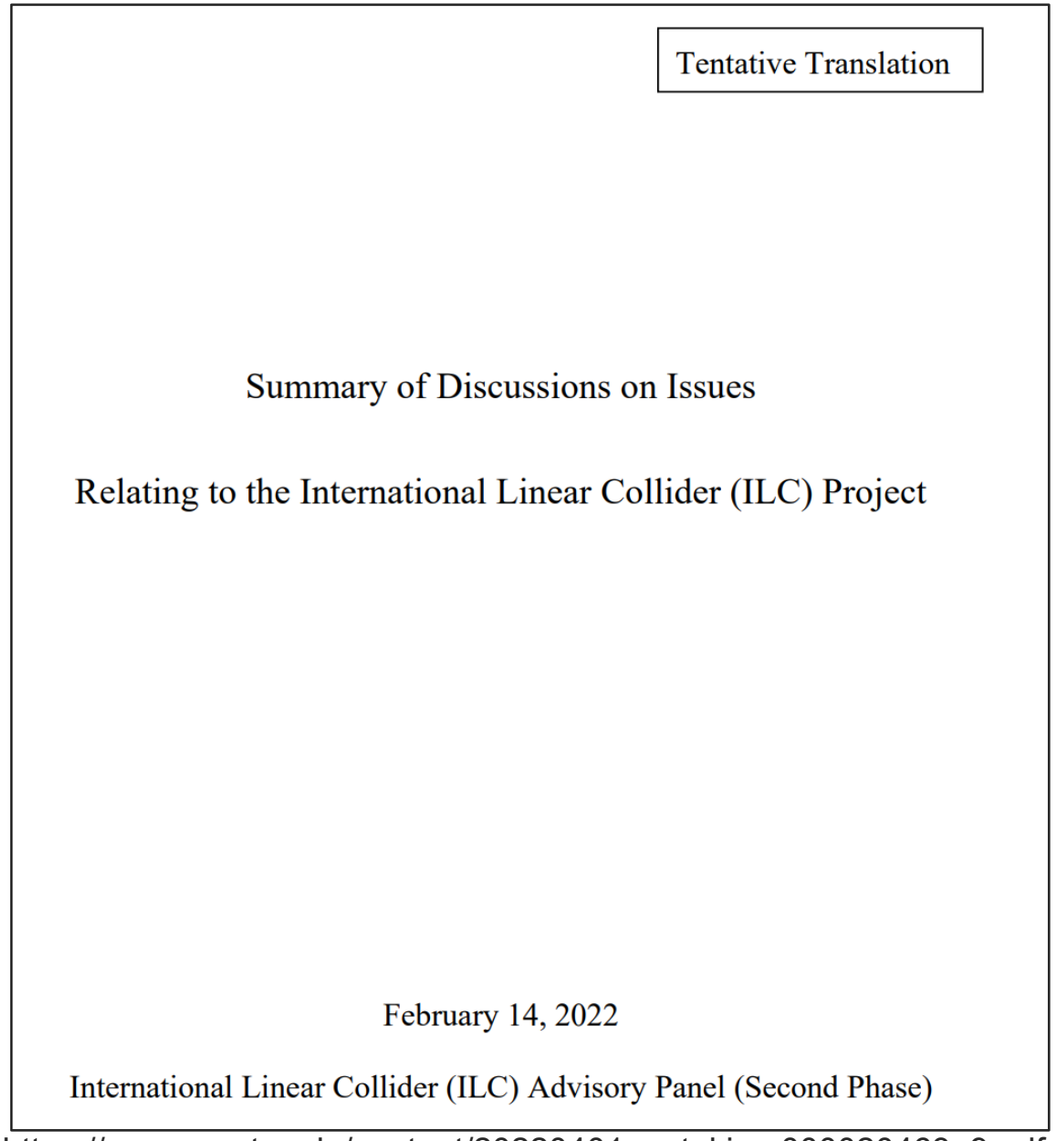
国際リニアコライダー（ILC）に関する有識者会議（第2期）（座長：観山正見）では、このたび、「国際リニアコライダー（ILC

- 国際リニアコライダー（ILC）計画の諸課題に関する議論のまとめ【本文及び参考資料】（PDF:655KB）
- 別添1 ILC計画に関する近年の動向（PDF:1.4MB）
- 別添2 ILC準備研究所提案書（PDF:2.9MB）
- （※ILC準備研究所提案書の外部リンク）
- 別添3 ILC計画に関する主な課題について（PDF:1.1MB）
- （※ILC計画に関する主な課題についての外部リンク）
- 別添4 1 提案研究者による説明資料（PDF:9.3MB）
- 別添4 2 提案研究者による説明資料（PDF:6.3MB）
- 別添5 委員からの追加質問に対する回答（PDF:8.6MB）
- 別添6 欧米の最新の動向について（PDF:304KB）

【英語版（仮訳）】
Summary of Discussions on Issues Relating to the International Linear Collider (ILC) Project（PDF:237KB）

https://www.mext.go.jp/b_menu/shingi/chousa/shinkou/064/toushin/220214.htm
Web site only in Japanese

Report from the panel and massage from KEK



Tentative Translation

Summary of Discussions on Issues

Relating to the International Linear Collider (ILC) Project

February 14, 2022

International Linear Collider (ILC) Advisory Panel (Second Phase)

https://www.mext.go.jp/content/20220401-mxt_kiso-000020463_9.pdf

Next step toward the ILC realization: MEXT expert panel publishes recommendations

Topics

2022/02/25

KEK has been working on the realization of the International Linear Collider (ILC) in Japan, together with ILC-Japan, a community organization under the Japan Association of High Energy Physicists (JAHEP), the ILC International Development Team (IDT) established by the International Committee for Future Accelerator (ICFA), and other supporting organizations around the world. In June 2021, IDT published the "Proposal for the ILC Preparatory Laboratory (Pre-lab)," which proposes an outline of the organizational framework, an implementation model, work plan and required resources for the preparatory phase of the ILC. At the same time, KEK and JAHEP submitted a report to the Ministry of Education, Culture, Sports, Science and Technology (MEXT) that summarizes progress on ILC activities over the past three years. In response to these developments, MEXT organized an expert panel in July 2021 for discussions to evaluate the progress of the ILC activities. On 14 February, the panel issued their recommendations, pointing out following five main points:

1. The panel recognizes the academic significance of particle physics and the importance of the research activities, including that of a Higgs factory, and understands the value of international collaborative research. However, the panel found that it is still premature to proceed into the ILC Pre-lab phase, which is coupled with an expression of interest to host the ILC by Japan as desired by the research community proposing the project.

2. Given the increasing strain in the financial situation of the related countries, the panel recommends the ILC proponents to reflect upon this fact and to reevaluate the plan. They should reexamine the approach towards a Higgs factory in a global manner taking into account the progress in the various studies such as the Future Circular Collider (FCC) and ILC.

3. The panel recommends that the development work in the key technological issues for the next-generation accelerator should be carried out by further strengthening the international collaboration among institutes and laboratories, shelving the question of hosting the ILC.

4. For realizing a very large project such as the ILC, cultivating a framework where the related countries can exchange information on their situations and discuss required steps would be important.

5. The panel recommends that the research community should continue efforts to expand the broad support from various stakeholders in Japan and abroad by building up trust and mutual understanding through bi-directional communication with the people concerned.

In light of the panel's findings, KEK will make an effort to reexamine the path for realizing the ILC as a Higgs factory,

https://www.kek.jp/en/topics-en/202202251335/

Roadmap

-success oriented and asuming no major incident-

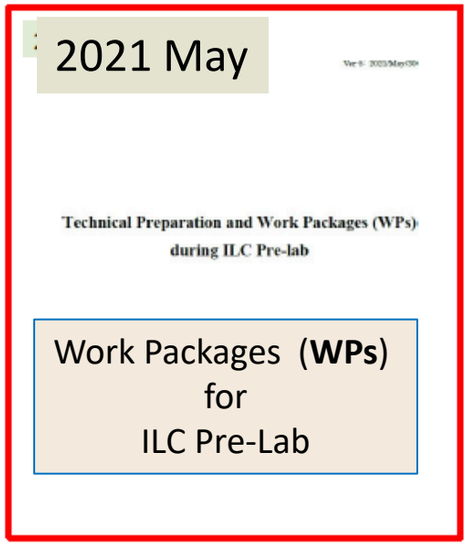
Technology Network Phase | **Preparatory Phase** | **Construction Phase** ~10 years for the construction and commissioning

2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 • • •

R&D and effort to gain a common view and understanding.

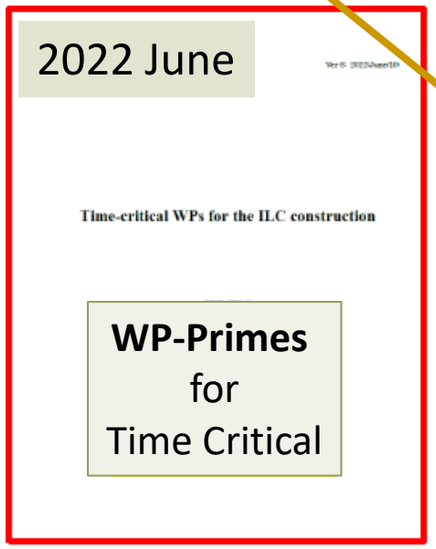
ILC preparation laboratory and intergovernmental discussion

2021 May


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

Work Packages (**WPs**) for ILC Pre-Lab

2022 June


Time-critical WPs for the ILC construction

WP-Primes for Time Critical

ILC Technology Network (ITN)

-- global collaboration program---

- **Acc. R&Ds** focusing on
  - SRF
  - e- & e+ Sources
  - Nano-beam

} Synergy with other colliders

KEK obtained a budget for these R&Ds and started the activity from this April.

http://doi.org/10.5281/zenodo.4742018

https://agenda.linearcollider.org/event/9735/contributions/50816/attachments/38190/59968/Time-Critical_WPsV8b.pdf

Administrative works for ITN

- KEK and CERN made agreement on the ITN
  - Collaboration with European institute will be organized by CERN
- Similar agreement is expected with US institutes
- ILC Japan will lead domestic collaboration in Japan

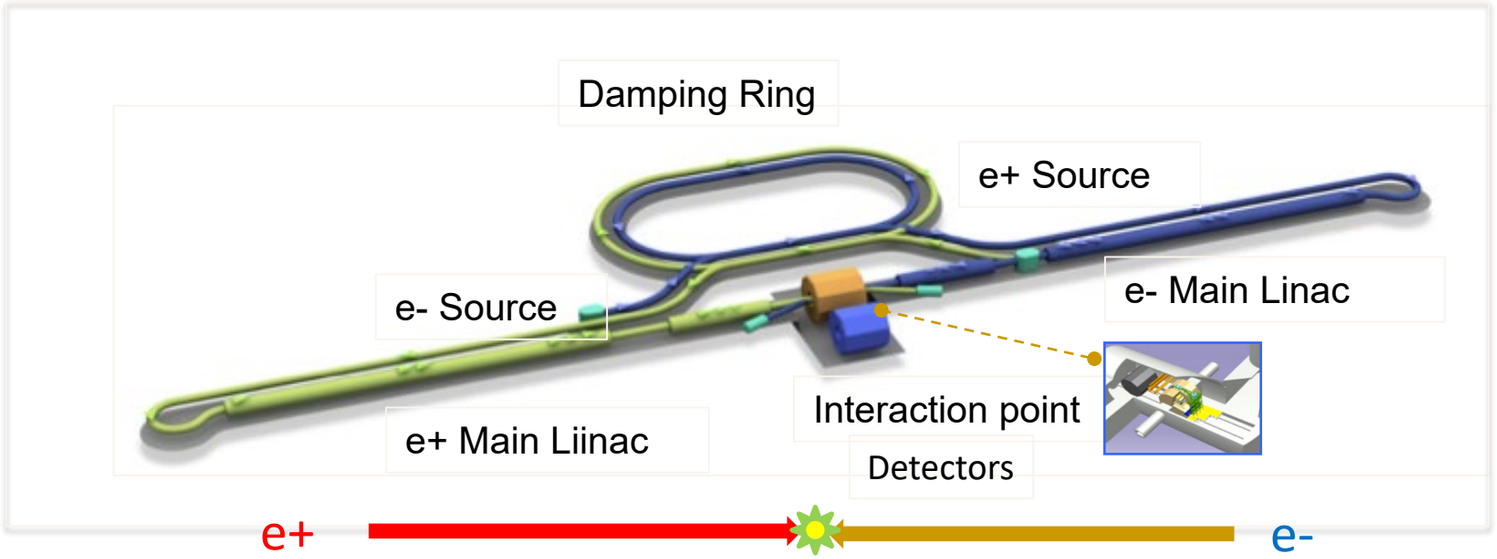
KEK and CERN Conclude Agreement on R&D for International Linear Collider

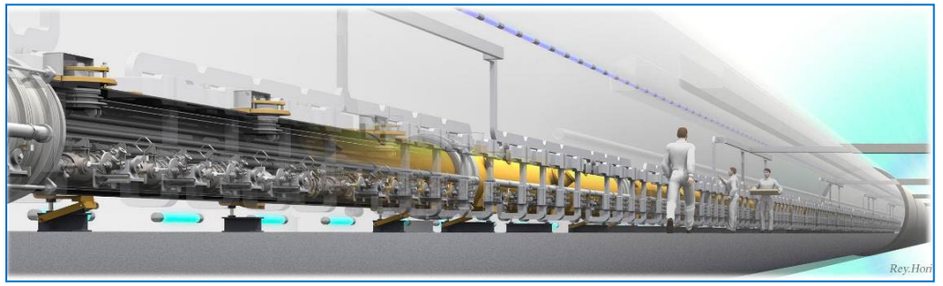
Topics

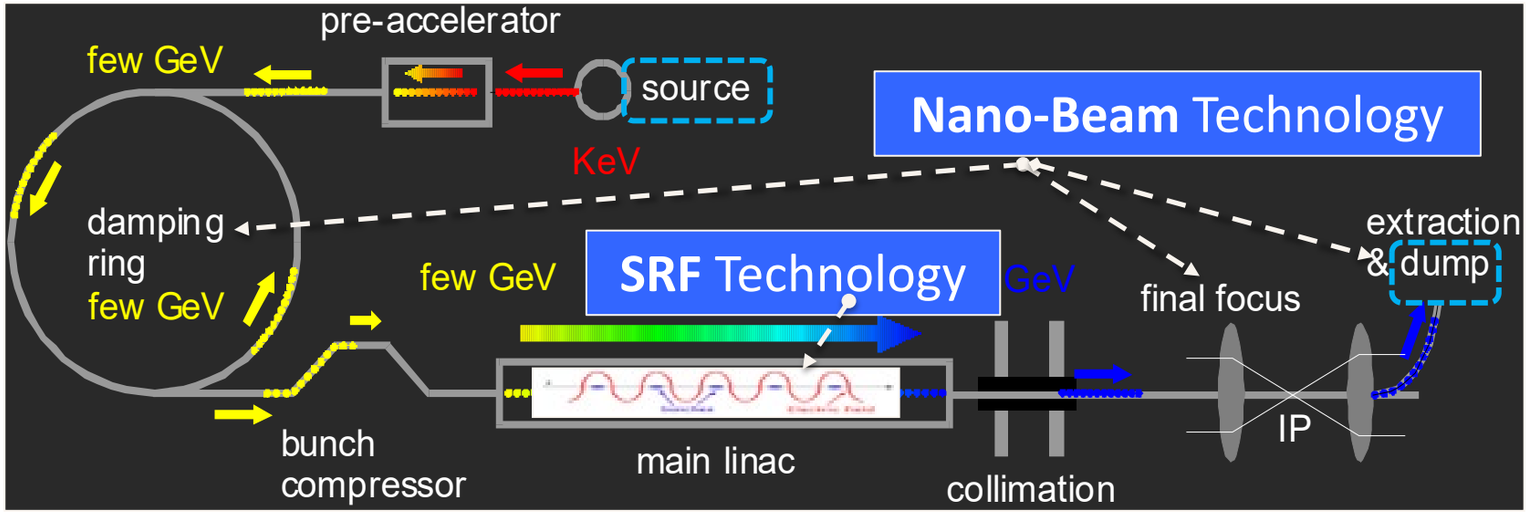
2023/07/08

Dr. Masanori Yamauchi and CERN Director General Dr. Fabiola Gianotti (left to right) (courtesy of CERN)

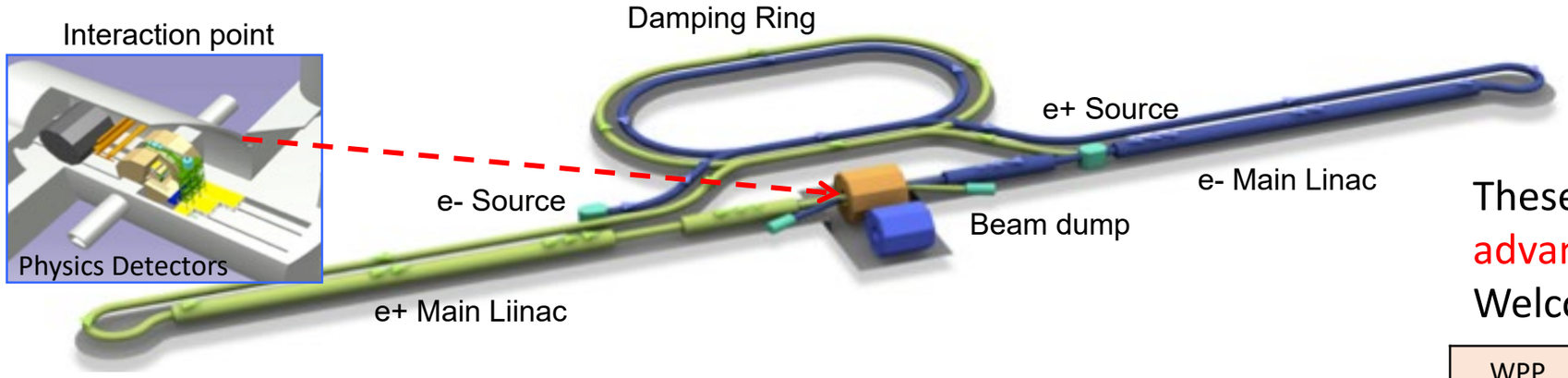
ILC accelerator





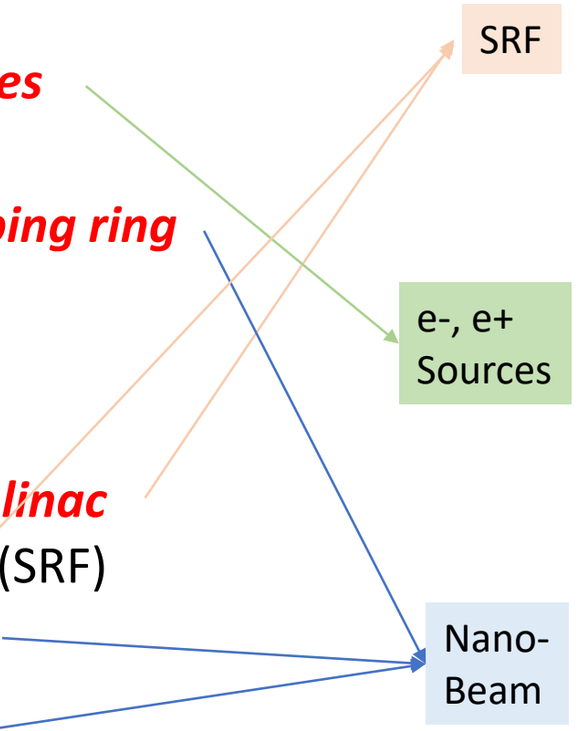


Parameters	Value
Beam Energy	125 + 125 GeV
Luminosity	1.35 / 2.7 x 10^{10} cm^2/s
Beam rep. rate	5 Hz
Pulse duration	0.73 / 0.961 ms
# bunch / pulse	1312 / 2625
Beam Current	5.8 / 8.8 mA
Beam size (y) at FF	**7.7** nm
SRF Field gradient	< 31.5 > MV/m (+/-20%) Q_0 = 1x10^{10}
#SRF 9-cell cavities (CM)	~ 8,000 (~ 900)
AC-plug Power	111 / 138 MW



These WPs can be applied to various advanced accelerators.
Welcome to join!

- Creating particles ***Sources***
  - polarized elections / positrons
- High quality beams ***Damping ring***
  - Low emittance beams
    - Small beam size (small beam spread)
    - Parallel beam (small momentum spread)
- Acceleration ***Main linac***
  - superconducting radio frequency (SRF)
- Getting them collided ***Final focus***
  - nano-meter beams
- Go to ***Beam dumps***



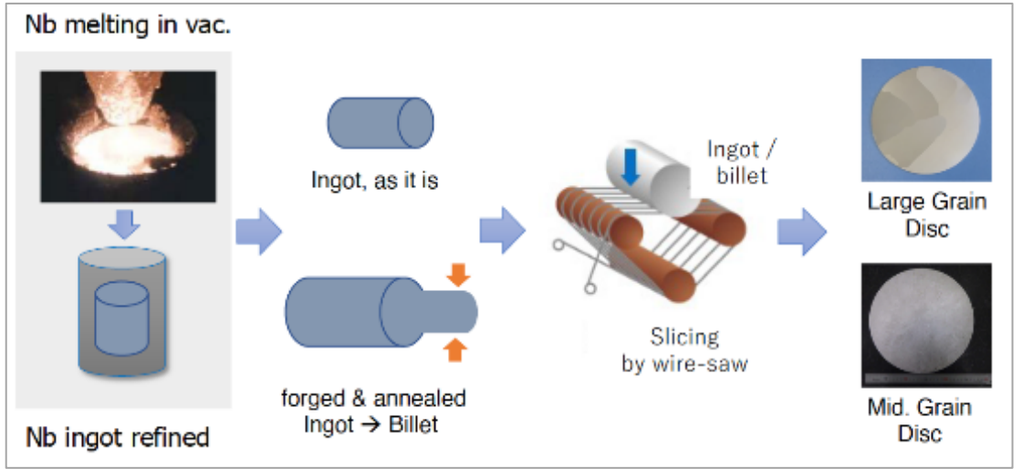
WPP	1	Cavity production
WPP	2	CM design
WPP	3	Crab cavity
WPP	4	E- source
WPP	6	Undulator target
WPP	7	Undulator focusing
WPP	8	E-driven target
WPP	9	E-driven focusing
WPP	10	E-driven capture
WPP	11	Target replacement
WPP	12	DR System design
WPP	14	DR Injection/extraction
WPP	15	Final focus
WPP	16	Final doublet
WPP	17	Main dump

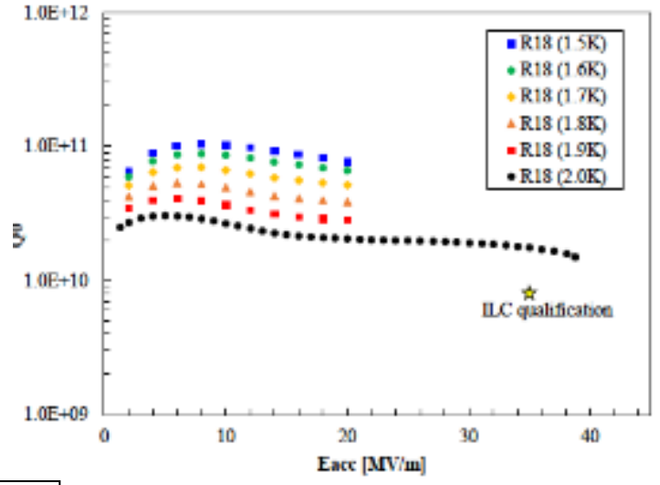
WP-prime 1: SRF Cavity

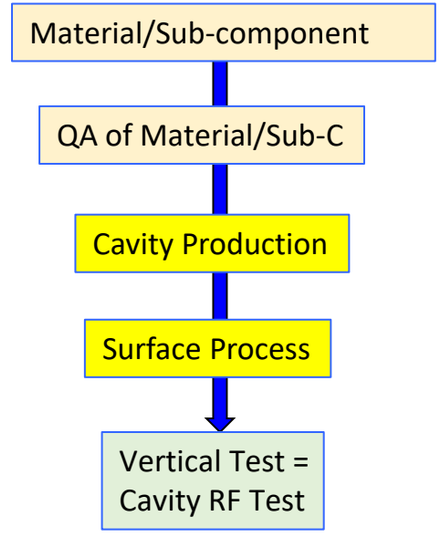
- Research with single-cell cavities to establish the best production process including:
  - Advanced Nb sheet production method
  - Advanced surface treatment recipe
- Globally common design with compatible High Pressure Gas Safety (HPGS) regulation
- 24 nine-cell cavities are to be developed for industrial-production readiness
  - 8 cavities (4 / batch) in each region
  - Production process encouraged to be optimized in each region
  - Cavity performance expected: E_{acc} = <35 MV/m> (+/− 20%), Q_0 = 1.0 x 10^{10}, Yield = ≥90%
- RF performance/success yield to be examined (including 2nd pass and further)
  - 3rd pass to be examined if effective

Referring European XFEL and LCLS-II experiences

	# of cavities to be produced		
	Americas	Europe	JP/Asia
single-cell	2	2	2 (+4)
nine-cell	8	8	8 (+ 4)





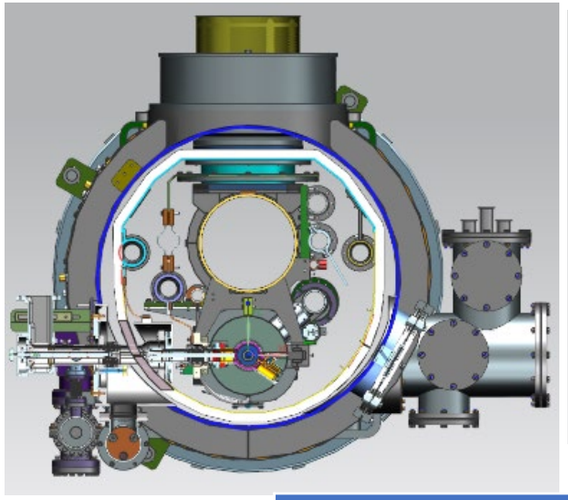


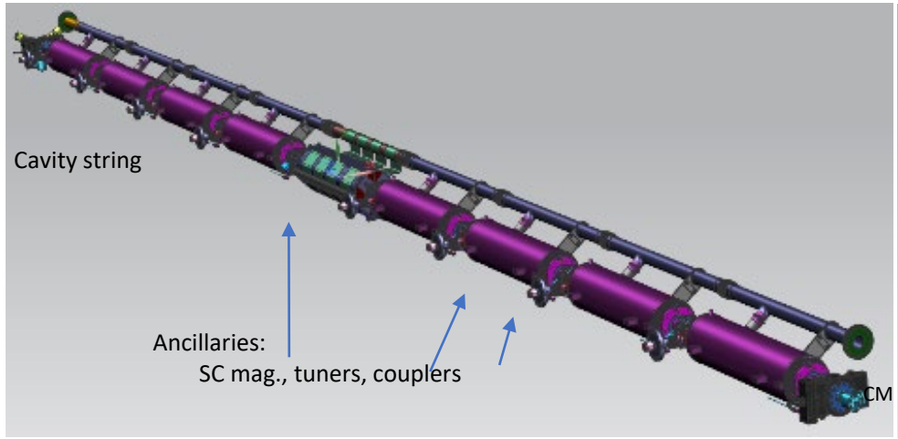
Production process

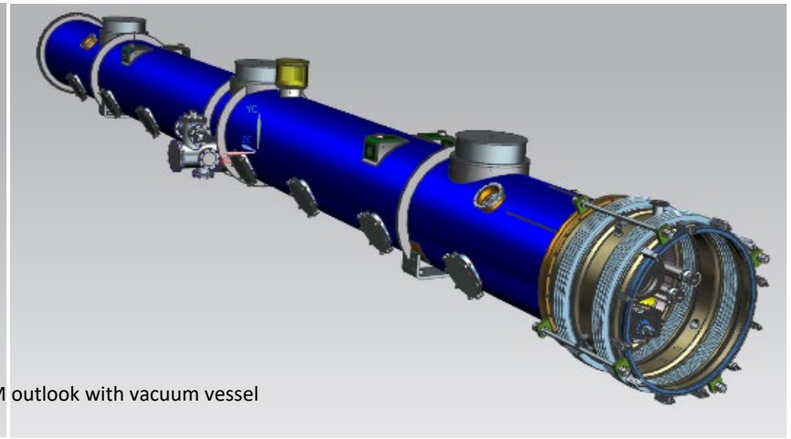
WP-prime 2: Cryomodule (CM) Design

Referring European XFEL and LCLS-II experiences

- Unify cryomodule (CM) design with ancillaries, based on globally common engineering design, drawings & data-base
- Establish globally compatible safety design base to be approved/authorized by HPGS regulations individually in each region, most likely referring ASME guidelines to be compatible with Japanese regulations.







Region Regulation	Americas ASME	Europe Eu-EN, TUV	Japan/Asia JP-HPGS Act
CM tech. design base	LCLS-II	Euro-XFEL	KEK-STF, AST-IFMIF
ILC CM design	Common CM design globally compatible to HPGS regulation in all regions, and most likely ASME guidelines to be compatible with Japanese regulations.		

12

CM test bench with concrete shield will be built within a few years in KEK for high power test of full CM.

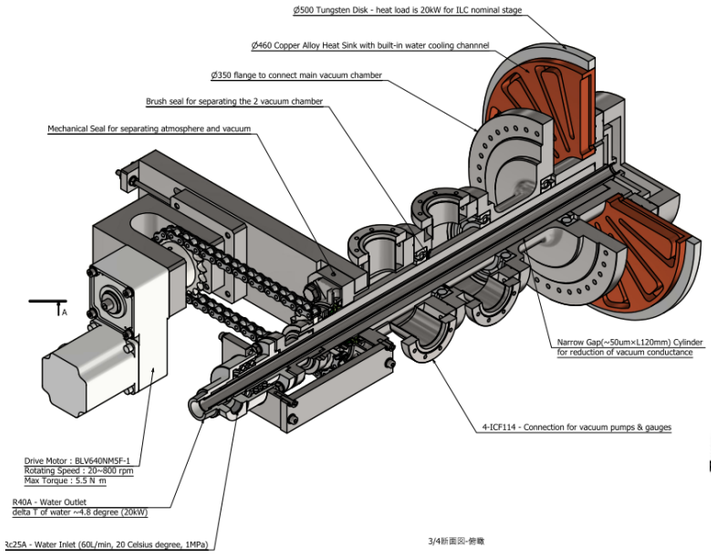
WP-prime 8～11: E-driven positron source

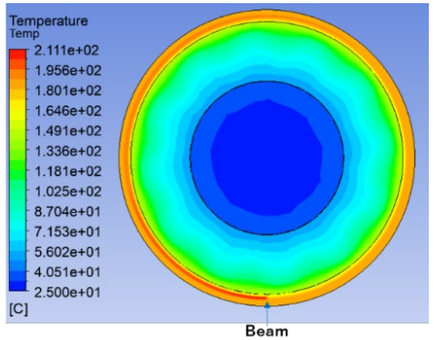
WP-prime 8: Rotating Target for e-Driven Scheme

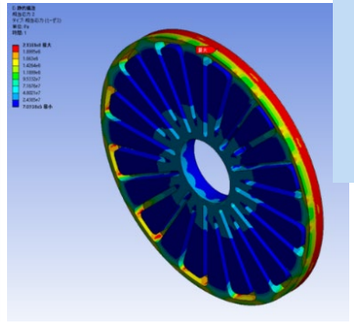
- ◆Target specification
  - ➢ W or W-alloy, ～16 mm (5 X_0) thick, diameter 50 cm
  - ➢ Rotating at 5 m/s in vacuum
  - ➢ Water cooled.
  - ➢ Vacuum seal
- ◆ R&D items to be done in 2 years
  - ➢ Target stress calculation with FEM
  - ➢ Vacuum seal
  - ➢ Target module design and prototyping
  - ➢ W-Cu connection test and evaluation

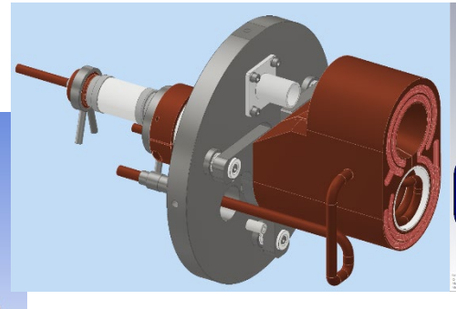
WP-prime 9: Focusing System

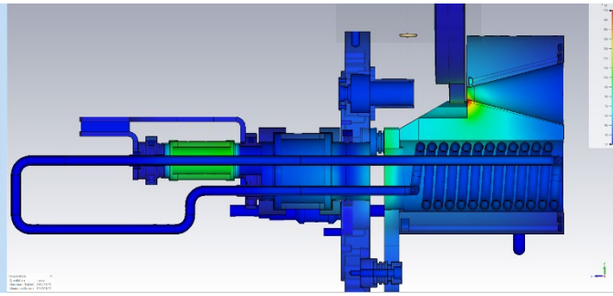
- ◆ Flux Concentrator (FC) is chosen as the focusing device after the target
- ◆ The specification parameters such as max field, electric current and the dynamic force are satisfied in existing target, but the pulse energy and the heat load are higher.
- ◆ A prototype necessary after detailed design study
- ◆ R&D items as WP-prime
  - ➢ Flux concentrator conductor design and prototype

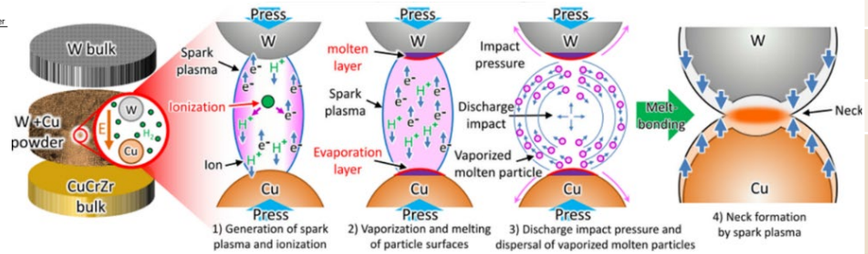










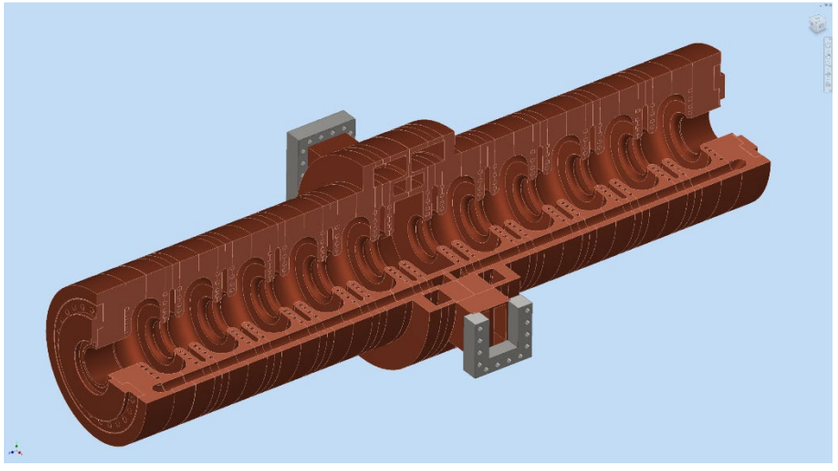


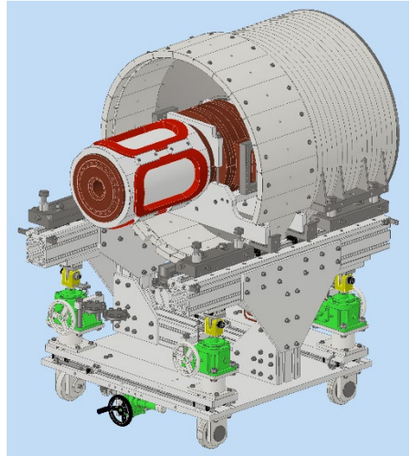
	SuperKEKB	ILC
Peak Bz	3.5 T	5 T
Aperture	7 mm	16～12 mm
repetition	50 Hz	100 Hz
Pulse width	5 us	10 ～ 25 us
Ohmic loss	0.5 ～ 0.8 kW (measured)	Around 10 kW (depend on aperture and pulse width)

WP-prime 8～11: E-driven positron source

WP-prime 10: Capture Cavity and Linac for e-Driven Scheme

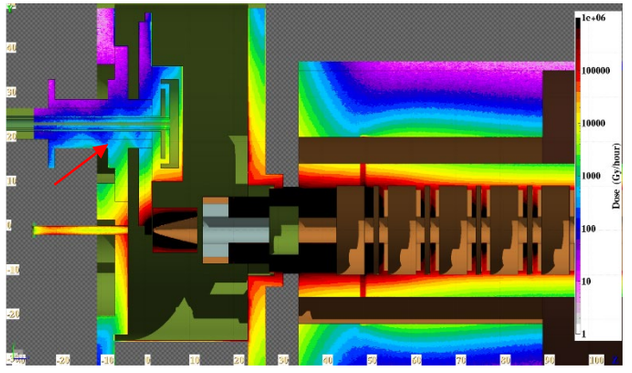
- ◆Technically challenges of capture cavity
  - ➢ High beamloading (up to ~1A)
  - ➢ Special bunch pattern
  - ➢ Electro-positron separation during flight in the cavity
  - ➢ High thermal load from shower
- ◆ R&D items as WPP-10 for the first 2 years
  - ➢ APS (Alternating Periodic Structure) cavity design and cold model
  - ➢ Beam-loading compensation and tuning method
  - ➢ Special design for extreme cooling capacity
  - ➢ Integrated design with solenoid and surrounding components
- ◆ Prototyping of these components in later years

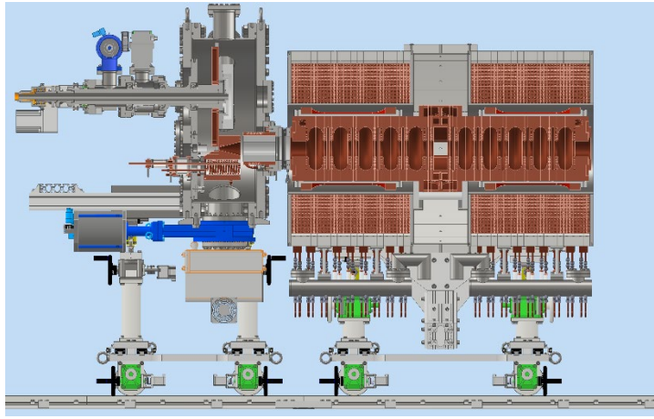




WP-prime 11:Target replacement

- ◆ Special attention is needed due to the high radiation of the target area. This is a common issue for E-Driven and Undulator positron source.
- ◆Careful design of shielding is required.
- ◆ The components near the target (target, flux concentrator, first cavity with solenoid) require replacement in every few years. The work must be done by remotely.
- ◆ The works to be done as WP-prime
  - ➢ Conceptual design
  - ➢ Fabricate Mockup
  - ➢ Prototyping of critical components

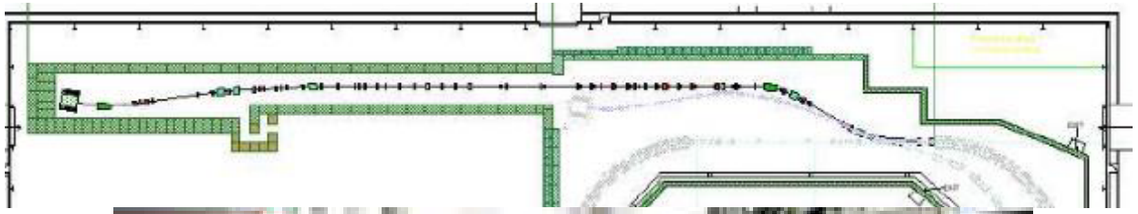


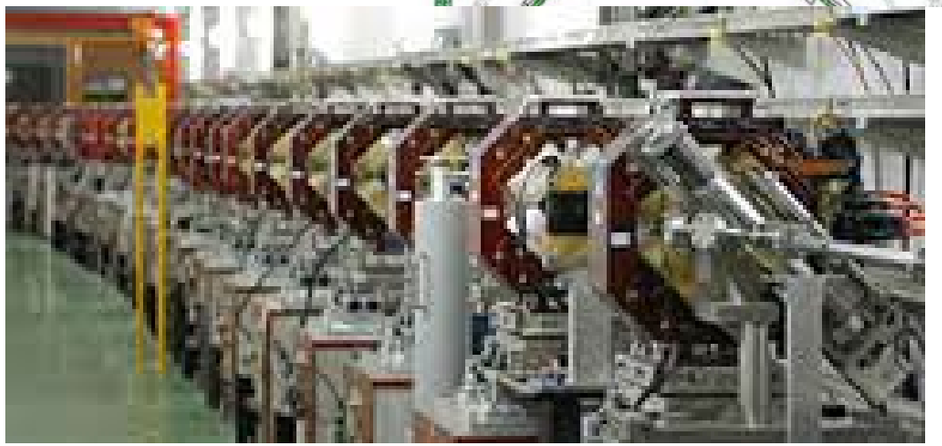


WP-prime 15: Final focus

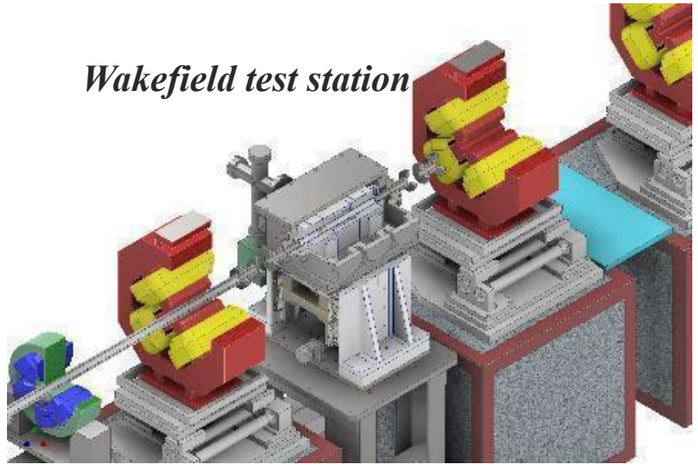
ATF collaboration

- ATF2 beamline is the only existing test accelerator in the world to test the final focus system (FFS) of linear colliders.
- The following 3 research topics are important to be pursued at the ATF.
  - wakefield mitigation
  - correction of higher-order aberration
  - training for ILC beam tuning
- The technical research at ATF2 beamline has proceeded and should continue to be based on the ATF international collaboration, or its extension (welcome to new collaborators).

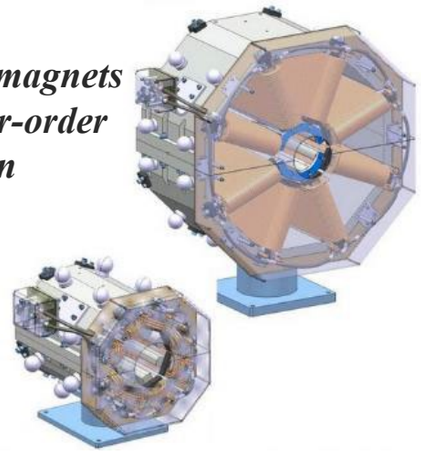




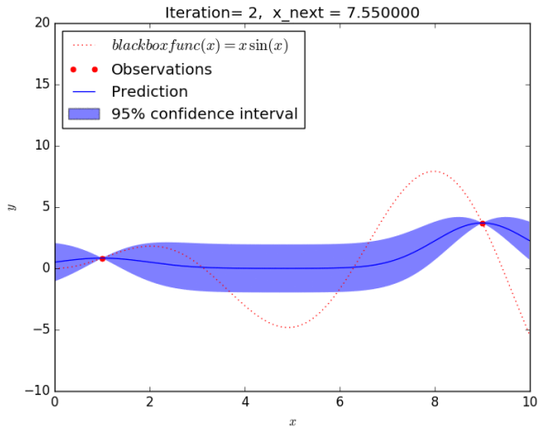
Wakefield test station



Octupole magnets for higher-order aberration



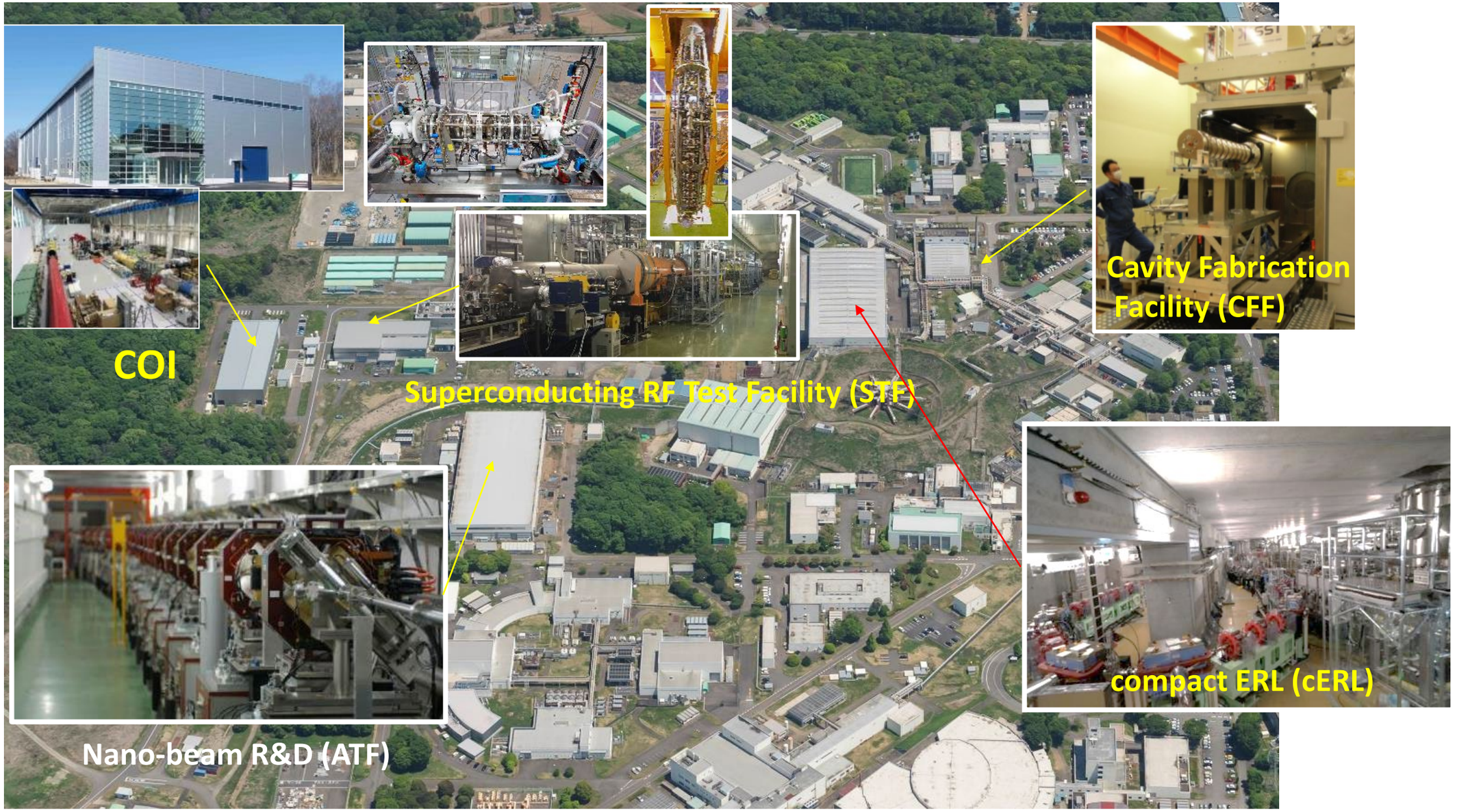
Maximum search algorithms to be applied to beam tuning (Machine Learning)



summary

- Report on recent status and progress on ILC
- Details about each work package and what we plan to do are explained in Shin MICHIZONO's presentation at LCWS2023
  - https://indico.slac.stanford.edu/event/7467/contributions/5492/attachments/2784/7852/LCWS2023-ITN.pdf
- ITN started from 2023
  - Agreement between KEK and CERN
  - Three major R&D topics, **SRF, source, nano-beam**
  - We welcome the world-wide Accelerator Laboratories' participation in the INT

Advanced accelerator facilities at KEK



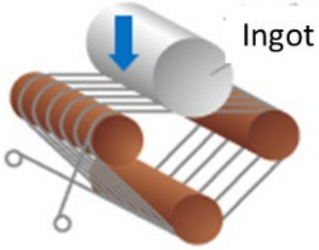
SRF

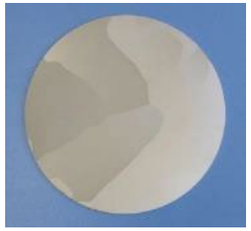
Superconducting RF (SRF) Test facility


508MHzTRISTAN (1989)


508MHzKEKB (1998)

SRF cavity R&D since 1980s
Experiences at TRISTAN/KEKB/SuperKEKB





STF (2005-) for Superconducting Cavity Evaluation

CFF(2011-) cavity fabrication facility


EBW

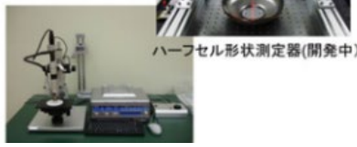
Chemical polishing

Cavity material R&D at CFF

KEK has extensive experience in the development of SRF accelerator since TRISTAN.

S1 global (2010)
4 KEKs, 2 each from Germany and US Cavities


Vertical test stand

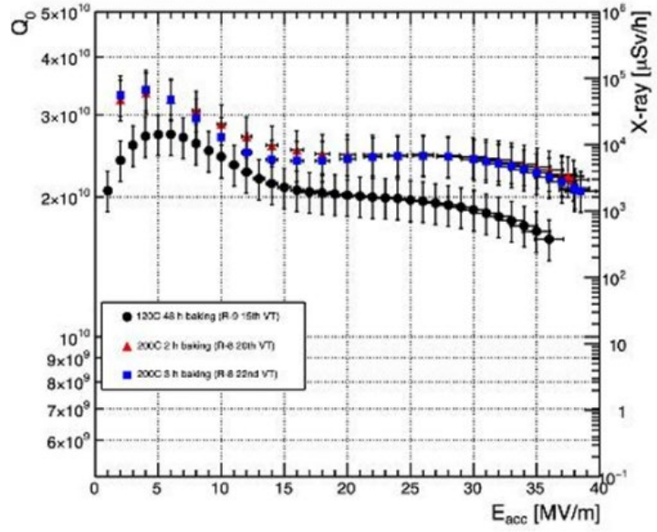


Surface Inspection


Press machine


Vertical lathe

High-Q/G R&D at STF




STF-2(2016～)
14 srf cavities

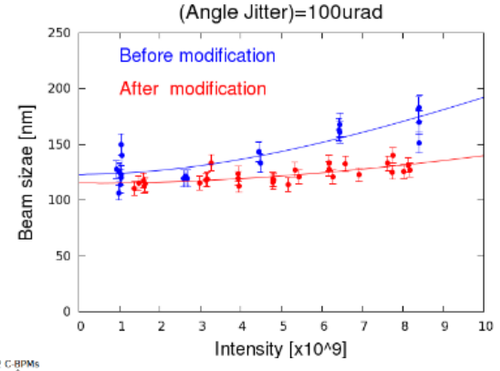
Nano-Beam

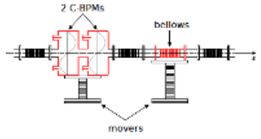
Nano-beam R&D at ATF2

~ 2017 | 2018 ~

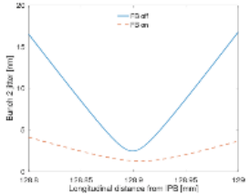
Tech. design completed
Spec. almost achieved

Wakefield effects

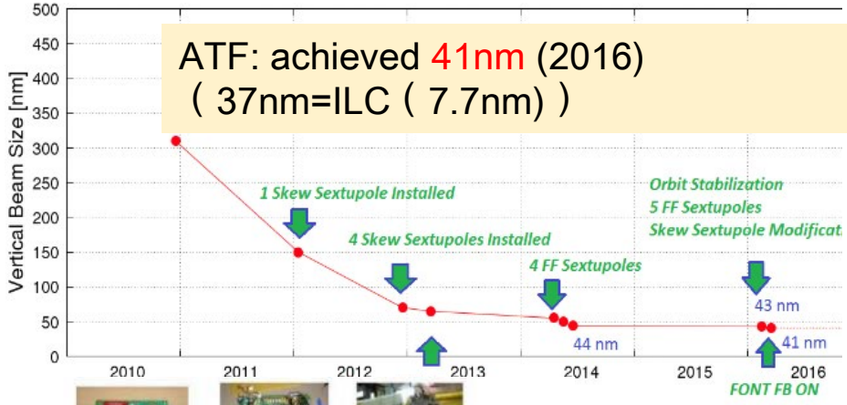




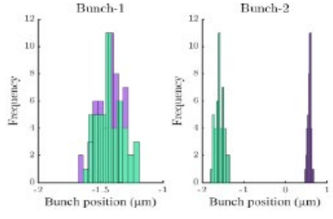
ATF2 wakefield knobs system be-tween BPM QD10BFF and QD10AFF

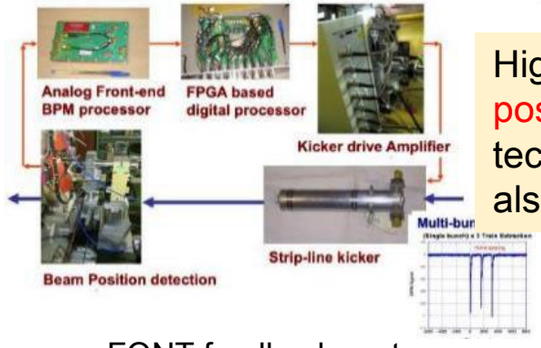


Distribution of bunch positions measured at IPB, with two-BPM FB off (green) and on (purple)



ATF: achieved 41nm (2016)
(37nm=ILC (7.7nm))





FONT feedback system

High-speed beam position control technology was also demonstrated.

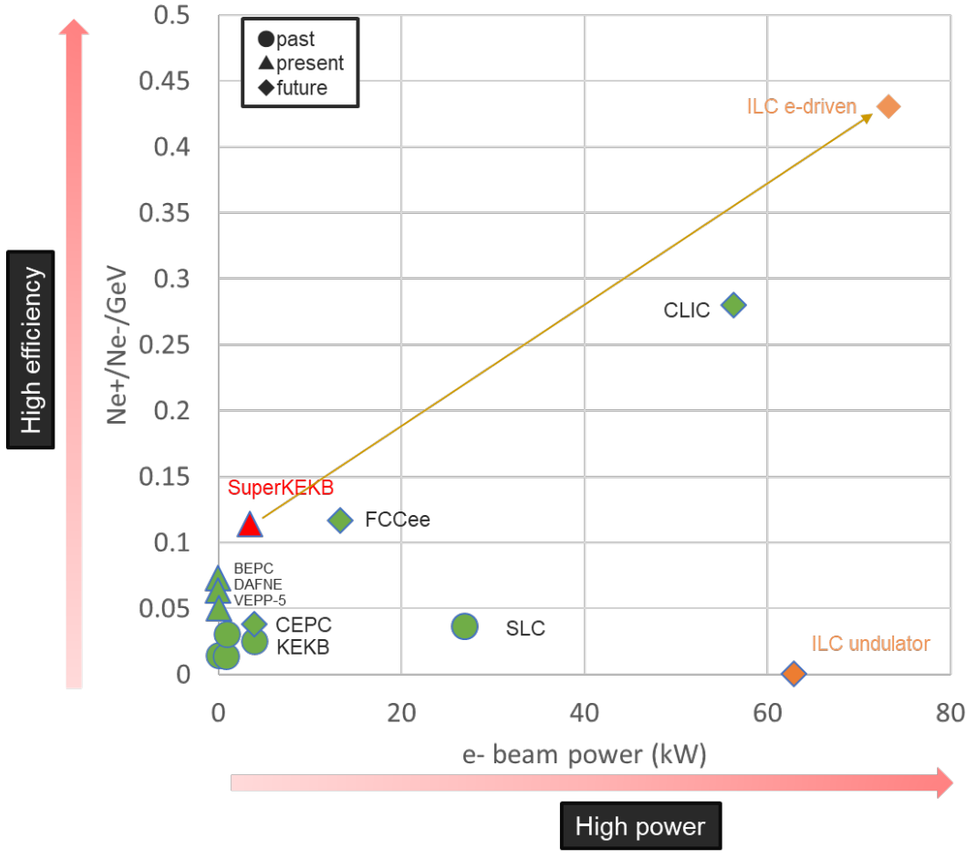
Wakefield effect was evaluated at ATF.
-confirm no serious problem at ILC
-demonstrate a technique to reduce the wakefield effect

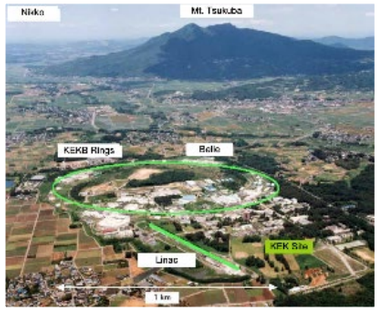
ATF International Review (Committee)*
-The committee highly evaluated the achievements of ATF so far.
-The committee pointed out the importance of continuing research to contribute to the detailed design of the ILC final convergence.

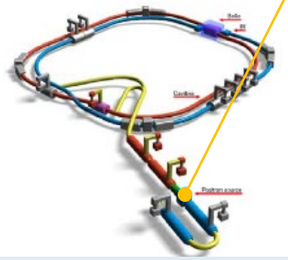
* https://agenda.linearcollider.org/event/8626/

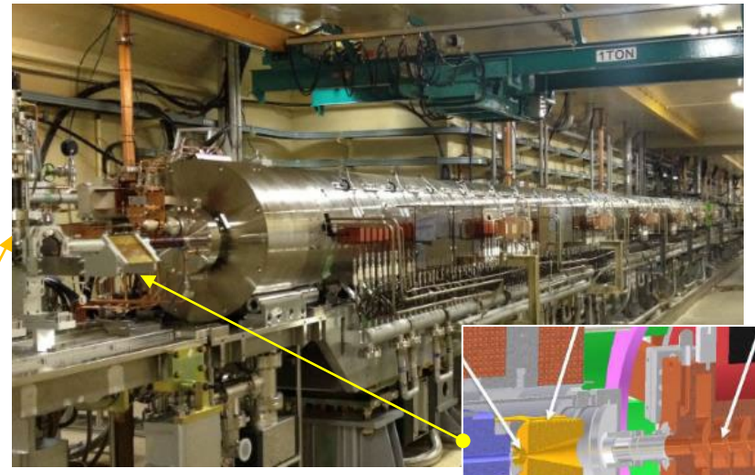
e-, e+ Sources

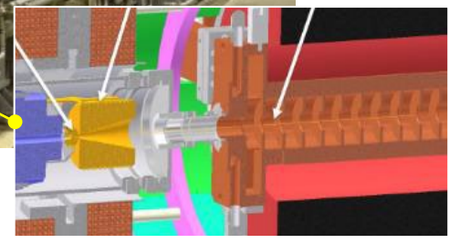
- KEK has long experience about positron source through TRISTAN, KEKB, SuperKEKB
- The source has many common R&D topics with FCCee, CLIC, C3, CEPC etc.



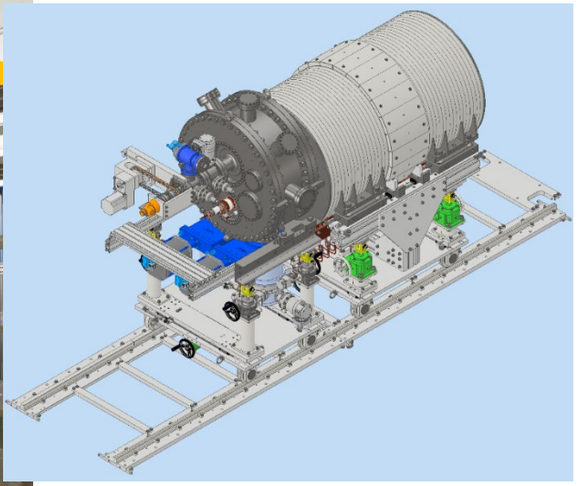








SuperKEKB positron source:
The most high-power positron source in operation!



The latest design of positron source for ILC
And test bench area