ILC Status

Shoji Asai (U.Tokyo,
ILC-Japan)

Contents

You can find both good news and bad news

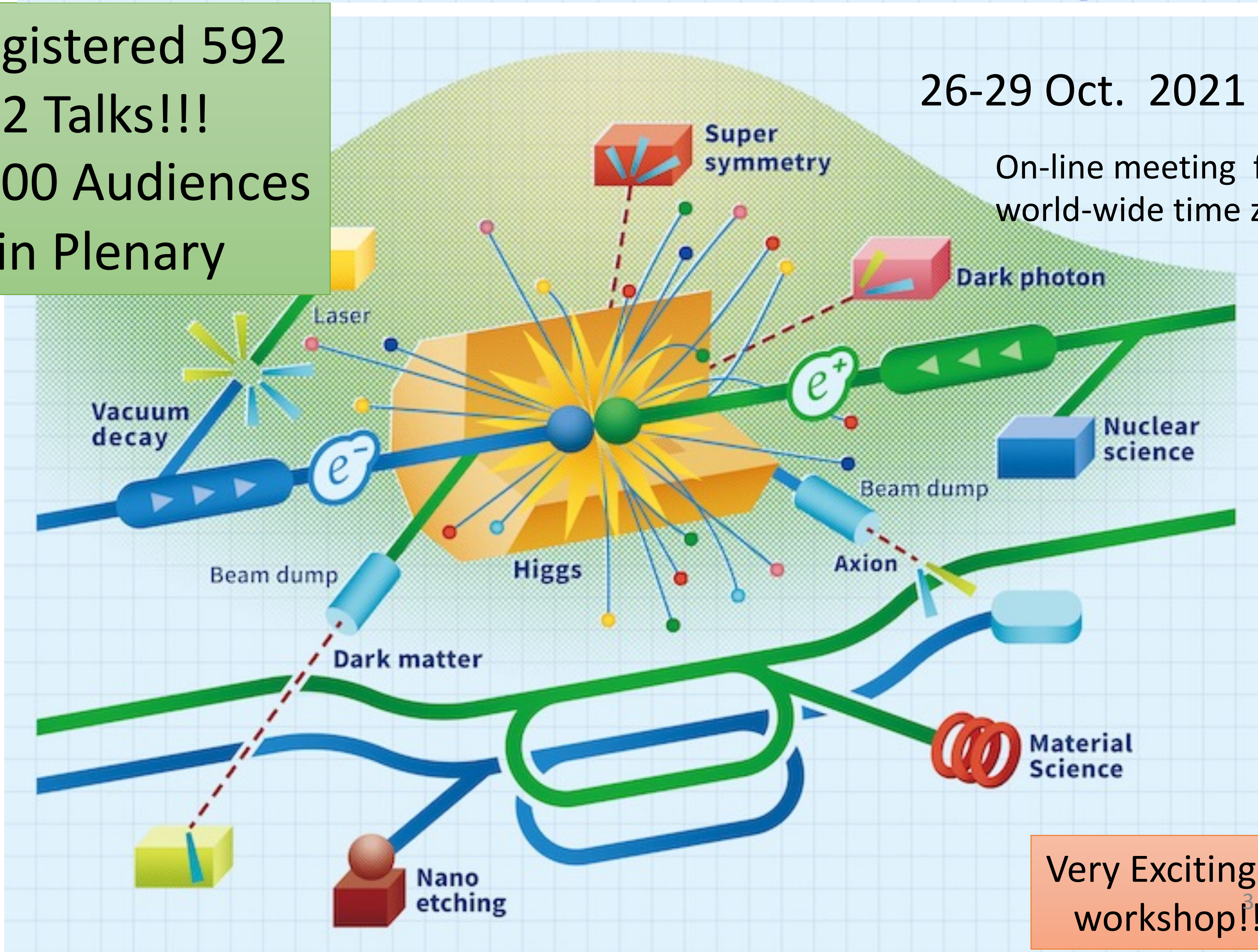
Many Thanks to Michizono-san and Nakada-san

ILCX2021 ILC Workshop on Potential Experiments

Registered 592
252 Talks!!!
~200 Audiences in Plenary

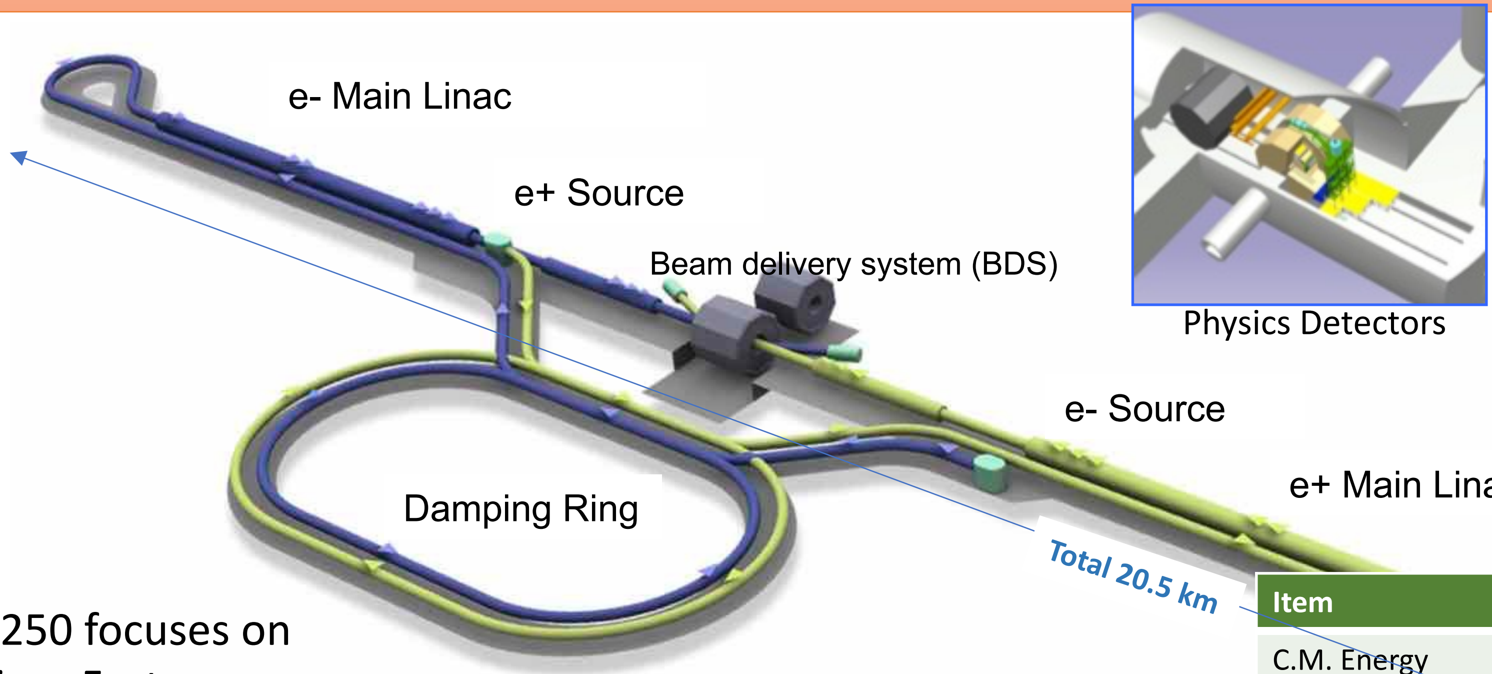
26-29 Oct. 2021

On-line meeting for world-wide time zone



Very Exciting workshop!!

[1] Design outline: ILC250 accelerator facility



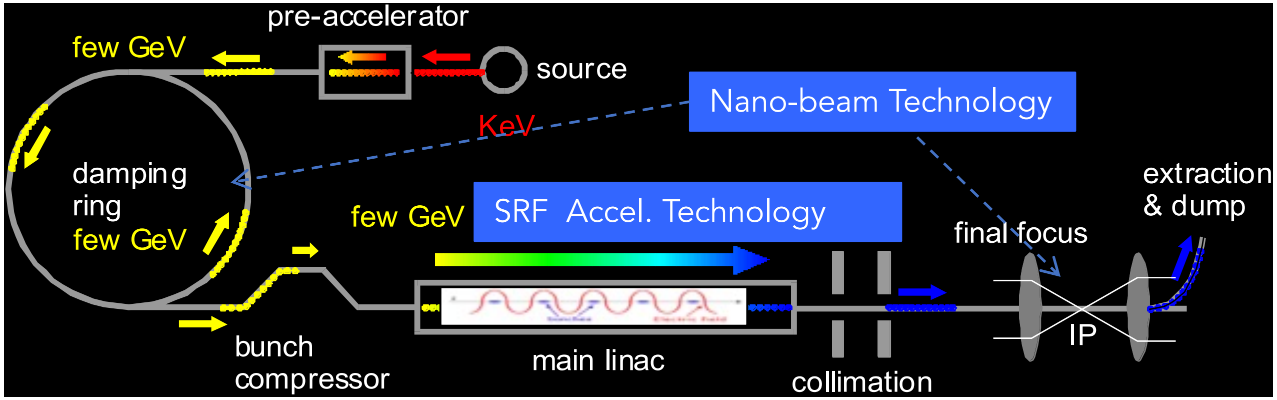
Physics Detectors

ILC250 focuses on
Higgs Factory;
Length becomes 20km

Total Cost of Acc. is ~**6BSF**
including human & Civil
Tunnel cost ~ **1.1BSF**

Item	Parameters
C.M. Energy	250 GeV
Length	20km
Luminosity	1.35×10^{34} $cm^{-2}s^{-1}$
Repetition	5 Hz
Beam Pulse Period	0.73 ms
Beam Current	5.8 mA (in pulse)
Beam size (y) at FF	**7.7** nm@250GeV
SRF Cavity G. Q_0	**31.5** MV/m (**35** MV/m) $Q_0 = 1x10^{10}$

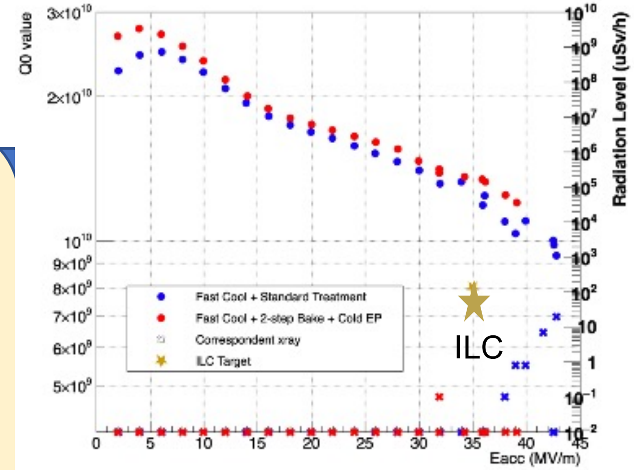
Key Technologies



Status of SRF

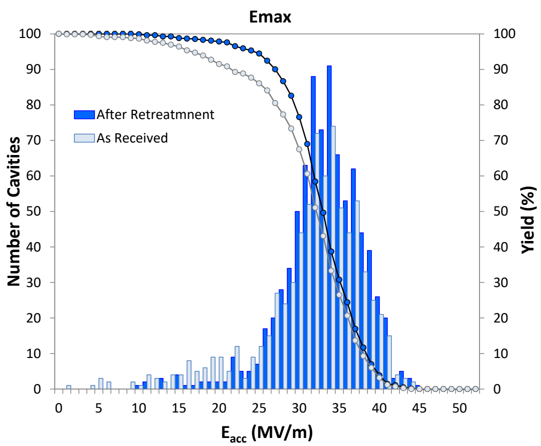
Cavity

US-Japan: high performance with new surface treatment, etc.

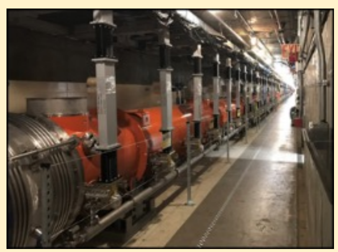


High performance and cost reduction

Quality cont. of Cavity



Euro-XFEL Operation (Europe)
~800 cavities/
~100 Modules



LCLS-II Construction (USA)
~280 cavities/
~35 Modules

Germany-Japan: Improving Efficiency in Cavity Manufacturing

France-Japan: Automation of cavity cleaning

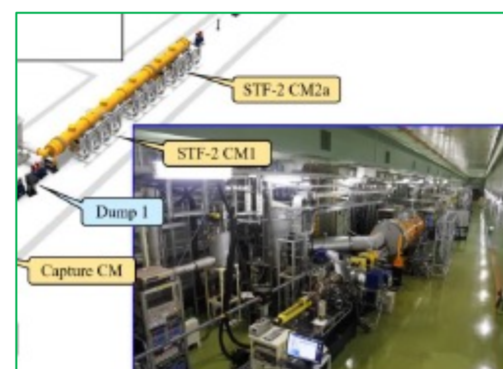
Final design is underway to comply with "High Pressure Gas Safety".

Cryomodule

Eng. design

Module assembly

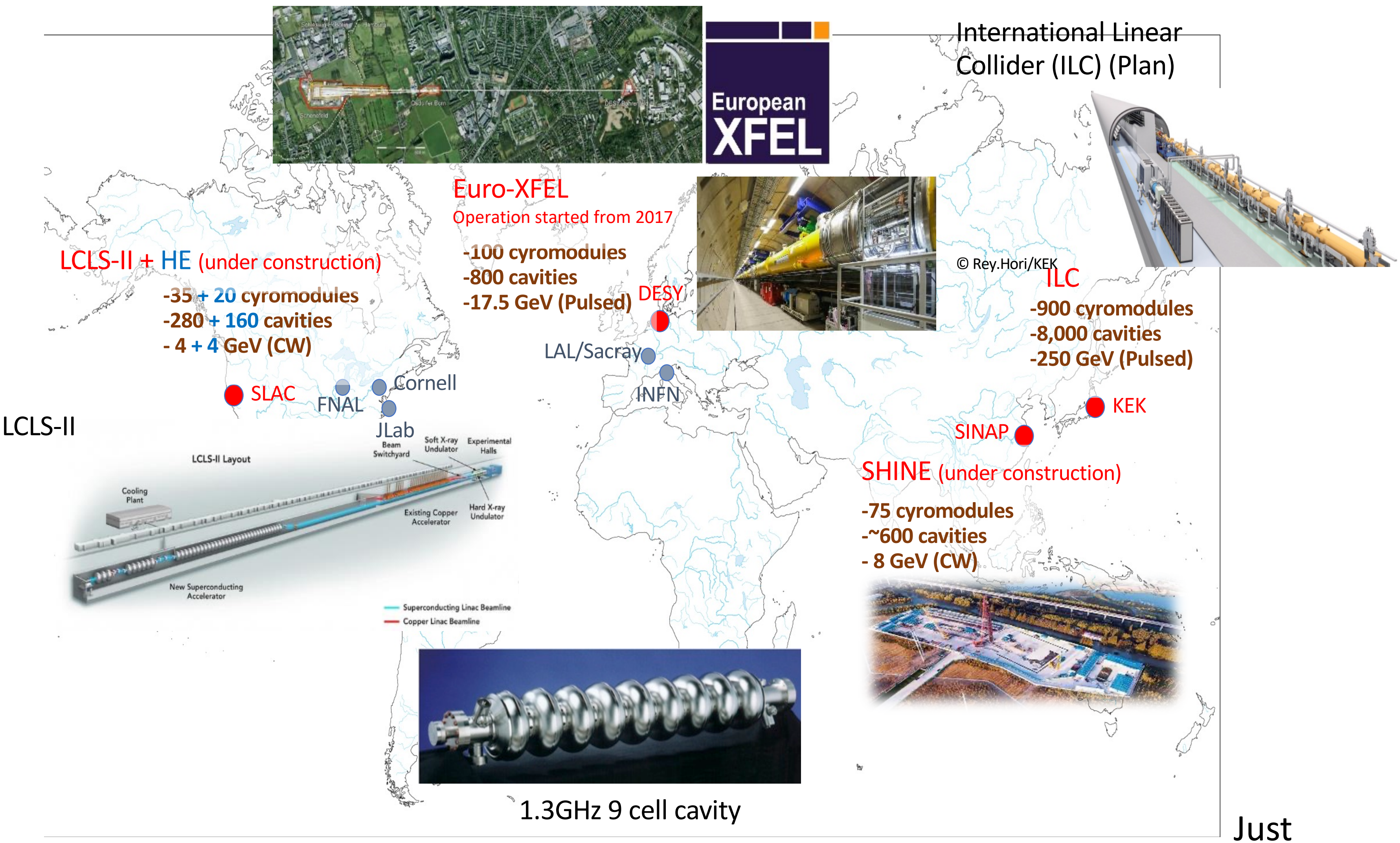
Accelerator performance verification at KEK-STF2



The mass production of European XFEL has reached ≥ 83% of the ILC specification yield (90%).

10% size of ILC
has been performed
for the XFELs
Work well int. collab.

SRF accelerators are worldwidely used for light source



ILC SRF technology is well-matured & Cost effective

Just
Factor 10
Scale up

Energy Upgrade possibility

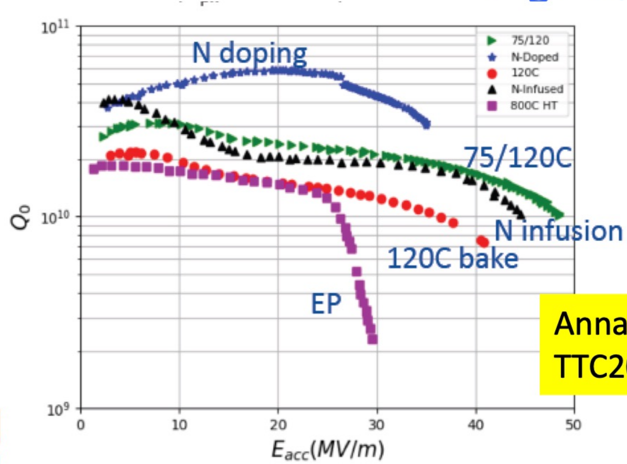
Quantity	Symbol	Unit	Initial	$\mathcal{L}$ Upgrade	TDR	Upgrades	
Centre of mass energy	$\sqrt{s}$	GeV	250	250	250	500	1000
Luminosity	$\mathcal{L}$	$10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$	1.35	2.7	0.82	1.8/3.6	4.9
Polarisation for $e^{-}(e^{+})$	$P_{-}(P_{+})$		80 %(30 %)	80 %(30 %)	80 %(30 %)	80 %(30 %)	80 %(20 %)
Repetition frequency	f_{rep}	Hz	5	5	5	5	4
Bunches per pulse	n_{bunch}	1	1312	2625	1312	1312/2625	2450
Bunch population	N_{e}	10^{10}	2	2	2	2	1.74
Linac bunch interval	Δt_{b}	ns	554	366	554	554/366	366
Beam current in pulse	I_{pulse}	mA	5.8	5.8	8.8	5.8	7.6
Beam pulse duration	t_{pulse}	μs	727	961	727	727/961	897
Average beam power	P_{ave}	MW	5.3	10.5	10.5	10.5/21	27.2
Norm. hor. emitt. at IP	$\gamma\epsilon_{\mathrm{x}}$	μm	5	5	10	10	10
Norm. vert. emitt. at IP	$\gamma\epsilon_{\mathrm{y}}$	nm	35	35	35	35	30
RMS hor. beam size at IP	σ^{*}_{x}	nm	516	516	729	474	335
RMS vert. beam size at IP	σ^{*}_{y}	nm	7.7	7.7	7.7	5.9	2.7
Luminosity in top 1 %	$\mathcal{L}_{0.01}/\mathcal{L}$		73 %	73 %	87.1 %	58.3 %	44.5 %
Energy loss from beamstrahlung	δ_{BS}		2.6 %	2.6 %	0.97 %	4.5 %	10.5 %
Site AC power	P_{site}	MW	129		122	163	300
Site length	L_{site}	km	20.5	20.5	31	31	40

130MW Power is reasoble

Tunnel can be extended to 30km, 40km

1TeV is achievable with the current Cavity

- Surface treatments for high-Q and high-G



Anna Grassellino
TTC2019 Vancouver

High Q-value and High Gradient
are developed

Surface treatments are important.

High Gradient -> Shorter Length
(Cheaper 1TeV)

High Q -> Green : (Quantum C application)

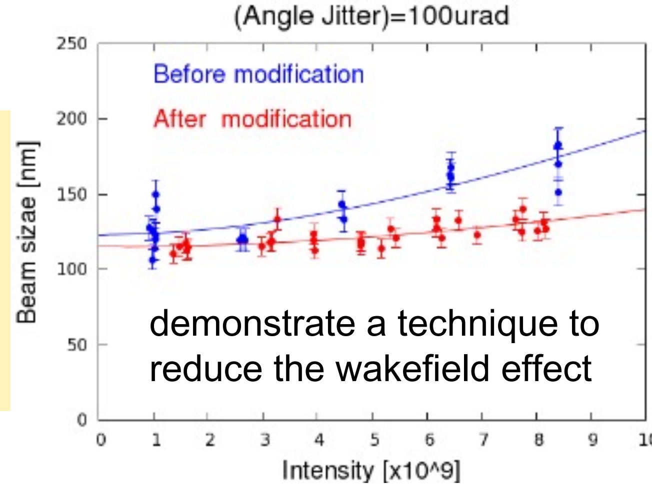
Nano-beam R&D

KEK ATF

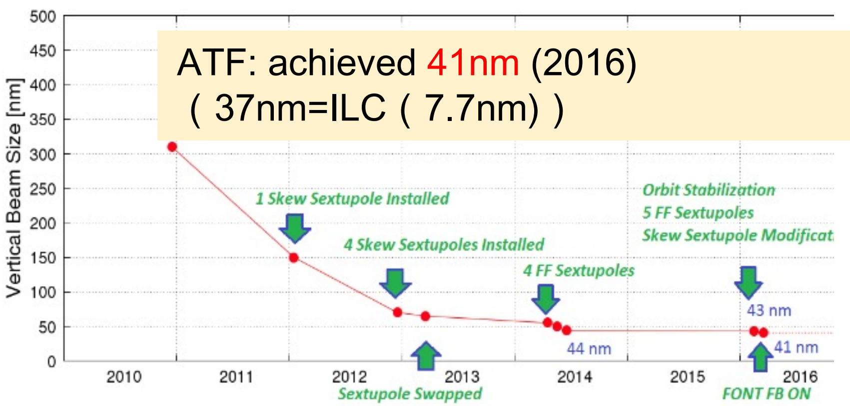
Establish the ILC final focus method with same optics and comparable beamline tolerances

- ATF2 Goal : **37** nm → ILC **7.7** nm (ILC250)
  - Achieved **41 nm** (2016)

Wakefield effect No serious problem

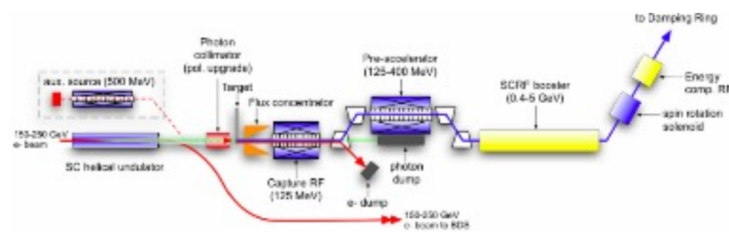


History of ATF2 small beam

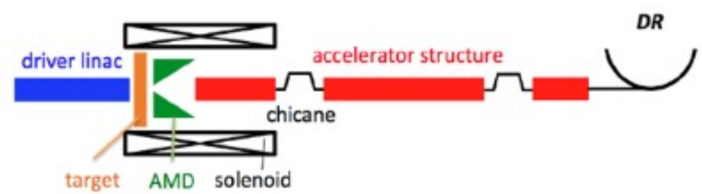


High-speed beam position control technology was also demonstrated.

Positron Source



Undulator (Polarization) is under study



Conventional e-Driven is almost ready for BU

Plan for Technical preparation

IDT-WG2 summarized the technical preparation as work packages (WPs) in the technical preparation document.

SRF is dominant, but also there are many interesting topics

Cost & FET are summarized

1 ILCU~ 1 SF

ILC Pre-lab

Actual cavity /CM manufacturing

SRF ~41MILCU 285 FTE-yr
- WP-1 Cavity production
- WP-2 Cryomodule assembly
- WP-3 Crab cavity

e- source ~2.5MILCU, 6 FTE-yr
- WP-4 Electron source

e+ source ~6MILCU, 15FTE-yr

Undulator scheme
- WP-5 Undulator
- WP-6 Rotating target
- WP-7 Magnetic focusing

e-Driven scheme
- WP-8 Rotating target
- WP-9 Magnetic focusing
- WP-10 Capture cavity
- WP-11 Target replacement

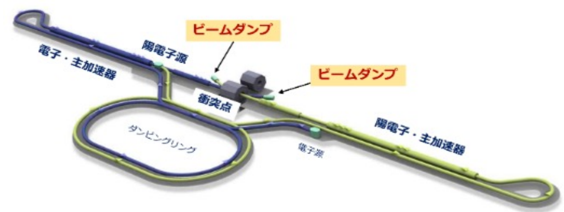
DR ~2.5MILCU, 30FTE-yr
- WP-12 System design
- WP-13 Collective effect
- WP-14 Injection/extraction

BDS ~2MILCU, 16FTE-yr
- WP-15 Final focus
- WP-16 Final doublet

Dump ~3MILCU, 12FTE-yr
- WP-17 Main dump
- WP-18 Photon dump

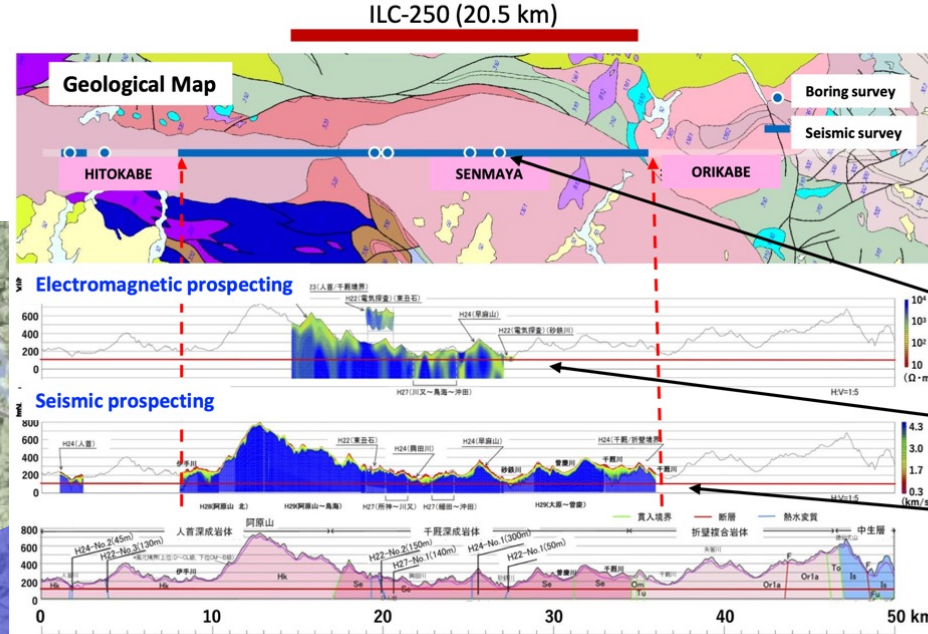
For detail,
http://doi.org/10.5281/ zenodo.4742018

SRF technology is energy-efficient, and its applications are increasing around the world.
These WPs will contribute to the promotion of SRF accelerators in each region.

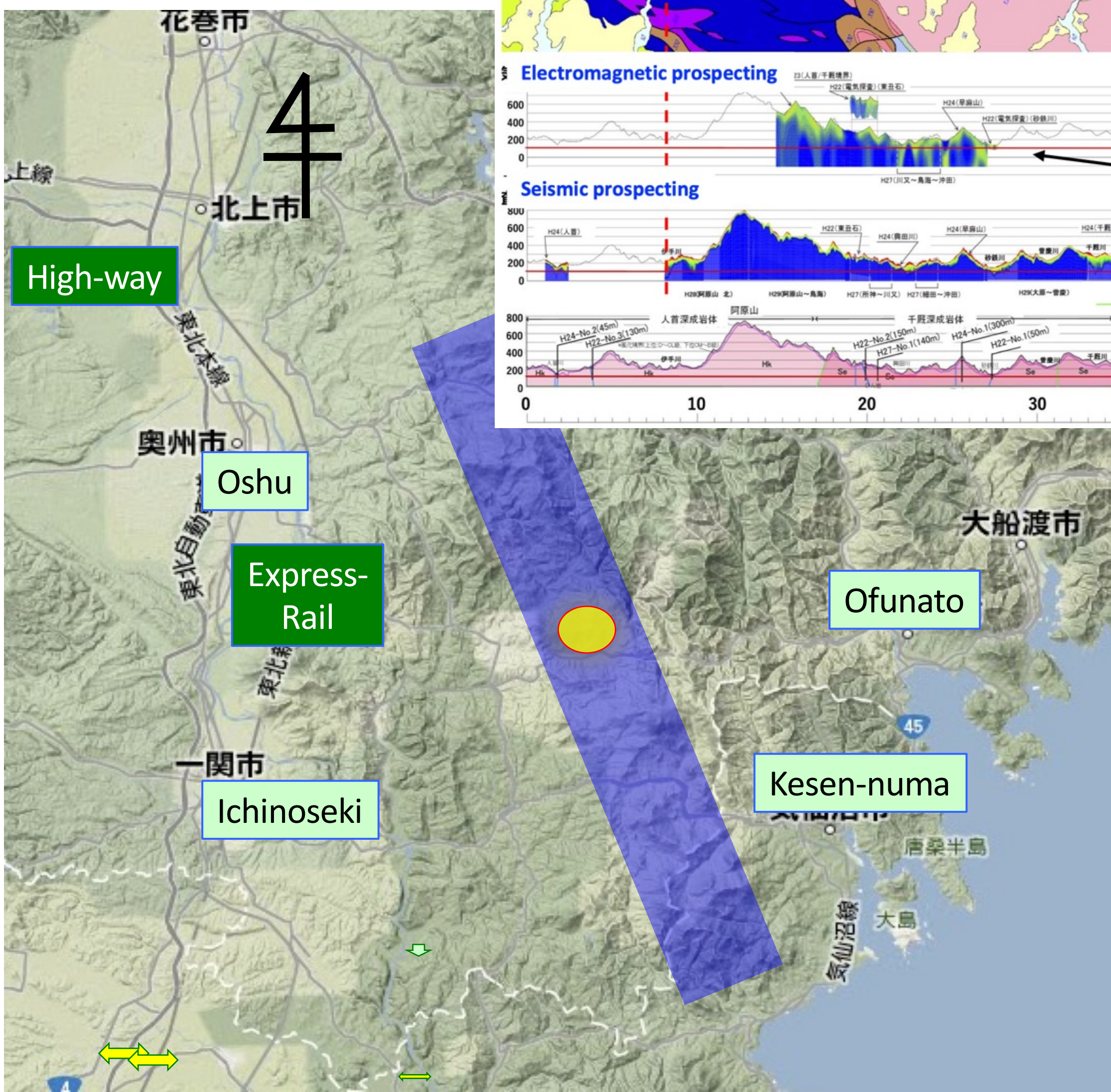


- The technical preparation document was reviewed by the international review committee (chair:Tor Raubenheimer (SLAC)).
- The total global cost of the project is about 60 MILCU and about 360 FTE-year. (This does not include the cost of the infrastructure for the WPs.)
- The cost will be shared internationally as in-kind contribution.

ILC Site Candidate Location in Japan: Kitakami



- **Continuous granite region**
  HITOKABE, SENMAYA and **ORIKABE** bedrock
- **Have capability to extend the ILC up to 50 km in future**
- **Boring geological survey**
  → Direct sampling down to the accelerator depth
- **Electromagnetic prospecting**
  → Cracks in the rock
- **Seismic prospecting**
  → Rock hardness



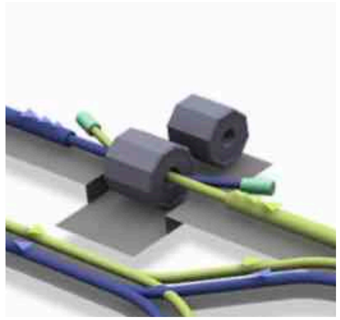
Tohoku ILC Project Development Center is established

Director Atsuto Suzuki

Toward zero CO2 emission : Green ILC

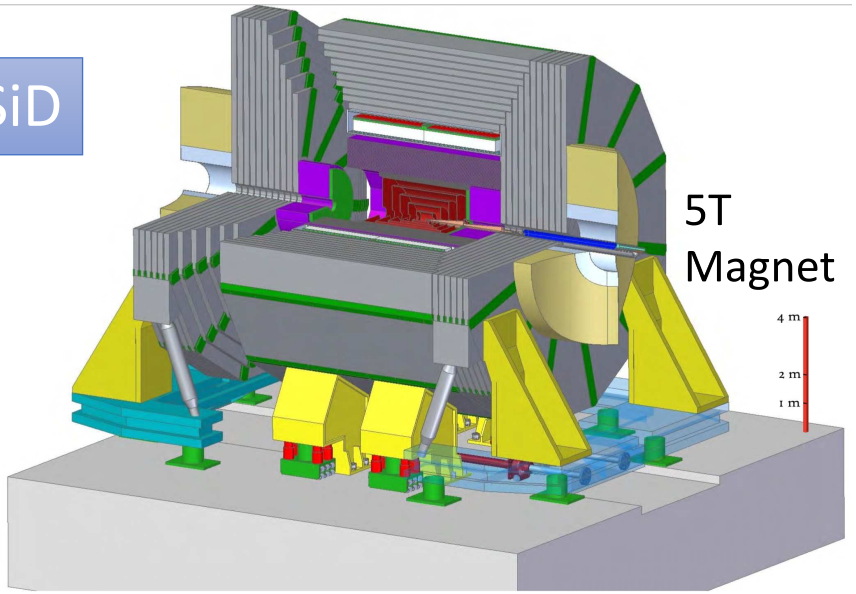
[2] Detectors

Two detectors are proposed



The similar Performance is obtained in both detectors
Significantly improved from the LHC detectors

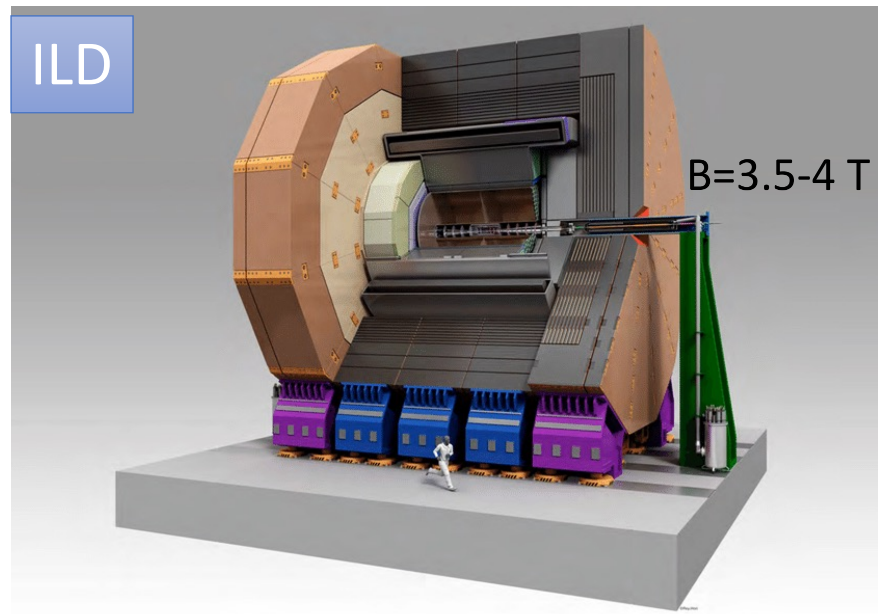
SiD



5T Magnet

Based on the Silicon pixel and strip detectors (except for HCAL)

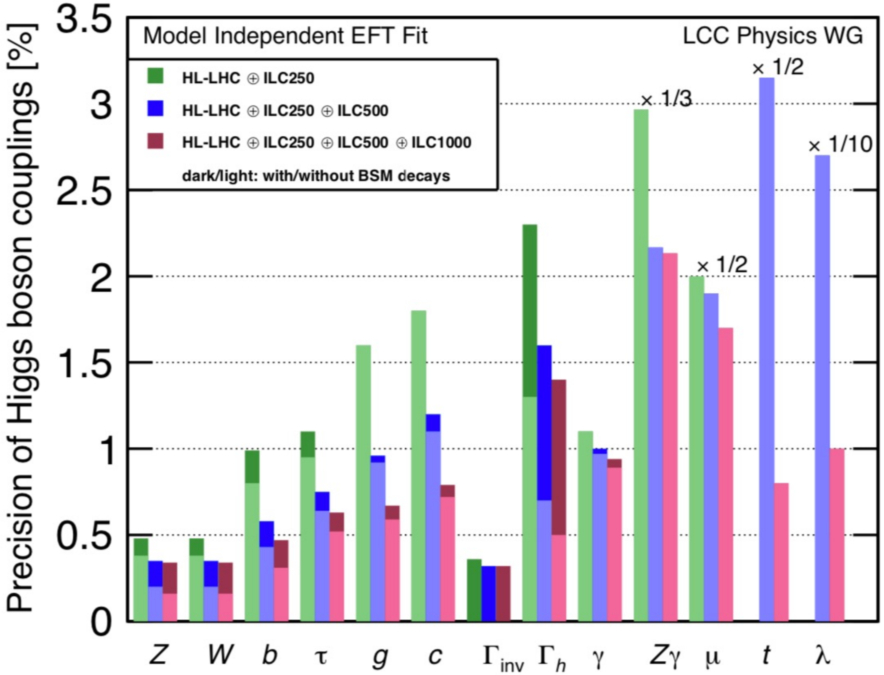
arXiv:2110.09965



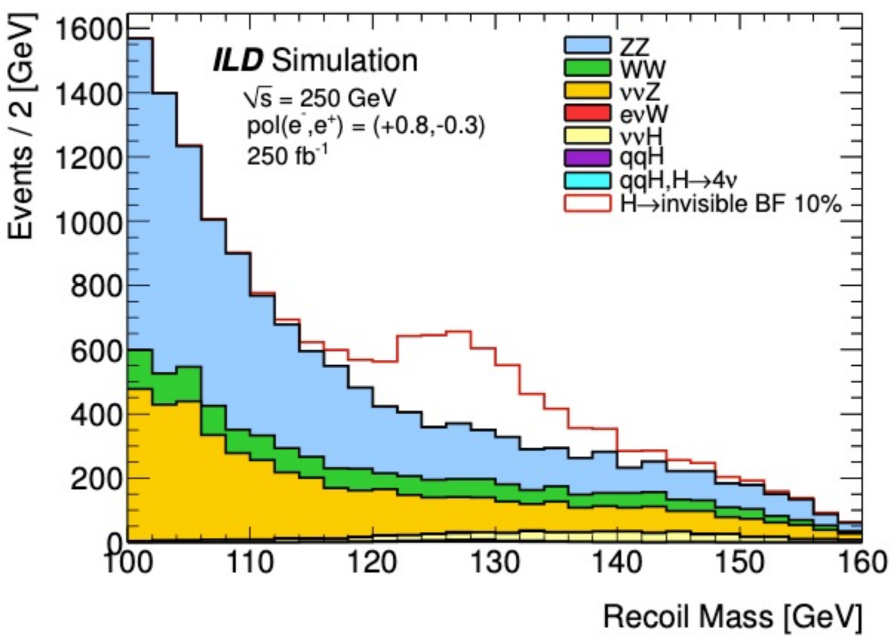
TPC/High Granularity Calorimeter
Readout Cell numbers is as larger as by factor 1000 of LHC

arxiv:2003.01116

[3] Physics Higgs Factory



arXiv:1908.11299

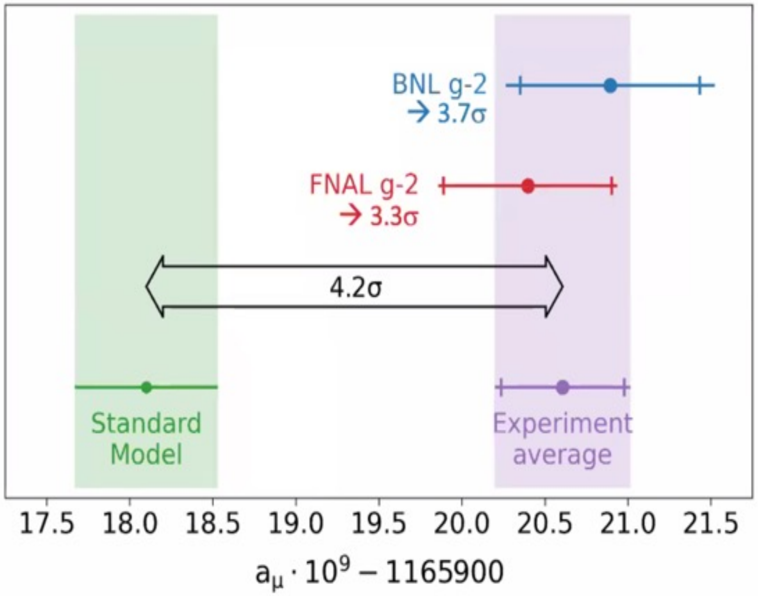


Higgs coupling can be measured precisely
Accuracy is about 1%
No necessary mention here

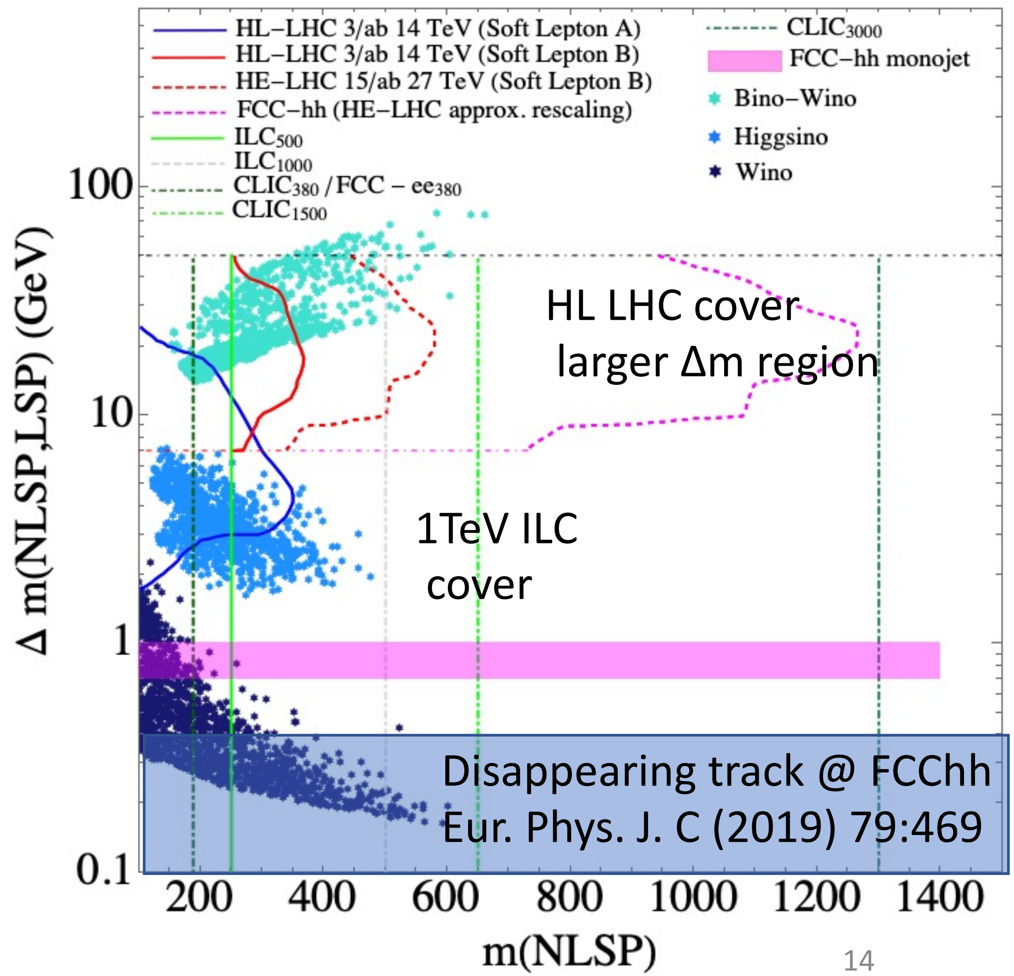
This show recoil mass distribution,
We can detect Higgs -> invisible
Higgs portal DM is interesting topics

Extendability of ECM is also important

Anomaly in muon g-2 is confirmed.



arXiv:2103.13403

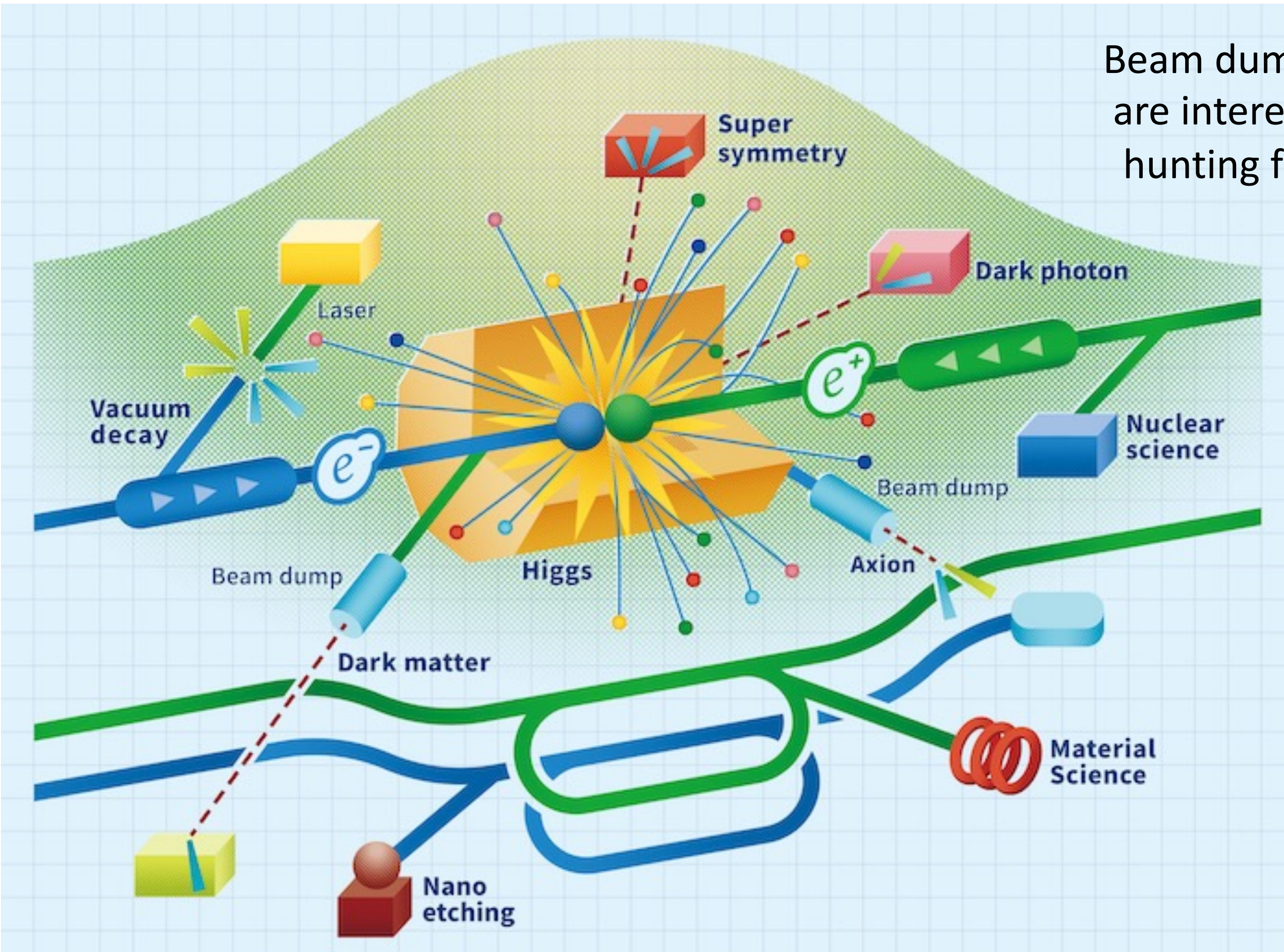


Light SUSY (color-single SUSY)
particles are expected ~< 500GeV
(Neutralino, chargino, slepton)

With DM/LHC constraint
degenerate case is expected.

[4] Diversities /applications

Higgs Factory / high energy colliders are very important for us;
But diversities and applications are important for faculity

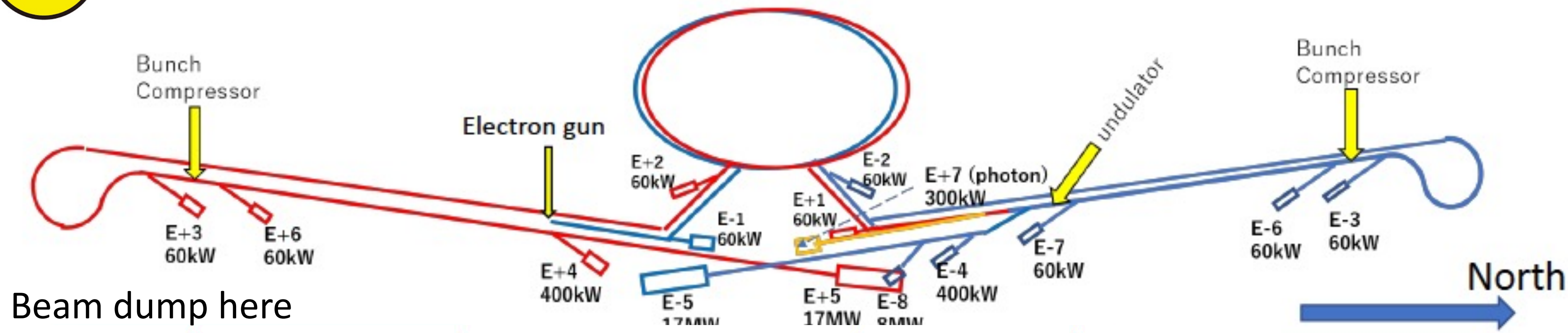


Beam dump experiments
are interesting
hunting for Axion / Paraphoton

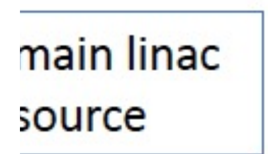
Light Source
Laser/XFEL
Nuclear Phys.
Material
Nano beam

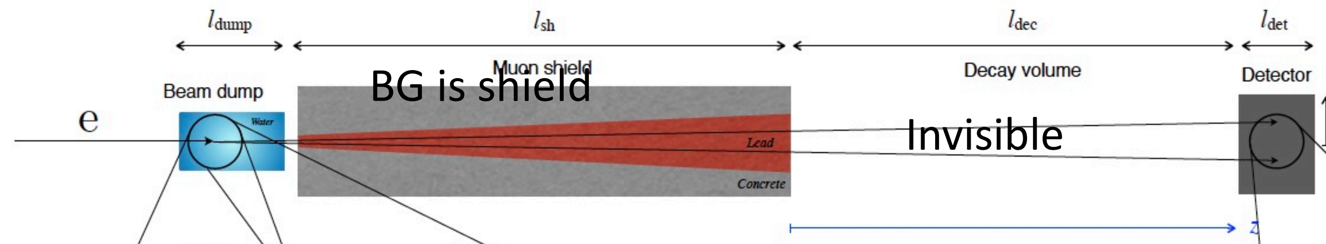
Various
proposals
are welcome

Beam dump experiment ALPs



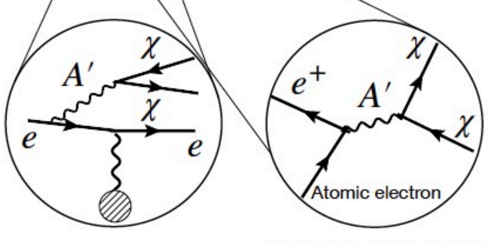
Beam dump here

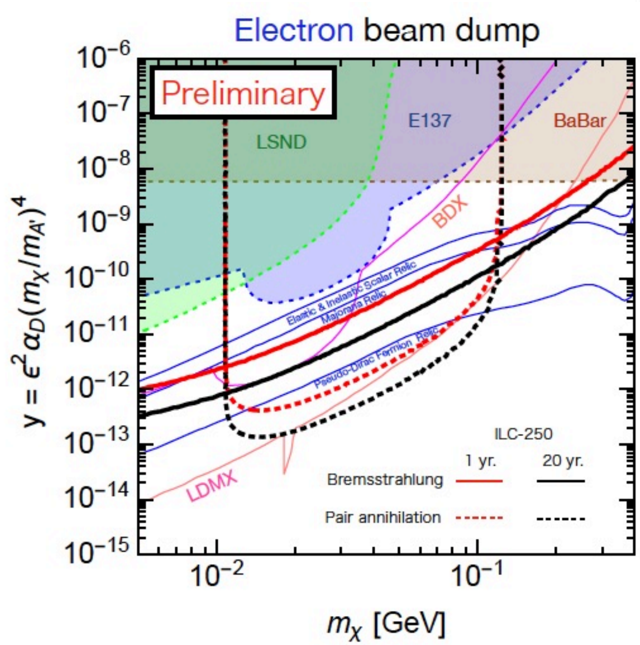


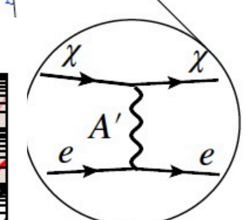


BG is shield

Invisible







Scatter @ detector

Many electron/positron
we can use

$$N_{\rm EOT} = 4 \times 10^{21}/\text{year}$$

Interesting
region for DM
can be covered.

[5] IDT and Milestone

Stage 1 International Development Team (~1.5 years)

Stage 2 ILC Pre-Laboratory (4 years)

Stage 3 ILC Laboratory (10 years for construction)

Stage 4 Experiment at ILC!

ILC is the big international project
Pre-Lab Phase is necessary before construction.

Boss is Nakada-san

ICFA

ILC International Development Team

International Org.

Executive Board

Americas Liaison	Andrew Lankford (UC Irvine)
Working Group 2 Chair	Shinichiro Michizono (KEK)
Working Group 3 Chair	Hitoshi Murayama (UC Berkeley/U. Tokyo)
Executive Board Chair and Working Group 1 Chair	Tatsuya Nakada (EPFL)
KEK Liaison	Yasuhiro Okada (KEK)
Europe Liaison	Steinar Stapnes (CERN)
Asia-Pacific Liaison	Geoffrey Taylor (U. Melbourne)

Working Group 1
Pre-Lab Setup

Working Group 2
Accelerator

Working Group 3
Physics & Detectors

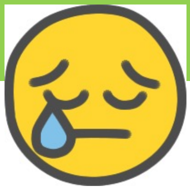
International Development Team (IDT) is established by ICFA

***IDT:** to prepare for smooth transition to the ILC Pre-lab*

- Prepare a proposal for the organization and governance of the ILC Pre-Lab
- Prepare the work and deliverables of the ILC Pre-laboratory and workout a scenario for contributions with national and regional partners

Accelerator : Michizono-sab
Physics: Murayama-san

Prelab is linked to approval of ILC



Yamauchi-san asked patiently MEXT to go PreLab

Message from MEXT (March 2021)

Message given by the MEXT Minister

- The ILC project needs to resolve its various challenges including its international cost sharing and technical feasibility, as well as to obtain broad internal and external cooperation not for its pre-laboratory but for the ILC project itself.

- Under the current situation that the perspective of broad internal and external cooperation for the ILC project itself as well as its pre-laboratory is not promised, it is difficult to obtain the people's understanding in Japan for investing the pre-laboratory. It is necessary to obtain the clear perspectives on financial contributions to the ILC project itself from the US and European countries in prior considering the pre-laboratory."

Three keys to move ILC forward given by MEXT:

1. Technical feasibility (← Prelab)
2. International cost sharing (← Governments, IDT, Phys. community)
3. Broad consensus in Japan (← Japanese phys. community)

From Slide Yamauchi-san @ ILCX

The Expert Panel (By MEXT) is ongoing

MEXT starts "Expert Panel" for 3 key points

It is OPEN meeting

1st (29th July)

Introduction and decide **discussion points** in members

2nd (14th October)

1. Introduction and Physics (T. Mori and H. Murayama)
2. Technology development and cost estimation for Accelerator (S. Michizono)
3. PreLab proposal from IDT (T. Nakada)

3rd (18th October)

1. Technology development and cost estimation for Civil (N. Terunuma)
2. Academic worth and Support from the other academia (S. Asai)
3. International collaboration and cost sharing (M. Yamauchi)
4. Human resource / Project Promotion (Y. Okada)

4th (End of Nov decided)

Answers/Discussions for questions from Panel members

1 or 2 more meetings we will have in this year.
The final report will be prepared in Jan. – March. 2022

All of you frustrate to Japanese Gov. MEXT

There are two serious problems to move Pre-Lab soon (By MEXT)

1) International discussion is low key
2) Which Budget? Not clear -> academic communities strongly against ILC
   They afraid budget cut for the other projects, if ILC go.

Not official statement
Just My Opinion

MEXT considers ILC is the same as "ITER"

A) International Lab. -> Cost sharing negotiations are very tough.
   MEXT is low key, many counties also low key.
B) If Japan shows initiative -> shortage of cost should be covered by MEXT?
   (In ITER, Int, treaty is used to collect budget, but does not work)
C) No strong Leadership in Government -> Budget is not clear

ITER is trauma for MEXT

But MEXT requires us
ILC has to have the International and domestic framework similar to ITER.
Otherwise we can not solve these problems.

[6] Strategy

ILC-Japan

MEXT. Diet Federation of ILC

New Organization of ILC Promotion in Japan from April 2021: I becomes spokesperson.

① Tight cooperation

Supporting organizations

AAA

Tohoku ILC

Support

ILC Japan

Spokesperson

Task forces

Phys. WG

Future Technology

Japanese high energy physics community establishes "ILC Japan" as a core of the ILC promotion in Japan. The ILC Japan represents the Japanese research community in ILC promotion, and will work with KEK to promote ILC in a responsible way.

International Physics Community

ICFA

IDT

Partici-pation

Coopera-tion

KEK

High Energy Accelerator Research Organization

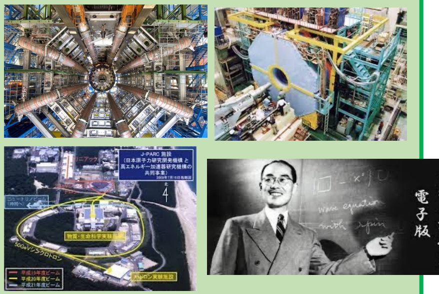
ILC Steering Committee

ILC Promotion Office

Partici-pation

Coopera-tion

Japan Association of High Energy Physicists



ILC Steering Panel

Other Academic Communities in Japan

② Human resource flow from the other projects

③ Discussion with other academic communities.

Plan/Strategy to realize ILC is modified

Stage 1 International Development Team

Stage 1.5 Transition phase to the Pe-lab: Some work packages start and intergovernmental discussion in parallel (a few years)

Stage 2 ILC Pre-Laboratory (4 years) and intergovernmental negotiation

Stage 3 ILC Laboratory (10 years for construction)

Stage 4 Experiment at ILC!

Adiabatic Approach is planed with KEK / IDT EB
During the IDT Pre-lab transition phase,
we should try
1) Sizeable budget in Japan
2) Start some of the accelerator Pre-lab packages
3) Boost up international talks at Government level
to increase the confidence and trust among the partners

For 3)
Continued interaction with their governmental authorities by the international communities is important

Summary

1) ILC is the most cost effective and technically matured program for the Higgs Factory.
2) IDT proposes Pre Lab to move the next step
3) Problems in MEXT becomes more clear
4) To solve these problems, adiabatic approach is proposed.
5) During the transition phase, support from MEXT and laboratories from many countries are important
   to start accelerator park packages.
6) R&D of accelerator is on going and well-established welcome to join the work packages
7) Detector preparation(SiD&ILD) are also on going
   strongly encourage to join
   New idea is also welcome

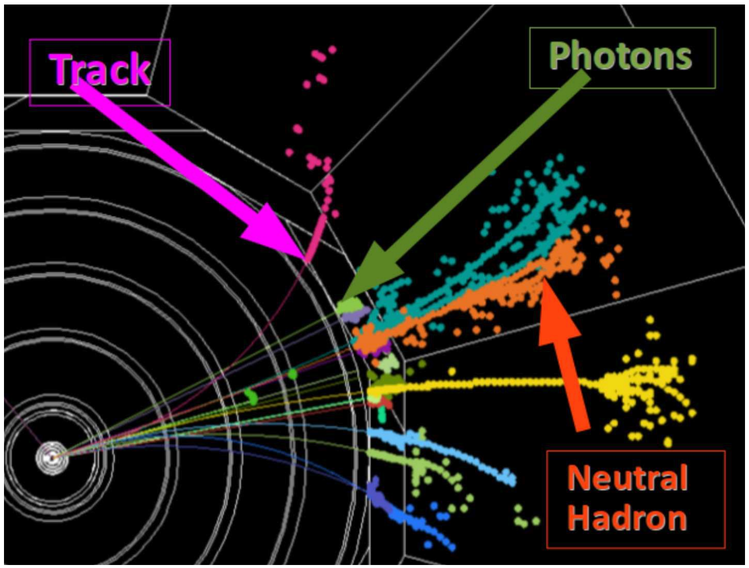
Backup

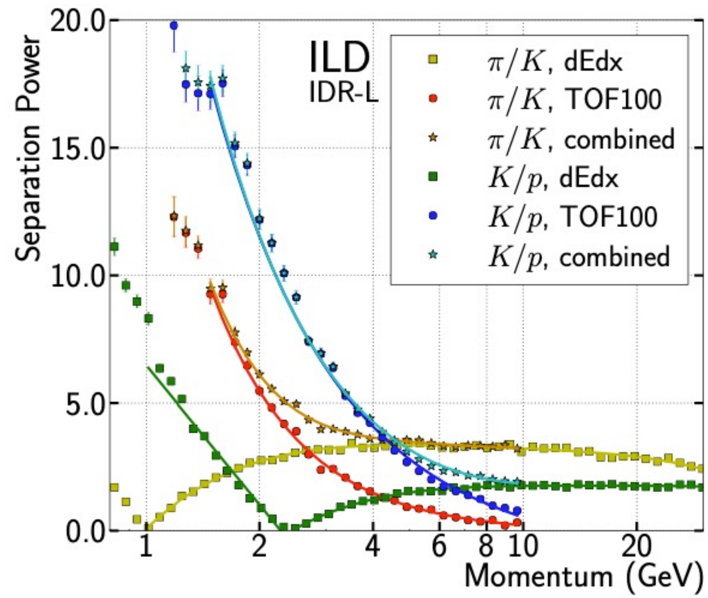
Detector Proposal

tracker: $\sigma_{1/p_T} \approx 2 \times 10^{-5}$ (GeV)
ECAL: $\sigma_E/E \approx 15\% / \sqrt{E}$ (GeV)
HCAL: $\sigma_E/E \approx 60\% / \sqrt{E}$ (GeV)

Tracking resolution is factor 10 improved
Calorimetry for jet resolution is improved by factor 3

Particle Flow technique



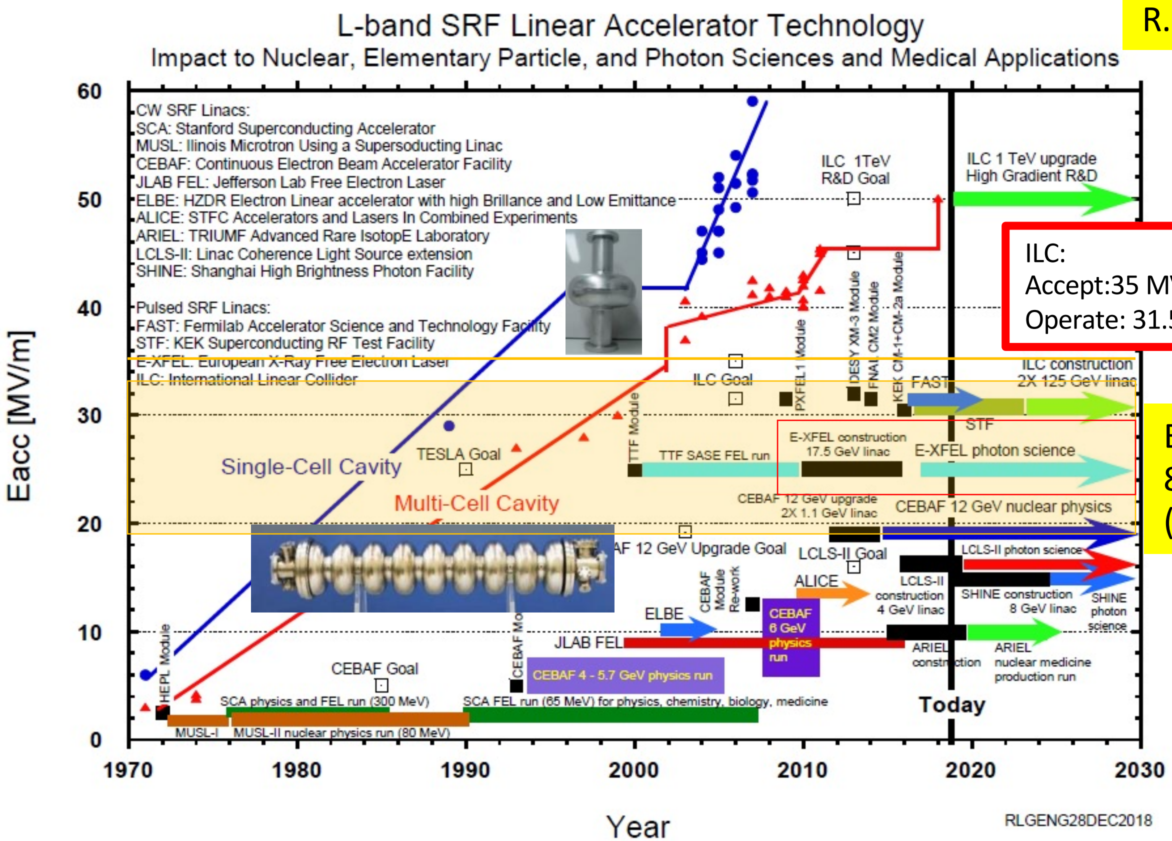


- Basic Design of both SiD& ILD is ready
  more optimization is necessary (Welcome to Join !!!)

PID is possible with TPC(ILD)

→ Time schedule depends on ILC decision.
→ Both Detectors are still OPEN for New Idea (Welcome)

Matured SRF technologies



R. Geng (JLAB)

ILC:
Accept:35 MV/m +/-20%
Operate: 31.5MV/m +/-20%

European XFEL
800 cavities
(10% of ILC ML)