Status of the ILC project and news from LCWS'2021

Aleksander Filip Żarnecki

High Energy Physics seminar
Faculty of Physics, University of Warsaw
March 19, 2021

Outline

- History of the ILC project
- ILC after European Strategy Update 2020
  - International Development Team
  - Activities in Japan
- Selected highlights from LCWS'2021
  - Accelerator design
  - Detector studies
  - Physics prospects
- Our results @ LCWS'2021
- Conclusions

History of the ILC project

Brief ILC History

- Late 1980s and 1990s:
  - Next Linear Collider:
    - SLAC/KEK warm RF designs
    - NLC detector group
  - TESLA:
    - European superconducting RF design
    - ECFA-DESY physics/detector studies →
      - **1st ECFA/DESY study: 1996/97**
      - **2nd ECFA/DESY study: 1998/2000**
      - **Extended Joint ECFA/DESY study: 2001/2003**
      - **ECFA study: 2003/2005**
  - + World-Wide Study of Physics & Detectors

  → **International Linear Collider Workshops organized starting 1991**

- 2000s:
  - Snowmass 2001
  - HEPAP recomendation 2002
  - **"Understanding Matter, Energy, Space and Time: The Case for the e+e- Linear Collider" 2003**

TESLA TDR: 2001

GLC Project Report: 2003

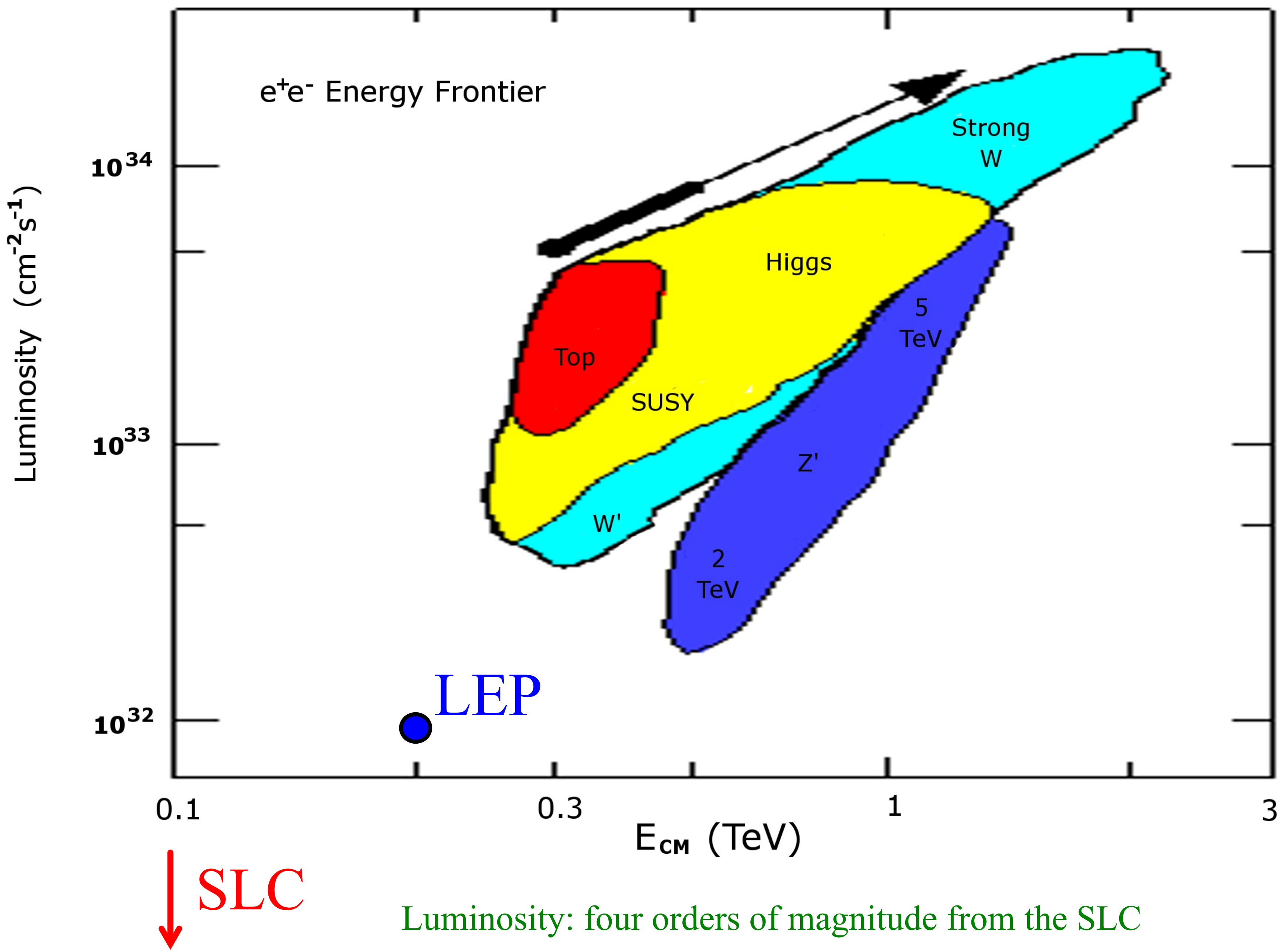
Physics motivation

Physics programme for the ILC depends on what appears at LHC but interesting scenarios can be considered in each case.

- *top measurements*
- *light "Higgs" measurements*
- *new particles (SUSY ?)*
- *precision measurements*

Should be found at LHC
studied at ILC

The energy and luminosity challenges for a future e+e- linear collider:



Luminosity: four orders of magnitude from the SLC


Higgs
Higgs
Higgs

If there is a light Higgs of any kind, seen or unseen at LHC, ILC will:

- *see it,*
- *measure its precise mass,*
- *measure its total and partial widths (BRs), determine its couplings to other particles,*
- *measure its spin and parity,*
- *measure Higgs selfcoupling.*

Many different scenarios have been investigated...

An Optimistic Conclusion: PDG 2016 ?

GAUGE AND HIGGS BOSONS

H

$J^{PC}=0^{++}$ [a]

Charge = 0

Mass m=120.0±0.040 GeV [b]

Full Width Γ =3.6±0.2 MeV[a]

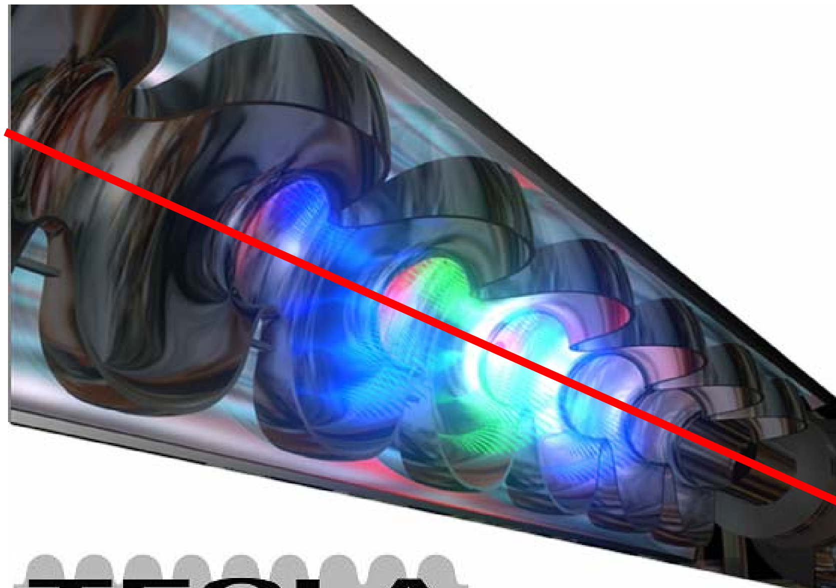
H DECAY MODES[b]	Fraction
bb	(67.8 ±1.6) %
cc	(3.08 ± 0.25)%
ττ	(6.8 ±0.35)%
gg	(7.04 ± 0.5)%
γγ	(0.21 ±0.0 5)%
WW	(13.3 ± 1.3)%

SUMMARY TABLES OF PARTICLE PROPERTIES
Extracted from the Particle listings of the
Review of Particle Physics
Published in Eur. Jour. Phys **C3**, 1 (2014)
Available at http://www.eilamgross.com

Like the Z boson measurements at LEP

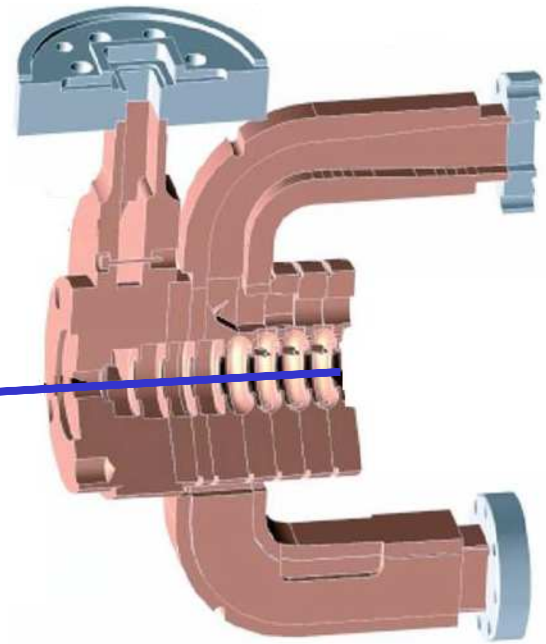
[a] LC, [b] LC/LHC

Competing technologies



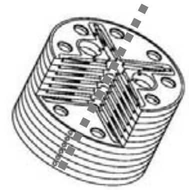
TESLA

1.3 GHz - Cold



NLC JLC

11.4 GHz - Warm



CLIC

30 GHz-Warm

The Recommendation

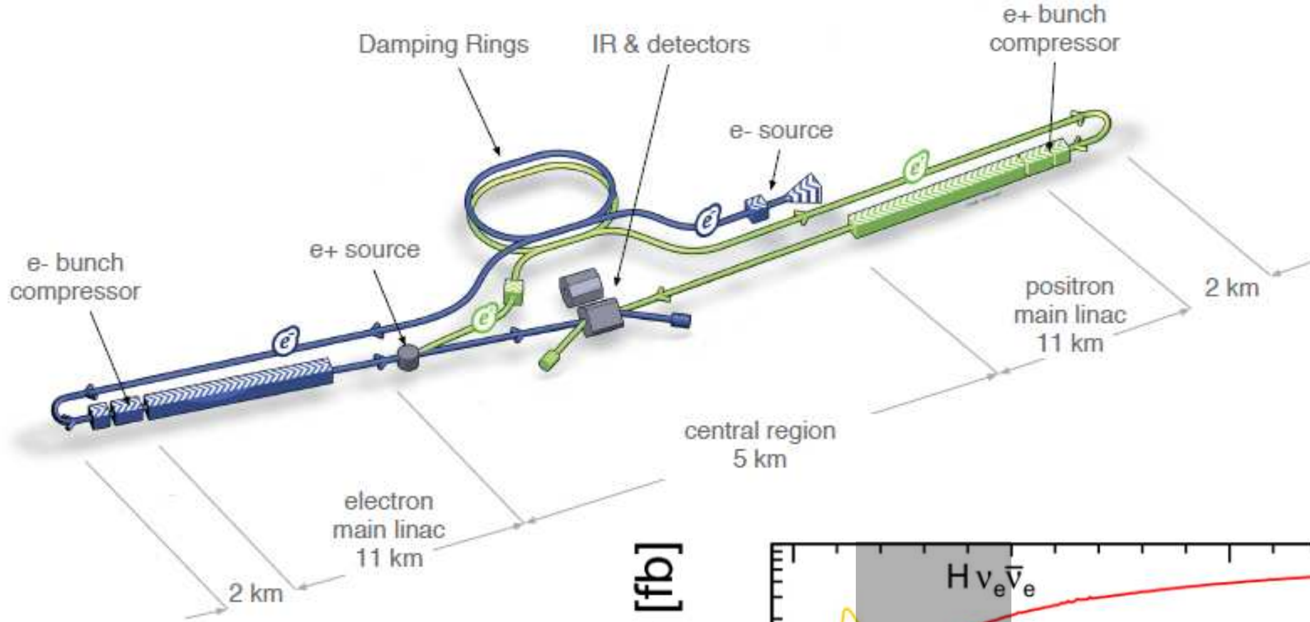
- **We recommend that the linear collider be based on superconducting rf technology (from Exec. Summary)**
  - **This recommendation is made with the understanding that we are recommending a technology, not a design. We expect the final design to be developed by a team drawn from the combined warm and cold linear collider communities, taking full advantage of the experience and expertise of both (from the Executive Summary).**
  - **We submit the Executive Summary today to ILCSC & ICFA**
  - **Details of the assessment will be presented in the body of the ITRP report to be published around mid September**
  - **The superconducting technology has features that tipped the balance in its favor. They follow in part from the low rf frequency.**

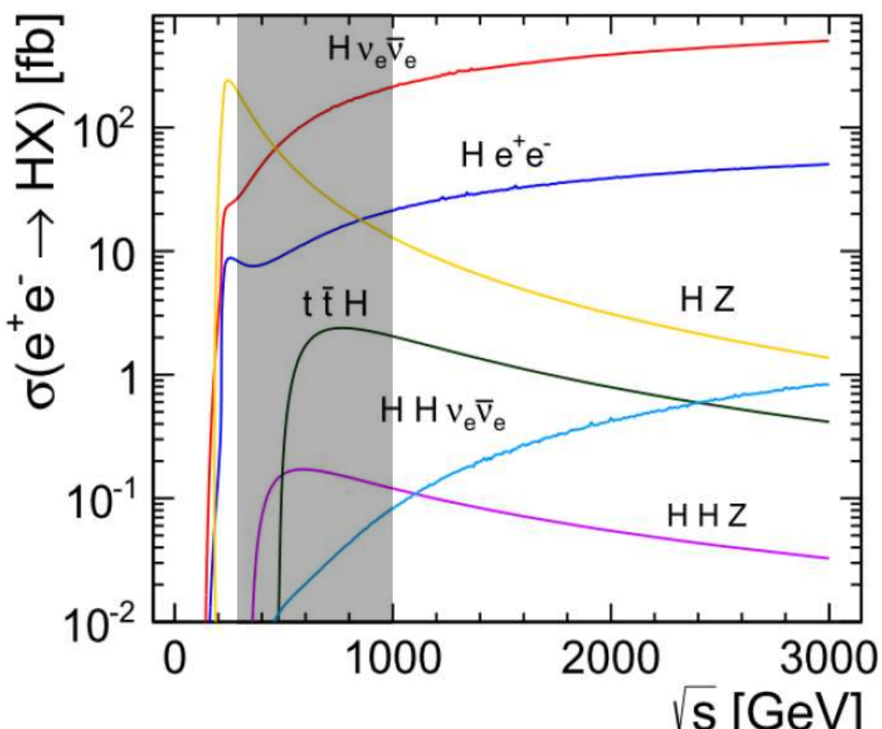
Some of the Features of SC Technology

- **The large cavity aperture and long bunch interval reduce the complexity of operations, reduce the sensitivity to ground motion, permit inter-bunch feedback and may enable increased beam current.**
- **The main linac rf systems, the single largest technical cost elements, are of comparatively lower risk.**
- **The construction of the superconducting XFEL free electron laser will provide prototypes and test many aspects of the linac.**
- **The industrialization of most major components of the linac is underway.**
- **The use of superconducting cavities significantly reduces power consumption.**

Both technologies have wider impact beyond particle physics. The superconducting rf technology has applications in other fields of accelerator-based research, while the X-band rf technology has applications in medicine and other areas.

ILC : e^+e^- Linear Collider at 250 GeV < $\sqrt{s}$ < 1000 GeV





LINEAR COLLIDER COLLABORATION

GDE Timeline

2005 2006 2007 2008 2009 2010 2011 2012 2013 2014

LHC physics

GDE

LCC

Reference Design Report (RDR)

Tech. Design Phase (TDP) 1

TDP 2

TDR published

~250 FTE per year (avg)

~2,000 MY (→ ~5,000 if pre-GDE included)

~300 M$ globally

Global Event
June 12

Tokyo CERN Fermilab

The committee makes the following recommendations concerning large-scale projects, which comprise the core of future high energy physics research in Japan.

- **Should a new particle such as a Higgs boson with a mass below approximately 1 TeV be confirmed at LHC, Japan should take the leadership role in an early realization of an e^+e^- linear collider.** In particular, if the particle is light, experiments at low collision energy should be started at the earliest possible time. In parallel, continuous studies on new physics should be pursued for both LHC and the upgraded LHC version. Should the energy scale of new particles/physics be higher, accelerator R&D should be strengthened in order to realize the necessary collision energy.
- **Should the neutrino mixing angle θ_{13} be confirmed as large, Japan should aim to realize a large-scale neutrino detector through international cooperation, accompanied by the necessary reinforcement of accelerator intensity, so allowing studies on CP symmetry through neutrino oscillations.** This new large-scale neutrino detector should have sufficient sensitivity to allow the search for proton decays, which would be direct evidence of Grand Unified Theories.

It is expected that the Committee on Future Projects, which includes the High Energy Physics Committee members as its core, should be able to swiftly and flexibly update the strategies for these key, large-scale projects according to newly obtained knowledge from LHC and other sources.

It is important to complete and start the SuperKEKB including the detector, as scheduled. Some of the medium/small scale projects currently under consideration have the implicit potential to develop into important research fields in the future, such as neutrino physics and as such, should be promoted in parallel to pursue new physics in various directions. Flavour physics experiments such as muon experiments at J-PARC, searches for dark matter and neutrinoless double beta decays or observations of CMB B-mode polarization and dark energy are considered as projects that have such potential.

July 4, 2012

- First day of ICHEP 2012 (International Conference on High Energy Physics), Melbourne, Australia
- Specially timed CERN Seminars by ATLAS and CMS Experiments
- Both experiments announced discovery of a new particle

CERN, Geneva, Switzerland

Melbourne, Australia

CERN Courier

A Proposal for a Phased Execution of the International Linear Collider Project

In March 2012, the Japan Association of High Energy Physicists (JAHEP) accepted the recommendations of the Subcommittee on Future Projects of High Energy Physics[1] and adopted them as JAHEP's basic strategy for future projects. In July 2012, a new particle consistent with a Higgs Boson was discovered at LHC, while in December 2012 the Technical Design Report of the International Linear Collider (ILC) will be completed by a worldwide collaboration.

On the basis of these developments and following the subcommittee's recommendation on ILC, JAHEP proposes that ILC be constructed in Japan as a global project with the agreement of and participation by the international community in the following scenario:

(1) Physics studies shall start with a precision study of the "Higgs Boson", and then evolve into studies of the top quark, "dark matter" particles, and Higgs self-couplings, by upgrading the accelerator. A more specific scenario is as follows:

(A) A Higgs factory with a center-of-mass energy of approximately 250 GeV shall be constructed as a first phase.

(B) The machine shall be upgraded in stages up to a center-of-mass energy of ~500 GeV, which is the baseline energy of the overall project.

(C) Technical extendability to a 1 TeV region shall be secured.

(2) A guideline for contributions to the construction costs is that Japan covers 50% of the expenses (construction) of the overall project of a 500 GeV machine. The actual contributions, however, should be left to negotiations among the governments.

October, 2012 The Japan Association of High Energy Physicists

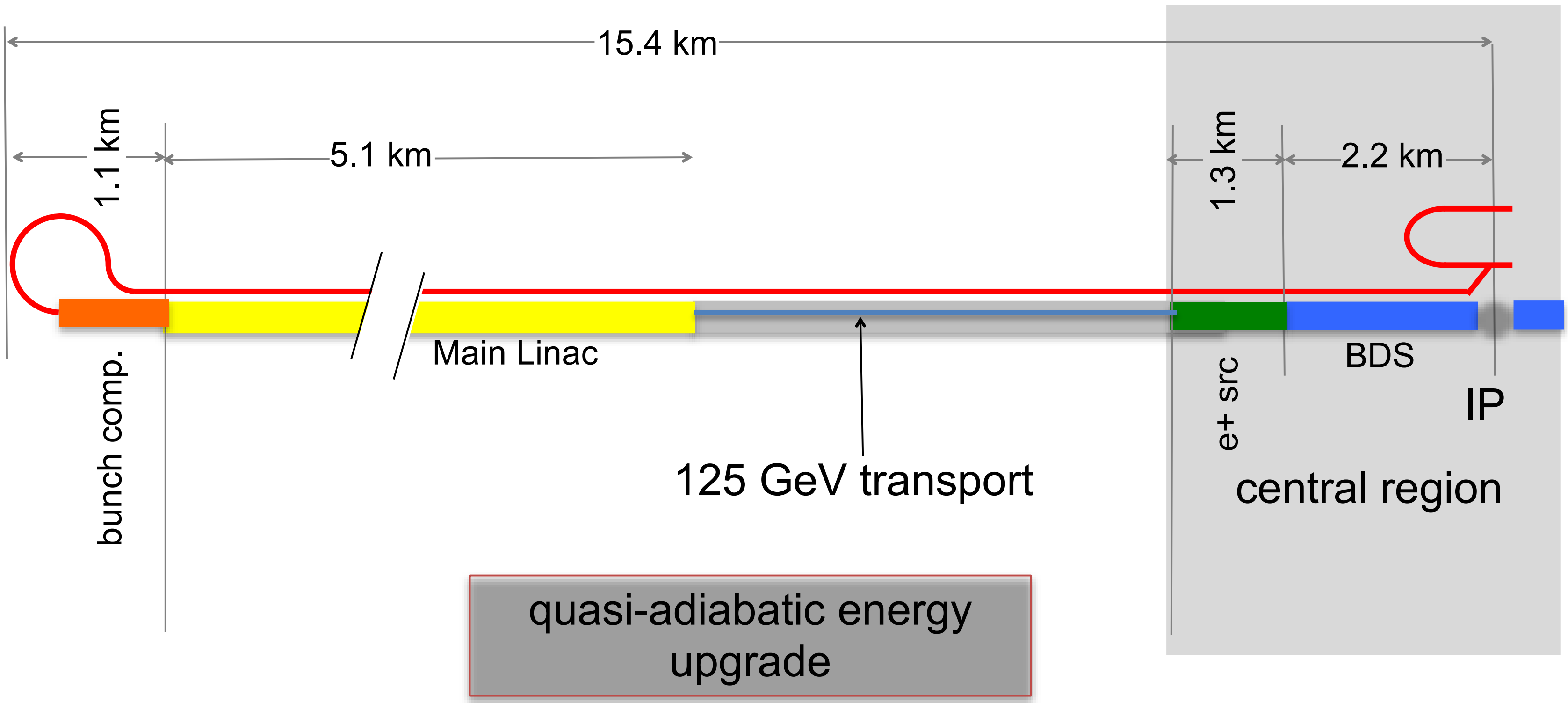
3 important points

TDR is ready now.
Technically Ready

ILC is a global Project.
Japan wish to play a important role as a Host.

ILC is not only Higgs Factory
Target is ～500GeV
and 1TeV extendability

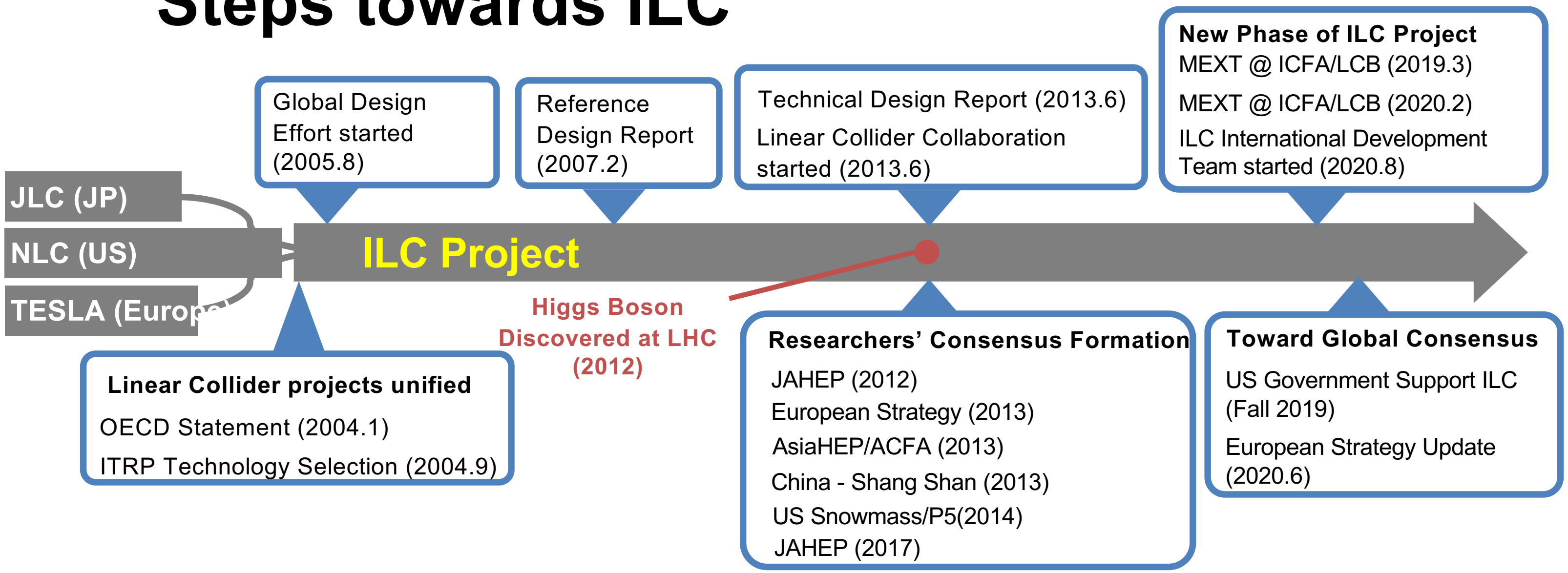
Staged construction: 250 GeV



- Complete civil construction for 500 GeV machine
- Install ~1/2 linacs for fist stage operation (and long transport line)
- Capital savings ~25%
- Adiabatic energy upgrade (lower rate cryomodule production)

Favoured by Japan

Steps towards ILC



In Japan, series of official assessments of ILC from the viewpoints of Academic Project has been done.

ILC-specific processes
2013 MEXT request Science Council of Japan (SCJ) to discuss
2014 SCJ report: Values, Issues, recommend MEXT to investigate
2014 MEXT advisory panel:
2017 JAHEP proposal of ILC to start from 250 GeV
2017 MEXT advisory panel for 250 GeV machine
2018 SCJ report: on 250 GeV machine

Regular process of academic large projects under SCJ
2019 SCJ master plan

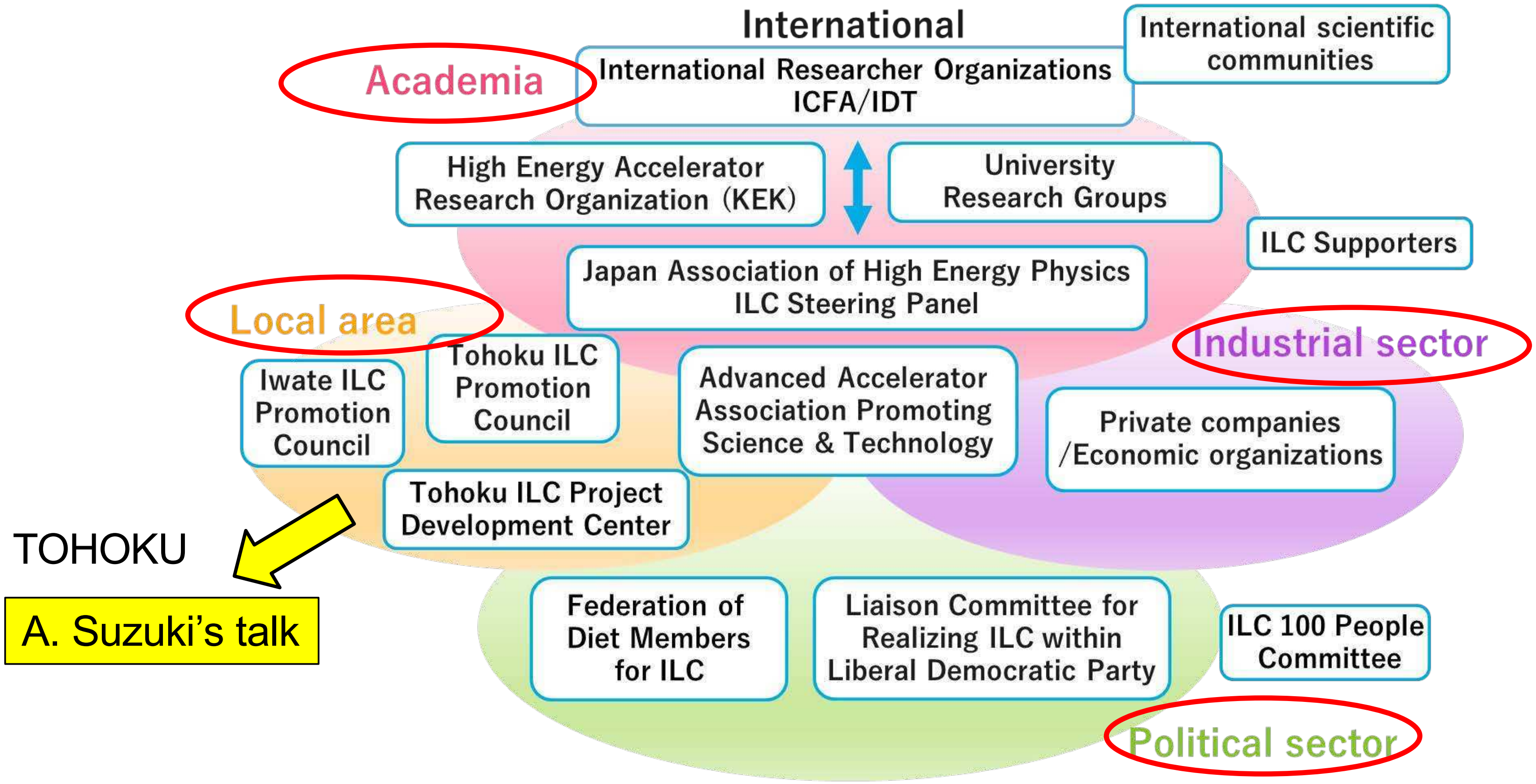
The academic value of the project has been evaluated to be high.

Main remaining issues (2018):

- Prospects of governmental-level International sharing of the cost and human resources.
- Technical issues especially for radiation safety (beam dumps)
- Issues to be solved in site-specific civil engineering design
- Further clarification of the importance of Higgs factory

Broad understanding among the public & understanding of other fields

Organizations Promoting ILC in Japan



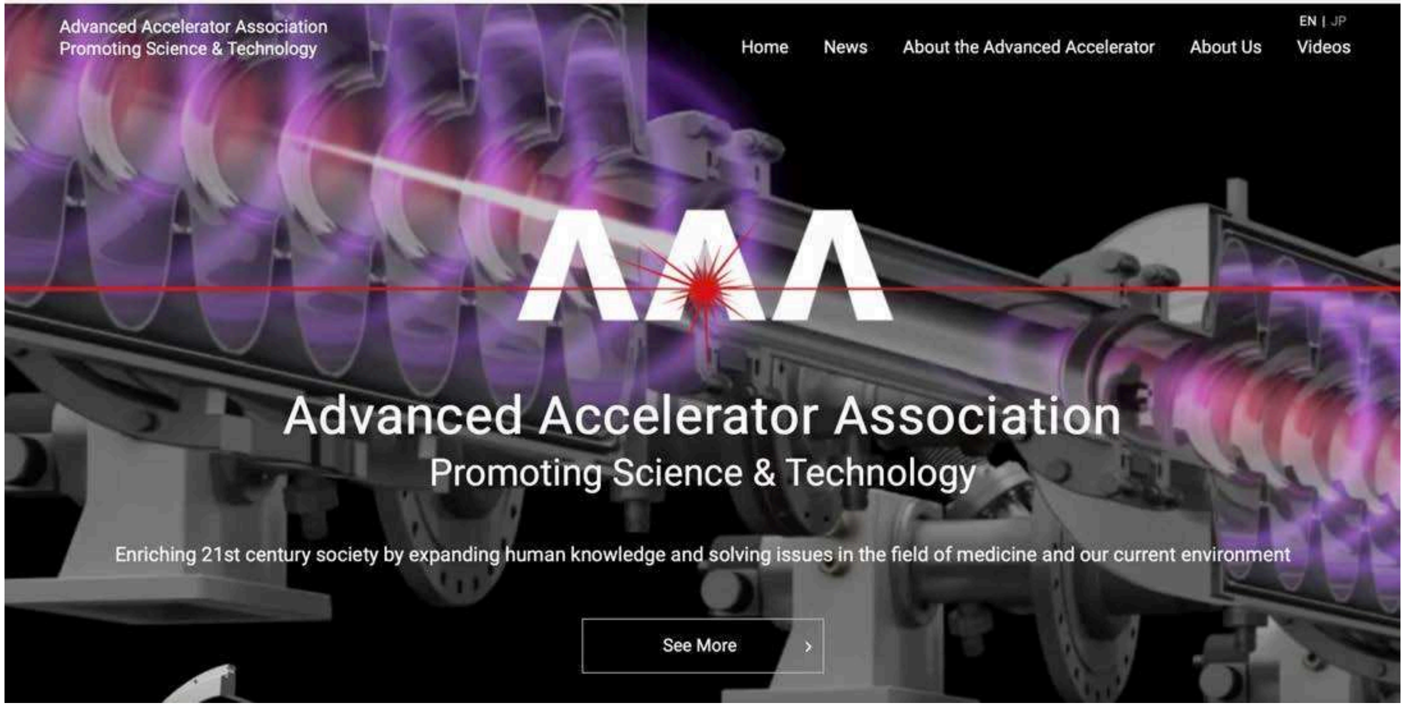
There are many organizations in Japan which are actively promoting the ILC project. Coordination of the various sectors are key to the realization of the ILC.

Advanced Accelerator Association Promoting Science and Technology (AAA)

Industry-Academia organization to promote ILC

Chair: Takashi Nishioka (Former MHI CEO and Chair of the Board)

Members: 112 companies
Supporting Members: 41 institutes (as of Feb. 2020)



Established in 2008 and be General incorporated association since 2014

https://aaa-sentan.org

Main Divisions

1. Project Promotion
2. Technology
3. Outreach

LCWS Industry Forum
AAA Secretary-General
Mr. Matsuoka's talk

AAA is the driving force to promote ILC in the industrial sector with academia,

led by large companies and research institutes in Japan.

Political Sector: Federation of Diet Members for the ILC

Over 100 members of National Diet of Japan

Founded in June 2006
with LDP members

Founder & First Chair
Hon. YOSANO Kaoru

July 2008: Became Multi-Party Federation

February 2013:
Hon. KAWAMURA Takeo becomes Chair

June 30, 2009, At Prime Minister's Office
ILC Seminar attended by 7 Ministers
(Lecture by Prof. M. Koshiba, 2002 Nobel Prize in Physics)

YOSANO Kaoru	Minister of Finance
NAKASONE Hirofumi	Minister of Foreign Affairs
KAWAMURA Takeo	Chief Cabinet Secretary
SHIONOYA Ryu	Minister of Education, Culture, Sports, Science & Technology
NODA Seiko	State Minister in Charge of Science & Technology Policy
NIKAI Toshihiro	Minister of Economy, Trade and Industry
KANEKO Kazuyoshi	Minister of Land, Infrastructure and Transportation
	(Position at the time)

The Federation of Diet Members for the ILC started with members of Liberal Democratic Party (LDP) and became a multi-party federation.

In 2009, during Prime Minister ASO Taro, an ILC Seminar was held at Prime Minister's Office building, which was attended by 7 Cabinet members.

Our current milestone is to reach this level again, which is important for the timely realization of ILC.

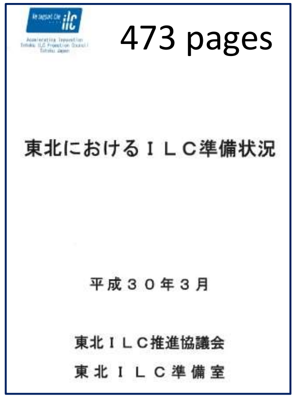
1. From Preparation to Construction Design/Plan for the ILC in Tohoku

June 14th, 2016

① Built : ILC Tohoku Preparation Office

Missions :

- Summarize key-issues required in the Tohoku region for the ILC project
- Foster full of motivation in the Tohoku region for constructing the ILC



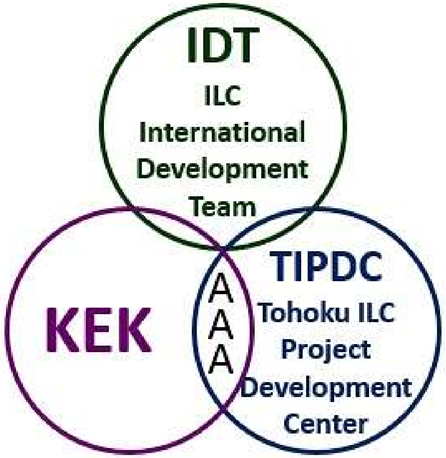
booklets of key-issues

August 6th, 2021

② Launched : Tohoku ILC Project Development Center (TIPDC)

Missions :

- Finalize regional detailed plans for the ILC Project
- Finalize local decision issues for constructing the ILC
- Take activities with a **closer link** to **IDT**, **KEK** and **AAA**

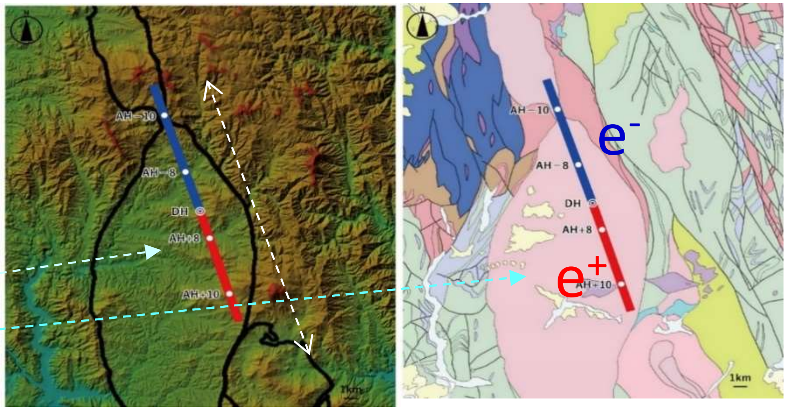


AAA: Advanced Accelerator Association promoting Science & Technology

2. Civil Engineering

① ILC Location

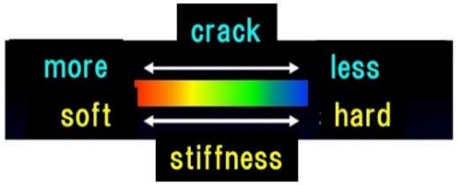
ILC accelerator area : inside the granite rock bodies
→ inside black curves (left)
→ in the pink color (right)
→ possible up to 50 km

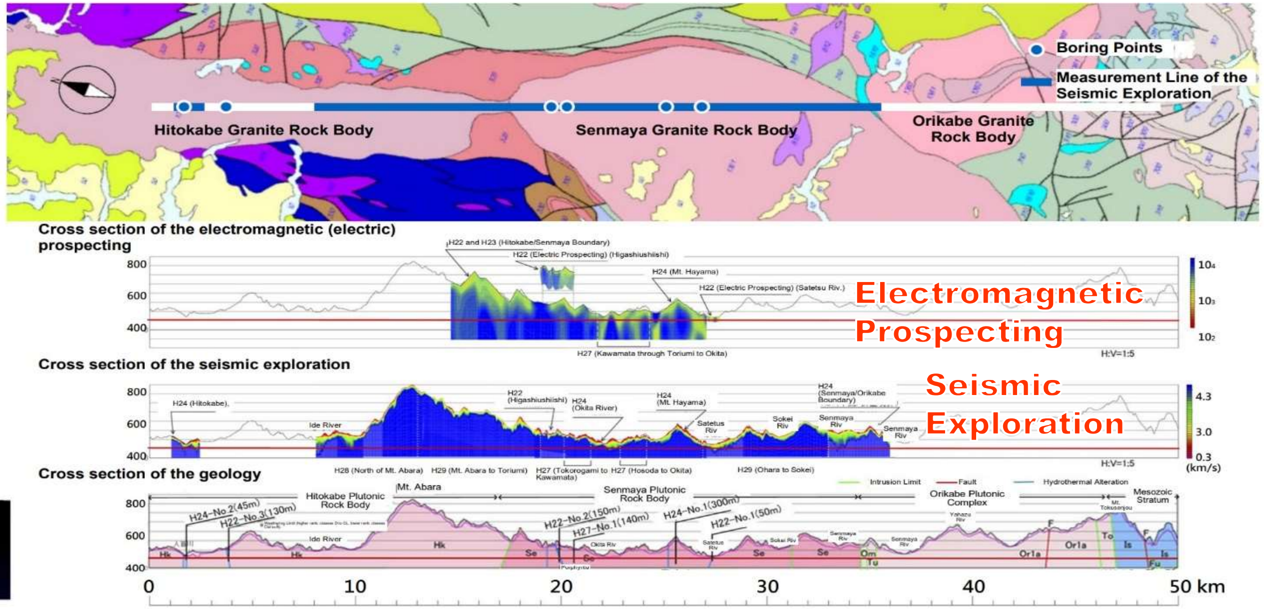


→ On-going jobs : Optimal accelerator placement, considering surface environment, land-use and land-acquisition

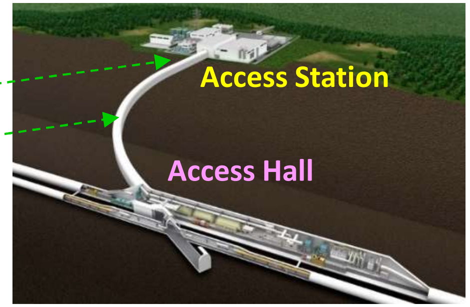
② Geological Surveys

- Electric Prospecting (crack)
- Seismic Exploration (stiffness)
- Boring Survey
- Borehole Camera
- Measurement of Initial Stress of the Ground





→ no issues from previous surveys
→ requiring : additional surveys around access tunnel head and access tunnel inside for detailed designing



5. Environmental Assessment

① Basic Policy

- Iwate/Miyagi Prefecture : Environmental Impact Assessment Act and the Environmental Impact Assessment Ordinance
- Ministry of the Environment : Strategic Environmental Assessment (SEA)

Evaluation items based on the characteristics of the ILC project

Environmental Items	Main environment	Air, water quality and hydrosphere, soil and ground
	Ecosystem	Biological growth and habitat, water cycle, organisms/ecosystems, greenery
	Living environment	Noise, traffic congestion, vibration, odor, communication disruption (radiointerference), overshadowing, radiation
	Amenities & culture	Landscape, nature activity sites, pedestrian comfort, historic and cultural sites
	Resources & waste	Water use, waste, and ecomaterials (oil-free)
	Greenhouse gas	Greenhouse gas, energy
Socio-Economic Items	Land use	Land use, regional fragmentation and relocation
	Social activities	Cultural activities
	Participation & collaboration	Communities, environmental awareness
	Safety, sanitation, security	Safety, sanitation, fire and disaster prevention
	Trafiic	Traffic congestion, access to public transportation, road safety
	Local industries	Agriculture, forestry and fisheries, commerce and industry, tourism
	Economy	Economic impact, employment

② Assessment Implementing Body

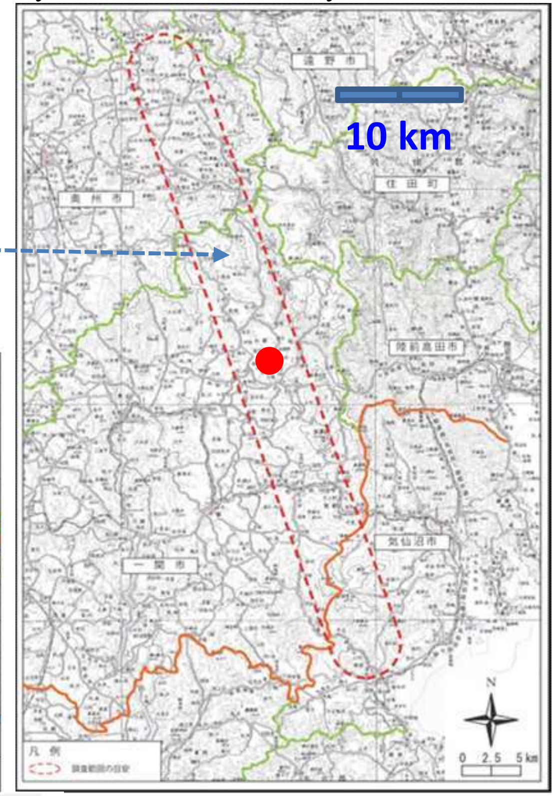
- Unit to implement the ILC facility plan
  = KEK → Pre-Lab. → ILC Lab.
  +
  Local Governments

③ Preparatory Survey by Local Government

Iwate Prefecture

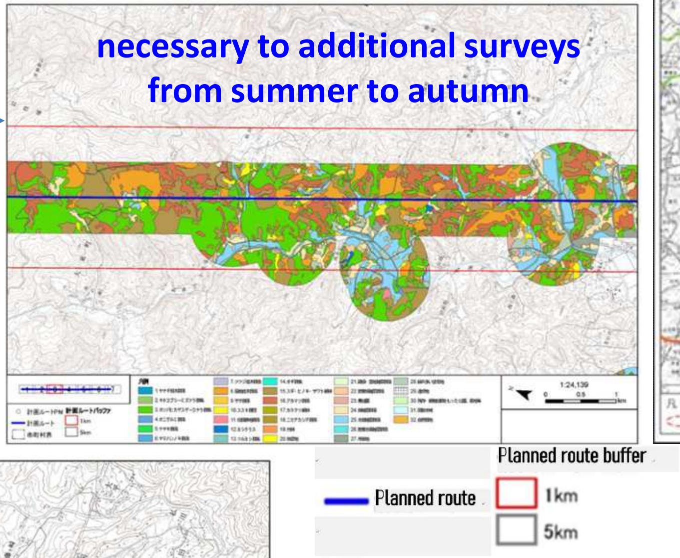
- carried out "Natural environment survey" related to the area of the ILC tunnel route
- formulated "Environmental impact assessment method (original draft)" that is expected to be carried out by the ILC implementing body

Surveyed Area surrounded by red dashed line

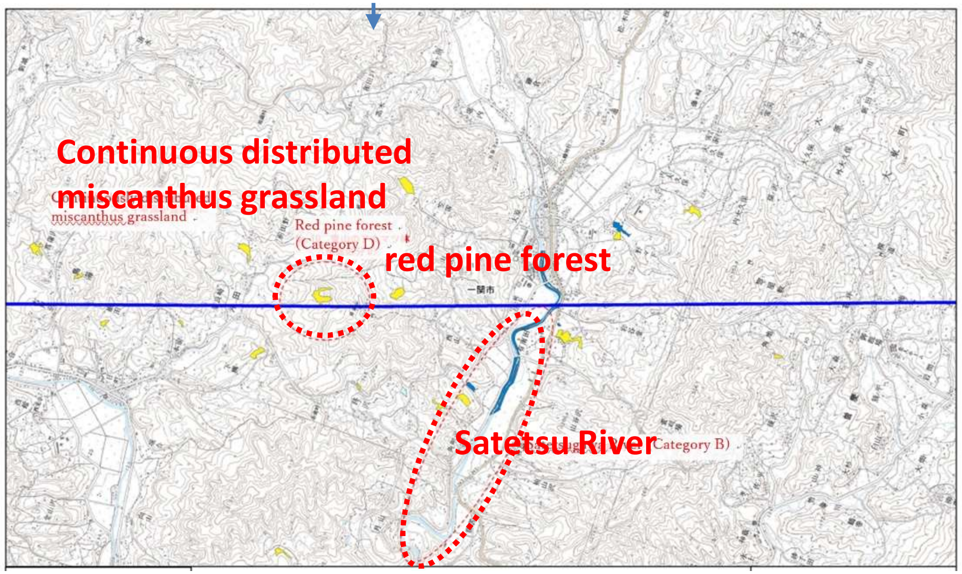


Overview of some results

- Vegetation map
- Natural environmental information map



Issues to be considered when constructing the ILC tunnel.



- Survey of raptors
  continuous surveys are required

ノスリ（H26.1.22 撮影）

写真 2.2-1 定点調査実施状況

7. Social Infrastructure toward the ILC Acceptance

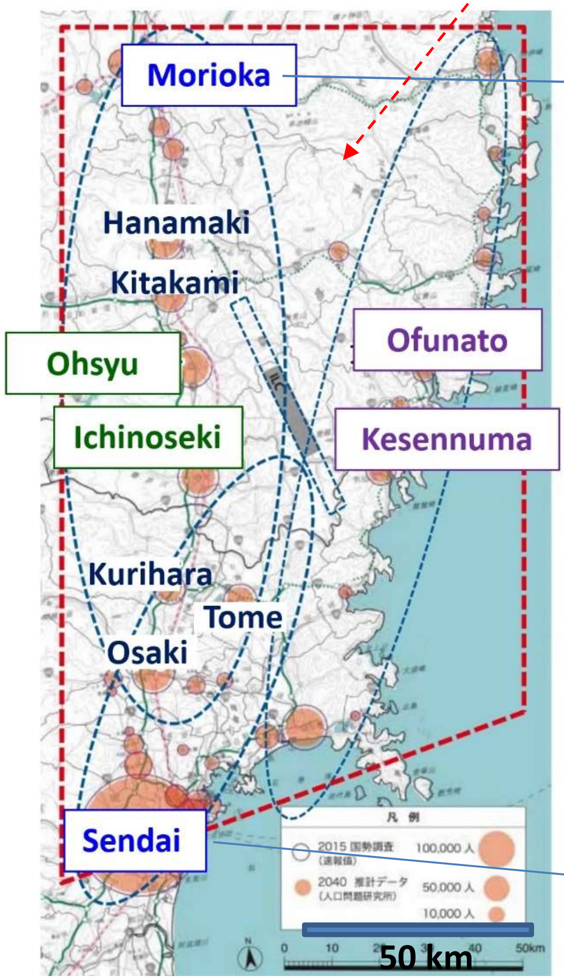
① Basic Policy

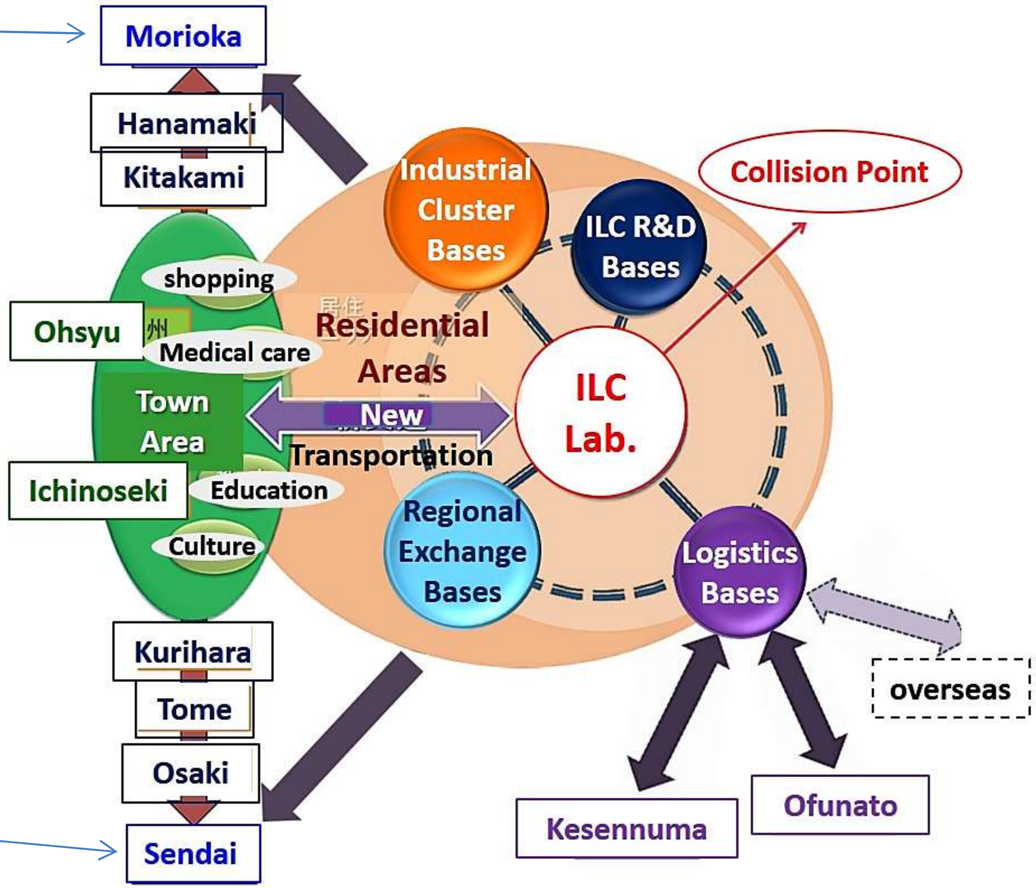
Wide regional revitalization for the ILC acceptance,

- utilizing social infrastructures along Sendai to Morioka (～160 km)

&

- developing Residential Zones, Regional Exchange Bases, Advanced Industrial Cluster Bases, ILC R&D Bases and Logistic Bases





ILC Central Collision Point-Eco Campus Concept utilizing Waste Heat

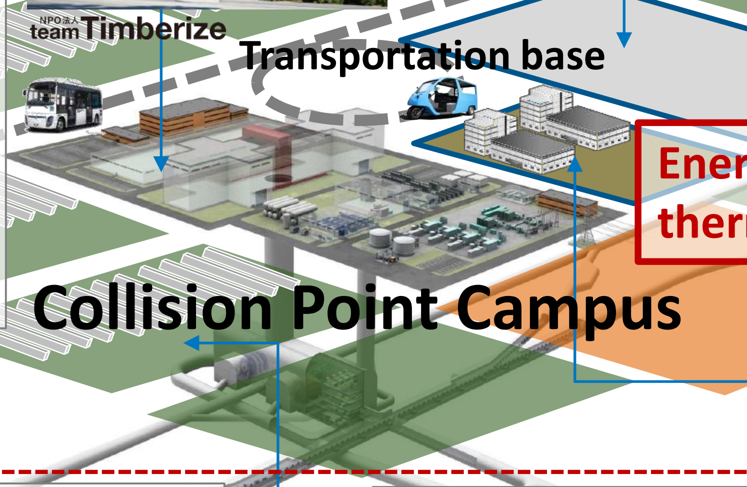
Vision2035

Agricultural land around the collision point will be consolidated and developed as a production base that supplies waste heat from the ILC to attract agricultural production corporations and land-based aquaculture companies. Also used as a wood drying and wood chip drying supply base

Collision Point Campus (wooden construction)

- On-site research office
- Control facility
- Experiment, maintenance, work facility
- Energy center (Power supply, air cooling equipment)

- Spa
- Community Site
- Roadside Station



Energy center with large scale thermal storage tank

Wood drying / Processing Woody biomass collection base

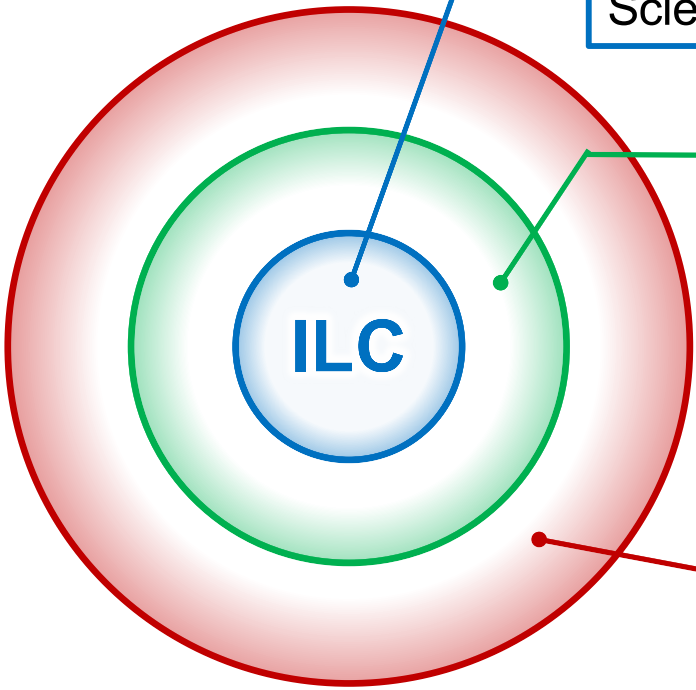
Agricultural house / plant factory

Land aquaculture

東日本機電開発株式会社　八幡平スマートファーム　久慈バイオマスエネルギー/マルヒ製材

NTT Facilities,INC. / Advanced Accelerator Association Promoting Science and Technology（AAA)

Benefits of the ILC Project for Japan to host (views from outside of researchers community)



Benefits of participating:
Scientific Merits

→ **MEXT**

Benefits of contributing: (example)
International Partnerships
Wide area of Technological Applications

MEXT, Ministry of Foreign Affairs (**MOFA**)
Cabinet Office (**CAO**) S&T, etc..

Benefits of hosting: (example)
New model for Japan in S&T diplomacy
Science for Peace
Regional Revitalization
Post-disaster Reconstruction (Tohoku)
Inbound Visitors, Economic impact, etc.

General meetings of the federation of Diet members regularly invite all 7 ministries and agency listed in right in order to prepare for the next step

← Cabinet Secretariat (**CAS**), **CAO**, **MEXT**, **MOFA**, **METI**, Ministry of construction (**MLIT**), Reconstruction Agency

The decision to host the ILC requires a comprehensive analysis of the costs and benefits from the **inter-ministry**'s views. ← top-down approach through political support is necessary.

ILC after European Strategy Update 2020

European Strategy Update

2020 Strategy Statements

3. High-priority future initiatives

It is essential for particle physics in Europe and for CERN to be able to propose a new facility after the LHC

- There are two clear ways to address the remaining mysteries: Higgs factory and exploration of the energy frontier
- Europe is in the privileged position to be able to propose both: CLIC or FCCee as Higgs factory, CLIC (3 TeV) or FCChh (100 TeV) for the energy frontier
- The dramatic increase in energy possible with FCChh leads to this technology being considered as the most promising for a future facility at the energy frontier.
- It is important therefore to launch a feasibility study for such a collider to be completed in time for the next Strategy update, so that a decision as to whether this project can be implemented can be taken on that timescale.

a) An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy. Accomplishing these compelling goals will require innovation and cutting-edge technology:

- *the particle physics community should ramp up its R&D effort focused on advanced accelerator technologies, in particular that for high-field superconducting magnets, including high-temperature superconductors;*
- *Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update.*

The timely realisation of the electron-positron International Linear Collider (ILC) in Japan would be compatible with this strategy and, in that case, the European particle physics community would wish to collaborate.

Halina Amramowicz

Development in 2020

- In February ICFA/LCB meeting at SLAC:
  after the presentations by
  Mr. H. Masuko, Deputy-Director General, MEXT Research Promotion Bureau
  Hon. T. Kawamura, Chairperson of the Federation of Diet Members for the ILC
  ICFA asked the LCB to propose a way to move to the preparatory phase for the ILC to be constructed in Japan.
- LCB worked out a proposal to setup the International Development Team (IDT), with KEK as the host, to pave a way to establish the ILC Pre-laboratory.
- In June, LCB/LCC ended their terms defined by the ICFA.
- In August ICFA meeting
  ICFA setup the ILC IDT and appointed the members of the Executive Board, with an aim to establish the ILC Pre-lab within ~1.5 year.
- Since then,
  the IDT Executive Board has started working.

Why Pre-lab?

- Facilities and resources are needed for the technical and engineering preparation work now to obtain a reliable cost estimate for the ILC that will be essential for the negotiation and reaching an agreements on the international cost sharing. (Some of the costs depend strongly on the site.)
- Framework and support is needed for the community for developing the ideas and preparing proposals for the experiments at the ILC facilities.

Some organisational structure is required, although it is before the decision of the ILC.

IDT organisation

ICFA

ILC-IDT

Executive Board

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

Working group 1
Pre-lab set-up

Working group 2
Accelerator

Working group 3
Physics & Detectors

Scientific secretary: Tomohiko Tanabe (KEK)
Communication team led by Rika Takahashi (KEK)

Unlike LCB/LCC, ILC-IDT is focused on the ILC.
KEK provides administrative, logistic and some financial support.

Rough timeline of the ILC under discussion

ILC IDT (~1.5 years)

- Prepare the work and deliverables of the ILC Pre-laboratory and workout with national and regional laboratories a scenario for their contributions
- Prepare a proposal for the organisation and governance of the ILC Pre-laboratory

In parallel:
Positive “signs” from the host country (Japan) government and agreements by the national/regional laboratories for providing their contributions.

ILC Pre-laboratory (~4 years)

- Complete all the technical preparation necessary to start the ILC project (infrastructure, environmental impact and accelerator facility)
- Prepare scenarios for the regional contributions to and organisation for the ILC.

In parallel:
Positive outcomes of the inter-governmental negotiation for the responsibility and cost sharing among the host (Japan) and partner countries

ILC laboratory

- Construction and commissioning of the ILC (~10 years)
- Followed by the operation of the ILC
- Managing the scientific programme of the ILC

Recent activities

- Communication team is working: e.g., (almost) monthly ILC Newsline and discussion on other activities on going.
- WG1 started to work on the Pre-lab organisation and legal framework
- WG2 has been busy compiling the list of technical work and make it work packages.
- WG3 newly organised with sub-groups and regular meetings and work started.
- Preparation of the interim Pre-lab proposal: ~30 page document

Technical issues pointed out by MEXT and SCJ

- The MEXT advisory panel and Science council of Japan pointed out some remaining technical issues that need to be resolved during the ILC preparation period.

  http://www.mext.go.jp/component/b_menu/shingi/toushin/__icsFiles/afieldfile/2018/09/20/1409220_2_1.pdf
  http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-24-k273-en.pdf

- These are discussed at international working group (KEK,2019) and summarized in the report.

  "Recommendations on ILC Project Implementation" https://www.kek.jp/en/newsroom/2019/10/02/1000/

Component	Issue	Summary of tasks	Candidates for collaboration
SRF Cavity	Mass production incl. automation	Performance statistics, mass production technology	France, Germany, US
	Cryomodule transport	Performance assurance after transport	France, Germany, US
Positron Source	Rotating target	Exchanging target, system design	CERN, France, Germany, US + industry-academia efforts
	Magnetic focusing system	System design	France, Germany, Russia, US
	Photon dump	System design	CERN, Germany, US
Damping Ring	Fast kicker	Test of long-term stability, system design	CERN, Italy
	Feedback	Test at SuperKEKB	Italy
Interaction Region	Beam focus/position control	Test of long-term stability	CERN, UK
Beam Dump	Total system	System design	CERN, US
	Beam window, cooling water circulation	Durability, exchangeability, earthquake-resistance	CERN, US + industry-academia efforts

ILC Pre-Lab

Real cavity and cryomodule production

ML&SRF
- WP-1 Cavity production
- WP-2 Cryomodule transfer
- WP-3 Crab cavity

Sources

Electron source
- WP-4 Electron source

Positron sources

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
- WP-12 System design
- WP-13 Collective effect
- WP-14 Injection/extraction

BDS
- WP-15 Final focus
- WP-16 Final doublet

Dump
- WP-17 Main dump
- WP-18 Photon dump

Technical Preparation Document (TPD) was summarized by IDT-WG2.

18 WPs were proposed.
Total ~60 MILCU ~360 FTE-yr
+ infrastructure (cavity/CM evaluation etc.) at each region

Please visit Accelerator plenary session

Accelerator activities at ILC Pre-lab phase

- *Technical preparations (Solve the technical concerns by international cooperation)*
- *Final technical design and documentation (Engineering Design Report, Cost confirmation)*
- *Preparation and planning of mass production*
- *Civil engineering, local infrastructure and site*

+ develop human resources necessary for ILC construction

Planning technical preparation was our first work at IDT-WG2

	IDT	ILC Pre-Lab				ILC Lab.										
	PP	P1	P2	P3	P4	1	2	3	4	5	6	7	8	9	10	Phys. Exp.
Preparation CE/Utility, Survey, Design Acc. Industrialization prep.																
Construction																
Civil Eng.																
Building, Utilities																
Acc. Systems																
Installation																
Commissioning																
Physics Exp.																

Following a four-year ILC Pre-Lab phase, ILC construction will continue for about ten years.

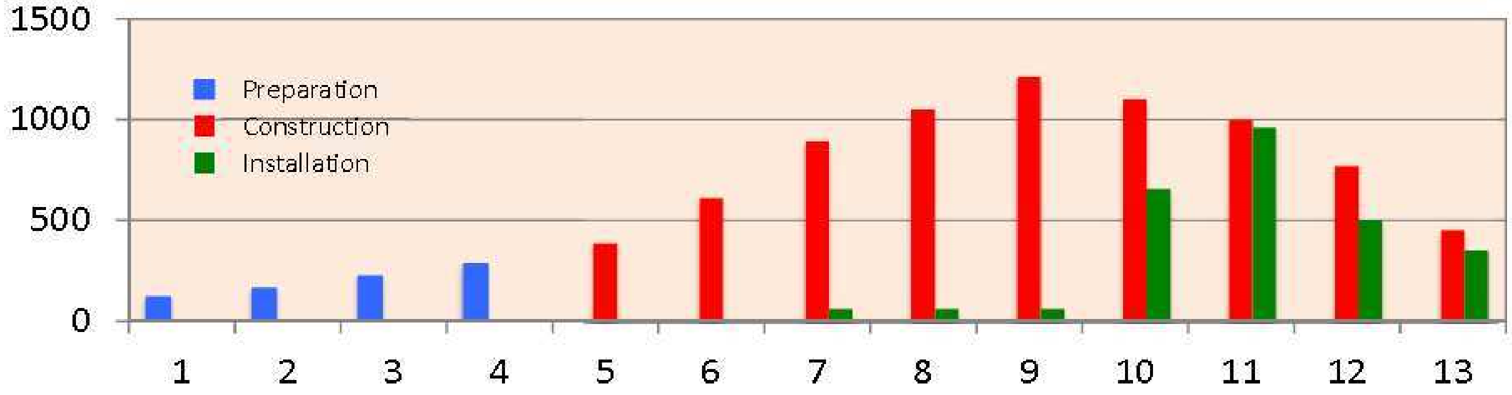
Human Resource Development

unit: person

Stage	Preparation				Construction									Total
	1	2	3	4	1	2	3	4	5	6	7	8	9	
Prep.	118	161	222	282										
Acc.	82	115	163	211			TDR, ILC-500 Ann. average: ~ 1,100 persons							
Constr.					410	922	1208	1350	1589	1480	1374	1106	679	10,118
Install.							80	80	80	768	1140	683	522	3,353
Total					410	922	1288	1430	1669	2248	2514	1789	1201	13,471
ILC-250							ILC-250: Ann. average: ~ 830 persons							
Constr.					385	610	890	1050	1210	1100	1000	770	450	7,465
Install.							60	60	60	655	960	500	350	2,645
Total					385	610	950	1110	1270	1755	1960	1270	800	10,110

Except Civil, common

Acc. total 571 FTE-yr



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

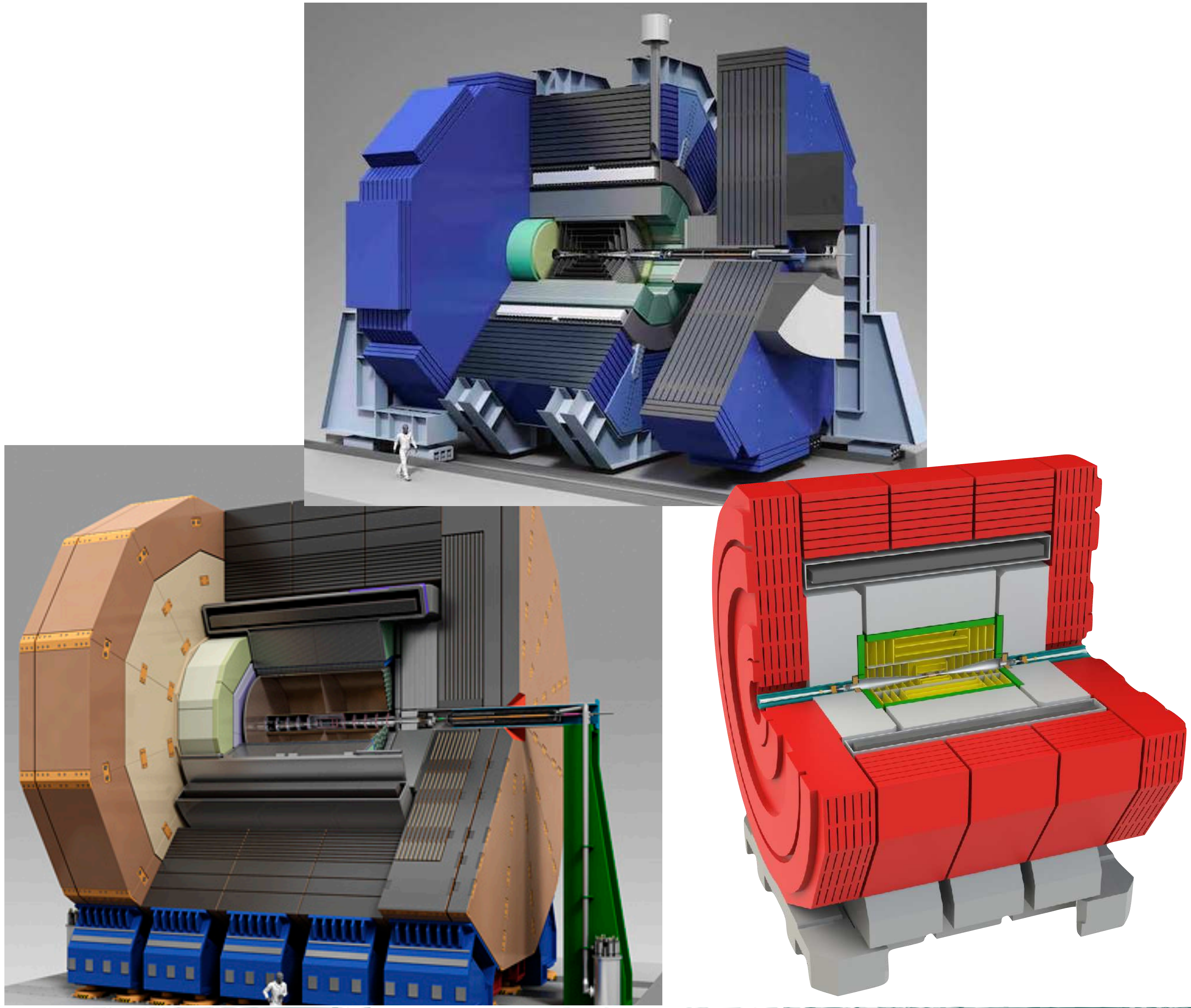
Technical preparation requires ~360 FTE-yr (+regional infrastructure)

EDR requires ~60 FTE-yr

The scientists/engineers working at ILC Pre-Lab will play the central role during the ILC construction.

The Linear Collider Detector Design - Main Features

Variations in terms of size, field and tracker / calorimeter details



- A **large-volume solenoid** 3.5 - 5 T, enclosing calorimeters and tracking
- **Highly granular calorimeter systems**, optimised for particle flow reconstruction, best jet energy resolution *[Si, Scint + SiPMs, RPCs]*
- **Low-mass main tracker**, for excellent momentum resolution at high energies *[Si, TPC + Si]*
- **Forward calorimeters**, for low-angle electron measurements, luminosity *[Si, GaAs]*
- **Vertex detector**, lowest possible mass, smallest possible radius *[MAPS, thinned hybrid detectors]*
- **Triggerless readout** of main detector systems

Expected Timeline

triggered by sign for substantial funding for pre-lab in Japan

Timeline for the ILC experiments

2021 IDT calls for EoI

Necessary R&D for EoI

2022 ---------- Assumed start of Pre-lab ----------

2022 EoI presentation

Necessary R&D for LoI

2023 LoI submission and presentation

Continuation of R&D
Selection process by the ILCC

2024 ILCC recommendation on the first set of the projects to proceed toward TP

Necessary R&D for TP

2025 TP submission and presentation of the first set of experiments

Continuation of R&D
Selection process by the ILCC

2026 ---------- Assumed start of ILC-lab ----------

2026-27 ILCC recommendation for the first set of experiments to proceed toward TDRs

2027 ILC-lab approval of the first set of experiments and request to proceed toward TDRs

- Funding agencies will not provide dedicated ILC detector R&D funds before the Pre-lab being established.
- For some EoIs, R&D would be needed to make LoIs.
  → driving the timing for the LoI submission
- Selection process starts with the LoIs.
  → driving the timing for the LoI decision
- Experiments are formally approved based on TPs.
- The ILC-lab is needed for approvals.
- Availability of resources is part of the approval criteria.
  → driving the timing for the TP decision
- These considerations are for the initial set of experiments. There could be more experiments proposed at later time.

IDT: International Development Team
EoI: Expression of Interest
LoI: Letter of Interest
TP: Technical Proposal
TDR: Technical Design Report
ILCC: ILC Committee

WG3 Organisation and mandates

Chair: Hitoshi Murayama (Berkeley/Tokyo)

Deputies: Jenny List (DESY) and Claude Vallée (Marseille)

Coordinator and Deputy coordinator(s)

Secretariat?

Steering Group
Subgroup conveners, Coordinator and Deputy Coordinator(s)

Andy White (UT Arlington), Ties Behnke (DESY), Yuanning Gao (Peking), Frank Simon (MPP), Jim Brau (Oregon), Keisuke Fujii (KEK), Phil Burrows (Oxford), Francesco Forti (INFN), Filip Zarnecki (Warsaw), Patty McBride (Fermilab), Mihoko Nojiri (KEK), CERN member, Timothy Nelson (SLAC), Kajari Mazumdar (Mumbai), Phillip Urquijo (Melbourne), Dmitri Denisov (Brookhaven)

Speaker's bureau

Kiyotomo Kawagoe (Kyushu), Alain Bellerive (Carleton), Ivanka Božović Jelisavčić (Belgrade)

Interface with machine

Coordinate the interactions between the accelerator and facility infrastructure planning and the needs of the experiments

Karsten Buesser (DESY), Yasuhiro Sugimoto (KEK), Roman Poeschl (Orsay), US

Detector and technology R&D

Provide a forum for discussion and coordination of the detector and technology R&D for the future experimental programme

Marcel Vos (Valencia), Katja Krueger (DESY) Petra Merkel (Fermilab), David Miller (Chicago)

Software and computing

Promote and provide coordination of the software development and computing planning

Frank Gaede (DESY), Jan Strube (PNNL) Daniel Jeans (KEK)

Physics potential and opportunity

Encourage and develop ideas for exploiting the physics potential of the ILC collider and by use of the beams available for more specialised experiments

Michael Peskin (SLAC), Junping Tian (Tokyo) Aidan Robson (Glasgow)

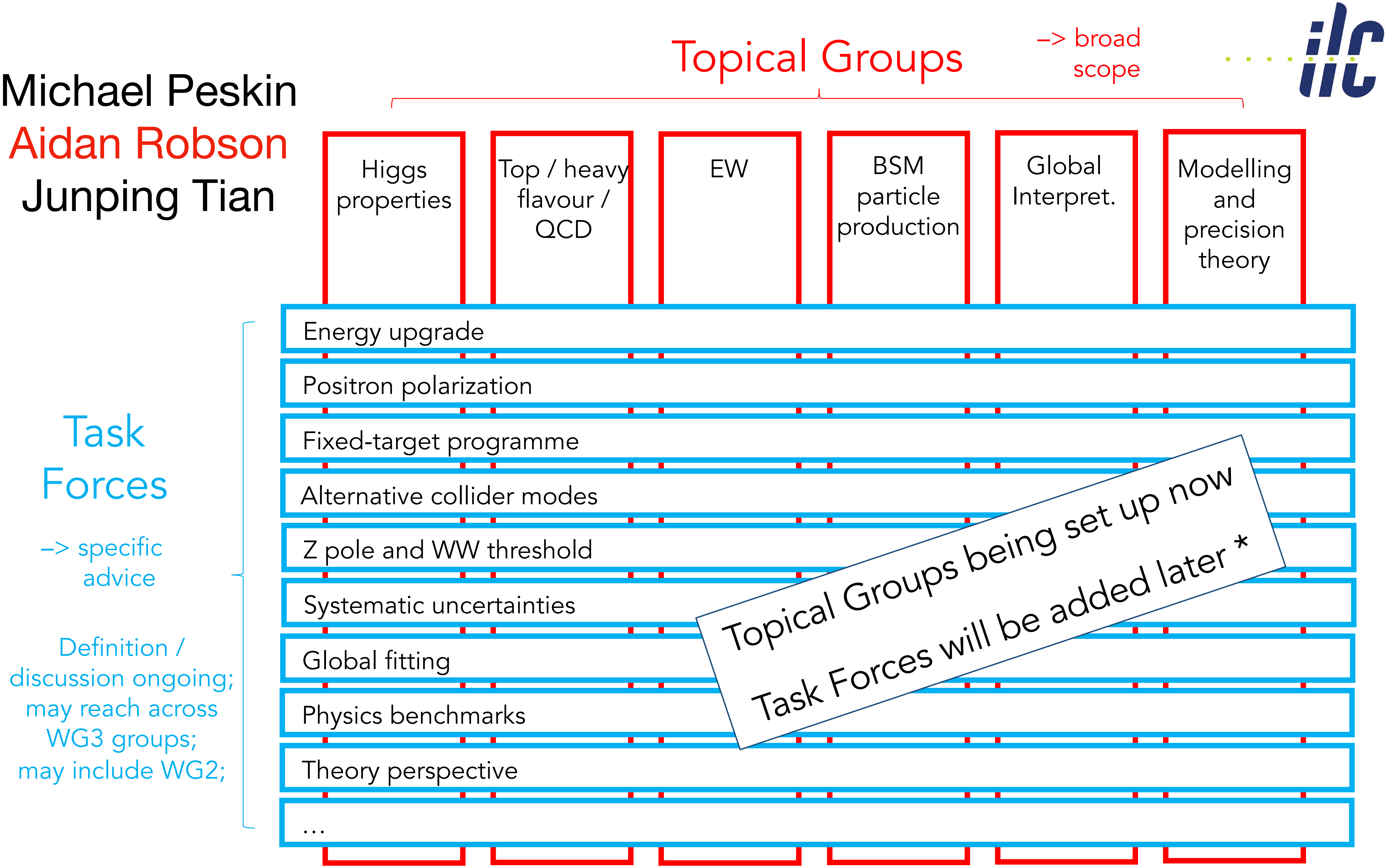
Open to anybody interested!

https://linearcollider.org/team/

approved by IDT EB Feb 4, 2021

Physics potential and Opportunities

Michael Peskin
Aidan Robson
Junping Tian



* Study Group on fixed-target / dark sector has started to meet

Current status and next steps

Now:

Topical Group conveners are being finalised

Initial group mandates will be finalised in discussion with conveners

April: Plan to launch full Physics Potential & Opportunities regular monthly meetings and Topical Group regular meetings

You can ***already*** pre-subscribe to the overall group and Topical Group mailing lists:

https://agenda.linearcollider.org/event/9154/

See presentation on ILC Snowmass Report from Michael Peskin in Thursday's LCWS Plenary

Looking forward to wide participation!

Selected highlights from LCWS'2021

Accelerator Tracks

A1: Superconducting RF (SRF) Technology
Conveners: Yasuchika Yamamoto (KEK), Mattia Checchin (FNAL), Marc Wenskat (Hamburg/DESY), Enrico Cenni (CEA-Irfu)

A2: Sources
Conveners: Masao Kuriki (Hiroshima), Steffen Doebert (CERN), Joe Grames (JLab), Gudrid Moortgat-Pick (Hamburg/DESY)

A3: Damping Rings, BDS, ATF-3, Dumps:
Conveners: Toshiyuki Okugi (KEK), Nobuhiro Terunuma (KEK), Andrea Latina (CERN), Angeles Faus-Golfe (IJCLab)

A4: Conventional Facilities and Siting (CFS)
Conveners: John Osborne (CERN), Nobuhiro Terunuma (KEK)

A5: Advanced & Novel Accelerators (ANA)
Conveners: Philippe Piot (ANL/NIU) - organized by the ICFA/ANA panel

New Research and Opportunities Track

N1: Dark Sector, Fixed-Target and Beam Dump Experiments
Conveners: Benno List (DESY), Michael Peskin (SLAC), Matthew Wing (UCL)

N2: New Technologies & Ideas for Collider Detectors
Conveners: Sarah Eno (Maryland), Philipp Roloff (CERN), Frank Simon (MPP)

N3: Beams for Accelerator and Detector R&D and Irradiation
Conveners: Mark J. Hogan (SLAC), Yoshihisa Iwashita (Kyoto), Benno List (DESY), Steinar Stapnes (CERN)

Industry Track

I1: Industry Session
Conveners: Nuria Catalán Lasheras (CERN), Juan Fuster (IFIC-Valencia), Jie Gao (IHEP), Hugh Montgomery (JLab), Tohru Takahashi (Hiroshima), Maxim Titov (CEA-Irfu), Marc Winter (IJCLab)

Physics & Detector Tracks

PD1: Theoretical Developments
Conveners: Nathaniel Craig (UCSB), Roberto Franceschini (INFN/Rome III), Sven Heinemeyer (IFCA-Santander), Shigeki Matsumoto (Kavli IPMU), Jürgen Reuter (DESY)

PD2: Global Interpretations
Conveners: Stefania Gori (UCSC), Christophe Grojean (DESY/Humboldt), Junping Tian (Tokyo), Dirk Zerwas (IJCLab)

PD3: Physics Analyses
Conveners: Akimasa Ishikawa (KEK), Roman Pöschl (IJCLab), Chris Potter (Oregon), Filip Żarnecki (Warsaw)

PD4: Software & Detector Performance
Conveners: Frank Gaede (DESY), Adrian Irles (IFIC-Valencia), Daniel Jeans (DESY), Manqi Ruan (IHEP), André Sailer (CERN), Jan Strube (Oregon/PNNL), Graham Wilson (Kansas)

PD5: Tracking Detectors
Conveners: Alain Bellerive (Carleton), Dominik Dannheim (CERN), Shinya Narita (Iwate), Marcel Stanitzki (DESY), Ivan Vila (IFCA-Santander)

PD6: Calorimeters
Conveners: Ivanka Božović-Jelisavčić (VINCA-Belgrade), Katja Krüger (DESY), David Miller (Chicago), Taikan Suehara (Kyushu)

PD7: MDI
Conveners: Karsten Büßer (DESY), Phil Burrows (Oxford), Tom Markiewicz (SLAC), Yasuhiro Sugimoto (KEK)

abstracts submitted to PD sessions: **144**

parallel sessions: **51**

scheduled talks: **292**

Number of Registrations: ~900
(after subtracting double registrations)

LCWS2021
INTERNATIONAL WORKSHOP ON FUTURE LINEAR COLLIDERS

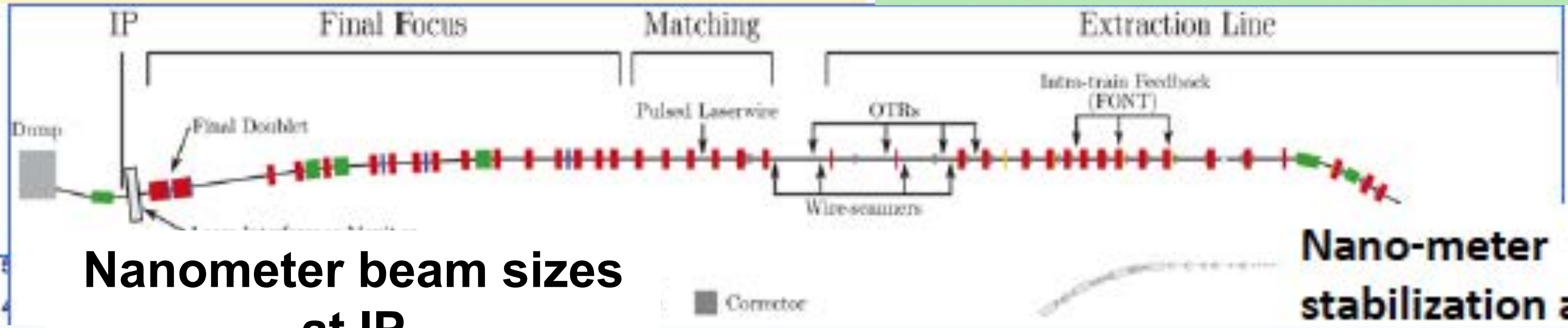
ATF2 goals and achievements

Goal 1: 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)

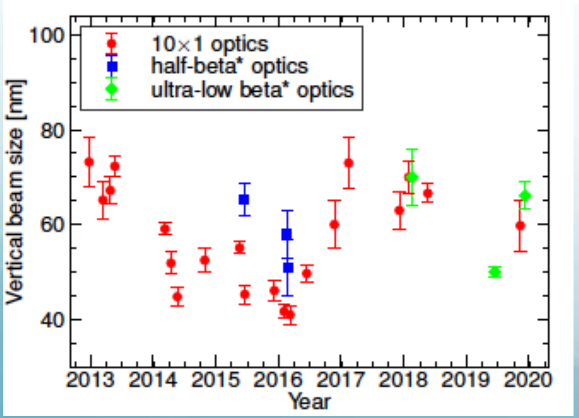
Goal 2: 2 nm beam stabilization at ATF2 IP, (much harder than nm stabilization in collision at ILC).

- **FB latency 133 nsec achieved** (target < 366 nsec)
- **Position jitter at ATF2 IP: 41 nm (2018)** (direct stabilization limited by IPBPMs resolution 20 nm). Upstream FB shows capability for 2nm stabilization. **Demonstrated ILC IPFB system.**

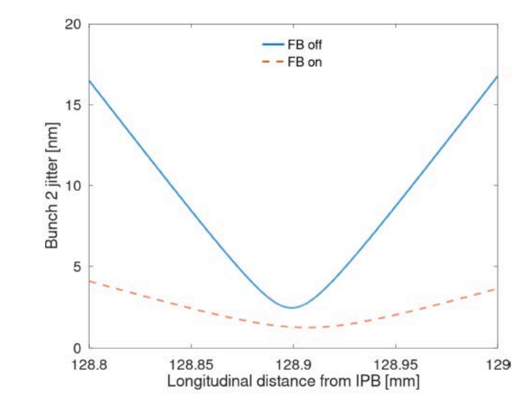


Nanometer beam sizes at IP

Nano-meter stabilization at IP

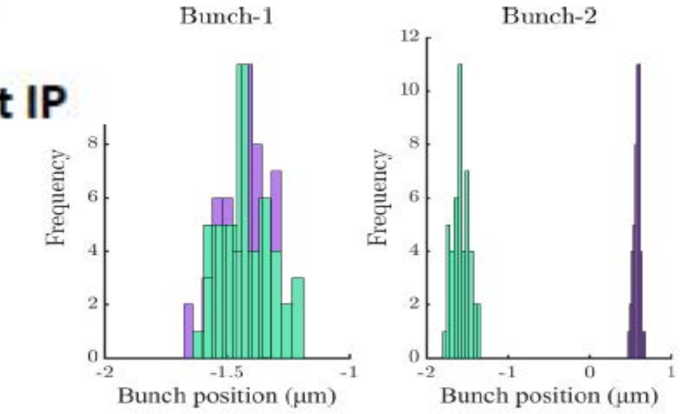


Small beam sizes were obtained with beam intensities of 0.5-1.5 10^9 e^- /bunch (10^{10} design value) and reduced aberration optics ($10\beta_x^* \times \beta_y^*$)



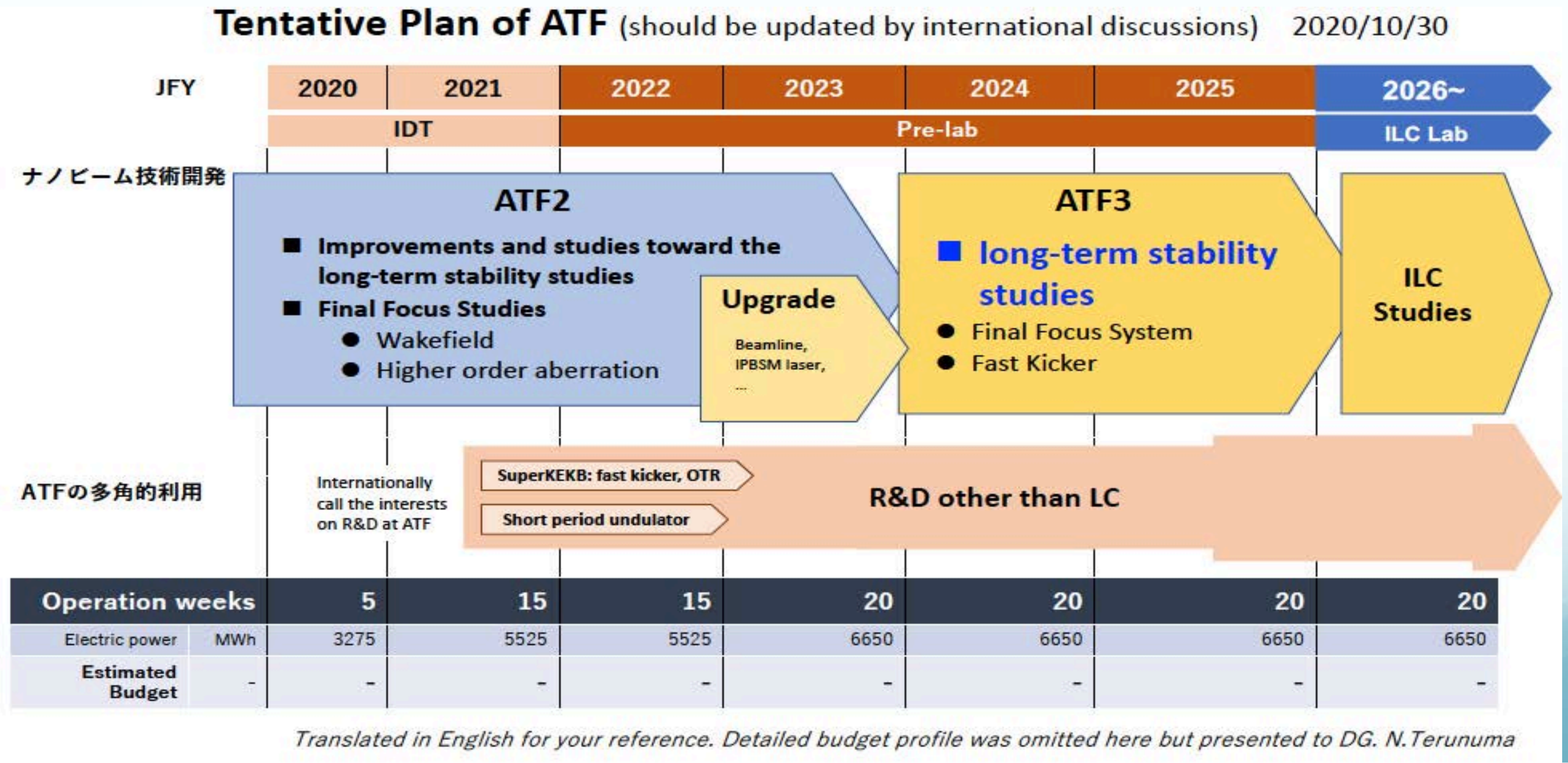
Predicted vertical position jitter with FB on-off

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



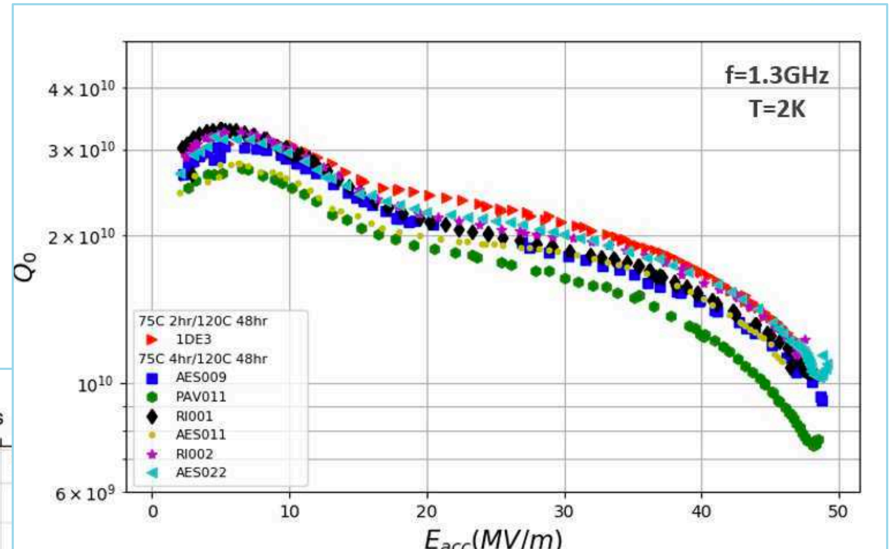
ILC FFS - ATF3 objective and collaboration:

Based on the achievements of the ATF2 no showstopper for ILC has been found, **ATF3** plan is to pursue the necessary R&D to **maximize** the **luminosity potential of ILC**. In particular the assessment of the **ILC FFS system design** from the point of view of the beam dynamics aspects and the technological/hardware choices and the **long-term stability operation issues.**



ILC Cost Reduction R&D: 2-step baking

- Systematic achievement of unprecedented gradients ~48-50 MV/m
- Performance linked to 2 effects
  - Ultra cold final EP that gives
  - Additional 75 C bake before 120 C in situ bake
- The branching cavity performance is correlated with cavity cooldown protocol



Cavity TE1AES022 post cold EP + 75/120C bake was tested at other labs (while always maintaining vacuum – no disassembly!)

FNAL – Batavia, IL

- Lower branch: ~43 MV/m
- Upper branch +50 MV/m (+210mT)!

Jlab – Newport News, Virginia

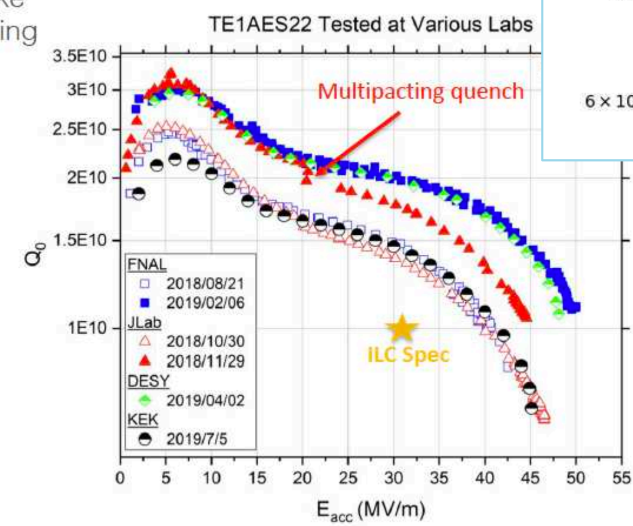
- Lower and Upper branch obtained

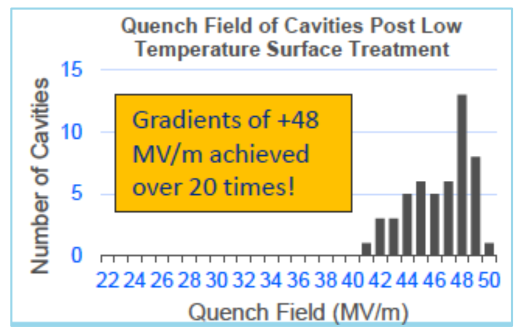
DESY – Hamburg, Germany

- Upper branch: +48MV/m confirmed

KEK – Tsukuba, Japan

- Lower Branch: +45MV/m confirmed

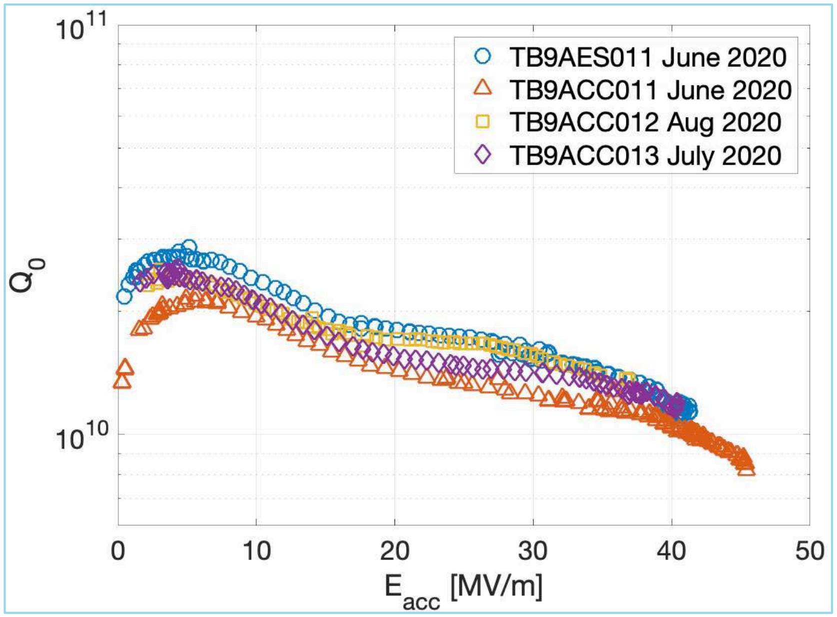




High gradient cryomodule demonstration

- Fermilab is in the process of refurbishing one of the old cryomodules (CM1) to demonstrate the new SRF advances:
  - Flux expulsion
  - Two step bake (75/120)
  - Cold EP
- Supported by the ILC Cost Reduction R&D with contributions from other labs throughout the world
- Goal is to reach higher gradient than has ever been demonstrated in CM test: 38 MV/m average gradient with a stretch goal of 40 MV/m. The Q_0 goal is 1.0×10^{10} at 38 MV/m.
- Some other CM improvements (magnetic shield, tuner, …)

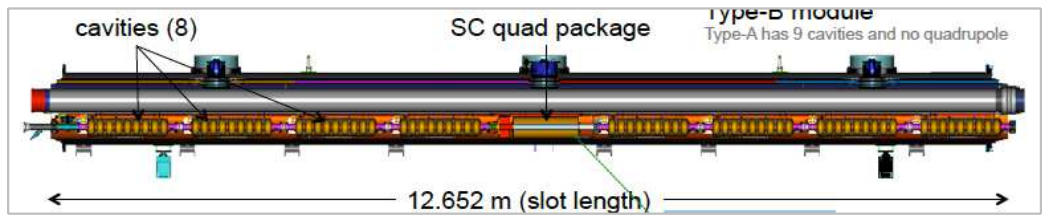
Cavity candidates to date (average gradient 41 MV/m):
- TB9AES011 – 41.3 MV/m
- TB9ACC011 – 45.5 MV/m
- TB9ACC012 – 36.9 MV/m
- TB9ACC013 – 40.4 MV/m

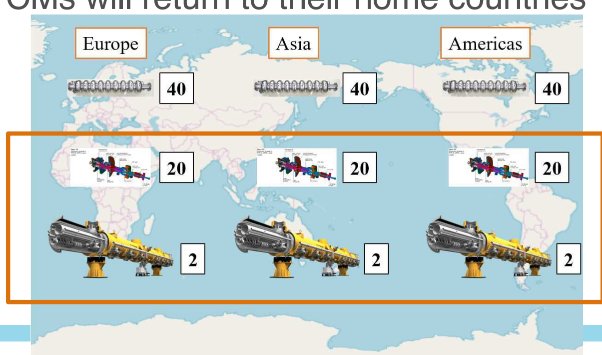


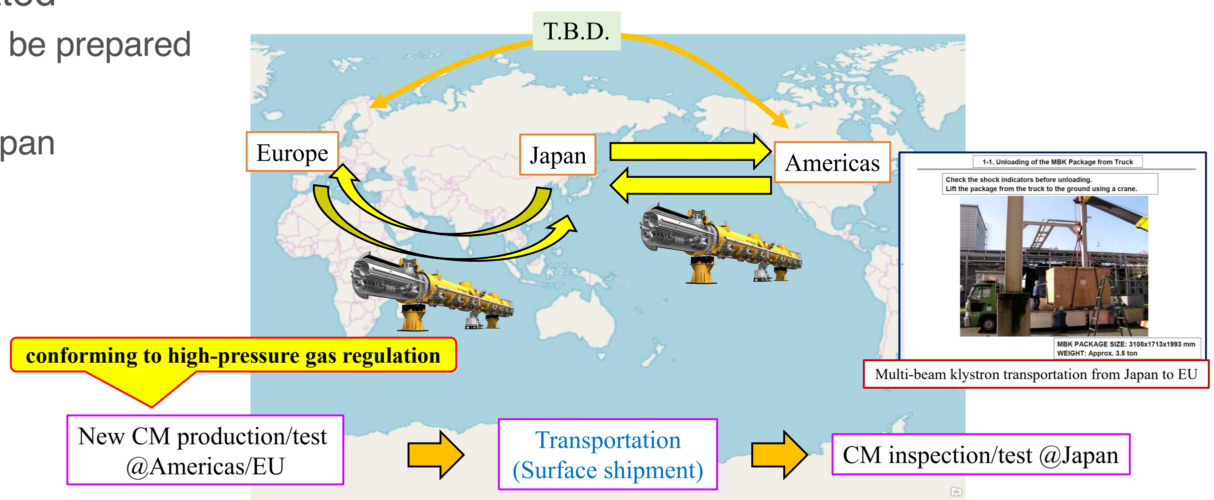
See more details in S. Posen's talk on Monday's SRF Session

WP-2: CM global transport and performance assurance

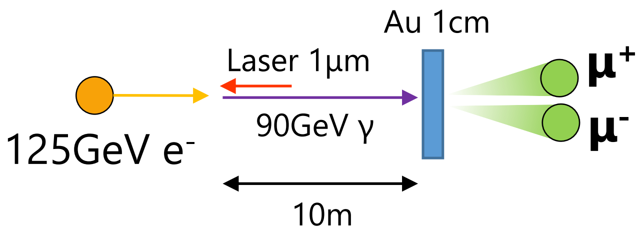
- Total 6 cryomodules (Type B in TDR) to be produced, 2 in each region
  - 48 cavities produced in WP-1 will be used
- Must comply with the high-pressure-gas safety act of Japan
- Associated components to be produced
  - Couplers, tuners, SC magnets, BPMs
- CMs are assembled and tested,
- Two CMs will be chosen for transportation
- First CM Global Transfer to be demonstrated
  - Dedicated cage, shock damper, container to be prepared
  - One CM each from Americas and Europe
  - Performance assurance to be checked in Japan
  - CMs will return to their home countries





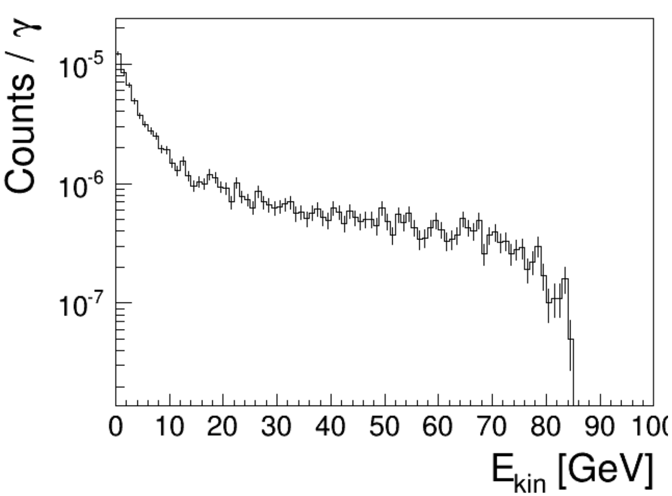


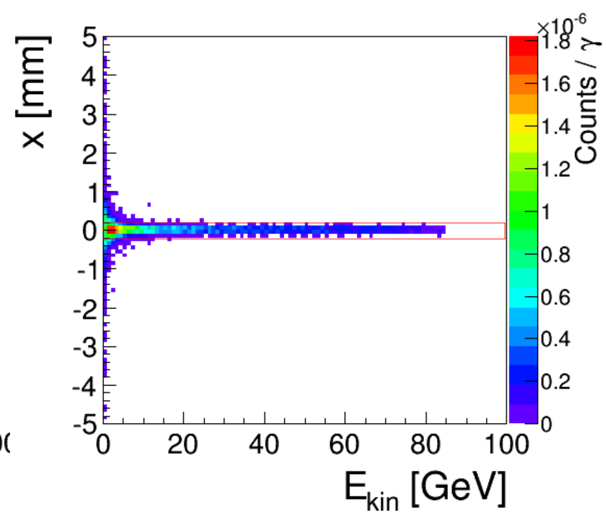
Case study: 90GeV LCS γ, Au 1cm

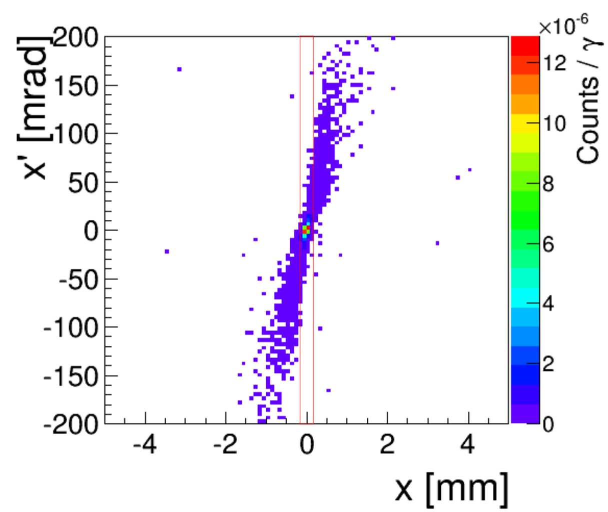


- The size of a muon source is determined by the distance from the LCS IP and the fixed target. 10m → 40μm (θ=4μrad)

- G4 simulation using monochromatic 90GeV γ
- If a collimator selecting |x|<0.1mm,
  - ✓ Eff.($\mu^+\mu^-$) = 2.7e-5 → **4.6e8 $\mu_+\mu_-$/s**
  - ✓ σ_x=45μm, $\sigma_{x'}$=6.9mrad, ε_x=0.27 mm*mrad
- **Intense, luminous, and high energy** (but broad energy spectrum)



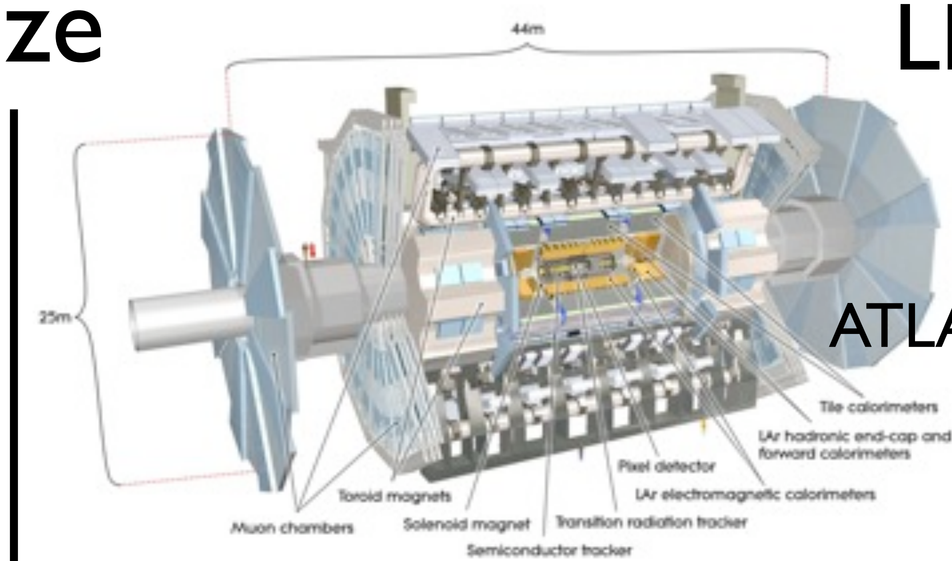




Detector Evolution

From LHC to ILC

Size



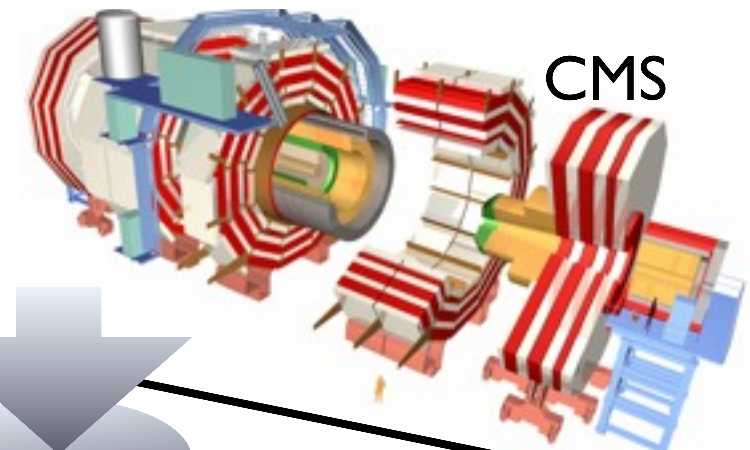
ATLAS

LHC : current state of the art

Use the cleanest modes to beat the huge QCD BG.

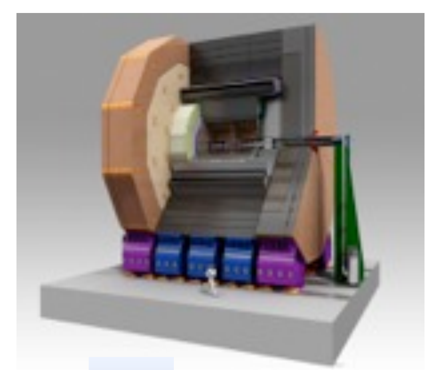
Moral

Energy Frontier Collider Detectors spearhead state-of-the-art detector technologies



CMS

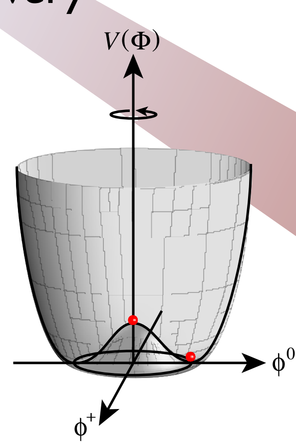
ILD



ILC : next generation

Use the dominant (jet) modes to take advantage of clean environment

LHC : Higgs Discovery



ILC : Full understanding of Higgs sector

Resolution

As compared to ATLAS

Vertex resolution	2-7 times better
Momentum resolution	10 times better
Jet energy resolution	2 times better

Granularity

As compared to ATLAS

Vertex	x800
Tracker	x2
EM Cal	x61 (Si)
	x7 (Sci)

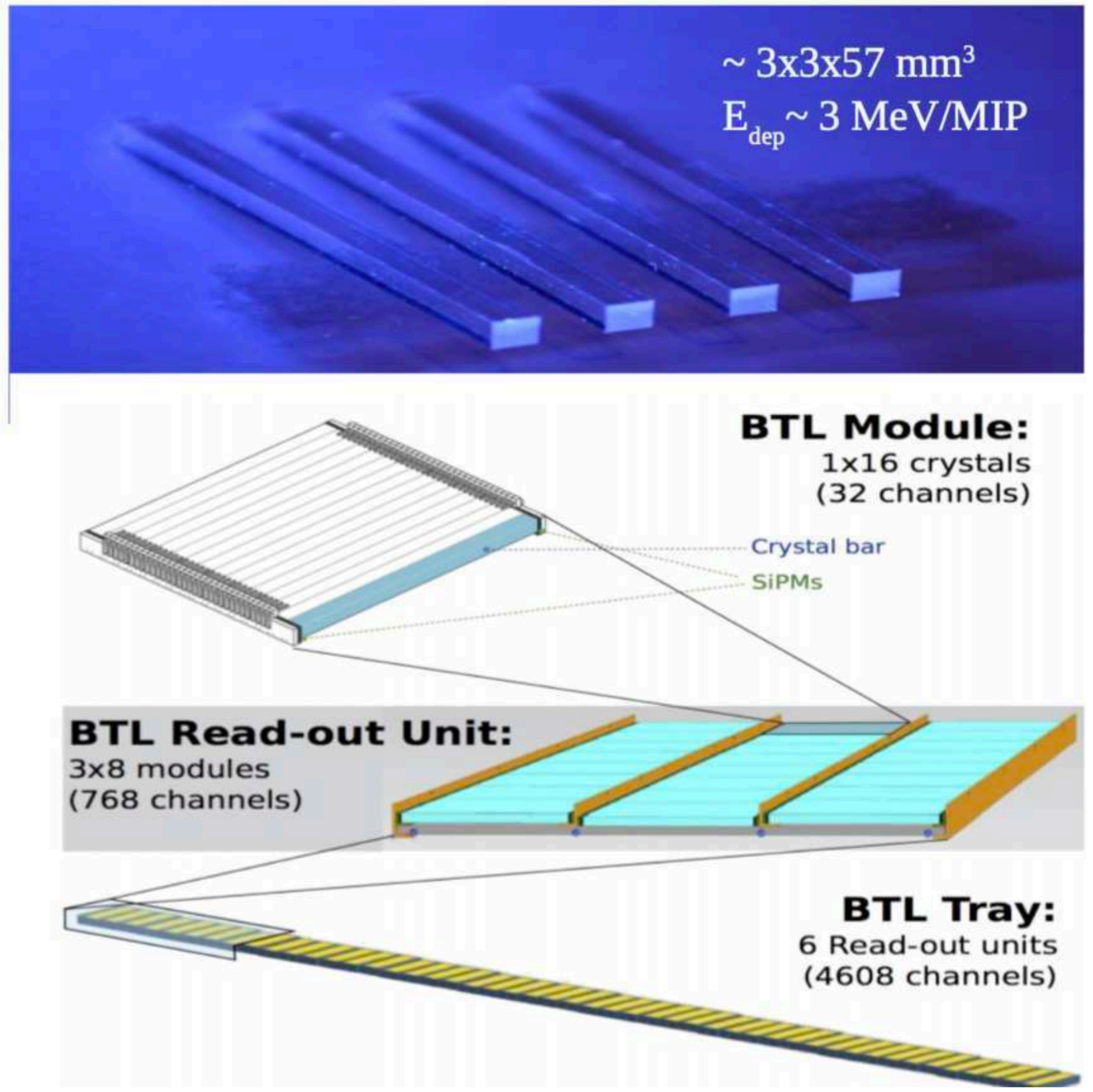
Adding Capabilities

The main trend: Timing

- Timing detectors with few 10 ps resolution now feasible - pioneered for HL-LHC upgrades

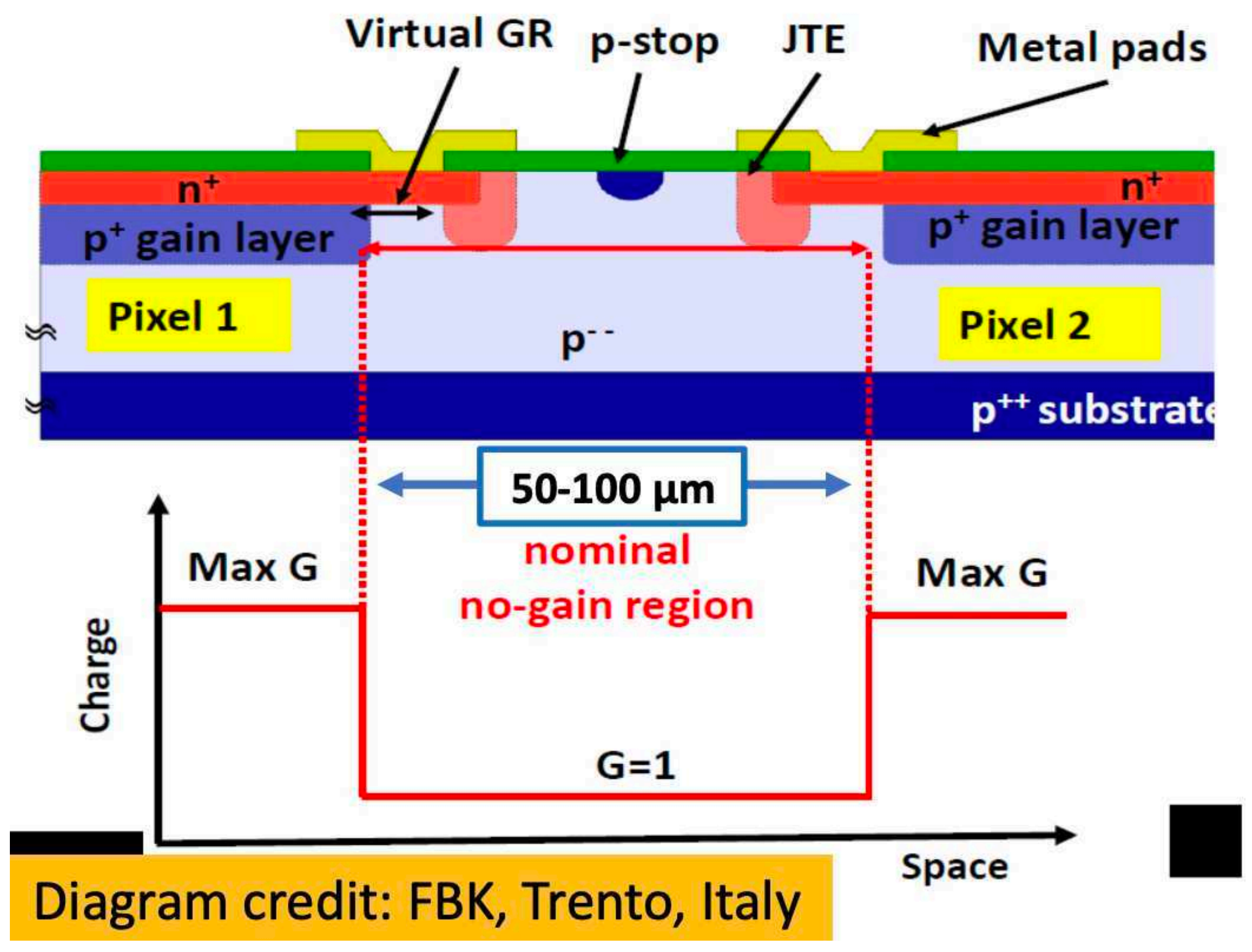
Optical:

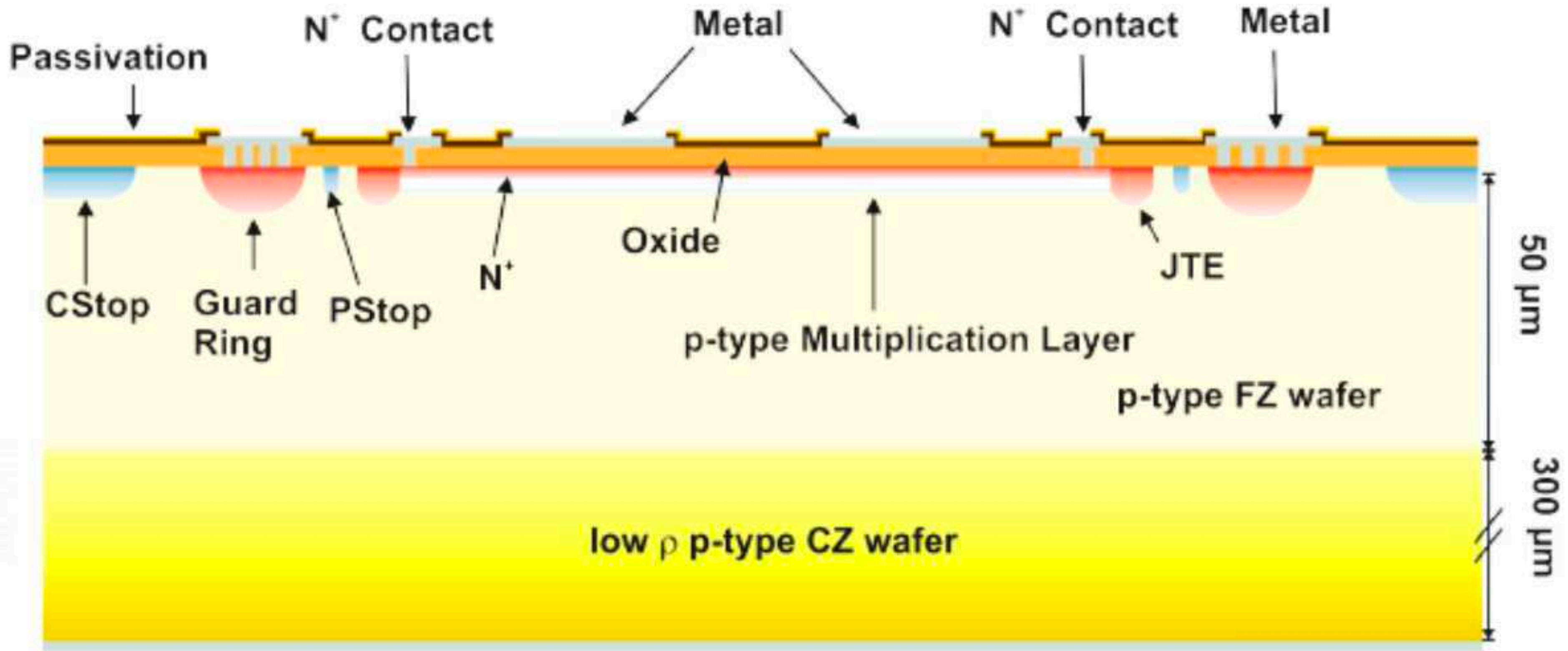
Fast scintillators, SiPMs



Silicon:

LGADs and variants





Newer ideas: AC-coupled LGADs, deep-junction, trenches, …
Potential for fine pixilation

➯ Dedicated timing systems, but also potential in trackers, calorimeters, …

Also here: interesting optimisation questions: A balance between time resolution, spatial resolution, data rate and power consumption

Adding Capabilities

Additional Dimensions: Timing and others

- Timing: What would we need?
  (note: Bgd rejection at LCs needs ~ns - level only)
  - A clear use case: PID via time-of-flight.
    In the focus: π/K separation - important for example for flavour tagging.
    - Typical momenta in the ~ 5 GeV region - depending on collision energy
  - Resolutions today: < 10 ps with multiple layers - but system challenges to scale this up are formidable
- Can provide an additional dimension in calorimetry: Separation of electromagnetic and hadronic processes based on time evolution
- Also: Dual readout - signal-based separation of em and hadronic components - now moving towards high granularity

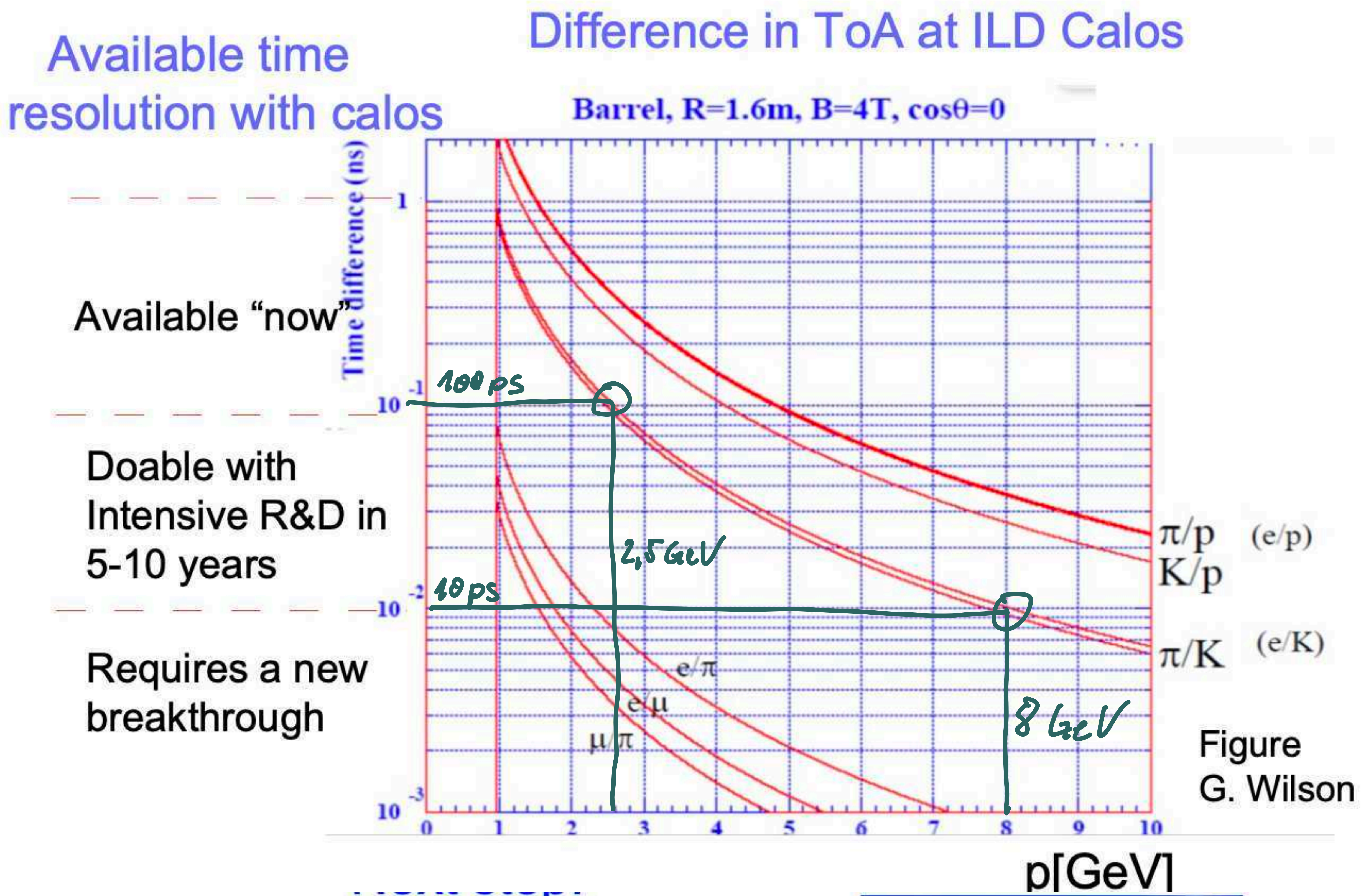
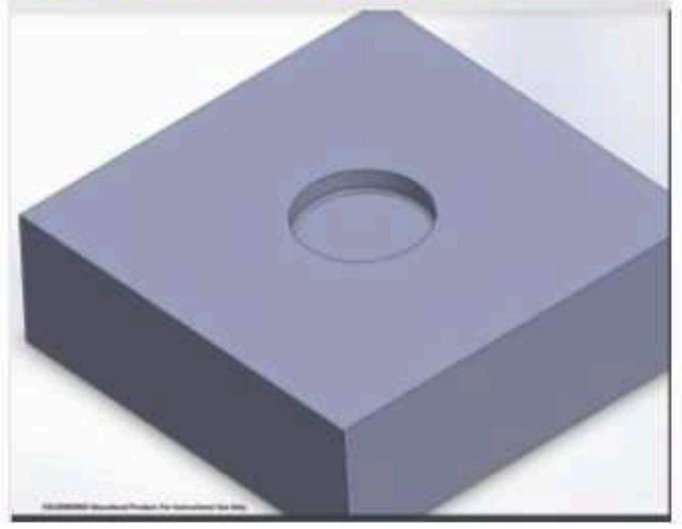


Figure G. Wilson



3x3 cm² Glass tile

3x3 cm² Plastic Tile

Shower reconstruction

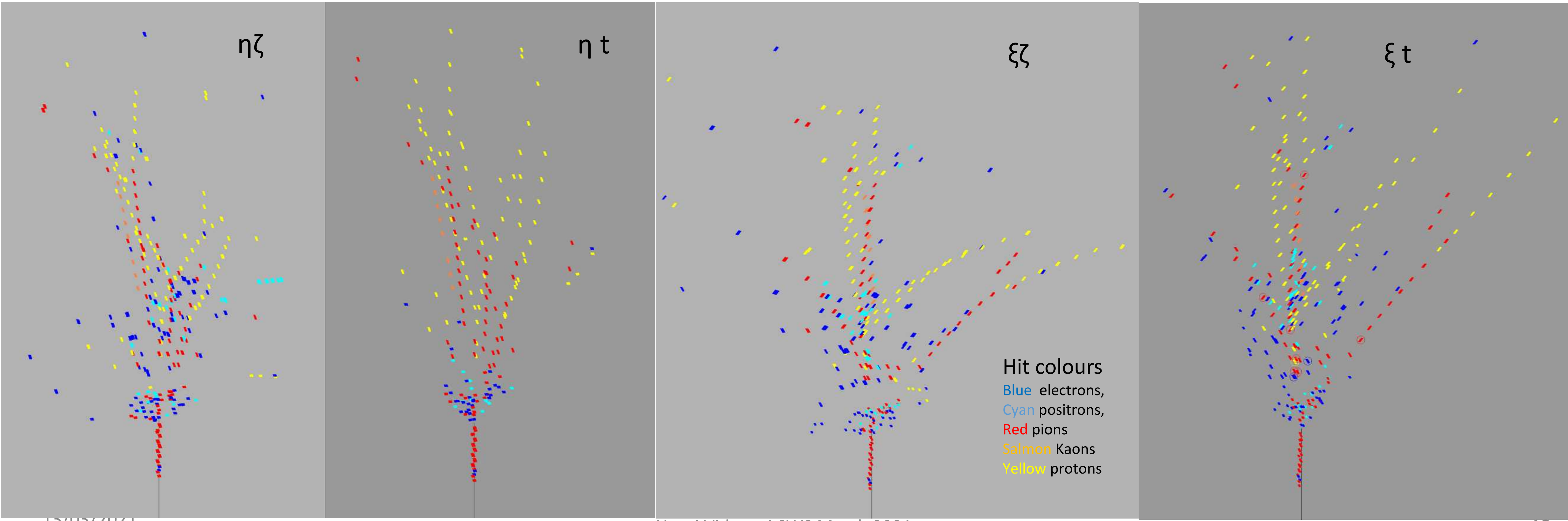
It is known that the more dimensions, the easiest to reconstruct patterns

Using the time-space

To figure out the pattern of a shower developed by a charged track or a neutral
We assume that the main direction of the shower, called ζ, is
- along the flight line from interaction to the earliest hit in the Ecal (or globally) for a neutral
- along the track direction at the position of the earliest hit for a charged track

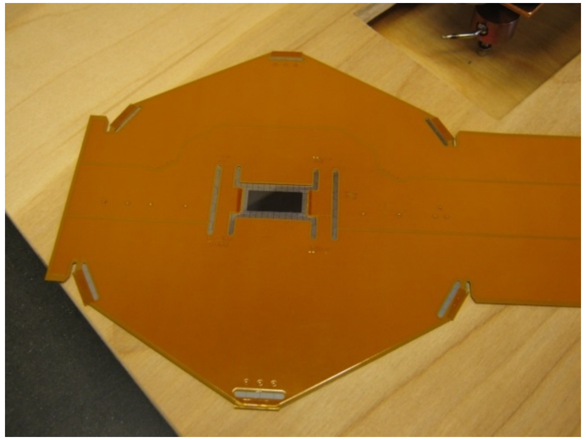
Two perpendicular coordinates, ξ and η, are chosen to optimise the match with the detector axes, mostly for visualisation.
Then t which is much correlated to ζ.

You see immediately
the role of the β
and how the protons slow down
when the pions do not

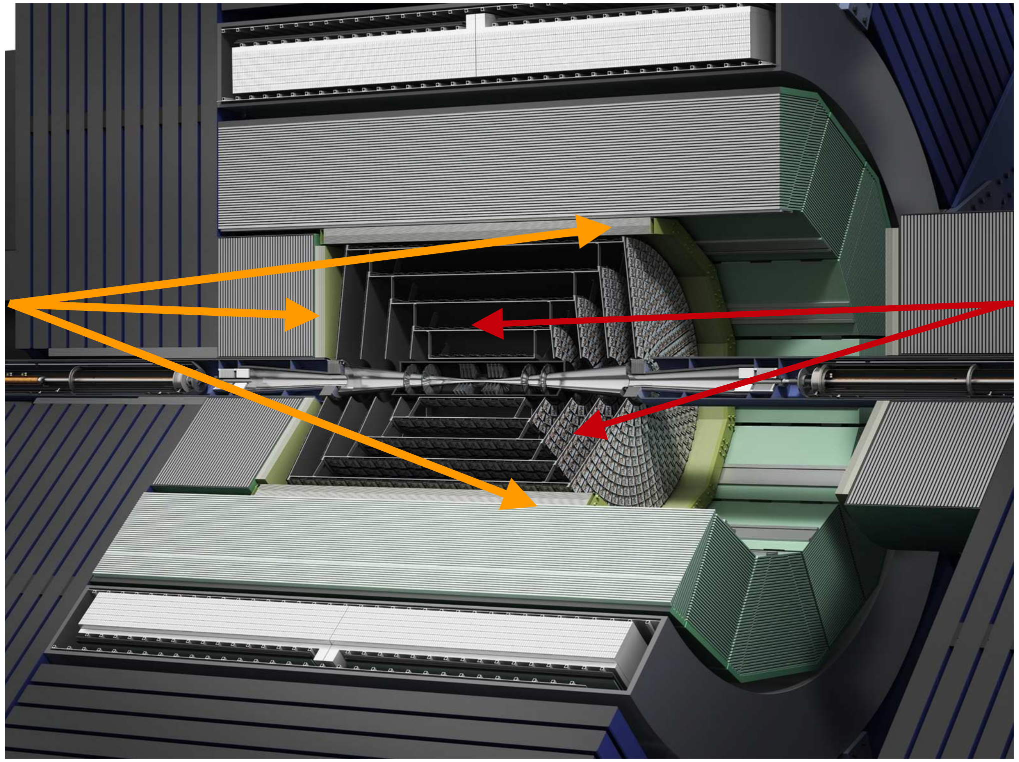


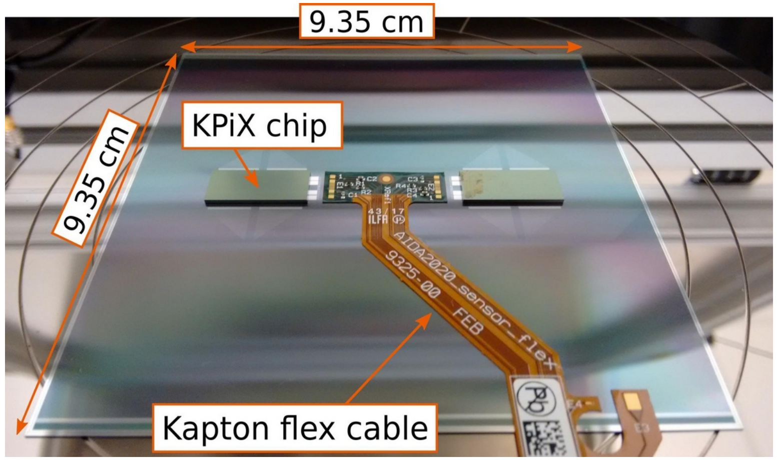
The SiD MAPS program

Using MAPS for Tracker & ECAL



ECAL:
1200 m² sensor area

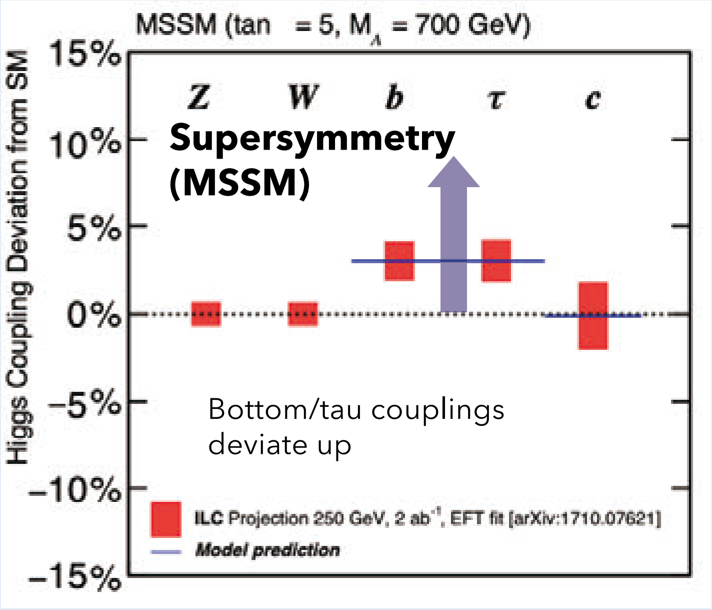




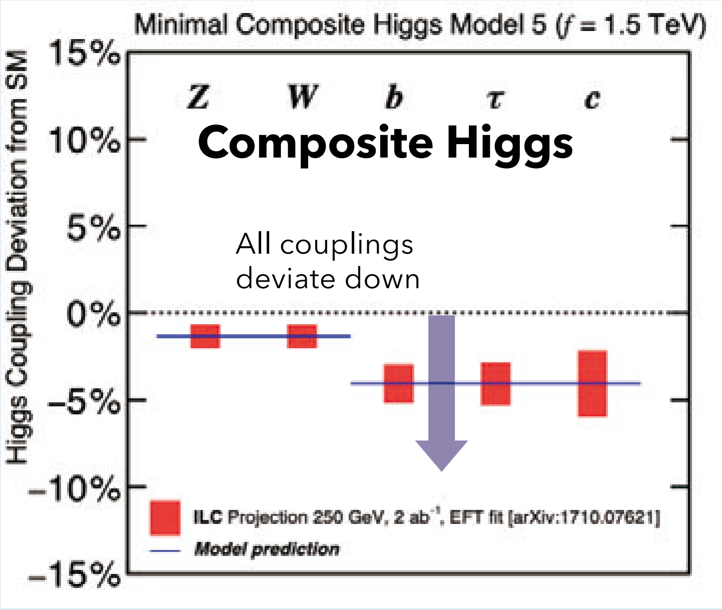
Tracker:
67 m² sensor area

Higgs Boson as a Discovery Probe

The pattern of Higgs boson couplings provides crucial information about the underlying new physics model:



LC sensitivity up to 2 TeV
(mass of the heavy Higgs boson m_A)



LC sensitivity beyond 10 TeV
(compositeness scale)

LC could discover signs of Supersymmetry, Extra Dimensions, or Compositeness.
If so, (1) the next direction in particle physics is determined;
(2) the next energy scale is determined;
(3) it sheds light on the type of Dark Matter favored by the model.

Global Fit with SM Effective Field Theory

Barklow et al. 1708.09079

$$\mathcal{L} = \mathcal{L}_{SM} + \underline{\Delta\mathcal{L}}$$

SU(2)xU(1) invariant
Dim-6 operators

LHC Run II results suggest 250 GeV is within the validity of EFT

Number of EFT coefficients: **17 @LC**

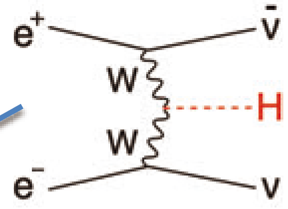
Fully exploiting the LC capabilities:

- e+e- initial state
- beam polarization
- all relevant decay channels
- access to essentially all phase space

Pre-SMEFT:

$$\Gamma_h = \frac{\Gamma(h \to WW^*)}{BR(h \to WW^*)}$$

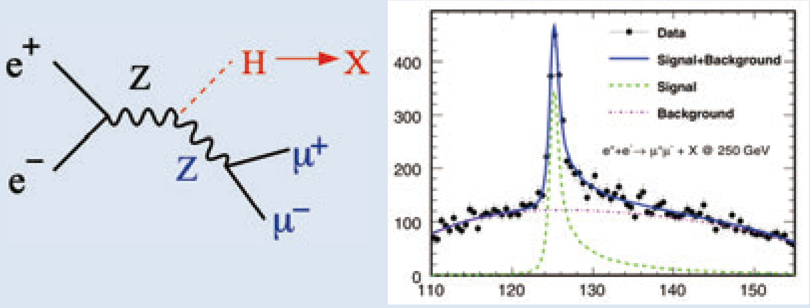
$$\Gamma(h \to WW^*) \propto \sigma(\nu\bar{\nu}h)$$



Cross section: small@250GeV

SMEFT relates hZZ and hWW couplings
→ Precise determination of Higgs total width

The importance of ***the σ_{Zh} measurement by recoil mass*** remains the same.

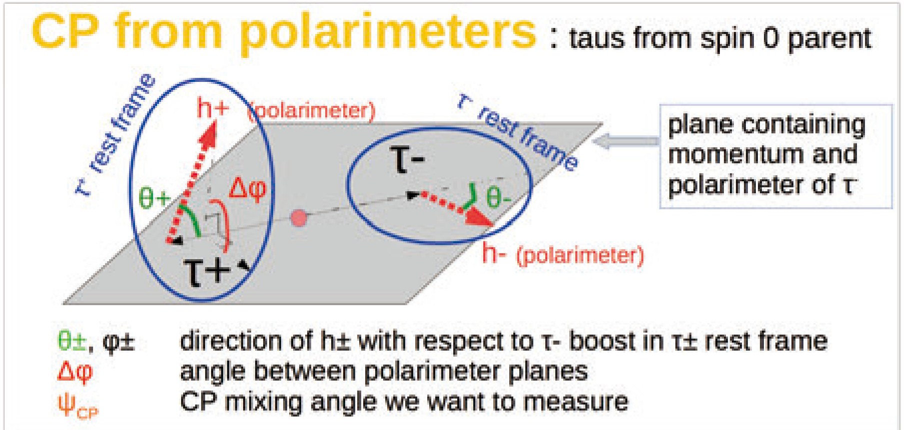


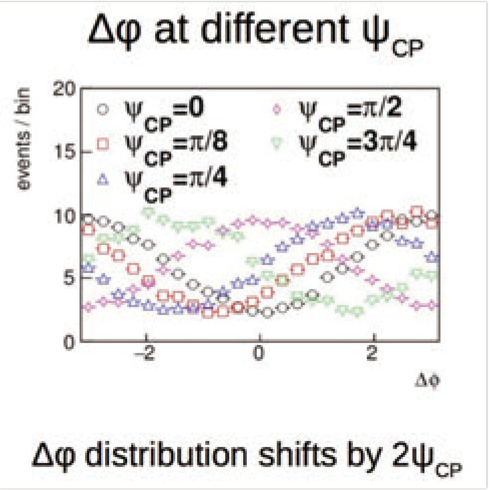
Absolute and model-independent determination of Higgs couplings possible with Higgs factory data.

Probing CP violation in Higgs sector

Measuring CP in H → $\tau^+\tau^-$ at ILC

$$\mathcal{L}_{h\tau\tau} = g\bar{\tau}\left(\cos\Psi_{CP} + i\gamma_5 \sin\Psi_{CP}\right)\tau\, h$$





2ab^{-1} @ 250 GeV

$$\delta\Psi_{CP} \simeq 4^\circ$$

Jeans, Wilson
PRD 98 013007 (2018)

In the SM, the Higgs boson is a CP even scalar.

BSM models with an extended Higgs sector contains multiple Higgs bosons.

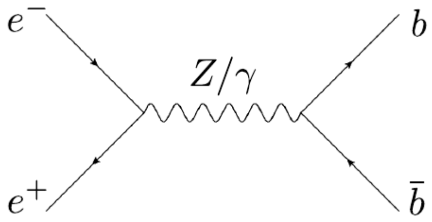
If a neutral CP-odd Higgs boson

CP mixing angle precision: 4 degrees

→ **Discover a new source of CP violation**
→ **Leads to Electroweak Baryogenesis**

Two fermions

▶ Differential cross section for (relativistic) di-fermion production



$$\frac{d\sigma}{d\cos\theta}(e_L^- e_R^+ \rightarrow f\bar{f}) = \Sigma_{LL}(1+\cos\theta)^2 + \Sigma_{LR}(1-\cos\theta)^2$$

$$\frac{d\sigma}{d\cos\theta}(e_R^- e_L^+ \rightarrow f\bar{f}) = \Sigma_{RR}(1+\cos\theta)^2 + \Sigma_{RL}(1-\cos\theta)^2$$

- The helicity amplitudes Σ_{IJ}, contain the couplings g_L/g_R (or Form factors or EFT factors)
- Left/right asymmetries (characteristic for each fermion)

▶ **BSM in these topologies are mainly discussed in terms of new Z' bosons, coming from an extension of the SM gauge group**

- **Most of these models modify the top-quark couplings**

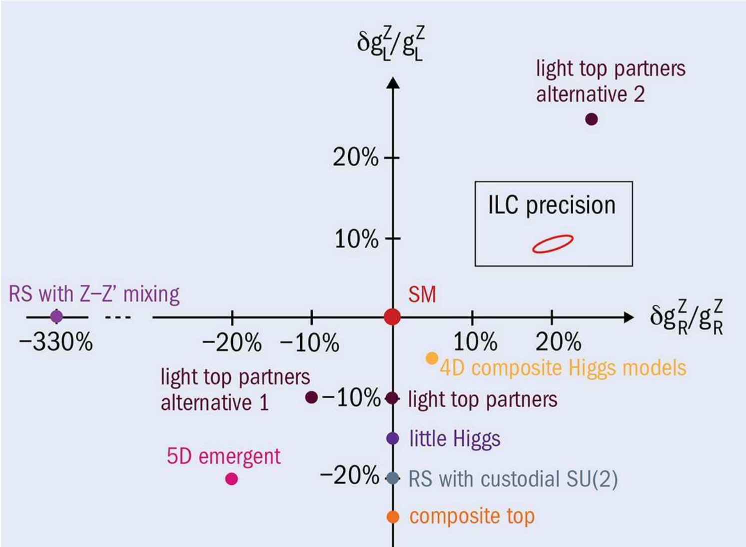
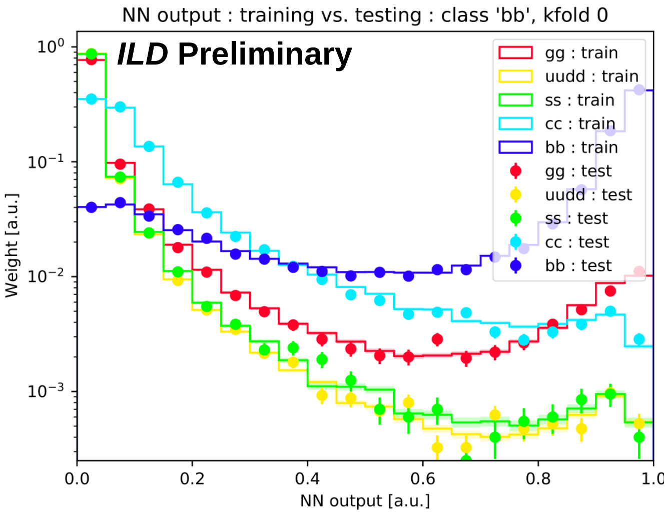
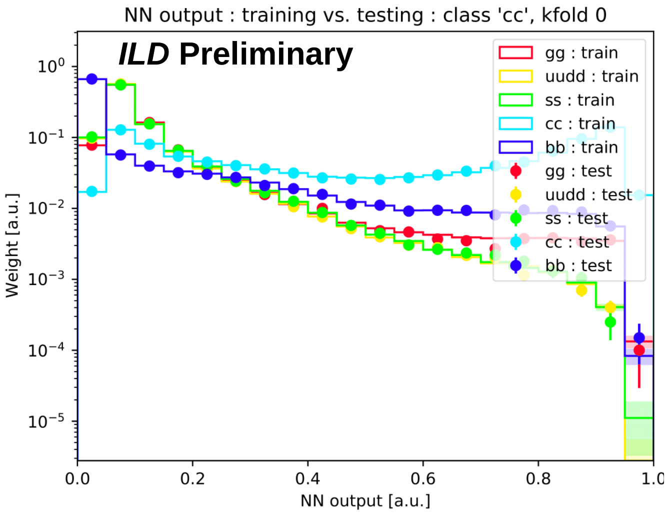
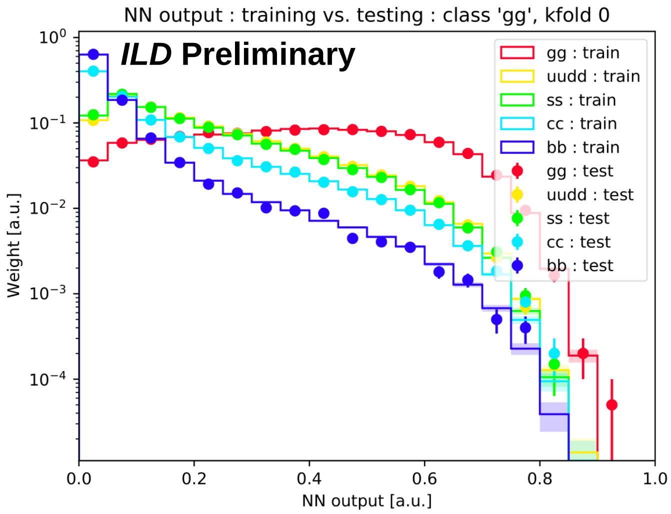


Figure from F. Richard

Performance: *b*, *c*, and *g* jets





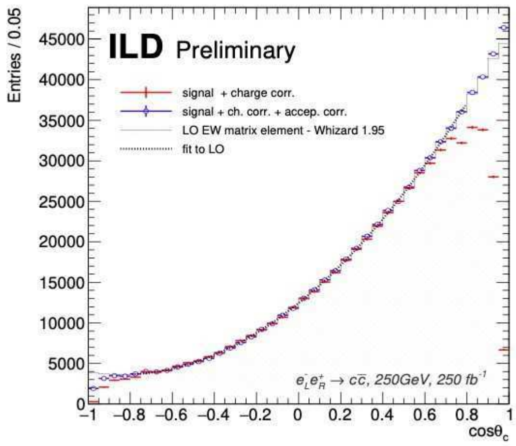


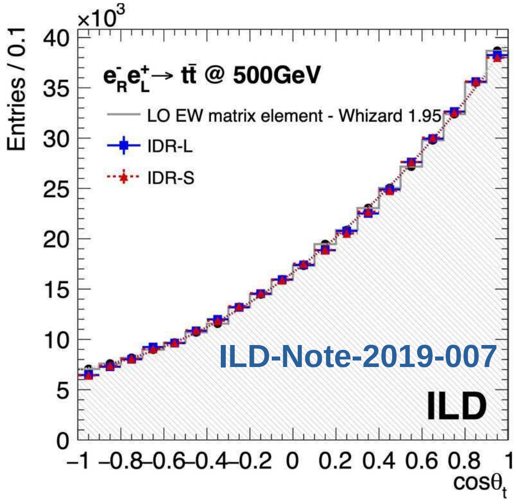
- MVA likely returning *b*/*c*-tagger scores – should do just as well or better than input BDT scores
- **Reasonable** discrimination of gluon jets – likely comes from $N_{\text{particles}}$ input

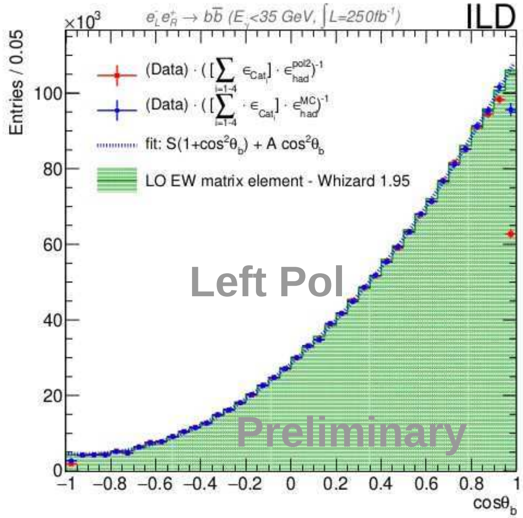
Realistic studies with full simulation

Probing the Chiral structure **of the SM and BSM** requires **:**

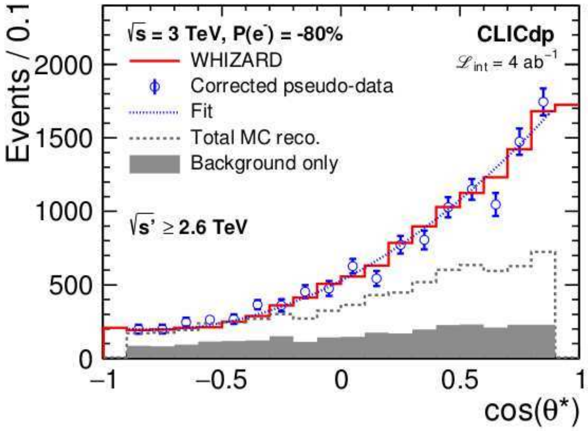
- ▶ **high precision predictions & global fits**
- ▶ **High precision measurements** (at the per mile level in some cases!!)
  - detailed studies with **full simulations with realistic detectors**
  - **Optimization of detectors and reconstruction techniques**
- ▶ EFT predictions will require input from differential distributions





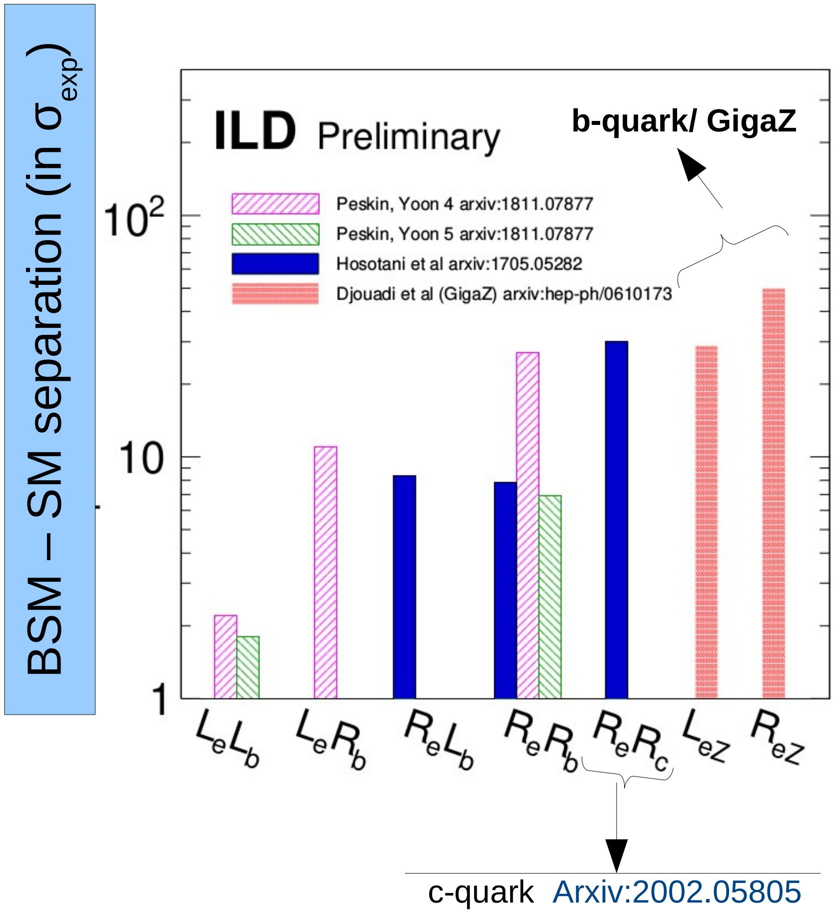


arxiv:2008.05526



FULL SIMULATION STUDIES

Access to Heavy Resonances at ILC250



▶ **BEAM POLARISATION allows to distinguish between different models**

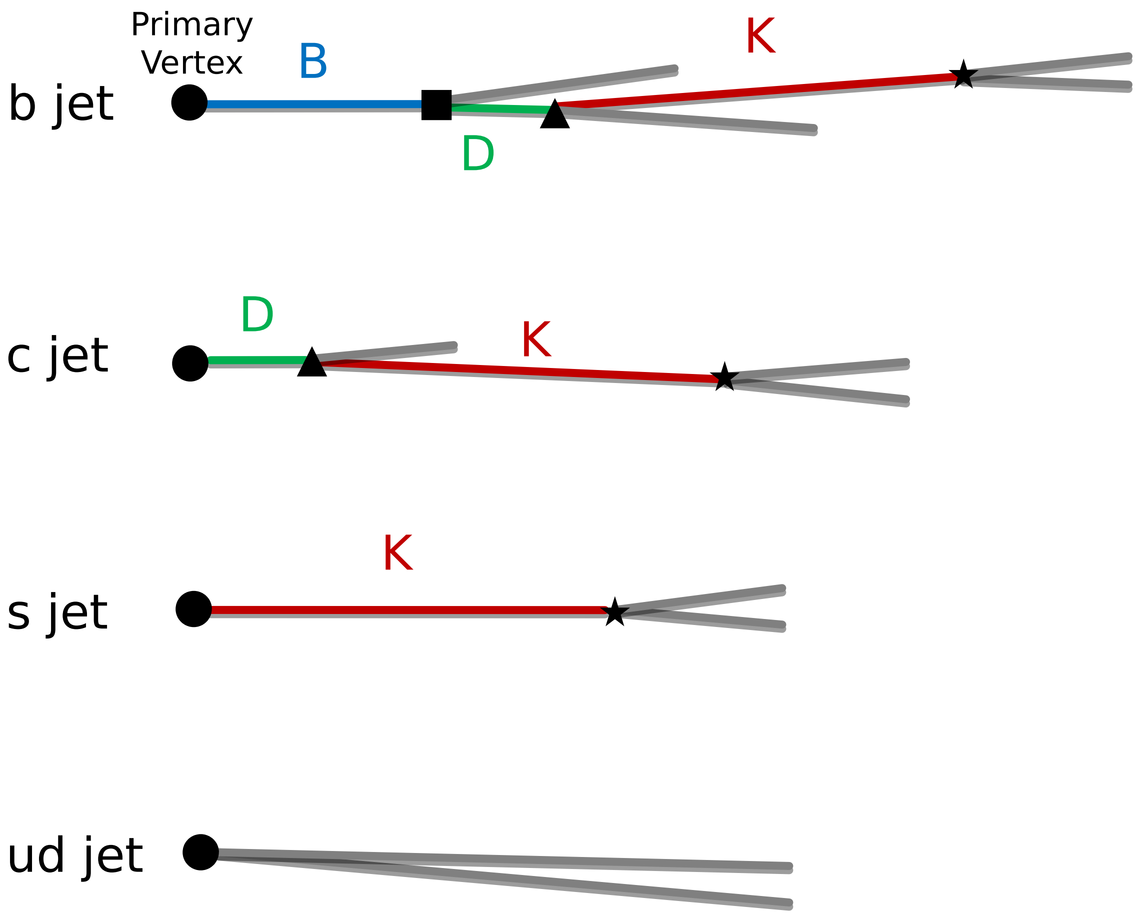
Expected number of standard deviations for different **RS/compositeness BSM scenarios** when determining the different EW couplings to c- and b-quark at **ILC250** (with GigaZ input).

- Models that predict multi-TeV Z' resonances
- With or without mixing at Z-pole
- See backup for more details on the models

Potential for discovery of new resonances mZ' ~ O(10-20) TeV at ILC250

Arxiv:1709.04289, PoS(EPS-HEP2019)624

Discriminants



Charged Kaon track

- Zero track impact parameter w.r.t. primary vertex
- Momentum fraction relative to the jet momentum carried by the leading Kaon
  - (Longitudinal vs transverse components?)

V⁰ (K_S^0,Λ^0)

- Vertex momentum & displacement must point in the same direction
- Mean vertex distance smaller compared to b/c

+ the usual b/c discriminants (vertex mass, impact parameter for all tracks, etc.)

Remember to normalize the discriminants to make them boost invariant (as much as possible)

Definition of Observable

- **Heavier quark tends to be difficult to emit gluon $q \to q + g$.**

  $\to b$ quark mass sensitivity appears on 3-jet events after gluon radiation.

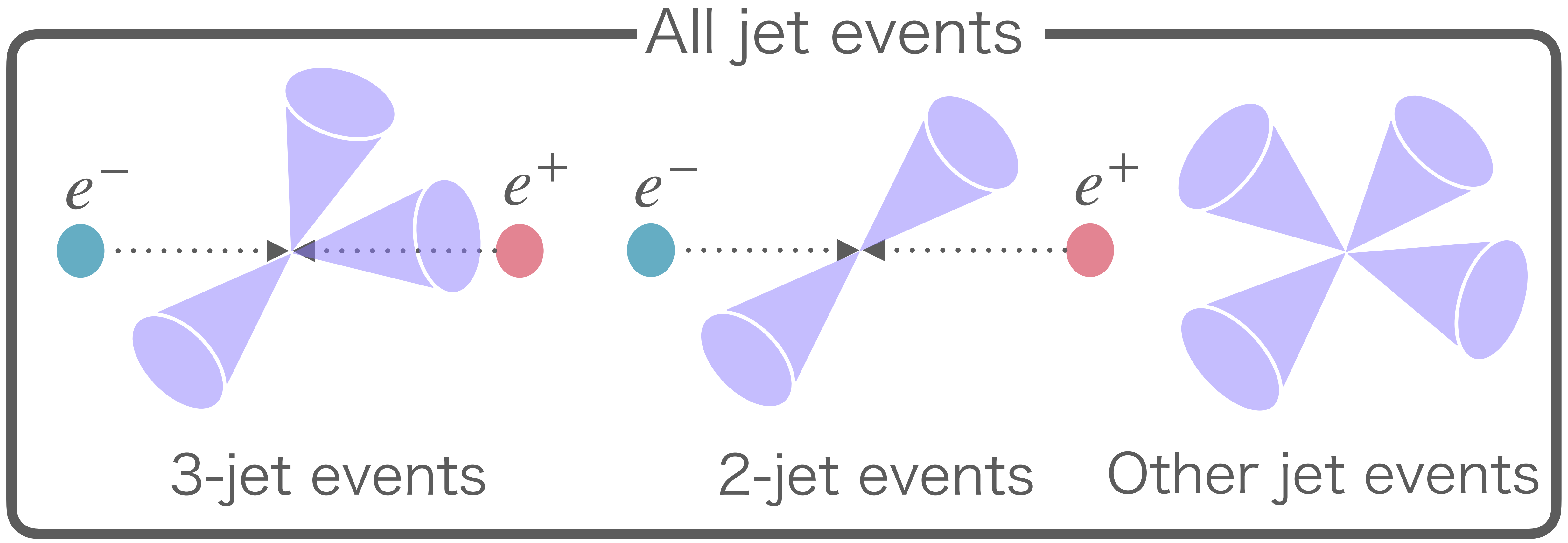
- Define **the double ratio of 3-jet fractions** for $e^+e^- \to q\bar{q}$.

$$R_3^{bl} = \frac{N_{3b}/N_b}{N_{3l}/N_l}$$

$$= 1 + \frac{\alpha_s}{\pi}a_{LO} + \frac{m_b^2}{s}\left(b_{LO}(m_b) + \frac{\alpha_s}{\pi}b_{NLO}(m_b)\right)$$

a_{LO} , b_{LO} : LO corrections b_{NLO} : NLO correction

$\sqrt{s}$: CM energy



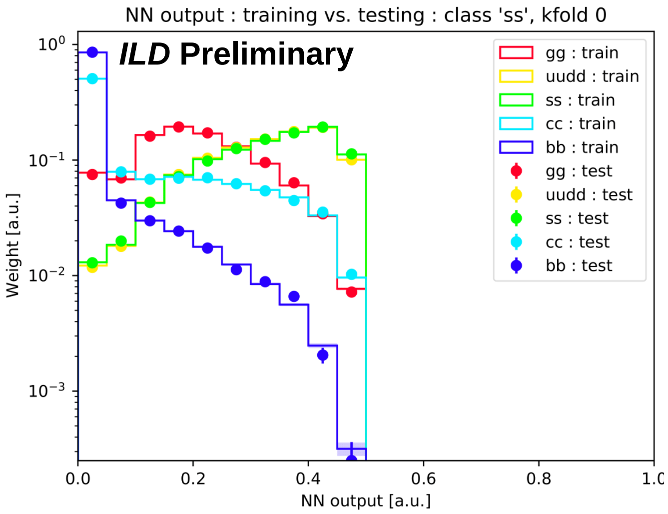
N_b : $e^+e^- \to b\bar{b} \to$ all jet events number

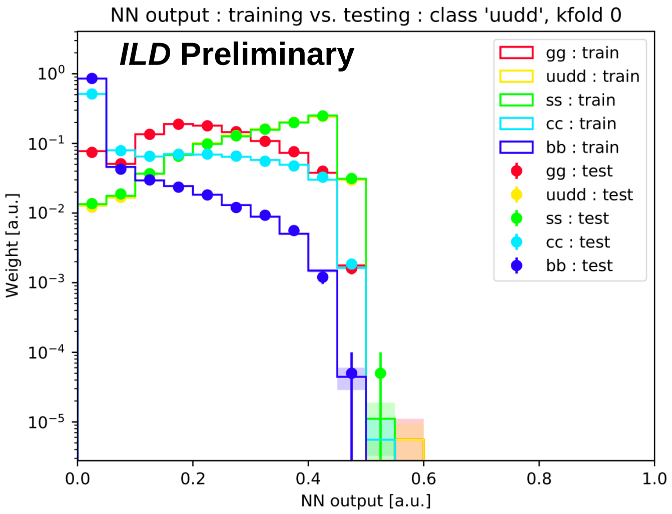
N_{3b} : $e^+e^- \to b\bar{b} \to$ 3-jet events number

N_l : $e^+e^- \to l\bar{l} \to$ all jet events number $(l = u \text{ or } d \text{ or } s)$

N_{3l} : $e^+e^- \to l\bar{l} \to$ 3-jet events number $(l = u \text{ or } d \text{ or } s)$

Performance: *s* and *u/d* jets



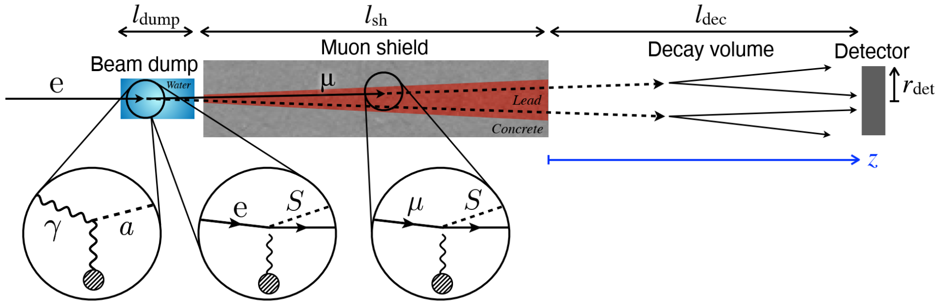


- Unfortunately, separation of strange and light jets is very **hard** (even p_{lead}/p_{jet} track each other quite closely for these classes)!
- Currently: reasonable separation possible for *b*, *c*, *g*, and *s+u/d*

Use of ILC Beam for Fixed Target Experiment

There are many possible experiments using the ILC beam other than the colliding experiment

- Experiments using the main dump
  - ✓ Observe particles created in the main beam dump
  - ✓ Dark photon, dark lepton, ALP (axion-like particle), Higgs-portal particles, ……
  - ✓ Positron main dump
    - Positron annihilation with atomic electrons
  - ✓ Parasitic with the main collision experiment



- Experiments using Extracted beam
  - ✓ Extract the strong ILC beam somewhere for e.g., strong QED experiment
    - This is perhaps difficult (the beam is too strong to ontercept)
  - ✓ Or, create and extract a weak beam
    - Low bunch intensity but many (>> 1312) bunches
    - Ideally, CW
    - Missing energy experiment to search for dark photons
    - Lots of accelerator issues such as beam creation, to avoid damping in DR, control of very weak beam, etc.

By Kaoru Yokoya on Tuesday 10PM (Europe)
"N1: Dark Sector, Fixed-Target and Beam Dump Experiments"

- Far detector
  - ✓ Long-lived particles may be produced at the IP
  - ✓ They may be detected by a detector behind 50-200m shield (natural rocks)
  - ✓ Need to construct a cavern (near the main beamline, or along the access tunnel)

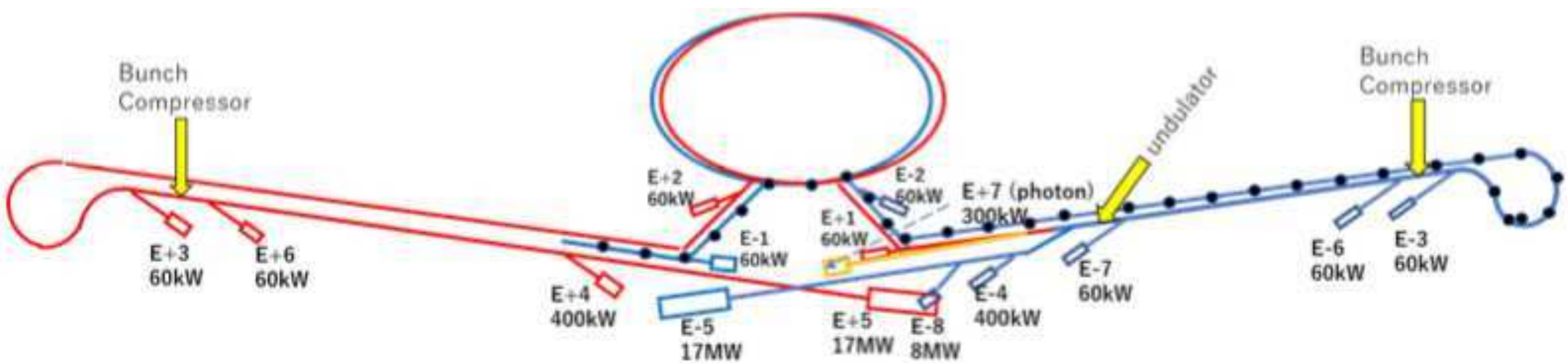
We would be happy to discuss the further possibilities of the ILC accelerator.

Some preferred locations are:

1. An area behind the e- and e+ main beam dumps and muon shields.

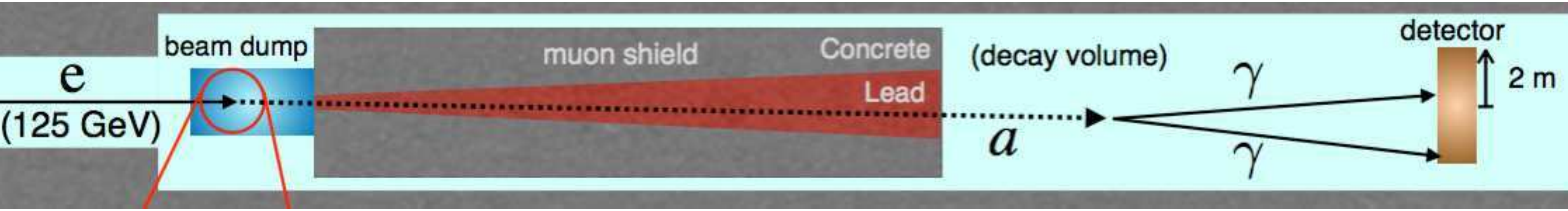
2. A dedicated fixed-target experimental hall with electron beams at E-4.

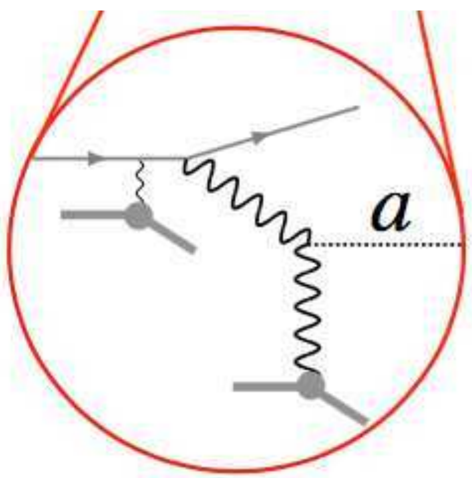
3. A cavern off of the collider hall access tunnel (e.g., for long-lived particles from Higgs decays)

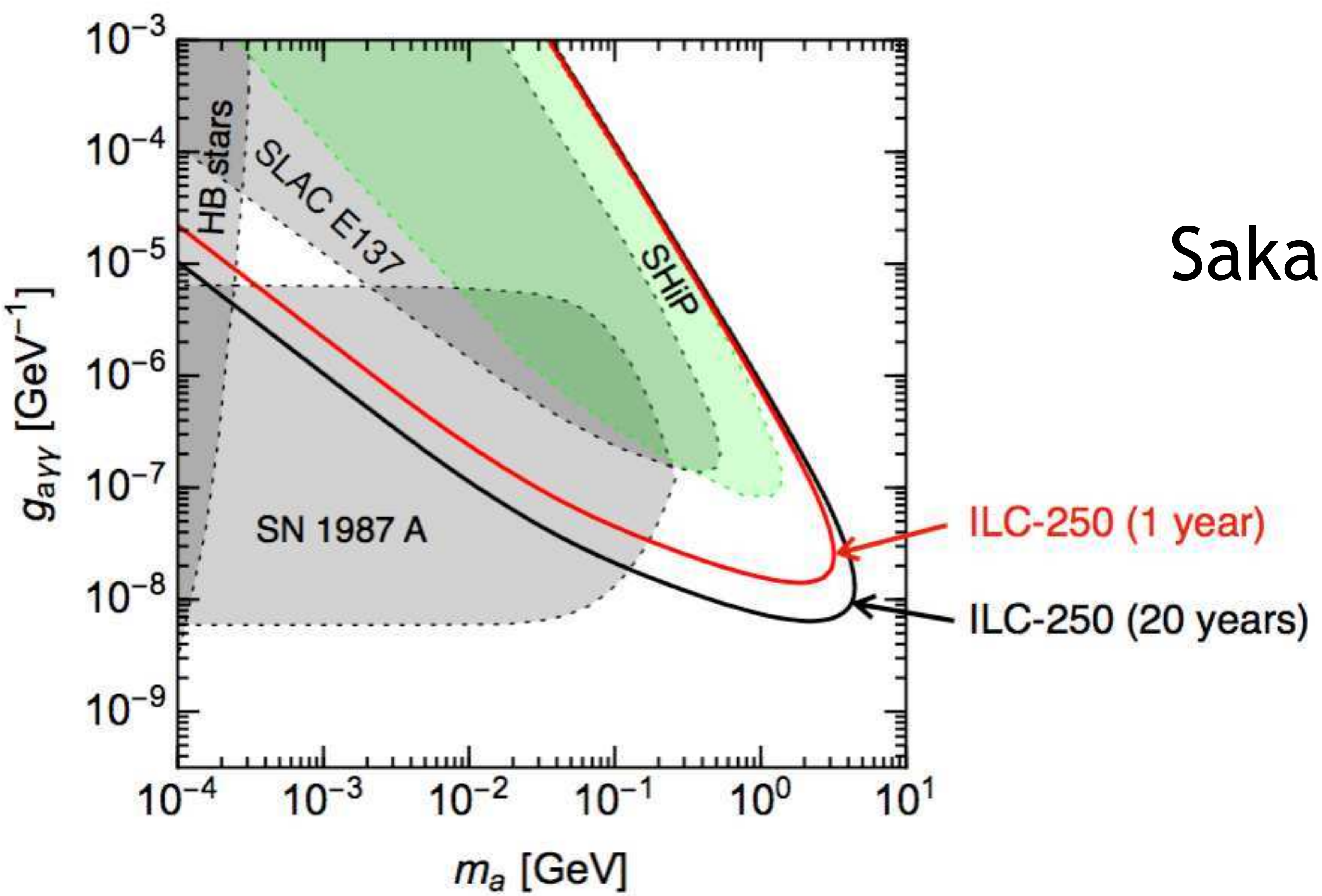


thanks to Kaoru Yokoya !

example of an axion/ALP search







Sakaki

Our results @ LCWS'2021

Optimising top-quark pair-production threshold scan at future e+e- colliders

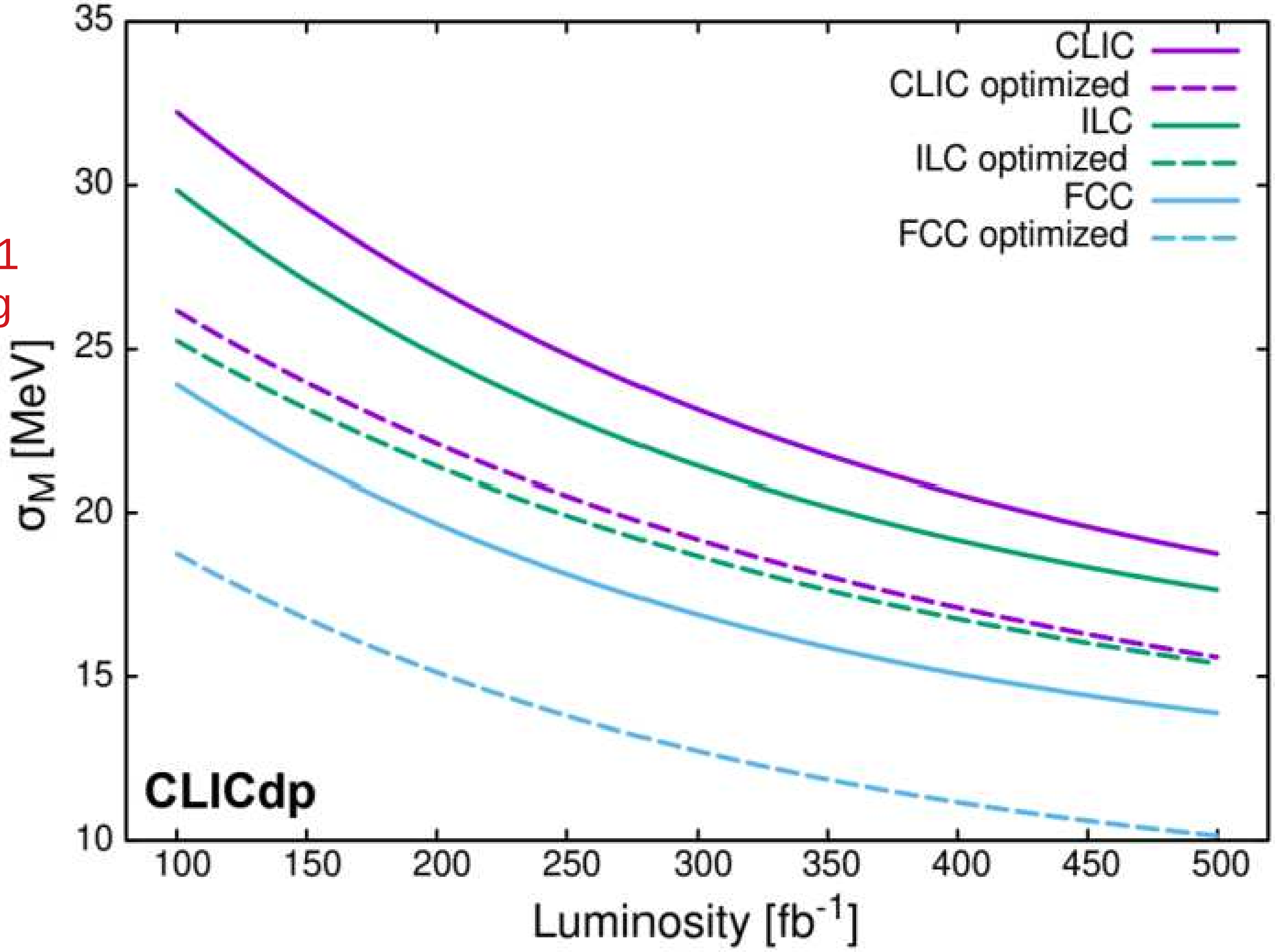
LCWS 2021, March 16, 2021

Kacper Nowak, Aleksander Filip Żarnecki

FACULTY OF PHYSICS UW

Influence of luminosity spectra

Normalization uncertainty 1%
Strong coupling uncertainty 0.001
Yukawa coupling ucertainty 0.1



Optimized for mass and width determination precision

Assuming **same** background and efficiency, **no polarisation**

CLIC sensitivity to invisible scalar decays

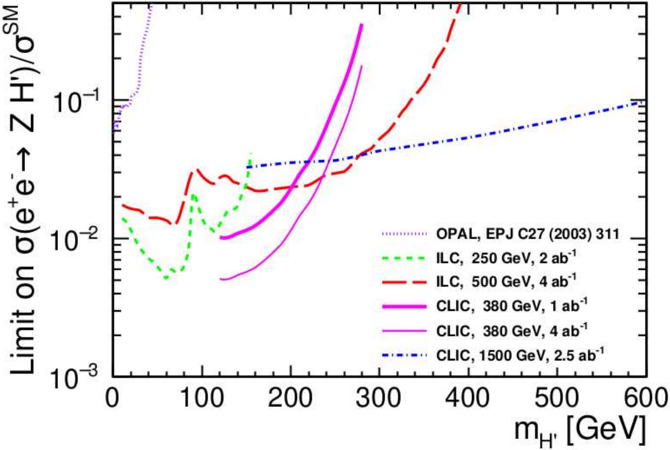
K.Mękała, A.F. Żarnecki, B. Grządkowski, M. Iglicki

Faculty of Physics, University of Warsaw

International Workshop on Future Linear Colliders, LCWS2021
17.03.2021

Mekala, K., Zarnecki, A.F., Grzadkowski, B., Iglicki, M.,
Sensitivity to invisible scalar decays at CLIC,
Eur. Phys. J. Plus **136**, 160 (2021),
https://doi.org/10.1140/epjp/s13360-021-01116-5

Limits on new scalar production



Heavy Neutrinos at Future Linear e^+e^- Colliders

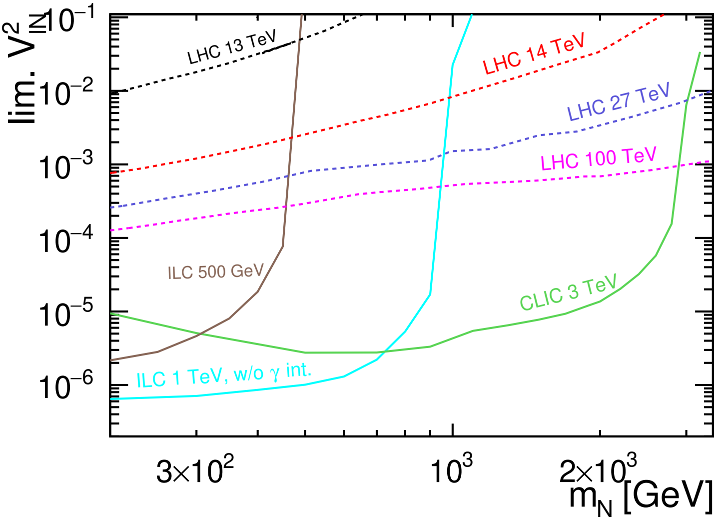
K. Mękała[1], A. F. Żarnecki[1], J. Reuter[2], S. Brass[2]

[1]Faculty of Physics
University of Warsaw

[2]Theory Group
Deutsches Elektronen-Synchrotron

International Workshop on Future Linear Colliders, LCWS2021
17.03.2021

Final results



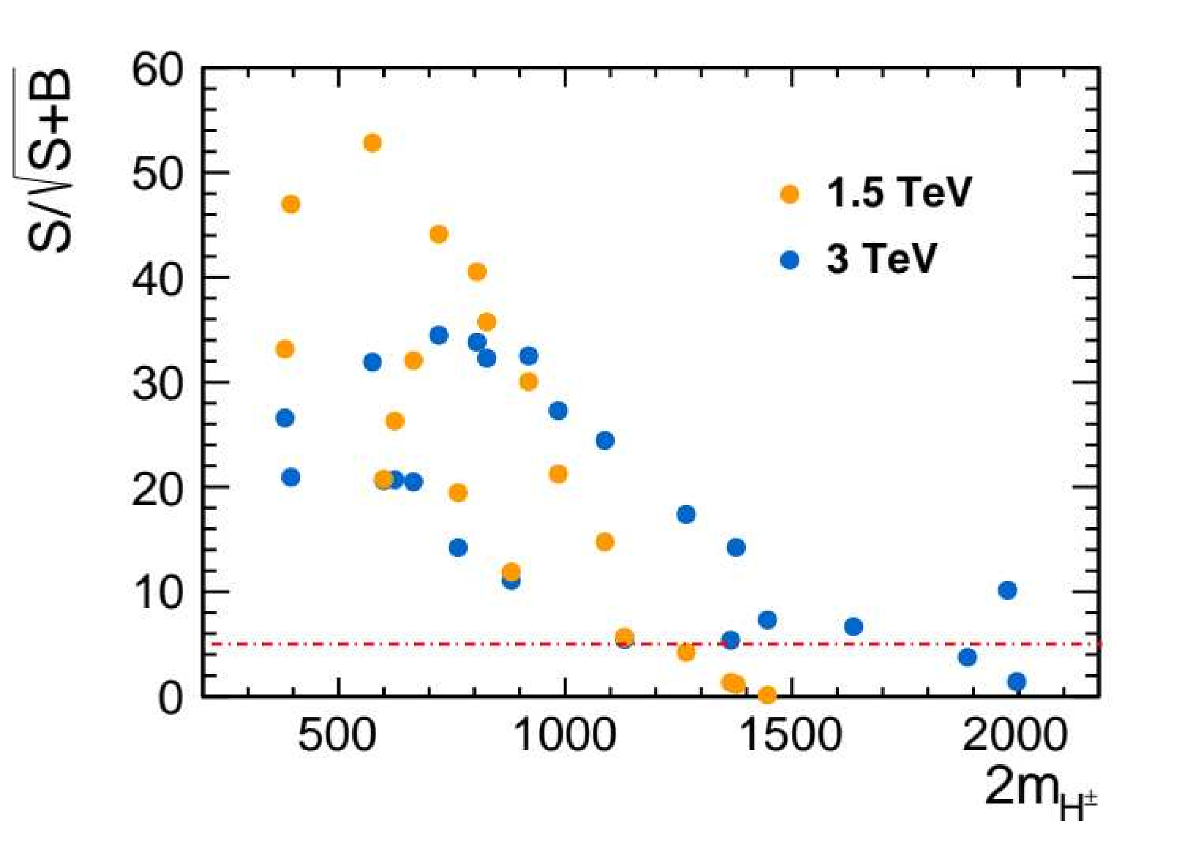
LHC analysis: [1812.08750], diff. assumption: $V_{eN} = V_{\mu N} \neq V_{\tau N} = 0$

Search for the pair-production of charged IDM scalars at high energy CLIC

J. Klamka, A. F. Żarnecki
Faculty of Physics, University of Warsaw

LCWS‘21, 16/03/21

Final results (all scenarios)



- Two BDTs trained separately: for all scenarios with **off-shell** $W^{+/-}$ and for all scenarios with **on-shell** $W^{+/-}$

- Most benchmarks **above 5σ** discovery threshold

Simulating hard photon production with WHIZARD

LCWS2021

INTERNATIONAL WORKSHOP ON FUTURE LINEAR COLLIDERS

Wojciech Kotlarski

TECHNISCHE UNIVERSITÄT DRESDEN

INSTITUTE OF NUCLEAR AND PARTICLE PHYSICS

in collaboration with: Jan Kalinowski, Krzysztof Mękała,
Paweł Sopicki and Aleksander Filip Żarnecki

based on Eur. Phys. J. C 80 (2020) 7, 634 [arXiv:2004.14486]

Technical details

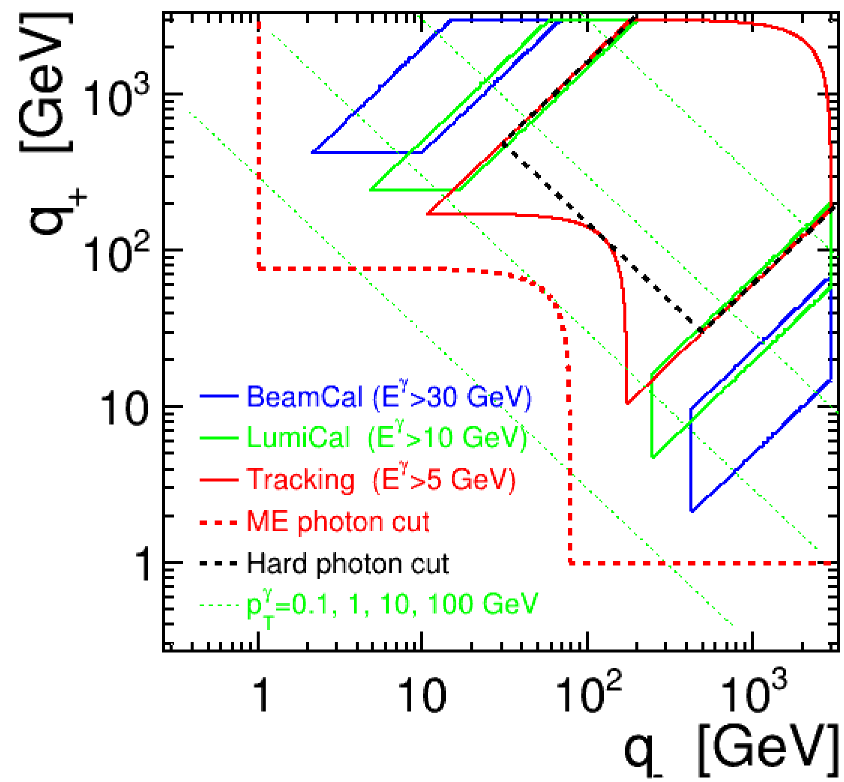
- Introduce variable

$$q_- = \sqrt{4E_0E_\gamma}\sin\frac{\theta_\gamma}{2}$$
$$q_+ = \sqrt{4E_0E_\gamma}\cos\frac{\theta_\gamma}{2}$$

  equivalent to description via (E_γ, θ_γ)

- Used do separate soft and/or collinear region for the region described by matrix element
- Generation: 1, 2 or 3 ME photons nonradiative events for signal only (for normalisation)
- all ME photons with $q_\pm$ > 1 GeV & E_γ > 1 GeV
- rejected are events with $q_\pm$ > 1 GeV & E_γ > 1 GeV for any of the ISR photons

detectro acceptance in $q_\pm$ variable at sqrt(s)=3 TeV



Dark matter production via light mediator exchange at future e^+e^- colliders

Jan Kalinowski[a], Wojciech Kotlarski[b], Krzysztof Mekala[a], Pawel Sopicki[a], **Aleksander Filip Żarnecki[a]**

[a] Faculty of Physics, University of Warsaw
[b] Institut für Kern- und Teilchenphysik, TU Dresden

Research supported by National Science Centre Poland

The 2021 International Workshop on Future Linear Colliders

Theoretical Developments & Physics Analyses session

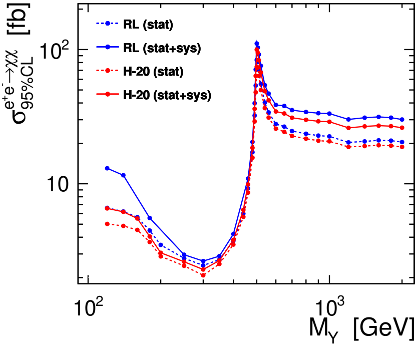
March 17, 2021

Results

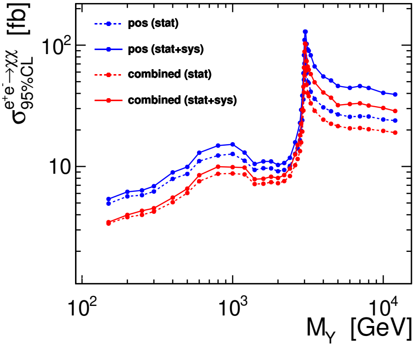
Systematic uncertainties PRELIMINARY

Limits for mediator with $\Gamma/m = 3\%$

ILC @ 500 GeV



CLIC @ 3 TeV



Influence of systematic effects reduced for light mediators, $M_Y < \sqrt{s}$

Conclusions

Worldwide Large-Scale SRF Technological Base for ILC

RI XFEL Cavities Statistics:

- ✓ **47 of 420 cavities** of RI cavity production exceeding **40 MV/m**
- ✓ **More than half** of the 420 RI cavities exceeded **35 MV/m**
- ✓ **Average accelerating gradient** of all RI cavities was **33 MV/m (RMS 6.5 MV/m)**

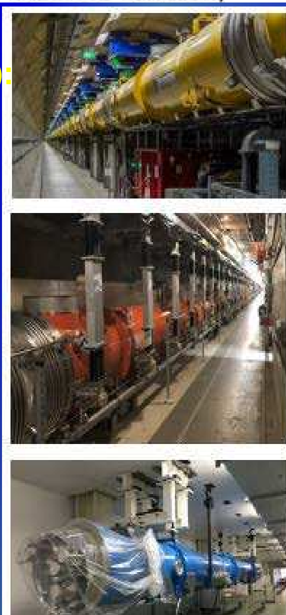
High Gradient Cryomodule Project (IDT & ILC Pre-Lab phase): effort to construct & test CM in high gradient regime

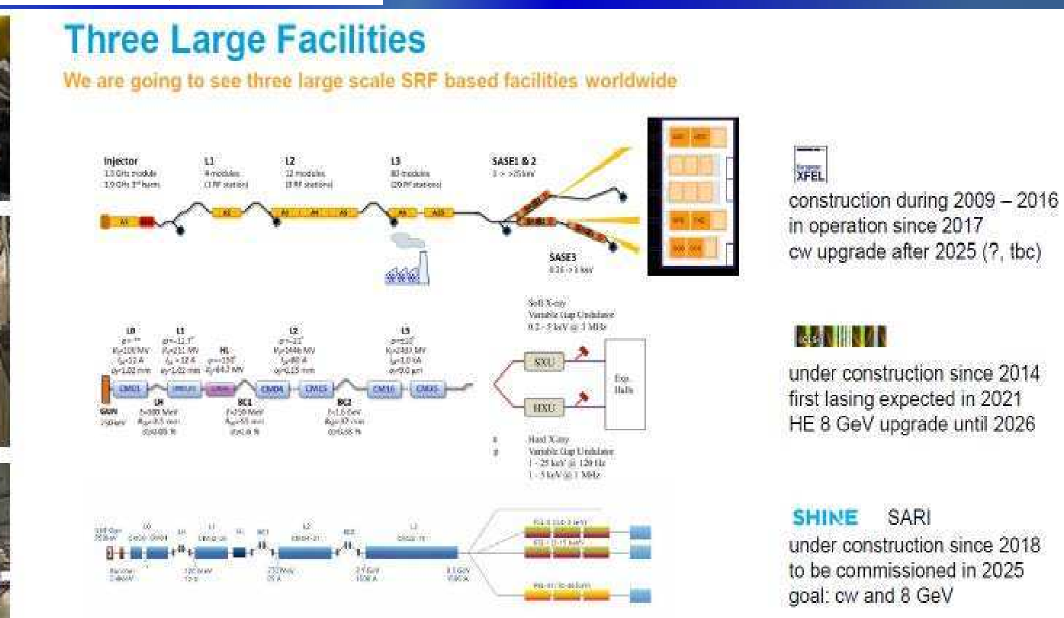
→ re-use existing CM1, take earlier ILC R&D cavities and treat them with new processes

Labs involved to date:

Fermilab, Jefferson Lab, DESY, cea, Cornell University, KEK-JAPAN, Argonne National Laboratory, TRIUMF

Supported by US DoE HEP with international participation

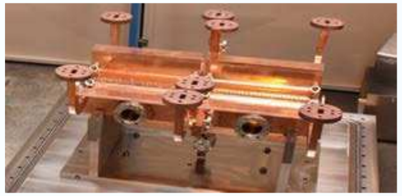


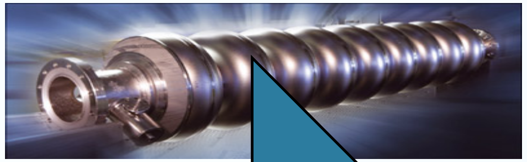


ILC Workshop on Potential Experiments ("ILCX")
Date: 26-29 October 2021
Location: Tsukuba, Japan
To be held in person, pandemic situation permitting
Stay tuned for announcements on ILC Newsline
https://newsline.linearcollider.org/

The workshop aims to cultivate new ideas and directions for research using the entire ILC facility -- collision point, far away from the collision point, beam dumps, use of extracted beams, etc.
Your idea might become a real experiment.

Clarification by T. Nakada:
I was informed by several people that there has been a confusion abut the EoI process. While the spring **LCWS** is for the discussion on physics that can be addressed in various ways at ILC, the **autumn workshop** is aiming for more concrete ideas of experiments, rather than a physics idea and sketchy detector concept, and with more people behind to work rather than just a single person. For the **real EoI presentation anticipated in 2022**, it is expected to include expected performance of the experiments resulted from some simulation studies and technical description of the detector. At this moment, submission of a written EoI document is not envisaged. The call for EoIs will be triggered by the iDT after seeing a concrete sign for the Pre-lab start, and EoI presentations will be organized by the Pre-lab after being launched.





Thanks for your attention

Backup slides

U.S. Government Perspective on ILC

The U.S. government, including DOE, Department of State, and Office of Science & Technology Policy (OSTP), has been very supportive of the ILC in Japan.

Oct. 2019: DOE Under Secretary Paul Dabbar visited Japan and met with MEXT officials and Diet representatives in order to advance the ILC project in Japan, focusing first on the Pre-lab stage because in the U.S. it takes at least 2 years to formulate the budget.

Feb. 2020: A letter from DOE Secretary of Energy Dan Brouillette to Japan's Minister of State for Science & Technology Policy Naokazu Takemoto in the Cabinet Office stated:

> The Japanese model of investments in major research infrastructures, and your government's continued commitment to our shared values, gives the U.S. Department of Energy (DOE) confidence that the ILC can become a center of excellence in particle physics research in Japan and across the globe.
> DOE is therefore ready to begin engaging with Japan and other international partners to discuss topics of shared, collaborative resources towards the project, the proposed governance models for a potential ILC Laboratory, and the remaining research and development efforts that are needed to realize a future facility.
> Such discussions would naturally form the basis of the "pre-laboratory" phase of the ILC project.

DOE welcomes recent statements from MEXT Minister Hagiuda regarding international partners coming to the table. DOE would be eager to come to the table.

Current idea for the Pre-lab governance model

- Pre-lab is set up as an international collaboration of national, intergovernmental and university laboratories governed through the Memorandums of Understanding (MoUs).
- Technical preparation works are defined as work packages and delivered by the participating laboratories as in-kind contributions..
- Assembly of the participating laboratories is the highest decision making body of the Pre-lab. A forum for the funding agencies and national authorities to monitor the progress.
- Directorate headed by the director is running the Pre-lab and coordinate the overall work, but the execution of the work packages are fully under the control of responsible laboratories, including the resource acquisition.
- Pre-lab facilitates the community to develop ideas, to make R&D and to form collaborations for designing and proposing the ILC experiments.

IDT work plan for the coming days

- IDT is now ready to start discussion with laboratories
  - to identify matching between the work packages and interest and expertise of laboratories.
  - to understand conditions where the laboratory could consider to signup for a work packages.
- Further develop the governance model and organisational structure reflecting the political development
- Explore ways to start the Pre-lab
- Keep stimulating the physics community through promoting new physics ideas and facilitating common effort.

NB: It is planned that the progress will be assessed by the ICFA end of this year

MANDATE AND WORKPLAN OF IDT-WG3

Terms of reference from ICFA:

WG3 carries out the ILC physics and detector activities. It continues the study of the ILC physics capabilities and detector efforts as previously carried out under the LCC framework, reflecting the on-going progress of the field. It guides the community to be ready when the ILC Pre-Lab will establish its physics program.

WG3 Community actions

ILC is moving towards the preparatory laboratory stage (Prelab), currently envisioned to start in 2022. In order to activate the community towards preparing the Expressions of Interest for the experiments, the Physics and Detector Working Group (WG3) aims to:

- Raise awareness and interest in the ILC development and expand the community.
- Support newcomers to get involved in physics and detector studies.
- Encourage new ideas for experimentations at the ILC

While achieving this, WG3 will pay special attention to:

- support of existing activities, as basis for any growth, through the IDT period
- visibility for young scientists engaging in ILC activities
- increased diversity among conveners

https://linearcollider.org/idt-wg3-mandate/

Japan Association of High Energy Physicists
ILC Steering Panel

New effort to lead the ILC promotional activities in Japan

Established in 28th of October 2020 to discuss strategies and drive the community-wide effort in Japan to realize the ILC project.

Mandate

- Leading the promotion of the ILC project in the high energy physics community in Japan.
- Coordinating the promotion activities in Japan working with KEK and the ILC International Development Team.
- Cooperating with various bodies in Japan, such as political organizations, government authorities, industry-academia associations, regional governments and organizations, and media, as well as relevant international organizations, towards the realization of the ILC.

Members:
Shoji Asai (Tokyo)
Kazunori Hanagaki (KEK)
Toru Iijima (Nagoya)
Kiyotomo Kawagoe (Kyushu)
Sachio Komamiya (Waseda)
Shinichiro Michizono (KEK)
Toshinori Mori (Tokyo)
Hitoshi Murayama (Berkeley/IPMU)
Yutaka Ushiroda (KEK)
Hitoshi Yamamoto (Tohoku/Valencia)
Satoru Yamashita (Tokyo) – Chair

Members from ATLAS, Belle II, and ILC
Meetings on a weekly ~ biweekly basis

Many support teams: Universities and KEK in working groups, editorial teams, so on..