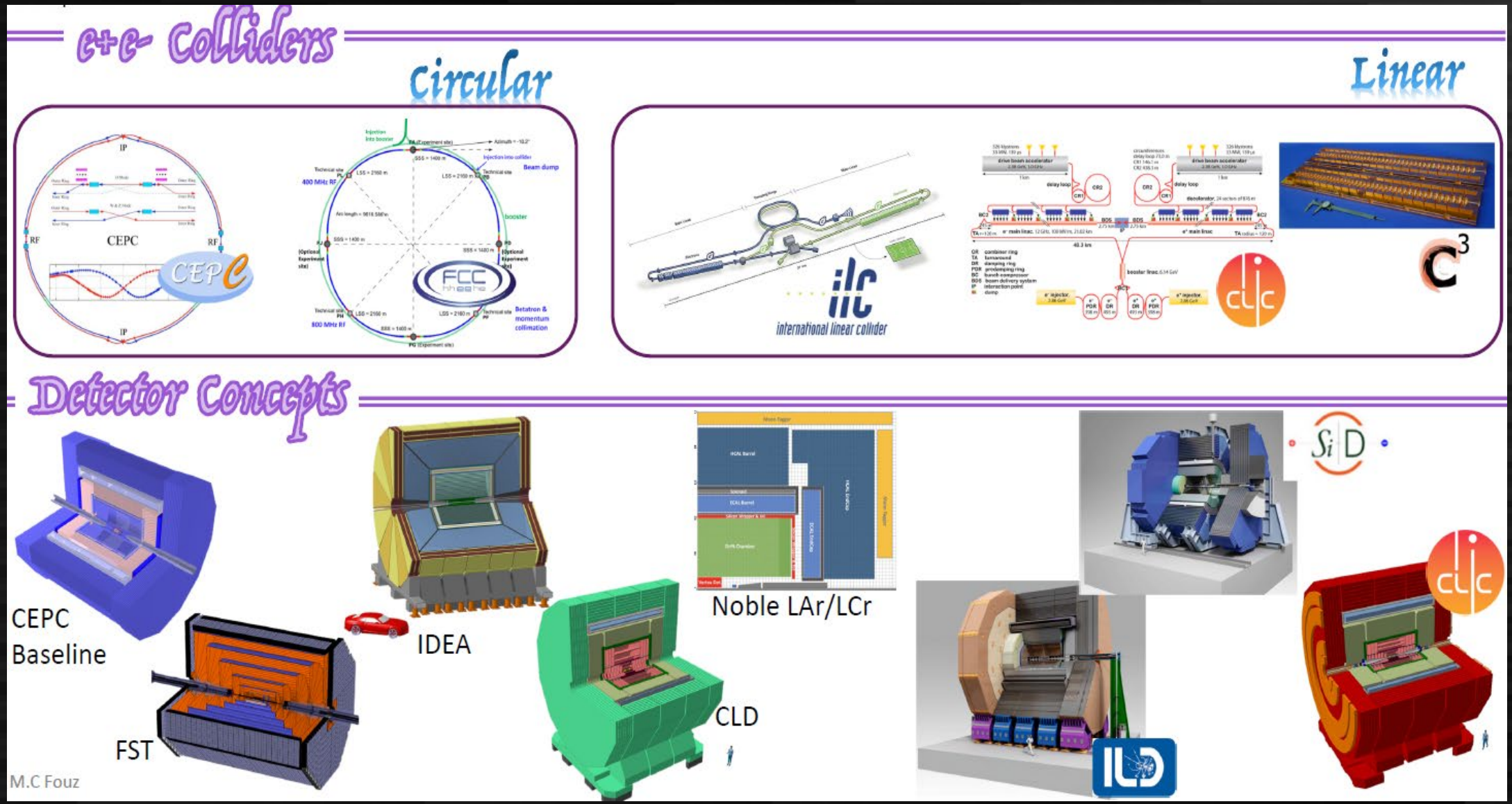
Situation of physics/detector studies for Higgs factories: IDT, ECFA, snowmass, etc.

Taikan Suehara (Kyushu U.)

Topics

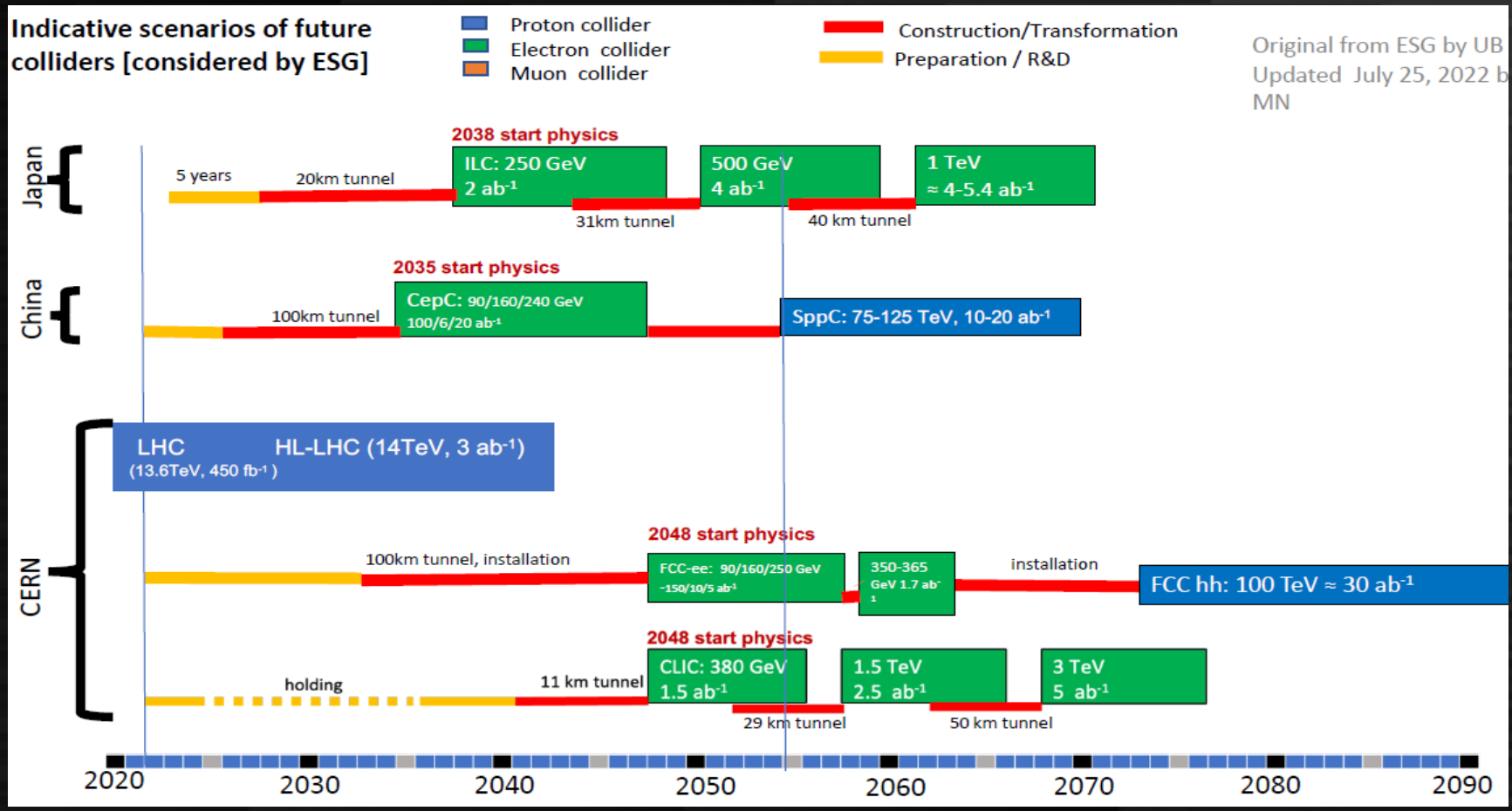
- Overview of Higgs factories (ILC, FCCee, C^3, CLIC, CEPC, …)
- Snowmass & activities in US
- ECFA Higgs/EW/Top factory studies & detector R&D roadmap
- ILC IDT, ILD/SiD, ILC-Japan
- Current situation of Phys/det studies in Japan & way to go

Higgs factories and detectors



Higgs factories: possible timeline

- ILC: 2038- (TDR)
  - 2+4y preparation
  - 10y construction
- CEPC: 2035- (CDR)
- FCC: 2048- (CDR)
  - FS: -2025
  - HL-LHC: -2042
    (Parallel construction)
- CLIC: 2048- (CDR)
- C^3: 2040's (Pre-CDR)



Critical technologies for Higgs factories

- Superconducting linac (ILC)
  - 31.5 MV/m almost proven, experiences in Euro-XFEL (10% scale)
  - Upgrade paths: 45 MV/m, 70 MV/m, ~100 MV/m
    by surface treatment, traveling wave, thin-film
- Normal-temperature (CLIC)
  - Acc. gradient proven (and higher), but no big production experience
  - Concern on luminosity and power
- Cryogenic normal-conducting (C^3)
  - New idea, still basic demonstration stage
- Circular (FCCee / CEPC)
  - High cost (2x ILC) for Higgs factory, detailed design still ongoing
  - Big issue on magnet (>20 yr needed?) for proceeding hadron collider

Snowmass: Energy Frontier Vision

EF Resources and Timelines

- **Five year period starting in 2025**
  - Prioritize *HL-LHC physics program,* including auxiliary experiments
  - Establish a targeted *e+e- Higgs Factory detector R&D* for US participation in a global collider
  - Develop an *initial design for a first stage TeV-scale Muon Coll.* in the US (pre-CDR)
  - Support critical *detector R&D towards EF multi-TeV colliders*
- **Five year period starting in 2030**
  - Continue strong support for *HL-LHC program*
  - Support and advance *construction of an e+e- Higgs Factory*
  - Demonstrate principal risk mitigation and deliver *CDR for a first-stage TeV-scale Muon Coll.*
- **After 2035**
  - Support continuing *HL-LHC physics program* to the conclusion of archival measurements
  - Begin and support the *physics program of the Higgs Factories*
  - Demonstrate readiness to construct and deliver *TDR for a first-stage TeV-scale Muon Coll.*
  - Ramp up funding support for *detector R&D for EF multi-TeV colliders*

L. Reina et al., Snowmass Summer Study

Snowmass: Energy Frontier Vision (cont.)

The intermediate future is an e^+e^- Higgs factory

The intermediate future is an e^+e^- Higgs factory, either based on a linear (ILC, C^3, CLIC) or circular collider (FCC-ee, CepC).

- **The various proposed facilities have a strong core of common physics goals**: it is important to **realize at least one somewhere in the world.**
- **A fast start towards construction is important**. There is **strong US support** for initiatives that could be realized on a time scale relevant for early career physicists.
- **For the next decade and beyond**
  - **2025-2030**: Establish a targeted e^+e^- Higgs Factory detector R&D for US participation in a global collider
  - **2030-2035**: Support and advance construction of an e^+e^- Higgs Factory
  - **After 2035**: Begin and support the physics program of an e^+e^- Higgs Factory

L. Reina et al., Snowmass Summer Study

Snowmass: Energy Frontier Vision (cont.)

EF Colliders: Opportunities for the US

- **Planning to proceed in multiple parallel prongs may allow us to better adapt to international contingencies** and eventually build the next collider sooner. Such a strategy will also help develop a robust long term plan for the global HEP community, with U.S. leadership in EF colliders.
- **Attractive opportunities** to be considered are:
  - **A US-sited linear e^+e^- collider (ILC/C^3)**
  - **Hosting a 10-TeV range Muon Collider**
  - **Exploring other e^+e^- collider options to fully utilize the Fermilab site**
- Bold "new" projects offer the next generation some challenges to rise to and inspire more young people from the US to join HEP and in the long term help with strengthening the vibrancy of the field.

Private summary

- Support "earliest Higgs factory" to realization (ILC, FCCee, or ILC/CLIC in Europe)
- Continue R&D for e+e- collider in US (if none will go) in 2040s (after DUNE)
- Muon collider R&D for long-range target

Snowmass: Detector development in US?

Detector R&D Needs

Preparation of a Technical Design for a Detector needs an R&D program

- Highly segmented detectors with good resolution were simulated to make the case for physics studies for Higgs Factories & Multi-TeV Colliders.
- **We do need complex/cutting-edge detectors to meet the ambitious physics goals!** The needs extend beyond generic R&D.
  - Address the specific detector challenges for e^+e^- colliders.
- **Such a program needs to start now**
  - to explore the technology to build a full-scale e^+e^- collider detector
  - It takes about 10 years from CD0 to end of construction of a collider detector.
  - **Thus investment in targeted detector R&D for a Higgs Factory has to start soon!**

Should check the P5 recommendation in next year (?)

European strategy (2020) and reflections

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.

The European particle physics community must intensify accelerator R&D and sustain it with adequate resources. A roadmap should prioritise the technology, taking into account synergies with international partners and other communities such as photon and neutron sources, fusion energy and industry. Deliverables for this decade should be defined in a timely fashion and coordinated among CERN and national laboratories and institutes.

- FCC feasibility study (2021-25)
  - FCCee detailed design including infrastructure
  - Magnet studies for FCChh
  - Financial feasibility
  - 100 M(SF) in total budget

→ Next strategy (2027?) will decide whether It should go or not

- Backup solutions for Europe
  - CLIC (will report 2025 also)
  - ILC in Europe?
- Participation of ILC in Japan if it will go “timely”
- Common Physics/detector R&D for Higgs factories

ECFA Higgs/EW/top factory studies

ECFA recognizes the need for the experimental and theoretical communities involved in physics studies, experiment designs and detector technologies at future Higgs factories to gather. **ECFA supports a series of workshops** with the aim **to share challenges and expertise, to explore synergies** in their efforts and to respond coherently to this priority in the European Strategy for Particle Physics (ESPP).

GOALS:	To bring the entire e+e- Higgs factory effort together, foster cooperation across various projects, collaborative research programs are to emerge

An **International Advisory Committee (IAC)** has been formed.

ECFA-chair would act as chair: Karl Jakobs
- **From RECFA:** Jean-Claude Brient, Tadeusz Lesiak, Chiara Meroni
- **With (HL-)LHC experience:** Jorgen D'Hondt, Max Klein, Aleandro Nisati, Roberto Tenchini
- **For theory:** Christophe Grojean, Andrea Wulzer
- **For Linear Colliders:** Steinar Stapnes, Juan Fuster, Frank Simon, Aidan Robson
- **For Circular Colliders:** Alain Blondel, Mogens Dam, Patrick Janot, Guy Wilkinson
- **For CERN:** Joachim Mnich

It suggested to establish **three Working Groups** led by conveners from both experiment and theory

Physics Potential	Physics Analysis Methods	Detector R&D
Juan Alcaraz - CIEMAT Jenny List - DESY Fabio Maltoni - UC Louvain /Bologna Jorge de Blas - Univ. Granada	Patrizia Azzi -INFN-Padova /CERN Fulvio Piccinini - INFN Pavia Dirk Zerwas - IJCLab/DMLab	Mary Cruz Fouz - CIEMAT Giovanni Marchiori – APC Paris Felix Sefkow - DESY

A **Yellow Report** will be produced as input to next European Strategy Update

1st workshop at DESY in Oct. https://indico.desy.de/event/33640/

Activities in ECFA HF studies

Common software framework for HF

Existing activities can be broadly classified in two categories:

detector concept studies
(within the different Higgs factory collaborations)
and **detector R&D efforts**

2 contact persons identify for each community

ILD
SiD
CLICdet + CLD
IDEA
LAr
CEPC

TF1 (Gas)
TF2 (Si)
TF4 (PID)
TF6 (Calo)
TF7 (Elec)
TF8 (Mech)

Using groups from
ECFA R&D Roadmap

ilcsoft	→	**key4hep**	
lcio		EDM4hep	new
DD4hep		DD4hep	already quite widely used
Marlin		Gaudi	LHCb, ATLAS, ...
		delphes	
		G4	
		MC generators	

5

→ Key4hep software stack
key4hep.web.cern.ch

idea: collection of packages, integrated into a easy-to-use coherent environment
modernised: e.g. multi-threading support

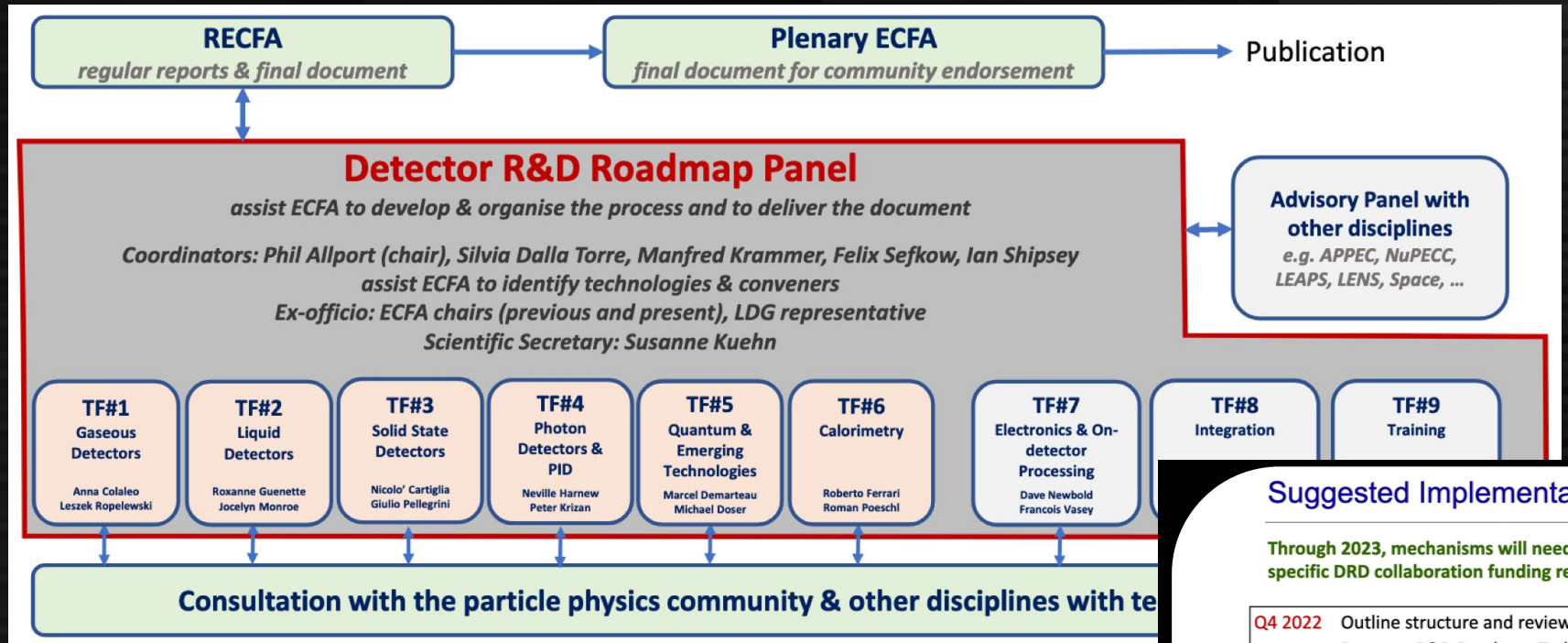
planned for use by detector studies @ ILC, CLIC, FCC, CEPC, EIC, …

current ilcsoft tools are either natively in key4hep, or can be “wrapped” to work within it.

active development: /cvmfs/ilc.desy.de/key4hep/
already ~usable, but not production-ready

few (direct) contributions from JP

ECFA detector R&D roadmap and DRDs



Strong top-down encouragement of future detector R&D

(though funding is unclear at this moment)

Current CERN-based collaboration (RDxx) as well as other HF-related (CALICE etc.) will be (somewhat) restructured to DRD

How to contribute/relate from Japan is the issue to be discussed

Suggested Implementation Timeline

Through 2023, mechanisms will need to be agreed with funding agencies in parallel to the process below for country specific DRD collaboration funding requests for Strategic R&D and for developing the associated MoUs.

Q4 2022	Outline structure and review mechanisms agreed by CERN Council. Detector R&D Roadmap Task Forces organise **community meetings** to establish the scope and scale of community wishing to participate in the corresponding new DRD activity. (Where the broad R&D topic area has one or more DRDTs already covered by existing CERN RDs or other international collaborations these need to be fully involved from the very beginning and may be best placed to help bring the community together around the proposed programmes.)
Q1 2023	**DRDC mandate formally defined** and agreed with CERN management; Core DRDC membership appointed; and EDP mandate plus membership updated to reflect additional roles.
Q1-Q2 2023	**Develop the new DRD proposals** based of the detector roadmap and community interest in participation, including light-weight organisational structures and resource-loaded work plan for R&D programme start in 2024 and ramp up to a steady state in 2026.
Q3 2023	**Review of proposals by DRDC** leading to recommendations for formal establishment of the DRD collaborations.
Q4 2023	DRD Collaborations receive formal **approval from CERN Research Board**.
Q1 2024	New structures operational for ongoing review of DRDs and R&D programmes underway.

Through 2024, collection of MoU signatures

ILC international development team

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

Jenny List (DESY/CERN)

Working group 1 Pre-lab set-up	Working group 2 Accelerator	Working group 3 Physics & Detectors

Scientific secretary: Wataru Ootani (Tokyo)
Communication team led by Rika Takahashi (KEK)

WG3 - Physics Potential and Opportunities

Michael Peskin, Aidan Robson, and Junping Tian

- Topical group conveners:
  - **Higgs:** Shinya Kanemura (Osaka), Patrick Meade (Stony Brook), Chris Potter (Oregon), Georg Weiglein (DESY)
  - **Top/Heavy Flavour/QCD:** Adrian Irles (Valencia), Hua-Xing Zhu (Zhejian), Alexander Mitov (Cambridge)
  - **BSM:** Mikael Berggren (DESY), Shigeki Matsumoto (IPMU), Werner Porod (Würzburg), Simone Pagan Griso (LBNL)
  - **Electroweak:** Taikan Suehara (Kyushu), Wolfgang Kilian (Siegen), Graham Wilson (Kansas), Mariarosaria d'Alfonso (MIT)
  - **Global Interpretations:** Tim Cohen (Oregon), Christophe Grojean (DESY), Sven Heinemeyer (Santander), Sunghoon Jung (Seoul)
  - **Modelling and Precision Calculation:** Gudrun Heinrich (KIT), Stefan Hoeche (Fermilab), Juergen Reuter (DESY), Zhao Li (IHEP)

WG3 Organisation and mandates

Chair: Jenny List (DESY/CERN)
Deputies: Roman Pöschl (IJCLab), Michael Peskin (SLAC), Daniel Jeans (KEK), Jinlong Zhang (ANL)

Coordinator and Deputy coordinator(s)

Kiyotomo Kawagoe (Kyushu), Carsten Hensel (Rio de Janeiro), Ivanka Božović Jelisavčić (Belgrade)

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

Speaker's bureau

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), Timothy Nelson (SLAC), Kajari Mazumdar (Mumbai), Phillip Urquijo (Melbourne), Dmitri Denisov (Brookhaven), Hitoshi Murayama (Berkley/Tokyo), Shoji Asai (Tokyo)

Interface with machine	Detector and technology R&D	Software and computing	Physics potential and opportunity
Coordinate the interactions between the accelerator and facility infrastructure planning and the needs of the experiments	Provide a forum for discussion and coordination of the detector and technology R&D for the future experimental programme	Promote and provide coordination of the software development and computing planning	Encourage and develop ideas for exploiting the physics potential of the ILC collider and by use of the beams available for more specialised experiments
Karsten Buesser (DESY), Yasuhiro Sugimoto (KEK), Roman Poeschl (IJCLab), Tom Markiewicz (SLAC)	Marcel Vos (Valencia), Katja Krueger (DESY), Jinlong Zhang (ANL), Shinya Narita (Iwate)	Frank Gaede (DESY), Jan Strube (PNNL), Daniel Jeans (KEK)	Michael Peskin (SLAC), Junping Tian (Tokyo) Aidan Robson (Glasgow)

in red: from Japanese institutes

Physics activities are coordinated under IDT WG3. Open meeting ~every month.

Was actively engaged in Snowmass study. Activities will be resumed soon…

IDT WG3 subscription instruction:
https://agenda.linearcollider.org/event/9154/

IDT activities (for snowmass)

arXiv:2203.07622

DESY-22-045, IFT–UAM/CSIC–22-028,
KEK Preprint 2021-61, PNNL-SA-160884,
SLAC-PUB-17662
July 15, 2022

The International Linear Collider: Report to Snowmass 2021

THE ILC INTERNATIONAL DEVELOPMENT TEAM AND THE ILC COMMUNITY

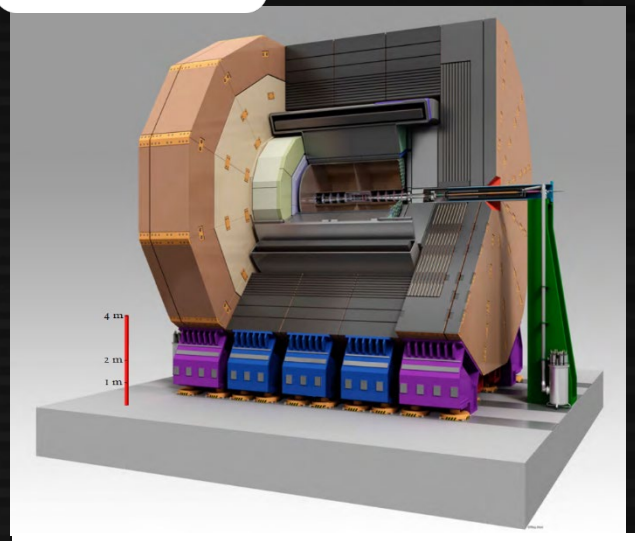
ABSTRACT

The International Linear Collider (ILC) is on the table now as a new global energy-frontier accelerator laboratory taking data in the 2030's. The ILC addresses key questions for our current understanding of particle physics. It is based on a proven accelerator technology. Its experiments will challenge the Standard Model of particle physics and will provide a new window to look beyond it. This document brings the story of the ILC up to date, emphasizing its strong physics motivation, its readiness for construction, and the opportunity it presents to the US and the global particle physics community.

Alexander Aryshev[1], Ties Behnke[2], Mikael Berggren[2], James Brau[3], Nathaniel Craig[4], Ayres Freitas[5], Frank Gaede[2], Spencer Gessner[6], Stefania Gori[7], Christophe Grojean[2,8], Sven Heinemeyer[9], Daniel Jeans[1], Katja Kruger[2], Benno List[2], Jenny List[2], Zhen Liu[10], Shinichiro Michizono[1], David W. Miller[11], Ian Moult[12], Hitoshi Murayama[13,14,15], Tatsuya Nakada[16], Emilio Nanni[6], Mihoko Nojiri[1,15], Hasan Padamsee[17], MaximPerelstein[17], Michael E. Peskin[6], Roman Poeschl[18], Sam Posen[19], Aidan Robson[20], Jan Strube[21], Taikan Suehara[22], Junping Tian[23], Maxim Titov[24], Marcel Vos[25], Andrew White[26] Graham Wilson[27], Kaoru Yokoya[1], Aleksander Filip Zarnecki[28] (Editors)

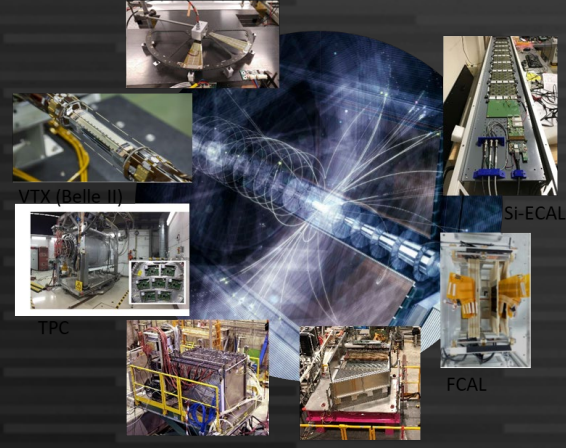
Comprehensive paper of the ILC phys/det/acc including upgrades to multi-TeV. >300 pages

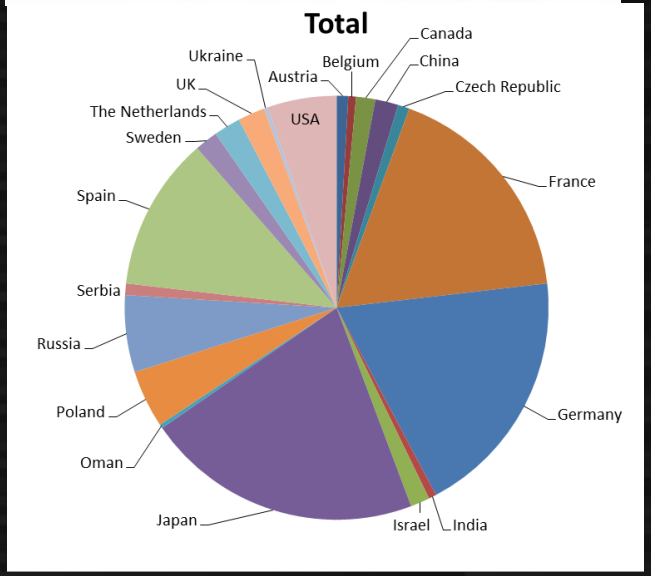
ILD and its activities



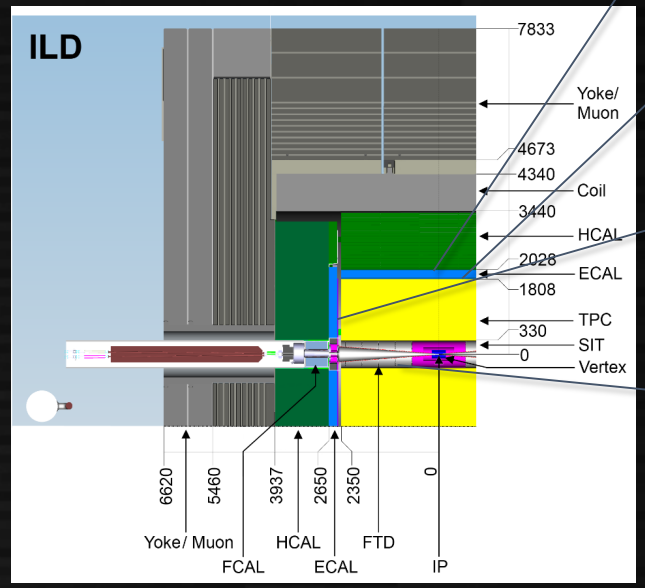
First concrete design of a full PFA detector
Critical contribution from Japan
A good playground for HF phys/det studies with good software support (matured for > 10 years)
Recently refocused to generic HF detector

- Adaptation to circular collider ongoing

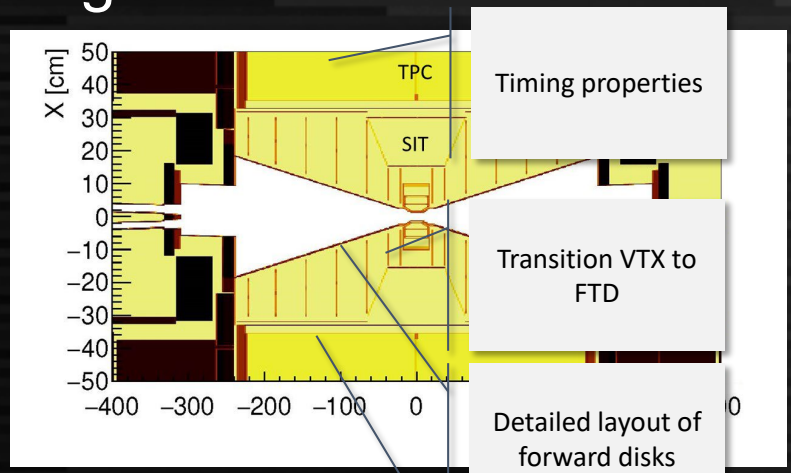




65+ institutes, ~300 members

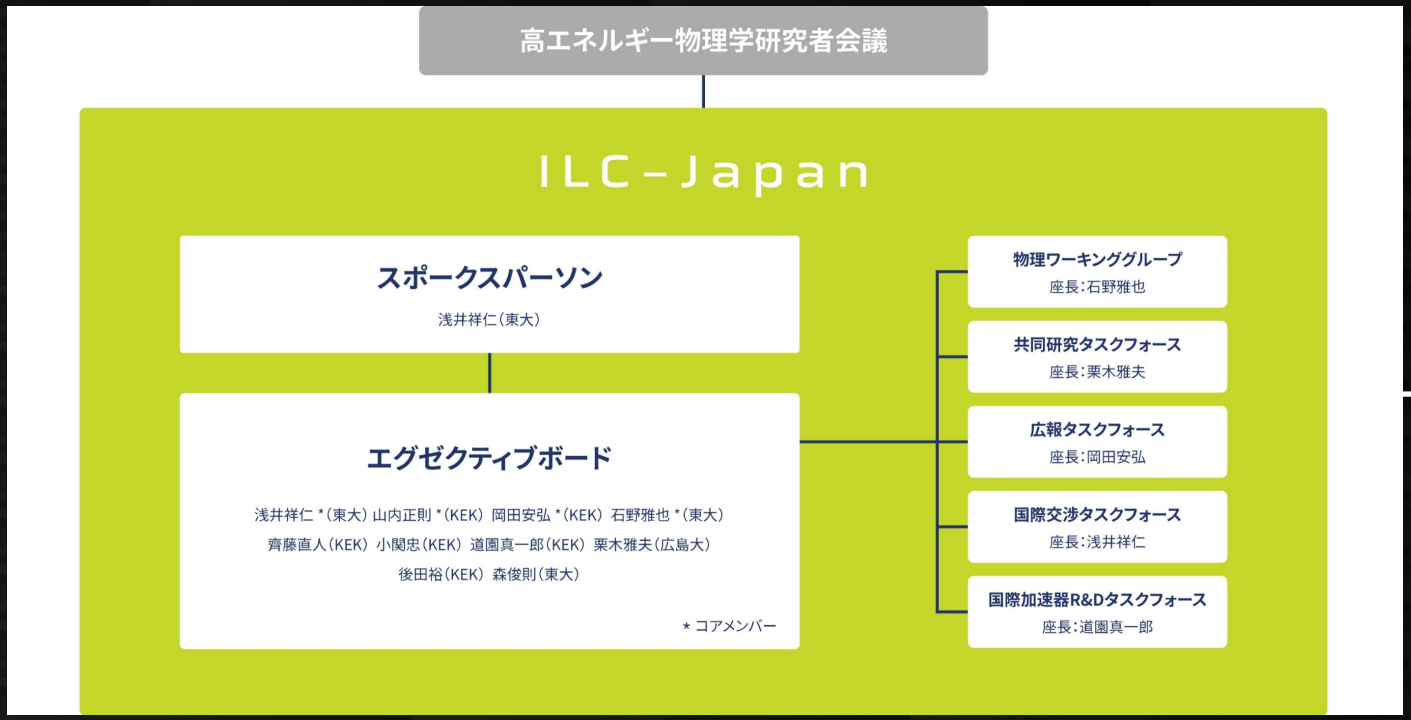


- Timing in the ECAL
- SET Design and parameters
- TPC endcap design, amplification technology
- Forward design



- Timing properties
- Transition VTX to FTD
- Detailed layout of forward disks
- Strip or pixel

ILC-Japan and physics WG



- Physics WG activities
  - 2021 (before snowmass)
    theorist-driven discussions on various key topics
    (Shirai-san's talk today and in JPS spring 2022)
  - 2022 (after snowmass)
    This activity initiated by Ishino/Suehara
    Strategy should be discussed in this meeting

IDT-ILCJ discussion

ILC-Japan, FPC, KEK & IDT-WG3

Wednesday 26 Oct 2022, 16:00 → 17:00 Europe/Zurich

- 1st IDT-ILCJ discussion
  - J. List, M. Peskin, R. Poeschl et al. as well as J. Tian, D. Jeans from IDT
- Regular discussions planned
  - 2nd round: December
- IDT willing to cooperate with ILC-J: concrete plans will be discussed in the following meetings

16:00 → 16:10 **Introduction and IDT-WG3 overview**
Speaker: Jenny List (Deutsches Elektronen-Synchrotron (DE))
IDTWG3_for ILCJap...

16:10 → 16:15 **Overview ILC-Japan Physics WG**
Speaker: Taikan Suehara (Kyushu University)
221026-ilcj_idt-ilcjp...

16:15 → 16:20 **Overview ILC-Japan Collaboration Task Force** ¶
Speaker: Prof. Masao Kuriki (Hiroshima U./KEK)
ILCJ-CTF_IDTWG3_... ILCJ-CTF_IDTWG3_...

16:20 → 16:25 **Overview JAHEP Future Project Committee**
Speaker: Yutaro Iiyama (University of Tokyo (JP))
jahep_cfp.pdf

16:25 → 16:30 **Overview KEK IPNS Energy Frontier group R&D activities**
Speaker: Makoto Tomoto (High Energy Accelerator Research Organization (JP))
EFGroup-en-202210...

16:30 → 17:00 **Joined discussion**

ILC (before ILC-J) physics activities in Japan

- A lot of work covered and high visibility kept in ILD in >10 years
  - 30-40% of the physics work covered despite low human resource
  - Also noticeable work in software development and simulation work
  - Good collaboration with theorists (lot of papers with theorists included)
- Now the group is getting resolved… need new wave/power

Symmetry Breaking & Mass Generation Physics

- ZH : H->bb,cc,gg -> EPJ C (2013) 73:2343, Ono+Miyamoto: IDR: Kurata
  H -> WW* anomalous coupling: publication: Takubo -> P.R.D88,013010(2013)
  -> H -> WW* to be reexamined: Liao Libo, Mila, Uli
  H->other modes (AA,mu+mu-) + Kawada/Tanabe/Suehara/Daniel, (tau+tau-)->publication -> EPJC (2015) 75:617., H->Zγ : Kazuki Fujii
  Recoil mass: Jacqueline -> P.R.D94,113002(2016), Suehara (qq), CP mixing in h->tau+tau-: Daniel
  -> accepted for publication in PRD, HVV couplings: Hγ : Yumi Aoki
  direct mH reconstruction: Junping
- EFT: EFT vs BSM, EFT fit on top EW couplings (NLO SMEFT): Junping
- Zgamma: Takahiro Mizuno
- ZHH : full simulation of the H->bb&Z->all modes, fast simulation of nunuHH: finished: Junping + Takubo (Ph.D thesis: done) -> New analysis with improved analysis tools: Junping + Claude + Suehara + Tanabe, Jet-clustering: Masakazu, Shaofeng Ge, LCFIPlus: Suehara,Yonamine; Vertex Finder: Kiichi Goto
  New analysis: ZHH->ZbbWW*: dE/dx: Kurata, Systematic Error: Tim, EFT: Junping, ZHH paper draft: Junping, Masakazu, Claude
- nnHH : full simulation @ 1TeV, done for DBD: Junping -> publication
- nnH, eeH : precision measurements of HVV couplingsm, mh=125GeV: Junping
  BR measurements: Ono, Christian
- TTH : quick simulation studies with NRQCD corrections
  -> P.R.D84,014033(2011) -> full sim. @ 0.5 & 1 TeV: (Yonamine left) Tanabe + Sudo
- TT Threshold : Top Yukawa measurement: Horiguchi + Ishikawa + Tanabe, Theory: Kiyo + Sumino -> publication? (cf. a recent significant theoretical development!): Ozawa-> Yuto Eda
- W mass (enW) : Koya Tsuchimoto -> Kotora (controlling systematic uncertainties)->Kotera
- AA->HH : quick simulation studies, so far H->bb and WW BG
  -> P.R.D85,113009(2012) : Kawada, Theory: Harada

Beyond the Standard Model

- SUSY : full simulation studies for LOI -> publication
  - EWkino (Compressed Spectrum Case): Jacqueline->Tomohiko : P.R.D101, 095026 (2020)
- Extra U(1) (Z' tail), Compositeness, Extra Dimensions, etc.
  - TT : full simulation studies for LOI -> New study with MELA: Yo Sato, vertex charge: Okugawa
  - tau tau : full simulation studies (benchmark process) -> Keita Yumino
  - 2f: full simulation study: Hiroaki Yamashiro -> Yuto Deguchi, Uesugi, bb: Seidai Tairafune
- Hidden Sector / XD : P.R.D78, 015008 (2008)
- LHT : P.R.D79, 075013 (2009)
- Model discrimination: Saito + Suehara .. : P.R.D84, 115003 (2011)
- R-handed neutrinos: Saito : P.R.D82, 093004 (2010) , New analysis: Yonamine, Jurina Nakajima, Daniel
- LHT: Kato (exp) + Harigaya (th): ZHZH finished, working on eHeH, nHnH, ..: Draft (n-1)?
- Very light gravitino: Katayama (Master's thesis), Tanabe (exp) + Matsumoto (th)
  --> 1st Draft --> Takuaki Mori (Tokyo) -> ?
- Quasi stable stau: Yamaura (Master's thesis) + Kotera + Kasama —> reactivated?
- Higgs portal/h->Invisible: Honda -> Yamamoto -> Ishikawa, Ogawa, Junping -> Yu Kato
- W-H+/W+H-: (Shinzaki), Ishikawa (exp) + Kanemura, yagyu (th)
- Generic DM search (mono-photon): Tanabe -> Yonamine
  (exotic higgs decay): Kurata, Special theory guest: Shigeki Matsumoto
- Other projects
  - Heavier Higgs bosons?: Yokoya, (Abhinav) -> Christian Drews
  - X(750) : Junping -> published in PRD (Phys.Rev. D94 (2016) no.9, 095015)
  - h->cc, bb, bs QFV decays: Hidaka
  - Kinematical Fitter : kajiwara
  - pair monitor : Ahmed
  - LGAD simulation : Mami Kuhara

K. Fujii, Mar. 2021

ILC physics activities from now

- Need more interaction with other projects – today's main topic
  - Community-wide support/enthusiasm is critical for realization of ILC
  - Physics discussion is the key base for interest to the project
  - How to establish the persistent cooperation structure?
- Topics to attract new people should be prepared/listed
  - Novel machine learning/AI application (see afternoon session)
  - Key physics issues – Higgs self-coupling, light DM, etc.
  - Synergy to studies in other projects (which?)
  - Any others?
- Detector with novel concept/technology – maybe done separately

Summary

- e^+e^- Higgs factory emerged as #1 priority next project in the world
  - Both in Europe and in US
- Many candidates appearing (ILC, FCCee, CLIC, CEPC, C^3, …)
  - ILC is still earliest but will be caught up in 5-10 years
  - Next ~5 years should be critical to realize “any” Higgs factory
- Global interest to raise detector R&D
- Most of physics/detector activities can be in common
  - Already forward in Europe, will see in US, in Japan…?