New Ideas on Detector Technology for the ILC Experiments

Maxim Titov

CEA Saclay, Irfu / CERN

on behalf of the ILC International Development Team Detector and Physics Group

11th Edition of the Large Hadron Collider Physics Conference
Belgrade, Serbia, May 22-26, 2023
The ILC (250 GeV) Accelerator:

- Creating particles
  - polarized electrons/positrons

  **ITN focus areas (>2023):**
  - **Sources**

  - **Damping ring**
    - High quality beam
      - low emittance beams
    - Acceleration
      - superconducting radio frequency (SRF)
    - Collide them
      - nano-meter beams
    - Go to
      - Beam dumps

ITN focus areas (>2023):

- **Sources**

  - **Undulator positron source**
    - Electron driven positron source

  - **Main linac**

  - **Final focus**

  - **Beam dumps**

Global Project → ILC (Japan) has to be Coexisting and Synergistic with CERN future

Recent talks (2022 eeFACT Symposium):
https://agenda.infn.it/event/21199/
The 2023 International Workshop on Future Linear Colliders (LCWS2023) will take place on May 15-19, 2023, SLAC, USA. The program will feature ILC progress in Japan, and the establishment of the International Technology Network (ITN) as the prominent topic, to review the progress in accelerator design, detector developments and physics studies. The progress of the CLIC studies within the same areas will also be covered and most sessions and topics will be common. The ILC project in Japan and CLIC project at CERN are also the central elements of the recently approved EU / EEAJADE (Europe-America-Japan Accelerator Development and Exchange) program. Emerging new linear collider concept, C^2, will also be presented. More details about the workshop program may be found at the conference website: https://indico.slac.stanford.edu/event/7467/. As a part of the LCWS2023 Symposium, we are pleased to announce the following special events:

**Industrial Forum on Accelerator Technologies and Advanced Instrumentation for Future Linear Colliders**

**Date:** 16 May 2023, 13:00 – 15:00 (PDT, US)

**Indico link:** https://indico.slac.stanford.edu/event/7467/sessions/441/#20230516

The goal of the event is to strengthen international cooperation between academia and industrial partners involved in the development of advanced accelerator technologies and instrumentation techniques. The forum will be devoted to the industrial aspects of future Linear Colliders, which offers an opportunity to valorise and highlight the expertise and innovation capabilities of national laboratories and their related industrial partners.

**13:00-13:15** Introduction to Industry and Sustainability Forum – Session Conveners

**13:15-13:35** Japan - AAA activity - Takahashi Tohru (Hiroshima Univ./AAA, Japan)

**13:35-13:55** US Office of Accelerator R&D and Production (ARDAP) – Ginsburg Camille (Deputy Director of ARDAP, USA)

**13:55-14:15** Advances in Spanish Science Industry – Fernandez Erik (INEUSTAR, Spain)

**14:15-14:35** Development of C-band RF infrastructure and initial experiments at RadiaBeam - Murokh Alex (RadiaBeam, USA)

**14:35-14:45** Experience in participating in the development of an electron-driven positron source as a company in the Tohoku region – Kondo Masahiko (Kondo Equipment Corporation, Japan)

**14:45-14:55** Development of Nb3Sn SRF cavity using electroplating method – Takahashi Ryo (Akita Chemical Industry Co., Ltd., Japan)

**15:00-15:30** Coffee Break

**Sustainability Forum for Future Linear Colliders**

The environmental credentials of future colliders are increasingly in the spotlight, because of their size and complexity, and will be under scrutiny for their impact on the climate. Therefore, sustainability has become a prioritized goal in the design, planning and implementation of future accelerators; approaches to improved sustainability range from overall system design, optimization of subsystems and key components, to operational concepts. A direct quantification of the ecological footprint, be it greenhouse gas emissions during construction and operation, or consumption of problematic materials, is currently performed only sporadically, mostly through translation of electricity consumption into equivalent CO2 emissions.

This forum will highlight studies to reduce power consumption of accelerator systems, to quantify the impact of future facilities in terms of CO2 footprint, to address smart integration of future accelerator infrastructure with the surrounding site and society (e.g. Green ILC concept), and to discuss medical and environmental applications of accelerator technologies.

**Date:** 16 May 2023, 15:30 – 18:00 (PDT, US)

**Indico link:** https://indico.slac.stanford.edu/event/7467/sessions/443/#20230516

**15:30-15:50** Sustainability Studies for ILC and CLIC – Benno List (DESY, Germany)

**15:50-16:10** High Efficiency Klystrons project at CERN: Status and updates – Syratchev Igor (CERN)

**16:10-16:30** Linear Collider Carbon Assessments: A Life Cycle Assessment of the CLIC and ILC Linear Collider Feasibility Studies - Evans Suzanne (ARUP Group)

**16:30-16:50** Green ILC Concept – Yoshicka Masakazu (Hwata University/KEK, Japan)

**16:50-17:10** Permanent magnet technology for sustainable accelerators – Shepherd Ben (STFC, UK)

**17:10-17:25** IHEP high efficiency, high power klystron development - Zhou Zusheng (IHEP, China)

**17:25-17:35** Basic research using synchrotron radiation and commercialization of waste heat recovery technology from ILC - Mitoya Goh (Higashi Nihon Kidenkaihatsu Co., Ltd., Japan)

**17:35-17:45** Town planning in the vicinity of ILC candidate site as a regional company - Kondo Masahiko (Kondo Equipment Corporation, Japan)

**Accelerator: Sustainability and Applications Session**

**Date:** 18 May 2023, 10:30 – 12:00 & 13:30 - 14:30 (PDT, US)

**Indico link:** https://indico.slac.stanford.edu/event/7467/sessions/450/#20230518

**10:30-10:50** Sustainability Studies for the Cool Copper Collider- Buillard Brendon (SLAC)

**10:50-11:10** Sustainability Considerations for Accelerator and Collider Facilities – Nappi Emilio (SLAC)

**11:10-11:30** Strong-field QED Experiments for & at Linear Colliders – List Jenny (DESY)

**11:30-11:50** High Temperature Superconducting RF cavity – Le Sage Gregory (SLAC)

**13:30-13:50** Progress of High-Efficiency L-Band IOT Design for Accelerator Applications at SLAC - Othman Mohamed (SLAC)

**13:50-14:10** High Efficiency, 1 MW, 1 MeV Accelerator for Environmental Applications – Shumaill Muhammad (SLAC)

**14:10-14:30** Applications of High Gradient Accelerator Research for Medical Accelerator Technology - Snively Emma (SLAC)
Many Forms of Linear Collider Detector R&D Efforts

RPC DHCAL Silicon ECAL LCTPC
KPIX SDHCAL (ILD) RPC Muon
GEM DHCAL CMOS MAPS Scintillator HCAL
Silicon ECAL VIP FPCCD Scintillator ECAL
TPAC DEPFET SOI Dual Readout
FCAL DEPFET ChronoPixel CLICPix

IDT-WG3: ensure interplay between detector concepts (ILD, SiD, Clicdp) & more generic R&D

- Keep various detector technology options and do not prioritize. This has the advantage that the technologies can be further developed until specific choices have to made once future Higgs Factory is approved.

- Furthermore — and as important — this keeps a broad community of detector research groups at universities and laboratories involved and increases the chance to arrive at the best technically possible detector solution when it has to be built.
ILC Detector Concept Groups: ILD and SiD

✓ ILD: International Large Detector
✓ SiD: Silicon Detector

ILD Re-optimisation: Large (L) & small (S) options


SiD Design Update: arXiv: 2110.09965

Both optimized for PFA Performance: \( \sim B \cdot R_{\text{ECAL,inner}}^2 \) (two-track separation @ ECAL)

- **B** = 3.5 T / 4 T
- **B** = 5 T

<table>
<thead>
<tr>
<th><strong>ILD (“L” &amp; “S”)</strong></th>
<th><strong>SiD</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_{\text{ECAL,inner}} = 1.8 / 1.46 \text{ m} )</td>
<td>( R_{\text{ECAL,inner}} = 1.27 \text{ m} )</td>
</tr>
<tr>
<td>Si + TPC tracking</td>
<td>Silicon Tracking only</td>
</tr>
<tr>
<td>Outer radius: 1.77 / 1.43 m</td>
<td>Outer radius: 1.22 m</td>
</tr>
</tbody>
</table>
ILC Tracking (ILD vs SiD): Two Complementary Approaches

ILD: Silicon + Gaseous Tracking

- long barrel of 3 double layers of Si-pixels
  \[ 0.3\% X_0 / \text{layer}, \sigma_{sp} \lesssim 3 \mu m \]

- Intermediate Si-tracker (SIT, SET, FTD)
  - SIT/FTD: silicon pixel sensors (e.g. CMOS)
  - SET: silicon strip sensors

- Time Projection Chamber with MPGDs
  - High hit redundancy (200 hits / track)
  \[ \rightarrow 3D \text{ tracking / pattern recognition; } \]
  \[ \rightarrow dE/dx \text{ information for PID} \]

SiD: All-Silicon Tracking

- short barrel of 5 single layers of Si-pixels
  \[ 0.15\% X_0 / \text{layer}, \sigma_{sp} \lesssim 3-5 \mu m \]

- 5 layers Silicon-strip tracker
  (25um strips, 50 um readout pitch)

  - Fewer highly precise hits (max. 12)
  - Robustness, single bunch time stamping

Still a lot of opportunities in ILD/SiD optimization: physics goals, software developments and technology options
Sensor’s contribution to the total $X_0$ is 15-30% (majority cables + cooling + support)

Readout strategies exploiting the ILC low duty cycle $0(10^{-3})$: triggerless readout, power-pulsing
→ continuous during the train with power cycling → mechanic. stress from Lorentz forces in B-field
→ delayed after the train → either ~5μm pitch for occupancy or in-pixel time-stamping

180 nm CMOS technology: VALIDATED

ALPIDE@ALICE ITS-3 (bending 50 um sensor)

MIMOSIS @ CBM-MVD

CMOS (MAPS): 2-sided ladders: « mini-vectors » concept for ILC with high spatial resolution & time stamping

ALICE-ITS3 upgrade drives the R&D:

Bending thin Si-layers (MAPS): Industrial stitching & large surfaces for low-mass detect.

Truly cylindrical, supportless CPS for ALICE-ITS3 upgrade (65 nm)

arXiv: 2105.13000

https://indico.cern.ch/event/1071914/
Silicon Tracking Conceptual Studies for ILC

Not much dedicated development work recently on Silicon tracking technologies → Baseline solution: silicon-microstrip tracker; also some enabling technologies (e.g. based on LGAD concept)

Timing Detectors open up 4D (and 5D) tracking → ATLAS/CMS upgrades include several m² of LGADs:

- Large area detectors
- High-precision tracking → a few um per layer
- High-precision timing → tens of ps per layer
- Optimal geometrical acc. (large fill-factor).
- Low material (50 μm thickness per plane).

Readout ASICs (power dissipation) may limit the intrinsic sensor performance → power pulsing to reduce energy consumption or the use of microchannels to complement air cooling
**Gaseous Tracking: TPC with MPGD-based Readout**

Three MPGD options are foreseen for the ILC-TPC:
- Wet-etched / Laser-etched GEMs
- Resistive Micromegas with dispersive anode
- GEM + CMOS ASICs, «GridPix» concept (integrated Micromegas grid with Timepix chip)

**ILC: gating scheme, based on large-aperture GEM**
- Machine-induced background and ions from gas amplific.
- Exploit ILC bunch structure (gate opens 50 us before the first bunch and closes 50 us after the last bunch)

**Spatial resolution of $\sigma_T \sim 100$ μm and dE/dx res. < 5% have been reached with GEM, MM and InGrid)**

**Electron transparency > 80% for $\Delta V \sim 5$V**

**CHALLENGES / FUTURE PLANS:**
- Common modules with a final design (with gating)
- Optimization of cooling & material budget
- GridPix development (dN/dx cluster counting)

**Added value of TIME information for ILC:**
- dE/dx combined with ToF (SiW-ECAL) for K-PID

**3D-printed monolithic cooling plate for a TPC using 2-phase CO2**

**arXiv: 2003.01116**

P. Colas @ ILCX2021
Particle Flow Calorimeters: CALICE Collaboration

Development and study of finely segmented / imaging calorimeters: initially focused on the ILC, now widening to include developments of all imaging calorimeters, e.g. CMS HGCAL for Phase II):

Imaging Calorimetry → high granularity (in 4D), efficient software (PFA).


Example: ILD detector for ILC, proposing CALICE collaboration tech.

<table>
<thead>
<tr>
<th>ECAL option</th>
<th>HCAL option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active layer</td>
<td>Absorber</td>
</tr>
<tr>
<td>silicon</td>
<td>tungsten</td>
</tr>
<tr>
<td>scint+SiPM</td>
<td>tungsten</td>
</tr>
<tr>
<td>scint+SiPM</td>
<td>steel</td>
</tr>
<tr>
<td>glass RPC</td>
<td>steel</td>
</tr>
</tbody>
</table>

Mixture of matured concepts and advanced ideas:

MATURED (CALICE):
- SiW-ECAL
- SciW-ECAL
- AHCAL
- DHCAL (sDHCAL)

→ (Almost) ready for large-scale prototype
→ Prepare for quick realization of 4-5 years to real detector

ADVANCED (beyond CALICE):
- MAPS ECAL
- Dual-readout ECAL
- LGAD ECAL (CALICE)

→ Evaluate additional physics impact to ILC experiment
→ Needs intensive R&D effort to realize as real detector
Particle Flow Calorimeters: CALICE Collaboration

Proof-of-principle with first generation physics prototypes (2003-2012)

Scalability tests with 2nd generation (>2010) technological prototypes (power pulsing, compact mechanical design, embedded electronics, assembly, calibration approaches)

➢ **Timing measurement for shower development (from 4D to 5D):**
Today’s CALICE prototypes (SiW ECAL, AHCAL) provides unprecedented granularity and cell-by-cell ns-level timing for validation hadronic models on different readout technologies (gas, silicon, schint.)

JINST9 (2014) P07022

ILC AHCAL & CMS HGCAL common test-beam

CMS HGCAL

ILC: Sci-AHCAL

CMS HGCAL has measured evolution of hadronic showers in the time domain with ~80ps accuracy (50ps TDC binning)

➢ improve GEANT simulation models
Particle Flow (Imaging) Calorimeters: The 5th Dimension?

Impact of 5D calorimetry (x,y,z, energy, time) needs to be evaluated more deeply to understand optimal time accuracy.

What are the real goals (physics wise)?

- Mitigation of pile-up (basically all high rates)
- Support for full 5D PFA → unchartered territory
- Calorimeters with ToF functionality in first layers?
- Longitudinally unsegmented fibre calorimeters

Replace (part of) ECAL with LGAD for O(10 ps) timing measurement

20 ps TOF per hit can separate π/k/p up to 5-10 GeV

The added value of timing information is recognized in the ILC concepts

Gain in scientific return of complete analysis still to be quantified
(Tracking PID? Calorimetry PID? Shower development?)

- Trade-off between power consumption & timing capabilities (maybe higher noise level)
- Timing in calorimeters / energetic showers?
  → intelligent reconstruction using O(100) hits & NN can improve “poor” single cell timing
  → can help to distinguish particle types: usable for flavour tagging (b/c/s), long-lived searches (decaying to neutrals), enhance σ(E) / E

ILC AHCAL & CMS HGCAL common test-beam

CMS HGCAL has measured evolution of hadronic showers in the time domain with ~80ps accuracy (50ps TDC binning)

T. Suehara @ILCX2021

Test beam at Tohoku October 2021

Timing resolution is affected by noise

<table>
<thead>
<tr>
<th>Sensor Description</th>
<th>Amp. th.</th>
<th>Time reso.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S8664-50K (Inverse)</td>
<td>20 mV</td>
<td>123 ps</td>
</tr>
<tr>
<td></td>
<td>40 mV</td>
<td>63 ps</td>
</tr>
<tr>
<td>S2385 (normal)</td>
<td>20 mV</td>
<td>178 ps</td>
</tr>
<tr>
<td></td>
<td>40 mV</td>
<td>89 ps</td>
</tr>
</tbody>
</table>
Fast Timing in Higgs Factory Detectors

- Suppression of beam induced backgrounds at muon colliders
- Time of Flight for Particle ID at low momentum and Long Lived particles
- Exploit the time structure of hadronic showers to enhance PFA and improve jet energy resolution

Full 4D tracking

Timing layers

5D Calorimetry

Timing layers or volumetric timing

Precision timing at the level of 10-30ps is a new capability to enhance PID and calorimeter measurements
- Large-radius Timing Layers in the in front of the calorimeter can provide Time-of-Flight (ToF) for PID
- Volume timing: good time resolution on the cell level in highly granular calorimeters
- Timing layers: extreme timing in a few selected layers inside of the calorimeter system
- can be combined with a wide range of technologies
- excludes applications that require timing in the full shower volume, rather than on object level

Technologies: LGAD, 3D silicon sensors, LYSO crystals

Precision Timing @ ILC

- Integrated time-stamping in the trackers
  - e.g. Background rejection in the Vertex Detector
  - Requiring ns-level resolution (intra-bunching timing)
  - Doable already today
- Timing measurements for shower development in calorimeters
  - Neutral and slow components
  - Requiring ~ns precision
  - Reachable today by reading out the cells
- Dedicated Timing Layers
  - Full 4D Tracking in the ILC environment
    - Nothing like the LHC
    - What about 3D calorimetry
    - How can precision timing be best used in PFA
    - What level of precision timing can make a real difference of calorimeter performance
    - Time-of-Flight systems for PID
    - 10 ps resolution as a goal to be competitive
    - What kind of physics does this enable and what are the Instrumentation implications
      - For a detector designed for 250-1000 GeV
New Trends: Ultra-High Granularity (MAPS ECAL)

CMOS Sensors for calorimetry → Synergies between LC Detector R&D and ALICE FoCAL

ALICE FoCAL: 24 layer MIMOSA CMOS sensor calorimeter Si-W stack

Forward electromagnetic and hadronic calorimeters:
✓ FoCal-E: high-granularity Si-W sampling calorimeter → direct γ, π0
✓ FoCal-H: Pb-Sc sampling calorimeter for photon isolation and jets

FoCAL: assuming ≈ 1m² detector surface

<table>
<thead>
<tr>
<th></th>
<th>LG</th>
<th>HG</th>
</tr>
</thead>
<tbody>
<tr>
<td>pixel/pad size</td>
<td>≈ 1 cm²</td>
<td>≈ 30x30 μm²</td>
</tr>
<tr>
<td>total # pixels/pads</td>
<td>≈ 2.5 x 10⁵</td>
<td>≈ 2.5 x 10⁹</td>
</tr>
<tr>
<td>readout channels</td>
<td>≈ 5 x 10⁴</td>
<td>≈ 2 x 10⁶</td>
</tr>
</tbody>
</table>

Could be a unique tool to improve shower simulation …

MAPS ECAL (SiD)
25 x 100 um² monolithic pixels → Common design to trackers

2.25 mm² prototype production in 2022 (WP1.2 CERN)
New Ideas: Dual-Readout Calorimetry + High Granularity

Extensive R&D by the DREAM/RD52/IDEA collaborations (Rev. Mod. Phys. 90, 025002, 2018): an old idea in 4th ILC concept → Recent technological progress (SiPM, 3D-printed absorber material) enables highly granular DREAM calorimetry

Dual-readout (DRO) crystal ECAL: J. Zhu @ILCX2021

A Segmented DRO Crystal ECAL with a DRO Fiber HCAL

Quantum Confinement changes material properties when particle size < electron wavelength (nm-size particles -> nanoparticles)

Eg increases with decreasing particle size, indicating UV photon absorption

Discrete energy levels form at the band-edges

Stokes Shift is the difference between absorption and emission wavelength

Emission wavelength decreases with decreasing size, indicating tunability

Readout Detector Development R&D: S. Magill @ILCX2021

R&D Focus: Optimal readout technologies for scintillation and Cherenkov signals — includes minimization of material between crystals to maximize sampling (→ homogeneous calorimeter)

S. Magill @ILCX2021
Forward Calorimetry R&D: FCAL Collaboration

**LumiCal:**
- Two Si-W sandwich EM calo at a ~ 2.5 m from the IP (both sides)
- Precise luminosity measurement
- $10^{-3} - 500$ GeV @ ILC

**BeamCal:**
- Very high radiation load (up to 1MGy/year) → similar W-absorber, but radiation hard sensors (GaAs, CVD diamond, sapphire)
- Inst. lumi measurement / beam tuning, beam diagnostics

**LHCAL:**
- Sampling calo (tungsten or iron with SI) → extend HCAL coverage

**Beam-test campaigns:**
- LumiCal prototypes multi-plane operation:
  - 2014 @ CERN PS
  - 2016 @ DESY
  - 2020 @ DESY

**LumiCal Challenges:**
- Build a ultra compact LumiCal (alignment, deformation);
- Edgeless sensors (to avoid dead areas);
- Multi-layer LumiCal prototype with new (FLAME) ASIC;

**BeamCal Challenges:**
- Development of sapphire sensors with dedicated ASIC;
- Ongoing radiation damage studies (GaAs, Si diode, CVD diamond, sapphire …)

A. Neagu @ ILCX2021
Efficient Muon Identification & Measurement of the Energy Leakage from Hadron Calorimeter

Main technology (compatible with HCAL) – Scintillation strips with WLS and SiPM readout

Muon efficiency & Pion contamination:

- Baseline option under development: Scintillator + WaveLengthShifter + SiPM;
- Development of the Key Elements Sc/WLS/SiPM – Digital Silicon Photomultiplier in CMOS technology is in progress;
- Gas Detector - RPC (high coordinate resolution, excellent granularity up to 1 x 1 cm² pads) not active for now;
- Not many groups are participating in the Muon System Study
- No significant challenges in terms of particle fluxes and radiation environment many technologies feasible
SERBIA @ VINCA Participation in ILC

- Active since TESLA times/BRAHMS development for FTD;
- Since 2005 MoUs with FCAL and ILD;
- Chairing the FCAL IB (2013-2015)

- Core expertise in **integrated luminosity measurement and forward region R&D**

- Muon detectors
  - Technical coordination for iron instrumentation @ ILD (2017)

- Higgs physics
  - Higgs/EW physics convening @ ILD (present)
  - ILD contacts for ECFA WG1 HTE and GLOBAL groups (present)

- Members of the ILC International Development Team (IDT)
  - Detector & Physics WG3 (present)
  - Chairing the IDT WG3 Speakers Bureau (present)
  - Member of the ILD PSB (present)

- 2 ILD PhD theses
- 2 EU projects (AIDA and E-JADE)
- Realizing the project IDEJE/IDEAS by the national Science Fund covering ILC detector and physics studies (and other future Higgs factories)
International Development Team (IDT) to Prepare ILC Pre-Lab

Established in August 2020

ILC International Development Team

Executive Board
- Americas Liaison: Andrew Lankford (UC Irvine)
- Working Group 2 Chair: Shinichiro Michimura (KFK)
- Working Group 3 Chair: Jenny List (DESY)
- Executive Board Chair and Working Group 1 Chair: Tatsuya Nishida (FPFI)
- KEK Liaison: Yasuhiro Okada (KEK)
- Europe Liaison: Steinar Stapanes (CERN)
- Asia-Pacific Liaison: Geoffrey Taylor (U. Melbourne)

Working Group 1: Pre-Lab Setup
Working Group 2: Accelerator
Working Group 3: Physics & Detectors

The original timescale to start the ILC Pre-lab in 2022 was too optimistic:
→ there was no progress in the “top-down” political-governmental approach (> 2021)
→ The IDT Pre-lab plan was reviewed by a MEXT appointed panel and deemed premature, referring to that the prospects for ILC international cost sharing are not clear.
→ increased support for technical developments & accelerator R&D was recommended (these plans were included MEXT budget request and has been approved by the JP Finance Ministry in FY2023 → double KEK resources for ILC preparation for the ILC ITN)

Proposal for the ILC Preparatory Laboratory (Pre-lab)

International Linear Collider
International Development Team

1 June 2021

ILC Pre-lab proposal developed by IDT-WG1 and submitted to MEXT on Jun. 2, 2021:

During the preparatory phase of the International Linear Collider (ILC) project, all technical development and engineering design needed for the start of ILC construction must be completed, in parallel with intergovernmental discussion of governance and sharing of responsibilities and risk. The ILC Preparatory Laboratory (Pre-lab) is intended to execute the technical and engineering work and to conduct the intergovernmental discussion by providing relevant information upon request. It will be based on a worldwide partnership among laboratories with a headquarters located in Japan. This proposal, prepared by the ILC International Development Team and reviewed by the International Committee for Future Accelerators, describes an organisational framework and work plan for the Pre-lab. Elaboration, modification and adjustment should be introduced for its implementation, in order to incorporate requirements arising from the physics community, laboratories, and governmental authorities interested in the ILC.

arXiv: 2106.00602

IDT-WG2 TP document:

IDT - WG2 summarized the technical preparation as Work Packages (WPs) for the Pre-Lab stage in the Technical Preparation (TP) Document

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