New Ideas on Detector Technology for the ILC Experiments

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

11th Edition of the Large Hadron Collider Physics Conference

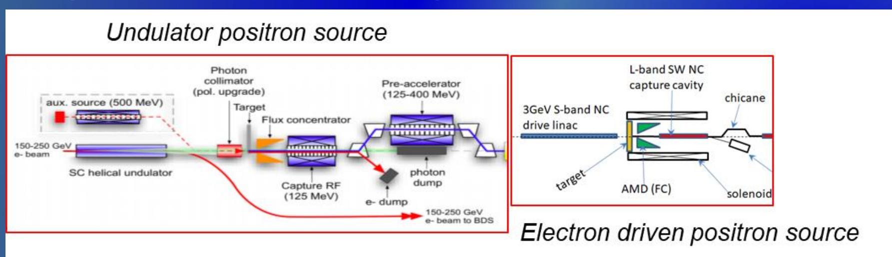
Belgrade, Serbia, May 22-26, 2023

The ILC (250 GeV) Accelerator:

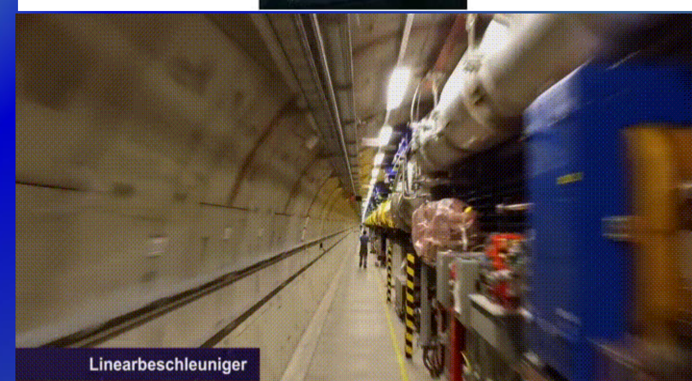
http://www.linearcollider.org/

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

- *Creating particles* **ITN focus areas (>2023):**
  - *→ polarized elections/positrons* ***Sources***



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



Recent talks (2022 eeFACT Symposium):
https://agenda.infn.it/event/21199/

LCWS2023 @SLAC: International Workshop on Future Linear Colliders (May 15-19, 2023)

LCWS2023 INTERNATIONAL WORKSHOP ON LINEAR COLLIDERS

LCWS203 Wokrshop
https://indico.slac.stanford.edu/event/7467/

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 / EAJADE (Europe-America-Japan Accelerator Development and Exchange) program. Emerging new linear collider concept, C^3, will be also 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 CO_2 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 – Yoshioka Masakazu (Iwate 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- Bullard 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 – Shumail Muhammad (SLAC)
14:10-14:30 Applications of High Gradient Accelerator Research for N[redacted] 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

Silicon ECAL (SiD) VIP FPCCD Scintillator HCAL

TPAC DEPFET SOI Scintillator ECAL

FCAL Dual Readout

ChronoPixel CLICPix

LINEAR COLLIDER COLLABORATION

DOI 10.5281/zenodo.4496000

Detector R&D Report

https://doi.org/10.5281/zenodo.3749461

doi:10.5281/zenodo.3749461

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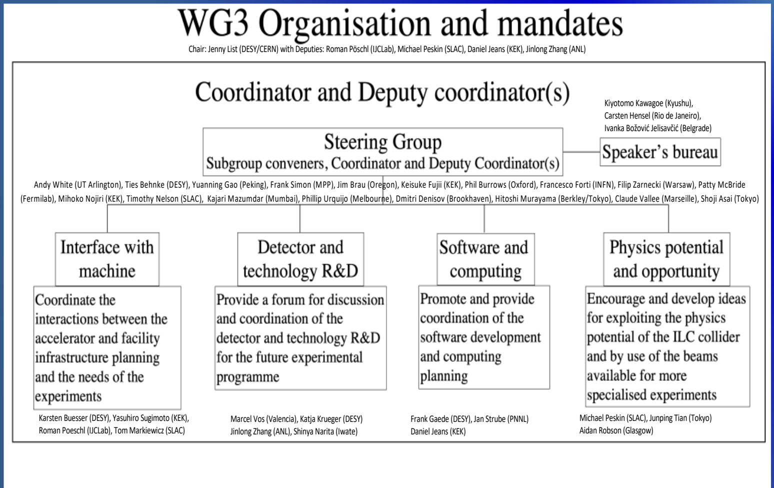
February 2, 2021

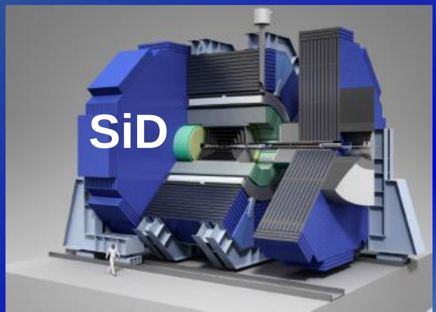
LINEAR COLLIDER COLLABORATION

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

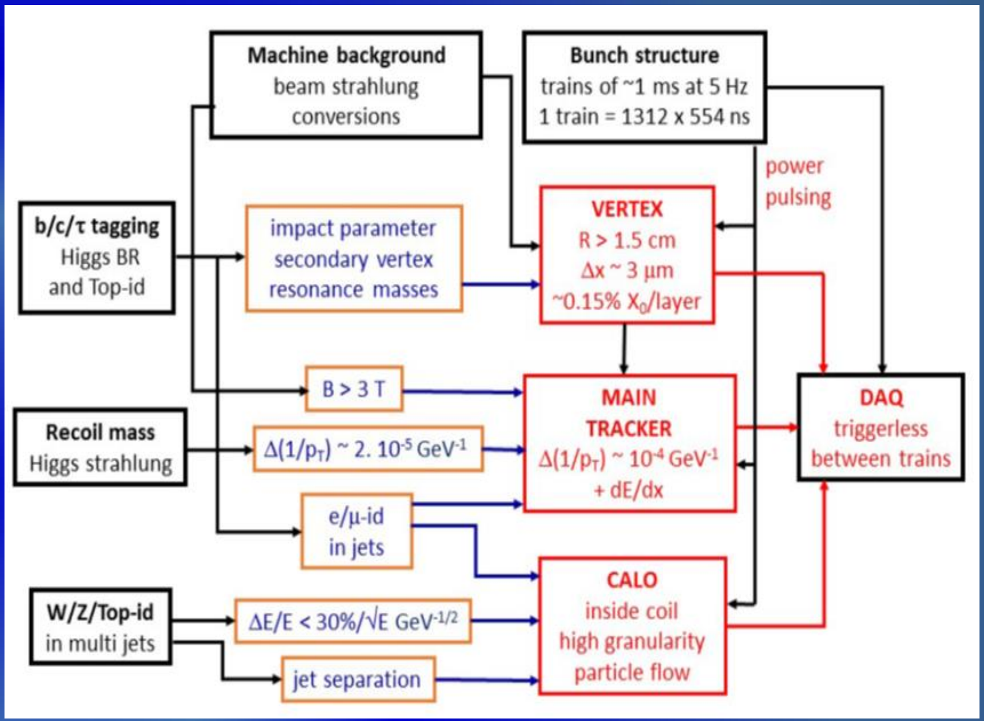


- ✓ *Keep various detector technology options and do not prioritize. This has the advantage that the technologies can be further developed until specific choices have to made once future Higgs Factory is approved.*
- ✓ *Furthermore — and as important — this keeps a broad community of detector research 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.*

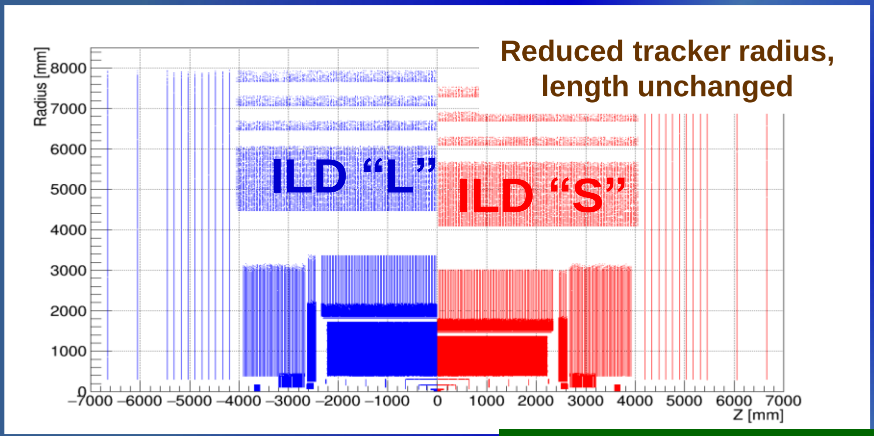
ILC Detector Concept Groups: ILD and SiD



- ✓ ILD: International Large Detector
- ✓ SiD: Silicon Detector



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



ILD ("L" & "S") — ILD Interim Design Report: arXiv: 2003.01116	SiD — SiD Design Update: arXiv: 2110.09965
Both optimized for PFA Performance: ~ $B \cdot R_{ECAL,inner}^2$ (two-track separation @ ECAL)	
B = 3.5 T / 4 T	B = 5 T
$R_{ECAL,inner}$ = 1.8 / 1.46 m	$R_{ECAL,inner}$ = 1.27 m
Si + TPC tracking Outer radius: 1.77 / 1.43 m	Silicon Tracking only Outer radius: 1.22 m

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 / layer, $\sigma_{sp} \lesssim 3\ \mu m$

VERTEXING:

- 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)
    - → 3D tracking / pattern recognition;
    - → dE/dx information for PID

TRACKING:

SiD: All-Silicon Tracking

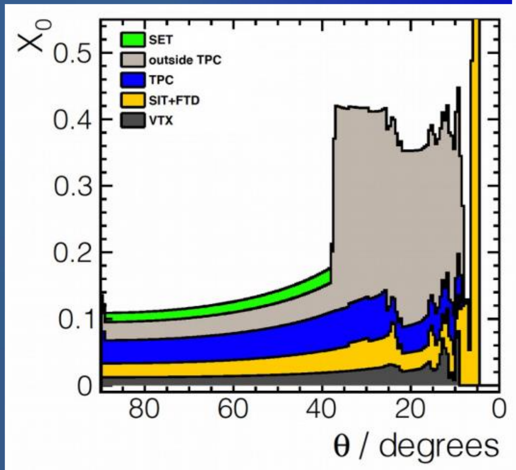
- short barrel of 5 single layers of Si-pixels

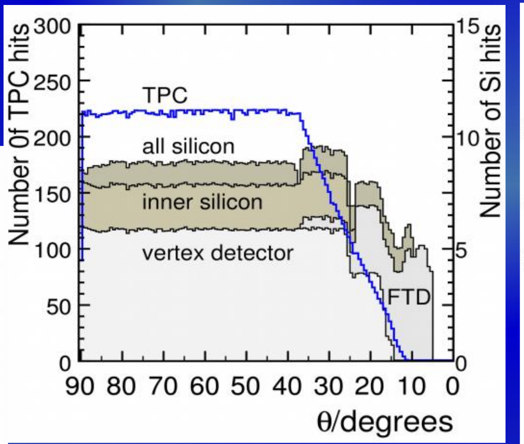
0.15% X_0 / layer, $\sigma_{sp} \lesssim$ 3-5 μm

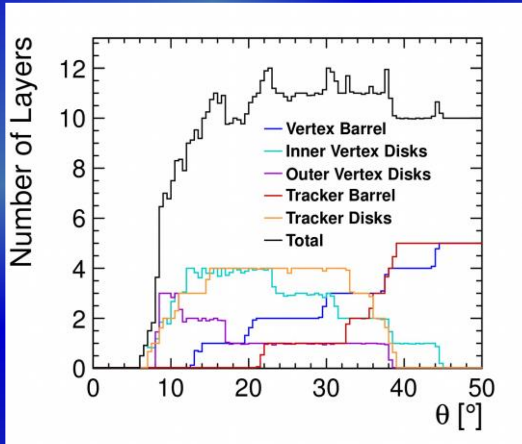
- 5 layers Silicon-strip tracker
  (25um strips, 50 um readout pitch)

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

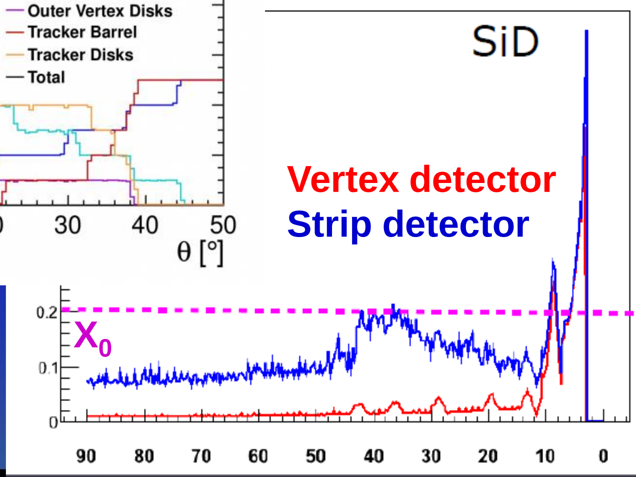
ILD:







SiD:



Still a lot of opportunities in ILD/SiD optimization : physics goals, software developments and technology options

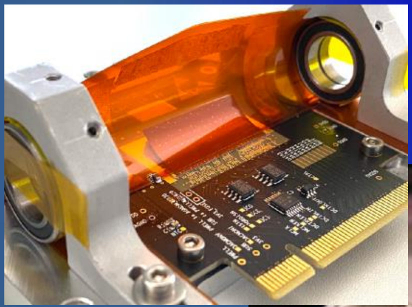
Vertex Technologies for Future Linear Colliders (ILC)

- **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

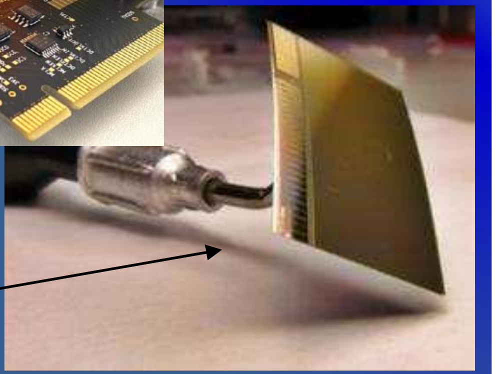
Physics driven requirements	Running constraints	Sensor specifications	
$\sigma_{s.p.}$ 2.8um		Small pixel	~16 μm
Material budget 0.15% X_0/layer		Thinning to	50 μm
	Air cooling	low power	50 mW/cm²
r of Inner most layer 16mm	beam-related background	fast readout	~1 μs
	radiation damage	radiation tolerance	≤3.4 Mrad/year ≤6.2×10¹² n_{eq}/(cm² year)

Technology	FPCCD	DEPFET	SOI	CMOS	iLGAD
Added value (example)	Very granular	Low material budget	2 tier process (high density μcircuits)	Industry evolution	PID

180 nm CMOS technology: VALIDATED

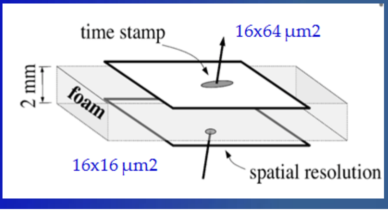


ALPIDE@ ALICE ITS-3 (bending 50 um sensor)



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:

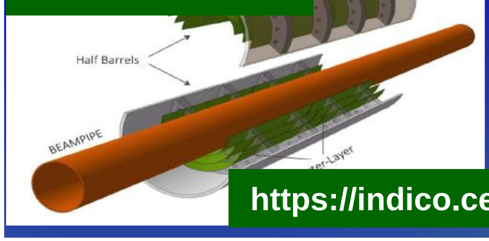
Bending thin Si-layers (MAPS):

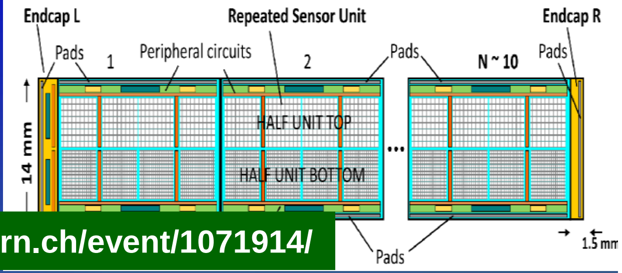
Truly cylindrical, supportless CPS for ALICE-ITS3 upgrade (65 nm)

Industrial stitching & large surfaces for low-mass detect.:

using several reticles from the same wafer (possible with both 180 and 65 nm)

arXiv: 2105.13000





https://indico.cern.ch/event/1071914/

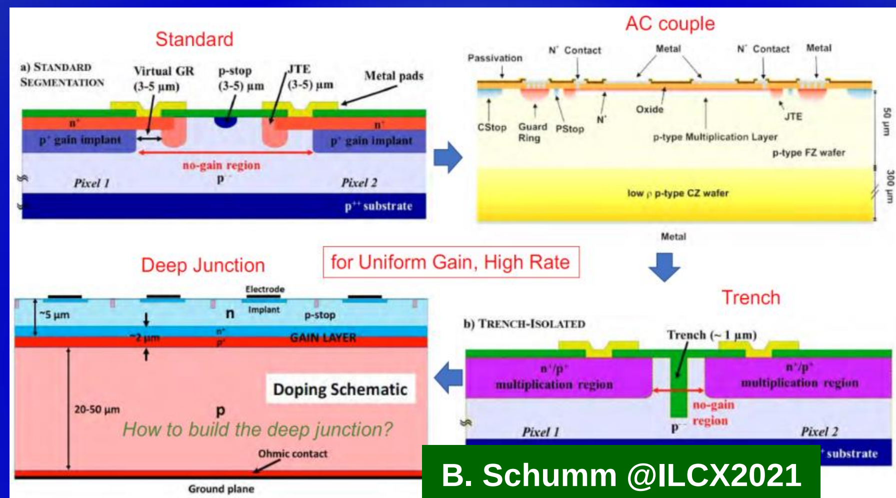
Silicon Tracking Conceptual Studies for ILC

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)

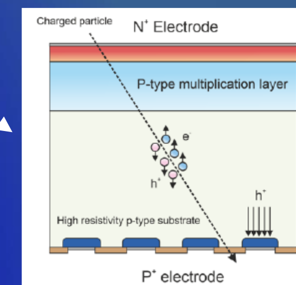
Timing Detectors open up 4D (and 5D) tracking → ATLAS/CMS upgrades include several m^2 of LGADs:

- ✓ 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).

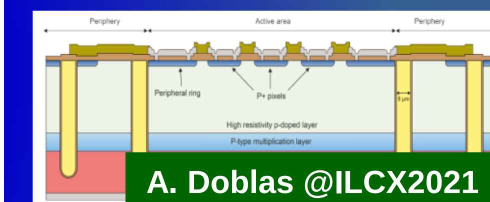


B. Schumm @ILCX2021

iLGAD:



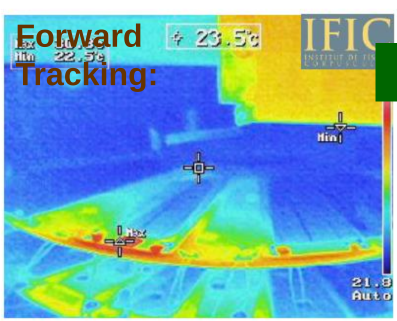
Trench iLGAD:



A. Doblas @ILCX2021

Readout ASICs (power dissipation) may limit the intrinsic sensor performance

→ power pulsing to reduce energy consumprion or the use of microchannnels to complement air cooling



M. Vos @ ILCX2021

Thermal management optimization strongly linked with supporting structure desing

A pattern of small trenches (3 x 10 μm) is etched on the backside of the pixel detector

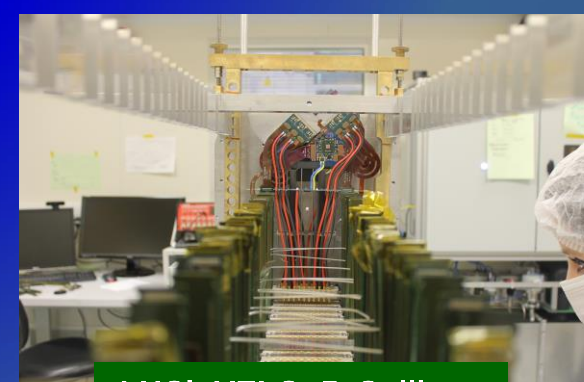
Microchannels are etched isotropically with XeF2.

A thin film of parylene (5 μm) seals the microchannels. It is finally cured by a thermal cycle.

M. Boscardin et al., NIM A, 2013
L. Andricek et al., JINST 11 (2016) P06018
C. Lipp, MSc Thesis, EPFL, 2017
I. Berdalovic et al., JINST 13 (2018) C01023

***Working MALTA CMOS sensor with integrated μ-channels*:**

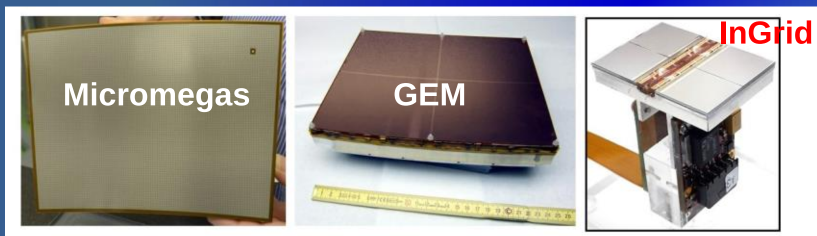
Ultra-light microchannel cooiling:



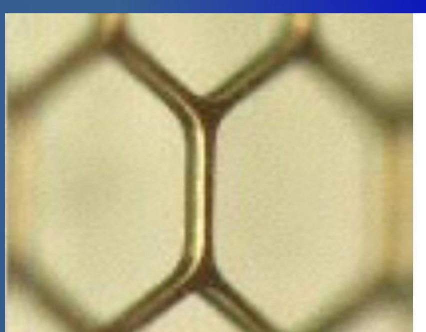
LHCb VELO: P. Collins; arXiv: 2112.12763

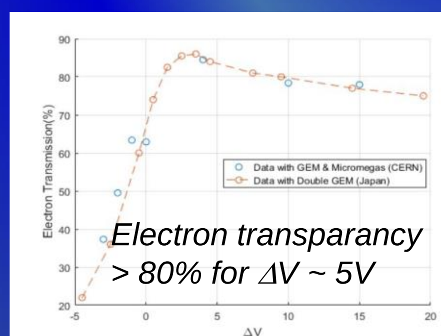
Gaseous Tracking: TPC with MPGD-based Readout

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)



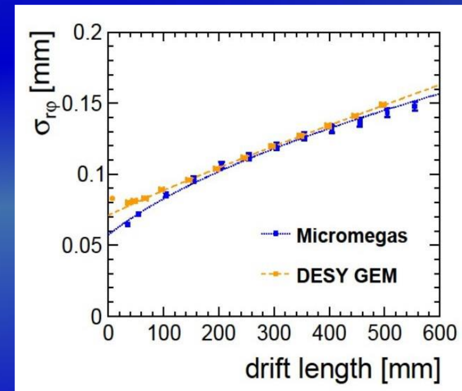
ILC: gating scheme, based on large-aperture GEM
- → Machine-induced background and ions from gas amplific.
- → Exploit ILC bunch structure (gate opens 50 us before the first bunch and closes 50 us after the last bunch)

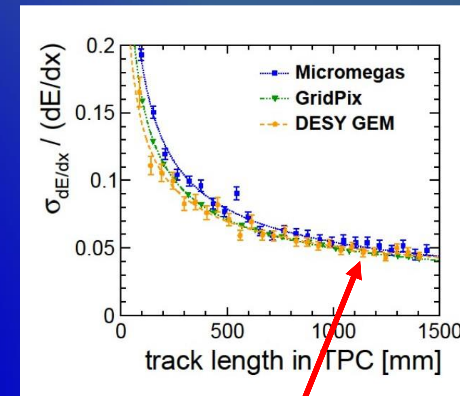




CHALLENGES / FUTURE PLANS:
- ✓ Common modules with a final design (with gating)
- ✓ Optimization of cooling & material budget
- ✓ GridPix development (dN/dx cluster counting)

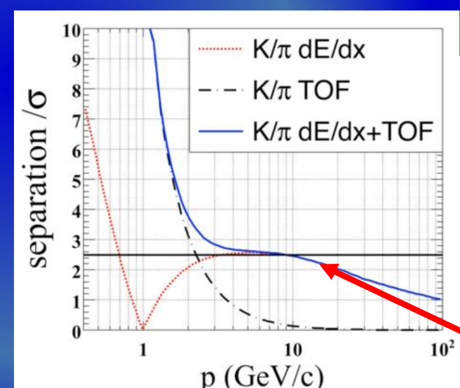
Spatial resolution of σ_T ~ 100 um and dE/dx res. < 5% have been reached with GEM, MM and InGrid)



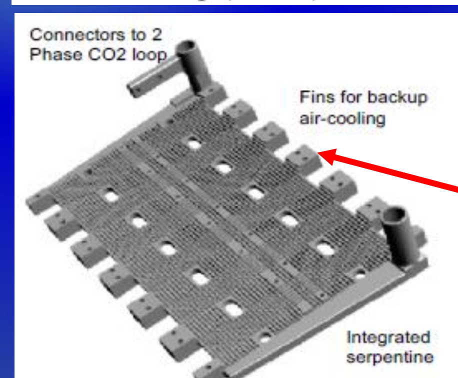


arXiv: 2003.01116

dE/dx ~ <4 % can be achieved with Gridpix (cluster-counting)



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



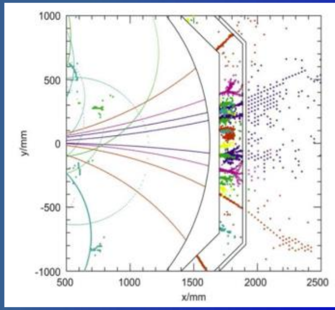
3D-printed monolithic cooling plate for a TPC using 2-phase CO2

P. Colas @ ILCX2021

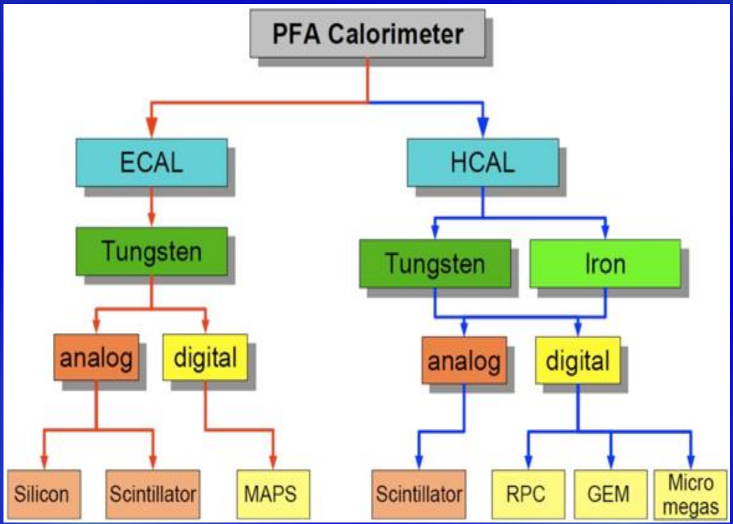
Particle Flow Calorimeters: CALICE Collaboration

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).



Issues: overlap between showers, complicated topology, sep. "physics event" from beam-induced bkg.



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

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

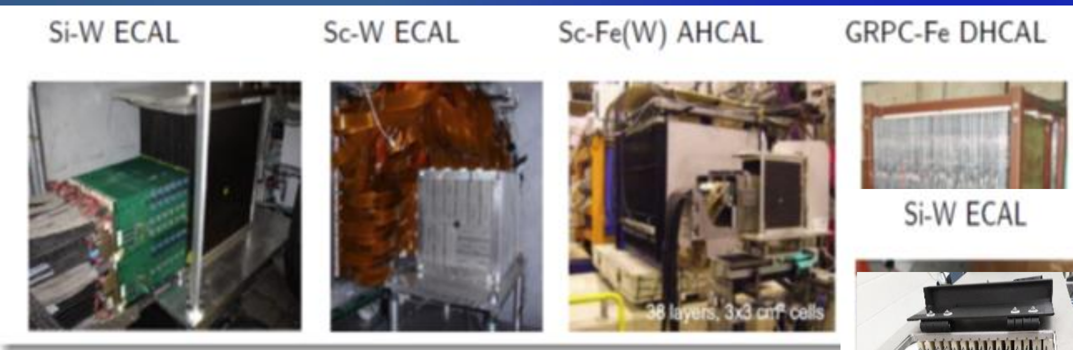
	ECAL option	ECAL option	HCAL option	HCAL option
Active layer	silicon	scint+SiPM	scint+SiPM	glass RPC
Absorber	tungsten	tungsten	steel	steel
Cell size (cm×cm)	0.5×0.5	0.5×4.5	3×3	1×1
# layers	30	30	48	48
Readout	analog	analog	analog	Semi-dig (2 bits)
Depth # (X_0/Λ_{int})	24 X_0	24 X_0	5.5 Λ_{int}	5.5 Λ_{int}
# channels [10^6]	100	10	8	70
Total surface	2500	2500	7000	7000

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

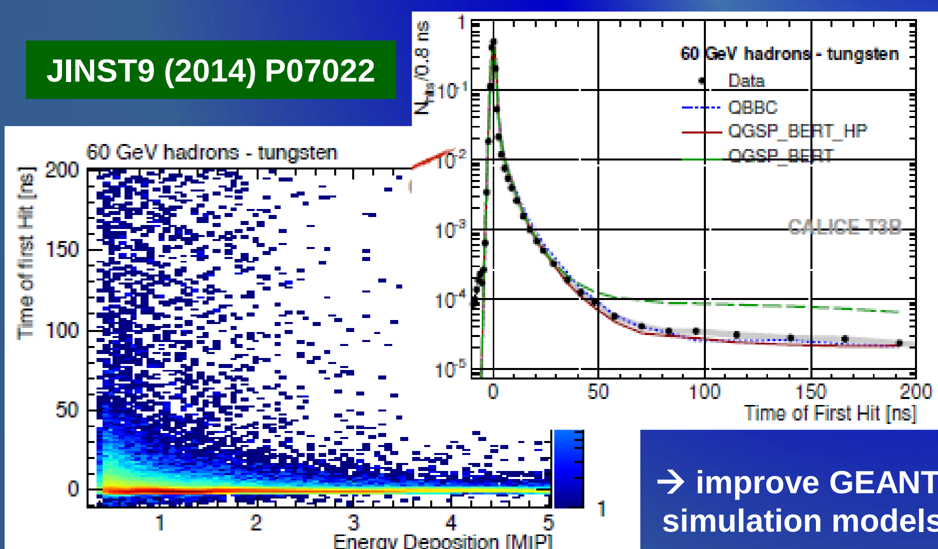


← Proof-of-principle with first generation physics prototypes (2003-2012)

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



→ improve GEANT simulation models

ILC AHCAL & CMS HGCAL common test-beam

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

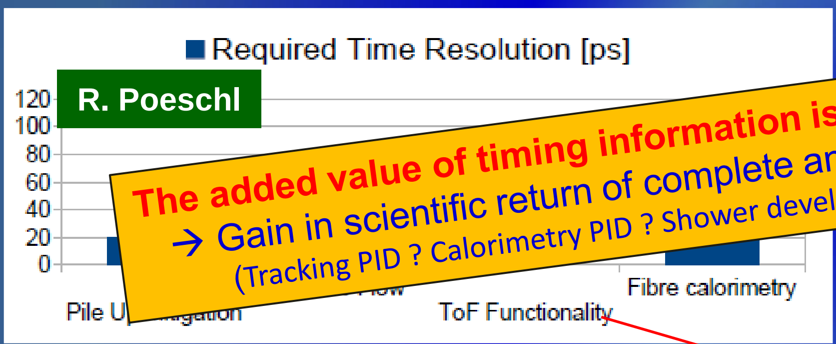
Particle Flow (Imaging) Calorimeters: The 5th Dimension ?

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

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

R. Poeschl



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)**

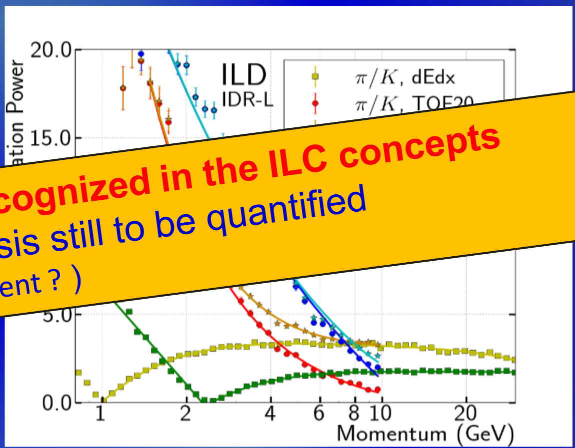
✓ Timing in calorimeters / energetic showers?

→ 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 $\sigma(E)$ / E

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

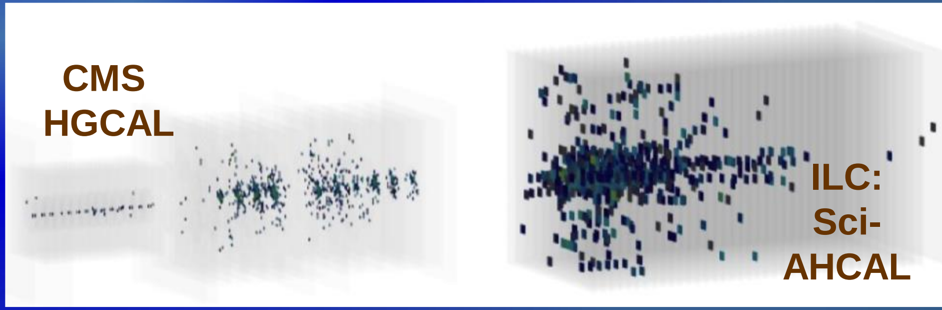


T. Suehara @ILCX2021

Timing resolution
Is affected by noise

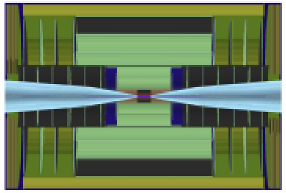
Sensor	Amp. th.	Time reso.
S8664-50K (inverse)	20 mV	123 psec
	40 mV	63 psec
S2385 (normal)	20 mV	178 psec
	40 mV	89 psec

ILC AHCAL & CMS HGCAL common test-beam



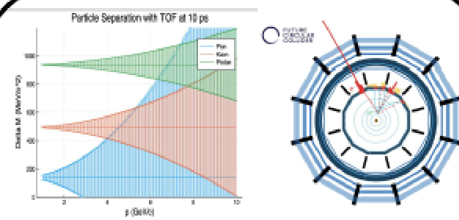
CMS HGCAL has measured **evoluton of hadronic showers in the time domain** with ~80ps accuracy (50ps TDC binning)

Fast Timing in Higgs Factory Detectors



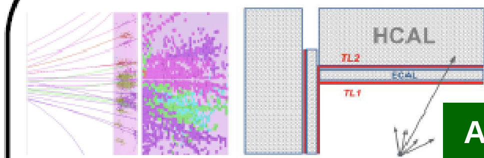
Suppression of beam induced backgrounds at muon colliders

Full 4D tracking



Time of Flight for Particle ID at low momentum and Long Lived particles

Timing layers



Exploit the time structure of hadronic showers to enhance PFA and improve jet energy resolution

5D Calorimetry

Timing layers or volumetric timing

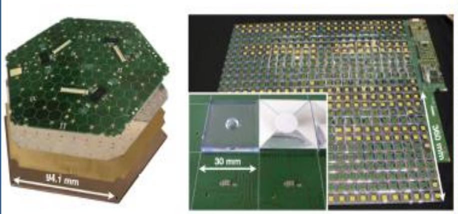
A. Schwartzman @LCWS2023

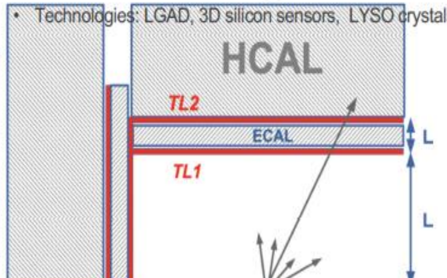
Z. Zhang @LCWS2023

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

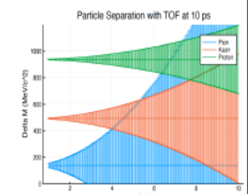
- ***Volume timing***: good time resolution on the cell level in highly granular calorimeters
  - requires technologies that can provide this timing; significant implications for electronics
  - potential compromises in timing for objects
  - Technologies: LGAD or silicon tiles
- ***Timing layers***: 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





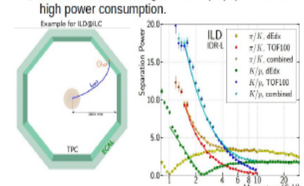
Precision Timing @ ILC

- 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 5D 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



TOF in the ECAL – Particle ID

- "Standard" silicon sensors could reach O(100-300ps)
- LGAD sensors could get us to O(10ps) Drawback: high power consumption.



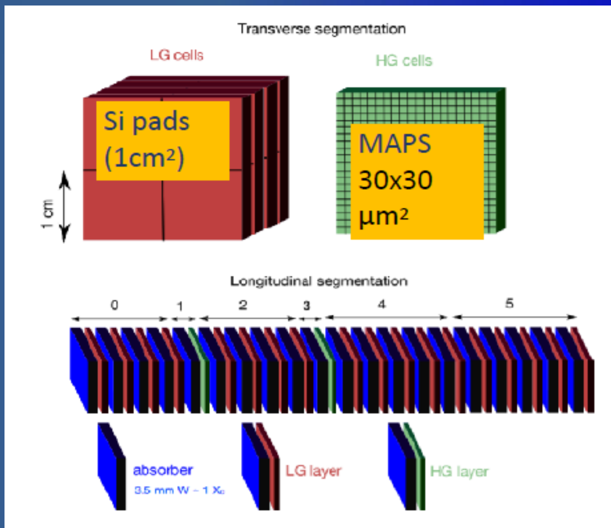
Impact in the physics reach?

- Could be a game changer for s-quark measurements

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**, $\pi 0$
- ✓ FoCal-H: Pb-Sc sampling calorimeter for photon isolation and jets

Digital ECAL prototype:

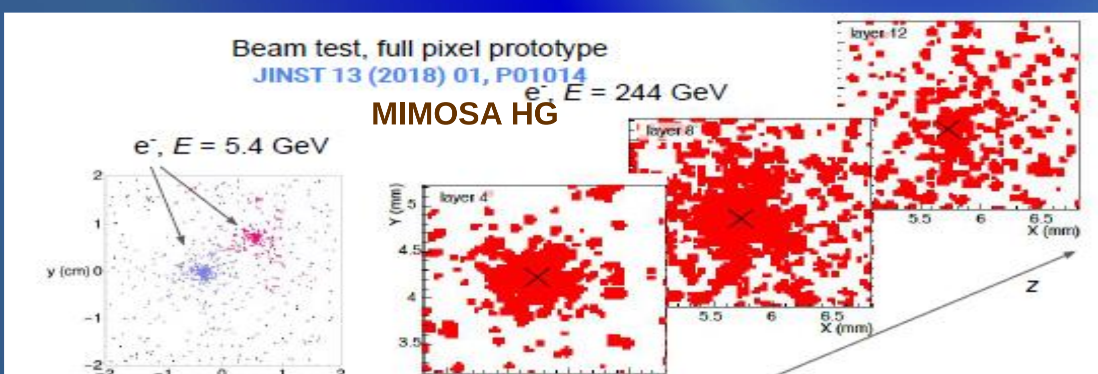
- number of pixels above threshol ~ deposited energy
- Monolithic Active Pixel Sensors (MAPS) PHASE2/MIMOSA23 wit a pixel size: 30x30 µm2
- 24 layers of 4 sensors each: activ area 4x4 cm2 , 39 M pixels
- 3 mm W absorber for 0.97 X0 pe layer R_M ~ 11 mm

FoCAL: assuming ≈ 1m² detector surface

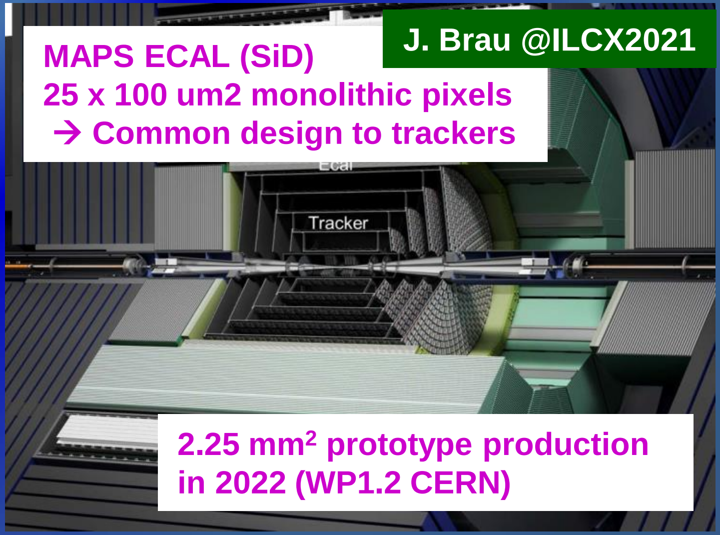
A. Rossi @ ICHEP2020

	LG	HG
pixel/pad size	≈ 1 cm²	**≈ 30x30 µm²**
total # pixels/pads	≈ 2.5 x 10^5	**≈ 2.5 x 10^9**
readout channels	≈ 5 x 10^4	**≈ 2 x 10^6**

Could be a unique tool to improve shower simulation …



T. Peitzmann, PH Detector Seminar, 25/10/2019
P. Allport, PH Detector Seminar, 10/09/2020
A. De Haas, JINST13 (2018) P01014



J. Brau @ILCX2021

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

Cherenkov fibres

Scintillating fibres

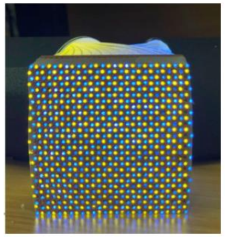
Fast signals

for relativistic (EM) component

Slow signals

for non-relativistic (hadronic)

Building Blocks:



SiPM for much better separation of Ch. & Sci. light

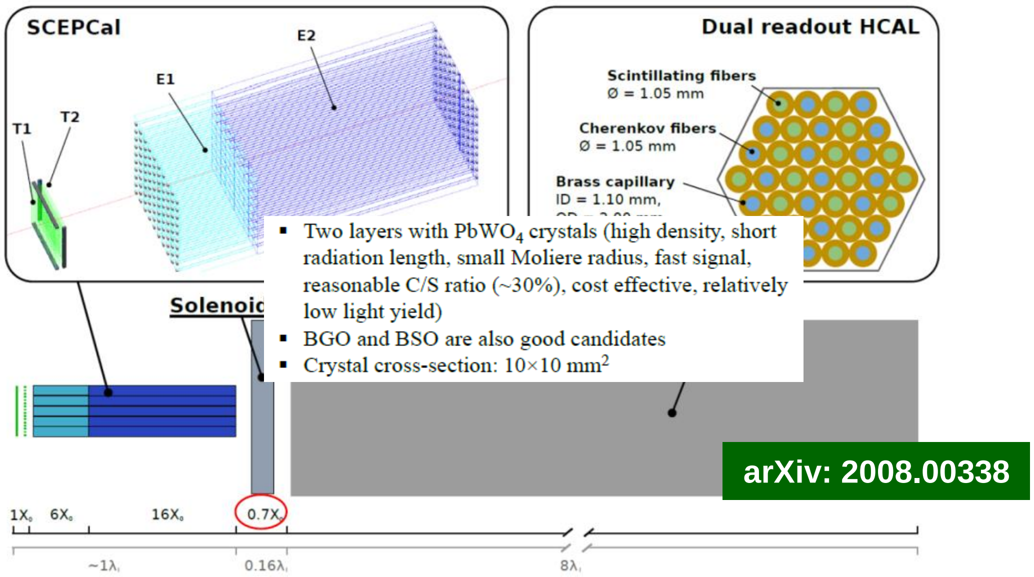
Dual readout to capture Electromagnetic and hadronic components of shower

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

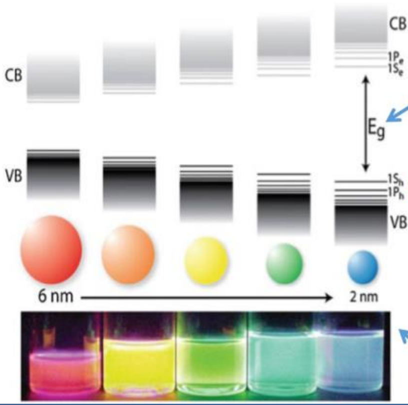
arXiv:2008.00338



- Two layers with $PbWO_4$ crystals (high density, short radiation length, small Moliere radius, fast signal, reasonable C/S ratio (~30%), cost effective, relatively low light yield)
- BGO and BSO are also good candidates
- Crystal cross-section: 10×10 mm²

arXiv: 2008.00338

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



Eg increases with decreasing particle size -> *UV photon absorption*

Discrete energy levels form at the band-edges

Stokes Shift is difference between absorption and emission wavelength

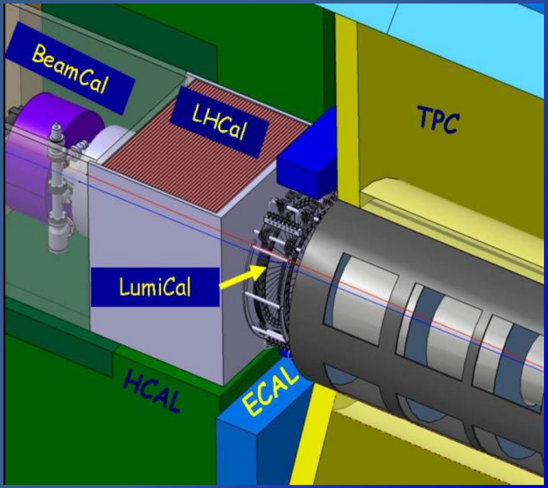
Emission wavelength decreases with decreasing size -> *tunability*

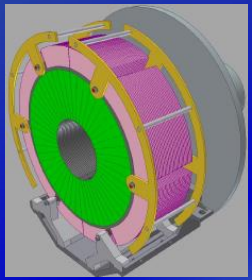
Readout Detector Development R&D: **S. Magill @ILCX2021**

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

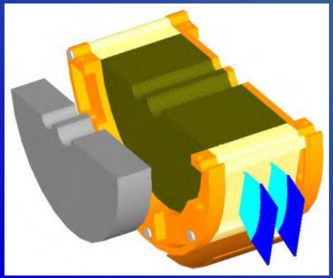
Wavelength conversion by nanoparticles discussed for detection of Cherenkov light

Forward Calorimetry R&D: FCAL Collaboration





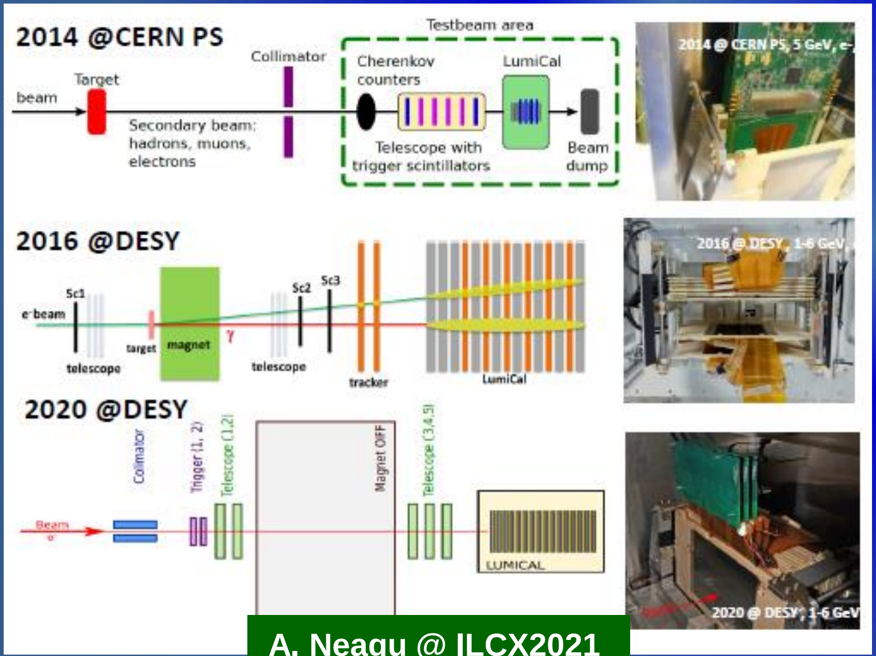
LumiCal:
→ precise luminosity measurement
10^{-3} - 500 GeV @ ILC



BeamCal:
→ inst. lumi measurement / beam tuning, beam diagnostics

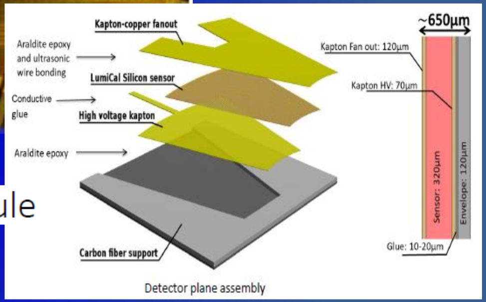
LumiCal: Two Si-W sandwich EM calo at a ~ 2.5 m from the IP (both sides)
BeamCal: very high radiation load (up to 1MGy/ year) → similar W-absorber, but radiation hard sensors (GaAs, CVD diamond, sapphire)
LHCAL: sampling calo (tungsten or iron with SI) → extend HCAL coverage

Beam-test campaings:
LumiCal prototypes multi-plane operation:



A. Neagu @ ILCX2021

LumiCal thin prototype module



LumiCal Challenges:

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

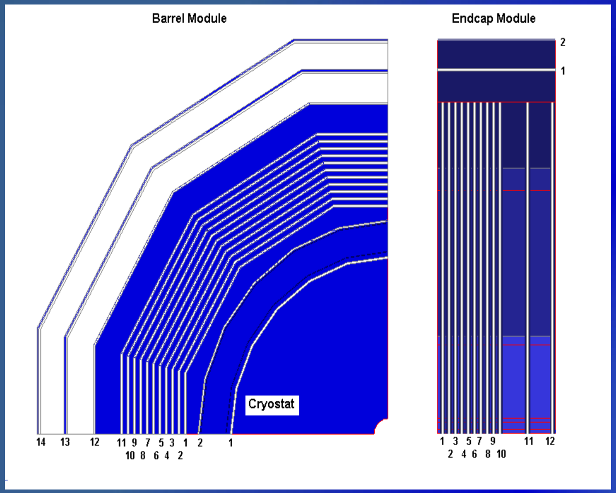
BeamCal Challenges:

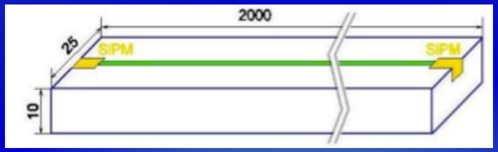
- ✓ Development of sapphire sensors with dedicated ASIC;
- ✓ Ongoing radiation damage studies (GaAs, Si diode, CVD diamond, sapphire …)

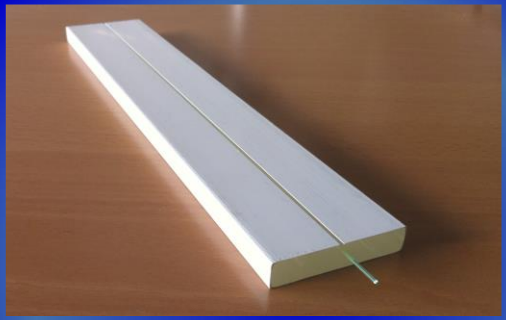
Muon System / York Instrumentation

Efficient Muon Identification & Measurement of the Energy Leakage from Hadron Calorimeter

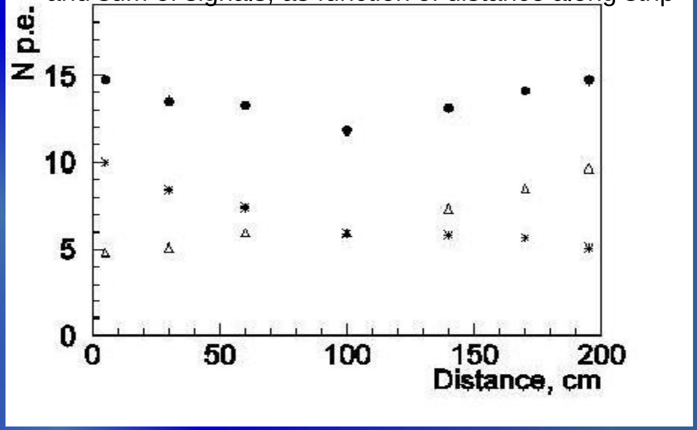
Main technology (compatible with HCAL) – Scintillation strips with WLS and SiPM readout



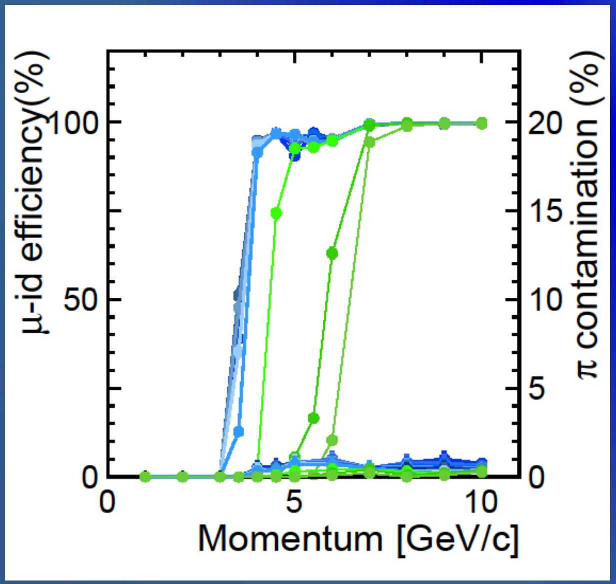




Number of photons detected from both side by SiPMs and sum of signals, as function of distance along strip



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 cm^2 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

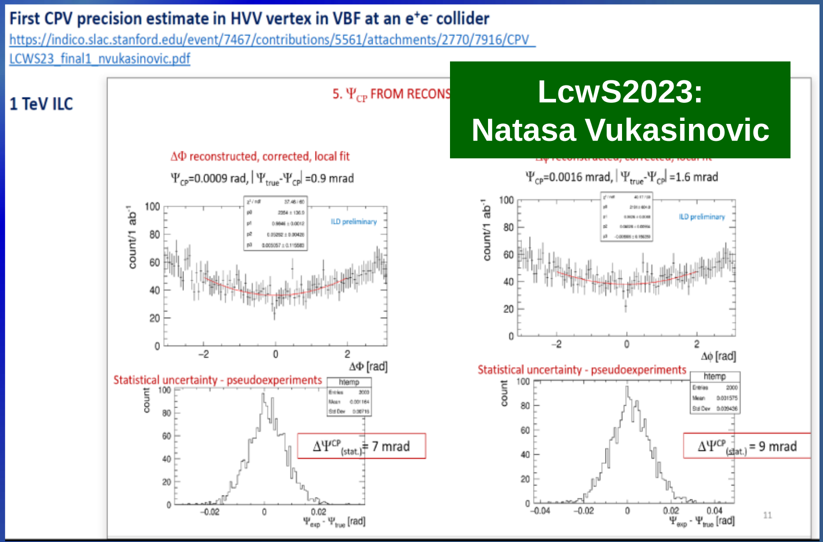
VINČA
INSTITUTE OF NUCLEAR SCIENCES
University of Belgrade
NATIONAL INSTITUTE OF THE REPUBLIC OF SERBIA

- 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** → **ECFA WG1-PREC LUMI Topical Expert Team (present)**
- 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

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

arXiv:2106.00602v1 [physics.acc-ph] 1 Jun 2021

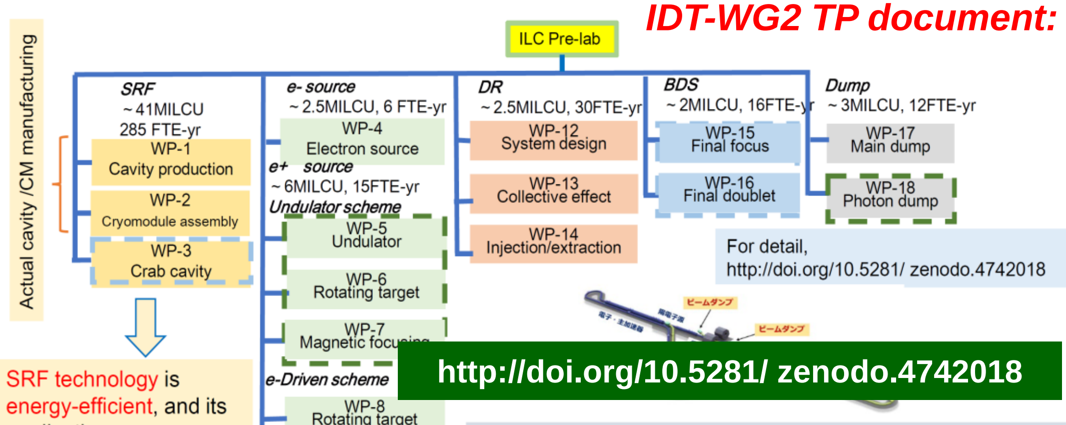
ILC Pre-lab proposal developed by IDT-WG1 and submitted to MEXT on Jun. 2, 2021:

Abstract

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 cost. The ILC Preparatory Laboratory (Pre-lab) is conceived to execute the technical and engineering work and to assist the intergovernmental discussion by providing relevant information upon request. It will be based on a worldwide partnership among laboratories with a headquarters hosted in Japan. This proposal, prepared by the ILC International Development Team and endorsed 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:



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

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

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

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