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DE CIENCIA  
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**Ciemat**

Centro de Investigaciones  
Energéticas, Medioambientales  
y Tecnológicas



# ILD

# My view of next 2 years

*Mary-Cruz Fouz*

**CIEMAT**

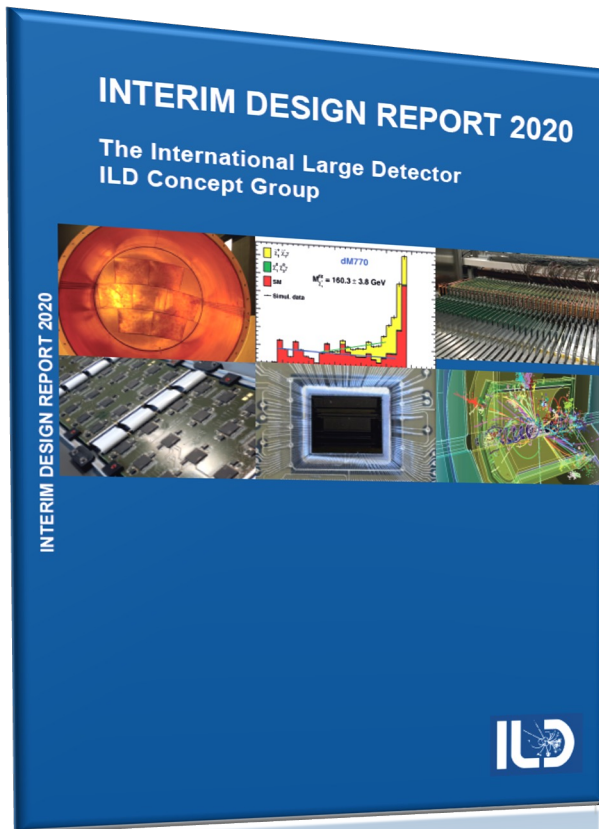
**ILD Meeting 2<sup>nd</sup> June 2026**

*I am deeply honoured to have been elected as ILD Spokesperson*

*At this important moment for our field, I am grateful for the opportunity to contribute to guiding ILD through its next stage of development*

# The ILD

## Key features

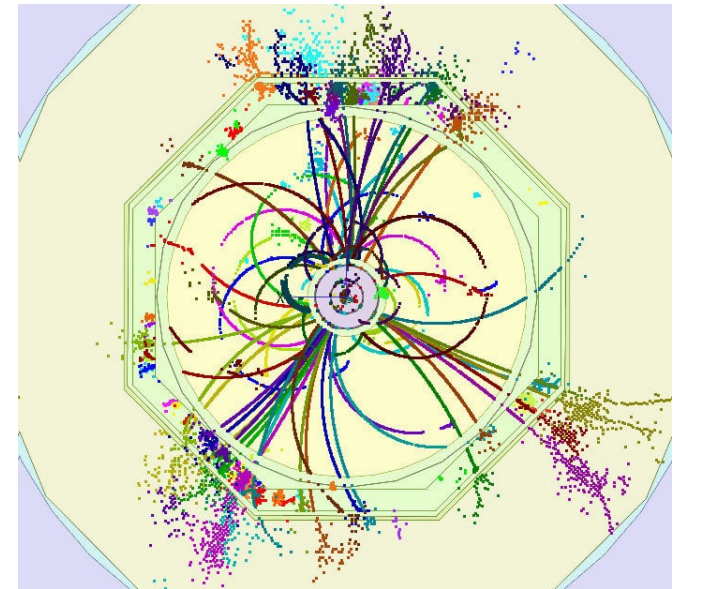
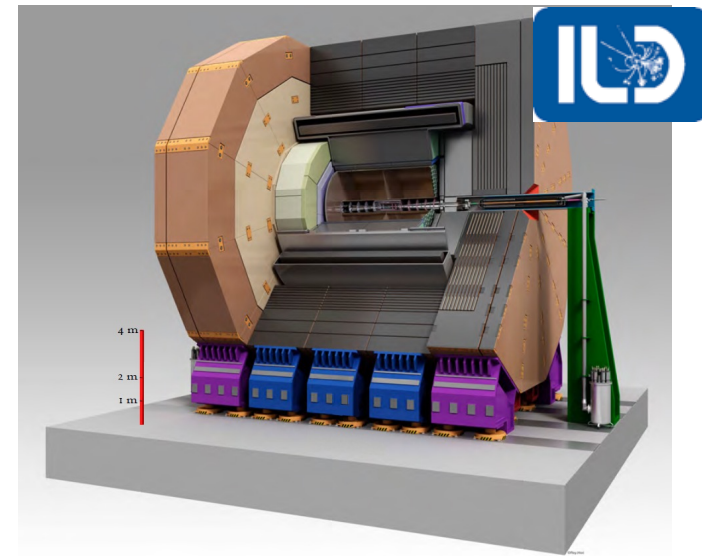


### Optimized around **particle flow**

- Highly granular calorimeters
- Low-mass tracking
  - Hybrid Silicon – TPC tracking
  - Silicon Vertex

**A robust detector for e+e- collider up to 1 TeV**

*ILD is a mature concept that **remains open to innovation and continuous evolution***



# The European Strategy for Particle Physics 2026 Update

[https://cds.cern.ch/record/2957411/files/Update%20European%20Strategy\\_Deliberation%20Doc\\_2026.pdf](https://cds.cern.ch/record/2957411/files/Update%20European%20Strategy_Deliberation%20Doc_2026.pdf)



## 3 !

### The next CERN flagship collider project

- A. The electron–positron Future Circular Collider (FCC-ee) is recommended as the preferred option for the next flagship collider at CERN.
- B. A descoped FCC-ee is the preferred alternative option for the next flagship collider at CERN.

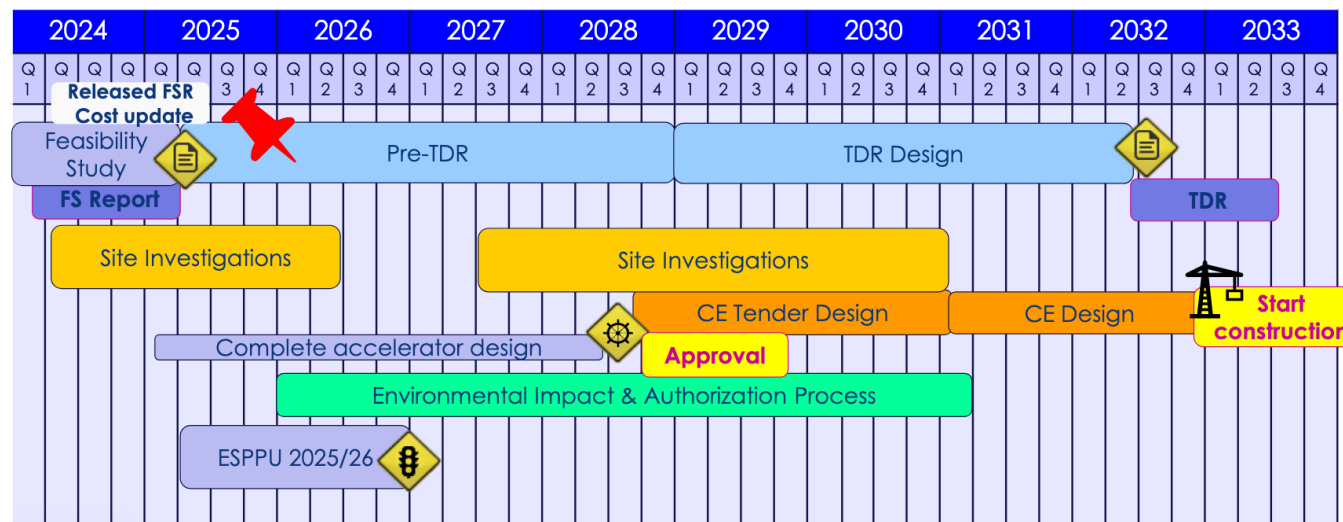
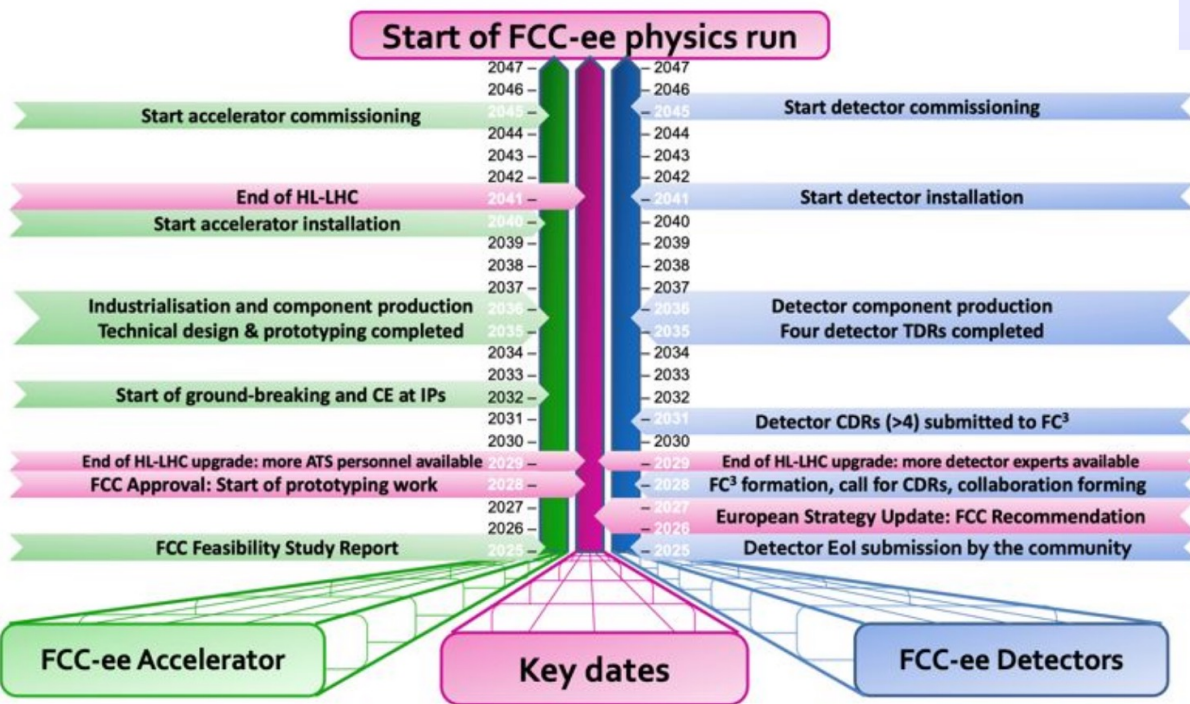
## 6

### Technologies

- E. For the DRD collaborations to address the requirements of future flagship projects, they must receive adequate funding. New R&D topics and initiatives should be integrated in the DRD scheme. The General Strategic Recommendations in the roadmap must be fully addressed by dedicated initiatives coordinated across the DRD collaborations.

# The FCC timeline

## Timescale towards FCC-ee



### PED priority items in the pre-TDR phase

1. Lay the foundations for the conceptual design studies of four (or more) detectors
2. Consolidate IR layout, detector integration, and related background mitigation
3. Complete the software & analysis toolkit to ease detector performance evaluation
4. Collaborate with IT to develop a computing architecture model for experiments
5. Confirm, with full analyses, the current uncertainty estimates on EWPOs (Z and W)
6. Gather the worldwide theory community to address the theoretical challenges
7. Streamline and optimise the procedure for centre-of-mass energy calibration
8. Develop an efficient PED Education/Communication/OutReach/InReach strategy
9. Ascertain the detector cost estimate
10. Articulate the physics case, feasibility, and schedule implications of other  $\sqrt{s}$  stages

# ILD must aim to be a leading actor in the next collider programme

**ILD should position itself as one of the key actors in the next collider programme** by preparing a strong EOI/LOI and consolidating its role among the future detector concepts. This objective must be pursued in a challenging environment: HL-LHC upgrades during LS3 will continue to absorb much of the available manpower and resources, while detector R&D within the DRD framework still faces limited financial support.

To succeed, ILD must remain visible and influential in the evolving PED structure, with its members actively contributing and taking leadership roles. At the same time, we must continue shaping a competitive and forward-looking detector concept, ready to meet the scientific and technological challenges of the next collider.

# Circular vs Linear – New challenges

Parameter	FCC-ee (Z)	ILC (GigaZ)	FCC-ee (ZH)	ILC (250)
CM Energy	91.2 GeV	91.2 GeV	240 GeV	250 GeV
Instantaneous Luminosity	<b><math>182 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}</math></b>	$4 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$	$7.3 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$	$2.7 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$
Collision Frequency	<b>100 MHz</b>	5 x 1312 Hz	3.3 MHz	5 x 1312 Hz
Bunches per beam	16640	1312	440	1312
Particles per bunch	$1.7 \times 10^{11}$	$2.0 \times 10^{10}$	$1.8 \times 10^{11}$	$2.0 \times 10^{10}$
Bunch Spacing	15 ns	554ns	994 ns	554 ns
Repetition Rate	Continuous	5 Hz	Continuous	5 Hz

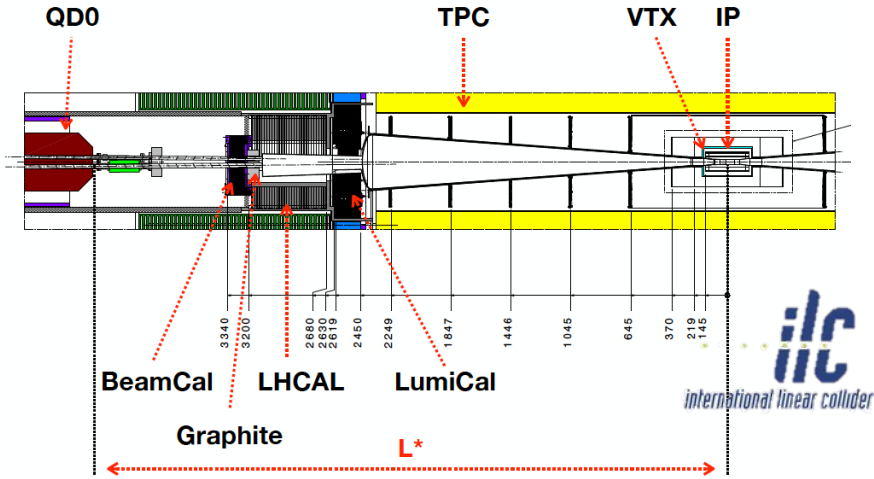
*Continuous vs. Pulsed structure  
Massive difference in event rate.*

Power Consumption: Active cooling could be needed  
(impacts on material budget and calorimetry homogeneity and compactness)

TPC: Large distortions induced by ion backflow,  
not yet fully demonstrated whether a TPC will be able to operate at Z pole

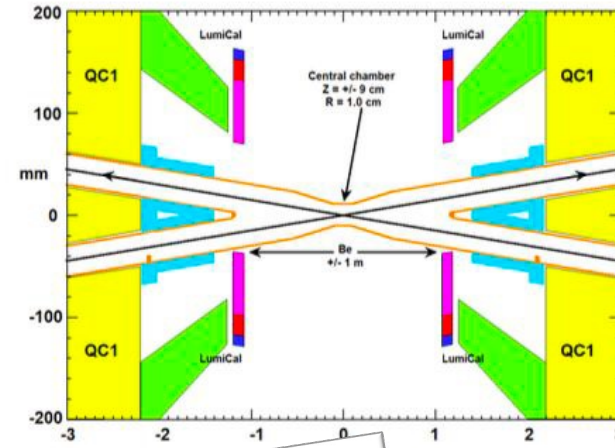
Is it still possible a triggerless readout?

# Machine Detector Interface



**FCC**  
hh ee ee

Crossing angle **30mrad**  
**L\* 2m**: Final Quadrupole **inside** the detector  
 Solenoid B field restricted to **2T** maximum  
**Lumical** at **~1m** from IP  
 Inner beam pipe radius **10mm**  
 → Tracker acceptance:  $\cos\theta \sim 0.984$

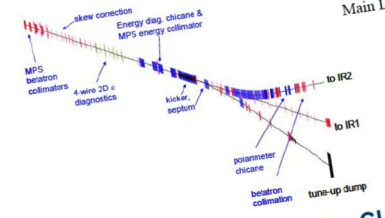
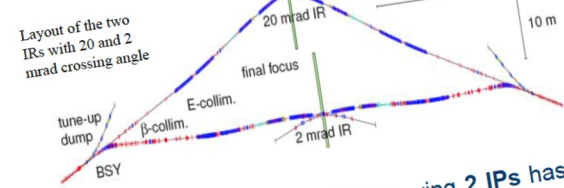


Crossing angle **14 mrad**  
**L\* 4.1 m**: Final Quadrupole **outside** the detector  
 Solenoid magnetic field **3.5 – 4 T**  
**Lumical** at **~2.5m** from IP  
 Inner beam pipe radius **16 mm**  
 Conical → Tracker acceptance:  $\cos\theta \sim 0.996$

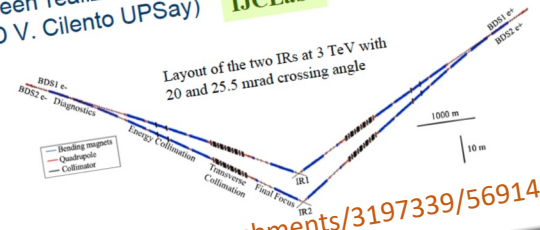
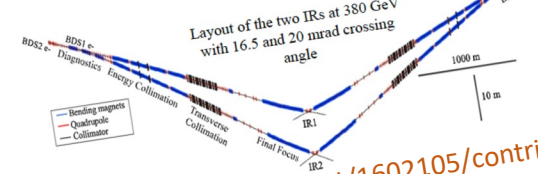
Very different designs  
 IR and Forward Region to be redesigned  
 Lower B field  
 Impacts on performance?

## Linear Collider Vision Two IP

In the ILC Baseline Conceptual Design, the ILC was designed with 2 BDS sections and two independent IRs with 20 and 2 mrad. At that time others schemes were under study, including one of 14 mrad and a head-or-tail scheme.



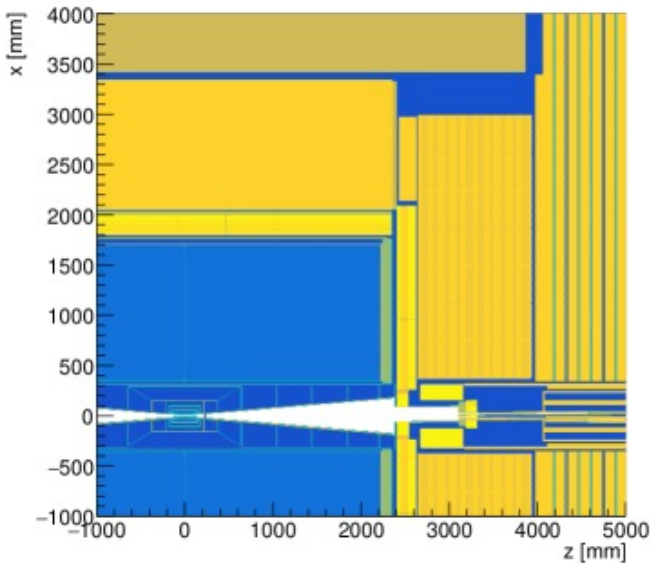
A detailed study of dual BDS serving 2 IPs has been realized in the framework of the CLIC project, this work could be taken as reference for future studies (PhD V. Cilento UPSay) **IJCLab**



# ILD simulation models

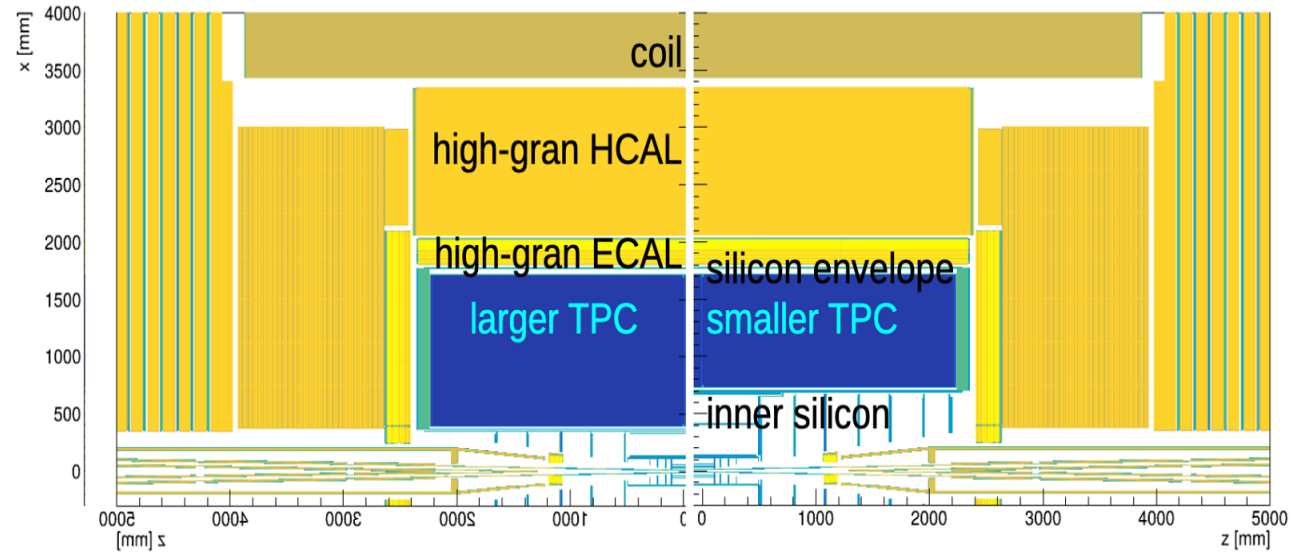


ILC (ILD\_I5\_v02)



ILD\_FCCee\_v01

ILD\_FCCee\_v02



all in k4geo

Backgrounds at FCCee need more detailed studies  
Extra shielding at luminometers?

# Advancing the ILD for next Collider

## ILD Challenges and Evolution for FCC-ee Detector Adaptation for Z-pole Operation

- New operational constraints at the Z pole
  - Power dissipation
  - Triggerless operation
  - Ion backflow in the TPC
- Interaction Region challenges
  - Final beamline elements closer to the IP
  - Increased importance of:
    - Background control
    - Detector acceptance
- Magnetic field
  - Present baseline around 2 T for Z-pole operation
  - Impact on high-energy performance to be assessed

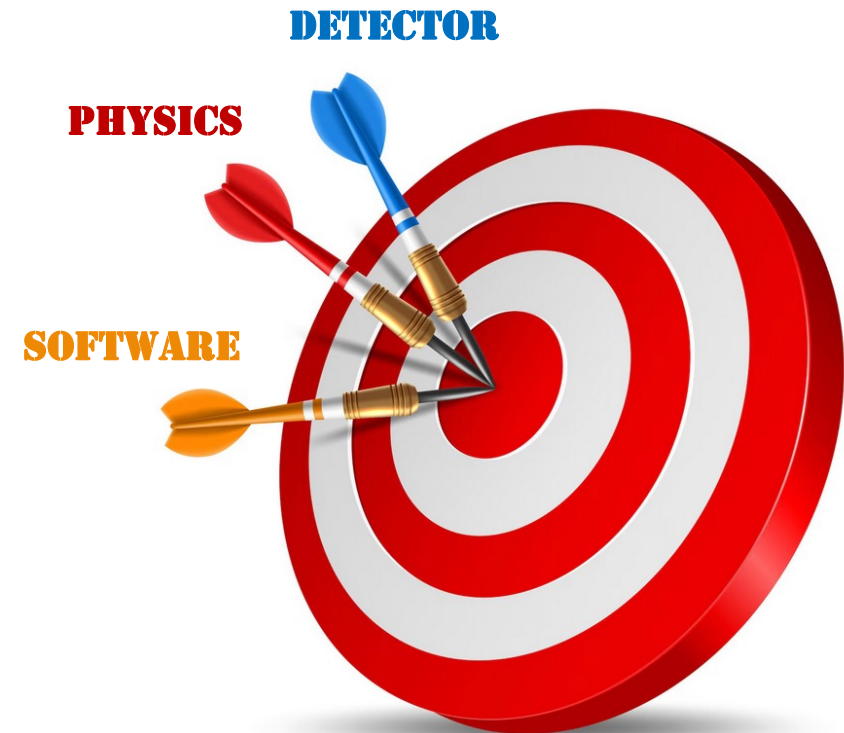
*ILD should remain open to advances in detector technologies*

improved silicon detectors and sub-nanosecond timing capabilities

faster sensors and suitable front-end electronics, while keeping power dissipation under control

*Optimisation studies will be essential to define the timing performance needed for tracking and possible use in calorimeter systems.*

Revisit the **DETECTOR** design to address new challenges and proactively integrate advances emerging from the DRDs, and evaluate and optimise the use of sub-nanosecond timing capabilities to further enhance ILD performance.



# Advancing the ILD for next Collider

## Detector R&D should be complemented by dedicated benchmark physics studies

- Optimise detector performance
- Evaluate overall physics reach at FCC-ee
- Guide detector design choices

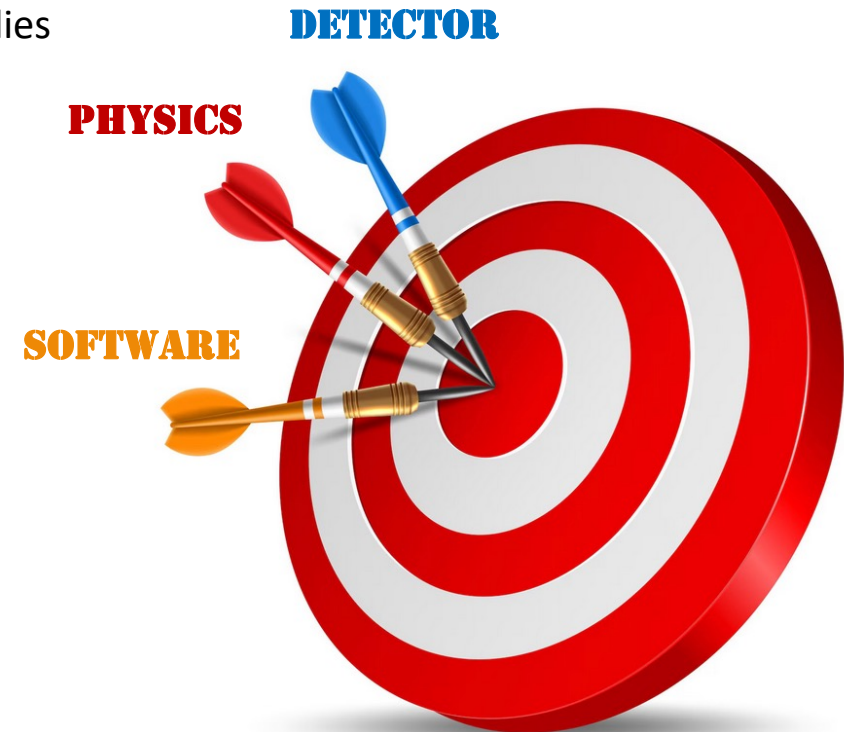
### Z Pole studies

- Previous ILD studies focused mainly on energies above
- Opportunities for Precision measurements and rare-process studies

Combine detector R&D with benchmark **PHYSICS** studies to optimise performance and assess ILD's full physics potential, especially at the Z pole.

### Key Questions for ILD

- Evaluate the real performance of ILD at the Z pole
- Identify strengths and limitations under FCC-ee conditions
- Assess possible advantages with respect to alternative detector concepts at lower energies



# Advancing the ILD for next Collider

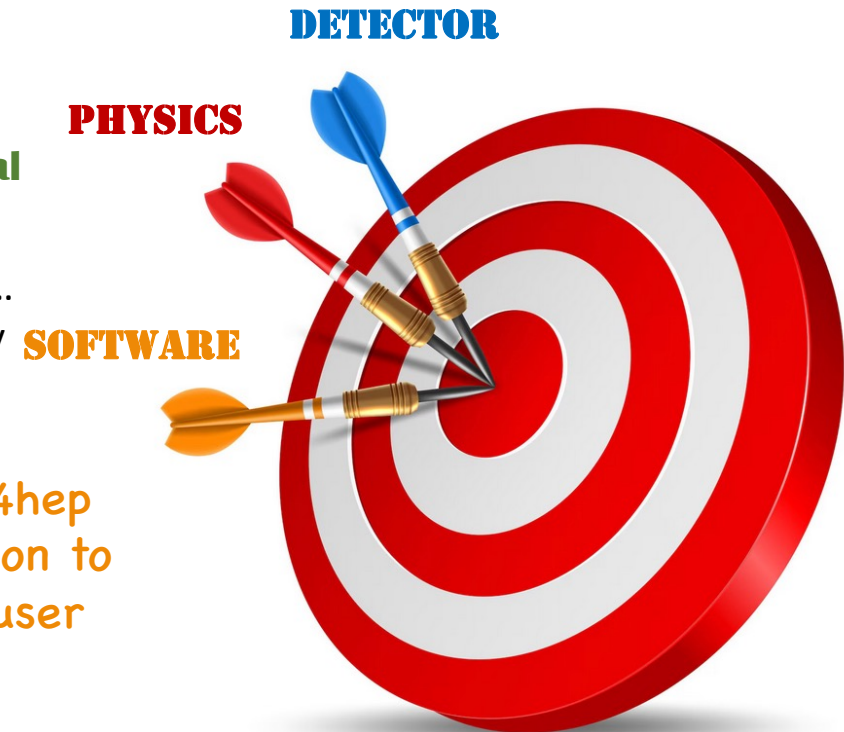
*ILD has always been strongly committed to the development of common software frameworks*

- **ILCSOFT** : It remains a powerful framework for ILD studies
- **KEY4HEP**
  - Full integration into Key4hep would provide major strategic benefits
    - Increased attractiveness for external FCC-ee users as reference *detector model* or for comparative analyses
    - Ensures stronger interoperability with the broader FCC software environment.

## Continued development of reconstruction and analysis tools is essential

Modern ML approaches already show significant improvements demonstrated benefits in PID, flavour tagging, reconstruction performance... Their integration into the ILD software framework offers a clear opportunity to further enhance detector performance and physics sensitivity.

Strengthen ILD **SOFTWARE** through full Key4hep integration and modern AI-based reconstruction to enhance performance and attract a broader user community.



# Advancing the ILD for next Collider

## TECHICAL COORDINATION

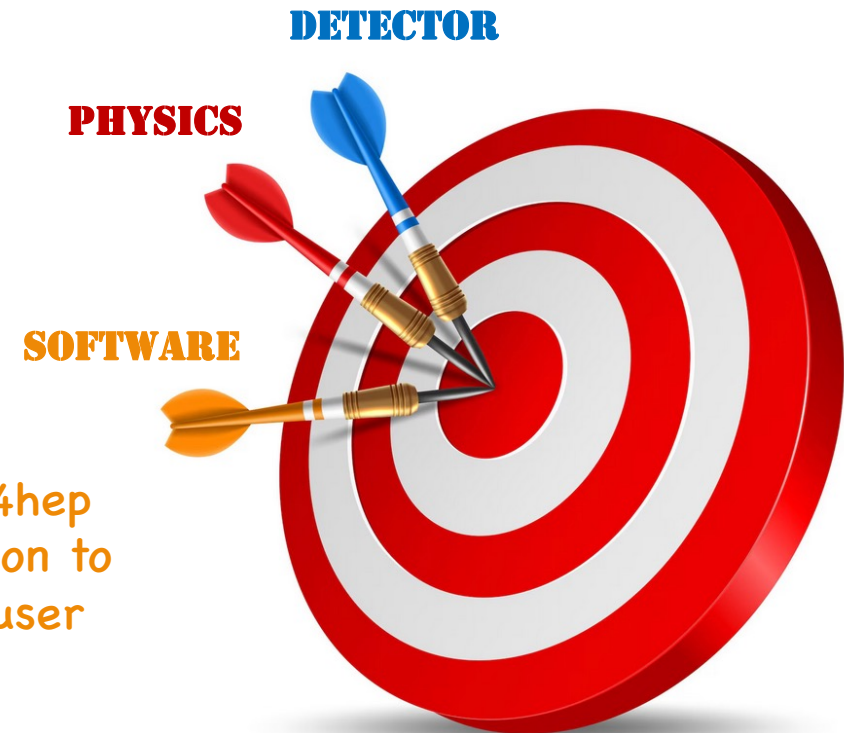
Revisit the **DETECTOR** design to address new challenges and proactively integrate advances emerging from the DRDs, and evaluate and optimise the use of sub-nanosecond timing capabilities to further enhance ILD performance.

## PHYSICS COORDINATION

Combine detector R&D with benchmark **PHYSICS** studies to optimise performance and assess ILD's full physics potential, especially at the Z pole.

## SOFTWARE COORDINATION

Strengthen ILD **SOFTWARE** through full Key4hep integration and modern AI-based reconstruction to enhance performance and attract a broader user community.



# Advancing the ILD for next Collider - Roadmap

- ❖ The European Strategy selected **FCC-ee** as the preferred next CERN collider, with a descoped version as a possible alternative. However, the final decision on CERN's future machine is not expected before 2028.
- ❖ Following the requirements of some countries the CERN Executive Board considered the presentation of two collider scenarios (**LEP3** and a single **Linear Collider** option)

In this context, ILD must be ready to deliver **before the end of 2026** a **ILD strategic roadmap** for the coming years, ensuring our activities remain fully aligned with both the **European and the broader worldwide collider roadmap**.

- ❖ **Mobilizing manpower is currently on of our greatest challenge**. With LS3 activities for the HL-LHC taking centre stage, available resources are under strong pressure. Additionally, the transition to the DRD collaborations hasn't yet secure the level of funding needed to support the long-term R&D.

We need to be strategic in how we involve our community and allocate our efforts to ensure that ILD remains competitive.

- ❖ The growing momentum around FCC-ee provides a unique window of opportunity. We should actively engage with groups that have not yet committed to a specific detector concept, **showcasing ILD's strengths** to **attract them to our community and broaden our collaboration**
- ❖ **Strengthening our links with the DRDs** is a strategic priority. We need to be **proactive ambassadors of the ILD concept** in these forums to attract new groups and talent. This synergy is a two-way street: it increases our critical mass and, crucially, ensures that the **latest technological breakthroughs** within the DRDs find a natural home in a redesigned, even more capable ILD

By strengtheing the links with the DRDs, we don't just grow in numbers, we evolve in capability

# People are ILD's greatest strength



The challenges ahead can only be met through the commitment, expertise, and active collaboration of the entire ILD community. To play a leading role in the next generation of collider experiments, **we must strengthen and expand the collaboration, attract new groups, and foster an open environment where new ideas and expertise can thrive.**

A special responsibility is to support and empower **Early Career Researchers**. They will be the driving force behind the future implementation of this project, and their talent, energy, and creativity will be essential for its success. We must therefore ensure that they find within ILD the mentoring, opportunities, recognition, and healthy working environment needed to grow and thrive.

**A strong, diverse, and motivated community will be the foundation of a successful ILD.**

# The proposed team

**TEAM COMPOSITION STILL EVOLVING  
&  
SUBJECT TO FINAL APPROVAL BY IA**

**Deputy Spokesperson:** *Frank Gaede*

**Technical Coordinator:** *Vincent Boudry*  
**Deputy:** *Karsten Buessen*

**Software Coordinator:** *Potential candidate being contacted*  
**Deputy:** *---*

**Physics Coordinator:** *Taikan Suehara*  
**Deputy:** *Potential candidate being contacted*

A stylized illustration of a road leading to a sunrise over mountains and clouds. The road is dark blue with white dashed lines, receding into the distance. The sky is a gradient of teal and yellow, with a bright sun rising behind a rainbow. The clouds are large and colorful, in shades of yellow, orange, and pink. The mountains are dark purple and pink. The overall style is flat and modern.

# **Together for the Future of ILD**

**The road ahead is challenging, but full of opportunity.  
With ambition, innovation, and a strong community,  
we can shape the next chapter of ILD together.**

