



# Report on status and plans

Ties Behnke

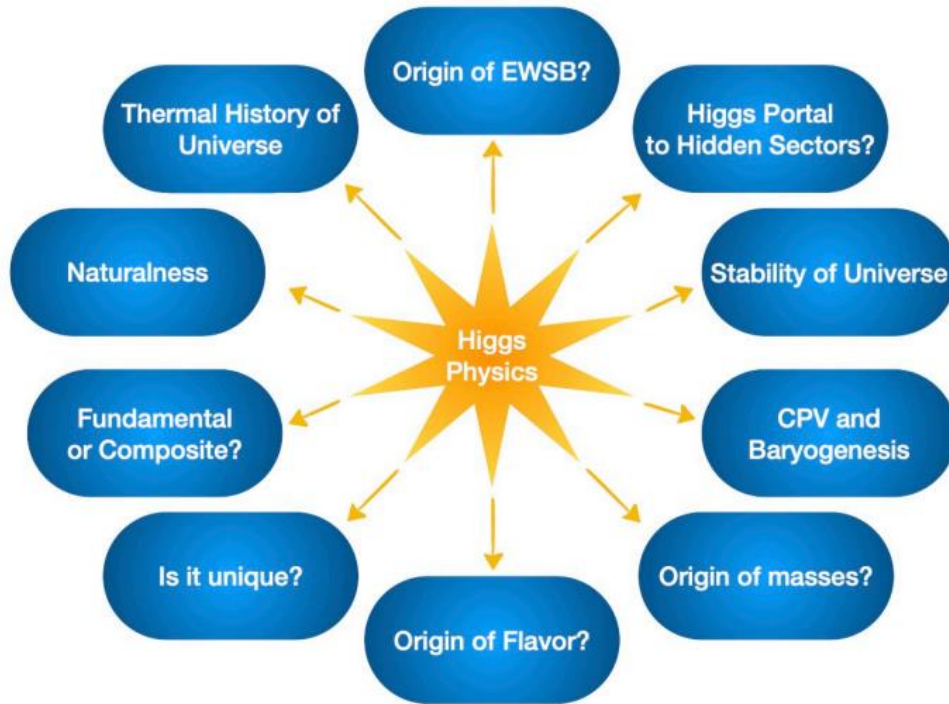
15.1.2024

ILD meeting CERN



ILD in person meeting at DESY 2022

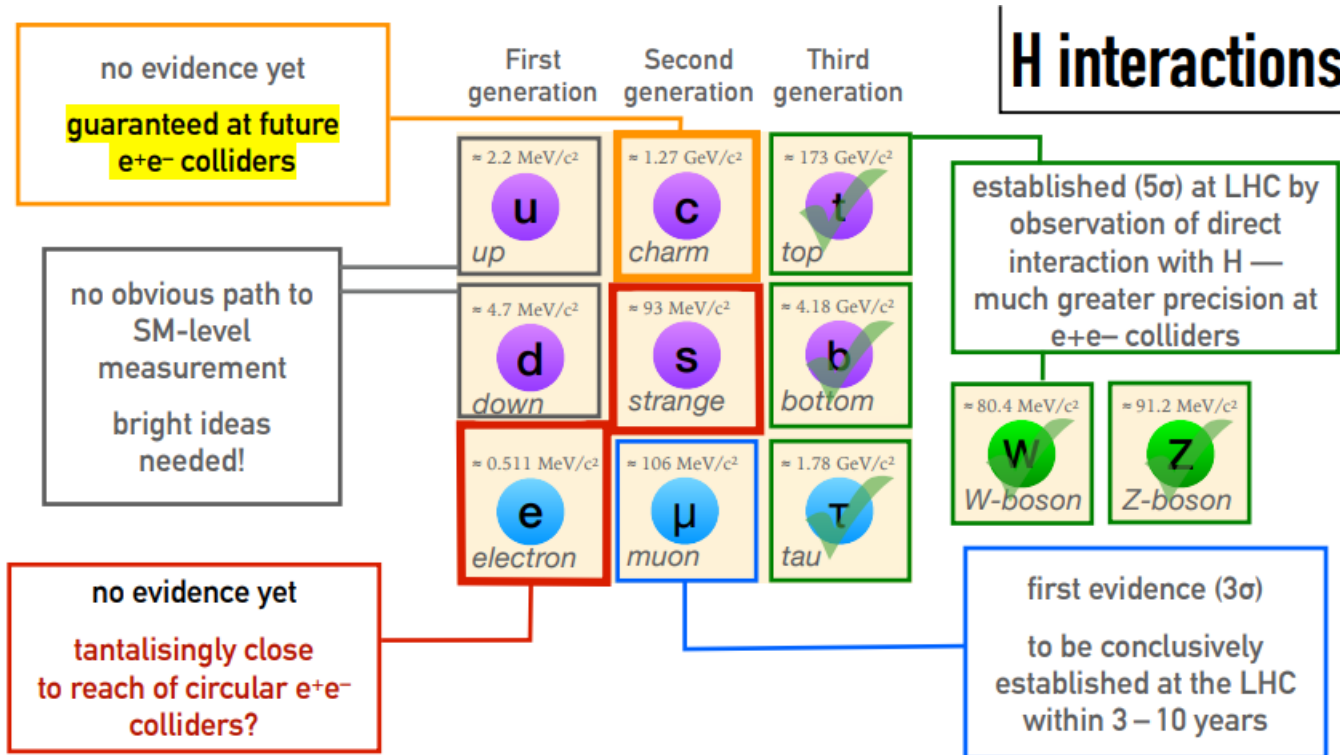
# The Future of HEP



From talk by Gavin Salam  
at ICFA Seminar 2023

- Higgs physics is at the core of most of our open questions
- There are “guaranteed discoveries” in the Higgs sector

# H interactions



Source G. Salam, 13<sup>th</sup> ICFA seminar at DESY, 2023

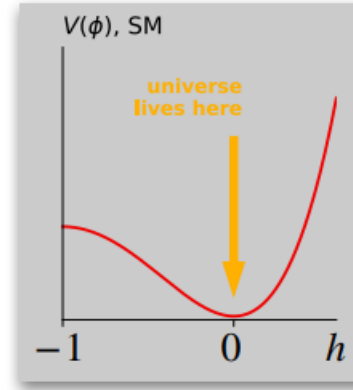
# Higgs Self Coupling

► take  $h$  as the Higgs field excitation in units of the field at minimum

$$V = \frac{m_H^2 v^2}{8} (-1 + 4h^2 + 4h^3 + h^4)$$

the Higgs boson mass term

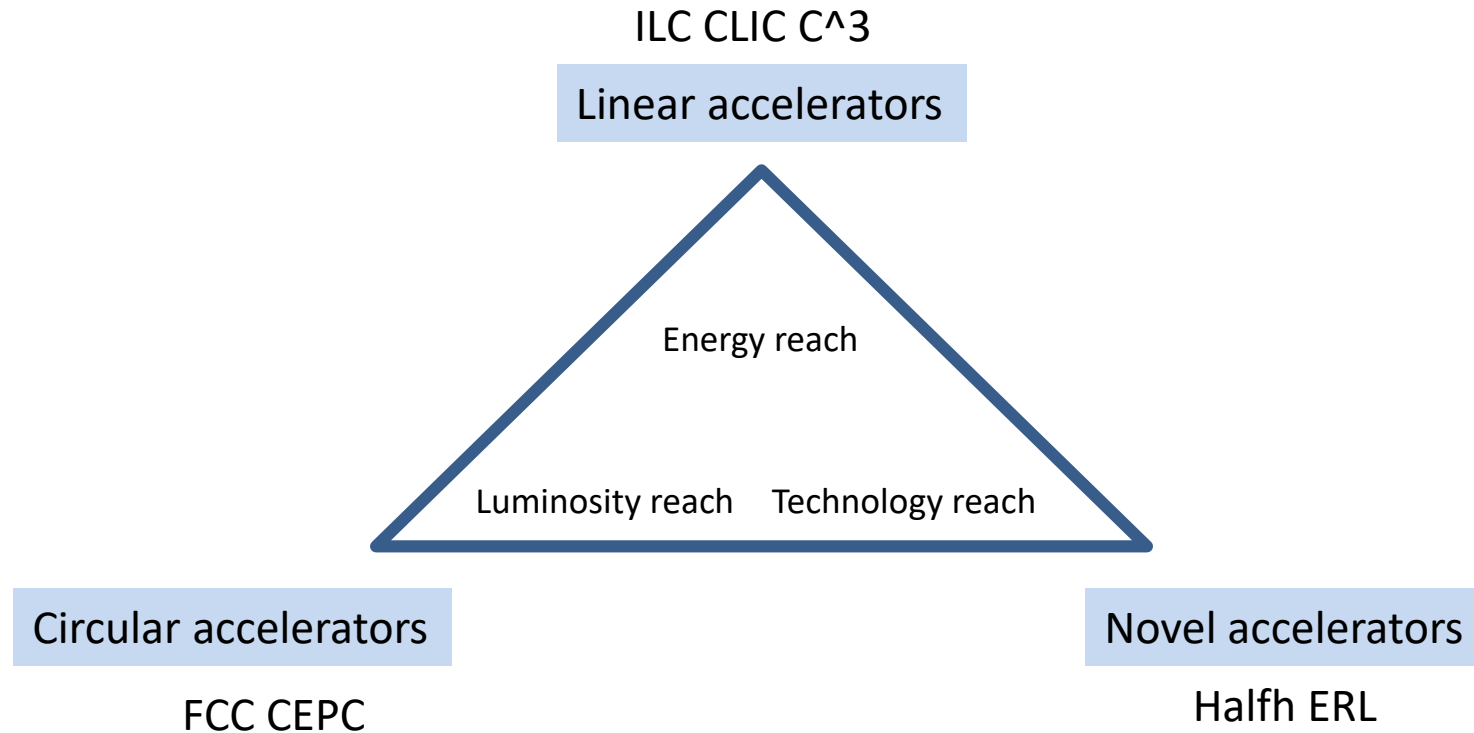
prediction of the strength of HHH interaction  
[modifier may be called  $\kappa_2$  or  $\kappa_3$ ]



Significant measurement of the Higgs Potential is

- Central to our understanding of the Higgs
- A “guaranteed” discovery at future machines

# The environment



# The environment

ILC CLIC C<sup>3</sup>

Linear accelerators



Circular accelerators

FCC CEPC

Novel accelerators

Half ERL

# The Global Situation



- European Strategy update has been published and “approved” by council
  - Higgs factory key priority
  - Feasibility study of FCC key priority
  - Accelerator and Detector R&D being organised
- Snowmass meeting this summer confirmed the case for a Higgs factory
- The international events (war in Ukraine, energy crisis in Europe, aftereffects of Pandemic) complicate the situation

# P5: Recommendation 1

Not Rank-  
Ordered

As the **highest priority** independent of the budget scenarios, complete construction projects and support operations of ongoing experiments and research to enable maximum science. We reaffirm the previous P5 recommendations on major initiatives:

- a. **HL-LHC** (including ATLAS and CMS detectors, as well as Accelerator Upgrade Project) to start addressing why the Higgs boson condensed in the universe (reveal the secrets of the Higgs boson, section 3.2), to search for direct evidence for new particles (section 5.1), to pursue quantum imprints of new phenomena (section 5.2), and to determine the nature of dark matter (section 4.1).
- b. **The first phase of DUNE and PIP-II** to determine the mass ordering among neutrinos, a fundamental property and a crucial input to cosmology and nuclear science (elucidate the mysteries of neutrinos, section 3.1).
- c. **The Vera C. Rubin Observatory** to carry out the LSST, and the LSST Dark Energy Science Collaboration, to understand what drives cosmic evolution (section 4.2).



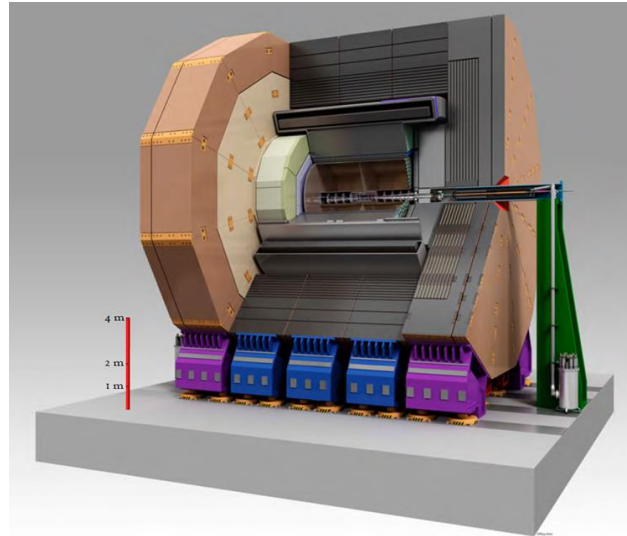
# P5: Recommendation 2

Rank-Ordered

- a. **CMB-S4**, which looks back at the earliest moments of the universe to probe physics at the highest energy scales. It is critical to install telescopes at and observe from both the South Pole and Chile sites to achieve the science goals (section 4.2).
- b. **Re-envisioned second phase of DUNE** with an early implementation of an enhanced 2.1 MW beam—ACE-MIRT—a third far detector, and an upgraded near-detector complex as the definitive long-baseline neutrino oscillation experiment of its kind (section 3.1).
- c. **An off-shore Higgs factory**, realized in collaboration with international partners, in order to reveal the secrets of the Higgs boson. The current designs of FCC-ee and ILC meet our scientific requirements. The US should actively engage in feasibility and design studies. Once a specific project is deemed feasible and well-defined (see also Recommendation 6), the US should aim for a contribution at funding levels commensurate to that of the US involvement in the LHC and HL-LHC, while maintaining a healthy US on-shore program in particle physics (section 3.2).
- d. **An ultimate Generation 3 (G3) dark matter direct detection experiment** reaching the neutrino fog, in coordination with international partners and preferably sited in the US (section 4.1).
- e. **IceCube-Gen2** for study of neutrino properties using non-beam neutrinos complementary to DUNE and for indirect detection of dark matter covering higher mass ranges using neutrinos as a tool (section 4.1).

# Role of ILD

- Well developed detector concept
- Adaptable to any of the proposals under discussion
- Common platform to study potential science performance



The ILD concept

# Why ILD?

- Has an active community to support ILD
- Has been designed
  - As a particle flow detector: precision
  - With a broad energy reach in mind: flexibility
- Is implemented in a modular and flexible fashion
- Has a broad range of well understood reconstruction tools in place

# Goal of the ILD meeting

- Explore the role of ILD at different Higgs factory proposals
- Understand the experimental challenges resulting from different collider concepts
- Move towards optimized ILD designs at different collider proposals, in particular:
  - FCC-ee
  - HALFH
- Plan the concrete steps for ILD in the next 1-2 years

# An ILD work program



1. The forward tracking region of ILD has a number of shortcomings. A dedicated optimization for this region, in particular of the acceptance of the vertex detector, should be done. This region will also be heavily affected by different environmental conditions at different collider projects, and might need dedicated solutions for each proposal.
2. Circular colliders will have a smaller inter-bunch timing difference than ILC, and also do not deliver bunch-trains, but rather continuous beams. This significantly changes the possibility to do power-pulsing for the front-end electronics of the ILD sub-detectors. The current design of the ILD sub-detectors depends crucially on their capability to manage the thermal load through power pulsing. Using the ILD sub-detectors at FCC will require a very detailed study of how the systems can perform without power pulsing, and the development of a concept of how the thermal management can work in this new situation, while minimising additional dead material in the system.
3. The close inter-bunch spacing and lack of inter-bunch train quiet periods puts additional challenges on the operation of a TPC in this environment. ILD should explore how an ILD-like TPC would perform in these different conditions, and where the limits are for the TPC. Since the TPC adds significant particle identification power in particular at lower center-of-mass energies, this study should focus on the lower range of energies at a Higgs/ EW/Top factory.
4. A focus of experimentation at circular colliders is a high-luminosity Z program. ILD should investigate how well the detector performs under these conditions, and identify components which might need replacement or modification.
5. Circular colliders will have a very different forward region, in order to control the machine backgrounds, and in order to provide the beam focusing. ILD should develop a concept for a forward region compatible with FCC-ee and study the impact this changed region will have on the detector performance.
6. A central challenge for a detector like ILD, optimized for precision physics, is the delivery of an excellent and stable calibration and alignment environment. These considerations need to be included from early on in the design. The different running conditions and beam conditions might impact the way the detector is to be calibrated and aligned, and need to be studied.

# ILD meeting 2024



Monday afternoon

13:00	<b>Welcome, Status of ILD</b> <i>Kiyotomo Kawagoe et al.</i>	
	222/R-001, CERN	13:00 - 13:30
	<b>Experimentation at the FCC-ee: Challenges and Opportunities</b> <i>Martin Aleksa</i>	
	222/R-001, CERN	13:30 - 14:00
14:00	<b>Experimentation at an asymmetric Higgs factory</b> <i>Antoine Laudrain</i>	
	222/R-001, CERN	14:00 - 14:30
	<b>IDT news</b> <i>Steinar Stapnes</i>	
	222/R-001, CERN	14:30 - 15:00
15:00	<b>Coffee break</b> <i>CERN</i>	
		15:00 - 15:30
	<b>TPC-Introduction</b> <i>Paul Colas et al.</i>	<b>Key4hep transition for ILD</b>
	222/R-001, CERN	
	15:30 - 15:50	
	<b>TPC in a circular collider environment</b> <i>Daniel Jeans et al.</i>	<b>32/S-022</b>
	222/R-001, CERN	
	15:50 - 16:10	
	<b>The Alice TPC in lead-lead collisions at LHC RUN3 : spac...</b> <i>Matthias Kleiner</i>	<b>Coffee</b>
	15:30 - 16:30	
	<b>Status of Pixel TPC R&amp;D</b> <i>Peter Kluit</i>	<b>32/S-022</b>
	222/R-001, CERN	
	16:30 - 16:50	
	<b>Gating Ideas and gating discussion</b> <i>Ron Settles</i>	<b>Flavour tagging tools</b>
	222/R-001, CERN	
	16:50 - 17:10	
	<b>CMOS technology Overview</b> <i>Marc Winter</i>	<b>32/S-022</b>
	222/R-001, CERN	
	17:10 - 17:30	
	<b>Adding precise timing to detectors (T.b.c)</b> <i>222/R-001, CERN</i>	<b>32/S-022</b>
	17:30 - 17:50	
	<b>Discussion time</b>	
18:00		17:00 - 18:00

# ILD meeting 2024



Tuesday morning

13:00	<b>Welcome, Status of ILD</b> 222/R-001, CERN	09:00	<b>An ILD detector variant at CEPC</b> Salle Andersen (40/S2-A01), CERN	Manqi RUAN
	<b>Experimentation at the</b> 222/R-001, CERN		<b>CLD: A detector for the FCC-ee</b> Salle Andersen (40/S2-A01), CERN	Andre Sailer
14:00	<b>Experimentation at an e</b> 222/R-001, CERN			09:30 - 10:00
	<b>IDT news</b> 222/R-001, CERN	10:00	<b>ILD concept development and simulation models</b> Salle Andersen (40/S2-A01), CERN	Daniel Jeans
15:00	<b>Coffee break</b> CERN		<b>Coffee break</b> CERN	10:00 - 10:30
	<b>TPC-Introduction</b> 222/R-001, CERN	11:00	<b>Key4hep and ILD software</b> Salle Andersen (40/S2-A01), CERN	Thomas Madlener
	<b>TPC in a circular collide</b> 222/R-001, CERN			11:00 - 11:20
16:00	<b>The Alice TPC in lead-le</b> Matthias Kleiner		<b>High level reconstruction in ILD</b> Salle Andersen (40/S2-A01), CERN	Frank Gaede
	<b>Status of Pixel TPC R&amp;</b> 222/R-001, CERN		<b>Linking ILD to the DRD Organisation</b> Salle Andersen (40/S2-A01), CERN	Didier Contardo
	<b>Gating ideas and gating</b> 222/R-001, CERN	12:00	<b>Electronics as a driver for future detectors</b> Salle Andersen (40/S2-A01), CERN	Christophe De La Taille
17:00	<b>CMOS technology Over</b> 222/R-001, CERN			12:00 - 12:30
	<b>Adding precise timing t</b> 222/R-001, CERN		<b>ECFA Focus topics</b> Salle Andersen (40/S2-A01), CERN	Jenny List
	<b>Discussion time</b>	13:00	<b>Lunch</b>	12:30 - 13:00
18:00				

# ILD meeting 2024



Tuesday afternoon

13:00	<b>Welcome, Status of ILD</b> 222/R-001, CERN	09:00	<b>An ILD detector</b> Salle Anders	14:00	<b>New Ideas on forward calorimeter design for ILD</b> 6/2-004, CERN Graham Wilson
	<b>Experimentation at the</b> 222/R-001, CERN				<b>Adapting the ILD vertex detector to FCCee context and related R&amp;D</b> 6/2-004, CERN Auguste
14:00	<b>Experimentation at an e</b> 222/R-001, CERN		<b>CLD: A detector</b> Salle Anders		14:20 - 14:40
	<b>IDT news</b> 222/R-001, CERN	10:00	<b>ILD concept</b> Salle Anders	15:00	<b>New particle identification calibration for ILD</b> 6/2-004, CERN Ulrich Einhaus 14:40 - 15:00
15:00	<b>Coffee break</b> CERN		<b>Coffee break</b> CERN		<b>Improvements in V0 performance</b> 6/2-004, CERN Sara Aumiller et al. 15:00 - 15:15
	<b>TPC-Introduction</b> 222/R-001, CERN	11:00	<b>Key4hep and</b> Salle Anders		<b>Status of pixel TPC reconstruction</b> 6/2-004, CERN Jan Klamka 15:15 - 15:30
	<b>TPC in a circular collider</b> 222/R-001, CERN				15:30 - 16:00
16:00	<b>The Alice TPC in lead-lead</b> Matthias Kleiner		<b>High level reconstruction</b> Salle Anders	16:00	<b>Focus topic reports</b> Adrian Irlas et al.
	<b>Status of Pixel TPC R&amp;D</b> 222/R-001, CERN		<b>Linking ILD</b> Salle Anders		<b>Calorimeters for ILD</b> 4/S-056, CERN 16:00 - 16:30
17:00	<b>Gating Ideas and gating</b> 222/R-001, CERN	12:00	<b>Electronics</b> Salle Anders	17:00	<b>Rates on Calorimeters in the several energy scenarios</b> Khalid Mekhemar et al.
	<b>CMOS technology Overview</b> 222/R-001, CERN				16:00 - 17:00
	<b>Adding precise timing to</b> 222/R-001, CERN		<b>ECFA Focus</b> Salle Anders	17:00	<b>Importance or not on high granularity for jet reconstruction at 250GeV</b> Jean-Claude Brient
	<b>Discussion time</b>	13:00	<b>Lunch</b>	17:30	<b>Discussion time</b> 4/S-056, CERN 17:20 - 17:45
18:00				18:00	<b>Exploring hidden sectors with two-particle angular correlations at future e+e- colliders</b> 6/2-004, CERN Emanuela Musumeci 17:50 - 18:10
					<b>Optimizing the Higgs self-coupling measurement at ILC with ML</b> 6/2-004, CERN Bryan Bilewicz 18:10 - 18:30



# ILD meeting 2024



Wednesday morning

13:00	<b>Welcome, Status of ILD</b> 222/R-001, CERN	09:00	<b>An ILD dete</b> Salle Anders	14:00	<b>New t</b> 6/2-00	09:00	<b>Priorities for the future analyses in ILD</b> Salle Andersen (40/S2-A01), CERN <i>Aleksander Filip Zarnacki</i>
	<b>Experimentation at the</b> 222/R-001, CERN		<b>CLD: A dete</b> Salle Anders		<b>Adapt</b> 6/2-00		<b>Final results from stau analysis</b> Salle Andersen (40/S2-A01), CERN <i>Mikael Berggren</i>
14:00	<b>Experimentation at an e</b> 222/R-001, CERN		<b>ILD concept</b> Salle Anders		<b>New p</b> 6/2-00		09:30 - 09:50
	<b>IDT news</b> 222/R-001, CERN	10:00	<b>Coffee break</b> CERN	15:00	<b>Impro</b> 6/2-00	10:00	<b>Probing Gauge-Higgs Unification models at the ILC with di-quark forward-backward asymmetry at center-of-mass energ...</b> Adrian Irlas et al.
15:00	<b>Coffee break</b> CERN		<b>Key4hep an</b> Salle Anders		<b>Status</b> 6/2-00		<b>Probing CPV mixing in the Higgs sector in VBF at 1 TeV ILC</b> Salle Andersen (40/S2-A01), CERN <i>Natasa Vukasinovic et al.</i>
	<b>TPC-Introduction</b> 222/R-001, CERN	11:00	<b>High level r</b> Salle Anders	16:00	<b>Coffee</b> 6/2-00		10:10 - 10:30
	<b>TPC in a circular collide</b> 222/R-001, CERN		<b>Linking ILD</b> Salle Anders		<b>Focus</b> 6/2-00	11:00	<b>Coffee break</b> CERN 10:30 - 11:00
16:00	<b>The Alice TPC in lead-le</b> Matthias Kleiner		<b>Electronics</b> Salle Anders	17:00	<b>Focus</b> 6/2-00		<b>Plenary: ILD organisation: Interface to other Higgs factory initiatives</b> Salle Andersen (40/S2-A01), CERN 11:00 - 11:45
	<b>Status of Pixel TPC R&amp;</b> 222/R-001, CERN		<b>ECFA Focus</b> Salle Anders		<b>Break</b> 6/2-00		<b>discussion: transition to key4hep</b> Salle Andersen (40/S2-A01), CERN 11:45 - 12:05
17:00	<b>Gating ideas and gating</b> 222/R-001, CERN	12:00	<b>Lunch</b>	18:00	<b>Explo</b> 6/2-00	12:00	<b>Discussion</b> Salle Andersen (40/S2-A01), CERN <i>Kiyotomo Kawagoe et al.</i>
	<b>CMOS technology Over</b> 222/R-001, CERN				<b>Optim</b> 6/2-00		12:05 - 13:00
	<b>Adding precise timing t</b> 222/R-001, CERN						
18:00	<b>Discussion time</b>	13:00				13:00	

# Organisational remarks



Local organization: Carsten Hensel

Coffee breaks: at the cafeteria

Dinner: Tuesday evening, details to be announced Tuesday

Meeting picture: today at coffee break after plenary session

All sessions will be transmitted by zoom  
(at least we wil try)

Speakers: please make sure your talks are uploaded  
before the presentations.