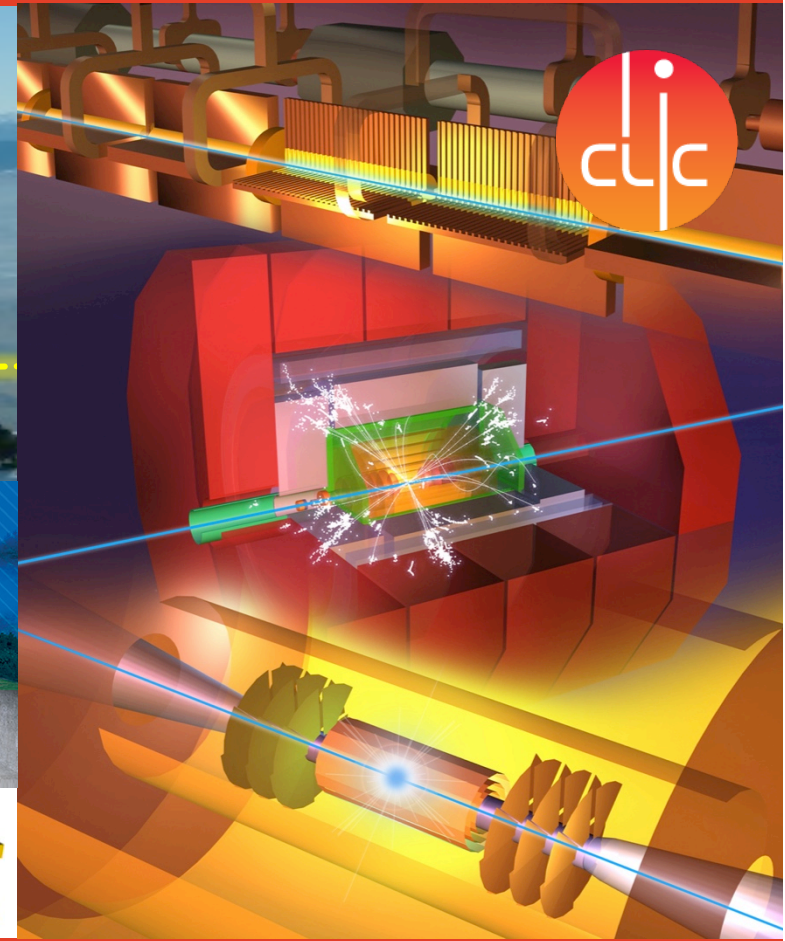# ECFA studies towards an e⁺e⁻ Higgs/EWK/top factory :
Synergies & Complementarities

FCC Physics Workshop, 23rd January 2023
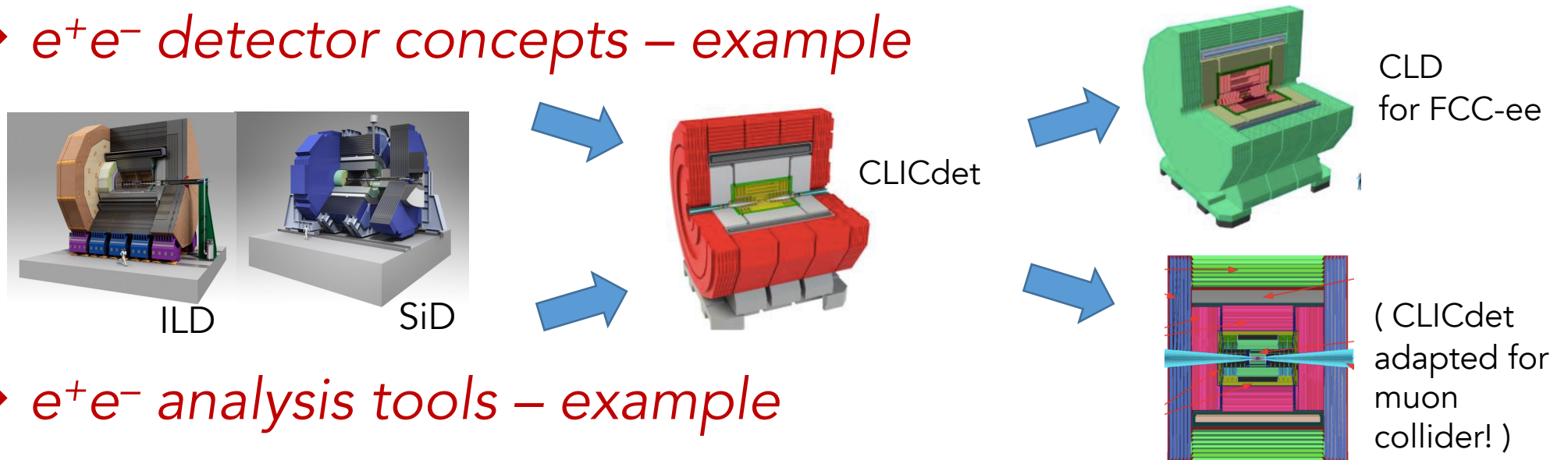
Aidan Robson, University of Glasgow

Context: shared effort – *examples*

◆ *e^+e^- physics*

 models – generators – interpretations

◆ *e^+e^- detector concepts – example*

ILD   SiD

CLICdet

CLD
for FCC-ee

(CLICdet
adapted for
muon
collider!)

◆ *e^+e^- analysis tools – example*

Detector	Collider	SW name	SW status	SW future
ILD	ILC	iLCSoft	Full sim/reco	
SiD	ILC	iLCSoft	Full sim/reco	
CLICdet	CLIC	iLCSoft	Full sim/reco	
CLD	FCC-ee	iLCSoft	Full sim/reco	Key4hep
IDEA	FCC-ee	FCC-SW	Fast sim/reco	
IDEA	CEPC	FCC-SW	Fast sim/reco	
CEPCbaseline	CEPC	iLCSoft branch-off	Full sim/reco	

ECFA studies towards an e⁺e⁻ Higgs/EWK/top factory

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

Goal: bring the entire e⁺e⁻ Higgs factory effort together, foster cooperation across various projects; collaborative research programmes are to emerge
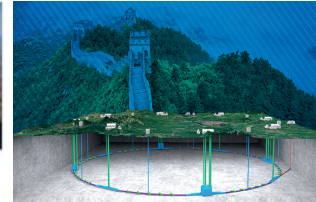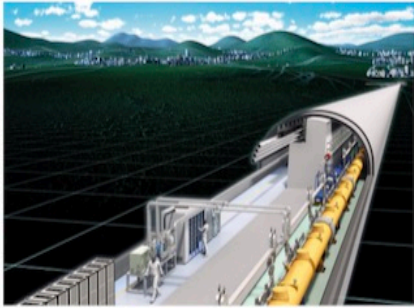
◆ ***ECFA study is intended to:***
– bring together communities & activities
– explore synergies
– discuss challenges

ECFA studies towards an e⁺e⁻ Higgs/EWK/top factory

◆ *International Advisory Committee (IAC)*
   broad representation across the collider community:

Alain Blondel (Geneva)
Jean-Claude Brient (Paris LLR)
Patricia Conde Muino (IST/LIP)
Didier Contardo (IN2P3),
Mogens Dam (Copenhagen NBI)
Juan Fuster (Valencia)
Jorgen D'Hondt (VU Brussel)
Christophe Grojean (DESY)
Karl Jakobs (Freiburg, Chair)
Patrick Janot (CERN)
Max Klein (Liverpool)

Tadeusz Lesiak (Krakow)
Chiara Meroni (Milano)
Joachim Mnich (CERN)
Aleandro Nisati (Rome I)
Aidan Robson (Glasgow)
Frank Simon (Munich MPP)
Steinar Stapnes (CERN)
Roberto Tenchini (Pisa)
Guy Wilkinson (Oxford)
Andrea Wulzer (Lausanne)

– e⁺e⁻ circular / e⁺e⁻ linear / LHC / detector technologies / theory

ECFA Working Groups underway

- ◆ WG1: **Physics programme** coordinators Fabio Maltoni, Jenny List, Jorge de Blas, Juan Alcaraz
- ◆ WG2: **Physics analysis methods** coordinators Patrizia Azzi, Fulvio Piccinini, Dirk Zerwas
- ◆ WG3: **Detector technologies** coordinators Felix Sefkow, Mary Cruz Fouz, Giovanni Marchiori

  – **coordinators from across community**

    –> Rich programme of seminars, topical meetings, mini-workshops

January 2023

    20 Jan   ECFA Higgs Factory seminars: Top Physics at Future e+e- colliders

November 2022

    25 Nov   ECFA Higgs Factory seminars: Flavor Physics at Future e+e- colliders

October 2022

    05 Oct - 07 Oct   First ECFA Workshop on e+e- Higgs/EW/Top Factories

June 2022

    10 Jun   ECFA Higgs Factory seminars: Precision physics in the e+e- -> WW region

    07 Jun - 17 Jun   Precision calculations for future e+e– colliders: targets and tools (FC CERN Workshop)

May 2022

    06 May   ECFA Higgs Factory seminars: Higgs self-coupling

    04 May - 05 May   ECFA Higgs Factories: 1st Topical Meeting on Reconstruction

April 2022

    08 Apr   ECFA Higgs Factory seminars: Physics with light quarks

March 2022

    04 Mar   ECFA Higgs Factory seminars: Implications of (g-2)_mu for e+e- Higgs factories: overview

February 2022

    01 Feb - 02 Feb   ECFA Higgs Factories: 1st Topical Meeting on Simulation

January 2022

    12 Jan   Focus Meeting: Beamstrahlung

November 2021

    09 Nov - 10 Nov   ECFA Higgs Factories: 1st Topical Meeting on Generators

June 2021

    18 Jun   Kick-off meeting of ECFA workshops on e+e- Higgs/EW/Top factory

Main entry point:
https://indico.cern.ch/event/1044297/page/22669-overview

ECFA Working Groups – WG1

◆ WG1: **Physics programme** coordinators Fabio Maltoni, Jenny List, Jorge de Blas, Juan Alcaraz
https://indico.cern.ch/event/1044297/page/23971-wg1-group-activities

5 Fronts of activity led by conveners from across the community:

WG1-PREC (Precision in theory & experiment):
Ayres Freitas (Pittsburgh), Paolo Azzurri (Pisa),
Adrian Irles (Valencia), Andreas Meyer (DESY)
　ecfa-whf-wg1-prec-conveners@cern.ch

WG1-GLOB (Global interpretations in (SM)EFT and UV complete models):
Sven Heinemeyer (IFCA/IFT), Alexander Grohsjean (DESY),
Junping Tian (Tokyo), Marcel Vos (Valencia), Jorge de Blas (Granada)
　ecfa-whf-wg1-glob-conveners@cern.ch

WG1-HTE (TOP-HIGGS-EW and connection with LHC):
Chris Hays (Oxford), Karsten Koeneke (Freiburg),
Fabio Maltoni (Louvain)
　ecfa-whf-wg1-hte-conveners@cern.ch

WG1-FLAV (Heavy Flavours):
David Marzocca (Trieste), Stephane Monteil (Clermont Ferrand),
Pablo Goldenzweig (KIT)
　ecfa-whf-wg1-flav-conveners@cern.ch

WG1-SRCH (Feebly interacting particles, direct low mass searches):
Roberto Franceschini (Rome III), Rebeca Gonzalez (Uppsala),
Filip Zarnecki (Warsaw)
　ecfa-whf-wg1-srch-conveners@cern.ch

Main entry point:
https://indico.cern.ch/event/1044297/page/22669-overview

WG1-PREC: theoretical and experimental precision
July 2022 MiniWorkshop: parametric uncertainties: α_em
Mar 2022 MiniWorkshop: parametric uncertainties: α_s
Mar 2022 MiniWorkshop: high-precision measurements

WG1-GLOB: global interpretations
Sept 2022 Analyses of concrete models
July 2022 Global interpretations in (SM)EFT and UV complete models

WG1-HTE: specific Higgs/Top/EW studies (+ connection w/ LHC)
Sept 2022 ECFA HTE meeting on Z pole physics
Apr 2022　1st Workshop of the Higgs/Top/EW group

WG1-FLAV: Heavy Flavour
June 22 1st Meeting

WG1-SRCH: Direct searches (weakly-interacting,
　　　　　　　directly accessible particles)
May 2022 ECFA HF WG1: 1st Workshop of the WG1-SRCH group
Feb 2022 Brainstorming session

Forthcoming in February:
10/2/23 WG1-HTE:
　Mini-workshop on e+e- physics at 125 & 160 GeV
https://indico.cern.ch/event/1240786/
17/2/23 WG1-SRCH:
Heavy Neutral Lepton search potential of future HET factories
https://indico.cern.ch/event/1242038/

ECFA Working Groups – WG2

◆ WG2: **Physics analysis methods** conveners Patrizia Azzi, Fulvio Piccinini, Dirk Zerwas
https://indico.cern.ch/event/1044297/page/27820-wg2-group-activities

1st Topical Meeting on Generators
9-10 November 2021

Focus Meeting: Beamstrahlung
12 January 2022

1st Topical Meeting on Simulation
1-2 February 2022

1st Topical Meeting on Reconstruction
4-5 May 2022

Forthcoming in spring:

2nd Topical Meeting on Generators

2nd Topical Meeting on Reconstruction
– focusing on higher-level tools

Main entry point:
https://indico.cern.ch/event/1044297/page/22669-overview

ECFA Working Groups – WG3

◆ WG3: **Detector technologies** coordinators Felix Sefkow, Mary Cruz Fouz, Giovanni Marchiori

WG3 initiated later, after ECFA Detector Roadmap finalisation

– demonstrate that detectors can be built that match the precision physics potential of future Higgs factories
– provide guidance for coherent detector R&D efforts to address the priority requirements of Higgs factory experiments
– support roadmap implementation process

- – provide input on detector requirements
- – provide a forum for feedback on R&D plans
- – help R&D groups to convincingly make their case for a strategic R&D program
- – make sure that Higgs factories are well represented among other targets of DRDs

Forthcoming in spring:

Workshops on:

– Calorimetry

– Vertexing & Tracking

Main entry point:
https://indico.cern.ch/event/1044297/page/22669-overview

First milestone: First workshop, DESY 5–7 October 2022

https://indico.desy.de/event/33640/

◆ 200 registrants in person and 145 online
◆ Plenary & parallel sessions, organised by WG conveners
◆ Poster session
◆ Public evening event

*–> **Great to see so many people in Hamburg***

–> experts across projects/geometries connecting ✅
– topics in simulation & reconstruction being actively worked on together ✅
– thematic topics emerging as good places for people to contribute ✅

Local organisers: **Ties Behnke**, Freya Blekman, Frank Gaede, Elisabetta Gallo, Alexander Grohsjean, Christophe Grojean, Johannes Haller, Katja Krüger, Gudrid Moortgat-Pick, Krisztian Peters, Jürgen Reuter, **Christian Schwanenberger**, Felix Sefkow, Marcel Stanitzki, Georg Weiglein

First ECFA WORKSHOP.
on e⁺e⁻ Higgs / Electroweak / Top Factories
5–7 October 2022, DESY, Hamburg

Topics:
- Physics potential of future Higgs and electroweak/top factories
- Required precision (experimental and theoretical)
- EFT (global) interpretation of Higgs factory measurements
- Reconstruction and simulation
- Software
- Detector R&D

Encouraging increased activity & participation

◆ So far, study has been 'community-led'; everyone bringing their own contributions
  - –> leads to a rich field of inputs
  - – ***continues to be very warmly encouraged***
  - – relevant WG conveners are glad to be contacted

◆ ***In addition to this, the ECFA study is proposing a limited set of 'focus topics'***
  –> use topics of active interest as a vehicle to:
  - – connect people working on similar topics on different projects
      and encourage them to work directly **together**
  - – develop tools for use across projects
      (e.g. reco algorithm / analysis technique / MC generator improvement / …)
  - – engage new people
  - – build community across projects

  –> motivation is to:
  - – focus limited effort,
  - – promote cross-group activity
  - – lower threshold for participation in e^+e^- studies
      (e.g. repository of example analysis codes builds on previous work)

  –> 'newcomers' can get up to speed on e^+e^- / get some 'training',
      and make a significant contribution

Encouraging increased activity & participation

◆ Proposed 'focus topics' are not intended to map the physics programme comprehensively. Intended to highlight areas of shared and mutual interest across projects, where there is real new scientific work to be done, and that span topics across the three WGs.

◆ Tools (and person-skills) developed along the way would naturally be expected to have a wider application/impact, beyond the physics of the focus topic itself

◆ **Focus topics have been developed bottom-up from WG1 topical conveners, with input from WG1-WG2-WG3 coordinators**

◆ ***Some input is still arriving; topics to be finalised this week***

The (not-quite final) Focus Topics

1. H->ss
2. CP studies of Higgs couplings
3. W mass at threshold and continuum
4. Full studies of WW and evW processes, aTGCs
5. Full analysis of top threshold scan
6. Top threshold scan optimisation
7. Luminosity measurement
8. Direct new particle topic 1 [tbc]
9. Direct new particle topic 2 [tbc]
10. $B_s \to D_s K$ at $\sqrt{s} = M_Z$
11. $B_d \to K^{0*}\tau^+\tau^-$
12. EWK precision: 2-fermion final states
13. Measurement of b- and c-fragmentation functions / hadronisation
14. Measurement of gluon splitting to bb / cc
& interplay with separating h $\to$ gluons from h $\to$bb/cc

Table 1: Topics relevant for each centre-of-mass energy stage.

$\sqrt{s}$: Topic #	M_Z	161 GeV	240/250 GeV	350 /365 /380 GeV
1			X	X
2			X	X
3		X	X	X
4			X	X
5				X
6				X
7	X	x	x	x
8	x	x	x	x
9	x	x	x	x
10	X	x	x	x
11	X	x	x	x
12	X	x	X	X
13	X	x	X	X
14	X	x	X	X

◆ In many of the topics there is already some effort; this can 'seed' the activities.
For each topic there is an attempt to highlight what is already present and can be built upon.

◆ Some input is still coming in from topical conveners => still some gaps

–> Look out for launch / information that will be circulated soon

Call to host ECFA workshop 2023

◆ **Call was sent out last week for host proposals for ECFA workshop 2023**

◆ Distributed via national ECFA delegates – it should be circulated in national communities

Universities, laboratories, or consortia are now cordially invited to propose themselves as hosts of the autumn 2023 workshop, expected to take place over three full days in October. An outline of the requirements is given below.

Potential hosts are asked please to register an initial interest with the ECFA Secretary, Patricia Conde Muíño (patricia.conde.muino@cern.ch), by Wednesday 1st February, with full proposals to follow by Wednesday 15th February.

Many thanks and best wishes,
Karl Jakobs, Patricia Conde Muíño, Aidan Robson for the IAC

Workshop parameters:

- Potential dates: Wed 11 - Fri 13 October, or Wed 25 - Fri 27 October (three full days);
- Capacity: ~250 attending in-person; facilities for remote participation;
- Venues: rooms for four parallel sessions (capacity ~ 60 people) for Wednesday and Thursday afternoons, the remainder of the workshop to be plenary;
- It would be appreciated if small satellite meetings could be possible during the day before the workshop;
- Good projection, network and video-conferencing facilities should be guaranteed;
- Please state the approximate accommodation costs as well as the availability of cheap accommodation;
- We would like to stress the importance of a modest financial frame, so that as many people as possible, including students and early career researchers, can attend.

–> **Looking forward to your proposal!**

Looking ahead

◆ **WG1 topical meetings, focus mini-workshops, and seminars are continuing**
  –> focus topics provide a basis, but do not at all exclude other subjects!

◆ **WG2 mini-workshops are building on previous mini-workshops**

◆ **WG3 mini-workshops are beginning**

◆ **Overall ECFA workshop to be held in October 2023, and in 2024**

  **–> everyone is encouraged to participate, and to contribute
  to these shared activities!**

◆ Study will be documented as an ECFA Report targeting 2025

◆ **To receive notifications, please make sure you are enrolled in the e-groups**;
  see: https://indico.cern.ch/event/1044297/page/27821-e-groups

◆ *Let's all work together
  towards the next collider*