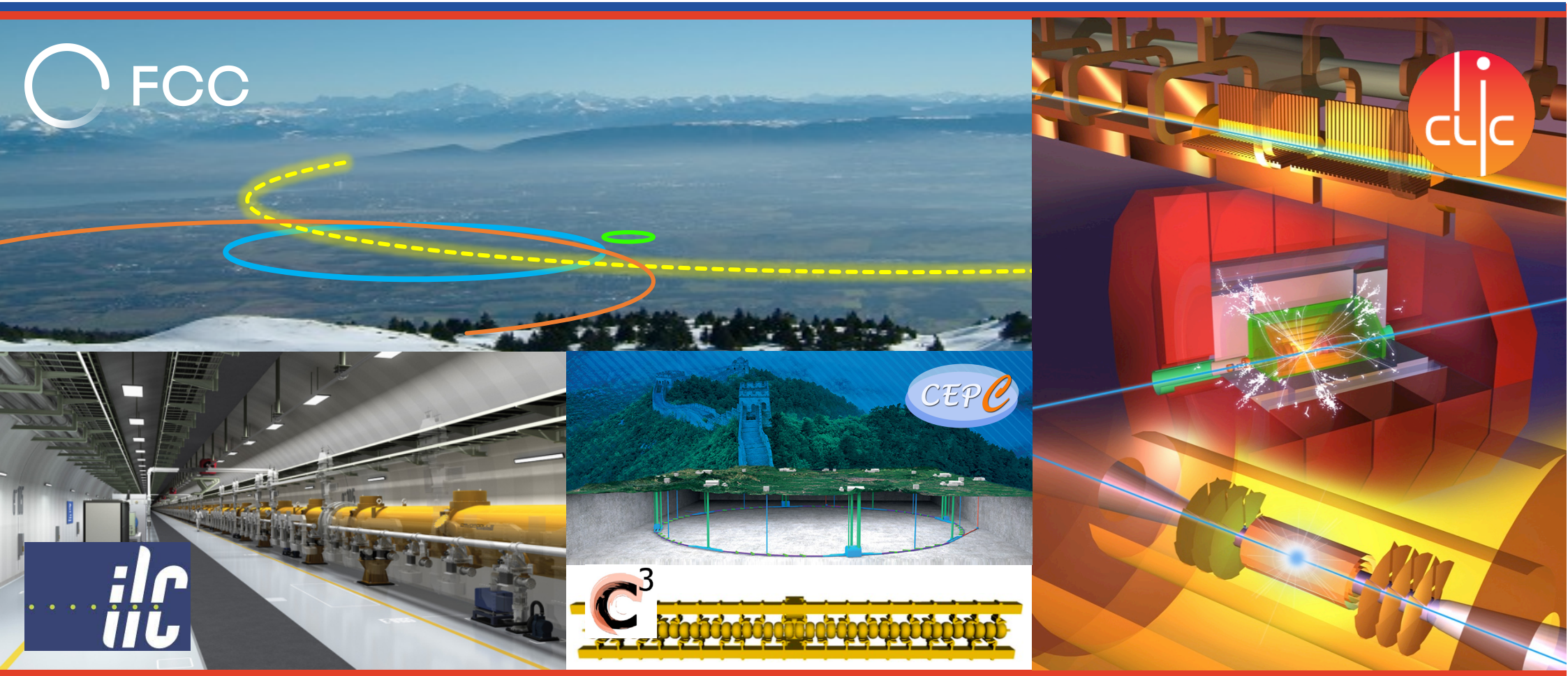
ECFA studies towards an e^+e^- Higgs/EWK/top factory



LCWS23, 16th May 2023, SLAC

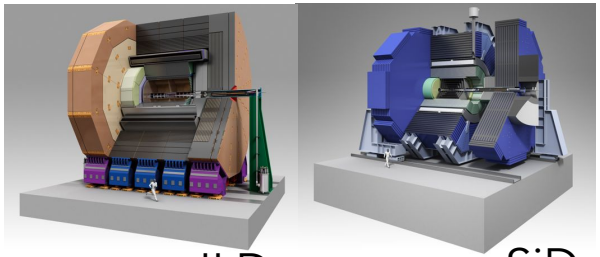
Aidan Robson, University of Glasgow

Context: shared effort – *examples*

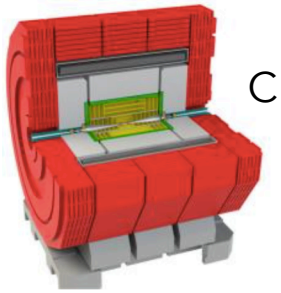
- *e^+e^- physics*

  models – generators – interpretations

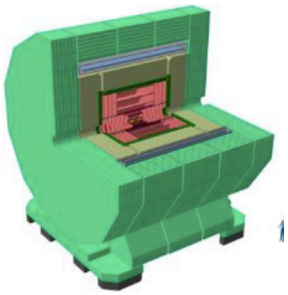
- *e^+e^- detector concepts – example*



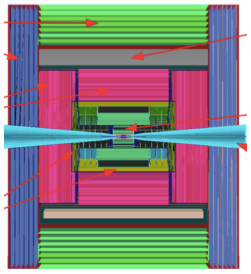
ILD SiD



CLICdet



CLD
for FCC-ee



(CLICdet
adapted for
muon
collider!)

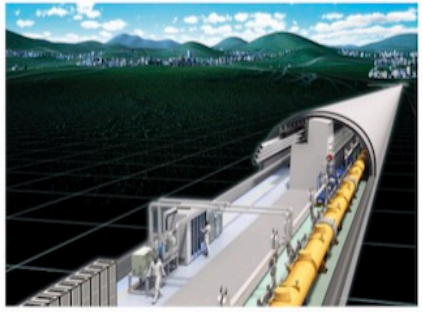
- *e^+e^- analysis tools – example*

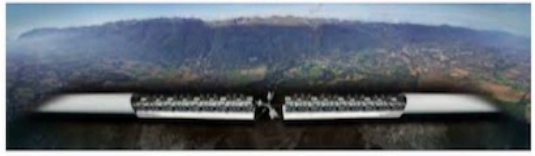
Detector	Collider	SW name	SW status	SW future
ILD	ILC	iLCSoft	Full sim/reco	Key4hep
SiD	ILC	iLCSoft	Full sim/reco	
CLICdet	CLIC	iLCSoft	Full sim/reco	
CLD	FCC-ee	iLCSoft	Full sim/reco	
IDEA	FCC-ee	FCC-SW	Fast sim/reco	
IDEA	CEPC	FCC-SW	Fast sim/reco	
CEPCbaseline	CEPC	iLCSoft branch-off	Full sim/reco	

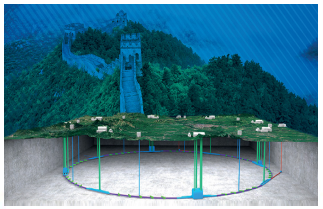
ECFA studies towards an e^+e^- Higgs/EWK/top factory

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 Working Groups underway

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

– coordinators from across community

+ study chief editors Aidan Robson, Christos Leonidopoulos

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

Main entry point:
https://indico.cern.ch/event/1044297/

Mailing lists

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  coordinators Jorge de Blas, Patrick Koppenburg, Jenny List, Fabio Maltoni
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  coordinators Mary Cruz Fouz, Giovanni Marchiori, Felix Sefkow

Present at LCWS23

– coordinators from across community

+ study chief editors Aidan Robson, Christos Leonidopoulos

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

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Mailing lists

ECFA Working Groups – WG1

- WG1: **Physics programme** coordinators Jorge de Blas, Patrick Koppenburg, Jenny List, Fabio Maltoni
  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

WG1-PREC: theoretical and experimental precision
April 2023 MiniWorkshop: cross-section linesanpes
Dec 2022 MiniWorkshop: luminosity
Nov 2022 MiniWorkshop: collision energy
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)
May 2023 Miniworkshop on e+e– physics at 160–240GeV
Feb 2023 MiniWorkshop on e+e– physics at 125 and 160 GeV
Sept 2022 MiniWorkshop on Z pole physics
Apr 2022 1st Workshop of the Higgs/Top/EW group

WG1-FLAV: Heavy Flavour
June 2022 1st Meeting

WG1-SRCH: Direct searches (weakly-interacting, directly accessible particles)
Apr 2023 Standard and exotic scalars at fuure HET factories
Feb 2023 Heavy Neutral Lepton search potential of future HET factories
May 2022 ECFA HF WG1: 1st Workshop of the WG1-SRCH group
Feb 2022 Brainstorming session

ECFA Working Groups – WG1

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Present at LCWS23

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Feb 2022 Brainstorming session

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:

2nd Topical Meeting on Generators
21-22 June 2023 – Brussels + hybrid
https://indico.cern.ch/event/1266492/

2nd Topical Meeting on Reconstruction
– focusing on higher-level tools
11-12 July – CERN + hybrid

–> See dedicated WG2 talk from Dirk Zervas in Thursday Detector Plenary

ECFA Working Groups – WG3

- WG3: **Detector technologies** coordinators Felix Sefkow, Mary Cruz Fouz, Giovanni Marchiori
  https://indico.cern.ch/event/1044297/page/28993-wg3-group-activities

Aims:

– 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

Topical workshop on Calorimeters, Photodetectors and Particle ID for Future Higgs Factories
3-5 May 2023

Forthcoming:

Topical workshop on Vertexing & Tracking
30-31 May 2023 – CERN + hybrid
https://indico.cern.ch/event/1264807/

Focus Topics

Main aims of the ECFA study are to bring people together (across projects) and to attract more people (e.g. LHC) into the community

–> we have been developing a set of 'focus topics' through bottom-up discussions to provide concrete entry points for contributions

- highlight areas of shared interest across projects
- draw attention to aspects from all three WGs
- build on previous studies where there is interesting new scientific work to be done

–> promote enhanced cooperation and new engagement

- develop common code / tools / datasets and person-skills that will have a wider application/impact, beyond the focus topics themselves

Focus Topics

1. H->ss
2. ZH angular distributions / CP studies
3. Higgs self-coupling
4. W mass at threshold and continuum
5. Full studies of WW and evW processes, aTGCs
6. Top threshold detector-level sim study & scan optimisation
7. Luminosity measurement
8. New exotic scalars
9. Long-lived particles
10. Exotic top decays
11. CKM matrix elements with on-shell & boosted W decays
12. B → $K^{0*}\tau^+\tau^-$
13. EWK precision: 2-fermion final states
14. Measurement of b- and c-fragmentation functions / hadronisation
15. Measurement of gluon splitting to bb / cc & interplay with separating h → gluons from h →bb/cc

	relevant $\sqrt{s}$			
	91 GeV	161 GeV	240/250 GeV	350-380 GeV
1			X	X
2			X	X
3			X	X
4		X	X	X
5			X	X
6				X
7	X	x	x	x
8	x	x	x	x
9	x	x	x	x
10				x
11		x	X	x
12	X			
13	X	X	X	X
14	X	x	X	X
15	X	x	X	X

All containing many aspects, e.g. theory calculations / MC generators / reconstruction techniques / EFT interpretation / detector-level studies / interface to detector requirements / …

Focus Topics

1. H->ss
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Example Potential aspects:
projected precisions on Br and differential cross-section
BSM models predicting deviations
flavour assumptions in EFTs (decouple 3rd generation?)
charged hadron ID (dE/dx / ToF / RICH ?)
reconstruction of in-flight decays
strangeness-tagging
s vs sbar separation
control of strange-tagging systematics
…etc

	relevant $\sqrt{s}$			
	91 GeV	161 GeV	240/250 GeV	350-380 GeV
				X
				X
				X
				X
				X
				x
				x
				x
				x
				x
				X
14	X	x	X	X
15	X	x	X	X

All containing many aspects, e.g. theory calculations / MC generators / reconstruction techniques / EFT interpretation / detector-level studies / interface to detector requirements / …

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	relevant $\sqrt{s}$			
	91 GeV	161 GeV	240/250 GeV	350-380 GeV
1			X	X
2			X	X
3			X	X
4		X	X	X
5			X	X
6				X
7	X	x	x	x
8	x	x	x	x
9	x	x	x	x
10				x
11		x	X	x
12	X			
13	X	X	X	X
14	X	x	X	X
15	X	x	X	X

- Most topics already have some effort to 'seed' the activities.
- Current status: WG1 topical group conveners are assembling 'expert teams' who will develop a detailed proposed work list for each topic; these will then be shared on the study website and via WG email lists as calls for interest/volunteers

Focus Topics

1. H->ss → expert team near complete
2. ZH angular distributions / CP studies
3. Higgs self-coupling → expert team has already met
4. W mass at threshold and continuum
5. Full studies of WW and evW processes, aTGCs
6. Top threshold detector-level sim study & scan optimisation
7. Luminosity measurement → expert team near complete / → expert team has already met
8. New exotic scalars
9. Long-lived particles
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For the remaining topics: those with prior knowledge welcome to volunteer for the expert teams! (from all projects, all regions!) – single point of contact Jenny List, or the other coordinators present at LCWS23

Then in the next step all (with or without prior knowledge!) are very welcome to participate in the active phase of the focus topic work

- Most topics already have some effort to 'seed' the activities.
- Current status: WG1 topical group conveners are assembling 'expert teams' who will develop a detailed proposed work list for each topic; these will then be shared on the study website and via WG email lists as calls for interest/volunteers

Further Topics

- Proposed 'focus topics' are not intended to map the physics programme comprehensively –> they are serving specific purposes as described
- ***Further physics topics*** continue to be explored through the WG topical group meetings. All welcome to propose talks to the topical conveners!
- Final target: ECFA Report in late 2025, as input to European Strategy 2026/27

Very preliminary sketch of WG1-FLAV report topics

5.1 CKM profile prospects
Leptonic decays and magnitude of the CKM matrix elements
CKM from hadronic decays
Global analyses. NP in neutral meson mixings

5.2 Rare decays of b- and c-flavoured particles
Flavour anomalies and related channels
LFU tests, angular observables, ...

5.3 Theory challenges
Expected precision from Lattice QCD
Prospects for $b \to s(d)l^+ l^-$ ($l = e, \mu, \tau$) predictions
Prospects for predictions of semileptonic decays
Impact of QED uncertainties

5.4 τ Physics
LFU tests in τ decays
LFV from τ decays

5.5 Heavy Flavour spectroscopy

5.6 Flavour Physics from $e\,e \to q\bar{q}$

5.7 Interplay with top, Higgs and electroweak precision measurements

Very preliminary sketch of WG2 report chapter

- Introduction
- Software Ecosystem
- Beamstrahlung
- Monte Carlo Generators
- Simulation and Reconstruction

for example:

Section Monte Carlo Generators:
- 1 subsection for each generator group
  - brief outline/overview
  - new/recent features to highlight
- *N* subsection(s) on combined activities (technical benchmarks.....)

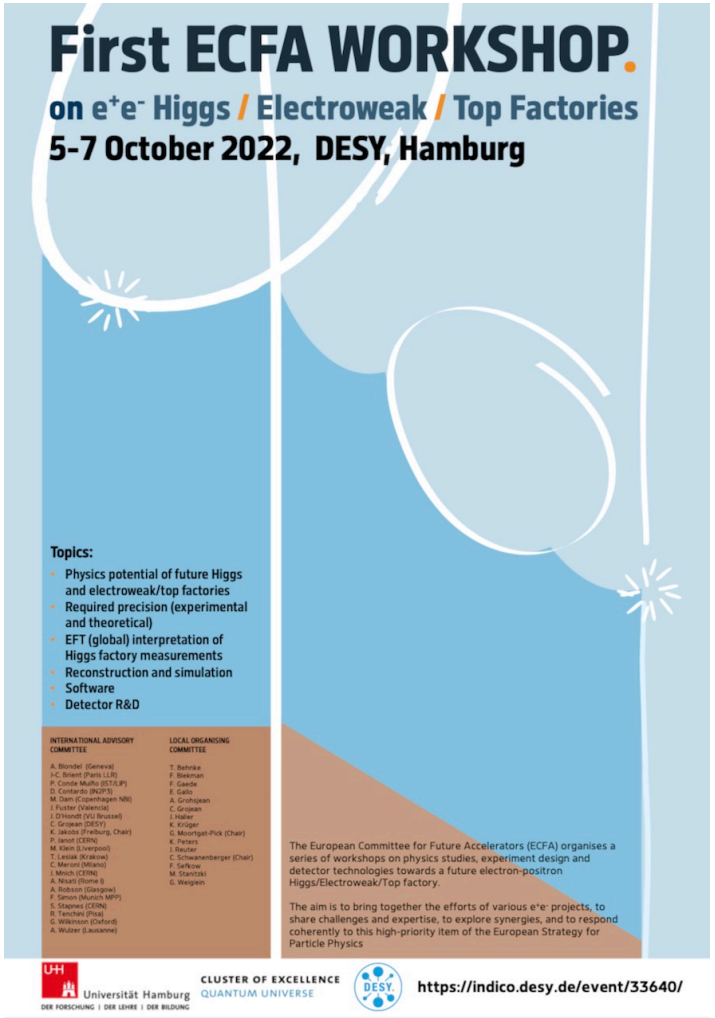
similar structure for the others e.g.:

Section Reconstruction
- subsections on "existing" reco algs (ACTS, CLIC, ILD,.....)
- *N* subsections on "combined activities",

e.g. running different algs on the same set through KEY4HEP

1st ECFA 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 ✅

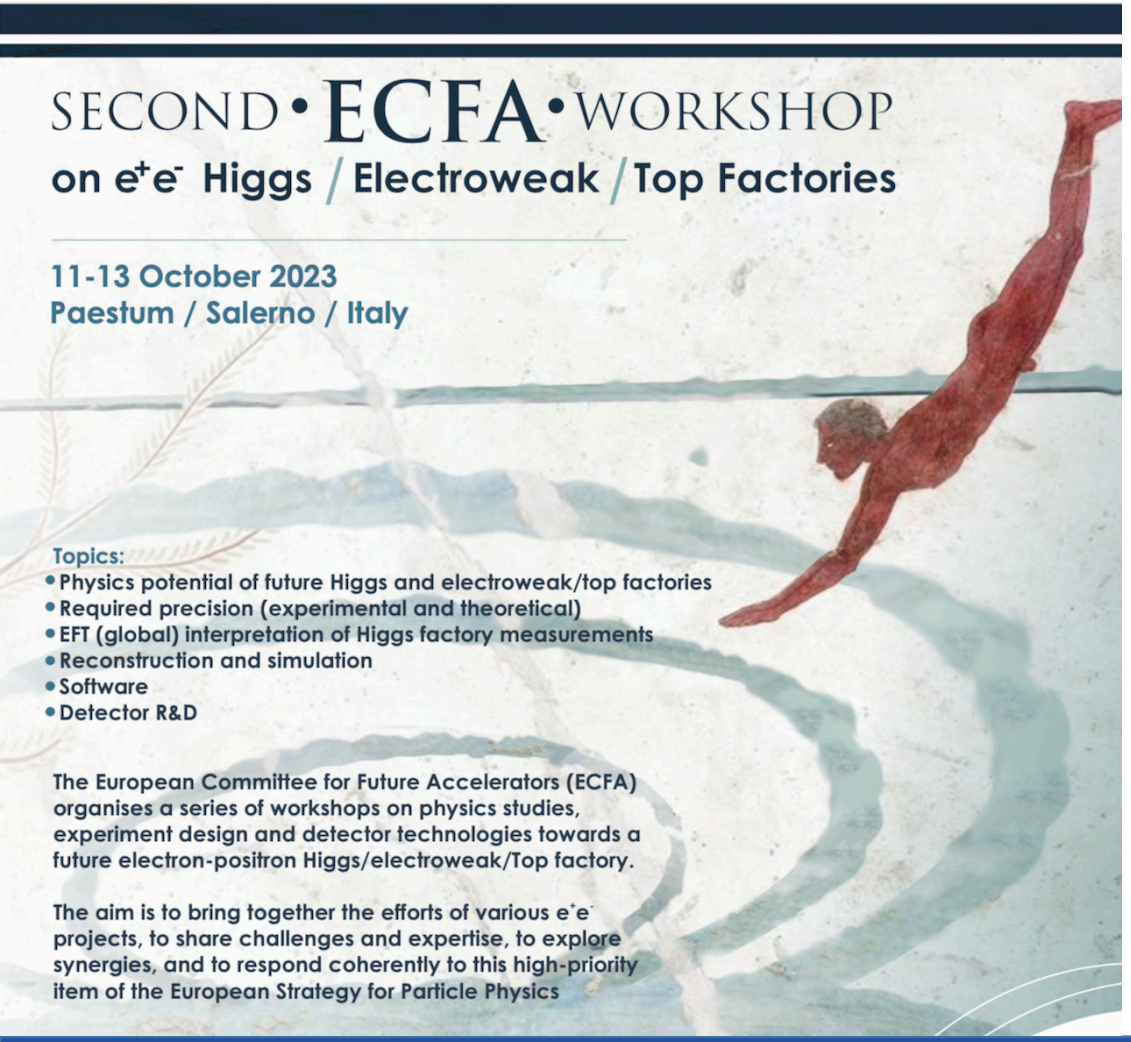
– topics in simulation & reconstruction being actively worked on together ✅

– 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

2nd ECFA Workshop, Paestum 11–13 October 2023

- Hosted by INFN Napoli, Università degli Studi di Napoli Federico II & Università degli Studi di Napoli Parthenope
- ***Registration now open***: https://agenda.infn.it/event/34841/



- Low cost (€460 full board, single-room accommodation) –> encourage wide participation especially among early-career researchers
- Expecting pre-meetings and software tutorial on 10th October before main workshop
- Programme will include plenary & parallel sessions; parallel will have both invited and submitted talks. Abstract submission for parallel talks and posters will open ~end May

All encouraged to come!

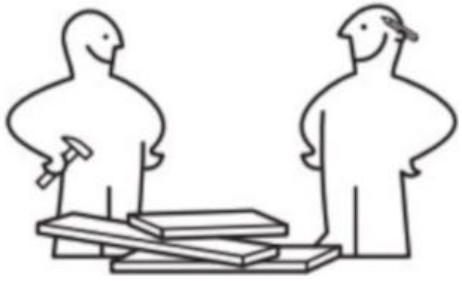
- Programme ctte:
  Patrick Koppenburg, Jenny List, Fabio Maltoni, Jorge de Blas
  Patrizia Azzi, Fulvio Piccinini, Dirk Zerwas
  Mary Cruz Fouz, Giovanni Marchiori, Felix Sefkow
  Christos Leonidopoulos, Aidan Robson

Looking ahead

- **Topical meetings and dedicated mini-workshops continuing in all three WGs**
  –> focus topics provide an entry point;
  wider topics are very welcome and will be included in the final report
- **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*



Spare slides

ECFA studies towards an e^+e^- Higgs/EWK/top factory

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

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)
Christos Leonodopoulos (Edinburgh)
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**