

# REPORT ON THE ECFA $e^+e^-$ WORKSHOP IN PAESTUM

- A glimpse of what you missed
- ... why you should come to the next

[indico]


Patrick Koppenburg

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Nikhef

# REPORT ON THE ECFA $e^+e^-$ WORKSHOP IN PAESTUM

- 
- Second in series, after the Hamburg 2022 workshop [\[indico\]](#)
  - 138 registered participants
    - Hard to compare with Hamburg, which had an online option
  - The workshop was preceded by a software tutorial [\[key4hep\]](#)

# REPORT ON THE ECFA $e^+e^-$ WORKSHOP IN PAESTUM



Welcome! Some of us you will see around...



Francesco Conventi



Elvira Rossi



Orso Iorio



Marcello Campajola



Adele D'Onofrio



Francesco Carnevali



Antimo Cagnotta



Antonio Corvino



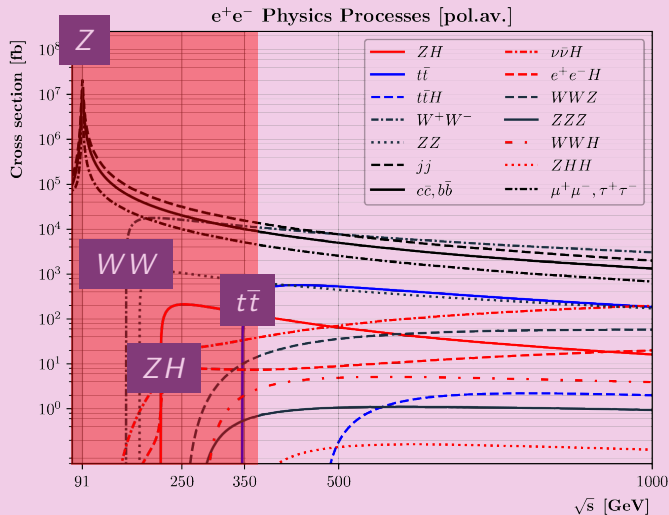
Leonardo Favilla



Carlo Di Fraia

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# ECFA $e^+e^-$ HIGGS/TOP/EW FACTORY STUDY





# ECFA $e^+e^-$ HIGGS/Top/EW FACTORY STUDY

## WG1 physics performance

Coordinators: Jorge de Blas, Patrick Koppenburg,  
Jenny List, Fabio Maltoni

GLOBAL INTERPRETATIONS (GLOB) Conveners:  
Jorge de Blas, Sven Heinemeyer, Alexander Grohsjean,  
Junping Tian, Marcel Vos

PRECISION (PREC): Conveners: Ayres Freitas,  
Paolo Azzurri, Adrian Irlles, Andreas Meyer

HIGGS/Top/EW: Conveners: Chris Hays,  
Karsten Köneke, Fabio Maltoni

FLAVOUR (FLAV): Conveners: David Marzocca,  
Stéphane Monteil, Pablo Goldenzweig

SEARCHES (SRCH): Conveners: Roberto Franceschini,  
Rebeca Gonzalez Suarez, Filip Zarnecki

## WG2 Physics Analysis Methods

Conveners: Patrizia Azzi,  
Fulvio Piccinini,  
Dirk Zerwas

## WG3 Detector R&D

Conveners:  
Mary Cruz Fouz,  
Giovanni Marchiori,  
Felix Sefkow

A photograph of several ancient Greek columns, likely from the Temple of Concordia in Agrigento, Italy. The columns are made of weathered stone and feature fluted shafts. They are arranged in a row, with some columns in the foreground and others receding into the background. The sky is a clear, bright blue.

# Focus topics

# ECFA $e^+e^-$ WG1 FOCUS TOPICS

Topic	lead group	Title
1 HtoSS	HTE	$e^+e^- \rightarrow Zh: h \rightarrow s\bar{s}$
2 ZHang	HTE (GLOB)	ZH angular distributions and CP studies
3 Hself	GLOB	Higgs self-coupling
4 Wmass	PREC	Mass and width of the $W$ boson
5 WWdiff	GLOB	Full studies of $WW$ and $e\nu W$
6 TTthres	GLOB (HTE)	Top threshold
7 LUMI	PREC	Precision luminosity measurement
8 EXscalar	SRCH	New exotic scalars
9 LLPs	SRCH	Long-lived particles
10 EXtt	SRCH	Exotic top decays
11 CKMWW	FLAV	CKM matrix elements from $W$ decays
12 BKtautau	FLAV	$B^0 \rightarrow K^{0*} \tau^+ \tau^-$
13 TwoF	HTE	EW precision: 2-fermion final states ( $\sqrt{s} = M_Z$ and beyond)
14 BCfrag	FLAV (PREC)	Heavy quark fragmentation and hadronisation
15 Gsplit	PREC (FLAV)	Gluon splitting and quark-gluon separation

Soon to be described in further detail in an arXiv preprint: contact conveners to contribute

} merged

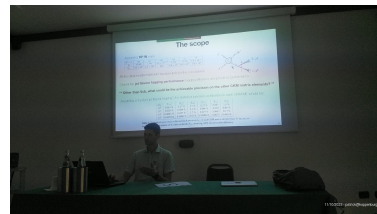
# ECFA $e^+e^-$ WG1 FOCUS TOPICS

Topic	lead group	relevant $\sqrt{s}$				
		91 GeV	161 GeV	240/250 GeV	350–380 GeV	$\geq 500$ GeV
1 HtoSS	HTE			✓	✓	x
2 ZHang	HTE (GLOB)			✓	✓	x
3 Hself	GLOB			✓	✓	✓
4 Wmass	PREC		✓	✓	✓	
5 WWdiff	GLOB			✓	✓	x
6 TTthres	GLOB (HTE)				✓	
7 LUMI	PREC	✓	x	x	x	x
8 EXscalar	SRCH	x	x	x	x	x
9 LLPs	SRCH	x	x	x	x	x
10 EXtt	SRCH				x	x
11 CKMWW	FLAV		x	✓	x	x
12 BKtautau	FLAV	✓				
13 TwoF	HTE	✓	✓	✓	✓	✓
14 BCfrag	FLAV (PREC)	✓	x	✓	✓	x
15 Gsplit	PREC (FLAV)	✓	x	✓	✓	x

# PARALLEL SESSIONS

17 parallel sessions with 4–6 talks each

<b>Parallel - Focus</b> <b>Topics: WG1-PREC</b> <i>Dr Adrian Irlas, Andreas Meyer, Ayres Freitas, Paolo Azzurri</i>  Sala Saturno, Hotel Ariston, Paestum 11:30 - 13:00	<b>Parallel - Focus</b> <b>Topics: WG1-GLOB</b> <i>Alexander Grohsjean, Jorge de Blas, Marcel vos</i>  Sala Nettuno, Hotel Ariston 11:30 - 13:00	<b>Parallel - Focus</b> <b>Topics: WG1-HTE</b> <i>Chris Hays, Fabio Maltoni, Karsten Köneke</i>  Sala Mercurio, Hotel Ariston, Paestum 11:30 - 13:00	<b>Parallel - Focus</b> <b>Topics: WG1-FLAV</b> <i>David Marzocca, Pablo Goldenzweig, Stephane Monteil</i>  Sala Medusa, Hotel Ariston, Paestum 11:30 - 13:00	<b>Parallel - Focus</b> <b>Topics: WG1-SRCH</b> <i>Aleksander Filip Zarnacki, Rebeca Gonzalez Suarez, Roberto Franceschini</i>  Sala Cassandra, Hotel Ariston, Paestum 11:30 - 13:00
<b>Parallel - WG1-SRCH</b> <i>Aleksander Filip Zarnacki, Rebeca Gonzalez Suarez, Roberto Franceschini</i>  Sala Cassandra, Hotel Ariston, Paestum 14:00 - 15:30	<b>Parallel - WG1-HTE+FLAV</b> <i>Chris Hays, David Marzocca, Fabio Maltoni, Karsten Köneke, Pablo Goldenzweig, Stephane Monteil</i>  Sala Mercurio, Hotel Ariston 14:00 - 15:30	<b>Parallel - WG2</b> <i>Dirk Zerwas, Fulvio Piccinini, Patrizia Azzi</i>  Sala Saturno, Hotel Ariston, Paestum 14:00 - 15:30	<b>Parallel - WG3</b> <i>Felix Sefkow, Giovanni Marchiori, Mary-Cruz Fouz Iglesias</i>  Sala Nettuno, Hotel Ariston, Paestum 14:00 - 15:30	
<b>Parallel - WG1-HTE</b> <i>Chris Hays, Fabio Maltoni, Karsten Köneke</i>  Sala Mercurio, Hotel Ariston, Paestum 16:00 - 18:00	<b>Parallel - WG1-PREC</b> <i>Dr Adrian Irlas, Andreas Meyer, Ayres Freitas, Paolo Azzurri, Paolo Azzurri</i>  Sala Saturno, Hotel Ariston, Paestum 16:00 - 18:00	<b>Parallel - WG3</b> <i>Felix Sefkow, Giovanni Marchiori, Mary-Cruz Fouz Iglesias</i>  Sala Nettuno, Hotel Ariston, Paestum 16:00 - 18:00	<b>Parallel - WG1-SRCH+FLAV</b> <i>Aleksander Filip Zarnacki, David Marzocca, Pablo Goldenzweig, Rebeca Gonzalez Suarez, Roberto Franceschini, Stephane Monteil</i>  Sala Cassandra, Hotel Ariston, Paestum 16:00 - 18:00	<b>Parallel - WG1-SRCH</b> <i>Aleksander Filip Zarnacki, Rebeca Gonzalez Suarez, Roberto Franceschini</i>  Sala Cassandra, Hotel Ariston, Paestum 14:00 - 16:00
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				<b>Parallel - WG3</b> <i>Felix Sefkow, Giovanni Marchiori, Mary-Cruz Fouz Iglesias</i>  Sala Nettuno, Hotel Ariston, Paestum 14:00 - 16:00








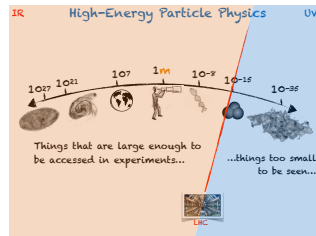
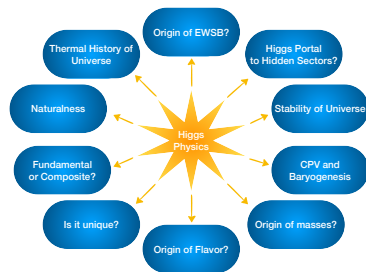
# Highlights

# PLENARY HIGHLIGHTS (PHYSICS)

STEFAN DITTMAYER:  Opening talk  
with emphasis on precision aspects

- Good physics does not necessarily require new particles
- $Hc$  coupling can be done at  $e^+e^-$ . What about  $Hs$  and  $He$ ?
- ✓ SM precision pushed to the extreme at the  $Z$  pole
- ➔ **The  $e^+e^-$  collider will make measurements in uncharted territory**

FRANCESCO RIVA: Closing talk with  
emphasis on size of the Higgs boson.

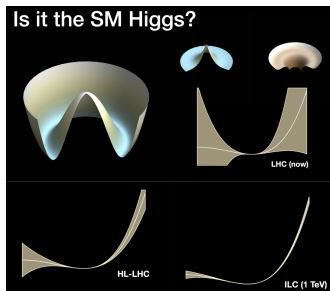


# PLENARY HIGHLIGHTS (FOCUS TOPICS)

JUNPING TIAN (HSELF): Higgs self-coupling; great potential at  $e^+e^-$

CATERINA VERNIERI (HTOSS) : Use  $H \rightarrow s\bar{s}$  to inform detector design

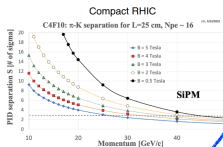
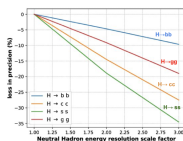
ROBERTO FRANCESCHINI (EXTT): Large potential of BSM top decays that are not explored at the LHC



## Lesson learned and moving forward

Use  $H \rightarrow ss$  to inform detector design, while monitoring other benchmarks' performance

- Neutral Hadron energy resolution
- dE/dx and dN/dx: powerful PID essential for H-strange coupling
- Timing resolution to be further investigated but less critical for s-tagging
- RHIC for improved reconstruction of  $K^{*+}$  at high momentum ( $< 30$  GeV)

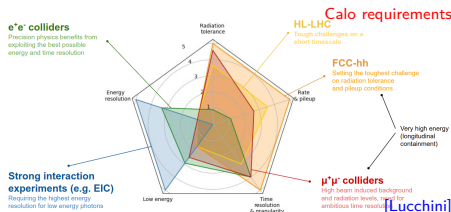


$u/c$

$t$

$\gamma, Z, g, h$

ZIAD EL BITAR Semiconductor  
DRD3 — plenty of R&D to follow



# PLENARY HIGHLIGHTS (WG2)



**JUAN MIGUEL CARCELLER:** Key4hep: wide community from different experiments

**ULI EINHAUS:** Reconstruction: make tools generic to use in Key4hep

**JÜRGEN REUTER:** Generators implement all necessary SM and BSM physics but a lot remains to be done.


**FRANÇOIS BRIEUC:** Simulation  $I_1 N_1 T_1 E_1 R_1 O_1 P_3 E_1 R_1 A_1 B_3 I_1 L_1 I_1 T_1 Y_4$


**ALAN PRICE:** Generator benchmarks  $R_1 E_1 P_3 R_1 O_1 D_2 U_1 C_3 I_1 B_3 I_1 L_1 I_1 T_1 Y_4$




# PLENARY HIGHLIGHTS (PROJECTS)

**JENNY LIST:** Overview of the projects , and a focus on sustainability.

**SRINI RAJAGOPALAN:** US view with strong support for an  $e^+e^-$  Higgs factory  (I noted the page on software)

**KARL JAKOBS:** ECFA activities 

➔ More efforts needed

**EMANUELE BAGNASCHI :** Important to involve ECRs.  The future is theirs!

## U.S. Higgs Factory Coordination Group

- ✦ Solid State: A. Apresyan, C. Haber, C. Vernieri
- ✦ Calorimeter: H. Chen, C. Tully, A. White
- ✦ Gaseous Detector: M. Hohlmann, G. Iakovidis, B. Zhou
- ✦ Readout/ASICs: J. Gonski, J. Hirshchauer
- ✦ Trigger/DAQ: Z. Demiragli, J. Zhang
- ✦ Particle ID: M. Artuso, G. Wilson, Z. Ye
- ✦ Quantum: M. Demarteau, C. Pena, S. Xie
- ✦ Software: H. Gray, O. Gutsche, J. Strube
- ✦ ex-officios: J. Brau, A. Canepa, D. Denisov, S. Eno, P. Grannis, K. Jakobs, A. Lankford
  - plus representation from DOE and CPAD.
- ✦ Chair: S. Rajagopalan

### Outlook

- Follow-up events at the national level, organized by local committees of the ECFA countries
- Goal: discuss country-dependent issues/aspects (e.g. funding sources, role of the national agencies etc.)
- Goal: help the formation of a cohesive ECR community at the national level
- Organization in progress, send an email to [ecfa-ecr-future-colliders@cern.ch](mailto:ecfa-ecr-future-colliders@cern.ch) to participate!

# NEXT STEPS



## NEXT STEPS (AIDAN ROBSON)


- 1 Document describing the focus topics later this year
- 2 Inputs by end 2025
  - Report structure by 2024
    - Focus input by May 2025,
    - Editing in summer
- 3 Next strategy in 2026–27



# Science Case

# SCIENCE CASE

JOSEPH MARTIN: Lessons from historical critiques of Big Science

HARRY CLIFF: Promise of revolutionary discovery is not the only standard by which future proposals should be held (Tevong You). Need a compelling argument for why we should build a future collider 

## Who do we need to persuade?

### The public

Politicians  
& decision  
makers

Future  
scientists

Scientific  
community

Physicists

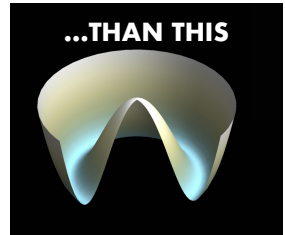
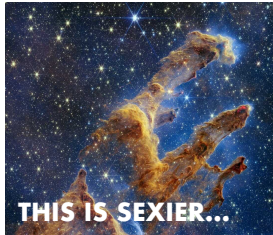
Ourselves

# SCIENCE CASE

JOSEPH MARTIN: Lessons from historical critiques of Big Science

HARRY CLIFF: Promise of revolutionary discovery is not the only standard by which future proposals should be held (Tevong You). Need a compelling argument for why we should build a future collider 🤖


## Some challenges





# SCIENCE CASE

JOSEPH MARTIN: Lessons from historical critiques of Big Science

HARRY CLIFF: Promise of revolutionary discovery is not the only standard by which future proposals should be held (Tevong You). Need a compelling argument for why we should build a future collider 

## A story for the Higgs

Questions related to the Higgs tend to be abstract. Harder to convey than 'we're going to discover a new particle' e.g.

1. Does the Higgs couple to the first generation as expected?
2. What is the natural width of the Higgs?
3. What is the form of the Higgs potential?

# SCIENCE CASE

JOSEPH MARTIN: Lessons from historical critiques of Big Science

HARRY CLIFF: Promise of revolutionary discovery is not the only standard by which future proposals should be held (Tevong You). Need a compelling argument for why we should build a future collider 🤖

## On Money

Costs of future colliders sound astronomical – tens of billions of euros/dollars.

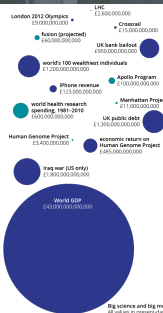
Should try to put these costs in context – e.g. cost per citizen per year / comparison with other large projects.

Great work by Andrew Steele on this at [www.scienceogram.org](http://www.scienceogram.org)



Discovering the Higgs boson literally cost peanuts.

The LHC cost CERN and the LHC costs us £1.50 per person per year, about the same as we spend on peanuts.



Big science and big money  
All values in present-day GBP

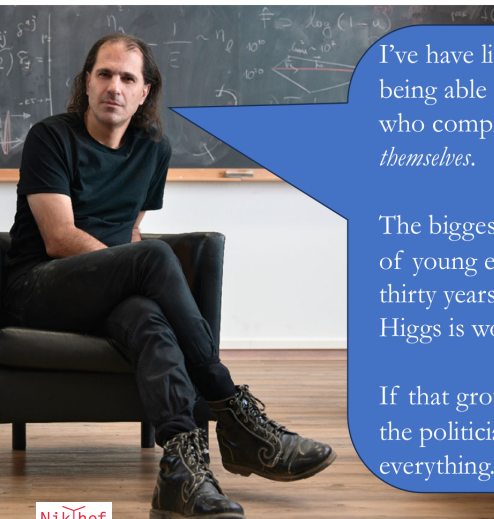
NOBODY WANTS TO FUND THIS SCIENTIFIC MEGAPROJECT, BUT IT'S ONLY \$25 BILLION! THAT'S LESS THAN A QUARTER THE COST OF MITTENING EVERY CEPHALOPOD!



12/10/2020 - patrick.koppenburg@unil.ch

JOSEPH MARTIN: Lessons from historical critique  
HARRY CLIFF: Promise of revolutionary discovery  
by which future proposals should be held (Tev  
compelling argument for why we should build

# The Biggest Bottleneck



I've have little sympathy for the belly aching about not being able to convince politicians. I find that the people who complain about this most of all can't convince *themselves*.

The biggest bottleneck is: Is there a big enough group of young experimentalists who think devoting twenty, thirty years of their lives to studying the hell out of the Higgs is worth it?

If that group of people does not exist, forget it! Screw the politicians, screw all the arguments, screw everything.

# The Biggest Bo

[Nima Arkani-Hamed in CERN courier]

## Who do we need to persuade?

The public

Politicians  
& decision  
makers

Future  
scientists

Scientific  
community

Physicists

Ourselves

I've have little  
being able to c  
who complain  
*themselves.*

**Most important is to build a  
community with a single goal  
... which was the main aim of  
the workshop**

If that group of people does not exist, forget it! Screw  
the politicians, screw all the arguments, screw  
everything.



# Conclusion



# Conclusion

- ✓ Very constructive spirit towards a common goal
- Work on commonalities
  - 3 WGs on physics, software and detector
    - Please join! [\[gitlab\]](#)
    - ✓ A plan with 14 focus topics
    - next strategy update
- Promote a narrative on why we need an  $e^+e^-$  Higgs/EW/top factory

# MITTENING ALL CEPHALOPODS

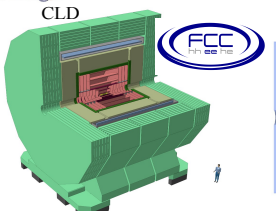
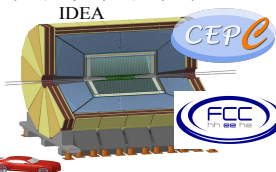
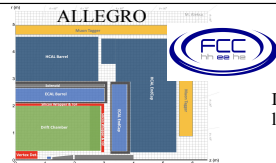
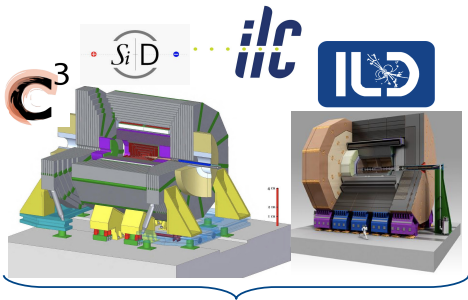




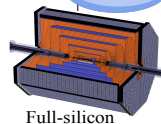
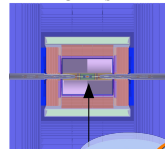
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# Backup

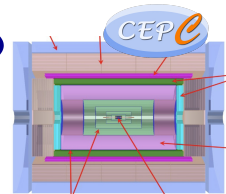
# The Detector Zoo



CRD's



ILD like



4<sup>th</sup> CEPC concept