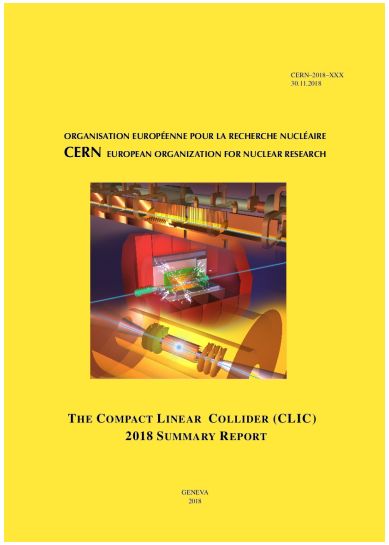
European Strategy

CLIC Workshop, 25 January 2019

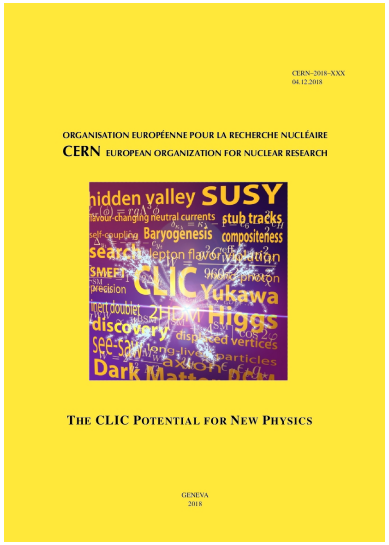
Aidan Robson, University of Glasgow & CERN

CLIC reports



CERN-2018-005-M

http://dx.doi.org/10.23731/CYRM-2018-002



CERN-2018-009-M

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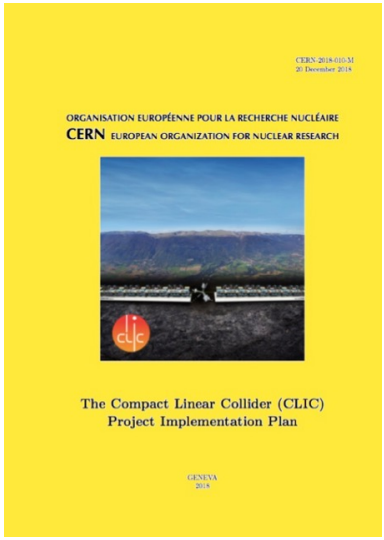


CERN-2018-010-M

http://dx.doi.org/10.23731/CYRM-2018-004

Detector Technologies for CLIC

in collaboration review

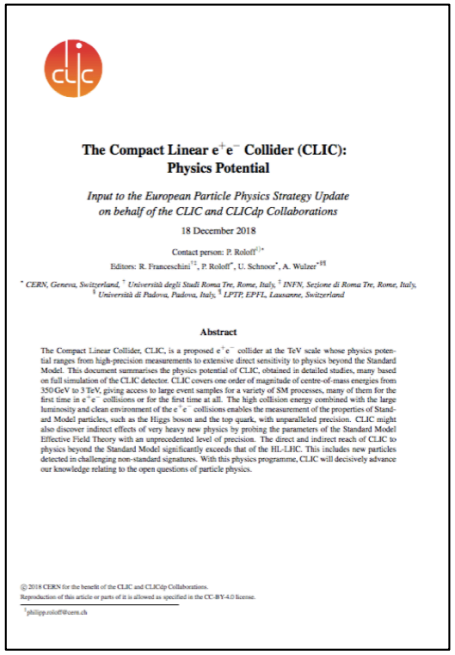
The Compact Linear e⁺e⁻ Collider (CLIC): Accelerator and Detector

Input to the European Particle Physics Strategy Update on behalf of the CLIC and CLICdp Collaborations

18 December 2018

Abstract

The Compact Linear Collider (CLIC) is a TeV-scale high-luminosity linear e^+e^- collider under development by international collaborations hosted by CERN. This document provides an overview of the design, technology, and implementation aspects of the CLIC accelerator and the detector. For an optimal exploitation of its physics potential, CLIC is foreseen to be built and operated in stages, at centre-of-mass energies of 380 GeV, 1.5 TeV and 3 TeV, for a site length ranging between 11 km and 50 km. CLIC uses a two-beam acceleration scheme, in which normal-conducting high-gradient 12 GHz accelerating structures are powered via a high-current drive beam. For the first stage, an alternative with X-band klystron powering is also considered. CLIC accelerator optimisation, technical developments, and system tests have resulted in significant progress in recent years. Moreover, this has led to an increased energy efficiency and reduced power consumption of around 170 MW for the 380 GeV stage, together with a reduced cost estimate of approximately 6 billion CHF. The detector concept, which matches the physics performance requirements and the CLIC experimental conditions, has been refined using improved software tools for simulation and reconstruction. Significant progress has been made on detector technology developments for the tracking and calorimetry systems. The construction of the first CLIC energy stage could start as early as 2026 and first beams would be available by 2035, marking the beginning of a physics programme spanning 25–30 years and providing excellent sensitivity to Beyond Standard Model physics, through direct searches and via a broad set of precision measurements of Standard Model processes, particularly in the Higgs and top-quark sectors.



The Compact Linear e⁺e⁻ Collider (CLIC): Physics Potential

Input to the European Particle Physics Strategy Update on behalf of the CLIC and CLICdp Collaborations

18 December 2018

Abstract

The Compact Linear Collider, CLIC, is a proposed e^+e^- collider at the TeV scale whose physics potential ranges from high-precision measurements to extensive direct sensitivity to physics beyond the Standard Model. This document summarises the physics potential of CLIC, obtained in detailed studies, many based on full simulation of the CLIC detector. CLIC covers one order of magnitude of centre-of-mass energies from 350 GeV to 3 TeV, giving access to large event samples for a variety of SM processes, many of them for the first time in e^+e^- collisions or for the first time at all. The high collision energy combined with the large luminosity and clean environment of the e^+e^- collisions enables the measurement of the properties of Standard Model particles, such as the Higgs boson and the top quark, with unparalleled precision. CLIC might also discover indirect effects of very heavy new physics by probing the parameters of the Standard Model Effective Field Theory with an unprecedented level of precision. The direct and indirect reach of CLIC to physics beyond the Standard Model significantly exceeds that of the HL-LHC. This includes new particles detected in challenging non-standard signatures. With this physics programme, CLIC will decisively advance our knowledge relating to the open questions of particle physics.

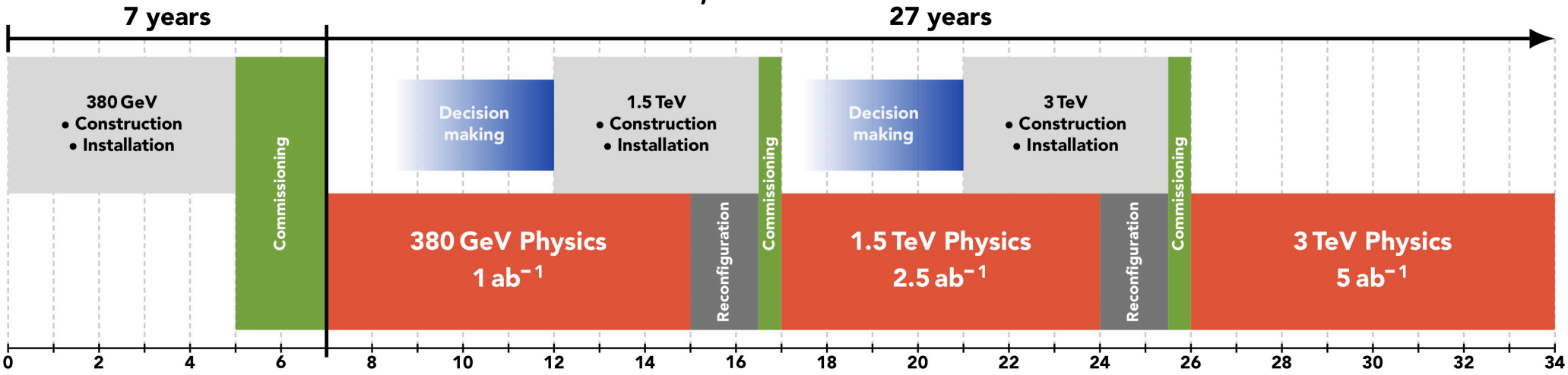
The CLIC 2018 Summary Report
The CLIC Potential for New Physics
The CLIC Project Implementation Plan
–> all published
as 2018 CERN Yellow Reports

Detector Technologies for CLIC in collaboration review

Two formal European Strategy Update submissions made on 18th December

Costs and schedules

CLIC TDR 2025, start construction 2026



Cost of stage 1: 5.9 BCHF

stage 2: + 5.1 BCHF

stage 3: + 7.3 BCHF

FCC (from DG's new year message)

Purely technical schedule, assuming green light to preparation work in 2020.

A 70 years programme

8 years preparation	10 years tunnel and FCC-ee construction	15 years FCC-ee operation	11 years FCC-hh preparation and installation	25 years FCC-hh operation pp/PbPb/eh
2020-2028		2038-2053		2064-2090

FCC-ee: Estimated cost: ~ **11.6** BCHF: 5.4 B (tunnel), 5.1 B (injectors + collider up to √s=240 GeV), 1.1 B (additional RF for operation at √s ~365 GeV)

FCC-hh: Estimated cost: ~ **17** BCHF (13.6 B collider [magnets!] + injectors) if built after FCC-ee (tunnel and part of infrastructure exists); 24 BCHF if standalone.

Time to make CLIC's message very clear:

Unprecedented, excellent, diverse physics reach
from lepton collider precision AND multi-TeV collisions

Demonstrated accelerator technologies

Feasible timescale

Cost of CLIC 380GeV + 1.5TeV < cost of FCC-ee

CLIC staging brings cost staging, and accompanying implications on affordability

Linear tunnel provides natural infrastructure for future beyond CLIC

All documentation available: https://clic.cern/european-strategy

CLIC Accelerator Organisation Publications | CLIC Detector & Physics Organisation Publications

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European Strategy for Particle Physics

The **Compact Linear Collider** (CLIC) is a **TeV-scale high-luminosity linear electron-positron collider** under development by international collaborations hosted by CERN.

The CLIC accelerator collaboration and CLIC Detector and Physics collaboration together comprise around **400 participants from approximately 75 institutes** worldwide. Additional contributions are made from beyond the collaborations.

A number of **documents** report on the **CLIC accelerator and detector and physics status** in advance of the **European Strategy update 2018-2020**, including the design, technology, and implementation aspects of the CLIC accelerator and the detector, and summaries of the physics potential of CLIC.

CLIC input to the European Strategy for Particle Physics Update 2018-2020

Formal European Strategy submissions

- **The Compact Linear e+e- Collider (CLIC): Accelerator and Detector** (arXiv:1812.07987)
- **The Compact Linear e+e- Collider (CLIC): Physics Potential** (arXiv:1812.07986)

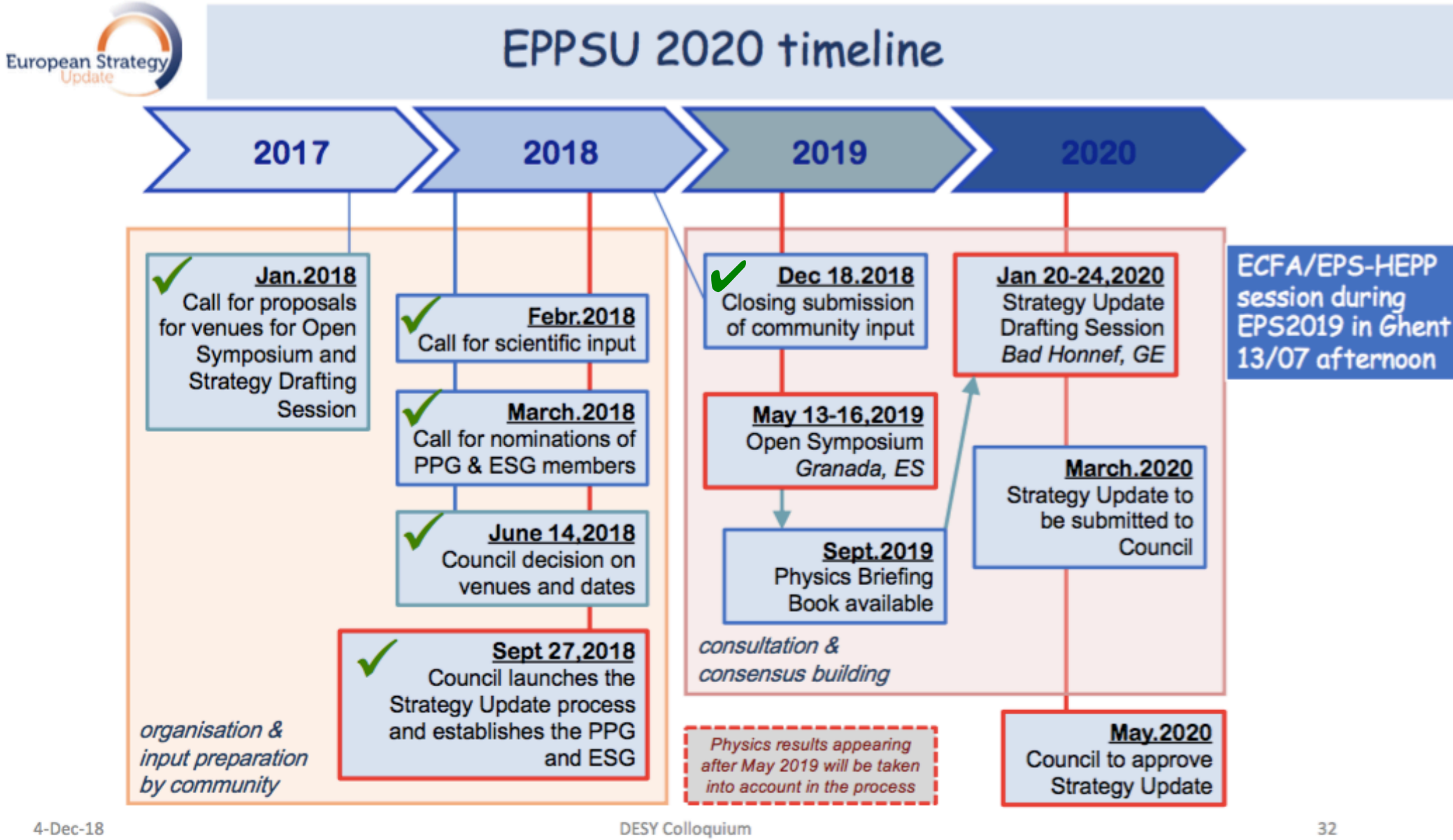
Yellow Reports

- **CLIC 2018 Summary Report** (CERN-2018-005-M, arXiv:1812.06018)
- **CLIC Project Implementation Plan** [Draft]
- **The CLIC potential for new physics** (CERN-2018-009-M)
- **Detector technologies for CLIC** [In collaboration review]

–> please publicise widely

European Strategy

Slides from Halina Abramowicz, DESY Colloquium 4/12/18



European Strategy

- Strategy Secretariat:
  - Halina Abramowicz (Chair)
  - Keith Ellis (SPC Chair)
  - Jorgen d'Hondt (ECFA Chair)
  - Lenny Rivkin (European Laboratories Directors' Meeting Chair)
- Physics Preparatory Group: 4 recommended by SPC, 4 by ECFA, 1 by CERN, 2 from Asia, 2 Americas

Halina Abramowicz – Tel Aviv University, Israel (chair); high energy experiments
Shoji Asai - Tokyo University, Japan; experimental non-accelerator particle physics and high-energy colliders
Stan Bentvelsen – Nikhef, Netherlands; experimental particle and astroparticle physics
Caterina Biscari – ALBA, Spain; accelerator science
Marcela Carena – University of Chicago and Fermilab, US; dark matter and BSM theory
Jorgen D'Hondt – University of Brussels (VUB), Belgium; high energy collider experiments
Keith Ellis –University of Durham, UK – QCD theory and colliders phenomenology
Belen Gavela – University of Madrid (UOM), Spain; beyond-the-Standard Model theory
Gian Giudice: CERN; theory (everything)
Beate Heinemann – DESY and Freiburg University, Germany; high-energy collider experiments
Xinchou Lou - Institute of High Energy Physics, China; heavy flavour physics and detectors
Krzysztof Redlich – Wroclaw University, Poland; QCD (strong interaction) theory
Lenny Rivkin – EPFL/PSI, Switzerland; accelerator science
Paris Sphicas – University of Athens, Greece, and CERN; high-energy collider experiments
Brigitte Vachon - McGill University, Canada; detector physics
Marco Zito – Saclay, France; experimental neutrino physics
Antonio Zoccoli – INFN Bologna, Italy; experimental heavy flavour physics

Among 17 members – 15 countries and CERN, 4(T) and 13(E), 6(F) and 11(M)

- European Strategy Group: all the above + member state representatives, lab representatives, invited others => 65 people

European Strategy

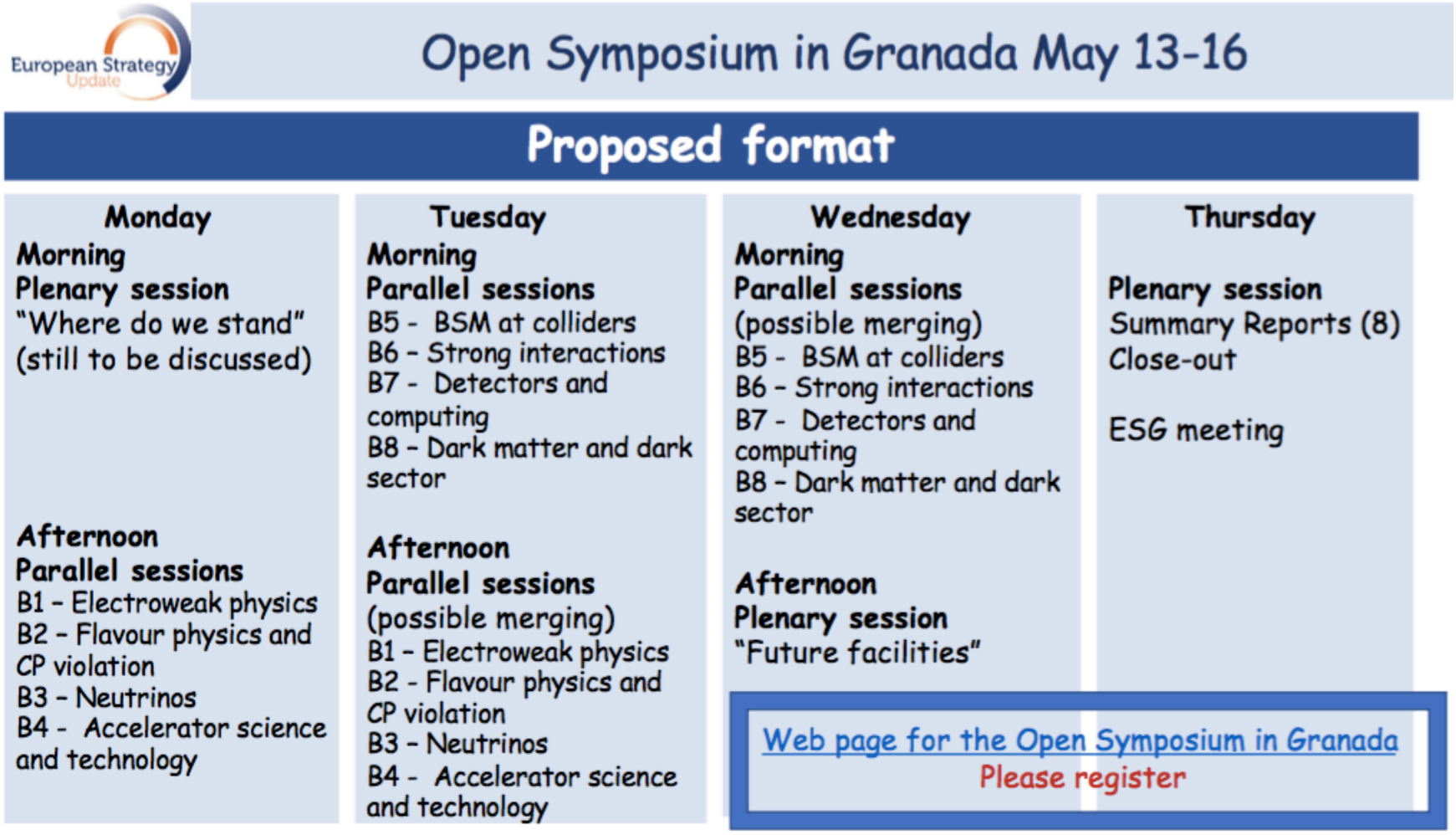
Proposed Input Themes and PPG/ESG assignments

* • Large experiments and projects - PPG
- National road maps - ESG
- Accelerator Science and Technology - Caterina Biscari and Lenny Rivkin
- Beyond the Standard Model at colliders (present and future) – Gian Giudice (th) and Paris Sphicas (exp)
- Dark matter and dark sector (accelerator and non-accelerator dark matter, dark photons, hidden sector, axions) – Marcela Carena (th) and Shoji Asai (exp)
- Instrumentation and computing – Xinchou Lou (exp) and Brigitte Vachon (exp)
- Electroweak physics (physics of the W, Z, H bosons, of the top quark, and QED) – Keith Ellis (th) and Beate Heinemann (exp)
- Flavour Physics and CP violation (quarks, charged leptons and rare processes) – Belen Gavela (th) and Antonio Zoccoli (exp)
- Neutrino physics (accelerator and non-accelerator) – Stan Bentvelsen (astro-exp) and Marco Zito (exp)
- Strong interactions (perturbative and non-perturbative QCD, DIS, heavy ions) – Krzysztof Redlich (th) and Jorgen D'Hondt (exp)
- Other (communication, outreach, strategy process, technology transfer, individual contributions,...) - ESG

There are 8 physics themes and 3 general ones. The large experiments/projects will be split among the physics themes.

4-Dec-18 DESY Colloquium 36

European Strategy



https://cafpe.ugr.es/eppsu2019/ –> we should be planning to be there

Then at the EPS-HEP conference in Gent (Belgium, http://eps-hep2019.eu), a joint ECFA-EPS open session will be held on 13 July 2019 "to further the discussions"

European Strategy – Higgs WG

Towards a working group on
"Higgs physics with future colliders in parallel and beyond the HL-LHC"

- Within its role, and in concert with the PPG, RECFA agrees to organize a working group of experts (typically non-ECFA members) with the objective to compare in detail the complementarity of the options, and this across the different colliders.
- The collider (and detector) settings of all future colliders will be input to the European Strategy process, to bring together the Higgs physics potential across colliders in a coherent and comparable manner is challenging
- The working group would inform the community towards the discussions organized in the context of the European Strategy

From Jorgen D'Hondt, P-ECFA 15/11/18

Mandate agreed by RECFA in consultation with the PPG
"Higgs physics with future colliders in parallel and beyond the HL-LHC"

- In the context of exploring the Higgs sector, provide a coherent comparison of the reach with all future collider programmes proposed for the European Strategy update, and to project the information on a timeline.
- For the benefit of the comparison, motivate the choice for an adequate interpretation framework (e.g. EFT, κ, …) and apply it, and map the potential prerequisites related to the validity and use of such framework(s).
- For at least the following aspects, where achievable, comparisons should be aim for:
  - Precision on couplings and self-couplings (through direct and indirect methods)
  - Sensitivities to anomalous and rare Higgs decays (SM and BSM), and precision on total width
  - Sensitivity to new high-scale physics through loop corrections
  - Sensitivities to flavor violation and CP violating effects
- In all cases the future collider information is to be combined with the expected HL-LHC reach, and the combined extended reach is to be compared with the baseline reach of the HL-LHC.
- In April 2019, provide a comprehensive and public report to inform the community.

There was a call for nominations and membership is the following:

Aleandro Nisati
Jorge de Blas
Maria Cepeda Hermida
Christophe Grojean
Fabio Maltoni
Riccardo Rattazzi
Wouter Verkerke

(+Beate Heinemann, Keith Ellis, Jorgen D'Hondt)

There was a further request for a CLICdp contact, which will be Philipp Roloff.

The BSM at Colliders theme conveners have also requested CLICdp contacts

European Strategy

Open Symposium 13–16 May 2019

https://cafpe.ugr.es/eppsu2019/ –> we should be planning to be there

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