European Particle Physics Strategy Update

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(McGill)

IPP AGM
7 June 2019
What is the EPPSU?

• Every few years, the European particle physics community reviews the roadmap and priorities of the field, updating the European Particle Physics Strategy (EPPS). More information is available here:

• The next update process was launched by the CERN Council in September 2018 and is scheduled to be completed in May 2020.
EPPSU organization

• **Strategy Secretariat:**
  - Organize/coordinate EPPSU process.
  - 4 members.

• **Physics Preparatory Group (PPG):**
  - Prepares the scientific input to the strategy update based on community input, and submits the "Briefing Book" to the ESG.
  - 17 members.
    - Delegates from the Americas: Marcela Carena (US), BV (Canada)
    - Delegates from Asia: Shoji Asai (Japan), Xinchou Lou (China)

• **European Strategy Group (ESG):**
  - Drafts strategy update to be submitted to CERN council for approval.
  - ESG is assisted by the Physics Preparatory Group.
  - ~ 36 members (+ 29 invitees).
EPPSU 2020 Process

European Particle Physics Strategy Update

2017
- Jan. 2018: Call for proposals for venues of Open Symposium and Strategy Drafting Session
- March 2018: Call for nominations of PPG & ESG members
- June 14, 2018: Council decision on venues and dates

2018
- Feb. 2018: Call for scientific input

2019
- Dec. 18, 2018: Closing submission of community input
- May 13-16, 2019: Open Symposium Granada, ES
- Sept. 2019: Physics Briefing Book available
- Sept. 27, 2018: Council to launch the Strategy Update process & establish the PPG and ESG

2020
- Jan. 20-24, 2020: Strategy Update Drafting Session Bad Honnef, DE
- March 2020: Strategy Update to be submitted to Council
- May 2020: Council to approve Strategy Update

Consultation & Consensus building
Scientific Input to EPPSU

- Call for community inputs issued in March 2018 with deadline for submission set for December 18, 2018.
- 160 written submissions received.

<table>
<thead>
<tr>
<th>Track ID</th>
<th>Granada sessions</th>
<th># inputs</th>
<th>Description</th>
<th>Conveners</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>40</td>
<td>Large experiments and projects</td>
<td>PPG</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>42</td>
<td>National road maps</td>
<td>ESG</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>22</td>
<td>Other (communication, outreach, strategy process, technology transfer, individual contributions,...)</td>
<td>ESG</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>21</td>
<td>Electroweak physics (physics of the W, Z, H bosons, of the top quark, and QED)</td>
<td>Keith Ellis, Beate Heinemann</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>27</td>
<td>Flavour Physics and CP violation (quarks, charged leptons and rare processes)</td>
<td>Belen Gavela, Antonio Zoccoli</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>25</td>
<td>Dark matter and dark sector (accelerator and non-accelerator dark matter, dark photons, hidden sector, axions)</td>
<td>Marcela Carena, Shoji Asai</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>51</td>
<td>Accelerator Science and Technology</td>
<td>Caterina Biscari, Lenny Rivkin</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>20</td>
<td>Beyond the Standard Model at colliders (present and future)</td>
<td>Gian Giudice, Paris Sphicas</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>31</td>
<td>Strong interactions (perturbative and non-perturbative QCD, DIS, heavy ions)</td>
<td>Krzysztof Redlich, Jorgen D’Hondt</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>27</td>
<td>Neutrino physics (accelerator and non-accelerator)</td>
<td>Stan Bentvelsen, Marco Zito</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>35</td>
<td>Instrumentation and computing</td>
<td>Xinchou Lou, Brigitte Vachon</td>
</tr>
</tbody>
</table>

- Open Symposium organized based on written inputs.
Canadian input to EPPSU

- Canadian submission prepared by IPP, CINP, TRIUMF and SNOLAB.
  - McDonald and Perimeter Institutes also reviewed and provided input.

- Submission based on 2017-21 Canadian Subatomic Physics Long Range Plan (LRP), including updates since the last LRP broad community consultations.

- Canadian submission attached to agenda.
Open Symposium

- Symposium consisted in both parallel and plenary sessions, organized and convened by members of the Physics Preparatory Group (PPG).

- Parallel sessions were organized around 8 different themes:
  - Accelerator science and technology
  - Instrumentation and computing
  - Electroweak physics
  - Strong interactions
  - Neutrino physics
  - Beyond Standard Model at colliders
  - Dark matter and dark sector
  - Flavour physics and CP violation

- Symposium schedule designed to provide sufficient time for detailed discussion.

- 603 participants
Perspectives from the Americas

"Perspective on the European Strategy from the Americas"

Planning and Executing

Year: 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27

Europe planning
U.S. planning
Canada planning

Executing the current plan

Europe input
LA planning
Canada planning
U.S. planning

Young-Kee Kim, University of Chicago
Next collider(s)?

• What is the best implementation for a Higgs factory?

• Path towards the highest energies: how to achieve the ultimate performance?

• How to achieve proper complementarity for the high intensity frontier vs. the high-energy frontier?
## Future Colliders

<table>
<thead>
<tr>
<th>Collider</th>
<th>Type</th>
<th>$\sqrt{s}$</th>
<th>$P \ [%]$</th>
<th>N(Det.)</th>
<th>$L_{\text{inst}} \ [10^{34} \text{ cm}^{-2} \text{s}^{-1}]$</th>
<th>$L \ [\text{ab}^{-1}]$</th>
<th>Time [years]</th>
<th>Refs.</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>HL-LHC</td>
<td>$pp$</td>
<td>14 TeV</td>
<td>-</td>
<td>2</td>
<td>5</td>
<td>6.0</td>
<td>12</td>
<td>[10]</td>
<td>HL-LHC</td>
</tr>
<tr>
<td>FCC-ee</td>
<td>$ee$</td>
<td>$M_Z$</td>
<td>0/0</td>
<td>2</td>
<td>100/200</td>
<td>150</td>
<td>4</td>
<td>[1]</td>
<td>FCC-ee</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$2M_W$</td>
<td>0/0</td>
<td>2</td>
<td>25</td>
<td>10</td>
<td>1-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>240 GeV</td>
<td>0/0</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$2m_{top}$</td>
<td>0/0</td>
<td>2</td>
<td>0.8/1.4</td>
<td>1.5</td>
<td>5</td>
<td>(+1)</td>
<td></td>
</tr>
<tr>
<td>ILC</td>
<td>$ee$</td>
<td>250 GeV</td>
<td>$\pm 80/\pm 30$</td>
<td>1</td>
<td>1.35/2.7</td>
<td>2.0</td>
<td>11.5</td>
<td>[3, 11]</td>
<td>ILC_{250}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>350 GeV</td>
<td>$\pm 80/\pm 30$</td>
<td>1</td>
<td>1.6</td>
<td>0.2</td>
<td>1</td>
<td></td>
<td>ILC_{350}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500 GeV</td>
<td>$\pm 80/\pm 30$</td>
<td>1</td>
<td>1.8/3.6</td>
<td>4.0</td>
<td>8.5</td>
<td></td>
<td>ILC_{500}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1 y SD before $2m_{top}$ run)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEPC</td>
<td>$ee$</td>
<td>$M_Z$</td>
<td>0/0</td>
<td>2</td>
<td>17/32</td>
<td>16</td>
<td>2</td>
<td>[2]</td>
<td>CEPC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$2M_W$</td>
<td>0/0</td>
<td>2</td>
<td>10</td>
<td>2.6</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>240 GeV</td>
<td>0/0</td>
<td>2</td>
<td>3</td>
<td>5.6</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLIC</td>
<td>$ee$</td>
<td>380 GeV</td>
<td>$\pm 80/0$</td>
<td>1</td>
<td>1.5</td>
<td>1.0</td>
<td>8</td>
<td>[12]</td>
<td>CLIC_{380}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 TeV</td>
<td>$\pm 80/0$</td>
<td>1</td>
<td>3.7</td>
<td>2.5</td>
<td>7</td>
<td></td>
<td>CLIC_{1500}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.0 TeV</td>
<td>$\pm 80/0$</td>
<td>1</td>
<td>6.0</td>
<td>5.0</td>
<td>8</td>
<td></td>
<td>CLIC_{3000}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2 y SDs between energy stages)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHeC</td>
<td>$ep$</td>
<td>1.3 TeV</td>
<td>-</td>
<td>1</td>
<td>0.8</td>
<td>1.0</td>
<td>15</td>
<td>[9]</td>
<td>LHeC</td>
</tr>
<tr>
<td>HE-LHeC</td>
<td>$ep$</td>
<td>1.8 TeV</td>
<td>-</td>
<td>1</td>
<td>1.5</td>
<td>2.0</td>
<td>20</td>
<td>[1]</td>
<td>HE-LHeC</td>
</tr>
<tr>
<td>FCC-eh</td>
<td>$ep$</td>
<td>3.5 TeV</td>
<td>-</td>
<td>1</td>
<td>1.5</td>
<td>2.0</td>
<td>25</td>
<td>[1]</td>
<td>FCC-eh</td>
</tr>
</tbody>
</table>

“Capability of future machines for precision Higgs physics”, M. Cepeda
Future Colliders

Proposed schedule

“Overview and technical challenges of proposed Higgs factories”, D. Schulte

Higgs @ Future Colliders Report: arXiv:1905.03764
Summary

- EPPSU process ongoing and to conclude with approval of strategy, by the CERN Council, in May 2020.

- CND written input to EPPSU was prepared by IPP, CINP, TRIUMF and SNOLab, with input from the McDonald and Perimeter Institutes, and submitted in December 2018.

- Open Symposium recently took place in Granada, Spain, 13-16 May 2019.

- Physics Preparatory Group (PPG) currently drafting the “Briefing Book” to be submitted to the European Strategy Group (ESG).

- Stay tune!
Additional Material
<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Secretary (Chair)</td>
<td>Prof. Halina Abramowicz (IL)</td>
</tr>
<tr>
<td>SPC Chair</td>
<td>Prof. Keith Ellis (UK)</td>
</tr>
<tr>
<td>ECFA Chair</td>
<td>Prof. Jorgen D'Hondt (BE)</td>
</tr>
<tr>
<td>Chair EU Lab. Directors’ Mtg</td>
<td>Prof. Lenny Rivkin (CH)</td>
</tr>
</tbody>
</table>
Physics Preparatory Group (PPG)

- **Strategy Secretary**
  - Halina Abramowicz (IL)

- **SPC chair**
  - Keith Ellis (UK)

- **Delegates nominated by SPC**
  - Caterina Biscari (ES), Belen Gavela (ES), Beate Heinemann (DE), Krzysztof Redlich (PL)

- **ECFA chair**
  - Jorgen D’Hondt

- **Delegates nominated by ECFA**
  - Stan Bentvelsen (NL), Paris Sphicas (GR), Marco Zito (FR), Antonio Zoccoli (IT)

- **Chair of European Lab Director meeting**
  - Lenny Rivkin (CH)

- **Delegate nominated by CERN**
  - Gian Giudice (CERN)

- **Delegate nominated by ICFA**
  - Americas: Marcela Carena (US) and Brigitte Vachon (Canada)
  - Asia: Shoji Asai (Japan) and Xinchou Lou (China)

[17 members]
Members:

- the Strategy Secretary (acting as Chair),
- one representative appointed by each CERN Member State,
- one representative appointed by each of the Laboratories participating in the major European Laboratory Directors’ meetings, including its Chair (CERN, CIEMAT (Madrid-Spain), DESY (Hamburg-Germany), Irfu (Saclay-France), LAL (Orsay-France), NIKHEF (Amsterdam-Netherlands), LNF (Frascati-Italy), LNGS (Gran Sasso-Italy), PSI (Villigen-Switzerland), STFC (Didcot-UK)),
- the CERN Director-General,
- the SPC Chair,
- the ECFA Chair.

Invitees: [~ 29 people]

- the President of the CERN Council,
- one representative from each of the Associate Member States,
- one representative from each Observer State,
- one representative from the European Commission,
- the Chairs of ApPEC and NuPECC,
- the Chairs of FALC and ESFRI,
- the members of the Physics Preparatory Group.