engineering & the future of accelerators @ CERN

Pushing LIMITS and boundaries in materials AND TECHNOLOGY
<table>
<thead>
<tr>
<th>Professional Category</th>
<th>Staff No.</th>
<th>Staff %</th>
<th>Fellows &amp; MPA (excl. users) No.</th>
<th>Fellows &amp; MPA (excl. users) %</th>
<th>Total No.</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research physicists</td>
<td>86</td>
<td>3.27</td>
<td>1,079</td>
<td>40.52</td>
<td>1,165</td>
<td>22.00</td>
</tr>
<tr>
<td>Scientific and engineering work</td>
<td>1,143</td>
<td>43.41</td>
<td>1,325</td>
<td>49.76</td>
<td>2,468</td>
<td>46.60</td>
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<tr>
<td>Technical work</td>
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<td>33.80</td>
<td>147</td>
<td>5.52</td>
<td>1,037</td>
<td>19.58</td>
</tr>
<tr>
<td>Manual work</td>
<td>57</td>
<td>2.16</td>
<td>19</td>
<td>0.71</td>
<td>76</td>
<td>1.44</td>
</tr>
<tr>
<td>Prof. admin work</td>
<td>175</td>
<td>6.65</td>
<td>45</td>
<td>1.69</td>
<td>220</td>
<td>4.15</td>
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<tr>
<td>Office and admin work</td>
<td>280</td>
<td>10.63</td>
<td>46</td>
<td>1.73</td>
<td>326</td>
<td>6.16</td>
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<tr>
<td>Office work</td>
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<td>0.08</td>
<td>2</td>
<td>0.08</td>
<td>4</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,633</strong></td>
<td><strong>100</strong></td>
<td><strong>2,633</strong></td>
<td><strong>100</strong></td>
<td><strong>5,296</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
2017 CERN DATA

Scientific and Engineering Work

2,468 out of 5,296

46.60% of CERN professionals

Research Physicists

1,165 out of 5,296

22% of CERN professionals
Dark matter

Dark energy

Anti matter

Revolutionary engineering
revolutionary engineering

FCC

- Novel Materials and Processes
- High-field Magnets
- Large-scale Cryogenics
- Power Efficiency
- Global Scale Computing
- Repair & Maintenance
- Reliability & Availability
• **Future Circular Collider (FCC)**
  Circumference: 90 -100 km
  Energy: 100 TeV (pp) 90-350 GeV (e⁺e⁻)

• **Large Hadron Collider (LHC)**
  Large Electron-Positron Collider (LEP)
  Circumference: 27 km
  Energy: 14 TeV (pp) 209 GeV (e⁺e⁻)

• **Tevatron**
  Circumference: 6.2 km
  Energy: 2 TeV (pp)
Curriculum

- Depends on every country
- 10th - 12th grades
- Different subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Course Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Fundamentals and Applications of Aquaculture and Food Processing in a Philippine Setting</td>
<td>AGRI1</td>
</tr>
<tr>
<td>Computer Science</td>
<td>Data Structures and Algorithm</td>
<td>CS5</td>
</tr>
<tr>
<td>Engineering Science</td>
<td>Special Topics in Engineering</td>
<td>ENGG</td>
</tr>
<tr>
<td>Technology</td>
<td>Design and Make Technologies</td>
<td>TECH</td>
</tr>
<tr>
<td>Science, Technology, Engineering, and Mathematics (STEM) Research 2</td>
<td>Knowledge Integration, Application and ExtensionResearch for a Sustainable Development</td>
<td>RES2</td>
</tr>
</tbody>
</table>
Problems we could find:

- Lack of time
- Lack of materials and resources
- Lack of motivation of our students
- Lack of mathematical skills
Abstract concepts
Physical world
Abstract concepts vs. physical world
But in reality...
How could we implement engineering and physics concepts in classroom?
A hands-on activity:

- Check prior knowledge
- Calculate parameters
- Construct and test a prototype
- Take and analyze data
- Make modifications to improve it
- Make connections to engineering and physics
Some useful links

https://www.teachengineering.org/
http://www.discovere.org/
http://teachers.egfi-k12.org/
https://tryengineering.org/
https://nscl.msu.edu/public/index.html
The Future of Accelerators

2012 Discovery of Higgs boson

2013 Studies for higher energy accelerators
Why a bigger accelerator?

- Find new heavier particles
- Improving resolution
How is it going to look?
Key technologies

16 T  High-field Magnets

\(\text{Nb}_3\text{Sn}\)  Novel Materials and Processes

Large-scale Cryogenics

Global Scale Computing

Power Efficiency
What can be done with future colliders?
"Of these four forces, there's one we don't really understand."
"Is it the weak force or the strong--" "It's gravity."
The standard model is considered “complete”, but there are still questions to be answered.

Future colliders may produce new particles which help us answer these questions.
Physics with Future Colliders

- LHC has a maximum beam energy of 14 TeV
- FCC could have maximum beam energy of 100 TeV
- This may reveal new particles!
What questions can we answer with future accelerators?

- What is dark matter?
- What is dark energy?
- Where is all the antimatter?
“The more important fundamental laws and facts of physical science have all been discovered...”
- Albert A. Michelson 1894
Should you go into physics today?
Should you go into physics today?

Engineering
Should you go into physics today?
Understanding how things work
Should you go into physics today?

Unraveling the mysteries of the universe
What has been achieved in the last few years:

Direct observation of a black hole

Actual image

Artistic rendering
What has been achieved in the last few years:

Measuring gravitational waves
What has been achieved in the last few years:

Discovering the Higgs boson
I am sorry to say, but professor Albert Michelson was wrong.
We are now manufacturing Anti-Matter

At cern Geneva
We are building magnets that were thought impossible before
Anti-proton cancer treatment,
This is Not science fiction, this is really happening!
Physics is advancing now more than ever.

Join us and change the world!
Thank you