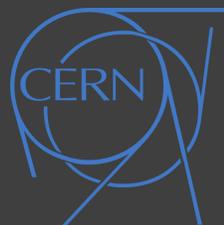




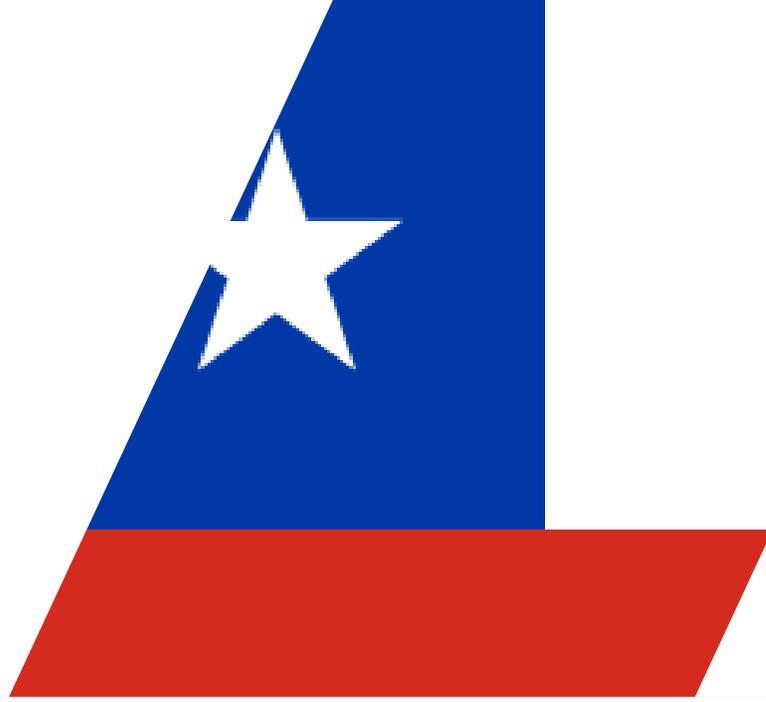
#ITW2019
Focus Group 5

Particle Physics & Errors and Uncertainty
16.8.2019 Geneva

Joseph Muise, Luis Filipe Afonso, Jamiu Temitope Aliyu,
Daniela Ambar Gayoso Miranda, Julia Janosikova







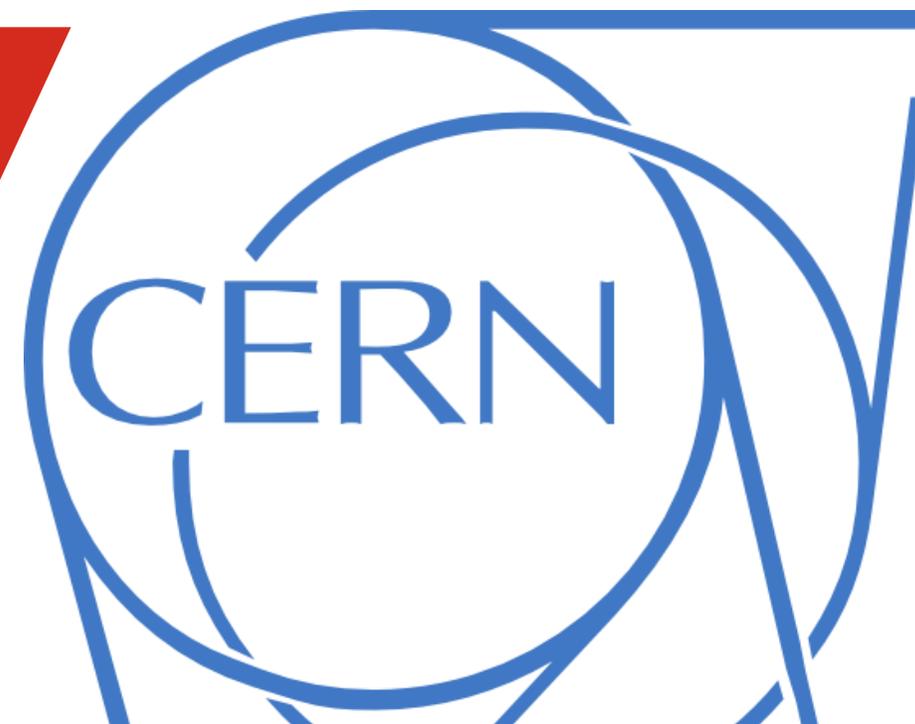




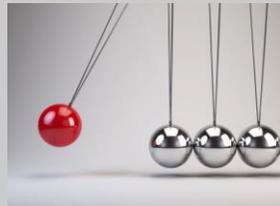
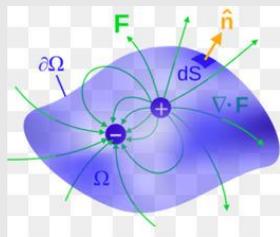




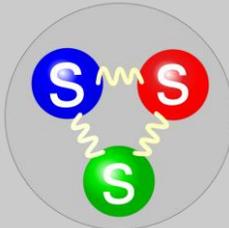
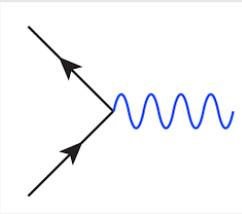
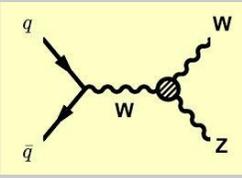
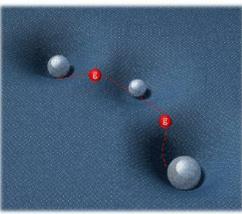
CERN



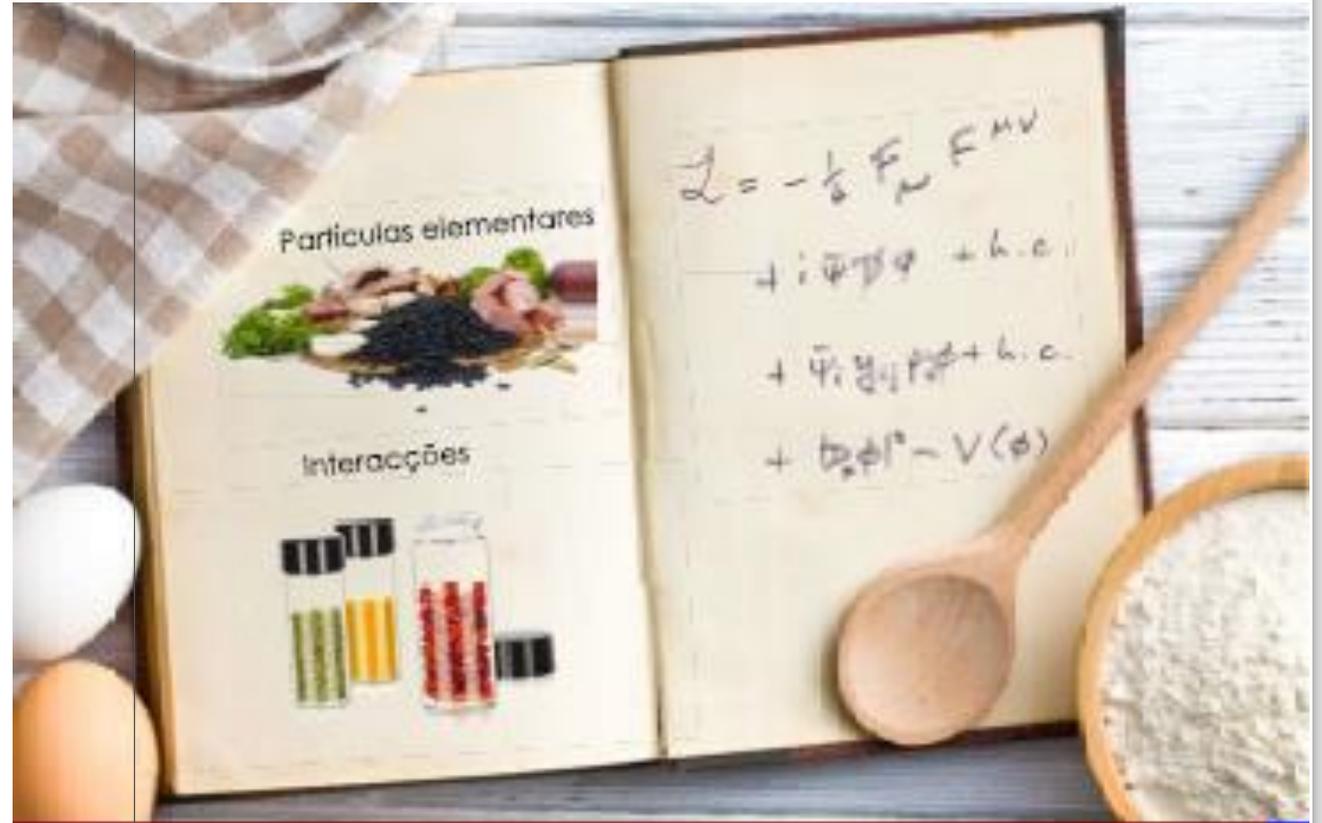
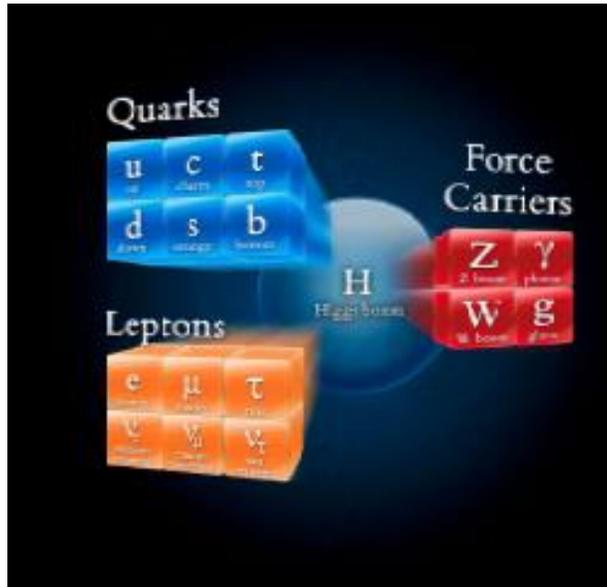
Before Particle Physics

Particle Properties	Field	Theory	Picture
mass	gravitational	Newton	 <p>http://bit.ly/2P74FTQ</p>
charge	electromagnetic	Maxwell	 <p>http://bit.ly/2Z0EXUH</p>

After - Four fundamental forces of nature

Interaction	Carriers	Theory	Picture
strong	gluons	quantum chromodynamics	 <p>Táto fotografia od autora Neznámy autor, platí licencia CC BY-SA</p>
electromagnetic	photons	QED	 <p>http://bit.ly/2MjJX0v</p>
weak	bosons w and z	electroweak	 <p>http://bit.ly/2Z4P4rl</p>
gravitational	gravitons	Relativity	 <p>http://bit.ly/2MjJX0v</p>

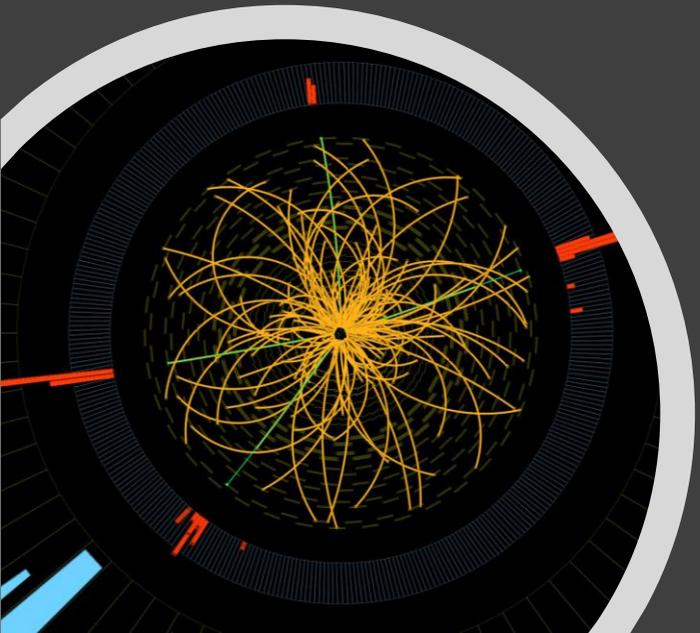
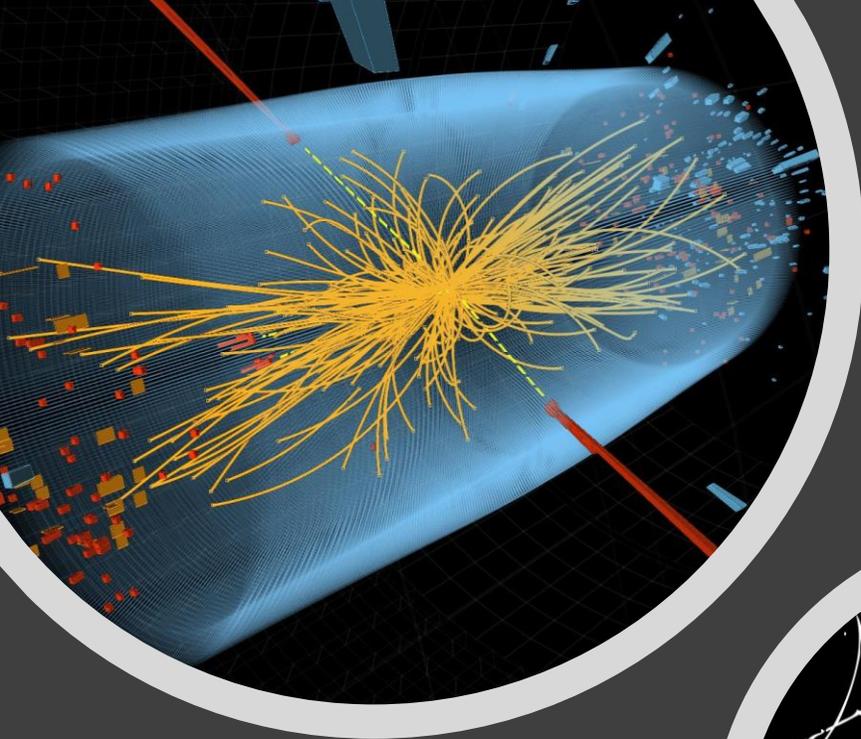
<https://indico.cern.ch/event/743767/timetable/>



<https://indico.cern.ch/event/664935/timetable/>

Potential students' conceptions & challenges

- Orders of Magnitude & error in physics
 - Error as bias & mistakes
 - Uncertainty as a limitation of measuring device
- Experimental design and dealing with error and uncertainty



Particle Physics and Error & Uncertainty

Key ideas

- Fundamental particles
- Particle system
- Particle properties
- Uncertainty
- Error
- Precision
- Accuracy





Educational Resources

By Perimeter Institute

Helpful material and resources

- **Perimeter Institute** - free resources created to help teach particle physics (and other topics)
- <https://resources.perimeterinstitute.ca/>

Detecting Alpha, Beta and Gamma Radiation

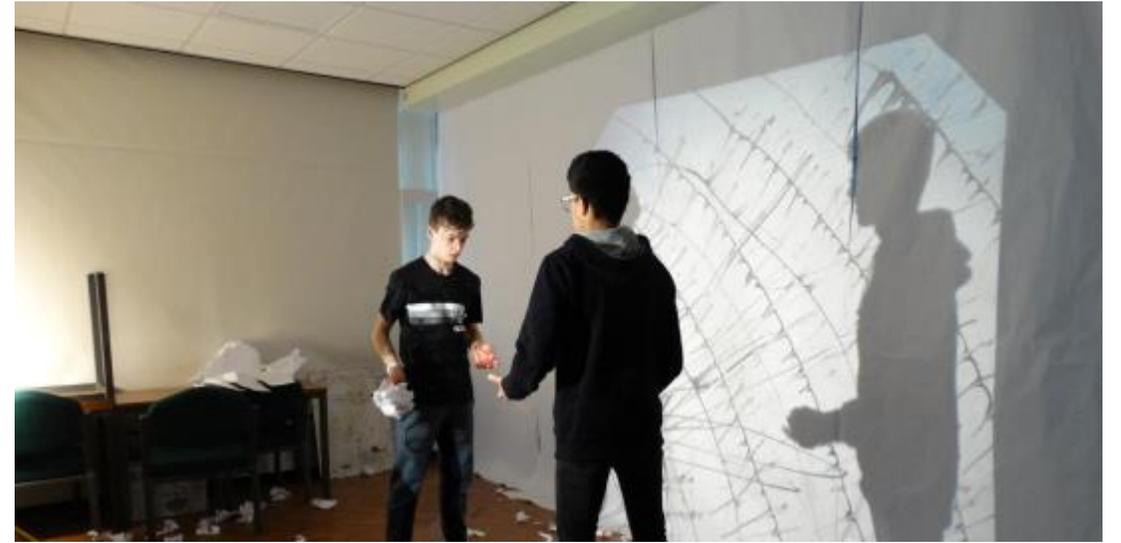
By: Microsoft Education & NASA | LAB PROCEDURE

HIGH SCHOOL LAB GUIDE >



Helpful material and resources

- **Help to explore space and particle physics**
- <http://bit.ly/2H6xJEi>



Helpful material and resources

- **Arts and Particle Physics workshop: Ian Andrews and Konstantinos Nikolopoulos**
- <http://bit.ly/2KyWsmM>



Helpful material and resources

- **Dance and Particle Physics: Mairi Pardalaki and Konstantinos Nikolopoulos**
- <http://bit.ly/2N6a5fa>



Helpful material and resources

- **Particle physics workshop for primary school:** Cristina Lazzeroni Maria Pavlidou
- <http://bit.ly/2MjdoQy>



Helpful material and resources

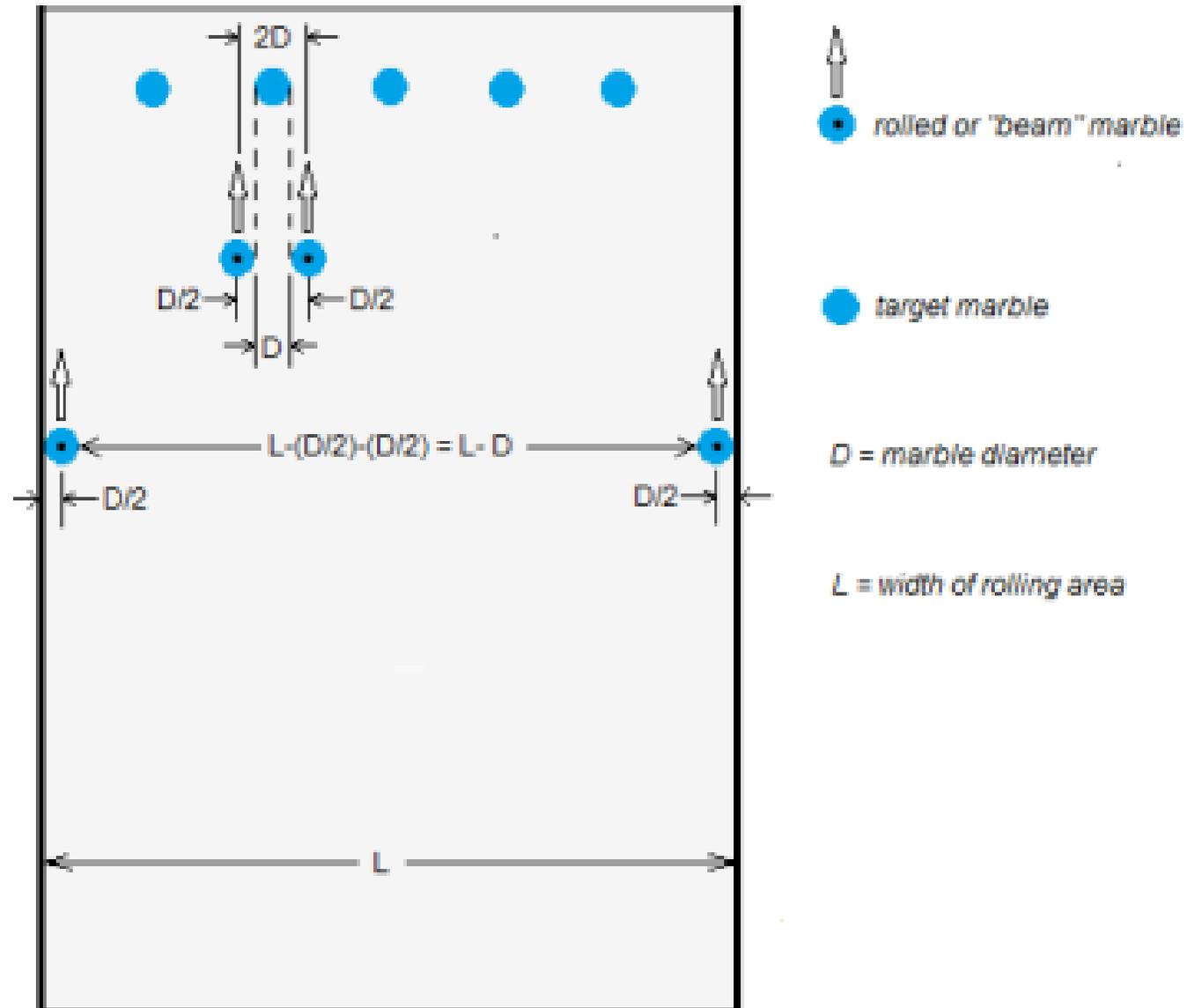
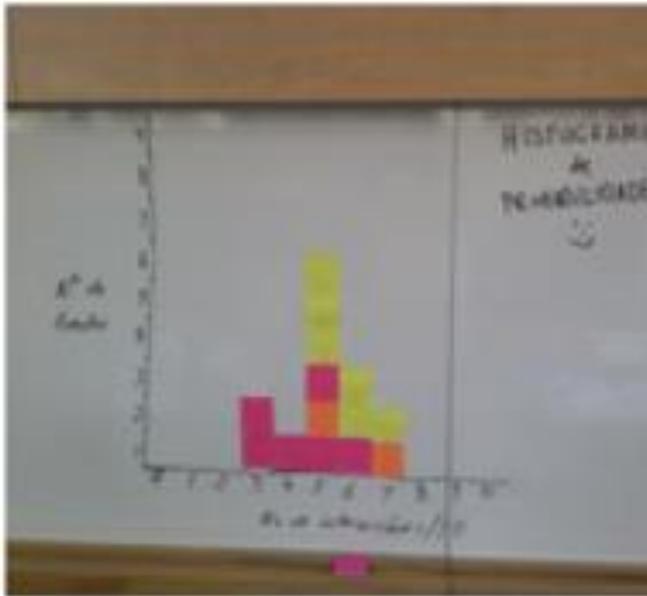
- Particle Physics Plushies
- <http://bit.ly/2YRymfK>

Best practice example

- Development of the standard model, building from macroscopic to sub-atomic.
 - Parallel to understanding of living things (Organism, Systems, Organs, Cells, Organelles)
 - Quantum 3
- Making models / analogies to explain physics concepts
 - Higgs Model - snow field
 - Basketball example: accuracy vs. precision.
 - Address limits of models

Best practice example

- Error & Uncertainty
- Rolling with Rutherford (Quarknet)
- <http://bit.ly/2H7FOZy>



$$P = ND/L$$



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