LHC Workshop Outline

Welcome and Introductions

Administrative Information

- Workshop goals
- Expectations (teachers, facilitators)
- Logistics—parking, lunch, bathrooms, etc.
- "Parking lot" for questions

Introduction: Enduring Understandings

- Basic research is a journey—not an event.
- The Standard Model is the current framework for our understanding of matter.
- The LHC and the detectors are designed to address fundamental questions not explained by the Standard Model.

Pre-Topic: The Standard Model

Resources Exploration

Activities

1. The Particle Adventure – The Standard Model – an interactive tour (from CPEP)
2. Quark Workbench – Using quark "puzzle pieces" of mesons and baryons to learn rules that describe their structure
3. Quark Applet - Quark combinations that show resulting particles
4. Fermilabyrinth – Law 'n Order - Online games (Fermilab's Lederman Science center exhibits)

Additional Resources

5. The Standard Model – Short description (from the SLAC Virtual Visitor Center)
6. The Standard Model - The Standard Model and more (from CERN)
7. What is the world made of? - Introduction for Inquiring Minds (from Fermilab)
8. The Standard Model of Particle Physics - Bit of history about organizing particles by characteristics (CERN YouTube video)

Topic 1: Testable Ideas

Resources Exploration

Activities

1. Higgs Reception - Classroom simulation of the Higgs cartoon
2. Run II Website - Run II data analysis of W and Z as precursor to the search for Higgs

Additional Resources

3. Higgs Cartoon - Cartoon analogy explaining the Higgs mechanism as a cocktail party (D. Miller and CERN)
4. Search for Higgs News Stories - *CERN Courier* and *Fermilab Today* articles from 1999 to 2011
5. Time Machine - Completing the journey back to the beginning of time (CERN video, 1998)
6. A subatomic venture - LHC physics, questions the LHC will address (from CERN)
7. LHC Physics - Questions the LHC will address (from US/LHC)
8. LHC Big Questions - PPT (from LHC fellows)

Talk/Discussion
What the Standard Model has told us. What secrets still remain?

Topic 2: Accelerators and Detectors

Resources Exploration

Accelerator Activities

1. Making it Round the Bend - Exploration of the basic physics at the heart of accelerator design
2. CERN Control Room Game – Dofferent workshop simulations preparing parts of the accelerator
3. Fermilabyrinth – Warp Speed – Online games (Fermilab's Lederman Science center exhibits)

Detector Activities

4. Make a Cloud Chamber - One of many sites for building a cloud chamber (Student Video of a cloud chamger (requires Windows Media Player))
5. Mass Calorimeter - Determine an unknown mass by building and calibrating a simple tabletop calorimeter.
6. Animation of CMS Wedge - Trace particle paths through CMS. (adapted by L. Quigg from CMS animation)
7. Fermilabyrinth – Ghost Bustin' - Online games (Fermilab's Lederman Science center exhibits)

Additional Resources

8. CERN – Building the LHC (*NOVA scienceNOW,* July 2007*)*
9. LHC Rap, 2008
10. US/LHC for Teachers and Students - Portal to all things LHC (from the U.S. community)
11. Overview of the LHC – PPT (from the LHC fellows)
12. ATLAS Built in 1, 3 or 5 Minutes - Video compiled from ATLAS webcam footage and still photos
13. History of Particle Detectors - PPT (from LHC fellows)
14. ATLAS Detector – PPT (from LHC fellows)
15. CMS Detector - PPT (from LHC fellows)

Talk/Discussion
Why do we need the LHC? Why not the Tevatron? Detectors measure energy and momentum

Topic 3: Data, Claims and Reasoning

Activities Exploration

Activities

1. Top Quark Mass - Investigation using vector addition to calculate the mass of the top quark
2. Rolling with Rutherford - Practice making indirect measurements
3. U.S. Penny Activity - Graphing penny mass as a way to understand particle mass plots
4. Online CMS Event Display - Exploration of CMS events (used in CMS e-Lab and masterclass)
5. CMS e-Lab - Investigations with CMS data (from I2U2)
6. CMS Masterclass – Teacher Pages - Exercises with CMS data (from QuarkNet)
7. ATLAS Masterclass - Exercises with ATLAS data (from IPPOG)
8. HYPATIA - Study particles through the inspection of the graphical display of ATLAS events.

(from University of Athens & Institute of Physics Belgrade)

9. Fermilabyrinth – Code Crackin' - Online games (Fermilab's Lederman Science center exhibits)
10. Sigma Lifetime Exercise – Advanced problem set using bubble chamber data

Additional Resources

11. What We Do Is Not in the Textbooks - Meet ATLAS physicists. (ATLAS YouTube video 2009)
12. Particle Hunters - Meet CMS physicists. (CERN video, 2004)

Talk/Discussion

Recent "bumps" and what they really mean. A discovery may appear when something unexpected happens in the data.

Topic 4: New Physics

1. Higgs – Is Higgs the mechanism responsible for mass?
2. Supersymmetry (SUSY) – Are particles paired with superparticles?
3. Dark Matter – What is dark matter?
4. Heavy Gauge Bosons – Are there heavy bosons?
5. Compositeness – Are there smaller structures hidden within quarks, leptons and force carriers?
6. Fourth Generation Particles – Did nature stop at three generations of quarks and leptons?
7. Extra Dimensions – Does our universe contain extra dimensions? Would that help us understand gravity?
8. Matter-Antimatter Asymmetry – What happened to the antimatter?
9. Technicolor – What is technicolor?

Wrap up
Classroom Reflection/Discussion
Evaluation