Five-Day Unit in Particle Physics for the Introductory Physics Classroom

Day 1

Introduction:

We would like the students to understand why high-energy physics is asking the questions they are asking. Today the students will explore a mythical universe and the particles and forces that make up that universe. Students will understand that these same questions are the ones that have puzzled humans throughout time. Students will also get an introduction to current particle physics terminology and be introduced to the basics of theory formation.

Materials for the Day:

Make student copies of "How Does the Universe Work?," pages 10 and 11 in the TMP Book.

Make student copies of page 2 and "Ultimate Periodical Table," pages 29-33 in the TMP Book.

Make overheads of page 2, page 6, page 9 (for day 3 summary discussion), page 11, and locate a copy of the Periodical Table used in a typical Chemistry class.

Timeline:

10 Minutes	Discuss overhead (p. 6), and evolution to the Periodic Table (try to pay attention to what students already know).
10 Minutes	Pass out and introduce "How Does the Universe Work?" See teacher notes on page 8 of the TMP Book (communicate to students that each group will be expected to write a model to be discussed on day 3).
25 Minutes	Students work in small groups brainstorming models for "How Does the Universe Work?"
5 Minutes	Hand out and point out key features of page 2 from the TMP Book and the "Ultimate Periodic Table Worksheet," pages 29-33 of the TMP Book (point out that this represents the ultimate particles and forces for where we are now).

Assignment:

"How Does the Universe Work?" models due day 4.

"Ultimate Periodic Table," pages 29-33 of the TMP Book due day 3.

Day 2

Introduction:

Today you and your students will develop an understanding of indirect measurement and the importance of this in particle physics. Today students will learn one technique used in particle physics to answer questions about unseen particles. Indirect measurements can provide experimentalists with accurate and precise results.

Materials for the Day:

Make student copies of pages 25 and/or 26 and "Student Worksheet," page 27. Be sure to read "Teacher Notes" on page 24 of the TMP Book. Please understand that these represent the solution, not the preparatory discussion.

One piece of carbon paper per group.

One marble per group.

Timeline:

5 Minutes	Introduce the task as presented in the "Teacher Notes." In discussion, develop a method for determining the radius of a single circle using only the carbon paper and marble. (Ask students what they do know and what they do not know . . . they can count the circles and they know the equation for the area of the circle and the area of the paper.)
30 Minutes	Data gathering and calculations by students for the radius of a single circle. Students may report their results on the front board.
15 Minutes	Discuss student data and analyze the methods used and results achieved by each group. The key is to point out that these accurate and precise results were obtained without a direct measurement. One can also discuss the applications of this measurement to Rutherford's Gold Foil Experiment and lead to discussion of what can and can not be measured directly in a physics lab.

Assignment:

Remind students that "How Does the Universe Work?" models due day 4.

"Ultimate Periodic Table," pages 29-33 of the TMP Book due day 3.

Day 3

Introduction:

Today you and your students will sit back and learn together how the game of particle physics is done today (including its agonies and defeats). Scientist will share their enthusiasm for particle physics and help students understand the machines and processes used today. Students will expand their familiarity with key terms and concepts presented in day one.

Materials For The Day:

Nova's "Race For The Top Quark"

Available through: Coronet Film and Video
108 Wilmot Road
Deerfield, IL 60015
1-800-621-2131

VCR Player

Timeline:

50 Minutes	This is a great video, but its length may cause students' minds to wander. Remind students that they should take notes on key concepts or questions generated during the video. (At some point, check that pages 29-33 are complete.)

Assignment:

Remind students that "How Does the Universe Work?" models due day 4.

Day 4

Introduction:

We would like the students to correlate and synthesize the ideas presented in days one and two. Students will see how their theories compare and compete with other student theories. Further, through the analysis of "The Ultimate Periodic Table" we will see how The Standard Model of matter represents our understanding today of basic objects and forces of the universe.

Materials for the Day:

Make student copies of page 34 in the TMP Book.

Make overhead copies of pages 29-33 and fill in the correct answers to facilitate discussion of student questions.

Timeline:

20 Minutes	Hand out answers and discuss questions from "The Ultimate

	Periodic Table" and correlate questions and answers to the "Race for the Top Quark" video.
30 Minutes	Student presentations and discussions of their models. (Focus discussion on the diversity of models as well as properties of well-formed models).

Assignment:

Generate a short written assessment that allows students to answer the following questions (or other questions you determined are important):

What did you come to understand?

What confused you?

What do you still have questions about?

Day 5

Introduction:

We would like the students to use **real data** actually collected in 1995 at Fermilab in Batavia, IL and used to determine the existence and mass of the top quark. Students will use familiar techniques of analysis to determine the mass the most recently discovered quark, that of the top quark. Students will also gain an understanding that mass and energy are one in the same thing!

Materials for the Day:

Make student copies of pages 18 and 19 in the TMP Book. Carefully review notes on pages 12-17 in the TMP Book. Make transparencies where appropriate for a 10-minute introduction of method.

Make overhead copies of page 13 in the TMP Book.

Pull out the colored computer plots at the end of the TMP Book. If students will mark on these, laminate or put them in protective sleeves to protect them.

Timeline:

10 Minutes	Pass out student worksheets and color plots (one set per group). Review directions with students as stated in the TMP Book on pages 12-17.
20 Minutes	Data gathering and calculations by students for the mass of the top quark. Students may report their results on the front board.
20 Minutes	Discuss variances and correct any mistakes in results. Once the momentums have been determined, determine the total

energy present in the collision, and use the energy values and the energy-mass equivalence to actually calculate the mass of the top quark!

Assignment:

Generate a short written assessment that allows students to answers the following questions (or other questions you determined are important):

What did you come to understand?
What confused you?
What do you still have questions about?

Extensions

These could be extra credit or supplemental activities to the unit.

EXTRA CREDIT/SUPPLEMENTAL OUTSIDE CLASSROOM

Some of these suggestions are for teachers and students who are in our area of Fermilab; you may adjust by adding activities that are close to you that may also have exhibits or information on high-energy physics.

1. Visit a local or private particle physics facility such as Wilson Hall at Fermilab and take the self-guided tour. Write a report.

2. Visit a local museum exhibit such as The Lederman Science Education Center at Fermilab. Write a report.

3. Visit a high-energy physics Web site (Page 62 of the TMP Book). Write a review of the site.

4. Pick a topic of further study that you would like to explore, do a library or Web search and report.

5. Try one of the computer programs available (Pages 58-62 in the TMP Book). Write or print a simulation.

6. View Creation of the Universe video and fill in the accompanying worksheet supplied with the video or have students create their own worksheet.

7. Have students create their view of a helium atom incorporating standard model particles and forces in some visual media (T-Shirt, Poster, Computer Program, Sculpture, Mobile, etc.).

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