Inside the Collision

How accelerator evidence tests the Standard Model

HS-PSII-10.5 "Know and describe how a particle accelerator functions and how current high energy particle physics experiments are being used to develop the Standard Model."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline what gives the proton beams energy and guides them, then circle what detectors record. Number two ways scientists use collision evidence to test the Standard Model.

From Proton Beams to Evidence

1. At CERN's Large Hadron Collider, protons travel in bunches through a ring beneath the ground. Electric fields in radio-frequency cavities give the bunches energy each time they pass. Magnets bend the beams around the ring and focus them into narrow streams. Two beams travel in opposite directions and cross at chosen points. When protons collide, some of their motion energy can become the mass of new, short-lived particles. Higher collision energy makes heavier particles possible.

2. The new particles often disappear too quickly for a detector to see directly. Instead, layers of sensors around a collision point record the paths of charged particles and the energy deposited by collision products. Scientists combine these signals to infer what formed in the collision. In 2012, experiments at the collider found evidence of a particle consistent with the Higgs boson by studying its decay products. The discovery confirmed a major prediction of the Standard Model.

3. The Standard Model describes known fundamental particles and three of the four fundamental forces, but it does not explain everything. Today's collider teams measure how often the Higgs boson and other particles are produced and how they decay. They compare those measurements with the model's predictions, accounting for uncertainty. Close matches strengthen the model's tested predictions. A persistent, well-checked difference could reveal a missing piece, but a single surprising event is not enough to change the model.

2 ANSWER WITH EVIDENCE

Use the passage

1. How do electric fields and magnets work together to make proton collisions possible?

2. How can scientists study a short-lived particle that a detector cannot see directly?

3. How did the collider experiments test a Standard Model prediction in 2012?

4. Why do teams compare many collision measurements with predictions instead of changing the model after one surprising event?

3 YOUR TURN

Your own words

A team measures more of one Higgs decay pattern than the Standard Model predicts. In three sentences, explain how the accelerator and detector produced this evidence and what the team should do before proposing a change to the model.

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PART 1 · READ AND MARK

Underline what gives the proton beams energy and guides them, then circle what detectors record. Number two ways scientists use collision evidence to test the Standard Model. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	How do electric fields and magnets work together to make proton collisions possible?	**Electric fields give proton bunches energy. Magnets bend and focus the opposing beams so they cross and collide.**
2	How can scientists study a short-lived particle that a detector cannot see directly?	**They record the paths and deposited energy of collision products, then use those signals to infer the particle that formed.**
3	How did the collider experiments test a Standard Model prediction in 2012?	**They studied decay products and found evidence of a particle consistent with the predicted Higgs boson.**
4	Why do teams compare many collision measurements with predictions instead of changing the model after one surprising event?	**They must account for uncertainty and check whether a difference persists. One event is not enough evidence to change the model.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Electric fields raise the energy of proton bunches, and magnets guide them into collisions that can produce Higgs bosons. Detectors record the paths and deposited energy of decay products, allowing the team to measure how often the pattern occurs. The team should gather more data and check uncertainties to see whether the difference persists before proposing a change to the Standard Model.

Accept descriptions that connect beam acceleration and steering to collisions, detector signals to inferred particles, and repeated measurements to tests of predictions. Do not accept a claim that one unexpected event disproves the model.