Preface

By any measure, the Large Hadron Collider is exceptional.

When the LHC begins taking data in 2008, the world's biggest experiment will be underway. The size of the undertaking is massive: thousands of scientists working at an accelerator nearly 30 km in circumference. The detectors responsible for recording the collisions have weights measured in the thousands of tons and are tens of meters on a side. The cost for this experiment is billions of dollars. Detector precision, data rates and storage, are all unprecedented.

Why take on such a massive project? Why do particle physicists, cosmologists, and others around the world so eagerly anticipate these data? It is because this machine may point the way to answer some truly fundamental questions that have puzzled scientists for decades.

Perhaps foremost among these questions is this: what lies beyond the Standard Model of particle physics? For while the Standard Model is a remarkable theory — it has thus far passed every test made at a particle accelerator — we know it must be incomplete. For example, it cannot account for the Dark Matter that we now know pervades out universe. It also provides several theoretical hints that it is not the whole story. The Standard Model's approach to the breaking of electroweak symmetry is a single new particle, the Higgs boson. While economical, this approach appears at odds with the current understanding of naturalness in physics. The LHC should finally provide definitive evidence for the physics that is responsible for the breaking of the electroweak symmetry, whether it be a single Higgs boson, or something more elegant.

The LHC will be the machine that leads us toward the fundamental theories that extend our knowledge beyond the Standard Model, and connects particle physics more strongly to cosmology. No amount of cosmology or astronomy can tell us what the dark matter actually is, or why the universe is made of matter and not equal amounts of matter and antimatter,

but the LHC may give us the data needed to answer these questions. It may also help formulate and test string theory. It is a discovery machine.

In this volume, we have tried to capture some of the excitement surrounding the impending LHC turn-on, the extraordinary detectors and experimental challenges, how the discoveries made there might unfold, and what they might mean for the future of particle physics.

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