Chapter 1 – Introduction – Big Science, Breakthrough Innovation and Society

No sub headings

Chapter 2 - CHASING SUCCESS: THE ATLAS AND CMS EXPERIMENTS

2.1 Introduction
2.2 Considerations leading to the two complementary general-purpose experiments
   The Role of ALICE and LHCb Experiments
2.3 The conception of the experiments
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   CMS
2.4 The evolution and construction of the experiments
   Some specific comment to ATLAS
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   Upgrades for the future high-luminosity phase of the LHC
2.5 Stories of successes or failures and lessons learnt
   2.5.1 CMS
   An example of complexity in construction
   An example of technological and economic evolution during the long period of construction
   2.5.2 Two examples from ATLAS (adapted from Ref. [15])
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2.6 General challenges and lessons learnt
2.7 The human factor
2.8 Concluding Remarks

Chapter 3 - DESIGN AND ENGINEERING INNOVATION – Intricacies of Precision, Accuracy and Imagination of Creating Old and New LHC

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   Birth of LHC
2.0 The design of the LHC
3.0 Magnets and cryogenics
   3.1 Machine layout
   3.2 Civil engineering
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1. Introduction: relation between science and technology
2. Superconductivity: an accelerator technology for society
3. Technical Challenges
   3.1 Challenges of contracts with industry
   3.2 Challenges of collaborations with institutions and universities
   3.3 Case study on accelerator technology: superconducting electrical transmission
4. Safety aspects
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6. Future technologies and application to society
7. Links of accelerator technology to society: climate change, archaeology and art
   7.1 Case study: Understanding our world. Informing climate change
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    7.3 Accelerator technology for cultural preservation
8. Concluding remarks

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5.2 What we do not know
5.3 What the FCC integrated programme offers
5.4 A puzzling particle
5.5 Dark secrets
5.6 Boldly Going where only the Universe has gone Before
5.7 Marching in unity: a brief lesson from the history of physics
5.8 *Shaping a vision for a new research infrastructure for the 21st century*
5.9 Advancing new technologies for new discoveries
5.10 Lessons and opportunities
5.11 Big Science & Public investment in fundamental science
5.12 Coda
5.13 Concluding Remarks

**CHAPTER 6 - COMPLEX SYSTEMS AND DESIGN THINKING** – CERN and European Innovation Strategy

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2.0 Knowledge Creation, Complexity and Design
3.0 Big Science, Knowledge Diffusion and Social Learning Cycle archetypes
4.0 Approaches and Practices of Design Disciplines
5.0 Diffusion by Design
6.0 Case 1. Design for Particle Physics. IdeaSquare, CERN: an experimental innovation platform within the organisation
7.0 Case 2. Design for Astrophysics. Museum Exhibition: balancing integrity of scientific truth with a meaningful visitor experience
9.0 Conclusion
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7.1 Leadership creating and shaping Big Science
7.2 Collective Leadership
7.3 Leadership Collisions
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7.5 Leadership as gender issue
7.6 Leadership from a machine or instrumentation builder
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8.2 Big science infrastructure in Astrophysics
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8.4 Innovation in global astronomy seen down under

8.4.1 A standard model
8.4.2 Global teams
8.4.3 Distributed opportunities
8.4.4 Radar to Radio
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8.5 Gravitational Waves and Big Science
8.5.1 History
8.5.2 Gravitational Waves: A Cascade of Scientific Breakthroughs
8.5.3 The Complexity of Gravitational Wave Detection
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9.4 Radiation, all its 50 shades of GyE and relevance to human health
9.5 Radiation in Medicine
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9.10 Convergence and intersections of technologies (NCEPT, multi-ion plasma, radioisotope development with accelerators)
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Chapter 10: Fundamental Science as a Complex Human Enterprise

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10.1 The Social Value of Basic Science
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   Science organisations
   The nature of the scientific process
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10.4 Valuating Science and the need of a new paradigm

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2.0 CERN openlab: a Public-Private partnership for Scientific and Technological Innovation
   CERN openlab: main Concept
3.0 Brief History
4.0 Collaboration principles: a Win-Win scenario
5.0 Education
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7.0 The case for social responsibility in the digital age
8.0 Public Science and Public Benefits – Well Ordered science.
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12.0 Role of Entrepreneurship is shaping people and nations
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   Enterprise as a Social Equity Mechanism
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   Reliable Knowledge and Entrepreneurship
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12.1 The Social Value of Basic Science: A Compass for Organizations
   Translation of Knowledge
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12.2 How to use big science ideas to social applications

12.3 From Fundamental Science Technologies to Business: Is it possible to Systematize Serendipity?
   Innovation Ecosystems: Systematizing Serendipity

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Chapter 13 - Future Physics- Asian Perspectives

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13.1 Characteristics of Asia’s Physics Community

13.2 What are enabling human and organisation factors that are necessary to induce Asian collaborations in physics

13.3 What are the key fundamental features underlying future physics – lessons from CERN, Europe and USA

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14.2 Knowledge and information flow in big science (SL)

14.3 Education strategies of large research infrastructures (CK)

14.4 The role of informal education in our classrooms (SG)

14.5 Global challenges facing science education (SG)
14.6 National and international science education networks (SG)

14.7 Coopetition – The collaborative aspects of large-scale science (SG)

14.8 Diversity and inclusion in big science (SG, VS & CK)

14.9 Implication of Big Science - Social Sciences perspectives and Future Skills (VS)

14.10 Science Enriching Other Disciplines Education (or Learning Experience)

14.11 Concluding Remarks

Chapter 15 – General Conclusion – all authors to contribute.