

BOOKSHELF

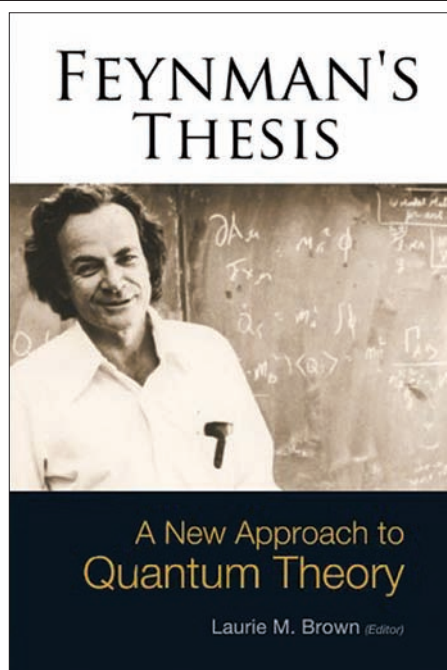
Feynman's Thesis: A New Approach to Quantum Theory by Laurie M Brown (ed.), World Scientific. Hardback ISBN 9812563660, £17 (\$28). Paperback ISBN 9812563806, £9 (\$14).

The title pretty much sums up this interesting short book, the latest Feynman work to be published since his death in 1988. It reproduces, in modern typeset, Feynman's PhD thesis entitled "The Principle of Least Action in Quantum Mechanics". In it Feynman outlined his brilliant reformulation of quantum mechanics in terms of the path integrals that now bear his name, together with two supporting papers and a preface.

Historians and physicists alike will enjoy this easy-to-read little book (119 pages plus the preface). Supplementing the thesis itself, which is just 69 pages long (if only all theses said so much in so little space), are reprints of Feynman's "Space-Time Approach to Non-Relativistic Quantum Mechanics", which was published in *Reviews of Modern Physics* in 1948 and Paul Dirac's "The Lagrangian in Quantum Mechanics". Dirac's paper is a little harder to find since it's from the *Physikalische Zeitschrift der Sowjetunion* and dates back to 1933. These provide excellent supporting material and in many ways bracket the thesis. Dirac's paper is not as widely read as it should be, and is of great importance as it provided much of the initial impetus for Feynman's work, making quite explicit the role of $\exp(iLdt/\hbar)$ as a transition amplitude between states separated by an infinitesimal time dt , and its connection to the classical principle of least action. Feynman's article is certainly well known and is perhaps rather more formal than the thesis itself, and therein lies much of charm of this book.

Brown also provides a 16 page introduction that essentially walks the reader through reading the thesis, summarizing the content of each section and adding many interesting historical anecdotes and quotations.

The thesis itself is a masterpiece of clear exposition. While there is little in the thesis that is likely to surprise most physicists, it is written in Feynman's uniquely chatty style, and reminiscent of the famous Feynman lectures. It is a delight to read and is likely to offer an insight, even to non-physicists, into both physics and the workings of Feynman's mind. I would not hesitate to recommend the book to anyone – working physicists, historians, philosophers and even "curious



fellows" who would like to "peek over the shoulder" of one of the 20th century's great physicists at work.

John Swain, Northeastern University.

Pioneers in Art and Science: Art, Poetry and Particle Physics by Ken McMullen (dir.), University of the Arts London and The Arts Council. DVD ISBN 072871096X, £14.99.

Where do art and physics meet, and what kind of interaction might they enjoy? In this hour-long film, CERN physicists Michael Doser (anti-hydrogen experimenter) and John March-Russell (theorist) talk to author and artist John Berger (best-known for his 1972 book *Ways of Seeing*) and Ken McMullen, artist and director of the film.

Their discussion is interspersed with sequences of sculptures, installations and other artworks inspired by particle physics – most from the Signatures of the Invisible exhibition of 2000–2001. I particularly liked Paola Pivi's *Prototype 3* installation of needles on wires performing a kind of synchronized dance and McMullen's work, *Lumen de Lumine*, featuring two women (or perhaps one woman, mirrored) whirling balls of light round and round in unison. There are also brief close-ups of famous physics equations being written on a whiteboard, for instance Paul Dirac's dynamics of spin 1/2 fermions (which led him to predict the existence of antimatter).

The core of the film is the frequently thought-provoking discussion between the scientists and artists. Subjects covered include the symmetry of physics equations versus the arrow of time; what Berger calls "the banal question" of how the huge costs of particle physics can be justified (to which Doser replies that, first, both art and science go beyond the everyday to give meaning to life and, second, pure research can give rise to wholly new types of technology, not just incremental improvements); the contrast between "risky" experiments that hope to gain fundamental insights and "safe" ones that accumulate data; classical versus probabilistic physics ("Where does necessity come into the quantum world?" Berger asks); the search for authenticity in art and for purity in science; and the mesmerizing quality that equations can hold for a physicist, even when they may be used to develop something like the H-bomb.

It is notable that the artists are asking the questions, and the physicists are providing answers. The flow of influence seems to be one way. The profound, often counter-intuitive ideas that science in general, and physics in particular, throw up – quantum theory, antimatter, chaos theory, multiple dimensions – provide non-standard concepts and metaphors to inspire artistic work.

How art might inspire or influence physics is less obvious. In the film, Doser and March-Russell don't ask Berger or McMullen about their techniques, purposes, or productions. But perhaps the art/science interaction is asymmetric. The general culture that art helps to shape is the pond in which the working physicist swims. And it's not just pure science that takes time – sometimes more than a century, as Doser points out – to be absorbed into the general culture; the same is true of radically new art.

Interactions of art and physics such as this film can play an important part in making scientific ideas more widely assimilated. Much work and funding go into sometimes rather patronizing efforts to increase the "public understanding of science" – as if bombarding children (and adults) with enough gee-whizzery is bound, sooner or later, to make them interested. This film, like the Signatures of the Invisible exhibition, stands for a more sophisticated and long-term approach, in which science, via art in this case, feeds ideas and inspiration to the broader culture.

• The DVD includes a number of additional items: extracts from the discussion not included in the main feature; a 15 minute film about the manufacture in a CERN workshop of McMullen's sculpture *In Puris Naturalibus*; and a reading and discussion of Simon Weil's poem, "Chance".

Michael Marten, Science Photo Library, London.

Books received

Theory of Neural Information Processing

Systems by A C C Coolen, R Kühn and P Sollich, Oxford University Press. Hardback ISBN 0198530234, £75 (\$154.40). Paperback ISBN 0198530242, £30 (\$64.50).

Presenting an explicit, coherent and up-to-date account of the modern theory of neural information-processing systems, this book has been developed for graduate students from any quantitative discipline, including physics and computer science. It has been class-tested by the authors over eight years and includes exercises, notes on historical background and further reading. Appendices provide further background, including probability theory, linear algebra and stochastic processes.

Hadronic Physics from Lattice QCD

by Anthony M Green (ed.), World Scientific. Hardback ISBN 981256022X, £54 (\$88).

The aim of this book is to introduce lattice quantum chromodynamics to non-specialists, in particular undergraduates and graduates, theorists and experimentalists, who have a background in particle and nuclear physicists. In particular it chooses topics that generally have analogies with more conventional areas in these fields, such as the interquark potential and interactions between hadrons.

Massive Neutrinos in Physics and Astrophysics, 3rd edition

by Rabindra N Mohapatra and Palash B Pal, World Scientific. Hardback ISBN 9812380701, £76 (\$103). Paperback ISBN 981238071X, £34 (\$46).

The third edition of this well-known book provides an up-to-date discussion of the latest



Art meets science: Paola Pivi and her installation of dancing needles, Prototype 3.

massive-neutrino results for the active researcher, and an introduction to various related theoretical and phenomenological issues for the non-expert. Elementary discussions on topics such as grand unification, left-right symmetry and supersymmetry are presented, and there is special emphasis on the implications of neutrino discoveries for the nature of new forces.

Selected Papers (1945–1980) With Commentary, 2005 edition by Chen Ning Yang, World Scientific. Hardback ISBN 9812563679, £29 (\$48).

First published more than 20 years ago, this collection of Chen Ning Yang's personally selected papers has been reprinted with the edition of two further articles published in 2003 and 2005. Supplemented with Yang's insightful commentaries, the book provides a valuable

window on research in physics from the end of the Second World War to the beginning of the 1980s. It includes the seminal work with T D Lee on the non-conservation of parity and the work with R L Mills that led to modern gauge theories.

Progress in String Theory: TASI 2003 Lecture Notes by Juan M Maldacena (ed.), World Scientific. Hardback ISBN 9812564063, £62 (\$108).

Intended mainly for advanced graduate students in theoretical physics, this comprehensive volume covers recent advances in string theory and field theory dualities. It is based on the annual lectures given at the School of the Theoretical Advanced Study Institute (2003), a traditional event that brings together graduate students in high-energy physics for an intensive course given by leaders in their fields.

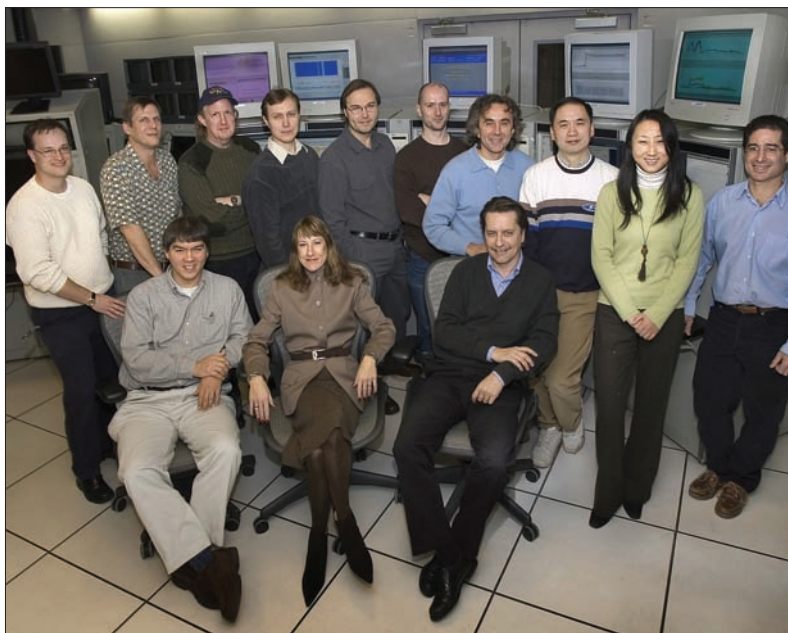
Time for accelerator experiments

Fulvia Pilat describes the work of the team that does machine physics experiments at Brookhaven's RHIC, to advance new techniques and understanding of the beams.

It is the owl shift on a Wednesday in the Relativistic Heavy Ion Collider (RHIC)/AGS Main Control Room (MCR). Instead of the usual quiet work of the night operation crew, who efficiently attend to the needs of the accelerators and the RHIC physics experiments, the MCR is bursting with activity. It is an accelerator-physics experiments (APEX) night: teams of physicists, supported by machine specialists and operators collaborate on testing the latest and newest beam techniques proposed for RHIC. Ever since its first years of operation, RHIC has not only fulfilled its main purpose of delivering luminosity to its physics experiments (PHENIX, STAR, BRAHMS and PHOBOS), but has also supported an organized beam-experiments programme.

The goals of the machine experiments are to explore new and advanced beam techniques, to foster machine performance, including development and testing of new diagnostics, and to widen the experimental understanding of accelerator physics. Beam experiments entail a longer time scale than the day-to-day optimization of machine performance: it typically takes a year for a technique successfully demonstrated in beam experiments to become fully operational.

The accelerator-physics programme for an upcoming run at RHIC is formulated and discussed at a regular summer workshop, and beam-experiment proposals are submitted in the autumn and reviewed and prioritized by an internal committee before the start of the run, typically in winter. Twelve hours a week for



The RHIC APEX team, standing from left: Gregory Marr, Mike Blaskiewicz, Waldo Mackay, Vadim Ptitsyn, Alexei Fedotov, Christoph Montag, Vladimir Litvinenko, Haixin Huang, Mei Bai, Rob Michnoff. Seated from left: Todd Satogata, Fulvia Pilat (APEX coordinator) and Thomas Roser. The other APEX team members not pictured above are Rama Calaga, Peter Cameron, Angelika Drees, Wolfram Fischer, Yun Luo, Nikolay Malitsky, S Y Zhang.

beam experiments are scheduled during the physics running time, with enough flexibility to minimize the impact on the overall programme.

The accelerator-physics topics that have so far received the most attention and effort are those aimed at overcoming limitations on the performance of RHIC, namely intra-beam scattering and the electron-cloud-induced pressure rise that occur during ion operations, and beam-beam effects and polarization during operations with polarized protons. Many of these performance issues at RHIC are common to other high-energy colliders.

Collaboration with other institutions and laboratories is a natural and strong component of the RHIC beam-experiments programme, and accelerator physicists from other laboratories actively participate in experiments of mutual interest. Colleagues

from CERN in particular have actively contributed to non-linear studies and the development of correction techniques that have eventually led to the reduction of the beam size at the experimental interaction point, resulting in increased luminosity. The development of new instrumentation and diagnostic techniques is another example of collaboration with CERN. These include the feasibility test of tune feedback during acceleration and the precise observation of electron-cloud formation – issues that are very relevant to the future performance of the Large Hadron Collider.

Future beam-experiments work at RHIC will focus on supporting and preparing for the planned RHIC upgrades: a ten-fold

increase in luminosity in RHIC heavy-ion collisions, made possible by a full-energy electron-cooling system planned for early in the next decade, and the eventual addition of an electron beam for electron-ion collisions. Near-term activities to support future projects include the development of a new magnet lattice with higher focusing to reduce the effect of intra-beam scattering, and tests of how the machine operates with an increased number of bunches.

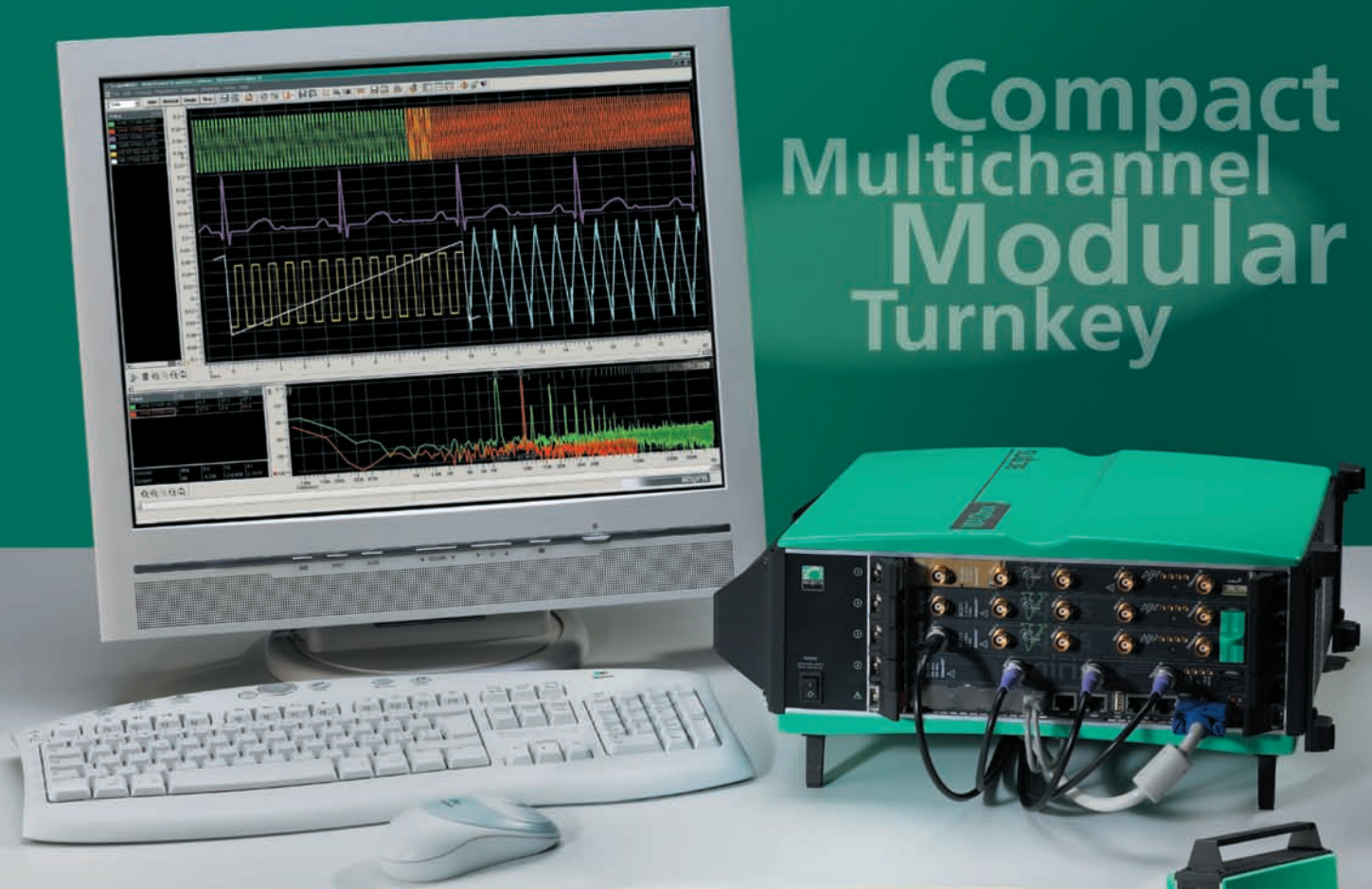
With Run 6 scheduled to start at RHIC in February 2006, after a couple of weeks of machine set-up and performance optimization, we are looking forward not only to delivering polarized-proton collisions to our physics experiments, but also to APEX with polarized proton beams.

Fulvia Pilat, APEX coordinator

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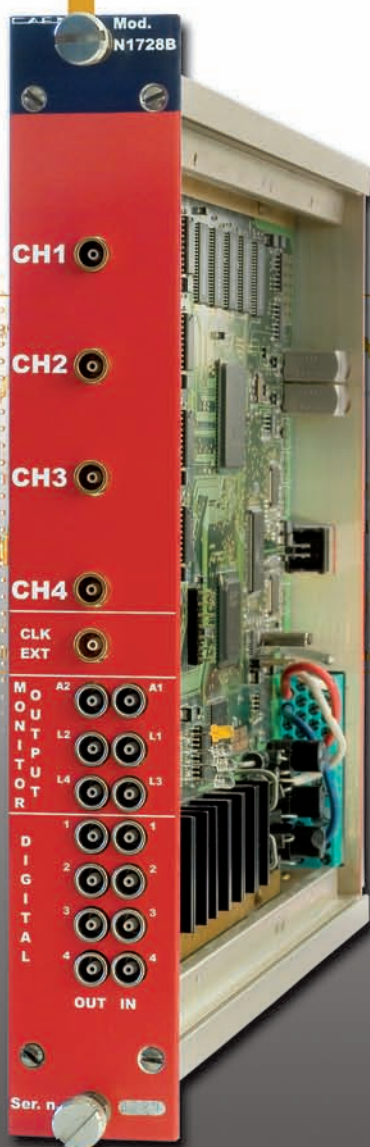
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Overview

The N1728 is a new NIM four-channel digital pulse processor and waveform digitizer.

The N1728 can work in "oscilloscope" mode, continuously storing waveforms (10 ms wide buffer with pre-trigger capability) and "Energy" mode, providing real time trapezoidal shaping, with a wide range of programmable filter parameters, and energy determination.

A dedicated digital trigger algorithm allows very low energy threshold operation ensuring immunity to noise effects. A digital Constant Fraction Discriminator (CFD) has been implemented for applications requiring accurate timing.

N1728 (NIM/USB2) 4 ch. 14 bit 100 MHz Digital Pulse Processor & Waveform Digitizer

Highlights

- 4 channel 14 bit 100 MHz FADC
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- "Energy" mode with real time trapezoidal shaping and energy determination
- Excellent integral linearity
- Digital trigger and CFD
- Trigger time stamping and counting information
- Base Line Restoration and pile-up rejection
- Programmable coincidence/veto time windows on all channels

Applications

- High resolution spectroscopy with germanium, silicon, CdTe, GaAs, HgI2 detectors in high counting rate environments
- Gamma ray tracking and Depth Of Interaction measurements in large volume segmented semiconductor detectors or PET systems
- Particle identification and n/γ discrimination in scintillation, semiconductor or gas filled detectors via Pulse Shape Analysis techniques