EPAC'94

Accelerators Remain a Driving Force

The Fourth European Particle Accelerator Conference (EPAC'94) that took place in the Queen Elizabeth II Conference Centre, London, on 27 June - 1 July attracted almost 750 participants from Europe, the USA, Japan, and other countries. As has become the tradition, the overall organization was impeccable, and with three days of plenary sessions and only two days of parallel sessions (giving a greatly appreciated minimisation of overlap), there were 28 sessions covering accelerator physics and technology as well as the use of accelerators for widely different applications. The number of abstracts exceeded 1000, almost 50% more than for the preceding EPAC. The invited papers were usually reviews offering a greatly appreciated and painless way to acquaint oneself with new fields. The proceedings, published by World Scientific, will be available shortly. Horst Klein, Chairman of the Programme Committee, noted in a humorous winding up to the conference that Sitges just south of Barcelona, the site of EPAC'96, will be somewhat different but also very agreeable.

In opening the scientific programme, Chris Llewellyn Smith (CERN's Director-General) deftly led the audience through recent experimental results that highlight the accuracy of the Standard Model but show that a better model is needed. He argued that there was a close match between the open questions and the accelerators being constructed or planned.

Light Sources Remain a Major Theme

Ian Gardner (Rutherford Appleton Lab), who chaired the EPAC'94 Local Organizing Committee, set the ball rolling by reviewing the status of ISIS, the RAL's 800 MeV rapid cycling synchrotron. It has reached its design intensity and improvements are foreseen, notably a 2nd harmonic RF system to allow a 50% increase in the beam intensity. On a larger scale, the European Synchrotron Radiation Facility – the world's first, major, third-generation light source which has its official inauguration on 3 September – now operates with a filling time of about 1 minute. During 1994, owing to vacuum system improvements, the lifetime at 100 mA has reached 56 hours (7 times the design value). Jean-Marc Filhol explained, in good humour, how the dynamic aperture had improved once the polarity of an incorrectly installed sextupole (one of 224) had been reversed. AC stabilization using an x-ray beam position monitor presently allows stabilization of insertion devices down to a few μm. Finally, a new High Quality Power Supply consisting of 10 diesel engine/alternator pairs giving 5 seconds autonomy will be installed to make the ESRF's accelerators less susceptible to thunderstorms. Albrin Wrulich described how the ELETTRA light source in Trieste stored its first beam last October after only three days of commissioning. The machine dynamics are well under control and the operating time for experiments is presently being increased to 55%. Mike Poole (Daresbury Lab) emphasised that synchrotron radiation has become a prime tool for research in industry and in a wide variety of sciences including biology. Some 54 storage rings for synchrotron radiation are in use around the world and European proposals (see table) are complementary to the ESRF. His review ended with a plea for a European VUV initiative to replace Super-ACO when it is closed down .

Proposed European synchrotron light sources

	Photons keV	Energy GeV	Current mA	Emittance nm.rad	Circumference m	Straight sections m
SLS	0.01 - 50	2.1/1.5	400	7.0 /3.6	230	18
SOLEIL	0.01 - 20	2.15	300	16	200	6
			60*	35		
ROSY	5 - 18	3.0	200	29	148	4
SLC	1 - 20	2.5	200-300	15-30	250	4
SINBAD	0.005 -0.2	0.7	300	10	100	15
DIAMOND	0.1 - 50	3.0	300	20	300	3

SLS: Swiss Light Source (Paul Scherrer Institute, Zurich): competitive with ESRF, but lower energy.
SOLEIL (LURE, Orsay): to replace LURE; many insertion devices; *: in 6 bunches.
ROSY: Rossendorf Light Source (Research Centre Rossendorf): medium emittance.
SLC: Synchrotron Laboratory of Catalonia (Barcelona): high flux/medium brilliance.
SINBAD (Daresbury Lab): to replace SRS; low energy/high brilliance.
DIAMOND (Daresbury Lab): to replace SRS; medium energy.

Major Facilities Progress

The performance of the world's largest collider (CERN's LEP machine) is limited by the beam-beam effect at the Z^0 energy (around 45 GeV beam energy) whereas the maximum intensity is limited at injection energy (20 GeV) by the transverse-mode coupling instability. Albert Hofmann showed how that despite the limitation by beam-beam effects, the design luminosity of 1.3×10^{31} cm^{-1} s^{-1} has been exceeded by some 50% and that the luminosity lifetime is much higher than expected. A unique performance limitation is the accuracy to which the beam energy must be known. The energy is calibrated by resonant depolarization of the beam and instantaneous measurements have been made down to accuracies of 1 in 10^5, although the operational knowledge of the energy throughout the year is significantly worse. The energy depends on a multitude of parameters, the most unusual being the lunar and solar phase, as well as the season of the year (wet and dry).

Bernhard Holzer (DESY, Hamburg) reviewed the HERA collider (now in its third year of operation). The integrated luminosity reached 1000 nb^{-1} in 1993, and this year after only about 30 days of operation it is more than half of last year's value. The num-

David Davis (Junior Minister for Science in the UK), photographed here giving the EPAC'94 opening address, emphasised the need to make the general public more aware of science. He went on to review the recent positive steps towards authorization of CERN's LHC machine.

Michel Olivier (CE-Saclay), who chairs the EPS Interdivisional Group for Accelerators (EPS-IGA) and the EPAC Organizing Committee, in opening EPAC'94 hoped that the attractive location would not be more interesting than the conference. Judging by the attendance right up to the very last session he need not have been worried.

ber of proton bunches has been increased to 170 and the bunch current increased to 300 mA. A sudden, unpredictable reduction in electron lifetime is attributed to the capture of micro-particles produced in the sputter-ion pumps and accelerated in the beam. The threshold for this effect has been increased by a factor of 5 by replacing a short length of beam pipe with integrated pumps. The big success story has been the production of longitudinally polarized beams following the installation of a spin rotator. With the rotator switched off, careful optimization produced 60% transverse polarization. The spin rotator was then switched on and almost miraculously, without any further adjustments, the longitudinal polarization rose to nearly 60% in just over one hour. HERA is now essentially running routinely with longitudinally polarized electrons.

Major new facilities are under construction, notably the Continuous Electron Beam Accelerator Facility (CEBAF) consisting of two 0.4 GeV linacs through which the beam passes 5 times giving an extraction energy of 4 GeV. Andrew Hutton reported that the linac had reached 110 mA (design 200 mA), and that a cryomodule of superconducting cavities had achieved a gradient of 8 MV/m with a beam (design: 5 MV/m). Dave Burke (Stanford Linear Accelerator Center) reported that the Final Focus Test Beam (FFTB) collaboration's very impressive test facility had met its design objective by producing beam spot sizes having the same demagnification as those assumed in designs for future linear colliders. Hospital-based radiation therapy units remain a dominant theme and Marco Silari (Milan) summarised an ambitious 1000 patients per year, hadron-therapy complex for Italy comprising a H^- synchrotron (60-250 MeV/10-20 nA proton beams). Two extraction channels would operate independently, with a possible upgrade to allow acceleration of light ions up to 400 MeV/u.

Accelerator Physics and Components

In a comprehensive report on the status of superconducting cavities, Bernhard Bonin (Saclay) pointed out that accelerating gradients in superconducting structures have been increased significantly in the last few years owing to improved cleaning techniques, high peak power RF processing, higher purity niobium, and improved heat treatments. High gradients have been achieved in several laboratories (notably for 3 Ghz, 1.8 K, 9-cell cavities made at Cornell and Wuppertal). Many are confident that these cavities will reach surface fields as high as 30 MV/m reliably (corresponding to a usable gradient of 15 MV/m). Nonetheless, while RF superconductivity has come of age it is still a long way from its ultimate possibilities.

In a very interesting presentation on a mm-wave linac and wiggler structures, Heino Henke (TU, Berlin) presented a new technology for fabricating accelerator components and wigglers based on silicon technology and high precision micro-mechanics (his pilot design was for a 50 MeV millimetre RF wavelength electron linear accelerator complex for producing coherent, tuneable synchrotron radiation - see cover). Solutions are apparently limited more by our imagination than by cost!

Comparisons of calculated and measured dynamic apertures in HERA were discussed by Frank Zimmerman (SLAC). This is an important issue for all present and future hadron or lepton colliders since the available current is directly related to the available dynamic aperture. The dynamic aperture is usually dictated by non-linear fields and its prediction is of crucial importance in ensuring that the required beam currents can survive. Zimmerman used for his tracking and analytical studies a very detailed model of the HERA magnets, including multipoles up to order 20. The predictions of dynamic aperture were optimistic by a factor of about two unless an assumed tune modulation was included. He concluded that the dynamic aperture for HERA's proton ring results from the combined effects of non-linear field errors, tune modulation and drifting magnetic parameters.

Martin Wilson, the Chairman of Oxford Instruments, speaking during the "Technology Transfer between Accelerator Laboratories and Industry" session which was organized and chaired by Neil Marks (Daresbury). It ended with an animated round-table discussion, led by Sergio Tazzari (INFN, Frascati), on the various needs for the future industrial development of accelerator technology.

Christine Petit-Jean-Genaz, the Executive-Secretary of both the IGA and EPAC, was as usual tireless in her quest for perfection.

Linear Colliders Need More Research

Wolfgang Schnell (CERN), in a very complete review of high-frequency linear colliders, explained that low frequencies favour efficient power transfer whereas high frequencies imply a short overall length and allow a higher accelerating gradient (since the onset gradient of dark current is proportional to frequency and that the stored electromagnetic field — proportional to the gradient of the wavelength squared — is greatly reduced). An interesting table illustrated the large divergence in opinions for the design of a 500 GeV linear collider for particle physics. After systematically analyzing the main issues (wakefields, accelerating structures, emittance control, RF power, final focus) with respect to the frequency, he concluded that a few more years of research are needed, along with exploitation of the various existing and proposed test facilities, in order to make a well-founded choice between the various proposals.

Accelerator-based mass spectrometry is an example of the diversity of modern accelerator physics and technology and the extent to which they impinge upon science. M. Suter (ETH, Zurich) described in detail the measurement of small concentrations of tracer isotopes which is the basis of dating using long-lived radioisotopes (for example, the Tyrolean iceman's age has been determined to be 4500 years). With presentations up to the last day on topics ranging from Φ-factories, accelerator research, medical applications, and high-energy beams in the universe, including cosmic rays, it is no wonder that most participants remained until the final talk before heading out into the hot, untypically British weather which we had enjoyed throughout the conference.

S. Myers, *CERN*

The Editor reviews the special session at EPAC'94 entitled "High Intensity Issues".

High Beam Intensity Comes to the Fore

Further Progress Needs New Machines

"Interesting applications that force innovation and development" was how Stan Schriber (Los Alamos National Laboratory) concluded his survey at EPAC'94 of proposed high-intensity accelerators and their applications. One is considering here accelerators with an average beam power of at least about 1 MW, typically 10-300 mA at 0.5-2.0 GeV as compared with existing state-of-the-art machines offering 45 mA at 35 MeV (Fusion Material Test Facility, Los Alamos,: commissioned in 1984) and 1 mA at 800 MeV (LAMPF, Los Alamos; commissioned in 1972). Using such devices, free-electron laser and neutral particle beam defense systems "got somewhere" before the US Space Defense Initiative discarded the directed energy approach. The technology that was developed is now being used elsewhere, and with the declassification last year of the US's defense-related work understanding will be extended.

Generally speaking, all reasonable applications of high-intensity accelerators need well thought out, robust, industrial-style, cost-effective, and safe designs with a high operating efficiency, a high power conversion efficiency and hands-on maintenance while ensuring precision control at high beam cur-