executed virtually unchanged by a single transputer, in which case the occam channels connect to memory locations. Of course processing is only truly parallel when more than one processor is involved in executing the program, but the transputer has special instructions that share the processor time between concurrent processes and inter-process communication, enabling a single processor to operate in quasi-parallel.

One of the first companies to put together complete systems built from transputers was the Bristol-based firm, Meiko Ltd. Their 'Computing Surface' is a modular system based on a hardware library of different board types, such as compute boards and graphics boards, which can be configured by means of electronic switching chips into a machine whose topology is appropriate to any given problem. At the University of Edinburgh, a large Computing Surface containing, at the time of writing, 200 T800 processors has been established in collaboration with Meiko. The Edinburgh Concurrent Supercomputer, as the machine is known, is already being exploited for a wide range of problems in science and engineering, including lattice QCD. We hope that this radically new machine will enable us to continue the attack on the problem of solving quantum field theories, to give us new insights into the sub-nuclear world.

We conclude by pointing out the existence of a number of other projects elsewhere in the world which are also exploiting the idea of parallel processing to attack the problems of lattice QCD. Special purpose computers have been constructed by groups at Columbia University and at Fermilab in the USA, at the University of Rome, and at Tsukuba in Japan. In each of these projects the computer architecture, although not exploiting transputers, is nevertheless based on a set of interconnected nodes, each containing fast floating-point hardware and large amounts of memory, allowing the geometric decomposition strategy outlined earlier to be adopted.

FURTHER READING

Physics on parallel computers

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Lattice QCD

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Transputers and occam

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Green Light for ESRF Red Book

After sheltering under the skirts of ILL for some 12 months the European Synchrotron Radiation Facility has finally emerged into the light. The formal Convention setting it up was signed in Paris on 16 December 1988 by the research ministers of eleven countries (see panel). France was represented by Hubert Curien the Minister for Research and Technology a most appropriate delegate as he was President of the European Science Foundation (ESF) for much of the "political" phase of the project.

The story of the ESRF goes back to 1975 when it became one of the first major studies of the ESF following its foundation in 1974. Through the initiative of H. Maier-Leibnitz a group was formed to consider the feasibility and usefulness of building a special purpose facility to span the X-ray region, based on a high current electron storage ring of 5-7 GeV. Their report (colour dark grey) which was presented to the ESF Assembly in November 1977 identified two light regions as being important — the UV and the X-ray and placed great hopes on the use of wigglers as a means of getting very high intensity in a narrow frequency range.

In addition to encouraging the parasitic use of high energy physics facilities, the report also recommended the establishment of a group to study the possibility of building a new (western) European X-ray synchrotron radiation laboratory starting in the 1980s. The report was endorsed and an *ad-hoc* Committee set up under Y. Farge, then Director of LURE at Orsay. This Committee, with its two Sub-committees — one for the machine chaired by D.J. Thompson from Daresbury, UK and the other for instrumentation chaired by B. Buras, from Copenhagen, Denmark, in turn produced its report, which came to be known as the Blue Book. In four volumes it established the general feasibility of the project, set out the scientific case, the basic machine design and the instrumentation required.

National projects seemed more important however, and while the Committee continued to improve the design and in particular develop the possibilities of undulators and wigglers, the project as a whole languished. Clearly a major political effort was needed and this was confided to an ESRF Progress Committee under Dr. Paul Levaux of Belgium. The Committee continued to work towards a solution to the funding question and a choice of site amongst the three put forward, namely Risø in Denmark, Trieste in Italy and Strasbourg in France. Later, Dortmund and (unofficially) ILL in Grenoble were added. A report was published (the Yellow Book) which updated the Blue Book and to avoid dispersing the technical group it was agreed to fund an ESR Project Group. This was formed in mid 1983 under B. Buras and

Contracting Parties

and contribution to construction costs exclusive of TVA

France	34%
Fed. Republic of Germany	24%
Italy	14.5%
United Kingdom	12.5%
Belgium	3%
Spain	4%
Nordic countries (DK, SF, N, S)	4%
Switzerland	4%

Machine Characteristics

Storage ring for electrons or positrons:
845 m round, 32 straight sections with ≥ 6 m between quadrupoles.

Experimental hall over ring accommodating beam lines up to 75 m long.

Beams at 6 GeV of *ca* 100 mA in multibunch mode, 5 mA single bunch;
No. of bunches 1-992; horizontal emittance 7×10^{-9} mrad, vertical 6×10^{-10} mrad.

Storage capability: > 8 hours for smooth fall to 1/e initial value.

Brilliance from undulator: > 10^{17} ph/s mrad^{2}mm^2 per 0.1% bandwidth and metre of undulator at 14 keV.

Flux: 8×10^{12} ph/s mrad per 0.1% bandwidth.

Photograph of a recent model of the ring and alongside, ILL.

S. Tazzari from Frascati, and located at CERN where it could take advantage of the infrastructure, the local expertise in accelerator design and the availability of big computers. Initially established for one year, its life was prolonged and successive improvements in design were made and reported in the Green Book, the first issue of which appeared in October 1984.

The Gordian knot that had developed was finally cut in 1985 by the joint announcement of France and the Federal Republic of Germany that they would guarantee up to 70% of the funding and the machine would be built in Grenoble. Denmark in particular was upset that international discussions had been bypassed and the claims of smaller countries again ignored. Strasbourg too was furious and expressed its choler in Le Livre Blanc. Nevertheless, in December of that year a memorandum of understanding was signed by France, the FRG, Italy, the UK and Spain which set up a Provisional Council and initiated the foundation phase. While details of the Convention and the Statutes were being worked out, site studies were made on the realism of placing it in the corner alongside ILL and early in 1986 a start was made on assembling a design and construction team under the Director General designate, R. Haensel previously Director of ILL. This produced in February 1987 the definitive project report, enshrined this time in the Red Book. In the December a protocol was signed which allowed the ESRF to begin functioning through the services of ILL.

The Convention covers the construction and operation of the European Synchrotron Radiation Facility on a site provided by France next to ILL in Grenoble. The executive instrument is a company subject to French law and in consequence subject to French value added tax. It will not benefit from the immunities granted to EC joint undertakings, but tax will not be levied on members' contributions and customs duties will not be applicable to goods imported by the company. The agreement is for an initial period of 19 years, automatically prolonged in three year steps unless participants announce their withdrawal. Until 31 December 2007, however, no retreat is allowed, although other countries are encouraged to join.

The full project is for a 6 GeV storage ring (see panel for details) with 30 beam lines to be realised in two steps. In the first phase due to be completed in mid 1994 and costing a maximum of 2200 MFF at January 1987 prices, the ring and associated facilities will be built and seven beam lines brought into operation. In the second phase due to terminate in 1998, the rest of the beam lines are to become available at a construction cost of 400 MFF maximum. By then, operating costs are expected to have risen to about 320 MFF/a.

Nominally then, all is settled, although one should note perhaps that only when governments contributing a total of at least 80% of the cost have announced that the necessary ratifications have been completed will the Convention actually enter into force. But that surely is a formality, and will not require a Purple Book to fill the gap.

Users' Meeting

An ESRF Users' Meeting will be held in Grenoble from 20-22 March 1989, with a view to defining the type of stations to be built in the first phase. Any scientist planning to carry out experiments at the ESRF or who has proposals for experimental beam stations, beam lines or new ideas for scientific projects may apply to attend. No registration fee is required and while participants are expected to fund their own expenses a small number of bursaries may be available for young scientists.

Those interested should write to:

The Director General, ESRF
BP 220,
F-38043 Grenoble Cedex