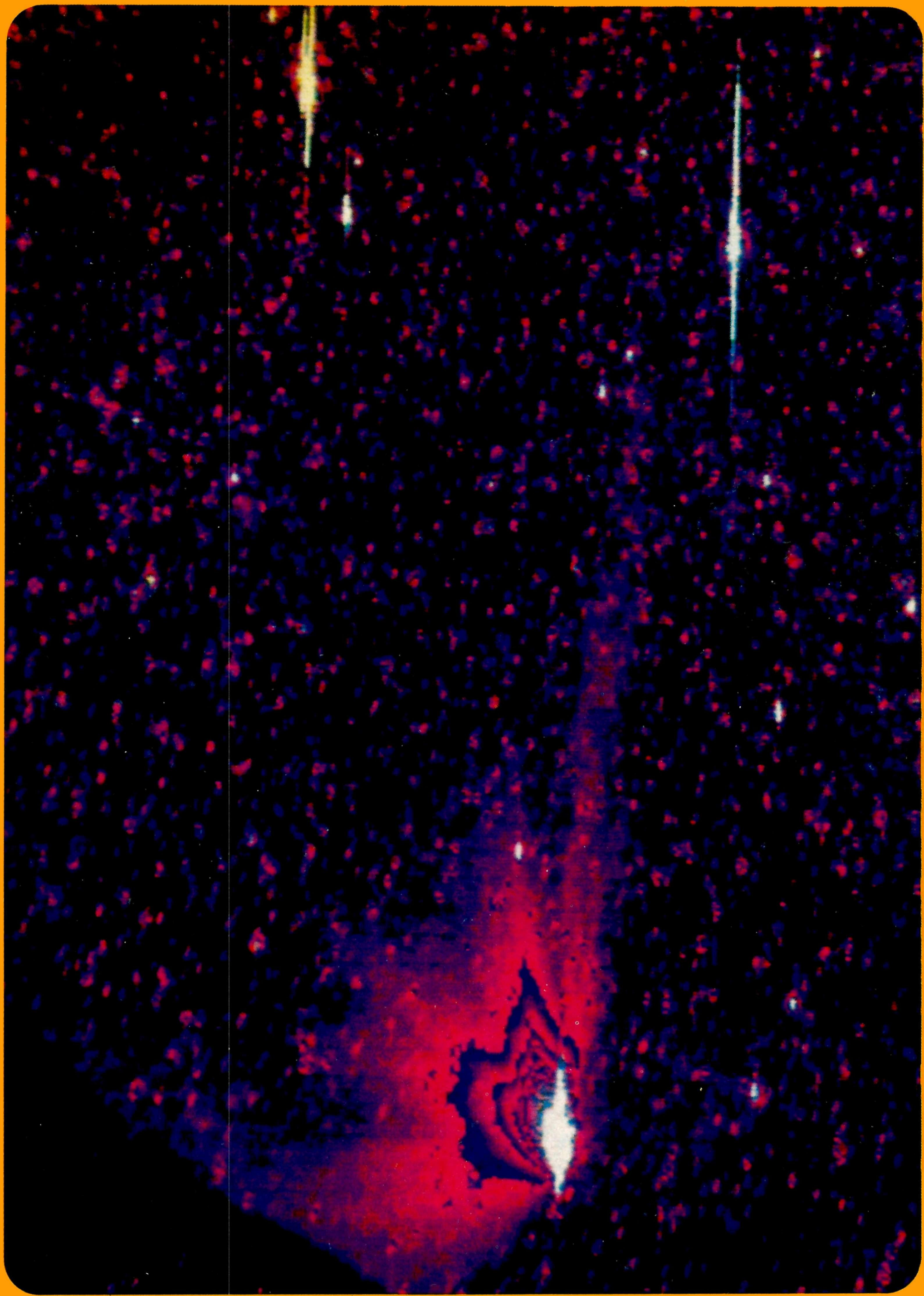
CERN COURIER

International Journal of High Energy Physics



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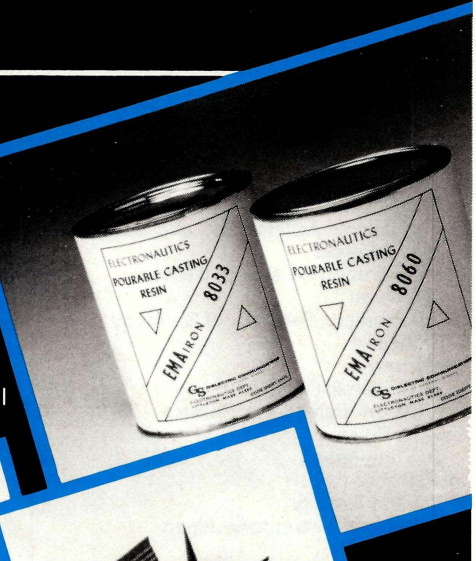
Cover photograph: Halley's comet rising above the horizon, as seen at the European Southern Observatory (ESO) La Silla, Chile, using a specially-designed wide-field CCD camera. Physicists from ESO and CERN were together in Garching, near Munich, in March for their second joint Symposium on Cosmology, Astronomy and Fundamental Physics, see page 29. CCD imaging techniques are also used in particle physics, see page 3 (Photo European Southern Observatory).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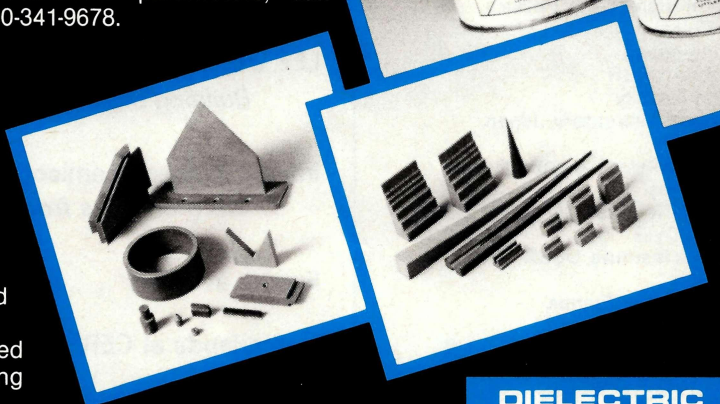
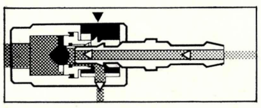
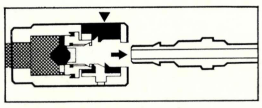






LEP experiments take shape

Excavation of the 27 kilometre tunnel and vast underground caverns for CERN's new LEP electron-positron collider is forging ahead, and equipment for the machine is arriving on the site in increasing quantities ready to attack the huge task of installation (see April issue, page 1).

At about the same time that LEP construction work began at CERN in 1983, physicists from some hundred research centres throughout the world began gearing up for the detailed design, construction and testing of the millions of components for the four big detectors — ALEPH, DELPHI, L3 and OPAL — which will study LEP's electron-positron collisions.

(For a detailed description of these four experiments, see July/August 1984 issue, page 227 (DELPHI), September 1984 issue, page 269 (ALEPH), November 1984 issue, page 375 (OPAL), and March 1985 issue, page 47 for L3.)

Three years later, preparations for these four mammoth experiments are well advanced. The major aim is to be ready to intercept LEP's first colliding beams towards the end of 1988, which means that some less essential detection subsystems are being left for later.

These projects require international collaboration on a scale unprecedented in a field of science already renowned for its ability to bring together scientists from different countries. Progress was highlighted at a recent meeting of the LEP Experiments Committee, which carefully monitors the progress of these projects.

One impressive aspect of the work is the development of ingenious tooling, often using sophisticated techniques, to facilitate construction and assembly of the detector components.

For L3, spokesman Sam Ting described how assembly of the huge 7000-ton magnet to surround the detector continues to make satisfactory progress with completion of coil segments at CERN keeping step with the supply of steel from the Soviet Union. Production lines are being set up for the high precision drift chamber system to pinpoint muons inside the magnet.

The first modules of the hadron calorimeter, using uranium supplied by the Soviet Union, are at the Swiss Federal Institute for Reactor Research, EIR.

A Ting video showed French numerically-controlled machines at work in Shanghai cutting and polishing the BGO crystals for the L3 electromagnetic calorimeter before sending them to CERN for acceptance tests.

After apologizing for having no video to show, ALEPH spokesman Jack Steinberger stressed the difficulties of fashioning an electromagnetic calorimeter with its acre and a half (6000 square metres) of wire planes containing 750 000 wires and millions of connections.

Meanwhile other parts of the detector are coming together smoothly. Winding of the superconducting magnet will soon get underway at Saclay in France, while sectors of the big Time Projection Chamber to track particles inside the solenoid should soon make their appearance at CERN. Also starting is the huge task of installing the thousands of streamer tubes of the hadron calorimeter inside the magnet return yoke.

DELPHI spokesman Ugo Amaldi

The experiments for the LEP electron-positron collider being built at CERN involve together physicists from some hundred research institutes all over the world. Here a consignment of equipment for the L3 experiment arrives at CERN from the Soviet Union.

(Photo CERN 226.2.86)

related how the iron for the yoke of the magnet barrel is making the long journey from Leningrad to CERN by boat, barge and road through Rotterdam and Strasbourg. Winding of the superconducting solenoid should soon start at the Rutherford Appleton Laboratory in the UK.

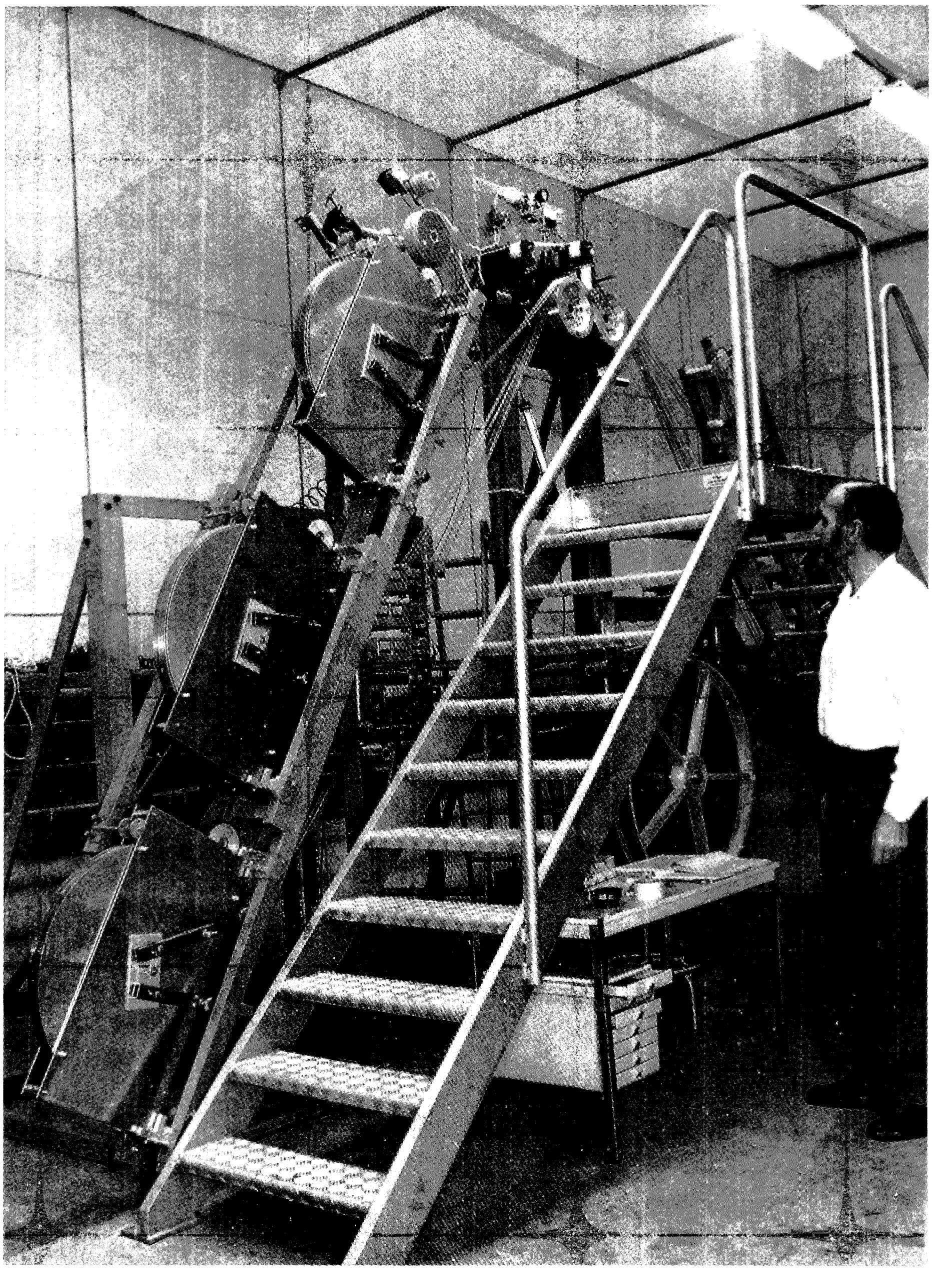
Useful results are coming in from DELPHI's prototype Ring Imaging Cherenkov (RICH), enabling the final design to be firmed up. Special tooling has been developed for the slotted High Density Projection Chamber of DELPHI's electromagnetic calorimeter.

The OPAL experiment prefers to use conventional technology throughout, but this does not detract from the difficulties of constructing a huge detector by a widely scattered collaboration to a strict timescale.

Spokesman Aldo Michelini described how all components for the magnet should be ready later this year, and how the 'clean room' is being got ready at CERN for assembly of the central detector jet chamber. It is hoped to operate this part of the detector for about a year prior to LEP's first particles.

Construction work for other parts of the detector is well advanced, while simultaneously prototype tests continue for the inner portions of the detector and for the electromagnetic presampler to be fitted between the solenoid and the surrounding lead glass of the electromagnetic calorimeter.

'The 21st century seems to have arrived', remarked one observer at the meeting.



Ingenious tooling has been developed to facilitate the construction of the often complex modules for the different LEP experiments. Here is the machine which glues lead wire into ribbons for the High Density Projection Chamber of the DELPHI electromagnetic calorimeter. These ribbons are bent into 'accordions' by another machine, built by Pietro Negri in Milan.

(Photo CERN 11.1.86)

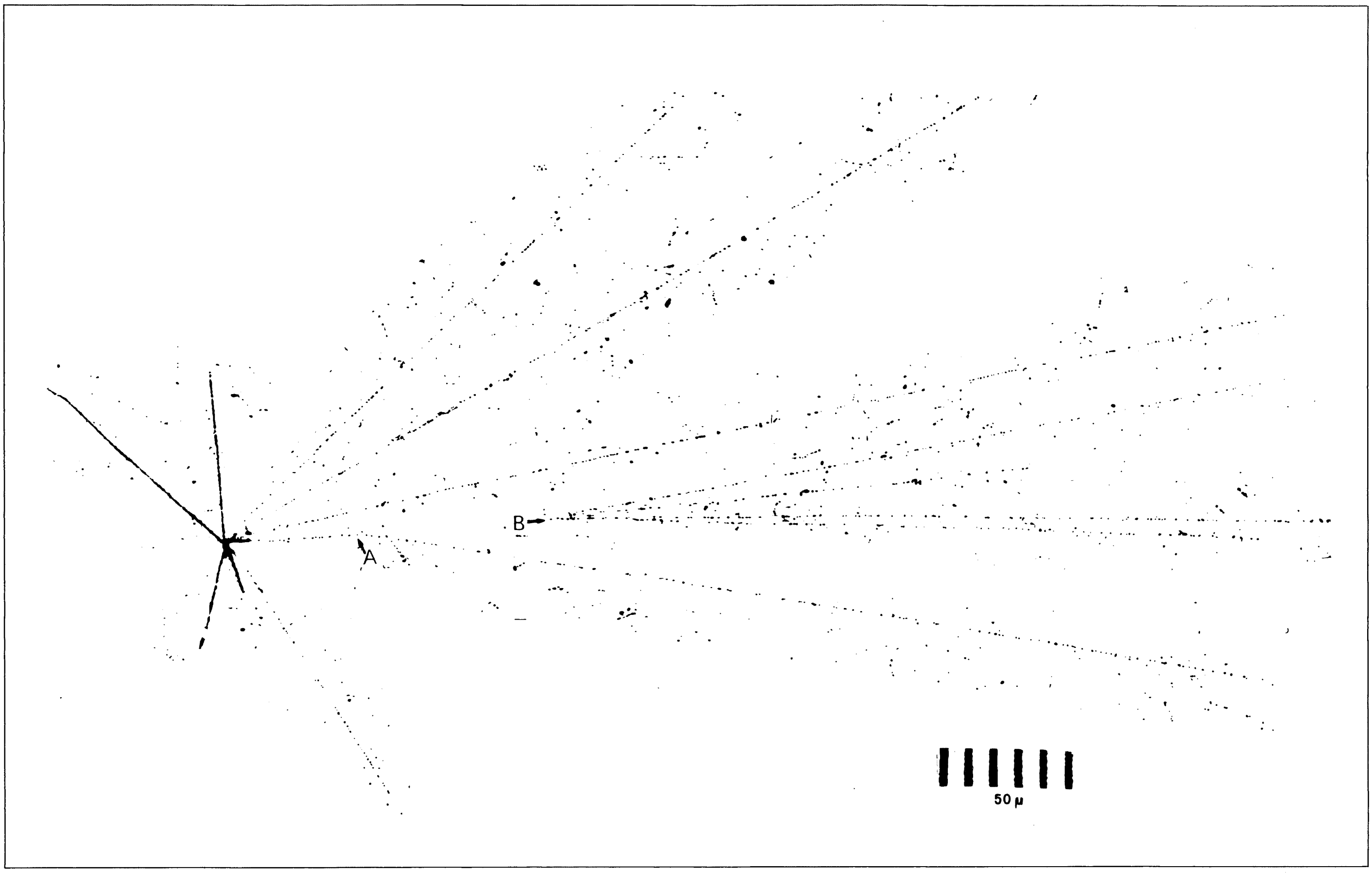
Images through semiconductors

Improved image processing techniques are constantly being developed for television and for scanners using X-rays or other radiation for industrial or medical applications, etc. As Erik Heijne of CERN explains here, particle physics too has its own special requirements for image processing. The increasing use of semiconductor techniques for handling measurements down to the level of a few microns provides another example of the close interplay between scientific research and technological development.

While the techniques used in particle (or nuclear) physics for handling three-dimensional images are similar to those used in other fields, the objectives are often very different. Conventional imagers view a 'lively' scene, continuous over space and time. The particle physicist creates his own scene, often within the detectors themselves. The images in this (most of the time empty) scene do not evolve, as in a lively motion picture, but the 'events' occur like fireworks, without correlation.

The imaging apparatus must be capable of recording these events, created by shooting a single particle on a fixed target or by colliding two particles head-on. Many thousands or even several millions of events per second may occur, however the physicist might be interested only in a certain type — perhaps one in ten thousand or even rarer. Within the short time before the next collision (at most 10 microseconds or so) it must be decided if the recorded event is possibly interesting. If not, all information from the detectors can be discarded. But if the event is of the right type, the images from the detectors must be stored in a

Production and decay of very short-lived (charm) particles as recorded by an experiment at CERN using a block of emulsion. Two charm particles are produced at the primary collision point (left) and subsequently decay at the points marked A and B. Despite travelling at almost the speed of light, they manage to travel only a fraction of a millimetre before decaying. Special detectors are needed to pick up such fine details.



more definitive format.

The images in particle physics contain sparse information, although a large area has to be covered due to the random distribution of particles in space. The data can be compacted, neglecting all empty space. A similar situation is found in robotics or in navigation problems, but the speed requirements are less stringent.

Most particle detectors provide a one- or two-dimensional projected image of the event, often with additional information such as energy loss (wavelength, or 'colour') or momentum (measured from the curvature of the track in a magnetic field). With this information the experimenter can reconstruct the event in space and time.

A great step was made in particle detection with the development of the multiwire proportional chamber towards the end of the 1960s. In such a wire chamber, the passage of a charged particle ionizes the gas and under the influence of a strong electric field the liberated electrons drift towards a plane of many parallel anode wires. These electrons initiate an avalanche towards a particular wire, giving a lever on the particle position.

Gas-filled detectors fitted with segmented electrodes have become more sophisticated, and even in large volumes, particle positions can be measured down to a hundred or so microns. Special small detectors can even get down to about twenty microns.

Gas-filled, wire-strung detectors are ideal for picking up the final products of a particle interaction once the emerging tracks have become well separated. However they are not suited to give an image of the region around the interaction point, where a system of wires with millimetre spacing is too coarse to record subtle details.

In the initial particle interaction, highly unstable secondary particles can be formed. Those carrying rare quarks like 'charm' and 'beauty' live for only about 10^{-13} s. Even travelling at nearly the speed of light, such particles do not travel more than a fraction of a millimetre before decaying.

Full three-dimensional images of such particle interactions and decays can be obtained in blocks of nuclear emulsion, which have to be developed after exposure and scanned under a microscope (see June 1983 isue, page 184). Other techniques have also been explored and used profitably. Those using semiconductor imaging devices are only beginning to make their impact and promise much for the future.

Semiconductor detectors

As it passes through matter, a charged particle loses energy by ionization. In a thin layer of silicon this energy loss is about 300 keV per mm, the exact figure depending on the particle energy as well as on the silicon thickness. The nice feature of a semiconductor material is that free electrons and holes are generated, in silicon on average one pair for every 3.62 eV of energy lost. And these electrons and holes can be collected at the electrodes in an appropriate device within 10 to 20 nanoseconds, thus creating a fast electric signal.

The amount of charge in this signal is small compared to the signals obtained in wire chambers or in conventional imaging. It is only about 80 electron-hole pairs per micron of silicon, and low noise amplifiers are required to detect the passage of a particle through a typical detector thickness of 0.3 mm. The lower the capacitance of the detecting element, the lower is the noise. Thinner silicon layers can be used if the detection elements are small 'pixels' (e.g. 40 x 40 microns) and if the capacitance is kept small by using an on-chip amplifier as in a 'Charge Coupled Device' (CCD).

(A CCD is essentially a row of adjacent capacitors with separated top electrodes (gates) which can be alternatingly biased, so that storage from one capacitor flows to the next, and so on, as in a dynamic analog shift register.)

For 'solid state' optical imaging nearly all efforts have concentrated on CCD and cameras are now on the market which incorporate such devices. For 'particle imaging', a team from Rutherford (UK) pioneered the application of a commercially available CCD device as part of a study of charm production at CERN (Amsterdam / Bristol / CERN / Cracow / Munich / Rutherford / Santander / Valencia group, first results in next month's issue). Because of the small signal of only a few hundred electrons, it is necessary to cool the CCD detector to -140 C to reduce electronic noise. For optical imaging this is not needed as the signal can be increased simply by looking a bit longer at the scene.

The CCDs are sophisticated devices, requiring skilful operation. Also, available types are small and fairly slow because all information has to be shifted through a single output amplifier and are not optimized for particle imaging. Nevertheless, impressive results have been obtained already and a double layer CCD detector is now under construction for an experiment at the new Stanford collider.

A simpler approach was adopted originally at CERN to show the viability of silicon position sensitive detectors for particle physics. These devices, dubbed silicon microstrip detectors, consist of many parallel diodes, made using silicon planar technology. Each diode is connected to an external amplifier and the availability of cheap, miniaturized low-noise amplifiers is essential.

The first microstrip detectors produced in 1980 had 100 strips of 200 micron pitch. Presently, various devices are available, with up to 1000 strips of 50 or 20 micron pitch. The chip size ranges from 10 x 10 mm to 50 x 65 mm. They have been developed in cooperation with commercial manufacturers, leading to rapid worldwide assimilation of this type of detector. The research effort by J. Kemmer at the Technical University of Munich, together with the particle physicists of the Max Planck Institute there, has played a vital role in this work.

In microstrip detectors with capacitative charge division particle positions could be determined to within a few microns. In principle these detectors can be programmed by hardwiring or by microprocessors to provide levels of inbuilt information selection. However the initial approach has been more one of brute force, connecting up nearly all imaging elements. But an effort is being mounted to produce the necessary integrated circuits and multiplexing so as to dramatically reduce the number of analog/digital converter channels required.

Solutions using addressable storage capacitors as well as a parallel-serial 'pipeline' signal processing CCD are being evaluated. Techniques like on-chip image processing and contrast enhancement are still too slow for particle physics needs.

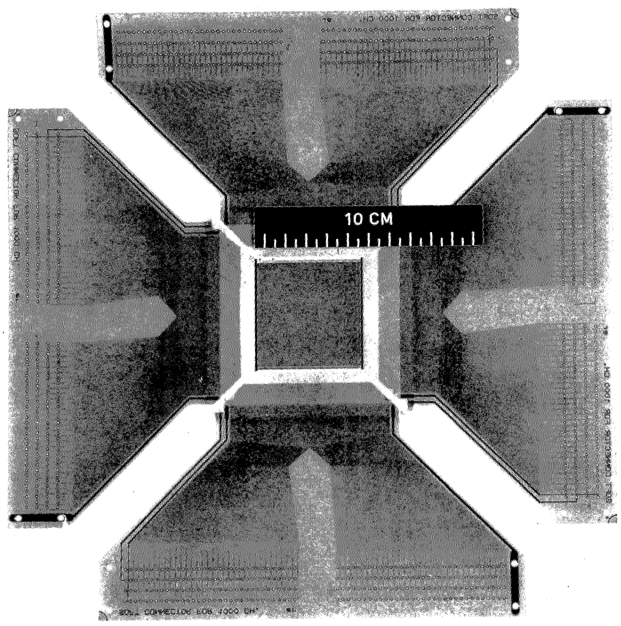
A third type of detector, the so-called silicon drift chamber, has been conceived with the aim of reducing the number of electronics channels. Where in a CCD the charge packets generated by the particles are shifted by phased external clocking towards the on-chip amplifier, in the drift chamber this is accomplished by a lateral drift field, created as a 'potential gutter' towards the electrode. The position of the particle is then derived from the drift time of the charge packet.

Various presentations during the recent symposium in Munich on 'New developments in semiconductor detectors' showed the importance of collaboration with commercial manufacturers on the one hand and microelectronics research institutes on the other. With this specialist help it may be possible to conceive true two-dimensional 'pixel' detectors with 'region of interest' readout. It appears that the requirements for particle physics have a significant overlap with other imaging applications, such as X-ray astronomy or robotics.

There is still a long way to go before modern signal processing based on customized microelectronics circuits will be fully integrated into particle physics. But thanks to the ingenuity of experimenters and a fruitful collaboration with electron device scientists and with silicon specialists, important progress is being made.

A silicon microstrip detector containing 1000 strips on a central ceramic base surrounded by the characteristic fanout of the readout electronics.

(Photo X530.1.86)



View of the Exhibition

FRANCE AT CERN, 11-14 MARCH 1986

More firms participated in the 1986 "France at CERN" Exhibition than in the previous exhibition in 1983. This year 55 firms, including three Chambers of Commerce and Industry, took part in the exhibition which comprised 34 stands covering an area of 310 m^2.

The choice of firms was approved by the official with responsibility for CERN at the Scientific and Technical Mission of the Ministry of Research and Technology, thereby ensuring that the exhibits corresponded to CERN's immediate needs and in particular to those of LEP.

- Stabilized power supplies, DC/DC converters,
- superconductors, DC and AC applications, classical magnets (accelerators, detectors),
- wires and cables for the nuclear industry, hook-up wires, coaxial cables,
- optical fibres,
- minicomputers for scientific and technical purposes,
- research and development in optics, optoelectronics and mechanics, prototype and series manufacture,
- research and development in mechanics, automatisms, special machines,
- assembly of electronic boards, manufacture of special wiring, automatic testing of electronic boards,
- electronic and electrical assemblies,
- microprocessor instrumentation, robotics, programmers,
- low-voltage equipment,
- measuring and monitoring machines, equipment,
- quick-release couplings for compressed air and liquid gases,
- laser markers,
- printed circuits,
- technology of transfer and welding of surface-mounted components,
- flexible workshop simulation software,
- electrical power supplies,
- graphic terminals,
- vacuum pumps, turbomolecular pumps, servo-motors, valve actuators,
- modular mechanics,
- machined aluminium components.

In parallel, some fifteen scientific and technical presentations were made by firms represented in the exhibition.

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France at CERN

The official opening ceremony of the 'France at CERN' exhibition at CERN on 11 March gave French atomic energy High Commissioner Jean Teillac the opportunity to highlight the importance of relations between France and CERN. France is in a special position as one of CERN's two host states, with French researchers contributing significantly to an important and fruitful international collaboration which has made an impact far beyond Europe.

The enthusiasm of French researchers in high energy physics and the contribution to the LEP project by French industry, in the shape of contracts for equipment, were singled out by Teillac who stressed the importance of industry's role in the increasingly competitive world market for technological development.

On the question of finance, he stated that France firmly believes in the importance of fundamental research since it brings technological innovation and helps to promote healthy relations between researchers and industry.

The 'France at CERN' exhibition was organized by the French Ministry for Research and Technology and brought together representatives from some 50 firms during the week.

These member state industrial exhibitions are now well established at CERN. This, for example, was France's second exhibition. In June it is the turn of the Netherlands, while Great Britain will exhibit at the end of September, then Sweden in March 1987; the newest member state, Portugal, will exhibit in May 1987, followed by Germany at the end of September, with other countries provisionally booked even further ahead.

Flanked by CERN Research Director Robert Klapisch (right) and Ambassador Yves Pagniez of the French permanent mission in Geneva, French atomic energy High Commissioner Jean Teillac admires a product of French industry at the recent 'France at CERN' exhibition. Below, a corner of the exhibition.

(Photo CERN 243.3.86)

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(DAF S. P. cont'd)

Some technologies
- aerodynamics
- dynamics
- mechanical transmission
- welding
- ergonomics

bv Koninklijke Maatschappij „de Schelde"

ROYAL SCHELDE
Mailing address: P.O. Box 16, 4380 AA VLISSINGEN
Contact (technical): J. E. Meijers
Telex number: 37815 nl

- components and subsystems for nuclear reactors and uranium enrichment plants
- heat exchangers: heat exchanger test loops
- special components for large experiments such as MHD channels, precision bellows and expansion joints vacuum vessels for Tokamaks
- products for power plants and process industry.

STORK BOILERS

STORK BOILERS
Mailing address: P.O. Box 20, 7550 GB HENGELO
Contact (technical): R. Overbeek Bloem
Telex number: 44324 nl

- boilers for special applications
- high pressure piping
- combustion equipment
- de-aerators, heaters condensors

NEDERLANDSE IJZERCONSTRUCTIEWERKPLAATSEN
Mailing address: P.O. Box 7, 8150 AA LEMELERVELD
Contact (technical): P. Koetsier
Telex number: 49658 nl

Specialized in design and production of large steel structures applied in:
- radar (tower)
- power stations (building)
- laboratories

polacel

POLACEL B.V./
POLACEL PROJECTEN B.V.
Mailing address:
P.O. Box 296, 7000 AG DOETINCHEM
Tel.: ++31 834033034
Contact (technical): T. J. Sloof
Telex: 45948 pola nl

Production line:
- Cooling towers
- Zerocoolers
- Closed circuit evaporative coolers
- Scrubbers
- Biological watertreatment
- Ventilators
- Filling materials
- Special projects stainless steel and glassfibre reinforced polyester
- Updating, upgrading and revision of existing equipment.

Products exhibited:
- Filling materials
- Photographs
- Demonstration Computer Aided Coolingtower Selection
- Sample parts of cooling towers.

STORK *FRIESLAND*

STORK FRIESLAND
Mailing address: P.O. Box 13, 8400 AA GORREDIJK
Contact (technical): A. van Zanten
Telex number: 46146 nl

Specialist in design and production of complicated piping and large vessels made of stainless steel and aluminium alloys.

SMALL AND PRECISION MACHINED COMPONENTS

BAYARDS
ALUMINIUM CONSTRUCTIES

BAYARDS
Mailing address: P.O. Box 9,
2957 ZG NIEUW-LEKKERLAND
Contact (technical): D. de Kluyver
Telex number: 24206 nl

Specialists in heavy and complicated welded aluminium constructions.

Machinefabriek
Boessenkool bv
Almelo - Holland

BOESSENKOOL/BRUMMER
Mailing address: Turfkade 13, 7602 PA ALMELO
Contact (technical): J. Flierman
Telex number: 44405 nl

Specialists in design and production of custom made containers and structures for storage and handling of components and parts of it.

BRANDT FIJNMECHANISCHE INDUSTRIE
H. J. E. Wenckebachweg 117 – 1096 AM AMSTERDAM
Tel. ++31 20681281
Telex: 13376 bfi nl
Telefax: ++31 20928354

Services:
- Precision machining: – prototypes
  – small series
- Surface grinding
- Cilindrical grinding
- 3 D-milling (computer controlled)
- Approved AQAP-4

Products Exhibited
- Sample parts of precision machining
- Photographs

COLPITT
Mailing address: P.O. Box 162, 2040 AD ZANDVOORT
Contact (tecnical): H. Slagman
Telex number: 41099

Specialised in automatic equipment for radio frequency and microwave heating.
- RF generators and power amplifiers
- pneumatic and hydraulic welding presses
- automatic HF welding lines.

FDO – TECHNICAL CONSULTANTS
Mailing address: P.O. Box 379, 1000 AJ AMSTERDAM
Contact (technical): C. B. W. Kerkdijk
Telex number: 16107 nl

Specialism
- energy technology
- design and production technology
- technical services.

FEENSTRA'S TECHNISCHE INDUSTRIE DALFSEN
Mailing address: P.O. Box 51, 7720 AB DALFSEN
Contact (technical): K. W. Landman, B. de Vries
Telex number: 42581 nl

- high-tech sheet steel work, components and welded alloyed steel structures
- special tools and apparatus for windtunnels
- high precision sheet steel components (e.g. for LEP)

GENIUS KLINKENBERG
Mailing address: P.O. Box 49, 1520 AA WORMERVEER
Contact (technical): J. G. A. Klamer
Telex number: 19162 nl

- equipment for the aerospace industry
- pressure vessels for (petro) chemical industry
- extruders
- high precision steel structures (wave telescope).

holvrieka ido

HOLVRIEKA IDO
Mailing address: P.O. Box 44, 7800 AA EMMEN
Contact (technical): A. J. Teunissen
Telex number: 30068 nl

- columns, washing towers
- heat exchangers, condensors
- pressure containers.

STORK PALTRAN

STORK PALTRAN
Mailing address: P.O. Box 50, 8470 AA WOLVEGA
Contact (technical): J. Petter
Telex number: 46449 nl

Manufacturers of custom made sheet metal works and custom made mechanical equipment.

STORK SERVICES

STORK SERVICES
Mailing address: P.O. Box 2013, 7550 CA HENGELO
Contact (technical): J. Odijk
Telex number: 72282 nl

- gascompressors and –turbines
- subcontractor for all kind of machining operations.

TNO TPD

TNO Institute of Applied Physics TRD carries out contract R&D
Mailing addres:
TNO Institute of Applied Physics
P.O. Box 155, 2600 AD DELFT
Telex 38091 tpddt nl
Tel.: ++31 15788020

Fields of activity:
- instrumentation: sensors and systems, computer applications, electronics
- optics: optical systems, instruments and sensors, laser applications
- heat technology: energy saving, solar energy, heat storage, building physics
- materials research: technology of glass/ceramics, analysis of crystaline materials
- acoustics: noise control in and around buildings, industries, machinery, in traffic and on board ships

metaalgieterij
Vostermans b.v.

METAALGIETERIJ VOSTERMANS
Mailing address: Jachthavenweg 5, 5928 NT VENLO-BLERICK
Contact (technical): J. Janssen
Telex number: 58363 nl

- castings of aluminium alloys
- pattern making for the polyester industry
- auxiliary tools and moulds for the packaging industry.

OOSTENDORP

OOSTENDORP APPARATENBOUW
Mailing address: P.O. Box 62, 4000 AB TIEL
Contact (technical): J. E. van den Boom
Telex number: 40165 nl

Specialized in design and production of high-tech constructions high grade steel alloys.
Some examples: supports for beam handling magnets, pressure vessels. ▶

CERN

INSTRUMENTATION ELECTRICAL AND MECHANICAL

DELTA ELEKTRONICA B.V.

Mailing address:
P.O. Box 27, 4300 AA ZIERIKZEE
Tel.: ++31 11103656
Contact (technical): C. J. Koopman
Telex: 55349 delek nl

Production line:

- Switched mode power supplies
- Switched mode laboratory power supplies
- Switched mode triple power supplies
- High efficiency linear power supplies
- Linear laboratory power supplies
- Linear modular power supplies
- Linear Eurocard power supplies
- Constant current sources
- Overvoltage protectors
- DC-DC converters
- Bus power supply controlers (IEC 625)

Products Exhibited:

- Regulated power supplies.

BRONKHORST HIGH – TECH B.V.

Mailing address:
P.O. Box 101, 7250 AC VORDEN
Tel.: ++31 57352929 (Contact: T. Bruggeman)
Telex: 49066 hitek nl

Production line:

- Mass flow meters/Controllers for gasses (0.1 mL_N/min – 1000 mL_N/min
- Mass flow meters/Controllers for liquids (0,05 mL_N/h – 20 L_N/h)
- Industrial mass flow meters for high gas flows
- Pressure transducers/Controllers for gasses and liquids
- Associated electronic readout systems

Products exhibited

- Samples of above mentioned products.

EBM TECHNIEK

Mailing address: P.O. Box 13, 3925 ZG SCHERPENZEEL
Contact (technical): H. T. van Gemert
Telex number: 79150 nl

The company is specialized in mechanical engineering and industrial automation.

ENRAF – NONIUS

Mailing address: P.O. Box 483, 2600 AL DELFT
Contact (technical): A. Vermeij
Telex number: 38083 nl

Enraf-Nonius is a high technology company specialising in instrumentation for the medical, laboratory and industrial fields.

Some products:

- single crystal and powder cameras
- recorders and modems
- pyranometers and solar integrators
- printed circuit boards, production and assembly.

FIJN MECHANISCH INDUSTRIE 'BERGEN OP ZOOM'

Mailing address: P.O. Box 124,
4600 AC BERGEN OP ZOOM
Contact (technical): W. C. Karman
Telex number: 78310 nl

Specialists in production of precision components and tools for amongst others the aerospace laboratories.

Some products:

- precision mechanical instruments
- precision assembly works
- custom made sheet metal work
- dies moulds, fixtures and checking tools

KELTORR

Mailing address: P.O. Box 39,
1720 AA BROEK OP LANGEDIJK
Telephone: ++31 22607174 (Contact: B. A. Rook)
Telex number: 57116 nl

- containers for liquid gasses
- vacuum superinsulated transfer lines and valves for liquified gasses
- liquid nitrogen conditioning equipment
- cryostats for liquid nitrogen and liquid helium
- low temperature measuring and control systems

MOGEMA

MACHINEFABRIEK MOGEMA 'T HARDE

Mailing address: P.O. Box 34, 8084 ZG 'T HARDE
Contact (technical): J. J. Pinkster, A. Visser
Telex number: 42945 nl

Specialists in high precision turning, milling, drilling and boring. Subcontractor for precision metal work.

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machinefabriek WILA b.v.

MACHINEFABRIEK WILA B.V.

Mailing address: P.O. Box 60, 7240 AB LOCHEM
Contact (technical): A. Enderink, C. B. Wansleeben
Telex number: 49326 wila nl

- slideways
- pressbrake tooling
- pressbrake accessories
- remachining of bending and cutting tools
- spark erosion

ELECTRONICS AND SOFTWARE

acs

APPLIED CONTROL SYSTEMS B.V.
Mailing address:
P.O. Box 95, 6100 AB ECHT
Tel.: ++31 47543663
Contact (technical): J. G. M. van der Aa
Telex: 36813 acs nl   Telefax: ++31 47545068

Services:
- CAD schematic drawing
- CAD designing of:
  Single sided print lay-outs
  Double sided print lay-outs
  Multi-layer lay-outs
  Thick and thin film lay-outs
  SMD lay-outs
- 24 Hour prototypes
- Print production
- Multilayers
- Post processing service
- Photo plotting via modem

Products exhibited:
- CAD schematic drawings
- Print lay-outs
- Printed circuit boards

COMPCONTROL
MICROSYSTEMS DESIGN AND APPLICATIONS

COMPCONTROL
Mailing address: P.O. Box 193, 5600 AD EINDHOVEN
Contact (technical): C. W. Lambrechtse
Telex number: 51603 nl

- VME-BUS modules: processor 68000/68010/68020
- SASI interface + FDO interface modules
- SCSI interface modules with DMA controller
- serial interface modules
- VME-BUS SYSTEMS

HAS NEDERLAND

HAS – NEDERLAND
Mailing address: P.O. Box 8362, 1005 AJ AMSTERDAM
Contact (technical): H. H. in 't Hout
Telex number: 13033 nl

Hoogovens Automation Systems is an independently operated subsidiary of the Hoogovens Group. Specialists in robotics and automation based on experience in the steel industry.

HYMEC B.V.
Mailing address:
P.O. Box 336, 6130 AH SITTARD
Contact (technical): M. ten Wolde
Tel.: ++31 449013220

Production line:
- Thick film hybrid circuit design
- Thick film hybrid circuit manufacture
- Sub-assemblies for aerospace applications
- Circuits for military applications
- Circuits for medical applications
- Circuits for telecommunication applications

Products exhibited:
- Samples of above mentioned applications

incaa

INCAA COMPUTERS
Mailing address: P.O. Box 211, 7300 AE APELDOORN
Contact (technical): G. Endendijk
Telex number: 49623 nl

A company that is specialized in the design and manufacturing of micro computer systems to customer specification. Standard products.
- capro – 68 k CAMAC computer
- CAMAC modules
- euro-card systems
- datacommunication protocol converters

PRINT SERVICE

PRINT SERVICE B.V.
Mailing address:
P.O. Box 34 – 6100 AA ECHT
Tel.: ++31 47549333
Contact (technical): A. de Haan
Telex: 36864 print nl
Telefax: ++31 47549193

Production line:
- Multilayers (Up to 30 layers)
- P.T.H. Boards (fineline and SMT)
- Flex-Rigid Multilayers (Up to 20 layers and 16 satellites)
- Heat sink P.C. Boards
- Press-Fit backpanels
- B.T., B.S. and MIL approved
- CAD and Photoplot service

Products exhibited:
- Samples of above mentioned products.

NON METALLIC COMPONENTS

askové kunststof industrie bv

ASKOVÉ KUNSTSTOF INDUSTRIE
Mailing address: P.O. Box 10, 5473 ZG HEESWIJK
Contact (technical): L. Gordijn
Telex number: 74679 nl

Specialist in design and production of high-tech products in plastics.
A wide experience is available in welding, forming, glueing, machining and laminating of thermo-plastics.

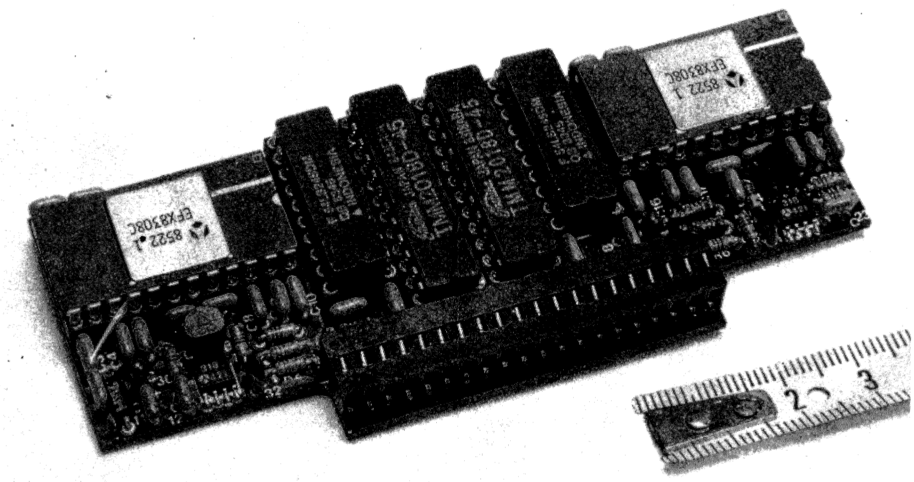
MEKUFA BV

MEKUFA
Mailing address: P.O. Box 7, 7680 AA VROOMSHOOP
Contact (technical): G. M. Hertsenberg
Telex number: 36561 nl

Specialist in working-up and processing of high-grade thermo-setting plastics.
Particularly experienced in production of components for HV applications made of expoxy-resins which are being sold under the registered trade name Kufalit.

CERN

Around the Laboratories



Circuit developed in collaboration between Laboratories and industry in France for the DELPHI experiment being prepared for LEP. Improved performance and a drastic reduction in price has been achieved by comparison with what was previously available on the market.

ELECTRONICS
New components for LEP

In 1983 an initiative in France (from the Atomic Energy Commission, Saclay and the Institut National de Physique Nucléaire et de Physique des Particules — IN2P3) led to the setting up of a Committee to look, in collaboration with French industry, at the electronics needs of the experiments for LEP. The Committee, known as 'VLSI for LEP', was composed of physicists and engineers involved in the experiments for the LEP electron-positron collider being built at CERN.

The aim was to stimulate industry to tackle high density integrated circuits which would be appropriate for the experiments and which were either not then available commercially or were prohibitively priced. It was also hoped that developments would have widespread applications in other fields.

Five proposals initially emerged from the Committee and two were retained for development in collaboration between the research Laboratories and industry. One was for large surface silicon photodiodes required by the L3 experiment. The other was for an 8 bit, 15 MHz flash analog-digital converter for the DELPHI experiment.

The firm Thomson-EFCIS showed a strong interest in this converter study and a development contract was signed between the firm and the two research institutes. A million French francs were made available for the development of this flash ADC with the money coming from the Laboratories and from Thomson-EFCIS.

A working group composed of specialists from the two institutes and from Thomson was set up with the aim of evaluating successive prototypes, determining the necessary modifications and ensuring the completion of the project. Successive prototypes were tested from the beginning of 1984 and their performance was sufficiently encouraging for Thomson-EFCIS to embark on industrial production. Improved prototypes were produced last summer and were passed to the DELPHI team.

When this work started, flash ADCs with these specifications were available only with high power consumption (2 W) and at a unit price which prevented them from being used in the large numbers required in the LEP experiments.

The outcome of the collaboration has thus been the development of a quality product at an affordable price. More than 30 000 have been ordered for DELPHI and industry anticipates sales in many other areas of digital technology. They have also been ordered by the ALEPH experiment.

Further information from Pierre Borgeaud, CEN-Saclay, 91191 Gif-sur-Yvette, France.

BROOKHAVEN
Polarized proton update

The Alternating Gradient Synchrotron is one of the world's few high energy machines currently providing beams of spin-aligned (polarized) protons. The AGS operations crew and physicists and their collaborators from Michigan, led by Alan Krisch, were finally able to relax on 12 February after seven weeks of polarized proton operations. During the final three-day period, the AGS accelerated an

average of 1.5 x 10^{10} polarized protons to 22 GeV with a polarization of 46 per cent. In order to reach this energy, the AGS beam had to negotiate 35 imperfection resonances and four intrinsic resonances. Three experimental teams collected data at 13.2 GeV where the polarization was 65 per cent, and at 18.5 GeV where the polarization was 50 per cent. Both the AGS physicists and the experimental teams are awaiting their next polarized proton running period so as to push on to higher energies and hopefully to unravel some of the yet unexplained depolarization phenomena encountered during the acceleration cycle.

CERN
More charm

Just before the CERN Intersecting Storage Rings (ISR) machine was closed in 1984, it was operated in a unique mode, and the accumulated data is still providing interesting results.

Instead of carrying separate beams in its two interlaced rings, in its final study the ISR carried a finely tuned beam of antiprotons in one ring, which collided with a fine jet of protons (hydrogen gas).

In these proton-antiproton annihilations, the selection rules are much less restrictive than for electrons and positrons, so that charmonium (charmed quark bound to a charmed antiquark) states can be studied directly which can only be accessed indirectly at electron-positron machines.

First results (see October 1984 issue, page 335) were on so-called chi states, where the charmonium quarks, in addition to having aligned spins, rotate around a common axis and thus carry orbital angular momentum. (In the famous J/psi, the quarks have their spins aligned but have no mutual angular momentum.) The high tunability of the circulating antiproton beam energy enabled the experimental team (Annecy / CERN / Genoa / Lyon / Oslo / Rome / Strasbourg / Turin) to pinpoint its chi states to within 1 MeV.

Results from scanning the energy range midway between the two chis show signs of a previously unknown charmonium state at 3525 MeV, probably with the charmed quarks carrying orbital angular momentum, but this time spinning in opposite directions.

Snowmass

From 23 June to 11 July, the third major study on future US machines will take place at Snowmass, Colorado, organized by the Division of Particles and Fields of the American Physical Society.

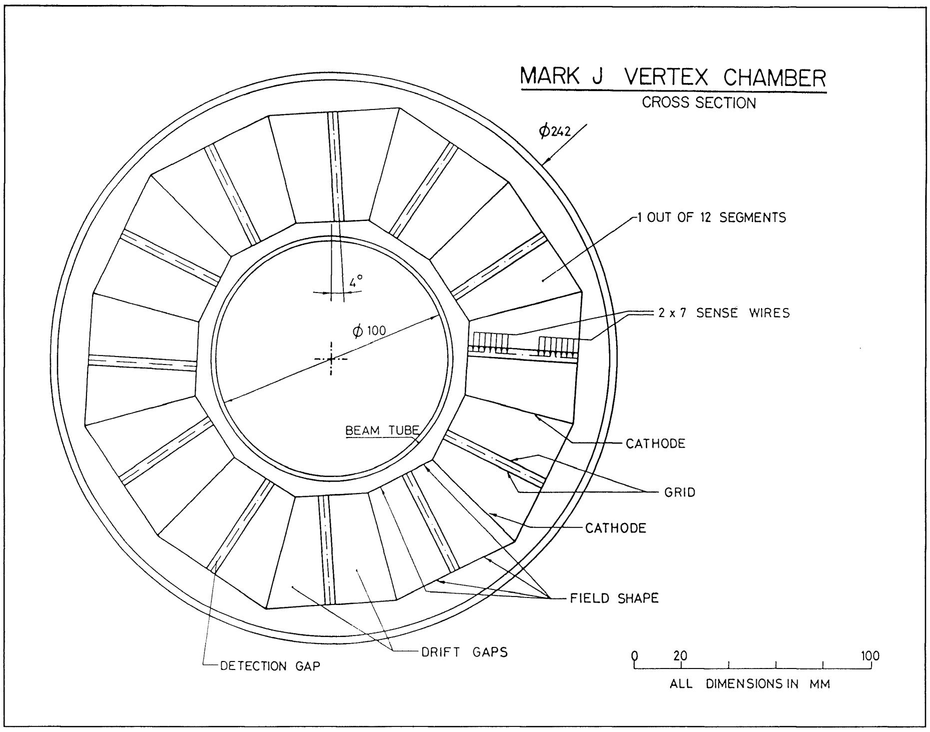
The main aim of Snowmass 86 is to study the design and exploitation of the proposed Superconducting Supercollider, SSC. Since an official proposal now exists, it will provide the major focus for study. Activities will be organized into four areas, accelerator physics (organized by A. Dragt and the Central Design Group), detector design (H. Williams and D. Nygren), physics issues (T. Gottschalk and G. Kane), and non-accelerator physics (D. Ayres). Lee Pondrom of Madison, Wisconsin, is overall organizer.

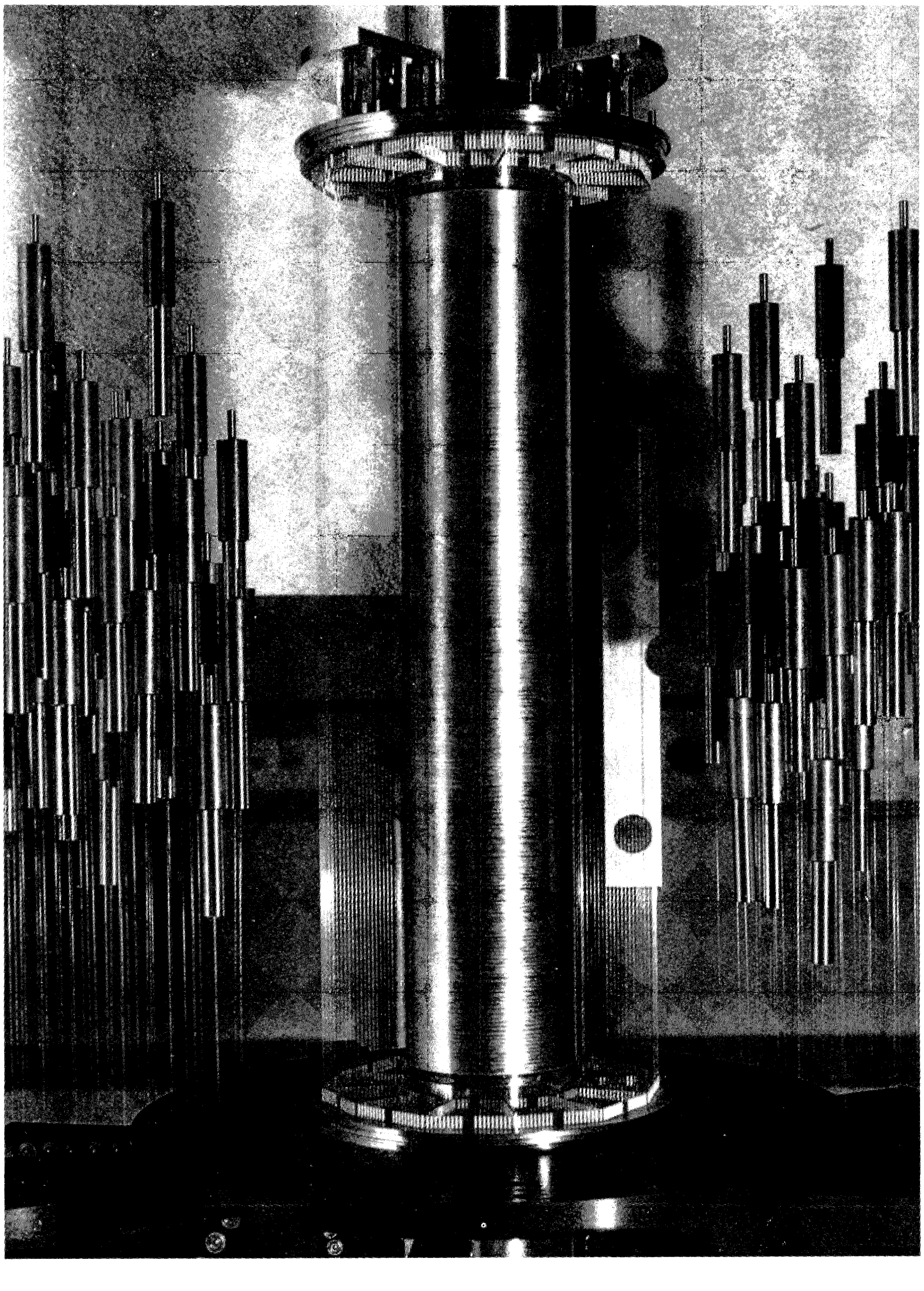
The accelerator and physics working groups will meet mornings, and the detector and non-accelerator groups afternoons. Most physicists will be active in a morning and an afternoon group, thus providing a mechanism for interaction and communication between the groups.

The first two days will be devoted to presentations about the SSC and related subjects, and the last two days to summaries of progress during the study. At the beginning of the second week the groups will describe what they have chosen to focus on, so participants in other groups will be informed and can provide input. The general emphasis will be on understanding even better how to do physics at high energies and luminosities, and effort will be made to stimulate interactions between accelerator, detector, and physics issues.

The study will build not only on the previous two Snowmass studies and on the very successful work of the Central Design Group, but also on a series of workshops at Oregon, Fermilab, UCLA and Madison designed to provide input to Snowmass 86. Considerable international participation is expected. Those interested in attending should write to Joanne Day, Argonne National Laboratory, Building 362, Argonne, Illinois 60439, USA.

Cross-section of the new Time Expansion Chamber for the Mark J experiment at the PETRA electron-positron collider at the German DESY Laboratory in Hamburg. The detection gaps are slightly inclined to the radial direction to avoid left-right ambiguity in the readout. Below a view of the new Mark J Time Expansion Chamber, flanked by wires under tension.





DESY
Picking up the pieces

For the Mark J experiment at the PETRA electron-positron collider, a new inner detector has been built to surround the beam pipe and pick up the fine details of particle interactions. In this region very close to the collision point, highly unstable particles decay after traversing only a fraction of a millimetre, and can only be properly identified and measured by their decay products.

Called the Time Expansion Chamber (TEC), the new detector, built by an Aachen / CERN / Geneva / MIT / Siegen / Zeuthen (DDR) / Zurich (ETH) team, is now being put through its paces with colliding beams.

The basic TEC idea proposed by Heinrich Walenta is a still further refinement of the powerful multiwire chamber technique. One initial refinement was the development of the drift chamber in which the position of a particle along an axis is determined from the drift time of ionization products towards a segmented electrode structure.

The TEC is an effort to reach the ultimate limit of drift chamber resolution by setting up a low field drift region (drift velocity about 5 microns/ns) separated from a small high field detection region; by shaping the analog pulses from the anode to cancel the ion tail; by fast (100 MHz) analog-digital conversion to sample the pulses and allow drift time to be determined by a centre of gravity method; and by a cool chamber gas to minimize diffusion effects.

The cross-section of the chamber is divided into twelve segments, each containing a 4 mm detection gap, inclined slightly to

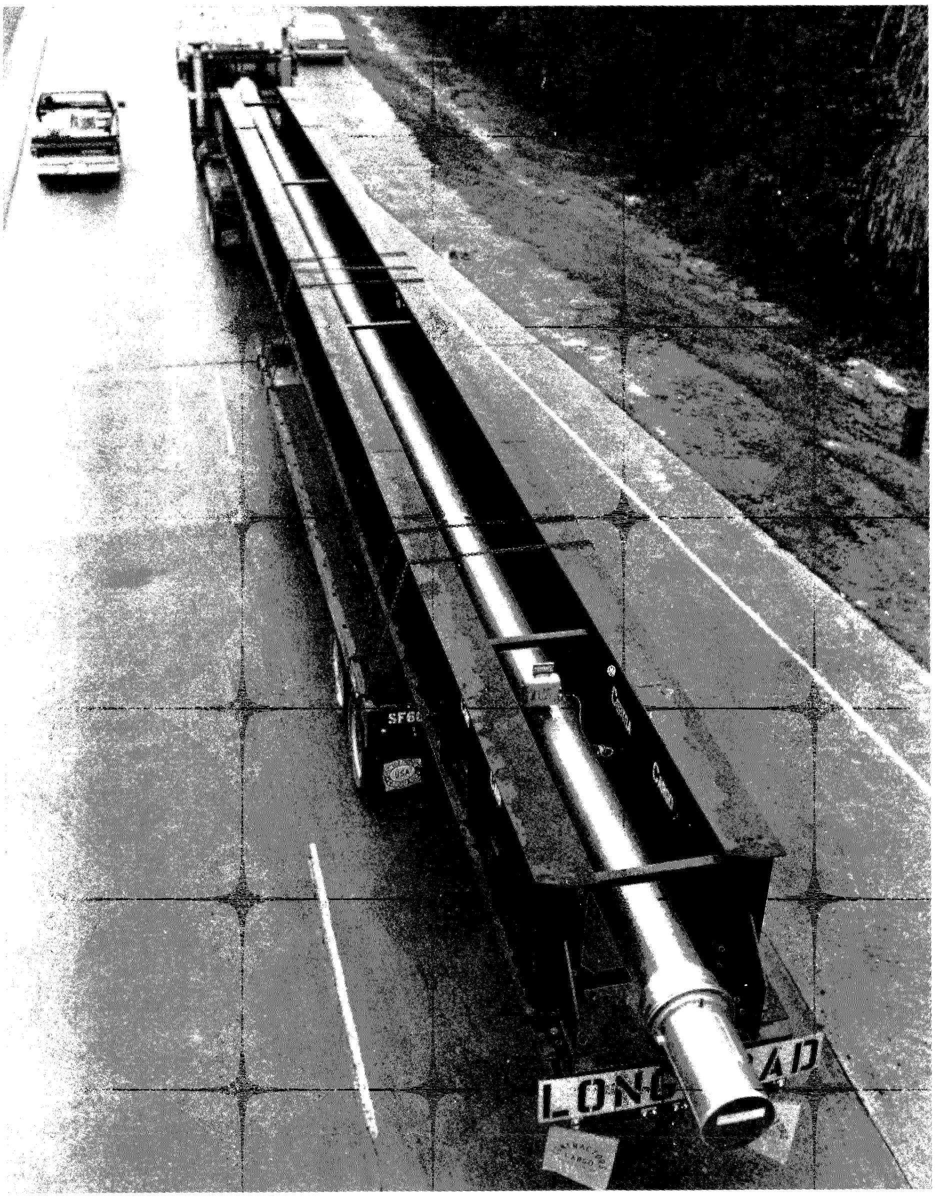
the radial direction to eliminate left-right ambiguity.

Spatial resolution of 35 microns was obtained in initial tests in an electron beam. The TEC has also been proposed as the innermost module of the big L3 detector now being built for the LEP electron-positron collider at CERN, which means that a lot of eyes are looking at what is happening inside the Mark J detector.

TEXAS
Supertex

Despite the decision last year that the mammoth proposed US Superconducting Supercollider (SSC) should go for the high field magnet design developed at Berkeley, Brookhaven and Fermilab (see November 1985 issue, page 383), the Texas Accelerator Center has taken delivery and tested 'Supertex', its first full scale 'superferric' magnet.

This 28 metre-long monster, the longest superconducting magnet ever built, was trucked from the General Dynamics factory in San Diego to Texas. Another two magnets are still being built. In the face of last year's magnet decision, Texas is still pointing out the potential benefits of its design.



'Supertex' on its way to the Texas Accelerator Center. 28 metres long, it is the longest superconducting magnet to be made. The small instrument visible on the top of the magnet records road shocks.

People and things

Dirac Medal

At the recent symposium on 'Perspectives in Particle Physics' at the International Centre for Theoretical Physics, Trieste, ICTP Director Abdus Salam presided over the first award ceremony for the Institute's Dirac Medals. Although expected, Yakov Zeldovich of Moscow's Institute of Space Research was not able to attend to receive his medal. Edward Witten of Princeton received his gold medal alone from Antonino Zichichi on behalf of the Award Committee.

UK Institute of Physics Awards

The Guthrie Prize and Medal of the UK Institute of Physics this year goes to Sir Denys Wilkinson of Sussex for his many contributions to nuclear physics. The Institute's Glazebrook Prize goes to Rutherford Appleton Laboratory director Geoff Manning for his contributions to physics applications at the Laboratory, particularly in high energy physics, computing and the new Spallation Neutron Source. The Rutherford Prize goes to Alan Astbury of Victoria, Canada, former co-spokesman of the UA1 experiment at CERN.

Philip Anderson (Princeton) and Abdus Salam (Imperial College London and the International Centre for Theoretical Physics, Trieste) have been elected Honorary Fellows of the Institute.

Third World Prizes

The 1985 Third World Academy of Sciences Physics Prize has been awarded to E. C. G. Sudarshan from India for his fundamental contributions to the understanding of the weak nuclear force, in particular for his work with R. Marshak on the theory which incorporates its parity (left/right symmetry) structure.

The Academy's Mathematics Prize goes to Liao Shan Tao from China for his fundamental contributions to the periodic transformations of spheres and the qualitative theory of dynamics.

The President of the Third World Academy of Sciences is Abdus Salam.

▲ *Friends and colleagues recently congratulated Aleksander Mikhailovich Baldin, Director of the Laboratory of High Energies of the Joint Institute for Nuclear Research, Dubna, USSR, on his sixtieth birthday.*

◀ *Ed Witten of Princeton (centre) admires his Dirac Medal awarded by the International Centre for Theoretical Physics, Trieste. He is flanked by ICTP Director Abdus Salam (right) and Antonino Zichichi, who made the award. The other medalwinner, Yakov Zeldovich of Moscow's Space Research Institute, was not able to attend the award ceremony, although expected.*

Opportunities in High Energy Physics Facilities

Brookhaven National Laboratory

The Alternating Gradient Synchrotron (AGS) Department of Brookhaven National Laboratory (BNL) is responsible for the operation of the 200 MeV Linac, the polarized proton injector, the 30 GeV AGS, and the Heavy Ion transfer line which will be commissioned soon. Under construction is a 1 GeV Booster Accelerator which will increase the AGS proton beam intensity and extend the AGS mass range to all heavy ion species. Funding is currently being sought to build a Relativistic Heavy Ion Collider.
Brookhaven National Laboratory is also a major participant in national research and development efforts for the Superconducting Super Collider. About 450 research and technical staff are assigned to the High Energy Physics Facilities organization at BNL.
We invite applications or nominations for the following staff openings:

Scientist-Engineer/Administrative

This is an opportunity for a PhD-level scientist-engineer experienced in accelerator physics research and development, with managerial experience. The responsibilities include technical oversight of AGS research and development efforts, machine upgrades, and reliability improvements, including a main role in the planning and execution of associated administrative functions. The position will report to the Chairman of the AGS Department.

Ultra High Vacuum Specialist

This is an opportunity for a PhD-level scientist-mechanical engineer with the necessary technical and managerial skills to head a vacuum group of approximately 20 individuals. The responsibilities include the research and development, construction and operation of the vacuum systems in an expanding AGS accelerator complex.

Chief Mechanical Engineer/ AGS Booster Project

This is an opportunity for a masters-level mechanical engineer to be responsible for the design, construction and installation of mechanical components and systems for the AGS Booster Accelerator. The Chief Mechanical Engineer will supervise a group of about 30 engineers, designers and technicians. Experience with high vacuum systems, large magnets and electromechanical devices, support structures, survey and alignment and radio-frequency cavities is required. Experience with particle accelerators is desirable.

Responses should be sent by June 15, 1986, to: J. Herbert, AGS Search Committee, Bldg. 911B, Brookhaven National Laboratory, Associated Universities, Inc., Upton, Long Island, New York 11973. Equal Opportunity Employer m/f.

BROOKHAVEN
NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES INC.

RESEARCH SCIENTISTS EXPERIMENTAL HIGH ENERGY PHYSICS

Supercomputer Computations Research Institute Florida State University

The Supercomputer Computations Research Institute of the Florida State University is seeking qualified candidates for 2 full time permanent research positions in experimental high energy physics. Preference will be given to scientists with strong software orientation willing to investigate the use of vector computers in the analysis of high energy physics data. Hardware experience is desired. Successful candidates will be involved in the ALEPH (LEP) or DO (Fermilab) collider experiments. Applicants should submit a curriculum vitae, list of publications and arrange for three letters of recommendation to be sent to

Dr. Joseph Lannutti
Director
Supercomputer Computations
Research Institute
Florida State University
Tallahassee, Florida 32306-4052
U.S.A.

The Florida State University is an Equal Opportunity, Affirmative Action Employer.

CERN
European Laboratory for Particle Physics
Laboratoire Européen pour la Physique des Particules
European Organization for Nuclear Research
Organisation Européenne pour la Recherche Nucléaire

The Experimental Physics Division intends to make an appointment to the position of a

PHYSICIST

in experimental particle physics research. Candidates are expected to have an excellent record of successful work in this field, and to have the ability to provide leadership. Preference will be given to candidates under 38 years of age. The appointment will be made for a fixed term, and may subsequently become permanent.

The holder will play an important role in all aspects of the conception and design of experiments, and of the construction and operation of detectors, and the development of on-line and off-line software and the analysis of data.

Please send letters of application, including the names of three referees, list of publications, a brief curriculum vitae and a brief description of research interests, to the

Leader of the
Experimental Physics Division,
CERN
1211 Geneva 23, Switzerland
quoting reference EP/RE,
before 10.7.86.

All in a Month's work

The US Particle Accelerator School is planning a new expanded school on accelerator physics and technology for the summer of 1987. Further information from Marilyn Paul, Fermilab MS 125, PO Box 500, Batavia, Illinois 60510, USA.

In the meantime the American Physical Society has set up a Topical Group on Particle Beam Physics for APS members, following a suggestion from US Particle Accelerator School Director Mel Month. Further information from Membership Department/Topical Groups, American Physical Society, 335 East 45th Street, New York, NY 10017, USA.

Roger Anthoine retires

The editor of the first issues of the CERN COURIER, Roger Anthoine, retired from CERN at the end of March after a career in CERN public relations spanning 27 years. During this time, hundreds of journalists and broadcasters came to know CERN and were able to convey something of CERN's work to many different audiences. Under his influence, CERN has also encouraged an open-doors policy, catering for groups of inquisitive visitors eager to find out what the business of watching particles is all about. In the early days, several hundred visitors per month was the norm, but in recent years the figure has swelled to several thousand per month and shows no sign of slackening off.

Proceedings

The Proceedings of the 1985 International Symposium on Lepton and Photon Interactions at High Energy, held in Kyoto, are available price 7000 yen per copy (including postage and handling) from ISLEPH85 Secretariat, c/o Yukawa Hall, Kyoto University, Kyoto 606, Japan. The Proceedings were edited by M. Konuma and K. Takahashi.

Roger Anthoine, 27 years after the first issue of the CERN Courier.

(Photo CERN 362.3.86)

The two frontiers of physics

D. Sciama of Oxford and Trieste — hoping that large-scale dynamics is getting understood.

In March at Garching, near Munich, physicists from different walks of life together took another hard look at the two major frontiers of physics — the very large and the infinitesimally small.

Organized jointly by CERN and the European Southern Observatory (ESO), the Garching 'Symposium on Cosmology, Astronomy and Fundamental Physics' was the second in a series launched at CERN in November 1983.

The goal of particle physics is to track down the smallest components of matter and to understand how they interact. Astrophysicists and cosmologists worry about the large scale structure of the universe and try to puzzle out why it is the way it is.

These two frontiers of physics are finding common ground, especially in the attempts to understand the formation of the universe in the convulsions of an initial 'Big Bang'.

The 1983 Symposium came in the wake of the unification of the weak and electromagnetic forces, and with other interesting new ideas — cosmological inflation, grand unification, etc. — held out fresh hope that the barriers around the biggest physics problem of all — the origin of the Universe — might be crumbling.

Two years down the line, some of that euphoria has evaporated, but fresh results have come in to keep a healthy interest alive. Garching summarizer D. Sciama of Oxford and Trieste was able to point to a shortlist of new observations and theoretical ideas which have made their mark on current thinking. 'Perhaps large scale dynamics are beginning to be understood', he claimed.

Cosmic background radiation

The faint glimmer of the 2.73 K cosmic background radiation discovered by Penzias and Wilson in 1964 is the last thermal vestige of the fiery incandescence from the Big Bang, and any structure in this radiation provides important clues.

G. Efstathiou of Cambridge described numerical simulations to find out what large-scale structure of matter would result from different sets of initial conditions. The cosmic background radiation does not show small fluctuations, ruling out certain possibilities for the moment. However continued precision measurements of this radiation could yet provide important clues to the early Universe.

F. Melchiorri of Rome reviewed the evidence for the dipole distribution of the cosmic background radiation and took a hard look at the limits for higher multipole distributions. The 'black body' nature of this radiation has now been confirmed over a wide range of wavelengths.

Satellite experiments

One important new aspect of the meeting was the inclusion of results from satellite-borne experiments, which free astrophysics measurements from the straitjacket of the earth's atmosphere.

M. Rowan-Robinson from London's Queen Mary College had results from observation of infrared emitting galaxies by the IRAS (Infra Red Astronomy) satellite, a very successful US / UK / Netherlands project. This reveals, as Sciama put it in his summary, '20 per cent more such galaxies in the North than the South'. This ties in with the dipole effect seen in the background radiation, showing that we appear to be pulled through space by some distant concentration of matter at the rate of about 500 kilometres per second.

Theorist D. Schramm of Chicago looked towards confirmation of such new measurements, quoting Eddington, father-figure of modern cosmology: 'do not believe astrophysical observations until confirmed by theory!'.

Neutrinos

Two major particle physics contributions came in the neutrino sector, covered by K. Winter of CERN. One concerned the mass of the electron-type neutrino, still a controversial question, where a limit of 18 eV from a Zurich experi-

The idea of 'inflation' was put forward by cosmologists to link the initial Big Bang with our present relatively smooth Universe. But even initial inflation ideas had problems, as depicted by A. D. Linde of Moscow.

ment on the beta decay of tritium at the Swiss Institute for Nuclear Research directly contradicts the slightly higher values obtained in a long-running Moscow study.

The other neutrino headline was from the experiments at the CERN proton-antiproton Collider. By looking at the formation and decays of the W and Z carriers of the weak nuclear force they find that there is only enough room for a maximum of about six types of neutrino. 'This adds credibility to the idea of the Big Bang', commented Sciama, noting how this figure is converging towards the one implied by the abundance of light elements.

The puzzle of the missing solar neutrinos continues to intrigue physicists, and exciting new ideas have recently been put forward (see April issue, page 2).

Dark matter

Astrophysical measurements and current cosmological thinking both imply that the Universe contains a lot of mysterious 'dark matter', which may make up about 90 per cent of its mass but which interacts only feebly with the rest.

One of the main driving forces behind the dark matter idea is the notion that the Universe may be 'closed' — containing enough matter for its present expansion to be halted ultimately by gravity.

The particle physics implications of this dark matter were covered by J. Primack of Santa Cruz. The list of candidate particles includes neutrinos (both known and unknown), axions, supersymmetric particles, and other weakly interacting massive particles (WIMPS).

For the astrophysicists, Martin Rees of Cambridge declared himself to be a 'baryon chauvinist', saying that there were too many dark matter candidates and maintaining that astrophysical remnants (black holes) and small faint stars (brown dwarves) could do the trick.

Rees was of the view that a convincing determination of the degree of closure of the Universe is required before delving too deeply into dark matter, but on the other hand advocates of a closed ('flat') Universe should not be discouraged.

S. Shandarin of Moscow, a disciple of Zeldovich, covered attempts to pin down the large-scale distribution of light and dark matter, using percolation analysis ideas borrowed from solid state physics. It is no longer clear that the distribution of observable galaxies coincides with the overall distribution of matter, but there is growing conviction in a 'biassed' picture in which visible galaxies tend to populate regions where invisible matter concentrates.

Inflation

A big problem once facing Big Bang cosmologists was to explain how their Universe turned out to be so flat and (almost) homogeneous. To get over these, and other hurdles, the so-called 'inflation' scenario was put forward to modulate the Big Bang picture, with additional phases of supercooling, reheating, etc. Inflation says that the Universe has to be very close to closure, providing a strong motivation for dark matter.

K. Enqvist of Helsinki covered the latest ideas in inflation technology. While inflation was once a relatively straightforward idea, session chairman T. Kibble said that life has become more compli-

cated. Sciama described inflation as 'baroque', but still full of possibilities.

Pulling strings

Theorists offer two kinds of 'string' mechanisms, very different but both of considerable appeal to cosmologists, gaining high ratings by Sciama.

Of the new particle physics ideas on the market, superstrings (see June 1985 issue, page 185) is by far the best seller. M. Green of London's Queen Mary College gave the motivation behind abandoning a conventional space-time of points and introducing an underlying geometry of strings in a 10-dimensional space-time.

This may help resolve the fundamental difficulties of reconciling quantum effects and gravity, with the enormous energies (the so-called 'Planck Mass' — 10^{19} GeV) required to reveal quantum gravitational effects.

When the extra superstring dimensions 'curl up', all sorts of tantalizing goodies drop out, including candidate symmetries for grand unification, suggestions of Einsteinian relativity, etc., said Green.

The 'unwanted' dimensions could also provide a home for the dark matter which interacts so feebly with the rest of the Universe, he suggested.

A very different kind of string was pulled by N. Turok of London's Imperial College. While Green's superstrings inhabit an invisible inner quantum space, Turok's strings arise through the (Higgs) mechanisms of spontaneously broken gauge theories and weigh in at about a thousand tons per fermi (10^{-13} cm)!

A 'spaghetti' of such strings could have been cooked around the time of the Big Bang, and Turok showed how this could have developed, with loops creating centres of energy and possibly seeding galaxies. Turok compared the calculated evolution of his string spaghetti to the observed distribution of (Abell) clusters of many bright galaxies.

Quark nuggets

When the quark soup of the early Universe cooled down sufficiently for hadronic matter to crystallize, other kinds of superdense matter could also have been formed. One new idea mentioned by Schramm and by Sciama is that of 'quark nuggets'. According to Schramm, quark nuggets are one dark matter candidate and could also seed galaxies.

Laboratory aspects of superdense matter were covered by K. Kajantie of Helsinki. With heavy ion collisions at high energy scheduled at CERN later this year, it is important, he said, to know how to recognize new dense matter formed in such 'Little Bangs'.

Particle physics

Carlo Rubbia of CERN spoke on the status and prospects of particle physics. In bygone days, said Rubbia, one built an accelerator, did an experiment and found out new things. With the implications of the Planck mass, he was 'concerned' about direct access to new physics, and foresaw new types of attack using non-accelerator experiments. However this did not detract from the 'essential' task of building new machines.

Rubbia demonstrated how the correlation of particles into jets using modern detection techniques (calorimetry) has simplified the study of particle constituents to a level where we can see the energy dependence of the underlying quark dynamics.

He also displayed new data from the 1985 run at the CERN proton-antiproton Collider, where he could still point to candidate events with 'missing energy' carried away by invisible particles, not easy to explain.

Simon van der Meer of CERN painted his picture of the future of high energy machines. Conventional ideas are reaching their limit, he claimed, and showed how machine physicists are looking towards exotic new forms of linear accelerator to continue their tradition of opening up higher energy horizons.

In a memorable presentation on the final day, S. Chandrasekhar of

Planck Mass

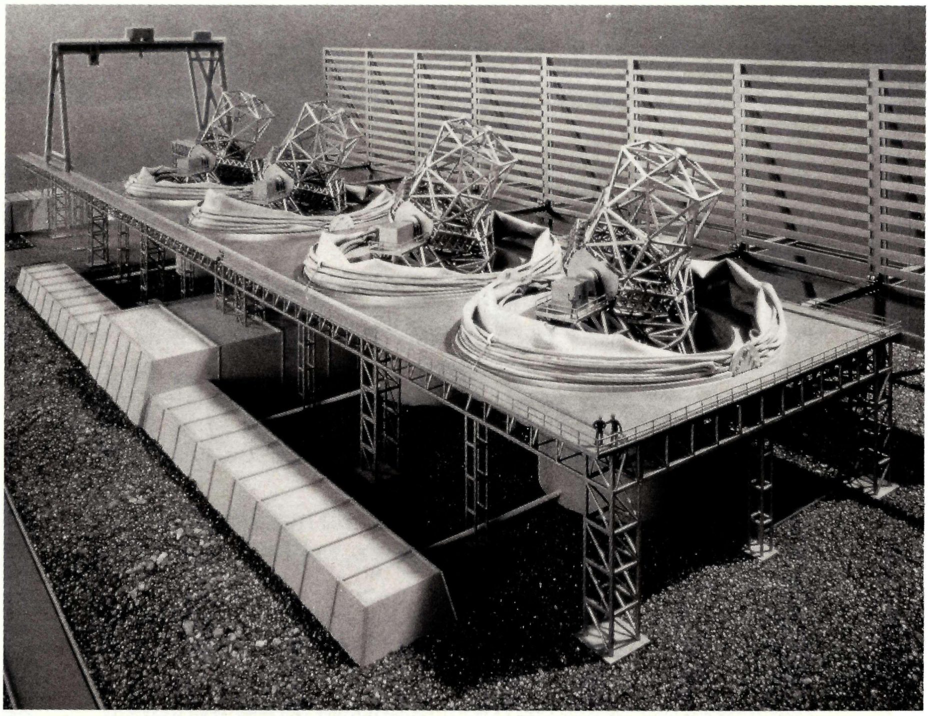
Quantum gravity effects are very feeble, and extreme energies would be required to make them show up. This is the so-called 'Planck Mass' of 10^{19} GeV — ten thousand million million times the energy of the Fermilab Tevatron. In the recent article by Guido Altarelli (April issue, page 6) a factor of a thousand million unfortunately fell somewhere by the wayside. But the essential point remains — the Planck Mass is way beyond anything imaginable on earth. Even using optimistic accelerating fields, it would need a machine several light-years long!

Halley's comet as recorded on 14 January in Miami, Florida, by a Notre Dame/Fermilab group using an 11 inch Cassegrain telescope together with detection and data acquisition systems developed to handle scintillations in an experiment at Fermilab to study the decays of particles carrying the charm and beauty quantum numbers.

Chicago reminded his audience that the implications of classical general relativity are far from exhausted.

In conclusion, Sciama hoped that the advent of the Space Telescope (hopefully not delayed too long) for observational astronomy, of new particle physics machines, and of the theoretical idea of superstrings should ensure that the next CERN / ESO meeting, scheduled for Bologna in 1988, should be particularly exciting.

by Gordon Fraser



Artist's impression of the 16 m 'VLT' optical telescope planned by the European Southern Observatory. Beams from the four 8 m unit telescopes would be recombined to form the final images. Because of its size, VLT would also dispense with the traditional domes covering the telescopes in favour of inflatable covers.

(Photo ESO)

Big Science

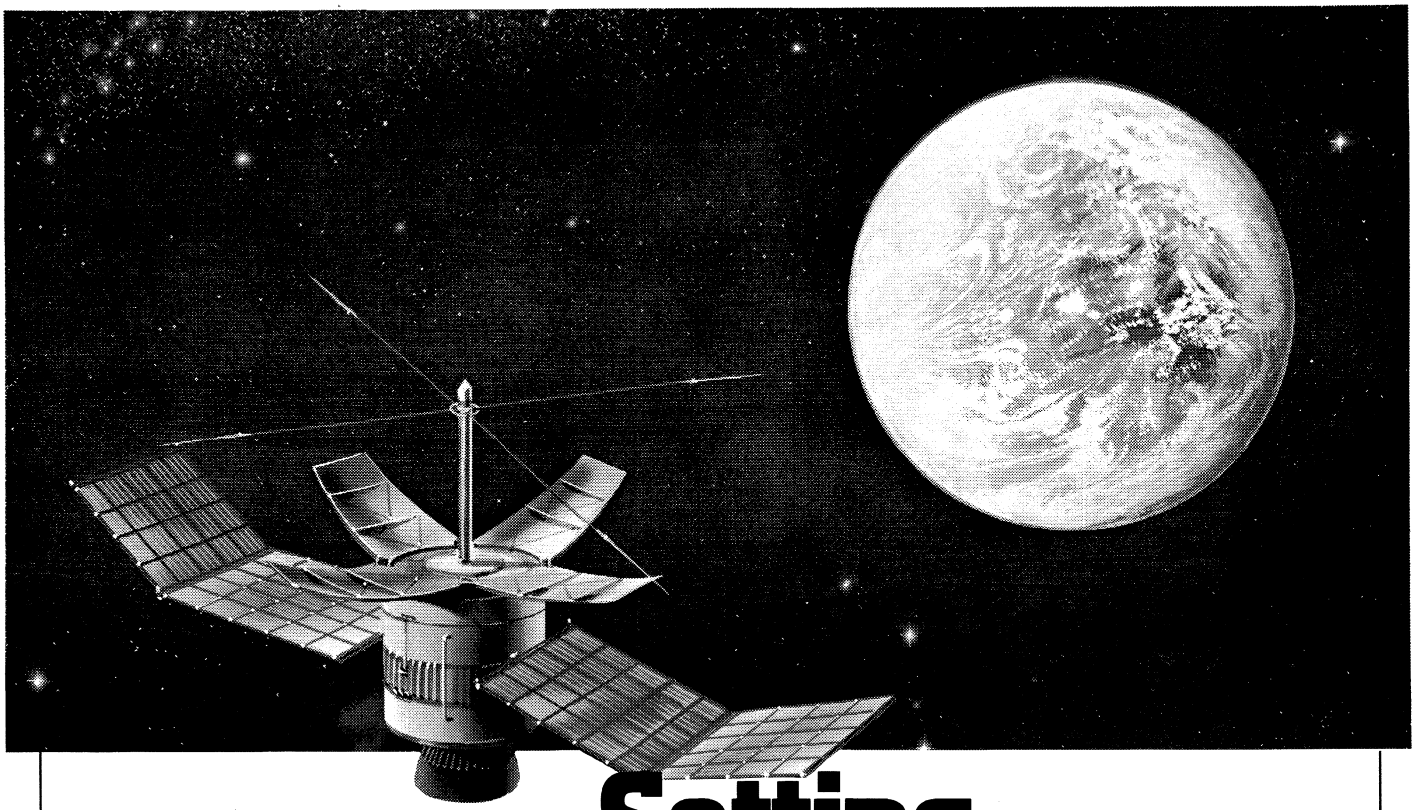
Astronomy, like particle physics, has become Big Science where the demands of front line research can outstrip the science budgets of whole nations. Thus came into being the European Southern Observatory (ESO), founded in 1962 to provide European scientists with a major modern observatory to study the southern sky under optimal conditions.

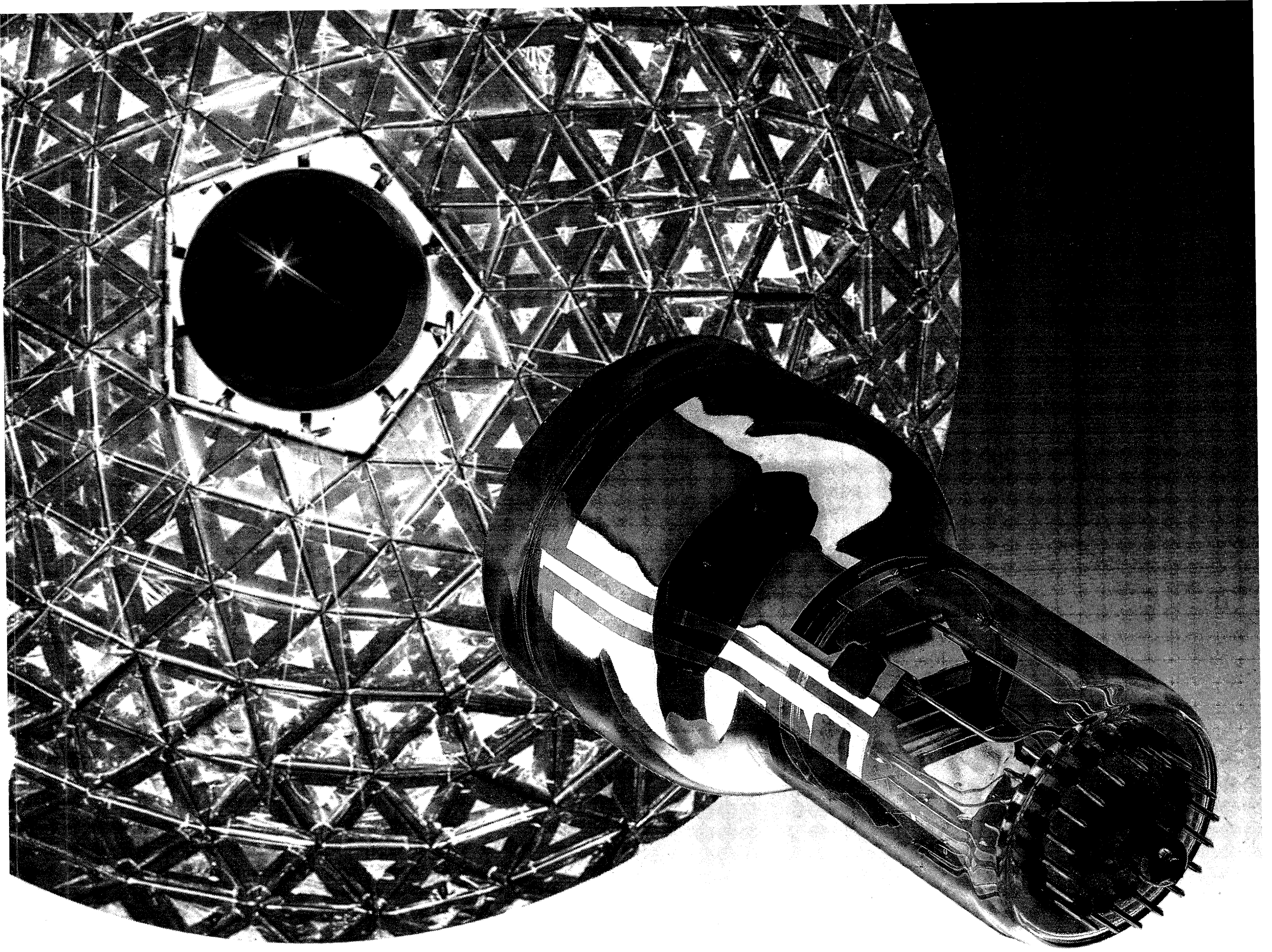
Before becoming installed in its Garching, near Munich, headquarters, ESO found a temporary European home at CERN. Reflecting this association, ESO was co-sponsor with CERN of the recent 'Symposium on Cosmology, Astronomy and Fundamental Physics' in Garching.

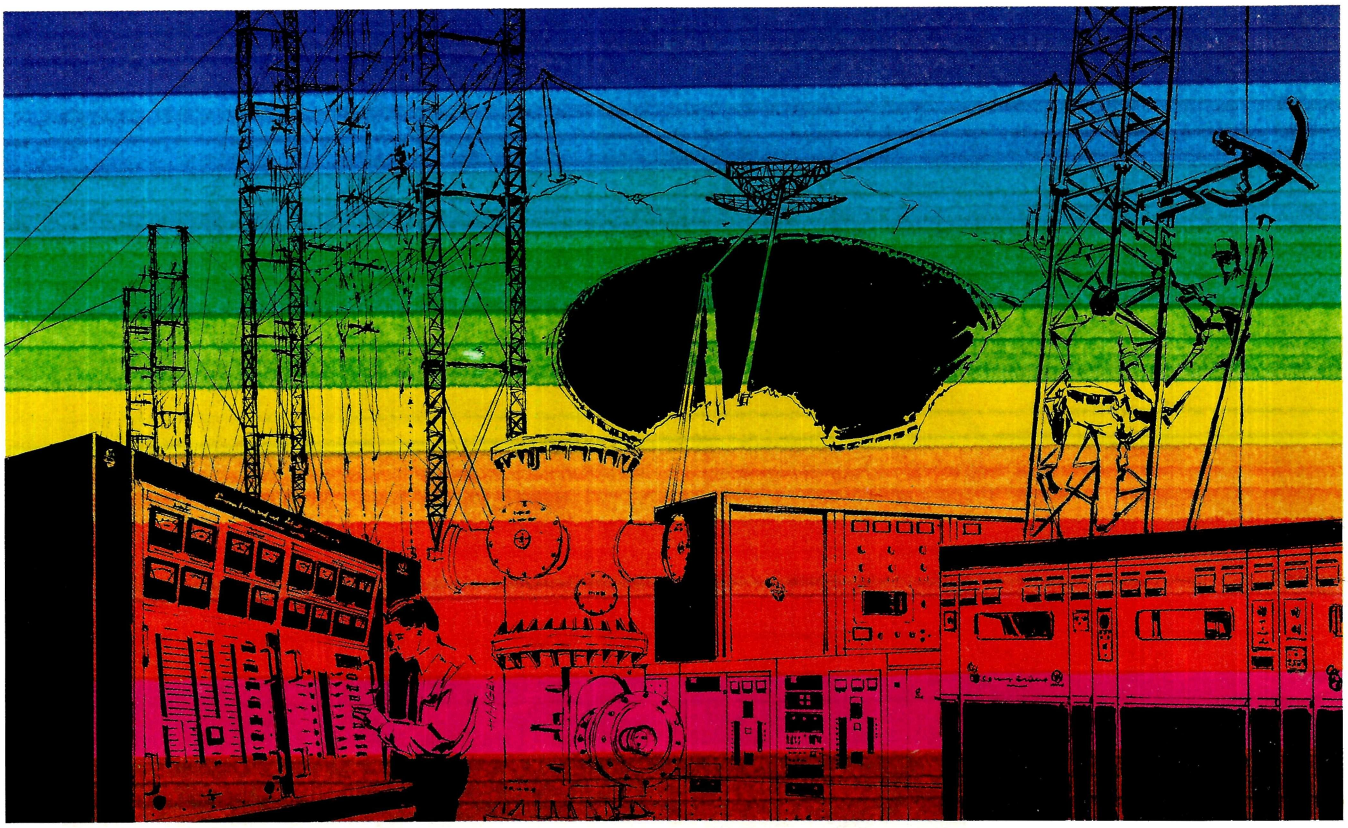
The largest instrument currently in use at ESO's Observatory in Chile is a 3.6 m telescope. From the beginning in 1976 this has been heavily oversubscribed. When Italy and Switzerland joined ESO in 1982, a 3.5 m 'New Technology Telescope' project was launched. Looking further ahead, ESO is planning an ambitious 16 m instrument to become one of the world's largest optical telescopes during the next decade.

Envisaged as an array of four separate 8 m instruments, this 'VLT' project would break new technological ground in many areas, reducing its unit cost compared with previous big telescopes. Among the VLT innovations are interferometric recombination of the beams from the separate unit telescopes and 'active optics' to compensate for image degradation in real time.

VLT would require an additional 300 million deutschmarks of funding, expected by ESO to be available by late 1987.







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