The IPHT's Beutenberg complex photographed earler this year. The soon to be completed clean-room facility is the last building on the left.

Jena, one of the two rival Zeiss companies, employed 27000 in Jena alone. The State of Thuringia oversaw restructuring and transformation of the *combinat* into Jenoptik and Jena-Optronik. It also provided significant investment, with the two companies and various spin-offs becoming important nuclei, along with Jena's Friedrich-Schiller University and several distinguished institutes such as the PTI itself, recreated as the Institute for Physical High Technology (IPHT), the Hans-Knöll Institute for Research on Biomaterials, the Institute for Molecular Biology, and the Fraunhofer Institute for Applied Optics and Fine Mechanics. Several of the institutes consolidated all or part of their activities to the Beutenberg science park on the outskirts of Jena that has become a principle focus for revived industry and research activities.

The PTI, which was well known for its work in plasma physics, magnetic materials, glass-fibre optics, and infrared sensors, had some 300 staff members at reunification. The plan is to stabilise the number at around 160, including 90 permanent positions with a significant number of temporary posts to provide flexibility and training opportunities (things that tended to be lacking in the past). Managing the transition remains difficult for most of today's approximately 180 staff members hold temporary positions, with funds for 50 of the 140 posts covered by Turingia due to end within the next two years. Some two-thirds of the IPHT's annual operating budget (28 MDM in 1993 including about 10 MDM for capital investment) presently comes from Thuringia, while the federal government supports through its research ministry — the BMFT — some 7 MDM of regular project funding. A further 1.5 MDM come from industrial contracts, mostly for work carried out in consortia. Expansion of the project work, including European Union projects, is vital, and the ground is being prepared for this. Major new investments include refurbishment of the institute and a new, almost completed, 15 MDM clean room equipped for circuit design, pattern generation and microfabrication, testing, and materials characterization. E. Hoenig from the Siemens research centre in Erlangen who was appointed IPHT Director in June 1993 says that the new facilities will offer "an environment allowing us to be really competitive". He also became a department head and it is in this capacity that he serves as the Director, for under the IPHT's new structure the position rotates among the four department heads, who also hold university appointments. As an association with a Board of trustees controlled by the State of Thuringia, the IPHT has adopted other organizational features common to most institutes in western Germany, including an independent scientific council.

The IPHT is concentrating on fibre optics for communications and sensors, laser-assisted processing and laser process monitoring, cryoelectronics, microsensors and systems, and high-T_c superconducting materials for electronic devices in the context of a major industrial consortium. A well-balanced project portfolio (see figure) will hopefully promote efficient synergies and stable budgets. Major initiatives include a "mini-foundry" to produce reasonably priced superconducting electronic circuits (including low-T_c types) and two electron-beam writing machines. The latter will be used to make both micro-optic devices with characteristic lengths below the wavelength of light and novel electronic devices (*e.g.*, single-electron tunnelling devices). Introducing the output from basic research into industry has become the dominant theme of virtually everything the IPHT tackles, the input from academic research being assured especially by two of the 15 new BMFT "innovation colleges". Given this motivation its is perhaps not surprising that the institute was largely responsible for launching and organizing the successful Europhysics Industrial Workshop on thermal microsensors — a fairly specialised and important topic, but one that has been chosen by the IPHT in staking out its future success.

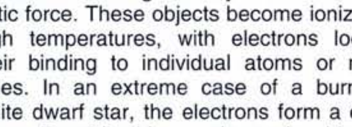
QUARK MATTER

New Round of Experiments Underway

Quantum electrodynamics (QED) describes how charged particles interact by exchanging photons to account for bound aggregates, ranging from atoms and molecules to solid materials held together by the electromagnetic force. These objects become ionized at high temperatures, with electrons loosing their binding to individual atoms or molecules. In an extreme case of a burnt-out white dwarf star, the electrons form a continuous Fermi liquid — a plasma in which the electrons are deconfined from their low-temperature bound states.

Quantum chromodynamics (QCD) describes how quarks interact by exchanging gluons, and helps explain bound aggregates of two or three quarks that we call hadrons (pions, kaons, protons, neutrons...) which are held together by the strong force. So QCD is an extended analogy of QED. It needs to be clarified whether the formal analogy with QED for cold objects extends to finite-temperature behaviour. QCD predicts that a plasma of quarks and gluons can exist where the colour-bearing constituents circulate freely in a hot vacuum that is transparent to colour (they are deconfined).

The only tool at hand to reach the conditions for deconfinement lies in the collision of heavy ions leading to a very hot and possibly thermalized quark-gluon plasma extending over the volume of the colliding ions. This phase will expand and cool until a phase transition is reached where the partons recombine into a hot hadron gas; the new hadrons keep interacting until further expansion finally lets them escape. So understanding the interesting part of the process (*i.e.*, the passage from the plasma state to its characteristic phase transition into hadrons) is shrouded by a pre-equilibrium partonic phase and subsequent hadronic rescattering. A decade of intense theoretical work has sought signals that might pin down the transient plasma and its phase transition. Two approaches have emerged, based on looking either at features established during the initial phase or at hadrons produced in the later stages.



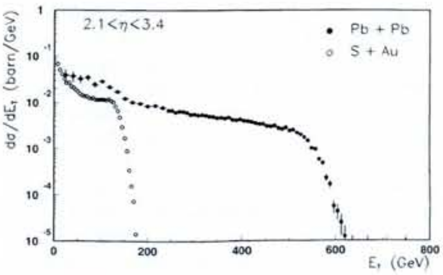
A simple model for the formation of the quark-gluon plasma envisages compression of hadrons in a vacuum. As the density increases, the hadrons start interacting and eventually merge into one another. The small vacuum bubble associated with each individual hadron fuses into a large bubble within which the constituent quarks can move over large distances. The same happens if a dilute hadron gas created in a high-energy collision is heated up (thermalized). A combination of compression and heating occurs in heavy-ion collisions.

First Round Encouraging

It appeared in the early 1980's that collisions of relativistic heavy ions in existing accelerators would most likely give the energy densities required for the formation of the elusive quark-gluon plasma. Moreover, data-taking involving the hundreds of secondary events produced in a typical collision appeared manageable. So a first round of fixed-target experiments got undeway using medium-sized ions (S, Si) accelerated to centre-of-mass energies per nucleon-nucleon collision of 20 GeV at CERN and of 5 GeV at the Brookhaven National Laboratory (BNL), USA. The energy densities sought were attained and there have been encouraging signals that some thermalization seems to be taking place: nucleus-nucleus collisions cannot simply be considered as mere superimpositions of nucleon-nucleon collisions. There is no doubt that a new state of matter is created, with a density 10-times that of hadronic matter. But one does not yet know if there is a phase transition between two very different forms of dense matter, as expected by QCD.

Second Round Starts

CERN proposed in 1988 a second round of fixed-target experiments based on adding several new accelerator systems and upgrading existing accelerators to produce Pb ions at 17 GeV per nucleon, BNL having recently extended its work to the heaviest ions at



Preliminary results from the NA 49 experiment's calorimeters at CERN's SPS Pb-ion facility confirm that the expected energy densities, sufficient to form the quark-gluon plasma, have been achieved. The figure shows the variation of the cross-section as a function of the sum of the electromagnetic and hadronic transverse energies for a pseudo-rapidity interval of 2.1 to 3.4. The formation time of the initial pre-equilibrium partonic phase is usually taken to be 1 fm/c where fm is one Fermi. Consequently, the Bjorken formula using the data for Pb on Pb collisions gives an estimated energy density in a primordial reaction volume (central collision) of 3.4 GeV/fm^3 compared with 1.4 and 2.3 GeV/fm^3 for S on S and S on Au collisions, respectively. Theory indicates that energy densities on the order of 2 GeV/fm^3 are sufficient to create the quark-gluon plasma.

4 GeV per nucleon. Both ventures brought together sizeable communities of particle and nuclear physicists — something that had not been seen since the early-1950's. As no single fixed-target experiment can cover all the potential signals of quark-gluon plasma formation (because instruments for one set of features are logically and topologically in the the way of instruments for other sets), CERN's Pb-ion programme involves seven major experiments. They are both complementary and partially overlapping, with all capable of selecting the central, head-on collisions offering the most favourable conditions for creating the plasma.

Setting up the accelerators started on 13 October and an (unextracted) beam was available only 11 days later. The intensity was soon close to design values. Helmuth Haseroth who is in charge of the accelerator aspects thinks the beam intensity can be doubled in the next run (scheduled for late-1995), something that can be tolerated by the experiments in spite of the very high data rates. The frequency swing of the last (and main) accelerator — the SPS — is not large enough for relativistic Pb ions. Avoiding a major rebuild to keep costs down (some two-thirds of the heavy-ion programme's funding comes from outside CERN) called for a novel acceleration scheme which is proving slightly acrobatic. It is based on the fact that batches of ions from the preceding accelerator do not fill the entire SPS ring, so the RF frequency can be adjusted during the beam-free period after every turn of the particles.

The main experiments must process huge amounts of data (some 18 MB/s in the case of NA 49, the largest experiment and capable of measuring almost all of the 2000 charged particles among the 3000 particles coming from a single event). Nonetheless, the collaborations are confident that first results will be reported early next year.

This report is based on personal communications from R. Stock (Frankfurt University) and M. Jacob (CERN).