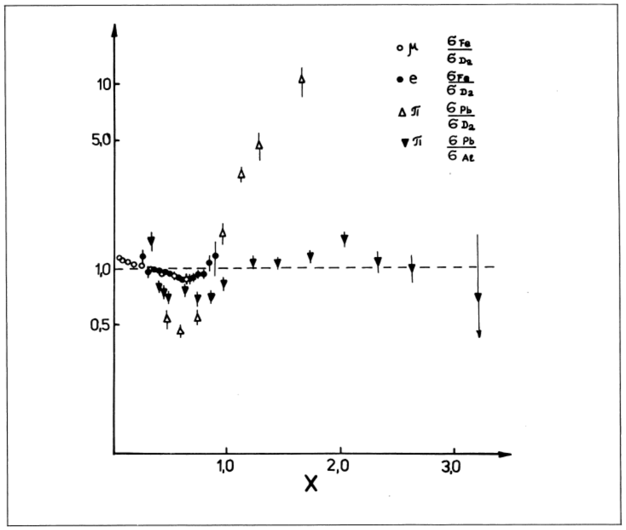


Variation in quark structure in nuclei with momentum fraction, x, as measured in different experiments. The ratio of effective nucleon cross-sections reflects the underlying quark structure (structure functions). The round data points are from deep inelastic experiments at CERN and SLAC, and the triangles from nuclear scattering at Dubna, measured under the conditions ('limiting fragmentation') which probe the constituent quark behaviour. The observation of structure for x greater than one implies 'superfast' quarks carrying the momentum of more than one nucleon.

trapped muons precess in the local magnetic fields before decaying. The emission of positrons in these decays is dictated by the laws of weak interactions, and their signals, conventionally monitored by scintillator telescopes, reflect the behaviour of the trapped muons.

For many purposes, a positive muon can be likened to a very light proton, so that 'chemically', the muon and the proton can be considered isotopes of the same element. The accessibility of muons to measurement through muSR provides a good window on the underlying properties of the sample.

The study of metals demands very low temperatures (down to the millikelvin range) and extremely pure samples. Studies at CERN have shown how muons are 'trapped' at impurity sites. Detailed studies of the diffusion steps leading to trapping and of the muon impurity configurations are under way. After this and other groundwork, studies of magnetic materials have gained momentum, and new magnetization behaviour has been seen which poses problems for theorists. In other substances, the onset of paramagnetic behaviour at the Curie temperature has been found to be less abrupt than once had been believed.

In many materials, the stopped muons can pair with electrons to form 'muonium' — a hydrogen-like atom with a muon, rather than a proton, as its nucleus. Like hydrogen, these atoms are highly reactive and can be used as probes of organic compounds.

A range of muonic organic radicals has been studied, and reveal interesting behaviour, both in the underlying properties of the sample and in an explicit comparison of muonium and hydrogen behaviour.

Development work in instrumentation has also paid dividends. A wire chamber detector has been developed at CERN which enables muon decay to be monitored in space as well as time. In conventional muSR detectors, the muon precessions are monitored by looking at the rate of positron decays picked up in a particular direction. This is prone to uncertainties due to beam impurities and other background effects.

The new detector correlates the observed positron trajectories with the muon decay vertex using coincidence techniques. First results have been gratifying, giving greatly increased rejection of spurious events.

Thanks to the cryogenic expertise at hand, muSR experiments at low temperature have already become something of a speciality at CERN. In addition, a new high pressure system has been developed for measurements on samples exposed to up to 14 kbar. First experiments will soon get under way.

Far from growing complacent and self-satisfied at its achievements so far, the muSR community is canvassing for extra support to cater for the growing list of potential users knocking at the door.

DUBNA
Quarks in nuclei

Until recently the structure of nuclei in terms of independent quarks was explored by studying nuclear reactions with large momentum transfers. Recent results from high energy muon experiments at CERN (see November 1982 issue, page 362) made it possible to obtain information on the nuclear quark structures (structure functions) in a hitherto inaccessible region of momentum fractions, x. These striking results, confirmed by the SLAC experiments on deep inelastic scattering of electrons on nuclei (see April 1983 issue, page 90) indicate that there is a significant difference between the nucleon's quark structure in nuclei and in free space.

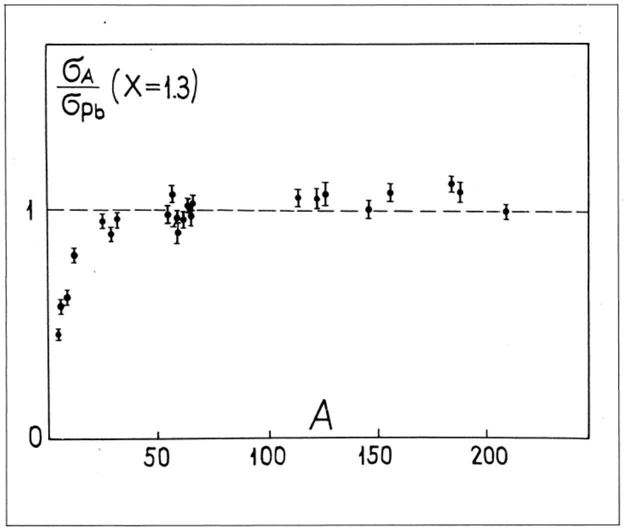
At Dubna, the data on the quark structure functions of nuclei obtained in relativistic nuclear physics (under suitable conditions — 'limiting fragmentation') have been compared with the data on deep inelastic scattering of leptons on nuclei. The CERN and SLAC data for deuterium and iron and the Dubna data for deuterium and other nuclei show that in the momentum fraction region between 0.5 and 1, the appropriate reaction rate on heavier nuclei is less than that on deuterium. Comparing the data from different nuclei shows that in this kinematic region, ratios of nucleon reaction rates (hence structure functions) go as the (x-1)/3 exponent of the ratio of atomic masses, and it will be interesting to test this in future experiments.

The region x greater than 1 ('superfast' quarks) is of special interest and has been probed in nuclear physics experiments at the Dubna synchrophasotron. Superfast quarks carry the momentum of a group of nucleons and are thought to come from multiquark states which exist in nuclei along with the nucleons.

These multiquark configurations are the result of fluctuations of quark plasma and the nucleus is viewed as a system near the critical point for the transition of nuclear matter into quark plasma.

The ratio of structure functions for various nuclei to that of lead for momentum fraction 1.3 is found to be independent of atomic mass number above 50. However for mass numbers less than 20 the structure function ratio decreases with mass. This implies that not only in deuterium, but in all the lightest nuclei, the quark configurations differ from each other and strongly differ from those in heavy nuclei.

Measured at Dubna for x=1.3 (superfast quarks), the nuclear quark structure relative to that of lead does not vary much above atomic mass 50. However for lighter nuclei, the relative structure changes significantly. This implies that not only in deuterium, but in all light nuclei, the quark configurations differ both from each other and from what is seen in heavier nuclei.



(From material supplied by A.M. Baldin.)

CONFERENCE
Computers and accelerators

In September of last year a Conference on 'Computers in Accelerator Design and Operation' was held in West Berlin attracting some 160 specialists including many from outside Europe. It was a Europhysics Conference, organized by the Hahn-Meitner Institute with Roman Zelazny as Conference Chairman, postponed from an earlier intended venue in Warsaw. The aim was to bring together specialists in the fields of accelerator design, computer control and accelerator operation.

The debates about the appropriateness of computer applications in accelerators are now long in the past and the discussions at the Conference were on the details of how to get optimum use rather than on any questions of principle. The computing power which can be bought per dollar continues to increase dramatically and the major restraints on applications are not related to the limitations of the computers themselves but rather to the ability to develop the necessary software programs. It is software which has become the dominant cost factor.

Because of the increased computing power, there is a new level of sophistication in control and operation. For example, rather than the operator adjusting individual machine elements, he can work directly on the machine parameters — Q value, chromaticity, etc. — with the computer taking charge of all the corresponding modifications.

Simulation programs to track beam through magnet systems are very much in vogue and can now incorporate collective effects, beam instabilities etc. Such simulations are particularly useful in storage ring operation where, rather than risk losing precious stored beams, it is important to be able to judge the effect of changes before actually implementing them in reality. These abilities enable machines to be 'modelled' at the computer, independently of the hardware, in a much more thorough way than before. The damping ring for the linear collider at SLAC is a recent example where models simulate the effects of errors and investigate correction schemes.