b) The FOCUS system

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the time needed to obey a single command is of the same order of magnitude as the human response time. However, the execution time for user written programs depends on the complexity of the problem that the computer is asked to solve, but the user is always able to control the process.

The abilities of the system are picked out in comments from users:

'The two characteristic features of the GAMMA system, namely that it is intrinsically a calculator of functions and that it offers on-line programming and on-line graphical display of calculated results, make it an attractive tool for numerical exploration of mathematical problems. Depending on the problem, the system rapidly provides either sufficient numerical insight to proceed with a further stage of algebraic work, or sufficient numerical insight to decide on how to program for extensive and/or more accurate computation off-line, or sufficient numerical information to regard the problem as solved.'

The following types of problems have been frequently treated on the GAMMA system:

I) Examination of convergence properties of successive approximation schemes and comparison between different schemes
II) Examination of the shapes of complicated curves and their dependence on parameters
III) Function inversion — elimination of a parameter in a parametric representation, for example, given \( F(x) \) and \( G(x) \) find \( F(G) \)
IV) Search for simple functional approximations to given data or curves
V) Qualitative study of parameter fitting to given data or curves
VI) Selection and detailed preparation of figures for scientific reports and publications.

Such problems were studied in both real and complex variables. The complex calculus implemented on GAMMA and the corresponding displays in the complex plane have proved very useful. Another important asset is the on-line production of hard copy of the display.

The GAMMA system has been used regularly over the past three years for an average of about twelve hours a week which has yielded considerable experience with this kind of interactive system. This was very helpful in designing an improved version which is now being implemented on the CDC 6000 computers at CERN. The language adopted has gone back to the algebraic formulation of normal programming languages, while many other basic features of GAMMA have been retained and extended. The new system will be operational on a small scale in a few months' time and the present GAMMA system on the CDC 3200 computer will then close down.

FOCUS is, basically, a complex file-handling system which was developed at CERN during the years 1967 to 1971. It does the file-handling job for users of the central computers and its tentacles reach out to all corners of the CERN site so that many users, for a variety of purposes, can be linked to the central computers.

The heart of the system is a medium size computer, a CDC 3100, aided by a Hewlett Packard 2116 which serves to concentrate the incoming and outgoing communications. The 3100 is linked to various other computers and terminals and it is from them that it receives data files and to which it sends data files. These input and output files contain different types of data, depending on the terminal. Thus FOCUS receives files from on-line experiments, from remote input/output stations or RIOS and, last but not least, from seventeen teletypes and four Tektronix 4002 displays that are
available to individual users. In the opposite direction, of course, it receives program output from the central computers — the CDC 6600 and 6500.

FOCUS assembles files into jobs ready for execution by the 6600 and 6500 and then passes them for processing to the big computers. The output is sent back to the RIOS or terminals where it can be printed out or projected on the displays. For a RIOS user there is almost no sign that FOCUS is at work. He reads his deck of cards into a small computer (for example, the IBM 1130 in the ISR building) and his output is printed out at the same station. Behind the scenes the IBM 1130 has passed the problem to the CDC 3100 (via the HP 2116) which has prepared it for the CDC 6600 and the results have travelled back through the same channels.

If we consider an individual FOCUS user sitting in front of a teletype or display screen the sequence of events would be as follows: The user first tells the system, via a special command, that he is there and wishes to make use of its services. After a few minutes the system will reply that all his files have now been read off tape and copied onto disk. This procedure is necessary because of the very limited disk space available — there is only sufficient for the files of about twenty users simultaneously and not for the files of all the inscribed users of FOCUS (now numbering about 200).

Once the user has his files available on disk (the files typically consist of several card images of FORTRAN programs, data card files, binary program files, and binary display files), he can change them, delete or copy them, send them to other users, assemble them into jobs and send them to the CDC 6500 or 6600 for execution, print them at any of the RIOS, or display them on his teletype. All this is made possible by the file handling programs resident on the CDC 3100 disk. If the user has been lucky enough to get hold of one of the Tektronix 4002 displays, he can, in addition, display pictures which have to be generated in the central computers using the GD3 plotting package.

Let us now take a look at two specific examples of ‘semi-interactive’ use of FOCUS in which the graphical display of results has been essential (of course, there are numerous others). The first example concerns the magnetic field plot of the ISR Split Field Magnet. The two Figures above show the contour plot of the main field component in one half of the magnet. The first Figure has areas free of field contour lines where, in the fifth-scale model of the magnet, the field could not be measured due to physical obstacles such as pillars and water supply tubes, shims, and compensators. The aim of the semi-interactive computing exercise was to fill in these areas with values of the field as it might look inside the obstacles if they were all made of non-magnetic material.

The simulation programs tracking particles through the fields were told to follow a particle into an unplotted region. Thus fairly reasonable field values in the empty parts, (values good enough to allow a rather precise tracking in these regions) were invented. This was done by interpolation between the existing values in an interactive way: in some twenty runs, using different numbers of points and different degrees of polynomials, this converged, via too low order fits and too high order fits, towards an adequate result (Figure 2) as judged from the smoothness of the curves.

The second example is illustrated in Figure 3. For an experiment of the CERN-Orsay-Vienna collaboration, it was necessary to study rejected events from a detection system consisting of cylindrical and plane wire chambers. The rather complicated layout of the detectors was displayed together with the signals that had occurred, and the information on the tracks which had been found. In a semi-interactive procedure certain parameters were varied in the track association program and the same events were reprocessed several times with only short delays.