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TOF, A NEUTRON TIME-OF-FLIGHT DATA ACCUMULATION AND REDUCTION CODE

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Abstract: TOF, a data accumulation and reduction code for neutron time-of-flight angular spectra measurements, has been developed for our IBM/360-44 computer and our LINAC as a pulsed source.It has been organized for "on-line" data accumulation, and reduction after adjustable length periods, for the experimenter to keep track of the measurement progress. Optionally it may be used for "off-line" data processing. TOF performs count rate loss, different sources of background, flight path transmission, detector efficiency, and time-of-flight corrections; and provides neutron flux per unit energy both for ungrouped and for resolution and statistics grouped channels. Detailed flowcharts show the organization of the code.

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1. Introduction

In the formulation of TOF the code HECTO(1) has been used as guide.

In the time-of-flight method, the neutron angular flux spectrum is measured by extracting a collimated beam from the experimental assembly at the desired position and angle, and measuring the time-of-flight over a fixed, known distance. Time zero is defined by pulsing the neutron source. In our experiments, the source is a target, usually a heavy metal such as depleted uranium or tungsten, bombarded by high energy electrons from the linear accelerator. The electrons generate bremsstrahlung, which in turn produces a broad spectrum of fast neutrons by photonuclear reactions. Neutron emission is coincident with, and proportional to, the bremsstrahlung (and electron) pulse, and in many experiments the bremsstrahlung or "gamma flash" counts serve as a convenient time marker. In bulk media a correction is made for the emission time: the time for a source neutron to-eventually multiply-slow down and diffuse to the point where it enters the collimated beam; also the correction is made for the time to capture in a moderating detector.

The time analyzer is started with a trigger pulse which stands in a fixed time relationship to the accelerator current pulse.When a neutron is detected, its arrival is timed by a fast discriminator, and one count is added to the proper channel. The source and analyzer are triggered repetitively until enough counts are accumulated for good statistical precision. In addition to the signal run there are other runs for the background corrections.

The cost per unit time of this type of experiments which use a linear accelerator is high. This fact implies the need of prompt detection in the net spectrum of failures like displacement of the electron beam spot- and hence of the neutron source which excites the assembly under study - and drift of photomultiplier high voltage. It also assigns an appreciable economic value to the experimenter immediate recognition of the results having reached the proper statistics for all energies of interest This has prompted us to organize TOF for on-line accumulation, and reduction after adjustable lenght periods.

2. Data-reduction procedure

On the basis of the tables and initial data, and before background and data counts accumulation or reading, these steps are followed:

a) Time-of-flight corrections.

They include the effect of different delays, of the finite channel width, of the emission time and of the time to capture in a moderating detector.

b) Neutron energy calculation.

c) Calculation of the sensitivity of the time-of-flight spectrometer.

It is taken as the energy dependent product of the intrinsic detector efficiency times the flight path transmission.

After such counts reading or (partial or complete) accumulation, these steps are completed:

d) Data count rate loss corrections.

The longest dead-times appear at the time analyzers. Options are available for three different time analyzers:

- RIDL model 34-12B adapted as reported in (2)
- LABEN model TV60
- A time to analog converter

e) Monitor count rate loss corrections.

Live monitor counts are corrected for dead time loss.

f) Background corrections.

The TOF background correction schemes apply to the following cases:

- Only one neutron detector is used.
- One neutron detector and one gamma detector both with the same efficiency to gammas are used.
- Delayed neutron counts have to be subtracted (multiplying media).
- A neutron detector insensitive to keV and slower neutrons is used.
- The counts in the earlier channels are only due to gammas.

g) Neutron flux per unit energy computation.

It is calculated for ungrouped and for resolution and statistics grouped channels.

3. Flowchart

TOF is divided in four phases (Fig. 1):

Phase 0 In the phase 0 the off-line reading of initial data and tables is performed. The tables may be read either from cards or disk. In the latter case those are previously read in and written by a separate program in the disk data set UDSTAB.
This phase executes a preliminary processing during which the tables corresponding to neutron energy, spectrometer sensitivity and time-to-energy interval conversion factor for each channel; and several constants, are calculated and recorded in the disk data set UDSDAT to be used later.
Besides, this phase calls the option for "on-line" or "off-line" treatment of data. In the latter case the data are previously read in and written by a separate program in UDSDAT.

Phase 1 In this phase the "on-line" or "off-line" reading of background data and additional data for its correction is performed. In the process 1 both the count loss corrected background, to be used in phase 2, and the raw background, are recorded in UDSDAT. Process 2 provides an opportunity to accumulate more background counts to improve the statistics: the raw background is added to the raw background recorded in UDSDAT during process 1.
The analyzers which perform the time-of-flight to digital conversion work with equal duration time channels in the whole time range after the neutron burst covered in every sweep. This does not take into account that at late times the time resolution is too fine compared to the meaningful energy resolution. An important saving both in memory and in handling of large amounts of words can be achieved by using the channel compression option which is available in all the "on-line" data accumulation processes (phases 1 and 2). Channels after a certain one are grouped in pairs by ignoring the last address bit, and so on.

Phase 2 In this phase the signal data are accumulated and periodically reduced during the experiment, using alternatively for each function two areas of the memory.

The data reduction in phase 2 is complete as described in 2., except for the channel grouping; it is done after "on-line" reading of additional parameters and reading from UDSDAT of the count loss corrected background, and the tables and auxiliary constants recorded in phase 0. The result is the neutron flux per unit energy as a function of energy, which is plotted, and eventually shown on an oscilloscope screen. In case something has been abnormal, and during an adjustable duration interruption which follows, the experimenter has the opportunity to eliminate the information obtained in the preceeding period, preventing it from being added to the whole experiment data accumulation in UDSDAT for final processing in phase 3. If such information is not accepted, the experimenter has also the option to continue or to stop the measurement.

Phase 3 In phase 3 the complete data reduction(included channel grouping for resolution and statistics) is performed. The data are those accumulated during the whole experiment(or read from cards) in UDSDAT.

4. Subroutines of TOF

a) ASSEMBLER

IUPSI	Test UPSI bits
KTXITE	Returns from external interrupt routine
OLDA	Starts on-line data acquisition and add one to memory process
OLWT	Waits completion of previous process
STXITE	(ROUT,I) - Sets external interrupt routine exit

b) FORTRAN

CORM	Monitor corrections for coincidence loss
DESN	Detector sensitivity calculation
LETAB	Reads tables from cards or disk
RDDIS	Reads data from disk

TABRD	Reads tables from disk by name
TERP	Performs interpolation
TIER	Channel energies calculation
UNIF	dt/dE = FEU calculation
WRDIS	Writes data into disk

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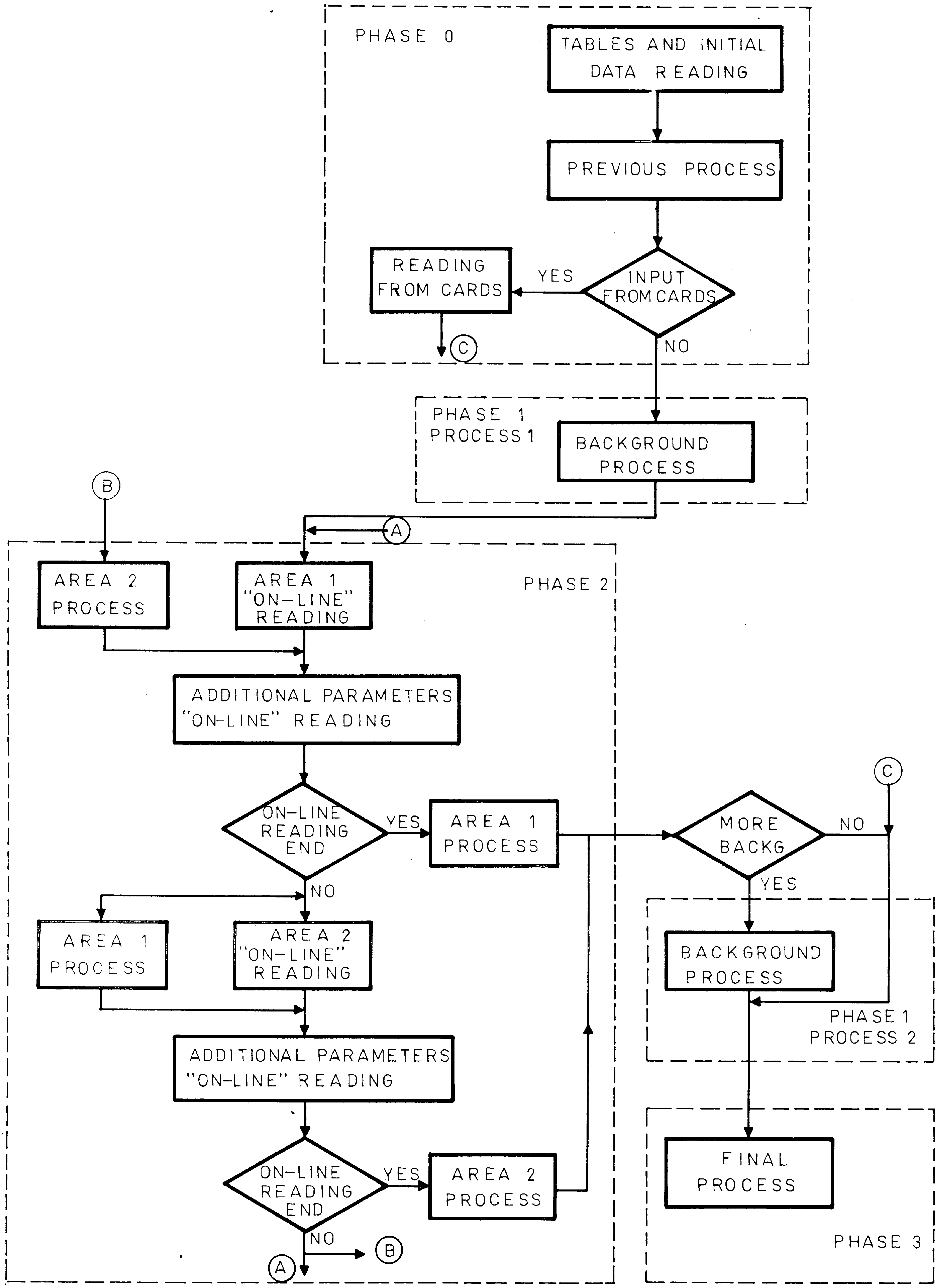

FIG. 1

FLOWCHART OF TOF "ON-LINE" CODE