§21. New World Record of Diagnostic Data Amount in Fusion Plasma Experiments

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In the 7th campaign of LHD experiment in 2003-2004, the quasi-steady-state plasma discharges had been successfully held, and their longest duration was ~ 756 s. The LHD data acquisition system, named LABCOM system, had established a new world record of the acquisition data amount 3.16 GB in a single plasma discharge of fusion experiments. Most of this data amount has been produced by the new real-time digitizers, therefore, the world record has also proved their practical usefulness very well. In recent few years, we have been preparing for the brand-new digitizer systems that can continuously run in steady-state operations.

Raw Data Growth in LHD Plasma Diagnostics

The LHD diagnostics have about 40 kinds of plasma measurements and their total number of signal channels is about 2000. Recently, the use of cameras, such as 2-D CCD, has been remarkably increased. In the 2003-2004 campaign, their typical amount of whole acquisition data went up to 1 GB/shot in 150 shot/day short-pulse operations. (See Fig. 1)

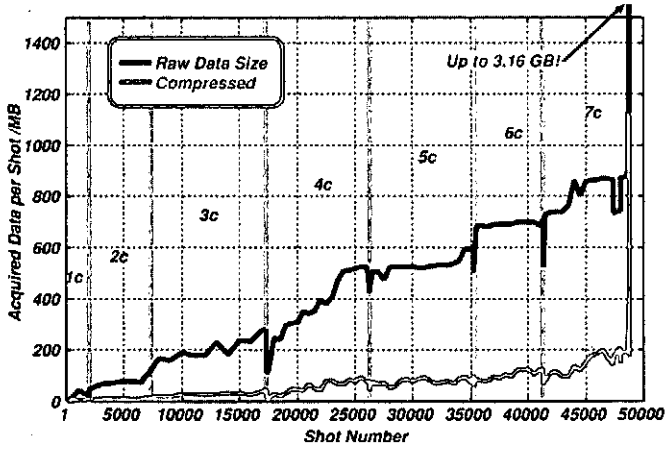

Fig. 1. Growth of shot-by-shot acquisition data amount in LABCOM system.

The growth rate of the raw data once slowed down in the recent few campaigns, however, near the end of the last one, it is coming back again. In the next one, the number of diagnostics will certainly become over 50. Almost all of the newly installed digitizers are not the conventional CAMAC ones, but the Yokogawa WE7000 and NI PXI series products. In the 7th and coming 8th campaigns, we have 15 new installations that consists of 10 WE7000 and 4 PXI, whereas the CAMAC based new measurement is only one. We can conclude from this fact that the digitizer change over from the conventional CAMAC has come off mostly.

Reinforcement of Mass Storage System

The intense growth of diagnostic data amount inevitably needs larger reinforcement of storage volumes every year than previous one. The total size of the LHD diagnostic data is about 21.6 TB for the whole six years' experiments, and even keeps growing with increasing rate.

As for the storage equipment and database system, the LABCOM system has three categories of the storage layer: The first one is the local disk arrays for each data acquisition computers where raw data just acquired have been stored into the virtual volume provided by the Object-Oriented DBMS. The adoption of OODBMS is for the seamless transformation between the volatile data objects in C++ application and their persistent instances in OODB space[1]. The second layer consists of plural sets of huge redundant disk array (RAID) servers, for providing fast data retrieval to clients. The third one has a few sets of so-called the mass storage systems (MSS): For the beginning four campaigns, three sets of 1.2 TB magneto-optical (MO) disk jukeboxes have been applied, and after that, DVD-R changers whose capacities are 1.8 TB or 3.3 TB for each are adopted until now. The numbers of running data servers are about 40, 3, and 4 in respective layers. Servers in the latter two categories are not operated on OODBMS. By means of the data migration mechanism between these layers, however, they can be considered as the virtual OODB extension area.

New Real-time Digitizers: Yokogawa WE7000 Series and CompactPCI (NI PXI) Series

From the 7th campaign, we have started to operate the Yokogawa WE7000 digitizer series. They are capable to make the real-time non-stop data acquisition at a reasonable sampling rate, which was quite difficult for conventional CAMAC ones. The primary part of the steady-state data acquisition in the previous 756 s long-pulse experiment has been done by them. As their cost-performance is quite reasonable compared with CAMAC, their utilization has greatly increased in LHD recently. (See Table.1)

For the faster streaming data acquisition, such as high resolution cameras, we have continued R&D of CompactPCI digitizers in recent few years[2]. Near the end of the 7th campaign, we finally revealed its practical usability with a combination of the PXI frame grabber and a fast IR camera that continuously outputs 16MB/s video stream. By the prototype examination, we have already confirmed that its maximum transfer rate goes up to 80 MB/s continuously from one PXI digitizer front-end to host PC.

Table 2. Cost and performance comparison between conventional and new digitizers.

Digitizers	Real-time	Sampling rate (No. of chs.)	Cost/ch.
CAMAC	No	~1 MHz (< 132)	150~250 k¥
VME	Yes	~10 Hz (8)	20~50 k¥
WE7000	Yes	~20 kHz (32~40)	55~80 k¥
CompactPCI	Yes	~1 MHz (28)	100~200 k¥

References
1) Nakanishi, H. et al.: Fusion Eng. Des. **48** (2000) 135
2) Nakanishi, H. et al.: Fusion Eng. Des. **56-57** (2001) 1011