§27. Modification for Uninterruptible Signal Monitoring and Ultra-Fast Diagnostics in LHD

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Data amount of fusion plasma diagnostics continues growing in about 50% annually, which corresponds to 10 times in 5 years and 100 times in 10 years. A constant data growth observed at LHD (Fig. 1) follows this *Moore's law* very well. Similar trends are also reported at many fusion experiments in the world. The number of data acquisition (DAQ) nodes also keeps increasing since the beginning of LHD experiments (Fig. 2). It already has more than 100 online DAQs and about 20 manually registered user data.

To store so-called an endless data stream having indefinite time duration, we have invented a new idea of 'subshot' that cuts the stream into 10 second time chunks[1)2)]. This enables us to access the data even while data writing is continuing till the end of the long pulse discharge. These subshot data can be retrieved by "*shot . subshot*" like *#123456.1* for the long pulse experiment.

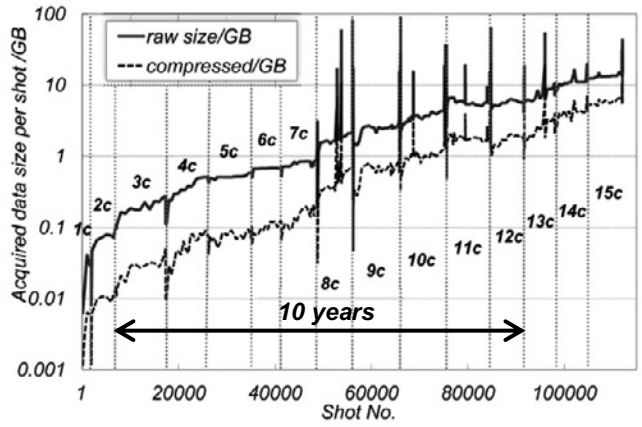

Fig. 1. Annual growth of acquired data in LHD: Compressed size shows the usage on storage capacity. Some spikes mean the long-pulse experiments.

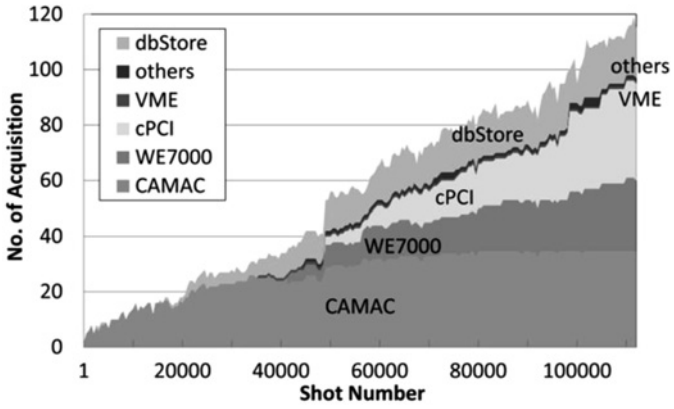

Fig. 2. Number of acquisitions for each digitizer type: The total number has been constantly growing, but legacy camac was saturated in an early stage and instead the real-time capable ones grow so rapidly.

The 10-second subshot rule has been implemented in the data archiving system. Since it was designed by taking PC performances of those days into account, the fixed subshot length gradually becomes unsuitable for such the slow 24/7 continuous monitors or much faster samplings.

A new PXIe-5186 digitizer can continue 12.5 GS/s/ch sampling and from the PXI-Express (PXIe) frontend we can sustain the data grabbing at about 600 MB/s. To process the 6 GB raw data is still troublesome on modern PCs so that shorter time chunks will be preferable, e.g. 1 second. It has already been implemented for a new diagnosis "CTSfosc1" and been operating for the last 15th campaign of LHD.

Oppositely, continuous monitoring of environmental signals or device healthiness often adopt 1 S/s – 1 kS/s slow sampling, which would produce too many little chunks if 10 second rule were applied. For exploring daylong trend graphs easily, we have to adopt longer time chucks, such as 10 minutes or 1 day. To satisfy above-mentioned opposed requirements, we have modified the DAQ system to cope with the variable chunk size.

Figure 3 shows the schematic view how to make daylong sparse sampling data for device healthiness monitor CDP (Control Data Processing system). The day-long CDPslowL are used for browsing long-term trends, while raw CDP are used for fine signal analyses. We have also been operating 16 channel environmental dose monitoring RMSAFE (Radiation Monitoring System Applicable to Fusion Experiments). Both of them adopt 10 minutes chunks and have been running for the past two years. Table I shows their details.

1) Nakanishi, H. *et al.*: J. Plasma Fusion Res. 82 (2006) 171
2) Nakanishi, H. *et al.*: Plasma Fusion Res. 2 (2007) S1117

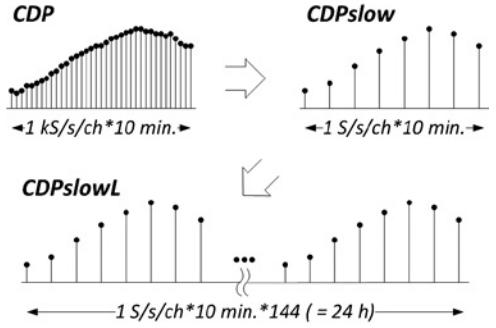

Fig. 3. Resampling of raw CDP signal: The raw 1 kS/s CDP will be automatically resampled into 1 S/s every 10 min., which will be coupled for daylong one.

Table I. 24/7 slow DAQs in LHD ('ss' means 'subshot')

	rate	sample/ss	period	ss/day
CDP	10^3 s^{-1}	600 000	10 min.	144
CDPslow	1 s^{-1}	600	10 min.	144
CDPslowL	1 s^{-1}	86 400	24 h.	1
RMSAFE	0.2 s^{-1}	120	10 min.	144