

### §31. Present Status and the Future Prospect of Optical Data Archiving in LHD

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The LHD diagnostics data archiving system has continued using optical or magneto-optical discs for long term data storage since the beginning of 1998 LHD experiment<sup>1,2)</sup>. In fusion experiments, many time series of one-dimensional waveforms and two-dimensional images are produced simultaneously, however, they are not necessarily very long due to the plasma duration time of milliseconds or seconds. As a result, the individual data “granularity” is smaller than so-called multimedia audios and videos and the number of data objects is much bigger to the contrary. Because of our long experiences on them, we know well that random accessible record media are more suitable than sequential access media, such as magnetic tape streamers, for fusion experimental data. Table 1 shows the NIFS history of using optical record media.

As show in Fig. 1, the total amount of acquired raw data is about 20 GB/shot recently. LHD usually iterates the short pulse plasma discharge experiments in every 3 minutes. We have consequently 170–180 shots per day very constantly. Daily recording amount will be  $20 \text{ GB} \times 170 \times 1/3$  averaged compression ratio = 1.1 TB/day. Until 2012, we had used 50 GB Blu-ray recordable (BD-R) media with 6 drives in parallel. However, it became almost impossible to burn the daily amount within a day.

Under the BD-R standard specification, we could not expect more than 6X high speed BD-R. Improving the writing speed is only possible by increasing the number of drives inside the library equipment and executing more numbers of parallel writing simultaneously. However, this would also involve equipment cost increase, and never solve the problem of increased number of media for daily data amount.

While we were hesitating for deciding the next-generation library equipment, SONY and Panasonic released the new BD-R data archiving technology and library products in 2013, which adopt cartridge-formed

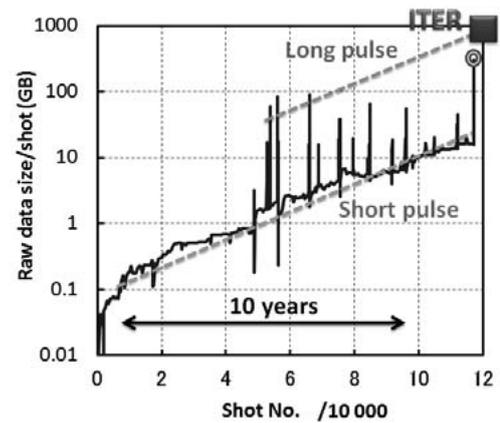


Fig. 1. Continuous growth of acquired data in LHD: The increase trend fits the Moore’s law quite well which almost corresponds to 100 times in 10 years. Upper spikes mean the long-pulse experiments, and the highest one signed by double circle is the world record of 328.5 GB/pulse.

magazines containing 12 of 100 GB BD-XL media and enables parallel access by using multiple optical pick-up devices<sup>3)</sup>. Especially, the Panasonic product can perform more than 200 MB/s striped reading/writing by using 12 drives in parallel. Day-long data storing could be, therefore, drastically shortened for a few hours. As we can obtain enough operational time margins in LHD’s daily data archiving, we have decided to adopt Panasonic’s LB-DM90 since 2013<sup>4)</sup>.

This fast data I/O speed and the capacity of one magazine are now quite comparable to the newest linear tape devices, such as LTO Ultrium 5&6. However, the BD-R data archiver has lost the ability to accept multi-user accesses as “near-line” storage. It takes about 60 seconds to get the 12 media ready for read/write access. As Fig. 1 clearly shows, we will also have to continue the innovation on archiving technology and devices to follow the continuous data growth.

- 1) H. Nakanishi, O plus E, **32**, 4 (2010) 422–425.
- 2) H. Nakanishi, FRL Storage News, 2013.3Q (2013) 13.
- 3) NIKKEI ELECTRONICS, 2013.5.13, (2013) 53–61.
- 4) NIKKEI ELECTRONICS, 2014.5.12, (2014) 16–17.

Table 1. History of optical disc archives in NIFS/LHD<sup>1)</sup>: Before the LHD experiments, 12-inch magneto-optical (MO) discs were used for the long term data archiving on the VAX/VMS system.

Year	Disc type	Total discs	Library device	Dises /unit	Units	Total capacity (TB)
– 1997	2.6 GB MO	~ 60	(DEC/VAX)	1	2	0.16
1998–2001	4.8 GB MO	714	HP SureStore Optical 1200ex	238	3	3.4
2001–2003	4.7 GB DVD+R	1400	Pioneer DRM-7000	700	1	3.3
2004	9.4 GB DVD-R	800	Kubota Comps BA-200	200	4	7.5
	4.7 GB DVD-R	840				
2005	30 GB UDO	300	Plasmon G438	438	1	13.1
2006–2007	50 GB BD-R	8451	ASACA AM-750BD	700	2	423
2008–2012			ASACA AM-1450BD	1400	2	
2013 –	100 GB BD-R * 12 (magazine)	90	Panasonic LB-DM90	90	1	90