Status Update for the HIT Accelerator Control System

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Abstract

Changes in the accelerator beamline of the Heidelberg Ionbeam Therapy-Center (HIT) and in virtualization hardware and software as well as demands for more redundancy and performance prompted an overhaul of the accelerator control system (ACS) and a new approach to the hardware base.

The addition of a third ion source necessitated an expansion of the Virtual Accelerator (VAcc) structure both in the database and the Device Control Units (DCU) software. To increase redundancy and system performance, new virtualization servers and storage systems were used and the ACS database needed to be revised. To take advantage of newer hardware and operating systems, all server programs and GUIs were converted to a 64 bit base. As a quality of life and security improvement, the download and flash functionality of the ACS were updated to enhance performance and security checks.

The new virtualization host server and infrastructure hardware in conjunction with the 64 bit update and ensuing efficiency increases have resulted in a safer and significantly faster ACS with higher redundancy in case of hardware failure.

HIT Accelerator Facility

The Heidelberg Ion Therapy Centre (HIT) is a dedicated hadron accelerator facility for radio-therapeutical treatment of tumour patients. The two horizontally fixed treatment places, the 360° gantry, as well as the experimental area can be served with proton and carbon beams with qualified beam parameters (MEFI - see table 1), helium is available for the experimental area and oxygen is being tested. The achieved energy range of 88-430 MeV/u for carbon ions and 48-221 MeV/u for protons and helium is sufficient to reach a penetration depth of 20-300 mm in water.

Parameter	Steps	Protons	Carbon	Helium
Energy	255	48 - 221 MeV/u	88 - 430 MeV/u	50 - 220 MeV/u
Focus	4 (6)	8 - 20 mm	4 - 12 mm	2 - 9 mm
Intensity	10 (15)	$4 \cdot 10^8 - 1 \cdot 10^{10}$ 1/s	$1 \cdot 10^7 - 1 \cdot 10^8$ 1/s	$1 \cdot 10^7 - 1 \cdot 10^9$ 1/s

Table 1: MEFI beam parameters for main ion types.

Third Ion Source

The addition of a third ion source(1) added new devices and required changes in the data structure of the virtual accelerators (VAcc). The therapy VAccs (1-10) correspond to the beam lines from the two ion sources (QL and QR) to the five target rooms (including beam dump). This data structure had to expand to 15 Vaccs to accommodate the third ion source (QD - see table 2).

As this structure is downloaded to the devices and held in the database for checksum verification, the device storage and database had to be restructured which led to a complete database overhaul to improve performance.

Ion Source	Hor. Rooms	Gantry	Experiment Room	Beam Dump
QL (carbon)	VAcc 1-2	VAcc 3	VAcc 4	VAcc 5
QR (proton)	VAcc 6-7	VAcc 8	VAcc 9	VAcc 10
QD (helium)	VAcc 11-12	VAcc 13	VAcc 14	VAcc 15

Table 2: New therapy VAccs

Software Update and Virtualization

The ACS Software was upgraded to run on 64-bit libraries and use the 64-bit Oracle client. This allows the server applications and client GUIs to use more memory and improves performance significantly.

Several quality of life improvements to GUIs and server applications made working with therapy data safer and easier. Chief among those is the new Download/Flash GUI (Fig. 2) which automatically verifies download and flash checksums and ensures data integrity on the devices. It also includes backup and restore of flash data and an “undo flash” function.

All server and gateway applications were also modified to work in virtual machines and hardware requirements were modified to work over Ethernet. PLC embedded systems and serial-to-ethernet boxes were used to provide communication to the virtual gateways computers.

Server Upgrades

A defective SAS controller driver for VMware ESXI caused a failure in our virtualization servers and prompted an upgrade to a more redundant and secure hardware setup. As the ACS was set to move to complete virtualization, we moved from blade servers to two identical dedicated HP Proliant DL380gen9 virtualization servers running ESXI 6. Storage was moved to a mirrored Eurostor RAID SAN with a dedicated 10GbE network providing iSCSI volumes for the cluster. For backup a Synology NAS box is used with Veeam backup of the virtualization environment (Fig. 3). The ACS servers run in a VMware cluster on both servers and each server is capable of running the complete ACS.

Conclusions

With the new server hardware, we now have a redundant setup with two identical virtualization hosts and a mirrored SAN for storage with failover procedures in place. Both hosts are clustered in vSphere and are capable of running all of the ACS servers with automatic failovers of virtual machines.

The more powerful host servers and database structure overhaul as well as a dedicated 10GB network between all ACS servers improved the system performance significantly. A complete therapy data download to all devices now takes ~5 minutes compared to ~15 minutes on the former blade system.

The GUI upgrades provide a safer and faster download and flash environment and numerous improvements to daily handling of the system.

Configuration of Ion Sources and LEBT

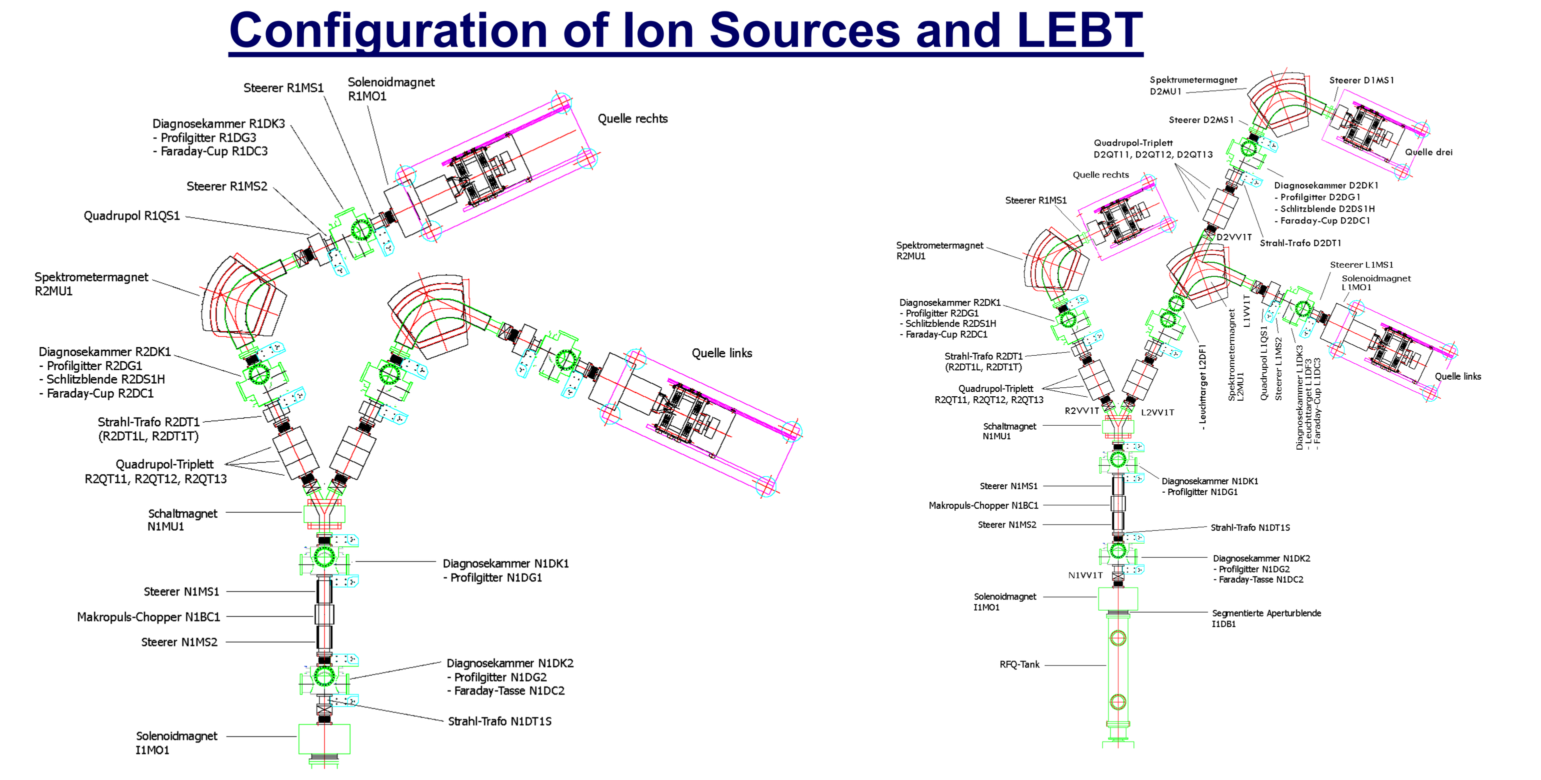

Fig. 1: left: old LEBT with 2 ion sources   right: new LEBT with 3 ion sources

Improved Download and Flash GUI:

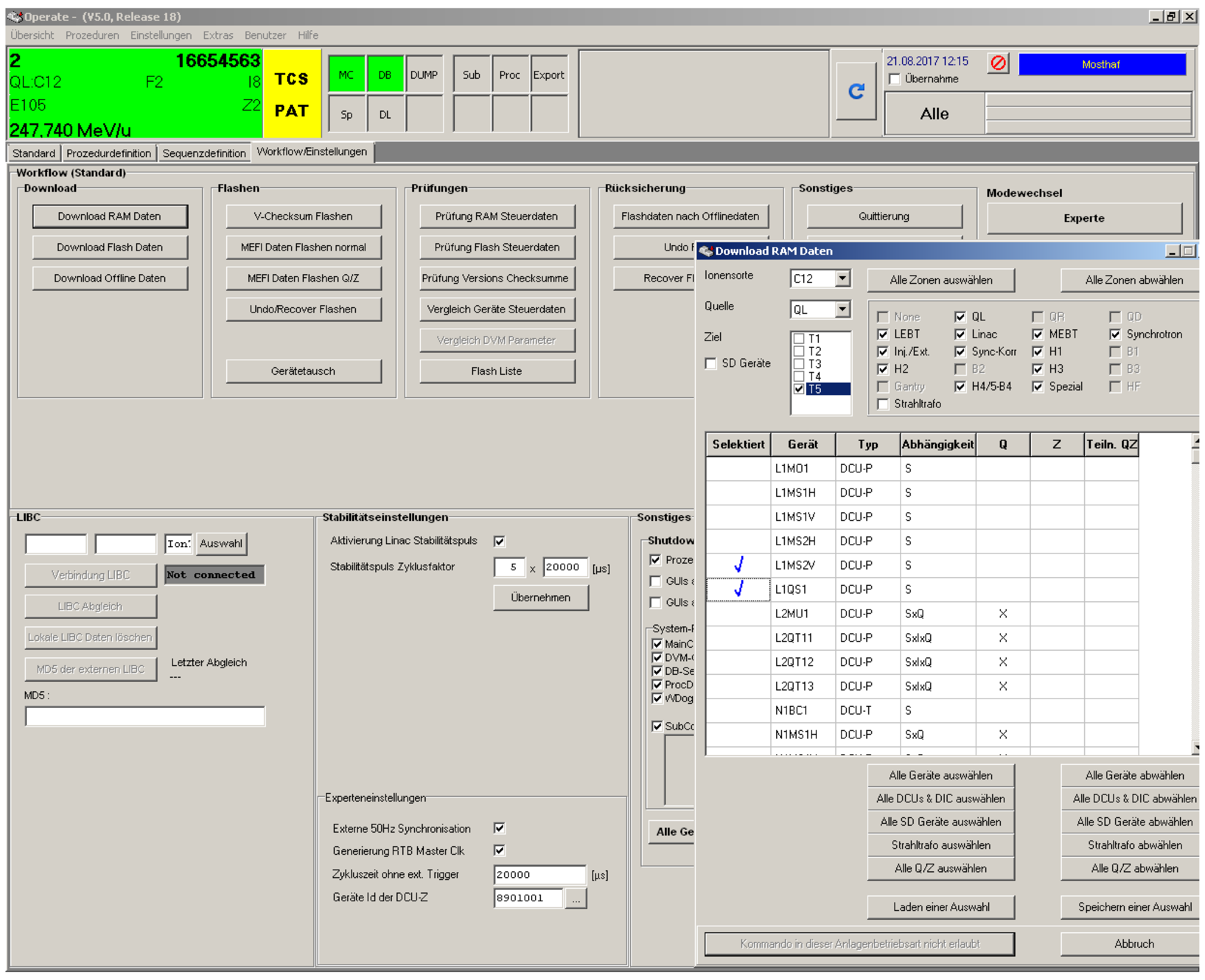

Fig. 2: Improved download GUI with selection window open. The flash GUI looks identical. The download will be checked against checksums in the database and repeated up to 3 times. Checksums can also be verified manually.

New ACS Server and Storage Infrastructure:

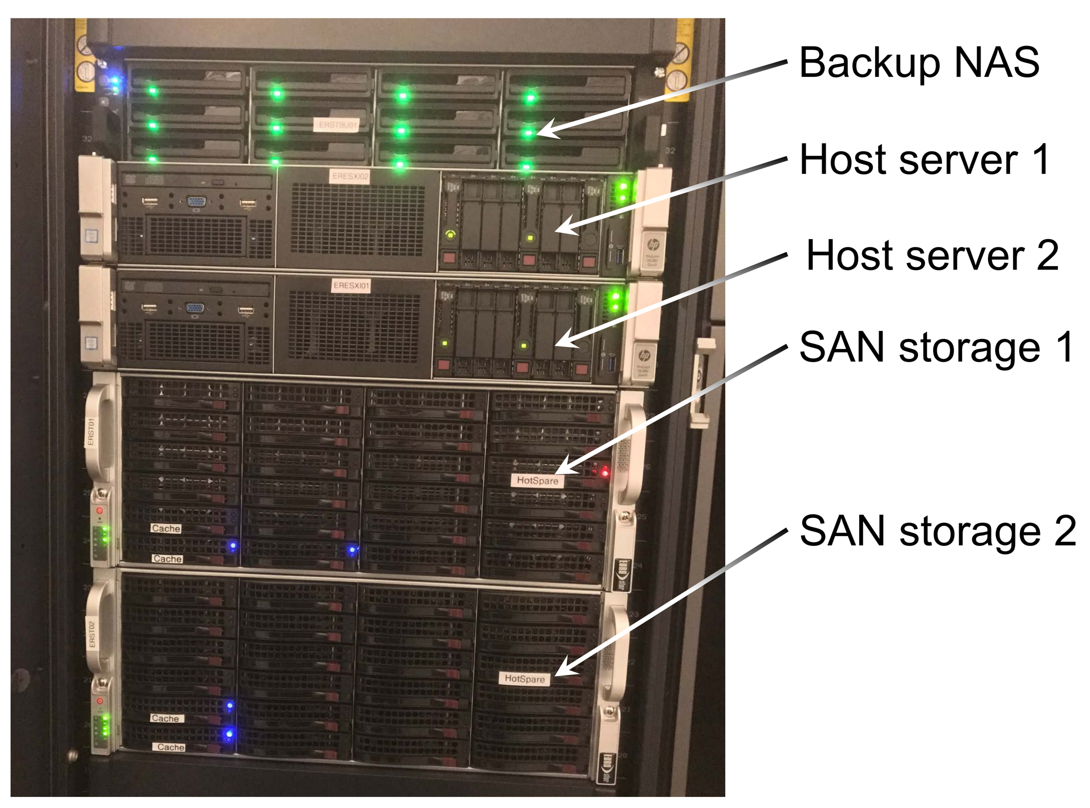

Fig. 3: ACS rack with servers (middle), storage (bottom) and NAS box (top) for backups

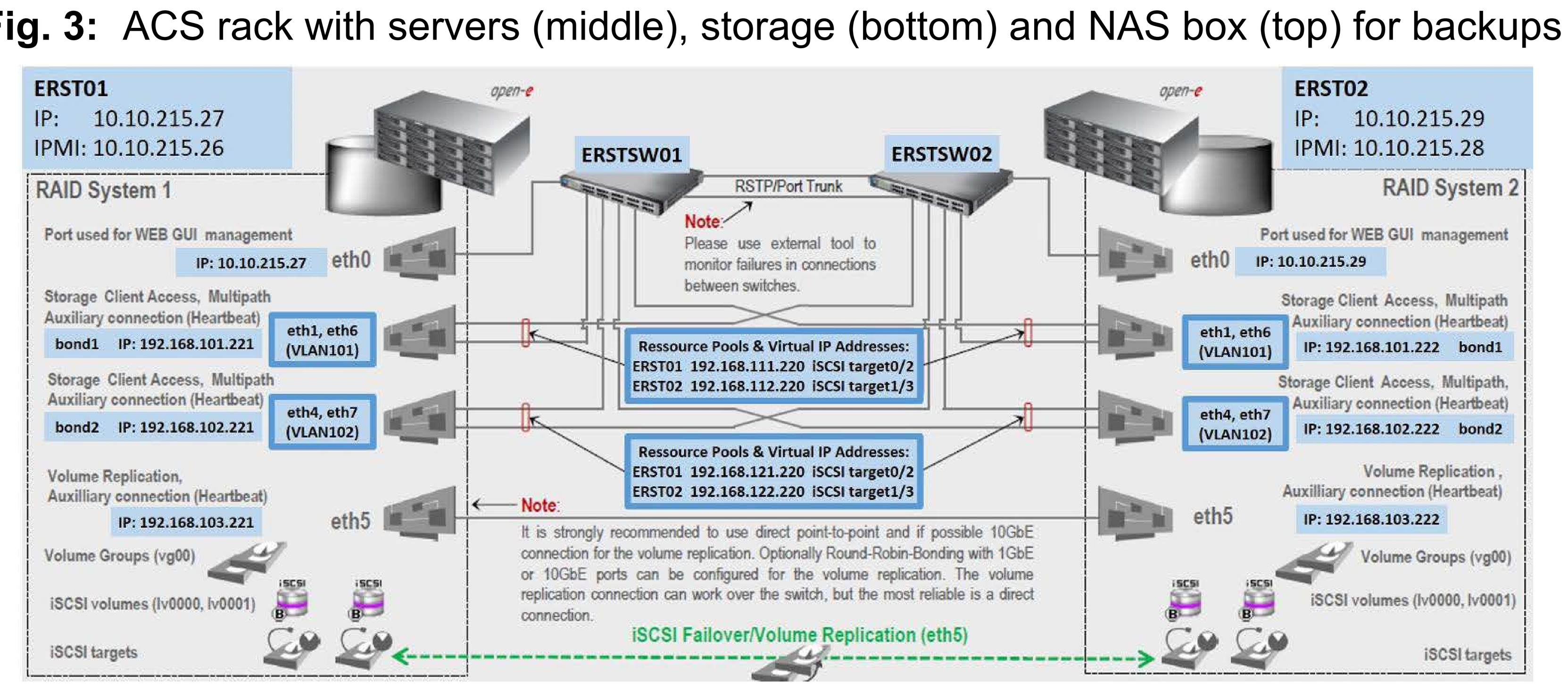

Fig. 4: Concept for the ACS Server Storage with 10GbE network iSCSI.

References

(1) ECRIS, Sydney, Australia(2012); TUPP03. *Integration of a Third Ion Source for Heavy Ion Radiotherapy at HIT*, T.W. Winkelmann, A.B. Büchel, R. Cee, A. Gaffron, Th. Haberer, J.M. Mosthaf, B. Naas, A. Peters, J. Schreiner [HIT, Heidelberg, Germany]