Experiences with an Industrial Control System: Traceability of Specifications, Commissioning Support and conclusions from the HICAT project

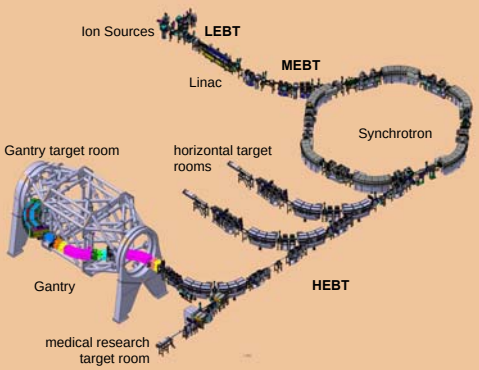
T. Fleck, R. Bär, M. Schwickert, U. Weinrich, *GSI Darmstadt, Germany*

Abstract

While the accelerator for HICAT (Heavy Ion Cancer Therapy) was designed by GSI, most components and systems were supplied by industrial partners. Despite of thorough and detailed specifications for the control system (CS) the concept allowed a rather high degree of freedom for the industrial partner regarding the implementation. The challenge of this combination established a good understanding of the necessary functionalities by our industrial partner. First we describe the process of implementation starting by the specifications made, sum up the tracing of the development and show how we assured proper functionality ab inito and necessary steps since then. Second we describe problems ranging from software bugs to demands regarding acceptance tests for other components and state how we managed to solve these problems with our industrial partner on a short time-scale. Lastly we show what can be learned from our experiences. Especially we discuss where it is more efficient to describe all necessary physical dependencies to the industrial partner instead of defining a proper interface where the programming can be done by accelerator experts and concentrate on areas that led to problems with the time schedule.

HICAT Facility

- 1300 patients a year
- Different ions
- Energies up to 430MeV/u
- 500 components
- µs timing for most components
- High reliability and stability for at least 25 years
- Combinations of 250 energies, 6 foci and 15 intensities (EFI)
- Pulse-to-pulse variation
- Only two operators in normal operation mode
- CS modes for therapy, quality assurance, commissioning
- Interface to therapy CS



Industrial Partnership: Eckelmann AG (EAG), Wiesbaden, Germany

- About 300 employees; < 100 km to GSI or Heidelberg
- Expert knowledge: CS, HW design for e.g. process automation
- No experiences in accelerator physics before project

• Industrial partner is fully responsible for:

- SW development of the whole CS
- HW design and production of front-end controllers
- HW delivery for CS and parts of access CS, vacuum CS, therapy CS
- Separate control systems for all these systems; interfaces to these systems
- Integration of beam diagnostic devices into the CS; additional independent controls
- Functional specifications, documentation, instructions, time management

• Support from the industrial partner:

- Good cooperation, high degree of flexibility
- Copies of the database at the companies site to analyze problems. Evaluation of traces and error logs.
- On-site support from 2005
- At least 1 daily delegate at the facility since 03/07.
- Attendance at each commissioning shift since 10/07. Additional telephone support.

Necessary Expansions / Further Specifications

• In this pilot project functional requirements had been written by GSI but not all necessary functions could be specified right from the start like algorithms for setting ramp generation. Detailed specifications have been provided in time to the industrial partner during the project.

• Further necessities emerged during commissioning and have been implemented like ventilation supervision, additional inspection of discrepancies between set and read values or additional visualizations of measured online-data.

2005 Developments Preceding Commissioning

- Prototypes of front end control units delivered to power supply manufacturers and GSI; intense tests
- Test facility at EAG (see pictures)
- Test facility at GSI for LINAC-RFQ . Test of first CS versions with components / beam diagnostic devices.
- Re-design of backplane bus (concerns: electrical interference)

2006 First Commissioning Steps

- 10/2005: First devices in Heidelberg. Set-up CS network. First power supplies. Ion source control.
- Early 2006: Low energy beam transport section. Current / profile measurements, optical diagnostics.
- 2006: LINAC commissioning with different ion types. Timing of CS important (rf units, chopper)

Changeover to Operation Mode

- Since 03/2007: Commissioning of Synchrotron, beamlines to two horizontal target rooms.
- Calculation and interpolation of all device settings for whole set of beam parameters.
- Implementation of all beam diagnostic classes.
- Verified device settings in nonvolatile memory.
- Beam requests by therapy CS.

2007

- Additional supervisions, IDs, checksums. All components integrated.

Problems (Time Schedule / Industrial partner)

- CS problems to a certain amount prevent proper commissioning.
- Underestimation of complexity, misinterpretation of required functionalities from industrial partner.
- June 2006: revision of the CS time schedule.
- Oct. 2007: 6 weeks delay accelerator commissioning; 5 months delay CS functionalities.
- Correct implementation of all EFI dependencies for device settings.
- Precious few CS experts / further briefing necessary.

Critical points

- Integration / data supply of BD systems.
- Reliable measurements / correlation to accelerator cycles.
- System performance (Real-time optimization, offline-analysis, BD systems, calculation of all therapy settings)
- System stability (problems with updates / system enhancement).

Experiences, Conclusions

- Complexity of necessary functionalities must be made clear to industrial partner.
- Partner must claim outstanding specifications.
- Comprehensive test procedures necessary / must cover final operation scenarios from beginning.
- User aspects (commissioning workflow and operability of GUIs) need high priority.
- Industrial partner must inform about achieved developments / performed tests.
- No system changes without proper description.
- Secure remote login to the CS (support / experts on call) proofed to be absolutely necessary.
- **Tests of CS:**
  - Objective criteria for system performance / stability (short but meaningful tests).
  - Large time blocks for extensive tests (must not be confined).
  - Facility must be fully operational for meaningful tests.

Discussion:

Definition of proper interface for own calculated device settings ? ⟷ Definition of all functional dependencies to industrial partner ?