GSI

Helmholtzzentrum für Schwerionenforschung GmbH

Project Initiation for TASCA Target Wheel Control

Result of the decision meeting

The enterprise will be executed.

Reasons

With respect to discussions with Beckhoff concerning the requirements specifications and test of Beckhoff motion equipment concerning noise on measurement signals the project seems to be feasible. Configuration and motion control will be done with TwinCat. Operation and Monitoring will be implemented with LabVIEW.

Technical Manager:	**Commercial Manager:**
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Document management

History of changes

Version	Status	Date	Person resp.	Reason for Changes
1.0	Initial	04.09.2009	Tanya Torres	-
1.1	revised	15.09.2009	Holger Brand	Adding more details
1.2	modified	29.09.2009	Holger Brand	Comments of Egon Jäger added

Persons authorized to make changes

Holger Brand	WTI - EE
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1 Project goal

An aluminium wheel that carries thin targets, figure 1, is used in TASCA experiments to enhance the ion beam intensity by distributing the energy loss across a larger surface. The target frames are segmented for stability reasons. The ion beam must not hit the aluminium support. Therefore the rotation frequency and phase of the target wheel must be synchronized with the ion beam bunch frequency and phase. Since the RF accelerator cavity power supplies are driven directly from the public power distributor (HEAG) the frequency and phase can vary slowly within certain limits. Hence, the target wheel motor needs to be driven by a closed control loop in real time.
The purpose of this project is to develop a replacement for the existing, but outdated and 20 years old, solution. The new solution should be based on state of the art industrial components. It should be easy to maintain and needs good documentation. The operation should be fool safe since the support structure could be activated or potentially radioactive targets could become destroyed with serious consequences. Therefore the system must be very reliable and connected with the accelerator interlock system.

This document is focussed on the control system for the TASCA target wheel, not on mechanical integration in the experimental facility.

2 Primary requirements

Figure 2.1 shows a segment of the target wheel with dimensions. Some additional information which serve as basis for further details is included. Next follows a list of primary requirements collected by Egon Jäger.

1. **Motor requirements**
    a. Due to the magnetic fluid vacuum lead-through of about 6.5 Nm plus target wheel ~30cm diameter, 3mm thickness of Aluminium, high power is needed. The existing motor is driven by U=280V, Io= 11A
    b. An absolute resolver is essential (refer to 3.a).
    c. Breaks are demanded, at least for operation mode *absolute positioning* (refer to 3.b).
    d. Safty-Interlock ist essential.
    e. Low/no noise induction in detectors and cables. Power cables must have very good screening.
    f. Cable lengthes:
        i. Motor – Servo amplifier: ~15m.
        ii. Servo amplifier - Feldbus-SPS-PC ~80m.
2. **Target wheels**: A least two types of target wheels will be used.
    a. Type 1 is a large rotating wheel
        i. ~310 mm diameter
        ii. Up to nine (banana like) target frames will be mounted at the edge.
        iii. Rotation frequency will be 18,75 Hz (1125 rmp).
    b. Type 2 is a small rotating wheel
        i. ~50 mm diameter
        ii. Three (banana like) target frames will be mounted at the edge.
        iii. Rotation frequency will be 33 Hz (1980rpm).
3. **Operation modes**
    Two different operation modes are required.
    a. *Synchronous rotation* mode: Continuously rotating wheel
        i. The accelerator control system provides a signal indicating beam delivery. The relative phase of beam signal and resolver output must be stable, but adjustable, with an accuracy of ±200µs and much smaller jitter.
        ii. In case of phase error an interlock must trigger the chopper to stop beam extraction.

iii. The control loop should be able to adjust the ion beam in the middle of the target frames.
iv. The motor must be ramped smoothly.
v. Bei Gegebenheit sollte eine Phasenverschiebung (einstellbarer Zeit-Delay) bei Soll-Drehzahl des Motors und der Zykluszeit von 20ms vom Beschleuniger einstellbar und darstellbar sein, d.h.auf GUI einsehbar sein
vi. Absolute position: The resolver output must determine the target frame ID which is currently irradiated to correlate it with other measurements in real time.
vii. *Two submodes* are requested:
   1. Irradiation of all targets, The resulting sequence is [3,6,1,4,7,2,5,8].
   2. Irradiation of s selected target. This requires to control the chopper to switch the ion beam on and off in real time.

b. *Absolute positioning* mode:
   i. A selectable single target frame becomes irradiated in a stationary position to be used as target or energy degrader.
   ii. The absolute position of the selected target frame with respect to the beam position must be stable, but adjustable at long time scales.
   iii. Breaks will possibly used to fix an adjusted position.

- **Beam characteristics**
  UNILAC delivers a bunched ion beam.
  - The frequency is derived from the public power distributor (HEAG). It varies around (50±0.x)Hz.
  - The ion beam must not hit any support structures, but target segments only.
  - *Standard mode*: 50Hz frequency (20ms intervall) and a duty cycle of 25% (5ms beam and 15ms pause).
  - *Future modes*:
    - UNILAC's duty cycle will maybe changed in future to deliver a duty cycle of 50% (10ms beam and 10ms pause).
    - The new system should be able to deal with other frequencies (≠50Hz), too. Of course this would lead to different arrangements of the target frames.

4. Operation

a. The system should be able to operate standalone, which means without operator PC. A hardware panel for local operation with few buttons and lamps is demanded.
   i. Buttons/Dials: Mode; Start; Stop; Interlock; Phase
   ii. Lamps: Stopped; Ramping; Synchronous

b. LabVIEW should be used for full status visualization and remote operation.

c. MBS (Multi Branch System DAQ) needs to be connected for real time status information, e.g. target index, synchronized etc.

5. Safety

a. The system has to react on external interlocks and should be able switch in different corresponding safety modes, e.g. safety ramp to stop, free wheel.

b. The system has to generate interlocks depending on the operation mode.
   i. **Chopper interlock** to switch off the ion beam if synchronization is not guaranteed or phase error.
   ii. …?

Kommentar [HB1]: Ist hier der HKR gemeint?

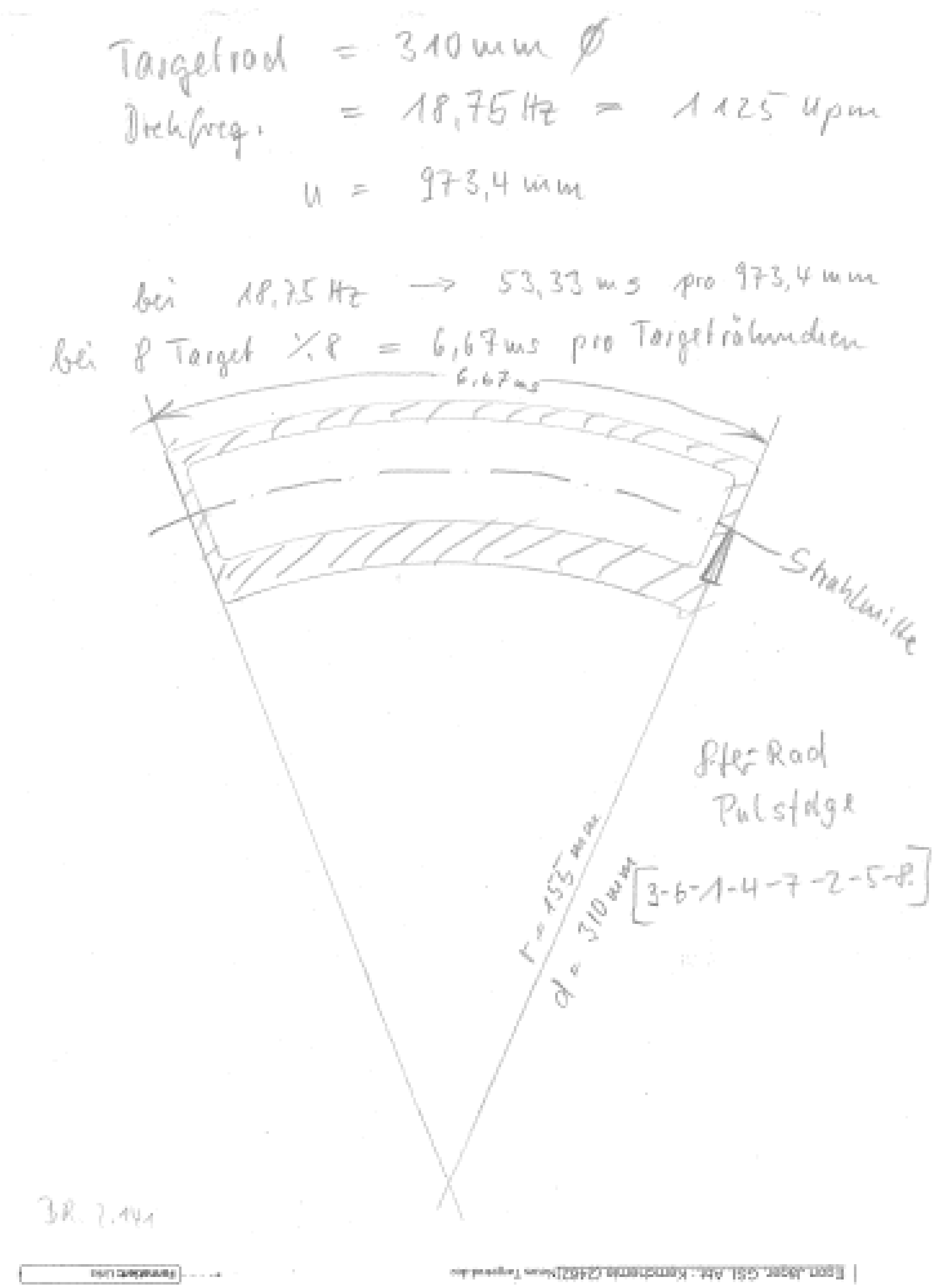

Figure 2.2: Sketch of the target wheel (Egon Jäger)

3 Proposed solution

On June 26th, 2009 Mr. Gruber, Beckhoff, visited GSI to discuss a possible solution using Beckhoff hardware and software. A sketch of a possible solution is shown in Figure 3.1.

A motor is connected to a digital compact drive amplifier that contains a safety card form interlock handling. The amplifier communicates via EtherCAT with an industrial PC. Additional IO can be connected to the same EtherCAT network. TwinCAT IO is used on the industrial PC to configure and communicate with the EtherCAT hardware.
An additional TwinCAT NC-PTP module allows programming the closed loop motion control in a soft SPS (cycle time 250-500µs). Using a combination of EK1100 and EL1252 timestamps can be acquired with 10µs resolution to be used for the position control feedback.

Additional Beckhoff IO modules can be used to connect a hardware operation console for local control. The TwinCAT OPC-Server is used to connect a LabVIEW DSC application for remote control, monitoring, alarming and trending.

MBS DAQ becomes connected via digital hardware signals (TTL or 24V) from the drive amplifier or other Beckhoff IO modules.

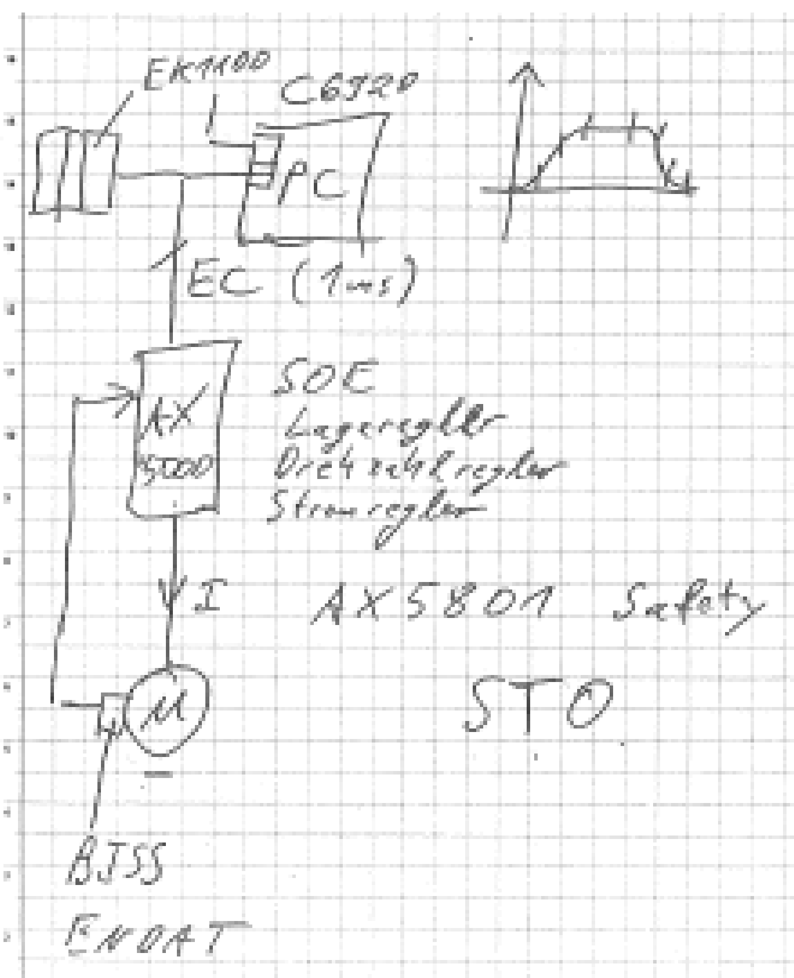

Figure 3.1: Notice of discussion with Mr. Gruber, Beckhoff

4 Proposed solution path

LabVIEW license and experience is available and following Beckhoff components were already ordered:

- Drive AM3053-0K31
- Digital compact drive amplifier AX5112-0000
- TwinSAFE – Drive – Card option AX 5801-0000-0000
- Industrial PC C6920-0000
- Memory enhancement C9900-R216
- Hard disk C9900-H148
- EtherCAT adaptar EK1100
- Motor induction AX2090-MD50-0012
- TwinCAT NC-PTP and OPC-Server

We like to follow basically the Siemens Standard System Development Method, http://www-win.gsi.de/stdseme/Default.htm. But, we perform activities and produce documents only as suitable and necessary for this project. Following list points out the most important activities only.

1. In a first step the delivered hardware will be commissioned using the Beckhoff software. Personnel need to familiarize with hardware and software.
   - Configuration
     - Installation of TwinCAT software on the industrial PC
     - Configuration of available Beckhoff hardware
   - Simple rotation with defined ramping
     - Manual operation in the laboratory
     - Development of first SPS programs
   - Phase shift and phase lock
     - Development of SPS programs to control frequency and phase with respect to external frequency signal from a signal generator.
   - Safety features
     - Evaluation of safety and interlock features
     - Reaction on external interlocks
     - Generation of interlock signals, e.g. in case of loosing synchronization
   - Simple LabVIEW program for remote control and monitoring via OPC
2. Definition
   - http://www-win.gsi.de/stdseme/p_defi/or_allg.htm
   - Definition of CM, http://www-win.gsi.de/stdseme/p_defi/quer_cm.htm
   - Detailed user requirement specifications
   - Prototyping, http://www-win.gsi.de/stdseme/p_prot/or_allg.htm
   - Definition of external interfaces
   - Definition of QA, http://www-win.gsi.de/stdseme/p_defi/quer_qs.htm
3. Design and Implementation
   - http://www-win.gsi.de/stdseme/p_desi/Default.htm
   - http://www-win.gsi.de/stdseme/p_impl/Default.htm
   - Documentation of cabling plan (E^3)
   - Configuration of motion drive amplifier and SPS closed loop programming
   - Design of local control panel with SolidWorks
   - Remote control and monitoring software
   - Testing
4. Commissioning and Operation
   - http://www-win.gsi.de/stdseme/p_oper/or_allg.htm

Kommentar [HB2]: Do we need a dummy load, target wheel with eddy current break for testing?

Kommentar [HB3]: Needs training period.

Kommentar [HB4]: Needs training period.

Kommentar [HB5]: Needs training period.

The implementation of the autonomous operation of the large target wheel gets high priority. In parallel, but lower priority the remote control software becomes implemented.

The small target wheel control will be addressed after this project has been finished.

5 Possible solution alternatives

An alternate solution based on ABB hardware and software was investigated, but rejected for GSI internal reasons:

- No experience with modern ABB hardware and software
- Lack of man power
- Existing experience with Beckhoff hardware and software in many other projects
- Reduction of necessary spare modules
- Easy system integration and reuse of existing solutions
- Support by members of Experimentelektronik

6 Quality assurance

Definition of quality requirements and quality assurance has to done by TASCA.

Quality requirement of the client	required QA measure
The relative phase of beam signal and resolver output must be stable	Accuracy of ±200µs and much smaller jitter.
Real time communication MBS	Correct target index for reaction events
Low noise on measurement signals	<mV ?
?	?

Quality assurance requirement of the client	required QA measure
?	?

7 Project organization and procedures

7.1 Responsibilities

- Mechanics for the experimental facility will be designed and implemented by the TASCA group.
- The electric control cabinet as well as the local control panel will be designed and cabled in close collaboration of TASCA and EE/KS.
- Controls software configuration, closed loop motion control as well as remote Control and monitoring will be done by EE/KS.

Function	Name	ORG unit/company	Remark
ORG unit responsible	TASCA	Nuclear Chemestry/GSI	
Project manager	?		
QA manager	?		
Project team	Holger Brand Harald Hahn Tanya Torres	EE/KS, GSI EE/KS, GSI EE/KS, GSI	

Function	Name	ORG unit/company	Remark
client's person responsible	Egon Jäger	NC, GSI	
...			

Due to limited development time for a first functional version, (planned experiment in January 2010) the project will be executed with respect to the incremental delivery model according to stdSEM, http://www-win.gsi.de/stdseme/themes/t_pa7.htm . It is a development project. Potential external contractors, e.g. cabling, production of PCB or frontpanels have to be paid by TASCA as well as all project specific hardware and software investments.

TASCA is responsible to takeover know-how and long-term maintenance.

Type of effort	Effort	Insecurity factor	Remark
Personnel	? MH	+/- ?%	the project team has no know-how about development environment
Operating resources			
Business trips			
... (e.g. training, reusability,...)			

8 Framework for deadlines

The following table points out some important milestones.

	Date/range of time	Remark
Project start	September 4th 2009	Assuming that suitable hardware was selected.
Commissioning of delivered HW	End Sep/Begin Oct.	Simple rotation with 50 Hz
Basic Version	December 2009	A first version should be available for testing with limited functionality (To be defined!)
First experiment	January 2010	

9 Risks

A list of already known risks follows.

- The responsible EE team is not really familiar with the components and the environment to be used in this project.
- Since personnel needs training on hardware and software, delivery of a first version with limited functionality cannot be guaranteed.
- Documentation for a first basic version will maybe not complete.
- Noise generation of motor and drive amplifier has to be measured in detail, refer to 1.e
- Timing constrains for the phase lock seem challenging, refer to 3.a.i.