Mirror Positioning Control System with TwinCAT and EPICS

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For monitoring and control of complicated detector system in large scale experiments, CBM (Compressed Baryonic Matter) at GSI is now designing the detector control system using the EPICS (Experimental Physics and Industrial Control System). For CBM RICH (Ring Imaging CHerenkov) prototype experiment the mirror positioning control system with EPICS and TwinCAT program (The Window Control Automation Technology) has been programmed.

1 Introduction

1.1 Ring Imaging CHerenkov Detector

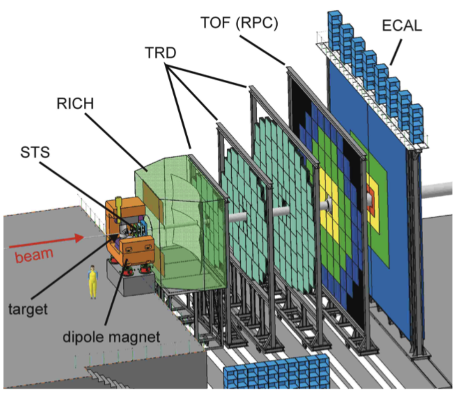

Fig. 1: *CBM at FAIR, GSI*

The CBM experiment will be a fixed target experiment being operated at FAIR in GSI. (Figure 1) It is designed for the research of quark matter under extreme conditions. Main purpose of the CBM experiment is investigating the properties of super-dense nuclear matter and measuring rare and penetrating probes such as dilepton pairs. Dileptons provide the key to vector-meson measurement in hot and/or dense medium. The measurement of electrons will be performed with a RICH detector for momenta below 8-10 GeV/c. The RICH detector is widely used for identifying particles, which fly through a specific medium with a speed higher than the speed of light in the medium (c/n, n : refractive index), and produce the Cherenkov radiation.

The principal components of the RICH detector are the vessel containing Cherenkov radiator, a concave reflector and photo detectors at the focal plane of the reflector. One of the great advantages of this Ring Imaging technique is, that you can easily change the measurable particle momentum range with changing the Cherenkov radiator with various refractive index.

1.2 Purpose of Project

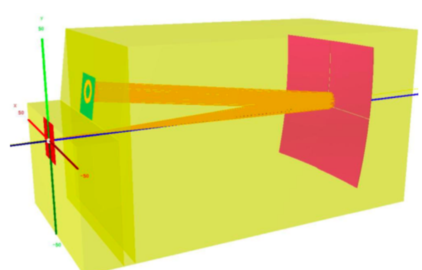

Fig. 2: *RICH prototype in Giessen University*

The CBM-RICH group in Giessen University, is responsible to develop the RICH detector used at the CBM experiment for FAIR (Facility of Antiproton and Ion Research) in GSI. Figure 2 shows a draft of the prototype which is made by Giessen University. According to the requirements of the CBM-RICH experiment, it is necessary to check the uniformity of the 16 MAPMTs (Multi-Anode Photo Multiplier Tube) mounted on the prototype. It was designed for a frame where 4 mirrors are mounted as concave reflector, which is able to move on the vertical and horizontal direction as a part of the prototype.

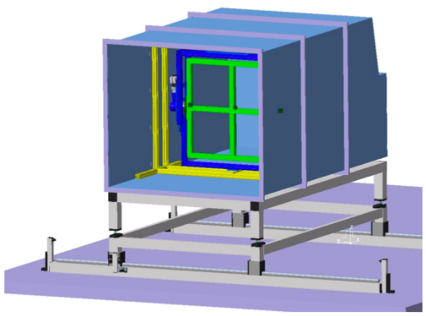

Fig. 3: *Frame in RICH vessel*

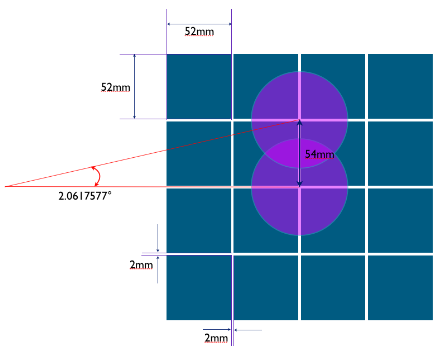

Fig. 4: *degree and expected ring image*

The mirrors are mounted on two frames as shown in Figure 3. These allow to move the mirror in the vertical direction using the inner frame and in the horizontal direction with the outer frame. The size of each MAPMT is $52 \times 52 mm^2$, the gap size between the MAPMTs is 2mm. Four MAPMTs are needed to cover a ring image. Since it is necessary to move the ring image, like on Figure 4, one step movement of $\pm 2°$ is needed on each axis. Two servo motors are responsible for the system movement. One is mounted on top of the frame which allows in the horizontal direction $\pm 2°$ and $90°$, the other one is located on left side of the frame which allows the movement in the vertical direction $\pm 2°$.

2 Hardware for Control system

The whole scheme of the hardware components is shown in Figure 6. The mirror frame will be connected to two servo motors (AM3021-0C41-0000) which are exclusively intended for speed- and/or torque-controlled operation via digital

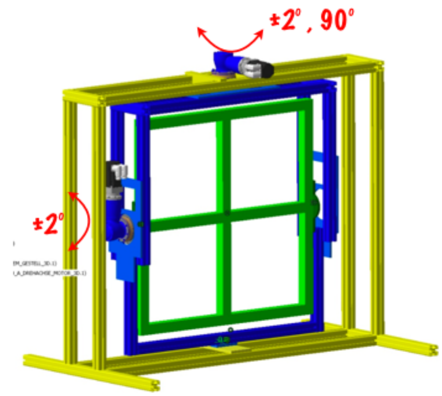

Fig. 5: *Frame for 4 mirrors*

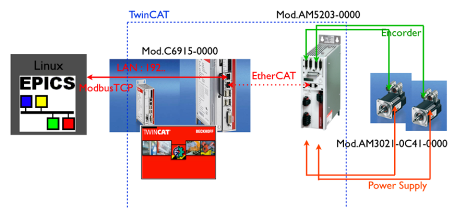

Fig. 6: *Hardware : IPC, Servo Drive, Servo Motors.*

servo drives from Beckhoff. Each motor have a gear head for slow rotation to prevent breaking mirrors. The servo motors are connected to servo drive (AX5203-0000) with two cables, one is for power supply and the other one is for encoder. For control system is an Industrial PC (C6915-0000) used. It is connected to servo drive and communicate by EtherCAT as ethernet system. The TwinCAT program was installed in this IPC based on window CE operating system. Finally the TwinCAT program in IPC will be linked with EPICS on linux machine via Modbus/TCP protocol.

3 Mirror Positioning Control System

3.1 TwinCAT

The TwinCAT (The Window Control Automation Technology) consists of the TwinCAT System Manager and the TwinCAT PLC control. TwinCAT System Manager is the central configuration tool. It is where the inputs and outputs of the software tasks and the physical inputs and outputs of the connected fieldbusses are managed.[1] The main screen of TwinCAT

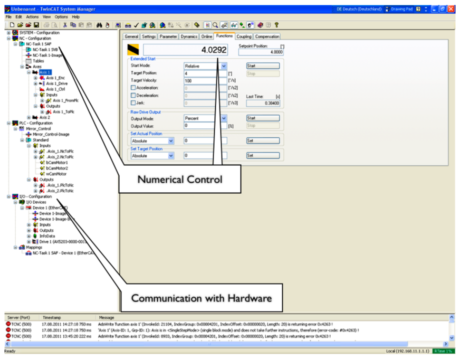

Fig. 7: *TwinCAT System manager*

system manager is shown in Figure 7. There are 3 parts.

1. I/O-Configuration: Hardware components of the system.
2. NC-Configuration: Axis configuration.
3. PLC-Configuration: Control software.

I/O-Configuration communicates with hardware and these inputs, outputs are linked to NC(Numerical Control) - Configuration. The NC allows to make the first operation of the system. Finally, the Input and output in NC - Configuration are linked to PLC - Configuration.

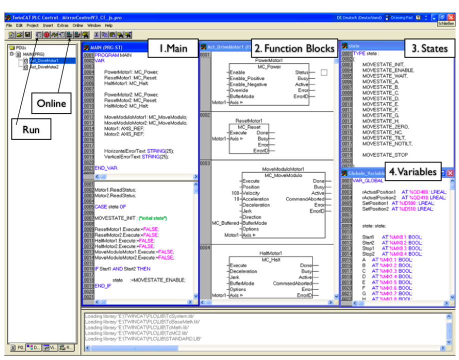

Fig. 8: *TwinCAT PLC control*

The TwinCAT PLC control is shown in Figure 8. There are code and function blocks for mirror positioning control. In Table 2 are the variables used in the program. TwinCAT PLC control provides also a local GUI (Graphic User Interface) and in Figure 9 the GUI for mirror positioning control system is shown. Each variables described in Table 2 are linked to a graphical element, so that it is easy to control the mirror position on this control panel. There are two start buttons and stop buttons to control the power supply for motors, sixteen squares represent each MAPMT and 9 circles show the position of the ring image. Pushing the circle of the wanted position, mirrors will be moved and finally it is able to see the ring image at the position. In this control system, it is not allowed to activated more than one button at the same time. On the right side of Figure 9 there are the feedback of real position and for numerical control. In case of numerical control, numerical pad appears which allows to set any position. The program is developed using a modulo function to prevent that mirrors move 360 degree.

Tab. 1: *Address rule*

Prefix	Description
I	Input
Q	Output
M	Memory location
X	Single bit
B	Byte (8 Bit)
W	Word (16 Bit)
D	Double word (32 Bit)

Tab. 2: *Variables*

Name	Type	meaning	address
Start1	BOOL	start	MX0
Start2	BOOL	start	MX1
Stop1	BOOL	stop	MX2
Stop2	BOOL	stop	MX3
A	BOOL	position (-2 , +2)	MX8
B	BOOL	position (0 , +2)	MX9
C	BOOL	position (+2 , +2)	MX10
D	BOOL	position (-2 , 0)	MX11
E	BOOL	position (+2 , 0)	MX12
F	BOOL	position (-2 , -2)	MX13
G	BOOL	position (0 , -2)	MX14
H	BOOL	position (+2 , -2)	MX15
Zero	BOOL	position (0 , 0)	MX4
Tilt	BOOL	position (+90 , 0)	MX5
NoTilt	BOOL	position (0 , 0)	MX6
NCcontrol	BOOL	NC enable	MX7
rActualPosition1	LREAL	real position	MD400
rActualPosition2	LREAL	real position	MD410
SetPosition1	LREAL	Set value	MD500
SetPosition2	LREAL	Set value	MD510

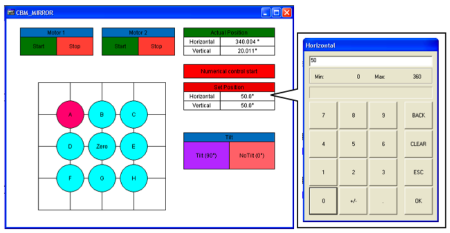

Fig. 9: *TwinCAT PLC control Graphic User Interface*

3.2 EPICS

As a SCADA (stands for Supervisory Control and Data Acquisition) system, EPICS is a set of Open Source software tools, libraries and applications, developed collaboratively and used worldwide to create distributed soft real-time control systems for scientific instruments.[3] Figure 10 shows EPICS architecture. The IPC communicates to IOC (Input Output Controller) via modbus TCP. The IOC as EPICS server provides information and service. A EPICS Client accesses the service or asks for information via channel access protocol. CSS(Control System Studio) is one of the EPICS client tools for GUI as shown in Figure 11. Every graphical element has a functionality same as in TwinCAT control panel.

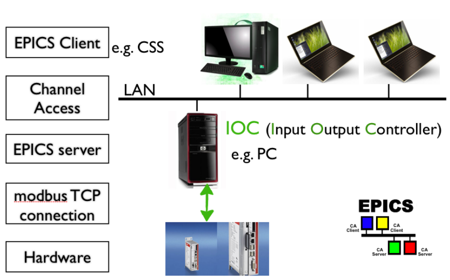

Fig. 10: *EPICS architecture*

4 Summary & Outlook

In order to control positioning of mirrors in RICH prototype, online control system is needed. It is programmed with TwinCAT and EPICS. This online control system is successfully installed and tested with servo motors. It will be used in experiment which will be done at CERN in Oct.

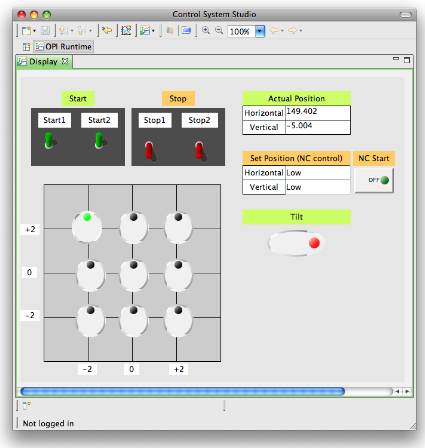

Fig. 11: *Control panel with CSS*

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References

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