EPICS – based Beam Diagnostics System in LEHIPA

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Outline

- Introduction

- Beam diagnostics in LEHIPA

- EPICS IOCs for data acquisition and motion control

- EPICS-based beam profile monitor

- Future developments

- Conclusions

Introduction

- Low Energy High Intensity Proton Accelerator
- 20 MeV, 10 mA
- Max. pulse width of accelerated beam = 250 us
- Max. repetition rate = 2 Hz

DTL

MEBT

RFQ

LEBT

ECR IS
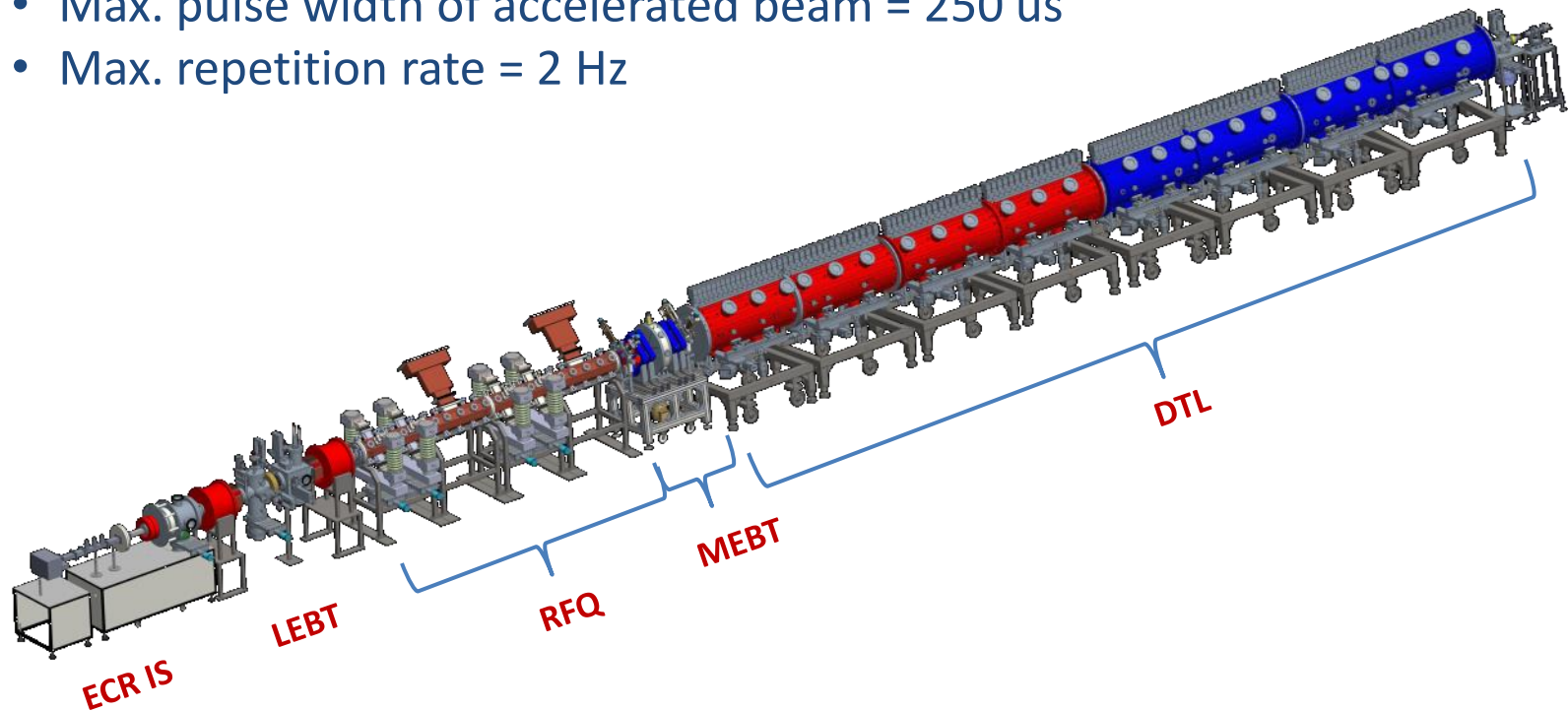
(3-D model courtesy: Dr. J V Mathew)

Beam diagnostics in LEHIPA

- Beam current monitors
  - DCCT *- DAQ*
  - ACCT *- DAQ*
  - FCT *- DAQ*

- Faraday cups *– DAQ + Motion control*

- Beam profile monitors (wire scanners)

  – DAQ + Motion control (synchronized)

- Beam position monitor *– DAQ, DAQ + Motion control (in case of movable BPM)*

  (Note: DAQ is trigger-based in all of the above.)

DAQ for Beam Diagnostics

- cPCI-based DAQ module
- Adlink cPCI-9116
- 16/32 AI channels, 16-bit
- 250 ksps, multiplexed
- Slow signals
- DCCT, ACCT, FC in LEBT

- PCI-based digitizer module
- Adlink PCI-9846
- 4 channels, 16-bit
- 40 Msps, simultaneous
- Fast signals
- FCs in MEBT and downstream, FCTs.

cPCI-9116 DAQ card
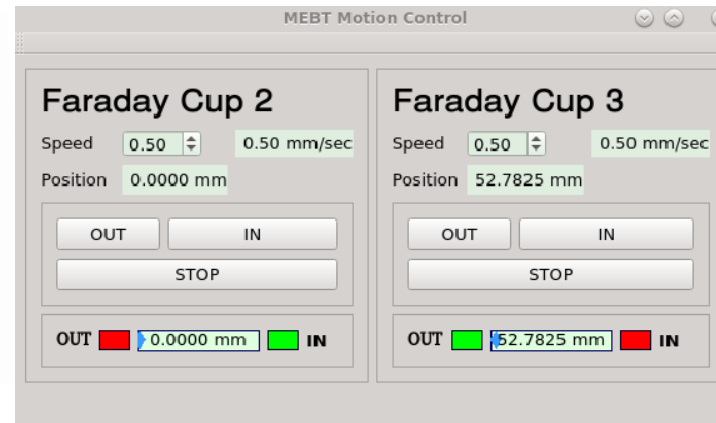

PCI-9846 Digitizer card

EPICS Interface for DAQ

- The device driver for the digitizer cards is compiled for CentOS 7/8, kernel 3.x.

- Application program is based on EPICS asynportdriver / Device Support.

- APIs for configuration and control of data acquisition are available in the Adlink PCI-DASK / WD-DASK libraries.

- GUI is developed on Qt-EPICS.

- Averaging of beam pulse signal inside the time window of interest.

- Trigger for start of data acquisition is supplied by the LEHIPA Timing System (LTS).

- Multiple IOCs for LEBT, MEBT and exit line. – Beam Transport System (BTS) IOCs.

BTS IOC

EPICS Interface for Motion Control

- Motion controller – Galil DMC-4080, 8 axes; external stepper motor drivers.
- EPICS IOC based on EPICS MotorRecord is developed by Galil.
- The EPICS database is modified as per the field requirements.
- Linear wire scanners, Faraday cups and movable BPM (using stepper motors).
- GUI – Qt-EPICS

Motion Control IOC

MEBT Motion Control

Faraday Cup 2
Speed 0.50 0.50 mm/sec
Position 0.0000 mm
OUT   IN
STOP
OUT 0.0000 mm IN

Faraday Cup 3
Speed 0.50 0.50 mm/sec
Position 52.7825 mm
OUT   IN
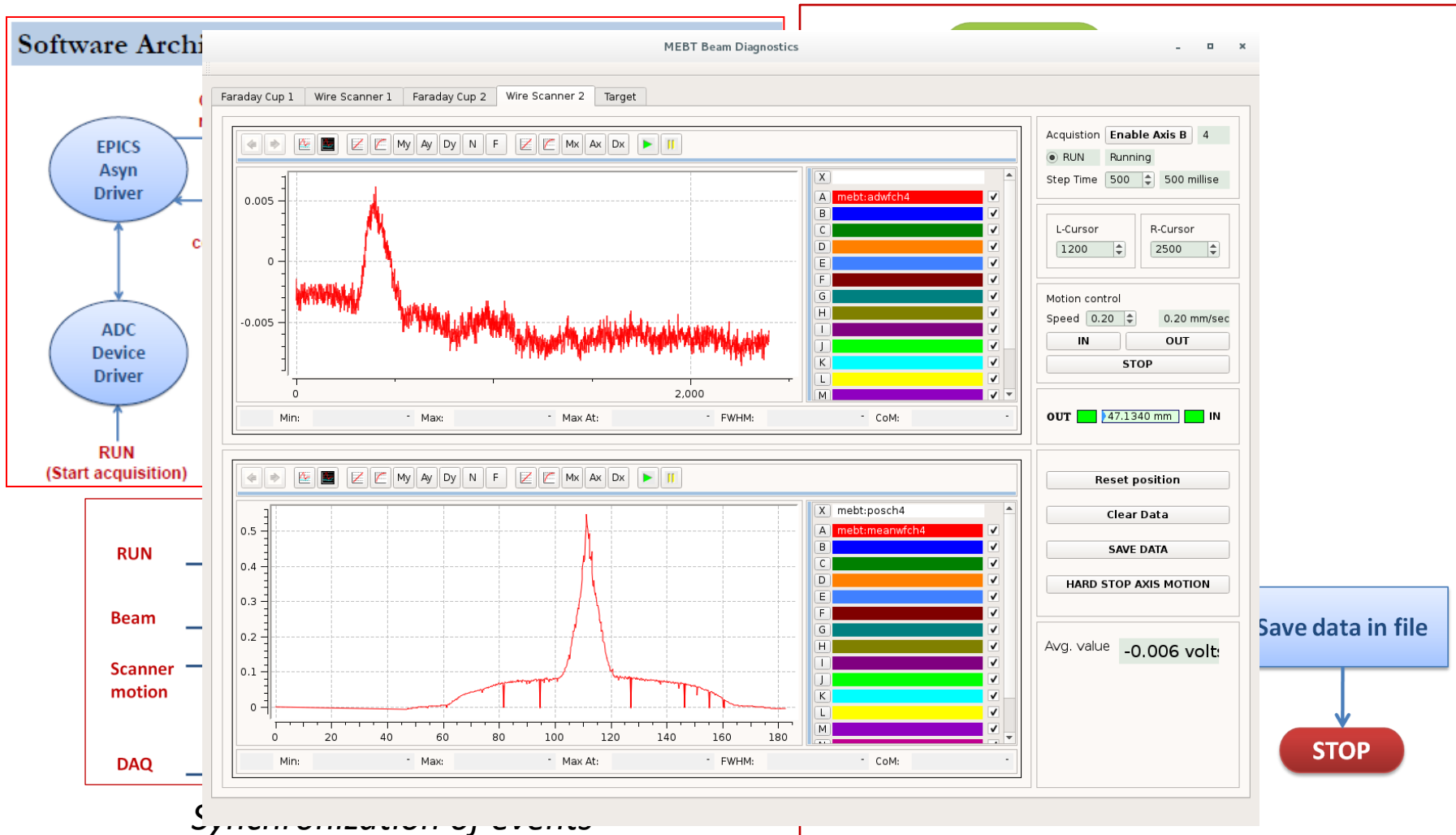STOP
OUT 52.7825 mm IN

Wire BPrM

(Courtesy: Dr. J V Mathew)

Automated Beam Profile Monitoring System

- Automated beam profile monitoring system is developed for LEBT and MEBT.
- Can be extended for emittance measurement.
- Utilizes the DAQ IOC and Motion Control IOC, synchronized with beam pulse.
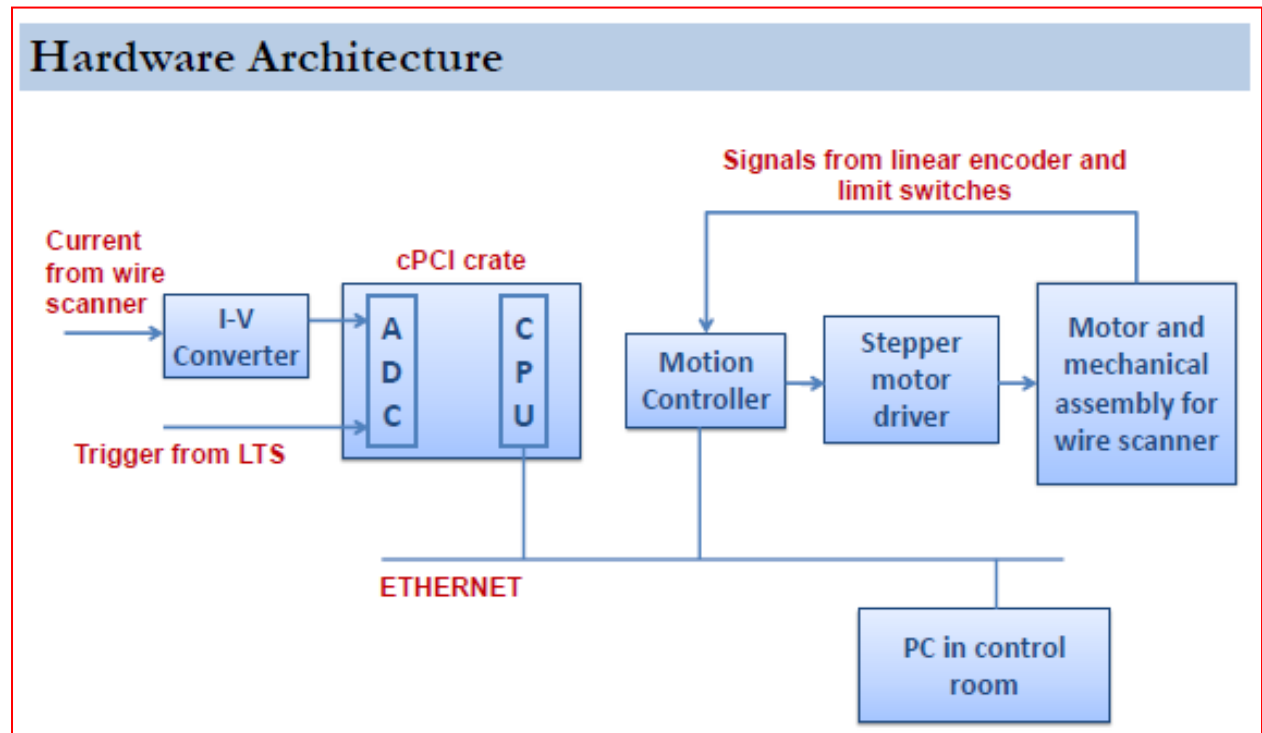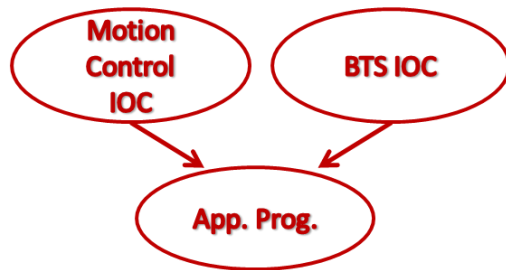
Automated Beam Profile Monitoring System

Automated Beam Profile Monitoring System

Accessing the PVs of Motion Control IOC from BTS IOC – an example

```c
#include <cadef.h>

chid motorRBV;
chid motorStop;
chid motorJogf;
chid motorJogr;
chid motorHLS;
chid motorLLS;
```

Reading PV

```c
/* Read position here*/
SEVCHK(ca_create_channel (motorPV_RBV, NULL, NULL, 0, &motorRBV), "Create channel failed");
SEVCHK(ca_pend_io(0.1), "Channel connection failed");
SEVCHK(ca_get(DBR_DOUBLE, motorRBV, &posVal), "Get failed");
SEVCHK(ca_pend_io(0.1), "Channel connection failed");
ca_clear_channel(motorRBV);
```

Writing to PV

```c
//system("caput mebt:B.JOGR 1");
SEVCHK(ca_create_channel (motorPV_JOGR, NULL, NULL, 0, &motorJogr), "Create channel failed");
SEVCHK(ca_pend_io(0.1), "Channel connection failed");
double jogVal = 1;
SEVCHK(ca_put(DBR_DOUBLE, motorJogr, (void *)&jogVal), "Put failed");
ca_clear_channel(motorJogr);
```

Future Development

- **Standardization** of platform for general purpose DAQ – LEHIPA upgrade & MEHIPA.
- **FPGA-based** multi-channel digitizer module designed in-house.
- Data is directly available on UDP / TCP-IP.
- EPICS IOC based on asynportdriver – deployed on Raspberry Pi – Plug and play.

Conclusions

- The various beam diagnostics elements in LEHIPA require data acquisition and motion control.

- The EPICS IOCs are developed for DAQ and motion control, interfacing commercial digitizers and motion controllers.

- An automated beam profile monitoring system is developed, and synchronization between the BTS and Motion Control IOCs is achieved.

- A standardized FPGA-based data acquisition system and its EPICS interface is developed in-house for upgrade of existing systems and upcoming MEHIPA project.

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