A BEAM PROFILER AND EMITTANCE METER
FOR THE SPES PROJECT AT INFN-LNL

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Abstract

New beam diagnostics tools have been developed for the SPES [1] project in the perspective of reusing them to upgrade the system currently in operation at LNL in the superconducting Linac ALPI.

The goal is providing the new R.I.B. facility, that will use ALPI as re-accelerator, with an homogenous set of tools and a common user interface to support beam transport over the future accelerators complex. This paper focuses on the realization of a new emittance meter and on design of control software that has been written using EPICS.

OVERVIEW

The Spes Project and the New Ion Source.

SPES is a new facility under construction at LNL whose aim is the production of radioactive nuclei beams that will be injected into the Linac ALPI. The production of unstable nuclei is accomplished by impinging a proton beam delivered by a commercial cyclotron (energy range 40-70 Mev) into a UCx target. The diagnostics on proton beam will be part of cyclotron delivery and will not be presented in this paper; instead, we shall discuss the diagnostics on secondary beam with particular emphasis on devices that have been realized to characterize the new ion source currently under test in the SPES Target laboratory.

The Beam Diagnostics at LNL

The Linac ALPI, together with its injector PIAVE, has about 80 QWR resonators in operation. Beam transport is carried out by observing its profile and measuring its current by means of 48 diagnostic boxes installed along the machine. Each diagnostic box contains a faraday cup and a couple of grids (horizontal and vertical), each one made of 40 wires. Current signals are converted to voltage by an analogue board closely installed on top of box, in order to minimize the noise induced by cables; the conversion factor is selectable by software and covers four decades. Grid signals are multiplexed and serialized before being transferred, over coaxial cables, to the data acquisition system. Serialization strongly simplifies the overall wiring: in fact, only one coaxial cable is required for a 40 wire grid The multiplexer is driven by a counter whose clock is generated by the ADC itself, to have the signal transmission synchronized with the conversion.

DEVICES FOR BEAM DIAGNOSTICS

Figure 1 shows the faraday cup designed for beam current measurement. Behind this device it is possible to notice the grid based profiler. The faraday cup is inserted or removed by means of a pneumatic actuator while the grids are moved by a stepper motor.
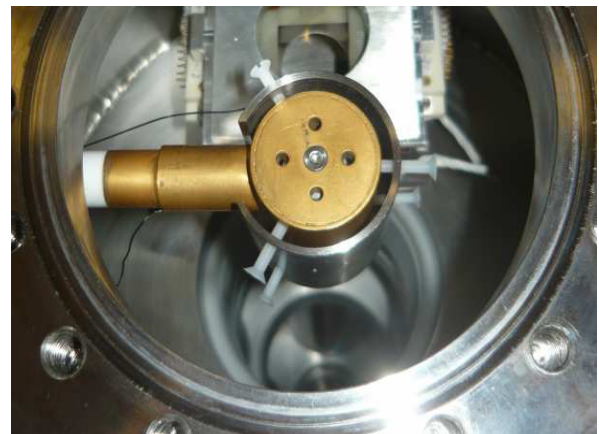

Figure 1: Faraday cup and beam profiler.

The Data Acquisition System

Signals from beam profilers and faraday cups are acquired by ADC cards installed in VME crates. The boards are XVME566 produced by XYCOM; they have 12 bit resolution and support a conversion rate of 100 KHz in streaming mode. Although higher performance products are available today we decided to continue using these modules, already installed in ALPI diagnostics system, because of the on board timer chip we use to generate the clock for the external multiplexer.

The stepper motor controllers are VME cards, designed in house, together with the associated power drivers; one controller manages 8 motors. The crate controller is an Emerson MVME3100, based on the PowerPC8540 processor and including 256MB RAM. The need of keeping the stream of serialized analogue signals coming from front-end electronics synchronized with the A/D conversion cycle imposes strict constraints in terms of response time. Because of this, the data acquisition software runs under the real time operating system Vxworks; the release currently in use is 6.8. The OS image has been tailored to support all features required to host an EPICS IOC using Wind River Workbench 3.2.

THE EMITTANCE METER

Measuring the emittance is of essential importance to evaluate the quality of beam produced by an ion source. The emittance meter designed for SPES [2] is based on two identical moveable slits (collimators) placed in front of a couple of horizontal and vertical grids. The slits have an aperture of 0.3 mm. and the distance from grids is 300 mm. By moving the collimators up and down (or right to left and acquiring data from vertical grids) it is possible to scan the whole beam area and evaluate the beam divergence by measuring the grid currents for different collimator's positions (the position is obtained by reading the output voltage of a linear encoder). Figure 2 illustrates the measurement scheme, while figure 3 shows the mechanical realization.
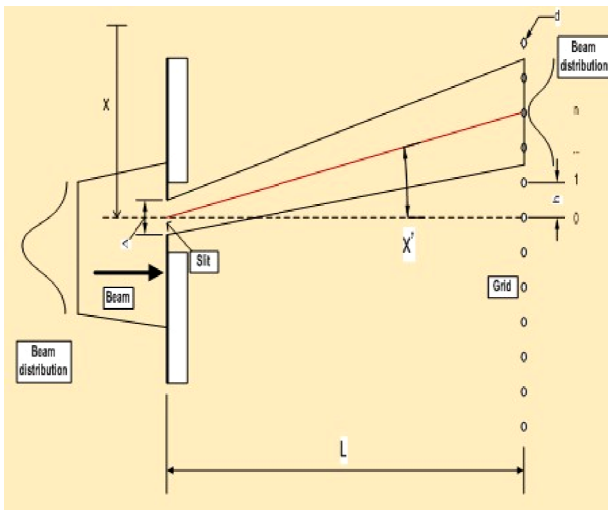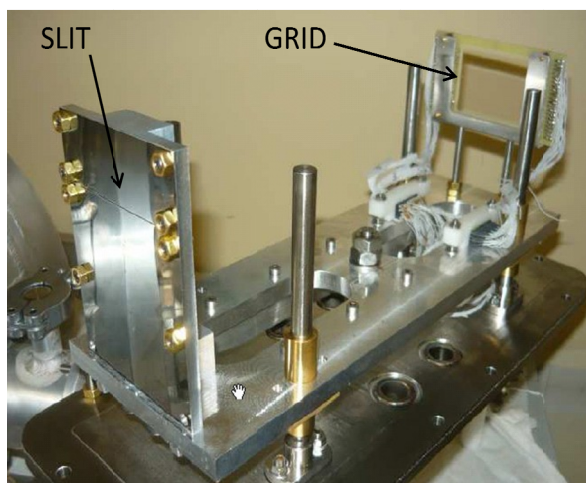

Figure 2: Scheme of emittance measurement.

Figure 3: Instrument mechanics.

SOFTWARE DEVELOPMENT

One key point of SPES new diagnostics system – and in perspective of ALPI diagnostics renovation – is the complete remake of control software. The choice of software tools for beam diagnostics development was coherent with our previous decision of using EPICS as general framework for SPES controls. It will allow us to take advantage of a plenty of utilities developed by the user community other than the great performance of data distribution system offered by Channel Access architecture.

This choice also fits naturally with our plan of ALPI diagnostics upgrade: reusing the rather large amount of legacy hardware installed in ALPI will be not a problem since the XYCOM I/O boards and the operating system Vxworks are supported by EPICS since its origin. Some modifications were required on drivers available from the community but the overall cost of migration will be strongly reduced.

The Emittance Measurement Software

According to EPICS terminology, the VME processor implements an IOC (Input Output Controller) providing the following functions:

- acquisition of grid signals, an array of integers configured as an instance of waveform record
- acquisition of collimator position from the linear encoder
- control of stepper motors, to synchronize the collimator motion with the grid signals acquisition

The database loaded in the IOC is relatively simple and provides minimal processing on raw data, mainly using C-sub records. Most calculations are performed on the client side, which is a Linux PC also used to run the graphic interface. The program is written in C++; it reads through the Channel Access the grid current arrays acquired by subsequent samples together with collimator position and stores all information in its disk, until the number of programmed steps is reached. At the end of the acquisition cycle it calculates the emittance and displays the result.

Data used for emittance analysis can also be stored in an EPICS Archiver for off-line review. The Archiver version currently in use is configured to work in conjunction with mySQL running on a Linux server. Replacement by a higher performance installation based on Hypertable [3] is planned for the near future.

The user interface has been realized using CSS (Control System Studio)[4], the new Java based graphic environment that provides a seamless integration of EPICS records management and high level supervisor functions (i.e. alarm handling, interface to the Archiver, etc.). Figure 4 is a snapshot of user interface, showing in a unique panel the raw beam profile as collected by grids, the faraday cup current and the phase space distribution.
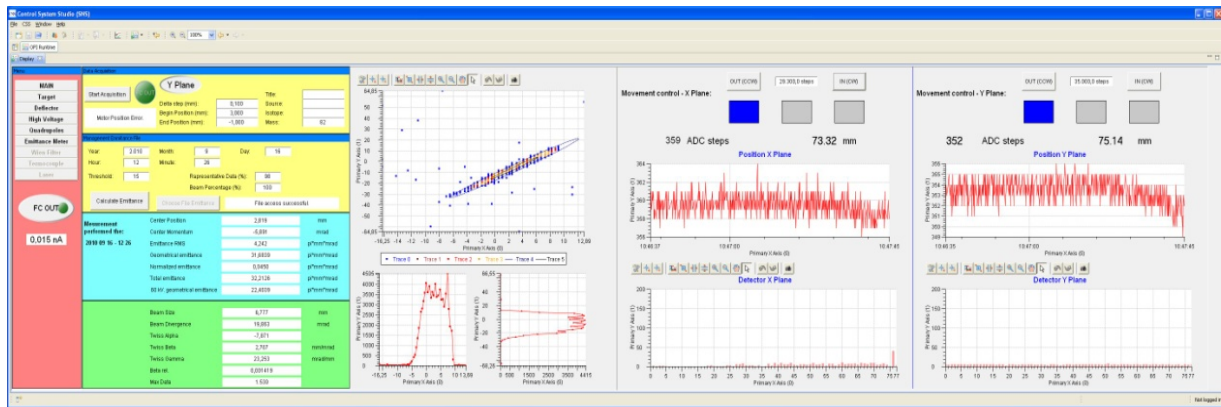
Figure 4: Snapshot of user interface based on CSS.

CONCLUSION

New diagnostics instruments were developed for SPES and are today in use in the Ion Source and Target Laboratory. The emittance meter has proven to be a very sensitive tool for the characterization of beams generated by the ion source prototype. The software migration to EPICS resulted in a significant increase of flexibility and performance of overall system. The software developed for SPES is being ported with minimal adaption to ALPI, in order to have an unique interface for the diagnostic systems of both facilities.

ACKNOWLEDGMENTS

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REFERENCES

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[2] J. Montano, J. Vasquez et al. "Off line emittance measurements of the SPES ion source at LNL", N.I.M.-A, vol. 648, aug. 2011

[3] http://www.lnl.infn.it/~epics/archiver.html

[4] http:// ics-web.sns.ornl.gov/css/