Diagnostics Used in Commissioning the IUCF Cooler Injector Synchrotron

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Abstract. Several new diagnostics systems were designed to aid in the commissioning of the IUCF Cooler Injection Synchrotron (CIS). Among them are a time of flight measurement system (ToF), a multi-wire profile monitor system (Harp) and a beam position monitor system (BPM). Pulsed beam from the 7 MeV linear accelerator is monitored using the ToF system. Several removable Harps are mounted in the injection beamline and ring which are instrumental for tuning ring injection and accumulation. BPMs are placed at the entrance and exit of the four ring dipole magnets to facilitate beam centering during injection and ramping. Fast and slow BPM displays are available to the operator for these functions. These diagnostics and their uses for CIS ring commissioning will be discussed.

ENERGY MEASUREMENT

A time of flight system (ToF) is being used in the 7 MeV injection beamline to detect changes in the beam energy from the RFQ/DTL. The system is similar to the one used at TRIUMF (1), where a change in energy is measured as a change in phase between two pickups of a fixed, known distance apart.

The 200 μs pulsed beam is accelerated through the RFQ/DTL using a 425 MHz, 300 kW rf amp. The non-interceptive, resonant, beam pickups are immediately downstream of the accelerator, 2.5 meters apart. A beam signal is detected, buffered and sent to the ToF electronics. An Analog Device AD607 (2) is used as an rf to if, 10.7 MHz, converter.

The AD607 is normally used in wireless communications as a down-converter amplifier. It has a mixer and log amp with AGC, as well as, an I & Q demodulator, all in a 20-pin surface-mount chip. It has been tested in the lab as an AGC beam position detector with a 75 dB range. The output of the AD607 is a constant 300 mV signal, which is fed into limiting amps and then a type II phase detector. The output is filtered to a DC level, amplified, and displayed on a scope.

In order to achieve an energy of 7 MeV, the DTL amplifier must be operated in an unregulated mode, relying on a large capacitance to hold the charge over the 200 μs pulse period. The resultant output energy can sag by as much as 500 keV over the span of the pulse period. Using the ToF monitor, the amplifier can be adjusted to minimize the sag (Fig. 1), flattening the output energy to the acceptance of the CIS injection aperture, 180 keV. The monitor also provides a good comparison between beam intensity on the stop in the CIS ring and the energy.

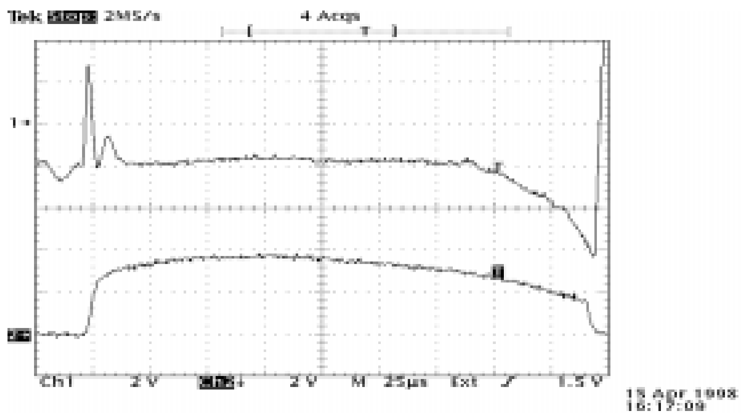

FIGURE 1. Top display is the ToF. The average energy is 7 MeV. The bottom display is the CIS stop located downstream of the first dipole. The energy sag at the end of the ToF pulse corresponds with the sag in intensity on the stop.

BEAM PROFILE MONITORS

Mechanically, the CIS Harps are very similar to those used in other labs. They are secondary emission multi-wire chambers using high-voltage cathode grids and multi-pin vacuum connectors. Each detector board uses 24 wire grids with 1 mm spacing. The circuit board is also a familiar design, using a large RC time constant at the input of the detector. The 48 signals are multiplexed through a single integrator. One interesting aspect of the Harp electronics design is the timing electronics, which are incorporated on the printed circuit board using a programmable array logic chip (PAL). A trigger from the devices on the board provides the ADC clock. The data acquisition parameters can be changed by reprogramming the PAL. This permits data acquisition and display of Harp signals to occur in two ways. For operations, the signal goes to a fast ADC with FIFO memory allowing the user to acquire data at a fast rate and display it whenever desired on the operations monitor.

During commissioning and troubleshooting, a stand-alone display system is used, incorporating a PC and graphical programming package from Hewlett-Packard, HP VEE, (3). The Harp has been the primary diagnostic during commissioning of the CIS ring. Two Harps have been placed in the ring injection beamline and one in the ring. The first Harp is mounted in front of a stop, allowing one to monitor intensity and shape of the beam over 200 µs pulse length while adjusting the profile. The Harps are moved in and out of the beam path using air actuated insertion devices. The flexibility of this setup, allows an operator to observe a Harp display of first-turn beam in the CIS ring along with multi-turns (Fig. 2) and also accumulate maximum intensity with the Harp out of the beam path. Plans have been made to remove the Harp presently used in CIS and replace it with a new low-profile design. There will also be five Harps in the beamline connecting CIS to the Cooler.

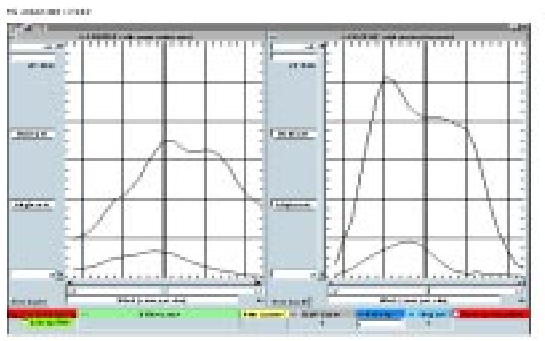

FIGURE 2. The CIS Harp as seen using HP-VEE. The small traces are first-turn beam in the ring. The large traces are multiple turns.

BEAM POSITION MONITORS

There are eight BPMs (4) in the CIS ring, positioned at the entrance and exit of each of four dipole magnets. All signal conversion is done at the pickup and the DC signals are multiplexed to different areas. The wide bandwidth of the position signals is useful for observing and changing ramp vectors, which are spaced every 11 ms (Fig 3). For the moment, vectors are changed by hand, but plans have been made to implement a feed forward loop to automatically adjust the vectors to keep the beam centered in the ring during ramping.

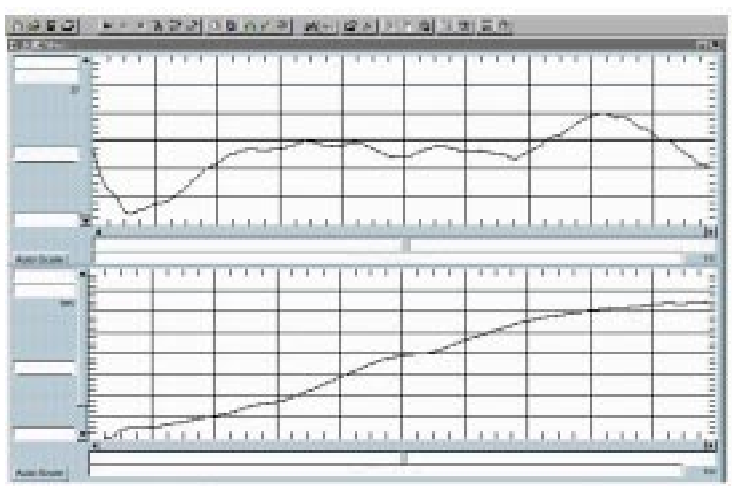

FIGURE 3. The upper display is the beam position (2 mm/Div.) in the CIS ring during a 7 MeV ramp. The bottom display is the intensity during the same ramp.

WALL GAP MONITOR

A wall gap monitor (WGM) is used to provide bunched beam information such as bunching factor measurements, and to observe beam intensity losses during the ramp (Fig. 4). A digital oscilloscope is used to capture the signal and display it for the operator. During ramping, losses are easily detected by comparing amplitude losses with BPM position distortions.

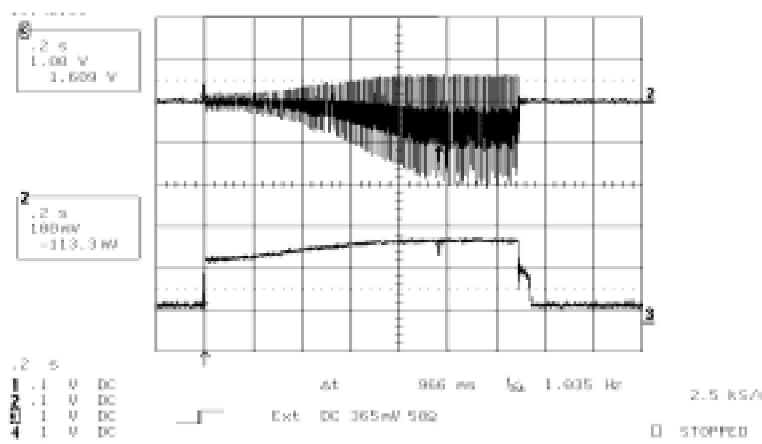

FIGURE 4. The top display is the WGM output during a 225 MeV ramp. The bottom display is the output from a logarithmic amplifier of the same ramp.

REFERENCES

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[3] Analog Devices "Linear Products Data Book," pp. 7.7–22, 1990/91.

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