DEVELOPMENTS IN BEAM DIAGNOSTICS AND ION TRACKING AT HRIBF

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Studies of nuclear reactions induced by radioactive beams is a new and rapidly growing area of nuclear science. While the availability of accelerated β unstable nuclei holds the promise of rapidly growing nuclear science, it also poses new challenges in beam delivery, as well as experimental studies. Some of the aspects that make life with radioactive beams different are:

- The beam particles are radioactive.

  Beam deposition on parts of the accelerator complex or on experimental devices hampers access and in many experiments will produce large and unwelcome backgrounds.

- The beam, in general, contains a mixture of isobars.

  Experimenters must monitor the relative intensities of all beam components. In some cases tagging or separation of isobars might be necessary.

- Beam intensities are generally lower than with stable beam nuclear physics experiments.

  Low intensities make beam handling and tuning extremely challenging.

At HRIBF, we have an ongoing effort to devise methods and detectors to address some of the specific problems mentioned above. Our efforts resulted in several improvements in detector technology.

- An improved version of a residual gas beam sampling monitor that combines two-dimensional ion position with ion drift time information to provide three-dimensional position information on sampled beam particles.

- A prototype tracking detector, which provides better than 1ns timing, 250 μm position resolution, is very efficient for heavy ions, introduces only one thin foil into the beam path and can count at rates near 1 MHz.

- Timing detectors that are very thin and provide 100ps timing information while operating reliably at rates up to 5×10^6 p/s.

All the detectors listed above are "pass through" detectors - they are not intended to absorb beam particles. These detectors were tested with stable and radioactive beams and proved to be crucial to the success of several radioactive beam experiments.

- In an experiment studying low-lying resonances in ^{17}F+p, absolute cross-section data were obtained by counting the ^{17}F beam with a thin timing detector. Low-energy background from β^- decay of the beam was filtered by timing the recoil proton with the beam detector.

- In an experiment studying the coulomb excitation of ^{132}Te and ^{134}Te on a ^{12}C target, the beam was monitored and counted by two timing detectors and the scattered beam was monitored by a tracking detector with a foil covering the angular range of 2 to 5 degrees with a 1" hole in the center allowing the beam to pass.

- In an experiment studying the fusion of ^{118}Ag with ^{9}Be using the CLARION, an array of Ge clover detectors, time-of-flight recorded between the gamma detector array and a tracking detector placed about 10 meters downstream, was used to select evaporation residues from a beam with intensity near 10^6 p/s.

The tracking detector was also put to use for tuning low-intensity beams. This position-sensitive particle detector detects single beam particles. A continuously refreshed display of the particle hit positions, simulating a phosphor with linear decay time, provides a near instantaneous profile of the beam. This system can be used for beam focusing and steering at counting rates starting at a few

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hundred particles per second. This "electronic phosphor" provides continuously updating beam profiles at count rates reaching 10^5 p/s - a rate at which the standard phosphor+camera combination can take its place. Figure 1 shows a beam line with two timing detectors and the tracking detector, used as an electronic phosphor. The displays affording the accelerator operator continuously updated rates for the beam timing detectors, as well as a two-dimensional dot display of the beam, are shown below.

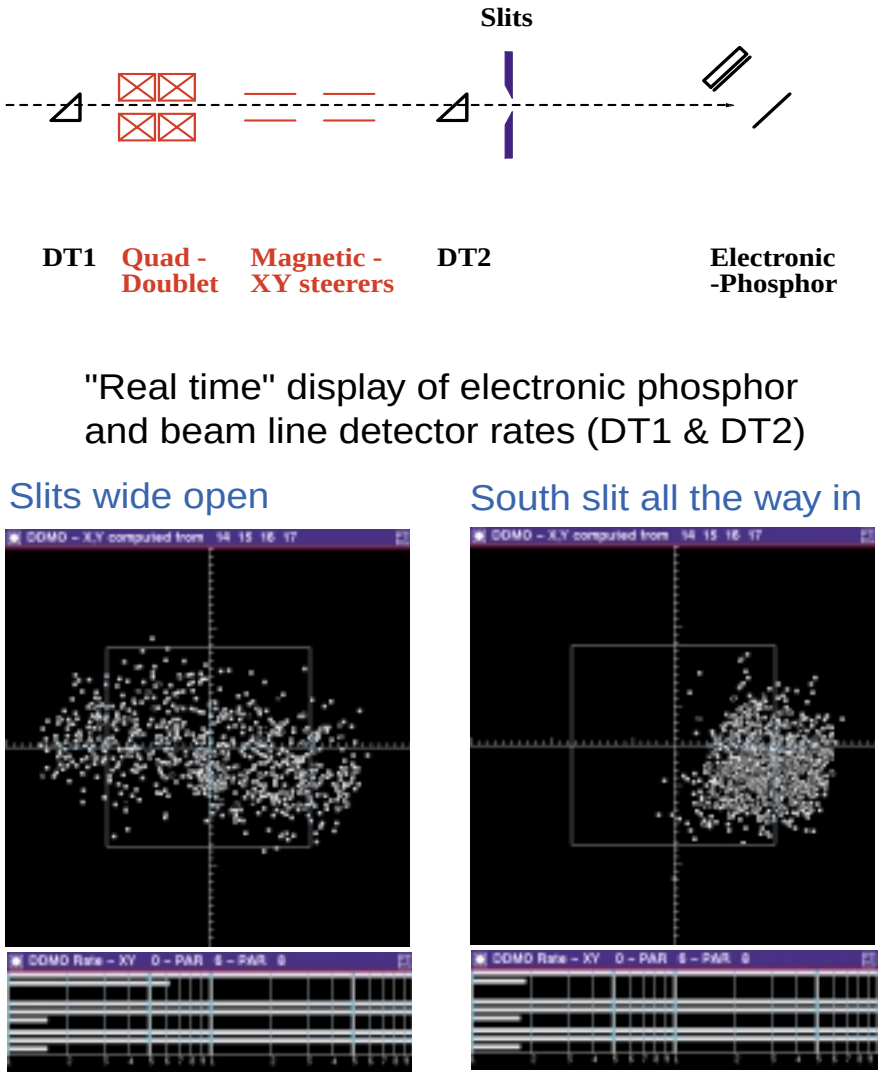

Figure 1: Snapshots of the continuous XY display generated by the beam hitting the "electronic phosphor".