High Resolution WS Beam Line for Grand Raiden Spectrometer

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The high resolution WS beam line has been designed and constructed to accomplish complete matching including both lateral and angular dispersion and focus matching with the high-resolution Grand Raiden spectrometer [1]. The WS beam line consists of six dipole magnets with a total bending angle of 270° (see Fig. 1). This beam line can be divided into five sections. The beam is focused in both the horizontal and vertical planes at the end of each section. The beam line polarimeter systems are positioned at the ends of first and second sections to measure all polarization components of the beam. They are separated by a bending angle of 115°, allowing the determination of horizontal components of the beam polarization.

Figure 2 shows beam envelopes from the object point (BV-EXT) to the target position for the dispersive mode. In dispersive mode, lateral and angular dispersions of the WS beam line are $b_{16} = 37.1$ m and $b_{26} = -20.0$ rad, necessary to satisfy dispersion matching conditions for Grand Raiden. The WS beam line can also deliver a double-achromatic beam with zero lateral and angular dispersion (b_{16}=b_{26}=0) on targets. The magnifications of the beam line are $(M_x, M_y) = (-0.98, 0.89)$ and $(-1.00, -0.99)$ for dispersive and achromatic modes, respectively.

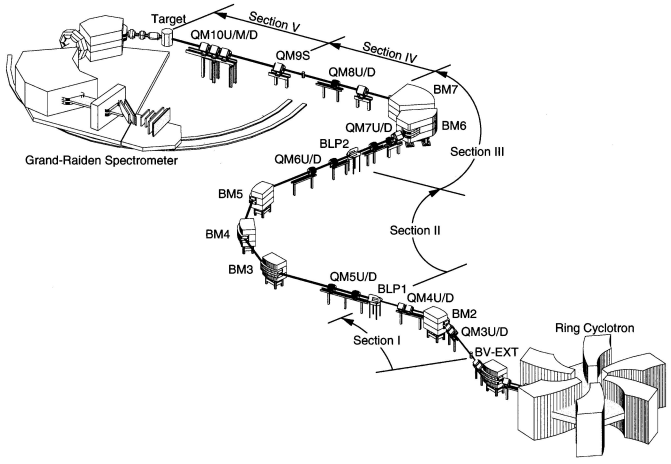

Figure 1: A schematic view of the WS beam line at RCNP from the object point at the Ring Cyclotron exit (BV-EXT) to the target position of the Grand Raiden spectrometer. There are five dipole and sixteen quadrupole magnets labeled BMn and QMnU/M/D/S, respectively. The beam line polarimeters BLP1 and BLP2 are positioned at double-focus locations of the beam line.

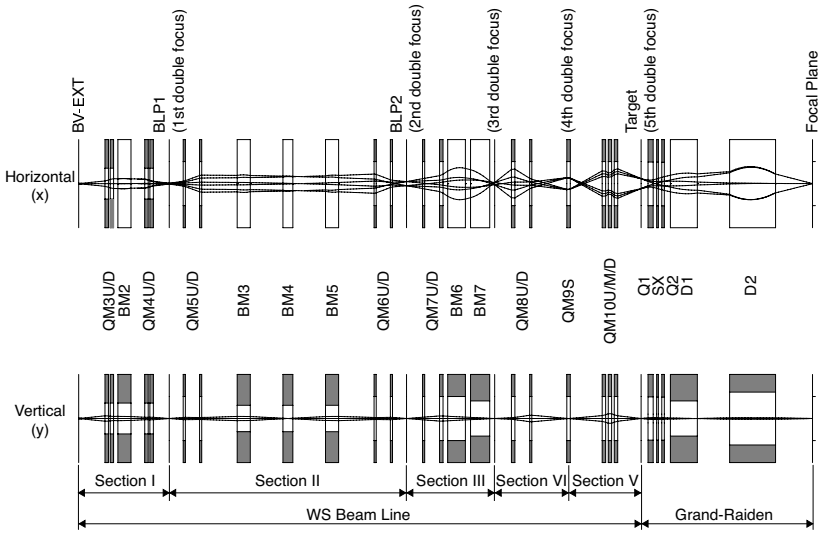

Figure 2: Envelopes of dispersive beam in the horizontal and vertical planes from the object point at the exit of the Ring Cyclotron (BV-EXT) via the target location to the focal plane of the Grand Raiden spectrometer. Trajectories are shown for particles with $\Delta p/p = \pm 0.03\%$, $\Delta\theta = \pm 2$ mrad, and $\Delta\phi = \pm 2$ mrad. The transverse scale is increased for illustration.

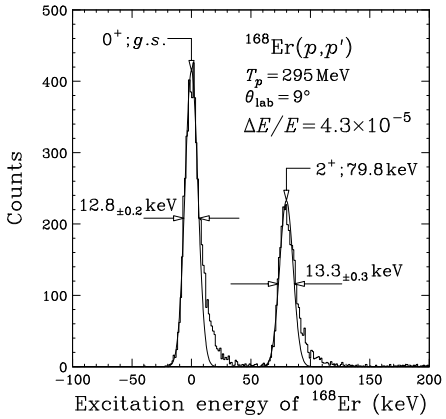

Figure 3: A typical excitation energy spectrum of the ^{168}Er(p, p') scattering at $T_p = 295$ MeV and $\theta_{\rm lab} = 9^\circ$ measured with the Grand Raiden spectrometer after employing the dispersion matching method.

Since April 2000 when the WS beam line was commissioned, the system was used for a variety of nuclear physics experiments. Measurements have been performed with various particle beams of $\vec{p}$, $\vec{d}$, ^{3}He, ^{4}He, etc., in a wide energy range. Energy resolutions of $\Delta E/E = 5 \times 10^{-5}$ and better are possible in dispersive mode.

The performance of the WS beam line in dispersive mode was studied by using the faint beam method for the ^{168}Er(p, p') scattering. Figure 3 shows the excitation energy spectrum for the ^{168}Er(p, p') scattering at $T_p = 295$ MeV and $\theta_{\rm lab} = 9^\circ$. An enriched ^{168}Er target with a thickness of 2 mg/cm^2 was used. The first excited 2^+ state of $E_x = 79.8$ keV is clearly separated from the ground state with an energy resolution of $\Delta E = 13.0 \pm 0.3$ keV in FWHM which is consistent with the ideal value of 14 keV given by the resolving power limit of the spectrometer.

References

[1] T. Wakasa *et al.* Nucl. Instrum. Methods Phys. Res. A, submitted.