Space Charge Driven Third Order Resonance at AGS Injection

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Periodic Resonances

Beams with intense space charge and chromatic detuning can cause the tunes to vary along the length of the bunch. Because of this, particles undergoing synchrotron oscillations in the bunch cross these resonances at several locations along the synchrotron period. This is known as a periodic resonance. There are two regimes this resonance can enter, adiabatic resonance and non-adiabatic resonance.

Adiabatic periodic resonances have smoothly varying transverse dynamics across the synchrotron period. Particles crossing the resonance that are not trapped in some stable region are lost causing distributed particle loss along the domain.

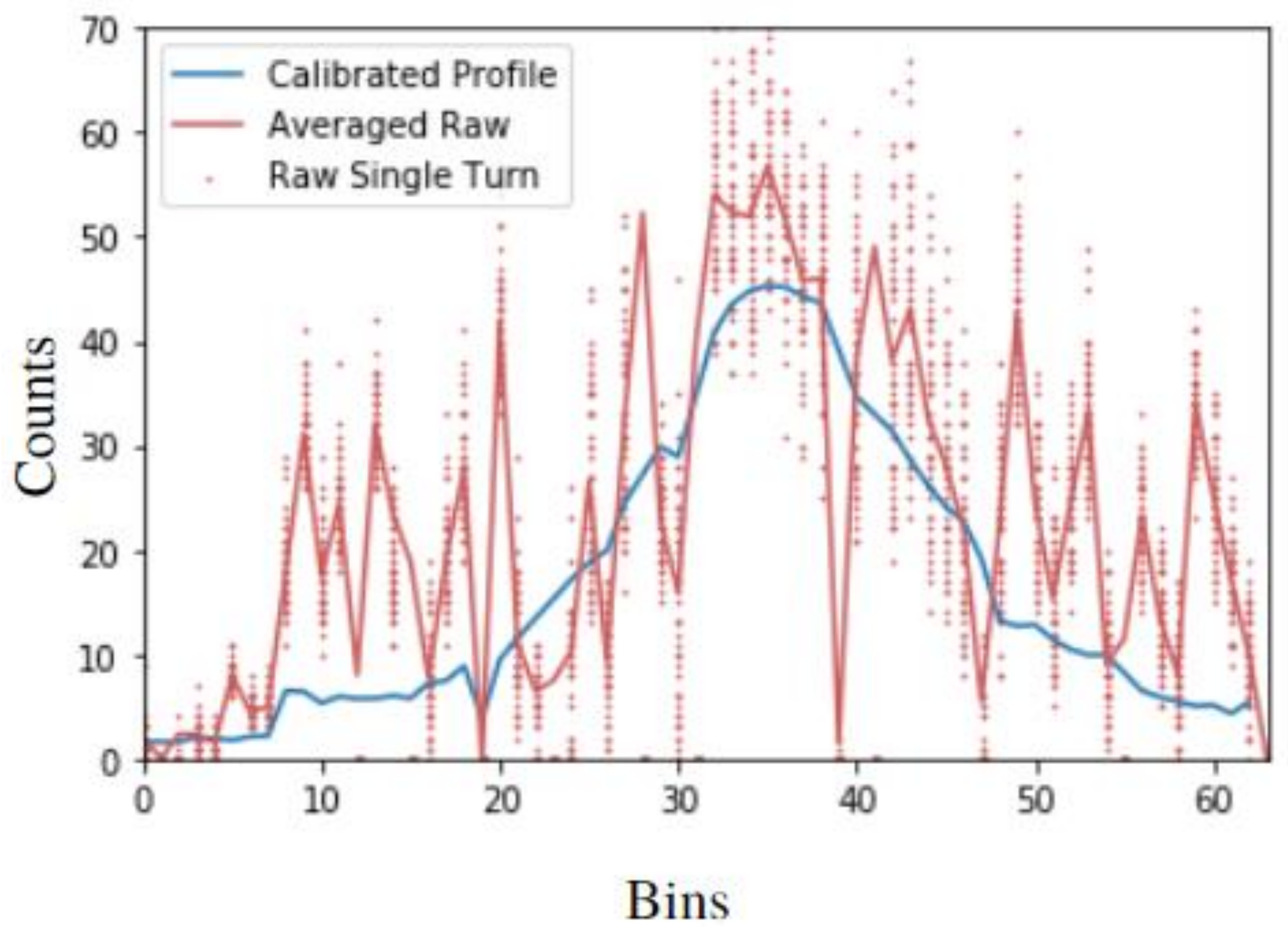
Non-Adiabatic resonance crossings cause the phase space portrait to change quickly along the synchrotron period. Particles with large transverse maxima will scatter out of the system even if they were previously in an island of stability. This causes emittance growth and eventual particle loss. This scattering continues until the loss of particles and emittance growth drives the tune shift above the resonance crossing.

To study these resonances and experiment was performed at AGS. A beam with large ΔQ_{sc} was injected at multiple tunes, each crossing the resonance with a different portion of the beam.

Electron Ionization Profile Monitor

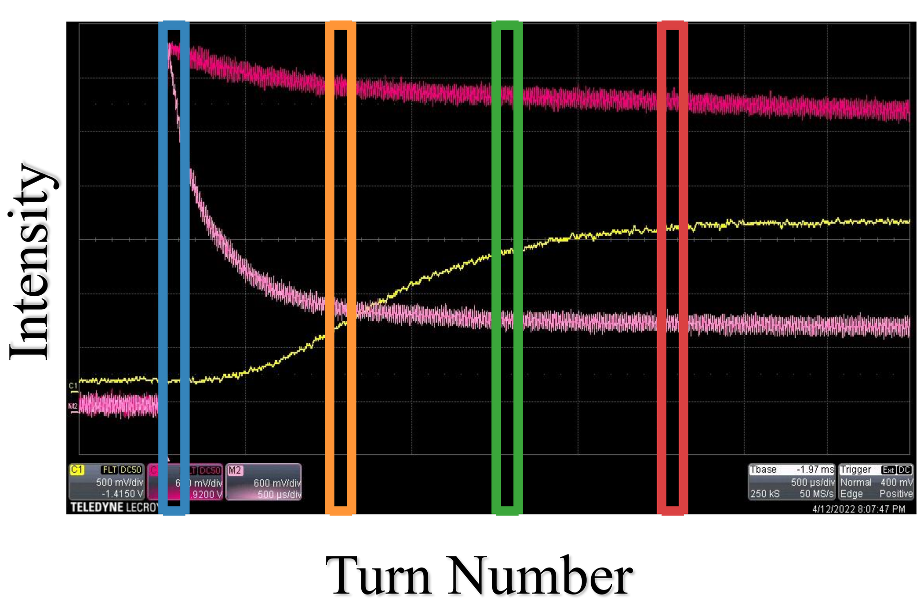
Two eIPMs are used to obtain high time resolution transverse profile data for the experiment. In an eIPM the beam interacts with a vented residual gas and ionizes some of the particles. Electrons produced by ionization are then swept by a high voltage (6 kV) onto a Micro Channel Plate (MCP) creating a transverse projection onto the MCP.

Vertical Distribution at Injection $Q_y = 8.6942$

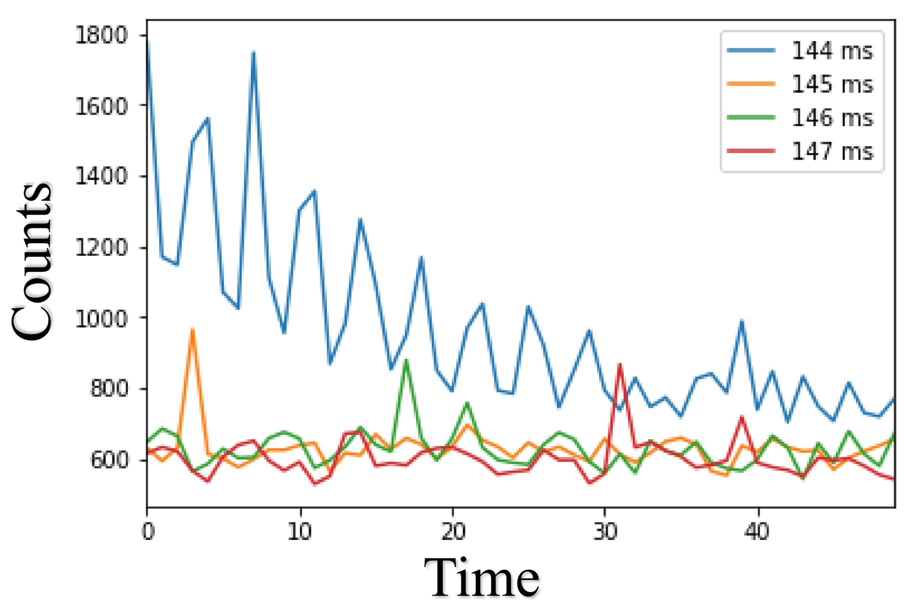


The above figure shows a vertical eIPM distribution taken at AGS injection. Raw profiles are in red, calibrated final profile is in blue. Bins with obviously incorrect results are considered 'dead' and are removed from the data. Since the measurement is taken at injection, tails are not due to 3rd order resonance.

Turn by Turn eIPM Counts



Fast Wall Current Transformer at Injection

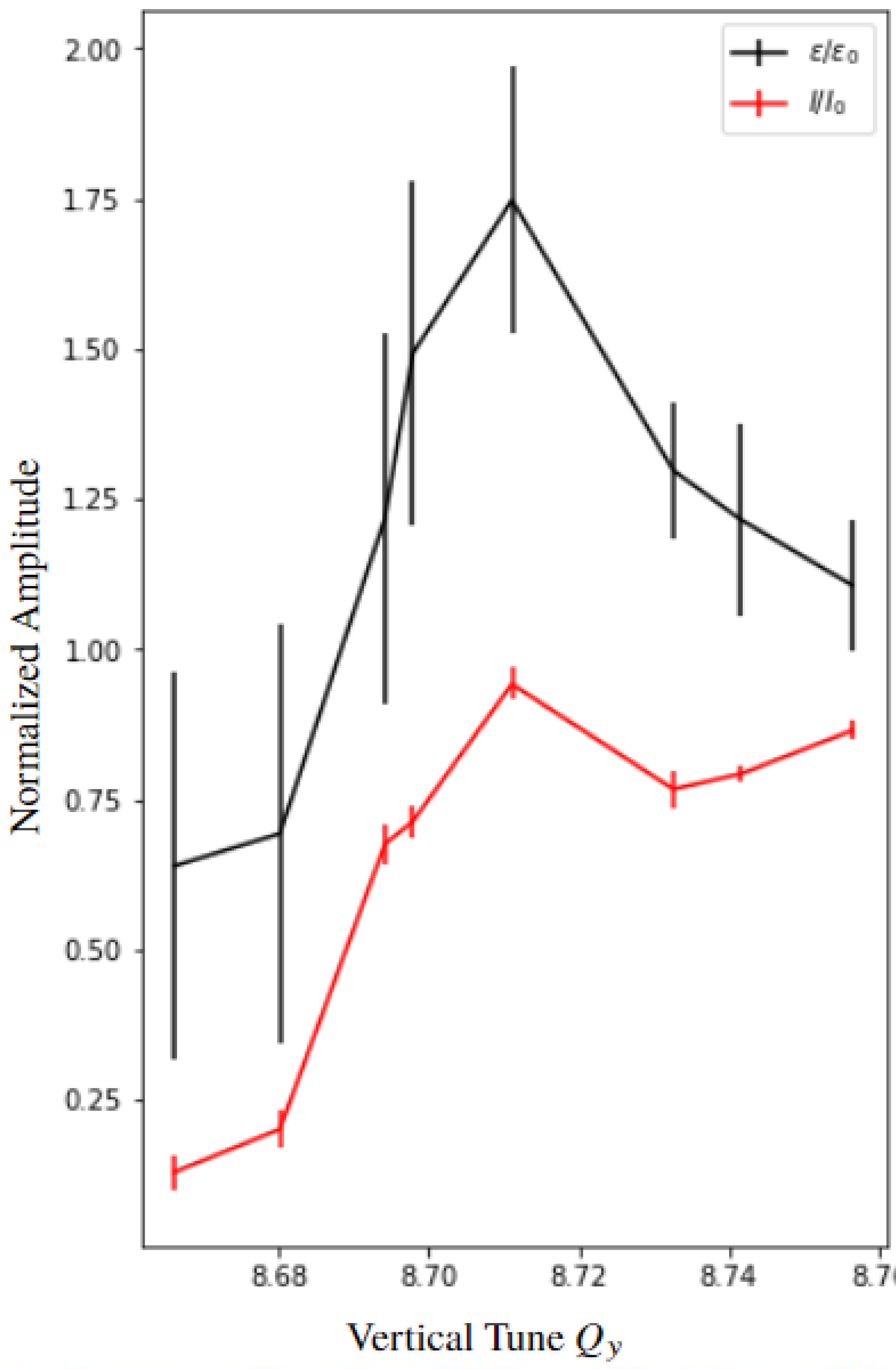


Both the Fast Wall Current Transformer and the eIPM give intensity measurements with high time resolution. The Wall Current Transformer is used to calibrate the eIPM intensity measurements. High time resolution is necessary due to the short saturation time for the resonance.

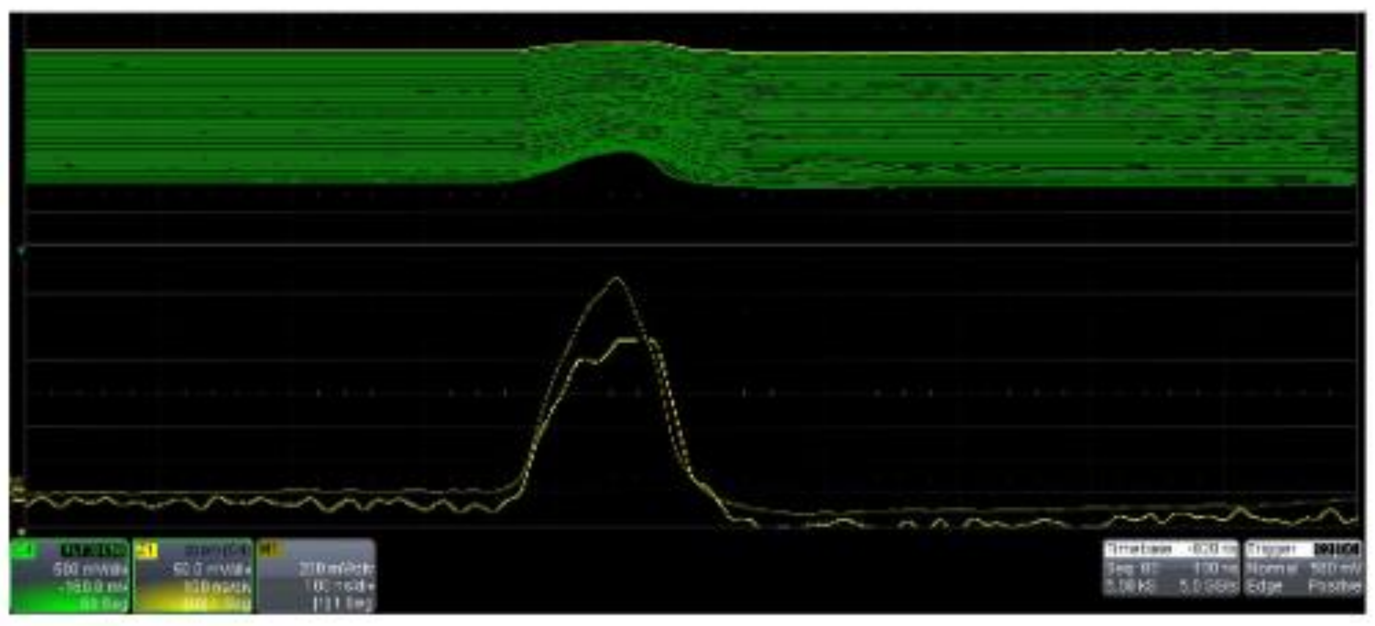
Results

The resonance crossing was studied by injecting a single bunch into AGS with a single particle tune above the resonance, and ΔQ_{sc} crossing it. Emittance growth peaks before significant particle loss occurs. Maximum particle loss is about twice that of adiabatic resonance in [1] implying the system is non-adiabatic.

Bunched Beam Near 3rd Order Resonance



Monitor Longitudinal Distribution Oscilloscope Trace



Longitudinal bunch lineshape varies little as the resonance saturates. This is true even in cases where particle loss is significant. This is consistent with crossing an adiabatic resonance.

Conclusion

It is currently unclear whether the probed resonances in the AGS are part of the adiabatic or nonadiabatic regime. The beam growth and particle loss profiles are consistent with the non-adiabatic regime. The lack of longitudinal bunch shortening is instead consistent with adiabatic regime. Future studies should be performed to better characterize and understand the characteristics of this system.

References

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Acknowledgments

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