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A Micro-Channel plate based RFA electron cloud monitor for the ISIS Proton Synchrotron

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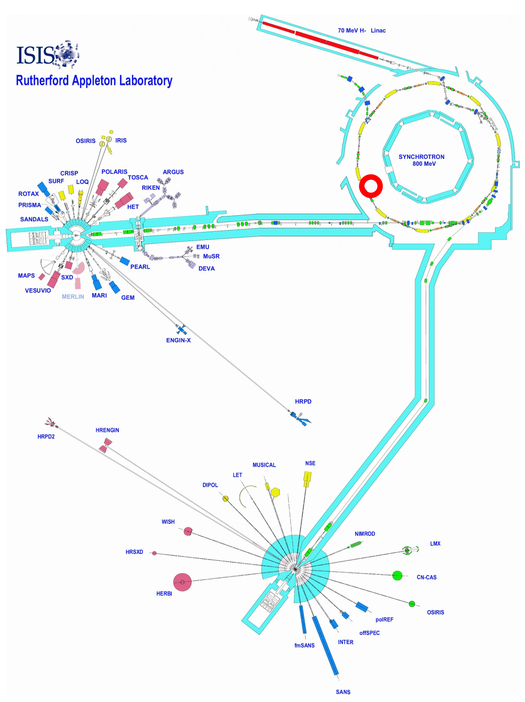
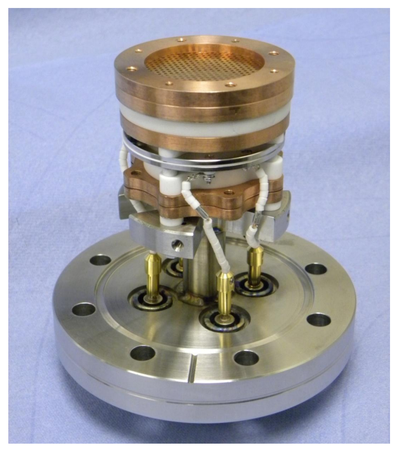
Introduction

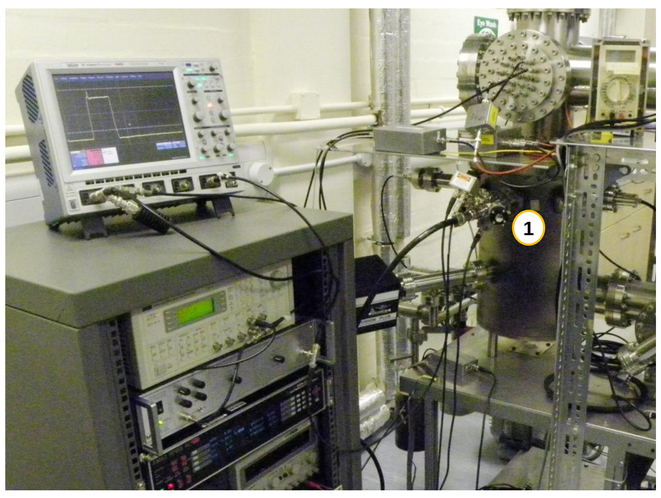
- The build up of electron clouds inside a particle accelerator produced by the passage of the beam can lead to strong transverse and longitudinal instabilities requiring the accelerator to run below its design specification
- To look for evidence of electron clouds at ISIS, a micro-channel plate（MCP） based （RFA style） electron cloud monitor has been designed and installed into the ISIS accelerator ring （previous attempts without an MCP were hampered by machine and beam induced noise）
- Results obtained from the electron cloud monitor clearly show the presence of electron activity within the ISIS vacuum vessel



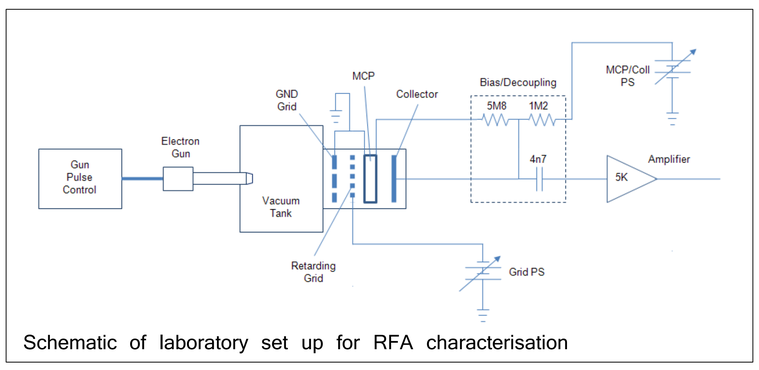
ISIS Electron Cloud Monitor



- The ISIS MCP based RFA electron cloud detector
- MCP provides current gain of up to 25K



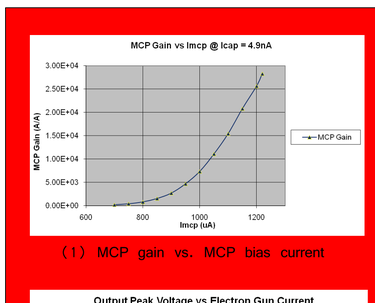
RFA test set-up using pulsed electron gun （1）



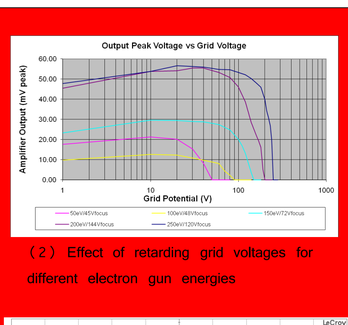
Schematic of laboratory set up for RFA characterisation

Lab based measurements using an electron gun and test chamber

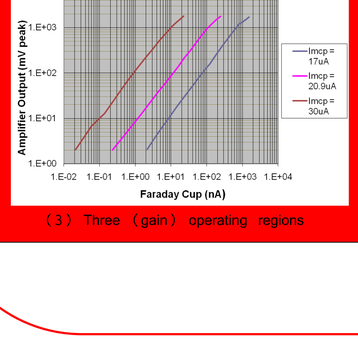
- RFA detector, MCP and amplifier system were characterised prior to installation using a pulsed electron gun and purpose built vacuum chamber.
- The electron gun was fitted with a faraday cup so known electron beam intensities and energies could be directed at the RFA device.
- Below （1） shows the gain of the MCP as a function of the MCP bias current （a linear region can be observed）.
- Below （2） shows that the electrons from the gun can be stopped by a negative potential on the retarding grid （used for energy analysis）.
- Below （3） shows three different gain operating regions for the MCP.
- Below （4） shows the trigger pulse to the electron gun and the resulting output pulse from the MCP.



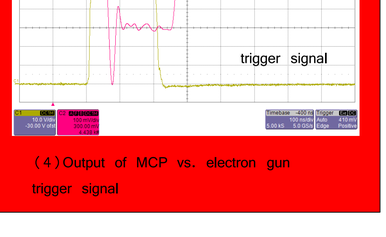
（1） MCP gain vs. MCP bias current



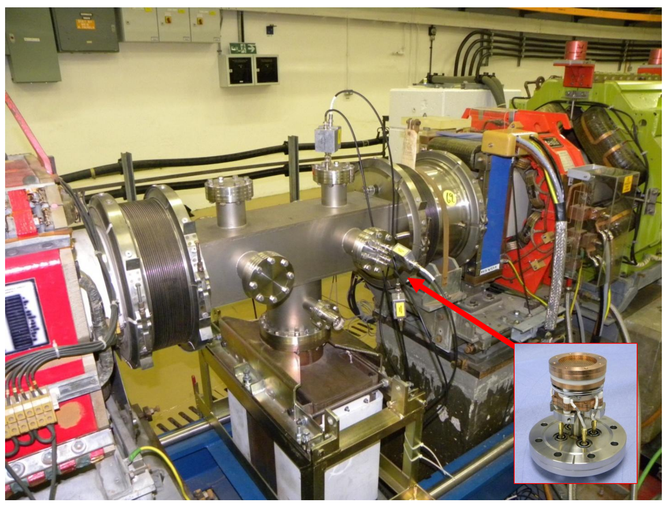
（2） Effect of retarding grid voltages for different electron gun energies



（3） Three （gain） operating regions

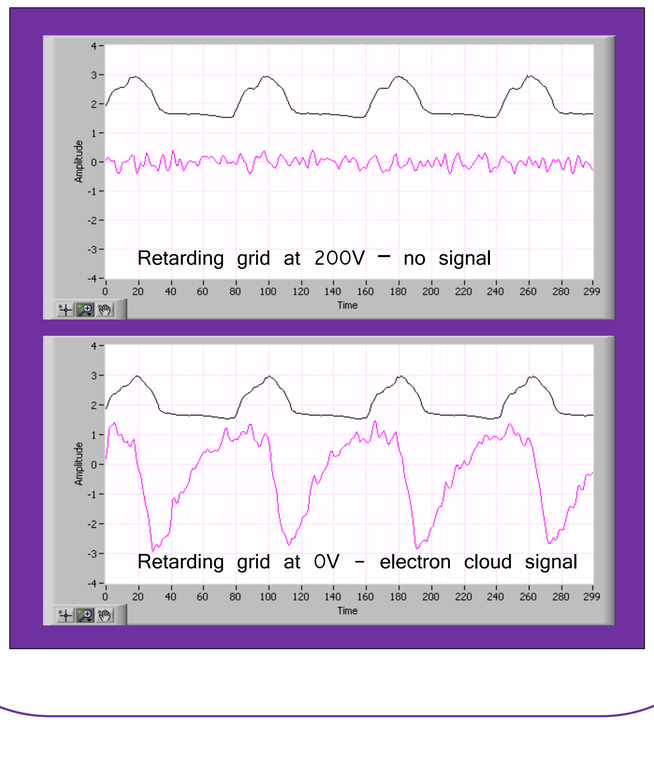


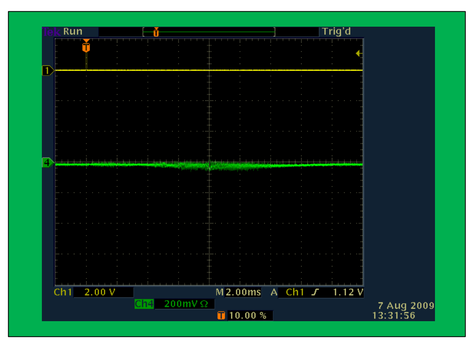
（4）Output of MCP vs. electron gun trigger signal



Installation and Commissioning work

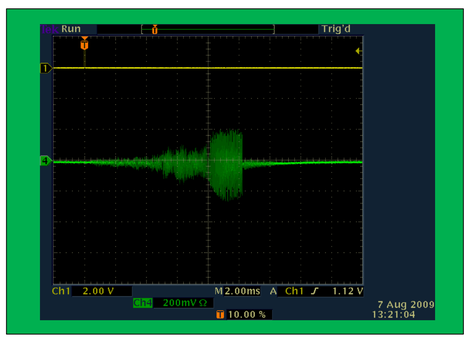
- MCP-based RFA detector installed into Straight 5 of the ISIS accelerator.（location (O) on the ISIS map）
- Timing for RFA data acquisition provided by a local beam position sum signal monitor. Two non-MCP RFA devices installed at same location as MCP-based RFA provide background noise readings
- Data acquisition provided by fast digitizer cards （125Ms/sec）
- Below （top） shows the output of the RFA detector when the retarding grid was set to 200V to block the electron signal
- Below （bottom） removal of the grid voltage allows a sample of the electron cloud to reach the MCP producing an output from the RFA device





Measurements without an MCP

- First attempt to measure electron cloud was made using a non-MCP RFA
- No electron cloud signal seen due to beam induced noise （green traces）
- above shows RF cavity noise pickup （no beam present）
- Below is beam induced noise in the RFA



Summary

- ISIS has no history of electron cloud instabilities
- Theoretical studies suggest that ISIS upgrade work could possibly produce e-cloud problems through, for example, increases in beam intensity.
- Measurements using the MCP-based electron cloud detector clearly show the presence of electrons within the ISIS accelerator
- Understanding why ISIS does not suffer from electron cloud problems is the next goal. This will be achieved through a combination of theoretical and experimental work.

Acknowledgements

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