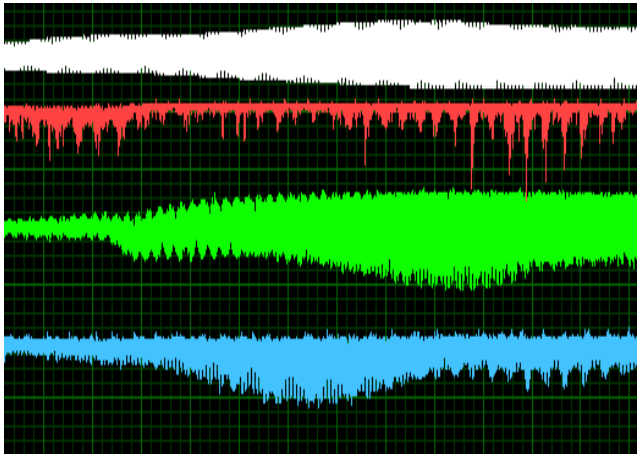
ELECTRON CLOUD OBSERVATIONS AT THE ISIS PROTON SYNCHROTRON

Alex Pertica

ECLOUD'12 - Isola d'Elba, Italy



Alex Pertica, alex.pertica@stfc.ac.uk

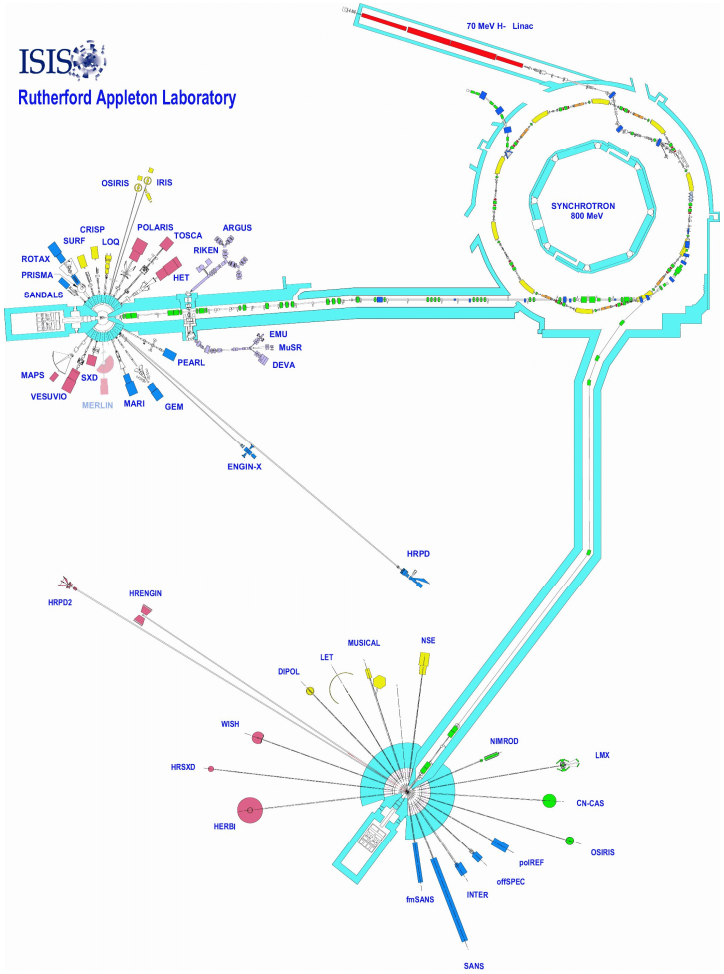
Science & Technology Facilities Council
ISIS

Topics

- Introduction:
  - What is ISIS?
  - Motivation for electron cloud (EC) studies
- Detector description and location
- Initial tests
- Electron cloud observations
- Summary

Alex Pertica, alex.pertica@stfc.ac.uk

Introduction - What's ISIS



- Neutron Spallation Source (two targets) and Muons (intermediate target), at the Rutherford Appleton Laboratory, in UK near Oxford
- 2.8×10^{13} protons per pulse (two bunches)
- Accelerated up to 800MeV
- 50 Hz rep rate (40pps TS1, 10pps TS2)
- Mean current 200uA

Alex Pertica, alex.pertica@stfc.ac.uk

Ecloud'12 – Isola d'Elba, Italy

Science & Technology Facilities Council
ISIS

Introduction - Motivations for electron cloud studies

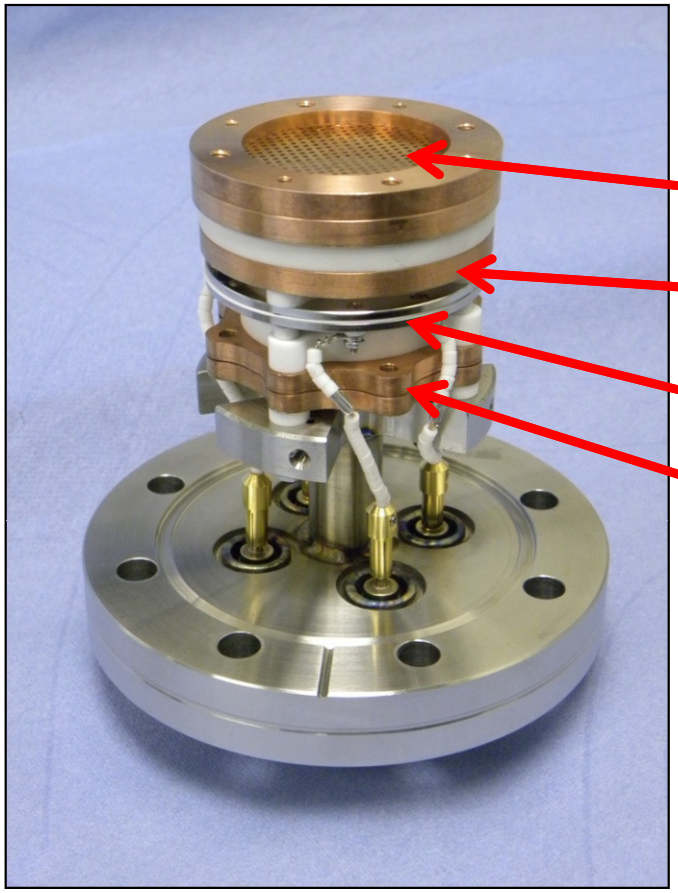
- Since ISIS entered into service in 1984, no evident signs of EC effects have been observed to date.

- According to previous simulation work, an increase in beam intensity (i.e. MW upgrade) could lead to a significant rise in the electron cloud density and thus the probability of EC related beam instabilities.

- In order to study and understand the electron cloud phenomenon, three RFA style electron cloud detectors have been installed in the ISIS synchrotron (2 RFA type and 1 RFA + micro-channel plate type).

Alex Pertica, alex.pertica@stfc.ac.uk

Detector assembly description



Ground grid (20% transmission)

Retarding grid (85% transmission)

Micro Channel Plate (MCP)

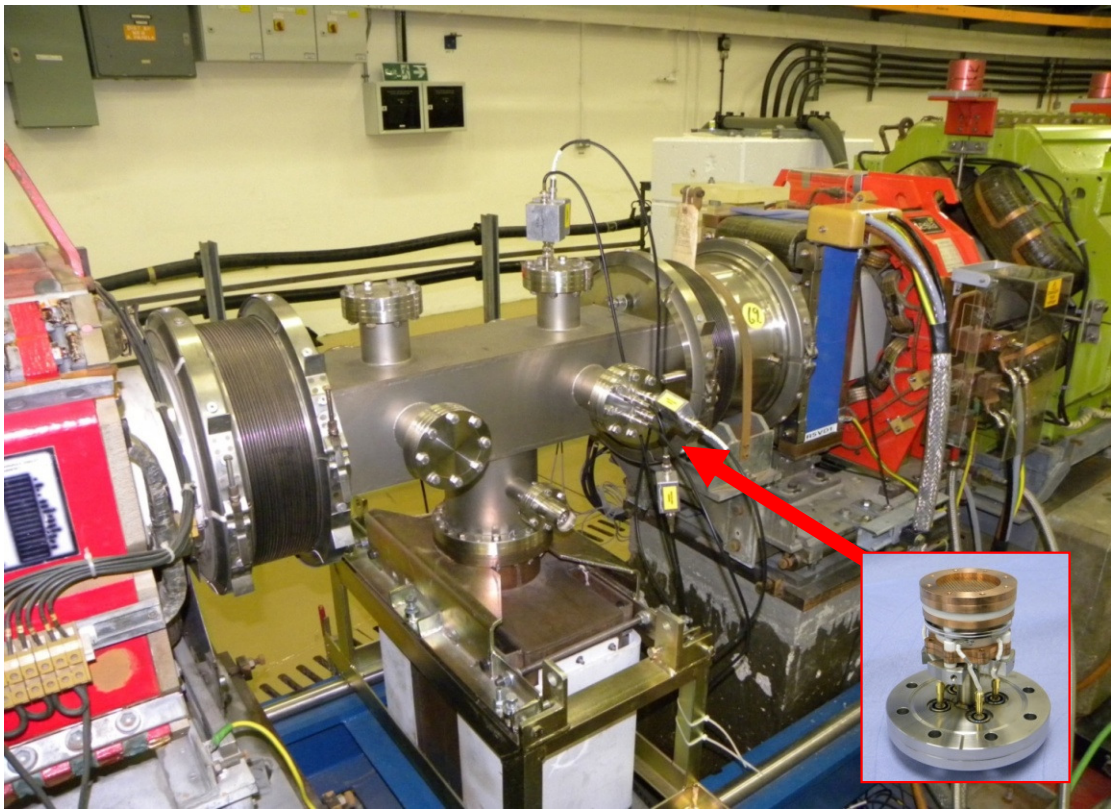
Collector assembly

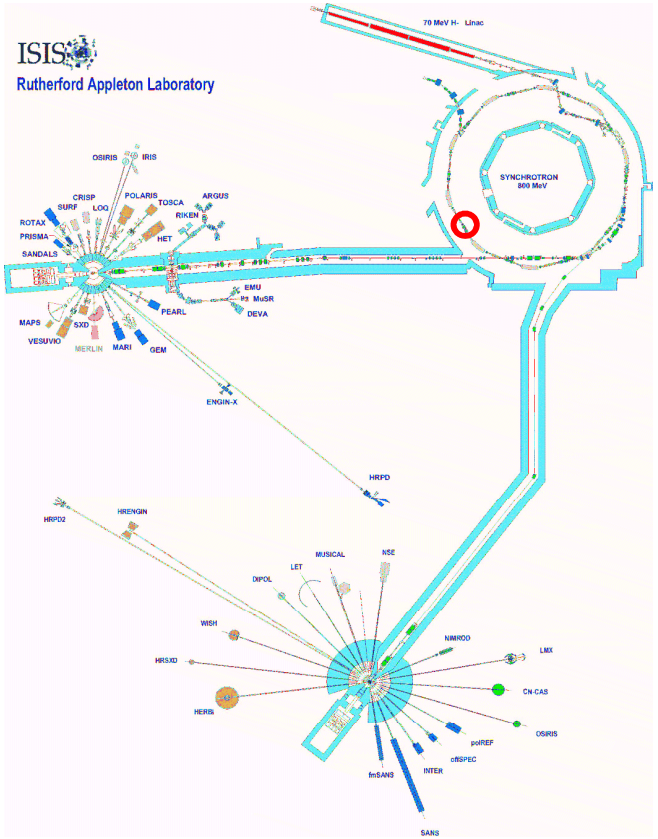
Mu metal shield

Alex Pertica, alex.pertica@stfc.ac.uk

ISIS electron cloud detectors location

The ISIS electron cloud monitors are installed in a drift space of a straight section (super-period 5) of the synchrotron ring. Two non-MCP versions are located at the top and outer sides of the beam pipe and the MCP version at the inner side.



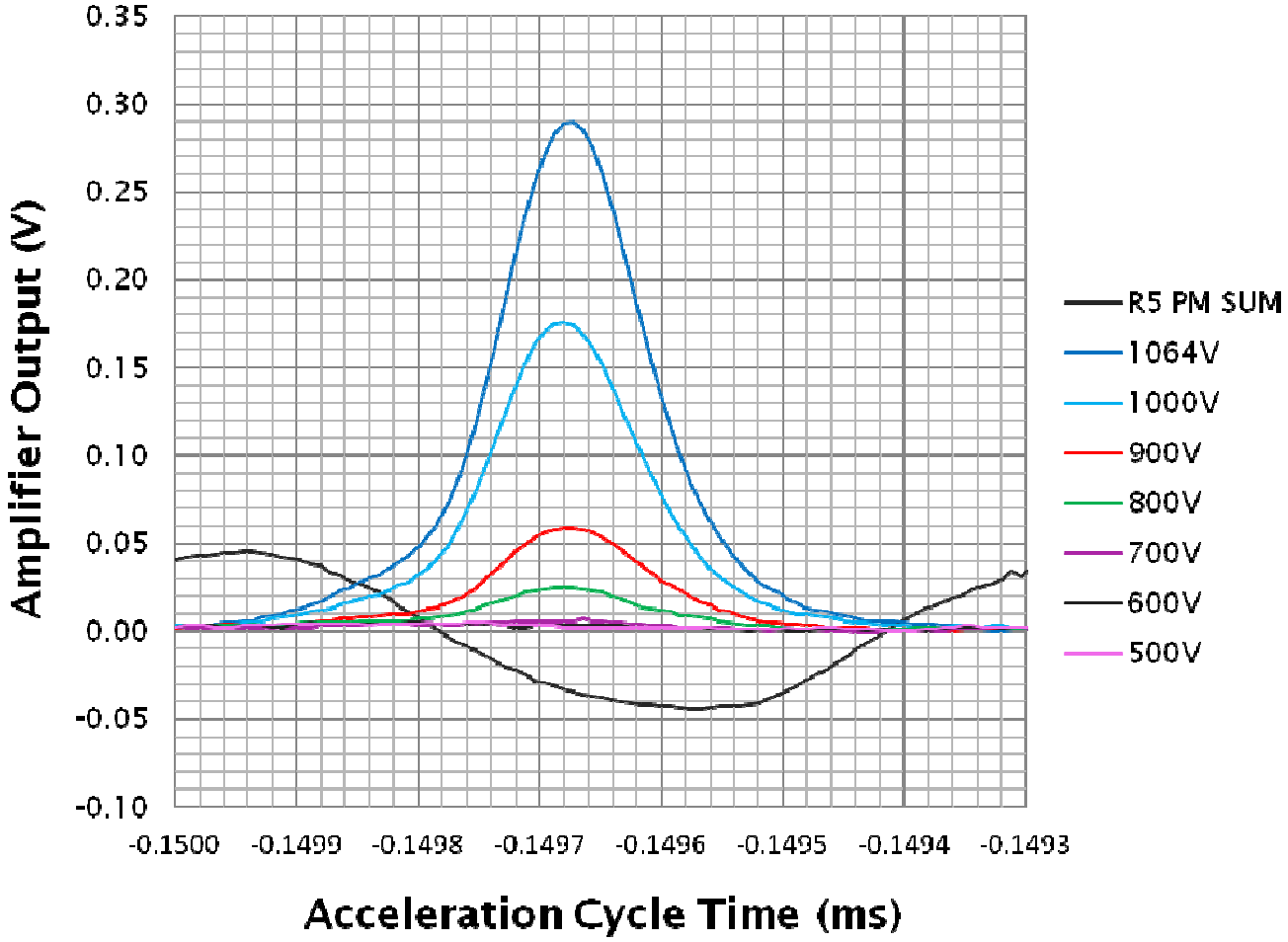


Alex Pertica, alex.pertica@stfc.ac.uk

Ecloud'12 – Isola d'Elba, Italy

Science & Technology Facilities Council
ISIS

Initial tests - MCP gain control



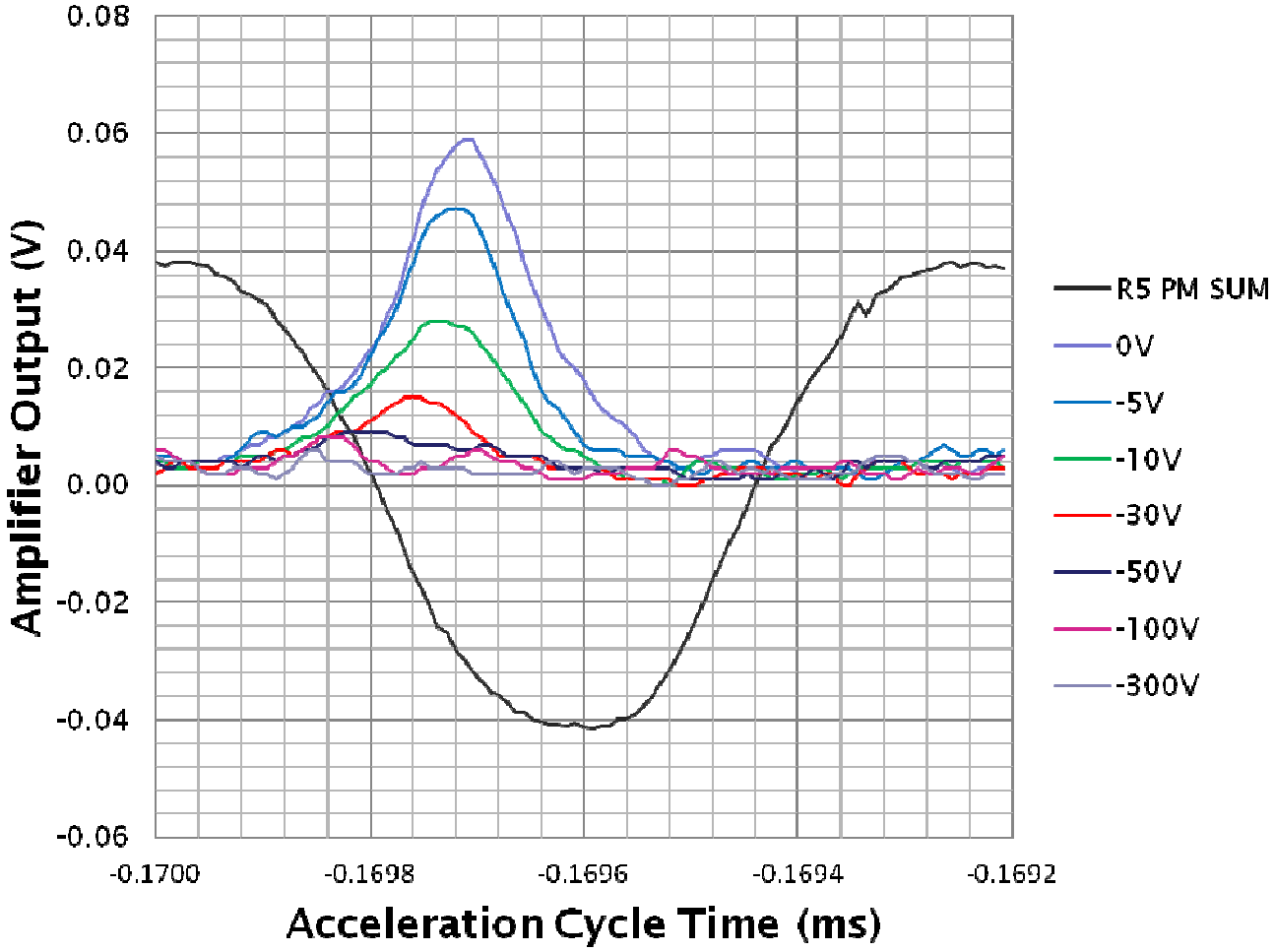
-A set of bias voltages have been applied to the MCP in order to record the gain variations.

- The electron signals shown on the graph were taken after the injection stage, using a rolling average filter.

Alex Pertica, alex.pertica@stfc.ac.uk

Science & Technology Facilities Council
ISIS

Initial tests - Retarding grid control

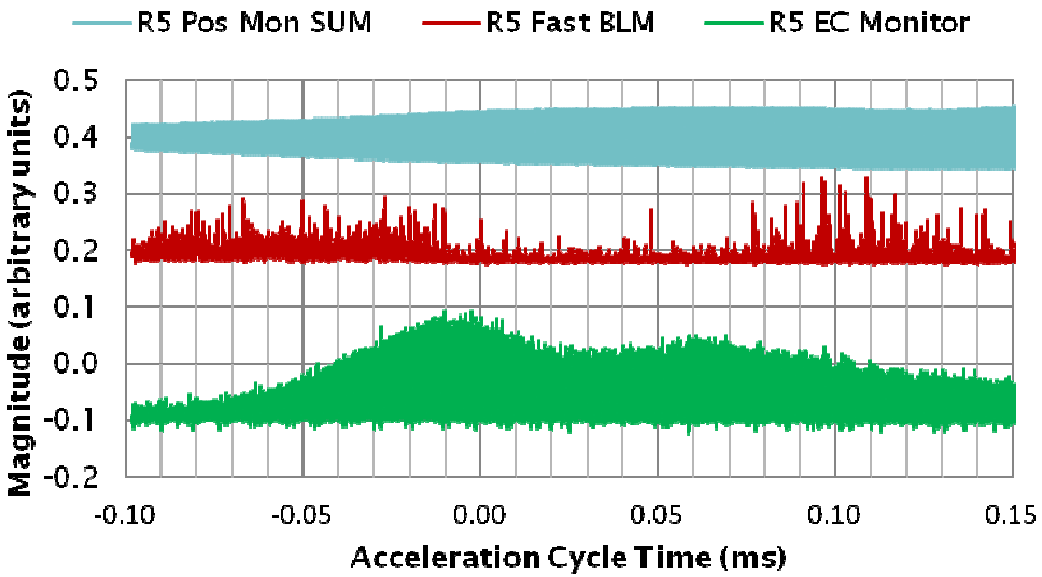


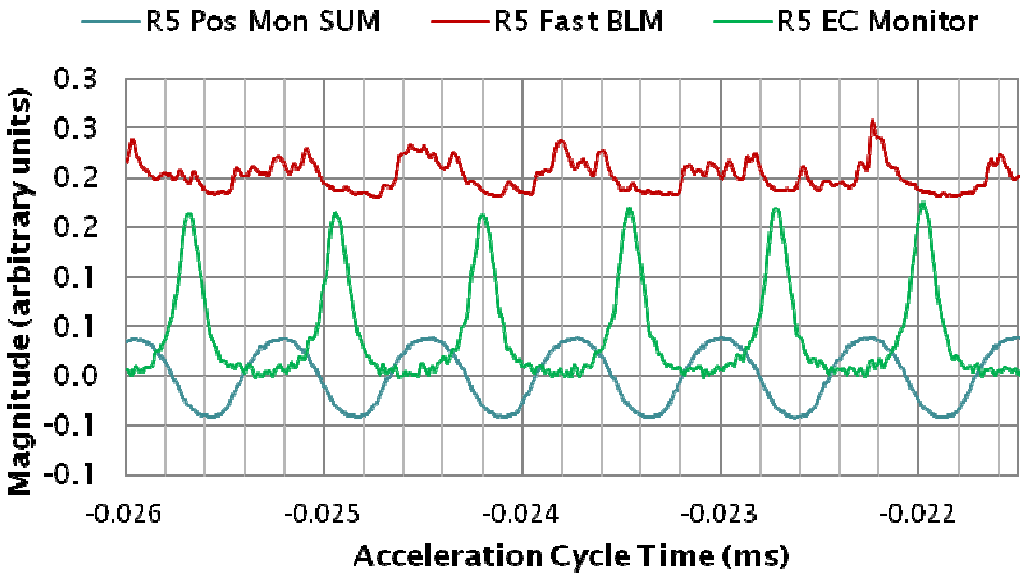
- By applying different negative voltages to the retarding grid, it is possible to test the grid's effectiveness by observing the reduction of the EC signal as the grid potential becomes more negative.

- The electron signals captured on the graph were taken after the injection stage.

Alex Pertica, alex.pertica@stfc.ac.uk

Electron cloud observations - Beginning of acceleration





- The largest EC signals have been observed at the beginning of the acceleration cycle.

-Beam loses are the largest as well -> EC created mainly by beam loses?.

- Beam bunches forming during this time – a possible mechanism for increasing the number of electrons?

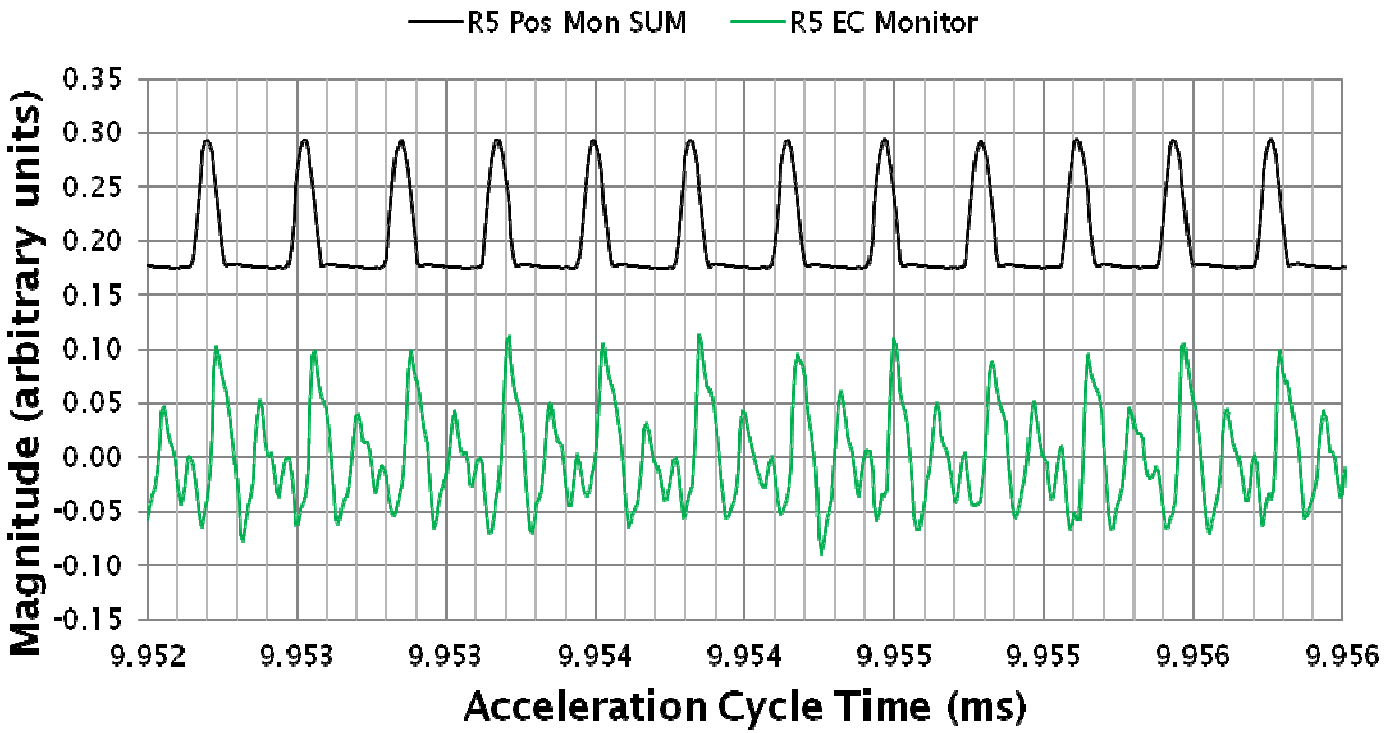
- The AC coupling on the EC amplifier means interpretation requires care (DC background not visible).

Alex Pertica, alex.pertica@stfc.ac.uk

Ecloud'12 – Isola d'Elba, Italy

Science & Technology Facilities Council
ISIS

Electron cloud observations - End of acceleration



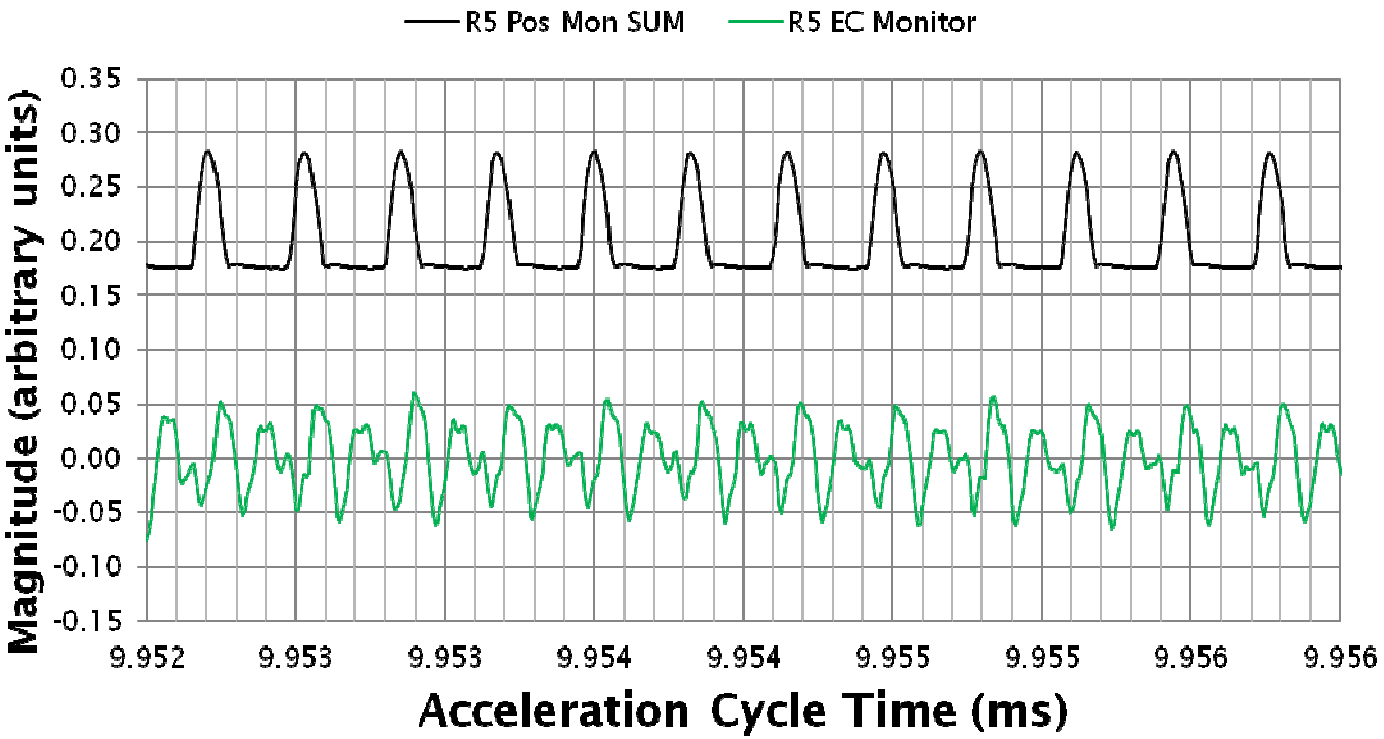
- No background subtraction
- No averaging
- Vgrid = 0V

The beam induced noise captured by the detector at the end of the acceleration cycle is too large for taking direct measurements.

Alex Pertica, alex.pertica@stfc.ac.uk

Science & Technology Facilities Council
ISIS

Electron cloud observations - End of acceleration

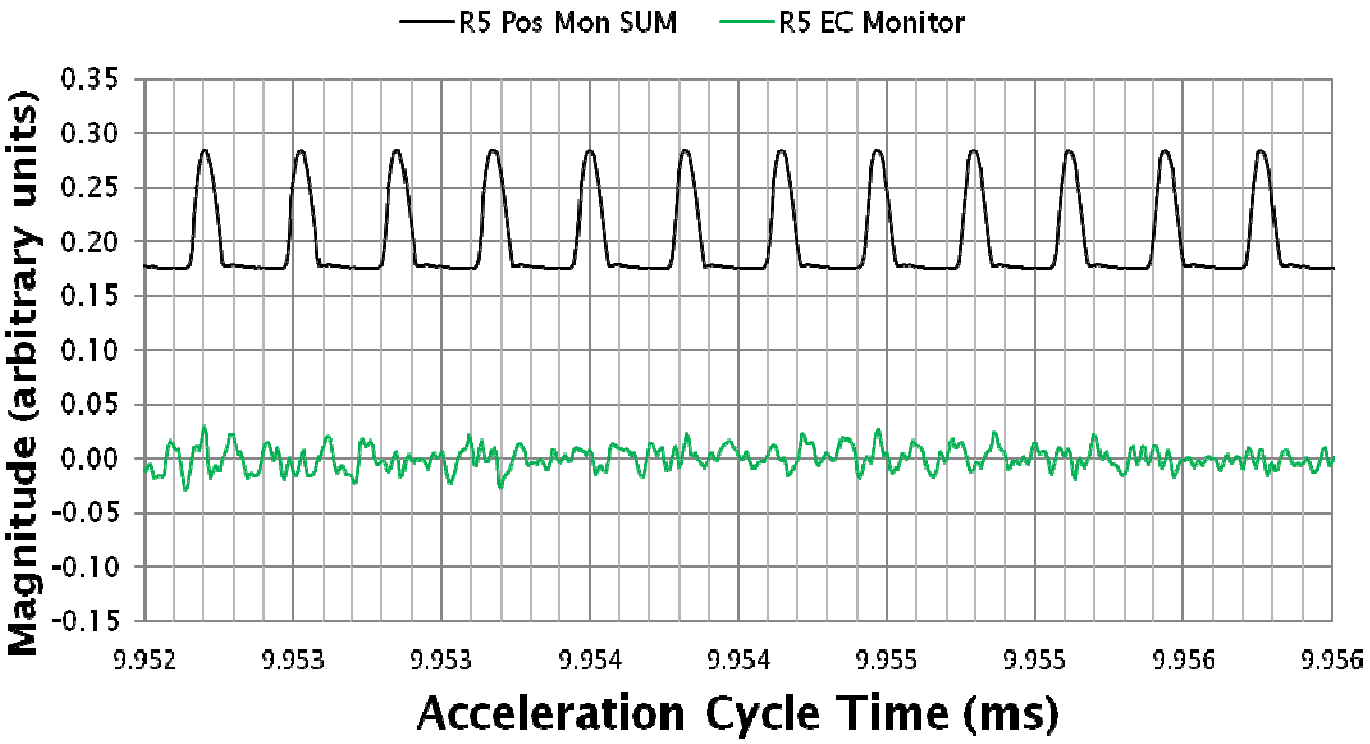


- No background subtraction
- No averaging
- Vgrid = -500V

When applying -500V to the retarding grid, in order to stop electrons reaching the detector, it is difficult to distinguish clearly the EC signal, despite of the signal reduction.

Alex Pertica, alex.pertica@stfc.ac.uk

Electron cloud observations - End of acceleration

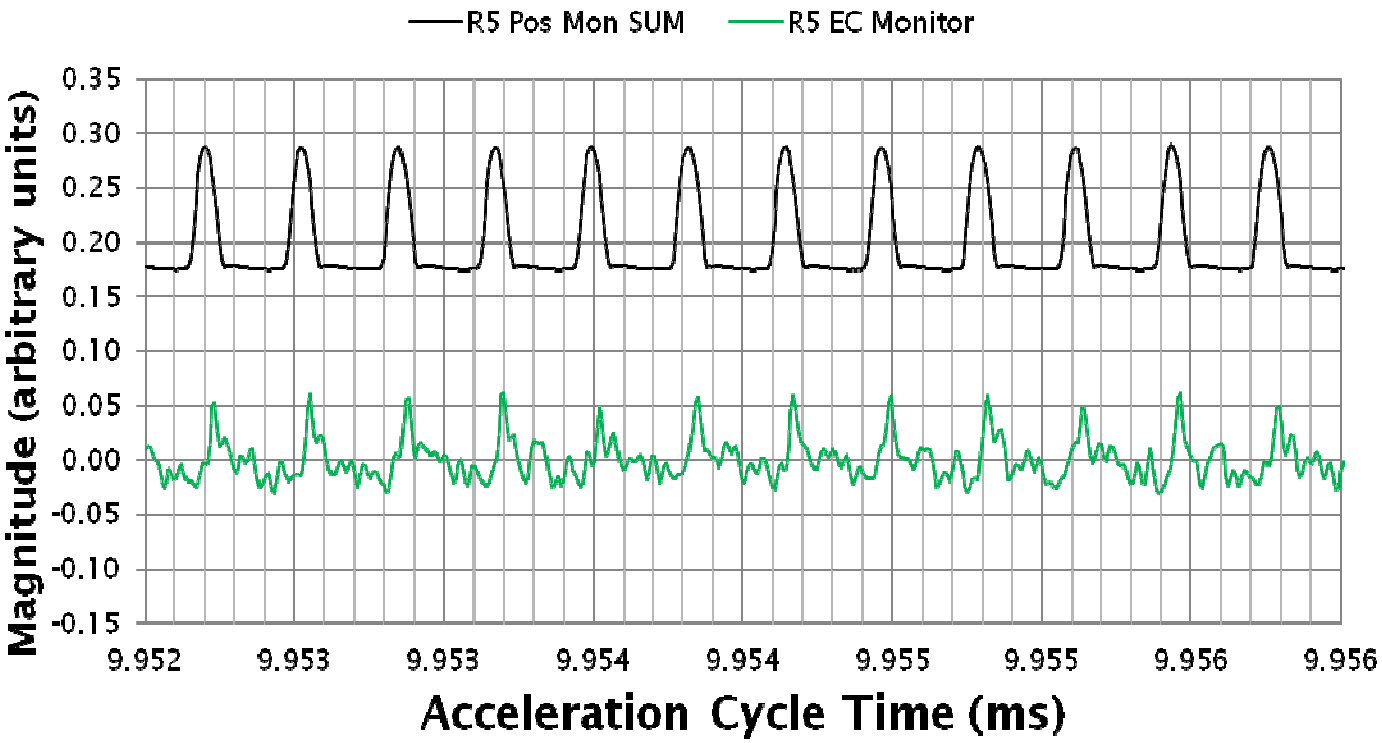


- Background subtraction
- No averaging
- Vgrid = -500V

By recording the background noise (rolling averaged), when a -500V potential is applied to the retarding grid, and subtracting it from the RAW signal, the measured noise can be reduced substantially.

Alex Pertica, alex.pertica@stfc.ac.uk

Electron cloud observations - End of acceleration



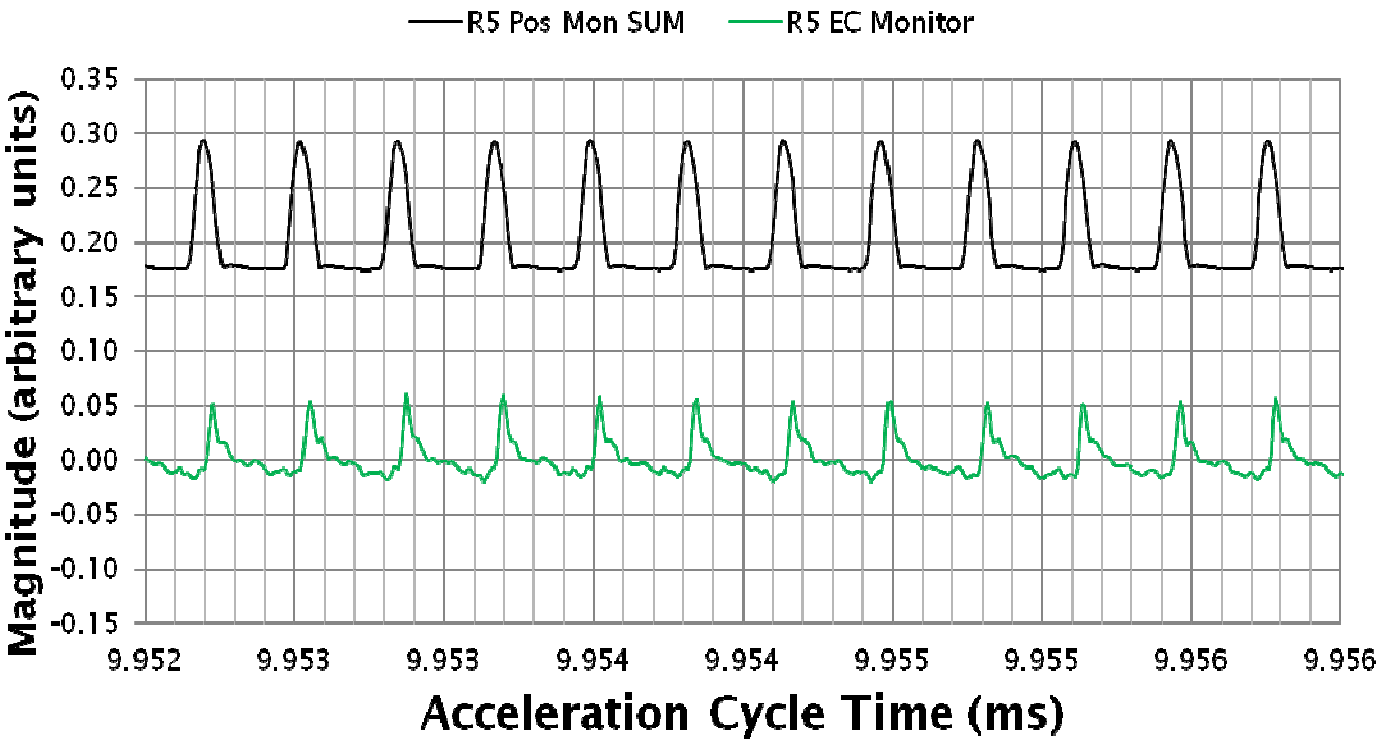
- Background subtraction
- No averaging
- Vgrid = 0V

Now, with the background noise subtracted, the EC signal can be clearly identified, when the retarding grid potential is set to 0V.

Alex Pertica, alex.pertica@stfc.ac.uk

Science & Technology Facilities Council
ISIS

Electron cloud observations - End of acceleration

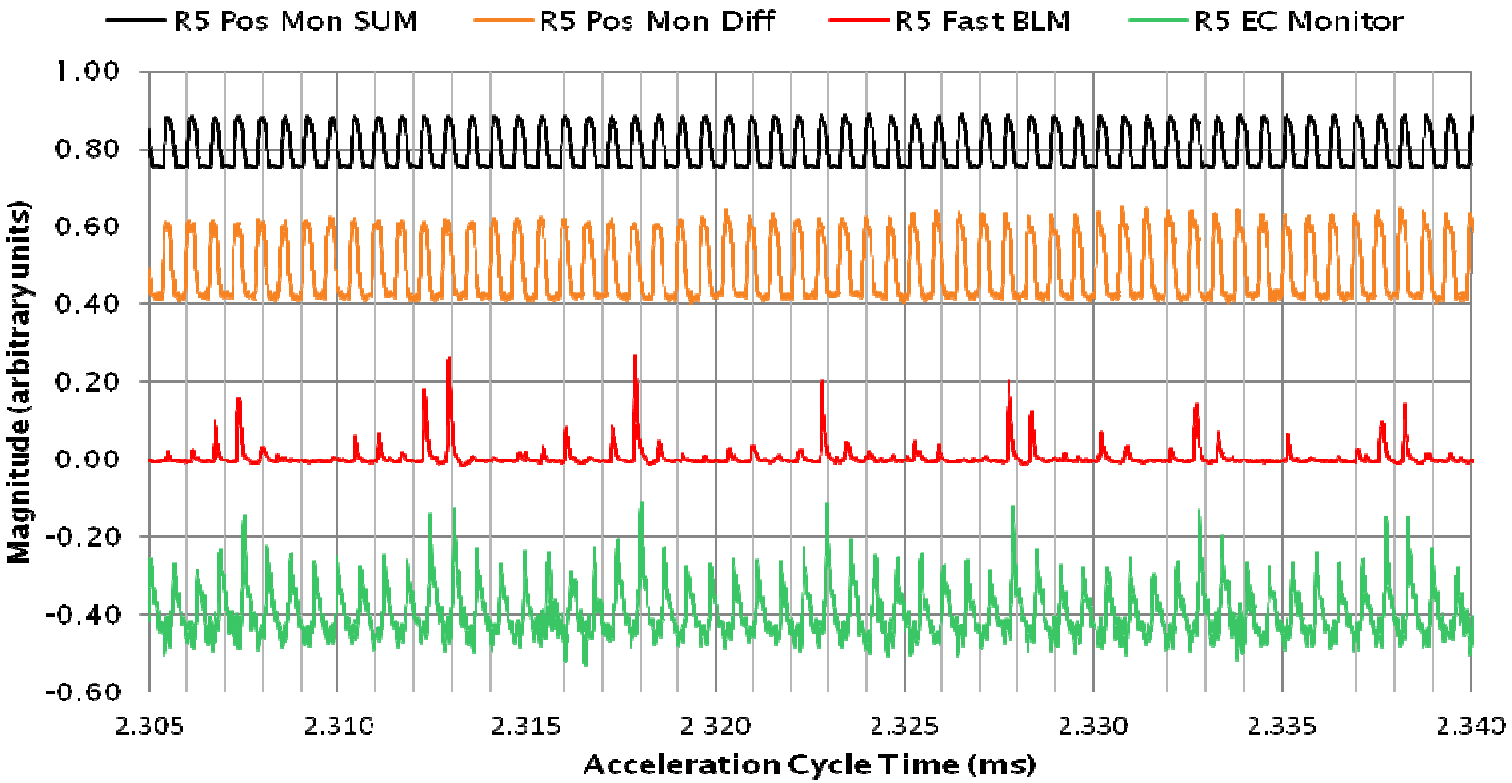


- Background subtraction
- Averaging AVG12
- Vgrid = 0V

By averaging the resulting signal it is possible to observe clearly the electron cloud signal.

Alex Pertica, alex.pertica@stfc.ac.uk

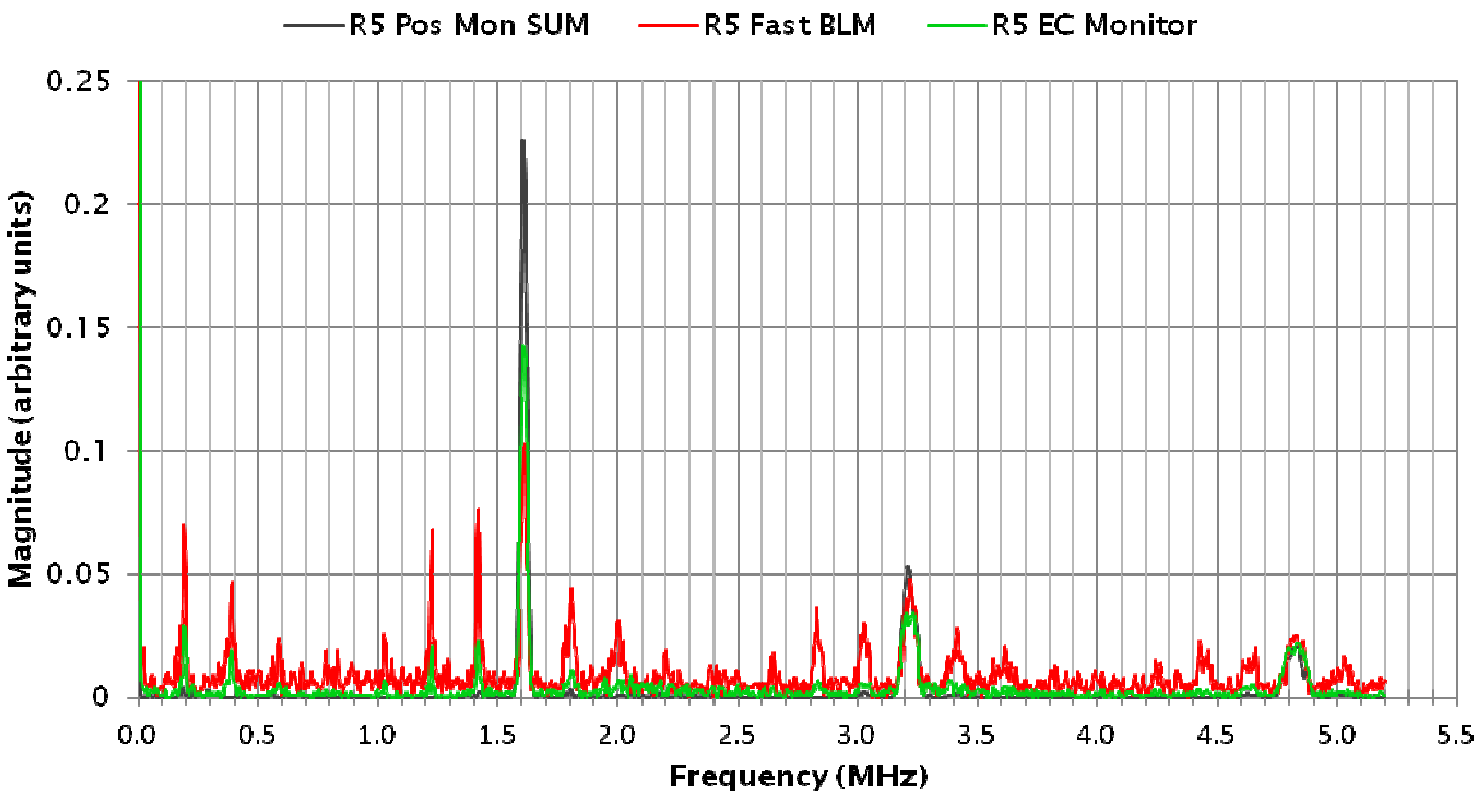
Electron cloud observations - Comparisons between electron cloud, beam loses and beam position



- The oscillations observed on the beam loss monitor signal can also be seen on the electron cloud signal.
- No evident oscillation was found on the horizontal position monitor, but data taken from a vertical monitor showed the same oscillation pattern.
- These oscillations are believed to be created by head-tail instability caused by resistive wall effects, not by electron cloud effects.

Alex Pertica, alex.pertica@stfc.ac.uk

Electron cloud observations - End of acceleration



- The frequency components of the signals show good agreement between them.
- As expected, the electron cloud signal is strongly related to the beam loses.

Alex Pertica, alex.pertica@stfc.ac.uk

Summary

- The electron cloud signal is stronger at the beginning of the acceleration cycle, where the beam loses are larger (could also be associated with the beam bunching process).

- There is a close correlation between the beam loses produced by the beam vertical plane oscillations and the electron cloud signal.

-The vertical position monitor signal needs to be integrated into the DAC system in order to make a more direct comparisons of EC signal and vertical oscillations.

- An additional MCP type EC detector could be installed in a vertical orientation as the main instabilities are produced on this plane.

-In order to verify potential EC build up it would be desirable to install a DC coupled version of the amplifier setup.

Questions?

Thank you!

Alex Pertica, alex.pertica@stfc.ac.uk
Ecloud'12 – Isola d'Elba, Italy

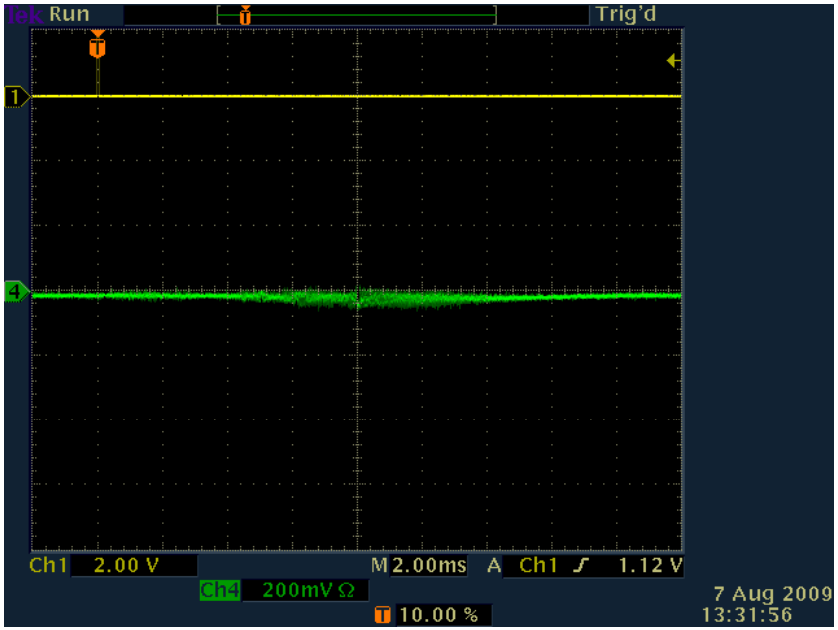
Science & Technology Facilities Council
ISIS

Spare slides

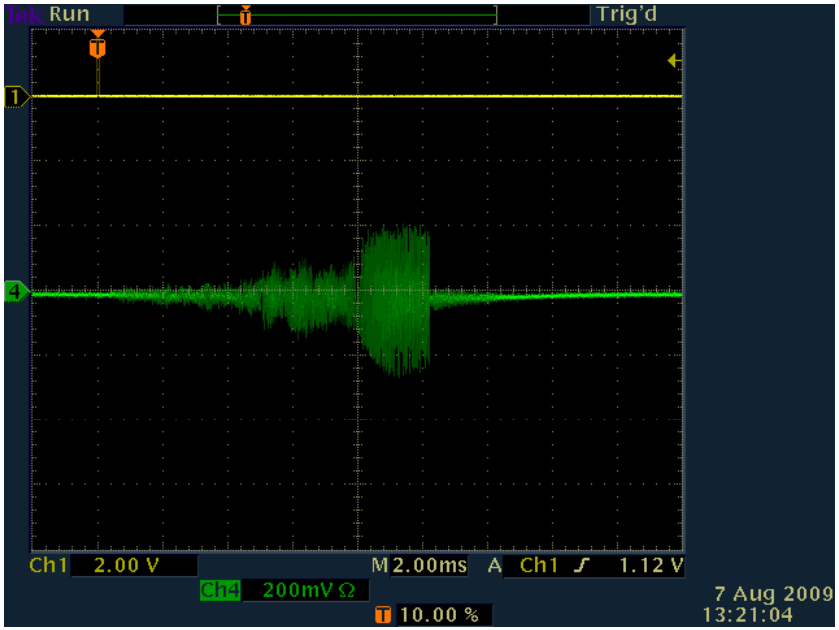
Alex Pertica, alex.pertica@stfc.ac.uk

Non-MCP version detector signals

RF noise



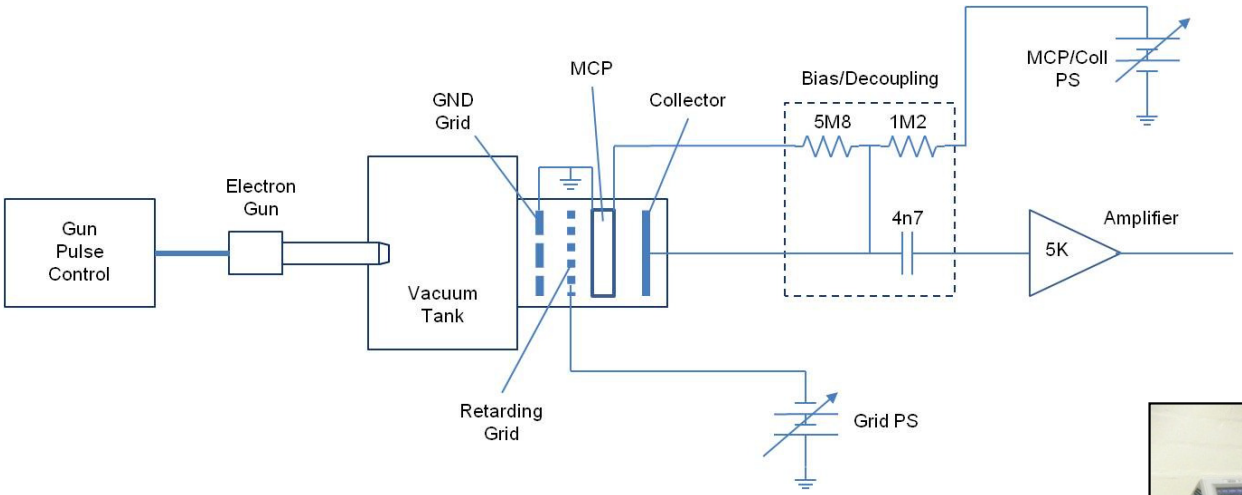
Beam induced noise

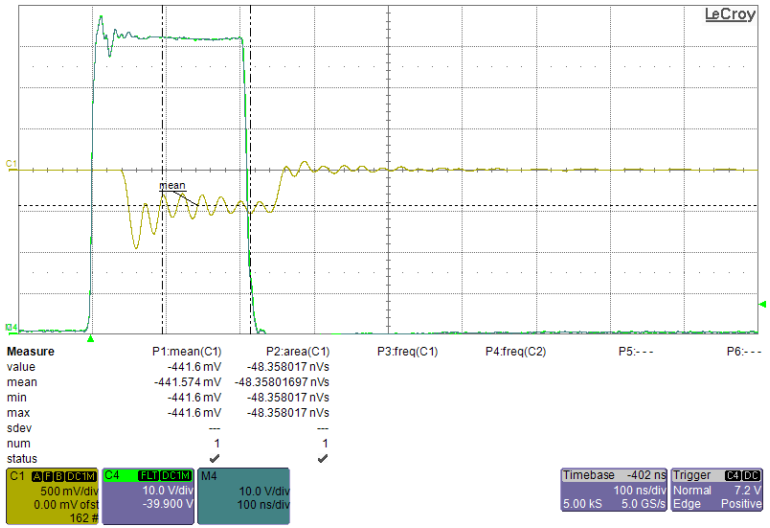


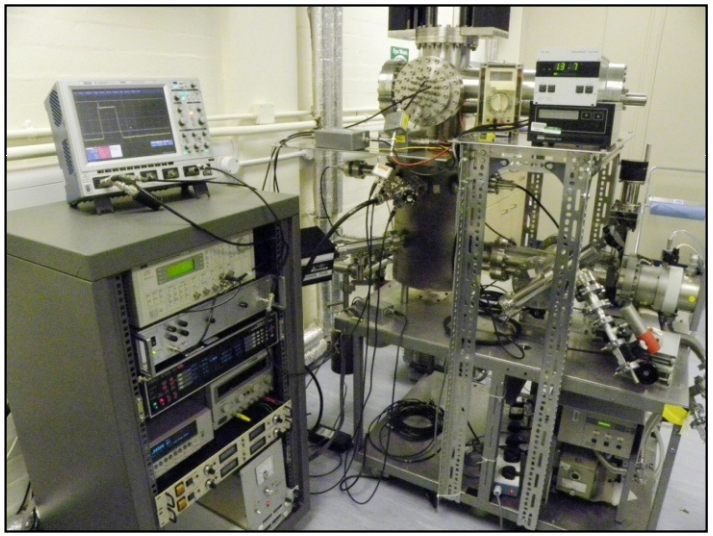
Even applying background removal techniques, it was not possible to obtain any clear electron cloud signal.

Alex Pertica, alex.pertica@stfc.ac.uk

Laboratory setup





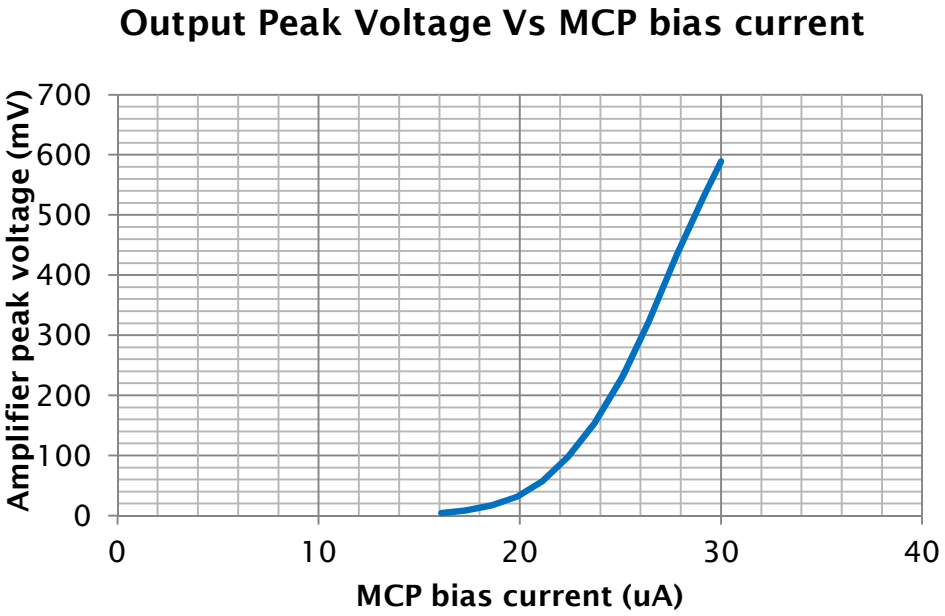


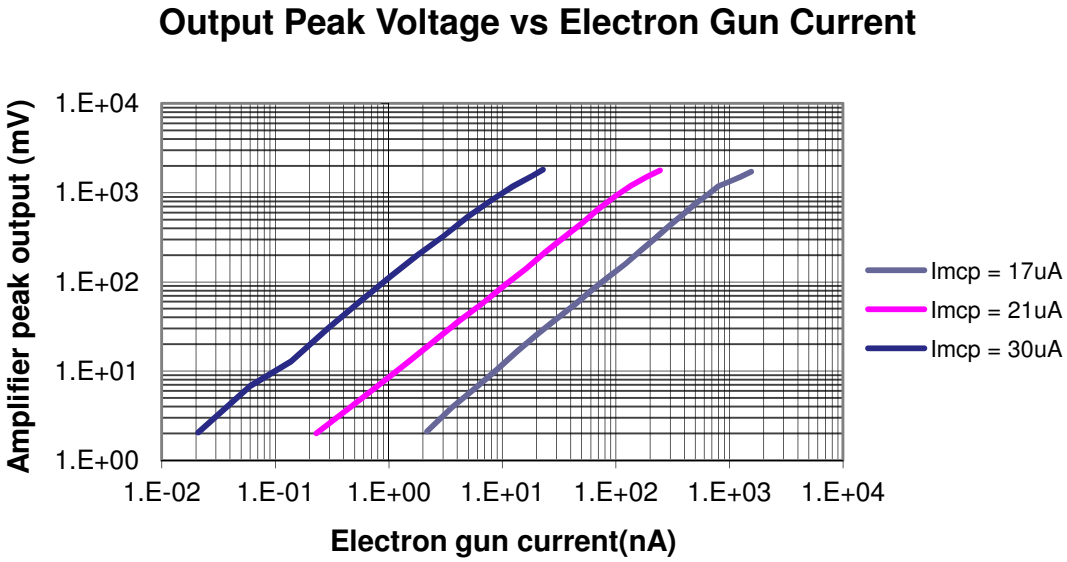
Alex Pertica, alex.pertica@stfc.ac.uk

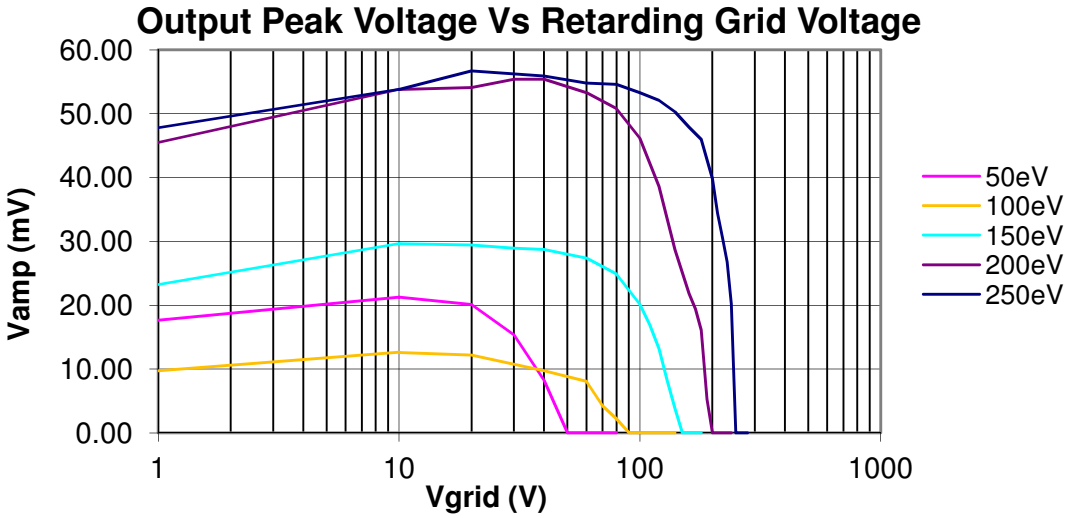
Ecloud'12 – Isola d'Elba, Italy

Science & Technology Facilities Council
ISIS

Laboratory results







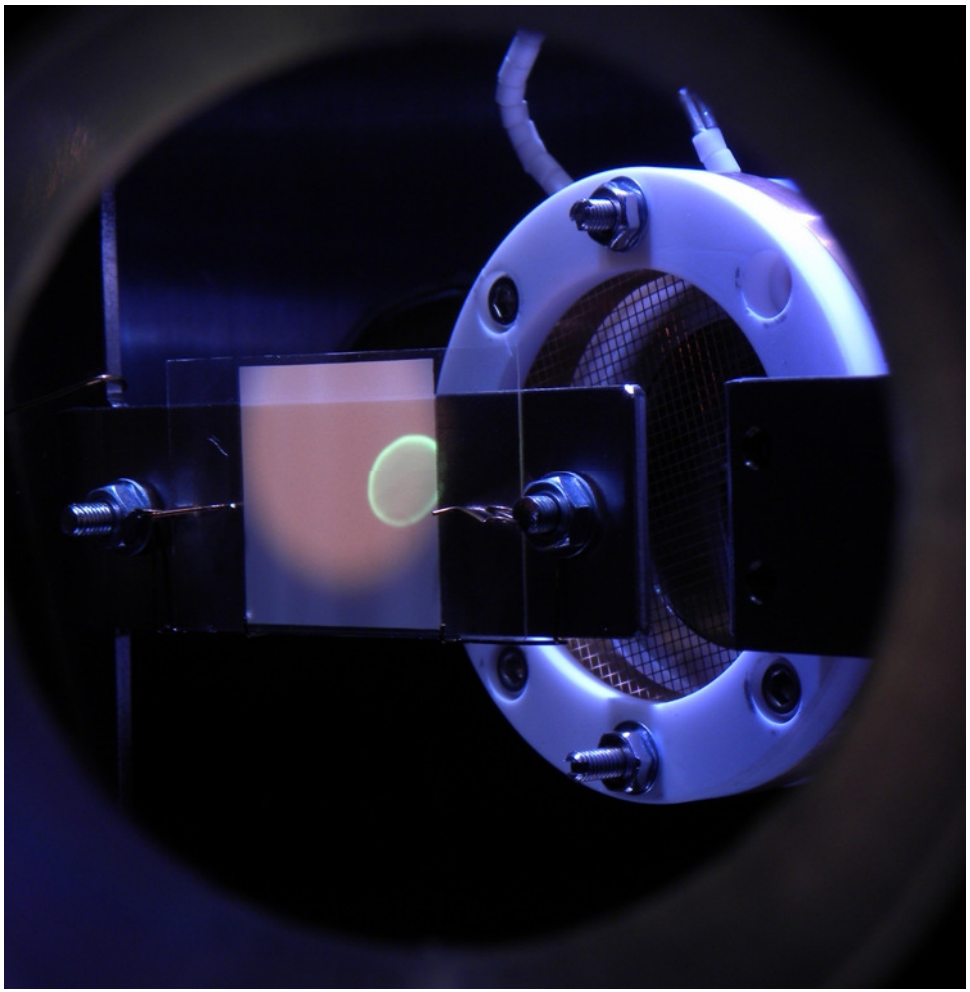
Alex Pertica, alex.pertica@stfc.ac.uk

Ecloud'12 – Isola d'Elba, Italy

Science & Technology Facilities Council
ISIS

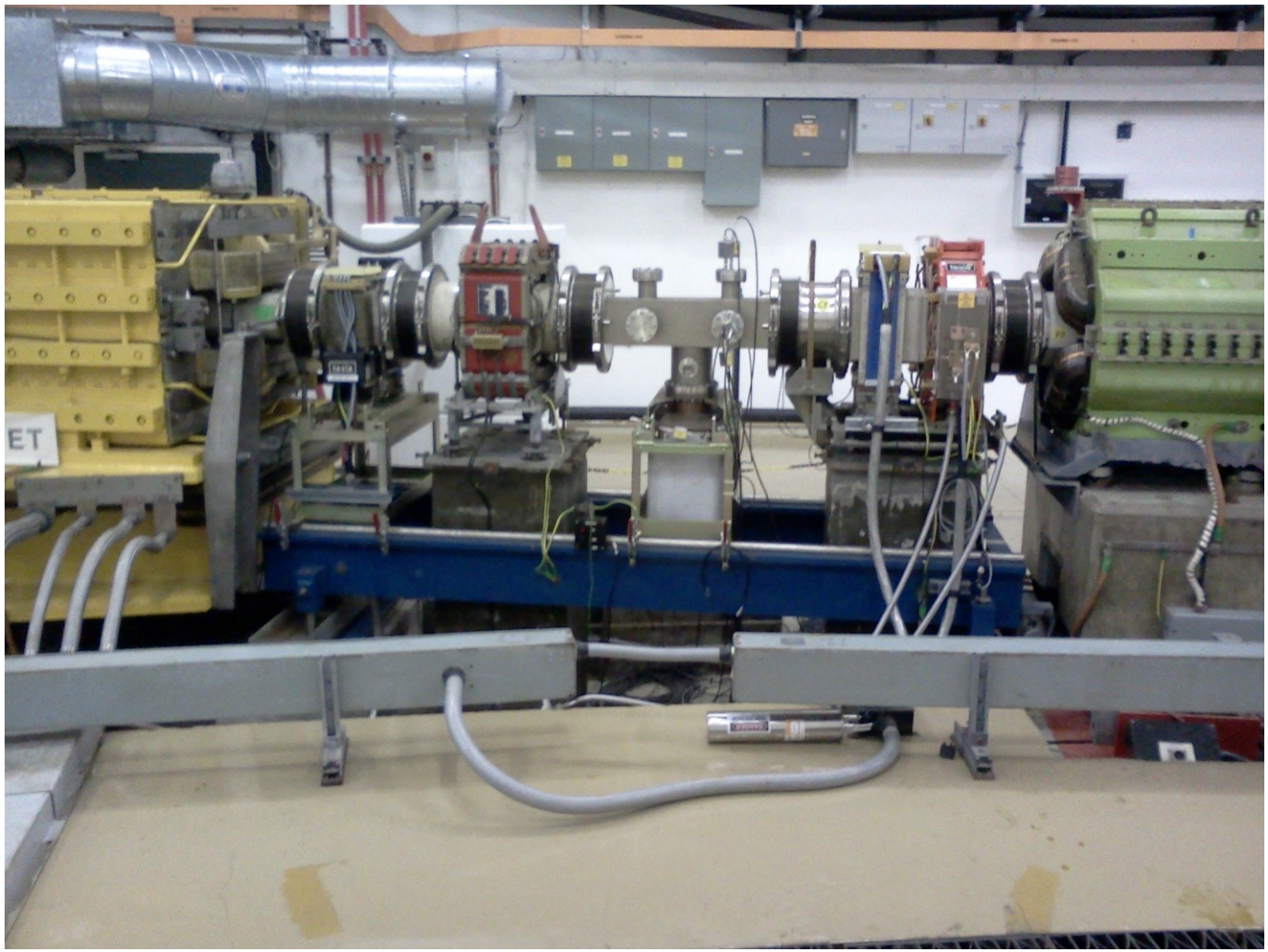
Laboratory tests - Electron gun alignment

Phosphor screen used in the alignment of the electron gun beam



Alex Pertica, alex.pertica@stfc.ac.uk

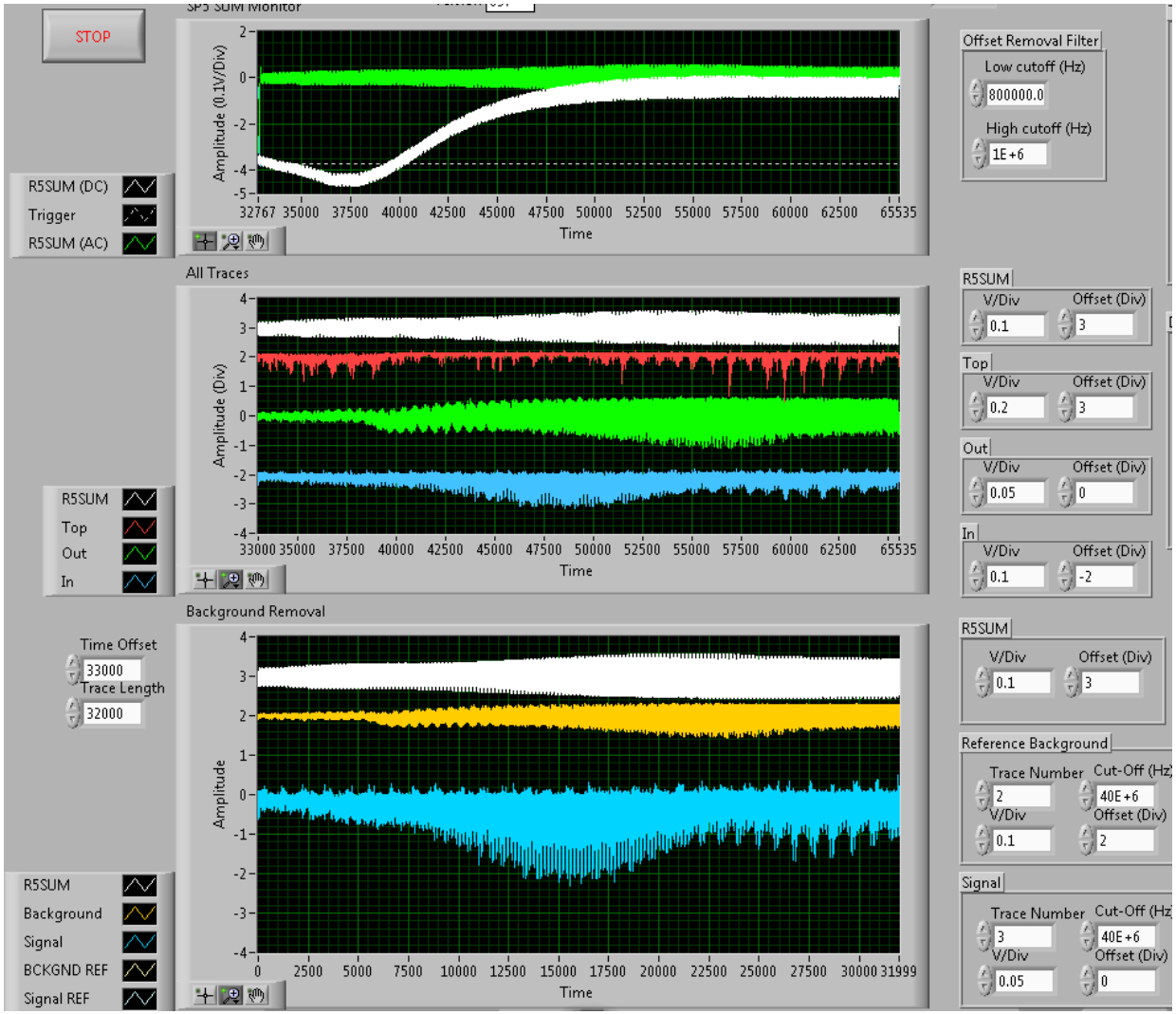
Electron cloud detectors at the ISIS super-period 5



Alex Pertica, alex.pertica@stfc.ac.uk
Ecloud'12 – Isola d'Elba, Italy

Science & Technology Facilities Council
ISIS

Electron cloud signal at injection (SUM monitor “bump”)

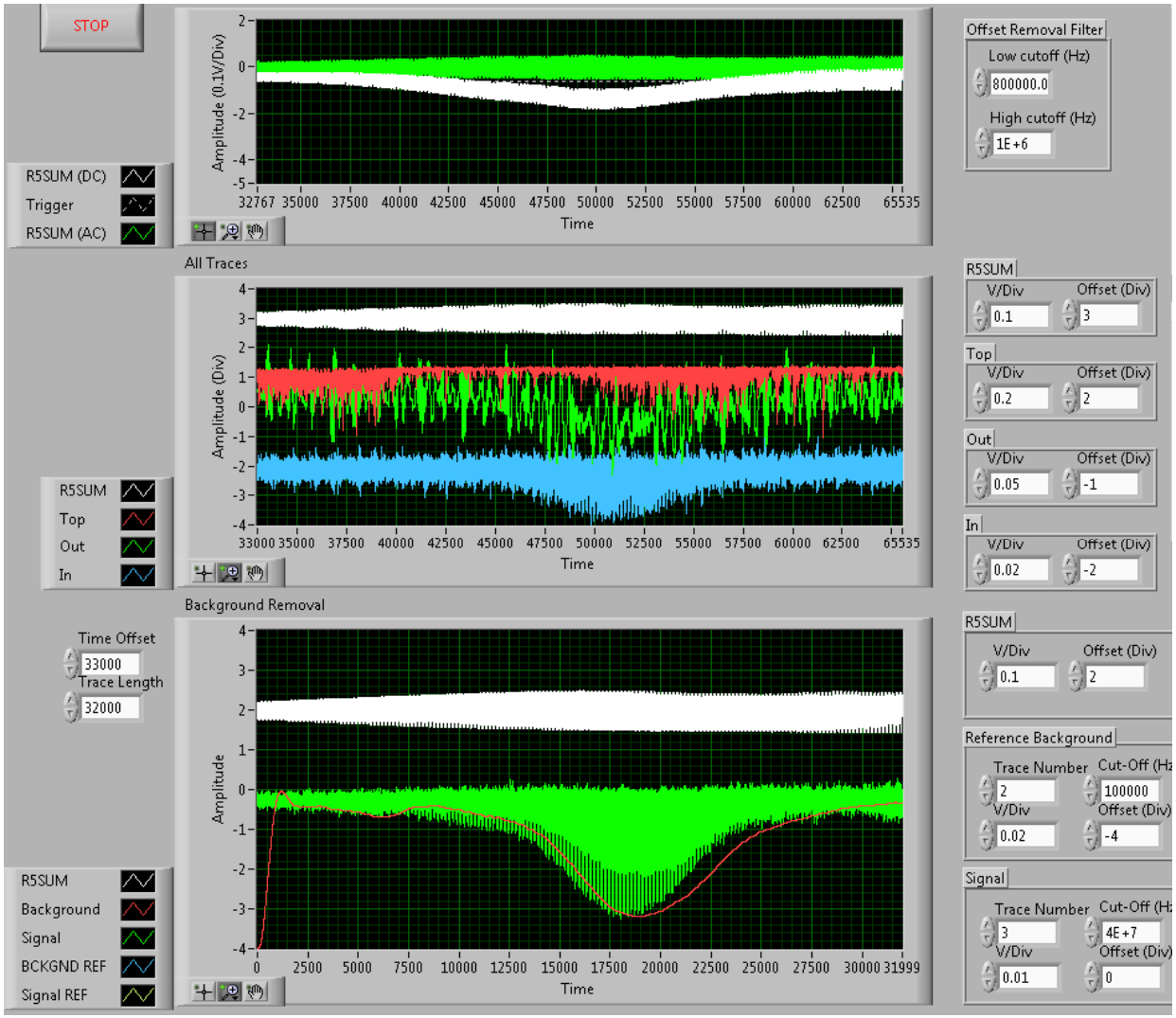


Alex Pertica, alex.pertica@stfc.ac.uk

Ecloud’12 – Isola d'Elba, Italy

Science & Technology Facilities Council
ISIS

Electron cloud signal at injection (DC amplifier test)



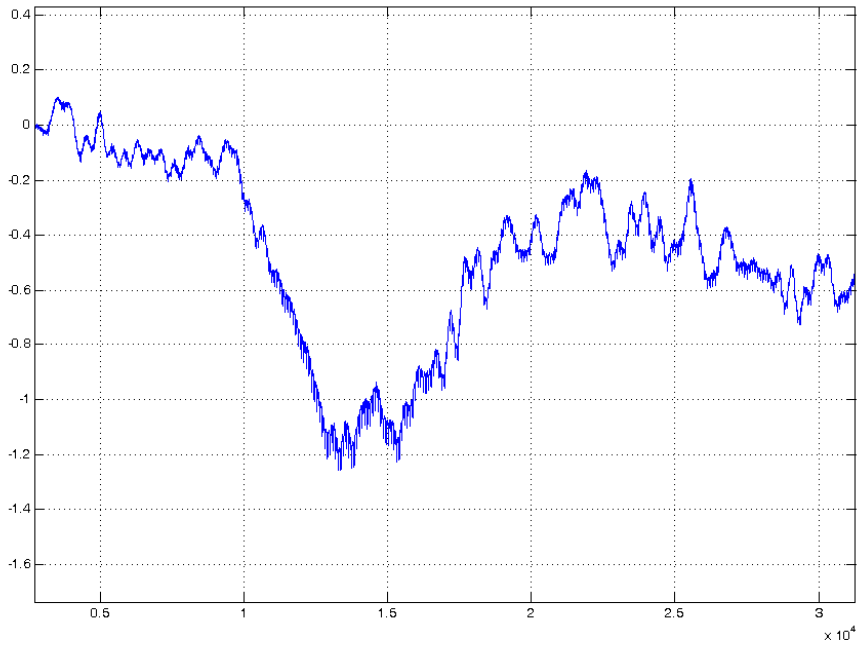
Alex Pertica, alex.pertica@stfc.ac.uk

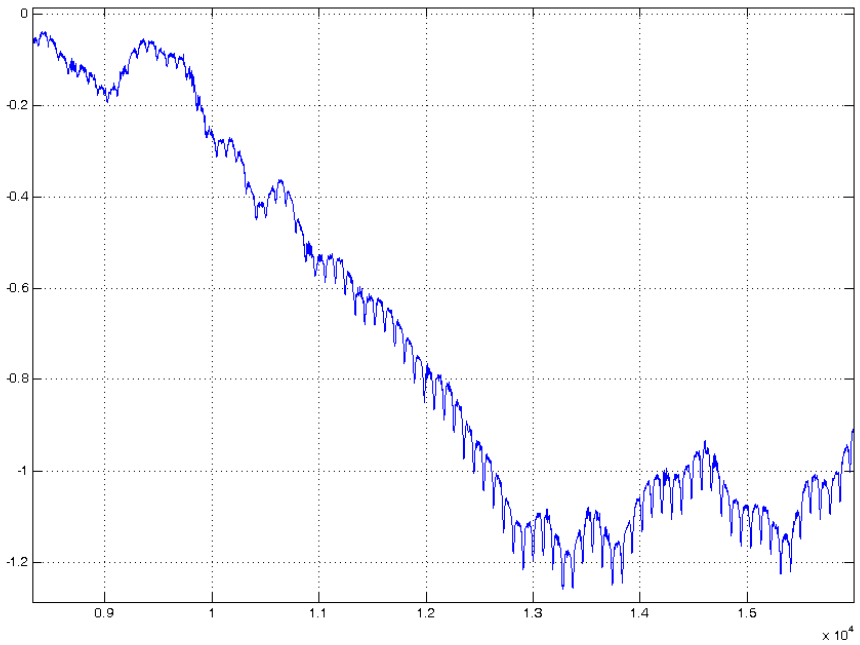
Ecloud'12 – Isola d'Elba, Italy

Science & Technology Facilities Council
ISIS

Electron cloud signal at injection (AC+DC signals)

Combined electron signal by adding the outputs from the AC coupled amplifier and the DC coupled version (possible collector charging effect due to high input impedance of the DC amplifier – around 1kohm).





Alex Pertica, alex.pertica@stfc.ac.uk
Ecloud'12 – Isola d'Elba, Italy

Science & Technology Facilities Council
ISIS