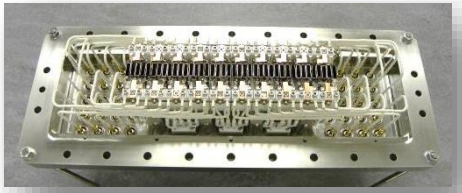
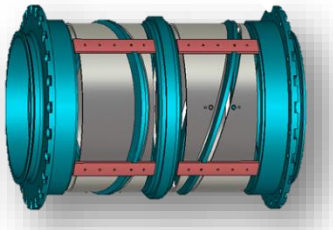
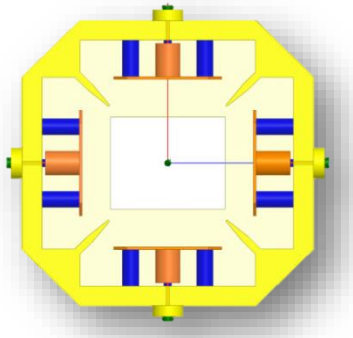
Science & Technology Facilities Council
ISIS

Overview of Diagnostics Work on the ISIS Accelerator

Alex Pertica

(…and Steve Payne, Chris Wilcox, David Posthuma De Boer, Tony Kershaw and John Medland)


PASI'15 Workshop - 11th – 13th November 2015 - Fermi National Accelerator Laboratory, Ilinois, USA

Outline

- An introduction to ISIS Diagnostics
- Recent developments and projects status
- Data Acquisition Systems
- Question Time

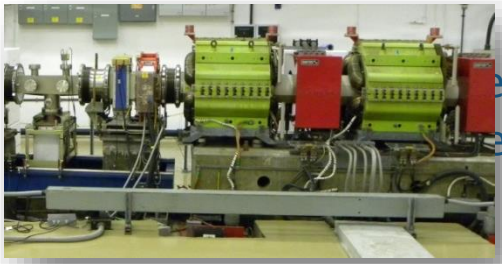
The ISIS Spallation Neutron Source

Accelerators:
Linac: 70 MeV H^-, 200 µs, 3×10^{13} ppp
Synchrotron: 800 MeV p^+, 2x 100ns bunches, 300ns apart, 50 Hz, 200 kW

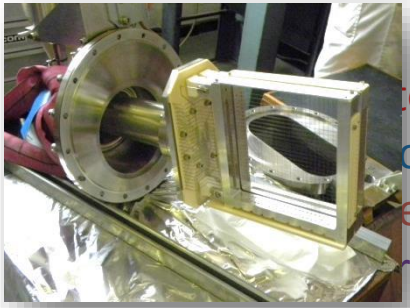
Operations:
Two target stations: TS1 (40pps) and TS2 (10pps)
Beam On 120-160 days/year in 4/5 cycles
Long shutdown of ~6 months every 3 years

Distribution of the Main Diagnostics

Injector:



e Monitors
e Monitor



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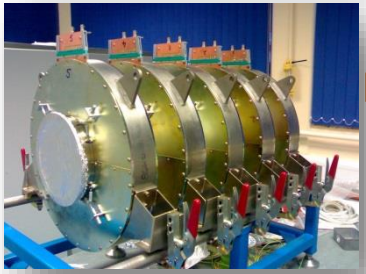
32 'Split Electrode' Posi rs



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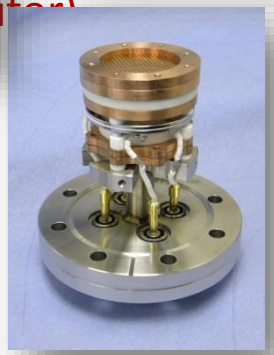

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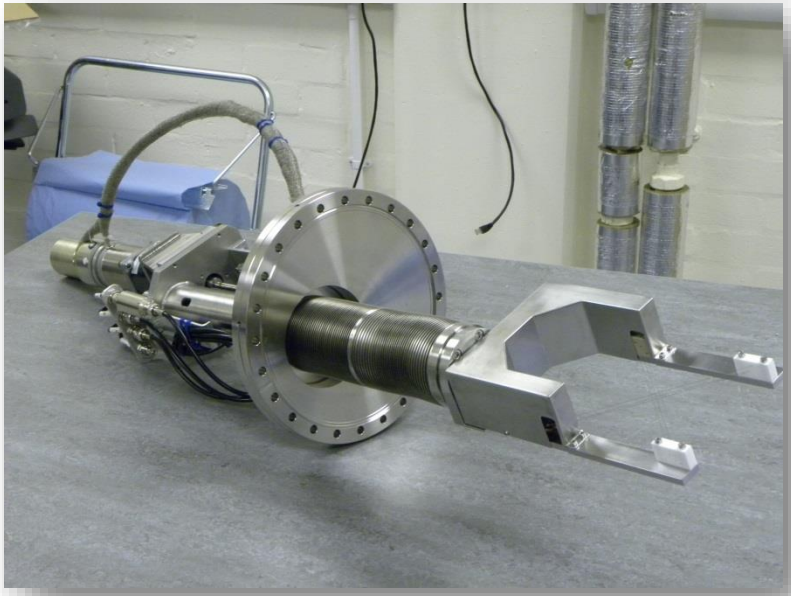
6 Split Plate Position Monitors
(1 Halo Monitor)

Recent Developments and Project's Status

New Injector Wire Scanner

- Double plane (1 wire per plane) - 90mm aperture
- Wires material: silicon carbide
- To be installed during January 2016 shutdown
- If successful, the next version will include multiple wires on each plane.

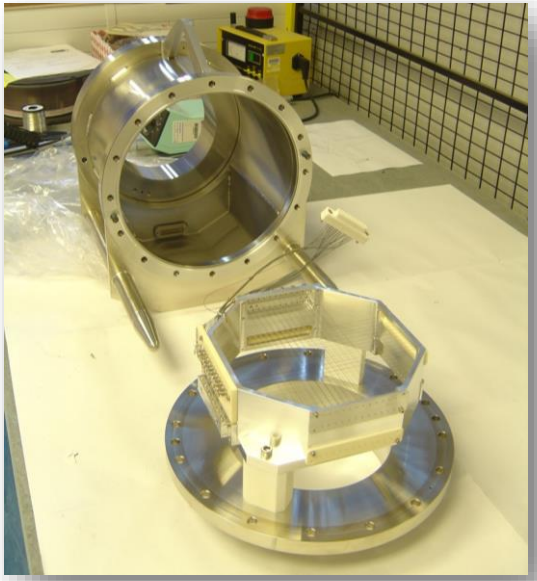


Wire Scanner assembly

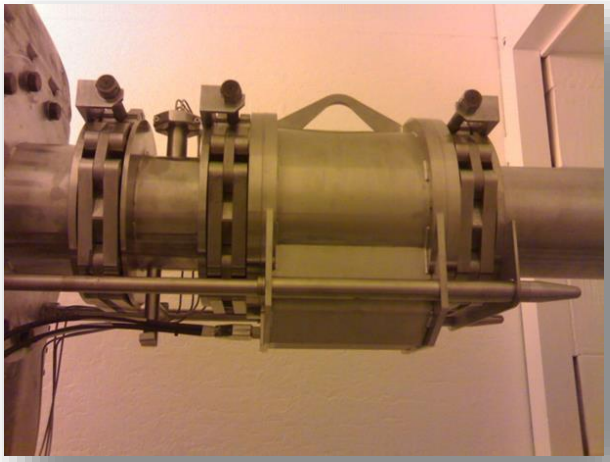
Detail of the wires on the bracket

EPB Near Target Profile Monitor

- Located just before the exit window on the EPB 2 target void vessel
- 10 pps repetition rate beam onto the target
- Ongoing work on wire heating studies for a 40pps operation on target station 1



The mounted monitor SEM grid assembly and the monitor body

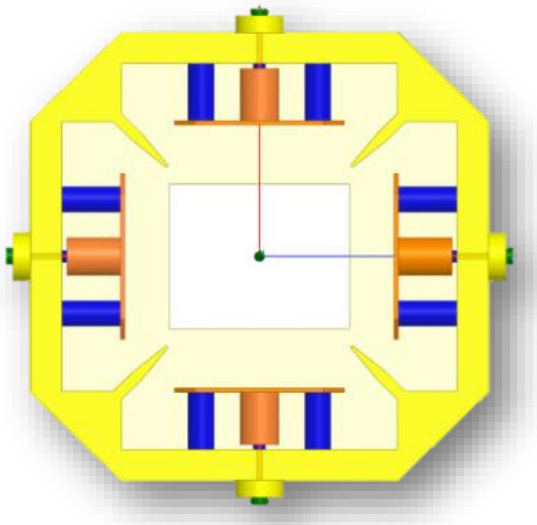


The new monitor installed next to the void vessel

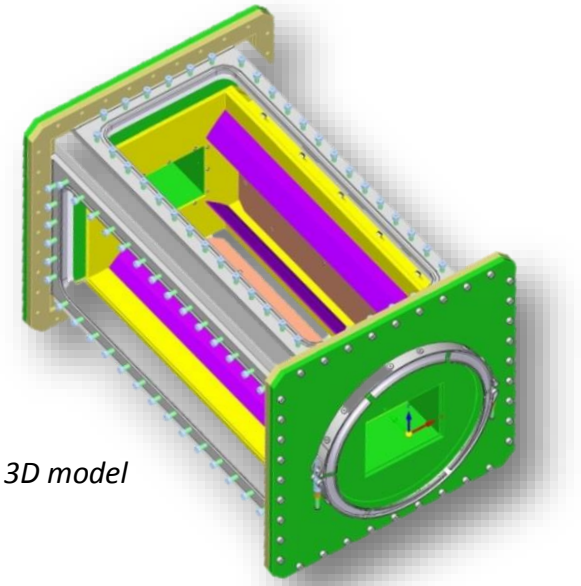
Strip-Line Monitor

- Designed in collaboration with SNS (ORNL)
- 1 – 250 MHz bandwidth
- First component of the fast feedback system
- In manufacturing stage now! ☺

  (Estimated delivery by Feb. 2016)
- Racks and cables installation ongoing



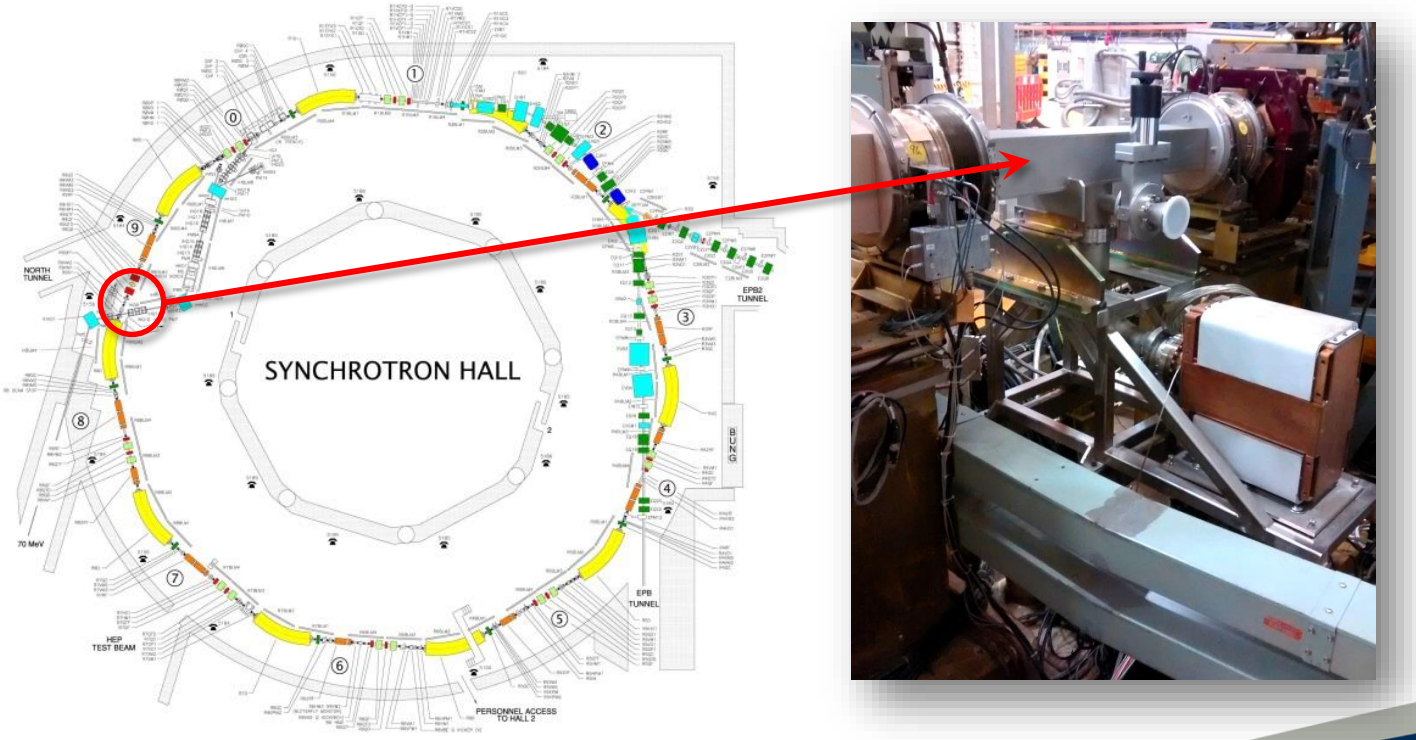
Strip-line electrodes arrangement



Strip-line 3D model

Strip-Line Monitor

- First monitor to be installed in super period 9 of the Synchrotron
- Feedback system to be tested initially with split electrode BPM + Strip-line (up to 50MHz)

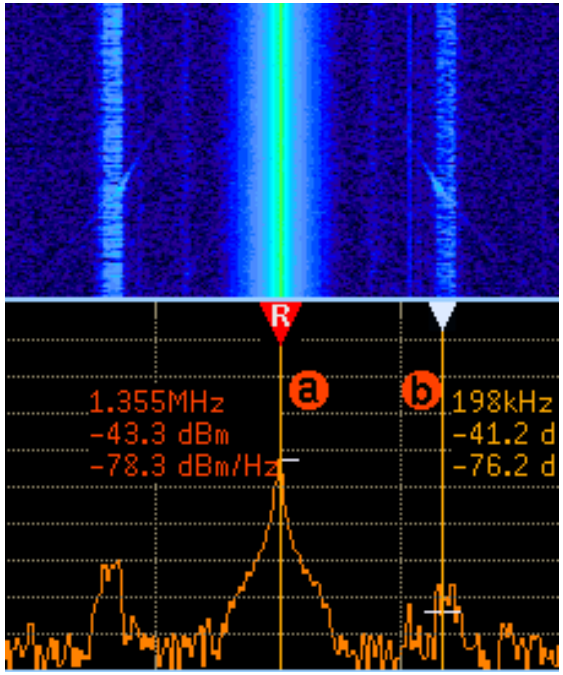


ISIS Synchrotron Strip-line chosen location

Betatron Exciter Based Damping System

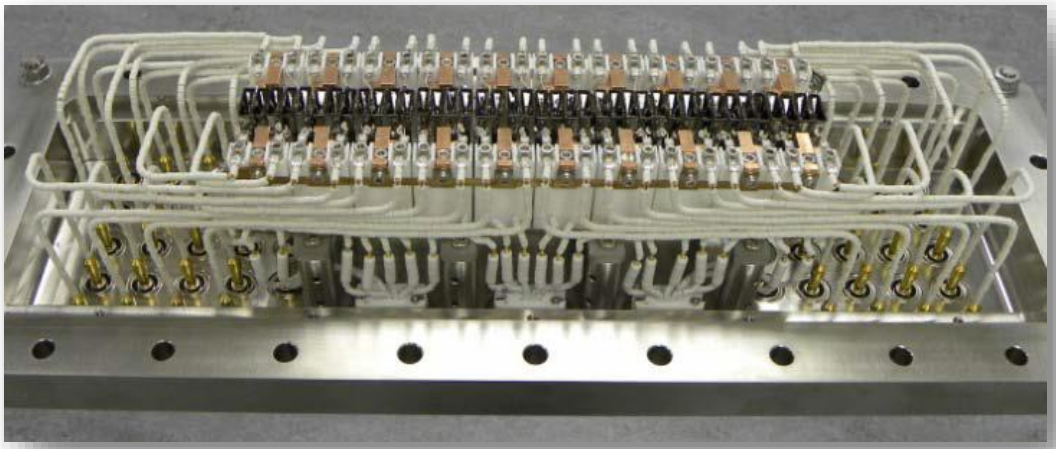
- Use of a ferrite loaded kicker for damping instabilities up to 20MHz
- Experimentation opportunity for Strip-line feedback system

ISIS Vertical Betatron Exciter (Ferrite Loaded Kicker)

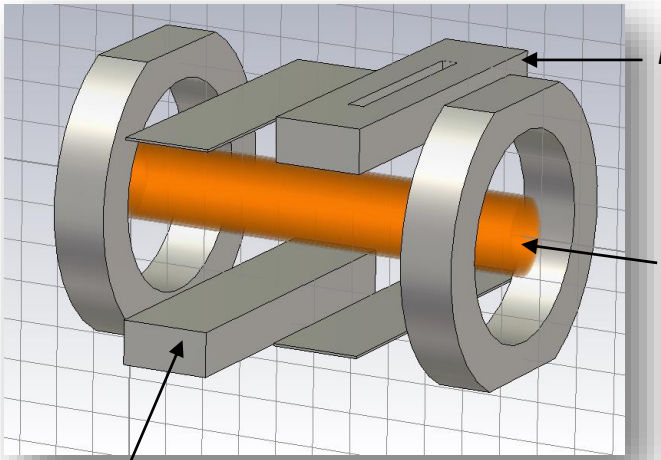


Beam excitation tests (vertical plane) using a sine wave frequency sweep to drive transverse beam motion

Ionization profile monitor work



The 40 channeltron array used to measure beam profile

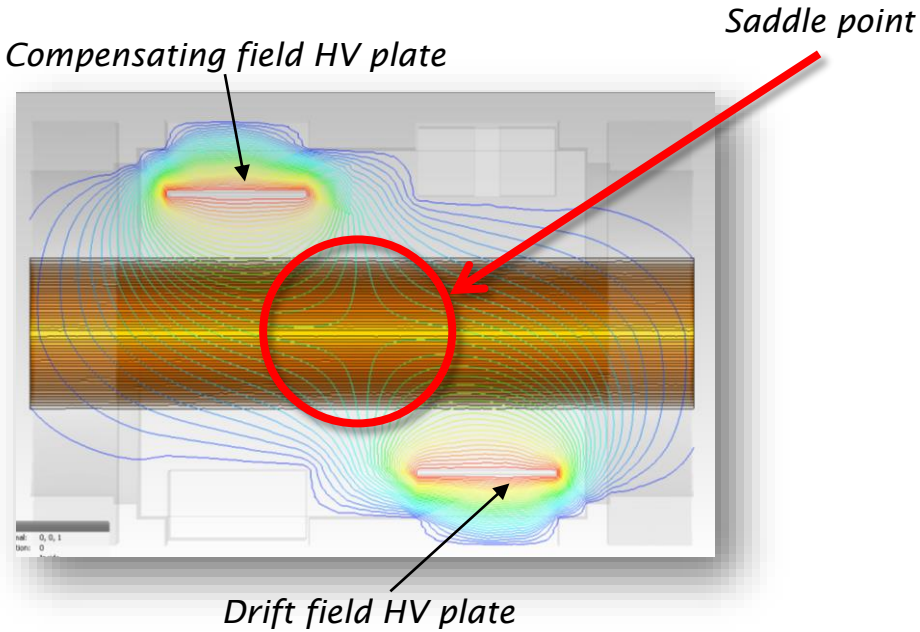


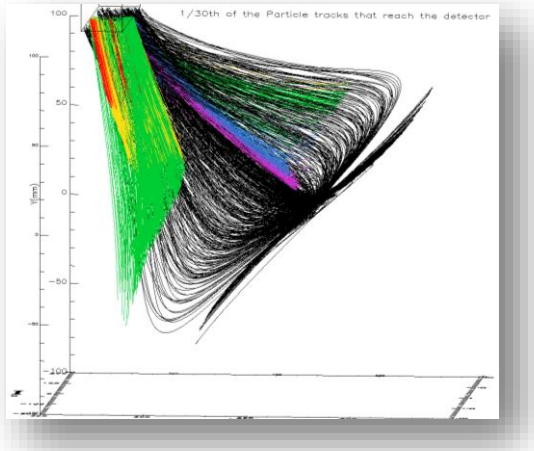
A Channeltron

- Positive drift field for residual gas ion detection
- 40 individual Channeltron tubes (electron multipliers)
- 6mm separation between centres
- Single pulse acquisition (not bunch by bunch)
- Auto-calibration performed against a motorized single Channeltron detector

Ionization profile monitor work

- The ring IPMS have no field shaping electrodes so the measured profile must be corrected for both space charge and drift field effects after measurement
- In addition, it is thought that extra ions reach the detectors due to the electric field shape where the 2 opposing drift fields meet ('saddle point')
- Work is being carried out to improve our understanding of the monitors by tracking the movement of residual gas ions through the monitor





Sample trajectories of ions that reach the channeltrons

Ionization profile monitor work

ISIS Extracted Proton Beam 1 (EPB1)

Beam

Profile

Harp

Position

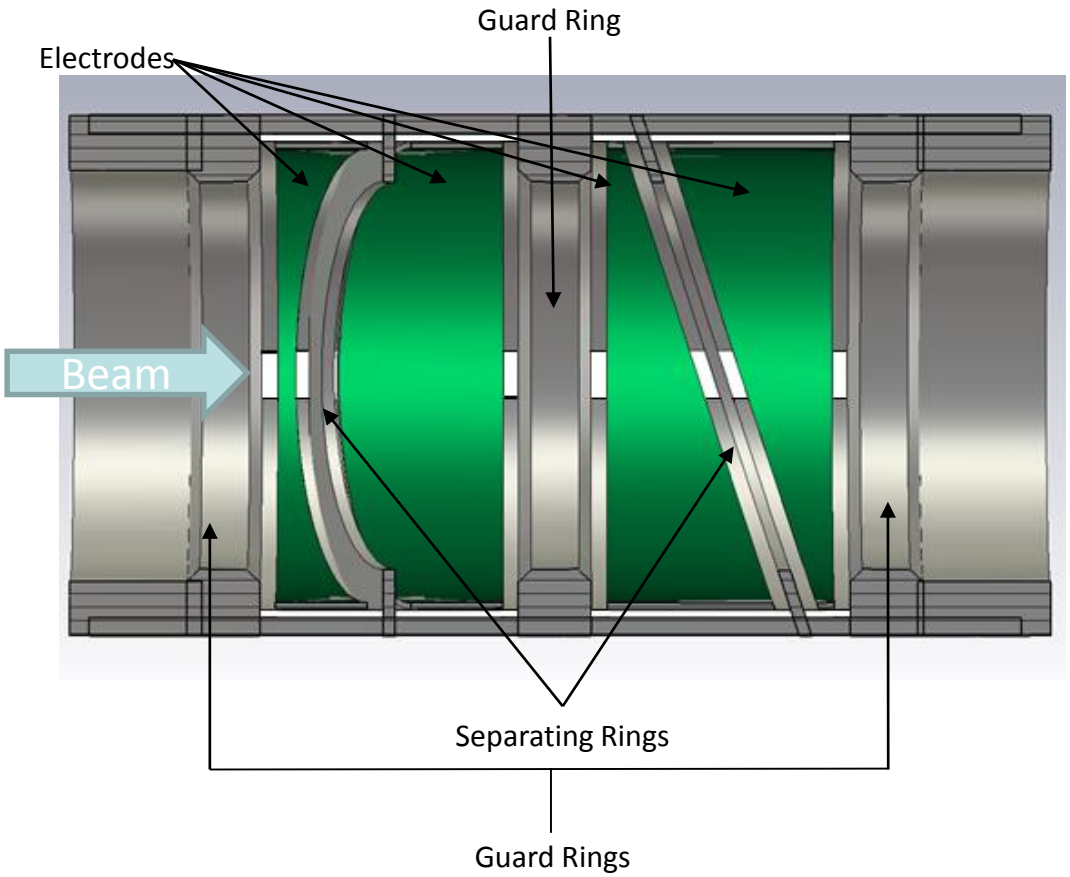
Profile monitor

Position monitor

Beam

SEM grid will highlight errors in gas ionisation profile monitors – this information will be used to correct measured profiles in the accelerator ring

EPB1 Double Plane Position Monitor

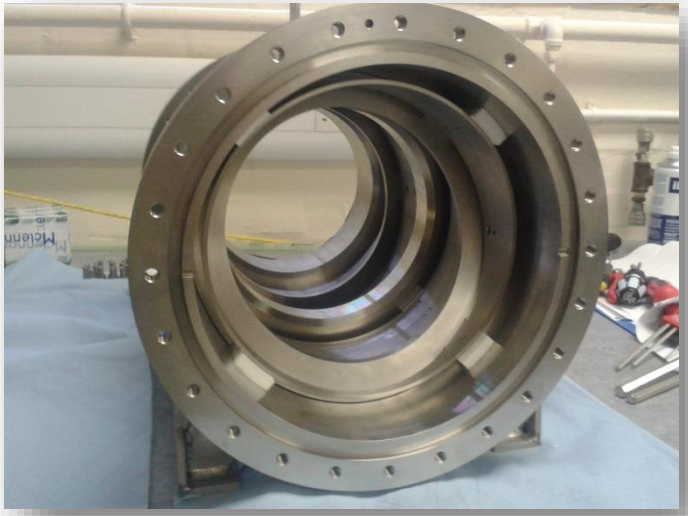


- Improved version from the one already installed on EPB1.
- Thinner electrodes

  (12mm → 3mm)
- Additional "guard rings" at each end of the monitor for symmetry
- Additional "separator rings" between each pair of electrodes
- Increased sensitivity
- To be installed on EPB1 upstream of IPM

EPB1 Double Plane Position Monitor

- The new monitor has now been manufactured and is ready for testing
- A new test rig has been built to calibrate the monitor and to verify the simulations results



Inside the New BPM

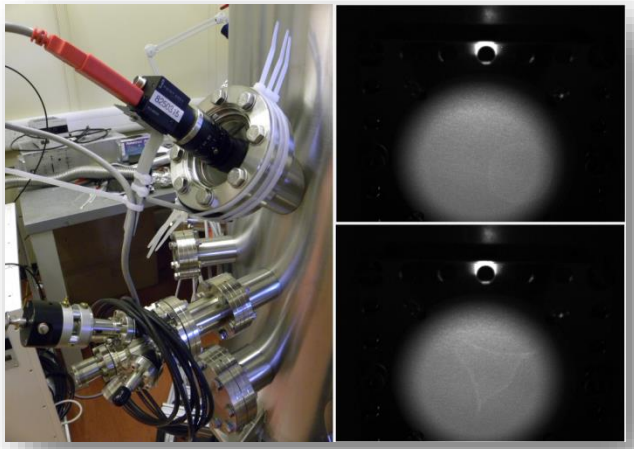
An Electrode Pair

The New BPM Test Rig

Vacuum Tank for Diagnostics Testing

- Aimed for detectors characterization/experimentation
- Electron gun installed and tested
- Ion gun and turbo-pump supports under development
- Ionization Ring Profile Monitor detectors to be characterized for electrons and ions

ISIS Diagnostics vacuum tank



Electron gun, screens and camera setup

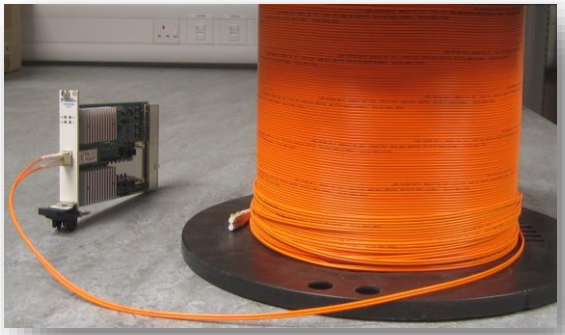
Data Acquisition Systems

Data Acquisition Overview

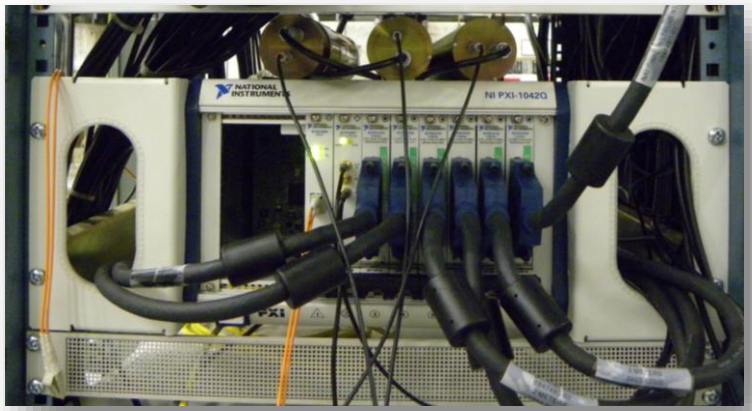
- The majority of the data acquisition systems used for beam instrumentation are based on National Instrument PXI hardware (approximately 30 systems)
- Critical systems are based on custom made dedicated hardware (i.e. beam protection)
- PXI systems are distributed around the accelerator in areas of varying shielding/accessibility
- Interfacing varies depending on beam instrument type
  - BPMs/Ionization chamber BLMs/SEM grid Profile Monitors interface through the ISIS Control System *(Vsystems VISTA)*
  - IPMs/Scintillator BLMs interface directly to User applications

Mitigating Radiation

- National instruments provide a means of extending the PCI bus of a PXI chassis to a remote chassis using a MXI interface card
- Use of a fibre-optic version of the MXI card, it is possible to situate the vulnerable PXI controller in a safe and easily accessible area



A PXI MXI-4 Card and fibre-optic spool



A chassis operating as a remote MXI drop

Special thanks to:

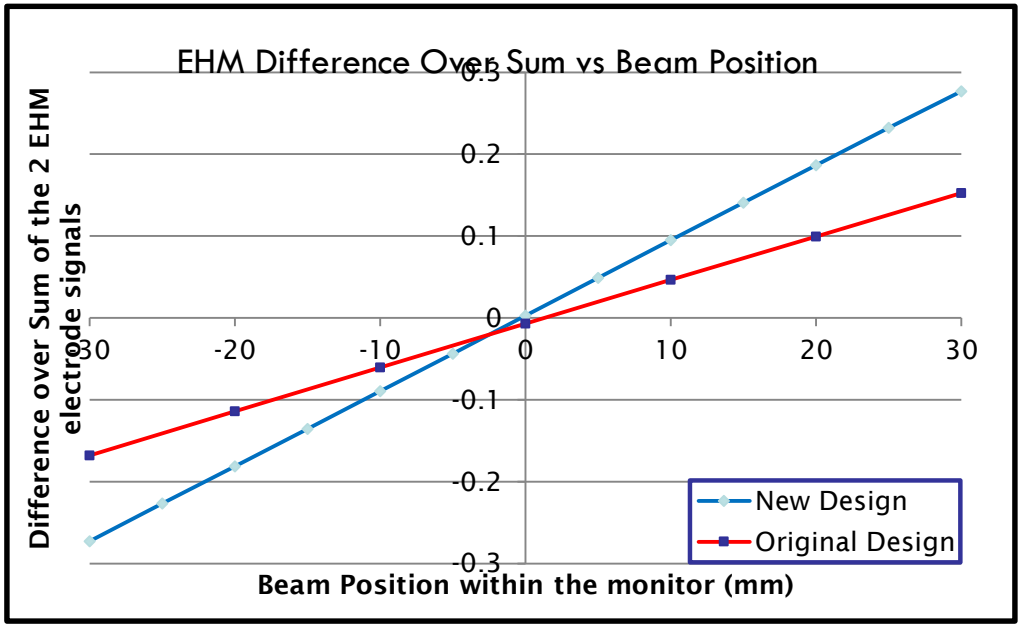
Steve Payne, Tony Kershaw, Chris Wilcox, David Posthuma de Boer and John Medland

Thank you!

Spare Slides

EPB1 Double Plane Position Monitor

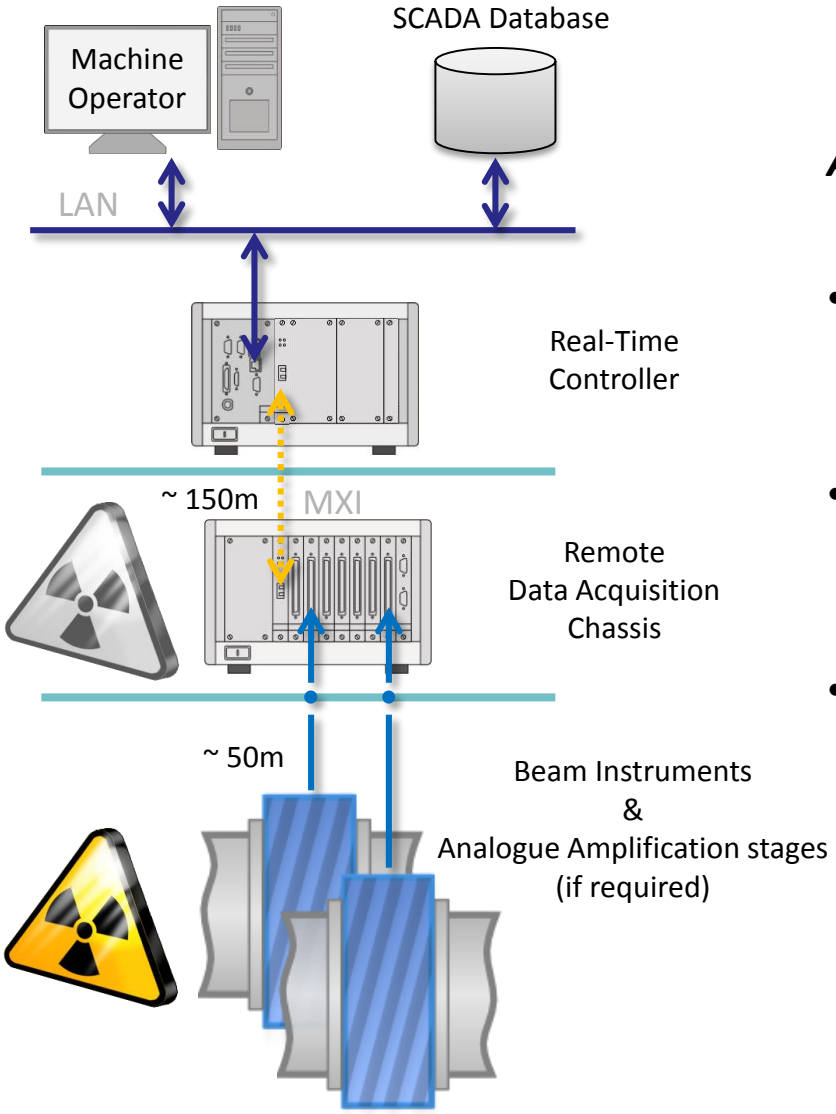
- Beam position is calculated by taking the difference over the sum (DOS) of the signals on a pair of electrodes
- The gradient of the graph between the DOS and the beam position characterises the sensitivity of the monitor
- The new monitor has significantly improved sensitivity when compared to the prototype, due to the decrease in electrode coupling



$$k = \frac{1}{gradient}$$

$$Measured\ Position = \frac{D.O.S.}{k}$$

Mitigating Radiation



Additional Benefits

- Reduced power and heat-generation in remote DAQ chassis improves chassis lifetime
- Controllers are always accessible in case of failure
- Multiple remote DAQ chassis can be connected to one controller