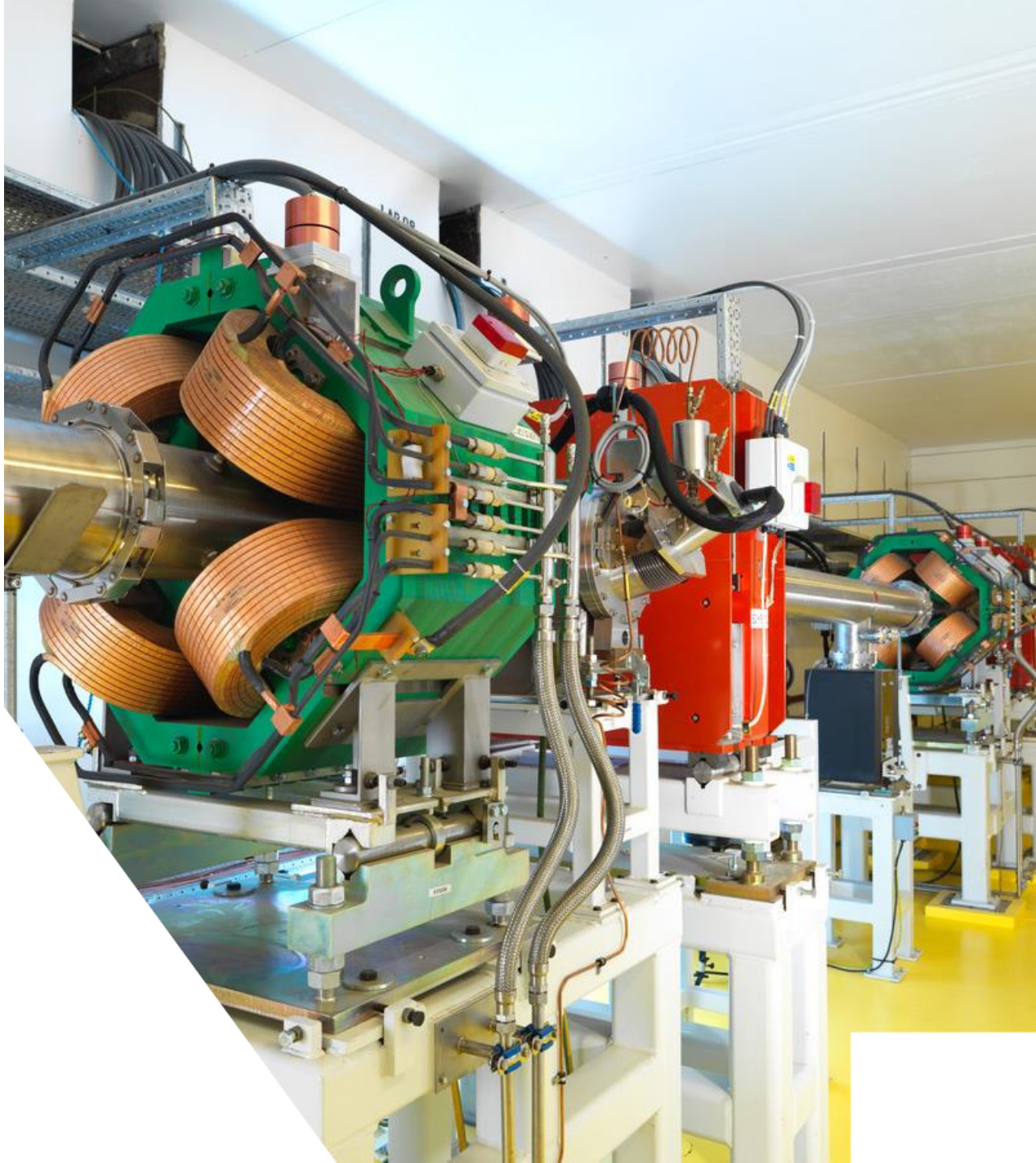
Accelerator Developments at ISIS

Hayley Cavanagh – July 2022

1. Brief Re-Cap/Introduction to ISIS
2. Developments Leading to Record Performance (2019-20)
3. Recent Long Shutdown 2021-22
4. Present & Future Work
5. Summary & Questions



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ISIS Neutron and Muon Source

The ISIS Facility

- Neutron and Muon Source
  - 29 neutron instruments
  - 5 muon instruments
- Rutherford Appleton Laboratory, Oxfordshire
- Research into physical and life sciences
- >2000 strong community

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The ISIS Accelerators

- 35 kV H^- Ion Source
- 665 keV RFQ
- 70 MeV DTL
- 200 μs, multi-turn charge exchange injection
- 3e13 ppp, 50 Hz, 240 μA (192 kW)
- 163 m, x10 super-period, 800 MeV RCS
- x6 fundamental and x4 dual harmonic RF cavities
- Extract 100 ns bunches, 154 and 144 m EPBs
- x2 Neutron (Ta/W) targets, x1 Muon target (C)

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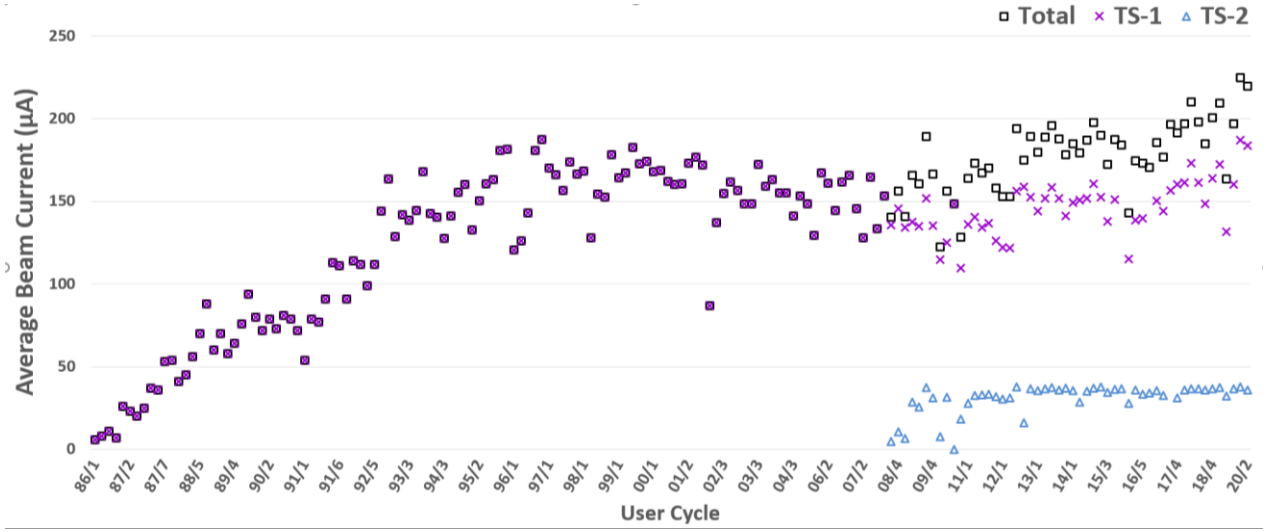
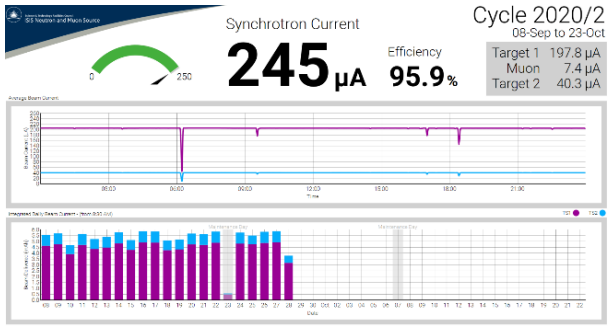
Record Performance - Operations

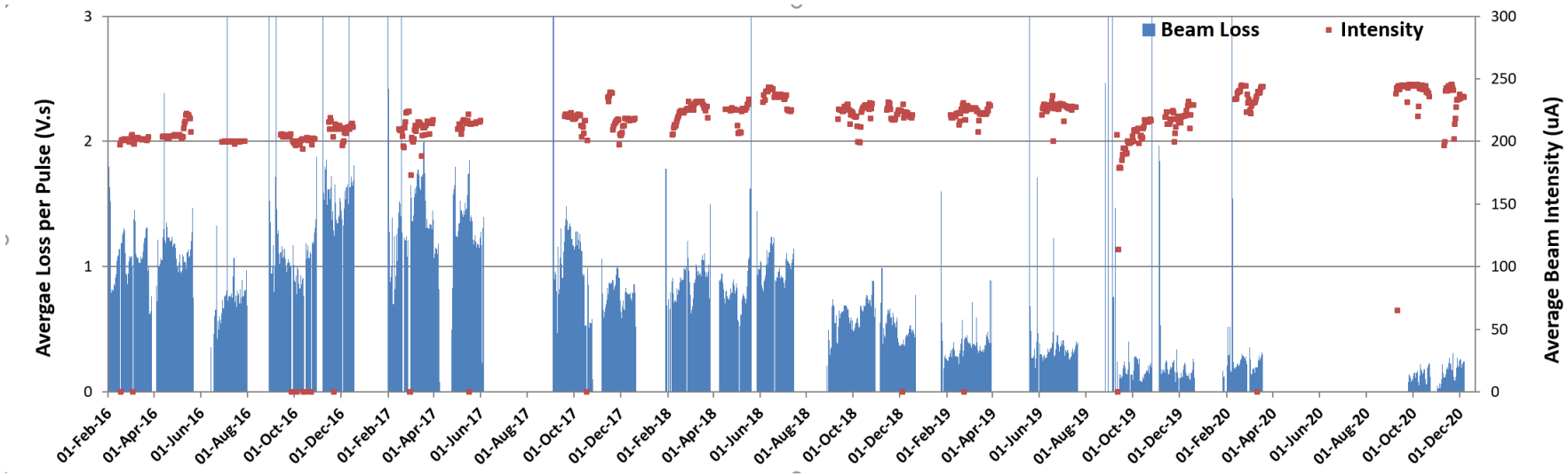
- 2019 record day **5.64 mAh**
- Feb 2020 record day **5.84 mAh**
- Sept 2020 record day **5.87 mAh**

Maximum beam 245 µA for 24 hrs

(2 minutes off!)







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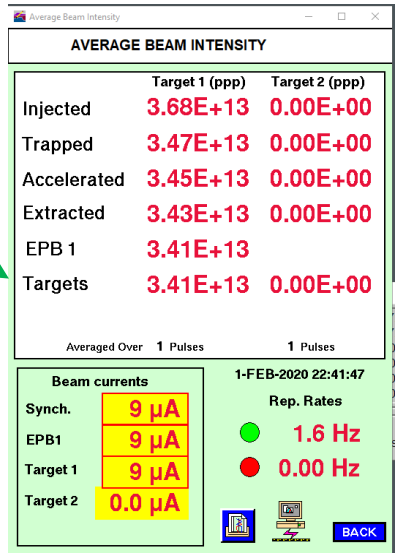
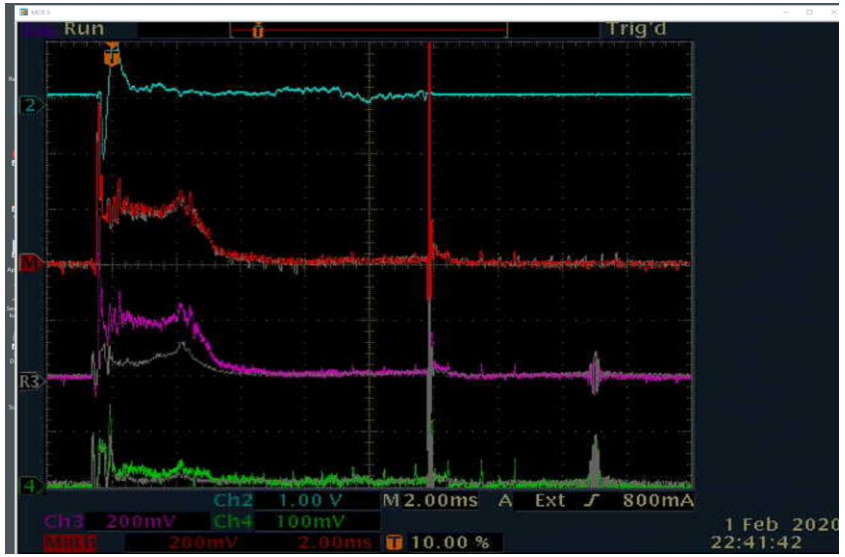
Record Performance – Machine Physics

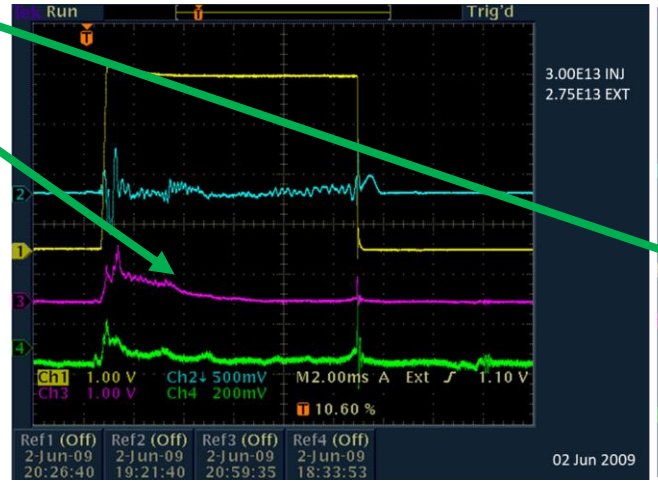
- **275 µA equivalent beam demonstrated during Feb 2020 machine physics**

- **Comparison of 220–240 µA beam loss between 2009–2020**

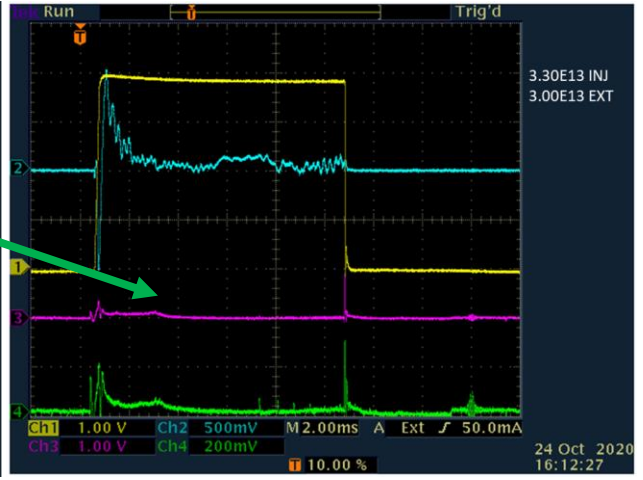
Beam loss control enables increased collimator aperture to accept higher intensities







220 µA June 2009



240 µA October 2020

Same 1 V Scale (now routinely run at 200 mV Scale)

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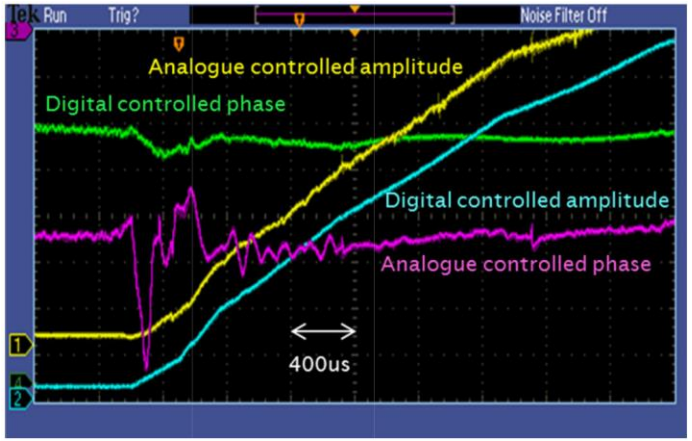
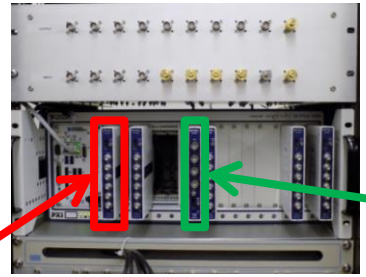
Accelerator Developments

Synchrotron RF Digital Low-Level Control

- >35 year old analogue controls obsolete
- New digital system based on NI FlexRIO Platform
- Frequency Law Generator demonstrated 2016
- Modular system developed, incorporating feed-forward beam compensation

Analogue/Digital comparison over first 3 ms of acceleration





x10 Cavity Control

Frequency Law Generator

https://arxiv.org/abs/1910.07302

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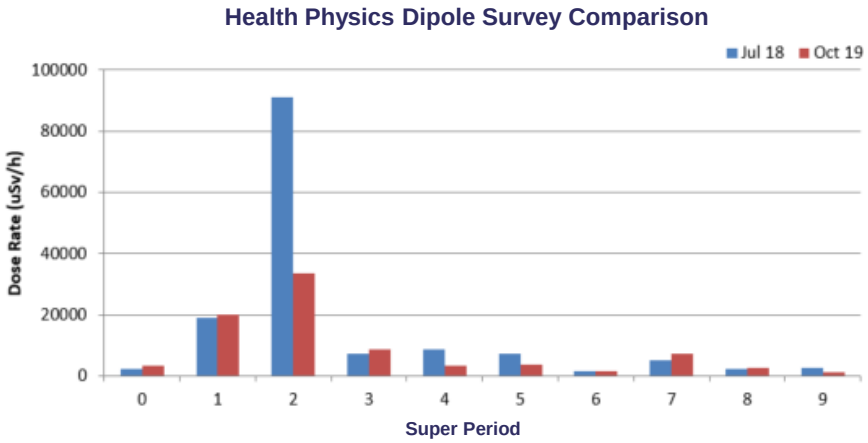
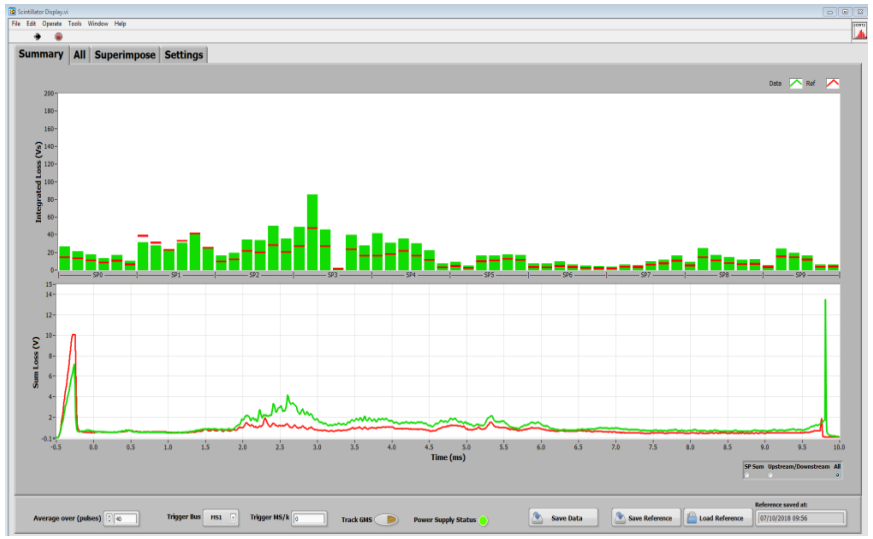
Accelerator Developments

Synchrotron Scintillator BLM System

- x6 novel BC408 plastic scintillators installed in each dipole since 2018
- Previously unseen beam losses in dipoles now measured
- 40% reduction in residual dipole activation





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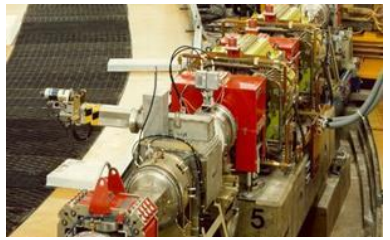
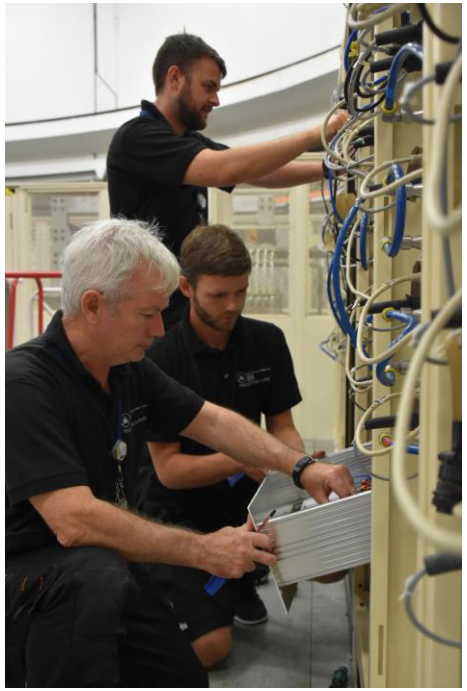
http://accelconf.web.cern.ch/AccelConf/ipac2019/papers/wepgw091.pdf

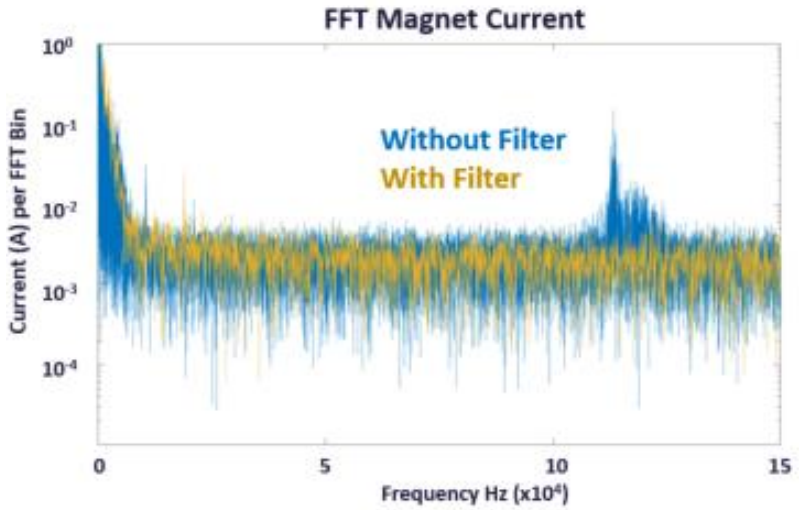
Accelerator Developments

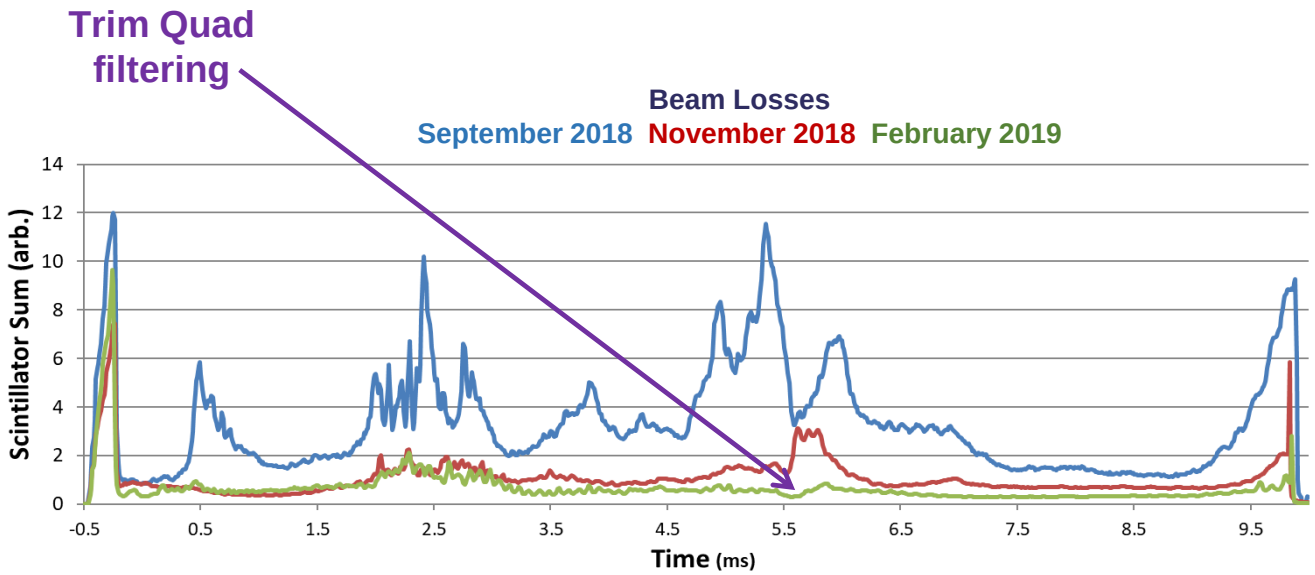
Trim Quad Power Supply Filtering

- x20 programmable trim quadrupoles, PSUs replaced 2010
- Switching frequency (120 kHz) seen by beam
- Filters applied to PSUs









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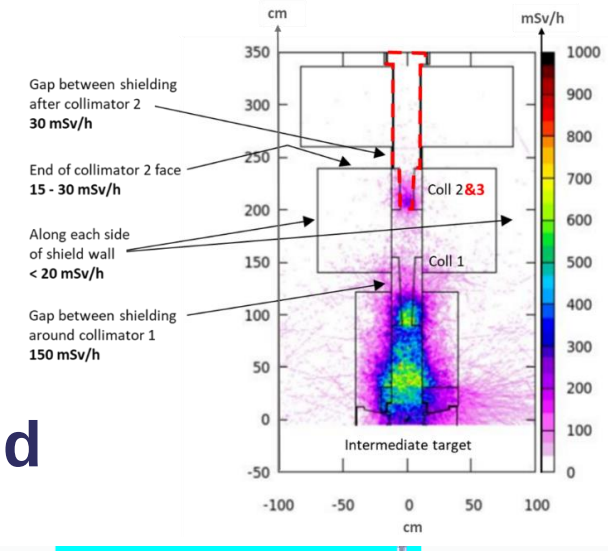
Long Shutdown Projects

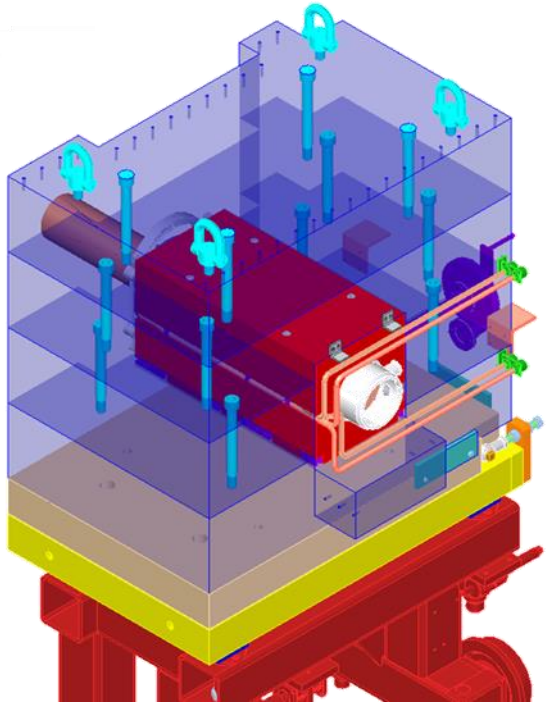
TS-1 Upgrade

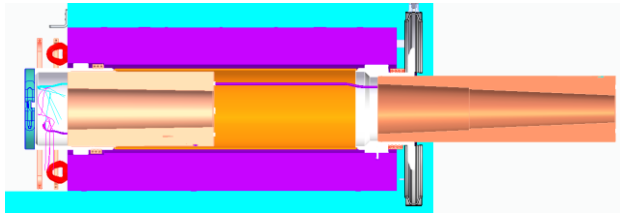
Target, Moderator, Reflector, and Services Due Autumn 2022!

Muon Target Collimator

- **Water leak November 2020**
- **High Dose Rates**
- **New collimator manufactured and replaced**
- **Commissioning Autumn 2022**







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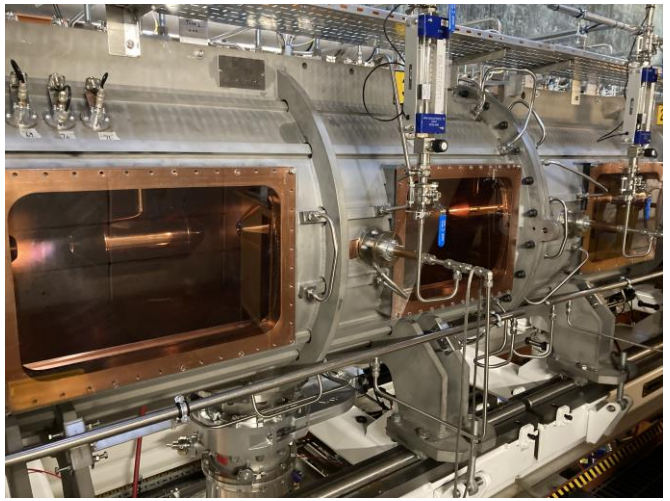
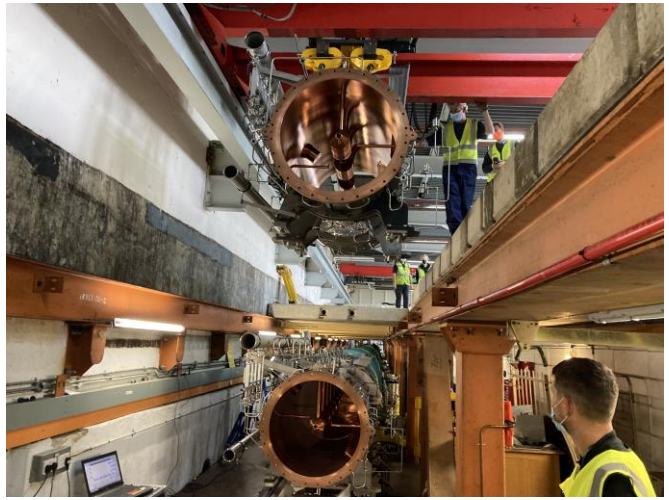
Long Shutdown Projects

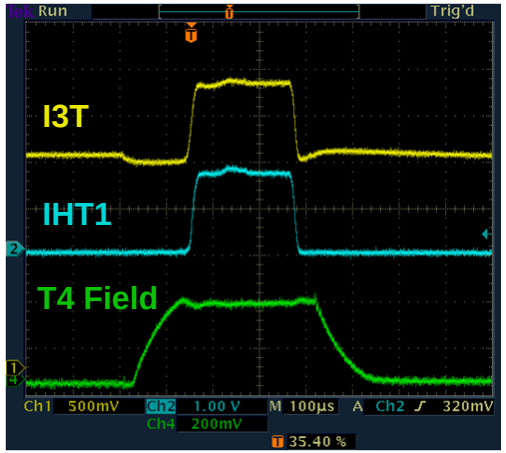
Linac Tank 4 Replacement

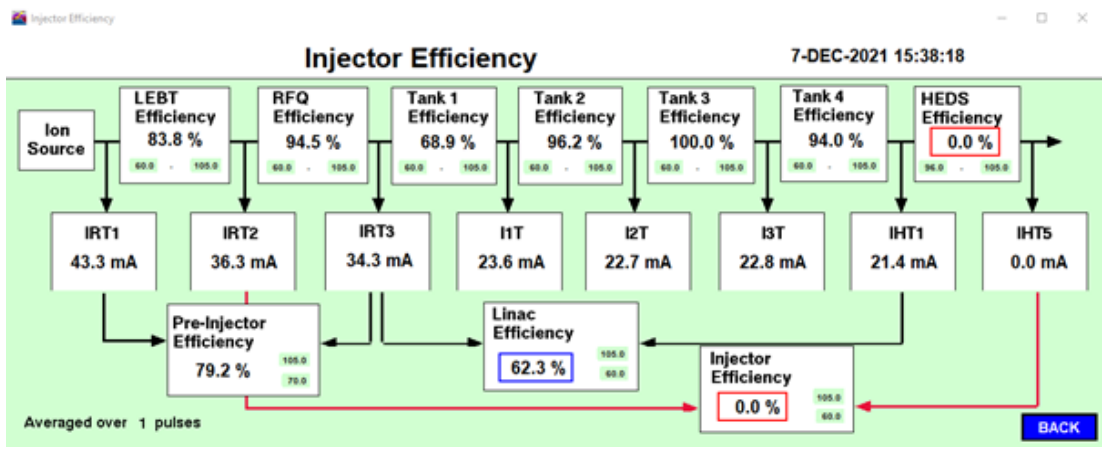
New Tank Installation





First beam
7th December 2021
94% transmission





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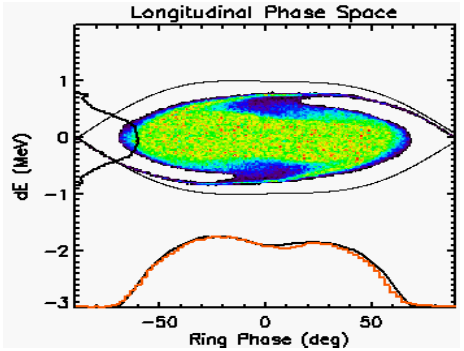
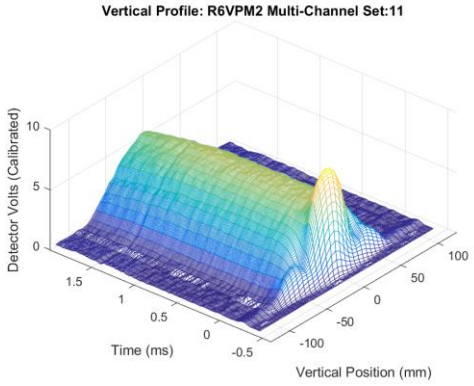
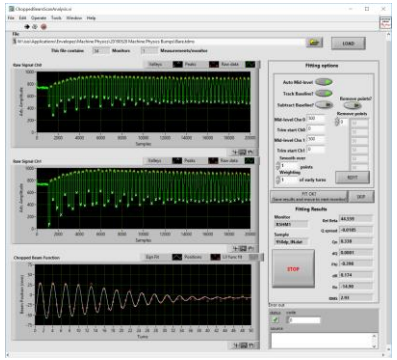
Present & Future Work

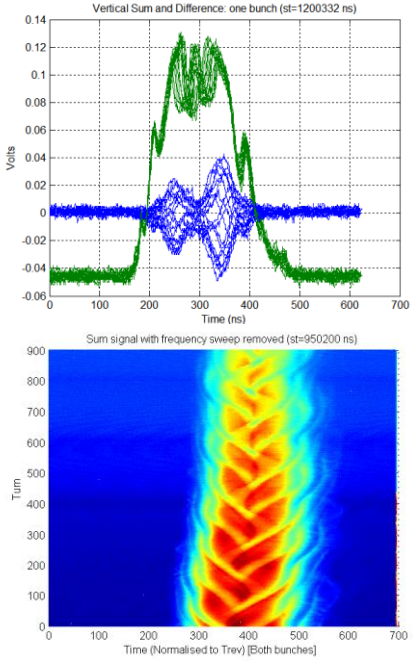
Machine Physics, Research & Development

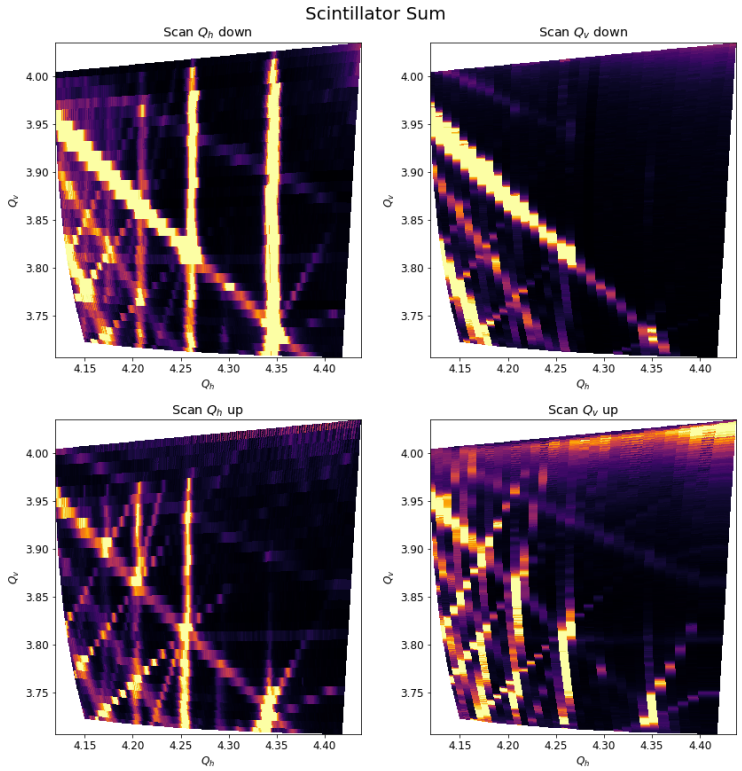




- **TS-2 only, recovering from long shutdown, yet to restore full performance**
- **High intensity space charge studies and simulations**
- **Transverse dynamics – resonance and losses**
- **Low intensity lattice measurements**
- **Head-tail instability & impedances**
- **Longitudinal dynamics**
- **Tune space mapping**







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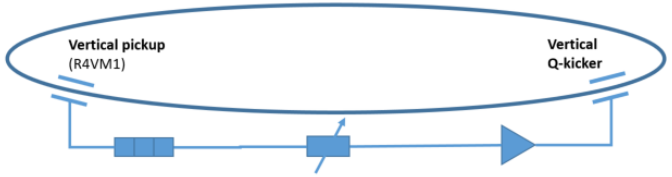
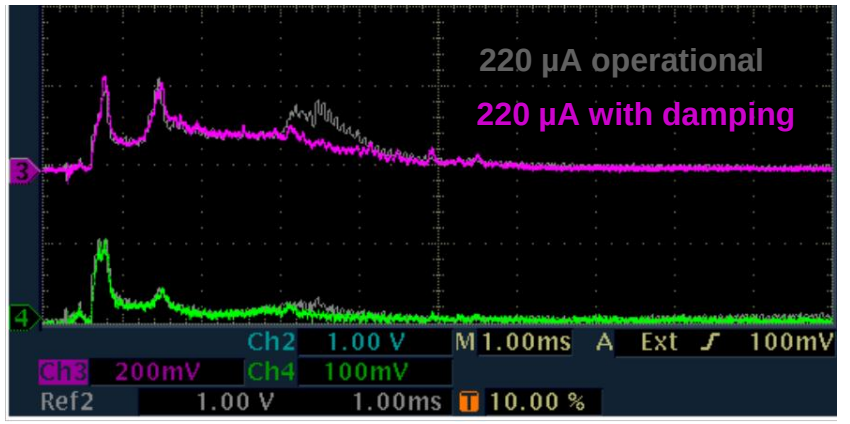
Present & Future Work



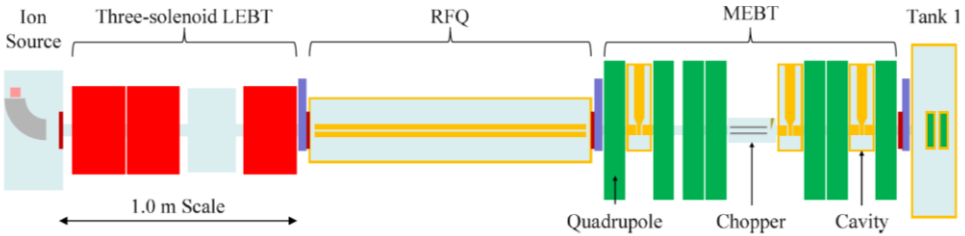
Hardware Upgrades

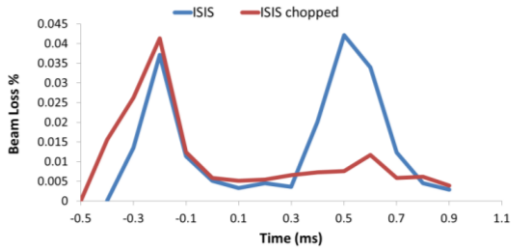
- Beam Damper System
- Multi-Wire Injector Profile Monitors

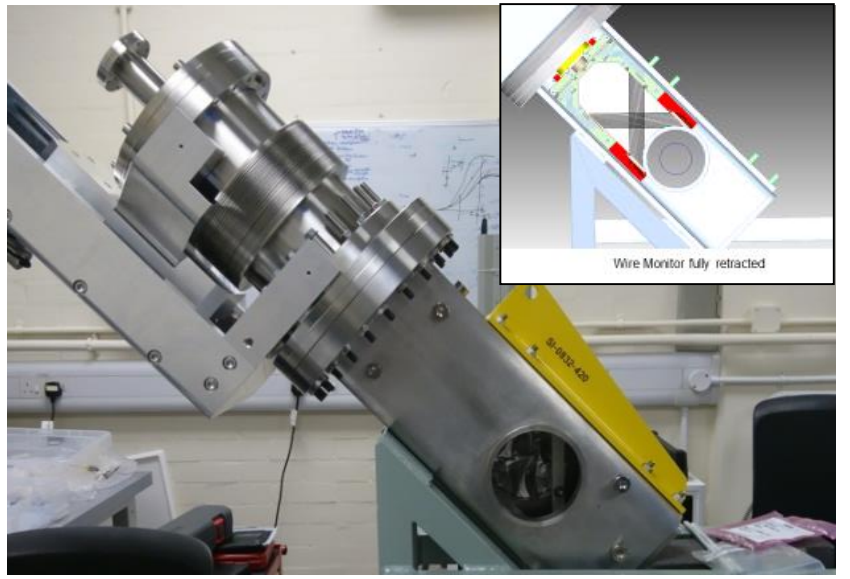


Next Long Shutdown

- MEBT! Reduce beam losses by injecting a chopped beam







Many other Accelerator Development Projects at ISIS…

- RF Ion Sources, FETS, ISIS-II, FFA Magnets …

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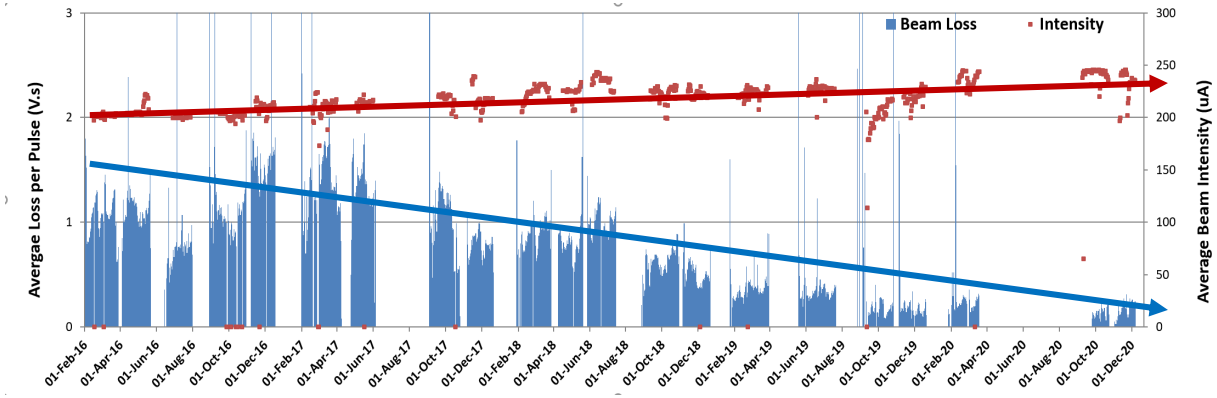
Summary

- 2020, record performance
- 2021, major projects in long shutdown
- 2022, busy operational year
- 2023+, lots to look forward to!



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Thank you

Questions?

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