ISIS RF Screen Impedances

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ISIS Neutron and Muon Source

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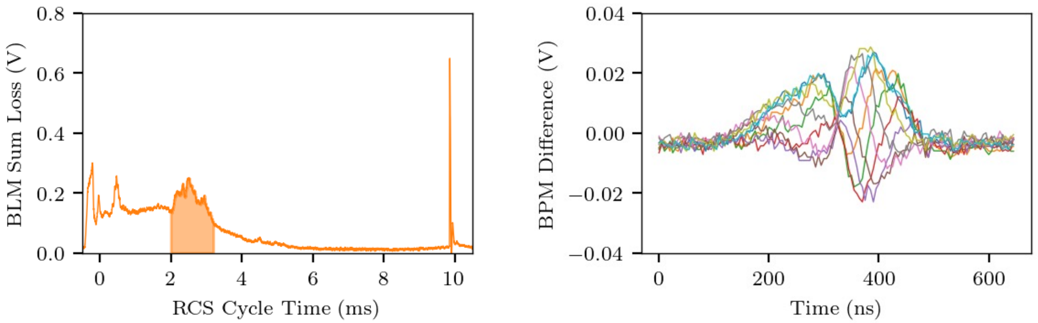
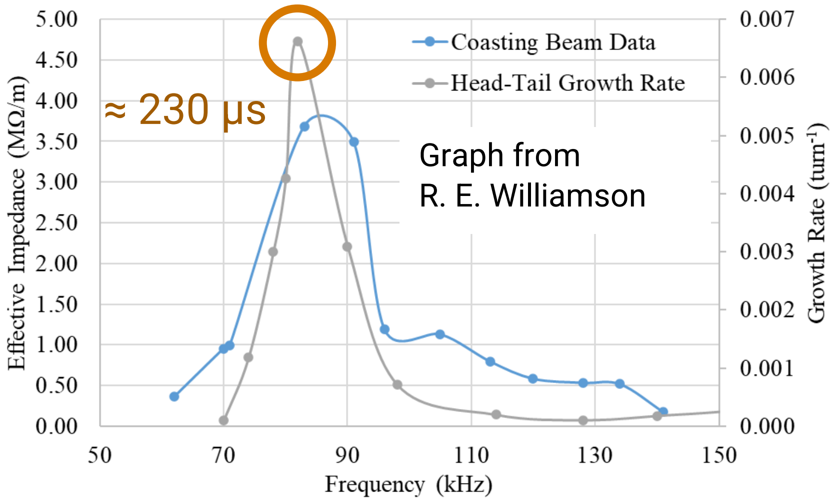
Beam-losses and Head Tail at ISIS

- Operational intensity at ISIS is limited by beam-loss.
  - A coherent vertical instability, with a growth time on the order of 100 μs, is a major sources of loss.
- The instability begins around 2 ms into the acceleration cycle and resembles a mode-1 head-tail instability.
- This was first measured around 1988, when resistive-wall was believed to provide the driving impedance.
  - This would cause growth times of ms, and modes 2 or 3.
- An extensive measurement campaign was run to characterise the instability, and hinted at a low-frequency narrowband impedance.

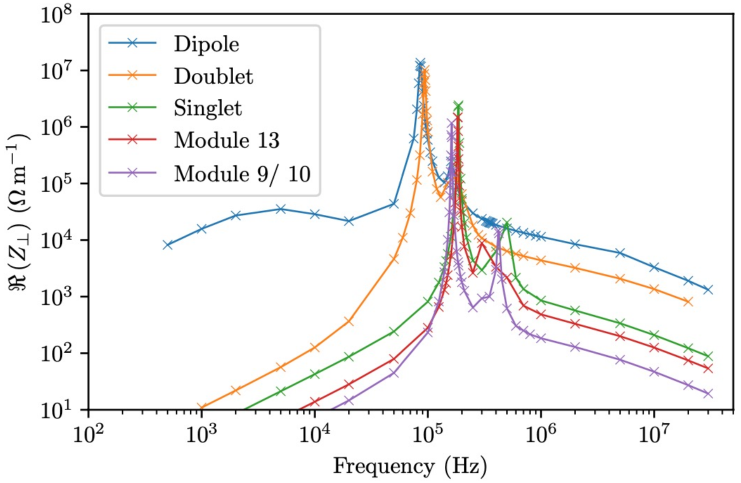


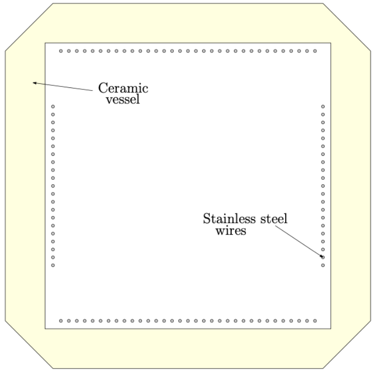


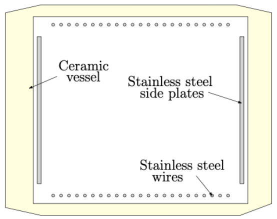
RF Screens at ISIS

- At HB2023, my results showed that I had identified a series of large, low-frequency narrowband impedances on the RF screens.
  - These were in the frequency range found by the measurement campaign, and had the same typical order-of-magnitude.
  - The result from the dipole magnet has changed since HB23 because of a correction to the model geometry.

- These structures are installed to limit Eddy current losses because of the AC main magnets.
  - The vacuum vessels are made from alumina ceramic.
  - The RF screens are stainless steel wires that run along the inside of the ceramic vessel (inside the vacuum).







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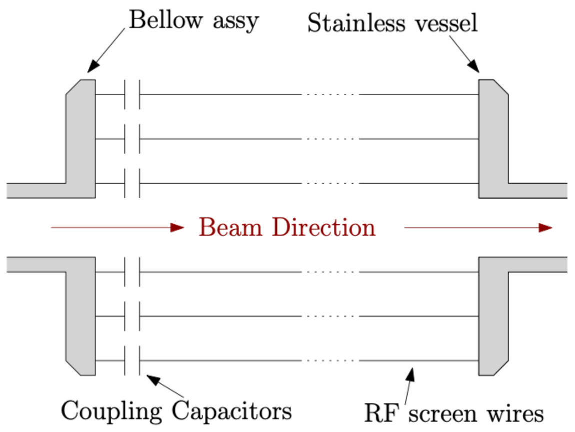
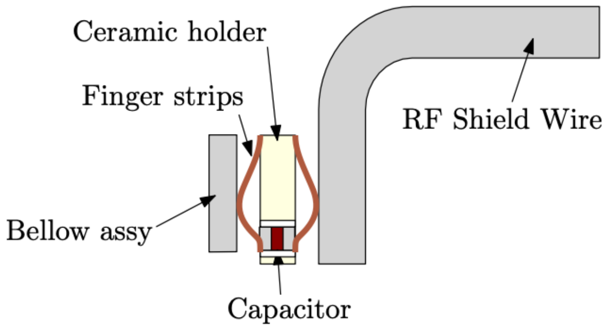
Capacitive Coupling

- If the RF screens were directly connected to the conducting vacuum vessels on both sides, then there would still be considerable Eddy currents.
  - At ISIS we overcome this by isolating each wire with a capacitor.

- My HB results showed that the resonances only appeared with capacitors in the model.



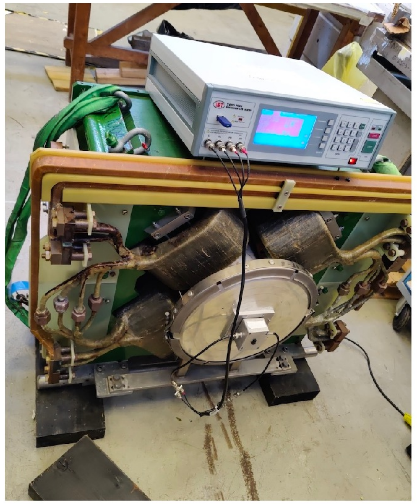


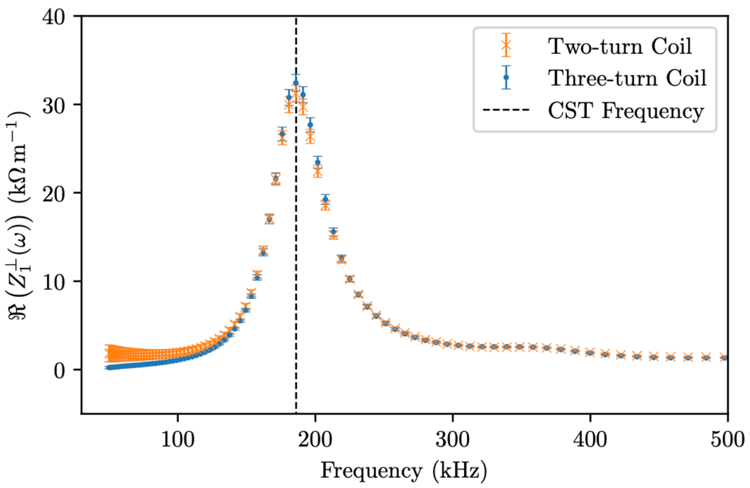
Measurements at ISIS

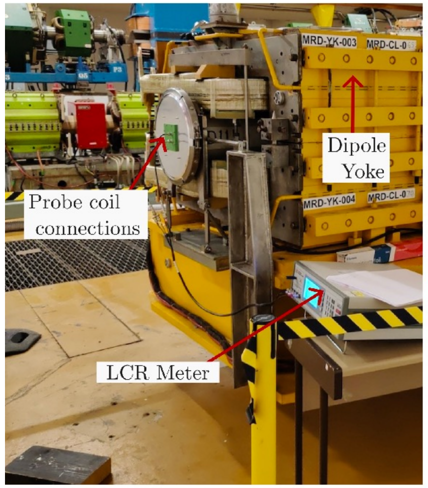
- At HB we showed experimental results from a singlet RF screen.

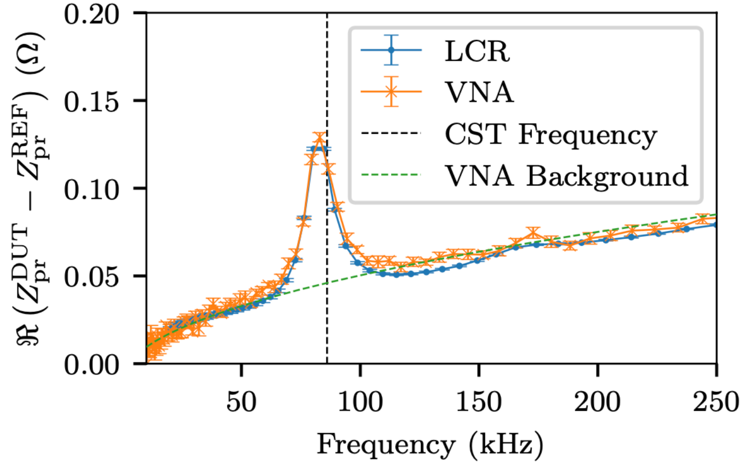
- Since then, we've also performed measurements on a dipole screen.
  - These were of particular interest, because their resonant frequency was ~80 kHz.
  - Close to the narrowband measured on ISIS.

- We weren't able to do a full measurement on a dipole, but a small probe loop confirmed there is a resonance at the predicted frequency.









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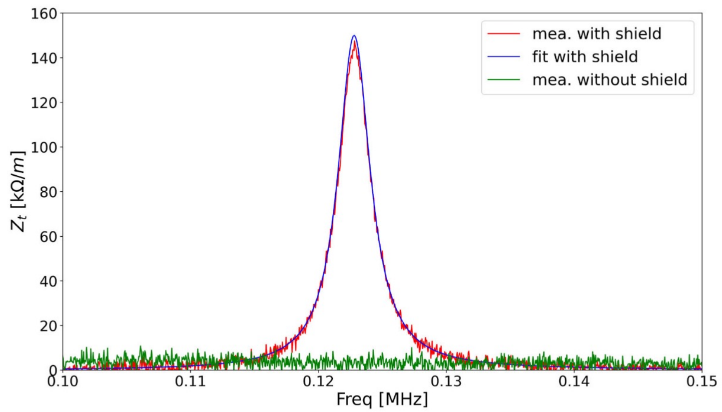
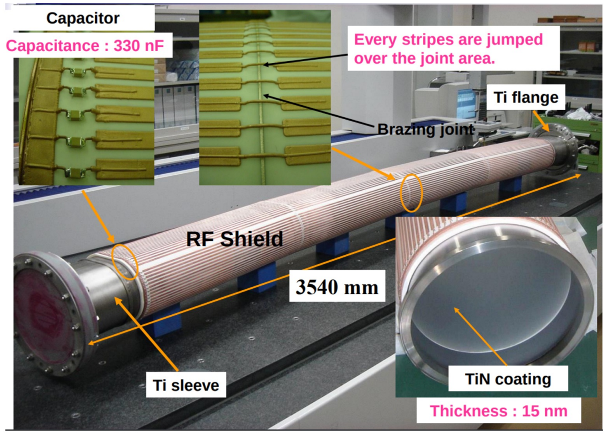
CSNS RF Screens

- Since HB23, CSNS has also reported finding similar resonances on their RF screens.
  - These are physically similar to the Jparc RF screens and also have capacitively coupled strips.

- It seems likely that we have the same problem.



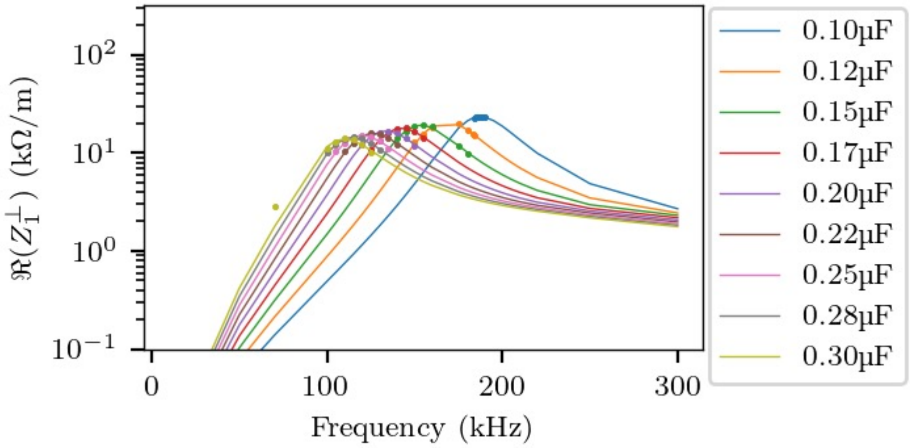
L. Huang et. al, “Source of instability in the rapid cycling synchrotron of the China spallation neutron source”



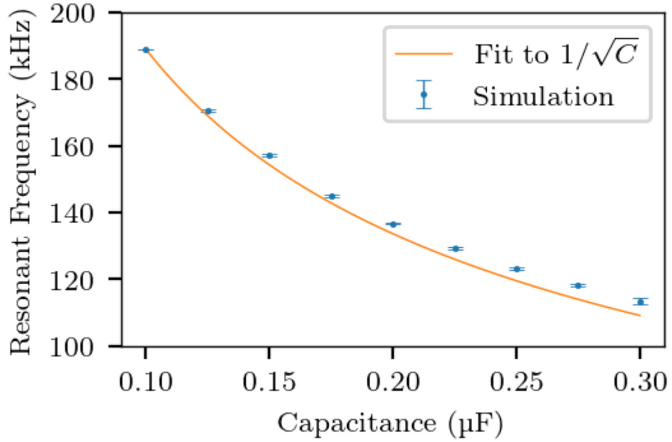
M. Kinsho, https://indico.fnal.gov/event/16269/contributions/36516/attachments/22688/28130/J-PARC-RCS-Vacuum-Chambers.pdf

Capacitance Change

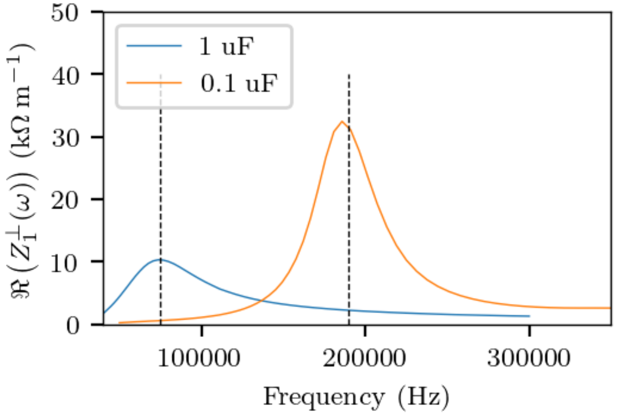
- We have verified in simulation that the resonant frequency is roughly proportional to 1/sqrt(C)
  - Amplitude also seems to drop with increasing C.



- We have measured this on a singlet magnet.
  - We tried 0.1 and 1 uF capacitors
  - Resonant frequency moved from ~190 kHz to 75 kHz.
  - Amplitude also fell



- Maybe a simple solution is to move these resonant frequencies to a more favourable value.
  - We are investigating this.



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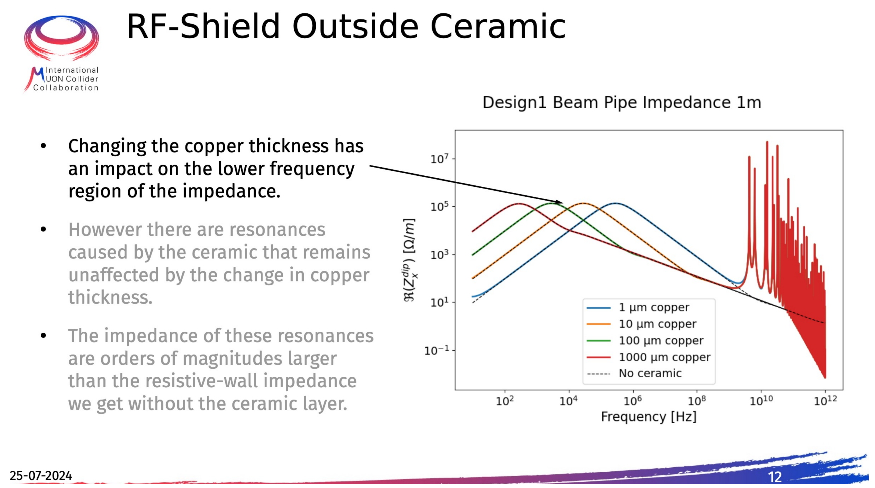
Some Questions

- From L. Huang et. al, “Source of instability in the rapid cycling synchrotron of the China spallation neutron source”
  - ”[…] the tune should initially exceed 0.77. As the space charge tune shift diminishes with energy ramping, the tune can subsequently be lowered. Consequently, an optimized tune curve has been developed to suppress the instability while controlling space charge effects.”

- RF Screens also being considered for the muon collider.
  - They have looked again at the question of directly exposing the ceramic chamber to the beam, and found the resonances in the dielectric.
  - Were these resonances considered when choosing the internal TiN coating?

E. Kvikne, D. Amorim



https://indico.cern.ch/event/1437002/contributions/6061674/attachments/2903847/5093368/Wrap-up_on_Eddy_Current_Effects_in_the_NC_RCS_Vacuum_Chamber.pdf