Improving the robustness of compact step range filter charge particle spectrometers on the NIF

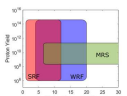
National Nuclear Security Administration

T. M. Johnson[1], B. Lahmann[1], A. Birkel[1], G. D. Sutcliffe[1], N. V. Kabadi[1], P. J. Adrian[1], J. H. Kunimune[1], B. L. Reichelt[1], J. A. Pearcy[1], M. Gatu Johnson[1], J. A. Frenje[1], F. H. Séguin[1], R. D. Petrasso[1], A. S. Moore[2], C. K. Li[1]

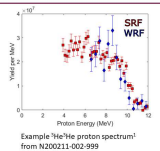
[1] *Plasma Science and Fusion Center, Massachusetts Institute of Technology*

[2] *Lawrence Livermore National Laboratory*

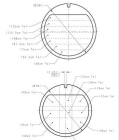
Step range filters (SRFs) are compact charged particle spectrometers used on the NIF



SRFs have large energy coverage[1] and proton yield coverage at the NIF.



Example ^{3}He^{3}He proton spectrum[1] from N200211-002-999



Schematic for two different SRF configurations

Step range filters are very configurable. Changing the filter thicknesses gives different energy coverages for different particles.

[1]B. Lahmann RSI (in review)

SRFs work by exploiting the properties of CR39

High energy particles break molecular bonds in the CR39.

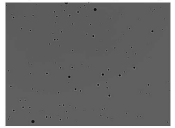
Etching with NaOH exposes the damage as particle tracks.

The diameter of the particle tracks is related to the energy of the particles.

The energy of the particles at the surface of the CR39 is "reversed-ranged" through the filter thickness using SRIM.

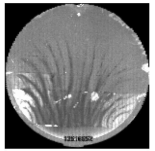
The energy coverage of multiple windows on the SRF overlap allowing for self constituent spectra to be measured.

CR39 particle tracks seen through a microscope



F. H. Séguin RSI (2003)

Heat flux from absorbed x-rays corrupts SRF data

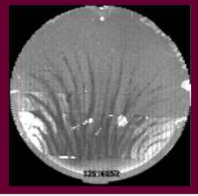


An example (N(x,y) plot) of the wrinkle effect on a 7 step SRF from N200928-001

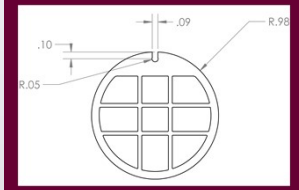
The large x-ray fluence on the NIF deposits a large amount of heat into the Ta filters of the SRF.

This in turn heats the CR39 and changes it's properties.

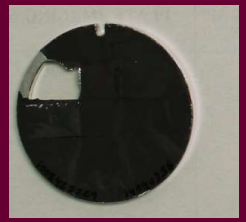
The result is data that cannot be analyzed.



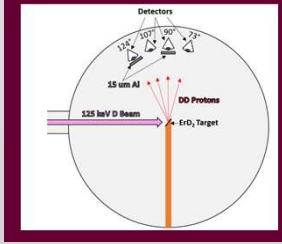
Heat transfer from the filter to the detector compromises the data analysis.



A gridded support structure prevents the wrinkle effect but filters are damaged.

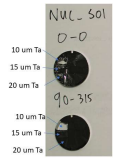


There are two ideas on how to support the thinnest filter: a "minigrid" and a mesh.



We are preforming accelerator experiments to examine the effect supports have on the data analysis.

The thinnest filter of the gridded SRF blows out most of the time



It isn't known currently if the filter being blown out compromises data analysis.

Switching the thinnest filter from 10 um Ta to 15 um Ta might help but changes the energy coverage of the SRF.

There are two ideas of how to support the thinnest filter on the SRF

The mesh SRF

The "mini-grid" SRF

It is current unknown how these ideas will impact the data analysis procedure.

We obviously don't want to support the SRF in a way that hurts our data.

We plan to use the MIT Linear Electrostatic Ion Accelerator (LEIA) to test how the additional supports will impact the data analysis

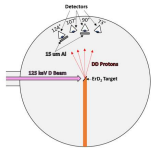
We will test multiple SRFs each three times:

1. Without any support (just the SRF)
2. With the minigrid support
3. With the mesh support

We will repeat this at very high fluence to test more realistic NIF conditions.

Partial ranging from the minigrid or the mesh could compromise the data analysis.

We will look for evidence of this effect.



B. Lahmann RSI (in review)

MIT PhD students work on NIF diagnostics (2nd DTn[1], WRF/SRF, PRAD[2], MRS-t[3], PTOF[4]) and fundamental physics (hohlraum x-rays[5] and fields[6])

[1] poster by Patrick Adrian
[2] poster by Graeme Sutcliffe
[3] poster by Justin Kunimune
[4] poster by Neel Kabadi
[5] poster by Ben Reichelt
[6] poster by Jacob Pearcy

LLNL-POST-819018