C-AD

Radiation

Safety Minutes of BLIP RSC Target Review Subcommittee June 24, 2015

Committee

Issued: June 30, 2015

Subject: One Week Irradiation of Sc in Low Energy Slot

Present: D. Medvedev, L. Mausner, N. Contos, D. Beavis, S. Smith, and C. Cullen

The committee discussed the target submission for a one week exposure of Sc and well as the critique report[1] from the previous Sc target failure.

Tgt_15_08: Low energy slot irradiation for one week of Sc metal with a possible extension to three weeks.

The critique report did not conclude on a cause for the target failure. However, the thermal analysis had a missing contact conductance between the Sc and Al causing the Sc temperature to be underestimated. The new target has both thinner Sc and Al to decrease the energy deposition.

The issue of possible oxide layers impacting the thermal analysis was raised. An oxide layer would change the color of the surface. The target was inspected after the meeting and no evidence of an oxide layer was detected.

The thermal analysis should be checked by another qualified engineer. This was conducted after the meeting and the analysis was confirmed. During the engineering review it was suggested that the Aluminum alloy be 6061 and that the outside surface be coated with Alodine corrosion inhibitor. *****

The thermal analysis was conducted for a beam with FWHM of 0.850 inches.
The FWHM of the beam for the 117 MeV Sr production targets is 1.02 inches Horizontal and 0.708 inches vertical with an average of 0.866 inches. The beam increases in size as it transverses the material upstream of the Sc target.

17 MeV of energy is deposited in the water at the rear of the target. In the past it was a concern how much air emissions may increase from large energy depositions in the water. The data[2] from the target failure and subsequent analysis suggests that the ^{13}N will have a 15% increase with the 17 MeV protons depositing their energy in the water gap after the Sc target. The emissions from the stack will be check during the irradiation.

Following the suggestion in the critique report the target will be inspected 1 hour after the initial

[1] http://www.c-ad.bnl.gov/ESSHQ/SND/Critiques/Critique%20-%20BLIP%20Scandium%20Target%20Failure%20%20%20%205-27-15.pdf
[2] D. Medvedev, June 30, 2015 e-mail to D. Beavis, attached.

exposure and then at the end of the first day. An effort to increase the water sampling will be made.

The benefits and risks of additional checking and sampling will be considered for future targets.

It was requested that allowing the target to be exposed up to a full three weeks be considered. The committee could not find a reason not to allow a three week exposure provided updated activation numbers were provided.

The target is approved for a one week irradiation. It will be inspected after the first week and if there are no concerns will continue to be irradiated for a total of three weeks.

The long term goal is to replace the copper beam stop at the back target box with Sc for long term irradiations. Since Ti-44 has a 60 year half-life it is desired to eventually have exposure times as long as possible. Extending the one week to three weeks will aid the development of this program.

The risk to the production targets was discussed and it was thought that there was essentially no risk for the production targets.

Attached e-mail on Increased ^{13}N Production

Note on the expected BLIP air emissions during irradiation of the Sc target at the low energy slot
Provided by D. Medvedev on June 30, 2015

Background: The proposed target was designed to ensure that Sc temperature stay well below 600 ^{0}C – the melting point of Aluminum cladding. Since the beam current is governed by Sr-82 production needs, the energy deposited in the Sc target was controlled by reducing the thickness of the target. In particular, out of 29 meV available at the back of RbCl target ~14 MeV (29→17) is deposited in Sc disk and cladding, and 17→0 MeV is deposited into the water gap behind the Sc target. Potential impact of this design on BLIP air emissions is evaluated below.
Air emissions during Sc target failure in April 21-23, 2015.
Radioactivity in BLIP air emissions are due nuclides produced in water such as O-15, C-11 and N-13. O-15 has been historically found to be a predominant radionuclide.
During previous Sc target failure in April 2015 the Sc metal and front window have developed a hole and as a result the protons traveled through the additional 0.137 inch layer of water (thickness of the front Cu window + thickness of Sc disk). This was equivalent to the energy loss of 29 MeV to 22 MeV. The beam stopped in the back Cu window, which was still intact. The air emission at BLIP through the month of April is shown in **Figure 1**.

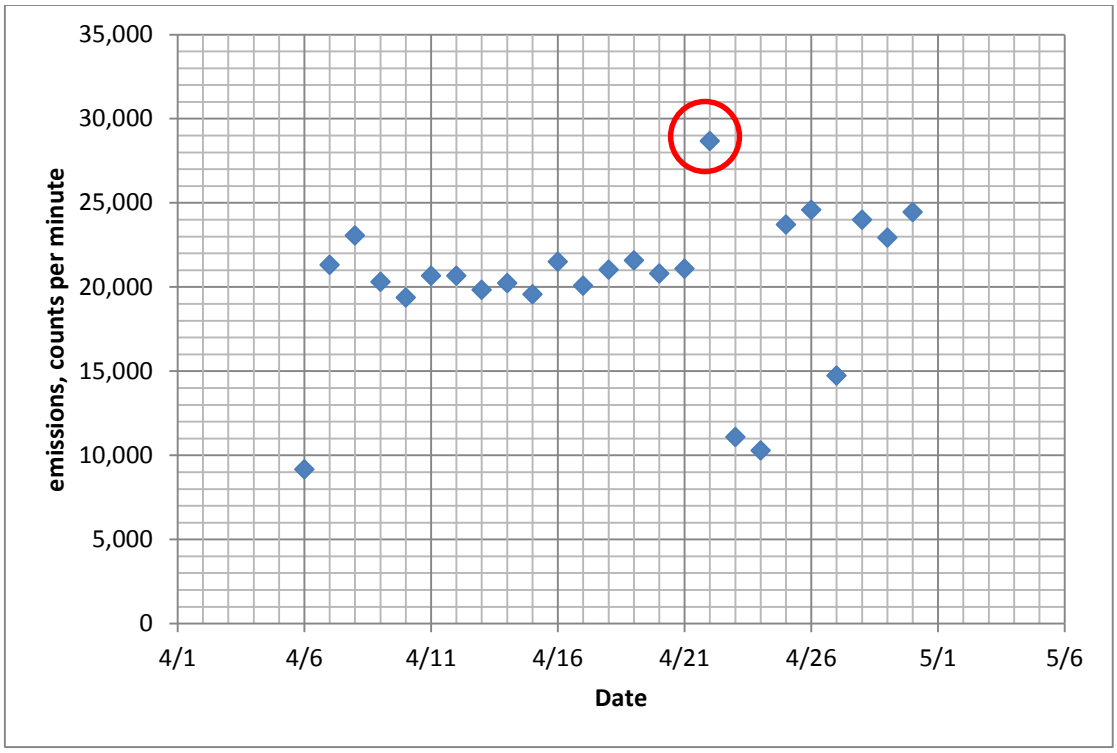

Figure 1. BLIP emissions during April. Sc target inserted on 04/21 and found disintegrated on 04/23

As evident from the **Figure 1** there was ~15% elevation in the emissions on 04/21, when the target perhaps disintegrated, followed by reduction in emissions due to beam shut down after the target failure. The reason for the elevated activity in emissions can be explained by examining excitation functions of O-15, C-11 and N-13 from O-16 in water (Figure 2).

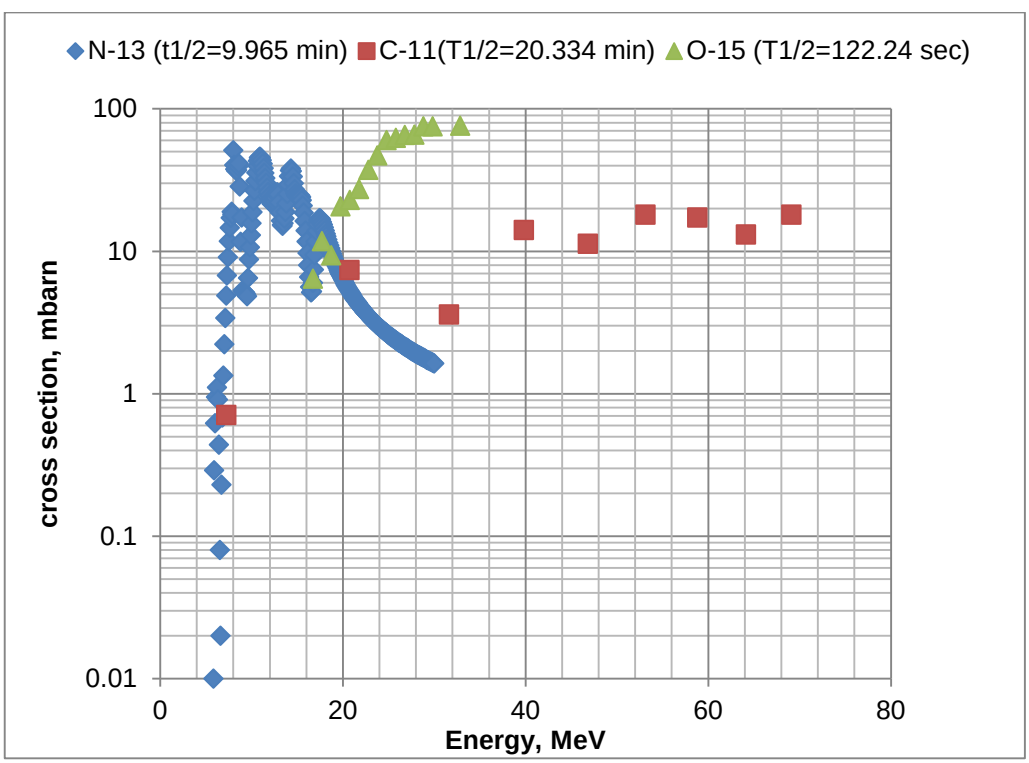

Figure 2. Excitation functions for certain nuclide production from O-16

As can be seen from **Figure 2** elevated emissions during last Sc target failure were mainly due to O-15 as cross sections for O-16(p,n)O-15 reaction are quite substantial between 22 and 29 MeV (water was exposed).

In the proposed array design, the 17 MeV proton beam will stop in the water gap behind Sc target. We do not anticipate substantial increase in emissions of O-15 at energies less than 17 MeV as cross sections are falling off rapidly below 20 MeV. However, we anticipate increased production of N-13. Calculated production of N-13 is 3.17 Ci per day, while average April emissions of BLIP were about 18 Ci per day.

Produced N-13 will **most likely stay in the BLIP cooling water** forming nitrate species such as $^{13}NO^{3-}$. Since we cannot rule out the formation of $^{13}N_2$ completely the BLIP emissions should be monitored closely during the Sc target run.

Conclusion: radioactivity in BLIP air emissions are due nuclides produced in water such as O-15, C-11 and N-13. O-15 has been historically found to be a predominant radionuclide. Production of O-15 from water with 17 MeV protons is low. Due to uncertainty in RbCl density and hence energy upon exiting RbCl targets, as well as potential N-13 production BLIP air emissions may increase at the worst case scenario by 15-17% during Sc target run.