Feasibility Study of a Non-Rad Camera for the SNS* Ring Injection Dump Imaging System (THPP32)

W. Blokland and A. Rakhman, Oak Ridge National Laboratory, Oak Ridge, TN, USA

Introduction

The to-be-upgraded Ring Injection Dump (RID) needs additional diagnostics to steer two waste beam species, leftover from the charge exchanging injection scheme, to the dump.

The two species are referred to as "H^0 beam", which is partially stripped linac H^- beam, and "H^- beam", the beam that misses the primary foil, see figure 1. Both species end up as H+ as they pass through a secondary stripping foil.

We chose to develop an optical imaging system that uses a luminescent coating window, mirrors, an imaging telescope and a camera to measure the beam profiles. To determine if a non-radhard (cheap) camera can survive the radiation we took radiation measurements, added shielding, and tested the camera in the tunnel.

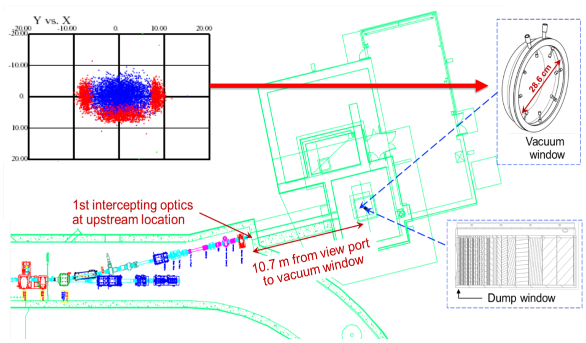


Figure 1. The Ring Injection Dump line along with the calculated projection of beam particles on dump window.

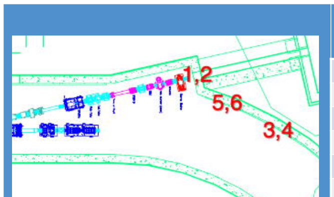
Radiation Environment

We used neutron and gamma dosimeters to get radiation measurements at various locations and estimated the camera survival using CERN HiRadMat results, see [1], to predict camera survival based on HEH (High Energy Hadrons):

- Time to Death (TD) is ~4.8 10^{11} HEH/cm^2 (116-161 Gy)
- Time to Significant Event (TSE) is ~1.5 10^9 HEH/cm^2 (0.36–0.5 Gy)

The locations and results are shown in table 1. Locations 1 (floor) and 2 (above beamline) are preferred for their shorter optical paths. Location 1 doesn't need a supporting structure.

Table 1. The measurement locations and radiation results.



Loca-tion	Total (Gy/MWHr)	Time to Death (HRS)	Time to SE (HRS)
1	0.29	285.27	0.91
2	0.24	339.09	1.09
3	0.04	2246.46	7.20
4	0.05	1797.17	5.76
5	0.08	998.43	3.20
6	0.08	998.43	3.20
7	0.0032	25673.88	82.29

The requirement for the profile measurement is that the system can survive at least a 16-hour study period. While the results indicate that the camera would survive even at 1.4 MW for 1 hour without the need for a reboot, studies typically have higher instantaneous losses and could crash the camera too often.

Shielding was installed to reduce the radiation at the preferred location. Due to the tight space and ease of assembly, we choose to install shielding bricks, see figure 2. The bricks are of stainless steel instead of tungsten to lower the cost.

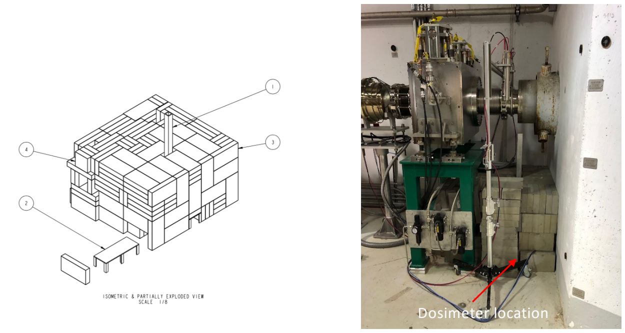


Figure 2. The shielding blocks to lower the radiation.

The shielding lowered the radiation by a factor of 30 (as estimated) and the camera should now last 2 days without crashing at 1.4 MW beam on target, see table 2.

Table 2. Shielded radiation result.

Location	Time to Death (Days)	Time to SE (HRS)
1	479	36.8

Camera testing

To verify the estimates, we installed a camera[1] in the shielded location and observed the camera during an injection dump study.

The bad pixel[2] count along with Beam Loss Monitor losses are shown in figure 3. One can see the sudden increase during high losses events. However the camera did not crash, and bad pixel count reduces during low losses periods.

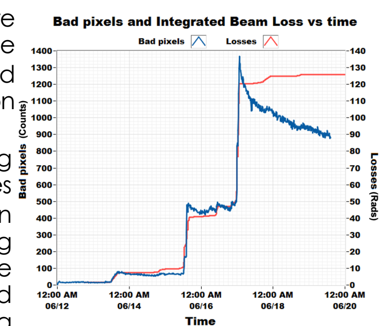


Figure 3. Bad pixel count.

[1] FLIR Blackfly 23S6M-C
[2] Bad pixel is defined as a pixel above a certain pixel value for specific camera

The camera was left in during production to see if a second study of the injection line is possible after a few weeks.

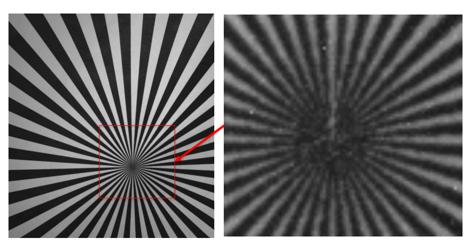


Figure 4. Pie chart image taken with camera after 50 days of 1.4 MW beam on target.

While the camera had to be rebooted many times, the damage pixel count went into the 10,000's of pixels, the image quality is still sufficient for profile analysis, see figure 4.

Conclusions

A non-radhard camera is feasible for the Ring Injection Imaging System and can be used even after running production beam for a while.

REFERENCES:
[1] S. Burger "Scintillation Screens and Optical Technology for transverse Profile Measurements", ARIES-ADA Topical Workshop, Krakow, Poland, April 1 to 3, 2019.

* Spallation Neutron Source