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LANSCE VACUUM SYSTEM IMPROVEMENTS IN THE LAST ~10 YEARS*

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Abstract

The Los Alamos Neutron Science Center (LANSCE) accelerator started its operation in 1972. To mitigate the vulnerability due to old equipment and to restore the 120 Hz operation capability we lost a while ago, we have gone through a refurbishment / risk mitigation project since 2007. This paper summarizes the improvements in the vacuum systems in the last ~10 years and shows some data on downtime caused by vacuum failures. The refurbished equipment is significantly more maintainable and will contribute to extend the life of this old accelerator, but it has been a challenge to reduce the downtime. Some examples that caused a long downtime will be described.

INTRODUCTION

The LANSCE, 800 MeV H+/- accelerator, formerly known as LAMPF (Los Alamos Meson Physics Facility), was proposed by Louis Rosen in the 1960s [1] and constructed at Los Alamos starting from late 1960s [2]. The first 800 MeV beam was achieved in June of 1972 [3].

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A refurbishment project (LANSCE-R) for old and obsolete equipment started in 2007 [4-8]. It was changed later to the Linac Risk Mitigation (LRM) project and NNSA's commitment amounts to \$250M over ~10 years [9]. The major efforts were made for RF systems especially to restore the 120 Hz operation capability [10, 11], but some efforts on vacuum systems were included as well [12].

LANSCE VACUUM SYSTEM

Reference [13] describes the vacuum system for each section of the LANSCE accelerator in detail. The major vacuum pumps being used are ion pumps (500 L/s, 2000 L/s and 2400 L/s) and cryopumps (8-inch and 10-inch flange sizes). Figure 1 summarizes the number of these pumps in each section. Currently, we use a total of 229 ion pumps and 16 cryopumps.

REFURBISHMENT / RISK MITIGATION PROJECT

The detailed plan of the LANSCE-R / LRM project for vacuum systems is described in [13]. Based on the plan, we did the following.

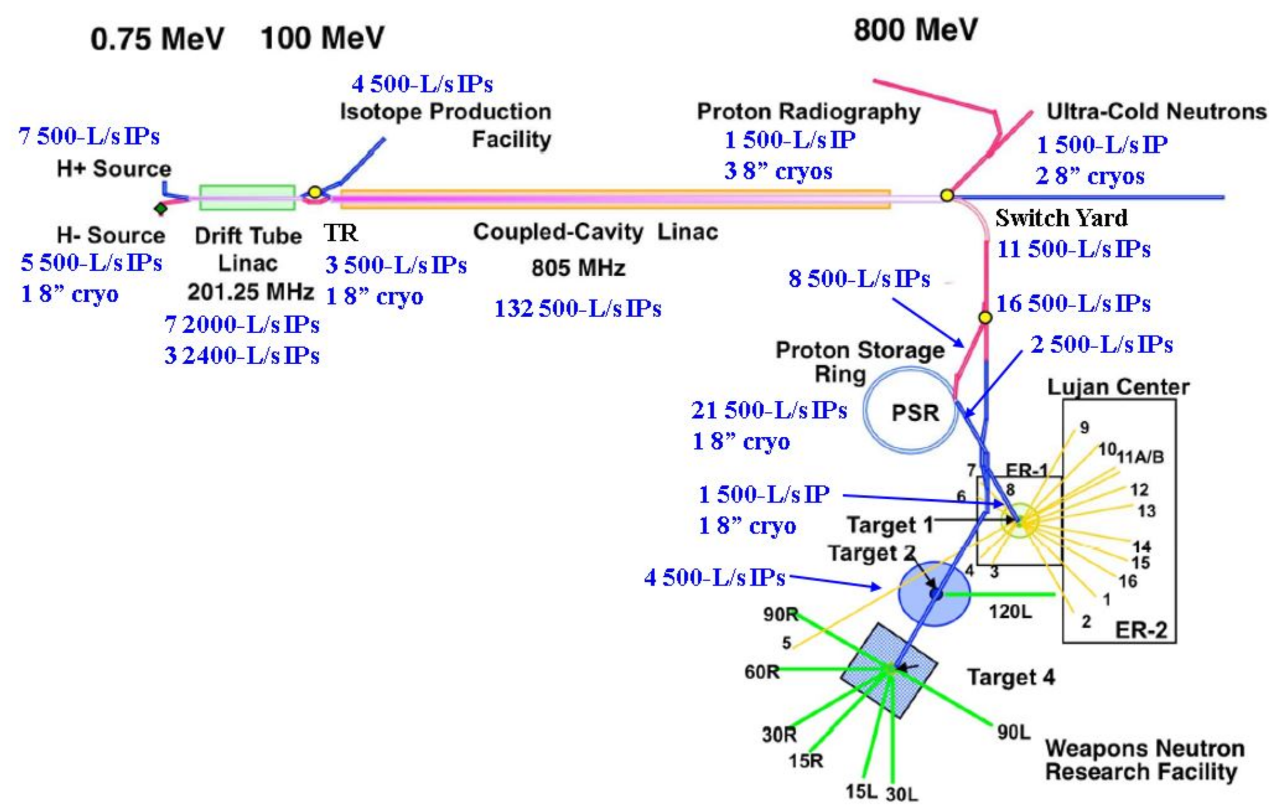

Figure 1: Distribution of ion pumps (IPs) and cryopumps in the LANSCE accelerator complex. (blue letters)

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- Replaced obsolete large and heavy ion pump controllers with modern, light and safer controllers.
- Installed independent chillers to run water-cooled helium compressors for cryopumps in the Drift Tube Linac (DTL) section to mitigate the loss of building cooling water that occurred more often than we expected.
- Installed fast valves to protect the LINAC from experimental areas in case of accidental leaks in the experimental areas.
- Replaced old custom-made inter-module isolation valves with standard off-the-shelf valves in the LINAC and installed some ion gauges between modules.
- Built more portable pumping carts with an air-cooled 1000-L/s turbo pump and a scroll pump that can be strategically distributed along the accelerator.
- Installed RGA sensors at some places where there might be some vacuum issues.

DOWNTIME DATA

At LANSCE, the downtime by each subsystem has been recorded for each experimental area during each run cycle with 1-minute resolution. Table 1 shows a summary of downtime at the Lujan Neutron Scattering Center caused by vacuum problem from 2001 through 2018.

Table 1: Lujan Neutron Scattering Center Downtime due to Vacuum

Run Cycle Year	Sch'ed operation time (h)	Vacuum downtime total (h)	% of ops time	No. of downtimes	Mean outage dur. (min)
2001	2734.8	12.1	0.44	4	45
2002	2972.4	58.5	1.97	43	82
2003	4509.1	191.2	4.24	42	273
2004	3826.5	15.4	0.40	17	54
2005	1437.0	7.0	0.48	8	52
2006	4677.6	28.3	0.60	29	58
2007	3255.2	16.1	0.49	25	39
2008	3532.4	13.3	0.38	10	80
2009	3329.8	16.3	0.49	26	38
2010	3389.9	12.8	0.40	24	32
2011	3358.0	33.3	1.00	43	46
2012	996.0	7.9	0.80	5	94
2013	3395.0	27.7	0.80	40	42
2014	1670.0	9.3	0.56	20	28
2015	2137.0	20.6	0.96	25	49
2016	3145.0	57.0	1.80	22	155
2017	3549.0	216.4	6.10	36	361
2018	4102.5	77.9	1.90	38	123

Figure 2 shows the ratio of downtime to scheduled operation time for each subsystem from 2001 through 2018.

After the LANSCE-R / LRM project, the maintainability increased significantly, e.g., it has become easier to replace failed ion pump controllers and deploy portable pump cart to problem areas, but it has not really reduced the downtime especially in the last 3 years as shown in Table 1.

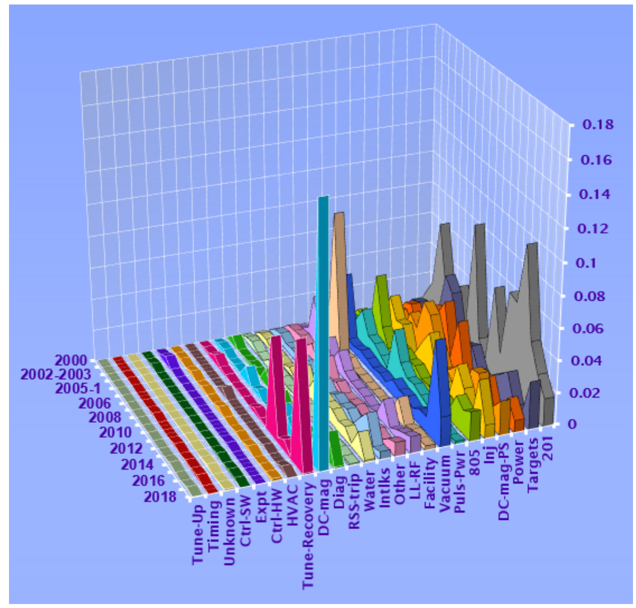

Fig. 2: The ratio of downtime to scheduled operation time for each subsystem.

Major Events that Caused a Long Downtime

In 2017, the downtime due to vacuum was >6 percent as highlighted in Table 1, while it is typically <1 percent. Here, we summarize what caused the long downtimes.

- Increased beam spills due to RF structure phase and amplitude errors [14] caused repeated leaks at an AL seal on a current monitor LDCM01 in the Switch Yard. (5850 minutes total downtime)
- A beam made a small hole on a beam tube in the transition region (TR). (3999 minutes total downtime)
- All 3 ion pumps on a module (M15) tripped repeatedly without a leak. (560 minutes total downtime) We replaced a suspicious pump and it seemed to have solved the problem at that time, but we had a similar incident recently.

AN UPDATE ON THE EMAIL ALERT SYSTEM

In 2006, we developed software to send an email to vacuum team members when any ion pump current exceeds a set point [13]. Initially, this set point was 5 mA (corresponding to ~7E-7 Torr), but over time, we reduced it to 0.5 mA (~7E-8 Torr) for the pumps that show <~0.2 mA and, for the pumps that show >0.5 mA, a set point that is ~0.5 mA above the average current has been set. This way, we have been able to catch the current rise at an early stage and, if it seems to be due to a leak, fix the problem before it becomes a big leak. Our system usually monitors the

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pump current every minute, but it can be reduced to 3 sec if necessary. We sometimes receive quite a few emails due to some ion pumps that exhibit pressure pulses with no practical issues. We plan to modify software to ignore these pulses. To reduce the number of unnecessary emails sent out, if the pump current exceeds more than once within an hour, it sends out an email every hour that shows how many times it exceeded. It might be interesting to develop software that has more intelligence, e.g., categorizes the symptoms and determines what is going on.

FUTURE IMPROVEMENT PLANS

Our next improvement plan includes a development of remote regeneration system for some cryopumps.

We plan to implement such a system for the cryopumps in the Proton Synchrotron Ring (PSR) and 1L Target cell in order to reduce the radiation dose of the workers involved in regenerating the cryopump. This will also be useful if a vacuum failure occurs during run cycle and the area is inaccessible due to too high radiation level.

The next area where we plan to install more cryopumps that can remotely regenerated is the 201 MHz DTL section. These DTL tanks have a very large volume (>10,000 liters) each and cryopumps play a very important role to pump down those tanks to a pressure low enough to turn on ion pumps in a reasonable time when we need to let up the tank for some repair work. Currently, each tank has only one 10-inch size cryopump. We plan to add another 10-inch cryopump to double the pumping speed and implement remote regeneration system on each cryopump so that one cryopump can be regenerated while the other is still running. This way, we will be able to regenerate cryopumps without interrupting the beam operation.

CONCLUSION

A brief summary of what we have done in the last ~10 years as a part of LANSCE refurbishment / risk mitigation project and downtime statistics since 2001 were shown.

While we believe those efforts will lead to a significantly longer life of the accelerator, so far, they have not contributed to a reduction of downtime. Obviously, failures originate from various sources and it is difficult to reduce them quickly.

Nevertheless, we will keep making efforts to improve our system and reduce response time to failuress, and hope that we will be able to reduce the downtime in the long run.

ACKNOWLEDGEMENT

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