Introduction
April 1, 2019 – March 31, 2020

Progress in research and operations at the Texas A&M Cyclotron Institute is summarized in this report for the period April 1, 2019 through March 31, 2020. The period covered by this report includes the onset of the COVID-19 pandemic world-wide and here in Texas. On the16 of March we suspended the SEE line running to establish new procedures to ensure that we could run as safe as reasonably achievable. We also instituted new procedures for the discovery science program that limited access to the operations portions of the building and reduced person density throughout the facility. Late in March all but essential research at the University was shut down. The CI continued to run the radiation effects program due to its importance to national security. I am indebted to the dedicated operations staff that kept the facility running during this challenging period.

TexAT has been fully commissioned and is a valuable device for the discovery science program, including a sensitive measurement of the democratic decay of the Hoyle state. AstroBox II is also producing science, including detection of low energy protons from the β-delayed protons of ^{27}P. AGGIE is fully installed and the characterization of this spectrometer is underway. TAMUTRAP is operational and producing some nice mass measurements. TexNUET is beginning construction. Progress is being made on the DAPPER array.

The Cyclotron Institute continued to explore the capability of producing radioisotopes for medicine, in particular the alpha particle emitter ^{211}At. The K150 cyclotron provided a beam of ^{4}He for the ^{209}Bi(α,2n)^{211}At reaction. Typically, the irradiation takes place overnight, the irradiated target being retrieved after approximately 8 to 12 hours. The irradiated bismuth target is chemically processed, and ^{211}At is separated and counted. Several runs were conducted, the highest quantity of ^{211}At produced in one run being approximately 40 mCi. Cooling the bismuth target, minimizing the handling of the irradiated target, and optimizing the ^{4}He beam will be future priorities in this project.

The Light Ion Guide (LIG) project entered a major upgrade phase: two new chambers were fabricated for easier installation and maintenance of the SPIG (SextuPole Ion Guide). In addition, the capability was added of extracting radioactive ions from the target cell in the direction opposite to the original direction in order to serve the TAMUTRAP project. For this project the production of ^{25}Si, ^{24}Si (proton emitting isotopes), and other isotopes (e.g.^{20}Na, $^{25\text{-}24}$Al) using a ^{3}He beam was successfully attempted using a larger gas cell and with a different extraction geometry. In the trial a ^{3}He beam impinged on an isotopically enriched ^{24}Mg target inside the gas cell and provided confirmation that the LIG can produce quantities of ^{25}Si useful to TAMUTRAP. This was the starting point for the future design of a separator that will purify and transport the radioactive products to the TAMUTRAP location.

The K500 provided an impressive 6416 hours of beam for both science and radiation effects testing. The K150 cyclotron provided 4024 hours of beam on target and continues to be used by external users for radiation effects testing with its proton beams. Additionally, efforts to meet the increasing radiation testing demand are underway by developing a series of 15 MeV/u heavy-ion beams from the K150. Significant effort was devoted during annual maintenance to improve the K150 cyclotron vacuum leading to new intensity records for light ions such as $^{4}He^{+}$ and $^{3}He^{+}$.

As in previous reports, I include here some scientific highlights.

- New constrains on the ^{22}Ne(α,γ) and ^{22}Ne(α,*n*) astrophysical s-factors with significant consequences for the final abundances of the s-process elements were obtained.

- Location of the 2s1/2 shell in ^{9}C has been identified in the ^{8}B+*p* resonance scattering experiment with Texas Active Target.

- First β-delayed charged particle emission measurements were performed with TexAT and the results on Hoyle state branching ratio and half-life were obtained.

- Search for a high-spin (6^{+}) member of the α:2n:α band in ^{10}Be resulted in tight constrains on the partial width for the hypothetical 6^{+} state.

- Determined the shell effect on the nuclear level density within the micro- and macroscopic ensembles method, using the extended Thomas-Fermi approximation, and compared with experimental data.

- State-of-art theory of the surrogate Trojan horse method has been developed, which was applied for the analysis of important resonance astrophysical reactions including carbon-carbon fusion playing a very important role in a wide variety of stellar burning scenarios such as massive stars, type Ia supernovae and superbursts.

Institute scientists remain active in a number of collaborative research efforts around the world. Major programs include: measurements of beta decays with the TRINAT collaboration at TRIUMF; nuclear structure measurements with TexAT at TRIUMF; continued work with the STAR collaboration at RHIC; fusion studies at MSU; and participation in the SAMURAI collaboration at RIBF in Tokyo, Japan.

The format of this report follows that of previous years. Sections I through III contain reports from individual research projects. Operation and technical developments are given in Section IV. Section V lists the publications with Cyclotron Institute authors and outside users and the Appendix gives additional information including talks presented by members of the Institute during the past year. Once again, the full volume of this year's Progress in Research is available only on our web site (http://cyclotron.tamu.edu). *Since most of the contributions presented here are truly reports on progress* *in research, results and conclusions should not be quoted from the report without the consent of the authors.*

I am indebted to Dr. Y.-W. Lui for assembling this report.

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August 15, 2020