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Precision Tests of the Electroweak Interaction Using Trapped Atoms and Ions

Final Technical Report

Period Covered: July 2011 – July 2016

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Report for ER41747: "Precision Tests of the Electroweak Interaction Using Trapped Atoms and Ions"

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In a broad sense, the goal of the project was to develop a two-pronged research program investigating the fundamentaly symmetries of the electroweak interaction via precision β-decay experiments. The major component which needed developing was construction and commissioning of "TAMUTRAP": a unique Penning-trap system to confine proton-rich radioactive ions in an exceptionally open geometry to allow very precise measurements of the angular correlations of their decays. In parallel, atom-trapping techniques were used at the TRIUMF Neutral Atom Trap (TRINAT) facility at TRIUMF to measure polarized correlations in the decay of ^{37}K. Both of these programs aim to test predictions of the standard model of particle physics and search for unexpected effects which would help guide theorists towards developing a more complete model of our universe.

Main objectives of the project and actual accomplishments

Here we provide a summary of the major goals of project and how successful we were. Following this section we discuss in greater detail the successes and difficulties encountered.

1. Design, construct and commission the RFQ cooler/buncher
   The first truly significant milestone of the project was the commissioning of a gas-filled radio-frequency quadrupole Paul trap, used to cool and bunch the ions to allow injection into the Penning trap. This goal was accomplished with a very robust and efficient RFQ which was commissioned in Year II of the project. This would have been completed even earlier, but after testing our first design, we found it was not structurally strong enough; with discussions from other experts and learning from our mistakes, we quickly developed the final version which performs as well as the best RFQs at other Penning trap facilities with a total efficiency of $\geq 65\%$ [1, 2].

2. Design, construct and commission the Penning trap
   The most important and visible objective was to construct the world's largest cylindrical Penning trap to provide a unique facility especially suited for precision experiments on β-delayed proton decays of isospin $T = 2$ superallowed decays. We have accomplished this goal by demonstrating the ability to: trap ions in a novel trap which we designed from first

principles; manipulate the eigenmotions of the trapped ions; and perform mass measurements using the time-of-flight ion-cyclotron-resonance (TOF-ICR) technique.

3. Begin trapping radioactive ions from TREX
   By the end of the project, we expected to have begun trapping radioactive ions in the Penning trap. Unfortunately, this goal was not realized due mainly to delays in the commissioning of the heavy-ion guide (HIG) system [3] at the Cyclotron Institute. We have been prepared to couple our beamlines to the HIG for about 2 years and will do so as soon as the multi-RFQ system is installed following the gas-catcher of the HIG. We clearly have also not been able to test production of the isotopes of interest, but we have performed detailed calculations and benchmarked the cross-sections used in these calculations with reaction studies using the MARS spectrometer at the C.I.

4. Measure the polarized correlation parameters at TRINAT
   The goal for the neutral-atom-trapping component of the project was to measure the β and neutrino asymmetry parameters for ^{37}K to $\lesssim 0.3\%$ precision. Here we were generally successful on a very ambitious goal: after a first measurement with a vastly upgraded system [4], our second beamtime at TRIUMF resulted in a very good data set, culminating in recently submitting a manuscript for publication in *Physical Review Letters* [5, 6] (and we are currently preparing at least another 2 publications for *Physical Review C*). This result – the most precise relative measurement of A_β in any nuclear system, including the neutron – required us to develop novel polarization techniques which allowed us to polarize the nuclei of laser-cooled atoms to 99.13(8)%, as described in Ref. [7]. We have not re-configured our system to be able to measure the neutrino asymmetry or other correlations because we can have a greater scientific impact by first continuing to reduce systematics in the A_β measurement before moving on to measuring the other correlation parameters.

While not all of the goals of the project were accomplished, the major milestones within our control were reached. Next we provide some more details on the activities since the start of the award.

Project activities

TAMUTRAP At the start of the award, our group had just acquired the 210-mm bore, 7-Tesla superconducting magnet for the Penning trap, and had designed the main components of the beamline using SimION. We had secured a dedicated location for the TAMUTRAP facility at the Cyclotron Institute, but no hardware existed at that time. Highlights of each year include:

Year I: We continued with more detailed SimION designs of the beamlines and began to fabricate components of the beamline (steerers, Einzel lens, etc.) for the TAMUTRAP facility. We had started to develop the gas-handling system and tested some of the electronics for the prototype RFQ, which we also built and assembled. M. Mehlman defended his M.Sc.

Year II: We commissioned the prototype RFQ including the rf electronics and gas-handling system (leading to a M.Sc. for Y. Boran), culminating in the ability to transport ions from our offline ion source into the RFQ with $\sim 60\%$ efficiency. We also built a number of beamline elements, including the injection and ejection optics for the RFQ, a spherical deflector and a cylindrical deflector.

Year III: We improved the injection efficiency of the RFQ to $>80\%$, but found the transmission efficiency to be low ($\sim 20\%$ in continuous mode). This led to designing an improved RFQ with much better mechanical stability and alignment. In parallel to this, we performed detailed LISE++ calculations of the radioactive ion beam (RIB) production from the K150 cyclotron. These calculations were validated based on two experiments performed locally using the K500 cyclotron and MARS beamline. We also continued to develop beamline elements and commissioned both the spherical and cylindrical deflectors, demonstrating $>95\%$ efficiency using a MCP beam diagnostic station with a phosphor screen readout.

Year IV: More beamline elements were also commissioned, including Faraday cup and MCP diagnostic stations. Armed with improved imaging of the beam into and out of the RFQ, most of this year was devoted to commissioning and optimizing the improved RFQ. In addition to demonstrating the ability to bunch ions cooled in the RFQ, we showed the RFQ performed better than the design specifications: $\sim 70\%$ transmission efficiency and a <2.0 μs time spread of the bunched ions. Two more experiments were performed to validate the RIB production calculations, and a GEANT simulation of the TAMUTRAP facility was initiated[1]. We also began designing the prototype Penning trap, which at half the size (90 mm diameter) is nevertheless the world's largest Penning trap. M. Mehlman defended his Applied Physics Ph.D.

Year V: We completed optimization of the RFQ and implemented the pulsing cavity prior to the Penning trap magnet to provide complete control of the beam energy when loading the trap, down to tens of keV. We built a field-mapping system and characterized the field of the 7-T solenoid in all three dimensions. We also built an electron-gun system to precisely align the magnetic field of the solenoid with the beamline axis. We completed construction of the prototype Penning trap (see Fig. 1) and installed it in the magnet. The beamlines were completed from just above the shielding blocks (above the HIG, which we are ready to couple to as soon as it is ready) all the way to the trap. Figure 2 shows the TAMUTRAP facility as of the end of this period.

Immediately following the end of the award period, in Sep. 2016, we trapped our first ions and quickly showed we could confined them for long periods ($\gtrsim 30$ s). Since then, we have demonstrated the ability to load cooled and bunched ions from the RFQ, excite the magnetron motion of the trapped ions, and, as shown in Fig. 1, the ability to excite the cyclotron resonance and perform mass measurements. The width of 80 Hz using just a 10 ms excitation time represents a mass-resolving power of 3×10^{-5}; this will improve by at least an order of magnitude once we align our field and increase the excition period.

TRINAT The TRINAT facility has a mature program which still boasts the world's best measurement of the β-ν correlation parameter in a superallowed β decay. Only a modest amount of direct financial support from the award was used for this project for travel to conferences and publication of the polarization result in the New Journal of Physics; in addition, significant amounts of time from the PI and Dr. Shidling (both supported in part by this award) were used to work on this effort and guide the two graduate students involved in this project. Given this fact, we only briefly summarize the main results from this research effort in less detail than for TAMUTRAP above.

[1]This effort has been put on hold when we lost the two graduate students who were going to lead this effort. A new graduate students has recently joined the group who will start by developing a detailed GEANT simulation of the facility and experiment.

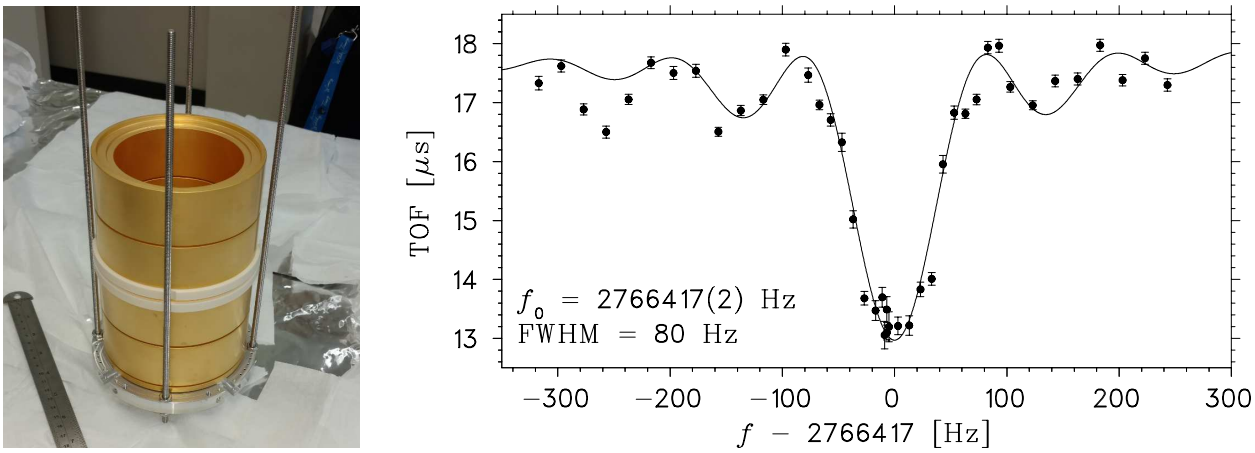

Figure 1: The prototype Penning trap (left) and TOF-ICR curve (right) demonstrating the abililty to perform mass measurements with the TAMUTRAP facility. Here we show the TOF of initially trapped ^{39}K ions from our offline ion source as a function of the applied rf frequency. The sidebands of this curve are not symmetric as expected, which is likely a result of a small misalignment of the magnetic and electric fields and the relatively poor vacuum of 1×10^{-7} mbar. Both of these issues will be easily remedied with an existing field-alignment system and more careful attention paid to attaining an ultra-high vacuum.

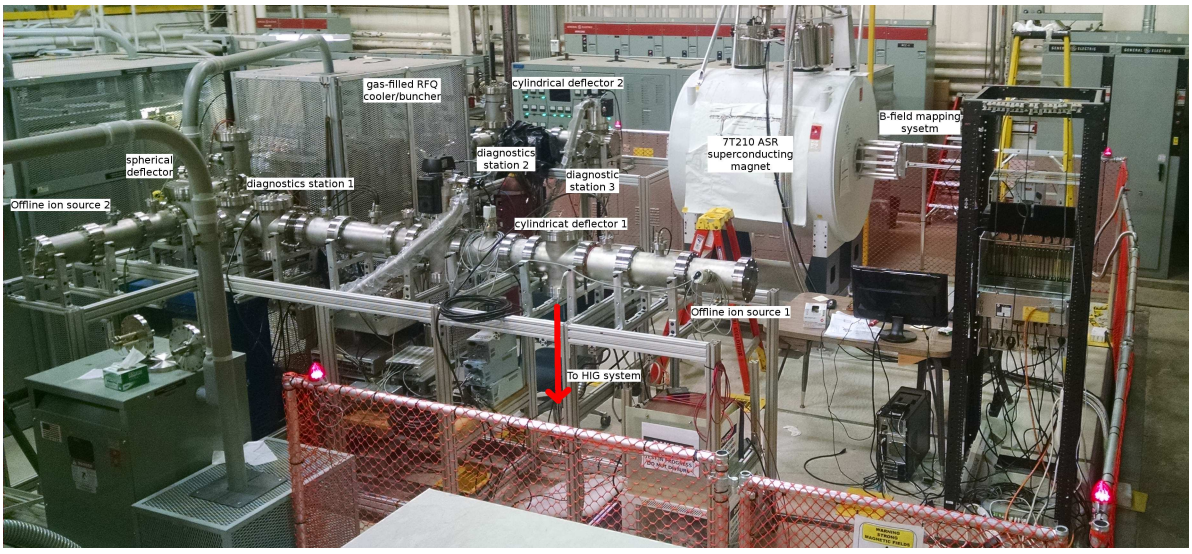

Figure 2: Picture of the high bay showing the beamlines and magnet of the TAMUTRAP station three months before the end of the award period. The majority of the equipment shown, not including the magnet, was acquired via this award. The major components of the layout are labelled and have all been commissioned. Many smaller components (Einzel lenses, steerers, pulsing cavities, gas-handling system, pumps, etc.) are not hightlighted but are nevetheless present and commissioned.

At the start of the award, we were in the process of designing the new measurement chamber of the TRINAT facility to allow for highly polarizing the laser-cooled atoms, and setting up two identical β telescopes along the polarization axis. Both of these developments were critical for a precision measurement of the β asymmetry parameter. Concurrently with this and other hardward developments, we created a very detailed GEANT simulation of the experiment both to help guide our design specifications as well as to analyze data we collected in two experimental runs. Our group took the lead role in the nuclear detectors (both creating the β-telescopes, associated electronics and data acquisition/analysis) and the modelling of the optical pumping process to extract the cloud polarization. Our first experiment with the new system was unfortunately unable to deduce an independent measurement of the polarization; it therefore didn't lead to a publication although the first graduate student was able to defend his Ph.D. based on the results. Soon after correcting some of the dominant sources of systematics, we performed a longer 2^{nd} experiment at TRIUMF givind B. Fenker his Ph.D. data. Two very significant results came out of this work: a very precise measurement of the nuclear polarization of the laser-cooled atoms (99.13(8)%) [7], and a measurement of the β-asymmetry parameter to 0.3% [5]. Both are world-class results and future publications are planned.

References

[1] M. Mehlman et al. Status of the TAMUTRAP facility and initial characterization of the RFQ cooler/buncher. *Hyperfine Interactions*, 235(1):77–86, 2015.

[2] M. Mehlman. *Development of the TAMUTRAP Facility for Precision Beta-Decay Studies*. PhD thesis, Texas A&M University, 2015.

[3] A proposed facility upgrade for the Texas A&M University Cyclotron Institute, Aug 2001. https://cyclotron.tamu.edu/facilities/upgrade/.

[4] R. S. Behling. *Measurement of the Standard Model Beta Asymmetry Parameter, A_β in ^{37}K*. Ph.D. Thesis, Texas A & M University, 2015.

[5] B. Fenker et al. arXiv:1706.00414, 2017.

[6] B. Fenker. *Precise measurement of the β asymmetry in the decay of magneto-optically trapped, spin-polarized ^{37}K*. PhD thesis, Texas A&M University, 2016.

[7] B. Fenker et al. Precision measurement of the nuclear polarization in laser-cooled, optically pumped 37 k. *New Journal of Physics*, 18(7):073028, 2016.

Personnel

The personnel on the project that was funded by the Early Career Award were consistently the P.I. (two months summer salary), Dr. Praveen Shidling (post-doctoral researcher promoted to assistant research scientist; 50%) and one graduate student (mostly M. Mehlman, 9 months to E. Bennett upon Dr. Mehlman's graduation; 100%). In addition, not funded by this award but working on this research, were graduate students, R.S. Behling, B. Fenker and J. Patti, who were either funded by teaching assistantships (only one fall and one spring semester) before being brought on as a research assistant using the main Cyclotron Institute grant, DE-FG02-93ER40773. We have also borrowed expertise from many of the local staff and visitors, particularly R.E. Burch (controls), Dr. Ania Kwiatkowski (new hire, trapping expert), Dr. Tommi Eronen (visitor, trapping expert), the CI design shop (particularly S. Molitor) and the CI machine shop.

Student tracking

All of the following were active members of the P.I.'s group during the course of the award. All students except Y. Boran and J. Patti have one academic year (fall and spring semesters) funded as teaching Assistants, but otherwise the funding is as indicated. Not shown are the 15 undergraduate students who have worked with the PI on the research of this award (REUs, international internships and Texas A&M undergrads).

Name	Department	Year joined		Graduate Degree(s)		Funding source
		dept	PI's group	awarded	expected	
R.S. Behling	Chemistry	Sep 2008	Jan 2009	Ph.D. 2015		C.I. grant
M. Mehlman	Physics	Sep 2009	Jan 2010	M.S. 2012, Ph.D. 2015		ER41747
B. Fenker	Physics	Sep 2010	Jan 2011	M.S. 2013, Ph.D. 2016		C.I. grant
Y. Boran	Physics	Sep 2011	Jan 2012	M.S. 2013		Gov't of Turkey
E. Bennett	Physics	Sep 2014	Jun 2015		N/A*	ER41747
J. Patti	Physics	Sep 2015	Sep 2015		N/A†	C.I. grant

*Mr. Bennett and I decided it would be best if he switched to another research group, Dr. G. Christian's, effective May 1, 2016.

†Mr. Patti decided to pursue his start-up company instead of continuing with graduate studies, effective July 15, 2016.

Publication and Presentations from the PI's group directly related to the award

Refereed Publications:

1. B. Fenker *et al.*, "*Precision measurement of the β asymmetry in spin-polarized ^{37}K*," Submitted to Physical Review Letters (arXiv:1706.00414). D. Melconian, R.S. Behling, M. Mehlman and P.D. Shidling are co-authors.

2. B. Fenker *et al.*, "*Precision measurement of the nuclear polarization in laser-cooled, optically-pumped ^{37}K*," New Journal of Phyics **18**, 073028 (2016), DOI: 10.1088/1367-2630/18/7/073028. D. Melconian, R.S. Behling, and M. Mehlman are co-authors.

3. B.E. Glassman *et al.*, "*Revalidation of the isobaric multiplet mass equation for the $A = 20$ quintet*," Physical Review C **92**, 042501(R) (2015), DOI: 10.1103/physrevc.92.042501. P.D. Shidling is a co-author.

4. P.D. Shidling *et al.*, "*Precision half-life measurement of the β^+ decay of ^{37}K*," Physical Review C **90**, 032501(R) (2014), DOI: 10.1103/physrevc.90.032501. Chosen as an *Editor's Suggestion* and highlighted as a *Physics Synopsis*. D. Melconian, R.S. Behling, B. Fenker and M. Mehlman are co-authors.

5. M. Mehlman *et al.*, "*Design of a unique open-geometry cyclindrical Penning trap*," Nucl. Instrum. and Meth. Phys. Res. **A712**, 9 (2013), DOI: 10.1016/j.nima.2013.02.004. P.D. Shidling, R.S. Behling, L.G. Clark, B. Fenker and D. Melconian are co-authors.

6. C. Wrede *et al.*, "*γ-ray constraints on the properties of unbound ^{32}Cl levels*," Physical Review C **86**, 047305 (2012), DOI: 10.1103/physrevc.86.047305. D. Melconian is a co-author.

7. D. Melconian *et al.*, "*β decay of ^{32}Cl: Precision γ-ray spectroscopy and a measurement of isospin-symmetry breaking*," Physical Review C **85**, 025501 (2012), DOI: 10.1103/physrevc.85.025501.

Refereed Conference Proceedings:

1. D. Ashery *et al.*, "*Physics beyond the standard model with trapped atoms in the LHC era*," XXX Workshop in Particle Physics, Il Nuovo Cimento **39C**, 346 (2017), DOI: 10.1393/ncc/i2016-16346-2. R.S. Behling, B. Fenker and D. Melconian are co-authors.

2. M. Mehlman *et al.*, "*Status of the TAMUTRAP facility and initial characterization of the RFQ cooler/buncher*," Proceedings of the 6$^{\text{th}}$ International Conference on Trapped Charged Particles and Fundamental Physics (TCP 2014), Hyperfine Interactions **235**, 77 (2015), DOI: 10.1007/s10751-015-1187-z. P.D. Shidling, R. Burch, E. Bennet, B. Fenker and D. Melconian are co-authors.

3. A. García, *et al.*, "*Decay studies for neutrino physics: Electron capture decays of ^{100}Tc and ^{116}In*," Hyperfine Interactions **223**, 201 (2012), DOI: 10.1007/s10751-012-0619-2. D. Melconian is a co-author.

4. D. Melconian *et al.*, "*Progress towards precision measurements of beta-decay correlation parameters using atom and ion traps*," Proceedings of the X$^{\text{th}}$ Latin American Symposium on Nuclear Physics and Applications (LASNPA), Proceedings of Science **X LASNPA**, 010 (2014), arXiv:1408.1648. R.S. Behling, B. Fenker, M. Mehlman and P.D. Shidling are co-authors.

5. J.A. Behr *et al.*, "*TRINAT: measuring β-decay correlations with laser-trapped atoms*," ISAC and ARIEL: the TRIUMF Radioactive Beam Facilities and the Scientific Program, Hyperfine Interactions **225**, 115 (2014), DOI: 10.1007/s10751-013-0887-5. R.S. Behling, B. Fenker and D. Melconian are co-authors.

6. D. Melconian, "*Isospin-symmetry-breaking effects in nuclear β decay*," Conference on the Intersections of Particle and Nuclear Physics, AIP Conference Proceedings **1560**, 604 (2013), DOI: 10.1063/1.4826852.

7. P.D. Shidling *et al.*, "*TAMUTRAP facility - program for the study of fundamental weak interaction*," Proceedings of the DAE Symposium on Nuclear Physics **57**, 155 (2012), URL: https://inis.iaea.org. M. Mehlman, D. Melconian, R.S. Behling and B. Fenker are co-authors.

8. P.D. Shidling *et al.*, "*Precise life-time measurement of the T=1/2 mirror β transitions*," Proceedings of the DAE Symposium on Nuclear Physics **57**, 580 (2012), URL: https://inis.iaea.org. D. Melconian, R.S. Behling, M. Mehlman and B. Fenker are co-authors.

9. D. Melconian *et al.*, "*The β^+ decay of ^{37}K as a multi-faceted probe of fundamental physics*," 2$^{\text{nd}}$ International Ulaanbaatar Conference on Nuclear Physics and Applications, AIP Conference Proceedings **1342**, 53 (2011), DOI: 10.1063/1.3583167. R.S. Behling, M. Mehlman and P. Shidling are co-authors.

Other Papers:

1. B. Fenker, Phys. Ph.D. Thesis: "*Precise measurement of the β asymmetry in the decay of magneto-optically trapped, spin-polarized ^{37}K*," Texas A&M University (2016), URL: hdl.handle.net/1969.1/158988.

2. M.S. Mehlman, App. Phys. Ph.D. Thesis: "*Development of the TAMUTRAP facility for precision β-decay studies*," Texas A&M University (2015), URL: hdl.handle.net/1969.1/155215.

3. R.S. Behling, Chem. Ph.D. Thesis: "*Measurement of the standard model beta asymmetry parameter, A_β, in ^{37}K*," Texas A&M University (2015), URL: hdl.handle.net/1969.1/155337.

4. D. Melconian, "*β decay using atom and ion traps*," arXiv:1205.2671, contribution to a White Paper resulting from the Workshop on Fundamental Physics at the Intensity Frontier, Nov 30–Dec 2, 2011, Rockville, Maryland.

Invited Talks:

1. D. Melconian: Tel Aviv University, Tel Aviv, Israel (Apr 2017, colloquium) "*Fundamentally cool physics with trapped atoms and ions.*"

2. D. Melconian: American Physical Society – Division of Nuclear Physics (APS-DNP) Conference, Vancouver, Canada (Oct 2016, invited) "*Status of the Cyclotron Institute Upgrade (and current research.*"

3. D. Melconian: High Sensitivity Experiments Beyond the Standard Model, Quy Nhon, Vietnam (Aug 2016, invited) "*Probing fundamental symmetries via precision correlation measurements of β decay.*"

4. D. Melconian: The 6^{th} International Conference on Trapped Charged Particles and Fundamental Physics (TCP 2014), Takamatsu, Japan (Dec. 2014, invited) "*A new correlation Penning trap for fundamental physics as Texas A&M.*"

5. P.D. Shidling: American Physical Society – Division of Nuclear Physics (APS-DNP) Conference, Waikoloa, HA (Oct. 2014, invited) "*TAMUTRAP: an ion trap facility for weak interaction and nuclear physics studies.*"

6. D. Melconian: Solvay workshop on *Beta-decay weak interaction studies in the era of the LHC*, Brussels, Belgium (Sep. 2014, invited) "*Measurements of correlations in β decay using laser and ion traps.*"

7. D. Melconian: The 15^{th} International Symposium on Capture Gamma-Ray Spectroscopy and Related Topics (CGS 15), Dresden, Germany (Aug. 2014, invited) "*β-decay correlation measurements using ion and laser traps.*"

8. D. Melconian: University of Notre Dame Nuclear Physics Laboratory, Notre Dame, IN (Feb. 2014, seminar) "*Probing properties of the weak interaction using trapped atoms and ions.*"

9. D. Melconian: X Latin American Symposium on Nuclear Physics and Applications, Montevideo, Uruguay (Dec. 2013, invited) "*Precision measurements of β-decay correlation parameters from trapped atoms and ions.*"

10. D. Melconian: National Superconducting Laboratory, Michigan State University, East Lansing, MI (Nov. 2013, seminar) "*Precision β-decay studies using trapped atoms and ions.*"

11. D. Melconian: Texas A&M University, College Station, TX (Oct. 2013, colloquium) "*Fundamentally cool physics with trapped atoms and ions.*"

12. P. Shidling: DAE Symposium on Nuclear Physics, Delhi University, New Delhi, India (Dec 2012, invited) "TAMU-TRAP facility for weak interaction physics."

13. D. Melconian: 7^{th} International Workshop on the CKM Unitarity Triangle, Cincinnati, OH (Sep 2012, invited) "The state of the art for extracting V_{ud} from nuclear β-decay."

14. P.D. Shidling: Inter University Accelerator Centre, New Delhi, India (June 2012, invited seminar) "*TAMUTRAP facility for weak interaction physics.*"

15. D. Melconian: 2012 Congress of the Canadian Association of Physicists, Calgary, AB (June 2012, invited) "*Polarized beta decay observables from laser-cooled atoms: progress and prospects for fundamental symmetry tests.*"

16. D. Melconian: The 11^{th} Conference on the Intersections of Particle and Nuclear Physics, St. Petersburg, FL (May 2012, invited) "*Isospin-symmetry-breaking effects in nuclear beta decay.*"

17. D. Melconian: April APS Meeting, Atlanta, GA (Apr 2012, invited) "*Isospin-symmetry-breaking effects in nuclear β decay.*"

18. D. Melconian: XXXII Mazurian Lakes Conference on Physics, Piaski, Poland (Sep 2011, invited) "*Physics with stopped beams at the TAMUTRAP facility.*"

Thesis defenses:

1. B. Fenker: Doctor of Philosophy presentation, Texas A&M University, College Station, TX (July 2016, thesis defense) "*Precise measurement of the β asymmetry in the decay of magneto-optically trapped, spin-polarized ^{37}K.*"

2. M. Mehlman: Doctor of Philosophy presentation, Texas A&M University, College Station, TX (Mar. 2015, thesis defense) "*Development of the TAMUTRAP facility for precision β-decay studies.*"

3. R.S. Behling: Doctor of Philosophy presentation, Texas A&M University, College Station, TX (Feb. 2015, thesis defense) "*Measurement of the standard model beta asymmetry parameter, A_β, in ^{37}K.*"

4. Y. Boran: Master of Science presentation, Texas A&M University, College Station, TX (July 2013, thesis defense) "*Design and commissioning of an off-line ion source for TAMUTRAP.*"

5. B. Fenker: Master of Science presentation, Texas A&M University, College Station, TX (Apr 2013, thesis defense) "*Measurement of asymmetry parameters in ^{37}K: Optical pumping of alkali atoms.*"

6. M. Mehlman: Master of Science presentation, Texas A&M University, College Station, TX (Apr 2012, thesis defense) "*Design of an open-geometry Penning trap,.*"

Contributed Talks:

1. D. Melconian: April Meeting of the American Physical Society, Washington D.C. (Jan 2017, contributed) "*Precision measurement of the positron asymmetry of laser-cooled, spin-polarized ^{37}K.*"

2. B. Fenker: American Physical Society – Division of Nuclear Physics (APS-DNP) Conference, Vancouver, Canada (Oct 2016, contributed), "*Precise measurement of the positron asymmetry in the decay of spin-polarized ^{37}K.*"

3. D. Melconian: American Physical Society – Division of Nuclear Physics (APS-DNP) Conference, Vancouver, Canada (Oct 2016, contributed), "*Status of the TAMUTRAP facility at Texas A&M Univerity.*"

4. B. Fenker: The 6$^{\text{th}}$ International Symposium on Symmetries in Subatomic Physics (SSP 2015), Victoria, BC (Jun 2015), "*Measurement of the nuclear polarization in optically-pumped ^{37}K: Progress towards a measurement of the β-asymmetry parameter.*"

5. M. Mehlman: The 6$^{\text{th}}$ International Conference on Trapped Charged Particles and Fundamental Physics (TCP 2014), Takamatsu, Japan (Dec. 2014, contributed) "*Current status of the TAMUTRAP facility.*"

6. M. Mehlman: APS – Texas Section 2014 Fall Meeting, College Station, TX (Oct. 2014, contributed) "*Current status of the TAMUTRAP facility.*"

7. P.D. Shidling: American Physical Society – Division of Nuclear Physics (APS-DNP) Conference, Waikoloa, HA (Oct. 2014, contributed) "*Half-life and branching ratio measurements of $T = 1/2$ mirror nuclei.*"

8. B. Fenker: American Physical Society – Division of Nuclear Physics (APS-DNP) Conference, Waikoloa, HA (Oct. 2014, contributed) "*Measurement of the β-asymmetry in the decay of magneto-optically trapped, spin-polarized ^{37}K.*"

9. P.D. Shidling: APS-DNP Meeting, Newport News, VA (Oct. 2013, contributed) "*Report on the current status of the TAMUTRAP facility.*"

10. R.S. Behling: APS-DNP Meeting, Newport News, VA (Oct. 2013, contributed) "*Report on the measurement of the beta asymmetry parameter, A_β, of ^{37}K.*"

11. B. Fenker: Texas Section of the APS Meeting, Brownsville, TX (Oct. 2013, contributed) "*Nuclear spin polarization of $^{37,41}K$ by optical pumping.*"

12. R.S. Behling: ISAC Science Forum, TRIUMF, Vancouver, BC (Dec 2012, invited progress report) "*^{37}K beta asymmetry.*"

13. P. Shidling: DAE Symposium on Nuclear Physics, Delhi University, New Delhi, India (Dec 2012, contributed) "*Precise lifetime measurements of $T = 1/2$ nuclei.*"

14. M. Mehlman: The 11$^{\text{th}}$ Conference on the Intersections of Particle and Nuclear Physics, St. Petersburg, FL (May 2012, contributed) "*Texas A&M Penning trap facility – program for the study of the fundamental weak interaction (TAMUTRAP).*"

15. A total of 6 undergraduates made oral presentations at the Cyclotron Institute at the end of each summer REU program.

Outreach Presentations:

1. D. Melconian: "Pizza and Profs" presentation for the Texas A&M University Honors Program, Texas A&M University, College Station, TX (Apr. 2015) "*Nuclear physics with trapped atoms and ions.*"

2. D. Melconian: Saturday Morning Physics lecture (for a general audience), Texas A&M University, College Station, TX (Feb 2013) "*Nuclear physics with trapped atoms and ions.*"

3. D. Melconian: Talk for students of the Research Experience for Undergraduates (REU) program, Cyclotron Institute, Texas A&M University, College Station, TX (Jul 2012) "*Weak (and ridiculously weak) interactions as tests of fundamental physics.*"

Poster Presentations:

1. K. Marble: APS-DNP Meeting, Vancouver, Canada (Oct. 2016) "*The cleaning, assembling, and testing of a unique open-ended cylindrical Penning trap (TAMUTRAP).*"

2. E.A. Bennett: APS-DNP Meeting, Newport News, VA (Oct. 2013) "*Transport efficiency of a cylindrical deflector for TAMUTRAP.*"

3. R.S. Behling: Summer Nuclear Institute at TRIUMF, TRIUMF, Vancouver, BC (Jul 2012) "*Update of the ^{37}K β-asymmetry experiment.*"

4. M. Mehlman: Exotic Beam Summer School 2012, Argonne National Laboratory, Argonne, IL (Aug 2012) "*Optimization of Penning Trap Geometry.*"

5. Erin France (REU student): APS DNP Meeting, East Lansing, MI (Oct 2011) "*Optimization of a scintillator for the measurement of positrons from trapped, polarized* ^{37}K."

6. A total of 6 undergraduate poster presentations at the yearly TAMU REU poster presentation.