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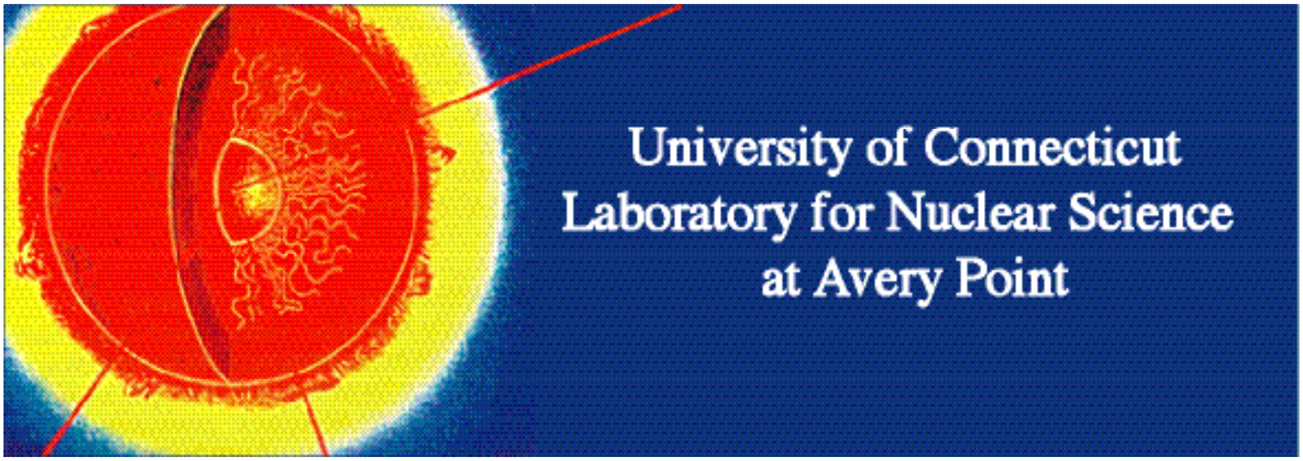

STATUS REPORT
2005-2006
(Two Year Period)

Laboratory for Nuclear Science
at Avery Point
University of Connecticut

USDOE Grant No: DE-FG02-94ER40870

Principal Investigator: Moshe Gai

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1.1 Abstract

Our research program encompasses studies in Low Energy Nuclear Astrophysics (and some studies in Weak Interactions) with emphasis on **High Sensitivity Experiments** in Search of Rare Decays or Rare Processes that are critical for our understanding of stellar processes and the detection of Dark Matter (DM). Our research program in Nuclear Astrophysics concentrates on stellar evolution: helium burning prior to supernova and the ^{8}B and ^{7}Be solar neutrino flux calculated in the standard solar model. We carry out a research program at the Wright Nuclear Structure Laboratory (WNSL) at Yale University and at the Triangle University Nuclear Laboratory (TUNL) at Duke University that we consider as our main user labs. We collaborate with colleagues at Yale, at Duke, at the Weizmann Institute of Science, Israel, at the PTB at Braunschweig, Germany, and the Catholique University at Louvain-La-Neuve, Belgium, to develop an Optical Readout Time Projection Chamber (O-TPC) detector to be used at the HIγS facility to study the formation of oxygen during helium burning. We collaborate with colleagues at Yale University and in the Instrumentation Division at Brookhaven National Lab on developing a low background (Cirlex-THGEM) charge readout for use in a two phase (Liquid/Gas) Xenon TPC detector for a search for Dark Matter that will be located at the Deep Underground Science and Engineering Lab (DUSEL).

1.2 Personnel and Facilities:

Faculty and Staff:

Moshe Gai, Professor of Physics, **PI**
Leonid Weissman, Ph.D, (50%)
James E. McDonald, Assistant Professor, University of Hartford
Ralph H. France III, Assistant Professor, Georgia CSU, Milledgeville, GA

Students:

Tristan J. Kadings (UConn)
Emily E. Kading (UConn)
George F. Burkhard (Yale)
Daniel A.R. Rubin (Yale)
Taritree Wongjirad (Yale)

International Collaborators and Visitors:

Yale University (and WNSL)	Professor Moshe Gai
	Professor Daniel McKinsey
TUNL/Duke University	Professor Henry Weller
North Georgia College and State University	Professor Richard Prior
Weizmann Institute, Israel	Professor Amos Breskin
	Dr. Rachel Chechik
PTB/Braunschweig, Germany	Dr. Volker Dangendorf
Louvain-La-Neuve, Belgium	Professor Thierry Delbar
Brookhaven National Lab	Dr. Veljko Radeka

1.3 Preamble:

With the completion of our (1300 square feet) Laboratory on the campus of the University of Connecticut at Avery Point (**http://astro.uconn.edu**) our students and post doc embarked on the research program funded by the US Department of Energy. Our newly constructed lab represents a major (approximately $300,000) investment by the University of Connecticut which allowed for an expansion of our research in detector development and Time Projection Chamber (TPC) technology. We now collaborate with the Instrumentation Division of Brookhaven National Lab, TUNL at Duke and people at Yale and WNSL at Yale, as well as with the Weizmann Institute in Israel, the PTB in Germany, and the Cyclotron Lab at Louvain-La-Neuve. The first post doc (2005) that worked in our new lab at Avery Point, Dr. Leonid Weissman, moved on to a permanent research position at the Soreq Nuclear Center in Israel, and we are searching for his replacement. **Dr. Weissman joins a proud long list of talented graduate students and post docs that graduated from our lab and found permanent employment in Academe:** James E.R. McDonald (Ph.D. 2001) is currently an Assistant Professor at the University of Hartford, Ralph. H. France III (post doc 2002) is an Assistant Professor at the Georgia College and State University with a pending tenure decision, Stephen O. Nelson (post doc, 2003) is an Assistant Professor at the University of Texas, and Edward L. Wilds (Ph.D. 1995) is the Director of the Connecticut Office of Radiation Safety. Our only Master student, Rebecca A. Jarvis (M.Sc. 2000) has completed a Ph.D. in Bio-Engineering at UConn and is employed by a Health Management Organization in Connecticut. Our undergraduate student from Avery Point, Tristan J. Kading (B.S. 2007) eagerly anticipates acceptance to the graduate Geophysics program at Yale University and our undergraduate student at Yale (B.S. 2006), George F. Burkhard is already enrolled in the graduate Physics program at Stanford. All our undergraduate students at UConn and at Yale participated in the CEU program of the Division of Nuclear Physics and after graduation moved to graduate Physics programs throughout the country.

Fig. 1: Members of the LNS and international visitors during October 6-7, 2006, collaboration meeting at Avery Point. From left to right: Delbar, Weller, France, Weintraub, McDonald, Bromberger, Gai, Mohammad, Tittelmeier, Dangendorf and Emily Kading at the top.

Our experimental program on precision measurements of inputs to the Standard Solar Model has come to fruition with the publication in the Physical Review C (and previously in the Physical Review Letters) of the study performed at GSI of the Coulomb Dissociation (CD) of ^{8}B to measure the ^{7}Be(p,γ)^{8}B reaction. The measurement at GSI serves as a clear demonstration (in fact a triumph) of the CD method since it agrees with the most recent Weizmann and Seattle direct capture measurements, but it preceded these measurements by three years. We commenced a new program at TUNL for precision measurement of the direct capture gamma-ray of the $^{3}He(\alpha,\gamma)^{7}Be$ reaction using an implanted ^{3}He target. Our technique for fabricating implanted helium target has been published in the (new) Journal of Instrumentation and we demonstrated the usefulness of such a target for a measurement of the cross section of the $^{3}He(\alpha,\gamma)^{7}Be$ reaction.

We made significant progress in our program for the study of the $^{12}C(\alpha,\gamma)^{16}O$ reaction at the TUNL/High Intensity Gamma Source (HIγS) facility and we anticipate first in beam experiment during the Spring of 2007. In this study the inverse reaction, the photodissociation of ^{16}O, will be measured using an Optical Readout Time Projection Chamber (O-TPC) detector containing CO_2 as the target. A study with a prototype O-TPC detector has been completed and published in the (new) Journal of Instrumentation. The O-TPC detector itself was already constructed and is being tested at our lab at Avery Point. Two complete optical readout chains from the CERN-CHORUS neutrino experiment with the necessary (40 channels) high voltage power supply were given to the collaboration by the UCL at Louvain-La-Neuve (a cost savings of approximately $150,000). One chain was tested at PTB and the second one was tested at the LNS at Avery Point and they have been incorporated into the readout of our O-TPC. After the completion of tests at the LNS at Avery Point and measurements of tracks from alpha-particles from an ^{241}Am, the detector will be transferred and installed at the HIγS at TUNL and be ready for the first in beam experiment. An international collaboration meeting was held at the LNS at Avery Point on October 6-7, 2007, see Fig. 1, at which time beam readiness was reviewed and plans were made for beam time in the Spring of 2007.

Our expertise in TPC technologies and with the use of Thick Gas Electrom Multipliers (THGEM) led us to a new collaboration with Yale University and Brookhaven National Lab for developing a low background readout of a two phase xenon TPC for a search of Dark Matter. The pilot program for this new studies was originally funded by a grant from the Yale-Weizmann collaboration awarded to the PI as an adjunct Professor at Yale. We are now applying for additional funds from the Yale-Weizmann program as well as from the Detector Development program of the Deep Underground Science and Engineering Lab (DUSEL). People funded by the current DOE grant are involved in this study of the LNS at Avery Point.

2.1 The Construction of the O-TPC for the Study of the $^{16}O(\gamma,\alpha)^{12}C$ Reaction (UConn)

M. Gai, T.J. Kading, L. Weissman, (UConn), G.F. Burkhard (Yale), A. Breskin, R. Chechik (Weizmann), V. Dangendorf, K. Tittelmeier (PTB-Braunschweig), Th. Delbar (UCL), M.W. Ahmed, H.R. Weller (Duke/TUNL), Ralph H. France (GCSU), and J.E. McDonald (UHartford).

We completed the construction of the Optical Readout Time Projection Chamber (O-TPC) for the study of the $^{16}O(\gamma,\alpha)^{12}C$ reaction with real photons at the HIγS facility at TUNL [1]. First tests of the O-TPC at the LNS with 250 torr gas pressure (so as to stop in the fiducial volume the 5.5 MeV alpha particles from the ^{241}Am source) demonstrate sufficient (of the order of 10^4) charge gain and good energy resolution. The observed stopped alpha-particle peak width is in fact equal to the energy spread of the sealed source (approximately 10%) and no significant contribution from the O-TPC could be measured. The performance of the O-TPC is as expected based on our measurement [2] with the smaller (10 cm diameter) prototype detector. We also completed the construction of all the optical components of the O-TPC and the optical readout shown in Fig. 1, as we report below in this status report. In Figs 2, 3 and 4 we show the design concept of support structure of the O-TPC at the HIγS facility at TUNL, and the O-TPC detector in various stages of construction and test at the LNS at Avery Point.

The design goal of the experiment is to measure the cross section of the $^{12}C(\alpha,\gamma)^{16}O$ reaction at energies as low as 700 keV and measure the much needed E1 and E2 astrophysical cross section factors at each energy. In Phase I we plan to measure down only to E_{cm} = 1.4 MeV and after major upgrade of beam intensity we will aim to reach (in Phase II) the design goal of E_{cm} = 700 keV.

A collaboration meeting was held at Avery Point on October 6-7, 2006, see section 1.3, with participation of all member institutes including European members from PTB, Germany, and UCL, Belgium, except for Weizmann, Israel. A review of the status of the experiment was presented and explicit plans were made for getting ready for the first in beam experiment planed during the Spring of 2007.

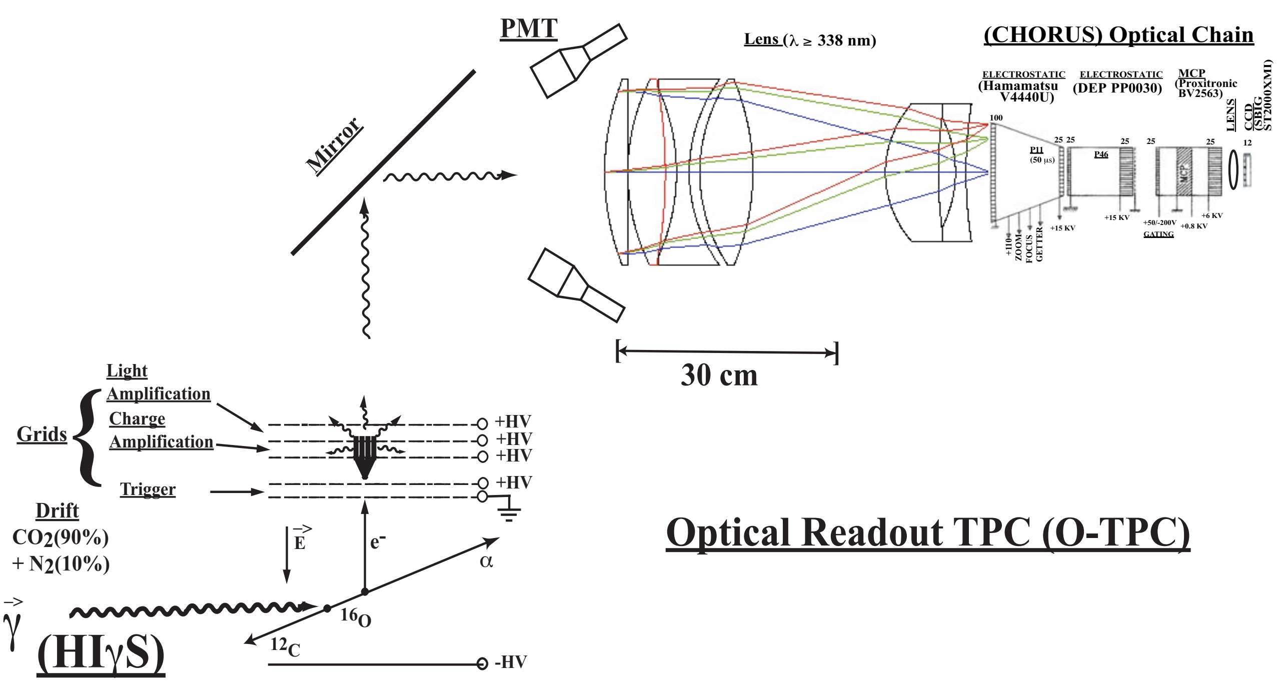


Fig. 1: Schematic diagram of the O-TPC including the Optical Readout and CCD camera.

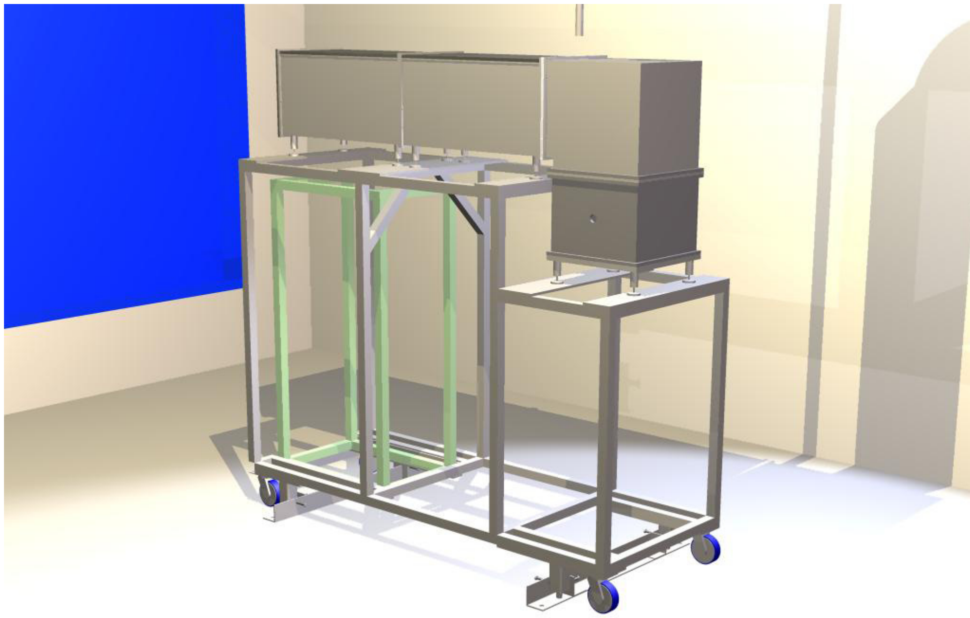
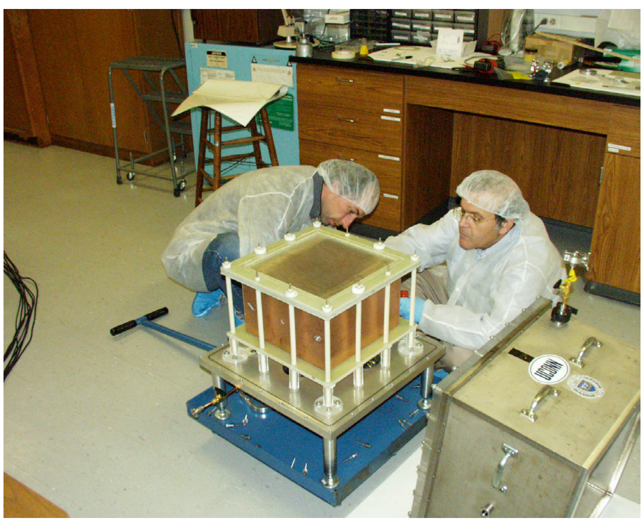


Fig. 2: A conceptual design of the support structure of the O-TPC at the HIγS at TUNL.



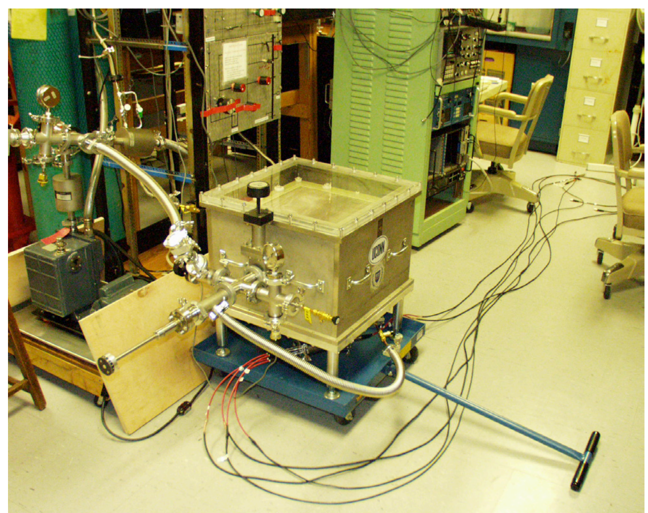


Fig. 3: Kai Tittelemeir (PTB) and Professor Gai assemble the O-TPC at the LNS at Avery Point.

Fig. 4: The test setup of the O-TPC at the LNS at Avery Point.

[1] M. Gai, A. Breskin, R. Chechik, V. Dangendorf and H.R. Weller; APH A, Heavy Ion Physics, **25**(2006)461; nucl-ex/0504003.

[2] L. Weissman, M. Gai, A. Breskin, R. Chechik, V. Dangendorf, K. Tittelmeier, H.R. Weller; Journal of Instr. **1**(2006)05002.

2.2 Test of Oxygen Rich Gasses for use in an Optical Readout TPC (O-TPC) (Weizmann)

L. Weissman, M. Gai (UConn), G.F. Burkhard (Yale), A, Breskin, R. Chechik, A. Raanan (Weizmann), V. Dangendorf, K. Tittelmeier (PTB-Braunschweig), and H.R. Weller (Duke/TUNL)

We performed extensive measurements on a smaller (10 cm diameter) prototype O-TPC in search of the gas mixtures to be used in our O-TPC for the study of the $^{16}O(\gamma,\alpha)^{12}C$ reaction at the HIγS facility. Our goal was to find an oxygen rich gas emitting copious amount of light (with large electron multiplication). To that end the following gas mixtures were tested: CO_2 + N_2, CO_2 + TEA (triethylamine), pure CO_2, N_2O + N_2, N_2O + TEA, pure oxygen, CO_2 + CF_4, CO_2 + CH_4, CO_2 + isobuthane, and CO_2 + oxygen. We used a 10 cm diameter two gaps O-TPC that was constructed at PTB at Braunschweig (OPAC1), for optimizing the electron multiplication (in the first gap) and increasing the photon/electron ratio (in the second gap). Tests utilizing Thick Gas Electron Multipliers (THGEM) were also conducted. A second identical O-TPC (OPAC2) was used in conjunction with an optical system composed of a UV lens, Image Intensifier and CCD camera to take pictures of the tracks produced by a 4.5 MeV alpha particles traversing 10 cm of gas at a pressure of 70-80 torr (losing approximately 1.5 MeV). The results of the measured electron gain, photoelectrons measured in the PMT and typical track are shown in Fig. 2. Note the solid angle of the PMT is approximately 5% of 4π and the Quantum Efficiency is approximately 20% for the near UV line(s) emitted by nitrogen (337 nm). Thus one needs to multiply by 100 the measured photoelectrons to estimate the total number of photons emitted . We found the gas mixture CO_2(90%) + N_2(10%) most suitable for our proposed experiment with an O-TPC [1].

[1] L. Weissman, M. Gai, A. Breskin, R. Chechik, V. Dangendorf, K. Tittelmeier, H.R. Weller; Journal of Instr. **1**(2006)05002.

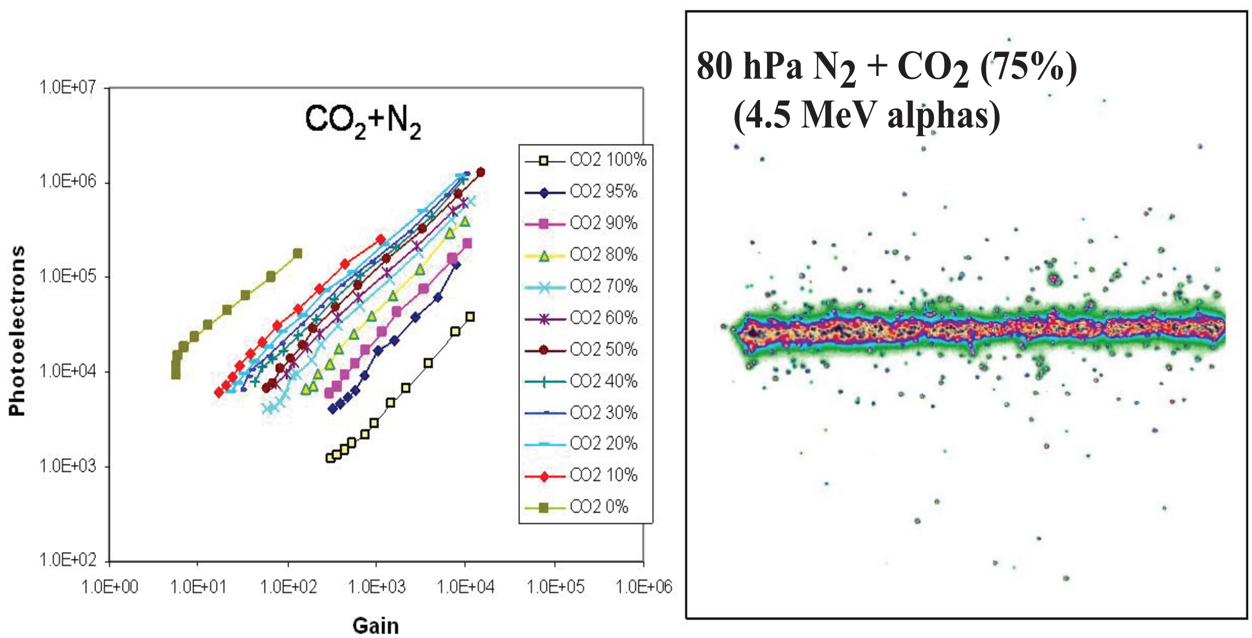


Fig. 1: Electron multiplication and photoelectron measured in the PMT of the prototype O-TPC (OPAC1) and picture of a track from alpha-particle (OPAC2).

2.3 Test of the CERN-CHORUS Optical Readout of the O-TPC Detector (PTB and UConn)

M. Gai, T.J. Kading (UConn), V. Dangendorf, K. Tittelmeier (PTB-Braunschweig), Th. Delbar(UCL), H.R. Weller (TUNL).

Two complete optical chains including 100-25 demagnifier, image intensifier and gated MCP with the necessary high voltage power supply were obtained from UCL at Louvain-La-Neuve as used in the CERN-CHORUS neutrino experiment [1]. A new CCD camera (SBIG-2000XMI) was purchased and a lens has been designed as shown in Fig. 1. We are seeking funds to purchase the so designed lens and meanwhile we are using a considerably smaller UV lens on loan from PTB. The first CHORUS optical system was tested at PTB, Braunschweig, Germany [2]. The photo-cathode was measured to have a reasonable quantum efficiency of approximately 20% for the nitrogen near UV line of 338 nmeter as shown in Fig. 2. The Contrast (Modulation) Transfer Function (CTF) was measured with several line pattern of up to 3 lines per mm and is shown in Fig. 3. We demonstrated that the CHORUS optical system is operating very well and has the required spatial resolution to identify tracks in the O-TPC. The necessary pattern recognition software is being developed at PTB. We constructed at the UConn machine shop the optical box including a quartz window and a mirror that will house the lens, optical chain and the CCD camera all placed on an optical track. Tests of the second optical chain were completed at the LNS at Avery Point and a CTF similar to the one shown in Fig. 3 was measured.

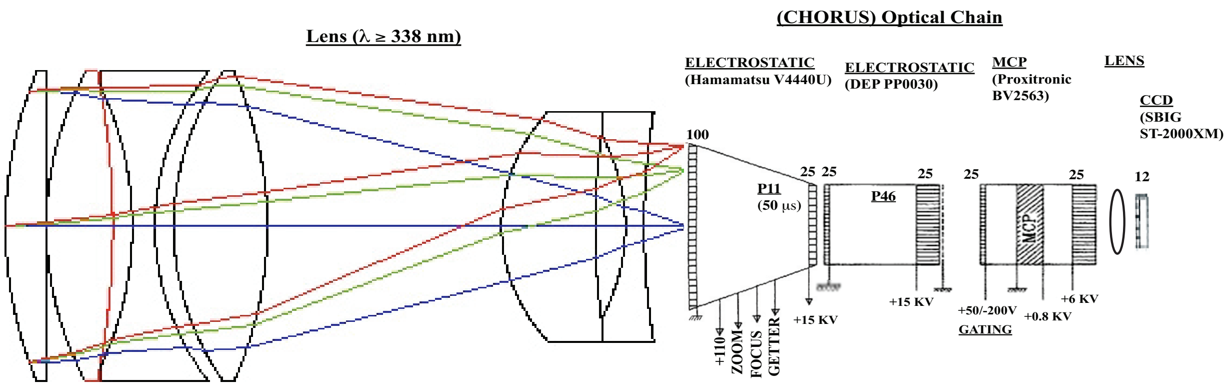


Fig. 1: A schematic diagram of the CERN-CHORUS optical chain, the lens and the CCD camera.

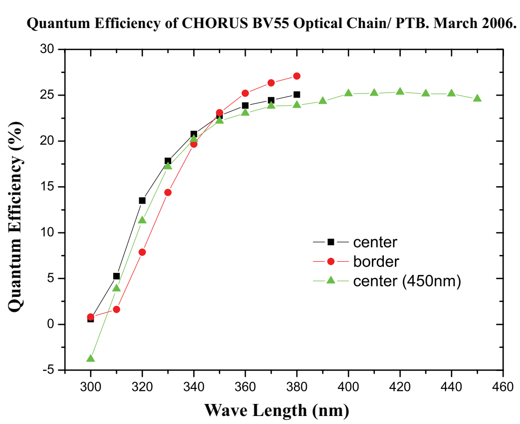


Fig. 2: The measured quantum efficiency of the photo-cathode of the demagnifier, the first element of the CERN-CHORUS optical chain.

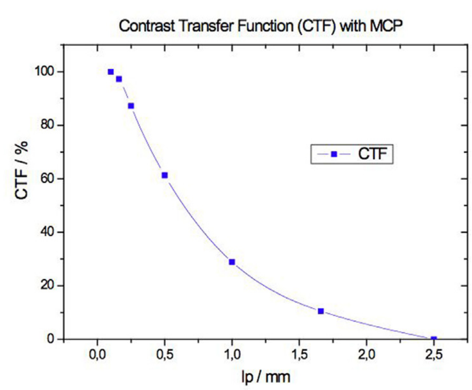


Fig. 3: The measured Contrast Transfer Function of the entire CERN-CHORUS optical chain.

[1] P. Annis et al.; Nucl. Instr. Meth. A367(1995)367.

[2] Tristan J. Kading, Moshe Gai, Benjamin Bromberger, Volker Dangendorf, and Kai Tittelmeier; Bull. Amer. Phys. Soc., **51,#6**(2006)55.

3.1 Test of Cirlex-THGEM electron multipliers for low background Dark Matter Detector (UConn)

M. Gai (UConn and Yale), R. Hasty, D.N. McKinsey, K. Ni, D.F. Rubin, T. Wongjirad (Yale)

Thick Gas Electron Multipliers (THGEM) have been developed at the Weizmann Institute in Israel as an alternative method for electron multiplication and single-photon detection [1,2]. They have been also investigated as photon-emitting electron multipliers for optical readout of gas avalanches [3]. They can be built from (Cirlex) material with very low U-Th content and thus low radioactivity, making them potentially useful for low-rate experiments. We are investigating the potential use of THGEMs for detecting ionization extracted from liquid xenon. Liquid xenon (LXe) detectors are now in use in searches for dark matter [4] where the photons emitted by the liquid xenon and the proportional photons produced by extracted ionization are detected using PMTs. The radioactivity of the glass of the PMTs is expected to be the limiting factor in future LXe based dark matter searches, therefore we propose alternative readout methods with the use of Cirlex-THGEM instead of PMTs.

We purchased a number of 13"x24" double copper clad Cirlex boards 0.4 mm thick from Fralock [5] and prepared [6] fifteen samples of Cirlex-THGEM boards as designed at the Weizmann Institute and shown in Fig. 1. One particularly good aspect of the boards produced by Fralock is that the copper cladding is adhered to the board using a proprietary method that does not involve additional material or glue. Hence the board includes only polyimide (kapton) and copper. This initial purchase was made possible by a small R&D grant from the Yale-Weizmann collaboration program awarded to Professor Gai at Yale and Professor Breskin at the Weizmann Institute in Israel. The Cirlex-THGEM boards were mounted in a gas cell test (OPAC1) chamber at the LNS at Avery Point and tested with CO_2(90%) + N_2(10%) gas mixture. The choice of this first test was so as to allow for direct comparison of their performance with G10-THGEM boards that were already tested in the same gas mixture by the UConn-Yale-Weizmann-PTB collaboration [3]. Additional tests were performed in argon gas. The gains obtained for Cirlex-THGEM are shown in Fig. 2, and compared to gains obtained in G10-THGEM as well as a two grid geometry.

[1] R. Chechik, A. Breskin, C. Shalem, D. Mormann; Nucl. Instr. and Meth. **A535**(2004)303.

[2] R. Chechik, A. Breskin and C. Shalem; Nucl. Instr. and Meth. **A553**(2005)35.

[3] L. Weissman, M. Gai, A. Breskin, R. Chechik, V. Dangendorf, K. Tittelmeier, H.R. Weller; Journal of Instr. **1**(2006)05002.

[4] E. Aprile, K.L. Giboni, P. Majewski, K. Ni, M. Yamashita, R. Gaitskell, P. Sorensen, L. DeViveiros, L. Baudis, A. Bernstein, C. Hagmann, C. Winant, T. Shutt, J. Kwong, U. Oberlack, D. McKinsey, R. Hasty; astro-ph/0407575.

[5] Fralock Div. Lockwood Ind., Canoga Park, CA 91304, http://www.fralock.com.

[6] Print Electronics, Israel, http://www.print-e.co.il.

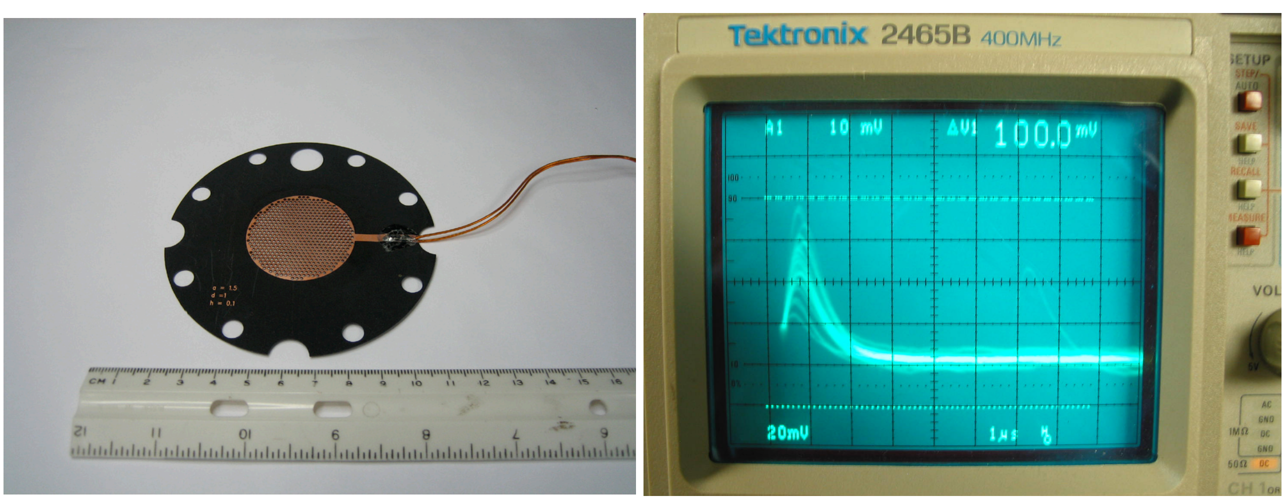


Fig. 1: The tested Cirlex-THGEM board and the obtained electronic signals.

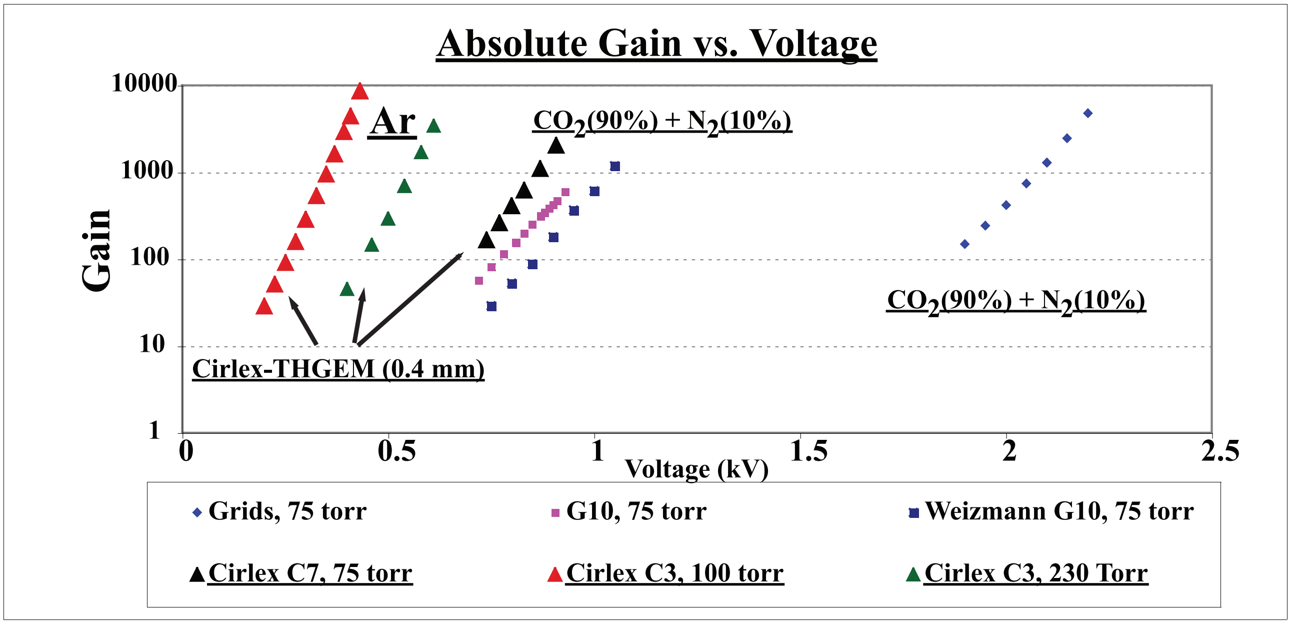


Fig. 2: Typical measured gain curves of the 0.4 mm Cirlex-THGEM boards in (low pressure pure argon and a gas mixture) compared to gains obtained with G10-THGEM boards and a two-grid geometry. These data were measured at the LNS at Avery Point.

3.2 Test of Cirlex-THGEM in the Yale xenon cell (Yale)

D.N. McKinsey, K. Ni, D.A.R. Rubin, T. Wongjirad (Yale), M. Gai (UConn and Yale)

The Yale Liquid Xenon (LXe) cell was built in the laboratory of Professor McKinsey and is now fully operational. It is cooled using a pulse tube refrigerator (PTR), and it currently fits two Hamamatsu 9288 photomultipliers, immersed in the LXe at 165 K. It was successfully filled with 600 g of LXe, and can purify and store LXe. Tests with 122 keV gamma rays yielded 5 photoelectrons/keV, which is comparable to the state-of-the-art in this field. The Yale LXe detector has also been operated in two-phase mode, and both prompt (S1) and proportional scintillation-light (S2) signals have been detected with low noise. In Fig. 3 we show the Yale LXe two-phase cell modified for the THGEM investigations. In this setup the radiation interaction occurs in the liquid phase of Xe and the drifting electrons are extracted into the Xe gas phase and multiplied in the THGEM; the latter replaces the original top PMT used in a XENON like cell.

The Cirlex-THGEM shown in Fig. 1, that were tested during the summer of 2006 in gas at the LNS at Avery Point were installed in the xenon test cell at Yale University, as shown in Fig. 3, and tested for electron amplification in xenon gas at room temperature. The obtained electronic signals are shown in Fig. 4. These data are still being evaluated but our preliminary analysis suggests the gain measured in xenon is similar to the one observed in argon as shown in Fig. 2. Time constraint did not allow us to test the cell in the liquid/gas two phase mode, but the results obtained in the gas phase at room temperature, that are shown in shown in Fig. 4, are very encouraging.

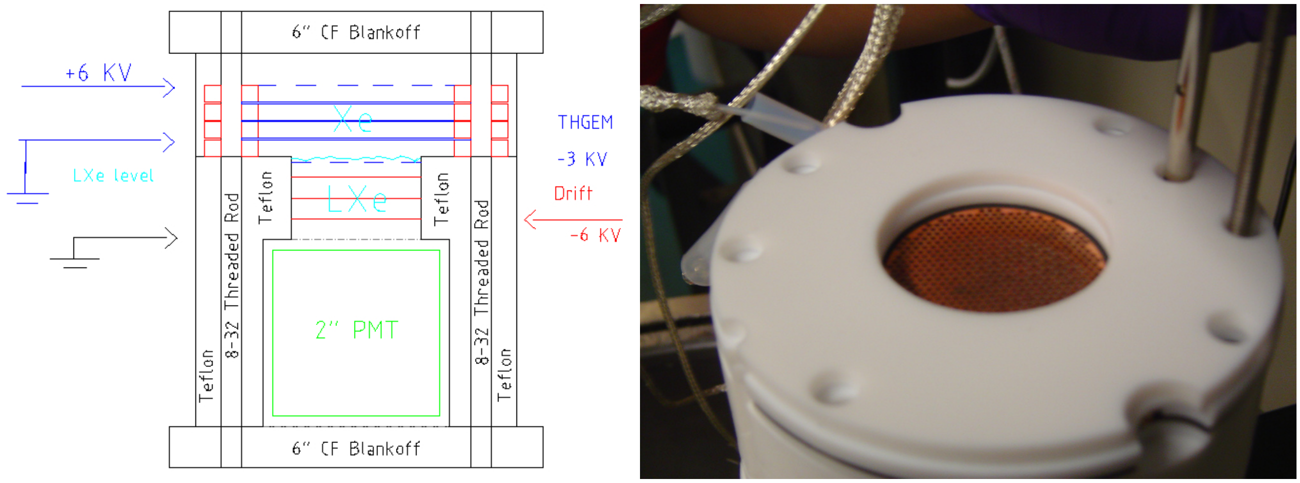
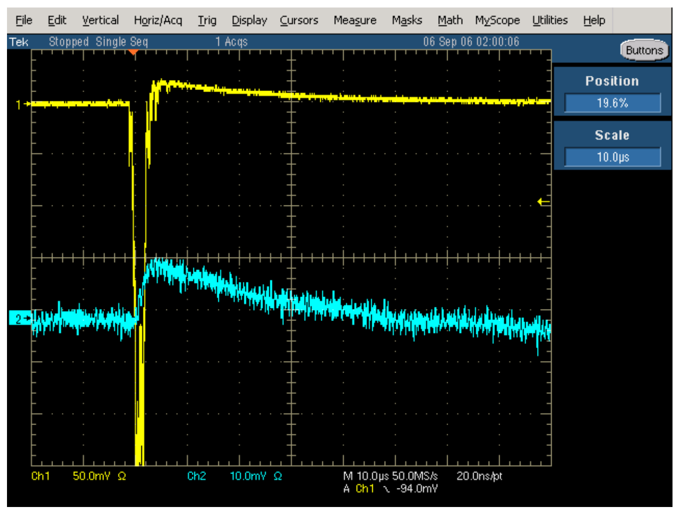


Fig. 3: A picture and a schematic diagram of the two-phase XENON test cell with the Cirlex THGEM board shown in Fig. 1 placed in the xenon cell at Yale University.

Fig. 4: First data obtained with the Cirlex-THGEM placed in the xenon cell at Yale University as shown in Fig. 3. The cell was operated with 500 torr xenon gas at room temperature and the top (yellow) trace is from the PMT output of the proportional light and the bottom (blue) trace is from the output of the Cirlex-THGEM.



4.1 The Coulomb Dissociation of ^{8}B: The Triumph of Good Science (UConn)

Moshe Gai (UConn)

The $S_{17}(0)$ values measured by the Coulomb Dissociation (CD) method, are shown in Fig. 1. Our CD results evolved in time to larger values with smaller error bars, and the final results of the GSI1 and GSI2 collaboration are in very good agreement with $S_{17}(0)$ extracted from the most recent measurements of the Direct Capture (DC) ^{7}Be(p,γ)^{8}B reaction that use the same extrapolation method, as shown in Fig. 1. However, our GSI1 and GSI2 measurements were performed and published long before the DC results. This confirms the CD method and strongly refutes [1,2] statements on disagreements between DC and CD and the need for sizeable corrections of CD data.

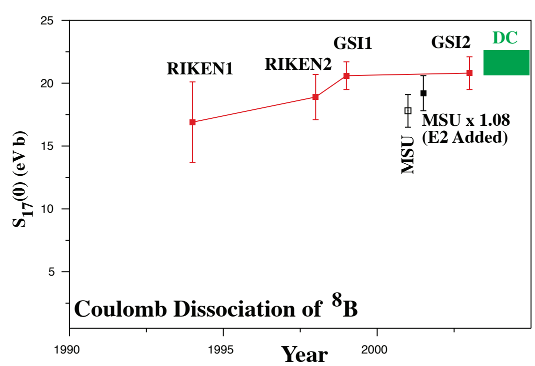


Fig. 1: The $S_{17}(0)$ values measured by the Coulomb Dissociation (CD) method compared to the most recent DC results.

[1] Moshe Gai; Phys. Rev. Lett. **96**(2006)159201.
[2] Moshe Gai; Phys. Rev. **C74**(2006)025810.

4.2 In Beam Tests of Implanted Helium Targets for a Measurement of the ^{3}He(α,γ)^{7}Be Reaction at TUNL (TUNL)

M. Gai, T.J. Kading, L. Weissman (UConn), D.A.R. Rubin (Yale), M.W. Ahmed, M.A. Blackston, Y. Parpottas, B.A. Perdue, H.R. Weller (TUNL), R.H. France III (GCSU), R.M. Prior, M.C. Spraker (NGCSU), J.E. McDonald, J.D. Yeoman (Hartford), Th. Delbar (LLN)

The cross section of the ^{3}He(α,γ)^{7}Be reaction needs to be measured with high accuracy (better than 5%) for an accurate prediction of the ^{7}Be (and ^{8}B) solar neutrino flux(es). We chose to measure the approximately 2.5 MeV gamma-rays from this reaction at energies around E_{cm} = 1.0 MeV with a target composed of ^{3}He implanted into nickel. A measurement with 2.5 MeV ^{4}He beam on a nickel foil showed no background above the ambient room background. Targets of helium implanted into aluminum reveal a large background due to ^{27}Al(α,p)^{30}Si.

Targets consisting of ^{3}He implanted into thin aluminum foils (216 μg/cm^2) were prepared using intense (a few μA) helium beams at low energy (45 keV). Uniformity of the implantation was achieved by a beam raster across a 12 mm diameter tantalum collimator at the rates of 0.1 Hz in the vertical direction and 1 Hz in the horizontal direction. One target was produced by implanting ^{3}He from both sides of the aluminum foil and this target was bombarded with moderately intense ^{4}He beams of approximately 100 particle nA over two days [1]. The helium content and profile was studied prior to bombardment using Rutherford Back Scattering of 2.5 MeV proton beams extracted from the TUNL tandem. After the prolonged bombardment it was tested with 1.0 proton beams extracted from Yale 1 MV Teaching Lab Accelerator. The spectra obtained at 1.0 MeV are shown in Fig. 1. The target was scanned with a 3mm diameter 1.0 MeV proton beams in eight steps of 2.4 mm each. The ^{4}He beam from the prolonged bombardment was with a diameter of approximately 6 mm in the center of the 12 mm implanted helium area. The results of the scan shown in Fig. 2 indicate the helium profile and content of the two layers remained stable even after the two day bombardment.

A ^{3}He implanted target with $5{\times}10^{17}$ atoms/cm^2 with a 2.5 MeV 500 nA ^{4}He beam yield a count rate of 100 counts per hour in a HPGe detector with a 2% efficiency for detecting the resulting 2.660 MeV direct capture gamma ray at 90, spread over approximately 30 keV (FWHM). At energies above the 2.614 MeV the measured room background with ^{4}He beam on a nickel foil is one count per hour per keV, smaller than the estimated reaction yield. Hence a nickel implanted ^{3}He target with moderately intense beams of approximately 500 nA are useful for studying the ^{3}He(α,γ)^{7}Be reaction.

[1] J.E. McDonald, R.H. France I I I, R.A. Jarvis, M.W. Ahmed, M.A. Blackston, Th. Delbar, M. Gai, T.J. Kading, Y. Parpottas, B.A. Perdue, R.M. Prior, D.F. Rubin, M.C. Spraker, J.D. Yeomans, L. Weissman H.R. Weller, and E.L. Wilds Jr; Journal of Instr. **1**(2006)09003.

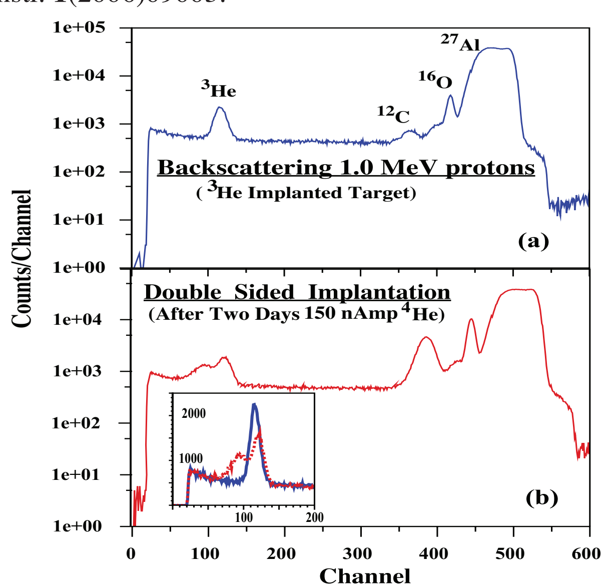


Fig. 1: The measured spectra of elastic acattering of 1.0 MeV proton beams from (a) single layer ^{3}He implanted target before bombardment (blue color) and (b) double layer ^{3}He implanted target after bombardment (red color). The observed carbon buildup in spectrum (b) is approximately 5 μg/cm^2 after two days of bombardment.

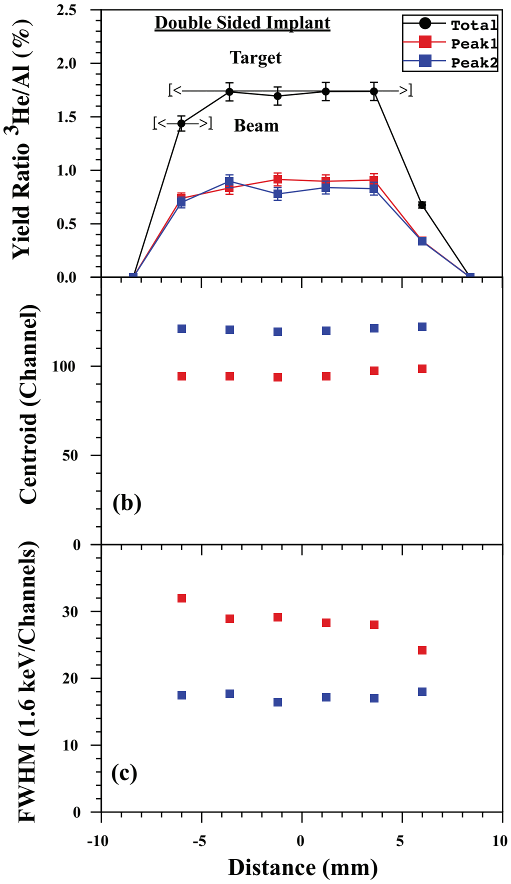


Fig. 2: Results of the scan across the double sided He implanted target using 1.0 MeV proton beams. We show (a) the ratio of yield of elastic scattering from ^{3}He and ^{27}Al for the two peaks shown in Fig. 1b, corresponding to the two helium layers and the total sum of yield, (b) the centroid of the two peaks, (c) the FWHM of the observed peaks. The scan was performed after a two day bombardment with ^{4}He beams. The ^{3}He implanted area (±6 mm from target center), and the 1.0 MeV proton beam spot (diameter of 3 mm) are shown. Lines are drawn to connect data points and guide the eye.

5.1 Dating of marine sediments with ^{210}Pb (UConn)

Moshe Gai and Tristan J. Kading

We are dating in collaboration with the Department of Marine Science at Avery Point marine sediments collected at the Chesapeake Bay using the standard ^{210}Pb dating method (half life of 22.3 Years). This study uses the alpha-counting method with a known mixture of ^{209}Po for normalization, see spectrum shown in Fig. 1. We are developing a new method that will utilize conversion electrons and will allow on one hand for a simple sample preparation (as in the case of gamma-counting) and on the other hand will have low background (as in the case of alpha-counting). In Fig. 1 we show alpha-particle spectrum measured in our lab for this study.

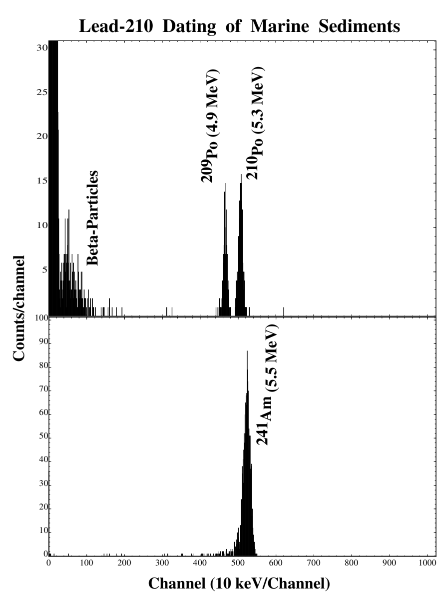


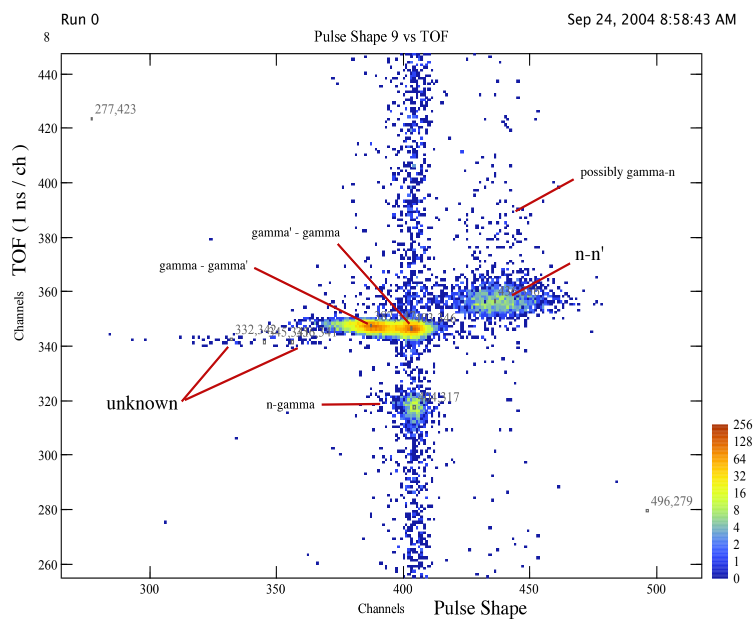
Fig. 1: Typical alpha-particle spectra from marine sediment including the ^{210}Pb line and the line from a known quantity of ^{209}Po used for normalization.

6.1 Calibration of the Efficiency of the Yale Neutron Ball (Yale)

Suzanna Williams, Carlos Aguilera, R.H. France III (GCSU), J.D. Yeomans, C.M. Przybycien, J.E.R. McDonald (UHartford), and M. Gai (UConn).

We plan (a GCSU project) to use detectors of the Yale Neutron Ball in a precision measurements at TUNL of the cross section of the $^{13}C(\alpha,n)^{16}O$ reaction which is an important source of s-process neutrons. The s-process occurs in the deep layers of stars involving slow neutron capture reactions and β-decays, resulting in the creation of elements heavier than Iron.The efficiencies of six neutron detectors from the Yale neutron ball were measured as a function of detection threshold using a calibrated 3.77 mCi ^{252}Cf source. Absolute efficiencies for each threshold ranging from 100 keV to 800 keV (electron equivalent) were measured. Relative efficiencies were measured with the source located 14 cm from the detector and absolute efficiency were measured at one threshold for each detector with the source located 110 cm from the detector. Neutron coincidence efficiencies were measured between detectors using a large ~1.0 Ci Am-Be neutron source. The coincidence measurement allows to improve discrimination between neutrons and gamma-rays by analyzing the neutron time-of-flight (TOF) between the detectors. For the time of flight coincidence measurements, the detectors were placed 14 cm apart, and the Am-Be source was placed 90 cm from the first detector, with the second detector shielded from the source by 95 cm of paraffin wax. The use of a liquid scintillator allows the use of pulse shape discrimination to distinguish between neutrons and gamma-rays detected in the scintillator. In Fig. 1 we show the obtained neutron-gamma separation using both pulse shape and TOF measurements.

Fig. 1: Typical Time of Flight (TOF) Vs Pulse Shape (PS) neutron detector spectrum.



7 Publications 2005-2006 (Two Years Period)

7.1 Publications in Refereed Journals:

(1) THE COULOMB DISSOCIATION OF ^{8}B AND A CRITICAL ASSESSMENT OF THE SEATTLE $S_{17}(0)$ RESULT.
Moshe Gai
APH A, Heavy Ion Physics, **24**(2005)347.

(2) HOW ACCURATELY DO WE KNOW THE FORMATION OF SOLAR ^{8}B?
Moshe Gai
Nucl. Phys. **B143**(2005)495.

(3) COMMENT ON RECONCILING COULOMB DISSOCIATION AND RADIATIVE CAPTURE MESUREMENTS.
Moshe Gai
Phys. Rev. Lett. **96**(2006)159201.

(4) LOW-ENERGY CROSS SCETION OF THE ^{7}BE(p,γ)^{8}B SOLAR FUSION REACTION FROM THE COULOMB DISSOCIATION OF ^{8}B.
F. Schumann, S. Typel, F. Hammache, K. Summerer, F. Uhlig, I. Bottcher, D. Cortina, A. Forster, M.Gai, H. Geissel, U. Greife, E. Grosse, N. Iwasa, P. Koczon, B. Kohlmeyer, R. Kulessa, H. Kumagai, N. Kurz, M. Menzel, T. Motobayashi, H. Oeschler, A. Ozawa, M. P loskon, W. Prokopowicz, E. Schwab, P. Senger, F. Strieder, C. Sturm, Zhi-Yu Sun, G. Surowka, A. Wagner, and W. Walu.
Phys. Rev. **C73** (2006)015806.

(5) OPTICAL READOUT TIME PROJECTION CHAMBER (O-TPC) FOR A STUDY OF OXYGEN FORMATION IN STELLAR HELIUM BURNING.
Moshe Gai, Amos Breskin, Rachel Chechik, Volker Dangendorf and Henry R. Weller.
APH A, Heavy Ion Physics, **25**(2006)461; nucl-ex/0504003.

(6) AMPLIFICATION AND SCINTILLATION PROPERTIES OF OXYGEN-RICH GAS MIXTURES FOR OPTICAL-TPC APPLICATIONS.
L. Weissman, M. Gai, A. Breskin, R. Chechik, V. Dangendorf, K. Tittelmeier, H.R. Weller.
Journal of Instr. **1**(2006)05002.

(7) CRITICAL ASSESSMENT OF THE CLAIM OF A SIGNIFICANT DIFFERENCE BETWEEN THE RESULTS OF MEASUREMENTS OF THE COULOMB DISSOCIATION OF 8B AND THE 7BE(P,G)8B DIRECT CAPTURE REACTION.
Moshe Gai.
Phys. Rev. **C74**(2006)025810.

(8) IN BEAM TESTS OF IMPLANTED HELIUM TARGETS.
J.E. McDonald, R.H. France III, R.A. Jarvis, M.W. Ahmed, M.A. Blackston, Th. Delbar, M. Gai, T.J. Kading, Y. Parpottas, B.A. Perdue, R.M. Prior, D.F. Rubin, M.C. Spraker, J.D. Yeomans, L. Weissman, H.R. Weller, and E.L. Wilds Jr.
Journal of Instr. **1**(2006)09003.

(9) THE COULOMB DISSOCIATION OF ^{8}B; A TRIUMPH OF GOOD SCIENCE.
Moshe Gai.
APH A, Heavy Ion Physics, (2006) in press and nucl-ex/0605001.

(10) PRODUCTION OF FAST NEUTRONS WITH A PLASMA FOCUS DEVICE.
Moshe Gai.
Proceedings of Science, POS/SISSA, FNDA2006, in press, and nucl-ex/0605003.

(11) STATUS OF THE STANDARD SOLAR MODEL PREDICTION OF SOLAR NEUTRINO FLUXES.
M. Gai
Phys. Atom. Nucl. **69**(2006)1805.

7.2 Invited Talks, Contributions, Conference Proceedings:

(1) OPTICAL RAEDOUT TIME PROJECTION CHAMBER (O-TPC) FOR STUDIES IN NUCLEAR ASTROPHYSICS.
Moshe Gai, Invited Talk.
21st Winter Workshop Nuclear Dynamics, Breckenridge, CO, 5-12 February 2005.

(2) STATUS OF THE STANDARD SOLAR MODEL AND PREDICTIONS OF SOLAR NEUTRINO FLUXES.
Moshe Gai, Invited Talk.
Fifth Int. Conf. on Non Accelerator New Physics, Dubna, Russia, 20-25 June 2005.

(3) IS THERE A SIGNIFICANT DIFFERENCE BETWEEN THE SLOPE OF CD AND DC DATA ON ^{7}Be(P,γ)^{8}B REACTION.
Moshe Gai
Bull. Amer. Phys. Soc. **50**(2005)118.

(4) HOW ACCURATELY DO WE KNOW THE CROSS SECTION OF THE ^{7}Be(P,γ)^{8}B REACTION?
Moshe Gai, Invited Talk.
Twelveth Int. Conf. on Capture Gamma-Ray, Notre Dame, 5-9 September 2005.

(5) STATUS OF THE STANDARD SOLAR MODEL AND PREDICTIONS OF SOLAR NEUTRINO FLUXES.
Moshe Gai, Invited Talk.
Bull. Korean Phys. Soc. **23,#2**(2005)397.

(6) THE COULOMB DISSOCIATION OF 8B: THE TRIUMPH OF GOOD SCIENCE.
Moshe Gai, Invited talk.
Workshop on Nuclear Structure and Astrophysics with Radioactive Beams, Weizmann Institute, Rehovot, Israel, June 4-6, 2006.

(7) LOW BACKGROUND CIRLEX-THGEM READOUT FOR A DARK MATTER SEARCH.
Louis W. Kastens, Kaixuan Ni, Daniel N. McKinsey, Marco Cortesi and Amos Breskin.
Bull. Amer. Phys. Soc. **51,#6**(2006)60.

(8) TEST OF THE OPTICAL READOUT OF THE UCONN TPC DETECTOR.
Tristan J. Kading, Moshe Gai, Benjamin Bromberger, Volker Dangendorf, and Kai Tittelmeier.
Bull. Amer. Phys. Soc., **51,#6**(2006)55.