Editors / Jack Houlton & Nathan Youngblood

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PhysicsFocus

Bethel University Physics & Engineering Newsletter

Newsletter article and photo submissions to Dr. Peterson (petric@bethel.edu) are welcome and appreciated.

Bethel students (Gus Olson and Sarah Anderson) and Dr. Hoyt featured in publicity poster for the Ann Arbor topical conference.

Update from Dr. Peterson

Bethel Physics and the Michigan Advanced Laboratory Conference

While I was lending assistance with some optical diagnostics on solid and fluid dynamics this summer, it was surely not "business as usual." For three years I have worked with others in planning this summer's Advanced Laboratory Topical Conference (ALTC) at the University of Michigan on July 23 – 25. There has been no other national physics conference of this sort since the NSF supported Lab Focus - '93 conference that I led way back in 1993 at Boise State University (with much editorial LaTeX help from students Kevin Johnson and Jodi Hansburger). This year's conference in Ann Arbor focused on physics teaching labs beyond introductory level, and it enjoyed very welcome support from NSF (National Science Foundation), AAPT (American Association of Physics Teachers), APS (American Physical Society), and ALPhA (Advanced Lab Physics Association).

In This Issue:

I was delighted that in spite of a global recession the conference was over-subscribed. The registration in early summer closed at about 130 participants from 91 colleges and universities – and 6 countries. The ALTC was partially supported by an NSF grant to the AAPT, registration fees, commercial apparatus vendors, ALPhA, and the APS.

Bethel was as strongly represented and featured at the conference as any university in the U.S. (Greenlee, Hoyt, Peterson, and Stein attending), with three papers from our department (two accepted poster papers and one invited paper) that featured experiments and apparatus developed and utilized in the last few years by our students and faculty. Eight Bethel physics majors were coauthors on these papers including Sarah Anderson (now a graduate student at Michigan), Adam Banfield, Jack Houlton, Sarah Kaiser, Justin Knapp, Brandon Peplinski, Chris Scheevel (now a graduate student at the U of MN), and David Swenson – along with coauthor faculty members Hoyt, Stein, and Peterson.

Over the last few decades Bethel has developed a national reputation as a leading proponent of project-based advanced labs. In these teaching labs within upper division courses, the student is not primarily repeating or confirming a historical experiment but instead is working with a team of class members (and one or two faculty members) in creatively extending or initiating an experiment in which even the faculty member is not sure of the anticipated result. At Bethel, this approach builds upon a General Physics I and II lab background that also concludes each semester with a team project, and after the sophomore year (incorporating both Beecken's electronics and Greenlee's modern physics labs) most students are ready for this mini-research approach within such areas as optics, laser physics, fluids, acoustics, and computer methods.

In comparison to the other 91 colleges and universities, one of the most positive distinctive features of Bethel's advanced lab program is that all of our five full-time faculty are actively working within these labs beyond the introductory level. In many schools such upper-division lab experiences often fall upon one or two faculty members or staff. The mini-research perspective of these labs also directly stimulates the role of undergraduate research in the department – both during the summer months (averaging 7 funded physics/engineering, on-campus student research positions during each of the summers of 2008 and 2009) and in our research course during the academic year. In addition these project-based advanced labs provide an ideal background for students when competing for summer research positions at larger universities often supported by the national REU (Research Experience for Undergraduates) program of the National Science Foundation. During the summer of 2009, Bethel students selected for such national programs included Carolyn Kan, Sarah Kaiser, Brandon Fosso, James Benhardus, and Adam Banfield.

Summer Teaching at Daystar University in May/June 2009

Dr. Peterson teaching a physics class at Daystar University in Kenya.

Daystar University is a 35-year old African Christian University having its main undergraduate campus near the little town of Athi River, about 20 miles SE of Nairobi, Kenya. Daystar has grown in size to include about 3700 students from Kenya and other African countries – and has two well-established campuses, including a crowded small site in Nairobi itself, plus the more spread-out 300-acre Athi River campus, and it will also have a new campus opening in the city of Mombasa (on the Indian Ocean coast) later in 2009. Sciences are just starting at Daystar to a large extent, while a new physics major has been approved for development during the next year or two. I was invited to come and teach a 5-week "block" of conceptual physics/physical science between May 23 and June 26 and to become more familiar with Daystar as they aim to build up the physical sciences. I felt comfortable in taking on the task because I knew Dr. Jon Masso (a physicist and Daystar's Dean of Science and Technology) - plus Bethel's physicist Provost of the early 90's, Dr. David Brandt, and our new President Dr. Jay Barnes both have strong Daystar connections. Support for Daystar from the U.S. comes from Daystar U.S.A. – and it also involves several leaders from Bethel past and my own home church (Roseville

Covenant). So I went, while still not knowing too much about the experience lying ahead.

After grading my Bethel final exams (some lab reports and lab finals for Laser Physics and the General Physics II finals) on a "considerably" faster than usual schedule, I flew to Africa on Thursday, May 21 and arrived in Nairobi on Friday night, May 22 – with classes starting on Monday, the 25th. After a most memorable 4-wheel drive/battle through gullies, fields, rocks, thick dust, and "road" construction to the Athi River campus from the Nairobi airport, the Masso's kindly got me to an apartment/flat on campus by late Friday night. I believe it is called the "White House" due to its relative "luxury" and the lack of normal skin pigment of many guests who stay there.

I taught Daystar's PHY 112 (2.25 hrs/day MWF), a general education requirement, as a physical science class with an "Energy" theme – on topics ranging from kinematics/dynamics and mechanical energy forms, wave energy, electrical energy, thermodynamics, chemical and nuclear energy, etc. After the first week (during which attendance is typically very poor), I had 42 in the class. If they miss more than 25% of classes, the student does not get credit, so I took roll daily for the first time in my life – via a distributed attendance sheet. The classroom utilized was designed to be a lab with 4-6 students at each table, so I walked quite a bit around the large room in trying to get in touch with folks and in an effort to get to know a few of them. Most students could not afford to buy a book, while there were copies of a 2nd Edition of Hinrich's Energy text on library reserve (with the 4th Edition now current in the U.S.). I brought a set of Logger Pro gadgets to use with my laptop, and Daystar was able to provide a digital projector that I could use each day. Demo equipment was however rather scarce, but I put a few things together for mechanics and waves, and I used quite a bit of my "bombs class" historical materials connected with nuclear energy in the 20th century.

They are on a British system, so only 30% of the grade comes from quizzes or "continuous assessment tools" or "CATS" during the class; while 70% of one's grade typically comes from the final exam. Then the instructor assigns tentative course grades that are often "moderated" (up or down) by the department. Thus final grades are actually the responsibility of the department as a whole – not the instructor. The department also must approve or "moderate" the questions on the final exam before they are printed, and students can only "sit for" the final exam if they have paid all bills and tuition. Final exams are taken in "script" booklets – or what used to be called exam "blue books" in the U.S.

Their students tend to be very serious and good memorizers of anything put before them, and it takes some effort to stimulate smiles or to get a laugh or two. I think it probably is a bit easier for the much more common African instructors. I learned only upon arrival that Daystar lecturers dress fairly formally and very often use suits and ties. So my one sport coat and tie that made the trip were heavily used. Nairobi is really close to the equator, but the altitude is high, so high temperatures during the day are usually (almost year round) in the 70's to mid-80's F – but the sun feels really hot. At night on the equator you can still see the big dipper in the north and also the kite shaped "southern cross" of the southern sky. Daystar chapel is held for well over an hour on Tuesday and Thursday mornings – and during the regular year there is required attendance. I had a hard time understanding many of the chapel preachers, as I found their Kenyan accents (while apparently still some form of English) especially hard to follow when they are preaching.

Kitengela Covenant Church

I went to church on Sundays, three times walking to the little Anglican chapel just outside the Athi River campus gate, and twice to the equally small Evangelical Covenant church in the "nearby" town of Kitengela (i.e. 25 minutes across perhaps 10 miles of quite rugged roads, ditches, and such) that has been supported quite a bit in recent years by Roseville Covenant. Both church buildings are of sheet metal construction and are trying to raise money to buy some sort of keyboard to go along with their African drum (or two) to use during the worship services, plus Kitengela Covenant is just this week completing a 2 or 3 hole toilet that will for the first time allow some relief when nature calls. Kitengela Covenant also has the only church chicken coop in this town (of close to 60,000) and raises chickens for both meat and eggs – with start-up help from World Relief. The second

week at Kitengela, I was able to preach the morning sermon with a translator (but no ping pong cannon). While most folks in Kenya know some English, the standard conversational language is Kiswahili, and during worship services they rather go back and forth between these languages. After one worship service (ending around 12:30) they went into a 1.2-hour long "business meeting" to decide how they should celebrate the pastor's coming diploma from Daystar. Consensus among men and women in the congregation was crucial in such a matter. Everyone is expected to say their thing – and after long, patient discussion, they eventually go around the big circle to see how much each person could donate (in spite of all being poor by U.S. standards). I learned to respect (if not always understand) the prized patience of Africans when the clock (or your hunger pains) is clearly not the most pressing or important issue.

I might add some final perspectives from back at the Athi River Daystar campus. Uniformed and somber security guards with night sticks are everywhere – including 4 or 5 at the entrance gate, one guard day and night by almost every large campus building (and also featuring guard dogs later at night), one guard by our "white house" residence, etc. Most of the 300-acre campus growth of weeds and grass are cut by crews of men and women with swinging knifes – enough to make quite a crop of hay after a few hours. I did see one small rotary push mower that was used (over a three day period) to mow the 3 soccer fields behind my apartment. During my 5 weeks they completed a pedestrian bridge over the ravine that I had walked across each day, and much of the job was done by mixing the concrete in 5-gallon pails by hand. And campus clean-up custodial crews are also present all day, not only after class is done. Labor is cheap (a few hundred Kenya shillings per day – like $2 or $3), and it is crucial that these people have jobs. Yet it is also recognized that morale among such workers is not always high, and quality may suffer in the construction trades.

I enjoyed being at Daystar during their annual commencement ceremony and during their 35th anniversary – in this case involving about 700 graduates [receiving either diplomas (like an AA degree) or 4-year degrees]. Commencement is truly a unifying community celebrative affair – more so it seems than for U.S. colleges and universities. Entire neighborhoods and churches show up to cheer on the ones that they have often supported in different ways. 10 - 15,000 attended this giant outdoor celebration under the midday Kenyan sun. Familiar hymns like "Great is Thy Faithfulness" or "To God be the Glory" are sung with deeper meaning – and Daystar's musical group Afrizo (to visit Bethel in September 2009) leads the throng in African worship songs, hymns, and the national anthem. I began to see more clearly the strength derived from community patience, unity, and prayers in sacrificially helping these young Christian leaders now become servants to the larger world – but with such opportunities often made possible by building on the blessings and prayers of their expanded families, villages and churches.

Daystar students celebrating commencement.

–Dr. Peterson

Images from the Shock Tunnel

For the past two years, the Bethel Physics department has had many students collaborating towards the goal of a shock tunnel with airflow speeds of up to mach 3.5. The purpose of the tunnel is ultimately to analyze supersonic airflow around objects of research interest. Through the efforts of students and faculty, the tunnel has gone from an idea, to a design, to fabricated parts, to a fully operational research tool.

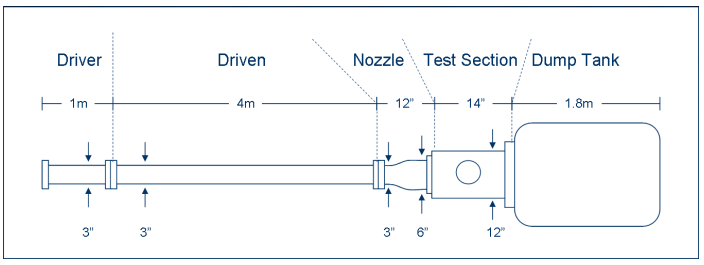
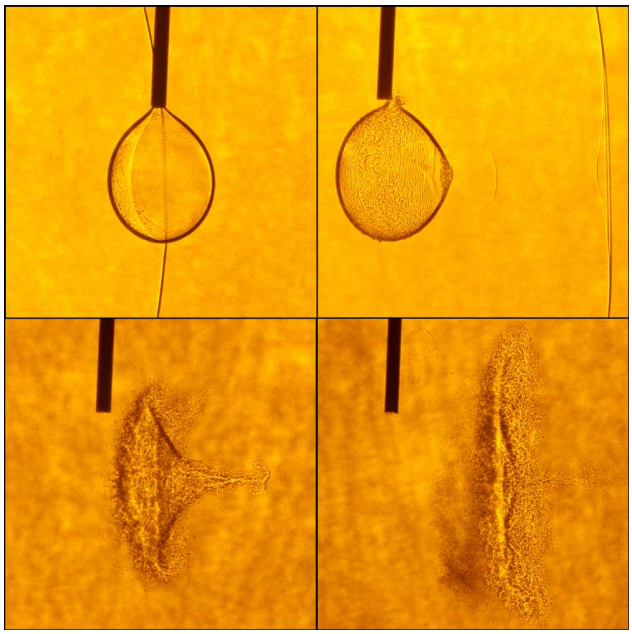


Diagram of the assembled shock tunnel. (Image courtesy of Andrew Rice)

During the spring semester of 2007, some students in Dr. Stein's fluids class worked on the design of the shock

tunnel as a lab project. Matthew Freeland continued working on the specifics of the design including the nozzle specifications utilizing in depth computational modeling and analysis over the summer of 2007. Using Freeland's suggested dimensions, Tim Johnson worked on the early assembly of the shock tunnel, fabricating some parts himself and contracting a local company to machine the more intricate components (i.e. the nozzle) during the 2007-2008 school year. At the end of the 2008 spring semester, the shock tunnel resided in the Carlson Analysis Center as an open-ended tube.

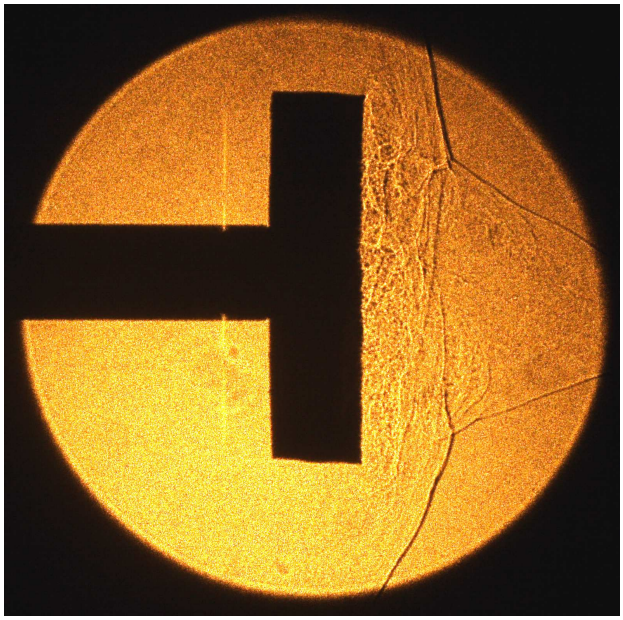
The summer of 2008 marked the final assembly of the shock tunnel. Justin Knapp and Jack Houlton worked on the installation of pressure sensors along the length of the tube. A local fabricator was employed to finish the construction of the nozzle, test section, and dump tank. Finally, the shock tunnel was assembled, ridded of leaks, and ready for full operation. Being joined by Brandon Peplinski and David Swenson the summer research team worked on imaging the shock wave produced by the open-ended tunnel using thorough shadowgraph testing and simple Schlieren techniques.



Shadowgraph images of a shock wave passing through a sulfur hexafluoride bubble taken at Bethel during the summer of 2008.

The tunnel consists of the following five major components: driver, driven section, nozzle, test section, and dump tank. A diaphragm and gaskets isolate the driver and driven sections so that a pressure difference can be established between the two sections. When the diaphragm ruptures, the air masses travel down the driven section towards the dump tank as a shock wave. This apparatus sustains supersonic flow conditions for several milliseconds.

Bethel's fully assembled shock tunnel.



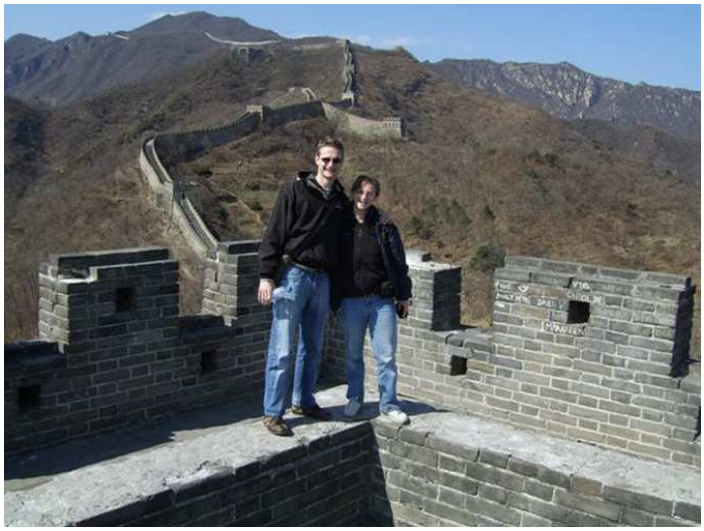
Shadowgraph of a shock wave hitting a blunt object in the test section of Bethel's shock tunnel.

Over the 2008-2009 school year, the now constructed shock tunnel was available for use in senior research projects. Andrew Rice and Jonathan Dallmann were the first to carry out senior research on the assembled tunnel. Andrew was able to perfect shock wave detection and timing while Jonathan used shadowgraph imaging to reveal how the shock wave enters the test section. This summer Jack Houlton and Nathan Youngblood experimented with how the shock wave interacts with blunt objects in the test section. Eventually the shock tunnel will be used to see how different models behave in supersonic environments and will be available as a teaching tool for future fluids classes and as a subject of research.

–Jack Houlton and Nathan Youngblood

Beyond Bethel Physics: The Ups and Downs of "Quarky" Research

In the past five years since I've graduated at Bethel I've continued my studies at the University of Illinois at Urbana-Champaign (UIUC). While here, I've been working on a Ph.D. in theoretical particle physics. My thesis work is focused on the method of calculation that we use at hadron colliders, perturbative QCD. It has been a busy 5 years filled with classes, calculations, conferences, talks, teaching, and summer schools.



Putty and Brittany on the Great Wall of China during one of the mission trips.

I've also be fortunate enough to be able to participate in some work with the physics education research group here at UIUC. In this context I've been able to work with teaching assistants to improve their teaching abilities, and been involved in course development in two different contexts: mechanics for under-prepared students and a program where we invited Illinois high-school teachers to come to UIUC for two weeks and receive some input with which they can improve their teaching curricula.

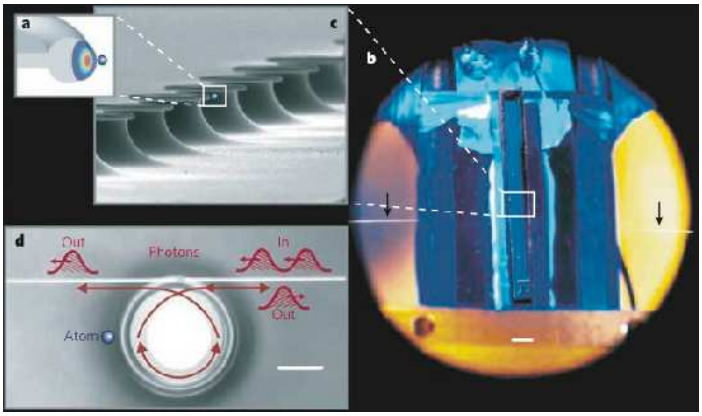
I've also maintained extra-curricular activities as time permits. I got married in 2005 to another Bethel graduate, Brittany Olson, and the next year we bought a house in Champaign. Somewhere along the way I wound up with a martial arts school (www.fiveanimalsclf.com) and have been trying to maintain involvement with my church in the form of leading a small group. I've also been able to travel to China for two short term missions trips with my church.

– Robert Puttman, "Putty"

Undergraduate Summer Research

This summer, several Bethel University physics students were both honored and privileged to participate in Research Experiences for Undergraduates (REU) programs. Adam Banfield, James Benhardus, Brandon Fosso, Sarah Kaiser, and Carolyn Kan worked in the physics departments of universities across the country, making important contributions to current scientific projects. What follows is a glimpse into a few of these students' projects and summers.

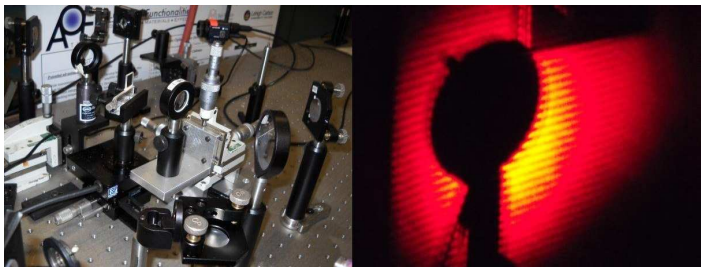
Sarah Kaiser, a Bethel Junior, spent her summer in sunny California, researching in Caltech's physics department. Sarah worked with Dr. Jeff Kimble, Dr. Nate Stern, and Daniel Alton on a project associated with Caltech's Quantum Optics Group. Their studies concerned the interactions between single Cesium atoms and microtoroidal cavities, which are observed with tapered optical fibers. Sarah worked to optimize the process by which consistent, high quality tapered optical fibers are constructed, adding quantitative precision to parameters involved in a fiber's construction such as the heat output and position of the flame used to soften the initially untapered fiber. Sarah's work also involved analyzing the mathematical models describing the interactions within these cesium atom microtoroidal cavity systems. "This application of these microtoroidal systems is promising for the development of the architecture of quantum information networks. The proposed work



a) Whisper gallery mode (WGM) in resonator that creates an evanescent field external to the resonator that can lead to strong interaction and coupling with the atom. b) Silicon chip with a linear configuration of microtoroid resonators in an ultra-high vacuum. c) Scanning electron micrograph of an array of microtoroidal resonators. d) A micrograph of an individual toroid and fiber taper from panel b. H. J. Kimble, The quantum internet, Nature, Vol 453, No 19, June 2008.

may play a role in better understanding quantum information processing in the future," writes Sarah.

Carolyn Kan, a Bethel Junior, spent her summer in Pennsylvania at Lehigh University's physics department. There, Carolyn used interferometry to investigate how the composition of tellurite glass affects its index of refraction. Her apparatus is an interferometer in which a glass sample is placed for analysis. One light beam is sent through the sample as it is turned, and an automated LabView program analyzes the shifting diffraction pattern at the end of the apparatus. When combined with some additional information and manipulated properly, this data gives the index of refraction of the sample. In addition to making strides in her field of research, Carolyn has gained a deep appreciation and wisdom as to what research is all about. "...what's the use of collecting loads of data if you don't even understand the physical principles behind what you're measuring? Anyone can just press buttons. The whole summer will have been worthwhile if I leave understanding the interferometer I use inside and out, if I manage to internalize the veneer of equations and turn the abstract concepts into something physically meaningful inside my head," writes Carolyn.



Carolyn's interferometer and a sample diffraction pattern.

–Jack Houlton

Bethel and the Space Grant: Money and Opportunities for Students

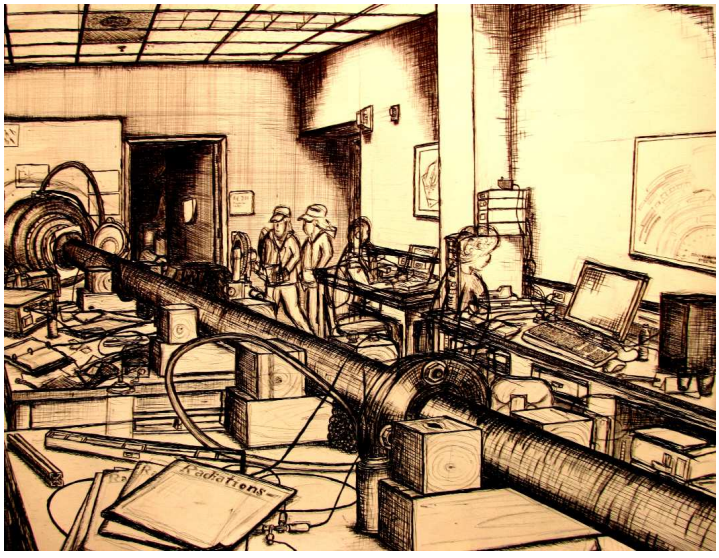
In the spring of 1993, Dr. Richard Peterson spotted an opportunity to enhance Bethel's visibility in the Twin Cities and to increase our department's funding. The Minnesota Space Grant Consortium, a group of schools that get money from NASA for projects relating to science education, wanted some new members. With the Bethel administration's permission, we applied for admission and were accepted. Our grant for the '93-'94 academic year was $5000, all to be used to pay student researchers in projects that could be incorporated into upper-division physics labs. Since then, I have been Bethel's principal investigator (meaning representative at meetings, paper-pusher, and accountant) for the grant.

Since 1993 our budget has grown steadily, and we can fund a variety of activities. Our total budget for the '09-'10 academic year is $37,650 and includes $17000 for student research (the largest single item), $8000 for scholarships, and $1000 for student travel to meetings to present research papers. I think it is safe to say that participation in summer research here would be much more limited without the grant. Over the years several students would have been much less able to afford Bethel without the scholarships which, by the way, require the easiest form you will ever have to fill out for any scholarship.

The Space Grant opportunities for students are not limited to Bethel's budget, though. Each spring the Consortium accepts applications for Consortium-wide scholarships. Over the years several Bethel students have received these, but many more could have. I know, because I have been on the evaluation committee. We have students who could come out very highly in the rankings. The application process is simple: the easy form referred to above, a letter of recommendation from a prof, and a personal statement of academic and career goals.

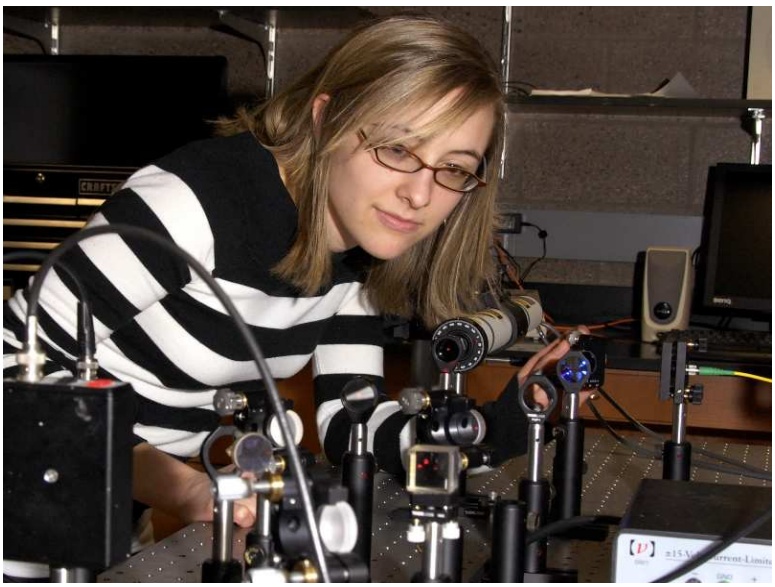
Check out the Consortium website at <http://www.aem.umn.edu/msgc/>.

–Dr. Greenlee

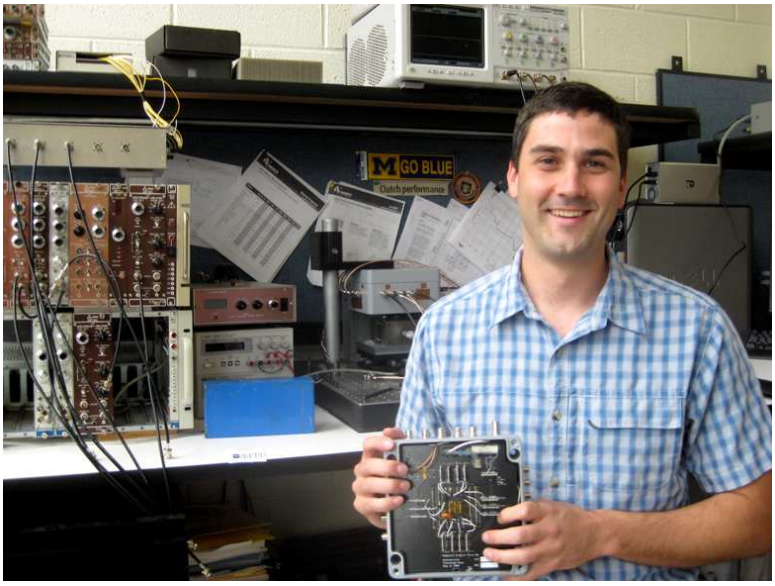


Analysis Center Sketch by David Swenson (Spring 2009)

Visiting Bethel "Anderson" Grads at Ann Arbor



I visited Sarah Anderson's research lab during the AAPT topical conference on Advanced Labs at the University of Michigan. At the conference, Sarah and I presented a poster on her senior research at Bethel: "Sub-picometer resolution from a low-cost wavelength meter." Sarah works in the experimental research group of Georg Raithel. Together with another graduate student she studies cold Rydberg atoms, or atoms that are in very high electronic energy states. These atoms can be used for sensitive measurements and hold promise for a quantum computation system. Her work involves laser cooling and trapping rubidium atoms, spectroscopy using selective ionization techniques, and, more recently, trapping atoms in an optical lattice. Sarah has stepped into an existing vigorous experiment and has learned a lot about lasers, cooling and trapping and atomic physics. – Dr. Hoyt



I enjoyed the bus ride to the Michigan North Campus and Steve Anderson's office and lab during our trip to Ann Arbor. Steve is completing the Ph.D. in nuclear engineering at Michigan. His interest in nuclear engineering and global nuclear policy issues dates back to a Princeton Plasma Physics Lab (PPPL) summer research experience that he did between Junior and Senior years at Bethel (along with Matt Borg, who very recently completed the Ph.D. in aerospace engineering at Purdue). Steve is working in the very active field of gamma ray imaging and specifically on digital analysis of the data coming from a gamma ray detection "chip." Digital analysis can pull much more radiation source information from such a chip than currently used analog techniques. Current priorities of security, defense, and national safeguards are making rapid, distant imaging of such radiation sources critical. Steve notes that around 50% of the graduate students in his research group enter with physics undergraduate backgrounds. – Dr. Peterson