Experiences in Early Undergraduate Research at a Community College

Walerian Majewski
Northern Virginia Community College, Annandale (ret.)

Meeting of CSAAPT, October 21, 2016, Loudon, VA

- National Academies of Sciences, Engineering, and Medicine held a convocation in Washington, DC, on May 11-13, 2015, entitled “Integrating Discovery-Based Research into the Undergraduate Curriculum.”
  We were the only 2-year college in the physics discipline, among 30 universities invited to develop a consensus paper, submitted later to the White House, on introducing discovery-based science experiences, beginning with the first-year students.

- This three-day Convocation was a follow-up on the February 2012 report, “Engage to Excel,” from the Presidential Council of Advisors on Science and Technology (PCAST, 2012), urging the STEM education community and funding agencies to “advocate and provide support for replacing standard laboratory courses with discovery-based research courses.” PCAST found that “economic forcasts point to a need for producing, over the next decade, approximately 1 million more college graduates in STEM fields than expected under current assumptions.”

The Council on Undergraduate Research (CUR)

CUR believes that faculty members enhance their teaching and contribution to society by remaining active in research and by involving undergraduates in research.

Community College Undergraduate Research Initiative (CCURI)

National Science Foundation (NSF)-funded project that started with Finger Lakes Community College (FLCC, affiliated with SUNY) eight years ago and has grown into a national network to incorporate research into science, technology, engineering and mathematics (STEM) programs.

NOVA Physics Students on Capitol Hill

- In September 2014 my students have participated at the first CCURI National Conference, which met on the Capitol Hill at the Hart Senate Building. We were invited to participate in the Poster Session as associate members of CCURI.

US Undergraduate Research

- Close to 600 colleges and universities in the United States and thousands of undergraduate students and faculty pursue undergraduate research every year. However, community colleges very rarely are able to provide such opportunities to their students.

What about Community Colleges?

Because close to 50 percent of all students who finished a four-year degree in 2010-11 had previously enrolled at a community college, it becomes imperative to give them the same opportunities of an early exposure to undergraduate research that university students have.

Early (freshman-sophomore level) Undergraduate Research Experiences in Physics for STEM NOVA students

- Established in 1985
- By now about 400-500 students
- At least five known physics PhDs, two MS teaching at NOVA, many MS and BS working all over US
- Transfer students go to GMU, Va Tech, UVA,UWM, GW, Georgetown U., MIT, Cornell, Berkeley…

Organizational framework at NOVA

- An honors course PHY 298 “Seminar and Project”, 1 cr, 3-hr lab; since 1985
- Established in 1990 a chapter of the Society of Physics Students, included PHY 298 research lab in their activities
- Outstanding SPS Chapter, for involvement in professional meetings, outreach efforts and community service: 1999, 2000, 2001, 2002, 2003, 2004, 2010, 2013, 2014 and 2015.
- NVCC SPS Chapter won eight Sigma-Pi-Sigma Undergraduate Research Awards, in years: 1992, 1994, 2000, 2002, 2005, 2009, 2013 and 2015.

Funding

- Teaching load credits from PHY 298, close to zero
- VCCS Professional Development program – release time, rarely and reluctantly
- NVCC Educational Foundation – equipment
- Research lab donations – equipment
- Society of Physics Students grants - equipment
- My volunteering

Where the ideas for research topics are coming from?

- From my research papers written before coming to a non-research college
- Suggested by partnership doctoral institutions
- Found out in current research papers and adapted to our funding and equipment
- Appropriate for our resources and what our students can handle – we have no external research grants, our students take only introductory physics

Give students an experience in scholarly activity

With a modest financial support, my physics students are building their experimental hardware, doing measurements, writing presentations and posters, and delivering their talks at professional conferences.

Adapting experiments performed at the research labs to the capabilities and needs of a community college lab: simplified versions. Spin-offs of the large lab's research. "Small research".

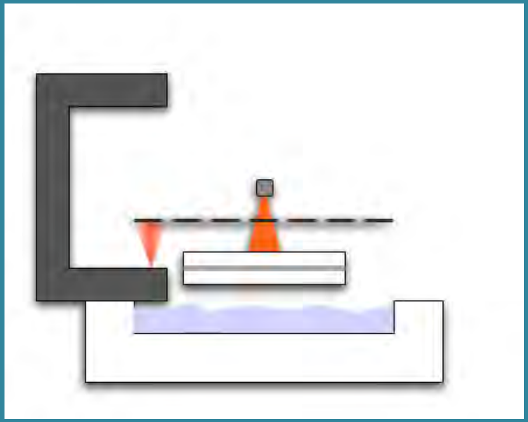
Experimentation

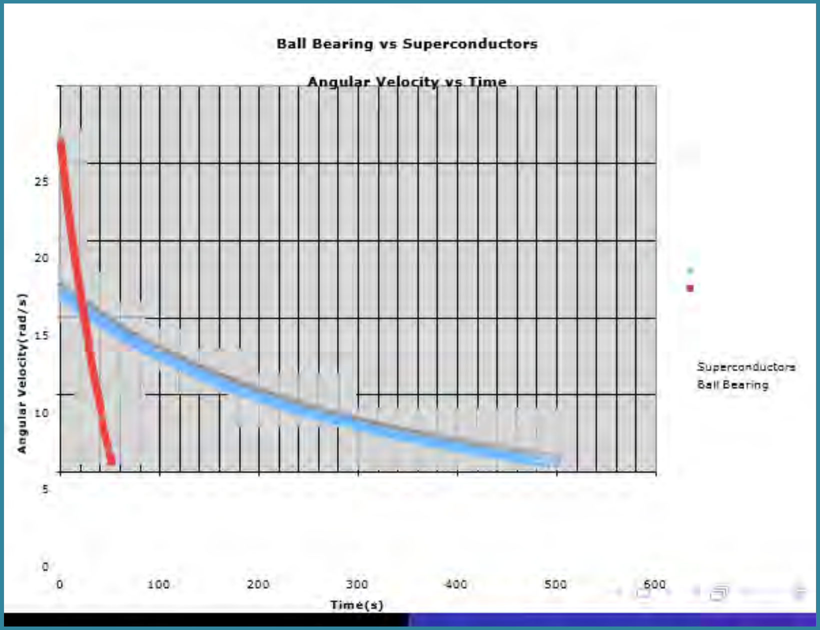
Rehearsals of presentations

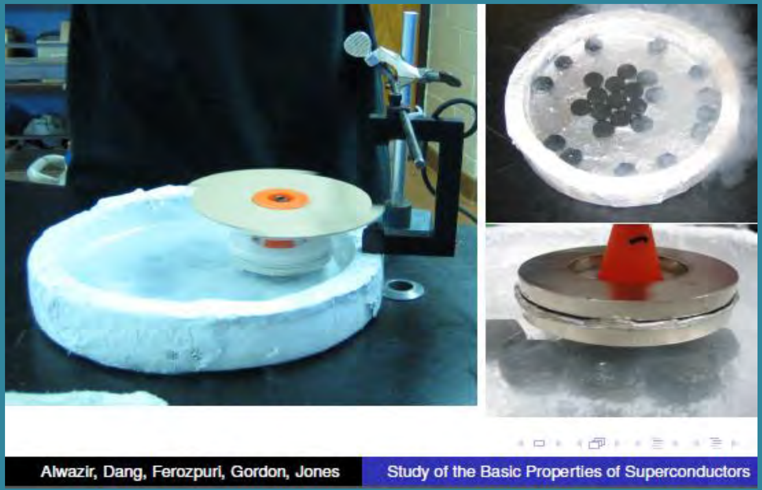
How to show off your poster?

They have to decide what to do by consensus, not by the teacher's instruction…

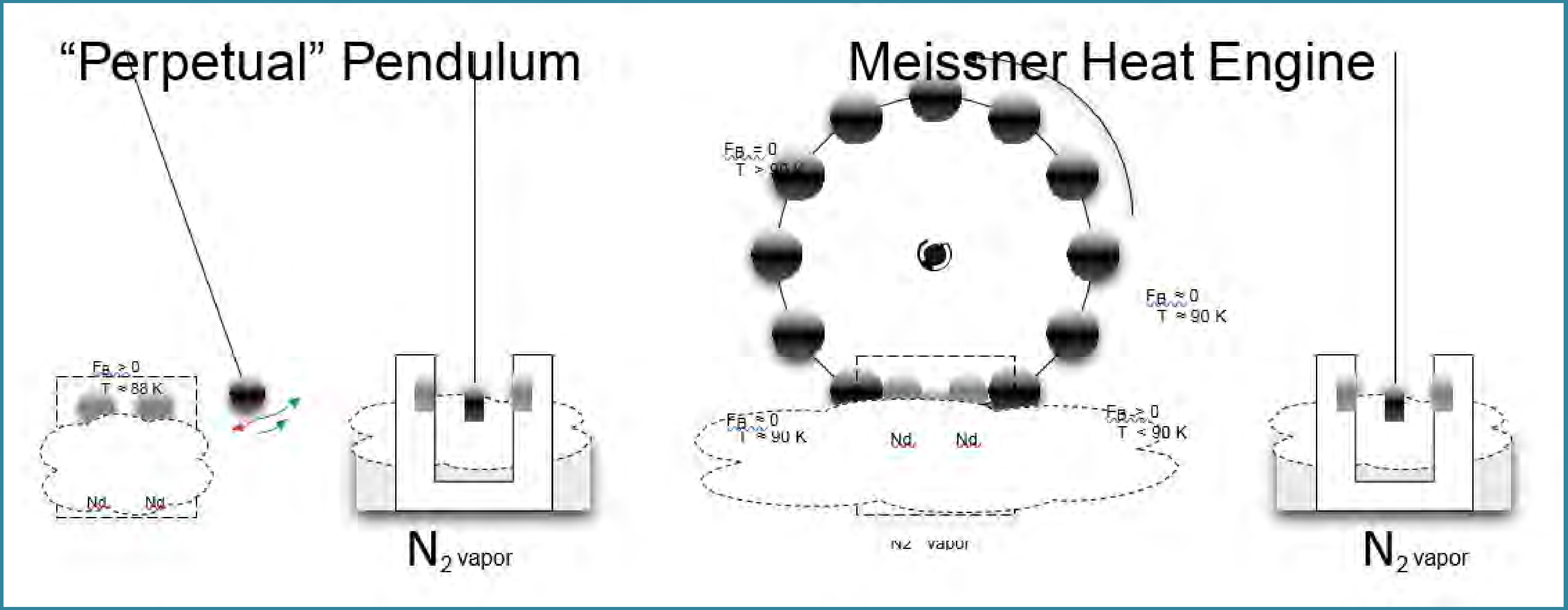
Superconducting Levitation of a Magnetic Flywheel; SC Pendulum







Superconductor moving in and out of the magnetic field bathed in N_2 vapor: possible sources of perpetual energy? Nope, these are actually thermodynamic systems



My first publications: Universal Fermi Interaction in Muon Capture in Hydrogen; with Zhou Guang-Zhao

УНИВЕРСАЛЬНОЕ ВЗАИМОДЕЙСТВИЕ ФЕРМИ И ЗАХВАТ μ-МЕЗОНА В ВОДОРОДЕ

Чжоу Гуан-чжао, В. Маевский

Предложенная Маршаком и Сударшаном [1], Фейнманом и Гелл-Манном [2] теория универсального взаимодействия Ферми с $(V-A)$-связью подтверждается всеми существующими экспериментами по β-распаду. Для объяснения равенства β-распадной константы Ферми и константы μ-распада Фейнман и Гелл-Манн выдвинули гипотезу сохраняющегося векторного тока в слабых взаимодействиях. Это предложение приводит к появлению эффекта аномального магнитного момента в β-распаде (
ки эффекта были сделаны Гелл-Манном и др. [3-5] и, по
уже экспериментальное подтверждение в β-распаде [

物 理 学 报

ACTA PHYSICA SINICA

普适費米弱相互作用理論及μ^-介子
在原子核上的俘獲*

周光召 B. 馬耶夫斯基

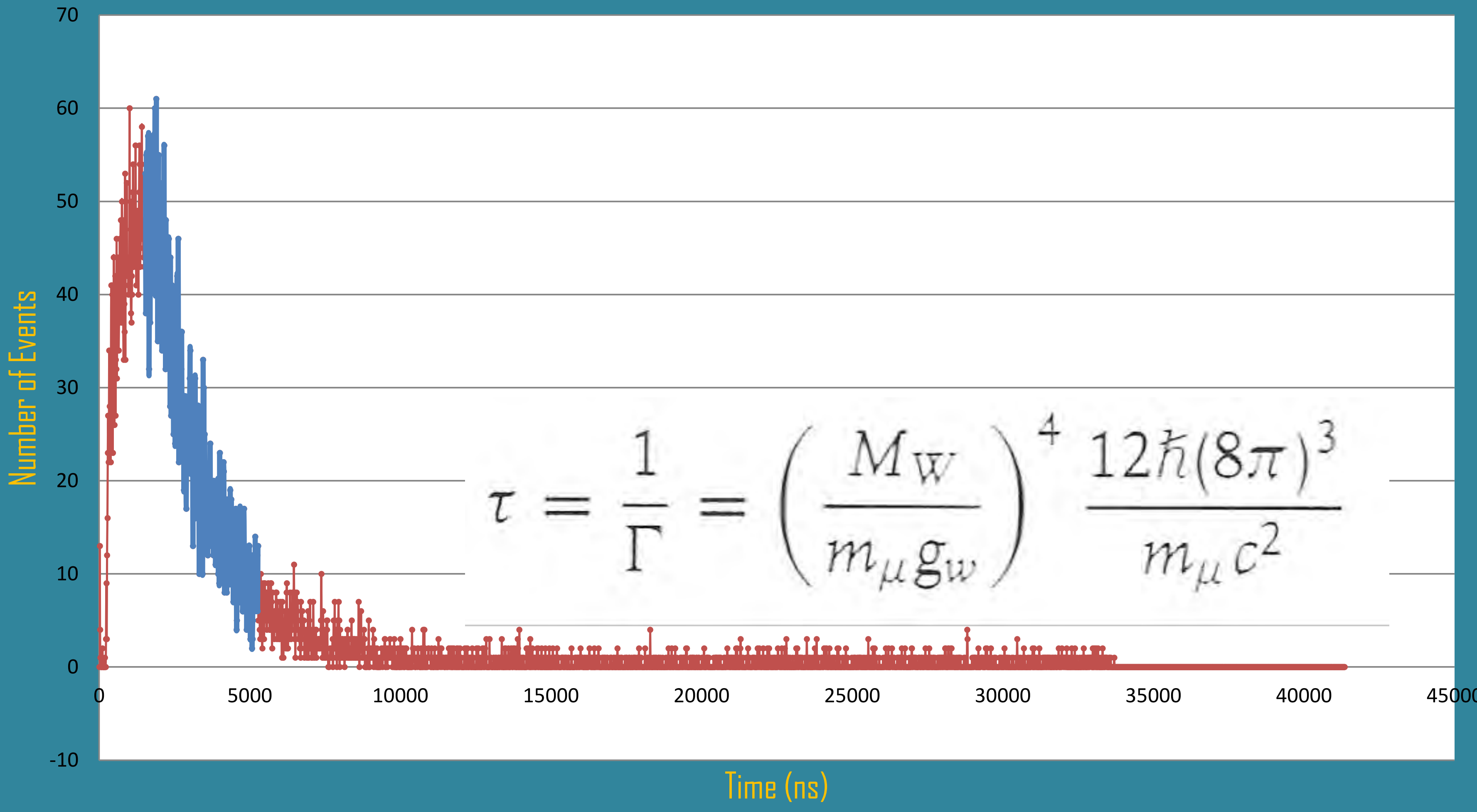
（联合原子核研究所，莫斯科）

Cosmic-ray muon decay, measurement of the lifetime; plastic scintillator, PMT, oscilloscope, power supply

Visualizing muons and electrons; hand count

Our updated muon system: new power supply/control box, , computer with ADC card PCI-DAS4020/1 and data analysis software

Distribution of Muon Lifetimes



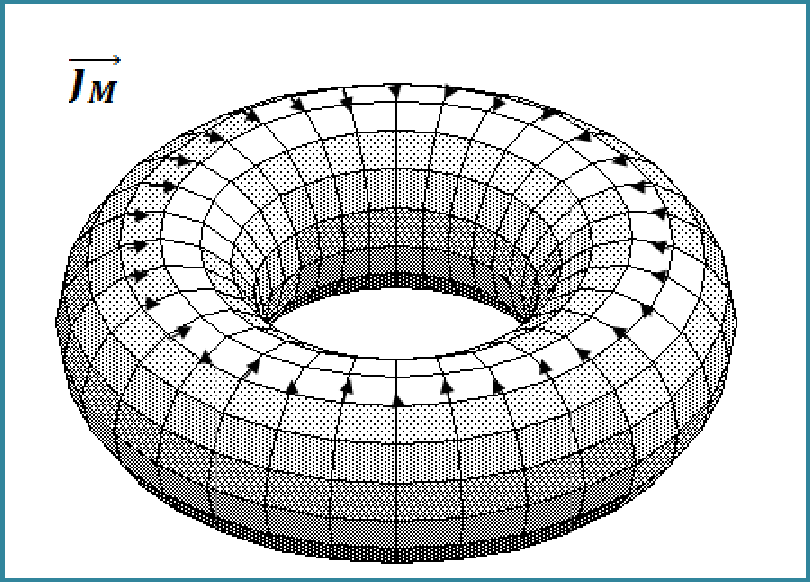
$$\tau = \frac{1}{\Gamma} = \left(\frac{M_W}{m_\mu g_w}\right)^4 \frac{12\hbar(8\pi)^3}{m_\mu c^2}$$

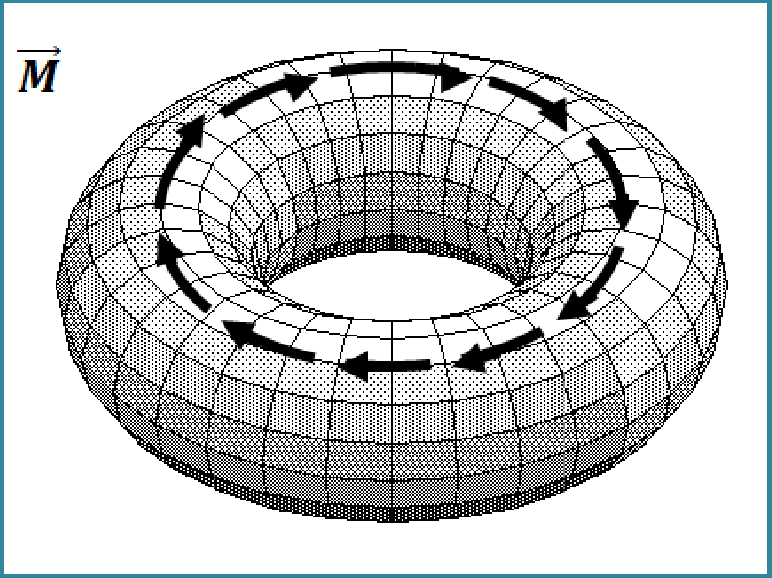
Standard Model of Particles: weak coupling constant gw, electric charge e and the vacuum expectation value of the Higgs field

- $g_W = 8(3\pi^3\hat{h}/2\tau m_\mu c2)^{1/4}(M_W/m_\mu)$ with accepted $g_w = 0.653$,
- $e = g_w \sin\vartheta\sqrt{\hbar c \varepsilon_0}$ with the textbook value of $1.6\text{x}10^{-19}$ C
- $v = (2\tau m_\mu c^2/3\pi^3\hbar)^{1/4}\ (m_\mu c^2/4\sqrt{\hbar c})$ with accepted v=236 GeV/$\sqrt{\hat{h}c}$.

Exotic System: Toroidal Dipole

STATIC TRANSVERSE ELECTRIC DIPOLE MOMENT OF THE PARITY-VIOLATING ATOM, pres. at VII International Conference on Atomic Physics, Cambridge, 1980; **Bull. Amer. Phys. Soc.** 26, 60 (1981).

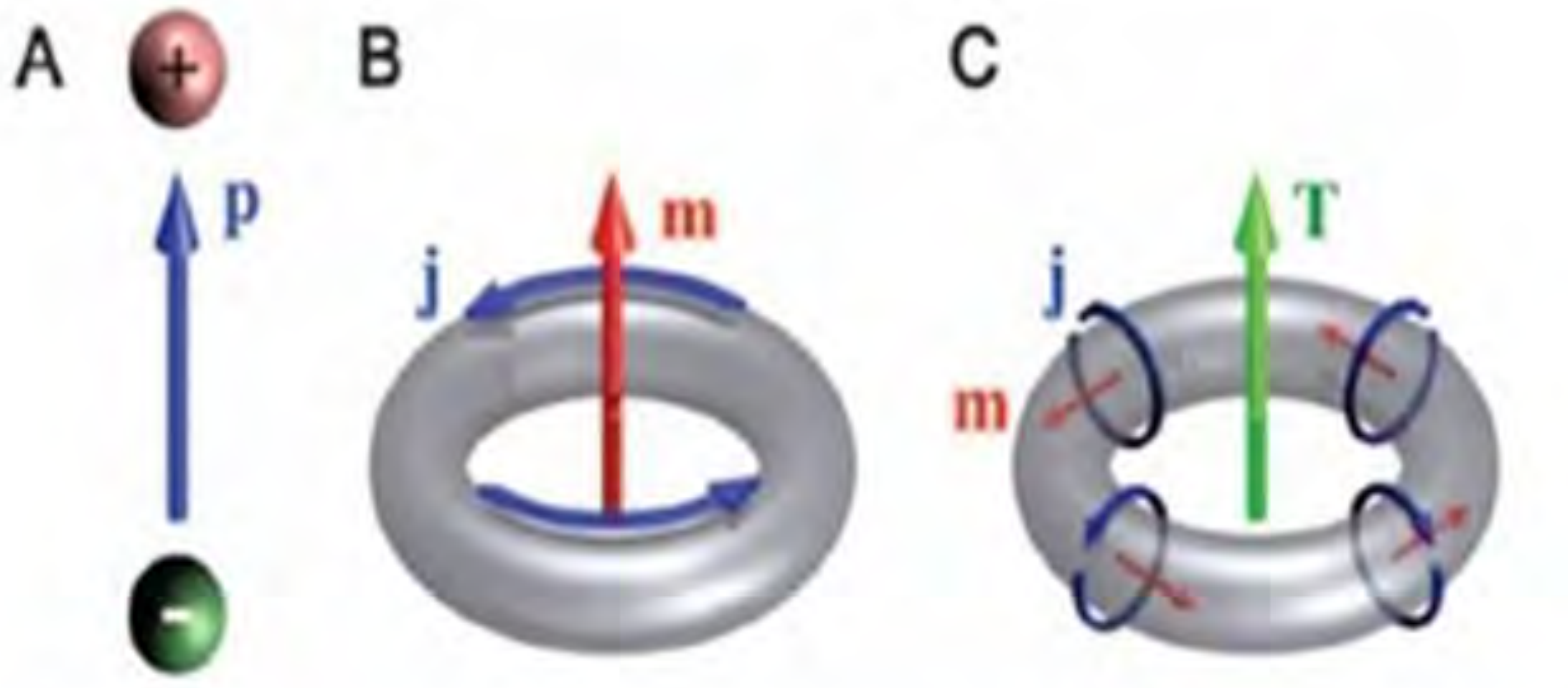




Toroidal coil with current density (**j**)

Torus with azimuthal magnetization (**M**)

Three elementary dipoles



p-electric m - magnetic, T - toroidal dipole moments;
j - current density

Toroidal dipole interacts with curl**B:** it has contact interaction with current or with a time-varying electric field

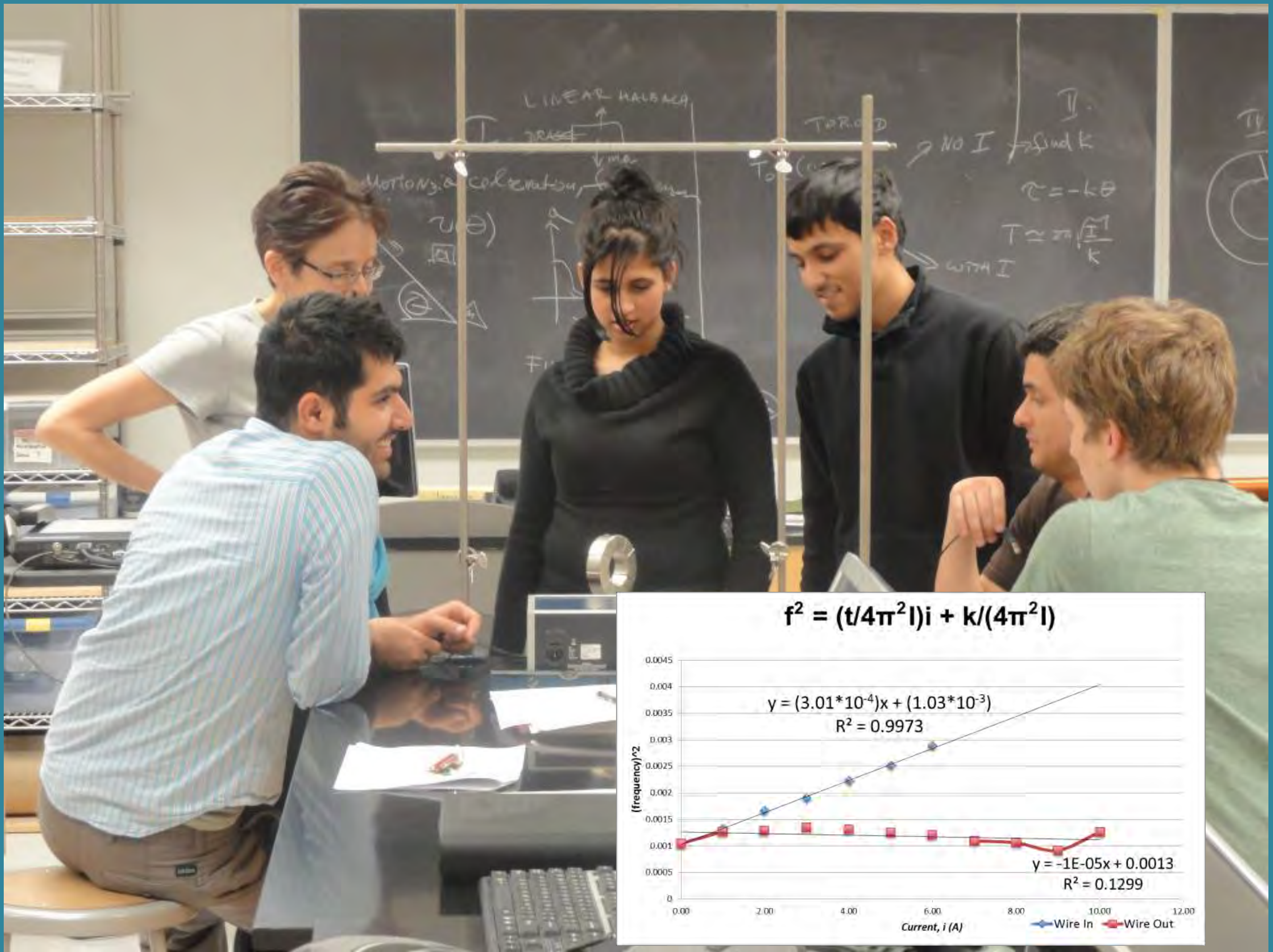
- Properties in the magnetic field:

$$\vec{\tau} = \overrightarrow{t_m} \times (\vec{\nabla} \times \vec{B}) \qquad U_m = -\overrightarrow{t_m} \cdot (\vec{\nabla} \times \vec{B})$$

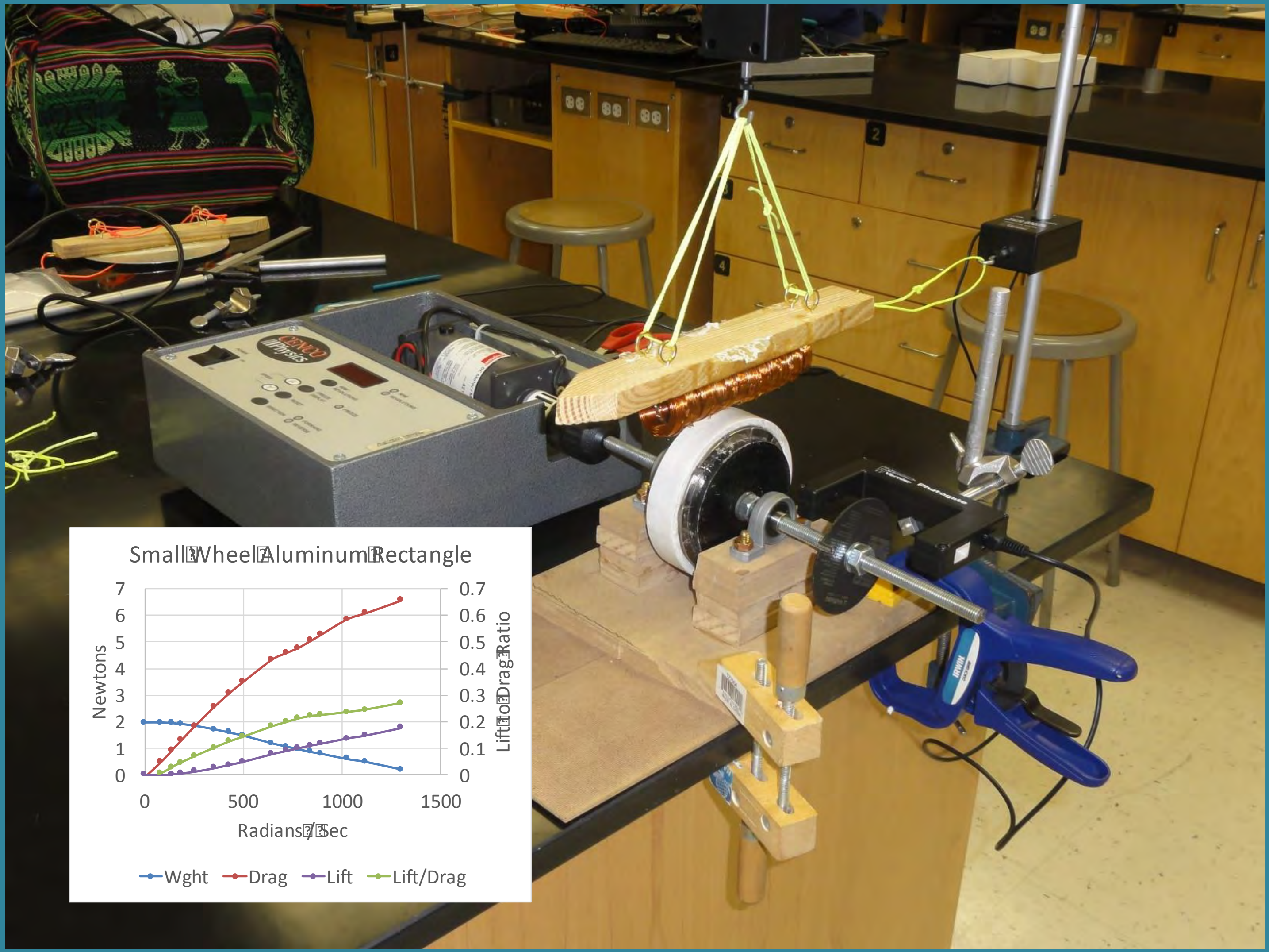
- Ampère-Maxwell Law:

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t} \qquad \oint \vec{B} \cdot d\vec{s} = \mu_0 \left[\vec{J} + \varepsilon_0 \frac{d\Phi_E}{dt} \right]$$

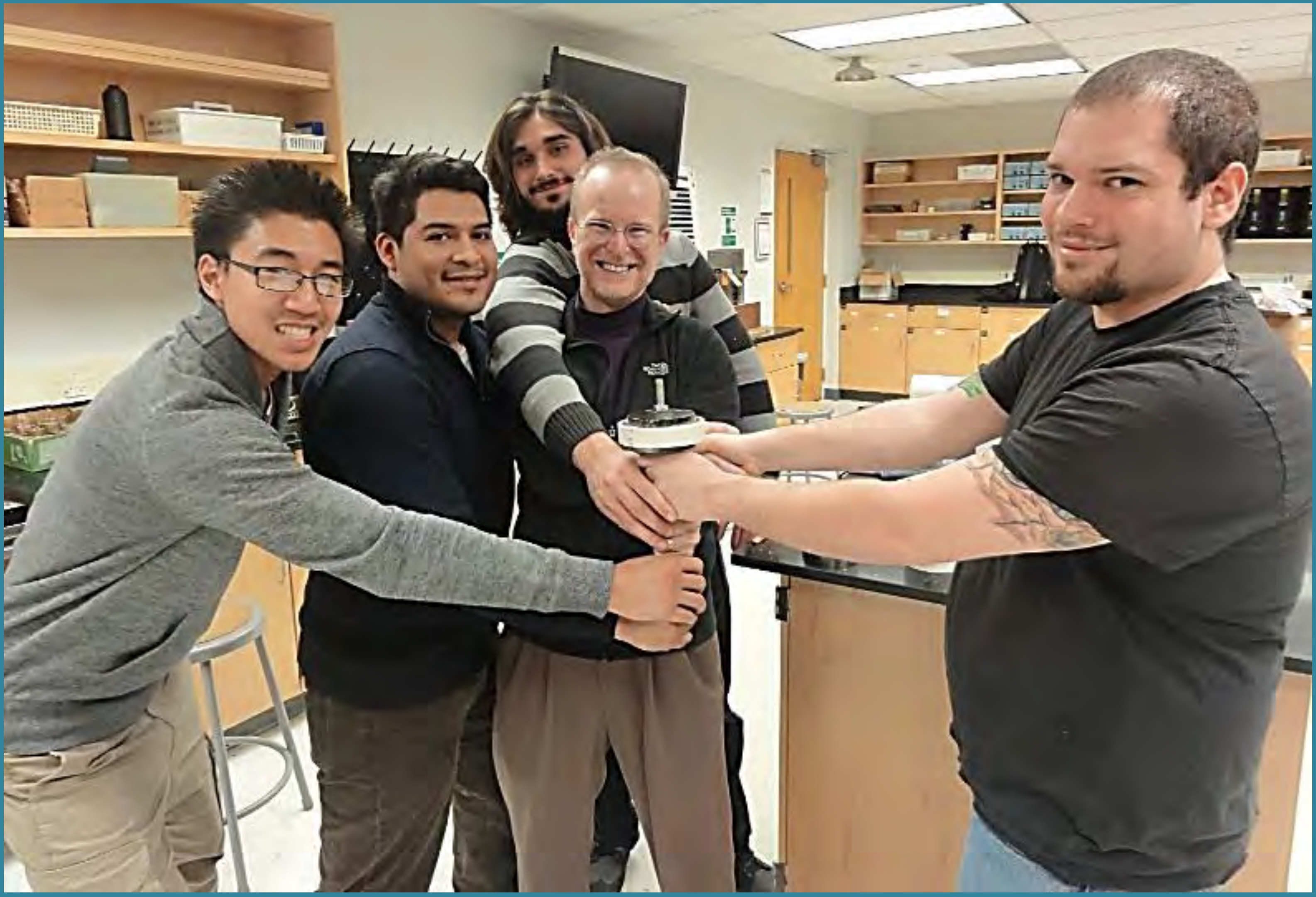
Toroid interacts directly with a current passing through it, acting as magnetic curlmeter/ammeter



Induction: rotating magnetic wheel levitates and propels the inductors



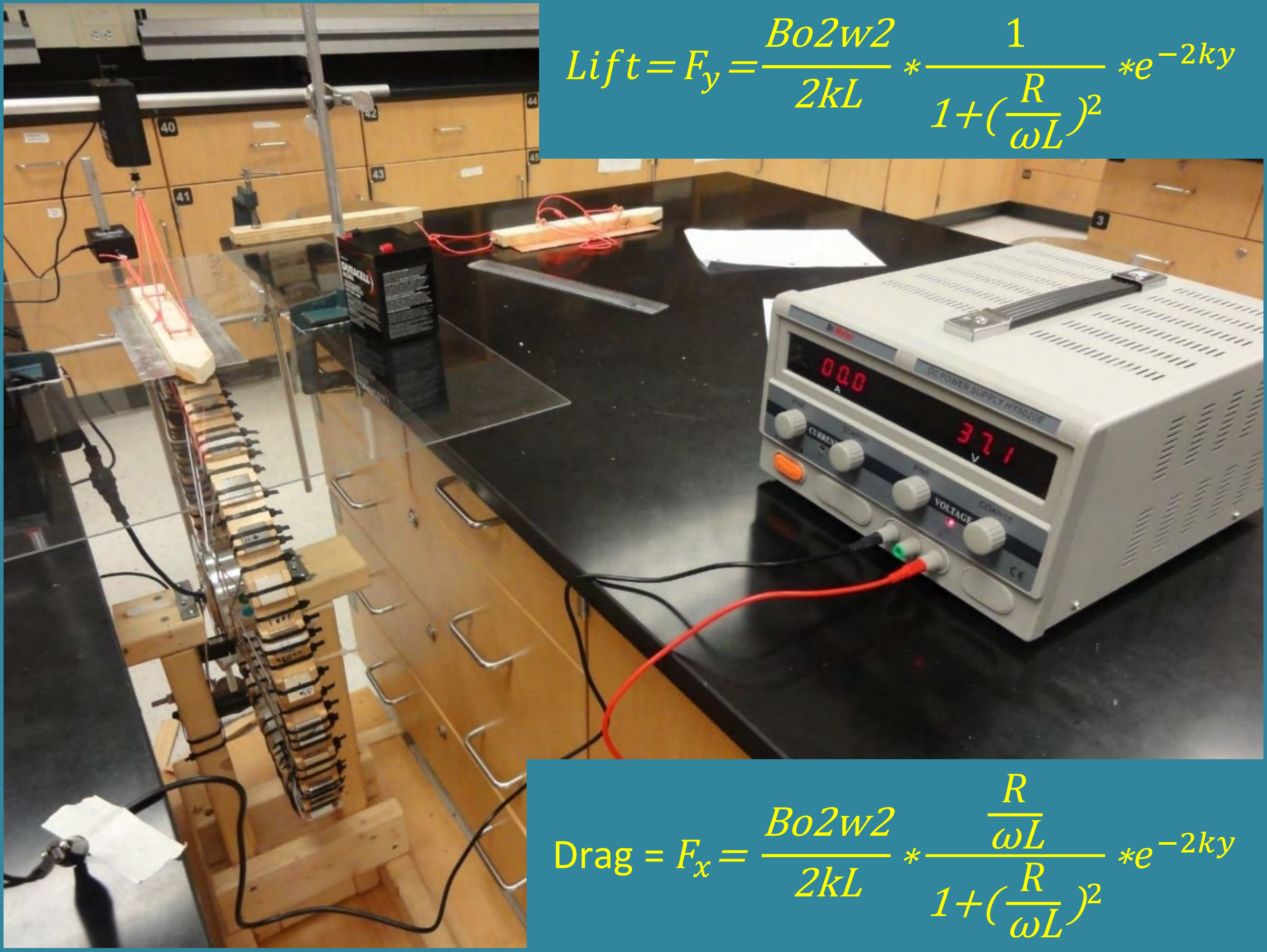
Putting 12 very strong 1-Tesla magnets into a small ring was quite an achievement!



James and Chris are building the next Electrodynamic Wheel: placing one-inch cubic Nd magnets on the rim of a motorized bicycle wheel


Force
Lift
Drag
Velocity

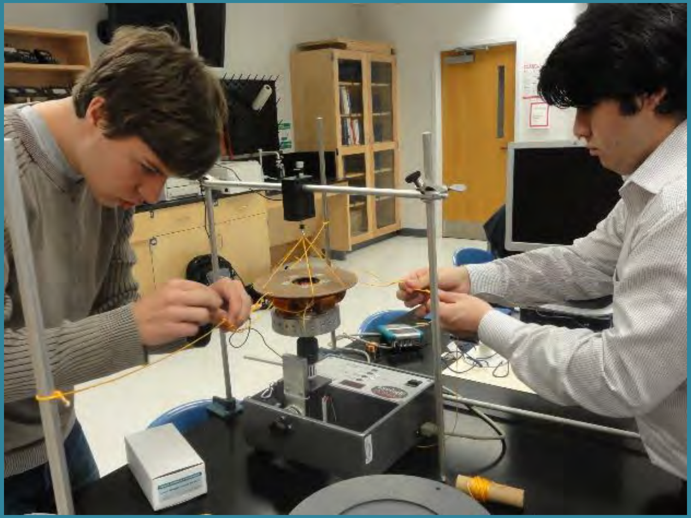
Rotating Large Electromagnetic Wheel levitates conducting plates

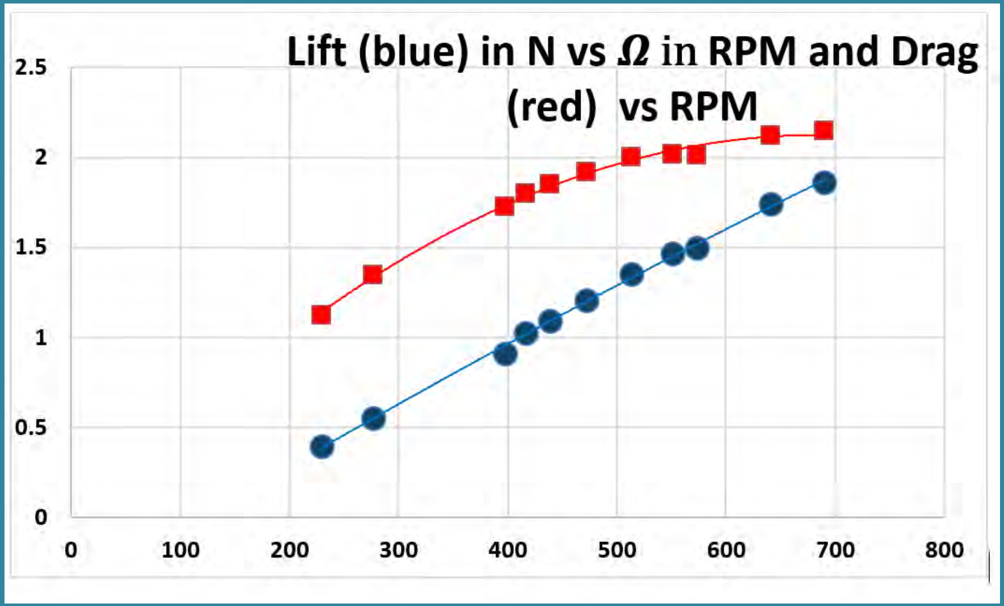


$$Lift = F_y = \frac{Bo2w2}{2kL} * \frac{1}{1+(\frac{R}{\omega L})^2} * e^{-2ky}$$

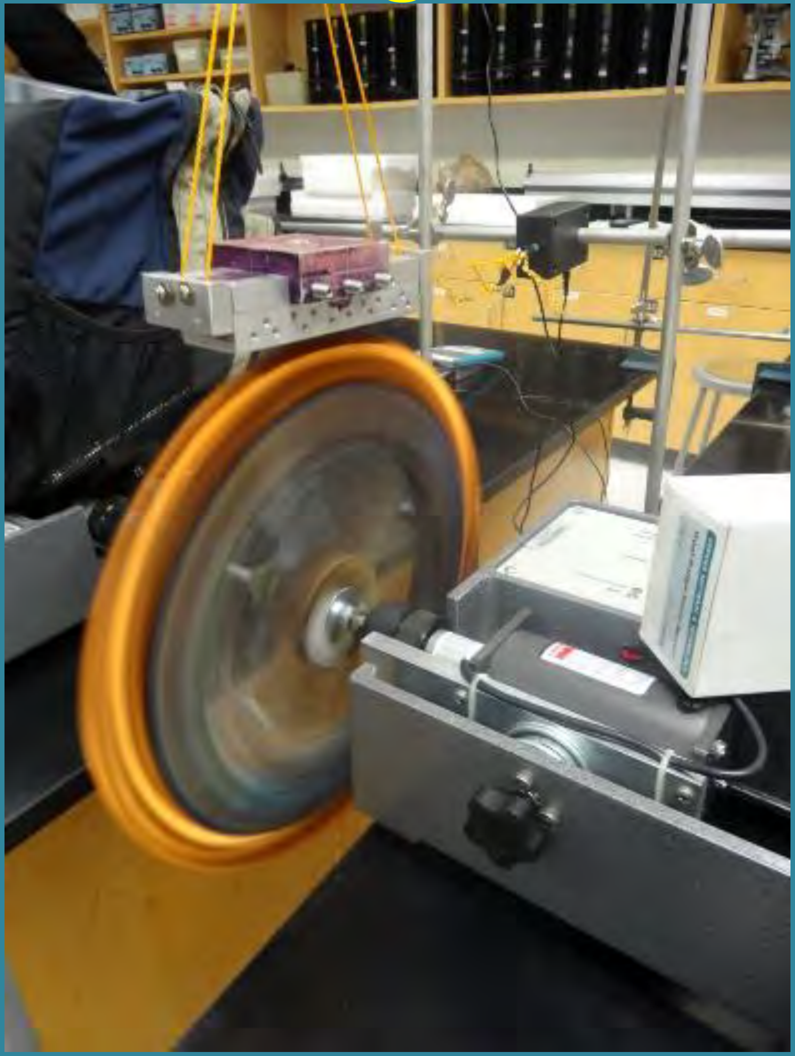
Drag = $$F_x = \frac{Bo2w2}{2kL} * \frac{\frac{R}{\omega L}}{1+(\frac{R}{\omega L})^2} * e^{-2ky}$$

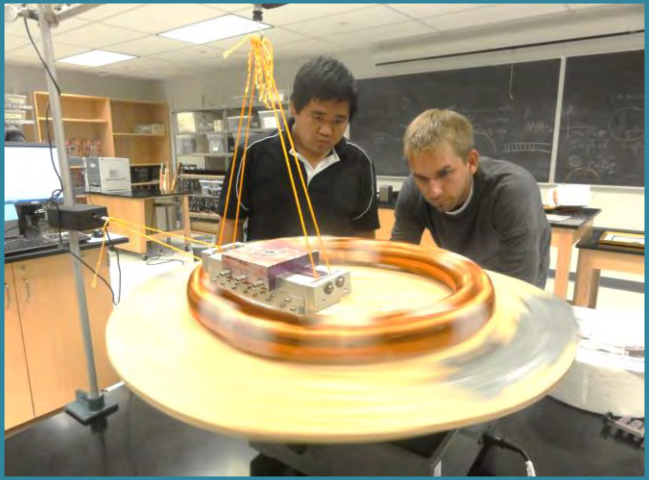
Another circular Halbach array: magnetic field maximized on the upper side of the magnetic ring; measure lift to drag ratio vs angular velocity of the magnet, gap size, kind of induction ring lifted by the rotating magnet

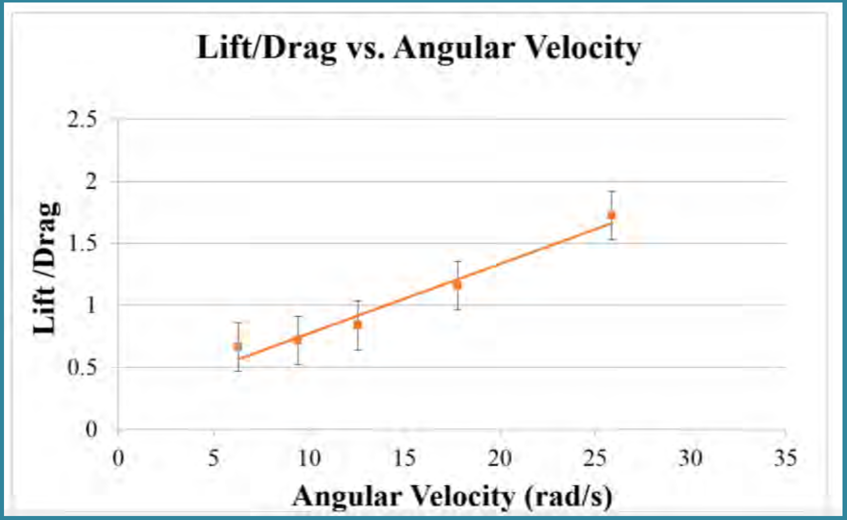




Induction wheels: rotating, they lift/drag a linear Halbach Magnet Array





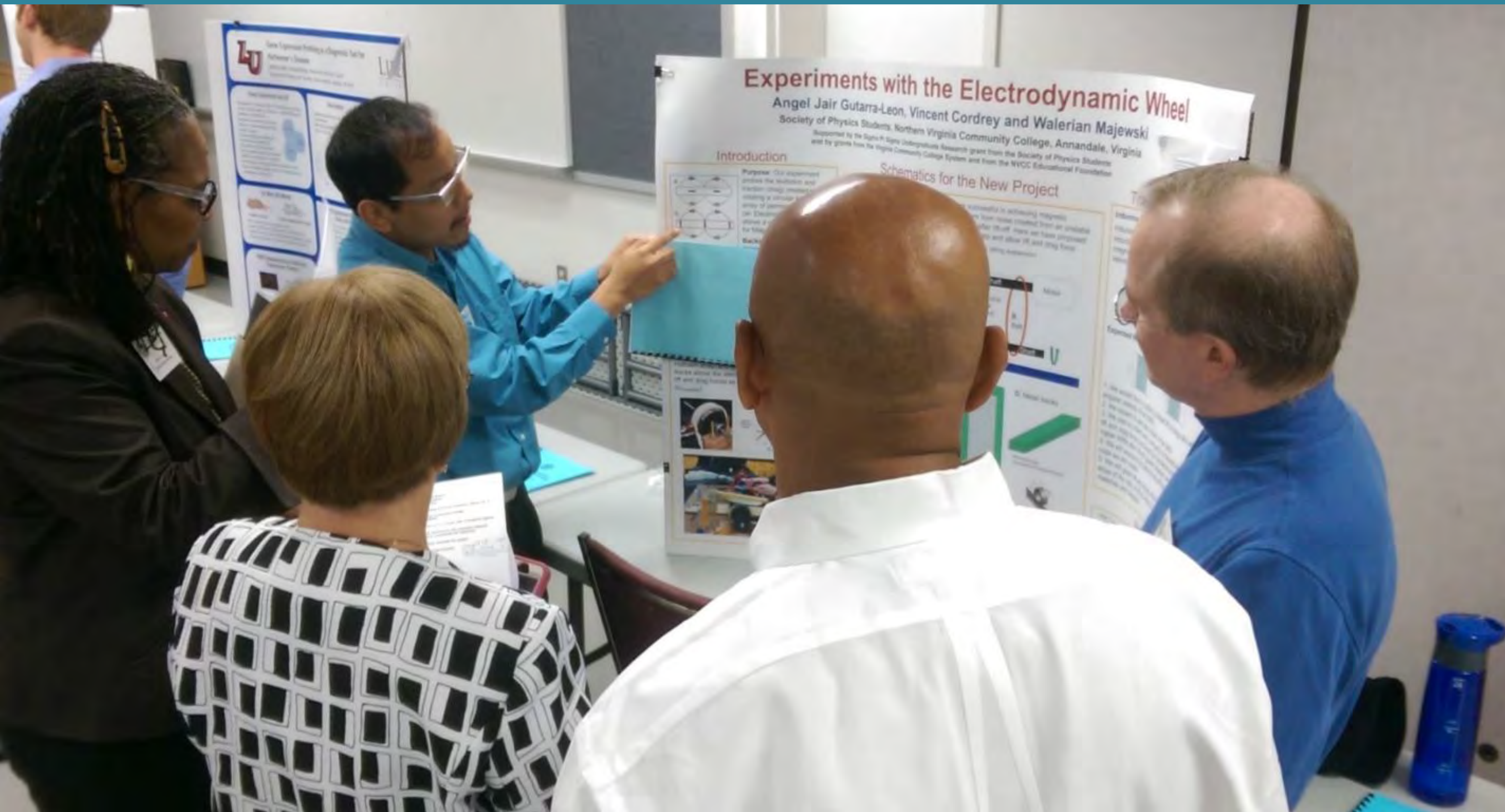


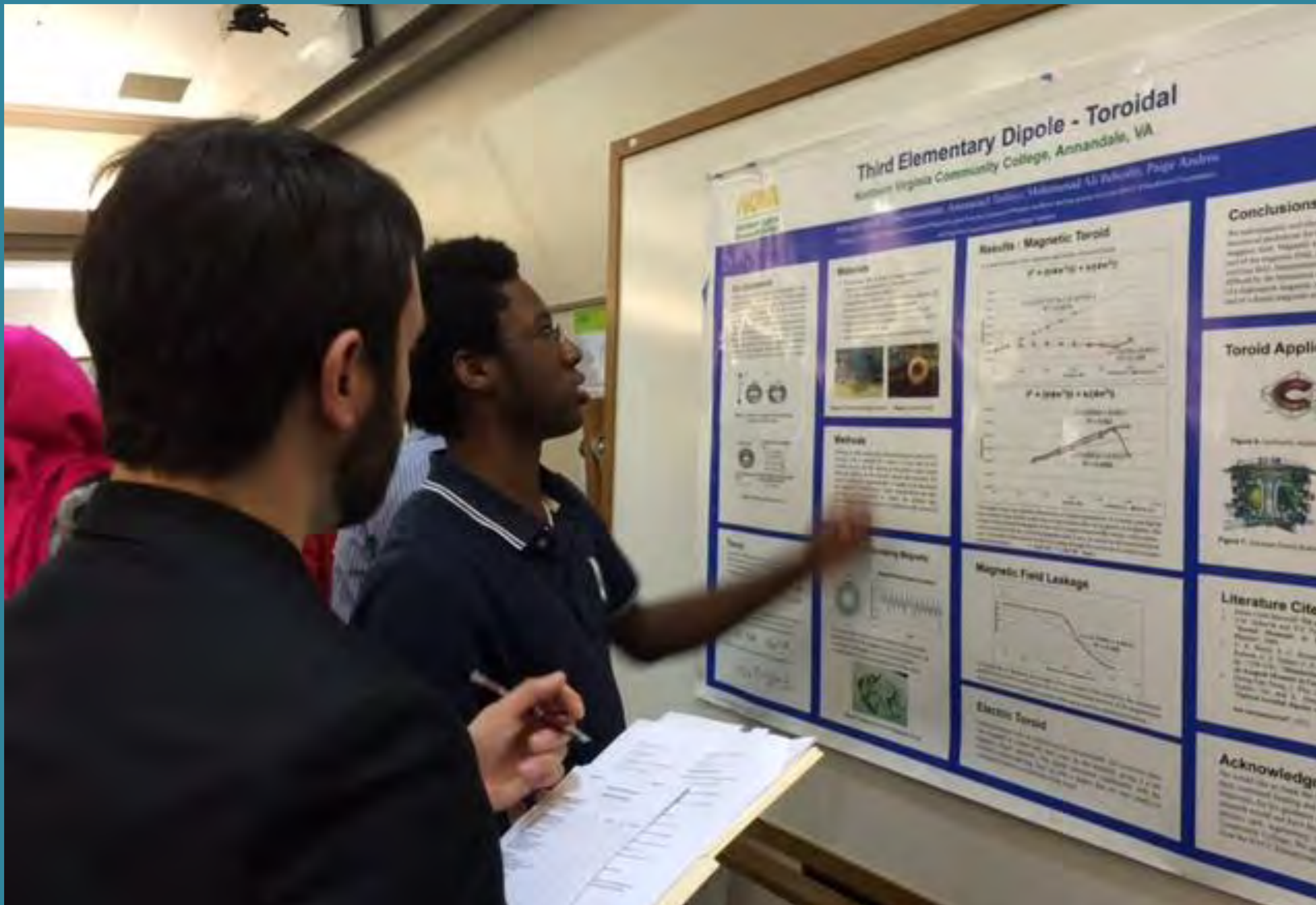
Our students presented many times at the meetings of the APS, SESAPS, CSAAPT, SPS, SPS Quadrennial Congress, VA Academy of Sciences, Washington Academy of Sciences, National Academy of Science, G. Washington U., George Mason U., AIP, BEACH Conference, US Congress, VA Assembly…

Vincent and Ian explain the theoretical lift-to-drag ratio calculations

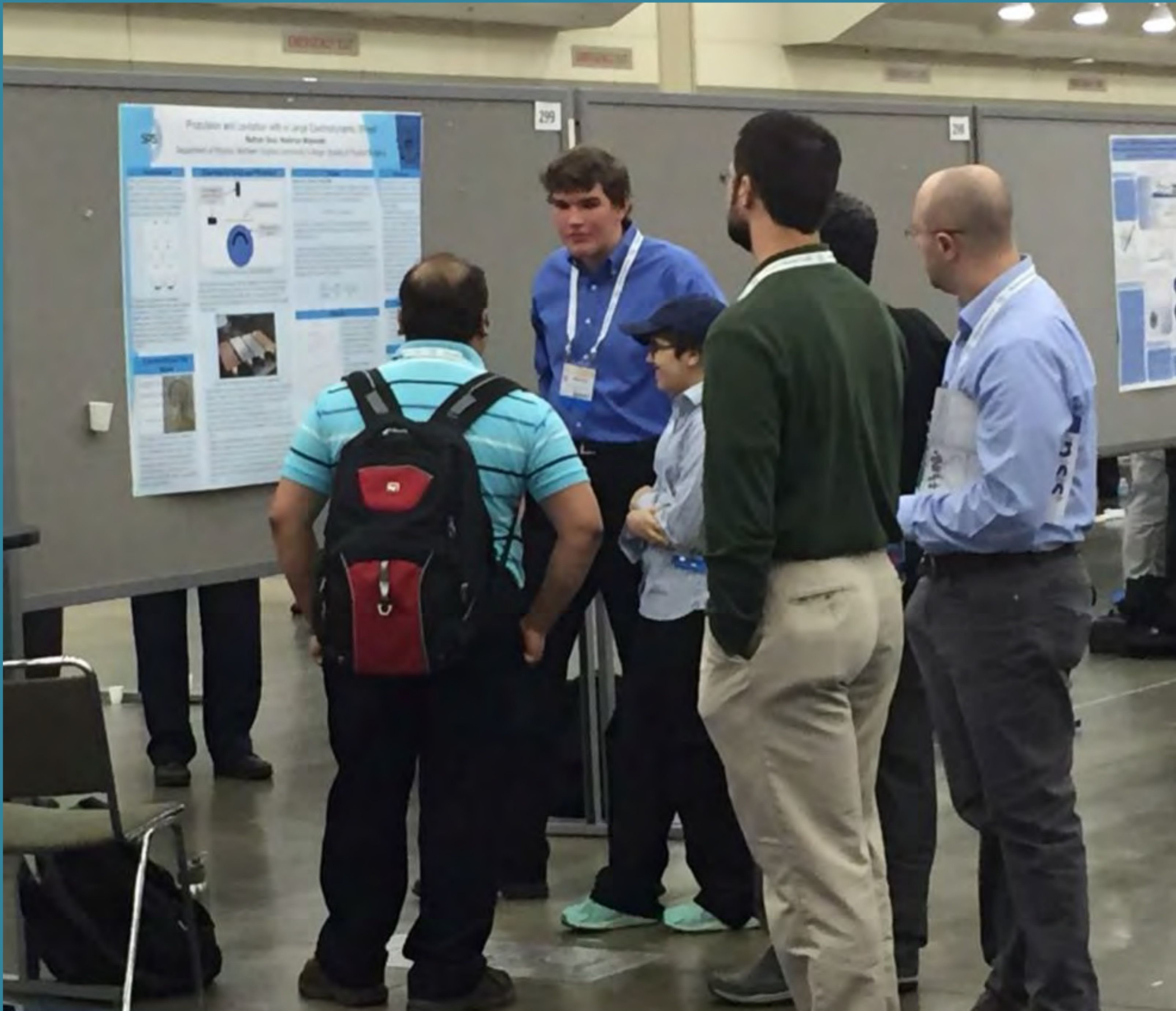
CSAAPT at the American Institute of Physics


Induction Wheels in Experiments on Magnetic Levitation
Douglas Zabransky, Phuong Le, Christopher Hill, James Carrico
Northern Virginia Community College, Annandale, Virginia
Grant from the Society of Physics Students and by grants from the NVCC Educational Foundation
the Virginia Community College System
Abstract
Theory
Experiment
Method 1
Method 3
Acknowledgments


Experiments with the Electrodynamic Wheel
Angel Jair Gutarra-Leon, Vincent Cordrey and Walerian Majewski
Society of Physics Students, Northern Virginia Community College, Annandale, Virginia
Introduction
Schematics for the New Project



Third Elementary Dipole - Toroidal
Northern Virginia Community College, Annandale, VA
Conclusions
Results : Magnetic Toroid
Methods
Magnetic Field Leakage
Literature Cited
Electric Toroid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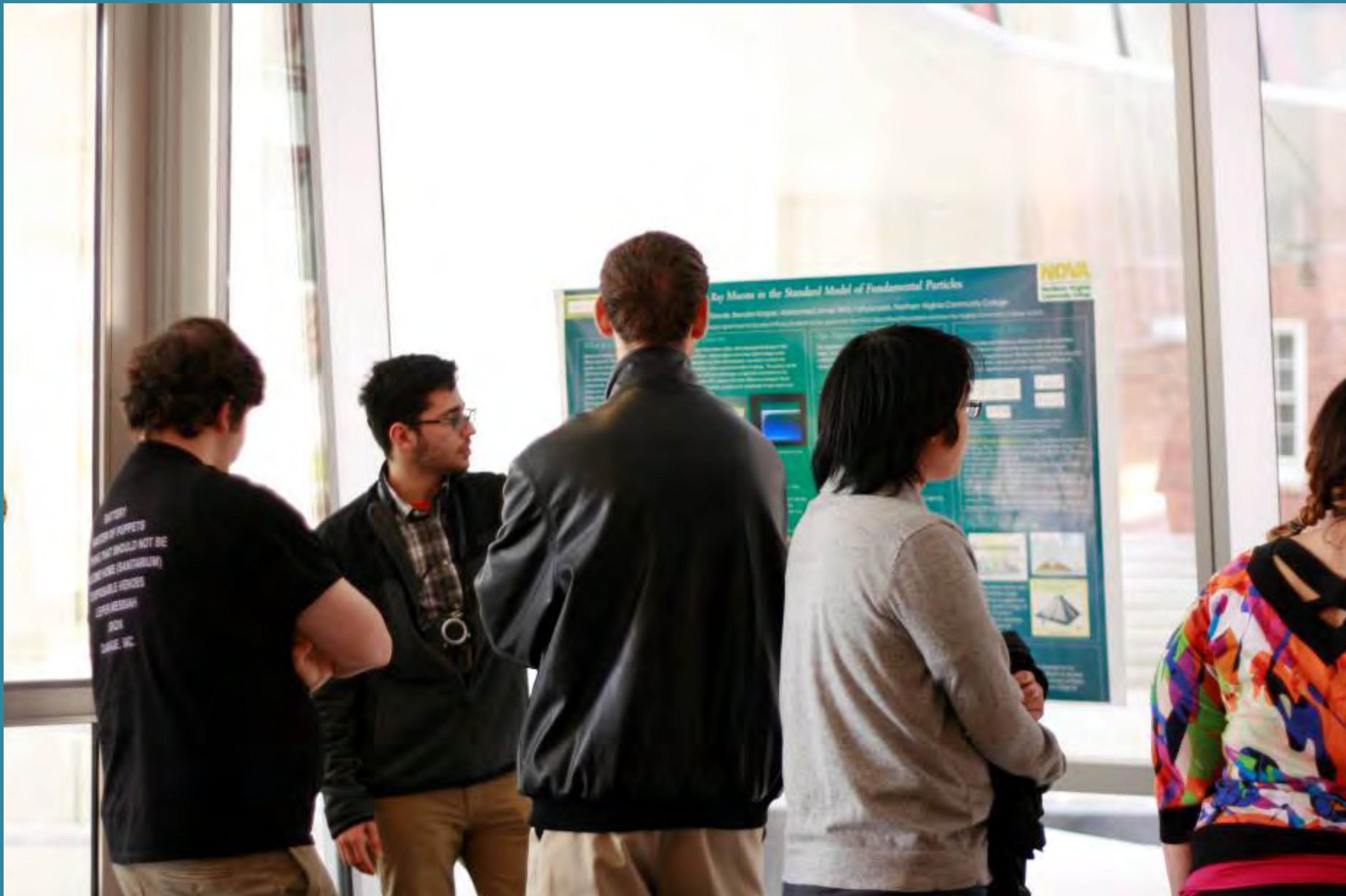
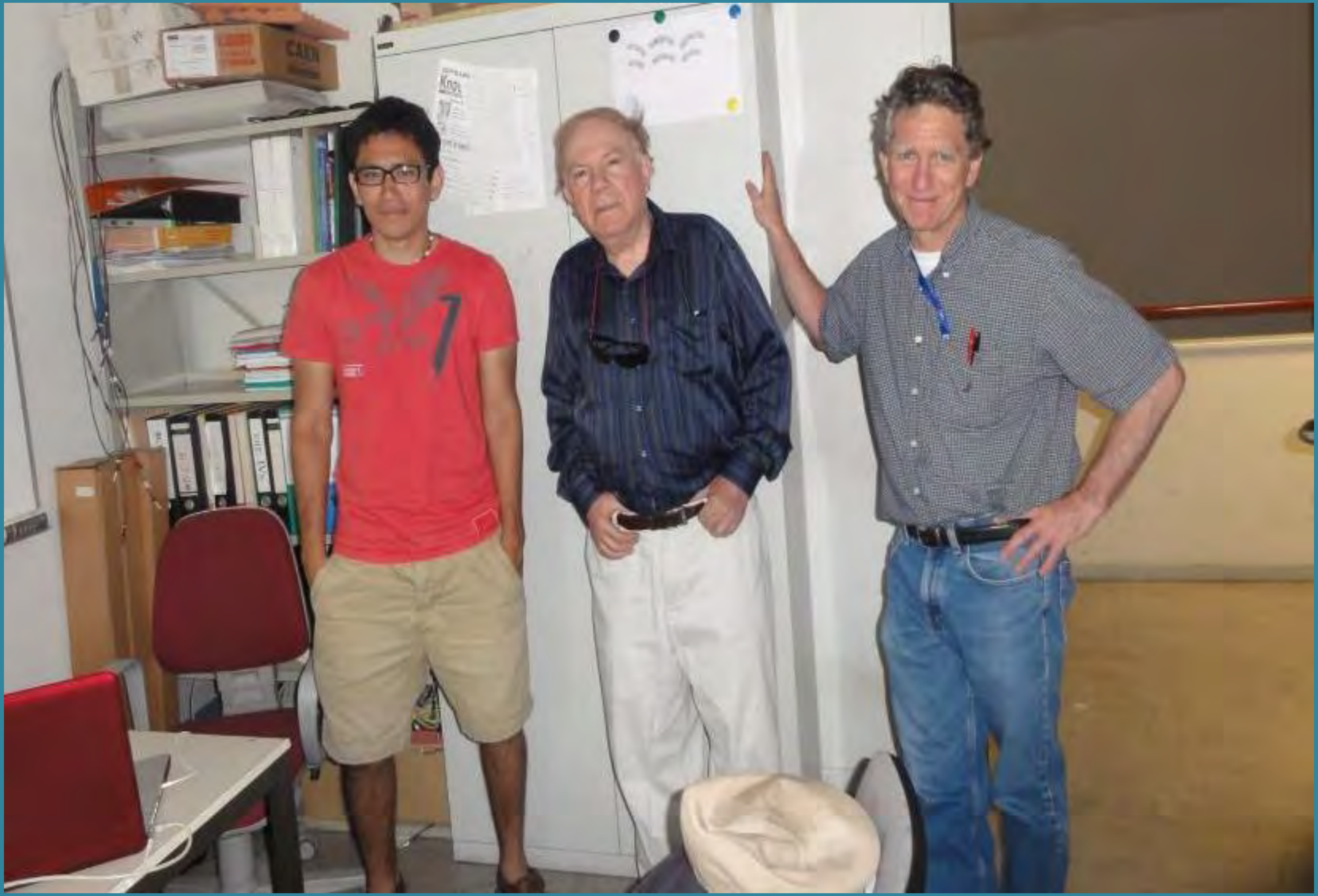
NOVA
Third Elementary Dipole - Toroidal
Induction Wheels in


Ray Muons in the Standard Model of Fundamental Particles
NOVA

Importance of internships. In five years from NOVA to LHC, then VT, then IceCube Neutrino Telescope on South Pole, now a PhD student at Berkeley: Mario Solano, Class 2011

NA-62 experiment at CERN: Rare Kaon Decay **K → π + ν + ν**



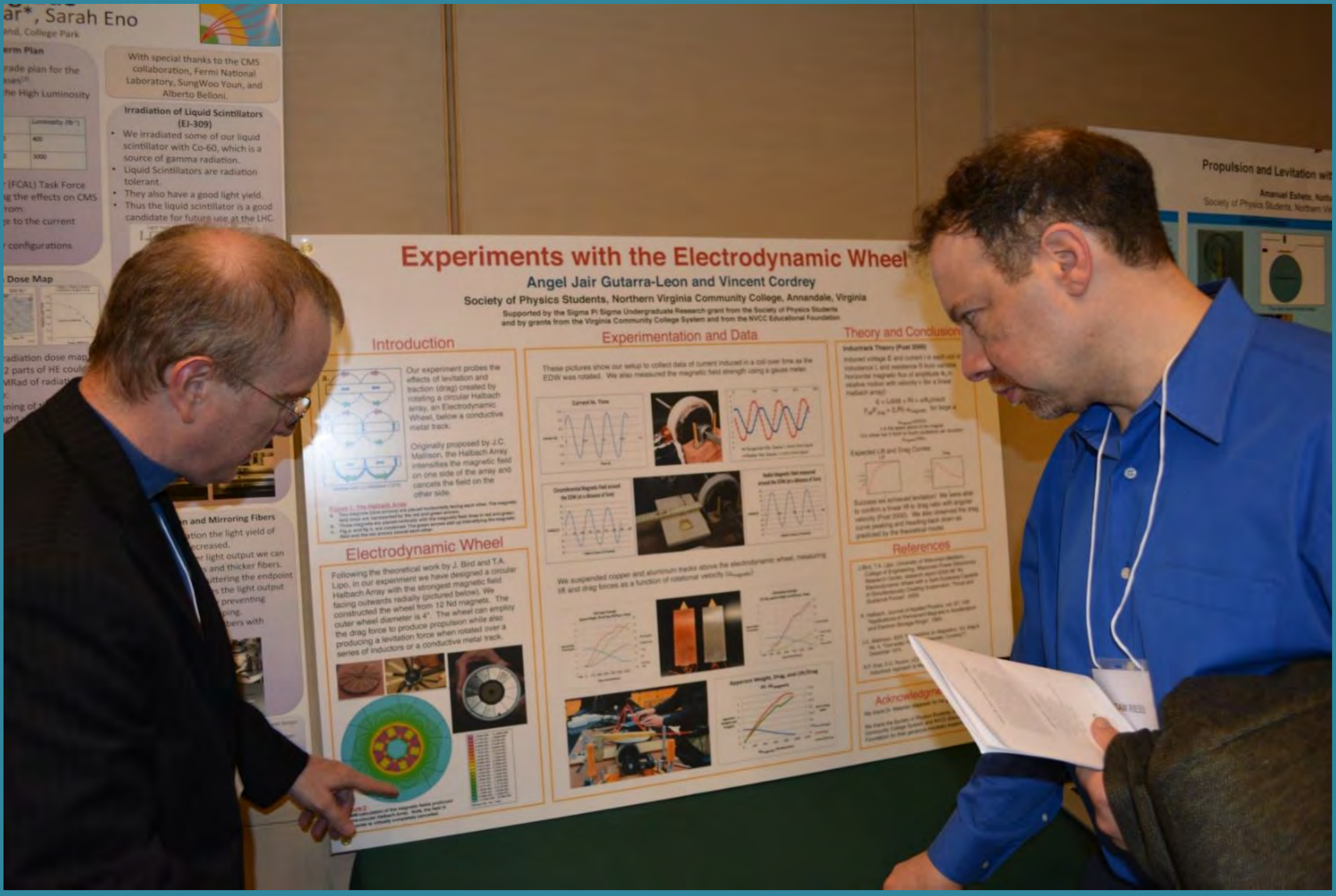
Transfer Benefits

Participation in this program has contributed to Armian Hanelli receiving 2014 Jack Kent Cooke Foundation Undergraduate Transfer Scholarship ($30,000 a year for up to three years).

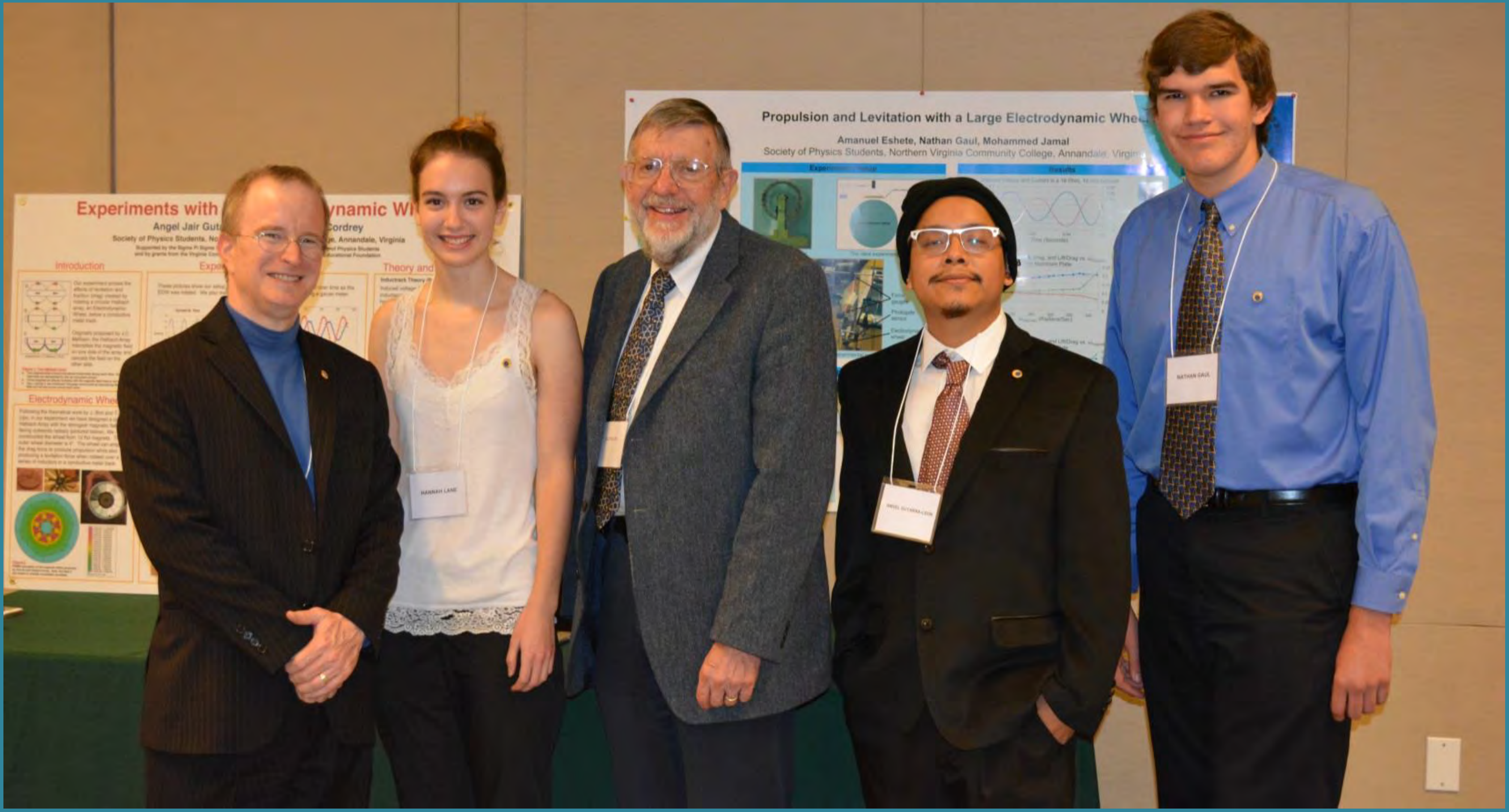
My former students, now PhD researchers, are coming back with seminar talks about their work: Dr Jarek Tuszynski, Senior Scientist, Leidos, Inc.

Angel Gutarra with Professor John Mather, Nobel 2006, Cosmic Background Radiation

Vincent Cordrey with Professor Adam Riess,Nobel Prize 2011, Accelerated Expansion of the Universe



Our SPS: Vincent, Hannah, Angel, Nathan with Professor William Phillips, Nobel Prize 1997, Bose-Einstein Condensate

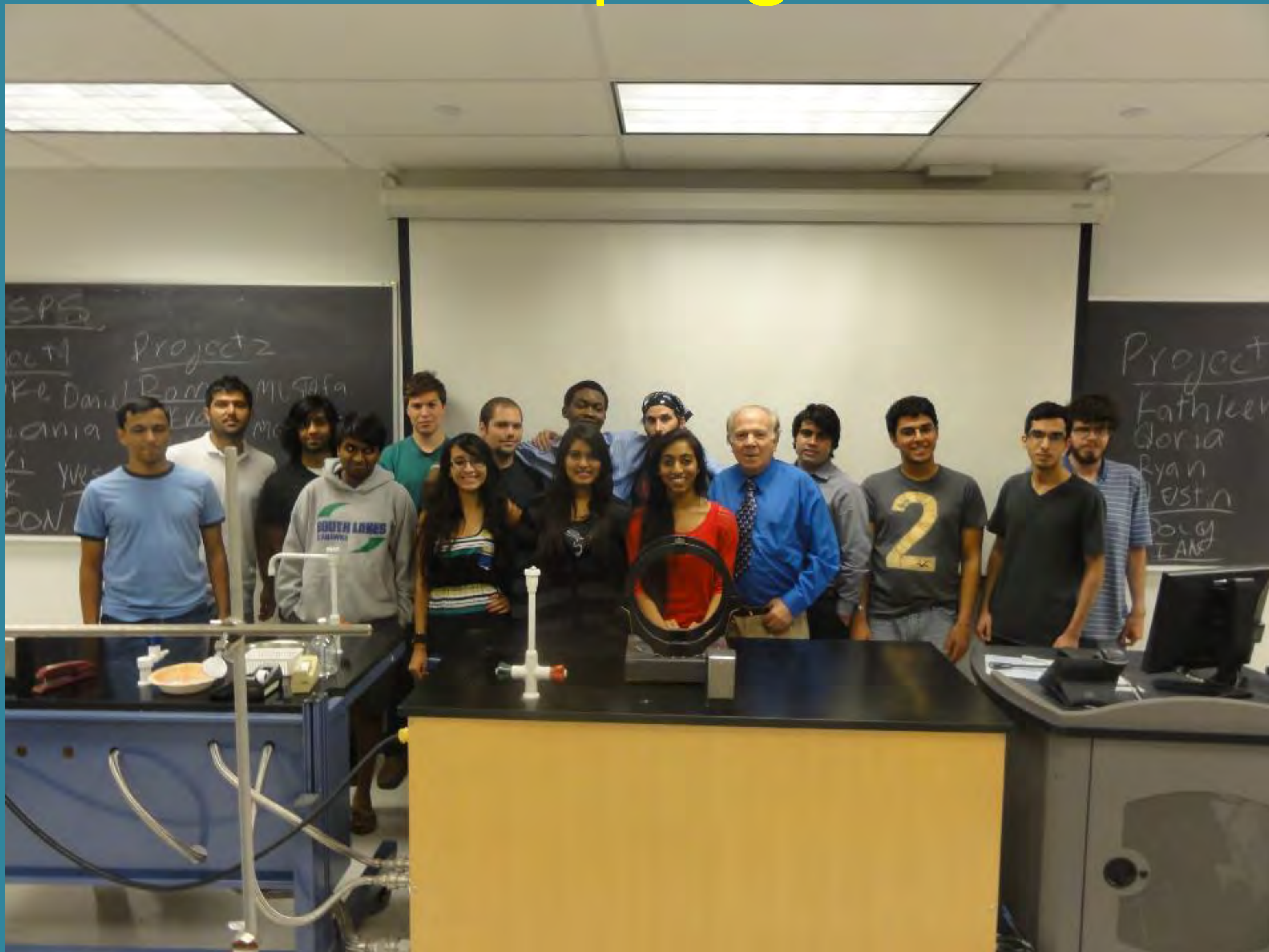


Our class with Professor David Weinland,Nobel Prize 2012, Atomic Beams

Our class with Professor Mather

Many physics shows for the college community

Class of Spring 2012



Class of Fall 2013

Class of Spring 2014

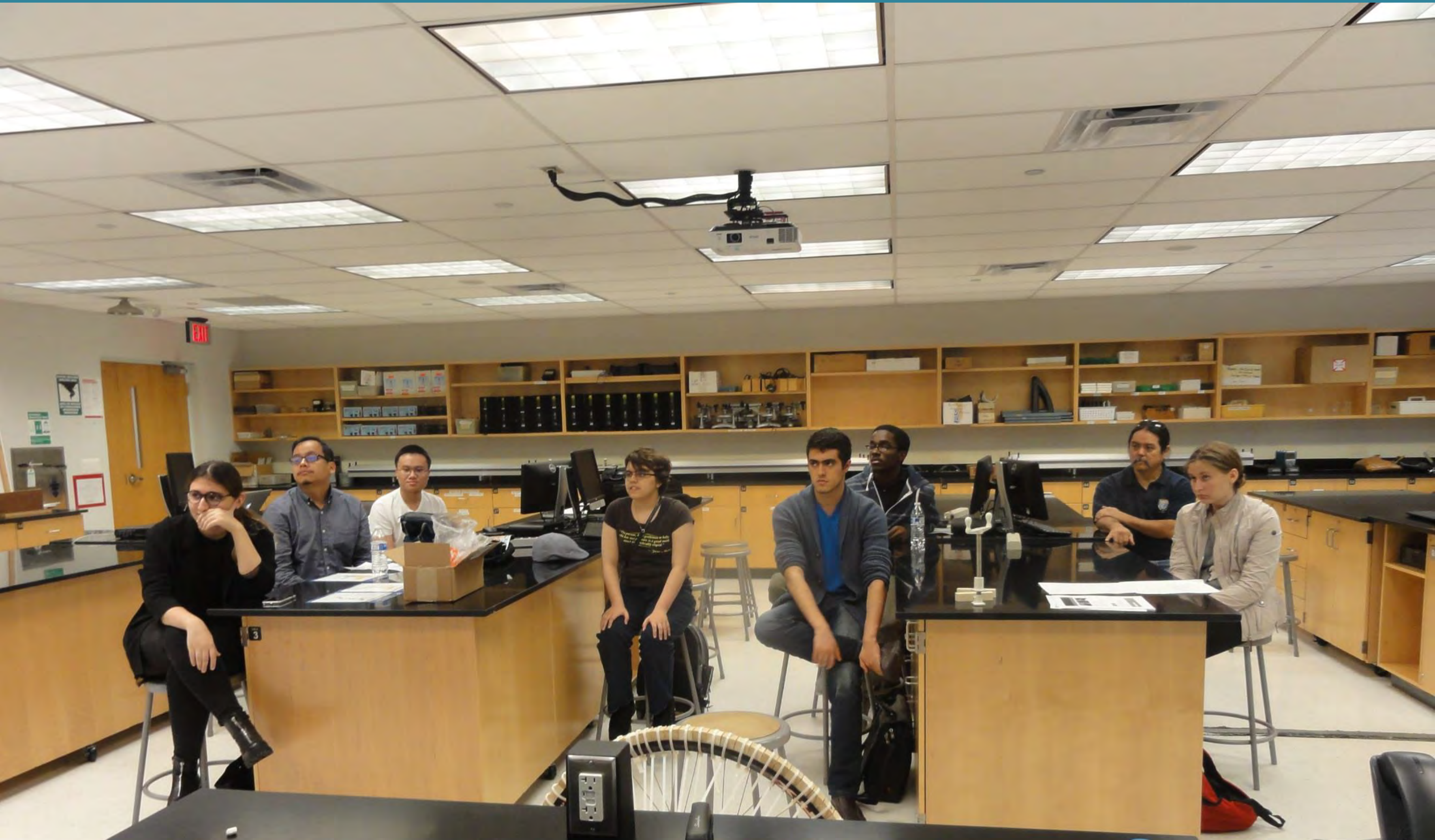
Class of Fall 2014

Class of Spring 2015

Class of Fall 2015

Spring 2016: writing 6 publications to "Exigence"

SPS Fall 2016



About Importance of us, the teachers:

- During the 18th century, the Kingdom of Prussia was among the first countries in the world to introduce tax-funded and generally compulsory education comprising an eight-year course of primary education, called *Volksschule.*
- There is a legend that in 1871, after the victory in the Franco-Prussian war, Prussian chancellor Otto von Bismarck declared, that Prussia has won the war thanks to the Prussian Teacher.