B3.00005

Integrating Research Experiences into the Undergraduate Education

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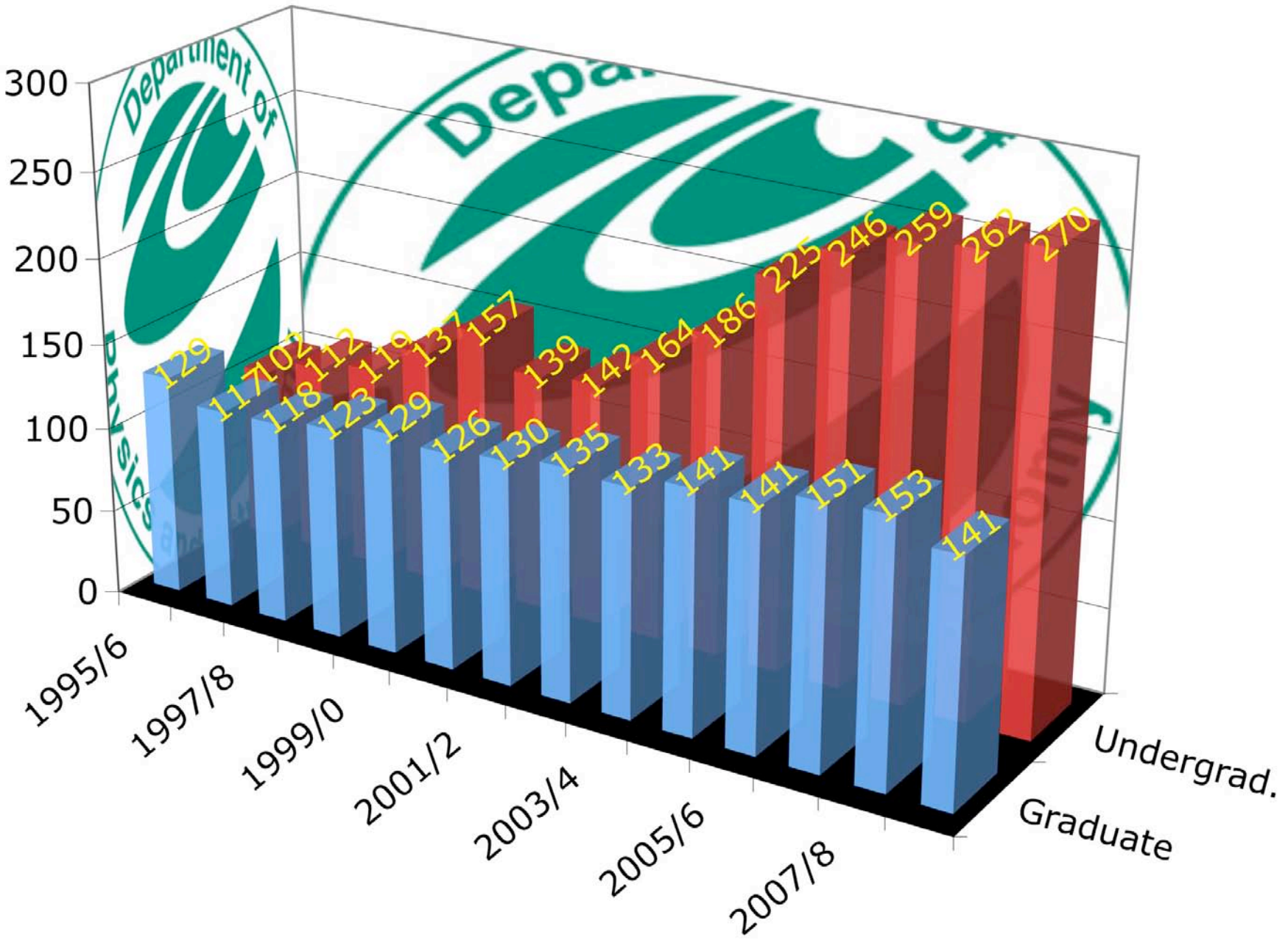
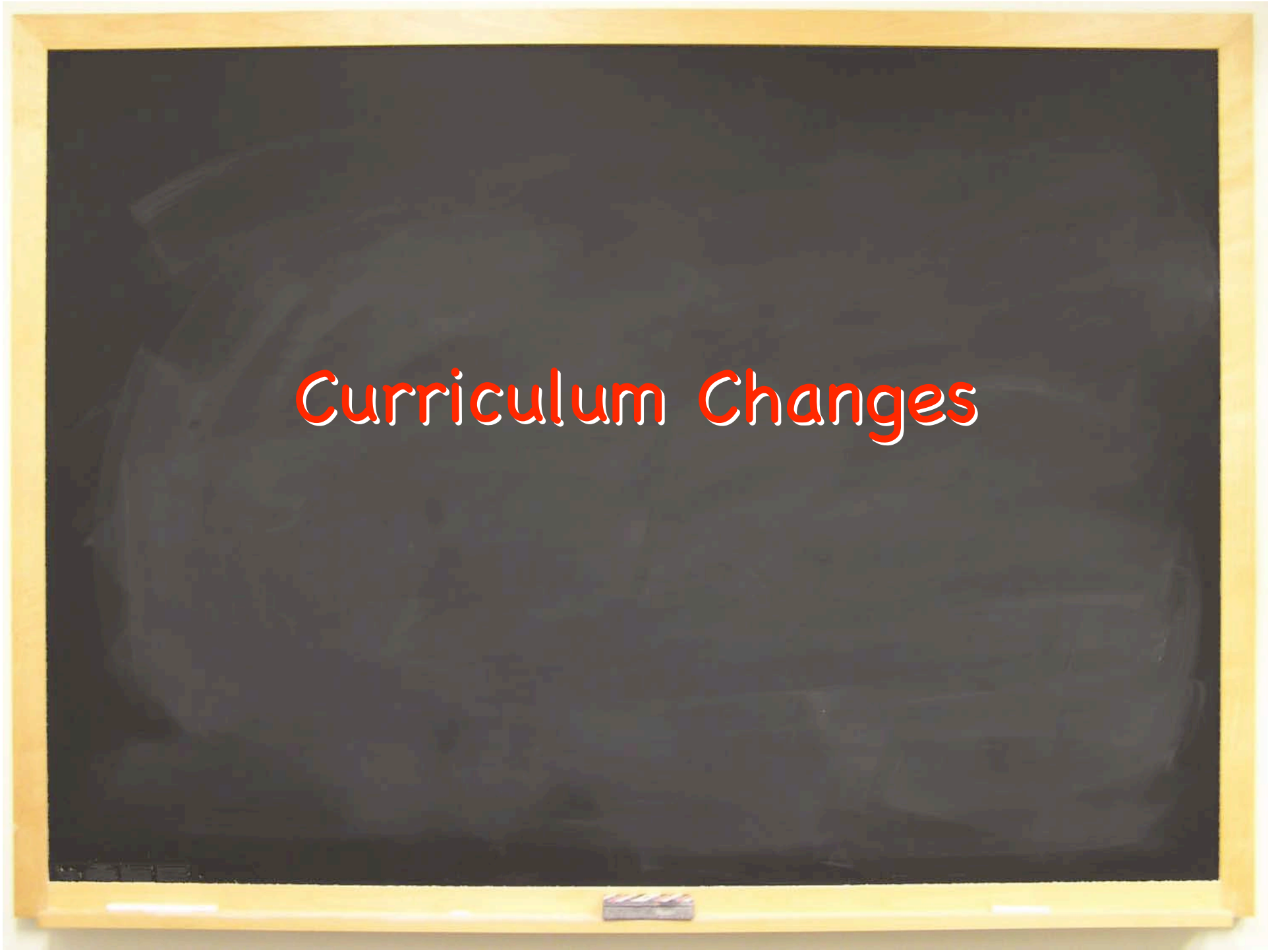
What I plan to cover …

- Changes in curriculum
- Outreach efforts to increase recruiting base
- Building a community for our undergraduates
- Research integration into the introductory curriculum
- Research experiences
- … a final thought on demographics

Physics Astronomy Enrollment




Curriculum Changes

Our Old Way of Offering Courses

- Take calculus first
- Take no physics class in 1st semester
- Start with calculus-based physics in 2nd semester (mechanics)
- Take E&M in 3rd semester, wait with modern physics until 4th semester
- Wait with exciting (advanced) physics labs until at least the junior year
- Pick up computer skills at your own peril

Our Old Result

- Physics majors did not take physics in the first semester
  - Top students moved to math in early semesters
- Physics majors saw very little of current interest until their junior year
  - Top students moved to engineering in sophomore and junior years
- Bottom line: Less than 80 physics majors in a university of ~40,000 students!
  - Compare: >150 grad students, ~60 faculty

Curriculum changes

- Get student to do some kind of meaningful experiments right away
  - Teach them the scientific method by inquiry
- Get them into small classes
  - Establish a community
- Enable students to use the computer right away
  - Allow them to tackle problems, for which they "do not have the math" yet

PHY170 (1st Semester Lab Course)

> Socratic method

Physics 170 is a special course in EXPERIMENTAL PHYSICS for first year students. The main aim of the course is to have you learn something about REAL physics as done in a research laboratory. There will be no formal lectures (or exams) so that all of **your learning** will be done by: (1) reading, (2) having discussions with your lab partner and the instructors, and (3) performing "hands-on" experiments.

> Just the basics

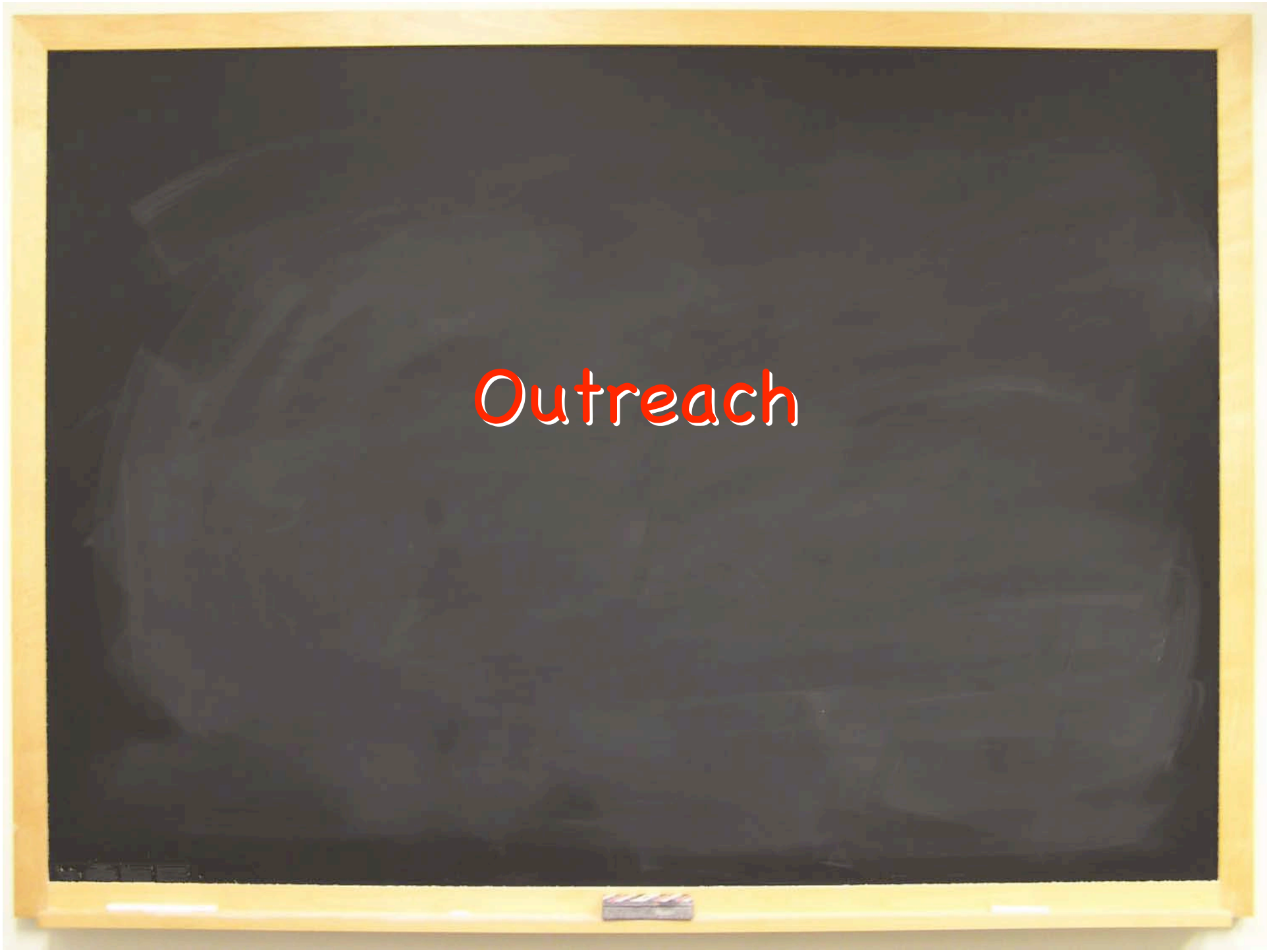
1. How to conceive, set up, and perform experiments in a few selected areas of physics.
2. How to use the computer to:
   a) Acquire, graph and analyze your data.
   b) Simulate your experiment.
3. How to keep a neat and meaningful laboratory notebook.
4. How to present your results in both written and oral format.

> Just two topics: Vacuum physics, optics

> 6 hours per week

Computers in Physics Classes

- Only open to physics and astronomy majors
  - Optional, but may be made mandatory in the future
  - Hands-on, experiential, small-class
- PHY102: Mathematica
  - Non-linear pendulum, chaos, maps, motion in gravitational field, …
- PHY201: Fortran 90
- PHY301: C/C++
- PHY480: Computational Physics


Outreach

Active physics outreach

Active Physics Outreach

- Science & Engineering Day
- Grandparents University
- Science Olympiad
- PAN (Physics of Atomic Nuclei)
- QuarkNet
- LON-CAPA
  - Many local high schools as partners
  - THE DUMP (Teachers Helping Everyone Develop User Materials and Problems)
  - See http://www.lon-capa.org/

lon-capa: the dump

Newsletter

- Once per year
- ~2,500 copies
- As PDF on the web

Website

- It's where prospective students look
- Free opportunity for self-promotion

Feature Undergrads & Recent Alumni

- Newsletter, website features
  - Scholarships (Goldwater, Gates, Rhodes)
  - Departmental scholarships (a lot of "advancement" work)
  - Other awards

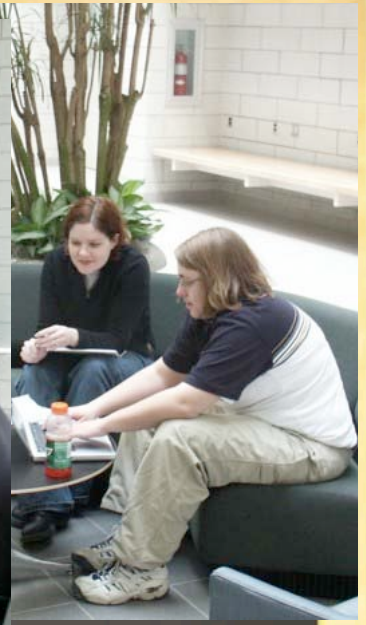

Community

A new building REALLY helps!

BPS Building

- Completed 04/2002
- 362,700 sqft
- $93 million
- Microbiology
- Physiology
- Physics/Astronomy

1st Floor



- Atrium with coffee shop
- WiFi, plenty of plugs
- Attractive space to hang out, do homework, discuss, meet friends
- Open even on the weekend

Department BBQ

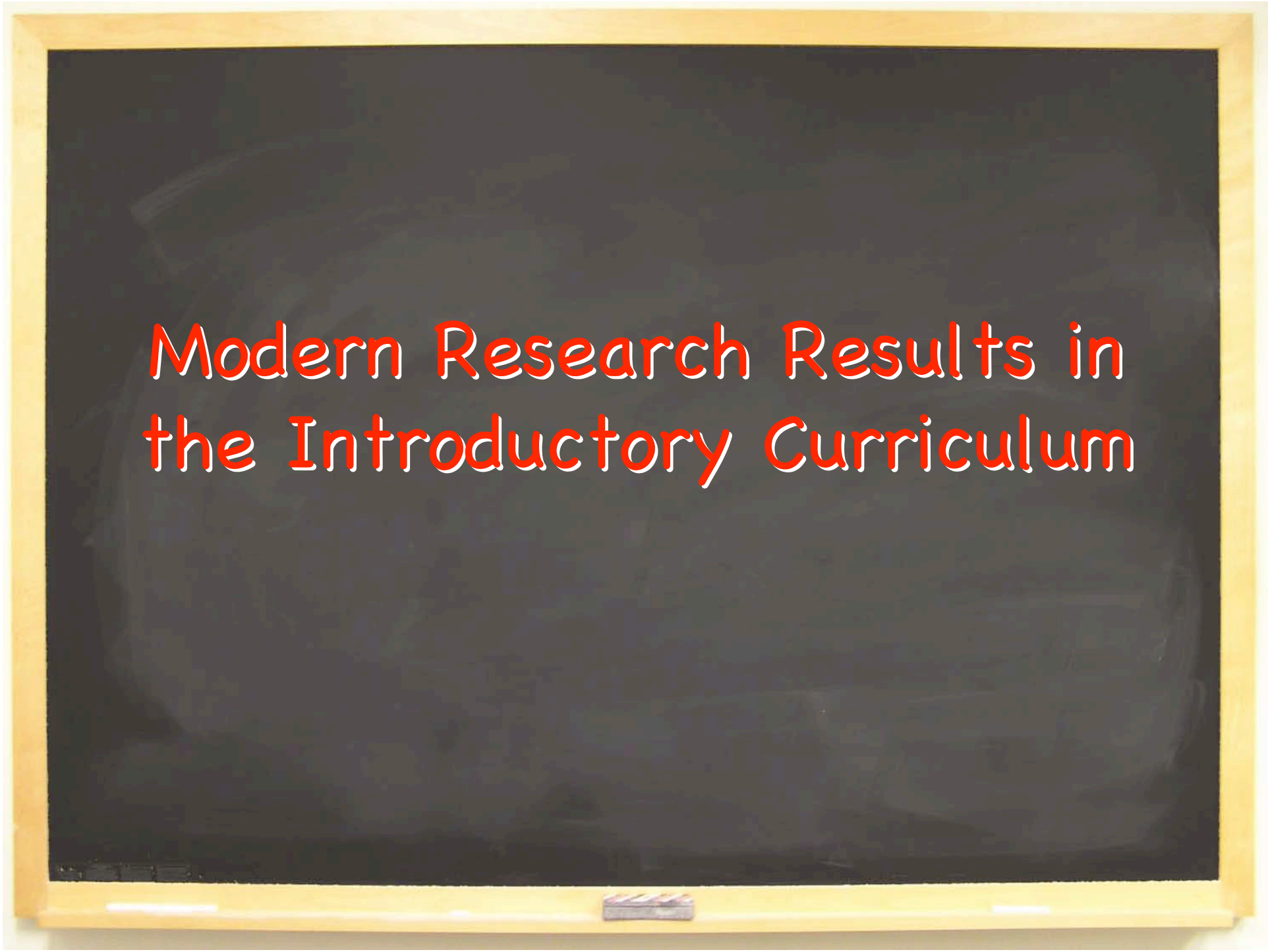
- Building community with undergraduates

"March Madness"

Student Organizations

- SPS
  - Receives annual funding from department
  - Has own lounge
  - Holds weakly seminars, but also movie nights
- Science Theatre
  - Initially founded by PHY grad students (Leslie-Pelicky, Mader, Kortemeyer)
  - Hands-off faculty advisor
  - Now more undergraduate students
- WAMPS
  - Women and Minorities in the Physical Sciences

Science Theatre

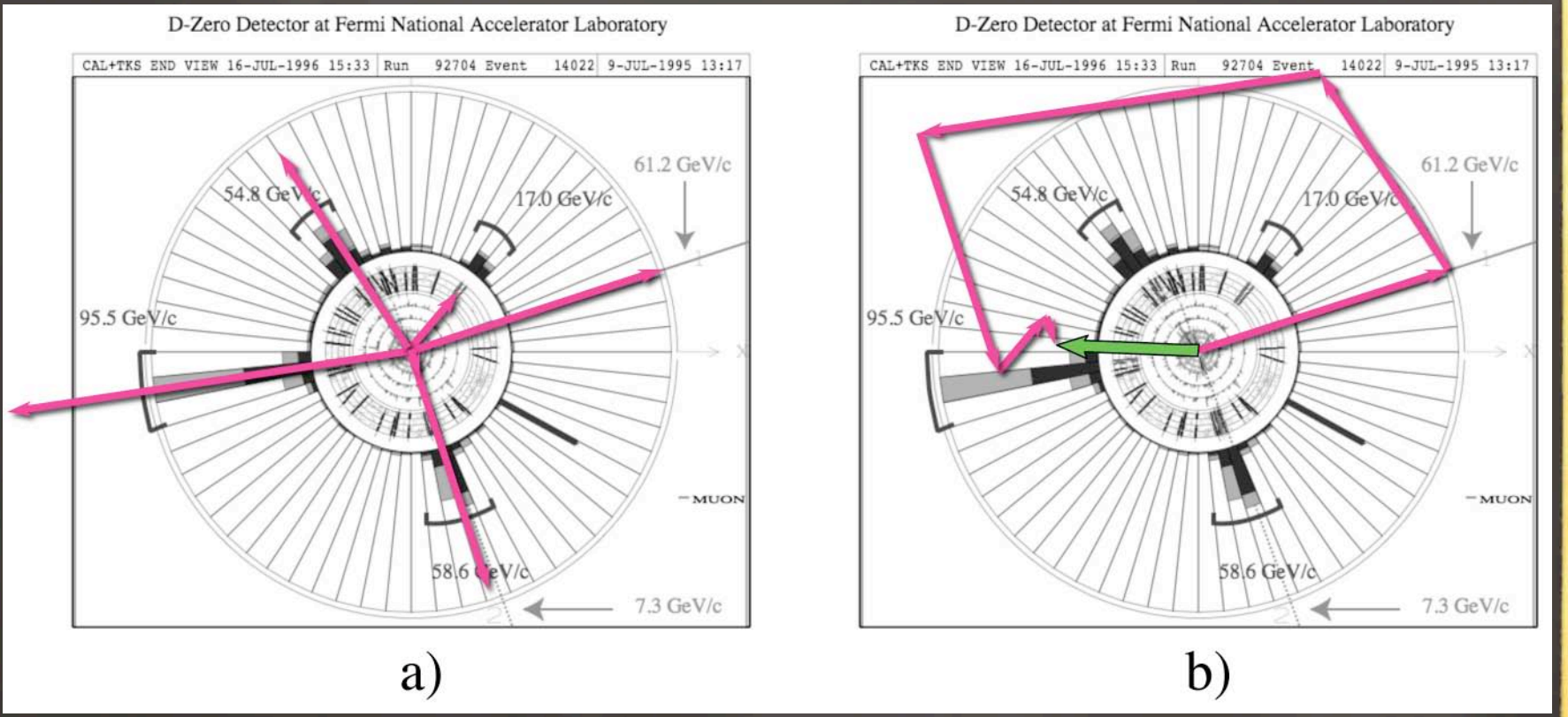

Modern Research Results in
the Introductory Curriculum

Recent Research Results

- Conventional lecture sequence emphasizes results that are older than 100 years
  - Biology: last 2 decades
- Can include recent results from particle physics, non-linear dynamics, astrophysics, nuclear physics, atomic physics into first year physics curriculum
  - Speaks to the relevance of the field
  - Lets students envision that they can contribute
  - Lets students see that physics is alive

Recent Research Results

- Example: Momentum conservation and top-quark discovery



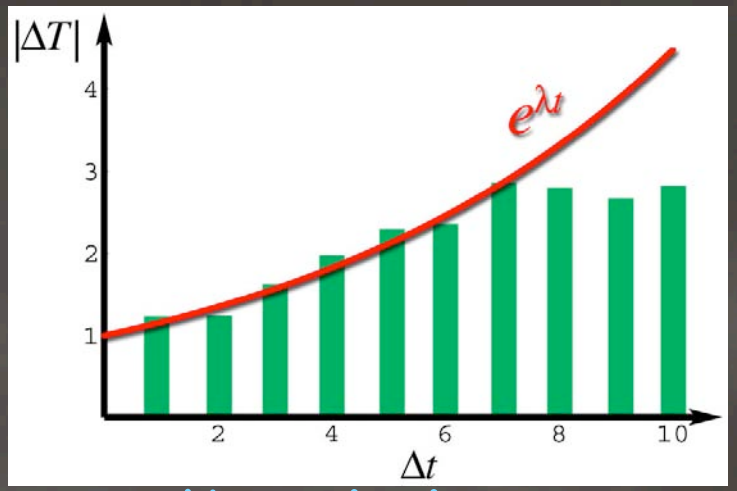

Research Experiences

Professorial Assistants

- Year-long one-on-one research experience for top incoming MSU freshmen in "lab" of a professor
- $3,000 stipend
- Renewable for subsequent years
- 100 students each year across MSU
- ~6-8/year in PHY
  - (0.5% of MSU students major in PHY)
  - More than 10 times more PAs than our "fair share"
- Excellent recruiting tool for PHY majors!

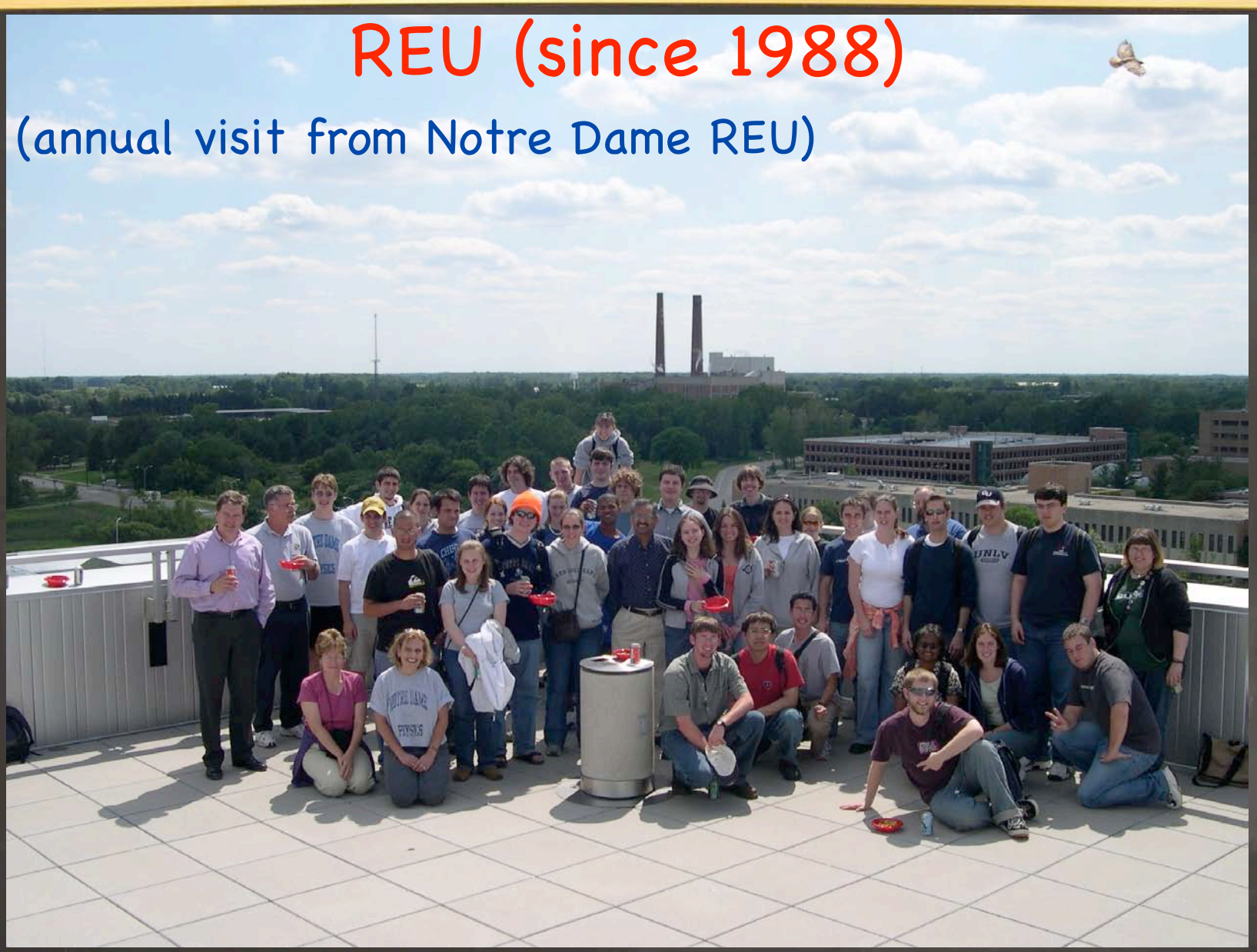
Weather Research

- Brad Keusch
  - MSU Freshman
  - Professorial Assistant
- Research project
  - Examine how chaotic the weather is in different parts of the country
  - Extract Liapunov exponents from comparing 10-day forecasts to the actual daily highs and lows

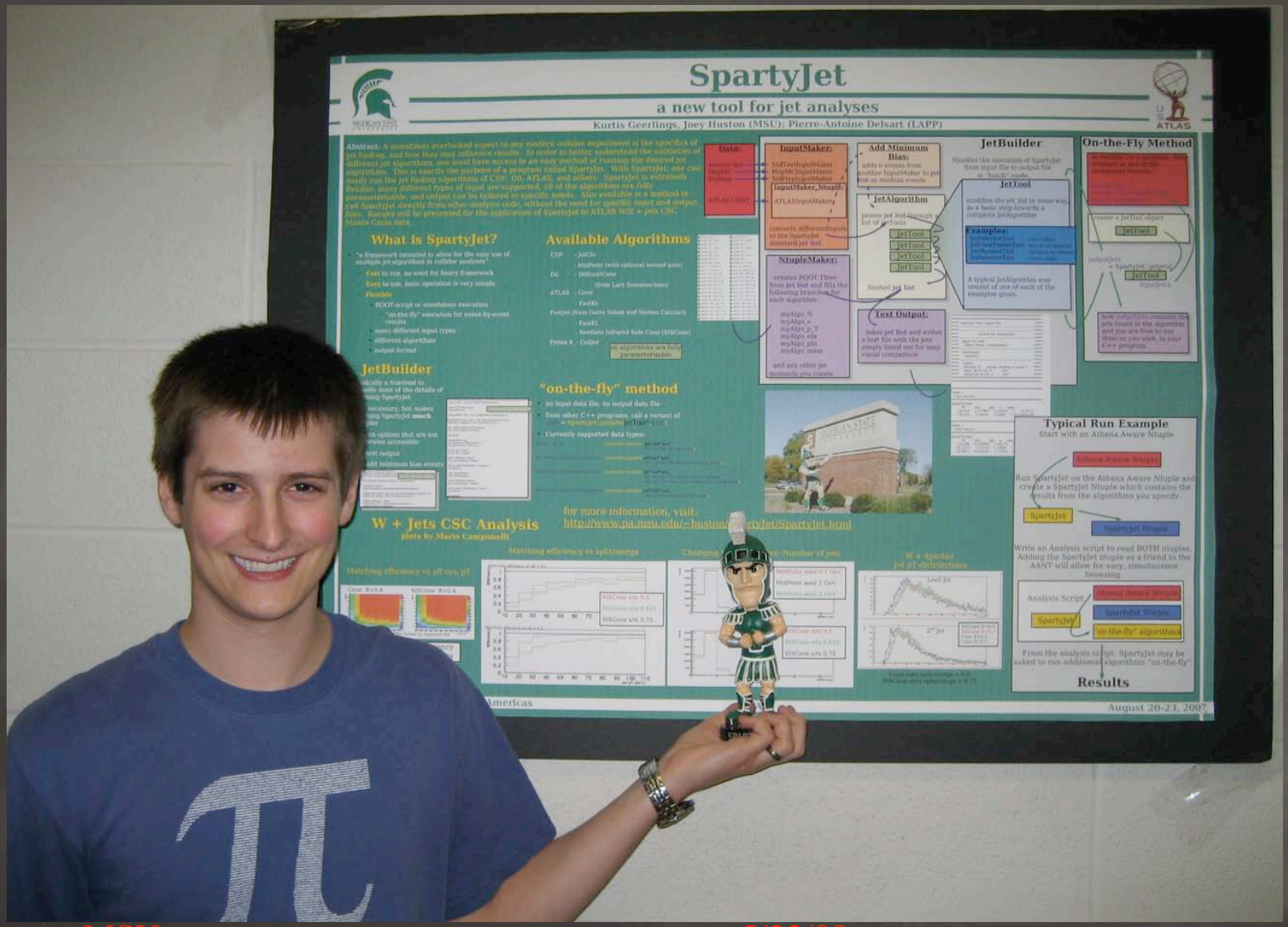


REU (since 1988)

(annual visit from Notre Dame REU)



Real Involvement in Real Research



Real Involvement in Real Research

- ATLAS Calorimeter

Real Involvement in Real Research

- SOAR Telescope (Andes, Chile)


SOAR Remote Control
& Observing
Room
SOAR
TELESCOPE

The Modular Neutron Array at the NSCL

MICHIGAN STATE UNIVERSITY

Michael Thoennessen

Issues and Events

Undergraduates Assemble Neutron Detector

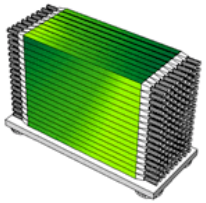
Spreading the construction of a detector across several institutions brings project visibility to participants.

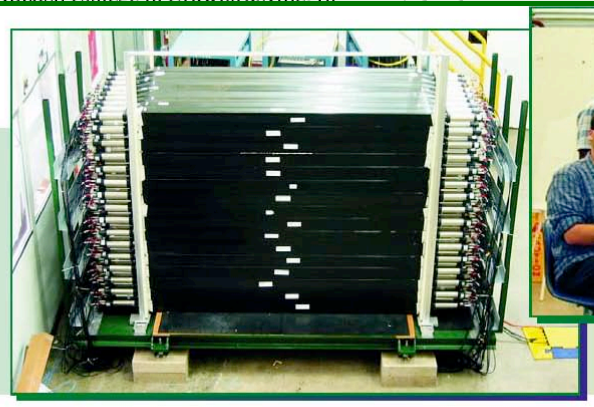
"The undergraduates come running." So says Ruth Howes about student participation in the Modular Neutron Array, or MoNA, a detector built in large part by undergraduate physics majors. Howes, chair of the physics department at Marquette University in Milwaukee, Wisconsin, says it is unusual and significant that students can work on MoNA without leav their home institutions. The dete was installed last summer at National Superconducting Cyclot Laboratory (NSCL) at Michigan S

The facilities offering the biggest competition for MoNA, he adds, are GSI in Darmstadt, Germany, RIKEN in Tokyo, and GANIL in France.

Ranking right up with the project's scientific potential is student involvement, which helped drum up funding. Recalls Jim Brown, a physicist at Wabash College in Crawfordsville, In-

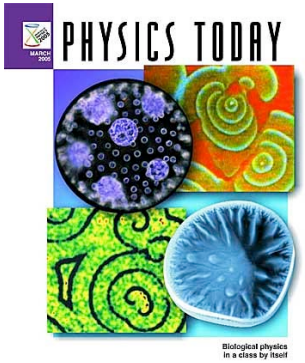
rectly through their physics departments. "Increasingly, undergraduate physics departments are seeing nontraditional students," says Howes. "One of my undergraduates had been a funeral director. He was 30 and had a steady girlfriend. Another had worked in industry and had a wife. They appreciate being involved in real, publishable research, but they can't leave home the way 20-year-olds can, for the whole summer."





THOMAS BAUMANN / MSU

The Modular Neutron Array (left) was assembled by undergraduates (above) at Concordia College and nine other institutions.



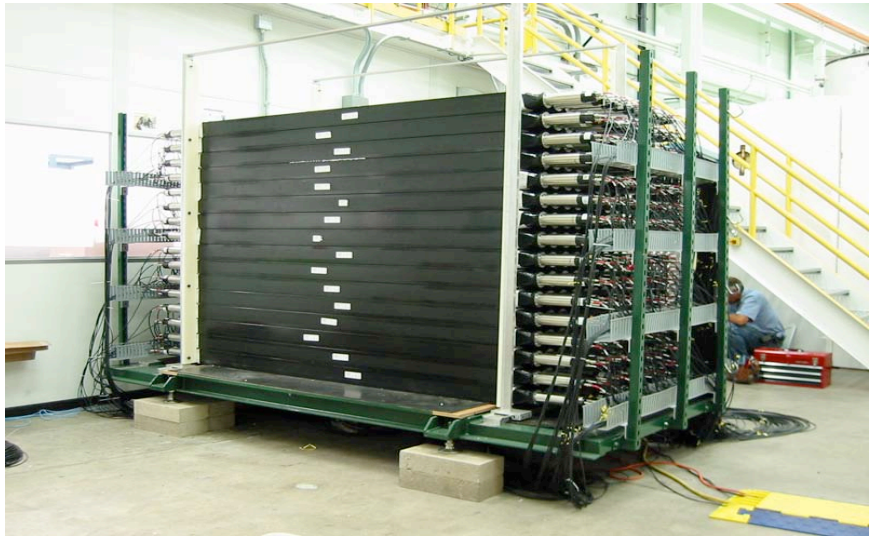
T. Feder, Physics Today March 2005, p.25

"That's what NSF is about" (Bob Eisenstein, NSF Assistant Director in 2001)

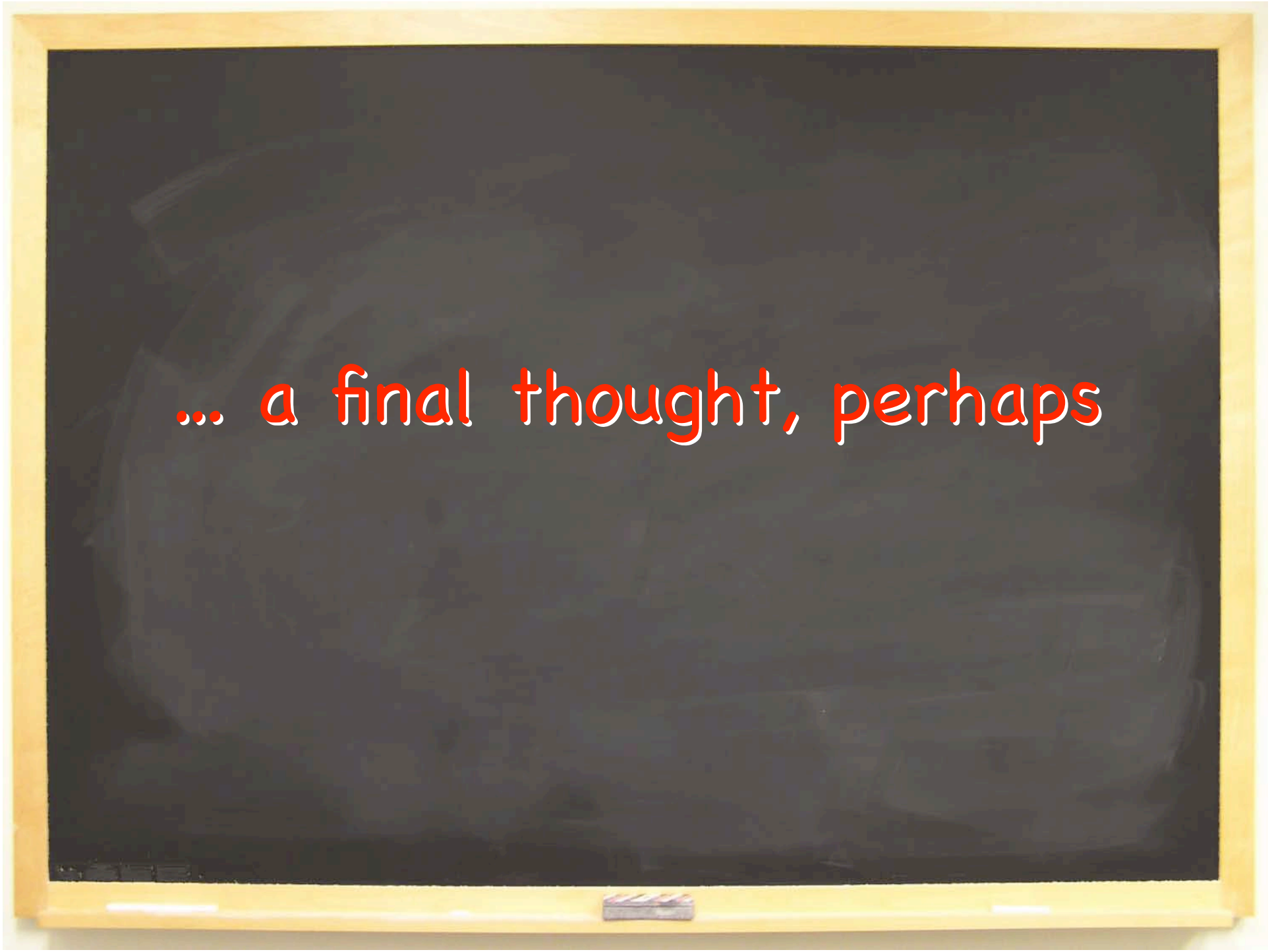
The Modular Neutron Array (MoNA)

Michael Thoennessen

- ToF Neutron Detector
- 10 X 10 X 200 cm Bar of Plastic Scintillator
- 9 Layers of 16 Stacked Bars
- Time Resolution < 1 ns
- Position Resolution ~ 10 cm
- Detection Efficiency ~ 70 % for 85 MeV/A Neutrons



Central Michigan University · Hope College · IUSB Indiana University South Bend · Concordia College Moorhead, Minnesota · Florida State University 1851 · Western Michigan University 1903 · Westmont College Christus Primatum Tenens · Wabash College · Marquette University · Michigan State University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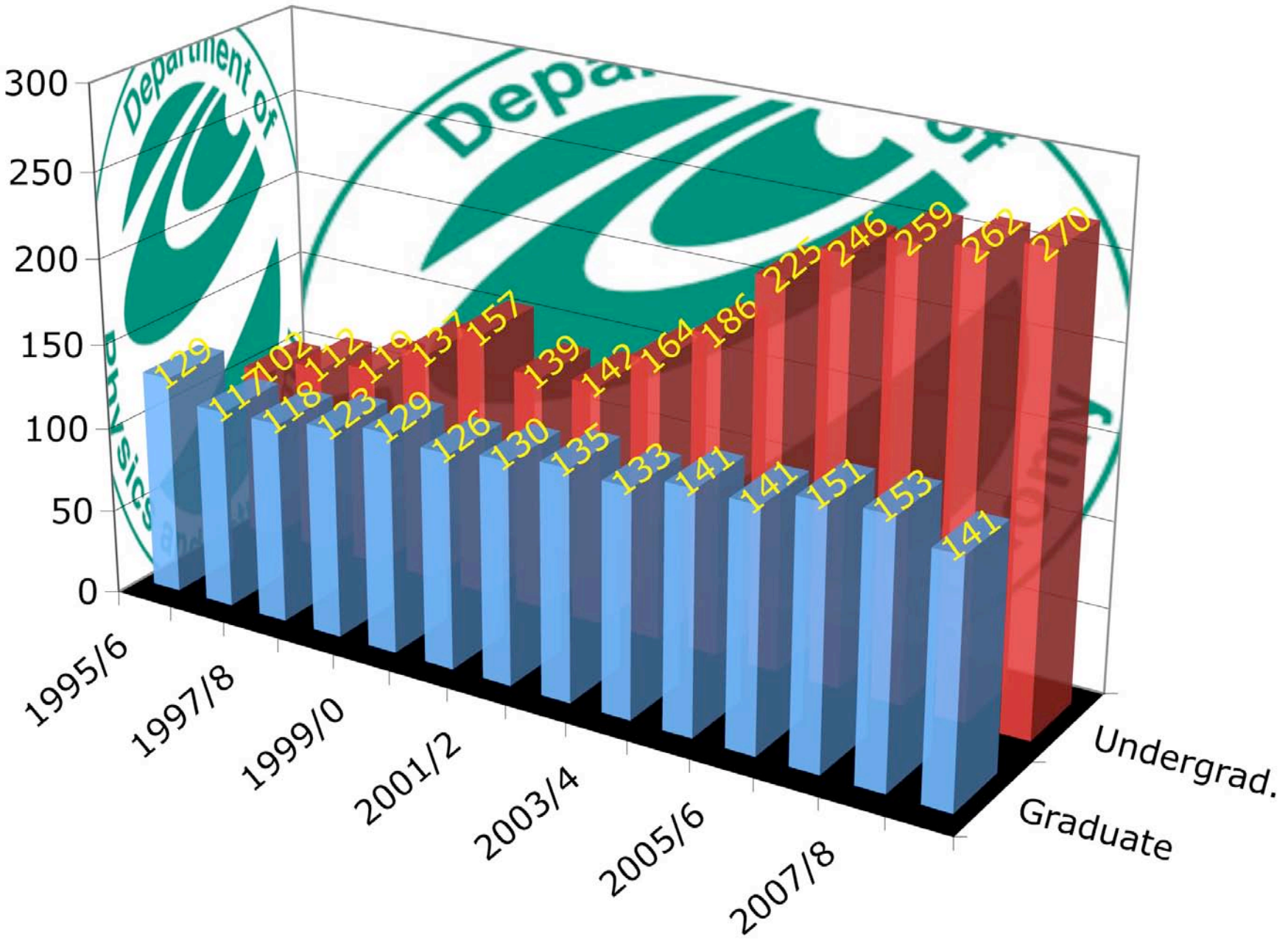
Physics Astronomy Enrollment



Physics Astronomy Enrollment