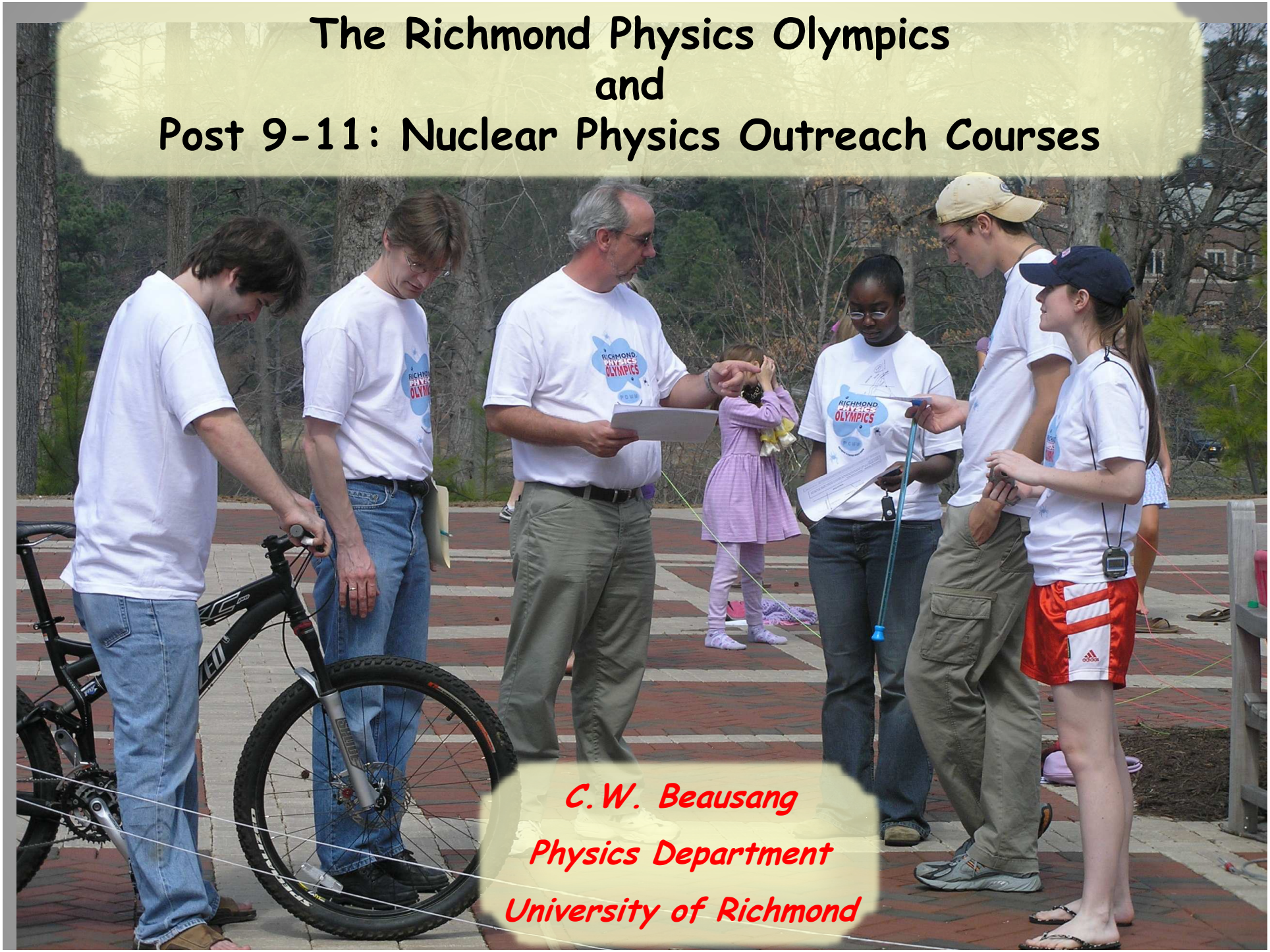
The Richmond Physics Olympics
and
Post 9-11: Nuclear Physics Outreach Courses

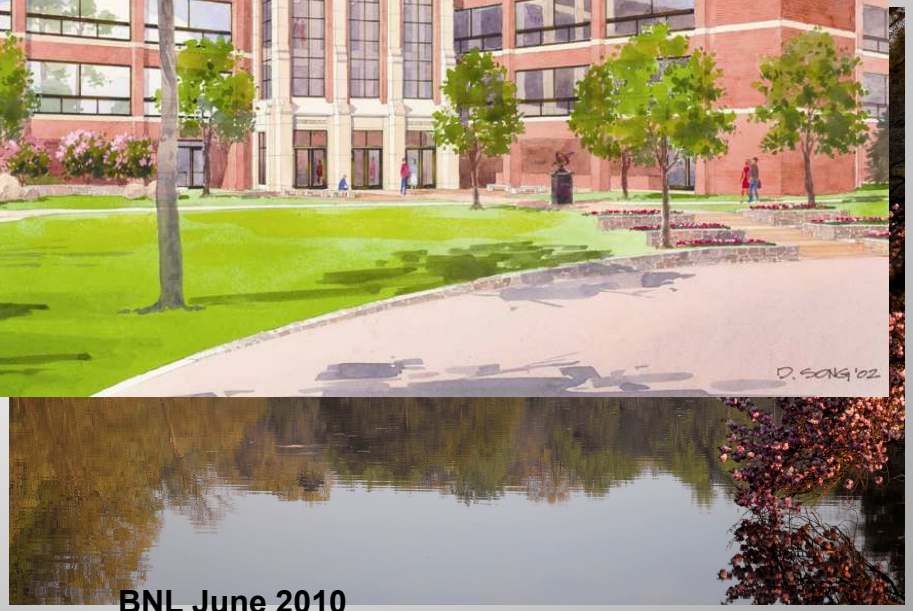


C.W. Beausang

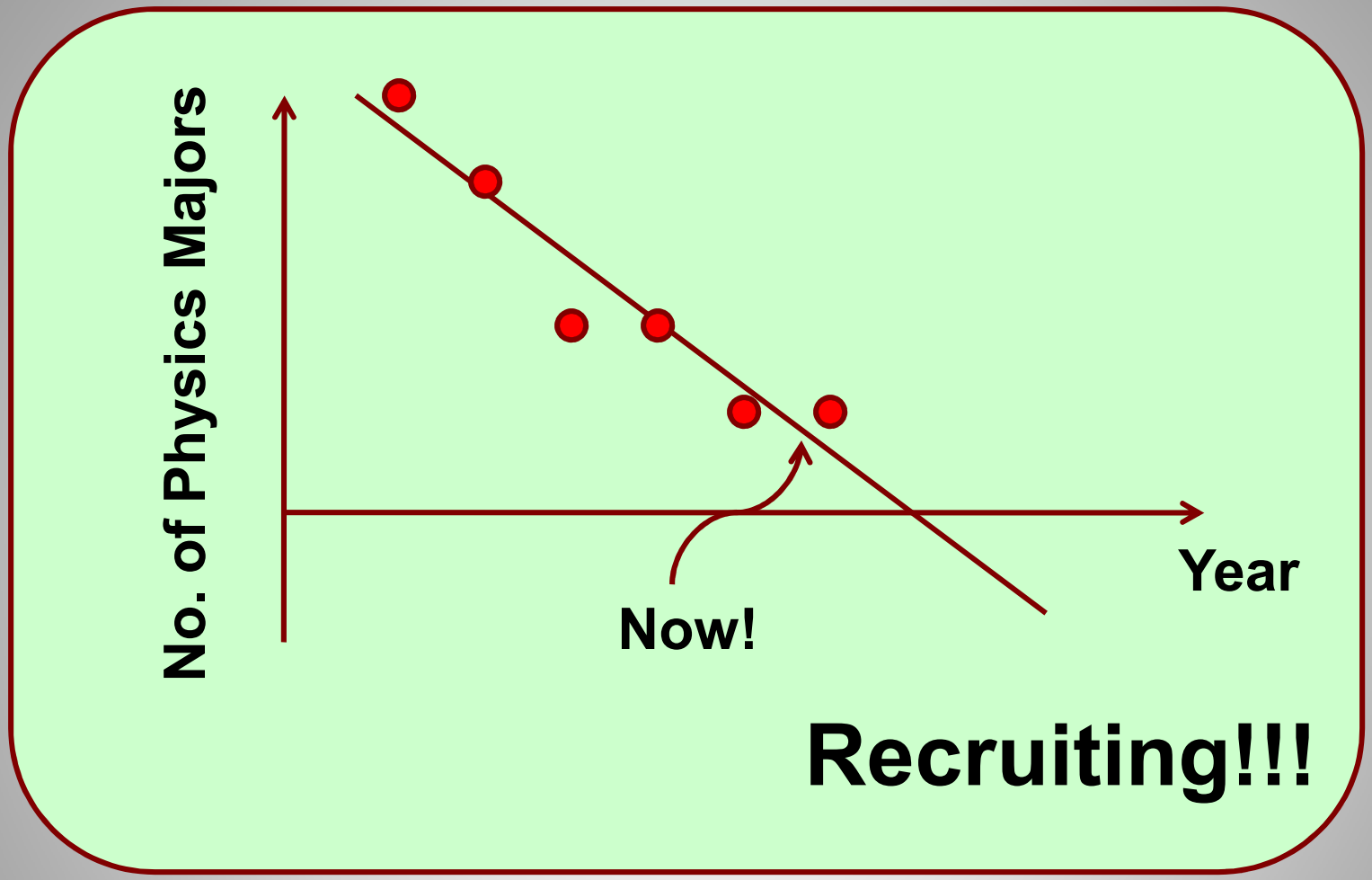
Physics Department

University of Richmond

The University of Richmond



My original motivation …



Note: You are (mostly) not recruiting the HS students

LIVERPOOL PHYSICS OLYMPICS

2009

Started: 1992

… still going strong

Started: 1998

… still going strong

RICHMOND PHYSICS OLYMPICS

Started: 2007

… still going strong

POWW: Spin off events organized in Perth (Australia), Darmstadt, Koln and Munchen (Germany), Padua (Italy).

RICHMOND PHYSICS OLYMPICS

Notre Dame

APS (DNP) Newport News

APS (DNP) Maui

BNL June 2010

WELCOME!

Richmond Physics Olympics 2010

BNL June 2010

Theme of our event …

PHYSICS IS FUN!

We are here to have a good time and I hope that all of you enjoy yourselves today!

RPO is…

not an exam

It's a competition

It is not the winning but the taking part that counts!

So don't worry about how you do, just relax and enjoy the day and enjoy the Olympics!!!

Don't Give UP … past experience shows that the winning team is the most consistent performer.

BNL June 2010

RPO is a competition for teams of high school students

- Day long competition
- Four students per team.
- Series of five ~30 minute events.
- Events require
  - team work,
  - problem solving and
  - even a little physics.

And remember
… it's supposed to be fun.

All Events are practical

- Limited
- non-optimal
- non-renewable resources

BNL June 2010

- Five Events

- Run in parallel throughout the day.

- Teams move from event to event throughout the day (inside and outside).

  - Brief Introduction
  - 30 Minutes
  - Then … onto the next event

9:30-10:00	*Coffee, Tea, Registration Gottwald Atrium*				
10:00-10:25	*Welcome and Organization Gottwald Auditorium*				
	Lab 1	*Lab 2*	*Lab 3*	*Lab 4*	*Lab 5*
10:30-11:00	*Infinity Orbit Ultraviolet*	*Beam Neutron Universe*	*Cyclotron Diode Proton*	*Electron Torque Vector*	*Atom Chaos X-ray*
11:05 – 11:35	*Universe Vector X-ray*	*Atom Torque Orbit*	*Beam Chaos Ultraviolet*	*Cyclotron Infinity Neutron*	*Diode Electron Proton*
11:40-12:10	*Diode Electron Proton*	*Ultraviolet Vector X-Ray*	*Atom Infinity Orbit*	*Beam Chaos Universe*	*Cyclotron Torque Neutron*
12:15 – 1:30	*Lunch Dining Hall*				
1:35 – 2:05	*Chaos Torque Neutron*	*Cyclotron Electron Proton*	*Universe Vector X-ray*	*Atom Diode Ultraviolet*	*Beam Infinity Orbit*
2:10 – 2:40	*Atom Beam Cyclotron*	*Diode Chaos Infinity*	*Electron Torque Neutron*	*Proton Orbit X-ray*	*Ultraviolet Universe Vector*
2:45 – 3:30	*Tour of Campus*	*Afternoon Break. Snacks* **Gottwald Atrium**			
3:30 – 4:00	*Debriefing and Awards Ceremony Gottwald Auditorium*				

Blue ticket

RICHMOND PHYSICS OLYMPICS

Bungee Madness

Aim To make a successful bungee jump.

Materials 500 g mass 50 elastic bands 1 meter stick

Method

- Use the elastic bands to construct a bungee cord.
- The spring constant ***k*** will be provided to you by the judges.
- Remember: The energy stored in a stretched spring is given by $E = 1/2kx^2$ where ***x*** is the extension of the spring from its non-stretched length. The potential energy of a mass ***m*** at height ***h*** is given by ***mgh***, where $g = 9.8\ ms^{-2}$ is the acceleration due to gravity.

Conditions

- The mass must be dropped from the indicated height ***h*** above the surface of the water and at full extent reach within the designated ***30 cm*** high target zone.
- Only the materials provided may be used.
- As many jumps as required may be made BUT
- Each jump must be witnessed by a judge.
- A **fifteen minute time penalty** will be awarded if the mass hits the water (jumper is dead)
- A **ten minute time penalty** will be awarded if the bottom of the mass does not reach the top of the target zone (jumper is a coward!)
- **No practice jumps** of any kind are allowed (i.e. **NO test drops**!)

Time Limit 30 minutes

Ranking The ranking order will be determined by the time taken to achieve a successful jump.

Team

Result

Do not write below line

Score

ne 2010

BNL June 2010

RICHMOND PHYSICS OLYMPICS

Super Straws

Aim: To measure the relative densities of two liquids (heavy and light water).

Materials: 1 super-straw, 2-m of string, 2 containers of liquid, 1 clamp, and 1 meter stick.

Conditions:

- Only the materials provided may be used.
- An old-fashioned mercury (or water) barometer uses the height of a column of liquid in an evacuated (i.e. vacuum above the liquid) closed tube to measure atmospheric pressure.
- The equation $\boldsymbol{P = \rho g h}$, relates the pressure $\boldsymbol{P}$ to $\boldsymbol{\rho}$ ***(rho)*** the density of the fluid, $\boldsymbol{g \sim 10\ m/s^2}$ the acceleration due to gravity, and $\boldsymbol{h}$, the height of the liquid in the tube.
- Express your answer as (Density of Blue Water) / (Density of Red Water)

.

Time Limit: 30 minutes

Ranking: The ranking order will be determined by the closeness of the answer to the correct density ratio.

Team ☐ Result ☐

Do not write below line Score ☐

Fancy Dress

e 2010

Super Straws

BNL June 2010

RICHMOND PHYSICS OLYMPICS

Target Practice

Aim: To hit a target with a projectile.

Materials: 1 super ball, 1 track, 10 cm masking tape, and 2 1-meter sticks.

Conditions:

- Initially you will not be told where the target position is.
- Use the first 20 minutes to map out the range of the projectile for different starting conditions.
- After this time, you will have three shots, observed by the judges at the target.

Time Limit: 30 minutes.

Ranking: The ranking order will be determined by the closeness of the three shots to the target.

Team

Result

Do not write below line

Score

Target Practice

•Limited, non-optimal, non-renewable resources are supplied

- We deliberately keep the apparatus very, very simple
- *Inexpensive*
- *High technology does not imply understanding*
- *Much more fun for us to watch*
- *And teachers/schools with limited budgets may be able to use these events as laboratories.*

We actually have six events (seven counting the fancy dress)

Fermi Quiz

We have prizes

Everyone gets a tee-shirt

(faculty, helpers, teams, teachers)

Best fancy dress

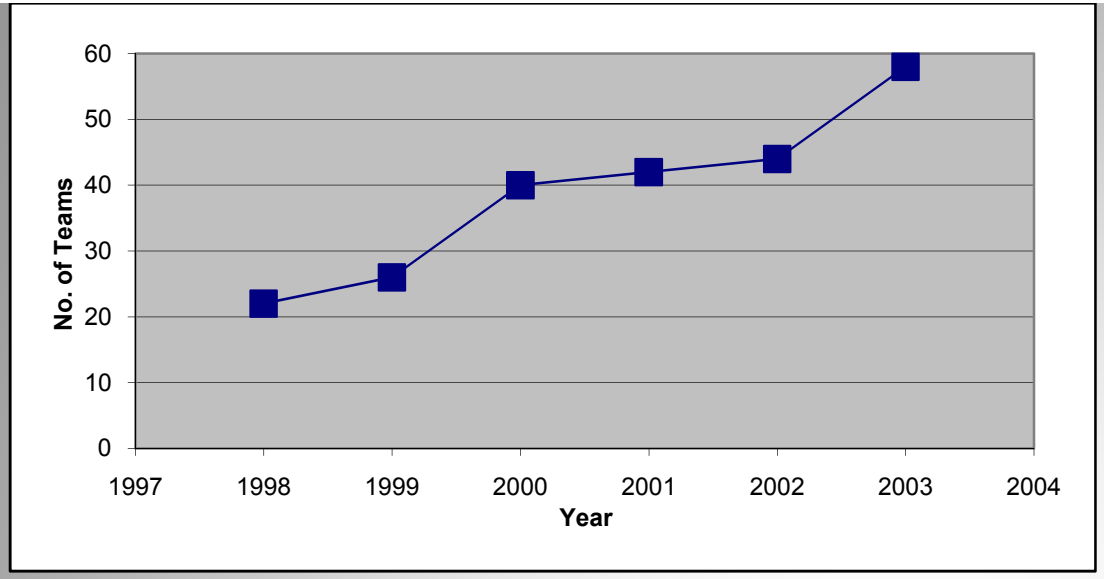
First place in each event

Overall 1st, 2nd & 3rd

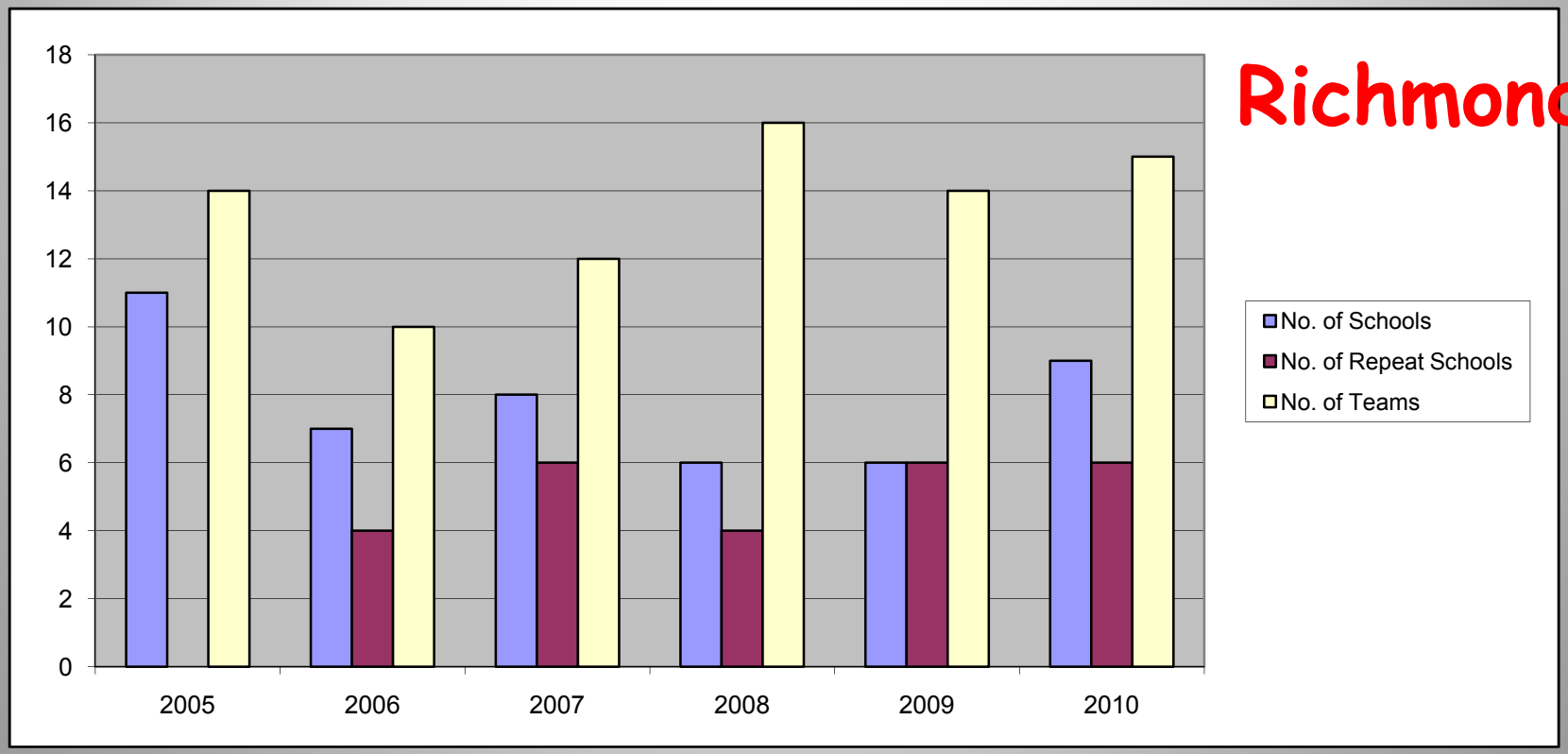
Staffing

- Faculty: 5-6
- Undergraduates: 20-30+:
(Four or five running each event)
- There has never been a problem recruiting students to help out.
- Mostly the problem is finding jobs for everyone.
- About half are physics majors. The remainder come from our introductory physics classes.

THIS IS THE RECRUITING PIPELINE



Yale



Richmond

BUDGET

$2500	Prizes
$1500	Food
$200-300	Apparatus
~$200	Misc.

Total: ~$5000

~$20 per person for prizes and $13 for food.

Richmond Physics Olympics

✓ WORKS

✓ Overwhelming positive response from all participants (high-school students, teachers, undergraduate students and faculty

✓ Does recruit high school students to physics … although probably not to your institution

✓Does recruit freshmen into your physics program

✓Does build great contacts with HS teachers

✓Can be organized and run very cheaply …$200

Let

The

Games

Continue!

Post 9-11: Nuclear Physics Outreach Courses

BNL June 2010

Motivation: 9/11 Terrorist attack

How can I (we) help?

Concern about and general ignorance of radiation and its effects in the general public (e.g. Scott H.) and first responders.

First responders now worry about searching for WMD (dirty bombs and nuclear bombs) entering or already inside the US.

How can the civilian nuclear physicist … academic, national laboratories, industry, medicine, etc. help?

A lot of people felt this way. How can we help?

Role of the Nuclear Physics Research Community on Combating Terrorism

Washington D.C., July 2002

Organized/Sponsored by the APS & the DOE/NSF

Leaders:

Joel Moss (Chair)	Brad Keister (NSF)
Don Geesaman (ANL)	Dennis Kovar (DOE)
Lee Schroeder (LBNL)	Jehanne Simon-Gillo (DOE)

Motivated in large part from grass roots input from the civilian nuclear physics community …

Attendance

‘Civilian’ University and National Laboratories

- ANL, LBNL, BNL, ORNL
- Yale, Stony Brook, Rochester, FSU, Notre Dame, etc.

‘Non-civilian’ Agencies and National Labs

- Livermore, Los Alamos, Sandia, Pacific Northwest, etc.
- TSA, Justice Dept, US Customs, FBI, CIA, NSA, USAF, etc., etc.

… some very interesting people!

Role of the Nuclear Physics Research Community on Combating Terrorism

Washington D.C., July 2002

Full report is (was?) available online

at

www.sc.doe.gov/production/henp/np/index.html

Community interest has continued

Division of Nuclear Physics of the American Physical Society meeting Nashville TN, October 2006

- **Mini Symposium: Stewardship Science**
- **Mini Symposium: Nuclear Physics and National Security**

- **60+ Abstracts, expanded to 3 sessions**

Outcomes …Personal Opinion!!!!

- There are, there have been, and there will continue to be some VERY smart people working on the problems of detecting and monitoring radiation and radioactivity.
- They are very good at what they do.
- There are a lot of first responders out there being asked to take on a lot more responsibility.
- Education and outreach activities to first responders is important

Outcomes …so when I got home …(in those days home was Yale)

- **Hey … we are good at educating people in universities … it's what we do!**
- **Set up an outreach course for first responders … police, fire etc.**
- **So, how do you do this?**

1. **Reached out to the University Administration**

   Is it ok with them if we do this?

   YES!!!

   Is it ok if we do it for free?

   YES!!!

2. **With the help of the university, reached out to the city of New Haven and the State of CT.**

   <u>Would the F.D. and P.D. find such a course welcome and useful?</u>

   YES!!!

3. **Designed and presented two separate courses on basic nuclear and radiation physics**
   1. **First Responders**
   2. **Non-science undergraduates**

Many people do outreach …

Examples of a FEW Activities

LLNL … large number of outreach courses going on for many years for trainin … LLNL provided a weal our courses.

PNNL … carry nders, customs officers etc., etc

ANL …RAP tea stly volunteers). The to incidents as required.

BNL … similar activities. Testing radiation detectors before deployment

LBNL … a similar outreach course to Yale's, they attract local firefighters

Apologies to the MANY others that I have not mentioned!

First Responders Course

1) Four, three hour sessions. Once a week for four weeks.
2) Mix of lecture / seminar and hands on laboratory session.
3) We used our detectors and also asked them to bring in their own equipment to compare and contrast.

What did we learn?

- Keep it SIMPLE
- They do not want to learn physics
- They probably left school a long time ago
- They are very motivated to learn. They put themselves in harms way.
- They are a very intimidating audience

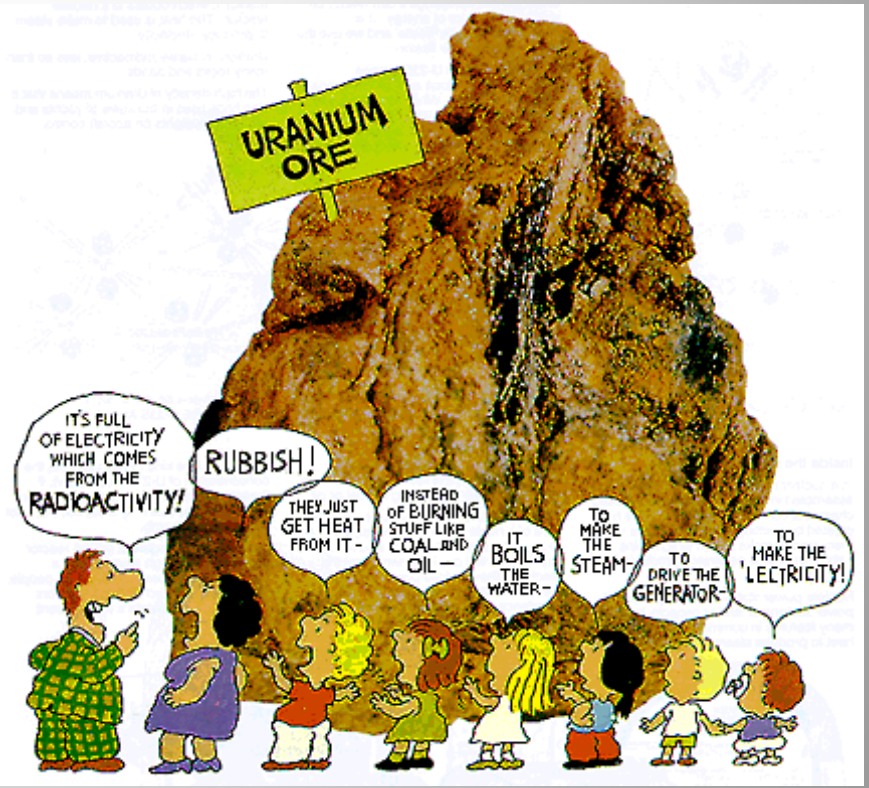
Week 1

Lecture … basic facts …radiation and radiation detectors… sources, fission, fusion, half-life etc. No need for units.

Hands -on Tour of the accelerator facility

Coffee and cookies

1 gram of Cobalt-60
has the same activity as
1800 tons of natural Uranium



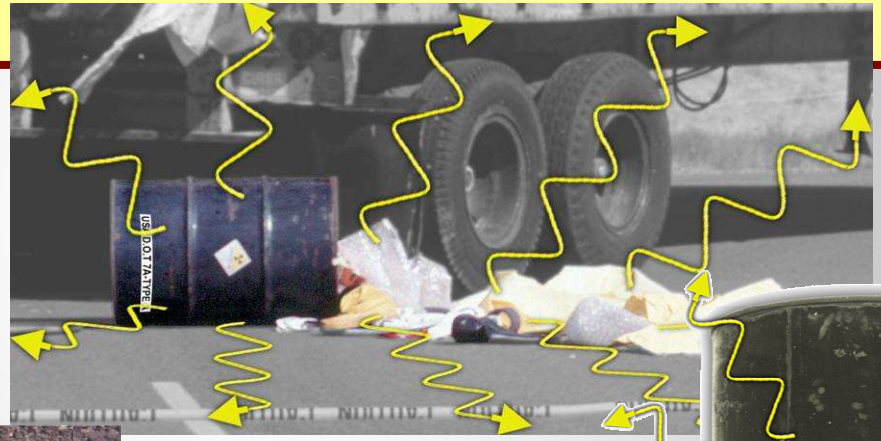
Week 2

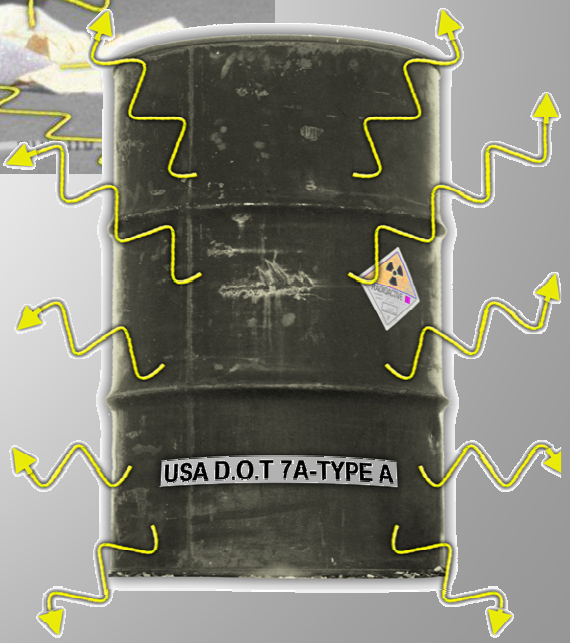
Lecture … Review of α, β, γ radiation. More on detectors. Contamination.

Hands-on … variety of detectors and sources.

Find the hidden source

Coffee and cookies





Week 3

Lecture … Radiation health effects. Health issues for large and small radiation doses. By a medical doctor

Hands-on … more of the above

Week 4

Lecture … Radiation units and definitions. Safety issues with large and small doses of radiation.

Question and answer period.

Final `exam'

… the four cookie question

Alpha-cookie

Beta-cookie

Gamma-cookie

Neutron-cookie.

Four choices

Throw one away

Put on in your pocket

Clasp one in your hand

Eat one

The laboratory / hands-on sessions were most useful …

- **small groups … instructor plus 3-4 officers**
- **They asked lots of questions … mostly, not about the detectors.**
- **Lots of time for informal interactions between the instructors and first responders (coffee and doughnuts)**

Team Taught!

CWB …	**Physics department.**
Bill Summers …	**Prof. of therapeutic radiation.**
Jeff Ashenfelter …	**Director of accelerator operations at Yale and ex nuclear-sub.**

A variety of postdocs and graduate students and other faculty.

ALL volunteers.

All for FREE (Yale got nothing … except good will and publicity).

Who did we get?

Big mixture of backgrounds

… both professional and educational.

… challenge to engage everyone.

Agency	Number of Attendees
U.S. Coast Guard	9
New Haven P.D.	7
New Haven P.D. Haz.Mat.	1
New Haven Board of Ed.	3
CT. State P.D. E.S.U.	11
New Haven Health Dept.	4
U.S. Customs	1
F.B.I.	3
Yale University P.D.	2
Yale University O.E.H.S.	1
Yale Med. School	1
Total	**43**

Was it worthwhile / useful?

YES !!!

- **Overwhelmingly positive feedback from the officers who attended**

- **`De-mystify' radiation for them.**

- **Horizontal blue indicators … fear of the unknown!**

I think (hope) that the course gave them some some feeling for …

1. **… what it means when their detectors go off.**

2. **… what their detectors can and cannot do and what they can and cannot detect.**

3. **… give them local knowledgeable contacts in case they need them. For example, USCG asked me to accompany them on a tour of a ship. Several officers came by with detectors to compare/ contrast, etc., etc.**

Yalies Course

1) Seminar course.
2) Once a week (2 hours) for ~13 weeks.
3) Small. Class size limited to 18.
4) Non-science majors.
5) Smart kids (very smart), who are interested in nuclear physics for a wide variety of reasons. But they do NOT want a rigorous physics course.
6) VERY Popular. Oversubscribed by factor of ~4.
7) Morphed into a regularly scheduled Freshman Seminar course.

Discovery of radiation and radioactivity, a historical perspective.

- **Introduction to the atom and to the nucleus.**
- **Types of radiation especially focusing on α, β, γ and neutrons.**
- **Radiation sources and effects, half-lives.**
- **Radiation detection and shielding.**
- **Environmental radiation, radon in buildings, cosmic rays etc.**
- **Uses of radiation and technology, peaceful and other, focusing especially on medical and nuclear power uses and issues.**
- **Terrorism issues.**

Richmond

Community and university mini course

The Department of Physics

PRESENTS

Nuclear Physics & Society

A free, four-day short course on nuclear physics and public policy for anyone who wants to better understand

nuclear power ● nuclear weapons ● scientific policy ● homeland security

Led by Dr. Patrick Regan, University of Surrey, Dr. Con Beausang, University of Richmond, and Dr. Jerry Gilfoyle, University of Richmond

MONDAY, APRIL 13

Open Lecture, 5:45 - 7:45 P.M.

Nuclear Basics: What are atoms made of? What is radioactivity? In addition to discussing the nucleus, alpha, beta and gamma decay, fusion, and fission, the talk will cover environmental and manmade radiation sources and the methods by which radiation is detected.

TUESDAY, APRIL 14

Laboratory Experience, 12:30 - 3:30 P.M.

Participants will be introduced to an environmental radiation laboratory and led through a series of simple experiments to demonstrate radiation detection and measurement. Laboratory space is limited, so register in advance by E-mailing cbeausan@richmond.edu.

TUESDAY, APRIL 14

Open Lecture, 6:15 - 8:15 P.M.

Nuclear Alchemy: How are the elements made? The talk will include explanation of nucleosynthesis or the creation of the elements in stars, including exploding stars, novae and supernovae, x-ray bursters, and seeding the cosmos with new elements.

WEDNESDAY, APRIL 15

Open Lecture, 6 - 8 P.M.

Applications of Nuclear Physics on Earth: Nuclear power, weapons, and nuclear medicine. Topics include homeland security, dirty and nuclear bombs, and the Litvinenko story.

THURSDAY, APRIL 16

Laboratory Experience, 12:30 - 3:30 P.M.

This lab will continue some of Tuesday's experiments. E-mail cbeausan@richmond.edu to register.

THURSDAY, APRIL 16

Open Lecture, 6 - 8 P.M.

Nuclear Extremes: (Some) current research frontiers in nuclear science. The talk will address modern nuclear physics research.

All open lectures take place in the Gottwald Science Center's auditorium. Lab locations will be E-mailed to registrants. Visit physics.richmond.edu for more details.

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