

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Physics 403. Modern Physics Laboratory

Summer 2017
Eugene V Colla & Paul Debevec



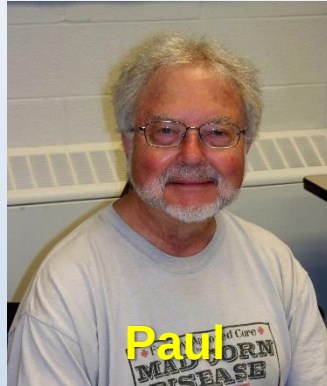
Physics 403 Modern Physics Laboratory

Summer 2017 Teaching Team



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Support from Kwiat research group

Outline

- I. Goals of the course
- II. Teamwork / grades / expectations from you
- III. Syllabus and schedule
- IV. Your working mode
 - In class and “after hours” access
 - Safety, Responsibility
 - Home and away computing
- V. Take a Lab tour !**
- VI. Let's get started
 - electronic logbooks
 - digital scopes



Course Goals. Primary goals:

- **Learn how to “do” research**

- ✓ **Each project is a mini-research effort**

- ✓ **How are experiments actually carried out ?**

The procedures aren't all written out

The questions are not in the back of the chapter

The answers are not in the back of the book

You will have to learn to guide your own activities

- ✓ **Use of modern tools, modern analysis software and data-recording techniques**



Course Goals. Primary goals:

- **Learn how to document your work**
 - **Online - electronic logbook ***
 - **Online – saving data and projects in student area on server**
 - **Using traditional paper logbooks**
 - **Making an analysis report**
 - **Writing formal reports**
 - **Presenting your findings orally**



Course Goals. Secondary goals:

- **Learn some modern physics**
 - **Many experiments were once Nobel-prize-worthy efforts**
 - **They touch on important themes in the development of modern physics**
 - **Some will provide additional insight to understand advanced courses you have taken**
 - **Some are just too new to be discussed in textbooks**



The Experiments. Three main groups.

- **Nuclear / Particle (NP)**
- **Atomic / Molecular / Optics (AMO)**
- **Condensed Matter (CM)**

You will do the experiment from all these groups



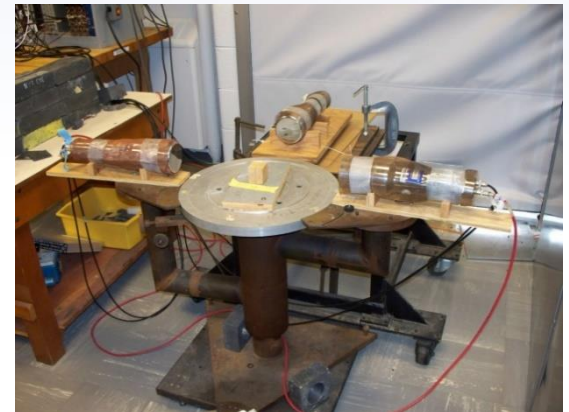
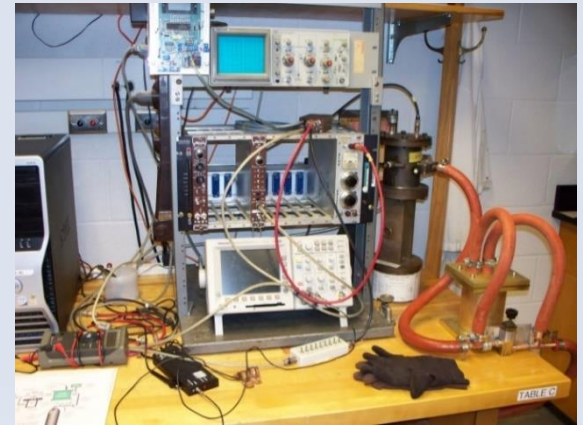
The Experiments

- **Nuclear / Particle (NP)**

- Alpha particle range in gasses
- Cosmic ray muons:

Lifetime, capture rate, magnetic moment

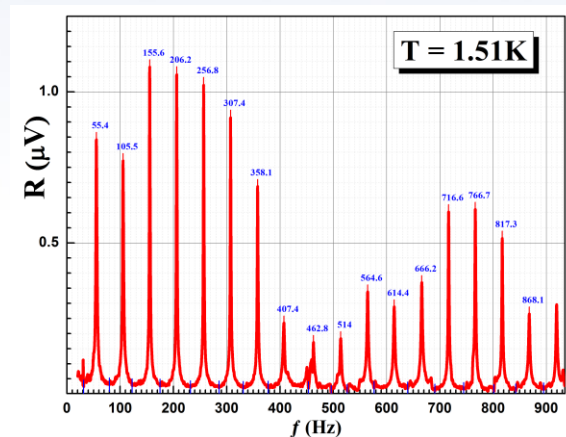
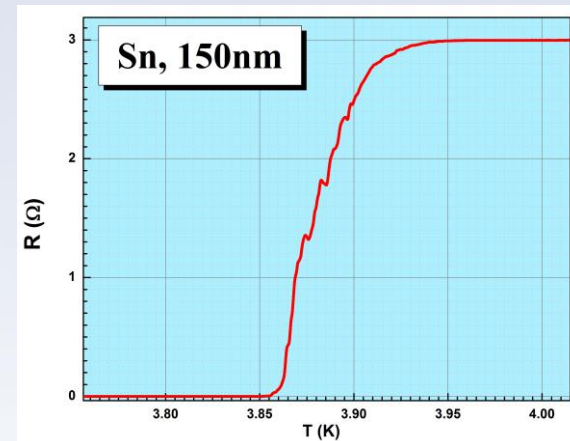
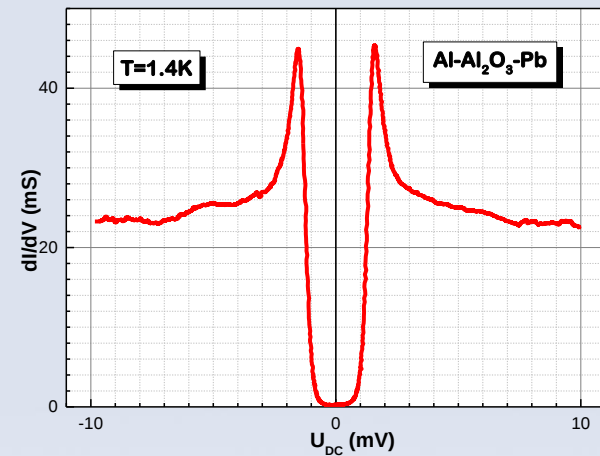
- Angular correlations in nuclear decay
- Angular distribution of cosmic rays
- γ - γ correlation experiment
- γ – spectroscopy
- Mössbauer spectroscopy (new)



The Experiments

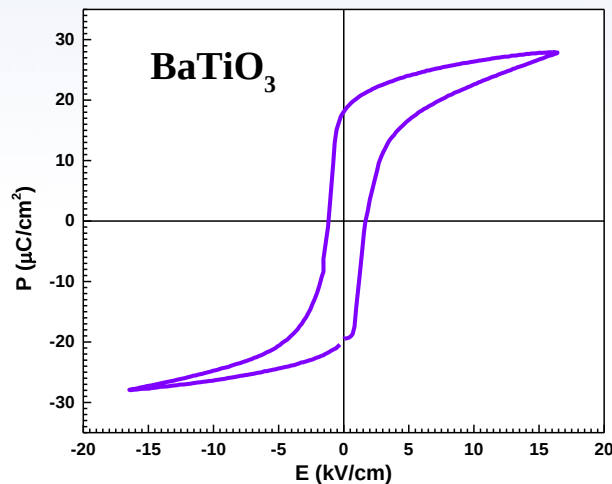
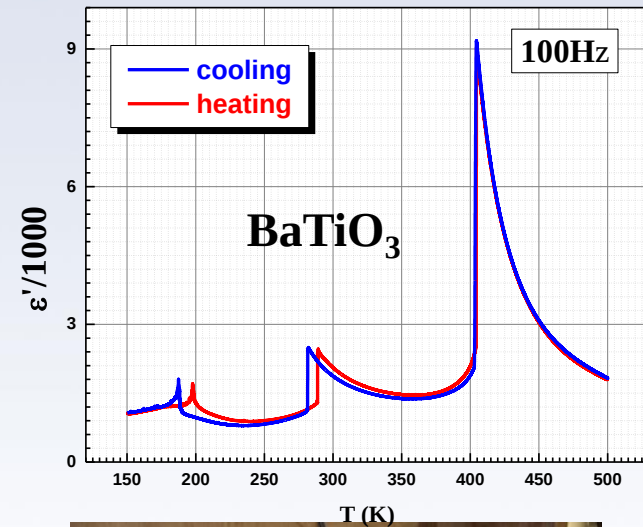
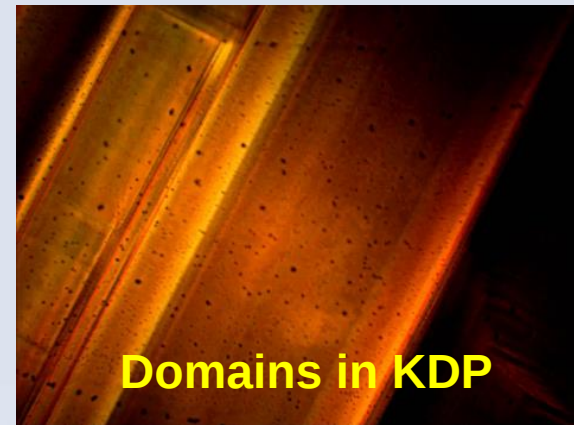
- Condensed Matter (CM)
 - Superconductivity
 - Tunneling in superconductors
 - 2nd sound in ⁴He superfluid

state



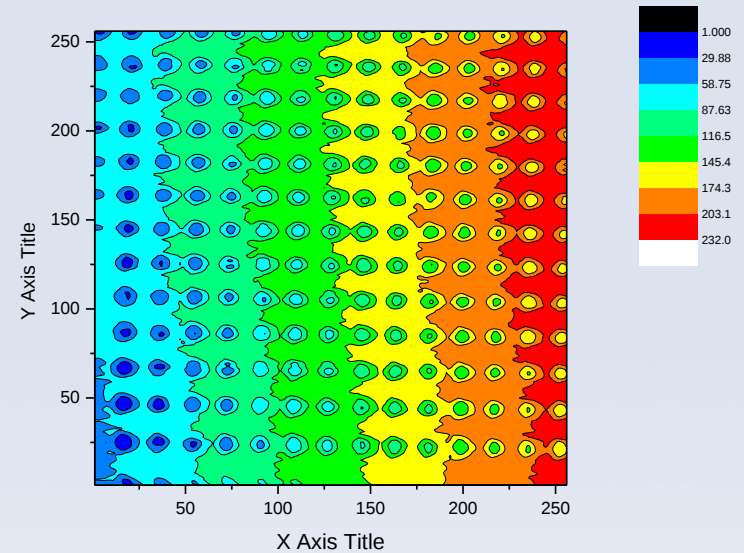
The Experiments

- **Condensed Matter (CM)**
 - Ferroelectrics and ferroelectric phase transition
 - Pulsed NMR
 - Calibration of temperature sensors



The Experiments

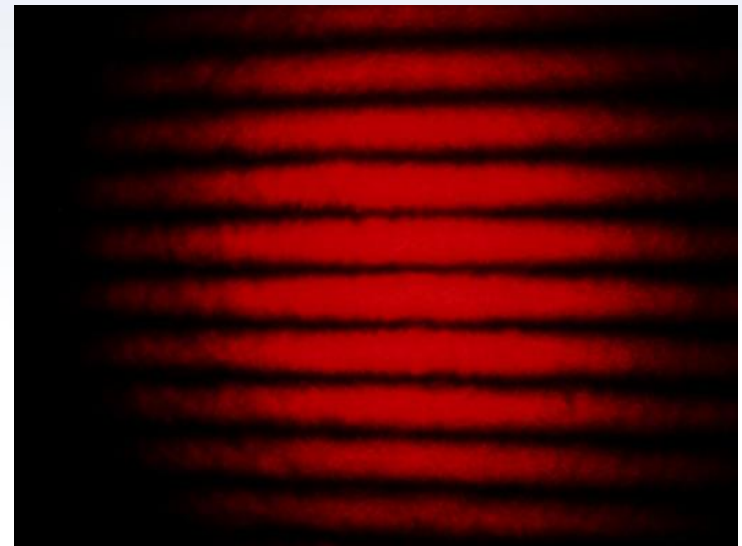
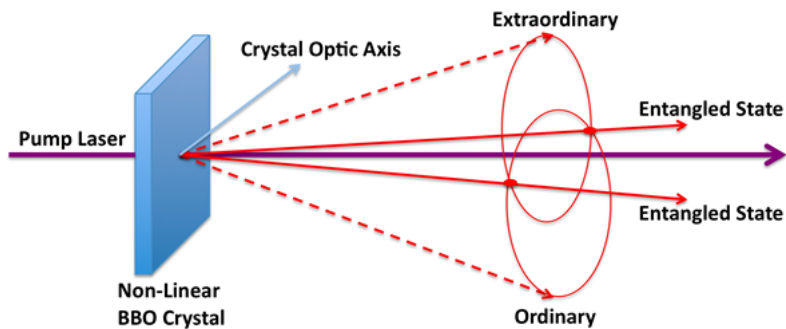
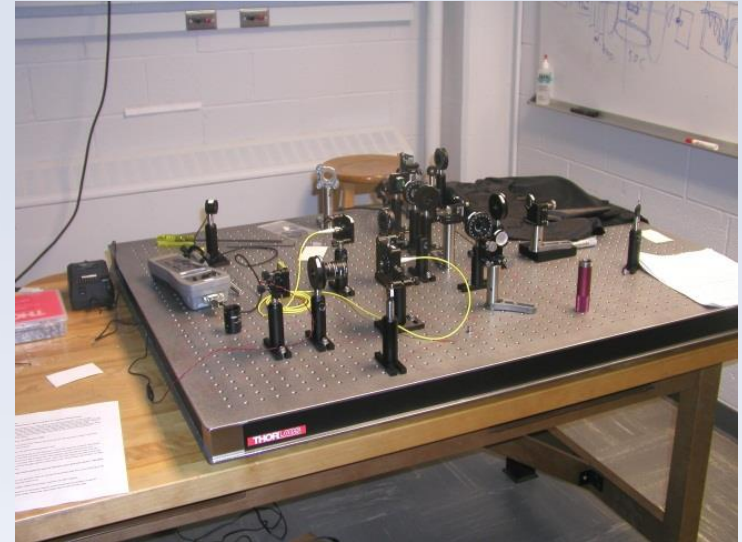
- **Condensed Matter (CM)**
- **Special Tools:**
- **Vacuum film deposition**
- **Atomic Force Microscope**
- **Polarizing microscope**



The Experiments

Atomic/Molecular/Optics (AMO)

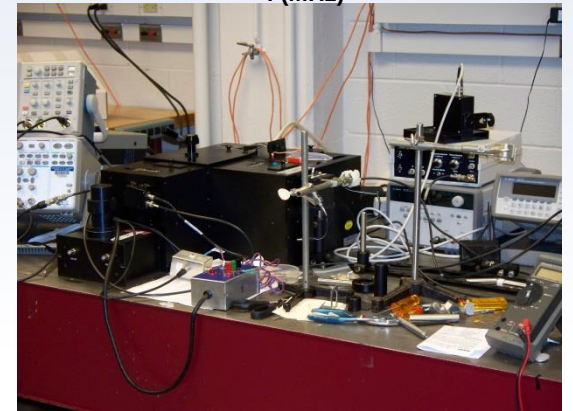
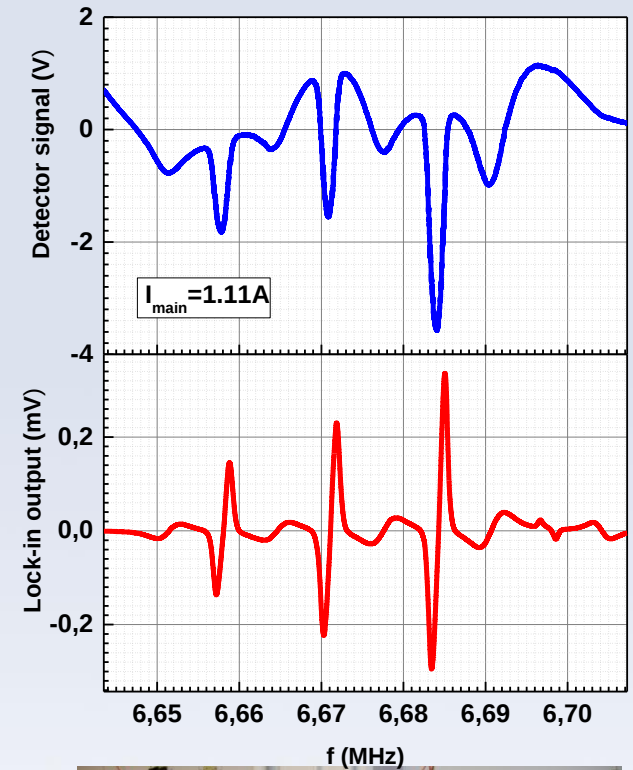
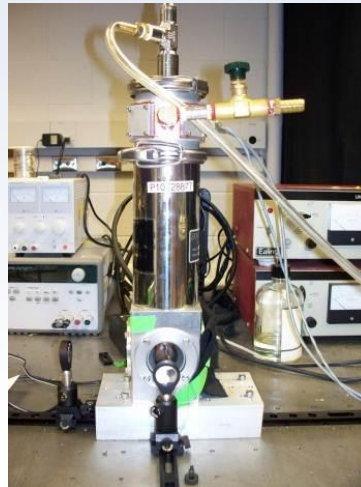
- Berry's phase
- Quantum erasure
- Quantum Entanglement



The Experiments

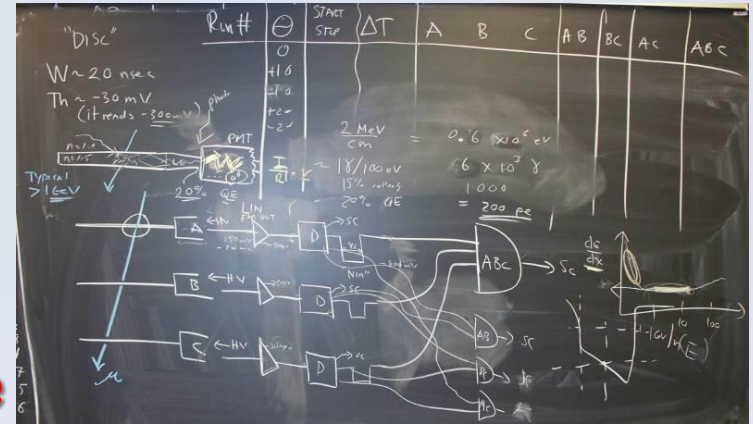
Atomic/Molecular/Optics (AMO)

- Optical pumping of rubidium gas
- Fluorescence spectroscopy

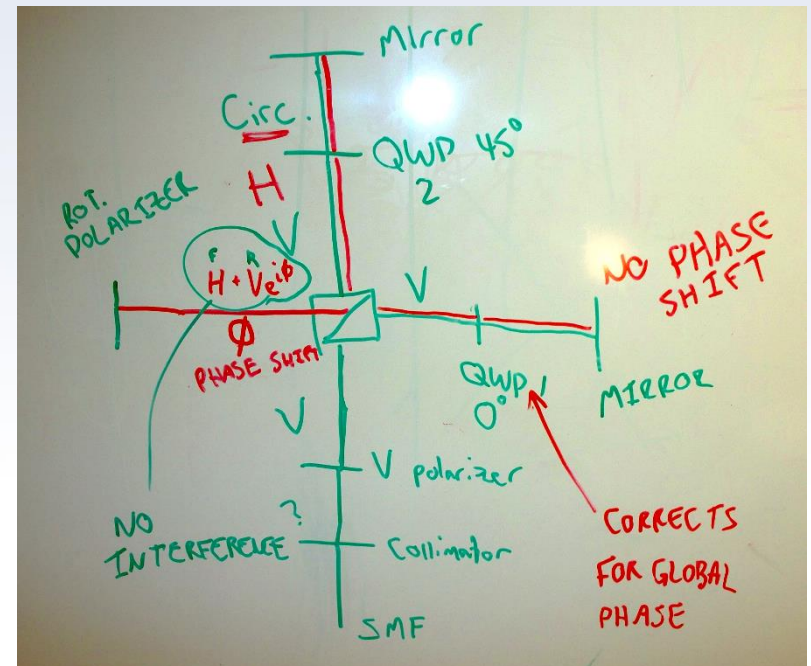


The “manuals”

- Many are just guides
- A only few purchased experiments have “real” manuals
- We serve as your guides ... like real research



OPTICAL PUMPING OF RUBIDIUM OP1-A



Grading: Distribution of “1000” points

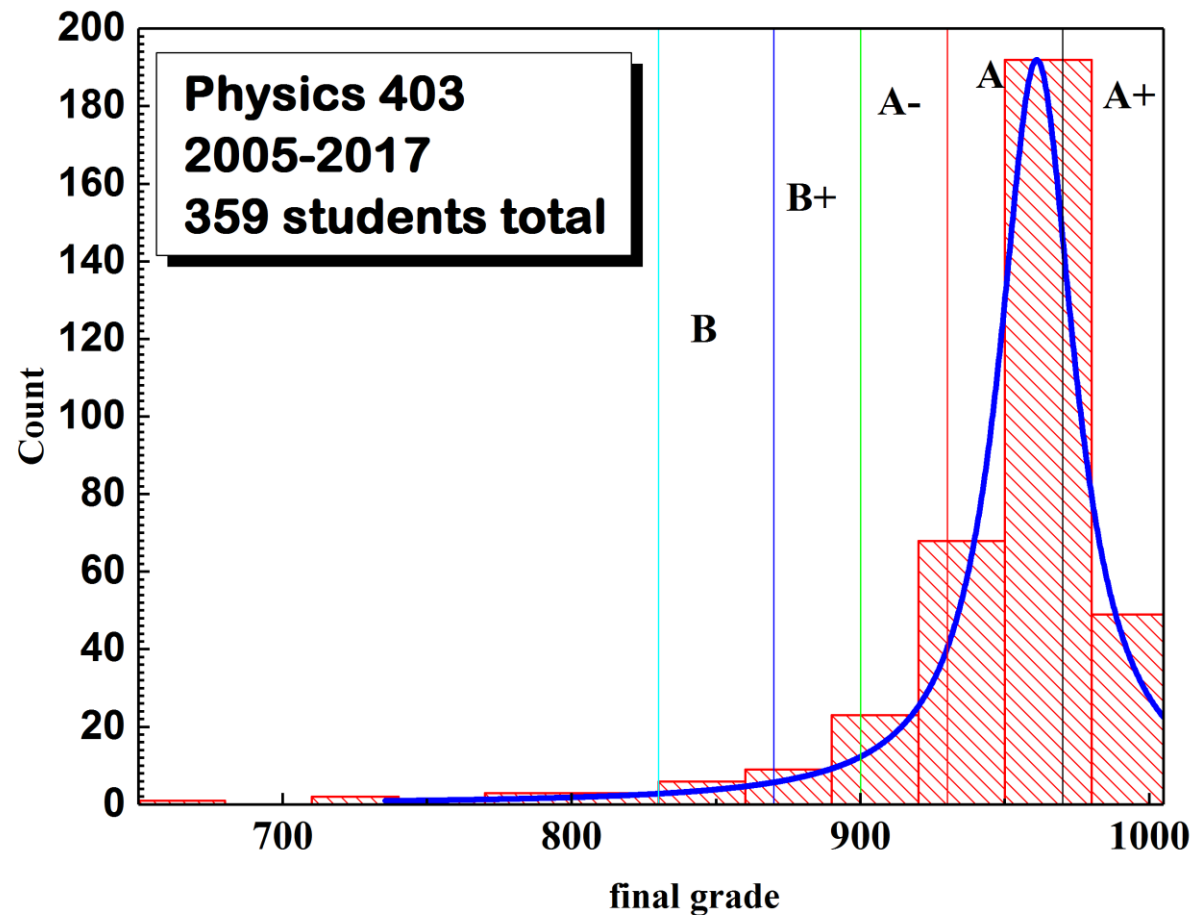
Item	Points
Expt. documentation: elog reports, shift summaries, plot quality; paper logbooks	120 Total 60 / cycle
Formal reports: physics case, quality of results, depth of analysis, conclusions	400 Total 100 / report
Oral reports: motivation, organization of presentation; fielding questions	150 75 / oral
Total	670

Letter grading scale is approximately 97% = A+, 93% = A, 90% = A-, 87% = B+, 83% = B, 80% = B-, etc



You can **RESUBMIT one lab report** to improve your grade (deadline for resubmissions August, 5)

Grading: a piece of history and analysis of the results



Submission of Lab-Reports

- Due dates as on syllabus at midnight
- The reports should be uploaded to the server:
- <https://my.physics.illinois.edu/courses/upload/>
- Accepted MS-Word or PDF
- For orals – MS-PowerPoint or PDF



Absences

- If you are sick, **let Eugene know by email**. Don't come in and get others sick. We are working side-by-side in a close environment for many hours.
- You can “make up” the time with arrangements and you can have access to the rooms. We will be accommodating.



Late Reports

- **Policy for late reports**

- You can have **ONE “late ticket”** for a **“free”** delay of up to **3** business days, but you must tell us you are using the ticket
- Reports are due at midnight on the date shown on the syllabus. After that we will charge:
 - 5 points for up to 1 week late. 10 points for up to 2 weeks late.
 - After that, it's too late.



Syllabus

Cycles



	Date	Day	Activity		Lectures: 10am Journal club: 3pm	Note	Due days
			8am-noon	1pm-5pm			
1	6/13	Tues	Orientation		About Phy403		
2	6/14	Wed	Cycle 1-1	Cycle 1-2	OriginPro Intro		
3	6/20	Tues	Cycle 1-3	Cycle 1-4	Elog Comments		
4	6/21	Wed	Cycle 1-5	Cycle 1-6	Lock-in Amps and FT		
5	6/27	Tues	Cycle 1-7	Cycle 1-8	Written Reports		
6	6.28	Wed	Cycle 1-9	Cycle 1-10	High Energy Physics		C1-Ex1(6.29.17)
7	7/05	Wed	Cycle 1-11	Cycle 1-12	Error analysis		
8	7/11	Tues	Cycle 2-1	Cycle 2-2	Oral Reports/Talks	Rotat e	
9	7/12	Wed	ORALS Cycle 1		Ferroelectricity		
10	7/18	Tues	Cycle 2-3	Cycle 2-4	Optical spectroscopy		C1-Ex2(7.13.17)
11	7/19	Wed	Cycle 2-5	Cycle 2-6	Noise		
12	7/25	Tues	Cycle 2-7	Cycle 2-8	Measuring Temperature		
13	7/26	Wed	Cycle 2-9	Cycle 2-10	Entanglement		C2-Ex1(7.27.17)
14	8/01	Wed	Cycle 2-11	Cycle 2-12	TBA		
16	8/02	Wed	ORALS Cycle 2				
17	8/3	Thurs			READING DAY		C2-Ex2(8.05.16)

* Lecture topics are subject to change

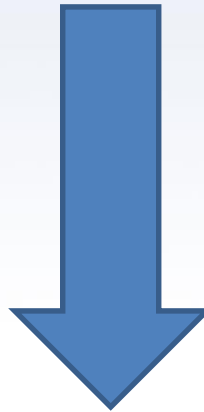


Assignment of experiments

2 cycles with 2 experiments

→ **teams change after cycle**

→ **joint team** reports and oral presentations



	NP	CM	Atomic + CM	Optics
	A. Cosmic Muon Stand i. Muon lifetime ii. Capture rate iii. Magnetic moment B. Alpha range C. Gamma Gamma D. Cosmic angular distribution	A. Ferro 1 B. Ferro 2 (imaging) C. 2 nd sound of ⁴ He D. pNMR E. Hysteresis loops F. Tunneling G. AFM H. T calibration	A. Optical pumping B. Superconductivity C. Mutual inductance	A. Quantum Table i. Berry's phase ii. Quantum erasure iii. Entanglement B. Florescence spectroscopy
	Paul, Domenic	Eugene	Eugene, Bruce	William and TA's from Kwiat Lab
C1-1	1-2; 3-4; 5-6; 7-8	13-14; 15-16; 17-18;	9-10; 11-12	19-20; 21-22; 23-24
C1-2	9-10; 11-12; 5-6; 7-8	19-20; 21-22; 23-24	1-2; 3-4;	13-14; 15-16; 17-18
C2-1	14-15; 16-17; 18-19; 20-21	2-3; 4-5; 6-7;	22-23; 13-24	8-9; 10-11; 1-12
C2-2	22-23; 13-24; 18-19; 20-21	8-9; 10-11; 1-12	14-15; 16-17	2-3; 4-5; 6-7;



In red - AFM with Jack

After 2 experiments (1 cycle) we will have oral session. The topic of the presentation will be chosen from the experiments done in this cycle. 9

Cycle	#	Experiment
C1-1	1,2	Cosmic Muon
C1-2	1,2	Superconductivity in Sn films – mutual inductance experiment

It is possible to split the team and give two talks in sole by each partner



Safety is your responsibility !

Hazards: *high voltage, radioactive sources, cryogens, chemical materials, high pressure*

In class work and “after hours” access & work requires responsible conduct with regards to

(I) safety/hazards and with

(II) equipment

Discuss potential hazards at the beginning of each experiment with an instructor or TA

When in doubt stop and ask

Problems after hours: 217 493 1576 (Eugene’s cell)



Follow Directly the Recommendations of Safety Working

<https://www.drs.illinois.edu/>

[Related Units @ Illinois](#) [Questions?](#) [Go](#)

**Division of
RESEARCH SAFETY** 

[Accident Response](#) [DRS Safety Programs](#) [Training](#) [Waste Management](#) [Safety Library](#) 

[My Campus User Login](#)



Laboratory Incidents

Learn about past incidents on the University of Illinois campus, and how you can prevent them in your lab.

News and Announcements

[View Archive »](#)

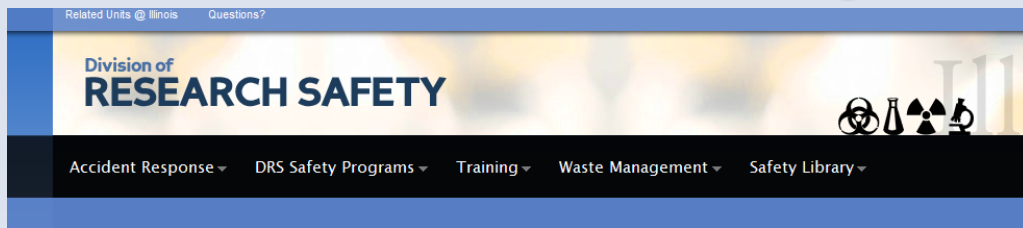
- NIH Guidelines Training Requirement**
6/6/2016
All faculty, staff and students working with recombinant or synthetic nucleic acids are required to take the on-line training course, NIH Guidelines Overview .
- Zika Virus**
3/2/2016
What is the Risk Assessment?
- Airgas Valve Alert**
1/27/2016
Following a recent gas cylinder valve malfunction on campus, DRS would like to warn all gas cylinder users of the difference between two different cylinder valves used.

Responsibilities

-  I work in a lab
-  I supervise a lab
-  My work takes me into labs



Follow Directly the Recommendations of Safety Working



Chemical Waste Collection and Storage

Before generating chemical waste, the researcher should determine how it will be collected and stored and obtain the necessary equipment (containers, labels) in advance. The choice of procedures depends on the type of waste and its final disposition. This section explains how to determine the final disposition of waste, select the appropriate waste container, and store waste in the lab or work area. It also suggests waste minimization strategies.

Determining How to Dispose of a Chemical Waste

The final disposition of a chemical waste is determined by the answers to a series of questions:

- Step 1. Is the waste [Contaminated Debris](#) (glassware, paper towels, clean-up materials), or is it a chemical or chemical mixture?
If it is contaminated debris: Go to Step 5.
If it is a chemical or chemical mixture: Go to Step 2.
- Step 2. Is the chemical a DEA (Drug Enforcement Agency) controlled substance? (Refer to the [DEA list controlled substances](#).)
Yes: Refer to the [DEA Controlled Substances Guide](#) for disposal procedures.
No: Go to Step 3.
- Step 3. Is the chemical a solid (not liquid or gas)?
Yes: Collect and store the waste as described in the waste container and storage guidelines listed below and dispose of it through the Division of Research Safety (DRS) chemical waste disposal program. See the section [Procedures for Requesting Chemical Waste Disposal](#) for the disposal procedures. (No solid chemical waste, hazardous or non-hazardous, should be placed in the regular trash.)
No: Go to Step 4.
- Step 4. Is the chemical a liquid non-hazardous waste as listed in the section [Liquid Non-Hazardous Chemical Waste Disposal](#)?
Yes: The chemical may be poured down the sanitary sewer (sink drain) with copious amounts of water.
No: Collect and store the waste as described in the waste container and storage guidelines listed below, and dispose of it through the DRS chemical waste disposal program. See the section [Procedures for Requesting Chemical Waste Disposal](#) for the disposal procedures.
- Step 5. Is the contaminated debris laboratory glassware (broken and unbroken)?
Yes: See the [Laboratory Glassware Waste Disposal](#) section.
No: Go to Step 6.
- Step 6. Is the debris contaminated with a substance listed in the section [Liquid Non-Hazardous Chemical Waste Disposal](#)?
Yes: The contaminated debris can be disposed of in the regular trash.
No: Collect and store the contaminated debris as described in the waste container and storage guidelines listed below: dispose



Waste container for ethanol, acetone, methanol, isopropanol.

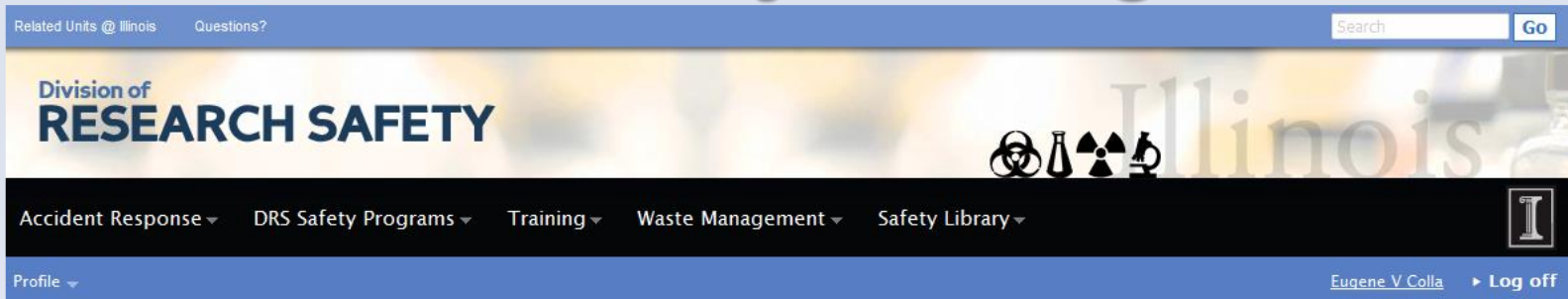


Waste container for mineral spirits.



Waste containers for chemicals used in NMR experiment

Follow Directly the Recommendations of Safety Working



Laboratory Sharps

Definition

Materials that qualify as “sharps” are defined at the state level and shall be disposed of as Potentially Infectious Medical Waste (PIMW). In Illinois, the Illinois Environmental Protection Agency (IEPA) has designated the following material (used or unused) as sharps:

- Any medical needles,
- Syringe barrels (with or without needle),
- Pasteur pipettes (glass),
- Scalpel and razor blades,
- Blood vials,
- Microscope slides and coverslips,
- Glassware contaminated with infectious agents.

NEVER dispose of these items in SDCs:

- Plastic items (except for syringes),
- Beverage containers (no pop cans!),
- Non-biologically contaminated laboratory glassware,
- Solvent/chemical bottles,
- Light bulbs,
- Any paper materials,
- Pipette tips,
- Plastic pipettes,
- Aerosol cans or cans of any type,
- Scintillation vials,
- Any item with liquid (except for blood in vacutainer tubes).



**Waste
container for
sharps**



How to record data

- **Work together**
- **Write down the equipment used**
- **Make a diagram of the setup**
- **Note the settings of dials, switches, gauges**
- **Take a digital photo if appropriate**
- **Use a software drawing program to make a detailed sketch**



How to record data

- Use the eLog (see next).
- Write down what you did in real sentences.
- Provide enough detail that you can reconstruct later what you did!
- How will you look at the data later?
- Do you have enough information?
- Did the equipment perform as expected?



How to record data

- Many experiments require you to “change and measure” something by hand
 - Make a table in a paper logbook for this
 - Be prepared to state your measurement uncertainty
 - Make a “**quick sketch**” of your results by hand; then, enter the data in an electronic table and make a final plot
 - Do you have enough points?
 - Do you have any obvious anomalies?
 - You can repeat points but do not throw them out. Use other measurements to check reliability



How to record data

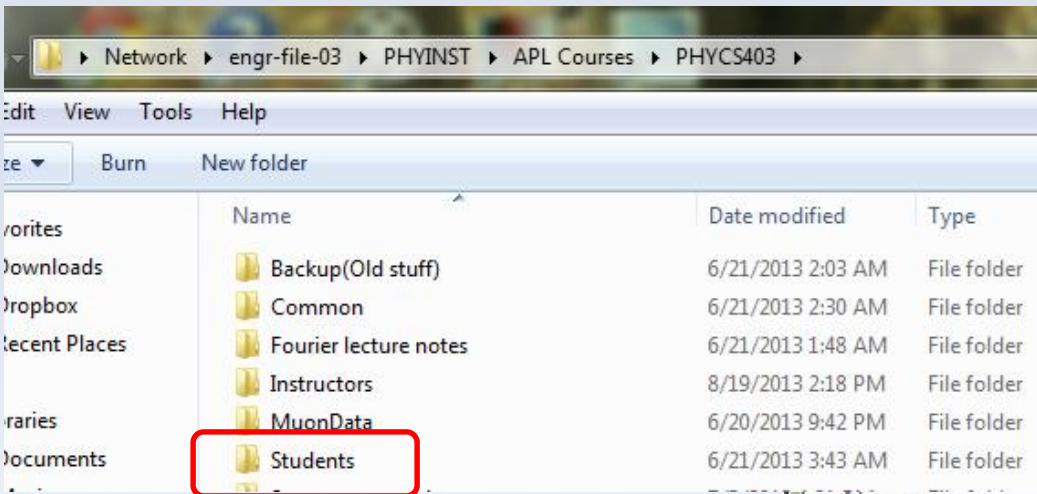
- Many experiments have built-in, computer-based data acquisition (DAQ)
 - You will not have time to fully understand the DAQ, but
 - Be sure you know functionally what it is doing – ask
 - A good idea is to make test measurements of something you know
 - As before, anomalies? enough points? uncertainties?



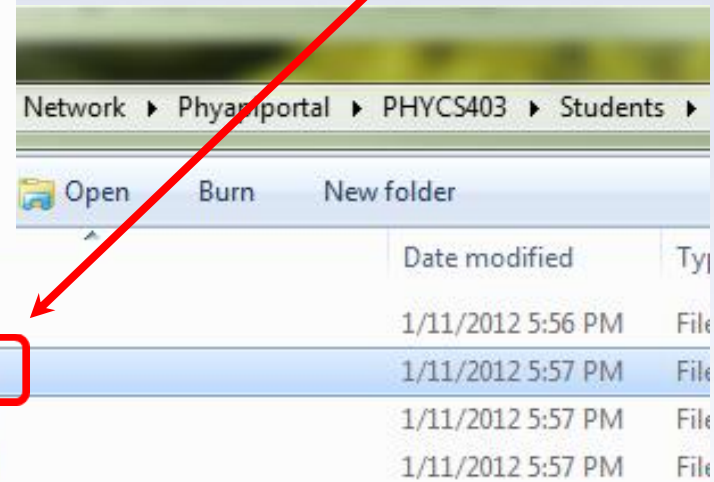
Where to exchange, store and retrieve course information.

(i) Your data, projects, tables etc

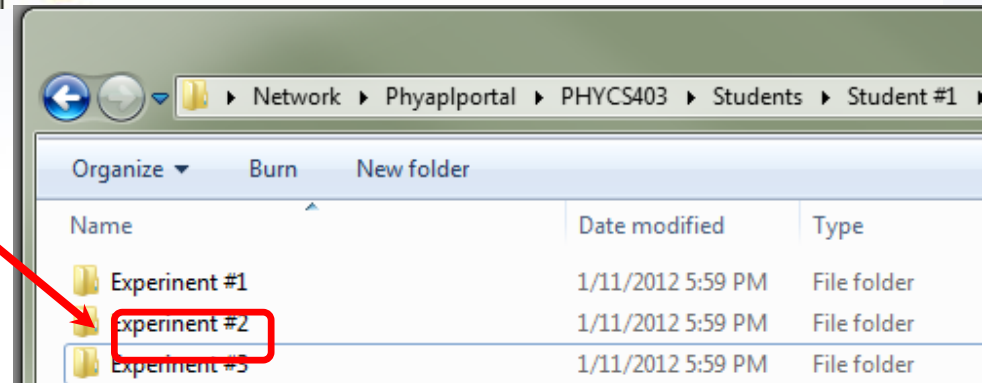
\\engr-file-03\PHYINST\APL Courses\PHYCS403



Make your own folder and put your work there



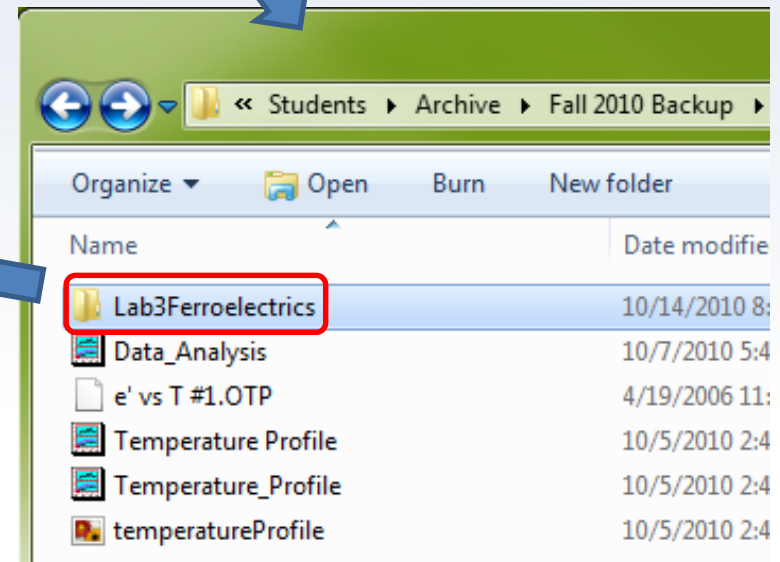
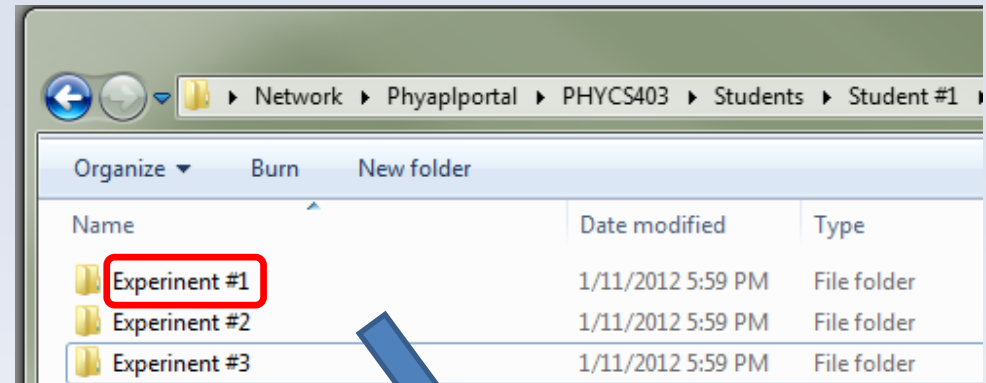
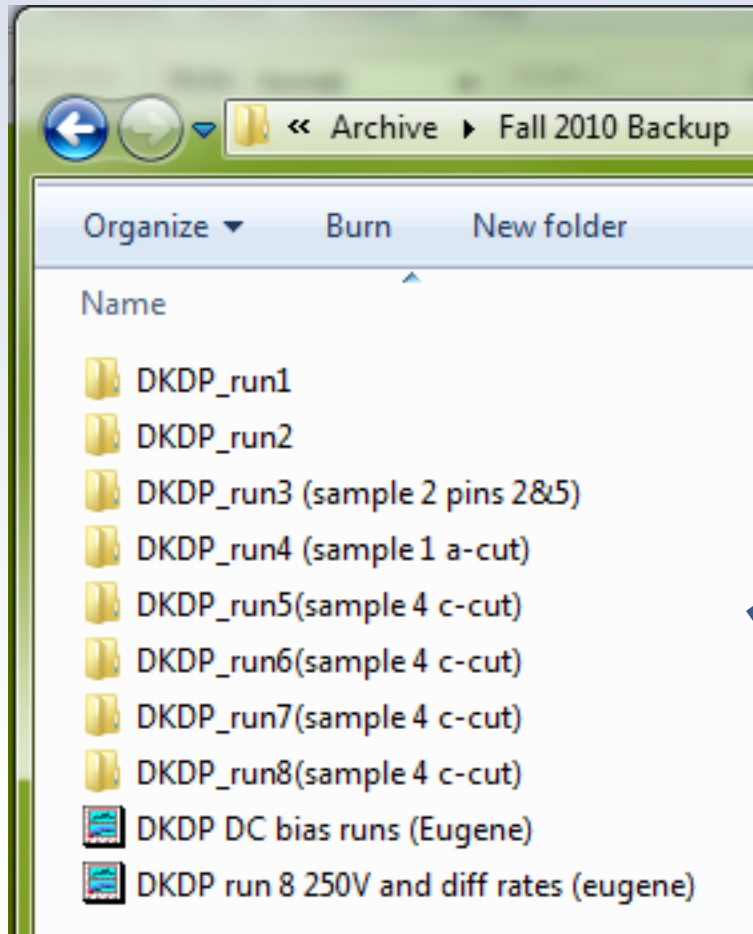
Store all experiment related materials in corresponding folder



Where to exchange, store and retrieve course information. (i)

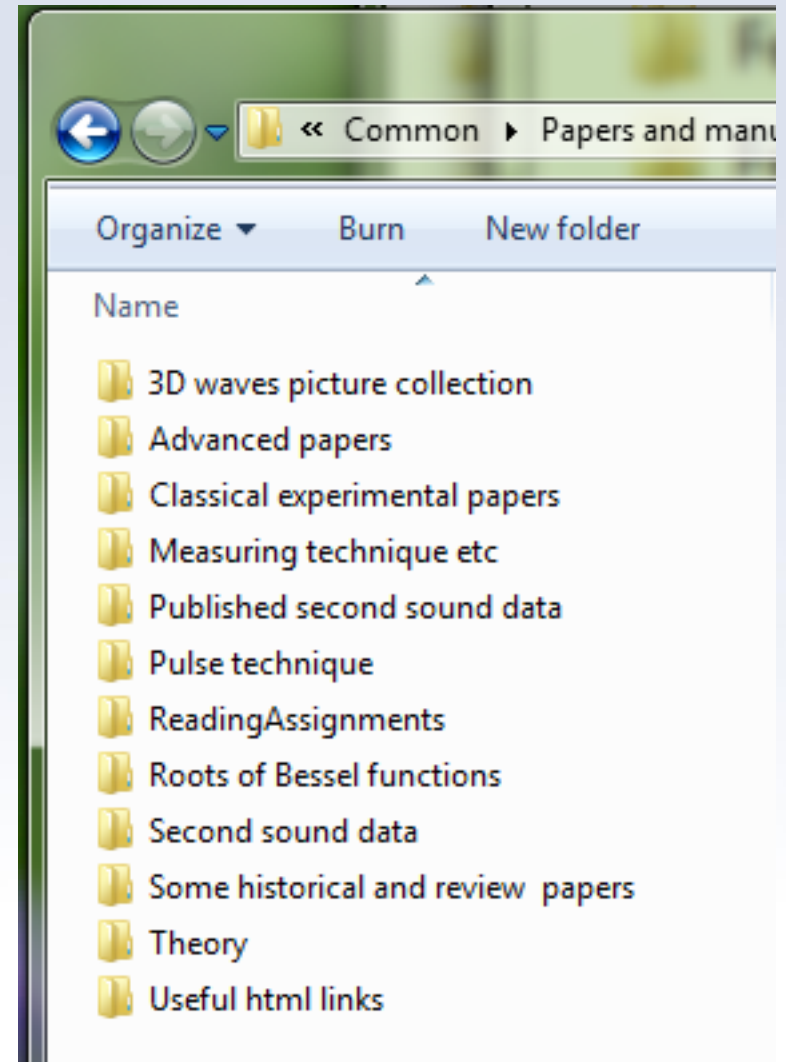
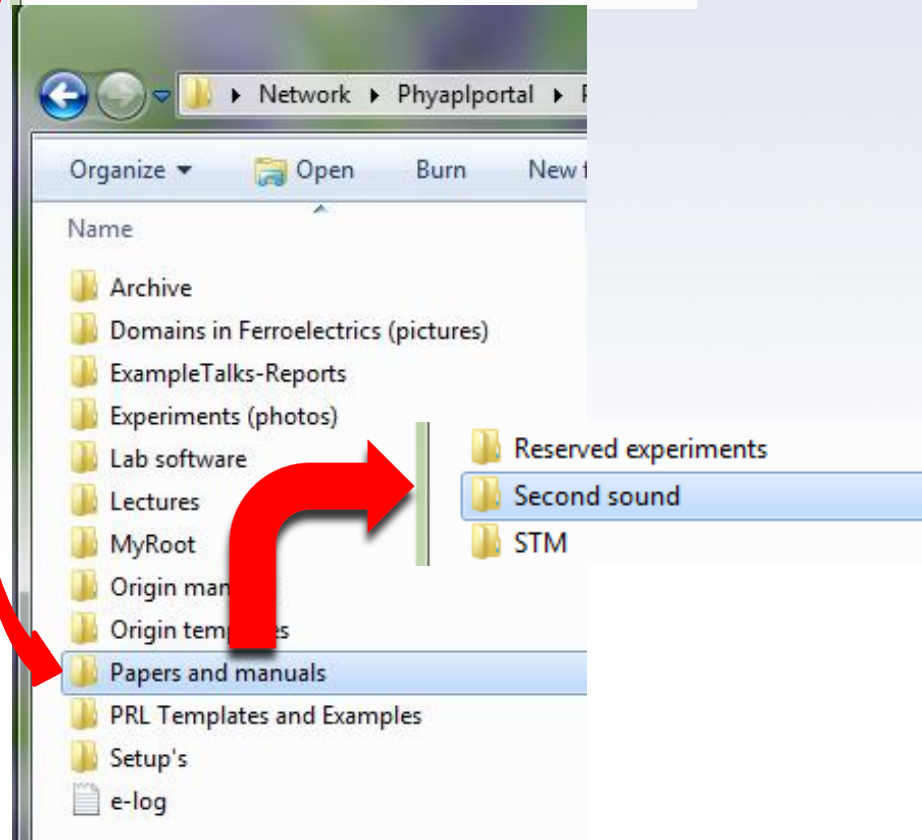
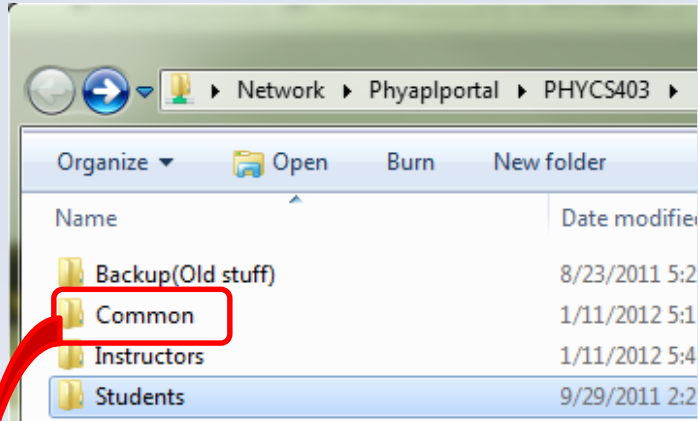
Your data, projects, tables etc

An example of the “smart” structure of folders containing the raw data and data analysis projects



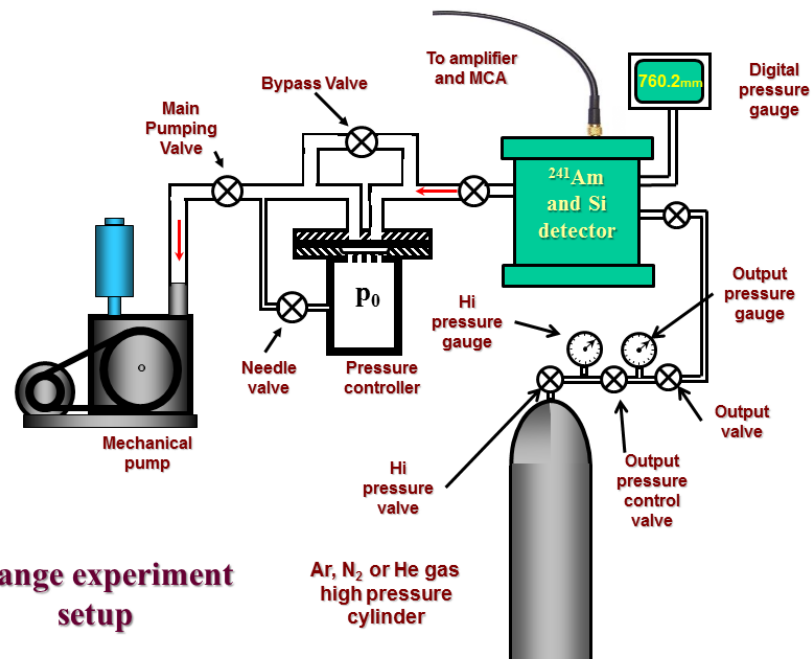
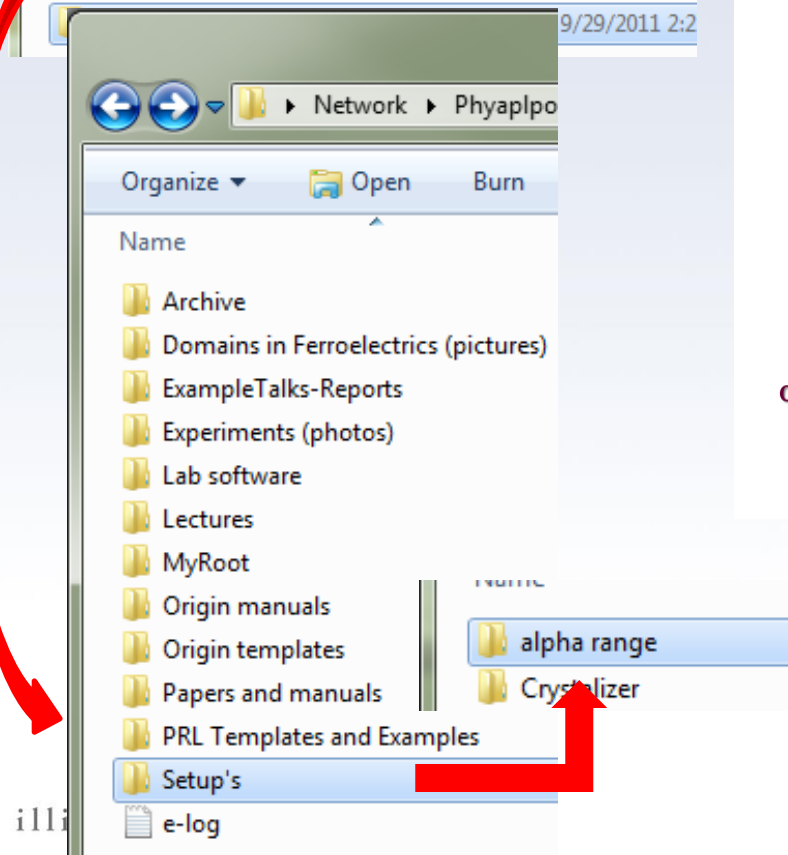
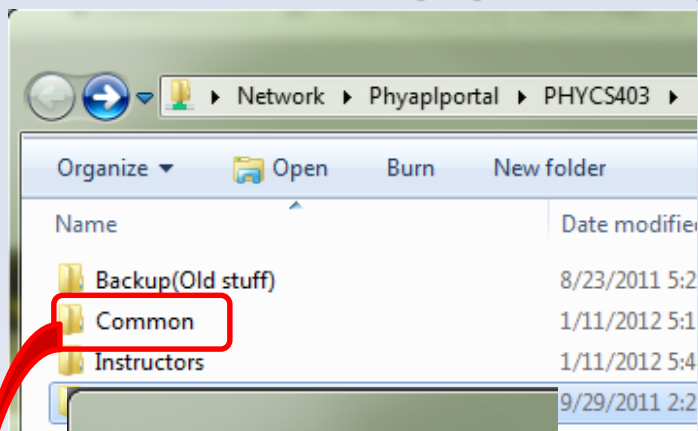
Where to retrieve course information.

Manuals, papers, setup diagrams and other useful materials



Where to retrieve course information.

Manuals, papers, **setup diagrams** and other useful materials



α -range experiment setup diagram

Where to retrieve course information.

Manuals, papers, setup diagrams and *other useful materials*

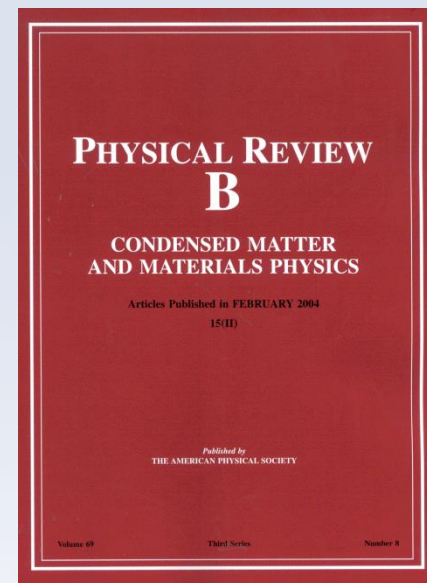
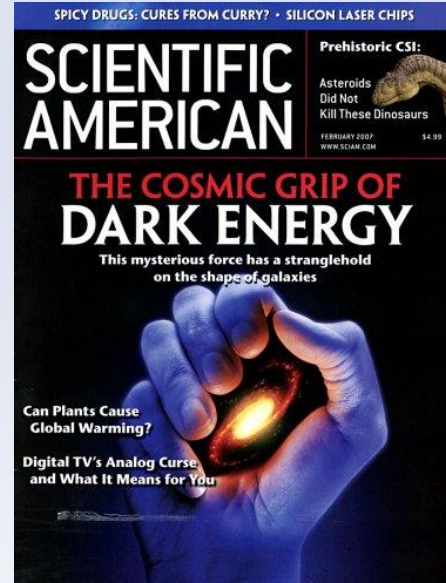
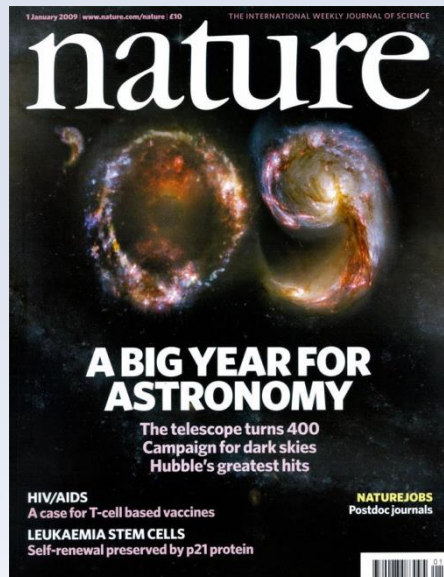
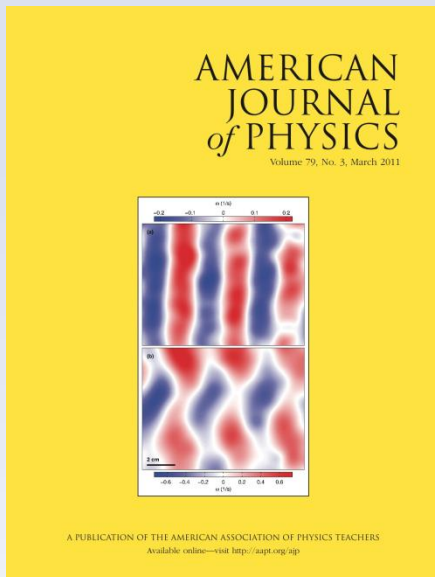
The screenshot shows a file explorer window with the following folders and files listed:

- Common
- Archive
- Domains in Ferroelectrics (pictures)
- ExampleTalks-Reports
- Experiments (photos)
- Lab software
- Lectures
- MyRoot
- Origin manuals
- Origin templates
- Papers and manuals
- PRL Templates and Examples
- Setup's
- e-log

Red arrows point from the following folders to descriptive text boxes:

- Common** points to: **Some old stuff (not very useful)**
- Domains in Ferroelectrics (pictures)** points to: **Sample pictures of ferroelectric domains**
- ExampleTalks-Reports** points to: **Examples of report and oral presentation**
- Experiments (photos)** points to: **Pictures of the setups of the experiments**
- Lab software** points to: **Software including DAQ software for different experiments. Newest version of Origin is also there**
- Lectures** points to: **P403 lecture notes**
- MyRoot** points to: **C++ scripts for Root**
- Origin manuals** and **Origin templates** point to: **Origin manuals + a very compressed version written by Eugene**
- Setup's** points to: **Origin templates (how to use them will be discussed in next lecture)**

“Journal club”



<http://ajp.aapt.org/#mainWithRight>

<http://www.nature.com/nature/index.htm>

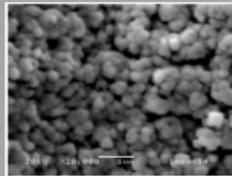
<http://www.scientificamerican.com/>

<http://publish.aps.org>
or <http://prola.aps.org/>



“Journal club”

Walking with Coffee: Why Does it Spill?



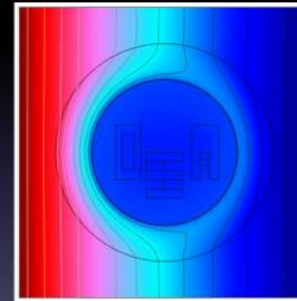
Growth of Diamond Films from Tequila

J. Morales^{1,2}, L. M. Apátiga², V. M. Castaño²

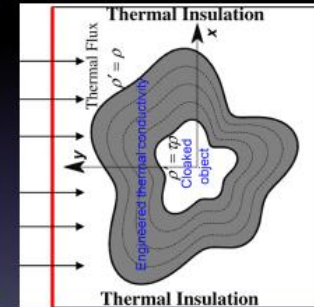
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Fabrication and Characterization of Ultrathin Three-Dimensional Thermal Cloak



(Credit: Guennea)



Student #1

University of Illinois at Urbana-Champaign

The Physics of Beer Tapping

PRESENTATION BY JOSEPH MIRABELLI

JAVIER RODRÍGUEZ-RODRÍGUEZ, I.* ALMUDENA CASADO-CHACÓN, AND DANIEL FUSTER

1 FLUID MECHANICS GROUP, CARLOS III UNIVERSITY OF MADRID

2 CNRS, UNIVERSITÉ PIERRE ET MARIE CURIE

e-logs: First a brief tour ...

<http://www.npl.illinois.edu/elog/modphys/>

How to use it

- Pause and summarize your work at natural stopping points in the action. This is useful for particular findings and measurement sequences.
- Along the way, save data, plots, scope shots to a temporary folder on your desktop.
- Near the end of the class, make a “**Shift Summary**” providing a rather complete overview of the highlights of your work. There, you can upload your plots, scope shots, etc. and describe the data



Entering the e-Log ...

(at this point, you need to work on a computer)

To access the e-log:

- Go to <https://elog-teach.physics.illinois.edu/>
- or <https://courses.physics.illinois.edu/phys403/su2017/> and click on E-LOG

Use your UofI login and Password



e-logs: Making a post ...

- **Create a New Post**
- **To create a new post, click "New" from the menu bar.**
- **Fill in the Author, Experiment, Post Type, and Subject**
 - **If the post is written by more than one person, use a comma separated list.**
 - **Be sure the Author name is the same you used when registering so that you can edit/delete the post if**
 **necessary.**