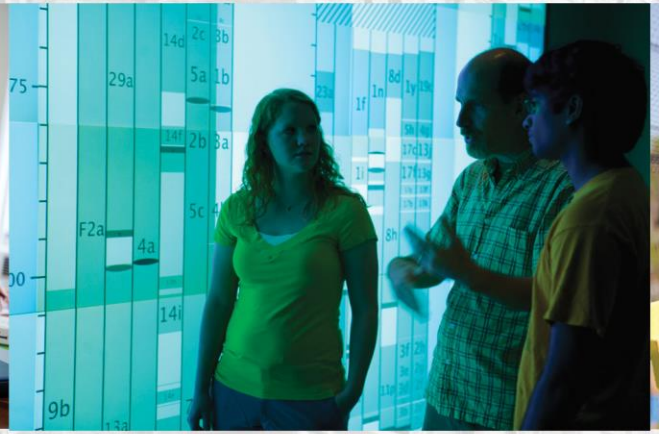
UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Physics 403. Modern Physics Laboratory

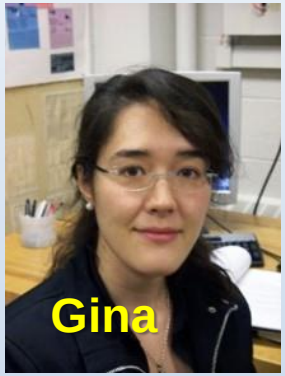
Fall 2019

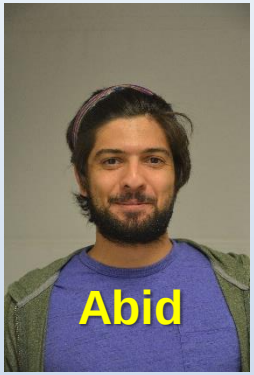
Eugene V Colla, Virginia Lorenz



Physics 403 Modern Physics Laboratory

Fall 2019 Teaching Team





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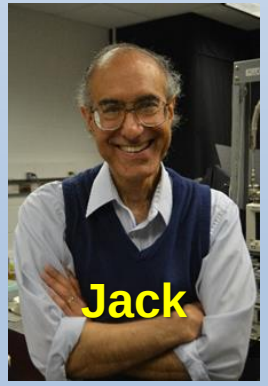

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Outline

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 and modern analysis 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

illinois.edu

* In red gradable assignments

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**

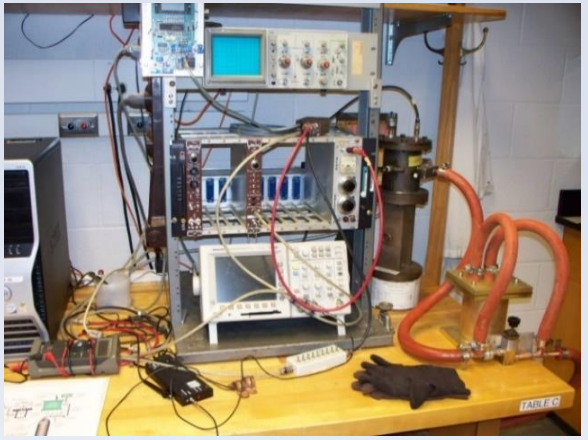
The Experiments. Three main groups

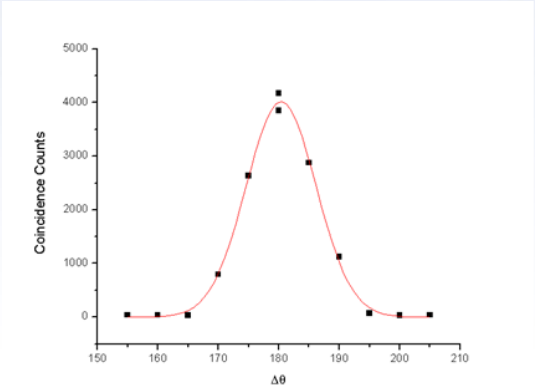
- Nuclear / Particle (NP)
- Atomic / Molecular / Optics (AMO)
- Condensed Matter (CM)

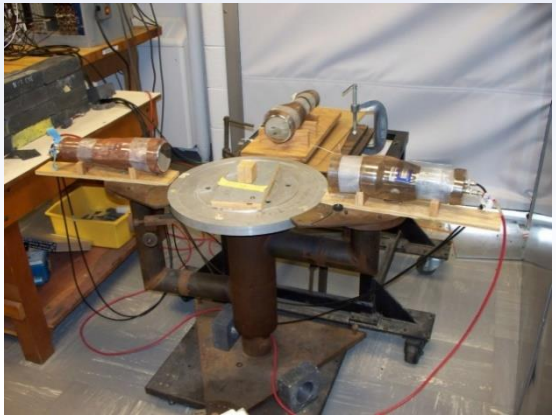
You will do the experiment from all these groups

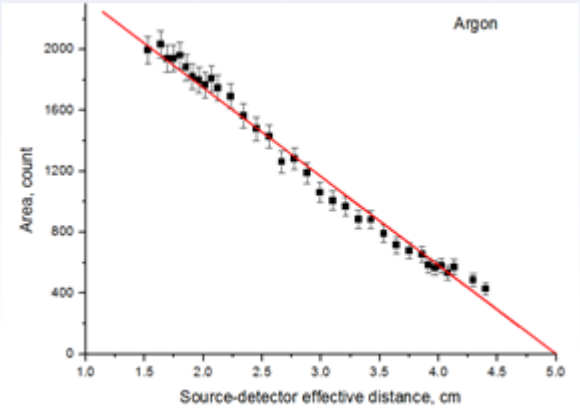
The Experiments

- **Nuclear / Particle (NP)**
  - **Alpha particle range in gasses**
  - **γ–γ correlation experiment**
  - **γ – spectroscopy**
  - **Mössbauer spectroscopy**





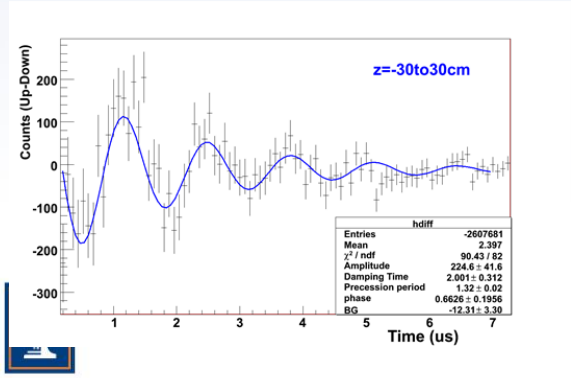


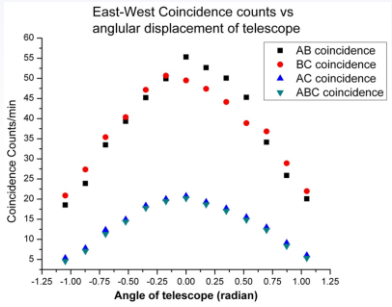


The Experiments

- **Nuclear / Particle (NP)**
  - **Cosmic ray muons:**

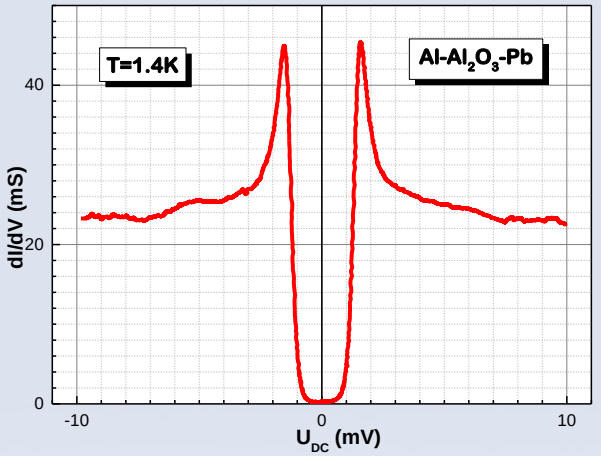
    Lifetime, capture rate, magnetic moment
  - **Angular distribution of cosmic rays**
  - **γ – spectroscopy**
  - **Mössbauer spectroscopy (new)**

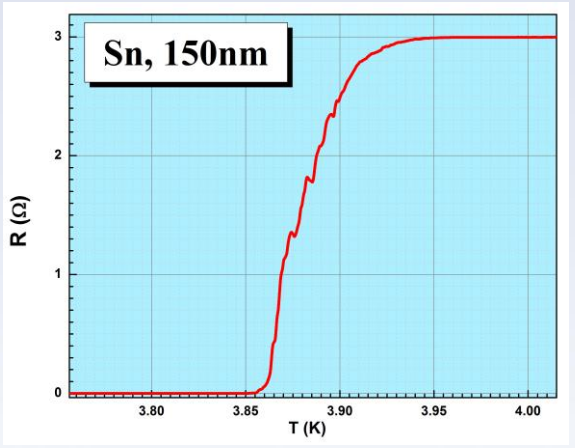


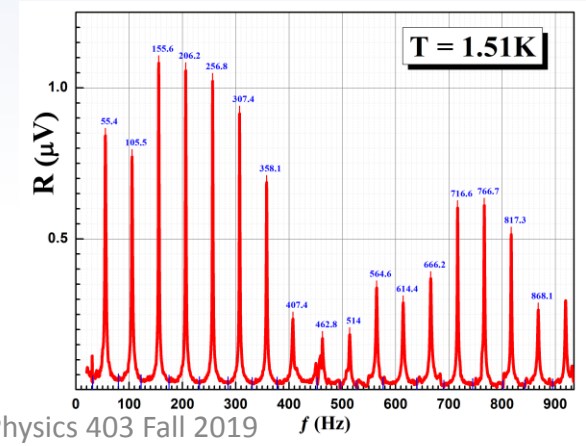


The Experiments

- **Condensed Matter (CM)**
  - **Superconductivity**
  - **Tunneling in superconductors**
  - **2nd sound in ^{4}He superfluid state**

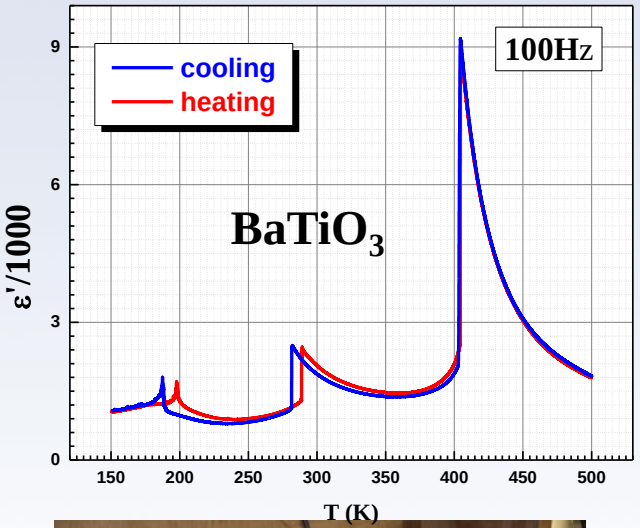


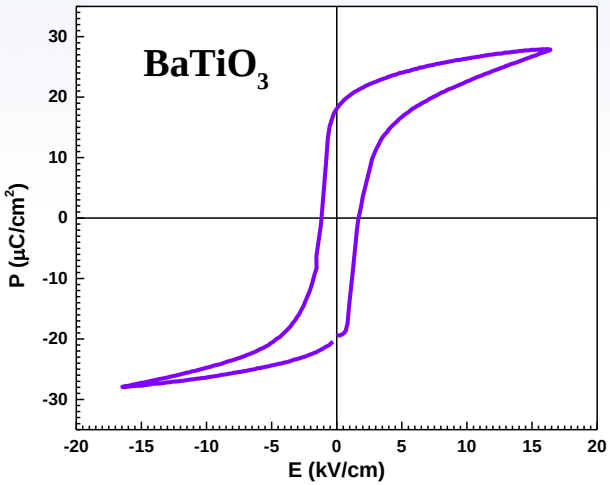


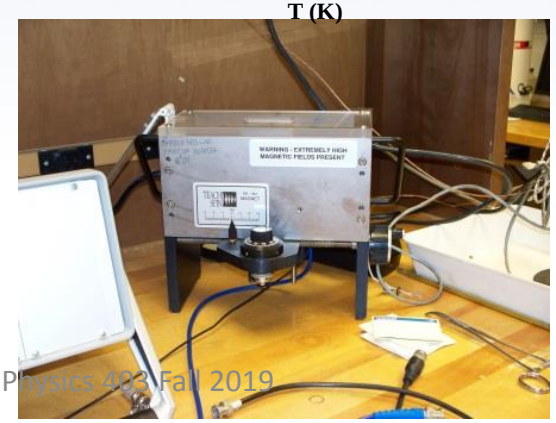


The Experiments

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

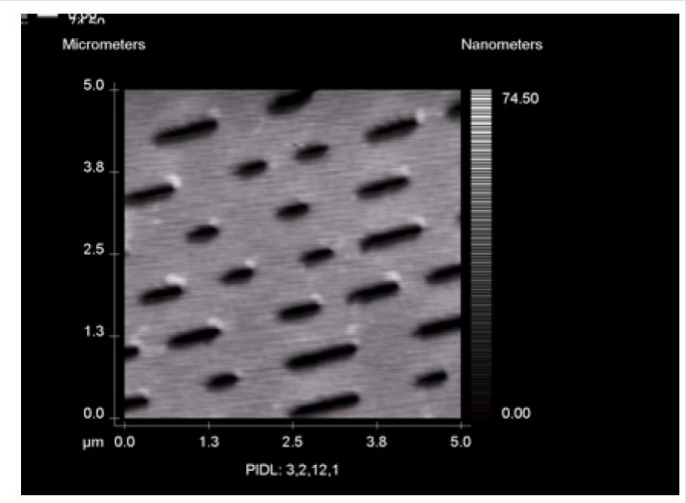


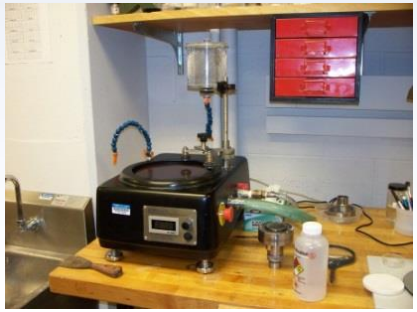




The Experiments

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

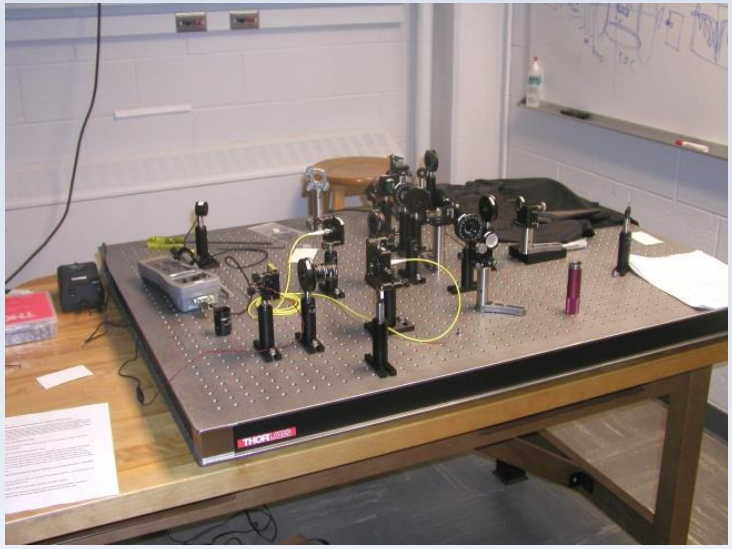


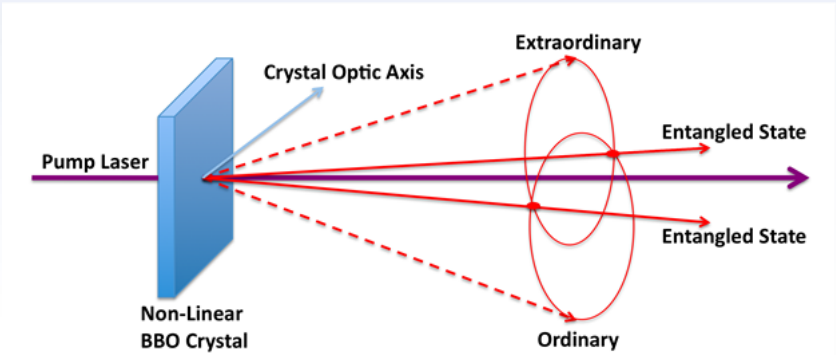


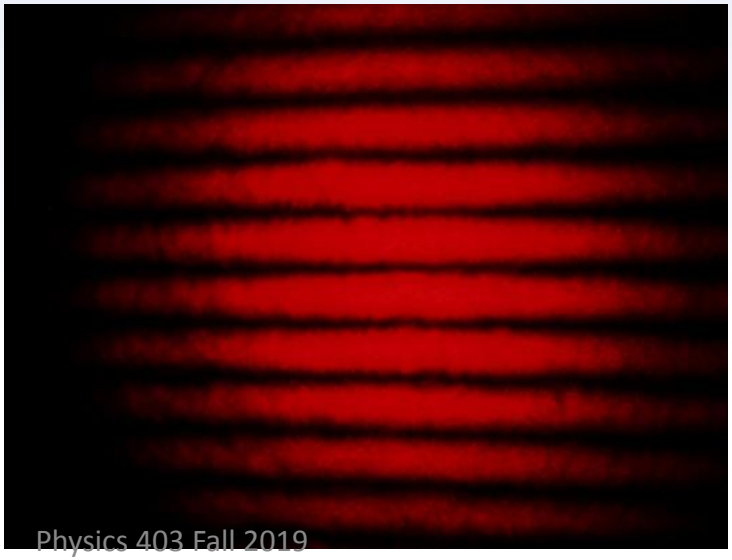
The Experiments

Atomic/Molecular/Optics (AMO)

- Berry's phase
- Quantum erasure
- Quantum Entanglement



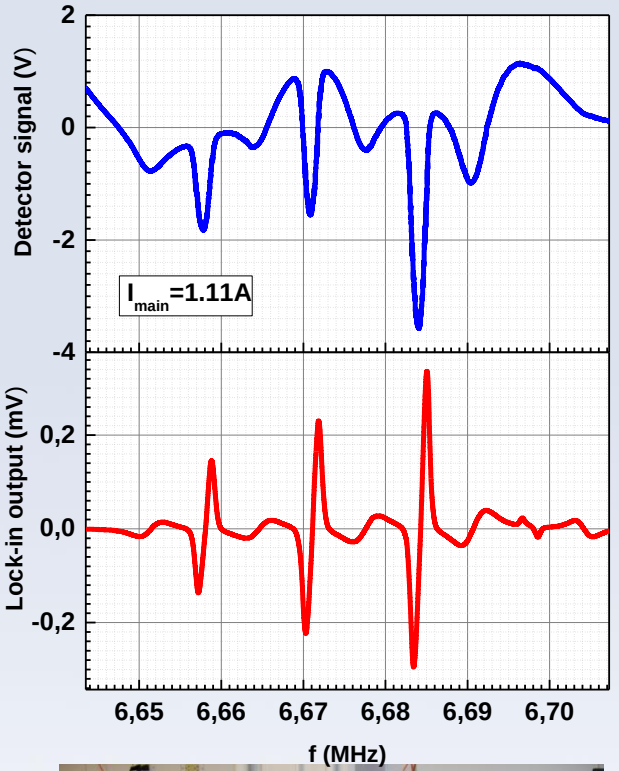


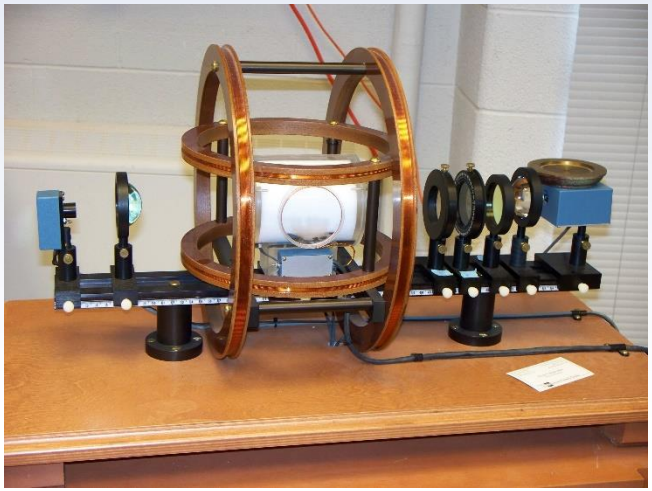


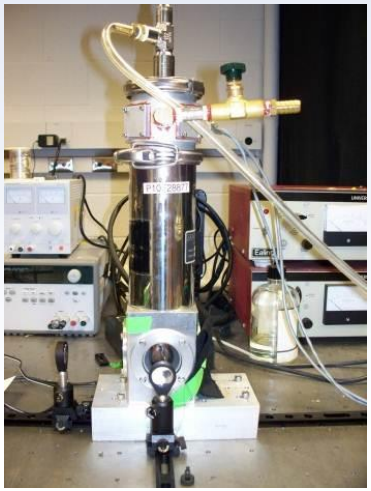
The Experiments

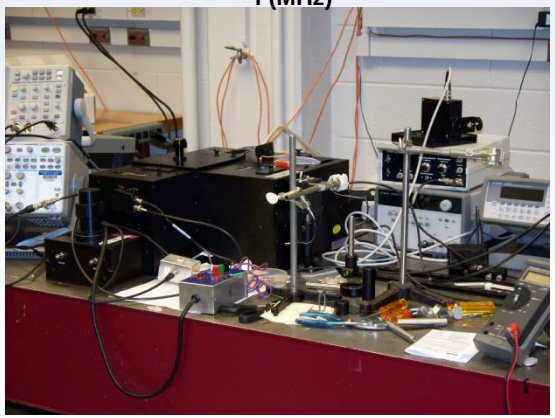
Atomic/Molecular/Optics (AMO)

- Optical pumping of rubidium gas
- Fluorescence spectroscopy



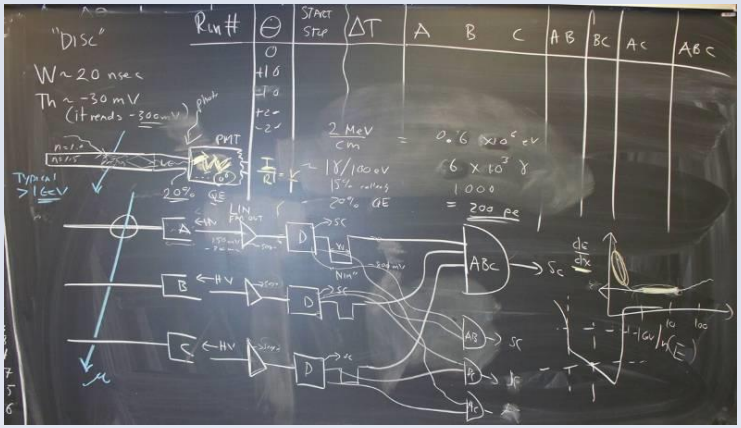






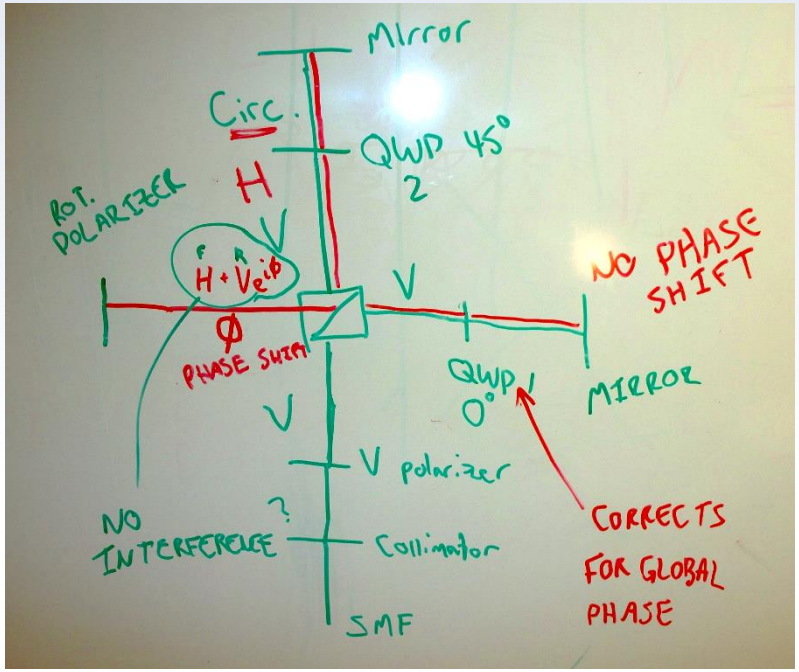
The "manuals"

- Many are just guides
- A only few purchased experiments have "real" manuals
- We serve as your guides … like real research



TEACH SPIN
Instruments Designed for Teaching

OPTICAL PUMPING OF RUBIDIUM
OP1-A



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Home and away computing

V. Take a Lab tour !

VI. Let's get started

electronic logbooks

digital scopes

Grading: Distribution of "1000" points

ASSIGNMENT	Points
Expt. documentation: elog reports, shift summaries, plot quality; paper logbooks	**180 Total** **60 / cycle**
Formal reports: physics case, quality of results, depth of analysis, conclusions	**600 Total** **100 / report**
Oral reports: motivation, organization of presentation; fielding questions	**100 Total** **50 / oral**
Final Oral Presentation ≡ Final Exam	**120**
Total **Effective point total will be**	**1000**

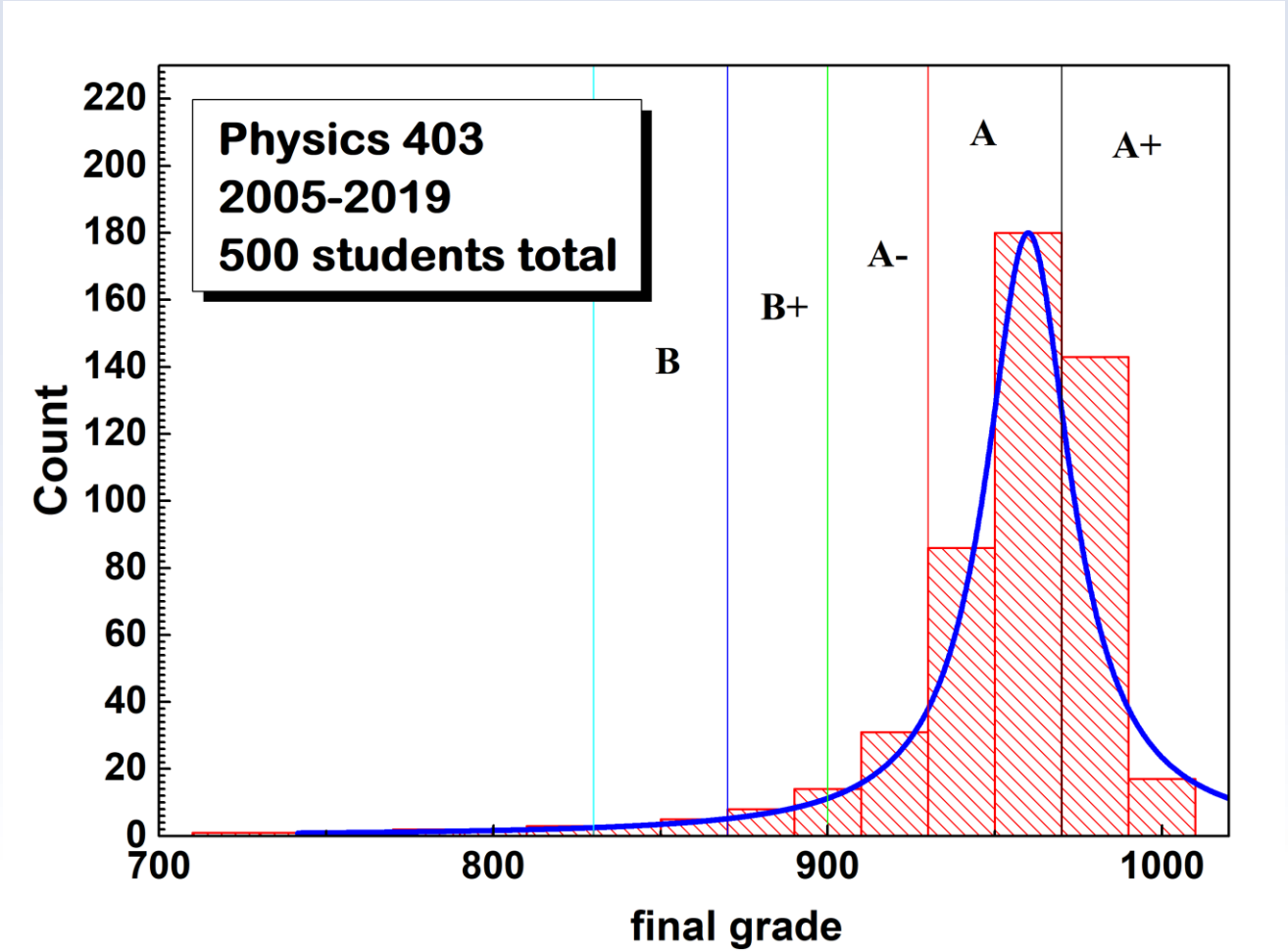
The grading scale will be a percentage out of "1000" :

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 December 15th)

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 (kolla@lllinois.edu). 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.

Absences. Excuse Policy.

- • You can be excused from only one missed assignment, and only if you provide medical documentation.
- • If the excused assignment is an oral presentation, you will receive half the credit earned by your partner (this credit is for the effort you made in preparing the presentation file)
- The Final Oral cannot be excused, as it is equivalent to a final exam. You cannot pass the course without credit for this assignment (see Student Code)

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, [illegible].

C1-Ex1(2.07.18)

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Syllabus

Cycles

	Date	Day	Activity	Comment	Due/Note
1	8/27	Tues	Orientation	About Phy403 (ec)	
2	8/29	Thurs	Cycle 1-1		
3	9/3	Tues	Cycle 1-2	OriginPro/Root (vl)	
4	9/5	Thurs	Cycle 1-3	Elog Comments (ec/vl)	
5	9/10	Tues	Cycle 1-4	Written Reports (ec)	
6	9/12	Thurs	Cycle 1-5		
7	9/17	Tues	Cycle 1-6	Error analysis (vl)	C1-Ex1 (9.18.19)
8	9/19	Thurs	Cycle 1-7		
9	9/24	Tues	Cycle 1-8	Oral Reports/Talks(ec/vl)	
10	9/26	Thurs	Cycle 2-1		*Rotate*
11	10/01	Tues	ORALS Cycle 1		
12	10/03	Thurs	Cycle 2-2		
13	10/08	Tues	Cycle 2-3	Optical spectroscopy	C1-Ex2 (10.09.19)
14	10/10	Thurs	Cycle 2-4		
15	10/15	Tues	Cycle 2-5	Ferroelectricity (ec)	
16	10/17	Thurs	Cycle 2-6		
17	10/22	Tues	Cycle 2-7	Noise (mw)	C2-Ex1 (10.23.19)
18	10/24	Thurs	Cycle 2-8		
19	10/29	Tues	ORALS Cycle 2		
20	10/31	Thurs	Cycle 3-1		*Rotate*
21	11/05	Tues	Cycle 3-2	High Energy Physics	C2-Ex2 (11.06.19)
22	11/07	Thurs	Cycle 3-3		
23	11/12	Tues	Cycle 3-4	Entanglement (vl)	
24	11/14	Thurs	Cycle 3-5		
25	11/19	Tues	Cycle 3-6	Lock-in Amps and FFT(ec)	C3-Ex1 (11.20.19)
26	11/21	Thurs	Cycle 3-7		
	11/25		Thanksgiving Break		
27	12/03	Tues	Cycle 3-8	Measuring Temp (ec)	
28	12/05	Thurs	FINAL ORALS		
29	12/10	Tues			
	12/12		READING DAY		C3-Ex2 (12.14.19)

* Lecture topics are subject to change

Fall 2019 Physics 403

	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. 2nd sound of ^{4}He D. pNMR E. Hysteresis loops F. Tunneling G. AFM H. T calibration	A. Optical pumping B. Superconductivity C. Mutual inductance D. Fluorescence spectroscopy	A. Quantum erasure B. Berry's phase C. Entanglement
	Virginia, Anabel	Eugene, Albur	Eugene, Shubhang, Abid, Gabriel	TA's from Kwiat Lab
C1-1	1-2; 3-4; 5-6; 7-8	9-10; 11-12; 13-14; 15-16	17-18; 19-20; 25-26	21-22; 23-24
C1-2	1-2; 3-4; 5-6; 7-8	9-10; 11-12; 13-14; 15-16	21-22; 23-24; 25-26	17-18; 19-20
C2-1	9-12; 11-14; 13-16; 15-10	17-20; 19-22; 21-24; 23-26; 25-18	1-4; 5-8; 7-2	3-6
C2-2	9-12; 11-14; 13-16; 15-10	17-20; 19-22; 21-24; 23-26; 25-18	1-4; 3-6; 7-2	5-8
C3-1	17-22; 19-24; 21-26; 23-18; 25-20	1-6; 3-8; 5-2; 7-4	9-14; 11-16	13-10; 15-12
C3-2	17-22; 19-24; 21-26; 23-18; 25-20	1-6; 3-8; 5-2; 7-4	13-10; 15-12	9-14; 11-16

Assignment of experiments

3 cycles with 2 experiments

➔ teams change after cycle

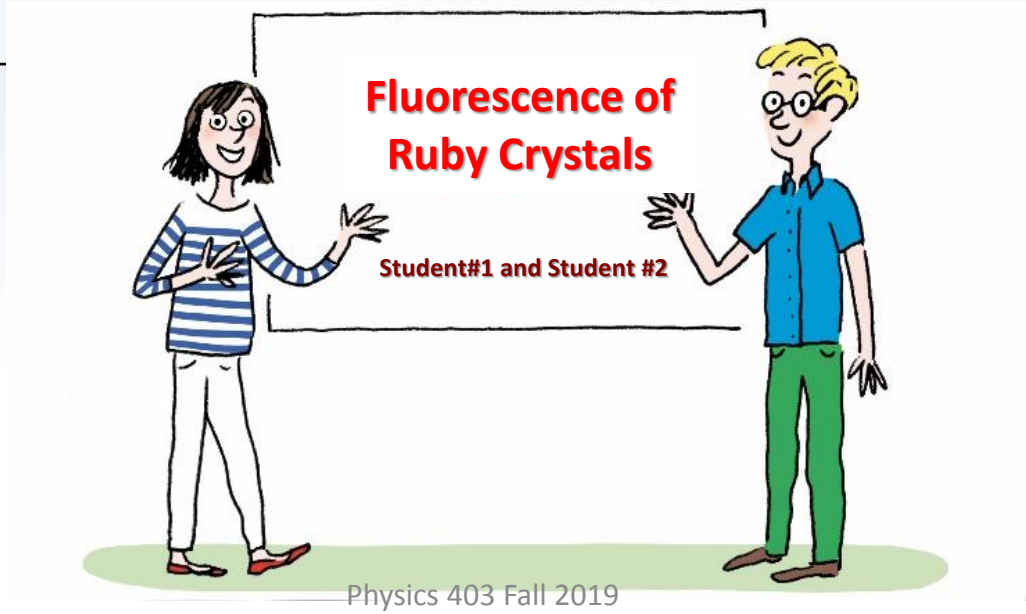
➔ joint team reports and oral presentations

➔Final Oral presentation will be done by each student personally

Spring 2019 Orals Physics 403

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.

Cycle	#	Experiment
C1-1	1,2	Cosmic Muon
C1-2	1,2	Gamma-Gamma



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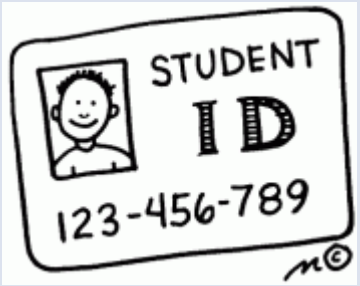
Lab Access



Use Your ID Card to Access the Lab

You can access the Lab not only on "Lab days"

Late time rules:

You can stay in the Lab until 8pm but need to work with partner

After 8pm and on weekend days – *you have to discuss this schedule with your instructor* and in general it is preferable to avoid working after 8 pm and on week

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

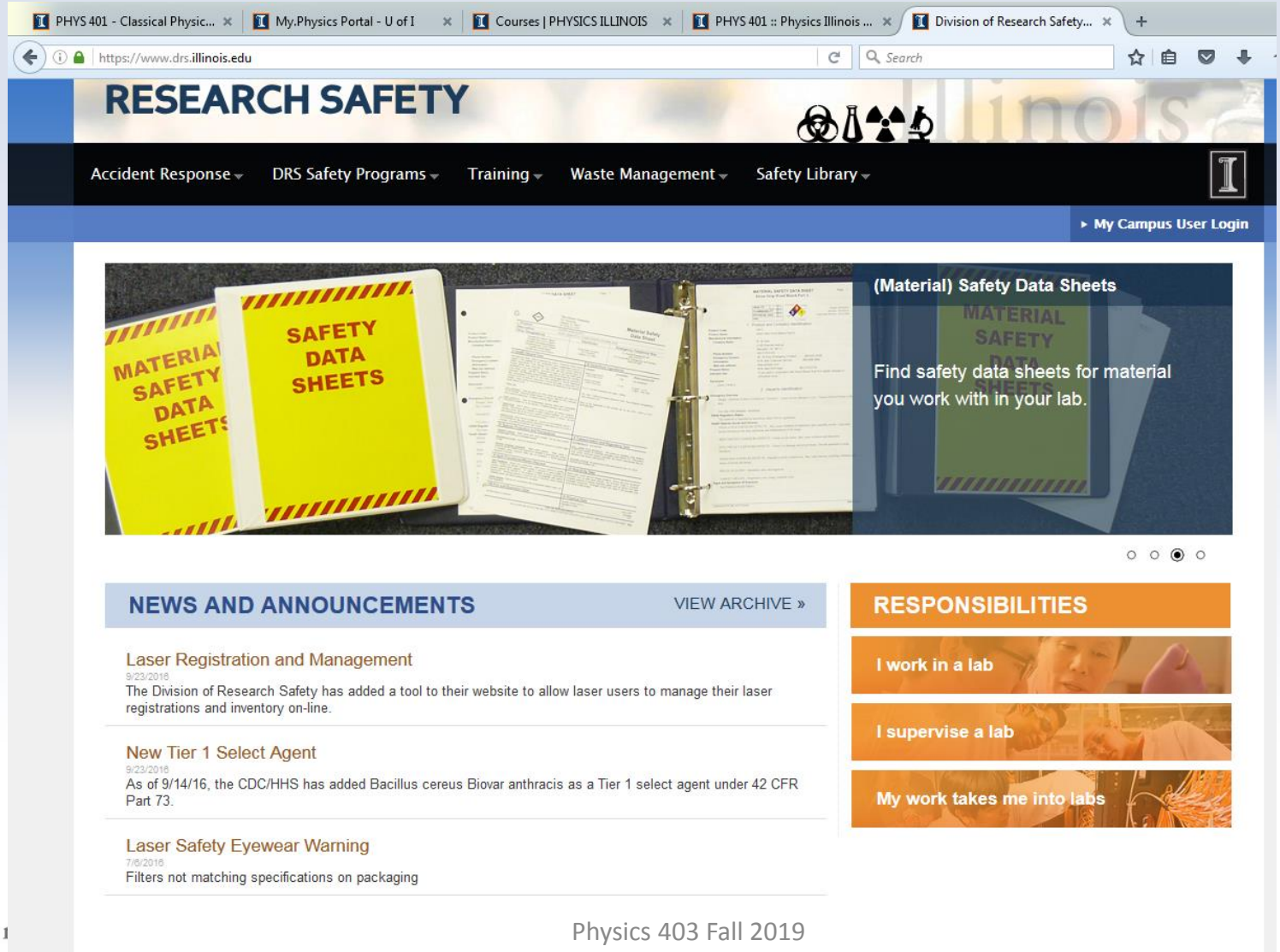
When in doubt stop and ask

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

302 521 2979 (Gina's cell)

Follow Directly the Recommendations of Safety Working

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



Follow Directly the Recommendations of Safety Working

Related Units @ Illinois Questions?

Division of
RESEARCH SAFETY

Accident Response | DRS Safety Programs | Training | Waste Management | Safety Library

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

Related Units @ Illinois Questions? Search Go

Division of
RESEARCH SAFETY

Accident Response DRS Safety Programs Training Waste Management Safety Library

Profile Eugene V Colla Log off

Laboratory Sharps

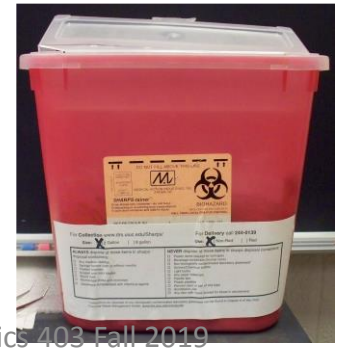
Definition

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

Outline

V. Take a Lab tour !

VI. Let's get started

electronic logbooks

digital scopes

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

How to record the 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 the 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 the 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

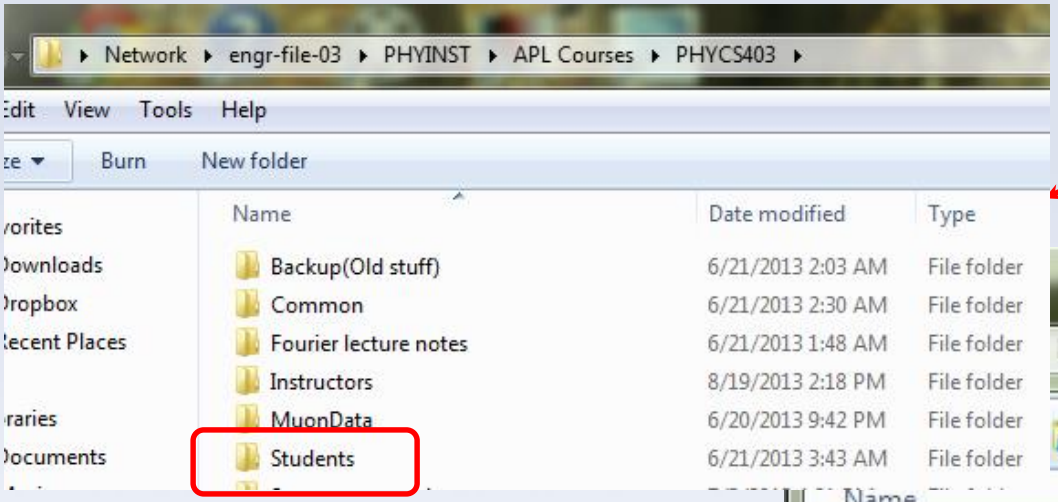
How to record the data

- 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?

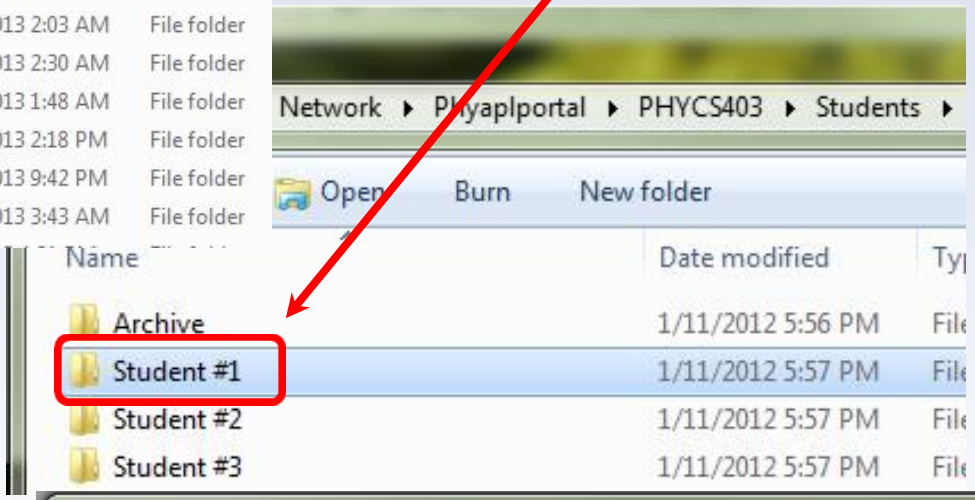
Where to exchange, store and retrieve course information.

(i) Your data, projects, tables etc

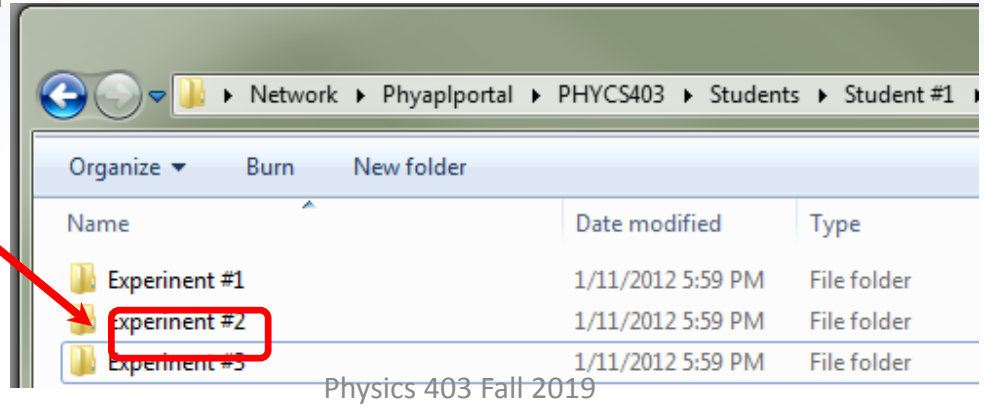
\\engr-file-03\PHYINST\APL Courses\PHYCS403



Each student has a folder



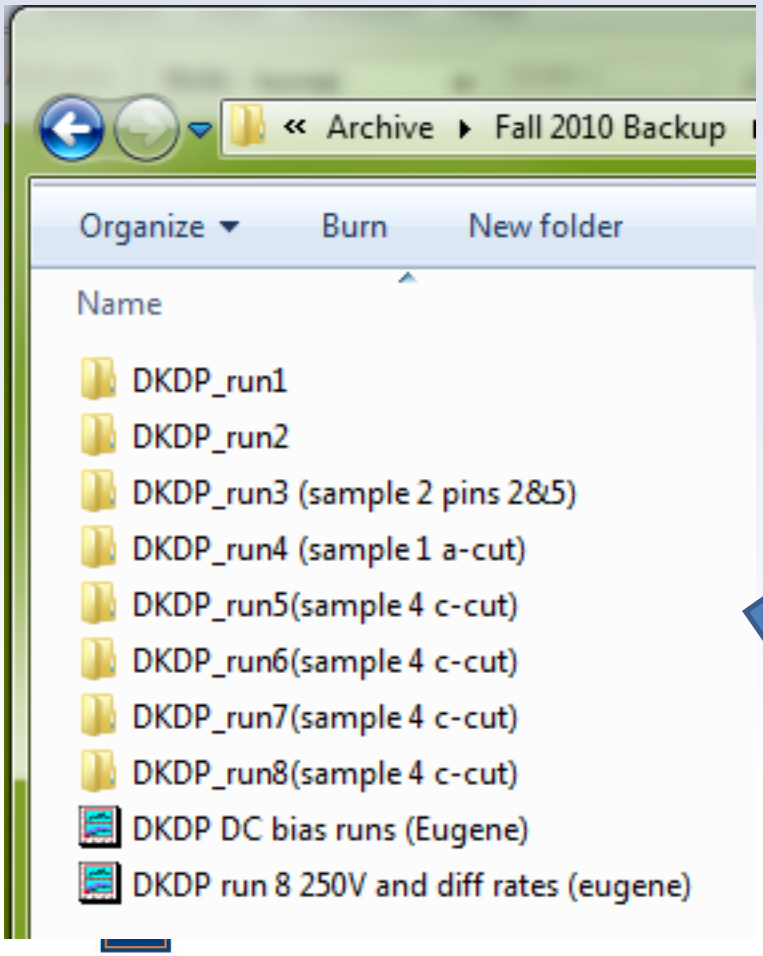
Store all experiment related materials in corresponding folder

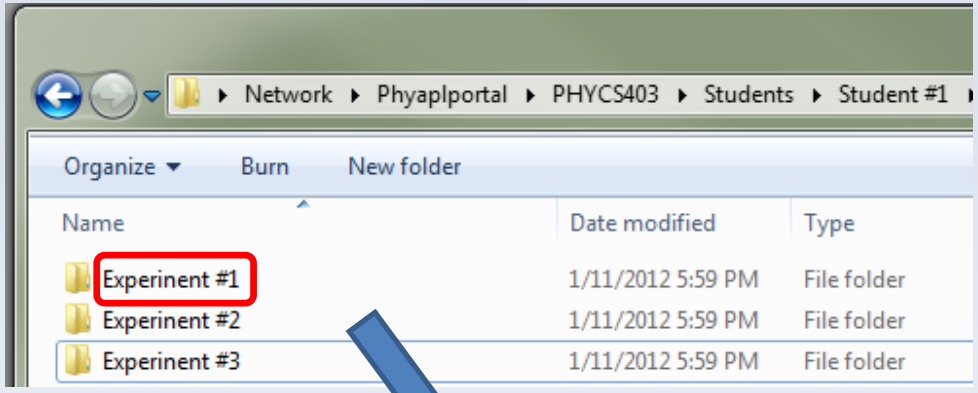


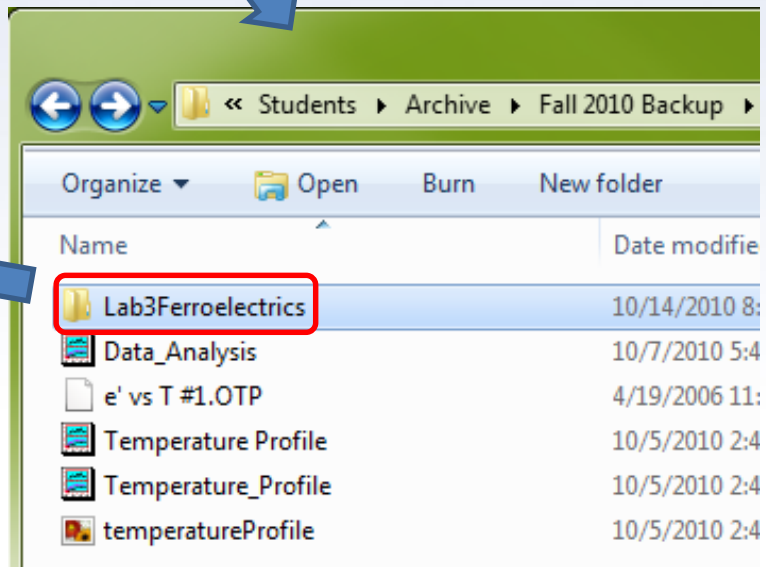
illinois.edu

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

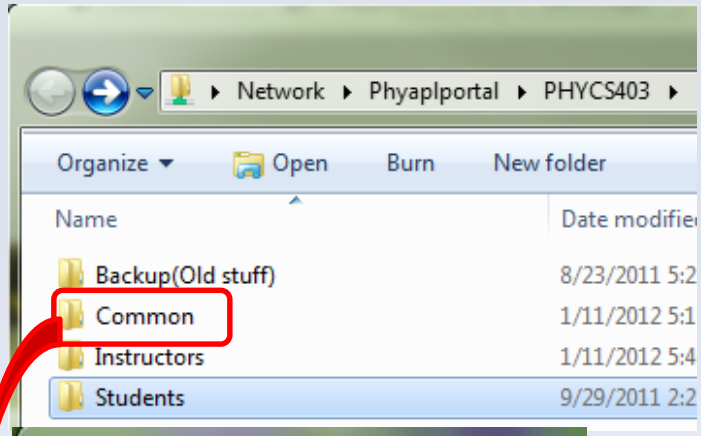


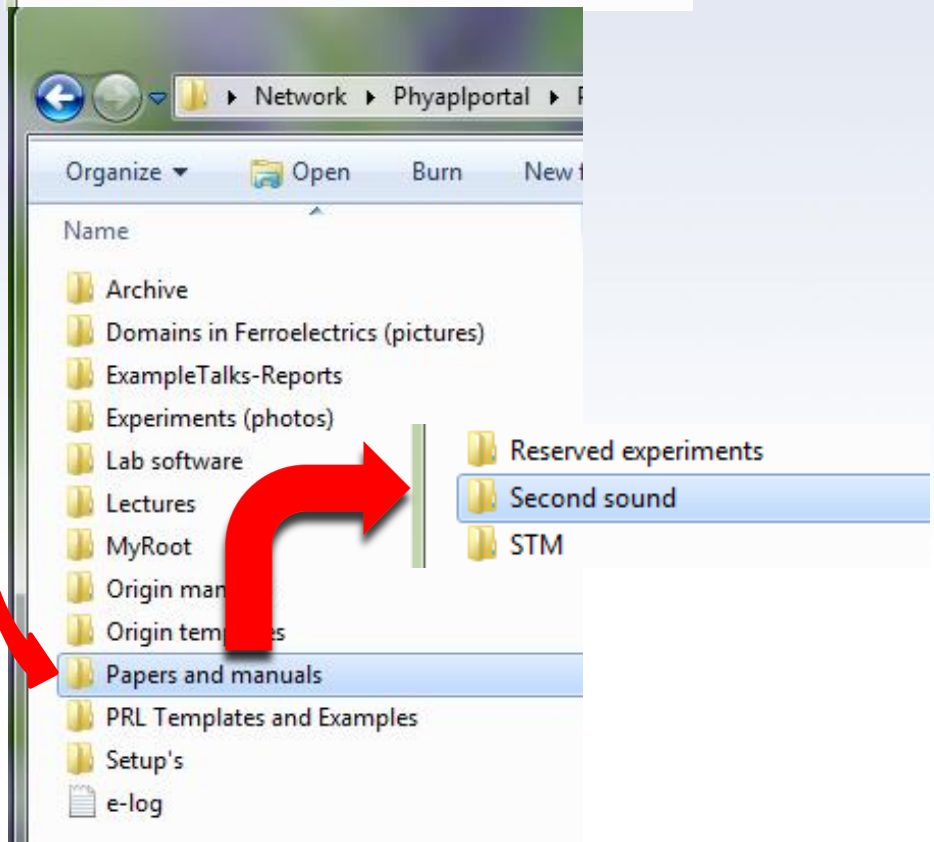


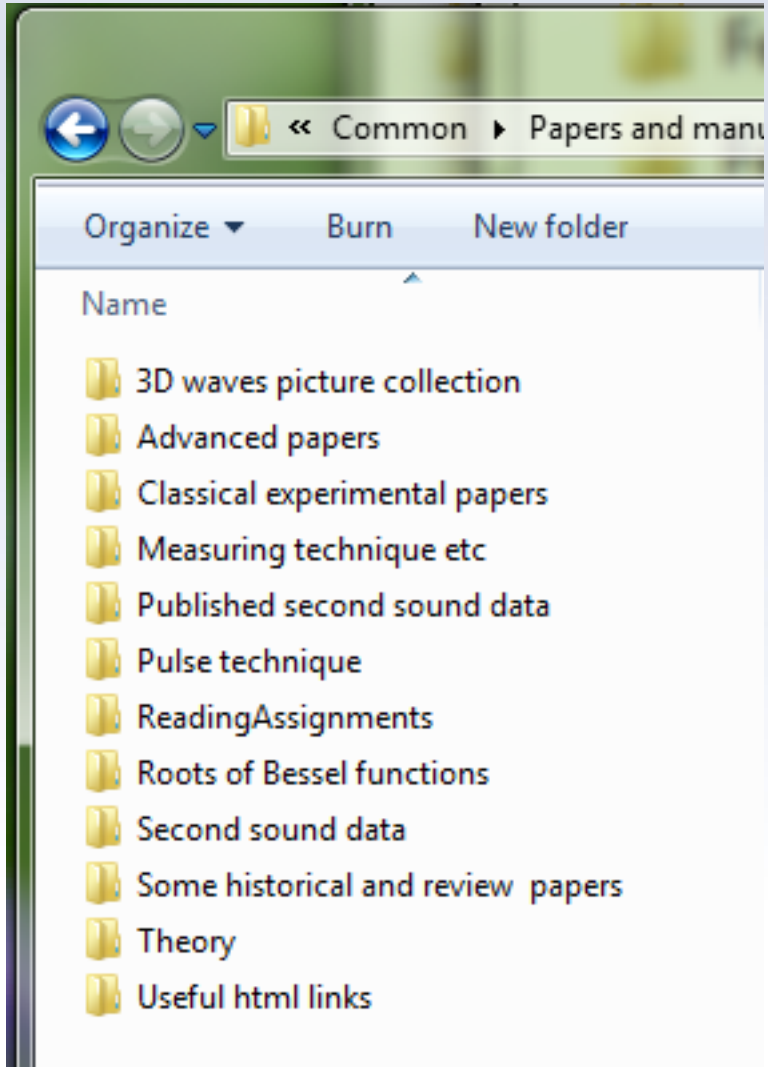


Where to retrieve course information.

Manuals, papers, setup diagrams and other useful materials

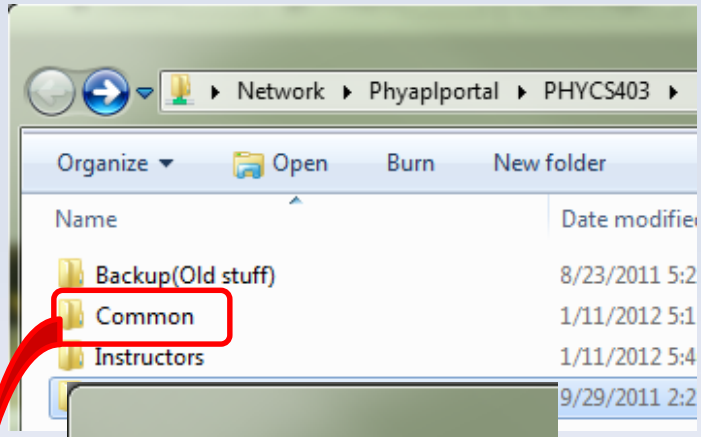


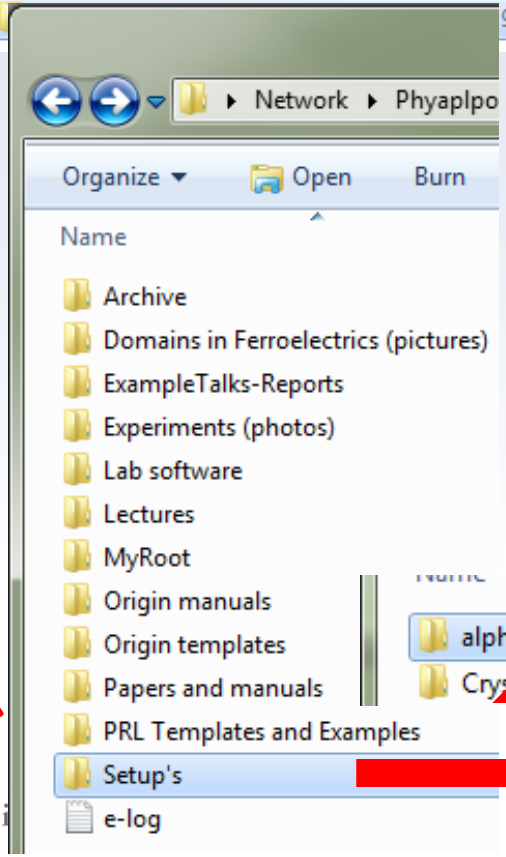


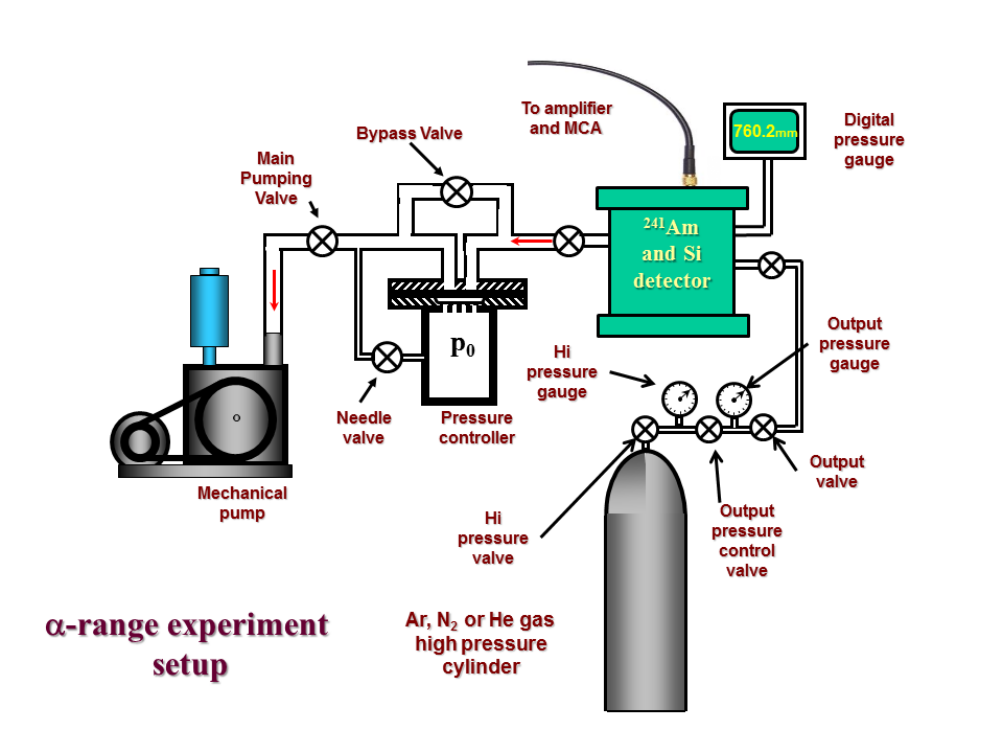


Where to retrieve course information.

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



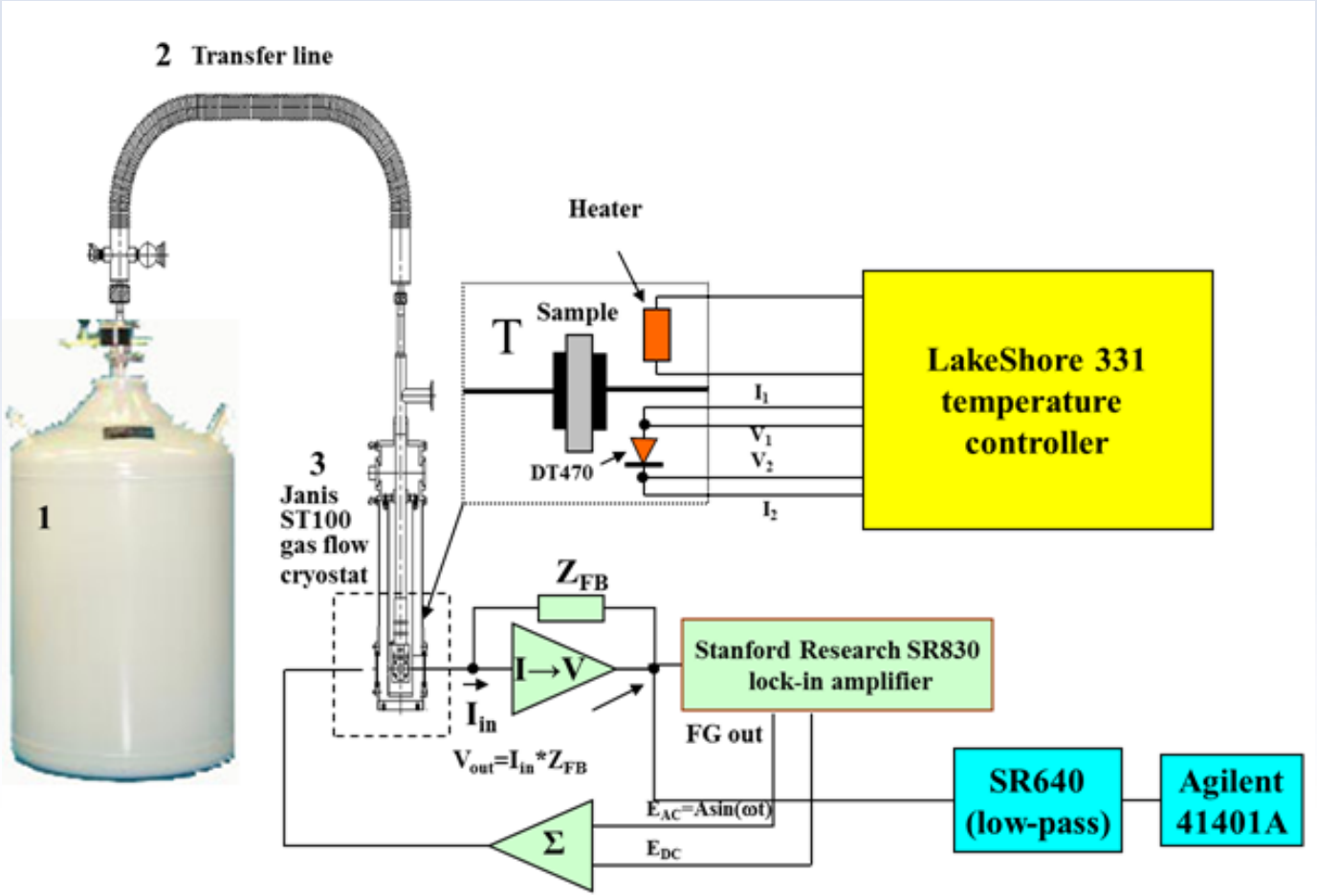




α-range experiment setup diagram

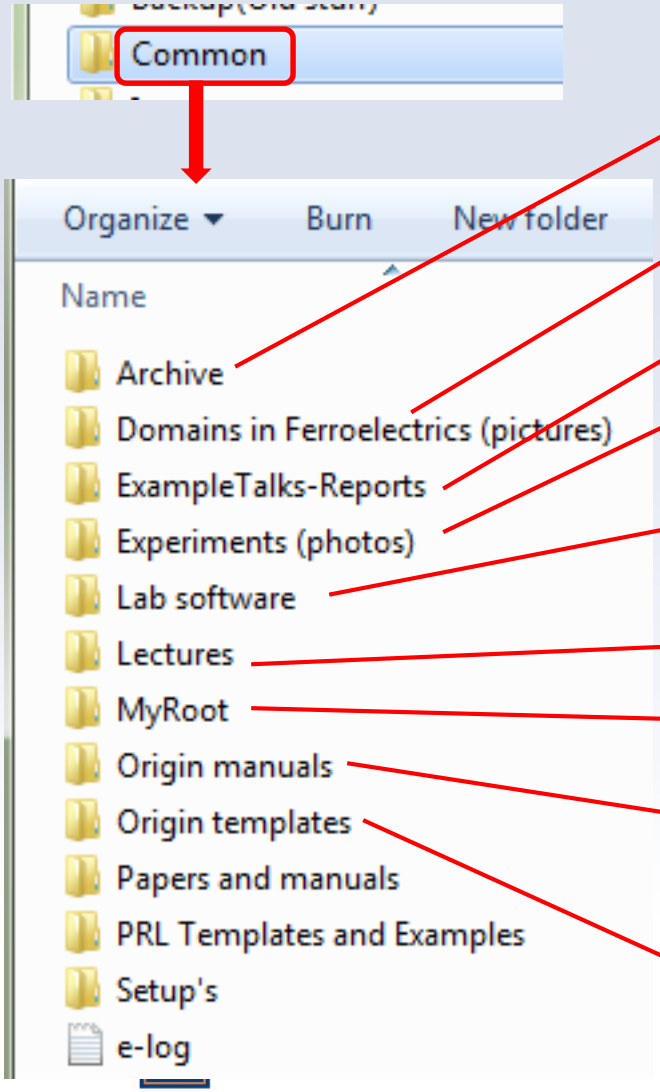
Where to retrieve course information.

Setup diagrams – do not use cellphones to take the image of the setup from manual – for most setups we have PowerPoint projects with setups.



Where to retrieve course information.

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



- Some old stuff (not very useful)
- Sample pictures of ferroelectric domains
- Examples of report and oral presentation
- Pictures of the setups of the experiments
- Software including DAQ software for different experiments. Newest version of Origin is also there
- P403 lecture notes
- C++ scripts for Root
- Origin manuals + a very compressed version written by Eugene
- Origin templates (how to use them will be discussed in next lecture)

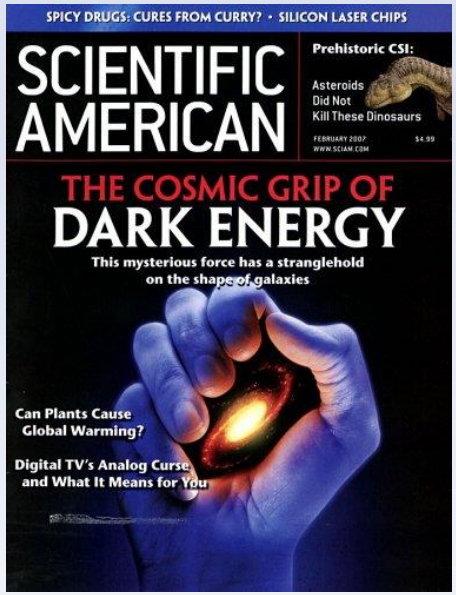
Connecting to the PHYS403 server

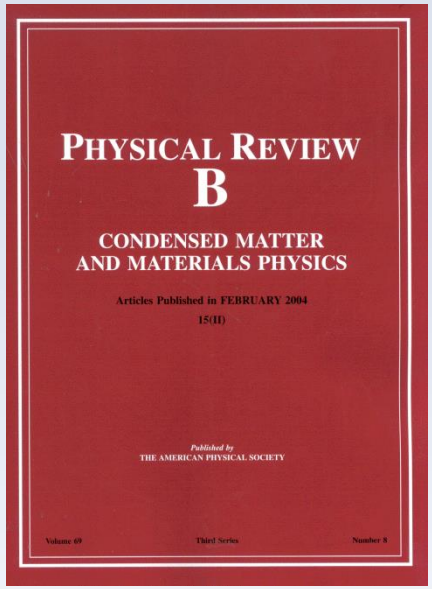
Connect to VPN following the instructions on the UIUC VPN website:
https://techservices.illinois.edu/services/virtual-private-networking-vpn/download-and-set-up-the-vpn-client

To connect to the PHYS403 Server:

- **Connect to the VPN first, then enter the following as the share to connect to:**
  - ***Mac users:*** Open Finder: Go: Connect to Server, type in address:
    smb://engr-file-03.engr.illinois.edu/PHYINST/APL Courses/PHYCS403
  - ***Windows users:*** Open Windows Explorer, type in address:
    \\engr-file-03.engr.illinois.edu\PHYINST\APL Courses\PHYCS403
    or, if that doesn't work:
    //engr-file-03.engr.Illinois.edu/PHYINST/APL Courses/PHYCS403
- ***When prompted for username and password, enter:***
  "UofI\[your netID]" and "[your netID password]"

"Journal club"





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

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

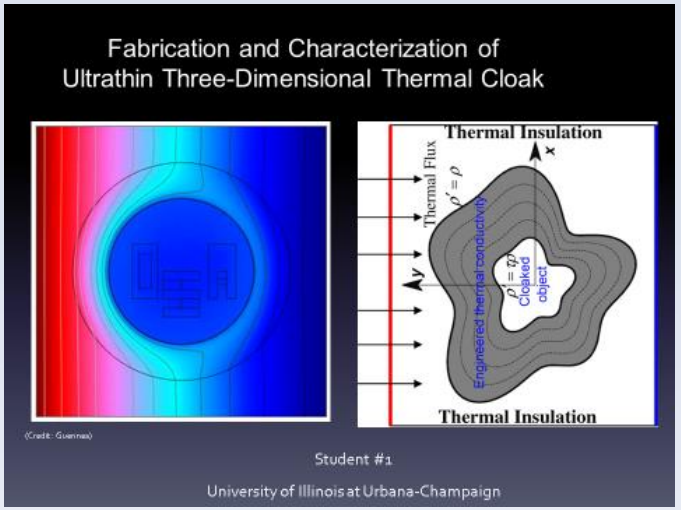
http://www.scientificamerican.com/

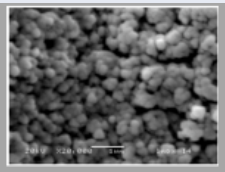
http://www.sciencemag.org/journals

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. Apátiga[2], V. M. Castaño[2]

1. Facultad de Ciencias Fisico Matemáticas, Universidad Autónoma de Nuevo León
2. Centro de fisica Aplicada y Tecnologia Avanzada, Universidad Nacional Autónoma de México

The Physics of Beer Tapping

PRESENTATION BY JOSEPH MIRABELLI
JAVIER RODRÍGUEZ-RODRÍGUEZ,1,* ALMUDENA CASADO-CHACÓN, AND DANIEL FUSTER
1 FLUID MECHANICS GROUP, CARLOS III UNIVERSITY OF MADRID
2 CNRS. UNIVERSITÉ PIERRE ET MARIE CURIE

"Journal club"

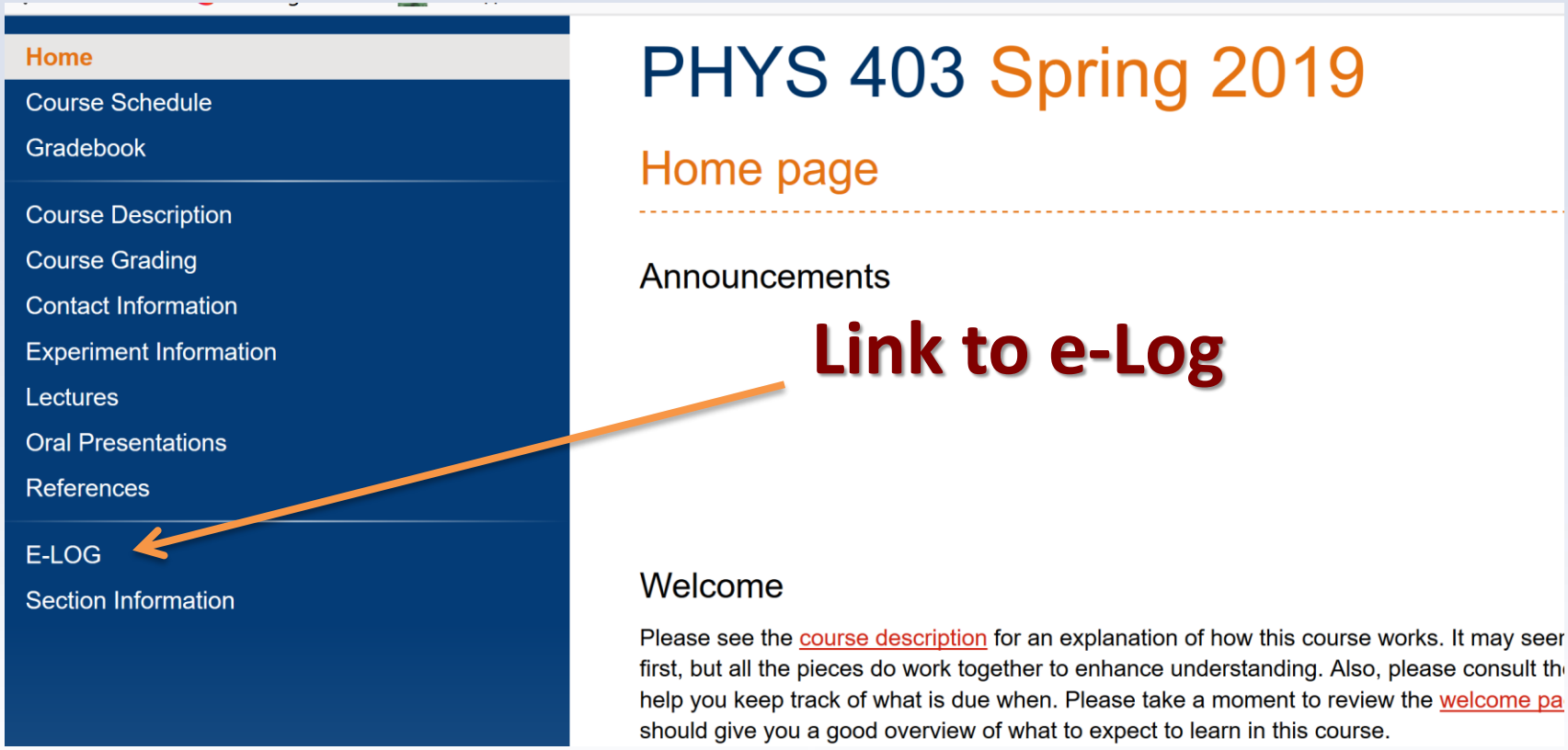
Journal Access

If you cannot access journal papers using VPN, go to UIUC's library proxy test site and enter the address of the paper you want to read:
http://www.library.illinois.edu/proxy/test/

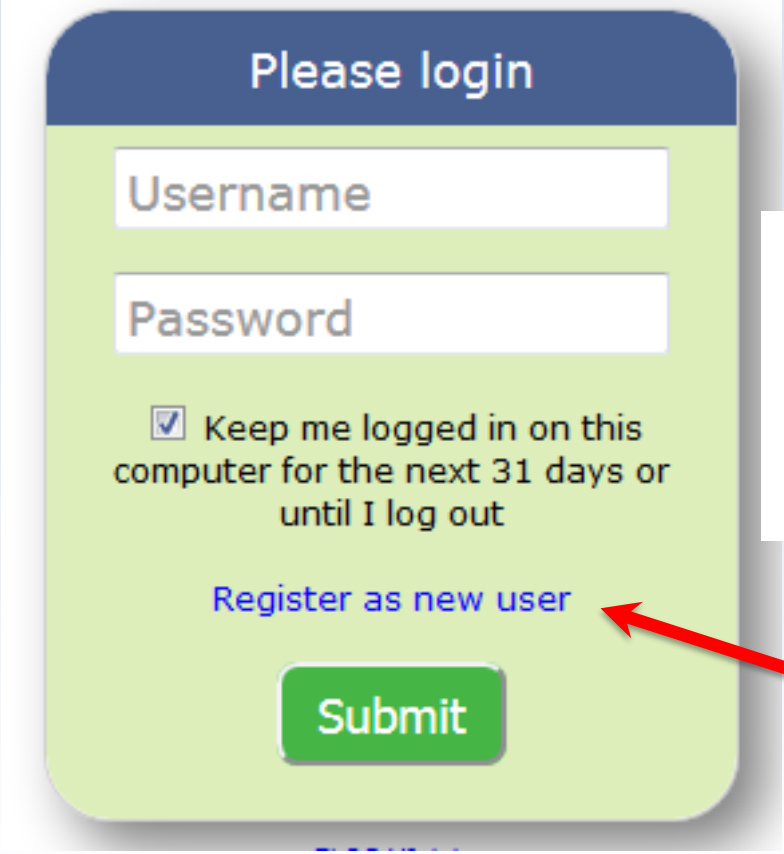
Recommended journal websites

- **American Physical Society Journals**: https://journals.aps.org/about
- **Nature**: http://www.nature.com/nature/index.html
- **Science**: http://www.sciencemag.org/journals
- **American Journal of Physics**: http://scitation.aip.org/content/aapt/journal/ajp

Entering the e-Log …

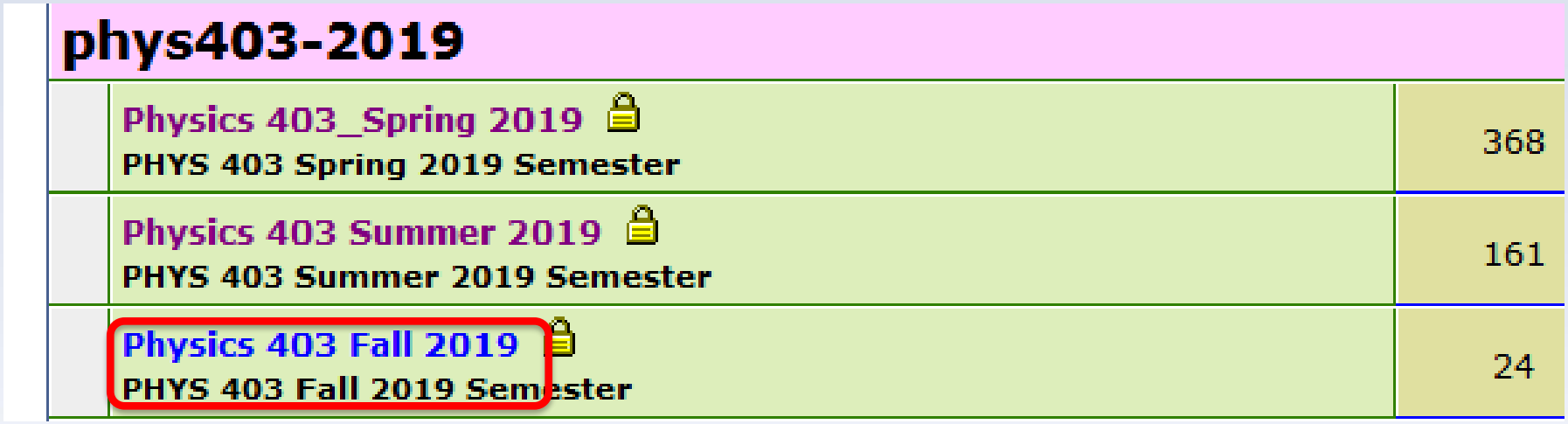


Entering the e-Log …



Use your University Username and Password

Entering the e-Log …



Entering the e-Log …

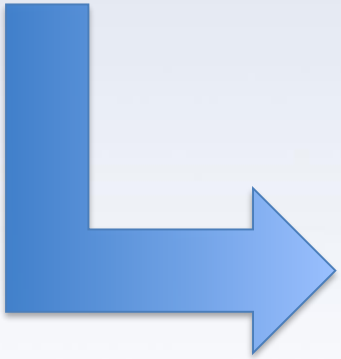
Selection Page | phys497EVC-2017 | phys403-2019 | phys403-2018 | phys403-2017 | phys403-2016 | phys
Physics 403_Spring 2018 | Physics 403 Summer 2018 | Fall2018 | Physics 403 | Physics 403_Spring 2019

PHYS 403 Spring 2019 Semester, Page 1 of 1

New | Find | Login | Logout | Admin | Config | Help | HelpELCode

Full | Summary | Threaded

ID	Date	Author	Experiment	Post Type	Subject	
1	01/14/19 21:30	Eugene Colla	none	Other	Welcome	Welcome to Physics 403 course



Message ID: **1** Entry time: **01/14/19 21:30**

Author:	Eugene Colla
Experiment:	none
Post Type:	Other
Subject:	Welcome

Welcome to Physics 403 course

e-logs: First a brief tour

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 your folder on the server.**
- **Near the end of the class, add a summary/conclusion, indicate future directions, and make sure the e-log provides a rather complete overview of the highlights of your work. Upload your plots, scope shots, etc. and describe the data.**

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.

e-logs: Making a post …

Author:	Your name and your partner's name
Experiment:	General
Post Type:	How-To
Subject:	Day [#]: brief description of work

Goal: Be specific. Not, "Learn about experiment," but, for example, "In helium below temperatures of 2.17K, a second sound due to thermal effects becomes measurable. We will measure second sound using a resonant cavity…"

Settings / Equipment Notes: Note important environmental and experimental parameters such as atmospheric pressure, settings on equipment, etc.

[Time Range 1]: Give time range, not just "before tea."

- Note important steps and results
- Include plots, photos, or scope shots in attachments below
- Use bullet points to make it easy to read

[Time Range 2]: …

Conclusions & Future Plans: What did you find and what is the next step? Be specific. Not, "We measured decay times," but, for example, "Ruby #2 sample with higher concentration chromium was observed to decay with a form…"