Physics 403 Modern Physics Laboratory

Spring 2013

403 Staff

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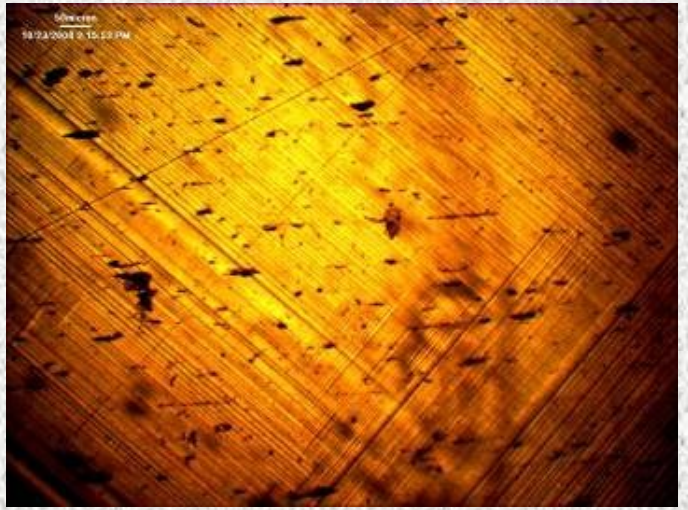
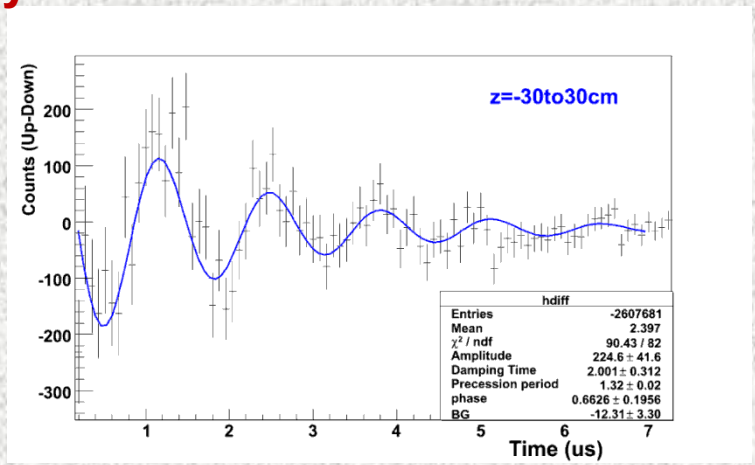
Support from research groups:
Grosse Perdekamp & Kwiat groups

Ferroelectric domains in $BaTiO_3$



Spin-precession of stopped cosmic ray muons



OUTLINE

- *Goals of the course*
- *Teamwork / grades / expectations from you*
- *Syllabus and schedule*
- *Your working mode*
  - *In class and "after hours" access*
  - *Safety, Responsibility*
  - *Home and away computing*
    - *In-class workstations and laptops*
    - *Downloads for home*
- *A brief physics primer of things to come → take a tour !*
- *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:

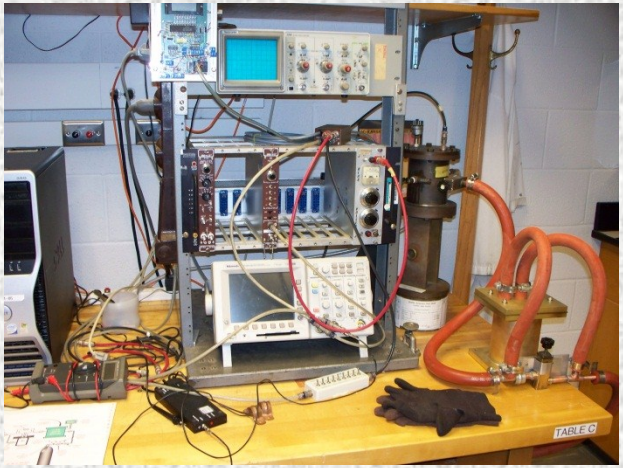
- *Learn how to document your work*
  - *Online, as you go in paper and electronic logbooks, data files, etc.*
  - *At intermediate summary points (e.g. completion of setup or calibration measurements, daily summary, etc.)*
  - *Making an analysis report*
  - *Presenting your findings orally*
  - *Writing formal reports*

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

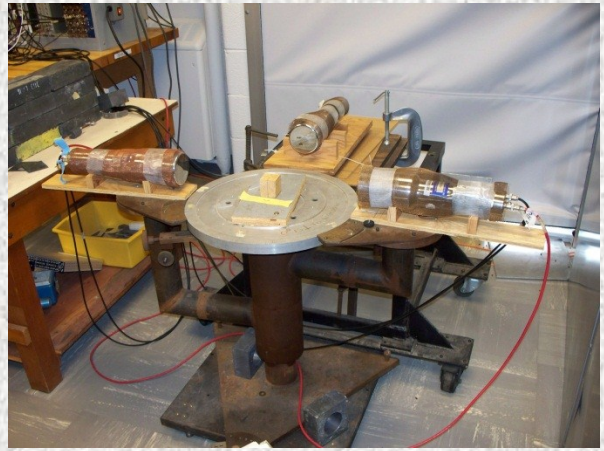
- *Nuclear / Particle (NP)*



  - *Alpha particle range in gasses*

  - *Cosmic ray muons:*

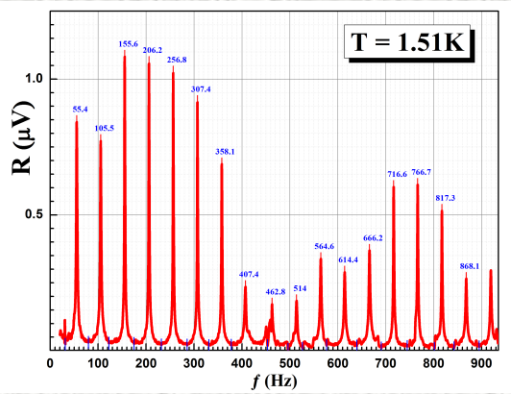
    Lifetime, capture rate, magnetic moment

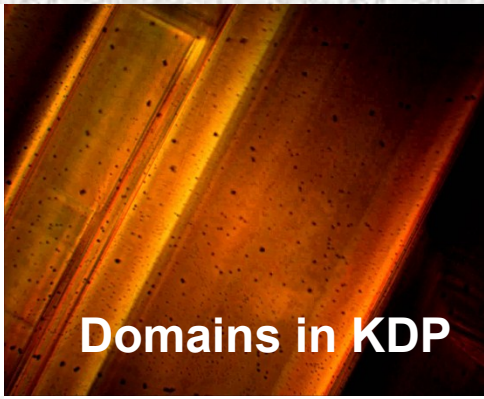


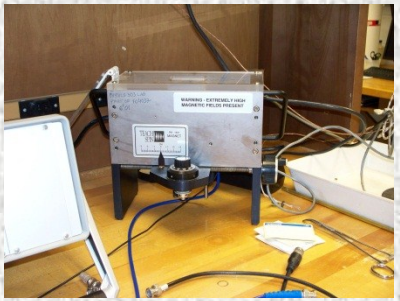
  - *Angular correlations in nuclear decay*
  - *Angular distribution of cosmic rays*

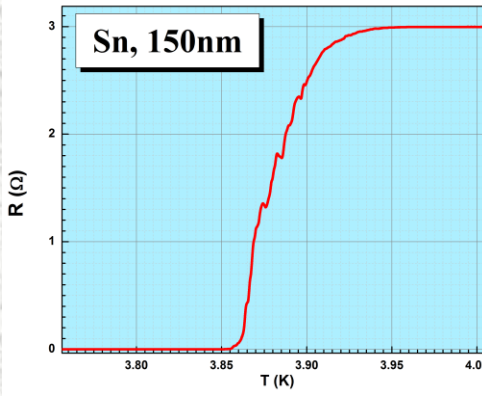
The Experiments

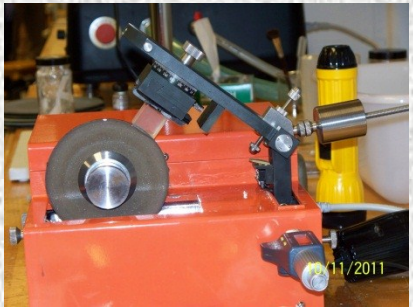
- *Condensed Matter (CM)*
  - *Superconductivity*
  - *Tunneling in superconductors*
  - *2nd sound in 4He superfluid state*
  - *Ferroelectrics and ferroelectric*
  - *phase transition*
  - *Pulsed NMR*
  - *Calibration of temperature sensors*
  - *Special Tools:*
    - *Vacuum film deposition*
    - *Atomic Force Microscope*
    - *Polarizing microscope*





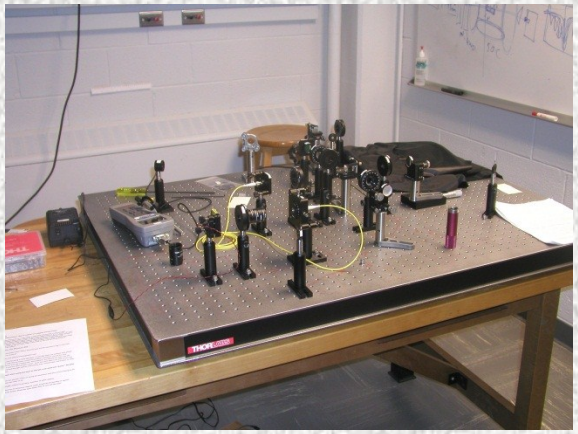


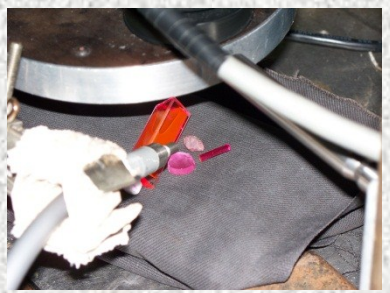


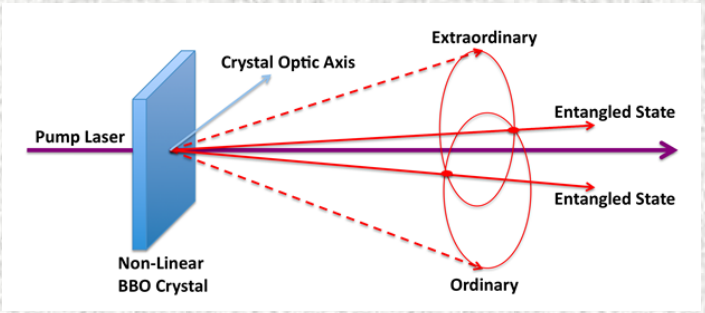


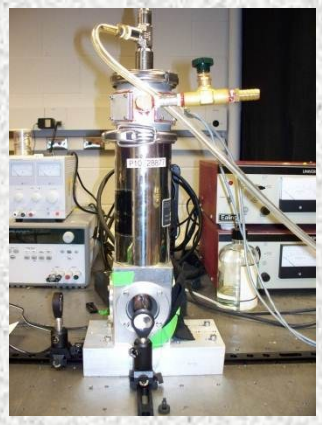
The Experiments

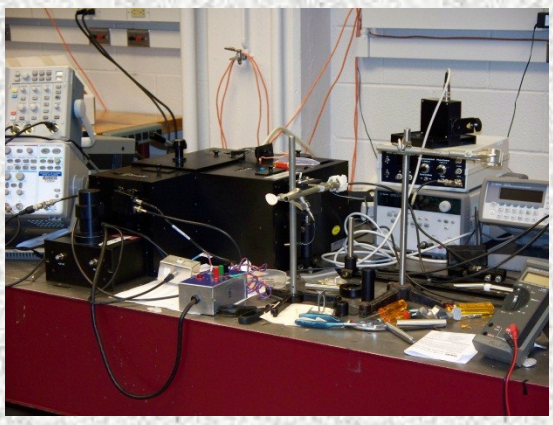
- *Atomic / Molecular / Optics*
  - *Optical pumping of rubidium gas*
  - *Berry's phase*
  - *Quantum erasure*
  - *Quantum Entanglement*
  - *Fluorescence spectroscopy*





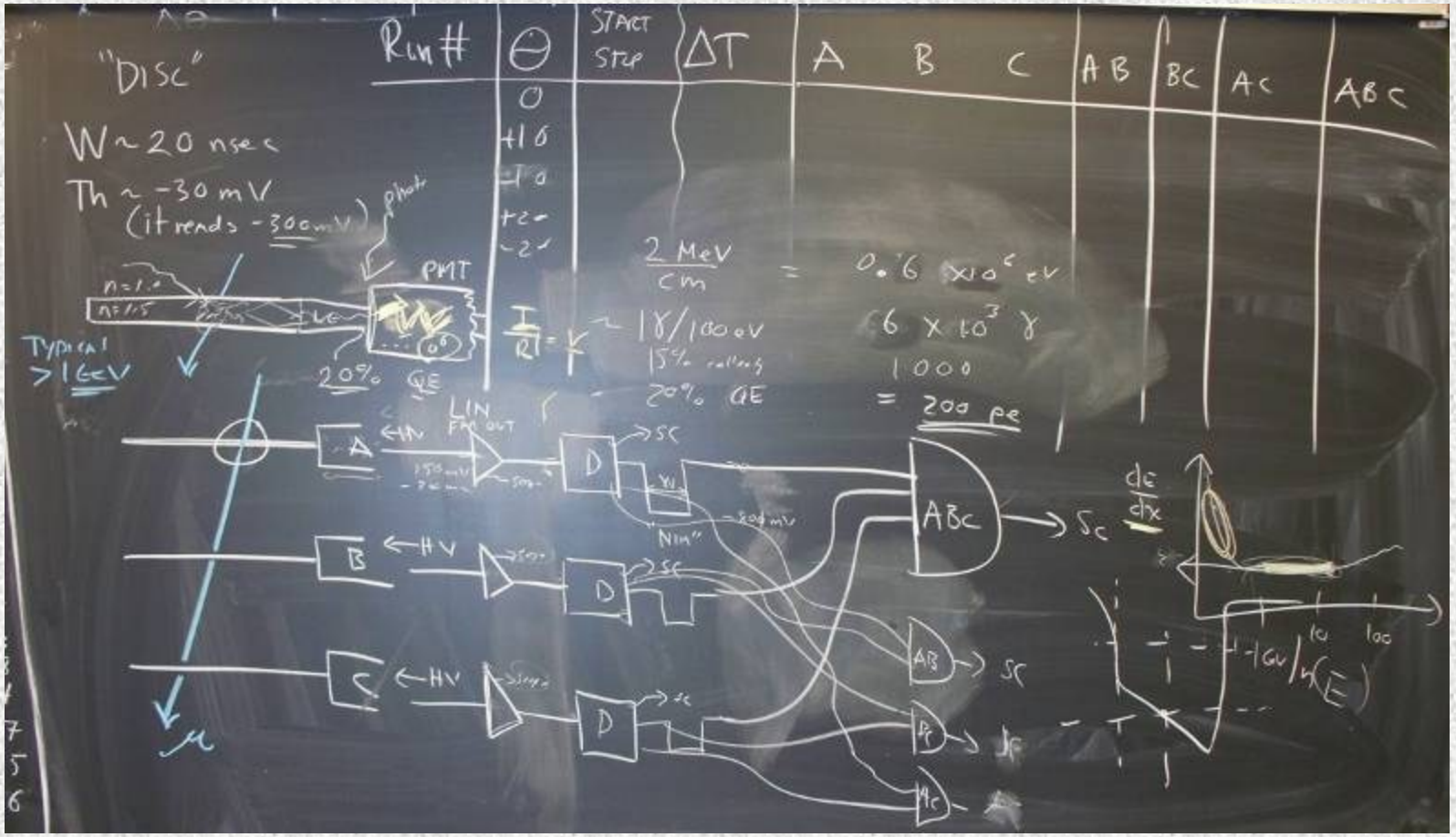






The “manuals”

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



Grading: Distribution of “1000” points

Item	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	225 75 / oral
Total Effective point total will be	1005 1000 ← grade

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 May, 3 – reading day).

Submission of Lab-Reports

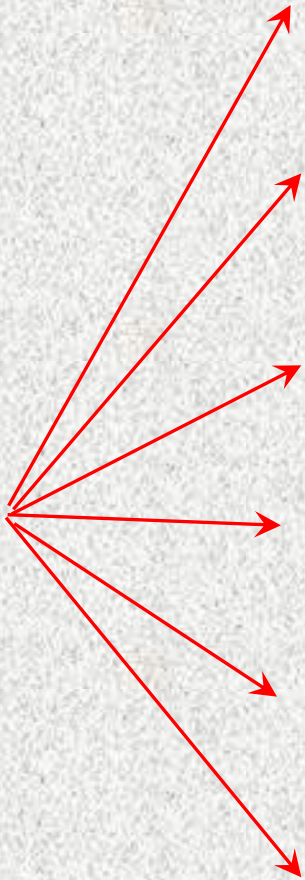
- *Due dates as on syllabus at midnight*
- *The reports should be uploaded to the server:*
- *https://my.physics.illinois.edu/courses/upload/*
- *Accepted MS-Word or PDF*

Absences / Late Reports

- *If you are sick, let Eugene 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.*
- *Policy for late reports*
  - *You can have ONE "late ticket" for a "free" delay of up to 3 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



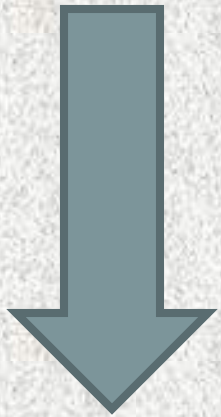
	Date	Day	Activity	Comment	Due	Note
1	1/15	Tues	Orientation	About Phy403 (ec)		
2	1/17	Thurs	Cycle 1-1			
3	1/22	Tues	Cycle 1-2	OriginPro Intro (ec)		
4	1/24	Thurs	Cycle 1-3	Elog Comments (ec)		
5	1/29	Tues	Cycle 1-4	Written Reports (ec)		
6	1/31	Thurs	Cycle 1-5		Rotate	
7	2/5	Tues	Cycle 1-6	Measuring Temp (ec)		
8	2/7	Thurs	Cycle 1-7		C1-Ex1	
9	2/12	Tues	Cycle 1-8	Oral Reports/Talks(ec)		
10	2/14	Thurs	Cycle 2-1		Rotate	
11	2/19	Tues		ORALS Cycle 1		
12	2/21	Thurs	Cycle 2-2			
13	2/26	Tues	Cycle 2-3	Optical spectroscopy (?)	C1-Ex2	
14	2/28	Thurs	Cycle 2-4			
15	3/5	Tues	Cycle 2-5	Basic Error Analysis (?)	Rotate	
16	3/7	Thurs	Cycle 2-6			
17	3/12	Tues	Cycle 2-7	Noise (mw)	C2-Ex1	
18	3/14	Thurs	Cycle 2-8			
				Spring Break		
19	3/26	Tues	Cycle 3-1	Lock-in Amps and FT(ec)	Rotate	
20	3/28	Thurs	Cycle 3-2			
21	4/2	Tues		ORALS Cycle 2	C2-Ex2	
22	4/4	Thurs	Cycle 3-3			
23	4/9	Tues	Cycle 3-4	Ferroelectricity (ec)		
24	4/11	Thurs	Cycle 3-5		Rotate	
25	4/16	Tues	Cycle 3-6	High Energy Physics & LHC (mgp)	C3-Ex1	
26	4/18	Thurs	Cycle 3-7			
27	4/23	Thurs	Cycle 3-8	Entanglement		
28	4/25	Tues		Working Day / Catch-up		
29	4/30	Tues		ORALS Cycle 3		
	5/2			READING DAY	C3-Ex2	

Assignment of experiments

3 cycles with 2 experiments

➔ teams change after each cycle

➔ joint team reports and oral presentations



	Nuclear / Particle	Condensed Matter	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 Sarvagya	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 Eugene	A.Optical pumping B.Superconductivity C.Mutual inductance Eugene + Charles	A. Quantum Table i. Berry's phase ii. Quantum erasure iii. Entanglement B. Florescence spectroscopy TA's from Kwiat and Bob Clegg group's
C1-1	1,2 9,10	3,4 11,12 17,18	5,6 13,14	7,8 15,16
C1-2	1,2 9,10	3,4 11,12 17,18	5,6 15,16	7,8 13,14
C2-1	4,13 5,14	1,10 6,15 7,16	2,11 8,12	3,17 9,18
C2-2	4,13 5,14	1,10 6,15 7,16	8,17 9,18	3,12 2,11
C3-1	8,12 3,16 15,18	2,5 9,13	7,11 14,17	4,10 1,6
C3-2	7,11 16,17 6,18	8,14 9,13	3,10 12,15	2,5 1,4

Who is who and who does what (not alphabetical order)

Name	#	NP	CM-1	Atomic / CM-2	Optics
Hao Li	1	2	2	-	2
Matthew Coon	2	2	1	1	2
Kevin Sullivan	3	1	2	1	2
Kangbo Hao	4	2	2	-	2
Aleksandr Marchevskiy	5	2	1	2	1
Tsung-Lin Hsieh	6	1	2	2	1
David Schmid	7	1	2	1	2
Kyle Kleyweg	8	1	1	2	2
	9	2	2	1	1
Aaron Reinhart	10	2	2	1	1
Zhao Zhangji	11	1	2	2	1
Timothy Torp	12	1	2	2	1
Martin Liu	13	2	2	1	1
Nella Granback	14	2	1	2	1
Caroline Wlodarski	15	1	2	2	1
Benjamin Meyer	16	2	2	1	1
Rebecca Glaudell	17	1	2	2	1
Joseph Nash	18	2	2	1	1

Safety is your responsibility !

Hazards: *high voltage, radioactive sources,*

cryogens, chemical materials

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

(I) safety/hazards and with

(II) equipment

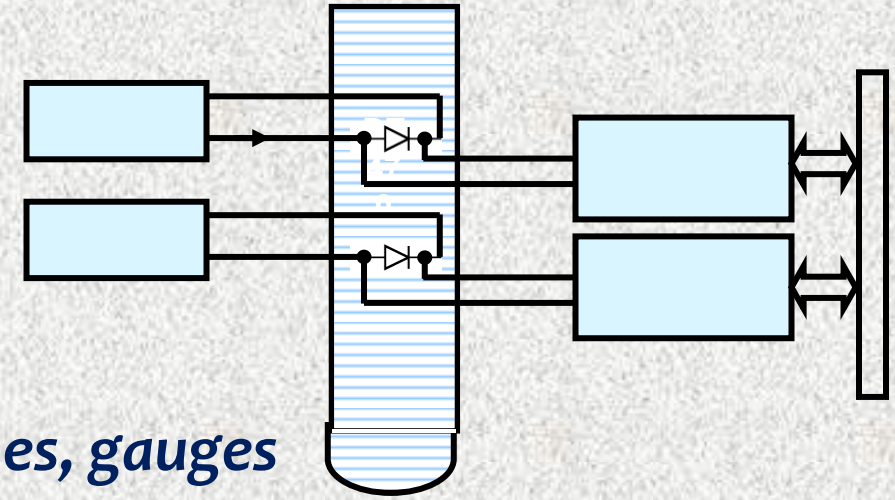
Discuss potential hazards at the beginning of each experiment with an instructor or TA . When in doubt stop and ask

All Lab facilities are open for you from 8 am to 6pm or up to 8pm in case of working at lest in team of two. Any other time – needs special permission given by instructor.

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

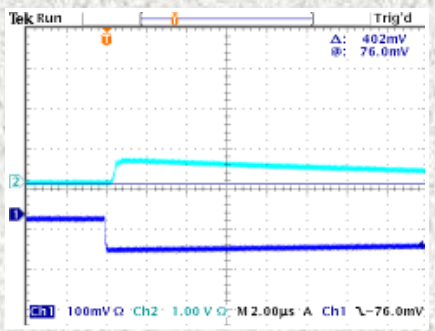
How to record data (1)

- *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. PowerPoint can be used for drawing. Origin can be used too but is less convenient.*



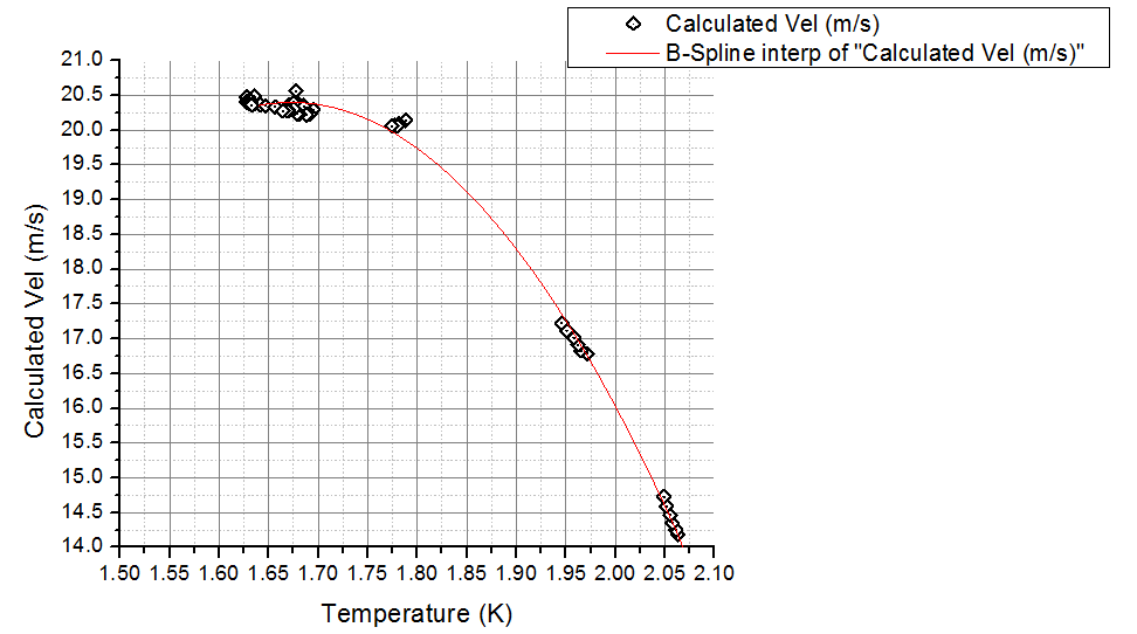
How to record data (2)

- *You will almost always look at some signals with a scope.*
  - *Record a representative trace using the Scope interface.*
- *When you have come to an intermediate stopping point, take a few minutes and summarize the recent steps*
  - *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 to record data (3)

- *Plan your plots and analysis as you go.*
  - *How will you look at the data later?*
  - *Do you have enough information?*
  - *Did the equipment perform as expected?*



How to record data (4)

- *Many experiments require you to "change and measure" something by hand*
  - *Make a table in a paper logbook for this*
  - *Double check points periodically to establish reliability*
  - *Be prepared to state your measurement uncertainty*
  - *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*

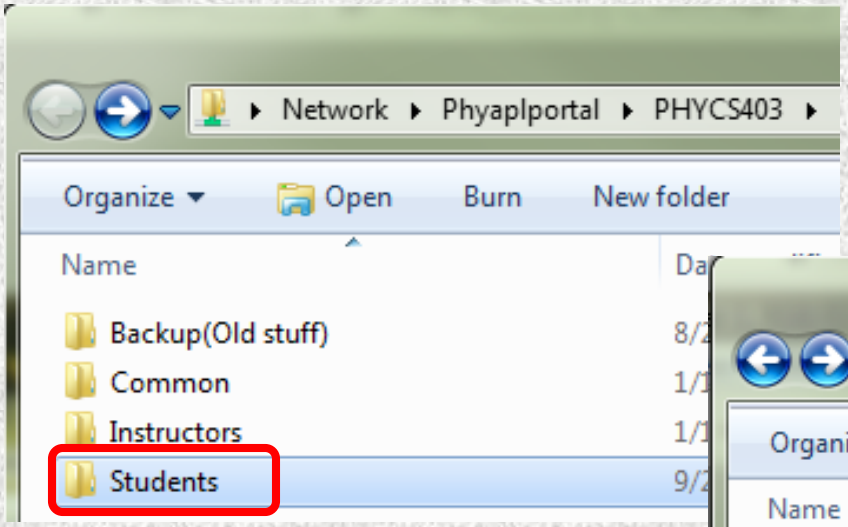
How to record data (3)

- *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*
  - *Because it's "automatic" don't be fooled into thinking it's "correct." You have the burden of overseeing this acquisition, even if the computer is doing the work.*
  - *As before, anomalies? enough points? uncertainties?*
  - *You will often get a built-in "online" plot of the results. Don't think that is the end of the game. But, look at the results !*

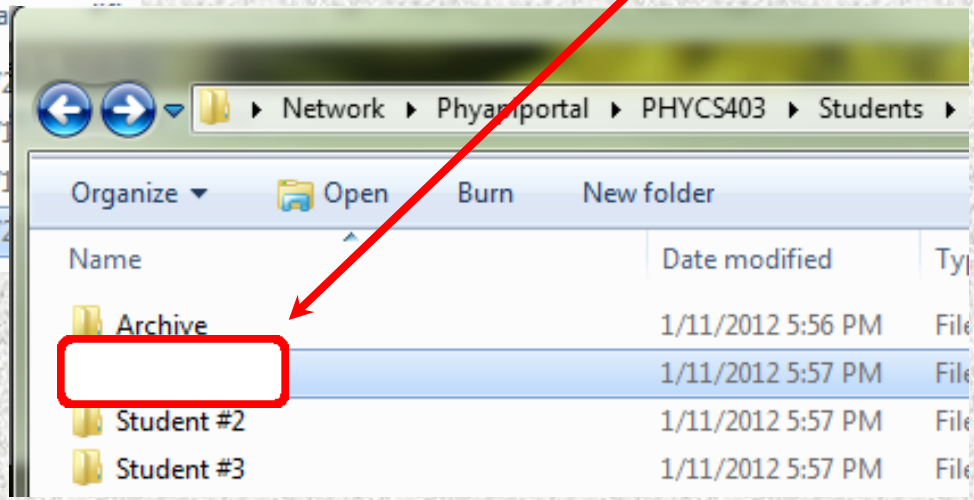
Where to exchange, store and retrieve course information.

(I) Your data, projects, tables etc

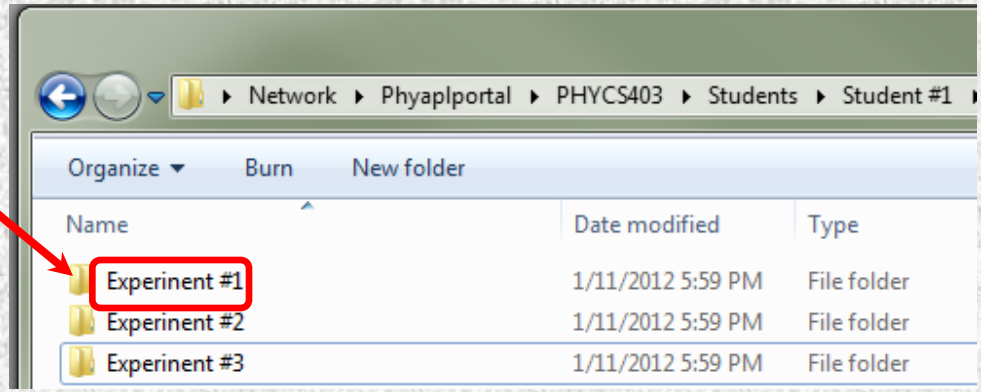
- ***\\Phyaplportal\phycs403***



Make your own folder and put your work there

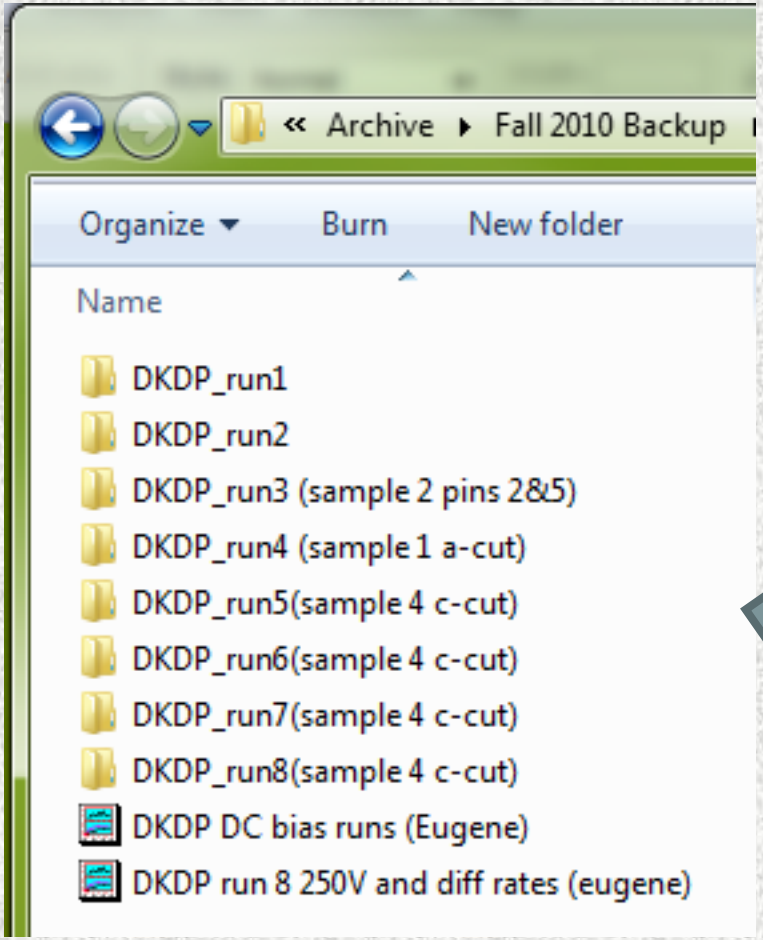


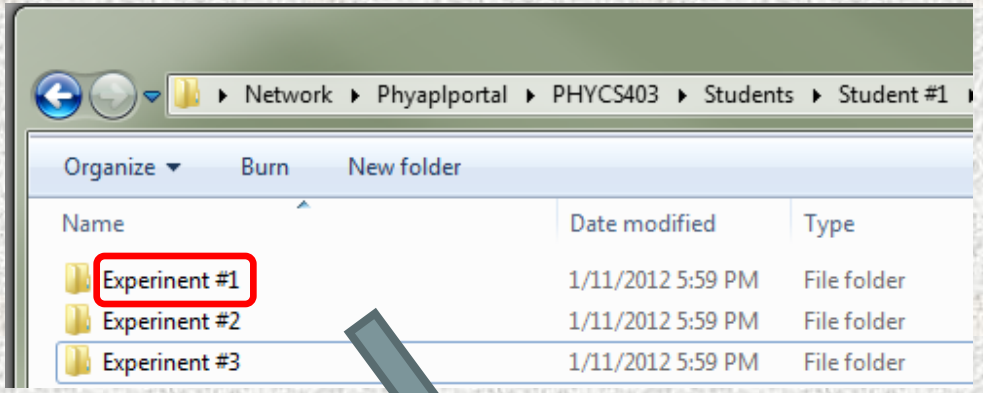
Store all experiment related materials in corresponding folder

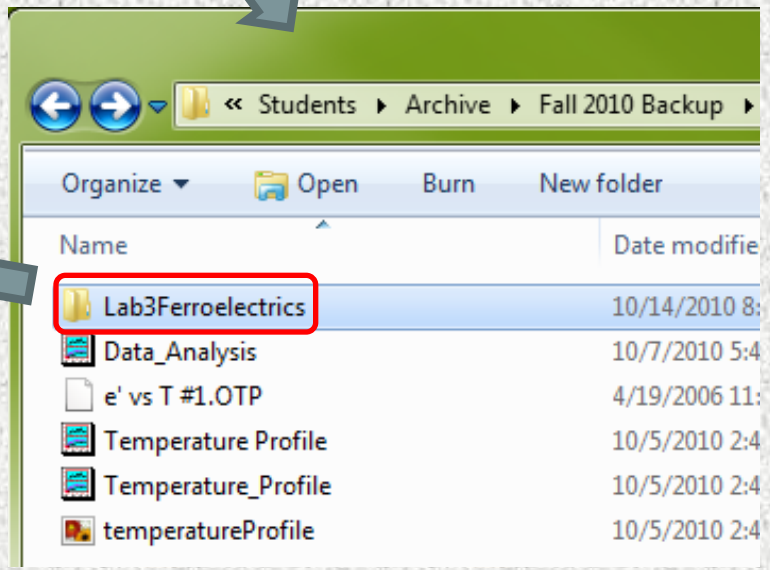


WHERE TO EXCHANGE, STORE AND RETRIEVE COURSE INFORMATION. *(I) Your data, projects, tables etc*

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

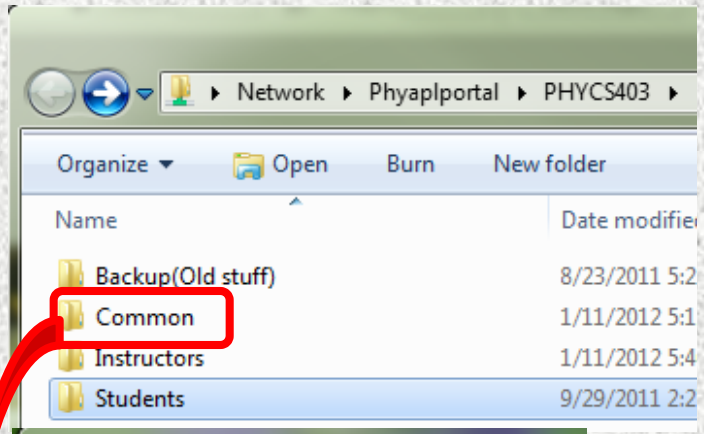


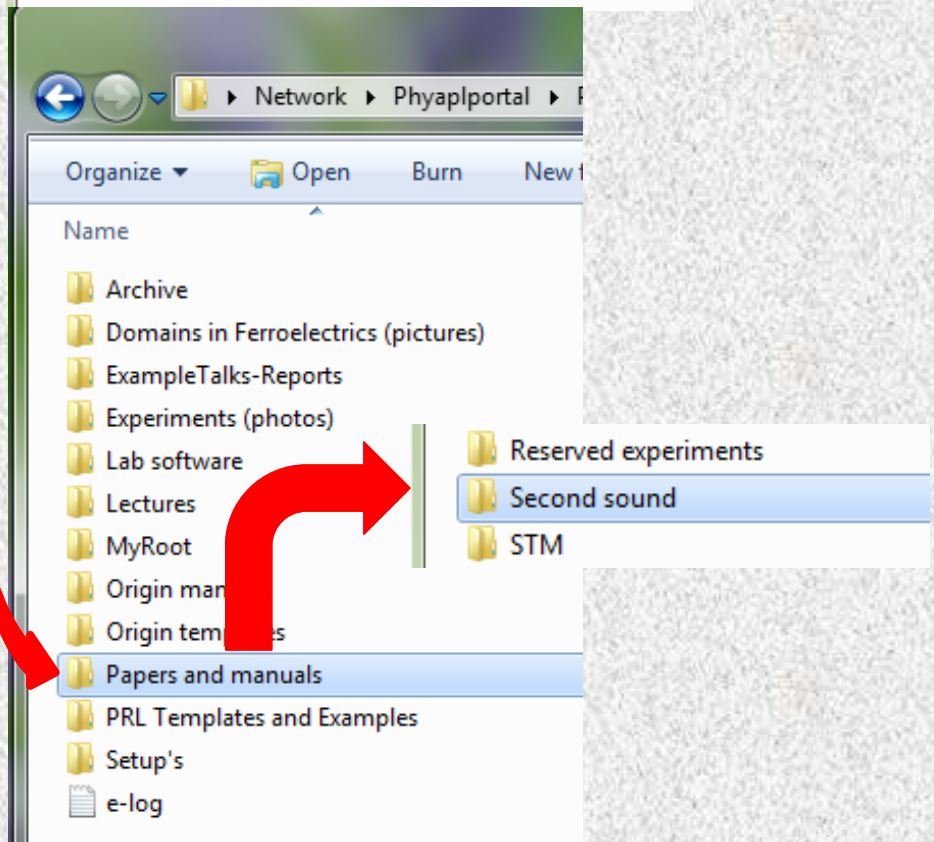


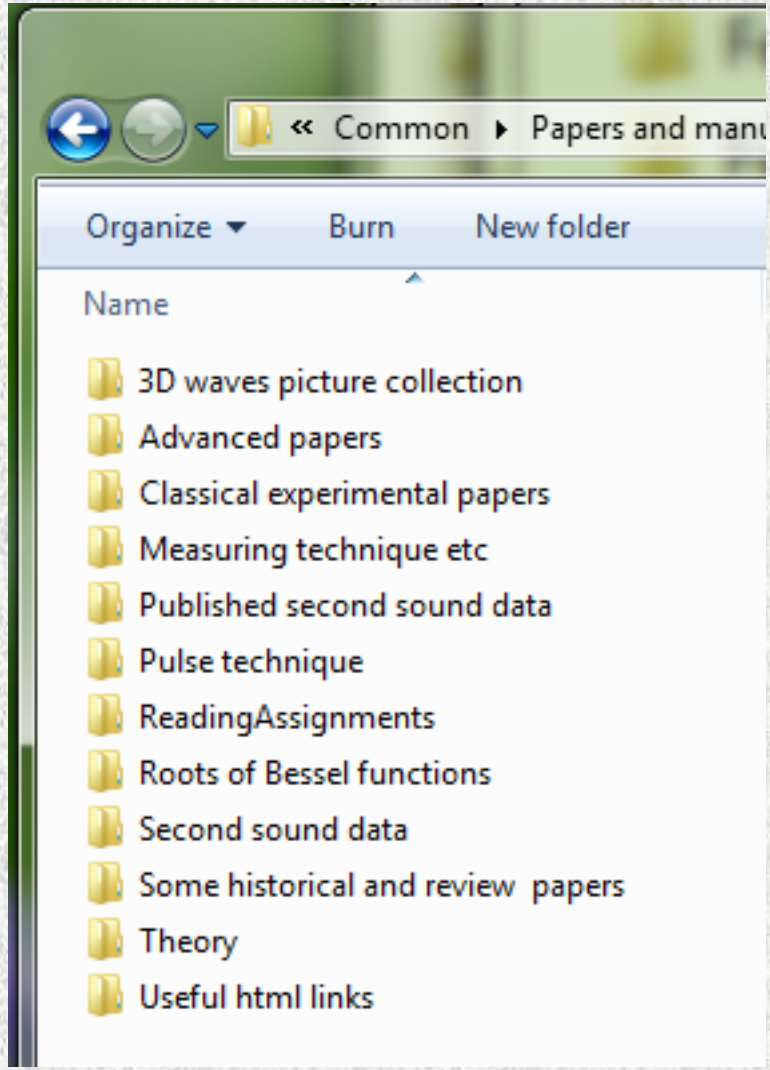


WHERE TO RETRIEVE COURSE INFORMATION.

Manuals, papers, setup diagrams and other useful materials

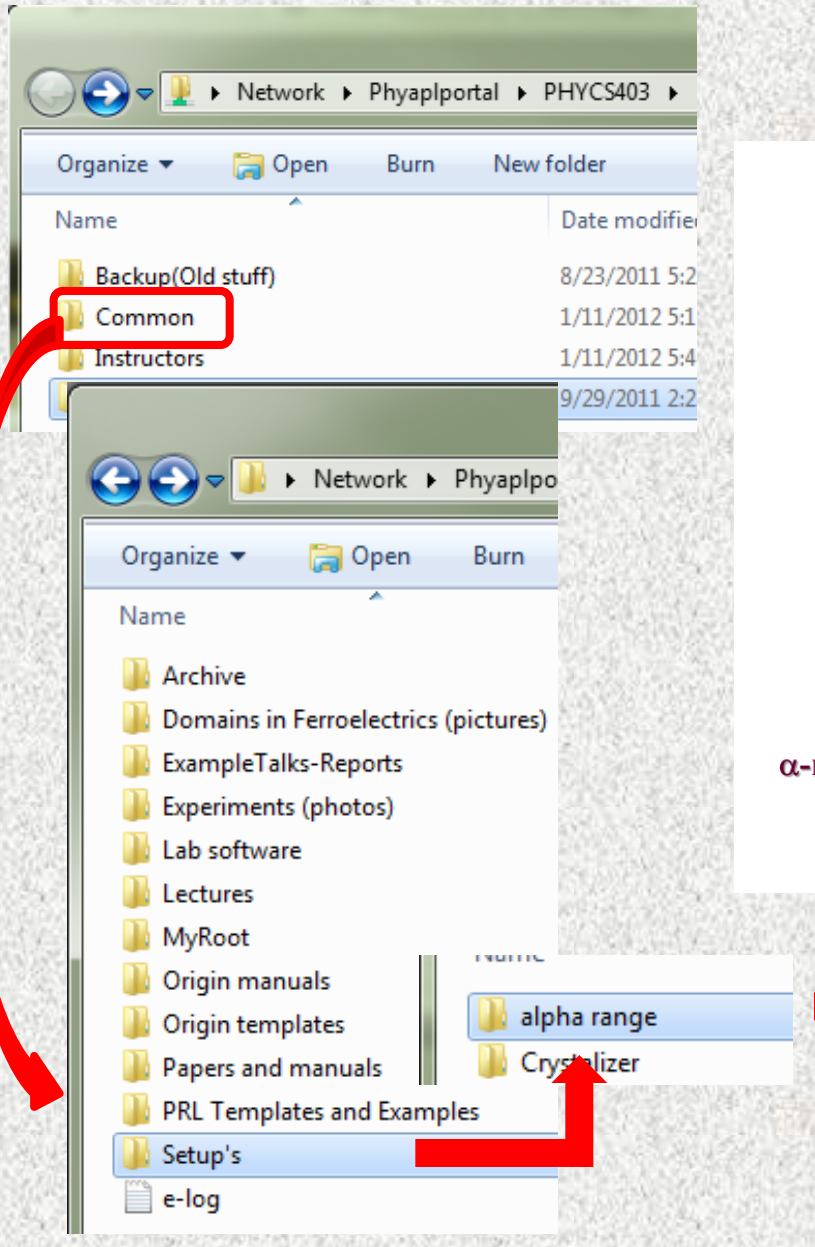


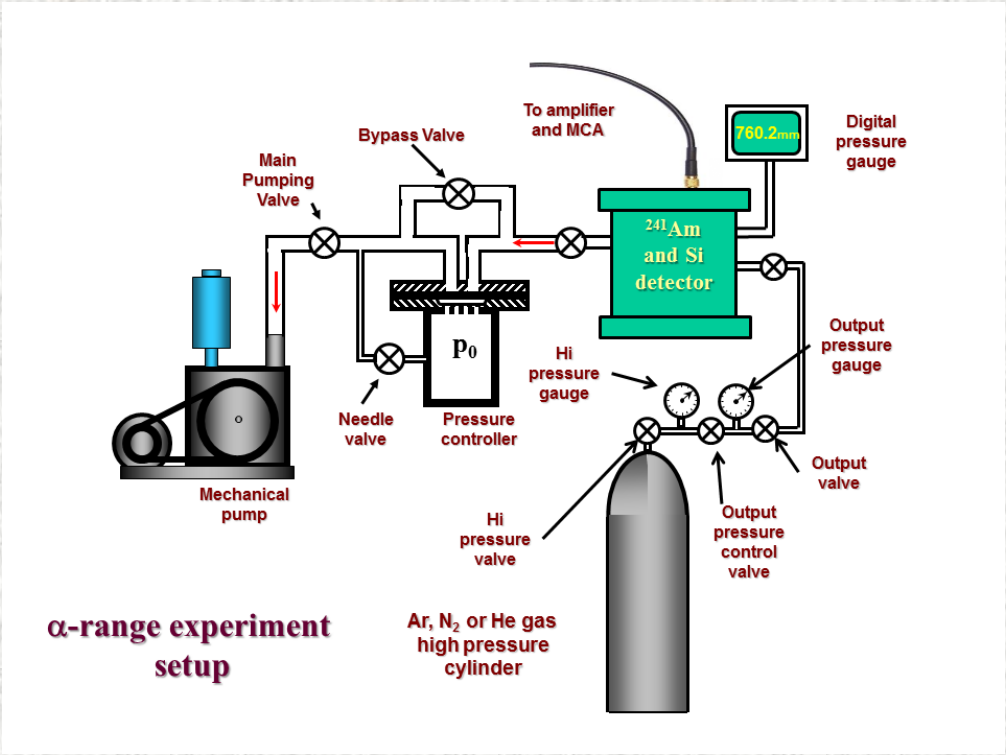




WHERE TO RETRIEVE COURSE INFORMATION.

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

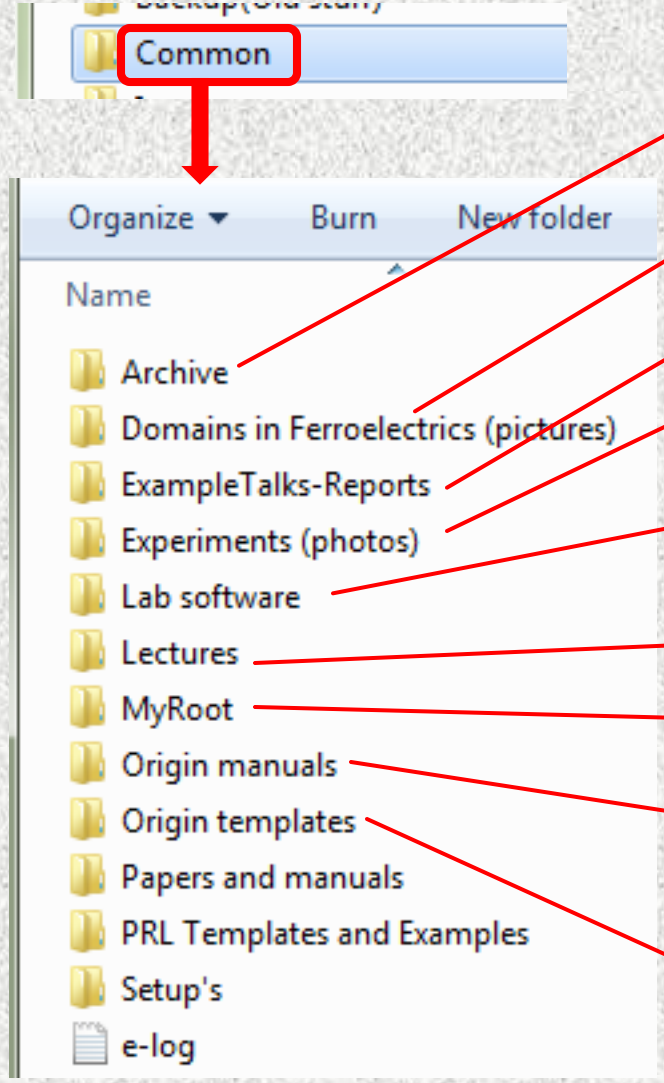




α-range experiment setup diagram

WHERE TO RETRIEVE COURSE INFORMATION.

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



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

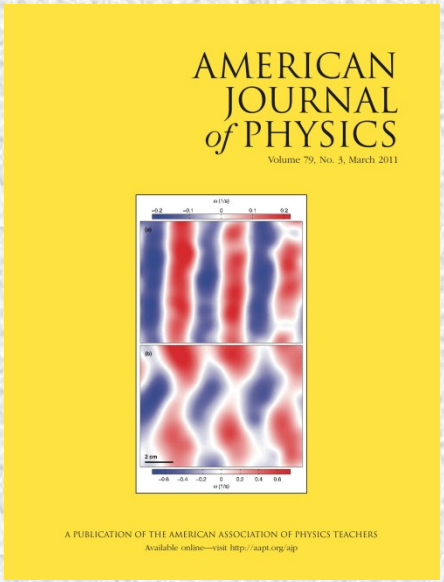
C++ scripts for Root

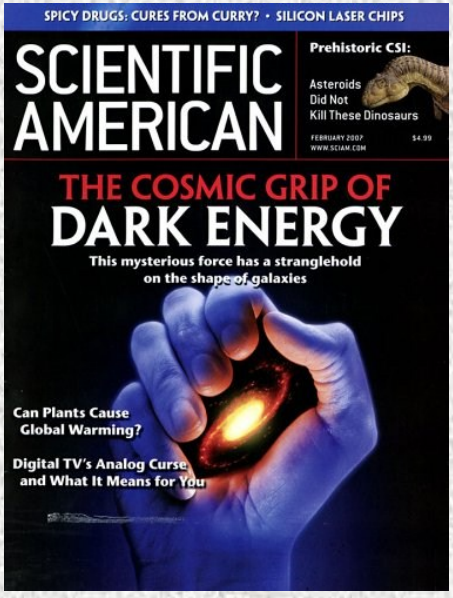
Origin manuals + a very compressed version written by Eugene

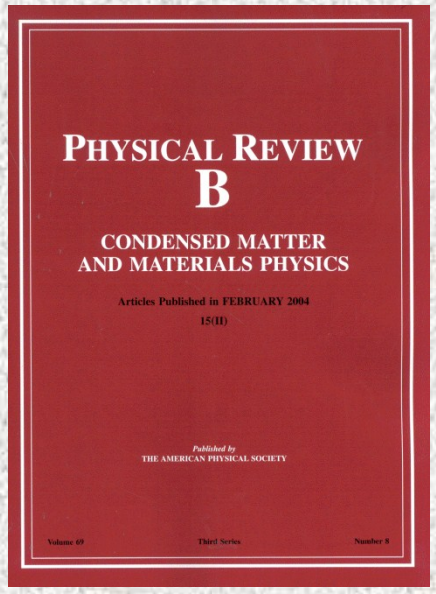
Origin templates (how to use them will be discussed in next lecture)

“JOURNAL CLUB”

This is a new proposed activity for Physic 403 course and it will be presented by Professor *Robert Clegg*







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/

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)

Registering as a new user

•Go to
http://www.npl.illinois.edu/elog/modphys/Modern+Physics+Laboratory+Fall+2011+Semester/
•Click "Register as new user" on the bottom right

•Fill in information for login name, Full Name, e-mail address, and password
PASSWORD IS NOT SECURE, DO NOT USE A "SENSITIVE" PASSWORD

•Click "Save" in the upper left hand corner

e-LOGS: ABOUT USING IT ...

- *Navigating the E-Log*
- *The e-log user guide can be found at http://midas.psi.ch/elog/userguide.html*
- *The Main Page*
  - *The main page shows a summary of the last 100 entries in reverse order (newest at top).*
  - *ID, Date, Author, Experiment, Post Type, or Subject can be clicked to sort by that category.*
  - *Full|Summary|Threaded change the way the main page is shown (default is Summary).*
  - *The menu bar contains several options:*
    - *New: Create a new post*
    - *Find: Search for a post*
    - *Login: Login as a new different user*
    - *Logout: Logout the current user*
    - *Help: As simple help page (not very useful)*
    - *HelpELCode: A help page on using the E-Log code when making posts*

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.*
  - *If you need a new Experiment or Post Type, click the button "Add Experiment" or "Add Post Type".*
    The large blank area is for the Text portion of the post

e-logs: Making a post …

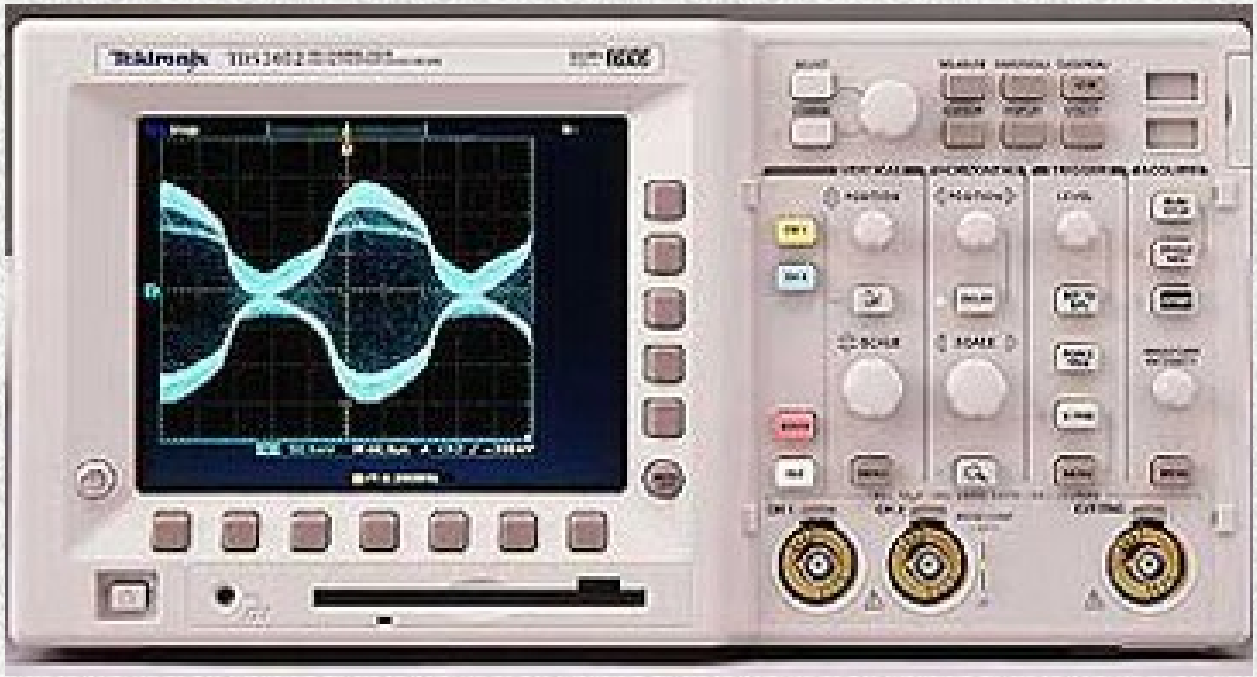
- *Towards the button is the Encoding option. "ELCode" translates the post using E-Log code, refer here for instructions on it's use.*
  - *"plain" makes the post in plain text with no formatting.*
  - *"HTML" translates the post according to HTML standards.*
  - *Attachments can be made in the attachment section.*
  - *Any file less than 10MB can be attached to the post.*
  - *Certain file types such as png, jpeg, gif, and txt will be shown at the bottom of the post.*
  - *To display figures in-line, see the ELCode Help Page*
- *When finished click "Submit"*
- *The "Suppress Email notification" box can be unchecked if you would like the entire class to receive an e-mail informing them that your post has been submitted. In general, leave this box checked.*

Analyzing Data with *ORIGIN* or *ROOT*

- *We aim to point you toward two powerful, professional analysis tools:*
- *ORIGIN (commercial; CM, AMO, bio, …)*
  - *Motivations*
    - *Very powerful and flexible*
    - *No necessary to have experience with C++*
    - *It's also free for you ; current available version is Origin Pro v. 8.6*
- *ROOT (CERN + users; nuclear, particle physics)*
  - *Motivations*
    - *Fantastically flexible*
    - *Outputs pub-quality plots in any format*
    - *Relatively easy to do complex tasks, like non-linear least-squares fitting, Monte-Carlo, etc.*
    - *World community of users contributing*
    - *IT'S FREE ! You can download the whole thing to your PC under Linux, Windows, or MAC oS*
    - *We provide a starter kit with a suite of tools*
    - *Lots of tutorials exits*

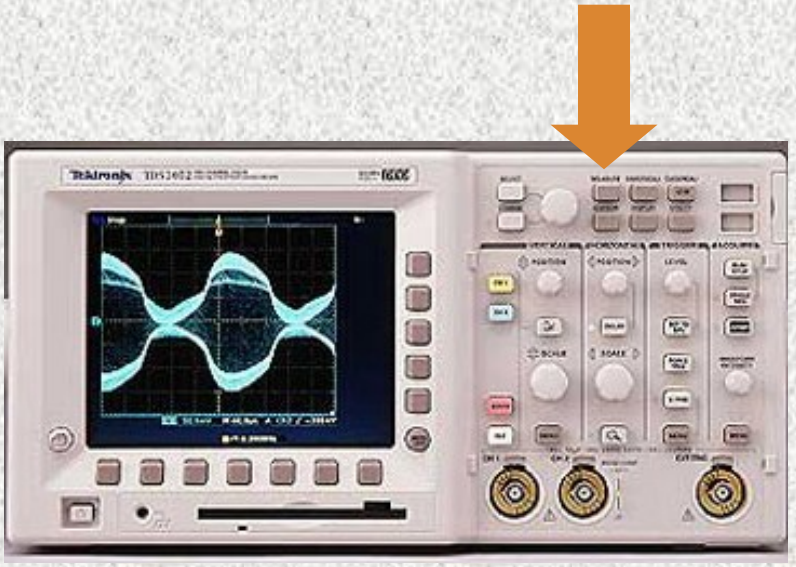
Next: Using the digital scopes

- *Each group of 2-3 should share a digital scope*
- *Function generator to create wave form*



Measure

- *Period*
- *Frequency*
- *Peak to Peak*



Quick Menu

- *Groups common things*