Birck Spintronics Lab (Quantum Design Systems)
New User Orientation

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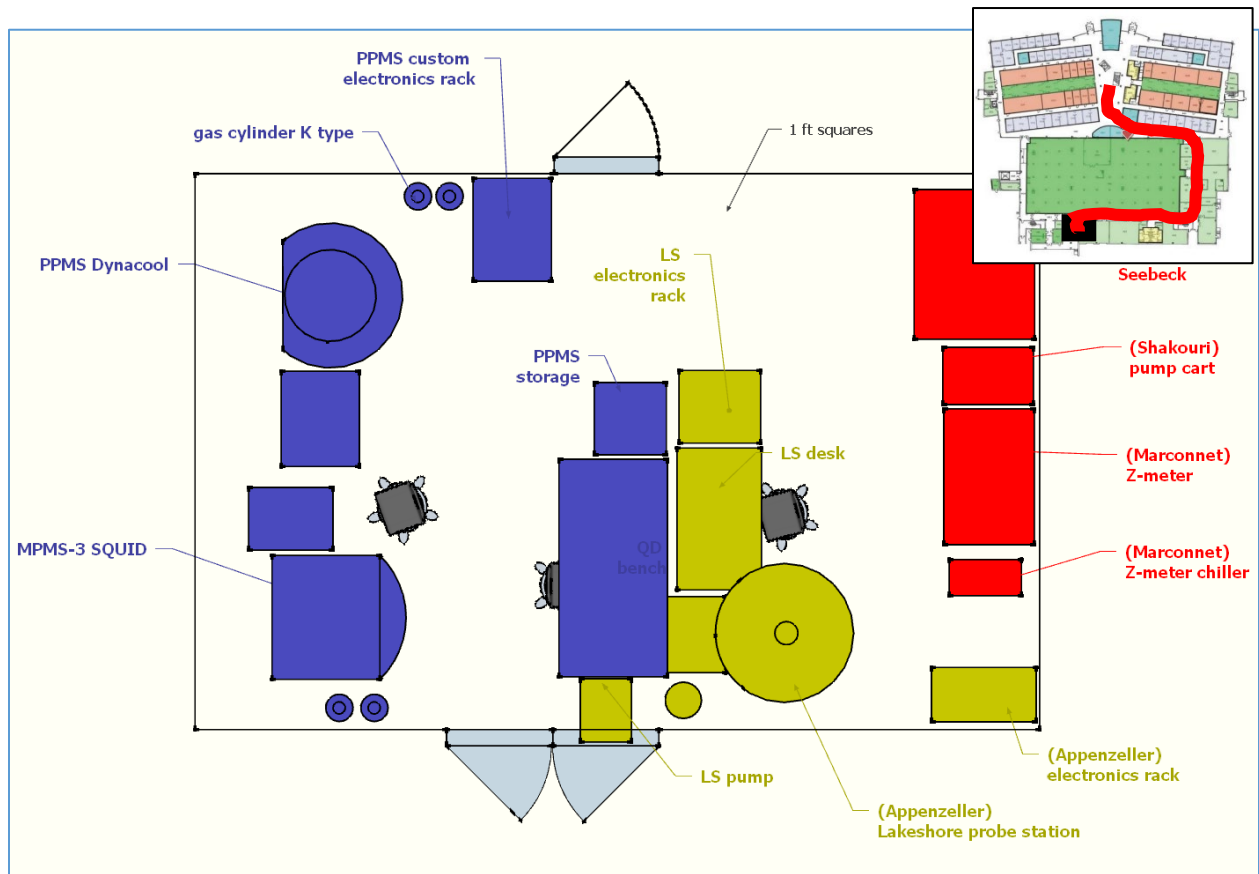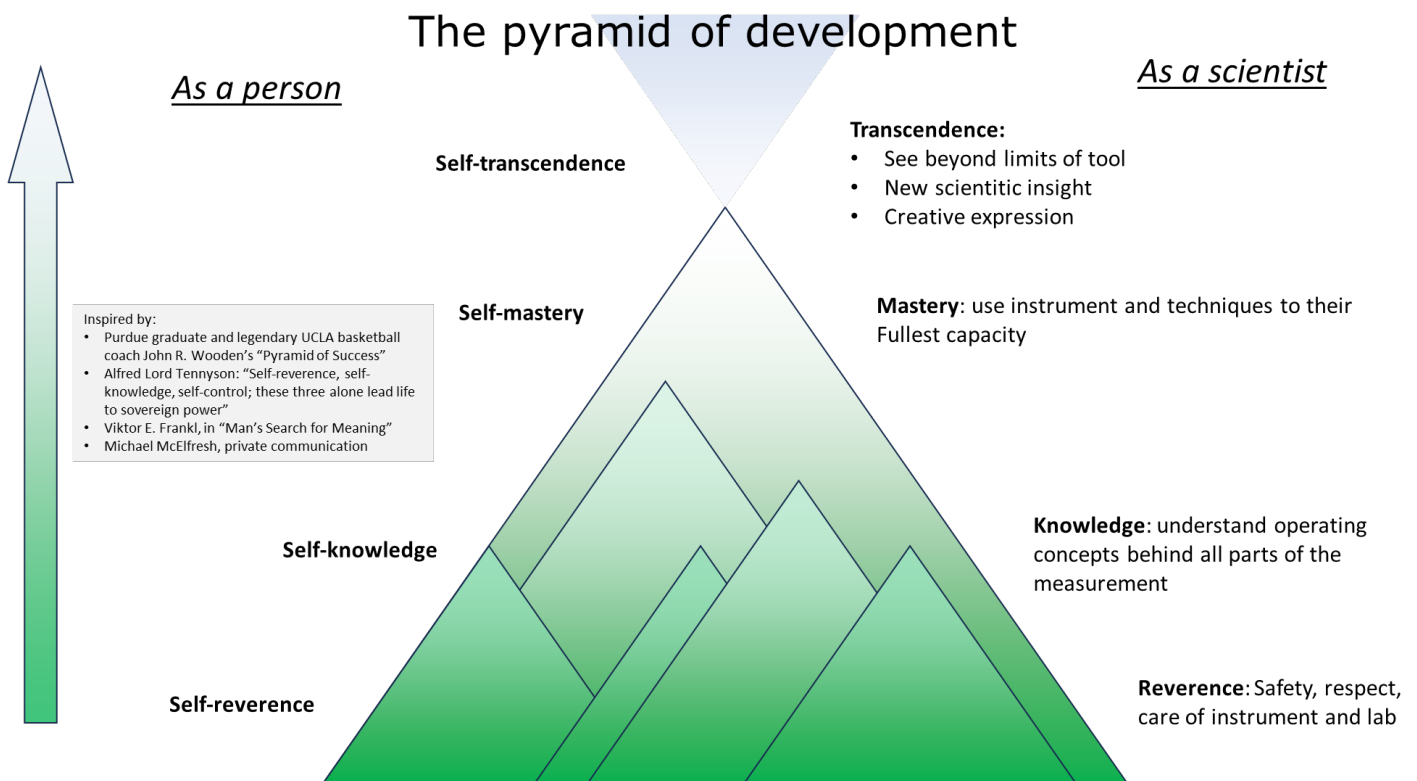

Figure 1: Spintronics Lab, with QD systems and associated furniture (blue) Lakeshore probe station (yellow) and thermal transport systems (red); (INSET) access route (red) to the lab from Birck 1st floor lobby.

Facilities provided in lab: 220 V, 110 V ("S" outlets are on an isolation transformer and are intended for sensitive equipment, NOT big motors), dry N2, roughing vacuum.

Some philosophy about experimental science and life

- **Good Citizenship**: we work together and rely on each other. If you leave the lab at least a little bit better than you found it, then we will all succeed. The alternative is chaos. See "trust".
- **Trust**: Nothing happens in society without trust, and our success as a species is due to the expansion of trust. Careers are build on trust
- **Insight**: "data" and "results" are not your goal here; instead, you are trying to produce new insights into nature. To collect data without a sharp focus on the desired insights is to waste your time and resources.

The pyramid of development

As a person

As a scientist

Self-transcendence

Transcendence:
- See beyond limits of tool
- New scientitic insight
- Creative expression

Self-mastery

Mastery: use instrument and techniques to their Fullest capacity

Inspired by:
- Purdue graduate and legendary UCLA basketball coach John R. Wooden's "Pyramid of Success"
- Alfred Lord Tennyson: "Self-reverence, self-knowledge, self-control; these three alone lead life to sovereign power"
- Viktor E. Frankl, in "Man's Search for Meaning"
- Michael McElfresh, private communication

Self-knowledge

Knowledge: understand operating concepts behind all parts of the measurement

Self-reverence

Reverence: Safety, respect, care of instrument and lab

An introductory talk by Neil Dilley about this lab is also on Nanohub here:
https://nanohub.org/resources/24815

1. Introductory glance at Quantum Design (QD) instruments

MPMS3 EverCool SQUID magnetometer

- Most sensitive instrument for measuring bulk magnetic dipole moment **m**
- Inductive measurement using gradiometer coils around a moving sample
- High speed: full magnetic m(H) hysteresis loops in just minutes
- Uses a "SQUID" : superconducting interferometer
- Samples: film, bulk, crystals, powder
- 8mm diameter sample space (4x4mm film typical)
- 10^{-8} emu (10^{-11} A-m^2) sensitivity
- Temp. : 1.8 – 400 K, oven : 300 – 1000 K
- Field : +/- 7 tesla (70 kOe)
- AC susceptibility: f = 0.1 – 1000 Hz
- electrical transport or biasing **while** measuring **m**
- EverCool: pulse-tube cryocooler recondenses the helium that evaporates from the dewar

DynaCool Physical Properties Measurement System (PPMS)

- General field/temperature platform:
    - Temperature: 1.8 – 400 K
    - Magnetic field: +/- 9 tesla (90 kOe)
    - 25mm diameter sample space
- Hosts wide variety of automated measurements...
- Electrical transport: magnetoresistance, Hall effect, I-V curves; external gating possible
    - Micro-ohm up to 5 giga-ohm
    - Automated sample rotation
- Heat Capacity microcalorimeter
- Thermal Transport:
    - Thermal conductivity
    - Seebeck & Nernst effects
- Magnetometry: DC magnetic moment using VSM
    - 10^{-6} emu up to 100 emu
- Ferromagnetic resonance (FMR) up to 18 GHz
- Custom probes, external electronics

2. Getting trained and approved on the equipment

User questionnaire

Each new user fills this out before starting this orientation; find this form on the BNC Wiki page for either instrument or inquire with Neil.

Safety

- In case of emergency, please go out the emergency exit door. Alarms will sound if this door is opened, so this is to be used ONLY IN AN EMERGENCY.
- Keep a 1m (3 ft) wide path clear to the emergency exit.
- Put your personal belongings (backpack, purse…) in the plastic bin by the door of the lab, not on the floor or on the bench.
- Wear eye protection while in the lab: safety eyewear is located next to the door.
- No shorts or open-toed shoes in the lab.
- See "Mental checklist" posted by the systems to ensure no harm to humans or machines results from your use of system!

Lab Protocols

- **Unlocking the PCs :** Neil or Mike will share the password to unlock each PC at these systems (passwords also written in front of MSDS binder in lab). They are not maintained by ECN but they are on the network.
- Sample mounting and experiment design guidance is found in the training binder for each system.
- **Do not bring loose sample material into lab:** powders, crystals or other materials that can contaminate the environment must be encased in your lab before coming. Please see Neil or Mike about this and we will provide a sample mounting solution for you. If necessary, we will involve our safety officer Stephen Jurss to advise how to ensure that there is *no risk to exposure* from your sample.
- **Note special drawer for MPMS3 mounting tools:** due to the highly sensitive MPMS3 magnetic measurements, we use ceramic tweezers, scissors and blades that should NOT be used for cutting anything metallic or magnetic. Find standard tools in PPMS sample mounting drawers.
- Put a clean 1109 wipe down in your work area before starting.
- **Always wear clean gloves when handling the samples, sample holders and sample rods.** This is critical in sensitive measurements of magnetism (where nano-grams of Fe can be detected) and thin film transport (where oils and impurities on surface can change your sample).
- Put all parts back into user kits, and user kits back into cabinet when done.
- Clean up the work area and take your samples with you when done.

Using the iLab software

This is how we track uage of the instruments and bill users so we can support the lab.

1. Reserve your time on the machine on iLab webpage: https://purdue.ilabsolutions.com/ .
2. At the beginning of your reservation, come to the lab and log into kiosk laptop (on bench) using "iLab Kiosk" link in browser if login page isn't already up. Click the Start Session link.
3. NOTE: hardware interlocks are installed on these machines. Only once the session is started, instrument interlocks will turn on the monitor and internet connection at the relevant instrument so you can access it.
4. Log out of the webpage if you plan a long session, in case another user needs to log in and start/stop a session at the kiosk.
5. At the end of your reservation, log in to kiosk and End Session.
6. If you do not start your session within 30 minutes of start of your reservation, the reservation will be forfeit and other users are able to reserve it or start sessions.
7. You are always able to start a session at the kiosk as a walk-up (without a reservation or if your reservation has lapsed), if it's available.
8. Billing policy: we charge in 4 hour increments, with 4 hours being the minimum. We round to the nearest 4 hour increment if past 4 hours: a 5 hour session will be billed 4 hours, while a 7 hour sessions will be billed 8 hours.

Reservation Policy

Advanced Reservations (8-14 days ahead)
Each user is allowed to schedule **ONE** reservation in the "advanced" timeframe.

Open Reservations (0-7 days ahead)
In remaining open slots for the current week, you can schedule multiple reservations, still following the time block rules above.

ALL reservations must also follow these guidelines:

Weekday, morning	Early morning – midday
Weekday, evening	midday – late evening
Weekday, overnight	5pm – 9am (max 16 hrs)
Weekend	Open (max 24 hrs)

Violations include: making more than one advanced reservation OR not fitting the reservation within the blocks above. A violation results in a 1-month lock-out of the user from the machines.
If you have special circumstances which cannot work within these blocks, please contact Neil at ndilley@purdue.edu to discuss.

Walk-Up sessions
These are done in the iLab kiosk website. The minimum walk-up time is now 2 hrs (instead of 4 hrs) – this allows us to make use of a <4 hr time slot that results from a no-show.

No-Shows and Canceling reservations
Reservations are forfeit 30 minutes after your start time and are called "no-shows". If you want to cancel a reservation, you need to do this **at least 8 hours in advance** of your start time.

No-show violation: If you no-show during a reservation **AND** this time slot goes unused. Three or more of these no-show violations in a month will result in a 1-month lock-out for the user.

Card activation

Your magnetic strip card (Purdue ID or Birck card) will be activated by Mike Bayless or Mary Jo Totten after the training is complete, and will give you access to this lab via the East hallway around the Sub Fab, see Figure 1.

3. Useful info

Copying your data files

Please do not use USB flash drives to retrieve your data from the PCs at the systems as this presents a big virus risk to all users and the PCs. Instead, copy your data over LAN using one of these methods:

Cloud storage or email: (e.g., Purdue Research Repository https://purr.purdue.edu)
this is the most common method.

Teamviewer: this remote access software (info given below) allows users to transfer files from the PCs to their own systems.

There is also a Network Attached Storage (NAS) in Neil's office which backs up the data on both systems nightly at 9-9:30pm (if they are on the network). Ask Neil if you want access to this drive to recover data that might have been lost on the system's PC.

Please see Neil if you have questions or concerns about this.

Data file format

Quantum Design measurement data files (*.DAT and *.RAW) are all multi-column, comma-delimited text files with multi-line headers. The number of lines in the header depends on the measurement option. These files can be imported easily in any spreadsheet program by starting comma-delimited import after the header. Below is an example of a VSM measurement data file from the PPMS (some parts shortened using "..."). The data section always starts with '[data]' and there are always column headers.

There is a program made by Quantum Design called `ExportData.exe` which is found in MultiVu under *Utilities > Tools > ExportData* (or located directly in the C:\QdSquidVsm\Tools or C:\qddynacool\tools folder). It can strip off the header, remove unused data columns, and even filter data based on min/max values.

```
[Header]
; VSM Data File (default extension .dat)
; Copyright (c) 2003-2013, Quantum Design, Inc. All rights reserved.
TITLE,
FILEOPENTIME,3675062553.18477,06/14/2016,10:43 am
BYAPP,VSM,1.0,1.0
INFO,DYNACOOL VSM Option Release 1.4.10 Build 1,APPNAME
INFO,Quantum Design Linear Motor Servo Controller,MOTOR_MODULE_NAME
INFO,3101-100 J0,MOTOR_HW_VERSION
INFO,MMC769,MOTOR_SERIAL_NUMBER
INFO,SRV No X-over 01.03.11,MOTOR_SOFTWARE_VERSION
.
.
.
DATATYPE,COMMENT,1
DATATYPE,TIME,2
STARTUPAXIS,X,2
STARTUPAXIS,Y1,5
[Data]
Comment,Time Stamp (sec),Temperature (K),Magnetic Field (Oe),Moment (emu),M. Std. Err...
,3675062766.727,299.798187255859,1000.16394042969,0.00370660506697534,...
```

Teamviewer remote access to PCs

While using the system, it can be very useful to be able to monitor experiment progress remotely. We have a channel under Purdue's account with TeamViewer for this. Note that we are NOT using Windows Remote Desktop as this has caused software crashing issues on both systems.

IMPORTANT RULE: please do not perform any sample chamber commands (vent/pump/purge/seal…) or initiate any sample insertion/removal through Remote access. The chamber cap might not seal and this can cause serious problems with ice blocks in the chamber.

Here are the Teamviewer IDs for both of the systems:

MPMS: **1 509 503 975**
PPMS: **1 405 430 993**

Passwords for the systems: same Windows unlock password.

Download **Teamviewer 11** app for PC at www.teamviewer.com at this specific link:

https://www.teamviewer.com/en/download/previous-versions/

or for mobile devices in the app store. **Note that we only have a license for Teamviewer 11 at this time**, so TV 12/13 will treat you like an unlicensed user and you may not get access to the machines.

MultiVu simulation mode software

MultiVu, the software that controls the QD instruments, can also be run in simulation mode on your Windows PC. It is a valuable visualization tool for the data files collected, also a place where you can write measurement sequences (programs) to run when you get system time. Lastly, it's a good training tool to get you more comfortable with the operating environment. You can find the installers for either the MPMS3 or DynaCool MultiVu at the bottom of the BNC Wiki pages for each tool.

User training resources

This document and other measurement training for MPMS and PPMS is to be found on the BNC Wiki site:

https://wiki.itap.purdue.edu/display/BNCWiki/Electrical+and+Magnetic+Properties

If you do not have access, make sure you are on the "BNC-all" mailing list, which is open to all Purdue users who have completed BNC 105 and 150 and are in good standing. The link to sign up is here:

https://engineering.purdue.edu/ECN/mailman/listinfo/bnc-all

www.qdusa.com/pharos

Pharos is QD's online digital library with a host of training resources for users at all levels, including:

- All user manuals for the systems
- Example data to give you an idea of the capabilities of the system
- Example sequences to get you started on your own measurements
- Training Videos on sample mounting
- Applications Seminars on all the measurement options

Signup is easy, just requiring a serial number taken from either system (guidance is given in the signup form). Please ask Mike or Neil if you need help locating this tag.