

APS - L-ID-C

April 4-~~9~~, 2018

Magneto-transport
+ XMCD

on $[Co(Pd)]_7Mn$

04/05/18

April 5.

8 am: Came at beamline 4-ID-c
chatted with previous users who were
also doing transport measurements, talked about
van der Pauw
4-wire measurement

Goal:

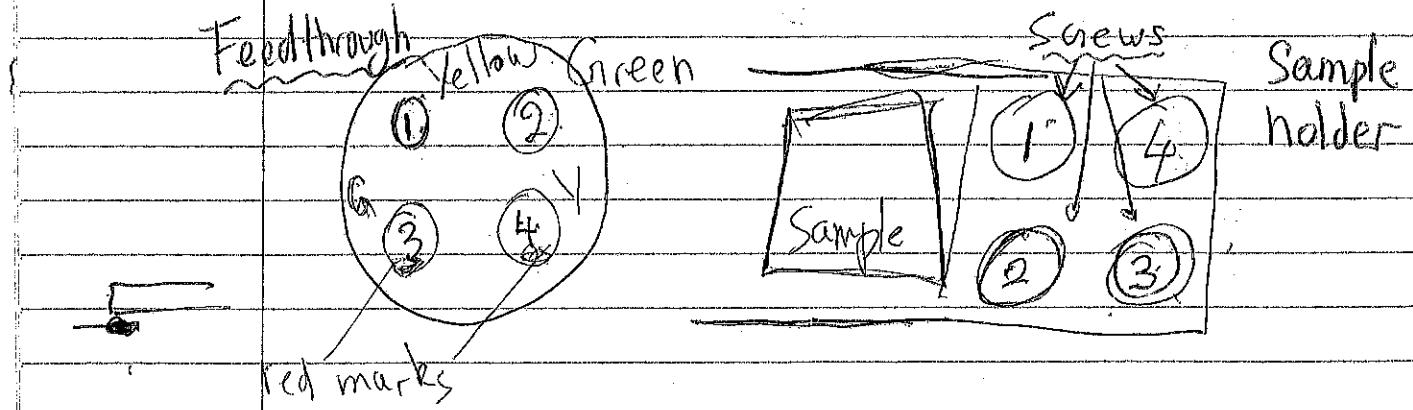
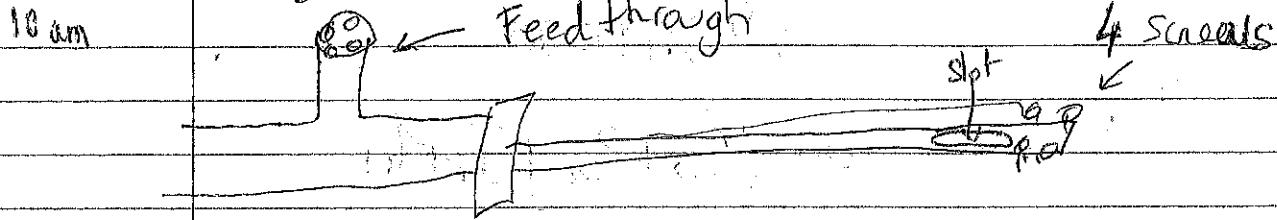
Connecting the sample

on sample holder

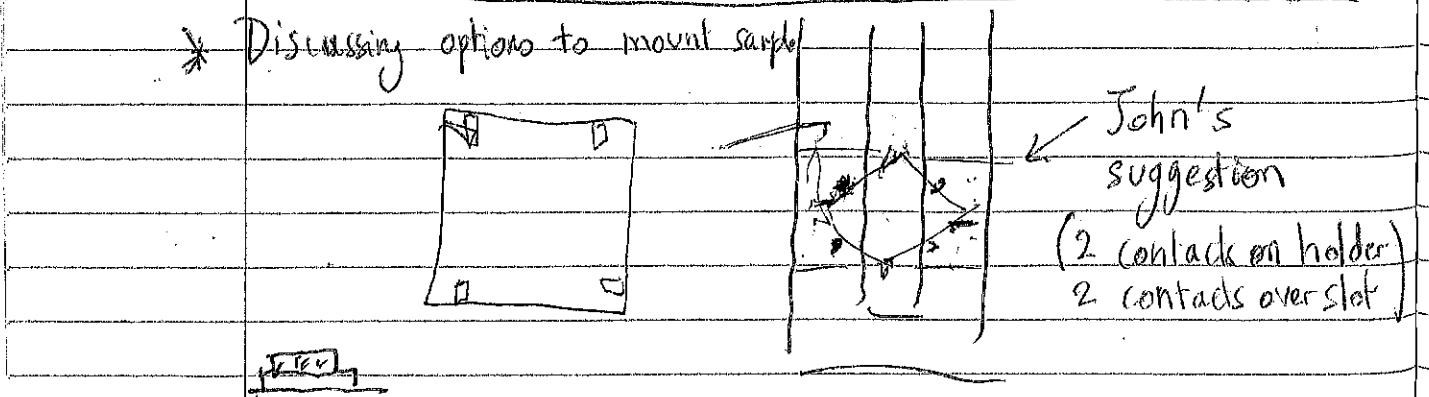
Using Van der Pauw geometry

9 am: John Freeland in - helped switching holder on cryostat, talked
about procedure

① Identifying the wires on holder:



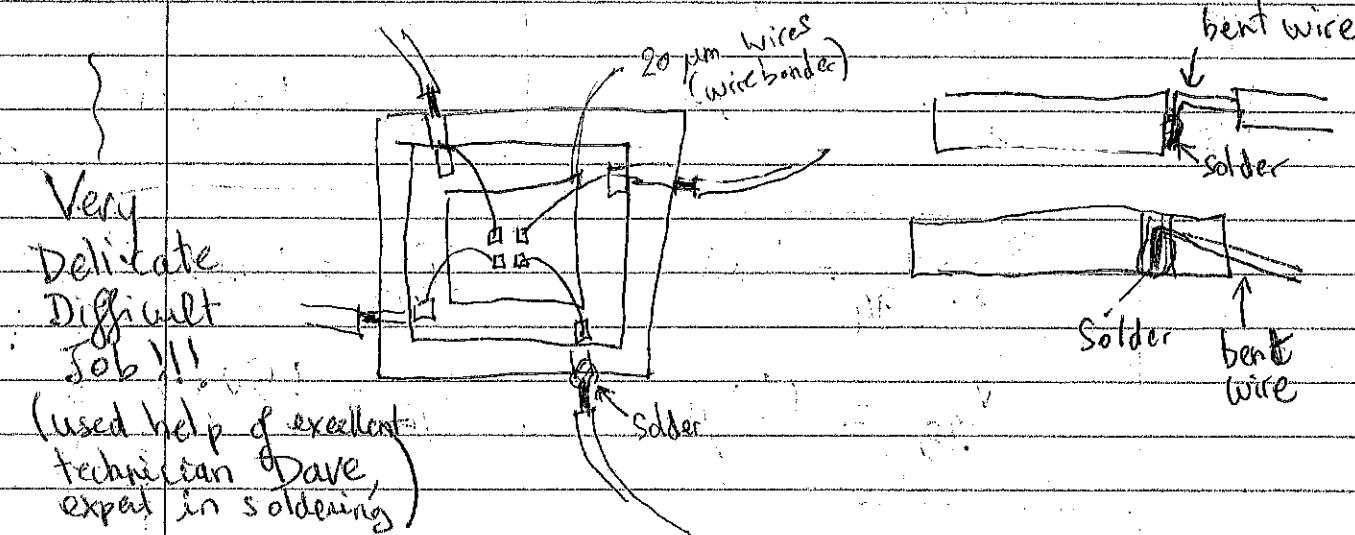
* Discussing options to mount sample



11 am

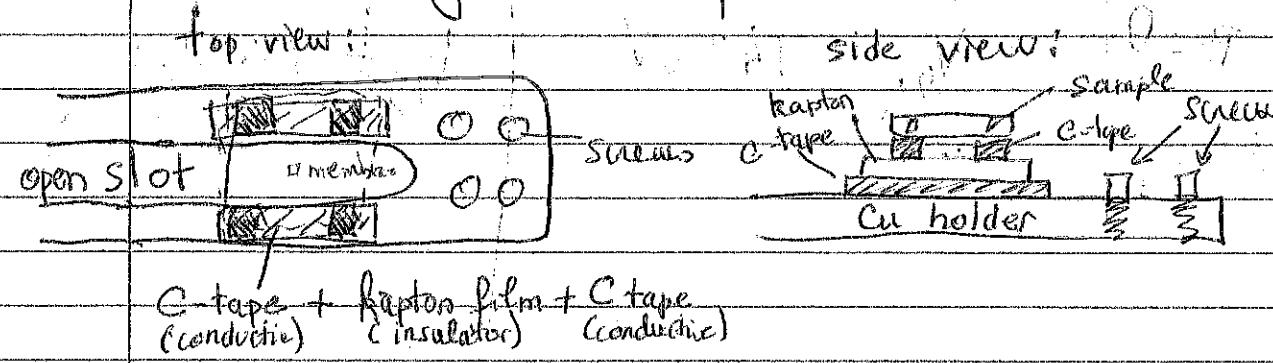
② * Soldering wires onto the chip

S2



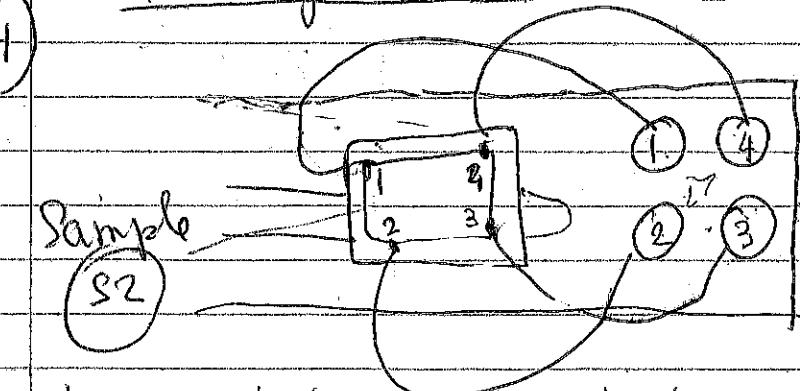
③ * Mounting sample on Sample holder

Making sure contacts are insulated!



2pm * Attaching wires to screws:

2:30 pm



⑤ Checking electrical insulation:

No contact between
(1,2,3,4) and
ground
OK!

This whole process took ~ 6 hours!!

04/05/18

Transport Measurements with
VAN der PAW - 4 wires

$$I_{34} V_{12} \text{ actual}$$

SHEEP	$I_{12} = 1 \mu\text{A}$	$T_{34} = 1 \mu\text{A}$	$20 \mu\text{s}$	$40 \mu\text{s}$	$60 \mu\text{s}$	$80 \mu\text{s}$	$100 \mu\text{s}$
R.S.	$V = 160 \mu\text{V}$	$V_{12} = 150 \mu\text{V}$	$324 \mu\text{s}$	$460 \mu\text{s}$	$720 \mu\text{s}$	$1000 \mu\text{s}$	$1270 \mu\text{s}$
	$I_{23} = 1 \mu\text{A}$	$T_{23} = 1 \mu\text{A}$	$1 \mu\text{A}$	$10 \mu\text{A}$	$30 \mu\text{A}$	$40 \mu\text{A}$	$60 \mu\text{A}$
	$V = 148 \mu\text{V}$	$V_{14} = 150 \mu\text{V}$	$168 \mu\text{V}$	$245 \mu\text{V}$	$330 \mu\text{V}$	$482 \mu\text{V}$	$636 \mu\text{V}$
	$(23)_{14} = 148 \mu\text{V}$	$V_{14} = 150 \mu\text{V}$	$168 \mu\text{V}$	$245 \mu\text{V}$	$330 \mu\text{V}$	$482 \mu\text{V}$	$636 \mu\text{V}$

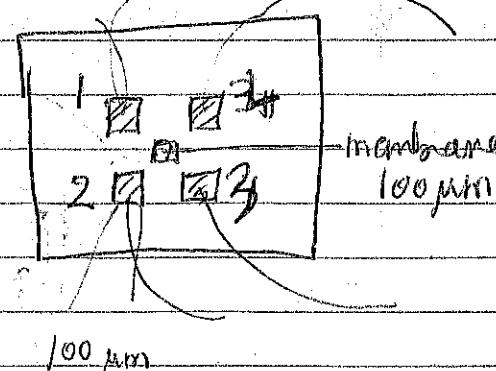
"Hall with $B=0$	$I_{13} = 1 \mu\text{A}$	$I_{24} = 1 \mu\text{A}$
CROSS R.H.	$V_{24} = 142 \mu\text{V}$	$V_{13} = 166 \mu\text{V}$
	$(24)_{13} = 142 \mu\text{V}$	$V_{24} = 166 \mu\text{V}$

2:30 pm lunch break

3:30 pm

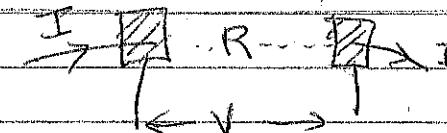
Transport measurements

5 pm



$$I_{12} V_{34}$$

I and V measured at
same location (2 pt measured)
"2 wires"



$$I_{14} V_{23}$$

$$I$$

$$I_{13} V_{24}$$

$$I_{24} V_{13}$$

04/05/18

4-wire measurement

TRANSPORT: MEASUREMENT
WITH 4-WIRES
(VAN DER PAUL)

 $I_{12} V_{34}$

(mA)	I	0	10	20	40	60	80	100
(mV)	V	106	107	108	100	92	76	60

 $I_{12} V_{43}$

(mA)	I	0	10	20	40	60	80	100
(mV)	V	108	114	120	132	147	158	170

 $I_{14} V_{23}$

(mA)	I	0	10	20	40	60	80	100
(mV)	V	107	108	120	127	138	146	154

 $I \quad -10 \quad -20 \quad +40 \quad -60 \quad -80 \quad -100$ $I_{34} V_{12}$

(mA)	I
(mV)	V

(mA)	I
(mV)	V

TRANSPORT: MEASUREMENT
WITH 4-WIRES
(VAN DER PAUL)

 $I_{13} V_{24}$

(mA)	I	100	80	60	40	20	0	-20	-40	-60	-80	-100
(mV)	V	85	89	93	99	103	108	114	118	120	125	133

 $I_{24} V_{13}$

(mA)	I	100	80	60	40	20	0	-20	-40	-60	-80	-100
(mV)	V	85	90	92	98	103	105	112	118	122	127	133

(linear fit for this data)

For
cross-resist.

$$\rho_1 x + \rho_2 \rightarrow R$$

$$\rho_1 = 0.2336 \text{ mV/mA}$$

 R_{cross}

$$\rho_1 = 101.9 \text{ mV} \Rightarrow R_{\text{cross}} \approx 0.2352$$

$$\rho_2 = 101.9 \text{ mV}$$

Non linear fit done on the avg.

$$\rho_1 = 0.237 \Omega$$

For
sheet resist.

$$I_{12} \quad \rho_1 = 0.71 \Omega$$

 R_s

$$I_{14} \quad \rho_1 = 0.47 \Omega$$

$$\text{avg} \quad \rho_1 = 0.50 \Omega$$

$$\Rightarrow R_s \approx 0.50 \Omega$$

x std: 4.16% python
(40?) 50 A highest value

04/05/18

* Quick check of the effect of field B

Cross configuration ($T_{24/1} V_{13}$) Sample @ $90^\circ - 0$

$\rightarrow F_{22}, V_3$ Field $B \approx 3800$ O₂ (40A)

(No X-rays yet)

100	I	0		100 μ A		-100 μ A
V	135		90 mV		138 mV	

Field $B \approx 3800$ O₂ (-40A)
on sample

I	0	+100		-100 μ A
V	114		90	139 μ V

$$B = 40 \text{ A} \quad p_1, x + p_2$$

fit of data

$$p_1 = -0.24 \text{ } \Omega$$

$$B = -40 \text{ A}$$

$$p_1 = -0.245 \text{ } \Omega$$

$$R_{\text{Hall}} \approx 0.24 \Omega \approx R_{\text{cross}}$$

Not visible
change with B ...

* David working on communication between station and electronics

5-6pm Setting connection between Keithley - Computer

Interface 'Keithley 2400, vi' (DAC/ADC)

"AUTO" Range using $100 \mu\text{A} = 10^{-4} \text{ A}$

6:15

Create Data file:

[NO X-RAY YET]

04/05/18

Data saved in 2018-1 / Chestof_Mar2018

* Work on setting automated scan for

magnetization loop $\checkmark (B)$

Hall

Make sure turn the Keithley "ON"

Keithley 2400
15 Auto Range
function output V_H B
Green

* Testing a scan on a Resistor $R \approx 100 \Omega$

Plotting

$\uparrow V_{\text{Hall}}$ measured in Detector #7

Screen

#1

 $\rightarrow B$ field

Pb with computer interfacing

Sch (10, 10, 0.2, 0.5) working!
 \uparrow min \uparrow max \uparrow step \uparrow time

6:30

Align sample with x-ray beam, turn $\theta - 45^\circ$

Screen
#3

Tuning x-rays to L₃ edge: 778 eV (eng(778))

Sample
in

$\theta = 90^\circ \quad x = 4.6, y \approx 0.8, z \approx 0$

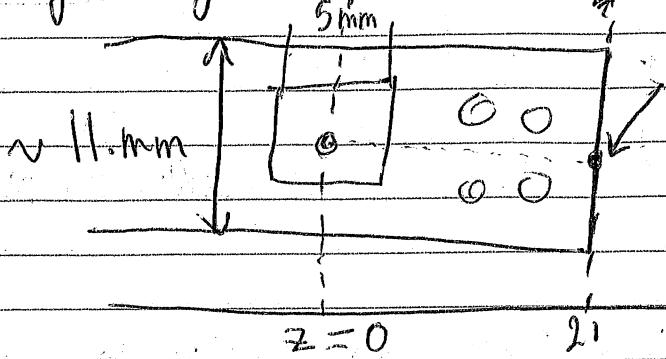
Sample out $z = 30$ mm

align detector [REF] $\approx 213,000$ cts
 $\uparrow z$ Monitor $I_0 \approx 250,000$ cts (on 10 μ A sensitivity)

7pm

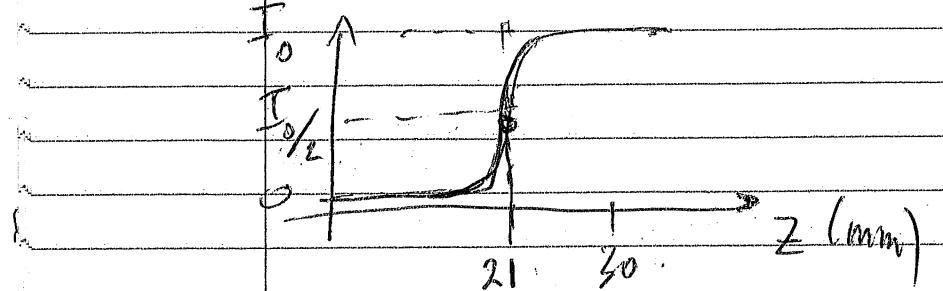
Aligning sample: X- Beam ON

* Finding edge: estimated 21 mm



Sample OFF: $z = 30 \text{ mm}$ $I_0 = 250,000$

REF = 184,000



* Find sample $z = 0$ ($x = 4.6$) impossible to align!

Scan y:

SCy (-2, +2, 0.05, 0.5)

SCy (2, 6, 0.05, 0.5)

SCy (6, 10, 0.05, 0.5)

~~y motor~~
Not reliable motion, gets stuck!!

limit of motion y: -14 \leftrightarrow +2

SCy (-14, 2, 0.05, 0.5) (Sample Vibrating)
Shaking

8pm Scan Y 50 increase 600

3.54 -14 2 8 → 10 ← Not actually moving stage

Change $X = 8$

Try jog Y from [-14, +6] NOT RELIABLE
Y motion!

Impossible to align!!

8pm

Back to Magneto-transport

X beam, OFF

$I_B = 100 \mu\text{A}$ set actually 100 mA

"Auto config on Keithley

I^{13} 2 3 4 V_{24}^{13}

sch (-50, 50) 1, 0.5

Keithley
disabled

only goes to -40!

then going back to zero

only went to 4000
+40A

flat
signal?

signal?

4000A

Finally able to set ($I = 100 \mu\text{A}$)

still flat output 10^{38} ?? Not measuring Voltage!

Turned Output to "AUTO"

Detection
does NOT work!

"CANNOT CONNECT"
TO SCAN. DOPU

9 pm

Try Manual Measurements!

$$I_{13} = 100 \mu A$$

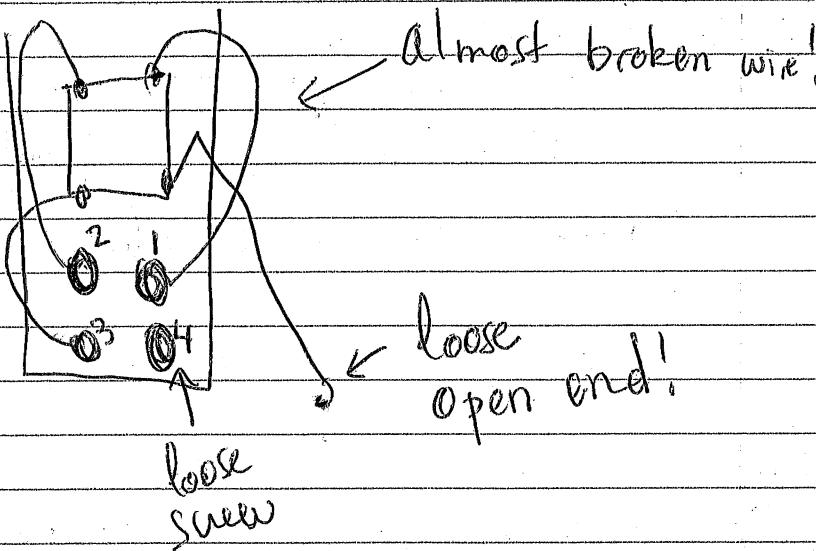
$$B = 40 A$$

$$-40 A$$

$$V = -190 mV$$

$$V = -200 mV$$

Looked at Sample:



Check 2-wire signal between (1) and (3)

$$I_{23} = +100 \mu A$$

$$V_{23} = +12.8 mV (!)$$

$$-100 \mu A$$

$$-12.6 mV$$

$$0$$

$$126 \mu V$$

9:30 PM Quit!

X10 times larger
than before!

Same
as before

Friday April 9

Close valves.

9:15 Venting the chamber

Open the chamber

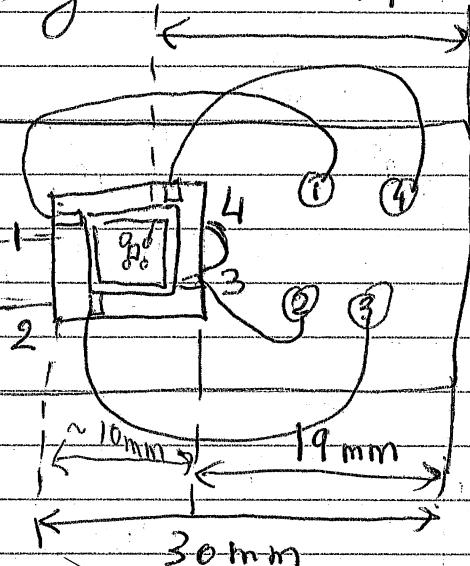
Work on re-soldering + contact 25 mm (with Dave)

+ shorten wires

+ scrape ends

+ tighten all wires

+ secure everything
with C tape
and wires



Checking the contacts

Cross

~~I~~

$I = 0$

$V = 100 \mu V$

$+100 \mu A$

$-100 \mu A$

$75 \mu V$

$+125 \mu V$

parallel

~~V~~

$I = 0$

$+100 \mu A$

$-100 \mu A$

$178 \mu V$

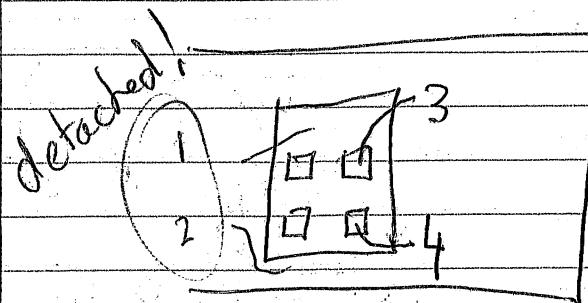
$178 \mu V$

11:30 Insert in Chamber

in chamber

CROSS:	I	0
parallel	V	2-12 mV

12pm checked under microscope
find that 2 wires detached from pads!!



2 wire	I ₃₄	0	+100 μA	-100 μA
		V ₃₄	100 μV	5.860 mV!
		(i)		-5.600 mV

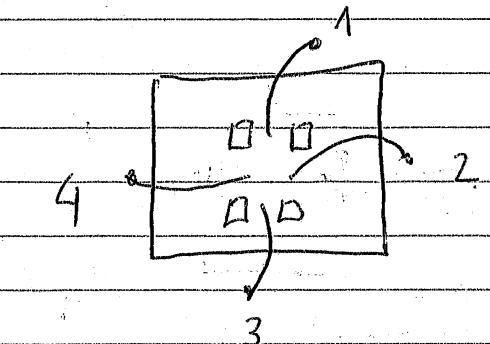
I₁₂: overflow $\underline{22} \Omega$

Cross up high voltage up to 21V
NOT CONNECTED anymore

2pm wire the new sample

with 8-μ wires

(S1)



check the transport signal

VdPaw	I ₁₂	0	+100 μA	-100 μA
		V ₃₄	95 μV	39 μV
				150 μV

I ₃₄	V ₁₂	0	+100 μA	-100 μA
		97 μV	40 μV	154 μV

I ₁₄	V ₁₂	0	+100 μA	-100 μA
		99 μV	24 μV	175 μV

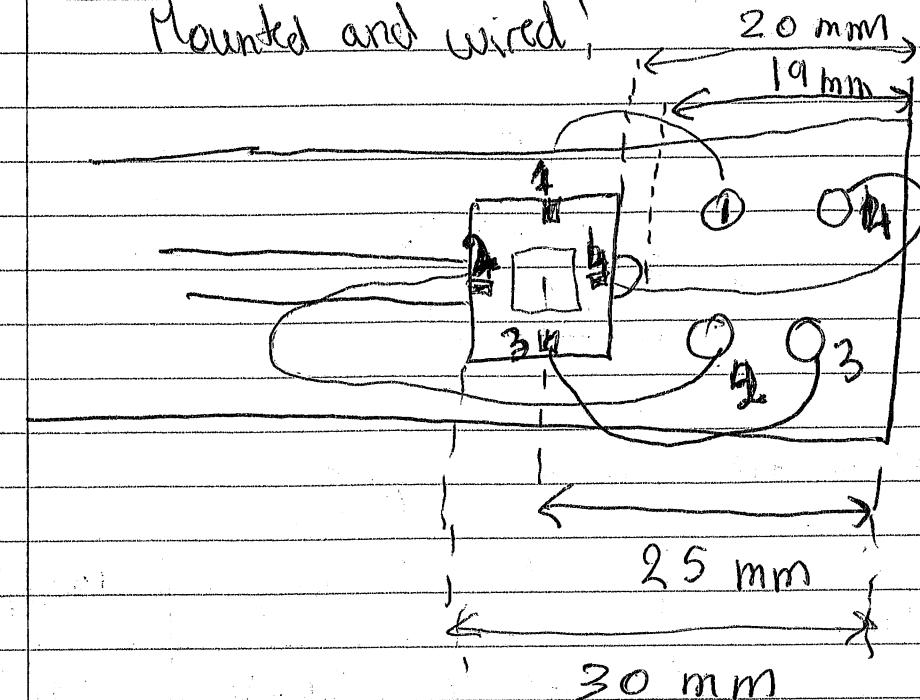
I ₂₃	V ₁₂	0	+100 μA	-100 μA
		97 μV	23 μV	174 μV

CROSS	I ₁₃	0	+100 μA	-100 μA
		97 μV	67 μV	125 μV
				127 μV

3:1 pm

New Sample (S1) 8-wire

Mounted and wired!



Cross: $I_{13} = 0 \quad 100 \mu\text{A} \quad -100 \mu\text{A}$

$$V_{2h} \quad 98 \mu\text{V} \quad 10^F \quad 88$$

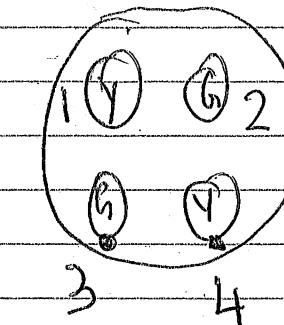
Parallel $I_{23} \quad 0 \quad +100 \quad -100$
Voltage $V_{1h} \quad 100 \mu\text{V} \quad 150 \mu\text{V} \quad 44 \mu\text{V}$

4:20 pm Insert in chamber, Check Voltage

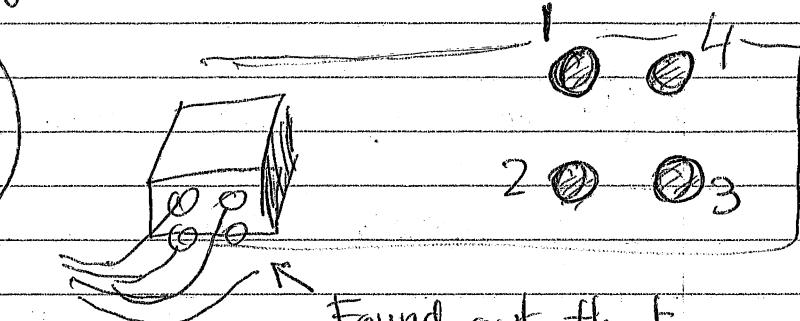
✓ Overflow! \Rightarrow Some wire must be disconnected?

Checking new Mapping of wires

Feedthrough



Screws



Found out that
one wire on the sample holder
was disconnected!

Reattach

• Check connections ok!

$$\begin{array}{l|l} I_{12} = 0 & I_{13} = 0 \\ V_{3h} = 100 \mu\text{V} \text{ ok!} & V_{2h} = 100 \mu\text{V} \text{ ok!} \end{array}$$

5 pm

Mount in chamber

- Pump

- Work on electronics

Keithley 4-wire does NOT communicate.

\Rightarrow Try 2 sets of Keithley 1 \rightarrow current $100 \mu\text{A}$
Keithley 2 \rightarrow voltage OUTPUT Signal

Setting Hall configuration (CROSS)

$$I_{12} = 0 \mu\text{A}, V_{24} = 250 \mu\text{V}$$

did not change
with field was current

Moving the sample around in X, Y, Z, 0

\Rightarrow Produce a change in voltage.

Now found a stable Voltage!!

Try again: Van der Pauw

$$I_{12} = 0 \mu\text{A} \quad +100 \mu\text{A} \quad -100 \mu\text{A}$$

$$V_{34} = 0 \mu\text{V} \quad +47 \mu\text{V} \quad -47 \mu\text{V} \quad \text{OK!}$$

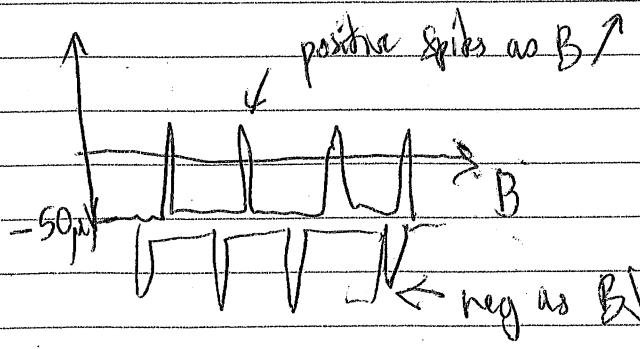
Communication with computer, worked!

Setting a menu for loop measurement

Trying on
parallel measurement

$$I = -100 \mu\text{A}$$

Scan #20, 21



Workspace #7

pssd: pyvisa

psd located in S4IDC/data/20B-1/Chevel - Apr 2018

Try with $I_{12} = +100 \mu\text{A}$, measuring V_{34} mean value $\approx 50 \mu\text{V}$

Scan #22 still spikes on ascending
No spikes on descending

Scan #23

"Settling" time $\Delta t = 1 \text{ sec}$

SpiKes are gone!

* Switching to Hall measurement

$I_{13} = +100 \mu\text{A}$, measuring $V_{24} \approx 18 \mu\text{V}$

Scan #24 Sch (-50, +50, 1, 0.5)

Scan #25 Sch (-50, +50, 1, 2) 10 min

dwell time
(= measurement)

7pm Mount the gyrostat to be ready to cool down

$I_{13} = +200 \mu\text{A}$ measuring $V_{34} \approx 36 \mu\text{V}$

26 Sch (-50, +50, 1, 2)

$I_{13} = +300 \mu\text{A}$ measuring $V_{24} \approx 55 \mu\text{V}$

27 Sch (-50, +50, 1, 2)

04/06/18

Hall measurement		300K	$R_{Hall} \approx \frac{20}{100} = 0.2 \Omega$
1.30 pm	Sch (-50, +50, 1, 2)		\checkmark_{24} (avg)
$I_{13} = +100 \mu A$	Scan # 25	18 μV	
+200 μA	scan # 26	36 μV	
(each scan 10 min)	+300 μA	# 27	56 μV
	+400 μA	# 28	75 μV
	+500 μA	# 29	95 μV
	+600 μA	# 30	113 μV
$R_{Hall}^{(II)} \approx 0.19 \Omega$	+700 μA	# 31	132 μV
	+800 μA	# 32	152 μV
(switch time has switched to 0.5 s somewhere)	+900 μA	# 33	170 μV
	+1000 μA	# 34	190 μV
We start to see the Hysteresis!	= 1 mA		
	2 mA	# 35	+380 μV
	3 mA	# 36	570 μV
Nice Visible Hysteresis!	4 mA	# 37	760 μV
	5 mA	# 38	955 μV
	10 mA	# 39	1.91 mV
	20 mA	# 40	3.8 mV

9:30 pm

Scan sch (-50, +50, 1, 0.5) + settling 1s

$$I_{13} = 40 \text{ mA} \quad \text{Scan # 41} \quad V_{24} \approx 7.6 \text{ mV}$$

$$= 60 \text{ mA} \quad \text{Scan # 42} \quad V_{24} \approx 11.4 \text{ mV}$$

$$= 80 \text{ mA} \quad \text{Scan # 43} \quad V_{24} \approx 15.5 \text{ mV}$$

$$= 100 \text{ mA} \quad \text{Scan # 44} \quad V_{24} \approx 19.4 \text{ mV}$$

10 pm Back to 20mA Scan # 45 $V_{24} \approx 3.85 \text{ mV}$
opening the other way

$$40 \text{ mA} \quad \text{# 46} \quad V_{24} \approx 7.62 \text{ mV}$$

$$30 \text{ mA} \quad \text{# 47} \quad V_{24} \approx 5.72 \text{ mV}$$

Loop is closed again! Choose to work at 30 mA.

Try finer step size: Sch (-50, +50, 0.5, 1)
(and settling time 0.5 s)

$$I_{13} = 30 \text{ mA} \quad V_{24} \approx 5.69 \text{ mV}$$

$$\text{" " " } \text{sch} (-50, +50, 0.25, 1) + 0.5s$$

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$$\text$$

71 pm

$$I_{13} = 30 \text{ mA}$$

$$V_{24} = 5.76 \mu\text{V}$$

Sample PERPENDICULAR TO FIELD

turned
 $x=0$
for moving

$$\theta = 130''$$

$$X = 3.0, Y = -4.0, Z = 5.0 \text{ mm}$$

(exact beginning of scan, we are at 0) then switched to 30 mA

51

$$I_{13} = 30 \text{ mA}, V = 5.75 \mu\text{V} \text{ sch}(-50, +50, 0.25, 1) + 0.25$$

52

Noisy signal, repeat to see if stabilized (9 min)

52

Same scan, Now ugly shape (7)

Bring sample down

$$Z = 2 \text{ mm}$$

53

$$\text{Quick scan sch}(-50, +50, 1, 1) + 0.25$$

54

$$\text{sch}(-50, +50, 1, 1) + 0.5 \text{ s.}$$

Rotate by another 5° ($\theta = 135$) ($X = 5, Y = -4, Z = 2 \text{ mm}$)
(To recenter)

55

$$\text{sch}(-50, +50, 1, 1) + 0.5 \text{ s.}$$

Lower sample further. ($Z = 0$)

56

$$\text{sch}(-50, +50, 1, 1) + 0.5$$

Very noisy, increase settling to 1

57

$$\text{sch}(-50, +50, 1, 1) + 1$$

(4 min)

Magnet behaves weird, with going backward.

Decide to increase I_{13} ...

$$\theta = 135, X = 5, Y = -4, Z = 0$$

00 am

Sample re-centered at 90° in octupolemeasuring V_{24} V_{24}

$$I_{13} = 30 \text{ mA}, \text{ sch}(-50, +50, 1, 1) + 1 \approx 5.74 \mu\text{V}$$

58

$$I_{13} = 40 \text{ mA}$$

$$\approx 7.7 \mu\text{V}$$

59

$$I_{13} = 50 \text{ mA}$$

$$9.61 \mu\text{V}$$

60

$$I_{13} = 60 \text{ mA}$$

$$11.5 \mu\text{V}$$

61

$$I_{13} = 80 \text{ mA}$$

$$15.6 \mu\text{V}$$

62

$$I_{13} = 100 \text{ mA}$$

Very noisy!! $19.5 \mu\text{V}$
here very noisymove $Y = -7$

63

$$I_{13} = 100 \text{ mA}$$

↑ and smooth here!

effect is gone!!! ?? (is current too strong?)

$$Z = 0.5$$

$$I_{13} = 20 \text{ mA}$$

back to $\theta = 115^\circ, X = 5, Y = -7$

64

$$\theta = 115 \quad (\Delta\theta \approx 20^\circ)$$

65

$$\theta = 120 \quad (\Delta\theta \approx 15^\circ)$$

66

$$\theta = 125 \quad (\Delta\theta \approx 10^\circ)$$

67

$$\theta = 130 \quad (\Delta\theta = 5)$$

68

$$\theta = 135 \quad (\Delta\theta = 0)$$

effect is gone!?

Is the field applied in right direction?

$$I_{13} = 20 \text{ mA}$$

$$x=5, y=-7, z=0.5$$

$\theta(^\circ)$ $\Delta\theta(^\circ)$ (from perpendicular position)

68

135

θ (effect gone)

69

90

(45) ~~strong effect!~~

70

45

90  X-ray direction

\rightarrow Signal at 45 mV

Something opened!

71

90

(45) Signal is back! $V \approx 3.8 \text{ mV}$

(Same as # 69)

72

80

55 Voltage back to front!

Awful ↑

Voltage trips when $\theta = 80^\circ$ ($\Delta\theta \approx 55^\circ$)

73

90

(45) Signal back (same as # 71)

74

95

40 

75

100

35 Looks like scans

at 45° gives the

76

105

30 best magnetooptic

77

110

25 contrast!

78

115

20 effect gone!

79

120

15 effect gone!

80

125

10 effect gone!

81

130

5 Signal lost

82

135

0

2:30

Choose $\theta = 45^\circ$?? $x = 5, y = -7, z = 0.5$

83

$I = 20 \text{ mA}$

Sch (-50, +50, 1, 1) +

84

$I = 30 \text{ mA}$

"

85

$I = 40 \text{ mA}$

86

$I = 50 \text{ mA}$

{ somewhat improves
the noise

87

$I = 60 \text{ mA}$

 starts opening

88

$I = 50 \text{ mA}$

Sch (-50, +50, 1, 1) + 1 (4 min 15 s)

89

V_{24}

Sch (-50, +50, 1, 1) 0.5 (3 min 30 s)

90

V_{24}

Sch (-50, +50, 0.5, 1) 0.5 (6 min)

91

V_{24}

Sch (-50, +50, 0.5, 1) 0.25 (5 min 55 s)

92

V_{24}

Sch (-50, +50, 0.25, 1) 0.25 (9 min 20 s)

93

V_{24}

Sch (-50, +50, 0.5, 2) 0.25 (8 min 30 s)

Looks like we are not gaining much more info by going to 250e steps compare to 500e steps

\Rightarrow can work with (500e steps) and 250e

This was $I_{13} = 50 \text{ mA}$ $V_{24} \approx 9.6 \text{ mV}$

slowly decrease $I \rightarrow 0$

3:45 am

Switch to I

24

0 μA	0
100 μA	170 mV
200 μA	380
400 μA	800
600 μA	1230
800 μA	1640
1 mA	2 mV
2 mA	4 mV
4 mA	8.5 mV
6 mA	12.5 mV
8 mA	16 mV
10 mA	20 mV

$$(2) R_{HALF} = 2 \Omega$$

10x bigger!

(??)

(5 min)

(10 min)

#94

24

Slowly I $\rightarrow 0$

Back to I

13

 $\rightarrow 50 \text{ mA}$

(5 min)

#95

Sch. (-50, +50, 0.5, 1) 0.25

OK! signal is back and consistent with

#93

V₁₃

0

170 mV

380

800

1230

1640

2 mV

4 mV

8.5 mV

12.5 mV

16 mV

20 mV

Now

Look at Magneto resistance (parallel)

First check I_{13} and V_{13} (same leads)0 44 μV 10 μA 80 μV 50 μA 320 μV 100 μA 680 μV 500 μA 3.28 mV

1 mA 6.5 mV

2 mA 12.9 mV

5 mA 32 mV

10 mA 64 mV

$$(R_{13} = 6.5 \Omega)$$

$$\#96 \quad (10 \text{ mA}) \quad \text{Sch. } (-50, +50, 0.5, 1) 0.25$$

$$\#97 \quad (20 \text{ mA}) \quad \text{too noisy...}$$

$$I \rightarrow 0$$

$$\text{Now } (I_{12}, V_{34}) \quad (\text{negative})$$

$$100 \mu A \quad 60-80 \mu V$$

$$500 \mu A \quad 600 \mu V$$

$$1 \text{ mA} \quad 1.3 \text{ mV}$$

$$5 \text{ mA} \quad 7.1 \text{ mV}$$

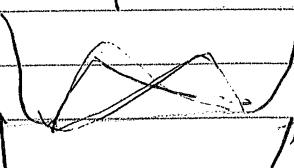
$$10 \text{ mA} \quad 14.3 \text{ mV}$$

$$R_{12,34} \approx 1.4 \Omega$$

5 am

x Van der Pol: Parallel (I_{12}, V_{34})#98 $I_{12} = 10 \text{ mA}$ Sch (-50, +50, 0.5, 1)#99 $I_{12} = 20 \text{ mA}$

noisy

#100 $I_{12} = 30 \text{ mA}$ #101 $I_{12} = 40 \text{ mA}$ peaks at $\pm 4200 \text{ de } (?)$ #102 $I_{12} = 50 \text{ mA}$

= actually dips in positive signal

Strongest signal at 40 mA

 $I \rightarrow 0$ x VdP parallel (I_{34}, V_{12})10 μA 25 μV 100 μA 30 μV 500 μA 38 μV 1 mA 50 μV 5 mA 200 μV 10 mA 380 μV 20 mA 720 μV #103 $I_{34} = 20 \text{ mA}$ #104 $I_{34} = 60 \text{ mA}$ #105 $I_{34} = 60 \text{ mA}$ #106 $I_{34} = 80 \text{ mA}$

6 am

x I_{14}, V_{23} 0 $\mp 3 \mu\text{V}$ 100 μA 200 μV 200 μA 280 μV 500 μA 1 mV

$$R_{14,23} = 2 \Omega$$

1 mA 2 mV

10 mA 20 mV

#107 $I = 10 \text{ mA}$ #108 $I = 20 \text{ mA}$ $I \rightarrow 0$ x I_{23}, V_{14} 0 $\mp 3 \mu\text{V}$ 100 μA 0500 μA 30 μV

$$R_{23,14} = 0.06 \Omega$$

1 mA 50 μV 5 mA 280 μV 10 mA 580 μV #109 $I = 10 \text{ mA}$ #110 $I = 20 \text{ mA}$ $I \rightarrow 0$

N, sign()

Back to original

 I_{13}, V_{24} #111 10 mA 150 μV 100 μA 5 μV

#112 20 mA signal

500 μA 10 μV

#113 50 mA lost (6.1)

1 mA 18 mV

Fidd Cooling (No X-rays)

6:30

Apply field $H = +50 \text{ Oe}$

Cool down : open LHe Valve

Initial LHe Scale = 234

Heater Not functioning?

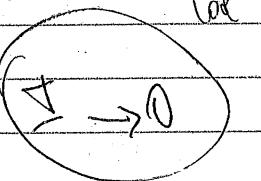
6:45

started cool down $T = 295 \text{ K} \rightarrow$

$\frac{1}{2}$ turn - went very fast $\rightarrow 150 \text{ K}$

$\rightarrow \frac{1}{4}$ turn back up $T \approx 190 \text{ K}$

$\rightarrow \frac{3}{8}$ turn (d slowly down $T_B \rightarrow 50 \text{ K}$)



7:30

$T \approx 50$ still cooling

Leave the beamline to go test

for a few hours.

Note:

in most field scans, there is a problem
with varying the field at 0 $\pm 3000 \text{ Oe}$

Saturday April 7

12:00 (noon) Kaine in

LHe Scale
 $= 233$

$T = "T_{\text{under}}"$??
 C

I assume (Sample is
to be determined later)
we are at low T and stable

Trying to get some transport signal now

	1 pm	I_{13}	V_{24}	
Now	0	50 μV		
R_{Hall}	100 μA	55 μV		Field was
0.02 Ω	500 μA	60		+50 A
only!	1 mA	60 μV		until now
(10 times smaller)	5 mA	122 μV		
there might be a short...	10 mA	195 μV		
→ may be some shortage	20 mA	345 μV		
#114	$I = 20 \text{ mA}$	$Sch (-50, +50, 0.5, 1)$	0.25	
	I_{13}		345 μV	
reverse \rightarrow				
voltage #115	$I_{13} = 30 \text{ mA}$			490 μV
to be				
positive #116	$I_{13} = 40 \text{ mA}$			600 μV
#117	$I_{13} = 50 \text{ mA}$			750 μV

FC low T \leftarrow below $5K$!

	I_{13}	V_{24}	(5 min)
# 114	20 mA	$365 \mu V$	Sch (-50, +50, 0.5, 1)-0.25
# 115	30 mA	490	
# 116	40 mA	620	unclear signal may be evidence of shift of jump.
# 117	50 mA	750	from 5000 \rightarrow 0
# 118	60 mA	920	
# 119	70 mA	$1050 \mu V$	we start seeing a jump @ $100 K$!!
# 120	80 mA	$1200 \mu V$	\Rightarrow BiAs visible!!
# 121	90 mA	$1350 \mu V$	
# 122	100 mA	$1480 \mu V$	still very noisy $100 K$
			Increase statistics: 1 sec \rightarrow 5 sec / pt (25 min)
# 123	100 mA	1480	Sch (-50, +50, 0.5, 5) +0.25

* checking direction of field: 'field (50)

looks like it is along beam $H = +50 A$

* Open He valve \Rightarrow T starts reading at 5K

Temperature Sensor T - under $< 5K$

when $T_{\text{sensor}} = 5K$ $T_{\text{sample}} \approx 25K$

slightly close He valve $\Rightarrow T_{\text{sensor}} \rightarrow 20K$ (Heater on)

$T_{\text{sample}} \approx 35K$ (maybe)

$T_{\text{sens.}} = 20K$ ($T_{\text{sample}} \approx 35K$)

124 100 mA $1500 \mu V$ Sch (-50, +50, 0.5, 1)-0.25

125 $\theta = 100$ ($D_0 = 35$) \downarrow Sch (-50, +50, 0.5, 1)

126 $\theta = 90$ ($D_0 = 75$)

last signal

* Trying to set Half lap for descending

Meanwhile T fluctuates, (heater trips when $T < 5K$)

\rightarrow close the He valve $T \rightarrow 30K$ (Heater on 20K)

\rightarrow open " slightly $T \rightarrow 12K$ (Heater on 20K)

Finally stabilizes at $\begin{cases} T = 20K \\ \text{sens.} \end{cases} = \text{Base T}$
 \rightarrow at the base of
 the cold finger
 $T_{\text{sample}} \approx 35K$ (according to Beamline)
 experience

4pm

Aligning X-ray beam

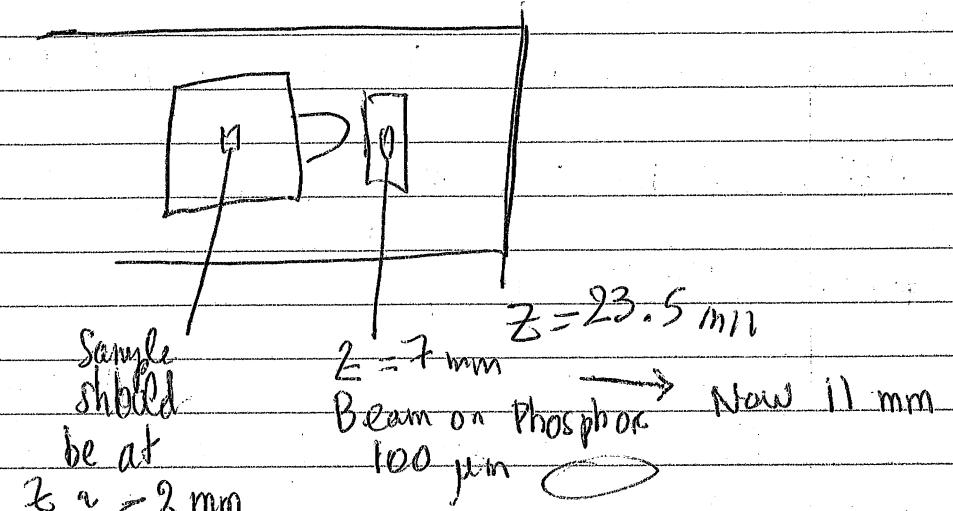
Move sample OUT $X=3, Y=-7, Z=29, \theta=40$

X-ray shutter OPEN

$$I_{\text{RF}} = 270,000$$

$$I_{\text{REF}} \approx 260,000$$

Velocity E
Workspace 2
ID GPU
charge E



Try to go to the sample location of sample can not reach it! (Z limit) = 0!

Move the beam UP ↑ by about 5 mm

Now able to access sample!

Workspace 1

Get file

info ↗
+ CopyReading
KeithleySceng
scxmcdcpIf using Sch \Rightarrow Regular* If using scxmcdcp,h8p \Rightarrow in TFY slot

5pm

Close shutter (No x-rays)

$T \in$ Base sensor $\approx 5K$
 $T_{\text{sample}} \approx 25K$

Bring sample to center of magnet, and where the beam should be

Try magneto-transport measurement again

$$I_{13} = 100 \text{ mA}$$

$$\text{Now } V_{2h} = 13 \text{ mV}!!$$

(Back to R = 0.13 Ω)

#134 Sch(-50, +50, 0.5, 1) + 0.5 s

YES!! NICE SIGNAL BACK! (Moving the sample around something?)

#135 $I_{13} = 50 \text{ mA}$ Sch(-50, +50, 0.5, 1) + 0.5 unclipped

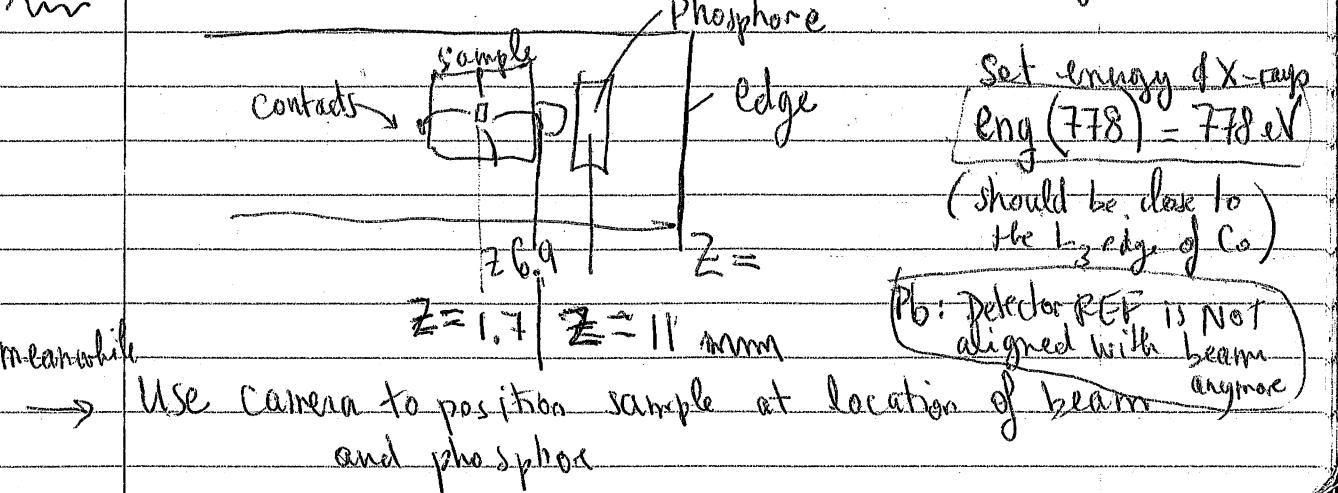
#136 $I_{13} = 50 \text{ mA}$ Sch(-50, +50, 0.5, 2) + 0.25 9 min

#137 Sch (-50, +50, 0.25, 1) + 0.25 9 min

#138 $I_{13} = 100 \text{ mA}$ sch (-50, +50, 0.25, 1) + 0.25 9 min

loops open \Rightarrow back to 50 mA OFF

Next: Illuminate Sample with X-rays (after FC + 50)



meanwhile

$Z = 1.7 \quad Z = 11 \text{ mm}$ (b: detector REF is NOT aligned with beam anymore)

Use camera to position sample at location of beam and phosphore

6pm

X-ray ON

E = 778 eV



Beam roughly illuminating
Sample area

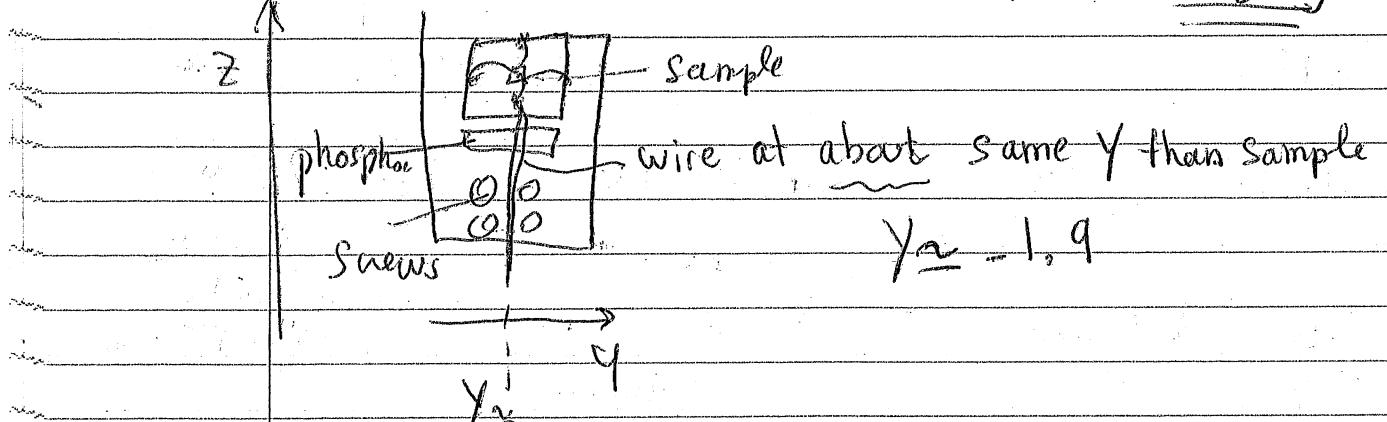
only positioned in $Z = 1.7$

No way to tell with camera \Rightarrow Not sure in y ? $y = -0.7$

$$X = 2.5 \quad Y = -0.7 \quad Z = 1.7 \quad \theta = 90^\circ$$

$$\# 139 \quad I = 50 \text{ mA} \quad \text{sch}(-50, +50, 0.25, 1) + 0.25$$

Go back to Phosphore, move y to the position
where the wire is clipping the beam
 \Rightarrow should refine the y position roughly



$$X = 2.5, Y = -1.9, Z = 1.1, \theta = 90^\circ$$

$$\# 140 \quad I = 50 \text{ mA} \quad \text{sch}(-50, +50, 0.25, 1) + 0.25$$

7pm

Need the detector REF be aligned with x-rays!

Move beam back down a bit

Workspace 6 : M2 VERTICAL

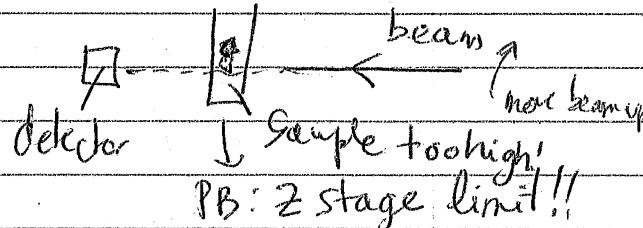
initial

M2 angle : $27.44 \rightarrow 27.22$ (beam went down
by about 1.2 mm)

sample $Z = 1.7 \rightarrow 0.5$ \leftarrow linear

check if see light on detector: no light (x)

impossible to align???



* Stage OUT $Z = 28 \text{ mm}$

Can only get light on detector when $M2 \text{ angle} \approx 25^\circ$

For $M2 \text{ angle} = 25.34^\circ$ $\text{REF} = 107,000$

* Now searching for beam on Phosphor:

Cannot find it ...

To see it back, have to move $M2 \text{ angle} \rightarrow 26.5^\circ$

Phosphor $Z = 6$ to see beam, but no light on REF
 $M2 Z = -0.55$, move to $M2 \theta = 25.46^\circ$ to see
93,000 ch

at this position, the beam is even outside view
of camera!

Beam on $I_0 = 122,000 \text{ d}$ $T \leq 5\text{K}$ [$T_{\text{sample}} \approx 25\text{K}$]

Next: try move the chamber down

Go back to phosphor!

To be able to see light on phosphor
and camera field of view

We have to move M2 angle = 25.84°

\Rightarrow Try move chamber down: (turn wheel)

phosphor ↑ beam spot moves up

Moved chamber down so spot on phosphor is at $Z = 10$

Move stage out ($Z = 28$) \Rightarrow Need to change $M2\theta = 25.24^\circ$
phosphor in: ($Z = 10$) to see beam again

NO LIGHT!

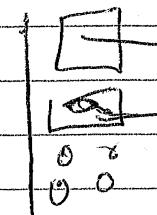
Have to move $M2\theta = 25.82^\circ$

Impossible to align all 3 (Beam + Sample + DET)

$M2\text{ angle} = 26.2^\circ \rightarrow$ get beam on sample
 $a [Z \approx 0.5]$

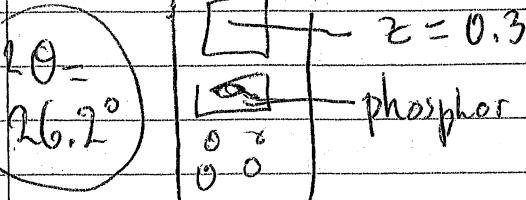
Stage out: REF 0 (1.4° to move to 25.24°)
to get signal

$M2\theta = 26.2^\circ$



$Z = 0.3$

phosphor at $9.7 - Z \approx 9$



Try defocusing beam to illuminate larger portion

* At Focus: $M2\text{ focus} = -0.8$ $Z = 0.3$, $Y = -0.6$
(100 μm beam)

141 $I = 50 \text{ mA}$ sch (-50, +50, 0.25, 1) voltage still = 6.8 mV

* Defocused: $M2\text{ focus} = -0.4$. moved vertically too
beam size? Scan # 142 $Z = 0.3$ $Y = 0.6 \text{ mm}$

Stay defocused and move Y at fixed $Z = 1.0$

142 $Y = -0.6$ $Z = 1.0$

143 $Y = -1.0$ sch (-50, +50, 0.25, 1)

144 $Y = -1.5$ $Z = 0.7$

145 $Y = -1.8$ $Z = 0.4$ ← wire dipped Y

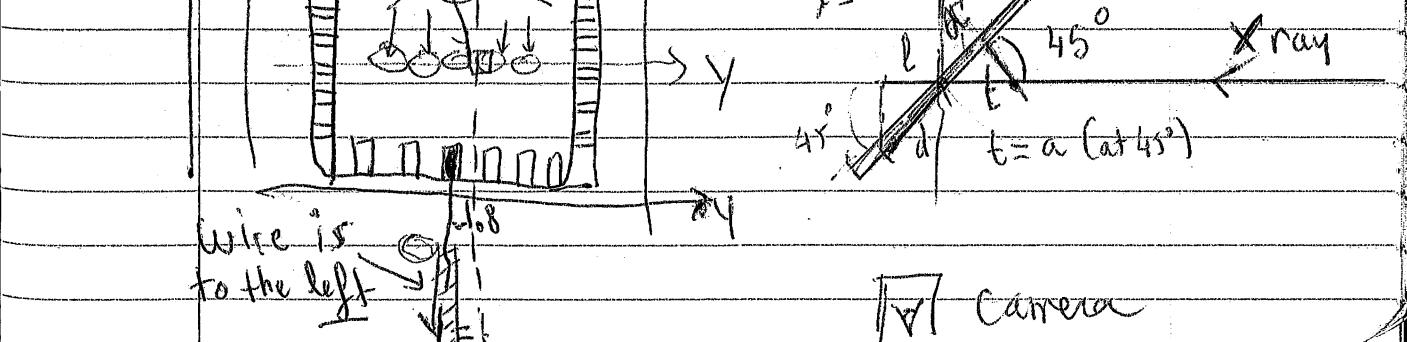
146 $Y = -2.0$ $Z = 0.3$

147 $Y = -2.2$ $Z = 0.3$

148 $Y = -2.4$ $Z = 0.2$

149 $Y = -2.8$ $Z = 0$ motion displacement $\Delta Y \rightarrow \Delta z$

Various spot positions Y $0.9 \Delta Y$

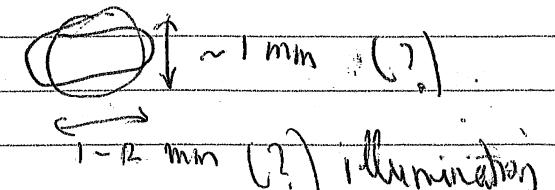


10:30

Go to $y = -2.0$ (biggest shifting effect)and study as function of z # 146 $y = -2.0 \quad z = 0.3$ # 147 $y = -2.0 \quad z = 0.1$ # 151 $z = 0.5$ # 152 $z = 0.7$

David came to help with alignment

Beam - chamber realignment

M1 Horizontal : $\theta = 12.06$, Focus = -0.28M2 Vertical : $\theta = 26.58$, Focus = -0.30Now spot on phosphor at $z \approx 10.0$ Study as a function of position on sample
with beam Fully Defocused in both direction

11:30 pm

 $|z=0|$ $I = 50 \text{ mA}$ $T_{\text{sample}} = 25 \text{ K}$ # 150 $y = 0.6 \quad \text{Sch } (-50, +50, 0.25, +1)$ # 151 $y = 0.3$ # 152 $y = 0$ # 153 $y = -0.3$ # 154 $y = -0.6 \leftarrow \text{write clip}$ # 155 $y = -0.9$ # 156 $y = -1.2$ # 157 $y = -1.5$ # 158 $y = -1.8$

159 shutter closed (still there, maybe reminiscence?)

 $|z = 1 \text{ mm}|$ # 160 $y = 0.6 \quad \text{shifted back! by about 100 De}$ # 161 $y = 0$ # 165 $y = -2.5$ # 162 $y = -0.6$ # 166 $y = -5.0$ # 163 $y = -1.2 \leftarrow \text{Total shift} \approx 1300 \mu\text{m}$

still there (?)

164 $y = -1.8$ # 165 $y = -2.5$

2:45 am

#167 Shutter closed (9 min)

#168 again (9 min)

Shutter open ($I_0 \approx 180,000$)

#169 $Y = +0.6$, \rightarrow Bias back!!

What is with this position??

#170 $Z = 2 \text{ mm}$, $Y = +0.6$ shifted now

#171 $Z = 2.0$, $Y = +0.6$

#172 $Z = 2.0$, $Y = -1.8$

#173 $Z = 2.0$, $Y = -1.8$

#174 $Z = 4.0$, $Y = -0.6$

#175 $Z = 5.0$, $Y = -0.6$

Shutter closed

#176 $Z = 1$, $Y = +0.6$

Shutter open

#177 $Z = 1$, $Y = +0.6$

still there (?)

5 am

Out of curiosity, looking at signal when close to Perpendicular

#177 $\theta = 110$ $X = -1.0$, $Z = 0$

#178 $\theta = 135$

$T < 5K$

$T_{\text{sample}} = 25K$

Back to

$\theta = 90$, $Y = -1.0$, $Z = 0$

* Effect of beam intensity: $E = 804$, $I_0 = 240,000$

Scan #	Defocused E (eV)	I_0
179	800	250,000
180	820	177,800
181	840	124,700
182	860	14,900
183	880	62,000
184	900	44,500
185	950	28,600
186	1000	22,200
187	1050	16,400
188	1100	14,500
189	1150	12,750
190	1200	9,760

Done at 7:34 am

Close shutter + close LHe Valve OK

Sunday April 8

10 am

David Ikkaiine

$LHe = 230$

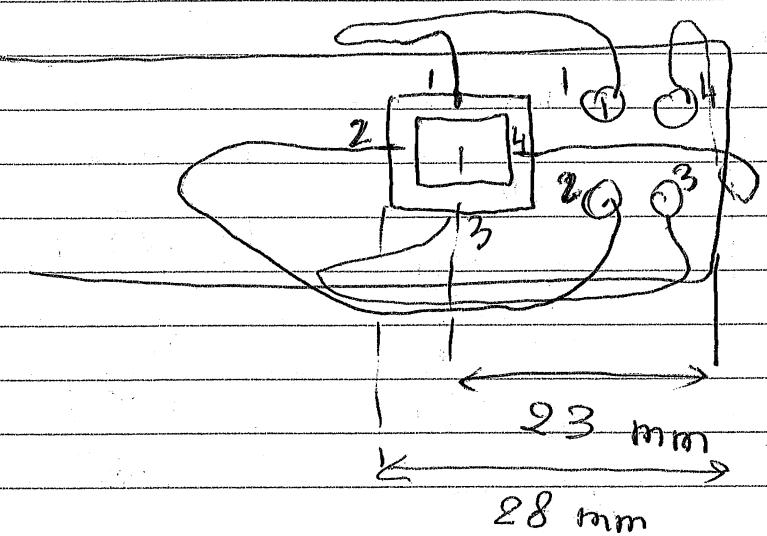
$T \approx 130K$ Set heater up $T \uparrow 300K$

10:30

open chamber

Slide the Sample down on holder

Re-secure wires

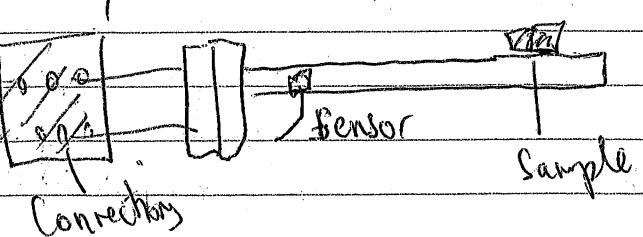


Checked Contacts: in 4 wire mode

parallel $R \approx 0.5 \Omega$

Cross $R \approx 0.2 \Omega$

Also, connect thermo couple



12:00 Insert Sample in chamber and pump down

Check contact parallel $R \approx 0.478 \Omega$ OK

Cross $T_{23} R \approx 0.66 \Omega$

$T_{13} R \approx 0.66 \Omega$

to get the
Plotting window
Pyinca

in workspace? that is about 3 time bigger

Reset 0 to physical position

While pumping, check magnet transport
 $P = 3.10^{-10}$ mBar

191, 192, 193 weird Sch (-50, -150, 1, 0.5) +0.25

Weird! does NOT go to -50 but only -25 and has some peaks again.

194 Sch (-50, +50, 1, 1) +0.25

peaks disappeared at 15, but the range is still off ~ [-2500, +2500]

195 Y=0 Sch (-50, +50, 1, 1) +0.25

{ Troubleshooting magnet power supplies ..

ALARM \rightarrow OFF \rightarrow STBY \rightarrow ON

Clear Faults

196 Sch (-45, 45, 1, 1) worked!

197 Sch (-50, +50, 1, 1)

1 pm

$$\theta = 45^\circ$$

$$T = 300 \text{ K}$$

S1

Optimizing measurement of magnetotransistor

197

$$I = 10 \text{ mA} \quad \text{sch}(-50, +50, 1, 1) \quad 6.6 \text{ mV}$$

198

$$I = 20 \text{ mA} \quad "$$

199

$I = 30 \text{ mA}$) \leftarrow magnet tripped twice!

200

$$I = 30 \text{ mA} \quad \text{sch}(-45, 45, 1, 1) \quad \leftarrow \text{magnet tripped!}$$

201

$$I = 30 \text{ mA} \quad \text{repeat, OK}$$

202

$$I = 40 \text{ mA} \quad 26.4 \text{ mV} \quad P = 8 \cdot 10^{-7}$$

203

$$I = 50 \text{ mA} \quad \leftarrow \begin{array}{l} \text{cleaner signal but} \\ \text{loop opens} \end{array}$$

204

$$I = 30 \text{ mA} \quad \text{sch}(-45, 45, 0.5, 1) \quad \text{loop crosses}$$

205

$$I = 40 \text{ mA} \quad "$$

206

$$I = 35 \text{ mA} \quad V = 23.5 \text{ mV}$$

Magnet trips! Looks like loop closes

207

$$I = 35 \text{ mA} \quad \text{sch}(-45, 45, 0.25, 1)$$

↑ This configuration was actually parallel

Now Magnet tripping all the time!

$$I_{14} \quad V_{23}$$

2:30

Now CROSS $I_{13} \quad V_{24}$

$$I = 35 \text{ mA} \quad V_{24} = 6.6 \text{ mV}$$

13

208 Scan sch(-45, 45, 0.25, 1) (negative voltage) \rightarrow tripped

209 sch (-45, +45, 0.5, 1) (positive V)

210 211 212 magnet tripped!!! and inconsistent sweep

$$I_{24} = 35 \text{ mA} \quad V_{13} = ?$$

→ PB: Octupole Magnet keeps tripping!!

as soon as reset, trips again!!

Now constantly tripping!

* WORK on sample alignment

OPEN valves

OPEN shutter

eng (778) tuned back

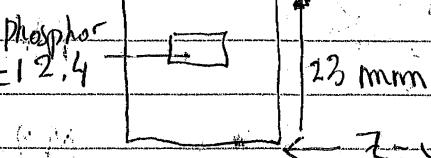
Find signal on detector: \times angle = 0.0

- beam on phosphor OK

$$I_0 = 274,000$$

DET =

→ Plug in edge at z



$$\text{Recent } X = 6.0$$

Recent Y from $\rightarrow Y = -5$
(using phosphor at 70°)

3rd 4 pm Troubleshooting magnets:

Pole ① +50 ② -50 ③ +50 ④ -50
 Pole ⑤ -50 ⑥ +50 ⑦ -50 ⑧ +50

Pole ① gives the sign

$H = 4750 \text{ Oe}$ with $\theta = 89^\circ, d = 0$
 (along beam)

Identified that Pole ④ is defective!

\Rightarrow CLAMP Pole ④

Same but with ④ at $I=0$; (CLAMP)
 using 7 poles gives $H = 4313 \text{ Oe}$ with $\theta = 78^\circ, d = 7$

Now with ④ and ③ at $I=0$. (CLAMP)

gives $H = 4156 \text{ Oe}$ with $\theta = 65^\circ, d = 18^\circ$
 $\sin \theta = 0.9 \times \cos \theta = 0.925$

Realigning beam: KB mirrors
 Beam Focused

M1: $\theta = 11.88^\circ, Y = 0.66$ Focus -0.64

M2: $\theta = 26.58^\circ, Z = -1.65$, Focus -0.60

had to readjust Z!

5pm

Lost the beam alignment

The highest current can get on mesh is $I_0 = 35,000$

Tried to move KB mirrors in all possible directions

Max can get on $I_0 \approx 33,000$

$M_2: \theta = 26.58^\circ, Z = 0.25$

Gave up on beam for now

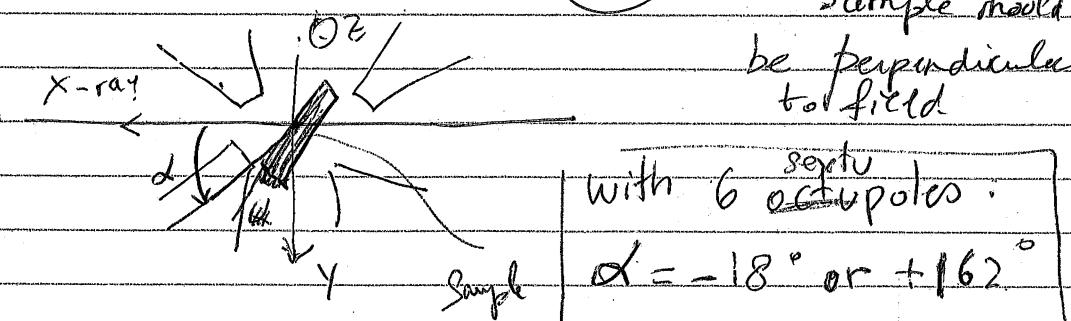
Focus on magneto-transport with 6 poles

Sample seems centered in magnet at about

$Z = 0$

$X = 5, Y = -4$ seems centered

Go to $\theta = 90^\circ + 18^\circ = 108^\circ$ \leftarrow this way
 Sample should be perpendicular to field



checked during scan; ok!

Hall # 214 $I = 35 \text{ mA}$ Sch (-45, +45, 0.5, 1) max field = 3200 G
 13

6pm $\theta = 72^\circ$ $I_{13} = 35 \text{ mA}$, measure V_{24} $E = 778 \text{ eV}$

#1915 Sch $(-50, +50, 0.5, 1)$ with 6 poles only

look like the current gets blocked at 30

#216 Back to $(-40, 40, 0.5, 1)$ ↑ Field

Stays to reach these values Values
Very unstable

#217 $\theta = 72^\circ$ $(-40, 40, 0.25, 1)$ & bit more stable
(Inconsistent sweep)

#218 $\theta = 90^\circ$, Sch $(-40, +40, 0.25, 1)$ 10 min

#219 $\theta = 108^\circ = (90+18)$

#220 $\theta = 45^\circ$ ↪ Best contrast (flipped upside down)

#221 $\theta = 45 - 18 = 27^\circ$ ↪ Stage voltage ($V \approx 50 \text{ mV}$)

$\theta = 45^\circ$ Now I_{24} measure V_{13}

#222 $\theta = 45$ sch $(-40, +40, 0.25, 1)$ ↪ Bad signal $V \approx 50 \text{ mV}$

#223 $\theta = 72^\circ$ sch $(-40, +40, 0.25, 1)$ ↪ $V \approx 50 \text{ mV}$

Now I_{12} V_{34}

#224 $\theta = 72^\circ$ sch $(-40, +40, 0.25, 1)$ $V \approx 16 \text{ mV}$

#225 $\theta = 45^\circ$ sch $(-40, +40, 0.25, 1)$ $V \approx 16 \text{ mV}$?

Yellow 4
Now $I_{14} = 35 \text{ mA}$, V_{23}

$X = 5, Y = -4, Z = 0$

#226 $\theta = 45^\circ$ sch $(-40, +40, 0.25, 1)$

45° NOT good
of angle

#227 $\theta = 72^\circ$ sch $(-40, +40, 0.25, 1)$

72° MUCH BETTER

Come back to $I_{13} = 35 \text{ mA}$, V_{24}

#228 $\theta = 72^\circ$ sch $(-40, +40, 0.25, 1)$ at $\theta = 72^\circ$

Next: FIELD COOLING $FC = +50$

First Heat up to 400K

7:30 David came to align beam:

Tune the KB mirrors

No luck!

Beam is lost

10 pm gave up!

10:10 scan #229 (negative voltage)

10:30 Apply Field $H = +50$

Note: Current
was flowing
while field

Heat up to 400K

10:40 Cool down

Cooling $I = 35 \text{ mA}$

11 pm $T_c \approx 5 \text{ K}$ $T_A \approx 25 \text{ K}$

1:30 am

$$T_A = 21.5 \text{ K}$$

wait until 2 am
for T_{sample} to stabilize

2 am Try magneto transport.

$$T = 21.6 \text{ K.}$$

$$x = 5.0, y = -4, z = 0 \quad \theta = 72^\circ$$

$$I_{13} = 35 \text{ mA} \quad V_{24} = +4.84 \text{ mV}$$

#230 Scan Sch $(-40, +40, 0.25, 1) + 0.25$

(7 min)

barely reaches saturation.

minor loop

#231 Scan Sch $(-45, +45, 0.25, 1) + 0.25$ 8:30 min#232 Scan Sch $(-50, +50, 0.25, 1) + 0.25$ 9:15 min

this one reaches saturation!

Field sweep NOT reliable!

average

#233 Scan Sch $(-50, +50, 0.25, 1) 0.25$ 9:15 min $\theta = 72^\circ$ Measure I_{24} V_{13} for symmetry damage#234 Sch $(-50, +50, 0.25, 1) 0.25$ } average

#235 //

#236 Sch $(-50, +50, 0.25, 2) 0.25$ 18 min } No better

3:30 am

 $\theta = 72^\circ$ I_{12} V_{34}

(Yellow-Green)

#237 Sch $(-50, +50, 0.25, 1) + 0.25$ (negative,
to be switched) I_{14} V_{23} (Yellow-Yellow)#238 Sch $(-50, +50, 0.25, 1) + 0.5$ $T = 27 \text{ K}$ Back to I_{13} (Yellow - Green-dot)shutter was open
for all no change
reading about on top of
LED compared to when
closed.#239 $\theta = 90^\circ$ sch $(+50, +50, 0.25, 2) + 0.25$ $T_A = 29.0 \text{ K}$ #240 $\theta = 72^\circ$ sch $(-50, +50, 0.25, 2) + 0.25$ $T_A = 31.0 \text{ K}$ #241 $\theta = 45^\circ$ $T_A = 31.0 \text{ K}$ #242 $\theta = 90^\circ$ $T_A = 32.3 \text{ K}$ I_{24}

(Green - Yellow dot)

check that
voltage is positive#243 $\theta = 27$ sch $(-50, +50, 0.25, 2)$ $T_A = 33.8 \text{ K}$ #244 $\theta = 45$ $T_A = 34.3 \text{ K}$ #245 $\theta = 72$ $T_A = 33.4 \text{ K}$ #246 $\theta = 90$ $T_A = 33.5 \text{ K}$

7:30 Turn I to zero. Close valve. Warm up

Instructions:

→ Wait for Cryostat to be warm
(may use the heater; set $T = 300\text{ K}$)

→ Wait for David to open chamber
and remove sample holder

→ Delicately remove Carbon tape attaching wires
unscrew the 4 wires from screw
detach chip from c-tape
using tweezers, grabbing from side

→ Put sample back in SEM box
with wires attached

→ Put box in bubble wrap pocket
and keep it securely with you in bag

→ Take this logbook with you

→ Take the data