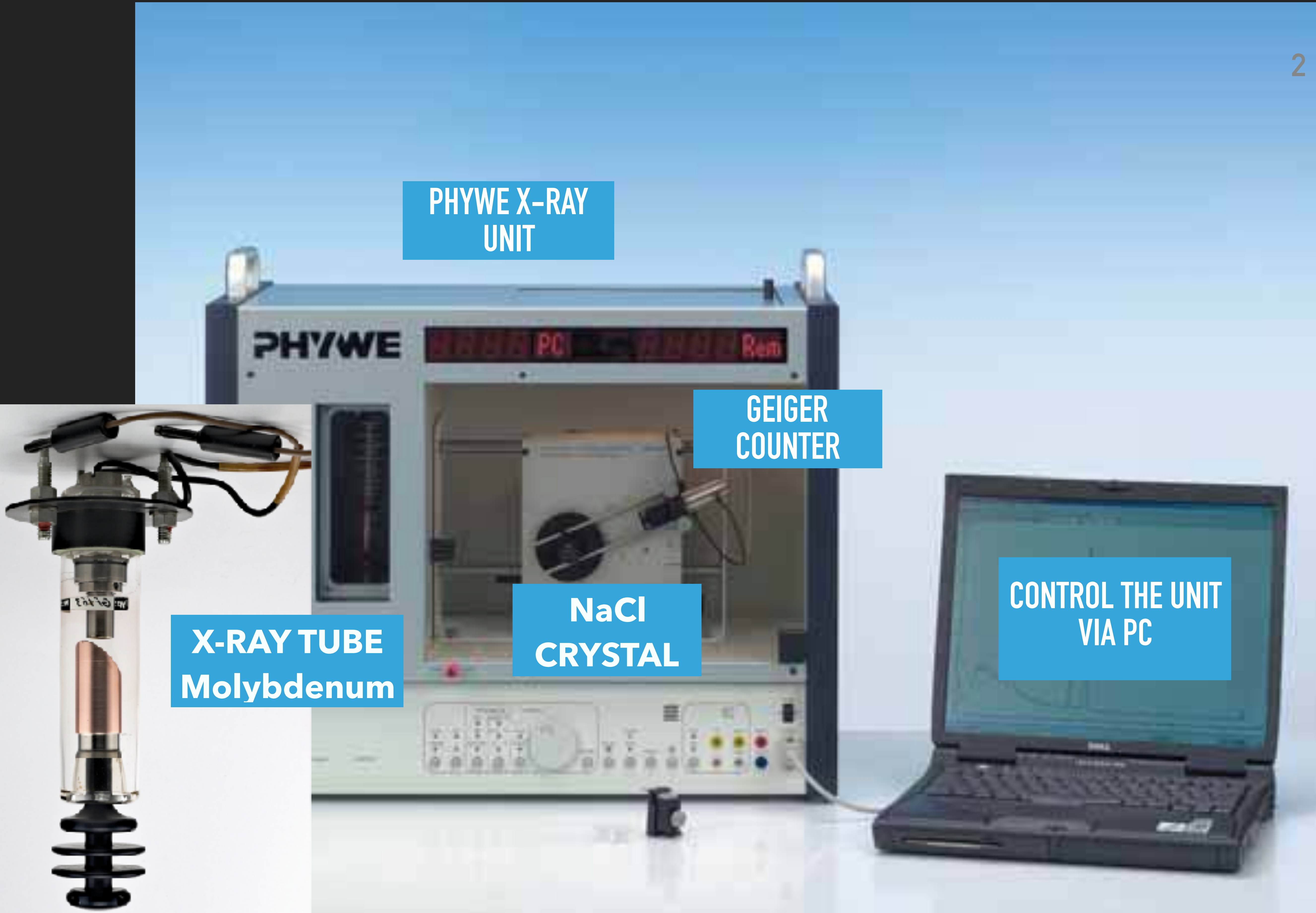
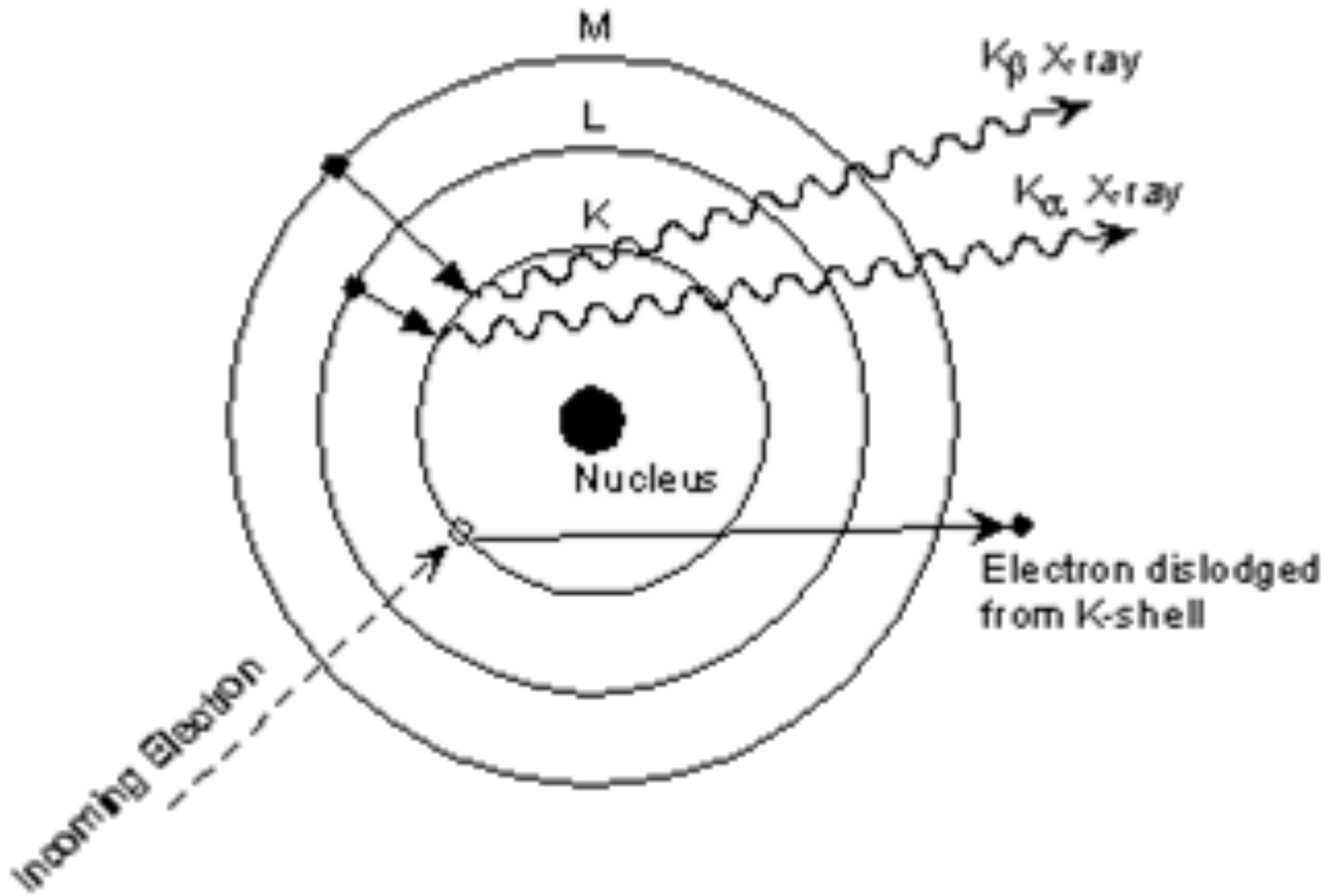
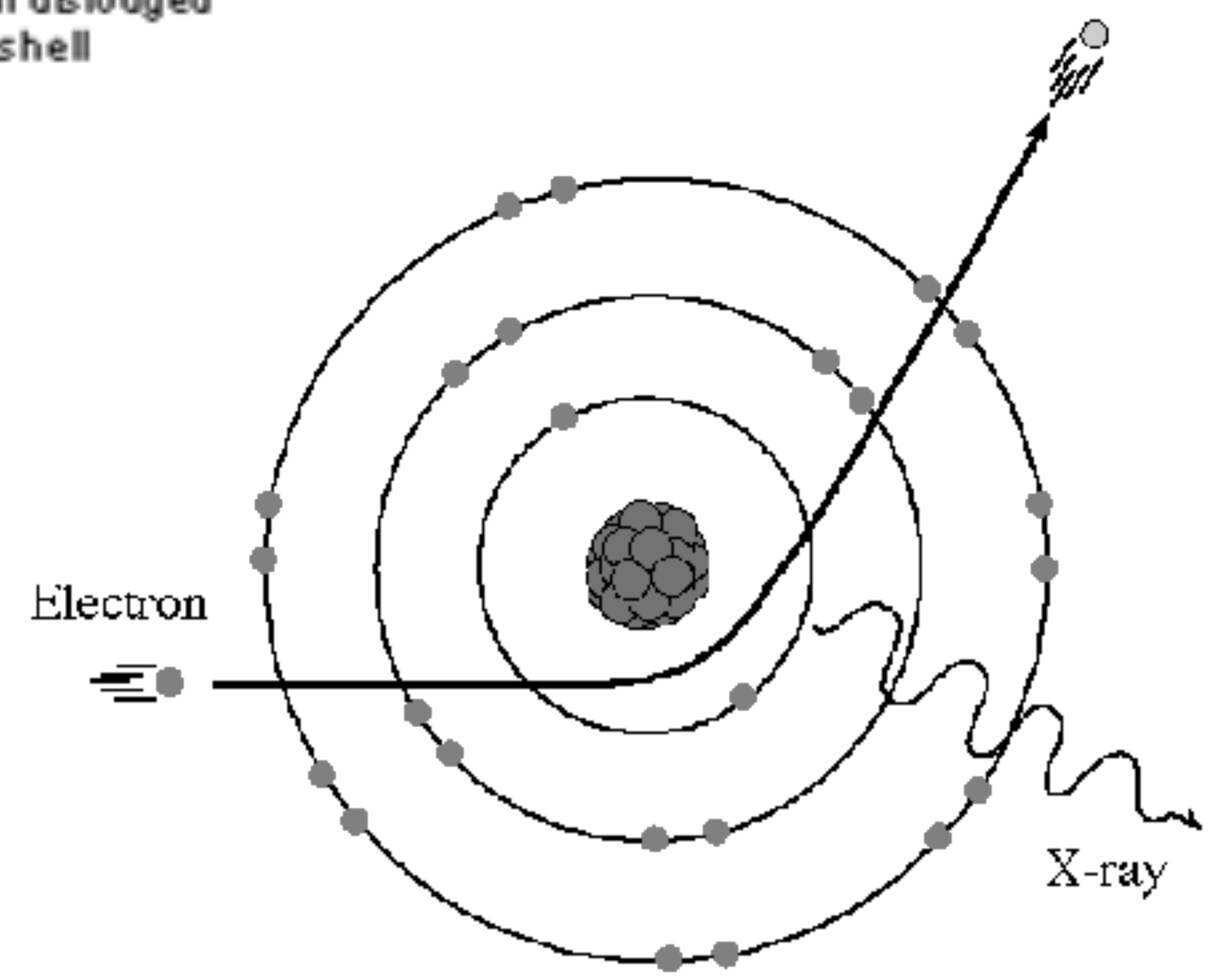
PHYS 442 - SPRING 2019

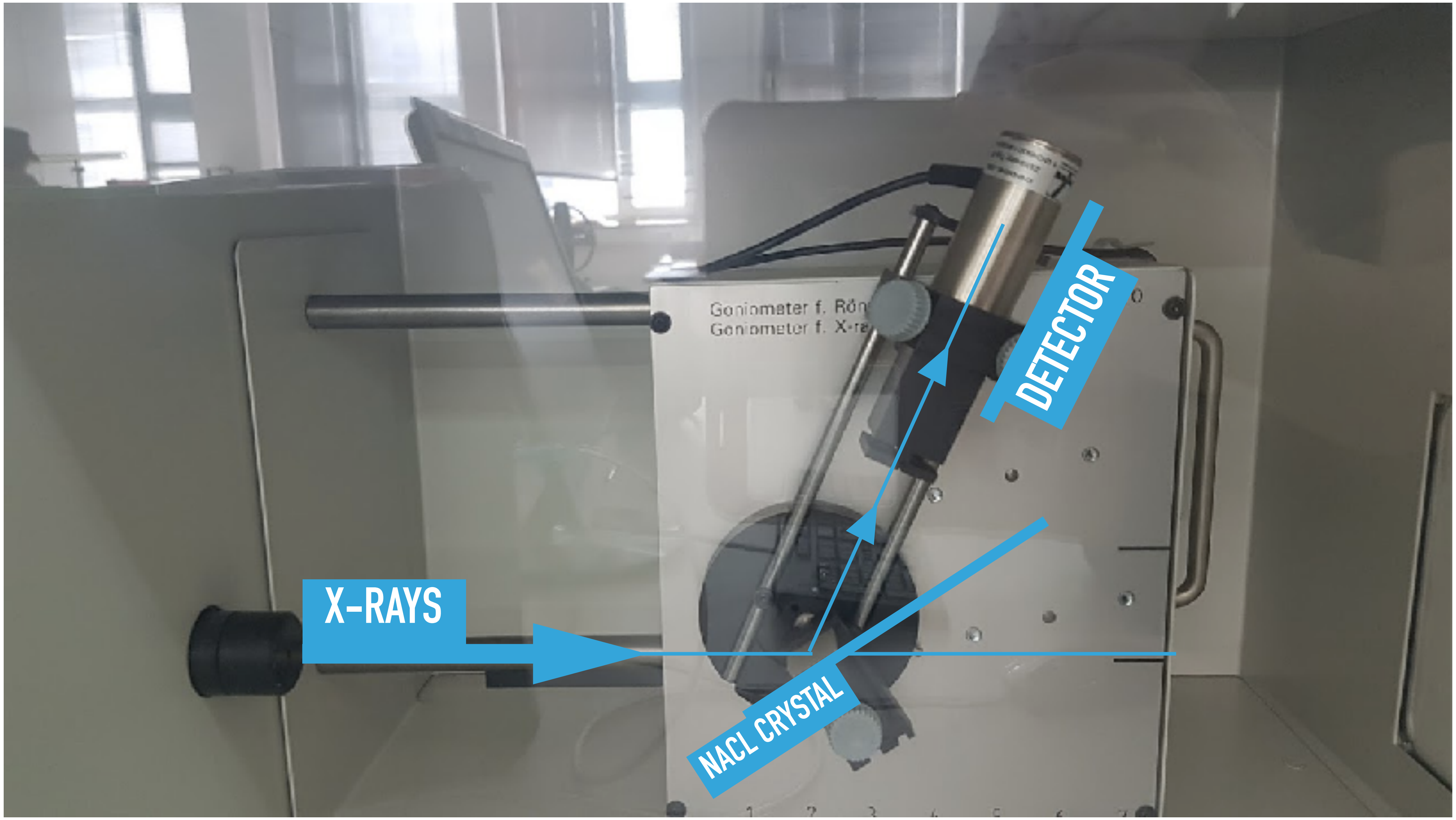
X-RAY EXPERIMENT

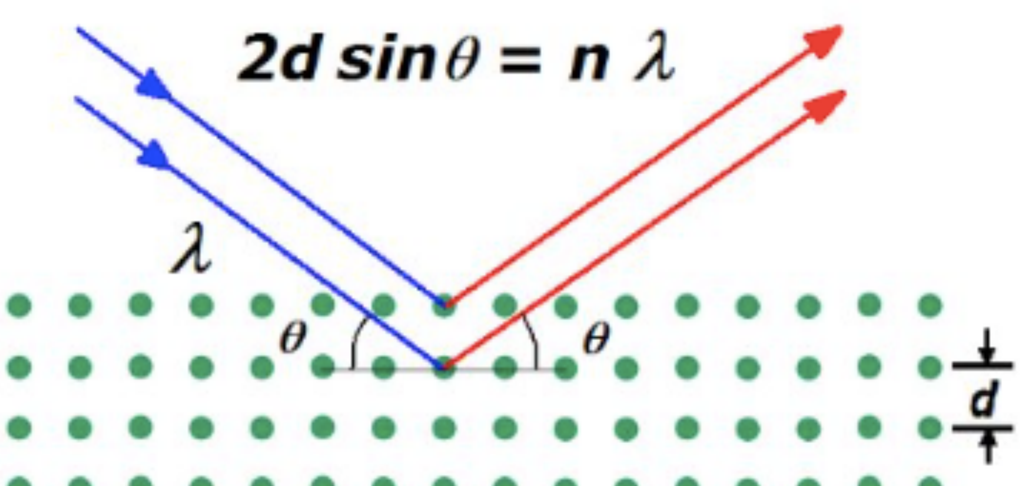

PHYWE X-RAY UNIT
PHYWE
GEIGER COUNTER
NaCl CRYSTAL
CONTROL THE UNIT VIA PC
X-RAY TUBE Molybdenum


M
L
K
Kβ X-ray
Kα X-ray
Nucleus
Electron dislodged
from K-shell
Incoming Electron

$$E = hf$$


Electron
X-ray





$$h\nu_{\mathbf{max}} = qV_{\mathbf{acc}}$$

$$2d\sin\theta = m\lambda,$$

X-RAY EMMISION LINES – K-LEVEL AND L-LEVEL EMISSION LINES IN KEV

No.	Element	Ka1	Ka2	Kb1	La1	La2	Lb1	Lb2	Lg1
3	Li	0.0543							
4	Be	0.1085							
5	B	0.1833							
6	C	0.277							
7	N	0.3924							
8	O	0.5249							
9	F	0.6768							
10	Ne	0.8486	0.8486						
11	Na	1.04098	1.04098	1.0711					
12	Mg	1.25360	1.25360	1.3022					
13	Al	1.48670	1.48627	1.55745					
14	Si	1.73998	1.73938	1.83594					
15	P	2.0137	2.0127	2.1391					
16	S	2.30784	2.30664	2.46404					
17	Cl	2.62239	2.62078	2.8156					
18	Ar	2.95770	2.95563	3.1905					
19	K	3.3138	3.3111	3.5896					
20	Ca	3.69168	3.68809	4.0127	0.3413	0.3413	0.3449		
21	Sc	4.0906	4.0861	4.4605	0.3954	0.3954	0.3996		
22	Ti	4.51084	4.50486	4.93181	0.4522	0.4522	0.4584		
23	V	4.95220	4.94464	5.42729	0.5113	0.5113	0.5192		
24	Cr	5.41472	5.405509	5.94671	0.5728	0.5728	0.5828		
25	Mn	5.89875	5.88765	6.49045	0.6374	0.6374	0.6488		
26	Fe	6.40384	6.39084	7.05798	0.7050	0.7050	0.7185		
27	Co	6.93032	6.91530	7.64943	0.7762	0.7762	0.7914		
28	Ni	7.47815	7.46089	8.26466	0.8515	0.8515	0.8688		
29	Cu	8.04778	8.02783	8.90529	0.9297	0.9297	0.9498		
30	Zn	8.63886	8.61578	9.5720	1.0117	1.0117	1.0347		
31	Ga	9.25174	9.22482	10.2642	1.09792	1.09792	1.1248		
32	Ge	9.88642	9.85532	10.9821	1.18800	1.18800	1.2185		
33	As	10.54372	10.50799	11.7262	1.2820	1.2820	1.3170		
34	Se	11.2224	11.1814	12.4959	1.37910	1.37910	1.41923		
35	Br	11.9242	11.8776	13.2914	1.48043	1.48043	1.52590		
36	Kr	12.649	12.598	14.112	1.5860	1.5860	1.6366		
37	Rb	13.3953	13.3358	14.9613	1.69413	1.69256	1.75217		
38	Sr	14.1650	14.0979	15.8357	1.80656	1.80474	1.87172		
39	Y	14.9584	14.8829	16.7378	1.92256	1.92047	1.99584		
40	Zr	15.7751	15.6909	17.6678	2.04236	2.0399	2.1244	2.2194	2.3027
41	Nb	16.6151	16.5210	18.6225	2.16589	2.1630	2.2574	2.3670	2.4618
42	Mo	17.47934	17.3743	19.6083	2.29316	2.28985	2.39481	2.5183	2.6235
43	Tc	18.3671	18.2508	20.619	2.4240	–	2.5368	–	–
44	Ru	19.2792	19.1504	21.6568	2.55855	2.55431	2.68323	2.8360	2.9645
45	Rh	20.2161	20.0737	22.7236	2.69674	2.69205	2.83441	3.0013	3.1438

http://www.med.harvard.edu/jpnm/physics/refs/xrayemis.html

Characteristic X-ray emission lines for some common anode materials.[15][16]

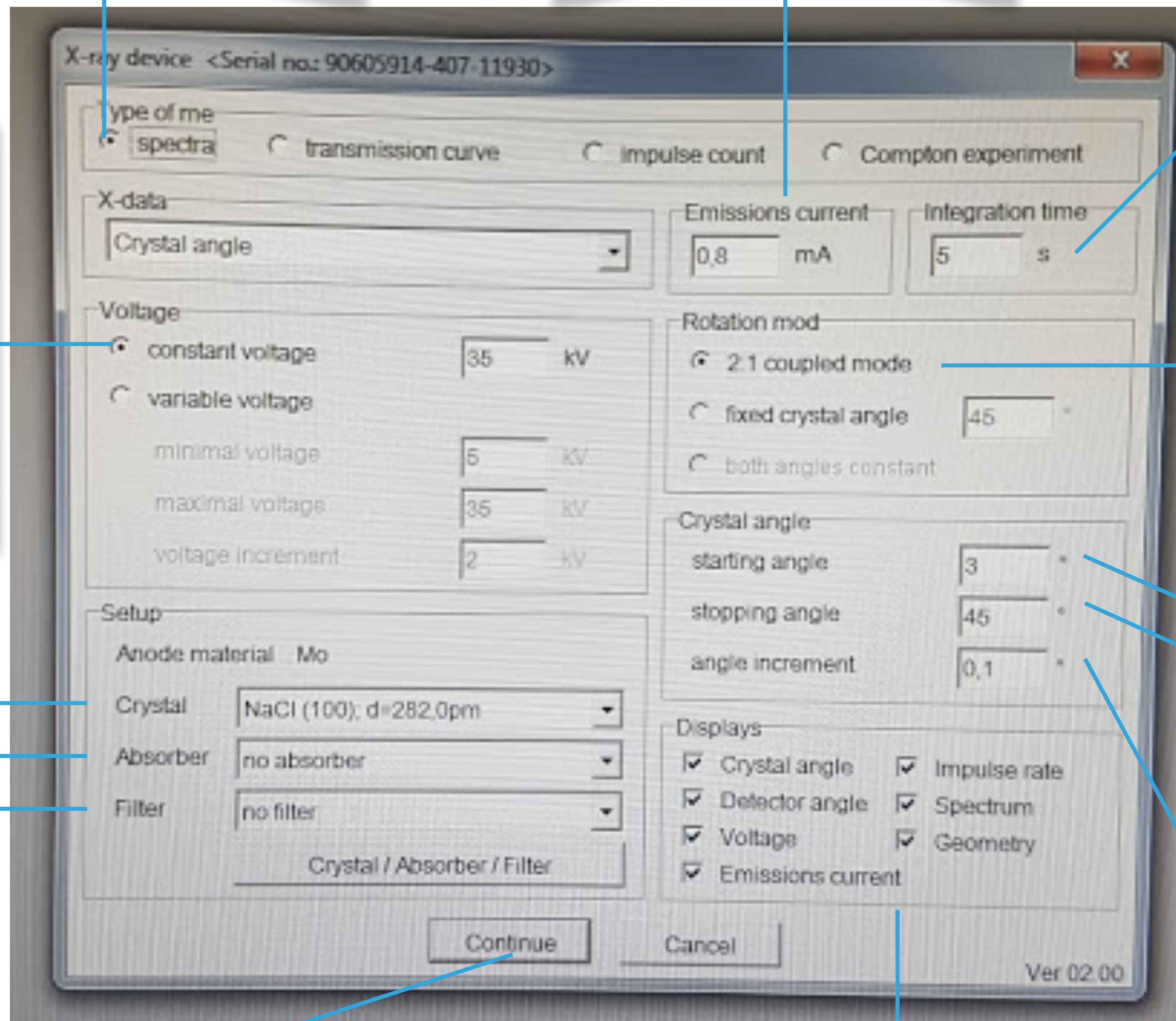
Anode material	Atomic number	Photon energy [keV]		Wavelength [nm]	
		$K_{\alpha 1}$	$K_{\beta 1}$	$K_{\alpha 1}$	$K_{\beta 1}$
W	74	59.3	67.2	0.0209	0.0184
Mo	42	17.5	19.6	0.0709	0.0632
Cu	29	8.05	8.91	0.154	0.139
Ag	47	22.2	24.9	0.0559	0.0497
Ga	31	9.25	10.26	0.134	0.121
In	49	24.2	27.3	0.0512	0.455

https://en.wikipedia.org/wiki/X-ray

We are taking spectrum

Just leave it constant

- We are using constant voltage.
- 35kV for calibration part
- 15-18-21-…-30kV for second part



Will wait for 5 sec for each data

Detector angle is twice the the crystal angle

- Start with 3^0
- Up to 45^0 for the first part and 20^0 for the second part
- Increment angle 0.1^0

NaCl crystal with no absorber with no filter

Press continue when you are done and do not forget to start in the next page

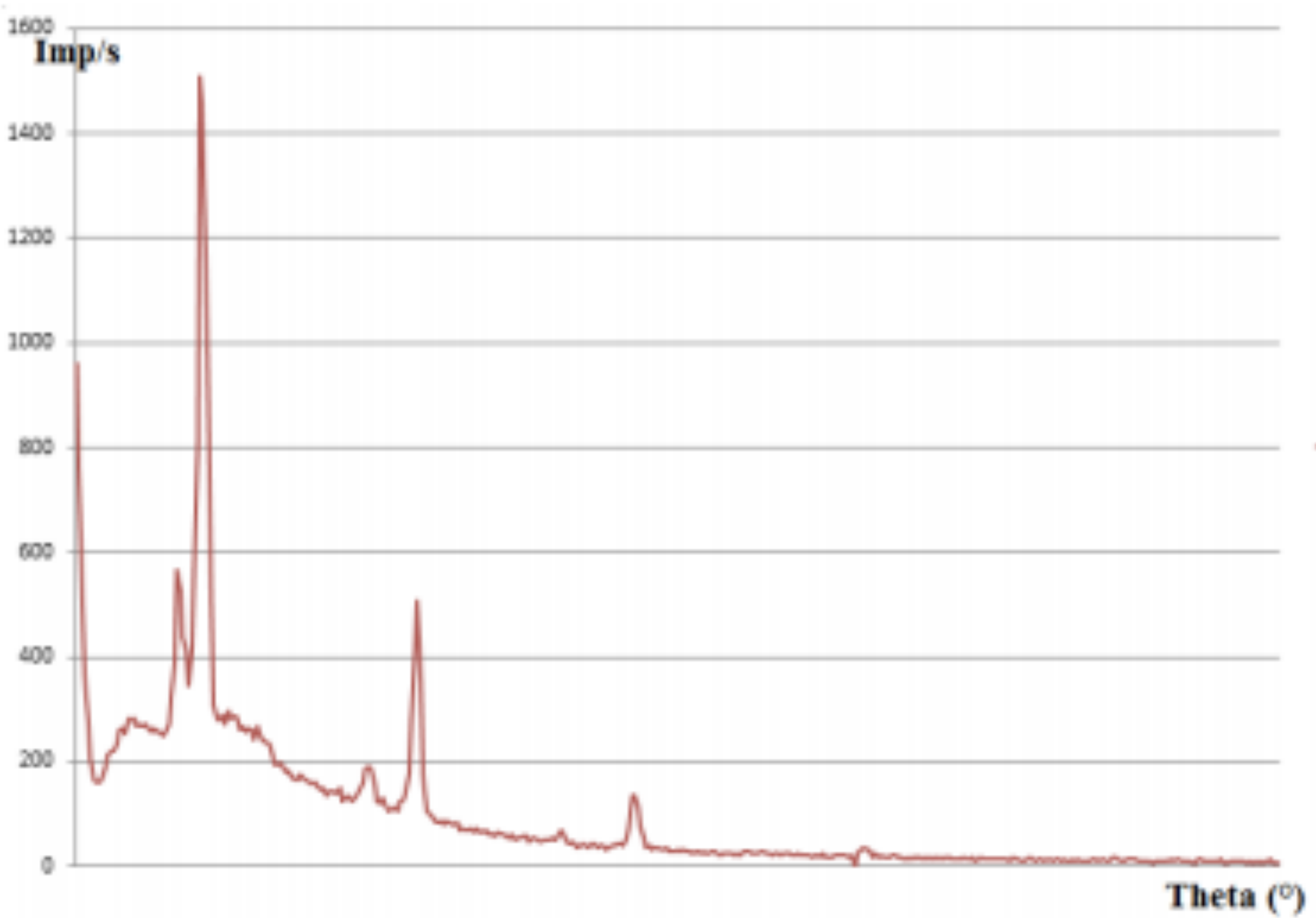
Show everything!

PROCEDURE

- First set the voltage to the highest possible value i.e 35kV to take full spectrum for calibration. ϴ: from 5 to 35 degree.
- Do not forget to save your data!
- Then set voltage applied to 15kV and ϴ: from 5 to 20 degree. You may stop taking data when you see the plateau.
- Repeat the same procedure by incrementing voltage 3kV each time up to 30kV.
- Do not forget to take copy of your data before you leave the lab!

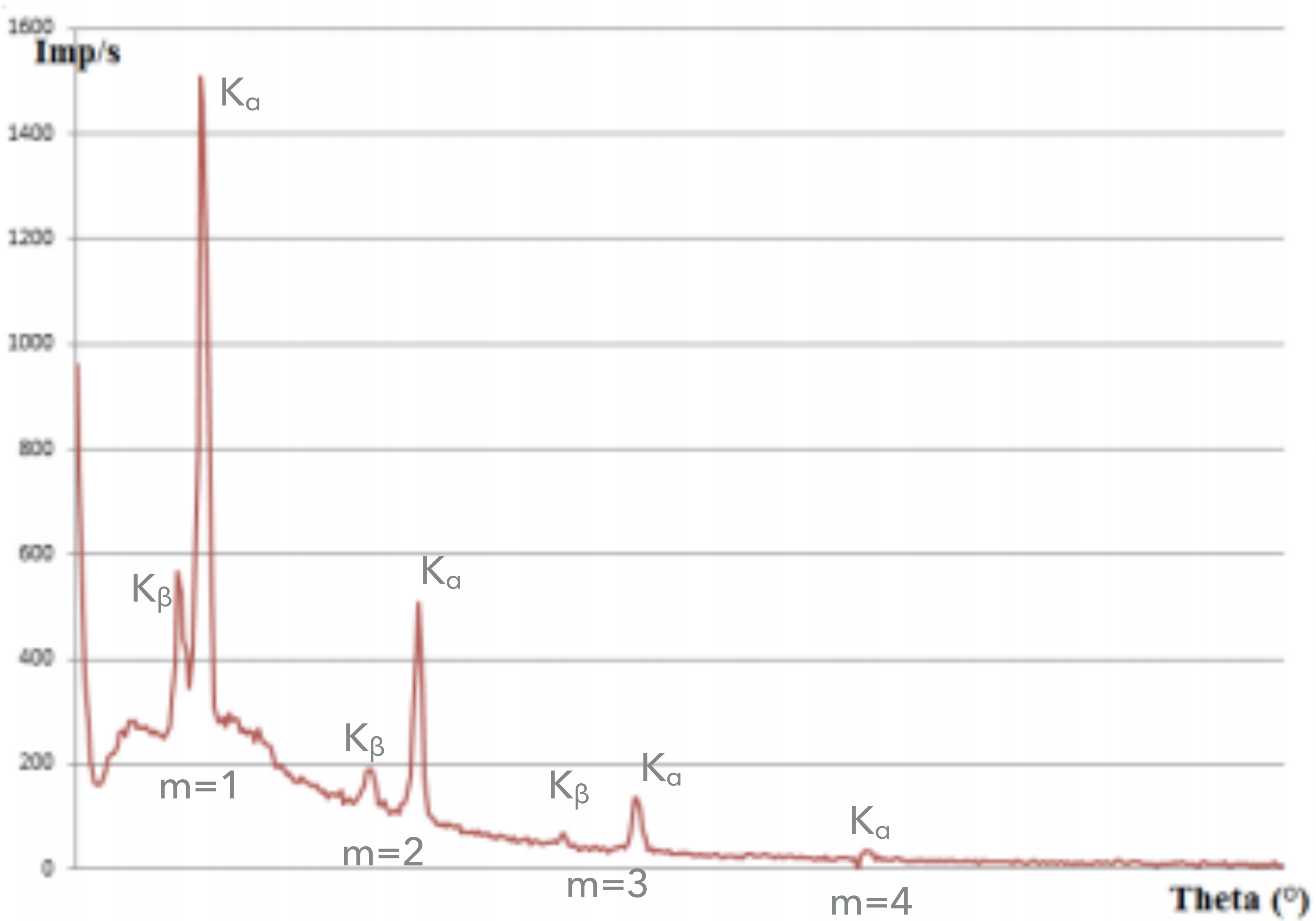
ANALYSIS

ANALYSIS – CALIBRATION



Intensity of reflected x-rays as a function of theta for V = 35 kV

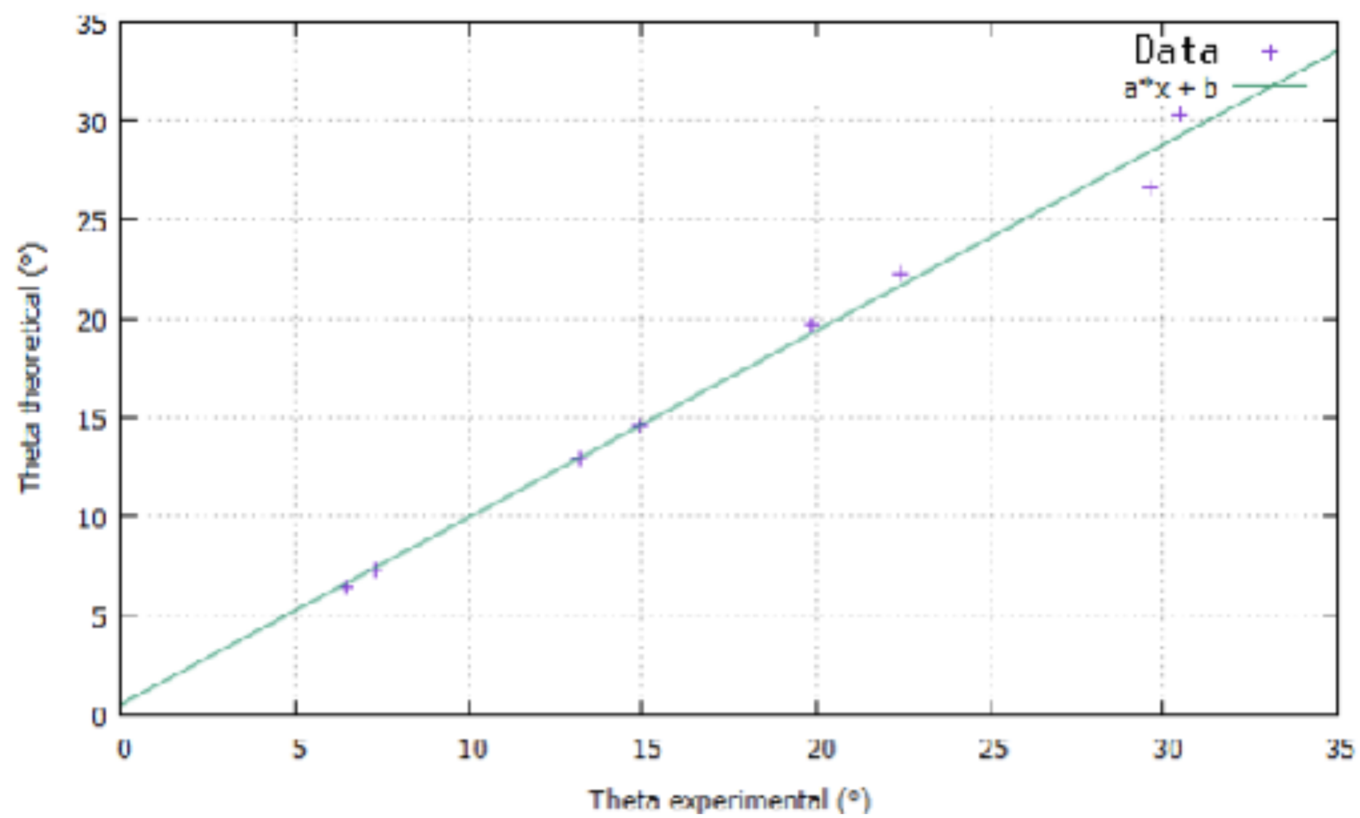
ANALYSIS – CALIBRATION



Intensity of reflected x-rays as a function of theta for V = 35 kV

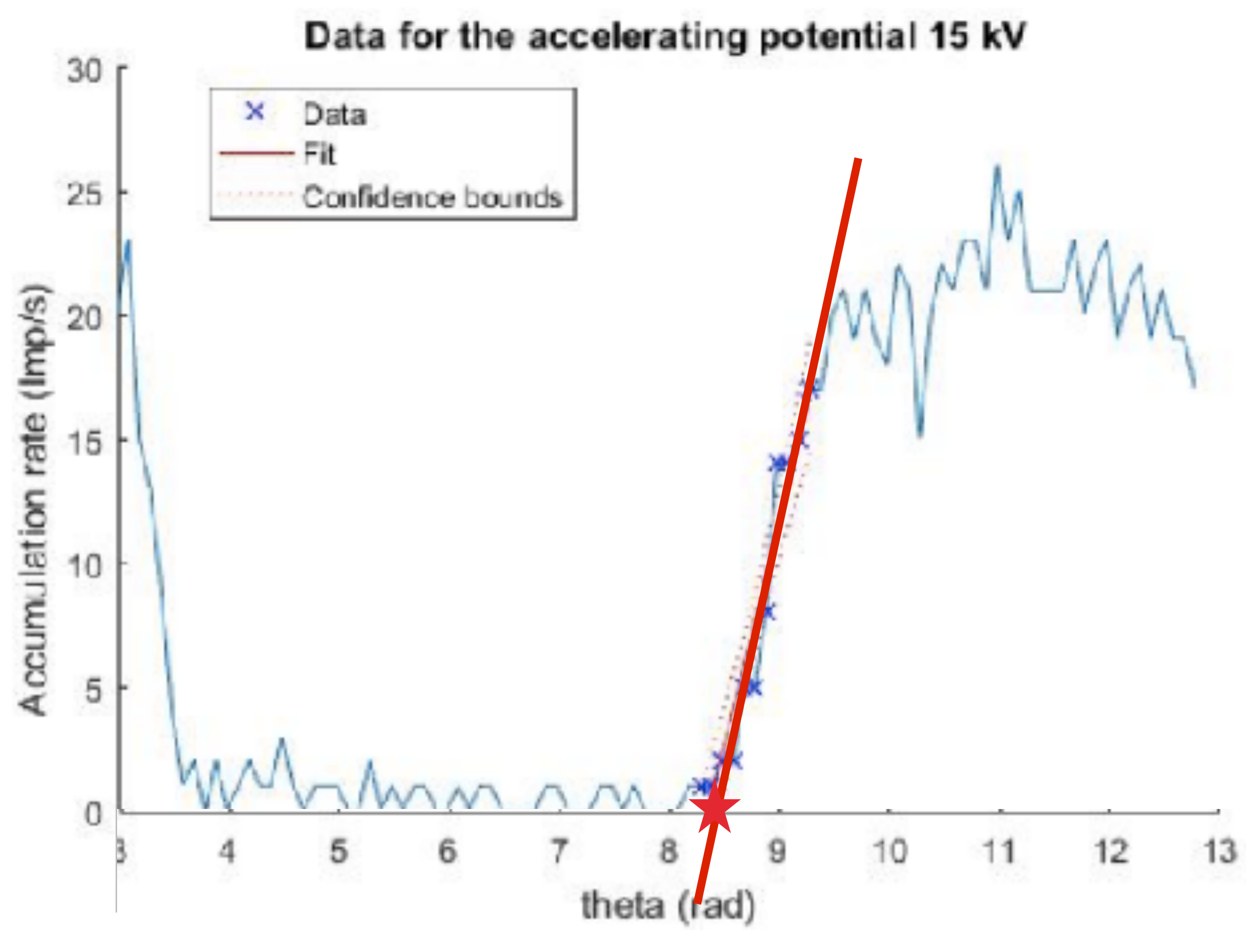
ANALYSIS – CALIBRATION

- Experimental Θ_α and Θ_β are read directly from the full spectrum of 35kV.
- Calculate theoretical Θ_α and Θ_β from the X-ray emission lines of Mo42.
- Plot experimental vs theoretical values, then perform a line fit to obtain a calibration function.
- This function will be used to calibrate angle in the second part



ANALYSIS – FINDING PLANCK CONSTANT

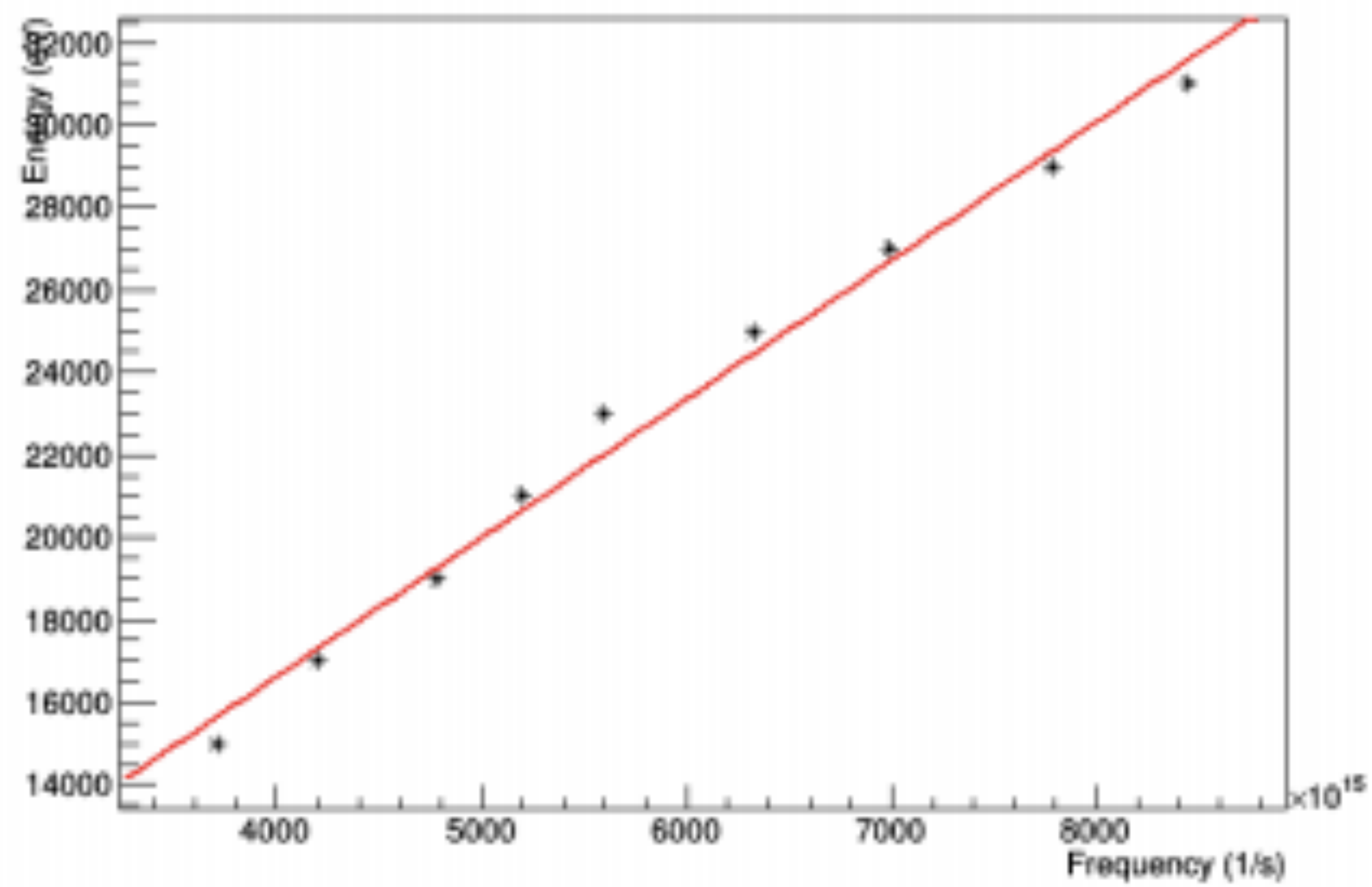
- For each voltage data select linear range at the begining and make a line fit to find where it intersects the x-axis.



- Θ_{min}

ANALYSIS - FINDING PLANK CONSTANT

- First correct your Θ_{min} values with the calibration you found in the first part.
- From the corrected Θ_{min} values calculate λ_{min} and then ν_{max}.
- *So you will have table of ν_{max} vs (q)V_{app} !*



-> The slope will give you the Planck constant!

-> Find the error on Plank constant!

-> Compare with the theoretical value!

DO NOT FORGET TO ANSWER THESE QUESTIONS IN YOUR REPORT (ANALYSIS OR CONCLUSION PART)

- Why did we perform calibration?
- Why is there a big jump in the intensity at around 5 degree or lower?
- What are the possible sources of errors?
- In your final graph, which you get plank constant, is there a non-zero intercept? Why do you have it?
- Why do we see K-lines only?

THE REPORT

THE REPORT

- (5) Abstract
  - Define the aim of the experiment and your motivation.
  - Explain the research methods you use.
  - Summarize your findings.
- (15) Theoretical Motivation
  - Theoretical background used in the experiment.
    - How X-rays are produced.
    - How X-rays scatter from the crystal (geometry)
    - Bremstrahlung and Duane Hunt displacement law.
    - Bragg scattering law.
    - Theoretical values used.
- (20) Apparatus, experimental procedure, data
  - Define the apparatus and how the units work.
  - Explain data taking procedure.
  - Explain how you take data
  - Show your data (graphs)
- (45) Analysis
  - Explain the analysis procedure clearly.
  - Show all your work; procedure, equations, results
  - Be careful about significant figure.
  - Use error propagation
  - Do not forget axis names, units, title, error bars in your plots
  - Express results clearly and discuss!
- (10) Conclusion
  - Discuss your results and findings.
  - Suggest further studies.
- (5) Reference
  - Include all the references (papers, books etc.) in an appropriate format.
- +5 bonus for using root,pyhton, matlab etc. & +5 bonus for using latex

IF YOU NEED HELP CONTACT ME!

- Saime Gürbüz
- Office: Engin Arık Lab

- For your questions, please contact via piazza!

- Email: saimesarikaya@gmail.com
- Phone (Wapp): 0538 367 28 00

- Please contact via phone for arranging meetings and **really short** questions! For long questions or for the parts that you do not understand, ask me for a meeting!