X-RAY PHOTOGRAPHY

- Analyze **Laue diagram** of LiF monocrystal
- Investigate unknown powder samples using **Debye-Scherrer photograph**

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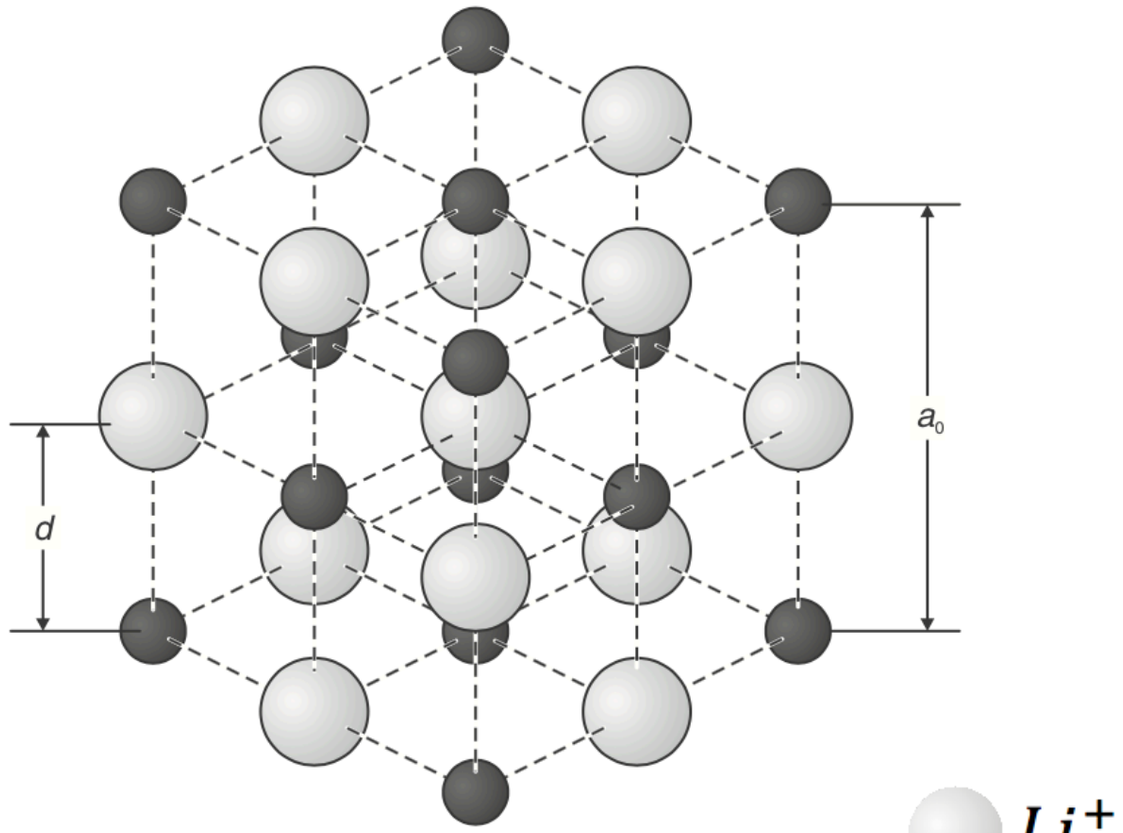
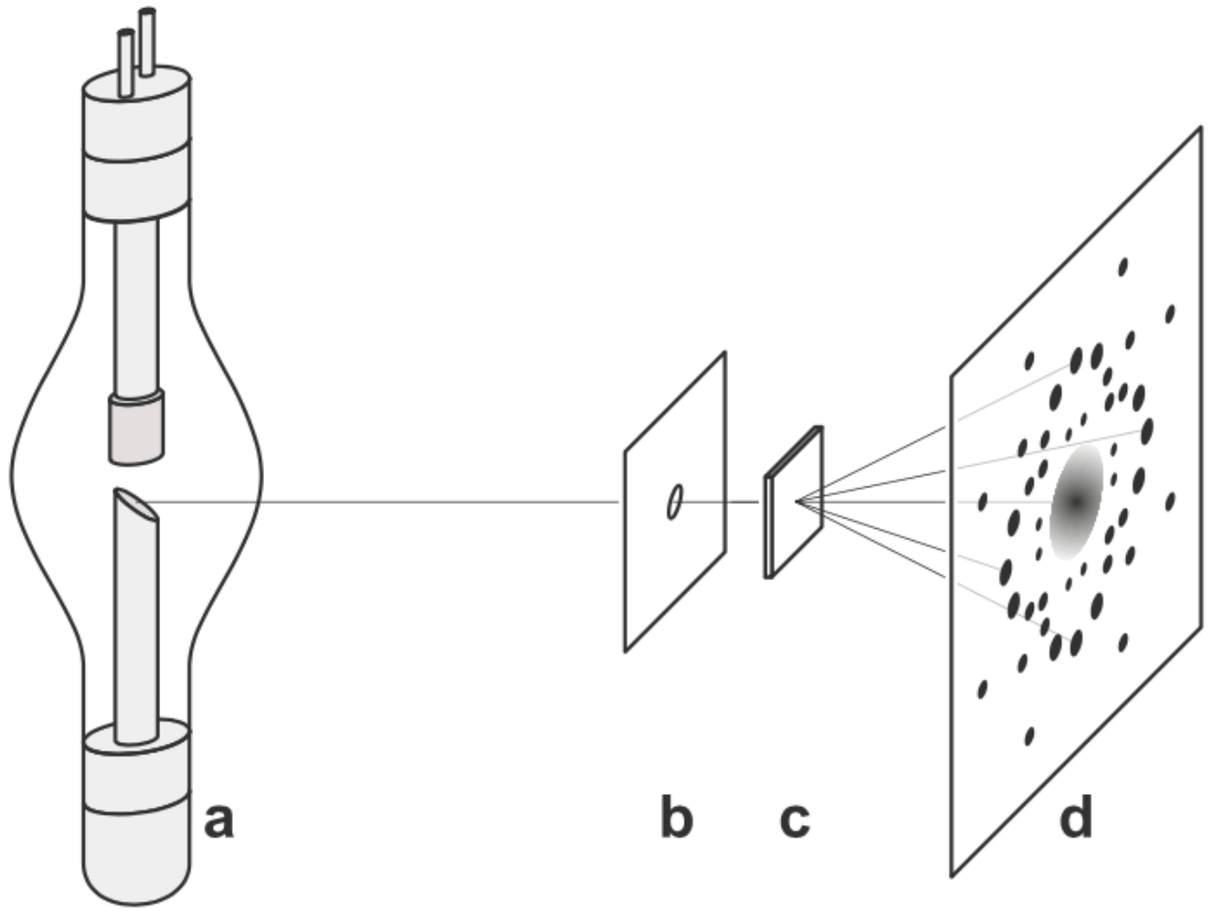
LiF Monocrystal

55477 LiF Crystal for Bragg Reflection

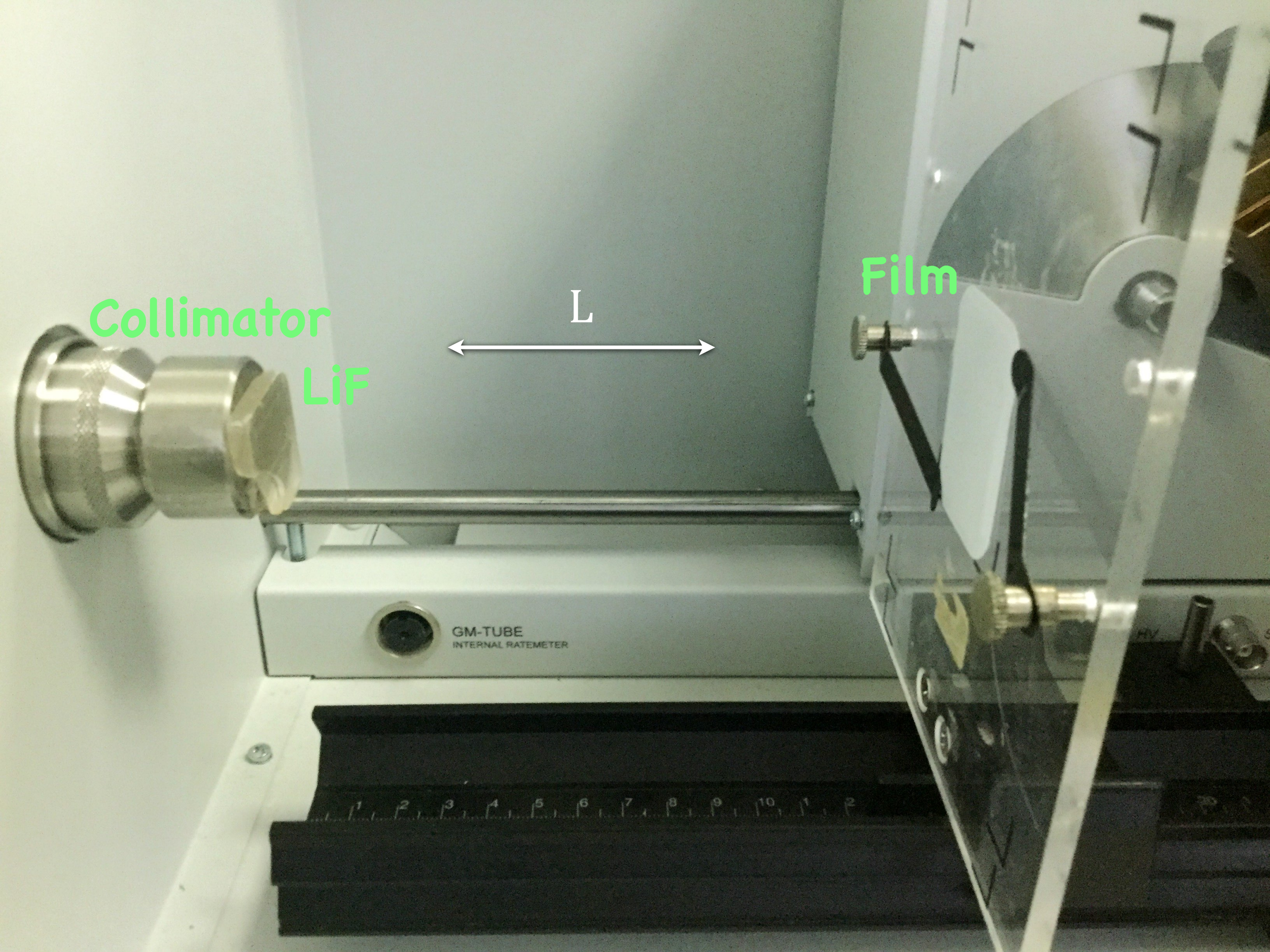
$556.00 Add to Cart

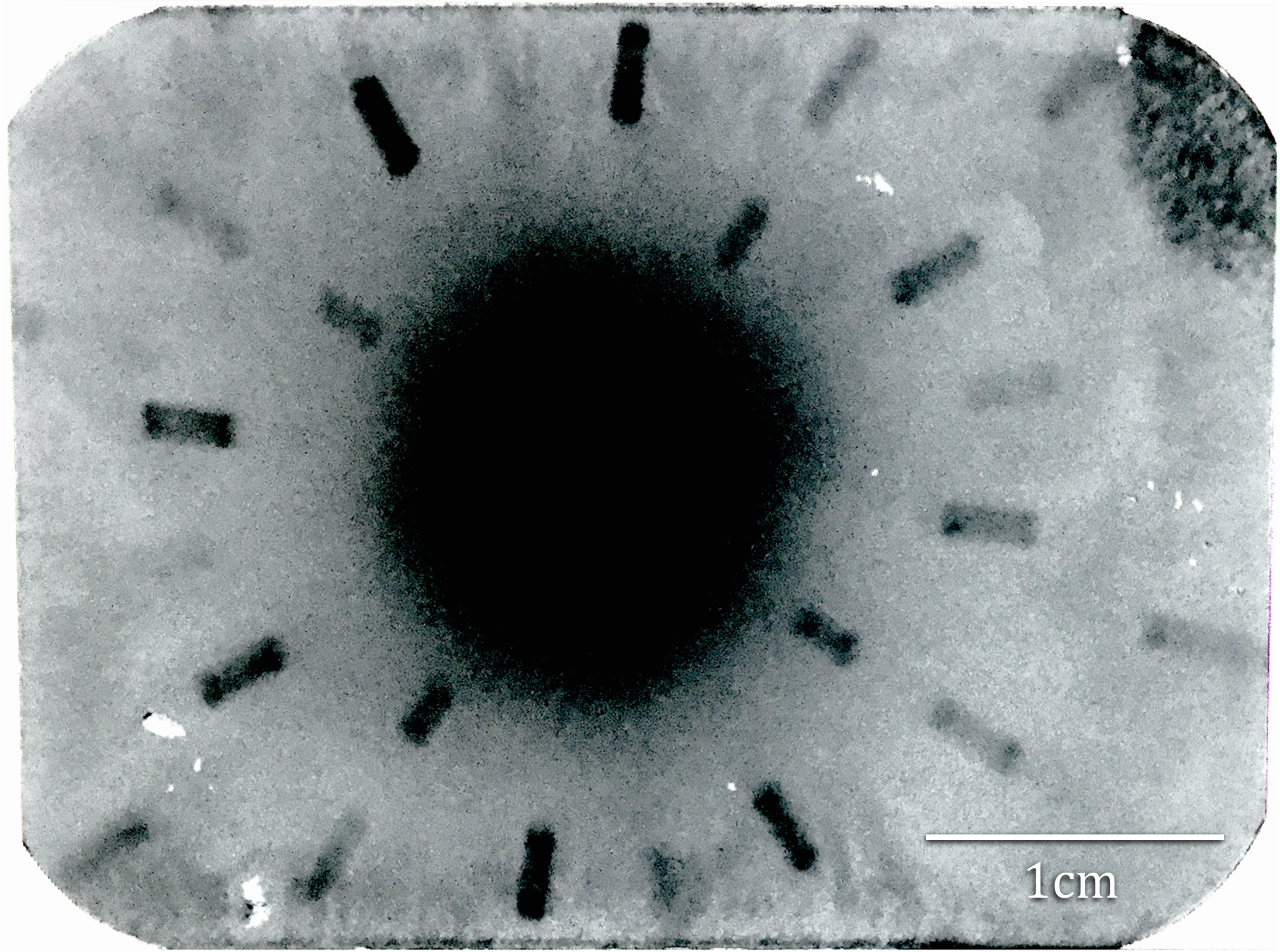


Laue Diagram



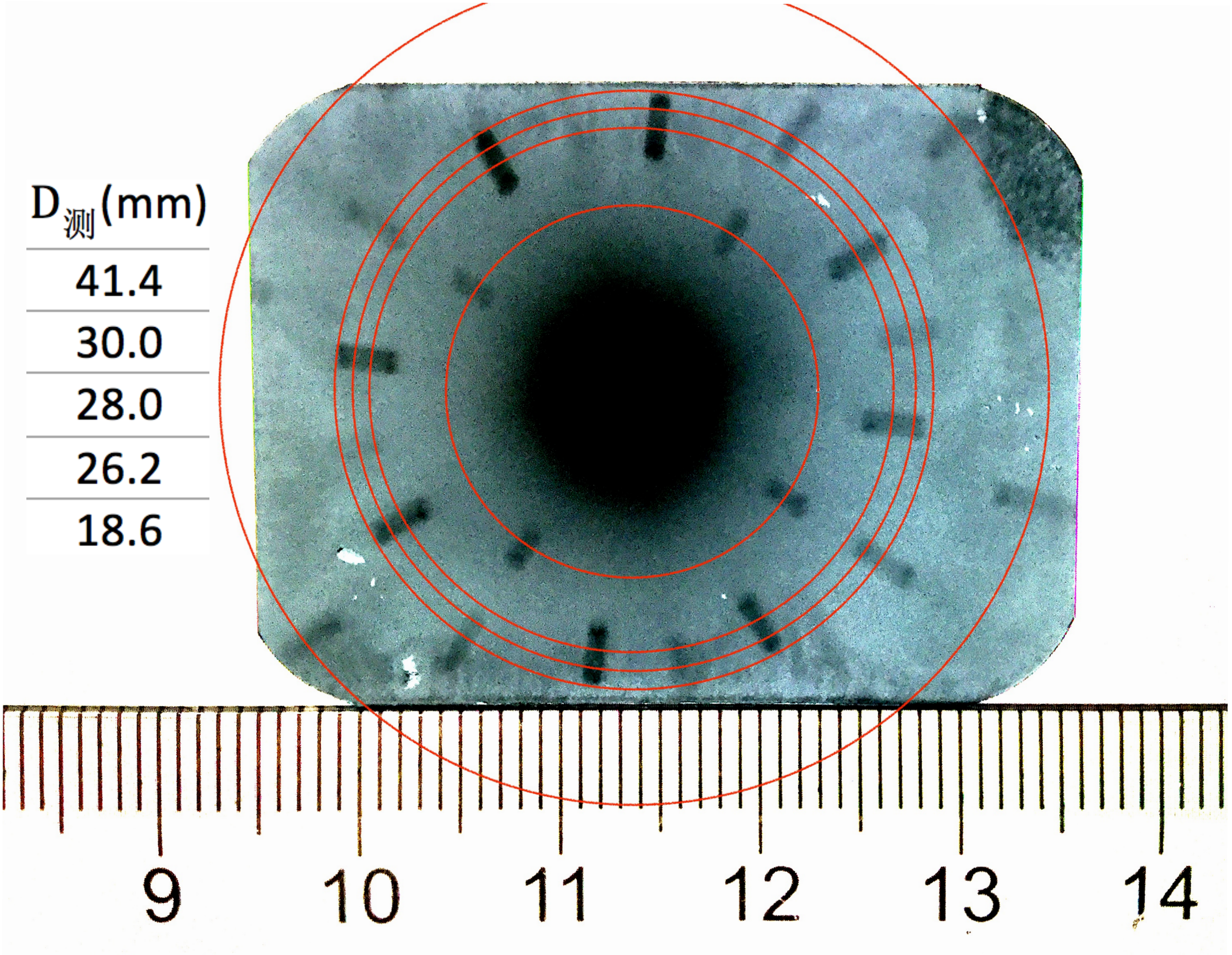
a	**b**	**c**	**d**
X-ray tube	Collimator	LiF Crystal	X-ray film


Collimator
LiF
L
Film
GM-TUBE
INTERNAL RATEMETER

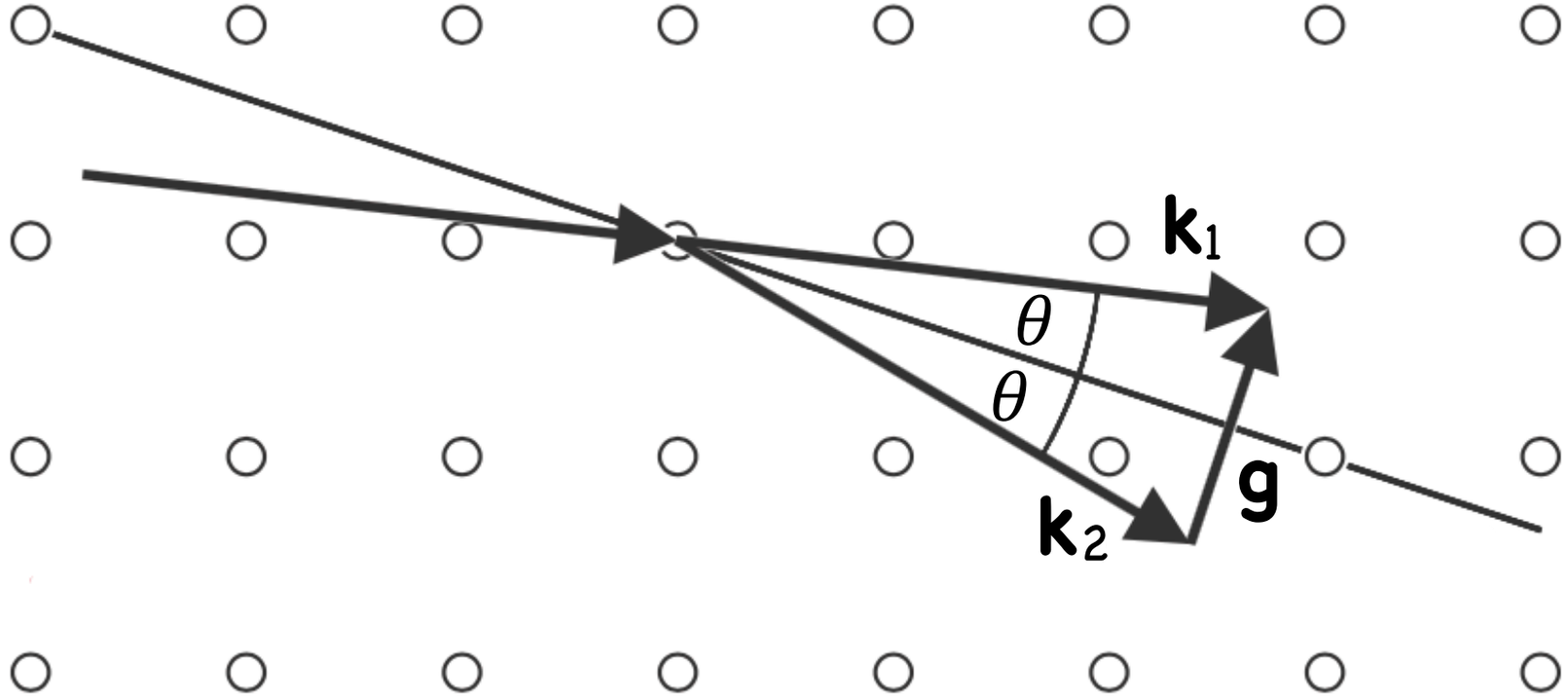


$L = 18\text{mm}$ $Time = 1.5\text{h}$ Thickness $= 5\text{mm}$

$D_{测}$(mm)
41.4
30.0
28.0
26.2
18.6



Laue Condition



$$\boldsymbol{k}_1 - \boldsymbol{k}_2 = \boldsymbol{g}$$

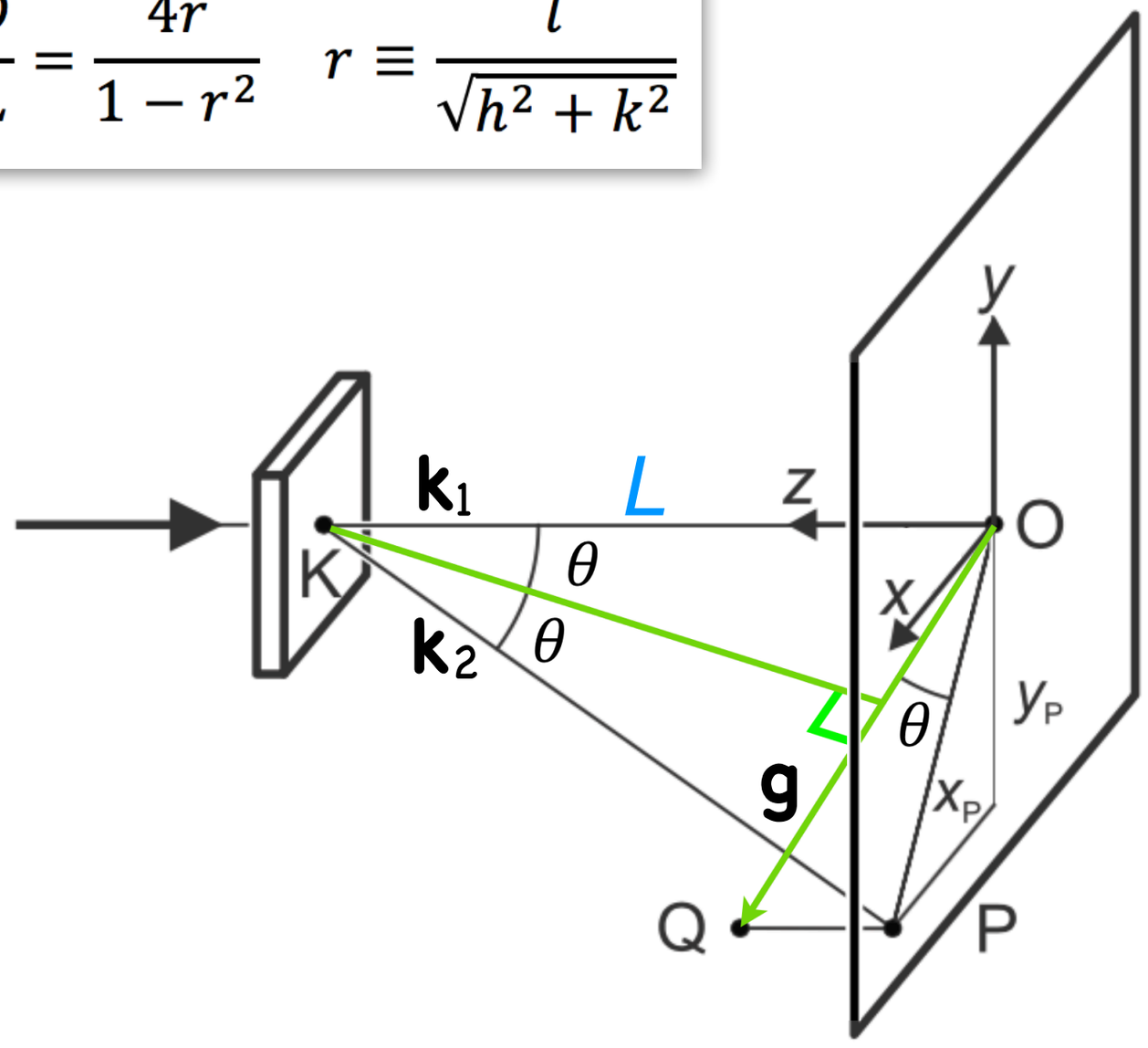
$$|\boldsymbol{g}| = 2|\boldsymbol{k}| \sin\theta$$

$$\boldsymbol{g} = \frac{2\pi}{a_0}(h,k,l)$$

$$\sin\theta = \frac{l}{\sqrt{h^2+k^2+l^2}}$$

$$\tan 2\theta = \frac{\sqrt{x_p^2+y_p^2}}{L} = \frac{D}{2L}$$

$$\frac{D}{L} = \frac{4r}{1-r^2} \qquad r \equiv \frac{l}{\sqrt{h^2+k^2}}$$



$$\boldsymbol{g} = \frac{2\pi}{a_0}(h,k,l)$$

$$\sin\theta = \frac{l}{\sqrt{h^2+k^2+l^2}}$$

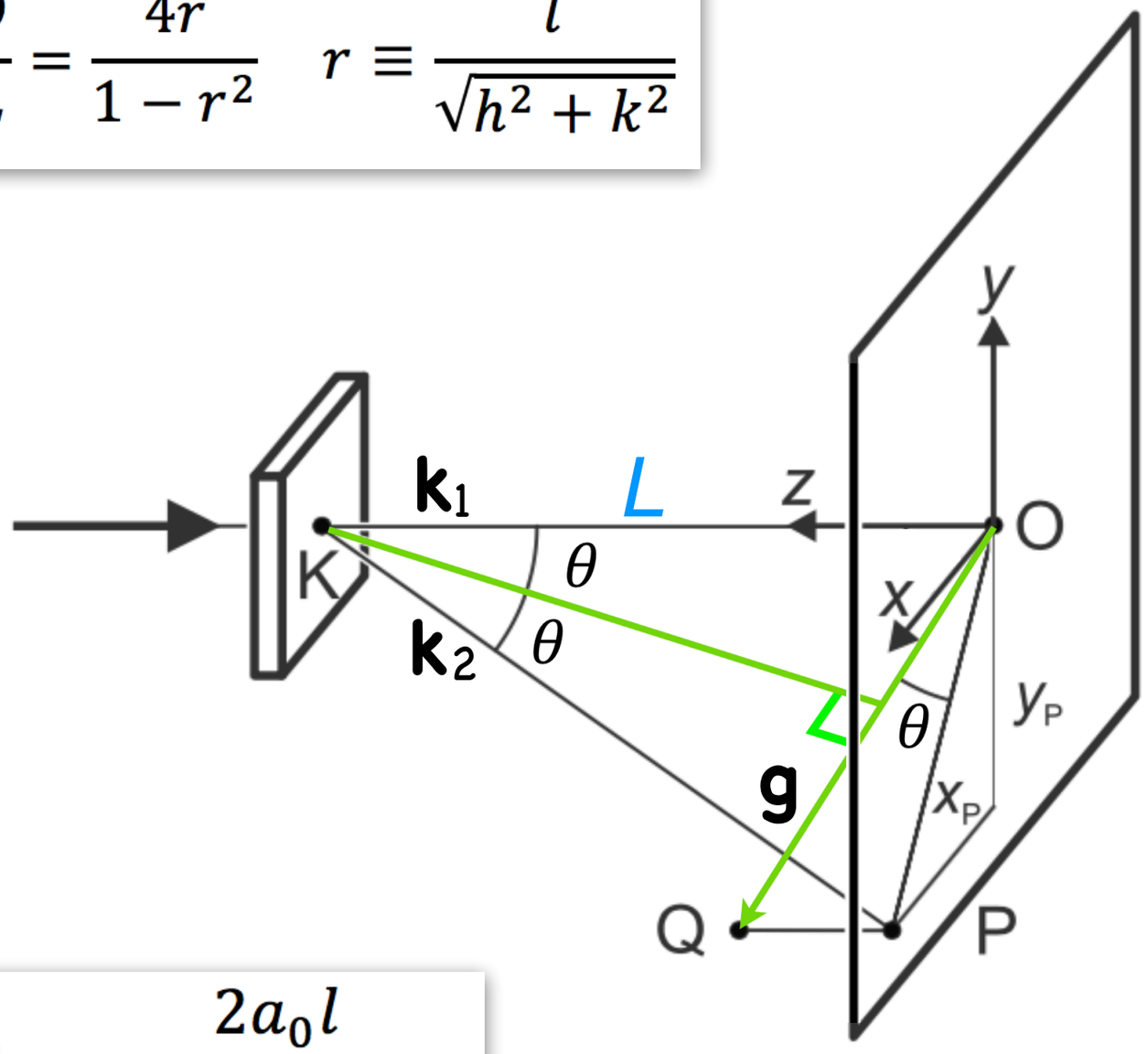
$$\tan 2\theta = \frac{\sqrt{x_p^2+y_p^2}}{L} = \frac{D}{2L}$$

$$|\boldsymbol{g}| = 2|\boldsymbol{k}|\sin\theta$$

$$|\boldsymbol{g}| = \frac{2\pi}{a_0}\sqrt{h^2+k^2+l^2}$$

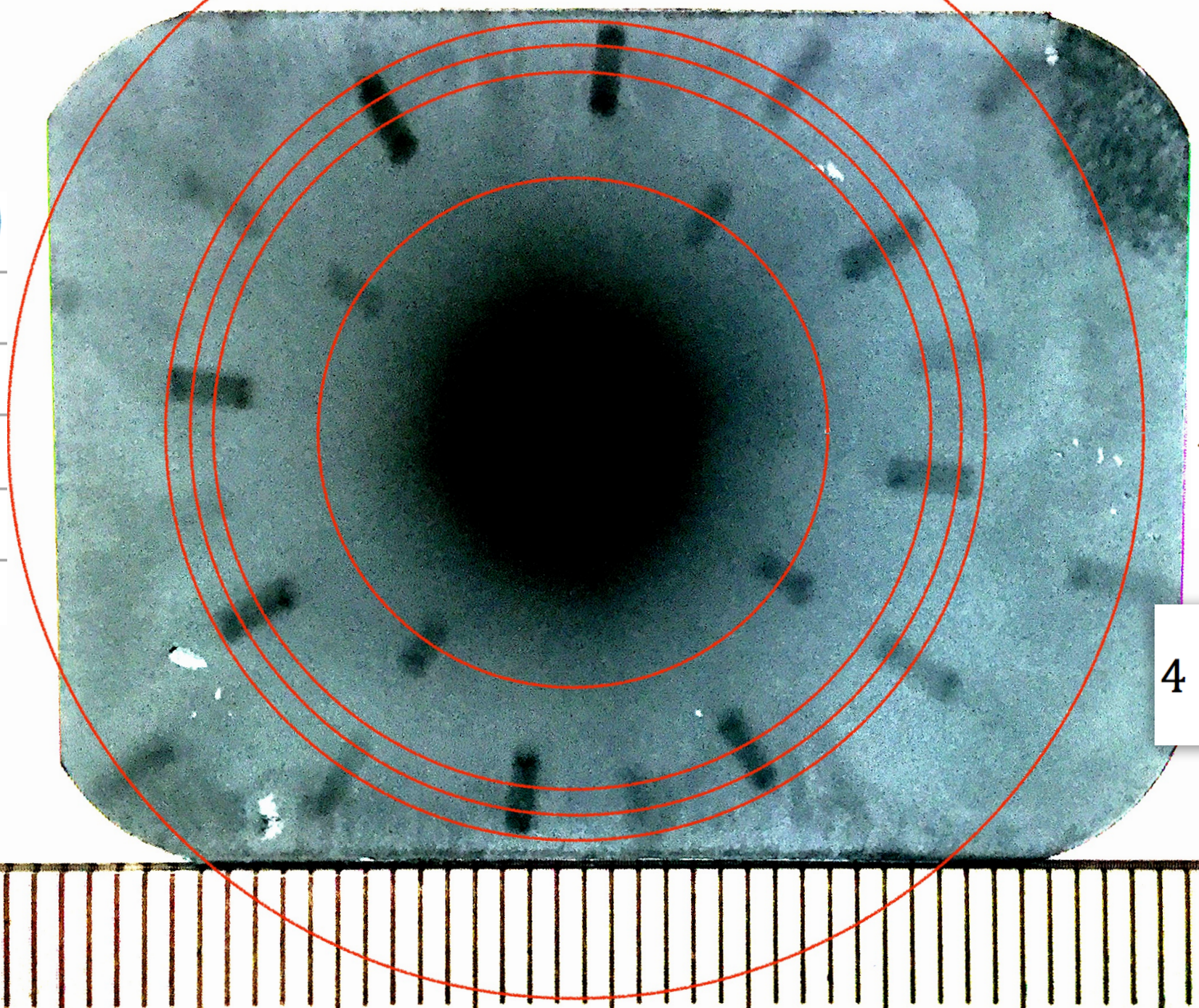
$$|\boldsymbol{k}| = \frac{2\pi}{\lambda}$$

$$\frac{D}{L} = \frac{4r}{1-r^2} \qquad r \equiv \frac{l}{\sqrt{h^2+k^2}}$$



$$\lambda = \frac{2a_0 l}{h^2+k^2+l^2}$$

$L = 18\text{mm}$



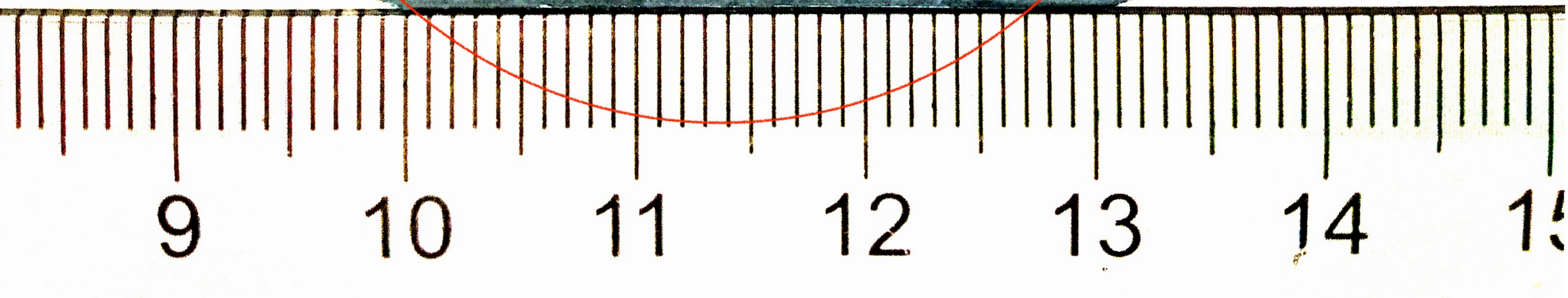
$D_{测}$(mm)
41.4
30.0
28.0
26.2
18.6

$$\frac{4}{5} < \frac{D}{L} < 3$$

$$\frac{D}{L} = \frac{4r}{1 - r^2}$$

$$r \equiv \frac{l}{\sqrt{h^2 + k^2}}$$

$$4 < \frac{h^2 + k^2}{l^2} < 30$$



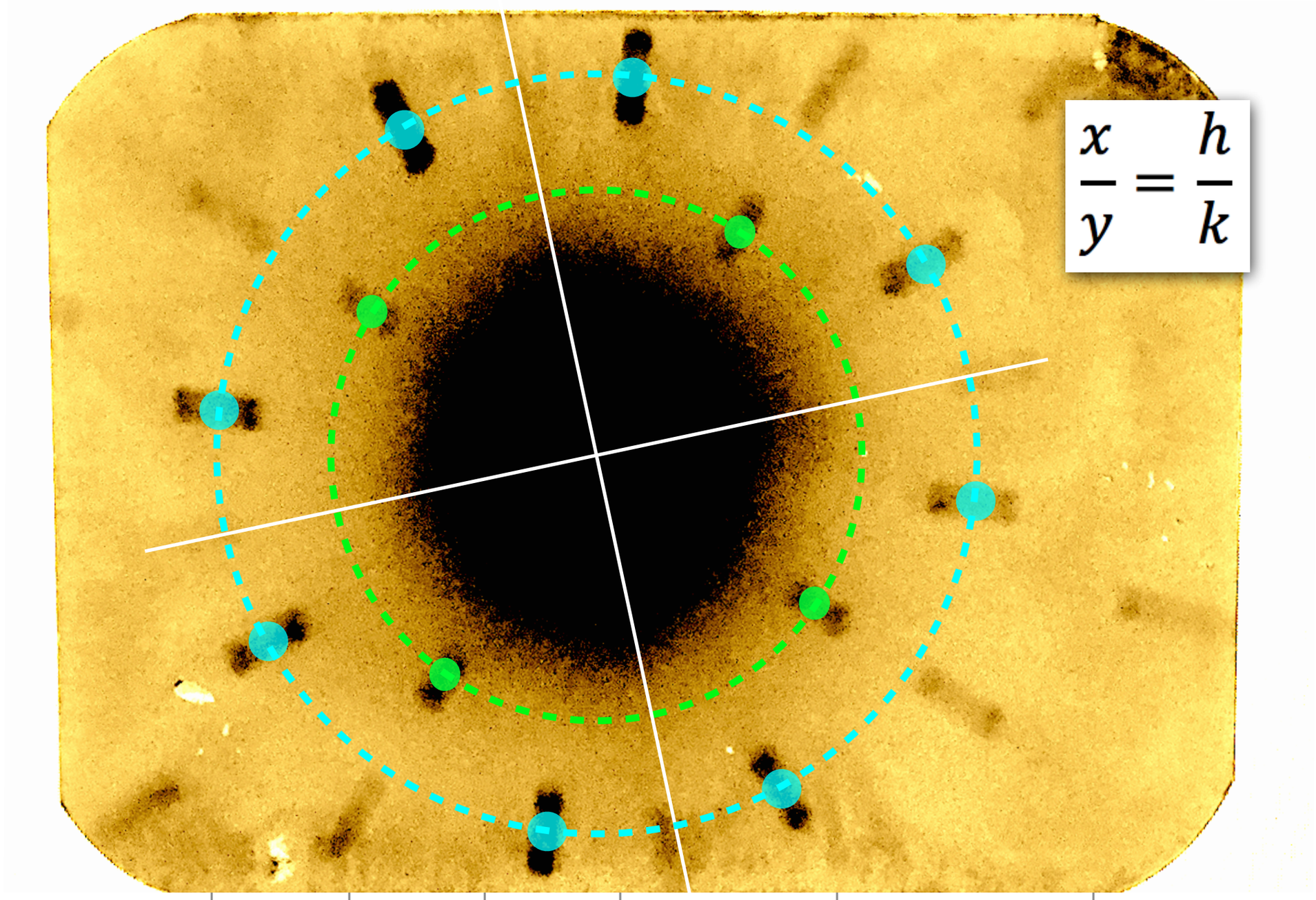
$$4 < \frac{h^2 + k^2}{l^2} < 30$$

$$h, k, l \ all \ even \backslash odd.$$

$$\frac{D}{L} = \frac{4r}{1 - r^2} \qquad r \equiv \frac{l}{\sqrt{h^2 + k^2}}$$

$L_{测} = 18 \pm 1\text{mm}$ $u(D) = 0.2\text{mm}$

multiplicity	h	k	l	D/L	$D_{理论}$(mm)	$D_{测}$(mm)	$L_{理论}$(mm)
8	4	2	2	2.236	40.2	41.4	18.5
4	4	4	2	1.616	29.1	30.0	18.6
4	6	0	2	1.500	27.0	28.0	18.7
8	6	2	2	1.405	25.3	26.2	18.6
4	3	3	1	0.998	18.0	18.6	18.6
4	6	6	2				
8	8	2	2	1.031	18.6	-	-
8	8	4	2	0.942	17.0	-	-
8	8	6	2	0.833	15.0	-	-
8	5	1	1	0.816	14.7	-	-

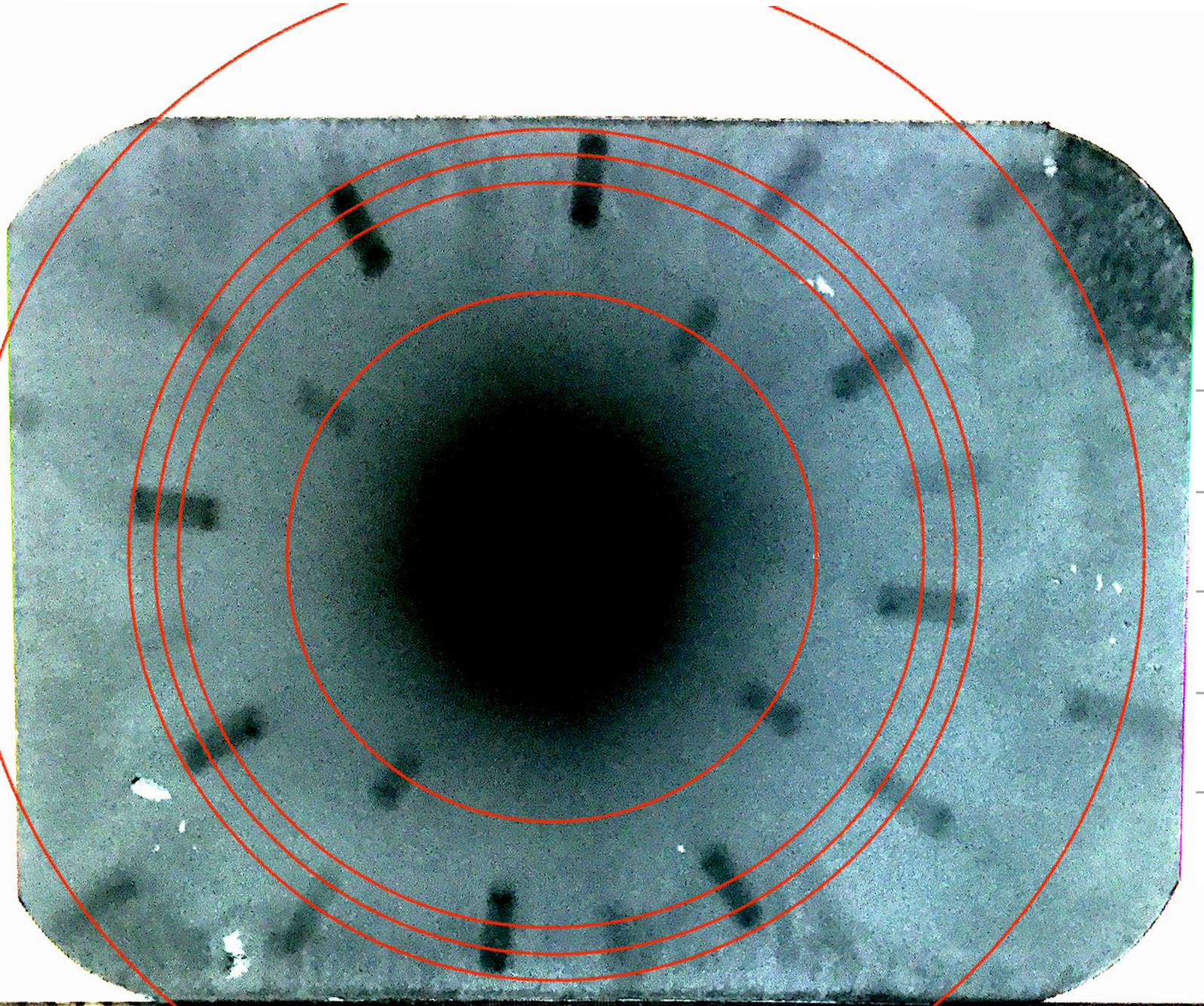


multiplicity	h	k	l	D/L	$D_{理论}$(mm)	$D_{测}$(mm)
8	6	2	2	1.405	25.3	26.2
4	3	3	1	0.998	18.0	18.6
4	6	6	2			
8	8	2	2	1.031	18.6	-
8	8	4	2	0.942	17.0	-

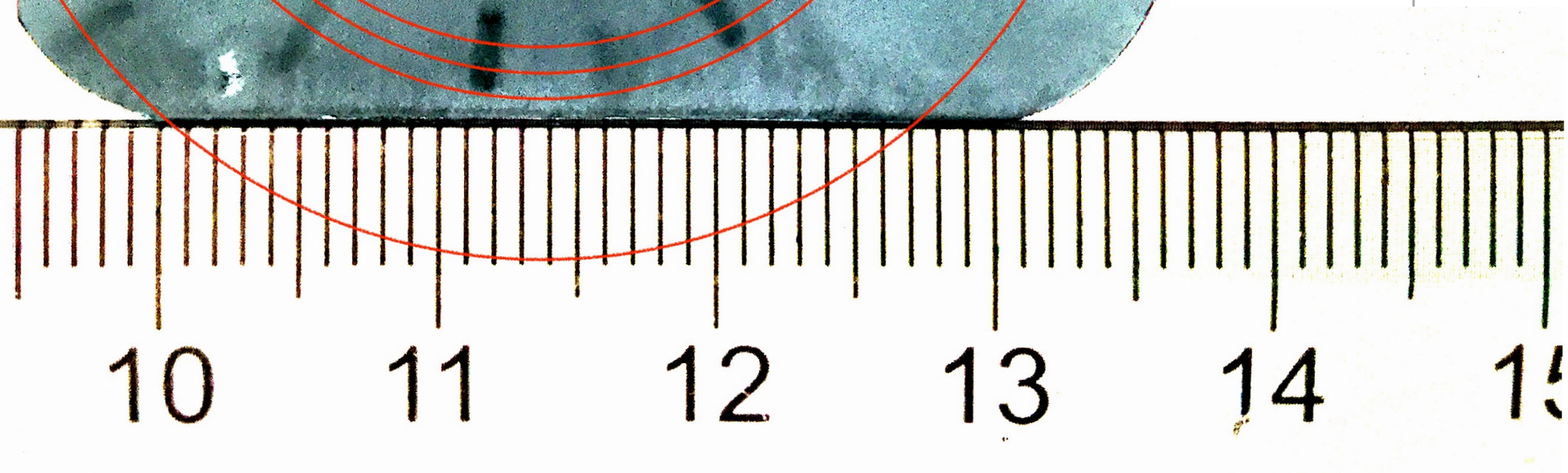
$$\lambda = \frac{2a_0 l}{h^2 + k^2 + l^2}$$

$$U = 35\text{kV} \quad \lambda_{min} = \frac{hc}{eU} = 35.43\text{pm}$$

h	k	l	D/L	D/mm	λ/pm
4	2	2	2.236	41.4	**67.13**
4	4	2	1.616	30.0	**47.76**
6	0	2	1.500	28.0	**40.28**
6	2	2	1.405	26.2	**36.62**
3	3	1	0.998	18.6	**42.40**
6	6	2			21.20
8	2	2	1.031	-	22.34
8	4	2	0.942	-	19.18
8	6	2	0.833	-	15.49
5	1	1	0.816	-	29.84



D/mm	{hkl}	λ/pm
41.4	422	**67.13**
30.0	442	**47.76**
28.0	602	**40.28**
26.2	622	**36.62**
18.6	331	**42.40**

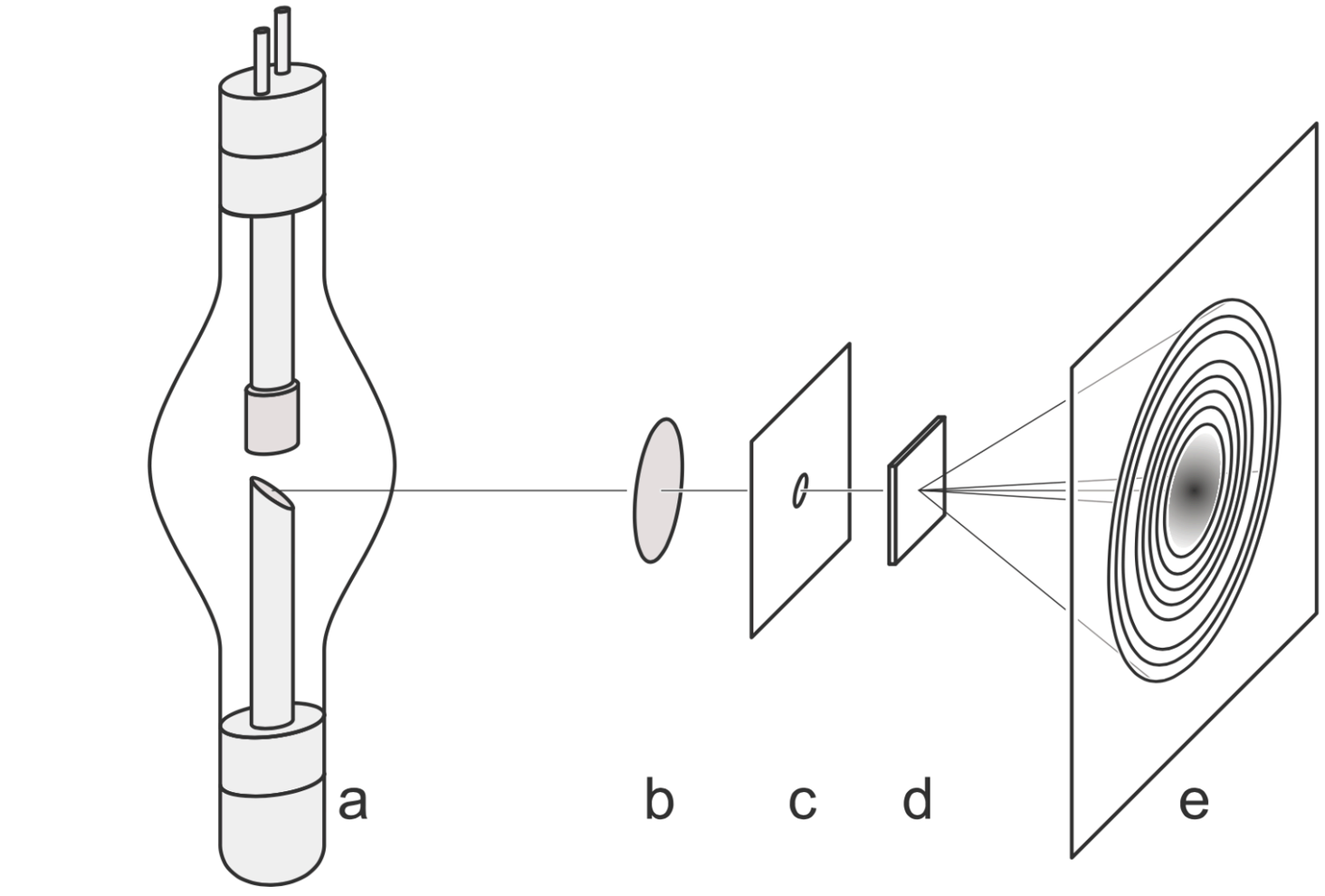


References

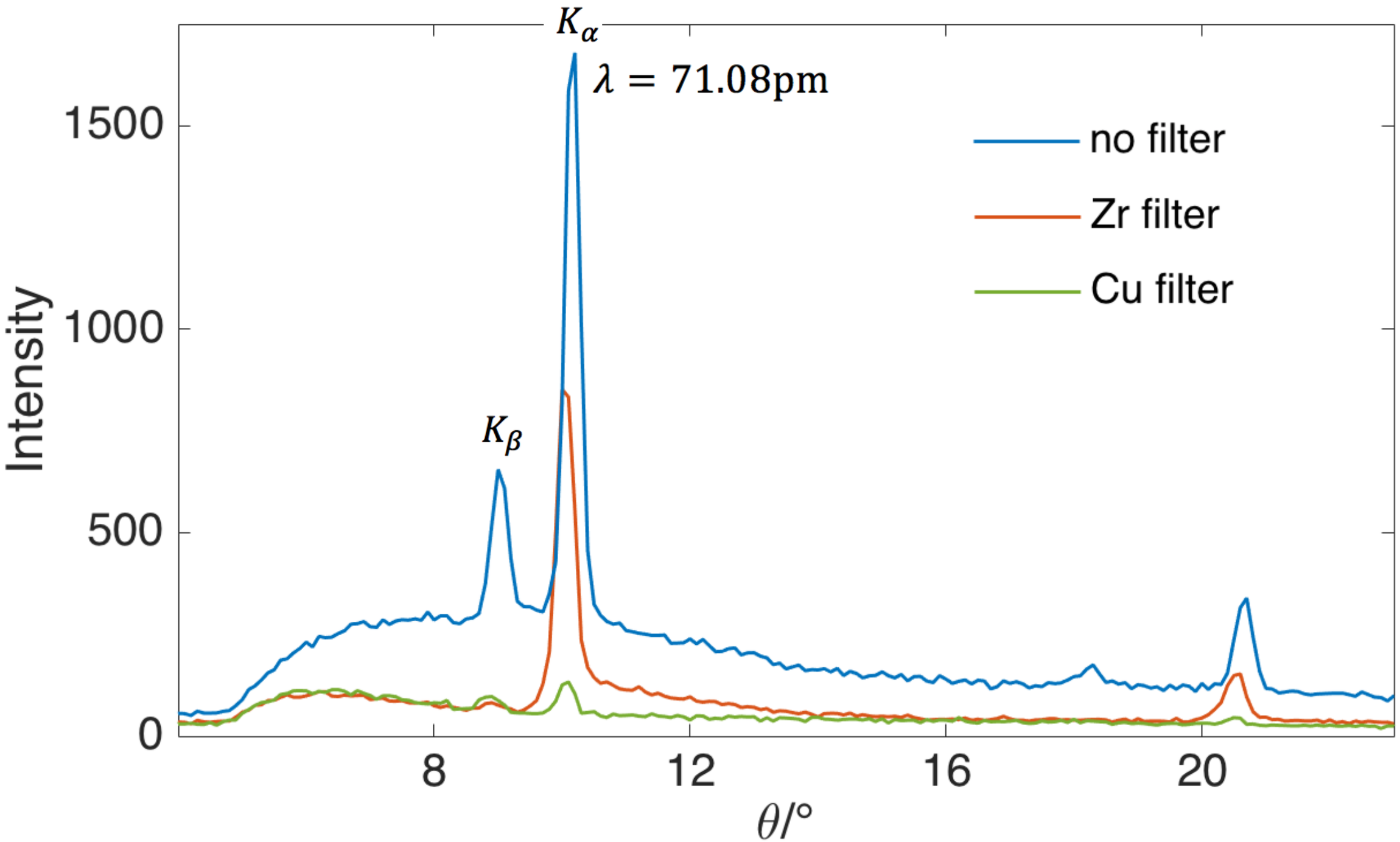
- Simon, S. H. (2013)
  The Oxford solid state basics. Chapter 14.
  OUP Oxford.

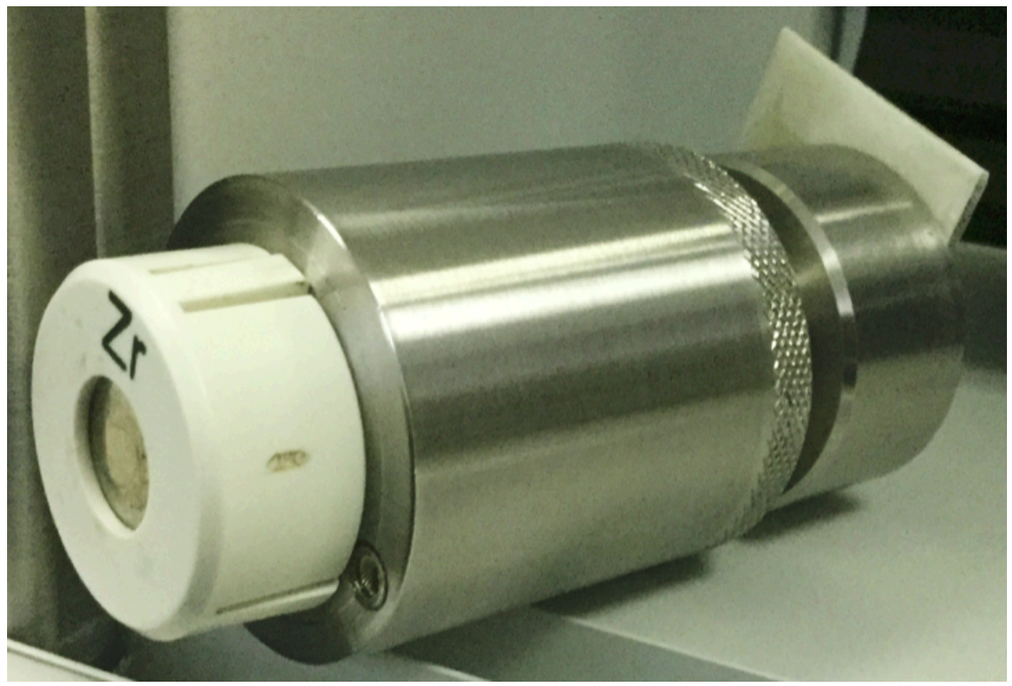
- Leybold-Didactic. (2015)
  Leybold Physics Leaflets. P 7.1.2.2, P 7.1.2.3.
  E. Leybold's Nachfolger.

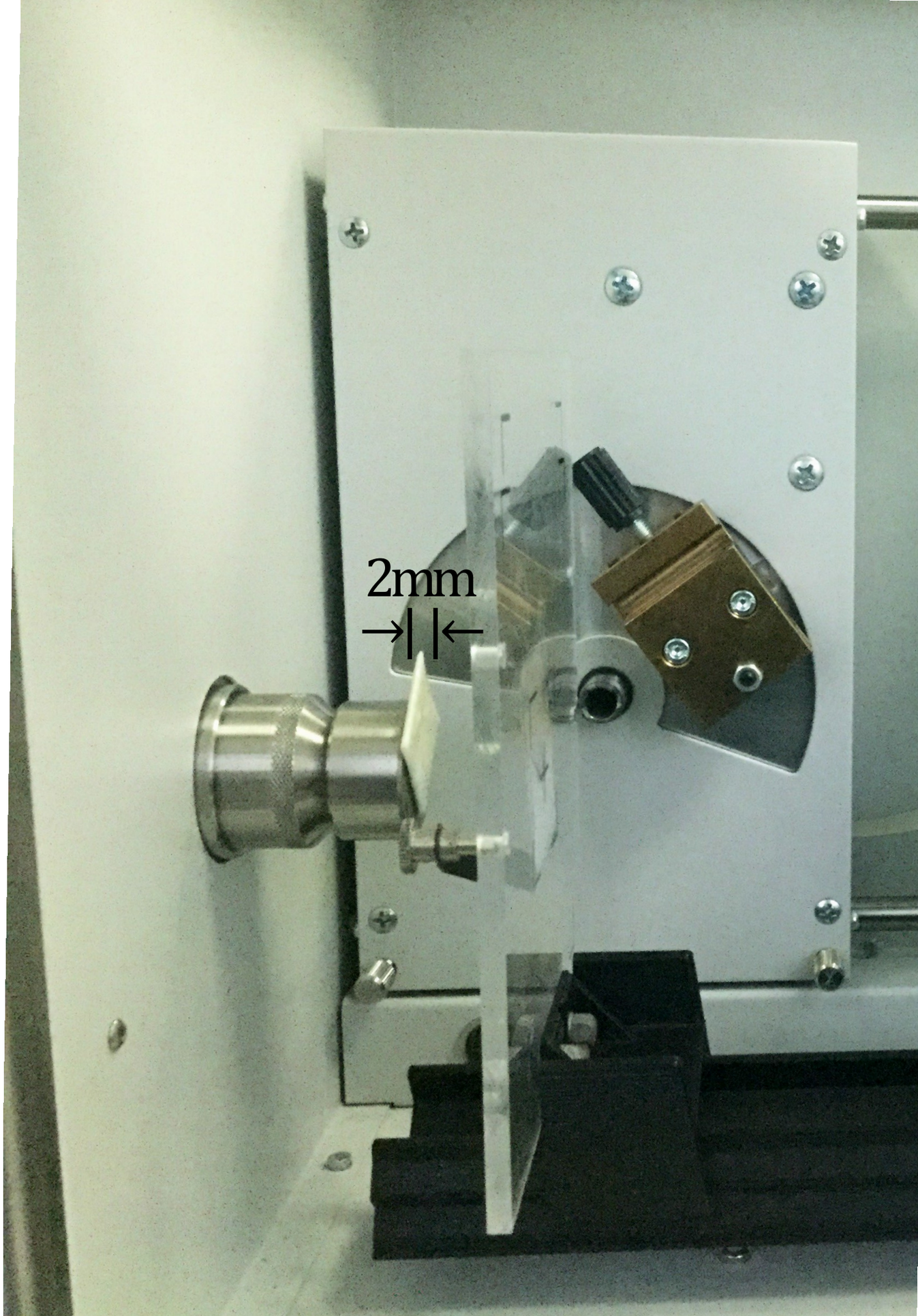
Debye-Scherrer Photography

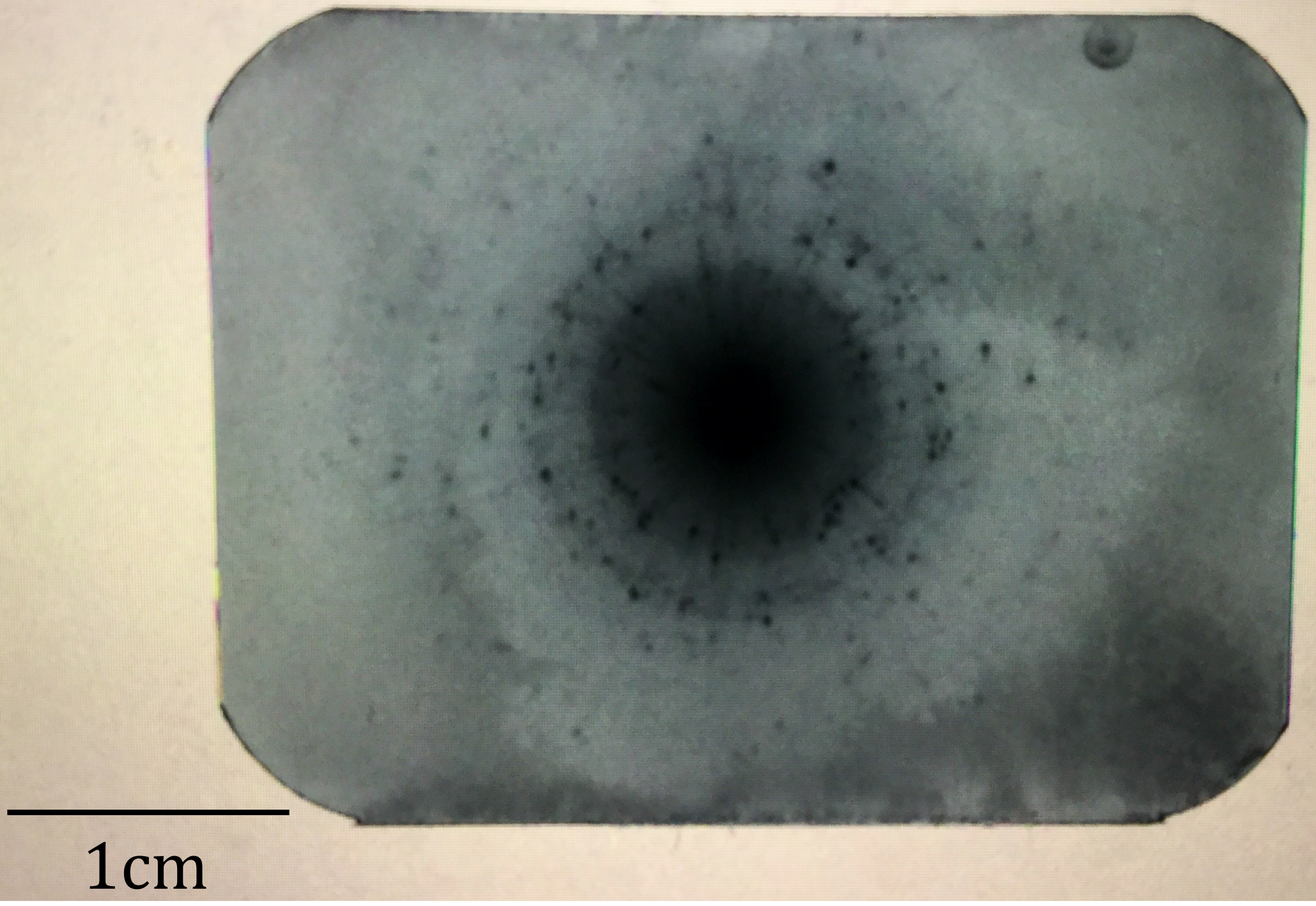


a	**b**	**c**	**d**	**e**
X-ray Tube	Zr Filter	Collimator	Powder	Film

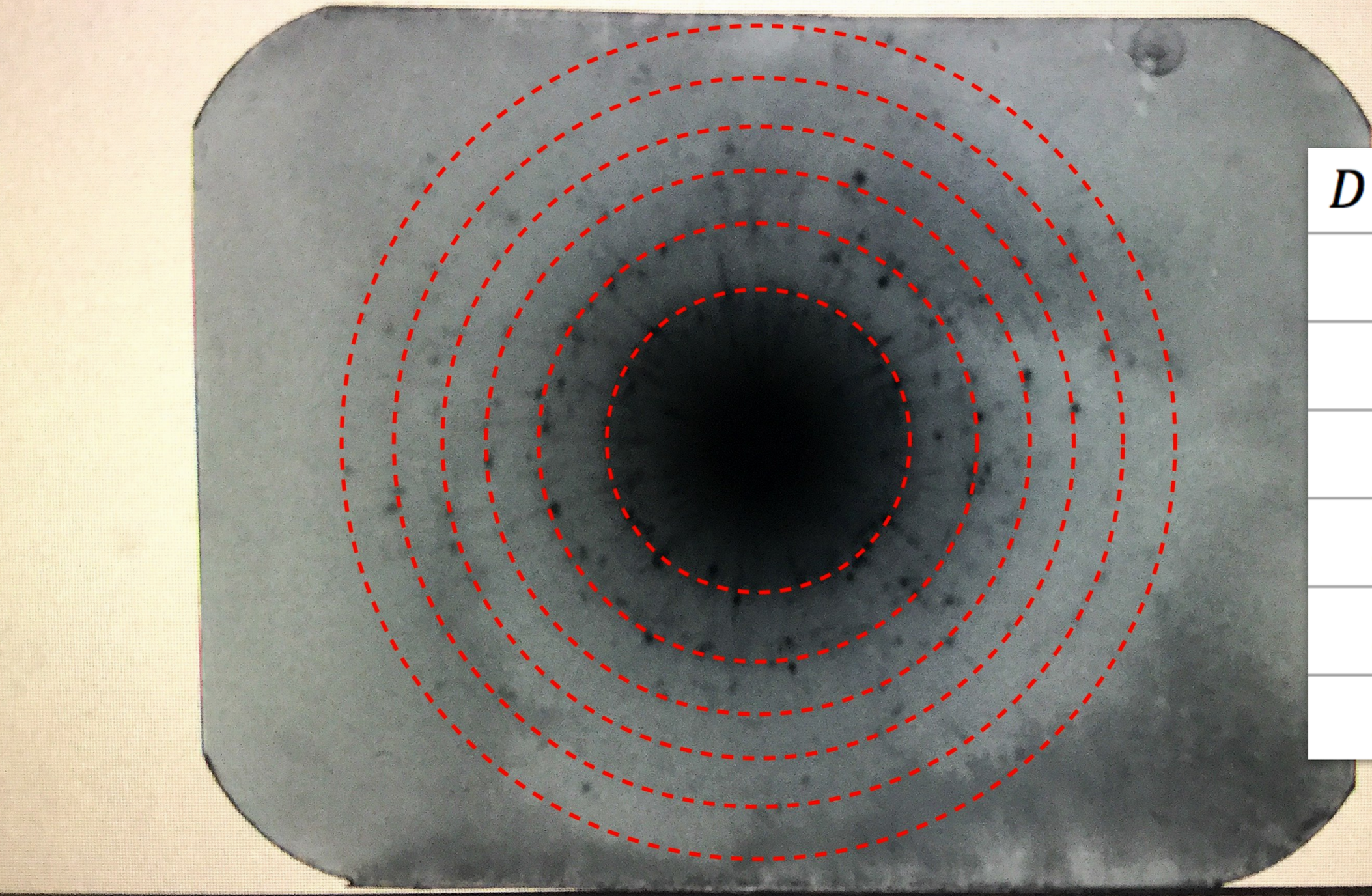

K_α
$\lambda = 71.08\text{pm}$
K_β
no filter
Zr filter
Cu filter
Intensity
1500
1000
500
0
8
12
16
20
θ/°




2mm

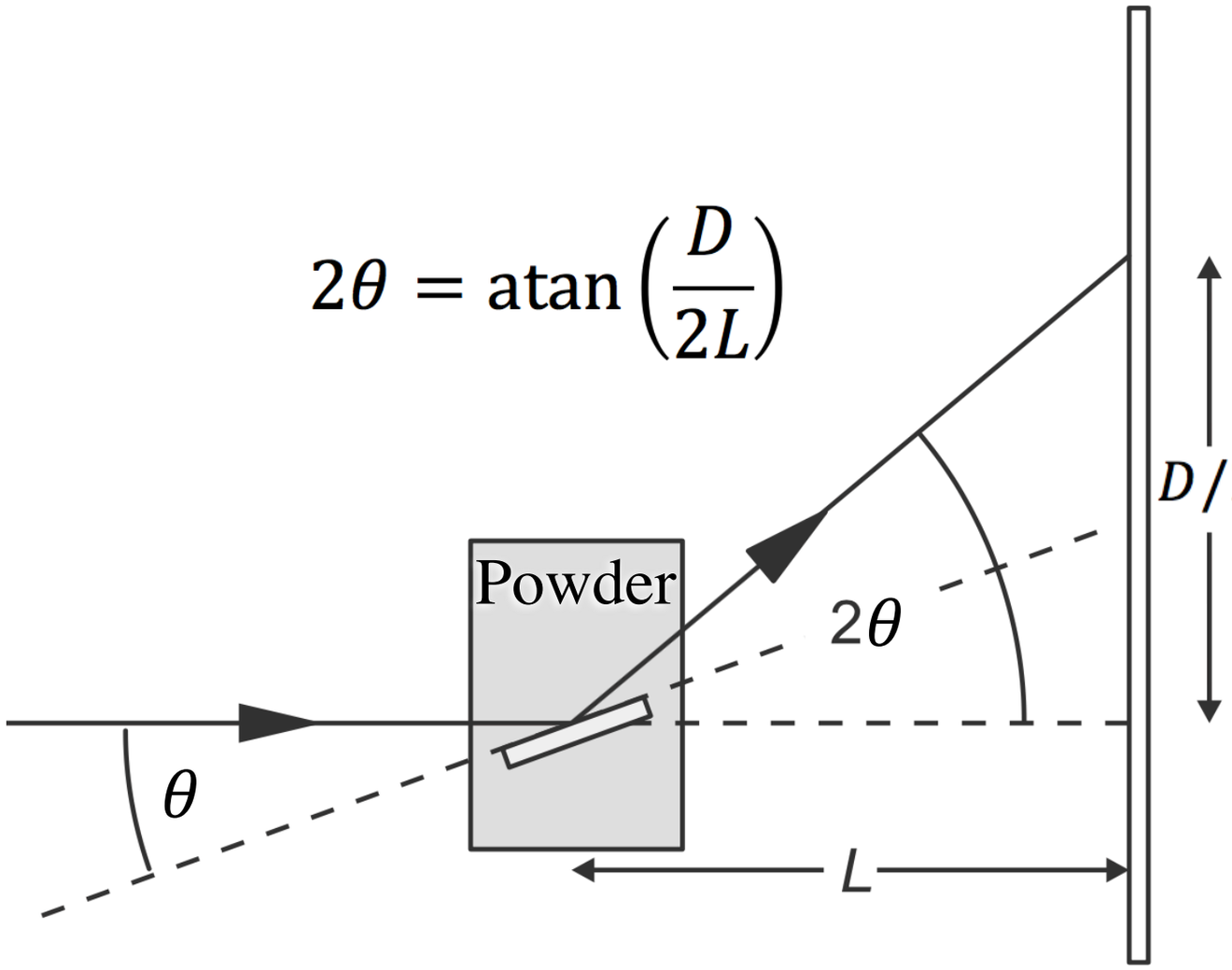


$L = 20\text{mm}$ $Time = 2\text{h}$



$D(\mathrm{mm})$
1.06
1.56
1.94
2.30
2.62
2.96

$$2\theta = \operatorname{atan}\left(\frac{D}{2L}\right)$$



$$d = \frac{2\pi}{|\boldsymbol{g}|} = \frac{a_0}{\sqrt{Z}}$$

$$Z = h^2 + k^2 + l^2$$

$$d = \frac{n\lambda}{2\sin\theta}$$

$$\left(\frac{d_1}{d}\right)^2 = \frac{Z}{Z_1}$$

$$d = \frac{\lambda}{2\sin(\frac{1}{2}\operatorname{atan}\frac{D}{2L})}$$

$$\left(\frac{d_1}{d}\right)^2 = \frac{Z}{Z_1}$$

$D(\mathrm{mm})$	$d(\mathrm{pm})$	$(d_1/d)^2$	Z/Z_1
1.06	275.2	1	1
1.56	192.2	2.1	2
1.94	158.7	3.0	3
2.30	137.8	4.0	4
2.62	125.0	4.9	5
2.96	113.5	5.9	6

$\{hkl\}$	Z
111	3
200	**4**
220	**8**
311	11
222	**12**
400	**16**
331	19
420	**20**
422	**24**
333	27
511	27
440	32
600	32

$$S = \begin{cases} 4(f_{Na} + f_{Cl}) & hkl\ all\ even \\ 4(f_{Na} - f_{Cl}) & hkl\ all\ odd \\ 0 & hkl\ mixed \end{cases}$$

$$\boldsymbol{Z_1 = 4}$$

D(mm)	d(pm)	$\boldsymbol{Z/Z_1}$
1.06	275.2	**1**
1.56	192.2	**2**
1.94	158.7	**3**
2.30	137.8	**4**
2.62	125.0	**5**
2.96	113.5	**6**

$\{hkl\}$	Z
111	3
200	**4**
220	**8**
311	11
222	**12**
400	**16**
331	19
420	**20**
422	**24**
333	27
511	27
440	32
600	32

$$S = \begin{cases} 4(f_{Na} + f_{Cl}) & hkl\ all\ even \\ 4(f_{Na} - f_{Cl}) & hkl\ all\ odd \\ 0 & hkl\ mixed \end{cases}$$

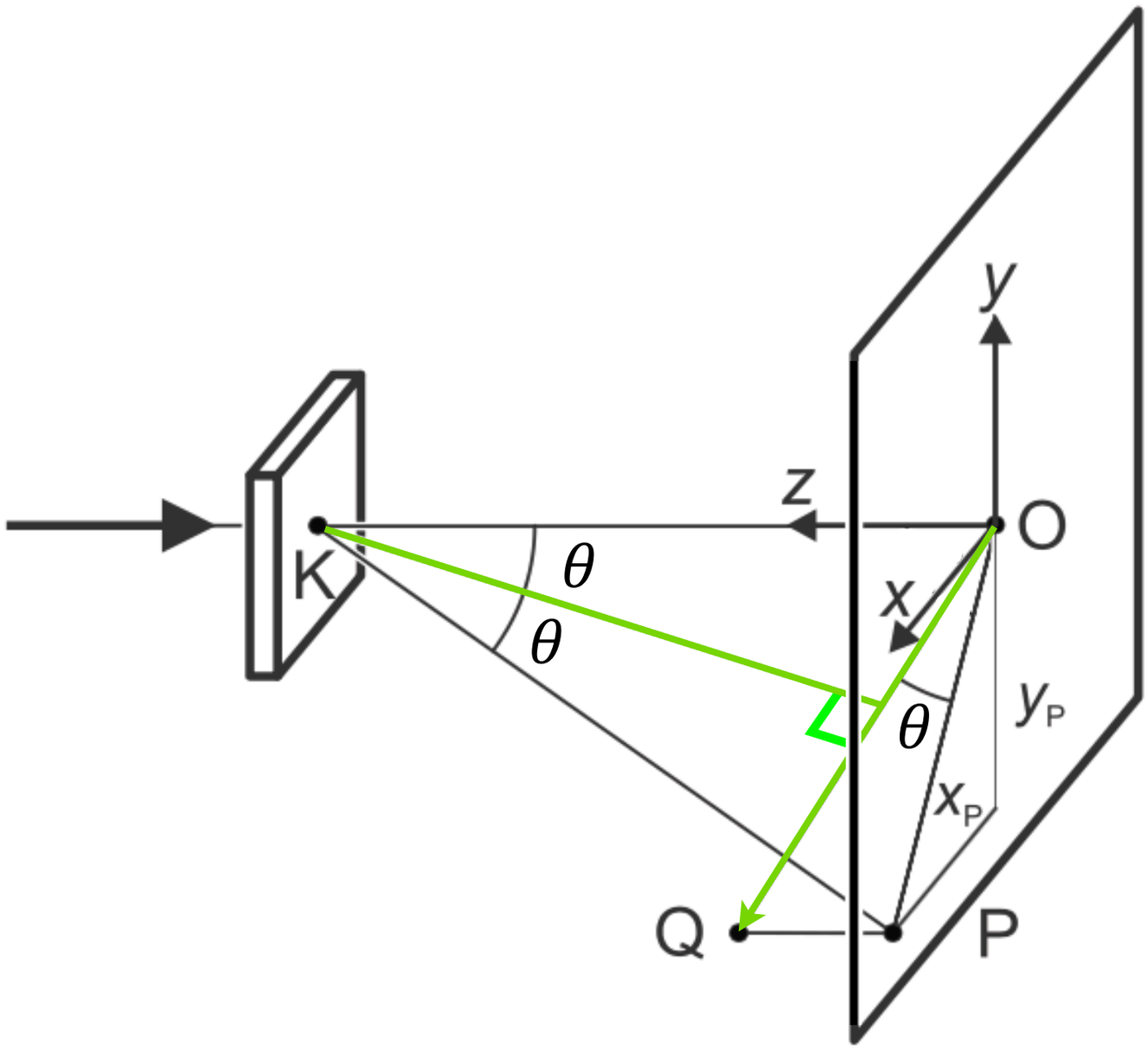
$$\boldsymbol{Z_1 = 4} \qquad a_0 = \sqrt{Z}d$$

D(mm)	d(pm)	$\boldsymbol{Z/Z_1}$	a_0
1.06	275.2	**1**	550.4
1.56	192.2	**2**	543.6
1.94	158.7	**3**	549.8
2.30	137.8	**4**	551.2
2.62	125.0	**5**	559.0
2.96	113.5	**6**	556.0

$$d = \frac{\lambda}{2\sin(\frac{1}{2}\operatorname{atan}\frac{D}{2L})}$$

$$\boldsymbol{a_0 = 551.7pm}$$

$$a_{NaCl} = 564.02pm$$


y
z
O
K
θ
θ
x
θ
y_P
x_P
Q
P