HESEB Helmholtz-SESAME Soft X-Ray Beamline for SESAME

Status report on the commissioning of HESEB

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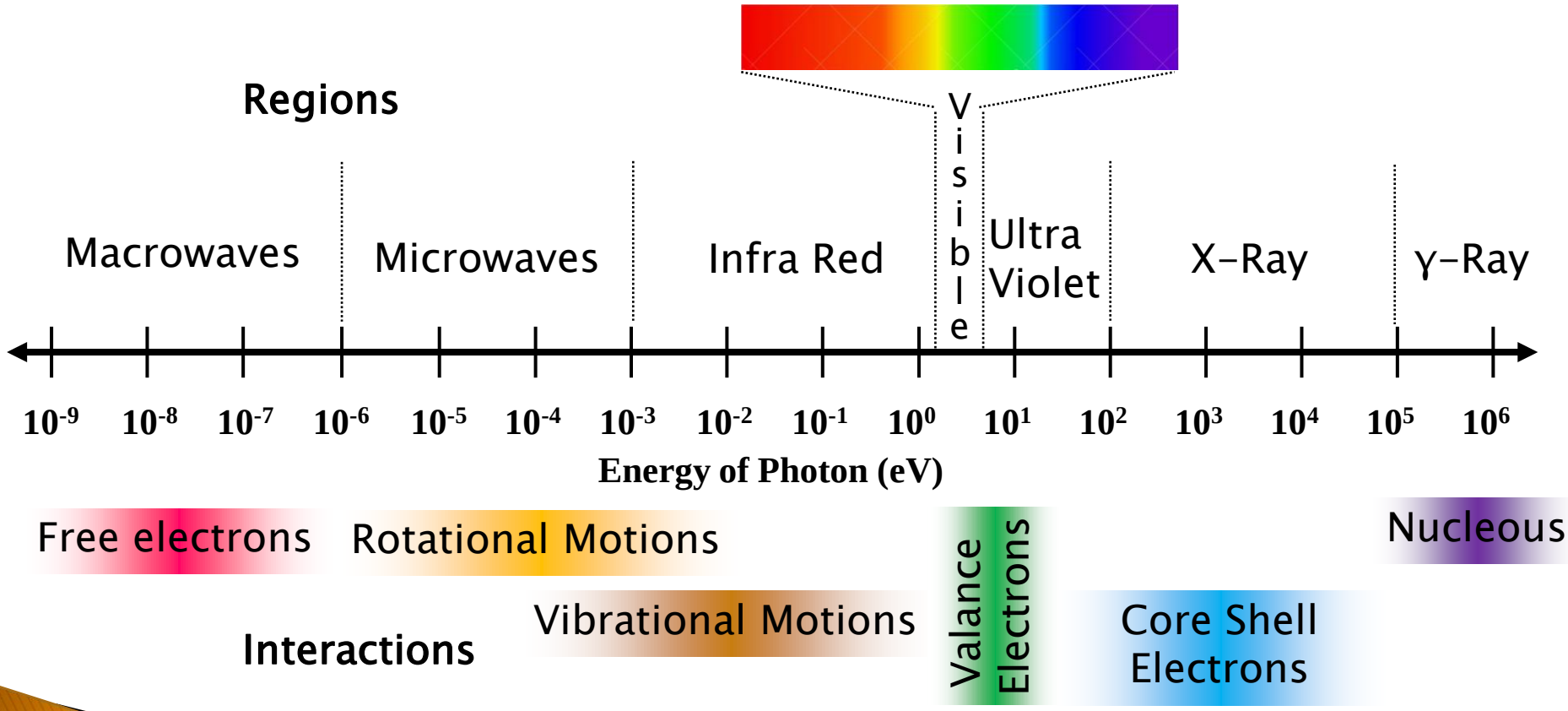
HESEB Soft X-Ray Workshop
at
Istanbul University
08-09/09/2022

Outline

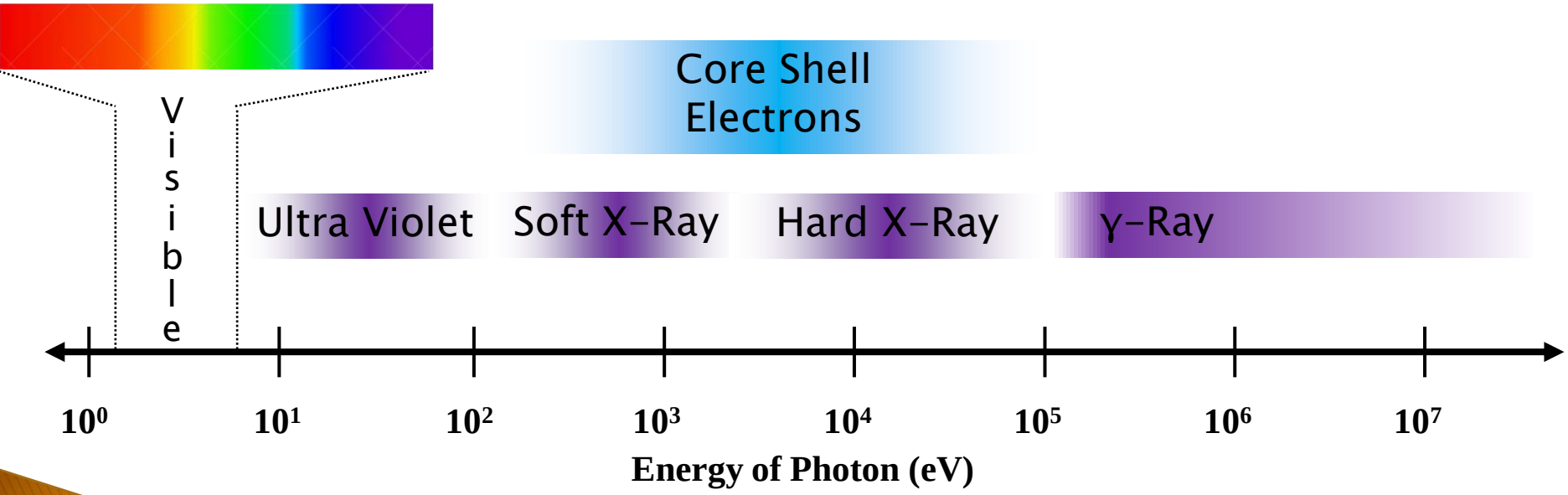
- What is Soft X Ray?
- Soft X-Ray/Matter Interaction
- Analyze with Soft X-Ray
  - X-Ray Absorption
  - X-Ray Emission
  - Photoelectron Emission
- Commissioning of HESEB
  - Properties of HESEB Beamline
  - Capabilities of HESEB Experimental Station
  - Progress and Forthcoming Steps

Electromagnetic Spectrum and Interaction with Materials

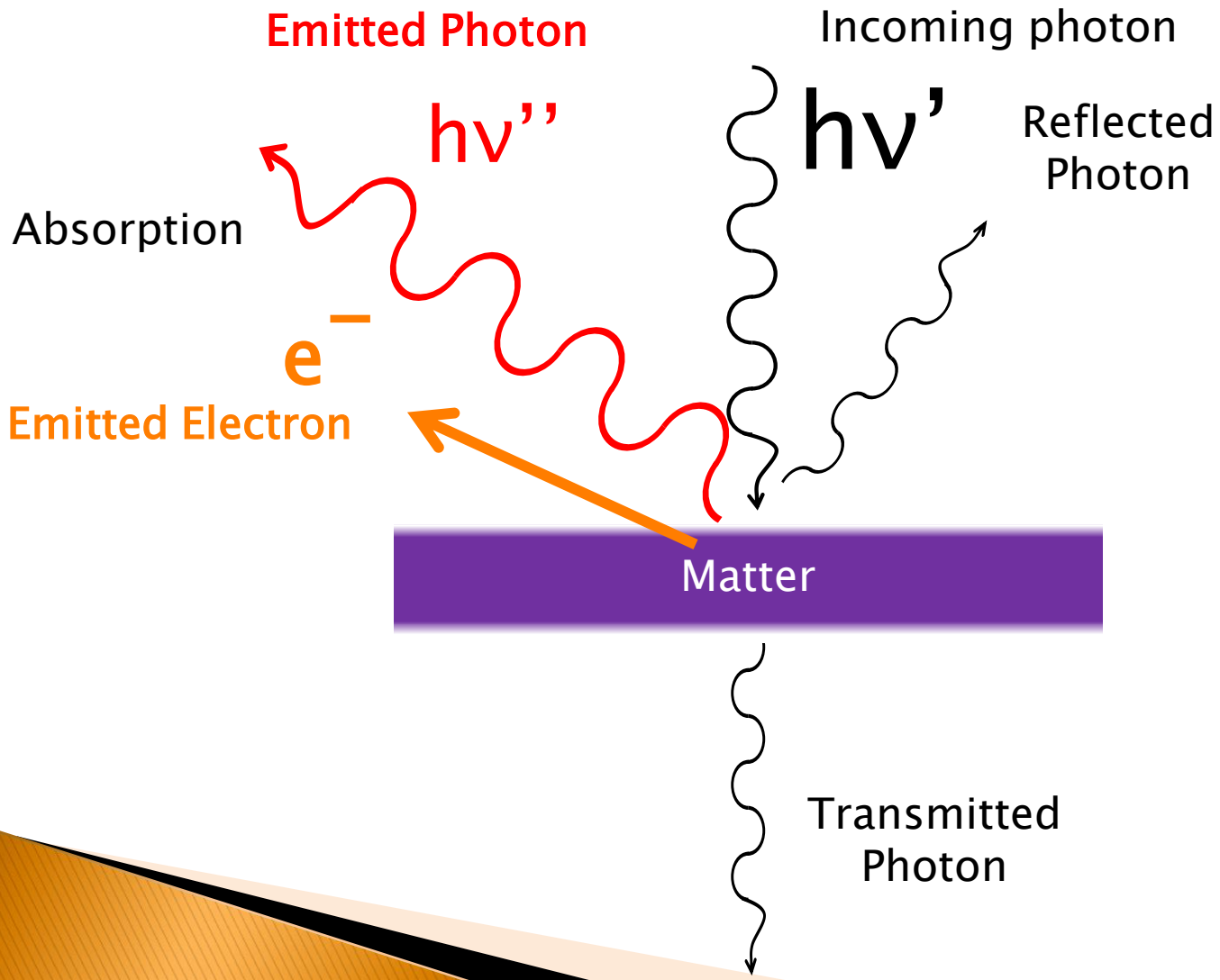


Electromagnetic Spectrum and Soft X-Ray

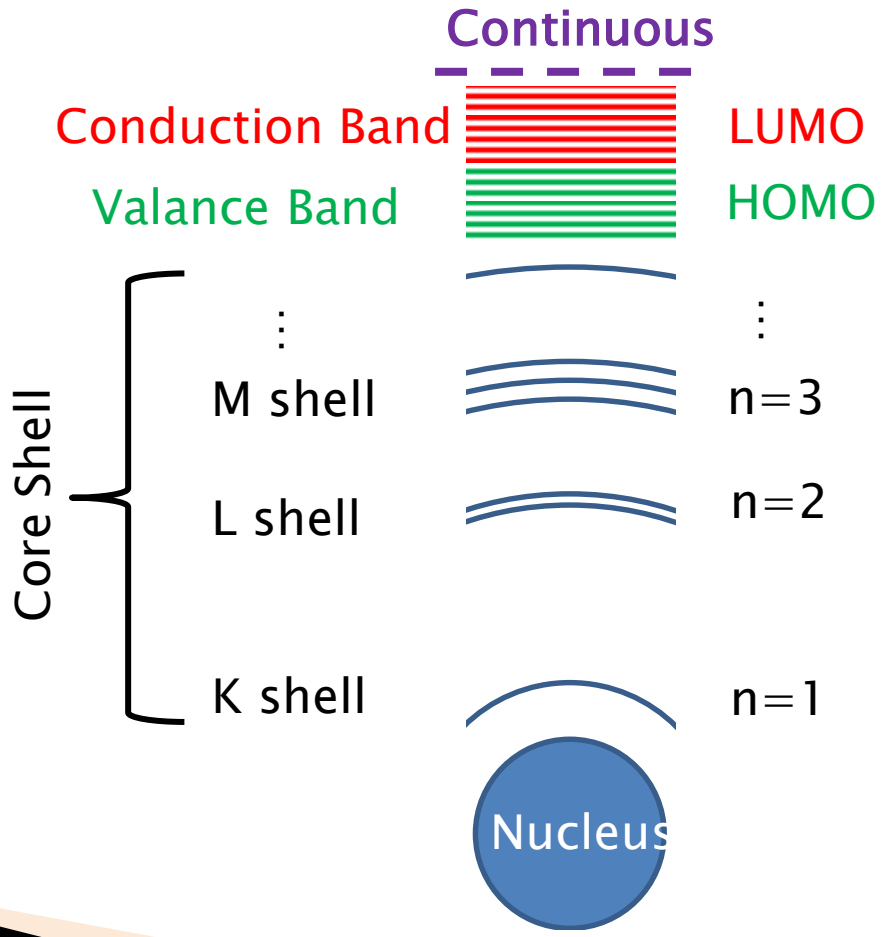
200 eV – 2000 eV
or
~ 6nm – 0.6 nm



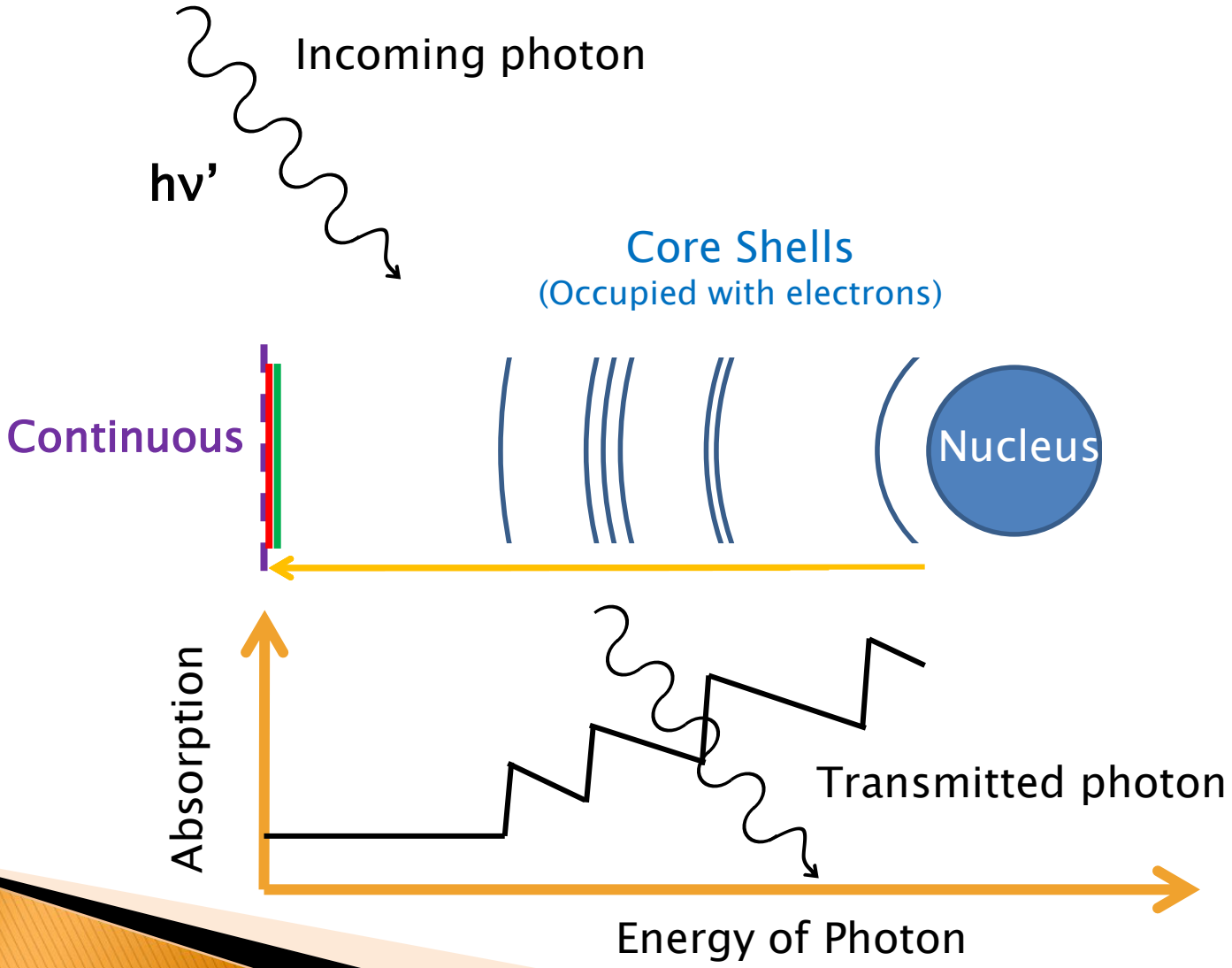
Interaction of Photon–Material and Spectroscopy



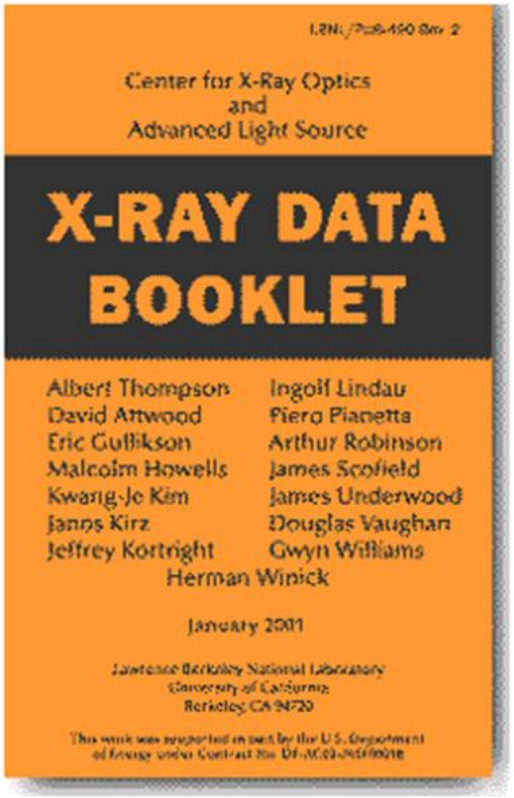
Absorption of X-Ray by Core Shell Electrons



Absorption of X-Ray



Energy of Some Core Electrons (200 – 2000 eV)



https://xdb.lbl.gov/

Energy of Some Core Electrons (200 – 2000 eV)

Table 1-1. *Electron binding energies, in electron volts, for the elements in their natural forms.*

Element	K 1s	L_1 2s	L_2 $2p_{1/2}$	L_3 $2p_{3/2}$	M_1 3s	M_2 $3p_{1/2}$	M_3 $3p_{3/2}$	M_4 $3d_{3/2}$	M_5 $3d_{5/2}$	N_1 4s	N_2 $4p_{1/2}$	N_3 $4p_{3/2}$
1 H	13.6											
2 He	24.6*											
3 Li	54.7*											
4 Be	111.5*											
5 B	188*											
6 C	284.2*											
7 N	409.9*	37.3*										
8 O	543.1*	41.6*										
9 F	696.7*											
10 Ne	870.2*	48.5*	21.7*	21.6*								
11 Na	1070.8†	63.5†	30.65	30.81								
12 Mg	1303.0†	88.7	49.78	49.50								
13 Al	1559.6	117.8	72.95	72.55								
14 Si	1839	149.7*b	99.82	99.42								
15 P	2145.5	189*	136*	135*								
16 S	2472	230.9	163.6*	162.5*								
17 Cl	2822.4	270*	202*	200*								
18 Ar	3205.9*	326.3*	250.6†	248.4*	29.3*	15.9*	15.7*					
19 K	3608.4*	378.6*	297.3*	294.6*	34.8*	18.3*	18.3*					
20 Ca	4038.5*	438.4†	349.7†	346.2†	44.3 †	25.4†	25.4†					
21 Sc	4492	498.0*	403.6*	398.7*	51.1*	28.3*	28.3*					
22 Ti	4966	560.9†	460.2†	453.8†	58.7†	32.6†	32.6†					

K– Shell

Sensitive to Air
Require Vacuum

L– Shell

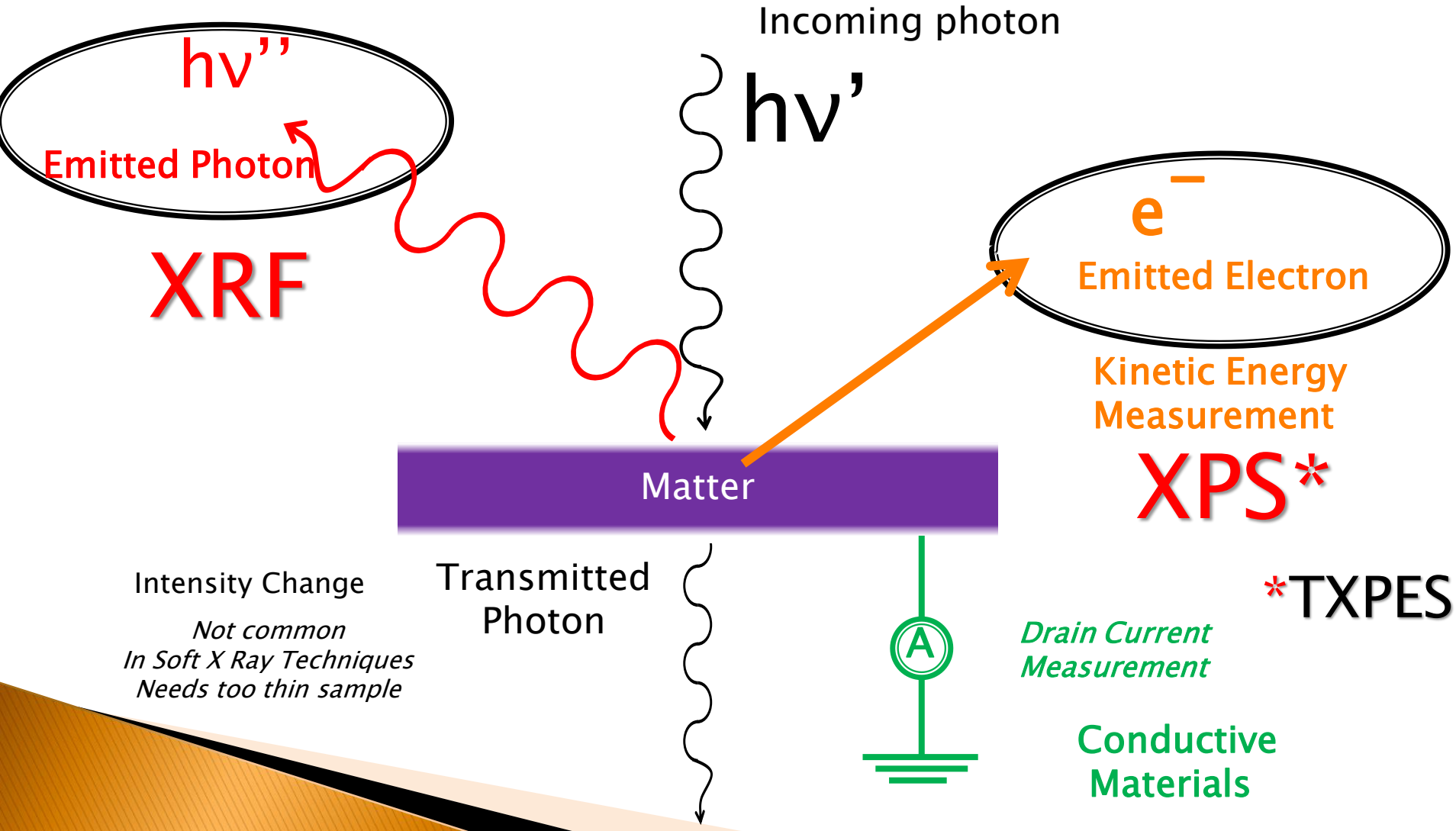
Table 1-1. *Electron binding energies, in electron volts, for the elements in their natural forms.*

Element	K 1s	L_1 2s	L_2 $2p_{1/2}$	L_3 $2p_{3/2}$	M_1 3s	M_2 $3p_{1/2}$	M_3 $3p_{3/2}$	M_4 $3d_{3/2}$	M_5 $3d_{5/2}$	N_1 4s	N_2 $4p_{1/2}$	N_3 $4p_{3/2}$
23 V	5465	626.7†	519.8†	512.1†	66.3†	37.2†	37.2†					
24 Cr	5989	696.0†	583.8†	574.1†	74.1†	42.2†	42.2†					
25 Mn	6539	769.1†	649.9†	638.7†	82.3†	47.2†	47.2†					
26 Fe	7112	844.6†	719.9†	706.8†	91.3†	52.7†	52.7†					
27 Co		925.1†	793.2†	778.1†	101.0†	58.9†	59.9†					
28 Ni		1008.6†	870.0†	852.7†	110.8†	68.0†	66.2†					
29 Cu	8979	1096.7†	952.3†	932.7	122.5†	77.3†	75.1†					
30 Zn	9659	1196.2*	1044.9*	1021.8*	139.8*	91.4*	88.6*	10.2*	10.1*			
31 Ga	10367	1299.0*b	1143.2†	1116.4†	159.5†	103.5†	100.0†	18.7†	18.7†			
32 Ge	11103	1414.6*b	1248.1*b	1217.0*b	180.1*	124.9*	120.8*	29.8	29.2			
33 As	11867	1527.0*b	1359.1*b	1323.6*b	204.7*	146.2*	141.2*	41.7*	41.7*			
34 Se	12658	1652.0*b	1474.3*b	1433.9*b	229.6*	166.5*	160.7*	55.5*	54.6*			
35 Br	13474	1782*	1596*	1550*	257*	189*	182*	70*	69*			
36 Kr	14326	1921	1730.9*	1678.4*	292.8*	222.2*	214.4	95.0*	93.8*	27.5*	14.1*	14.1*
37 Rb	15200	2065	1864	1804	326.7*	248.7*	239.1*	113.0*	112*	30.5*	16.3*	15.3 *
38 Sr	16105	2216	2007	1940	358.7†	280.3†	270.0†	136.0†	134.2†	38.9†	21.3	20.1†
39 Y	17038	2373	2156	2080	392.0*b	310.6*	298.8*	157.7†	155.8†	43.8*	24.4*	23.1*
40 Zr	17998	2532	2307	2223	430.3†	343.5†	329.8†	181.1†	178.8†	50.6†	28.5†	27.1†
41 Nb	18986	2698	2465	2371	466.6†	376.1†	360.6†	205.0†	202.3†	56.4†	32.6†	30.8†
42 Mo	20000	2866	2625		506.3†	411.6†	394.0†	231.1†	227.9†	63.2†	37.6†	35.5†
43 Tc	21044	3043	2793		544*	447.6	417.7	257.6	253.9*	69.5*	42.3*	39.9*
44 Ru	22117	3224	2967	2838	586.1*	483.5†	461.4†	284.2†	280.0†	75.0†	46.3†	43.2†
45 Rh	23220	3412	3146	3004	628.1†	521.3†	496.5†	311.9†	307.2†	81.4*b	50.5†	47.3†
46 Pd	24350	3604	3330	3173	671.6†	559.9†	532.3†	340.5†	335.2†	87.1*b	55.7†a	50.9†
47 Ag	25514	3806	3524	3351	719.0†	603.8†	573.0†	374.0†	368.3	97.0†	63.7†	58.3†

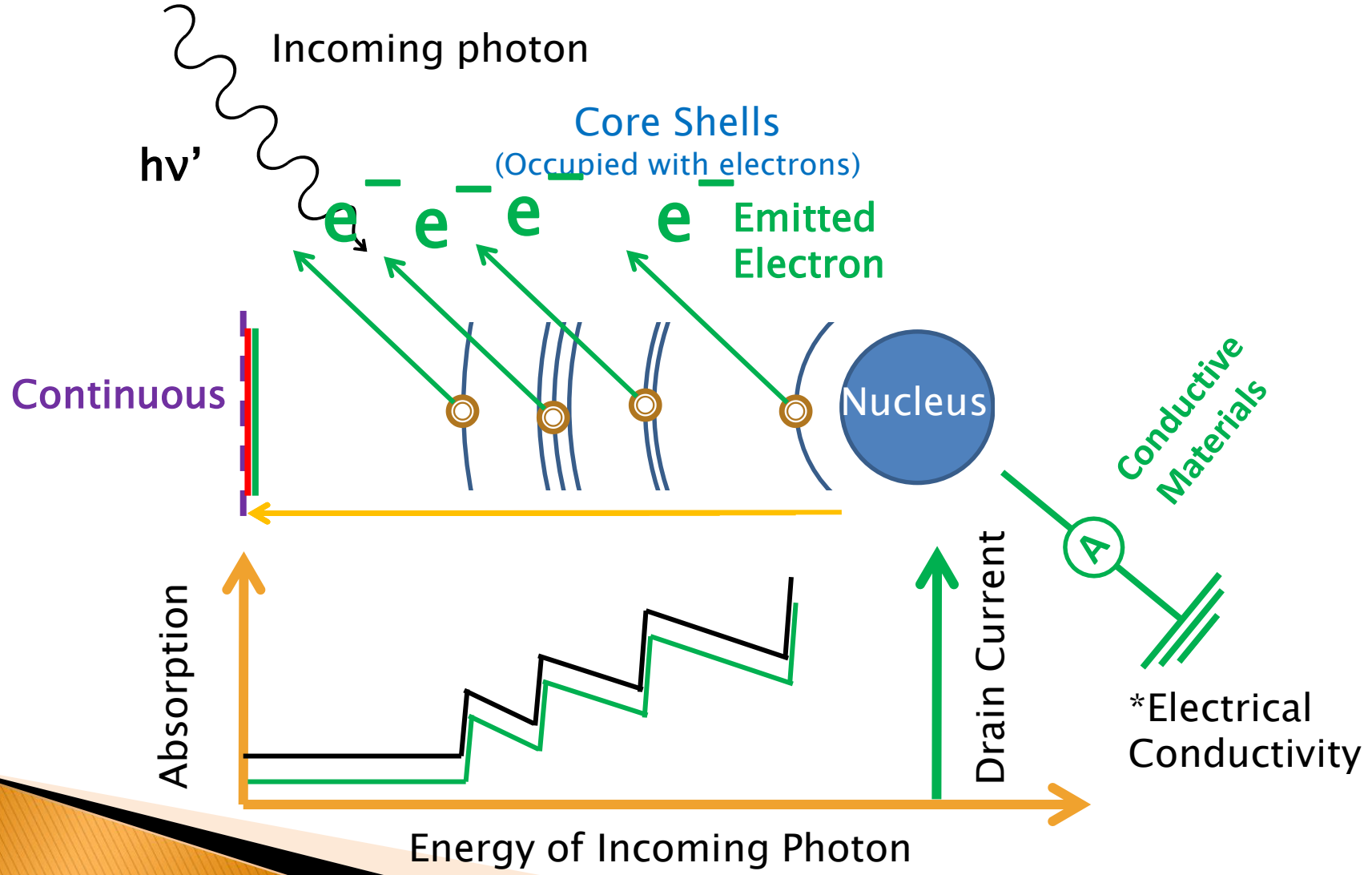
L– Shell

M– Shell

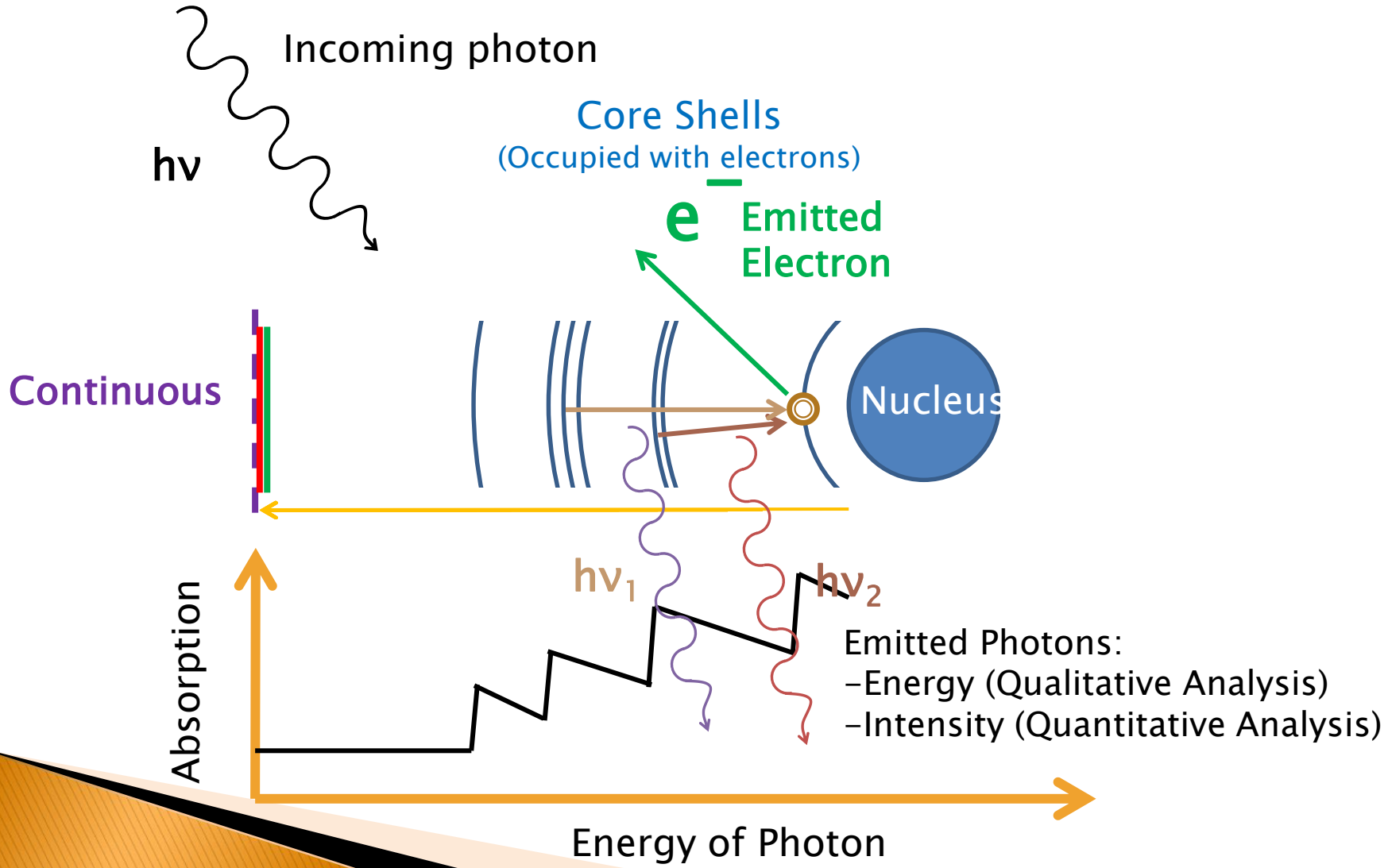
X Ray Absorption Related Techniques



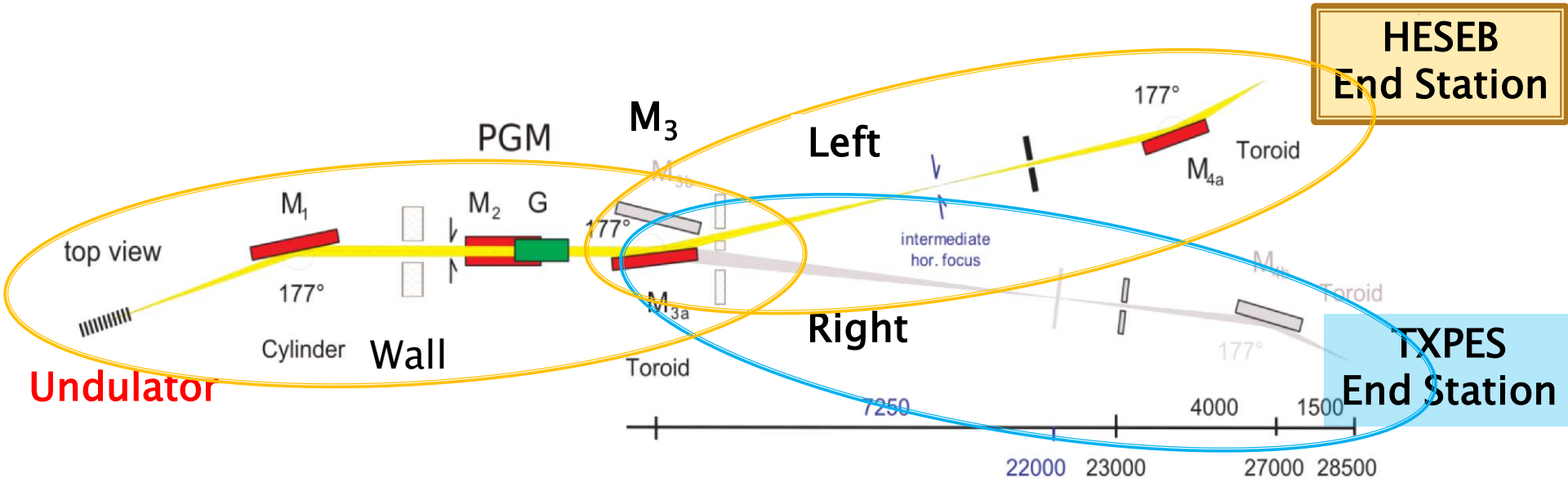
Absorption of X-Ray: Total Electron Yield



Absorption of X-Ray: XRF (X Ray Fluorescence)



Plan View of HESEB and TXPES



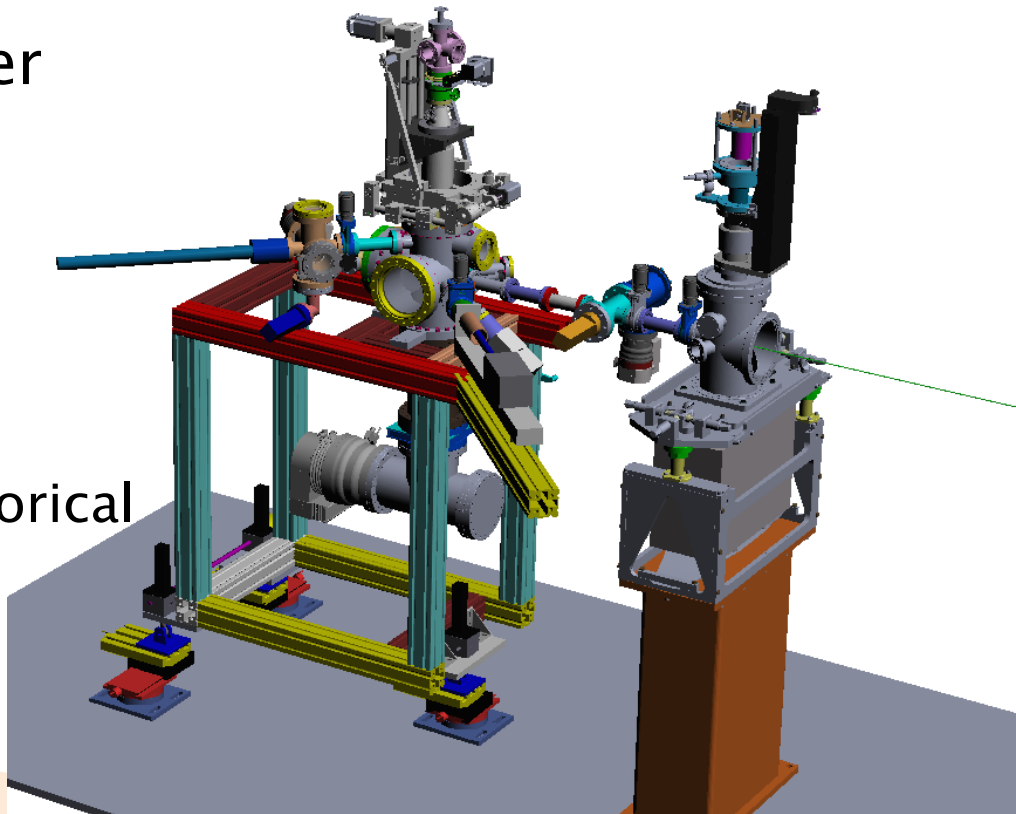
Undulator: Apple II/UE56-SE

Properties of HESEB Beamline

- Third Generation Source: Undulator
- Flux: 10^{12} photon/s on sample
- Energy Resolution: 10^4 $E/\Delta E$ @400ev (40 meV)
- Polarization: Linear and Circularly
- Extended Photon Energy Range: 70-2000 eV
- Spot size: 200x20 μm^2 (h x v)
  - With optical capillary 20x20 μm^2

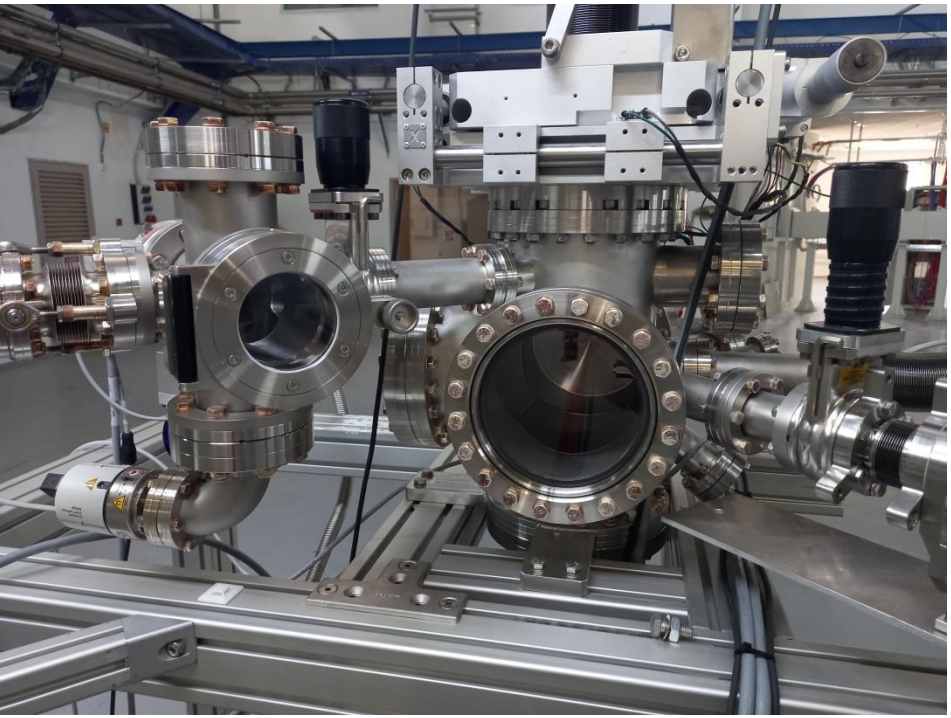
Properties of HESEB End Station

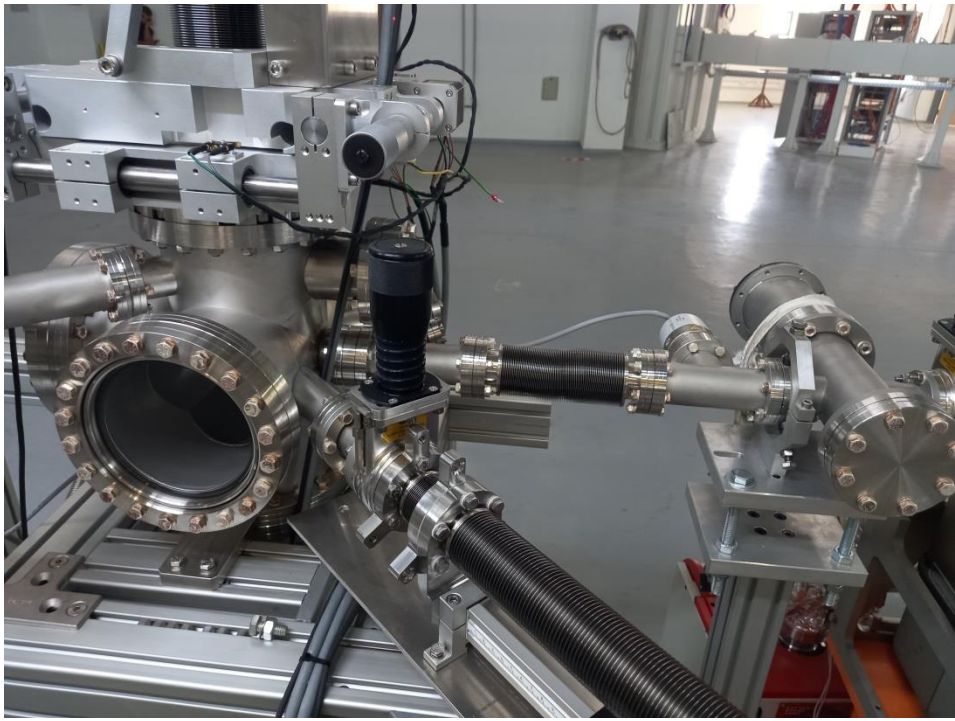
- Fluorescence Detector (XRF)
- Total Electron Yield measurement
- LN_2 Cooling
- Sample Heating
- E-Beam Cleaning
- Motorized Sample Holder for 2D Mapping
  lateral resolution 1μm
- Partial Pumping
  - Measurement at low vacuum at He atmosphere for vacuum sensitive samples (i.e. Historical samples)



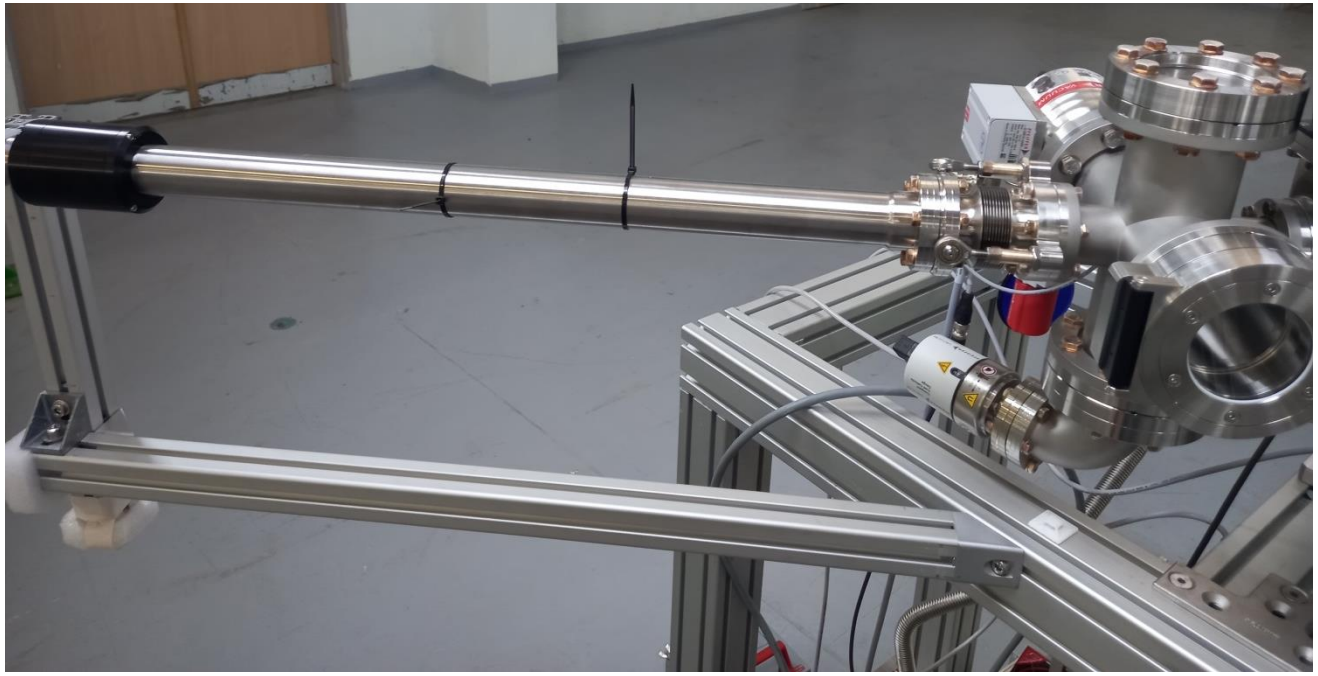
HESEB End Station

HESEB End Station: Chamber

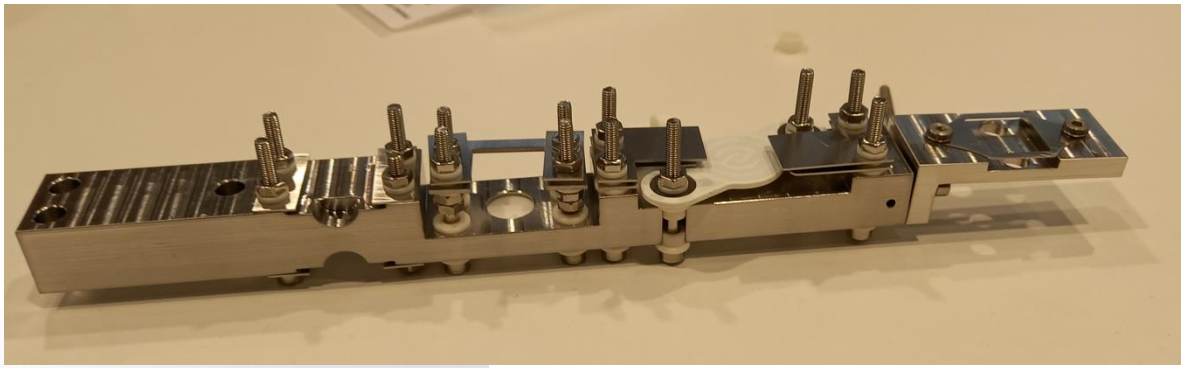


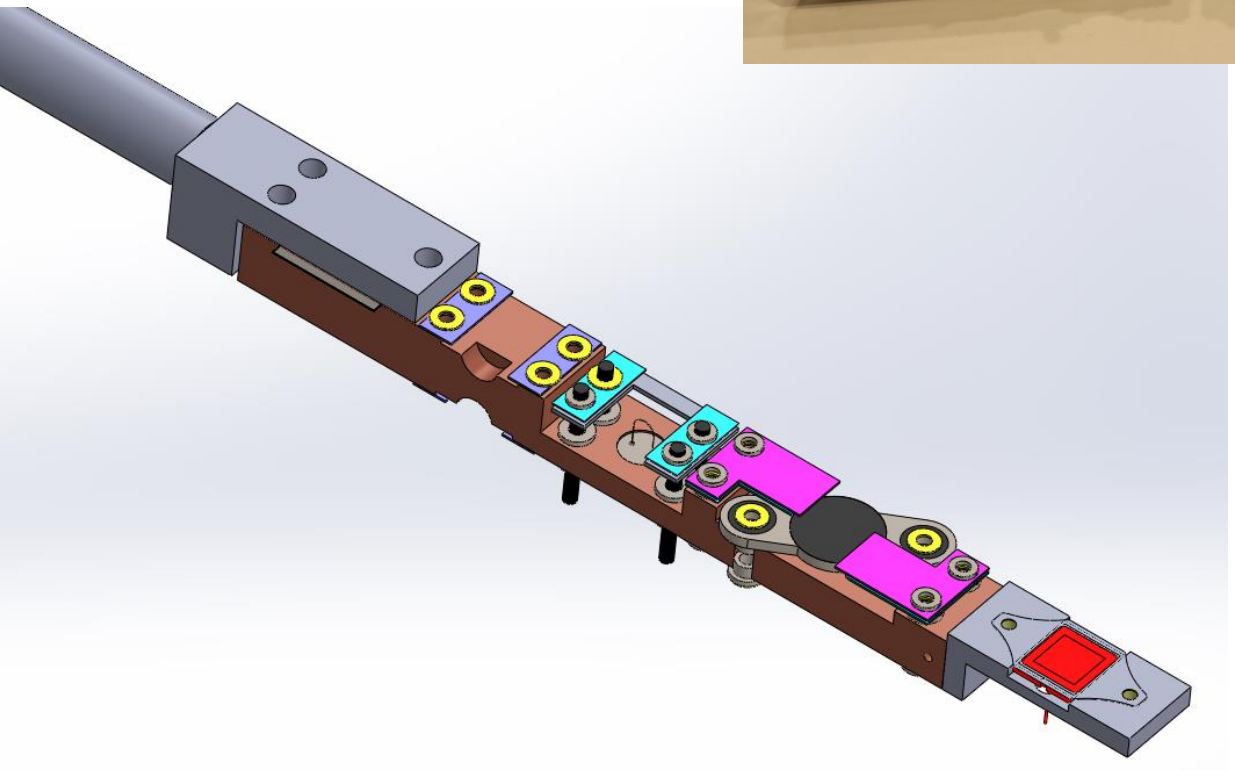


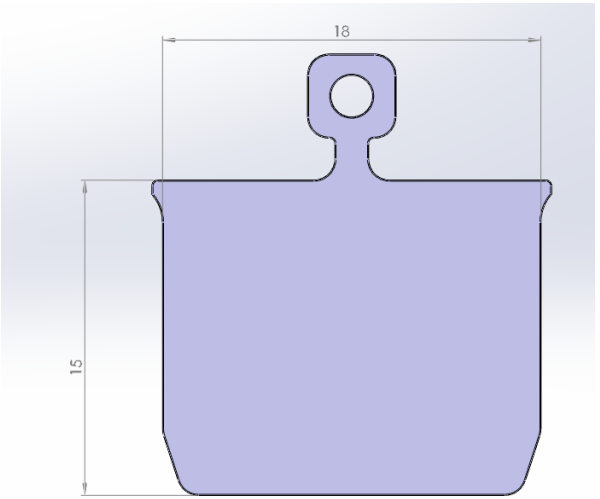
HESEB End Station: Load lock



HESEB: Sample holder and Receptacle Part





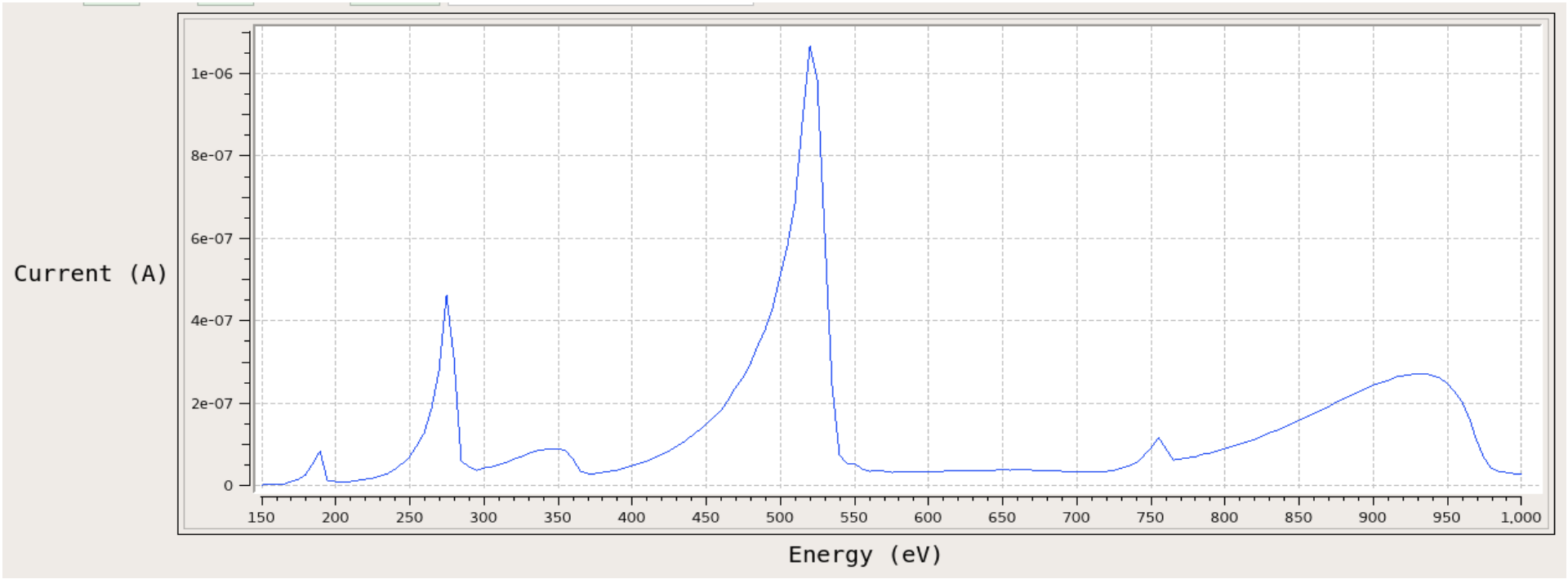


First Beam in HESEB Beamline

08.06.2022

Harmonics of The Undulator

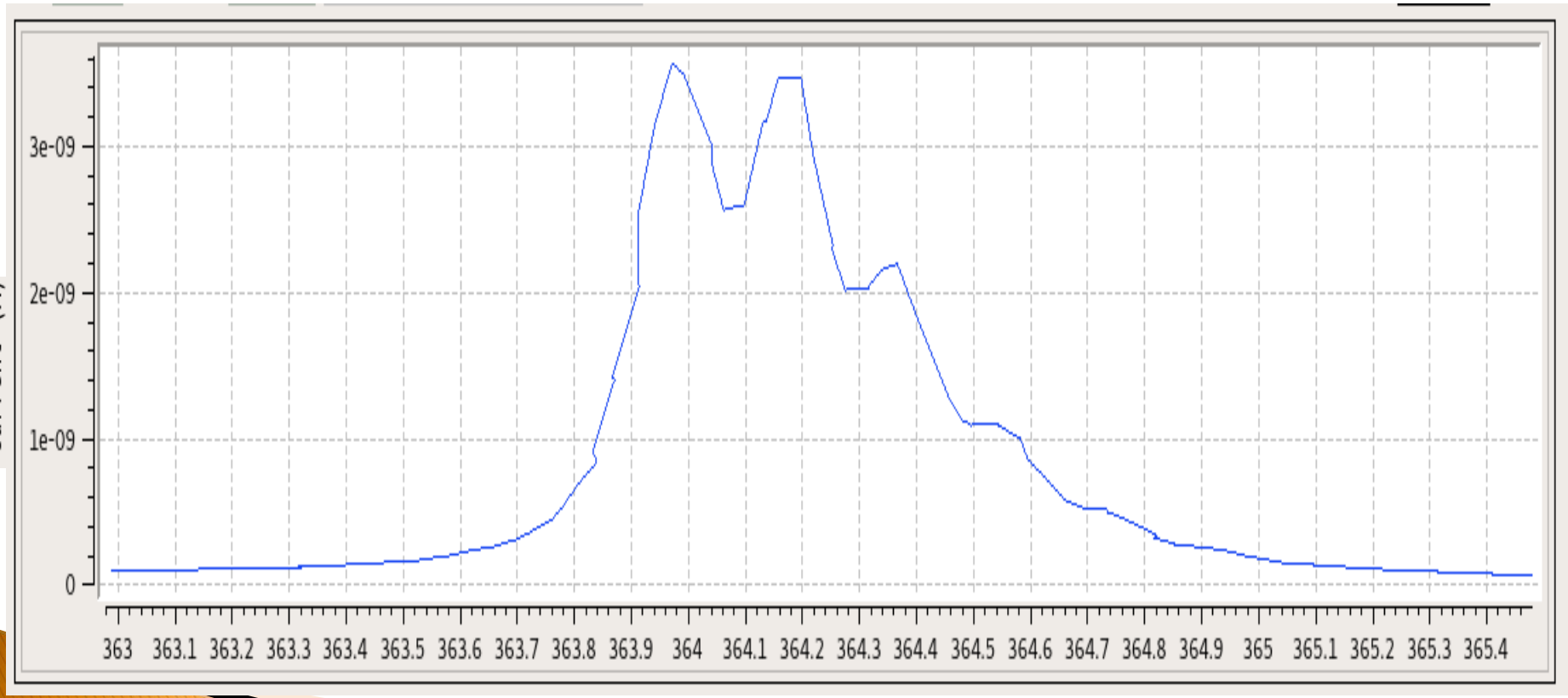
Undulator gap= 33 mm



22.07.2022

N_2 gas peaks(N1s → Π*)

Grating type= 400 grove/mm
Energy steps= 0.02 eV
V slit= 0.02mm

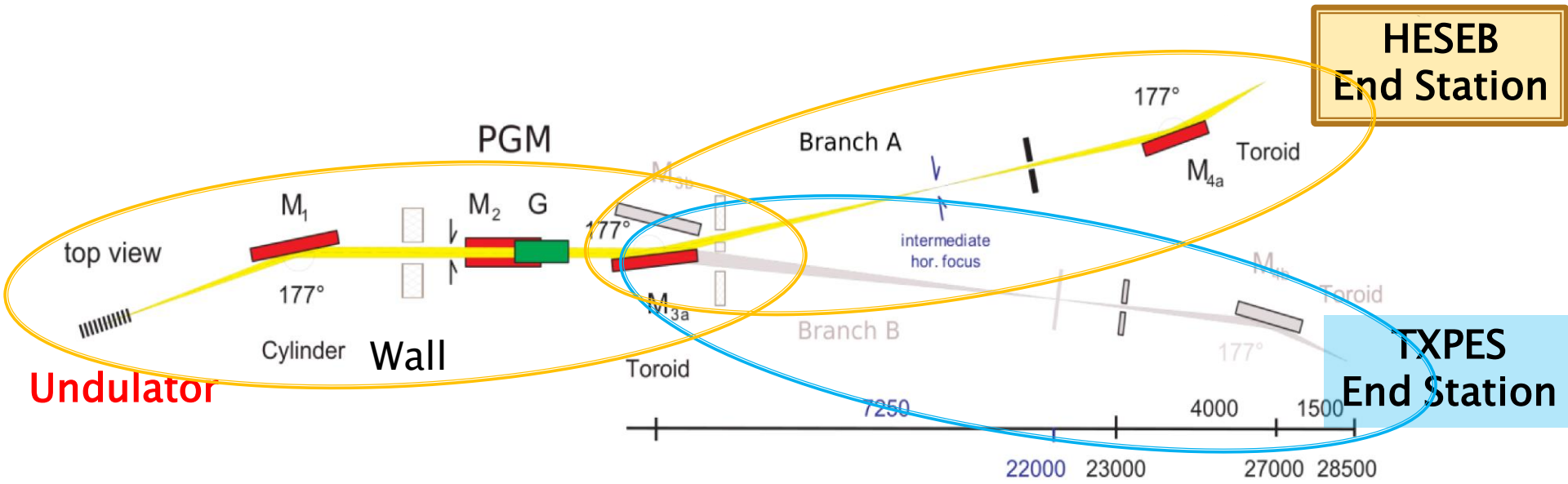


26.07.2022

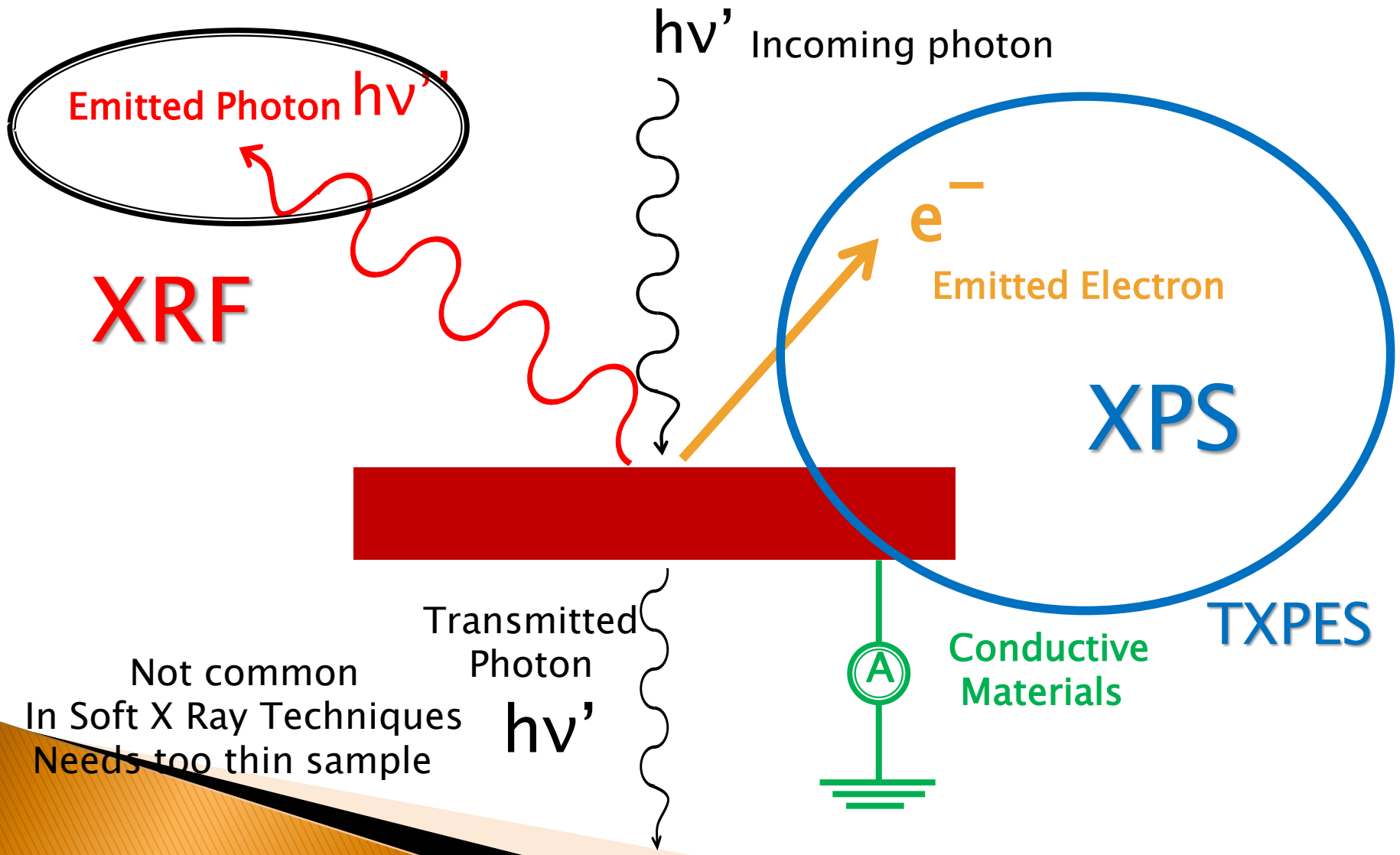
Forthcoming Steps

- Alignment and calibration of photon beam
- Tests on Experimental chamber
- Friendly user – December 2022
- Collecting Proposal – March 2023

Plan View of HESEB and TXPES



X Ray Absorption Related Techniques



Acknowledgments

- HESEB project team
- My SESAME colloquies

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THANK YOU!

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