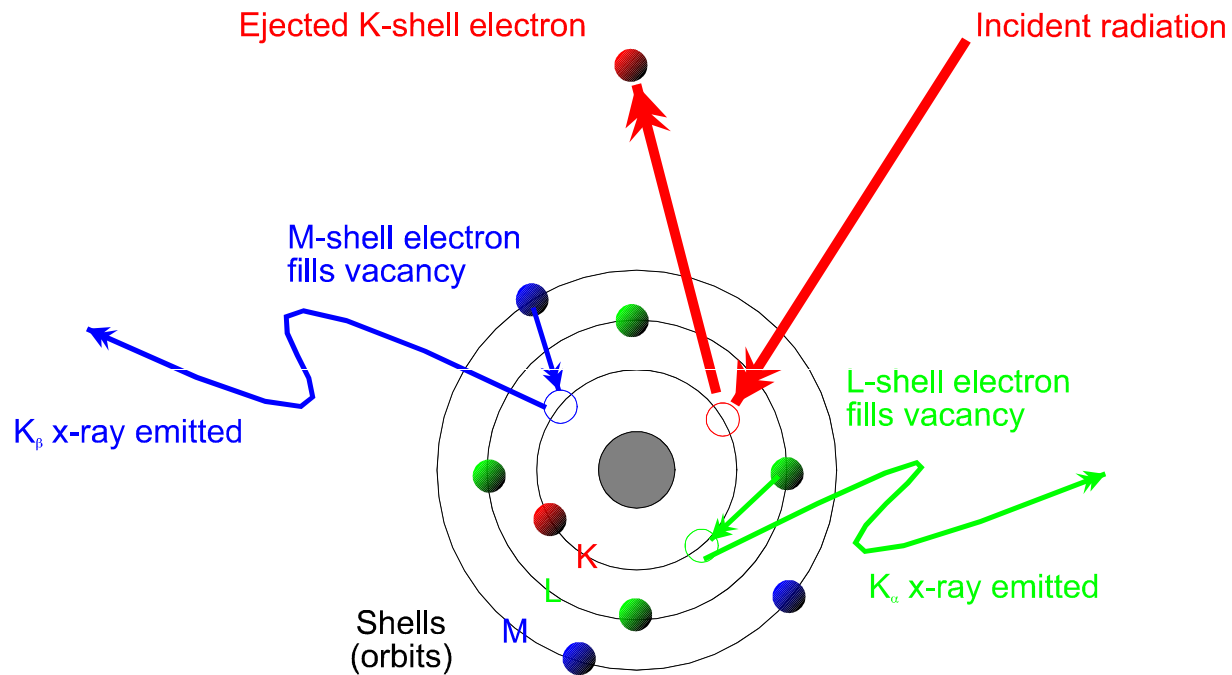




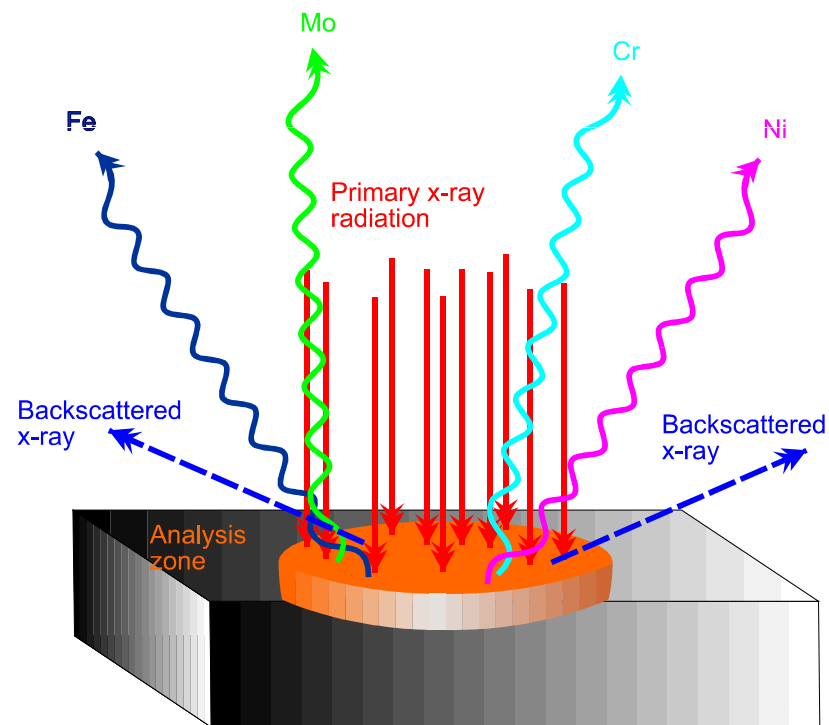
# Basics of Handheld XRF

# Characteristic x-ray production

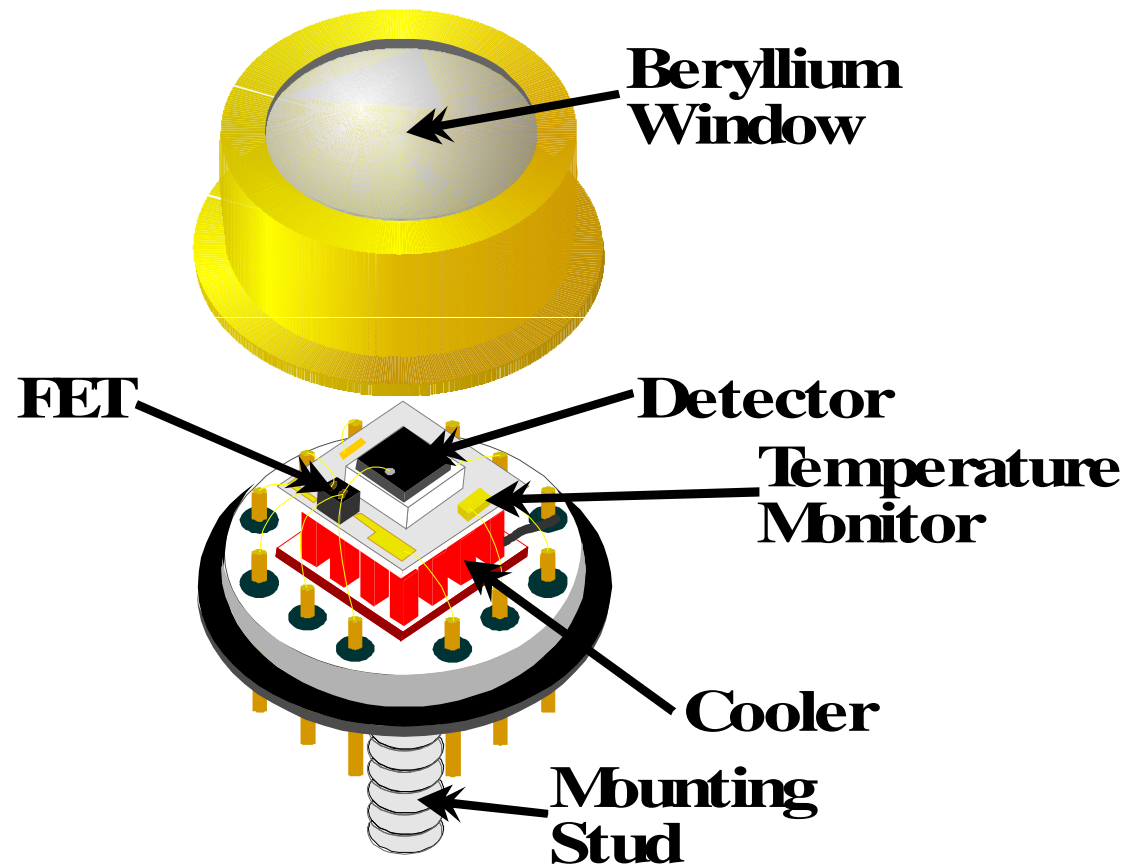


Each individual element produces its own set of characteristic x-rays

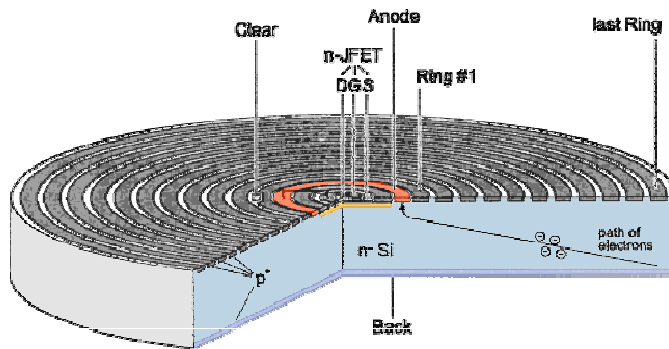
Backscatter also reaches the detector and can be used to determine density of matrix



# SiPIN/SDD Detector

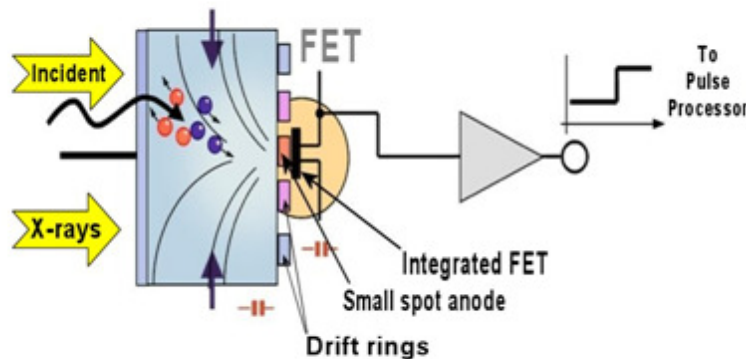


# Silicon Drift Detector



## X-Flash SDD

- ❖ Integrated drift structure results in low capacitance
- ❖ Integrated FET supports high throughput
- ❖ Thin entrance window



SDD Schematic

## SDD Offers

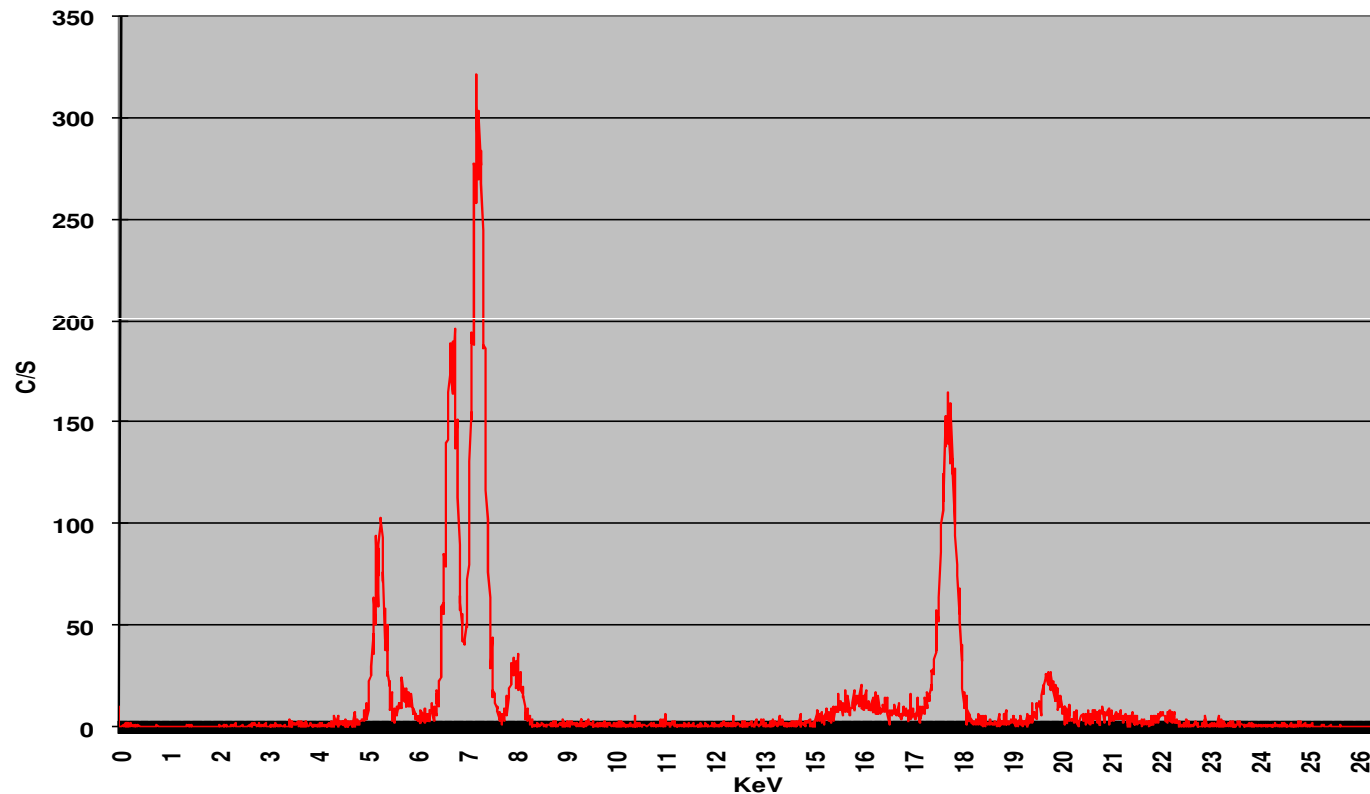
- ❖ Improved Resolution
- ❖ Higher Count Rate
- ❖ Good light element sensitivity

# XRF Spectrum

## L to R = Cr, Co, Ni, and Mo



NI Alloy MP35N



**Note: when X-ray energies exceed 25-30 kV use L lines**  
**Ex: Pb Ka @ 74.97 kV use La @ 10.55 kV**

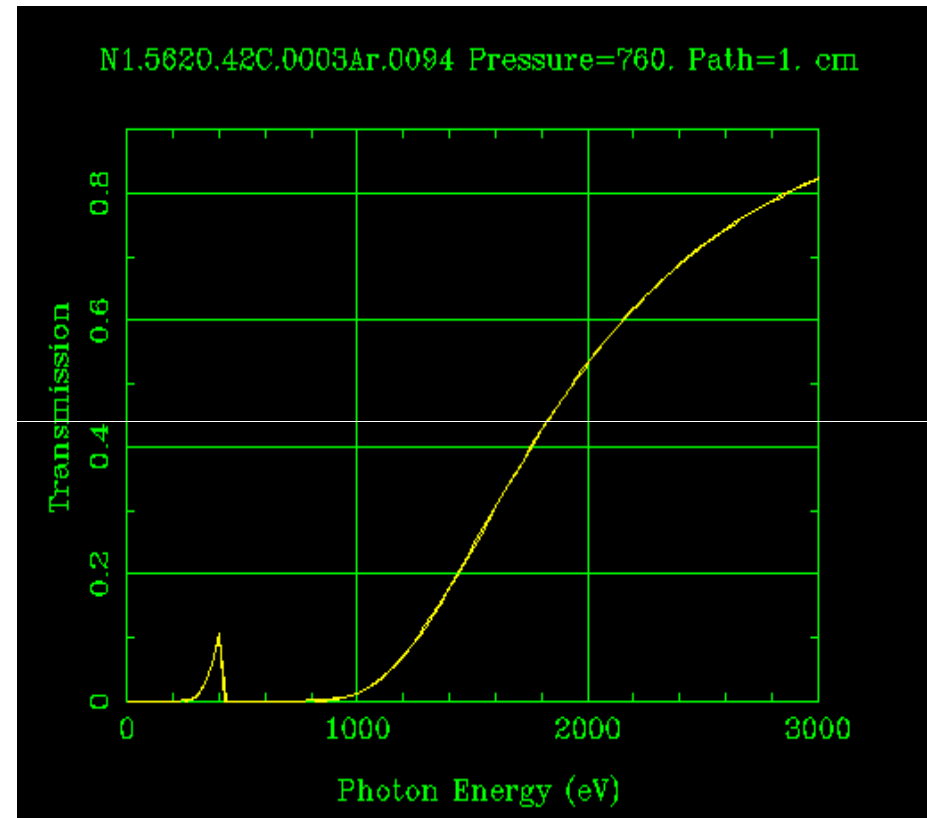
# XRF Rules



- 1. Energy of X-ray tells you what element is present**
- 2. Number of X-rays tells you how much is present**
- 3. Energy decreases with atomic number**
- 4. Absorption increases with decreasing energy**

## Absorption of 1 cm Air Path

	Energy	Trans.
Mg	1.3	11.9%
Al	1.5	24.0%
Si	1.7	36.6%
P	2.0	53.2%
S	2.3	65.5%





H																	He	
Li	Be											B	C	N	O	F	Ne	
Na	Mg	Sc											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Tu	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
Fr	Ra	Ac																
			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

Transmitted	Air ~10%	Air > 50%		Air > 90%			Kapton >90%		
Line	1 kV	2 kV	3 kV	4 kV	5 kV	6 kV	7-10 kV	10-20 kV	20-30 kV
Ka	Mg, Al, Si	P, S, Cl		Ca, Ti	V, Cr	Mn	Fe, Co, Ni, Cu, Zn	Sr, Y, Zr, Nb, Mo	Ag, Cd, Sn, Sb
La		Zr, Nb, Mo	Ag, Cd, Sn, Sb				Hf, Ta, W, Au, Hg	Pb, Bi,	

# Statistics



- Accuracy
  - How close is the answer to the real value
  - Determined by standards and calibration
  
- Precision
  - How repeatable is the answer
  - Determined by number of counts in the peak
  - Increasing counting time increases precision
  - Increasing absorption decreases precision

## Standard Deviation

- $\text{Std} = \sqrt{\text{number of counts}}$

## Relative Standard Deviation

- $\text{RSD} = \frac{\sqrt{N}}{N} \times 100$
- $= \frac{1}{\sqrt{N}} \times 100$
- At 1000 counts  
 $\text{RSD} = \frac{1}{\sqrt{1000}} \times 100 = 3.2\%$
- At 4000 counts  
 $\text{RSD} = \frac{1}{\sqrt{4000}} \times 100 = 1.6\%$

**Increase counts and therefore precision by increasing measurement time**

# S1 Turbo<sup>SD</sup>

## Calibration Models



### Empirical

- Based on standards
- Most accurate results for alloys in the calibration
- Separated by matrix (ex. Low Alloy; Stainless; Copper)
- Empirical calibration for Al, Ti, Fe, Co, Ni, Cu alloys
- Reports only the elements in the calibration

### Fundamental Parameters

- Theoretical based
- Covers a broad range of elements and alloy types
- Covers above list plus Zn, Zr, Sn alloys
- Covers 29 elements from 0-100%
- Ti; V; Cr; Mn; Fe; Co; Ni; Cu; Zn; As; Se; Zr; Nb; Mo; Ru; Rh; Pd; Ag; In; Sn; Sb; Hf; Ta; W; Ir; Pt; Au; Pb; Bi

# S1 Turbo<sup>SD</sup> Analysis Modes



## Dual – Only for LE Models

- Only active for GradeID Emp
- Runs two sets of measurement conditions
  - Normally 40kV for elements Ti (22) and above
  - Followed by 15 kV for elements from Mg to Zn
- Time for each condition set by user
- Condition 2 run only for alloys which might contain Mg; Al; Si - e.g. Co alloys will not run second condition
- Condition 2 alloys are defined in a file – e.g. No Match will not run a second condition

# S1 Turbo<sup>SD</sup>

## Analysis Modes



### Universal

- Automatically selects GradeID Emp and determines the proper Empirical Model (e.g. Fe/Co/Ni/Cu; Ti; Al) or PMI-FP
- Adds about 2 sec before first data display (not to total)
- Will switch to FP after 3 sec if alloy is not ID'ed
- Runs Condition 1 (40kV) for 5 seconds
- If alloy is in Dual Table (only on LE version)
  - In Manual Condition 2 (15 kV) run until trigger released
  - In Auto Condition 2 (15 kV) runs until total time equals set value
- If alloy is not in Dual Table continues in Condition 1

# Sample Preparation



- Analysis is done to a depth of approx. 0.1 mm for steels; 1-2 mm for aluminum
- Ideal sample is clean flat surface which covers the window area.
- For light elements sample surface matters
- Coatings/Paint/Rust may need to be remove.