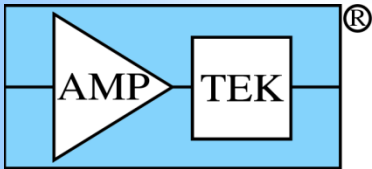


**Amptek Inc.**  
**14 Deangelo Drive**  
**Bedford, MA 01730 USA**  
**[www.amptek.com](http://www.amptek.com)**

# What does it take to do XRF analysis?

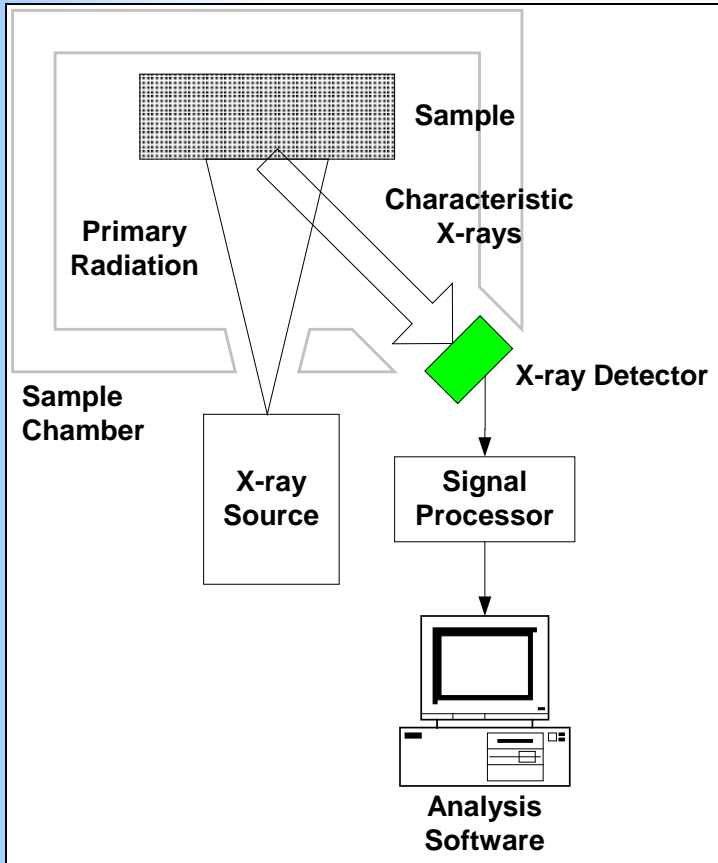
## **AMPTEK, INC.**

14 Deangelo Drive, Bedford, MA 01730  
Ph: +1 781 275 2242 Fax: +1 781 275 3470  
[sales@amptek.com](mailto:sales@amptek.com) [www.amptek.com](http://www.amptek.com)

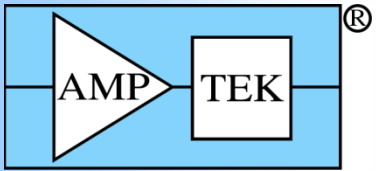


# Instrument

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
www.amptek.com



- Excitation source
  - X-ray tube or radioisotope
- Spectrometer
  - X-ray detector
  - Signal processing electronics
- Software
  - Spectrum correction and processing software
- Other
  - Sample preparation
  - Radiation shielding
  - Sample fixture



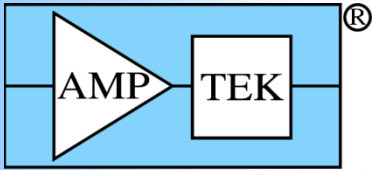
# Instrument

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
[www.amptek.com](http://www.amptek.com)



## Sample Turn-key XRF Analyzers

A "turn-key solution" is a complete product ready for immediate use.



# Instrument

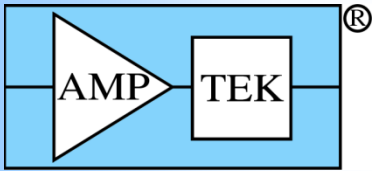
Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
[www.amptek.com](http://www.amptek.com)

## How easy is XRF?

- It is easy to see major elements in many samples
- It is difficult to obtain high accuracy and/or low detection limits in complex samples.

## What makes the difference between mediocre and good results?

- System must be optimized for specific elements and samples
- System must be calibrated for the samples of interest
- Sample preparation is important
- Operating procedures are important



# Excitation Source

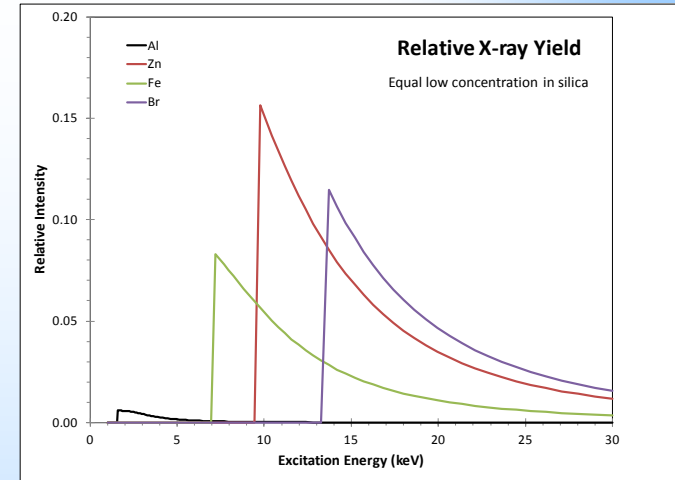
Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
www.amptek.com

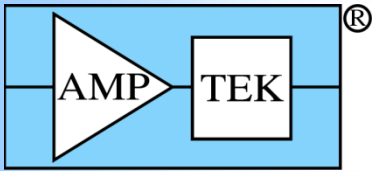
## What is the purpose of the source?

- Excite elements to be analyzed
- Produces the signal

## What is an ideal XRF source?

- Energy just above edge of analyte
- Monoenergetic → Low background
- Intense, stable flux → Fast, accurate measurement
- Source must be optimized for analyte element and sample
  - E.g. choose energy, current, beam filters, optics



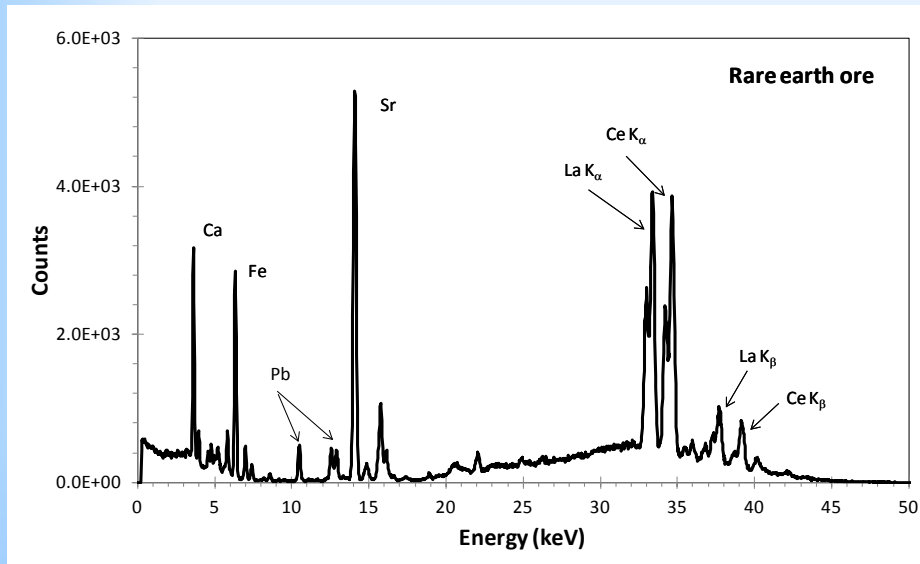


# Spectrometer

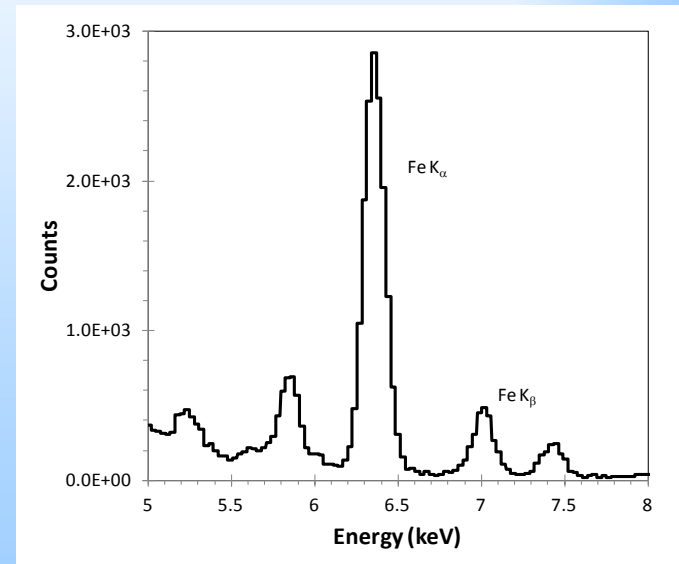
Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
www.amptek.com

## What is the purpose of the spectrometer?

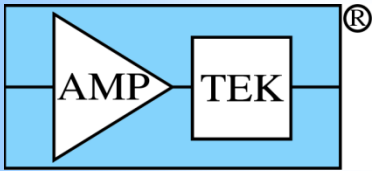
- Measures energy deposited by each X-ray interacting in detector
- Outputs the spectrum, a histogram showing the number  $N_i$  of X-rays in each energy channel, between  $E_i$  and  $E_i + \delta E$



Typical spectrum



Region expanded to show channels in histogram

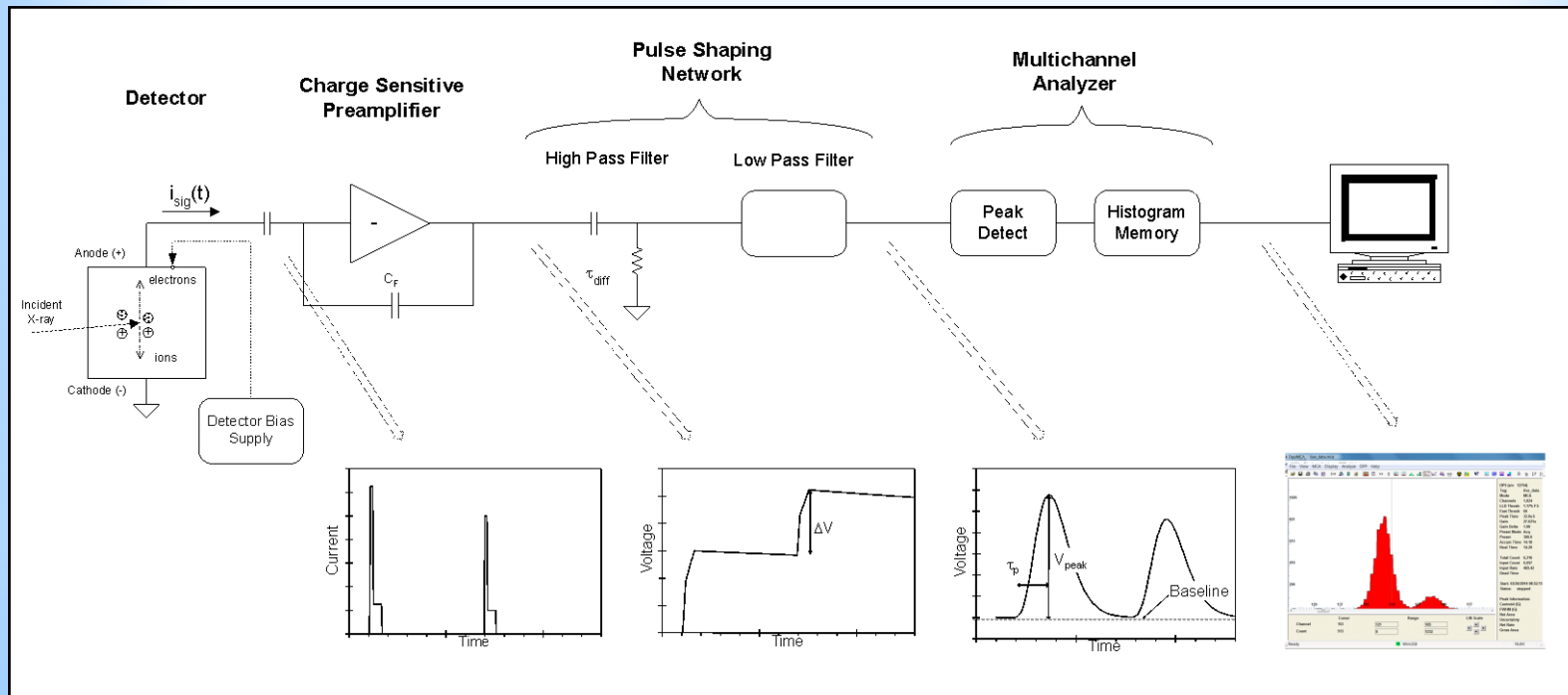


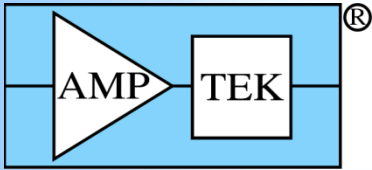
# Spectrometer

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
www.amptek.com

## What does the spectrometer include?

- Detector, signal processing electronics, multichannel analyzer





# Spectrometer

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
[www.amptek.com](http://www.amptek.com)

## Detector

- Converts energy of each X-ray into a current pulse
  - Typical pulse is 10 nA for 100 ns.

## Preamplifier

- Converts current pulse into a voltage pulse

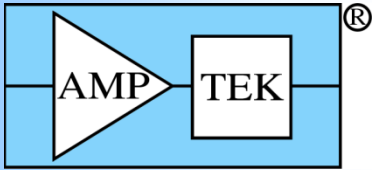
## Pulse shaping (pulse processing)

- Applies a noise filter and gain
  - Long filter time → Better resolution and poorer count rates
- Detects overlapping pulses, slow pulses, and does many functions

## Multichannel analyzer (MCA)

- Measures energy from pulse height for each X-ray
- Integrates results to produce spectrum as a histogram



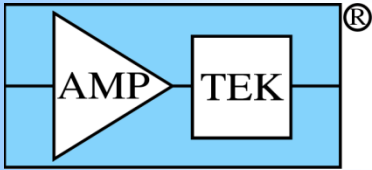


# Spectrometer

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
[www.amptek.com](http://www.amptek.com)

## What would make an ideal spectrometer?

- Good energy resolution
  - Narrow photopeaks → Separate signal from background and from closely spaced X-ray lines
- Clean detector response
  - Low background, Gaussian peak shapes, etc
- High count rate and efficiency
  - More “counts” → Better precision and/or faster measurement
  - Implies large area, high efficiency, short pulse shaping time
- Practical
  - Compact, simple, low power, no cryogenics, rugged, inexpensive,...
- Real world spectrometer must be optimized by selection of detector and configuration of processor for best results

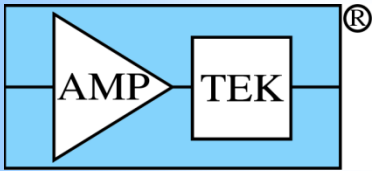


# Software

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
[www.amptek.com](http://www.amptek.com)

## What does the software do?

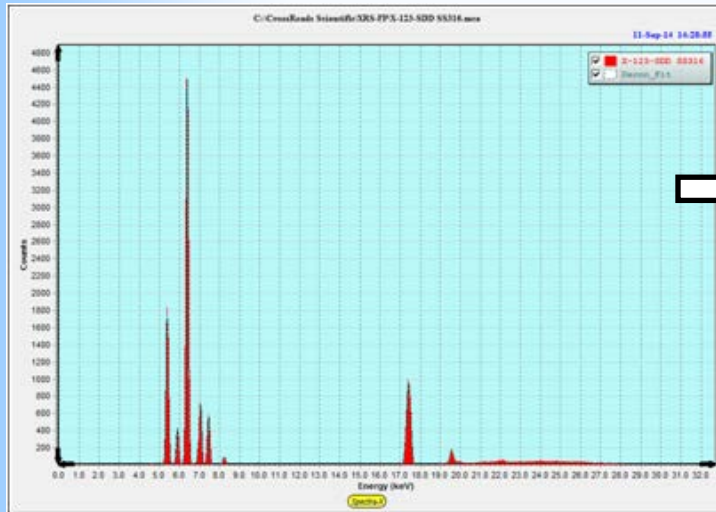
- Acquisition software
  - Configures the hardware, starts and stops data acquisition
  - Outputs a raw pulse height spectrum (histogram)
- Analysis software
  - Applies energy calibration
  - Corrects raw spectrum for various artifacts
  - Identifies photopeaks
  - Computes intensities of each photopeak
    - Subtracts background, overlapping peaks
  - Computes concentrations
    - Applies calibration factors
    - Corrects for matrix effects
  - Produces final result: concentrations with estimated uncertainty



# Software

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
www.amptek.com

## What does the software do?



Typical raw spectrum  
(stainless steel)

Element	Intensity (cts/sec)
V	0.8 ± 0.8
Cr	359.8 ± 7.3
Mn	16.2 ± 2.1
Fe	975.2 ± 12.0
Co	0.0 ± 1.2
Ni	128.6 ± 4.4
Cu	2.6 ± 0.9
Mo	461.1 ± 8.3

Intensity of peaks

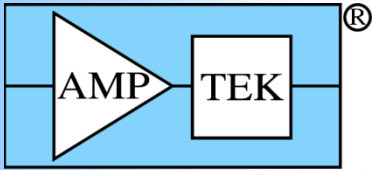
After correction  
and processing

Element	Concentration
V	0.06% ± 0.07%
Cr	19.20% ± 0.39%
Mn	0.81% ± 0.10%
Fe	64.66% ± 0.80%
Co	0.00% ± 0.00%
Ni	12.05% ± 0.42%
Cu	0.17% ± 0.06%
Mo	3.05% ± 0.05%

Element concentrations

Final answer

There are several critical steps between each of these!!



# Software

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
www.amptek.com

## Measurement equations

*Simplified but illustrative*

### – Equation [1]

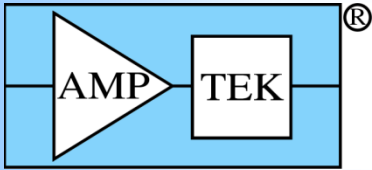
- $C_i$  is the concentration of element  $i$
- $I_i$  is the X-ray intensity of element  $i$  (in counts/sec)
- $K_i$  is the calibration coefficient
- $M$  is a matrix correction factor
  - The “matrix” is all the other elements in the sample besides the analyte
  - X-rays emitted by every element in the sample interact with the atoms from all the other elements
- $S$  is a "homogeneity" factor

### – Equation [2]

- $G_i$  is the gross or total counts in a region of interest (ROI) for the peak of element  $i$
- $B_i$  is the background counts
- $P_i$  is counts from overlapping or interfering peaks
- $\gamma_i$  is correction for artifacts
- $T$  is the measurement time

$$C_i = I_i \cdot K_i \cdot M \cdot S \quad [1]$$

$$I_i = (G_i - B_i - P_i + \gamma_i) / T \quad [2]$$

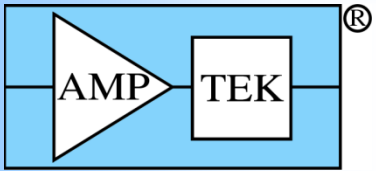


# Instrument

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
[www.amptek.com](http://www.amptek.com)

## Procedures

- Optimization, configuration, calibration of instrument
- Sample preparation
  - Grinding and pressing
  - Surface preparation
  - Sample geometry
- Maintaining measurement conditions
- Quality assurance
  - Establishing measurement uncertainty and detection limits
  - Verifying results

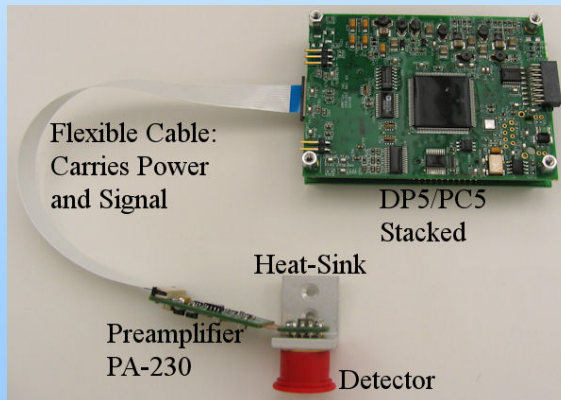


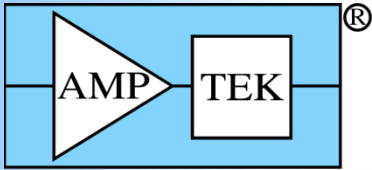
# Amptek, Inc

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
www.amptek.com

## Amptek provides components used in EDXRF

- X-ray detectors and preamplifiers
- Signal processing electronics
- X-ray tubes
- Analysis software
- Experimenter's Kit





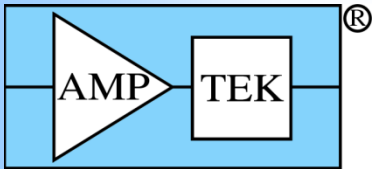
**Amptek, Inc**

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
[www.amptek.com](http://www.amptek.com)

## **Amptek provides components used in EDXRF**

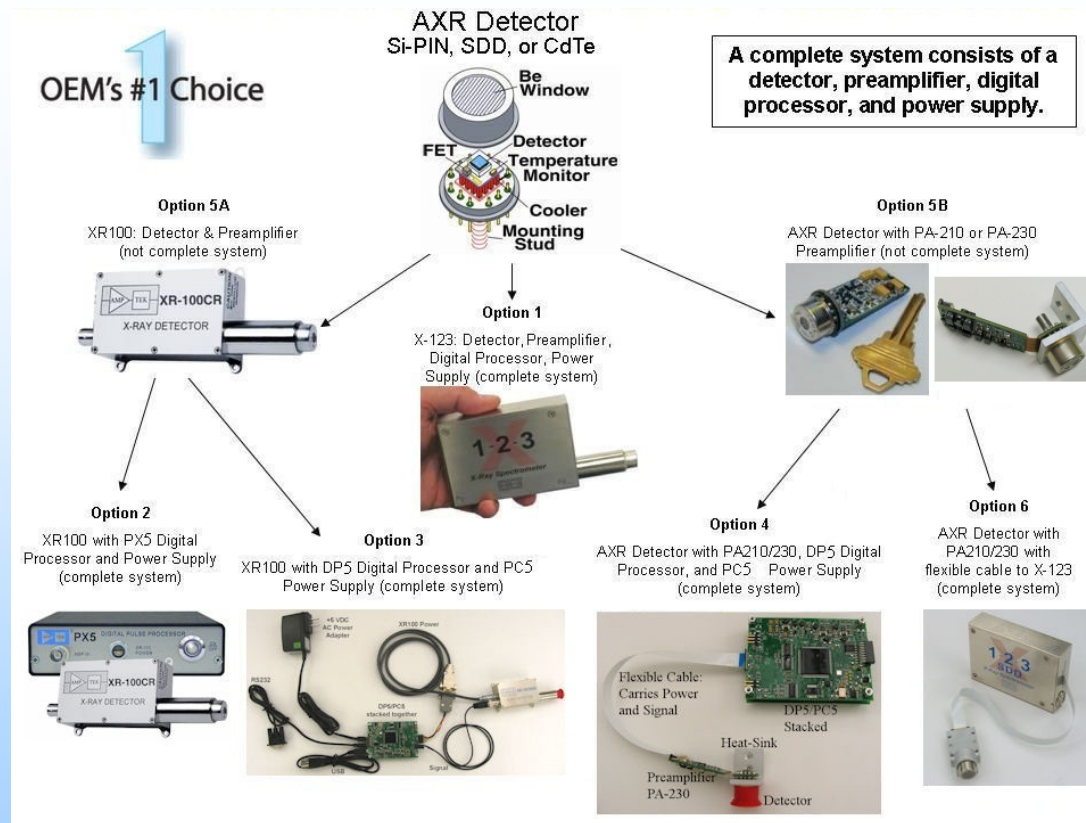
- Amptek is the leading OEM provider to manufacturers of turn-key analyzers
- Amptek provides much equipment to laboratory and field users with custom requirements
- Amptek does not sell turn-key analyzers
  - Amptek's products require optimization and calibration





# Amptek, Inc

Amptek Inc.  
14 Deangelo Drive  
Bedford, MA 01730 USA  
www.amptek.com



**Contact Amptek for your XRF instrumentation needs!**