



# ZSX Primus III+

Sequential wavelength dispersive X-ray fluorescence

Elemental analysis by WDXRF spectroscopy



**Rigaku**

Leading With Innovation

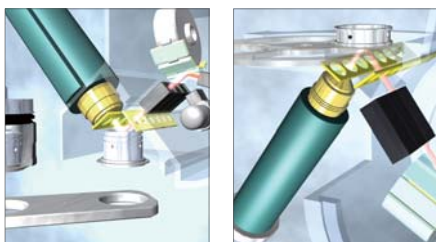


## Fast, precise elemental analysis of beryllium (Be) through uranium (U)

The Rigaku ZSX® Primus series of sequential wavelength dispersive X-ray fluorescence spectrometers provides unequaled flexibility, sensitivity and reliability – the three core requirements that underlie the superior value inherent in all Rigaku XRF instrumentation. Since the introduction of our first sequential WDXRF – the Rigaku GF-S – in 1962, we have incorporated this essential philosophy into all aspects of our instrument design, development and manufacture. Through continued focus on scientific innovation and ongoing partnerships with the world's leading research institutions and industrial laboratories, Rigaku has changed the face of XRF analysis and broadened the scope of XRF applications deployed throughout the world.

### Flexibility

ZSX Primus series of elemental analyzers offers a choice of tube-above or tube-below optical configurations for maximum flexibility.



### Reliability

Rigaku XRF spectrometers are the most reliable in the world. The ZSX Primus and ZSX Primus II spectrometers include automatic pressure control and a dual pump vacuum system. Our robust X-ray tube cooling system is internal, and the ZSX Primus sample chamber is designed for easy cleaning. Furthermore, automatic cleaning of the proportional counter detector center wire ensures consistent performance.

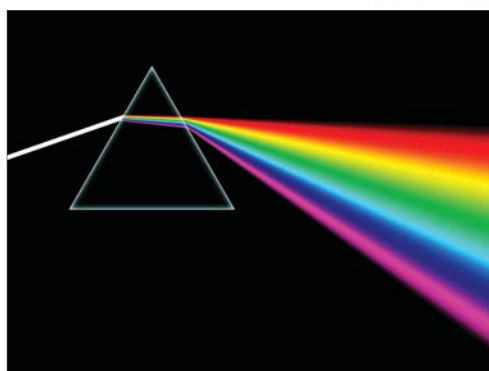
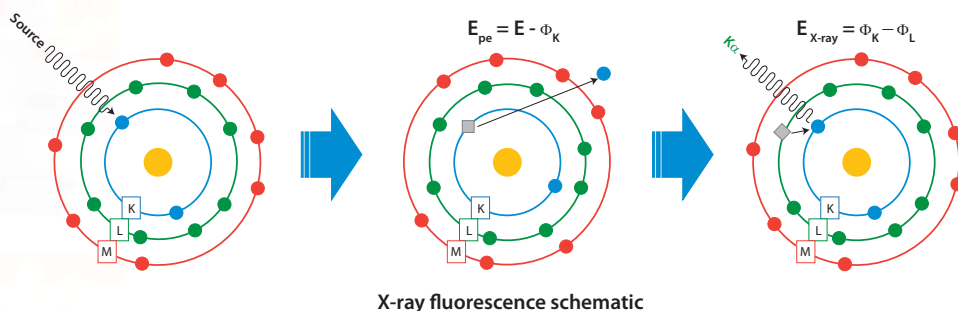
### Sensitivity

At the heart of an XRF spectrometer is the X-ray tube. Available tubes range from a 3 kW, 60 kV end window on the ZSX Primus III+ to a SuperTrace™ 30 4.0 kW end window X-ray tube that delivers unparalleled low-Z sensitivity, available for the ZSX Primus and ZSX Primus II.

# Flexibility • Reliability • Sensitivity

## What is XRF?

In X-ray fluorescence (XRF), an electron can be ejected from its atomic orbital by the absorption of X-rays (photons) from an X-ray tube. When an inner orbital electron is ejected (middle image), a higher energy electron transfers to fill the vacancy. During this transition, a *characteristic* photon may be emitted (right image) that is of a unique energy for each type of atom. The number of *characteristic* photons per unit time (counts per second or cps) is proportional to the amount of that element in a sample. Thus, qualitative and quantitative elemental analysis is achieved by determining the energy of X-ray peaks in a sample spectrum and measuring their associated count rates.



Analyzing crystals disperse radiation in the X-ray spectral region in the same way that a prism spreads the spectrum of visible light

## How WDXRF works

Wavelength dispersive X-ray spectroscopy (WDXRF) is a method used to separate and measure the *characteristic* fluorescent X-rays emitted from a sample. The technique employs an analyzing crystal to spatially spread the X-ray light, much like a prism spreads visible light into its component colors. The wavelength of the impinging X-ray and the crystal's lattice spacings are related by Bragg's law and produce constructive interference when they satisfy the Bragg equation. The X-rays emitted by the sample are collimated by parallel metal blades (Soller slit) and irradiate an automatically selected analyzing crystal at a precise angle. X-ray light diffracted by the analyzing crystal is spatially spread out, so that *characteristic* photons may be collected by a detector positioned at a precise angle to record the X-ray intensity of a specific element.

## X-ray optics

In WDXRF, the sample, analyzing crystal and detector are all mounted on a variable angle optical mechanism called a goniometer. As illustrated (at right), the goniometer precisely varies the angles so that the detector can record X-ray fluorescence from any element of interest. The entire X-ray optical mechanism is contained within a vacuum chamber to eliminate absorption of soft radiation (low-energy photons) by the air.

The ZSX Primus series of spectrometers contain up to ten analyzing crystals that can be automatically selected depending on the wavelength being analyzed, enabling elements from almost the entire periodic table to be analyzed.

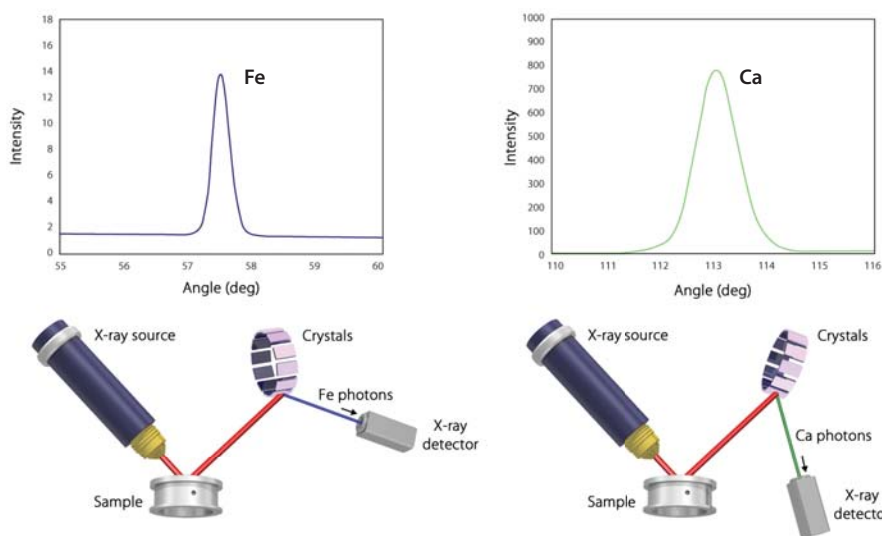
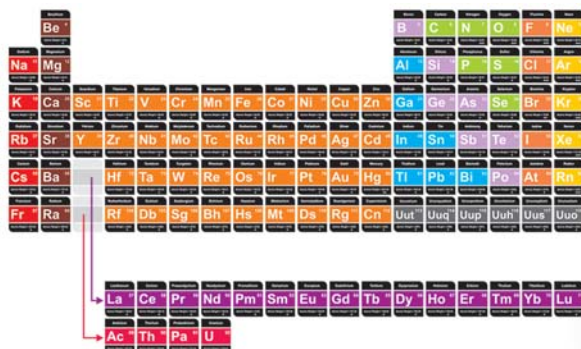


Illustration of how different analyzing crystals and angles allow various elements to be measured



Analyze from beryllium through uranium

# ZSX PrimusIII+



Be	B	C	N	O	F	Ne											
Na	Mg	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	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
Fr	Ra	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Uuq	Uup	Uuh	Uus	Uuo	
Lanthanide and Actinide Series																	
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu			
Ac	Th	Pa	U														

## Tube-above X-ray optics

Rigaku offers a choice of optical configurations to provide the best fit for any specific application or environment.

## Flow-bar based GUI

Provides guidance through the calibration process and random access to interface windows. Flow-bar represents a "best practice" in analytical software design.

## Scattering FP

Accurate analysis, without analyzing major light element (low-Z) components is now possible with fundamental parameters (FP). Monte Carlo simulations consider the distribution of scattering angles for each geometrical location of the sample.

## Self-cleaning F-PC detector

Flow proportional counter detector (F-PC) features automatic center wire cleaning to reduce routine maintenance.





### **Self-calibrating PHA**

The pulse height analyzer (PHA) is automatically adjusted using a PHA sample to ensure optimal performance.

### **EZ Analysis**

Qualitative, semi-quantitative and quantitative analysis all in a single easy-to-use interface.

### **Photo-electron correction**

Patented FP correction considers the effect of photo-electron excitation for ultra-light elements.

### **Fixed-angle (FA) analysis**

SQX semiquant fundamental parameters feature automatic background point selection to eliminate errors in net peak intensity.

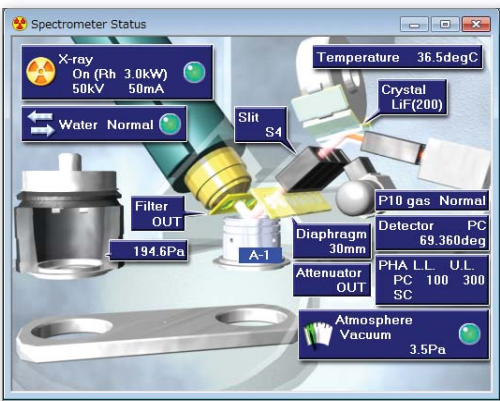


Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25
Atomic Weight = 39.10	Atomic Weight = 40.08	Atomic Weight = 44.96	Atomic Weight = 47.87	Atomic Weight = 50.94	Atomic Weight = 52.00	Atomic Weight = 54.94
Rubidium	Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Technetium

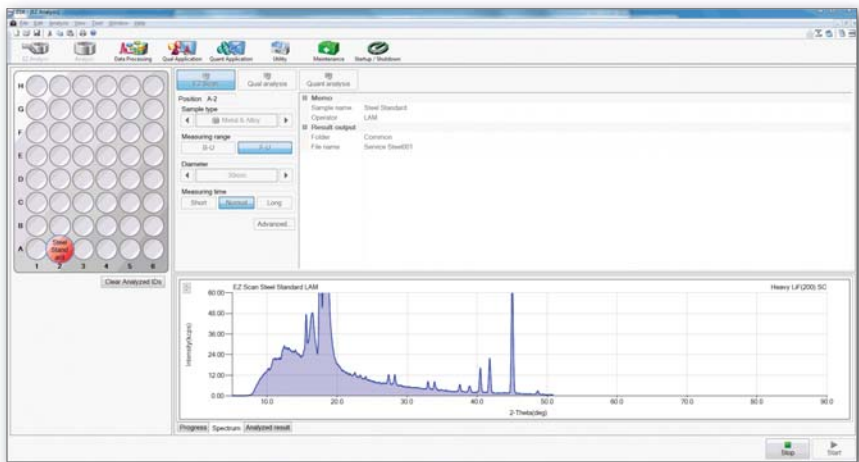
# Graphical user interface

## Powerful software that is easy-to-use

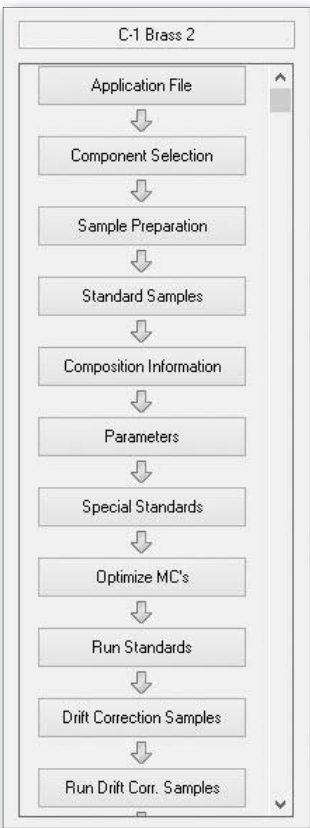
With an eye toward the future, Rigaku has combined extensive experience in applications development and unsurpassed technical knowledge to create the world's best XRF analytical software. With a firm belief that knowledge is power, Rigaku has developed software that is not only user-friendly, but sophisticated and powerful enough for the most complex analysis. The ZSX Primus series Windows® based software was conceived and built with end-user needs and requirements in mind.



Spectrometer status window



EZ Analysis window



Flowbar

## Graphical spectrometer status display

Another famous Rigaku innovation is the graphical instrument status window. Real time display of key parameters allows users to assess the condition of the spectrometer at a glance. This feature saves the operator time and increases situational awareness.

## EZ Analysis for routine operation

EZ Analysis is a "best practice" design feature that makes everyday routine operation intuitive. A single interface contains everything you need to know about the status of your samples, what your data measurement parameters are, and a running output of your results.

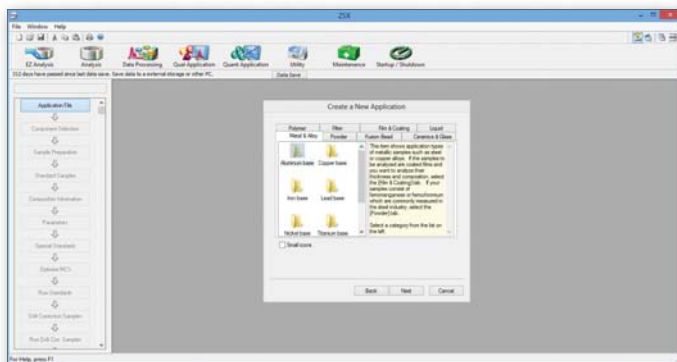
## Flowbar guidance makes it easy

Based on the famous Rigaku easy-to-use flowbar interface, ZSX Primus series software walks the user through the steps required to set up either an empirical or a fundamental parameters application. For empirical calibrations, the flowbar covers every detail, from setup of an application file to the selection of a template and the components to be measured. The user is then guided through acquisition parameters setup, the setup of standards and drift correction, through calibration and reporting.





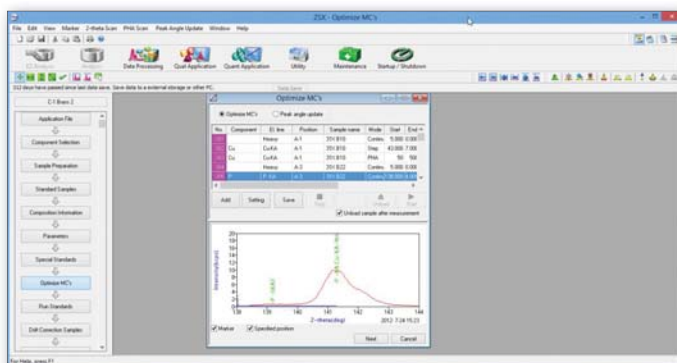
Iron	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium
5 Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32
Atomic Weight = 55.85	Atomic Weight = 58.93	Atomic Weight = 58.69	Atomic Weight = 63.55	Atomic Weight = 65.38	Atomic Weight = 69.72	Atomic Weight = 72.64
Rhodium	Palladium	Platinum	Silver	Cadmium	Indium	Tin



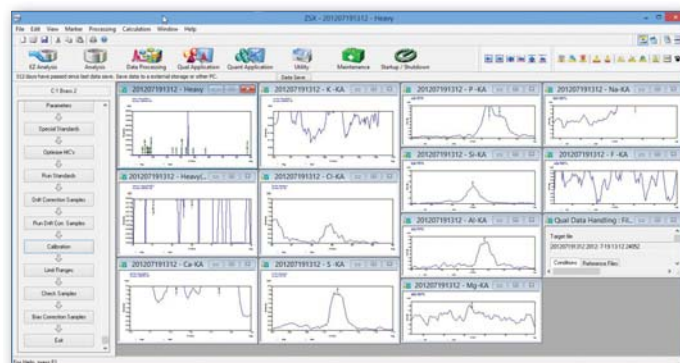
Templates for qualitative and quantitative applications guide you through each setup



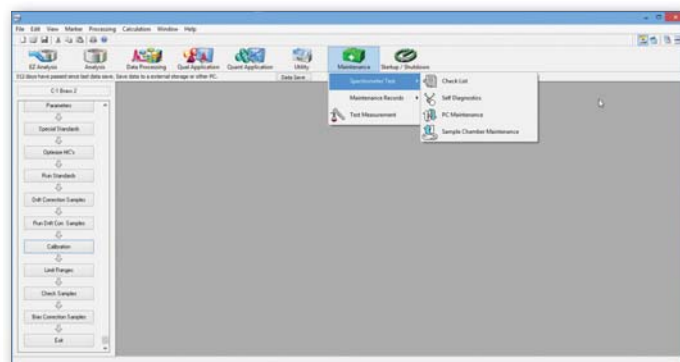
Calibration windows are clear and easy to understand



The "Optimize" window allows the adjustment of a variety of conditions, ensuring the best response possible



Qualitative scans are organized for easy interpretation and automatically list potential interfering elements



Built-in diagnostics maximize uptime and reliability

# ZSX PrimusIII+

Neodymium	Osmium	Iridium	Platinum	Gold	6 Mercury
Atomic Weight = 144.24	Atomic Weight = 190.23	Atomic Weight = 223.03	Atomic Weight = 195.08	Atomic Weight = 196.97	Atomic Weight = 200.59

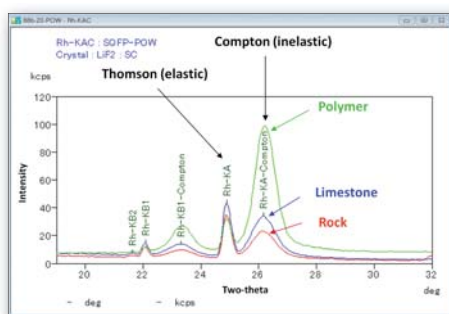
# Fundamental parameters

## SQX fundamental parameters

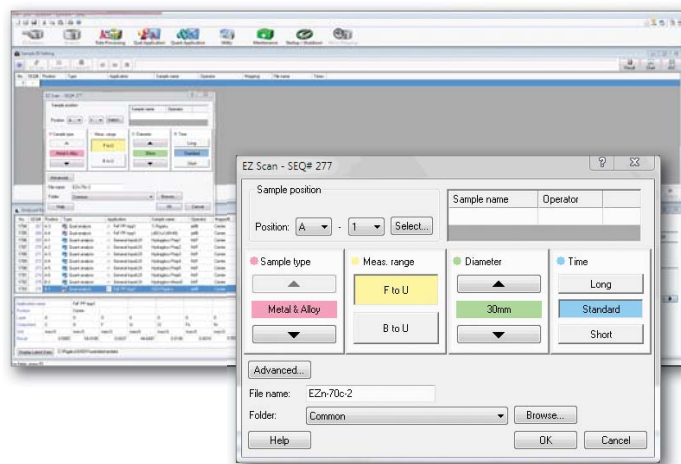
Rigaku ZSX series spectrometers are available with Rigaku SQX fundamental parameters (FP) software that provides semi-quantitative analysis of almost all sample types without standards – and rigorous quantitative analysis with standards. SQX greatly reduces the number of required standards, for a given level of calibration fit, as compared to conventional empirical methods. As standards are expensive, and can be difficult to obtain for many applications, SQX can significantly lower the cost of ownership and reduce workload requirements for routine operation.

## Scattering FP method

Accurate analysis, without analyzing major light element (low-Z) components, is now possible. Previously, it was difficult to accurately analyze samples – such as fly ash, soil, tissue or polymers – unless all the invisible elemental components were defined properly. With the newly developed Scatter FP method, scatter lines are used to estimate the effect of these non-analyzed components. Scattering FP employs a computational model, using Monte Carlo simulations, that considers the distribution of scattering angles for each geometrical location of the sample. It also considers the effect of photo-electron excitation (patented) for ultra-light elements.



Thompson/Compton ratio by sample type



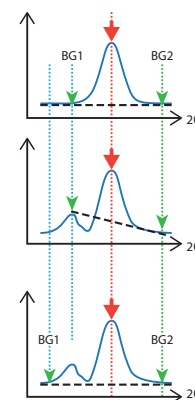
EZ Scan interface

## EZ Scan

EZ Scan allows you to analyze unknown samples without any prior setup and with only a few clicks of the mouse to get started. Combined with Rigaku SQX fundamental parameters software, it provides the most accurate and rapid XRF results possible. SQX is capable of automatically correcting for all matrix effects, including line overlaps. SQX can also correct for various atmospheres, impurities and sample film absorption. Increased accuracy is achieved using a matching library.

## Fixed Angle (FA) analysis

Unlike other software using fixed angles (top), SQX features automatic background point selection to eliminate errors in net peak intensity (middle). Patented FA analysis (bottom) delivers higher measurement precision and lower detection limits due to dramatically improved counting statistics.

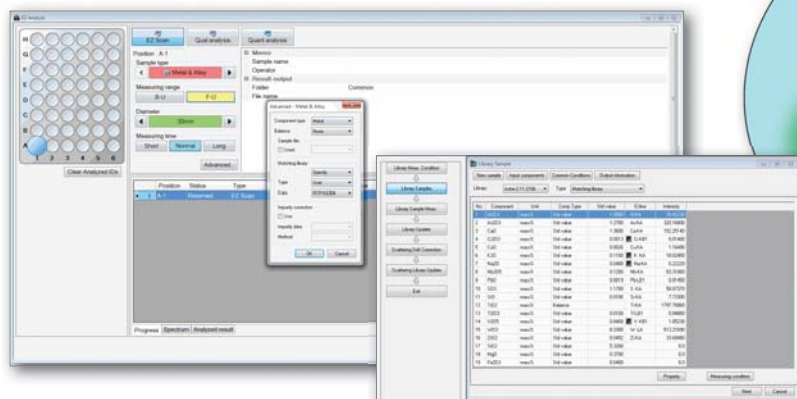
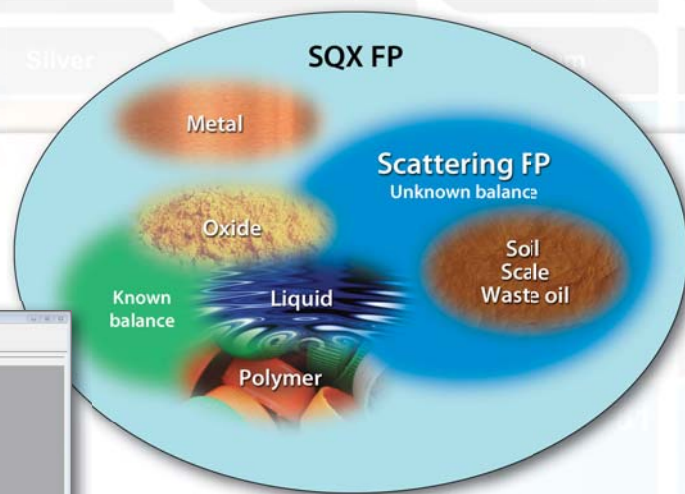
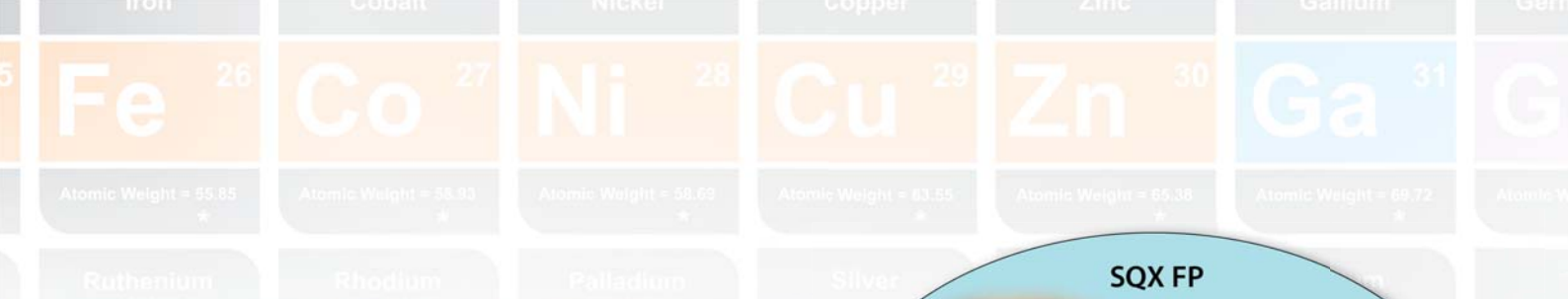


FA example

### Coal ash by SQX Scattering FP method (units: mass%)

Element	Na	Mg	Al	Si	P	S	K	Ca	Ti
Reference value	1.69	1.27	12.6	23.6	0.26	0.196	1.05	6.36	0.79
Scattering FP	2.14	1.08	12.6	20.3	0.25	0.28	1.04	6.23	0.79
FP (Balance: C)	1.2	0.59	6.74	10.7	0.13	0.14	0.534	3.19	0.4
Element	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga
Reference value	0.0243	0.0075	0.05	3.64	0.0037	0.0032	0.0122	0.0063	(0.0045)
Scattering FP	0.025	0.0112	0.0515	3.42	0.0049	0.0055	0.013	0.0064	0.0044
FP (Balance: C)	0.013	0.0057	0.0258	1.72	0.0025	0.0028	0.0066	0.0033	0.0022
Element	As	Rb	Sr	Y	Zr	Nb	Pb		
Reference value	0.0029	0.0054	0.11	(0.0054)	(0.046)	(0.0025)	0.0047		
Scattering FP	0.0035	0.0052	0.113	0.0046	0.031	0.0015	0.0038		
FP (Balance: C)	0.0017	0.0027	0.0586	0.0024	0.017	0.0008	0.0019		





Scan using Matching Libraries

## SQX FP features and benefits

- **Matching Libraries turns semiquantitative analysis into quantitative analysis**

Use Rigaku's Matching Libraries or build a custom library with your standards

- **Scattering FP and photo-electron correction for superior matrix modeling**

Reliably accounts for effects of the unanalyzed low-Z element portion of the sample

- **Fundamental parameters based line overlap correction for complex spectra**

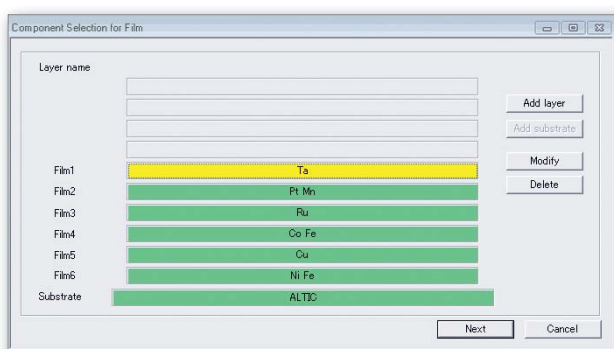
Overlap factors conveniently adapted to both bulk and thin film samples using theoretical intensities

## Quant fundamental parameters

Rigaku quantitative FP software has a variety of unique functions for applications like thin films, geological samples, and fused beads.

### Coatings and multi-layer thin films

Thin film materials play an important role in many of today's core industries. Applications to determine thin film composition and thickness are vital in the production of semiconductor devices, industrial coatings, and solar energy conversion devices. XRF measurements offer precise, non-destructive elemental analysis capabilities that can be used across the broad spectrum of application requirements.



## Quant FP features and benefits

- **Advanced matrix correction works synergistically with Compton scatter**

Enhanced accuracy for heavy elements in rocks, ores and other geological samples

- **Matrix, dilution, and evaporation corrections for fused beads**

Mathematically account for flux or sample LOI without pre-ignition of samples

Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25
Atomic Weight = 39.10	Atomic Weight = 40.08	Atomic Weight = 44.96	Atomic Weight = 47.87	Atomic Weight = 50.94	Atomic Weight = 52.00	Atomic Weight = 54.94
Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Technetium	Ruthenium

## Options

### UltraDry

A vacuum hotplate (Cat. # RS-P1100) specifically designed for routine analysis using MicroCarry and UltraCarry, the Rigaku UltraDry is available as an XRF accessory. Up to ten (10) UltraCarry samples may be processed simultaneously.



Element	4	5	6	7	8	9	11	12	13	14	15	16	17	19	-	23	24	-	92	Characteristics
Crystal	Be	B	C	N	O	F	Na	Mg	Al	Si	P	S	Cl	K	-	V	Cr	-	U	
Standard																				
RX25																				
PET																				
LiF(200)																				
Optional																				
RX40																				
RX61																				
Ge																				High sensitivity
LiF(220)																				High resolution
RX35																				
RX45																				High sensitivity
RX75																				

Available analyzing crystals with their elemental coverage

### ZSX Primus IV

Featuring a unique tube-above optical configuration for enhanced reliability, the Rigaku ZSX Primus IV delivers rapid quantitative determination of major and minor atomic elements, from beryllium (Be) through uranium (U), in a wide variety of sample types — with minimal standards. ZSX Primus IV is optionally available with a 96 position sample deck for customers needing unattended high-throughput operation.



96 position changer



Small sample cell



Y mask



Scatter elimination

### ZSX Primus

Rigaku ZSX Primus delivers rapid quantitative determination of major and minor atomic elements, from beryllium (Be) through uranium (U), in a wide variety of sample types — with minimal standards. ZSX Primus features a 30 micron tube, the thinnest end-window tube available in the industry, for exceptional light element detection limits. Combined with a mapping package to detect homogeneity, the ZSX Primus provides analytical insights not easily obtained by other analytical methodologies.



Liquid cell



UltraCarry



Small volume cell



Oil solidification cell

### Supermini200

As the world's only high-power benchtop sequential WDXRF spectrometer for elemental analysis of oxygen through uranium of almost any material, the Rigaku Supermini200 uniquely delivers low cost-of-ownership (COO) with high resolution and lower limits-of-detection (LLD). With a 200 W X-ray tube, Rigaku Supermini200 delivers high sensitivity for light elements and superior spectral resolution.



Loose powder



MicroCarry



Centering rings



Bead holder

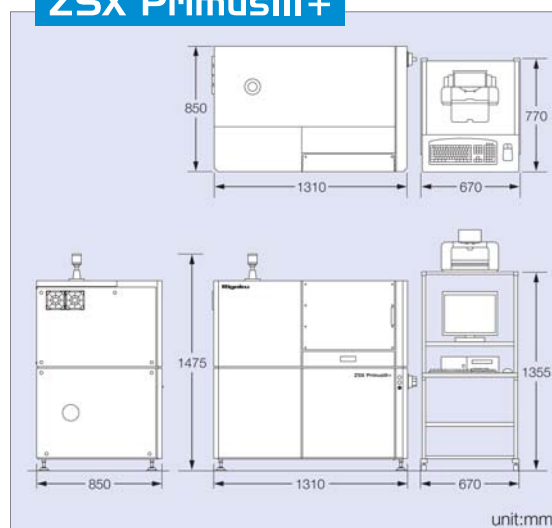
# Specifications

		ZSX Primus III+
General	Elemental range	${}^8\text{O}$ – ${}_{92}\text{U}$ standard ( ${}^4\text{Be}$ – ${}_{92}\text{U}$ optional)
	Optics	Wavelength dispersive, sequential, tube above
	Power	3 phase 200/208 V 40 A 50/60 Hz Single phase 100 – 240 V 50/60 Hz (PC)
X-ray generator	X-ray tube	End window type, Rh-anode
		3 kW
	High voltage generator	High frequency inverter system
		60 kV
	Cooling device	Water-to-water heat exchanger (built-in)
Spectrometer	Geometry	Tube-above
	Sample changer	Expandable sample changer up to 48 positions
	Sample inlet	Air lock system
	Maximum sample size	51 mm (diameter) x 30 mm (high)
	Sample rotation	30 rpm
	Primary X-ray filters	Al25, Al125, Ni40, Ni400
	Analysis area diaphragm	4 sizes automatic exchange mechanism 35, 30, 20, and 10 mm $\phi$
	Primary Soller slit	3 positions automatic exchange mechanism Standard and high resolution slits Ultra coarse slit (optional)
	Secondary Soller slit	2 slits for SC and F-PC
	Goniometer	$0 - 20^\circ$ independent driving mechanism
	Angular range	SC: $5 - 118^\circ$ , F-PC: $13 - 148^\circ$
	Continuous scan	$0.1 - 240^\circ/\text{min}$ (20)
	Crystal exchanger	10 crystal automatic exchange mechanism
	Analyzing crystal	LiF(200), PET, RX25
		Curved LiF(200), Ge, PET, RX4 (optional)
		Ge, LiF(220), RX4, RX9, RX35, RX40, RX45, RX61, RX61F, RX75 (all optional)
	Vacuum system	High speed vacuum system
Counting system	Detector	SC for heavy elements F-PC for light elements Heating-type center-wire automatic cleaning
	Attenuator	In-out automatic attenuator exchanger Attenuation factor: 1/10 for 30 and 20 mm $\phi$

## Backed by Rigaku

Since its inception in 1951, Rigaku has been at the forefront of analytical and industrial instrumentation technology. Today, with hundreds of major innovations to our credit, the Rigaku Group of Companies are world leaders in the field of analytical X-ray instrumentation. Rigaku employs over 1,400 people worldwide in operations based in Japan, the U.S., Europe, South America and China.

### ZSX PrimusIII+





# ZSX Primus III+

Sequential wavelength dispersive X-ray fluorescence



[Rigaku.com/products/xrf/primus3](http://Rigaku.com/products/xrf/primus3)



**Rigaku Corporation and its Global Subsidiaries**

website: [www.Rigaku.com](http://www.Rigaku.com) | email: [info@Rigaku.com](mailto:info@Rigaku.com)

