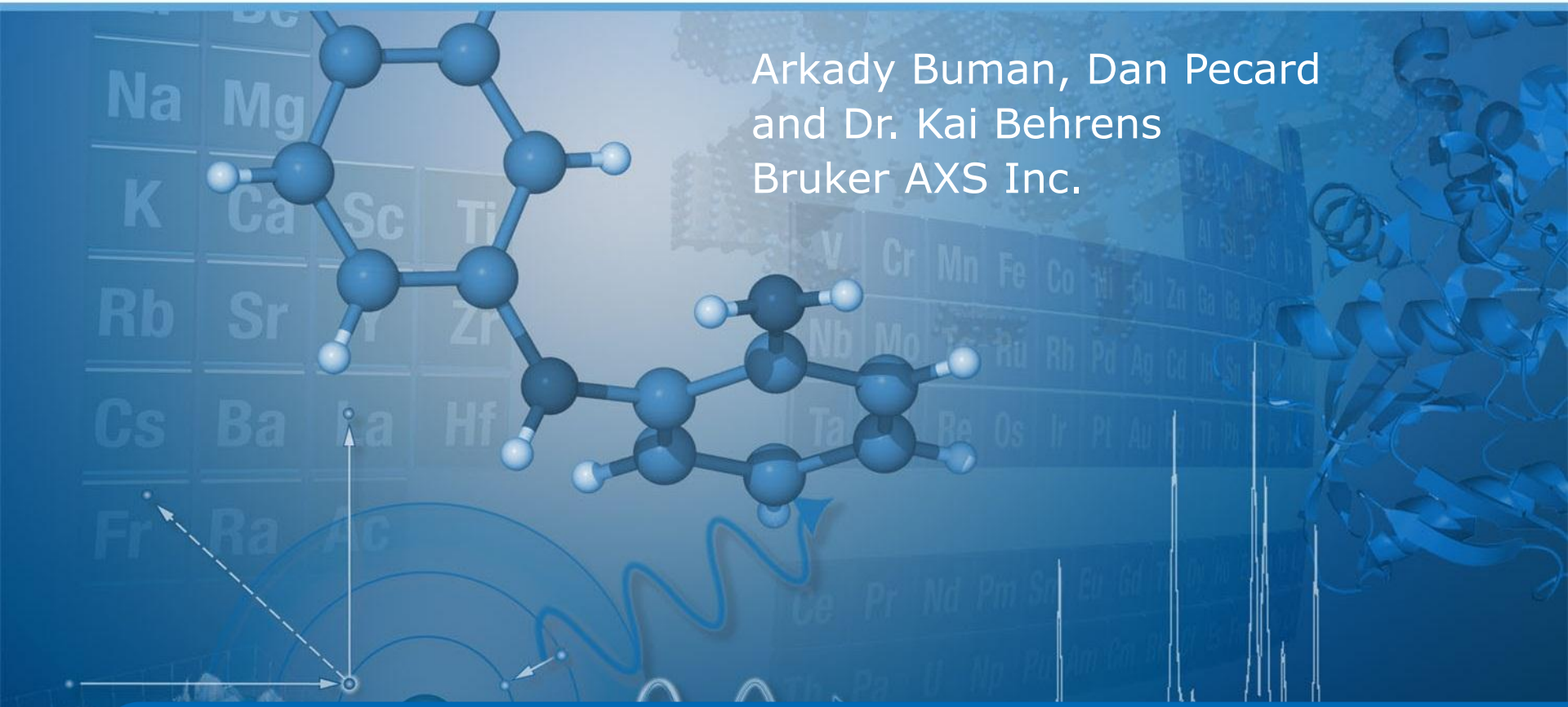
How to Boost Cost Efficiency and Analytical Quality with XRF in Your Petrochemical Lab



Arkady Buman, Dan Pecard
and Dr. Kai Behrens
Bruker AXS Inc.

Welcome
Today's Speakers

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How to Boost Cost Efficiency and Analytical Quality with XRF in Your Petrochemical Lab

- Introduction
  - Basics of XRF for petrochemical applications
- Sulfur in petroleum products according to ASTM D 2622
  - Cost-effective solutions based on WDXRF
- Additives in lubricating oils
  - WDXRF, the optimal choice
- Challenges in petrochemical applications
  - Wear metal in engine oils
  - How to get maximum performance out of WDXRF
- Summary

Oil Refinery Products

Crude Oil

20°	$C_1 – C_4$	Gas (for PE, PP)
70°	$C_5 – C_9$	Naphtha (Chemicals)
120°	$C_5 – C_{10}$	Gasoline
170°	$C_{10} – C_{16}$	Kerosene, Paraffin
270°	$C_{14} – C_{20}$	Diesel
	$C_{20} – C_{50}$	Lubricating Oil
600°	$C_{20} – C_{70}$	Fuel Oil (Ships, Heating)
	$> C_{70}$	Residue (Bitumen, Petcoke)

Oil Refinery
Product Mix
max. 197,000 m^3 crude oil/day

Fuels		90 %
• Gasoline	40%	
• Diesel	23%	
• Fuel Oil	15%	
• Kerosene	10 %	

ASTM D 2622
Sulfur

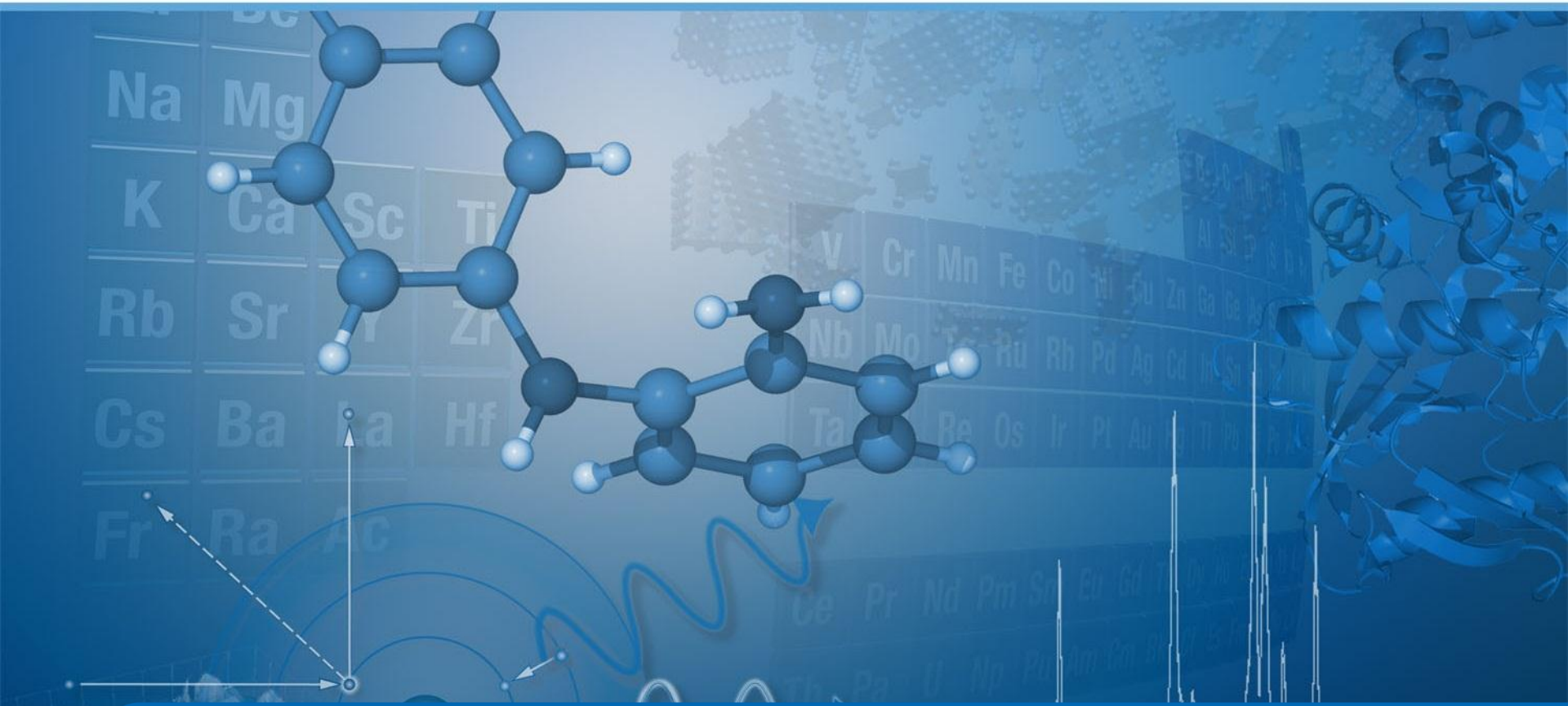
Non Fuels	5%
• Lubricants	
• Bitumen	
• Wax	

ASTM D 6443
Additives

Fuel for the refining process	5%
Heat recycling	
Loss to atmosphere	0.5%

X-Ray Fluorescence Analysis (XRF)

Basic principles and applications



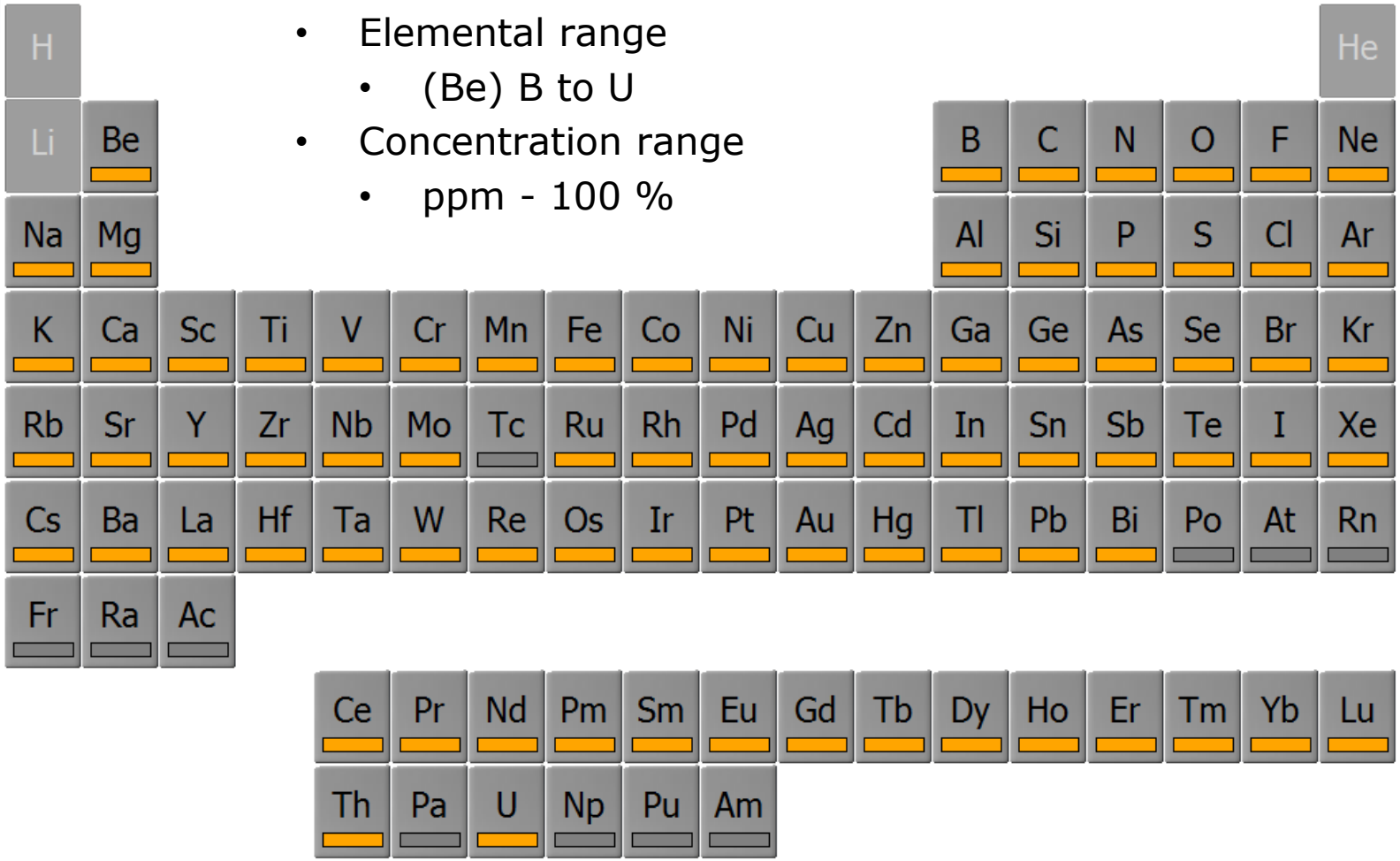
X-ray fluorescence analysis (XRF) Definition

X-ray fluorescence analysis (XRF) or X-ray spectrometry

- A method to do qualitative and quantitative analysis of the elemental composition by excitation of atoms and detection of their characteristic X-rays

X-ray fluorescence analysis (XRF)
Ranges

- Elemental range
  - (Be) B to U
- Concentration range
  - ppm - 100 %



XRF X-ray Fluorescence Analysis
X-ray Spectrometry

- ... is the method to do qualitative and quantitative analysis of elemental
- composition by excitation of atoms and detection of their characteristic
- X-rays: one form of "Electromagnetic Radiation"

Energy [keV]	Wavelength	Description
< 10^{-7}	cm to km	Radio waves
< 10^{-3}	μm to cm	Microwaves
< 10^{-3}	μm to mm	Infrared light
0.0017 - 0.0033	380 to 750 nm	Visible light
0.0033 - 0.1	10 to 380 nm	Ultraviolet light
0.1 - 100	**0.01 to 10 nm**	**X-rays**
10 - 5000	0.0002 to 0.12 nm	Gamma radiation

X-ray fluorescence analysis (XRF) Capabilities

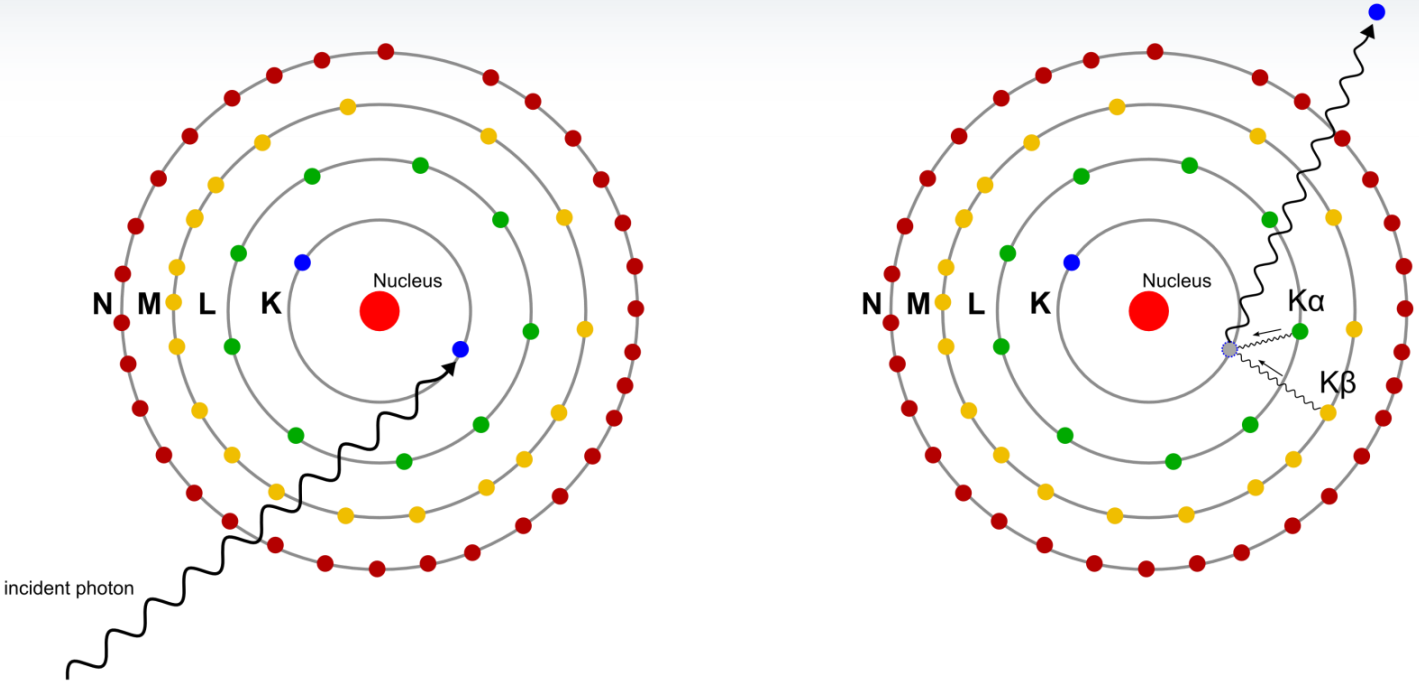
- Qualitative Analysis
  - Identification of elements
  - “What’s inside?”
- Quantitative Analysis
  - Determination of concentrations
  - “How much is inside?”
- Semi-Quantitative Analysis
  - Estimation of concentration
  - “About how much?”

X-ray fluorescence analysis (XRF) Capabilities

Samples measured as

- Liquids
  - directly
- Powders
  - directly
  - as pressed pellets
  - as fused beads
- Bulk
  - directly, after fitting into sample cups

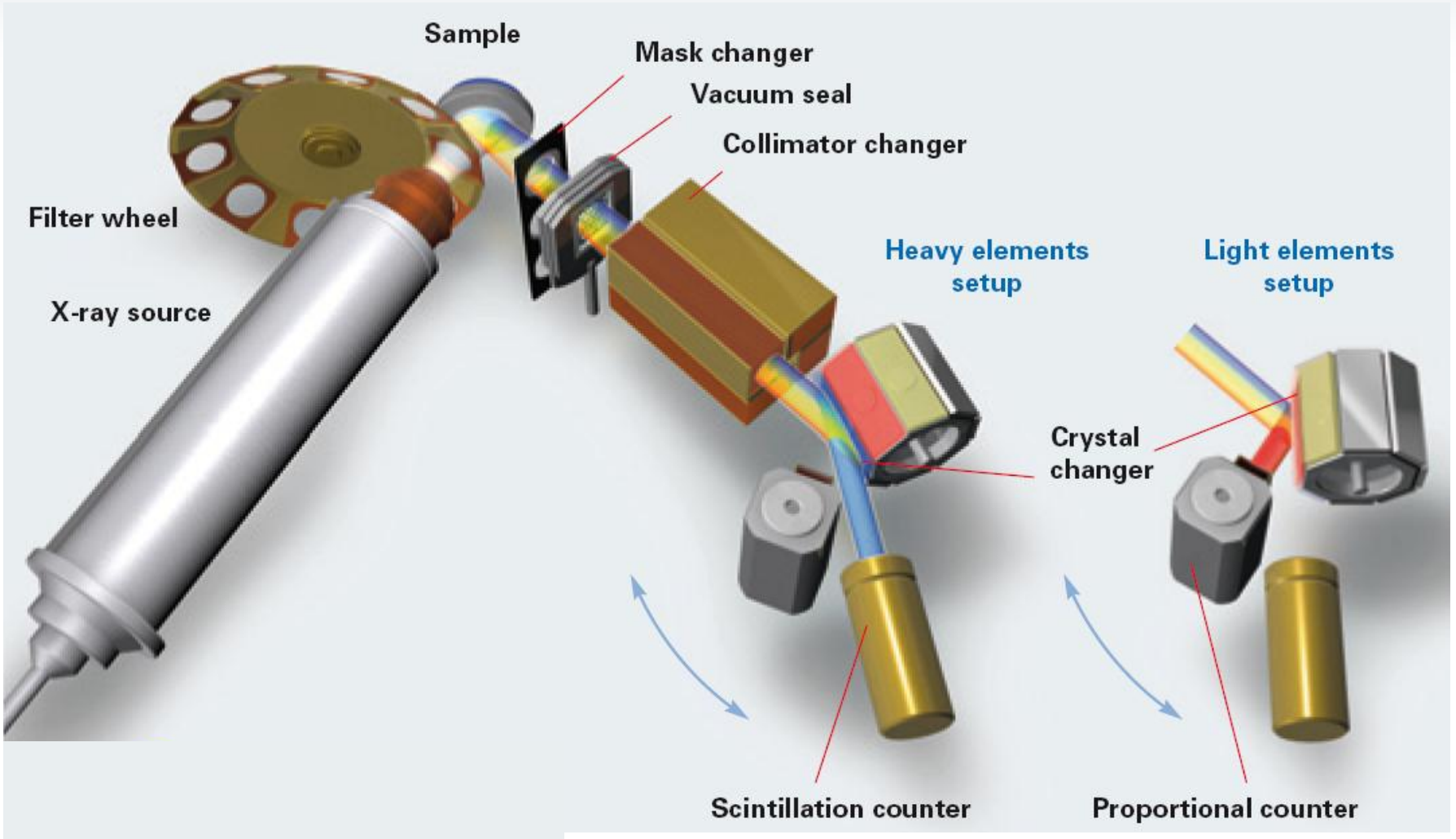
X-ray fluorescence analysis (XRF)
Principle – Photoelectric Effect



- Sample excited with an X-ray beam causing fluorescence
- Electron ejected from an inner shell of its atom
- Electron from a shell farther out falls into the vacancy
- Energy difference is emitted as an X-ray photon

- Discrete energy or wavelength is characteristic for the emitting element
- Intensity of characteristic radiation is proportional to concentration of the element in the sample

WDXRF Sequential Spectrometer Beam Path



X-ray fluorescence analysis (XRF)
Advantages of XRF

- Solid and liquid samples can be analyzed directly: large range of applications
- Little or no sample preparation required
- Analysis is non-destructive to the sample
- Sampling-to-analysis result time is relatively short
- Quantitative and qualitative analyses are possible
- Accuracy and long term stability
- Elemental range: (Be) Na to U
- Linearity from ppm to 100%

Instrumental Requirements for the Analysis of Liquids by XRF

- X-ray tube is located below the sample to ensure constant distance
- High spectral resolution to resolve neighboring lines
- Helium purge to avoid evaporation and to reduce absorption of light element X-rays
- High sensitivity to achieve better LLD and/or precision
- Sample protection with effective cooling of the X-ray tube
- Instrument components protection – SampleCare™
- Reliability in handling liquid samples – high instrument uptime and low maintenance costs

Audience Poll

Please use your mouse to answer the question in the poll window on your screen.

What analytical techniques are you currently using? (Select all that apply.)

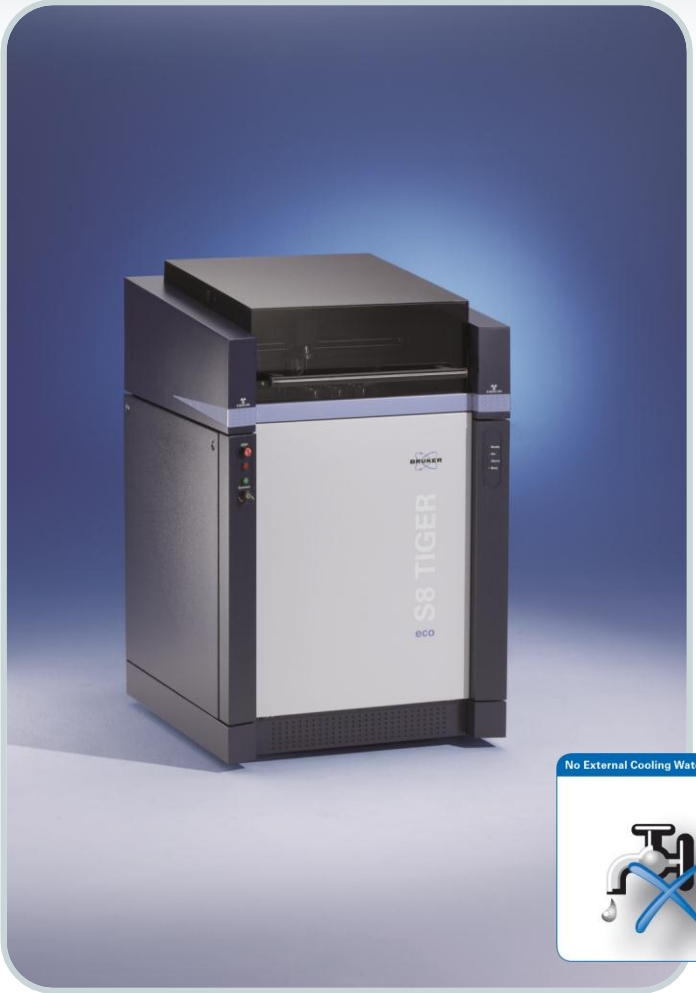
a. ICP
b. ICP-MS
c. FT-IR
d. AAS
e. XRF

We'll share the poll results in a few minutes.

New WDXRF spectrometer series S8 TIGER ECO

- For dedicated applications in petrochemistry, Bruker has optimized the S8 TIGER for uniquely low cost of ownership
- Based on proven WDXRF technology
- Reducing
  - investment costs
  - expenses for consumables
  - maintenance and service costs

WDXRF spectrometer series:
S8 TIGER ECO



Optimal analytical performance with a uniquely low cost of ownership:

- Optimal analytical sensitivity and resolution based on WDXRF technology for dedicated applications
  - 1 kW excitation power based on Bruker X-ray technology
  - 60% savings on electrical energy
- No cooling water required
- No compressed air
- Reduced helium consumption
- Smallest footprint (~ 0.8 m^2)

S8 TIGER ECO
Long Lifetime X-ray Tube (LLT)

The S8 TIGER ECO comes with the Long Lifetime X-ray tube:

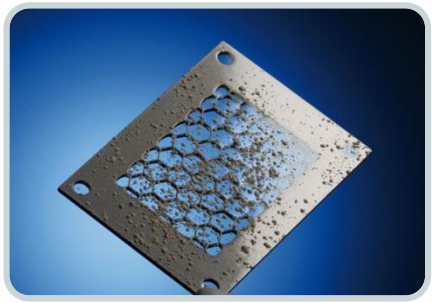
- End window tube design
  - 75 µm beryllium window
- 1 kW excitation
  - Up to 50 kV high voltage
  - Up to 50 mA current
- Uniquely low cost of operation
  - Long tube life
  - 5-year tube warranty
    - 2 years full
    - 3 years pro-rated

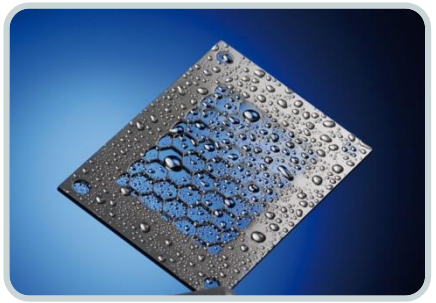
S8 TIGER ECO
Vacuum Seal

- Low cost of maintenance due to high transmission vacuum seal
  - Protects goniometer from
    - Dust from solids
    - Droplets from liquids
- Optimal sensitivity
  - High transmission for light elements
- Low cost of operation
  - Reduced helium consumption when analyzing liquids or loose powders
  - Saves 20% helium

Safe analysis of liquid samples: Vacuum Seal

- Vacuum seal protects spectrometer in case of sample cup leakage
- Minimized helium flushed volume
- Minimized pump-down times when changing from helium to vacuum mode
- Minimized helium consumption
- Spectrometer chamber with all analytically relevant components (collimators, analyzer crystals, detectors) remain under stable vacuum





Petrochemical applications
Norms

Analytical norms define and govern:

- scope
- range
- accuracy
- precision

for a given application and suitable tool

The aim of norms is to make results comparable and traceable as a basis for regulatory compliance.

S8 TIGER ECO "Petro" for low sulfur Configuration

- Optimal configuration for low sulfur in refineries and service laboratories

Configuration	S8 TIGER ECO "Petro" for low sulfur
Compliant to international Standard	ASTM D 2622 EN ISO 20884
Sample types	Liquids in cells Solid samples
Atmospheric mode	Vacuum/Helium
Analyzer crystal	Germanium
Collimator	0.46°
Detector	Gas flow proportional counter

Standards and Applications of XRF for Automotive Fuels

Sulfur in automotive fuels:

- EN ISO 20884

  Low range: 5 – 50 ppm

  High range: 50 – 500 ppm

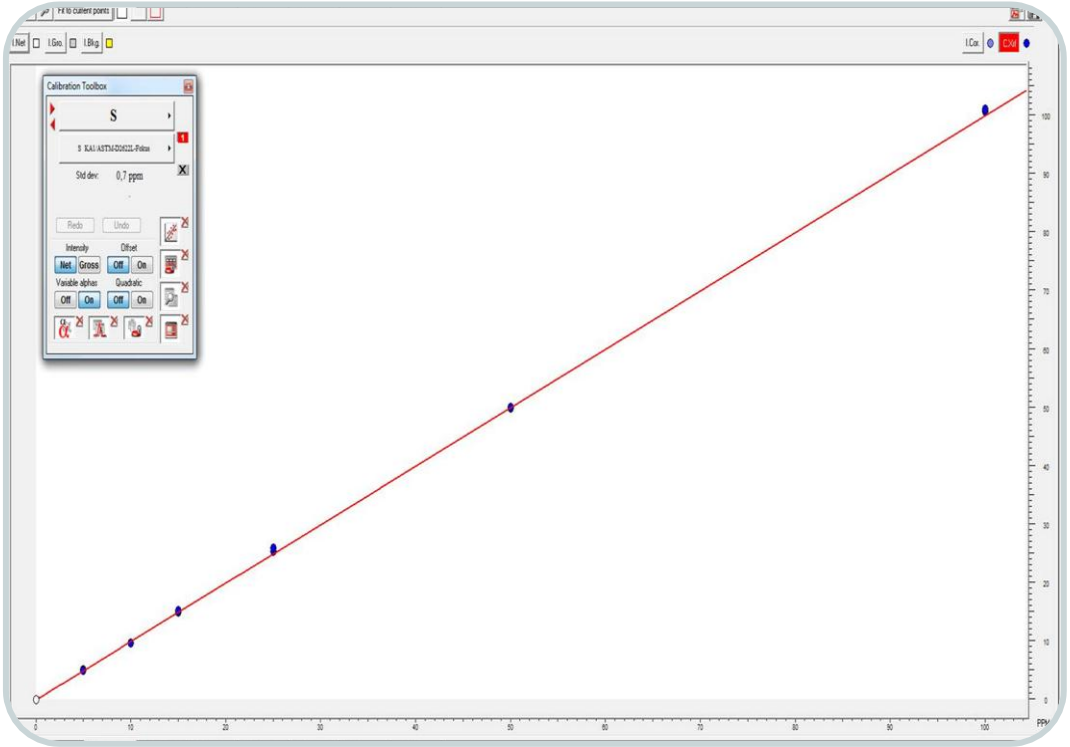
- ASTM D 2622

  Low range: 5 – 1000 ppm

  for gasoline, mineral oil

S8 TIGER ECO
ASTM D 2622 – Low Sulfur in Gasoline

- Reduction of sulfur in fuels for cars, trucks and jets is a worldwide imperative to prevent SO_x emission!
- Typical limit: < 10 ppm
- Analytical demands: Stay as close and accurate as possible to < 10 ppm



Concentration Range:

- 5 – 100 ppm

Calibration Std. Dev:

- 0.1 ppm

Detection Limit:

- 0.4 ppm (3σ, 100s)

S8 TIGER ECO
ASTM D 2622 – Low Sulfur in Gasoline

Measurement Finished	S (PPM)	Diff. to prev. [ppm] ASTM max. allow. 0.9 ppm
14:02	10.4	
14:08	10.5	0.1
14:14	10.1	-0.4
14:20	10.2	0.1
14:26	10.2	0.0
14:32	10.2	0.0
14:38	10.1	-0.1
14:44	10.2	0.1
14:50	10.0	-0.2
14:56	10.0	0.0
15:02	10.2	0.2
15:08	9.8	-0.4
Average	**10.2**	
Abs.Std.Dev.	**0.18**	
Rel.Std.Dev.	**1.8%**	
Minimum	**9.8**	
Maximum	**10.5**	
Range	**0.7**	

Short term repeatability for Sulfur:

- +/- 0.7 ppm
- Relative standard deviation of less than 2% for 10 ppm
- with 4.5 minutes measurement time

ASTM D 2622 performance check is easily passed, all measurements are in agreement.

S8 TIGER ECO
ASTM D 2622 – Low Sulfur in Gasoline

Long term repeatability for Sulfur:

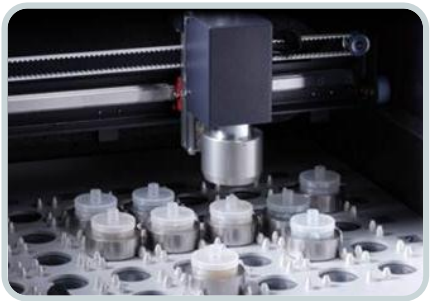
- +/- 0.7 ppm
- Relative standard deviation of 2.1% for 10 ppm (in 2 weeks time)
- with 4.5 minutes max. measurement time

ASTM D 2622 performance check is easily passed, all measurements are in agreement.

Measurement Finished	S (PPM)	Diff. to prev. [ppm] ASTM max. allow. 0.9 ppm
21.06.2013 14:02	10.4	
24.06.2013 11:03	10.0	-0.4
25.06.2013 09:34	10.4	0.4
26.06.2013 09:47	10.3	-0.1
27.06.2013 09:22	10.4	0.1
28.06.2013 08:31	10.1	-0.3
01.07.2013 10:21	10.2	0.1
02.07.2013 10:37	9.7	-0.5
03.07.2013 10:39	10.3	0.6
04.07.2013 10:32	10.2	-0.1
05.07.2013 08:59	10.2	0.0
09.07.2013 11:25	9.9	-0.3
Average	**10.2**	
Abs.Std.Dev.	**0.21**	
Rel.Std.Dev.	**2.1%**	
Minimum	**9.7**	
Maximum	**10.4**	
Range	**0.7**	

S8 TIGER ECO “Petro“ for low sulphur Optimal Performance

- S8 TIGER ECO “Petro”
  for low sulfur, compliant to ASTM D 2622
  - Compliant with
    - ASTM D 2622
    - EN ISO 20884
  - Time to result
    - 4.5 minutes for gasoline
  - Detection Limit (LOD)
    - 0.4 ppm
  - Sample throughput
    - More than 15 samples per hour



Standards and Applications of XRF for Lubricants

- EN ISO 14596 Low S
- EN ISO 14596 High S
- EN ISO 14597 V and Ni
- EN ISO 15597 Cl and Br
- DIN 51790 S, V and Ni
- DIN 51363 P
- DIN 51391 Zn and Ca
- DIN 51431 Mg
- ASTM D 6443 Ca, Cl, Cu, Mg, P, S and Zn

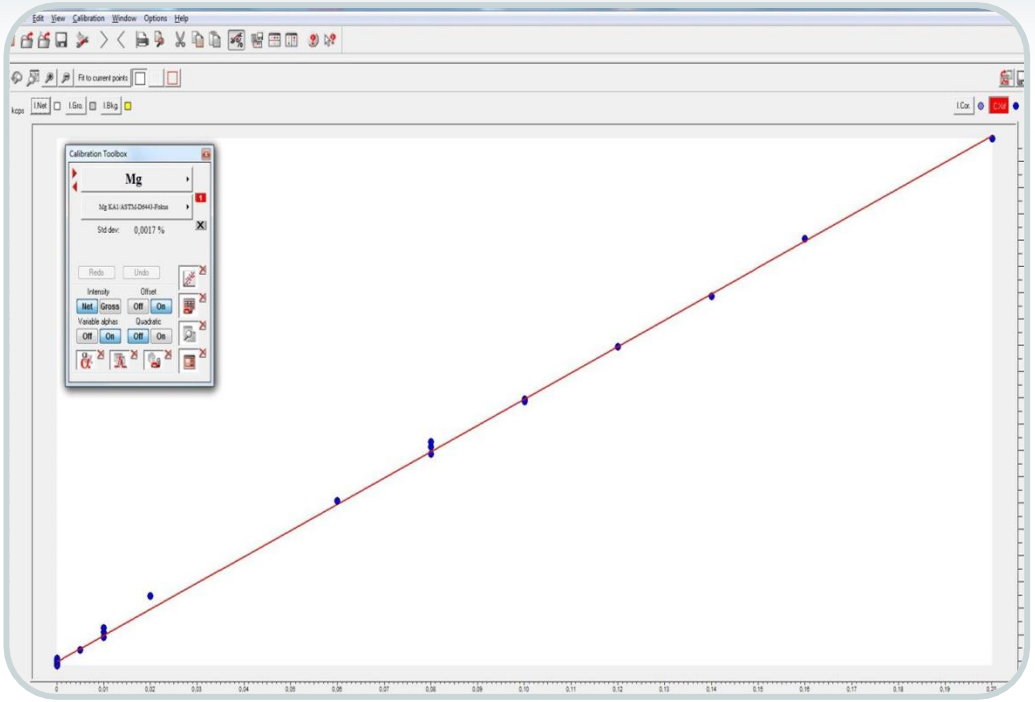
A lubricant is a substance introduced between two moving surfaces to reduce the friction between them, improving efficiency and reducing wear. It may also have the function of dissolving or transporting foreign particles and of distributing heat. Typically lubricants contain 90% base oil (most often petroleum fractions, called mineral oils) and less than 10% additives. Additives deliver reduced friction and wear, increased viscosity, improved viscosity index, and resistance to corrosion and oxidation, aging or contamination.

S8 TIGER ECO “Petro“ for lubricants Configuration

Configuration	S8 TIGER ECO "Petro" for lubicating oils
Compliant to international Standard	ASTM D 6443 EN ISO 14597 EN ISO 15597 DIN 51363 DIN 51391 DIN 51790
Sample types	Liquids in cells Solid samples
Atmospheric mode	Vacuum/Helium
Analyzer crystal	XS-55, PET, LiF200
Collimator	0.46°
Detector	Gas flow proportional counter

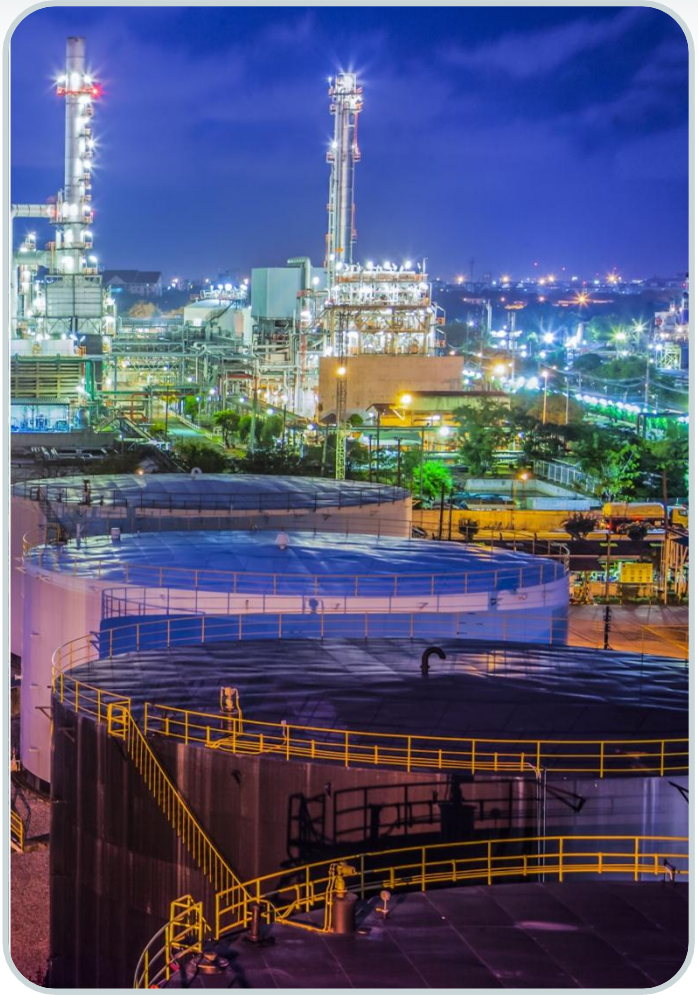
- Optimal configuration for analysis of additives in lubricants
- Applicable also for additives in polymers

ASTM D 6443 Performance
S8 TIGER ECO



- Additives and contaminants in lubricants
- Straight calibration curves based on traceable standard reference samples
- Calibration Std Dev below 20 ppm for all elements
- Typical measurement time approx. 10 minutes, optimzed based on statistical counting error to increase sample throughput
- 140 samples per day with optimal precision

Low sulfur in automotive fuels
ASTM D 2622 with the S8 TIGER ECO



- Precise and close control of low levels possible by WDXRF
- Several calibrations for each matrix with ASTM D
- Internal standards (EN ISO) for just one method for all matrices
- Enhanced analytical performance with lower COV compared to EDXRF
- Better handling of various matrices, e.g. biofuels, compared to FT-IR, AAS and other methods
- Atmospheric purge vs reduced pressure to enhance analytical performance and reliability for volatile samples
- ECO configurations reduce cost of ownership

Audience Poll

Please use your mouse to answer the question in the poll window on your screen.

What type of XRF instrument do you use most often?

a. Multi-element EDXRF
b. Multi-element WDXRF
c. Single-element WDXRF
d. Polarized-beam XRF
e. I currently don't use XRF

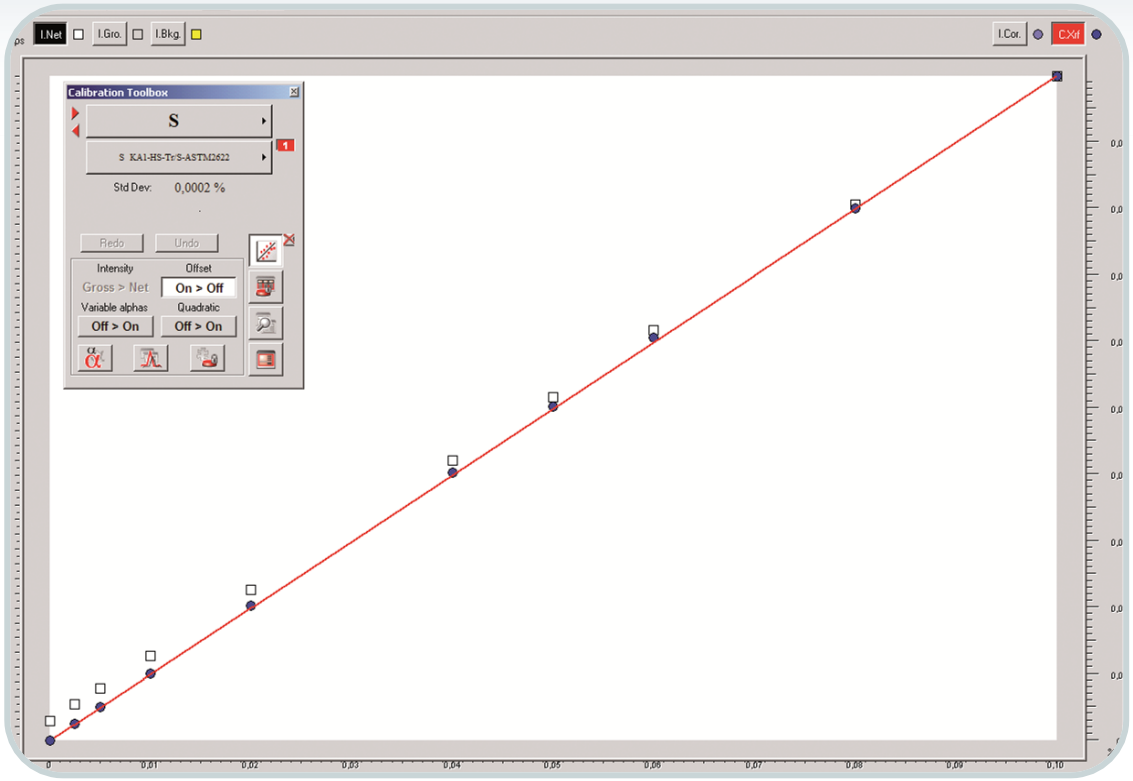
We'll share the poll results in a few minutes.

More Demanding Petrochemical Applications - Norms for Petrochemistry

- Various norms regulate the use of a specific analytical techniques and tool for petrochemical applications
- Full 4-kW power WDXRF is the most sensitive instrument of choice for the precise determination of sulfur in petrochemicals

ASTM 2622 ISO 20884 ISO 14596	WDXRF	gasoline petroleum products fuels	ultra low detection limits (< 0.2 ppm) highest precision

S8 TIGER 4 kW
Maximum precision and throughput



The S8 TIGER with 4 kW excitation power offers:

- Very low detection limits down to 0.2 ppm
- High sample throughput of more than 30 samples per hour
- Optimal precision with less than 1.5% variation at 10 ppm

PETRO-QUANT
ASTM D 6443: Lubricating Oils

Analysis of additives in lubricants:

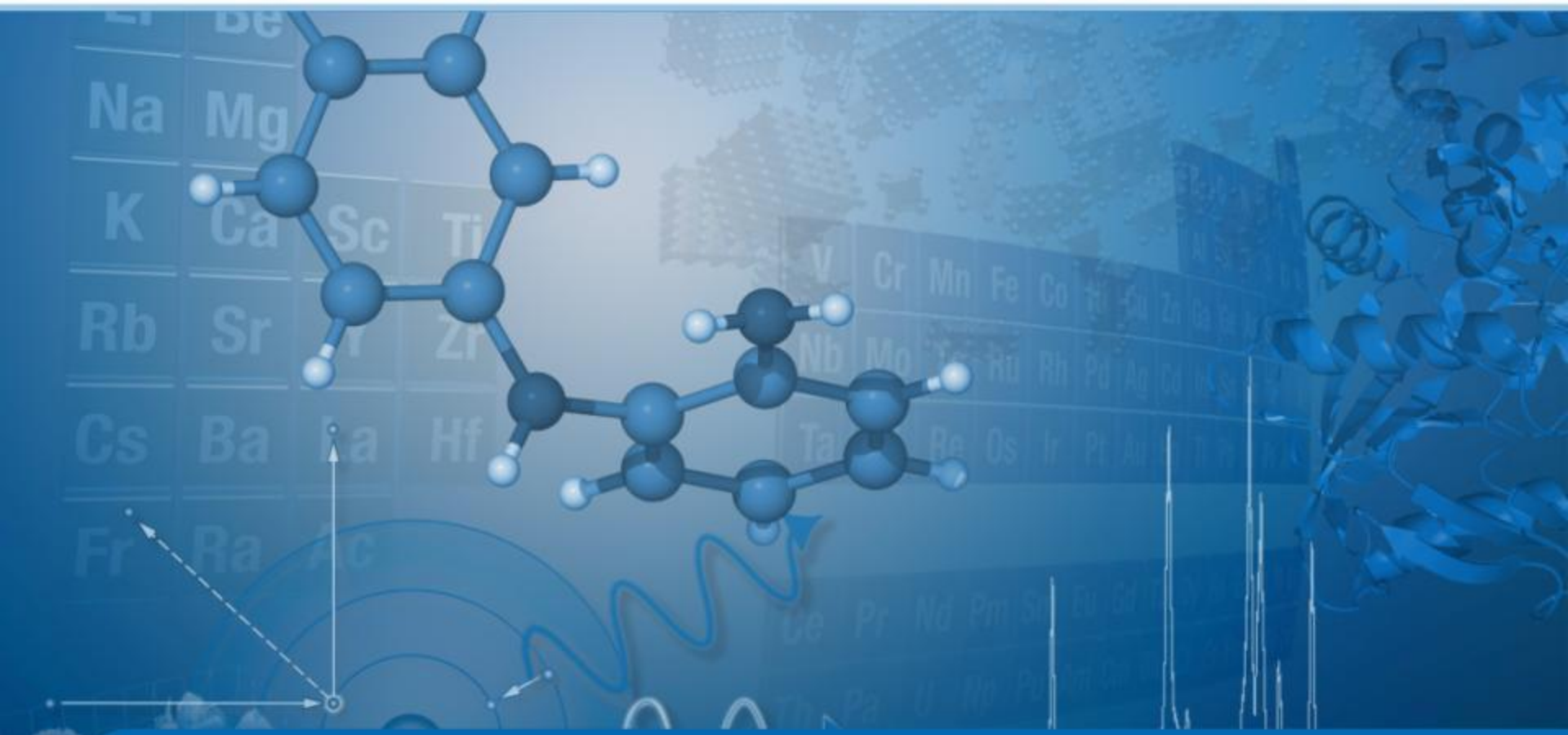
- Turn-key solution, norm-compliant
- Ultimate high precision allows accurate blending
- Cost savings: expensive additives saved

	Mg	P	S	Cl	Ca	Cu	Zn
Cal. Range [ppm]	2000	1500	7500	1500	5000	500	1500
Detection Limit [ppm] LOD	2.3	2.1	1.6	3.0	1.1	0.8	1.1
Repeatability [11 times]							
Mean value [ppm]	823	493	2749	500	1997	198	493
Abs. Std. Dev. [ppm]	6	5	10	4	8	1	5
Precision [%]	0.8	0.9	0.4	0.9	0.4	0.3	0.9

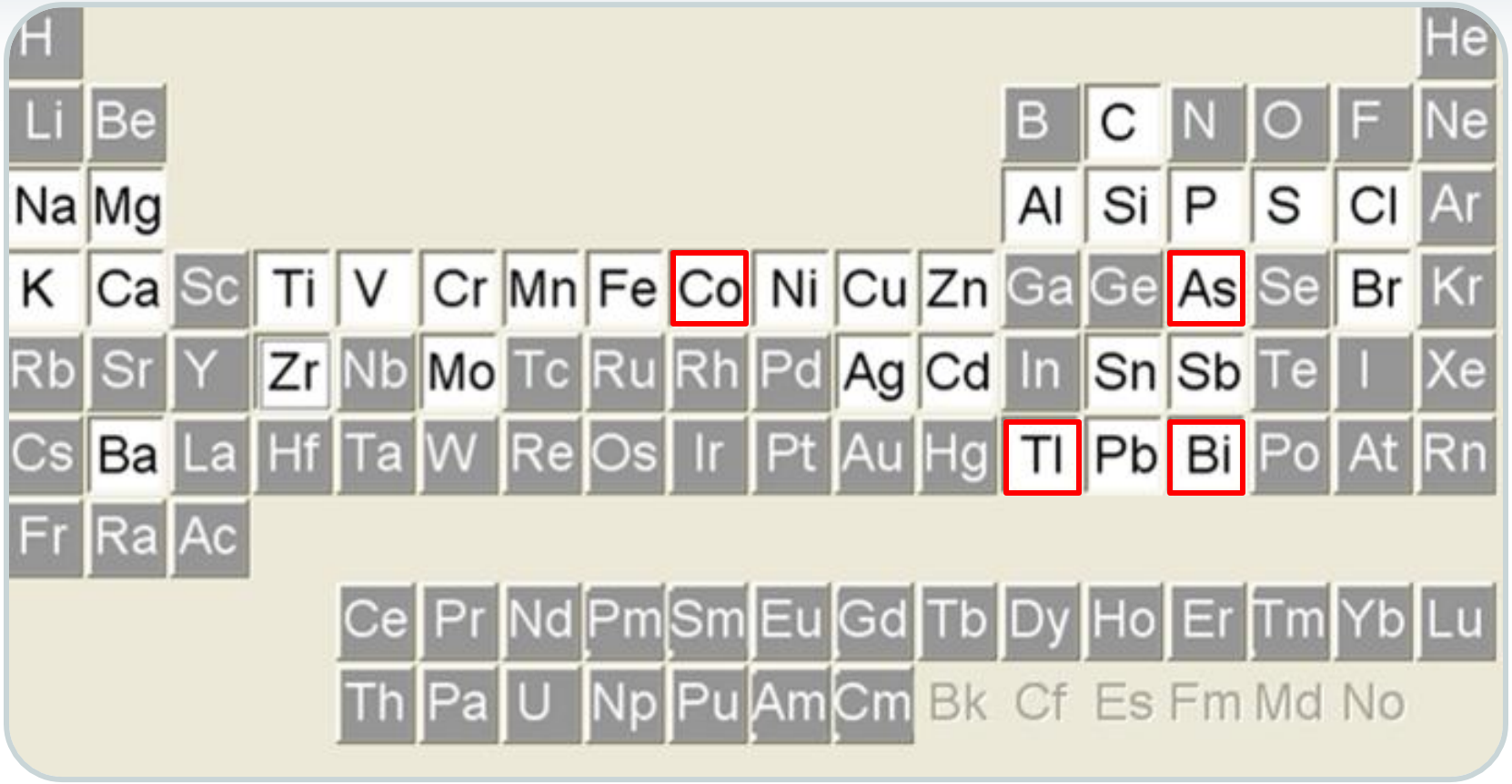
PETRO-QUANT
Solutions for the Petrochemical Industry

- For more sophisticated applications, Bruker offers ready-to-analyze solutions
- Control of engine oils for wear metals in motor development and on the race course
  - Reliable and early warning for engine breakdowns in development and on the race course to avoid high costs and risks
  - Very good reproducibility for “modern“ elements Mg, Al, Si in car engines

S8 TIGER
PETRO-QUANT V2



PETRO-QUANT
Unique Solutions for Petrochemicals



Universal petrochemical calibration for up to 30 elements in hydrocarbon-based matrices – straight out of the box

NEW: 4 additional elements: Co, As, Tl, Bi as additives and contaminants

PETRO-QUANT
Unique Solutions for Petrochemicals

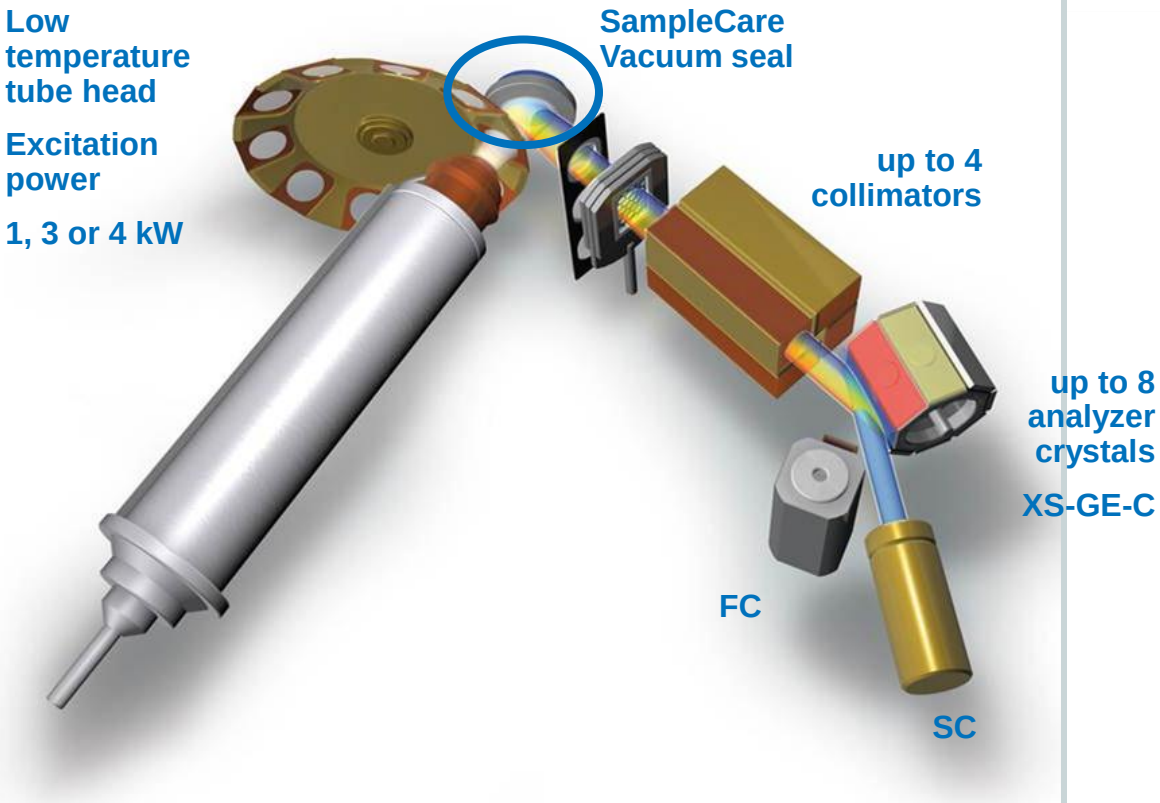
Universal Calibration for:

- Matrix: 95% or more hydrocarbons
- Elements: natural contaminants and technical additives
- Optimized sample prep for liquids and polymers
- Concentration ranges:
  S, Cl: LLD to 5% (heavy fuels and metal working fluids)
  Mg, P, S, Ca and Zn: up to several thousand PPM (additives)
  Ni, V and wear metals: max several hundred PPM (traces)

Performance

- LLD´s: a few ppm’s, typically less than 1 PPM
- accuracy: a few ppm
- precision: a few ppm

PETRO-QUANT
SampleCare™: Vacuum Seal



- Very fast change-over from vacuum to helium to vacuum to helium...
- Goniometer chamber (Soller slits, crystals and detectors) are permanently protected
- Helium consumption is minimized

PETRO-QUANT
Ultimate Analytical Performance

Universal Calibration for petrochemicals based on SPECTRA*plus*:

- Variable alpha (Fundamental Parameter) model for wide concentration ranges

PETRO-QUANT
Ultimate Analytical Performance

Universal Calibration for petrochemicals based on SPECTRA*plus*:

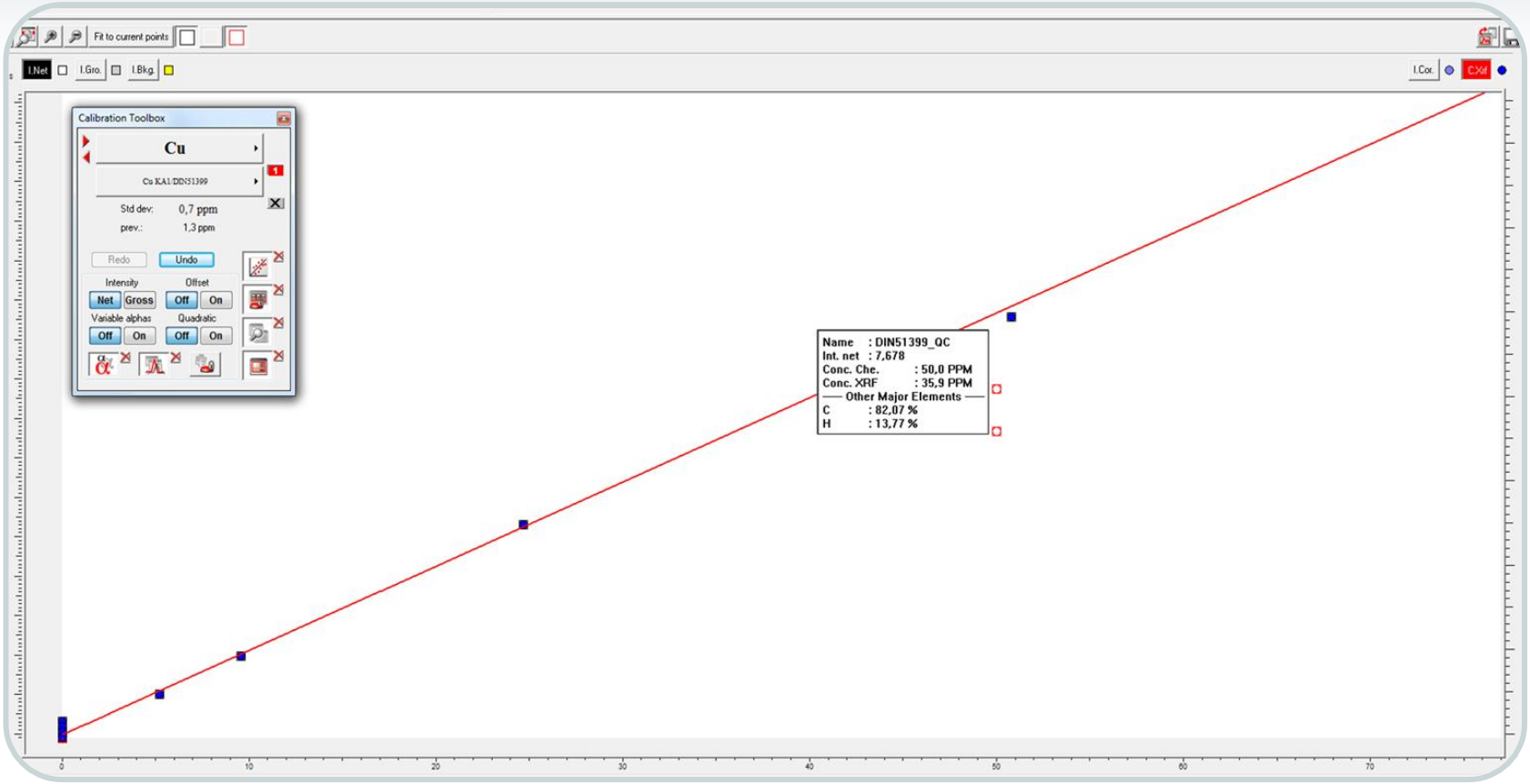
- Variable alpha (Fundamental Parameter) model for wide concentration ranges
- Automatic selection of best lines for high concentrations (S, Cl) and severe line overlaps (As, Tl, Pb, Bi)

PETRO-QUANT
Ultimate Analytical Performance

Universal Calibration for petrochemicals based on SPECTRA*plus*:

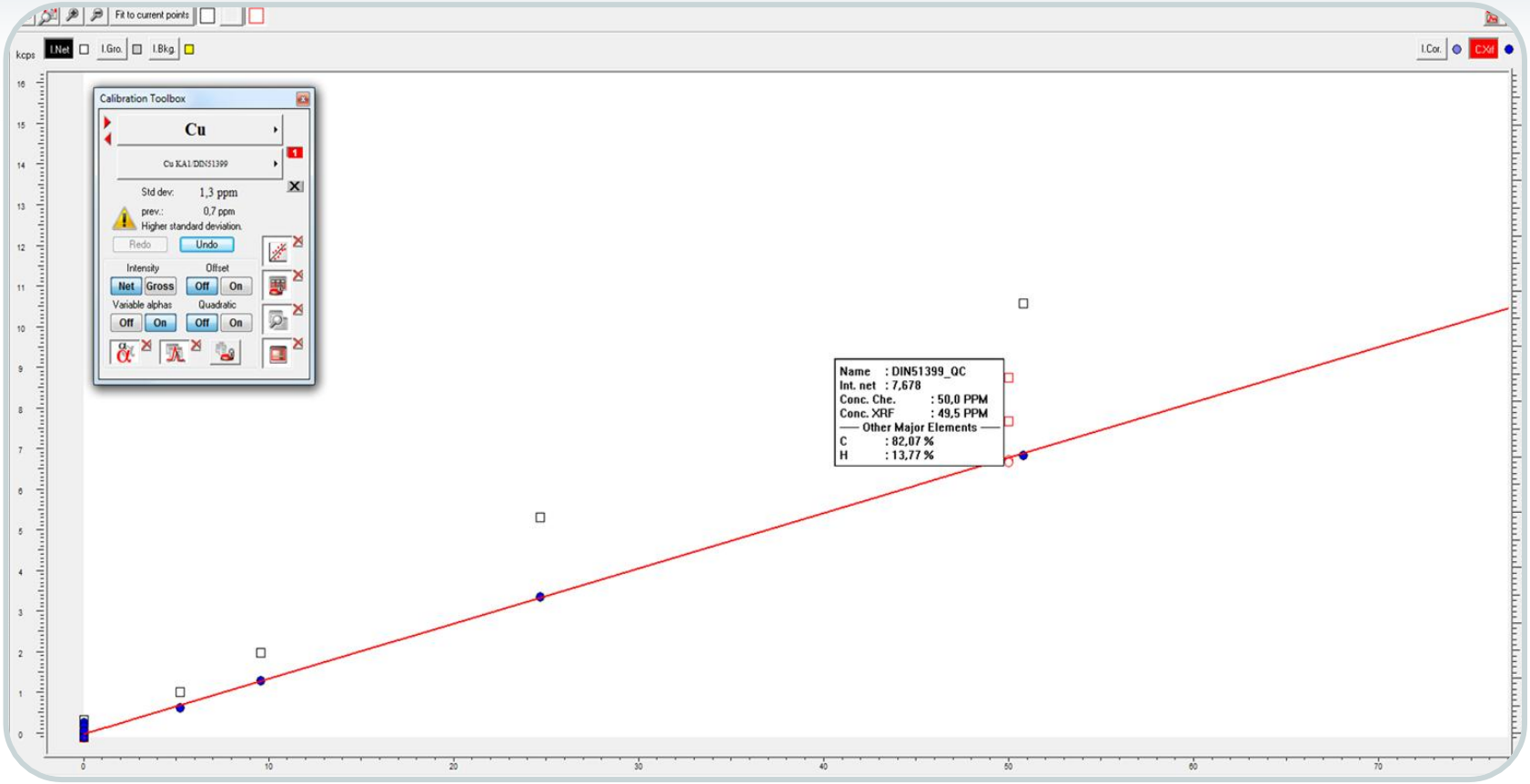
- Variable alpha (Fundamental Parameter) model for wide concentration ranges
- Automatic selection of best lines for high concentrations (S, Cl) and severe line overlaps (As, Tl, Pb, Bi)
- Aut-**O**-matic: Quantification of light element matrix

Matrix effects for wear metals in oils
Variation for S (up to 2.5 %) and O (up to 20%)



Copper at 50 ppm evaluated as 35 ppm due to matrix effects not being compensated correctly

Matrix effects for wear metals in oils
Variation for S (up to 2.5 %) and O (up to 20%)



Copper at 50 ppm evaluated as 49.5 ppm due to variable alpha matrix correction and oxygen evaluation by PETRO-QUANT Aut-O-Matic method

PETRO-QUANT
Ultimate Analytical Performance

Aut-**O**-matic:

Quantification of light element matrix

- Determining a compound using Compton Ratio:
- Oxygen cannot be measured directly (absorption of its intensity by the cup foil)
- Determination of additional matrix compounds using Compton optimization

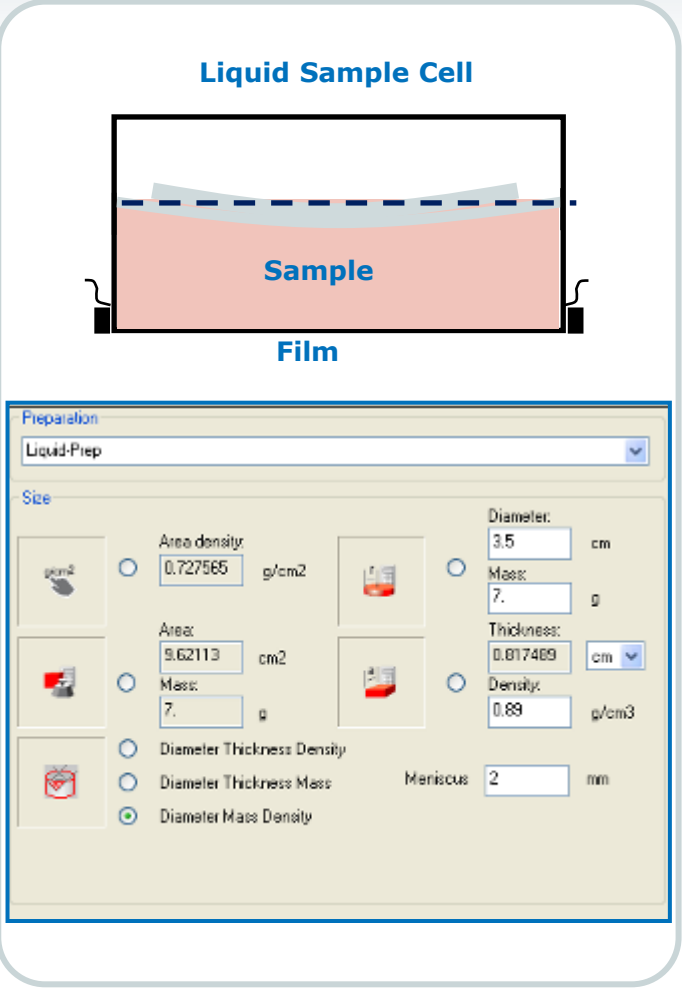
- In hydrocarbons for example:
- The oil matrix (CH_2) is determined by the balance to 100%
- The oxygen content is determined by optimization of the Compton intensity

PETRO-QUANT
Ultimate Analytical Performance

Universal Calibration for petrochemicals based on SPECTRA*plus*:

- Variable alpha (Fundamental Parameter) model for wide concentration ranges
- Automatic selection of best lines for high concentrations (S, Cl) and severe line overlaps (As, Tl, Pb, Bi)
- Aut-**O**-matic: Quantification of light matrix
- Geometric Correction of Wedge Effect
- Meniscus Correction

PETRO-QUANT
Ultimate Analytical Performance



Geometric Correction of Wedge Effect and Meniscus Correction

- Liquid samples often exhibit the meniscus effect, where the top surface of the liquid is concave instead of flat
- This will introduce errors in the calculation of the composition (wrong sample height)

- Meniscus Effect Correction for liquid samples:
- Insert size of the meniscus effect in the ApplicationWizard

PETRO-QUANT
Ultimate Analytical Performance

Universal Calibration for petrochemicals based on SPECTRA*plus*:

- Variable alpha (Fundamental Parameter) model for wide concentration ranges
- Automatic selection of best lines for high concentrations (S, Cl) and severe line overlaps (As, Tl, Pb, Bi)
- Aut-**O**-matic: Quantification of light element matrix
- Geometric Correction of Wedge Effect
- Meniscus Correction
- Set for density measurement included

PETRO-QUANT with the S8 TIGER 4 kW
Let's Make a Method for Racing…

- Control of engine oils for wear metals in motor development and for racing
- Remove elements from method to customize the application for exact requirement for speed and accuracy
- Lowest possible LLD with quick measurements:
  - lowest ppm level
  - short analysis time (≤ 10min)
  - highest precision (≤ 1 ppm), esp. for Mg, Al, Si (≤ 2 ppm)
  - analyzes also particles (early warnings for engine breakdown (compared to Rotrode measurements)

PETRO-QUANT
Wear Metal Debris – Speed, Speed, Speed

Sample	Mg (PPM)	Al (PPM)	Si (PPM)	P (PPM)	Ca (PPM)	Ti (PPM)	V (PPM)	Cr (PPM)	Mn (PPM)
1	12.,5	8.9	7.6	8.8	12.1	9.2	10.3	10.7	10.6
2	11.2	6.7	8.4	8.9	10.1	10.6	10.4	10.9	10.3
3	10.5	8.0	10.0	9.1	10.7	10.0	11.8	10.1	10.0
4	10.1	5.8	5.8	10.1	9.6	10.6	10.2	11.0	10.4
5	12.5	8.0	11.3	8.7	9.6	11.1	9.9	10.5	9.9
6	8.9	7.5	9.0	9.2	10.4	9.5	10.1	9.0	10.2
7	11.8	9.9	10.6	9.4	11.9	10.7	10.1	10.0	11.1
8	7.3	9.0	11.0	8.7	11.2	10.4	10.6	10.6	10.1
9	9.7	7.2	8.1	10.1	12.5	10.8	10.3	10.5	10.5
10	10.2	7.3	8.5	10.8	10.4	10.8	10.3	10.0	10.2
11	10.6	8.5	5.9	8.9	11.1	9.8	10.3	10.0	9.9
12	8.4	8.3	6.5	9.3	12.5	10.4	11.2	10.3	10.1
Mean	**10.3**	**7.9**	**8.6**	**9.3**	**11.0**	**10.3**	**10.5**	**10.3**	**10.3**
Std. Dev.	**1.6**	**1.1**	**1.9**	**0.7**	**1.0**	**0.6**	**0.5**	**0.5**	**0.3**
Max	**12.5**	**9.9**	**11.3**	**10.8**	**12.5**	**11.1**	**11.8**	**11.0**	**11.1**
Min	**7.3**	**5.8**	**5.8**	**8.7**	**9.6**	**9.2**	**9.9**	**9.0**	**9.9**
Range	**5.2**	**4.1**	**5.5**	**2.1**	**2.9**	**1.9**	**1.9**	**2.0**	**1.2**

PETRO-QUANT
Wear Metal Debris – Speed, Speed, Speed

Sample	Fe (PPM)	Ni (PPM)	Cu (PPM)	Zn (PPM)	Mo (PPM)	Sn (PPM)	Pb (PPM)	Sample
1	10.5	11.0	10.2	9.9	9.8	9.8	9.1	**1**
2	9.7	9.9	10.0	9.9	9.3	11.8	9.8	**2**
3	9.4	10.2	9.9	9.8	9.6	10.5	9.4	**3**
4	11.0	10.1	10.1	9.9	9.3	8.2	9.7	**4**
5	9.3	11.0	10.3	9.6	9.7	6.6	10.1	**5**
6	10.2	10.2	10.1	9.7	8.3	9.8	9.8	**6**
7	9.6	10.5	10.0	9.8	8.9	10.5	10.1	**7**
8	10.2	10.2	10.2	10.1	8.5	14.0	9.9	**8**
9	9.6	9.9	10.5	10.1	9.9	9.4	9.6	**9**
10	9.7	10,2	10.1	10.4	9.1	11.0	9.5	**10**
11	9.1	10.5	10.3	9.9	10.0	9.4	9.7	**11**
12	10.4	10.3	10.4	9.9	9.8	10.0	10.0	**12**
Mean	**9.9**	**10.3**	**10.2**	**9.9**	**9.4**	**10,1**	**9.7**	**Mean**
Std Dev	**0.6**	**0.4**	**0.2**	**0.2**	**0.6**	**1.8**	**0.3**	**Std Dev**
Max	**11.0**	**11.0**	**10.5**	**10.4**	**10.0**	**14.0**	**10.1**	**Max**
Min	**9.1**	**9.9**	**9.9**	**9.6**	**8.3**	**6.6**	**9.1**	**Min**
Range	**1.9**	**1.1**	**0.6**	**0.8**	**1.7**	**7.4**	**1.0**	**Range**

Petrochemical applications
Norms

Norm-specific Calibrations:

ASTM, ISO and DIN

- PETRO-QUANT can be fully calibrated for each norm
- User selects norm
- Optional standards / QC samples are available from Bruker AXS
- Instrument is calibrated onsite using either delivered or provided standards
- In addition to PETRO-QUANT base training, method training is provided
- Norms package consists of calibration standards, drift samples, QC samples, complete setup and training

PETRO-QUANT
Norms available

- ASTM D2622 Low S in Mineral Oil
- ASTM D2622 Low S in Gasoline
- ASTM D2622 Low S in Diesel
- ASTM D2622 Medium S in Mineral Oil
- ASTM D2622 High S in Mineral Oil
- ASTM D5059 Lead in fuels
- ASTM D6443 Ca, Cl, Cu, Mg, P, S and Zn in unused Lubricating Oils
- EN ISO 20884 Low S in automotive fuels
- EN ISO 20884 High S in automotive fuels
- EN ISO 14596 Low S contents in petroleum products
- EN ISO 14596 High S contents in petroleum products
- EN ISO 14597 V and Ni in Mineral Oil
- EN ISO 15597 Cl and Br in Mineral Oil
- DIN 13723 Pb in Gasoline
- DIN 51363 P in Lube Oils and Additives
- DIN 51391 Zn and Ca in Lube Oils
- DIN 51399 Wear metals in engine oils with FP
- DIN 51431 determination of Mg in lubricants
- DIN 51790 S, V, and Ni in Mineral Oil

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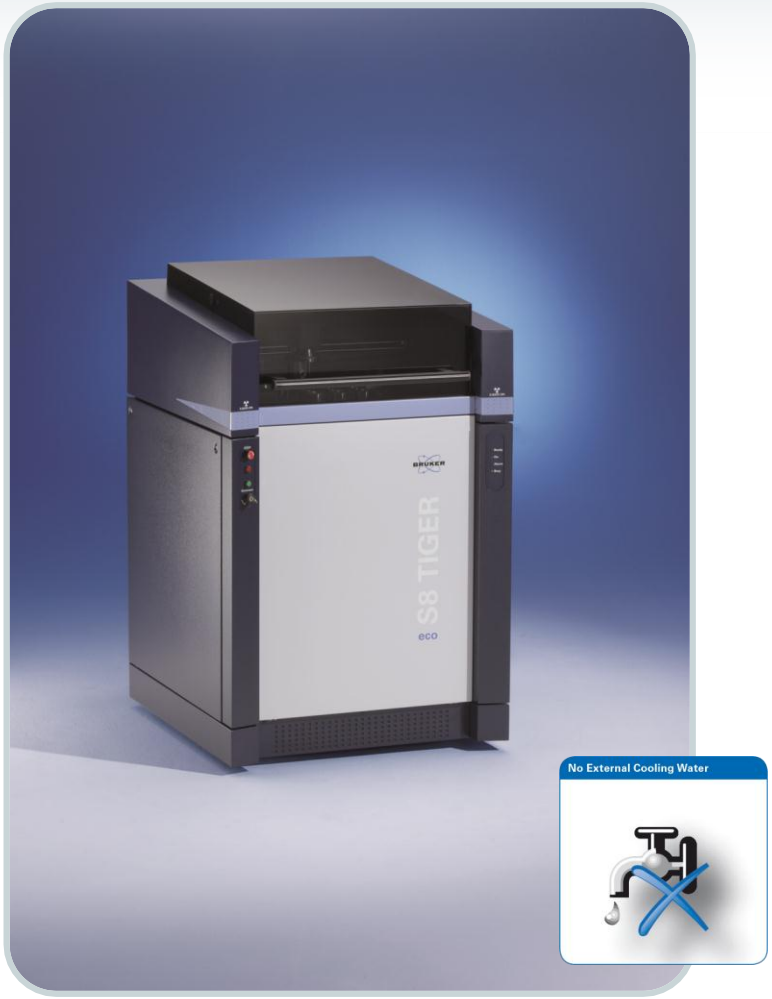
S8 TIGER ECO



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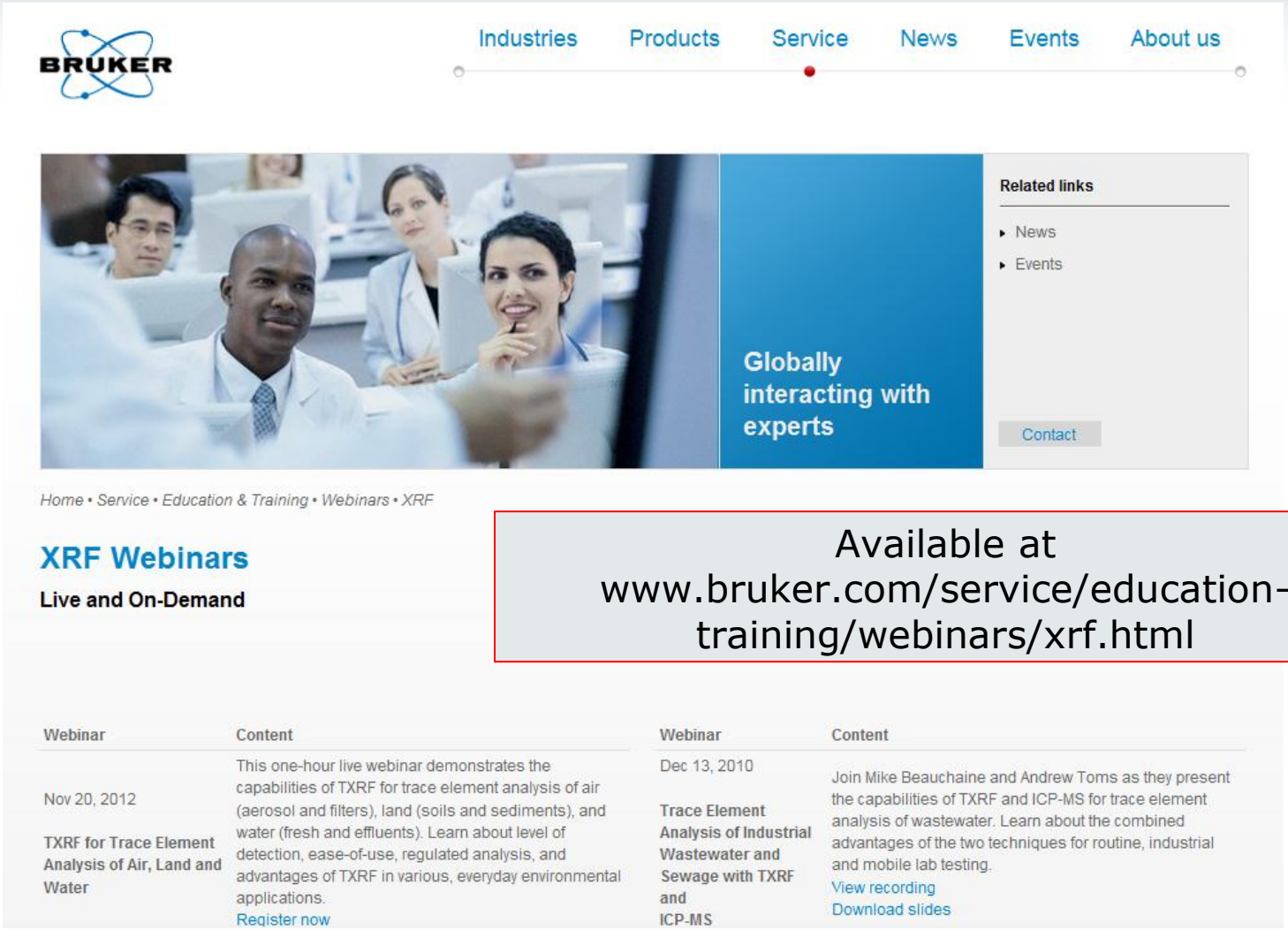

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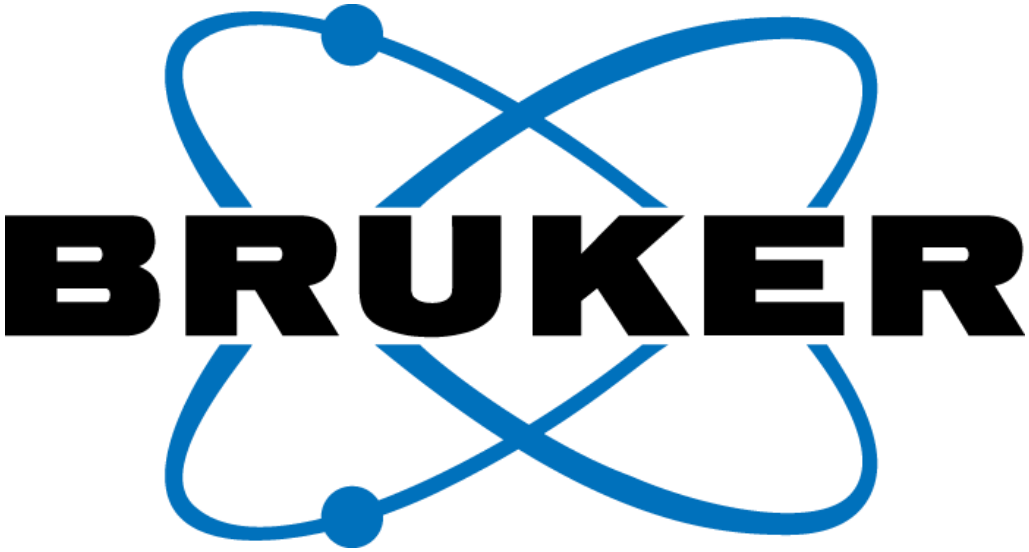

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