WEBINAR SERIES 2021

# Fast & Easy Analysis of Marco- and Micro-Nutrients: Applications of XRF in the Animal Feed Industry

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24.11.2021

# Fast & Easy Analysis of Marco- and Micro-Nutrients: Applications of XRF in the Animal Feed Industry


01 Basics about XRF

02 Benefits of XRF
Where to use XRF in Feed & Agriculture

03 The importance of Sample Preparation

05 Application examples: From Raw Material to final feed

06 Summary and Q&A


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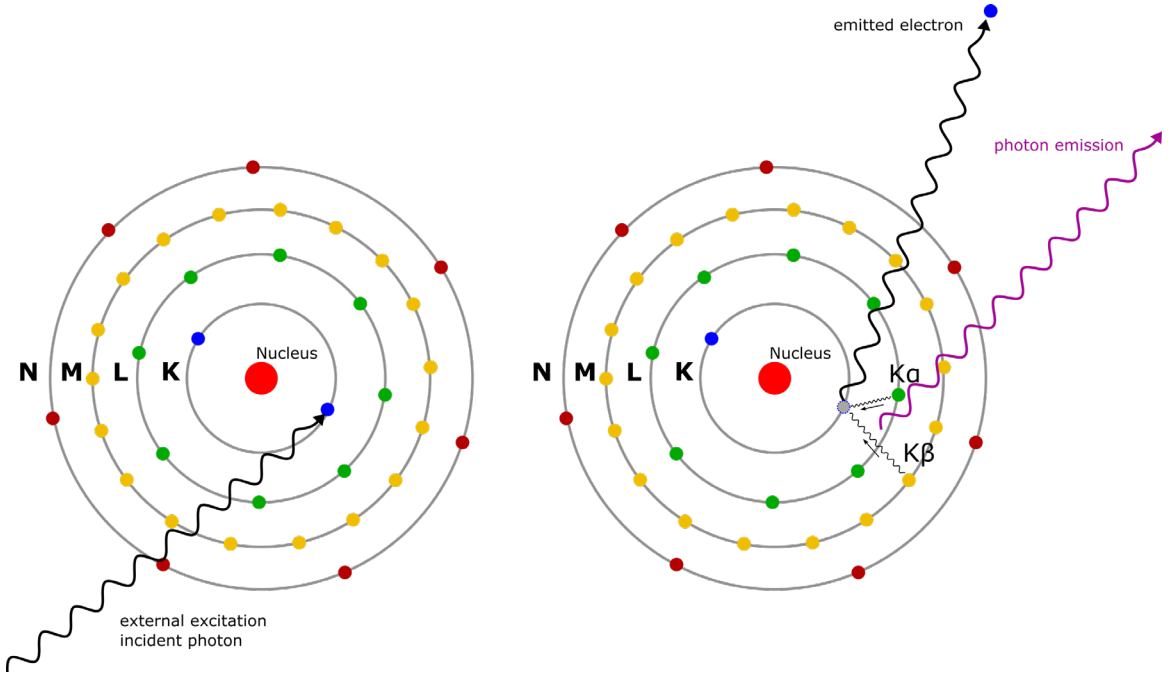
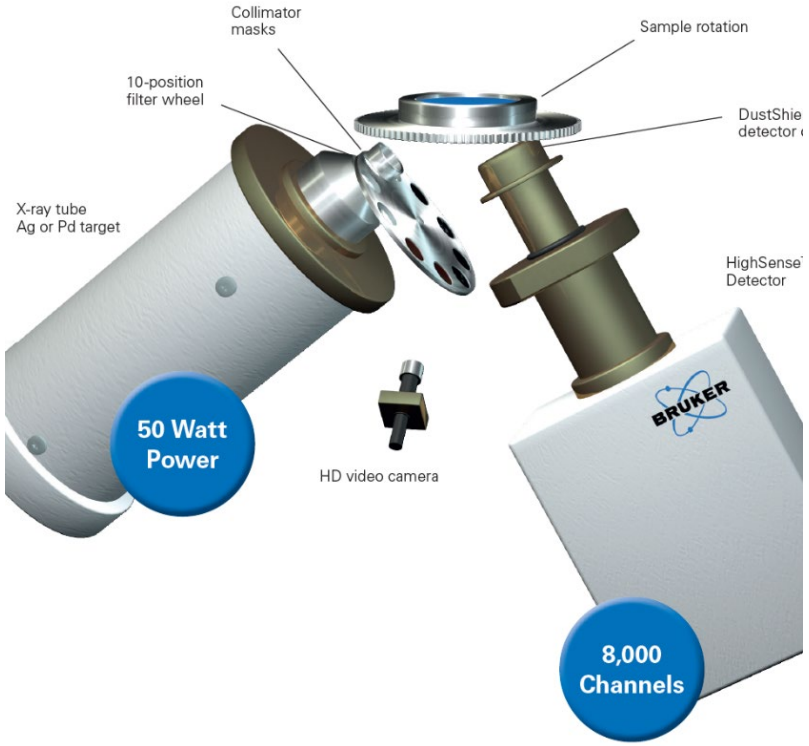
# X-Ray Fluorescence (XRF)
# Analysis principle – photoelectric effect




- 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 / transition
- Intensity of characteristic radiation is proportional to concentration of the element in the sample

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# Quality control in feed and agriculture by XRF

**Grains**
whole/ground

**Oil Seeds**
whole/ground/expeller

**Legumes**
ground

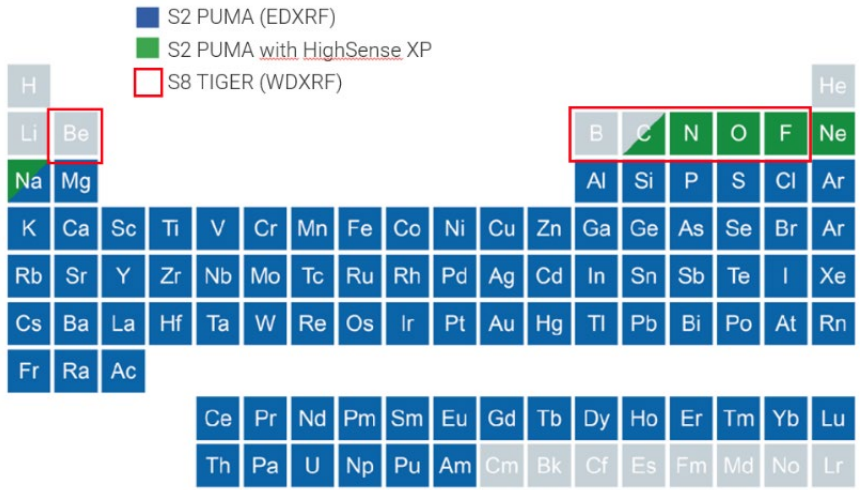
**Animal proteins**
ground

**Feed**
ground/pellets

**Forages**
wet/dry

## Elemental Ranges

- Wide coverage of the periodic table: F to U




## Concentrations & Time

- Marco-, Micro- and Trace Mineral Nutrients
  - µg/g (ppm) to 100%
- Time-to-result: 3 to 15 min

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# Benefits of XRF vs. AAS and ICP Cost of Ownership

The investment for the analytical instrument is only one part of the total cost of ownership. Expenses for laboratory equipment, labour and consumables add to that cost.

## ICP-OES/AAS

- Use of expensive accessories (AAS: graphite tubes)
- Consumption of noble gases (ICP: Argon)
- Need for hazardous chemicals (compliance with high-level safety regulations)
- Complicated sample preparation equipment (training and time)

## S2 PUMA Series 2 EDXRF Spectrometer:

- No hazardous consumables
- No highly trained lab-technician needed
- No gas or very little gas consumption (Helium for volatile liquids)

## Example: ICP vs. S2 PUMA Series 2

- Final Feed measure as pressed powder pellet
  - XRF: <$2000/year for binding material
  - ICP: >$20.000/year for gas, refences and other consumables

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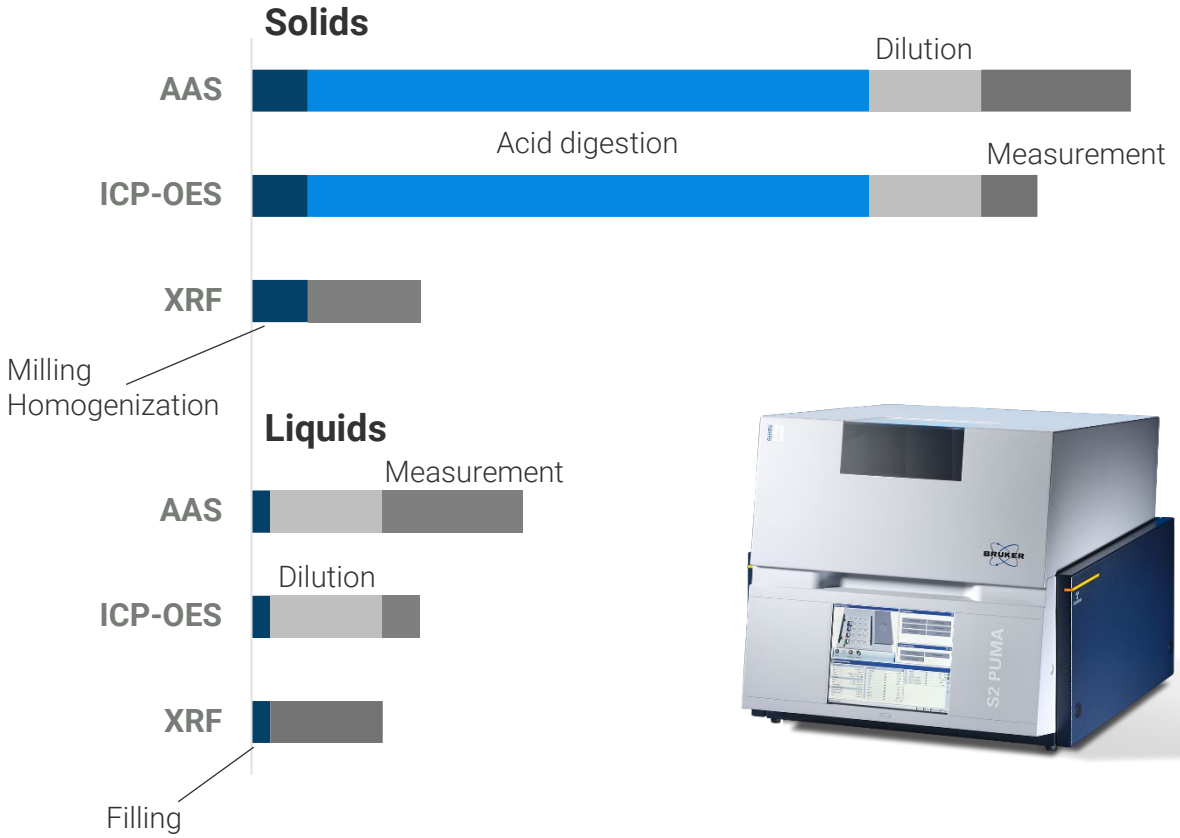
# Benefits of XRF vs. AAS and ICP
# Ease of use and Time to Result

- XRF makes Quality Control Fast and Simple!

**ICP/AAS**

**XRF**

## Time to Result



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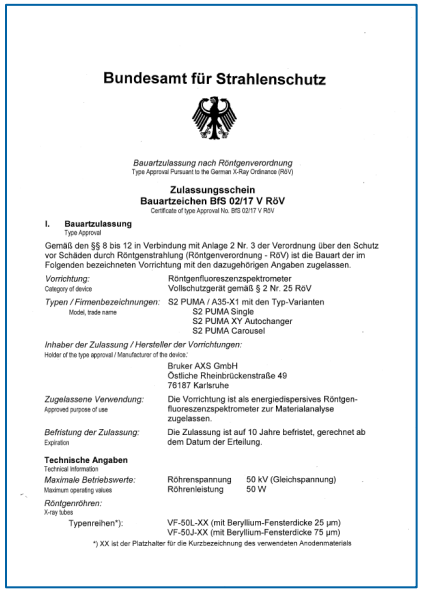
# Highest Safety Standards S2 PUMA Series 2



Bundesamt für Strahlenschutz

*Bauartzulassung nach Röntgenverordnung*
Type Approval Pursuant to the German X-Ray Ordinance (RöV)

**Zulassungsschein**
**Bauartzeichen BfS 02/17 V RöV**
Certificate of type Approval No. BfS 02/17 V RöV

I. **Bauartzulassung**
Type Approval

Gemäß den §§ 8 bis 12 in Verbindung mit Anlage 2 Nr. 3 der Verordnung über den Schutz vor Schäden durch Röntgenstrahlung (Röntgenverordnung - RöV) ist die Bauart der im Folgenden bezeichneten Vorrichtung mit den dazugehörigen Angaben zugelassen.

*Vorrichtung:* (Category of device) — Röntgenfluoreszenzspektrometer, Vollschutzgerät gemäß § 2 Nr. 25 RöV

*Typen / Firmenbezeichnungen:* (Model, trade name) — S2 PUMA / A35-X1 mit den Typ-Varianten
S2 PUMA Single
S2 PUMA XY Autochanger
S2 PUMA Carousel

*Inhaber der Zulassung / Hersteller der Vorrichtungen:*
Holder of the type approval / Manufacturer of the device:
Bruker AXS GmbH
Östliche Rheinbrückenstraße 49
76187 Karlsruhe

*Zugelassene Verwendung:* (Approved purpose of use) — Die Vorrichtung ist als energiedispersives Röntgenfluoreszenzspektrometer zur Materialanalyse zugelassen.

*Befristung der Zulassung:* (Expiration) — Die Zulassung ist auf 10 Jahre befristet, gerechnet ab dem Datum der Erteilung.

**Technische Angaben**
Technical information

*Maximale Betriebswerte:* (Maximum operating values)
Röhrenspannung 50 kV (Gleichspannung)
Röhrenleistung 50 W

*Röntgenröhren:* (X-ray tubes)
Typenreihen*): VF-50L-XX (mit Beryllium-Fensterdicke 25 µm)
VF-50J-XX (mit Beryllium-Fensterdicke 75 µm)

*) XX ist der Platzhalter für die Kurzbezeichnung des verwendeten Anodenmaterials

BUREAU VERITAS

**CERTIFICAT DE CONFORMITE**
**N°2450423-14** **A LA NORME NF C 74-100**
*Certificate of conformity N°* *2450423-14*

*Identification de l'article :* / *Identification of item* — Groupe radiogène de radiologie industrielle et scientifique composé d'un générateur haute tension type UX50P50X4786 et d'un tube radiogène type VF-50L-AG (ou VF-50J-AG), intégré au système de spectrométrie de fluorescence « X » modèle S2 PUMA Single (30 kV).

Références : NF C 74-100 de juin 1981 et NF C 74-100 ADD 3 de juin 1984

*Fabricant* / *Manufacturer* : BRUKER AXS GmbH, Oestliche Rheinbrueckenstrasse 49, 76187 Karlsruhe, Allemagne

*Fourni par* / *Delivered by* : BRUKER AXS GmbH, Oestliche Rheinbrueckenstrasse 49, 76187 Karlsruhe, Allemagne

*Demandeur du certificat:* / *Applicant* : BRUKER AXS GmbH, Oestliche Rheinbrueckenstrasse 49, 76187 Karlsruhe, Allemagne — BRUKER AXS S.A.S, 4 Allée H. Lorentz, 77420 Champs Sur Marne

Au vu des résultats et des remarques figurant dans le rapport d'essai n°2450423-13, l'article testé est déclaré conforme aux exigences du document de référence dans les limites du domaine défini dans le bulletin d'identification.
*On the basis of the results and remarks contained in the test report n°2450423-13, the item tested is in conformity with the requirements of the above referenced document inside the limits defined in the "identification bulletin".*

Osny, le 08 aout 2016

Yann Foucher, Responsable Technique

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ФЕДЕРАЛЬНОЕ АГЕНТСТВО
ПО ТЕХНИЧЕСКОМУ РЕГУЛИРОВАНИЮ И МЕТРОЛОГИИ

**СВИДЕТЕЛЬСТВО**
об утверждении типа средств измерений

**DE.C.31.541.A № 66277**

**Срок действия до 09 июня 2022 г.**

НАИМЕНОВАНИЕ ТИПА СРЕДСТВ ИЗМЕРЕНИЙ
**Спектрометры рентгенофлуоресцентные энергодисперсионные S2 PUMA**

ИЗГОТОВИТЕЛЬ
**Фирма "Bruker AXS GmbH", Германия**

РЕГИСТРАЦИОННЫЙ № **67730-17**

ДОКУМЕНТ НА ПОВЕРКУ
**МП-242-2067-2016**

ИНТЕРВАЛ МЕЖДУ ПОВЕРКАМИ **1 год**

Тип средств измерений утвержден приказом Федерального агентства по техническому регулированию и метрологии от **09 июня 2017 г. № 1302**

Описание типа средств измерений является обязательным приложением к настоящему свидетельству.

Заместитель Руководителя
Федерального агентства — С.С.Голубев

..... 2017 г.

Серия СИ — № 029670

- Fully radiation-protected system
- German Type Approval and Vollschutz according to BfS RöV
- NF C 74-100 Approval (France)
- GHOST Certificate (Russia)
- 30 kV option, to reduce regulatory efforts in certain countries:
  - Austria/Italy/France
  - Belgium/Luxembourg
  - Egypt/Taiwan

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# Examples for Quality Assurance (QA) & Quality Control (QC) in Feed & Agriculture

- Macro & Micro mineral nutrients, and trace level contaminant in feed and feed supplement / pre-mixes
- Raw Material ID, Production Monitoring, Quality Control
- Safety: Avoid toxic chemicals (e.g., Ni, Pb), foreign materials (e.g., metal, plastic)

- Dairy cows: Ensure the correct contents & ratio of Ca, P, Mg, Na, K, Cl, and S
  - Urine Analysis: Monitor the health of the cow → Use the speed of XRF to drive immediate actions at the farms
- Soils: Analyze nutrients and toxic elements from major (Al, Si) to minor (Na, Mg, K, P) to trace (As, Pb) levels
  - Use to results for actions like type selection and amount of fertilizer
- Fertilizer quality and production control
  - Precise analysis of active components (P, K, Mg, Zn) and toxic traces (As, Cd, U…)

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# How much preparation is needed for XRF?

Depends on the Application: raw material, pre-mix, forages, final feed,...

- 1. Loose powder or grains
  - Benefit: Fastest and easiest sample preparation
  - Challenges: Matrix sensitive, grain size effects, heterogeneities.
    → Grinding to improve homogeneity and reduce grain size effects
- 2. Pressed powder pellet
  - Benefit: Simple, quick and reproducible sample preparation
  - Challenges: Matrix sensitive
    → for high accuracy samples can be grouped
- 3. Fused glass bead
  - Benefit: Global calibration for many materials possible
  - Challenges: More sophisticated sample preparation

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# Quality control in grain and oil seed sector

## Sample pre-processing

- Pre-processing can be essential, especially grinding
- Homogeneity of solid samples is a key point for gaining best accuracy and repeatability
- Grinding takes few minutes and pays back especially for rapeseed, sunflower seed and corn.

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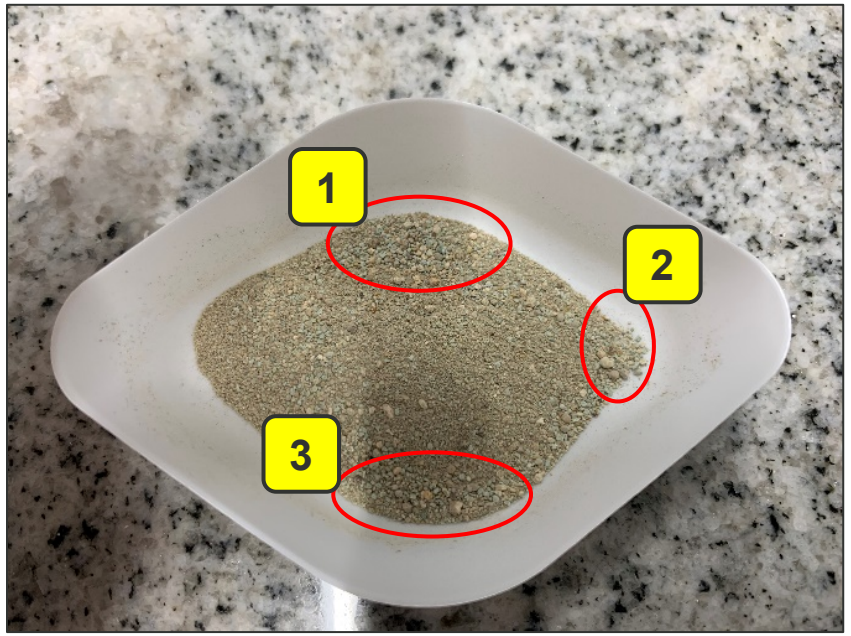
# The importance of grinding
# Example: Pre-mix heterogeneity



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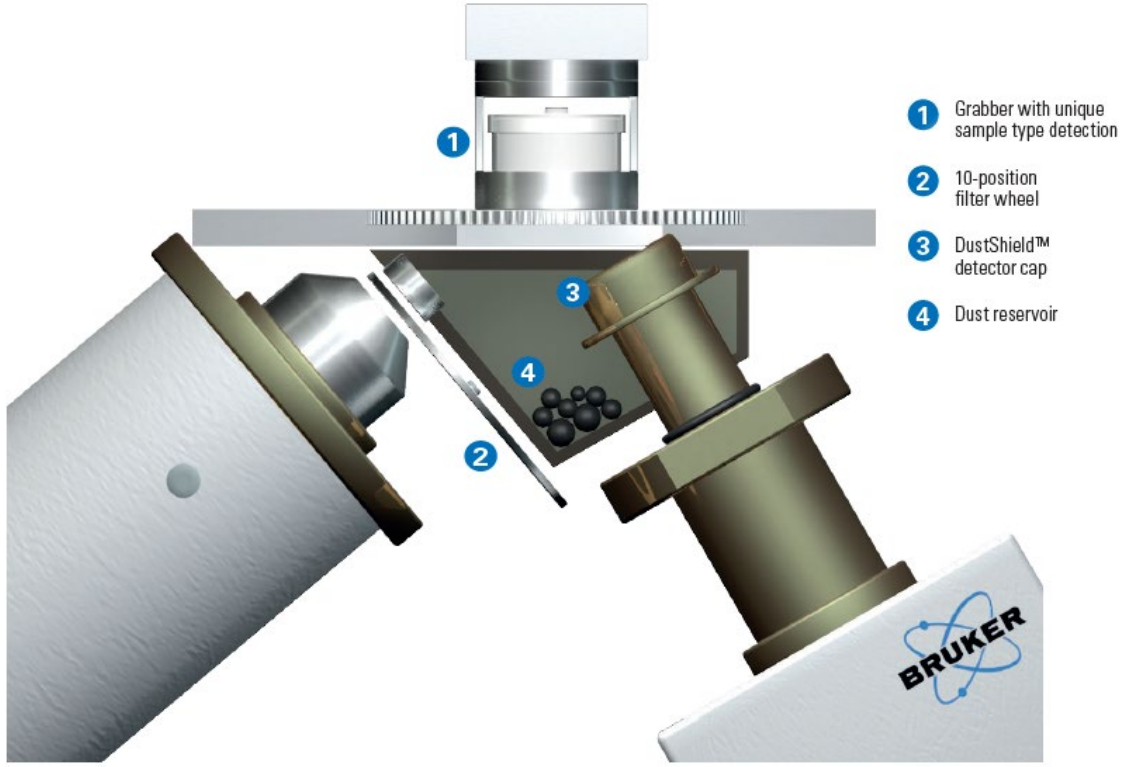
# Low Maintenance thanks to SampleCare™ S2 PUMA Series 2

## Worry-free operation, even for dusty feed samples

- SampleCare is a unique, multi-layer system, protecting vital spectrometer components
- XY Grabber with liquid cup recognition ensures He mode for liquids
- 10-position filter wheel protect the X-ray tube head
- DustShield detector cap avoids spillage of liquids and contamination with small sample particles on detector head
- Dust reservoir enable easy cleaning

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ELEMENTAL ANALYSIS IN THE ANIMAL FEED INDUSTRY

# Animal Feed Application Examples

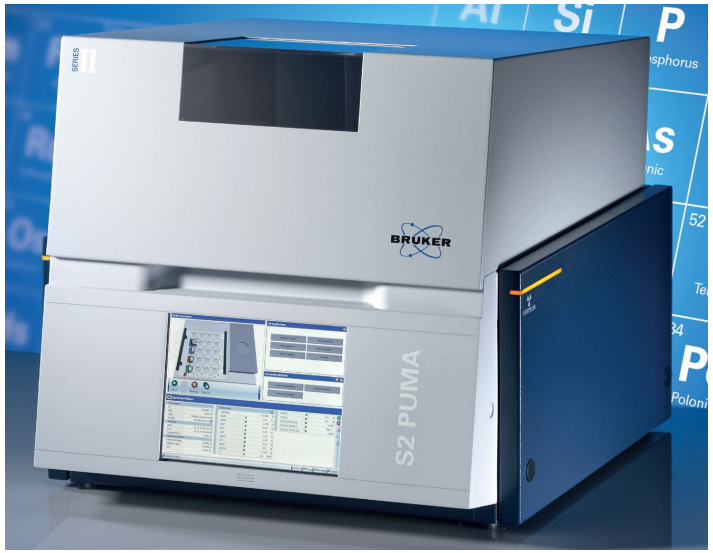
# Standardless analysis with EDXRF and WDXRF Great choice for Raw Material ID and Verification

SMART-QUANT  is set up to work in full Fundamental Parameter (FP) mode – this means no calibrations necessary!

Excellent for raw material testing and whenever special samples outside the analytical routing need to be measured.

- F to Am (FP) / Na to Am (WD)
- ppm to 100%
- Air, Helium, Vacuum
- 30 and 50 kV

SMART-QUANT: Push-button solution for quick and reliable analysis of unknown samples




S2 PUMA: High-performance EDXRF

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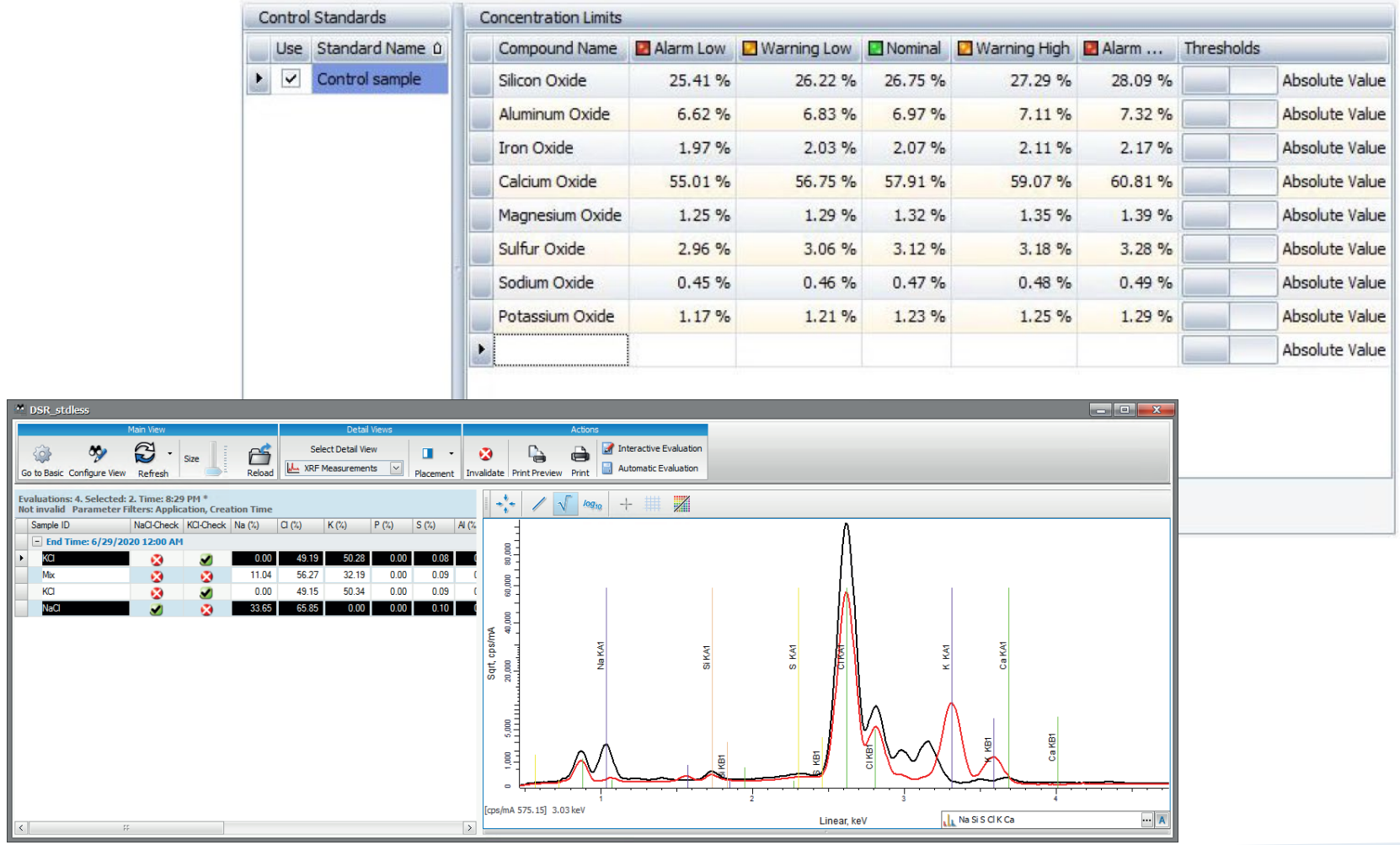
# Raw Material ID and Quantification Setting Control Limits

- Setup color-coded control limits for allow a quick decision during production, e.g.:
  - Nominal → all good
  - Warning → production can continue but a closer look or re-analysis may be needed
  - Alarm → immediate production stop

- **Example:** Cl / $Cl_2$ compliance for salt labeling requirements (NaCl, KCl or $CaCl_2$)

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# How to calibrate a XRF spectrometer Example: Pig feed

## Standard Material for calibration

- 3 BIPEA, 5 AAFCO standards with known composition
- Covering 12 key Macro- and Micronutrients
  - Na, Mg, Al, P, S, Cl, K, Ca, Mn, Fe, Cu, Zn

## Sample Preparation

- Ground to a fine powder
- Pressed to a pellet
- Run in one go on the XY Autochanger

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# Why pressed pellet preparation?

- Foil used for liquid/powder analysis mainly affects light elements
- A smooth surface is of particular importance for the measurement of light elements

Thickness of the sample from which 90% of the measured intensity is derived

| Element | Line | Energy (KeV) | Graphite | Glass | Iron | Lead |
|---|---|---|---|---|---|---|
| Cd | KA1 | 23.17 | 14.46 | 8.2 | 0.7 | 77.3 |
| Mo | KA1 | 17.48 | 6.06 | 3.6 | 0.31 | 36.7 |
| Cu | KA1 | 8.05 | 5.51 | 0.38 | 36.4 | 20 |
| Ni | KA1 | 7.48 | 4.39 | 0.31 | 29.8 | 16.6 |
| Fe | KA1 | 6.4 | 2.72 | 0.2 | 164 | 11.1 |
| Cr | KA1 | 5.41 | 1.62 | 0.12 | 104 | 7.23 |
| S | KA1 | 2.31 | 116 | 14.8 | 10.1 | 4.83 |
| Mg | KA1 | 1.25 | 20 | 7.08 | 1.92 | 1.13 |

- µm-range
- mm-range
- cm-range

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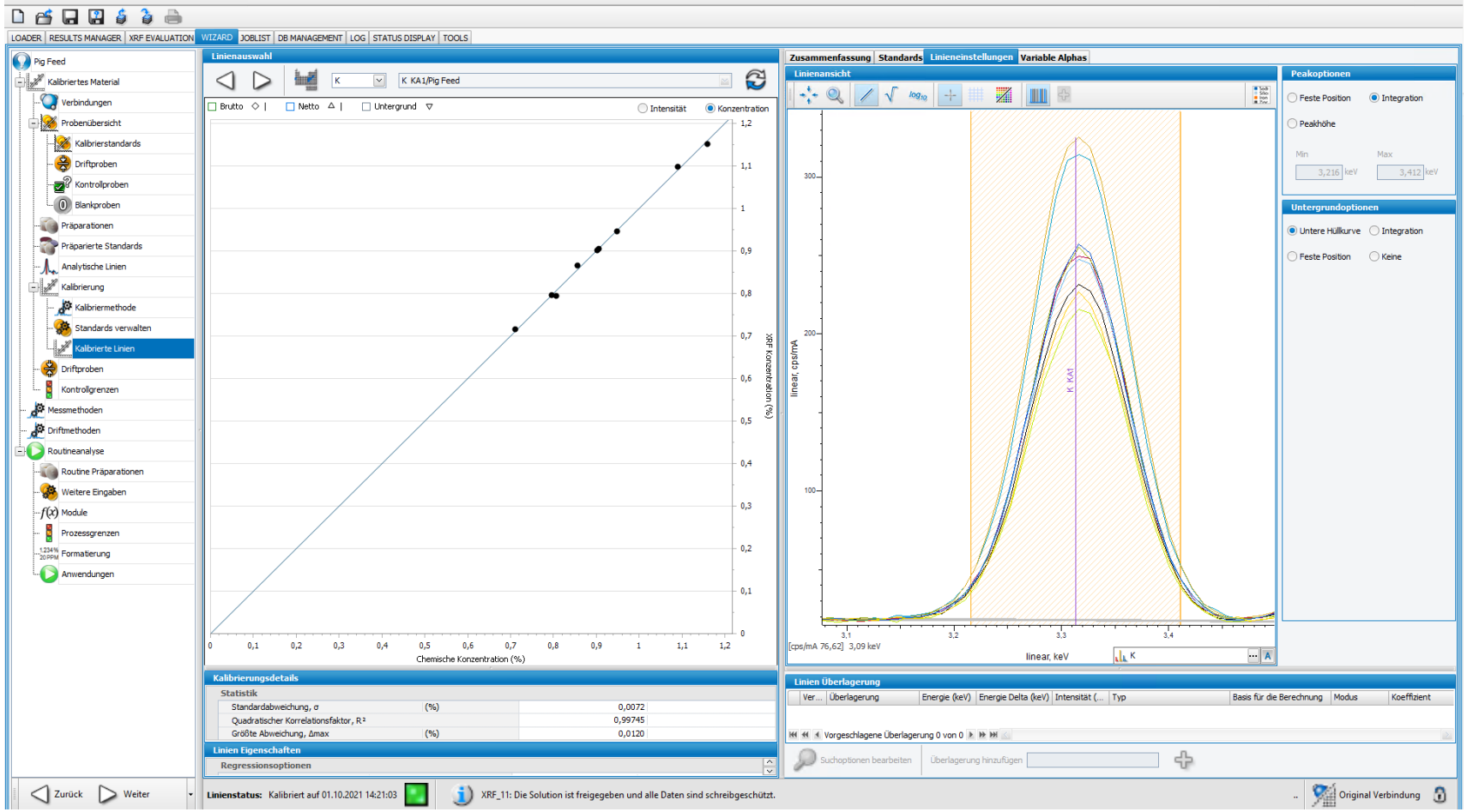
# How to calibrate a XRF spectrometer Example: Pig feed




## SPECTRA.ELEMENTS

- **WIZARD:** the proven tree-structure guide you through the calibration process
- Quick learning with intuitive User Interface. Hints provide help when needed

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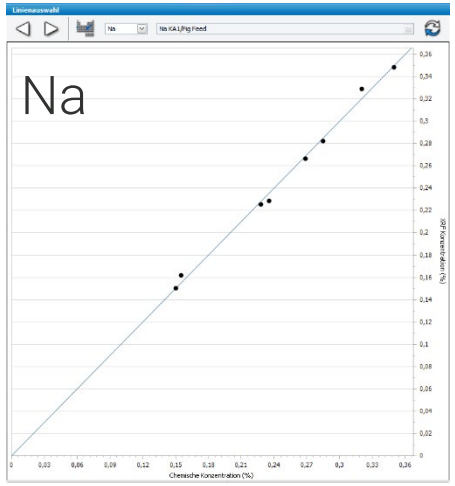
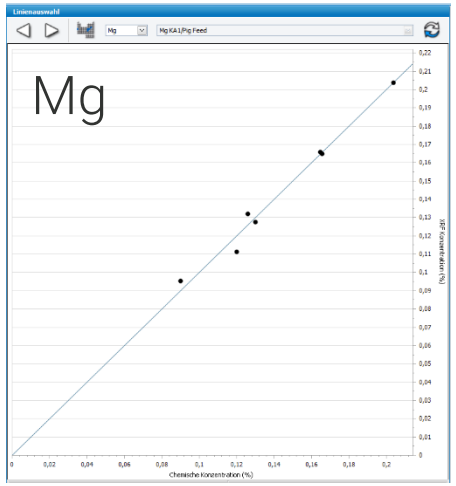
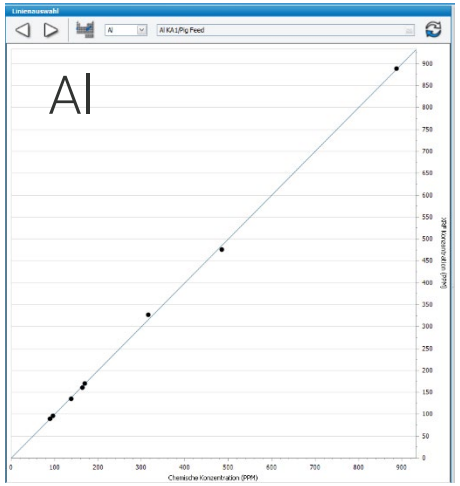
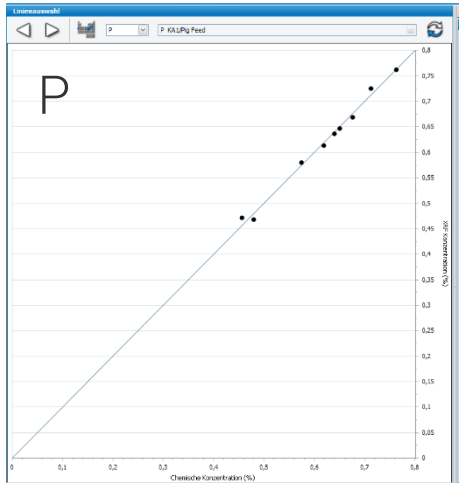
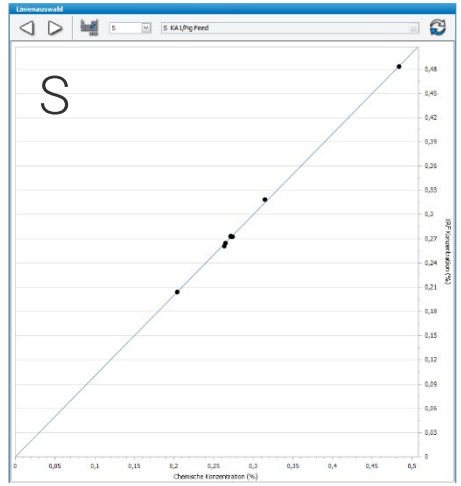
# How to calibrate a XRF spectrometer
# Example: Pig feed

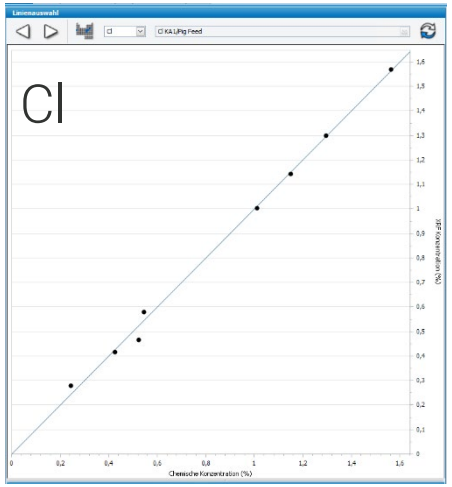


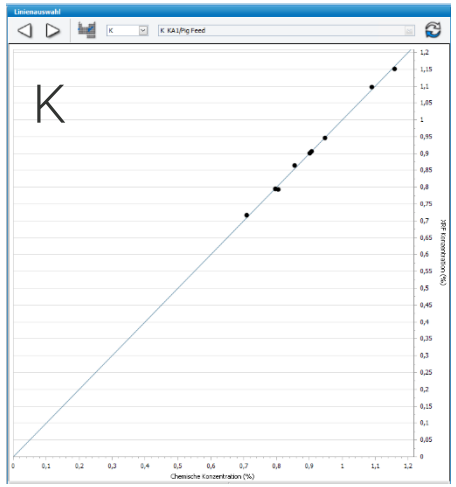



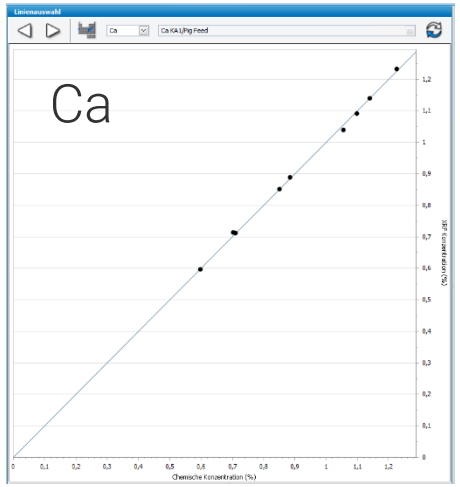



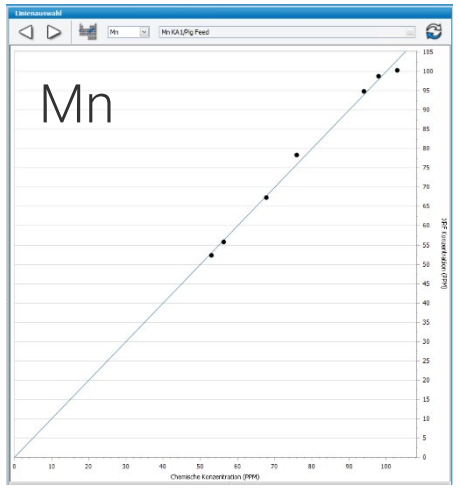



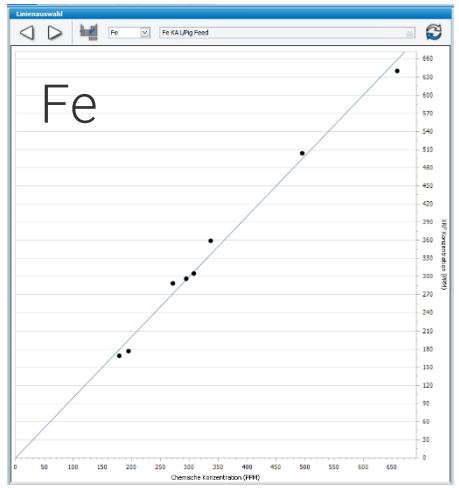

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# Quality control with XRF Example: Pig feed

## Repeatability test

- Measuring the same sample multiple times
- Loading/unloading the sample between the measurements
- Precision: 2-3% for light element, <1% for medium and heavier element

| Sample ID | Na (%) | Mg (%) | Al (PPM) | P (%) | S (%) | Cl (%) | K (%) | Ca (%) | Mn (PPM) | Fe (PPM) | Cu (PPM) | Zn (PPM) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rep-1 | 0.298 | 0.120 | 160.9 | 0.654 | 0.279 | 1.67 | 0.980 | 0.931 | 89.9 | 312.9 | 140.9 | 175.8 |
| Rep-2 | 0.302 | 0.119 | 160.7 | 0.654 | 0.280 | 1.66 | 0.978 | 0.930 | 88.8 | 312.4 | 141.2 | 176.4 |
| Rep-3 | 0.302 | 0.115 | 157.3 | 0.652 | 0.279 | 1.66 | 0.972 | 0.931 | 90.2 | 312.7 | 140.6 | 174.7 |
| Rep-4 | 0.297 | 0.116 | 165.0 | 0.650 | 0.278 | 1.64 | 0.972 | 0.912 | 89.7 | 312.3 | 139.8 | 174.5 |
| Rep-5 | 0.297 | 0.116 | 165.0 | 0.650 | 0.278 | 1.64 | 0.972 | 0.912 | 89.7 | 312.3 | 139.8 | 174.5 |
| Rep-6 | 0.283 | 0.115 | 166.8 | 0.647 | 0.277 | 1.63 | 0.959 | 0.923 | 88.3 | 309.6 | 139.1 | 173.7 |
| Rep-7 | 0.283 | 0.115 | 166.8 | 0.647 | 0.277 | 1.63 | 0.959 | 0.923 | 88.3 | 309.6 | 139.1 | 173.7 |
| Rep-8 | 0.283 | 0.115 | 166.8 | 0.647 | 0.277 | 1.63 | 0.959 | 0.923 | 88.3 | 309.6 | 139.1 | 173.7 |
| Average | 0.293 | 0.117 | 163.7 | 0.650 | 0.278 | 1.64 | 0.969 | 0.925 | 89.2 | 311.4 | 140.0 | 174.6 |
| Std.Dev. | 0.009 | 0.002 | 3.6 | 0.0031 | 0.001 | 0.01 | 0.009 | 0.005 | 0.8 | 1.5 | 0.9 | 1.0 |
| Rel.Std.Dev. | 3.0% | 1.7% | 2.2% | 0.5% | 0.3% | 0.9% | 0.9% | 0.5% | 0.9% | 0.5% | 0.6% | 0.6% |

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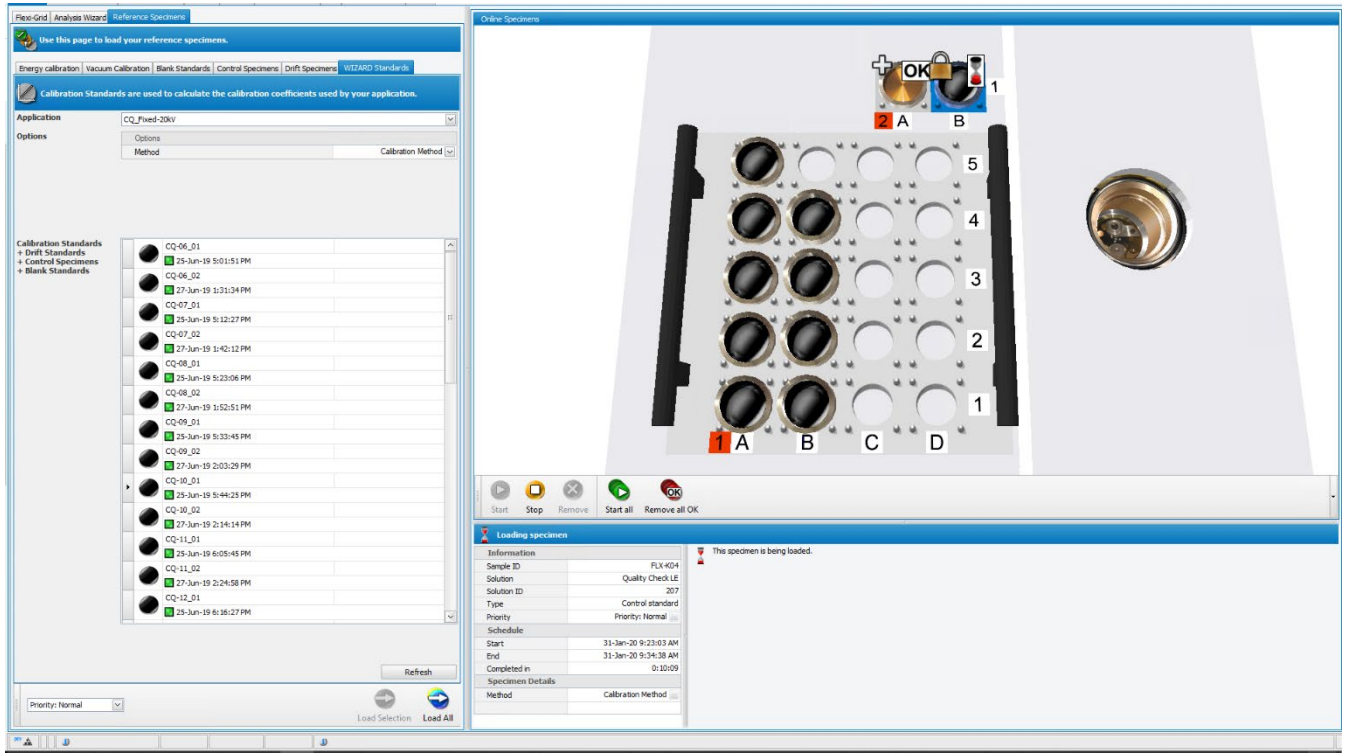
# Routine operation made easy
# Thanks to SPECTRA.ELEMENTS

## Faster. Smarter. Easier.

- **Intuitive:** Quick learning with new User Interface
- **Tab Structure** enables easy navigation. No floating windows.
- **LOADER:** Intuitive interface for routine operation
- **RESULT MANAGER:** Access all your data quickly and get extended reporting
- **LIMS compatible**: For automatic reporting




The LOADER: load / unload samples; adjust priorities; start / stop your measurements;  view your results.

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# Forage Analysis
# What are the challenges?

## Different matrices:

- Corn silage, grass silage, haylage, hay, small grain silage, total-mixed ratio (TMR).

## Many elements:

- Na, Mg, Si, P, S, Cl, K, Ca, Mn, Fe, Cu, Zn, …

## Wide concentration range:

- Low ppm to several wt%

## Minimal sample preparation:

- Drying & grinding (like for FT-NIR)
- Measure as loose powder in a cup

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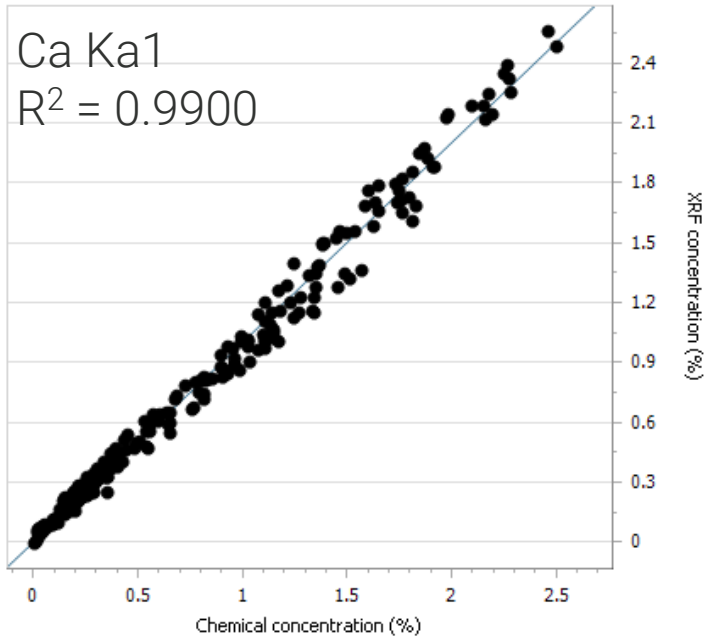
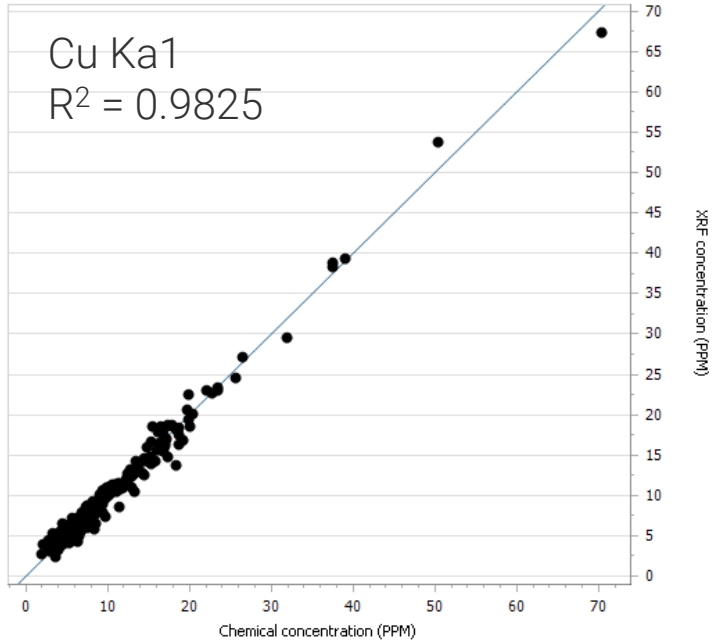
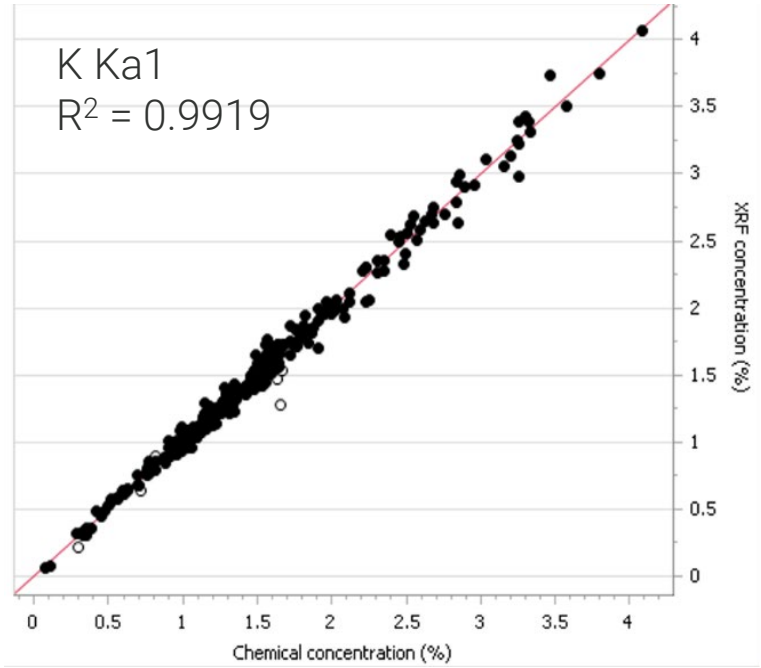
# Forage Analysis
# What are the challenges?

- 270 secondary reference materials were used for the calibration
- All 7 material types can be covered by a single applications
- Time-to-result: 7 min

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# Forage Analysis
# What are the challenges?

## Repeatability test

- Excellent precision except for Na (due to Prolene® thin film)
- Comparable precision: Well ground loose powder vs. pressed pellet without grinding
- Accuracy: Will always be better with dedicated, matrix-based calibrations

| TMR | Ca (%) | P (%) | Mg (%) | K (%) | S (%) | Na (%) | Cl (%) | Fe (PPM) | Zn (PPM) | Cu (PPM) | Mn (PPM) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rep-1 | 0.519 | 0.339 | 0.385 | 1.432 | 0.197 | 0.076 | 0.379 | 376 | 316 | 69 | 131 |
| Rep-2 | 0.513 | 0.340 | 0.384 | 1.429 | 0.197 | 0.081 | 0.378 | 373 | 315 | 69 | 129 |
| Rep-3 | 0.515 | 0.339 | 0.381 | 1.437 | 0.197 | 0.086 | 0.378 | 375 | 315 | 70 | 130 |
| Rep-4 | 0.521 | 0.338 | 0.387 | 1.431 | 0.197 | 0.093 | 0.378 | 374 | 315 | 69 | 129 |
| Rep-5 | 0.517 | 0.340 | 0.397 | 1.435 | 0.197 | 0.100 | 0.378 | 375 | 316 | 70 | 130 |
| … | … | … | … | … | … | … | … | … | … | … | … |
| Rep-20 | 0.510 | 0.340 | 0.386 | 1.427 | 0.197 | 0.094 | 0.379 | 373 | 316 | 69 | 128 |
| Average | 0.513 | 0.338 | 0.386 | 1.428 | 0.197 | 0.090 | 0.378 | 374 | 315 | 69 | 128 |
| Std.Dev. | 0.003 | 0.001 | 0.005 | 0.007 | <0.001 | 0.011 | 0.001 | 1.4 | 1.0 | 0.3 | 1.5 |
| Rel.Std.Dev. | 0.6% | 0.3% | 1.2% | 0.5% | 0.2% | 12.2% | 0.2% | 0.4% | 0.3% | 0.5% | 1.1% |

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“EDXRF (energy dispersive X-ray fluorescence) is a newer technology that has evolved to be a cost-effective solution for the rapid determination of mineral content in various forage and feed materials. Where NIR is a rapid method for organic constituents, it is not valid for mineral determination. EDXRF is a complementary technology that allows for rapid (4 to 8 min) determination of multiple minerals (+10) relevant to animal nutrition. It can be run on the same ground material used for NIR determinations.”

Ralph Ward, CEO, Cumberland Valley Analytical Services (CVAS), *LinkedIn*

CVAS uses the S2 PUMA in several countries across the globe.

# Quality Control of Maize Kernel

- Use of Maize / Corn: Animal feed (corn silage), biofuels, food (vegetable, flour, … ), starch, …
- Analytical questions:
  - Macro and micro mineral contents and ratios (e.g., for dedicated animal feed diet)
  - Contaminant & safety (e.g., heavy metals)
  - Contents of P, Cl, and S (biofuel production)

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# Analyzing Maize Seedlings to investigate the effect of Fertilization S2 PUMA Series 2

## Research & Development Application

- Understand the effect of fertilization on the growth rate & resistance of different maize types
- Understand the nutritional uptake of based on the timing, amount and type of fertilizer
- GOAL (1): Optimize fertilization process
- GOAL (2): Determine/develop the optimal seeds

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# Analyzing Maize Seedlings to investigate the effect of Fertilization S2 PUMA Series 2

## Exemplary Calibration

- Maize seedlings: Calibration with 10 secondary reference materials (measured by ICP)
- Covering 9 elements with concentrations ranging from few ppm up to ~ 4 wt% (Mg, P, S, Cl, K, Ca, Mg, Fe, Zn)
- Preparation options:
  - Loose powder: coarse or ground?
  - Pressed pellet: with or without wax?
- **Best performance:** Pressed pellet with ground material (no wax needed)
- **Time-to-result optimized:** Pressed pellet with ground powder and wax

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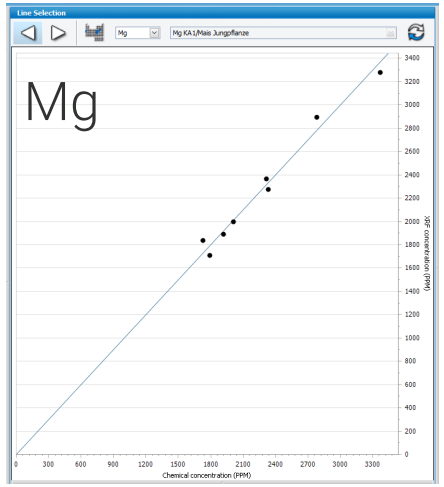
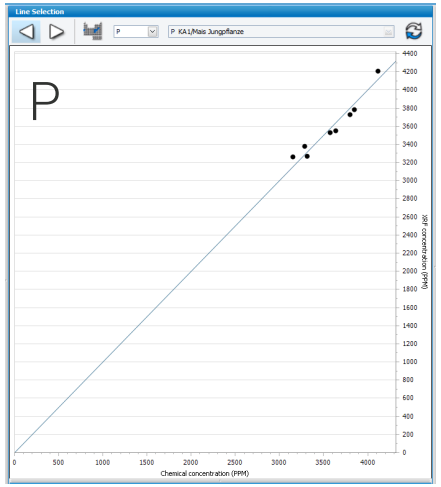
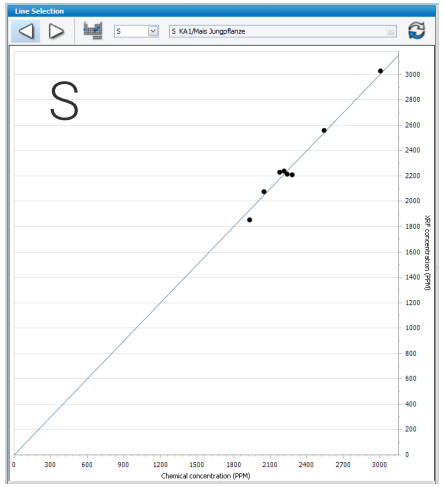
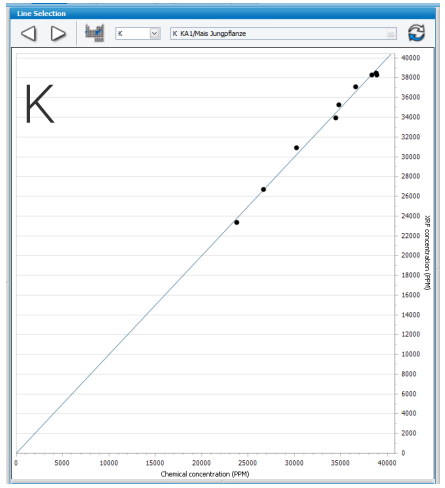
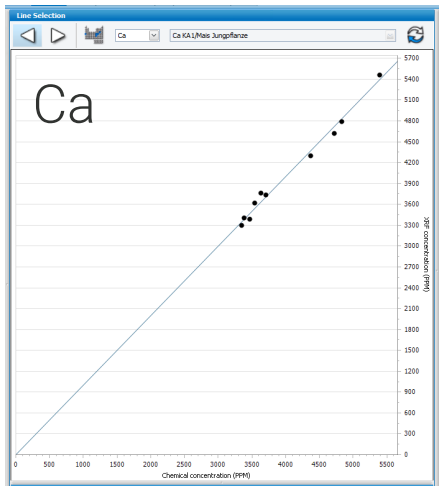
# Analyzing Maize Seedlings to investigate the effect of Fertilization S2 PUMA Series 2

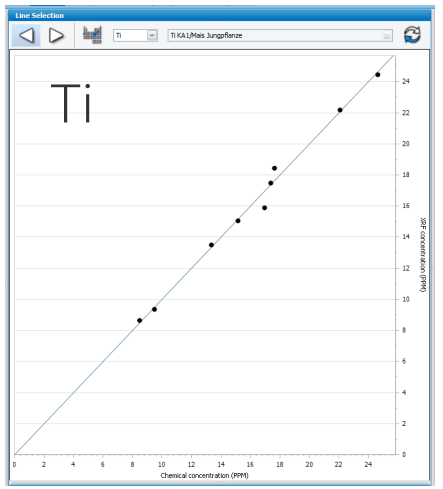


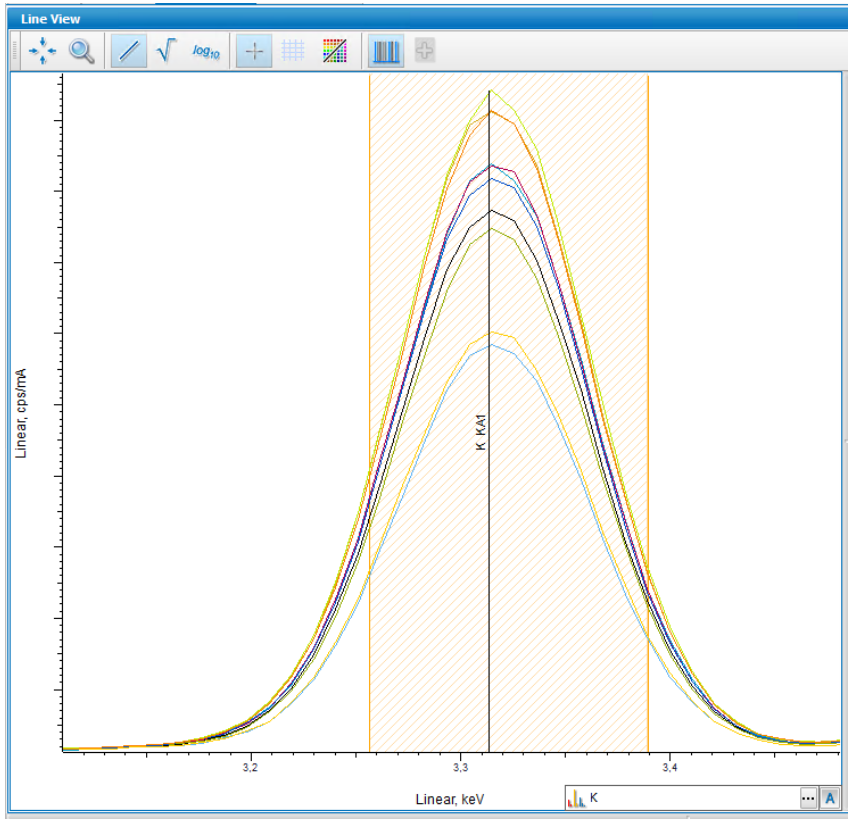




- Exemplary calibration curves
- Peak for K (KA1)

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# Analyzing Maize Seedlings to investigate the effect of Fertilization S2 PUMA Series 2

- Excellent precision macro and micro minerals.

| | Mg (PPM) | P (PPM) | S (PPM) | K (%) | Ca (PPM) | Ti (PPM) | Mn (PPM) | Fe (PPM) | Zn (PPM) |
|---|---|---|---|---|---|---|---|---|---|
| Rep-1 | 1767 | 3809 | 2379 | 3.91 | 3366 | 10.6 | 26.8 | 329 | 27.7 |
| Rep-2 | 1749 | 3802 | 2372 | 3.90 | 3369 | 10.5 | 26.7 | 328 | 27.7 |
| Rep-3 | 1733 | 3798 | 2377 | 3.91 | 3384 | 10.5 | 26.2 | 327 | 27.7 |
| Rep-4 | 1769 | 3791 | 2372 | 3.89 | 3388 | 10.5 | 27.0 | 328 | 27.9 |
| Rep-5 | 1759 | 3795 | 2374 | 3.90 | 3380 | 10.5 | 25.9 | 327 | 27.4 |
| Rep-6 | 1760 | 3798 | 2376 | 3.90 | 3357 | 10.5 | 26.8 | 328 | 27.4 |
| Rep-7 | 1758 | 3789 | 2364 | 3.89 | 3392 | 10.5 | 26.8 | 328 | 27.4 |
| Rep-8 | 1762 | 3792 | 2367 | 3.88 | 3392 | 10.6 | 26.3 | 329 | 27.5 |
| Rep-9 | 1748 | 3787 | 2365 | 3.88 | 3369 | 10.5 | 27.0 | 327 | 27.8 |
| Rep-10 | 1766 | 3778 | 2366 | 3.88 | 3391 | 10.4 | 26.8 | 325 | 27.4 |
| **Average** | **1757** | **3794** | **2371** | **3.89** | **3379** | **10.5** | **26.6** | **328** | **27.6** |
| **Std.Dev.** | **11** | **9** | **5** | **0.01** | **13** | **0.1** | **0.4** | **1** | **0.2** |
| **Rel.Std.Dev.** | **0.6%** | **0.2%** | **0.2%** | **0.3%** | **0.4%** | **0.5%** | **1.4%** | **0.4%** | **0.7%** |

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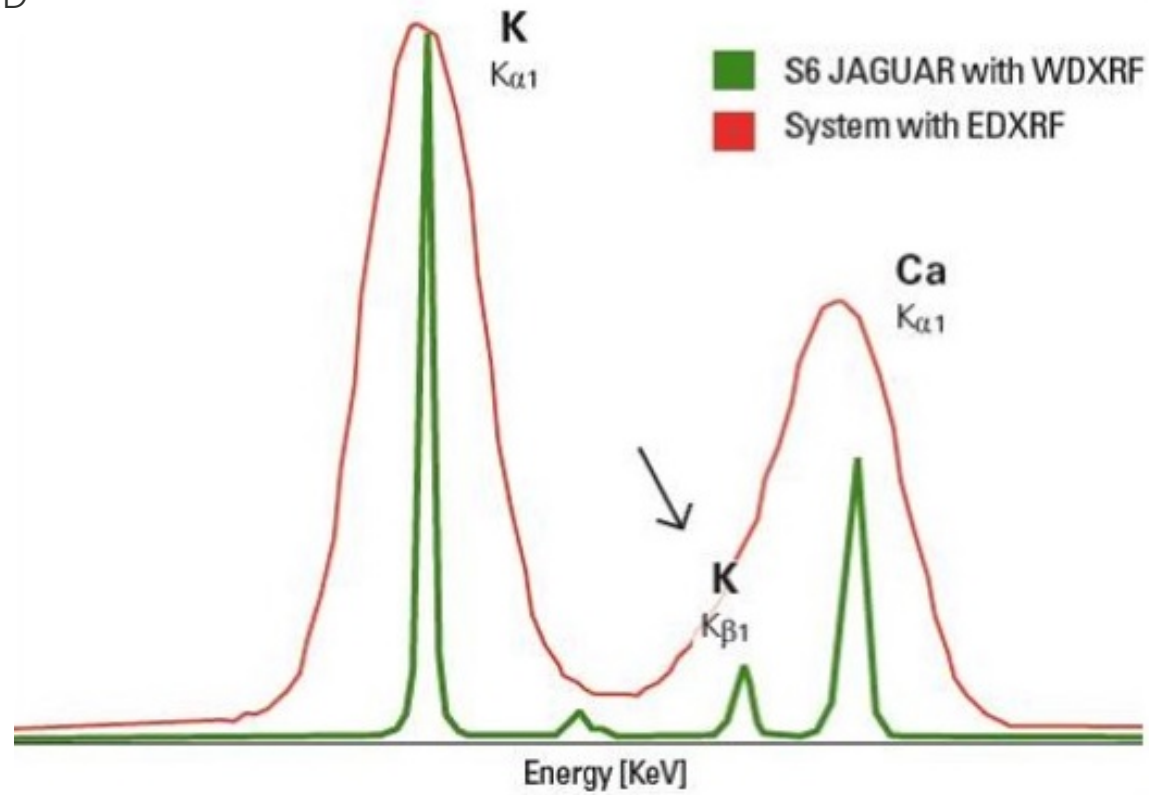
# Enhance the Performance for Light and Trace Elements
# S6 JAGUAR: Benchtop WDXRF

- The S6 JAGUAR with WDXRF HighSense Goniometer excels ED based systems in energy resolution and analytical precision

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“The XRF is mostly used to analyse TMR, forages, milk and urine, and allows us to gather accurate information about the concentrations of the minerals measured by the instrument. This is a very useful insight as it means we can not only determine what the cow needs for her own health and wellbeing, but also what minerals she will need to produce better quality milk.”

Dr. Rita Fornaciari, Nutristar
(*New Food Magazin*)

S6 JAGUAR enables high performance also for low concentrations of light elements in urine samples

# Enhance the Performance for Light and Trace Elements HighSense™ Goniometer: Impressive versatility

- 400 W excitation
  - 20 – 50 kV
  - 1 – 17 mA
  - Optimal settings for every single element at full power
- 5 position beam filter (optional) for improved peak-to-background ratio
- 4 sample masks (optional for different sample sizes)
- Vacuum seal for low-cost-of-operation
- Up to 4 analyzer crystals for the entire element range and specific demands
- Flow counter and HighSense XE detector for 2 Mcps count-rates for high calibration ranges

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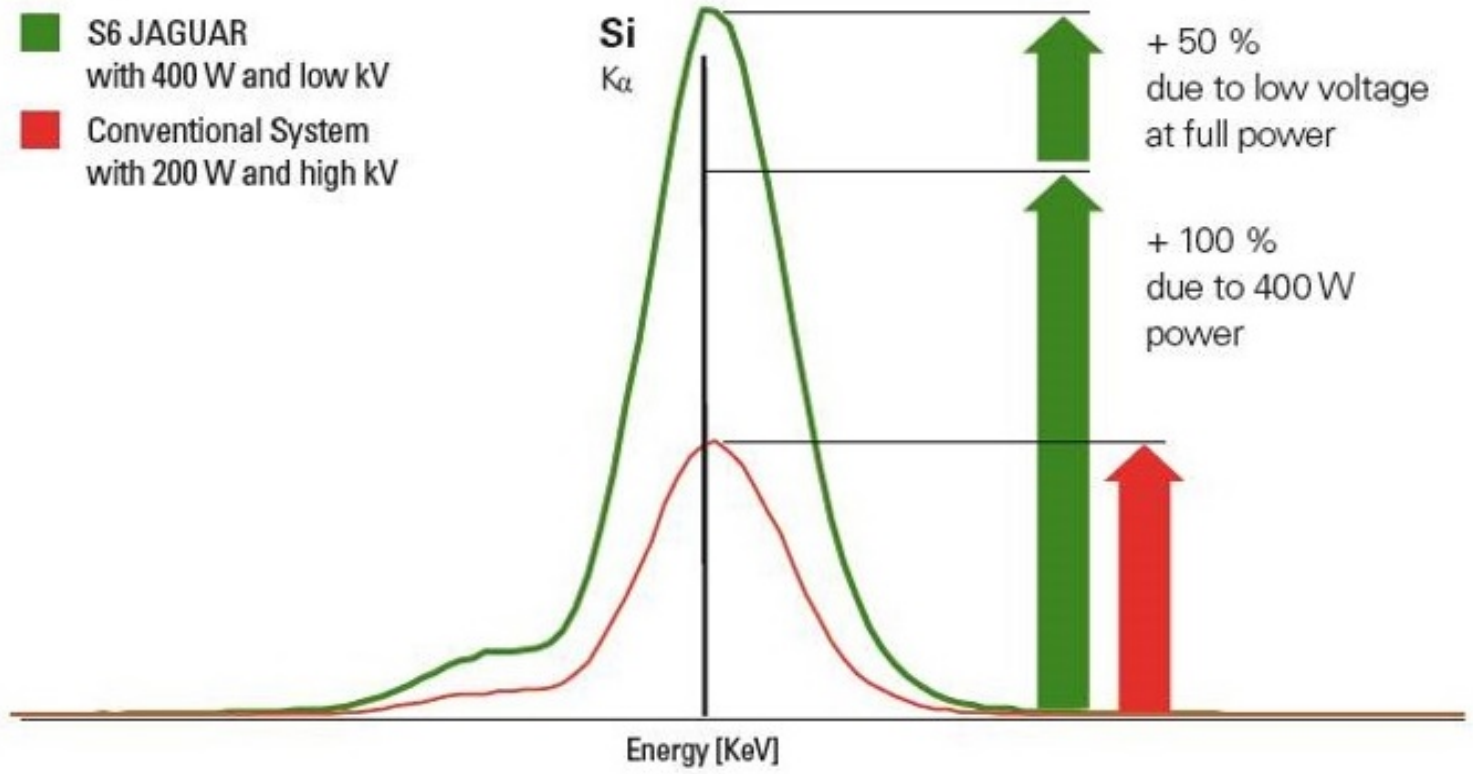
# Enhance the Performance for Light and Trace Elements HighSense™: Full 400 W excitation power

## S6 JAGUAR analyzes light elements with optimal low voltage and full 400 W power settings!

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“This machine can carry up to 20 samples and takes approximately 10 minutes (per sample) to turn around solid sample results, and seven minutes for liquid samples. We achieve an excellent precision and accuracy with lower costs and in a shorter time than ICP.”

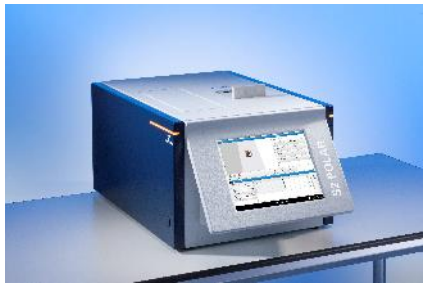
Simone Blotta, Lab Technician, Nutristar (*New Food Magazin*)

S6 JAGUAR with XY Autochanger enables the required sample throughput

ELEMENTAL ANALYSIS IN THE FEED INDUSTRY

# Summary

# XRF: An excellent technique for rapid and reliable quantification of macro and micro mineral nutrients in animal feed and more!



- XRF is used for a wide range of applications in the food industry:
  - Macro and micro nutrition,  toxic traces, foreign particles, raw material ID, quality control, process control, and more
- Key benefits of XRF: Wide range of elements and concentrations, simple sample preparation, ease-of-use, low operation costs, high accuracy & precision, high throughput.
- Bruker offers a full portfolio of laboratory equipment for food and feed applications:
  - S2 PUMA Series 2 is the ideal choice for many food and feed applications – including milk powder, forage/feed premix, etc.
  - S6 JAGUAR for enhanced performance for low contents of light elements
  - S2 POLAR is used for traces in liquids/oils (e.g., P, Cl, S)

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# FT-NIR & XRF: Perfect Team-Work for Feed Applications
# Combine speed with performance

## FT-NIR for Organics

**Composition analysis of ingredients and finished feeds**
- Moisture, Fat, Protein, Fiber, Ash, NDF, ADF, and other parameters

**Conformity testing**
- Check for product conformity and uniformity
- Screening of organic contaminants

**Material ID for ingredients and premixes**
- Identification of pure materials
- Verification of components in solid, semi-solid and liquid ingredients

Grinding

NIR & XRF: Powder Analysis

## XRF for Inorganics

**Mineral nutrients composition**
- Ingredients, premixes, and finished formulations, e.g. Na, Ca and P in feed, ash content

**Premixes and additives**
- Material ID
- Fe, Zn, and Co analysis

**Contaminants**
- Toxic metals taken up by plant in local soils e.g., As, Cd, and Pb
- Detection of fraud

**Foreign Body Analysis**
- Analyzing foreign materials in production

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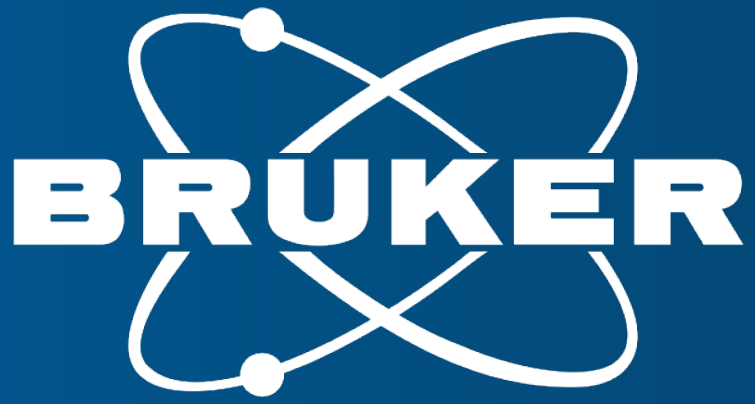
# Any Questions?

# Thank you!

Kai Behrens, Frank Portala, & Adrian Fiege




Innovation with Integrity