LYNCIS

Online Elemental Analyzers

Real-time Decision Making in Mineral Processing

Based on Laser Online Elemental Analysis

About Company

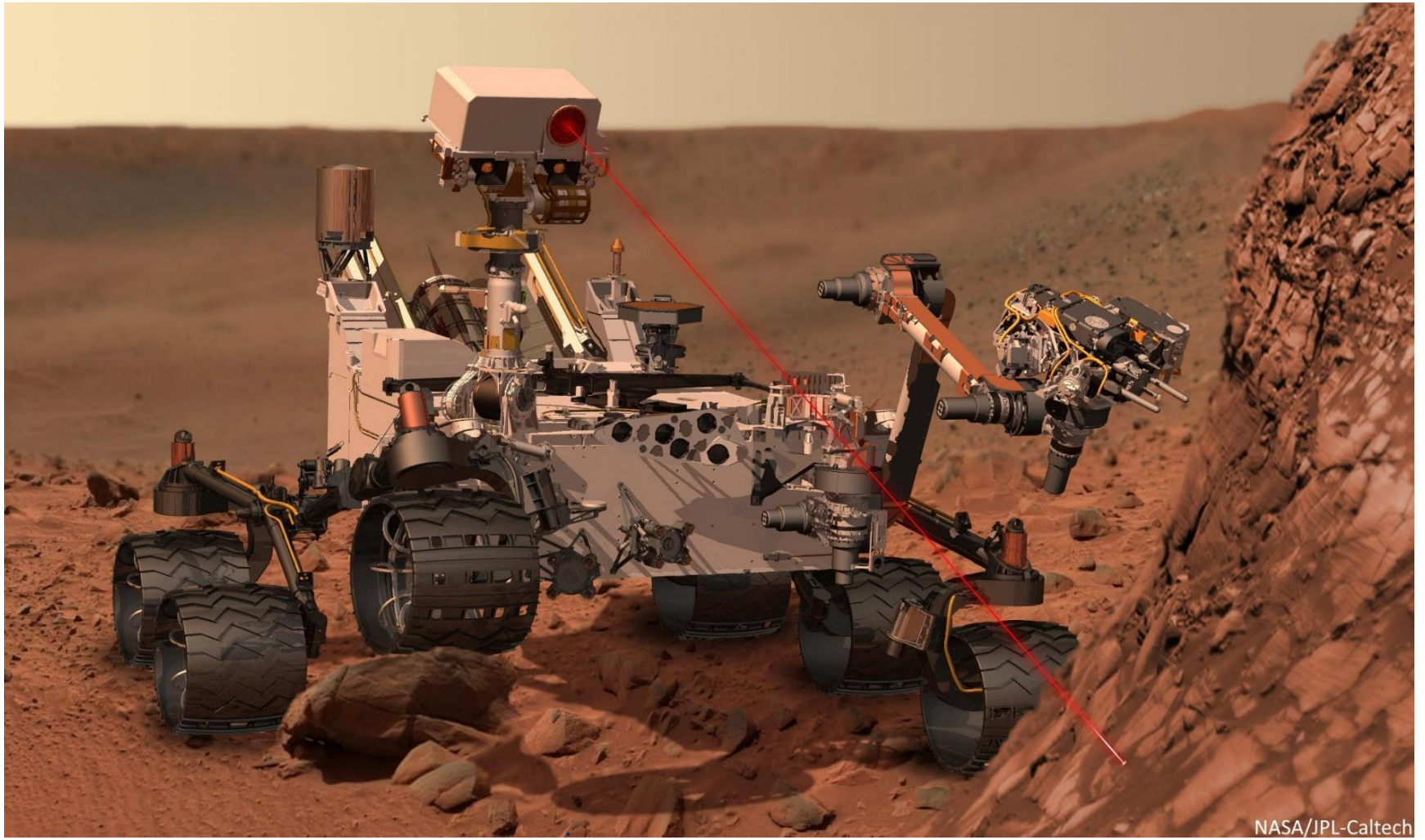
- **LYNCIS** is a laser measurements technology company based in Lithuania – one of the biggest European centres of laser and spectral technologies.
- **Expertise** – material sampling, laser spectroscopy, chemometrics and machine learning
- Strong technical team including PhD specialists in technologies, physics and mathematics
- Member of **Lithuanian Laser Association**

Quantum Electronics Department & Laser Research Center
Semiconductor Physics Department
Institute of Applied Research

FIZINIŲ IR TECHNOLOGIJOS MOKSLŲ CENTRAS
Department of Laser Technologies
Department of Molecular Compound Physics
Department of Optoelectronics

femtika · HOLTIDA · integrated optics · LIDARIS · LIGHT CONVERSION · LYNCIS · OPTOGAMA · optonas · Altechna · Altechna Coatings · BROLIS SEMICONDUCTORS · DMC · Optronika · Quantum Light Instruments · Spranao · standa · EKSMA · EKSMA OPTICS · EKSPLA · elas · TERAVIL · WOP Workshop of Photonics

LIBS - Technology used for Mars rock chemical analysis by NASA



This artists concept depicts the rover Curiosity as it uses its Chemistry and Camera (ChemCam) instrument to investigate the composition of a rock surface.

LIBS capabilities bring advanced process opportunities to the mining and mineral processing industry!

Raw Material Online Chemical Analysis

Real-time chemical analysis of material streams with no sample preparation. Simultaneous measurement directly above conveyor or liquid flow. Materials:

- Raw ore
- Dry mix
- Slurry/Brine
- And more ….

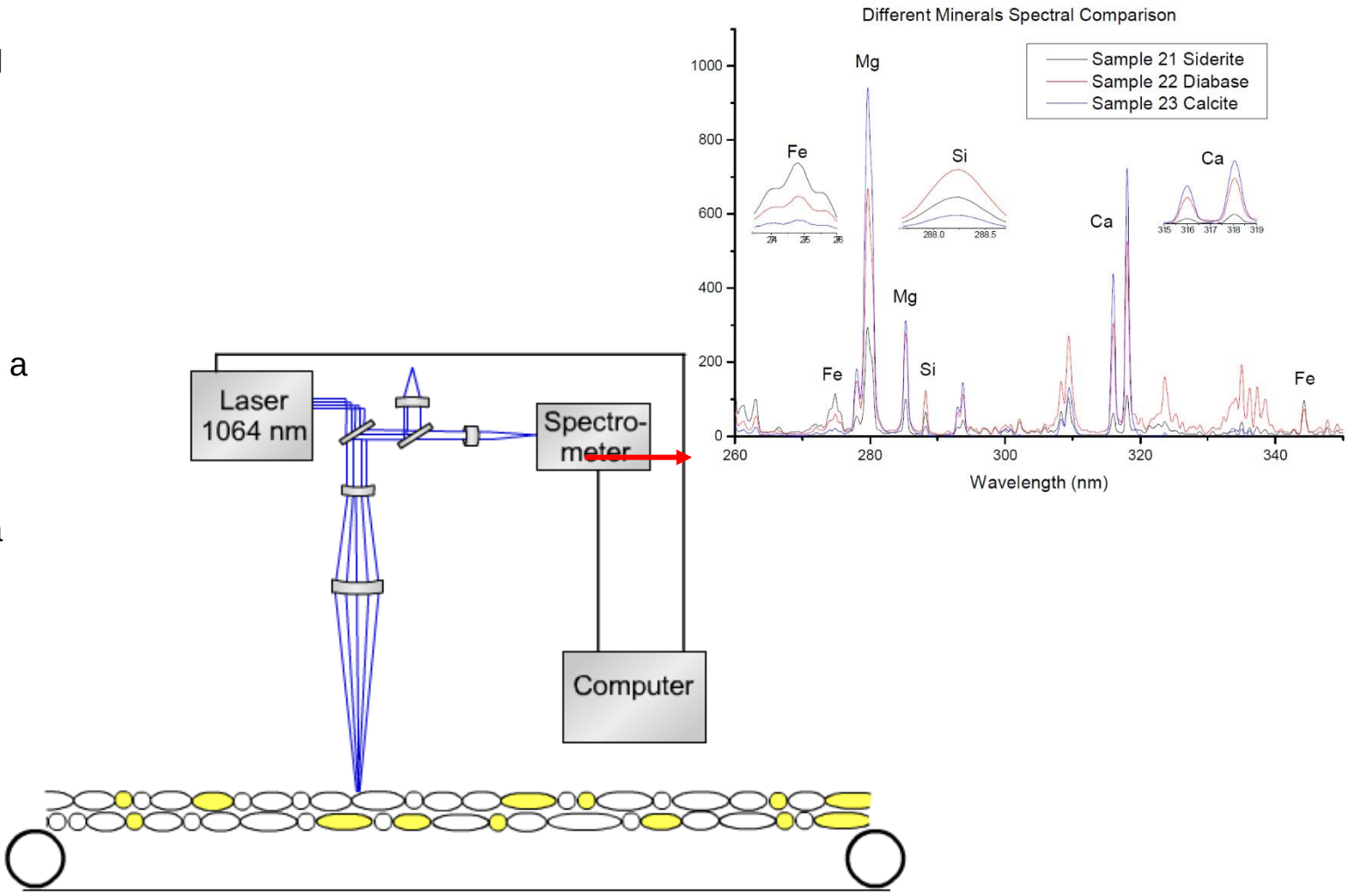
Online analysis above Conveyor belt

Online analysis of slurry/brine

Working Principles

Operation Principles:

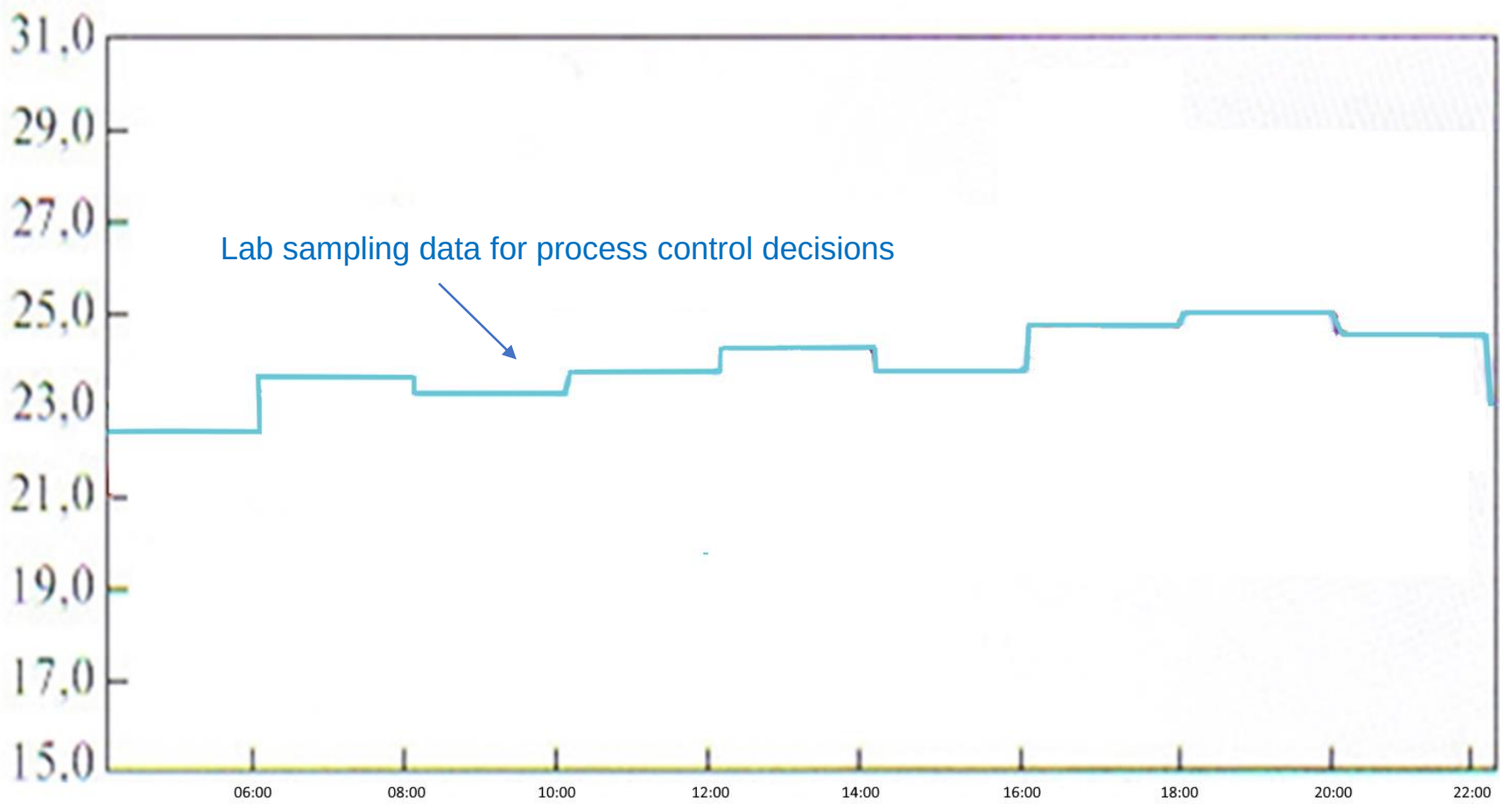
1. Pulsed laser beam is focused on the material
2. Solid/liquid material transforms to plasma around the focus point
3. When cooling, the plasma emits light
4. Spectrometer collects this light and produces a wavelength-based spectrum
5. Chemical analysis of all elements and minerals is calculated based on spectral data
6. The process is repeated thousands of times per minute to providing a representative measurement of bulk flow



Why Online?

Conventional samplers and lab analysis might not tell you the true story of chemical composition variations in raw ore flow.

And if it does, the results come when it’s often too late to change anything….

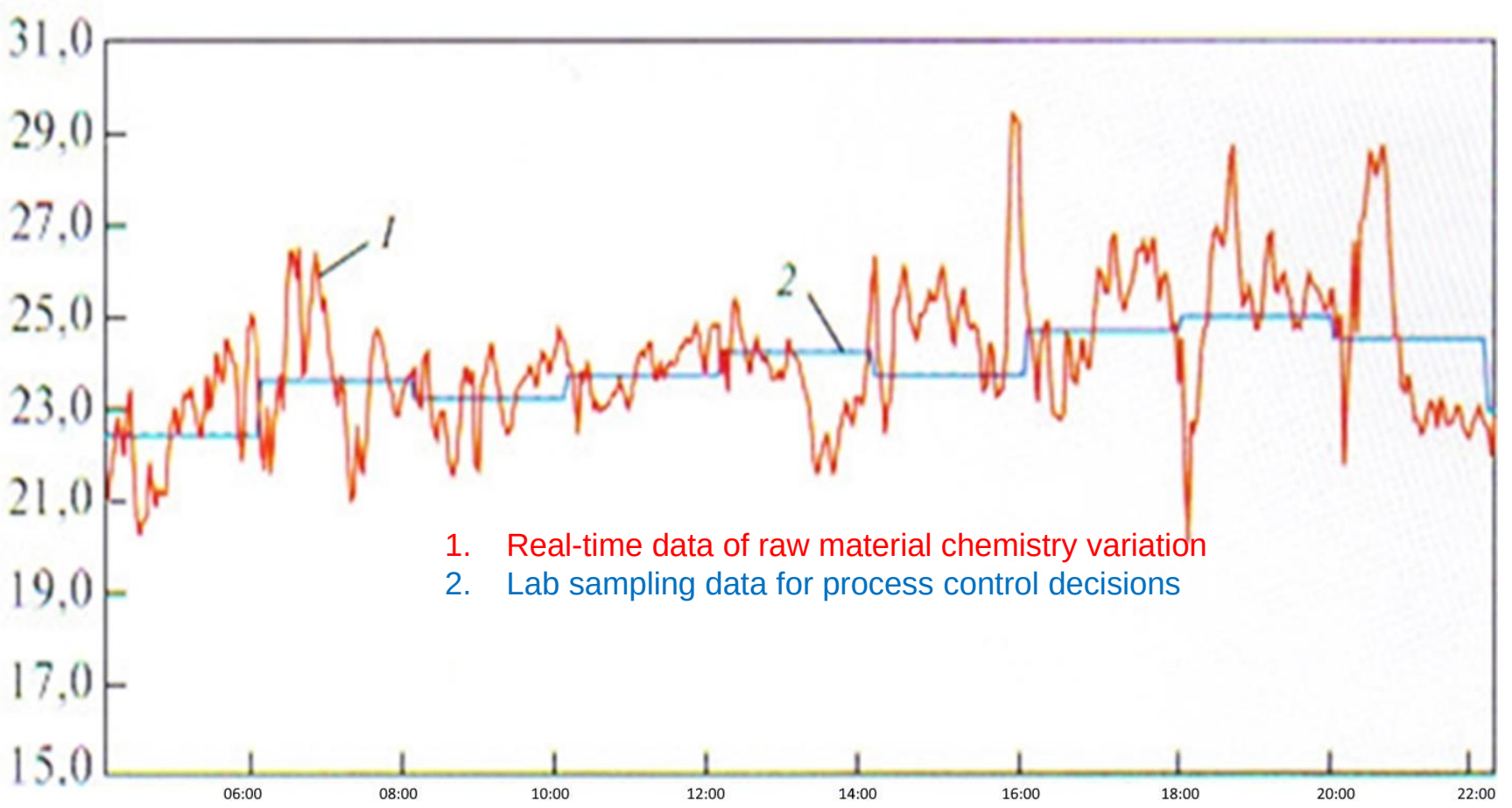


Why Online?

"If you cannot measure it, you cannot control it"
Lord Kelvin

The true variation might be not as you expected (red curve).

If you can control production parameters in real-time - you can create additional value from your raw ore.



Why Online?

Economic benefits from real-time information about product chemistry

Optimal raw mix preparation

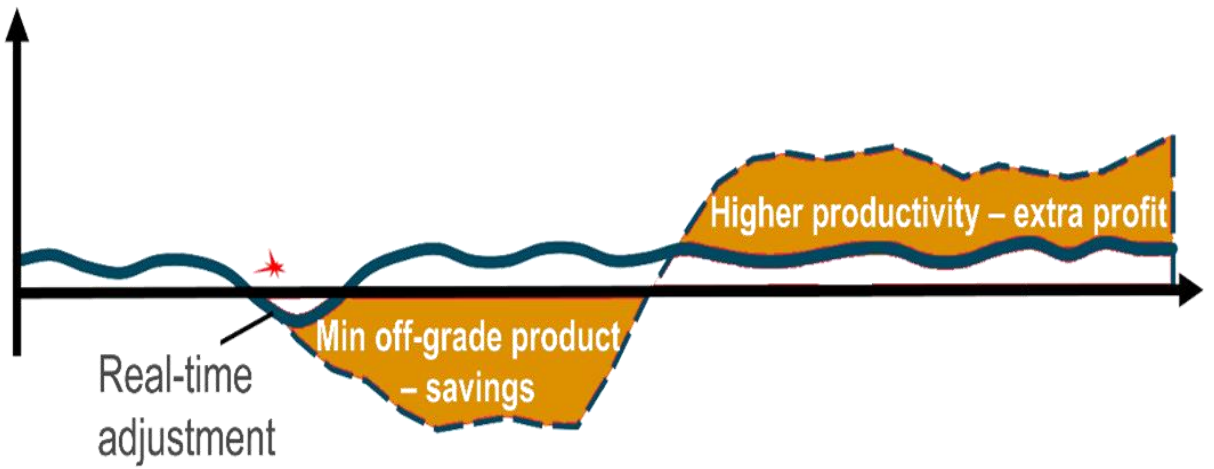
- Raw material supply without impurities and low grades
- Optimal blending and dosage of additives/reagents
- Stable raw mix chemistry

Optimal technological process

- Stable burning / smelting / flotation
- Stable product/ contaminations ratio
- Savings in fuel, energy and reagent consumption

Stable final product quality

- Increased production volume due to reduced positive tolerance
- Higher profits for higher grade products
- Reduced processing cost for off-grade ores
- Eliminated off-grade product penalties

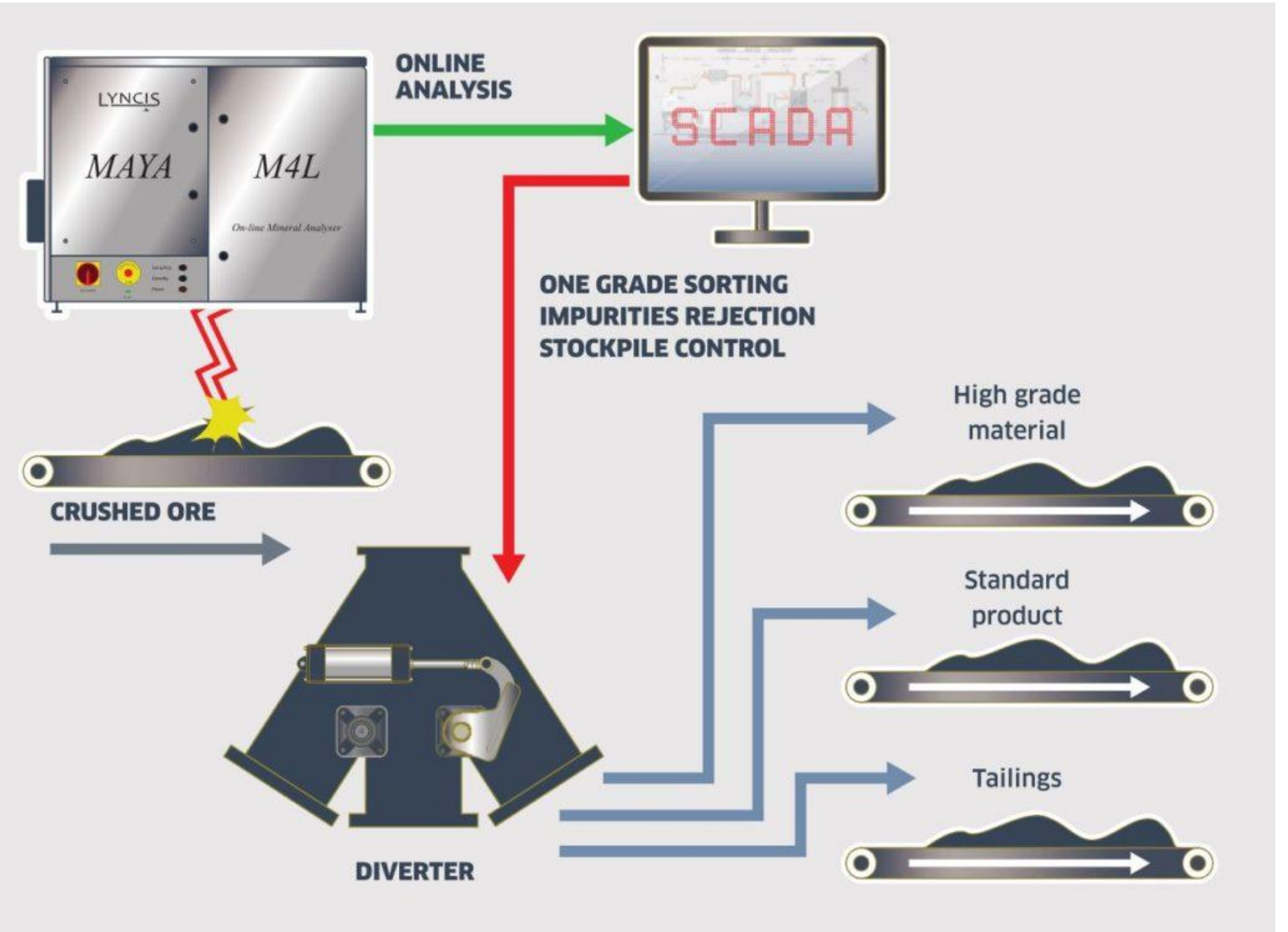


Applications

Effective Ore Sorting or Impurities Rejection

Scenarios:

- A processing plant discards waste rock at the mining stage. The plant reduces the consumption of reagents and energy, CO2 emission drops from the calcination process. Less ore needs to be transported and the tailings management becomes easier.
- A mining company forms stockpiles based on the concentration of valuable minerals. The company sells higher grade ore at a higher price. Additional revenue is generated.
- Greenfield projects can benefit from smaller mill size requirements.



Case Study – Impurities Rejection

Deposit Rock

Refractories Industry - Magnesite Ore Mining

At the mine

Ore on a conveyor after crusher

Case Study – Impurities Rejection

Grain size – max 300 mm.

Conveyor speed – 1.5 m/s

Rate – 600 t/hr.

Ore Online Elemental Analyzer above a conveyor

Case Study – Impurities Rejection

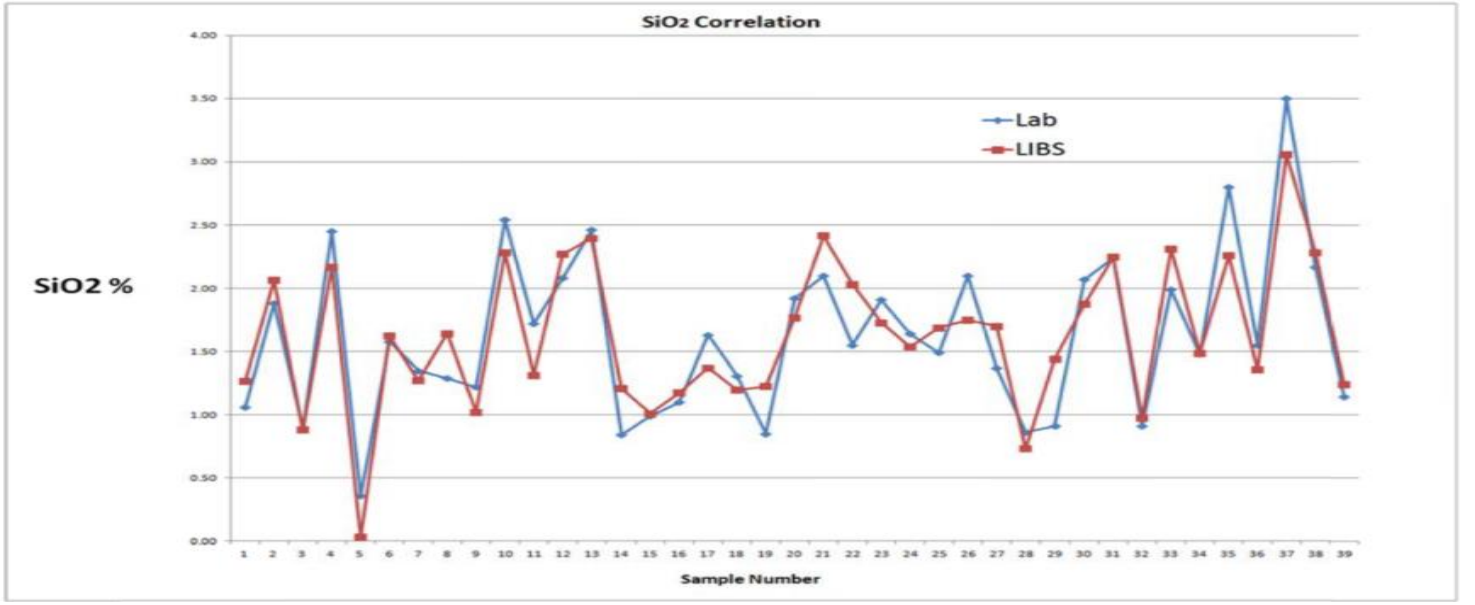
A gravity diverter was installed 90 m from the analyzer

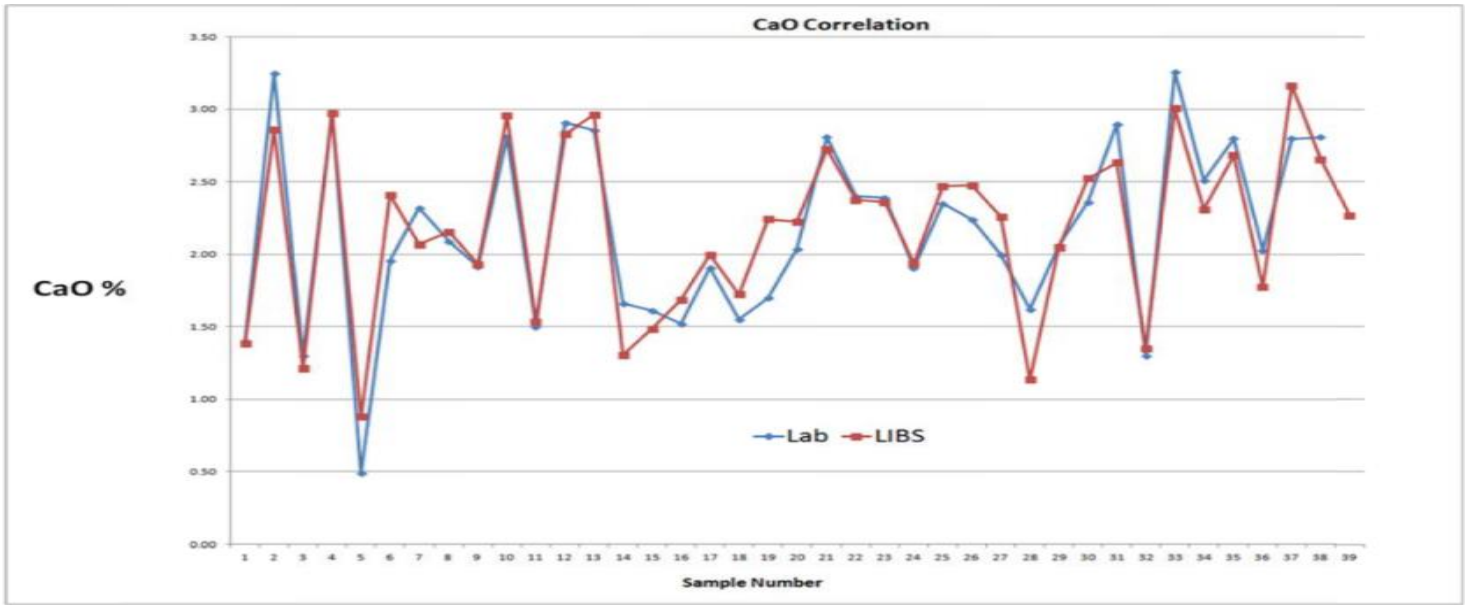
Automatic diversion control was implemented based on real-time chemical composition data from the analyzer

When SiO_2 content in 60-second batch exceeds a threshold level, the batch is diverted to the waste pile

Plant Lab and LIBS Online comparison

Online analysis measurement performance was assessed comparing the results with the plant lab sampling analysis.

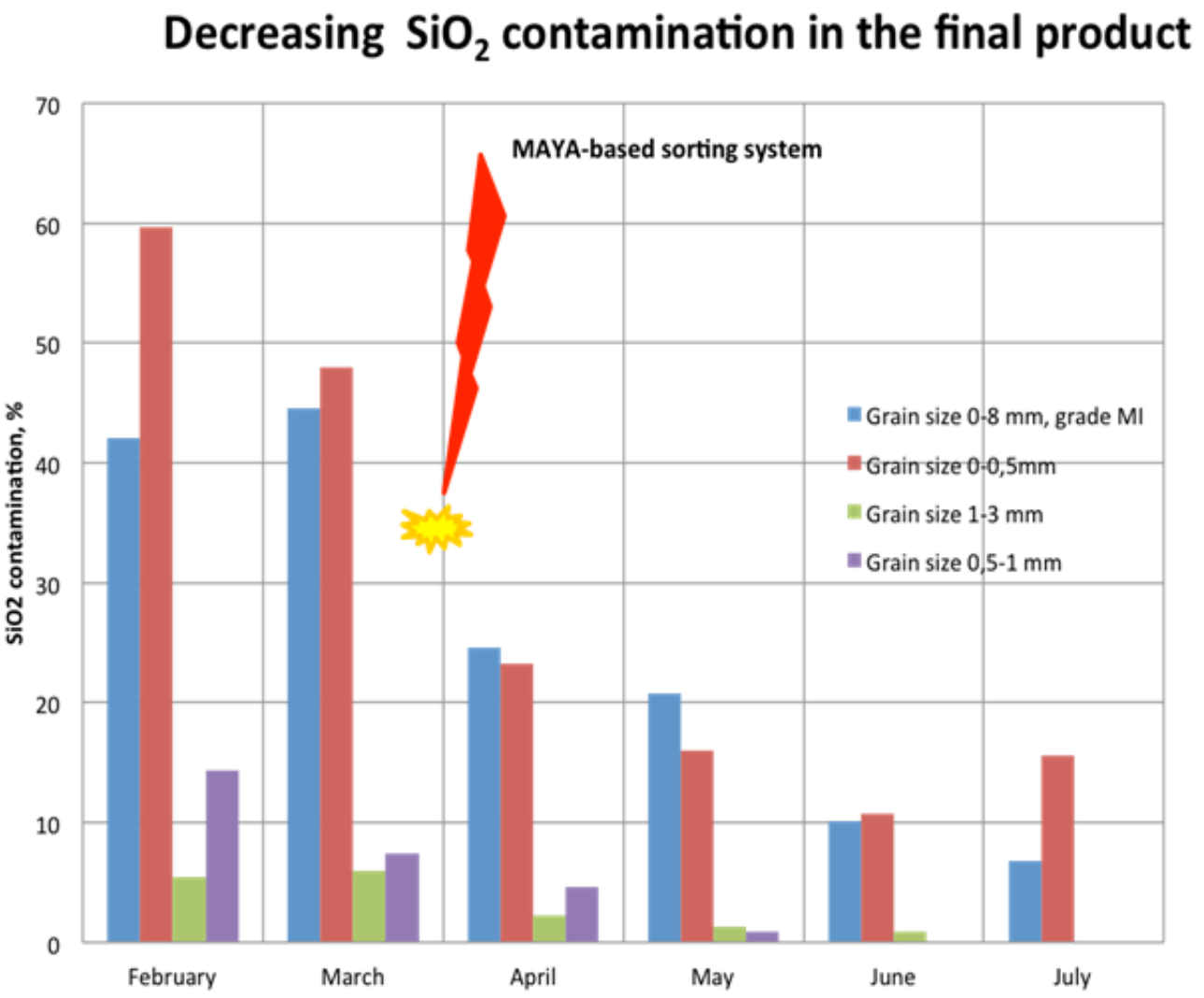




Case Study – Impurities Rejection

SiO_2 decision point for grade was set to 2,9%

After installation, SiO_2 contamination in the final product has dropped and average concentration of SiO_2 during 30 min meet desired < 3,0%

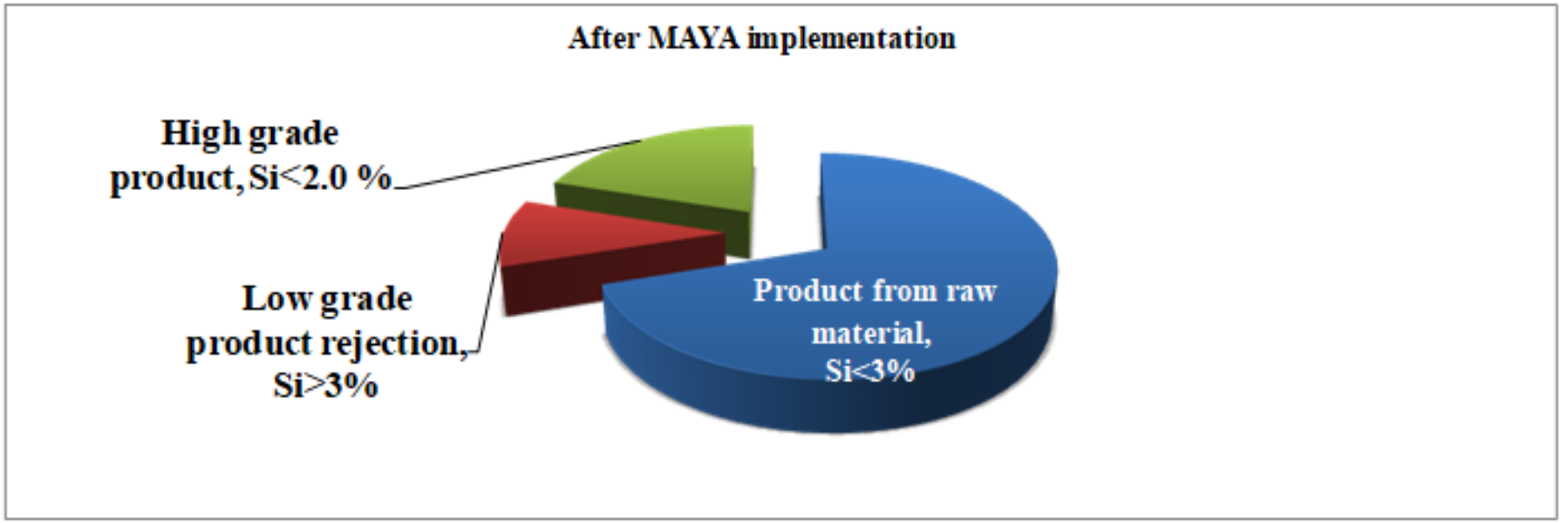


Case Study – Impurities Rejection

Payback ~ 2-3 months

Due to

- The products meets client's requirements
- Additional earnings from high grade product

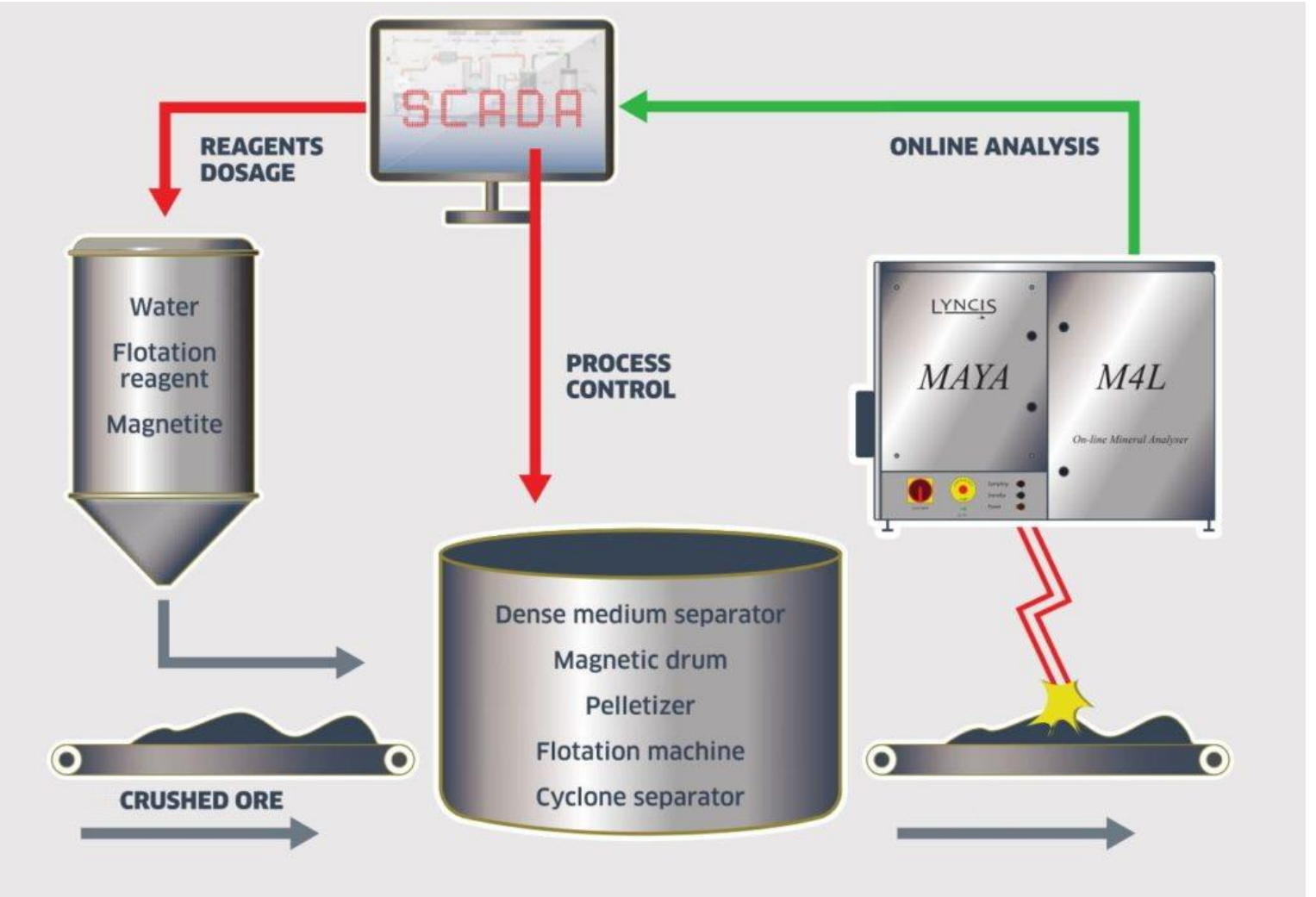


Applications

Advanced Beneficiation Process

Scenarios:

- Online chemical composition data drives beneficiation process decisions in real-time. The optimal dosage of flotation reagents minimizes production cost.
- Feed-forward control by monitoring incoming production quality and adjusting separation technology parameters ensure the highest mineral recovery.
- Tailings are monitored making sure the production is set to minimize the loss of valuable minerals.



Case Study – Advanced Beneficiation Process Control

Fertilizer Plant

Production of fully soluble
Potassium chloride (96-98 % KCl)

Case Study – Advanced Beneficiation Process Control

Laser online analyzer was installed on a production conveyor after hot leaching and crystallization process to monitor incoming product quality.

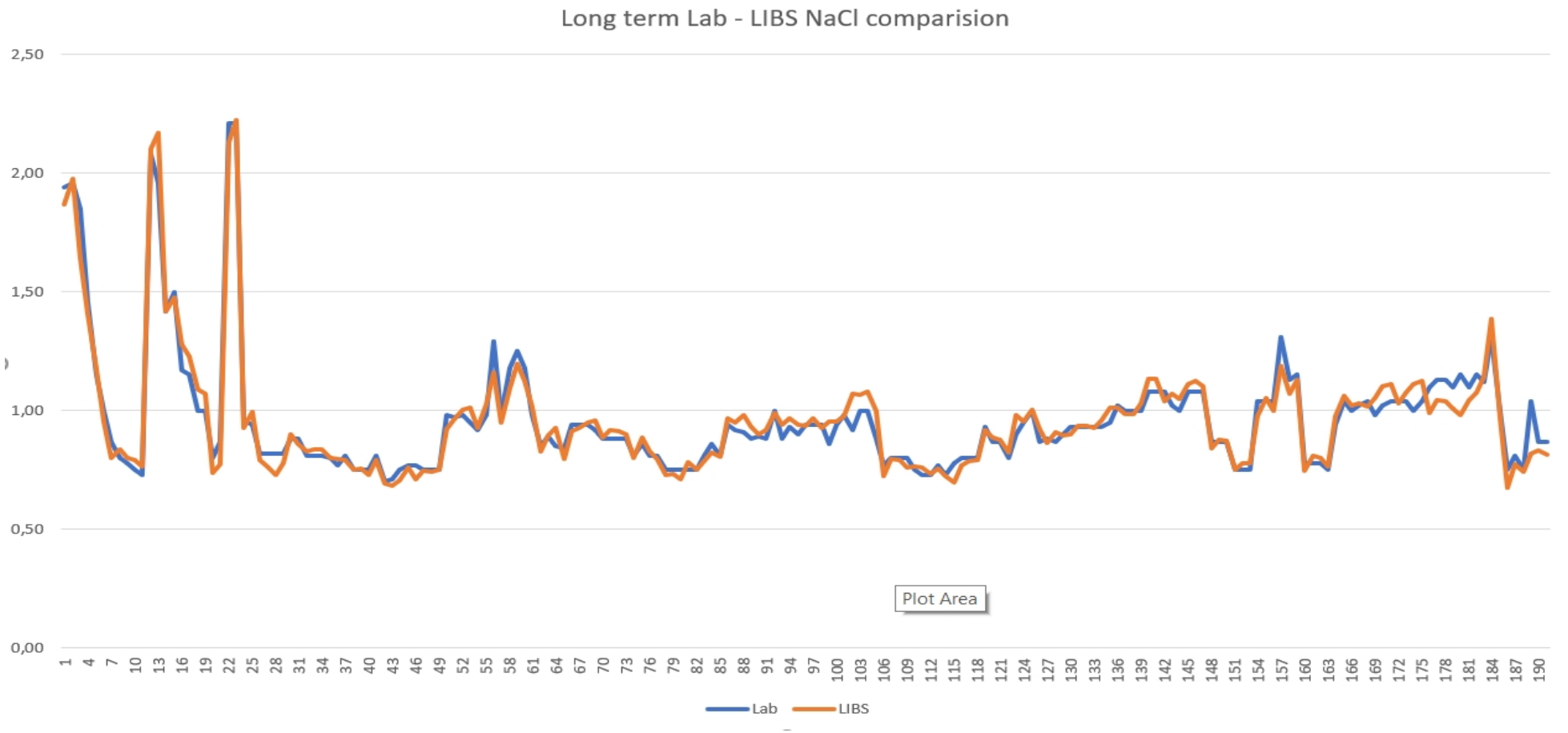
Analytical Task:
Online measurement of NaCl, Ca, Mg, KCl in wet cake

Automation Process Control:

- Leaching/Crystallization process feedforward control by water dosage based on NaCl level in the product

Plant Lab and LIBS Online comparison

Long lasting good correlation with laboratory analysis in real time conditions with materials on conveyor belt



Case Study – Water Dosage in Crystallization Process

Automated Process Control

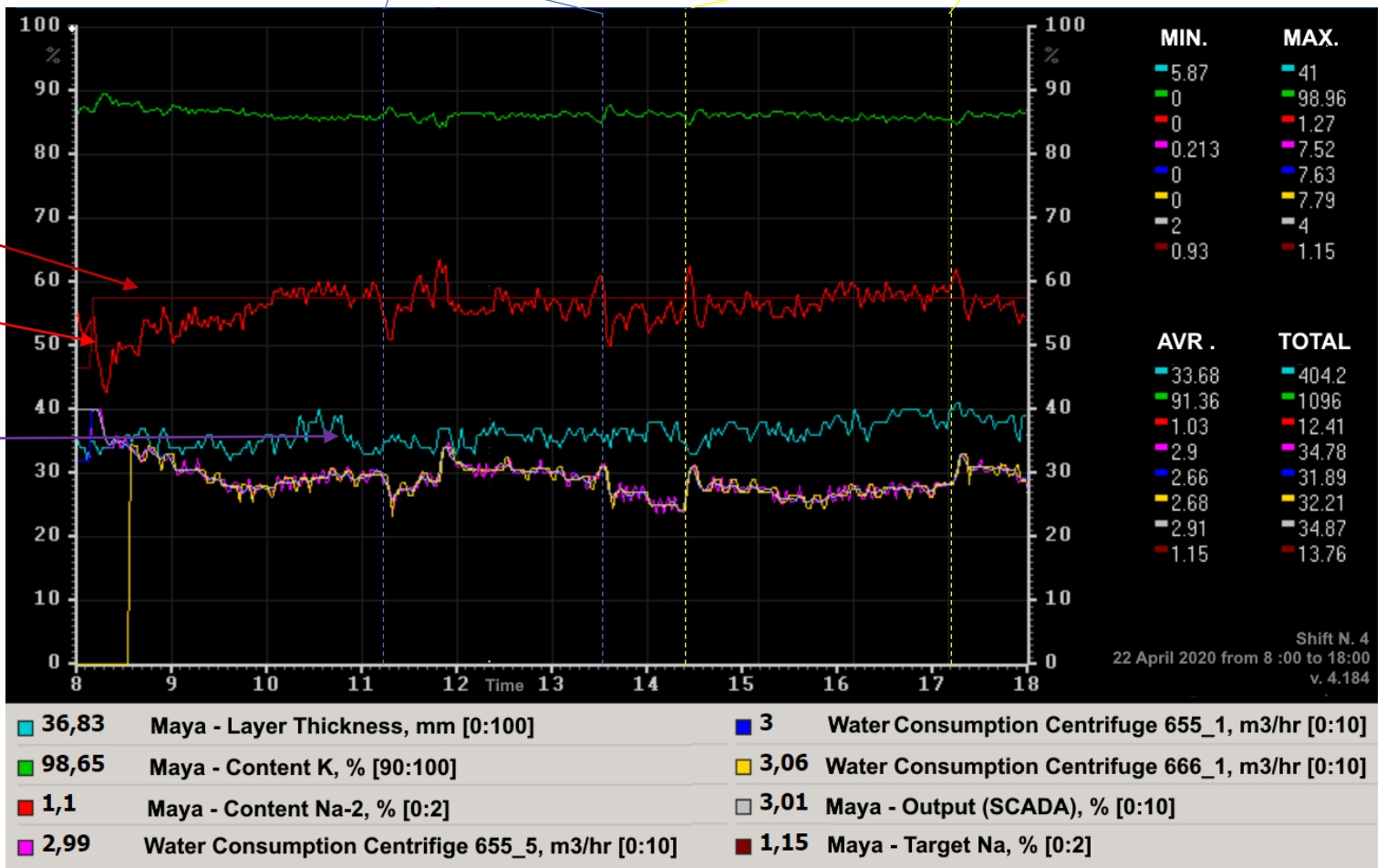
At these points NaCl becomes lower than required and the event triggers decrease the water supply in leaching process to increase NaCl content in the production.

At these points NaCl becomes higher than desired. Water supply is increased automatically to drive NaCl concentration down.

Target level of NaCl (1.15%)

Actual (Measured by online MAYA analyzer) Concentration of NaCl in a product

Adjusted water supply level to control NaCl concentration in a product.
Water supply is increased if NaCl levels are too high, and decreased if is too low.



Benefits

- **Higher utilization of valuable minerals with the same raw material throughput**
- **Reduced consumption of water and energy**
- **Minimize Tailings**
- **Reduced manual labor in sample preparation**

Investment Payback – 6 months

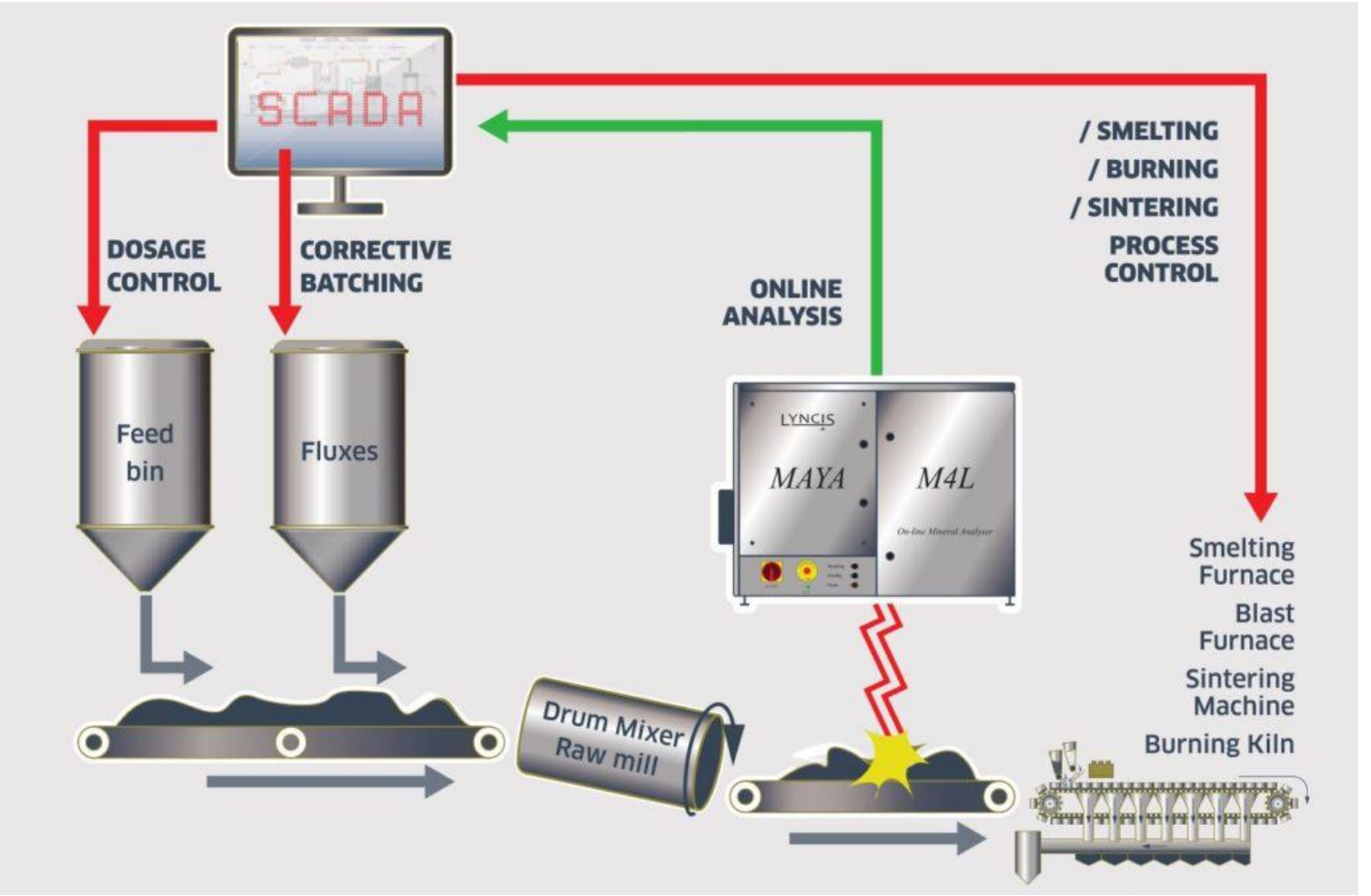
Applications

Optimal Blending and Targeted Mix Control

Scenarios:

- Real-time chemical composition data is used to adjust weight feeders delivering required dosage of raw materials and additives. Stable and targeted product quality can be achieved without overuse of valuable minerals.

- Stable kiln performance ensures lower energy consumption.



Case Study – Dosage of additives

Task:

Online analysis of CaO and Fe for automatic dosage of fluxes

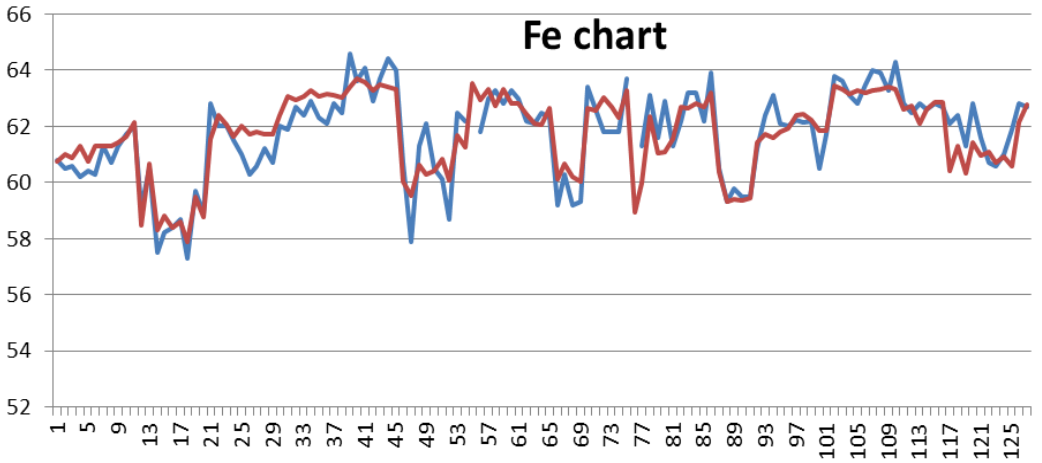
Economic benefits

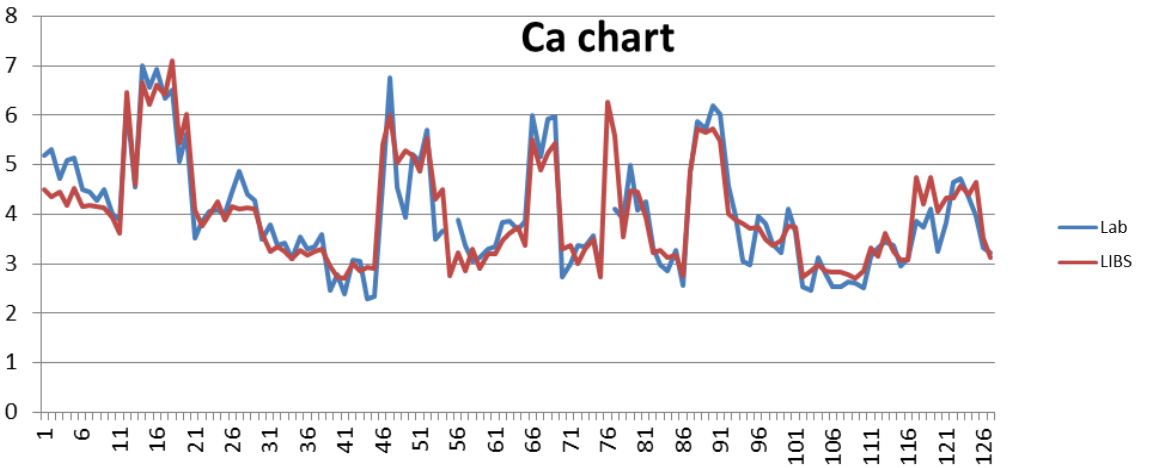
- The average standard deviation of product quality was reduced by 20%. It led to stable operations, higher product quality, and reduction of fuel consumption in furnace operations

Payback ~ 3-4 months

Case Study – Dosage of additives

Long term Fe & CaO stable and reliable online measurements



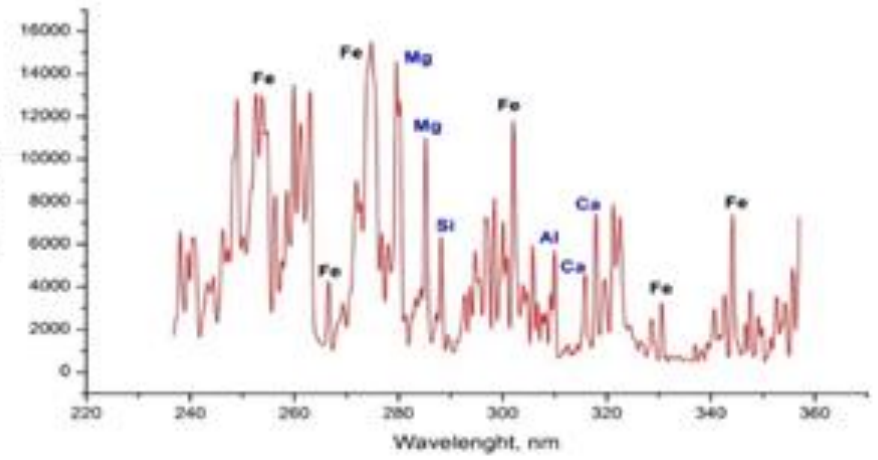


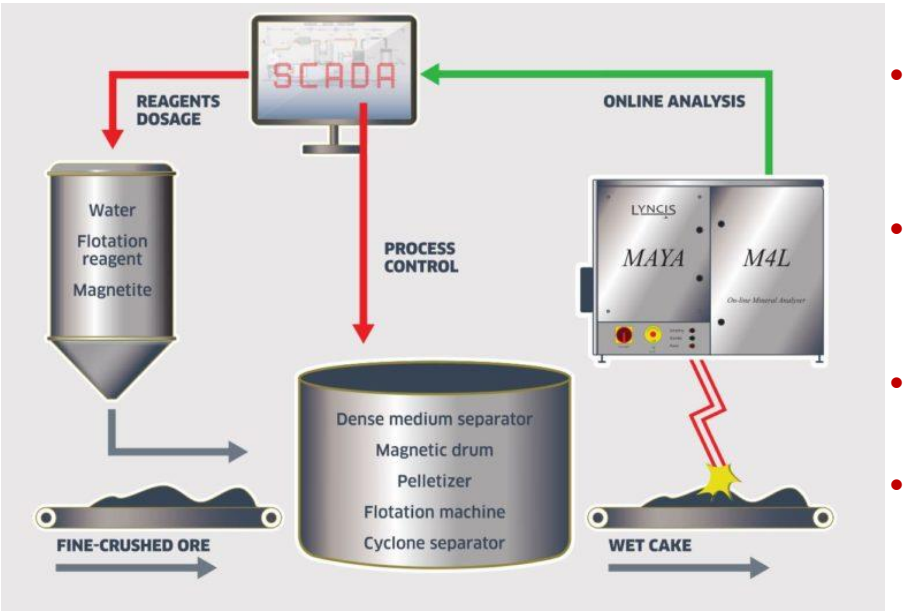
Conclusion

Discover hidden value from raw ore chemistry fluctuations

Access to real-time elemental analysis enables you to make better decisions in the production process

Online chemical analysis → Real-time process control → Improved KPIs





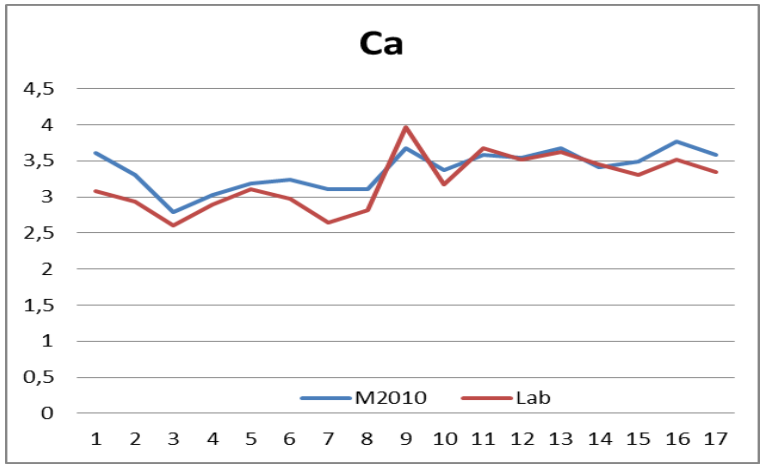
- **Higher recovery of valuable minerals**
- **Reduced consumption of reagents, water, energy**
- **Targeted product quality**
- **Reduced manual labor in sample preparation**

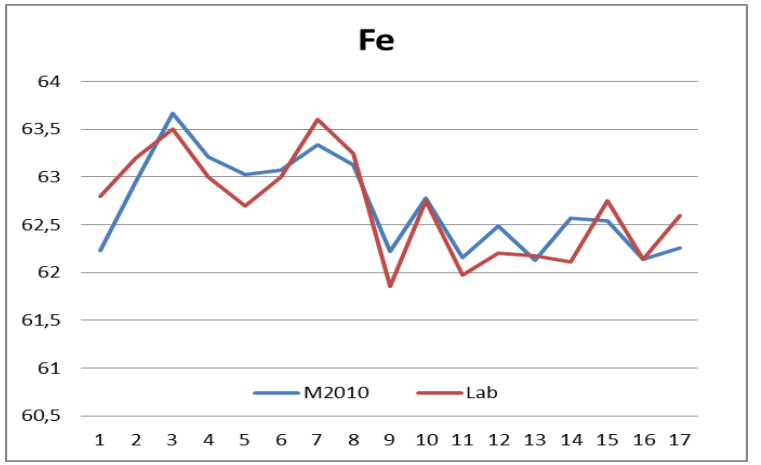
LIBS - Future for Accurate and Reliable online measurements in mining and mineral processing industry

Advantages:

- **Low detection limit, accurate and stable analysis** of all elements of interest and parameters such as moisture, loss of ignition and others
- **No regular re-calibration requirements**
- **Low operational and maintenance cost** compared with alternative online analysis technologies
- **Radiation Free,** environment and people safe technology

Messurment after one year operation with initial calibration





At metalurgical plant LIBS Online system was 7 years in operations without a need for recalibration

Safety

Safety First!

LIBS - Environmentally and personal safe technology

- No gamma-ray, neutron or X-ray radiation. No governmental permissions and licenses are needed for operating and transporting the equipment.

What about your plant? Is there additional value hidden in your raw material flow?

1. Pinpoint the locations in your process schematics where real-time data could help you to optimize your production
2. Assess The Benefit such system can create
3. Start the project which could lead to high ROI

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Additional Information

1. Industries
2. Surface Measurement – True Bulk Flow Measurement
3. LIBS Spectrum
4. Advanced Data Analytics
5. Long term stable continuous automatic operations
6. Equipment Technical Specifications
7. Software
8. Installation and Routine Maintenance

Industries

10+ years of experience in various industries
Industry-proven technology, used by clients in N. America, Europe and Asia. First installation - in 2008 (USA)

We operate in the following industries:

- **Fertilizers** (phosphate, potassium, composite NPK – P, K, Na, moisture and others)
- **Iron and Steal** (iron ore and concentrate, sinter mix, limestone, coke -Fe, Si, Ca, Mg, Mn, C, moisture and others)
- **Industrial Minerals** (limestone, quartz, clays, nepheline…)
- **Cement** (limestone, raw meal – Ca, Si, Al, Fe…)
- **Refractories** (Mg, Si, Ca, Fe, Al, Cr, B, Mn and others)
- **Coa**l (C, ash content, volatiles, moisture – Fe, Al, Si, Mg, Ca…)
- **Base metals** (Cu, Al, Co, Mo, Zn and others)
- **Bauxite and Alumina**

and others

Examples of Installations:

Iron

Fertilizers

Limestone

Slurry, brines

Refractories

Coal

Surface Measurement – True Flow Measurement

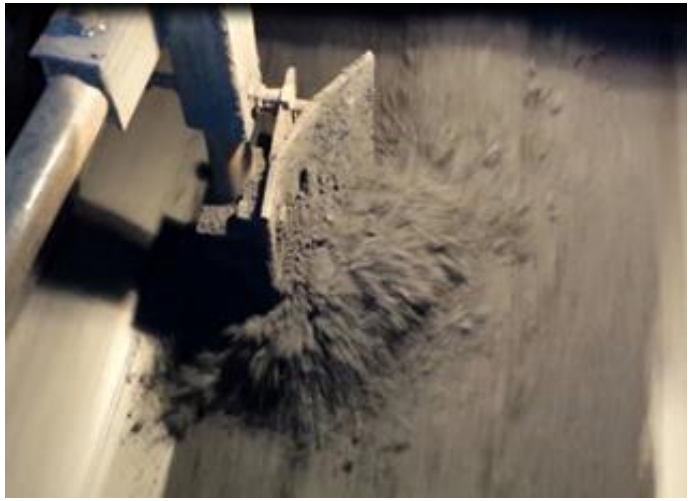
LIBS provides accurate material flow measurement and is not affected by layer thickness, material load or conveyor construction and does not require measurement corrections based on additional sensors or assumed material distribution models.

LIBS system can perform thousands of measurements per minute to deliver representative data of the entire flow. The analyzer is installed at the location where material distribution has random nature. Locations after raw ore crusher, mill, discharge chute can be defined as having random material distribution and this can ensure that statistically accurate chemical composition of entire flow is measured.

If no random distribution exists at desired measurement point simple mechanical tools (plunges, chains) are used to mix the material on a conveyor and ensure the surface measurement statistically represents an entire flow.

Example of random distribution of raw ore on conveyor belt from installation site

Examples of mechanical aid to ensure entire flow chemical composition analysis is delivered



LIBS Spectrum

LIBS Signal Features:

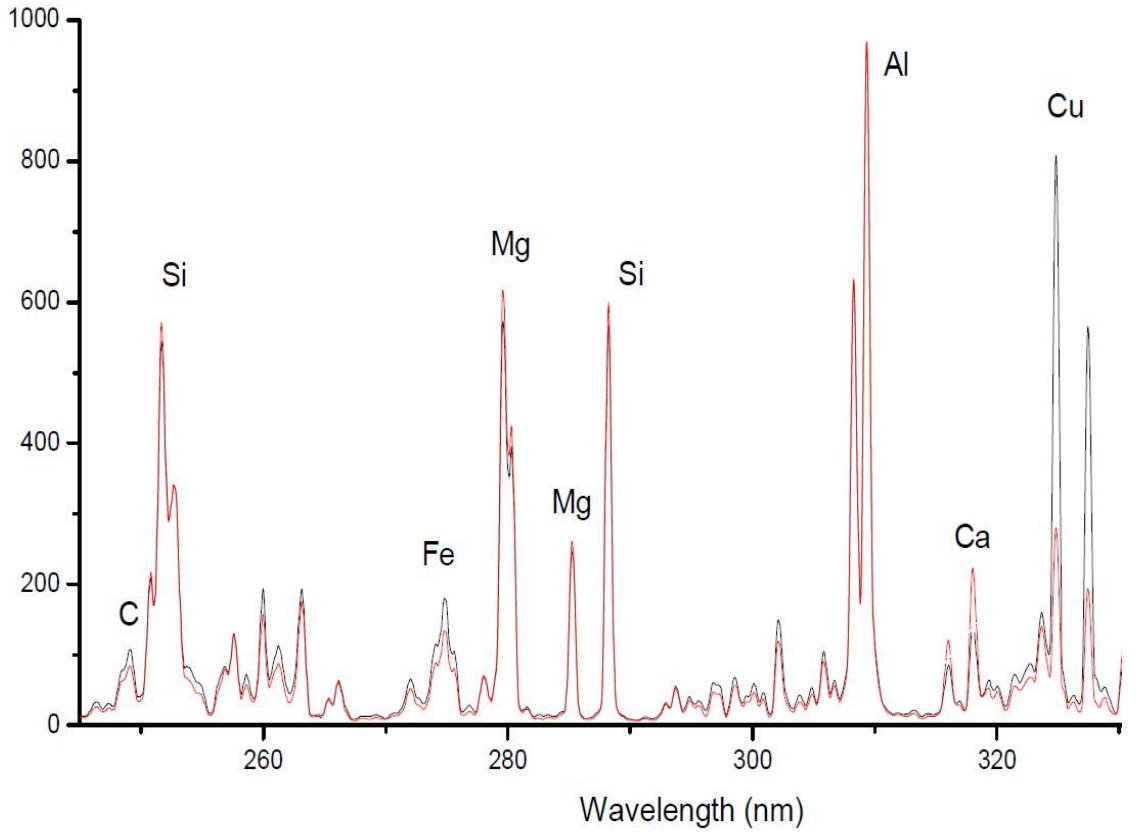
- Clear analytical lines of all required major elements and impurities of interest with no interference

- High signal/background ration

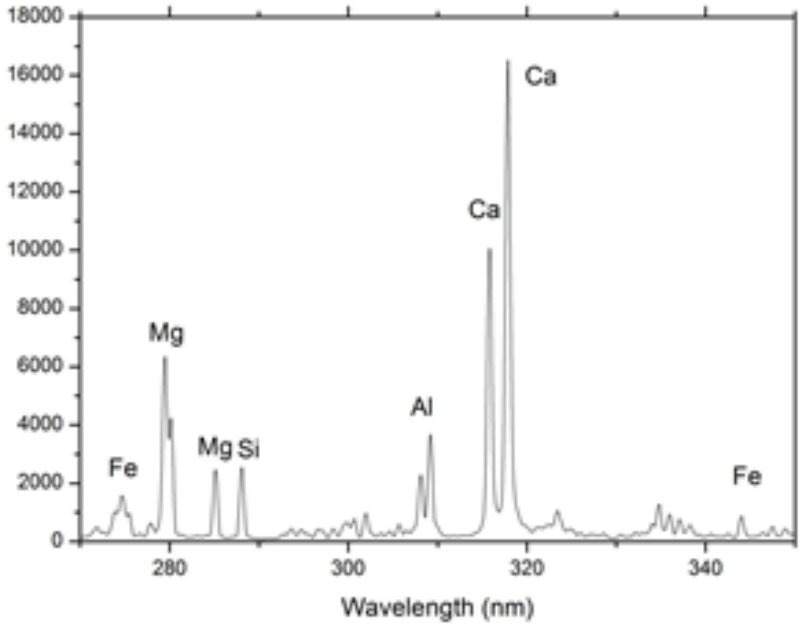
Ability to perform:

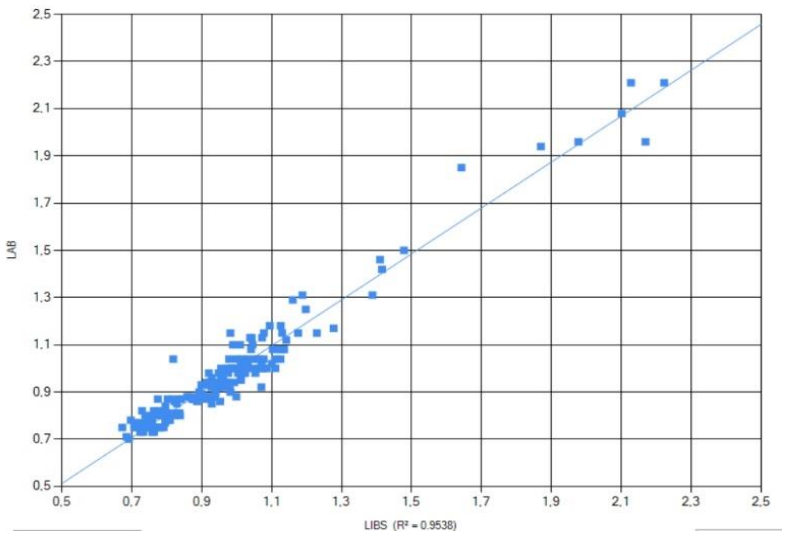
- Bulk and fine materials analysis
- Slurry and pulp analysis

LIBS spectra



Advanced Data Analytics





Machine Learning and chemometrics

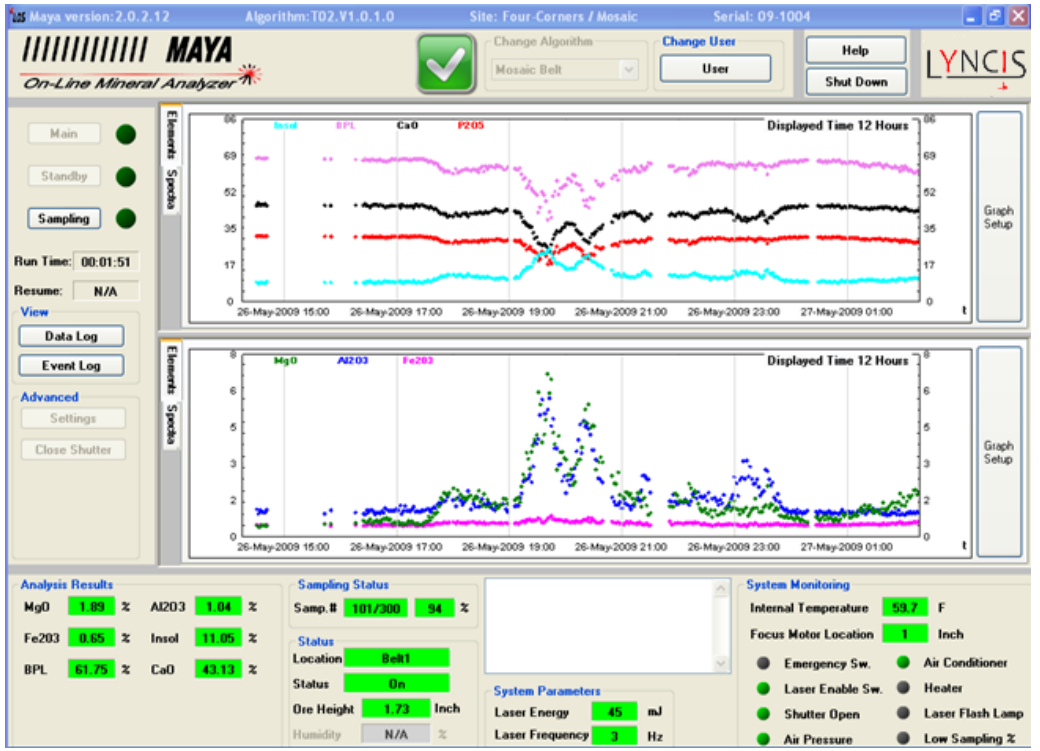
Online elemental analyzers are equipped with data processing modules and use advanced machine learning and chemometrics technics to monitor and learn the material changes during continuous processes.
This ensures accurate and stable measurements through the lifetime of the processing plant.

We use for data reprocessing and optimal calibration:

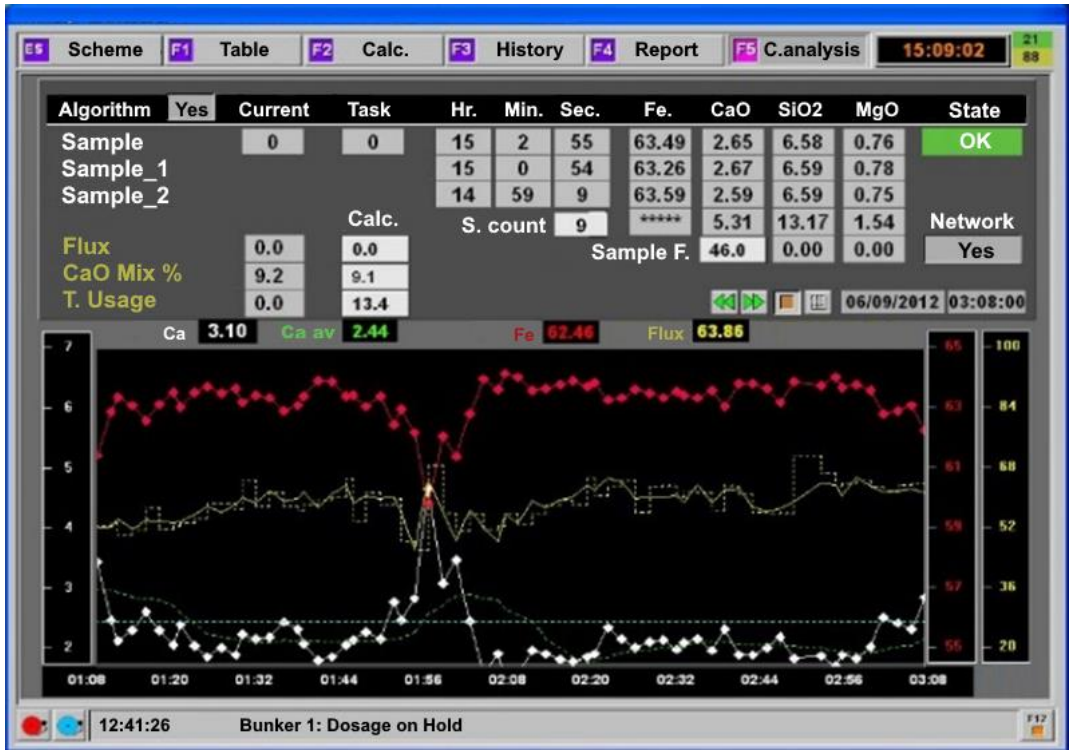
- **PCA/PCR** - Principal Component Analysis/Regression)
- **Neural Networks**
- **SVM** - Support-vector machine)
- **PLS** - Partial least squares regression)
- **Classification algorithms**

Long term stable continuous automatic operation

Fully automatic 24/7 operation provides real-time chemistry of material streams without sampling and sample preparation



Integration with customer's SCADA for prompt process control



Technical specifications

Operation temperatures from -20 ^{o}C to +50 ^{o}C

Protection class - IP65

Corrosion, dust and vibration protection

Integration with all SCADA types; cloud and remote communication capabilities

Nd:YAG solid state impulse laser 1064 nm
Laser safety Class 1

Spectrometers detect 170 – 960 nm range

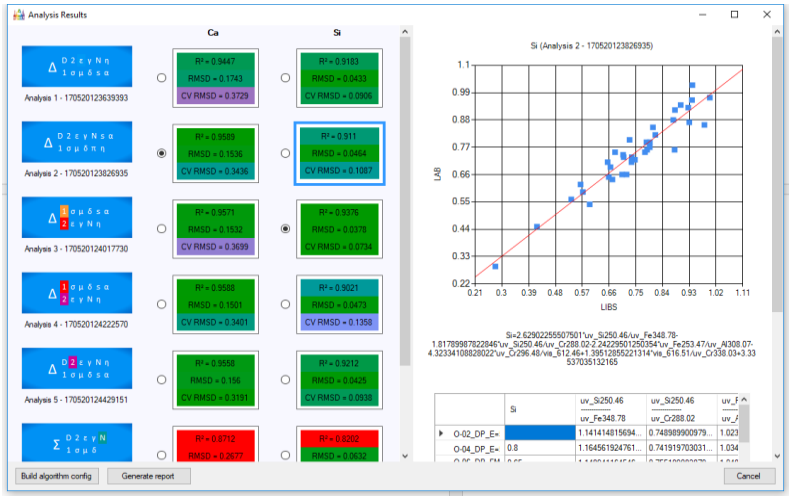
Safe Radiation-Free LIBS technology generates only optical wave range during excitation and emission

24/7 continuous operation
Direct on-belt / pipeline analysis
NO sampling
Designed for harsh industrial environment

Software

- **Performance monitoring and auto notification if calibration fine tuning is recommended**
- **Easy addition of new sample points to calibration database**
- **Remote Control and assistance in monitoring and adjusting machine performance**
- **Industry 4.0 integration**

  Full SCADA/PLC integration and networking capabilities allow the analyzers to be integrated in any Industry 4.0 and manufacturing ecosystem.



Installation and Maintenance

Requirements for installation

- Simple frame:
  Installed **30 – 120 cm above the material**
  Dimensions~1.5 (L) x 0.9 (D) x 1.3 (H) m
  Weight ~ 450 kg

- **Compressed Air** – 600-1200 l/min, 8 bar

- **Maintenance**

- Laser diode replacement **once in 5-10 years**

- Air filters – cleaning or replacement – depends on dustiness **- monthly**

- Protection window manual or air cleaning – **weekly**

Low cost of ownership compared to any other online measurement alternatives