

Development of an XRF Borehole Probe for Depths up to 500 m

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Why Borehole Probe Development ?

- Exploration is done by borehole drilling
 - Core Drilling
 - Cores can be analyzed with hand held XRF devices
 - Later analysis in laboratory
 - Time consuming
 - Very expensive
 - Very precise

Why Borehole Probe Development ?

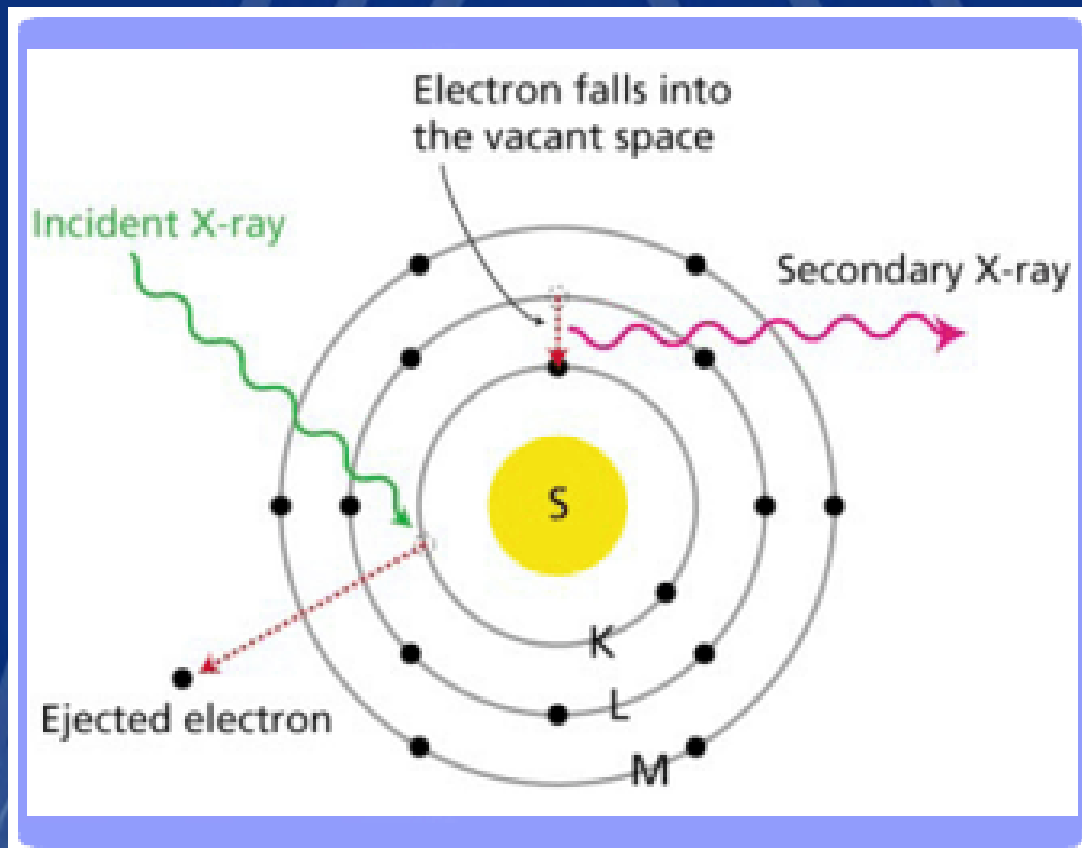
- Exploration is done by borehole drilling
 - Conventional Drilling
 - Drill debris is collected as sample
 - Evaluation of subsamples is done in laboratory
 - Analysis in laboratory is time consuming and costly
 - Samples represent average of certain part of the drilled hole (e.g. 20 m)
 - Poor depth resolution
- Conventional methods do not allow fast action according to results

X-Ray Fluorescence

- Suitable for Elemental Analysis
- Present Status:
 - XRF measuring devices in operation under various conditions
 - On-belt measurement
 - Slurry measurement
 - Hand held devices for sample investigation
 - Logical step: Use of XRF for Borehole Logging

X-Ray Fluorescence

- Basic Measurement Principle



XRF Probe: Feasibility

- Prototype Development:
 - Borehole Probe
 - Depth up to 30 m
 - Not pressure proof
 - Width 90 mm
 - Cable based real-time data transmission to surface
 - Designed for blasthole logging

XRF Probe: Feasibility

- Prototype Development:

- Based on standard XRF Analyzer
- Big drum
- Electronics included inside drum
- Purpose: feasibility testing



XRF Probe: Feasibility

- Prototype Development:
 - Sensor length 600 mm
 - Standard X ray tube
 - Standard X ray sensor
 - No center alignment
 - No adaption to changing borehole diameters



XRF Probe: Feasibility

- Prototype Development:
 - Control of measurement is done with a laptop using WLAN



XRF Probe: Development

- Development of Industrial Version:
 - Borehole Probe
 - Joint development with GFZ, Potsdam, Germany

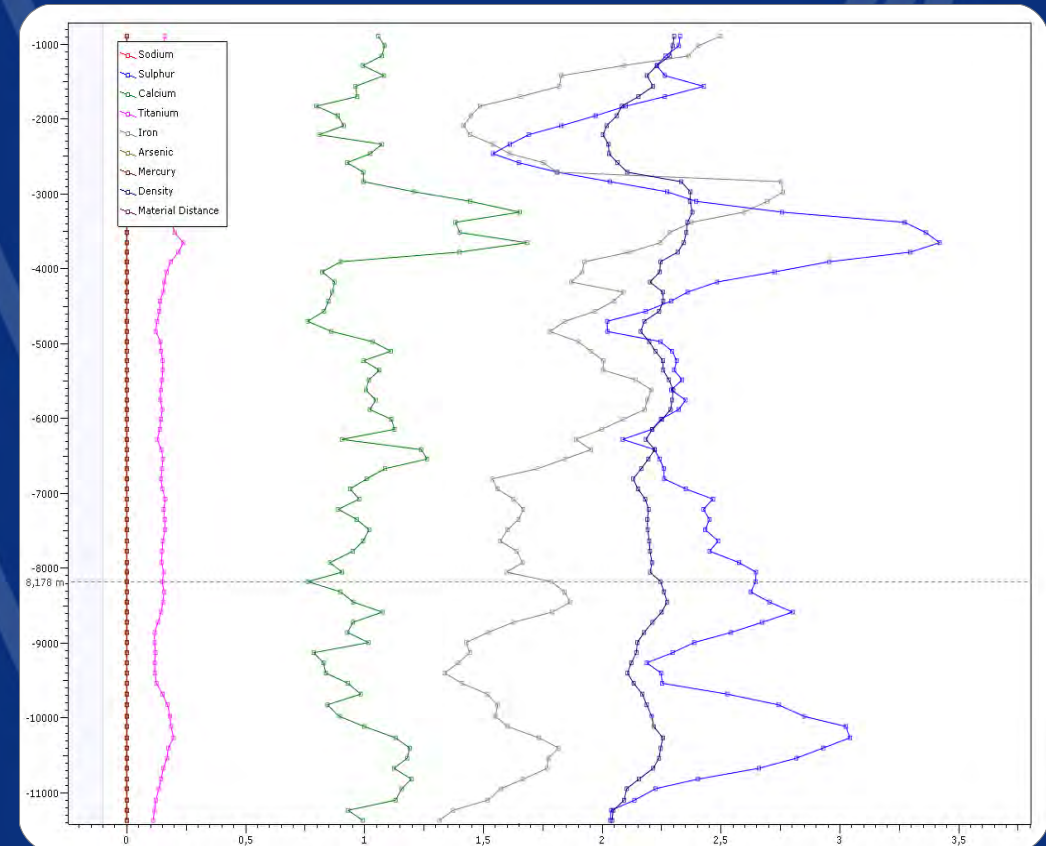


XRF Probe: Development

- Development of Industrial Version:
 - Borehole Probe
 - Depth up to 500 m
 - Withstands pressure up to 5 MPa
 - Width 53 mm
 - Length approx. 2.000 mm
 - Cable based real-time data transmission to surface

XRF Probe: Development

- Borehole log
 - Logging speed variable
 - Accuracy increases with decreasing speed
 - Raw Sensor Data acquisition
 - Simultaneous logging of different elements
 - Density log



Borehole Probe

Challenges of high depth

	Prototype	Final Development
Depth	30 m	500 m
Temperature	Up to 40 °C	Up to 70 °C
Borehole Width	90 mm	53 mm
X-Ray Power Supply	Ground Level	Inside of Probe
Data Transmission	Ethernet	DSL
Data Transmission Range	30 m	500 m
Scan Speed	10-200 mm/s	10-200 mm/s

XRF Probe: Width

- All components must fit into the probe
 - Restriction
 - Available space: 43 mm inner diameter
 - Requirements
 - Development of a special power supply for voltages up to 50 kV
 - Development of an adapted X-ray sensor
 - Use of a miniaturized X-ray tube
 - Development of a high speed data transfer using standard winch cables

XRF Probe: Depth

- Increasing outside temperature with depth
 - Restriction:
 - All components must withstand increased temperature range
 - Requirements:
 - Excess heat has to be absorbed or exchanged to the environment
 - Heat pipes
 - Peltier cooling for sensor and electronics
 - Intelligent energy management

XRF Probe: Electronics

- All electronic components had to be adapted
 - Sensor
 - Adaption of an industrial available sensor
 - Sensor module with new supply board

XRF Probe: Electronics

- All electronic components had to be adapted
 - X-ray power supply
 - Commercially available power supplies (50 kV, 50 W) do not fit into tube
 - Complete new development required

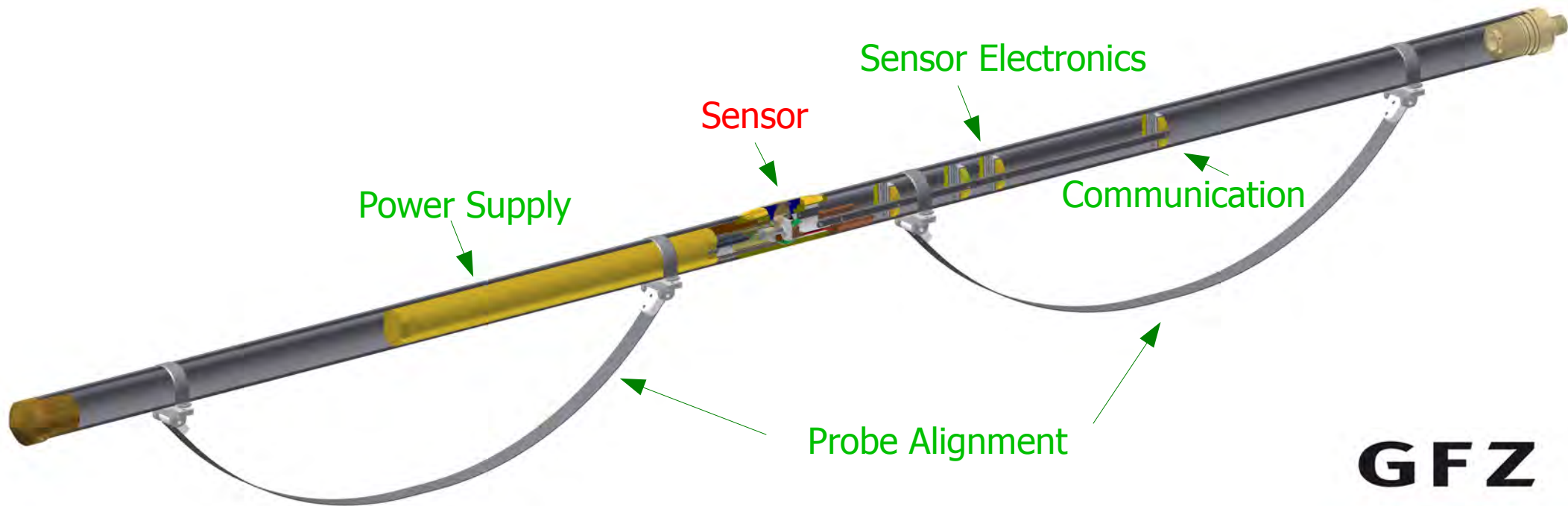
XRF Probe: Electronics

- All electronic components had to be adapted
 - Data transmission
 - Adaption of existing ADSL techniques
 - Commercially available modules do not fit into tube

XRF Probe: Physics

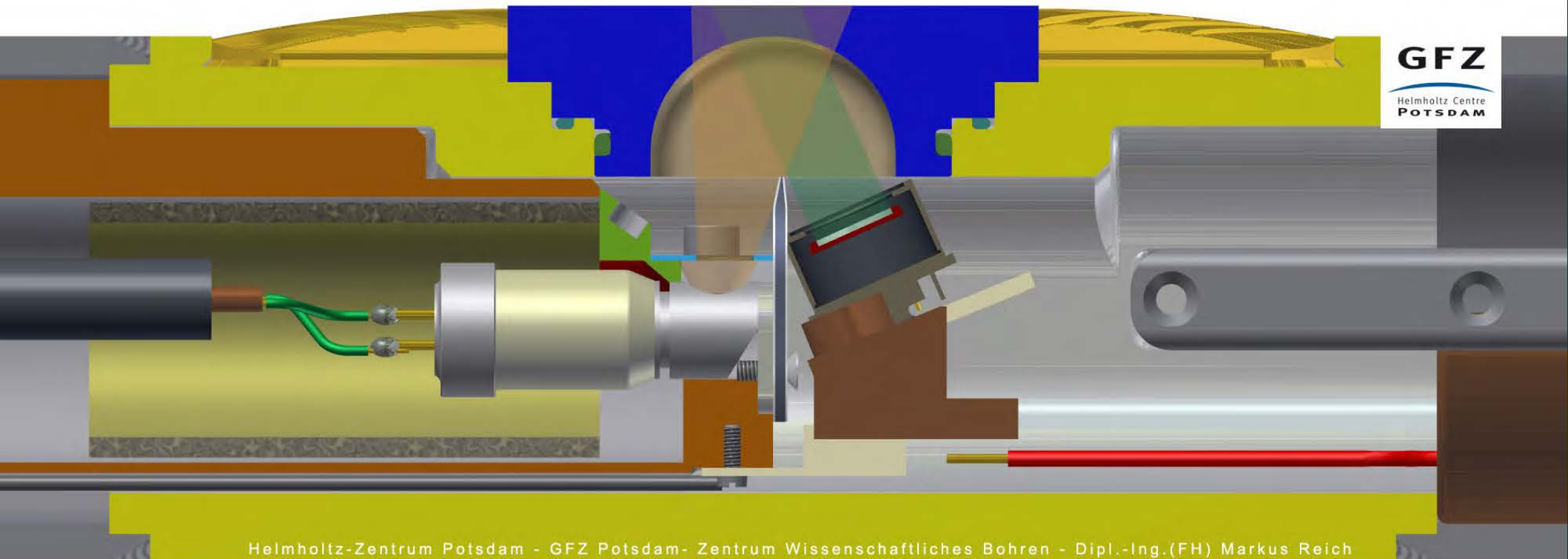
- Probe must be tight, heat resistant and transparent for low energy X-rays
 - Requirements:
 - Thin window
 - Low Z window material
 - Pressure resistant
 - Temperature resistant
 - Solution:
 - High sensor sensitivity (10 Mio cps)
 - High X-ray intensity

Borehole Probe



Borehole Probe

- Sensor Design

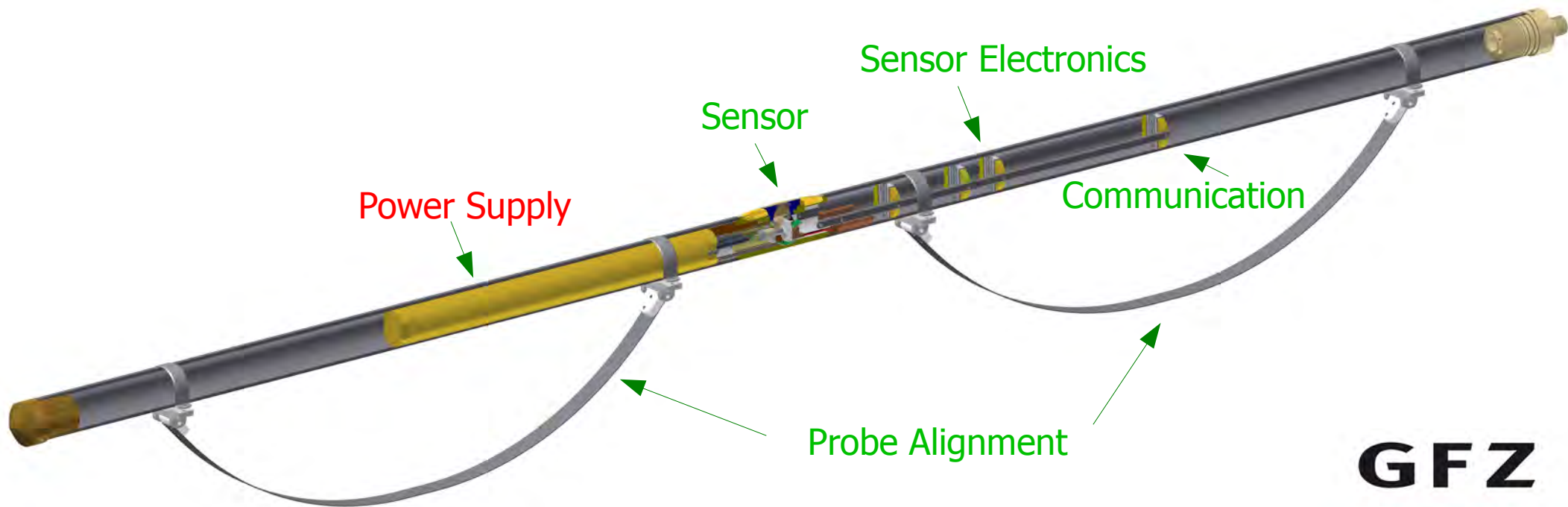


GFZ
Helmholtz Centre
POTSDAM

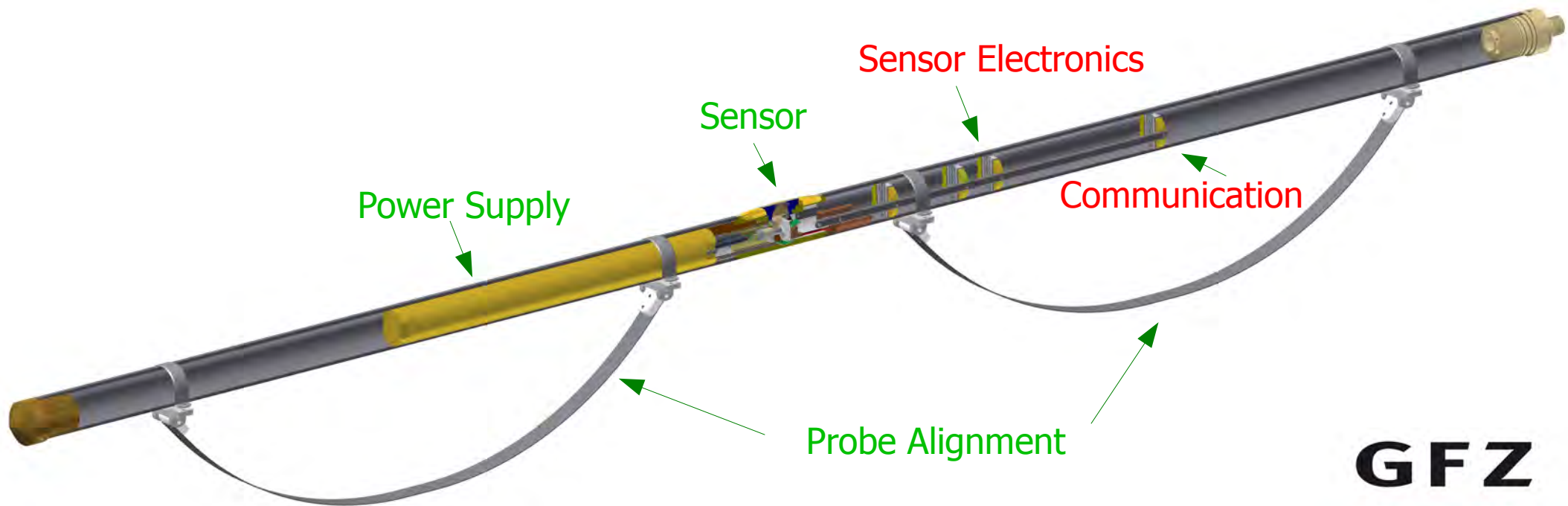
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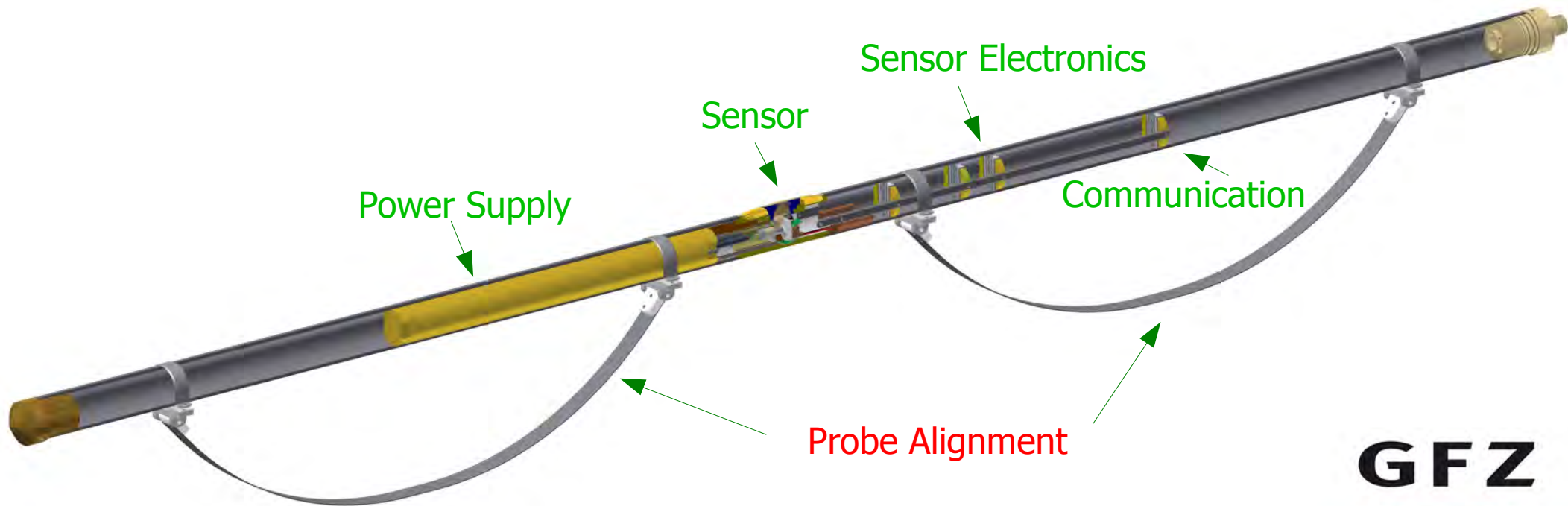
Borehole Probe



Borehole Probe



Borehole Probe



XRF Borehole Probe

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XRF Borehole Probe

Thank you for your attention !

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