Innovations for a better compatibility with the environment and the territory

Smart management of power cable transmission networks

Stefano Franchi Bononi
stefano.franchibononi@prysmiangroup.com

Prysmian Group

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Innovations for a better compatibility with the environment and the territory

Agenda

- A new approach on asset management
- Introduction to Partial Discharges
- Solutions overview
- Experience and Success cases

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Smart Asset Management

Provides **advanced Condition Assessment technologies** to achieve:

- **Increased reliability:** mitigation of operational risks and no false positive
- **Increased safety**
- **Increased power transmission**
- **Reduced maintenance cost and enviromental impact**
- **Increased support to owner on Risk-based decisions**

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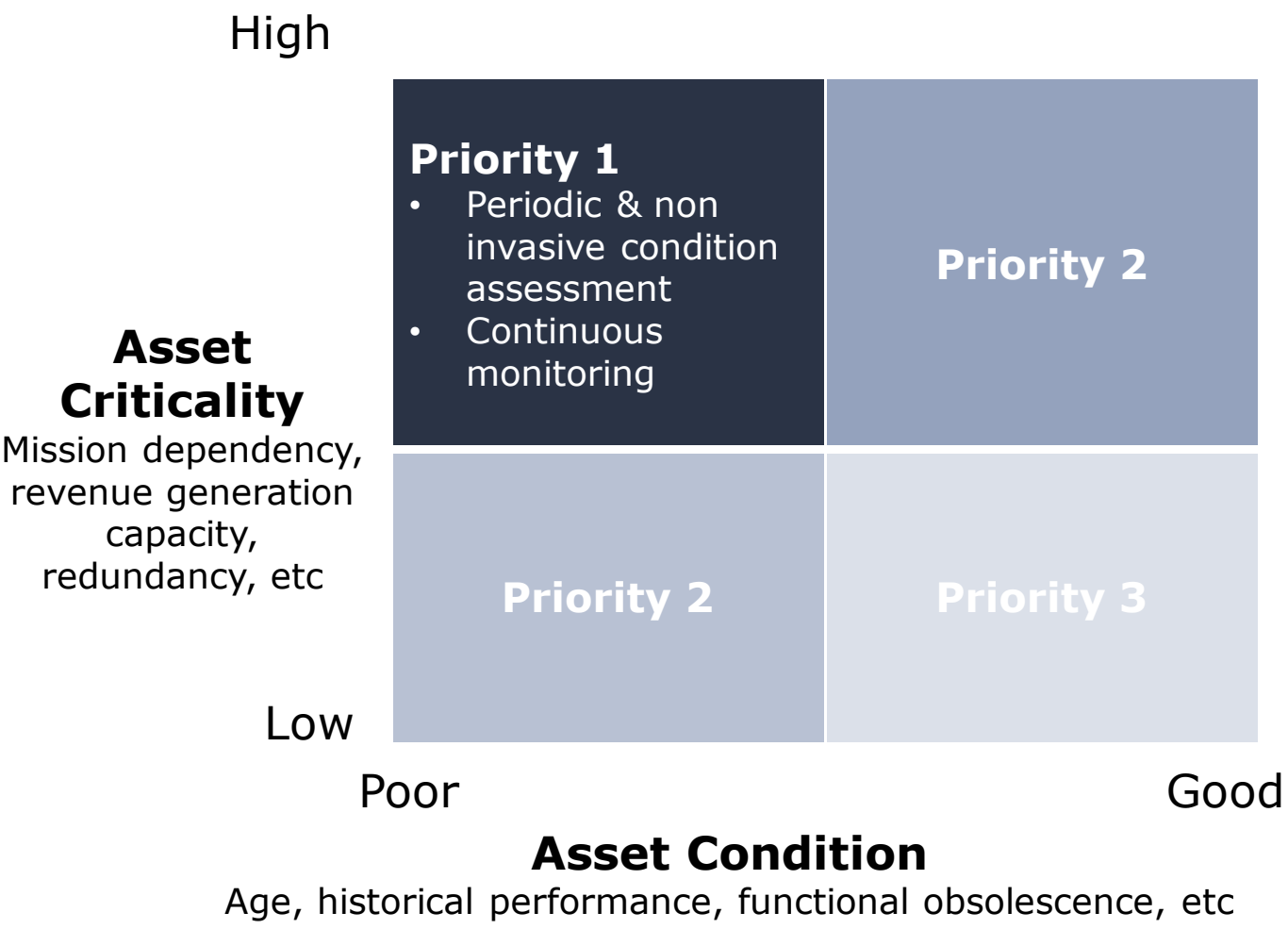
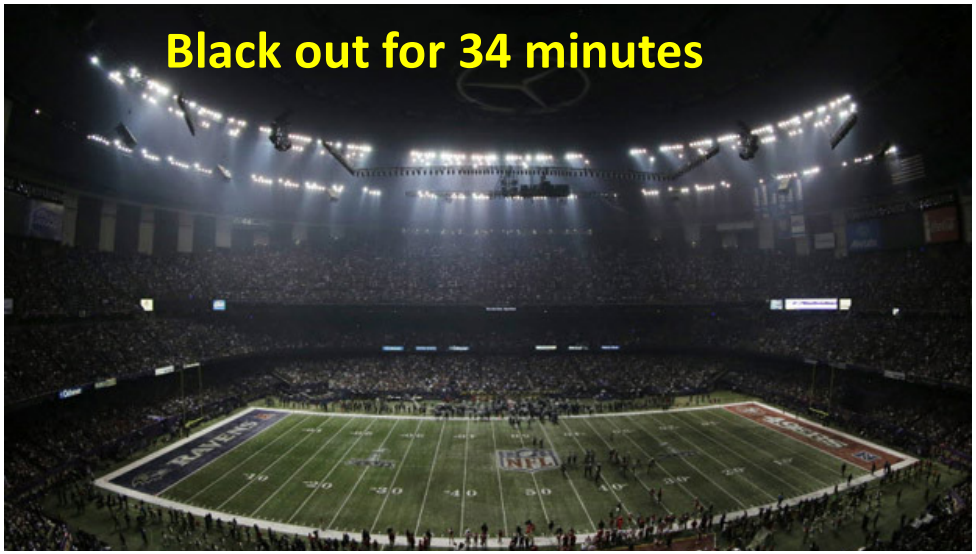
Asset Management approach



When Condition Assessment would have helped…



The 2013 Super Bowl was played in New Orleans and was watched by **115.5 million live around the world**

Suffered a **34 minute delay due to a power outage** caused by a MV switchgear problem

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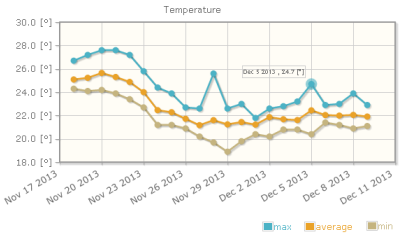
Asset key Parameters for condition-assessment

What shall be monitored:

- Partial Discharges
- Temperatures (linear sensing or concentrated)
- Pressures (for FF cable systems)
- Currents (sheath currents)
- Voltages
- SVL status
- Floodings in link boxes or in man holes
- Humidity, Smoke, Intrusions
- Others



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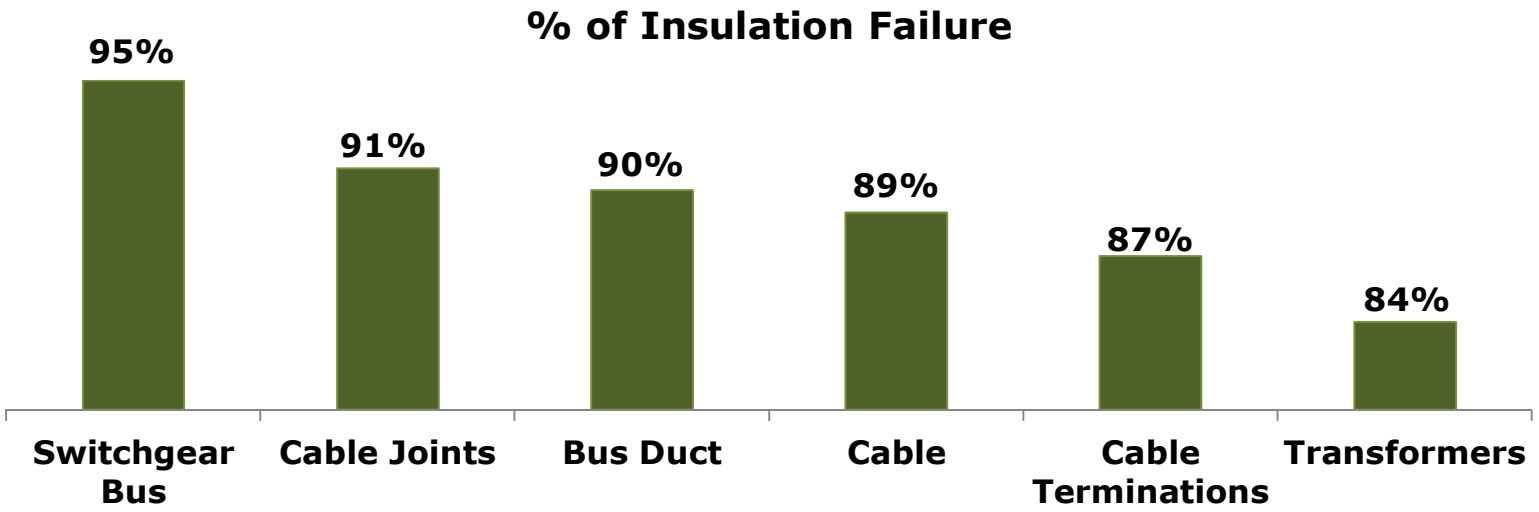
More than 80% of disruptive failures in HV/MV assets are related to Partial Discharge (PD) activity

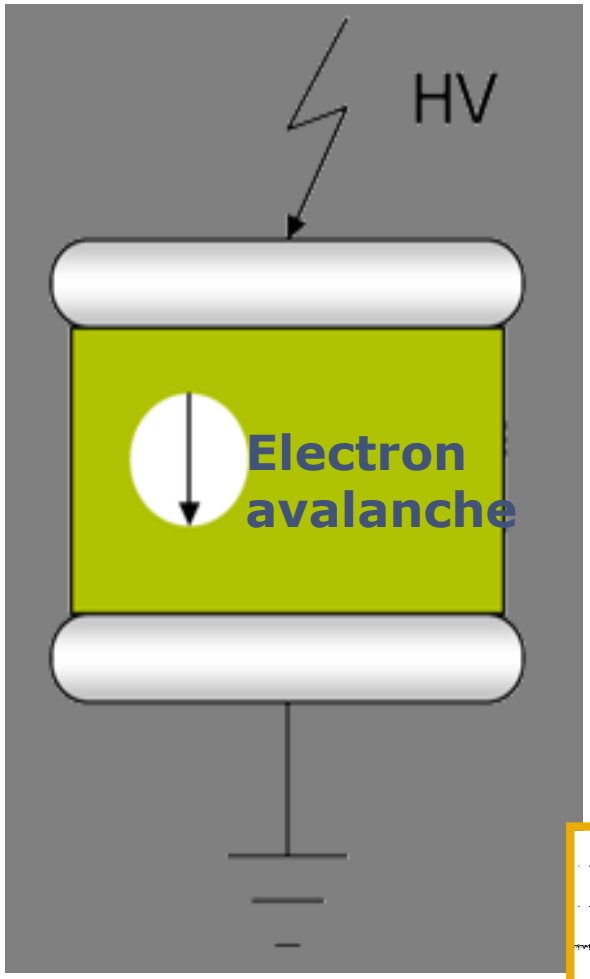


Source: 493-1997 - IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (Gold Book)

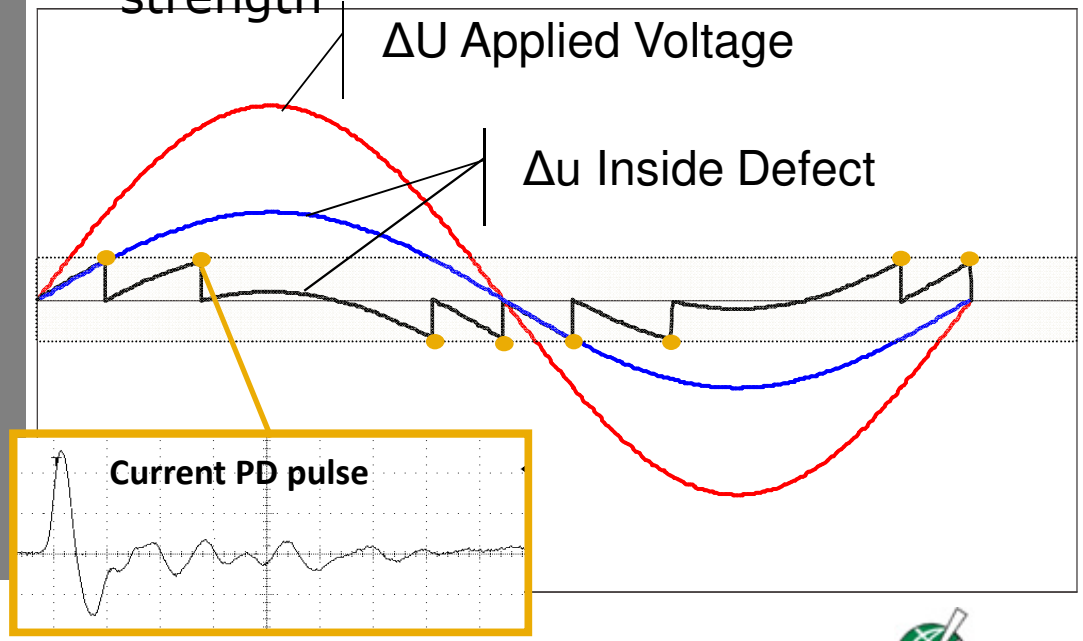
Agenda

- Introduction to Partial Discharges
- Solutions overview
- Experience and Success cases

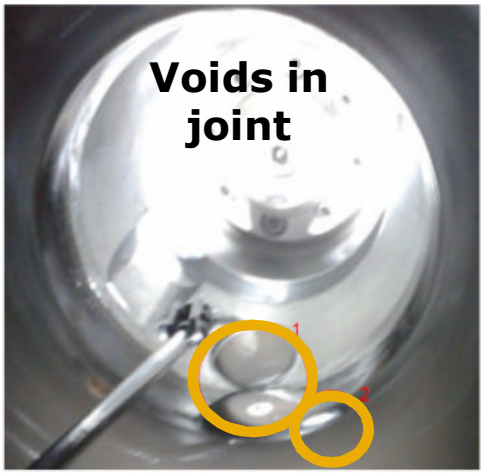
What is Partial Discharge



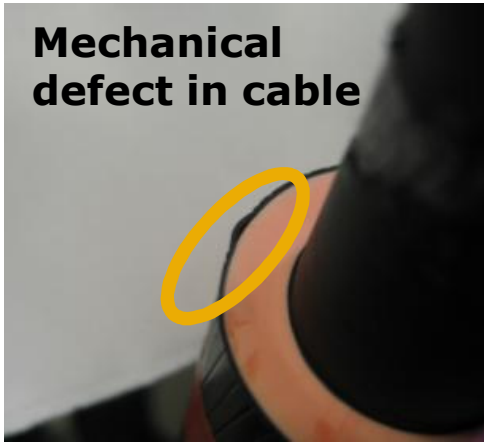
- **Definition:** electrical discharge that bridges only a small portion of the insulation between two conducting electrodes
- PDs occur where the electric field strength exceeds the breakdown strength



Partial Discharge Causes



Detachment in joint



- **Voids** within solid insulation
- **Contamination by particles**
- **Irregularities** (e.g. sharp points)
- **Gas bubbles** in liquid insulation
- **Floating particles** in gas insulation
- **Mechanical defect or damage** in insulation materials

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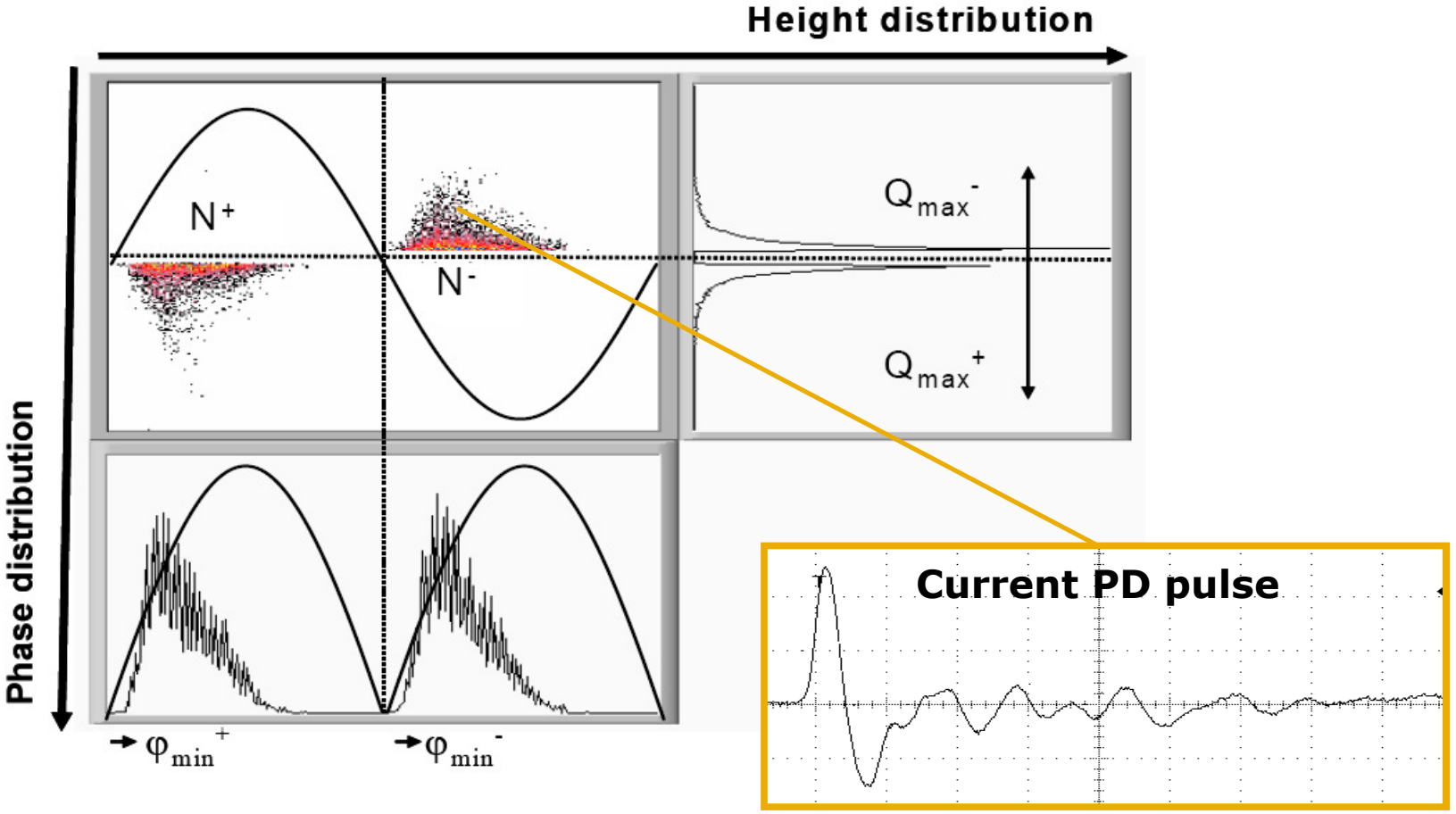
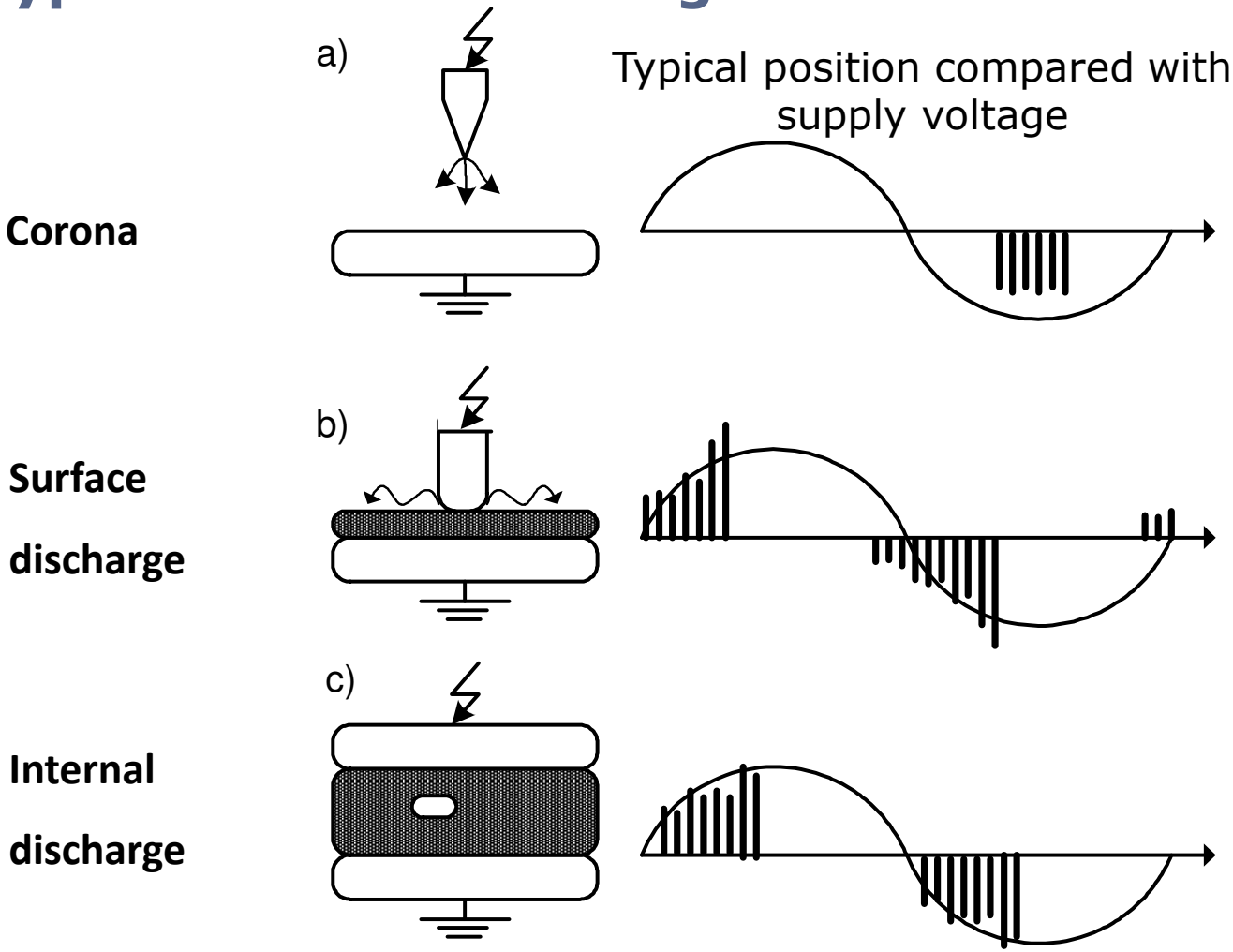
Advanced diagnosis requires the complete PD pattern



Type of Partial Discharge



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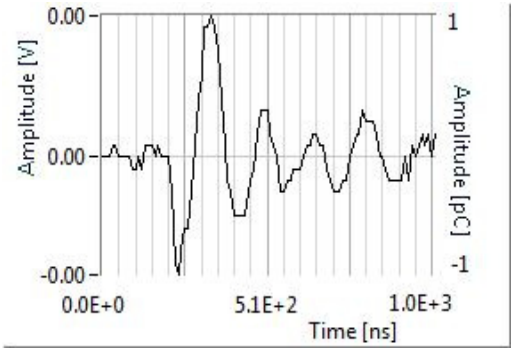
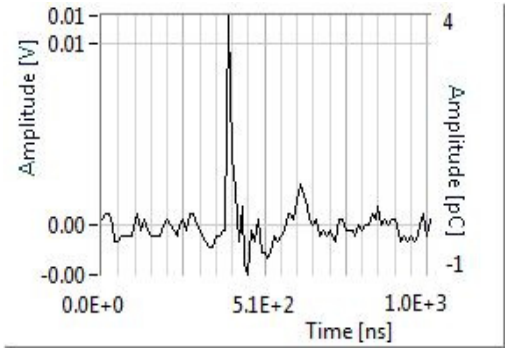
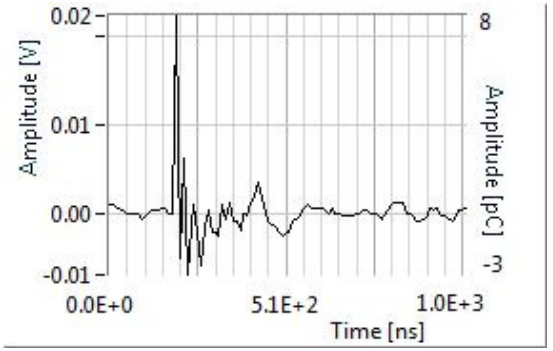
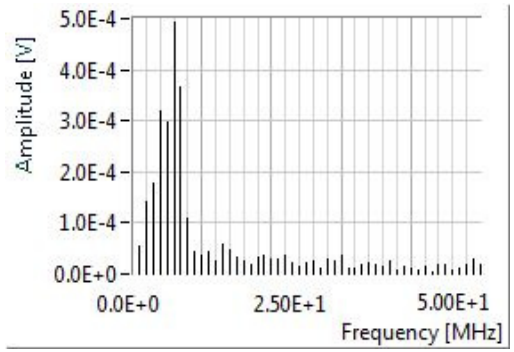
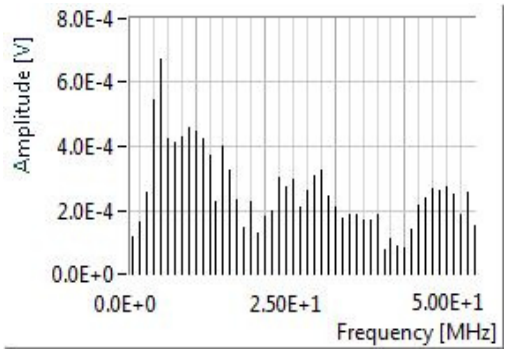
PD pulse typical frequency content

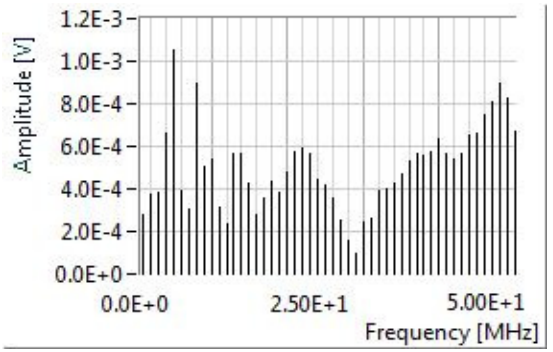












"Slow" pulses

Duration >1us

Spectrum <20 MHz

Typically surface PD

"Middle-fast" pulses

Duration <1us

Spectrum <40 MHz

Typically corona PD

"Fast" pulses

Duration <100 ns

Spectrum <80 MHz

Typically internal PD

Source IEEE Transaction on Dielectric and Electrical insulation papers

Agenda

- Solutions overview
- Experience and Success cases

Innovations for a better compatibility with the environment and the territory

Tools for asset management

Portable for spot PD measures

Grids for continuous monitoring

Wings sensors for PD and temperature

DLog for monitoring of analog signals

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1. Portable Differential EM Field PD sensor

PD instrument with:

- **Electro-magnetic field sensor**
- **Portable**
- **Wireless**
- **Galvanic isolation**
- **100MHz bandwidth**
- **Two outputs: PD pattern and AC synch.**
- **0,5pC sensitivity**

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1. Portable Differential EM Field PD sensor

Key advantages

- **Maximum safety** for operators thank to the galvanic isolation
- **Accurate and reliable diagnosis** thank to the complete PD pattern acquisition
- **No supply interruption**
- **Maximum flexibility** to test several components with one device

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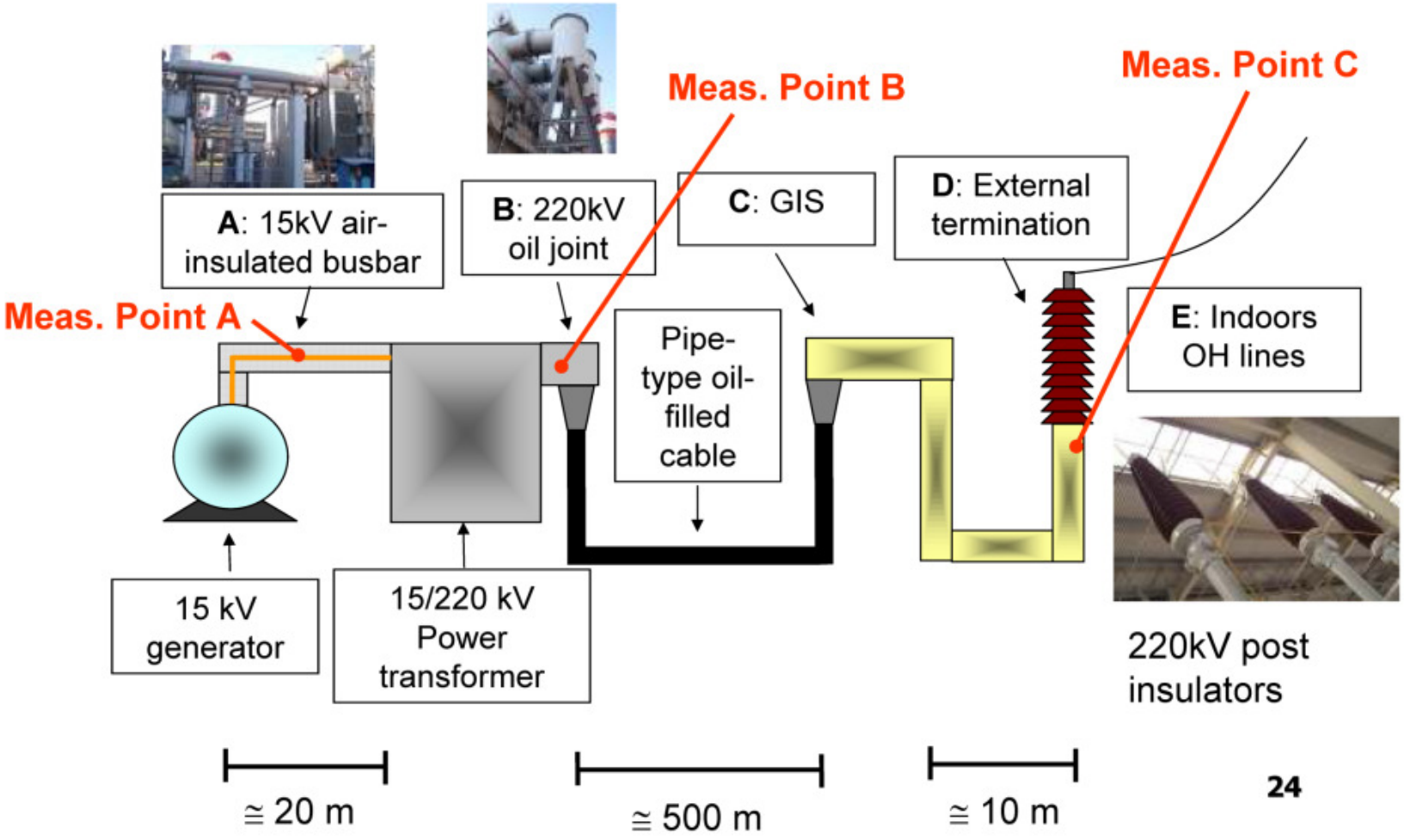
Why a portable instrument for PD measurements?



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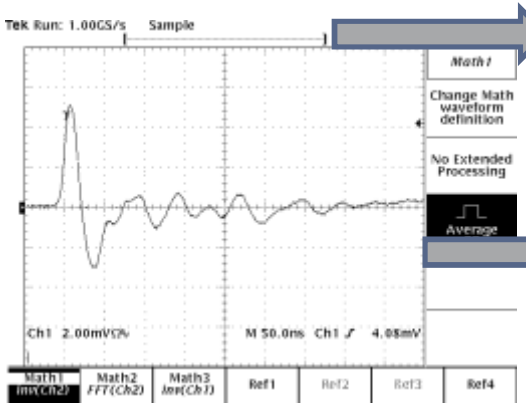
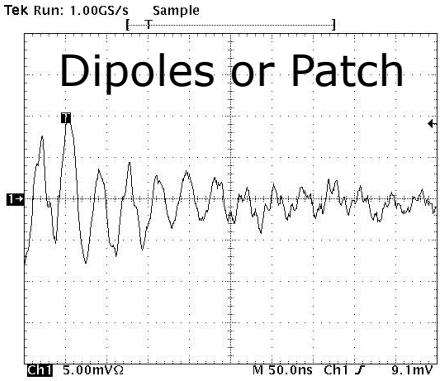
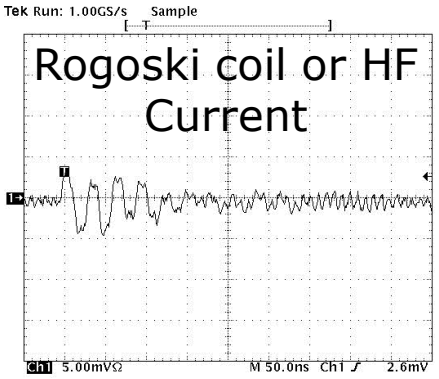
The sensor matters

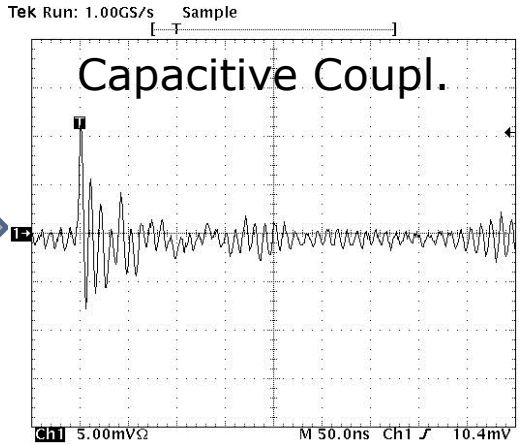
PD pulse

Adapted circuit 50Ω



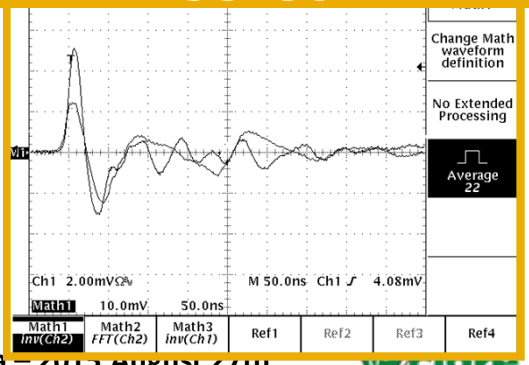






Accurate PD pulse reconstruction up to 100MHz

Differential EM field sensor



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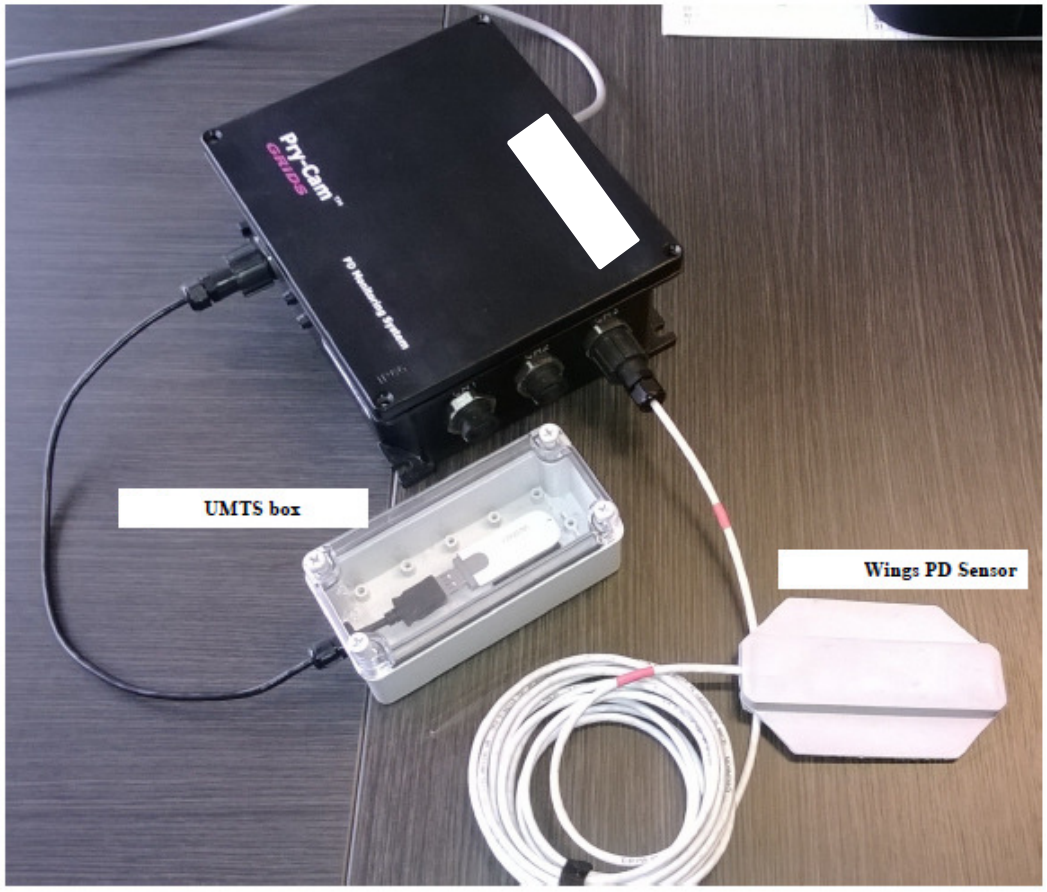
2. Grids permanent monitoring



Monitoring system with:

- **Continuos monitoring of PD, temperature, current, etc**
- **Installation without service interruption**
- **Galvanic isolation**
- **50MHz bandwidth**
- **1pC sensitivity**

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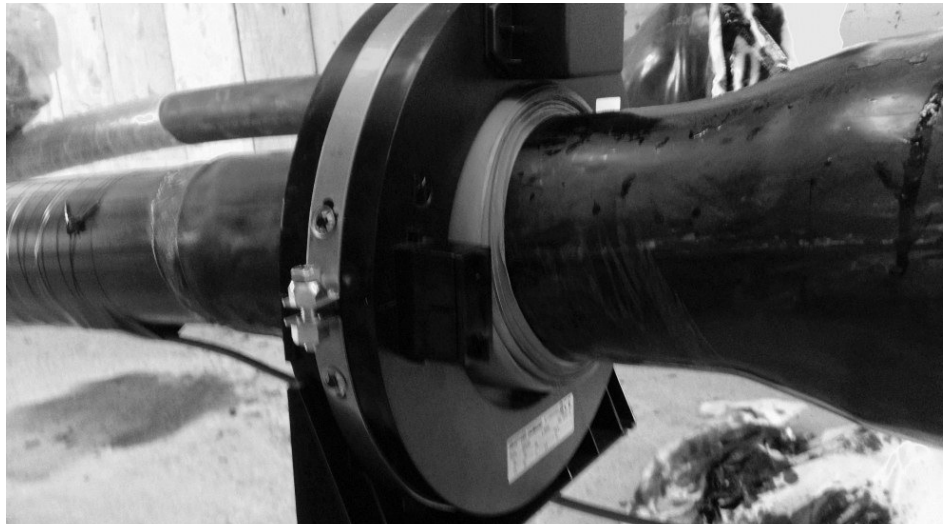
2. Grids permanent monitoring



Optional LV aux supply

- Energy Harvester Device
- External battery
- PV panel

Possibility to harvest power from HV cable sheath

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3. Wings Sensor

Wings sensors

- **PD, temperature and current** measurement
- **Easy-to-stick** on any components **without service interruption**
- Suitable for retrofitting

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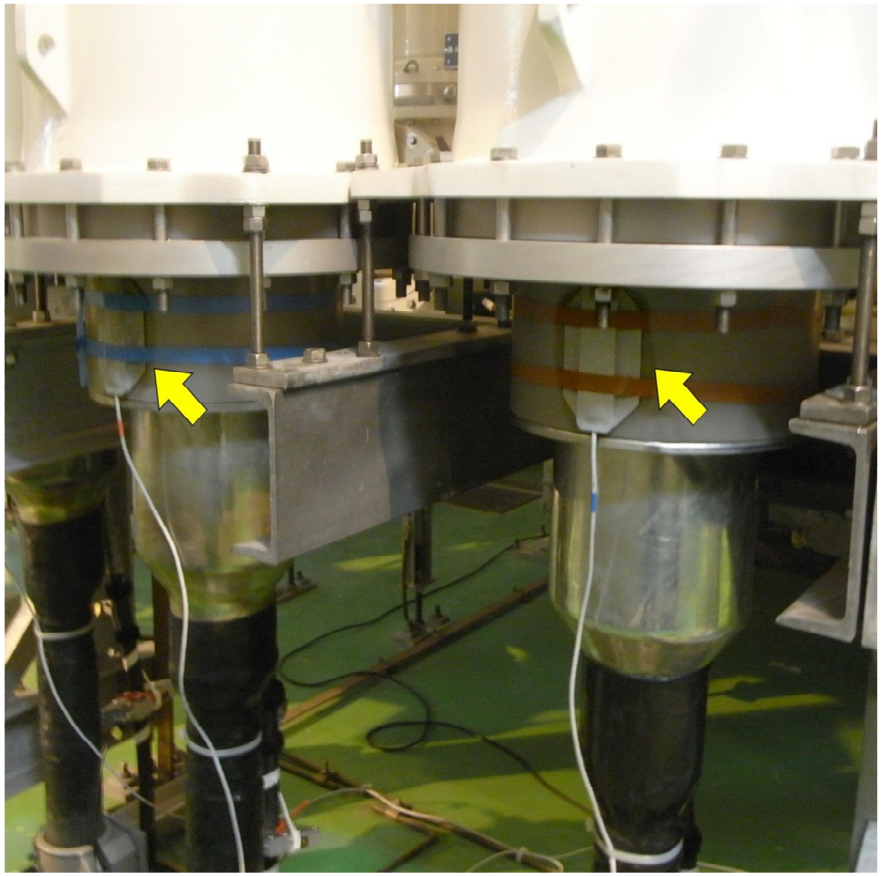
3. Wings Sensors

Wings sensors on power cable

Wings sensors on GIS terminations



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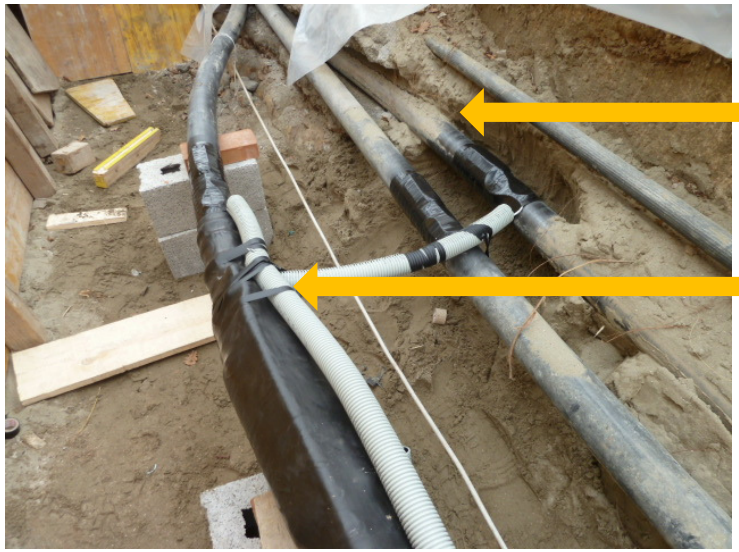
3. Wings Sensors



Wings PD sensors sticked and convered with tape

Plastic conduit for sensor cables to ground level

Sensor cable connectors protection at gound level

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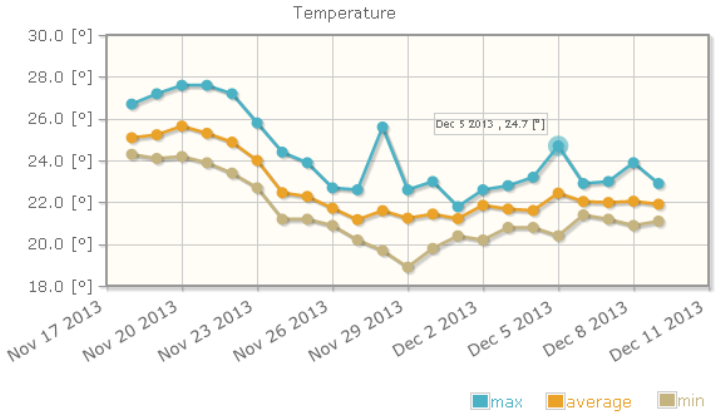
4. DLog for other key signals monitoing



Product features

- **inputs for analog signals** (e.g. temperature, pressure, current, voltage)
- **digital inputs or outputs**
- **Remote monitoring and processing**

Key advantages

- **Continuous tracking key parameters**
- **Advanced alarm functions**
- **Installation without service interruption**

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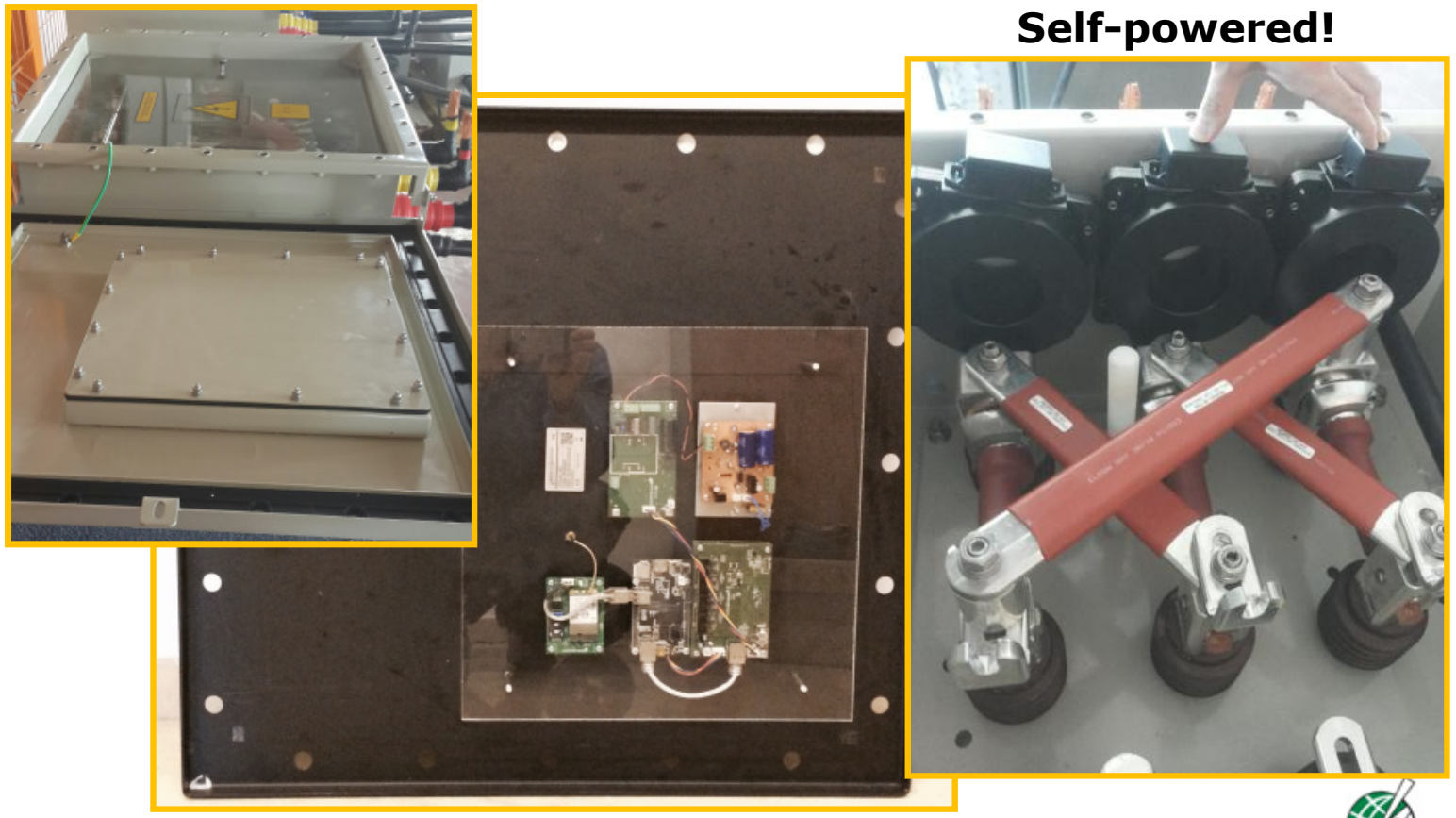
Tool for asset management: Smart LinkBox

Remote monitoring of key parameters: Screen Currents, SVL State, PD, internal flooding



Self-powered!

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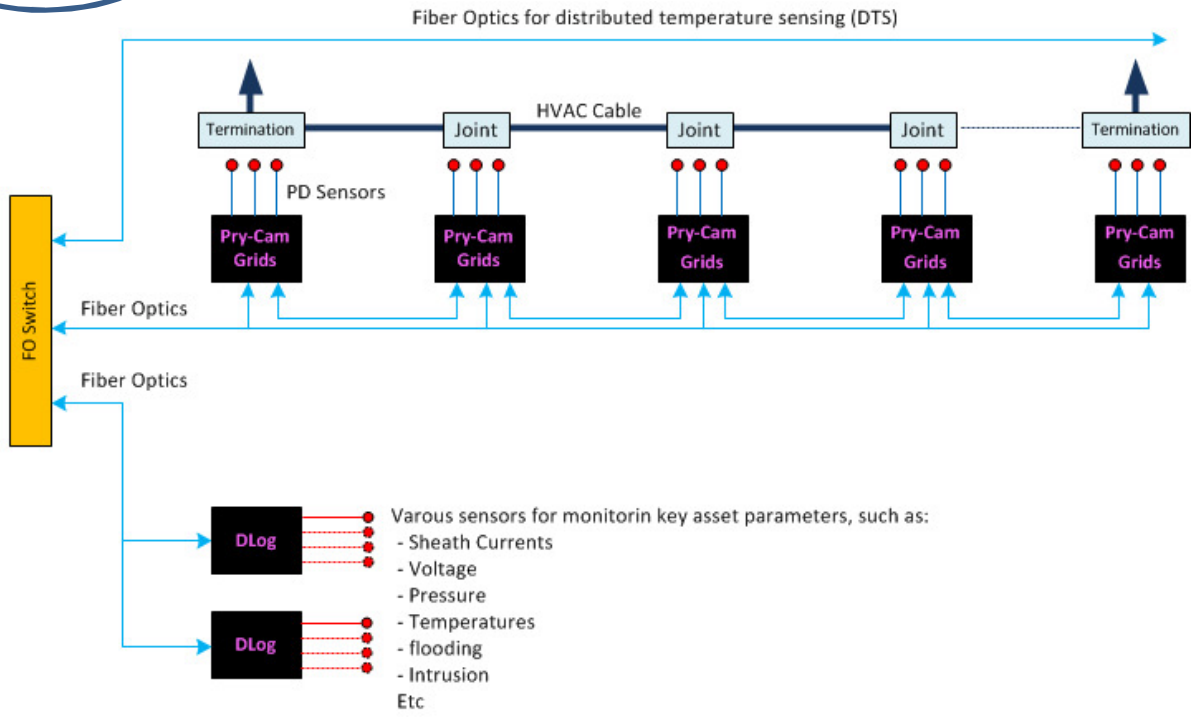
Example of combined Asset Monitoring

Asset Management common Platform

Pry-Cam Asset Management Local Server



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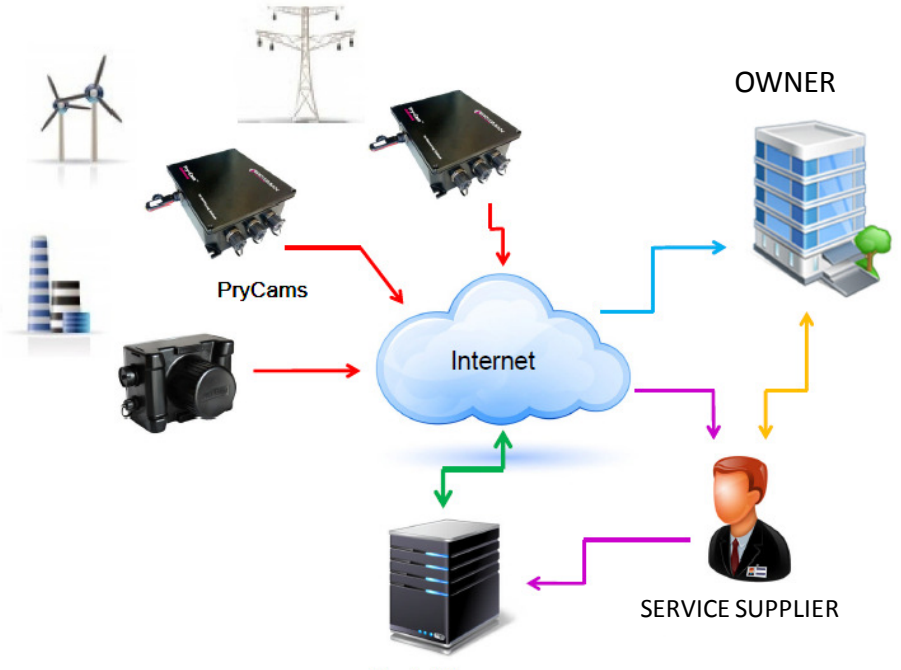
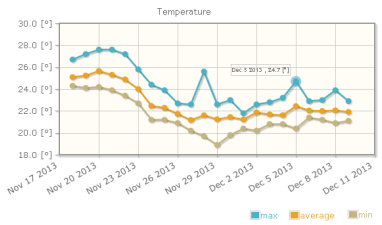
Asset Management Web Platform





Key advantages

- ***Remote monitoring***
- Data storage and protection
- ***Remote support from service supplier***
- ***Processing tools***:
  - Trendings
  - Alarms
  - Remote diagnosis
- ***Integrated asset supervision***:
  - PDs
  - Currents, Voltage
  - Temperatures, Pressures
  - Humidity, Smoke, Floodings, Intrusions
  - Others

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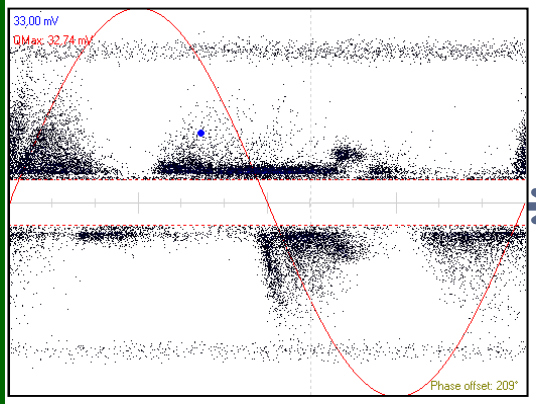
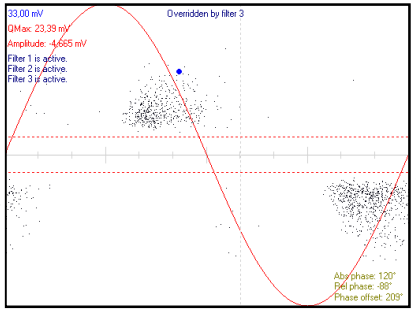
PD separation & classification

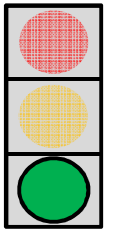
Complete PD pattern

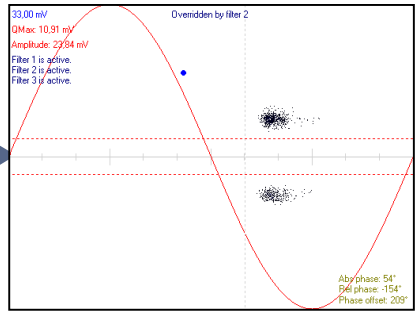


Advanced algorithm for PD separation

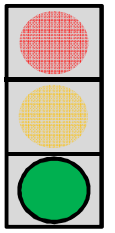


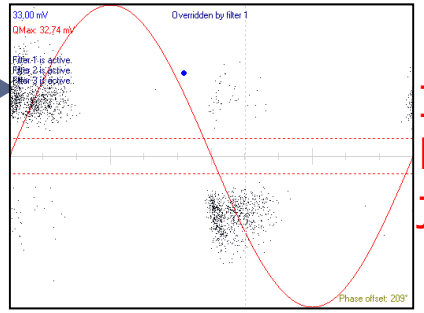
Surface PD on another phase



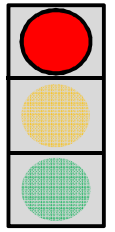


Corona





Internal PD on joint



Agenda

- Experience and Success cases

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Experiences

- More than 20,000 PD measurements

- More than 60 permanent PD monitoring systems

In different countries:

- Italy
- Spain
- UK
- France
- Middle East
- USA
- Canada
- Brazil
- Mexico
- Argentina
- Korea
- Turkey
- Netherlands

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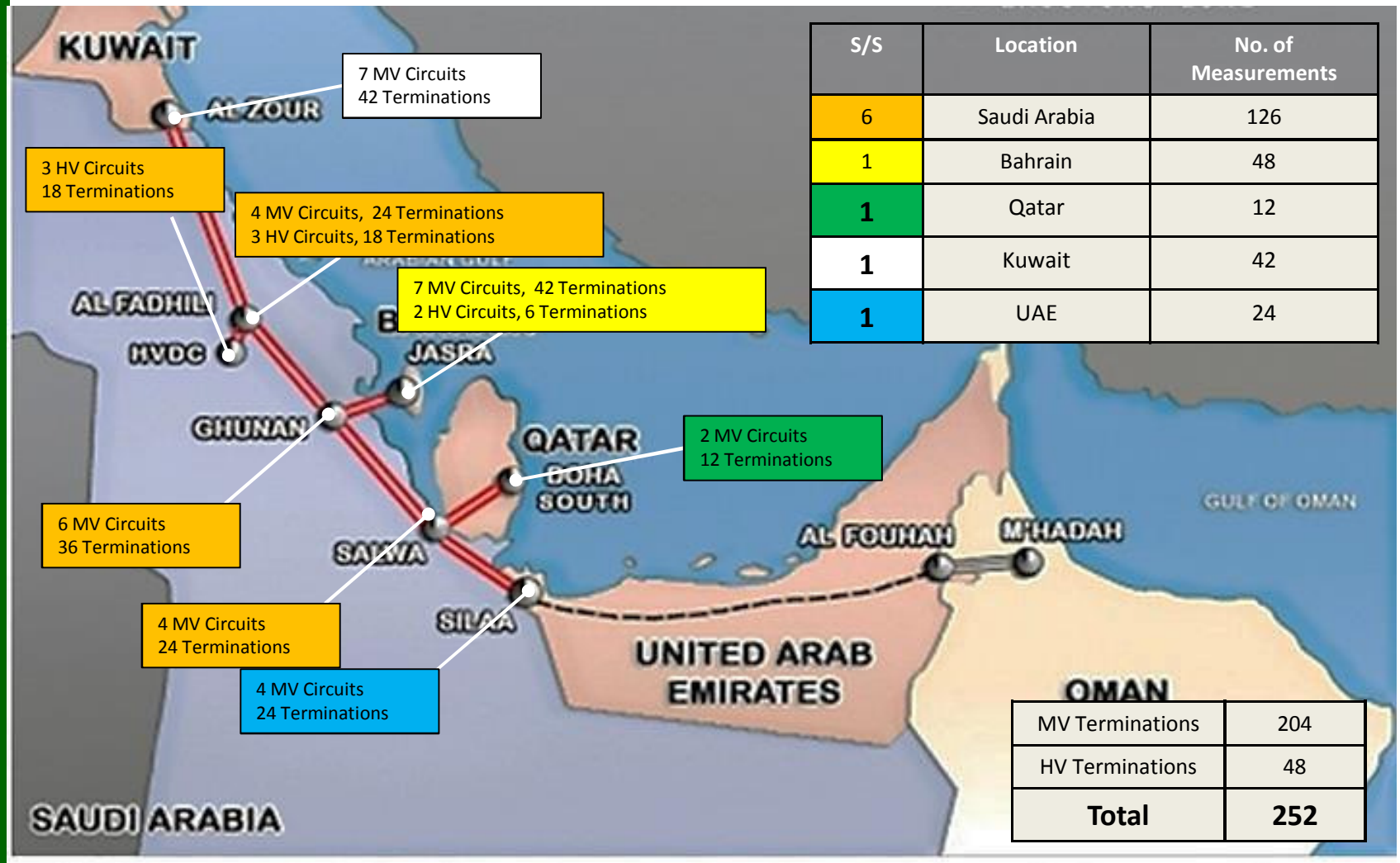
Experience case in Middle East (one shot)



S/S	Location	No. of Measurements
6	Saudi Arabia	126
1	Bahrain	48
1	Qatar	12
1	Kuwait	42
1	UAE	24

MV Terminations	204
HV Terminations	48
Total	**252**

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Experience case in UK - PD Monitoring on 400kV OF cable systems

PD monitoring on 2 critical & old circuits

- 400kV OF 10km
- 400kV OF 6kV
- 23 Grids systems with 200 Wings sensors
- 3G/UMTS connectivity

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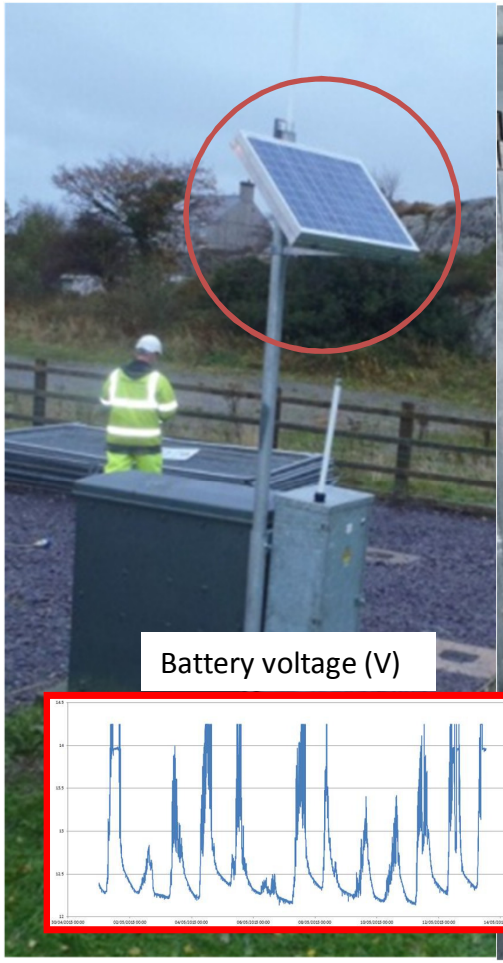
Experience case in UK - PD Monitoring on 400kV OF cable systems



- **3G/UMTS connectivity**
- **Data sent to Web Server**
- **Power supply with battery+PV panel**

Thanks to the low power demand of the measurement system

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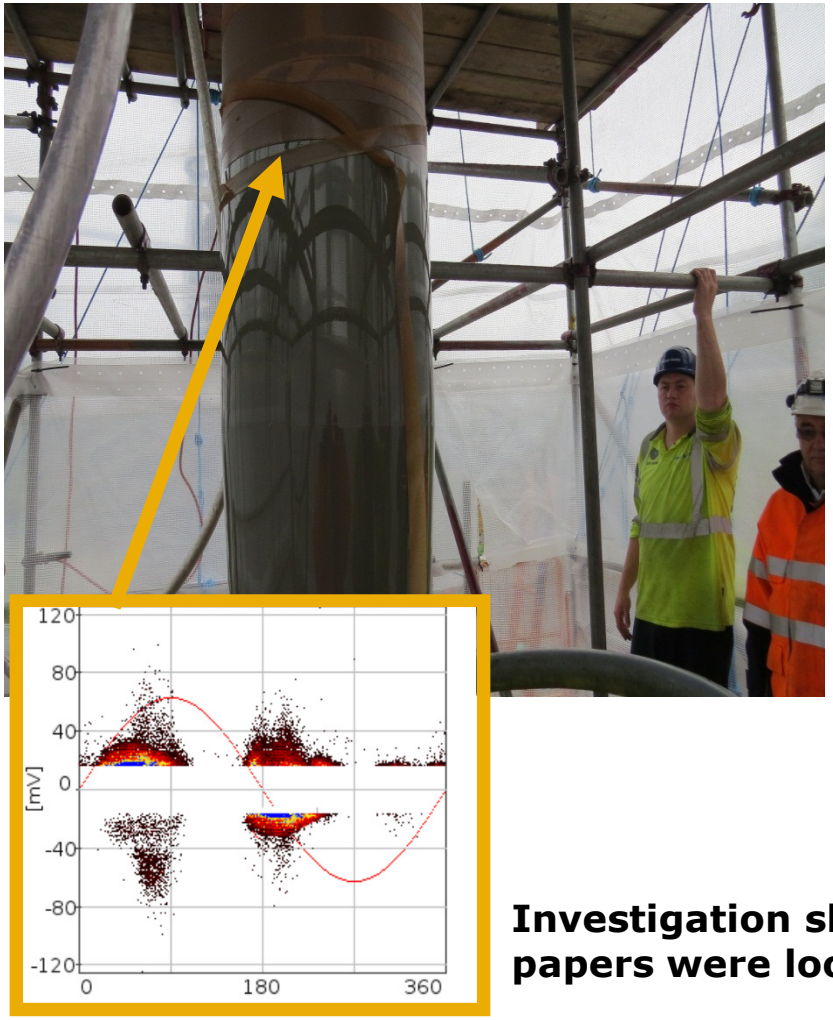
Success case in UK – PD detection on OF termination in Nuclear Power Station



- OF Termination having high levels of dissolved gas
- Potential loss of generation and explosion risk

Results with portable differential EM field PD detector:

- **Internal PDs found on phase B in few minutes**
- **Faults prevention**
- **No supply interruption**

Investigation showed that papers were loose/unwinding

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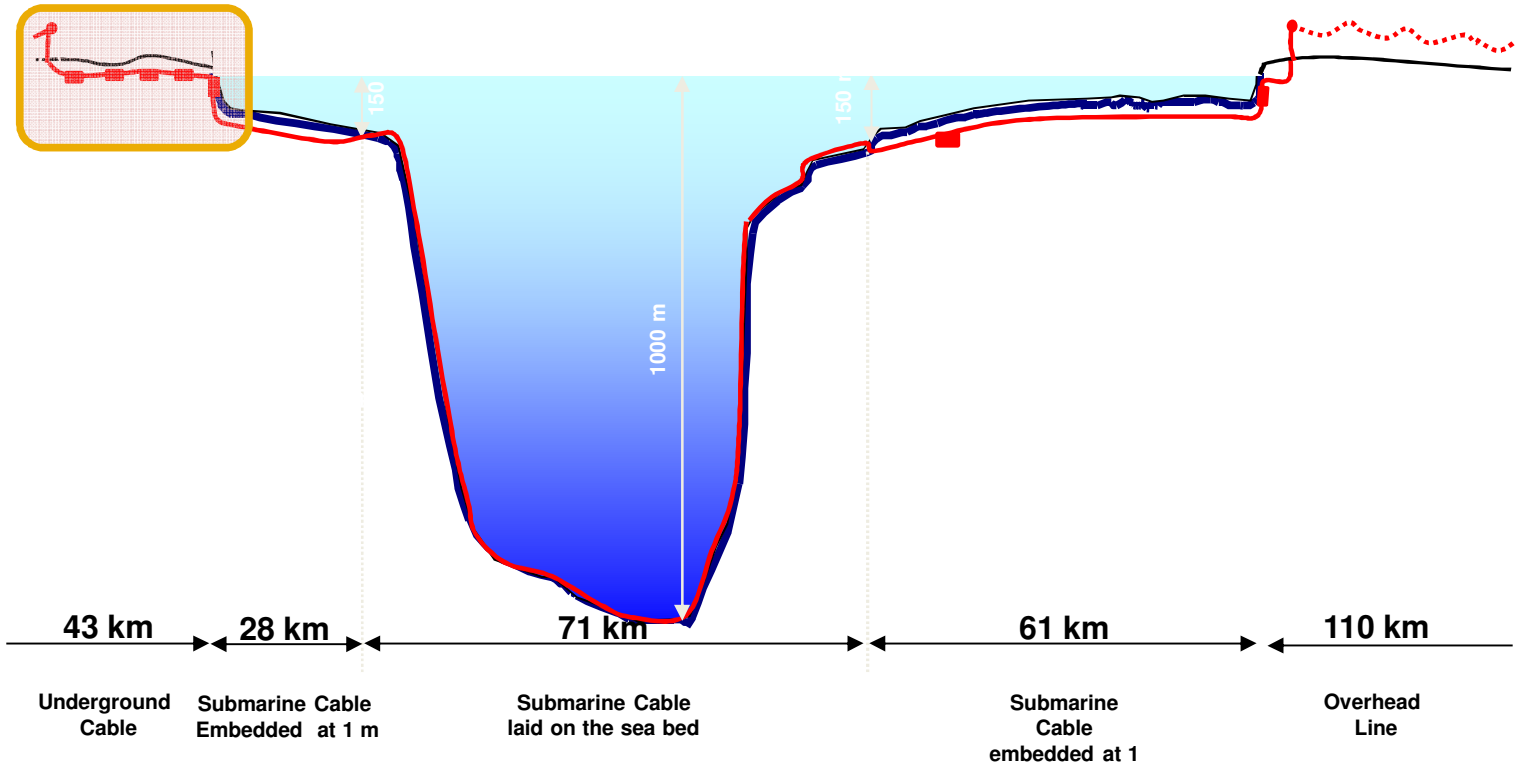
400 kV HVDC OF/Mass Impregnated (Italy)

Pressure and temperature monitoring on land oil filled cable system



Problems to be solved:

- **Analog Pressure monitoring out of order**
- **Not real time temperature monitoring**

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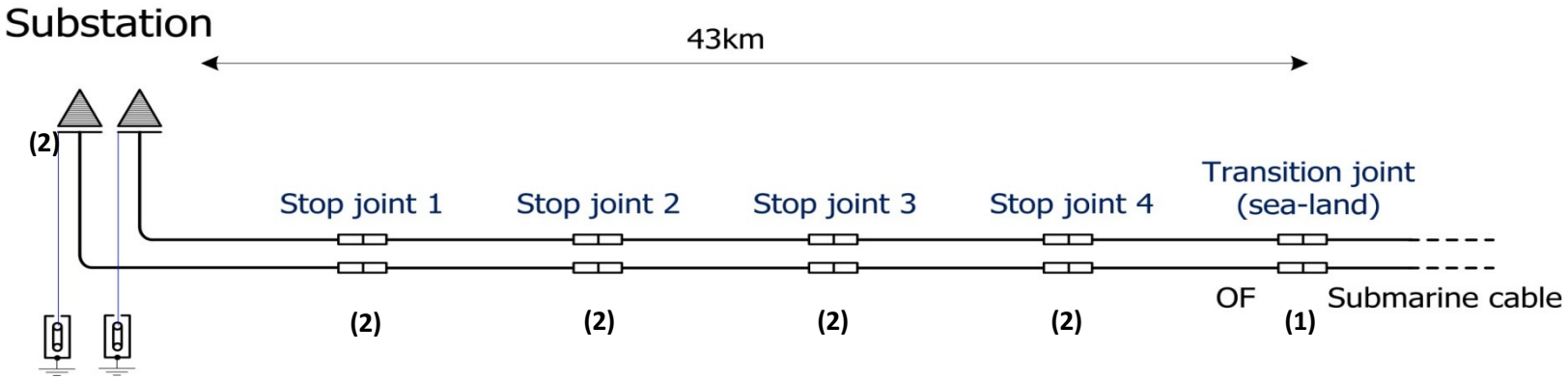
400 kV HVDC OF / Mass Impregnated (Italy)

Pressure and temperature monitoring on land oil filled cable system



Pressure monitoring on every hydraulic circuit (1)
Hot spots temperature monitoring (1)
Temperature real time monitoring on straight joints (2)

(1) - On transition joints, stop joints and outdoor terminations
(2) - Several straight joints (33 in total) are present between stop joints; only on some of them the temperature is monitored

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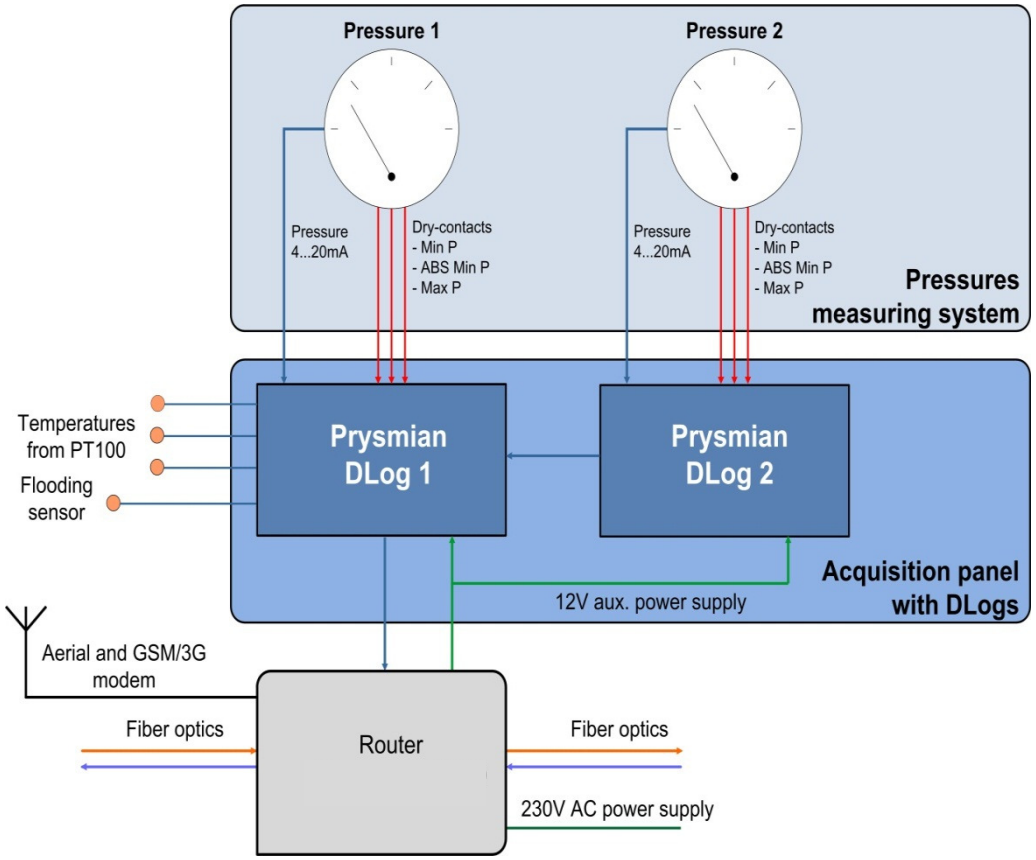
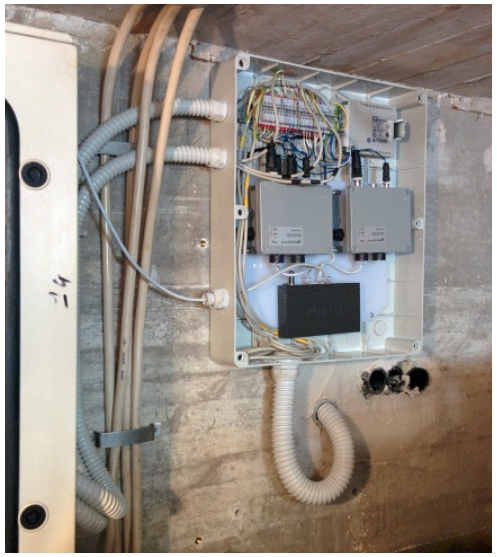
400 kV HVDC OF / Mass Impregnated (Italy)

State of the art solution



Acquisition panel

- High performance data logger
- Fibre optic connectivity to local server



Innovations for a better compatibility with the environment and the territory

400 kV HVDC OF / Mass Impregnated (Italy)

Asset Management Server

- **Analog pressure monitoring**
- **No temperature monitoring**

Real-time pressure and temperature monitoring from local server

Innovations for a better compatibility with the environment and the territory

Succes case in Canada

Comparative PD Tests

- Performance of the smart asset management compared with previous measurements
- 12 Dry Gel Terminations investigated

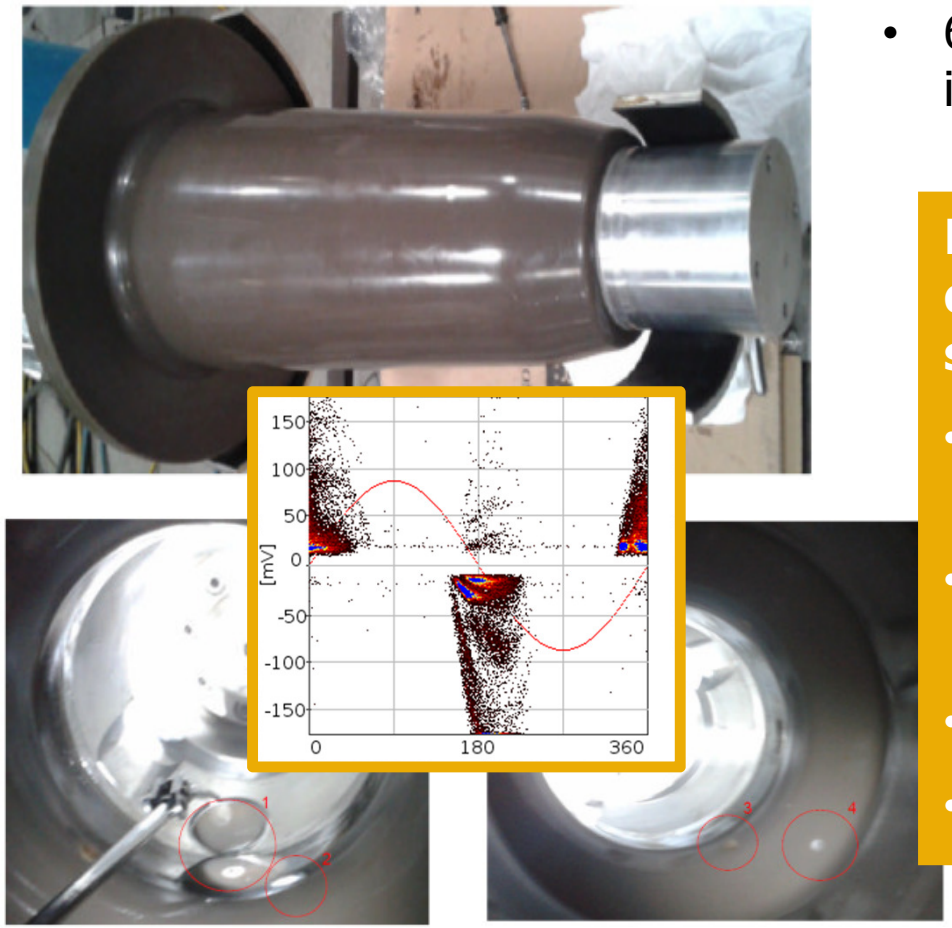
Results with portable differential EM field sensor:

- **More accurate and reliable diagnosis**
- **No supply interruption**
- **80% time saving**
- **Robust noise rejection**
- **No false positive**

Innovations for a better compatibility with the environment and the territory

Succes case in Spain

PD detections on HV terminals



- 6 HV terminations investigated

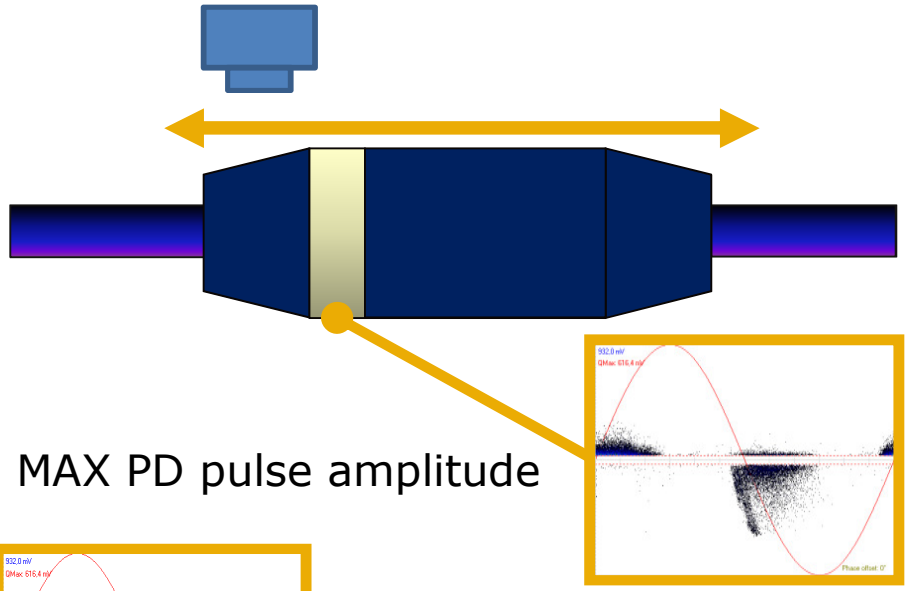
Results with portable differential EM field sensor:

- **Accurate and reliable diagnosis**
- **Detection of PDs on 2 terminations**
- **Faults prevention**
- **No false positive**

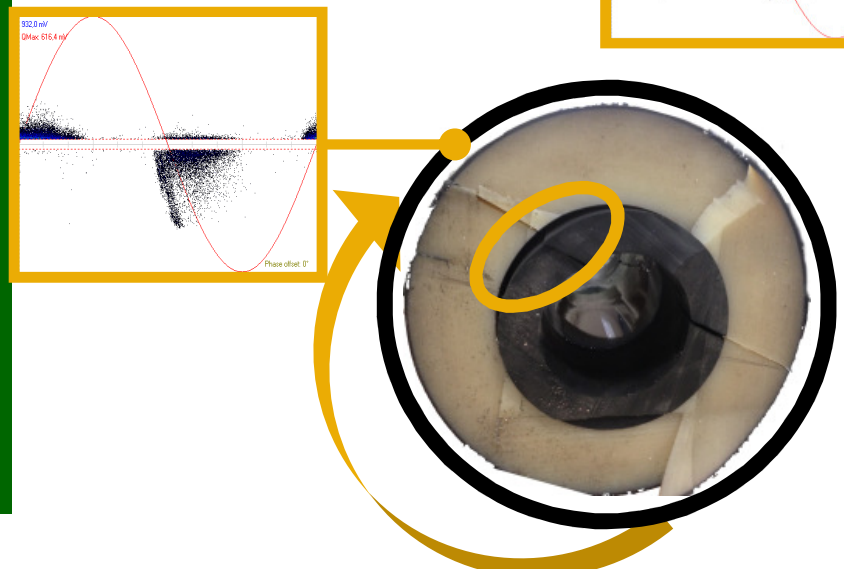
Innovations for a better compatibility with the environment and the territory

Succes case in Italy

Damage localization on Joint



MAX PD pulse amplitude



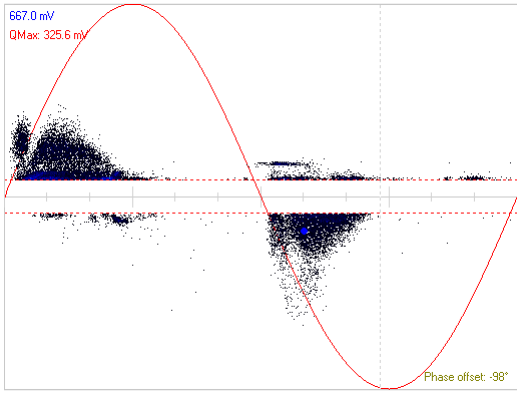
- HV joint
- PD measurements along and around the joint by simply moving the Pry-Cam

Results with Pry-Cam:

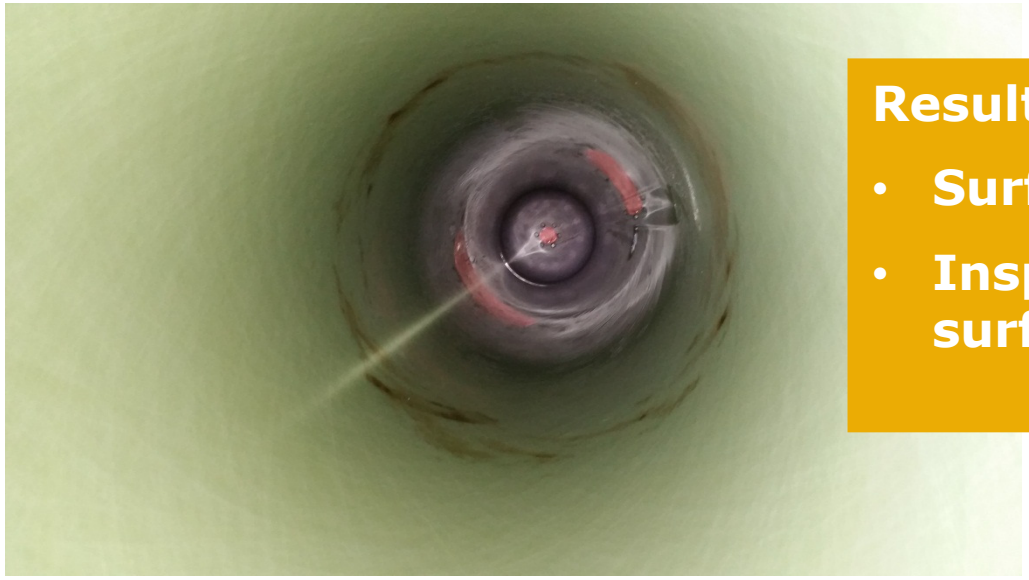
- **Accurate defect localization**

Innovations for a better compatibility with the environment and the territory

Succes case in Latvia



- 330 kV oil termination investigated under owner request



Results with Pry-Cam:

- **Surface PDs detected;**
- **Inspection confirmed surface PDs activity**

Conclusions

- Smart Asset Management is helping system operators and utilities to:
  - Increase reliability and safety
  - Decrease maintenance costs
  - Take risk-based decisions
- There is a strong correlation between disruptive failures and PDs
- On-line PD monitoring is crucial for fault prevenction and risk based maintanance
- Actual state-of-the-art of technologies and huge ammount of experiences are now available for network asset management optimization

Thank you

Prysmian Group

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Draka