Scienta Envinet

MIRA

Gross gamma detection system

July 2021

MIRA

Gamma dose rate monitoring system

Gamma dose rate monitoring system

- Gamma dose rate measurement with temperature-compensated GM tubes
- For mobile as well as fixed applications
- Extra wide dose rate range: 10 nSv/h – 10 Sv/h

- No infrastructure required
  - Extremely low power consumption
  - Battery and / or solar operation
  - Bi-directional, redundant wireless data communication
  - Compact design
- >10 years non-volatile memory, data synchronisation with network centre

Measurement

Two Geiger-Müller Tubes, LD + HD:

- Temperature and background compensated
- Deadtime correction
- Automatic switching between LD- and HD channel with overlap
- Detection range from 10 nSv/h – 10 Sv/h
- Individual calibration with certificate

All functionality on board

Full set of functions

- Base measurement interval 1min with three configurable aggregations
- Spontaneous calls on anomalous events
- Automatic switching to intensive mode
- 40+ technical and 10+ radiological statuses
- Internal health watchdog
- Automatic integrated accuracy test with detector health check and Android app

Robust design

Self-contained device for all conditions

- Optimized glass fibre housing for minimal gamma absorption and highest environmental resistance
- IP68 detector compartment, resistant to water, dust, sand and salt
- No maintenance required

- Operation range: -40°C – 60°C
- Wind resistance beyond 120 km/h

- GPS sensor for localization
- Optional binary rain sensor

Lowest power consumption

Fully autonomous operation

- 10mW power consumption
- Internal and external solar panel available
- Up to 40 days operation using the internal battery

- Battery exchangeable by user
- IP65 battery compartment

- 5V DC (USB)

Communication ready!

Manifold communication options:

- Built-in: LAN, RS 485, LTE/3G/2G (antennas inside)
- Service: RS 232, Bluetooth
- In cabinet: Iridium satellite, RF radio, LoRa WAN

- Bi-directional TCP/IP communication, compressed binary
- Secure TLS/SSL data transfer, APN

- Up to 5 monitoring centres
- Full support in NMC

Perfectly integrated with NMC

The network centre, local and in the cloud:

- Time series plots and analysis
- Reporting and data-sharing functionality

- Alarm management
- GIS integration

- Secure communication and remote configuration
- Consolidation of communication channels

Variants available (examples):

Gamma Detector	Fixed Monitoring Station	Autonomous Station	Mobile Station
			
• Flexible application	• Remote application	• Various applications	• Mobile use, with GPS

CONFIGURED TO YOUR NEEDS

	• LAN, LTE, RS-485 etc.	battery buffer • Wireless communication, LTE and satellite	• Wireless communication • Quickly deployable

A selection of useful accessories

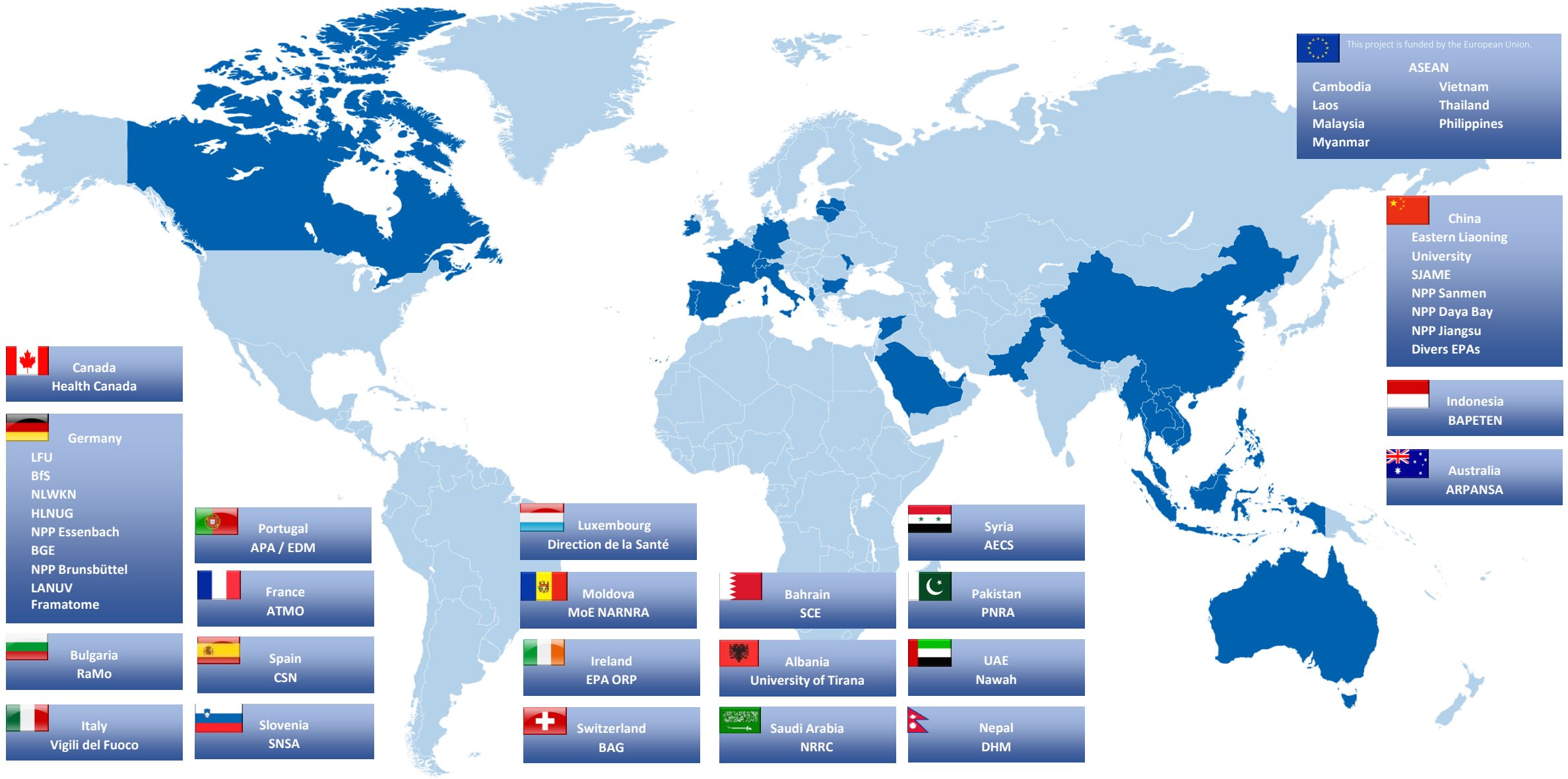
Test set

- For recurring automatic accuracy test
- Cs-137, ~360 kBq or Eu-152, ~500 kBq
- Including carrying case

Vaisala weather station

- High quality weather data
- Precipitation, humidity, temperature, wind speed and direction, pressure
- Low power consumption
- Perfect addendum for measurement plausibility checks and GDR prediction

MIRA: Reference customers



This project is funded by the European Union.

ASEAN
- Cambodia
- Laos
- Malaysia
- Myanmar
- Vietnam
- Thailand
- Philippines

China
- Eastern Liaoning University
- SJAME
- NPP Sanmen
- NPP Daya Bay
- NPP Jiangsu
- Divers EPAs

Indonesia
- BAPETEN

Australia
- ARPANSA

Canada
- Health Canada

Germany
- LFU
- BfS
- NLWKN
- HLNUG
- NPP Essenbach
- BGE
- NPP Brunsbüttel
- LANUV
- Framatome

Portugal
- APA / EDM

France
- ATMO

Spain
- CSN

Slovenia
- SNSA

Bulgaria
- RaMo

Italy
- Vigili del Fuoco

Luxembourg
- Direction de la Santé

Moldova
- MoE NARNRA

Ireland
- EPA ORP

Switzerland
- BAG

Bahrain
- SCE

Albania
- University of Tirana

Saudi Arabia
- NRRC

Syria
- AECS

Pakistan
- PNRA

UAE
- Nawah

Nepal
- DHM

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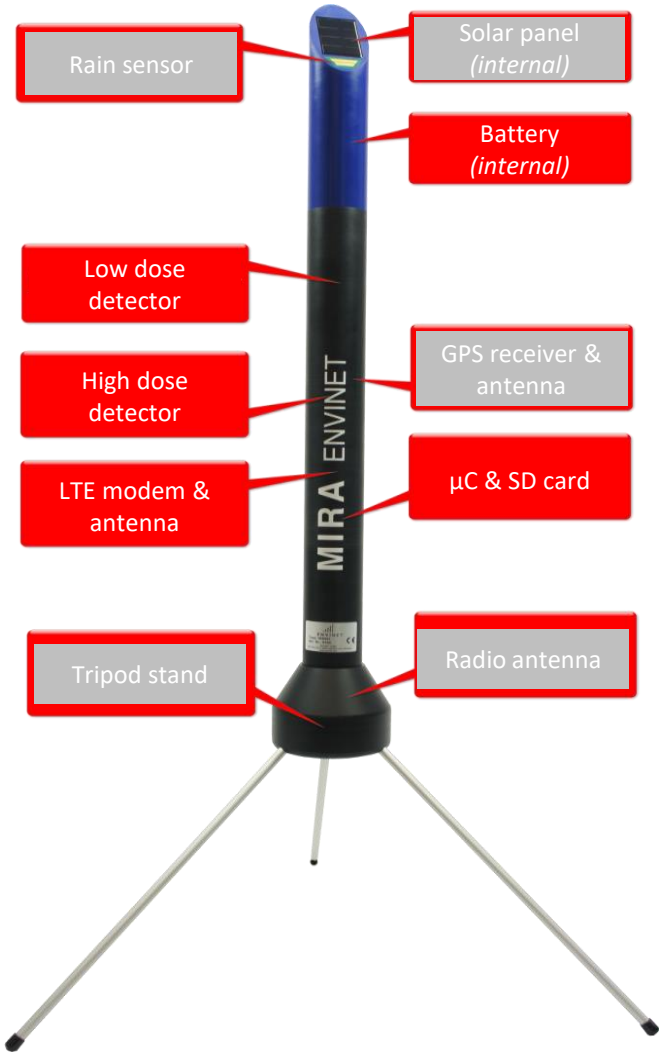
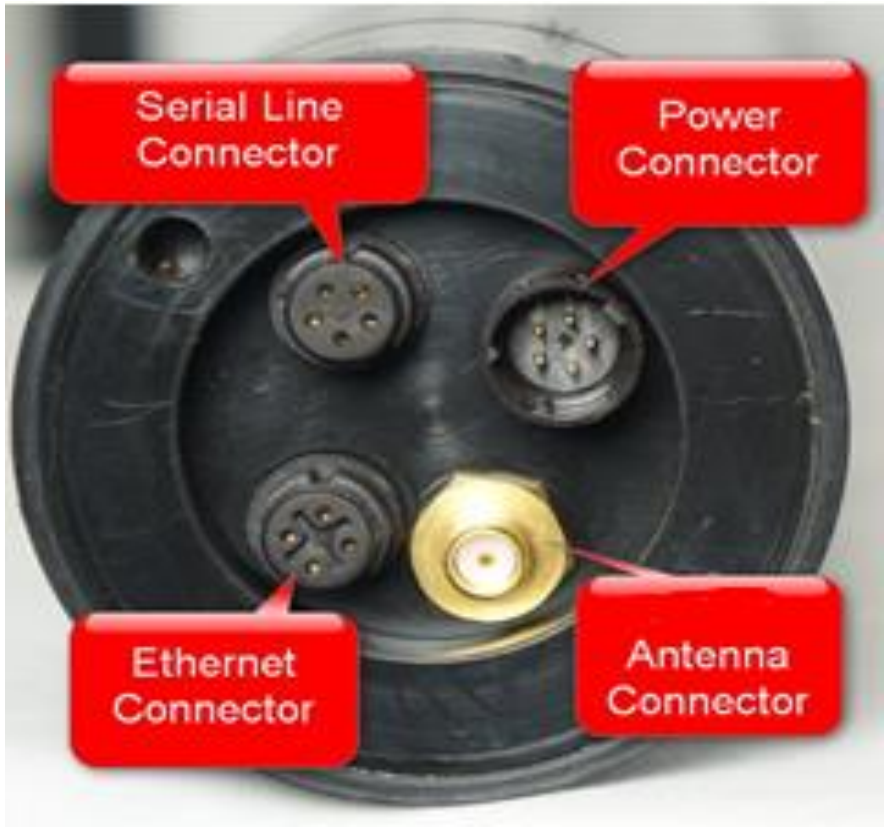
Components and supply

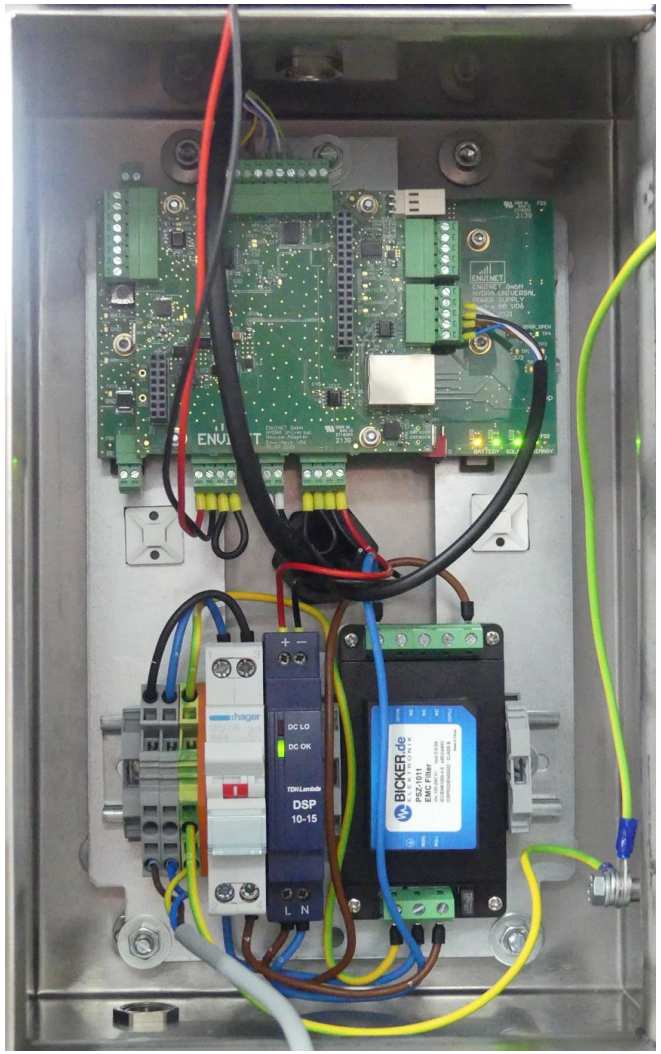
Major components



Binder type



Fischer type



Main features

- Supply via mains and/or solar
- UPS functionality (supports Li and Pb batteries)
- Overvoltage protection
- 12 VDC and 5 VDC supply voltages

- “Door open” and “battery low” signal
- Power status LEDs

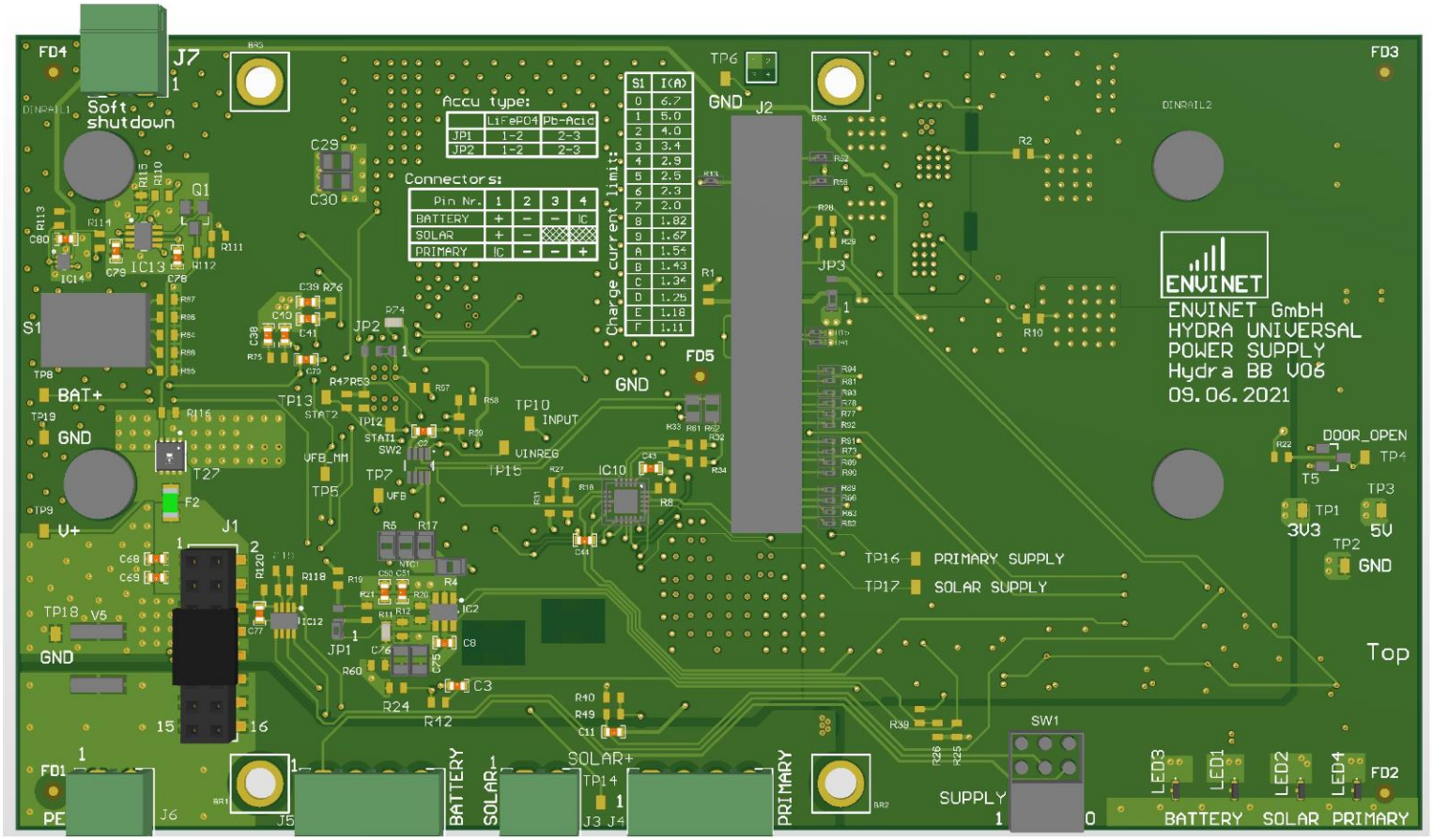
- Unique interface to MIRA and SARA
- Access to serial console via USB
- LAN interface
- Serial interfaces to external devices
  (radio or satellite modems, weather transmitter etc)

- External display *(option)*

Cabinet with external devices

- incl. stack with
  Hydra BB – EnviNeck - UARTNeck
- required for
  2 or more serial devices to be connected

Power supply connectors *(Hydra)*



PE

Battery

Solar panel

Mains supply
5 … 25 VDC

ON/OFF
external supply

Batt voltage present

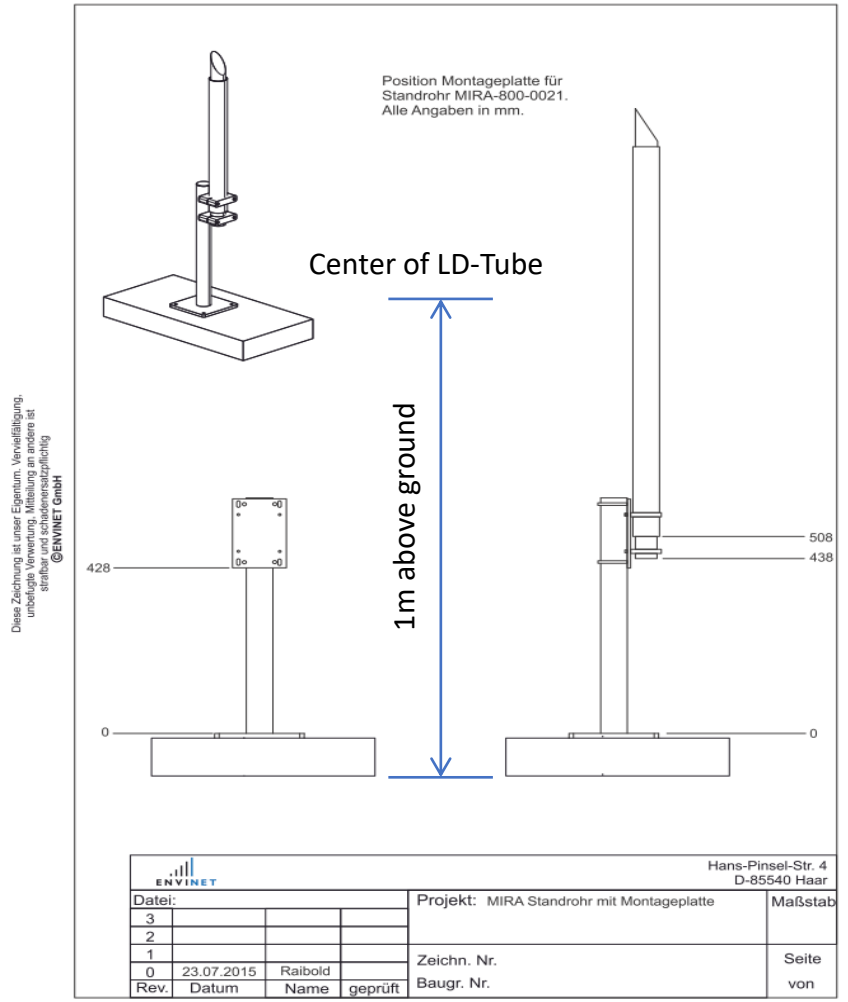
Batt voltage good

Solar supply present

Mains supply present

Battery voltage must be < 15 VDC for LED signaling

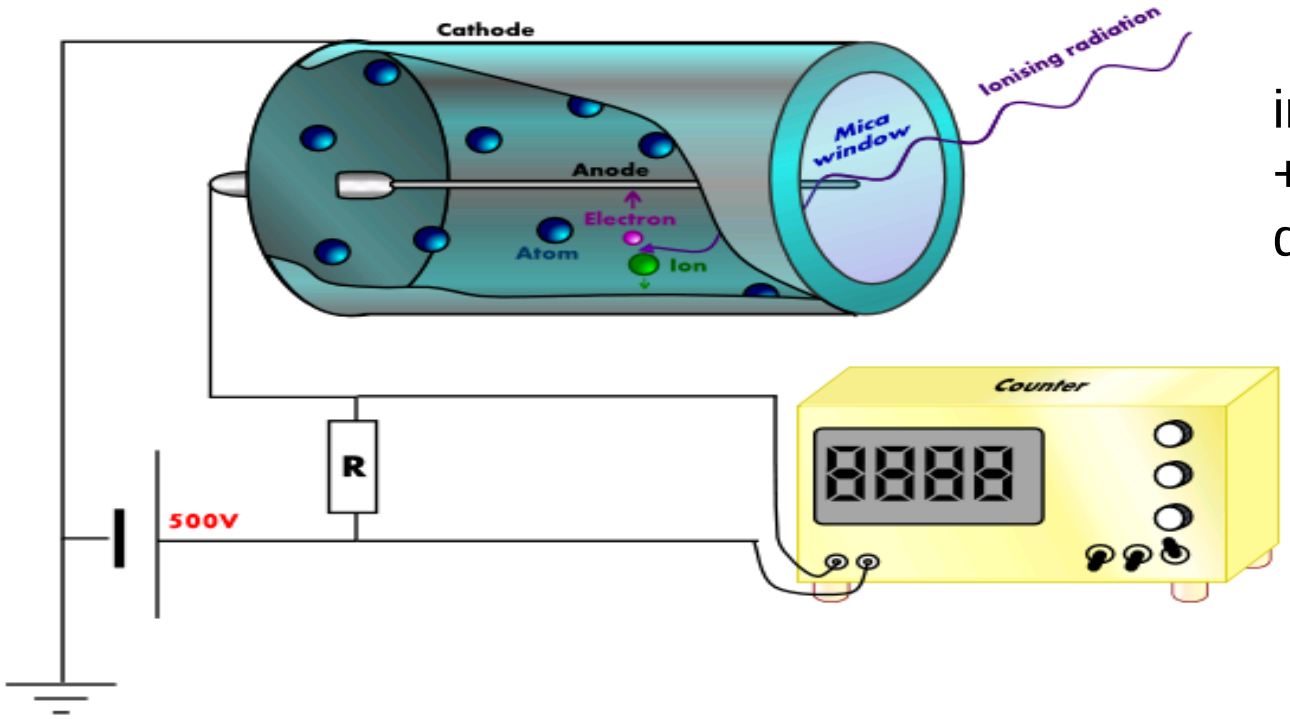
Mounting the probe



MIRA

Measuring gamma dose rate

Detection of ionizing particles with Geiger-Müller-Tubes

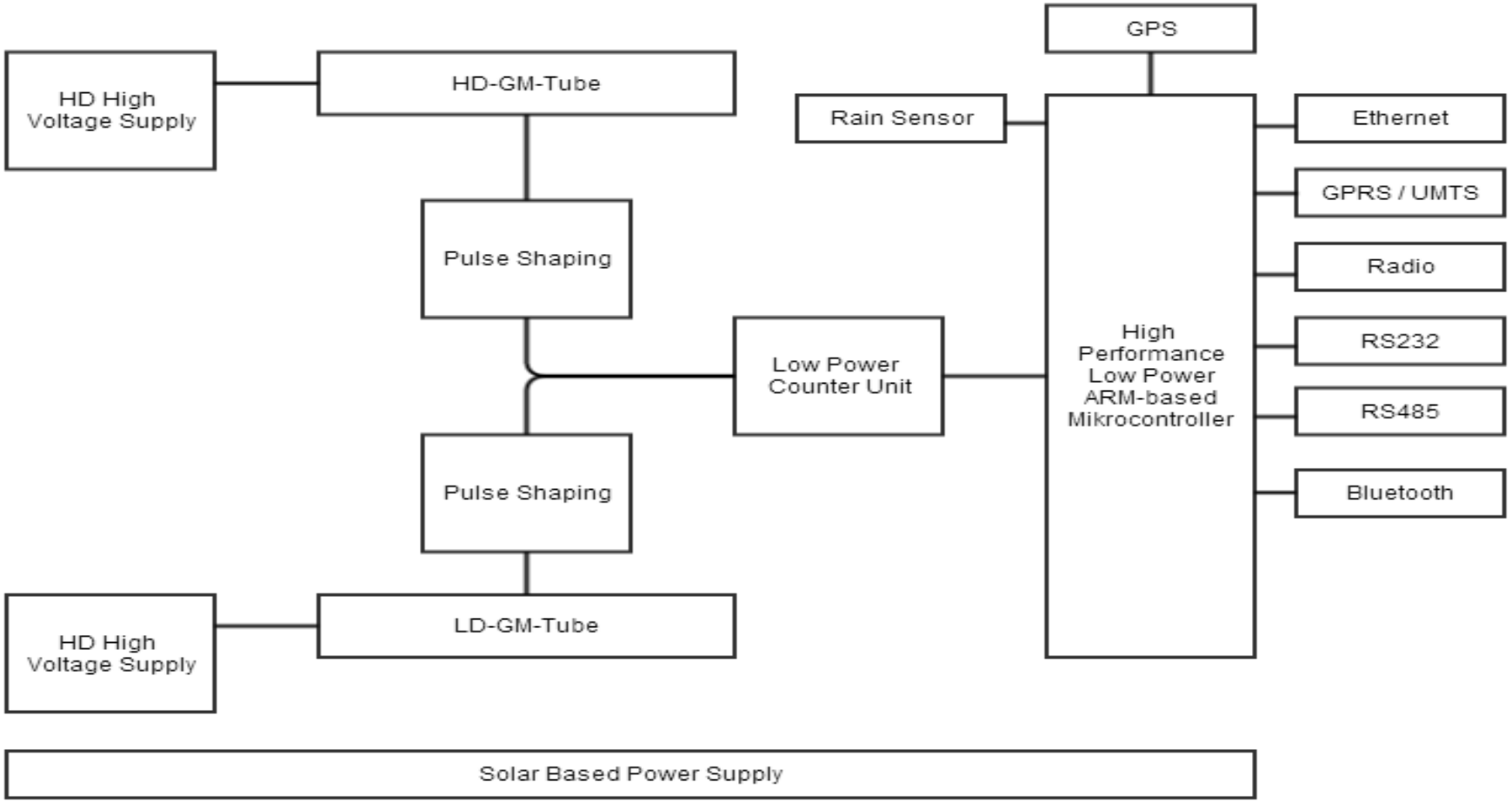


inert counting gas (Ne)
+
quenching gas (halogen)

Result: counts per minute (cpm) ~ intensity of gamma radiation field

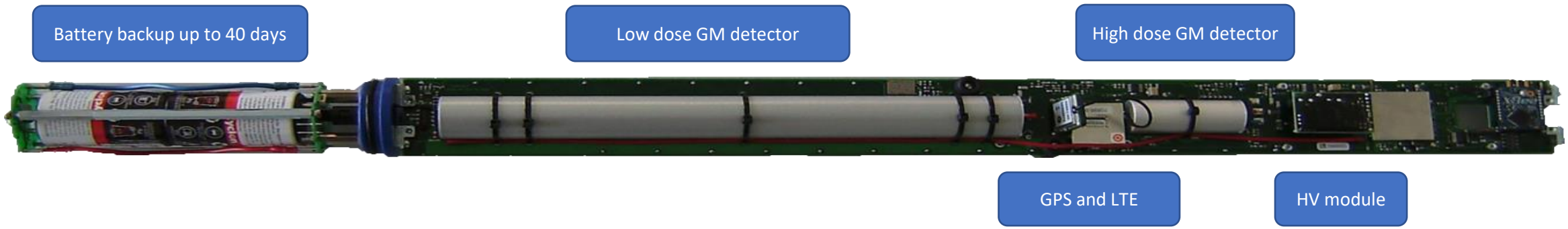
(α, β absorbed)

Functional structure gamma probe

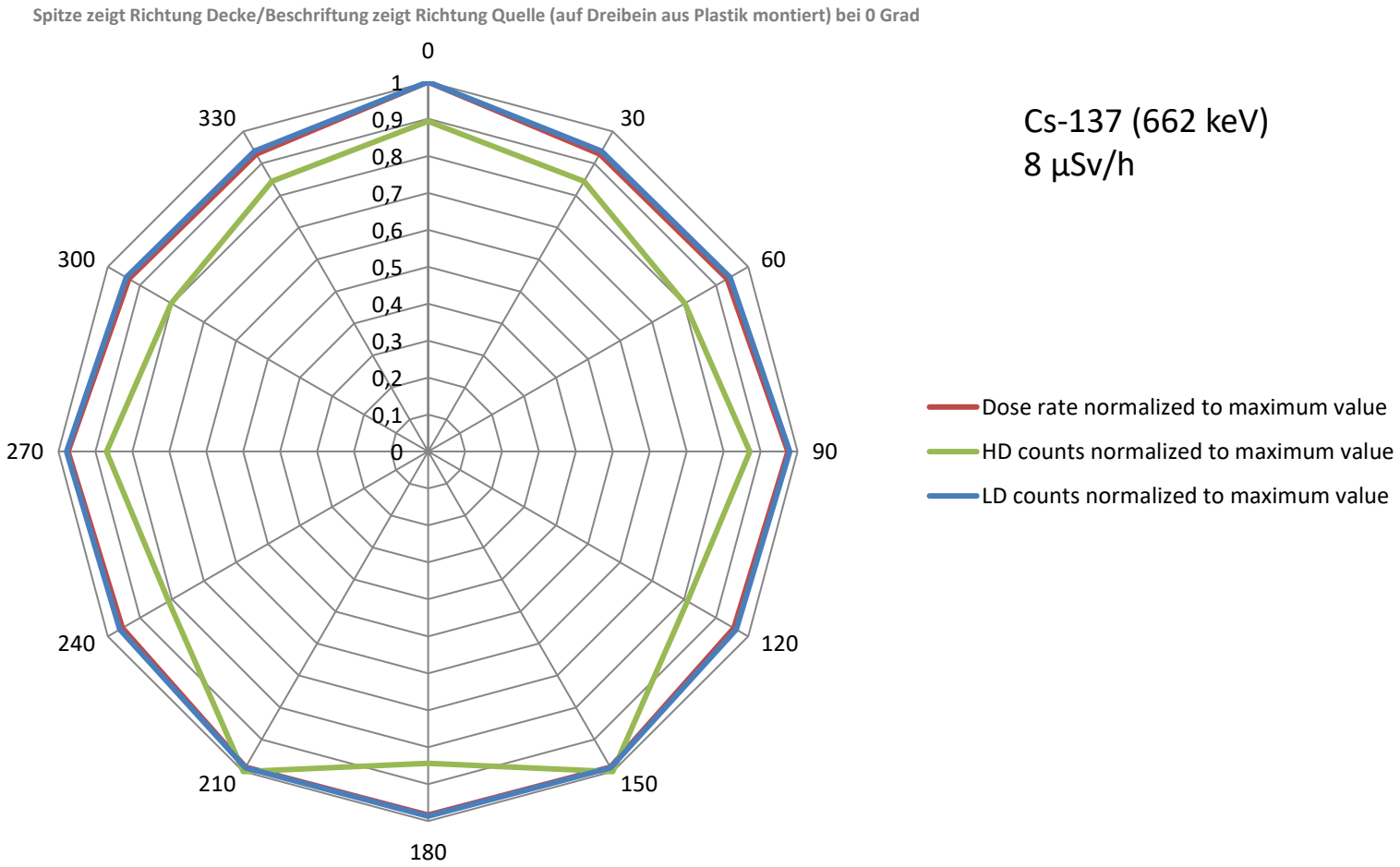


GM detector specification

- Detection range 10 nSv/h … 10 Sv/h
- Accuracy ± 15 %
- Calibrated energy range 38 keV … 1.3 MeV (3 MeV)
- Temperature compensation < 1% per 10°C
- Sensitivity LD 809.5 cpm / µSv/h (max 300,000 cpm)
  HD 0.9404 cpm / µSv/h (max 3,000,000cpm)
- LD intrinsic background compensated
- Operating temperature - 40° … + 60°C



Polar response



Cs-137 (662 keV)
8 µSv/h

MIRA

Options and extensions

Vaisala WXT530 Series

- Measure parameter options
  - Precipitation 0 … 200 mm/h @ < ± 5%
  - Wind speed and direction 0 … 60 m/s @ ± 3% / 0 … 360° @ ± 3°
  - Pressure 600 … 1100 hPa @ ± 1 hPa
  - Temperature -52 … +60°C @ ± 0.3°C
  - Relative Humidity 0 … 100 %rH @ ±3/5 %rH
- Connection via serial interface
- Low power consumption (42 mW)
- Full integration
  - Part of MIRA measure value ensembles
  - Display as data series in NMC

Iridium Edge

NETWORK

- Frequency: 1616 – 1626.5 MHz
- Message Size: 270 bytes (Receive), 340 bytes (Transmit)
- SBD Transceiver: Iridium 9602N
- Antenna: Integrated Iridium® certified antenna

ENVIRONMENTAL

- Operating Temperature Range: -40C to 85C
- Storage Temperature Range: -40C to 85C
- Vibration: SAE J1455, Section 4.10

MECHANICAL

- Dimensions: 130 mm (L) x 80 mm (W) x 30 mm (H)
- Ingress Protection: IP 67
- Side and Bottom Cable Exits
- Connector: M12-8 pin male, terminated on 20cm pigtail cable
- Installation Options: Pole, Screw, Tape

CERTIFICATIONS

- Iridium® Satellite Network Certification
- RoHS Compliant
- FCC, IC, CE, Australia Approvals

POWER

- Power Supply: (9-32V), SAE J1455 Load Dump Protected
- Maximum Power: 1.6W (Peak for Short Transmit Burst)
- Low Power Modes: < 200uA
- Reverse Polarity Protection

INTERFACES

- RS232 AT Command Interface
- On/Off Control Lines

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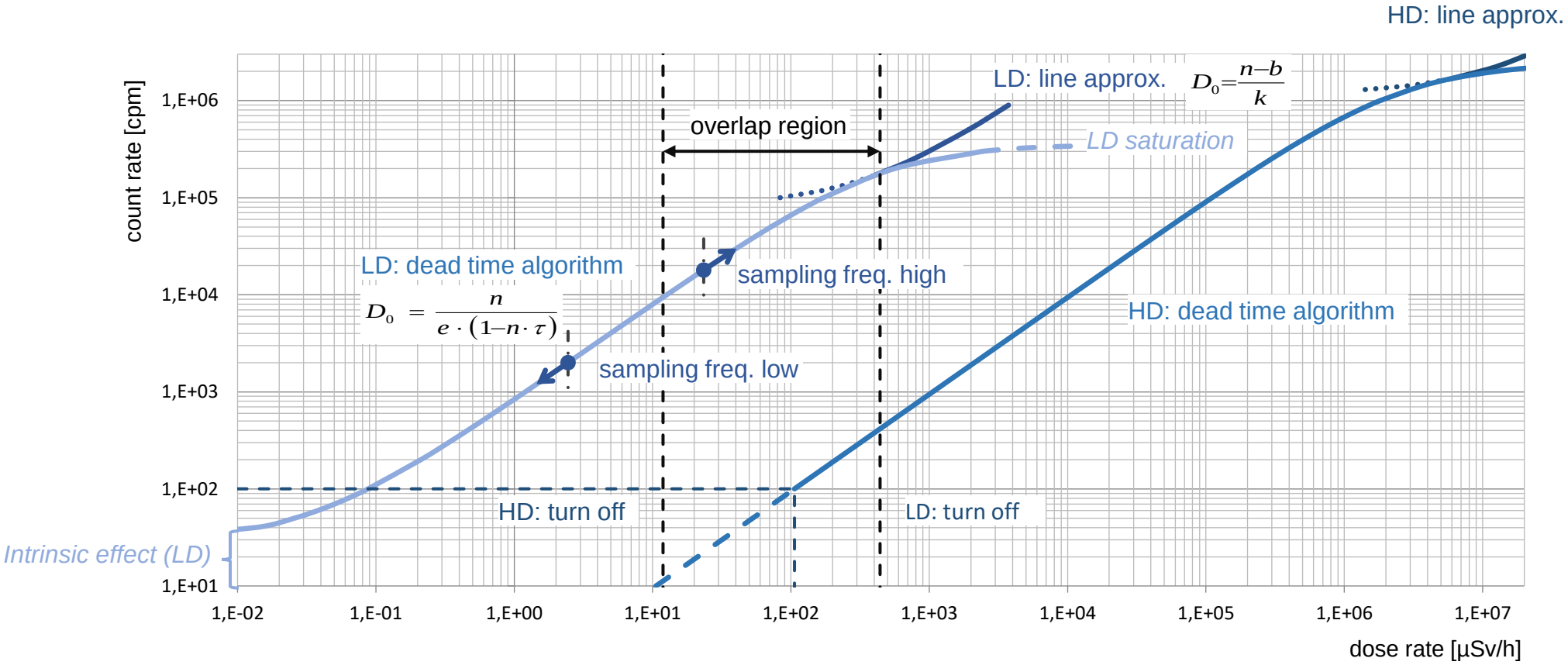
Data evaluation

Energy compensation / no discrimination between gamma energies

Calibration with reference to **Cs-137 (662 keV)** source up to 10 Sv/h
at standard laboratory HZM (Helmholtz-Zentrum München)



Periodic self-test

- Probe enters state 0 (LD/HD on, high sampling freq.)
- Raw pulse rates from LD and HD used to check detector functionality:
  - Minimum criteria ($\sum_{t_{min}} n_i > n_{min}$ for each channel)
  - Pulse rate correction after clock synchronization
  - Comparison LD – HD cannel
  - Pulse rate drift

Dose rate calculation

Evaluated pulse rate n

10 sec base interval *(default)*

correct interval for time synchronisation

Calculate uncorrected dose rate D_0

$$D_0 = \frac{n}{e \cdot (1 - n \cdot \tau)}$$

e Sensitivity

τ Dead time

dead time algorithm

line approximation $D_0 = \frac{n - b}{k}$

Calculate corrected dose rate

- subtract temperature compensation $D_T = \frac{1}{e}\left(p_1 + \frac{1 + p_2(T + p_3)^2}{1 + p_4 \cdot T}\right)$
- subtract intrinsic effect *(~ 30 … 40 nSv/h)*
- subtract location correction factor *(configurable; default =0)*
- plausibility of readings in succeeding intervals *(disabled)*

Sum up aggregated values

System time: UTC

Options for real time synchronization

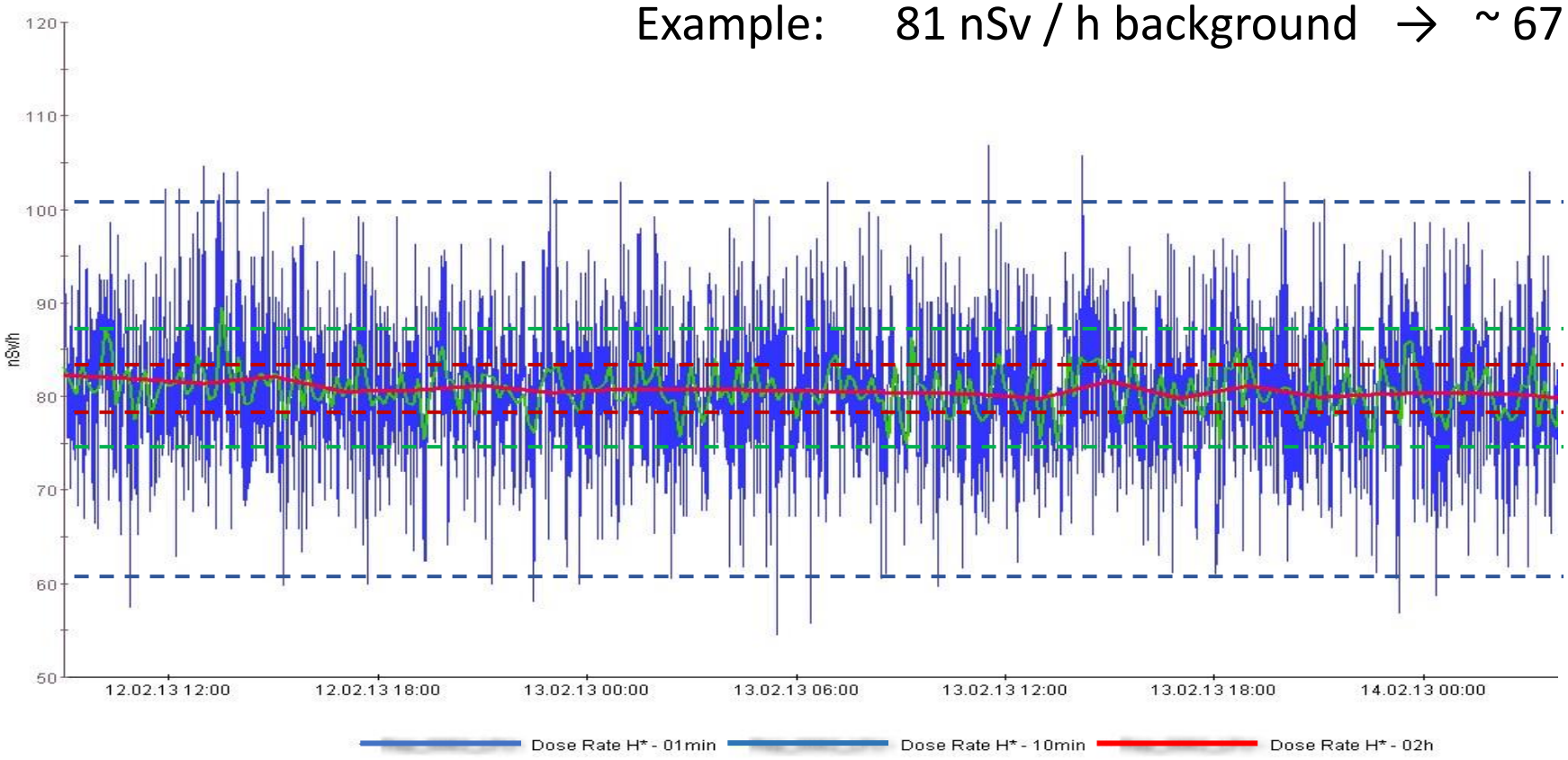
- SNTP triggered by NMC server (on Δt > 2 sec; adjustable)
  → access to NTP server required
- NMC server time
- GPS time (mobile stations; on request)

Data aggregation and buffering

- Configurable basic measure interval
  (default: 1 min)
- 3 configurable aggregation ensembles
  (default: 10 min, 1h, 1d)
- Permanent data storage during the probe's live time
  (up to 1 GB SD card)

Poisson distribution: Standard deviation $\sigma = \sqrt{n}$ (68%(2σ: 95%) of all measurements)
Standard error $1/\sqrt{n}$

Example: 81 nSv / h background → ~ 67 cpm



81 nSv/h mean value

1 min: 2σ = 24% i.e. ± 20 nSv/h
10 min: 2σ = 7.7% i.e. ± 6.3 nSv/h
1 h: 2σ = 3.2% i.e. ± 2.6 nSv/h

- **Secondary cosmic component**

  GM detectors and HPIC: overestimation due to increasing sensitivity above 1.3 MeV

  NaI / LaBr Scintillators: underestimation due to cutoff at 3 MeV

- **Terrestrial component**

  Difference IGS421/AGS421/MIRA ↔ IGS711 ± 2 nSv/h

  (measured in mining plant)

- **Intrinsic effect**

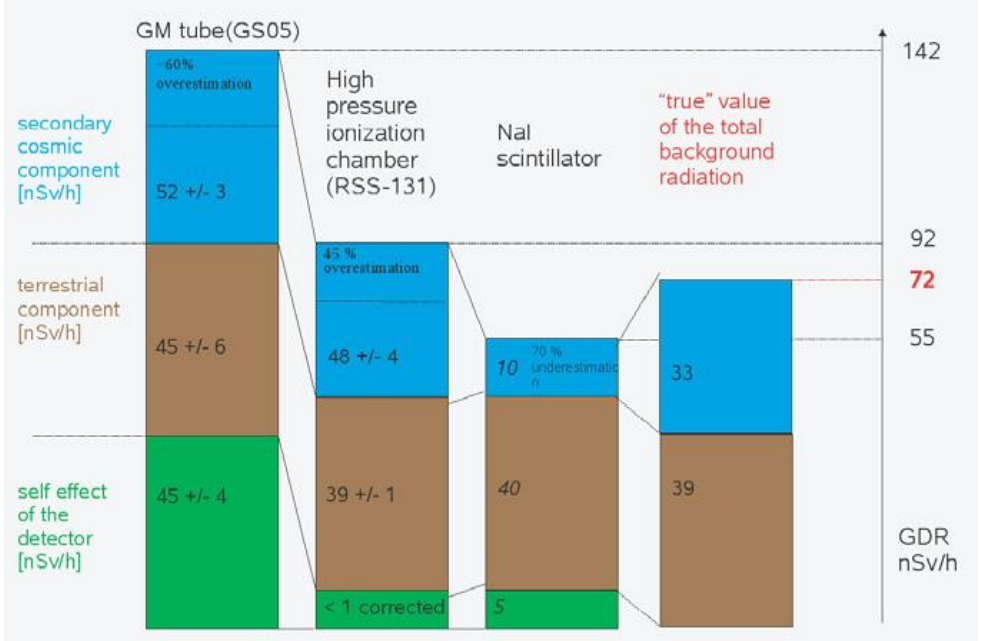
  MIRA 30 … 40 nSv/h *(K-40)*

  SARA NaI(Tl) 2 … 4 nSv/h

  SARA LaBr 100 nSv/h *(La-138)*

  (measured in Pb chamber)

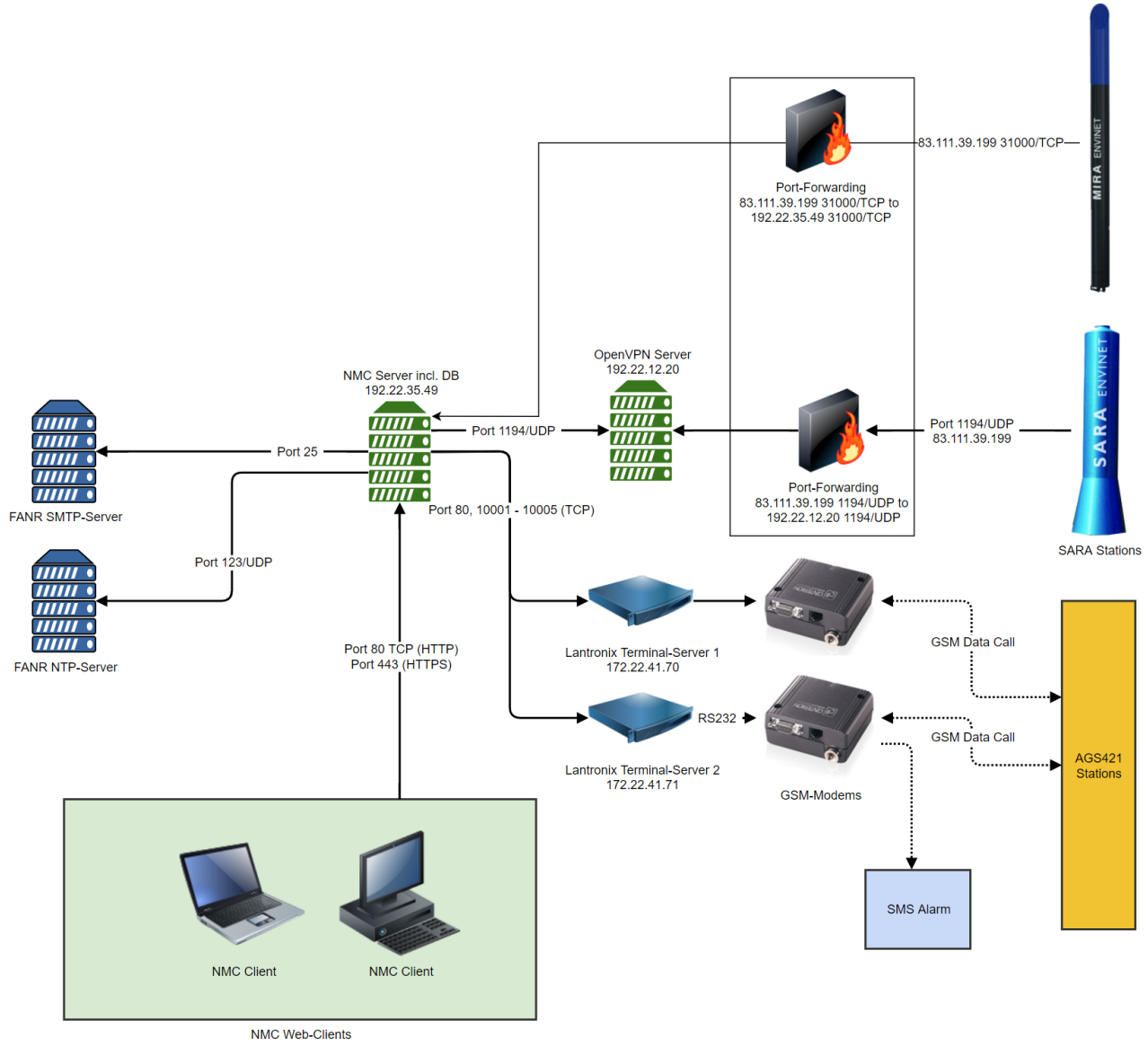
➢ *Offset setting for the background reading aligment*



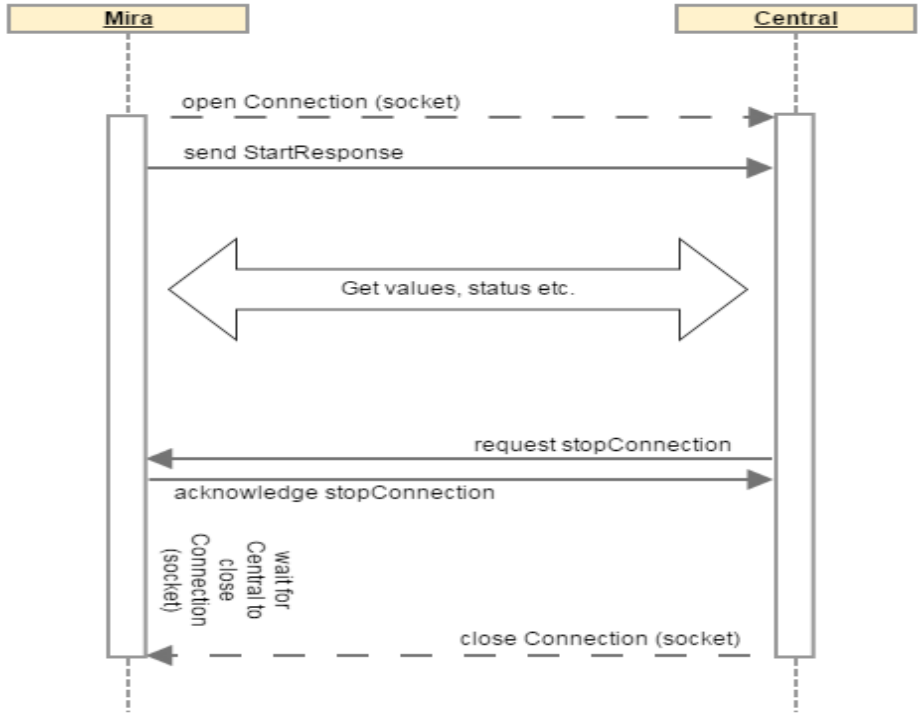
reference: BfS

MIRA

System architecture and data transmission


83.111.39.199 31000/TCP
Port-Forwarding
83.111.39.199 31000/TCP to
192.22.35.49 31000/TCP
MIRA ENVINET
OpenVPN Server
192.22.12.20
NMC Server incl. DB
192.22.35.49
Port 1194/UDP
Port 1194/UDP
83.111.39.199
SARA ENVINET
SARA Stations
Port-Forwarding
83.111.39.199 1194/UDP to
192.22.12.20 1194/UDP
Port 25
FANR SMTP-Server
Port 80, 10001 - 10005 (TCP)
Port 123/UDP
FANR NTP-Server
Port 80 TCP (HTTP)
Port 443 (HTTPS)
Lantronix Terminal-Server 1
172.22.41.70
GSM Data Call
RS232
GSM Data Call
AGS421
Stations
Lantronix Terminal-Server 2
172.22.41.71
GSM-Modems
SMS Alarm
NMC Client
NMC Client
NMC Web-Clients

- TCP/IP socket connection to NMC-Server
- TCP/IP port 31000
- Station ID for identification @ NMC
- Binary protocol basing on Google Protocol Buffers
  including messages for
  - Data transfer
  - Station status queries
  - Configuration
  - Firmware updates
  - Time synchronisation



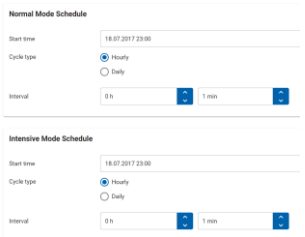
- 5 data server (= monitoring center) configurable
  + update server & service
- IP address + port selectable (default: port 31000)
- 4 comm devices per server configurable (fall back mechanism)
- Standard protocol („protocol buffers“)
- Encryption TLS 1.3 available
- TCP/IP based (i.e., additional services like NTP for time sync available)
- Control of communication schedule by NMC
  - Intensive mode data call cycle
  - Comm alarm in case of missing scheduled MIRA call
  - Report comm statistics and next expected data call (monitor)
- Permanent availability (comm device ON) as option

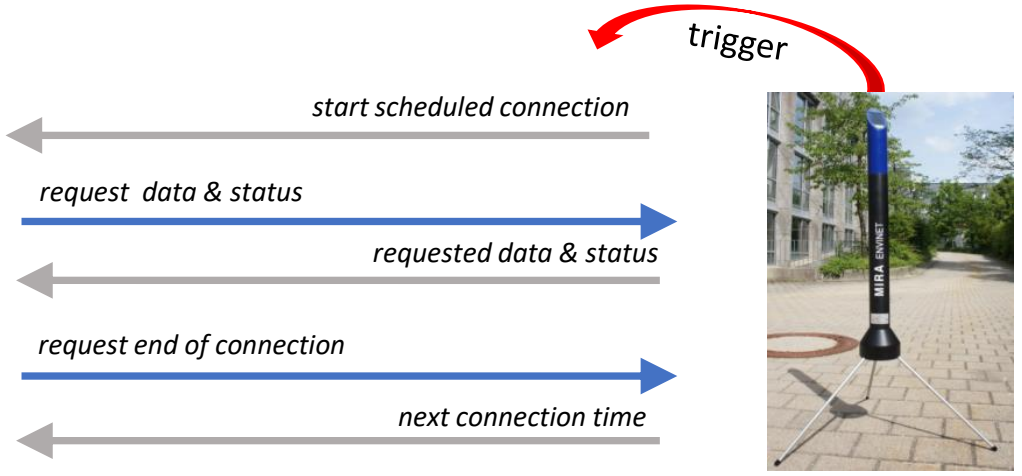
- LAN
  - Local networks
  - Parallel processing of several MIRA calls
  - External connection to router (GPRS/UMTS/LTE, WLAN, radio, ADSL, …)
    serving infrastructure and security requirements (e.g. VPN, IPsec, IPv6, …)
- LTE
  - Server with fixed public IP address
  - Parallel processing of several MIRA calls
- Radio
  - external radio modem with antenna
  - „Line of sight“ required (radio network design)
  - Time slice method
- Serial (RS232 / RS485 / Bluetooth)
  - no addressing
  - Time slice method
  - no service console during normal measurement operation for RS232/BT
- Satellite
  - External satellite modem with antenna
  - UDP “one shot”
  - E-mail

Scheduled data call

NMC Server

Time settings

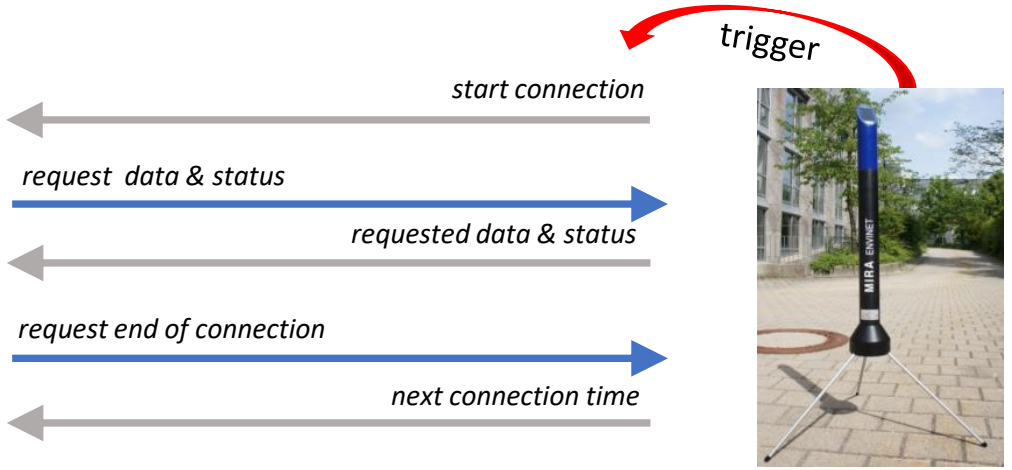




Spontaneous call (event triggered)

NMC Server

CommCo



Event

- technical issue
- threshold exceeding
- start / reset

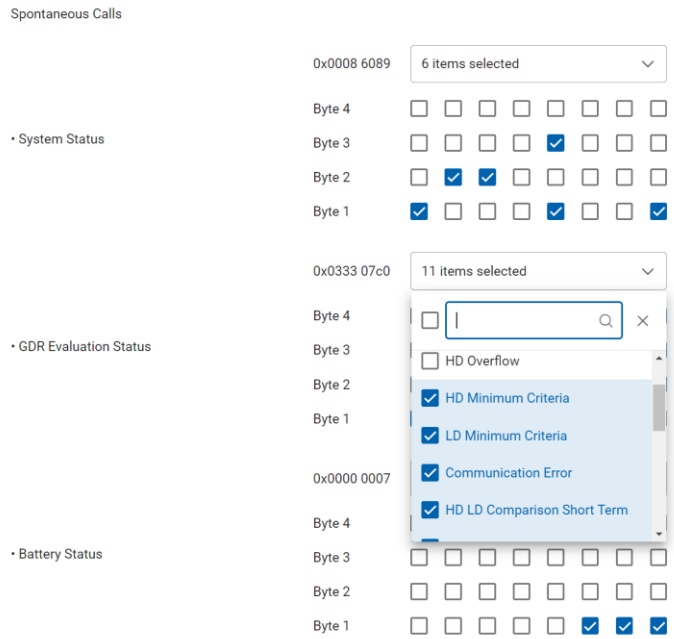
MIRA

Data access and alarming

Actual and registered status

10.02.2022 17:45

Detailed Status	Current	Registered
MIRA System Status		
Firmware version	1.5.7_release_R913_3fe8da2d_k60_lte	-
Digital Board Version	3	-
Analog Board Version	3	-
System starting	0	0
Service mode	0	0
Test mode	0	0
Minute timeout	0	0
Source detected	0	0
Source removed	0	0
SD-Card failed	0	0
Wake up	0	0
Base interval invalid	0	0
Time invalid	0	0
Time synchronization	0	0
GPS fix failed	0	0
GPS fix available	0	0
Moisture detected	0	0
Door open	0	0
Time synchronization failed	0	0
Communication failed	0	0
2G fallback	0	0
Task timeout	0	0
Task critical	0	0
Continuous test mode	0	0
MIRA Battery Status		
Battery low	0	0
Battery serious	0	0
Battery critical	0	0



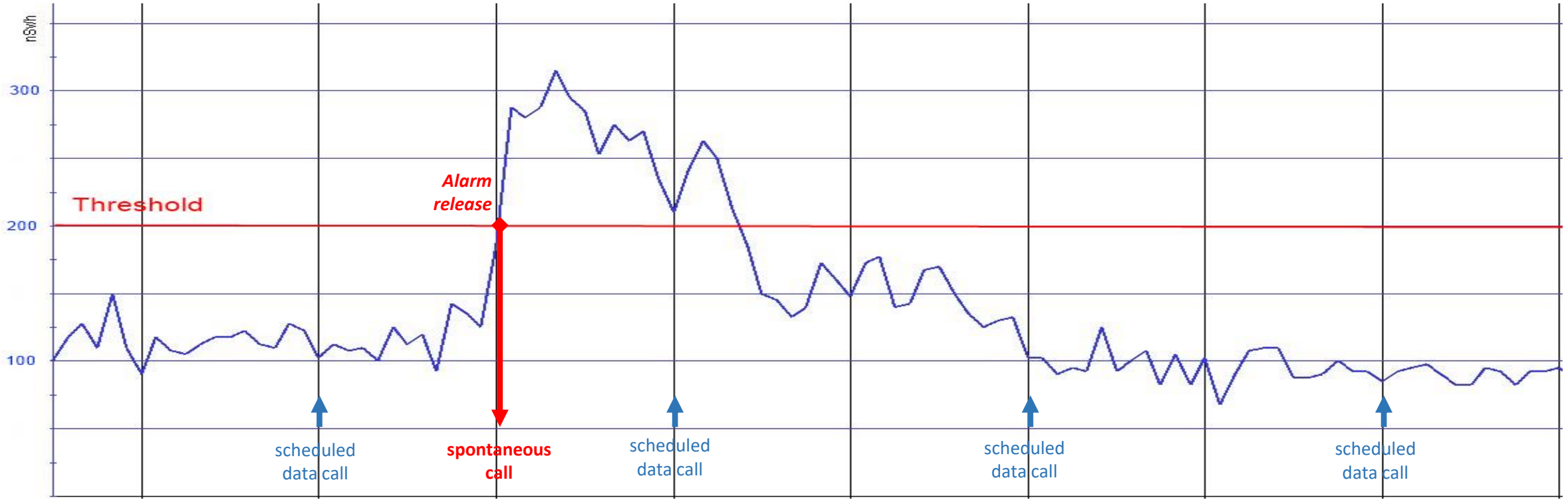
Actual status
Station status
at time of data transmission

Registered status
Events occurred
since last successful data transmission

Alarm mask
enables events for
spontaneous call

Example for status handling

	Threshold exceeding				
Station status	0	1	1	0	0
Registered status	0	1	0	0	0



remote

LAN
GPRS/LTE
Radio

MIRA communication protocol

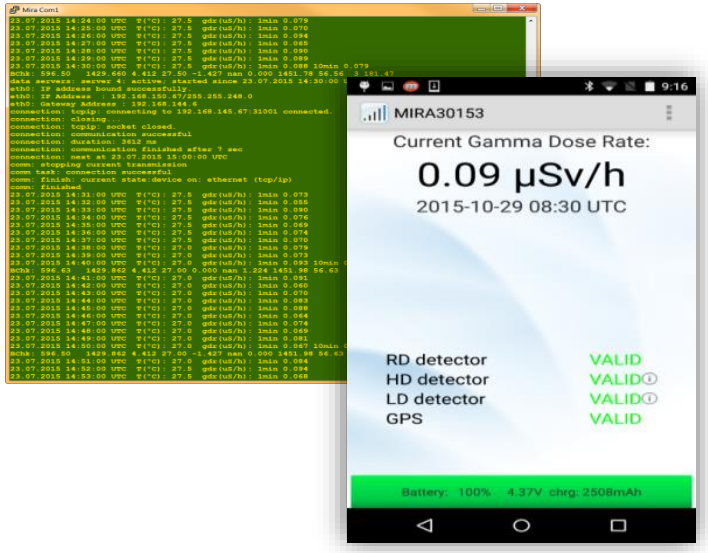
RS232 / Bluetooth

on site

NMC

- all transmitted data
- actual and historic status
- remote configuration
- Tables / graphs / maps

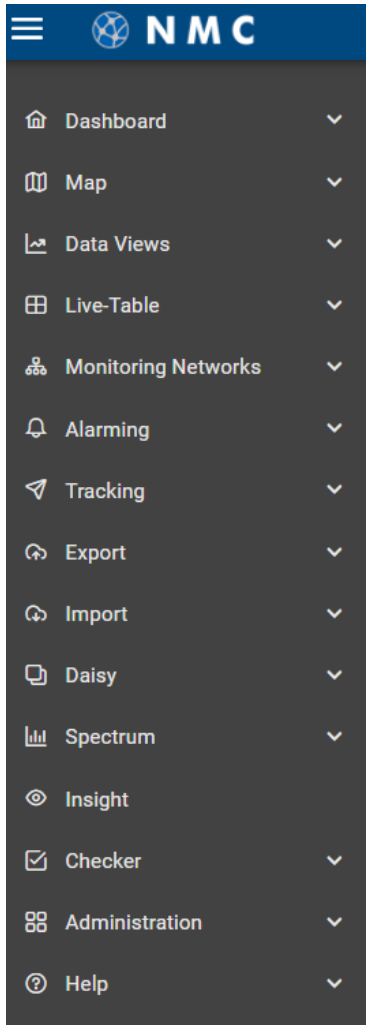
Text based serial console / MIRA App

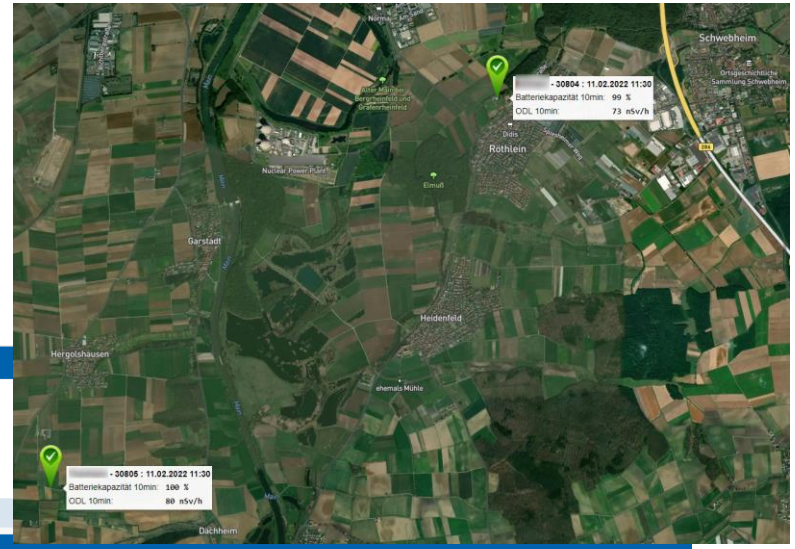


- current values
- current status
- local configuration
- communication setup
- accuracy test

Data and alarm management with NMC

- Storage in relational data base
- Automatic operation with
  - scheduled data transfer
  - scheduled export
  - scheduled reporting
- Presentation
  - Graph
  - Table
  - Map
- Alarming functions (remote / local)
- Remote configuration
- Centralized network control
- Device management





MIRA

- System status
  - MIRA System Status Registered
  - MIRA Battery Status Registered
- Channel 10: Dose Rate H*(10)
  - MIRA Evaluation Status Registered

MIRA Evaluation Status Registered

Name	Alarm							Custom message
Rain			☐	☐	☐	☐	☐	
Time synchronization			☐	☐	☐	☐	☐	
HD overflow			☐	☐	☐	☐	☐	
HD minimum criterion	Technical	●	☐	☐	☐	☑	☐	
LD minimum criterion	Technical	●	☐	☐	☐	☑	☐	
Communication error	Technical	●	☐	☐	☐	☑	☐	
HD LD comparison short term	Technical	●	☐	☐	☐	☑	☐	
HD LD comparison long term	Technical	●	☐	☐	☐	☑	☐	
Test source present	Blocker		☐	☐	☐	☐	☐	
Test mode			☐	☐	☐	☐	☐	
1min values: 1. threshold exceeded	Radiological	●	☐	☑	☑	☑	☐	1min values: 1. threshold exceeded
1min values: 2. threshold exceeded	Radiological	●	☑	☑	☑	☑	☑	1min values: 2. threshold exceeded
10min values: 1. threshold exceeded	Radiological	●	☐	☑	☑	☑	☐	10min values: 1. threshold exceeded

MIRA

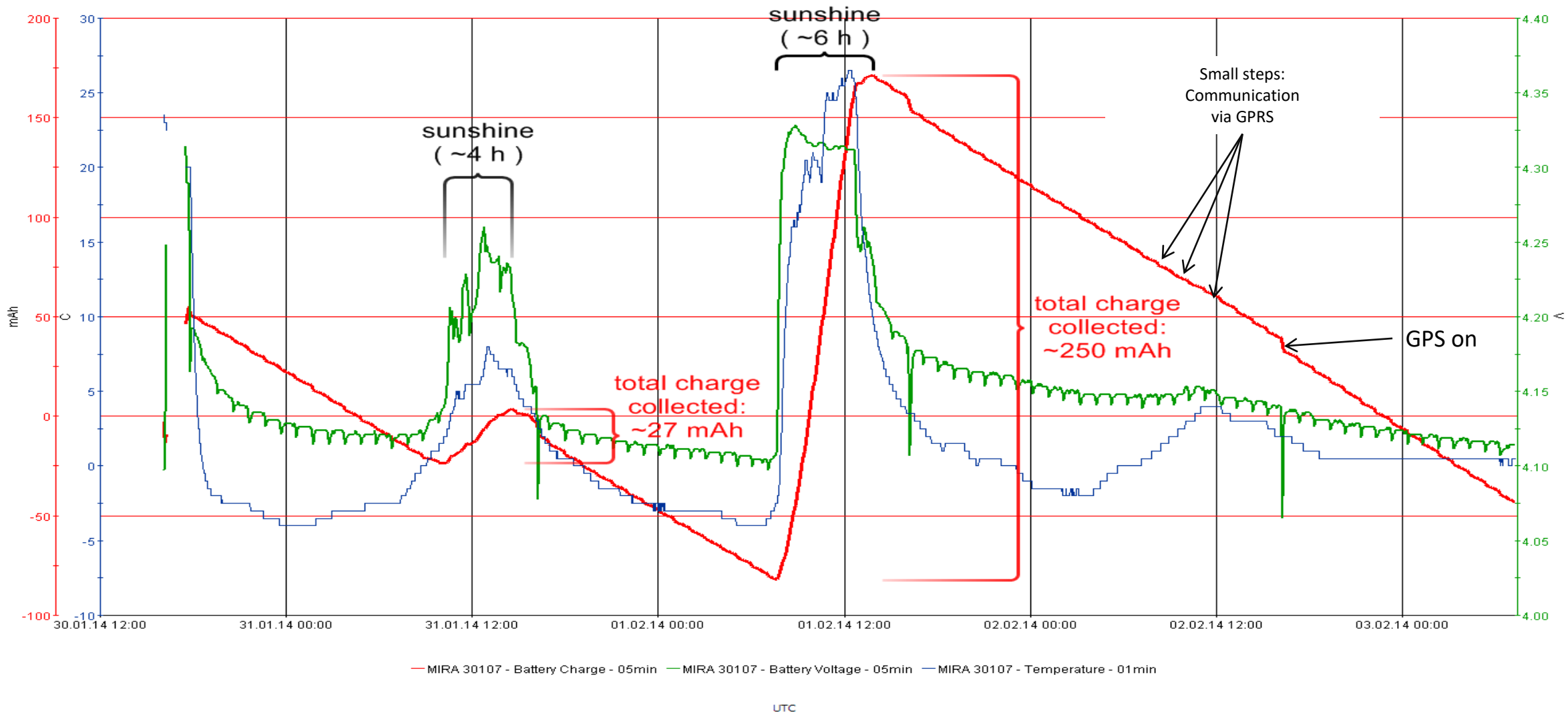
Power management

Power supply boundaries

- Internal battery allows up to 40 days of operation
- Can be recharged by
  - Mains power (standard USB power adapter, supply)
  - Solar panel (integrated or external)
- Major power consumers
  - µC
  - LTE modem
  - LAN interface
  - GPS receiver

➢ Backup time strongly depends on communication interval

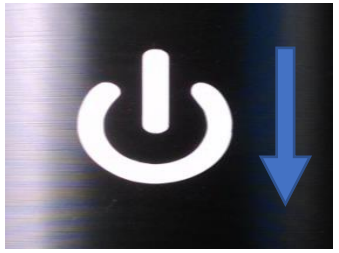
➢ Sophisticated power management with
µC and internal devices are powered on scheduled basis

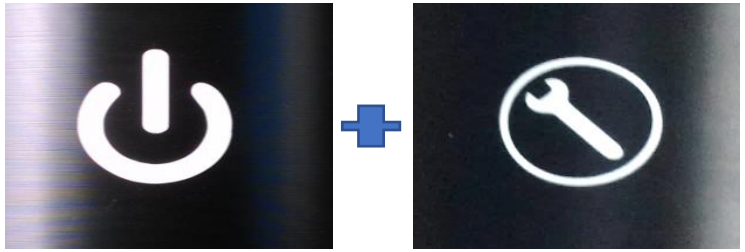

sunshine
(~6 h)
sunshine
(~4 h)
Small steps:
Communication
via GPRS
total charge
collected:
~250 mAh
total charge
collected:
~27 mAh
GPS on
mAh
°C
V
200
150
100
50
0
-50
-100
30
25
20
15
10
5
0
-5
-10
4.40
4.35
4.30
4.25
4.20
4.15
4.10
4.05
4.00
30.01.14 12:00
31.01.14 00:00
31.01.14 12:00
01.02.14 00:00
01.02.14 12:00
02.02.14 00:00
02.02.14 12:00
03.02.14 00:00
MIRA 30107 - Battery Charge - 05min
MIRA 30107 - Battery Voltage - 05min
MIRA 30107 - Temperature - 01min
UTC

MIRA

Configuration and maintenance

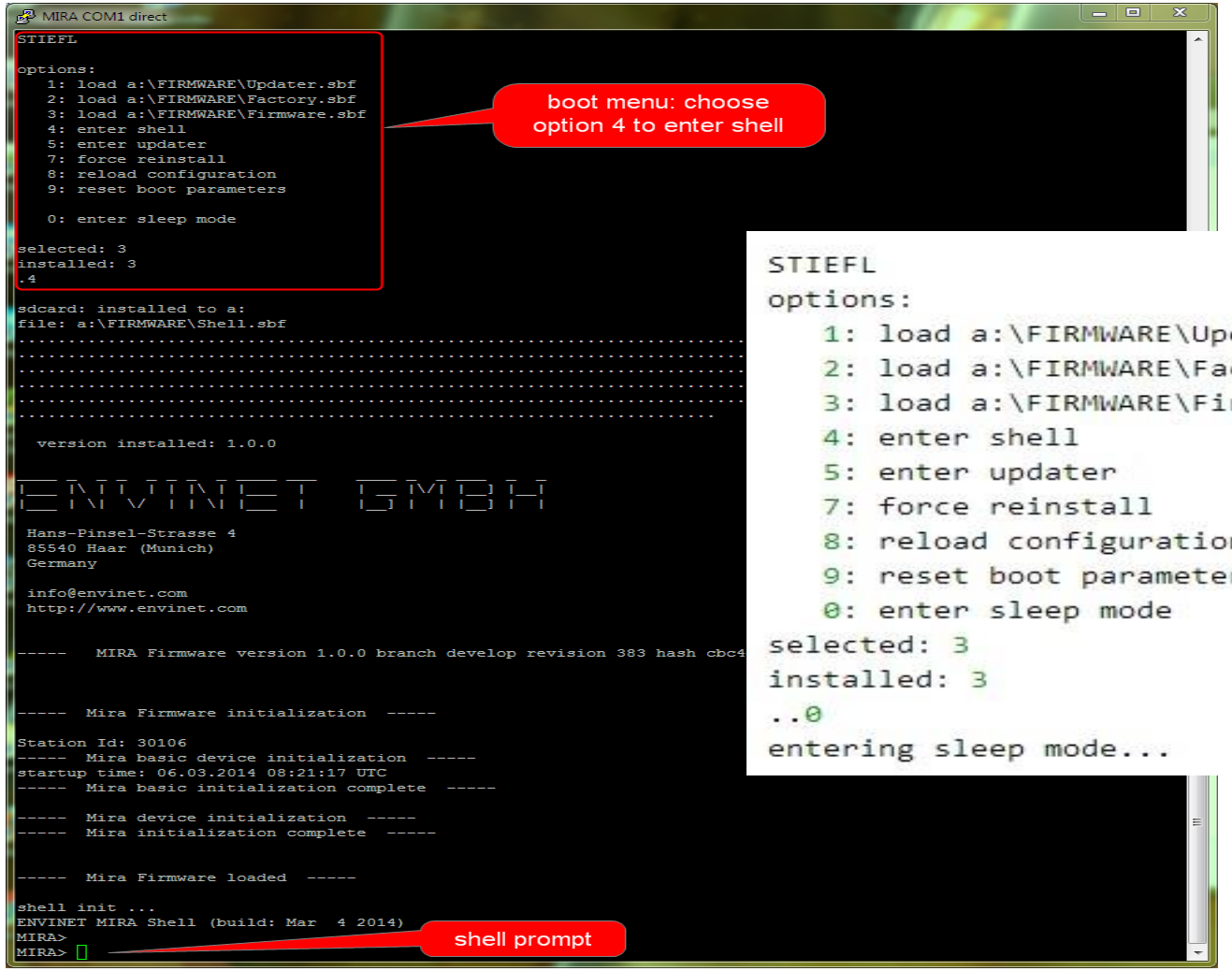
- Input with magnet
  - Wake up (trigger 1x) / restart (trigger 2x)
  - Switch on BT for service ⟶ Access with App
  - Accuracy test (triggered by test source)





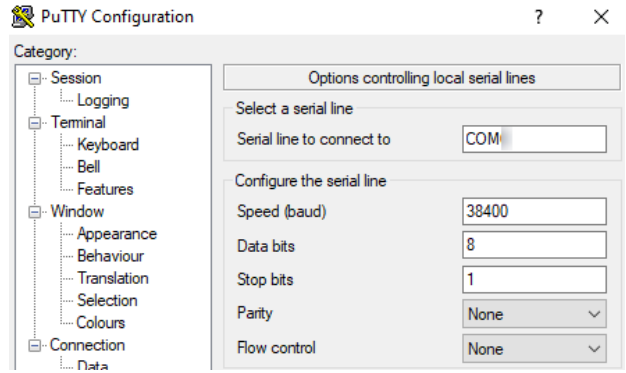
- Output with buzzer

Local access



Input:

- Magnetic switch
- Serial console (RS232 / bluetooth)



Speed via BT: 115200 bd

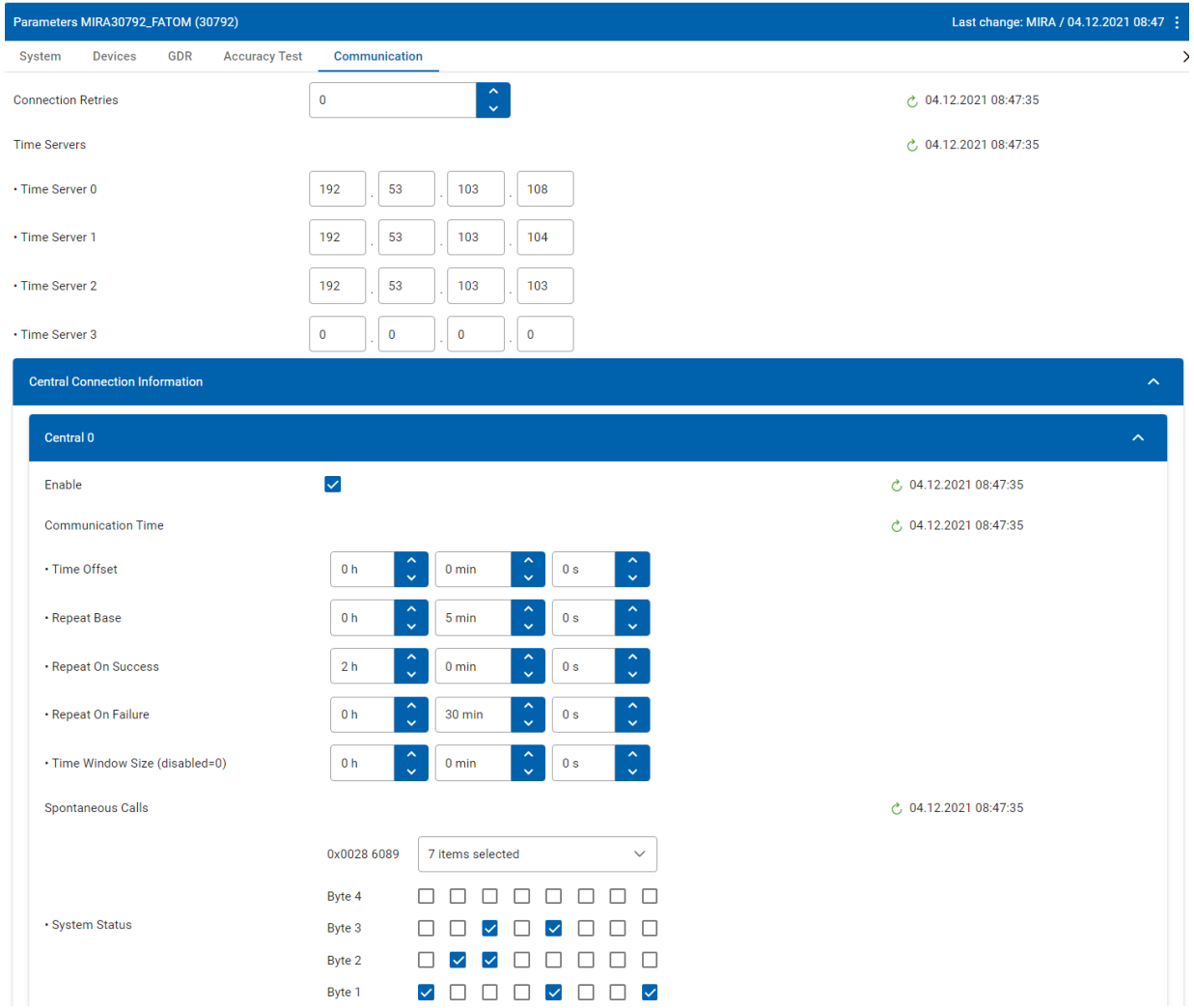
Output:

- Beeper
- Serial console (RS232 / bluetooth)

Configuration options

- Station ID
- Device Settings
  - LAN
  - LTE
  - Radio
  - GPS
- Communication settings
- Cyclic calls
- Spontaneous calls
  - GDR thresholds
  - Alarm conditions
- Time Servers
- Accuracy test settings

- Counter tube and probe characteristics



NMC-Server

schedule parameter retrieval

Next scheduled data call

retrieve complete parameter set

review and modify
schedule parameter transfer

Next scheduled data call

send changed parameters

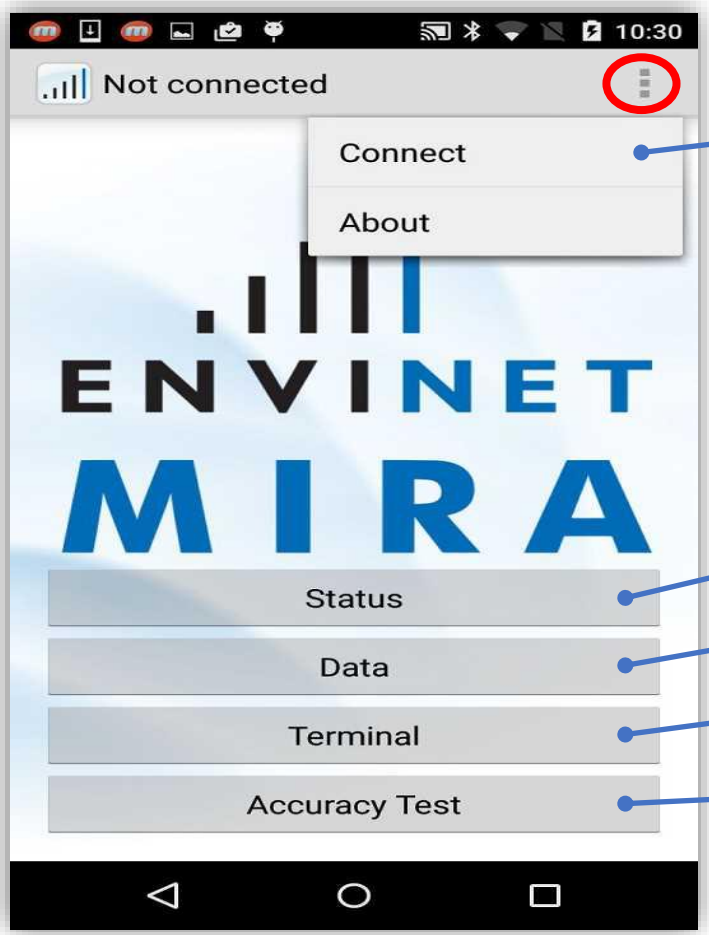
store in flash memory

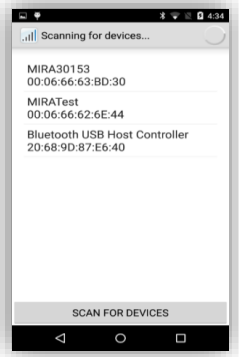
retrieve newly stored parameters

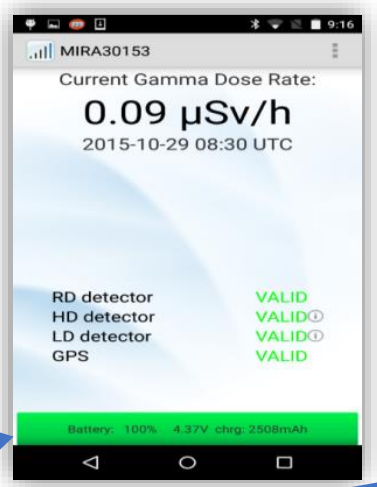
review changes

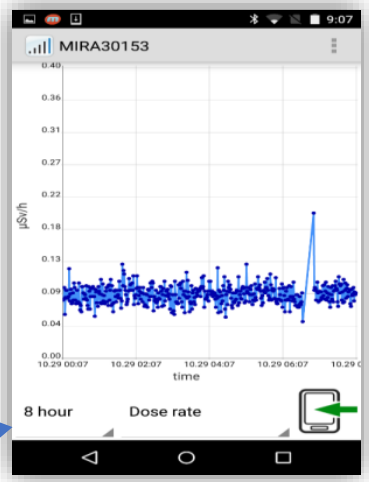
MIRA

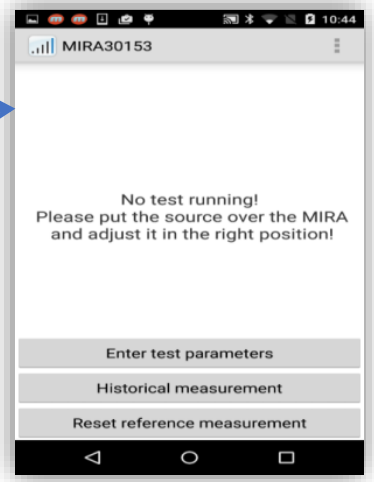
Accuracy test


10:30
Not connected
Connect
About
ENVINET
MIRA
Status
Data
Terminal
Accuracy Test


Scanning for devices...
MIRA30153
00:06:66:63:BD:30
MIRATest
00:06:66:62:6E:44
Bluetooth USB Host Controller
20:68:9D:87:E6:40
SCAN FOR DEVICES


MIRA30153
Current Gamma Dose Rate:
0.09 µSv/h
2015-10-29 08:30 UTC
RD detector VALID
HD detector VALID
LD detector VALID
GPS VALID
Battery: 100% 4.37V chrg: 2508mAh


MIRA30153
µSv/h
time
8 hour
Dose rate


MIRA30153
No test running!
Please put the source over the MIRA
and adjust it in the right position!
Enter test parameters
Historical measurement
Reset reference measurement


16.12.2015 11:08:00 UTC T(°C): 23.0 gdr(uS/h):
1min 0.086
acctest: t=60 s/120 s LD=83 cts HD=0 cts
16.12.2015 11:07:00 UTC T(°C): 23.0 gdr(uS/h):
1min 0.066
acctest: t=0 s/120 s LD=0 cts HD=0 cts
16.12.2015 11:06:00 UTC T(°C): 23.0 gdr(uS/h):
1min 0.082
info: at task=14("Connect") code=2, exception=3
(0x00130010)
info: at task=14("Connect") code=2, exception=3
(0x0012000f)
bluetooth: connected
Send

Accuracy test procedure

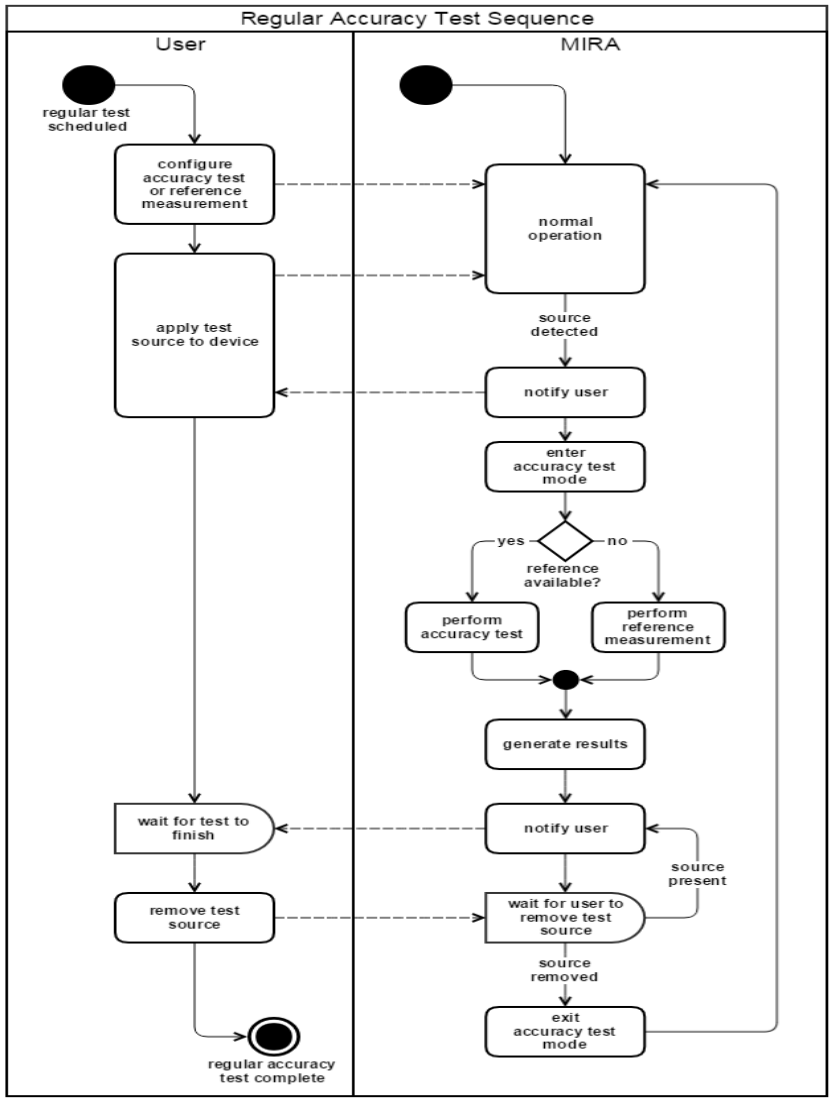
- Standard sources

  Eu-152 (500 kBq)

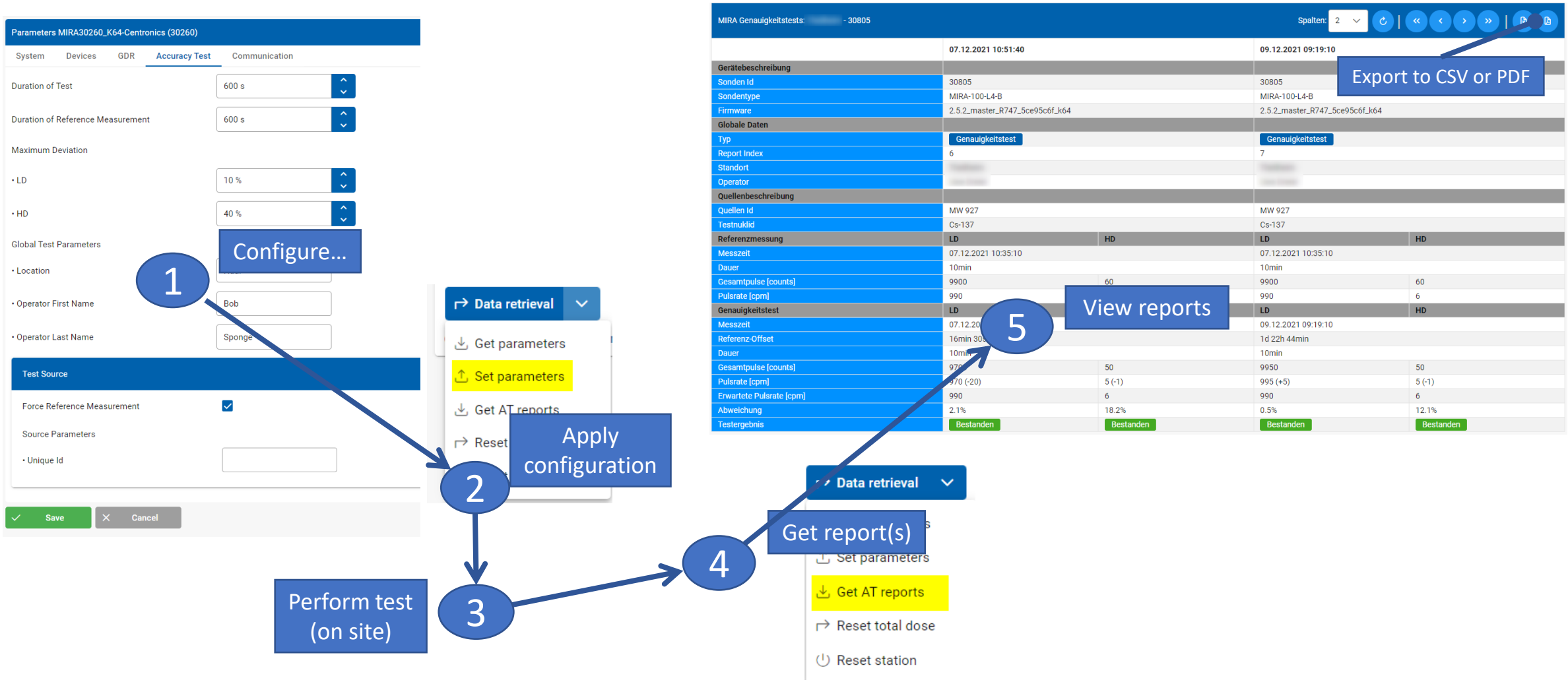
  Cs-137 (360 kBq)

- Procedure

  1. Preconfiguration via NMC / App:
     - Source type and s/n (requires new reference measurement)
     - Location of accuracy test/reference measurement
     - Operator
     - Duration of accuracy test/reference measurement
     - Evaluation criteria
  2. Place test source → Start indicated by acoustic signal
  3. Accuracy test
     - Switch to test mode
     - Wait for stable measure value (basic interval)
     - LD and HD pulse rate collection for preconfigured duration
     - Observation via BT + App
  4. End test indicated by acoustic signal → remove test source
  5. Evaluation and protocol
  6. Retrieve protocol from NMC

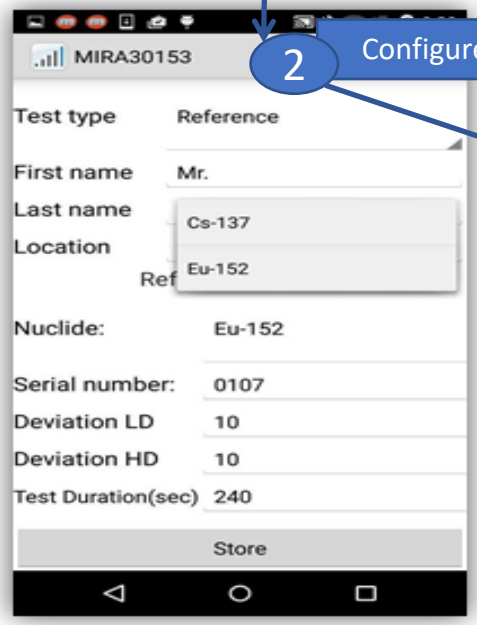


Configuration and viewing reports by means of NMC



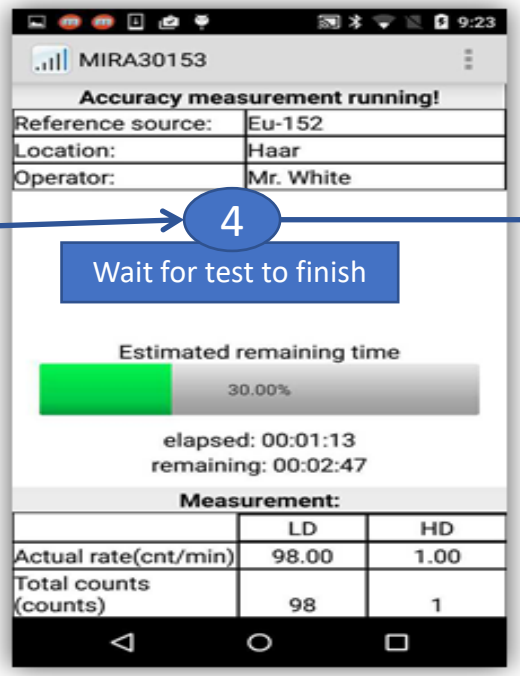
… using the MIRA APP (on site)

1 Trigger service mode and connect the app



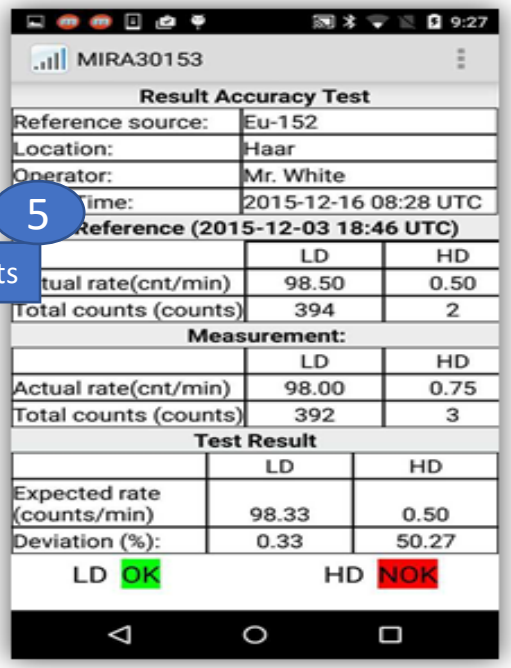
2 Configure…

3 Apply test source



4 Wait for test to finish

5 View results



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