Detection & Identification
Personal Radiation Detector

AccuRad PRD
Operating Manual

MIRION TECHNOLOGIES Health Physics Division

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Information

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Considering local regulation in force: person and equipment protection against electric shocks, Mirion Technologies (MGPI) SA recalls that ANY WORK ON A POWERED EQUIPMENT SHALL MANDATORILY BE PERFORMED BY QUALIFIED AND AUTHORIZED PERSONNEL.

Ionizing radiation of the sources used is dangerous for the worker whenever the protective measures are not strictly applied.
Although our equipment items are built in compliance with the most severe safety standards, the ionizing radiation source represents a danger when the worker is not qualified or not warned.
ANY HANDLING OF RADIOACTIVE SOURCES SHALL MANDATORILY BE PERFORMED BY QUALIFIED AND AUTHORIZED PERSONNEL. Consequently, all precautions shall be taken to prevent any non-authorized or non-qualified person from using this equipment, endangering others and themselves.
Prior to any handling, those qualified and authorized to use this equipment shall get information on the protective measures set forth by the national standards in force.
Abandon or destruction of equipment containing a radioactive source is FORBIDDEN. If no longer required, the user must inform Mirion Technologies (MGPI) SA who will arrange to take the source back (according to the contract) and establish a certificate stating that the source has been taken back. In the event that the source is lost or stolen, the user must inform the appropriate authorities soon as possible.

Directive 2002/96/EU of the European parliament and of the council of january 2003 on waste electrical and electronic equipment (WEEE).
At the end of the product's useful life, please dispose of it according to the local legislation. If necessary, please send an email to:
environnement-iso14001@mirion.com

CAUTION:
The AccuRad PRD is not certified for explosive atmospheres!

Revision Log

Ind.	Date	Verified by	Approved by	Origin and description of revision	Revised pages
A	2019-05			Document creation	/
B	2020-05			Added Bluetooth info Edited screenshots	

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1. Introduction

The AccuRad PRD is a Personal Radiation Detector (PRD), packaged in a small, rugged and easy to use form factor. The AccuRad PRD (AccuRad for short) is a high-performance measurement device for operations requiring detection, search and localization of radiation sources. AccuRad addresses all applications requiring efficient detection of radiological threats in civilian defense.

The AccuRad combines one sensitive low range detector to quickly detect low gamma radioactivity levels and one high range detector for extended dose rate range and dose measurements.

The AccuRad is a self-operating device that automatically detects radioactive and nuclear sources. A unique “on the move” localization algorithm enables intuitive source search by directional screen indicator

When a source is detected, the AccuRad triggers various audible, visual alarms and/or vibration alarms. It has a built-in discreet mode for silencing alarm sounds, thus making it convenient to use in crowded environments (airports, malls, metro stations, stadiums, streets, etc.).

The AccuRad is compact-sized for performing one-handed measurements, even when wearing gloves. The user-friendly interface utilizes two display screens; one large front case display; a smaller top display, and five buttons. The integrated belt clip affixes securely to a belt or pocket, allowing easy view of the top display without removing.

The AccuRad is powered by two commercially available AA batteries (1.2V to 1.5V).

The AccuRad is designed for pairing to a smartphone with the AccuRad App. The AccuRad App provides sharing features including data logging, batch processing, messaging (email, SMS), and reachback connectivity to common operational data platforms.

AccuRad complies with the relevant current international standards (IEC, IAEA, ANSI).

Optionally, the AccuRad can also be remotely monitored by the **SpirVIEW** Supervision software or RadResponder for situational awareness along with the other SPIR family instruments.

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2. Features

- **Exceptional Radiological Performance**

The AccuRad measurement range is from background to 1000 rem/h (10 Sv/h) utilizing a combination of two energy compensated detectors. Dose measurements are in compliance with various industry dosimetry standards. VBS inhibits false alarms from normal background variations.

- **Smooth User Experience**

The AccuRad can operate in full autonomy, only alerting the operator when a source is detected and to assist in localizing and evaluating the threat. Effective alarm indicators are provided: loud audible, attentive vibrator, clear visual display information and bright LEDs.

The operator can acknowledge an alarm to silence the sound, LED and/or the vibration by pressing any button. The sound alarm indicators help the operator easily distinguish weak from dangerous alarms. In addition, audible chirps and flashing LEDs help to locate the source.

The large front display helps the operator clearly read alert messages during use.

Saving device data is automated and no operator actions are required.

- **Radar indication for accurate source localization**

A built-in and intuitive radar screen display (localization indicator) helps the operator localize the detected source.

- **Discreet mode for covert operations**

The discreet mode silences alarms for stealth applications. For more discretion, the operator can connect headphones to the AccuRad using the USB-C port.

- **Robust protection for resistance to water, dust and sand ingress**

The AccuRad is resistant to dust, sand and moisture. The integrated rubber case protection improves shock resistance and handling.

The AccuRad can be used in temperatures as low as -4°F (-20°C) and as high as 140°F (60°C).

- **>900 hours continuous operation**

The AccuRad uses a “standby” mode for outstanding battery life. The AccuRad is powered by two commercially available AA batteries (1.2V to 1.5V).

- **Simplified data transmission over the smartphone application via Bluetooth**

The AccuRad integrates Bluetooth with Near Field Communication (NFC) for pairing and transmission of AccuRad data to a dedicated smartphone application.
For smartphone without NFC, manual pairing remains possible via Bluetooth Low Energy (BLE).

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3. AccuRad Description

3.1 What's in the box

- AccuRad device with belt clip
- AA alkaline batteries
- Spare belt clip
- Quickstart Guide

AccuRad

Alkaline Batteries

Spare Belt Clip

Quickstart Guide

See *§9.8 Accessories, options* for accessories and spare.
The AccuRad Operating Manual can be downloaded at https://accurad.mirion.com/

3.2 AccuRad Overview

3.2.1 Physical Overview

The AccuRad includes five buttons, two screens, two indicators and a connector:

- A large **front display screen**
- The **top display screen**
- The ⏻ **on/off button** is used to power on (short press); power off (long press) and turn of/turn off the front display screen (short press).
- The ◄ **back button** returns to the previous menu screen or exit the Search mode.
- The ○ **enter button** is used to access and select a settings parameter.
- The ▲/▼ **arrow buttons** navigate the display and the settings menus.
- The **Alarm LED indicator** colors are:

□ Red, slow blinking: low or high alarm
□ Red, fast blinking: danger alarm
□ Green, blinking: search mode enabled (the faster the blink, the closer to the source)
□ Purple: a failure is reported. Refer to *§8.1 Troubleshooting*.

- **Battery Cover Tab:** quarter-turn to open or close the battery cover.
- The **USB-C port** for connection of external headphones or Service operations (updates, calibration). It can also be used to charge batteries.
- The **USB LED Indicator** colors are:

□ Green, solid: battery full
□ Red, solid: battery in charge
□ Red/green, blinking: battery depleted, or inserted battery cannot be recharged

3.2.2 User Interface Overview

3.3 Detectors

The low range detector is designed to detect weak gamma radiation activity. For the low range detector, isotropy around its axis on both planes is optimal, giving priority to the reference direction and to the front extremity when the AccuRad is handheld.

The high range detector increases the dose rate capabilities of the device.

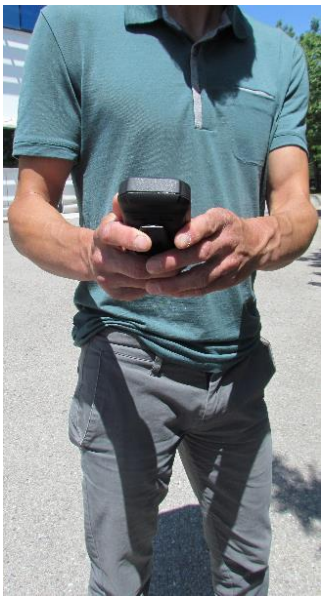
Please refer to *§10.3 Appendix 3: AccuRad drawings* for more details.

3.3.1 Wearing the AccuRad

The reference direction of the measurement is orthogonal to the front display to guarantee an optimal measurement of both detectors when the AccuRad is carried. The reference direction of the measurement and the distance measurement have an impact of the quality measurement.

- **Reference direction when worn**: Best accuracy for integrated dose.

- **Reference direction for Search Mode**



Note:
The Search Mode should only be used when a source is present (to localize) and not for search in low background environment.

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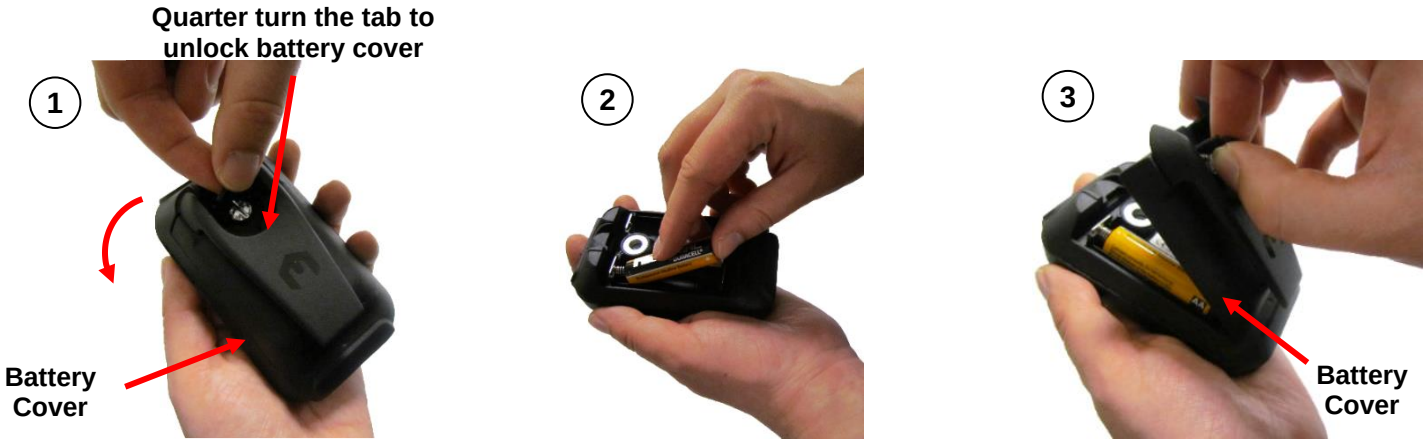
4. Using the AccuRad

4.1 Battery insertion



Release and turn the battery cover tab. Lift the battery cover.

Insert two AA batteries into the AccuRad. Ensure the correct polarity position.

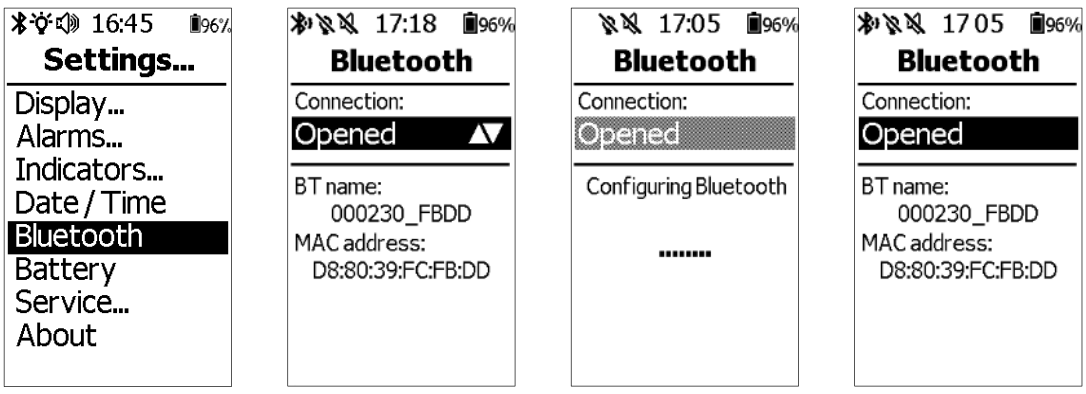
Reinstall the battery cover. Turn the cover tab to lock it.

The AccuRad can work with the following types of batteries:

- AA (LR6) 1.5V alkaline batteries,
- Lithium 1.5V batteries (non-rechargeable),
- NiMh 1.2V batteries (rechargeable).

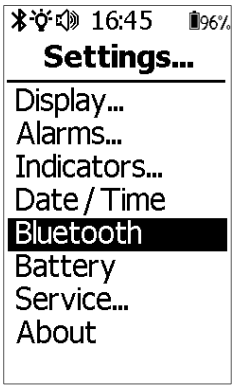
Make sure to set the AccuRad with the correct type of batteries. For more information refer to paragraph *§6.6.3 Using* Opened mode

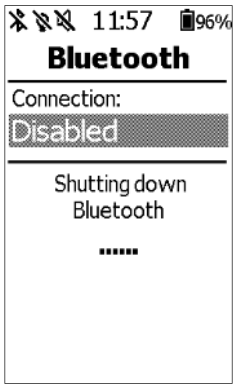
- Open Settings, **Bluetooth**: on the screen, the Bluetooth name and the MAC Address are indicated.
- Press ○, enter the PIN code and then ▲/▼ to select **Opened**, then press ○ to confirm.
- Wait for Bluetooth configuration.
- When done, the BT name and MAC address are displayed.

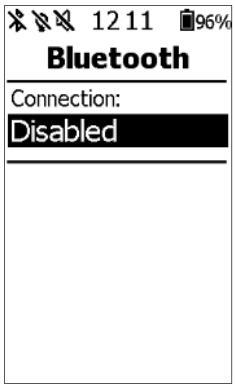


4.1.1 Using Disabled mode

- Open Settings, **Bluetooth**: on the screen, the Bluetooth name and the MAC Address are indicated.
- Press ○, enter the PIN code and then ▲/▼ to select **Disabled**, then press ○ to confirm.
- Wait for Bluetooth shutdown.
- When done, Bluetooth is disabled. In Disabled mode, all Bluetooth connection are disabled, hence the AccuRad is neither detectable nor connectable. When Bluetooth is disabled, no pairing is possible, even with NFC.







Battery.

Caution:
- When inserting the batteries, make sure to respect the polarities.
- Always use batteries of the types given above. Using non-compatible batteries may cause the explosion of the AccuRad!

4.1.2 Charging NiMh batteries

If using NiMh batteries, connect the AccuRad to the mains via the USB-C port to charge it. The power adaptor automatically detects if the batteries can be charged and if they work properly. If that is not the case, the USB LED indicator blinks red and green.

The batteries may heat a little during charge, it is a normal reaction. However, if the temperature exceeds 50°C / 122°F, the build-in thermal security forbids the charge and a default message is displayed.

Charging time may vary depending on the NiMh batteries, for instance a complete charge of 2000 mAh NiMh batteries takes about 5 hours.

4.2 First use of the AccuRad

1

Press the ⏻ on/off button.

2

Check the interface language, then select Save.

3

Check the unity to be displayed, then select Save.

4

Set the date, then select Save.

5

Set the time, then select Save.

6

Select a time fuse, then select Save.

7

The AccuRad initiates a self-test sequence; wait a few seconds.

8

After initialization, background update is triggered; wait a few seconds.

9

When a measurement is displayed, the AccuRad is ready to use.

4.3 Start the AccuRad

Press the ⏻ on/off button.

The AccuRad initiates a self-test sequence; wait a few seconds.

After initialization, background update is triggered; wait a few seconds.

When a measurement is displayed, the AccuRad is ready to use.

***Note**:*
At start up, the AccuRad warns the user *if the battery is low, if the date and time are not consistent, and if the calibration due date is expired.*

4.3.1 Calibration expired

If the energy calibration is expired the AccuRad notifies it twice, during the startup and, if enabled, with a **CAL** pictogram on the main screen.

The calibration is performed with a high range calibrator/irradiator. For more information about calibrating the AccuRad, contact your Mirion Technologies representative.
When the calibration is done, enter the calibration date in the settings (refer to *§6.8.1. Calibration*).

4.4 Use Summary of the AccuRad

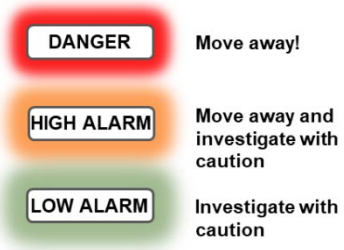
The AccuRad is designed for comfortable one-handed or hands-free operation.

The front and side buttons are easily accessible for one-handed operation

4.4.1 Detection Mode Operation Summary

The operator is wearing or holding the AccuRad in Detection Mode. Dose Rate is provided on both display screens

The AccuRad alarms when a source is detected. The operator presses any button to acknowledge the alarm and responds accordingly.



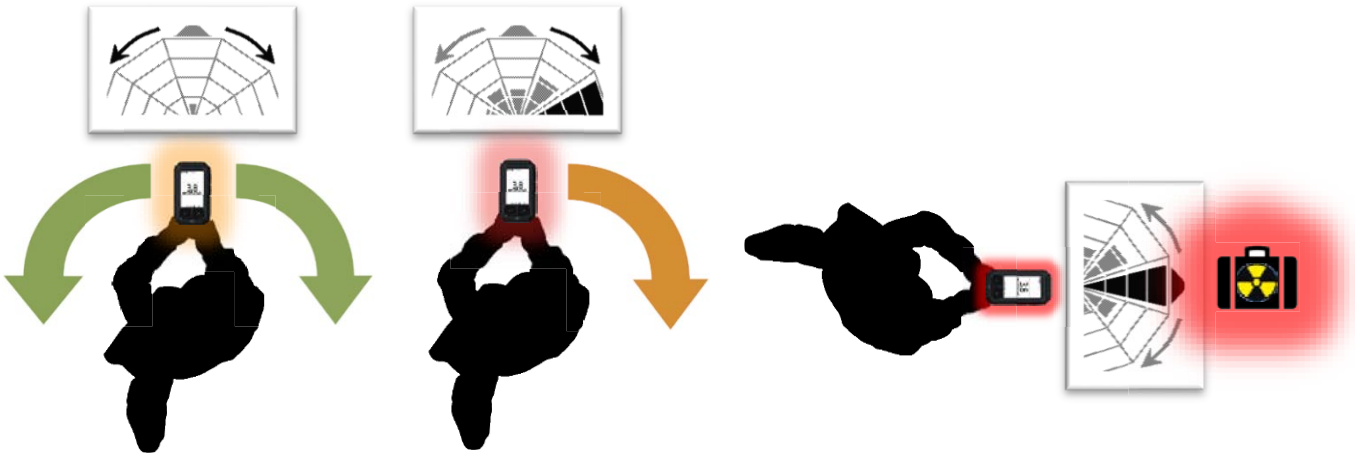
Detection Mode Operation Summary (cont.)

Press ○ **enter button** twice to switch to Search mode and press ▲/▼ **arrow buttons** to choose trend or radar.
Press ◄ **back button** to exit Search mode. In Search mode: no alarm sound, chirping only, unit = cps.

Detection (Trend) *Menu* *Search (Trend)* *Search (Radar)*

Search with Radar Mode Operation Summary

In **Radar** mode, the operator turns with the AccuRad to build the radar sectors, then follows the black sectors and the arrows to find the source.



***Note**:*
The radar must be calibrated to work properly. Refer to §6.8.2 Perform radar calibration.

4.5 Discreet Mode Overview

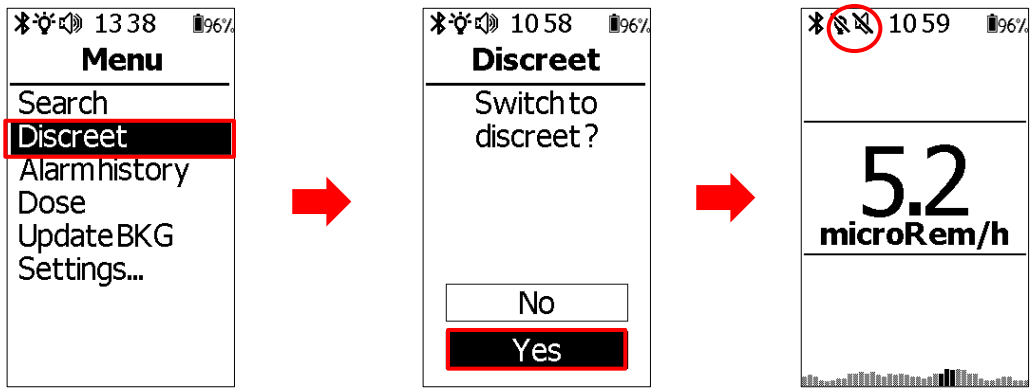
The discreet mode can be used when the operator does not want the alarms generated by the AccuRad to be perceived by the environmental people.

By default, in this mode, the audible and visual alarms (LEDs) are deactivated, however audible alarms can be heard if using earphones. The AccuRad continues to alarm the operator through its vibrator and the warning messages are displayed.

Discreet mode behavior is configurable in the settings. For more information, refer to paragraph *§7.4.4.3 Indicators*.

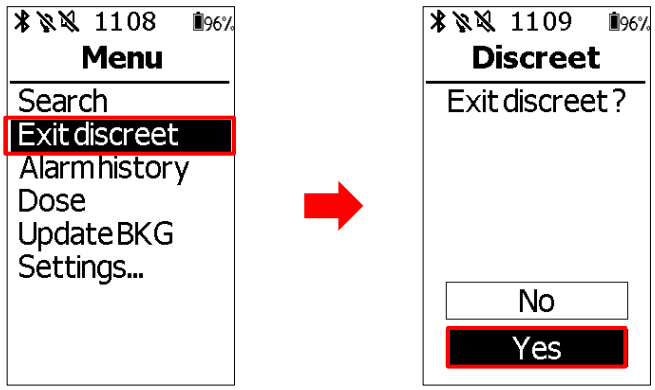
4.5.1 Switching to Discreet Mode

- Open the menu, select **Discreet**. The Discreet menu is prompted.
- Select **Yes** to switch to Discreet mode and exit settings. Note the icons at the top of the screen, meaning the alarm LED indicator is off and the sound is muted.



4.5.2 Disabling Discreet Mode

- Open the menu and select **Exit Discreet**. The Discreet menu is prompted.
- Select **Yes** to disable Discreet mode and exit settings. Note the icons at the top of the screen, meaning both the alarm LED indicator and sounds are enabled.



4.5.3 Using earphones

Connect the optional earphones to the USB-C port. The sound is automatically switched to the earphones but the LEDs are still functioning.
Use the earphones buttons to control the sound volume and acknowledge alarms.

In discreet mode, connecting the earphones automatically redirects all the sounds (alarm + chirp) into the earphones.

Note:
- The AccuRad is compatible with passive headphones only.
- Mirion can supply earphones tested for operability. Mirion cannot guarantee similar functionality in other brand models. It is recommended to test before using in the field. For more information contact your Mirion representative.

Caution !
High acoustic pressure! Risk of hearing impairment!
Do not use at high volume during extended periods.

4.6 Powering off the AccuRad

There are two methods to power off the AccuRad:

- Continuous press of the ⏻ **on/off button** for about 5 seconds and the AccuRad will automatically power off at the end of the countdown.
- Long press the ⏻ **on/off button** button, to display the Power OFF window, then select **OK** to power off the AccuRad.

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5. AccuRad Advanced Operation

5.1 Main Menu Overview

To access the main menu, press ○ **enter button**:

The menu consists of the following features:

- **Search**: switch to Search mode. For more information, please refer to *§5.4 Using AccuRad in Search Mode*.
- **Discreet**: switch to discreet mode. For more information, please refer to *§4.5 Discreet Mode Overview*.
- **Alarm history**: an internal log of the alarms triggered by the AccuRad. For more information, please refer to *§5.5 Analyzing AccuRad Alarm History Data.*
- **Dose**: view the current cumulative dose information. For more information, please refer to *§5.6 Dose.*
- **Update BKG**: update the background value. For more information, please refer to *§5.7 Update Background (BKG).*
- **Settings**: provides access to advanced features. For more information, please refer to *§6 AccuRad Settings.*

Note:
Fields or menu selections that are GREYED are either locked and require a PIN code to be unlocked or are not available in the current configuration.

5.2 Using AccuRad in Detection Mode

Detection mode is used when worn for operation in background environments. In Detection mode, the large displayed is off and only on the top display screen is active. The top display shows:

- The battery level.
- The current dose rate with measurement unit.

□ During an alarm, the alarm type is displayed (LOW ALARM, HIGH ALARM, DANGER (Rate) DOSE ALARM and DOSE DANGER).
□ During a failure, specific messages are displayed.

In alarm event, the AccuRad vibrates with a visual and/or sound alarm, depending on the selected alarm indicators. For more information about alarm indicators, refer to *§6.4 Indicators*.

Note:
The device may automatically switch to search mode, depending on the settings. For more info about this setting please refer to §6.2.2 Behavior.

Note:
To return to the detection mode, click on ◄ back button or press the ○ Enter button to return to the detection screen and power off the front screen.

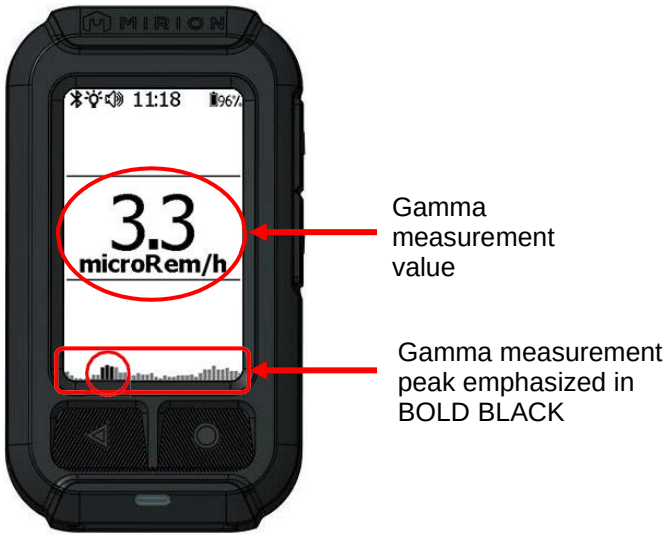
The operator is wearing or holding the AccuRad in Detection Mode. Dose Rate is provided on both display screens.

The AccuRad alarms when a source is detected. The operator presses any button to acknowledge the alarm and responds accordingly.

5.2.1 Using the Trend Screen

The Trend Screen provides:

- Measurement value (dose rate or count rate)
- Graphical trend view corresponds to the real time instantaneous measurement value. The scale is auto adaptive and shows the last 10s of measurement, to help the operator find the source.
- The height and/or color of the trend peaks varies in real time and depend on the gamma dose rate. Peak dose rates are emphasized in **bold black**.



5.3 Using AccuRad in Alarm

5.3.1 AccuRad behavior

In case of alarm, the AccuRad triggers various signals, in the following order:

- Sound
- Vibration
- LED

These signals are repeated until acknowledgment or if the threat is over.

5.3.2 Alarm Indication

During an alarm, the **Alarm LED indicator** flashes in red.

A **sound** alarm (wav file) is periodically (1s) generated in alarm until the acknowledgement, except in Discreet mode or if using earphones.

- **Vibration** is periodically active in alarm until the acknowledgement.
- Slow blinking LED, sound and vibration indicate low and high alarm levels. Fast alarm rates indicate danger levels.
- The **Displays** (Front and Top) always show the alarm event until it ends.
- When the alarm is **acknowledged,** the displayed alarm **message** is displayed **greyed out**.

5.3.3 Acknowledging Visual and Sound Alarm

- During an alarm, the AccuRad vibrates with visual and/or sound alarms, depending on the configured alarm indicators.
- Press any button to acknowledge the alarm and silence the sound and vibration.
- Press any button a second time to wake the display.

5.3.4 Recommended Alarm Actions

The following recommendations are for operator actions upon alarm activation. The top display screen notifies which alarm has been triggered:

- LOW ALARM: Investigate.
- HIGH ALARM: Evacuate and investigate.
- DANGER: Evacuate.

These recommendations shall not replace operator training, procedures or CONOPS.

For more details about alarm levels, refer to paragraph *§6.2.1.2 Using the 0-9 Measurement Scale Display.*

5.4 Using AccuRad in Search Mode

When a low alarm or a high alarm is triggered, the operator switches in Search mode to investigate and find the cause of the alarm.

5.4.1 Activating the Search Mode

Search Mode becomes active:

- **Automatically** when a source is detected, if configured in settings. For more details, please refer to paragraph *§6.2.2 Behavior*.
- **Manually**, when the operator enables it. To activate it, press ○ **enter button** two times to open the Settings menu and **▲/▼ arrow buttons** to select the Search mode.

In Search Mode, both displays are active until timeout. The operator holds the AccuRad and uses various screens to locate the source.

5.4.2 Using the Search Mode

In Search mode, both displays are active. The operator holds the AccuRad and observes the Trend screen for increased radiation levels or the Radar screen for localizing.

There are two types of graphical Gamma measurement displays:

- **Trend** screen. For more information, please refer to paragraph *§5.2.1 Using the Trend Screen.*
- **Radar** screen. For more information, please refer to paragraph *§5.4.2.1 Using the Radar Screen.*

The alarm LED indicator blinks green in **Search** mode and as the operator moves closer to the source, the green LED blinks faster. When the source is found, the alarm LED indicator blinks red. If the AccuRad is in alarm and in Search mode, the alarm LED indicator blinks red.

In addition, the audible chirp, when used, behaves like the alarm LED - the AccuRad chirps faster moving closer to the source.

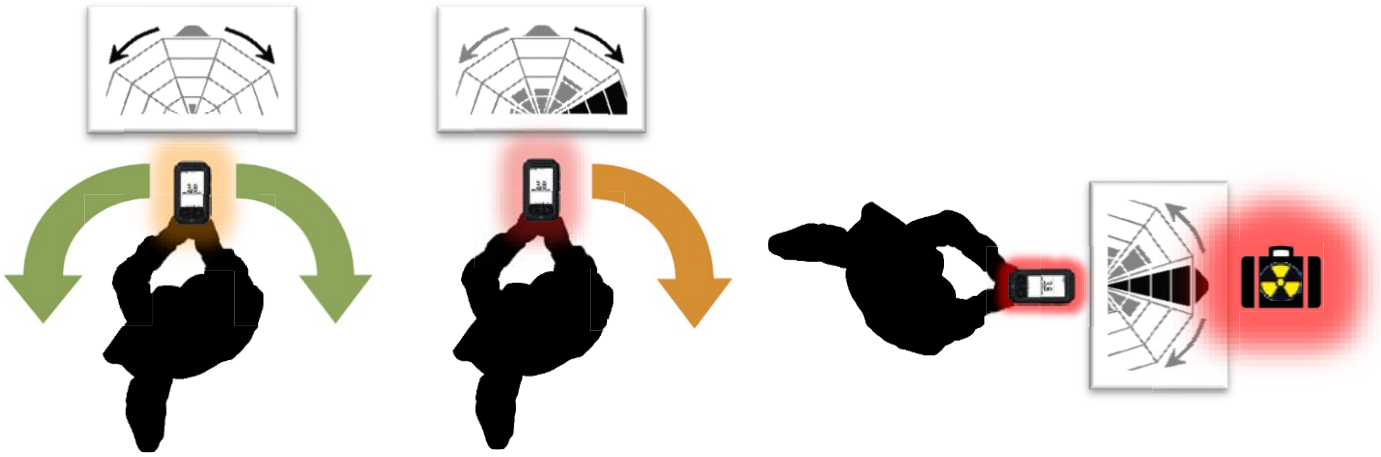
There are two types of gamma measurement values for the Search mode:

- **Dose rate / Count rate** measurement display (by default). For more information, please refer to paragraph *§6.2.1.1 Setting up the Dose Rate or Count Rate Measurement Display*.
- **0-9 Measurement Scale** display. For more information, please refer to paragraph *§6.2.1.2 Using the 0-9 Measurement Scale Display*.

Operator Actions:

- Press ○ **enter button** twice to switch to search mode and press ▲/▼ **arrow buttons** to choose trend or radar. Press **back◄ button** to go exit Search mode.
- In **Search** mode: no alarm sound, chirping only, unit = cps.
- In **Search** Mode with **Radar**, no alarm sound, chirp on/off, unit cps

When using the **Radar**, the operator turns with the AccuRad to build the radar sectors, then follows the black sectors and arrows to locate the source, as shown below:



5.4.2.1 Using the Radar Screen

The Radar display helps the operator localize the detected source. The Radar screen consists of 10 sectors (only 5 are displayed), each sector representing the directions of detection of the radioactive sources.

In order to operate the radar, its calibration must be performed. For more information refer to paragraph §6.8.2 *Perform radar calibration*.

The Radar screen sectors are shaded/filled during the rotation of the AccuRad, and will help find the source.

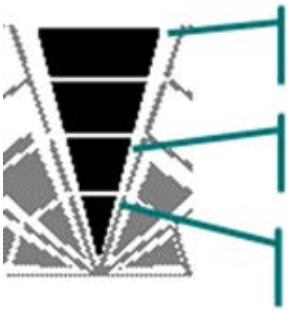
Note:
The radar information and calibration can be affected by magnetic environment, magnets, iron (Buildings, car, truck…).

The radar screen is built during the rotation of the AccuRad, used to find a source around the operator. The AccuRad uses an inertial measurement unit (IMU) sensor to measure the rotation. The radar records the maximum count rate measured for each of ten sectors of 36°.

The information remains accurate only if the operator turns while maintaining the AccuRad at the same angle during the rotation. The radar information will not be accurate if the operator deviates from the original horizontal plane. In this case, the radar will need to be reset by exiting to the trend window and returning to the radar window.

Sectors represent the directions of detection of the radioactive sources. The detection of a radioactive source is represented by the number of the sector(s) that shows the direction of the source. When three sectors are completed (3 x 36°), the sector where the maximum count where detected is painted in bold black.

Sector scale:



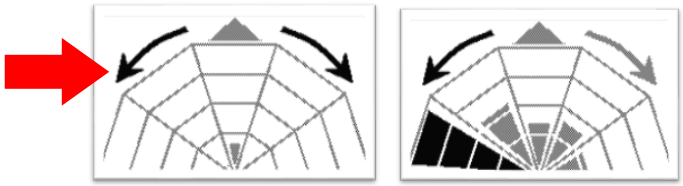
10 times background or more

3 times background

1.5 times background

Note:
All the sectors are progressive except the first one that is fully filled when the sector is scanned.

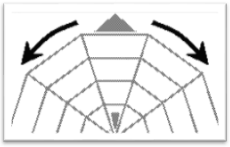
When the arrows are **bold black**, the AccuRad is prompting the operator to turn around.



When three sectors or more are scanned, the arrows now show the rotation to perform in order to maximize the axis of the AccuRad, confirmed by the top arrow.

Press the ▲/▼ **arrow buttons** to reset the radar scope. The process restarts.

How to use the Radar:

	Operator Action	On Screen
1	  The operator moves around to find the direction of the source.	  The radar adapts its position according to the user position, like a compass. The first sector in grey is fully filled when the sector is scanned. Arrows ↙ ↘ are now showing the rotation to do by the user to put the maximum in the axis of the AccuRad, confirmed by the top arrow ▲.
2	 When the direction of the source is found, the operator walks in its direction.	 When the operator is getting closer to the source, the radar sectors widen. The wider they are, the closer the source is. The sectors numbers vary depending on the radiation level and the maximum count where recorded is painted in black.
3	 After the search completes the operator presses **▲/▼ arrow buttons** to perform a reset to the source search.	 The radar is ready for a new search, the first grey sector is scanned.

5.4.3 Stopping the Search Mode

To exit the Search Mode, press ◄ **back button**.

5.5 Analyzing AccuRad Alarm History Data

Alarm history can be viewed by opening the Alarm History from the menu

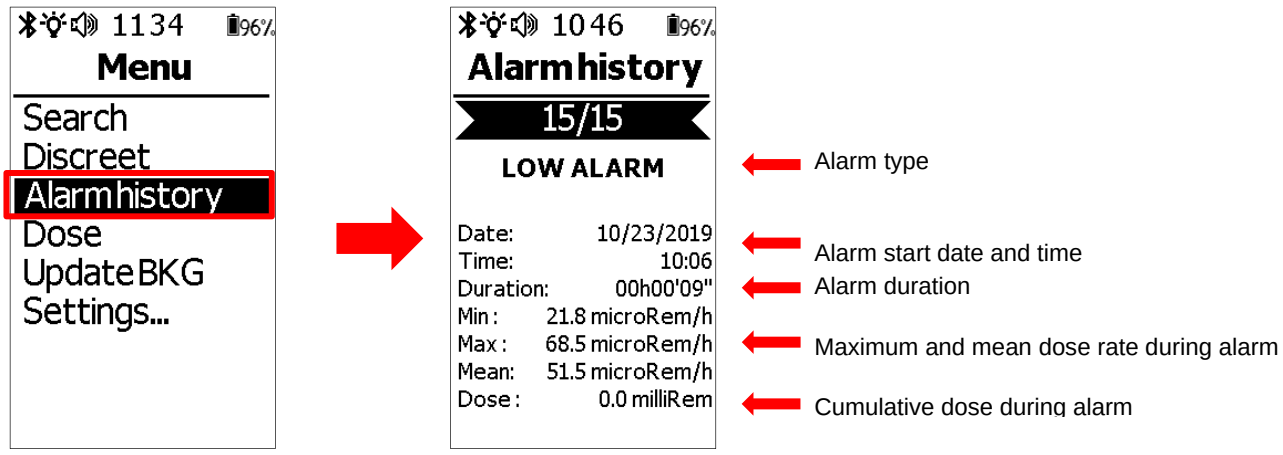
5.5.1 Accessing Alarm History Data

Alarm history is accessible from the measurement screen or in the main menu. This history is only for alarms and allows the user to see the alarm history from the newest to the oldest by scrolling. To access events reports history:

- Open the Menu, select **Alarm History**.
- Use the **▲/▼ arrow buttons** to select historical data events.

The alarm history provides the following information:

- Alarm type: Dose rate warning (significant count rate elevation), Dose rate Alarm (absolute dose rate), Dose rate Danger (absolute dose rate), Dose Alarm, Dose Danger.
- Alarm start date and time.
- Alarm duration.
- Maximum and mean dose rate during alarm.
- Cumulative dose during the alarm.



Note:
Up to 400 alarms, 16 failures and 16 informations can be stored in the AccuRad memory. If the memory is full, the new alarm replaces the oldest.

5.5.2 Sending Alarm History Data to a Remote Monitoring Station

The operator can send an event report using the AccuRad Application to a remote monitoring location.

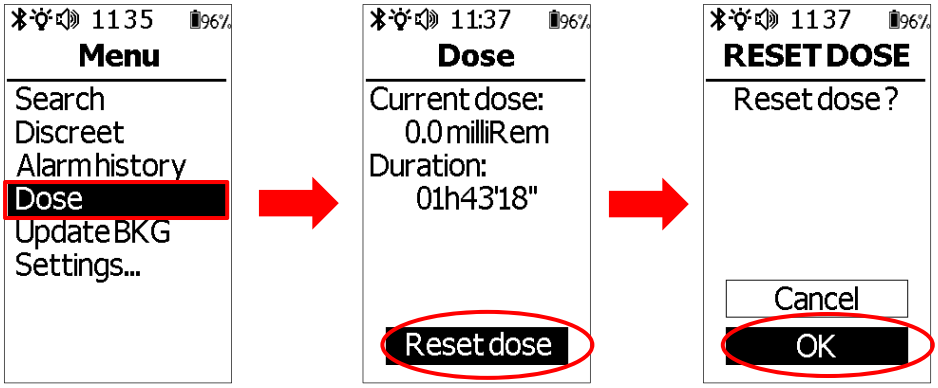
- The AccuRad App records the event data from the AccuRad.
- The operator selects an event from history.
- The operator sends the event to a remote monitoring station using the AccuRad App. Localization is added by the AccuRad App.

5.6 Dose

The AccuRad measures dose continuously or can be reset for each use

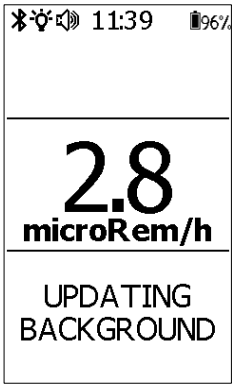
- To **reset** the **Dose**:

□ Open the menu and select **Dose**.
□ Select Reset dose
□ Enter PIN code
□ Press **OK**.



5.7 Update Background (BKG)

The device learns the background at startup, and then along the usage. If the background radiation levels are variable, is VBS is disabled, if the background variation is out of VBS range, or if the operator moves from outdoors to indoors (for example), it is strongly advised to update the background to compensate for the changing.

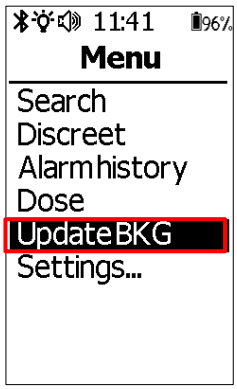


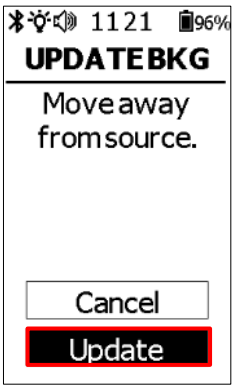
Front screen

Top screen

Updating the background is especially important to ensure low alarm accuracy (sigma)

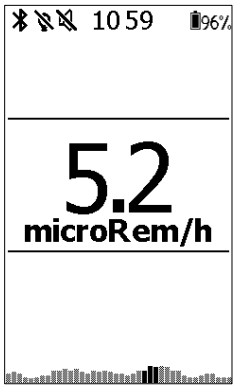
- Open the Menu.
- Select **Update BKG** and then **Update**. The background update starts immediately.





Front screen

Top screen



The AccuRad is ready to be used when the background update is complete.

6. AccuRad Settings

The AccuRad is delivered with a default set of parameters. These settings are stored in non-volatile memory.

The AccuRad can detect a corruption on its parameters. In this case, the user is warned and the device switches to default values to avoid dead lock behavior.

All AccuRad settings can be modified by the configuration tool with USB or Bluetooth link and some can be modified on the device itself. Each setting can be made available or not on the device by configuration. (Set by profile from external device).

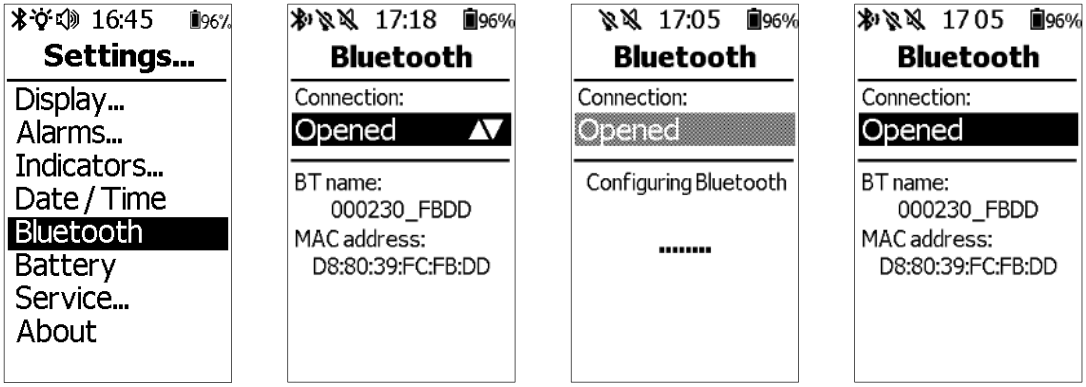
To access the **Settings Menu**:

- Select ○ **enter button** to access the menu.
- Press **▲/▼ arrow buttons** to select **Settings**. Press **◄ back button** to return to the previous sub-menu.

The **Settings Menu** consists of the following features/functions:

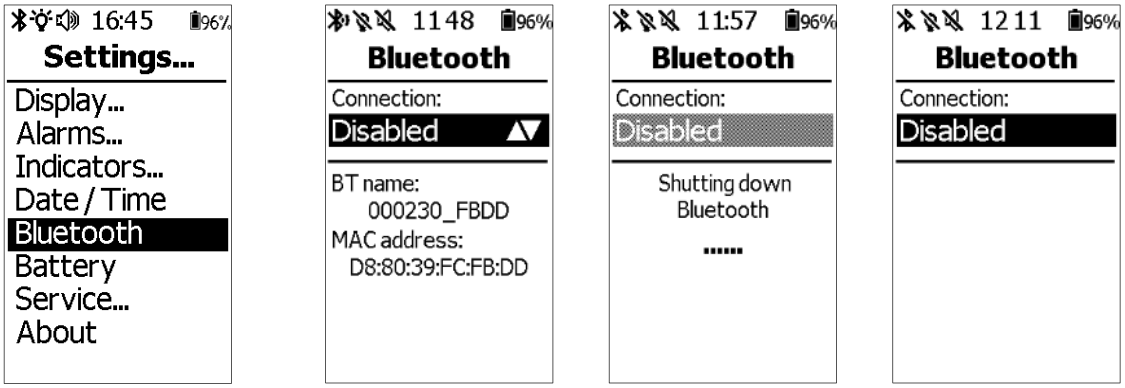
- **Display**: set the units, the behavior and the language. For more information, refer to paragraph *§6.2 Display*.
- **Alarms**: set the different alarm thresholds. For more information, refer to paragraph *§6.3 Alarms*.
- **Indicators**: set the discreet mode, the search mode, and the volume of the headphones. For more information, refer to paragraph *§6.4 Indicators.*
- **Date/ Time**: check and adjust the AccuRad date and time. For more information, refer to paragraph *§6.5 Configuration Date/Time*.
- **Bluetooth**: set the Bluetooth. For more information, refer to paragraph *§6.6 Bluetooth.*
- **Battery**: set the battery chemistry. Refer to paragraph *§6.6.3 Using* Opened mode
- Open Settings, **Bluetooth**: on the screen, the Bluetooth name and the MAC Address are indicated.
- Press ○, enter the PIN code and then ▲/▼ to select **Opened**, then press ○ to confirm.

- Wait for Bluetooth configuration.
- When done, the BT name and MAC address are displayed.



6.1.1 Using Disabled mode

- Open Settings, **Bluetooth**: on the screen, the Bluetooth name and the MAC Address are indicated.
- Press ○, enter the PIN code and then ▲/▼ to select **Disabled**, then press ○ to confirm.
- Wait for Bluetooth shutdown.
- When done, Bluetooth is disabled. In Disabled mode, all Bluetooth connection are disabled, hence the AccuRad is neither detectable nor connectable. When Bluetooth is disabled, no pairing is possible, even with NFC.



- Battery.
- **Service…**: set the calibration, the PIN code, perform a health test and manage the history. For more information, refer to paragraph *§6.8 Service*.
- **About**: info about the AccuRad. For more information, refer to paragraph *§6.9 About*.

6.2 Display

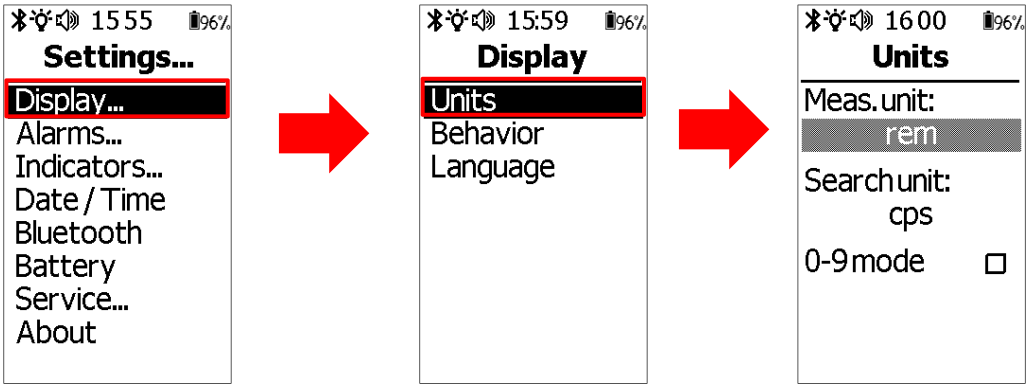
6.2.1 Units

6.2.1.1 Setting up the Dose Rate or Count Rate Measurement Display

The **dose rate measurement display** shows the gamma dose rate or count rate of the detection. To set this type of display:

- Open the menu **Display**.
- In the **Units** menu, set the following items:

□ **Meas.unit**: select the measurement unit to be displayed in Detection mode. Available choices are rem and Sievert.
□ **Search unit**: select the measurement unit to be displayed in Search mode. Available choices are cps or the selected measurement unit.
□ **0-9 mode**: check this option to switch to 0-9 measurement scale display.



A Trend display, which represents the current measured count in detection mode, can be added on the bottom of the front screen via the Trend option, in the Behavior settings. For more information, please refer to paragraph *§6.2.2 Behavior.*

6.2.1.2 Using the 0-9 Measurement Scale Display

The **0-9 Measurement Scale Display** corresponds to ten levels of radiation defined by default following this table (Example of conversion values provided by manufacturers):

Unit-less value displayed	Equivalent exposure rate range (mRem/h)	Equivalent exposure rate range (µSv/h)	* Response Action
0	0 - 0.017	0 – 0.17	No response
1	0.017 - 0.028	0.17 – 0.28	Investigate
2	0.028 - 0.048	0.28 – 0.48	
3	0.048 - 0.087	0.48 – 0.87	
4	0.087 - 0.162	0.87 – 1.62	Evacuate & investigate
5	0.162 - 0.308	1.62 – 3.08	
6	0.308 - 0.590	3.08 – 5.90	
7	0.590 - 1.136	5.90 – 11.36	Evacuate
8	1.136 - 2.191	11.36 – 21.91	
9	2.191 – 1000 Rem/h	21.91 – 10 Sv/h	

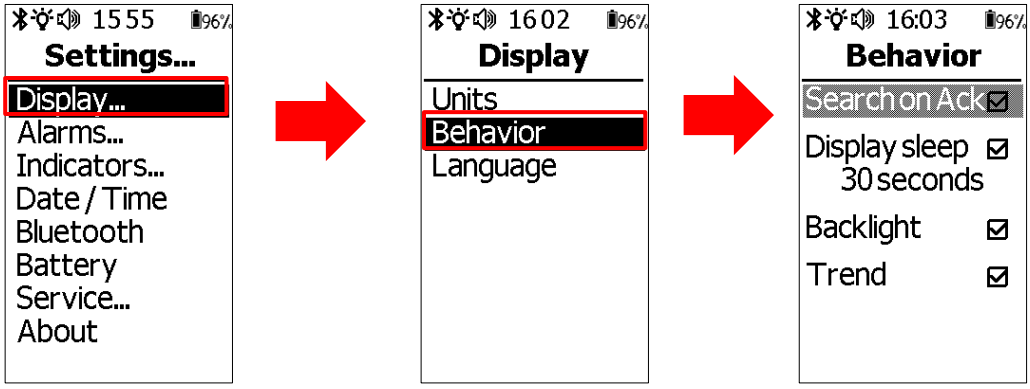
* Response Actions are recommendations only and should not replace procedures or CONOPS

6.2.2 Behavior

In the Behavior submenu, the operator can configure Search mode activation, Display sleep and Backlight of the screen device, in addition to the Trend display.

- Open the menu **Display**.
- Set the following items:

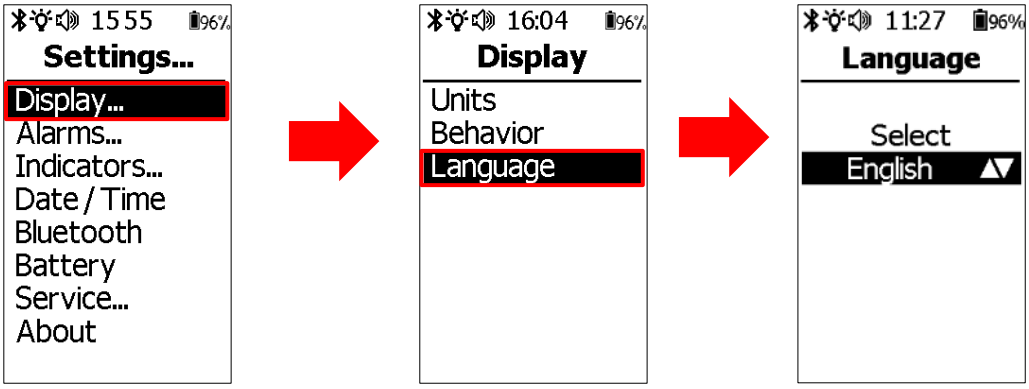
- **Search on Ack**: when enabled, the AccuRad automatically switches to Search mode after the operator acknowledges an alarm.
- **Display sleep**: preset time to turn off the front display without operator action.
- **Backlight**: when the operator enables this function, the backlight will automatically activate with the front display.
- **Trend**: enable the Trend display in detection mode (always enabled in Search mode).



6.2.3 Language

The submenu allows to select the desired language of the AccuRad.

- Open the menu Display / Language.
- Enter the PIN code, and then select the language.



6.3 Alarms

The Alarms menu is used to modify different alarm thresholds which warn the operator of a radiation level increase:

- Low alarm
- High alarm
- Danger alarm

- **Low alarms** when a source, sufficient enough to generate a significant increase of the measurement above the background, is detected. It is a background relative threshold.
- **High/ Danger alarms** are alarms corresponding absolute dose rate used to inform the operator of a risk of personal dose rate exposure. Note that high alarm can be inhibited but not danger alarm.
- **Dose alarm/Danger**: the AccuRad also provides two levels of integrated dose to inform the operator about the level of dose integrated since the device was powered on.

Caution:
Thresholds are different in 0-9 mode and in Dose rate / Count rate measurement display!

If the low range detector saturates, the AccuRad automatically switches to the high range detector to measure the dose rates and protect the low range detector and the operator.

Some alarms can be disabled, viewed and modified on the device. In Discreet mode, a dose alarm does not generate any sound or visual LED flash.

6.3.1 Alarms Strategy for Dose Rate & Count Rate

There are four rate alarm thresholds:

- **Low Alarm**: Based on sigma threshold calculated using averaged count rate of the background and dose rate threshold
- **High Alarm**: Absolute dose rate threshold
- **Danger**: Absolute dose rate threshold.

And two dose alarm thresholds that:

- **Dose Alarm**: dose alarm (starts from 0 at startup)
- **Dose Danger**: absolute dose threshold

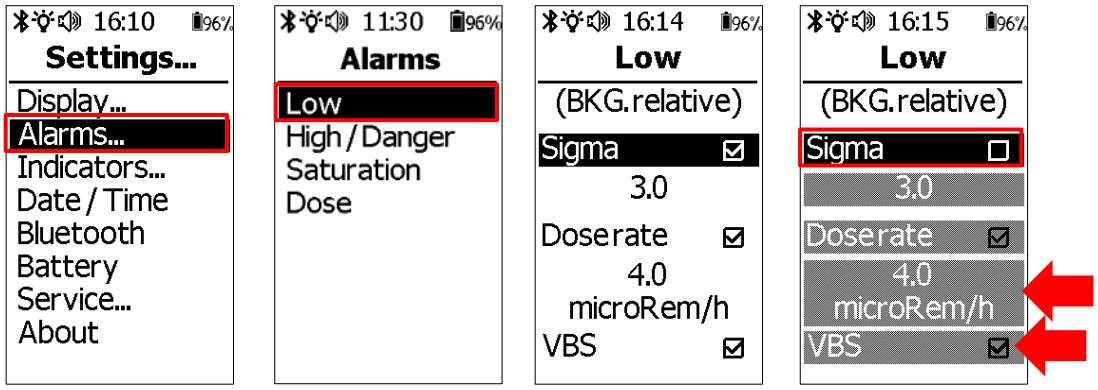
6.3.1.1 Low

This menu is used to select or adjust the low alarm threshold.

- Open the menu, select **Alarms,** then select **Low**.

- □ **Sigma**: threshold in number of standard deviation of the current background level. Use a higher number to reduce the sensitivity and the false alarm rate. A value of 3 is recommended.
- □ **Dose rate**: used to limit the number of false alarms. If activated, low alarm is triggered only if the sigma threshold is reached and if the background increase is higher than the set value. A value of 40nSv/h is recommended.
- □ **VBS: Varying Background Suppression** inhibits alerts due to sudden variations of background noise radiation. The variable background suppression (VBS) algorithm inhibits alerts due to a sudden change in background radiation. For example, a sudden change can occur when the operator moves from a location with low background radiation, such as indoors, to another location with a higher background radiation levels, such as a city street or underground rail station.

When the alarm sigma is locked / unchecked the displayed alarm **message** is displayed **greyed out**.



Dose rate alarm and VBS are locked and greyed out.

6.3.1.2 High/Danger

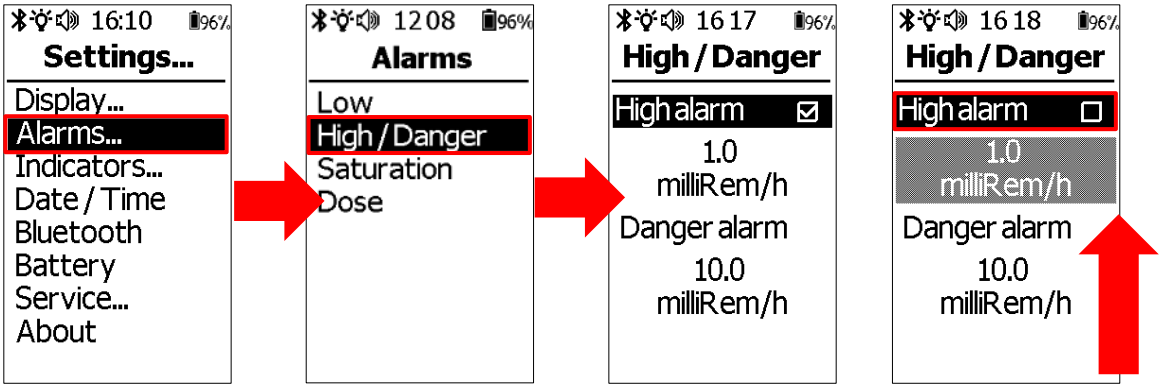
This menu is used to adjust the absolute dose rate Alarm & Danger thresholds.

- Open the menu, select Settings, Alarms, High/Danger

When the high alarm is locked / unchecked the displayed alarm **message** is **greyed out**.

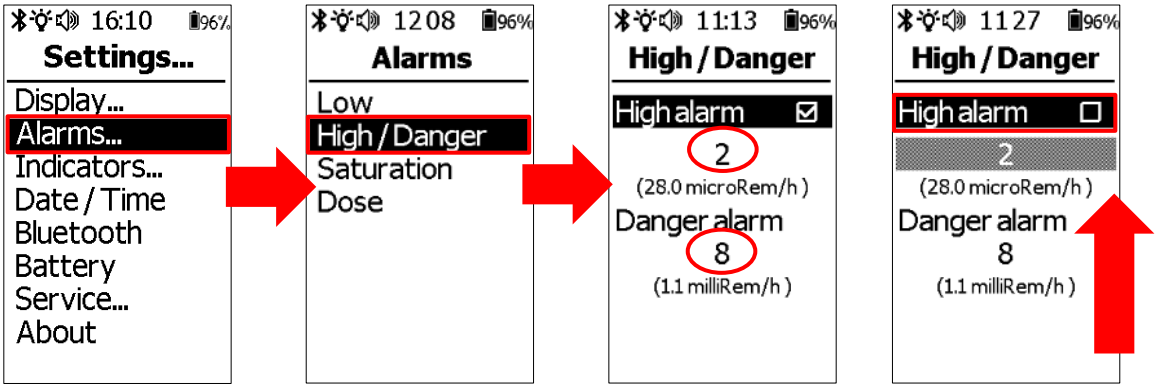
The Danger threshold corresponds to the alarm threshold which is always activated.

- Display screen with the dose rate measurement:



High alarm is disabled and greyed out.

- Display screen with the 0-9 measurement scale:



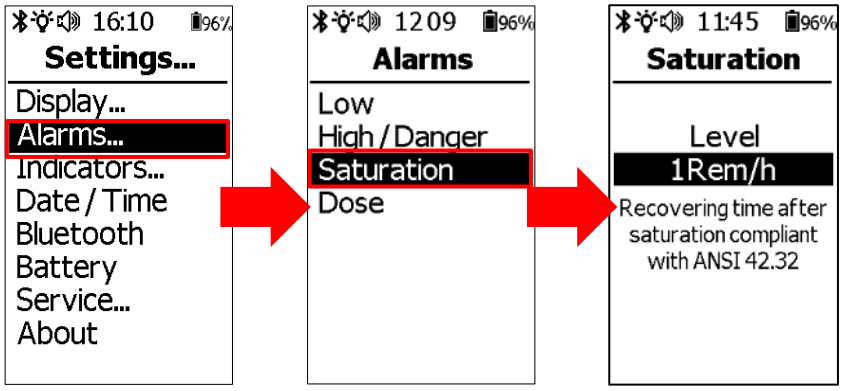
High alarm is disabled and greyed out.

Note:
In 0-9 mode, the alarm level is set to the lowest value of the measurement range of the selected level

6.3.1.3 Saturation

This menu is used to set the saturation level.

- Open the menu **Display / Saturation**.



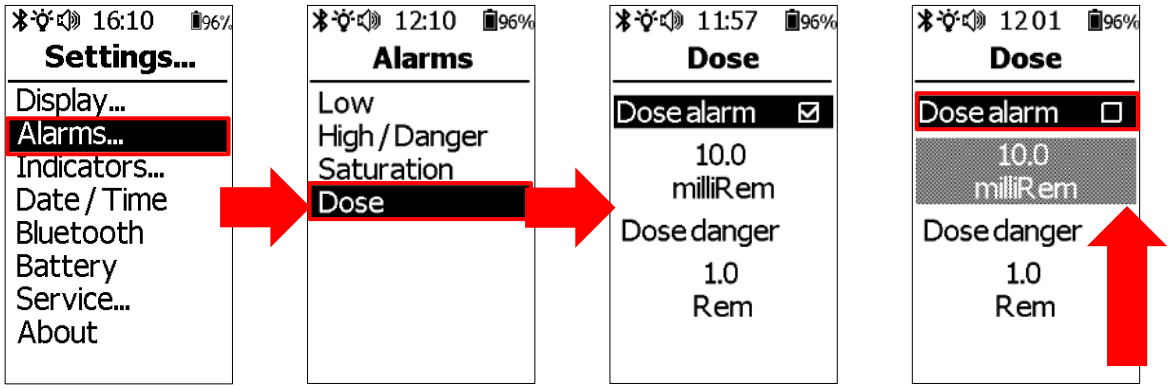
6.3.1.4 Dose

This menu is used to adjust the Dose Alarm and the Danger thresholds.

- Open the menu **Alarms / Dose**.

When the dose alarm is **disabled,** the alarm level is **greyed** out.

The Danger threshold corresponds to the alarm threshold which is always activated.



Dose alarm is disabled and greyed out.

6.4 Indicators

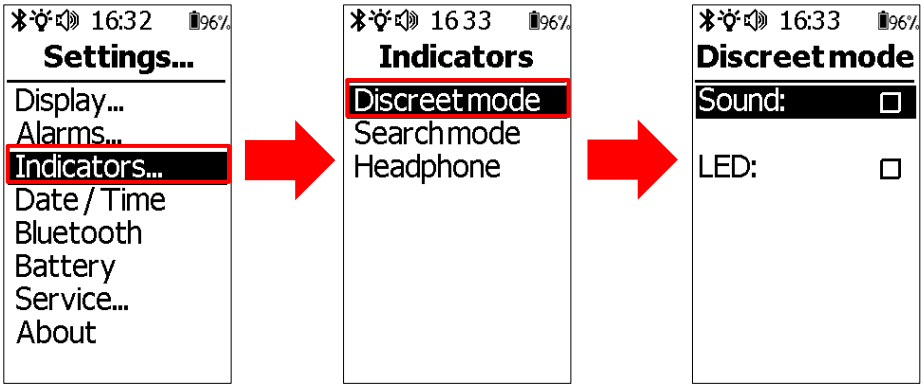
Use to configure the discreet mode, the search mode, and the volume of the earphone.

Open the menu **Indicators**, and then go to **Discreet mode, Search mode** or **headphone**.

6.4.1 Discreet mode

- Open **Settings**, **Indicators**, **Discreet Mode** and configure the following:

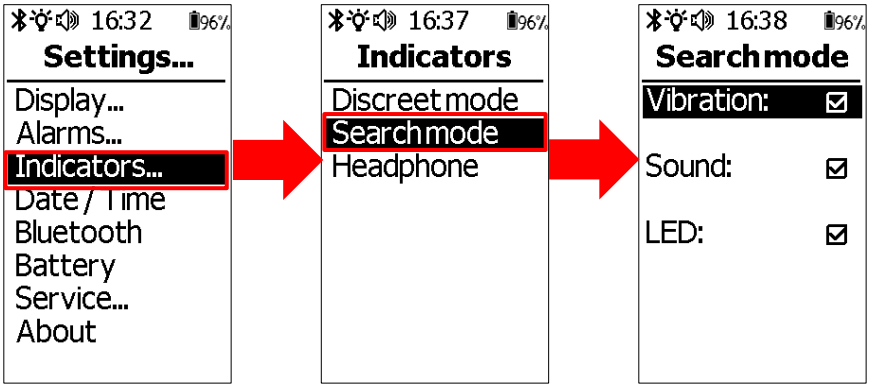
□ **Sound** (disabled by default): if disabled, alarm and event sounds can only be heard via earphones in Discreet mode.
□ **LED** (disabled by default): Enable or disable the LED flash.



6.4.2 Search Mode

- Open **Settings**, **Indicators**, **Search Mode** and configure the following:

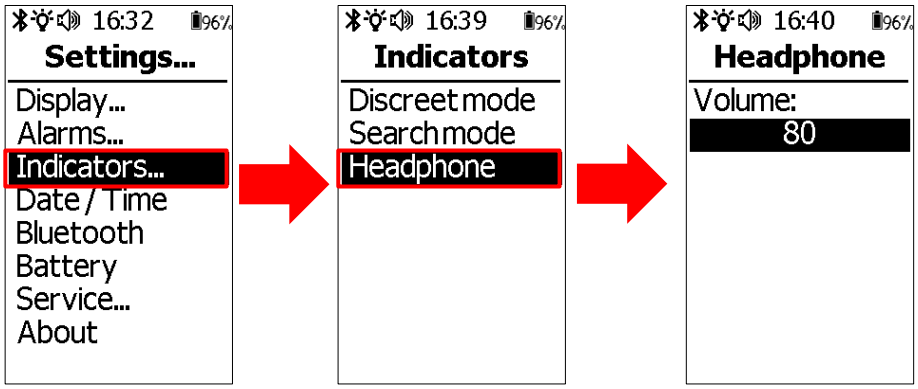
□ **Vibration** (enabled by default): enable/disable vibration which will vibrate in the rhythm of the dose rate in search mode.
□ **Sound** (enabled by default): enable the AccuRad to generate the chirp sound in search mode.
□ **LED** (enabled by default): enable/disable the RGB LED flash



6.4.3 Headphone

- ■ Open **Settings**, **Indicators**, **Headphone** and configure the following:
- □ **Volume**: Controls the volume of the headphone/earphone. The volume can also be controlled using the integrated control buttons (if available). The chirp is enabled when this menu is activated for adjusting the headphone volume.

Note *:*
The internal loudspeaker volume can not be adjusted in the menus.



6.5 Configuration Date/Time

Check and adjust the AccuRad date and time.

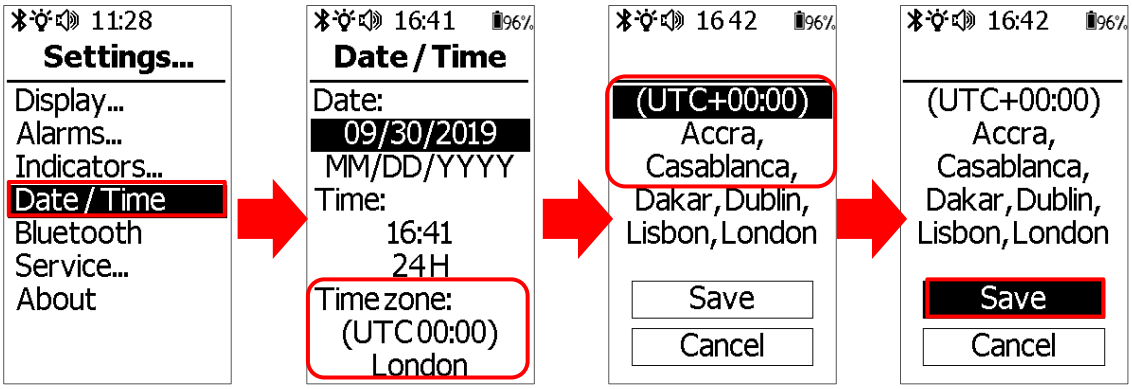
Open the menu, select **Date/Time** and set the following items:

- **Date**:

□ **Date**: **▲/▼ arrow buttons** and ○ **enter button** to select the date. Modify the year, month and day.
□ **Format**: **▲/▼ arrow buttons** and ○ **enter button** to select the format.

- **Time**:

□ **Hour, Min**: **▲/▼ buttons** and ○ **enter button** to select the time.
□ **Format AM/PM**: **▲/▼** buttons and ○ **enter button** to select the format.
□ **Time zone**: **▲/▼** buttons and ○ **enter button** to select the time zone. Select the value and **Save** the selection.



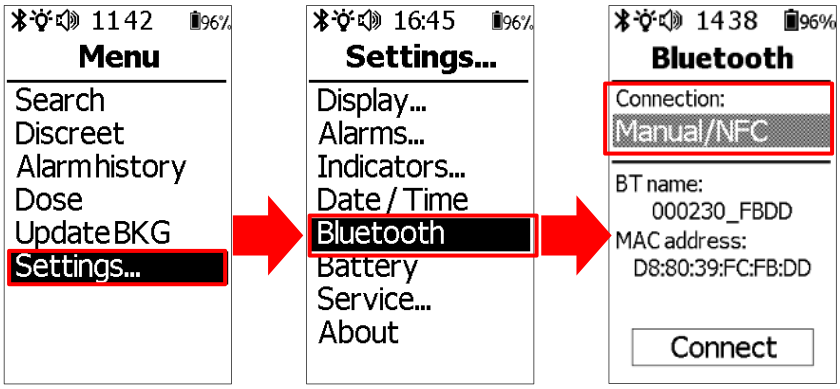
6.6 Bluetooth

This option is used to manage Bluetooth connection, for instance to pair the AccuRad to a Smartphone without using NFC. Bluetooth can also be disabled here.

Bluetooth connectivity provides access to all settings and internally stored data.

To access Bluetooth parameters, open **Settings** and then **Bluetooth**.

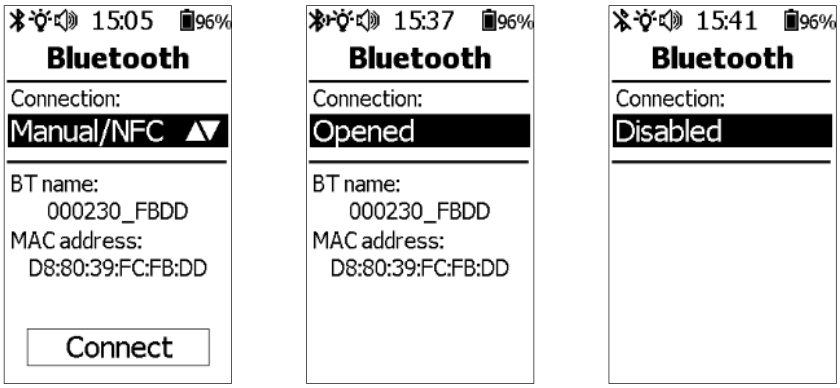
On the screen, the Bluetooth connection, name and the MAC address are indicated.



6.6.1 About Bluetooth modes

On the **Bluetooth** menu, press ○ and then ▲/▼ to select the type of Bluetooth connection. There are three types of Bluetooth connections:

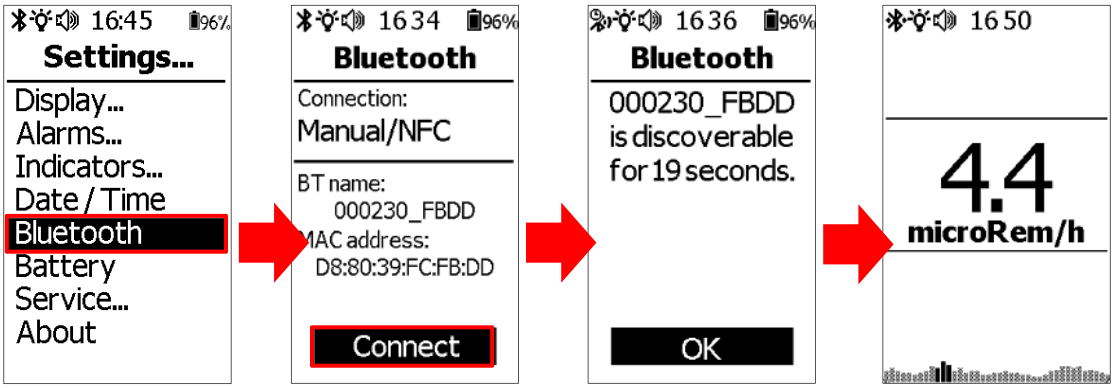
- **Manual/NFC**: in this mode, the AccuRad PRD can be manually connected via Bluetooth or NFC. For more information, refer to paragraph *§6.6.2 Using Manual/NFC mode*.
- **Opened**: in this mode, the Bluetooth connection is always on, meaning the AccuRad PRD is always connectable and detectable without user action, from startup to shut down; however the autonomy of the AccuRad PRD is limited in this mode.
- **Disabled**: in this mode, all Bluetooth connection are disabled, hence the AccuRad is neither detectable nor connectable. When Bluetooth is disabled, no pairing is possible, even with NFC. This mode is interesting for users searching for the best autonomy.



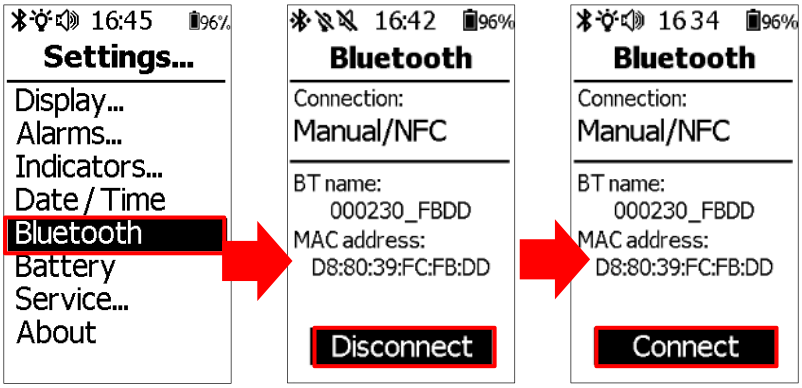
6.6.2 Using Manual/NFC mode

- Open Settings, **Bluetooth**: on the screen, the Bluetooth name and the MAC Address are indicated.
- Press ○ and then ▲/▼ to select **Manual/NFC**, then press ○ to confirm.
- Select **Connect**: If the NFC is not available on the Smartphone the operator can use this command to perform a manual connection.

□ Discoverable: The AccuRad is available and can be connected to the smartphone.
□ Not discoverable: After 30s, the Bluetooth is not discoverable.

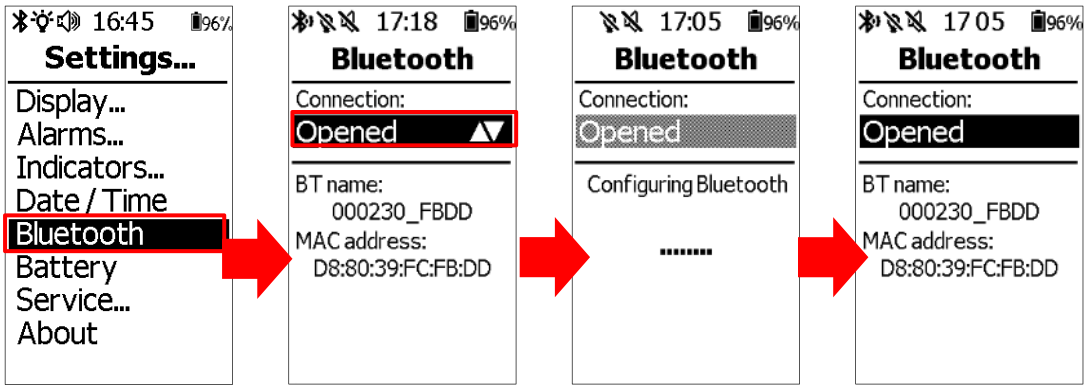


- **Connect**: the operator can connect (pair) the AccuRad to a Smartphone using the NFC. Enabling takes about 30 seconds to initialize the module.
- Select **Disconnect** to disconnect the AccuRad PRD.



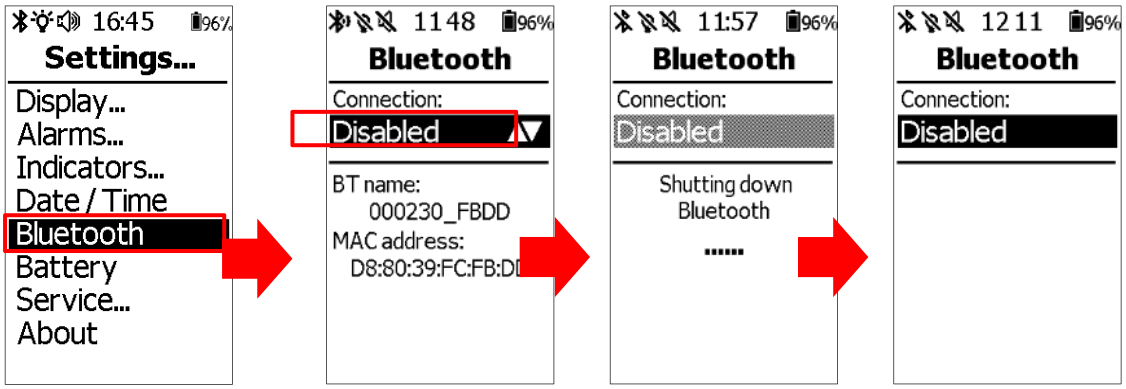
6.6.3 Using Opened mode

- Open Settings, **Bluetooth**: on the screen, the Bluetooth name and the MAC Address are indicated.
- Press ○, enter the PIN code and then ▲/▼ to select **Opened**, then press ○ to confirm.
- Wait for Bluetooth configuration.
- When done, the BT name and MAC address are displayed.



6.6.4 Using Disabled mode

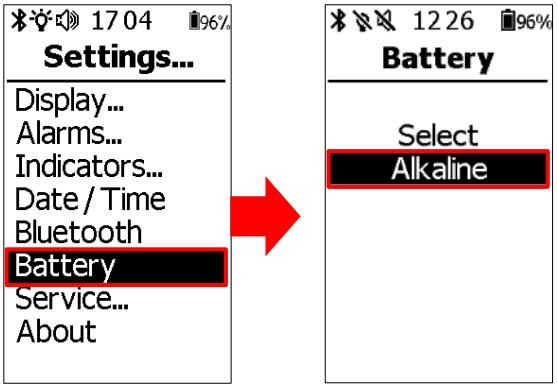
- Open Settings, **Bluetooth**: on the screen, the Bluetooth name and the MAC Address are indicated.
- Press ○, enter the PIN code and then ▲/▼ to select **Disabled**, then press ○ to confirm.
- Wait for Bluetooth shutdown.
- When done, Bluetooth is disabled. In Disabled mode, all Bluetooth connection are disabled, hence the AccuRad is neither detectable nor connectable. When Bluetooth is disabled, no pairing is possible, even with NFC.



6.7 Battery

Change the type of battery to adapt the battery meter with the battery chemistry.

- Open **Settings** and select **Battery**.
- Select the type of battery in the AccuRad. Available choices are Alkaline, Lithium and NiMH.



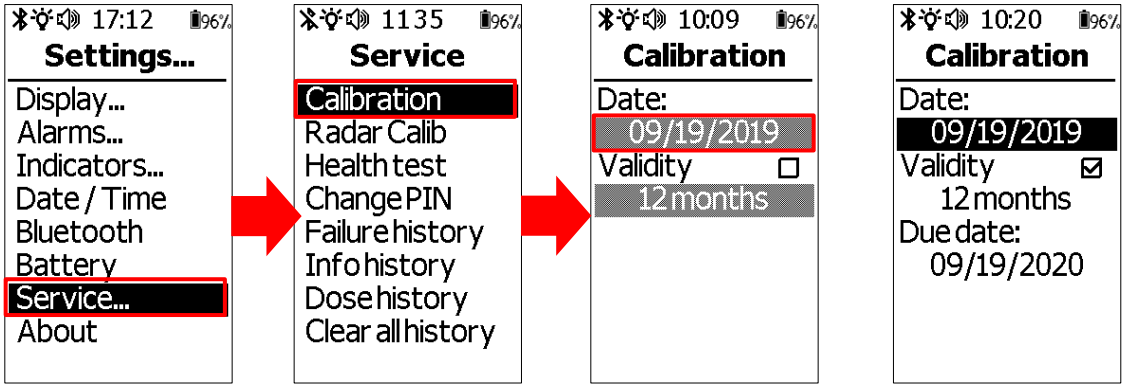
6.8 Service

6.8.1 Calibration

View the calibration service date, validity period and, if validity is checked, the due (expiration) date.

The calibration is performed with a high range calibrator/irradiator. For more information about calibrating the AccuRad, contact your Mirion Technologies representative.

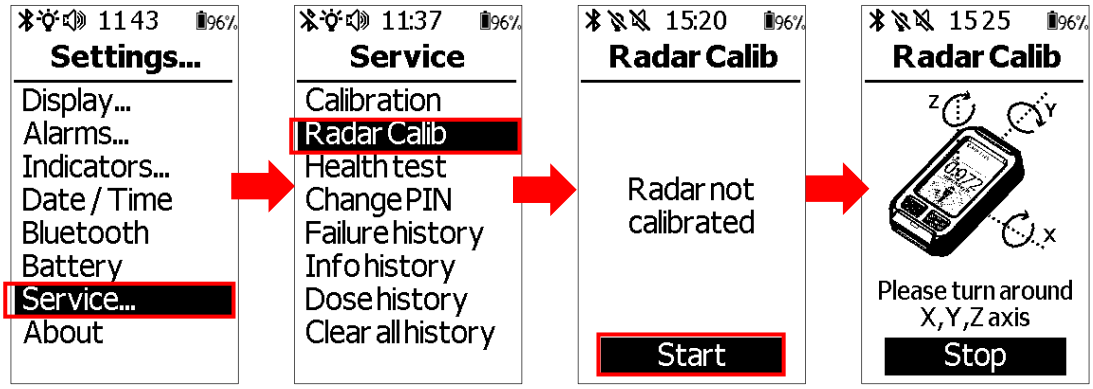
- Open **Settings**, **Service**, **Calibration**.



Note *:*
The Calibration date settings should only be modified at the time of calibration and in accordance with procedures and/or CONOPS.

6.8.2 Perform radar calibration

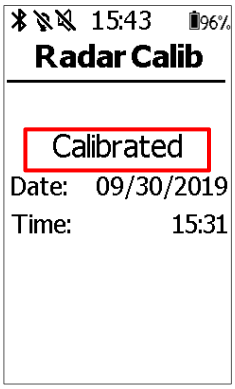
- Open the menu, select **Service…**, select **Radar Calib** and then **Start**



- *Slowly* rotate the AccuRad on each of the rotation axis (X, Y and Z), 5-7 times, so that the calibration is done correctly.

Note:
If calibration is not completed within thirty seconds, start again. Move away from any metallic or magnetic elements nearby. At any time, you can stop the calibration by selecting the Stop button.

- When the calibration is complete, the AccuRad will vibrate and display the "**Calibrated**" message.

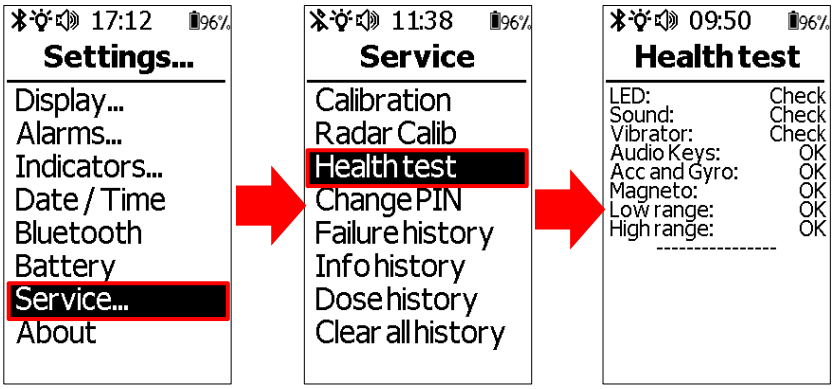


6.8.3 Perform Health Test

Restart the same sequence that for the AccuRad initialization.

During the test, the LEDs, sound and vibrator should be checked by the user.

For more details please refer to *§4.3 Start the AccuRad*.



Note *:*
If any of the Health Test items show FAIL, refer to paragraph §8.1 Troubleshooting or contact your Mirion Technologies representative.

6.8.4 Change PIN

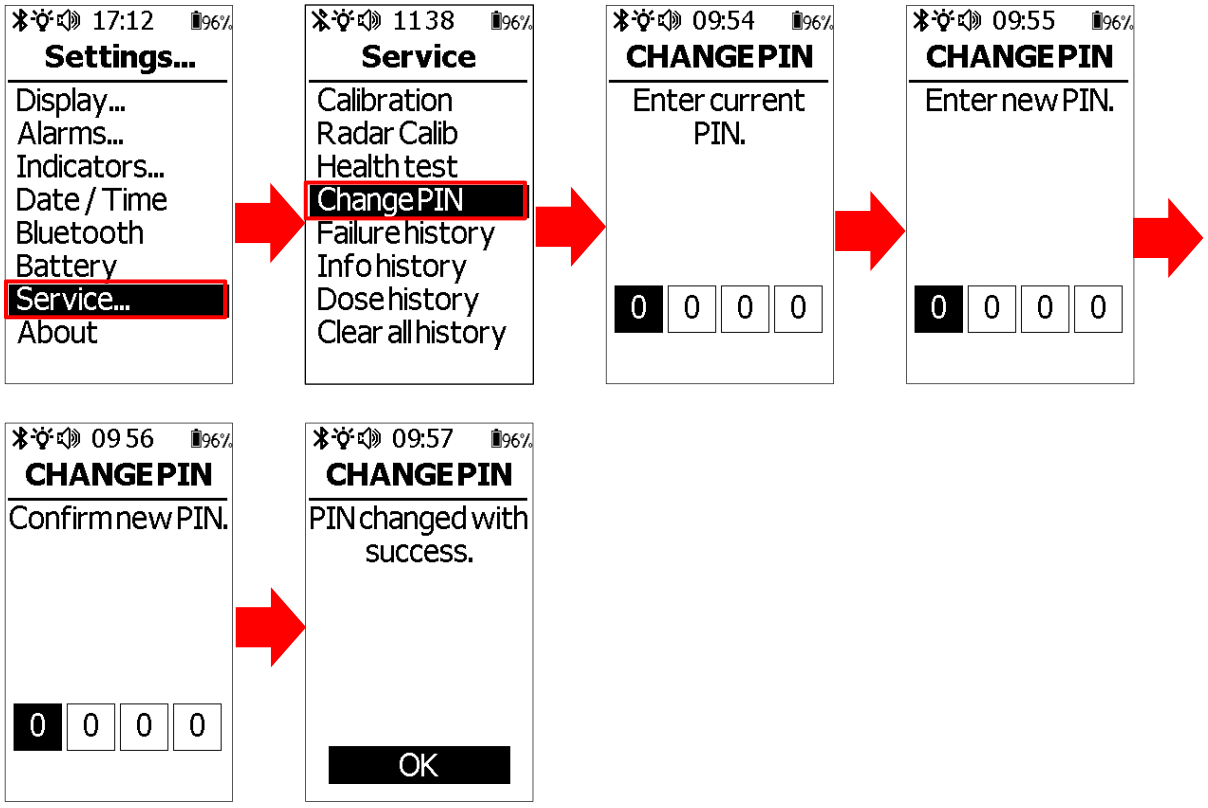
The PIN Code is used to protect all the critical settings and features of the AccuRad that are **greyed**. A programmed PIN Code is required to change the PIN Code.

- Open **Settings**, **Service**, **Change PIN**.
- Enter the current PIN code.
- The **Enter New PIN** window appears:

□ Press ○ **enter button** to select the field
□ Use the **▲/▼ arrow buttons** to increase or decrease the number in the field
□ Use the ○ **enter button** to validate each field.

- **Confirm the PIN** when prompted.

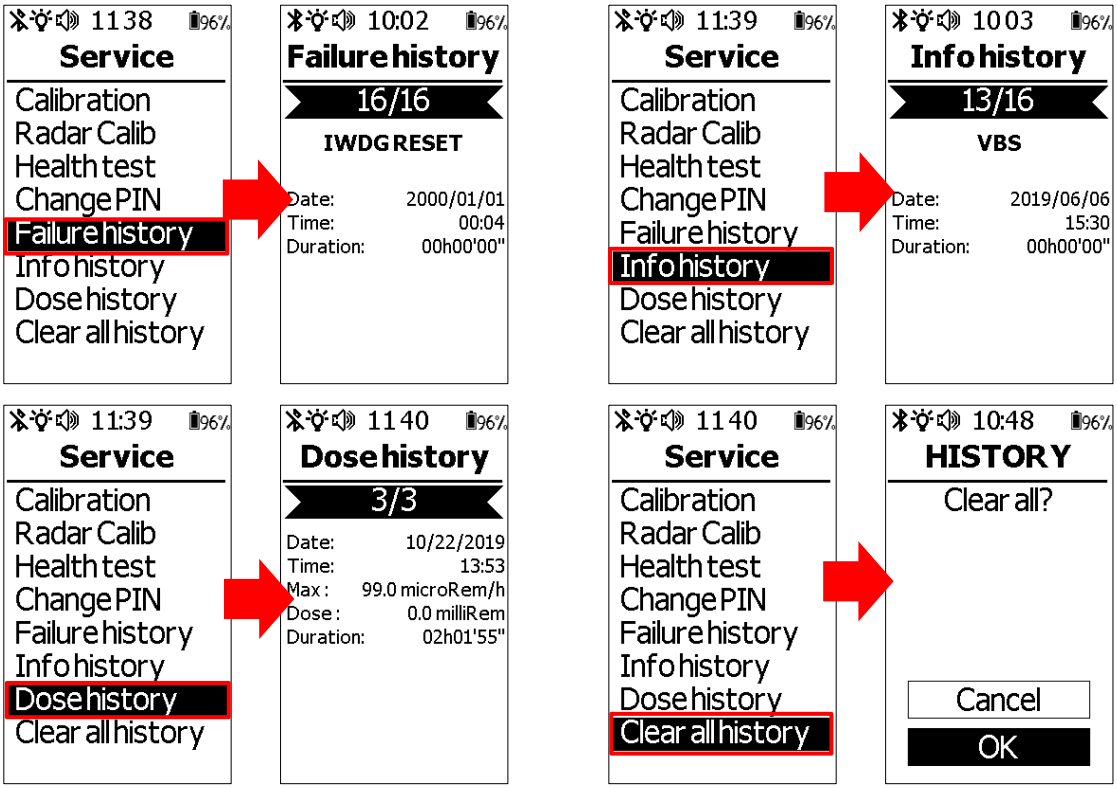
If the PIN is correct, the modification is complete. A message will appear for an incorrectly entered PIN code, try again.



6.8.5 Failure, Info, Dose and Clear all History

View, manage and erase the failure and info history data.

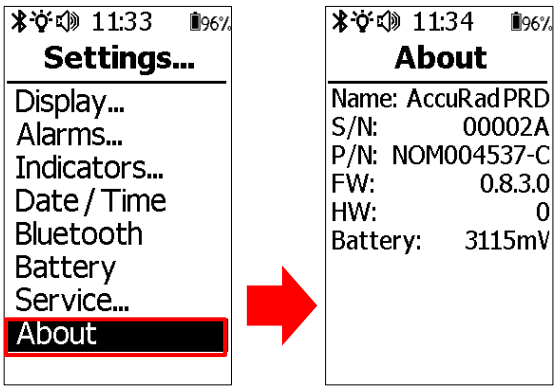
- **Failure history**: the operator can review the list of AccuRad failures.
- **Info history**: the operator can review historical events that such as high background.
- **Dose history:** the operator can review dose events.
- **Clear all history**: allows to erase all the history (alarm, failure and info).



6.9 About

Displays miscellaneous AccuRad information:

- Name
- Serial number
- Part number
- Firmware version
- Hardware version
- Battery voltage (not available if connected on USB)



7. AccuRad Smart Application Overview

The AccuRad Smart Application is the companion interface for the AccuRad.

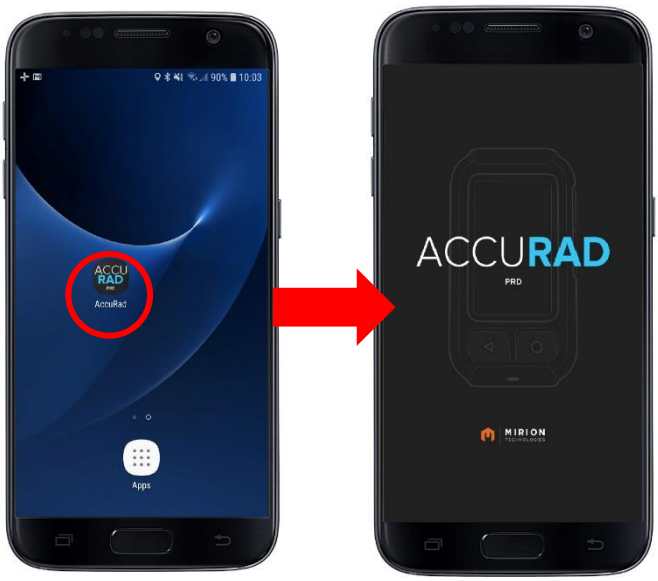
The application is available on the Apple Store or Google Play download platform.

7.1 Using AccuRad App

The AccuRad App improves the speed of data transmission and facilitates the retrieval of information to be transmitted. It is available on the download platform "App Store" or "Google Play" depending on the smartphone used.

7.2 Starting the AccuRad App

- Click on the application icon, the AccuRad app home screen appears.



7.3 Connecting the AccuRad App to the AccuRad Device

There are two ways to connect the phone with the AccuRad App: via NFC or via Bluetooth.

Three methods of communication are available:

- **NFC**: used to easily connect the AccuRad to a Smartphone with the AccuRad app. The AccuRad app is a convenient way to setup one or several AccuRad devices. NFC connection is easier than Bluetooth connection but is not mandatory. For more info about NFC connection, please refer to paragraph *§7.3.1 NFC Connection*.
- **Bluetooth Low Energy (BLE)**: used to transmit events data to the AccuRad App, and then these events data can be send from the AccuRad App to a monitoring station. For more info about BLE connection, please refer to paragraph *§7.3.2 Bluetooth Connection*.
- **USB**: used for firmware update only. For more info about firmware update, please refer to Chapter *8 Recommendations, Troubleshooting and Maintenance*.

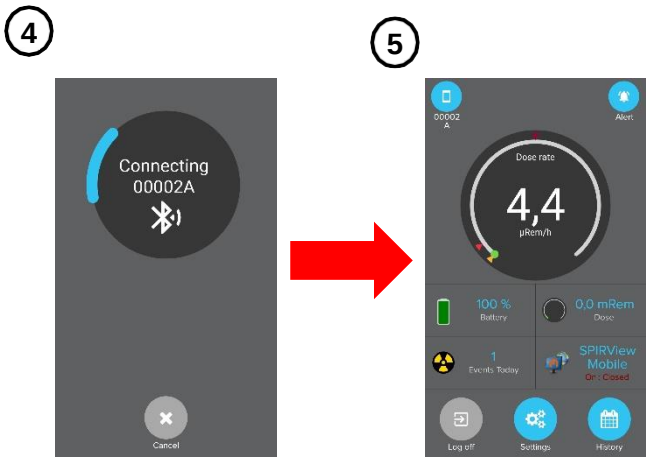
7.3.1 NFC Connection

- Open the AccuRad App on the smartphone.
- Place the smartphone next to the AccuRad (see picture), with the two NFC logos in contact.

Note *:*
The location of the NFC contact point may change depending on the smartphone model. For more information, refer to your smarphone user's manual.

7.3.2 Bluetooth Connection

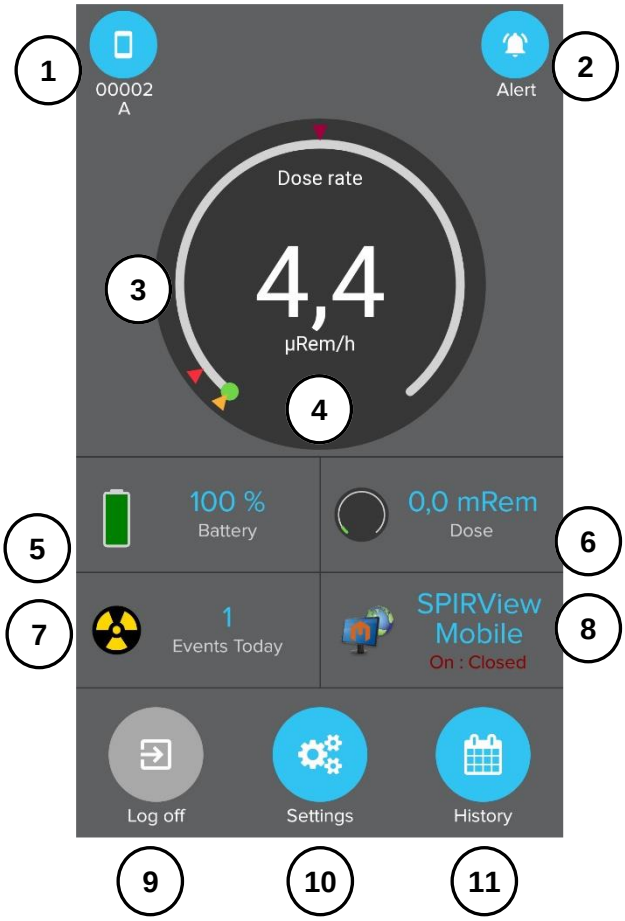
- On the AccuRad device: open the menu, select **Settings**, **Bluetooth**, **Connect**. A 30-second sequence starts for the Smartphone to detect the AccuRad (refer to paragraph *§6.6 Bluetooth*).
- Open the AccuRad App on the smartphone, and then press the **Scan** button and select the **nearby device** (see picture).
- The connection is established when the AccuRad App displays **Connecting**.
- The AccuRad App is ready for use.



7.4 Using AccuRad App

7.4.1 Interface Overview

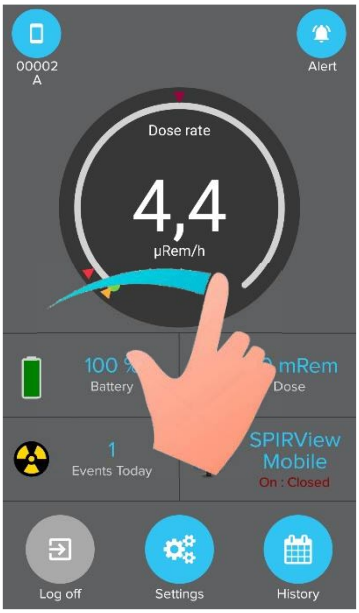
1. **AccuRad**: access device information.
2. **Alert**: switch the AccuRad device to discreet mode. For more information refer to *§4.5 Discreet Mode Overview*.
3. **Status Gauge**: displays the system status. The color of the status gauge vary depending on the current status.
4. **Real Time Gamma Measurement**
5. **Device Battery Level**
6. **Measurement Unit**: displays dose measurement.
7. **Events**: number of alarm events to send.
8. **Monitoring Connection**: connect with monitoring station to transmit history alarm.
9. **Disconnect**: disconnect the AccuRad device from the App.
10. **Settings**: settings menu of the connected AccuRad device.
11. **History**: visualize recorded alarms.



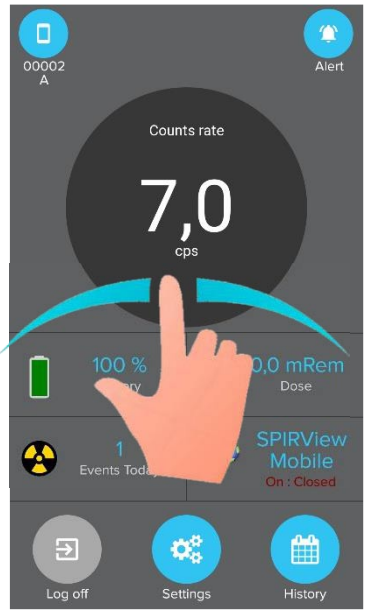
7.4.2 Basic Navigation

- The operator can easily scroll between the three mains screens using a finger swipe motion on the upper part of the screen. Each screen provides level, status information and unit measurement.

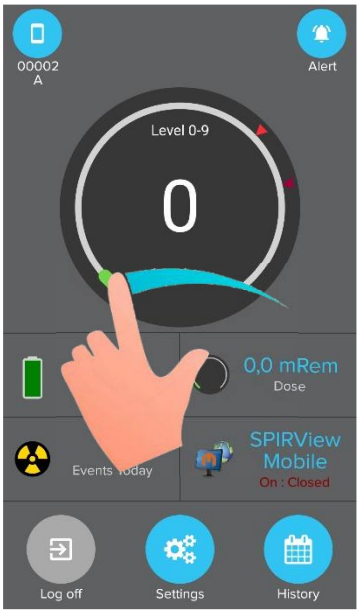
Dose Rate Screen



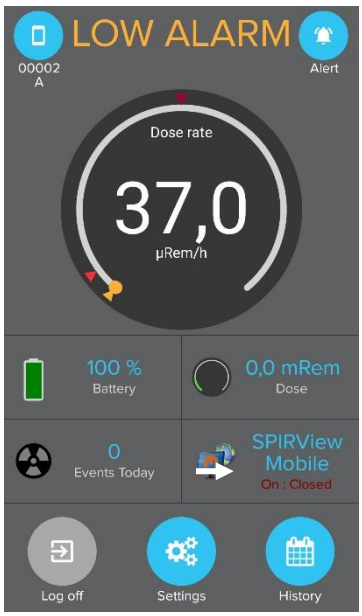
Count Rate Screen

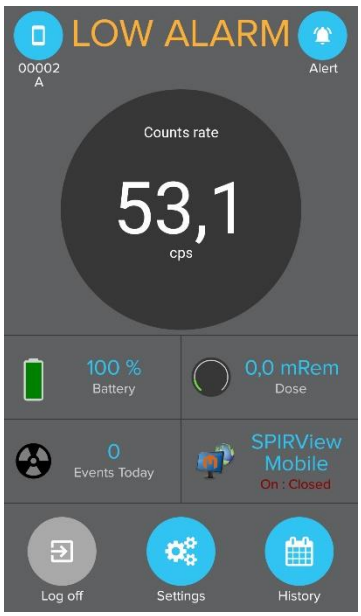


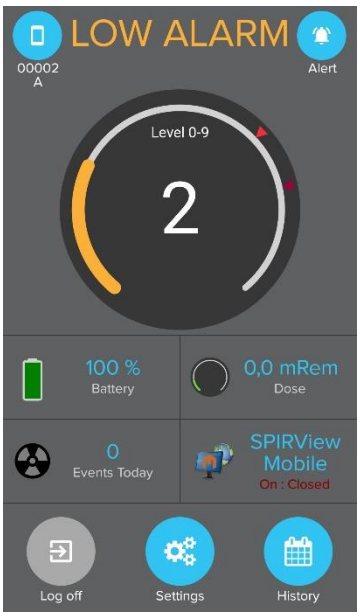
0-9 Indicator Screen



- When a low alarm appears, the operator can press the upper part of the screen to acknowledge it and scroll through the three screens:



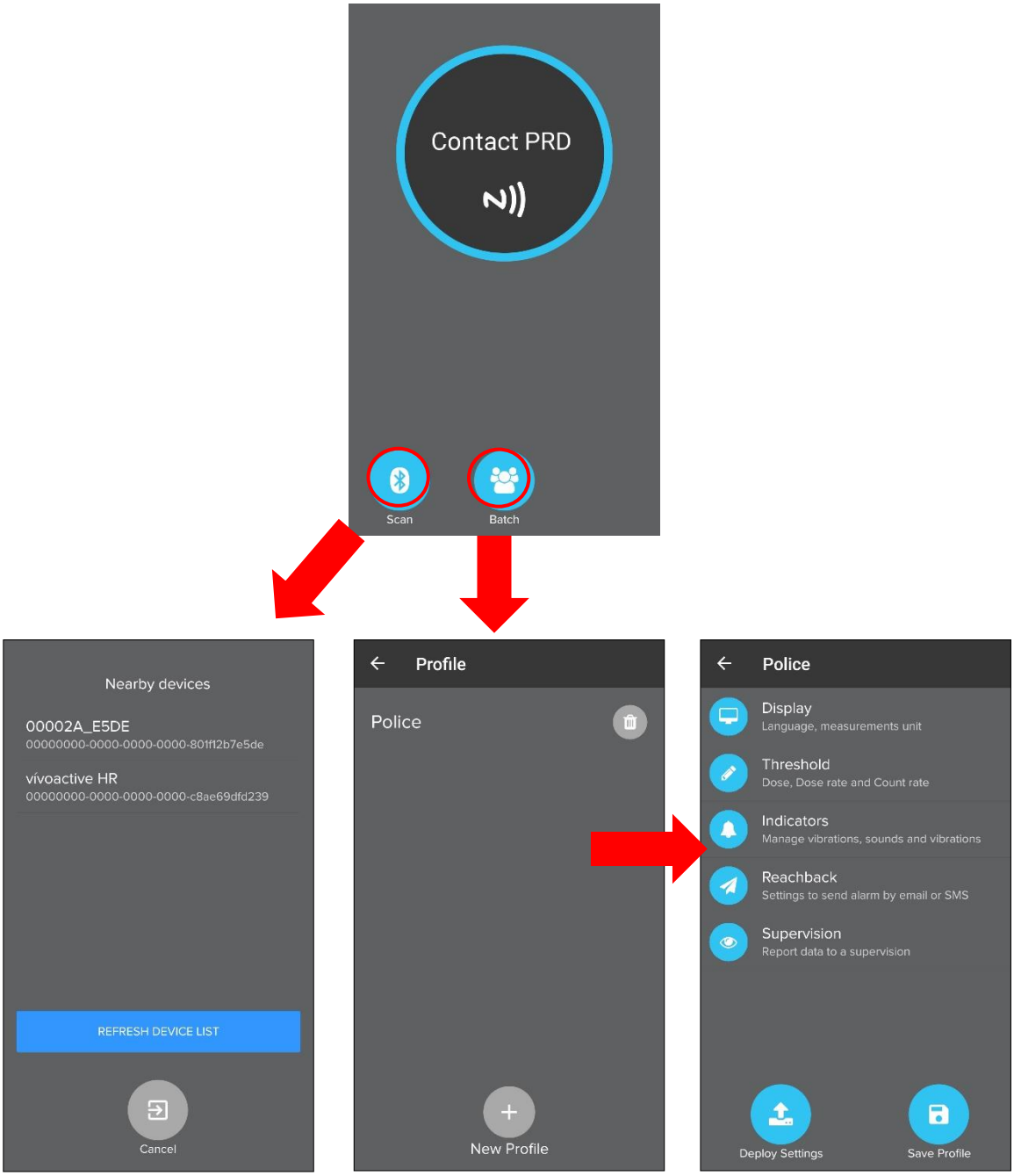


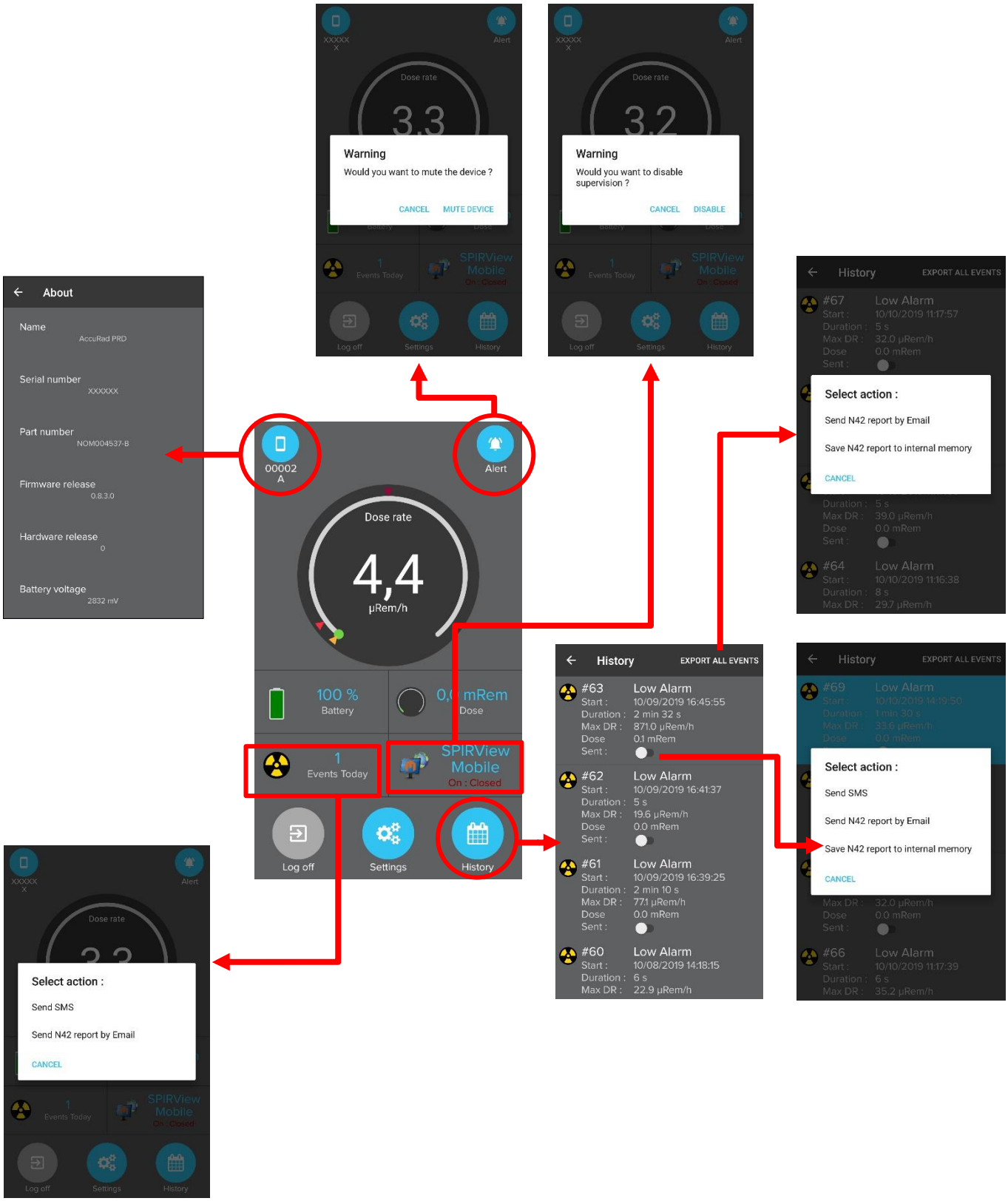


7.4.3 Home Screen AccuRad App

On the AccuRad App start screen, there are three buttons:

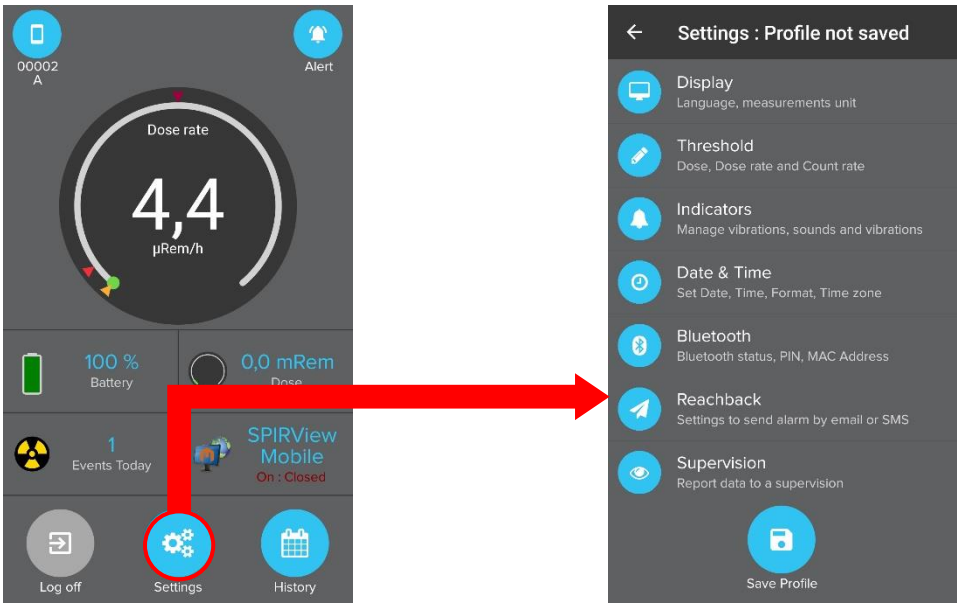
- **Scan**: connect to a device.
- **Batch**: create a profile for a defined setting.





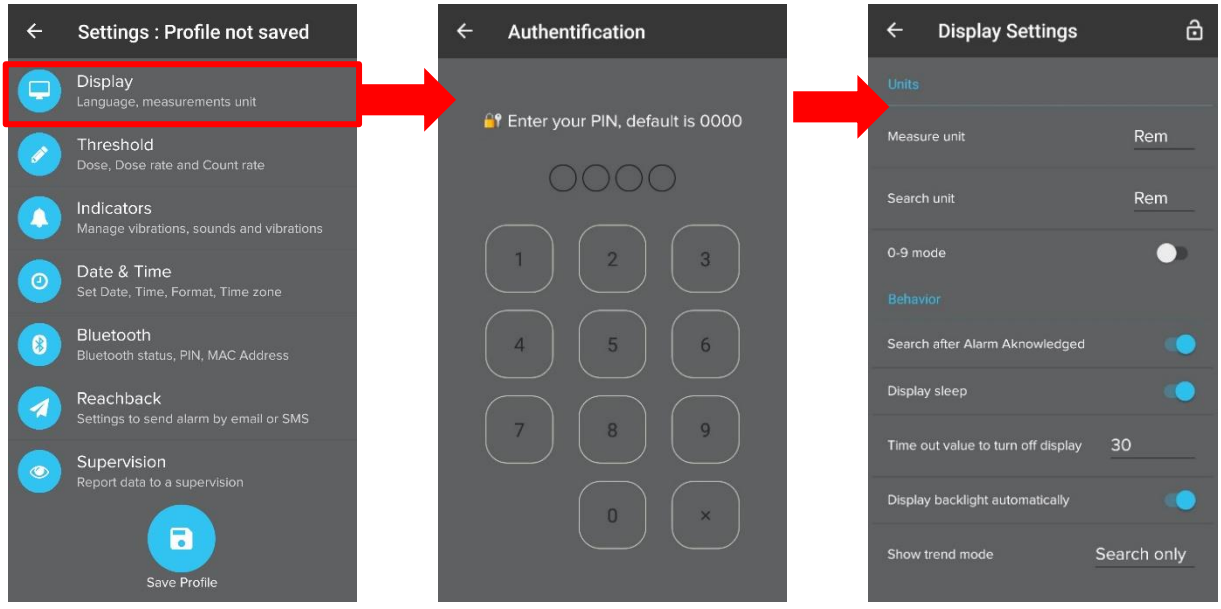
7.4.4 Settings Menu

The settings menu is used to modify the AccuRad device configuration. These settings are identical to what can be found in the AccuRad device settings, refer to the corresponding paragraphs for more information.



7.4.4.1 Display

- **Units**: Select the measurement units or measurement method.
- **Behavior**: Configuration of Search mode activation, the display sleep, backlight and show trend.



Note *:*
The PIN code is the same than on the AccuRad device.

7.4.4.2 Thresholds

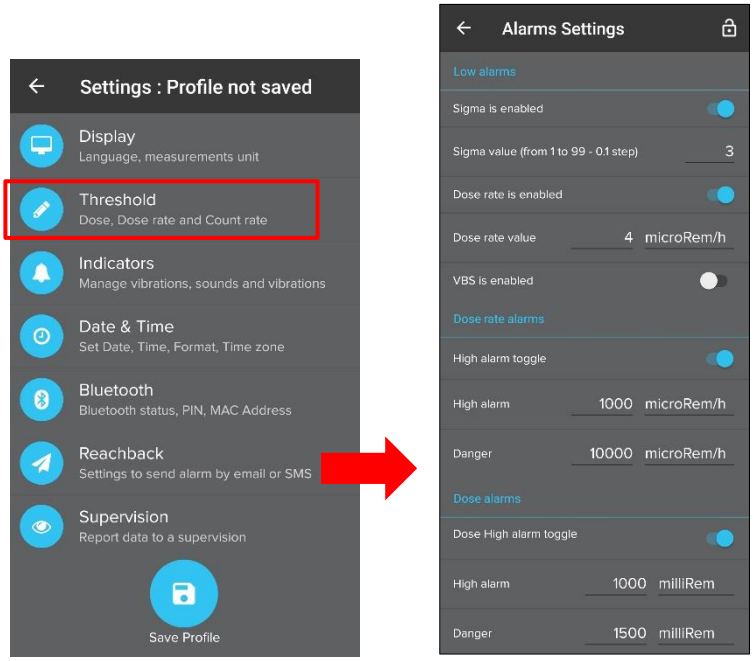
Select the type of alarms: Low and High / Danger, and edit the corresponding alarm thresholds.

- **Low alarms**: Select or adjust the low alarming threshold. For more information, refer to paragraph *§6.3.1.1 Low*.

When the alarm is **locked,** the displayed alarm **message** is **greyed** and not selectable.

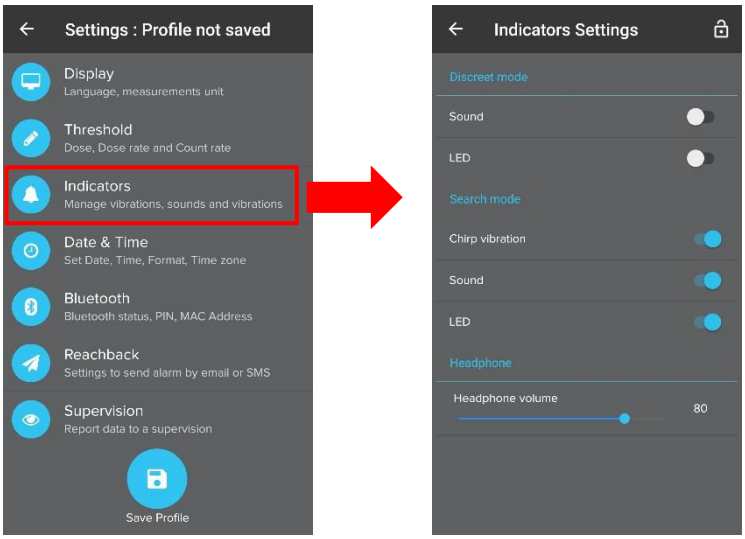
- **Level 0-9 alarms**: The default levels can be modified to meet operator requirements. There are two level alarm thresholds for the 0-9 measurement scale:

□ Level High: 1 to 9
□ Level Danger: 1 to 9.



7.4.4.3 Indicators

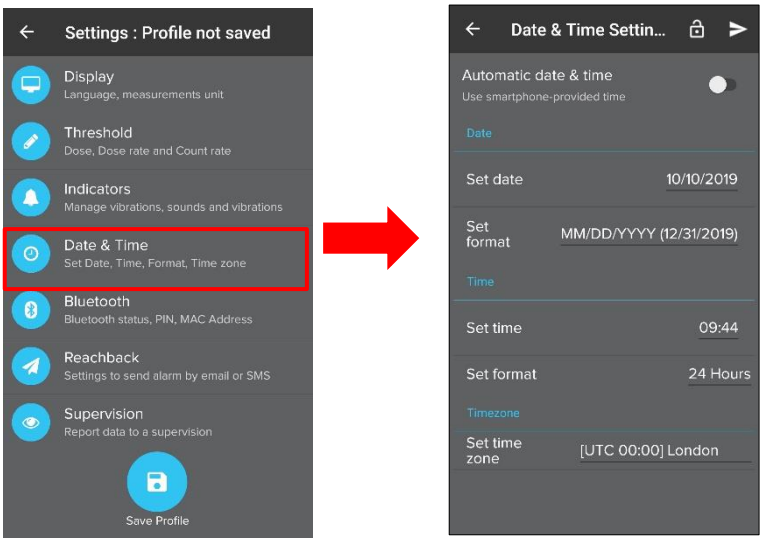
Configure **Discreet** mode, **Search** mode and the **Headphone** volume.



7.4.4.4 Date & Time

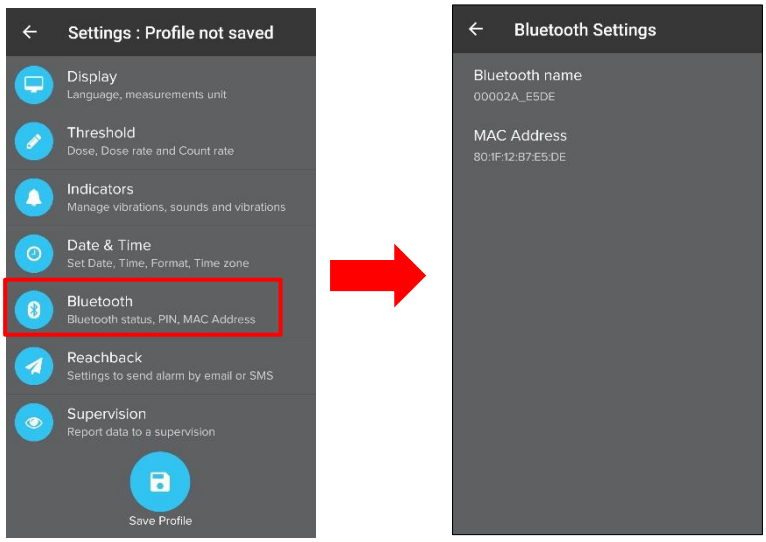
Check and adjust the AccuRad **Date** and **Time**.

- **Automatic Date and Time**: sync time with the Smartphone



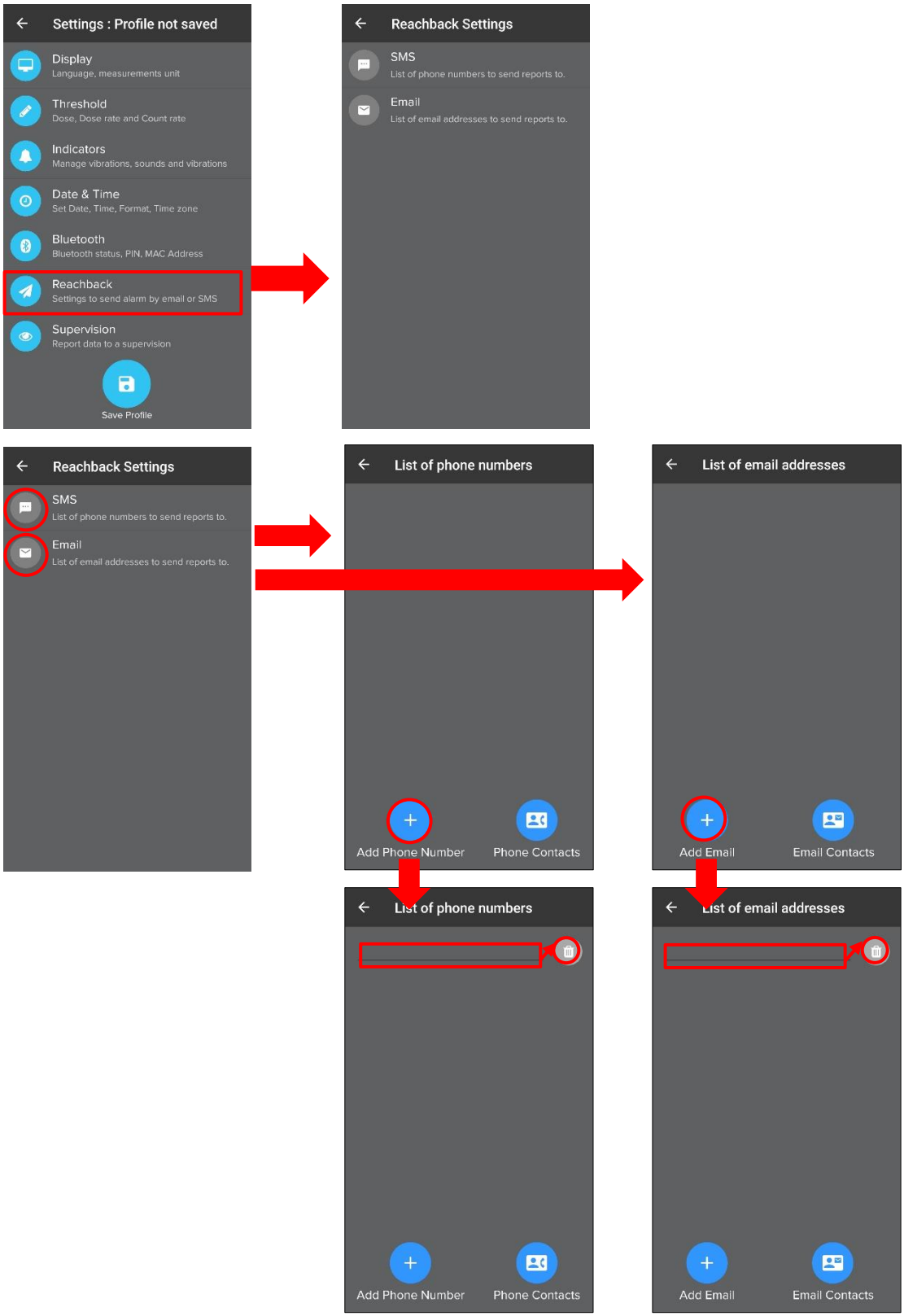
7.4.4.5 Bluetooth

Display the Accurad Bluetooth status, MAC name and address and PIN Id (if a PIN code has been created).



7.4.4.6 Reachback

The reachback feature transmits events to email and/or phone number.



7.4.4.6.1 Communication for Reachback

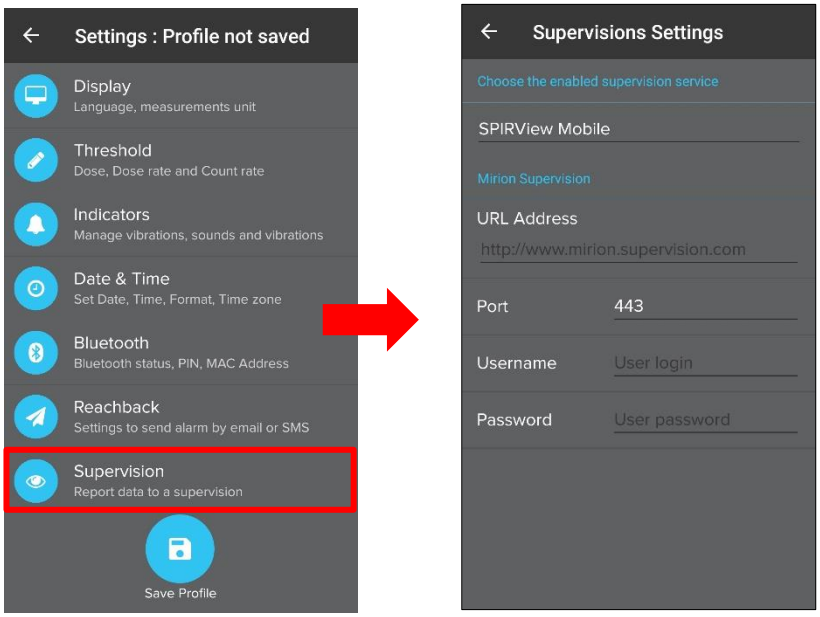
The AccuRad can connect to an Android/iOS Smartphone via BLE or NFC to transmit events to a remote reachback system.

The latest event information is transmitted. Examples of other data that can be transmitted:

- Instrument type
- serial number
- measurements
- GPS location
- alarm status
- battery status

7.4.4.7 Supervision

Select the available supervision platform by URL address.



7.4.4.8 Communication for Supervision

The device can be connected to an Android/iOS Smartphone via BLE to send data to Supervision system.

The Smartphone application aggregates the device data with the Smartphone position

The Smartphone application sends data to the supervision system every (TBD) seconds, minimum every 1s or use smart transmission (Sigma + Geo grid function of speed).

Data will be sent automatically to the supervisor.

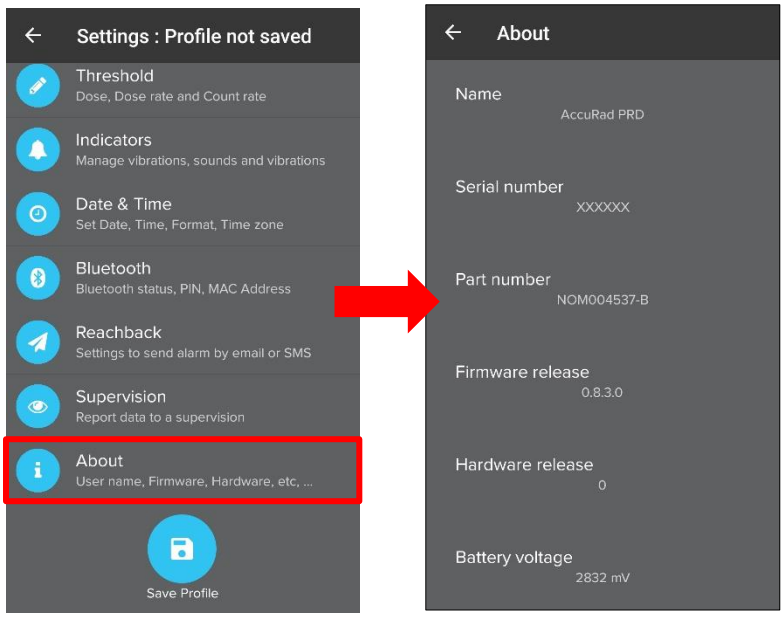
In the event of communication interruptions, data will be maintained and transmitted as soon as the connection is restored.

Examples of other data that can be transmitted:

- Instrument type
- serial number
- measurements
- location if available
- alarm status
- battery status

7.4.4.9 About

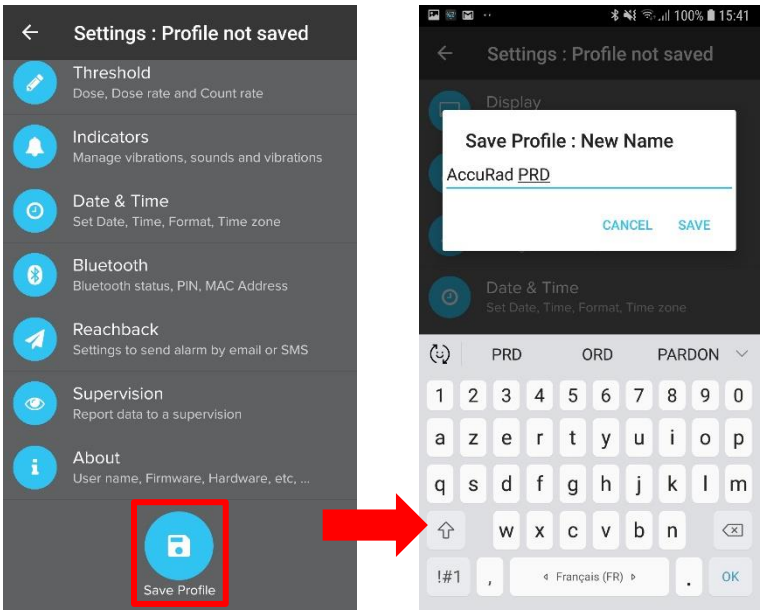
Information about the AccuRad.



7.4.4.10 Save profile

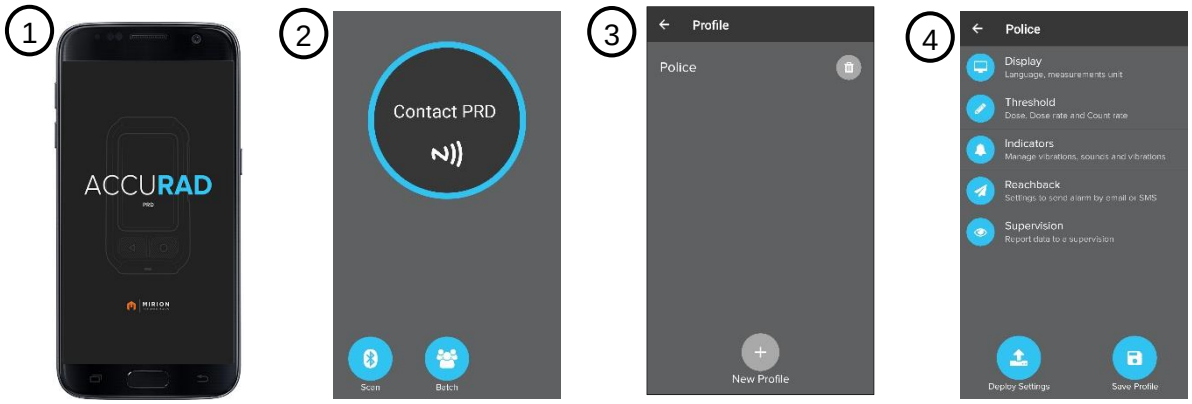
- Press the **Save Profile** button to save the settings profile under a new name.

Saved settings profiles can be applied to one or several AccuRad, ensuring that all devices have the same settings.



7.4.5 Applying settings to an AccuRad batch

- Open the AccuRad App on the smartphone.
- Press the **Batch** button.
- Select a settings profile in the list, or press the **New Profile** button to create one.
- Review the settings of the settings profile.
- □ If necessary, edit the settings and then press the **Save Profile** button.
- Press the **Deploy Settings** button.
- Place the smartphone next to the AccuRad (see picture), with the two NFC logos in contact. When the AccuRad vibrates, the settings profile is applied.
- Repeat the previous step with the next AccuRad of the batch.
- When all AccuRad have been set, press the **Stop Batch** button on the app.



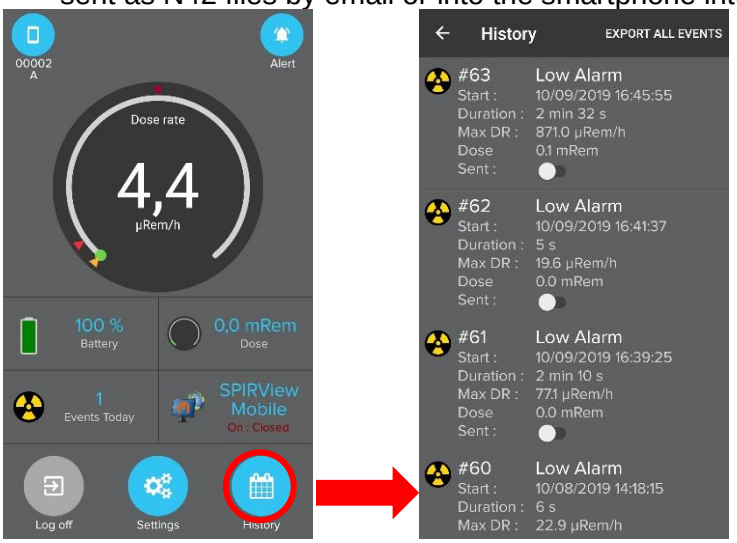
7.4.6 History menu

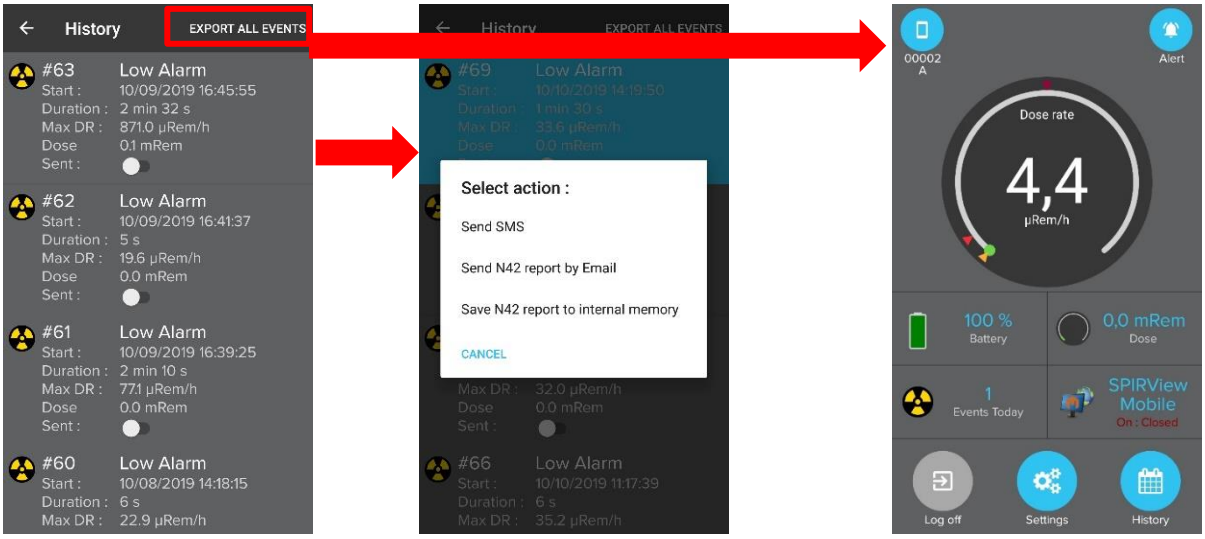
The History menu is used to check and export the events saved in the AccuRad.

- From the main menu, press **History**.
- There are two means to export events:

□ To export one specific event, select it. In the pop-up window that is displayed, choose how to send the event: by SMS, by email as a N42 report, or into the smartphone internal memory as a N42 report.

□ To export all events, press the Export all events button. In this mode, events can only be sent as N42 files by email or into the smartphone internal memory.

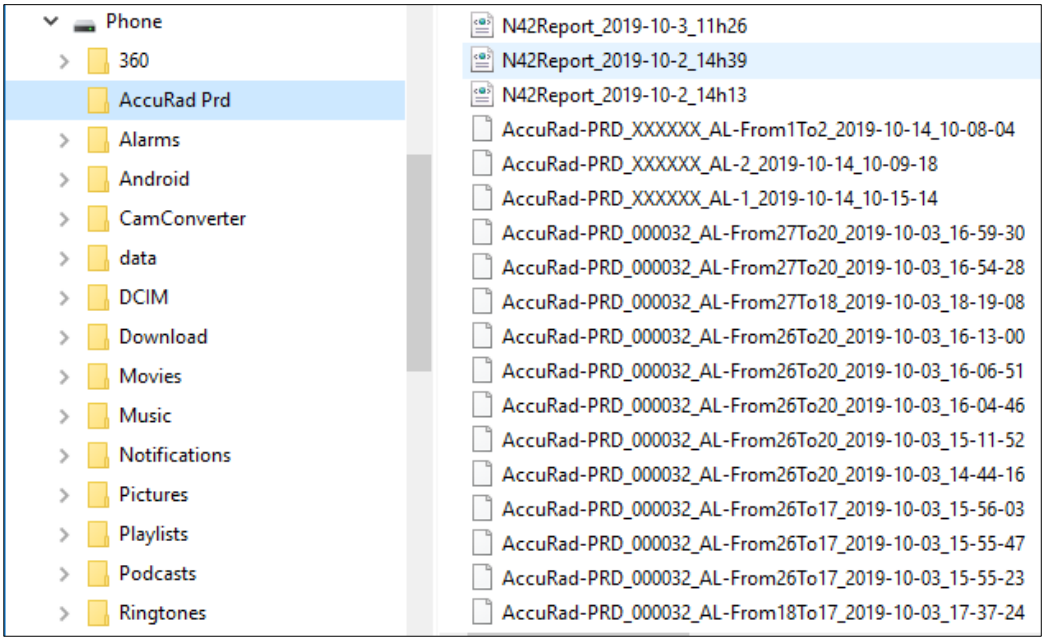




Note:
- Only four events can be sent at once by SMS.
- Events can also be exported by pressing the Daily alarms button in the main interface.

7.4.6.1 Retrieving events reports from the smartphone internal memory

- Connect the smartphone to a PC.
- From the PC, open the smartphone directory and then open the AccuRad Prd directory to find the reports as N42 files.



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8. Recommendations, Troubleshooting and Maintenance

8.1 Troubleshooting

Note:
Always follow the recommendations provided in the previous chapters.

The AccuRad periodically performs self-testing and diagnostics to ensure it is mission ready. In the event of a test failure, the AccuRad:

- displays a failure message on both display screens,
- has a purple flash from its alarm LED,
- emits an audible failure tone.

In that case, the AccuRad should be removed from service.

Note:
A low battery is not considered as a failure.

8.1.1 Troubleshooting Table

Problem (Symptom), Message	Cause	Actions
High background.	Background becomes too high to ensure a good detection	Perform a background acquisition (see *§5.7 Update Background (BKG))* Move away to a radiation-free area. If the problem persists, contact your Mirion representative.
Detector failure	Issue with the low range detector polarization voltage, or no count.	This failure is latched and cannot be manually acknowledged. Auto-acknowledged if the read value becomes good and checked every 2500ms cycle for counting fault, few seconds for polarization, at power up for threshold. The failure is cleared by powering off the AccuRad. If the problem persists, contact your Mirion representative.
Temperature too low / too high	Temperature out of range.	The correct behavior of the AccuRad is not ensured. Move the AccuRad to a place with compliant temperatures. Auto-acknowledged if the read value becomes good and checked every 10s. If the problem persists, contact your Mirion representative.

Problem (Symptom), Message	Cause	Actions
Temperature failure	No communication with temperature sensor	Reboot the AccuRad. If the problem persists, contact your Mirion representative.
Bluetooth failure	No communication with Bluetooth component	Reboot the AccuRad. If the problem persists, contact your Mirion representative.
Audio failure	No communication with Audio component	Reboot the AccuRad. If the problem persists, contact your Mirion representative.
Flash failure	No communication with Flash memory (log storage)	Reboot the AccuRad. If the problem persists, contact your Mirion representative.
Accelerometer failure	No communication with accelerometer and gyroscope components	Reboot the AccuRad. If the problem persists, contact your Mirion representative.
Magneto failure	No communication with Magnetometer component	Reboot the AccuRad. If the problem persists, contact your Mirion representative.
NFC failure	No communication with NFC component	Reboot the AccuRad. If the problem persists, contact your Mirion representative.
E2P failure	No communication with EEPROM component (settings storage)	Reboot the AccuRad. If the problem persists, contact your Mirion representative.
IDWG Reset	The AccuRad has unexpectedly rebooted	Reboot the AccuRad. If the problem persists, contact your Mirion representative.
User parameter error (menu name)	The user parameter area has been restaured with the default parameters.	Go to the menu indicated by the message, check and edit the parameters.
Factory parameter error	The factory parameter area has been restaured with the default parameters.	This failure is latched and cannot be acknowledged. Contact your Mirion representative.
User and factory parameters error	The user and factory parameter area has been restaured with the default parameters.	This failure is latched and cannot be acknowledged. Contact your Mirion representative.
Calibration Date Expired	Calibration date is too old.	The AccuRad requires a calibration. Contact your Mirion representative.
VBS	VBS has detected a change in background type	No action required
Battery low	Battery are too low	Charge or change the batteries. If the problem persists, contact your Mirion representative.
The device is powered off and does not start.	Battery depleted	Change the batteries and press the ⏻ on/off button. If the problem persists, contact your Mirion representative.

8.2 Maintenance

The AccuRad does not require preventive maintenance. However, a periodic verification is recommended when poor performance is observed, and a calibration is recommended once a year.

8.2.1 Periodic Verifications

- Built-in health test

AccuRad is designed with a built-in health test, which is automatically performed when the device is powered ON and periodically when the AccuRad is on except for sound, vibration and LED. Refer to paragraph *§6.8.3 Perform Health Test.*

- Measurement Capability Verification

When poor performance is observed, Mirion recommends to verify the device measurement capabilities using a reference gamma radiation source.

8.2.2 Calibration

The calibration is made by Mirion Technologies. Please contact your Mirion representative for more information.

8.2.3 Cleaning

- Frequency: after use; weekly.

8.2.3.1 Materials Required

- Lint-free soft cloths,
- Warm water, mild soap. Do not use abrasive cleaners or chemicals.
- Isopropyl alcohol

8.2.3.2 Procedure

- Power off
- Remove batteries
- Clean the screen with a clean cloth damped with soapy water.
- Clean the battery compartment and internal battery cover with a dry cloth only.
- Carefully check the battery connector contacts. If they show signs of oxidation, clean with a lint-free cloth and isopropyl alcohol.

CAUTION:
Do not touch the other parts of the device with isopropyl alcohol.
If necessary, contact your Mirion representative.

8.2.4 Decontamination

Decontamination consists of removing unwanted dust or fluids. When performing decontamination, personnel should wear the appropriate personal protective equipment (PPE) to the level of the hazard and training (radiological, chemical, etc.) or as prescribed in operating procedures.

8.2.4.1 Decontamination Methods

The following decontamination material methods can be used:

- Lint free cloths
- Warm water, mild soap
- Compressed dried air (<1 bar and only if determined non-hazardous)

9. Specifications

9.1 Measurements

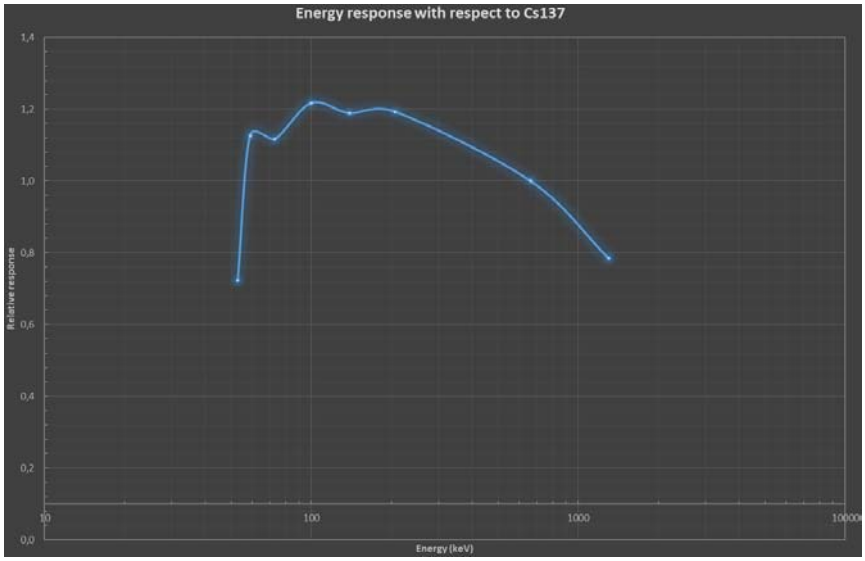
■ Type of instrument	PRD (Personal Alarming Radiation Detector)
■ Type of radiation	Photons (Gamma, X)
■ Dose & dose rate equivalent quantity:	Hp(10)
■ Unit for dose equivalent rate	microSv/h or microrem/h
■ Unit for dose equivalent	milliSv/h or millirem/h
■ Unit-less mode	0-9, see table on page 43
■ Unit for gross count rate (for search)	cps (counts per second)
■ Units spelling / scaling	for readability, µrem and mrem are displayed microRem and milliRem

9.2 Detectors

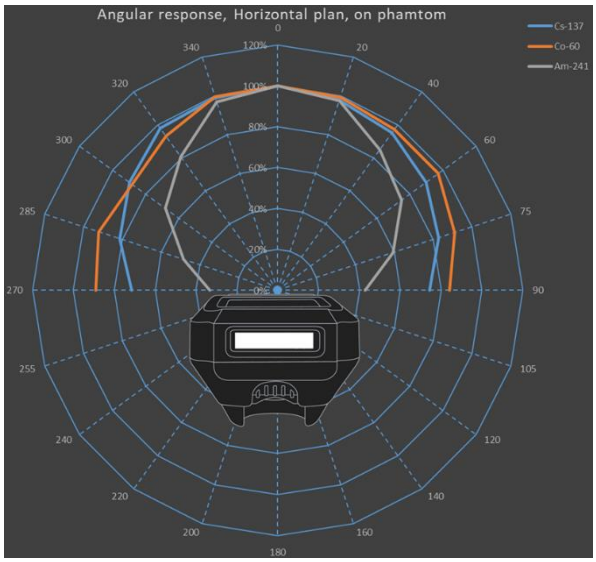
■ Low range detector	detection & dose equivalent rate measurement
□ Detector type	CsI(Tl) scintillation detector with temperature compensated Si-PM, with energy compensation
■ High range rate detector	dose rate and integrated dose measurement
■ Detector type	Silicon diode with energy compensation

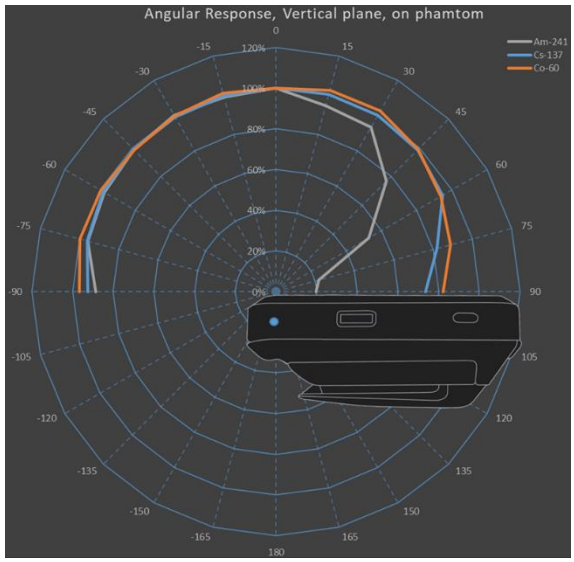
9.3 Dose equivalent and dose equivalent rate

- ■ Standard — ANSI N42.20 section 5.3 (radiological requirement) for a type 1 device (accuracy, energy, angular, over-range)
- ■ Range
- □ According to ANSI N42.32 section 6.6 — Up to 1 rem/h (10 mSv/h)
- □ Extreme (1) — Up to 1000 rem/h (10 Sv/h)
- ■ Accuracy (dose equivalent rate) — +/-20 %
- ■ Accuracy (dose equivalent) — +/-20%
- ■ Energy response:



- ■ Angular response:





(1) The device is able to measure dose rates up to 1000 rem/h accurately. However, above 10 rem/h, the recovery time is longer than required in the ANSI N42.34.

9.4 Alarming

■ False alarm rate (stable background)	Less than 2 alarms per 8 hours in stable background
■ False alarm rate (varying background)	VBS technology minimizes alarms due to background variations
■ Response time	Alarms to 50 µR/h increase in 2s as per ANSI N42.32-2016
■ Alarm types (dose rate)	Low alarm, high alarm, danger (personal protection alarm)
■ Energy range	30 keV to 3 MeV (gamma)
■ Alarms types (rate)	
□ Low	Detection of a low level of radiation, background relative threshold. Settable in sigma over background and dose rate over background.
□ High	Detection of a higher level of radiation. Settable in dose rate (absolute)
□ Danger	Possibly harmful radiation, step back. Settable in dose rate (absolute)
■ Dwell time (refresh rate)	0.25 s

9.5 Display, controls and interface

■ Top display	
□ Resolution:	38 x 184
□ Size:	6 mm x 29 mm
■ Front display	
□ Resolution	240 x 400
□ Size	36 mm x 60 mm
■ LEDs	Multicolor, Alarms, Gamma pulse failures & info
■ Sound	Loudspeaker for alarm Acknowledgeable, mutable Chirp for search, alarm
■ Sound level	More than 85 dB (A) and less than 100 dB (A) at 30 cm
■ Vibration	For alarms and search, mutable
■ Buttons	Four buttons for operations plus one button for ON/OFF (protected)
■ Earphones	Optional

9.6 Connectivity

■ NFC	For Bluetooth pairing without PIN code
■ Bluetooth	BLE 4.2, AES 128 To connect to the smartphone application
■ USB	For maintenance (firmware update) and calibration

9.7 Environmental, electrical, physical characteristics

9.7.1 Environmental characteristics

■ Climatic

□ Operating temperature	-20°C to 60°C (-4°F to 140°F)
□ Thermal shocks	According to ANSI N42.32-2016 section 7.2
□ Humidity	93% RH at 35°C according to ANSI N42.32-2016 section 7.3
□ Water and dust ingress	IP67 according to IEC 60529
□ Extreme temperature startup	According to ANSI N42.32-2016 section 7.5

Note : *In case of long-term storage, the battery has to be stored separately, in a controlled environment.*

■ Electromagnetic

□ ESD +/- 6 kV, contact discharge	according to ANSI N42.32-2016 section 8.1
□ Radiated Immunity	50 V/m (80 MHz – 2.5 GHz) according to ANSI N42.32-2016 section 8.2
□ Magnetic fields	100 A/m (3 gauss) 60 Hz AC according to ANSI N42.32-2016 section 8.3
□ Radiated emissions	FCC/CFR15.109, class A, according to ANSI N42.32-2016 section 8.4

■ Mechanical

□ Vibration	0.01 g^2/Hz (5 Hz – 500 Hz) according to ANSI N42.32-2016 section 9.1
□ Drop	1.5 m on concrete floor according to ANSI N42.32-2016 section 9.2
□ Impact	0.2 J impact according to ANSI N42.32-2016 section 9.3

9.7.2 Electrical characteristics

■ Batteries	Two AA (1.2V to 1.5V), alkaline, lithium (non-rechargeable) or NiMh
■ Battery life time (20°C, non-alarming)	900 hours

9.7.3 Physical characteristics

- Dimensions 108 x 61 x 36 mm without clip
- Weight with batteries and clip 200 g (7 oz)

9.8 Accessories, options

9.8.1 Regular packaging content

- Polystyrene/carton box
- AccuRad PRD
- 2 AA alkaline batteries
- Quick start guide
- Spare clip

Note : *Delivery with other packaging/case or in trays on request.*

9.8.2 Optional accessories and spare parts

- USB-C headphones
- Battery cover
- Clip

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10. Appendix

10.1 Appendix 1: Communication protocol

10.1.1 Transmission mode

AccuRad PRD supports two type of link:

1 – USB virtual COM PORT: on host side a port COM is created to emulate a serial COM Port link. The configuration of this port is only limited by host driver since the real communication uses USB and the driver emulate a serial port COM with its settings (speed, data length….).

2 – Bluetooth virtual COM port service: as for USB a COM Port is emulated on host ends. The AccuRad PRD sends data at 921600 bps. The reception can be configured regardless this speed since the host driver will emulate a link according to its own settings.

10.1.2 Protocol definition

- Data sent in binary format.
- Word sent low significant **byte** first:
    - Example: $4660_{decimal}$ = $1234_{hexadecimal}$ bytes are transmitted in this order: $34_{hexadecimal}$, $12_{hexadecimal}$
- Byte sent most significant **bit** first.
    - Example: $100_{decimal}$ = $64_{hexadecimal}$ = 01100100_{binary} is transmitted in this order: 0, 1, 1, 0, 0, 1, 0, 0
- Byte are place side-by-side with no alignment byte (packed data).
- Each frame starts with #!AccuRad!# pattern
- Data integrity is guaranteed by 2 bytes CRC

10.1.2.1 Frame format

A frame contains five parts:

#!AccuRad!# LEN ID XXXXX CRC

1. **#!AccuRad!# : frame start marker**
2. **LEN: frame length (length of XXXXX + CRC in bytes). Frame length is a 2 bytes word (max 65535 bytes)**
3. **Frame ID: number that allow to identify the reply at a low level.**
4. **XXXXX: N bytes of data (payload)**
5. CRC: CRC (computed on XXXXX). CRC is a 2 bytes word.

Example:
Data to send from AccuRad PRD to host:

0xAA	0xE7	0xBB	0x11	0x7E

frame:

Start											length		ID		Payload (XXXXXX)					CRC	
#	!	A	c	c	u	R	a	d	!	#	0x08	0x00	XX	XX	0xAA	0xE7	0xBB	0x11	0x7E	XX	XX

10.1.3 CRC_{16} calculation

```
#define POLYNOM16  0xAC5E      //  1.X^15 + 0.X^14 + 1.X^13 + 0.X^12      1010    A
                               //+ 1.X^11 + 1.X^10 + 0.X^09 + 0.X^08      1100    C
                               //+ 0.X^07 + 1.X^06 + 0.X^05 + 1.X^04      0101    5
                               //+ 1.X^03 + 1.X^02  + 1.X^01 + 0.X^00     1110    E

U16 Crc16(const void* data, S16 sizeofData)
{
    U16     Crc      = 0xFFFF;
    U16     ByteCnt = 0;
    U8      BitCnt   = 0;
    U16     Parity   = 0;
    if (sizeofData <= 0 || data == NULL) return 0;
    U8* ptr = (U8*)data;
    for ( ByteCnt = 0 ; ByteCnt < sizeofData ;  ByteCnt ++)
    {
        Crc ^= *( ptr + ByteCnt);
        if( Crc == 0 ) Crc = 1;
        for ( BitCnt = 0; BitCnt <= 7 ; BitCnt ++)
        {
            Parity = Crc;
            Crc >>= 1;
            if ((Parity & 1) !=0 )  Crc ^= POLYNOM16;
        }
    }
    return(Crc);
}
```

10.1.4 Exchange between host and device

This section describes frame payload (previously noted XXXXX). Each frame type has an ID that allow determining payload content.

10.1.4.1 Data description

10.1.4.1.1 Date and time

	Type	Size (byte)	Description
1	10.1.4.1.3	10.1.4.1.3	Time
2	10.1.4.1.2	10.1.4.1.2	Date

```
typedef struct _DateTime_t_
{
  Time_t Time;
  Date_t  Date;
}DateTime_t;
```

10.1.4.1.2 Date

Date is coded inside a 4-bytes word sent in little endian convention. Bits field's description:

Bit	size	Description
0-2	3 bits	Day of week
3-7	5 bits	Day
8-11	4 bits	Month
12-31	20 bits	Year

```
typedef union _Date_t_
{
  uint32_t  All;
  struct
  {
    uint32_t DayOfWeek      : 3;    /* 00 – 02*/
    uint32_t Day            : 5;    /*03 – 07*/
    uint32_t Month          : 4;    /*08 – 22*/
    uint32_t Year           : 20;   /*12 – 31*/
  }d;
}Date_t;
```

10.1.4.1.3 Time

Hour is coded inside a 4-bytes word sent in little endian convention. Bits field's description:

Bit	size	Description
0-4	5 bits	Hours
5-10	6 bits	Minutes
11-16	6 bits	Seconds
17-29	13 bits	Milliseconds
30-31	2 bits	Daylight saving time : 0 = none, 1 = add 1 hour, 2=subtract 1 hour

```
typedef union _Time_t_
{
  uint32_t  All;
  struct
  {
    uint32_t Hours          : 5;      /*00 – 04*/
    uint32_t Minutes        : 6;      /*05 – 10*/
    uint32_t Seconds        : 6;      /*11 – 16*/
    uint32_t MilliSeconds   : 13;   /*17 – 29*/
    uint32_t DayLight       : 2;      /*30 – 31*/
  }t;
}Time_t;
```

10.1.4.1.4 Data

10.1.4.1.4.1 System state

The system state is a synthesis of the device state. It is composed by a 4 bytes word sent in little endian convention.

Bit	Nom	Description
0	CountingFault	Counting fault on SED PRD and/or SED 15 keV subassembly
1	TempSensorFault	Temperature sensor failure
2	TempOutOfRange	Current device temperature is out of working range
3	CheckDateTime	Date/Time not up to date (date time lost)
4	AccumulationEnabled	Spectrum accumulation activated
5	AccumulationInProgress	Spectra accumulation in progress
6	Acknowledged	Device is in acknowledged state
7	Low alarm	Low alarm activated
8	High alarm	High alarm activated
9	Danger	Danger alarm activated
10	Dose alarm	Dose alarm activated
11	Dose danger	Dose danger activated
12	Low Power	Device is actually in low power mode
13	SearchMode	Device is in search mode
14	MicrophonyRejection/Reserved	Version ≥ 1.1.0.3 : Microphony rejection in progress after strong impact Version < 1.1.0.3 :Reserved
15	CalibrationExpired	Device calibration need to be checked
16	VBS	VBS is triggered (background variation)
17	MagnetometerFailure	Magnetometer is out of order or reports an error
18	AccGyrometerFailure	Accelerometer/Gyroscope are out of order or reports an error
19	E2PFailure	E2PROM memory failure
20	FlashFailure	Flash memory failure

21	AudioFailure	Audio failure
22	BLEFailure	Bluetooth communication failure
23	Discreet	Discreet mode activated
24	AlarmThresholdsNotConsistent	Current thresholds are not compliant with the rule “Dose rate High alarm” < “Dose rate Danger” < “Saturation”
25	Reserved	Reserved
26	Reserved	Reserved
27	Reserved	Reserved
28	Reserved	Reserved
29	Reserved	Reserved
30	Initialized	Initialization sequence is over
31	RemoteCtrl	Remote control is activated

```
typedef union _SystemState_t_
{
    uint32_t All;
    struct
    {
        uint32_t CountingFault                  : 1;    /* 00 */
        uint32_t TempSensorFault                : 1;    /* 01 */
        uint32_t  TempOutOfRange                : 1;    /* 02 */
        uint32_t CheckDateTime                  : 1;    /* 03 */
        uint32_t AccumulationEnabled            : 1;    /* 04 */
        uint32_t AccumulationInProgress     : 1;    /* 05 */
        uint32_t Acknowledged                   : 1;    /* 06 */
        uint32_t LowAlarm                   : 1;    /* 07 */
        uint32_t HighAlarm                  : 1;    /* 08 */
        uint32_t Danger                     : 1;    /* 09 */
        uint32_t DoseAlarm                  : 1;    /* 10 */
        uint32_t DoseDanger                 : 1;    /* 11 */
        uint32_t LowPower                   : 1;    /* 12 */
        uint32_t SearchMode                 : 1;    /* 13 */
        uint32_t NotUsed_14                 : 1;    /* 14 */
        uint32_t CalibrationExpired         : 1;    /* 15 */
        uint32_t VBS                        : 1;    /* 16 */
        uint32_t MagnetometerFault          : 1;    /* 17 */
        uint32_t  AccGyrometerFault         : 1;    /* 18 */
        uint32_t E2PFault                   : 1;    /* 19 */
        uint32_t FlashFault                 : 1;    /* 20 */
        uint32_t AudioFault                 : 1;    /* 21 */
        uint32_t BLEFault                   : 1;    /* 22 */
        uint32_t Discreet                   : 1;    /* 23 */
        uint32_t AlarmThresholdsNotConsistent   : 1;    /* 24 */
        uint32_t NotUsed_25                 : 1;    /* 25 */
        uint32_t NotUsed_26                 : 1;    /* 26 */
        uint32_t NotUsed_27                 : 1;    /* 27 */
        uint32_t NotUsed_28                 : 1;    /* 28 */
        uint32_t NotUsed_29                 : 1;    /* 29 */
        uint32_t Initialized                : 1;    /* 30 */
        uint32_t RemoteCtrl                 : 1;    /* 31 */
    }b;
```

}**SystemState_t**;

10.1.4.1.5 Merged

10.1.4.1.5.2 State

1 byte word

Bit	Name	Description
0-1	Origin	Measurement origin : 0 : Unknown 1 : From low range (SED PRD/CsI(Tl)) 2 : From high range (SED 15 keV/Pin diode) 3 : Both (SED PRD/CsI(Tl) and SED 15 keV/Pin diode)
2	PRD_15keV_Incoherence	Measurement from low and high range are not consistent. It is an indication of geometric issue (detectors axes) on measurement
3	Reserved	Reserved
4	Reserved	Reserved
5	Reserved	Reserved
6	Overload	Device is in overload state
7	Initialized	Initialization is over

```
typedef enum _Measurement_Origin_t_
{
  MEASUREMENT_FROM_UNKNOWN,
  MEASUREMENT_FROM_SED_PRD,      //data from CsI(Tl) = low range = SED PRD
  MEASUREMENT_FROM_SED_15KEV,    //data from Pin diode = high range = SED 15 keV
  MEASUREMENT_FROM_BOTH,//data from CsI(Tl) + Pin diode = Low and high range = SED PRD+
SED 15 keV
}Measurement_Origin_t;

typedef union _MergedMeas_State_t_
{
  uint8_t All;
  struct
  {
    uint8_t Origin                    : 2;   /*00-01*/ //Measurement_Origin_t values
    uint8_t PRD_15keV_Incoherence     : 1;   /*02*/
    uint8_t Reserved_03               : 1;   /*03*/
    uint8_t Reserved_04               : 1;   /*04*/
    uint8_t Reserved_05               : 1;   /*05*/
    uint8_t Overload                  : 1;   /*06*/
    uint8_t Initialized               : 1;   /*07*/
  }b;
}MergedMeas_State_t;
```

1.1.1.1.1.**Measurement**

	Type	Size (byte)	Description
1	Real	4	Dose rate (µSv/h)
2	Real	4	Count rate (cps)
3	Real	4	Background dose rate (µSv/h)
4	Real	4	Background count rate (cps)

5	Real	4	Level (0-9 display)

10.1.4.1.5.3 Data

	Type	Size (byte)	Description
1	10.1.4.1.5.2	10.1.4.1.5.2	State
2	1.1.1.1.1	1.1.1.1.1	Measurement

```
typedef struct _Merged_NuclearData_t_
{
  float DoseRate_uSv_h;
  float CountRateFiltered_cps;
}Merged_NuclearData_t;

typedef struct _Merged_Measurement_t_
{
  MergedMeas_State_t State;
  Merged_NuclearData_t Meas;
  Merged_NuclearData_t Bkg;
  float Level;
}Merged_Measurement_t;
```

10.1.4.1.6 Dose (SED 15keV/Pin diode)

10.1.4.1.6.4 State

None

10.1.4.1.6.5 Measurement

Send the dose integrated since the Accurad startup or the last reset.

	Type	Size (byte)	Description
1	Real	4	Dose measurement (µSv) from SED 15keV/Pin diode
2	Real	4	Duration associated with dose measurement = integration duration (s)

```
typedef struct _Dose_Measurement_t_
{
    float Dose_uSv;
    float Duration_s;
} Dose_Measurement_t;
```

10.1.4.1.6.6 Data

	Type	Size (byte)	Description
1	10.1.4.1.1	10.1.4.1.1	Date/time
2	10.1.4.1.6.5	10.1.4.1.6.5	Measurement

```
typedef struct _Dose_Data_t_
```

```
{
  DateTime_t            DateTime;
  Dose_Measurement_t Values;
} Dose_Data_t;
```

10.1.4.1.7 Battery

10.1.4.1.7.7 State

1 byte word

Bit	Name	Description
0	LevelTooLow	Battery level low
1	LevelCritical	Battery level reach critical level (shutdown)
2	USB_Connected	USB is connected
3	Reserved	Reserved
4	Reserved	Reserved
5	Reserved	Reserved
6	Failure	Failure on battery
7	Initialized	Battery management phase terminated

```
typedef union _Battery_State_t_
{
  uint8_t All;
  struct
  {
    uint8_t LevelTooLow          : 1;   /*00*/
    uint8_t LevelCritical        : 1;   /*01*/
    uint8_t USB_Connected        : 1;       /*02*/
    uint8_t Reserved_03       : 1;   /*03*/
    uint8_t Reserved_04          : 1;   /*04*/
    uint8_t Reserved_05          : 1;   /*05*/
    uint8_t Failure              : 1;   /*06*/
    uint8_t Initialized          : 1;   /*07*/
  }b;
}Battery_State_t;
```

1.1.1.1.2.Measurement

	Type	Size (byte)	Description
1	UINT	1	Battery level (%) : if USB is connected, this value should be ignored

1.1.1.1.3.Data

	Type	Size (byte)	Description
1	10.1.4.1.7.7	10.1.4.1.7.7	State
2	0	0	Measurement

```
typedef struct _Battery_Data_t_
{
  Battery_State_t   State;
  uint8_t               Level_perc;
}Battery_Data_t;
```

10.1.5 Request description

10.1.5.1 Device information access (ID = 0)

To get device information, the following bytes sequence need to be sent “as is”:

0x7E	0x04	0x00	0x10	0xA7	0x07	0x46	0xE7

Reply payload. **Frame ID = 0**

	Type	size (byte)	Description
1	byte[15+1]	16	Device manufacturer string (zero terminated string)
2	byte[15+1]	16	Device part number string (zero terminated string)
3	byte[15+1]	16	Device serial number string (zero terminated string)
4	UINT	4	Firmware number
5	UINT	4	Firmware version : 0xAABBCCDD => AA.BB.CC.DD
6	10.1.4.1.1	10.1.4.1.1	Current date and time
7	Byte	1	Time zone index : 00 : (UTC-12:00) Universal line -12 01 : (UTC-11:00) Universal line -11 02 : (UTC-10:00) Papeete, Honolulu 03 : (UTC-09:30) Marquesas Islands 04 : (UTC-09:00) Anchorage 05 : (UTC-08:00) Los Angeles, Vancouver, Tijuana 06 : (UTC-07:00) Phoenix, Calgary, Ciudad Juárez 07 : (UTC-06:00) Chicago, Guatemala City, Mexico City, San José, San Salvador, Winnipeg 08 : (UTC-05:00) New York, Lima, Toronto, Bogotá, Havana, Kingston 09 : (UTC-04:00) Caracas, Santiago, La Paz, Manaus, Halifax, Santo Domingo 10 : (UTC-03:30) St. John's 11 : (UTC-03:00) Buenos Aires, Montevideo, São Paulo 12 : (UTC-02:00) Fernando de Noronha 13 : (UTC-01:00) Cape Verde, Greenland, Portugal 14 : (UTC+00:00) Accra, Casablanca, Dakar, Dublin, Lisbon, London 15 : (UTC+01:00) Berlin, Lagos, Madrid, Paris, Rome, Tunis, Vienna, Warsaw 16 : (UTC+02:00) Athens, Bucharest, Cairo, Helsinki, Jerusalem, Johannesburg, Kiev 17 : (UTC+03:00) Istanbul, Moscow, Nairobi, Baghdad, Doha, Khartoum, Minsk,Riyadh 18 : (UTC+03:30) Tehran 19 : (UTC+04:00) Baku, Dubai, Samara 20 : (UTC+04:30) Kabul 21 : (UTC+05:00) Karachi, Tashkent, Yekaterinburg 22 : (UTC+05:30) Delhi, Colombo 23 : (UTC+05:45) Kathmandu 24 : (UTC+06:00) Almaty, Dhaka, Omsk 25 : (UTC+06:30) Yangon 26 : (UTC+07:00) Jakarta, Bangkok, Krasnoyarsk, Ho Chi Minh City 27 : (UTC+08:00) Beijing, Taipei, Singapore, Kuala Lumpur, Perth, Manila, Denpasar 28 : (UTC+08:45) Eucla 29 : (UTC+09:00) Seoul, Tokyo, Ambon, Yakutsk, Pyongyang 30 : (UTC+09:30) Adelaide 31 : (UTC+10:00) Port Moresby, Sydney, Vladivostok 32 : (UTC+10:30) New South Wales 33 : (UTC+11:00) Noumea 34 : (UTC+12:00) Auckland, Suva 35 : (UTC+12:45) Chatham Islands 36 : (UTC+13:00) Apia, Nuku'alofa 37 : (UTC+14:00) Kiribati

```
typedef struct _Device_Information_t_
{
    char        Manufacturer[15+1];
    char        PN[15+1];
    char        SN[15+1];
    uint32_t    FirmwareNumber;
    uint32_t    FirmwareVersion;
    DateTime_t  DateTime;
    uint8_t     TimeZone;
}Device_Information_t;
```

10.1.5.2 Device measurement access (ID = 1)

To get device information, the following bytes sequence need to be sent “as is”:

0x7E	0x04	0x00	0x11	0xA7	0x1E	0x43	0xE7

Reply payload. **Frame ID = 1**

	Type	size (byte)	Description
1	10.1.4.1.5	10.1.4.1.5	Merged data
2	10.1.4.1.6	10.1.4.1.6	Dose data
3	10.1.4.1.7	10.1.4.1.7	Battery data
4	10.1.4.1.4.1	10.1.4.1.4.1	System state
5	UINT	4	Measurement ID : counter incremented every internal cycle (250 ms)

```
typedef struct _Device_Data_t_
{
    Merged_Measurement_t    Merged;
    Dose_Data_t             Dose;
    Battery_Data_t          Battery;
    SystemState_t           SystemState;
    uint32_t                Id;
}Device_Data_t;
```

10.1.6 Appendix

Example using terminal:

The easiest way for decoding, if host memory uses little endian convention, is to declare a kind of structure and do a memory copy from received buffer to this structure.

10.1.6.1.1 Device information

Request: 7E 04 00 10 A7 07 46 E7

Answer : 0x23 0x21 0x41 0x63 0x63 0x75 0x52 0x61 0x64 0x21 0x23 0x45 0x00[Length] **0x00 0x00[Id]** 0x4D 0x41 0x4E 0x55 0x46 0x41 0x43 0x54 0x55 0x52 0x45 0x52 0x00 0x00 0x00 0x00 0x4E 0x4F 0x4D 0x30 0x30 0x34 0x35 0x33 0x37 0x2D 0x43 0x00 0x00 0x00 0x00 0x00 0x30 0x30 0x30 0x30 0x32 0x34 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x0B 0x06 0x00 0x00 0x00 0x00 0x01 0x01 0xEE 0x41 0x68 0x06 0xC1 0x42 0x7E 0x00 0x0E 0x02 0x5B[CRC]

Below table : “index inside whole frame” / “index in payload”

Start marker pattern

#	!	A	c	c	u	R	a	d	!	#
0x23	0x21	0x41	0x63	0x63	0x75	0x52	0x61	0x64	0x21	0x23
00 / --	01 / --	02 / --	03 / --	04 / --	05 / --	06 / --	07 / --	08 / --	09 / --	10 / --

Length	
0x45	0x00
11 / --	12 / --

▶

Length
0x0045 = 69

ID	
0x00	**0x00**
13 / --	14 / --

▶

ID
0x0000 = 0

Manufacturer

M	A	N	U	F	A	C	T	U	R	E	R				
0x4D	0x41	0x4E	0x55	0x46	0x41	0x43	0x54	0x55	0x52	0x45	0x52	0x00	0x00	0x00	0x00
15 / 00	16 / 01	17 / 02	18 / 03	19 / 04	20 / 05	21 / 06	22 / 07	23 / 08	24 / 09	25 / 10	26 / 11	27 / 12	28 / 13	29 / 14	30 / 15

Part Number

N	O	M	0	0	4	5	3	7	-	C					
0x4E	0x4F	0x4D	0x30	0x30	0x34	0x35	0x33	0x37	0x2D	0x43	0x00	0x00	0x00	0x00	0x00
31 / 16	32 / 17	33 / 18	34 / 19	35 / 20	36 / 21	37 / 22	38 / 23	39 / 24	40 / 25	41 / 26	42 / 27	43 / 28	44 / 29	45 / 30	46 / 31

Serial number

0	0	0	0	2	4										
0x30	0x30	0x30	0x30	0x32	0x34	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00
47 / 32	48 / 33	49 / 34	50 / 35	51 / 36	52 / 37	53 / 38	54 / 39	55 / 40	56 / 41	57 / 42	58 / 43	59 / 44	60 / 45	61 / 46	62 / 47

Firmware #			
0x0B	0x06	0x00	0x00
63 / 48	64 / 49	65 / 50	66 / 51

▶
▶

Firmware #
0x0000060B = 1547

Firmware version			
0x00	0x00	0x01	0x01
67 / 52	68 / 53	69 / 54	70 / 55

▶
▶

Firmware version
0x01010000 = 1.1.0.0

Time			
0xEE	0x41	0x68	0x06
71 / 56	72 / 57	73 / 58	74 / 59

▶
▶

Time			
0x066841EE = 14:15:08.820			
06	68	41	EE
0000 0110	0110 1000	0100 0001	1110 1110

5 bits “Hours” = 0 1110 = 0x0E = 14 H
6 bits “Minutes” = 00 1111 = 0x0F = 15 min
6 bits “Seconds” = 00 1000 = 0x08 = 8 s
13 bits “Milliseconds” = 0 0011 0011 0100 = 0x0334 = 820 ms
2 bits “Daylight” = 01 = 0x1 = 1

Date

▶

Date

0xC1	0x42	0x7E	0x00
75 / 60	76 / 61	77 / 62	78 / 63

▶

0x007E42C1 = 2020/02/24			
00	7E	42	C1
0000 0000	0111 1110	0100 0010	1100 0001

3 bits “Day of week” = 001 = 0x01 = Monday
5 bits “Day” = 1 1000 = 0x18 = 24
4 bits “Month” = 0010 = 0x02 = 2 = February
20 bits “Year” = 0000 0000 0111 1110 0100 = 0x007E4 = 2020

Time zone index
0x0E
79 / 64

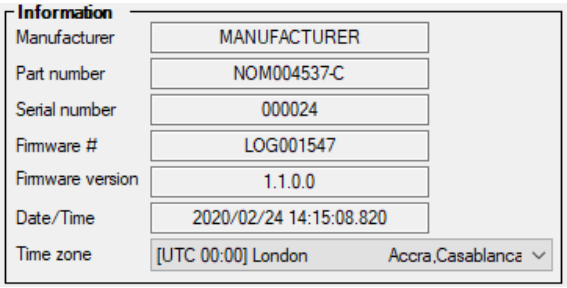
▶ ▶

Time zone index
0x0E = 14 = UTC+0 (London)

CRC	
0x02	0x5B
80 / --	81 / --

▶ ▶

CRC
0x5B02 = 23298



10.1.6.1.2 Device data

Request: 0x7E 0x04 0x00 0x11 0xA7 0x1E 0x43 0xE7

Answer : 0x23 0x21 0x41 0x63 0x63 0x75 0x52 0x61 0x64 0x21 0x23 0x33 0x00[Length] **0x01 0x00**[Id] 0x81 0xD7 0x86 0x4E 0x3D 0xE8 0x0A 0xE5 0x40 0x13 0x39 0x13 0x3D 0x4F 0x69 0xE8 0x40 0xFE 0xD9 0x61 0x3E 0x2B 0xCD 0x27 0x00 0xC1 0x42 0x7E 0x00 0xF6 0xBE 0xFA 0x3D 0x00 0x34 0x12 0x46 0xA4 0x60 0x00 0x00 0x00 0x40 0x32 0x92 0x00 0x00 0x4F 0xA9[CRC]

Start marker pattern

#	!	A	c	c	u	R	a	d	!	#
0x23	0x21	0x41	0x63	0x63	0x75	0x52	0x61	0x64	0x21	0x23
00 / --	01 / --	02 / --	03 / --	04 / --	05 / --	06 / --	07 / --	08 / --	09 / --	10 / --

Length	
0x33	0x00
11 / --	12 / --

▶

Length
0x0033 = 51

ID	
0x01	**0x00**
13 / --	14 / --

▶ ▶

ID
0x0001 = 1

Merged data

State
0x81

15 / 00

State
0x81 1000 0001 [0-1] = 1 = from low range (SED PRD/CsI(Tl) [2] = 0 = measurement is consistent [3-5] = 0 = reserved [6] = 0 = device not in overload state [7] = 1 = device initialized

Dose rate (µSv/h)			
0x D7	0x 86	0x 4E	0x 3D

16 / 01 17 / 02 18 / 03 19 / 04

Dose rate (µSv/h)
0x3D4E86D7 = 0.050421562

Count rate (cps)			
0x E8	0x 0A	0x E5	0x 40

20 / 05 21 / 06 22 / 07 23 / 08

Count rate (cps)
0x40E50AE8 = 7.15758133

Background dose rate (µSv/h)			
0x 13	0x 39	0x 13	0x 3D

24 / 09 25 / 10 26 / 11 27 / 12

Background dose rate (µSv/h)
0x3D133913 = 0.035943102 1

Background count rate (cps)			
0x 4F	0x 69	0x E8	0x 40
28 / 13	29 / 14	30 / 15	31 / 16

Background count rate (cps)
0x40E8694F = 7.262855

Level			
0x FE	0x D9	0x 61	0x 3E
32 / 17	33 / 18	34 / 19	35 / 20

Level
0x3E619FE = 0.220558137

Dose

Time			
0x2B	0xCD	0x27	0x00
36 / 21	37 / 22	38 / 23	39 / 24

Time			
0x0027CD2B = 11:41:57.019			
00	27	CD	2B
0000 0000	0010 0111	1100 1101	0010 1011

5 bits “Hours” = 0 1011 = 0x0B = 11 H
6 bits “Minutes” = 10 1001 = 0x29 = 41 min
6 bits “Seconds” = 11 1001 = 0x39 = 57 s
13 bits “Milliseconds” = 0 0000 0001 0011 = 0x0013 = 19 ms
2 bits “Daylight” = 00 = 0x0 = 0

Date			
0xC1	0x42	0x7e	0x00
40 / 25	41 / 26	42 / 27	43 / 28

Date			
0x007E42C1 = 2020/02/24			
00	7E	42	C1
0000 0000	0111 1110	0100 0010	1100 0001

3 bits “Day of week” = 001 = 0x01 = Monday
5 bits “Day” = 1 1000 = 0x18 = 24
4 bits “Month” = 0010 = 0x02 = 2 = February
20 bits “Year” = 0000 0000 0111 1110 0100 = 0x007E4 = 2020

Dose (µSv)			
0x F6	0x BE	0x FA	0x 3D
44 / 29	45 / 30	46 / 31	47 / 32

Dose (µSv)
0x3DFABEF6 = 0.122434542

Duration (s)			
0x 00	0x 34	0x 12	0x 46
48 / 33	49 / 34	50 / 35	51 / 36

▶

Duration (s)
0x46123 400 = 9357

Battery

State
0xA4
52 / 37

▶

State
0xA4 1010 0100 [0] = 0 = battery level is not low [1] = 0 = Battery level is not critical [2] = 1 = USB is connected (charging is battery present) [3-5] = reserved [6] = 0 no failure detected [7] = 0 Battery measurement initialized

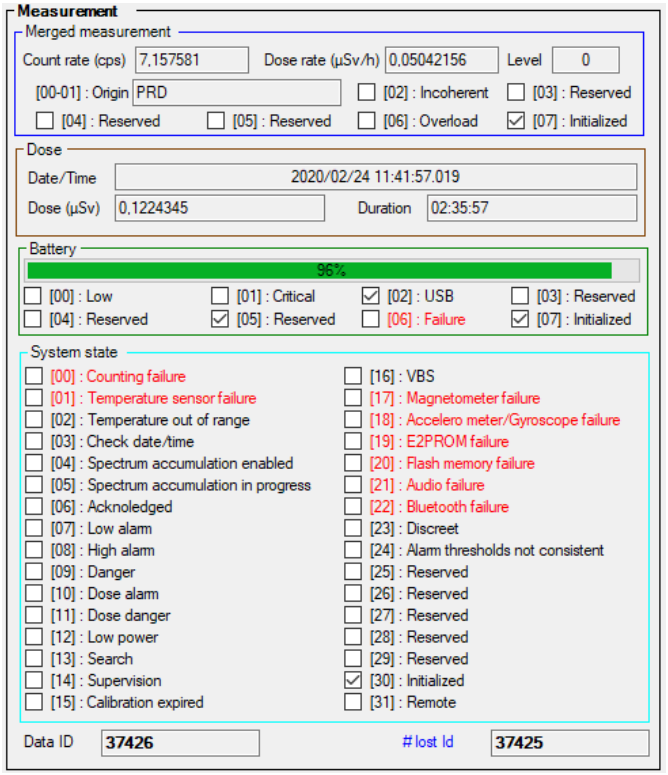
Level %
0x60
53 / 38

▶

Level %
0x60 = 96%

System state

State				►	State
0x00	0x00	0x00	0x40	►	0x40000000
54 / 39	55 / 40	56 / 41	57 / 42		



[00] = 0 = counting OK
[01] = 0 = Temperature sensor OK
[02] = 0 = Temperature OK
[03] = 0 = Date/time OK
[04] = 0 = Accumulation disabled
[05] = 0 = No accumulation
[06] = 0 = device not in acknowledged state
[07] = 0 = no low alarm in progress
[08] = 0 = no high alarm in progress
[09] = 0 = no danger alarm in progress
[10] = 0 = no dose alarm in progress
[11] = 0 = no dose danger in progress
[12] = 0 = device not in low power state
[13] = 0 = “normal mode” in progress
[14] = 0 = reserved
[15] = 0 = Calibration expired
[16] = 0 = VBS triggered
[17] = 0 = Magnetometer OK
[18] = 0 = Accelerometer/Gyroscope OK
[19] = 0 = E2Prom memory OK
[20] = 0 = Flash memory OK
[21] = 0 = Audio OK
[22] = 0 = Bluetooth OK
[23] = 0 = Not in discreet mode
[24] = 0 = Alarm thresholds OK
[25] = 0 = Reserved
[26] = 0 = Reserved
[27] = 0 = Reserved
[28] = 0 = Reserved
[29] = 0 = Reserved
[30] = 1 = Initialized
[31] = 0 = no remote control

Measurement ID				►	Measurement ID
0x32	0x92	0x00	0x00	►	0x00009232 = 37426

58 / 43	59 / 44	60 / 45	61 / 46

CRC		►	CRC
0x02	0x5B	►	0x5B02 = 23298
62 / --	63 / --		

10.1.6.1.3 Bluetooth Connection

The Transparent UART Service is instantiated as a Primary Service. Its UUID is 49535343-FE7D-4AE5-8FA9-9FAFD205E455. The Transparent UART Service contains the following data characteristics:

transparent UART Transmit (TX) Characteristic

The Transparent UART TX Characteristic is used for data transmission by the Server or the Client. Once the Client Characteristic Configuration Descriptor (CCCD) of Transparent UART TX Characteristic is enabled, the Server sends data to the Client using the Notify property. The Client can also send data to the Server using the “Write”/”Write without response” properties.

The transparent UART TX UUID is: 49535343-1E4D-4BD9-BA61-23C647249616 (properties : Notify, Write, Write without response).

When the Bluetooth connection with the AccuRad is established, it is recommended to wait 1s before sending any request to the device else, the communication can fails.

10.2 Appendix 2: Data Export Examples

Data stored in the database can be exported in two different formats: ANSI N42.42 or csv files.

The ANSI N42.42 files contain measurement data plus spectra data, CSV files contain measurement data only.

10.2.1 ANSI N42.42 File Example

```
<RadInstrumentData xmlns="http://physics.nist.gov/N42/2011/N42">
 <RadInstrumentInformation id="RadInstrumentInformation-1">
  <RadInstrumentManufacturerName>Mirion Technologies</RadInstrumentManufacturerName>
  <RadInstrumentIdentifier>00002A</RadInstrumentIdentifier>
  <RadInstrumentModelName>AccuRad PRD</RadInstrumentModelName>
  <RadInstrumentClassCode>Personal Radiation Detector</RadInstrumentClassCode>
  <RadInstrumentVersion>
   <RadInstrumentComponentName>Firmware</RadInstrumentComponentName>
   <RadInstrumentComponentVersion>0.8.8.0</RadInstrumentComponentVersion>
  </RadInstrumentVersion>
  <RadInstrumentVersion>
   <RadInstrumentComponentName>Hardware</RadInstrumentComponentName>
   <RadInstrumentComponentVersion>0</RadInstrumentComponentVersion>
  </RadInstrumentVersion>
  <RadInstrumentQualityControl>
   <InspectionDateTime>2019-09-19T00:00:00Z</InspectionDateTime>
   <InCalibrationIndicator>false</InCalibrationIndicator>
  </RadInstrumentQualityControl>
 </RadInstrumentInformation>
 <RadDetectorInformation id="RadDetectorInformation-1">
  <RadDetectorCategoryCode>Gamma</RadDetectorCategoryCode>
  <RadDetectorKindCode>CsI</RadDetectorKindCode>
  <RadDetectorVolumeValue>2.8</RadDetectorVolumeValue>
 </RadDetectorInformation>
 <RadDetectorInformation id="RadDetectorInformation-2">
  <RadDetectorCategoryCode>Gamma</RadDetectorCategoryCode>
  <RadDetectorKindCode>Other</RadDetectorKindCode>
  <RadDetectorDescription>PIN diode</RadDetectorDescription>
 </RadDetectorInformation>
 <AnalysisResults id="AnalysisResults-2">
  <AnalysisStartDateTime>2019-10-14T08:52:58.96Z</AnalysisStartDateTime>
  <AnalysisComputationDuration>PT6.762S</AnalysisComputationDuration>
  <RadAlarm>
   <RadAlarmDateTime>2019-10-14T08:52:58.96Z</RadAlarmDateTime>
   <RadAlarmCategoryCode>Gamma</RadAlarmCategoryCode>
   <RadAlarmDescription>Low Alarm</RadAlarmDescription>
  </RadAlarm>
  <DoseAnalysisResults>
   <MaximumDoseRateValue>0.119055361</MaximumDoseRateValue>
   <TotalDoseValue>0</TotalDoseValue>
  </DoseAnalysisResults>
 </AnalysisResults>
</RadInstrumentData>
```

10.2.2 CSV File Example

Excel compatible data file that contains date and time, position, levels, ID and spectrum duration.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Date	Location_Lat	Location_Lor	Location_Alt	Location_He	Location_Spe	Measuremer	Measuremer	Measuremer	Measuremer	Measuremer	Measuremer
2	2015-08-07 1	9999	9999	0	9999	0	0	Initialized	32.82201	0.03118054	35.08414	0.03441076
3	2015-08-07 1	9999	9999	0	9999	0	0	Initialized	33.14009	0.02927982	35.13008	0.03329889
4	2015-08-07 1	9999	9999	0	9999	0	0	Initialized	32.6262	0.02941887	34.77363	0.03316746
5	2015-08-07 1	9999	9999	0	9999	0	0	Initialized	32.16365	0.02834665	34.43499	0.03244393

10.3 Appendix 3: AccuRad drawings