

# TRTR & IGORR Research Reactor Conference

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**MIRION**  
TECHNOLOGIES



# UPGRADE of NEUTRON FLUX MONITORING SYSTEMS of RESEARCH REACTORS with DIGITAL SYSTEMS

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# Content

- Mirion's new [proTK™ / 260 series](#) of digital signal processing units for neutron flux monitoring
- The digital wide-range channel [DWK 260](#)
- Embracing digital ([Why digital](#) ? Performance, safety, reliability, ....)
- A recent upgrade project (NCSU / PULSAR)



# proTK™ / 260 Series

## A NEW generation of proTK signal processing units

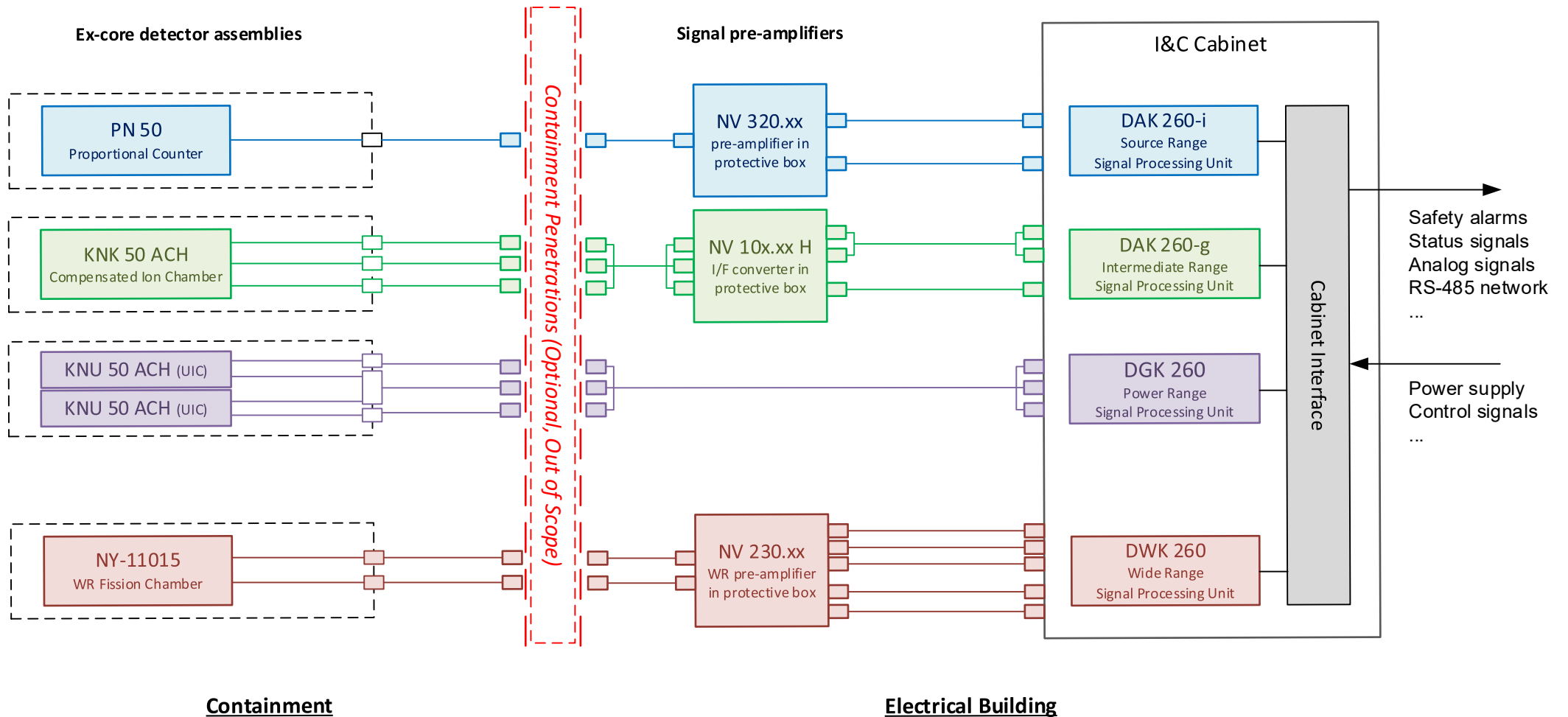
*Faster response times, additional I/O signals, complete V&V acc. IEEE 323 / IEC 60780 and IEC 60880 (SW for Cat. A systems, i.e. I&C systems important to safety)*

- DAK 260-i**      **Source Range Channel**  
(start-up/pulse range, for proportional & fission counter)
- DAK 260-g**      **Intermediate Range Channel**  
(DC current measurement, CICs and UICs)
- DGK 260**        **Power-Range Channel**  
(linear channel, UICs)
- DWK 260\***      **Wide-Range Channel**  
(pulse/AC/DC and combined wide range lin/log signals, for wide range fission chambers)

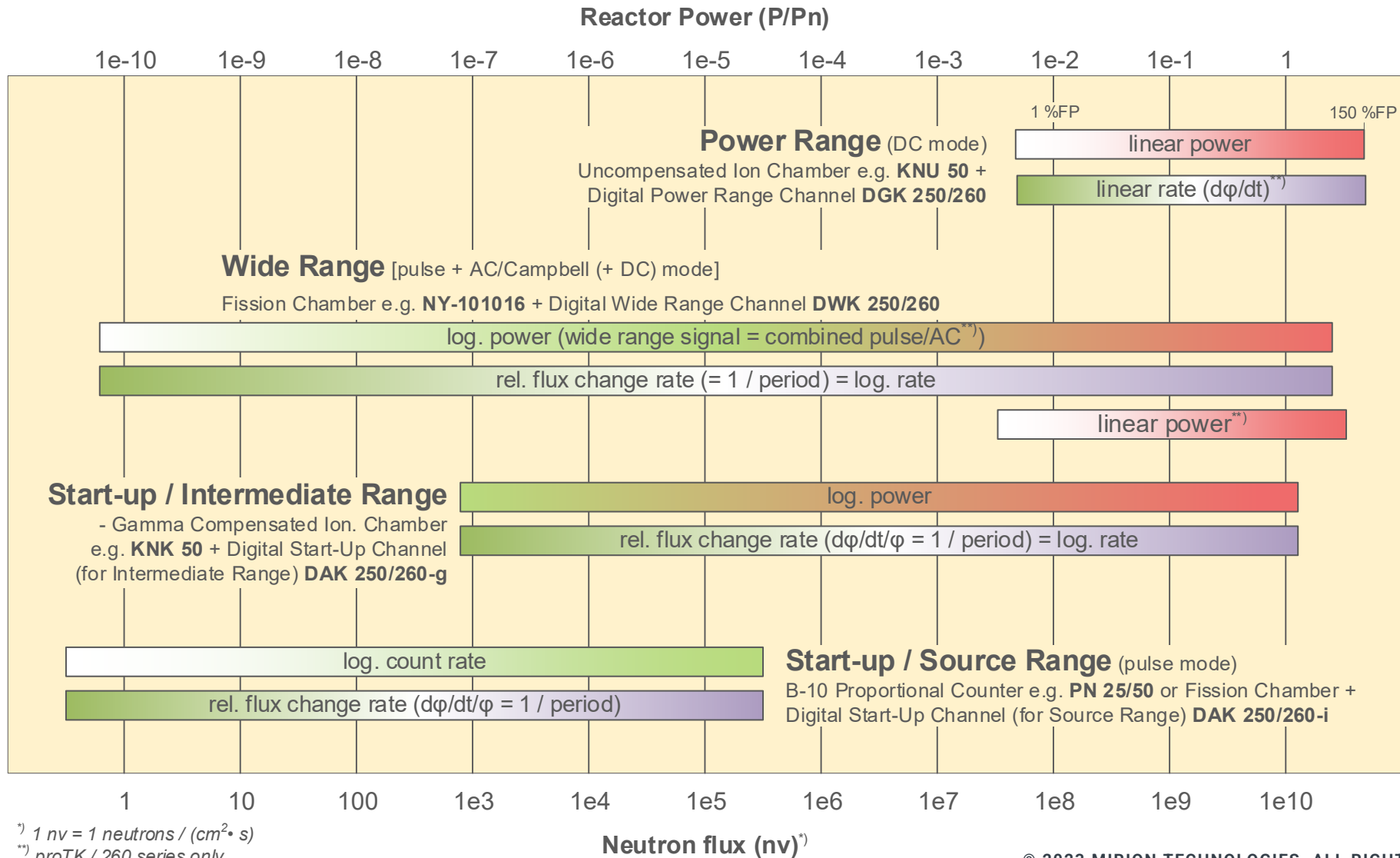
**Note: All proTK / 250 Series signal processing units are still available and maintained.**



# proTK™ / 260 Series – Overview Ex-core NIS



# proTK™ / 260 Series – Neutron Flux / Power Ranges

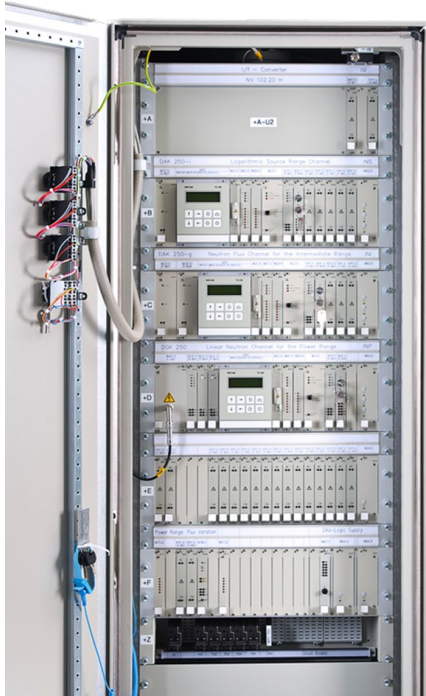


<sup>\*)</sup> 1 nv = 1 neutrons / (cm<sup>2</sup>• s)

<sup>\*\*)</sup> proTK / 260 series only



# proTK™ / Digital Signal Processing Units



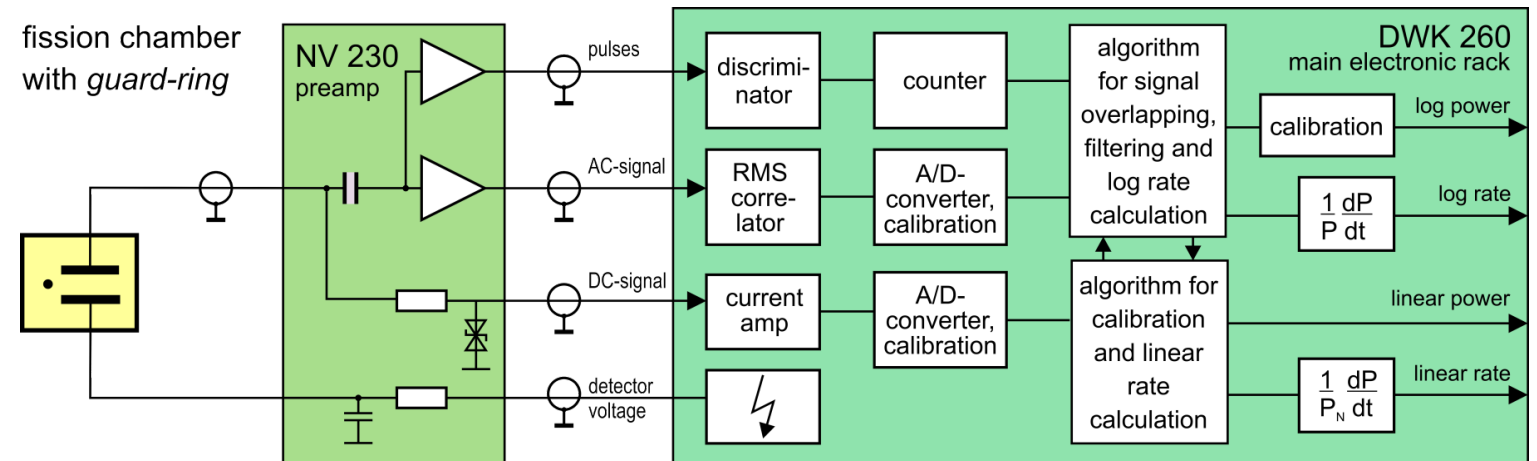
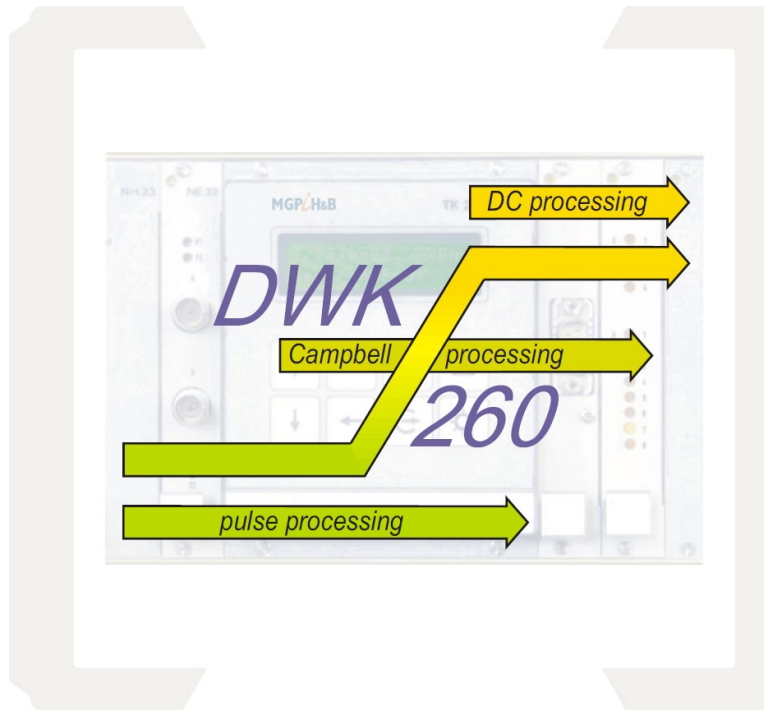
- Modular, multi-microprocessor system, one dedicated microprocessor for the “safety signal path”
  - SW with fixed cycles and fast processing
  - Low heat generation technology
  - Protected SW, efficient self monitoring
  - Integrated signal generators and signal simulation capabilities (remote activation)
  - Qualified according to IEC 60780, IEEE 323, IEC 60880 (for Cat. A SW), KTA 3501/3505
- ✓ Simple & Clear
  - ✓ Deterministic & Fast
  - ✓ Reliable
  - ✓ Safe
  - ✓ Simplified testing
  - ✓ Independent V&V and Certification



# proTK™ / DWK 260 Digital Wide Range Channel

## DWK 260

Pulse, Campbell (AC) and DC processing  
Combined Wide-Range lin./log. signal generation,  
for wide-range fission chambers

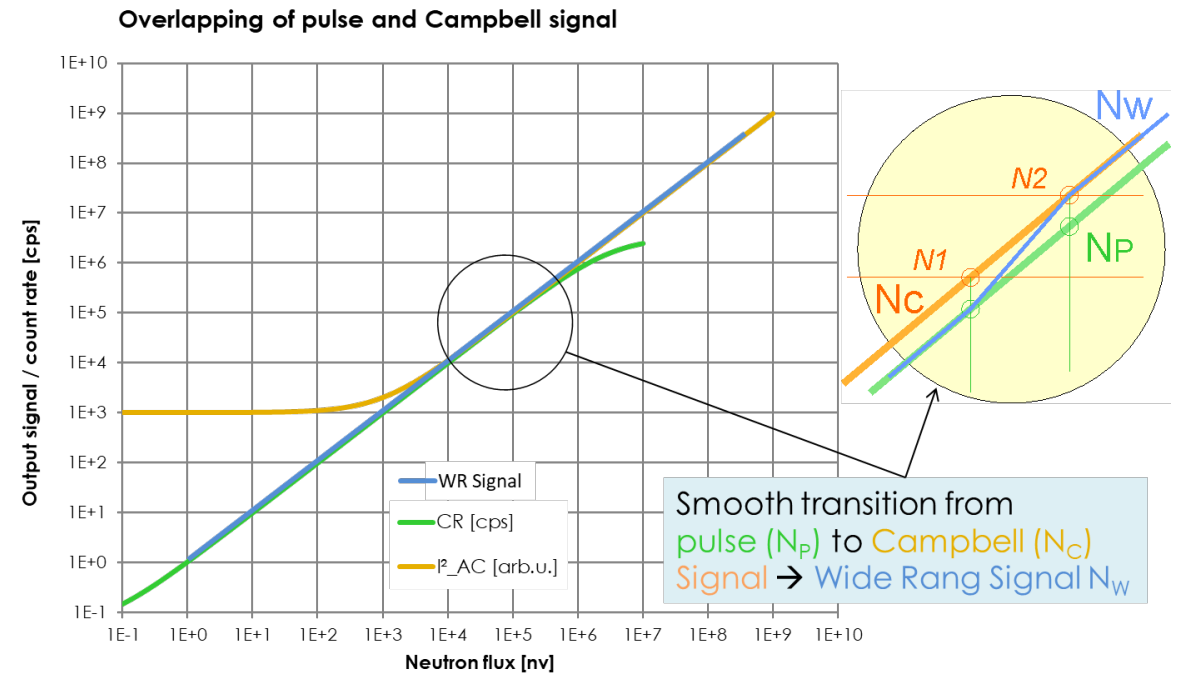
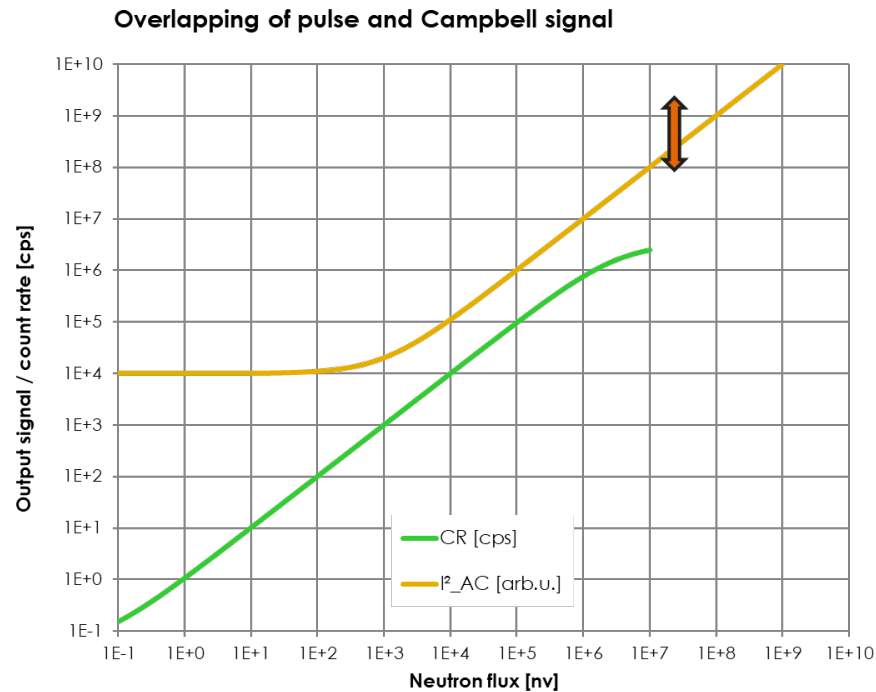




# proTK™ / DWK 260 Digital Wide Range Channel

## DWK 260

Combine Pulse + Campbell (AC) processed detector signals to a Wide-Range Signal (+ DC processing)



# proTK™ / DWK 260 Digital Wide Range Channel

## DWK 260

Signal Processing Units for Wide Range Operation  
For reactor start-up (source + intermediate) and power operation

## Features

- 5 ms cycle time, > 10 decades of dynamic range
- Signal filtering with adaptive low-pass filter parameters
- Analog and binary output signals (SW configurable) for the reactor protection system based on the following internal signals:
  - ✓ Logarithmic count rate [cps] and MSV (Campbell) [%FP] signals
  - ✓ Logarithmic power [%FP] or neutron flux [nv]
  - ✓ (Relative) flux change rate [1/s] (= 1 / reactor period)
  - ✓ Linear power [%FP]
  - ✓ ...



# proTK™ / DWK 260 Digital Wide Range Channel

## DWK 260

Signal Processing Units for Wide Range Operation  
For reactor start-up (source + intermediate) and power operation

## Features *(continued)*

- User adjustable, non-volatile parameters; secured by a key switch
- Elaborate testing concept based on
  - ✓ Remote-controlled test generators in the input module (for both signal paths)
  - ✓ Simulation of measurement values, analogue and binary outputs
- Optional: operation and monitoring via serial interface (RS-232 / RS-485)
- Continuous functional self-monitoring
- SW qualified according to IEC 60880  
*(I&C systems important to safety - SW aspects for computer-based systems performing category A functions)*



# proTK™ / Digital Signal Processing for Safety Applications

## Why digital ?

- Operational **flexibility** and **comfort**, wider set of configuration parameters and settings  
E.g. use of adaptive signal filtering parameters (time constant of low-pass filter)
- **Complex features and functions** for improved performance and higher degree in reliability due to easier implementation of monitoring functions for the integrity of a system  
E.g. generation of wide-range signal
- **Reliable** and **stable** readings with **high precision** over an unlimited period, e.g. calculation of logarithmic scales and trip signals -> no gradual **shifting** due to **drifting** characteristics of analogue components, and therefore no need of periodical verification for these
- The **calibration** of the output signals e.g. into neutron flux density or percent power consists of a **simple** conversion through numerical multiplication -> **stable no drift**



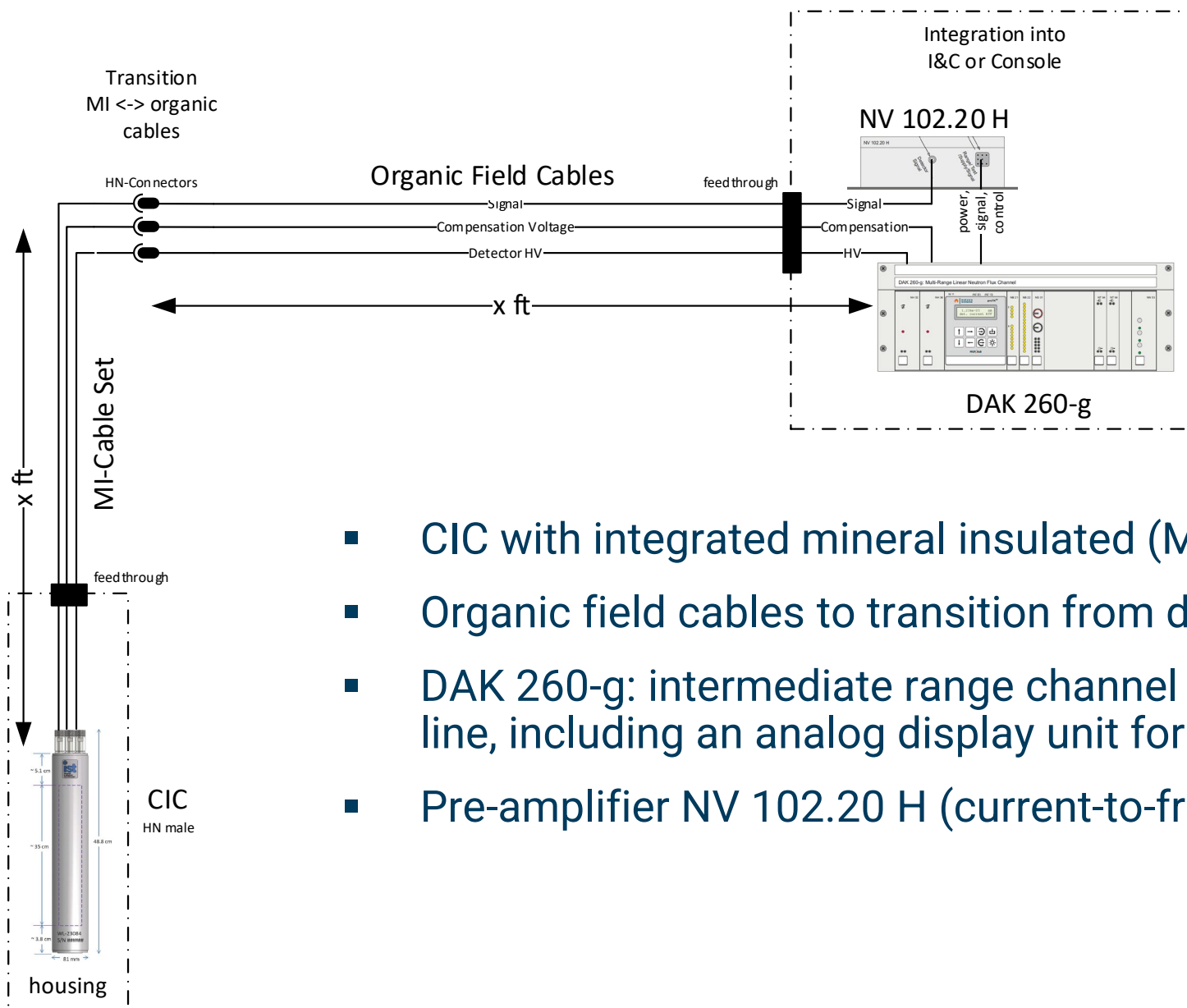
# proTK™ / Digital Signal Processing for Safety Applications

## Improved safety, reliability, economical viability

- A high degree of self-monitoring for hardware and software is implemented for minimizing the risk of undetected failures. This allows increasing the period between periodical tests due to increased reliability.
- Extensive self-testing features are integrated. This includes test signal generators that can be remotely activated and the possibility of simulating output signals of any kind (e.g. binary alarms and trips or analogue output signals). This shortens the duration of the periodical testing.
- The software and the algorithms of the signal processing are implemented in EPROM or stored in flash memory. In both cases the code is protected from malicious manipulations and is continuously monitored for potential changes.
- User adjustable parameters are checked for validity when deliberately adjusted and continuously monitored for inadvertent changes.
- No detected SW failures in any Neutron Flux Channel. In operation since the early 1990s.



# NCSU / PULSAR: Upgrading the Linear and Safety Channel



- CIC with integrated mineral insulated (MI) cables
- Organic field cables to transition from detector MI cables to cabinet
- DAK 260-g: intermediate range channel from Mirion's proTK product line, including an analog display unit for the neutron flux
- Pre-amplifier NV 102.20 H (current-to-frequency converter)



# NCSU / PULSAR: Upgrading the Linear and Safety Channel

Further clarification became necessary after the project has already started:

- Clarify the position of the pre-amplifier
  - > pre-amplifier in cabinet with signal processor DAK 260-g
  - > main advantage: EMI/EMC aspect
- Specify feeding of the field cables into I&C cabinet.
- Clarification of the interface to the reactor protection and control system



# Summary

- Mirion's **proTK™** product line offers a full range of equipment for neutron flux monitoring as well as for other safety critical applications, which are vital for operating nuclear power generating stations or research reactors.
- The provided engineering services by Mirion and the modularity of proTK™ channels as well as the micro-controller-based signal processing that is central to those units, enables an **efficient customized implementation** of all the required **safety functions**, which in turn helps owners to operate their reactor in a **comfortable, safe and economic way**.
- [World Nuclear News: US research reactor goes digital in licensing 'first'](#)

