CANBERRA CRITICALITY ACCIDENT ALARM SYSTEMS: Recent Developments

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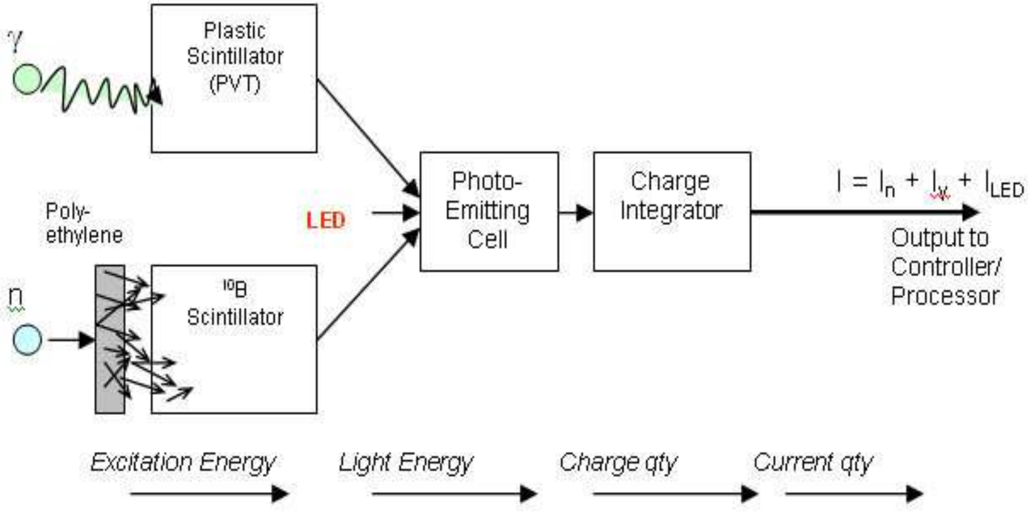
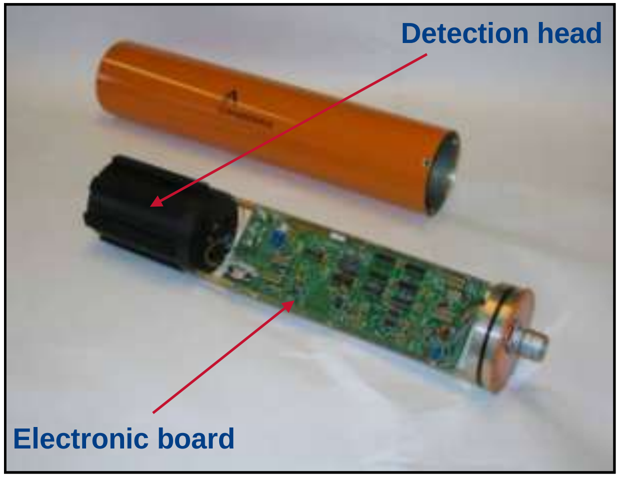
Introduction

- **EDAC-21 is CANBERRA's current generation Criticality Accident Alarm System (CAAS), with a 30+ year history in the field**
  - **Developed for single-area monitoring inside a hot cell or small hot area**
  - **Neutron and gamma sensitivity**
  - **More than 50 EDAC systems with over 800 probes have been in use worldwide, some in continuous operation since 1980**
  - **Mean time before failure (MTBF) of 56 years, without a single instance of a system failing to alarm when required.**
- **Recent R&D efforts**
  - **Support EDAC-21 and enhance for wide area coverage**
  - **Develop Next Generation CAAS system: EDAC-21→CAAS-3S**

EDAC-21 Overview

- The EDAC γ+n probe:
  - PVT gamma scintillator
  - Boron-loaded ZnS neutron scintillator
  - Both sensors optically couple to single phototube
  - light-emitting diode provides continuous state of health monitoring.
  - Processing electronics board
- EDAC processing cabinet monitors 3 or 4 probes (choice of voting logic)
- Power supply cabinet ensures full functionality during power outages
- Supervisory software for remote monitoring and control





CAAS R&D objectives

- **Support & enhance current generation EDAC-21 system**
  - **Address parts obsolescence, minimize future obsolescence risks**
  - **Enhance probe performance to increase coverage area**
- **Develop next generation system**
  - **Response to US market needs for wide area coverage of larger facilities**
  - **Update system architecture for multi-zone monitoring**
  - **Update & modernize electronics for control, state-of-health monitoring**
  - **Maintain continuity with established performance history**
  - **Availability target Q1 2014**

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EDAC-21 support and enhancement

- **Obsolescence management**
  - **Photomultiplier tube**
    - New supplier identified
    - Limited New Old Stock in inventory to sustain previous generation probes
  - **Neutron detector**
    - Replaced Boron-loaded ZnS with Li-6 sensor (new supplier)
- **Increased probe sensitivity for expanded coverage area**
  - **Alarm threshold setting: 20 mGy/h (2 R/h) → 1 mGy/h (100 mR/h)**

Probe Detection	Dose (Gy)	Dose rate (Gy/h)
Gamma + Neutron (High Range)	$25x10^{-6}$	$1x10^{-3}$
Gamma	$25x10^{-6}$	$5x10^{-4}$
Neutron	$25x10^{-6}$	$1x10^{-3}$
Gamma + Neutron (Normal Range)	$25x10^{-6}$	$20x10^{-3}$

- **Alarm processing circuitry is unchanged, maintaining performance lineage of the system.**
- **All changes fully qualified for compliance with IEC 60860 (1987), ISO 7753 (1987) and ANSI/ANS-8.3 (1997)**

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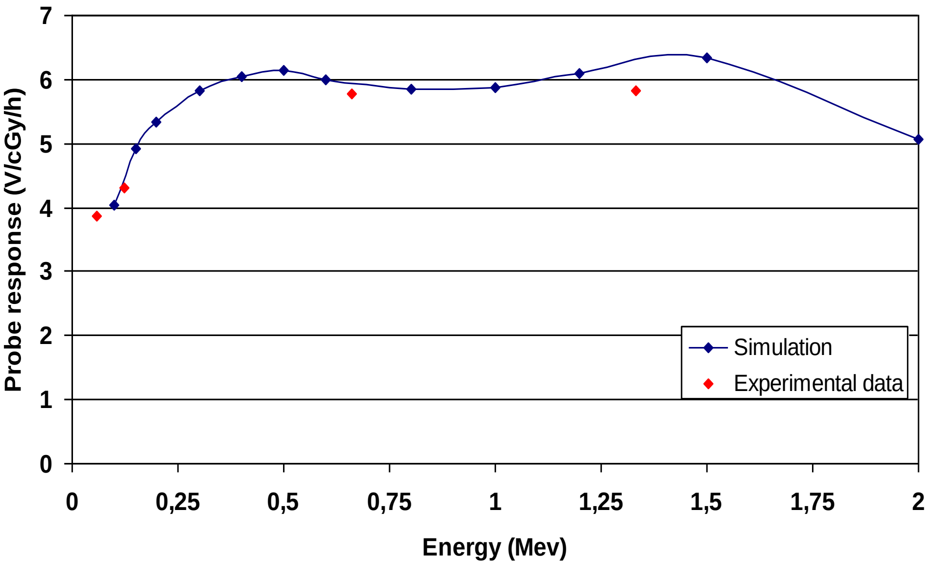
Qualification Testing: Gamma Response

- Response measured over 100 keV-1.33MeV range (IRSN, Canberra Loches)
- Co-60, Co-57, Cs-137, Am-241 sources
- Variation in response can not exceed 35% rel. to Co-60.

- EDAC probe meets all requirements
- Exceeds energy range down to 59keV



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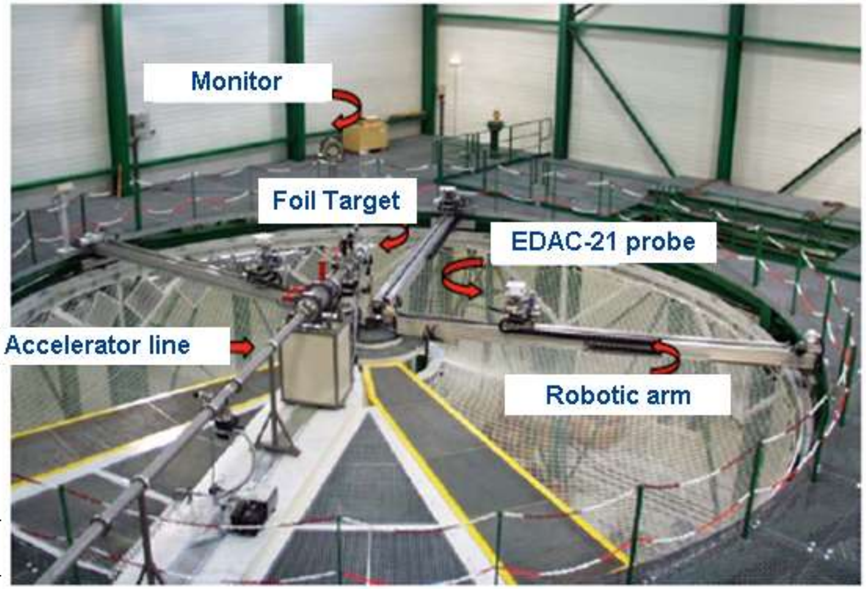
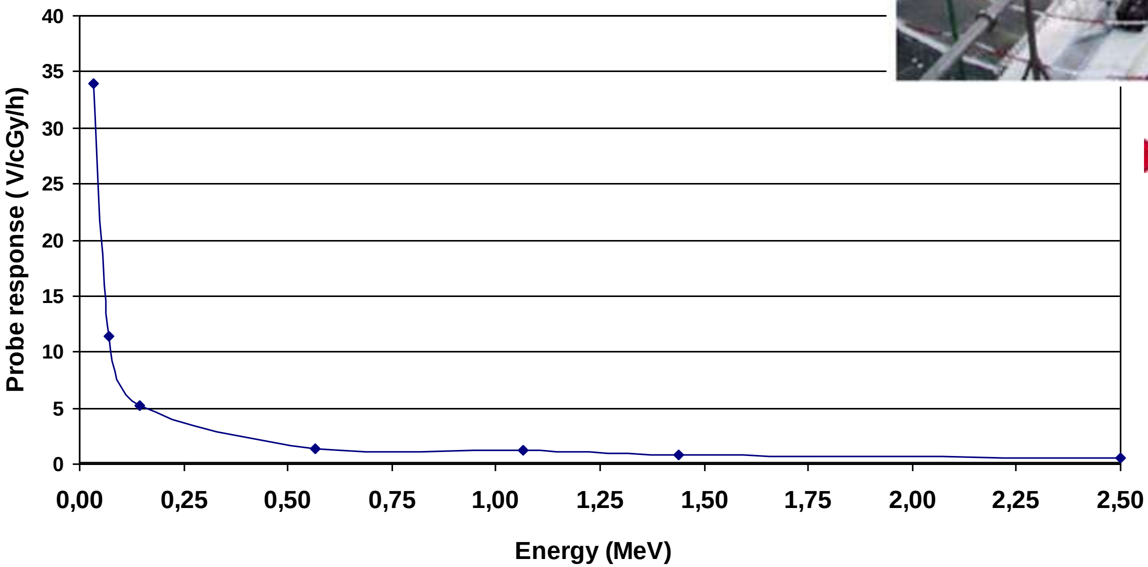
Qualification Testing: Neutron Response

- **AMANDE neutron accelerator (IRSN Cadarache, France) generates neutrons from the keV range up to 15 MeV**
- **The probe energy response was measured from 7.5 keV up to 2.5 MeV**





- **Measured Neutron Response vs Energy enables simulation for probe placement**

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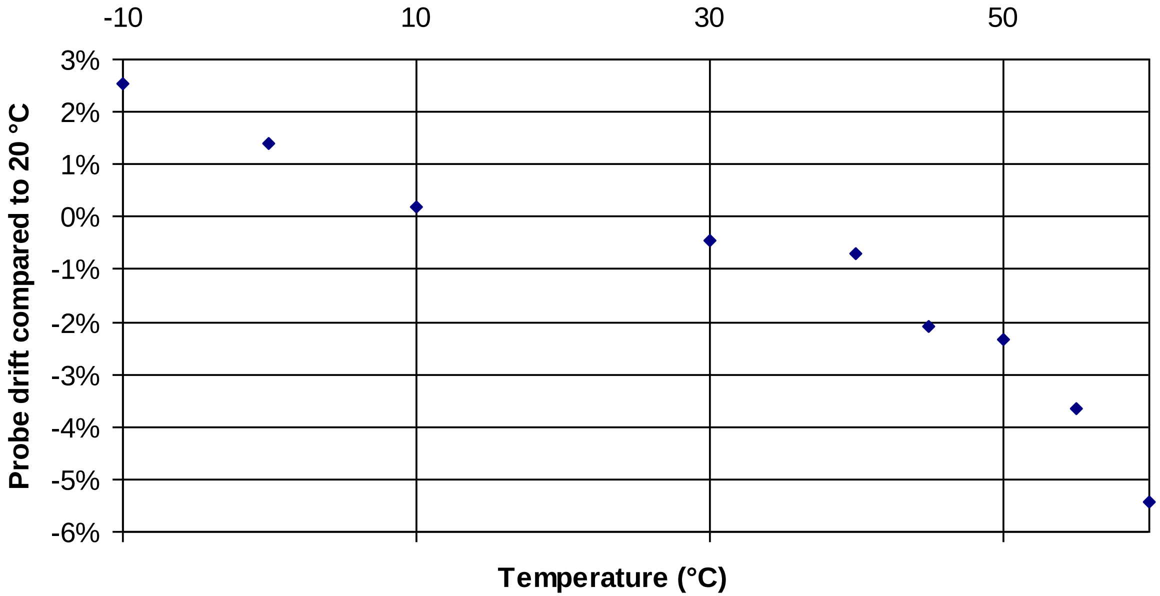
Qualification Testing: Temperature Stability

- Probe performance was tested from -10°C to 60°C
- No thermally induced false alarms
- Stable response within +/- 6%



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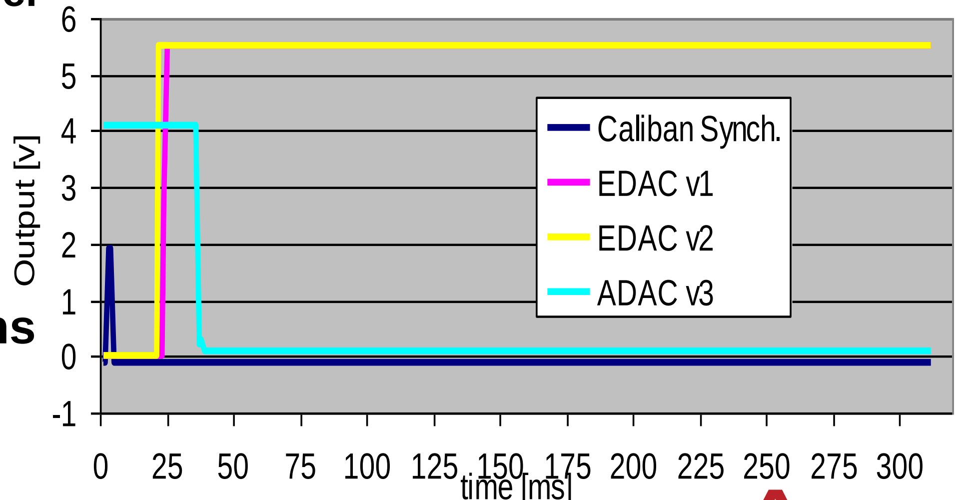
Criticality Reactor Tests

- **Probes tested at two criticality reactor facilities (PROSPERO and CALIBAN) to demonstrate response to criticality event**
  - **CALIBAN : criticality events with time constants *smaller* than probe electronics (60µsec – 2.1 msec)**
  - **PROSPERO: response to longer events**
- **EDAC probe response time << 300ms requirement**
- **Verify gamma-to-neutron response ratio unchanged between new, old probe designs (ongoing…)**

Standard	ANSI	IEC	ISO
Detection criterion	0.2Gy in 60 sec at 2m	0.2 Gy in 60 sec at 2m	0.2Gy/min at 2m
Time to alarm	500 msec after accident detection	300 ms after exposure to twice the alarm threshold	-

Probe Response Time



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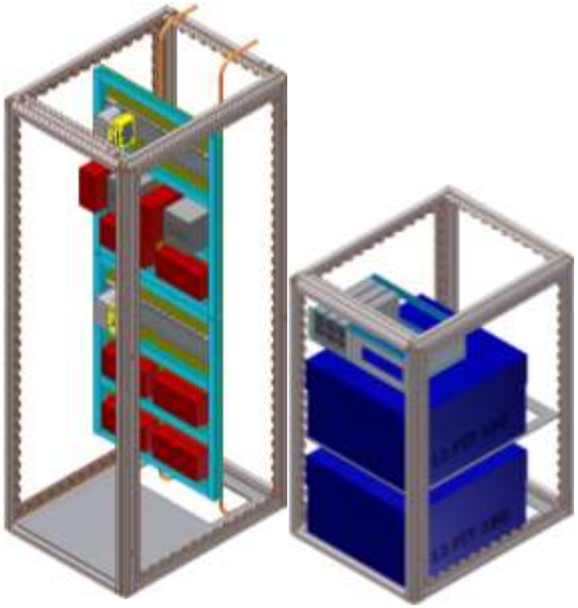
Next Generation: The CAAS-3S System

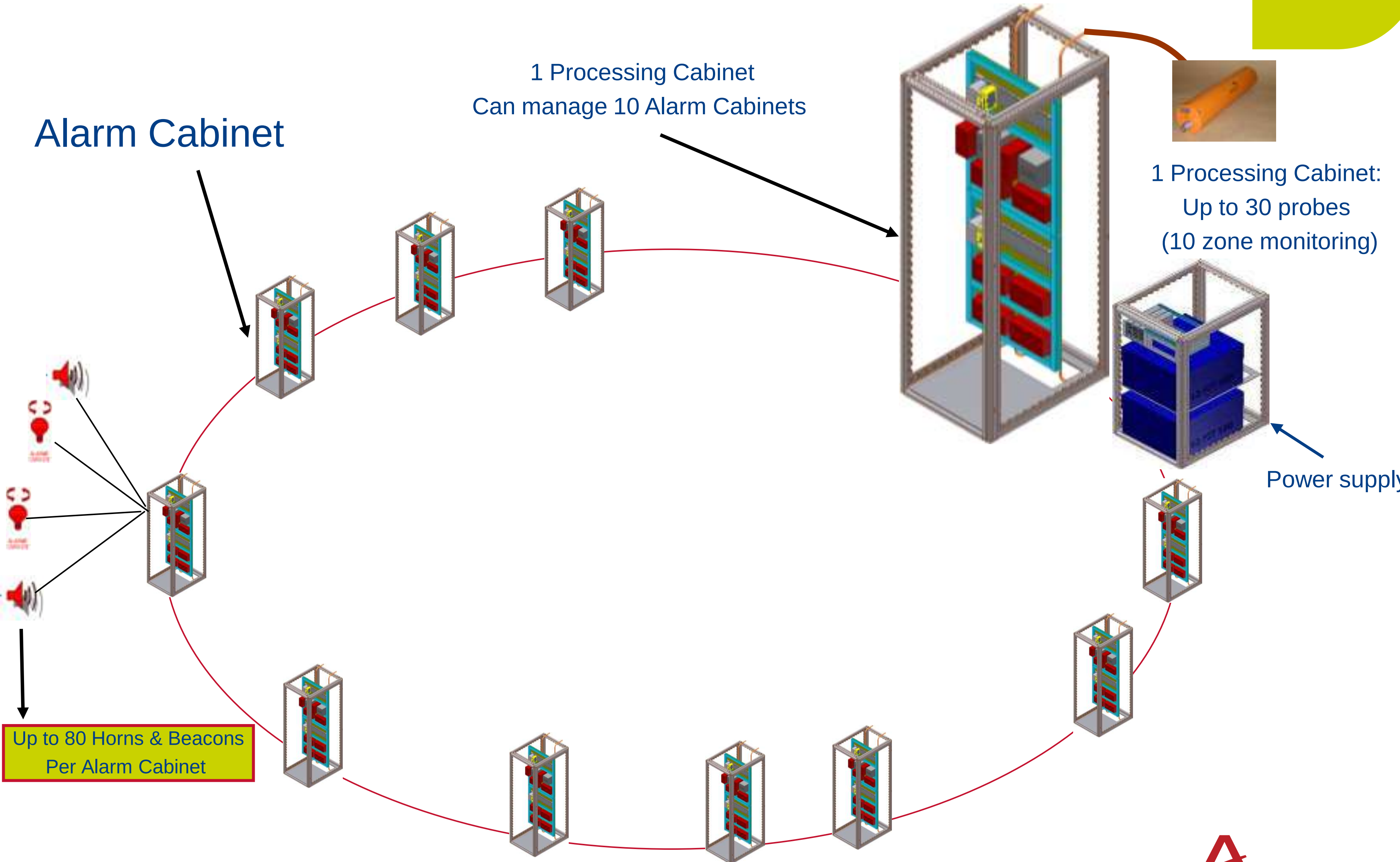
- New System Architecture to support multi-zone
- The CAAS-3S probe is built on the same detection technology
- All signal detection electronics intentionally preserved as analog
- Non-safety related features enhanced with Digital- FPGA based electronics:
  - Enhanced diagnostics & state-of-health
  - Tracking of criticality accident
  - Temperature drift compensation
  - Radiation hardened digital technology (Anti-fuse FPGA) was selected to resist integrated dose in the range of 5000 Gy.
  - This electronics architecture is currently under development

CAAS-3S Components

- **Processing cabinets**
  - **Support up to 30 probes each**
  - **Monitor up to 10 zones (3 probes per zone, 2 out of 3 voting logic)**
  - **Monitor up to 7 zones (for 4 probes per zone, 3 out of 4 voting logic)**
  - **Cabinets located outside the hot cell / processing area**
- **Alarm cabinet:**
  - **Houses PLC control of horns and beacons**
  - **Up to ten alarm cabinets per processing cabinet**
  - **Up to 80 alarms per alarm cabinet**
- **Supervisory Software**
  - **Control and state of health monitoring can be done remotely through client-server supervisory software**



EDAC-21 → CAAS-3S: Network Architecture



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Summary

- Canberra's EDAC-21 CAAS has a long, reliable performance and maintenance history.
- Recent R&D efforts have sustained and enhanced this product line.
- Current Generation - EDAC-21
  - Addressed obsolescence issues on components
  - Increased probe sensitivity for single-area monitoring applications.
- Next Generation System In Development
  - CAAS-3S
  - Supports large-area multi-zone monitoring
  - Maintains continuity of the detection components with previous generations
- With each new development the system is re-qualified to ensure that all criticality standards are met

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Gamma Response Vs. Energy