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IAEA UNATTENDED MONITORING SYSTEMS: A BRIEF OVERVIEW

Futures Toolkit

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NGSI Student VTC Series

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A High Level View of IAEA Safeguards

STATE LEVEL ASSESSMENT

Correctness

(Declared Facilities and Activities)

- INFCIRC 153/66
- SSAC (domestic)
- Reporting
- Design Information
- Facility Attachment
- Inspections

Completeness

(Undecleared Facilities and Activities)

- INFCIRC 540
- Provision of Information
- Complementary Access
- Open Source Analysis
- Satellite Image Analysis
- National Technical Means

IAEA Significant Quantities

	Material	Significant Quantity	Safeguards apply to:
Direct-Use Nuclear Material*	Pu (<80% Pu-238)	8 kg	Total Element
	U-233	8 kg	Total Isotope
	U [U-235>/= 20%]	25 kg	U-235 Contained
Indirect-Use Nuclear Material**	U [U-235<20%]	75 kg	U-235 Contained
	Thorium	20 t	Total Element

* NM that can be converted into nuclear explosive components without transmutation or further enrichment

** All NM except direct-use material

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Did You Know?

According to the International Atomic Energy Agency (IAEA), 25 kg of HEU (about the size of a grapefruit) or 8 kg of plutonium (about the size of a soda can represent a "significant quantity" required to make a crude nuclear weapon.

IAEA Conversion Times (Weaponization)

Beginning Material Form	Conversion Time
Pu, HEU or U-233 Metal	Order of Days (7-10)
PuO2, Pu(NO3)4, or other pure Pu compounds; HEU or U-233 oxide or other pure compounds; MOX or other non-irradiated pure mixtures containing Pu, U [(U-233+U-235)>/=20%; Pu, HEU and/or U-233 in scrap or other miscellaneous impure compounds	Order of Weeks (1-3)
Pu, HEU or U-233 in irradiated fuels	Order of Months (1-3)
U containing < 20% U-235 and U-233; Th	Order of one year

What is an Unattended Monitoring System (UMS)?

- It is a system that automatically monitors the flow of nuclear materials 24 hours a day / 365 days a year without the need for human interaction
- It is permanently installed in a nuclear facility
- It is computer based for data retrieval either on-site or remotely
- It may use a variety of sensors such as radiation, pressure, temperature, flow, vibration, & electromagnetic fields to collect qualitative or quantitative data
- All external components are in tamper indicating enclosures

Why does the International Atomic Energy Agency use UMS?

- It provides the highest level of safeguards assurance through continuous monitoring of activities in nuclear facilities.
- It minimizes impact on the facility operator by allowing uninterrupted facility operation
- It minimizes the impact on the Agency by reducing inspector visits and thereby inspection resources including the high cost of world-wide travel
- It reduces radiation exposure to personnel and can operate in radiation areas too dangerous for humans

INFCIRC/153 – The Structure & Content of Agreements Between the Agency & States in Connection with the NPT

- **PART I, paragraph 4, The Agreement should provide that safeguards shall be implemented in a manner designed:**
  - **(a) To avoid hampering the economic and technological development of the State … in the field of peaceful nuclear activities, including international exchange of nuclear materials;**
  - **(b) To avoid undue interference in the State's peaceful nuclear activities, and in particular in the operation of facilities; and**
  - **(c) To be consistent with prudent management practices required for the economic and safe conduct of nuclear activities.**

WHAT ARE THE MAJOR COST DRIVERS IN THE DEPARTMENT OF SAFEGUARDS?

RECENT FINANCIAL PLAN

- **Staff = 68%**
- **Other Direct Costs = 13%**
- **Travel = 10%**
- **Laboratory = 5%**
- **Shared Costs = 3%**

The easiest one to impact with new safeguards approaches is travel

Mid-2004 IAEA Worldwide Statistics of UMS

- **90 Systems Installed (+115 Mid-2005)**
  - **79 Radiation Based**
  - **5 Thermo-hydraulic Based**
  - **6 Process Monitoring Based**
- **44 Facilities**
- **22 Countries**
  - **SGOA - 30 Systems (SE Asia)**
  - **SGOB - 40 Systems (N. & S. America, Africa, India, Pakistan, Iran)**
  - **SGOC – 20 Systems (Europe, Kazakhstan, Ukraine)**

What are the Primary Goals of UMS?

- No loss of safeguards significant data
- Assurance that the data is authentic

How are these Goals Obtained?

- Use of high reliability and/or redundant critical components and/or reduced reliance on low reliability components
- Use of uninterruptible power supply
- Employs multi-layer Security

Objectives for Unattended Measurement Systems

Collect SG-information without Inspector's Presence:

- **Verify flow and inventory of nuclear materials**
- **Minimize intrusiveness on Operator**
- **Reduce IAEA & Operator manpower requirements**
- **Decrease radiation exposure**
- **Standardize hardware and software**
  - **Minimize maintenance**
  - **Minimize training**

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UMS Design Considerations

- Cost - Benefit
- Reliability and stability
- Meet IAEA Operation's User Requirements
- Use Facility Operator provided equipment
- Authentication requirements
- Early Involvement of Agency in planning stages (Safeguards by Design)
  - Allows Integration of facility specific SG features into final plant designs

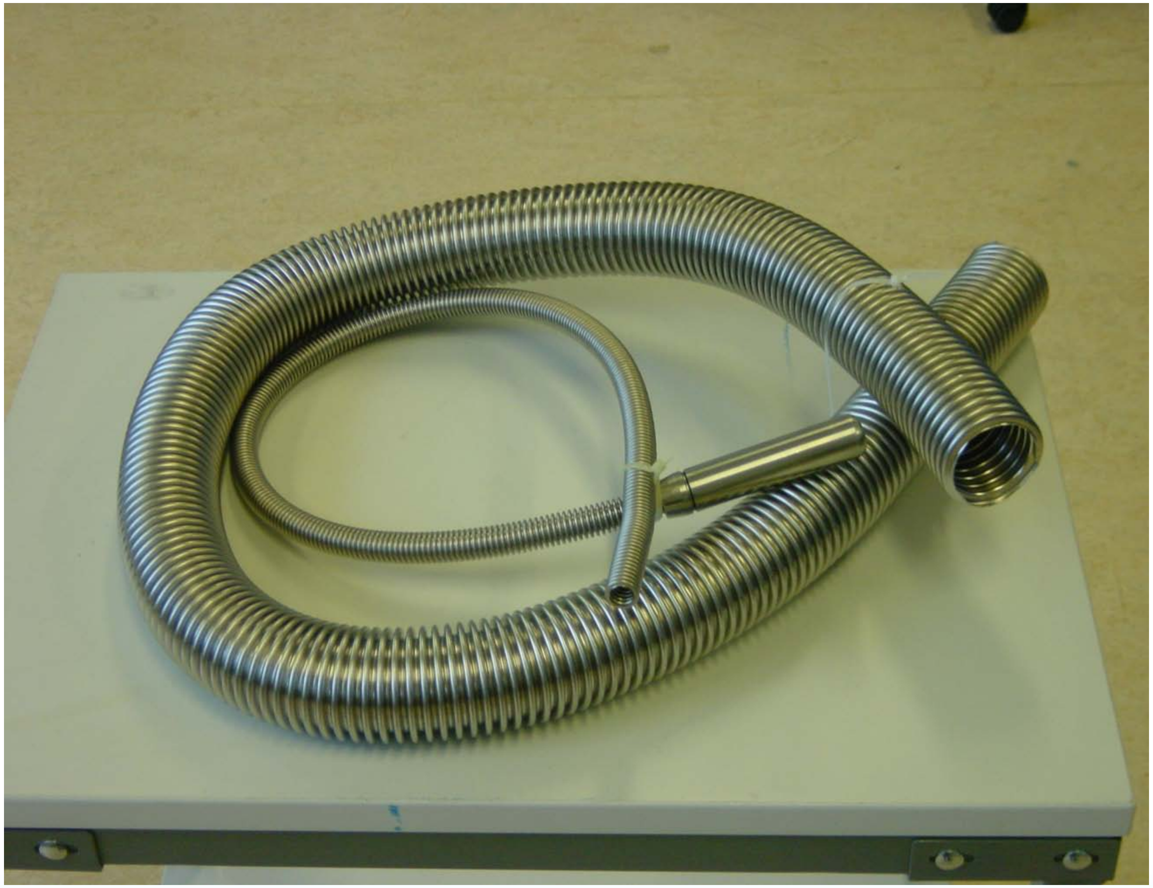
Security Methods

- Software controlled
- Tamper indicating enclosures
- C/S on detector head and electronics
- Visual Inspection of components and cables
- Efficiency check with normalization source
- Supervision of maintenance
- Cross correlation with other SG measures
- Use of unique data signature on all digital data
- Encrypted data transmission between cabinets and for remote monitoring
- Uninterrupted Power Supplies

Metal E-cup Seal

SOME TAMPER INDICATING FEATURES

Tamper Indicating Conduit



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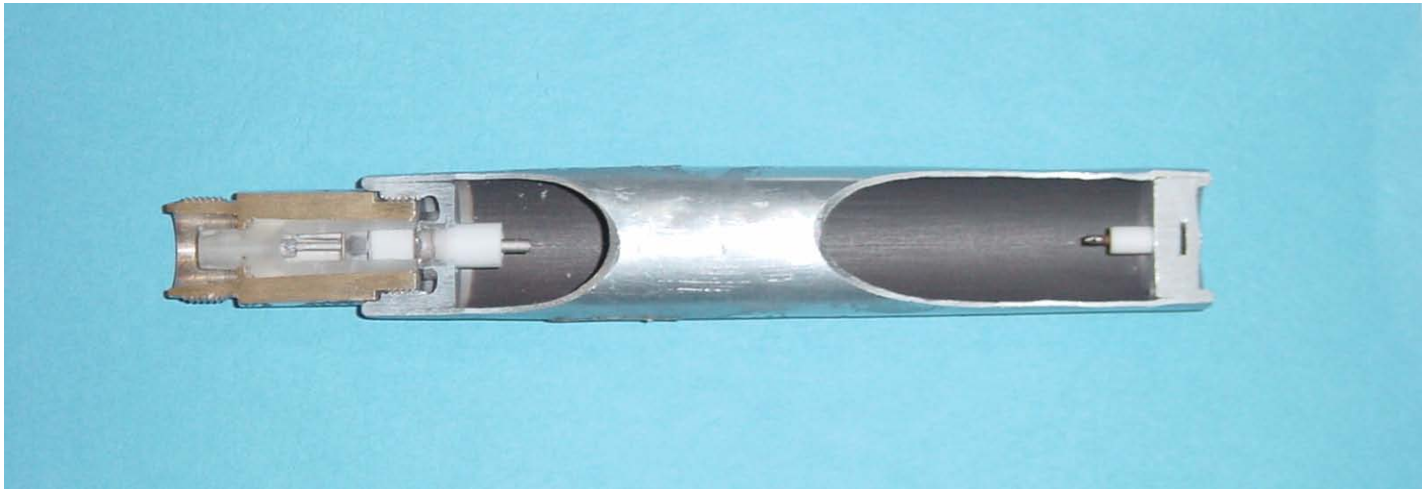
ENGM Detector

Radiation Sensor: Ionization cut away



Radiation Sensors: Silicon Diode, Ionization, Fission Chamber

Security Solution: VPN

- Netscreen 5XP or 5XT
- Meets FIPS 140 Level 2
- Small, << $1000 each
- Doesn't take firewall expert
- Wire or Wireless

Wireless Solution

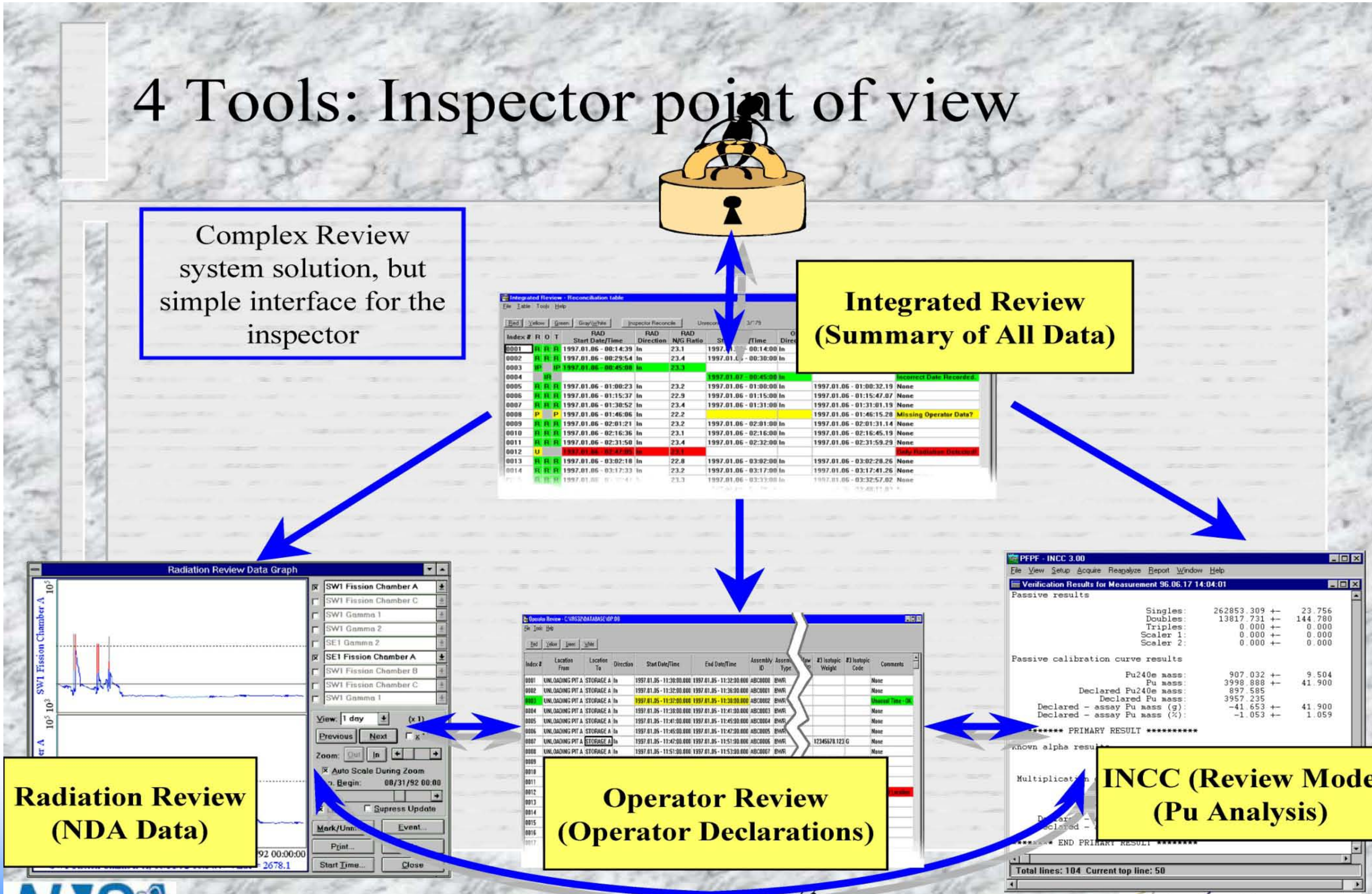
- **Alvarion AP-10 & SA-10**
- **AP-10 indoor wireless hub, ~$ 1,000 each**
- **SA-10 station adaptor for end user computer, ~$ 500 each**
- **10BASE-T Ethernet using RJ-45**
- **Data rate - up to 3 Mbps**
- **Range – 150m (500 ft.)**

SOFTWARE STANDARDS

Collect Software
(Multi-instrument Collect: MIC, primary function is polling of data generators)

Review Software
(Integrated Review Software: IRS, note that IAEA does no real time data analysis)

Integrated Review Software



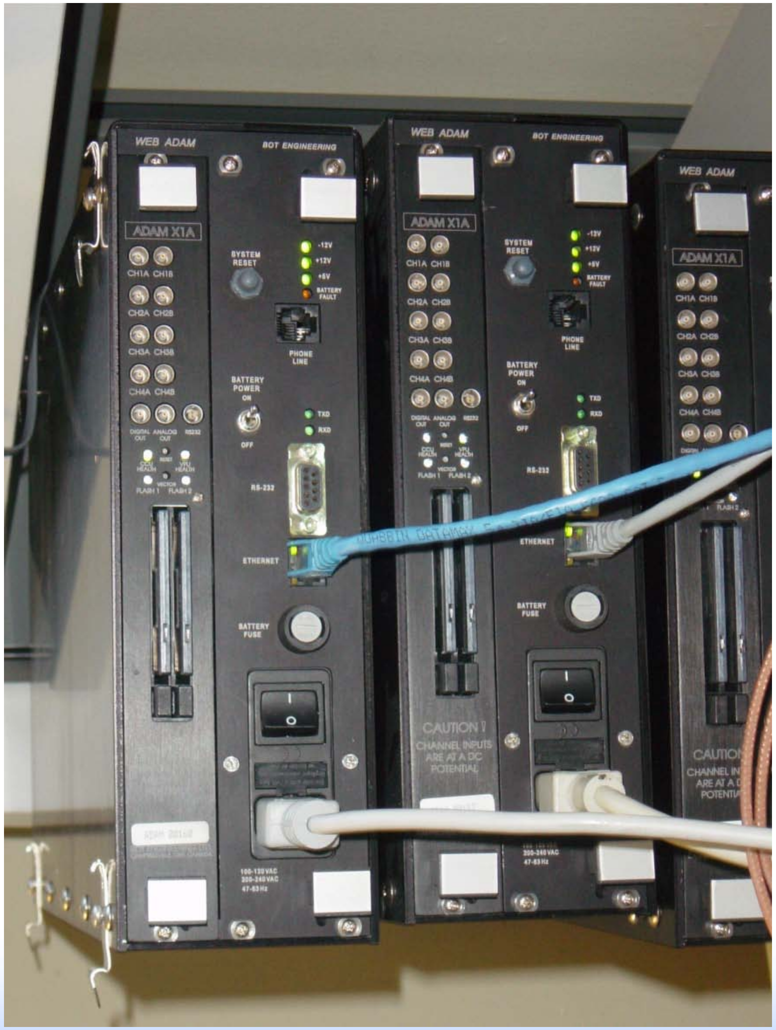
HARDWARE STANDARDS

Surveillance Data Generator

DCM 14 (German Support Prog.)

- Digital image
- Scene change detection
- Image compression
- Image/data authentication
- Image/data encryption
- Battery back-up
- Rotating buffer memory
- External triggers
- On board 100 days data storage
- State of health

Data Generators – continued



Standalone

ADAM

Autonomous

Data

Acquisition

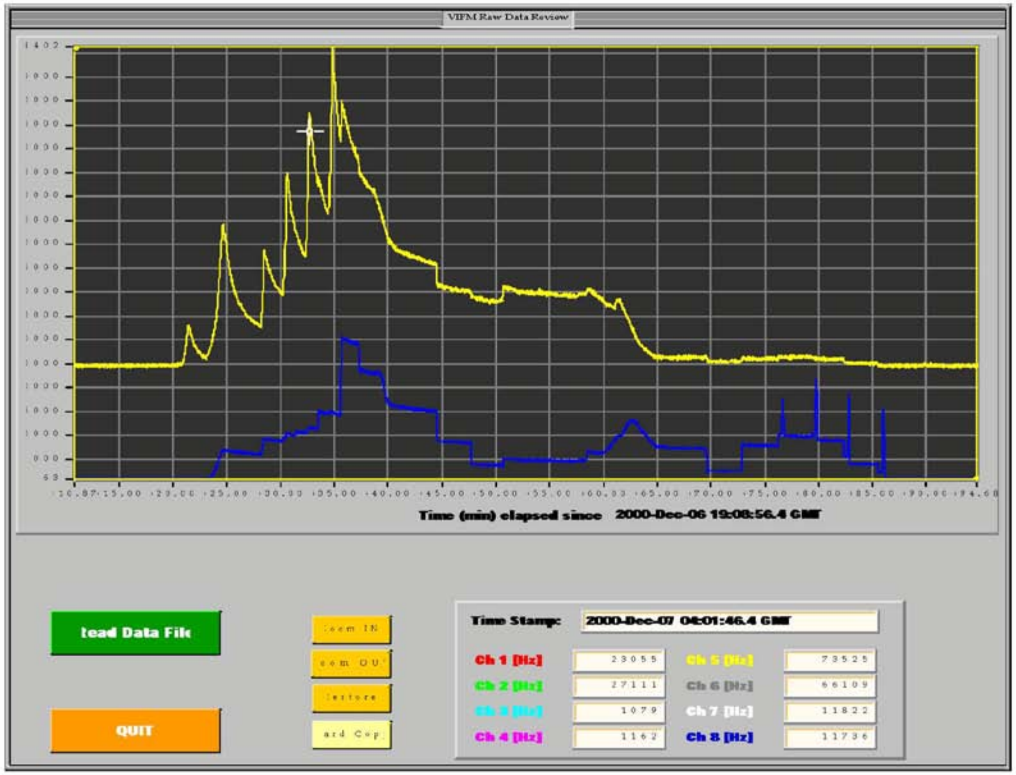
Module

(Canadian Support Program)

VIFM CABINET DESIGNED TO MONITOR SF BUNDLES FROM CANDU REACTORS

(Canadian Support Program)

VIFM – VIFC: Core Discharge Monitor



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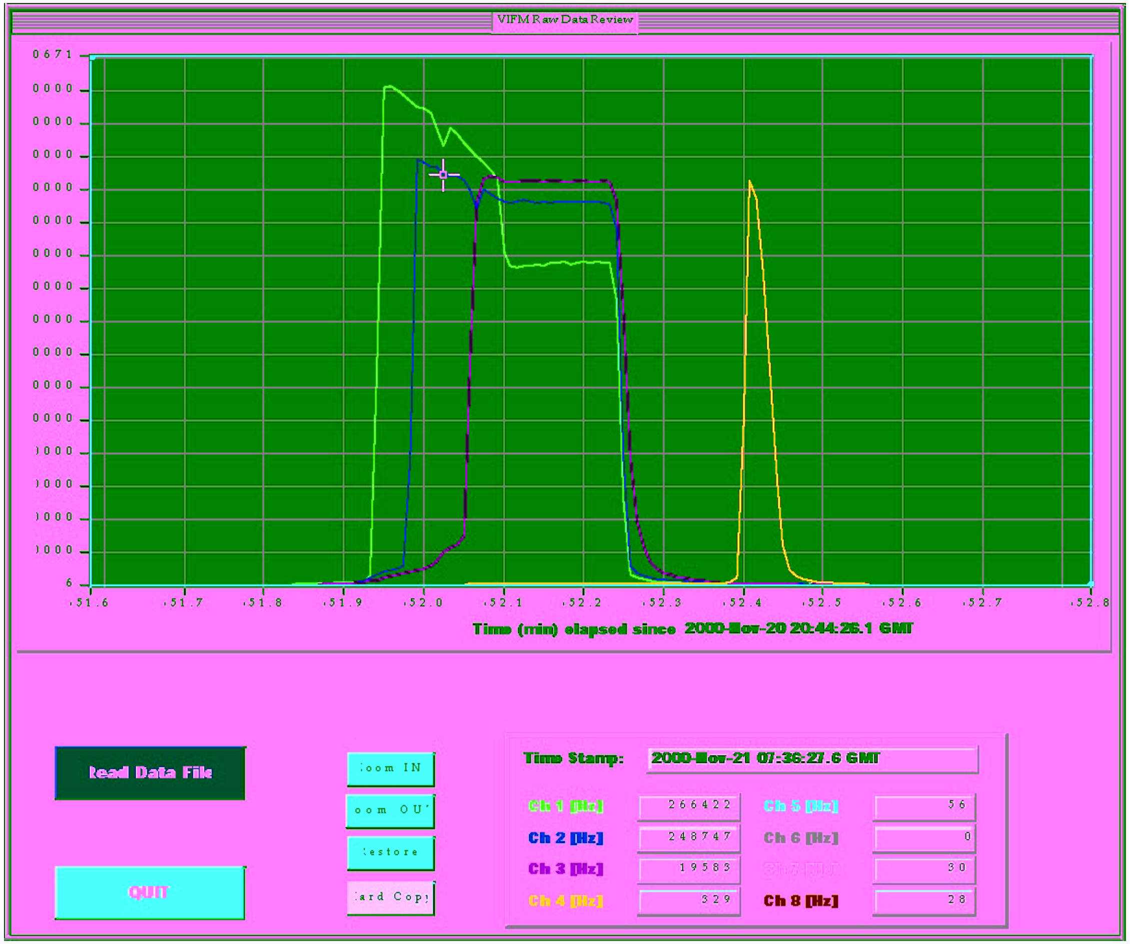
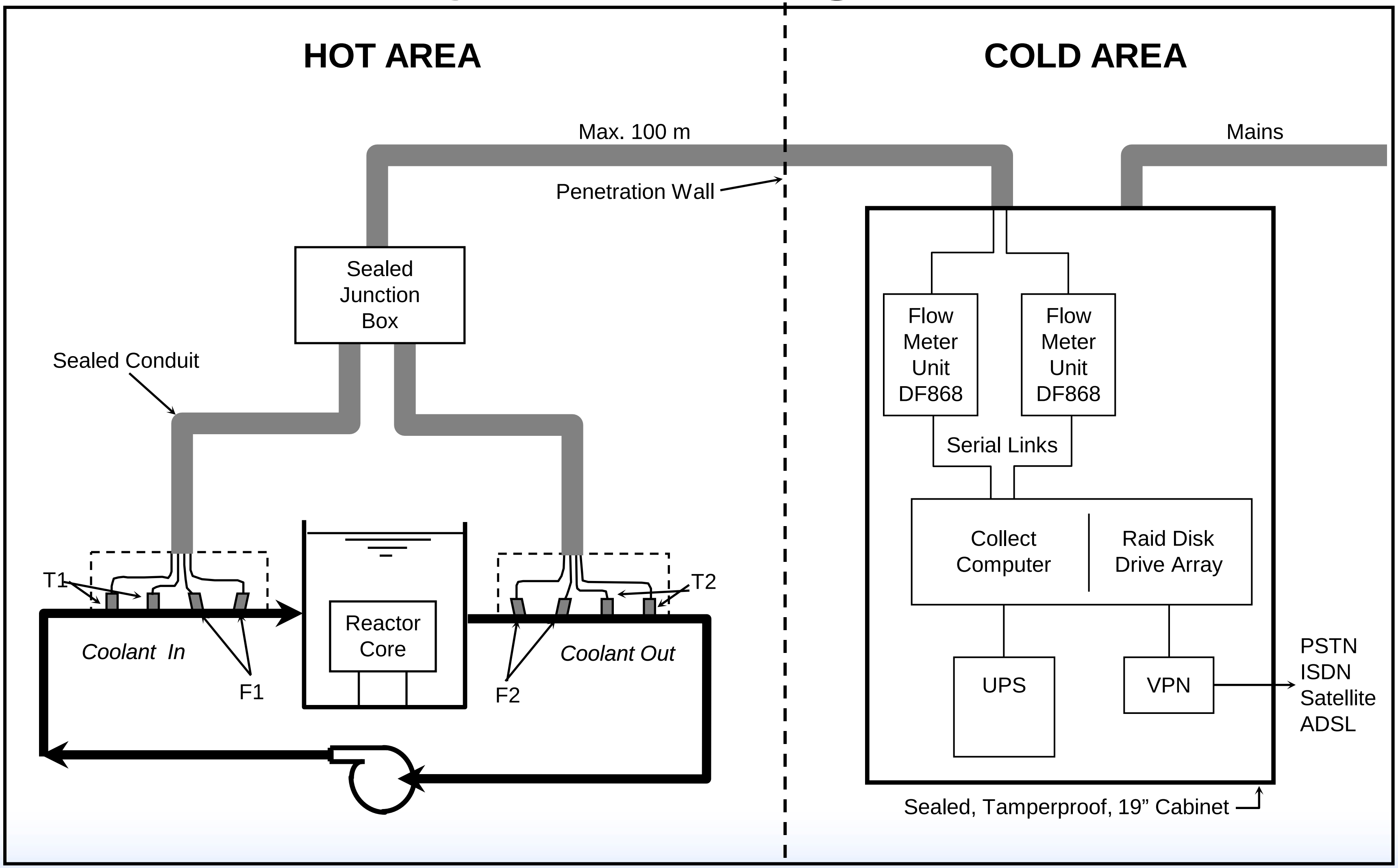
VIFM – VIFB: Bundle Counter



ATPM System Diagram



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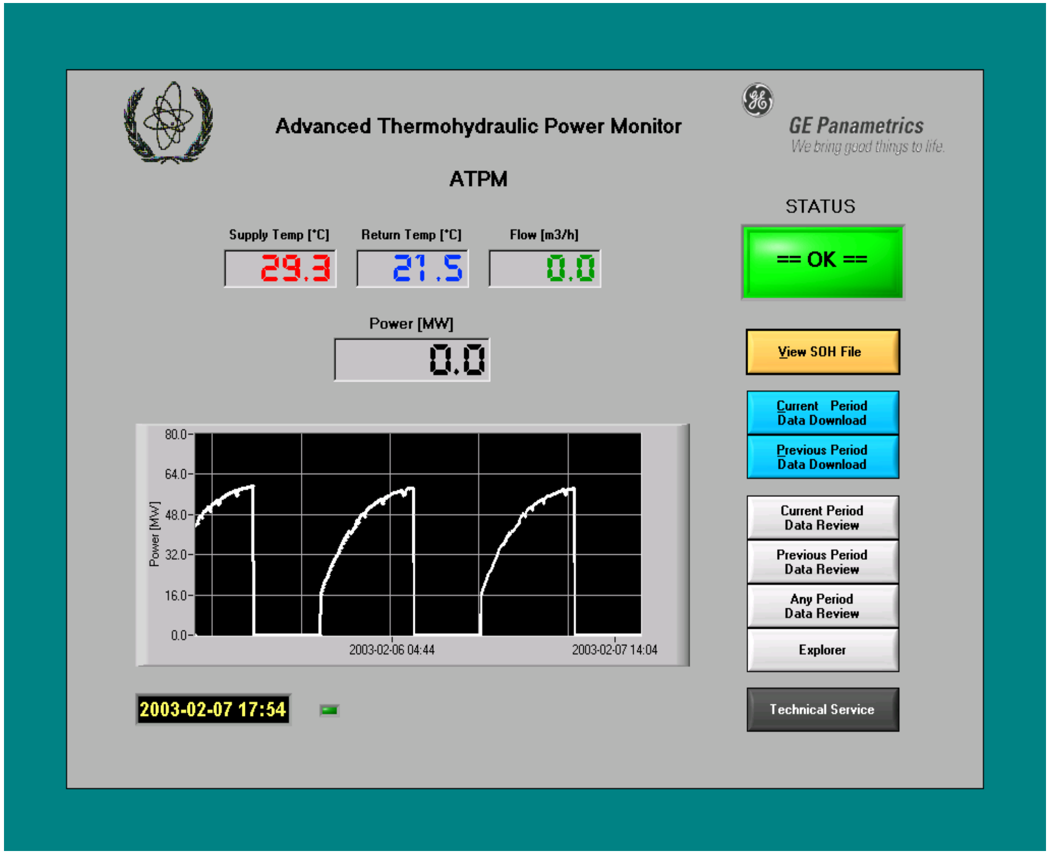
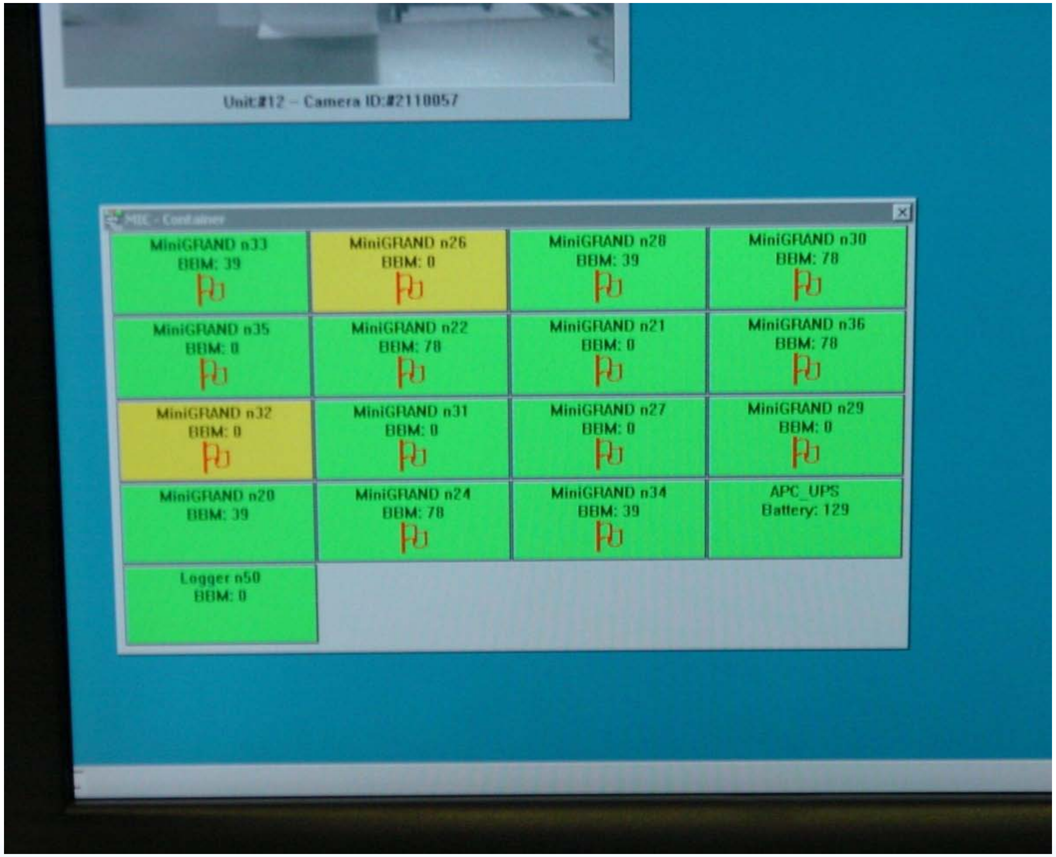
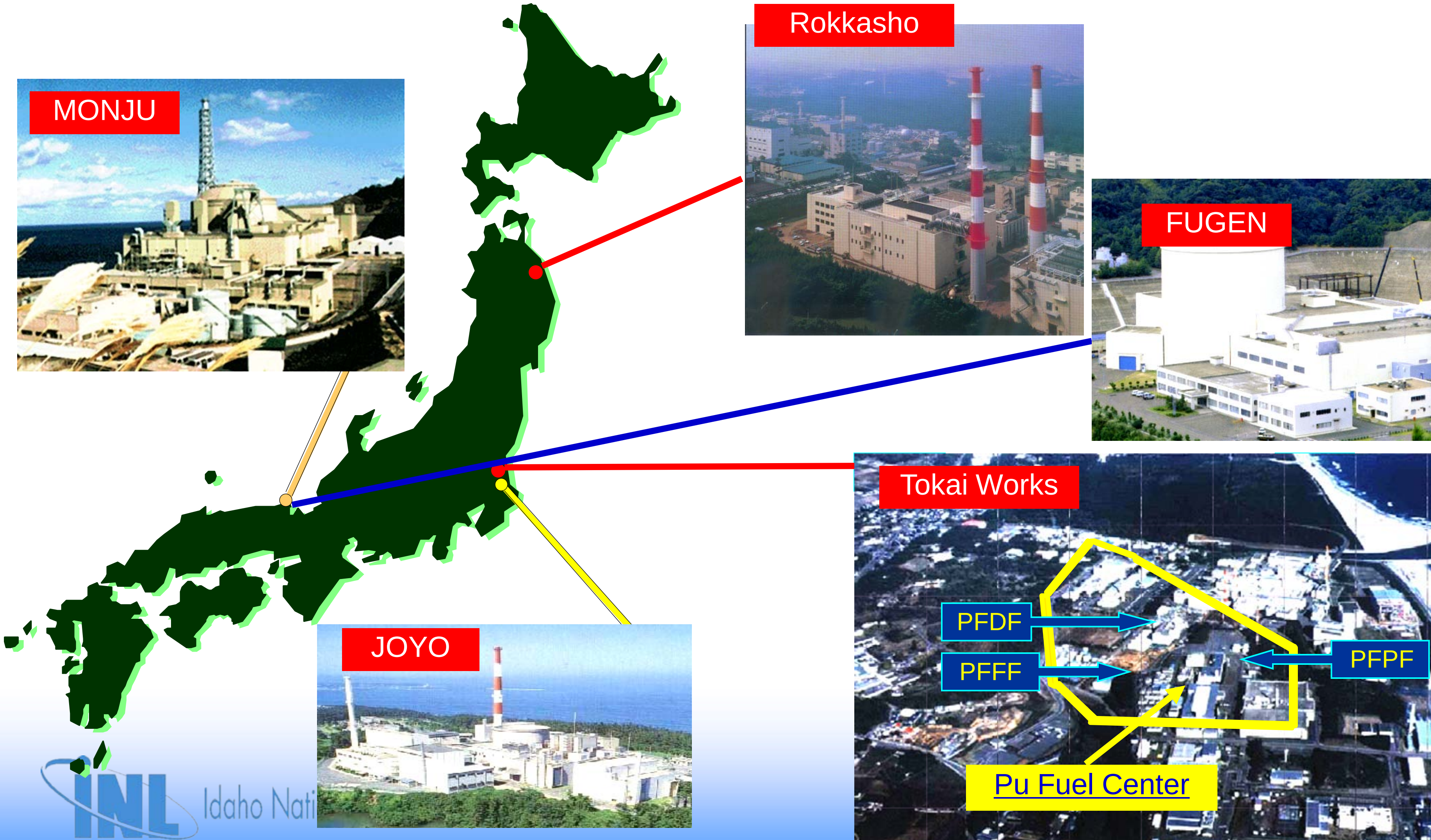
ATPM Front Screen



Chernobyl System
SOH – State of Health Flags



Japan: Largest non-weapons state with complete fuel cycle under IAEA safeguards



Rokkasho Reprocessing Plant Characteristics

- Only large scale reprocessing plant outside a Nuclear Weapons State (full scope IAEA safeguards)
- Safeguards on bulk handling facilities (vs. item) 800 tons heavy metal ~ 8 tons Pu/yr
- Analytical error (~0.3% including sampling error) gives a 1σ error on throughput of Pu of ~24 kg per year
- 2σ is 48 kg = ~4 kg/month (considering abrupt diversion, compare to IAEA significant goal quantity 8kg, with 95% C.L. that reduces to ~2.5kg)

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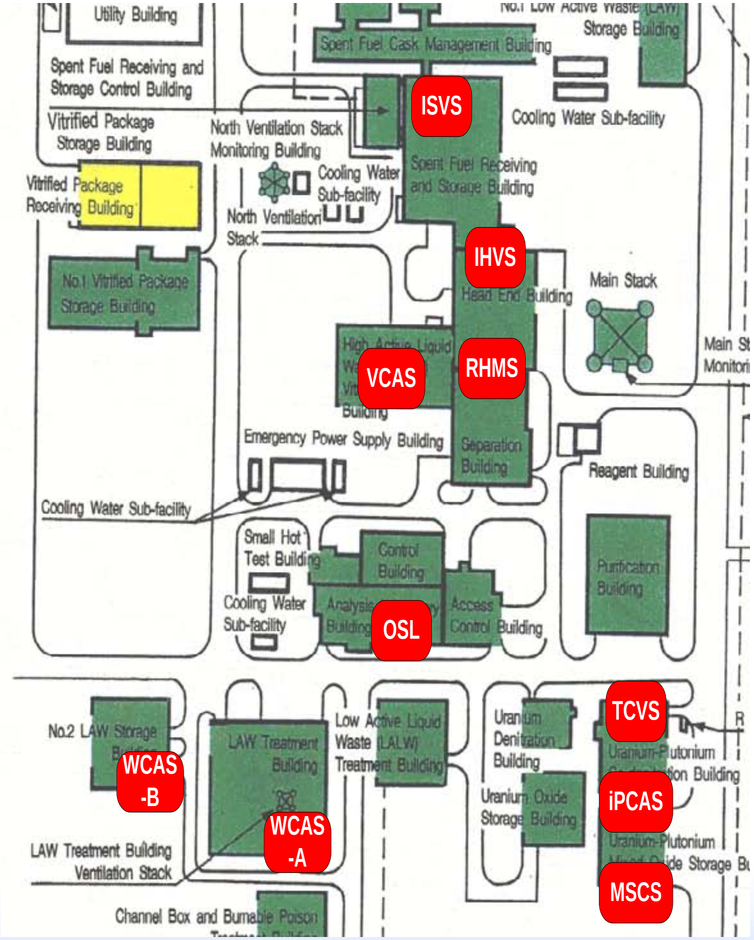
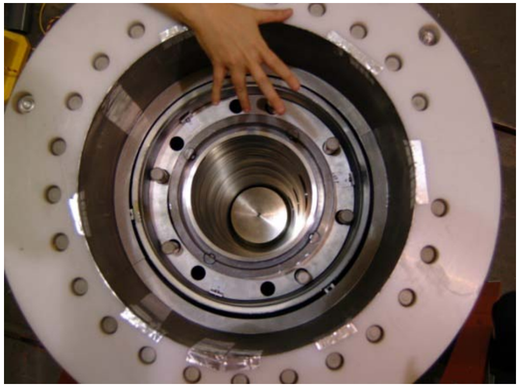
NDA systems at Rokkasho Reprocessing Facility are the State of the Art.

- •ISVS – Integrated Spent fuel Verification System
- •IHVS – Integrated Head end Verification System
- •RHMS – Rokkasho Hulls Measurement System
- •VCAS – Vitrified waste Canister Assay System
- •HKED – Hybrid K-Edge Densitometer
- •TCVS - Temporary Canister Verification System
- •iPCAS - improved Plutonium Canister Assay System
- •WCAS A/B - Waste Crate Assay System

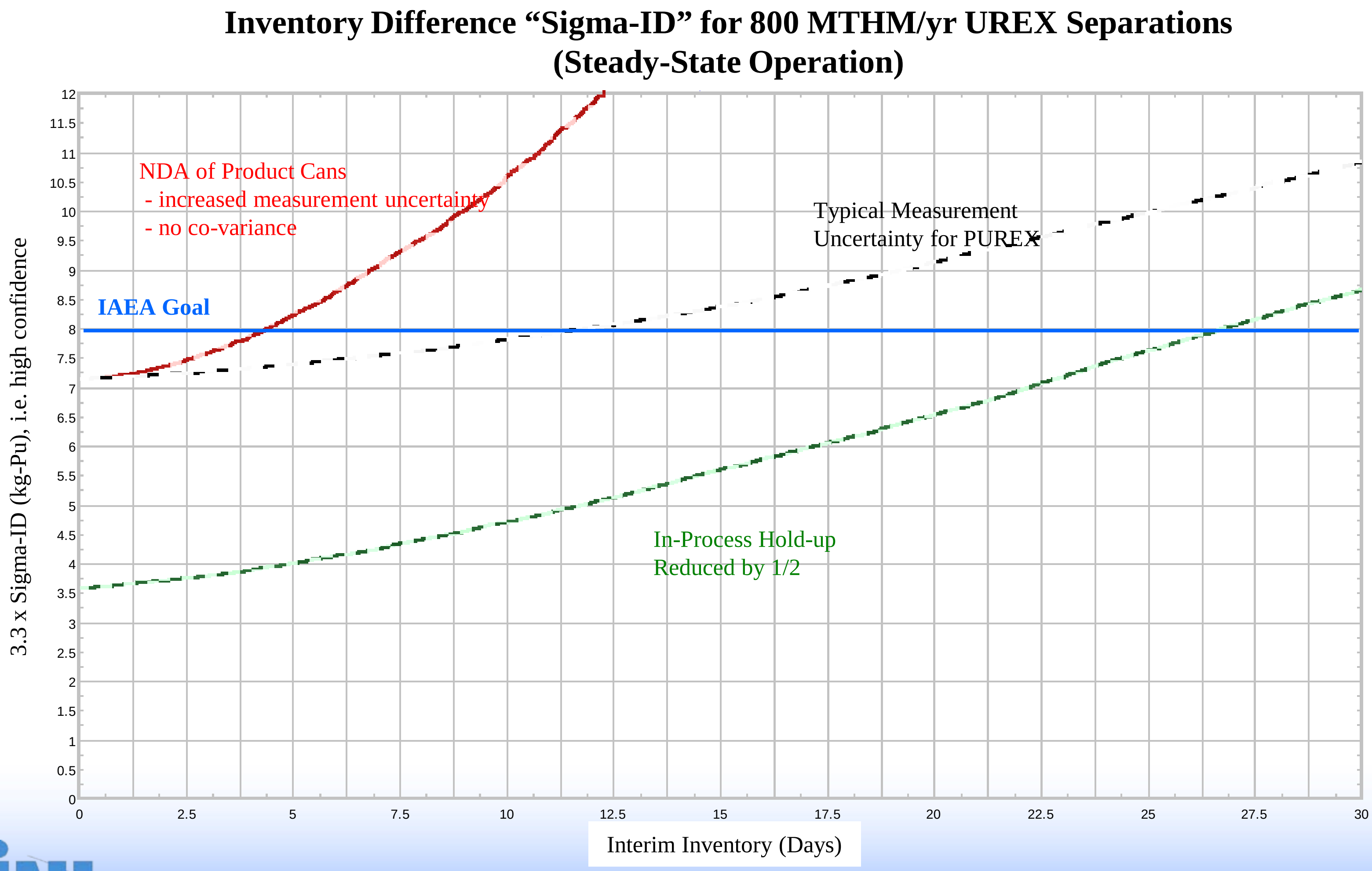


iPCAS (US Support Program)



Installed in
RRP
March 2004

Advanced Safeguards: Cost Reduction Example (Reduced Number of Inventory Periods)



Other Thoughts: IAEA Safeguards

- **Unattended Monitoring Systems are at the forefront of IAEA safeguards at declared facilities.**
- **The ability to draw definitive safeguard conclusions in complex facilities is a great challenge.**
- **Over reliance on this technology does raise a concern about an inspector's facility specific knowledge.**
- **IAEA faces far greater challenges then DOE/NNSA Safeguards**

Undeclared Facilities - S&O

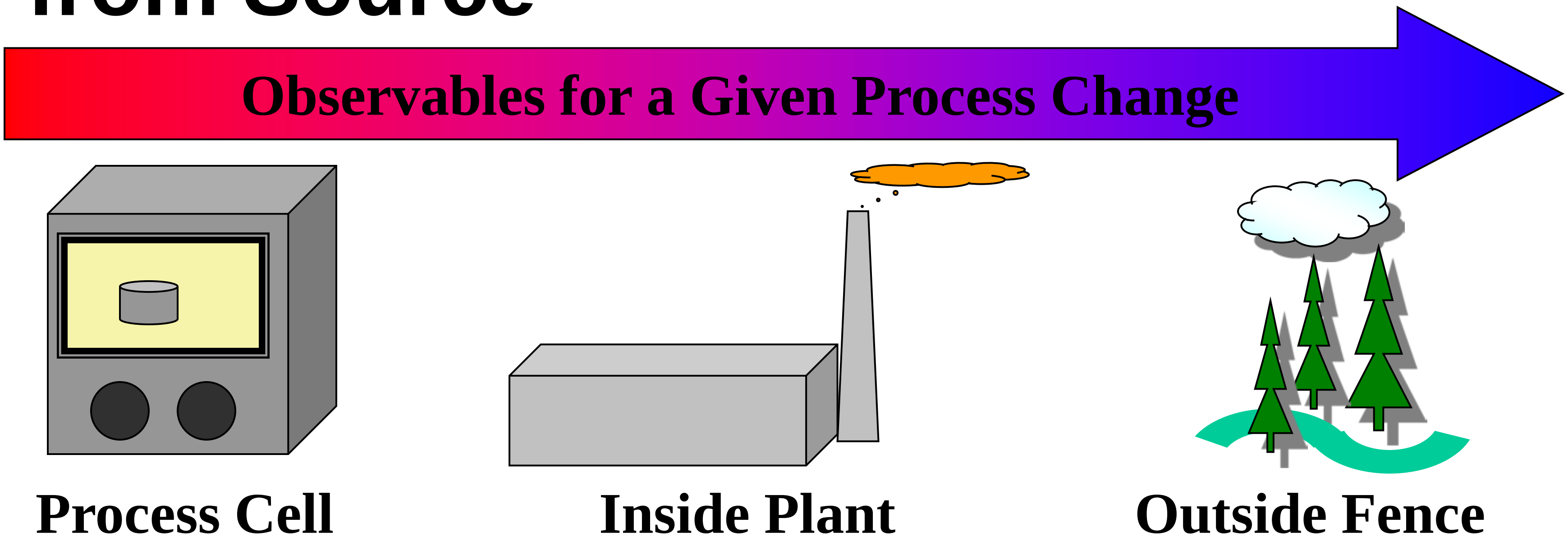
- **1997 INFCIRC 540, the IAEA task: Providing credible assurance of the absence of undeclared nuclear activities in a State.**

This is unequivocally the greatest challenge to the IAEA.

Definitions

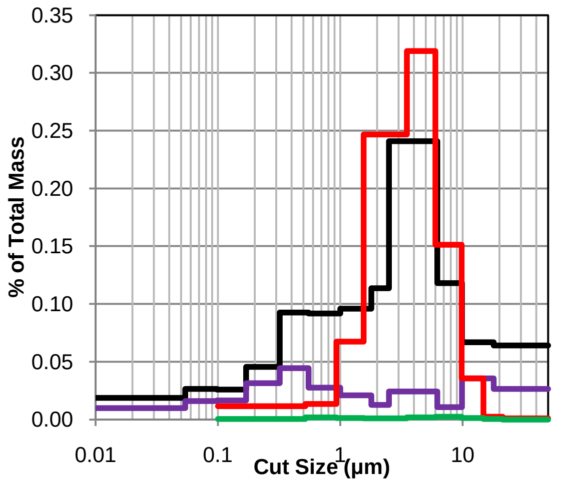
- **Signatures: An identifying characteristic or mark of one or more physical characteristics associated with a proliferant process or activity. Examples: acoustic signal, chemical.**
- **Observables: A physically measurable phenomenon, which can be observed, generated by an object of interest that conveys information about the object's properties. Examples: particles, waves, chemicals, effluent, electromagnetic signal.**

Observables Change with Distance from Source



- Processes Effecting the Observable
  - Gravimetric Settling
  - Filtration
  - Conglomeration
  - Electrostatic forces

Sampling Process



Environmental Sampling

Current primary in-field tool used by the IAEA in support of INFCIRC 540

- **Swipe sampling kits**
- **Samples sent to the IAEA Safeguards Analytical Lab (SAL) in Seibersdorf for analysis (NWAL)**
  - **Powerful destructive analysis tools are applied**
- **Timeliness is an issue, this impacts an inspector's effectiveness in the field**
- ***Best transparency for a State would be unattended environmental monitoring***

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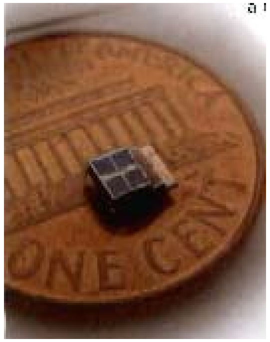
Next Decade: Futures Toolkit

- Robust safeguards technical infrastructure: people, facilities, nuclear and non-nuclear materials, and stable/flexible funding
- Program should not be limited by
  - Current IAEA inspection regimes
  - Current safeguards concepts
  - Current treaty limitations



Solar cell, Battery and 1 ARM Cortex-M3 processor microprocessor. Uses less than 1 nanowatt

- Examples
  - Nano-Tags-chemically bind with elements of interest
  - Nano-Markers-unique component in a nuclear material flow stream
  - Nano-Sensors-nuclear & non-nuclear observables, powered by environment, wireless and self organizing, inexpensive

Questions?