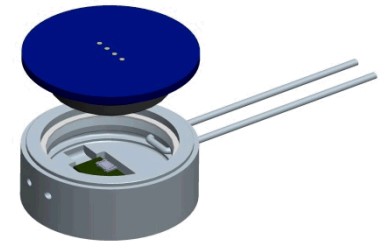


Exceptional service in the national interest



Material Sealing and Monitoring

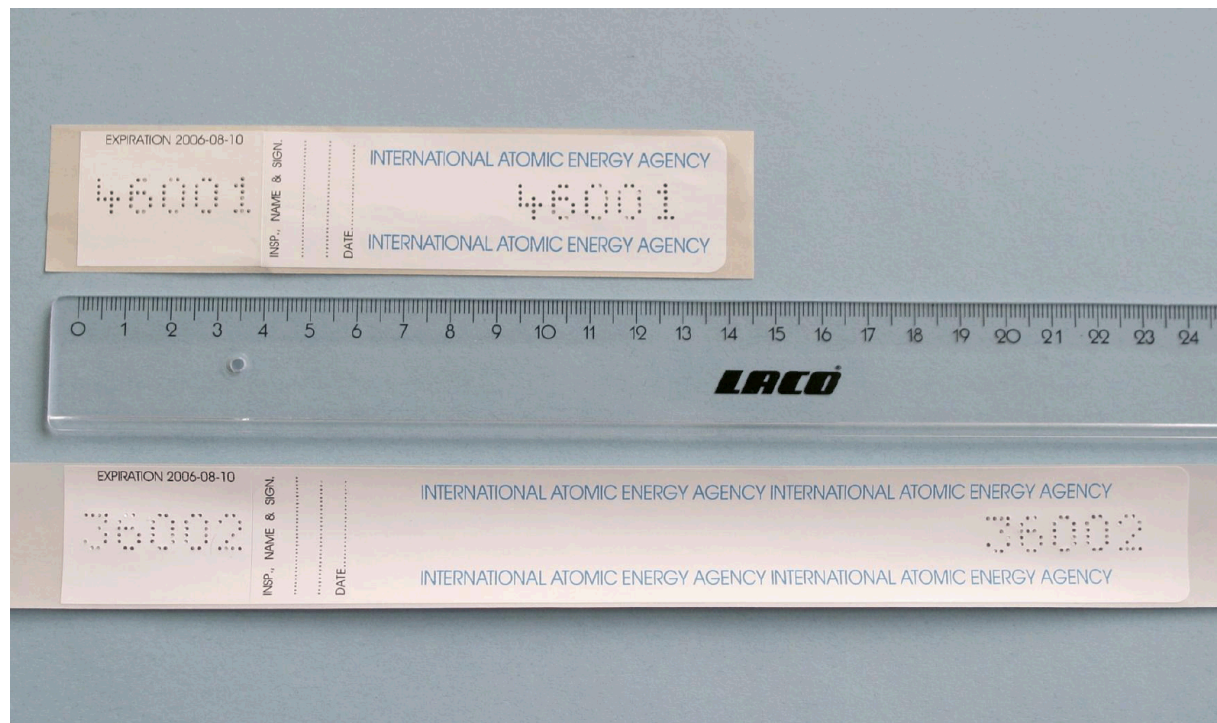
Ross Hymel

Sandia National Laboratories

Nuclear Monitoring & Transparency

What is a Seal?

- Tamper indicating device designed to leave non-erasable, unambiguous evidence of entry or altering
 - Seals are not locks!



Why Seal?

- To provide an indication of item alteration
- To provide credible assurance to the international community that nuclear materials and other items are not diverted or misused
- To provide credible assurance that all nuclear materials remain in peaceful activities
- To support the efforts of the international community in connection with nuclear disarmament

Desired Seal Attributes

- Unattended operation – may be left for months to years!
 - Reliable
 - Able to withstand environmental conditions
- Authenticable
- Tamper resistance
- Remote retrieval of data
- Internal storage for events and status
- Reusable
- Independence from facility operator's power supply

Types of Seals

- Passive - do not require an energy source while attached nor receive energy from seal interrogation
 - Adhesive seal
 - Metal cup seal
 - Cobra seal
- Active - require power for the seal to operate
 - Remotely Monitored Sealing Array (RMSA)
- Around 2006, IAEA fielded ~30,000 passive seals per year and ~2,000 active seals

Passive Seals

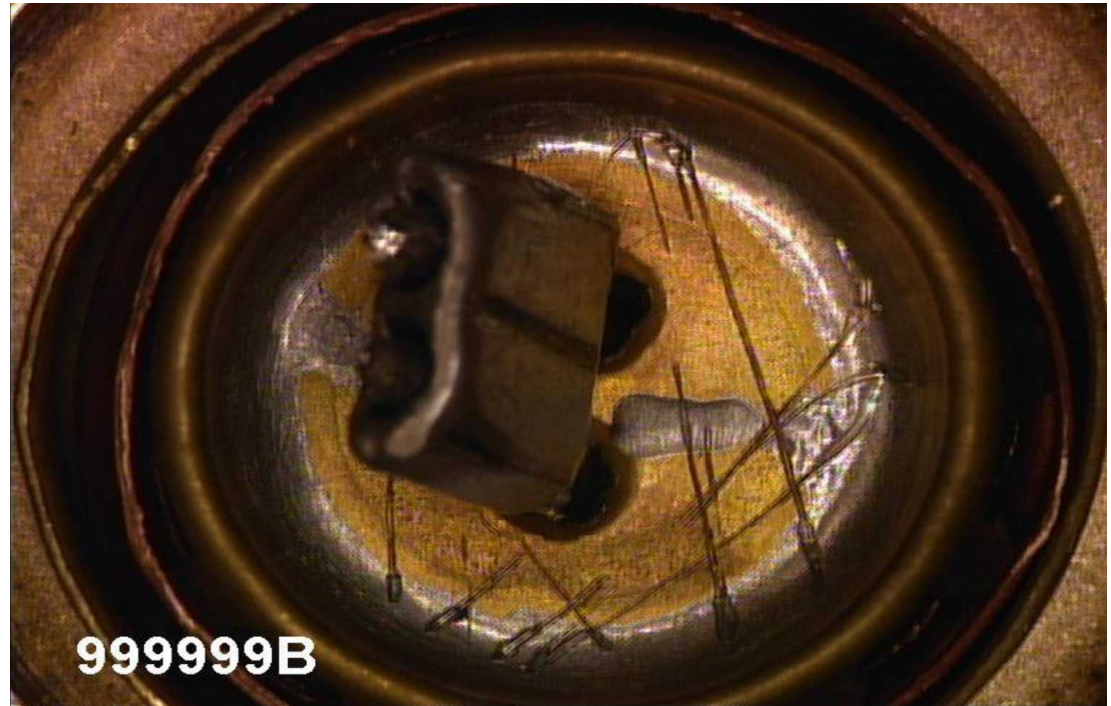
- Advantages:
 - Typically inexpensive to apply and interrogate
- Disadvantages:
 - May require forensics to determine seal's integrity
 - Do not provide timely detection
 - Require proximity reading and inspection (exposure issues)

Metal Cup Seal

- Conventional loop seal
 - Wire ends are secured inside seal body
- Simple, passive, single use
- Survivable in extreme conditions and physically robust
- Small size and lightweight
- Verification labor intensive (not in situ)
 - Done at IAEA HQ
 - Image random scratches on inside surface to verify its unique identity
 - Laser surface authentication (LSA) possible on top surface for identity verification
- IAEA uses about 18,000 per year



Metal Seal Security

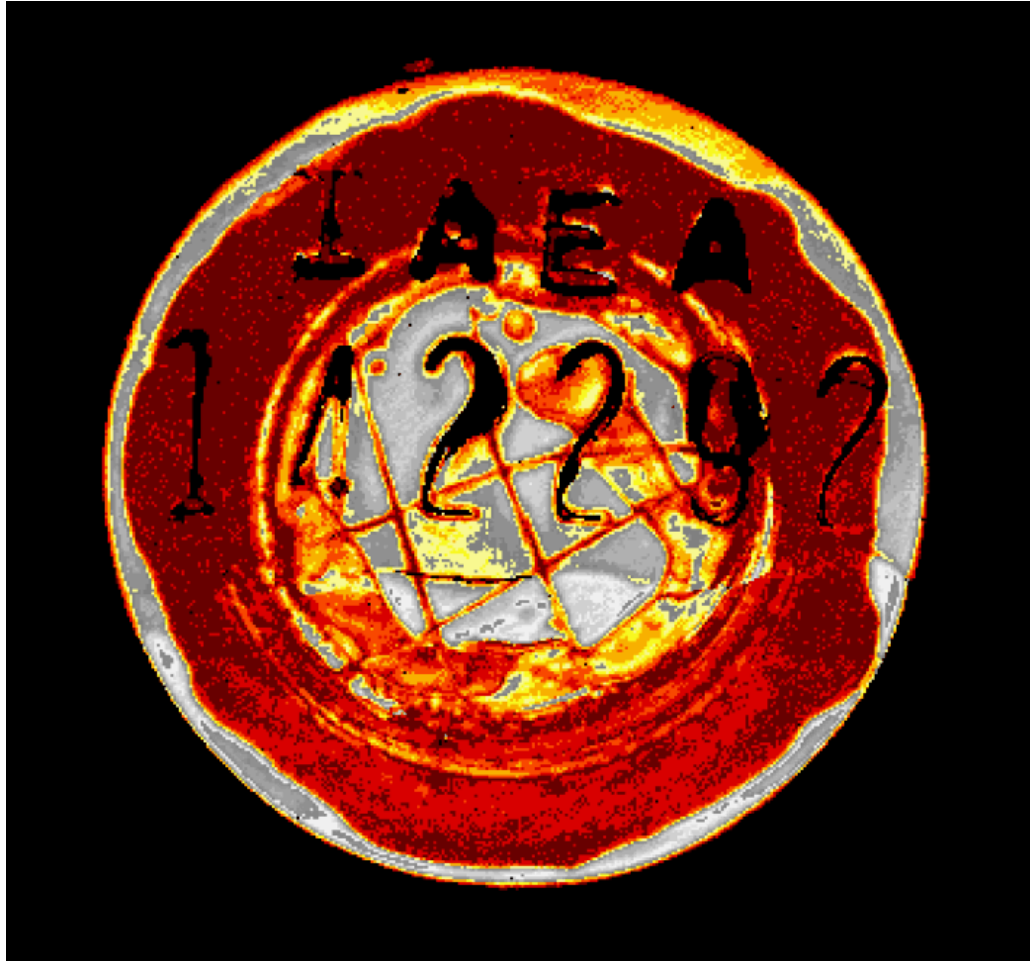


999999B

Sample Signature Element

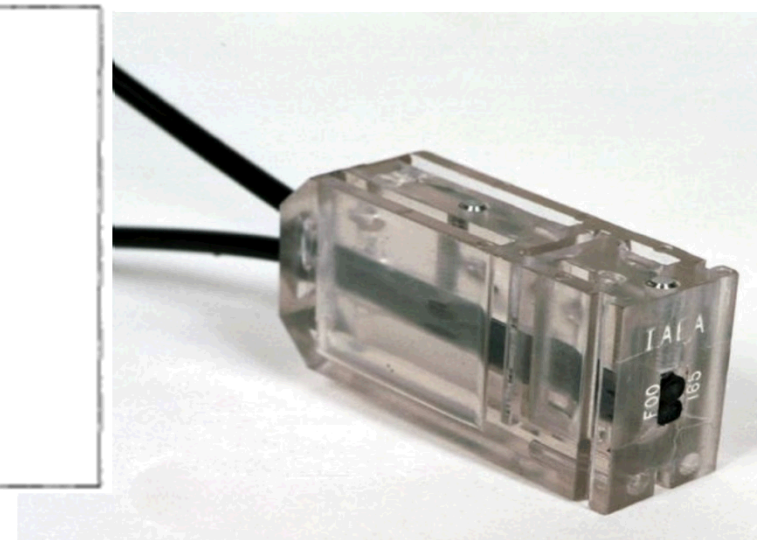
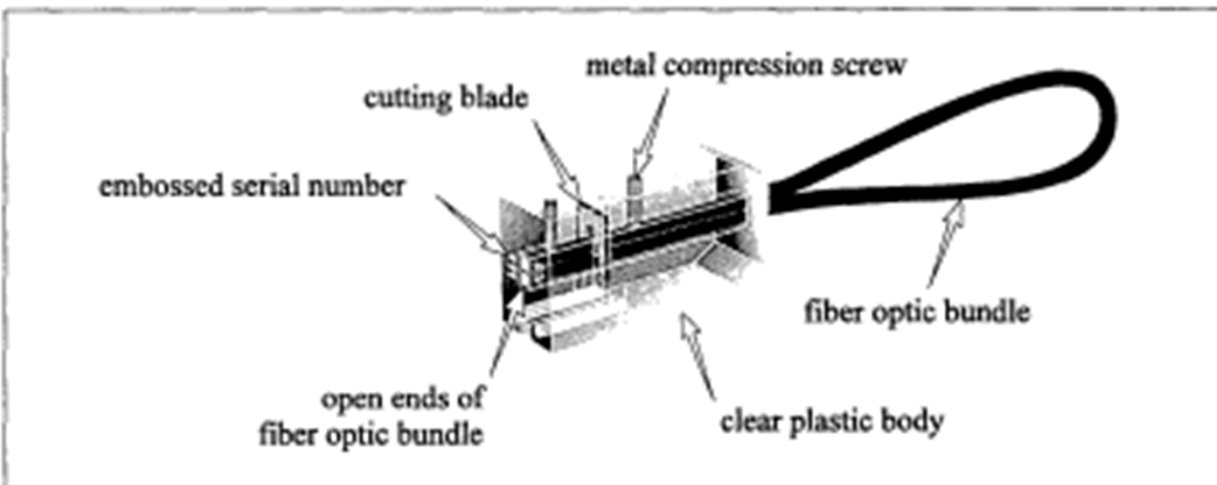


Surface Imaging



Cobra Seal

- Fiber optic loop seal
 - More expensive than conventional loop seals
 - More time intensive to operate/install
- Insertion of a blade into fiber optic bundle cuts into and impedes light flow through arbitrary strands

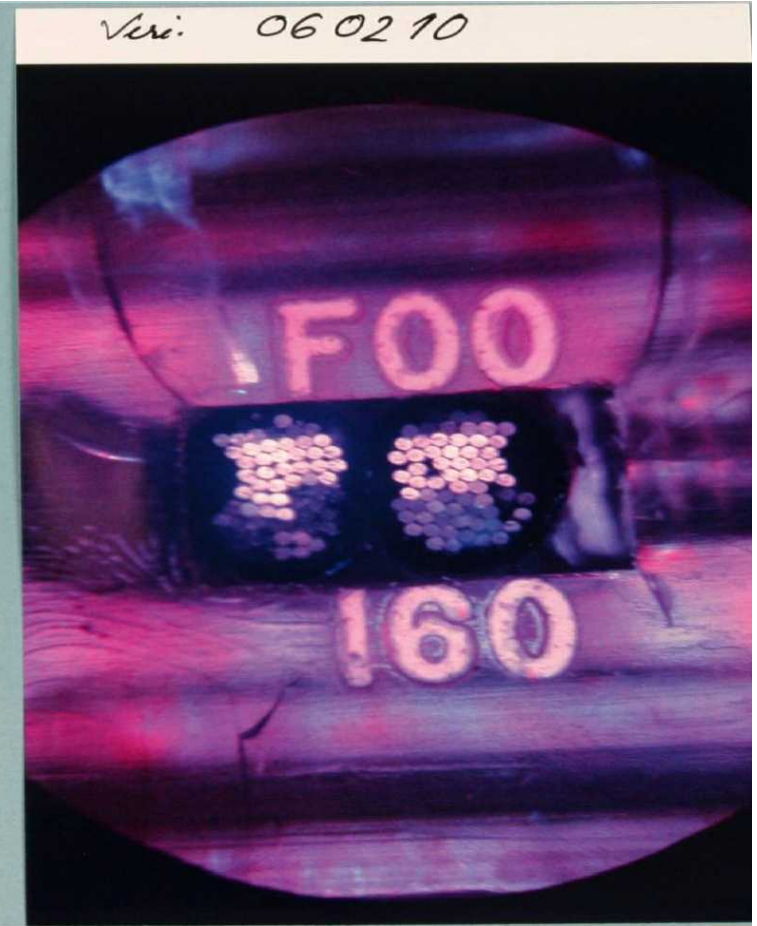
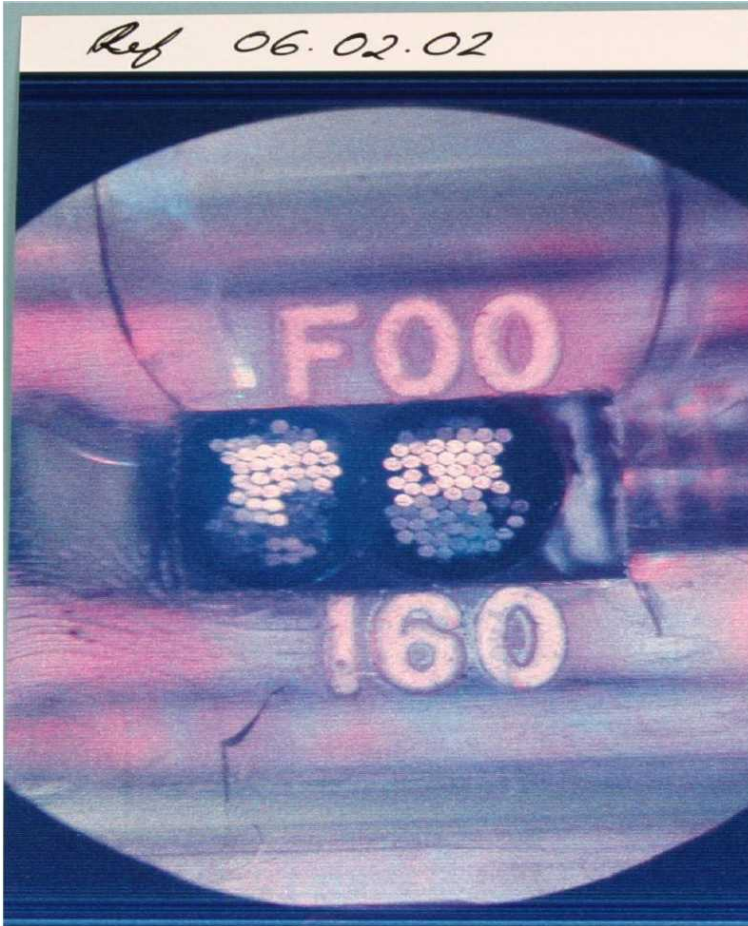


Cobra Seal

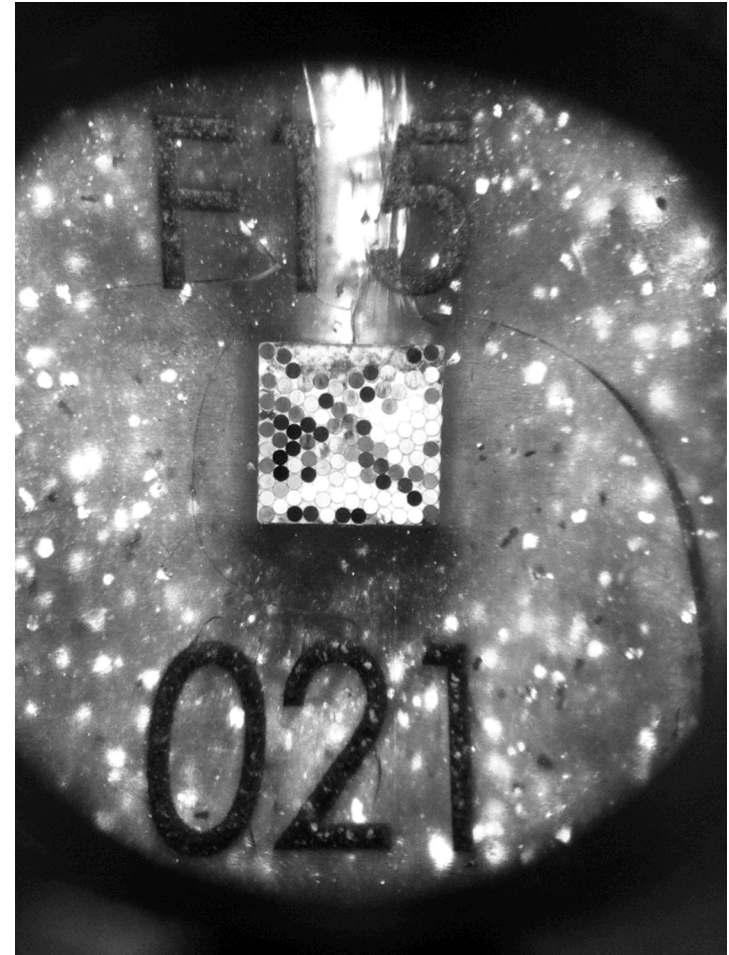
- Digital images are used to record and verify distinctive characteristics of light through cut fiber strands
- Performs well against most environmental factors
 - Radiation sensitivity
- Durable and easy to use
- Verification of seal identity and integrity in situ
- Small and lightweight
- IAEA uses about 1,200 per year



Cobra Seal Signature



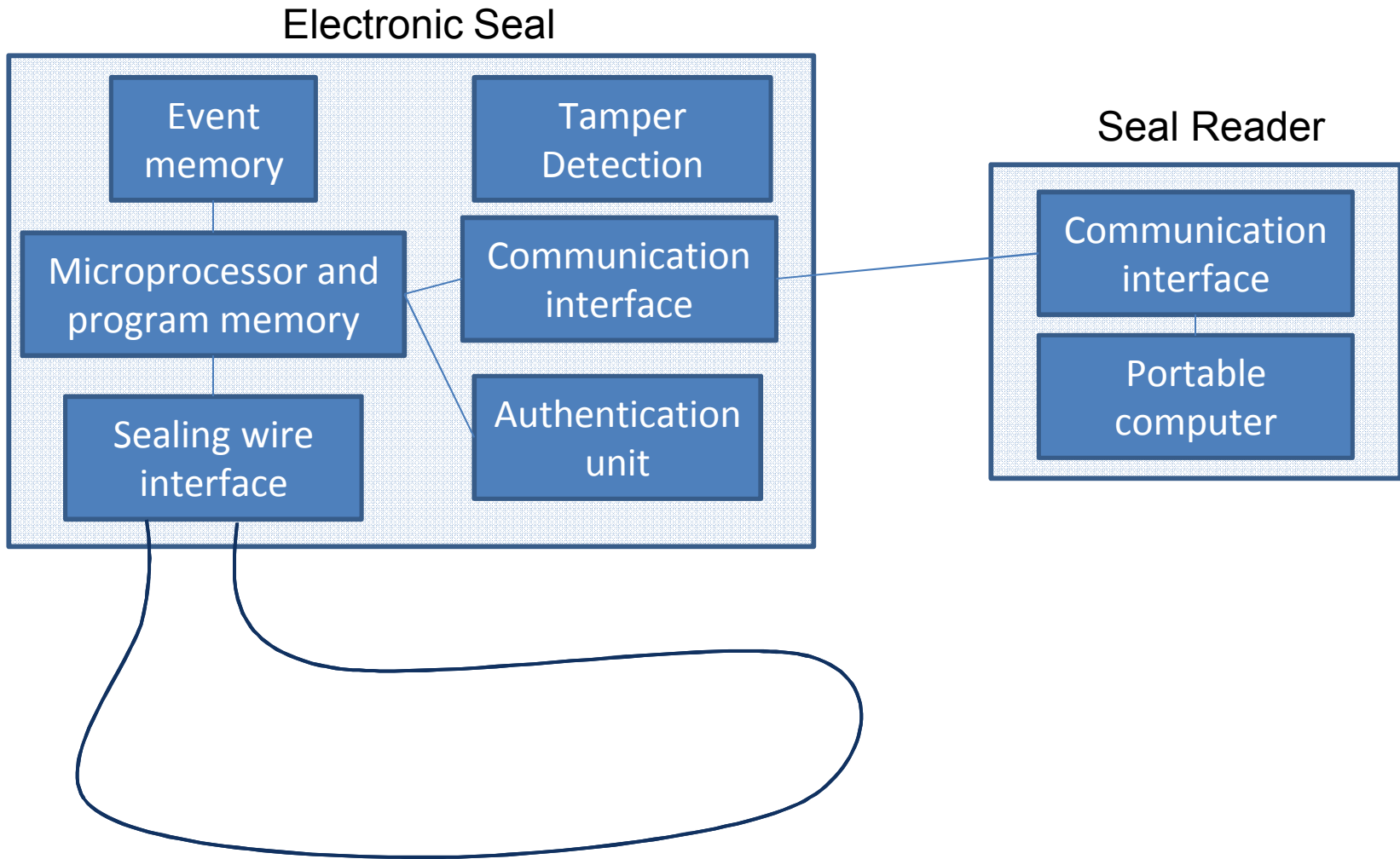
iCOBRA



Active Seals

- Disadvantages
 - Typically higher cost than passive devices
 - Requires a system for interrogation
 - Periodic maintenance may be required
- Advantages
 - Timely detection
 - Reduced personnel exposure
 - Increases the complexity of adversarial attack through sophistication
 - Typically provides a broader suite of sensing

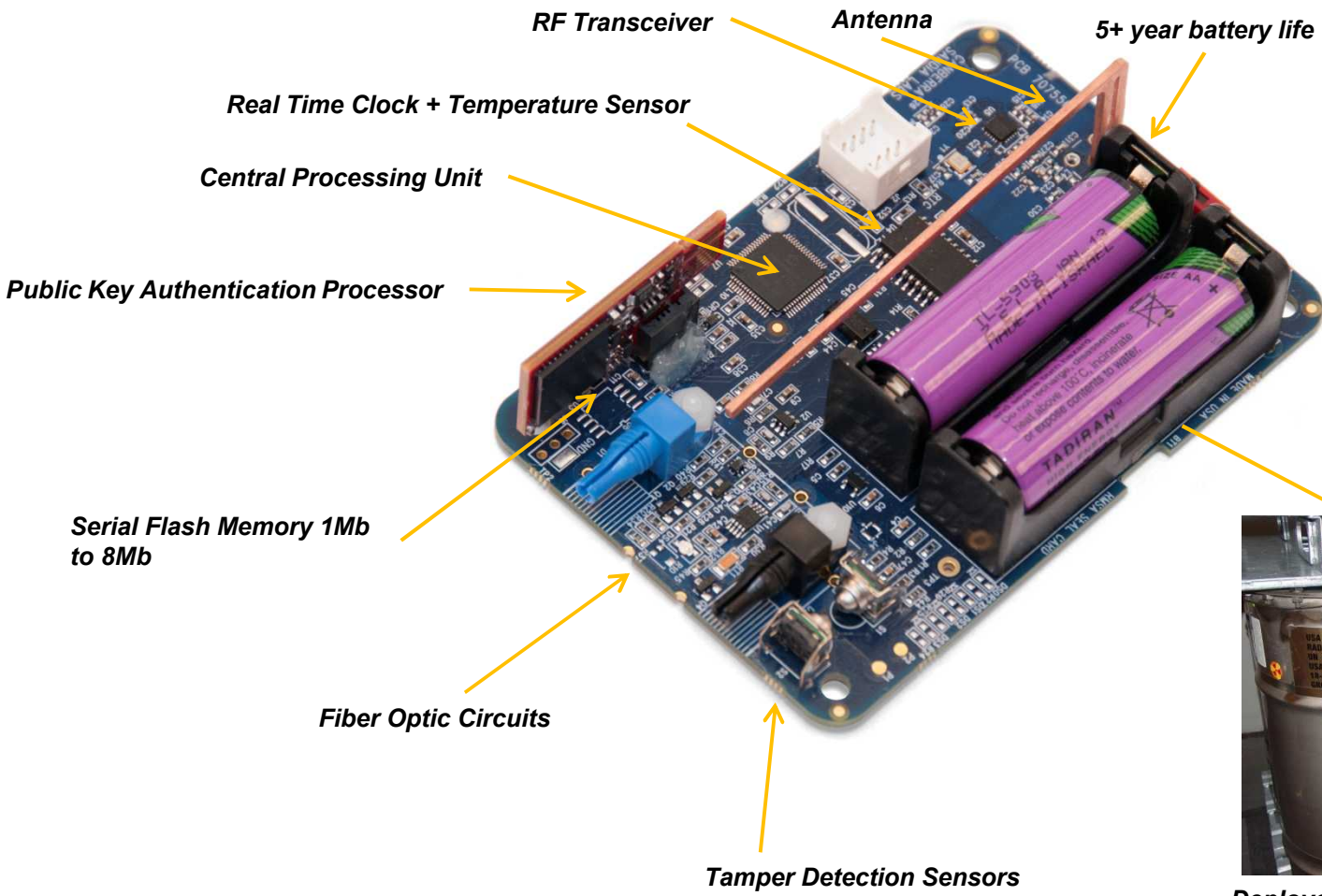
General Electronic Seal System Components



Active Seal Requirements

- Low cost
- -40 to +85° C ambient operation
- Low-power RF (6LoWPAN)
- Security (AES 128-bit encryption)
- Authentication (ECDSA 233-bit) } NIST approved cryptography
- Long battery life (5+ years)
- Store messages locally
- Real-time clock
- Tamper detection
- Fiber optic loop (up to 50 meters)
- Remote data collection

Remotely Monitored Sealing Array (RMSA)



Deployed RF fiber optic seal security sensor on nuclear material containers

RMSA

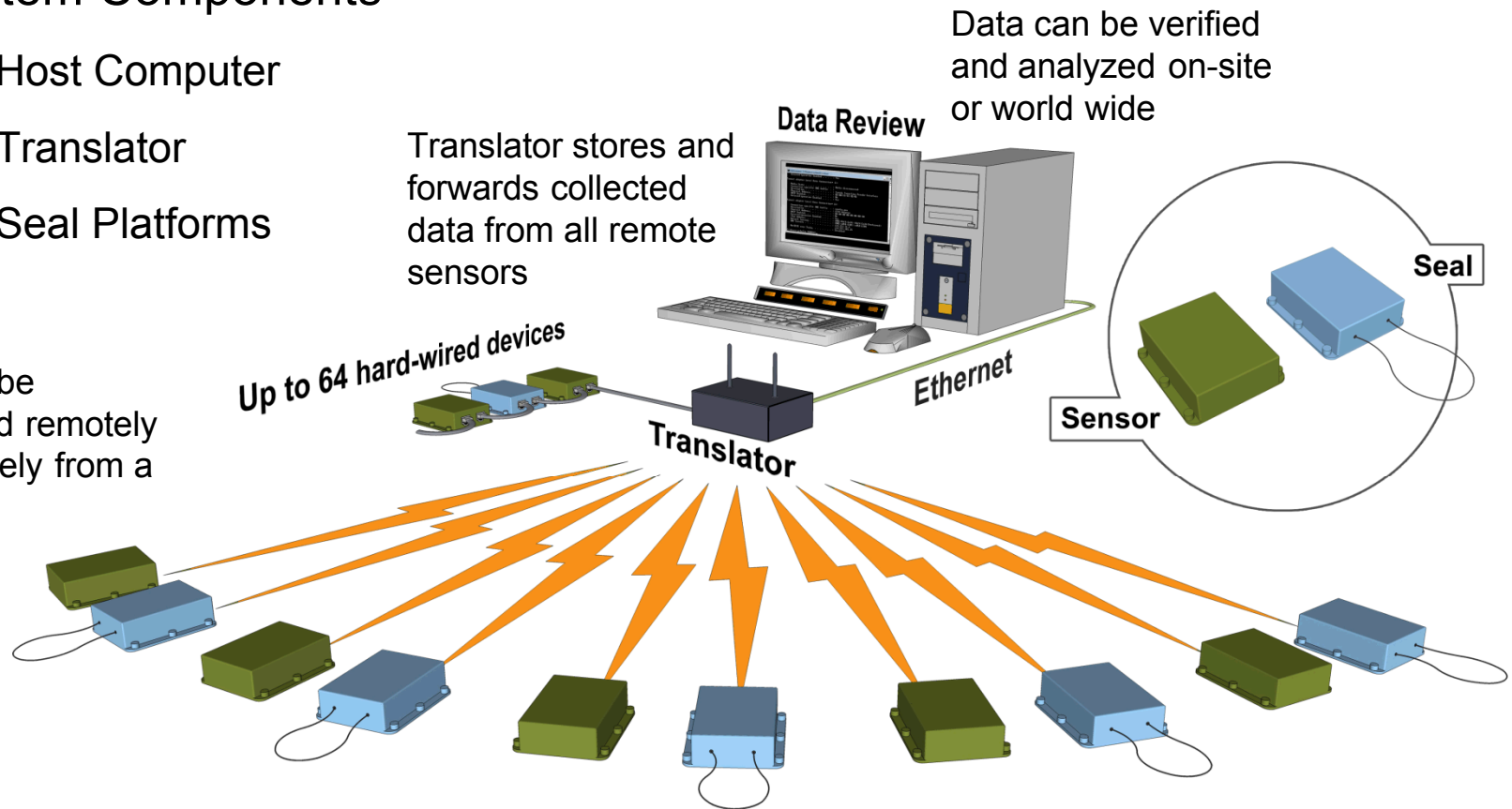


System Configuration

► System Components

- ◆ Host Computer
- ◆ Translator
- ◆ Seal Platforms

Data can be transferred remotely and securely from a translator



Translator stores and forwards collected data from all remote sensors

Data can be verified and analyzed on-site or world wide

Up to 64 hard-wired devices

Ethernet

Translator

Sensor

Seal

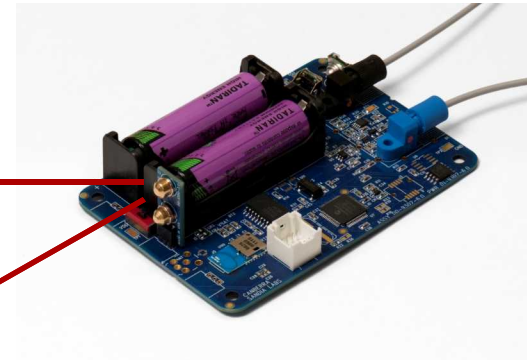
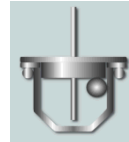
Large numbers of RF connections

Remote sensors store and forward via RF or hardware to local translator

Derivatives



Authenticated Switch



Environmental Monitoring
Security Seal (EMSEC)



Tiny Gamma-ray Spectrometer (TGS)