

QSA GLOBAL.

Quality and Safety Assurance (QSA)

Products For Medical Therapy, Petrochemicals, Nuclear Power and Process Industries

Radioisotopes and Alternatives – an Industry Perspective
on Well Logging

RADIATION SOURCE APPLICATIONS

	ANNUAL ACTIVITY	ANNUAL UNITS	ANNUAL SALES Pre C19
• Radiation Processing (COMMODITIES) Co-60	MCi's /y	100's units /y	\$10's M/y
• Fire Prevention (SAFETY SECTOR) Am-241	10s Ci's /y)	10M's/y	\$100's M/
• Gas Detection (SECURITY SECTOR) Ni-63, H-3	10's Ci's /y	1000's /y	\$1's M/y
• Effluent Monitoring (ENVIRONMENTAL SECTOR) C-14, H-3	10's Ci's /y	1000's /y	\$1's M/y
• Instrument Calibration (HEALTHCARE & INDUSTRY SECTORS) Co-57, Ge-68, Na-22, + many more	Ci's /y	10k's /y	\$10's M/y
• Medical Therapy (HEALTHCARE SECTOR) Ir-192, I-125, Pd-103, Y-90, P-32, Ra-223, Ac-225 + many more	100k Ci's /y	100,000's /y	\$100's M/y
• Nuclear Power (ENERGY SECTOR) Cf-252, SbBe	Ci's /y	100's units /y	\$10's M/y
• Gauging and Control (PROCESS INDUSTRY SECTOR) Co-60, Cs-137, Sr-90, Kr-85, Pm-147, Am-241, AmBe, Cf-252 +	1000's Ci's /y	10,000's /y	\$100's M/y
• Gamma Radiography (SAFETY SECTOR) Co-60, Ir-192, Se-75, Yb-169	10's MCi's /y	10,000's /y	\$100's M/y
• Oil Exploration, Well Logging (ENERGY SECTOR) Cs-137, Am-241/Be, Cf-252, Ir-192, Kr-85, H-3, KUTh	1,000's Ci's /y	100's /y	\$10's M/y
TOTAL			\$Bns/y

Gamma Backscatter
Measures Formation
Density and Porosity

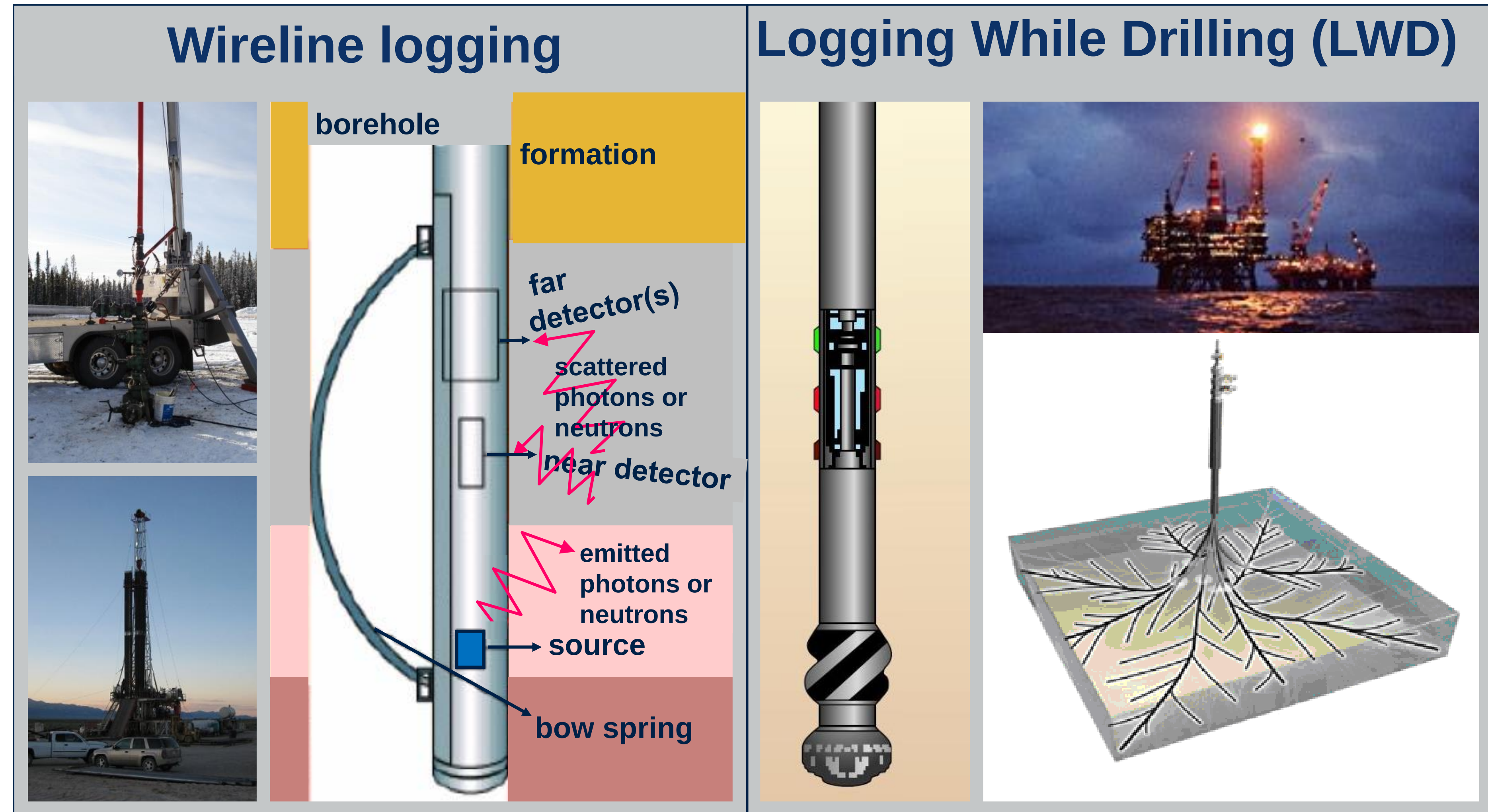
Neutron Backscatter
Measures Water and
Hydrocarbon Content
& Elemental Analysis

Well Logging Verifies
Commercial Viability
Before Developing a
Well for Production

High Accuracy is
Needed to Mitigate
Financial Risks

OIL AND GAS EXPLORATION – WELL LOGGING

Sealed Radiation Sources Using Cs-137 and AmBe



Downhole: High Pressure, Shock, Vibration, Corrosion, Temperature

Cs-137

Half Life 30.1 years

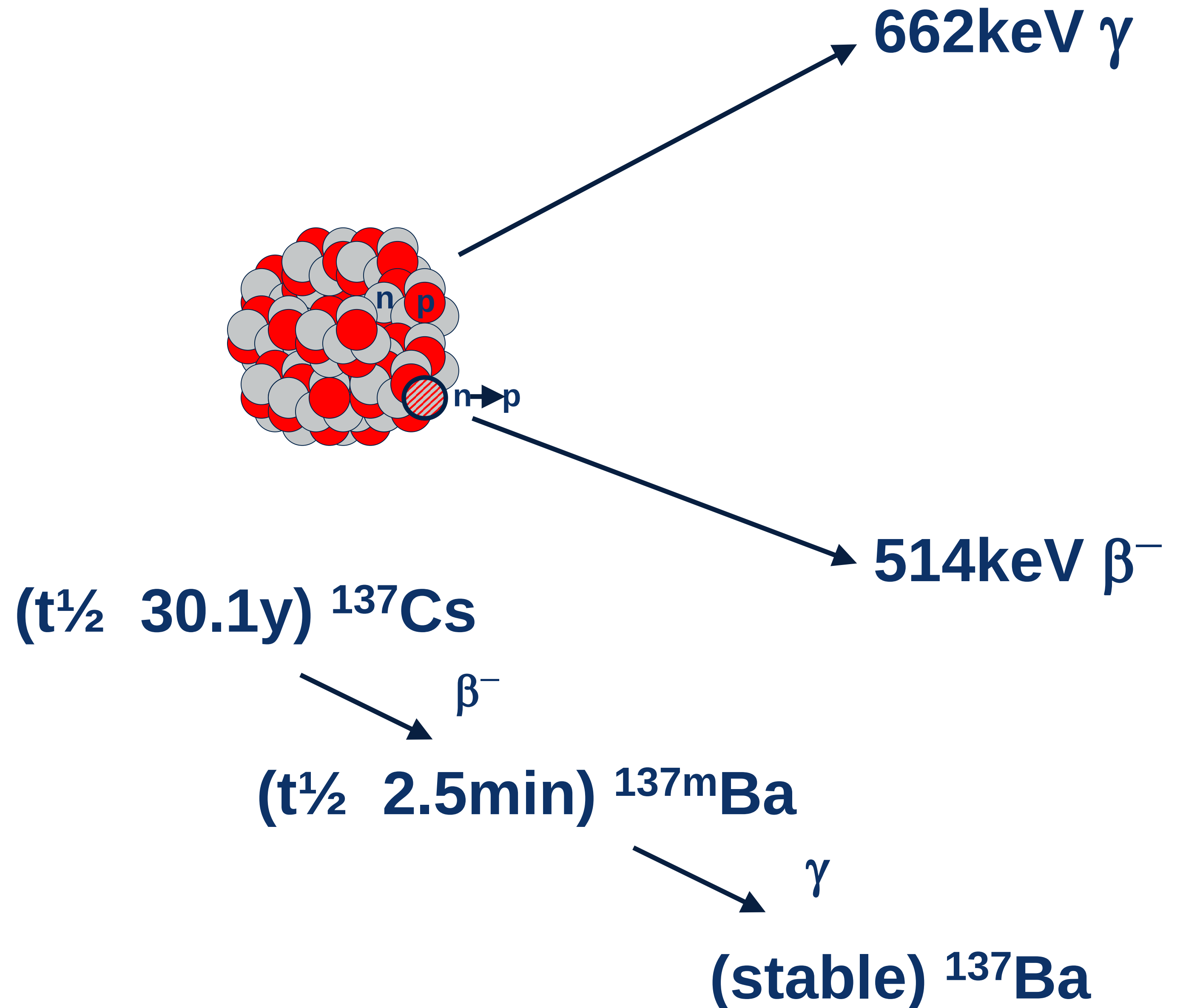
Emissions

514keV beta particle

662keV gamma ray

1 keV = 1000 electron volts

A keV is the energy of an electron after it has been accelerated from rest through a voltage of 1000 volts



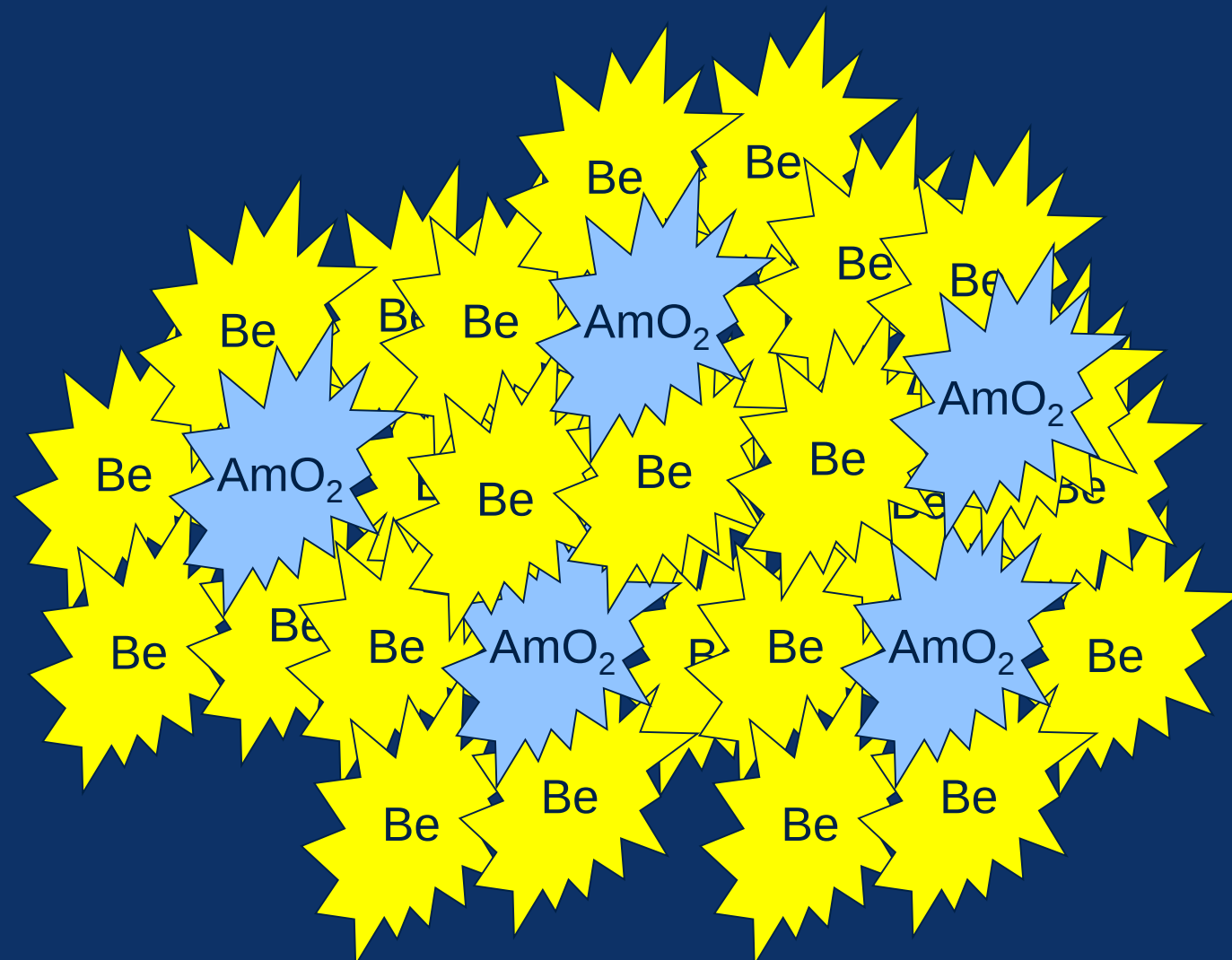
Am-241 + Be (AmBe)

Half Life 432.2 years

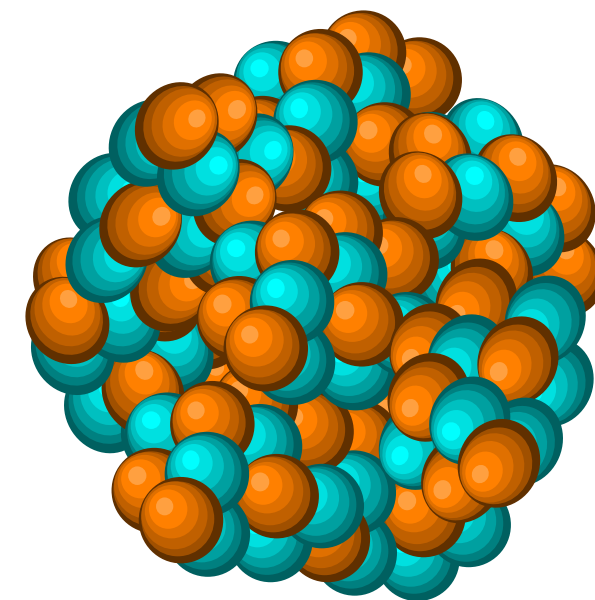
Emissions

5.5MeV alpha (85%)

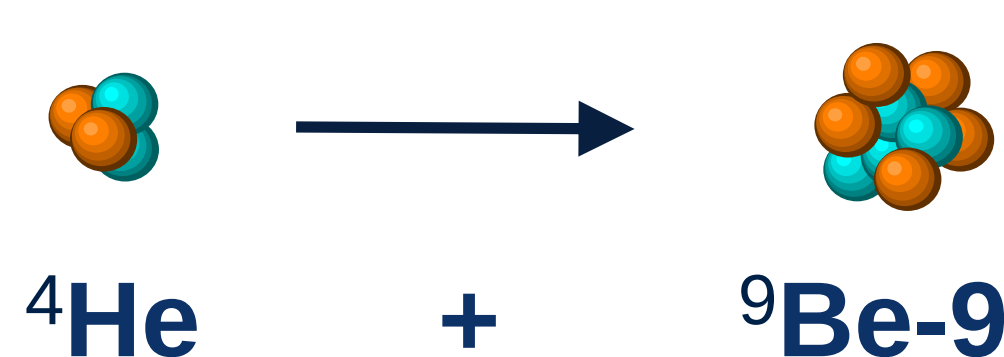
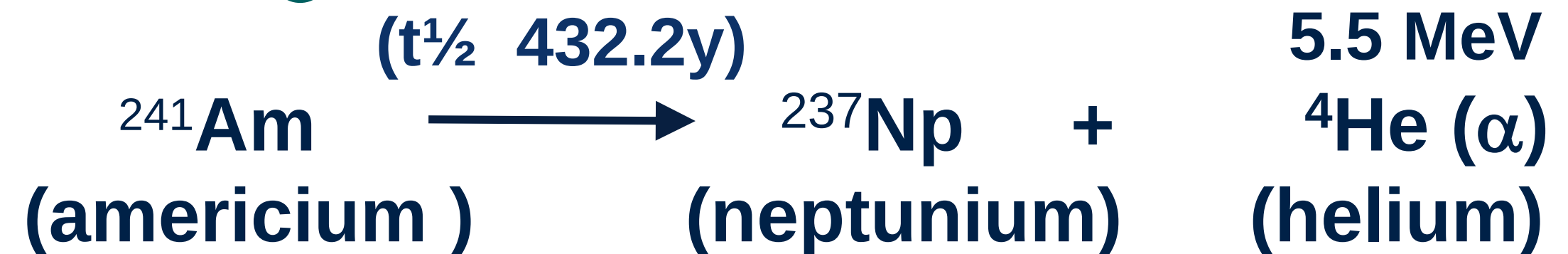
60keV gamma (36%)



95 protons
146 neutrons

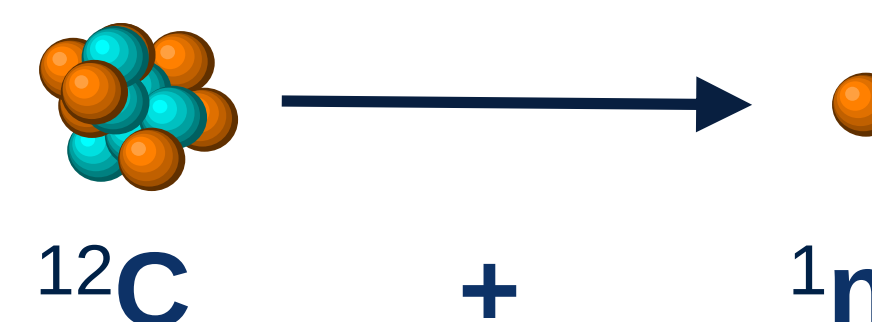


Americium-241
Decays by Emitting
an Alpha Particle
and 60keV gamma



An alpha particle >2.5MeV can
knock a neutron out of beryllium-9

This happens about
one in 18,000 collisions

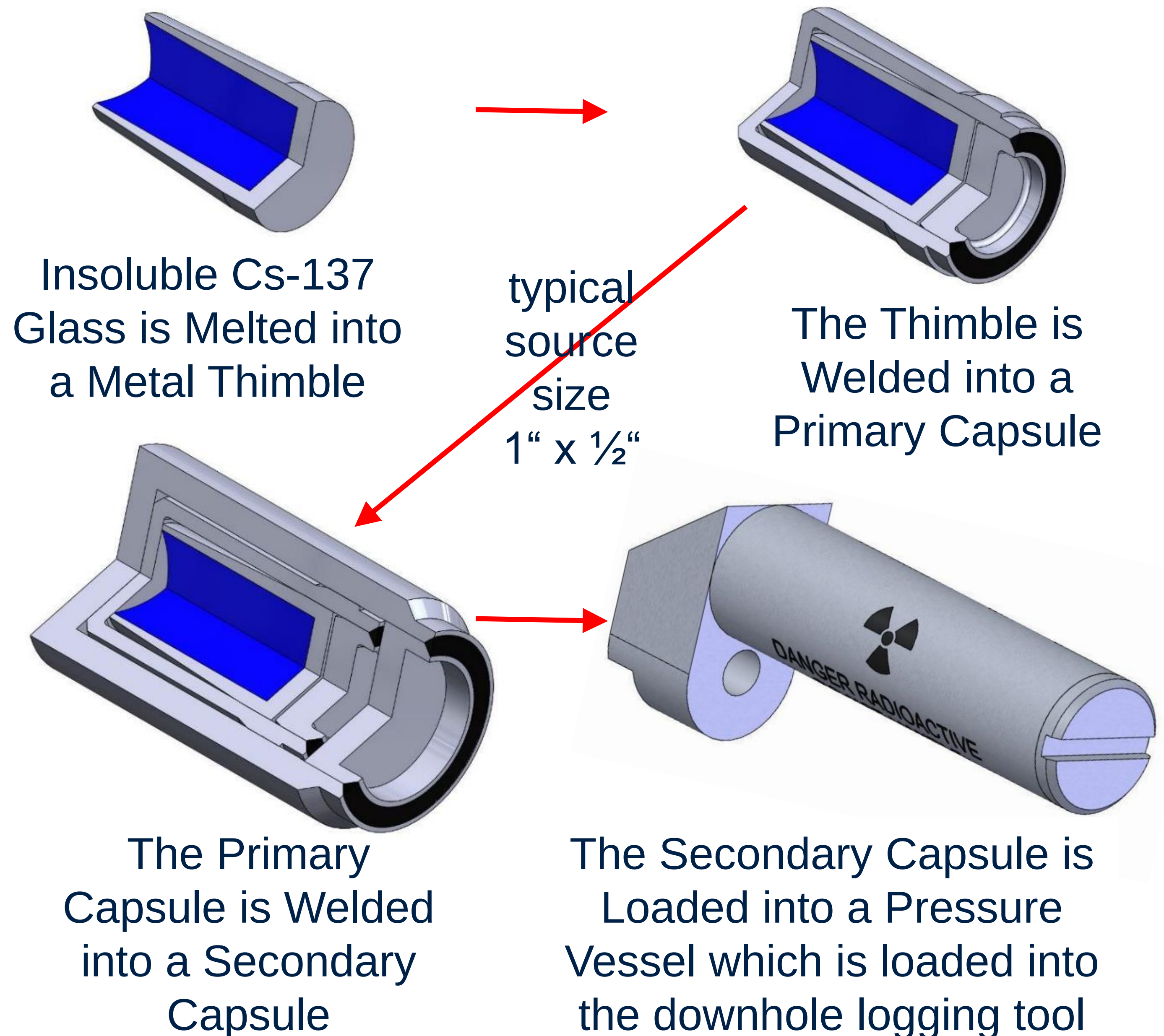


up to 11 MeV neutrons
and 4.4 MeV γ from ^{12}C

Cs-137 Gamma Source Technology

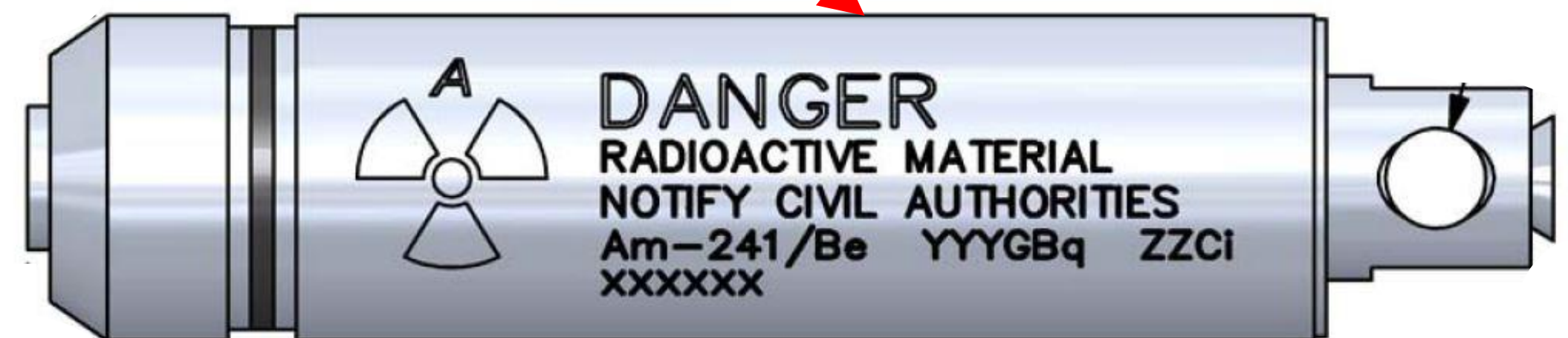
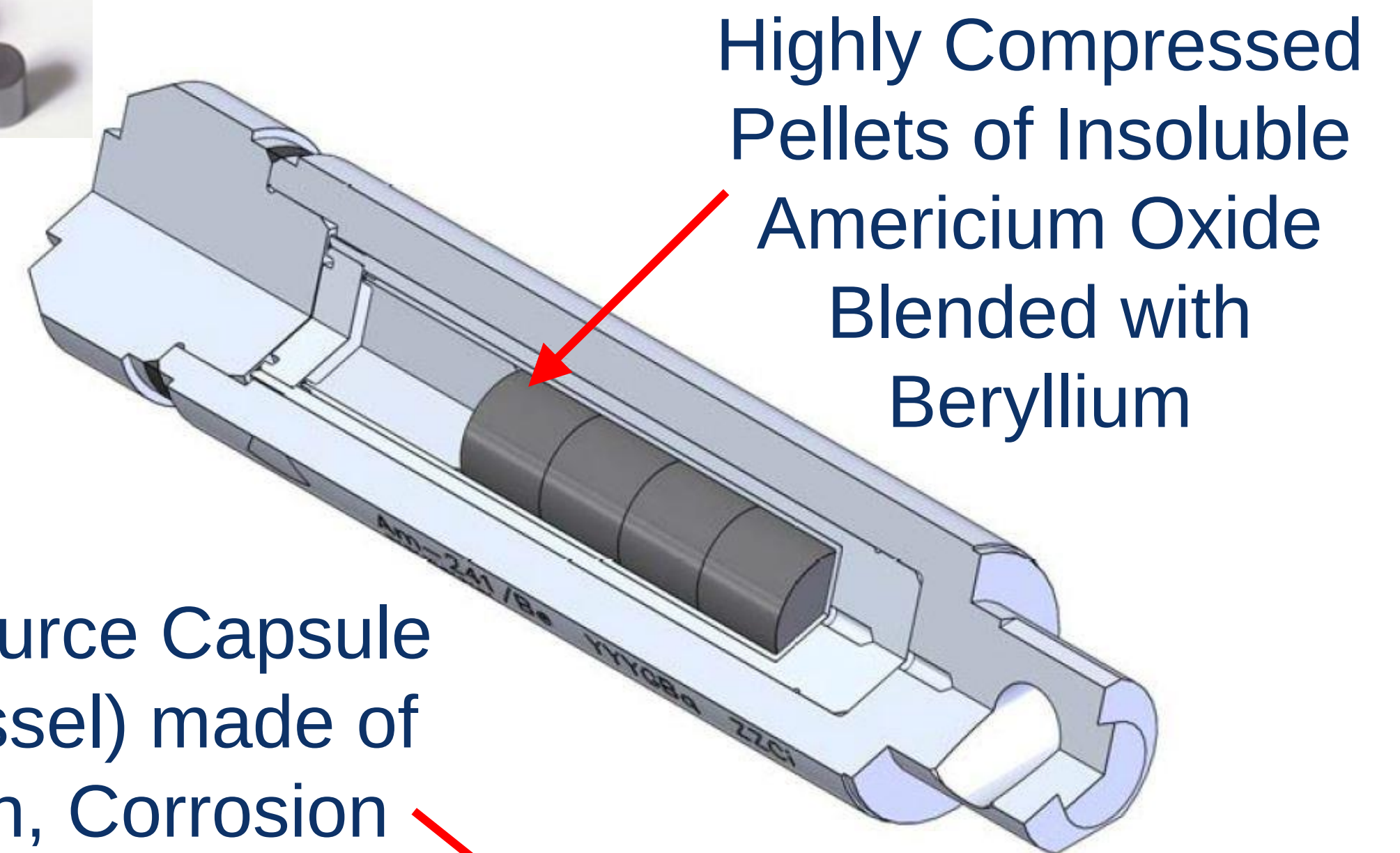
- Very Stable Emission (No Change in Emission under Continual High Shock, High Vibration, High Temperature, High Corrosion, High Pressure (60,000psi) over Working Life)
- No Radioactivity Leakage (Insoluble Material Inside does not Leach into Ground water even if a Source is Ruptured)
- Contains Refractory Oxides or Glass Ceramics
- 800°C Special Form Thermal Test
- 1200°C Petrochemical Fire Test

Double or Treble Encapsulation



AmBe Neutron Source Technology

- Very Stable Emission (No Change in Emission under Continual High Shock, High Vibration, High Temperature, High Corrosion, High Pressure (60,000psi) over Working Life)
- No Radioactivity Leakage (Insoluble Material Inside does not Leach into Ground water even if a Source is Ruptured)
- Contains Refractory Oxides or Glass Ceramics
- 800°C Special Form Thermal Test
- 1200°C Petrochemical Fire Test



Source Dimensions can typically be 1-1½ inches in Diameter and 3 to 5 inches Long

Oil Well logging Tools

What they look like

Sources are stored separately in shielded bunkers before they are loaded into tools, calibrated and then transported to field sites

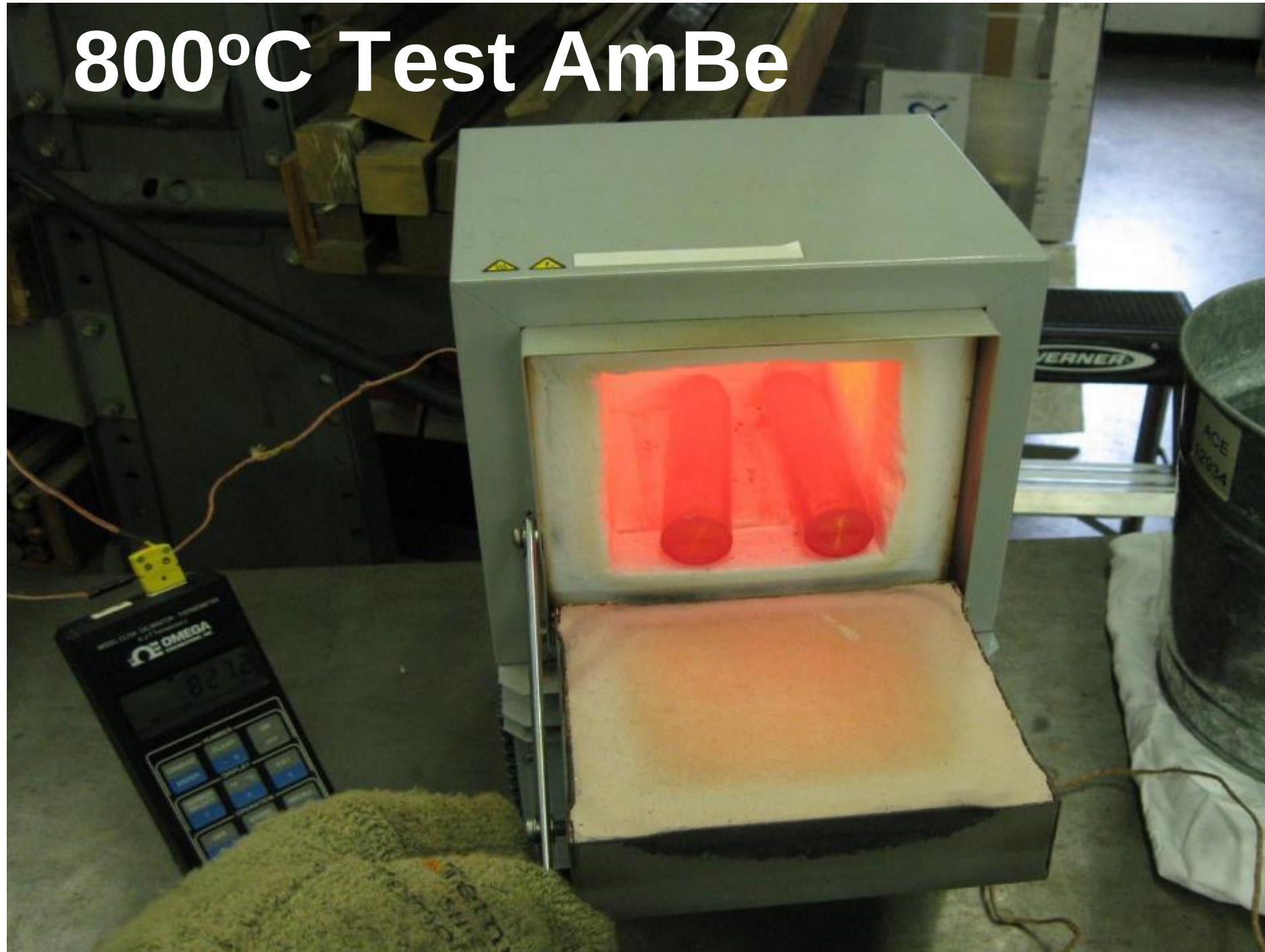


Sealed Source Manufacturing at QSA Global.

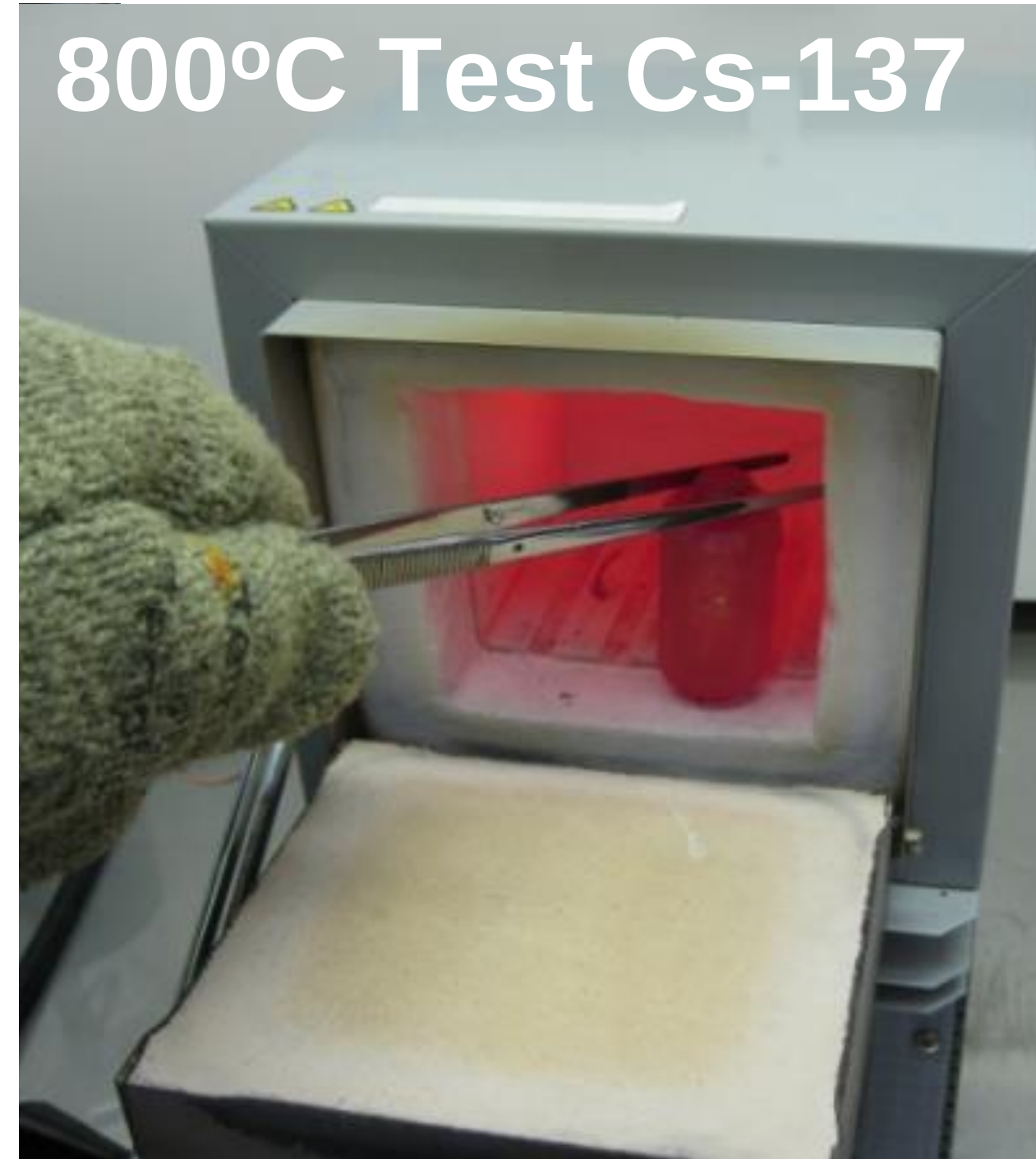


Source Durability Testing

800°C Test AmBe

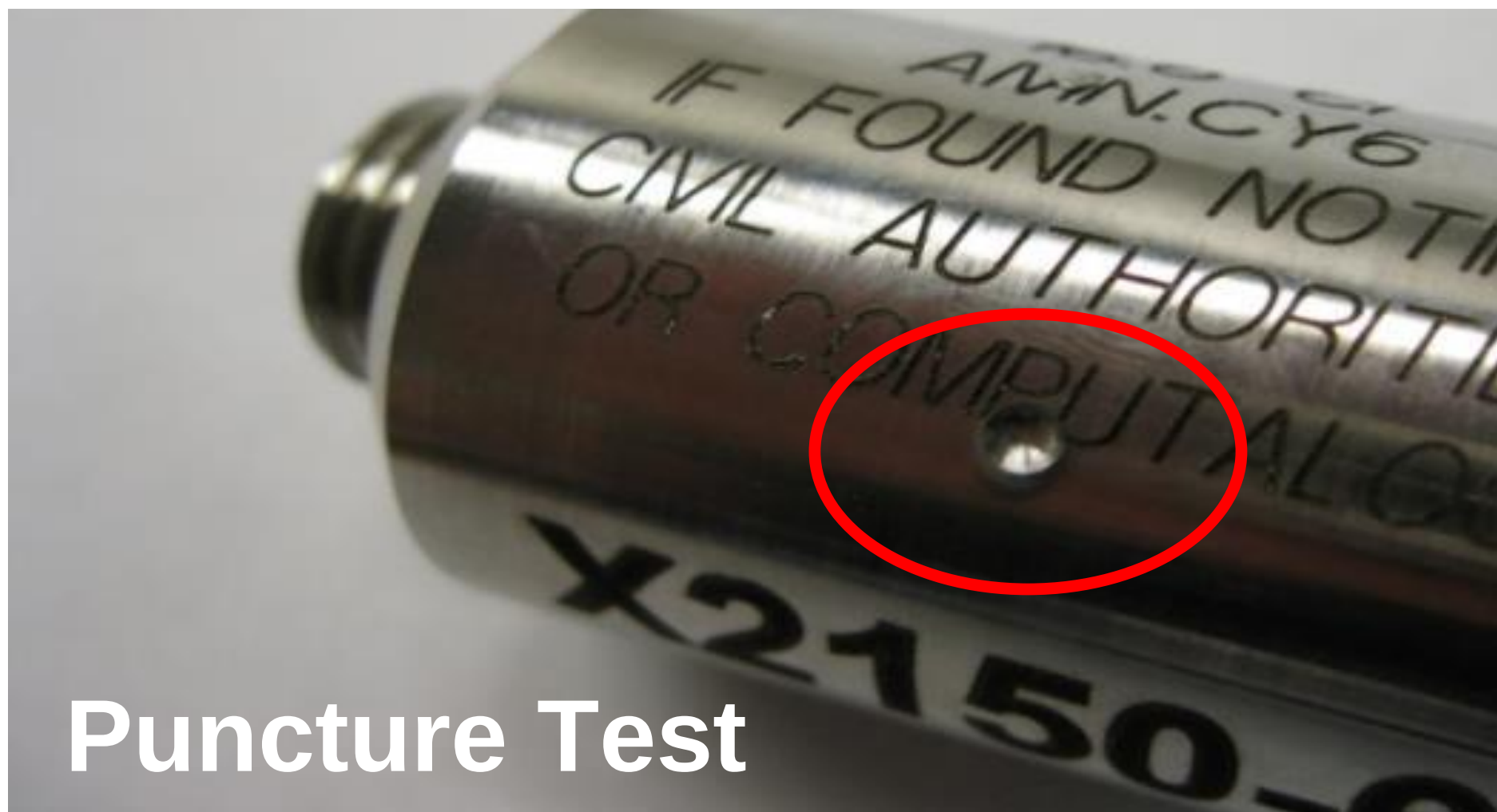


800°C Test Cs-137



Weld Quality
Impact Test

Puncture Test



Cold Water
Quench Test



**Sources are
Made Using
The Most
Durable
Materials**

Alternative Technologies

Acoustic (Seismic)

Magnetic (Nuclear Magnetic Resonance)

Miniature Linear Accelerator (Linac)

Deuterium-Tritium

Deuterium-Deuterium

Deuterium-Lithium7

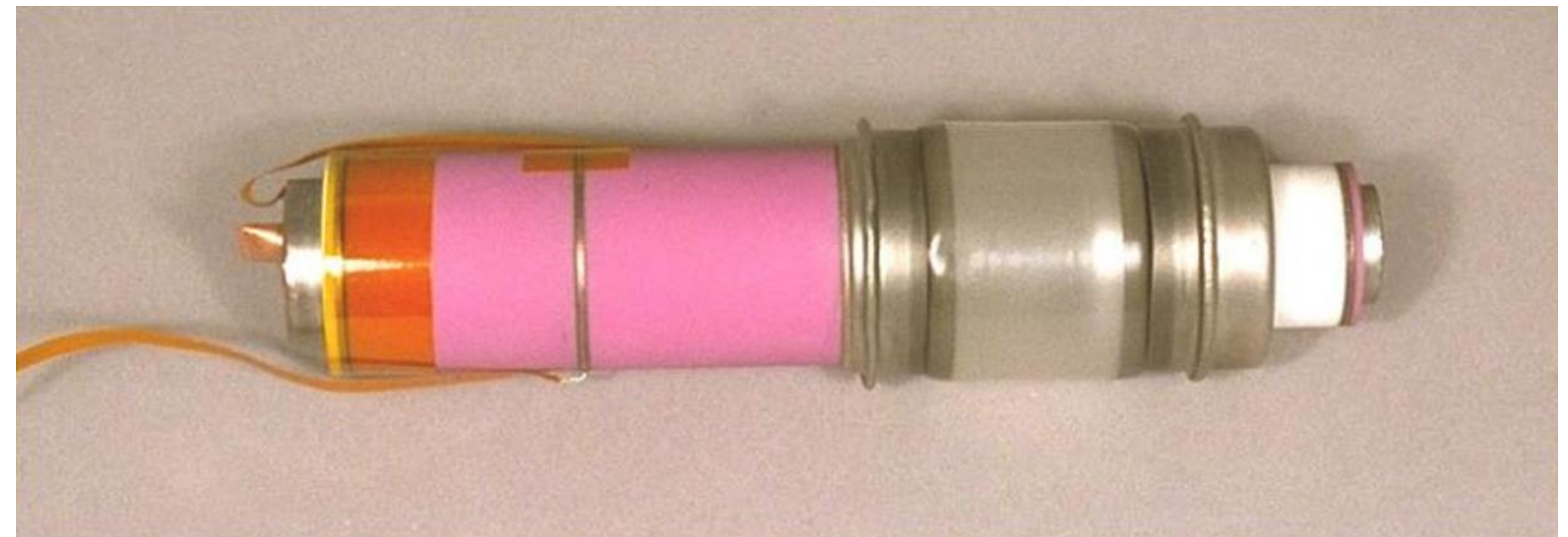
Inelastic n- γ Density (INGD) via (D-T)
Neutron Generator

Resistivity / Conductivity

X-Ray Tubes



Neutron Tubes



Neutron Tube Configured for Oil Well Logging

Technology Features Cs-137 and AmBe

- Smaller, Self Powered, More Durable
- Longer Working Life (15y)
- Faster Logging Speed than NMR
- More Stable Emissions
- More Accurate (≤ 1 porosity unit)
- More Archived Logging Reference Data
- Lower Cost
- Pulsed Mode is not Available
- Always On
- Higher Operator Dose
- 3 x Lower Neutron Output
- More Difficult to Ship & License, Leak Tests Required
- Safety / Security Risks of Radioisotopes

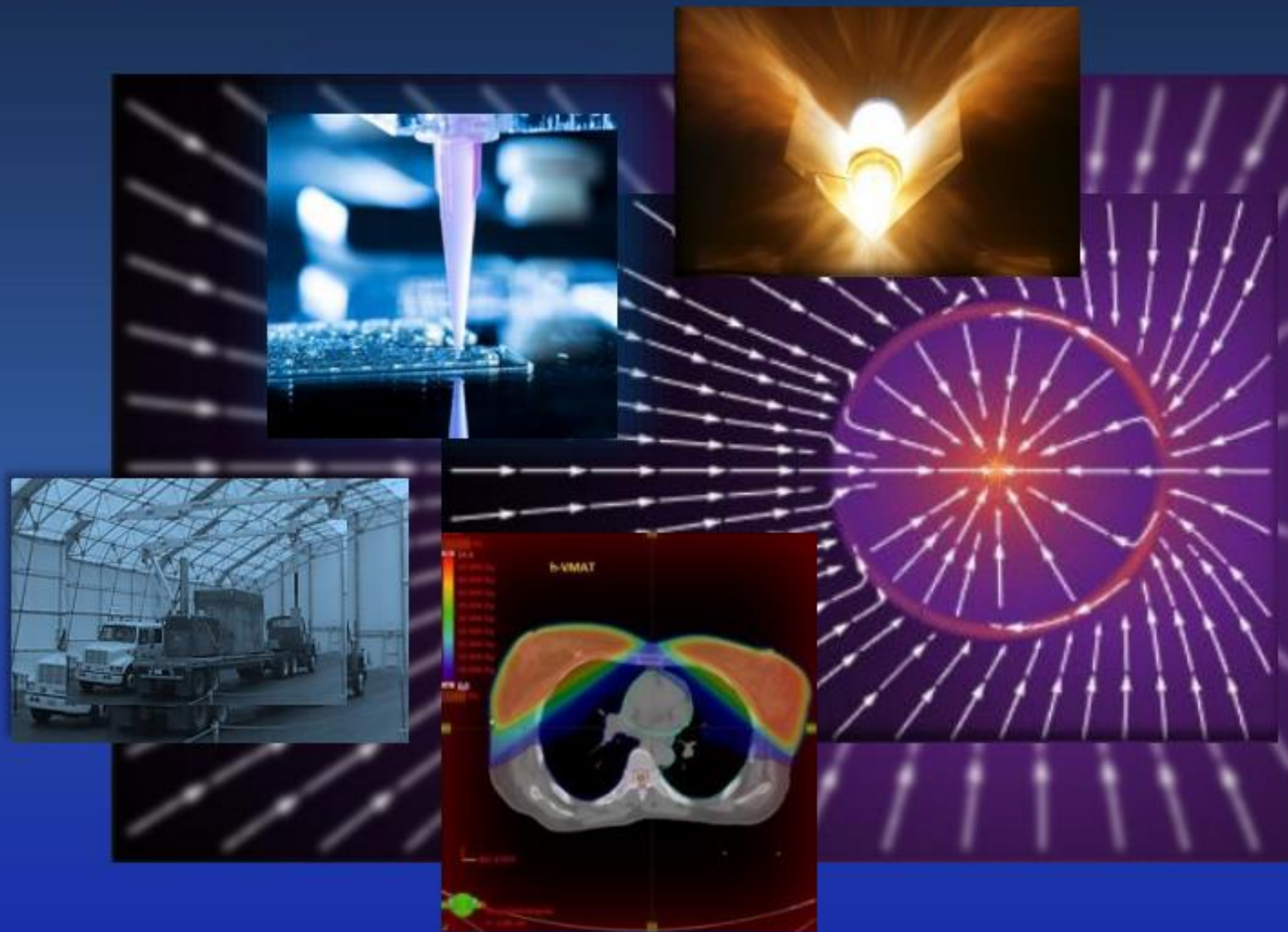
Technology Features Alternative Technologies

- Larger, Powered, Less Durable
- Shorter Working Life (1000-8000hrs)
- Slower Logging Speed in case of NMR
- Less Stable Emissions
- Less Accurate (≥ 2 porosity units)
- Less Archived Logging Reference Data
- Higher Cost + On Site Spares Needed
- Pulsed Mode Enables More Measurement Types
- Can be Turned Off, but must be used Monthly to Maintain Tube Life
- Lower Operator Dose when Switched Off
- 3 x Higher Neutron Output (when new)
- Easier to Ship & License, Leak Tests Not Required
- Lower Safety / Security Risks of Tritium
- There is no viable Cs-137 Alternative Yet

Basic Research Needs Workshop on Compact Accelerators for Security and Medicine

Tools for the 21st Century

May 6-8, 2019



- AmBe can be substituted by neutron tubes in several well logging applications when conditions are not too harsh
- Cs-137 cannot yet be effectively substituted by alternate technologies
- Gamma Radiography Isotopes cannot be substituted in all applications. Other technologies are complementary rather than substitutional
- Development of alternative technologies that are intended to mitigate safety and security risks of radioisotopes must not adversely impact test efficacy & economic viability