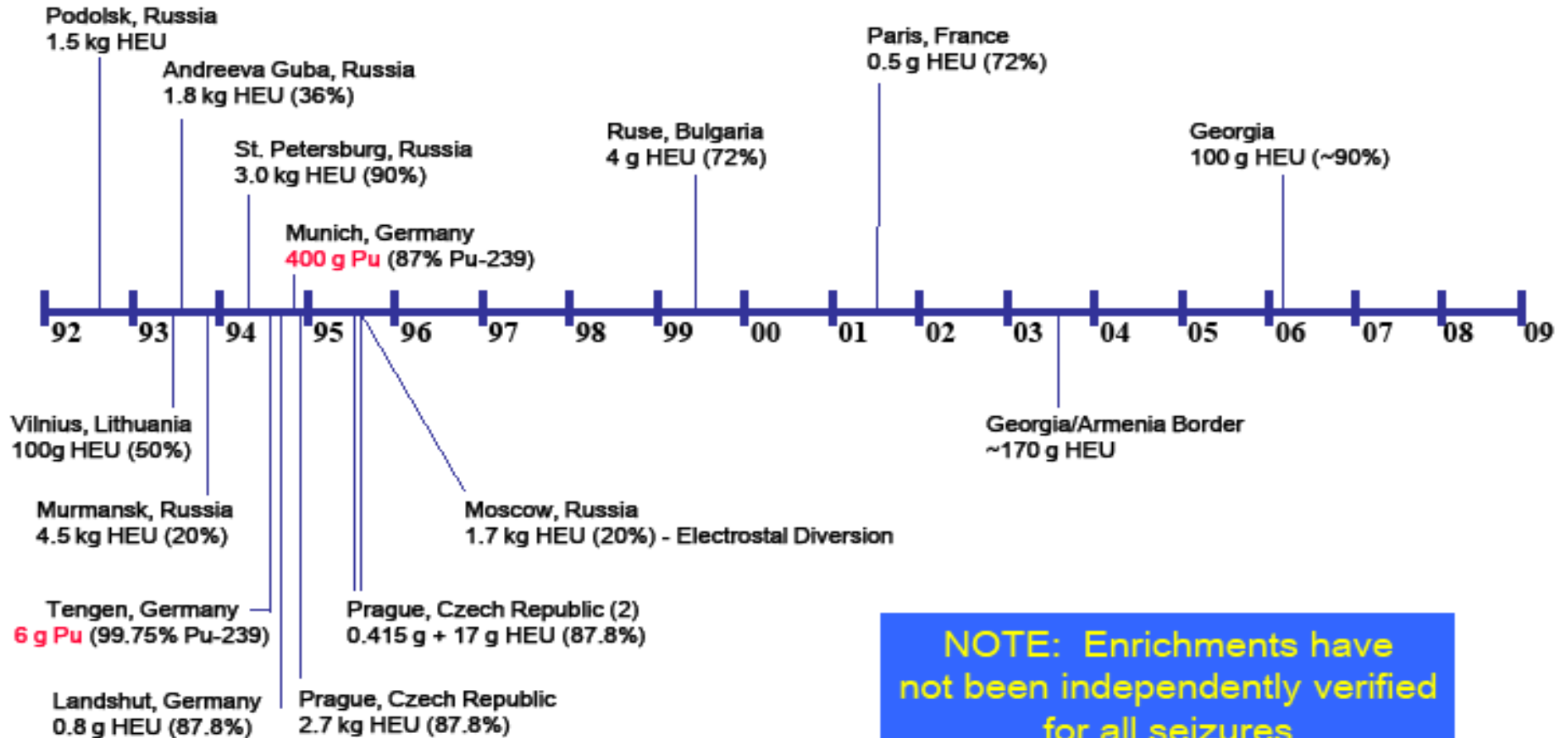


# Nuclear Forensics

## (1) Back ground: Illicit nuclear traffickings reported



**NOTE: Enrichments have not been independently verified for all seizures**

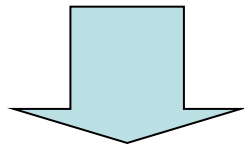
As of 1 June 2009



# Nuclear Forensics

## (2) Objectives

- \* Determine attribution
- \* Identify locality of nuclear materials, by analyzing samples taken from stolen materials, or at the scene of nuclear terrorism



- \* **Prosecute criminals**
- \* **Enhance deterrence power**

TABLE 2. SUGGESTED SEQUENCE FOR LABORATORY TECHNIQUES AND METHODS

Techniques/methods	24 hours	One week	Two months
Radiological	Estimated total activity Dose rate ( $\alpha$ , $\beta$ , $\gamma$ , $n$ ) Surface contamination		
Physical	Visual inspection Radiography Photography Weight Dimensions Optical microscopy Density	SEM/EDS XRD	TEM (EDX)
Traditional forensic	Fingerprints, fibres		
Isotope analysis	$\gamma$ spectroscopy $\alpha$ spectroscopy	Mass spectrometry (SIMS, TIMS, ICP-MS)	Radiochemical separation
Elemental/chemical		ICP-MS XRF Assay (titration, IDMS)	GC-MS

SEM/EDS: Scanning electron microanalysis with energy dispersive sensor; TEM: transmission electron microscopy; SIMS: secondary ion mass spectrometry; TIMS: thermal ionization mass spectrometry; ICP-MS: inductively coupled plasma mass spectrometry; XRF: X ray fluorescence analysis; IDMS: isotope dilution mass spectrometry; GC-MS: gas chromatography-mass spectrometry. (See Appendix II for further references.)



# Nuclear Forensics

## (3) Relevant radionuclide signature

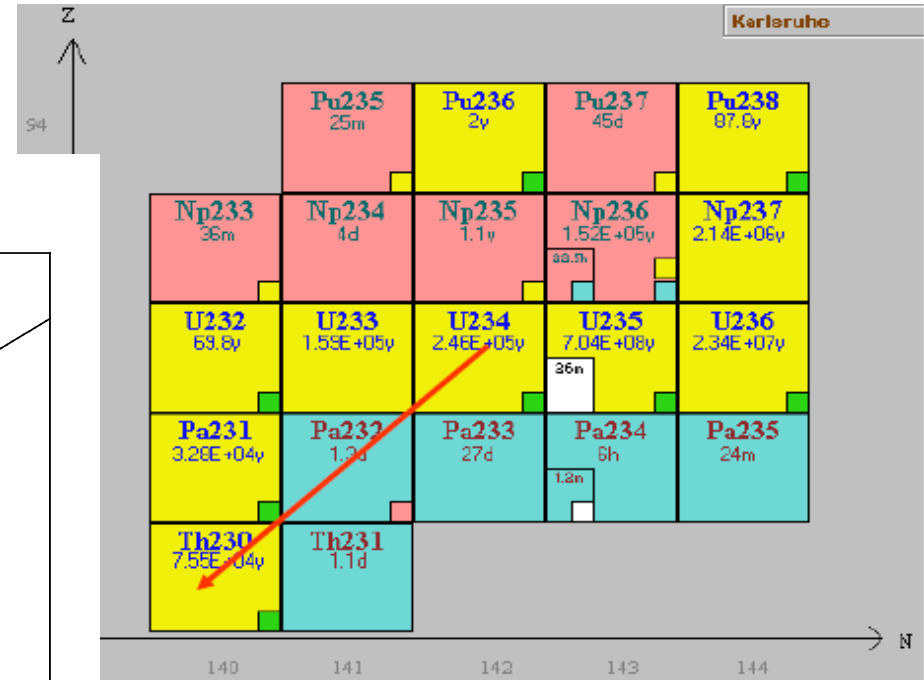
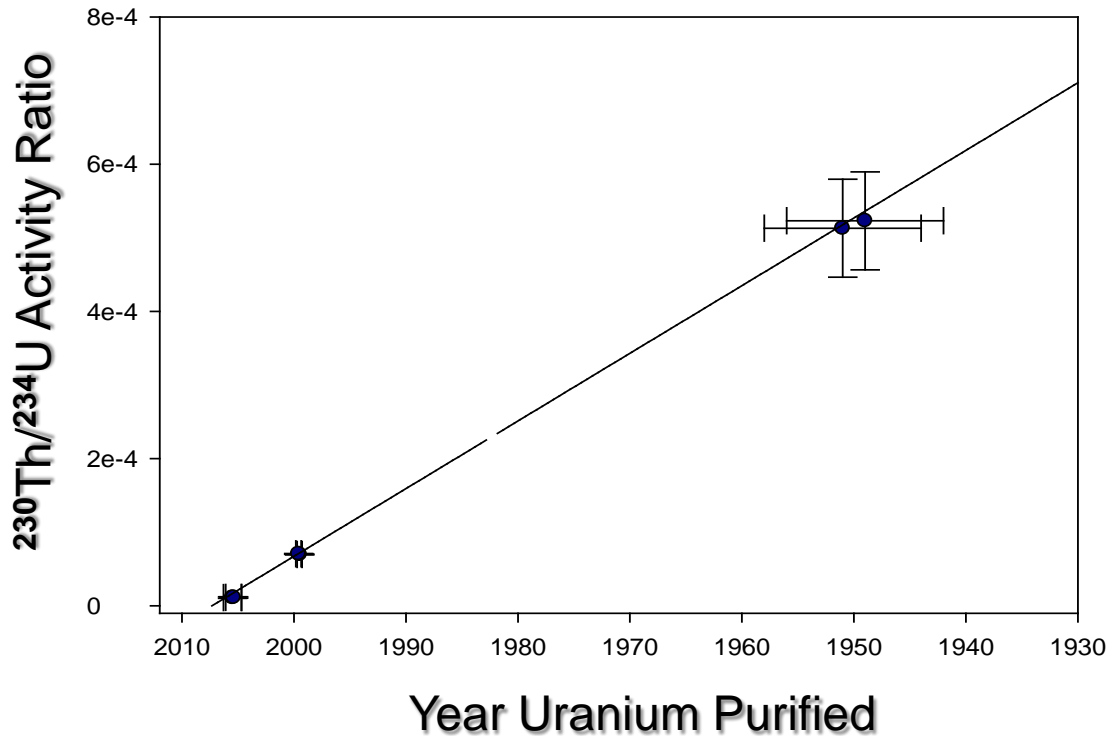
<b>Signature</b>	<b>Information revealed</b>
In-growth of daughter isotopes	Chemical processing date
Pu isotope ratios	Enrichment of U used in Pu production Neutron spectrum and irradiation time in the reactor
Residual isotopes	Chemical processing techniques
Concentration of short lived fission product progeny	Chemical yield indicators

Ref.: Nuclear forensics support, IAEA (2006)

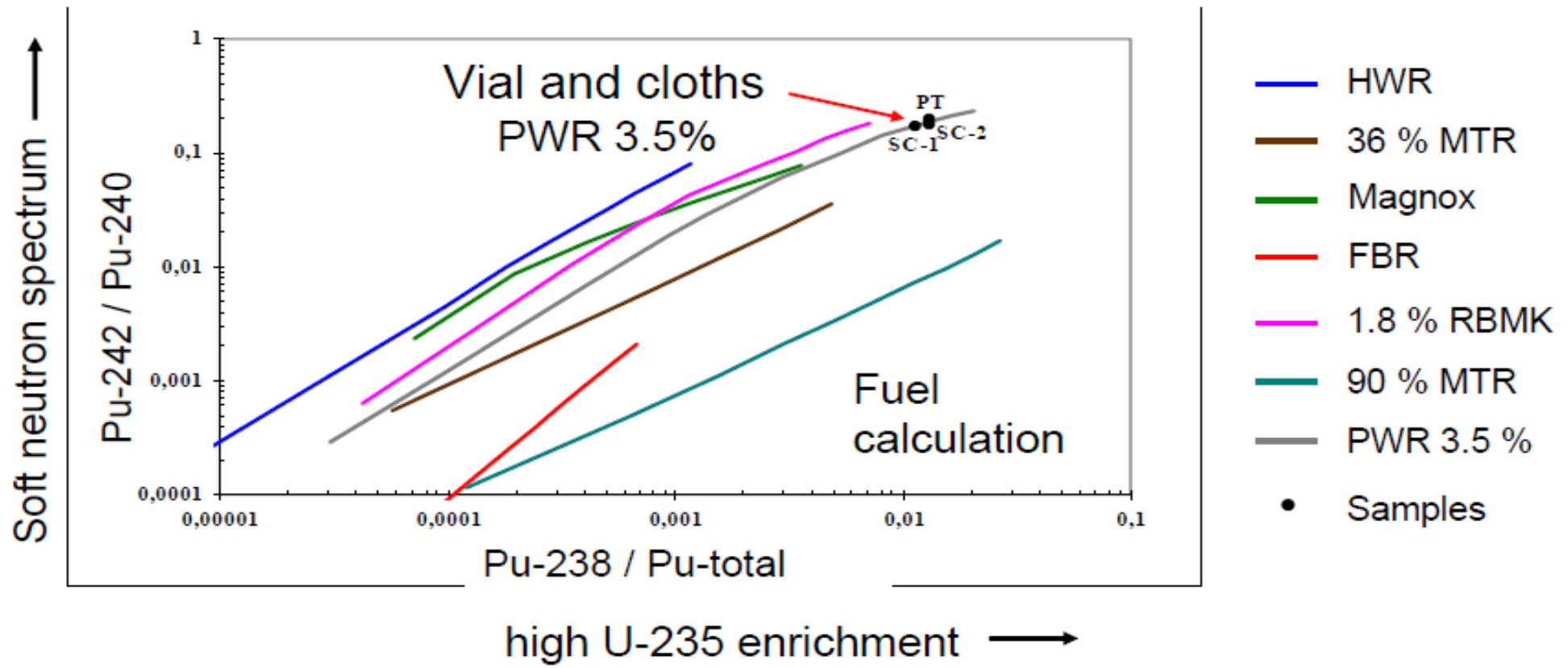
## (4) Examples:

### ① U age determination

Age of Several Uranium Oxide Samples

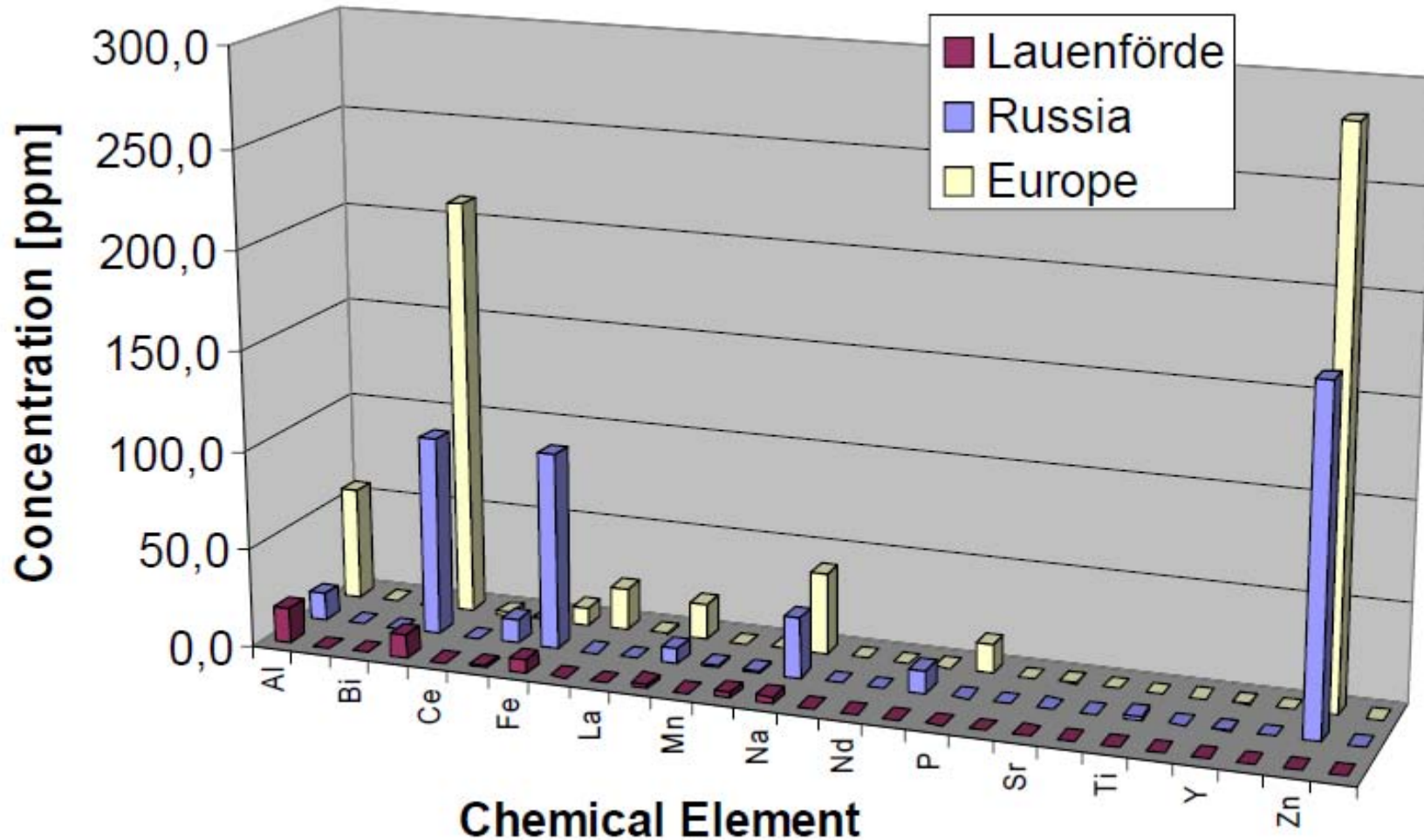


## ② Pu isotopic composition and reactor types

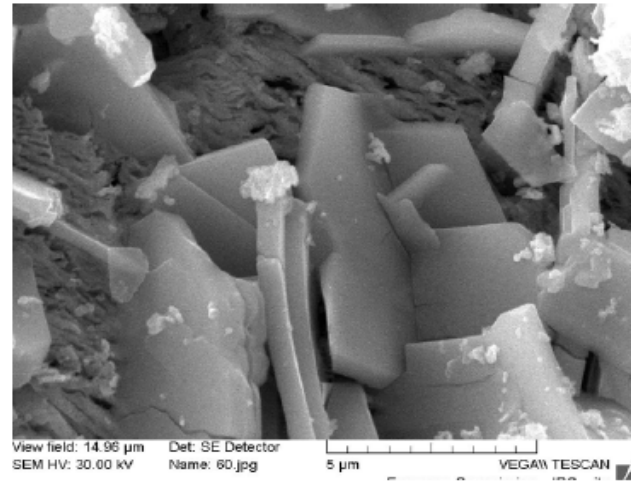
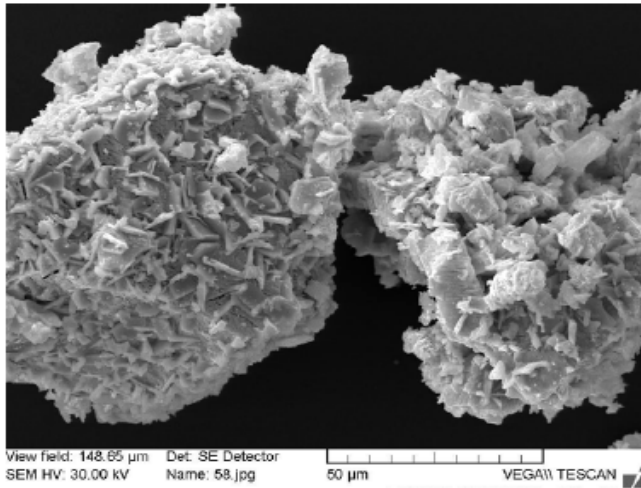




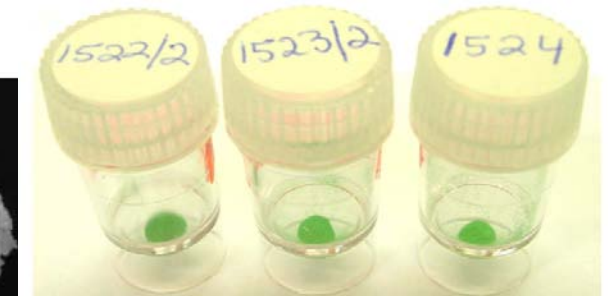
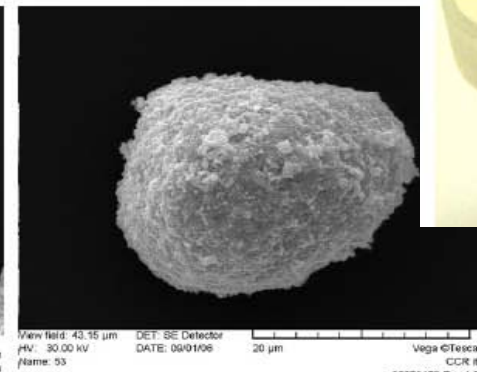
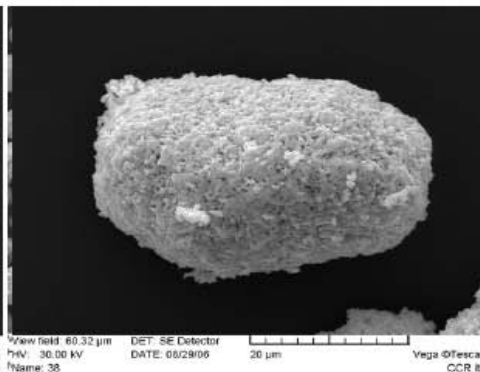
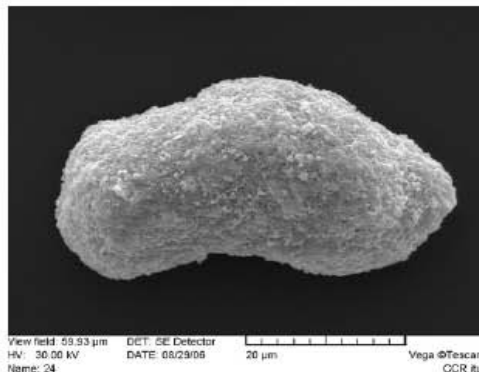
## ④ Impurity in uranium oxide



## ⑤ Particle morphology



SEM images of  $U_3O_8$  particles



SEM image of  $UF_4$  particles



# Nuclear Forensics

## (5) Flow diagram of Nuclear Forensics Analysis

