



Nuclear Security at the JRC

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JRC institutes active in Nuclear Security: *IPSC / Ispra (I)*
IRMM / Geel (B)
ITU / Karlsruhe (D)

Traditional Safeguards

- Nuclear material accountancy (owner)
- Independent verification (Euratom, IAEA,...)

Isotope & Element Assay

Strengthened Safeguards

- Absence of undeclared activities (Add. Protocol)

Environmental Analysis

Illicit trafficking and nuclear forensics

- Detection
- Source attribution

Chemical Analysis

Macro-/Microscopic Parameters

Nuclear Safeguards and the Additional Protocol:

- Technical / scientific support to Safeguards authorities, DG TREN (Euratom Safeguards) and IAEA
 - New detection and verification technologies
 - Improvement of measurement methods, preparation of reference materials, utilisation of on-site laboratories
 - Analysis of micro-particles to detect undeclared nuclear activities
 - Training and education

Strengthened Safeguards: Particle Analysis

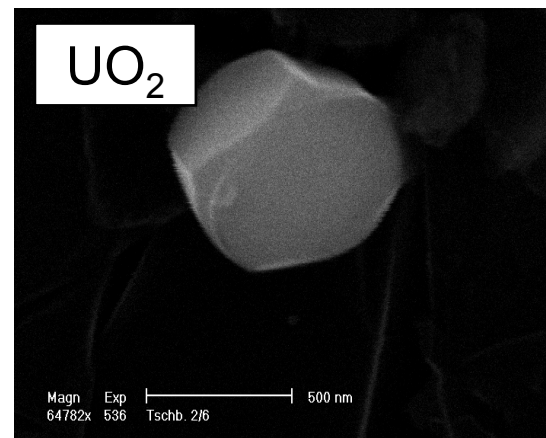
Analysis of uranium and plutonium in particles sampled in a broad range of nuclear safeguards contexts (env'tl sampling).

Safeguards objectives

- Enrichment plants
 - no enrichments higher than declared!
 - no undeclared material!

- Hot cells, Nuclear forensics,...

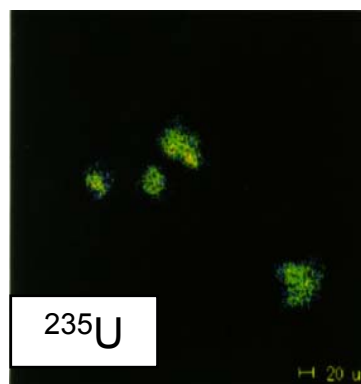
→ swipe samples from equipments or buildings



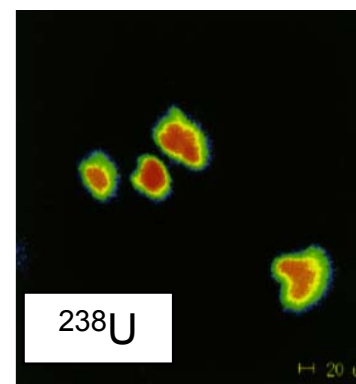
Scanning Electron Microscopy (SEM)

Secondary Ion Mass Spectrometry (SIMS) is used at ITU, to a lesser extent also FT-TIMS.

Typical particle sizes: few sub-microns up to 30 microns



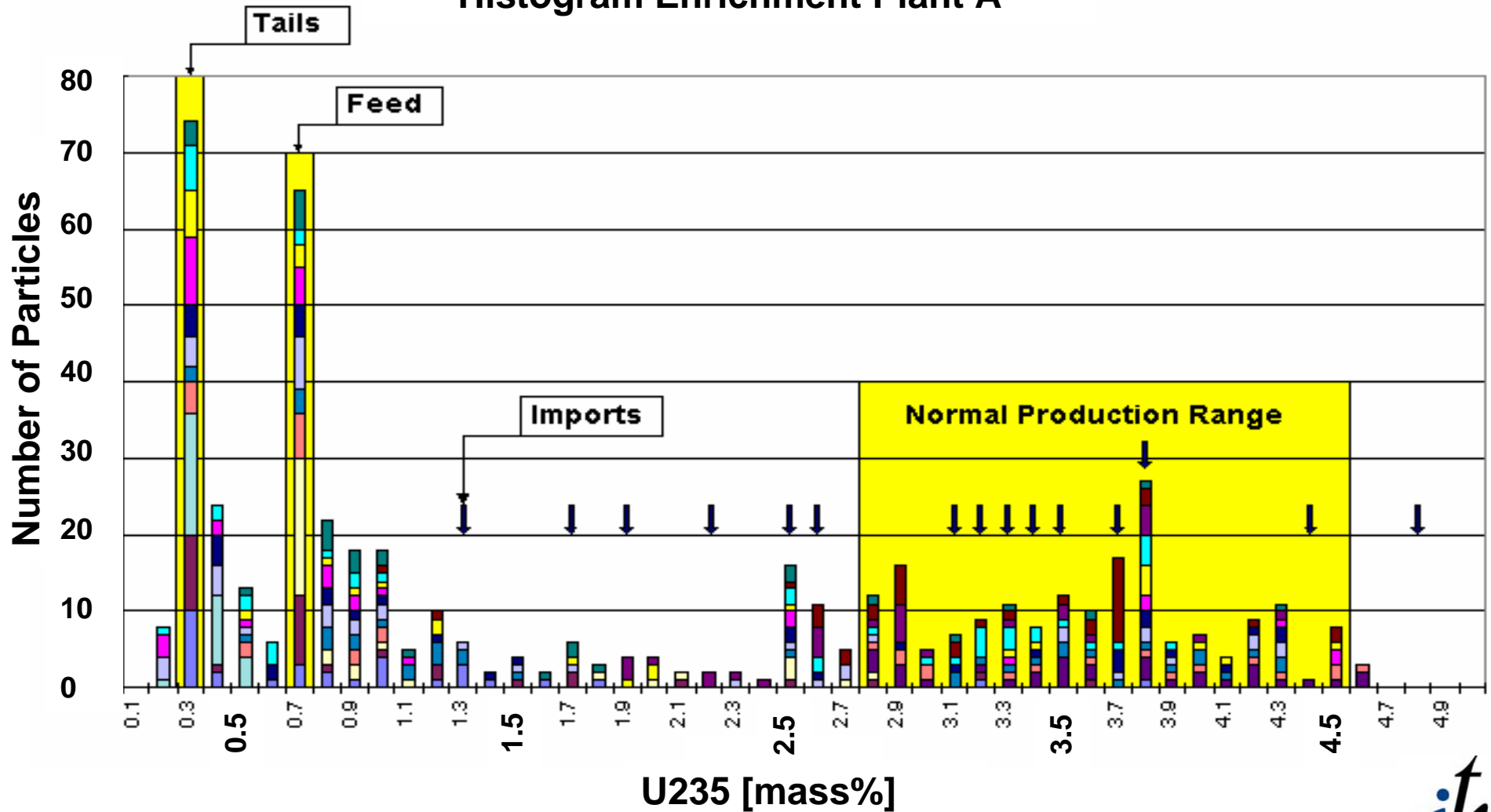
U-235 SIMS image



U-238 SIMS image

Swipe analyses for IAEA (NWAL) and Euratom

Histogram Enrichment Plant A



Illicit Trafficking and Nuclear Forensics

- Traditional Safeguards and Physical Protection fail (operator accountancy versus verification)
- Illicit trafficking of nuclear material
- Seizure (border control, intelligence services)
- Nuclear Forensic analysis

Threat by nuclear terrorism:

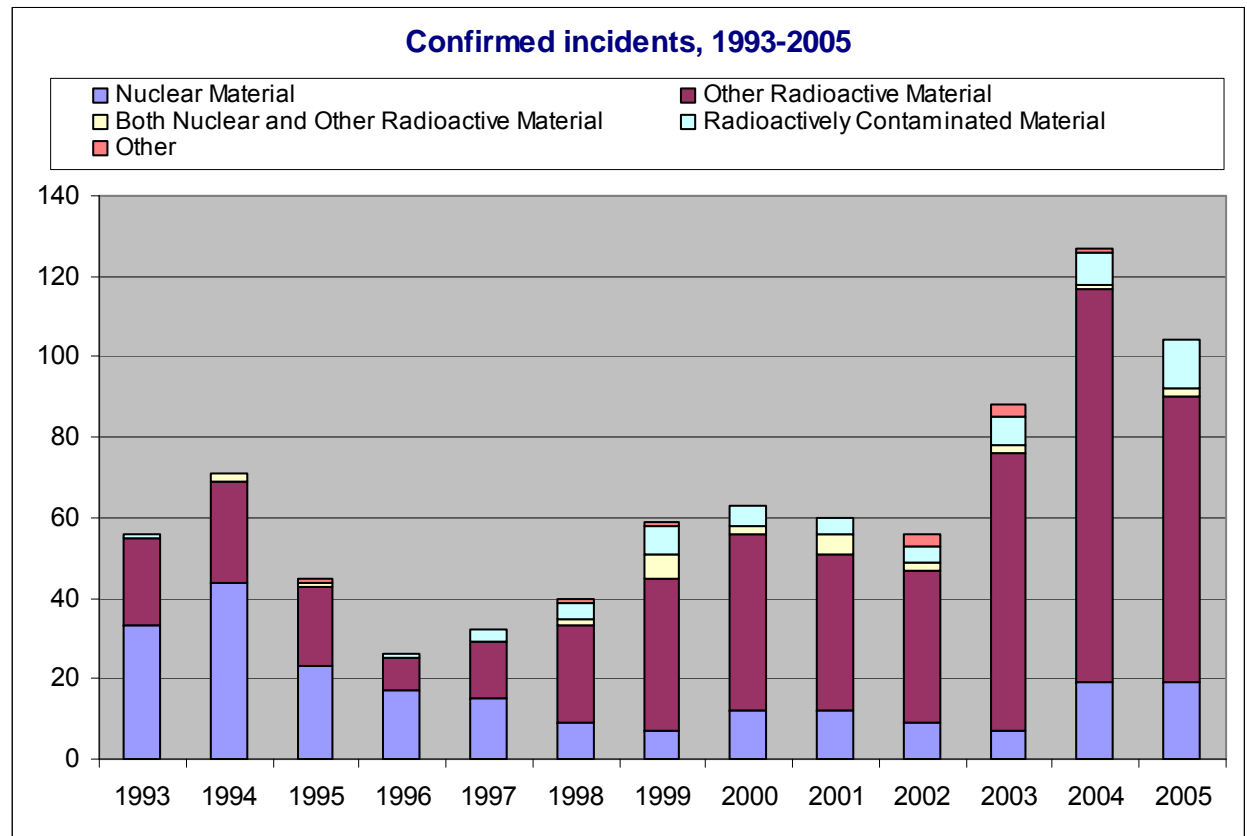
- Theft of nuclear material to produce a nuclear explosive device
- Theft of radioactive material (→ Dirty Bomb)

IAEA



UO₂ Fuel

- stolen in Lithuania,
- seized in Poland,
- produced in Russia,
- analysed at JRC-ITU



Projects JRC/ITU - Bulgaria (INRNE, ...):

- RITNUM Handbook
national Response to Illicit Trafficking of Nuclear Material
(developed jointly with ITWG)
- Delivery of equipment
portable equipment for categorisation of material
- Training sessions for law enforcement services and
laboratory experts jointly with IAEA
- Demonstration exercise (border BG/TR)
- Joint participation to the G8 Nuclear Smuggling International
Technical Working Group (ITWG)

First Responders:

- ✓ Customs
- ✓ Border Guards
- ✓ Police
- ✓ Security Service



Main topics for first responders

- Procedures for detection
- Verification of alarm
- Securing material
- Self and site protection
- Preservation of evidence



Measurement experts:

- ✓ Research Institute
- ✓ Environmental Protection
- ✓ Health & Safety
- ✓ Radiation Protection



Main topics

- Categorisation
- Preservation of Evidence
- Sample taking/ Shipment
- Radiological advice



Demonstration Exercise

Border Bulgaria/Turkey - Kapikule
(joint exercise) 2002



Nuclear Forensics

- ✓ Research Institute
- ✓ Measurement Laboratory



- ✓ Joint Analysis

The TACIS *Multicountry Project* to combat illicit trafficking of nuclear and radioactive material

Technical Assistance to the Commonwealth of Independent States



Estimated duration: 60 months

- training of personnel
- installation of hand-held and mobile equipment
- Improvement of scientific/technical infrastructure
- implementation of the RITNUM handbook and creation of a Model Action Plan
- demonstration exercises
- workshop to strengthen regional co-operation and co-ordination
- Joint Analysis Agreement to analyze seized material

What is Nuclear Forensics ?

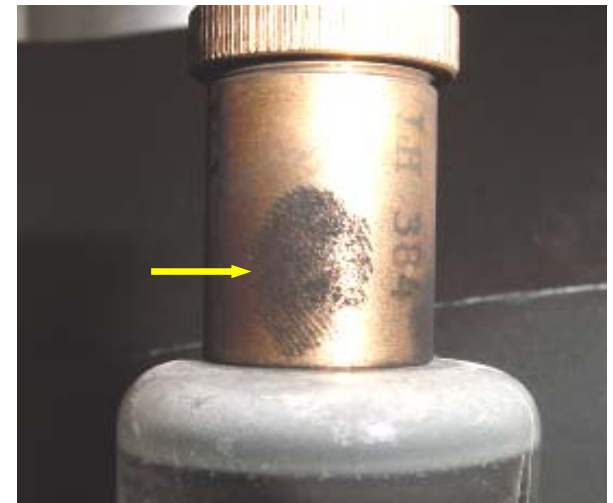
Information on the nature of the seized material, its intended use and its origin

Fingerprint ?

Characteristic properties
(isotopic composition, trace elements,
macro- and microscopic structure)

→ Origin, legal owner,
intended use, ...

▶▶ Examples

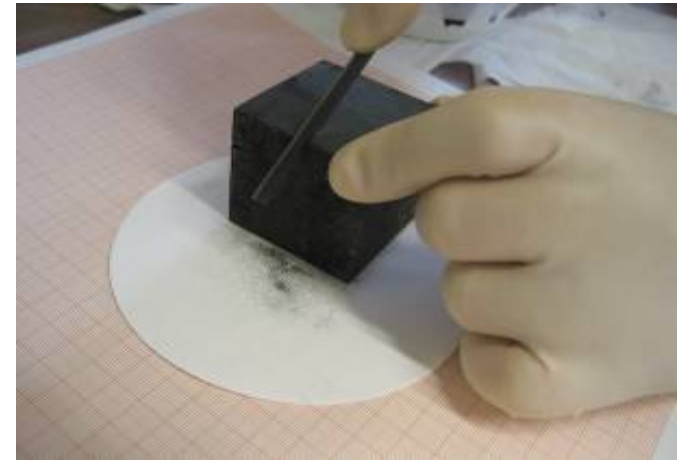




Origin and intended use ?

First observations/conclusions:

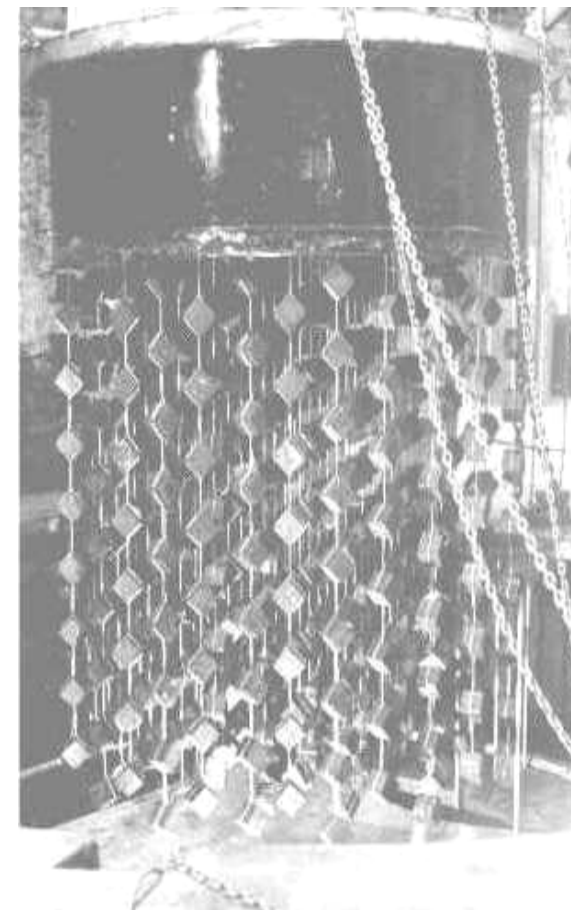
- geometry → 5 x 5 x 5 cm,
unconventional application/reactor
- elemental composition → pure U metal
- isotopic composition → natural U →
D₂O or graphite moderated reactor
- main impurities → Al, Ca, **Fe**, Mg, Mn,
Na, Pb, Si
(200 mg material)



Intended use and origin

- elemental composition: pure U metal, unconventional application/reactor isotopic
- composition → natural U → D₂O or graphite moderated reactor
- Open literature

Geometry points at German origin



Age determination

- spiking with ^{228}Th (or ^{233}Pa)
- chemical separation
- measurement: alpha spectrometry or mass spectrometry

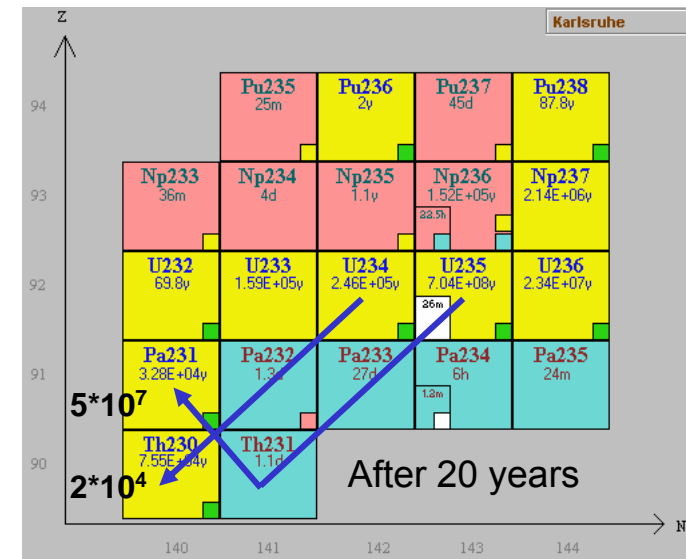
Age via $^{234}\text{U} / ^{230}\text{Th}$

α -spec.: 59.0 ± 1.5 years (in 2003)

ICP-MS: 59.3 ± 2.0 years

=> Date of production: second half of 1943

Age indicates German (or US) nuclear programme



22 February 2007

14 Uranium Pellets found in a garden



Questions:

1. How did the material get there?
2. Origin of the material ?
3. Intended use of the material?
4. Age of the material?

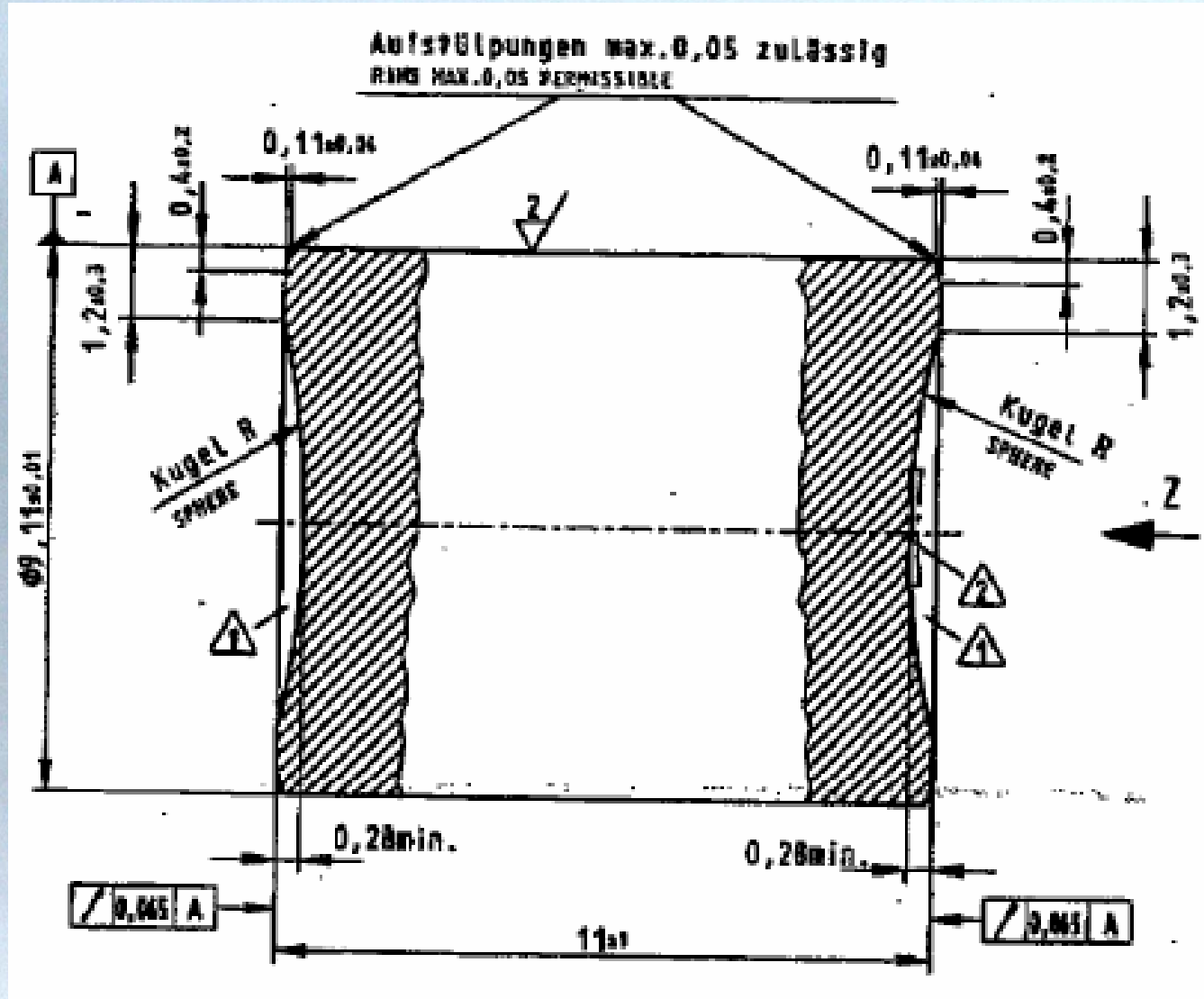
Isotopic Composition measured by Thermal Ionisation Mass Spectrometry (TIMS)

	U-234	U-235	U-236	U-238
Isotope abundance (mass%)	0,029 4 %	3,455 %	0,005 2 %	96,511 %
Measurement uncertainty	0,000 3 %	0,004 %	0,000 1 %	0,003 %

Pellet geometry



Pellet geometry



5 mm

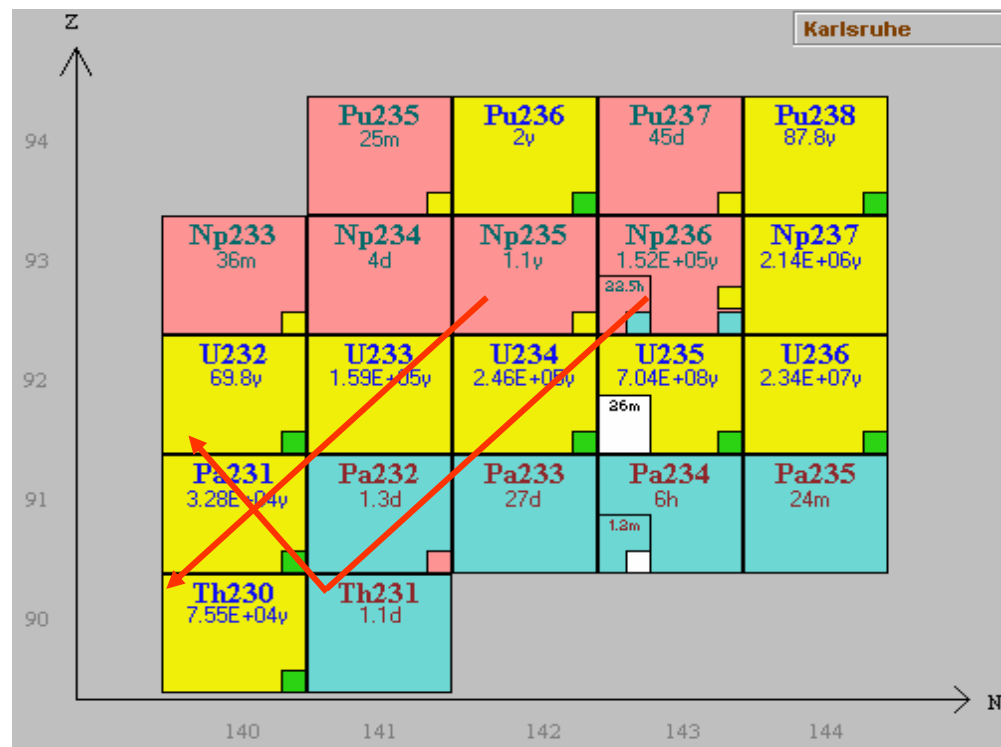
Database query

		Measurement		Database [1]		Database [2]	
		Mean	StDev	Nominal	Tolerance	Nominal	Tolerance
Diameter	mm	9.26	0.02	9.11	0.02	9.11	0.02
Dishing Diameter	mm	6.71	0.08	6.7*	0.3*	6.73	0.05
Dishing Distance (Land)	mm	1.22	0.16	1.2	0.3	1.2*	0.1*
Chamfer Width	mm	0.44	0.04	0.4	0.2	<i>0.61</i>	<i>0.05</i>

Siemens (RBU) Brennelementfabrik Hanau

Age determination

- Based on $^{234}\text{U}/^{230}\text{Th}$
- ICP-MS
- Alpha Spectrometry
- Last chemical separation
Nov./Dec. 1990
- Pellet production campaign
Feb./March 1991
- Fall 1991 Upgrade of physical
protection at RBU plant



Pellets are

- Homogeneous
- Typical western European PWR Pellets
- Raw, unground
- Russian origin can be excluded
- Based on Geometry RBU (Hanau) was identified as the only possible manufacturer
- Theft/diversion before grinding

Implementation of Nuclear Security Policy

- Develop concepts (Model Action Plan)
- Share experience (Nuclear Forensics)
- Co-operation Member States, JRC, ...
- Joint efforts (Training, Joint nuclear forensics analyses)