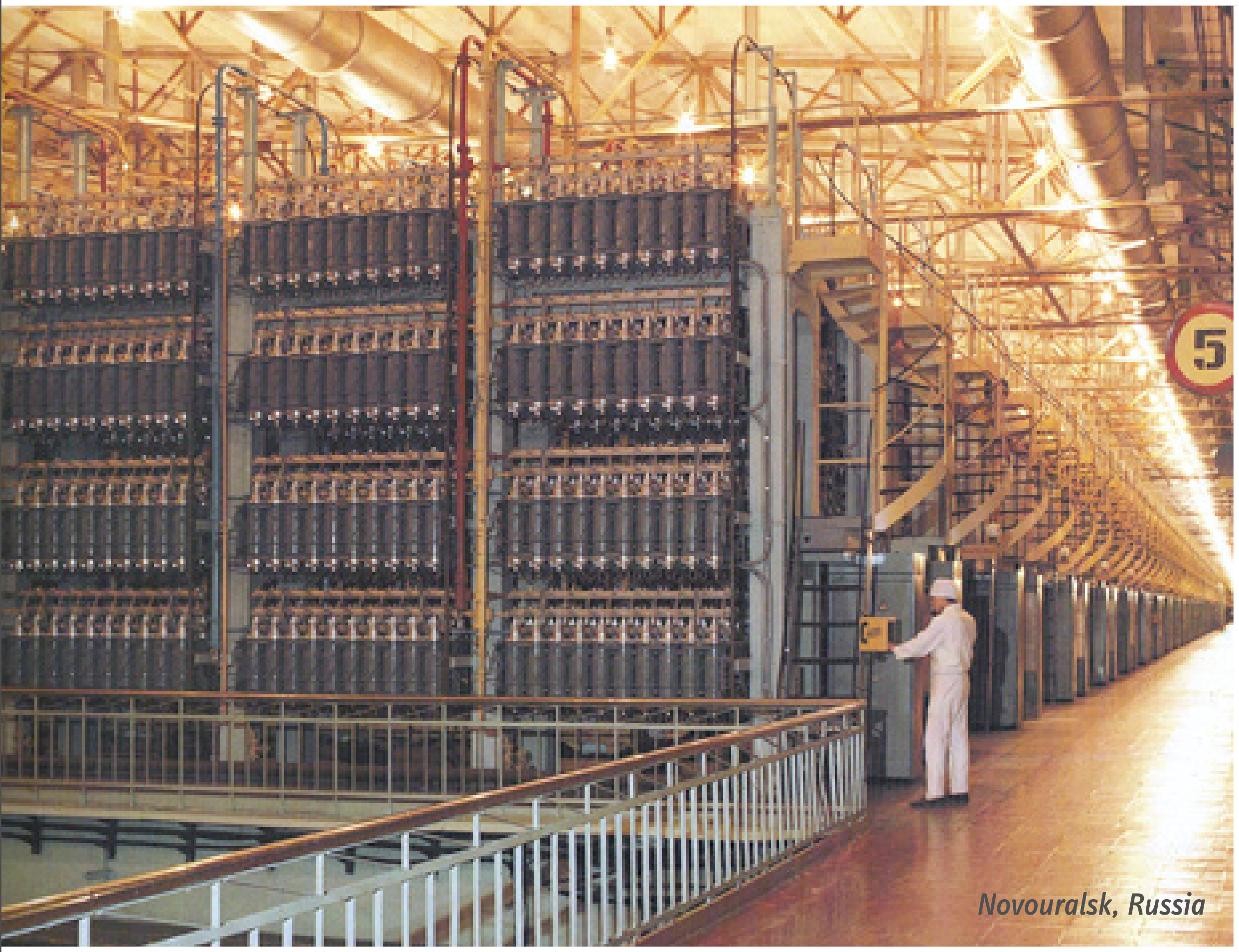

Novouralsk, Russia

Verification of an FMCT

The Case of Enrichment Facilities

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49th INMM Annual Meeting, Nashville, TN
July 16, 2008

Revision 4

HEU Production Periods

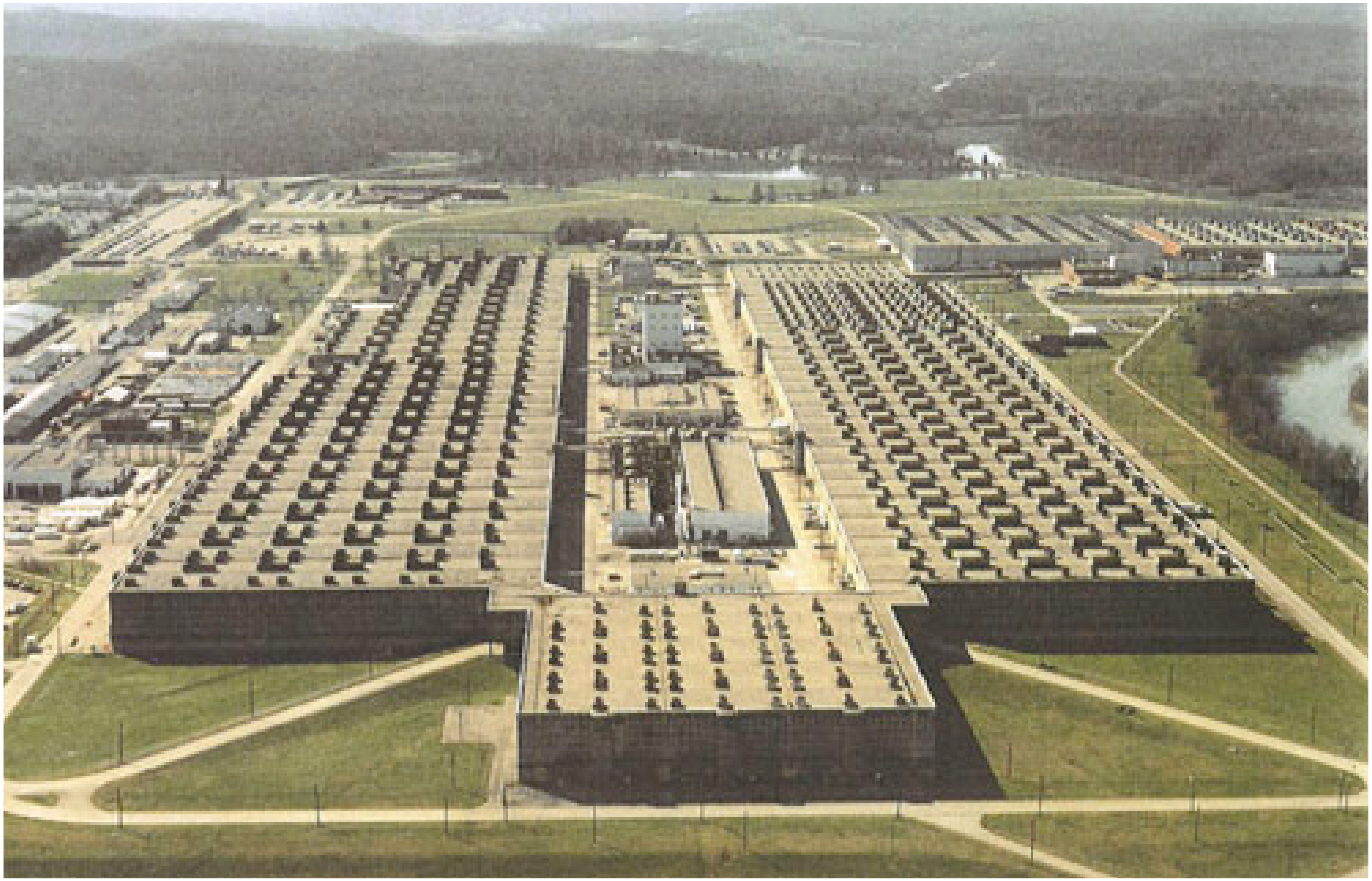
(in nuclear weapon states)

	Production Start	Production End
China	1964	1987-89
France	1967	1996
India	mid 1990s	*continuing*
Pakistan	1983	*continuing*
Russia	1949	1987-88
United Kingdom	1953	1963
United States	1944	1992*

*1964 for weapons

Oak Ridge Gaseous Diffusion Plant K-25

(demolition underway)

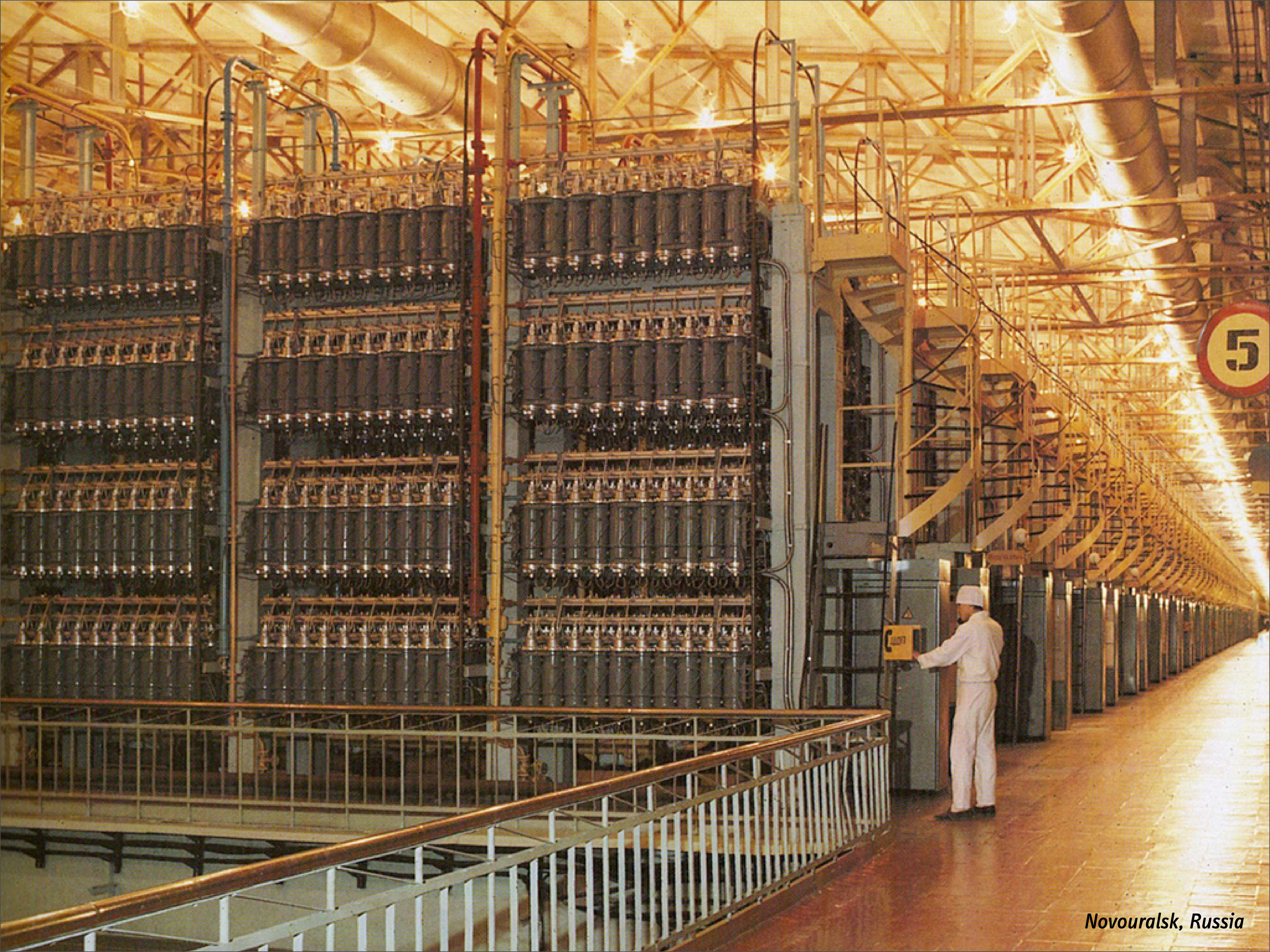


Centrifuge Enrichment Facilities

(as currently expected for the year 2015)

	Country	Facility	Safeguards Status	Capacity [tSWU/yr]
Non-weapon states	Brazil	Resende	Yes	120
	Germany	Gronau	Yes	4,500*
	Iran	Natanz	Yes	250
	Japan	Rokkasho	Yes	1,050
	The Netherlands	Almelo	Yes	3,500
Weapon states	France	George Besse II	Yes	7,500
	U.K.	Capenhurst	Yes	4,000
	United States	Piketon, Ohio	offered	3,500
		Eunice, NM	offered	3,000
		Areva, Idaho	(offered)	3,000
	China	Shaanxi	Yes	1,000*
		Lanzhou II	offered	500
	Russia	Angarsk II	(offered)	5,000
		4 others	No	about 30,000
	India	Rattehalli	No	4-10
	Pakistan	Kahuta	No	15-20

**after currently planned expansions are complete*



Novouralsk, Russia

Verification at Previously Operating Enrichment Facilities

Need of Retrofitting Safeguards Measures in Operating and Potentially HEU-contaminated Plant

Ideally, capture same set of safeguards objectives pursued in other enrichment plants

Fundamental objective is detection of covert HEU production

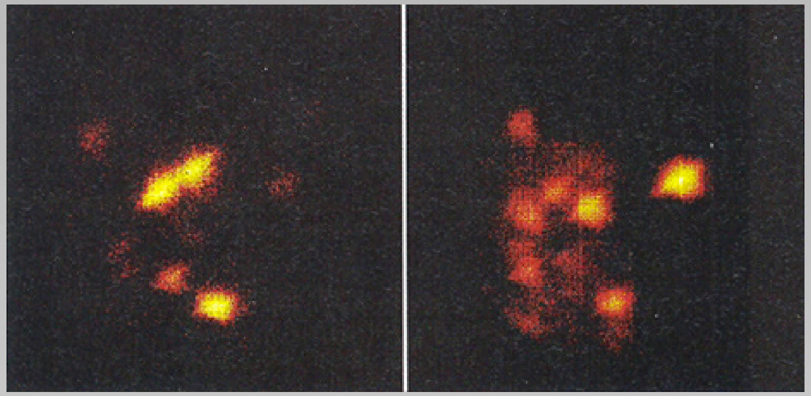
Note: if a "focussed approach" is pursued, then any effort targeted at excess production or diversion of LEU would be meaningless

Methods and Tools to Detect HEU Production

Environmental sampling techniques

Continuous (or Portable) Enrichment Monitors

Identifying HEU Particles from Historic Production with Swipe Sampling Techniques



Images of micron-sized uranium particles made with a Secondary Ion Mass Spectrometer

Left: U-235 Concentration
Right: U-238 Concentration

Isotopic Signature

Isotope ratios (e.g. U-234 and U-236 fraction as a function of U-235 enrichment) are characteristic for the feed composition and production process

Particle Age

Based on fractional concentration of decay products, particularly challenging for uranium

Accurate for large (microgram) samples

Could particles be used that have been obtained with swipe sampling techniques ?

Age-Dating of Small-Size Highly Enriched Uranium Samples

Reported Detection Limits for Various Isotope-Ratio Analysis Techniques

Technique	Reported Detection Limits (for Actinides)	Advantage	Disadvantage
High-Efficiency TIMS	10^4-10^6 atoms	High Precision	Time-consuming sample preparation Hydrocarbon interferences
Multi-Collector ICP-MS	10^4-10^6 atoms	High Precision	Isobaric and molecular interferences Memory effect
RIMS	10^6-10^8 atoms	High Selectivity Less Interference	Time-consuming sample preparation

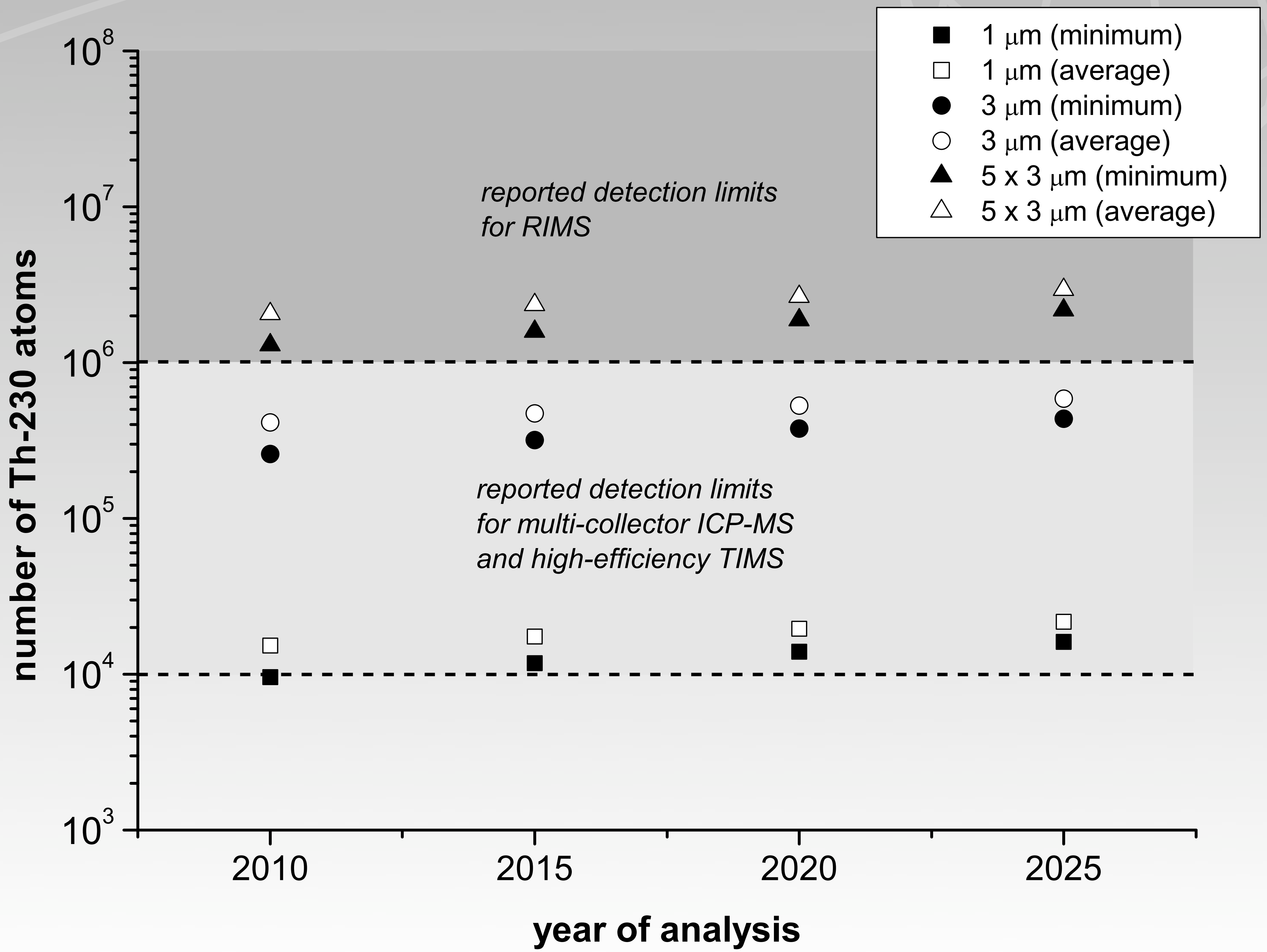
TIMS: Thermal ionization mass spectrometry; ICP-MS: Inductively coupled plasma mass spectrometry;
RIMS: Resonance ionization mass spectrometry

Data from various sources, summarized in S. Bürger et al., "Isotope Ratio Analysis of Actinides, Fission Products, and Geolocators by High-Efficiency Multi-Collector Thermal Ionization Mass Spectrometry," forthcoming.

Buildup of Decay Products in an HEU Particle

	U-232	U-234	U-235	U-236	U-238
Half-Life	68.9 years	245,500 years	0.7 billion years	23 million years	4.5 billion years
Long-lived Daughter	Th-228	Th-230	Pa-231	Th-232	U-234
Decayed Fraction in 100 years	63%	0.03%	0.0000098%	0.0003%	0.0000016%
HEU Isotopics (clean)	-	1%	93%	-	6%
Potential Chronometer	-	*1*	*0.03*	-	*0.0003*
HEU Isotopics (from RepU)	4×10^{-8} %	1.15%	93%	1.35%	4.50%
Potential Chronometer	*0.00008*	*1*	*0.03*	*0.01*	*0.0002*

Uranium Age Determination



Summary and Conclusion

All new enrichment plants under construction or planned in nuclear weapon states are likely to be offered for international safeguards

From the perspective of FMCT verification, it would be beneficial to select these facilities for safeguards once they become operational

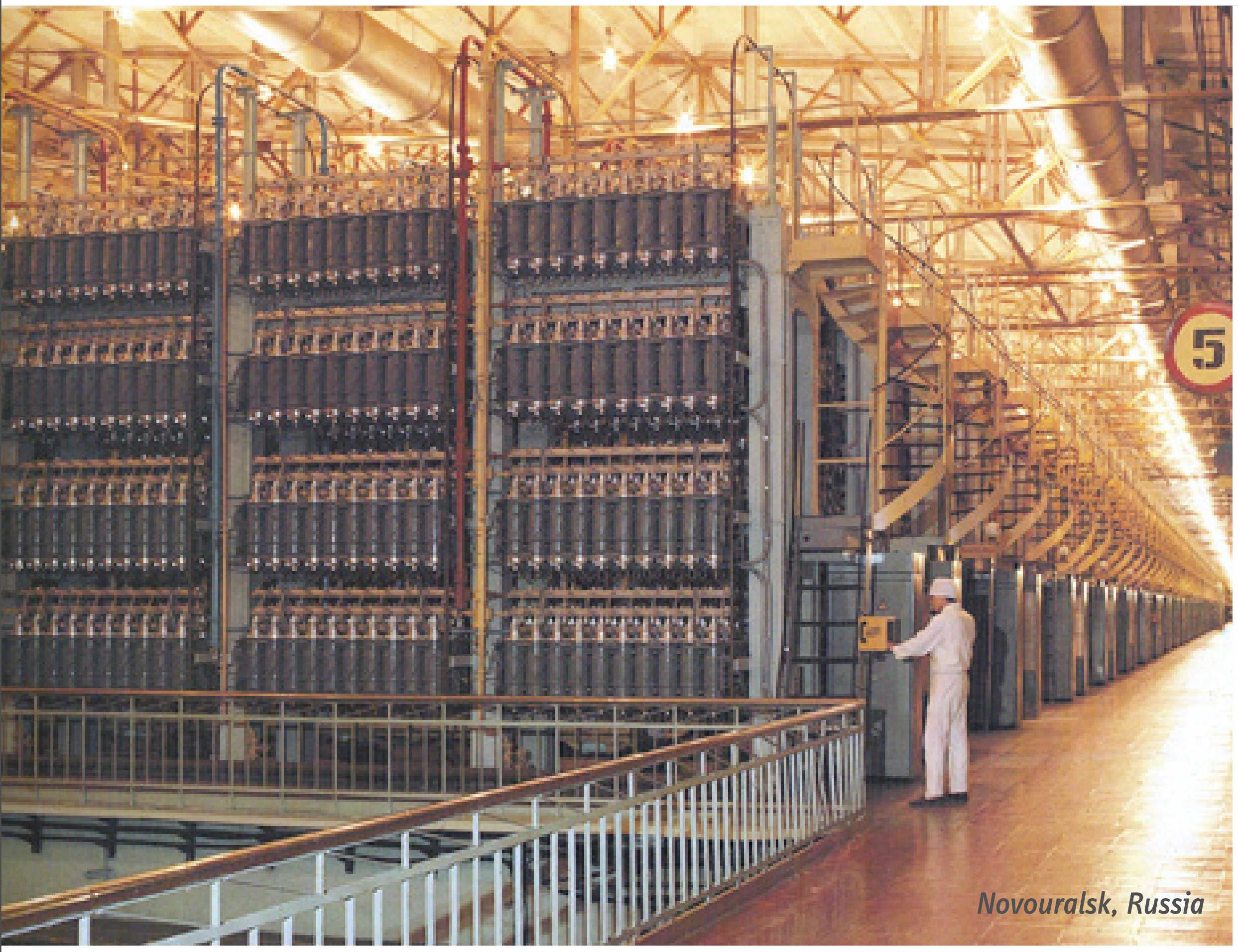
Detection of HEU production is key verification objective

Traditional safeguards tools include enrichment monitoring and environmental sampling

Age-dating techniques for HEU particles found in “legacy facilities” could play an important role in the verification of an FMCT

Current state-of-the-art methods can confirm a minimum-age of 20-25 years even for micron-sized samples of highly enriched uranium

Improvements in detection limits are continuously being reported



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