Fast Neutron Direct Interrogation (FNDI)

International Partnership for Nuclear Disarmament Verification (IPNDV) Working Group 3

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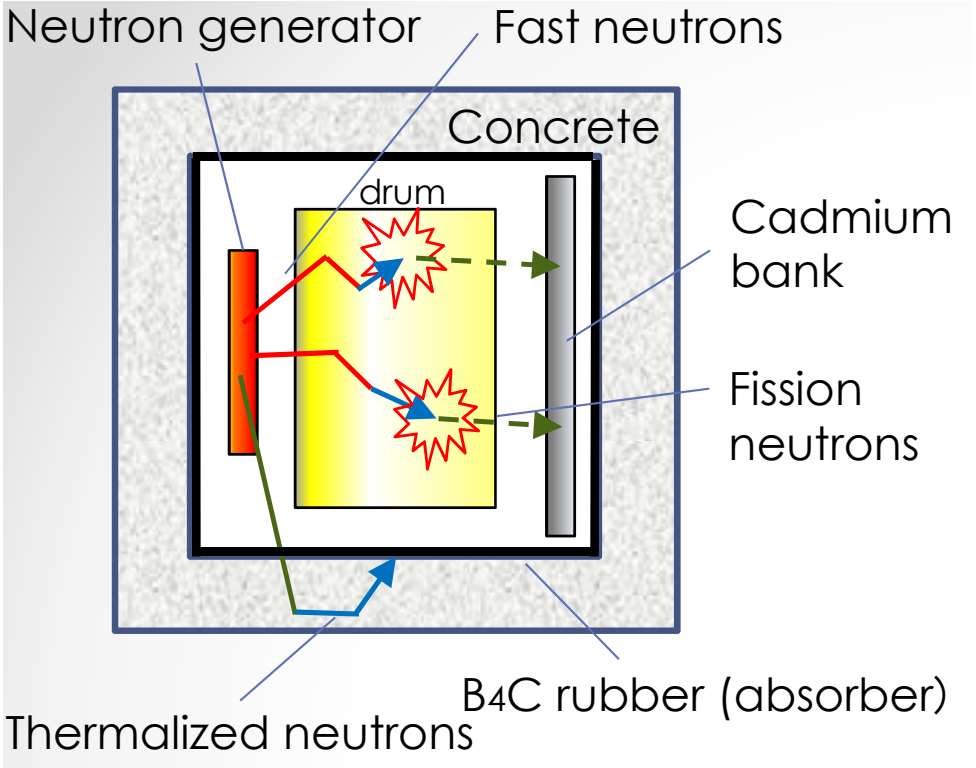
FNDI method (Outline)

Fast Neutron Direct Interrogation (FNDI) method:

⇒Active neutron NDA method for quantifying fissile materials

- Source:
  Pulsed Fast Neutron (14MeV)
- Detector:
  ^{3}He Detector (Cadmium Bank)

➢ Less positional dependence of fissile materials (U, Pu) in monitoring targets (drums)

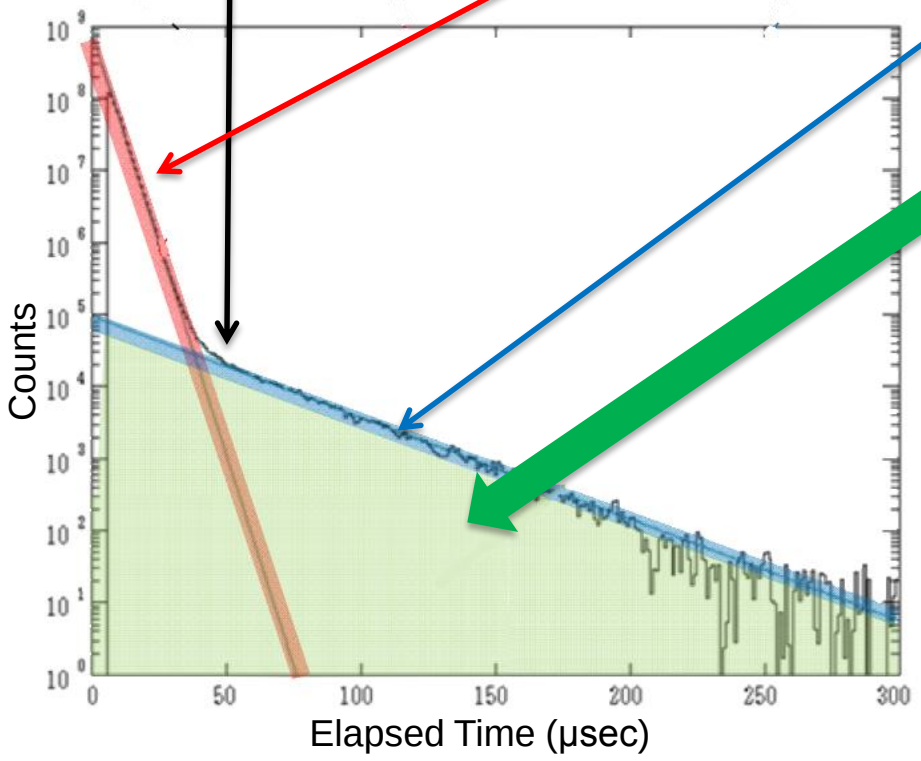


(Outline of System Configuration)

FNDI method (Physical Principles)

$$S(t) = a_0 + a_1 \times \exp(-\lambda_1 t) + a_2 \times \exp(-\lambda_2 t) + \cdots + a_n \times \exp(-\lambda_n t)$$

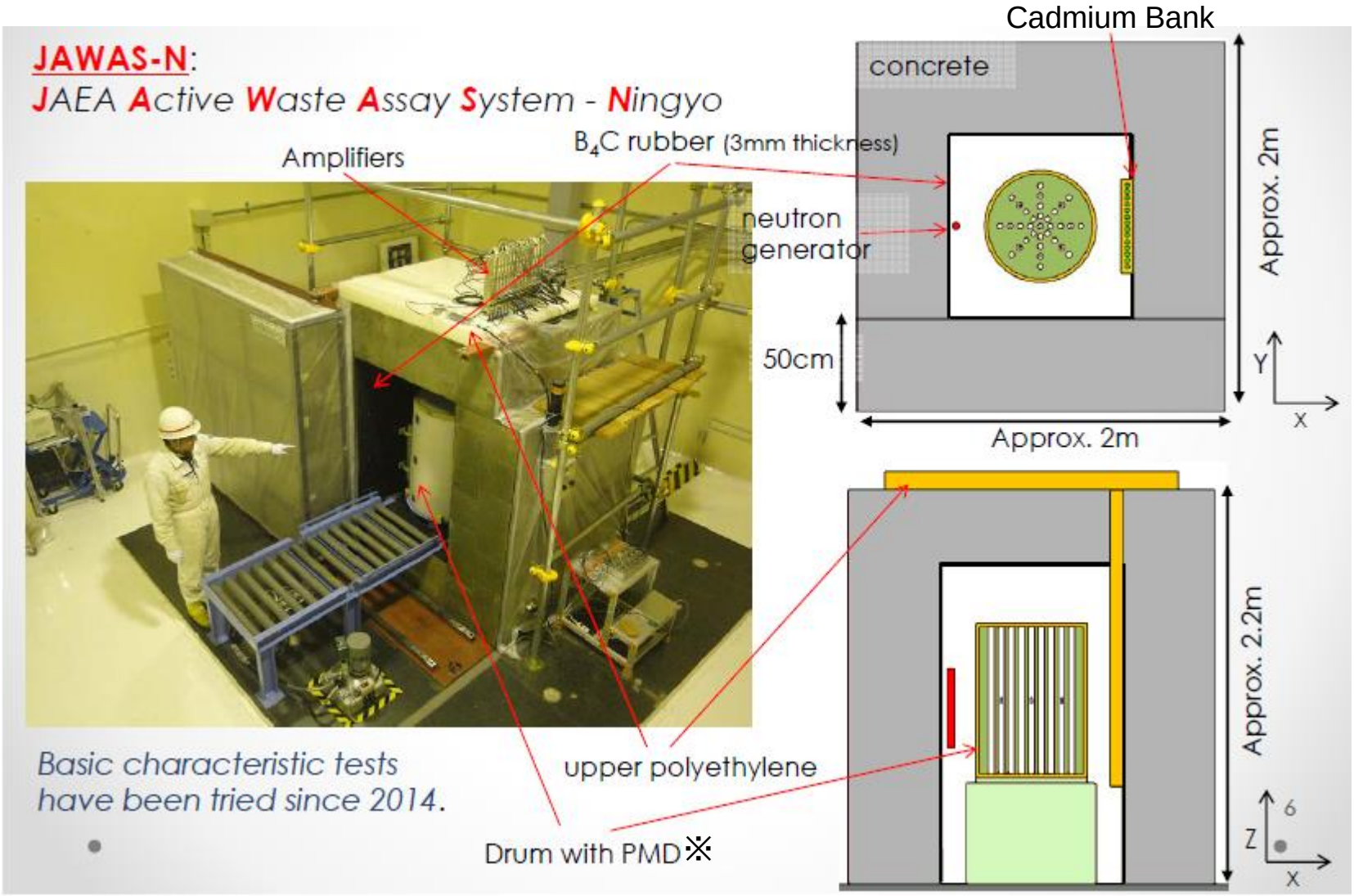
Measurement Interrogation Neutrons Fission Neutrons



Integrated Fission Neutrons
∝ Fissile Materials Mass

- Measurement data is separated into the two components by non-linear least square method.
  - ➢ Fission neutrons component can be simply separated.

FNDI method (Example: JAWAS-N)



※Polyethylene Moderator

FNDI method (Example: JAWAS-N)

Inner Structure (1Hx1Dx1.25H [m])

- (Left) D-T Neutron Generator: 10^8 n/sec, 14MeV
- (Middle) Drum Rotator: 2.5 rpm
- (Right) Cadmium Bank
  - Surface: 2mm Cd-plate
  - 14 ^{3}He-detectors
  - Polyethylene moderator is filled between the Cd-plate and detectors.

Measurement Control Unit

- HV supply
- Timing Pulse Generator
- MCS (Multichannel Scaler)
- PC (control/data log)
  - Analysis System: JAEA original

FNDI method (Performance/Applicability)

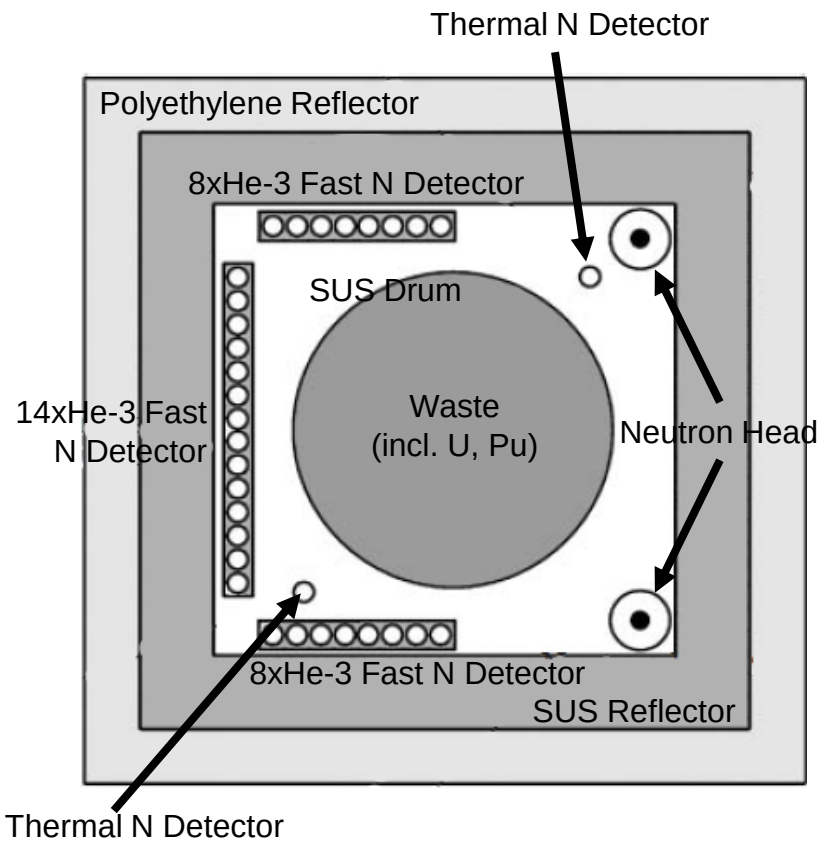
- Performance/Applicability Example (JAWAS-N experiences)

Items	Chemical Form	Applicability
Scrap uranium	UF_4	OK
Uranium absorbed with aluminum oxides pellets	UF_4, UO_2F_2	OK
Uranium absorbed with sodium fluorides pellets	UF_4	OK
Uranium oxides powders	UO_2, UO_3 Mixture of UO_2, UO_3, U_3O_8	OK
Uranium absorbed with calcium precipitates	CaF_2-CaU_2O_7	NG
Small amount of sample	UF_6, UF_4	OK
Others (included solutions)	$UO_2(SO_4)_2$, $UO_2(NO_3)_2$	NG

Demand	Features
Objective Packages	200 litter drum (metal containments)
Detective Range	3gU-200kgU
Accuracy	<20% (in case of <1kgU), <1% (in case of >1kgU)
Measuring Time	10min with additional time (10-15min in case of gamma-ray detection)

FNDI method (Performance/Applicability 2)

- Expected Detection Limit for Pu (Evaluated by simulation code)



Simulation Model

Waste Type	Target Material	Detection Limit		
		mg	Bq/g (α)	PPB
Cementation*1	60% Pu	0.0186	0.545	0.0387
	95% Pu	0.0134	0.0739	0.0279
	Natural U	2.31	0.000122	4.82
Metallic*2	60% Pu	0.0478	3.12	0.222
	95% Pu	0.0345	0.424	0.161
	Natural U	5.96	0.000702	27.7
Cellulose*3	60% Pu	0.0121	2.00	0.142
	95% Pu	0.0875	0.272	0.103
	Natural U	1.51	0.000451	17.7

*1 Total weight: 480kg, 10min of measurement.
*2 Total weight: 215.6kg, 10min of measurement.
*3 Total weight: 85kg, 10min of measurement.

%: ^{239}Pu density