ポータブル核物質NDA測定装置の開発計画

Development of Portable Non-Destructive Assay System for SNMs

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Checking of Detected Objects

Safety checking

After detection of objects with strong suspicions of containing NMs at airports / harbors / Stations / Big Events, and at the time of taking out of NMs from containers

To check whether or not the objects contain explosives or toxic materials before opening.

Checking of NM

(At the same time as safety checking in non-destructive manner)

It is desirable to check the followings.

-fissile contents

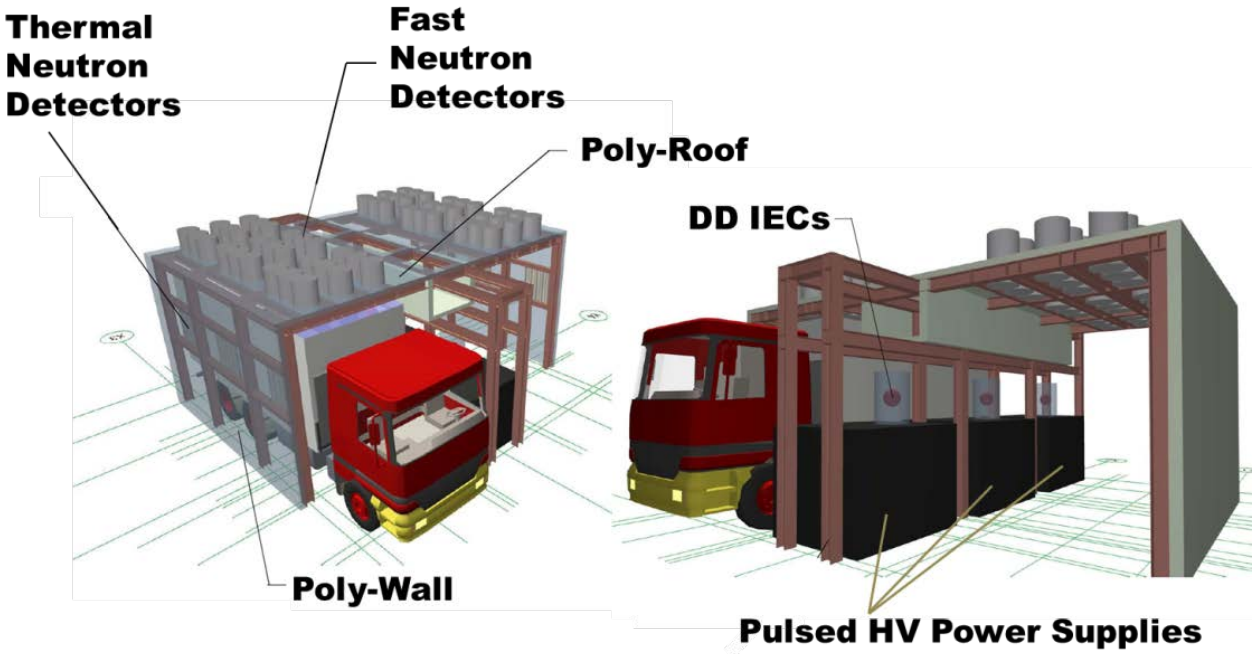
-U/Pu isotopic compositions

R & D in NDA for SNMs

- Several **active interrogation systems** for deployment in seaports and airports have been proposed.

Our team's activity
(R&D FY2012 – 2016)
Supported by JST / MEXT

Successful reduced-scale demo
Detect 1kg HEU hidden in 20ft container
Inspection time: 3 min (400 containers per day)
False alarm rate: <10 %



3 pulsed DD-IECs of 1e8 n/sec

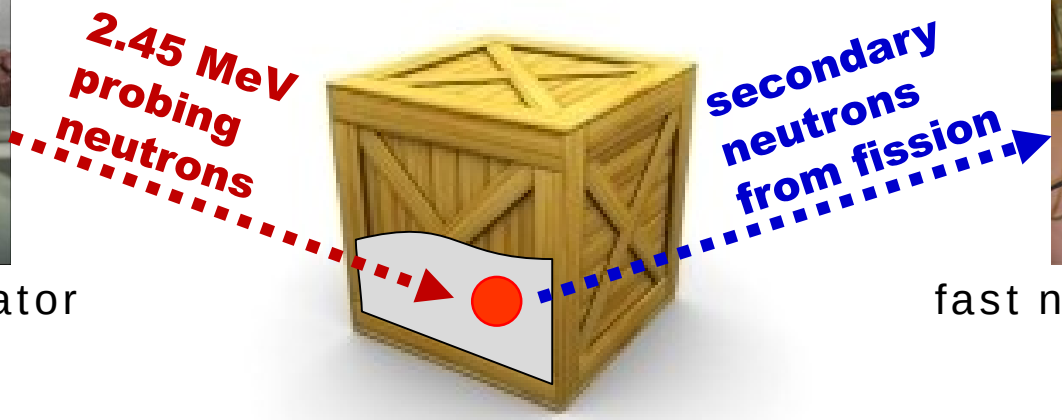
Developed measurement method for active interrogation system

Method	Principle	Neutron Source
NRTA Neutron Resonance Transmission Analysis	Measure the Energy distribution of transmitted neutrons	Pulse Neutron Source + TOF (large facility)
DGA Delayed Gamma-ray analysis	Measure the delayed Gamma-rays from nuclear fission.	Pulse Neutron Source
DDA Differential Die-Away analysis	Measure the Secondary Neutrons from Nuclear Fission	(DT) Pulse Neutron Source
TENA Threshold Energy Neutron Analysis	Measure the Neutrons which has higher energy than the DD neutrons	DD Neutron Source (compact => portable!)

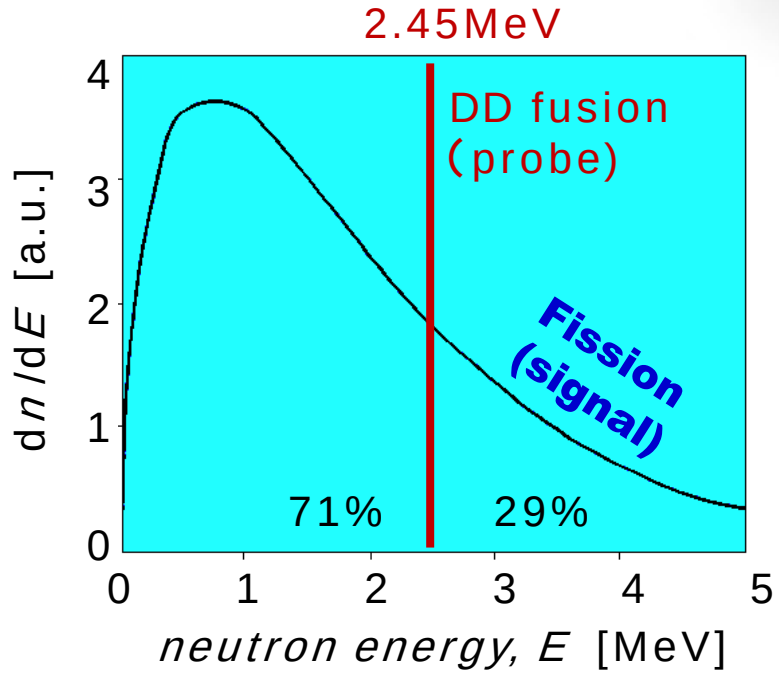
①good SN ratio
②Tritium free
③CW machine : compact

Threshold Energy Neutron Analysis (TENA)

DD neutron generator



fast neutron detector



A significant portion of fission neutrons is above DD neutron energy.

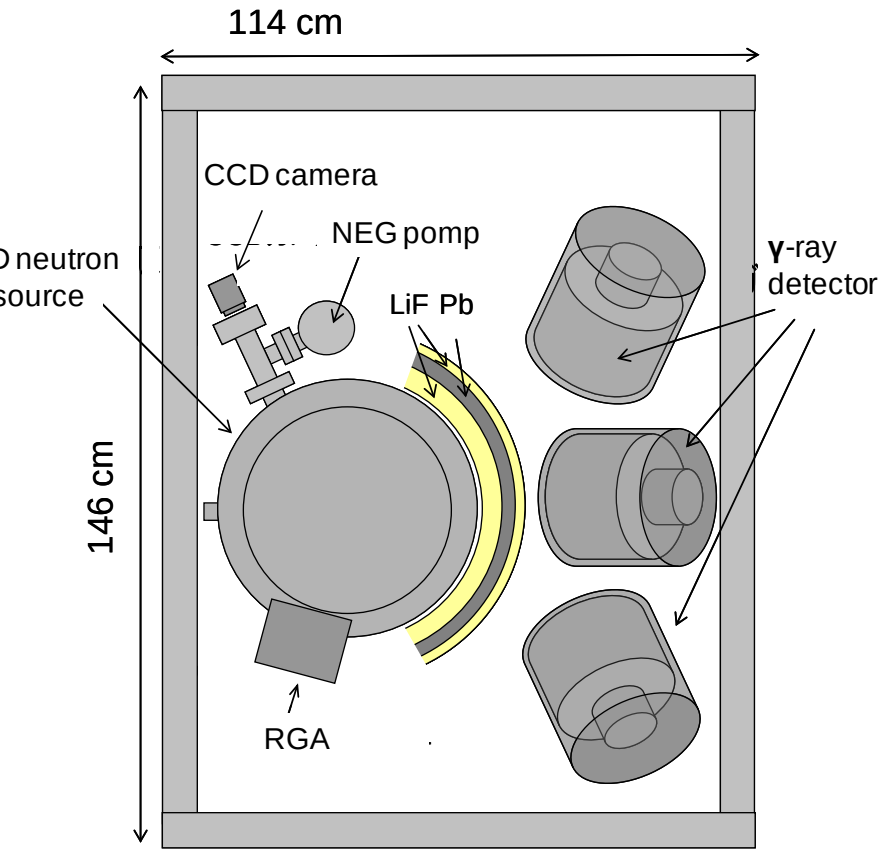
Detect secondary neutrons above the threshold energy.

Scattering makes the probing neutron energy lower.

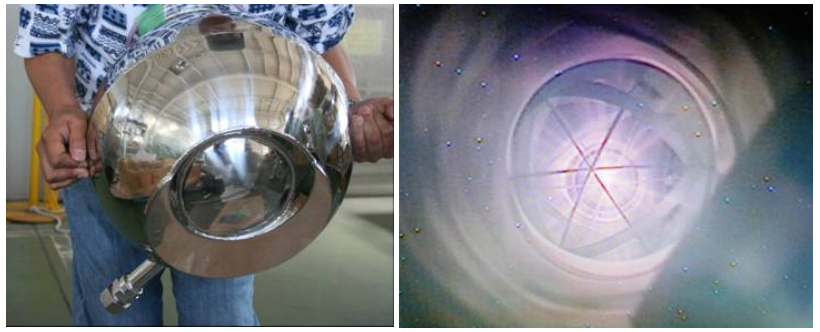
Unless SNMs present, no neutrons above the threshold.

- ✓Use of DD is the key. Neither DT nor RI neutron source is applicable.
- ✓No need of pulsing the neutron generator.

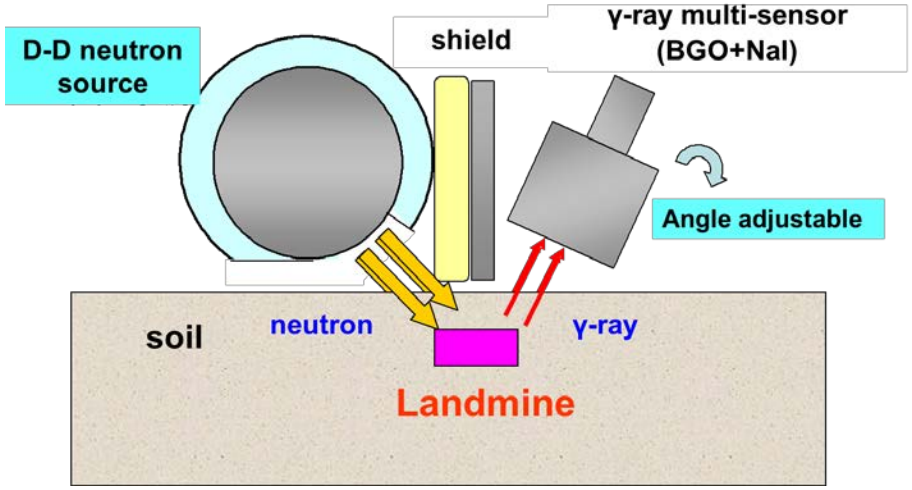
R&D of Explosive Detection (Anti-personnel Landmine, 2002-2007)



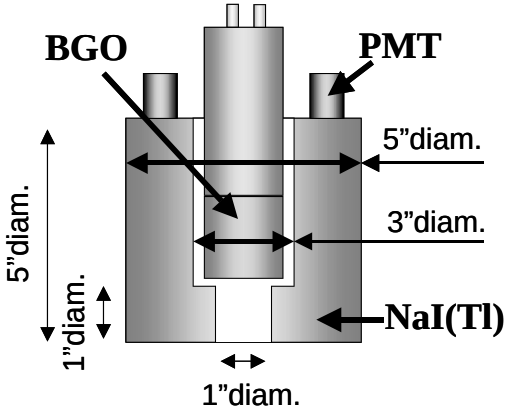
Landmine detector prototype
by use of a DD-IEC neutron source
and directional γ-ray detectors



Compact DD-IEC neutron source and discharge photo inside



Schematic view of landmine detection
via PGA of explosive (nitrogen)



BGO / NaI(Tl) combined γ-ray detector
for directionality through anti-
coincidence technique

Experiments by use of Landmine Simulants (Wax-diluted TNT & RDX)

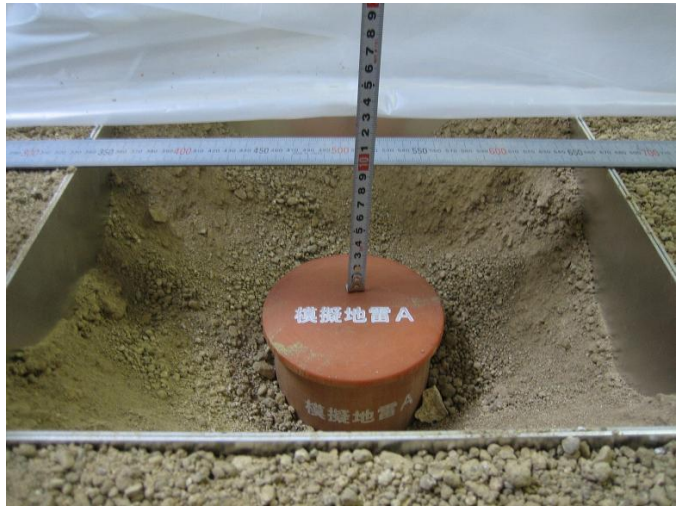
TNT : 240g & 100g

RDX: 100g & 29g

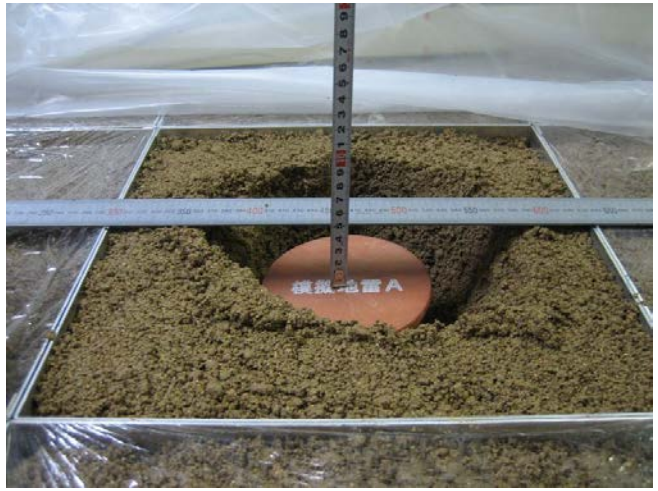
Soil moisture :
2 , 10, 18.5 wt%

Buried depth:
5, 10, 15 cm

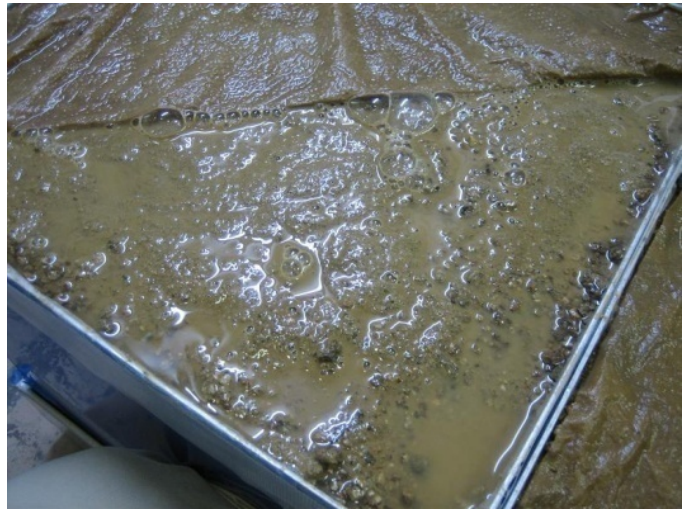
Measurement time:
10 min



Soil moisture 2 %

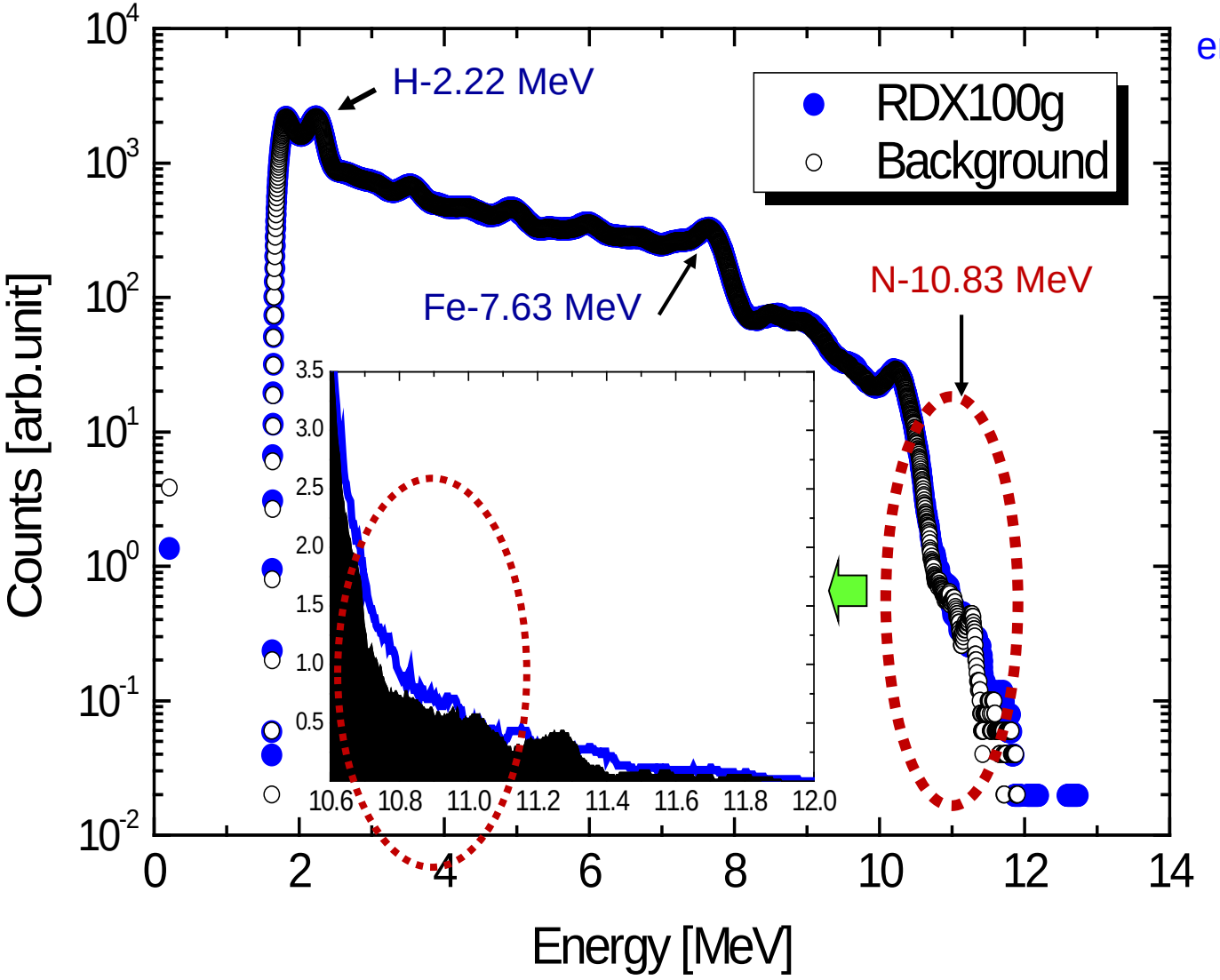


Soil moisture 10 %

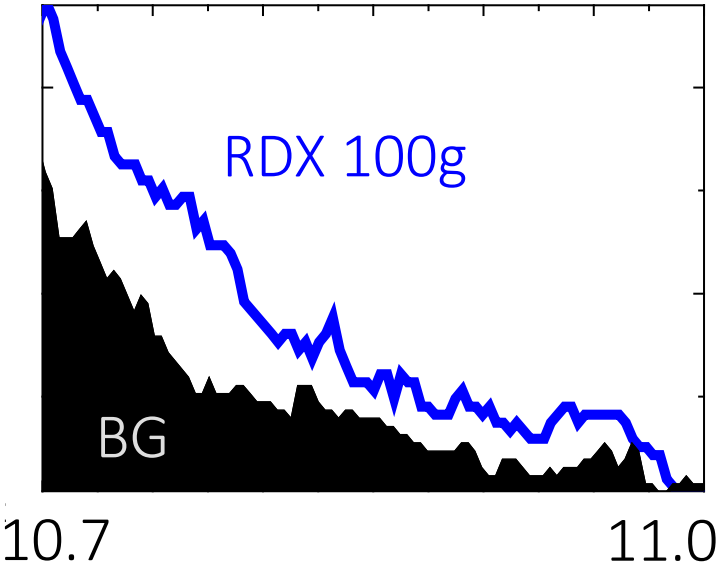


Soil moisture 18.5 %

Measured γ-ray Spectrum Example (100g RDX, BGO/NaI(Tl))



energy calibration by use of
H – 2.22 MeV
Fe – 7.63 MeV



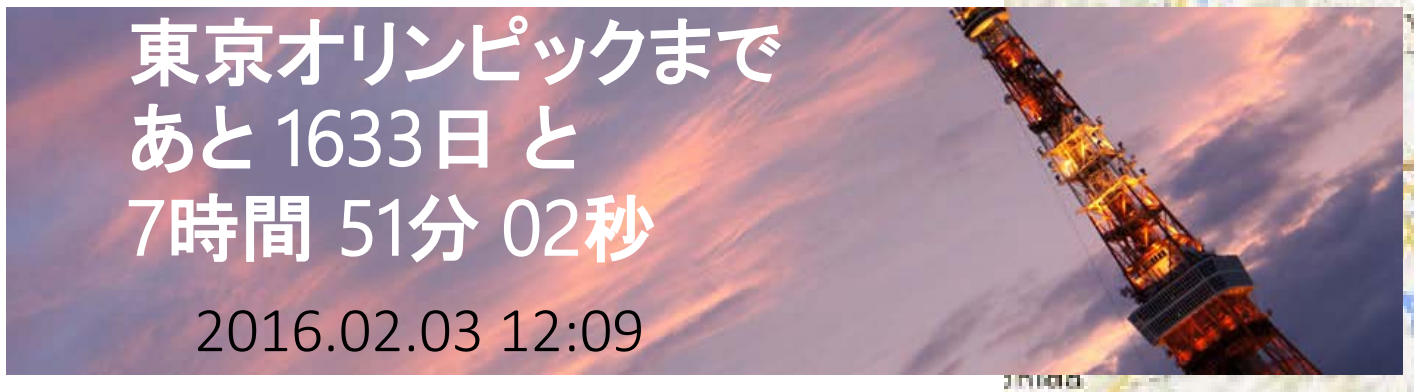
ROI for N-10.83 MeV
to avoid influence of Si – 10.6 MeV

Development of Basic Technologies for Detection / Property Checking of NMs in Japan

Location	Detection Systems	Property Checking Systems
1. Airports/Harbors Illicit NMs in cargo containers	- Setting type (Large size) - Reliable (perfect) detection of NMs (2015JFY-2019JFY) NRF-NDA Demonstration of NMs in Heavy Shielding	- Setting type (Large size) - Reliable (perfect) checking of NMs (2015JFY-2017JFY) Development of Active Neutron NDA Techniques with a D-T Neutron Source
2. Any Locations (Checkpoints) Illicit NMs in freights	- Portable type (Small size) - Reliable detection of NMs	- Portable type (Small size) - Reliable checking of NMs
	Development of Basic Technology for Portable NM Detection/Property Checking System using a D-D Neutron Source (budget to be requested)	

2020TOKYO2020

2020tokyo2020.com



Expected 10M visitors

Olympics: Tokyo to Beef Up 2020 Security After Paris Attacks

Japan's Olympics Minister Toshiaki Endo on Monday promised to public safety the "top priority" of the 2020 Tokyo Games following deadly Paris terror attacks.

Requirement of Immediate Industrialization

- Target : Prototype 2018, Deploy until 2020
- Conventional technology
  - Neutron generator:

    DD Glow-discharge IEC

  - Neutron detector: Commercial Product

    Tensioned Metastable Fluid Detector (TMFD)

NEDO

What are crucially needed for successful "portable" system?

- Identification method to distinguish fission neutrons from probing neutrons.
  - ➢ Threshold Energy Neutron Analysis (TENA)

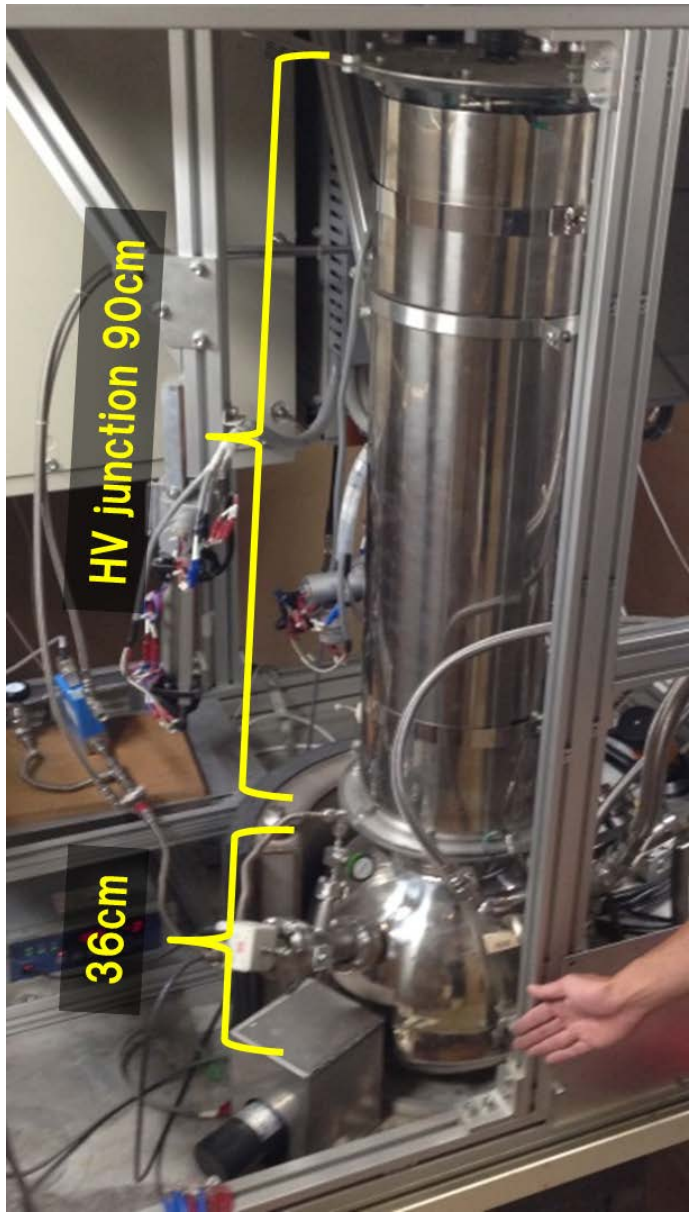
    Ref) K. Masuda et al., US-J IEC workshop (2012).

    Ref) Y. Takahashi et al., Proc. Nuclear Physics and Gamma-ray Sources for Nuclear Security and Nonproliferation, 341 (2014).
- Neutron generator: portable and intense, DD mandatory.
  - ➢ DD Glow-discharge IEC

    Cf) Compact, transportable DD IEC developed ten years ago at KU for LM-detection.
- Neutron detector: blind to probing DD neutrons and background gamma-rays, sensitive to neutrons above 2.45 MeV.
  - ➢ Tensioned Metastable Fluid Detector (TMFD)

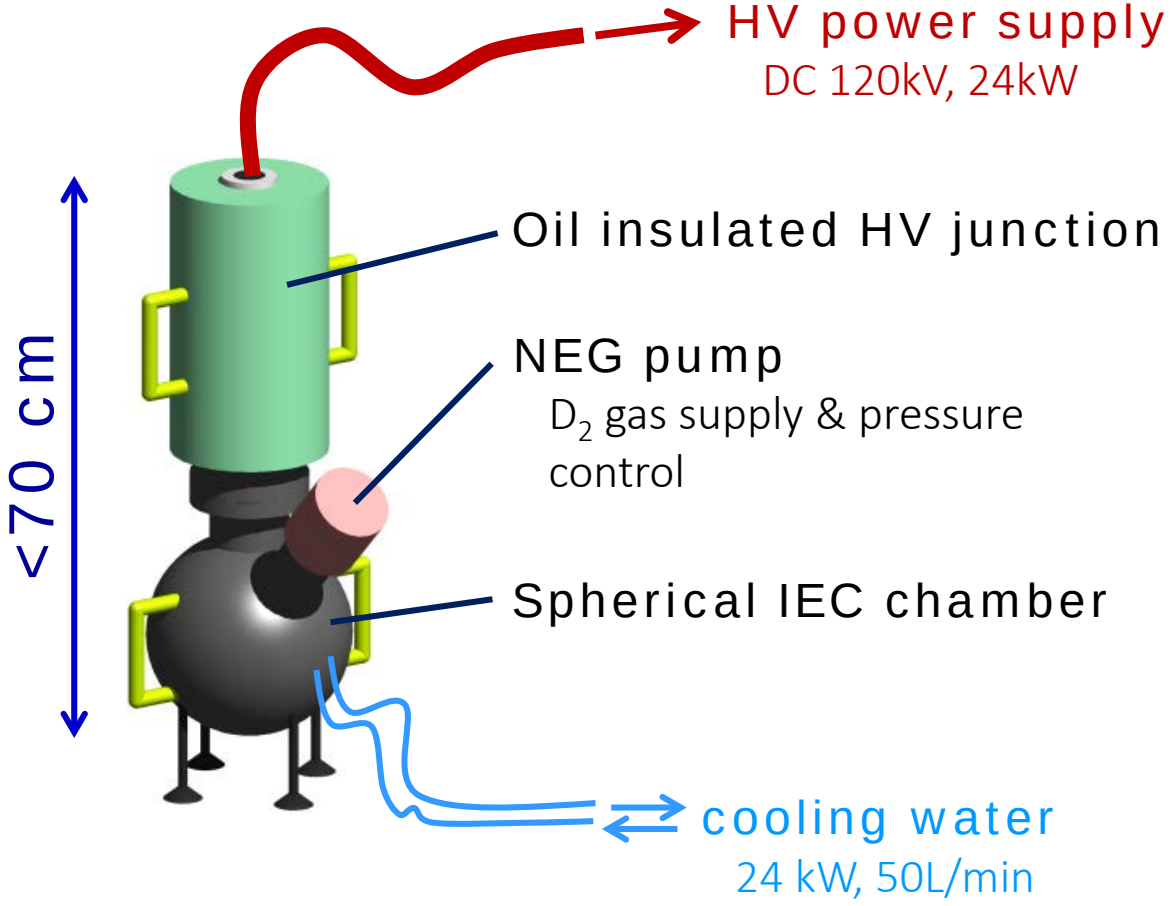
    Ref) R.P. Taleyarkhan et al., Nuclear Engineering and Design 238, 1820 (2008).

Portable DD-IEC

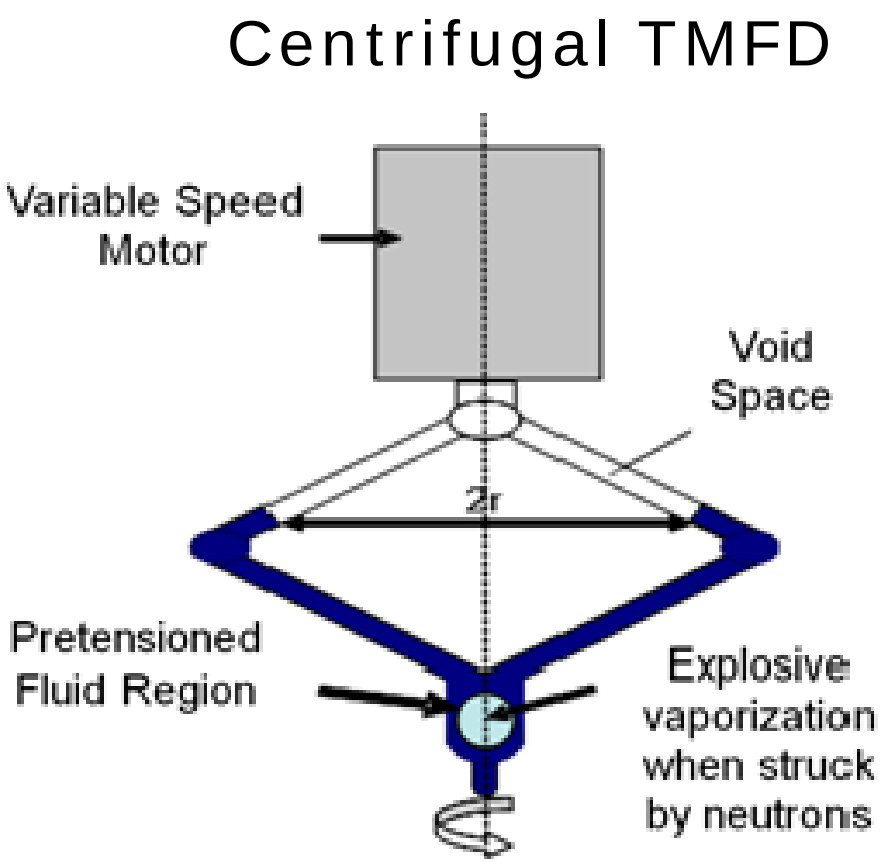


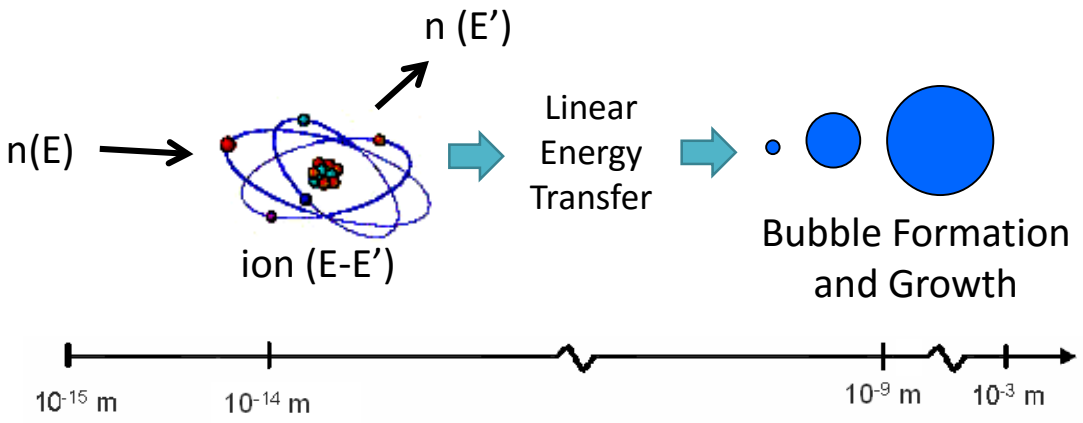
Weight < 30 kg

NPR > 5 x 10^7 n/sec (DD)

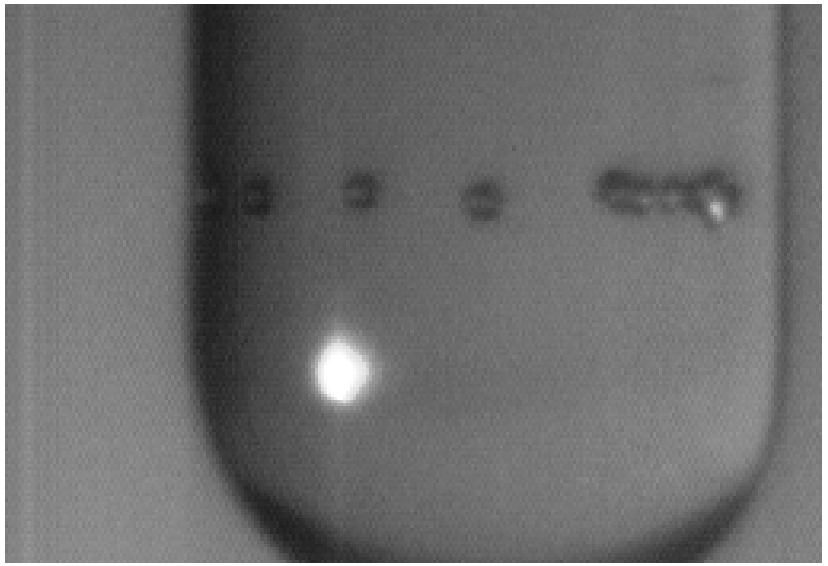


Tensioned Metastable Fluid Detector (TMFD)





- 100% blindness to X/gamma-rays.
- Blind to neutrons below a threshold energy.
- The threshold energy is variable.
- High detection efficiency above the threshold.
- Directionality (by A-TMFD).



Nano-Second Multiplicity Event
Timing with CTMFD & Neutron Directionality

Summary

- Our team has been developing the active interrogation system of SNMs.
- Starting R&D of the portable NDA for SNMs, especially targeting to Tokyo Olympic 2020 supported by the JPN government (NEDO / METI).

- Key technologies are: TENA analysis, TMFD neutron detector, and portable DD-IEC.
- Next step : Explosive detection and development of TMFD,
  Superior performance