



# Development of the 2<sup>nd</sup> Generation of a Quad-CZT Array Based Uranium Enrichment Measurement Equipment

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**3**

**EXPERIMENTS AND RESULTS**

**4**

**CONCLUSION AND FUTURE STUDY**

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## INTRODUCTION

# 1

## INTRODUCTION

### 1. The necessity of a research

- The necessity of the undeclared Uranium Enrichment Facility detection equipment
- The absence of domestic technology for inspection activities
- To improve existing nuclear safeguards inspection equipment



**Alternative  
Technology**



**Rapid  
Detection**



**Field  
Application**

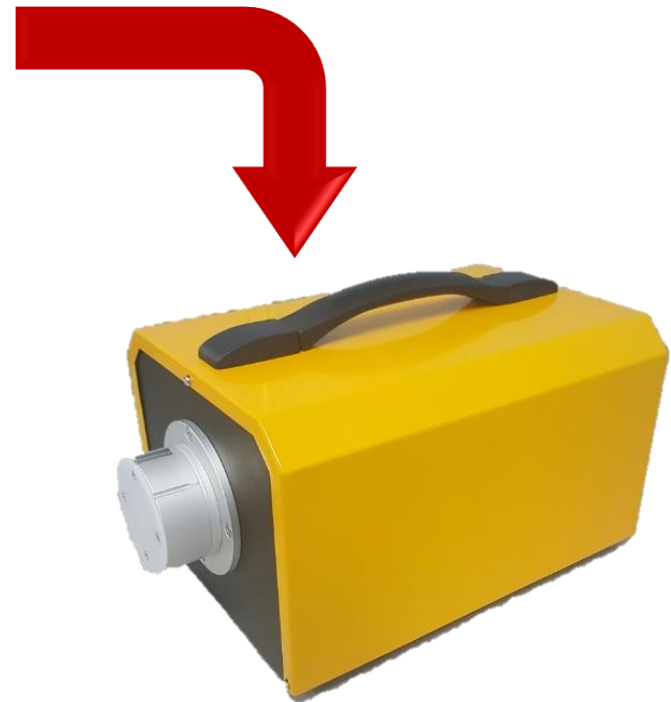
# 1

## INTRODUCTION

### 2. The purpose of a research



**1<sup>st</sup> Quad-CZT array system**



**2<sup>nd</sup> Quad-CZT array system**

**Development of the 2<sup>nd</sup> Quad-CZT array system  
to improve the drawback of the 1<sup>st</sup> Quad-CZT array system**



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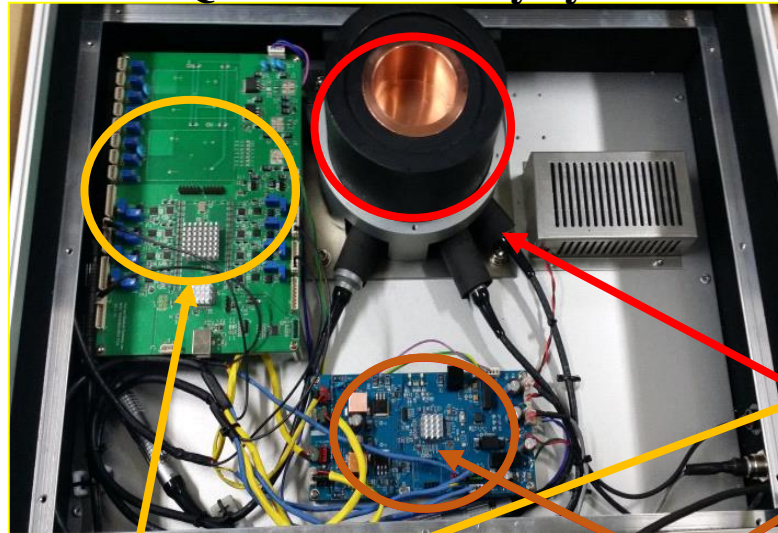
2

**DEVICE  
AND  
METHODS**

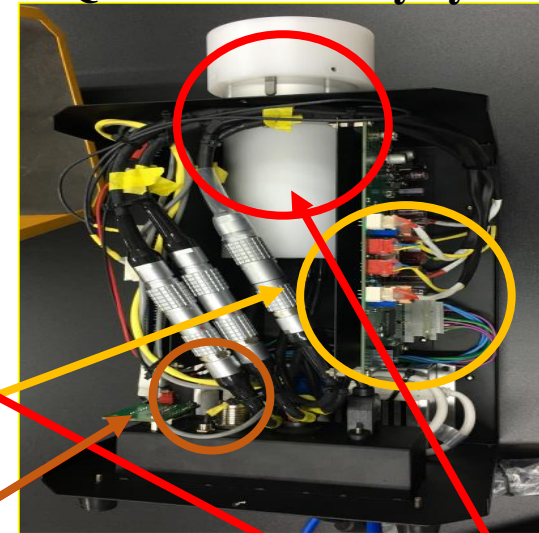
# DEVICE AND METHODS

## 2.1 Quad-CZT Array system Hardware

1<sup>st</sup> Quad-CZT array system



2<sup>nd</sup> Quad-CZT array system



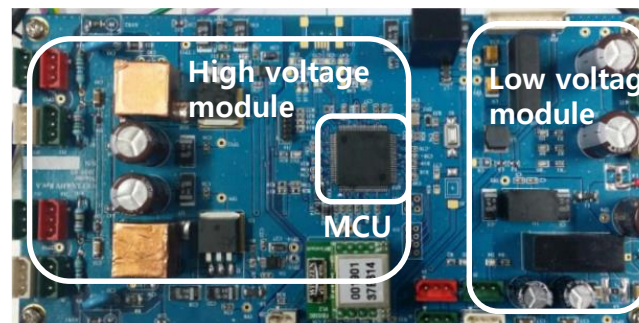
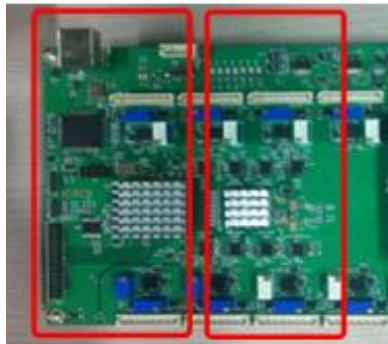
DAQ Board

High Voltage  
Control Board

4 CZT array  
Detector

FPGA &  
MCU

Signal process  
ADC

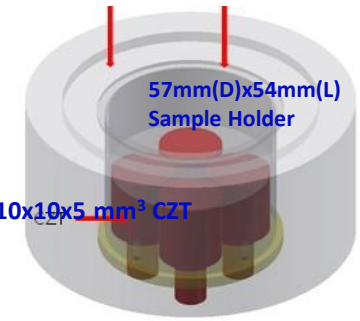


30 mm Pb

2.0 mm Cu

57mm(D)x54mm(L)  
Sample Holder

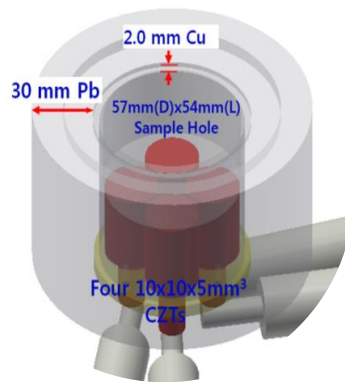
10x10x5 mm<sup>3</sup> CZT



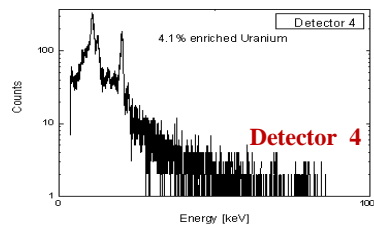
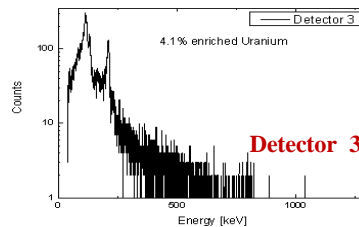
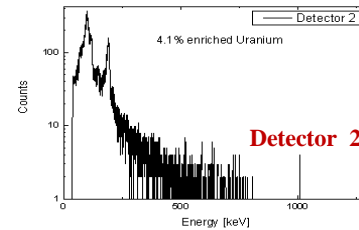
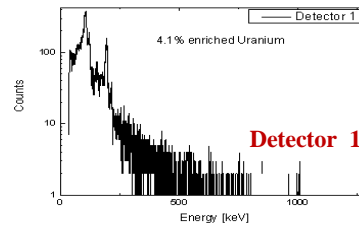
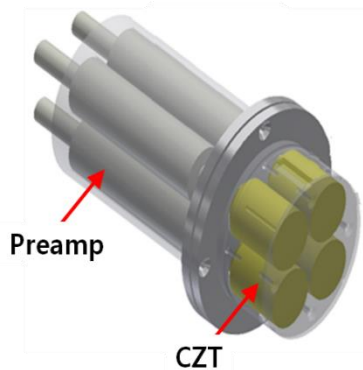
# DEVICE AND METHODS

## 2.2 Quad-CZT Array system Software

### 1<sup>st</sup> Quad-CZT array



### 2<sup>nd</sup> Quad-CZT array



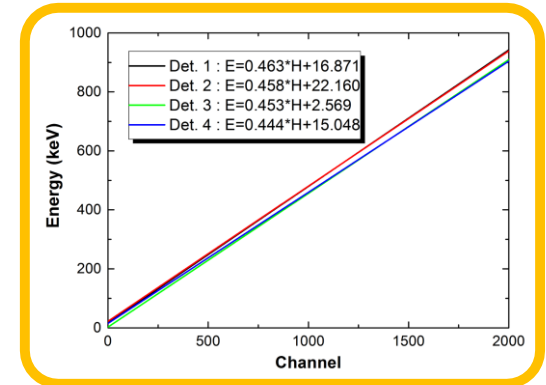
Individual Spectrum



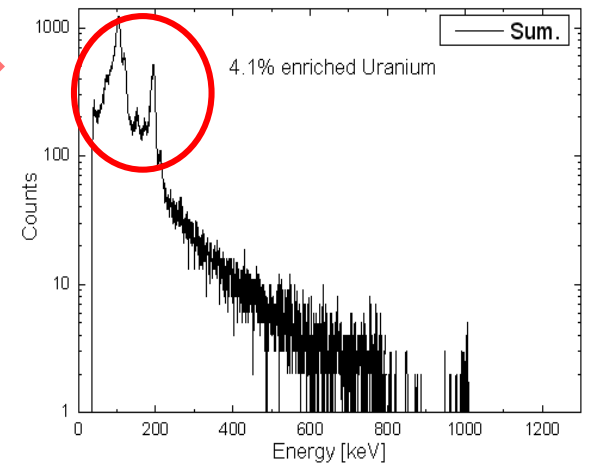
SUM



### Detector Calibration



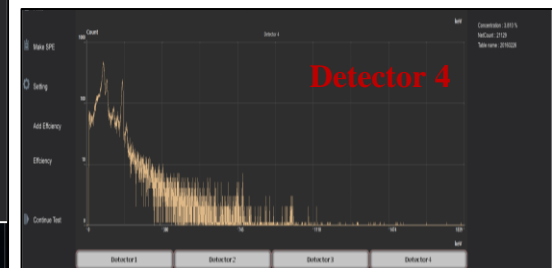
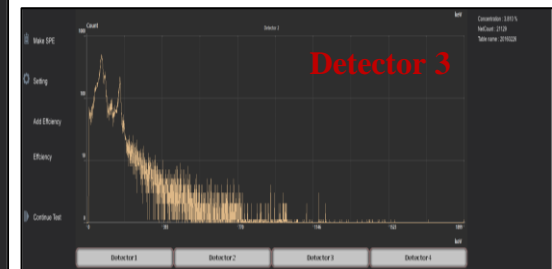
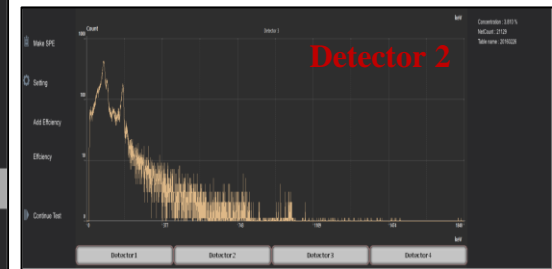
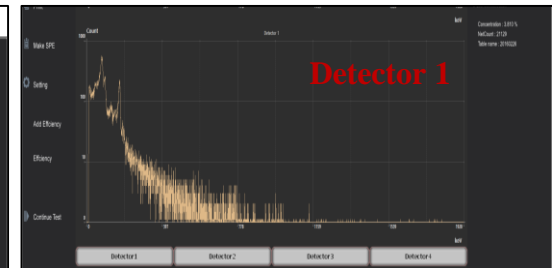
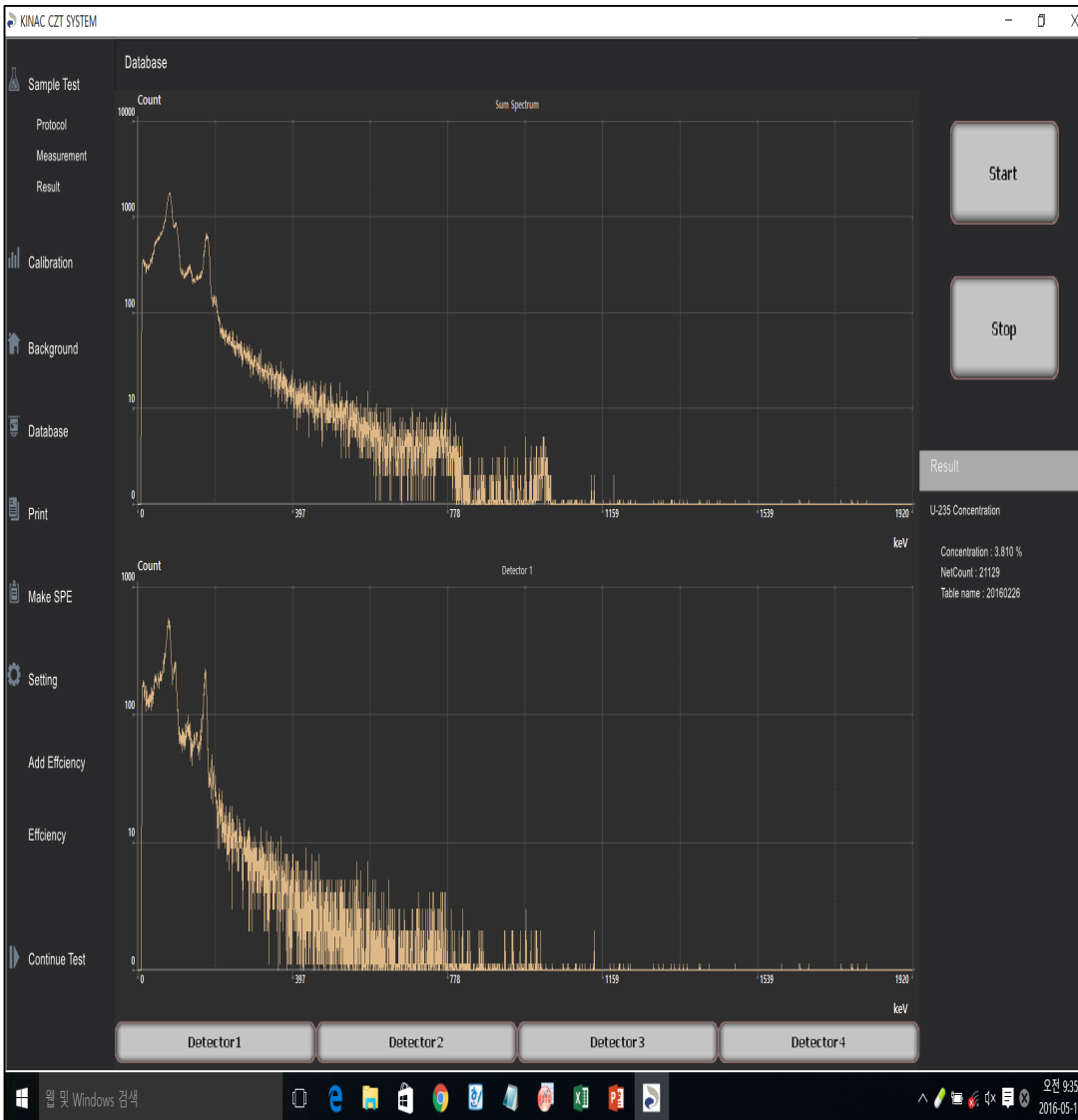
### Sum Spectrum





# DEVICE AND METHODS

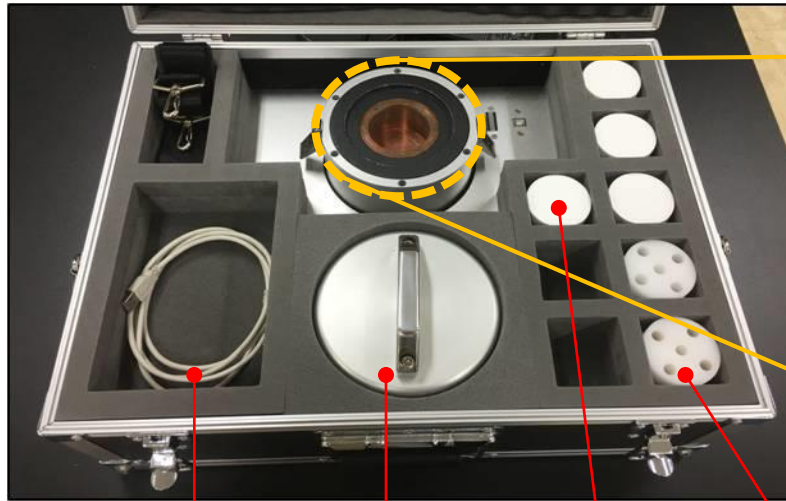
## 2.2 Quad-CZT Array system Software



# 2

## DEVICE AND METHODS

### 2.3 The 1<sup>st</sup> Quad-CZT Array system

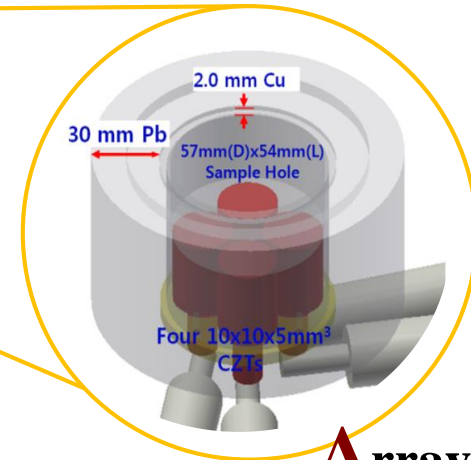


Cable

Lead shield

Sample container

Pellets adaptor



Array structure

\* This equipment was developed portable gamma spectrometry system utilizing the quad-CZT array in 2014.

#### ❖ Equipment Specification

- **S**ize : (H) 23.5 cm x (W) 51 cm x (L) 38.5 cm
- **W**eight : 28 kg
- **S**pectrum channel : 4096 channel
- **E**nergy range : ~ 1.8 MeV

# DEVICE AND METHODS

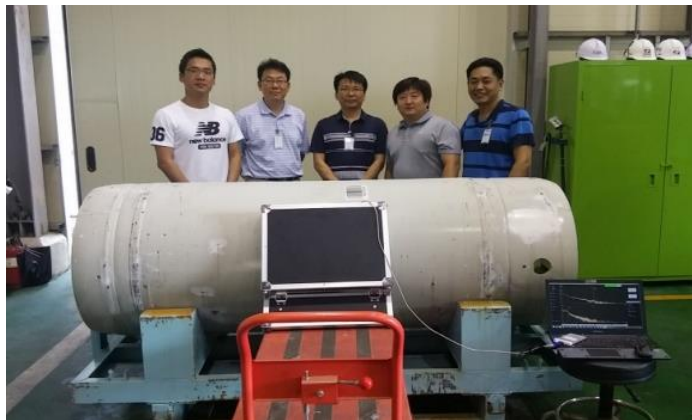
## 2.3 The 1<sup>st</sup> Quad-CZT Array system

### ❖ Field application test

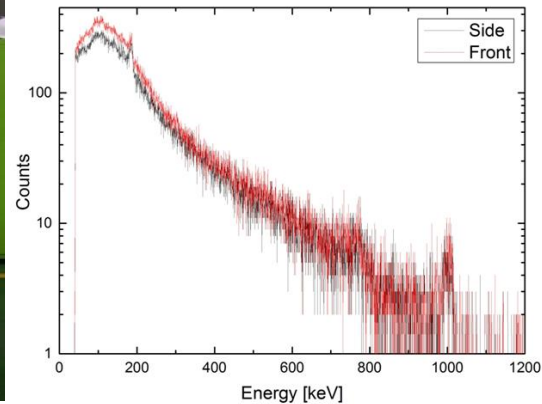
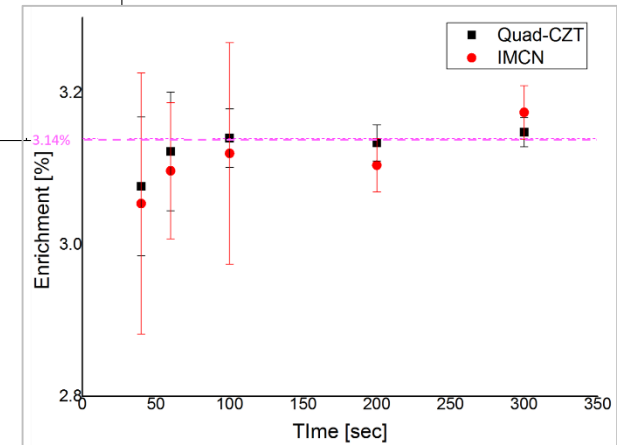
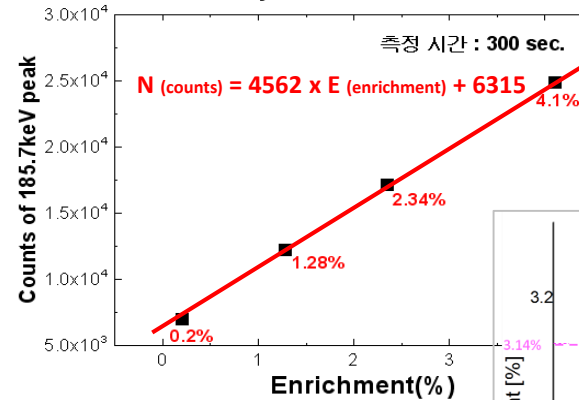
#### < UO<sub>2</sub> Pellets >



#### < UF<sub>6</sub> Cylinder >

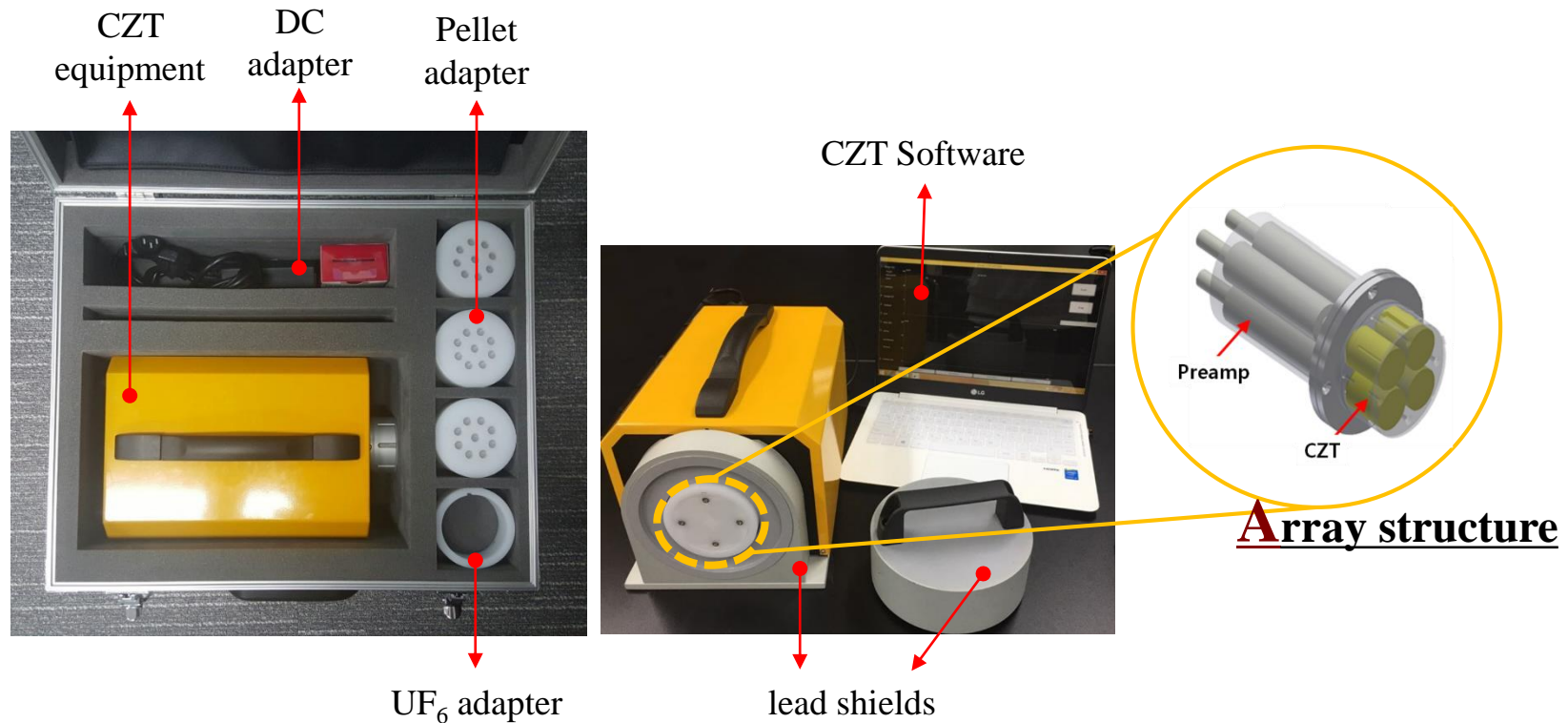


4 CZT Array 검출기를 이용한 농축도 측정



# DEVICE AND METHODS

## 2.4 The 2<sup>nd</sup> Quad-CZT Array system



### ❖ Equipment Specification

- **Size** : (H) 23.5 cm x (W) 51 cm x (L) 38.5 cm
- **Weight** : 5 kg (only equipment), 12 kg (including shields)



# 2

## DEVICE AND METHODS

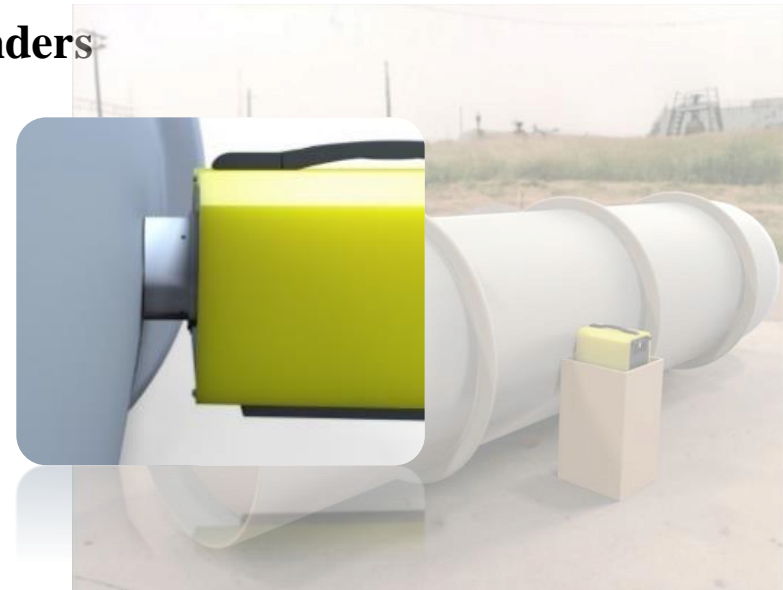
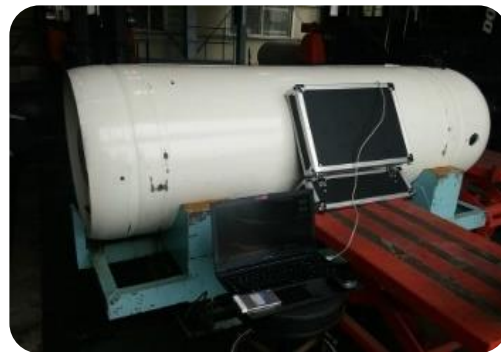
### 2.4 The 2<sup>nd</sup> Quad-CZT Array system

#### ❖ Equipment improvements (1<sup>st</sup> system → 2<sup>nd</sup> system)

##### 1. Equipment Optimization

- **S**ize : 23.5 cm x 51.0 cm x 38.5 cm → 18.2 cm x 19.2 cm x 32.4 cm
- **W**eight : 28 kg → 5 kg
- **D**etachable lead shields
- **M**ore User-friendly

##### 2. Approachableness at UF<sub>6</sub> cylinders



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**3**

**EXPERIMENTS  
AND  
RESULTS**

# 3

## EXPERIMENTS AND RESULTS

### 1. Comparing the performance of Quad-CZT Array systems

1<sup>st</sup> Quad-CZT array system



2<sup>nd</sup> Quad-CZT array system

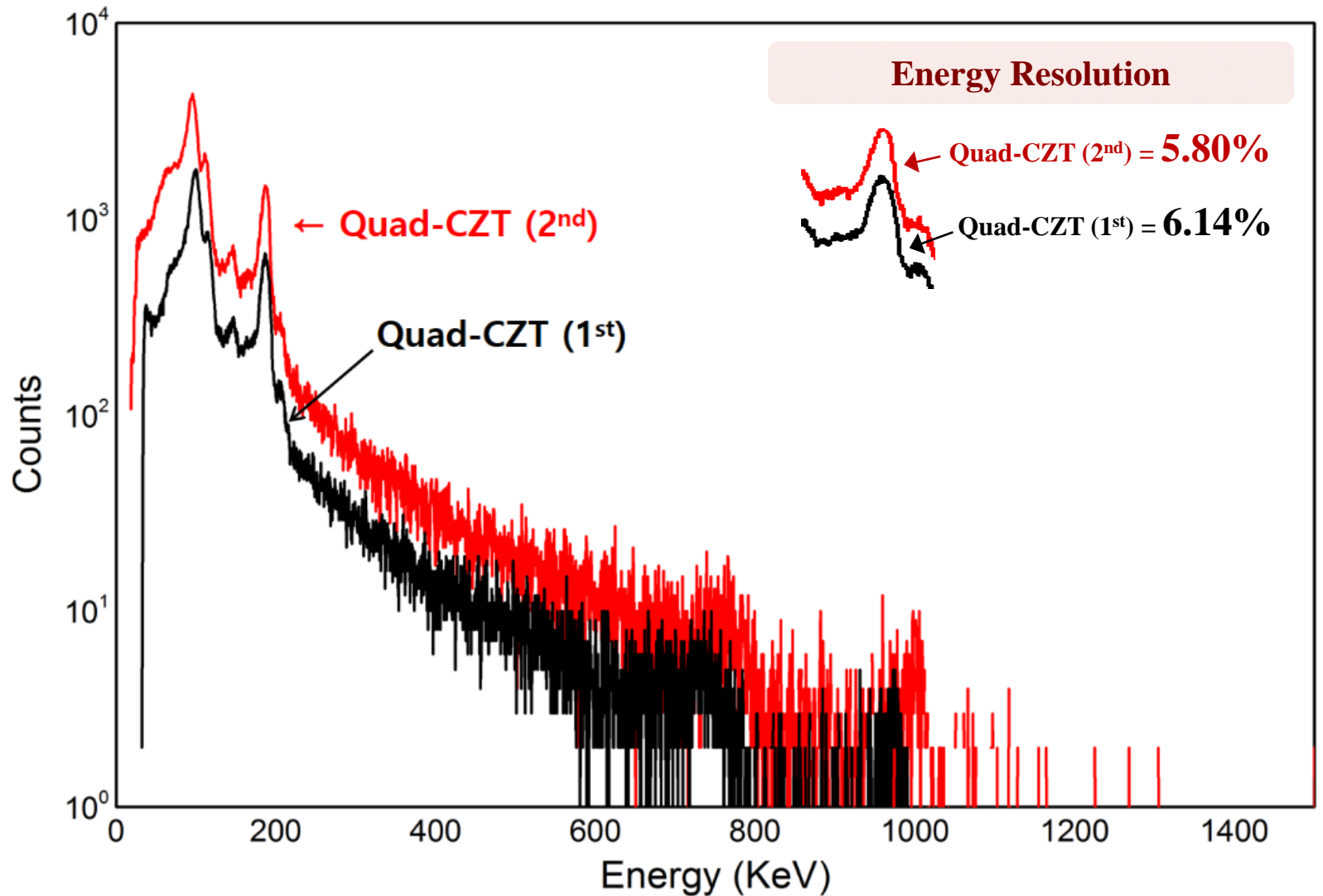


Comparing the measurement results for the same sample  
by Quad-CZT array systems

- **Sample** : 3.8% enriched uranium pellets
- **Measurement time** : 300 sec
- **Analysis Method** : Fast Uranium Enrichment Screening test

# EXPERIMENTS AND RESULTS

## 1. Comparing the performance of Quad-CZT Array systems





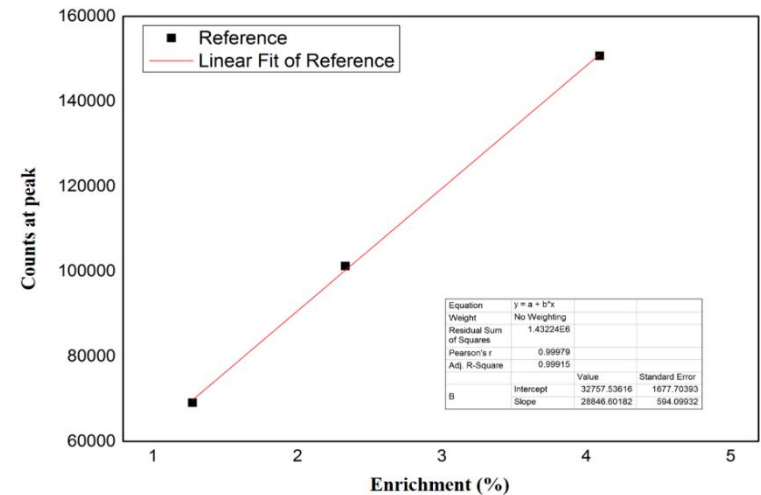
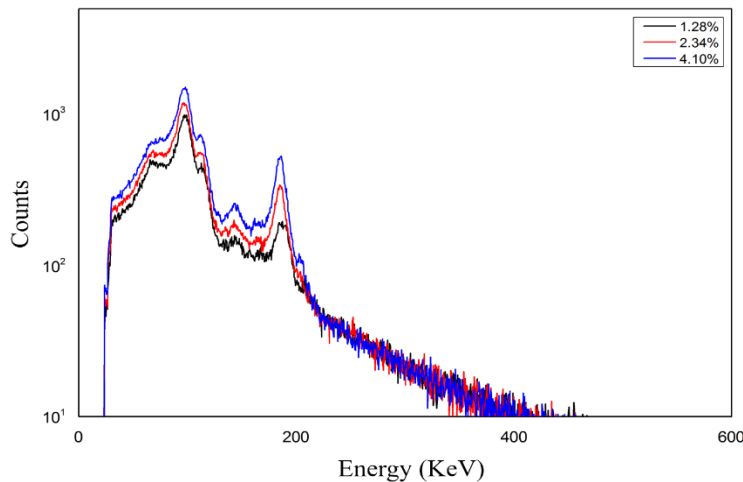
# EXPERIMENTS AND RESULTS

## 2. Fast Uranium Enrichment Screening test

### Reference sources

#### ❖ Reference information

- Measurement time : 300 sec
- Enrichment : 1.28%, 2.34%, 4.10%



Enrichment	Net Counts	type
1.28%	69,078	4-pellet
2.34%	101,226	4-pellet
4.10%	150,665	4-pellet

a (intercept)	b (slope)	R <sup>2</sup>
32,757	28,846	0.99979

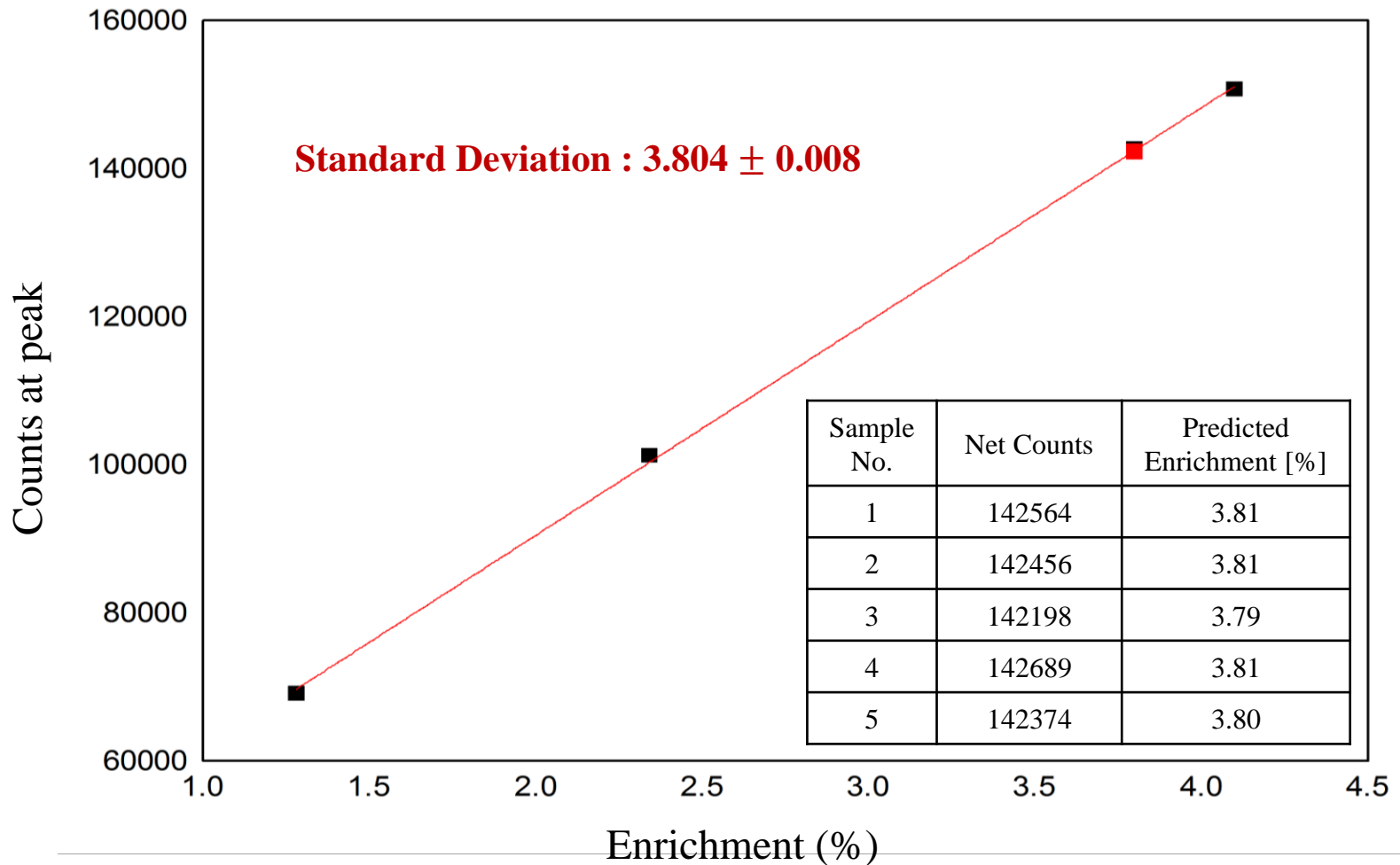
$$\text{Enrichment (\%)} = \frac{(\text{Counts} - 32757)}{28846}$$

# 3

## EXPERIMENTS AND RESULTS

### 2. Fast Uranium Enrichment Screening test

#### The Measurement Result of Unknown samples



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4

**CONCLUSION  
AND  
FUTURE STUDY**

# CONCLUSION AND FUTURE STUDY

1. Development of the 2<sup>nd</sup> Quad-CZT array system to improve the drawback of the 1<sup>st</sup> Quad-CZT array system

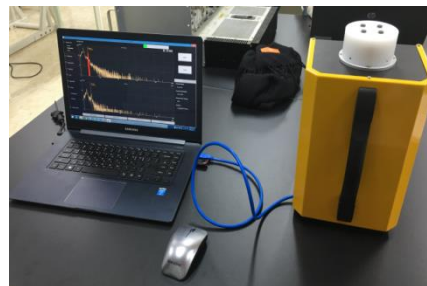


1. Miniaturization    2. Approachableness

2. Evaluation of the 2<sup>nd</sup> Quad-CZT array system performance.

## ❖ FUTURE STUDY....

- ✓ Field application test
- ✓ Software improvement
- ✓ Development and application of the Embedded monitoring system for CZT equipment







**THANK YOU FOR  
YOUR ATTENTION**