

Development of a γ -ray Spectroscopy System Using CsI(Tl)-PIN Diode Detector for Educational Purpose

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Y.M. NAM, B.J. MIN, H.S. KIM and J.H. HA



Nuclear Training & Education Center
Korea Atomic Energy Research Institute

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About NTC/KAERI



□ Missions

- Development of nuclear human resources in Korea
- International cooperation in nuclear education and training



NTC's Main Building

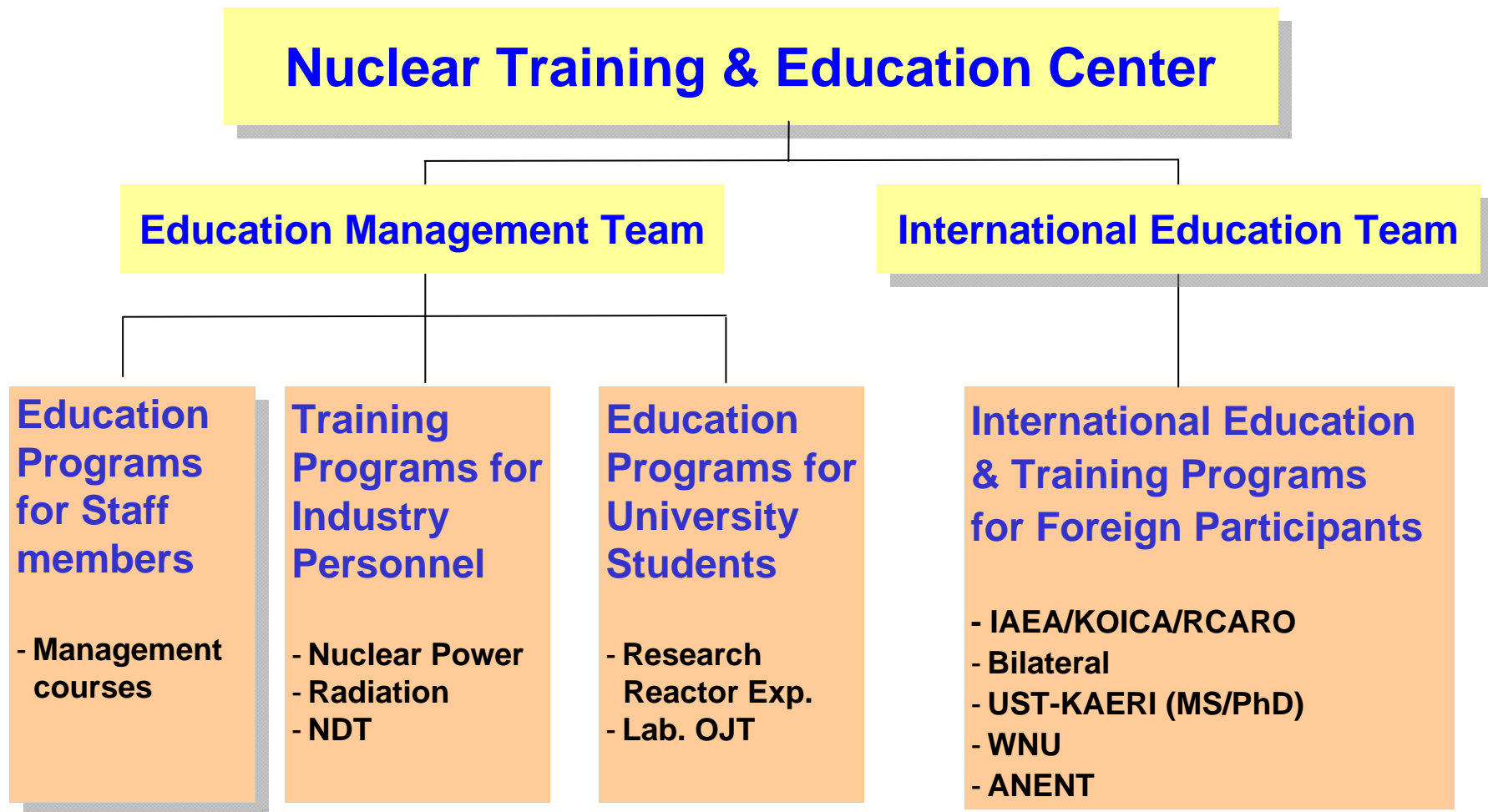
NTC's INTEC Building



About NTC/KAERI



❑ Organization and Programs



About NTC/KAERI



□ Gamma Spectroscopy Lab. at NTC/KAERI

- 3 NaI spectroscopy systems
- 2 HPGe spectroscopy systems



Background



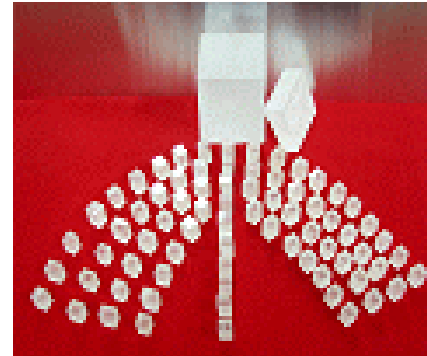
- ❑ Hands-on experiments involving radiation at schools would be an effective way to enhance the understanding and perception for students
- ❑ Conventional NIM modules for γ -ray spectroscopy have some drawbacks for student experiments
 - Systems are not cheap nor simple
 - They are generally fragile and require a high voltage or cooling system
 - For safety concerns, they should be operated by professionals
- ❑ A simpler and cheaper γ -ray spectroscopy system would be an effective equipment to educate students in radiation fields
- ❑ We at KAERI developed a simple γ -ray spectroscopy tool kit that can be readily deployed for the above mentioned aspirations

CsI(Tl)/PIN Diode Detector



□ CsI(Tl) scintillator

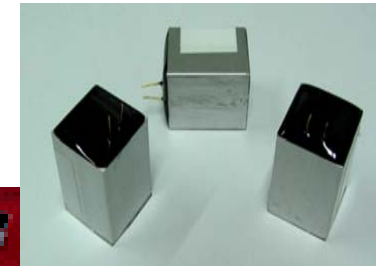
- Size: 10mm(W)×10mm(L)×20(H)mm
- Density: 4.51g/cm²
- Hardness: 2Mohs
- Emission spectrum: 550 nm



CsI(Tl) Scintillators

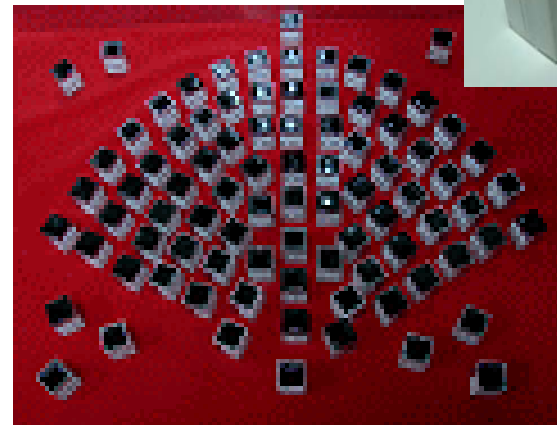
□ PIN diode

- Model: Hamamatsu 3590-08
- Size: 10 mm²
- Absorption spectrum of Si:~ 550 nm



□ CsI(Tl)/PIN diode detector

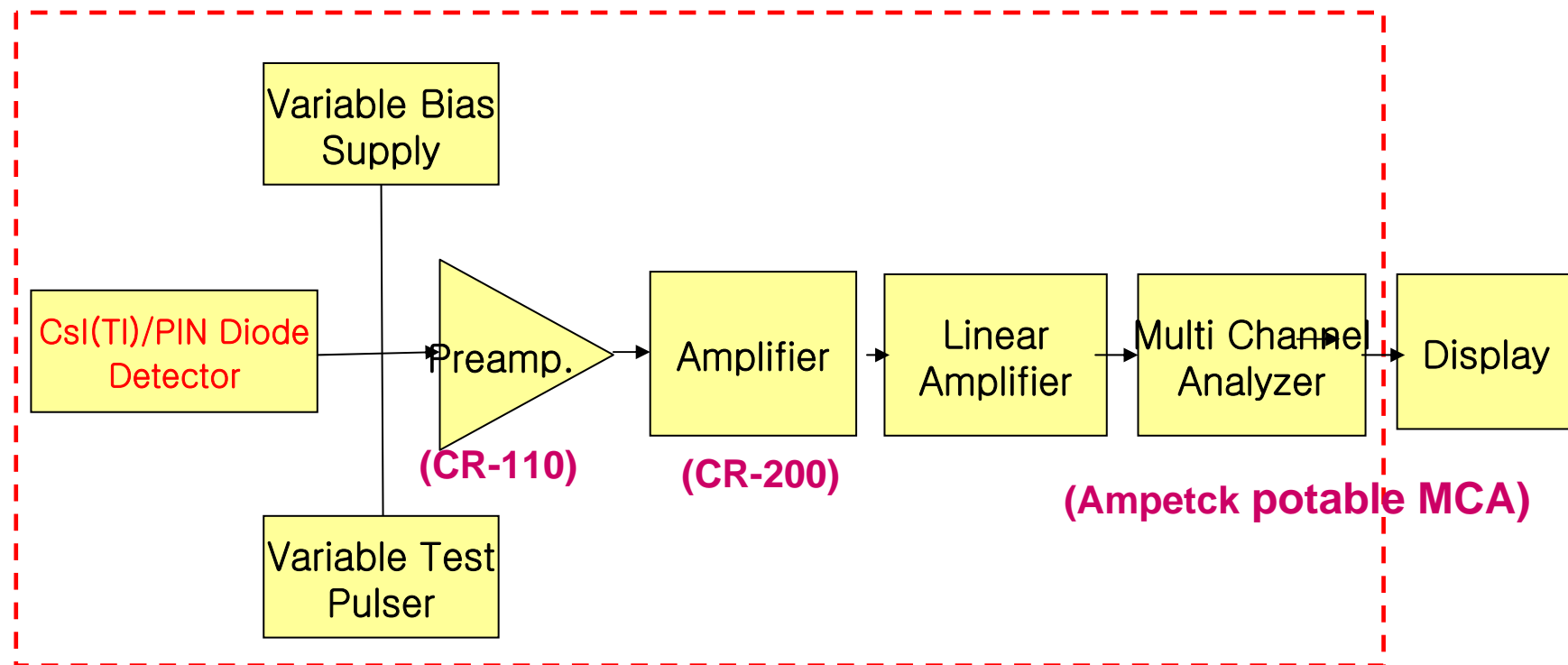
- Using optical grease and PTFE tapes, CsI(Tl) scintillator and PIN diode are assembled into CsI(Tl)/PIN diode detector



CsI(Tl)/PIN diode detectors

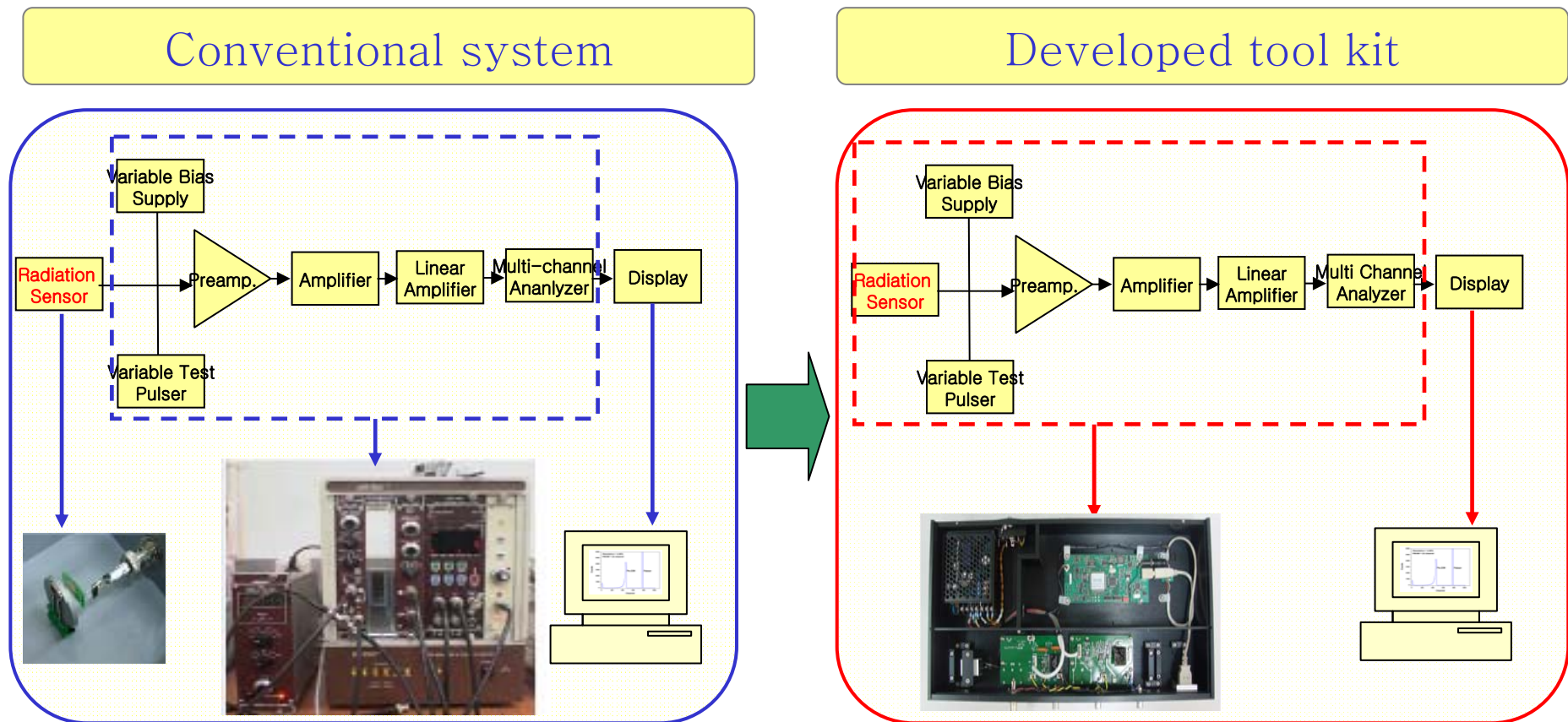
Design of a Spectroscopy Tool Kit (1)

- Owing to the use of PIN diode, it was able to mount the whole system in a small aluminum chassis



Design of a Spectroscopy Tool Kit (2)

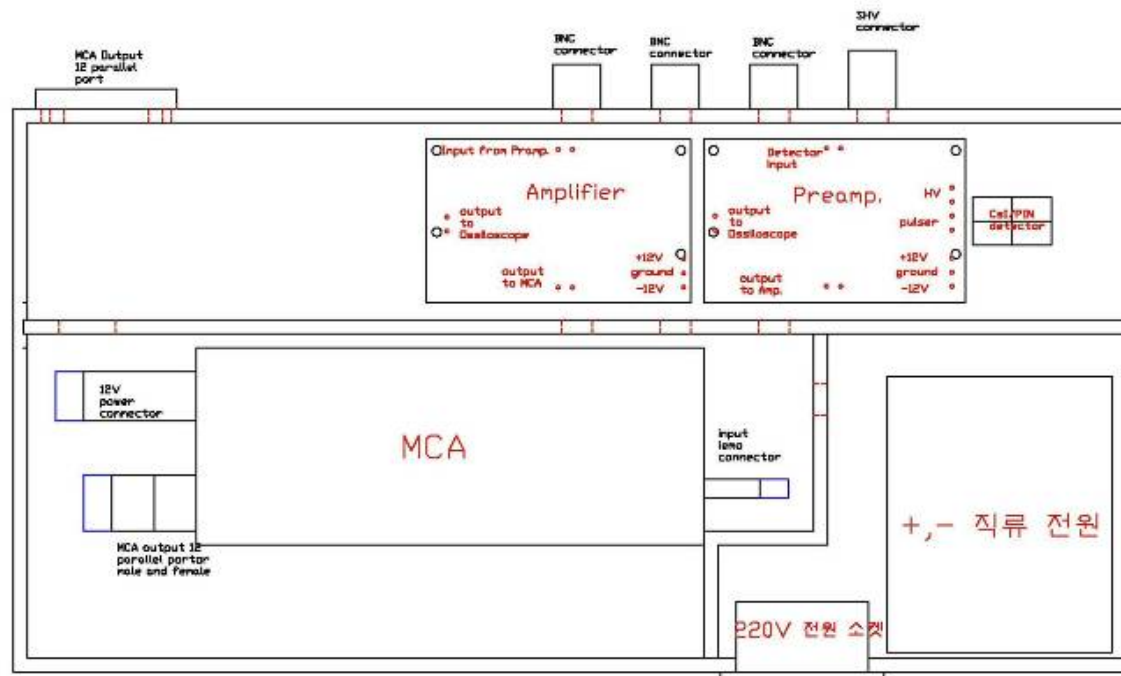
Comparison between a conventional system and the developed spectroscopy tool kit



Design of a Spectroscopy Tool Kit (3)

Layout of the simple γ -ray spectroscopy tool kit

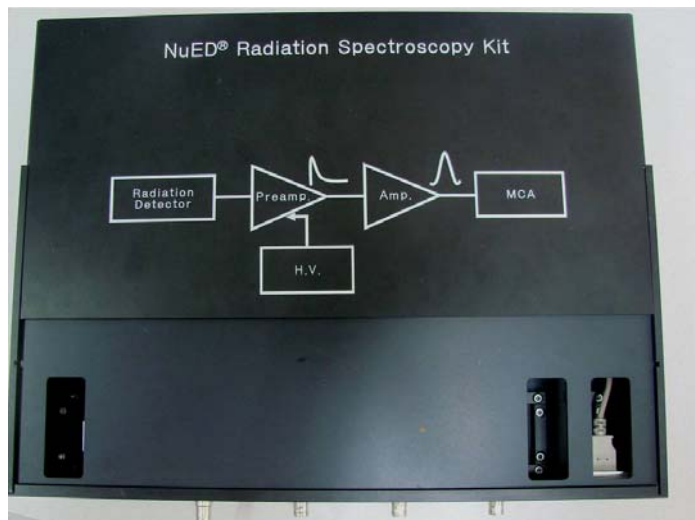
- ➔ The system consists of a CsI(Tl)/PIN diode detector, integrated electronics and a multi-channel-analyzer
- ➔ The tool kit is rugged, quite compact and portable



Fabrication of the prototype(1)

□ Exterior view of the prototype

- Size: 40 cm (W) X 20 cm (L) X 6 cm (H)
- Module components are shown on the top lid
- Double lids are used to reduce noise, the top lid slides easily
- Rectangular opening on the left is for replacement of the source/sample



Fabrication of the prototype(2)



□ Interior view of the prototype

- **BNC Connectors for test, preamp. and amp.:** check pulse shape from preamplifier and amplifier
- **USB port used for connection with a laptop**



Fabrication of the prototype(3)



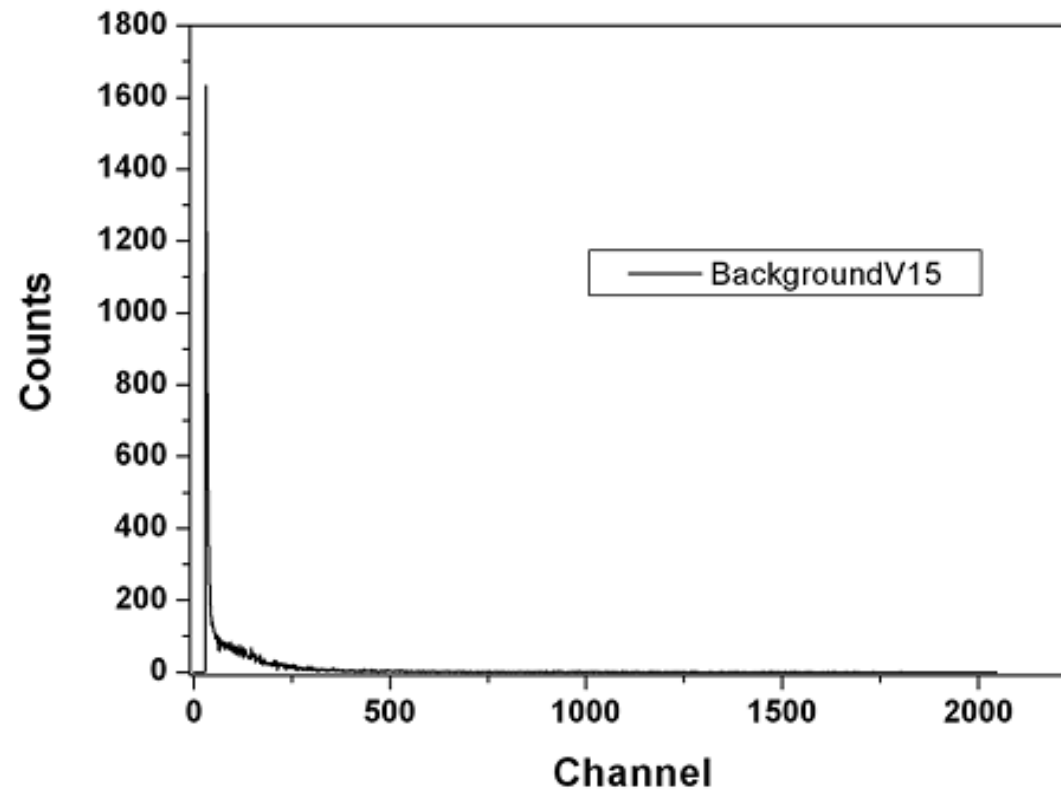
□ Spectrum display via a laptop



Performance (1)



□ Background spectrum without source



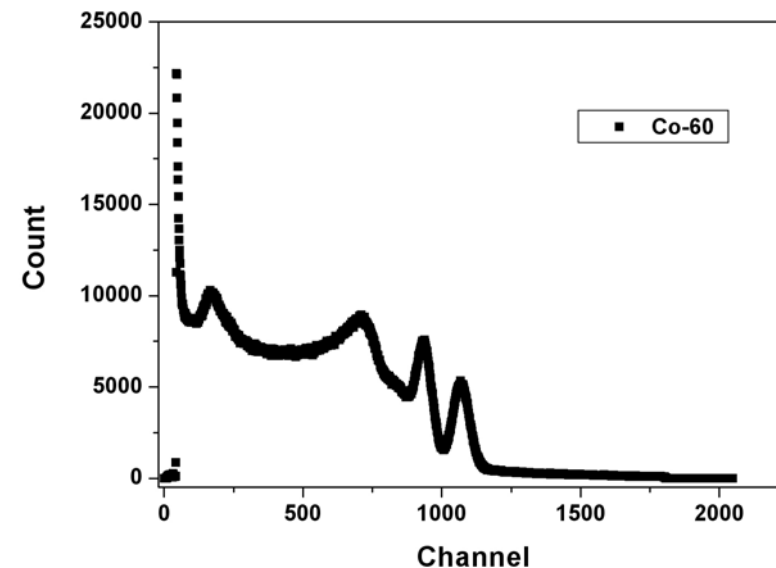
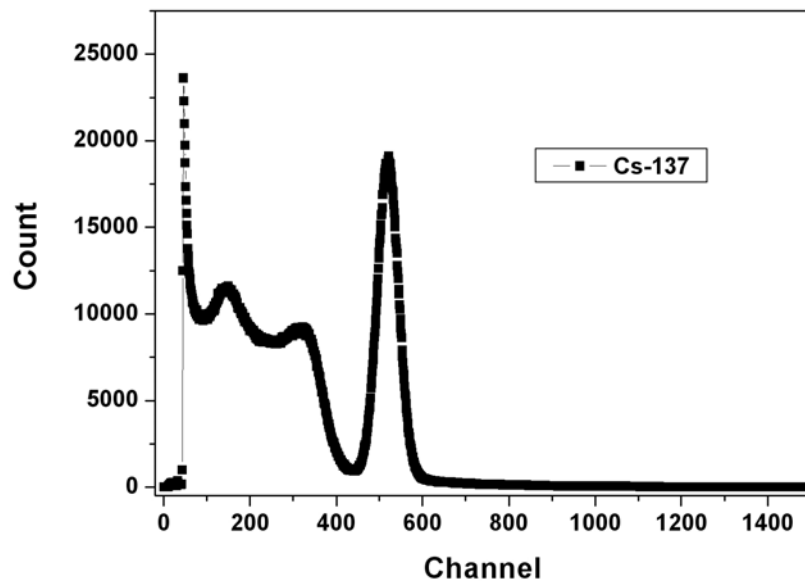
Performance (2)



☐ ^{137}Cs and ^{60}Co energy spectra

Resolution for ^{137}Cs 660 keV: 7.9%

Resolution for ^{60}Co 1,332 keV: 4.9%



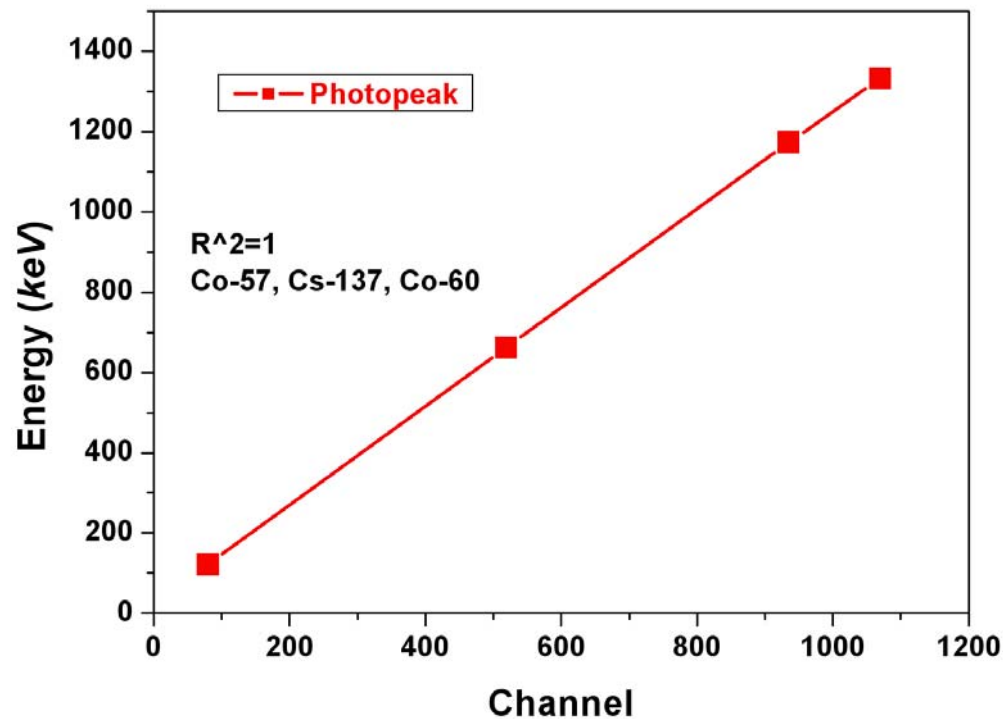
Sufficient to accumulate a quality spectrum in a few minutes using weak and encapsulated sources

Performance (3)



□ Energy dependence

- ↘ ^{57}Co : 122 keV, ^{137}Cs : 660 keV ^{60}Co : 1170 keV, 1330 keV
- ↘ Linearity for γ energy : Root mean square = 1

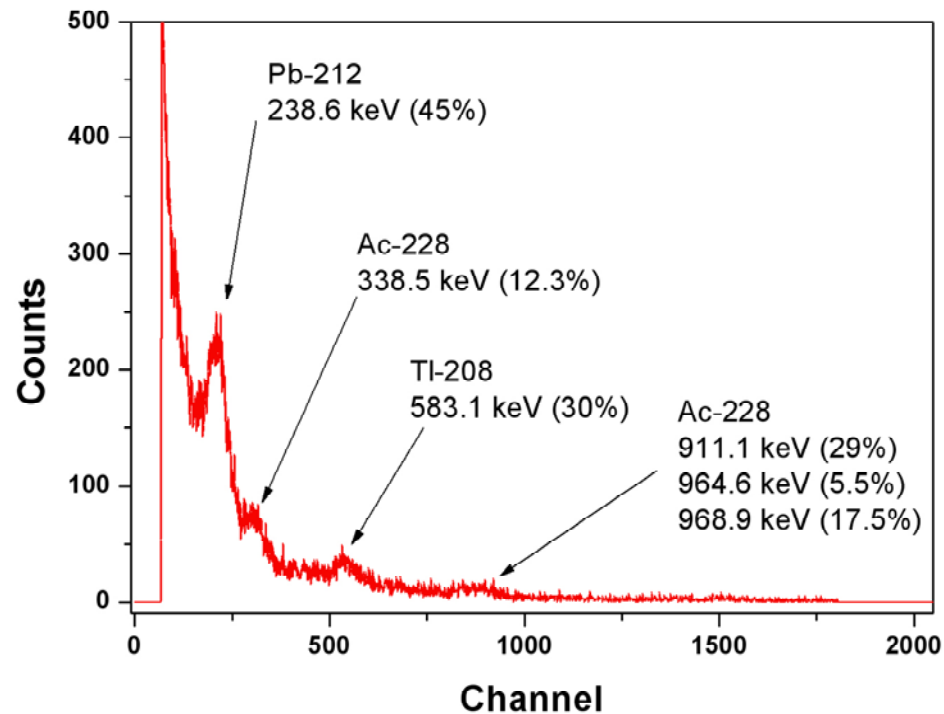


Performance (4)



□ Energy spectrum of a pottery piece

➔ measured with the spectroscopy tool kit (20 minutes counting)



Apparently, there are significant amounts of heavy metals in the pottery piece

Conclusions (1)



- ❑ The γ -ray spectroscopy tool kit that is cheap and simple compared with conventional spectroscopy system has been developed, fabricated and tested.
- ❑ The developed spectroscopy tool kit is safe to operate, inexpensive to procure, and very portable for educational purposes at secondary school level and beyond.
- ❑ Results measured from the prototype show that its resolution and efficiency are good, making it quite suitable for such as
 - **ambient background radiation observation**
 - **monitoring intensities of selected radioactivity**
 - **demonstration experiments at secondary schools and up**

Conclusions (2)



- ❑ The tool kit can replace Geiger-Muller counters in many traditional basic experiments with the pulse height analysis capability.
- ❑ The tool kit can be widely adopted for education and even for more sophisticated and higher level investigations.



Thank You !

Youngmi Nam: ymnam@kaeri.re.kr

