Detectors, Pulse signals

nuclear reaction experiment - schematic view

Radiation Detectors

detection

Pulse Signals

propagation of fast pulses

T. Motobayashi

a scheme of reaction experiments

nuclear reaction study with energetic beams

Since the Rutherford experiment

accelerator

signal (information) processing
(analog – digital – data – knowledge)

amplitude, time, (angle) …

energy, speed, PID, …

cross section

structure of nucleus
nuceosynthes in stars

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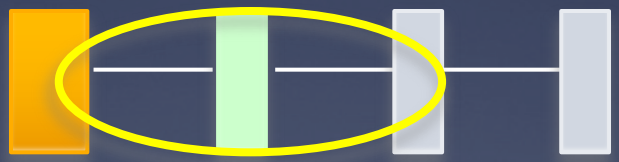
Pulse signals



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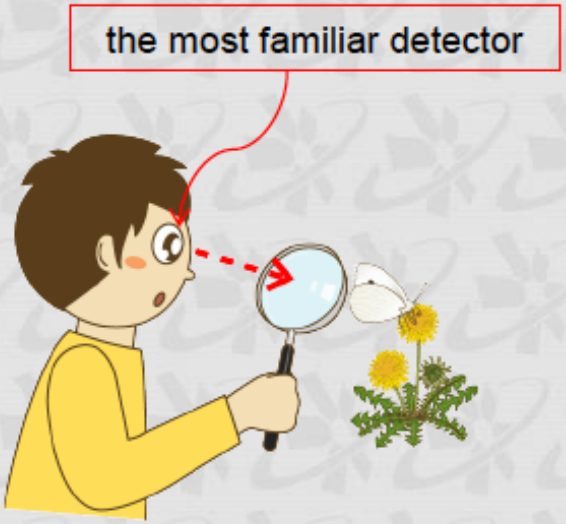
Radiation detector

slides by Hiromu Sato (Nishina Center)

Detector (1)

Detector = “Eye” to see nature



The eye senses lights.

⇩

The information is carried to your brain by the optic nerve.

⇩

The information is analyzed in your brain.

⇩

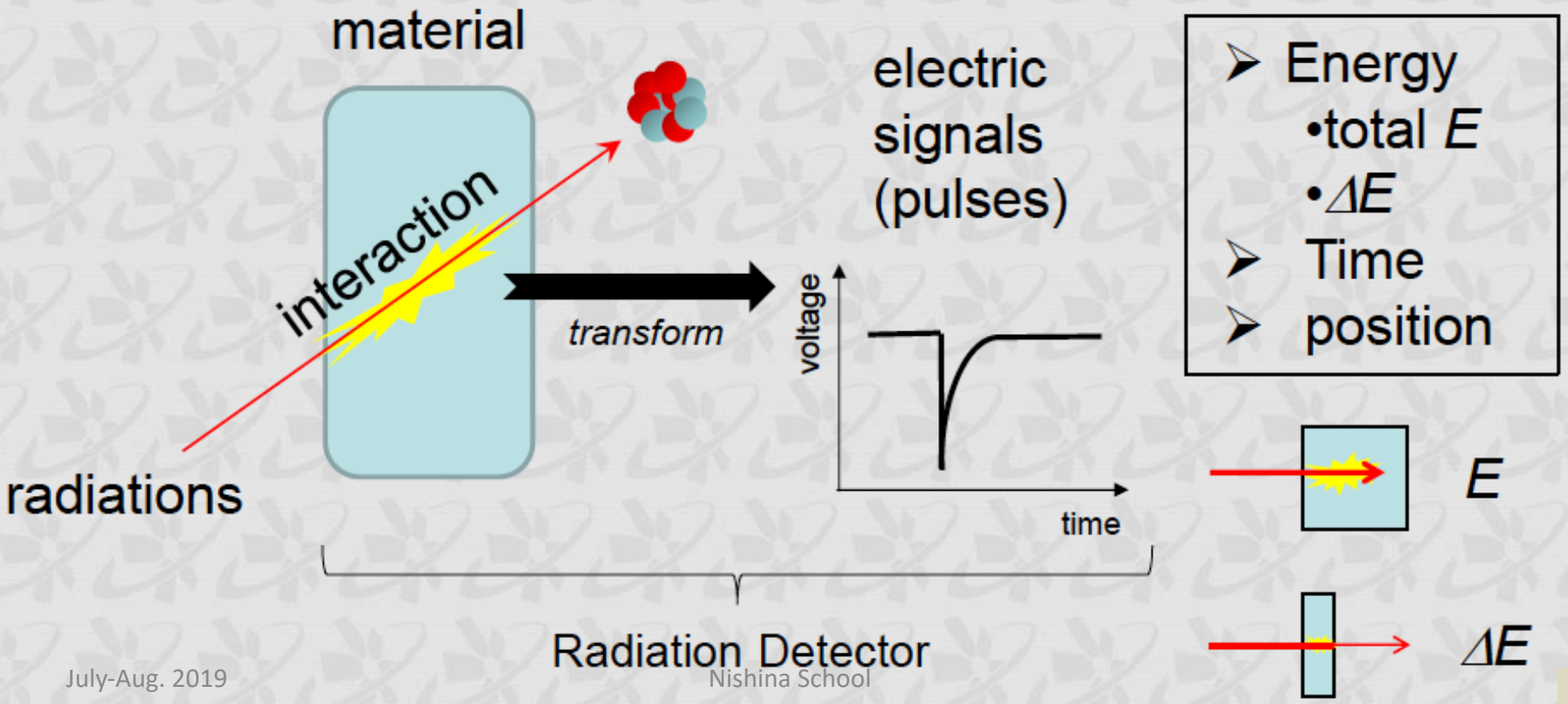
You get the picture what you are seeing.

receive a signal ⇨ output

How can we detect radiations ?

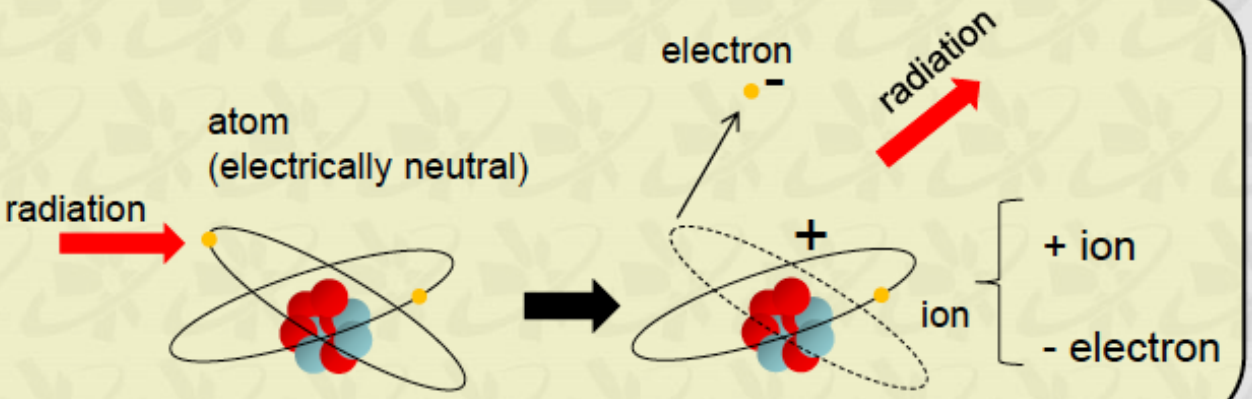
Radiations interact with materials.

(Pieter Ishiyama's lecture this afternoon)

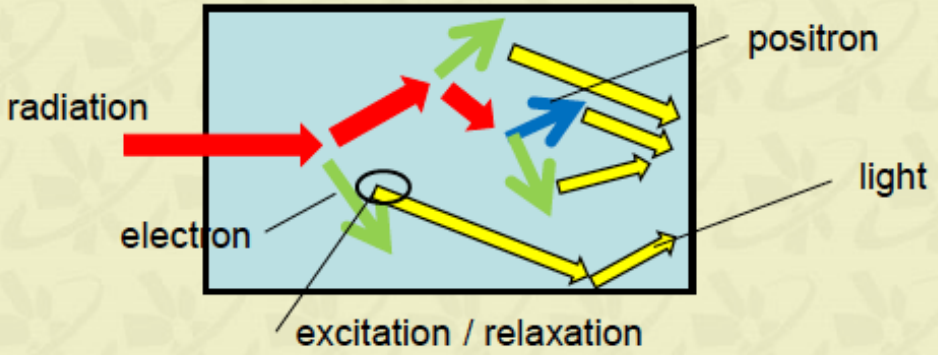


Detection principle

Ionization



Emission of light (=Scintillation)



Chemically-induced change of materials

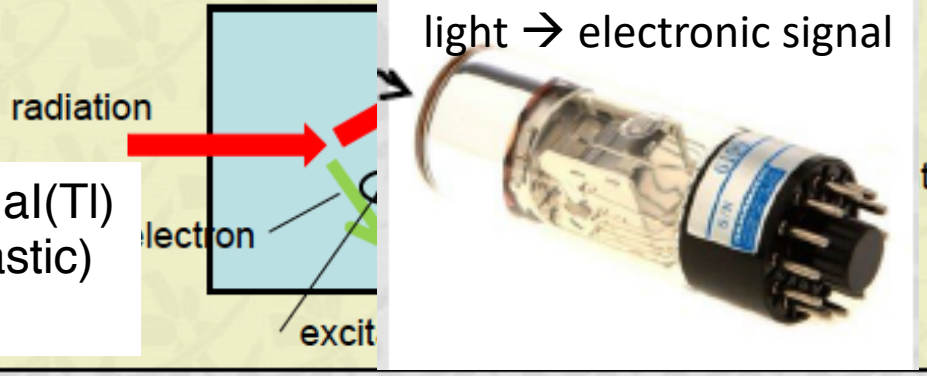
Detection principle

Ionization

ionization chamber
Proportinal counter
GM tube
semiconductor detector

Emission of light (=Scintillation)

In organic crystal as NaI(Tl)
organic scintillator (plastic)
liquid



Chemically-induced change of materials

Scintillation counter (4)

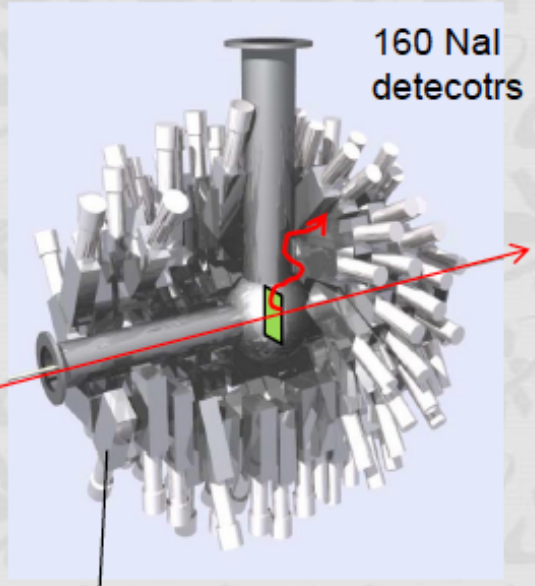
crystal

NaI(Tl) scintillator

NaI(Tl) crystal

γ rays

DALI2 in RIBF



photomultiplier

NaI(Tl) with Al cover

NaI(Tl) crystal

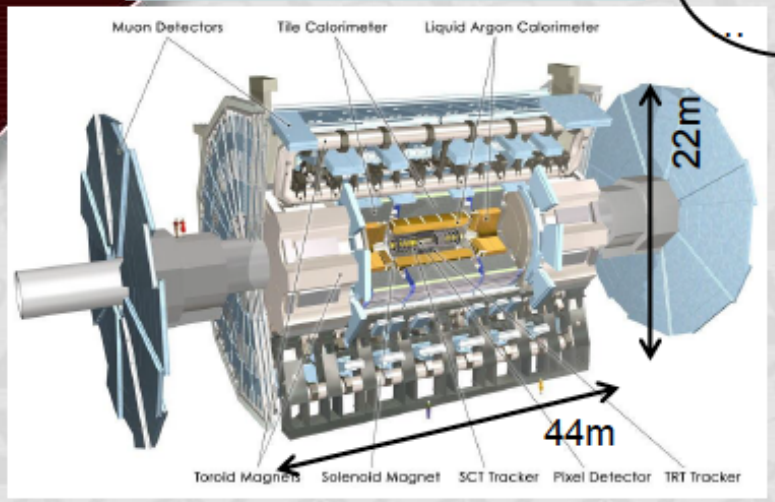
deliquescent material
→ cover is needed

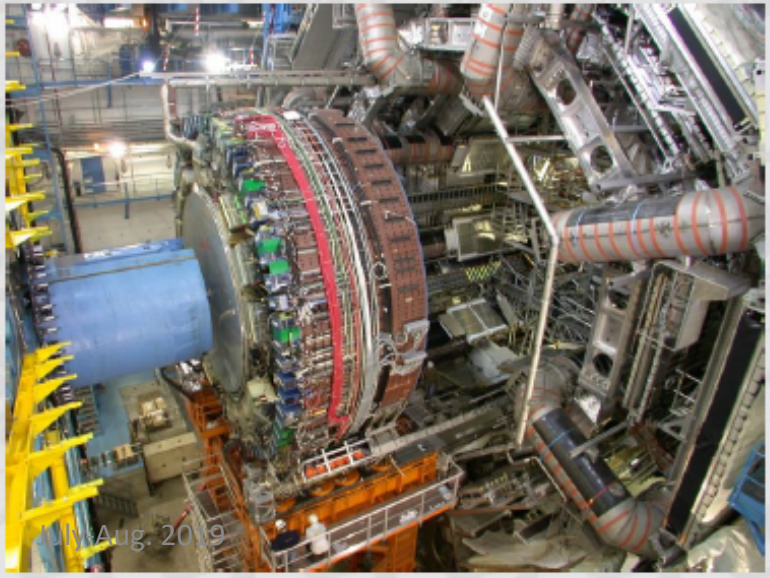
Huge Detectors

Huge, but in the same principles.

ATLAS@CERN

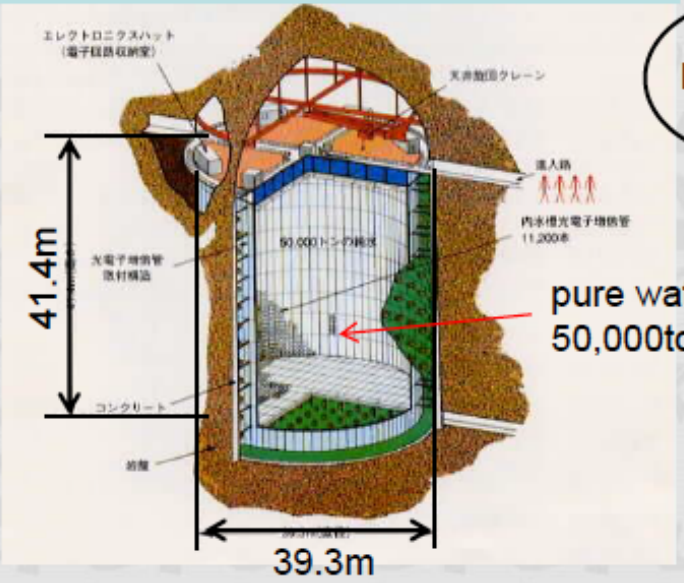
Higgs
dark matter
..

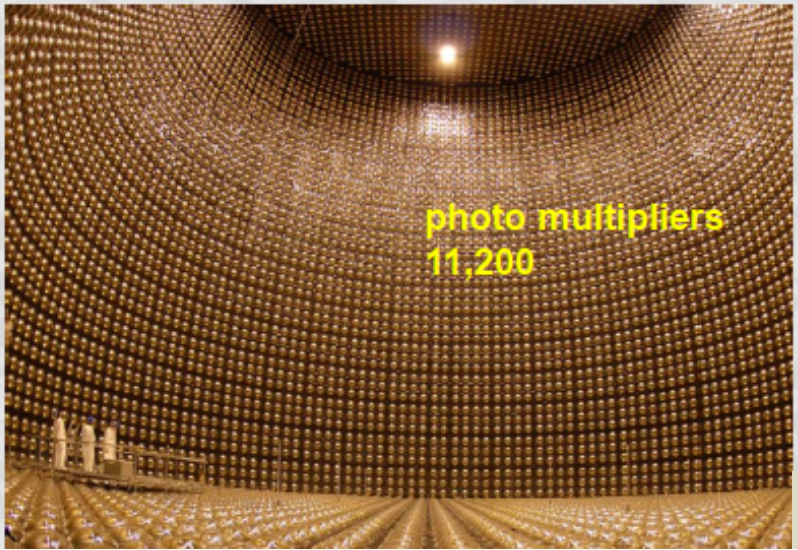




Super Kamiokande

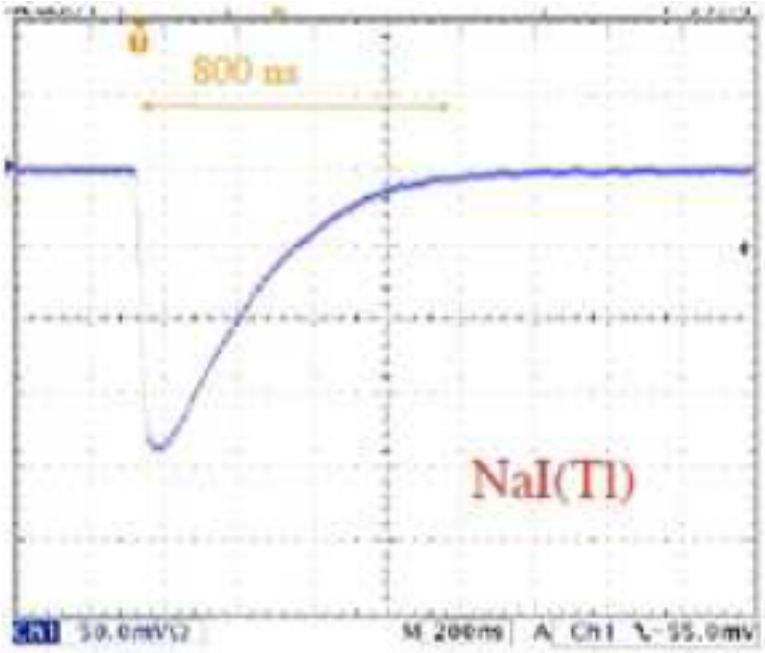
Neutrino





Fast* pulses from a detector

for detectors based on ionization or scintillation

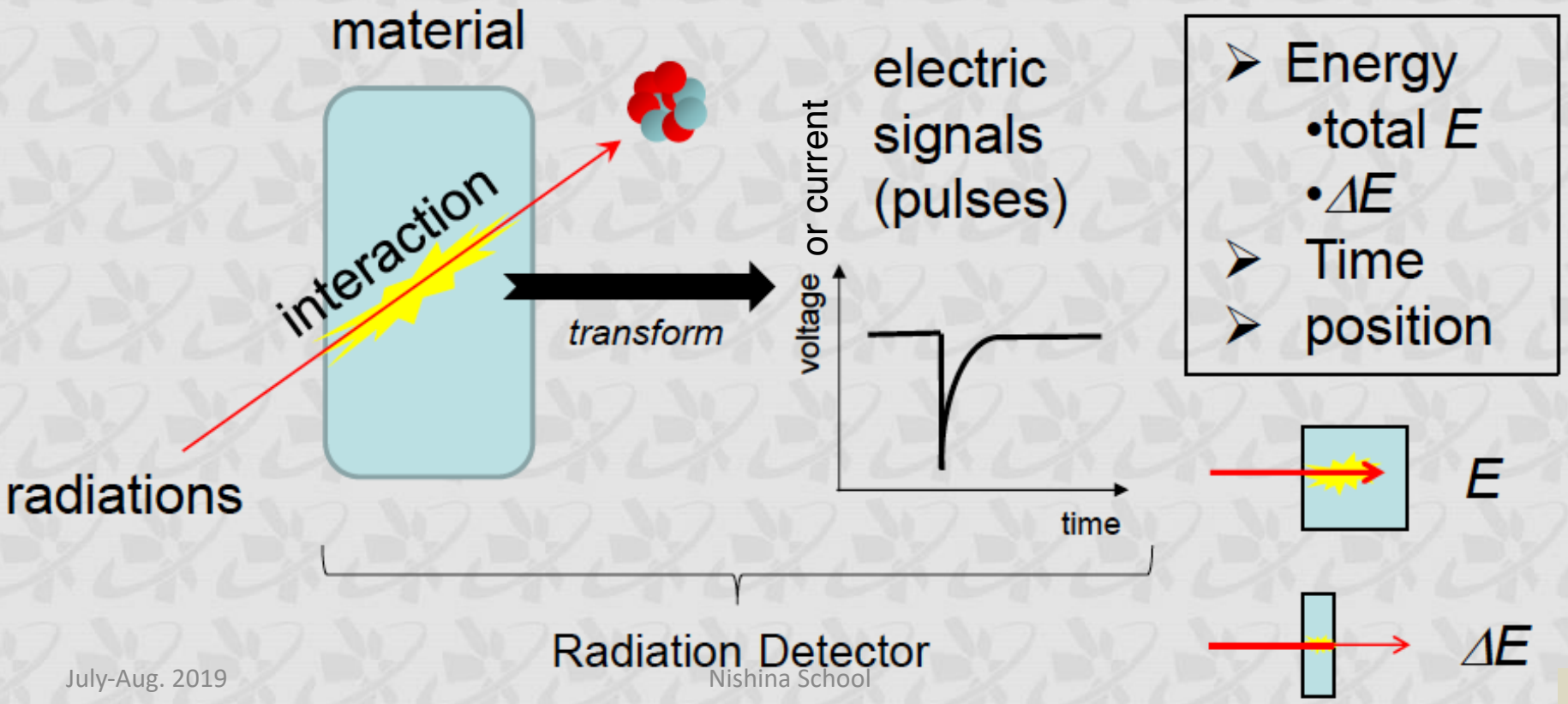


* ~μs or 10^{-6} s for NaI(Tl)

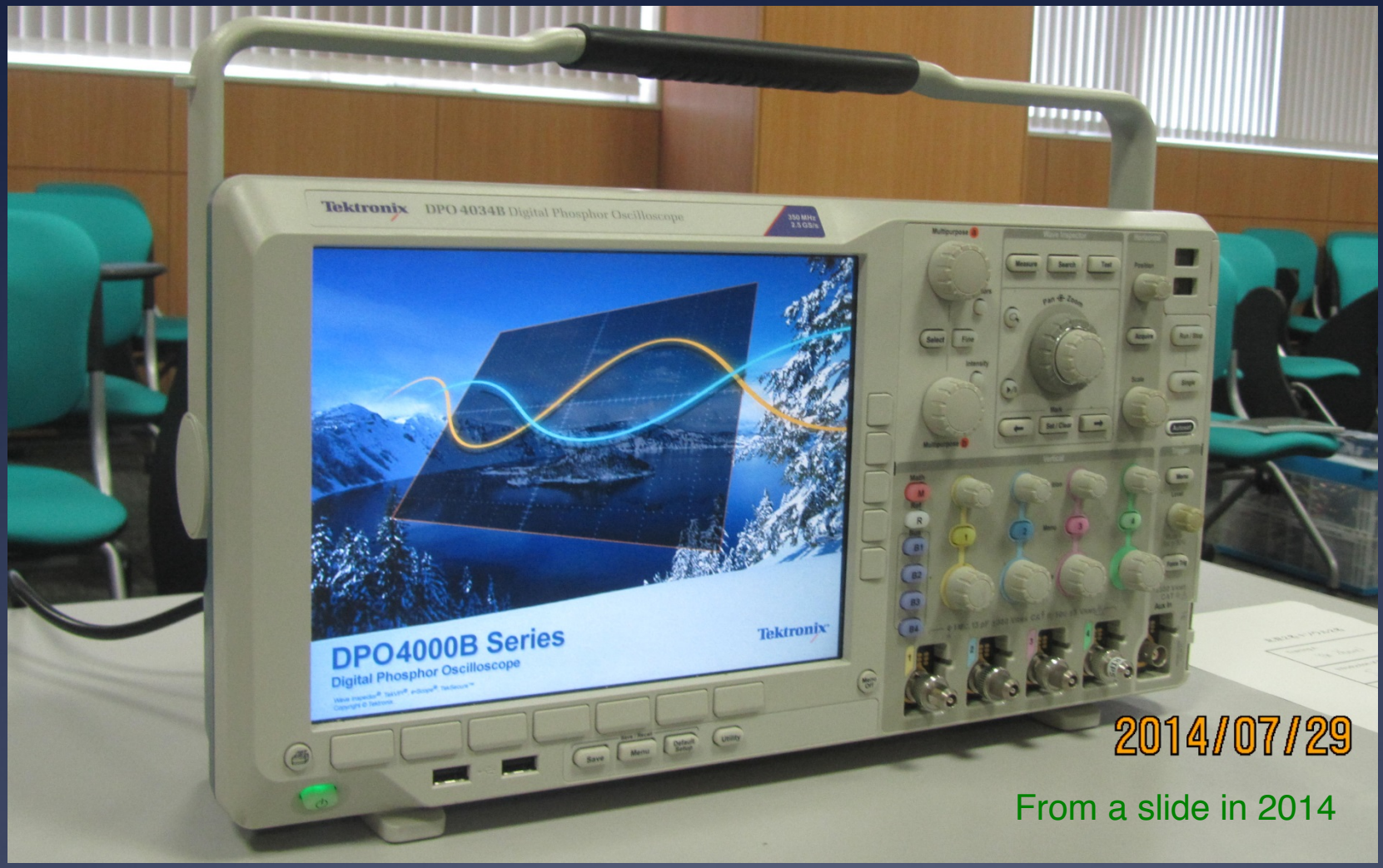
How can we detect radiations ?

Radiations interact with materials.

(Pieter Doornenbal's lecture tomorrow)

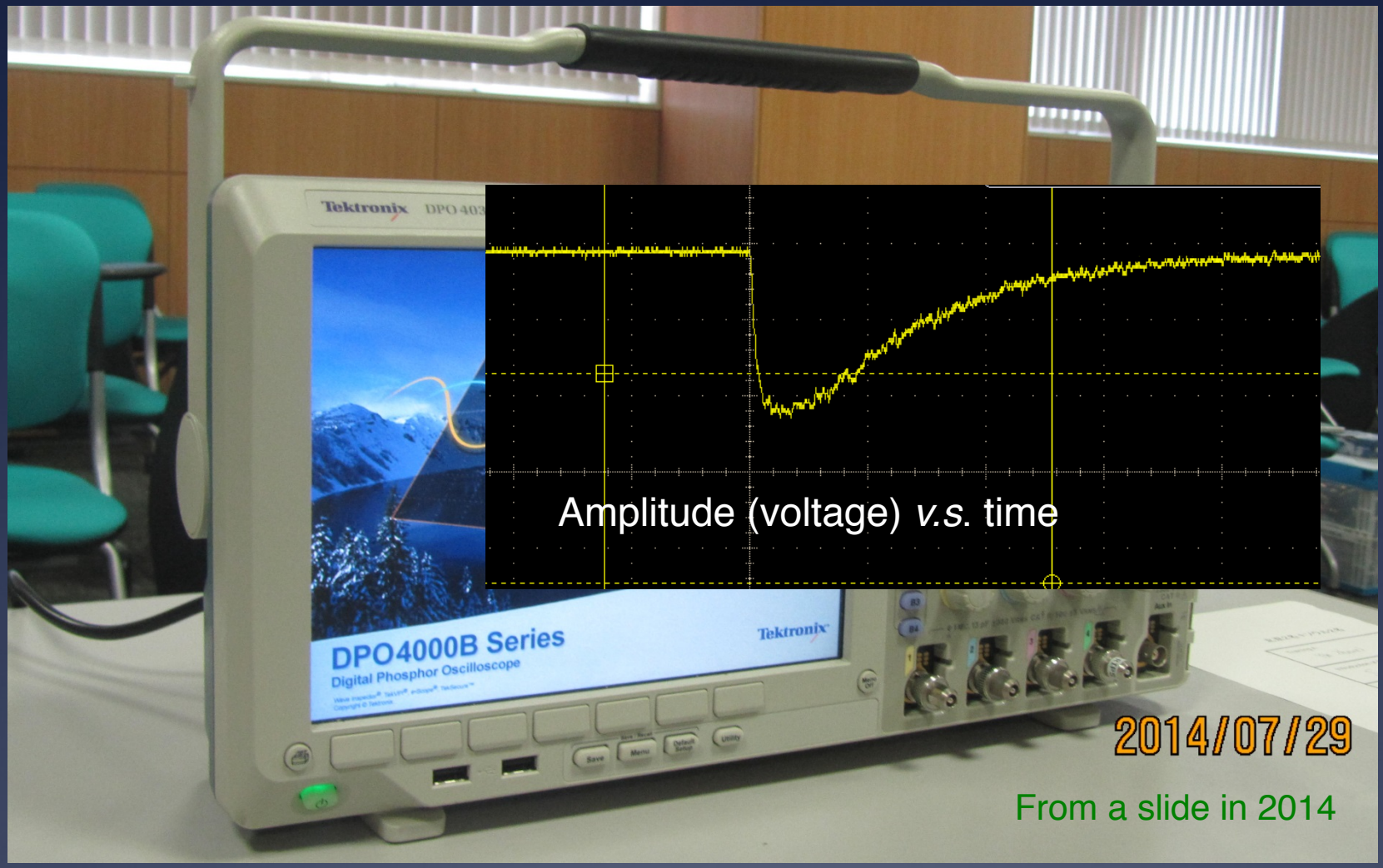


(Digital) Oscilloscope

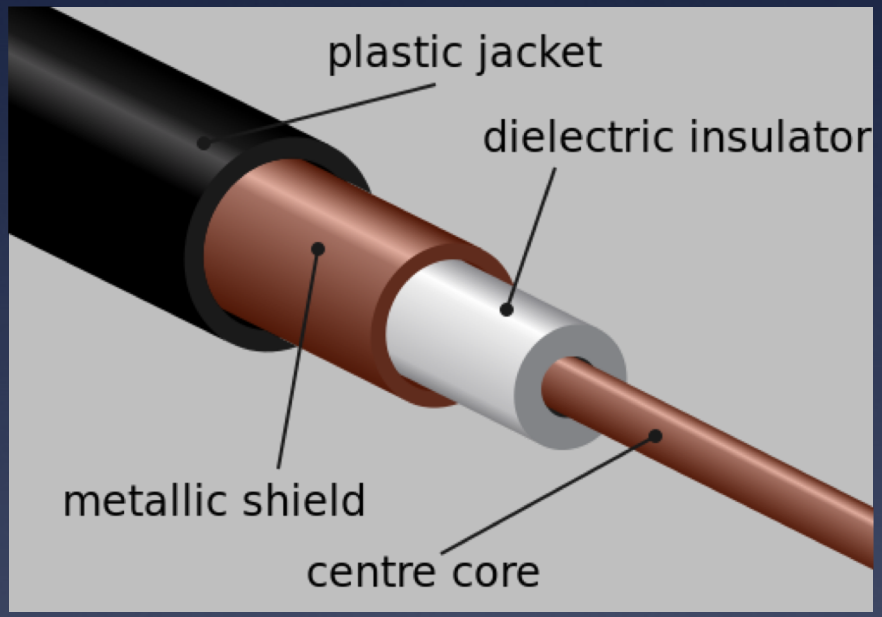


From a slide in 2014

(Digital) Oscilloscope



Coaxial cable



used for fast (high-frequency*) pulses

Why?

- ~500 MHz for Japanese TV(UHF)
  1 cycle - 2×10^{-9} s

impedance -- something like “resistance in AC”

Impedance depends on the frequency.

e.g. $Z=R$

$Z=L\omega$ inductance becomes resistive at large ω

$Z=1/C\omega$ capacitor becomes conductive at large ω

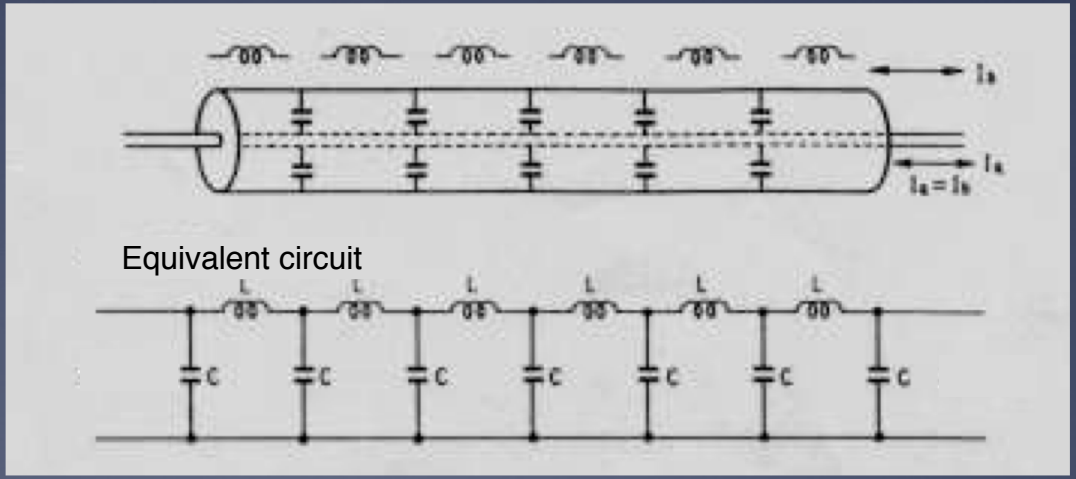
coaxial structure

→ frequency independent impedance

for minimizing deterioration of a pulse

characteristic impedance (of coaxial cable)

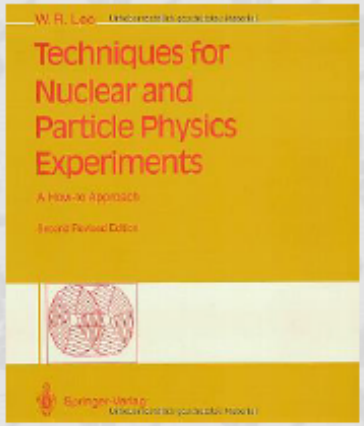
$Z = (L/C)^{1/2}$



Textbooks

- Techniques for Nuclear and Particle Physics Experiments

  William R. Leo



- Radiation Detection and Measurement

  Glenn F. Knoll