A Study of Phoswich Detectors for Dosimetry Measurements

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Outline

- Motivation
- Theoretical background
  - Detector principles
  - Scintillators
  - Photomultiplier (PMT)
- First preliminary results
- Future work
  - Electronics

Motivation

- **Importance for Dosimetry**

- Neutrons have a high impact on biological cells
  - There is a significant production of high energy secondary neutrons in the space craft material
  - These neutrons add a great amount to the dose equivalent

  → discrimination of neutrons and γ is needed

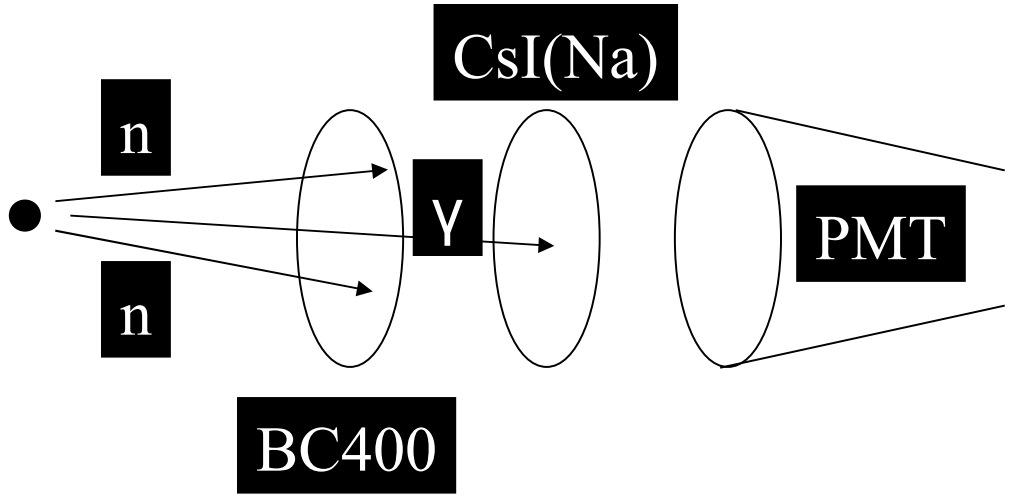
- Not possible with silicon telescope → underestimation of neutrons

- **With phoswich** : relatively easy discrimination between neutrons and γ is possible

  - So far mostly liquid scintillators have been used to measure neutrons

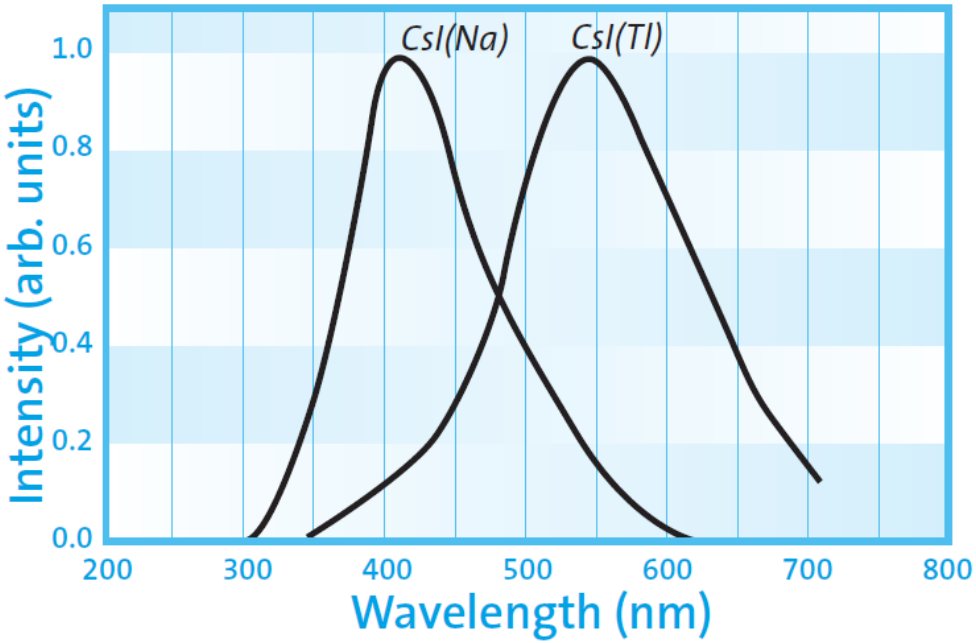
Phoswich Detectors

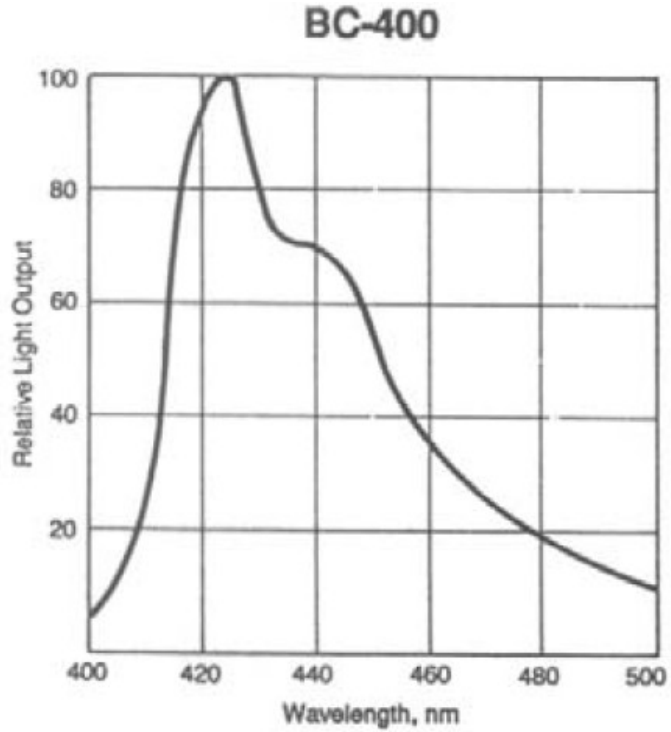
- Two or more dissimilar scintillators are optically coupled to one photomultiplier
- By pulse shape discrimination the pulses from the two scintillators are separated



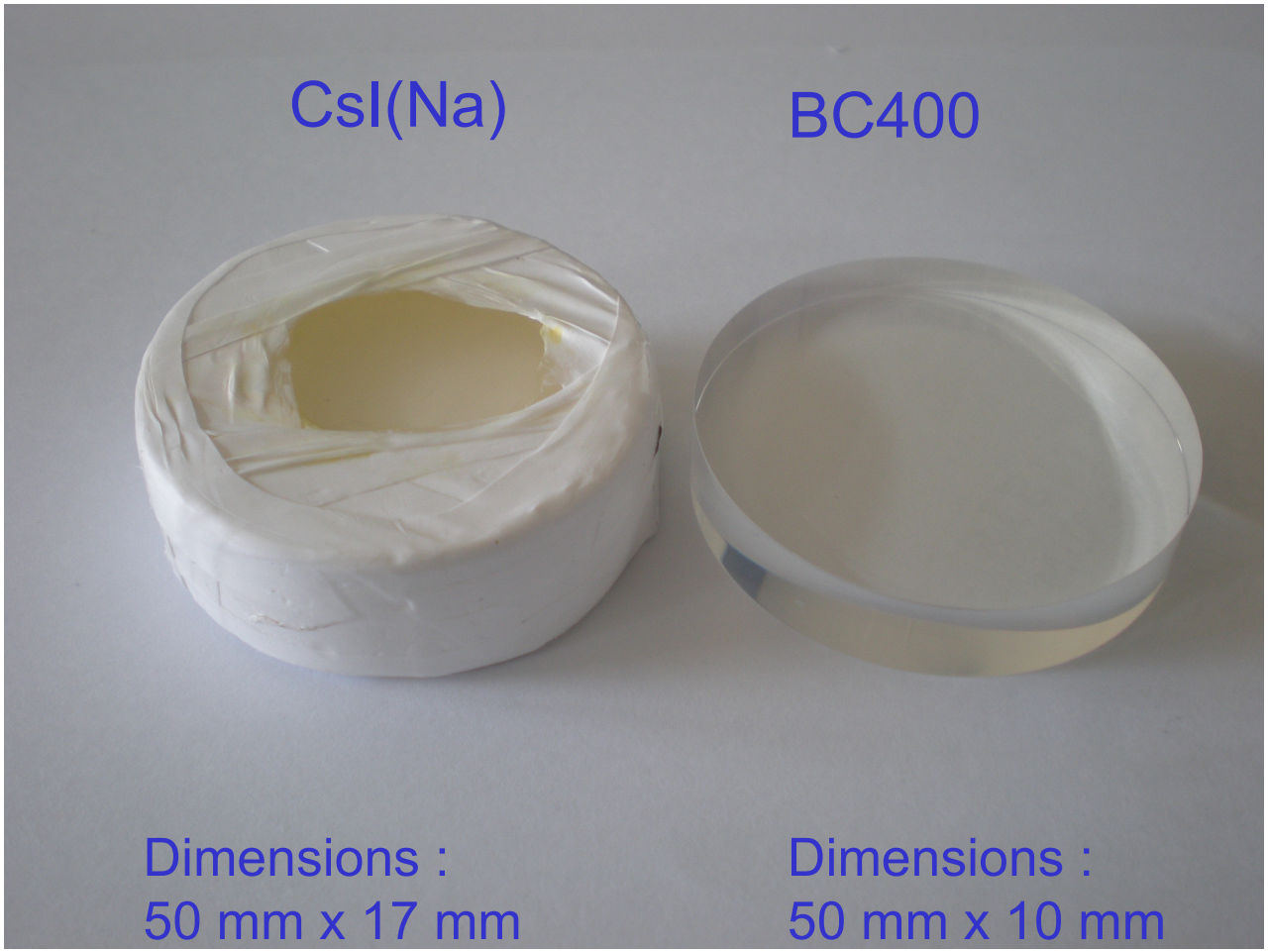
Scintillators

- BC-400
  - based on polyvinyltoluene, density : 1.032 g/cc
  - decay time 2.4 ns
  - wavelength of max. emission : 423 nm
- CsI(Na)
  - high density (4.51 g/cm²) and high atomic number → high γ stopping power
  - decay time 630 ns
  - Wavelength of max. emission : 420 nm





The Scintillators

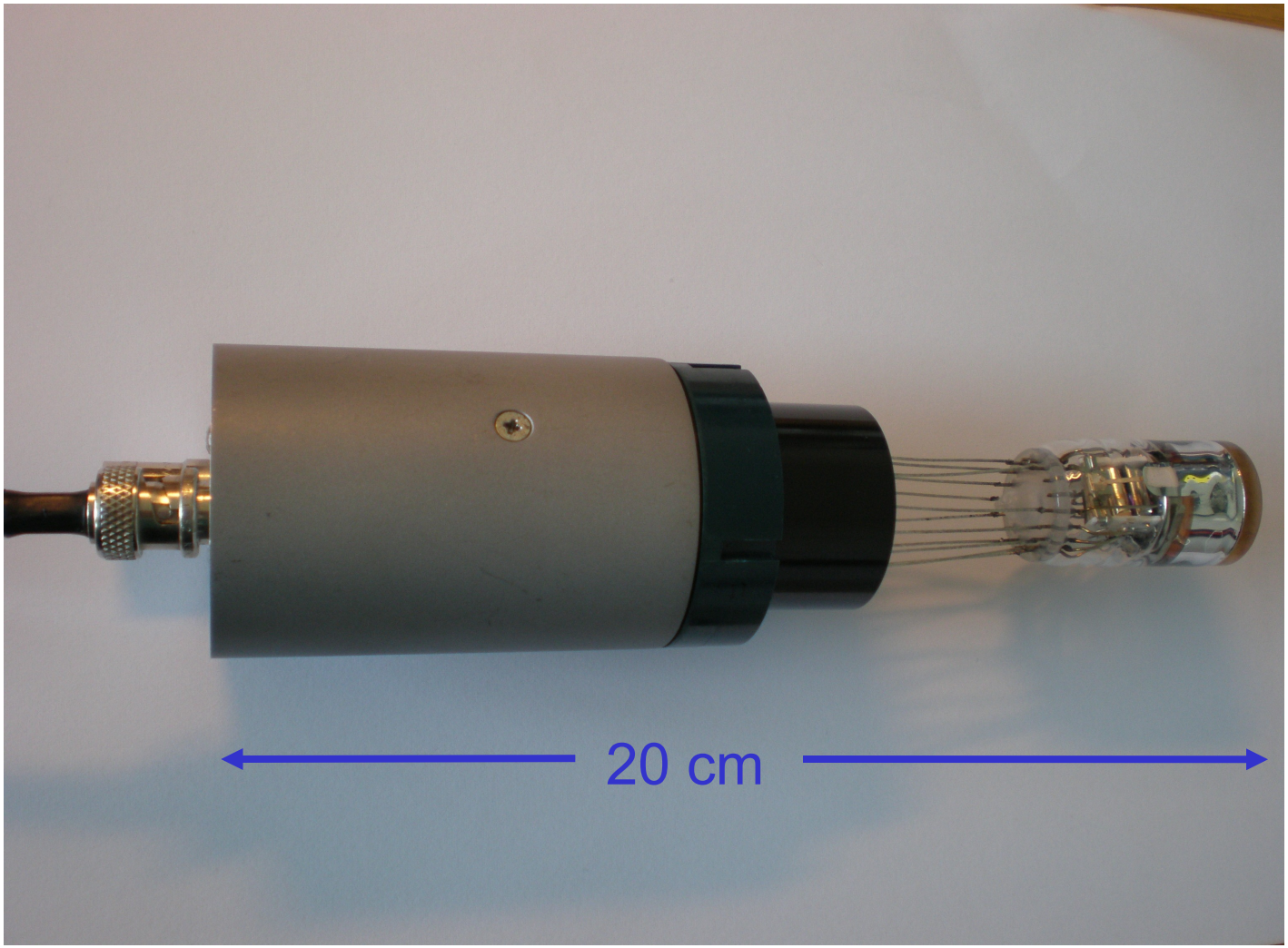


- Crystals are wrapped in millipore and teflon tape
- To attach scintillator to window of PMT optical grease (BC-630) is used

Photomultiplier

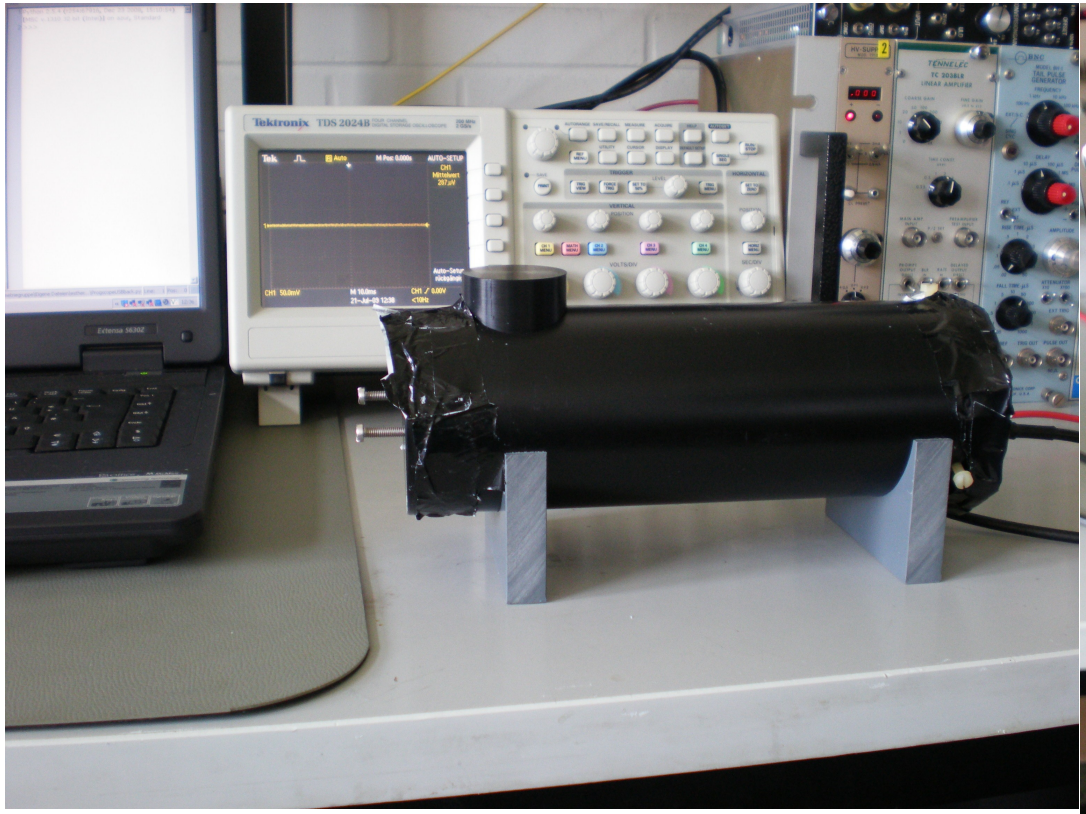
- **test setup** : PMT R1924-01 (Hamamatsu)
  - Wavelength of maximum response : 420 nm ± 50 nm
  - Window diameter : 2.4 cm
  - Bias voltage : positive up to 2.5 kV

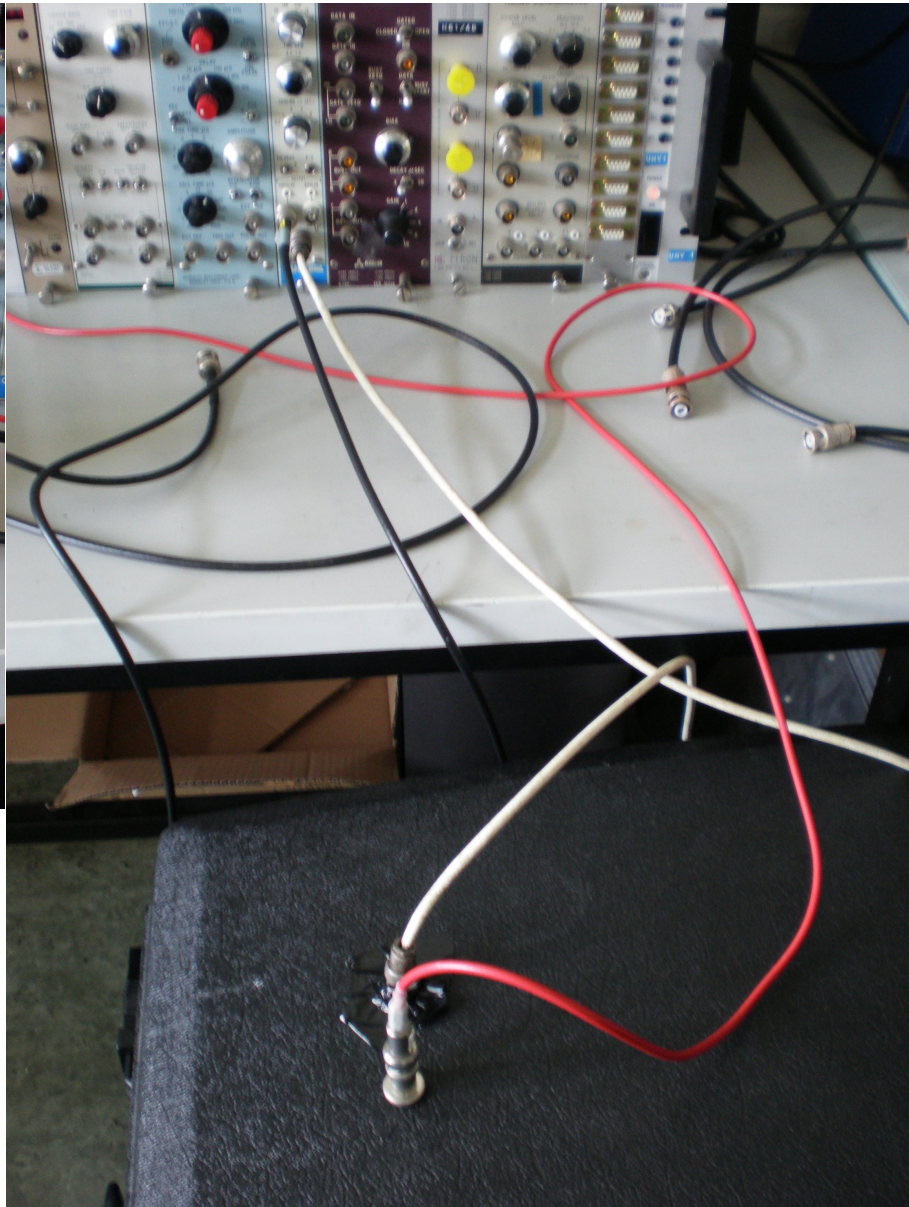
Electronics



- Socket contains resistor divider and preamplifier : output rise time ≤ 50 ns

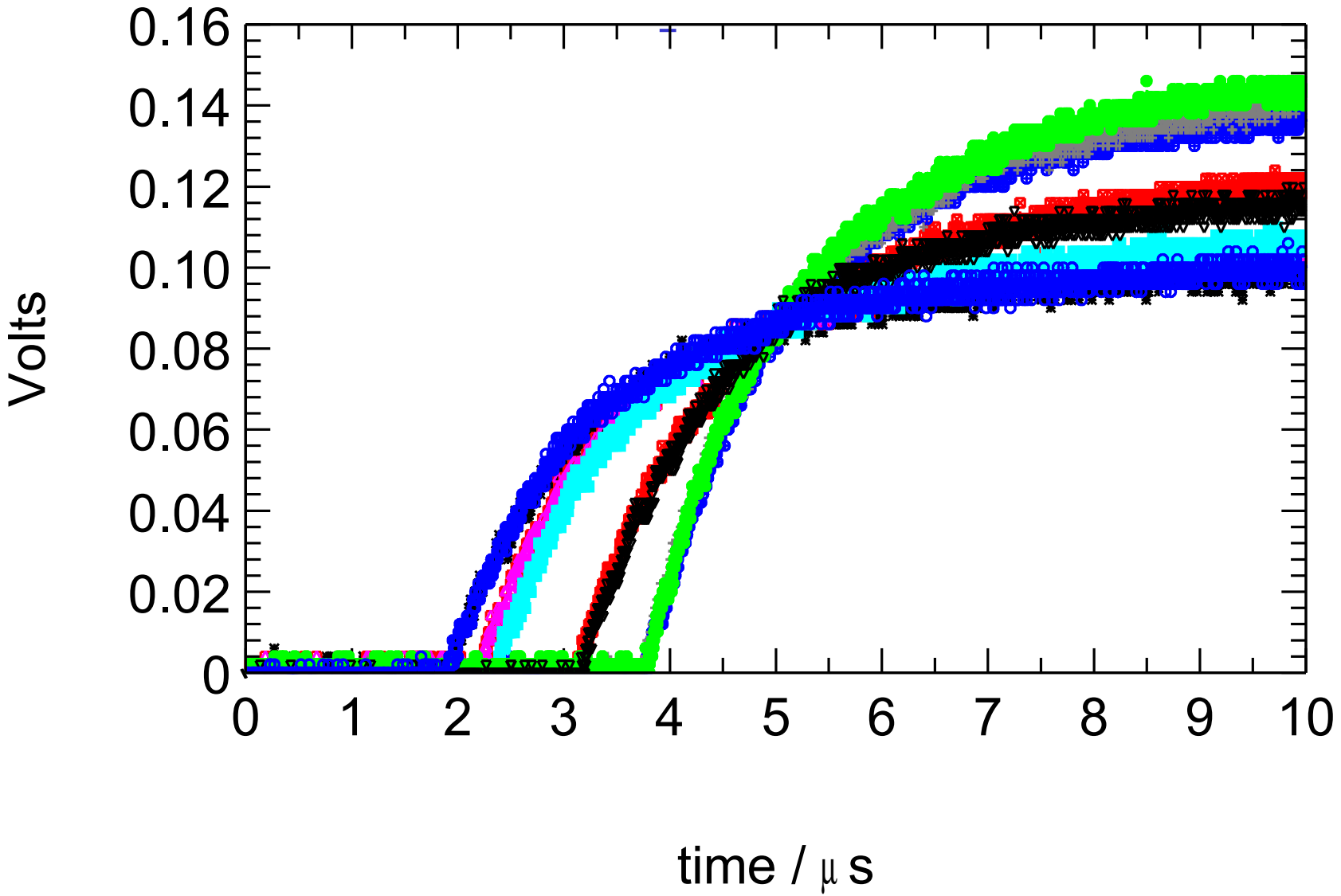
Experimental Setup





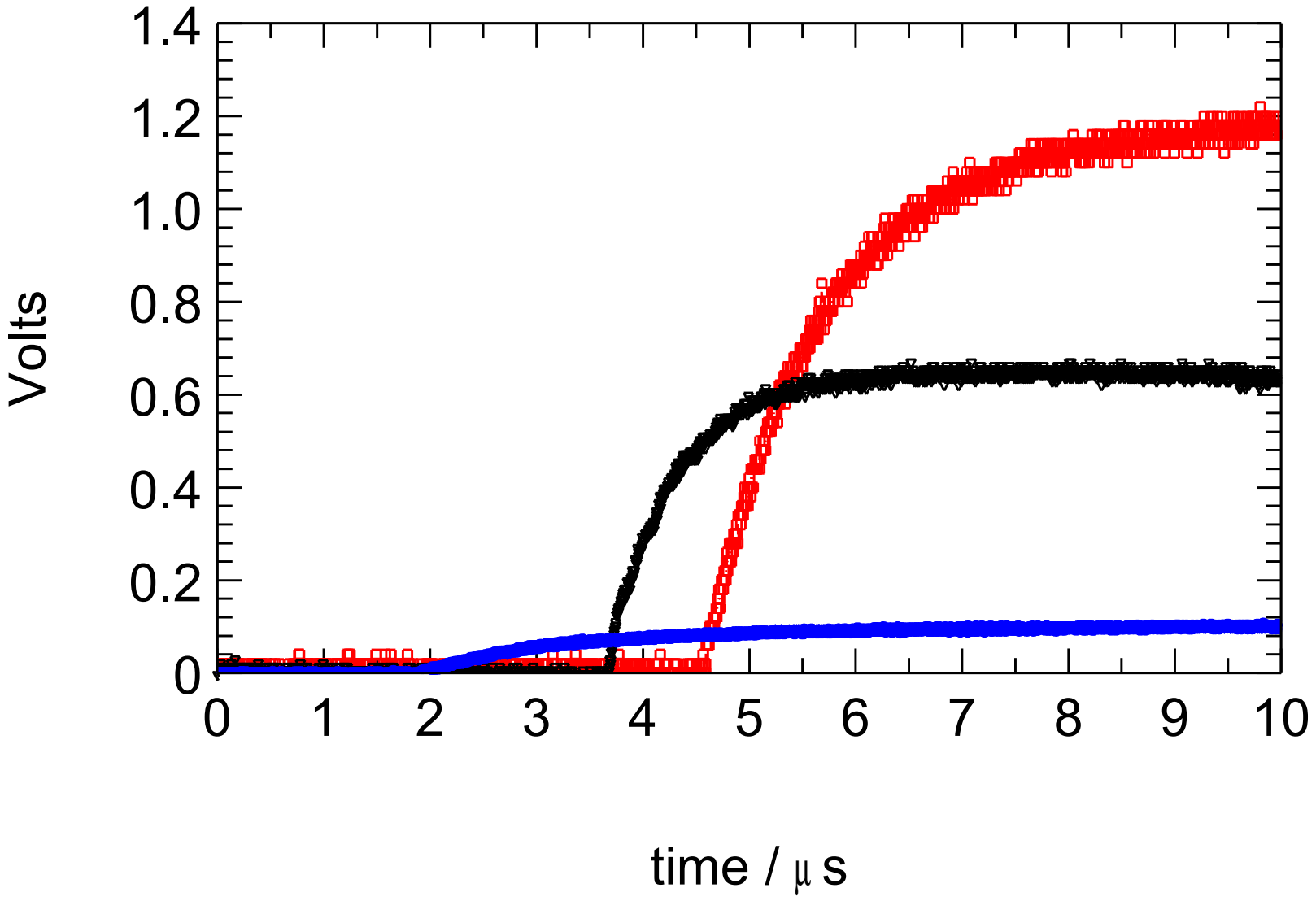
- The output pulse of the preamplifier is measured with an oscilloscope

Measurement with CsI(Na)



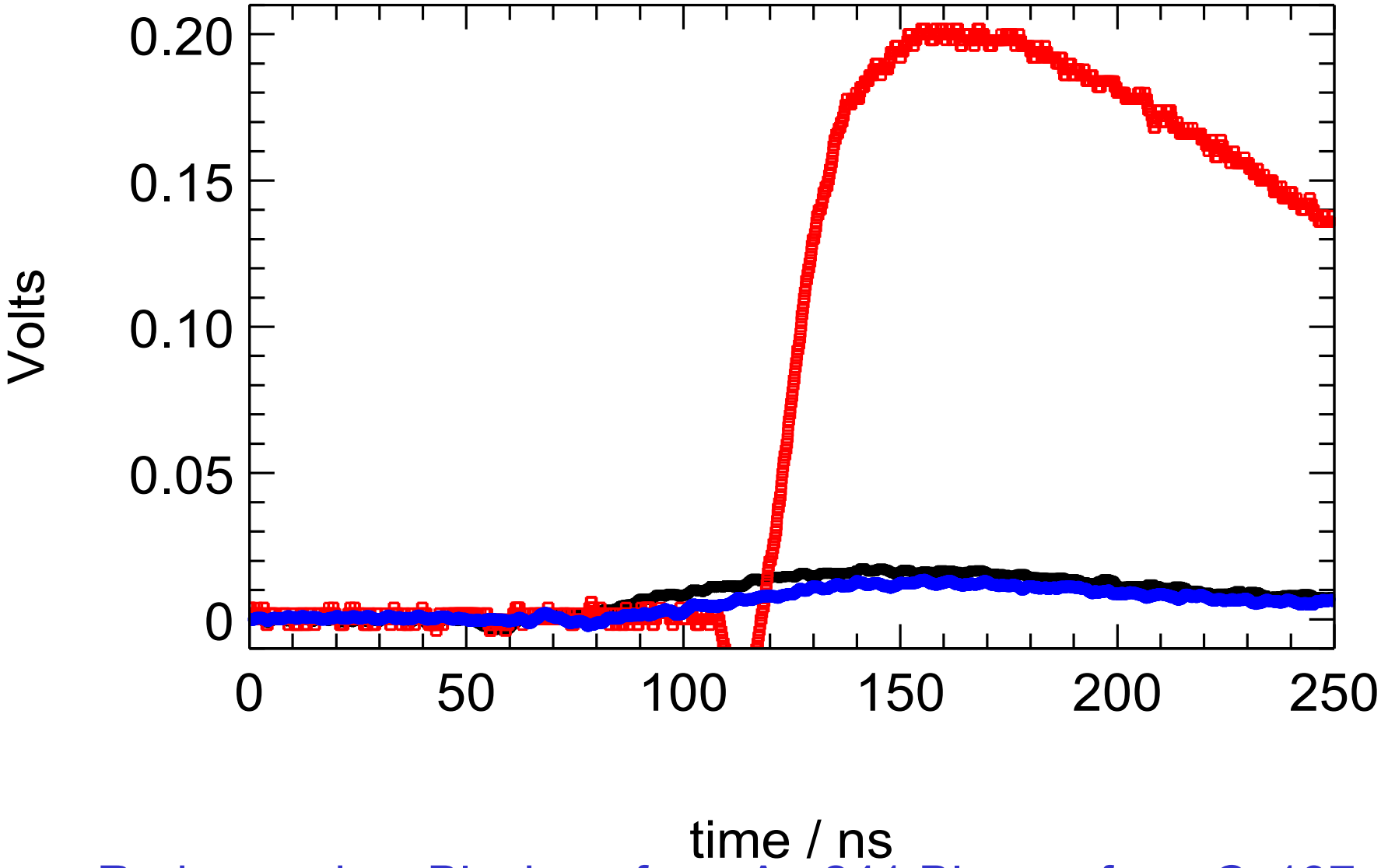
- Source : Cs137 γ with energy of 662 keV

Measurement with CsI(Na)



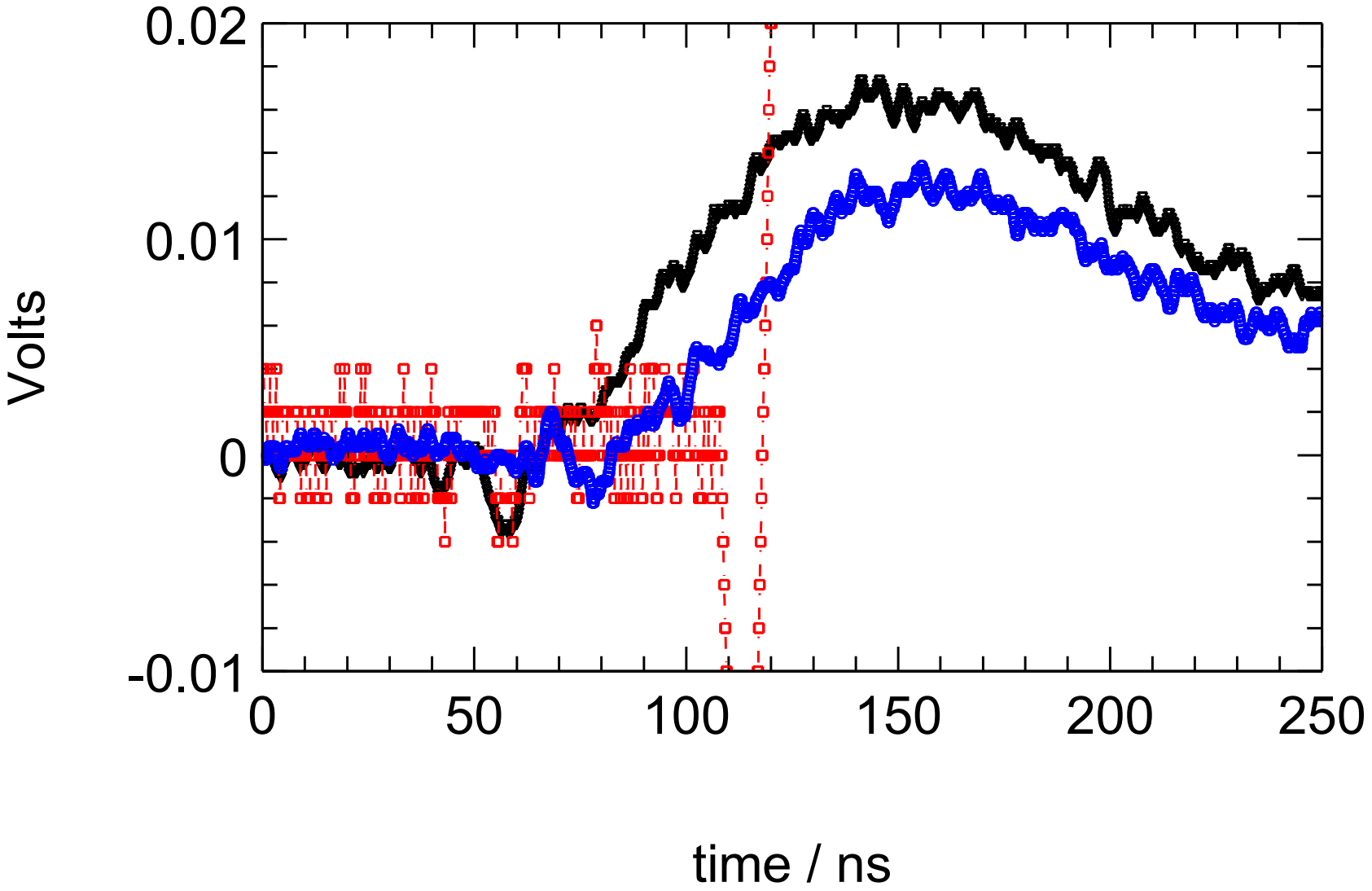
- Red: cosmic μ Black : α from Am241 Blue: γ from Cs137

Measurements with BC400



- Red: cosmic μ Black : α from Am241 Blue: γ from Cs137

Measurements with BC400

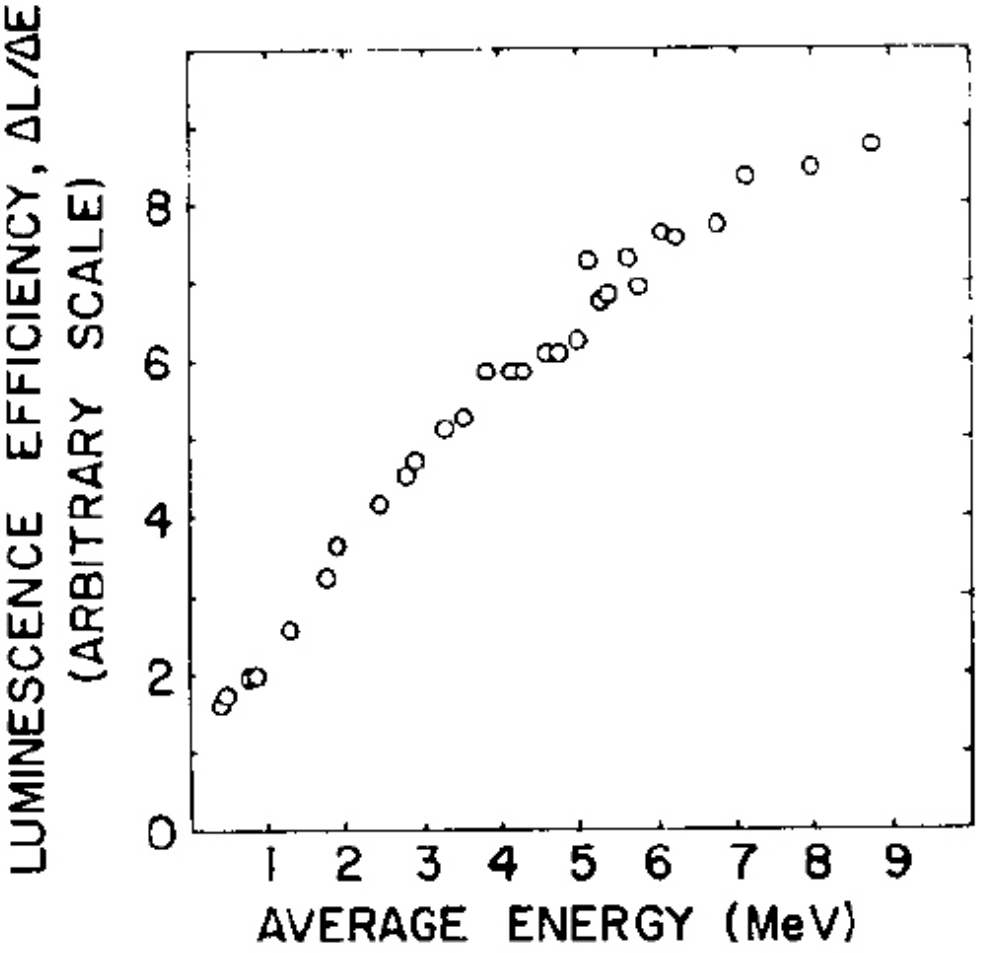


- Red: cosmic μ Black : α from Am241 Blue: γ from Cs137

Quenching in Plastic Scintillators

- de-excitation within the scintillator is non-radiative
- Instead of the production of light for example heat is generated

→the light output of the crystal is not equivalent to the energy of the incident particle anymore



(Muga and Bridges, 1976)

Slew rates of single pulses

- **Slew rates**

- Pulses from BC400 much faster than CsI(Na)

- For both scintillators
  - Smallest slew rate for γ
  - largest slew rate for μ

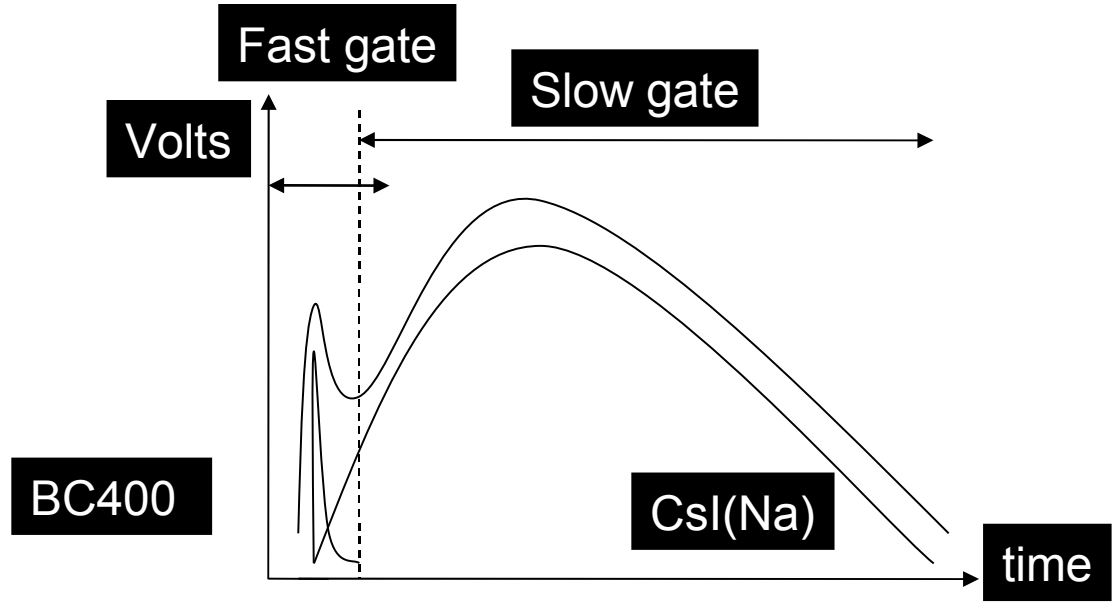
scintillator / source	CsI(Na) [mV/μs]	BC400 [mV/μs]
γ	10.7	167.2
α	34.86	332.2
μ	352.7	1646

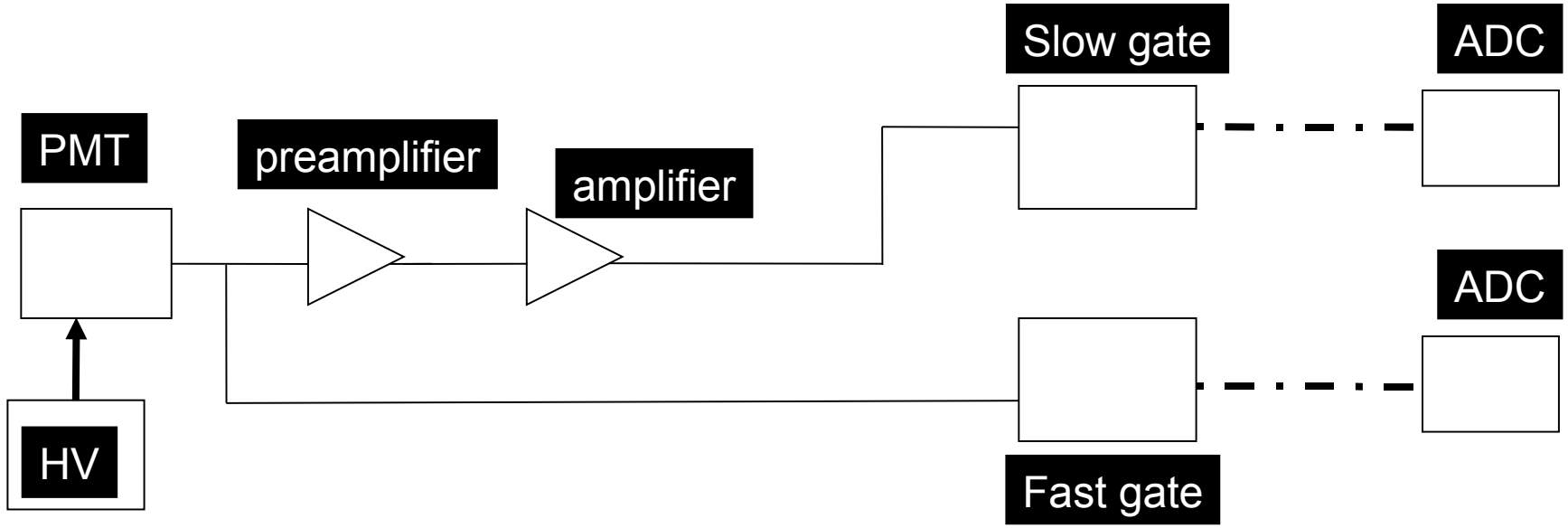
Future Work

- Need to use faster preamplifier to read out the plastic scintillator properly (maybe from Ortec)
- look at the signal from the anode directly → no alteration of the signal by the preamplifier

  → linear or integrating preamplifier
- study other scintillator materials
- look at two scintillators together with one PMT

Electronics





Summary

- It is possible to distinguish between neutrons and γ using a phoswich detector

- preliminary results
  - pulses from BC400 and CsI(Na) can be separated because of their different decay times
  - in both scintillators : μ pulses are the fastest and γ pulses are the slowest
- significant quenching in plastic scintillator

- goal : build a phoswich detector which is capable of measuring charged as well as neutral particles plus distinguish between neutrons and γ