





# A new Design of a highly Segmented Neutron Detector

# Motivation

## Interaction of neutrons with matter

- No coulomb interaction
    - High penetration depth
  - Strong interaction
    - Secondary charged particles, mainly protons
- Indirect detection
- Low efficiency detection:  $\sim 1 \text{ \%}/\text{cm}$
- Counting rate capability:  $\sim 1 \text{ MHz}$

# Motivation

## Requirements:

- High neutron detection efficiency
- High counting rate capability

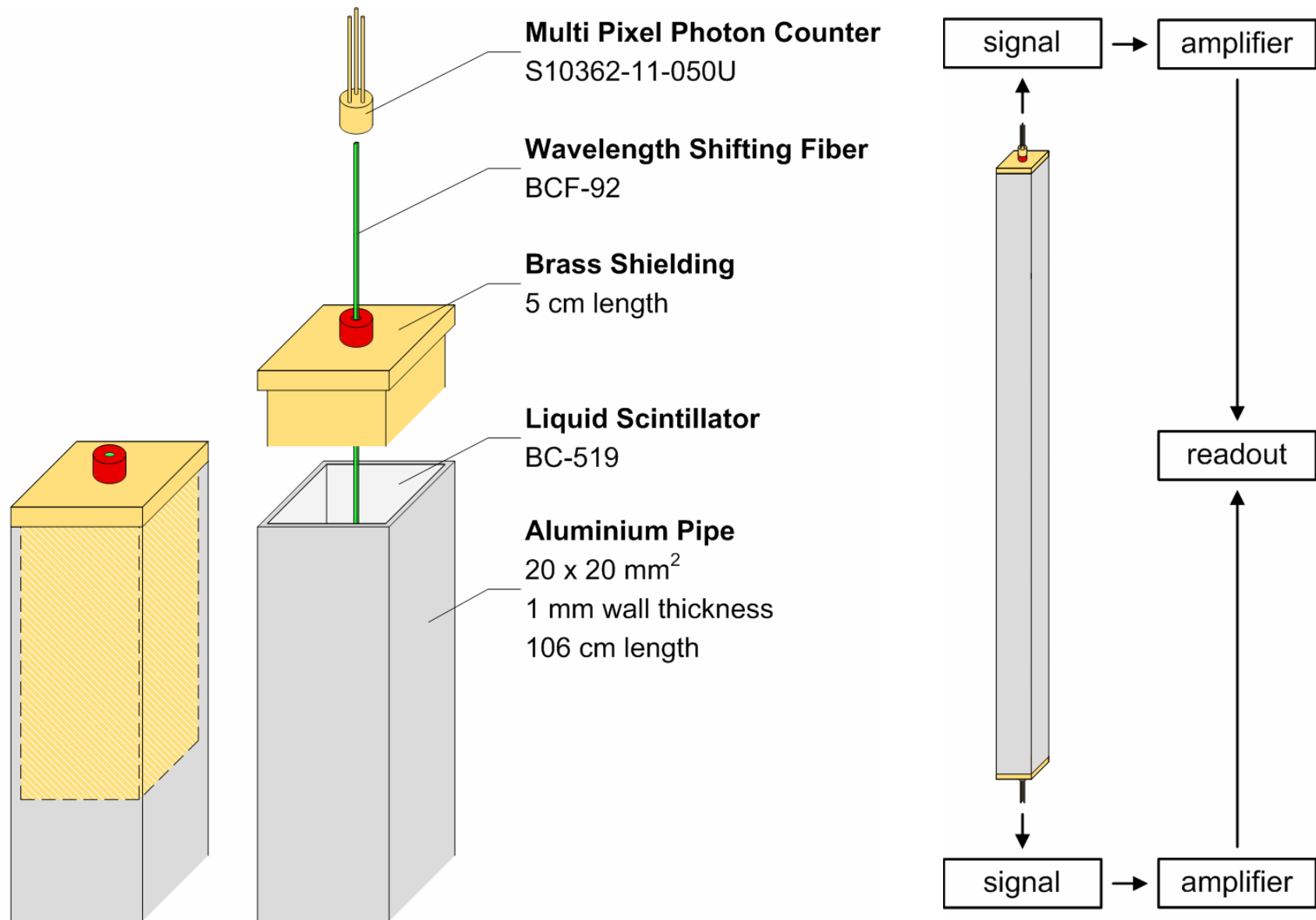
→ High segmentation

→ High detector volume

→ Low priced and standardized components:

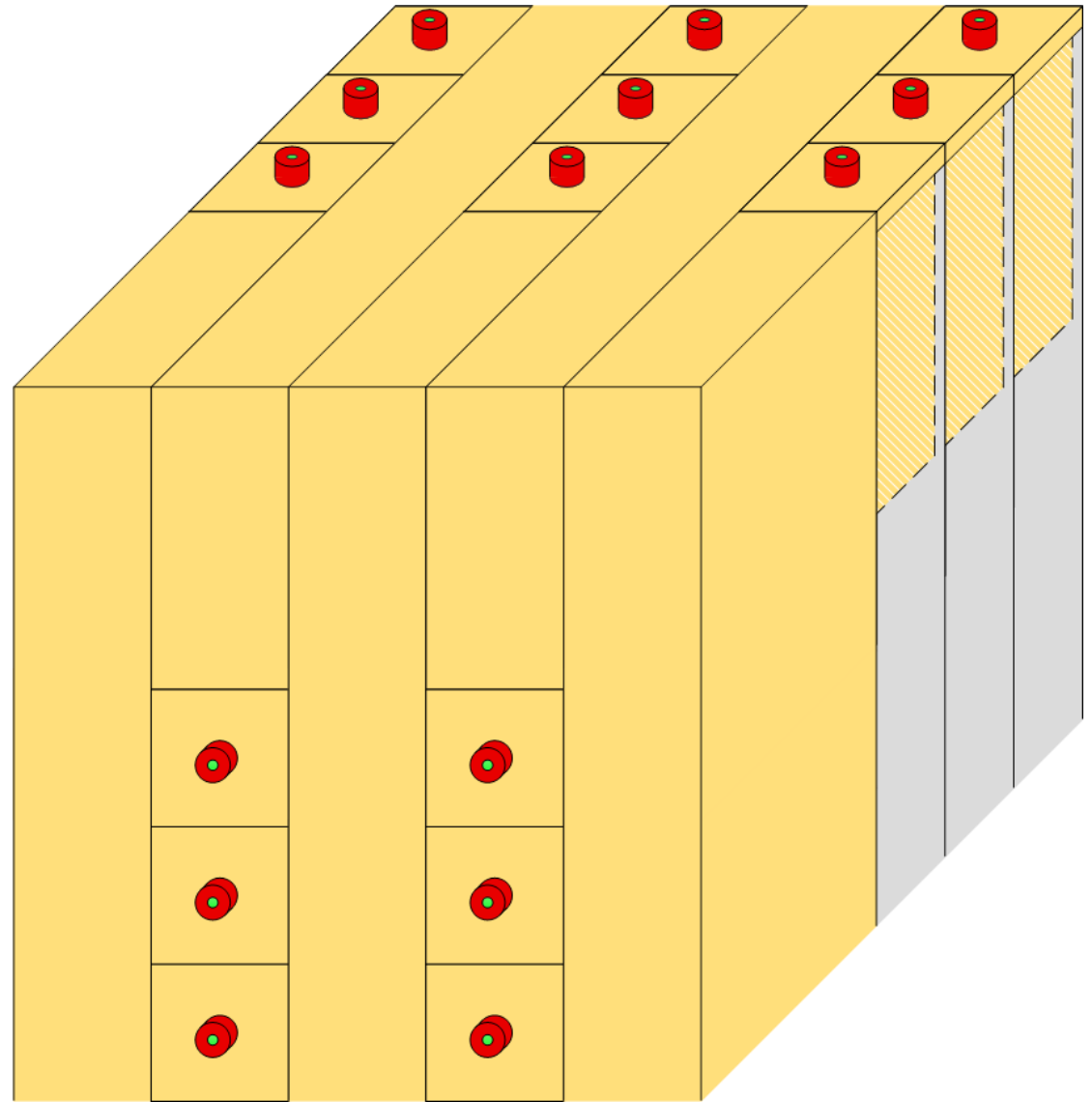
Photomultiplier → Silicon Photon Counter

# New Design



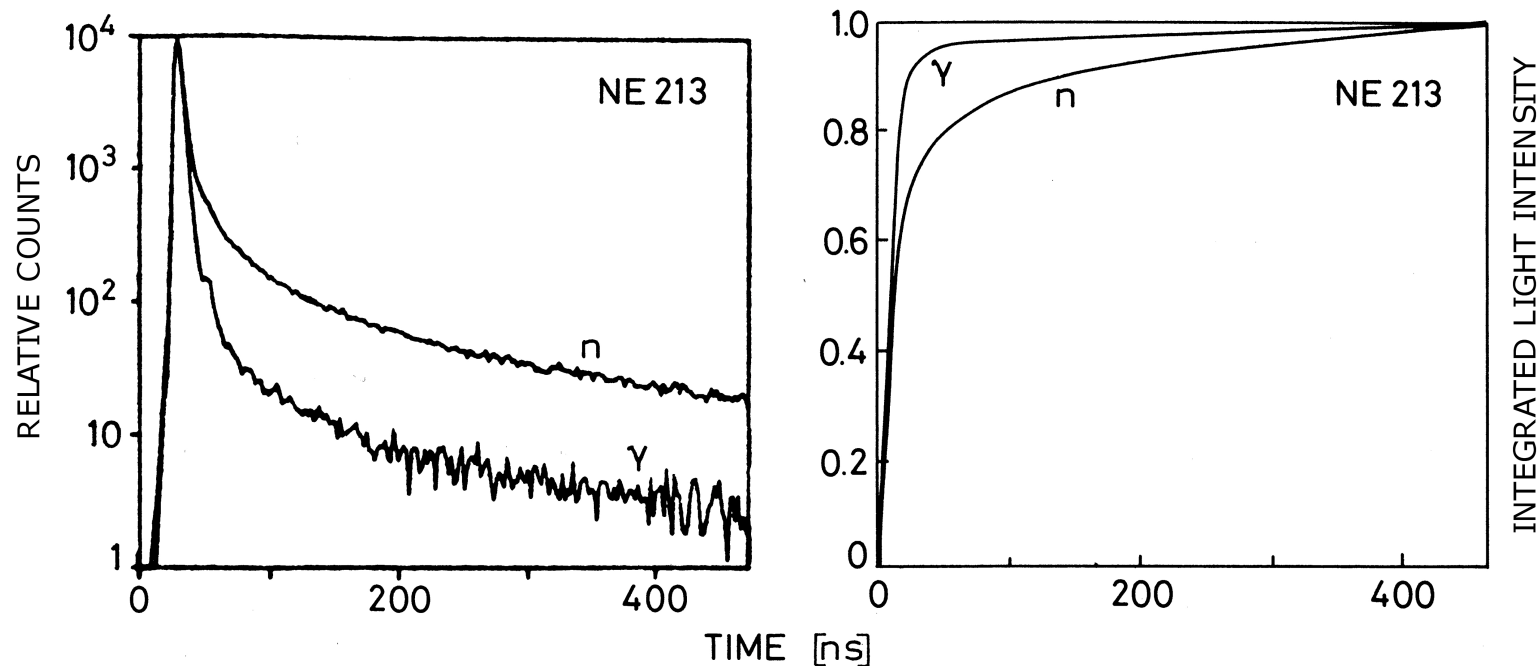
# New Design

- Layers of 48 pipes
- Up to 48 layers  
(90° rotated)  
→ 4608 channels
- Detector volume:  
 $(0.96 \text{ m})^3$



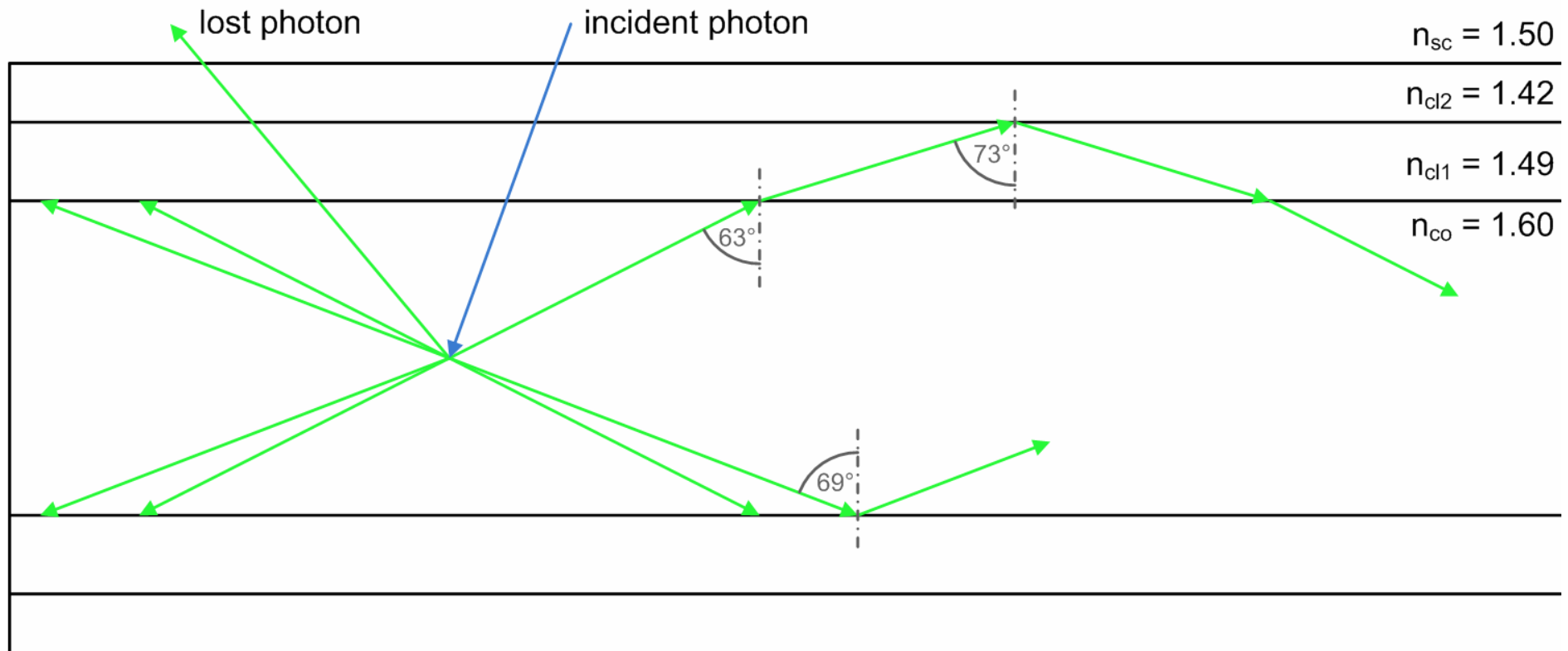
# Liquid Scintillator

- BC-519 (Saint-Gobain)
- Maximum emission: 425 nm
- Light output: 60% Anthracene
- **P**ulse **S**hape **D**iscrimination



# Wavelength Shifting Fiber

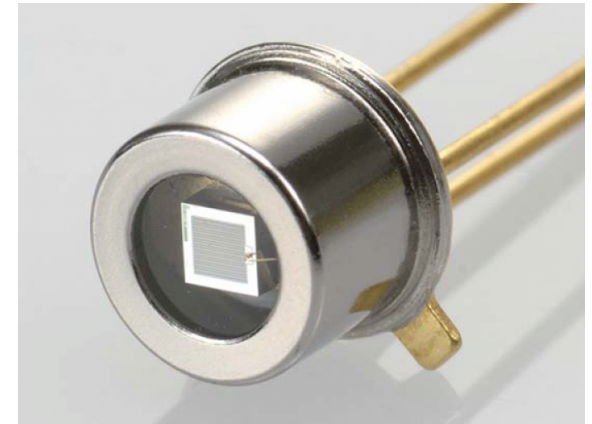
- BCF-92 (Saint-Gobain)
- Maximum emission: 492 nm
- Multi-clad fiber





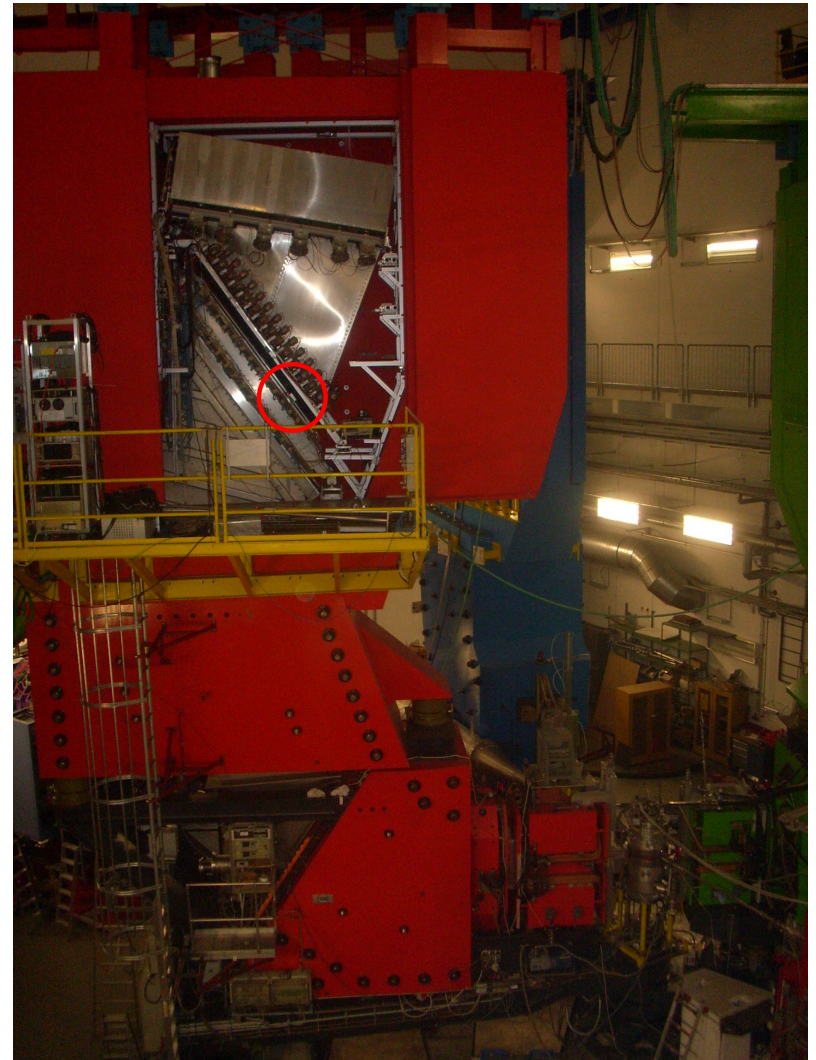
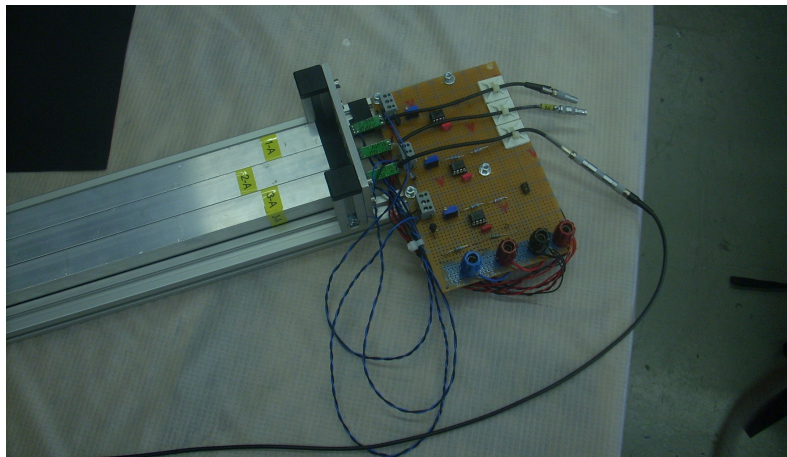
# Multi Pixel Photon Counter

- S10362-11-050U (Hamamatsu)
- Active area:  $1 \times 1 \text{ mm}^2$
- 400 **A**valanche **P**hoto **D**iode pixels in Geiger mode  
( $V_{\text{op}} > V_{\text{br}}$ )
- Gain:  $7.5 \cdot 10^5 \text{ e}/\gamma$
- Low operating voltage:  $\sim 70 \text{ V}$   
→ Individual for each MPPC
- Peak sensitivity: 440 nm
- Photon detection efficiency at 440 nm: 50 %



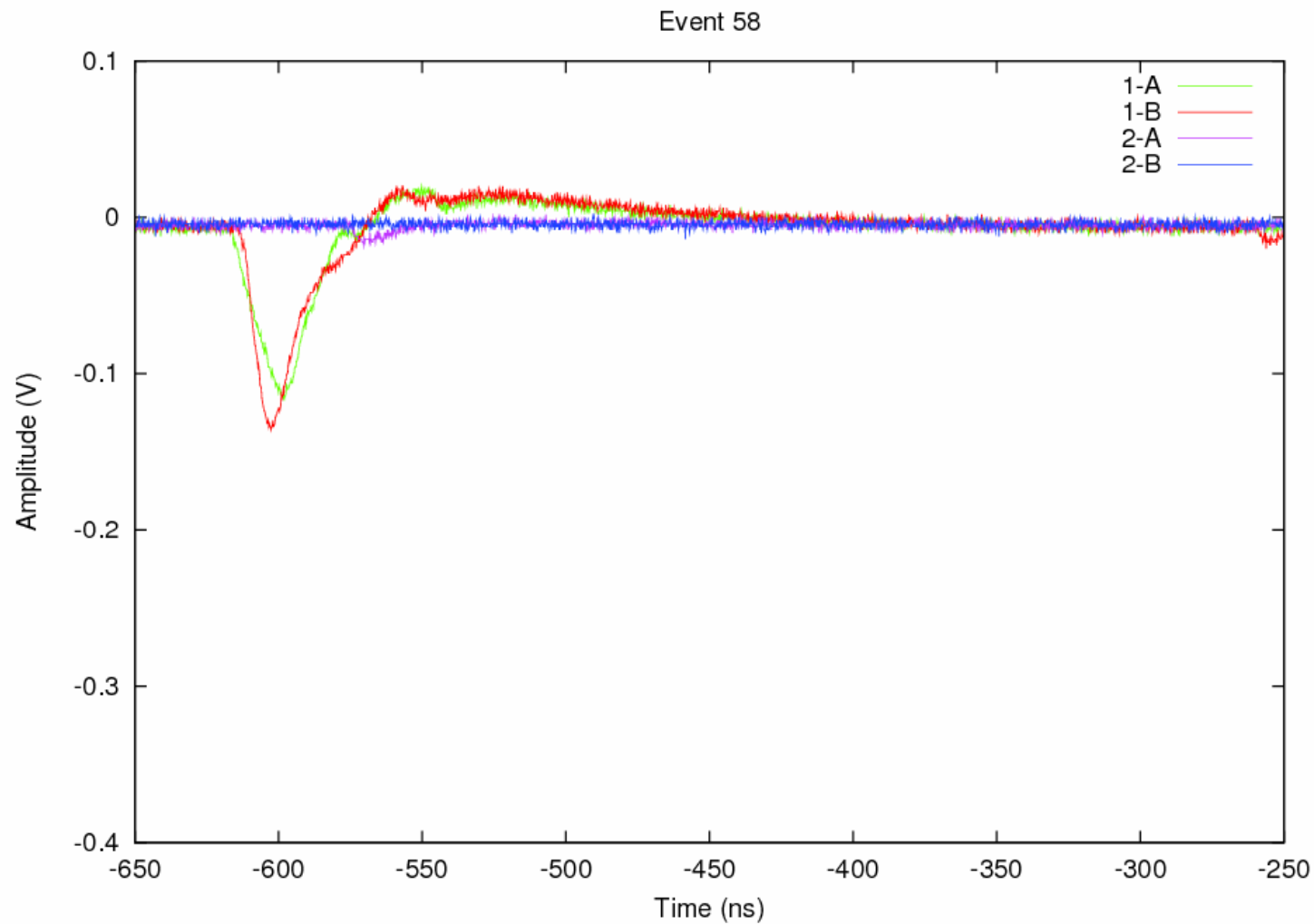
# Experiment

- Prototype with 3 modules
- Spectrometer A
- Particles well-known
  - Identified protons
  - Position



# Experiment

- Readout with oscilloscope



# Data Analysis

- Time resolution  $\Delta T$
- Signal time  $T_0 = 0.5 \cdot (T_A + T_B - T)$
- $\Delta T = 1/\sqrt{2} \cdot \text{FWHM}(T_0)$
  
- Module 1:  
$$\Delta T_{1-A,1-B} = 3.09 \text{ ns}$$
- Module 2:  
$$\Delta T_{2-A,2-B} = 3.03 \text{ ns}$$

# Modifications

Scintillator

Liquid → Plastic

Wavelength shifting fiber

Square → Round

Photon detection

MPPC → Multianode Photomultiplier Tube Assembly

# Summary

New detector design is working

Neutron detector with

- high detector volume
- high segmentation

→ High detection efficiency

→ High counting rate capability