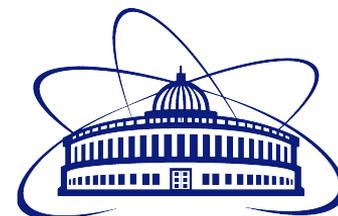


# Neutron spectrometer for the experiments with radioactive beams on the ACCULINNA-2 fragment separator

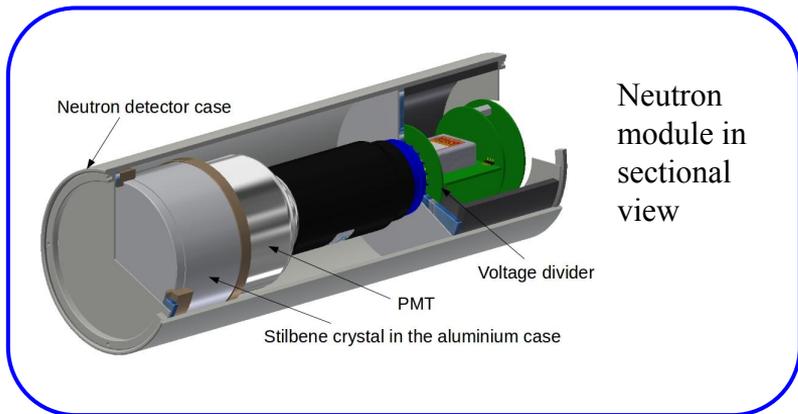
Gazeeva Elvira and  
ACCULINNA group

Flerov Laboratory of Nuclear Reactions,  
Joint Institute for Nuclear Research

Alushta, 2018



## Stilbene based neutron detector



- diameter 8 cm, height 5 cm
- molecular formula  $C_4H_{10}$
- time resolution of 400 ps
- threshold of n- $\gamma$  discrimination of 200 KeV

Array of neutron detectors

### General properties of stilbene crystal

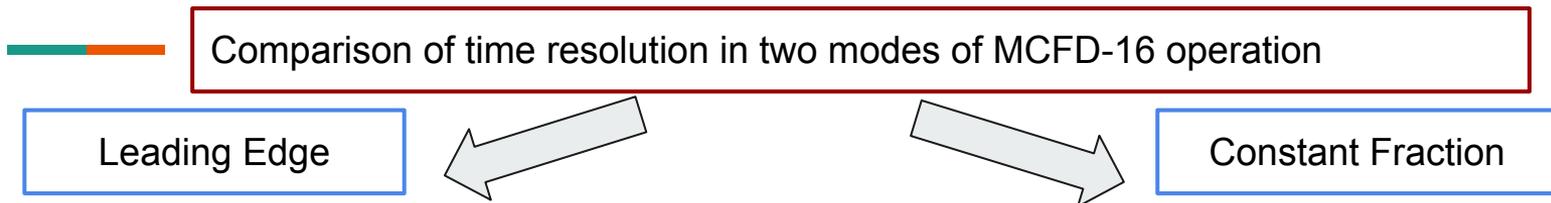
Density	1.22 g/cm <sup>3</sup>
Peak emission	390 nm
Decay time	3.5 ns
No of H atoms/No of H atoms	0.857



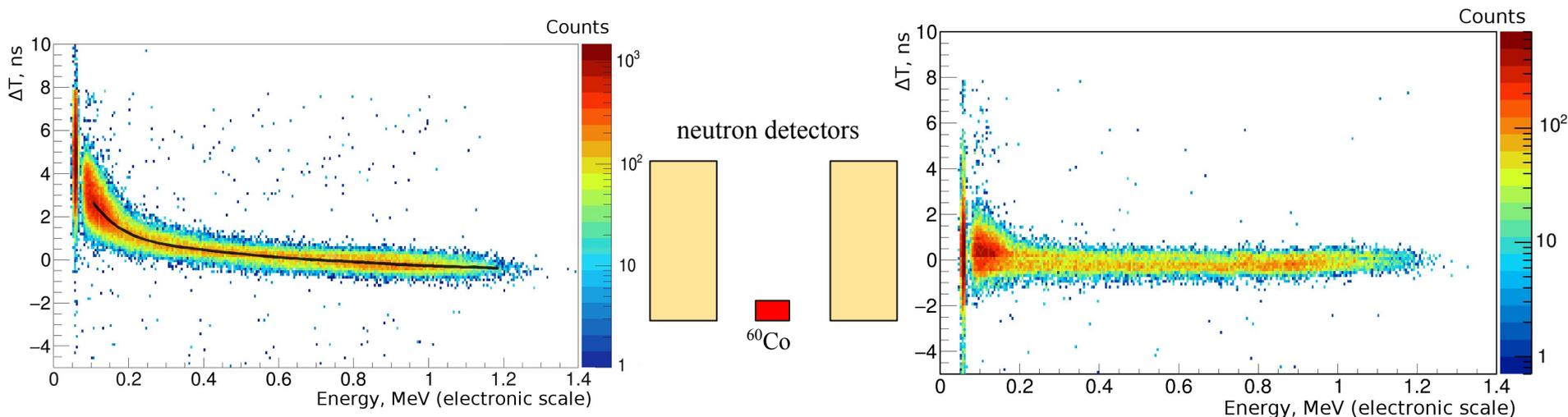
Stilbene crystal in the aluminium container



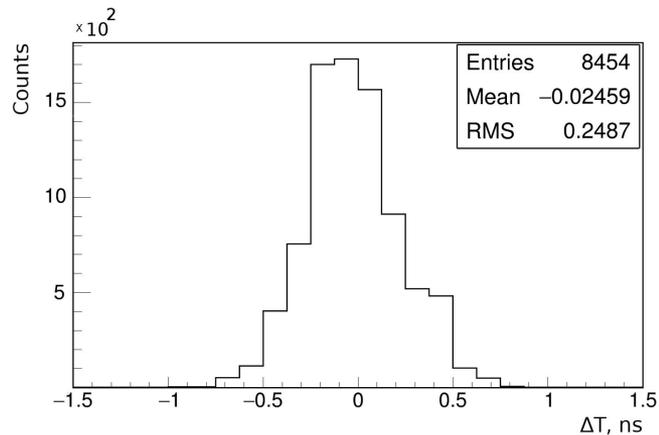
## Time resolution of the neutron detector



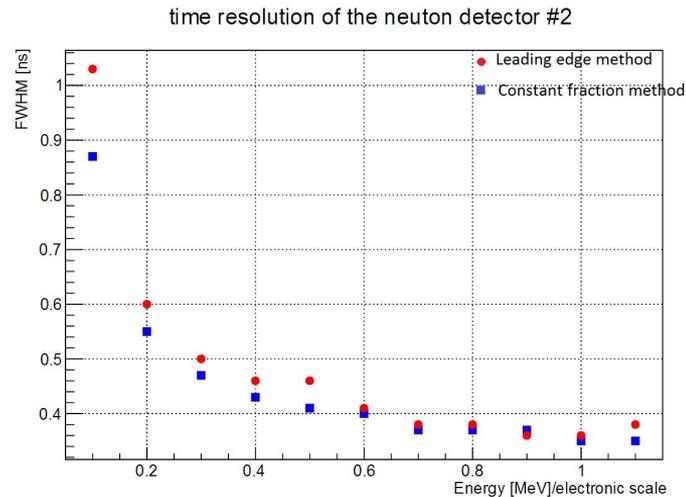
A two-dimensional histogram shows the dependence of the amplitude of detector 2 on the difference of the registration time of two gamma quanta emitted by  $^{60}\text{Co}$  source towards two equidistant detectors at a fixed amplitude range 0.9-1.0 MeV in the first module



## Time resolution of the neutron detector



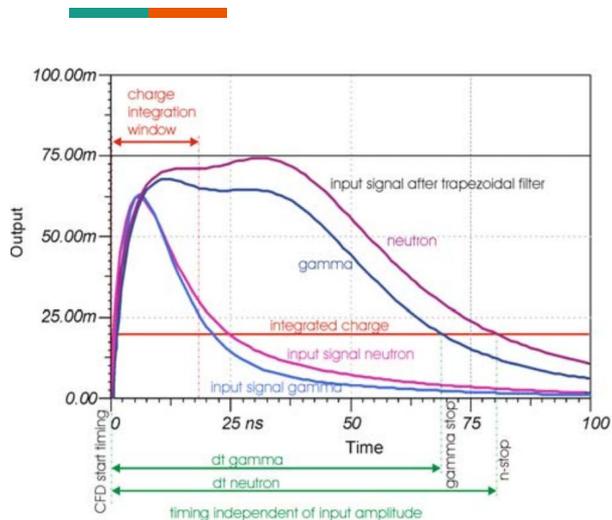
A one-dimensional histogram corresponds to a fixed range of amplitudes in detector № 2:  
0.9 - 1 MeV



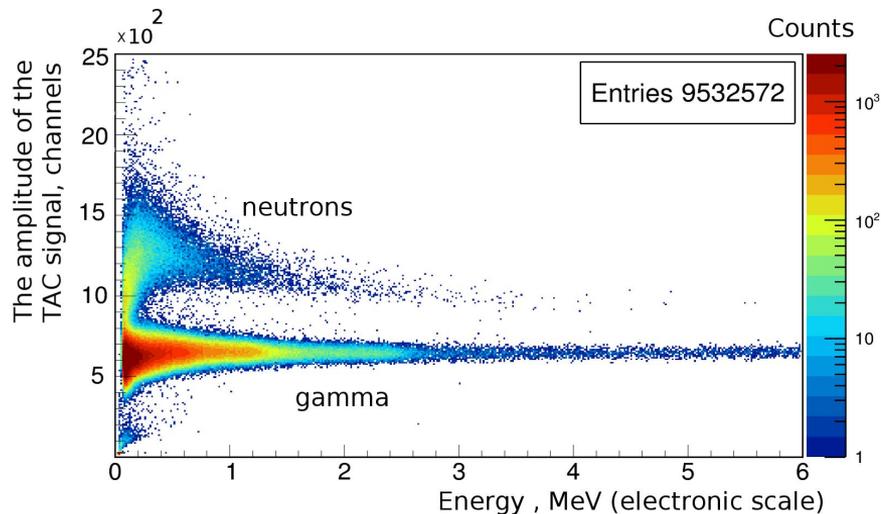
Dependence of the time resolution on the amplitude of the signal for two modes of MCFD-16 operation: 1 - leading edge, 2 - constant fraction

time resolution of 400 ps

## Threshold of the n- $\gamma$ discrimination

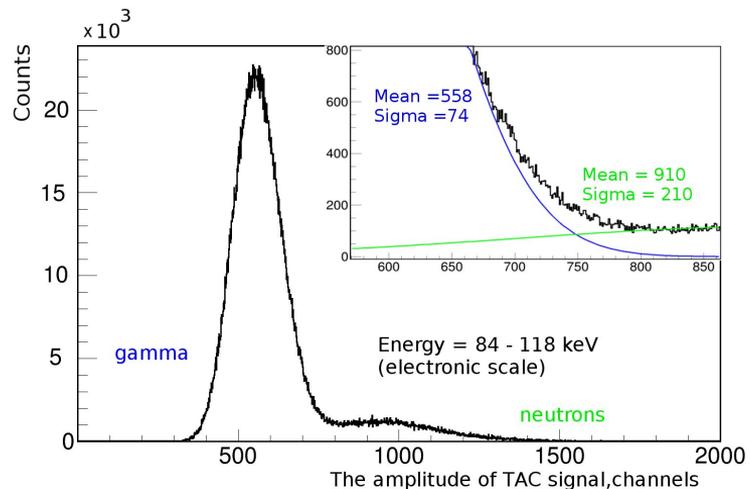


Formation of an internal trapezoidal signal from the input analog signal.



Two dimensional plot of the n- $\gamma$  discrimination made by MPD-4 module. Neutron and gamma source is  $^{252}\text{Cf}$  source.

## Threshold of the n-γ discrimination



The distribution of the TAC signal values for the fixed amplitude range 84-118-keV (electronic scale)

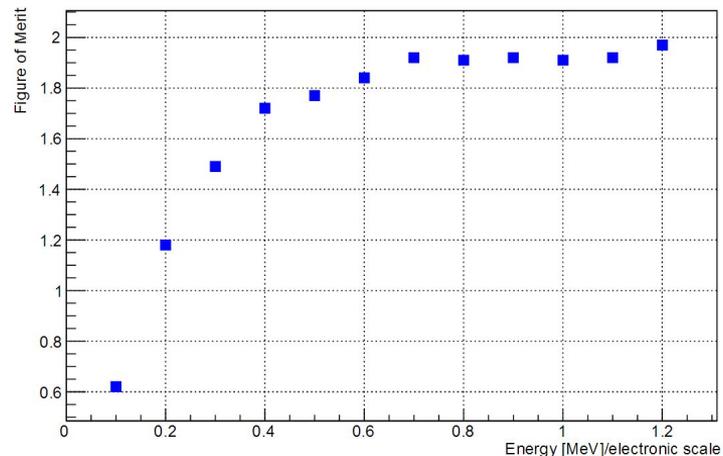


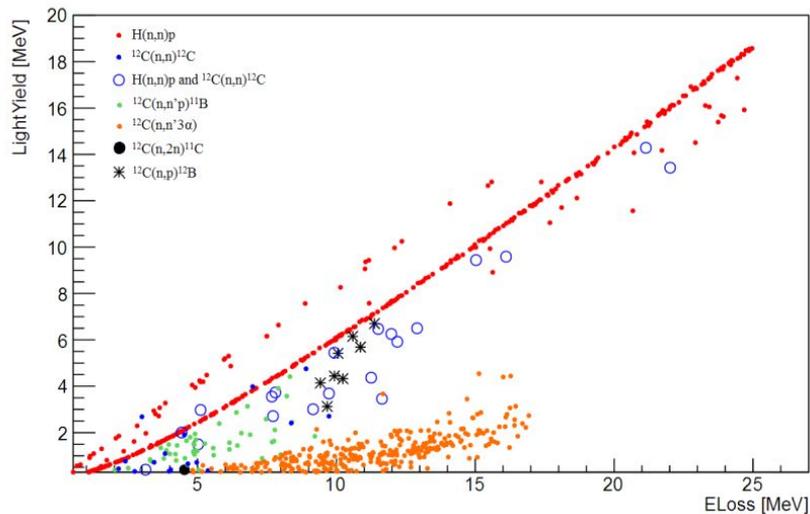
Figure Of Merit (FOM) in dependence on the amplitude of the signal (electronic scale)

$$FOM = \frac{T_{n-\gamma}}{W_n + W_\gamma}$$

$T_{n-\gamma}$  is difference between the gamma and neutron peaks,  
 $W_n + W_\gamma$  is the sum of its FWHMs.

threshold of n-γ discrimination  
 of 200 KeV

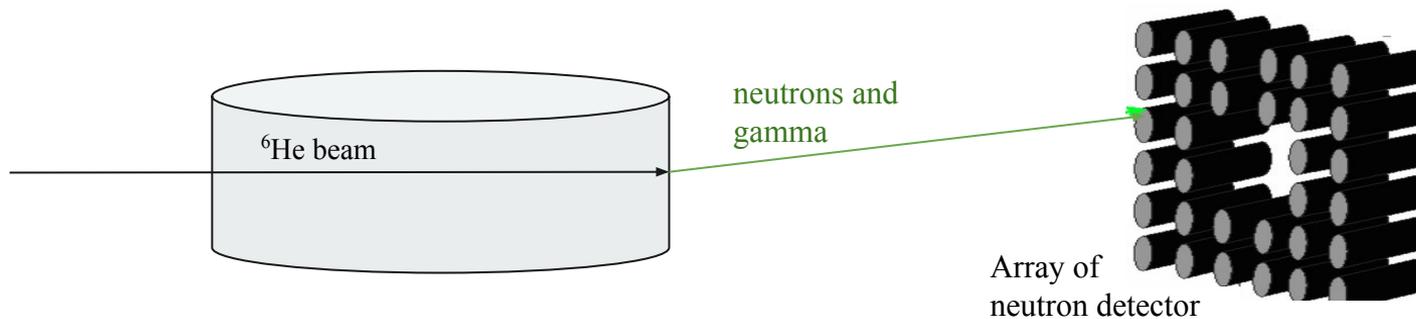
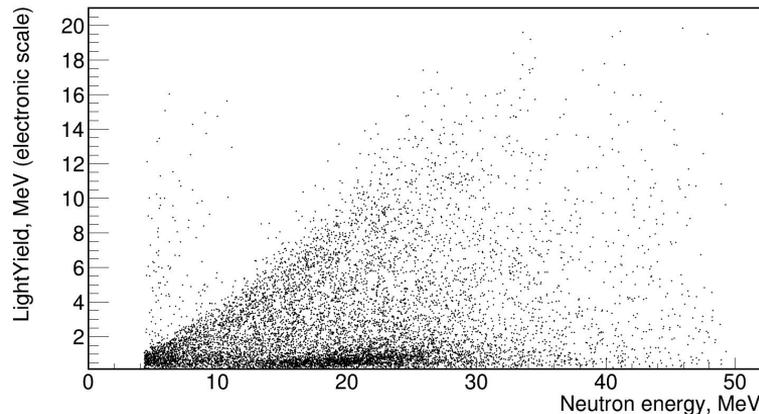
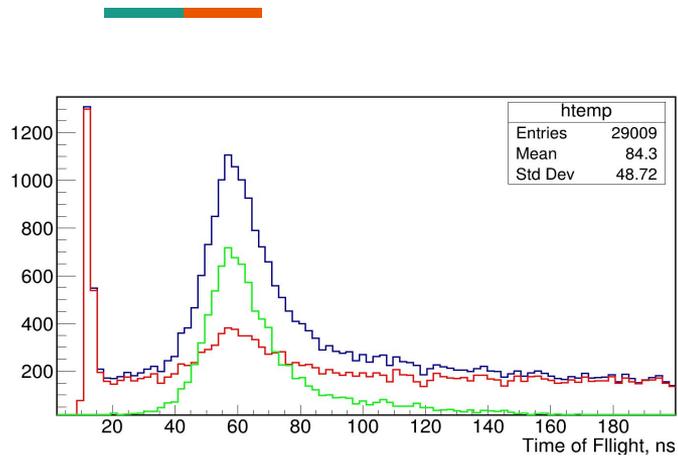
## Contributions to the total efficiency of the main interaction reactions inside the stilbene at neutron energy 25 MeV



- Elastic scattering by hydrogen and carbon nuclei  $\text{H}(n,n)p$ ,  $^{12}\text{C}(n,n)^{12}\text{C}$
- Inelastic scattering by carbon nuclei  $^{12}\text{C}(n,n')^{12}\text{C}^*$
- Nuclear reactions  $^{12}\text{C}(n,\alpha)^9\text{Be}$ ,  $^{12}\text{C}(n,n')3\alpha$ ,  $^{12}\text{C}(n,n')^{11}\text{B}$ ,  $^{12}\text{C}(n,p)^{12}\text{B}$ ,  $^{12}\text{C}(n,2n)^{11}\text{C}$

Reactions	Energy of reaction [MeV]	Threshold of reaction [MeV]
$^{12}\text{C}(n,\alpha)^9\text{Be}$	-5.7	6.2
$^{12}\text{C}(n,n')3\alpha$	-7.3	7.9
$^{12}\text{C}(n,n')^{11}\text{B}$	-15.9	17.3
$^{12}\text{C}(n,p)^{12}\text{B}$	-12.6	13.6
$^{12}\text{C}(n,2n)^{11}\text{C}$	-18.7	20.3

## The first data from neutron detectors





**Thank you for attention!**