Scintillation neutron detector with dynamic threshold

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Neutron spectroscopy

- $S_m(E)=S_0(E)\ \varepsilon(E)\ \alpha_1(E)\ldots\alpha_n(E)$

- (n,p) scattering
- Multiple scattering
- Pulse-shape analysis
- Scattering on environment
- (n,a), (n,p), (n,γ) reactions

→ $\varepsilon(E)$ efficiency

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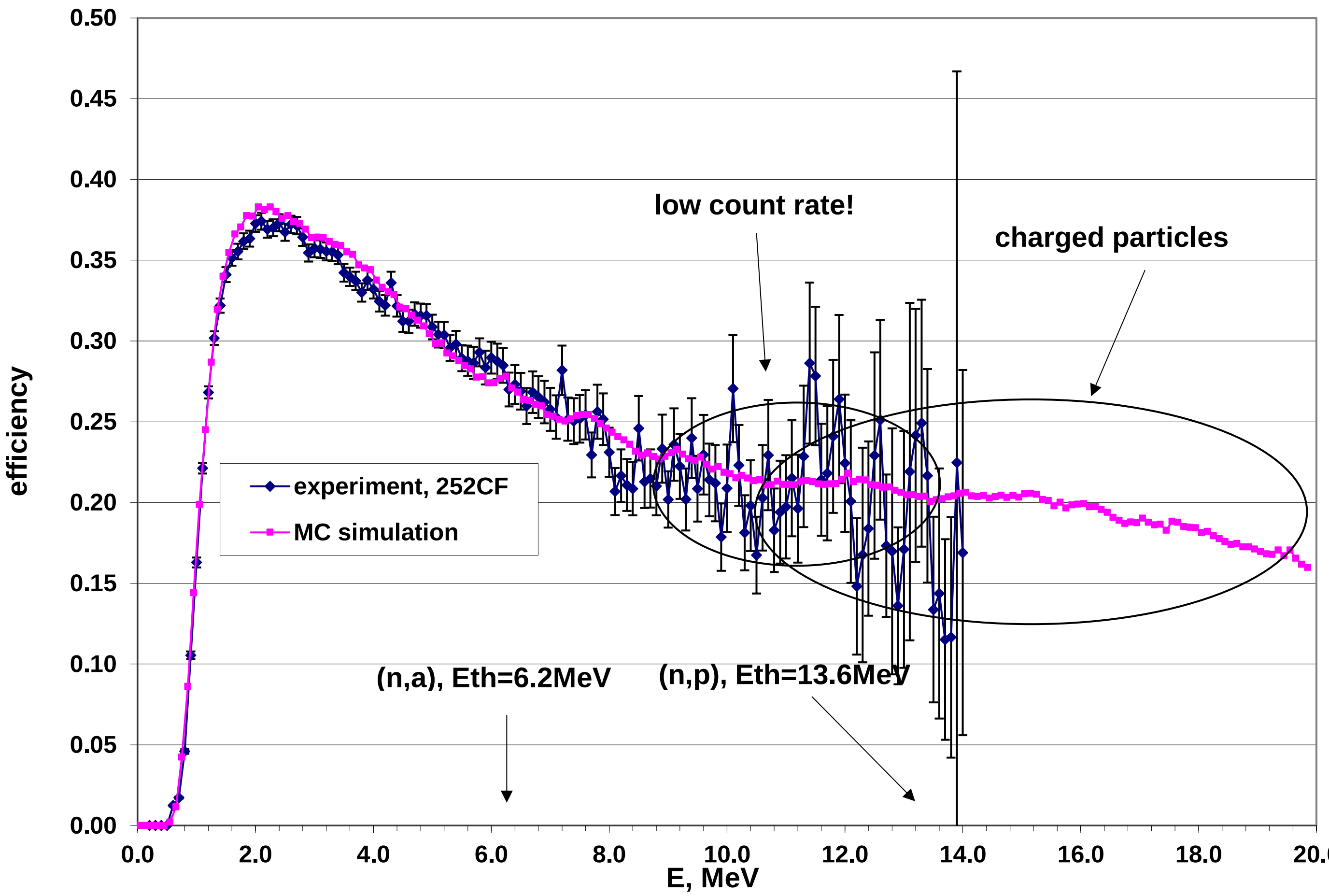
Efficiency should be measured in whole energy range



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^{238}U fission chamber as a neutron detector

$$\varepsilon(E) \sim \sigma_{nf}(E)$$

- Very low efficiency
- Very long run time
- “Start” and “stop” signal are producing with similar “fast current sensitive preamp”

- Can be combined advantage of “scintillation detector” and “fission chamber”????

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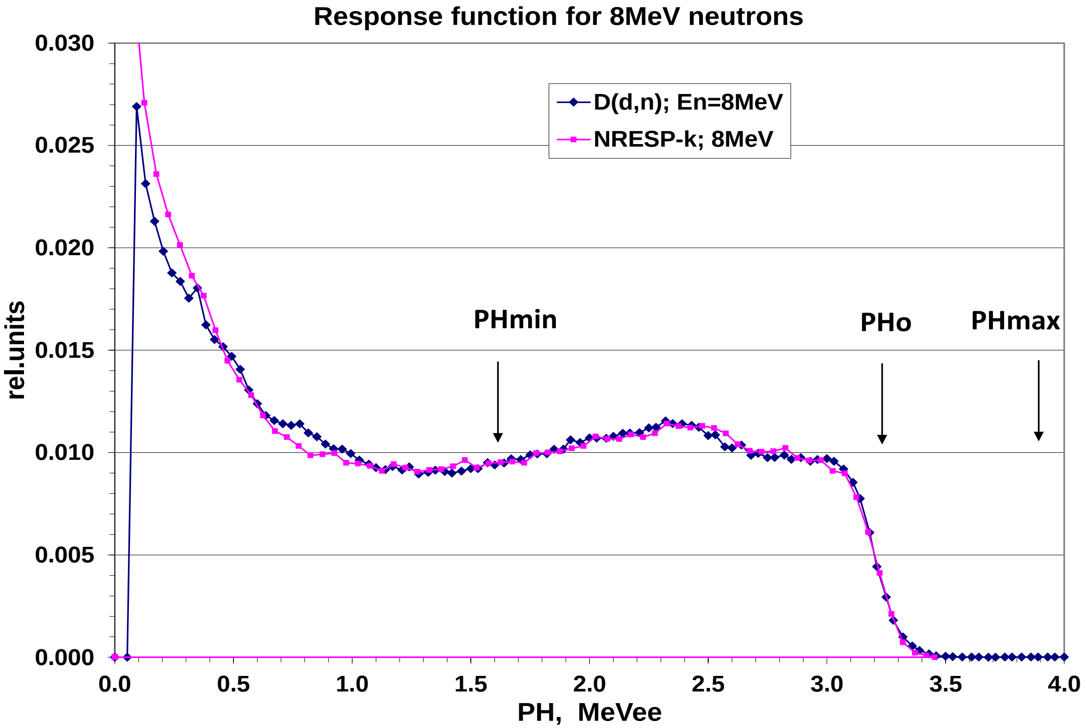
Idea of dynamic threshold



E from TOF

$PH_0 = L(E)$

$E_{min} = E * \cos(\theta)^2$

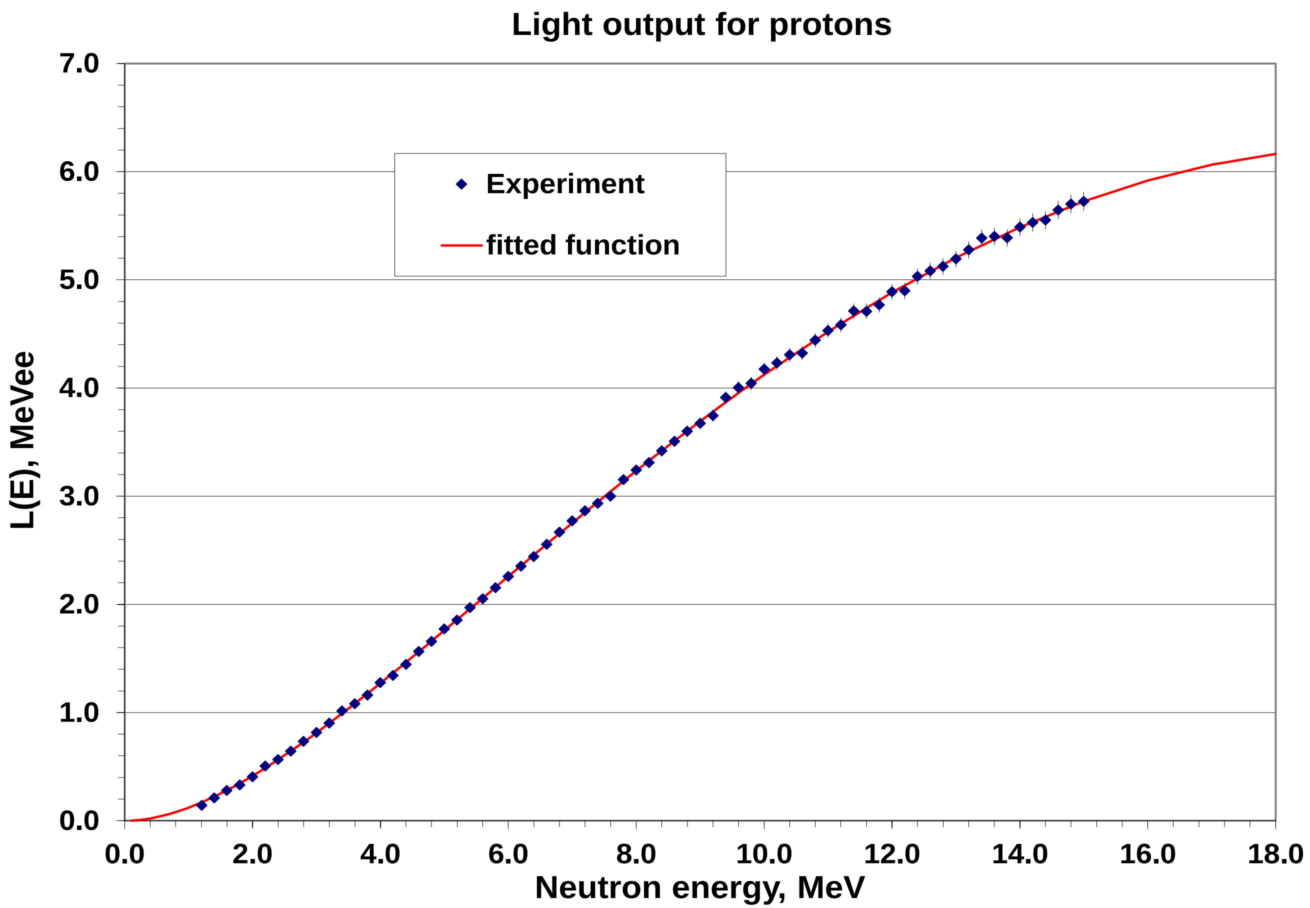
$PH_{min} = L(E_{min})$

$PH_{max} = PH_0 + 3 * \sigma(E)$

$Ph_{min} < PH < PH_{max}$

L(E) – light output
σ(E) – PH resolution
Should be measured

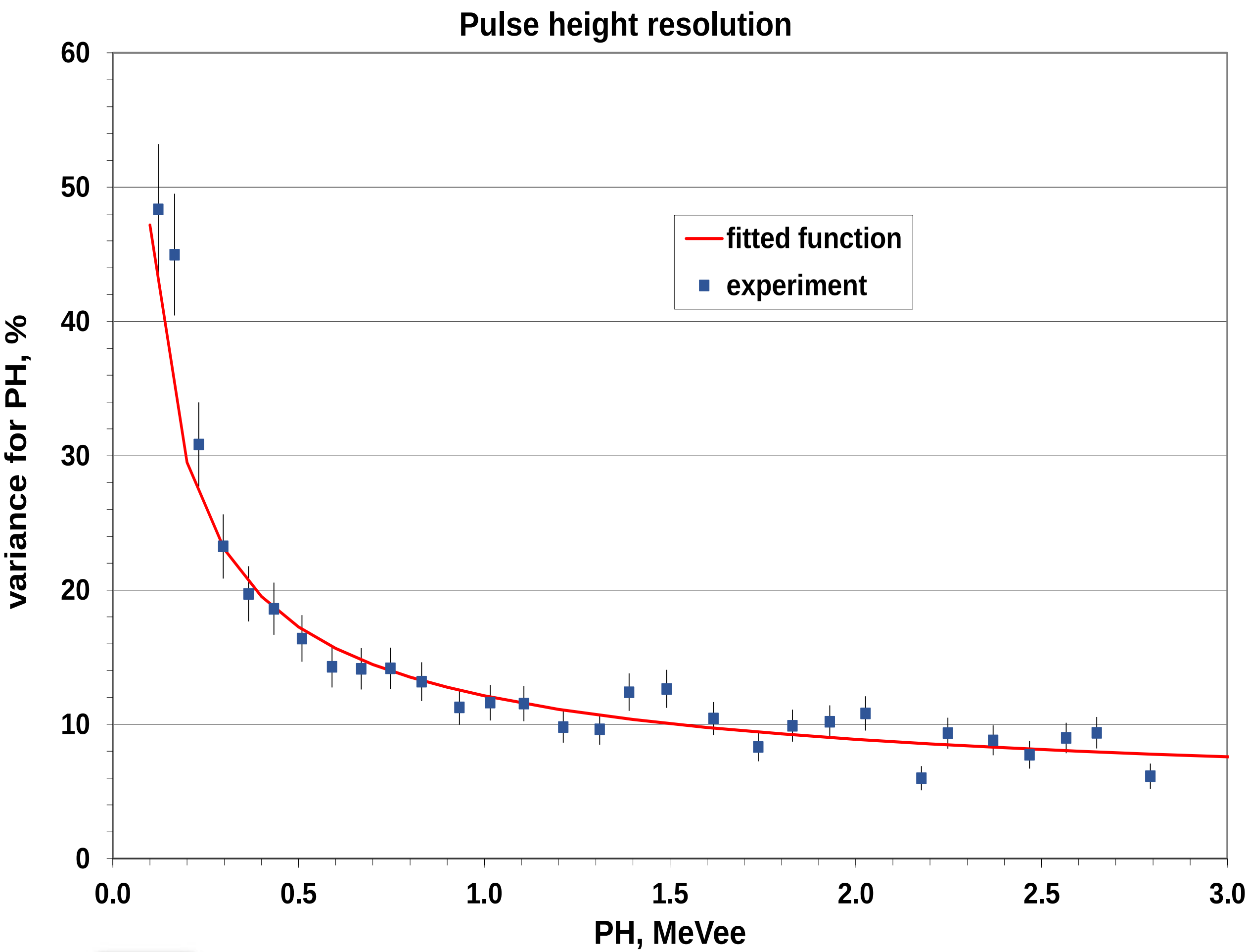
B(d,n) reaction for L(E) and σ(E)



$$\mathbf{L(E) = (ao + a1 * E)\frac{E^2}{E + Eo}}$$

a_0=0.986
a_1=-2.76E-2
E_0=6.810

B(d,n) reaction for L(E) and σ(E)



$$\sigma = L\left(\alpha^2 + \frac{\beta^2}{L} + \left(\frac{\gamma}{L}\right)^2\right)^{0.5}$$

α=0.04

β=0.11

γ=0.10

^{252}Cf experiment

Detector
NE213, Ø=12.5cm, H=5.08cm
RCA 4522

Flight path
L=4.1 m

Cf-source
N= 2.28E4 1/s

Total time resolution
FWHM=2.4 ns

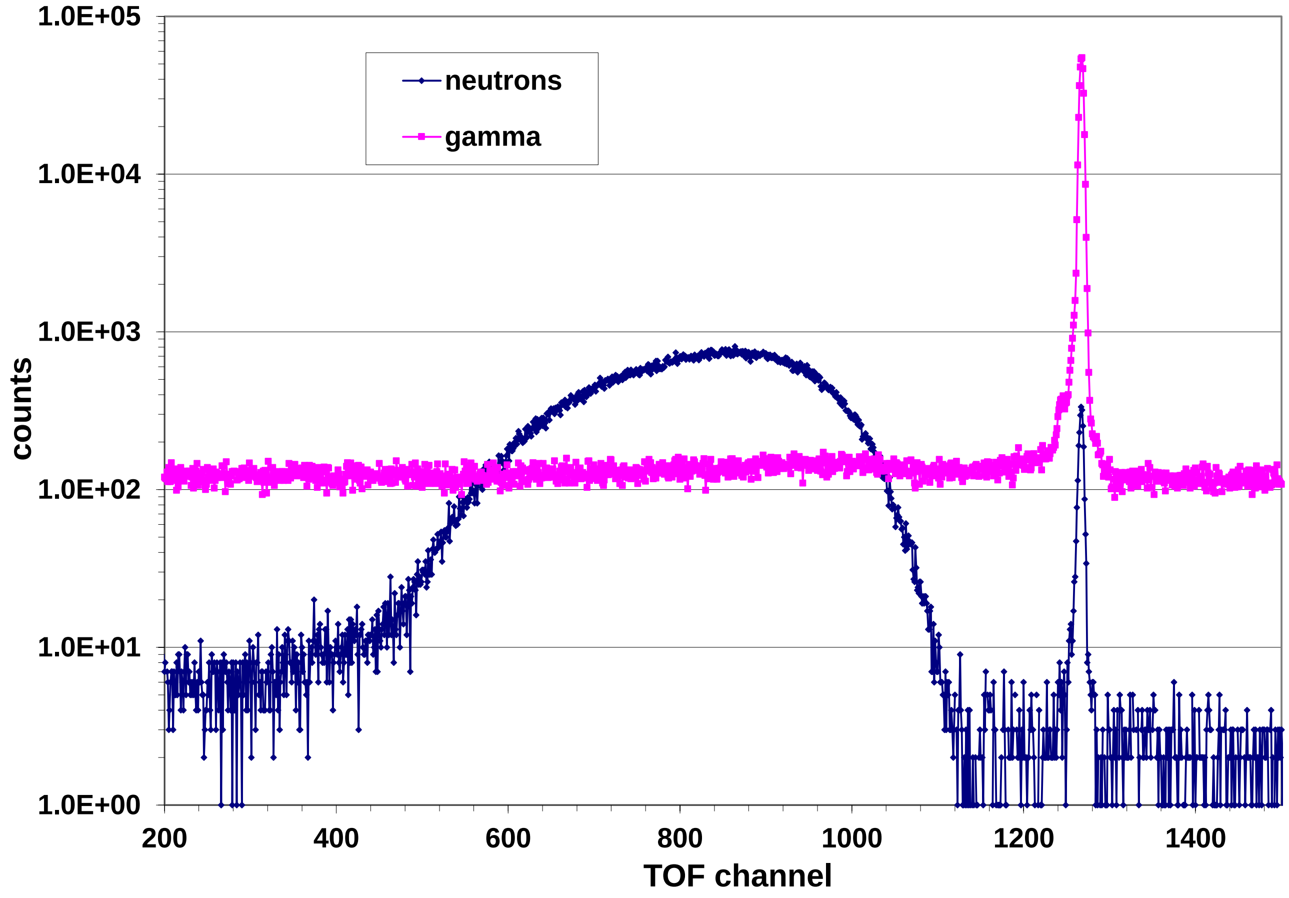
Evens from detector were collected in “list mode”
For each event were measured:

Time of Flight - TOF;

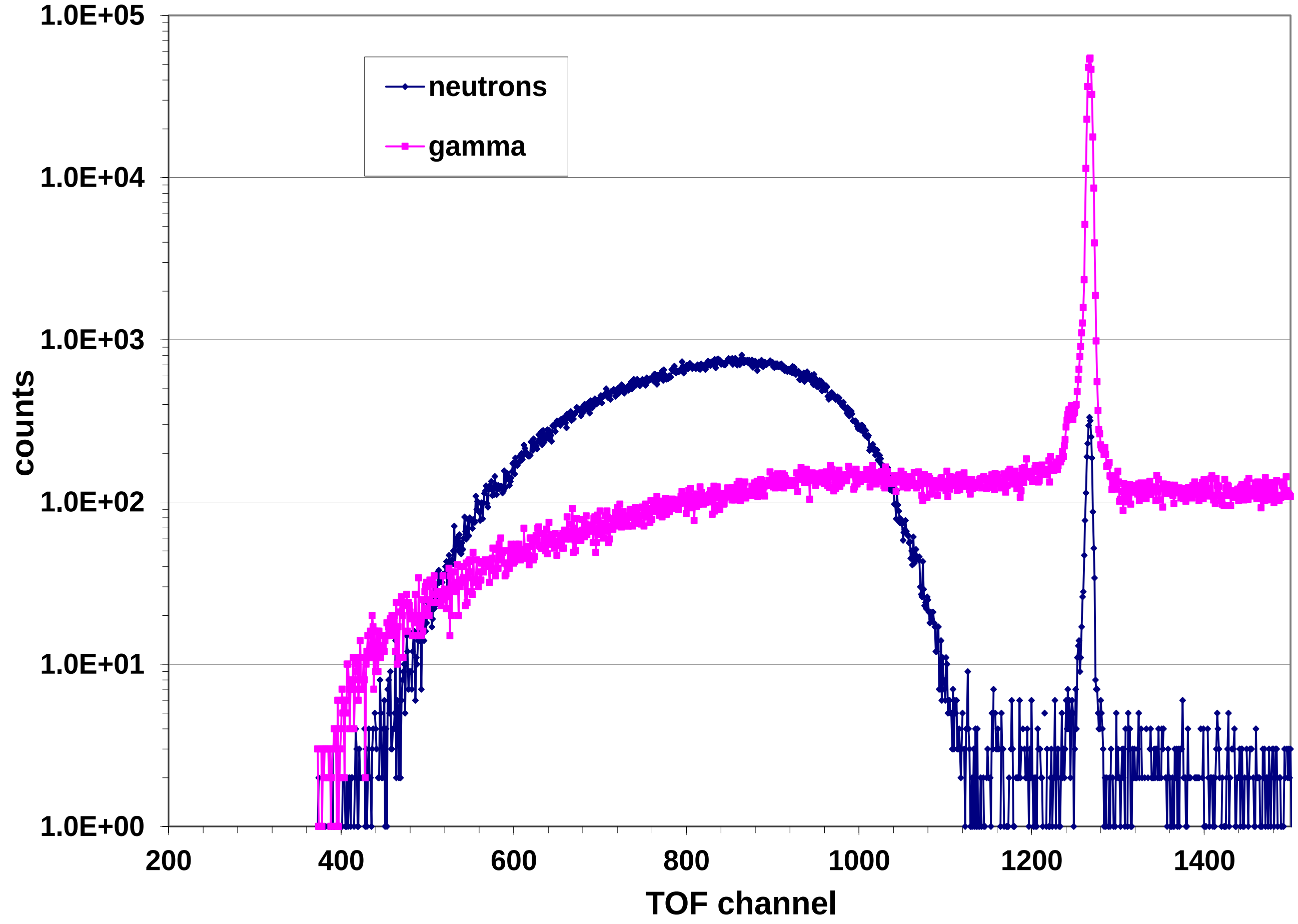
Pulse Height - PH;

Pulse shape - PS.

TOF spectra without selection



TOF spectra cos(θ)=0.1, PH_{max} selection



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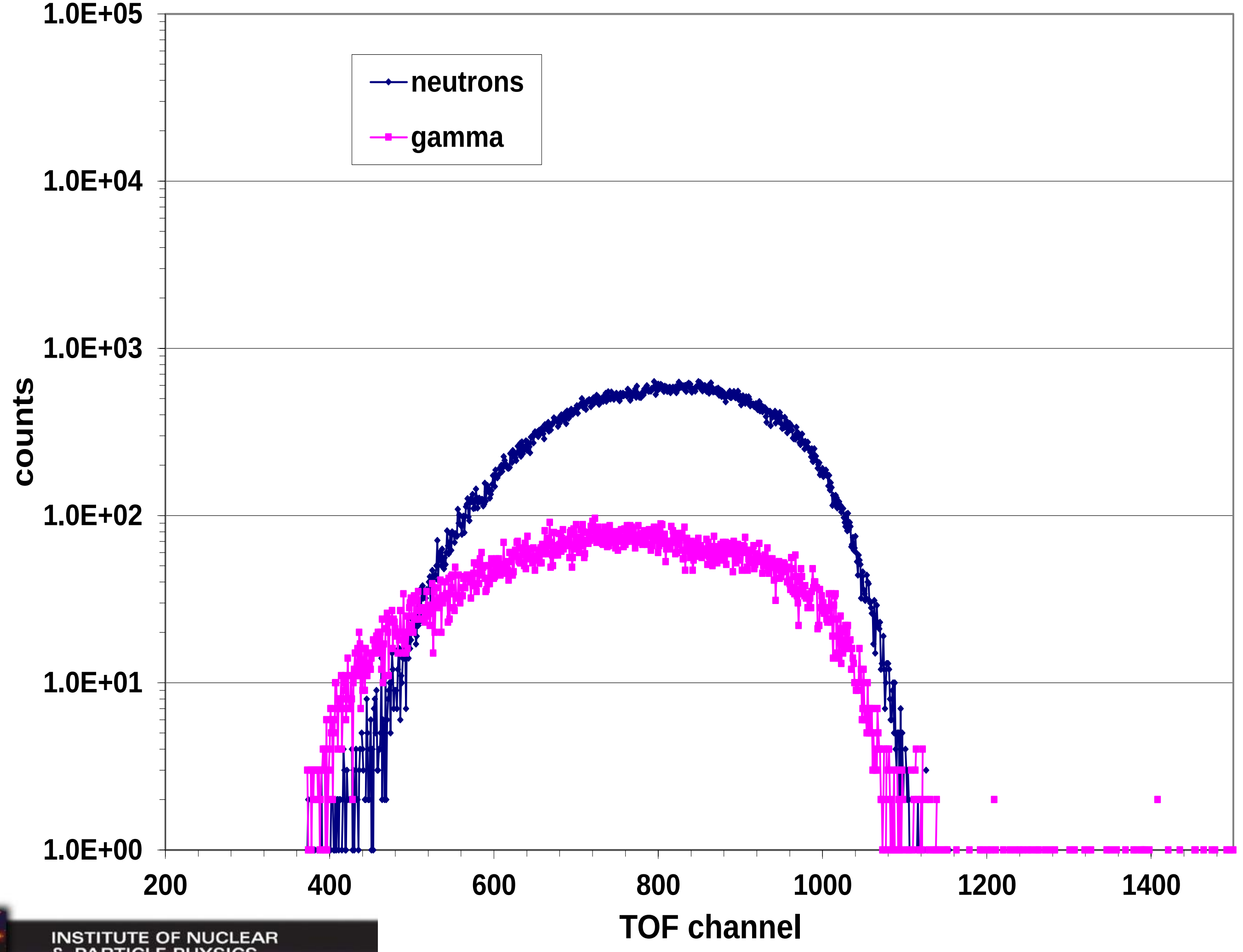
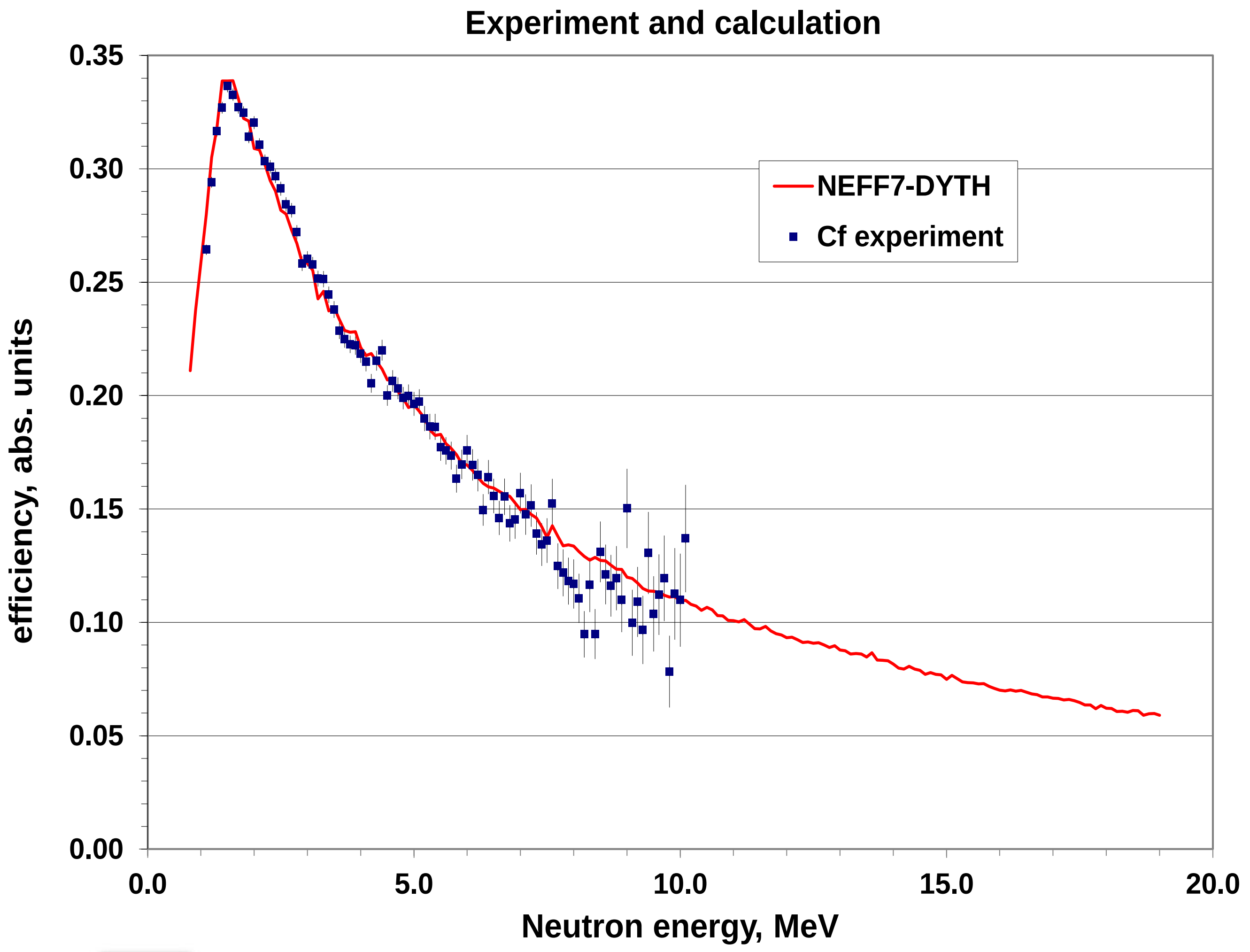
Total selection cos(θ)=0.707



Efficiency with dynamic threshold



R=E/C=1.012±0.004

1.3 -6 MeV

Conclusion

- Dynamic threshold method was developed for NE213 detector and was investigated with ^{252}Cf neutron source. A first attempt "A dynamically biased neutron detector" was realized in 1971 for background reduction in TOF experiments. Our realization and motivation are different very much. One should highlight that successful realization of this method is not possible without experimental light output function for particular detector.

- The unique peculiarity of this method is that its application removes events connected with (n,α) reaction in organic scintillator. This allow us to increase an accuracy for extrapolation of calculated data to high energy range 10-20MeV.

- This method also: reduces time independent background, reduce contribution of neutrons scattering on the detector environment, and reduces the time resolution.

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Conclusion

- In whole energy range <20MeV only one reaction (n,p)-scattering is responsible for formation of the detector efficiency after application of the dynamic threshold.
- It seems that the contribution of multiple scattering inside detector, interaction with detector environment are reduced very much. In the energy range <8 MeV the agreement between experimental and calculated results is perfect. Hence, we may expect that extrapolation to energy range 10-20MeV may be done with high accuracy also.
- However, detailed investigation of the uncertainties in whole energy range is important direction of future activities.

- This method is very useful for experimental investigations of inelastic neutrons scattering on Fe, ^{238}U nuclei at the incident energies 6-8MeV, and ~14MeV.

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The end