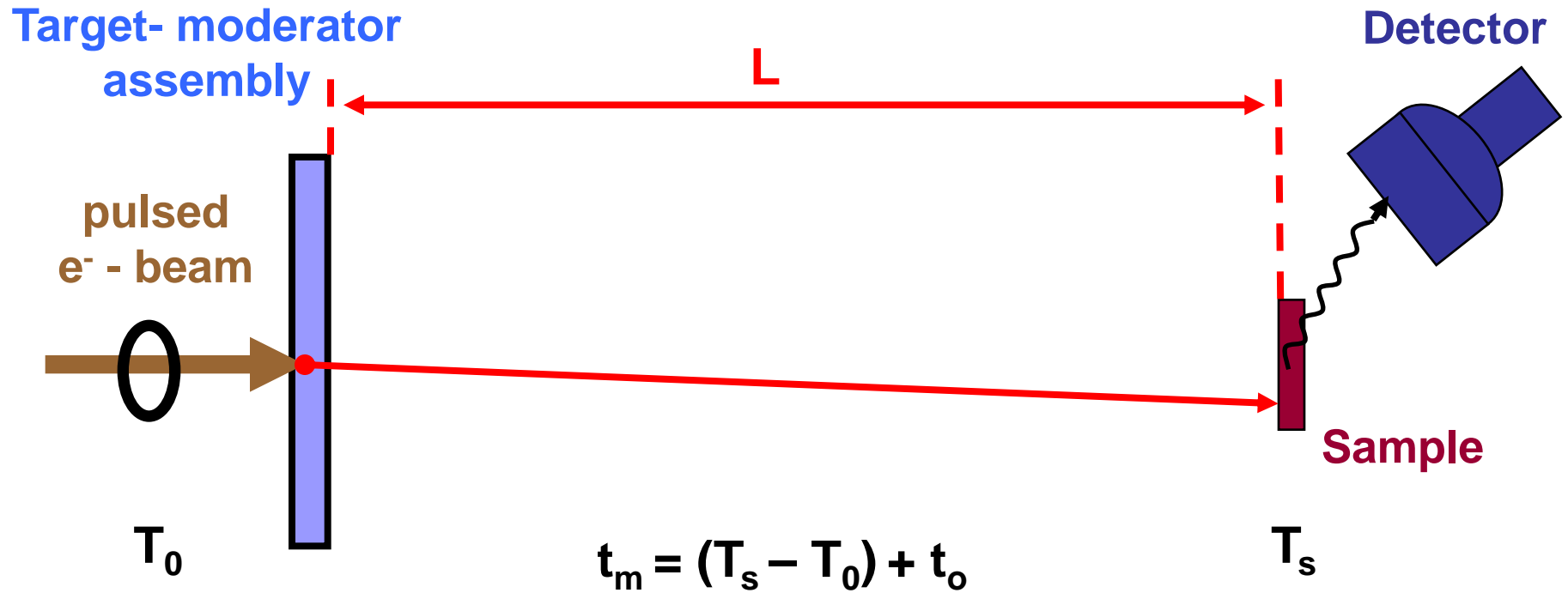


Reporting of response function of a TOF - spectrometer

EC – JRC – IRMM

SG – 36, 23 – 05 -2012, WPEC, NEA Paris

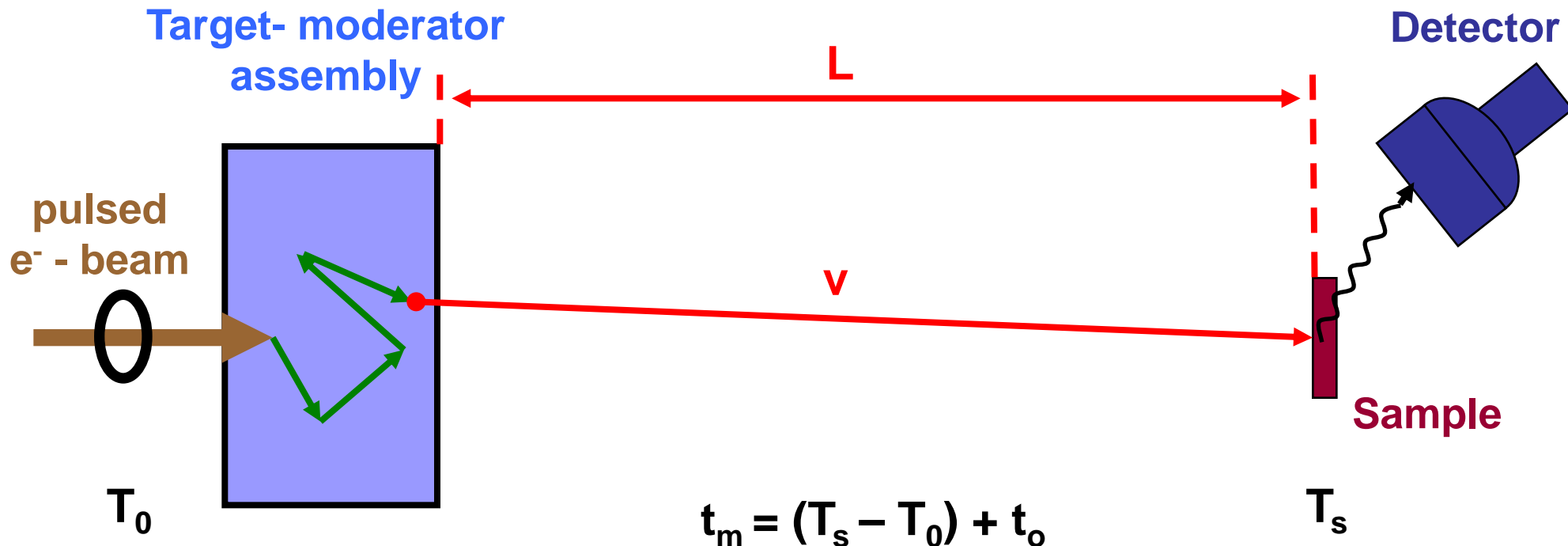
Time-of-flight technique



$$v \approx \frac{L}{t_m}$$

$$E = m_n c^2 \left(\frac{1}{\sqrt{1 - (v/c)^2}} - 1 \right)$$

Response of TOF-spectrometer



$$t_m = (T_s - T_0) + t_o$$

$$t = t_m - (t_t + t_d)$$

$$v = \frac{L}{t}$$

Response of TOF-spectrometer

$$v = \frac{L}{t} \quad \Rightarrow \quad E = m c^2 (\gamma - 1)$$

$$\frac{\Delta v}{v} = \sqrt{\frac{\Delta t^2}{t^2} + \frac{\Delta L^2}{L^2}} \quad \Rightarrow \quad \frac{\Delta E}{E} = (\gamma + 1) \gamma \frac{\Delta v}{v}$$

- ΔL (~ 1 mm)

- Δt

- Initial burst width

 ΔT_0

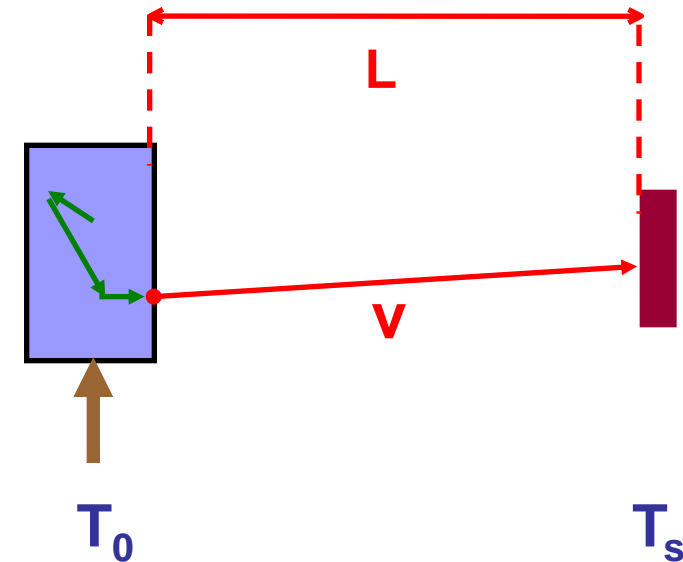
- Time jitter detector & electronics

 ΔT_s

- Neutron transport in target - moderator

 Δt_t

- Neutron transport in detector

 Δt_d 

$$t = t_m - (t_t + t_d)$$

Response of TOF-spectrometer

$$v = \frac{L}{t} \quad \Rightarrow \quad E = m c^2 (\gamma - 1)$$

$$\frac{\Delta v}{v} = \sqrt{\frac{\Delta t^2}{t^2} + \frac{\Delta L^2}{L^2}} \quad \Rightarrow \quad \frac{\Delta E}{E} = (\gamma + 1) \gamma \frac{\Delta v}{v}$$

- ΔL (~ 1 mm)

- Δt

- Initial burst width

 ΔT_0

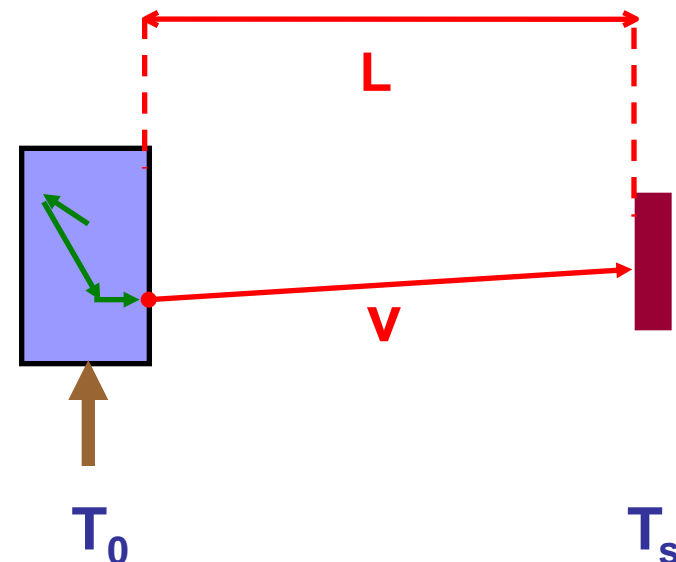
- Time jitter detector & electronics

 ΔT_s

- Neutron transport in target - moderator

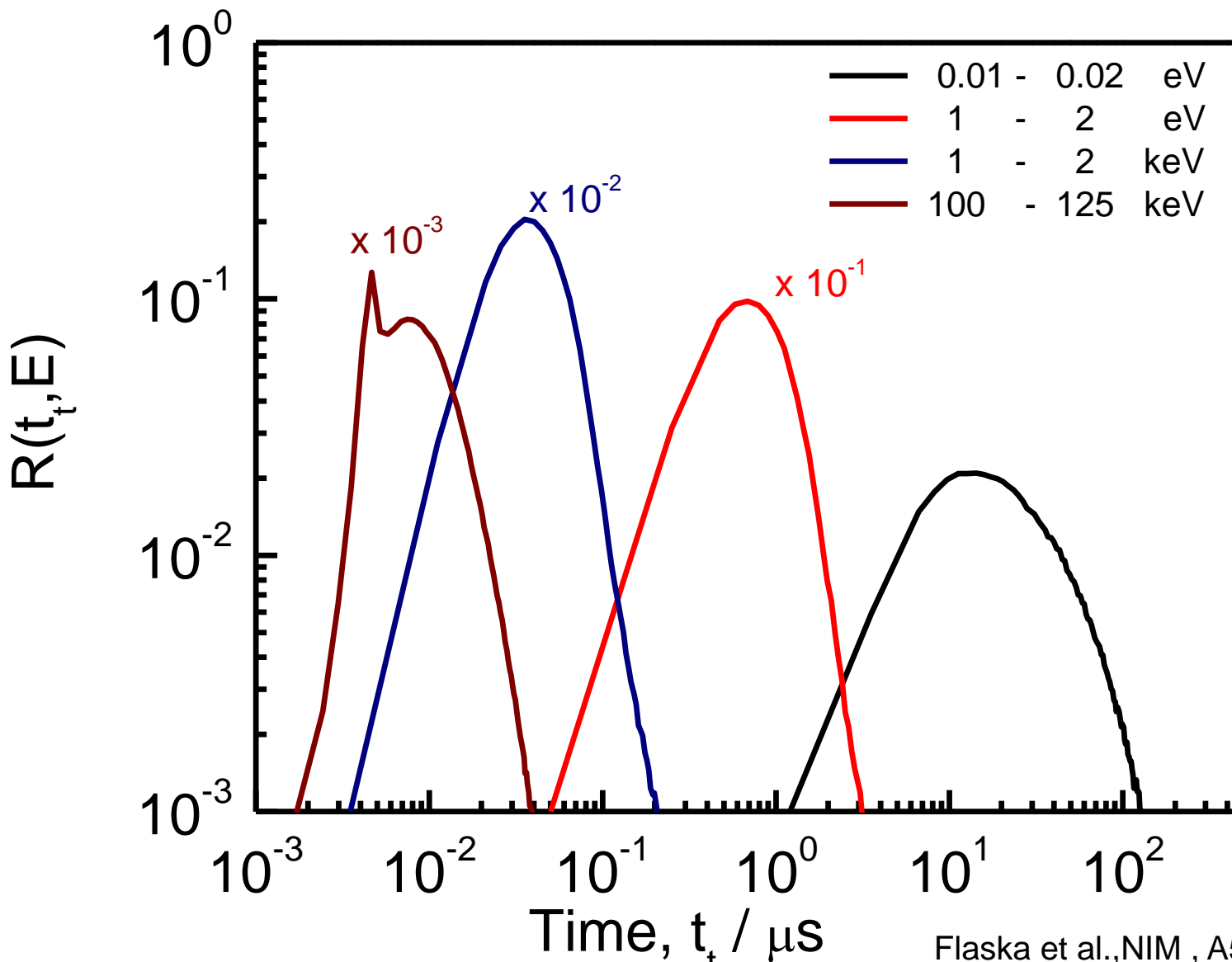
 Δt_t

- Neutron transport in detector

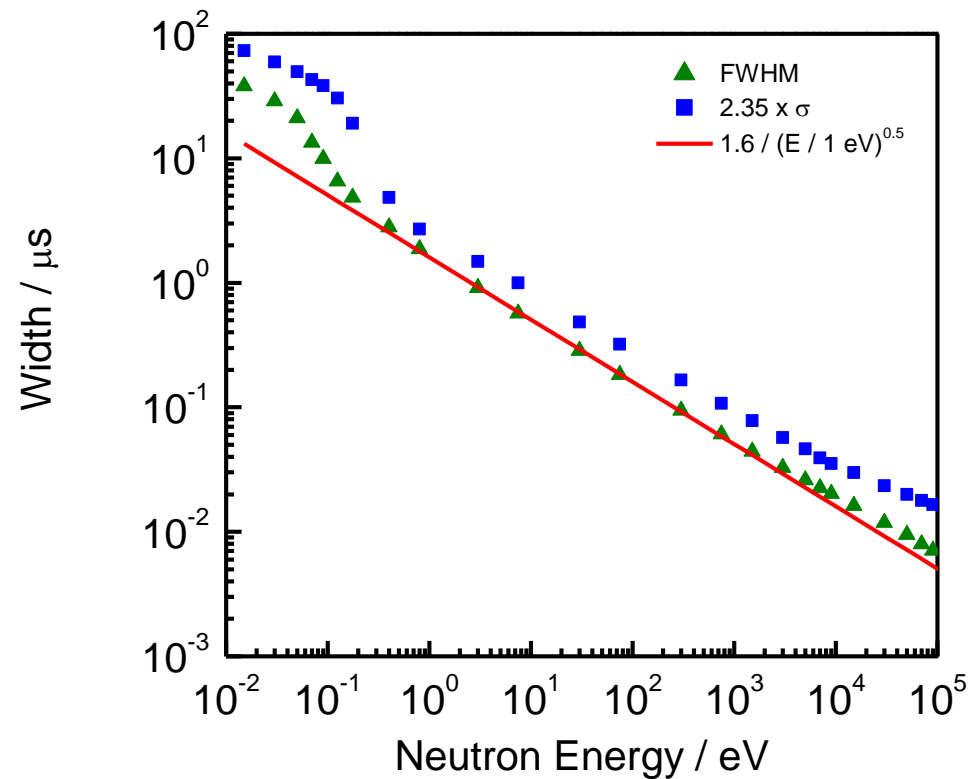
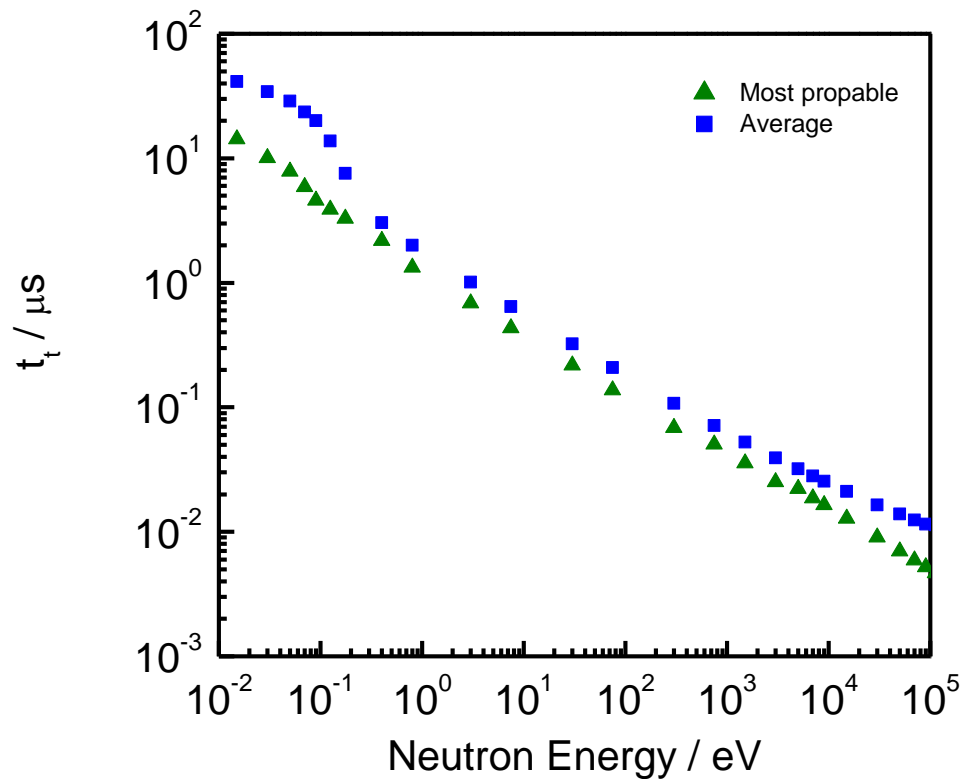
 Δt_d 

$$t = t_m - (t_t + t_d)$$

Probability distribution of t_t : GELINA

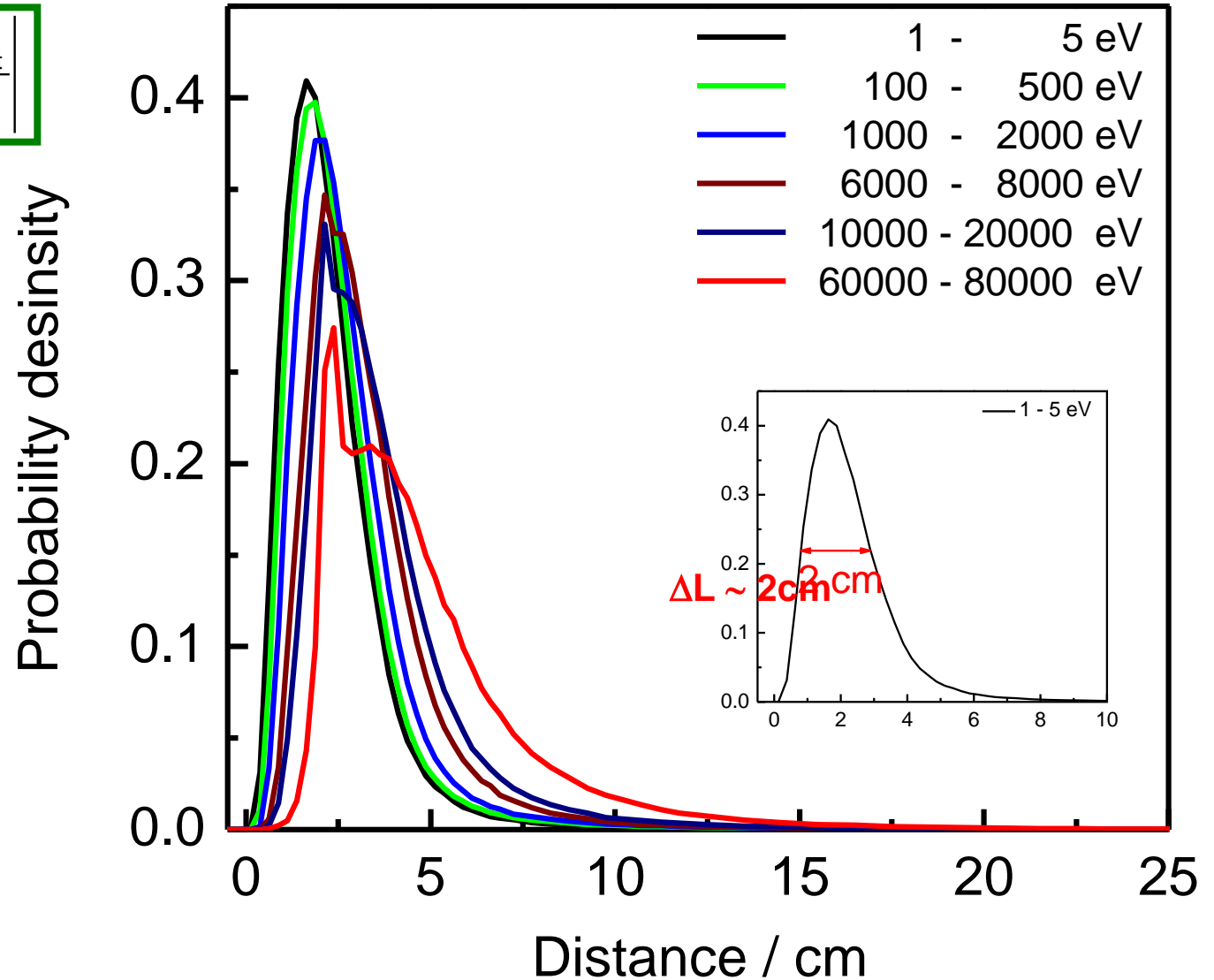


Characteristics of $P(t_t)$ for GELINA

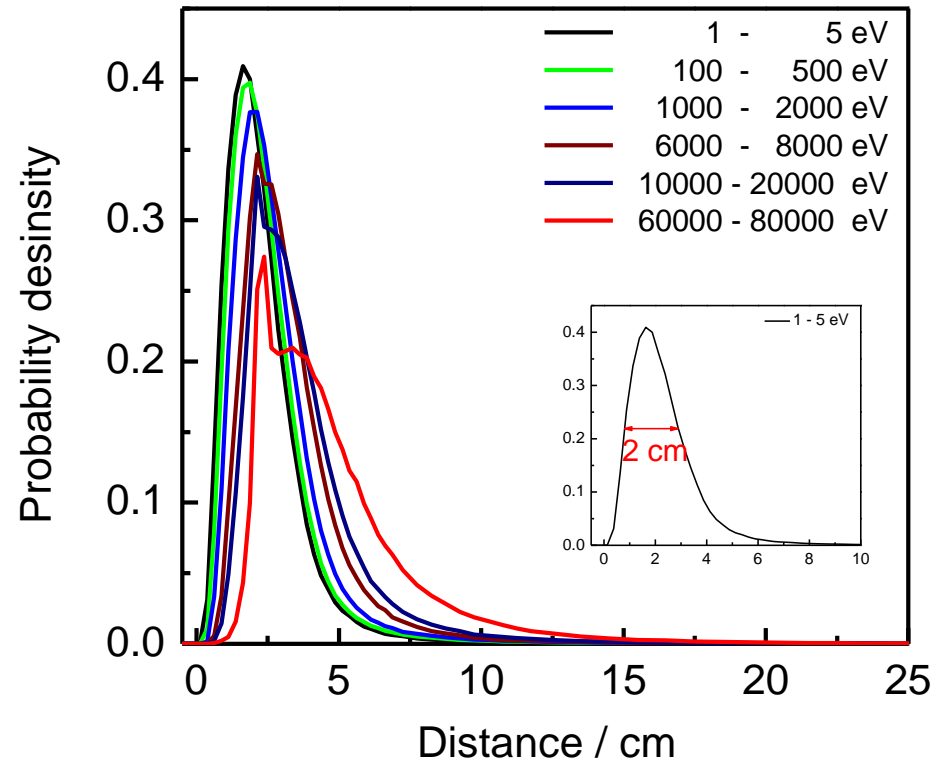
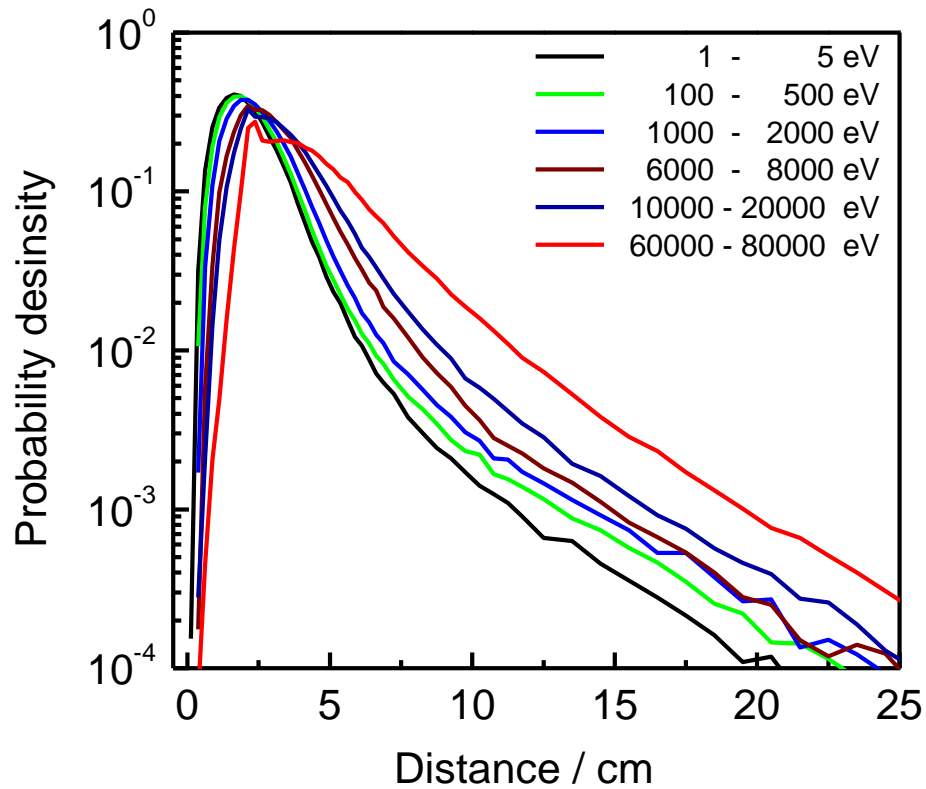


Equivalent distance : $L_t = v t_t$

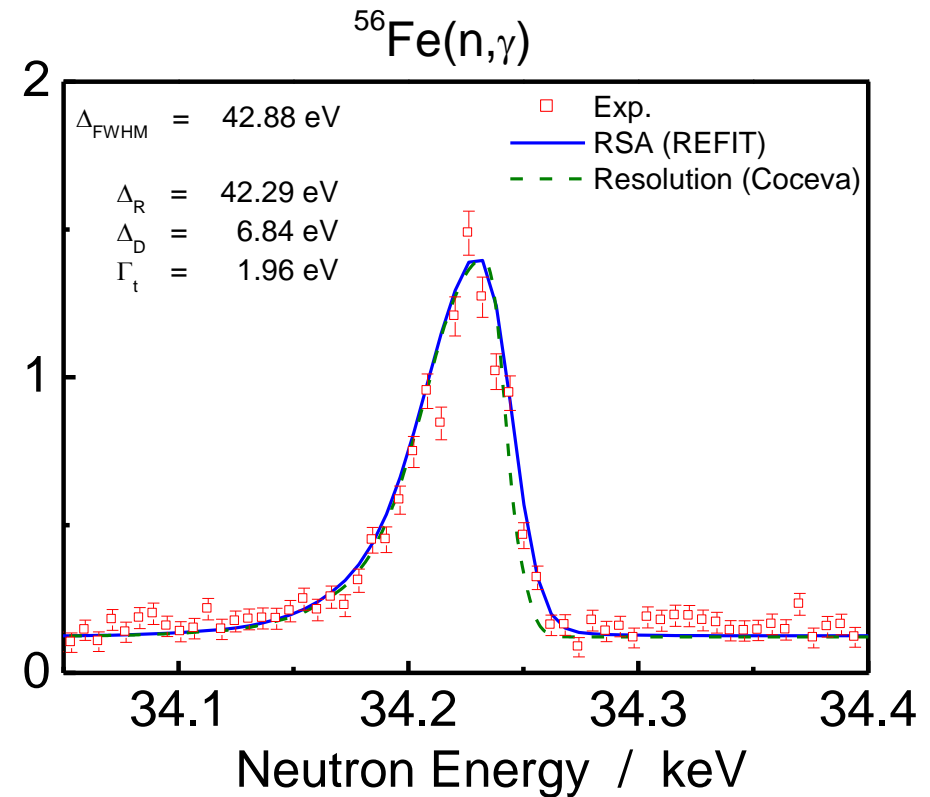
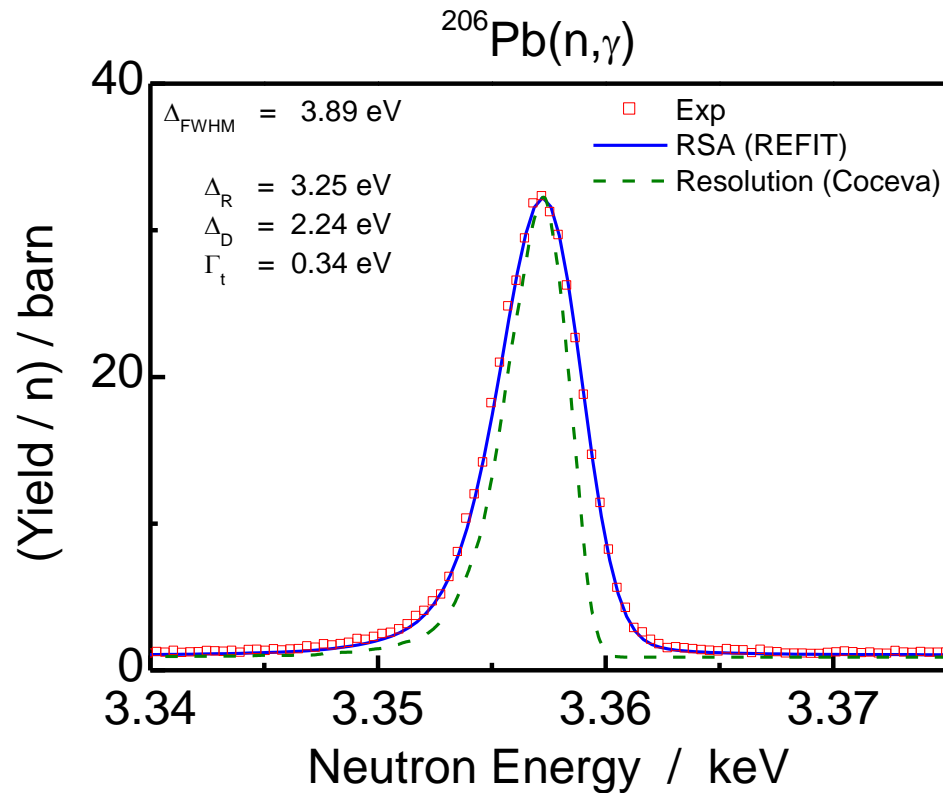
$$P(t_t, E_n) = P'(L_t(t_t), E_n) \left| \frac{dL_t}{dt_t} \right|$$



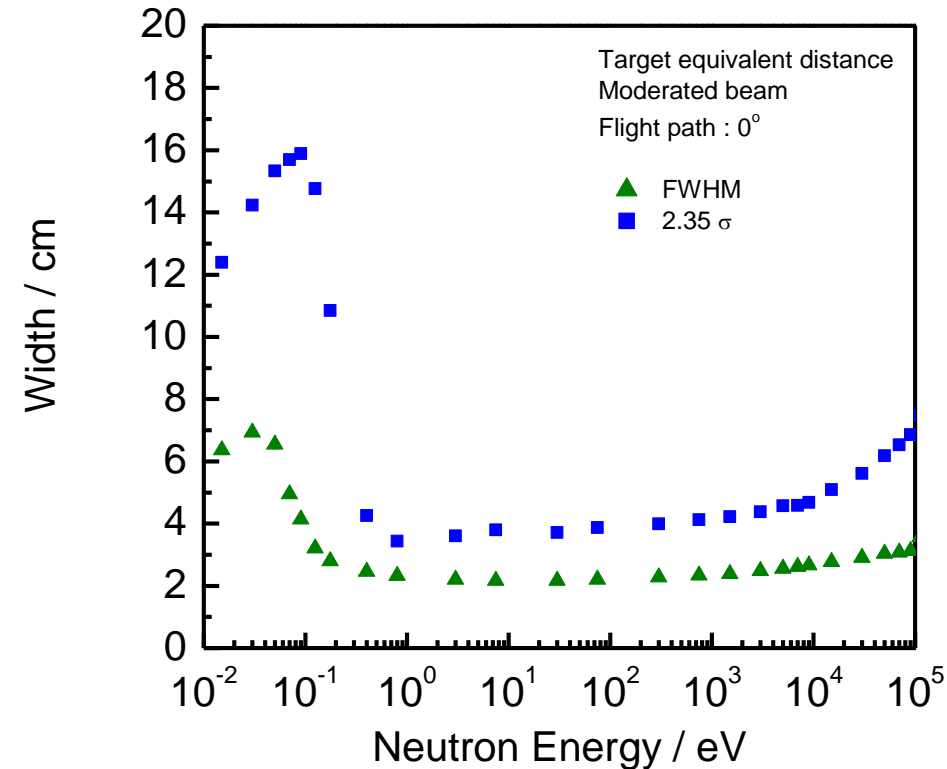
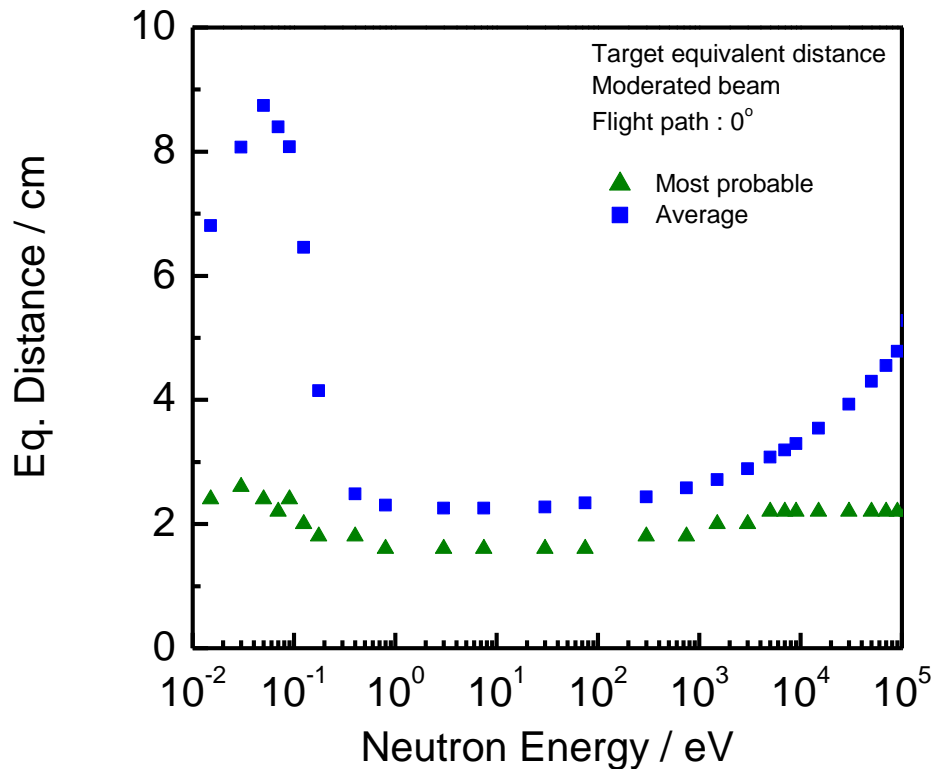
Response function $R'(L, E_n)$



Resolution : experimental verification

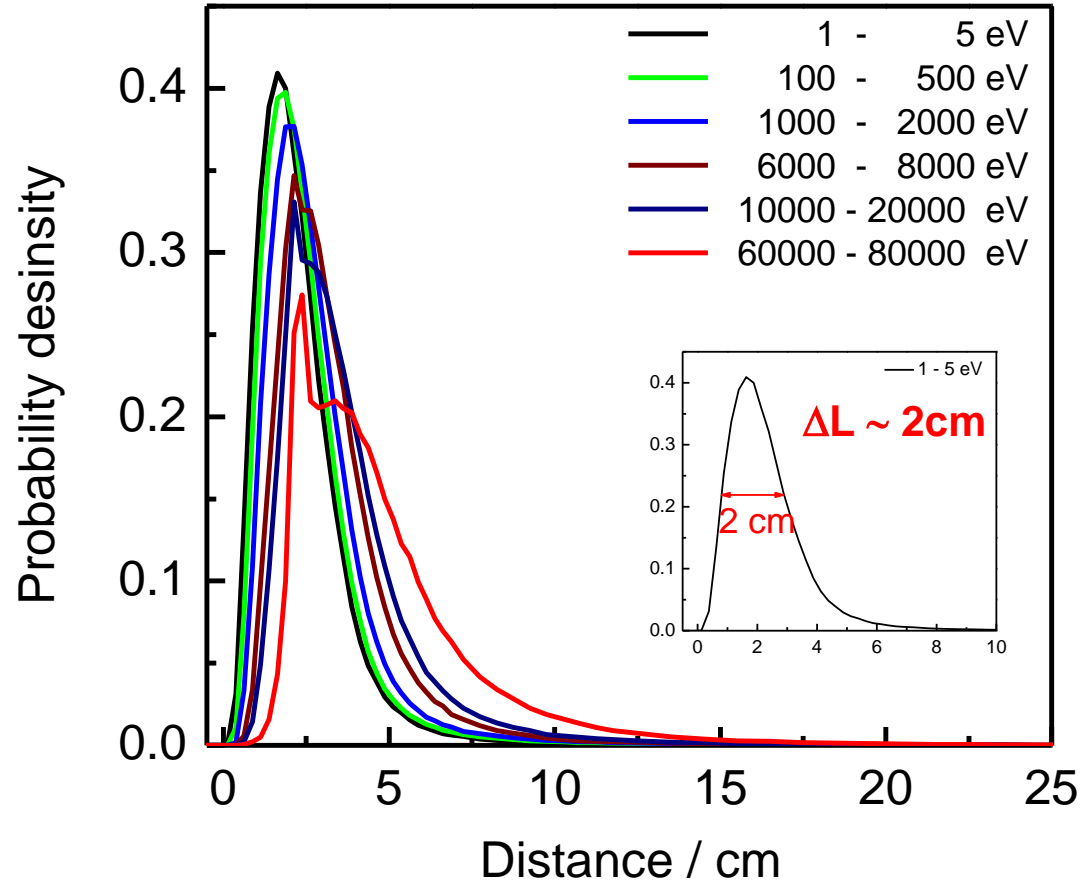


Characteristics of $P(L_t)$ for GELINA



How to report data in energy : use average or most probable equivalent distance ?
Report data in time-of-flight

Characteristics of $P(L_t)$: analytical



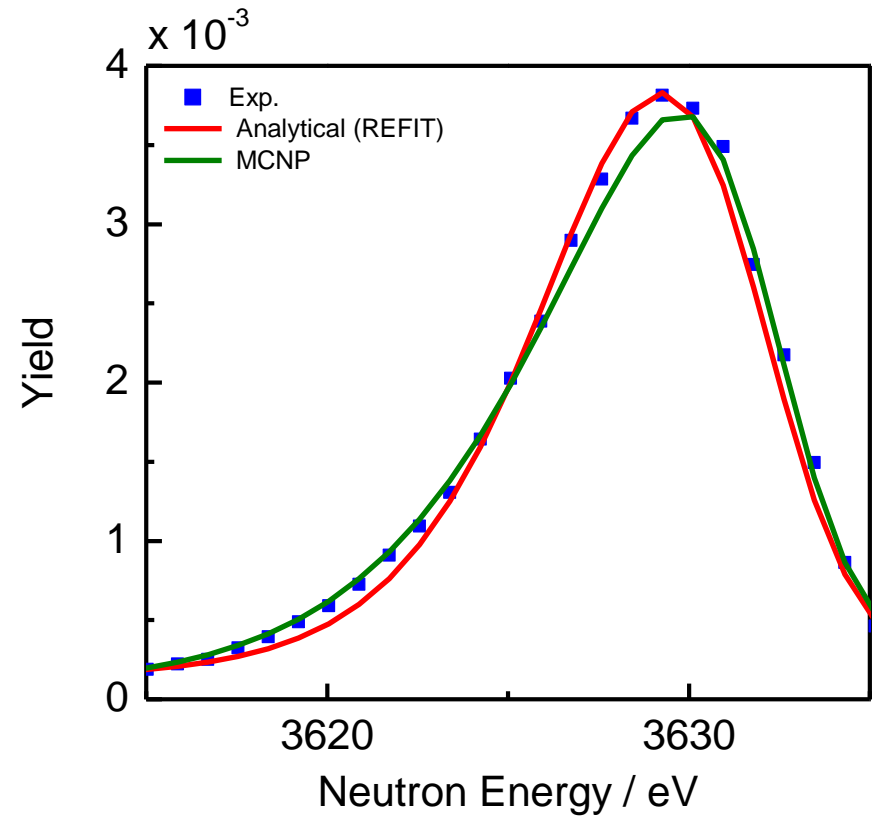
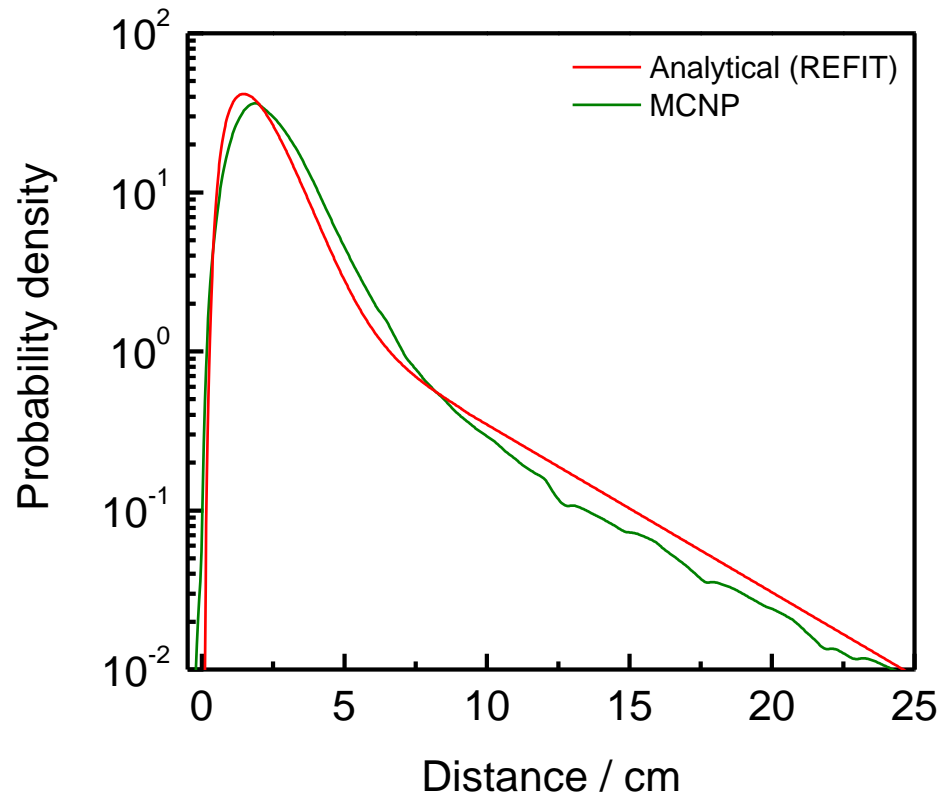
$$P(t_t, E_n) = P'(L_t(t_t), E_n) \left| \frac{dL_t}{dt_t} \right|$$

- **Between 0.5 eV and 2000 eV:**
 $R'(L_t, E_n)$ dominated by χ^2 due to moderation process and almost independent of E_n
- **Above 1 keV : more complex**

TOF – response : analytical - MCNP

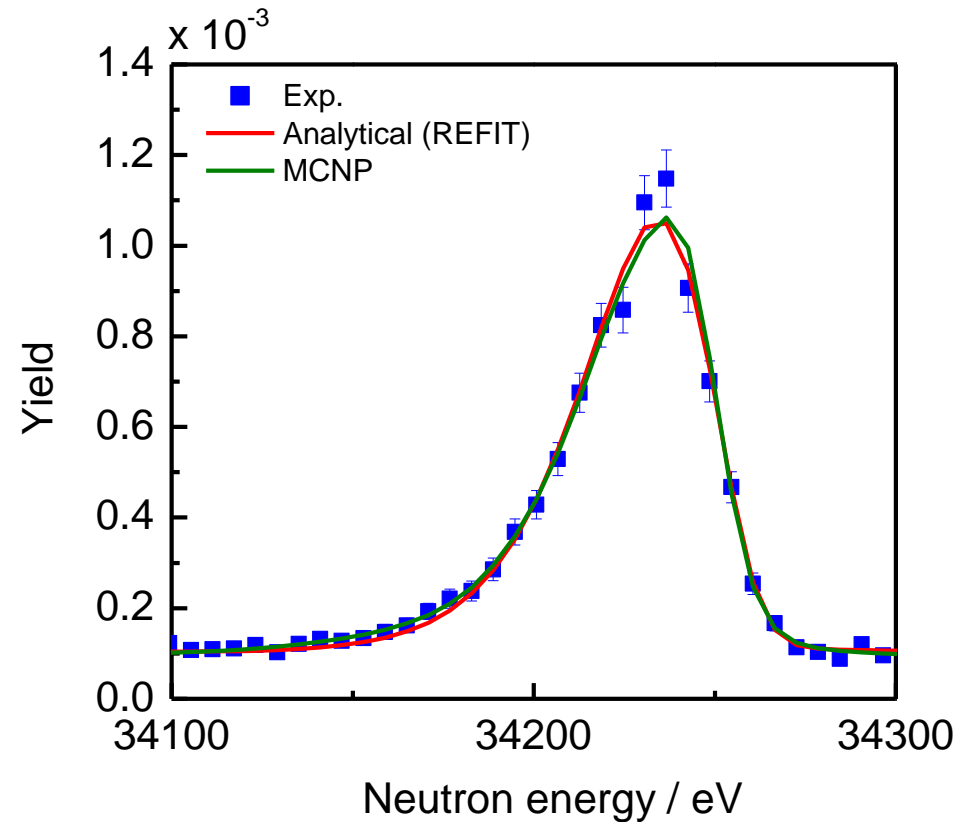
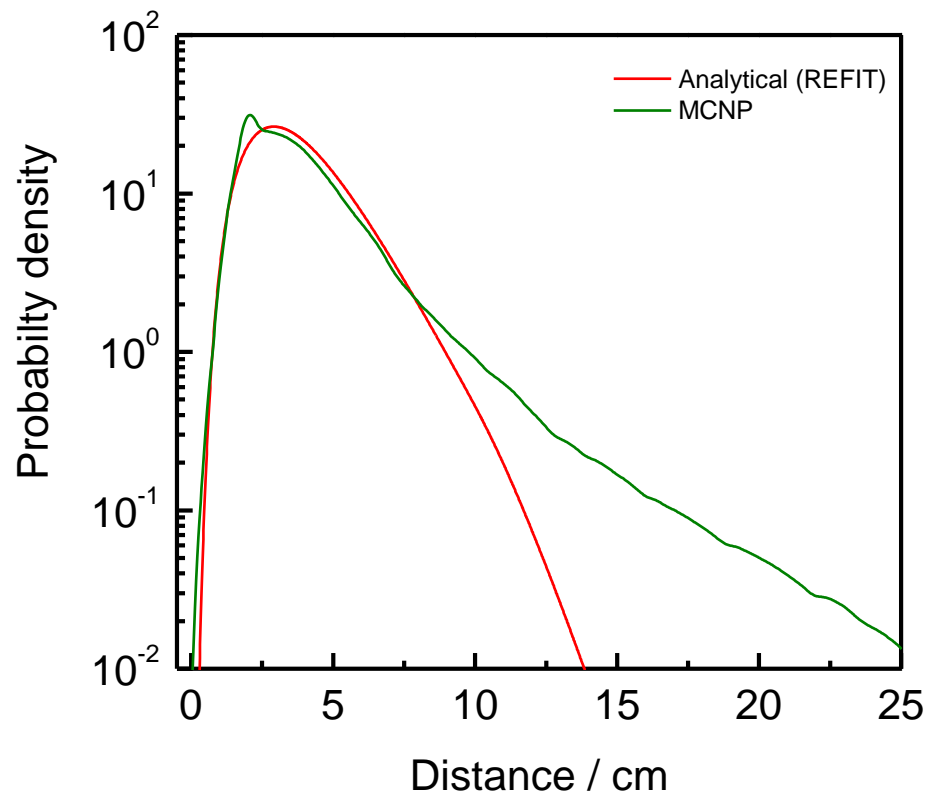


GELINA L = 12.5 m and 18°
 $^{103}\text{Rh}(n,\gamma)$



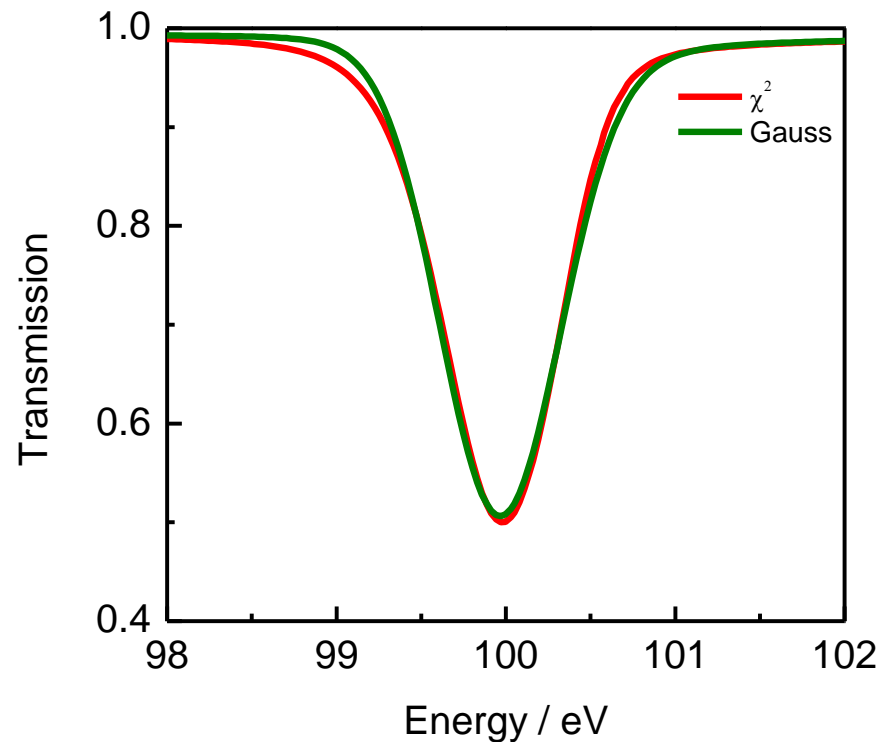
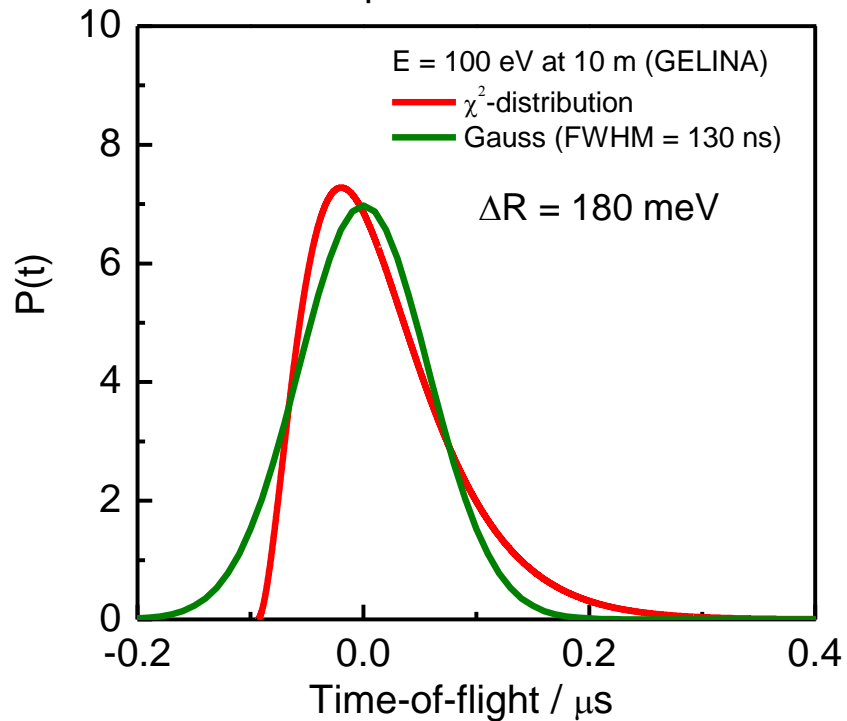
TOF – response : analytical - MCNP

GELINA L = 60 m and 9°
 $^{56}\text{Fe}(n,\gamma)$



Impact of response function

Response function



$$E_r = 100 \text{ eV}$$

$$\Gamma_n = 10 \text{ meV}$$

$$\Gamma_\gamma = 100 \text{ meV}$$

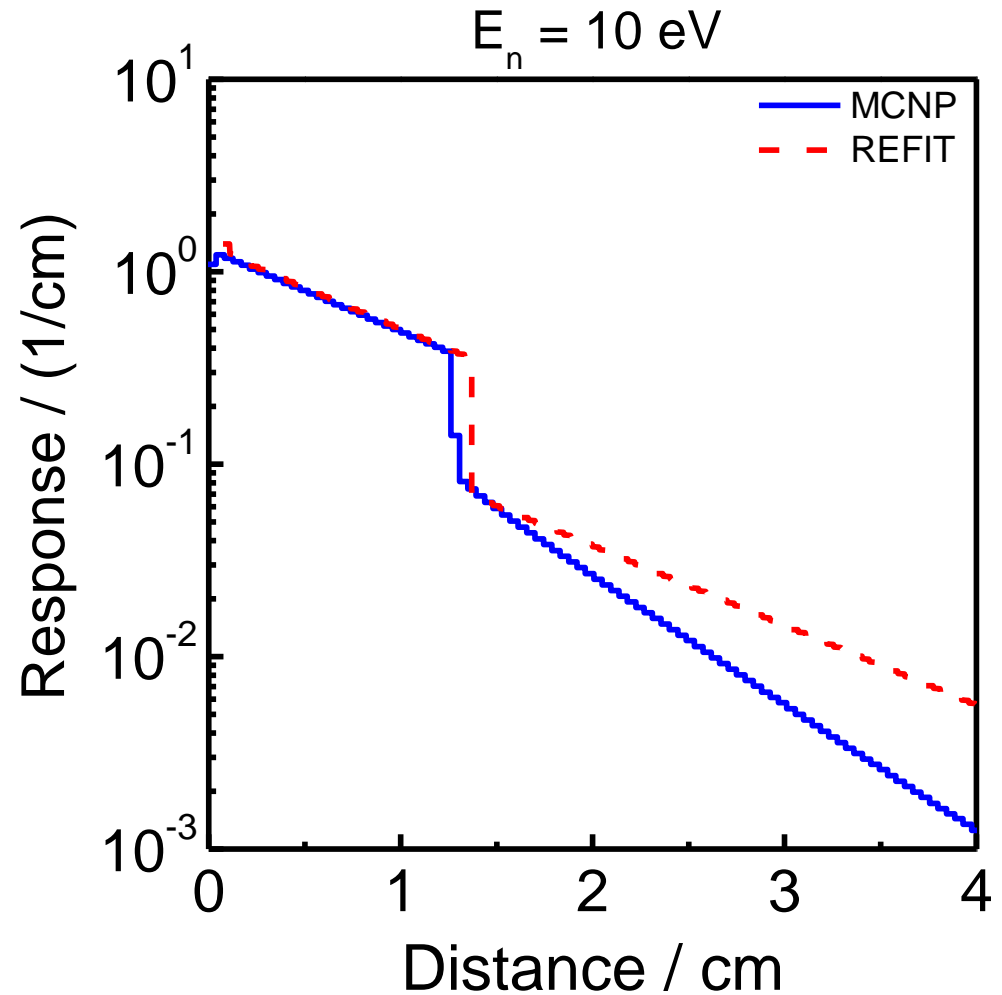
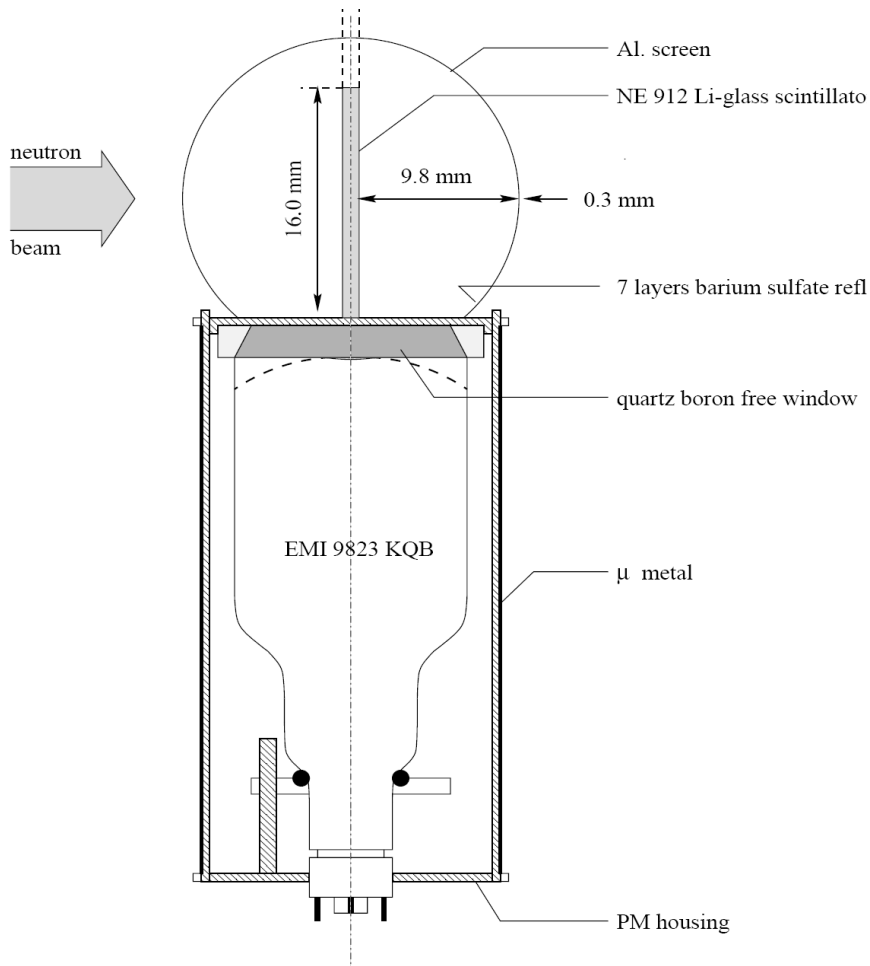
$$E_r = (99.963 \pm 0.002) \text{ eV}$$

$$\Gamma_n = (9.97 \pm 0.02) \text{ meV}$$

$$\Gamma_\gamma = (85.2 \pm 4.4) \text{ meV}$$

Lithium-glass scintillator : $P(L_d)$

${}^6\text{Li}(n,t)\alpha$ Scintillator + PMT



Low energy : ${}^6\text{Li}(n,t)\alpha$ Li-glass
 High energy : $\text{H}(n,n)\text{H}$ Plastic scintillator

Reporting response of TOF-spectrometers



- Many emails, no specific suggestions
- GELINA :
 - MC response : per configuration $P(L_t, E)$ dim. 120 x 35
 - 5 angles

- How to proceed?
 - Recommendations for EXFOR
 - TOF-response
 - Transmission detectors