WP3: Innovative detector concepts

Status and Perspectives

WP Coordination

CIEMAT (Madrid, Spain)

Objectives

- Explore new uses of the existing materials, optimization of detectors and combining them to extend their applicability.

- Investigate by MC simulations, new materials as possible detectors for E<100keV neutrons (calculate efficiencies, time/energy resolution…):

  - $LaBr_3$/$LaCl_3$/$CeBr_3$ crystals coupled to appropriate neutrons converters
  - Inorganic scintillators doped with ^{6}Li (LiI, glass scintillators)
  - Organic scintillators doped with ^{10}B and ^{6}Li (BC523A, EJ339, EJ309B, BC454)
  - Elpasolites CLLB, CLLC and CLYC (Cs+Li+La(Y)+Br(Cl)
  - Other new organic scintillators (EJ299-33)

- Test in laboratory with neutron sources (^{252}Cf, AmBe) and with fast neutron DD/DT generators
- Access to reference neutron beams for characterization (ERINDA program, other) in facilities.

Status:

- Started Monte Carlo simulations with possible candidates, EJ309 with 5% Boron (nat) content (closed session)
- Acquisition of several detectors:
  - EJ309 and EJ309B5 (dim. Ø5cm x L5cm) Ciemat
  - A small plastic EJ299-33 (dim. Ø5cm x L5cm) LNL, Ciemat
  - A stilbene crystal (dim. Ø5cm x L5cm) Ciemat, LPC

Future:

- Continue with MC simulation work
- We plan to perform some test at CIEMAT with a ^{252}Cf/AmBe (new metrological reference facility built in Spain)
- ERINDA funded the characterization of EJ309 detectors at PTB (ErindaPAC3/5, 96h beam time)
- We intend to initialize paperwork for the purchase of DD generator (long process)

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MC simulations with EJ309B5 liquid scintillator

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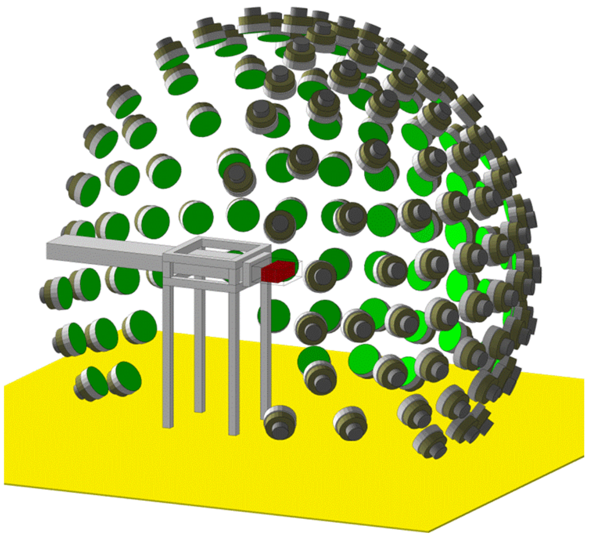
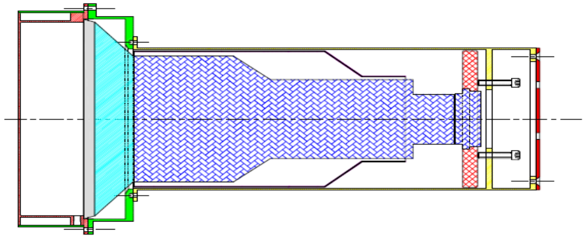
General characteristics of MONSTER

- **Reasonable intrinsic efficiency (~50% @ 1MeV)**
- **Energy threshold ~ 30 keVee (E_n ~200 keV)**
- **Reasonable energy resolution < 10% up to 5 MeV:**
- **Good neutron timing ~1ns**
- **Requires a good β timing ~1ns**
- **Reasonable flight path 2-3 m TOF**
- **Good total efficiency: 100 – 150 detectors**
- **Cylindrical cells 20 x 5 cm filled with BC501A/EJ301**



• Flammable (flash point 28ºC), toxic ≠ Laboratory Safety Rules
• Insensitive to slow neutrons En<200keV

Alternatives or complementary materials: AVAILABLE
EJ309 (similar to BC501A but non-flammable) and can be doped with ^{10}B (**EJ309B5**)

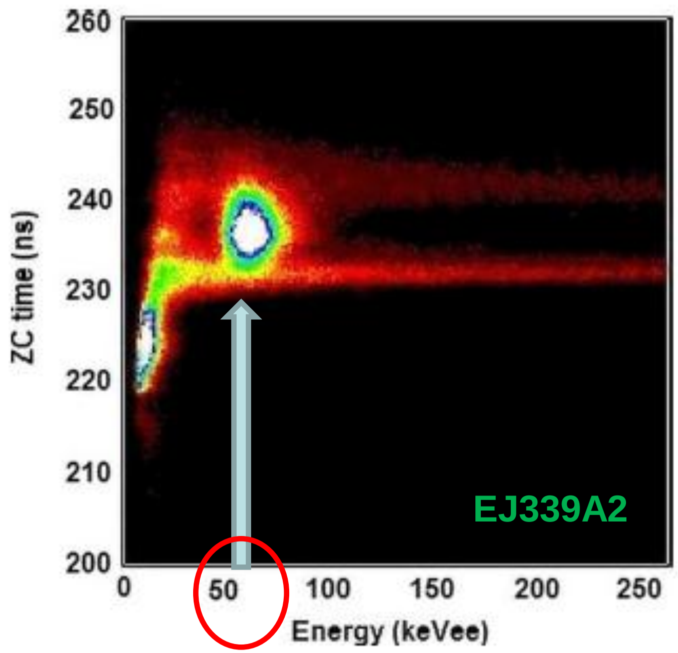


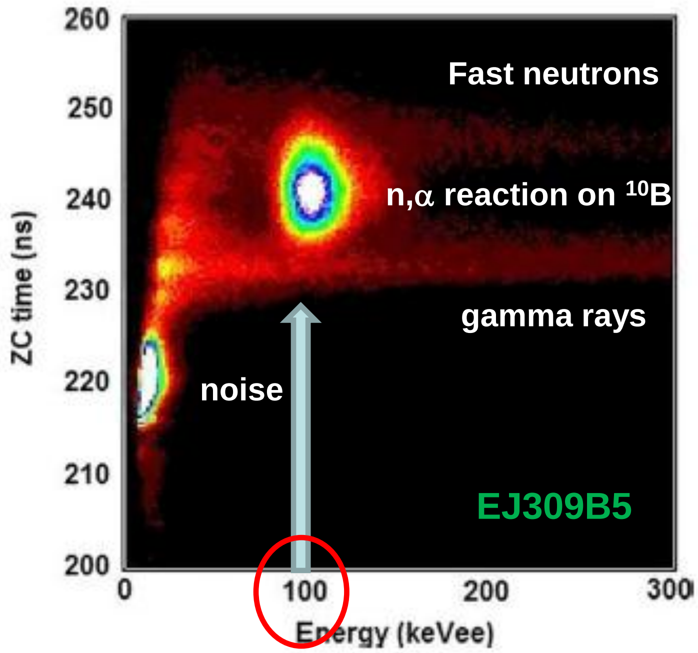
Ø=20cm x L=5cm

Feasibility to distinguish α from recoils and count n with En<100keV?
Suitable for neutron TOF spectrometry? → MC simulations

^{10}B doped liquid scintillators (BC523A, EJ339, EJ309B)

Swiderski et al. IEEE TNS 57(2010)375



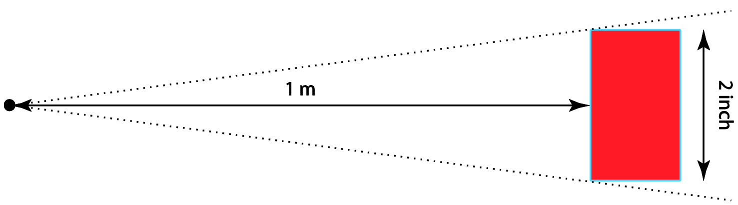


Advantages of EJ309B:

- Lower quenching of scintillation produced by α and ^{7}Li, capture peak at higher energies well above noise
- Good discrimination (even if lower phe/MeV) between, gamma, fast and slow neutrons
- Non-flammable liquid

MC simulations

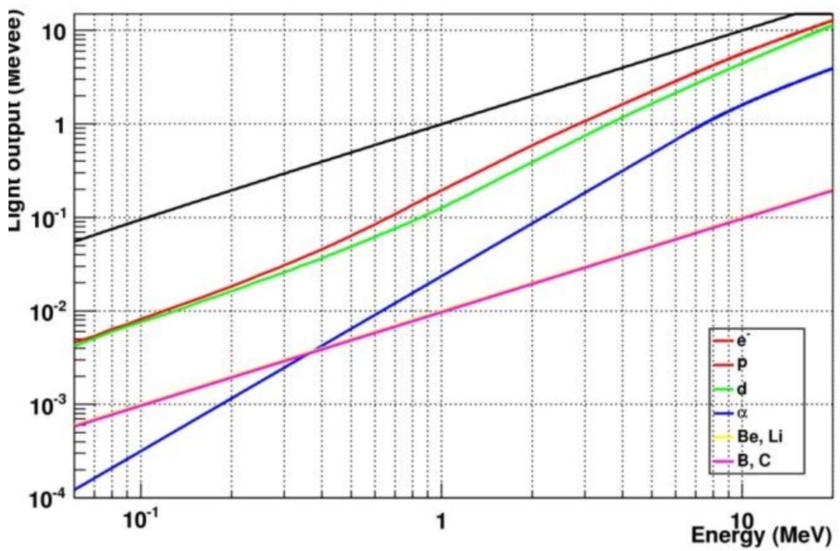
- Simulated 10^6 neutron events in the solid angle ΔΩ subtended.
- E_n for 1, 10, 100 eV 1, 10 and 100keV
- Distance of 1m flight path
- Several detector dimensions have been simulated



Capture process:

$^{10}B+n \rightarrow {}^{7}Li+\alpha$ (BR=6%) Q=2.792 MeV
$^{10}B+n \rightarrow {}^{7}Li+\alpha+478$ keV (BR=94%) Q=2.310 MeV

Light output functions for different particles from PTB NRESP references for NE213/BC501A

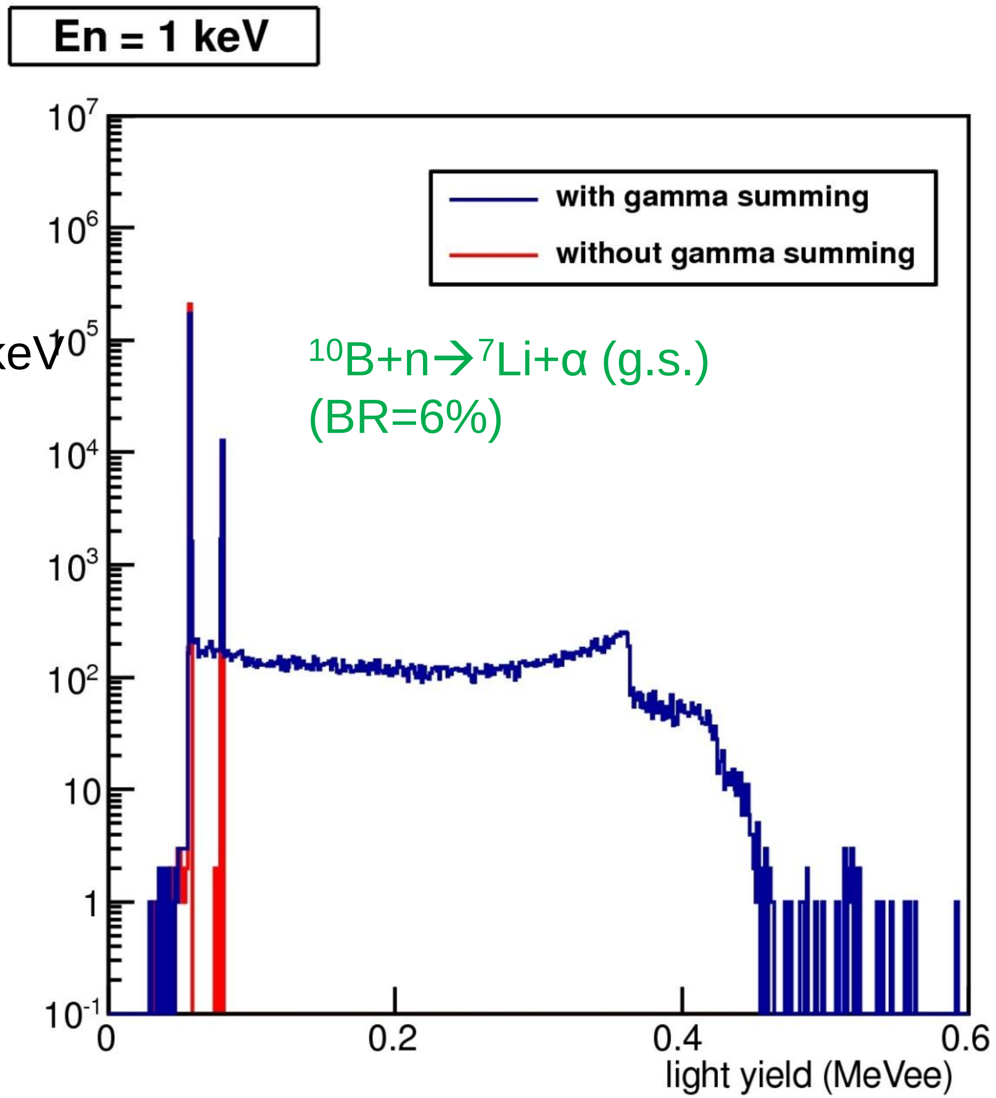


Calculate detection efficiency and time resolution

Light Response Function (not convoluted with experimental resolution)

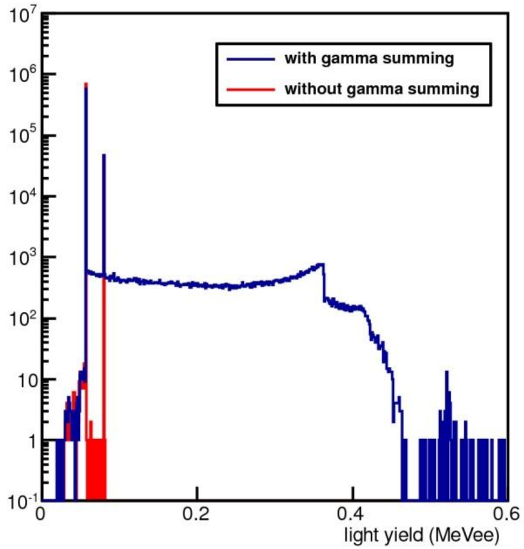
Response of capture reaction (excluding recoil collision)

$^{10}B+n \rightarrow {}^{7}Li+\alpha+478$ keV (BR=94%)

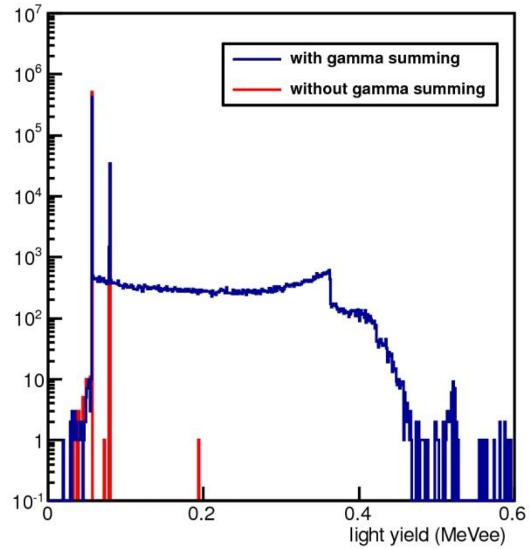


$^{10}B+n \rightarrow {}^{7}Li+\alpha$ (g.s.) (BR=6%)

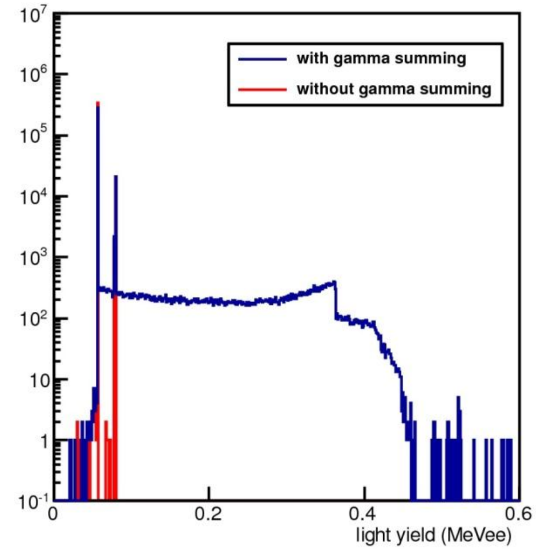
En = 1 eV



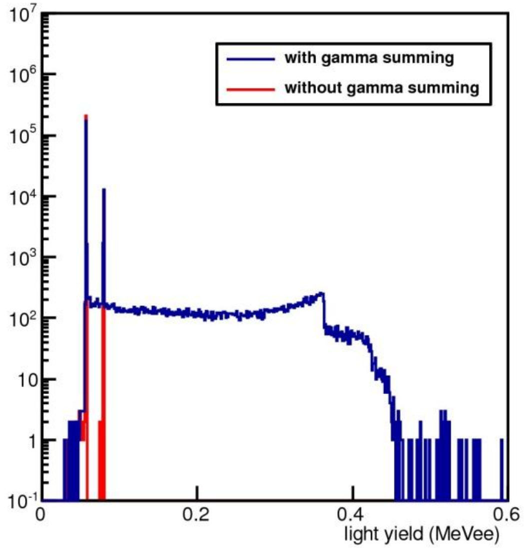
En = 10 eV



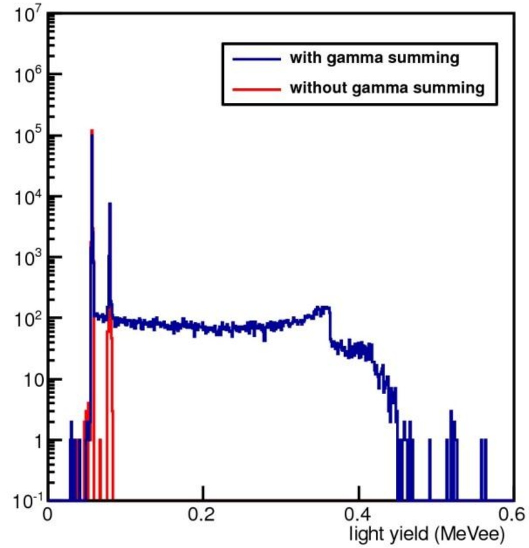
En = 100 eV



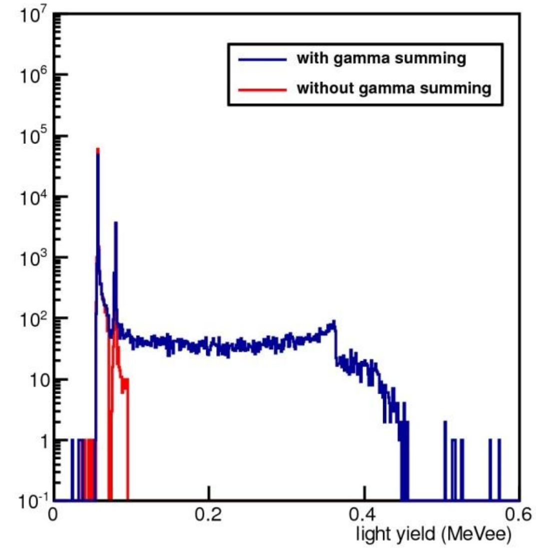
En = 1 keV



En = 10 keV



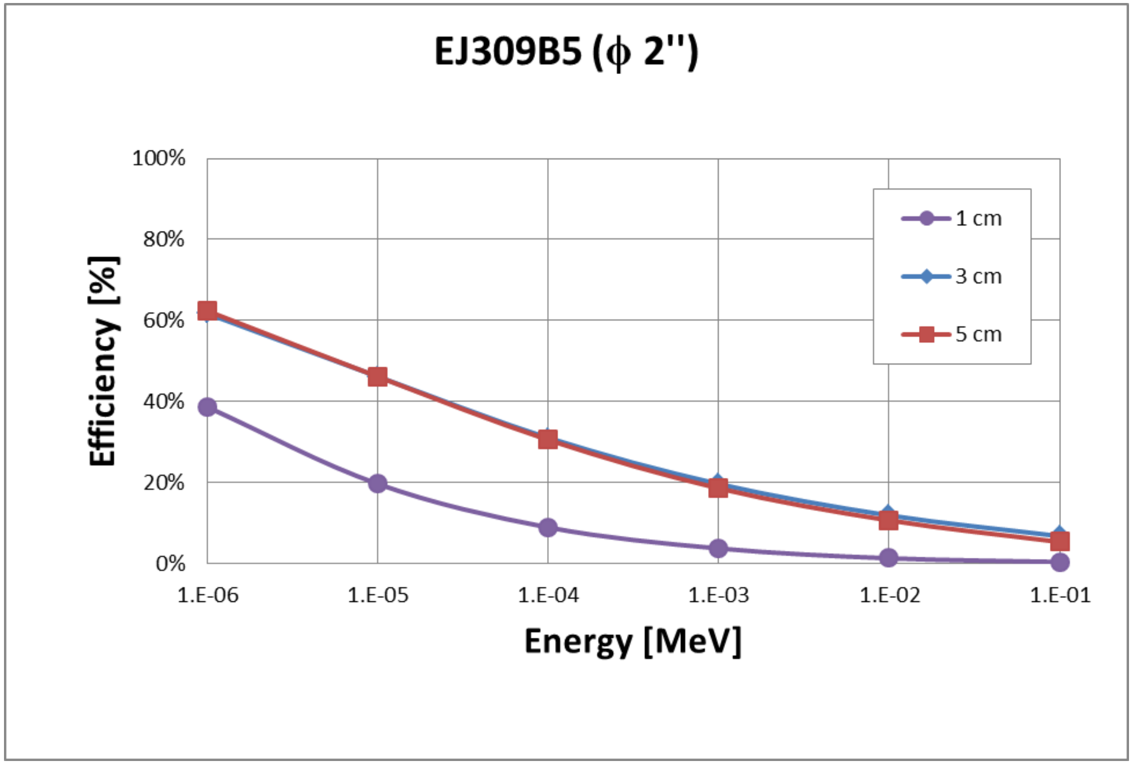
En = 100 keV



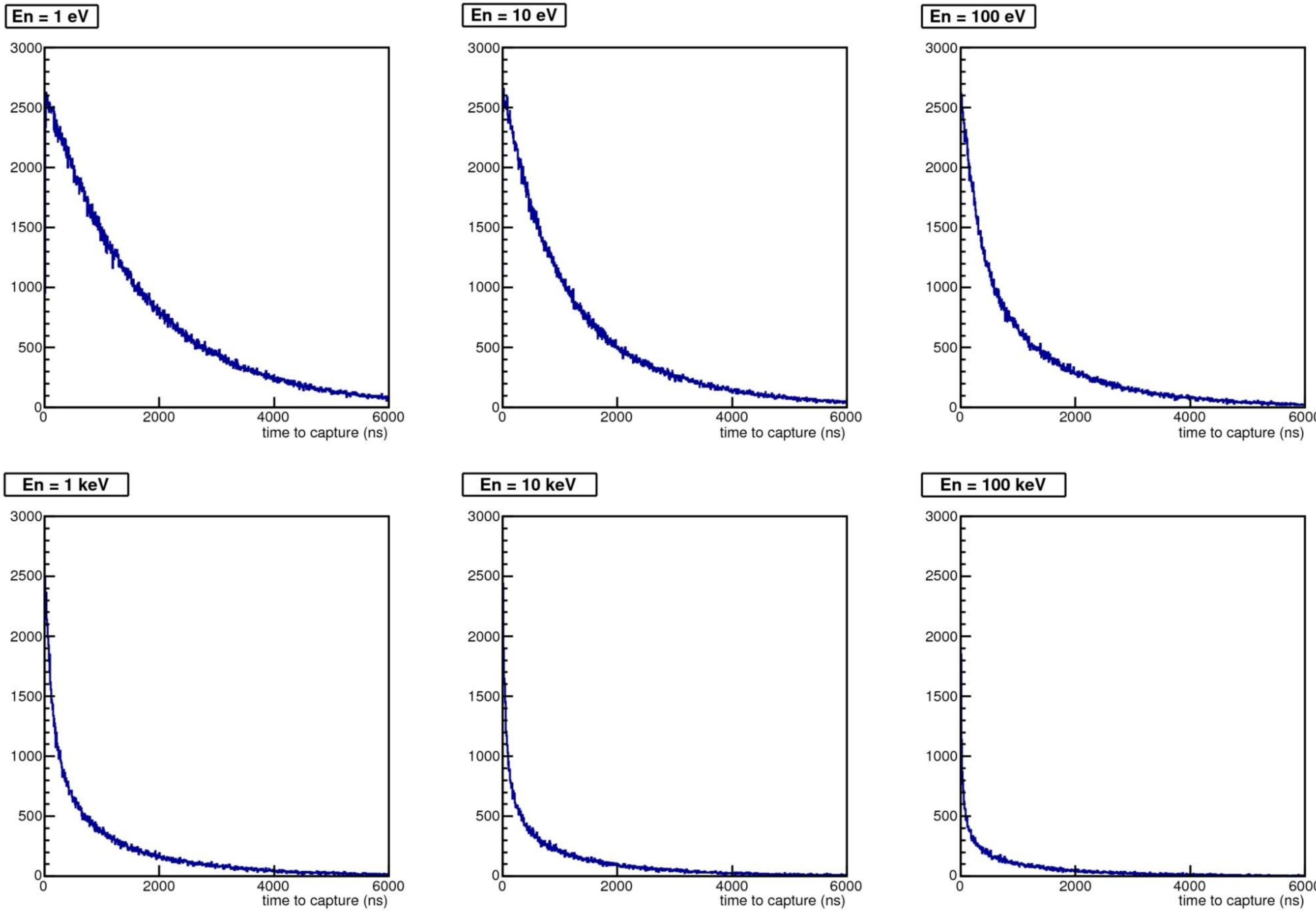
Detection efficiency

Efficiencies for detector dimensions
Ø=2'' Thick= 1,3,5 cm

Low efficiency values En=100keV



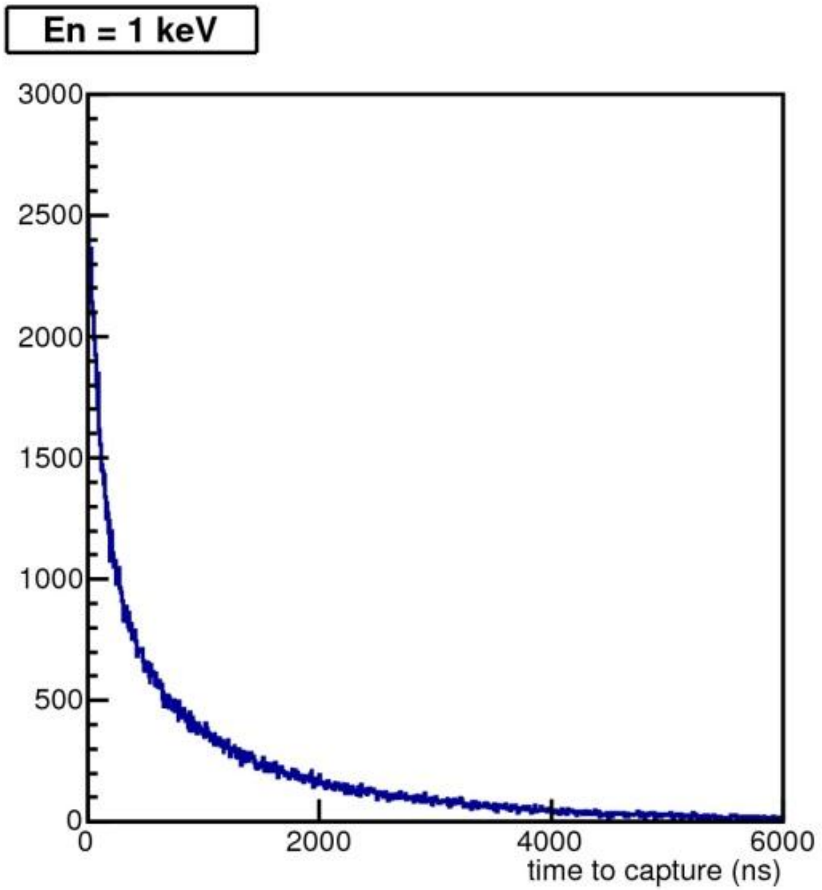
Capture Time = time from the first recoil collision



Capture Time Window

Time resolution function

L(m)	DE/E (%)		
	1keV	10keV	100keV
2	10	23	43
3	6	15	30



Conclusion

We have purchased EJ309 and EJ309B5, to compare with BC501A and EJ301

We have make MC simulation with EJ309B5 to verify the feasibility for neutron TOF spectrometry.
The low efficiency values obtained at energies around 100keV and the worse energy resolutions makes it not suitable to extend the detection capabilities of MONSTER below E_n<100keV

Uses in other areas (SNM) are in development