WARSAW UNIVERSITY OF TECHNOLOGY
DEVELOPMENT PROGRAMME

Spiral2 Preparatory Phase

Centrum Studiów Zaawansowanych PW
Center for Advanced Studies WUT

Neutron multiplicity filter NEDA – properties of BC501A and BC537 scintillators

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HUMAN CAPITAL
NATIONAL COHESION STRATEGY

UNIA EUROPEJSKA
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FUNDUSZ SPOŁECZNY

Outline:

Goal:

To build state of the art neutron multiplicity filter:

* efficiency better then for Neutron Wall:

  ε(n): 25% → 40%, ε(2n): 3% → 6%, ε(3n): 0.1% → 1%;

  thus:

  * low probability of generating signals in more then one detector;
  * good time resolution;
  * good neutron-gamma discrimination.

Things to be tuned:

→ the material – liquid scintillators: proton (BC501A) or deuter (BC537) based.

→ the geometry – single detector: L=20 cm, ϕ = 5”;
– and the whole array - see poster by. T. Hüyük.

→ PSA algorithms – to achieve good time resolution.

→ PSA algorithms – for good neutron-gamma discrimination.

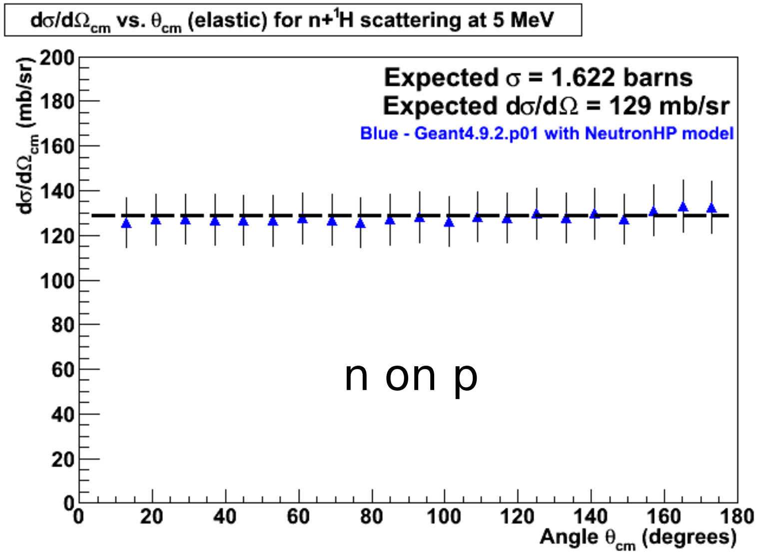
Results of Geant4 simulations and preliminary results of the NEDA prototype detectors will be presented.

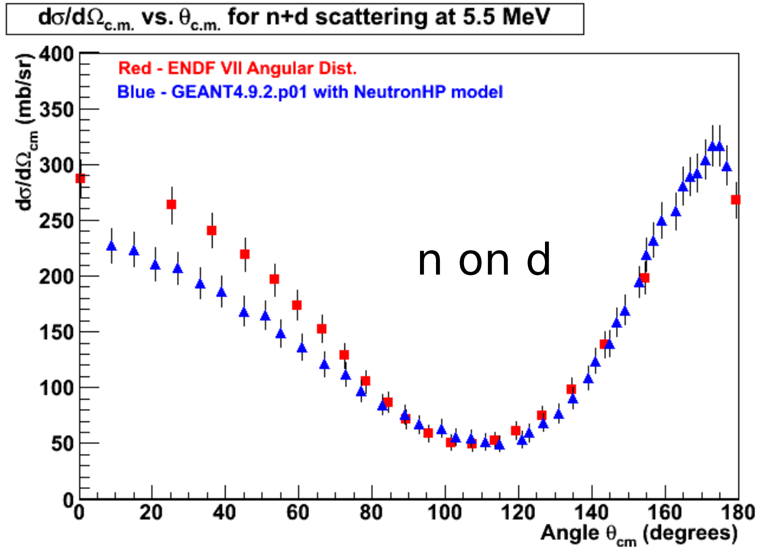
BC501A and BC537

Commonly used scintillator for neutron detection: C_8H_{10} – BC501A, NE213, BC501 – xylene. Nordball NWall, NWall, NRing, NDA@HRIBF, NShell, ...

New option: deuterated scintillator: C_6D_6 – BC537, NE230, deuterated benzene. DESCANT (TRIUMF).

anisotropic scattering of n on d, may produce signals which are more correlated with the incoming neutron energy – could be used to improve multiple neutron discrimination.



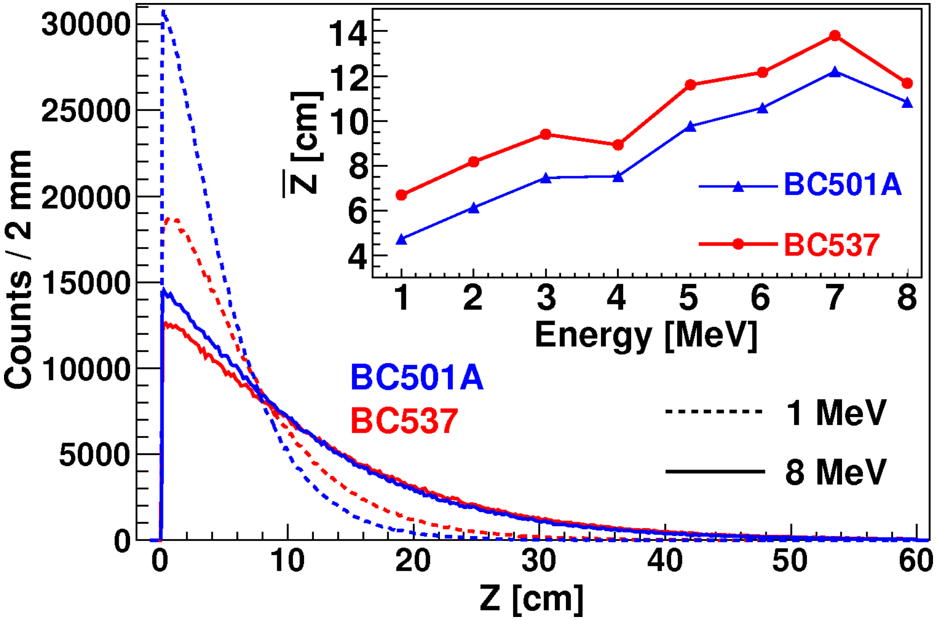


plots by B. Roeder

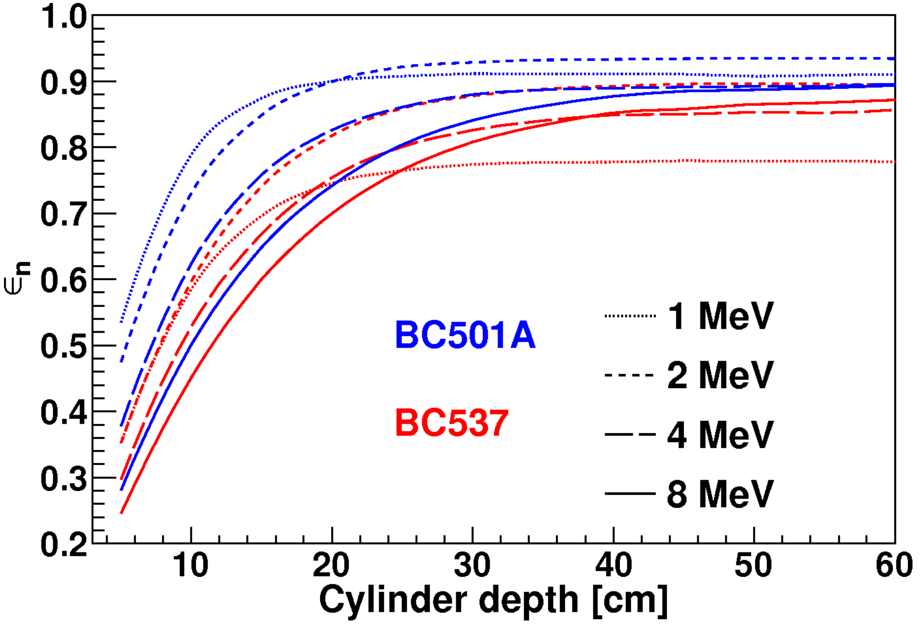
Geant 4 simulations

Neutron detection efficiency

Depth of the interaction – distribution and average



Neutron detection efficiency



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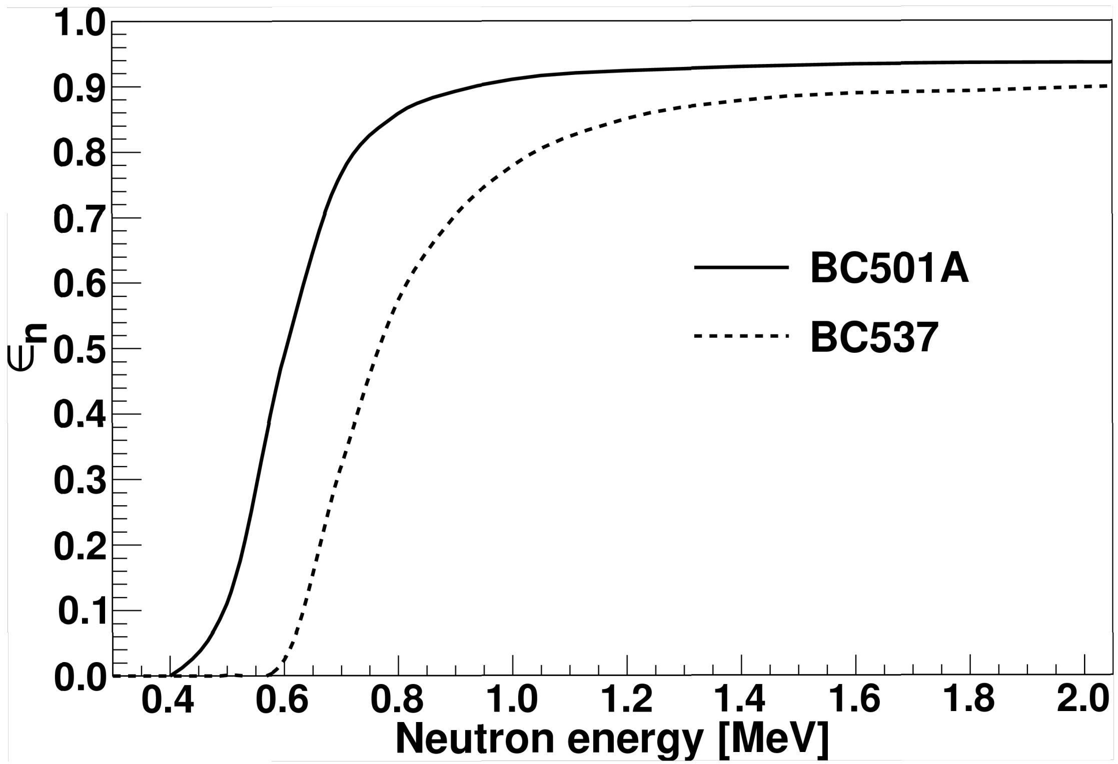
Geant 4 simulations

Neutron detection efficiency



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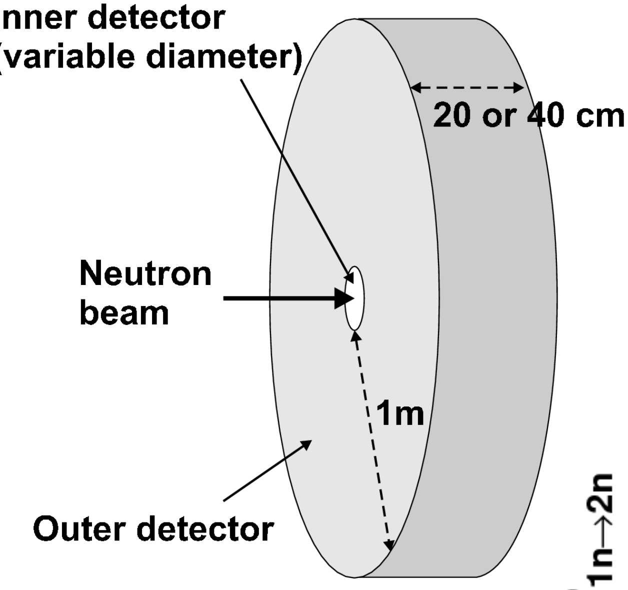
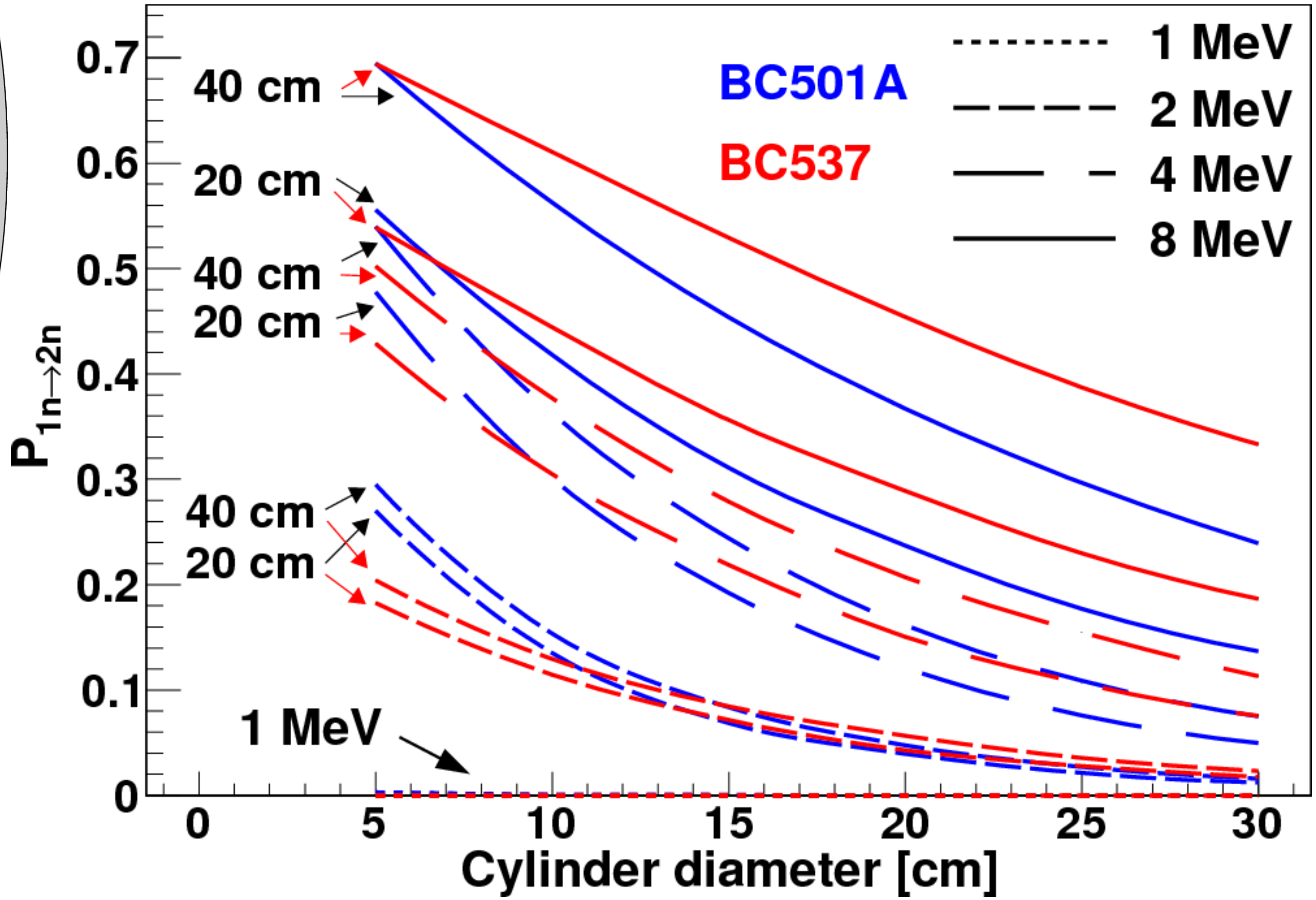
Geant 4 simulations

$p_{1n \to 2n}$





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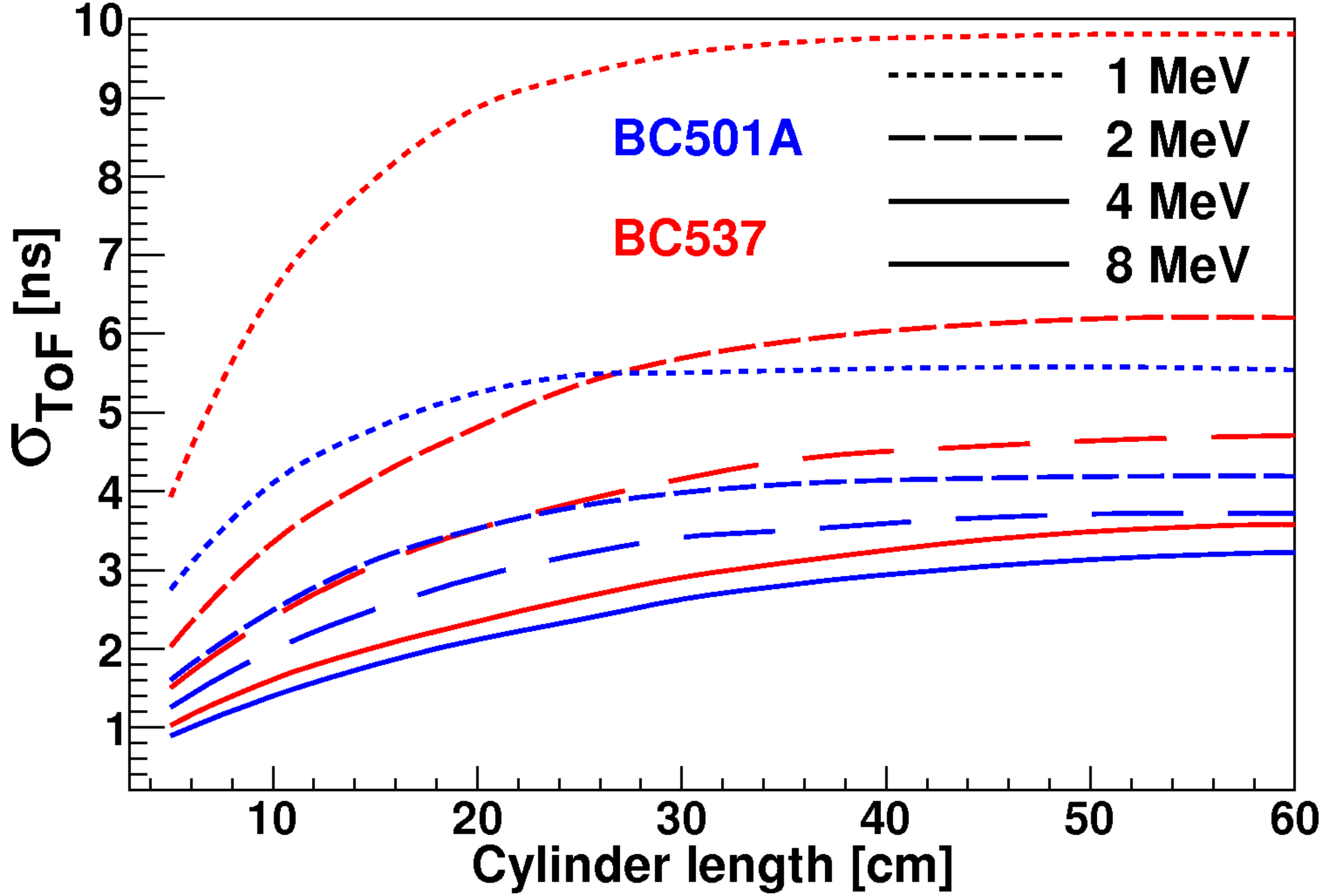
Geant 4 simulations

Time resolution due to variation of the interaction depth



$\sigma_{int} = 1.5$ ns

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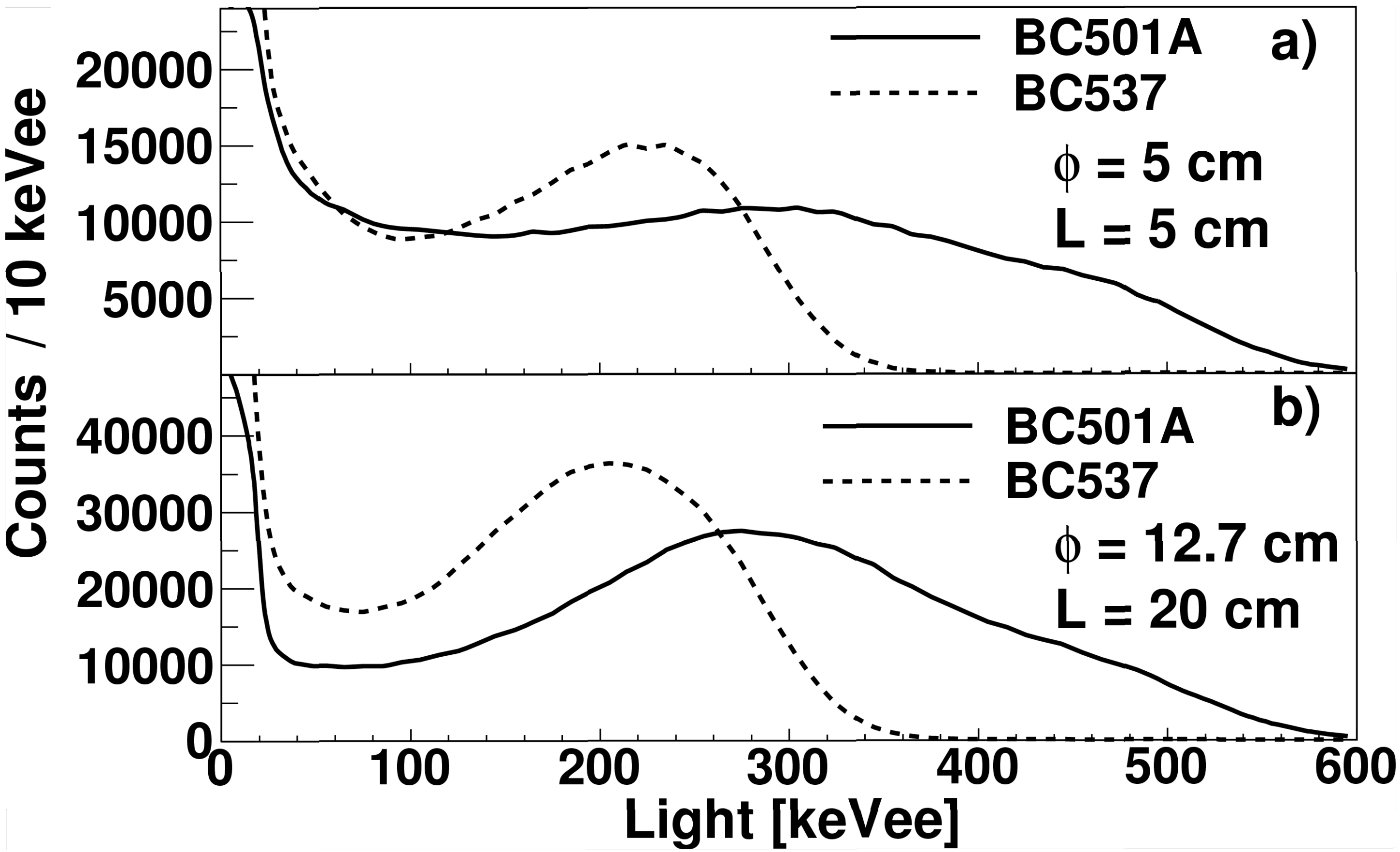
Geant 4 simulations

Light to energy dependence

Light output for 2 MeV neutrons
Instrumental response function included



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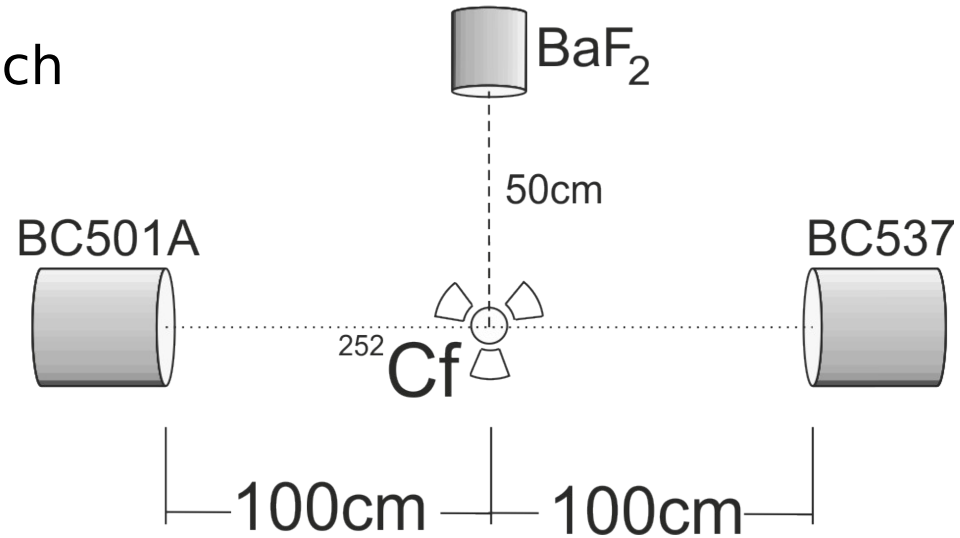
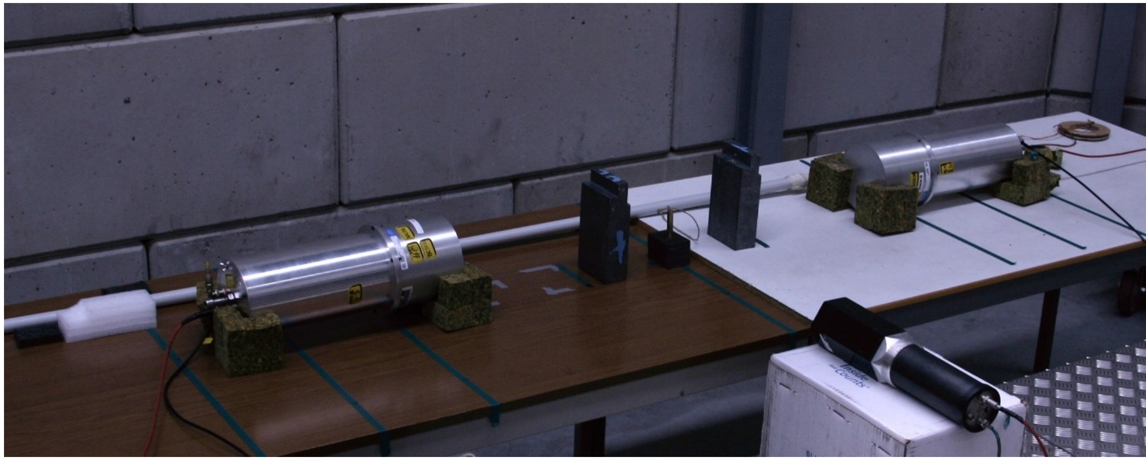
Tests of NEDA prototype detectors

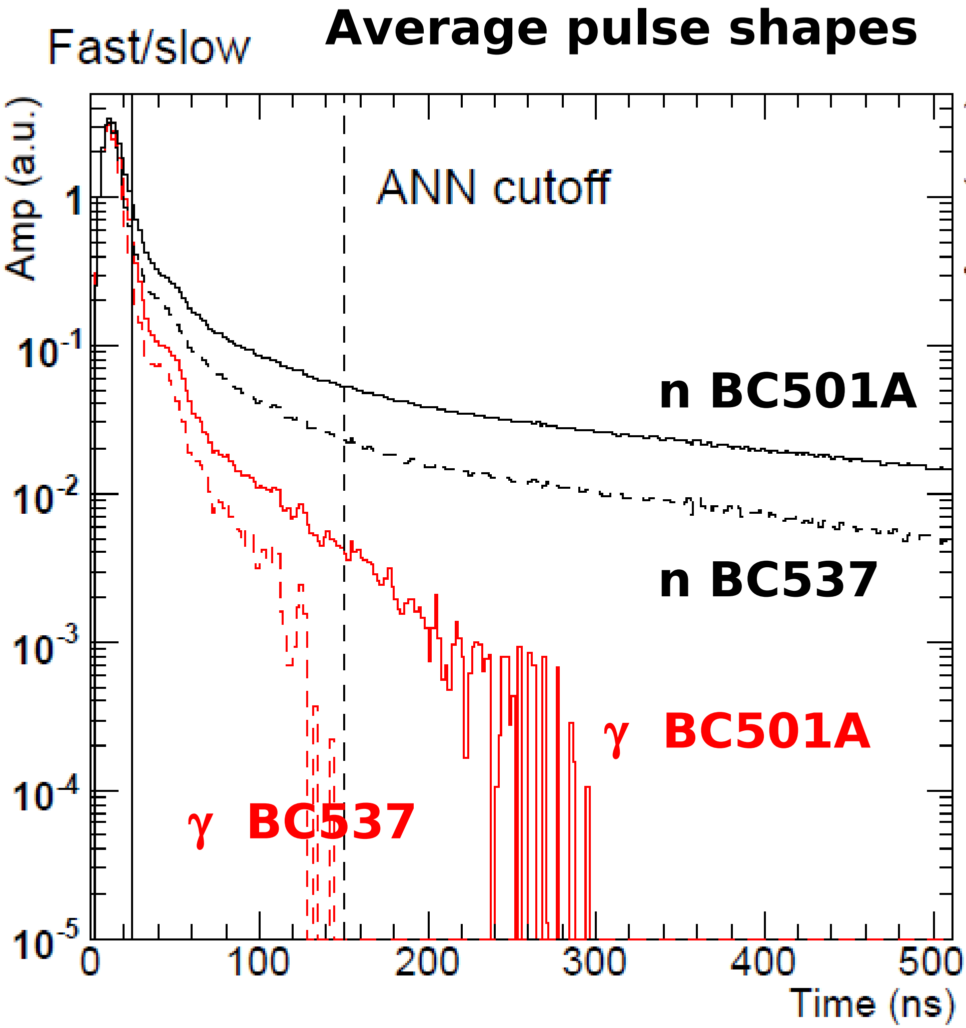
Legnaro

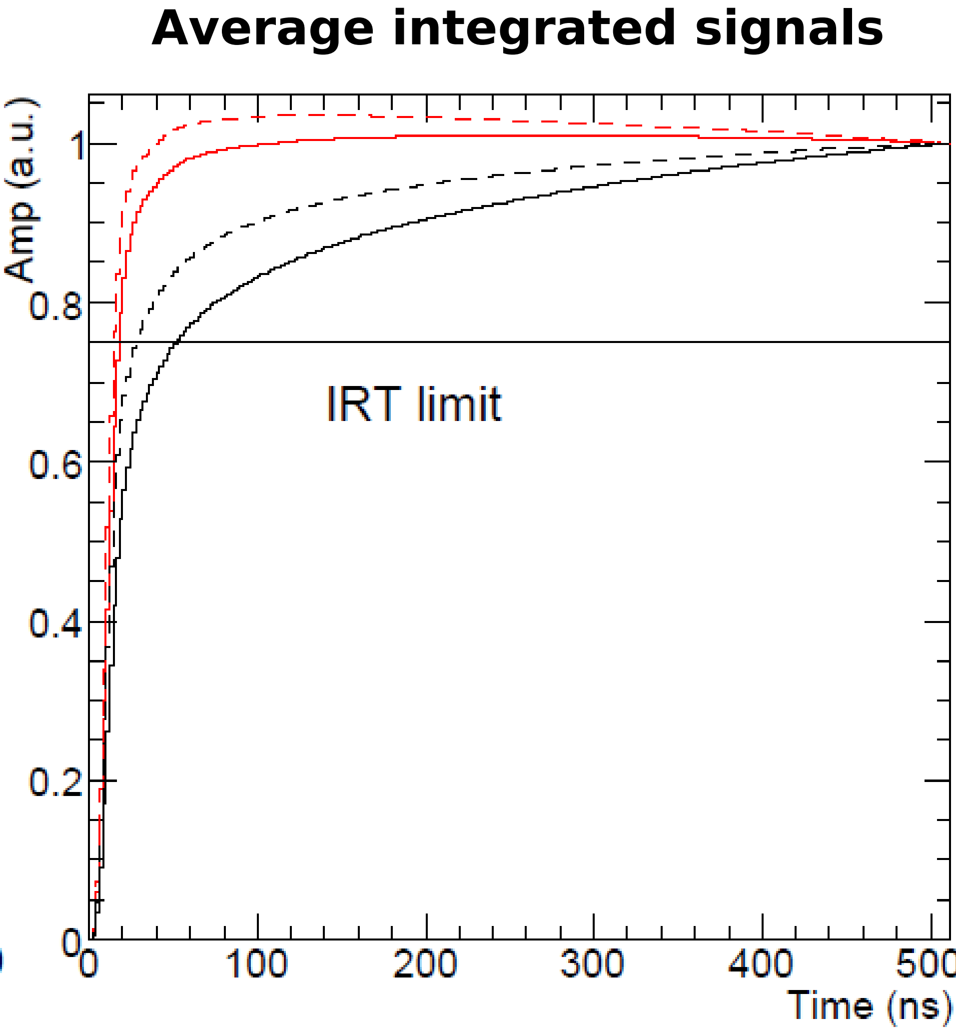
- 5x5 inch cylinders
- BC501A and BC537 – 2 of each type
- Photonis XP4512
- Struck SIS3350
  (500 MHz, 12 bit)
- VME-based DAQ system by
  J. Agramunt-Ros
- BaF_2 for time reference





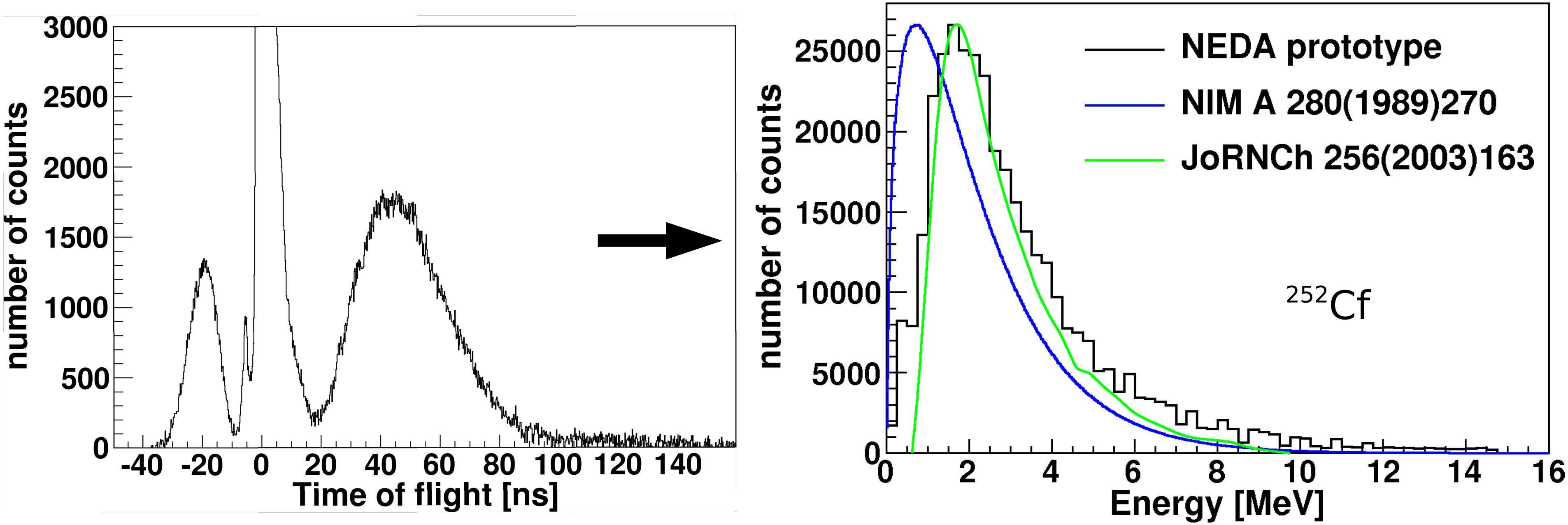
Tests of NEDA prototype detectors





by P-A. Söderström

Tests of NEDA prototype detectors

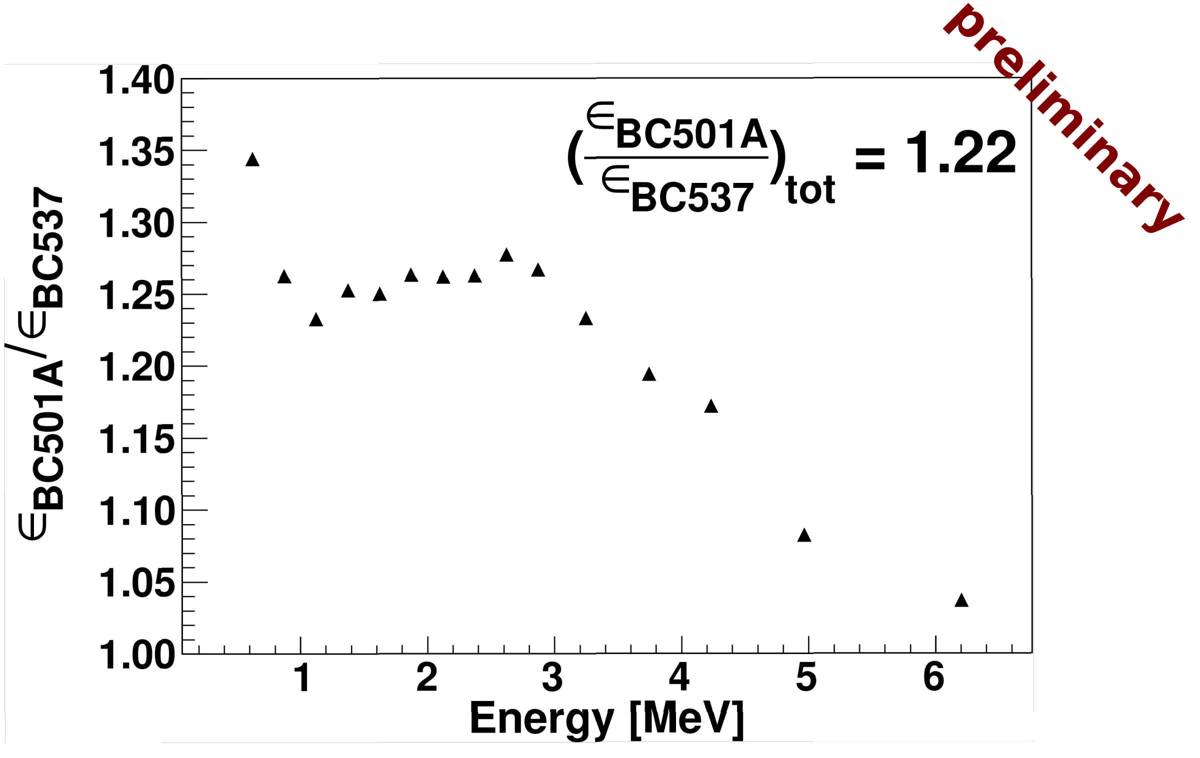


^{252}Cf neutron energy distribution

Tests of NEDA prototype detectors

Relative efficiency of the two scintillators

ToF as the only independent n/γ discrimination method,
not favoring any scintillator



TODO:
→ uncertainties;
→ simulations;

Conclusions on deuterated vs proton-based scintillator

→ better light to energy correlation for deuterated scintillator only for small detectors – not NEDA case.

Proton-based BC501A:

→ gives more light;

→ has higher efficiency;

→ has better time resolution;

→ has better n/γ discrimination;

→ has smaller $p_{1n->2n}$;

→ is much less expensive.

NEDA decided to use standard proton based scintillator

Collaborators

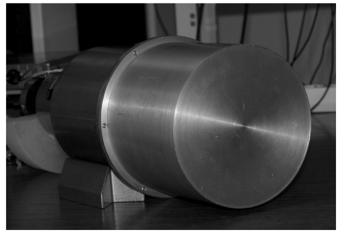
J. Agramunt Ros, G. de Angelis, M. Clement, G. de France, A. Di Nitto,
J. Egea, N. Erduran, S. Erturk, E. Farnea, A. Gadea, V. Gonzalez,
T. Hüyük, J. Nyberg, M. Palacz, B. Roeder, P.-A. Söderström, E. Sanchis,
R. Tarnowski, A. Triossi, R. Wadsworth, J.J. Valiente Dobon and G. J.

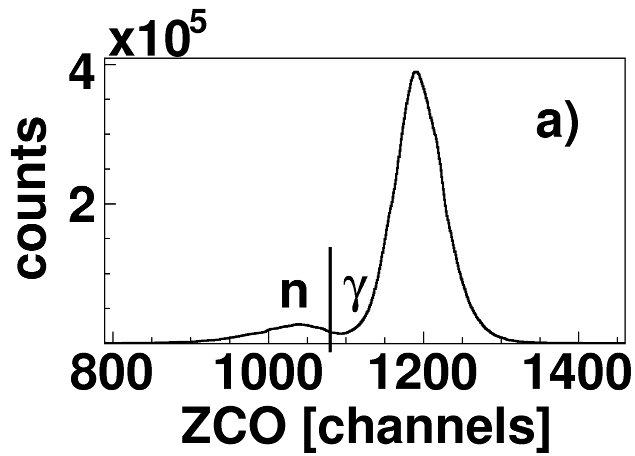
Thank you for your attention.

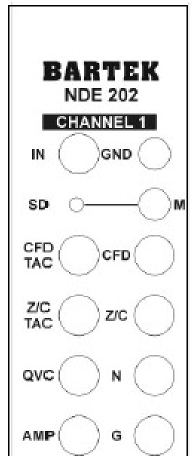
neda

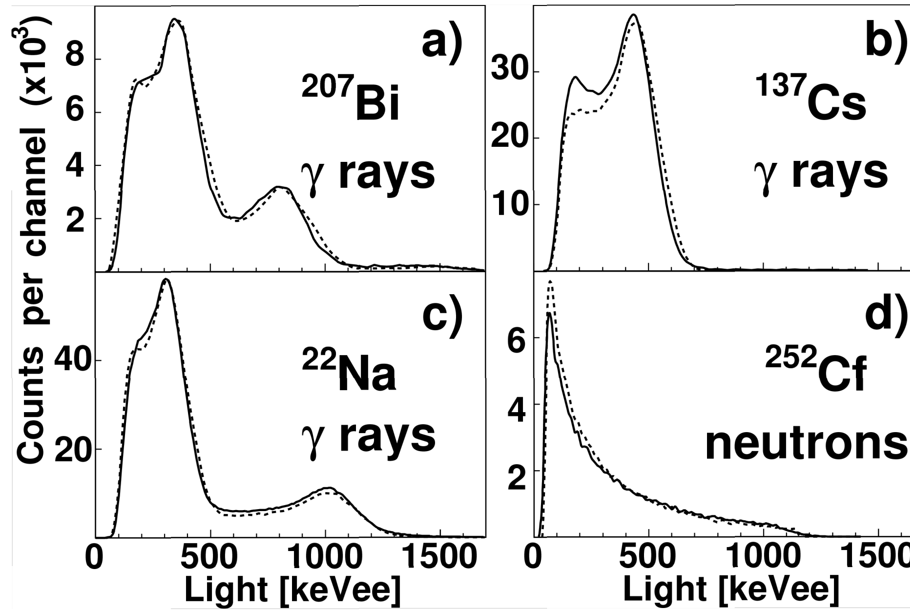
it's good for you!

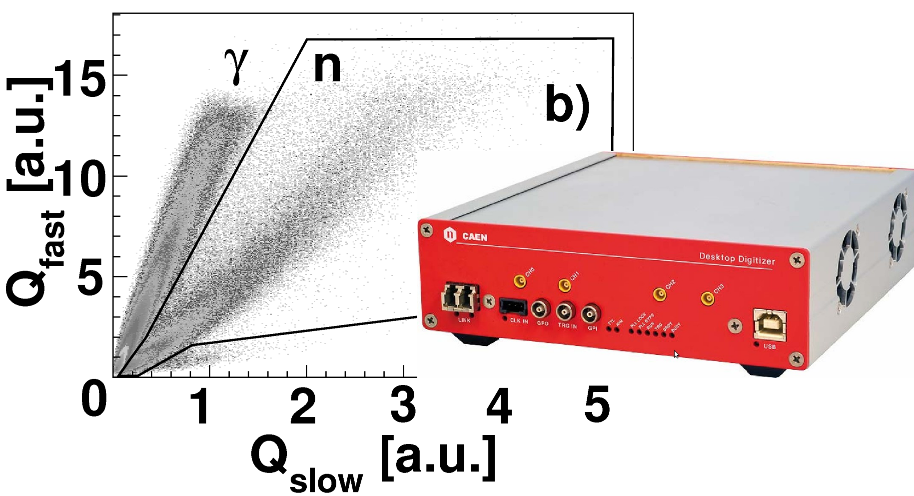
Validation of the simulations





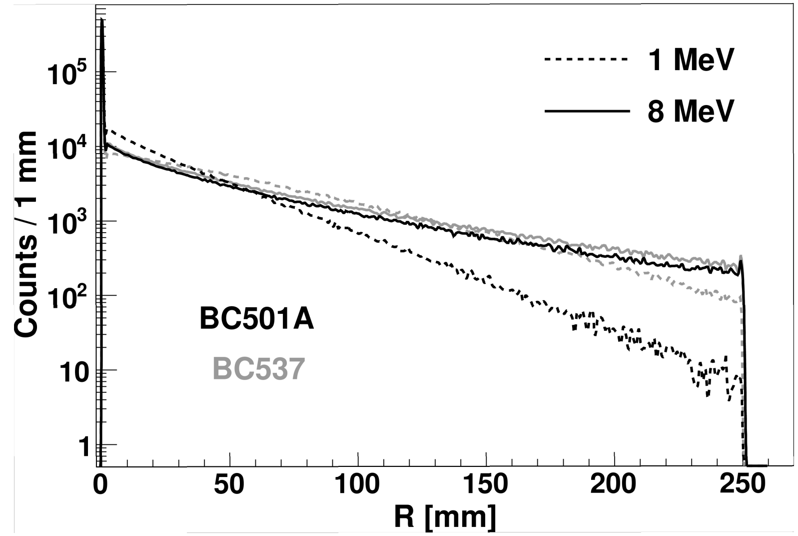




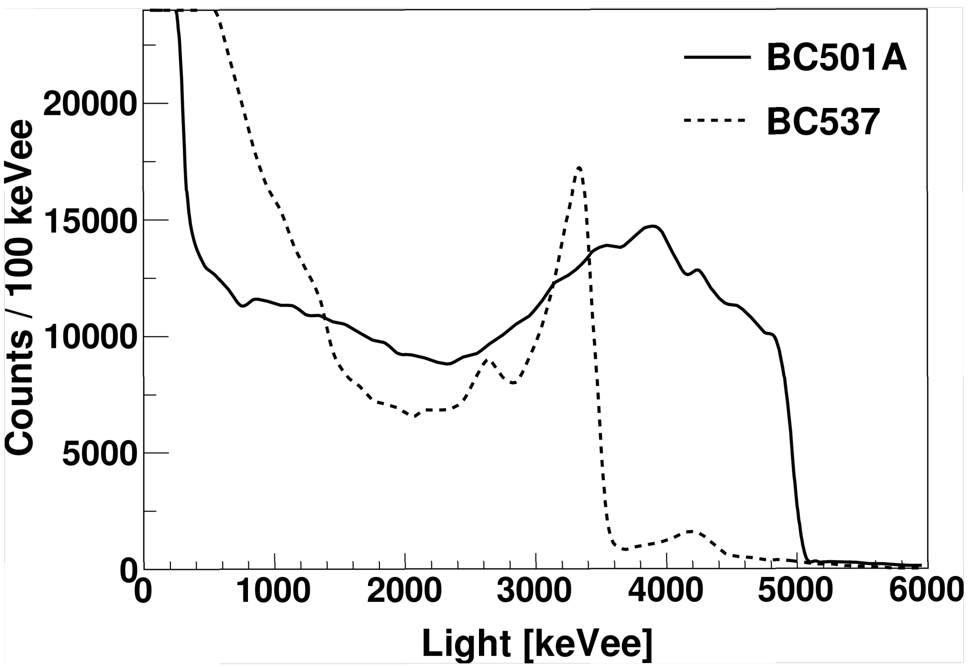


	Efficiency (%) Absolute	
Detector and radioactive source	Exp.	Sim.
NORDBALL:		
^{137}Cs γ rays, 50 cm	0.30(1)	0.285(1)
^{252}Cf neutrons, 51 cm	0.174(9)	0.241(2)
Cylindrical:		
^{252}Cf neutrons, 5 cm	6.1(3)	6.64(2)

Transverse position of the sig. interaction



Light output for 10 MeV neutrons
An instrumental response function not included



Influence of the 100 ns detection time limit on the p(1n→2n).