

# NEDA simulations

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## ***NEDA and AGATA***

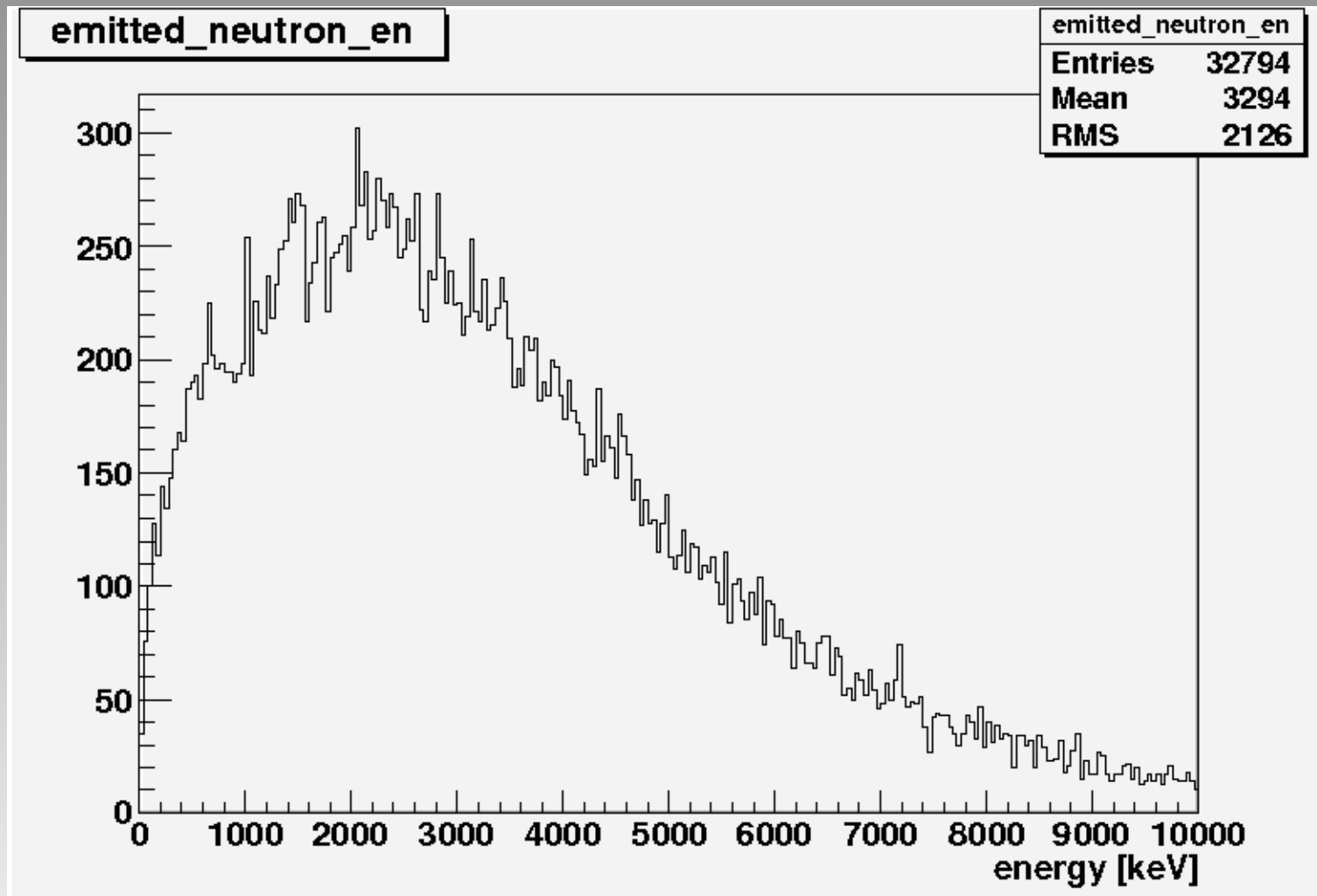
NEDA is a new neutron detector array, (part of the SPIRAL2PP project), at the design stage, with the primary goal to detect neutrons emitted in fusion-evaporation studies of proton rich nuclei (successor of the Neutron Wall)

- Will be used in future with AGATA
- Geant4 and Agata Simulation Code are employed for the simulations.

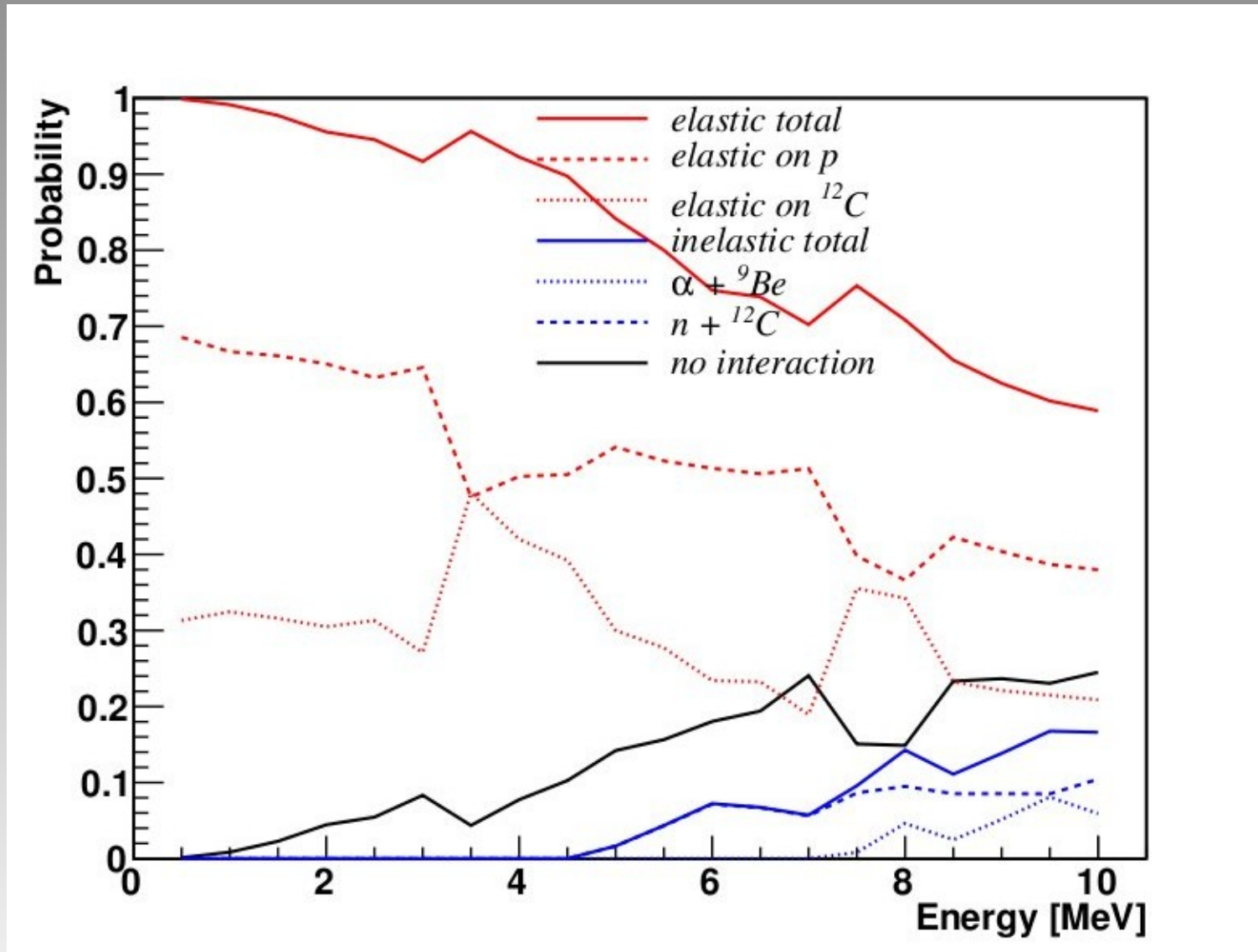
## ***NEDA - what do we look at***

- Validation of the neutron interaction model of Geant4
- Optimum size of a single detector:
  - efficiency
  - probability of 1 neutron in 2 or more detectors (cross-talk)
  - time resolution and other timing effects
- Comparison of two liquid scintillators:
  - proton based BC501A - C<sub>8</sub>H<sub>10</sub> (Xylene)
  - deuterated BC537 - C<sub>6</sub>D<sub>6</sub> (Benzene)
- Possible geometries of the array

# NEDA - neutrons of interest



# Neutron interactions in the BC501A scint.



## ***Deficiencies of neutron interaction model in G4***

Geant4 versions < 4.9.2, elastic and inelastic reactions:

- Cross sections, energy and angular distributions of neutrons not properly reproduced
- Wrong energy and angular distributions of the recoiling targets (momentum conservation law violated)
- Wrong gamma-ray lines produced

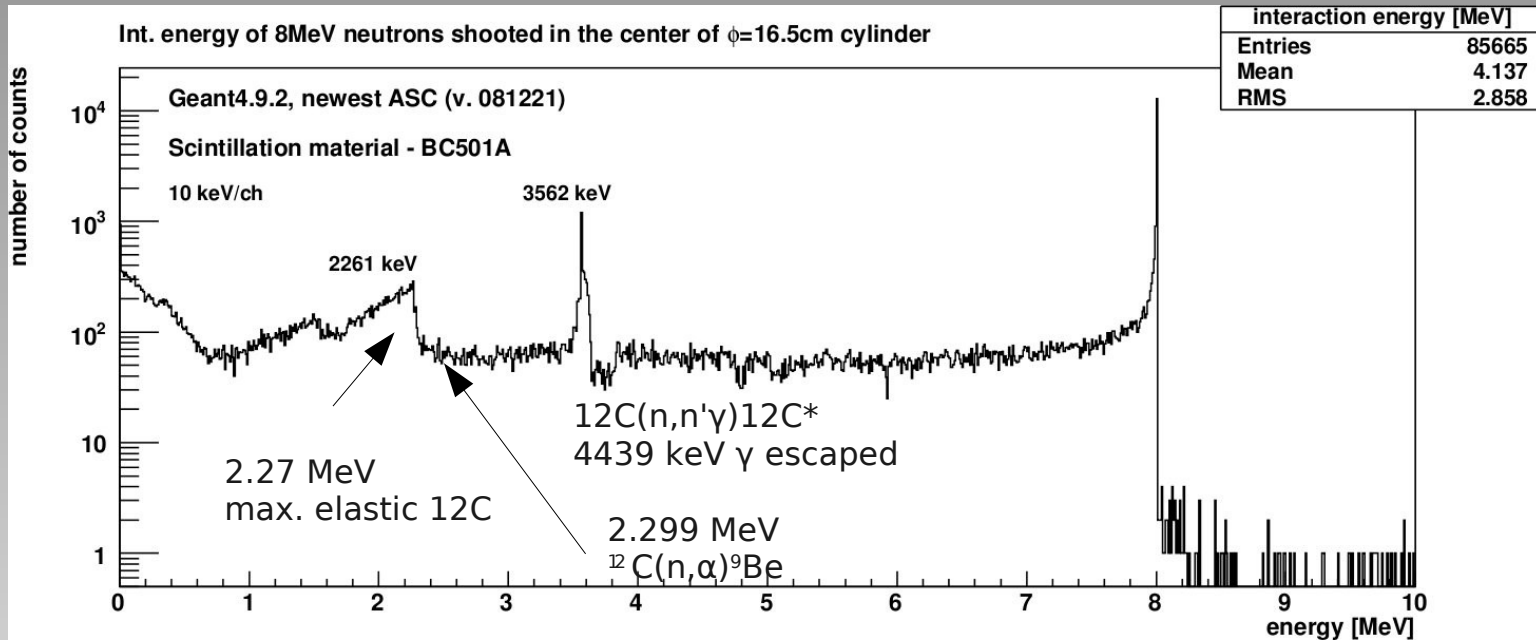
See geant4.9.2 release notes,  
especially bug#1008 and  
B. Pirard, L. Desorgher, March 2008,  
<http://cosray.unibe.ch/~laurent/g4bug/>  
for the discussion of the HP inelastic bugs.

Major problems fixed in g4.9.2 (Dec. 2008)

Patched versions: g4.9.2.p01 (March 2009),  
g4.9.2.p02 (Nov. 2009)

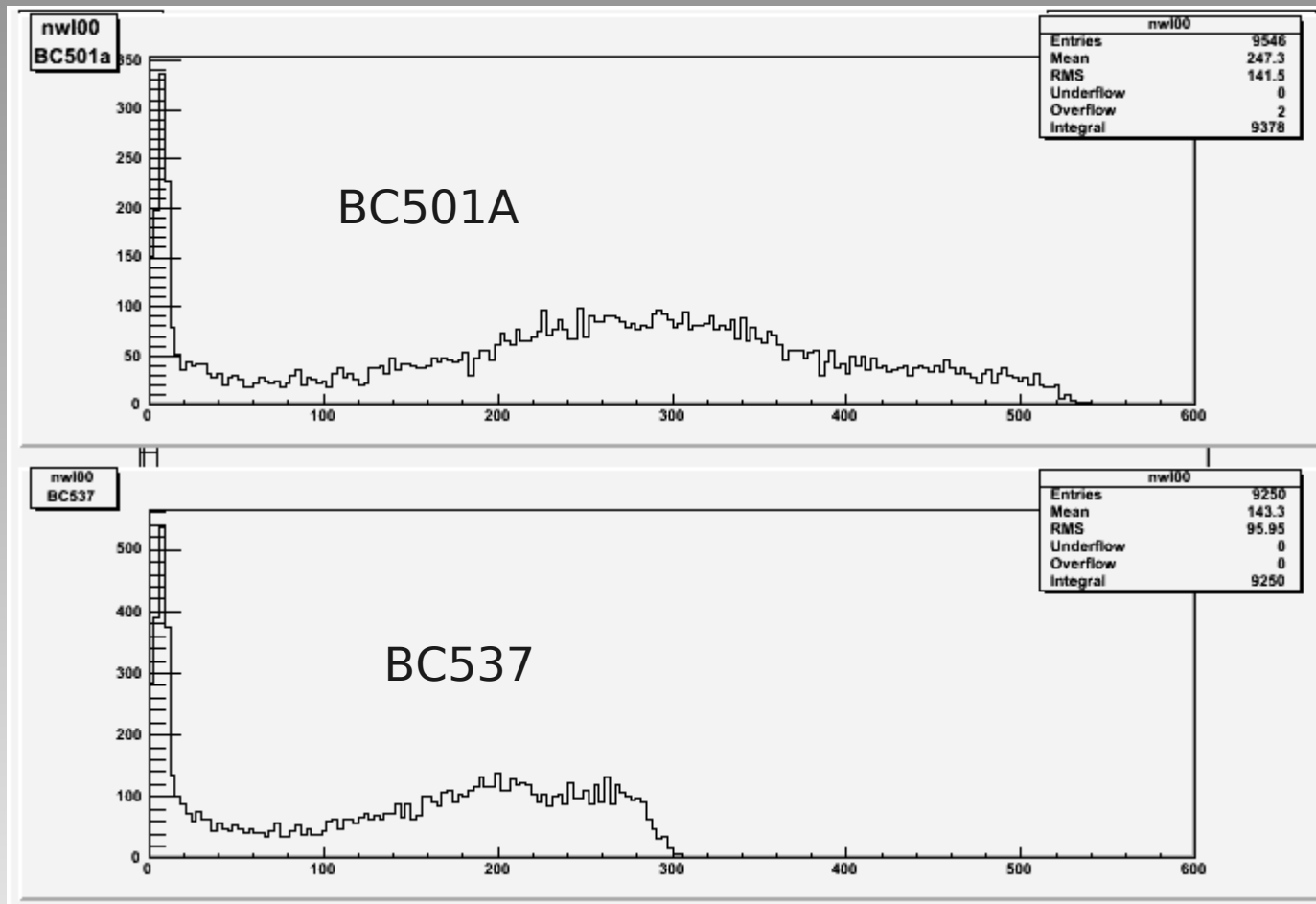
Most recent G4 version: g4.9.3 (Dec. 2009)

# Neutron energy deposit in BC501A



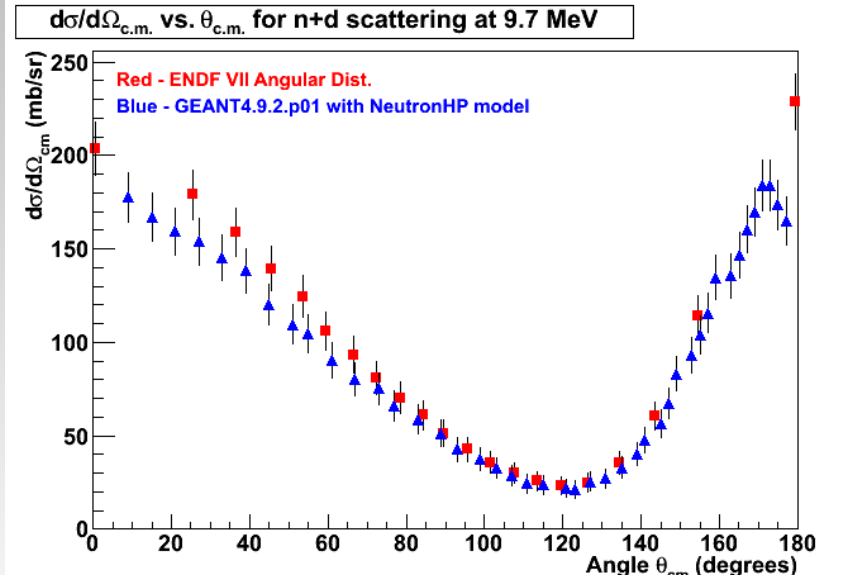
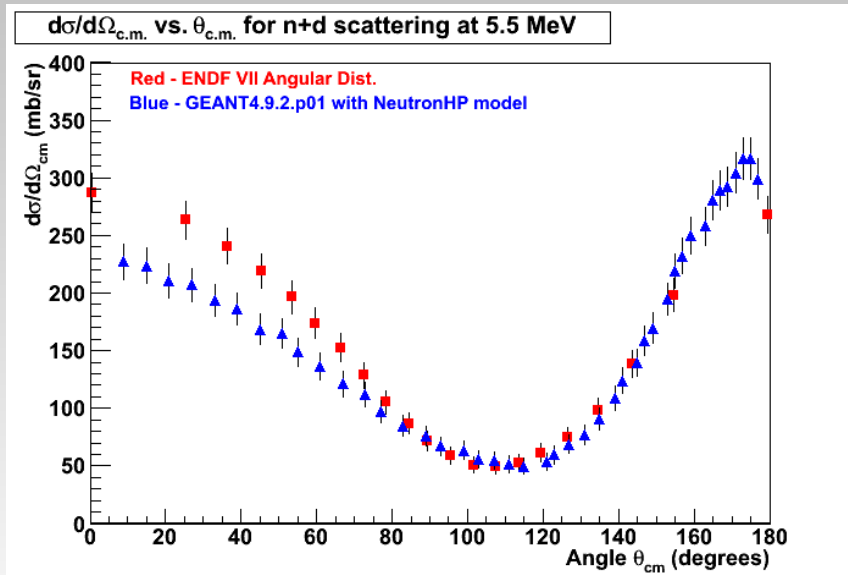
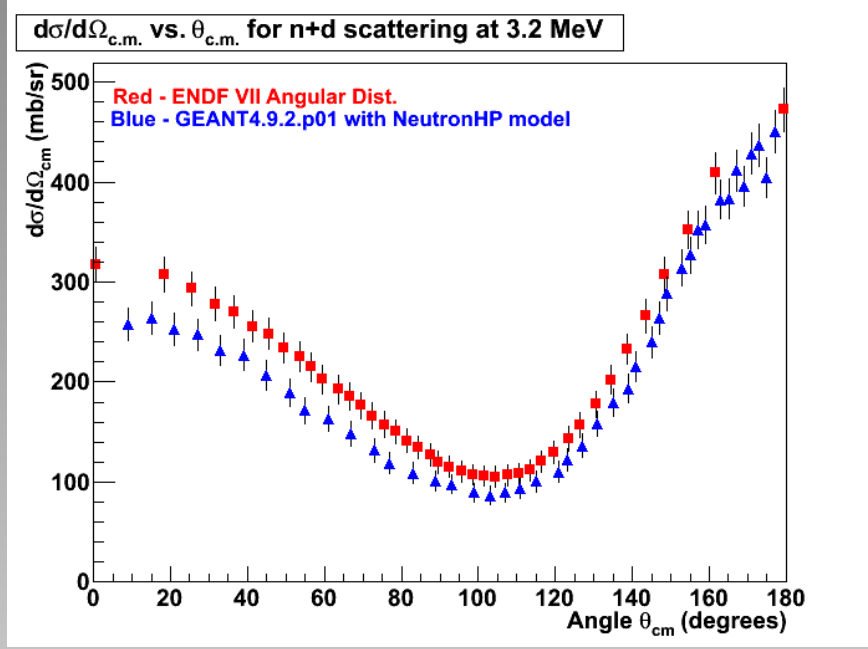
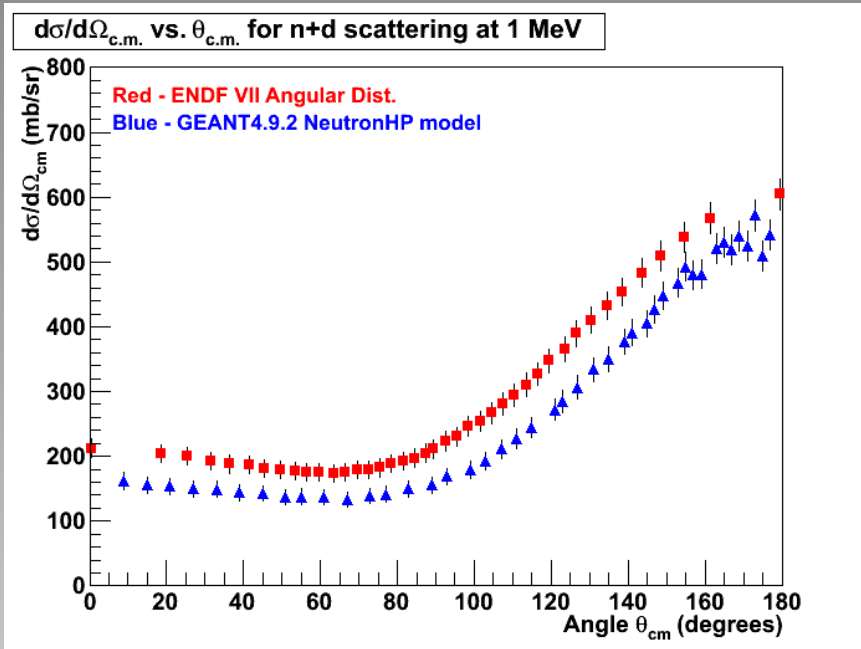
# Light produced in the scintillator

2 MeV neutrons





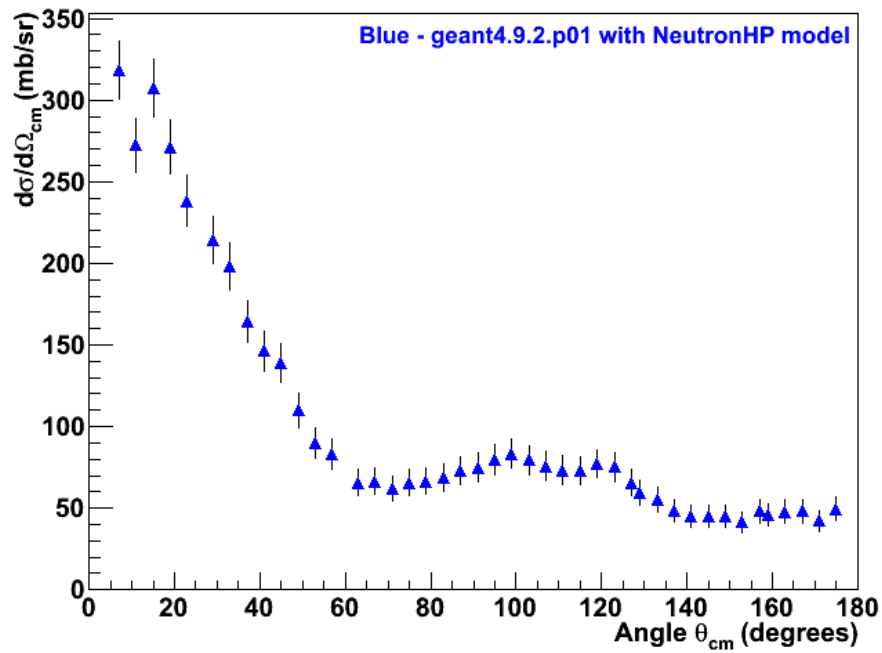
# Angular distributions - elastic scattering on d



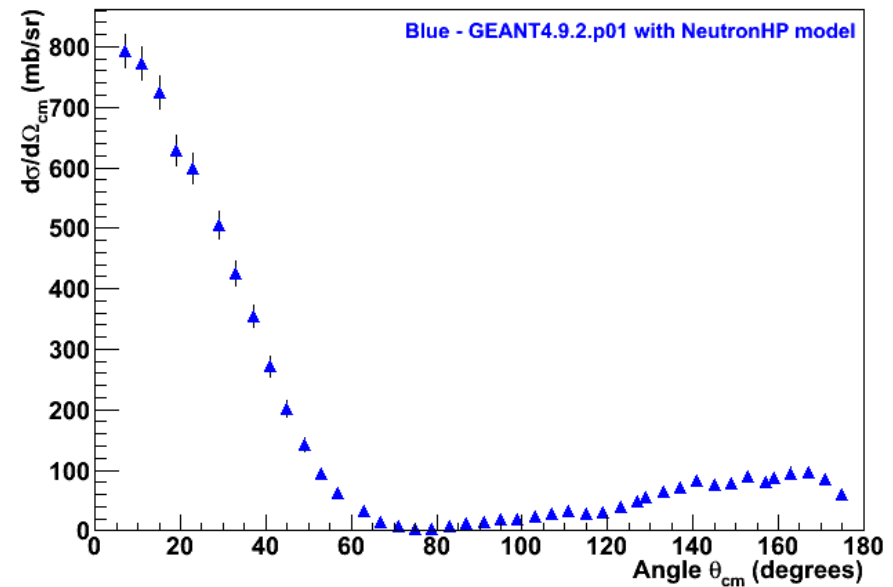
by Brian Roeder

# Angular distributions - elastic scattering on $^{12}\text{C}$

$d\sigma/d\Omega_{\text{cm}}$  vs.  $\theta_{\text{cm}}$  (elastic) for  $n+^{12}\text{C}$  at 5 MeV



$d\sigma/d\Omega_{\text{cm}}$  vs.  $\theta_{\text{cm}}$  (elastic) for  $n+^{12}\text{C}$  scattering at 8 MeV



by Brian Roeder

## Validation of Geant4.9.2.p01 (p02)

- Neutron HP model in G4.9.2.p02 much improved comparing to earlier version
- Total cross sections and angular distributions for elastic scattering on p, d, and  $^{12}\text{C}$  reasonable
- Correct (high energy)  $\gamma$ -ray lines produced
- Inelastic interactions not fully validated. Wrong kinematics (angular distributions?) in the  $^{12}\text{C}(n,\alpha)^9\text{Be}$  reaction.
- Important reactions still missing, like  $^{12}\text{C}(n,n')^3\alpha$ ,  
- not significant in the  $< \sim 10$  MeV energy range
- **Remaining deficiencies not important for neutrons of interest**

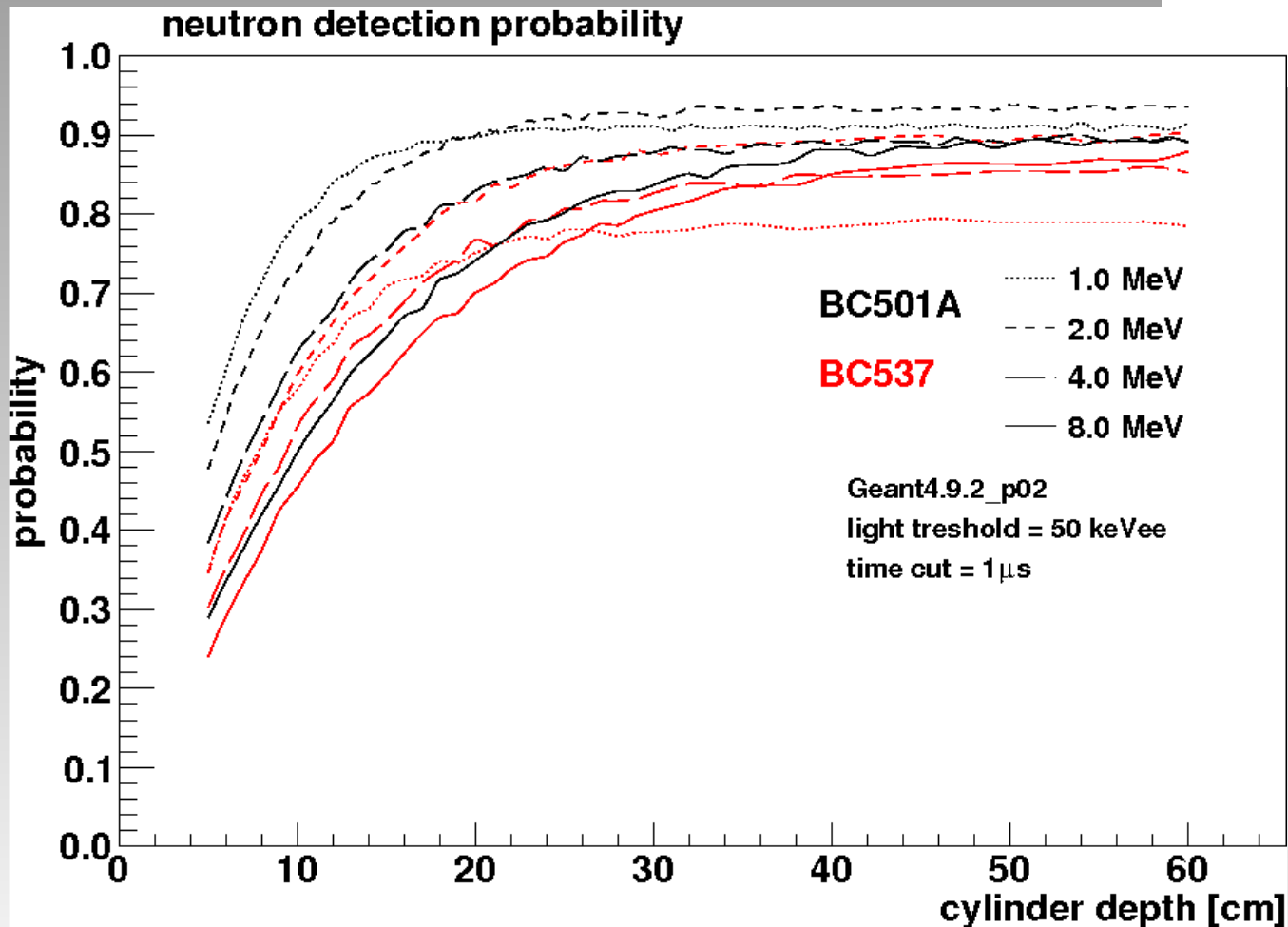
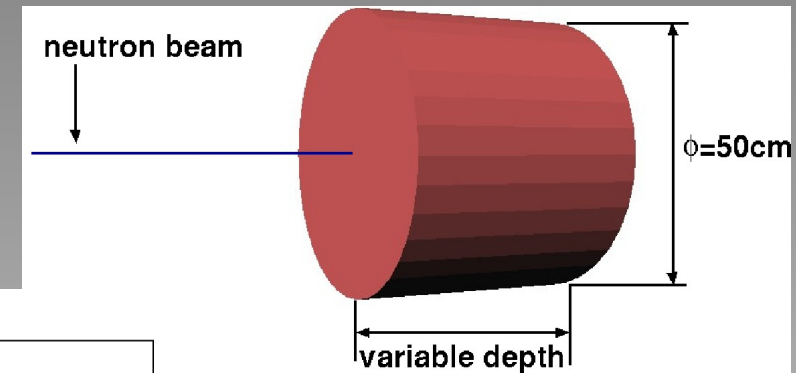
## *Times of interactions*

Hits (interactions) in G4 (Agata Simulation Code) are not necessarily listed in time order, packed interactions times determined as weighted average.

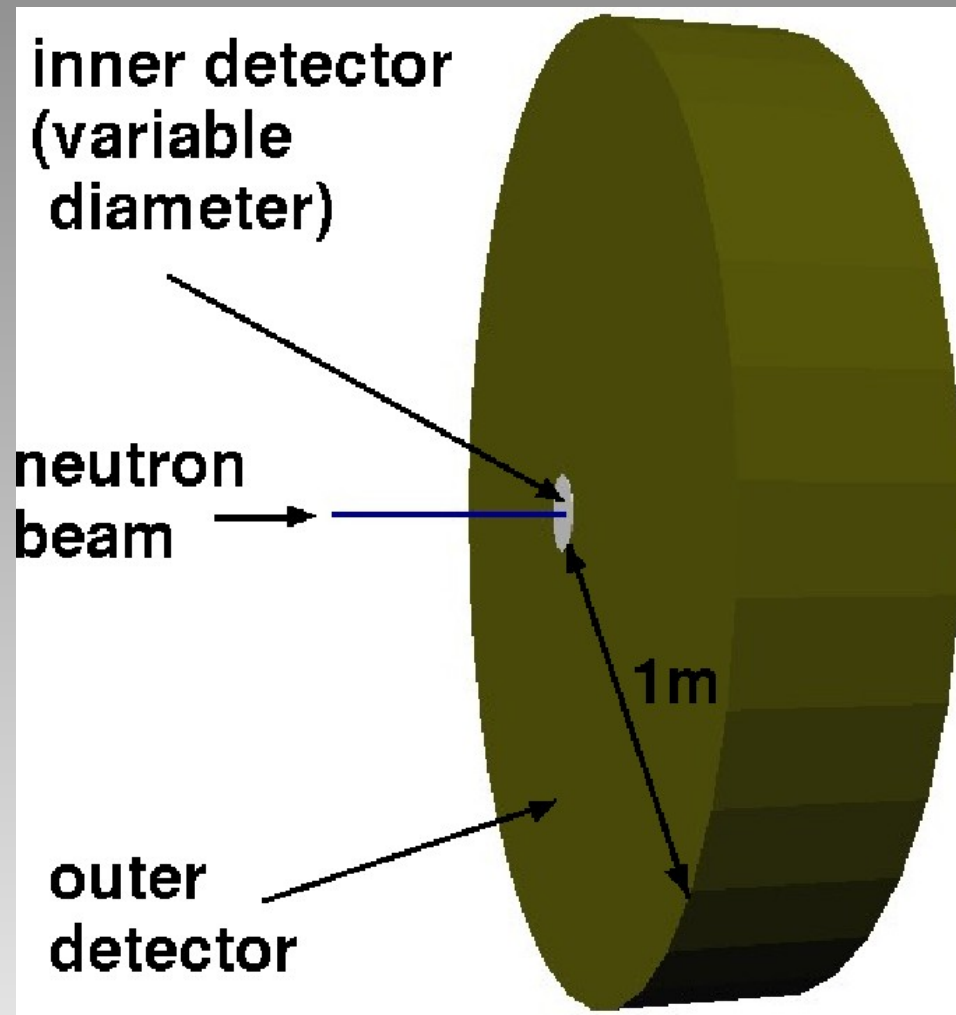
Patch:

- interactions sorted in time order,
- signal generated when the total light produced in the detector exceeds the threshold

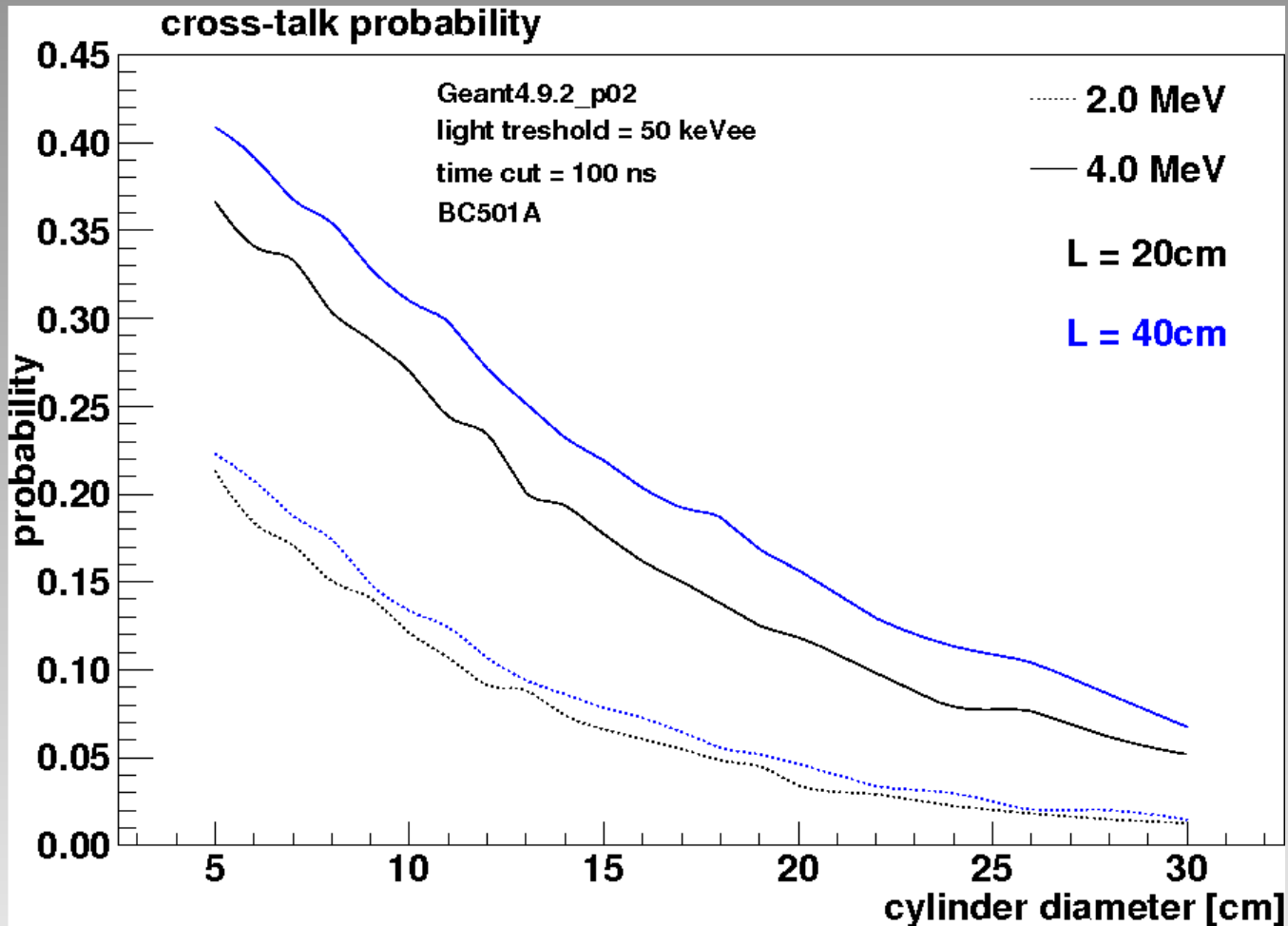
# Efficiency of a single detector



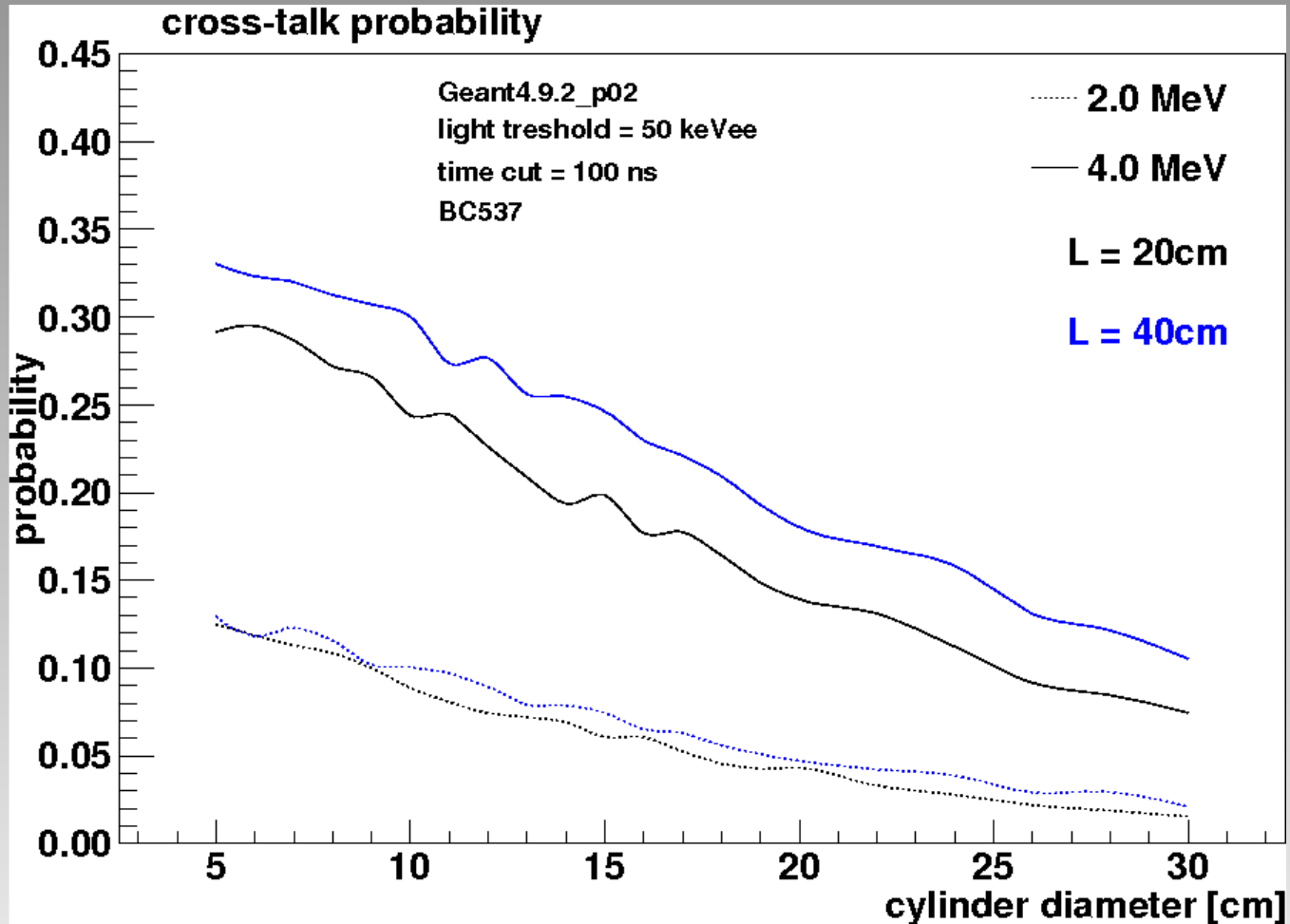
# Cross-talk



# Cross-talk - BC501 ( $C_8H_{10}$ )

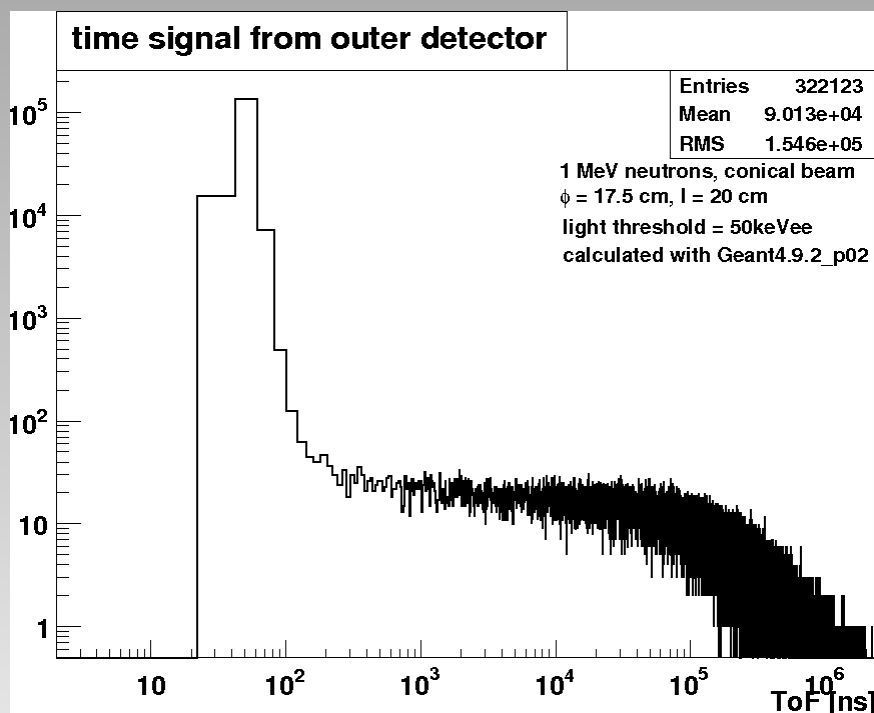


# Cross-talk - BC537 ( $C_6D_6$ )

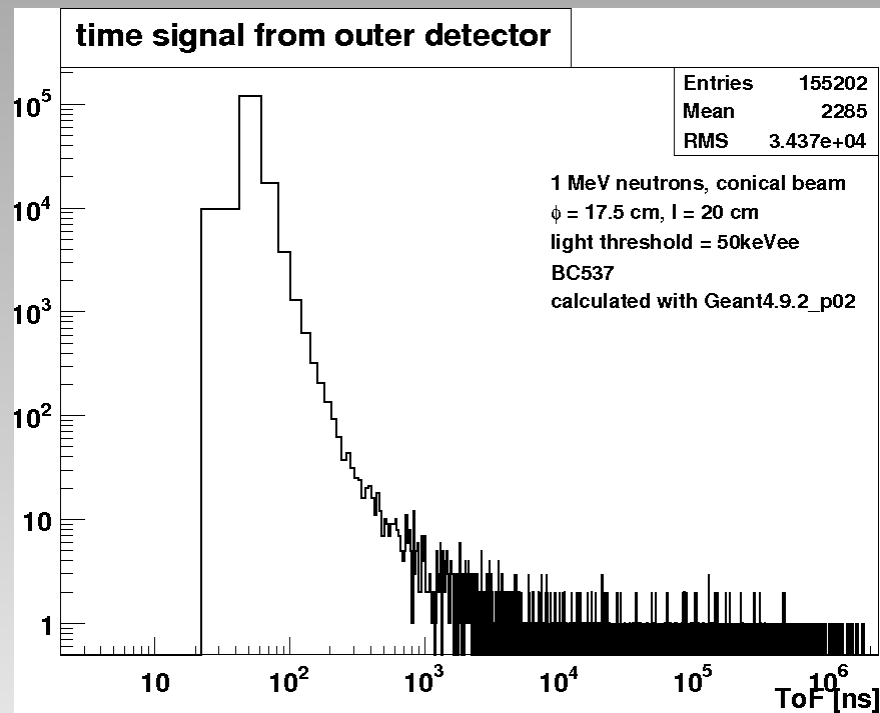




# Times of interactions

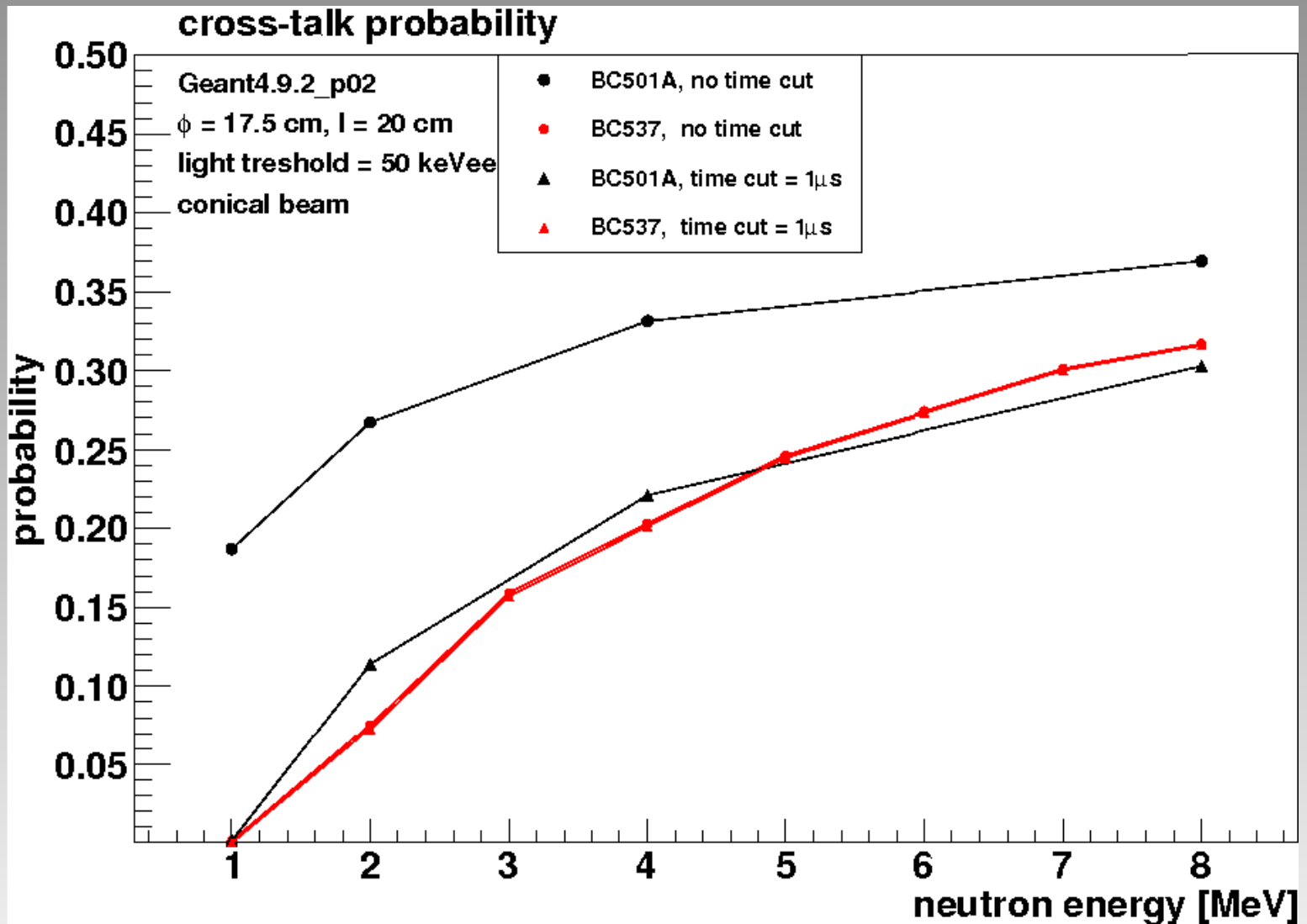


BC501A  $C_8H_{10}$

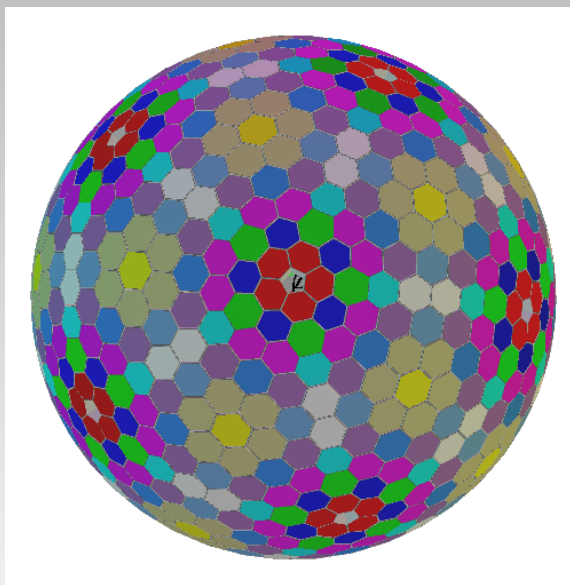
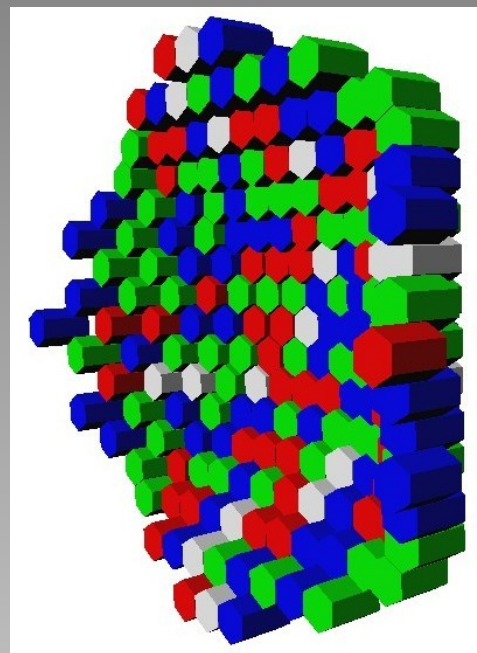
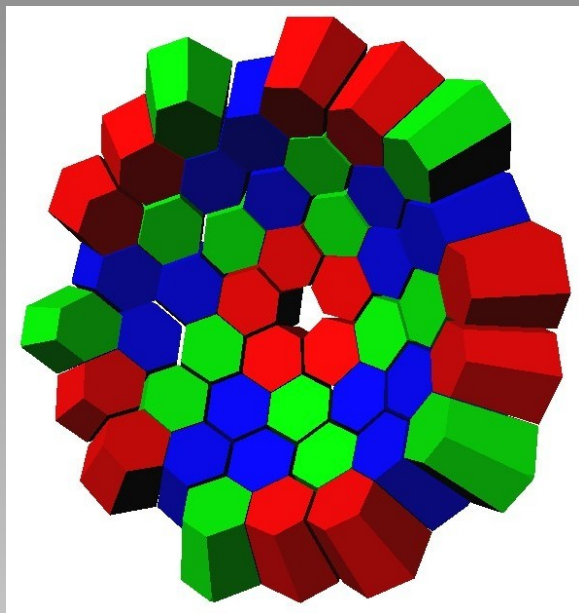


BC537  $C_6D_6$

# Time cut effect on cross-talk



# NEDA geometries



Thanks do D.Bazzaco

## Summary

- Neutron interactions in Geant4.9.2.p02 reasonable for  $E_n = 0$  to  $\sim 10$  MeV
- Single NEDA detector size: 20 cm long, 5 inch diameter  
Distance from the target to the detector:  $\sim 1$ m (or less)
- Two scintillators compared
- Work on NEDA geometry is in progress
- NEDA simulations progress report:  
[www.slacj.uw.edu.pl/neda/](http://www.slacj.uw.edu.pl/neda/)

# Test cylinder calculations - BC537

