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Title: Results of  $^6\text{Li}$ -glass detector tests for  $\chi$ -nu

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<abstract>

Results of  $^6\text{Li}$ -glass detector tests for chi-nu

Hye Young Lee

I will present the current status of the  $^6\text{Li}$ -glass detector development done for chi-nu project. The calibration work with  $^{252}\text{Cf}$  source and in-beam test on  $^{235}\text{U}$  will be discussed for charactering the detector performance and understanding the detector efficiency.

# Results of $^6\text{Li}$ -glass detector tests for $\chi$ -nu

Hye Young Lee

LANSC-NS

LANL

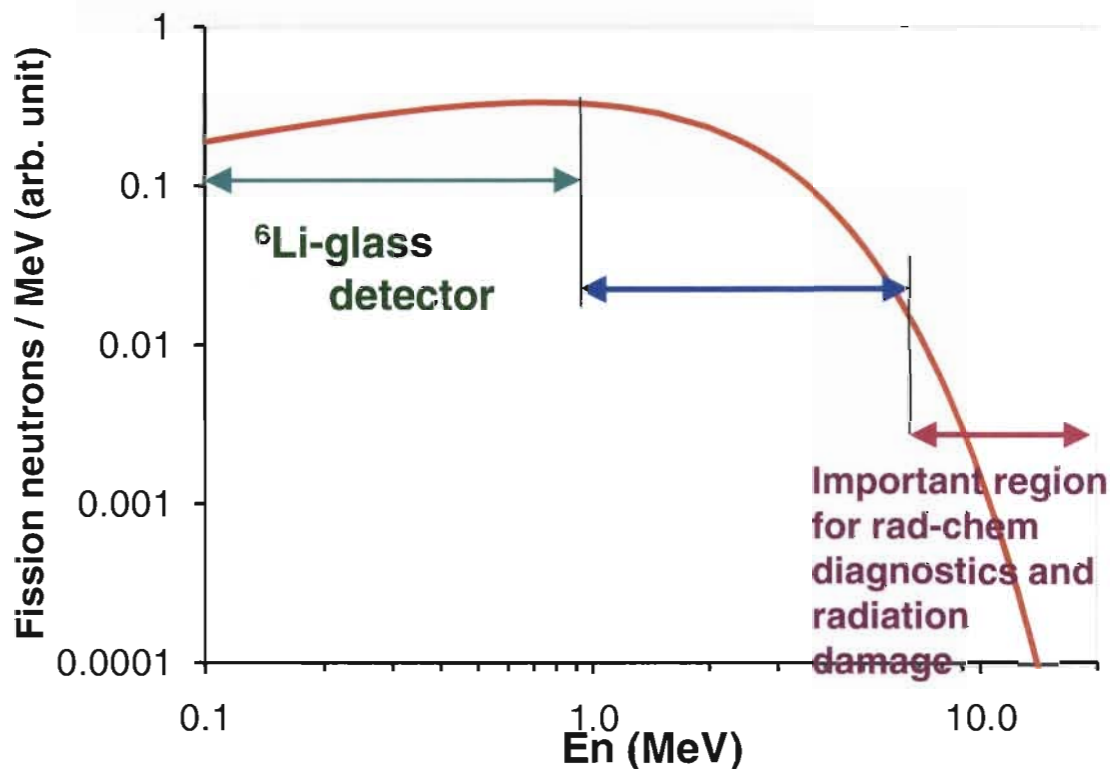
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## Li-glass detector tests

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- **Calibration runs in Jan. 2011 using  $^{252}\text{Cf}$  source**
  - Establish the analysis method for low energy measurements
  - Comparison with MCNPX Monte Carlo calculations
  - Determination of detection efficiency at  $E < 1 \text{ MeV}$
- **Preliminary results on the in-beam  $^{235}\text{U}(\text{n},\text{f})$  measurements in Jun.-Sep. 2010**
  - Average neutron output energy
  - Nu-bar : neutron multiplicity

## Fission neutron output spectrum (typical) : Watt distribution



**Green arrow** : about 35 % of fission-induced neutrons are produced at less than 1 MeV.

**Blue arrow** : number of neutrons in this region is determined by  $\bar{\nu}$  and the shape of the entire spectrum.

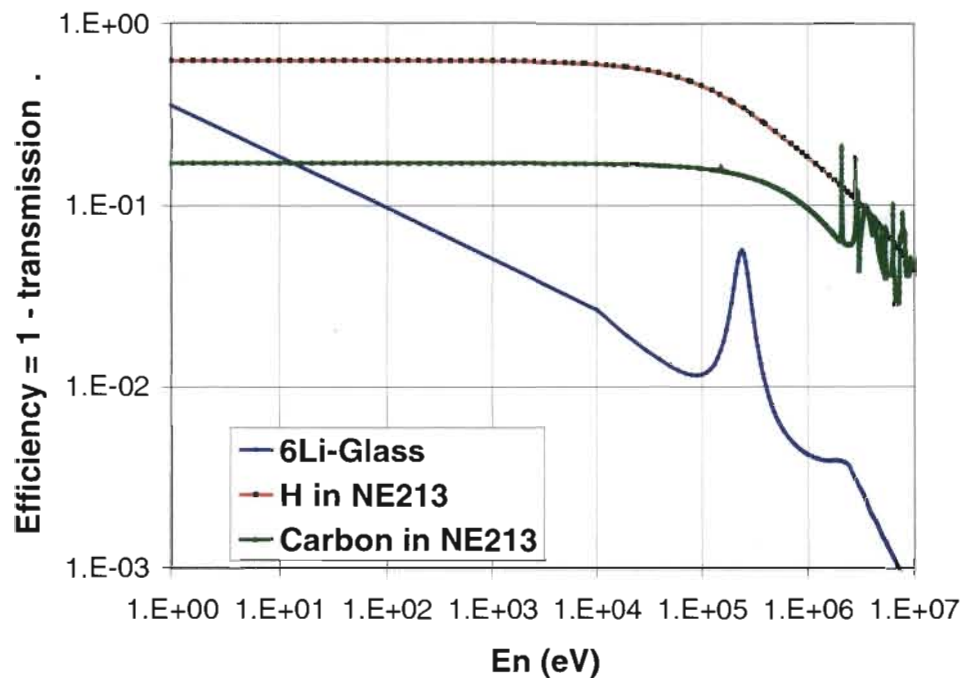
**Purple arrow** : above 6 MeV, hydrogen and helium generated from (n,p) and (n, $\alpha$ ) can do radiation damage on structural materials.

\* This plot is made from the neutron emission from spontaneous fission of  $^{252}\text{Cf}$ .

Up to now the unmeasured data below 1 MeV are obtained by fitting to Watt distribution.

## $^6\text{Li}$ -glass detectors for measuring low-energy neutrons ( $< 1 \text{ MeV}$ )

Scintillator efficiencies -- all 1 cm thick



NE213 shows the similar characteristics as Liquid Scintillators used in Chi-Nu. Although the efficiencies (red and green lines) are still high at  $E_n < 1 \text{ MeV}$ , it is impossible to discriminate neutrons from gamma rays.

$^6\text{Li}$ -glass detector has a usable efficiency below 1 MeV and can differentiate neutrons from gamma rays in this region. The pulse height is generated from the  $^6\text{Li}(n,\alpha)^3\text{H}$  reaction, where the  $\alpha$  and triton products have a kinetic energy of about 4.8 MeV.

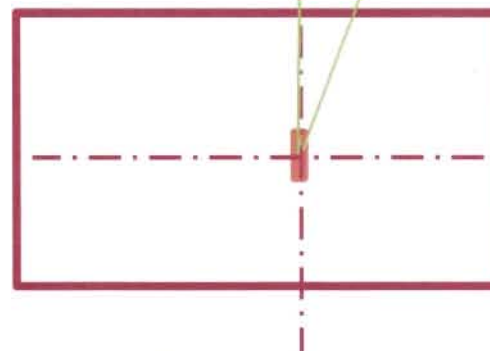
# $^{252}\text{Cf}$ source measurement

## Li-glass detector setup

$^{252}\text{Cf}$ -PPAC is manufactured to be identical as the real PPAC chamber, except the 9 extra foils.

$^6\text{Li}$ - and  $^7\text{Li}$ - glass detectors (4"X1") were used.

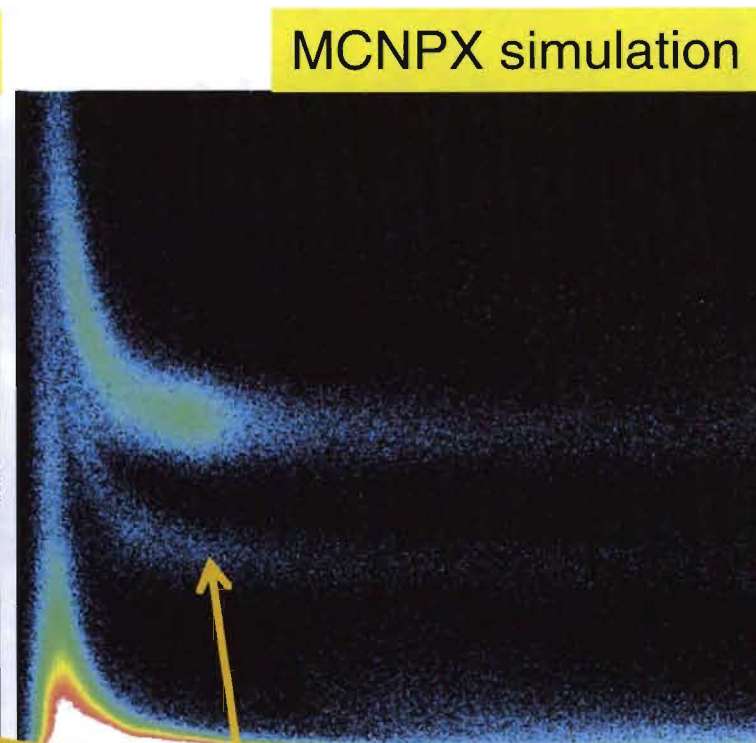
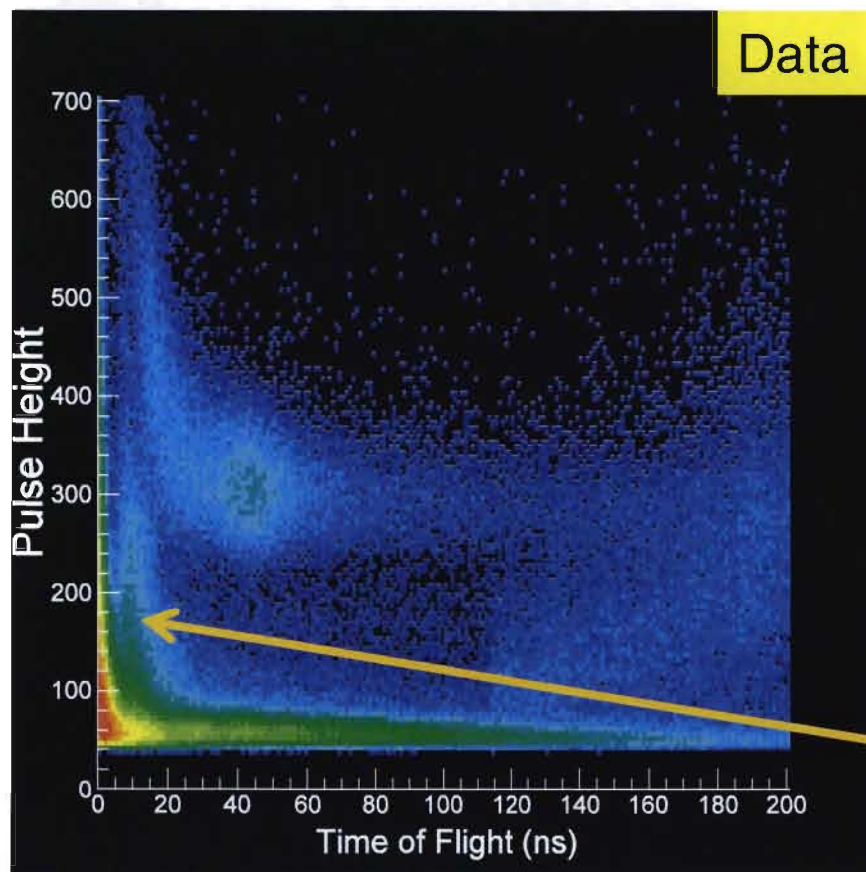
$^{252}\text{Cf}$ -PPAC chamber with a source deposited on the center foil



*Drawing to scale*



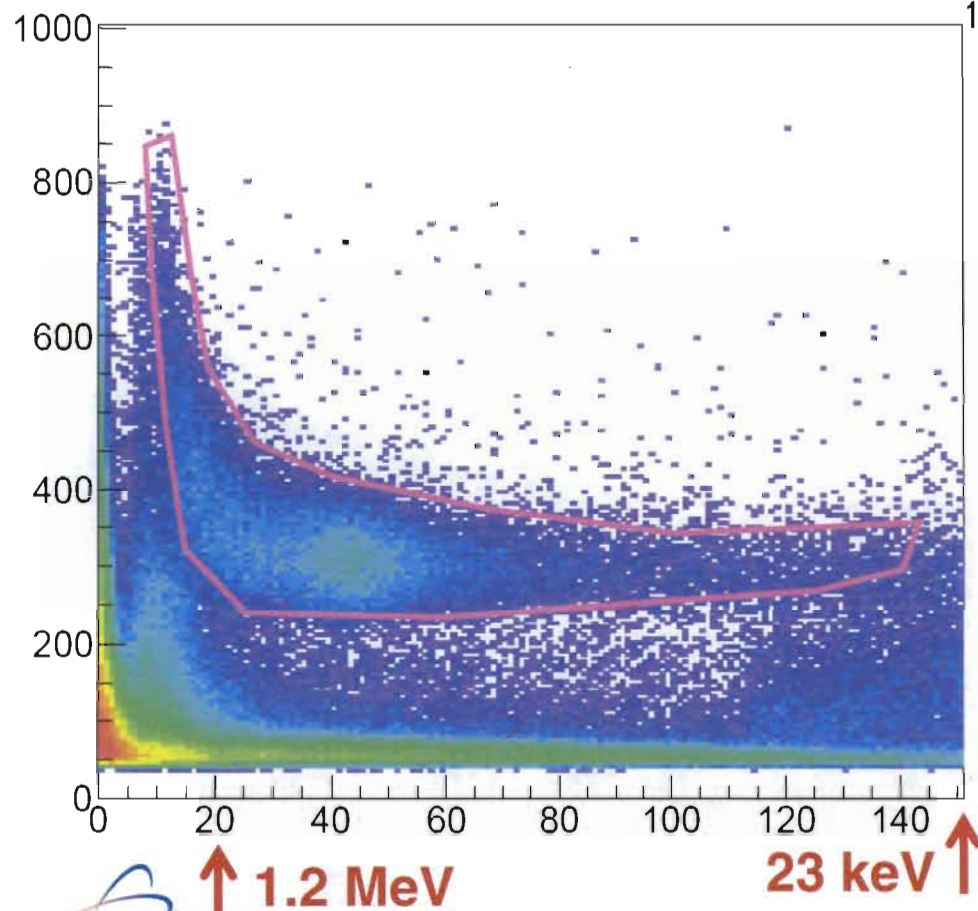
## Pulse height (y-axis) vs. Time of Flight in ns (x-axis) : data and simulation



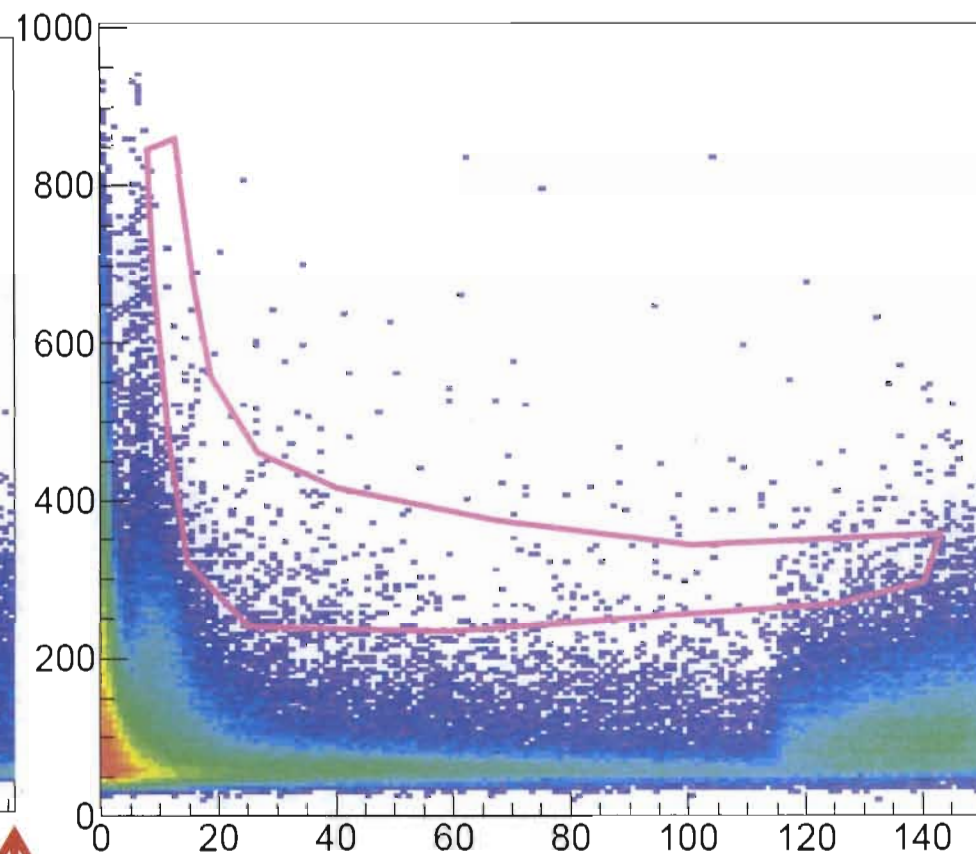
Background reaction on  
glass materials

# Detector efficiency vs. neutron energy

6Li(1): pulse height vs. TOF

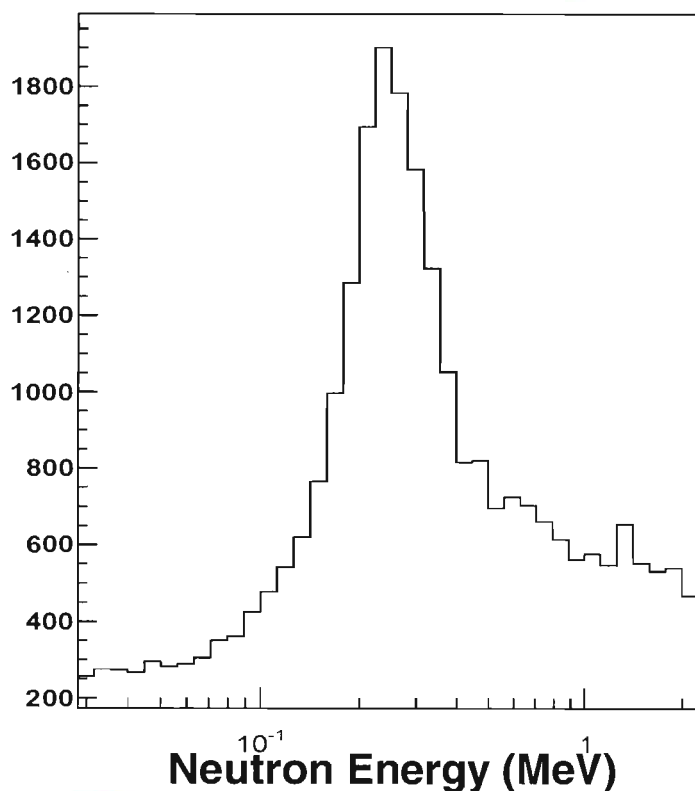


7Li: pulse height vs. TOF

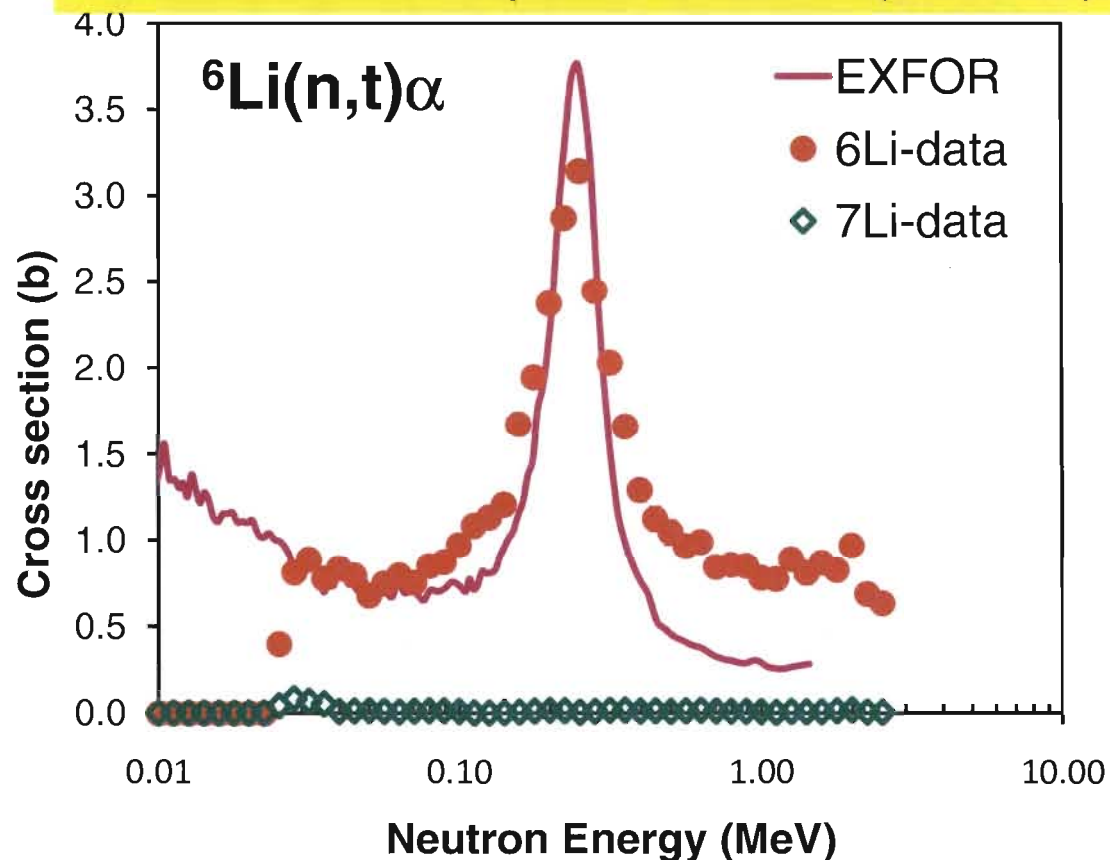


# Neutron Output Yield from $^{252}\text{Cf}$

## Raw yield

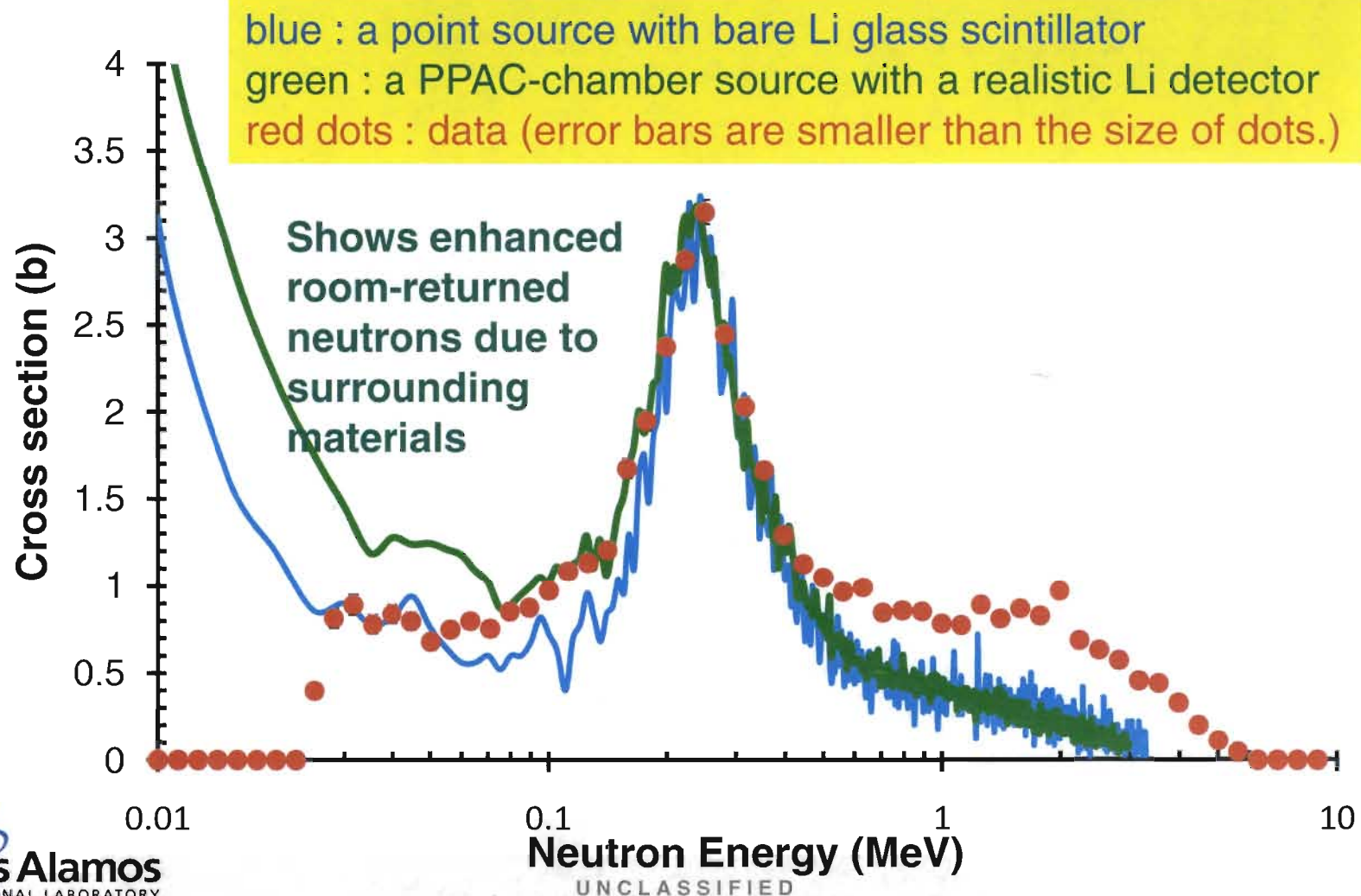


Data are normalized to Watt distribution  
-> the detector response function (red dots)





## Data compared to MCNP calculation for realistic setup



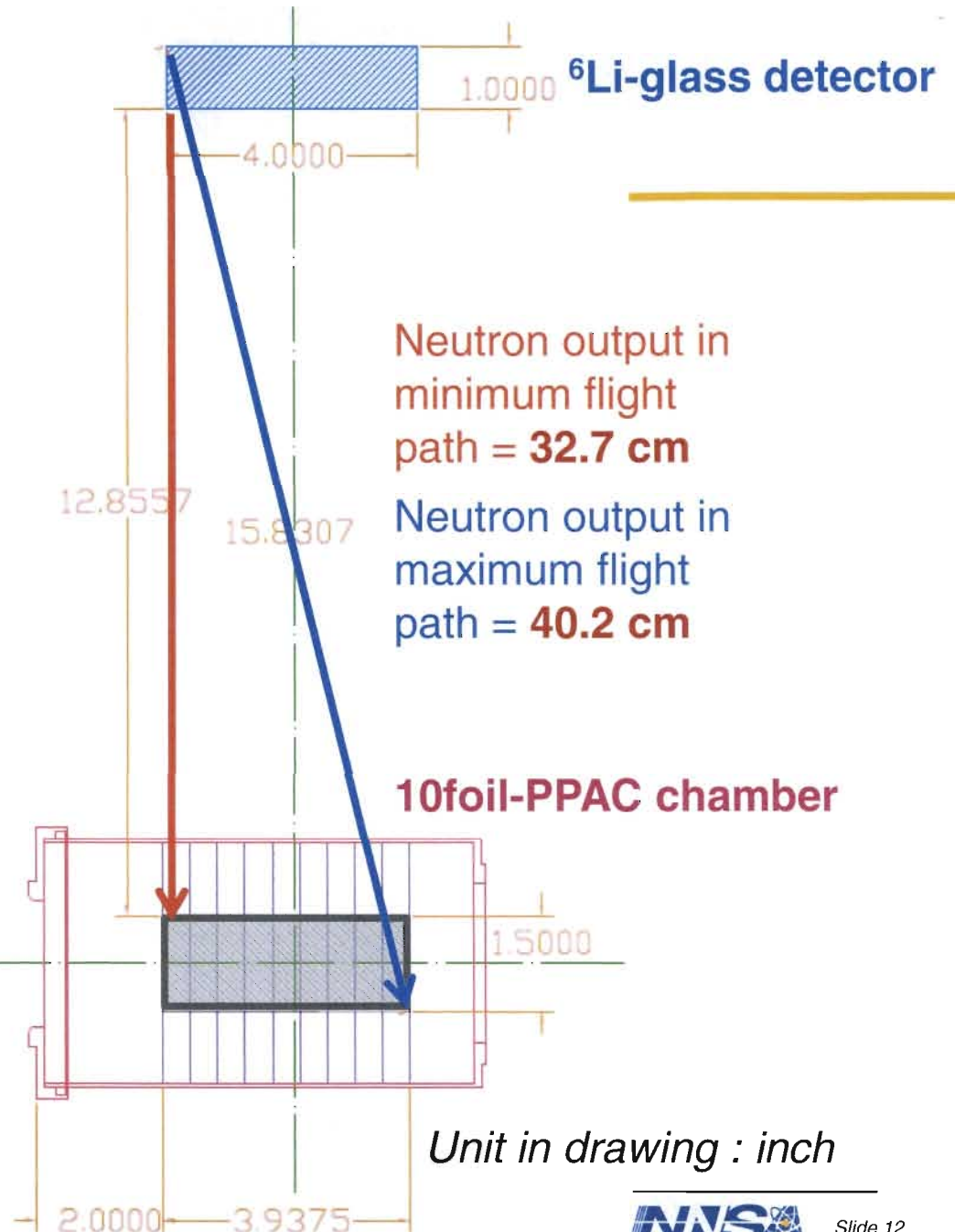
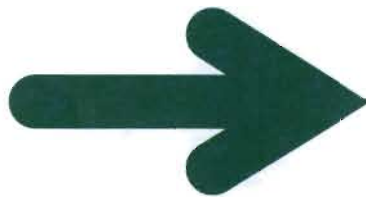
# $^{235}\text{U}(\text{n},\text{f})$ measurement

## Li-glass detector setup

Contribution to the broadening :

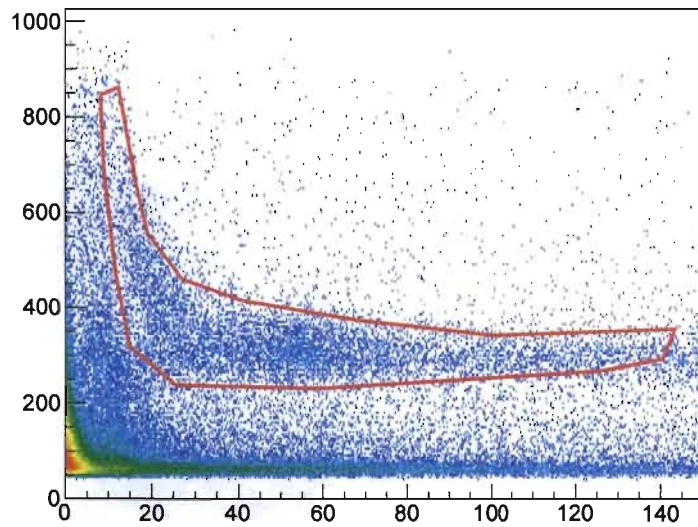
1. Extended foil elongation  
-> can be corrected from the data, so FWHM is improved to be 215 keV (~20 %)
2. Extended beam spot
3. Large solid angle for  $^6\text{Li}$  glass

Incoming Beam :  
4 cm in diameter

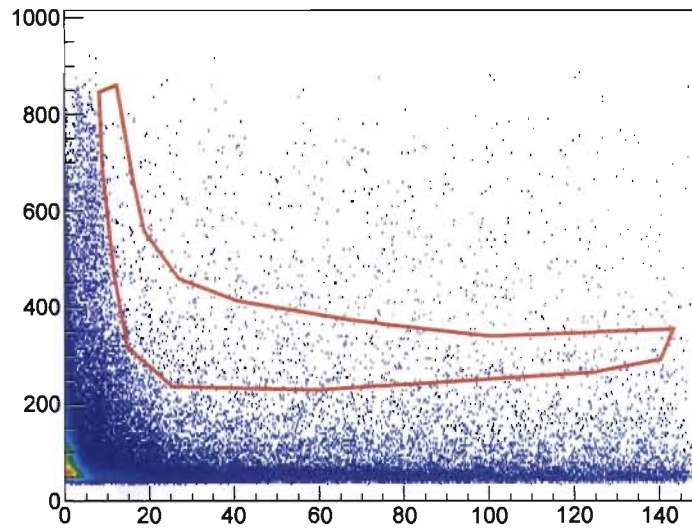


## $^{235}\text{U}(n,f)$ : offline analysis steps

6Li(2): pulse height vs. TOF



7Li: pulse height vs. TOF



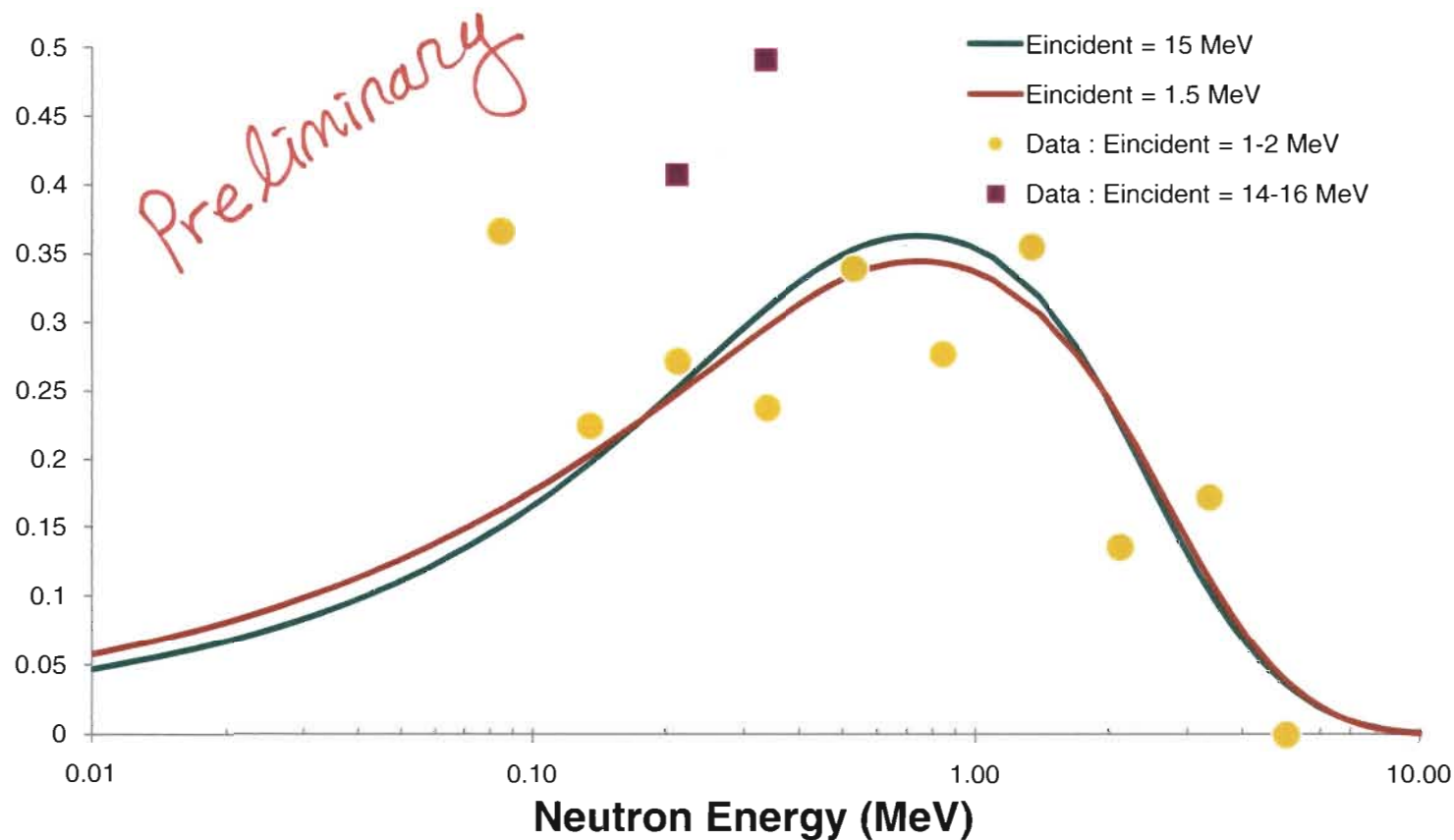
[1] Yield is obtained by applying the same graphical locus as the  $^{252}\text{Cf}$  analysis.

[2] Subtract the yield of  $^7\text{Li}$ -glass data from that of  $^6\text{Li}$ -glass data.

[3] Normalize it to the detector response function, taken from the  $^{252}\text{Cf}$  measurement.

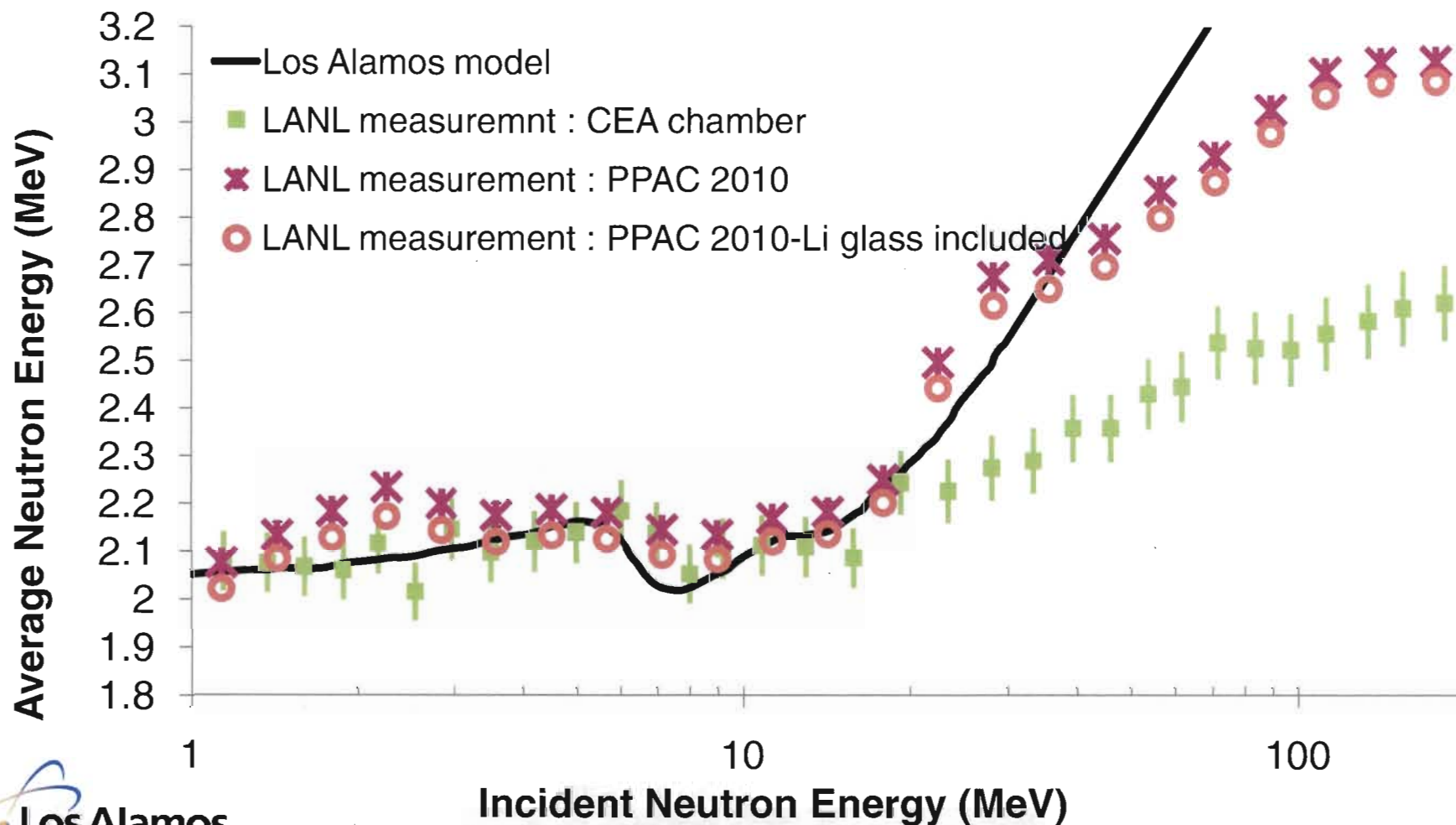


## Neutron output distributions compared with the LA model





## Preliminary Average neutron output energy



## Preliminary Average neutron multiplicity ( $\bar{\nu}$ )

