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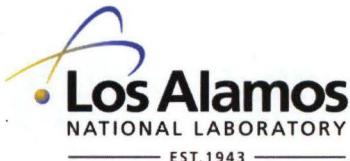
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Title: Low energy detectors : 6Li-glass scintillators

Author(s): Hye Young Lee

Intended for: Attending the Fission Workshop meeting for the Chi-Nu project at Los Alamos National Laboratory



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Low energy detectors : ^6Li -glass scintillators

Hye Young Lee

I will present the detector response study done for the ^6Li -glass detectors in the Chi-Nu project. The calibration work with ^{252}Cf source and in-beam test on ^{235}U will be discussed for characterizing the detector response and establishing the analysis method for the convoluted neutron output data.

Low energy detectors : ^6Li -glass scintillators

Hye Young Lee
Terry Taddeucci (MCNP calculations)

Los Alamos Neutron Science Center
-Neutron and Nuclear Science
(LANSCE-NS)

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Contents

- **Detector Response Calibration using ^{252}Cf source**
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 - Comparison with MCNP calculations
 - Sensitivity of Li-glass measurements to the underlying fission spectra
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 - Reduced room-induced background
- **Preliminary Prompt Fission Neutron Spectrum from $^{235}\text{U}(n,f)$ at FIGARO setup**
- **Outlook**

How to determine the detector response



Detector response function

- Yield =
Neutron distribution X Detector response function X Detector solid angle
- Neutron distribution = Watt distribution
- Detector response function =
 ${}^6\text{Li}(\text{n},\alpha)\text{t}$ cross section X light response in glass & PMT
- Yield (${}^{252}\text{Cf}$) / Watt distribution (${}^{252}\text{Cf}$) =
Detector response function at a fixed position for one detector

Lajtai measurement using a ^{252}Cf source

1. Triggers were selected by “slow” signal discrimination (1-dim. cut); for fission fragments from the alphas and for neutrons from gammas+background

2. Correction factor $a(t)$:

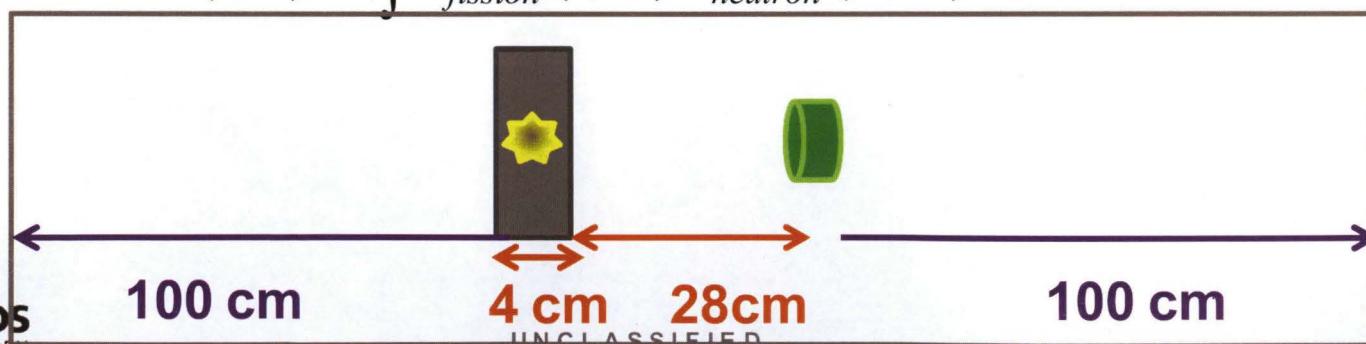
$$a(t) = \frac{\int \delta[t - t(E)] \epsilon'(E) \phi(E) dE}{\int F(E, t) \phi(E) dE}$$

where $f(E)$ is a Maxwellian distribution with a $T=1.42$, $\epsilon'(E)$ is the theoretical efficiency of the neutron detector calculated on the basis of $\epsilon'(E) = \int F'(E, t) dt$, where $F'(E, t)$ is the probability of recording at instant t of neutrons emitted from the source with energy E and travelling towards the detector and back within the solid angle.

3. The realistic response function $F(E, t)$:

where $F''(E, t)$ is identical to $F'(E, t)$, except that real experimental conditions were assumed for both source and detector; $F'(t, t')$ is the instrument portion.

$$F'(t, t') = \int F_{\text{fission}}(t, t'') F_{\text{neutron}}(t', t'') dt''$$



^{252}Cf source measurement



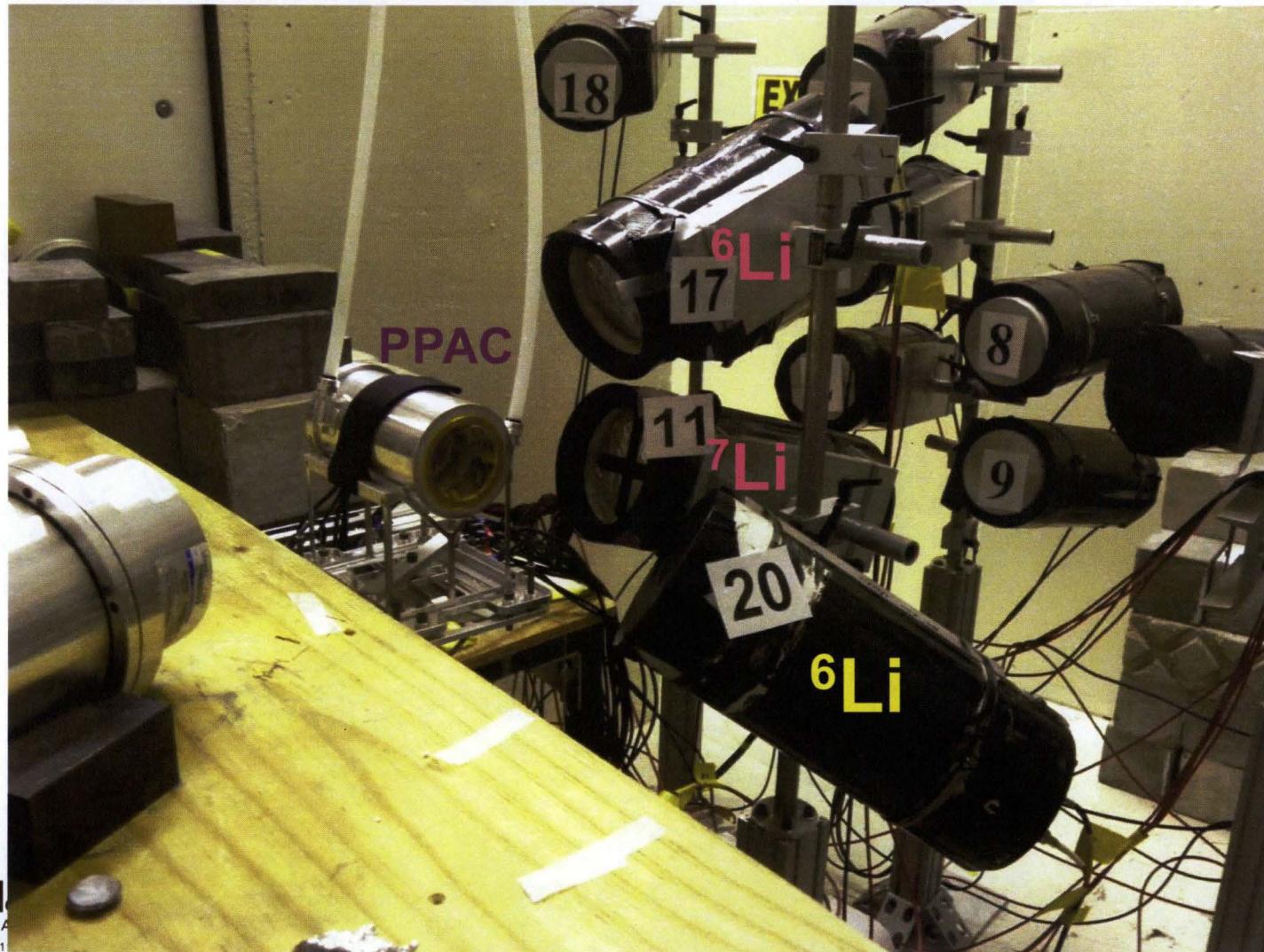
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Experimental setup with ${}^6\text{Li}$ -glass detector and PPAC ${}^{252}\text{Cf}$ source



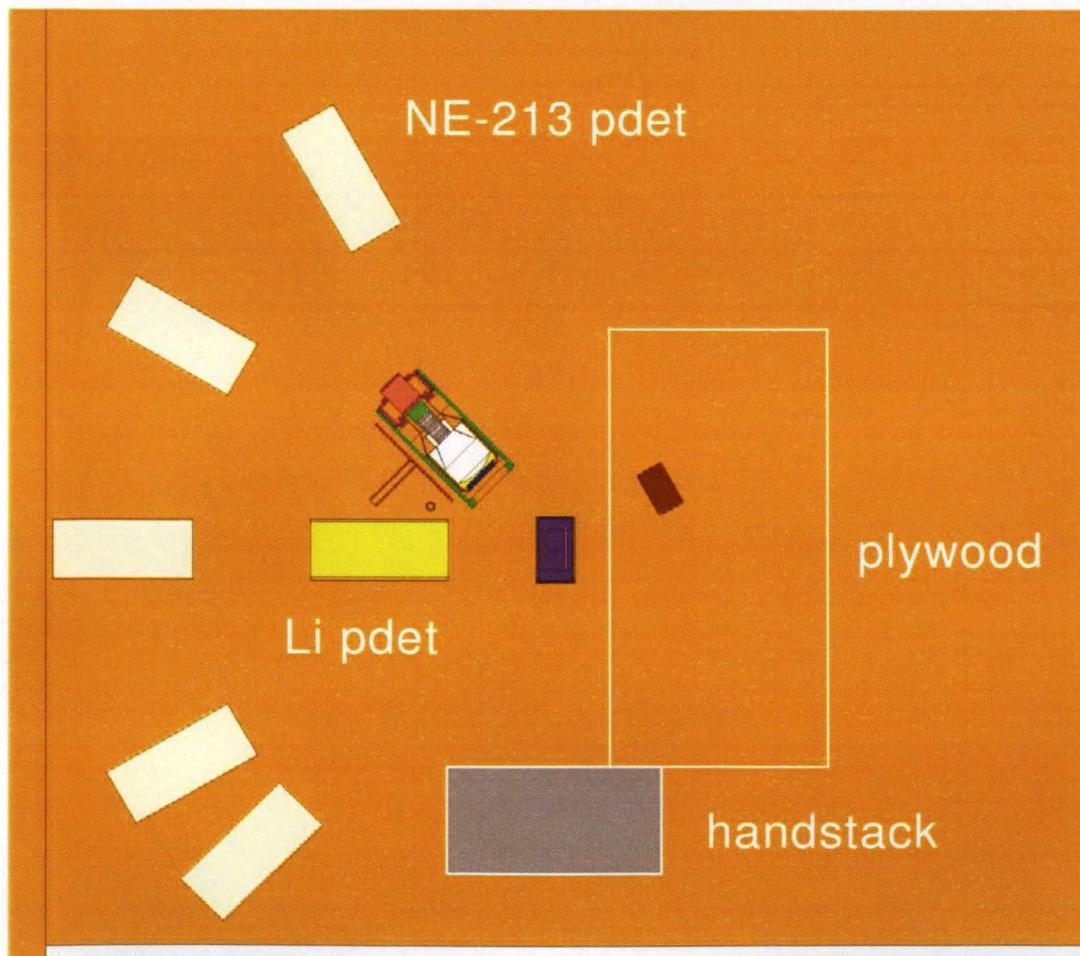
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MCNP geometry for FIGARO target room

central 3 meters



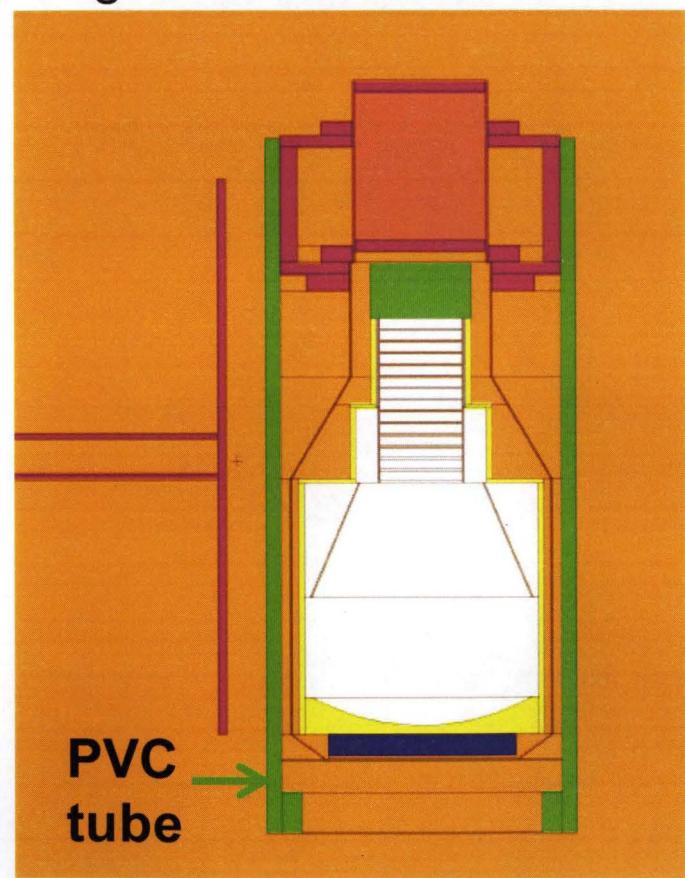
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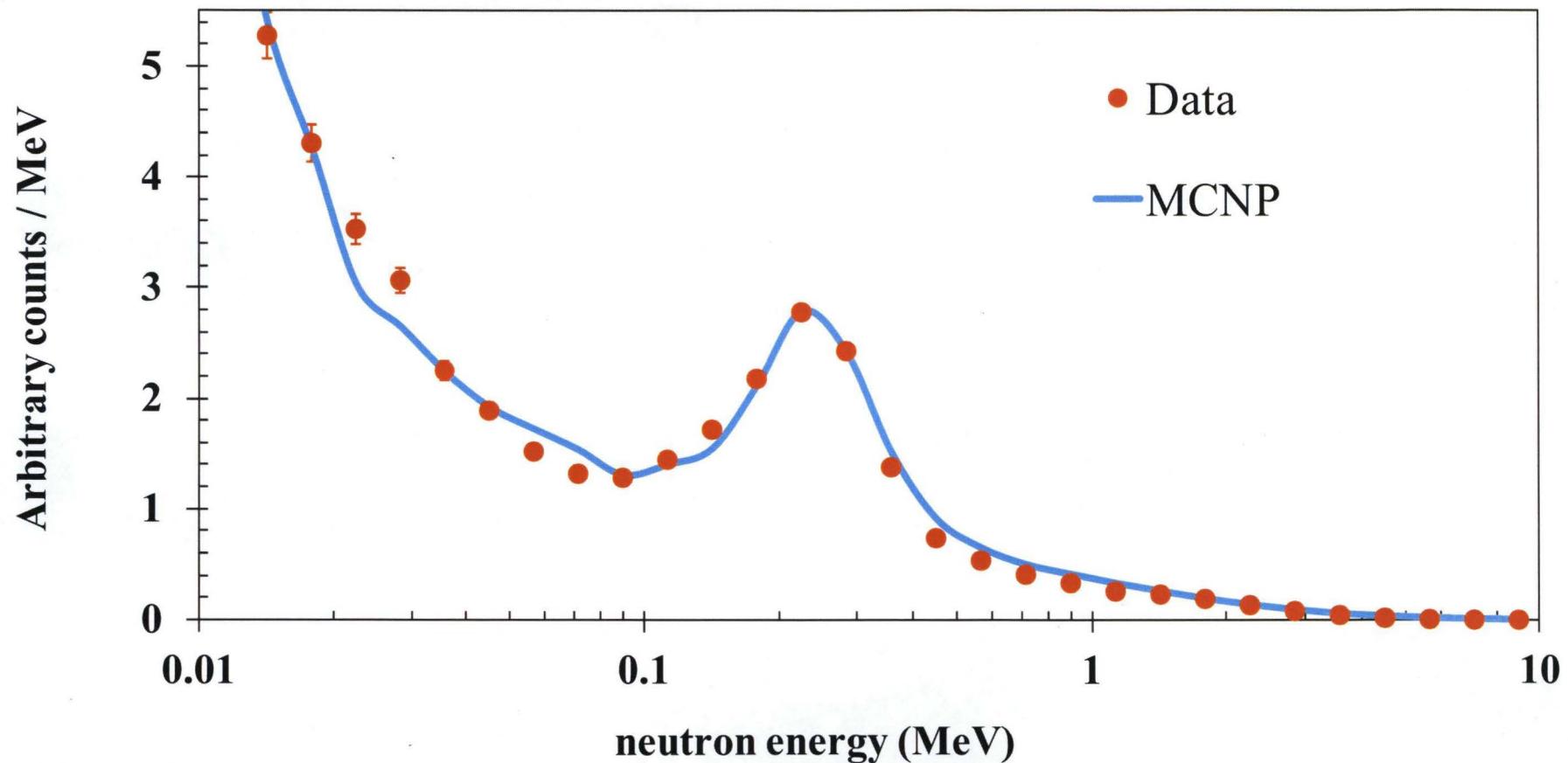
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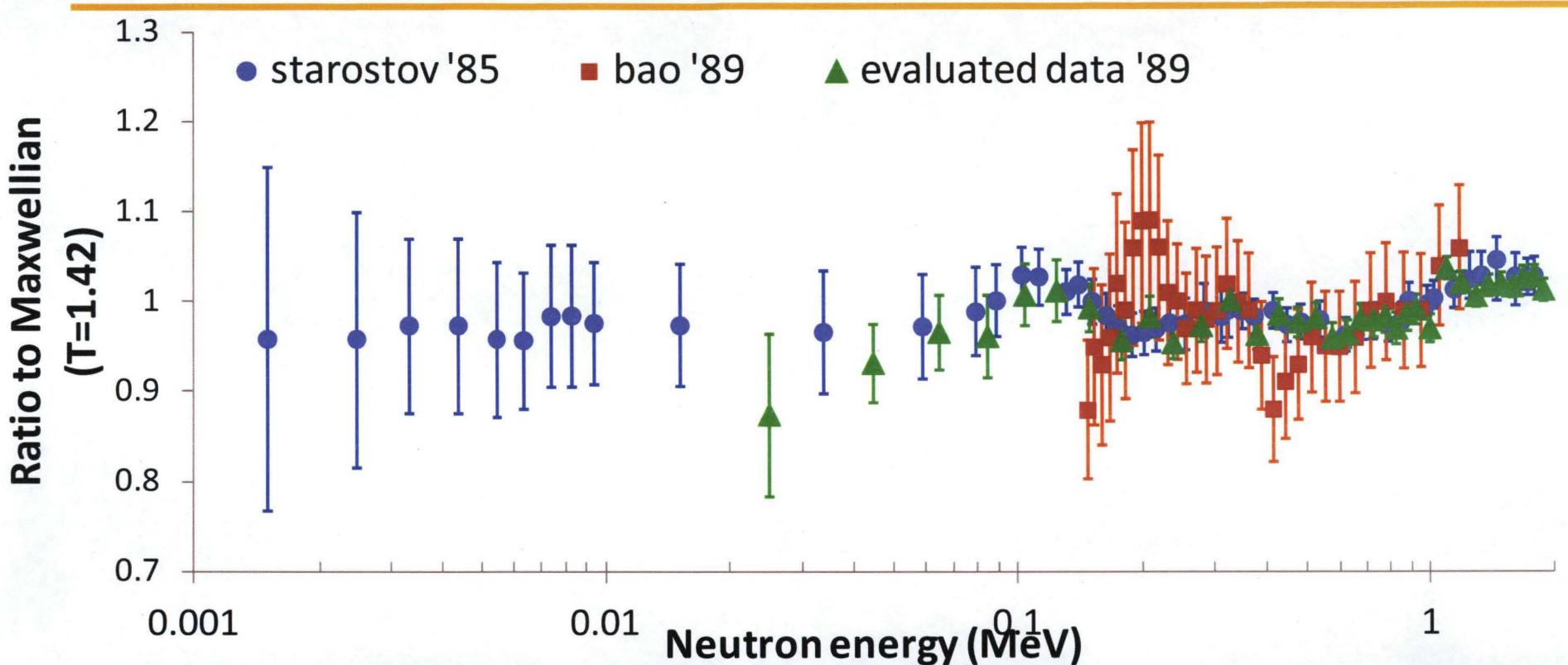
Complete geometry for ${}^6\text{Li}$ -glass detector and PMT



Experimental yield compared with MCNP yield

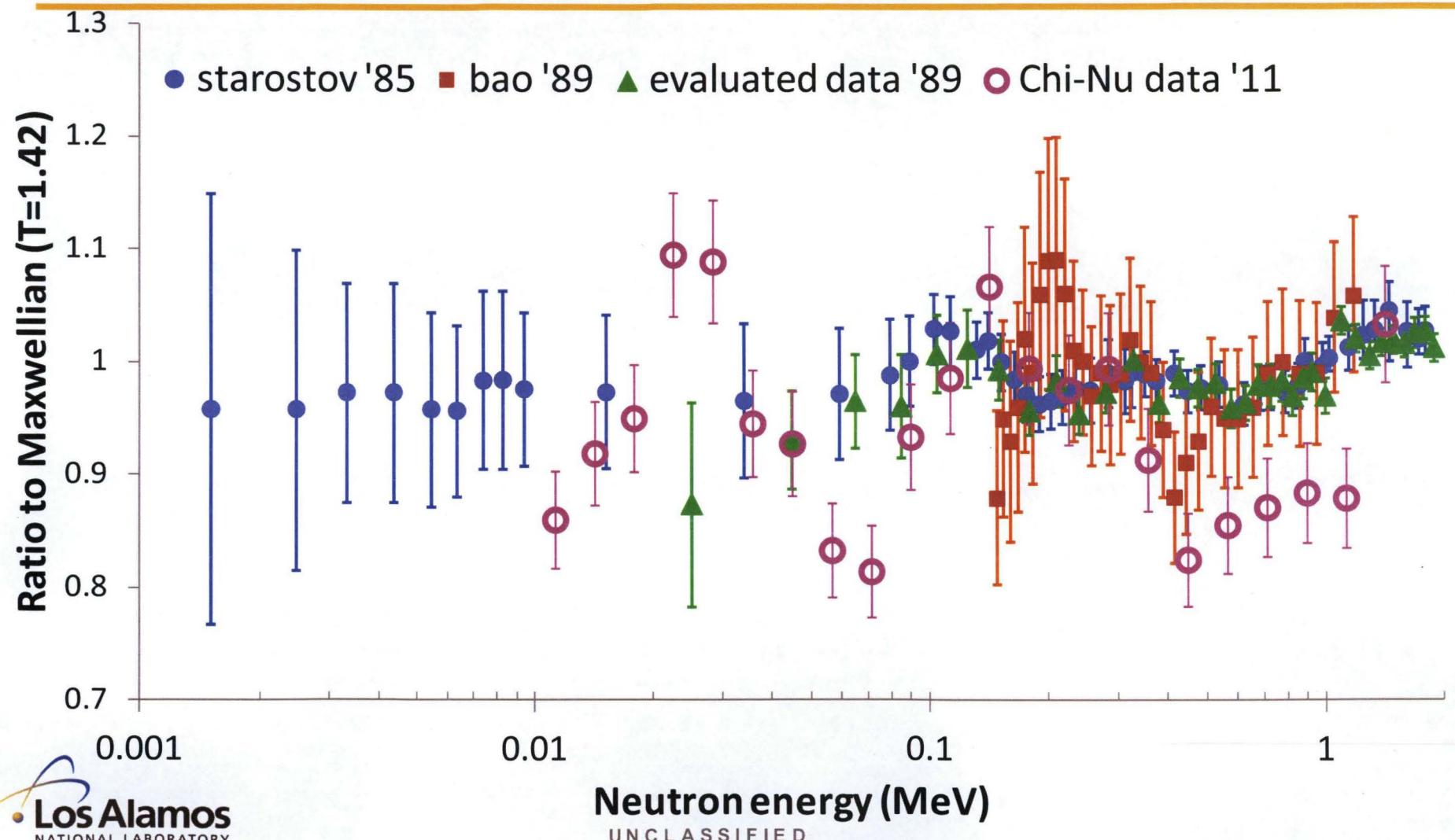


Compilation of Prompt Fission Neutron Spectrum on ^{252}Cf (Presentation by Mannhart at IAEA Consultants' Meeting 2008)

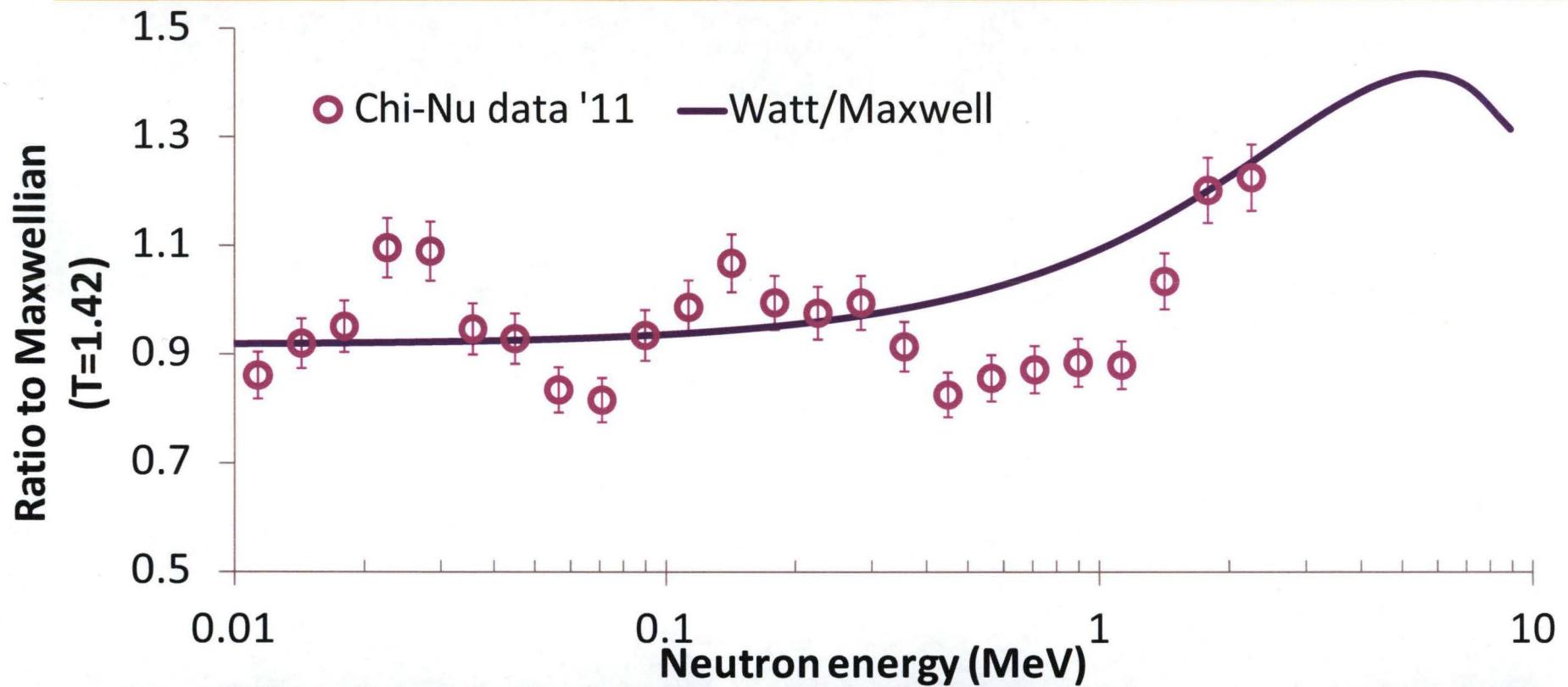


- Evaluation '89 : Lajtai (> 25 keV), Boldeman, Blinov (> 40 keV), Poenitz
- Starostov data were excluded due to failing the criteria, i.e. TOF data, detailed documentation, proper corrections for random coincidence events and non-isotropic fissions detection.
- No recent experiment has been performed after 1990.

Comparison of FIGARO data with the compilation



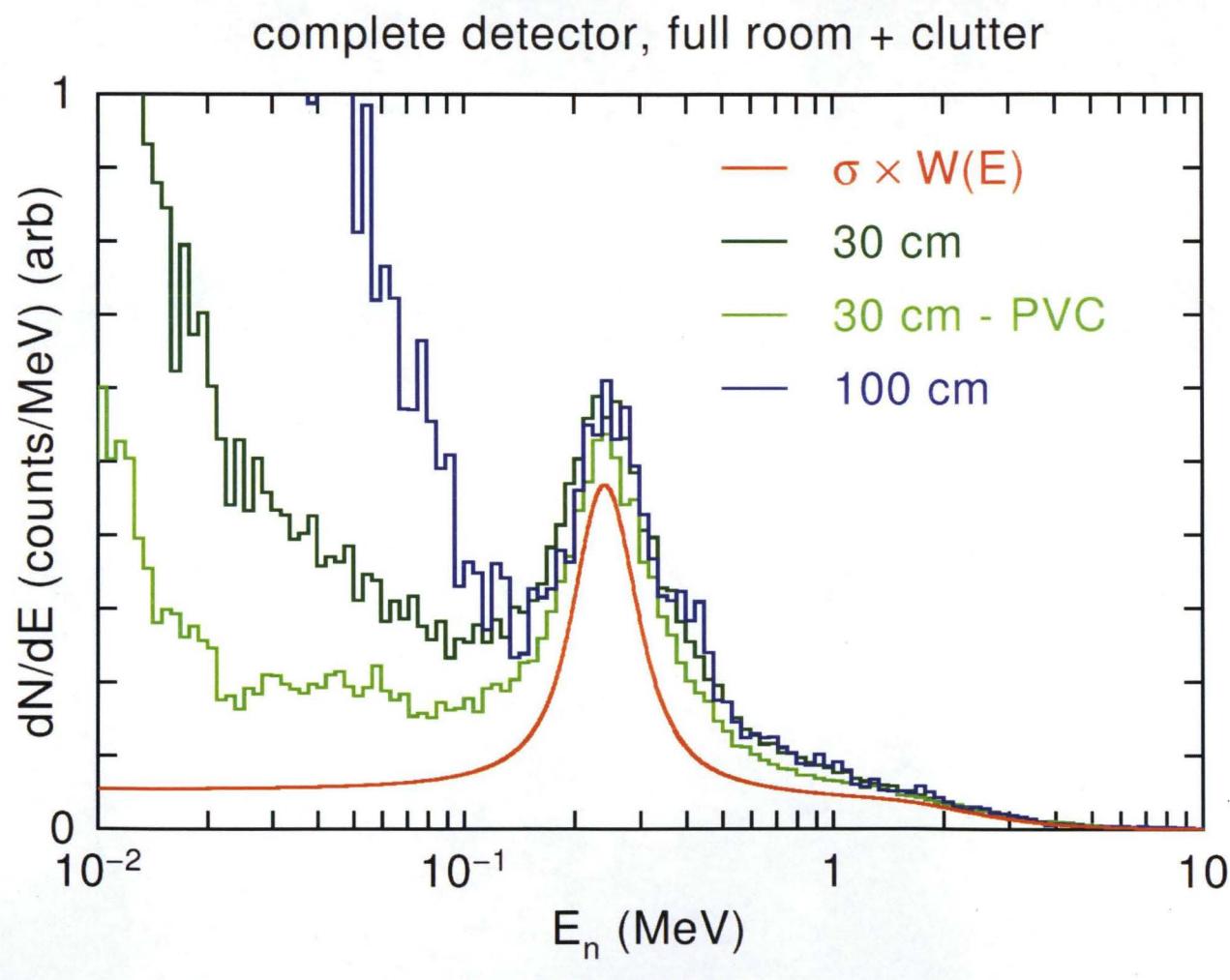
Data vs. Analytical ratios to Maxwellian



$E < 100$ keV : missing room geometry in estimating the down-scattered neutrons

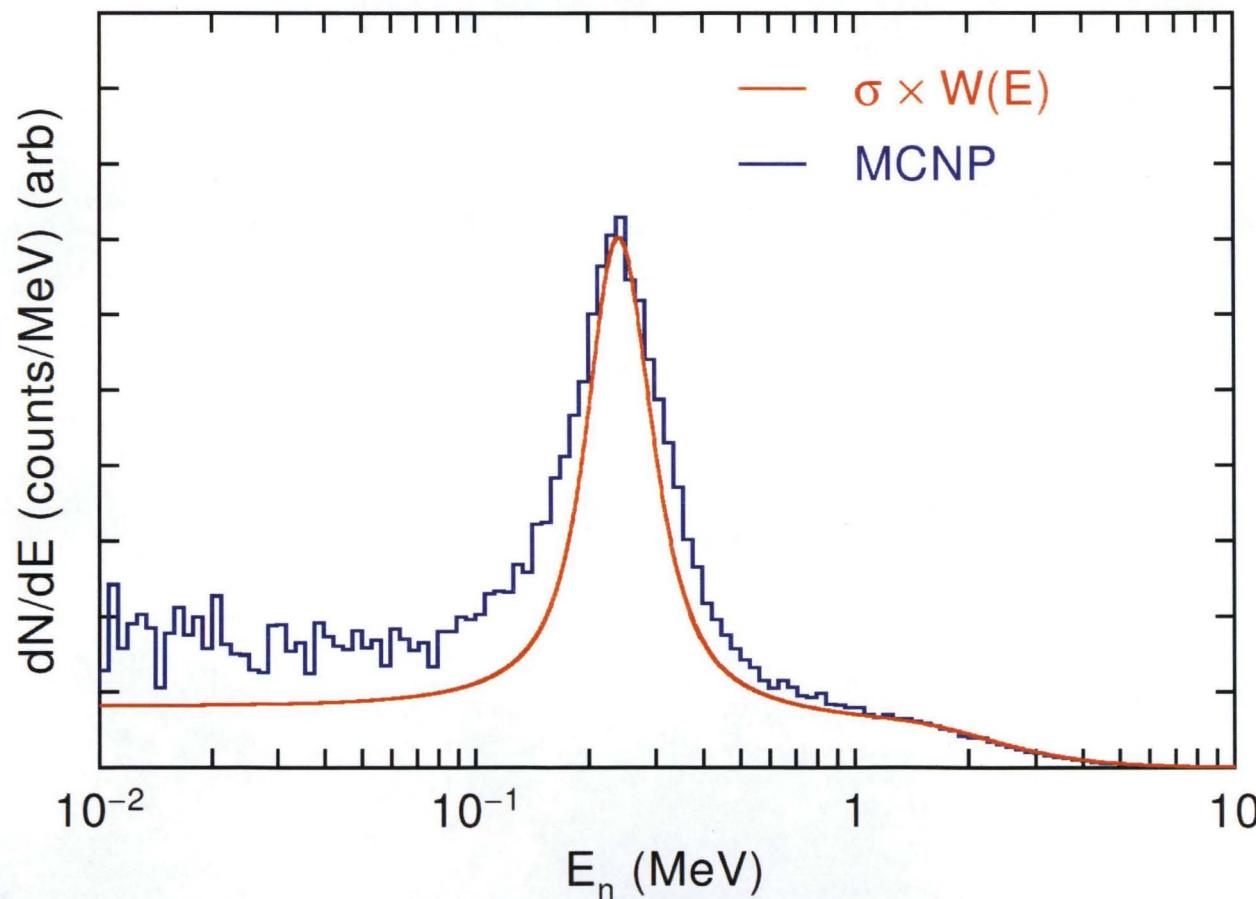
$E > 500$ keV : Further investigation in consistency of data and Physics in MCNP

Current ${}^6\text{Li}$ -glass detector response at the FIGARO room



New ${}^6\text{Li}$ -glass detector response

new detector design + PPAC @ 30 cm



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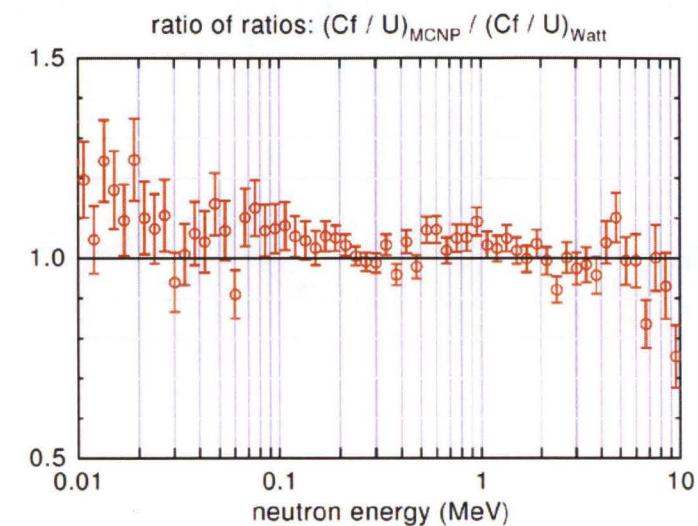
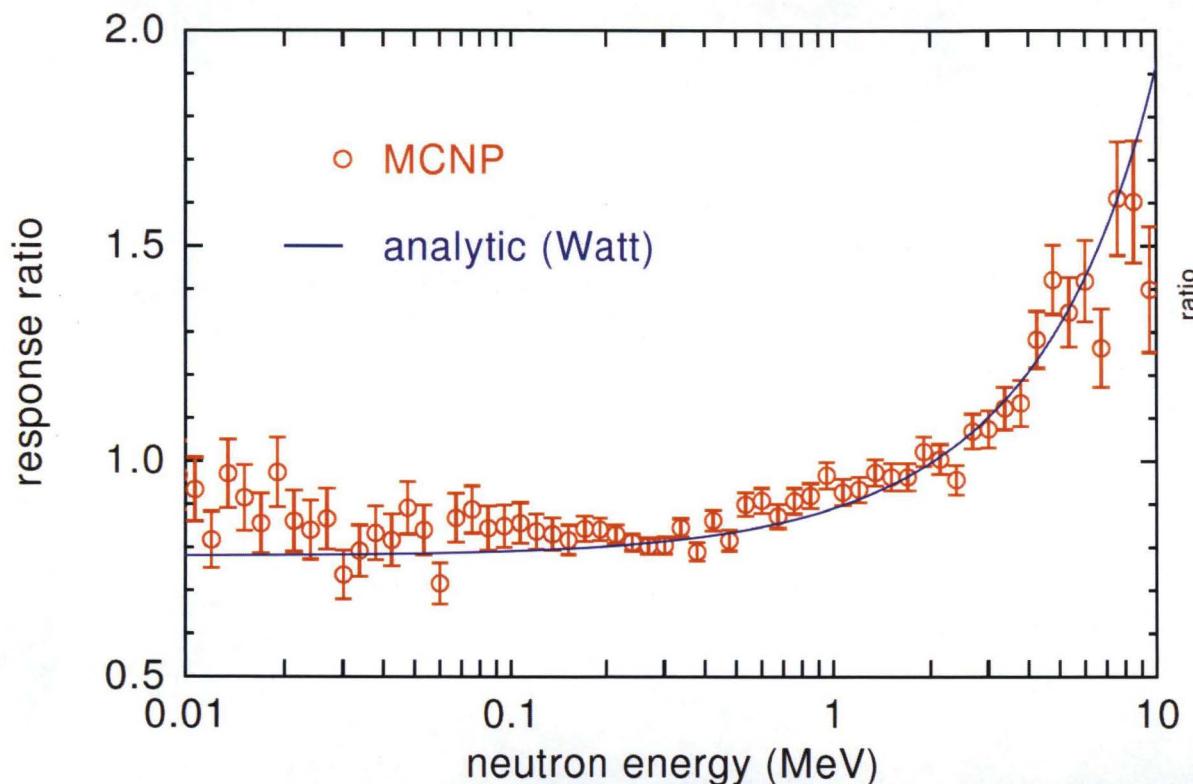
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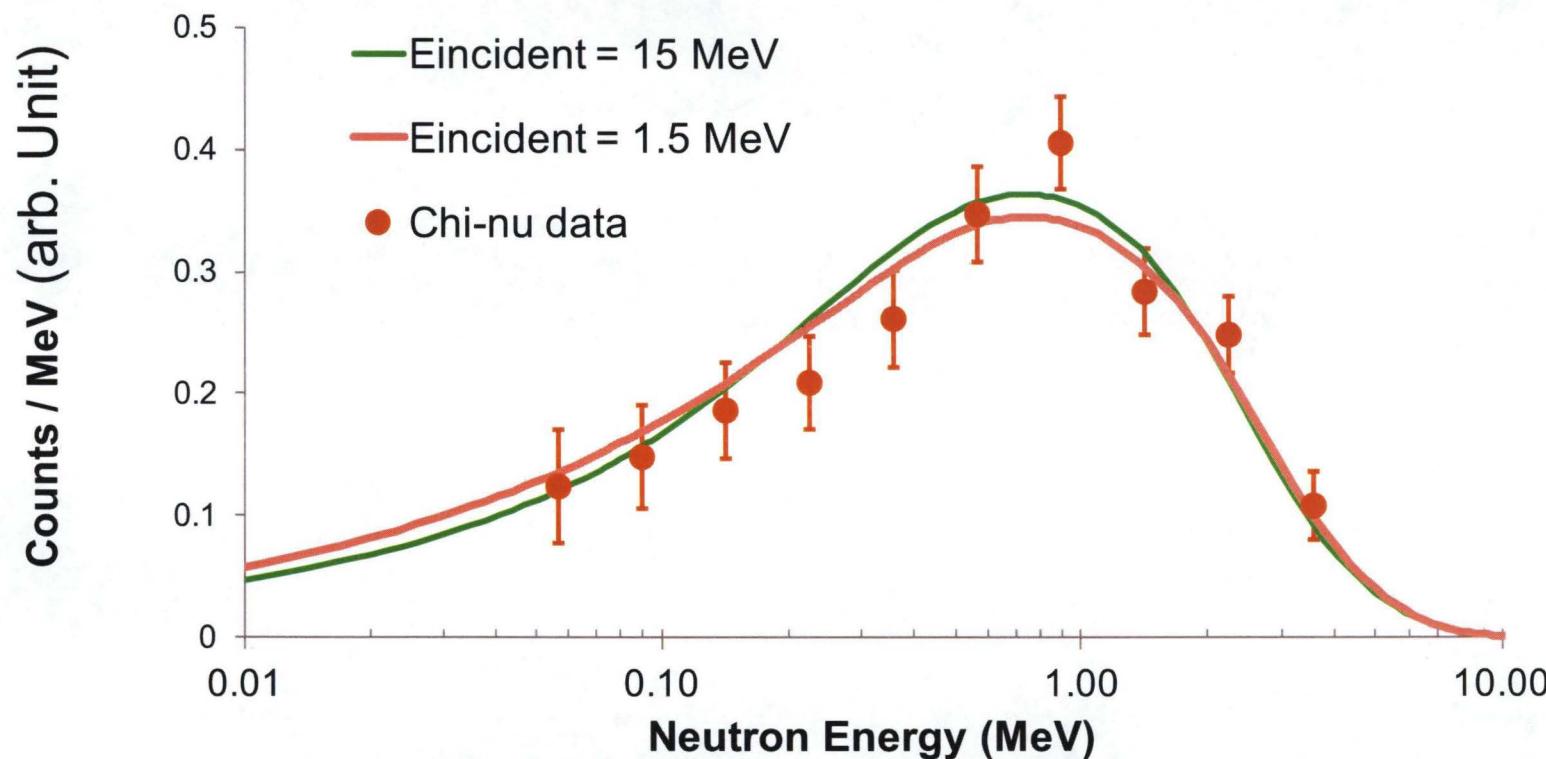
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${}^6\text{Li}$ -glass response ratio for ${}^{252}\text{Cf} / {}^{235}\text{U}$



The sensitivity study of ${}^6\text{Li}$ -glass detector regarding different fission yields shows about 10 % different from the analytical Watt distributions at neutron energy of 10-20 keV.

Preliminary Neutron output distributions of $^{235}\text{U}(\text{n},\text{f})$ data compared with the LA model (Madland and Nix, 1982)



The Chi-nu data are taken for all incident energies at the previous FIGARO setup, due to limited statistics.

Summary and Outlook

- 1. Detector response calibration using a²⁵²Cf is compared with a complete MCNP calculation and they showed a good agreement**
- 2. Plan to take data with a ²⁵²Cf fission ionization chamber as an independent measurement,**
 - a. to estimate the systematic uncertainties**
 - b. to calibrate ⁶Li-glass detectors absolutely**
- 3. Further investigation on determining the detector response.**