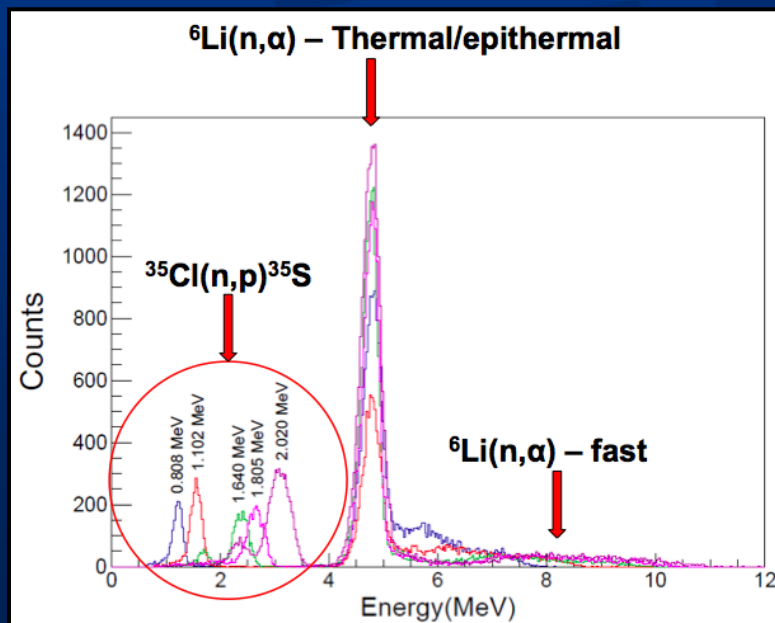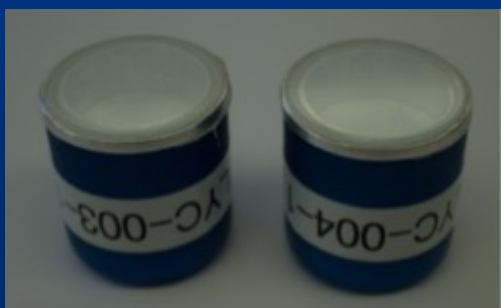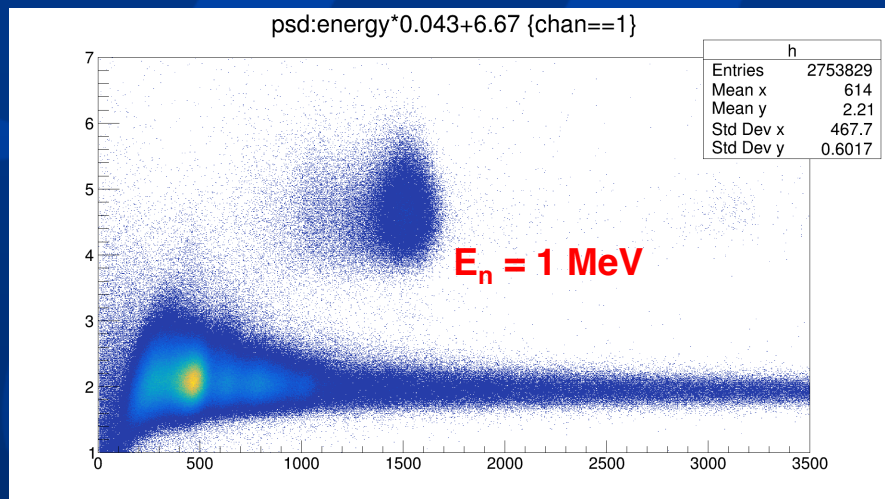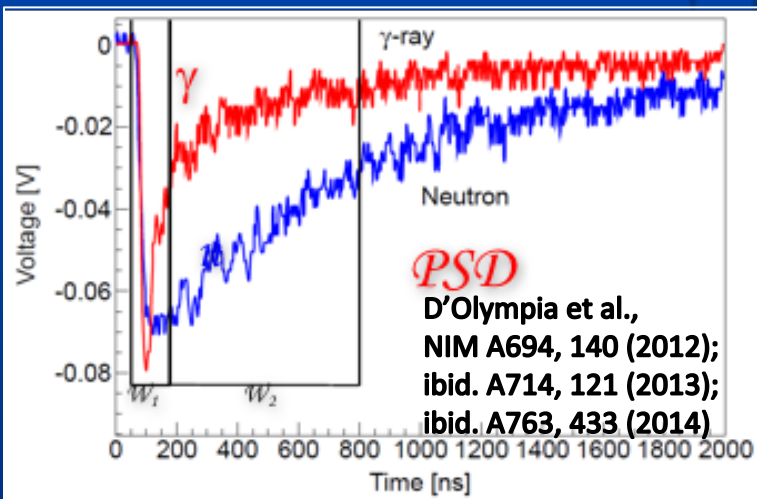# C^{7}LYC for Neutrons

Partha Chowdhury
University of Massachusetts Lowell

Work supported by U.S. Department of Energy

Overview

- Unique dual n-γ scintillator Cs_2LiYCl_6 (CLYC)

- n-γ discrimination and spectroscopic properties

- Fast neutron spectroscopy with ^{7}Li-enriched C^{7}LYC

- Benchmark science capabilities with C^{7}LYC array

- Larger crystal sizes and efficiency measurements

- Auxiliary scintillator for FRIB science?

# novel scintillator for fast neutron spectroscopy

C^{7}LYC for nuclear science

- Gamma response better than NaI
- Excellent n-γ pulse-shape discrimination
- ~10% neutron pulse height resolution
- No ToF needed, increased geometrical efficiency

- Explore fast neutron spectroscopy potential
- Eliminated ^{6}Li(n,α) peak via ^{7}Li-enriched C^{7}LYC
- Built a 16-element array of 1" x 1" C^{7}LYC
        (largest crystals available at the time)

- Elastic/inelastic neutron scattering at Los Alamos
- Beta-delayed neutron spectroscopy at CARIBU
- Efficiency and low energy measurements at UML
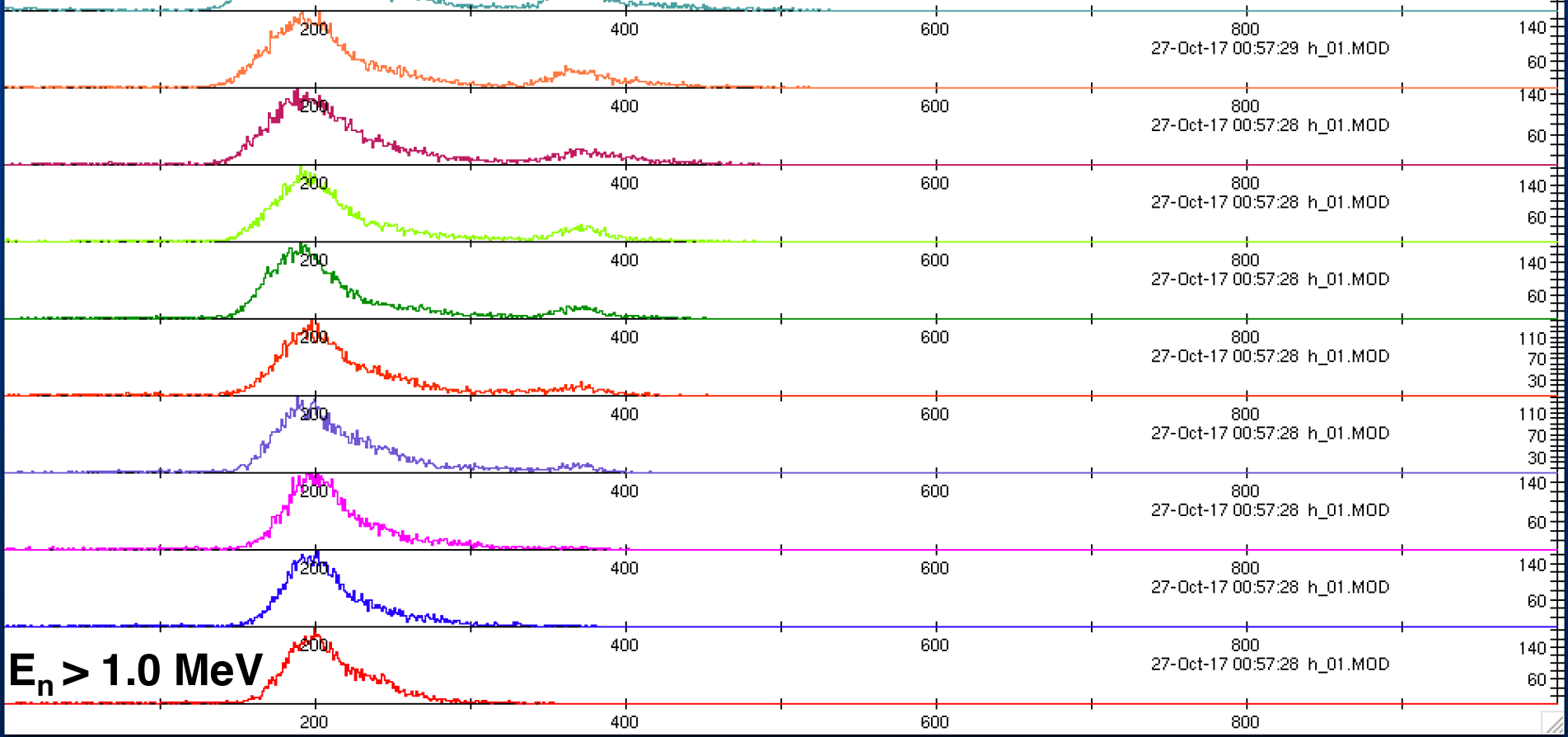
^{56}Fe(n,n') at LANSCE
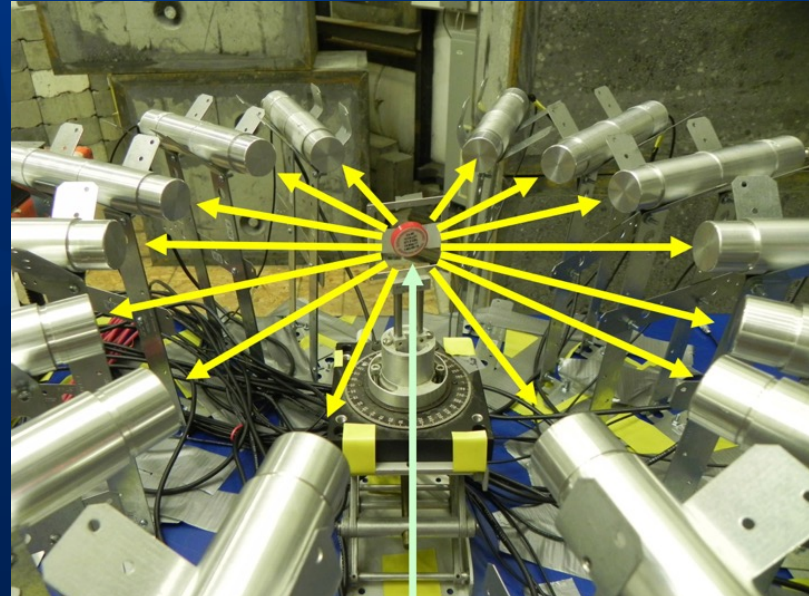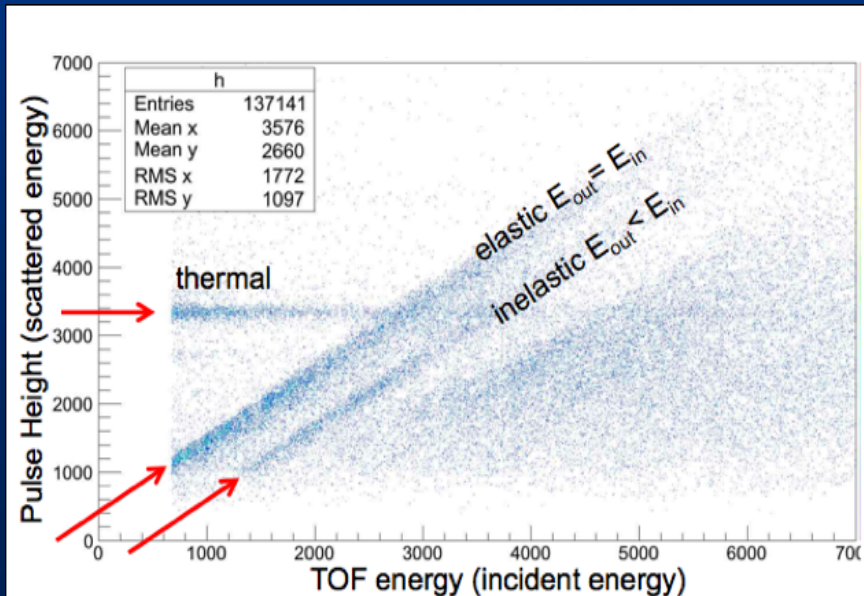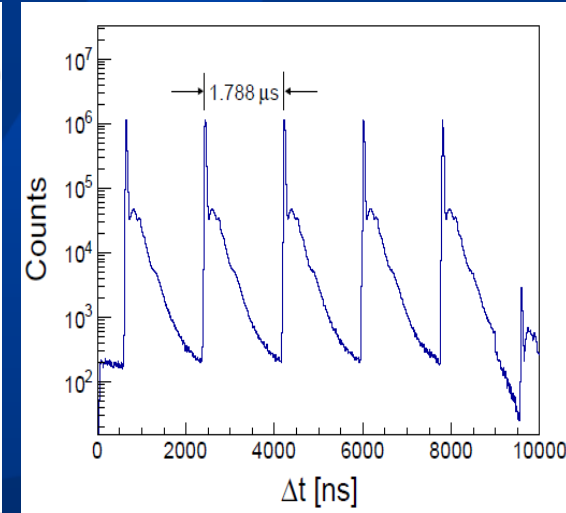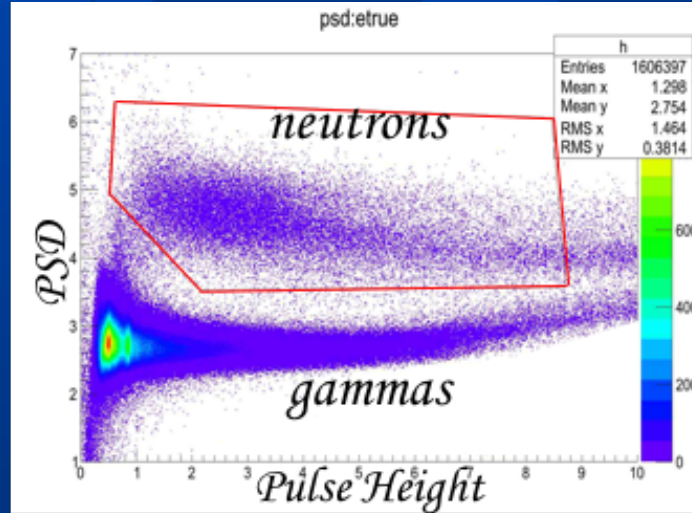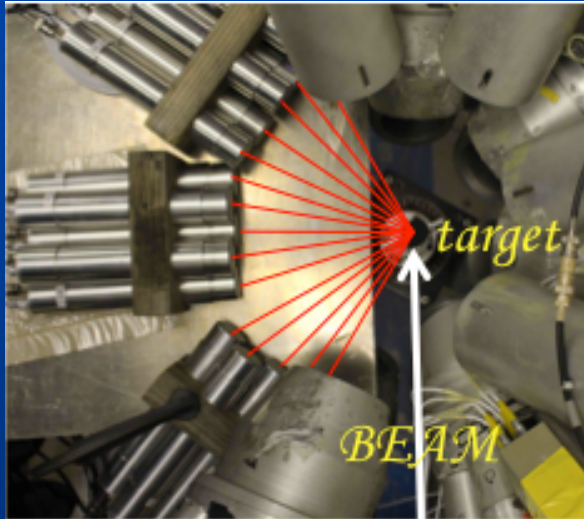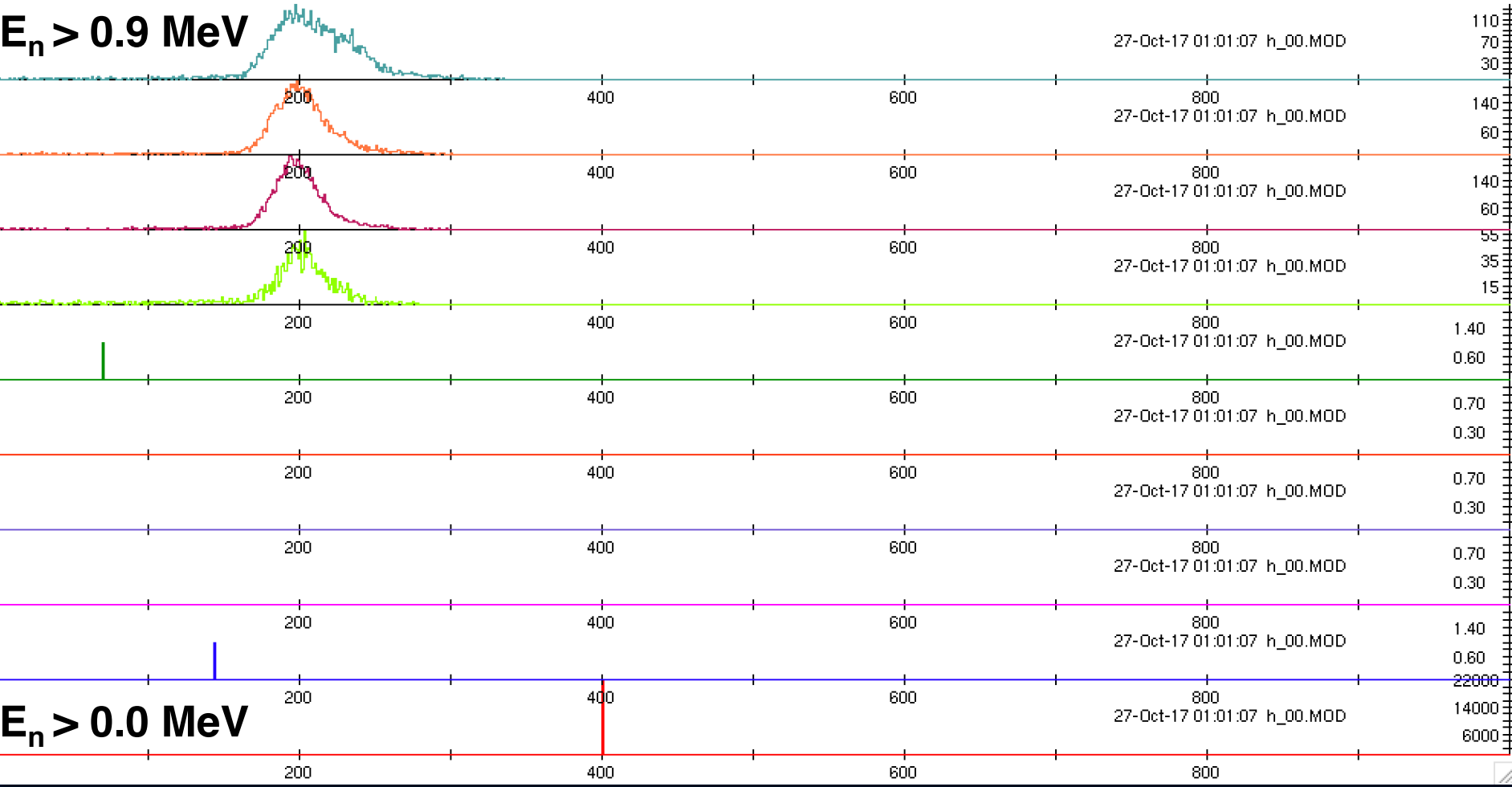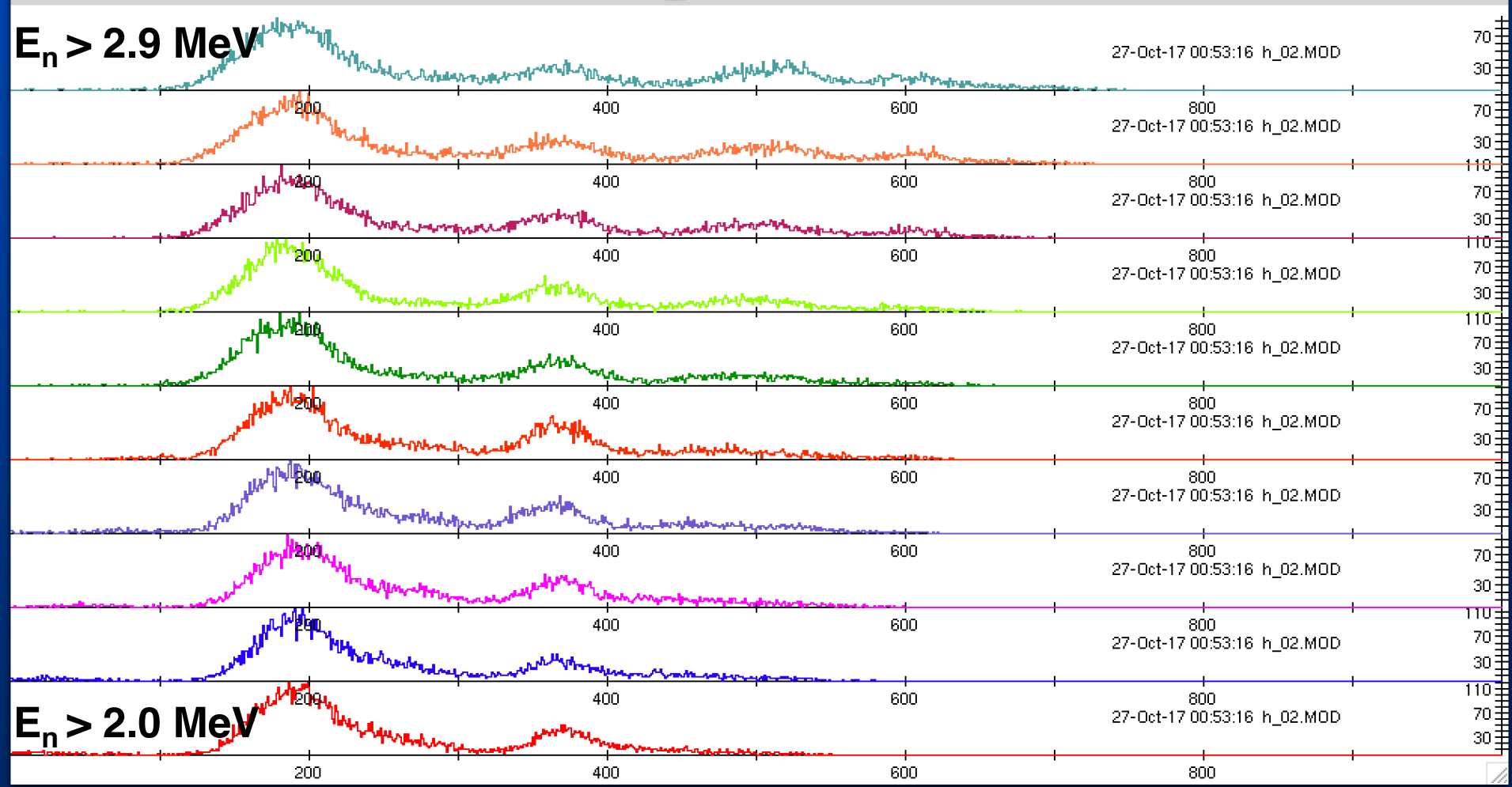
100 keV slices on incident neutron energy
$^{56}Fe(n,n')$ at LANSCE

100 keV slices on incident neutron energy
$^{56}Fe(n,n')$ at LANSCE
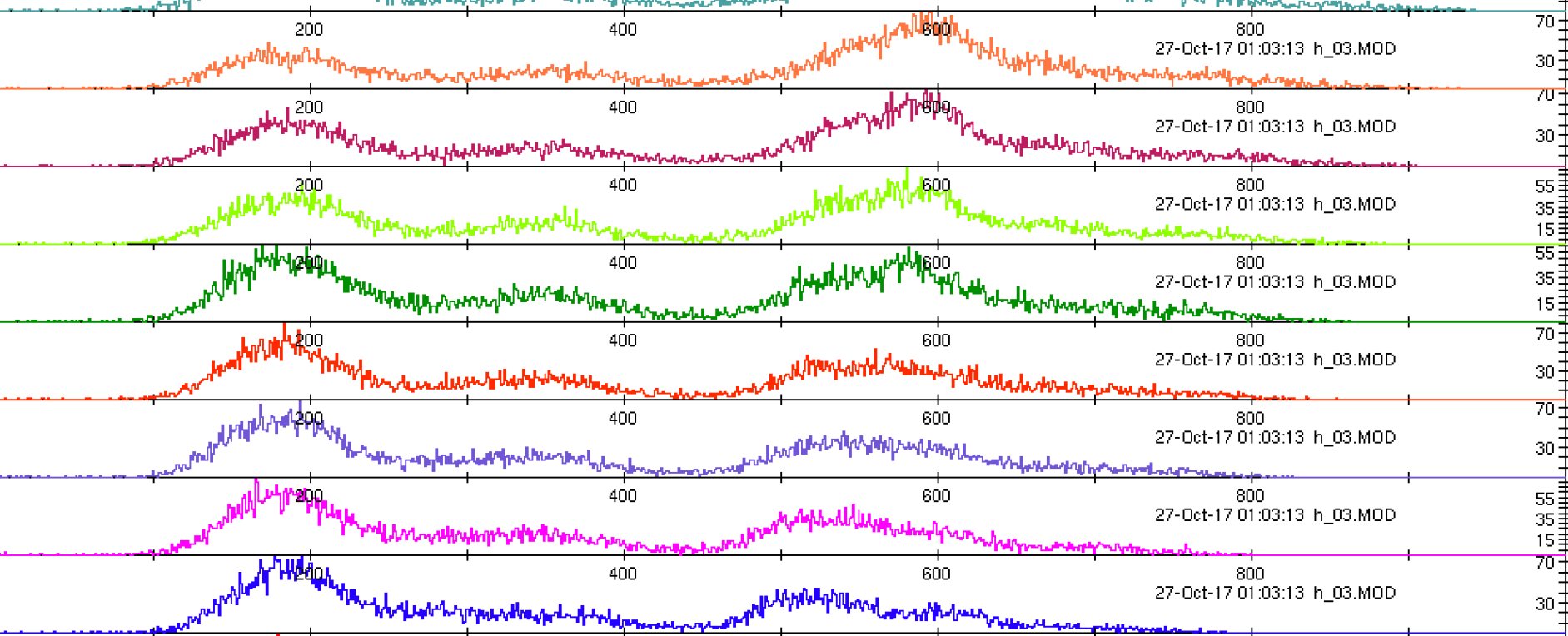
100 keV slices on incident neutron energy
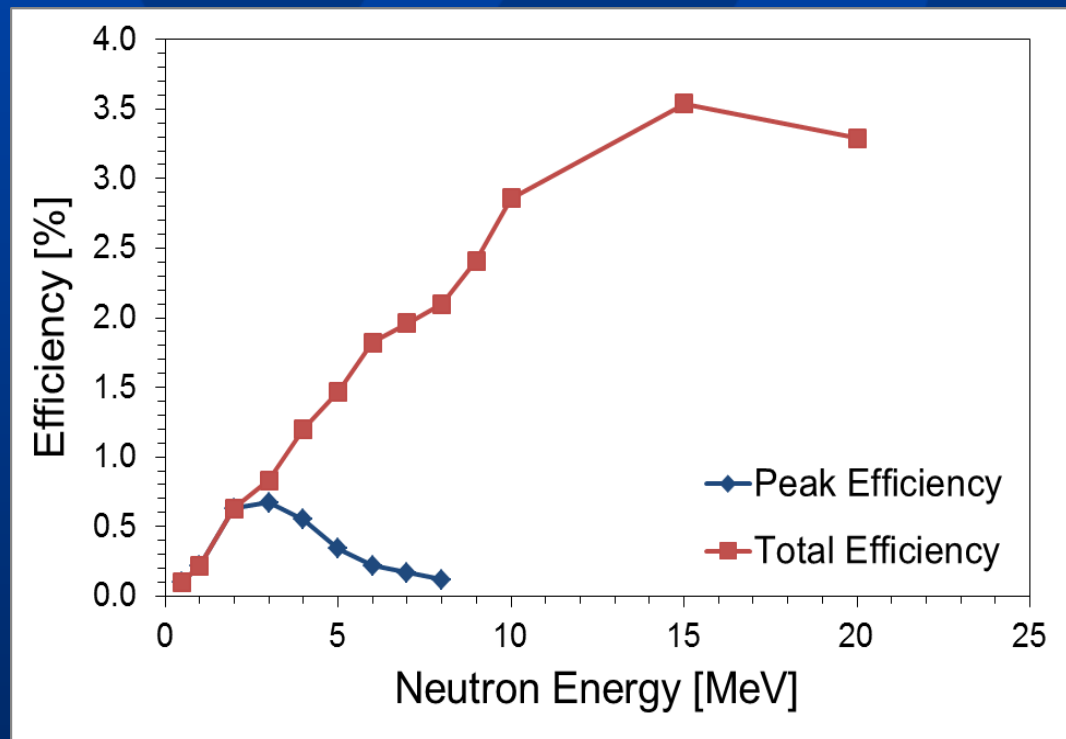## $^{56}Fe(n,n')$ at LANSCE
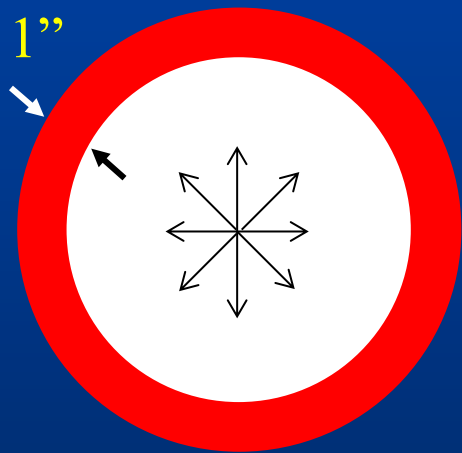
100 keV slices on incident neutron energy
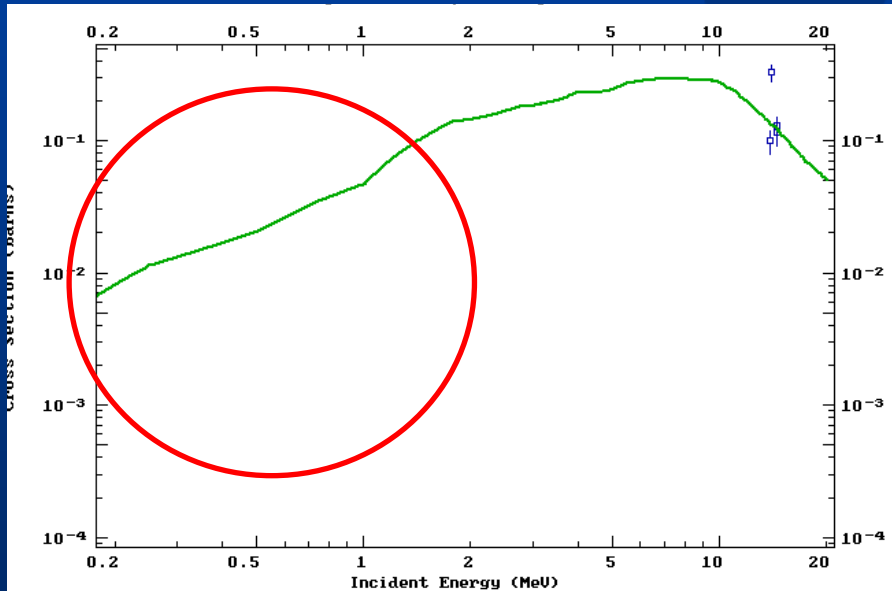$^{56}Fe(n,n')$ at LANSCE

MCNPX efficiency "estimates"

Large uncertainty in Monte Carlo simulations
^{35}Cl(n,p) cross-section measurements lacking

^{35}Cl(n,p) cross-sections

ENDF/B-VII.0 (2006)

ENDF/B-VII.1 (2011)
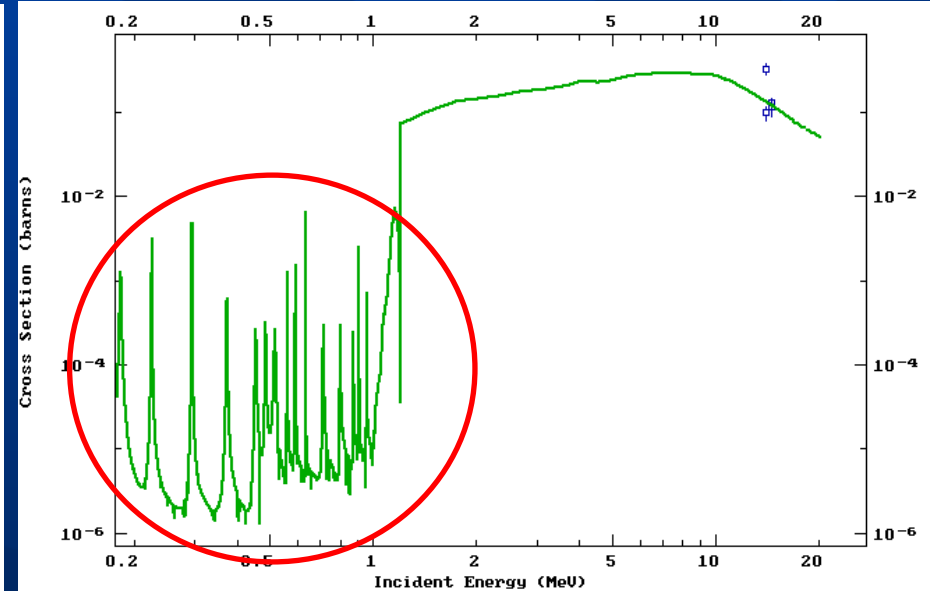
LANL-led experiment (Jan 2018) to measure ^{35}Cl(n,p) cross-sections

relative cross-section estimates

Ramirez et al, PRC 95,064605 (2017)

relative cross-sections (expt 1)
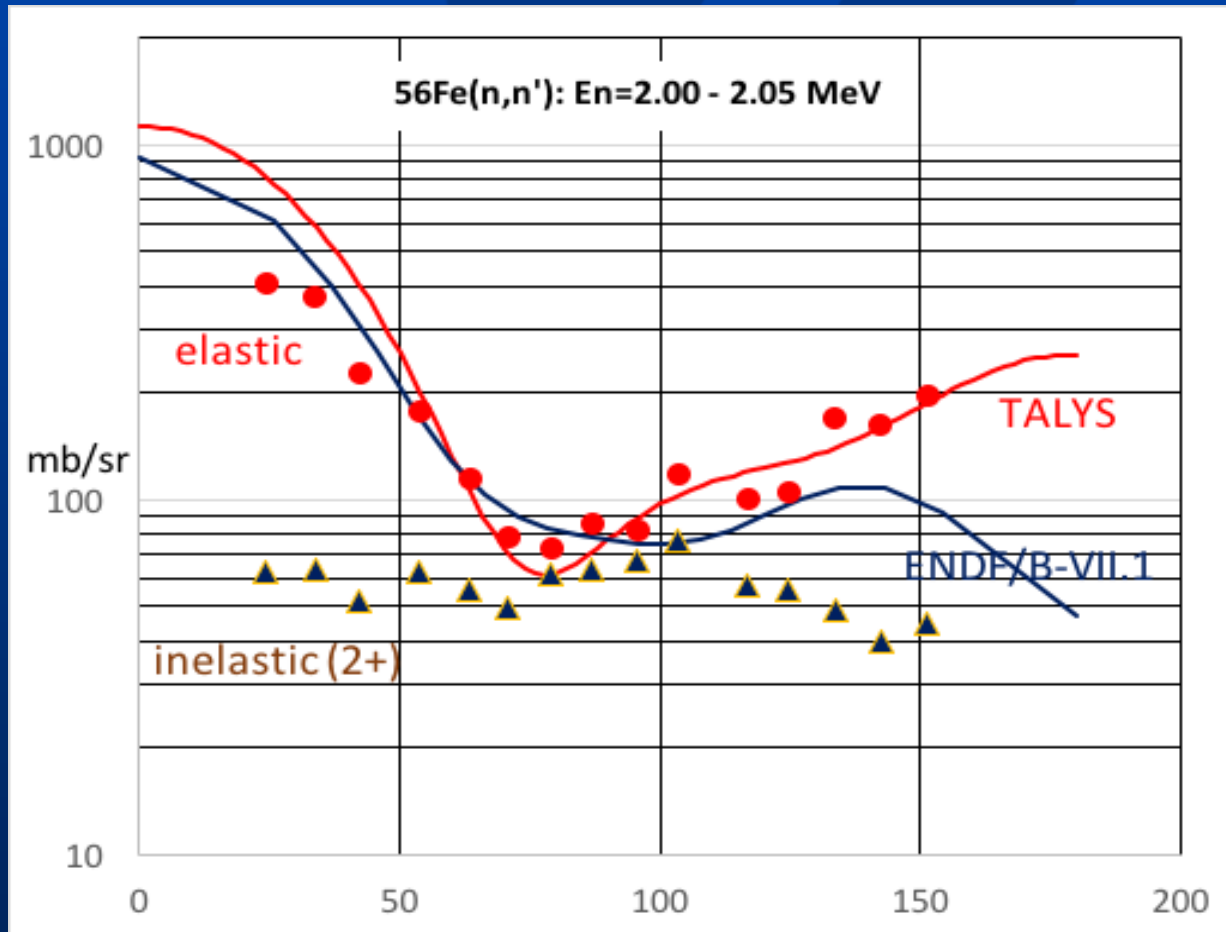
present data (50-keV slice with arbitrary normalization) compared with simulations/database for elastic angular distribution cross-sections)

relative cross-sections (expt 2)
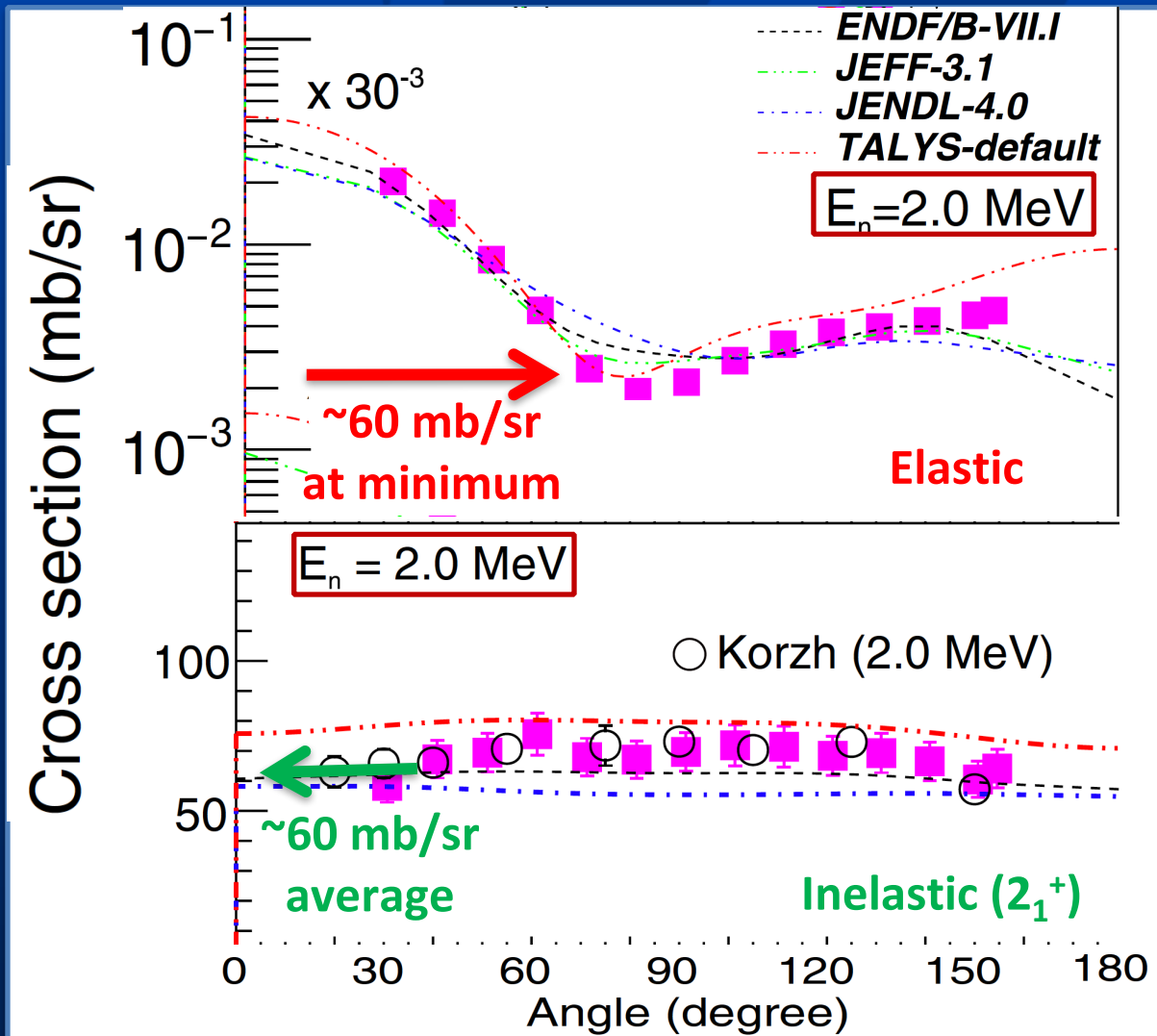

present data (50-keV slice with arbitrary normalization) compared with simulations/database for elastic angular distribution cross-sections)

β-delayed neutron trials at CARIBU

$^{94}Rb_{56}$

$P_n = 10.2(2)\%$

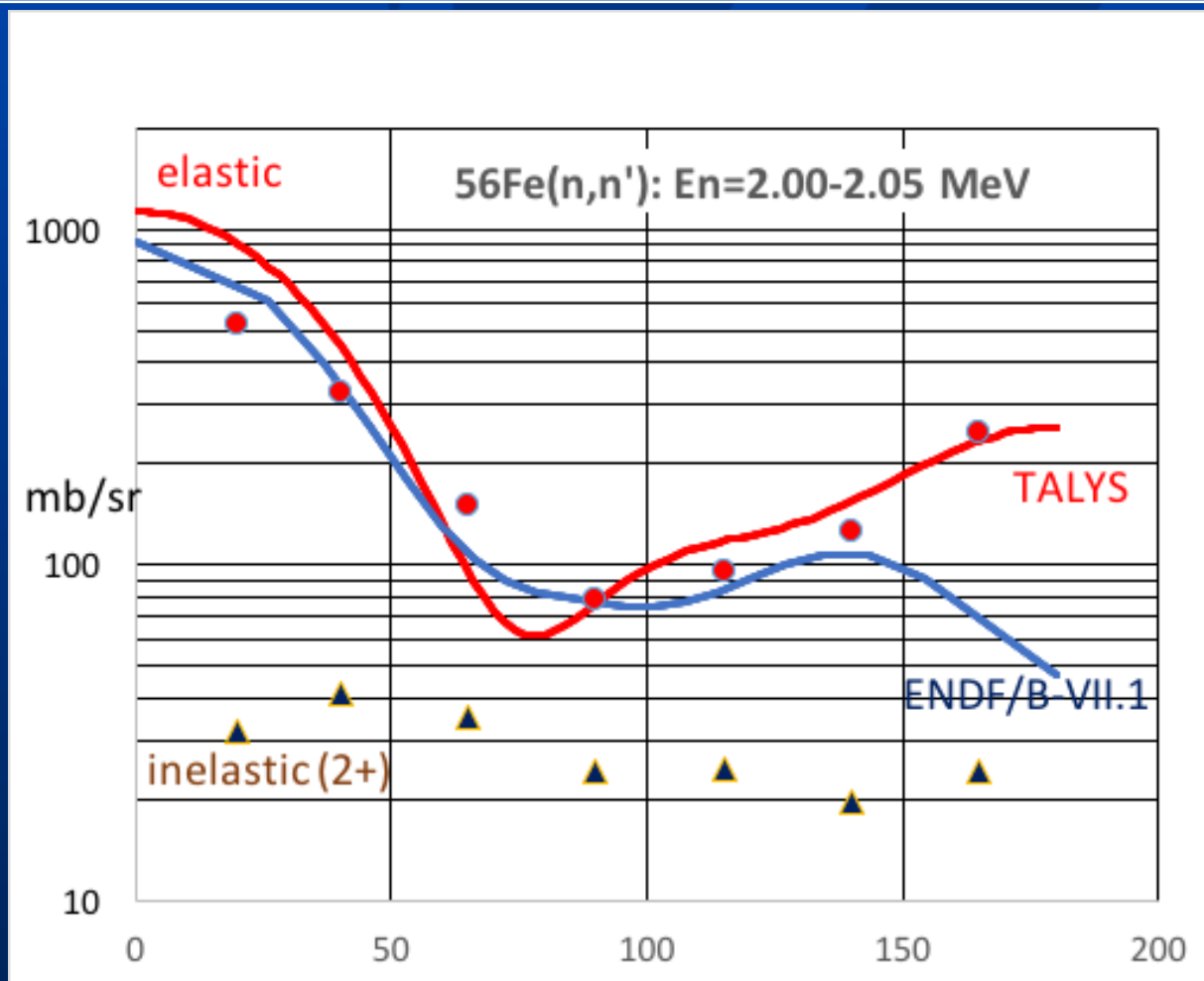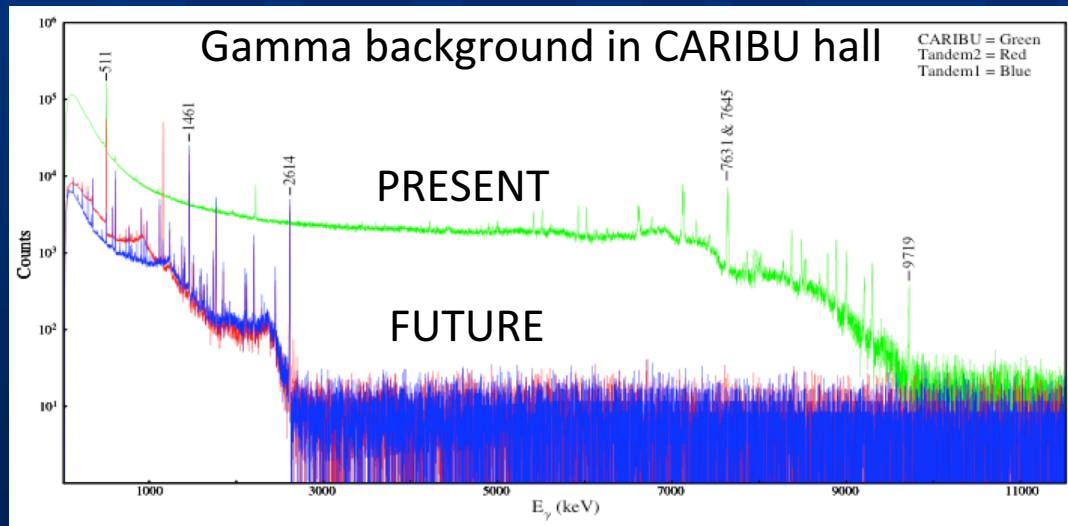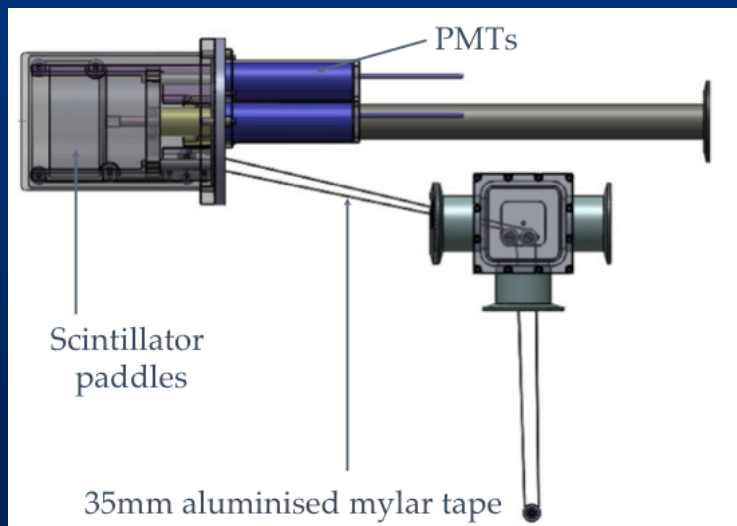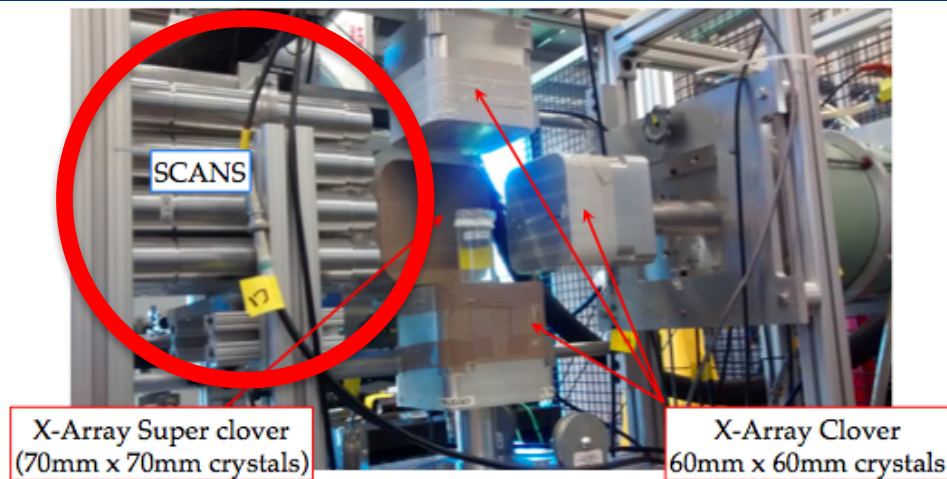$E_n(\text{min}) = 0.0$ MeV
$E_n(\text{max}) = 3.2$ MeV

$S_n = 6.83$ MeV

$Q = 10.28$ MeV

γ ↓ 837 keV

$^{93}Sr_{55}$

$^{94}Sr_{56}$

SCANS

X-Array Super clover (70mm x 70mm crystals)

X-Array Clover 60mm x 60mm crystals

PMTs

Scintillator paddles

35mm aluminised mylar tape

Gamma background in CARIBU hall

CARIBU = Green
Tandem2 = Red
Tandem1 = Blue

PRESENT

FUTURE
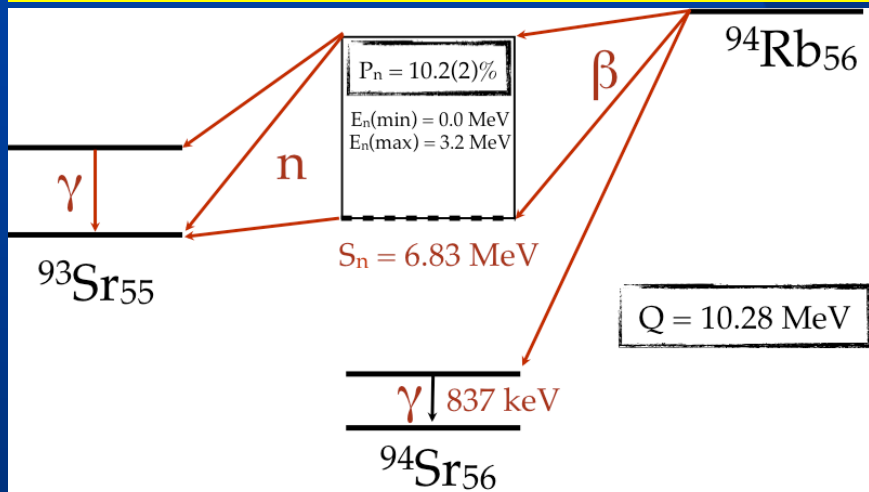
(CLYC results inconclusive, to be repeated in new low-background CARIBU hall)

the first 3" x 3" C⁷LYC

Active volume
Array X 1.7

the first 3" x 3" C⁷LYC

C⁷LYC Efficiency 98% of NaI

C⁷LYC FWHM 5.8%
NaI FWHM 7.8%

03-Aug-17 01:11:13 spe1

¹³⁷Cs
661 keV

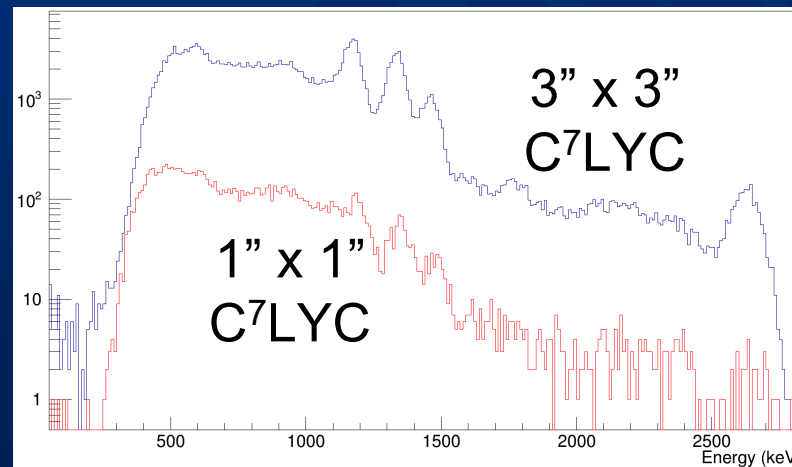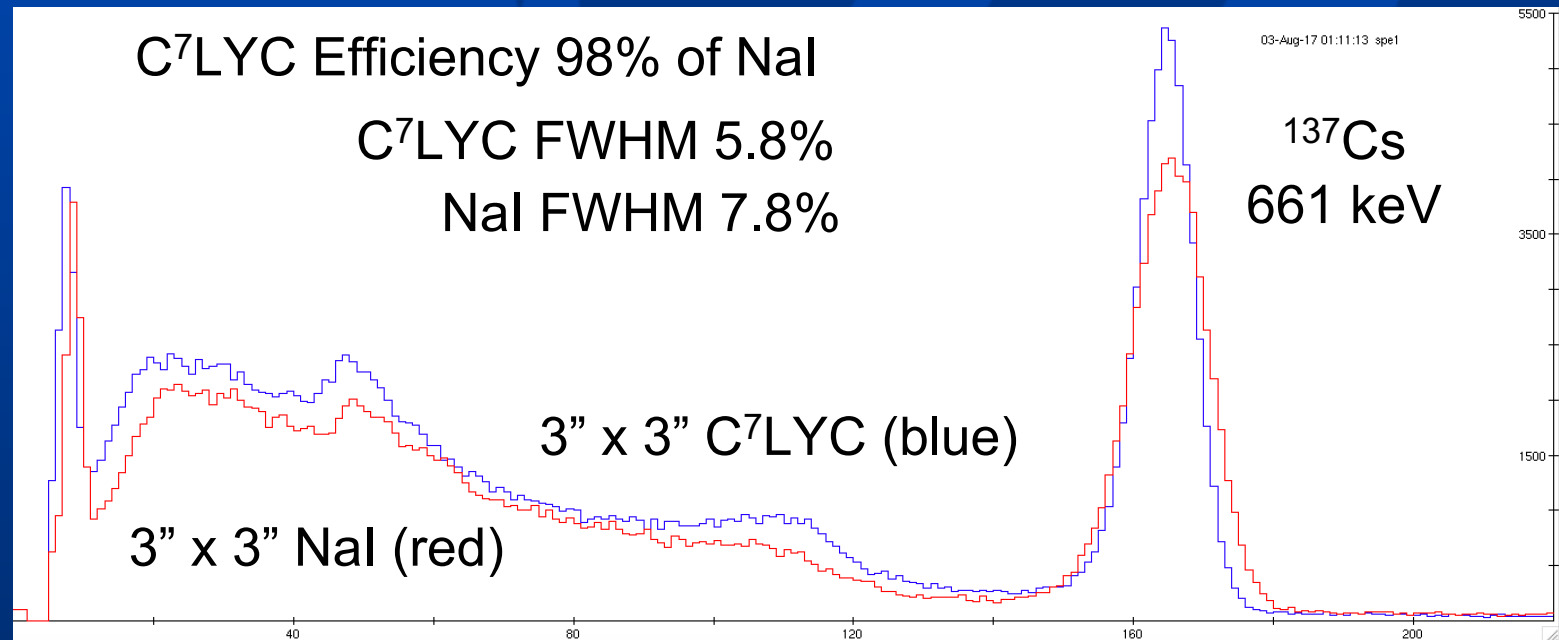3" x 3" C⁷LYC (blue)

3" x 3" NaI (red)

3" x 3"
C⁷LYC
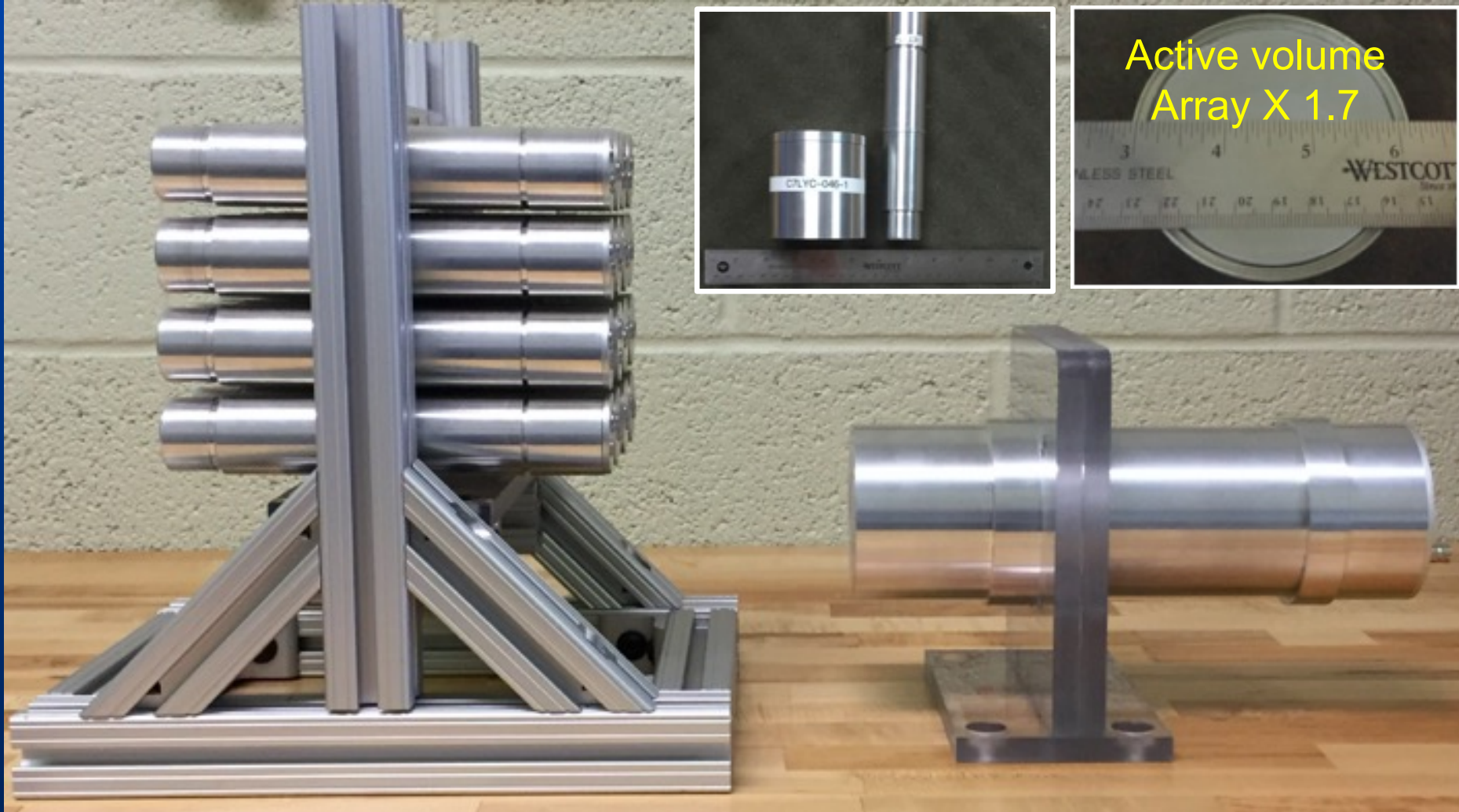
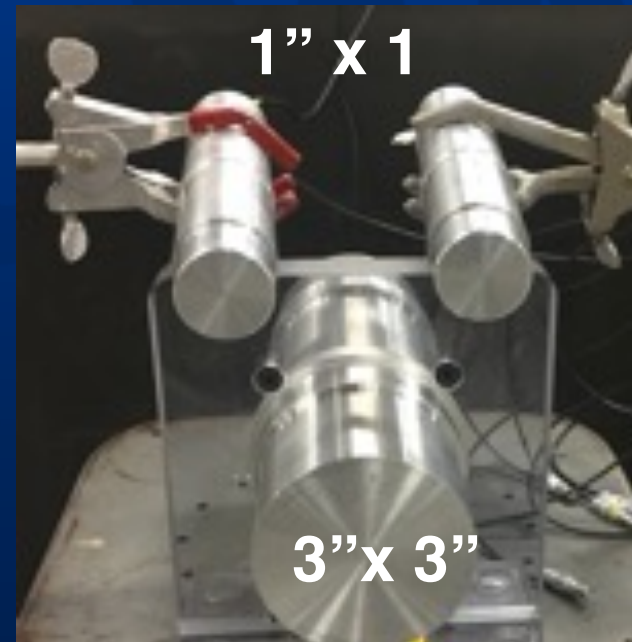1" x 1"
C⁷LYC

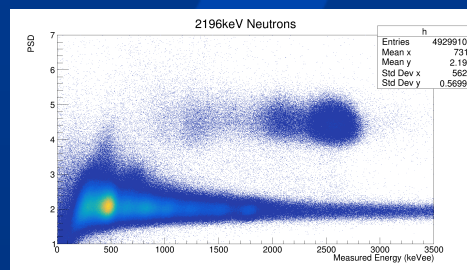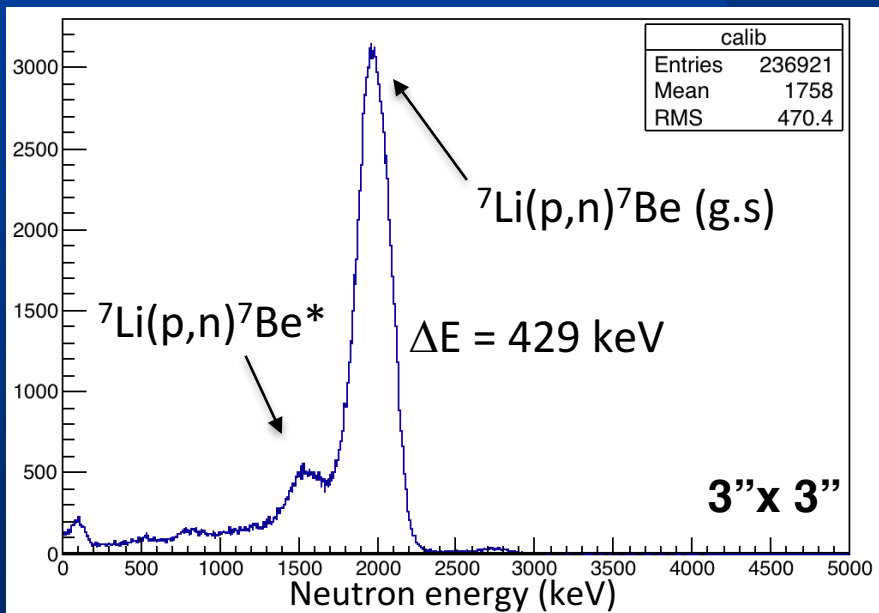# C⁷LYC tests at UMass Lowell

- Directly measure C⁷LYC efficiency at accelerator
- Mono-energetic neutrons via $^7\text{Li}(p,n)^7\text{Be}$
- Neutron production rate via ^7Be assay (52-day half-life)
- One ^7Be per neutron, 10% β-decay branch, 479-keV γ-ray

In-situ lithium target evaporator

1" x 1

3"x 3"

C⁷LYC tests at UML

E_n = 2 MeV

Neutron gated spectrum

calib	
Entries	236921
Mean	1758
RMS	470.4

$^7Li(p,n)^7Be$ (g.s)

$^7Li(p,n)^7Be^*$

$\Delta E = 429$ keV

3"x 3"

Neutron energy (keV)
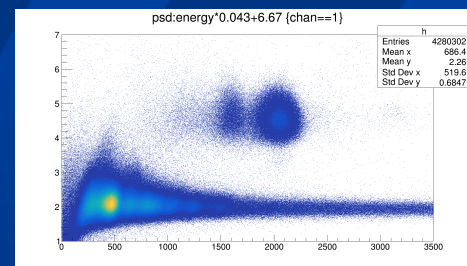
E_n = 1.5 MeV
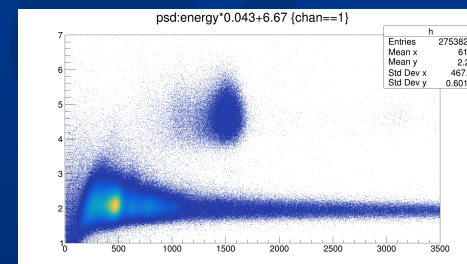
E_n = 1 MeV

E_n = 0.5 MeV

E_n = 0.25 MeV

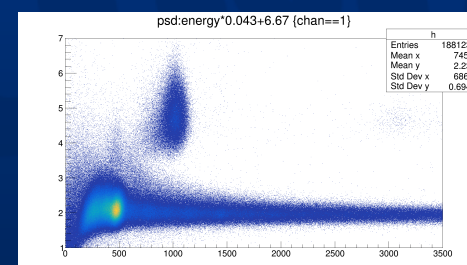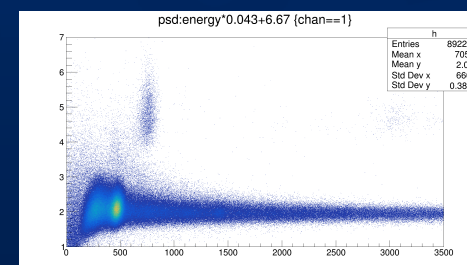# status and outlook

- Benchmark C^{7}LYC for fast neutron spectroscopy
- LANL (n,n') experiments very promising
- Measure efficiency and low energy response at UML
- Explore (d,n) spectroscopy at UML
- Explore PSD + TOF for low energy neutrons
- ^{35}Cl(n,p) cross-section measurements (LANL lead)
- Detailed simulations with measured cross-sections
- Beta-delayed neutron experiments at new CARIBU hall
- Optimize n-gamma coincidence capabilities with array
- Test as auxiliary detector with large gamma arrays

UMASS LOWELL

Collaborators

UMass Lowell

Tristan Brown, Emery Doucet, Kim Lister, Gemma Wilson,
Chris Morse, Andrew Rogers, Nathan D'Olympia,
Alan Mitchell, Emily Jackson

Los Alamos

Matt Devlin, Jaime Gomez, Shea Mosby, Ron Nelson

THANK YOU!