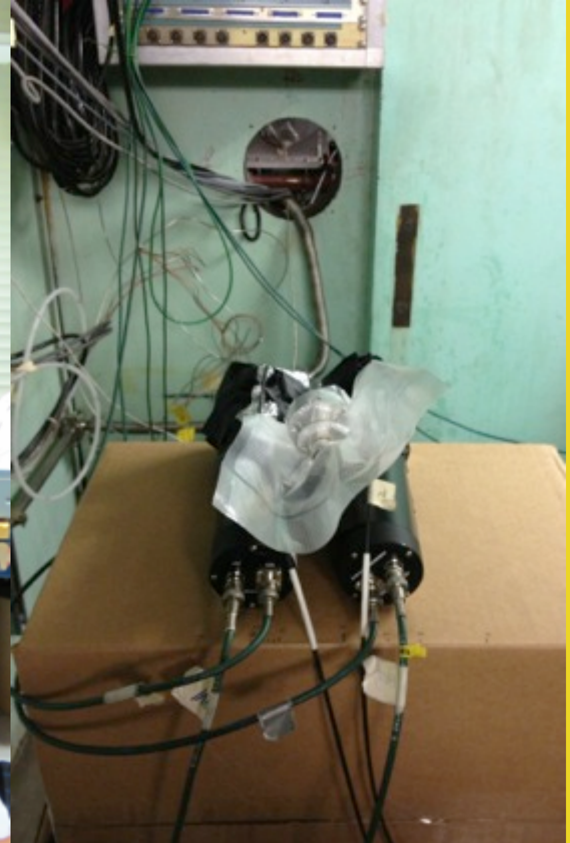


CHARACTERIZATION OF STILBENE-DOPED BIBENZYL SINGLE-CRYSTAL ORGANIC SCINTILLATOR FOR NTOF DIAGNOSTICS AT NIF

B.L. Goldblum

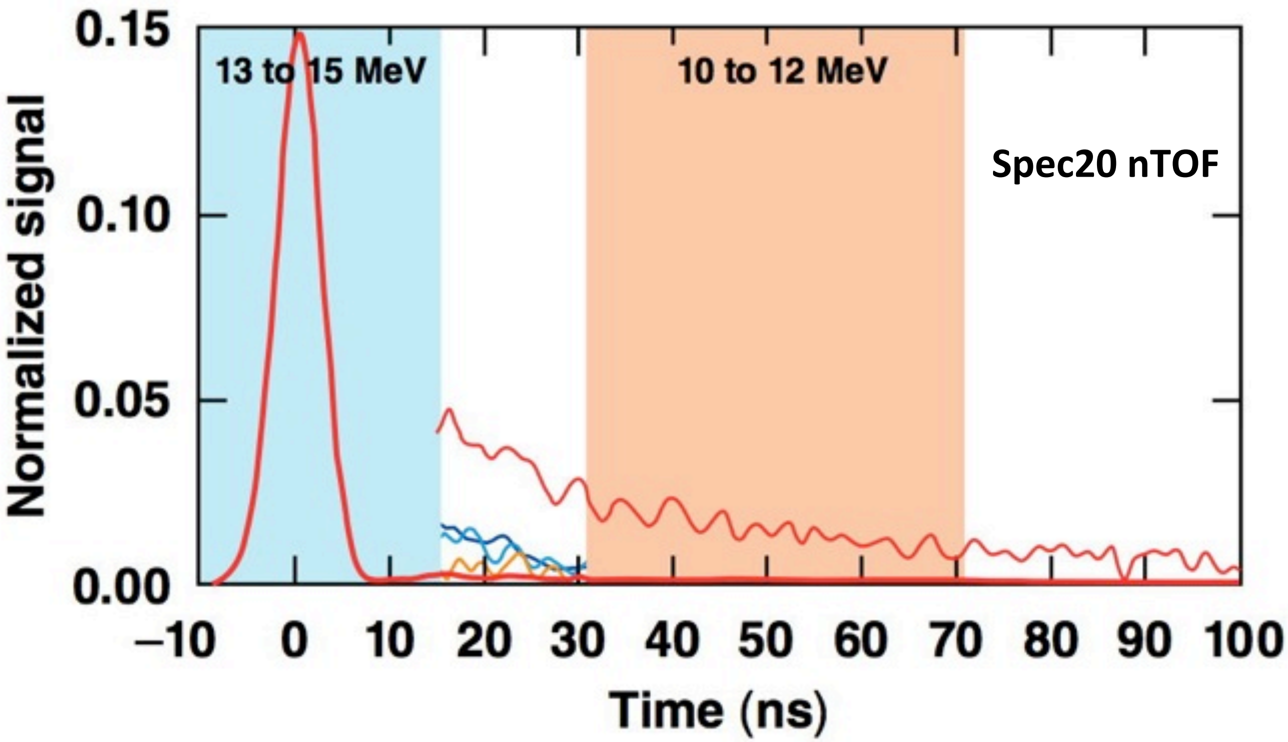
Department of Nuclear Engineering

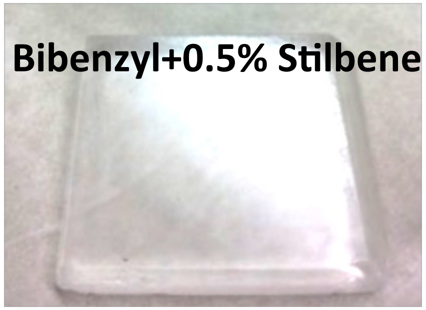
University of California, Berkeley

NSSC 7

NUCLEAR SCIENCE and SECURITY CONSORTIUM

Novel Scintillators with Rapid Temporal Response and High Light Yield





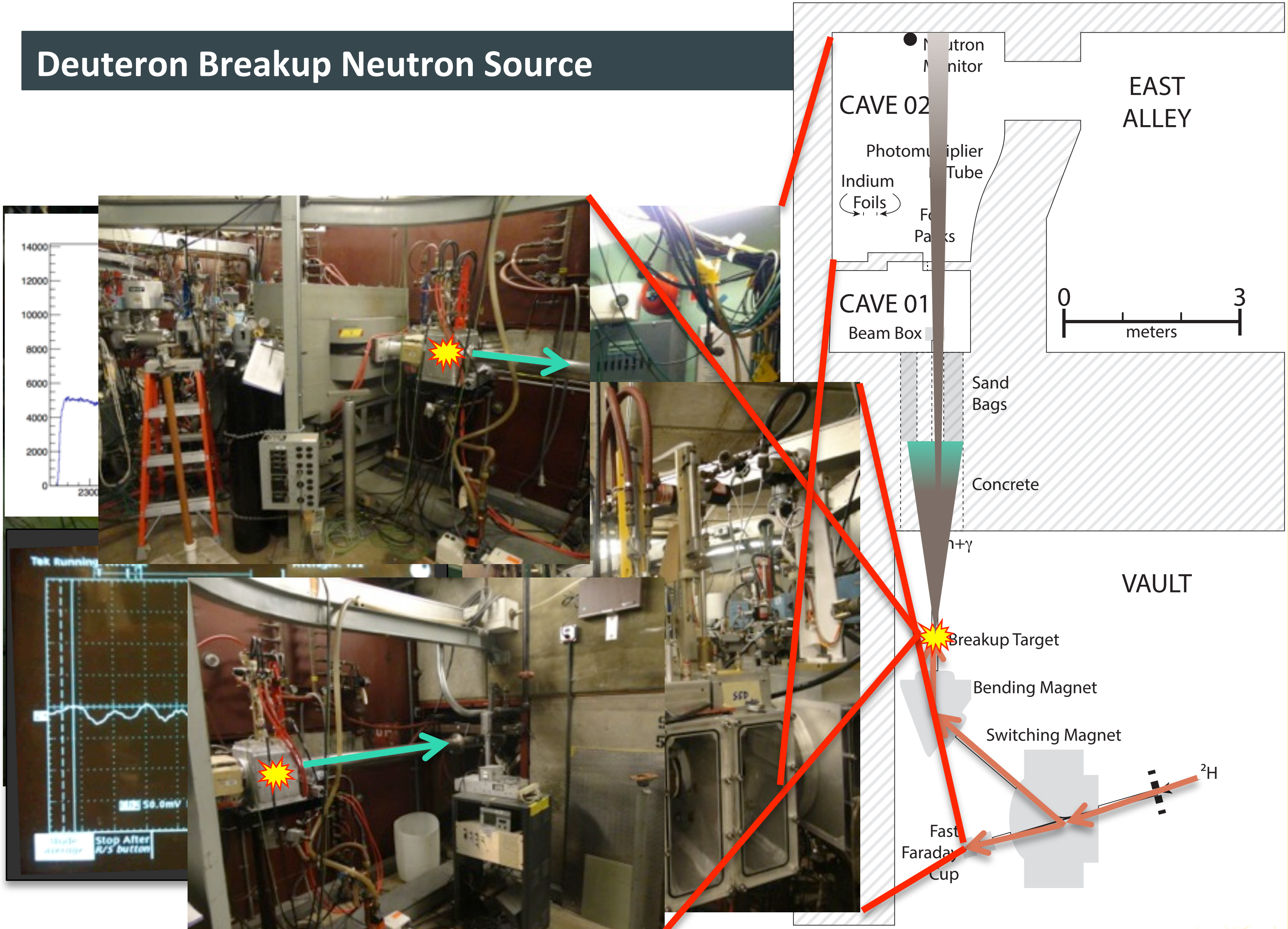
Rapid temporal response

R. Hatarik, *et al.*, Rev. Sci. Instrum. 83, 10D911 (2012).

To verify the shape of the neutron spectrum, the total neutron response of the scintillator as a function of energy must be measured.

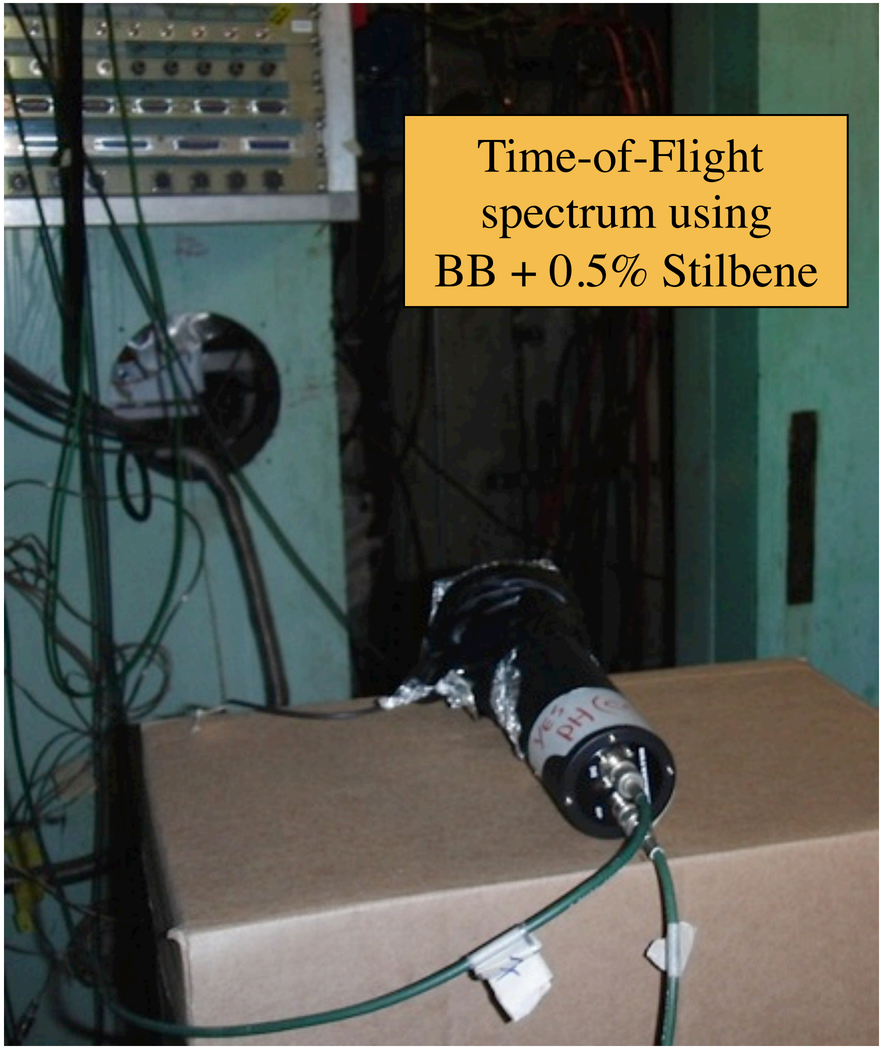
J.P. Knauer, 53rd Annual Meeting of the American Physical Society, Division of Plasma Physics, Salt Lake City, UT, November 14-18, 2011.

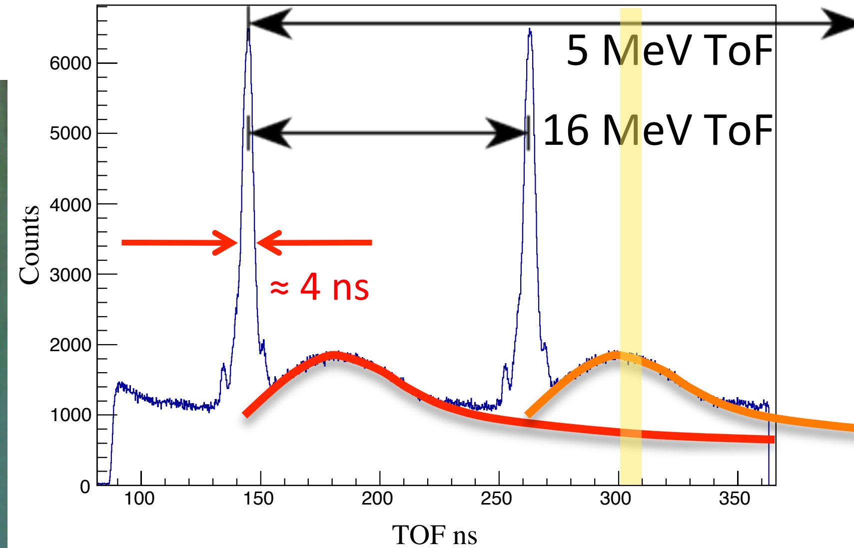
Deuteron Breakup Neutron Source

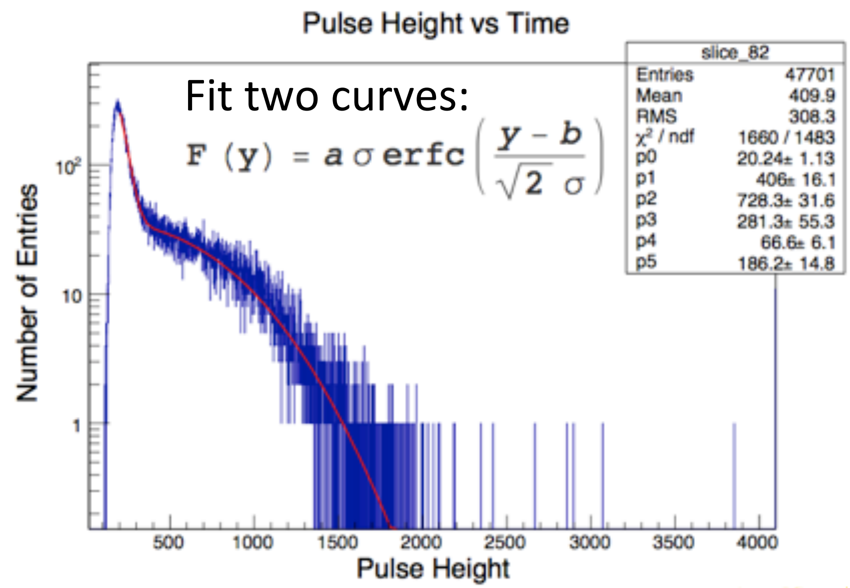


LBNL 88-INCH CYCLOTRON – CAVE 0

Neutron Spectrum Characterization using nTOF







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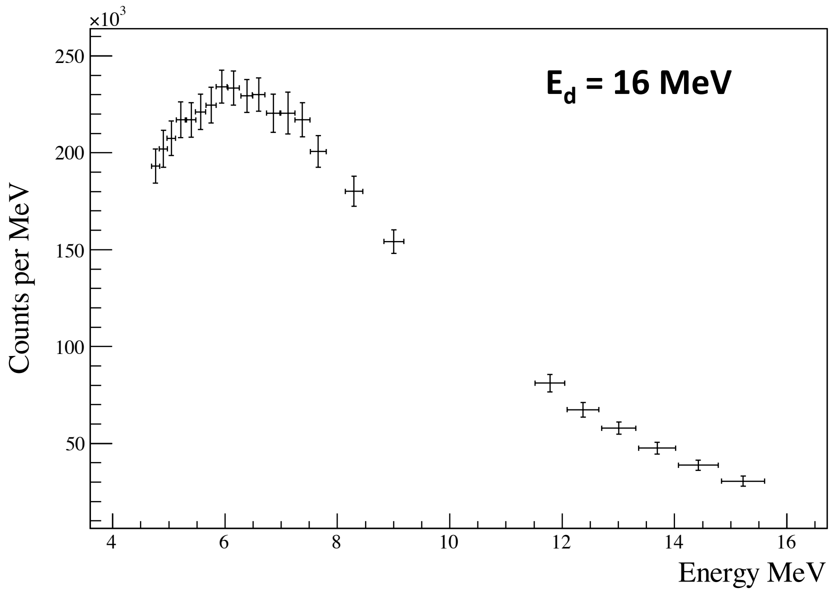
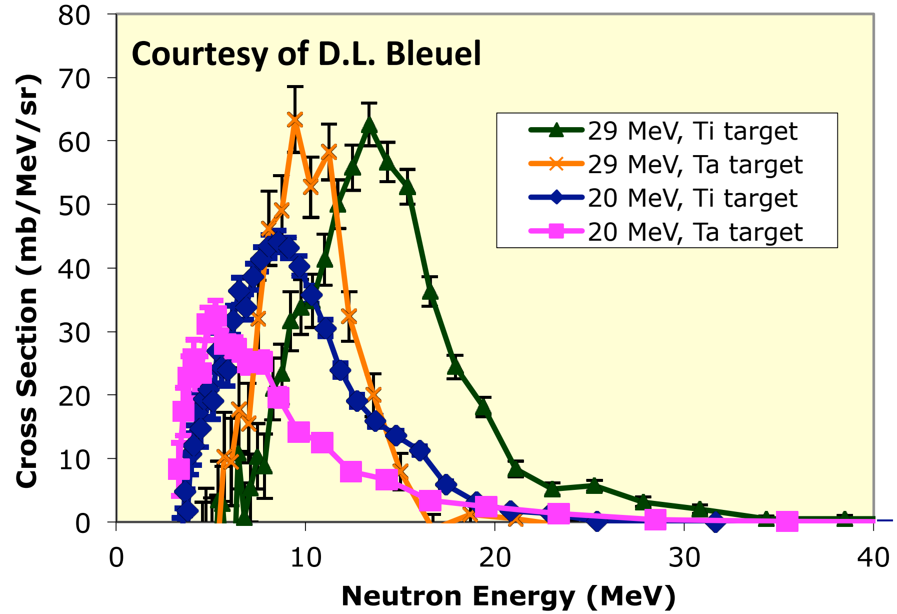
Tunable Neutron Beam

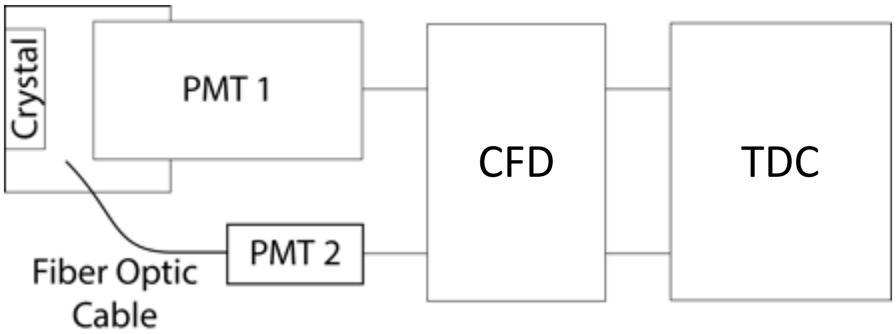


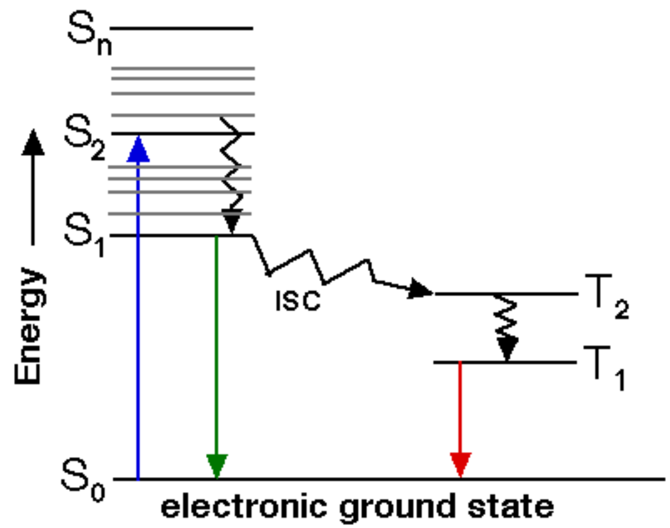


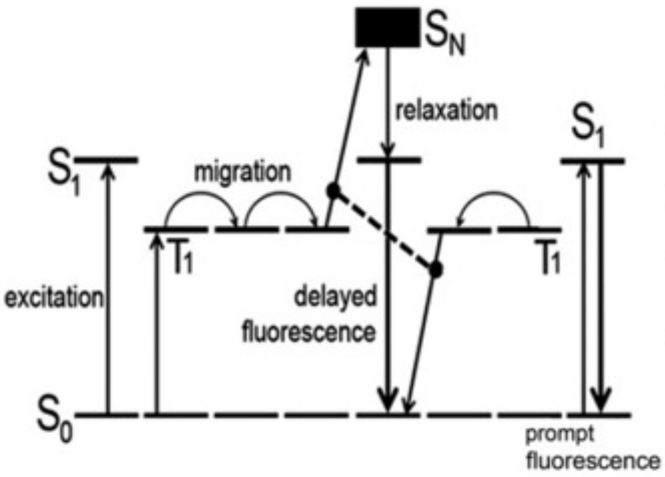
Cardboard housing with 1.5 cm diameter aperture

- Energy-dependent neutron detection scintillation efficiency measured at WNR at LANL
- Calibrated using ^{238}U fission chamber

Temporal Response

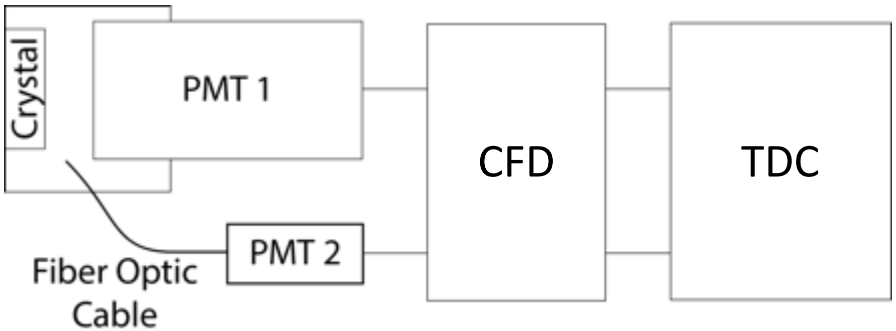


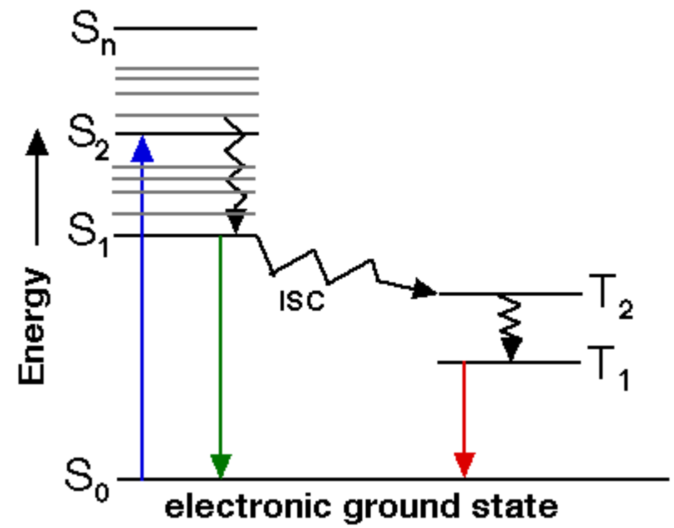


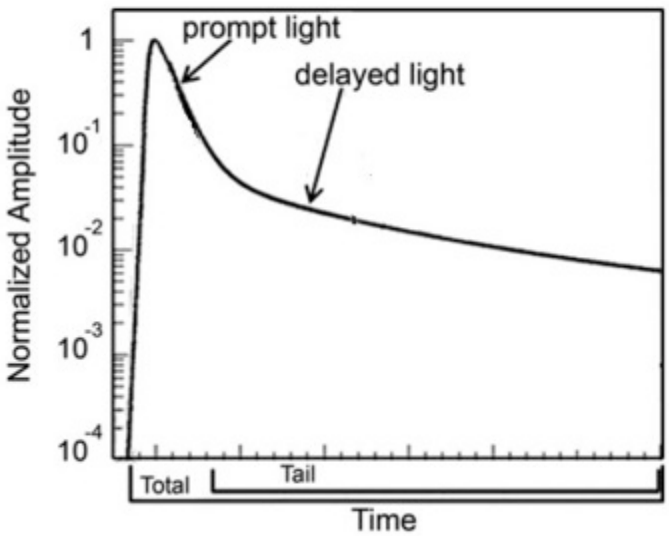


L.M. Bolinger and G.E. Thomas, Rev. Sci. Instrum. **32**, 1044 (1961).

Temporal Response







L.M. Bolinger and G.E. Thomas, Rev. Sci. Instrum. **32**, 1044 (1961).

Methodology: Temporal Response

$$\frac{dn_S}{dt} = -K_S n_S - \cancel{K_{ST} n_S} + \cancel{\phi K_{TT} n_T^2}$$

Temporal evolution of single state population density

$$\frac{dn_T}{dt} = -K_T n_T + K_{ST} n_S - \phi K_{TT} n_T^2$$

Temporal evolution of triplet state population density

$$K_{TT} \approx 0$$

Highly suppressed triplet-triplet annihilation

$$K_{ST} << K_S$$

Rate of intersystem crossing is much smaller than the fluorescence rate

Methodology: Temporal Response

$$\frac{dn_S}{dt} = -K_S n_S$$

Temporal evolution of single state population density

$$n_S(t) = \alpha e^{-\frac{t}{\tau}}$$

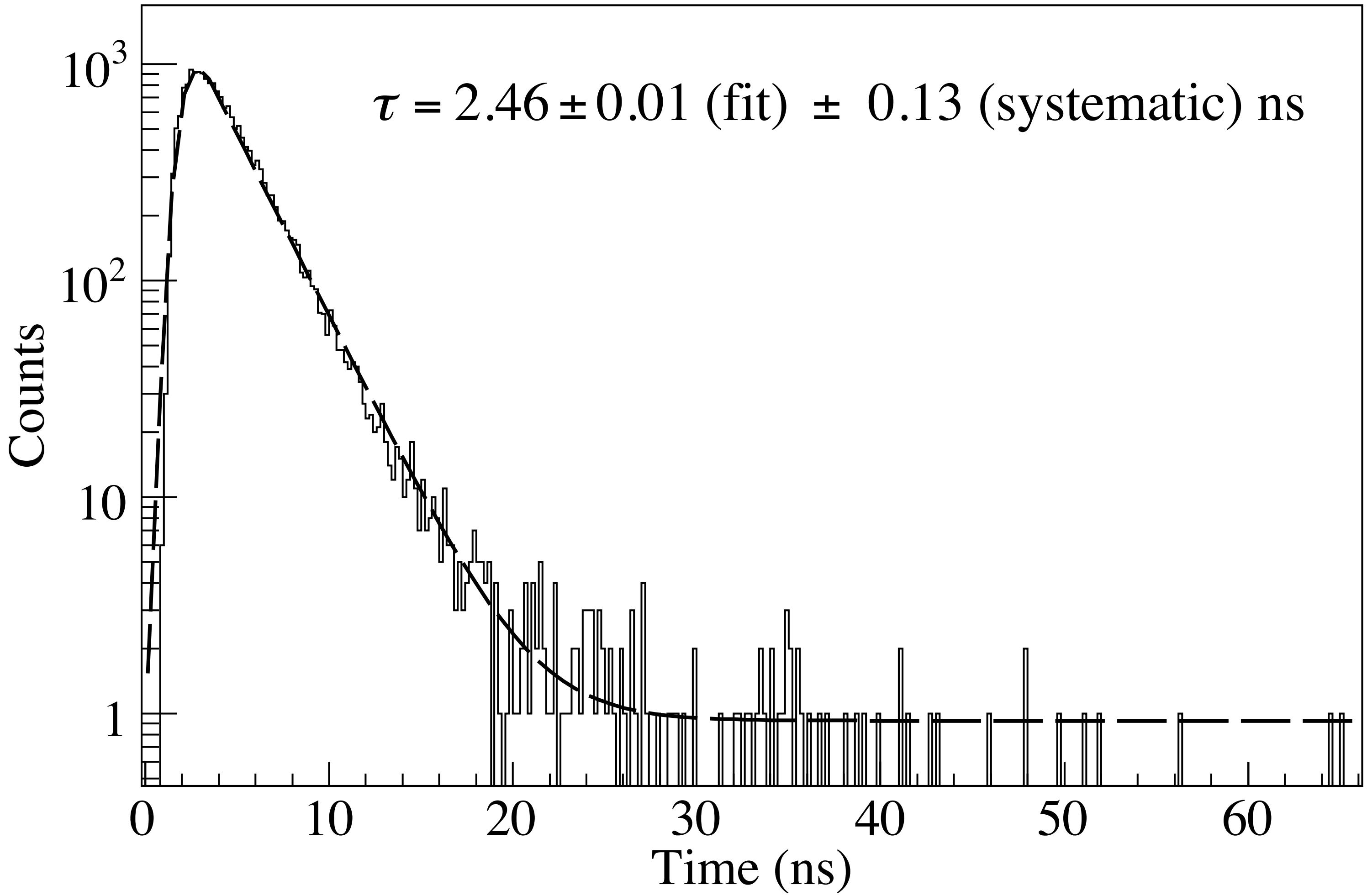
$$K_S = \frac{1}{\tau}$$

$$I(t) = \int_0^{\infty} e^{-\frac{1}{2}\left(\frac{t}{\sigma}\right)^2} \alpha e^{-\frac{t}{\tau}} dt$$

Convolution with Gaussian instrument response function

$$\boxed{I(t) = \alpha e^{\left(\frac{\sigma^2}{2\tau^2} - \frac{t}{\tau}\right)}\left[1 + \operatorname{erf}\left(\frac{t}{\sqrt{2}\sigma} - \frac{\sigma}{\sqrt{2}\tau}\right)\right] + B}$$

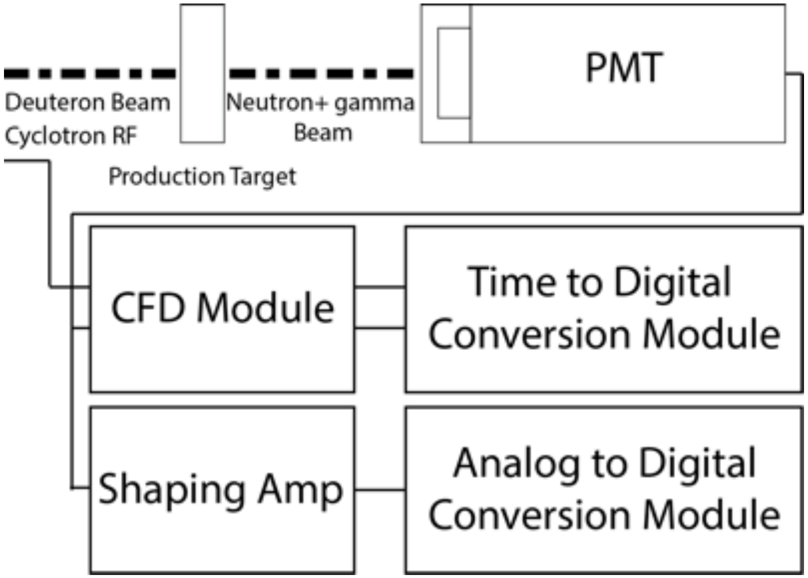
Time dependence of the intensity of scintillation light

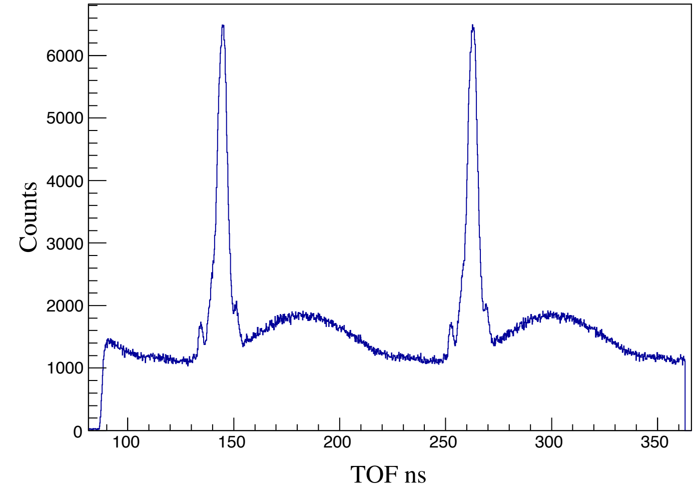


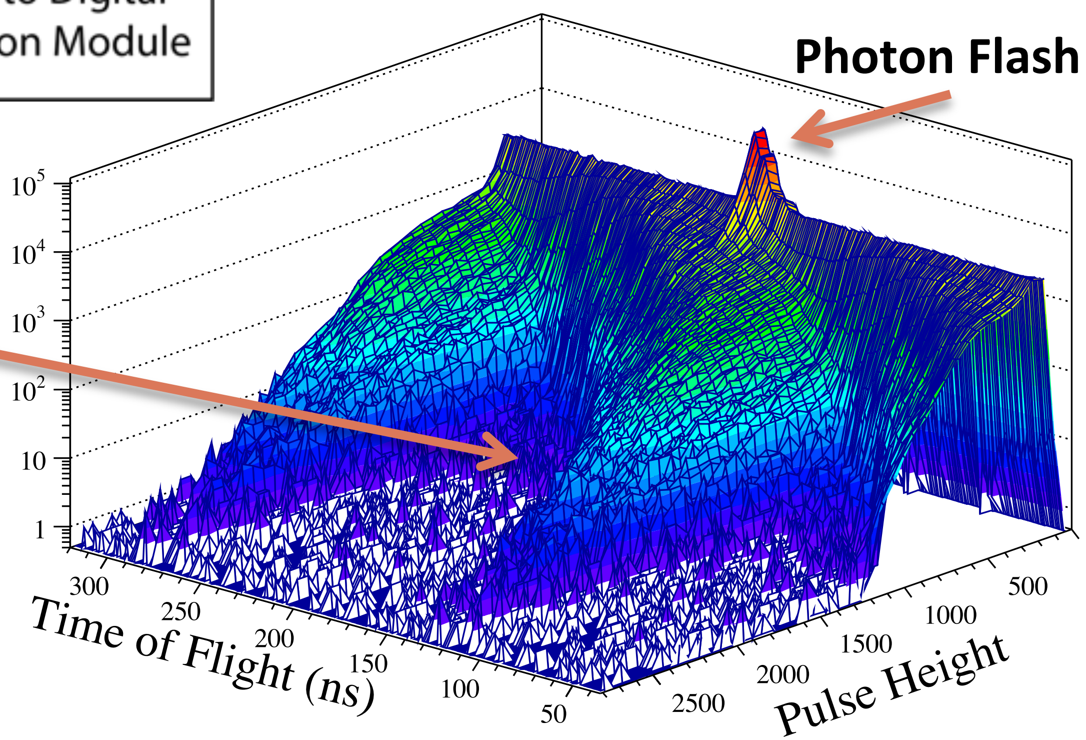
Consistent with Hatarik, *et al.*, within estimated uncertainty

BIBENZYL + 0.5% STILBENE SINGLE-CRYSTAL

Scintillator Light Output



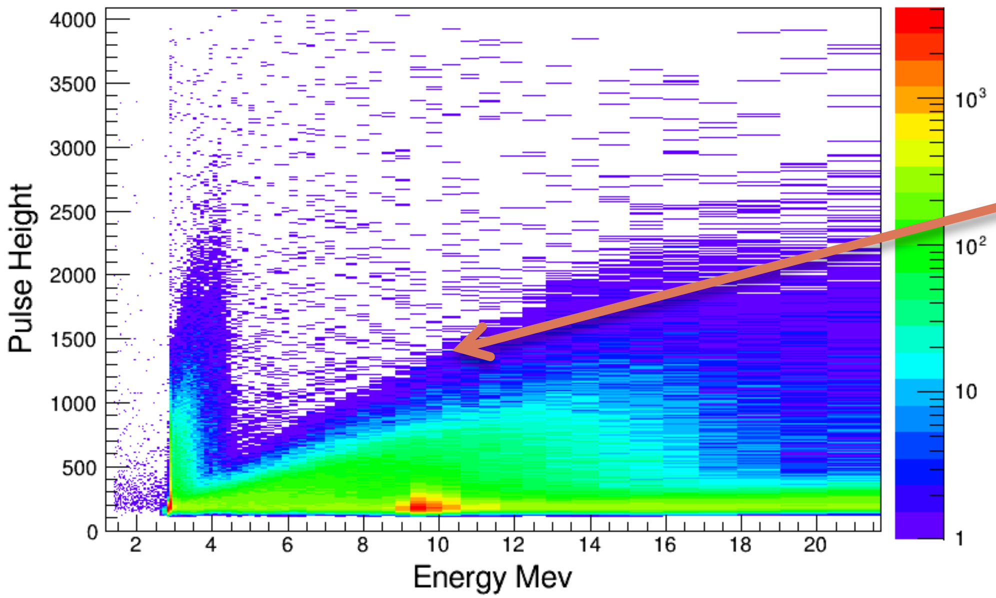




Maximum pulse height corresponds to recoil protons from (n,p) elastic scattering

PULSE HEIGHT V. NEUTRON TIME-OF-FLIGHT

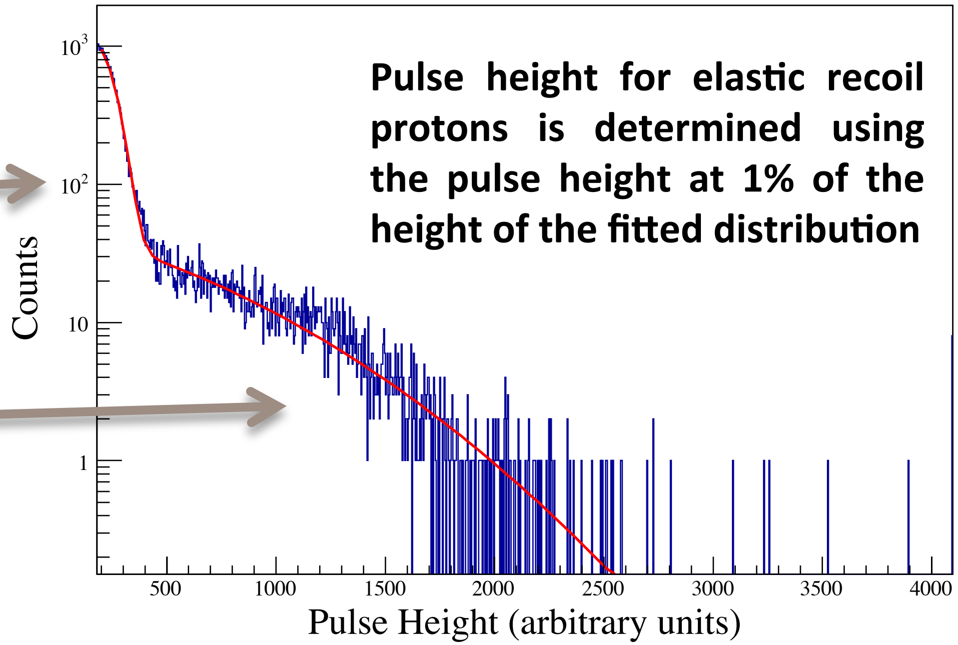
Characterizing Maximum Light Output for Recoiling Protons



Characterized this edge using a superposition of complementary error functions

Slow neutrons from previous turn

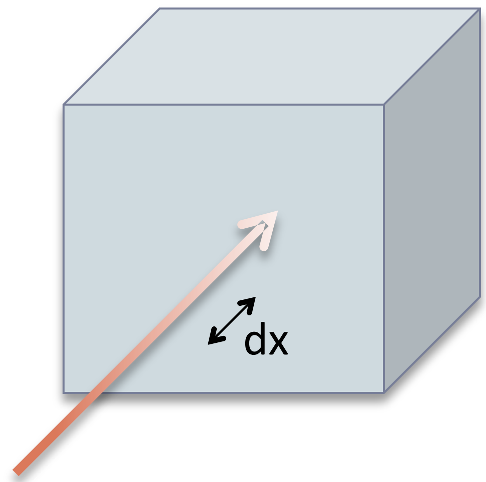
Data of Interest



Pulse height for elastic recoil protons is determined using the pulse height at 1% of the height of the fitted distribution

Scintillator Light Output: Methodology

$$\left(\frac{dx}{dE}\right)\frac{dL}{dx} = \frac{S\left(dE/dx\right)}{1+kB\left(dE/dx\right)}\left(\frac{dx}{dE}\right)$$

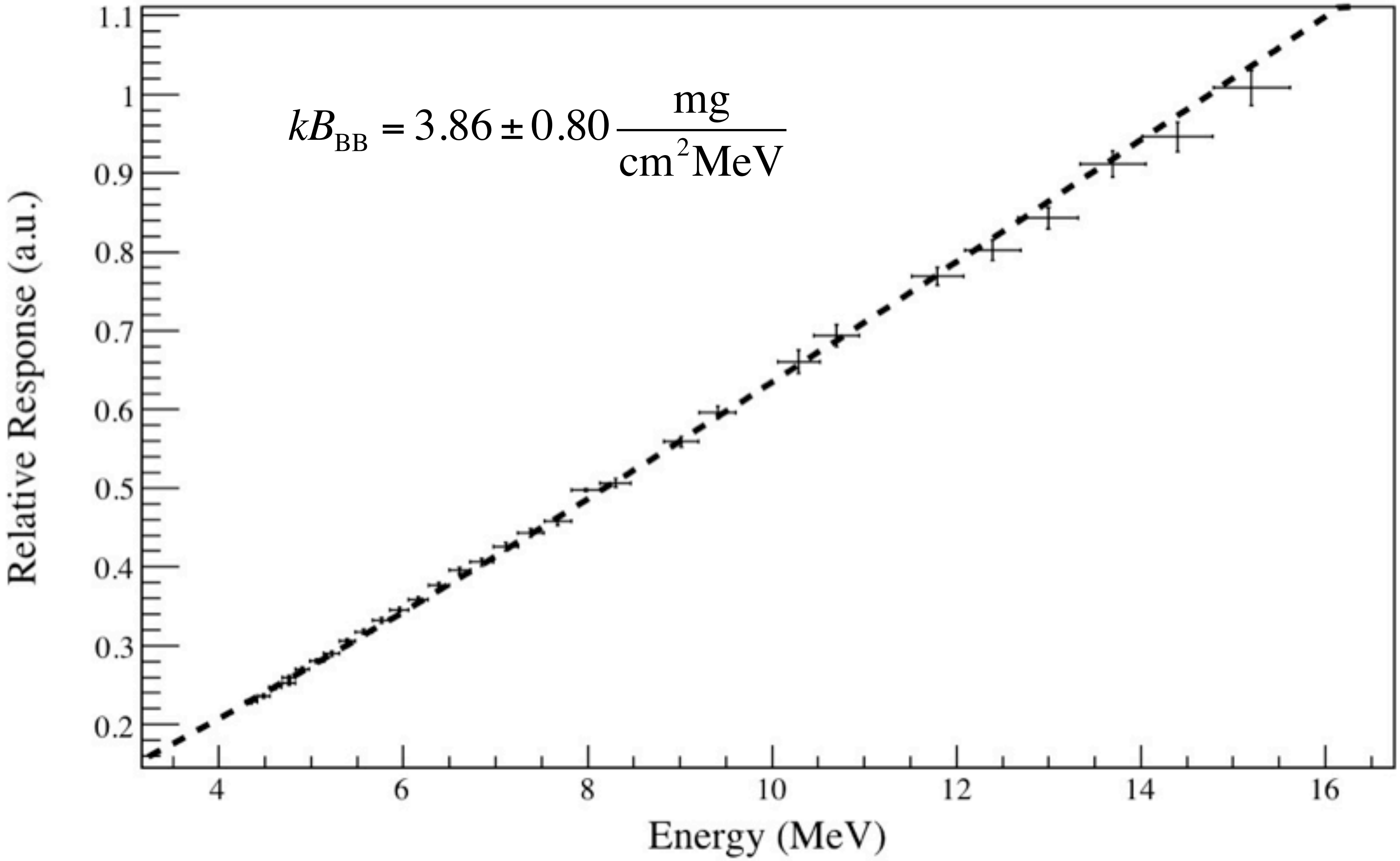


Birks Relation

$$\frac{dL}{dE} = \frac{S}{1+kB\left(dE/dx\right)}$$

$$\boxed{L(E) = \int_0^E \frac{S}{1+kB\left[\frac{dE}{dx}(E')\right]}dE'}$$

Light Output as a function of Proton Energy



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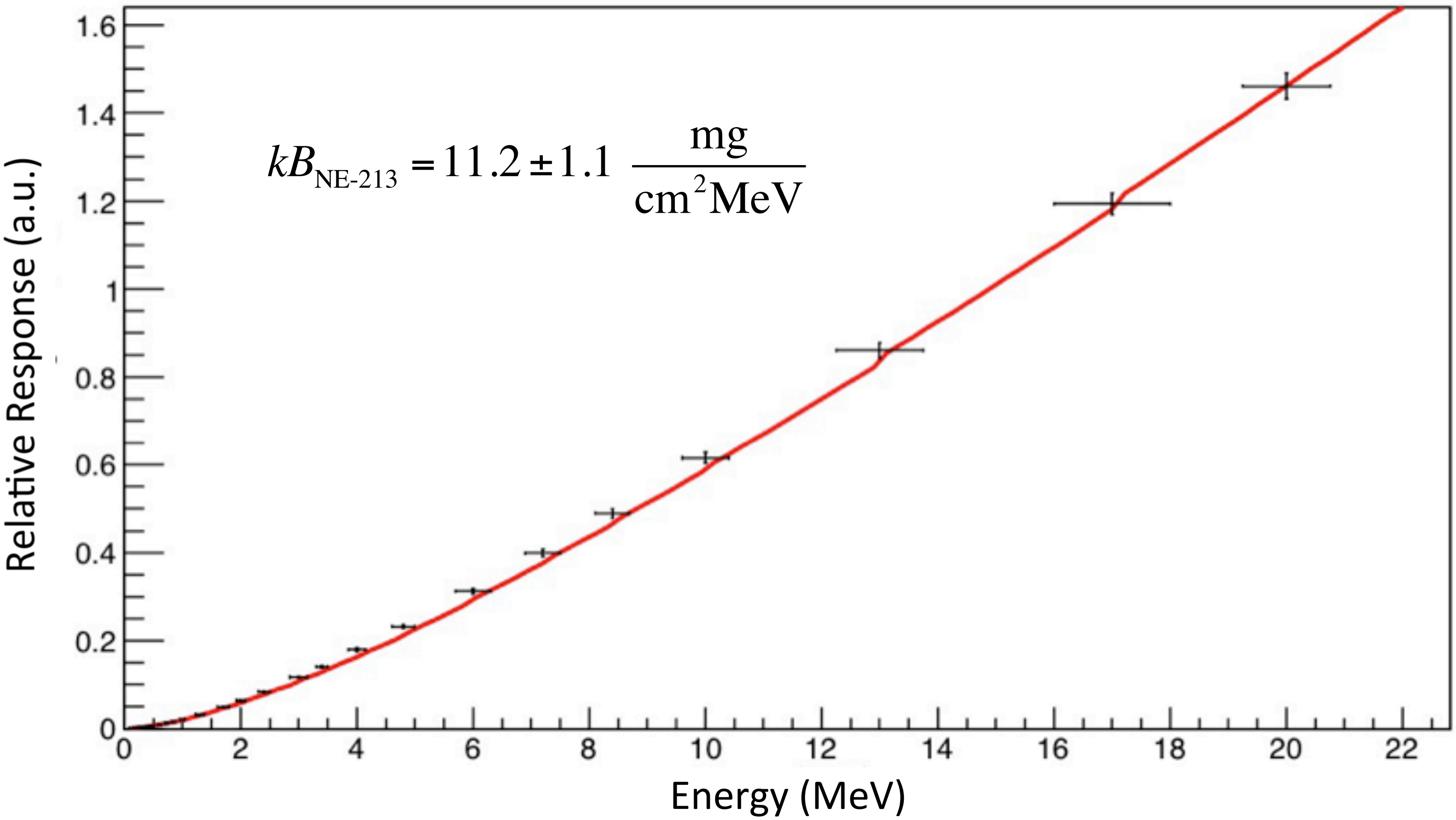
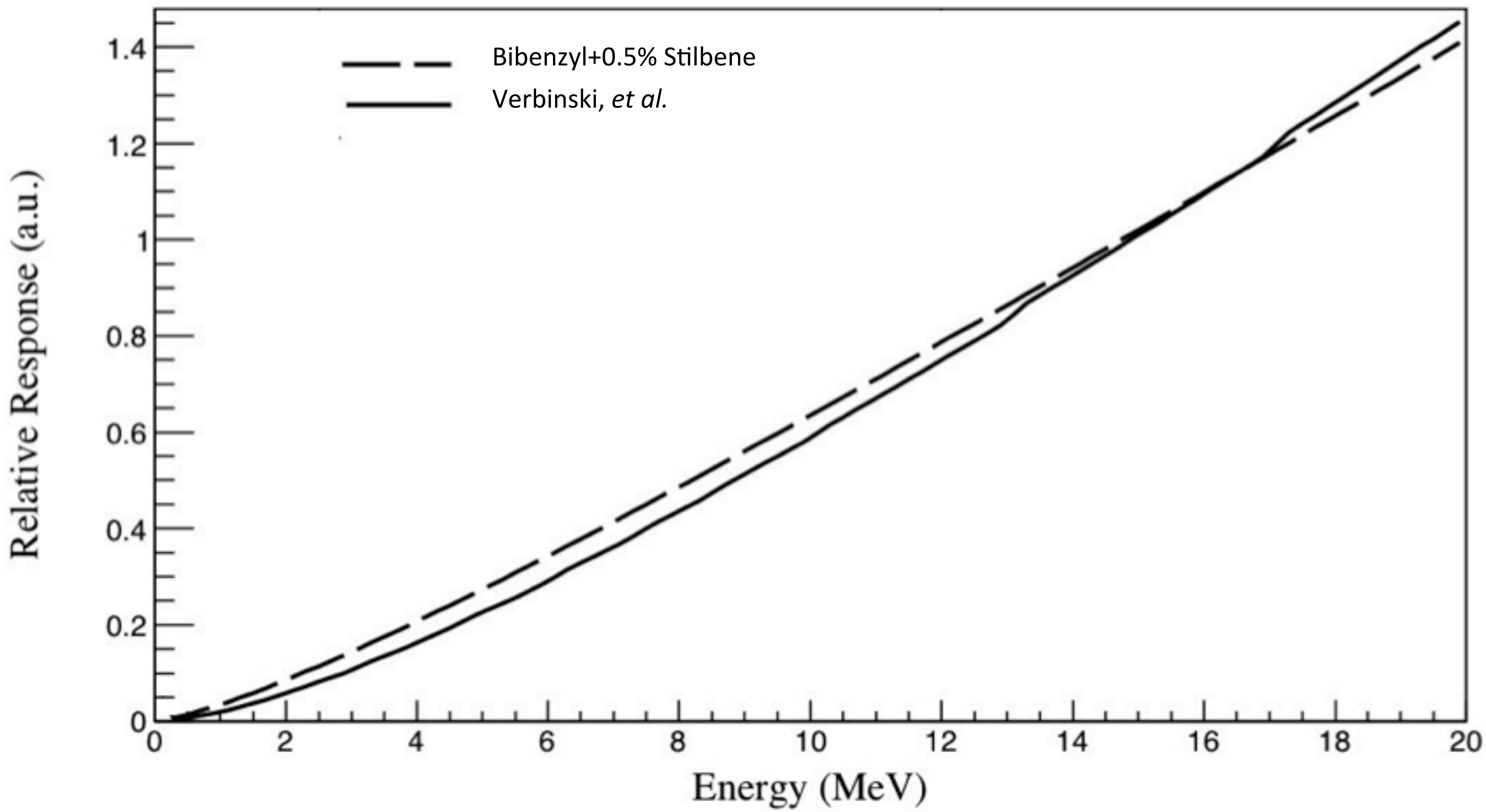
Analysis of Light Output for NE-213 Results from Verbinski, *et al.*,



V.V. Verbinski, *et al.*, Nucl. Instrum. Meth. **65**, 8 (1968).

Comparison of Light Output for BB+0.5% Stilbene and NE-213



	kB (mg/cm^2 MeV)
Bibenzyl + 0.5% Stilbene	3.86 ± 0.80
NE-213 (Verbinski, *et al.*)	11.2 ± 1.1
NE-213 (Craun and Smith)	12.5

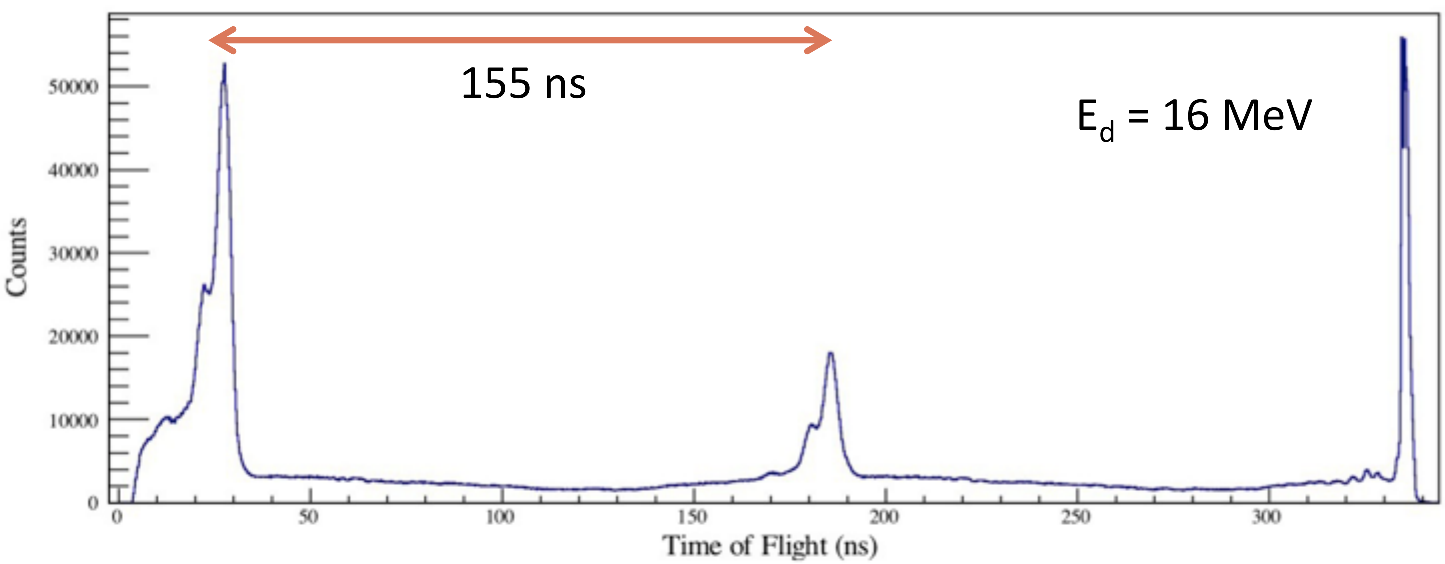
V.V. Verbinski, *et al.*, Nucl. Instrum. Meth. **65**, 8 (1968).
R.L. Craun, *et al.*, Nucl. Instrum. Meth. **80**, 239 (1970).

Conclusions

- Bibenzyl+0.5% Stilbene proton response curve was measured
- 20% discrepancy between BB & NE-213 proton response at 2 MeV
- Can be used in Stanton calculations to obtain neutron response

These calculations can be correlated with experiment!

- Installation of beam chopper will remove every other beam pulse
- Development underway



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S.A. Wender

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