



Year 1 Deliverables

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Caltech

August 10, 2022

Presented in CalVision General Meeting

Overall Plan

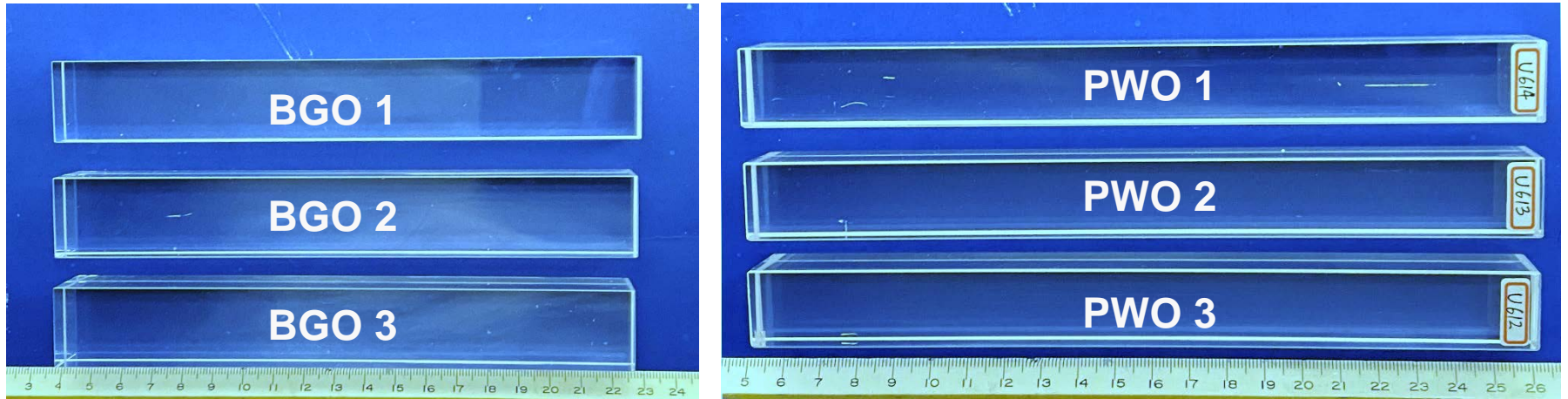
Junjie and student Yuxiang Guo visited Caltech on March 3 and 4, 2022. Following their visit, we measured three each of long BGO and PWO crystal samples. Listed below, is our report delivered to Junjie on 4/28/2022.

Our plan in the 1st year is to understand current status of inorganic scintillators relevant for the CalVision mission and encourage potential vendors to develop scintillating glass.

Test Beam Matrix: Characterize small size crystal samples (1.5 X0 cubes) of BGO, BSO, PbF₂ and PWO etc. from producers world-wide: Crytur and Saint Gobain in Europe and SIC in China etc.

Blue Sky HHCAL R&D: Characterize small scintillating glass samples (1.5 X0 cubes) produced by producers world-wide: the US (Scintilex, AFO and RMD), Europe (Giessen: Czech Precios and German Schott), and China (BGRI, Jinggangshan University etc.). Hope also to see a discussion in SCINT2022.

Report on BGO and PWO Crystals



ID	Dimension (mm ³)	#	Polishing
BGO-1,2,3	25x25x180	3	All faces
PWO-1,2,3	20x20x200	3	All faces

All samples from U. Michigan received on March 2nd, 2022 (Wednesday)

Experiments

Measured at room temperature: X-ray excited luminescence (XEL), Longitudinal/Transverse transmittance (LT/TT), Emission Weighted Longitudinal transmittance (EWLT), Pulse Height Spectra (PHS), Light Output (LO) & Decay Time (τ), Light Response Uniformity (LRU). Light Yield (LY) with Emission Weighted Quantum Efficiency (EWQE) taken out.

Measurement Setup

Na-22
position

G →
F →
E →
D →
C →
B →
A →

2xTyvek wrapping
Grease Coupling to PMT

LO & τ

PMT 2059

LO & Decay Kinetics: **A**
Pulse Shape: **A**
LRU/PHS: **A-G** (only
200/2,000 ns gate for
PWO/BGO)

X-ray excited luminescence

HITACHI
F4500

X-ray Tube

XEL spectrum measured for each sample
With no wrapping and air gap coupling

Transmittance

HITACHI 3210

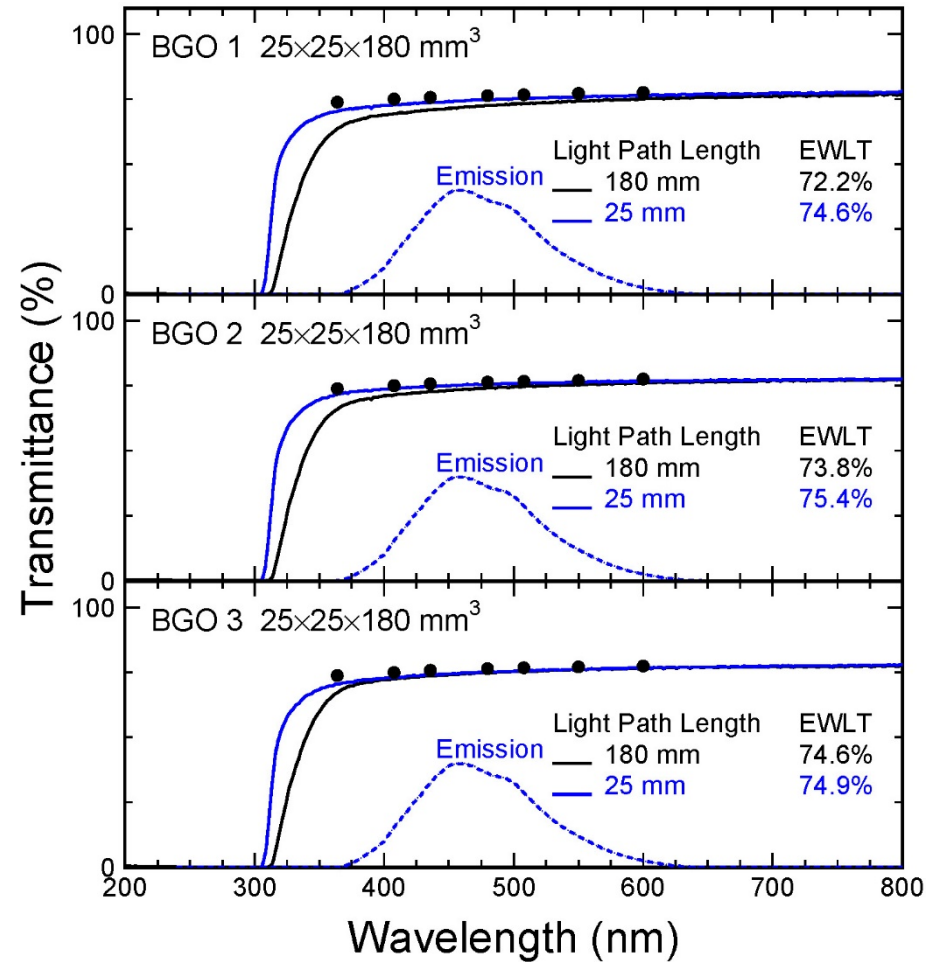
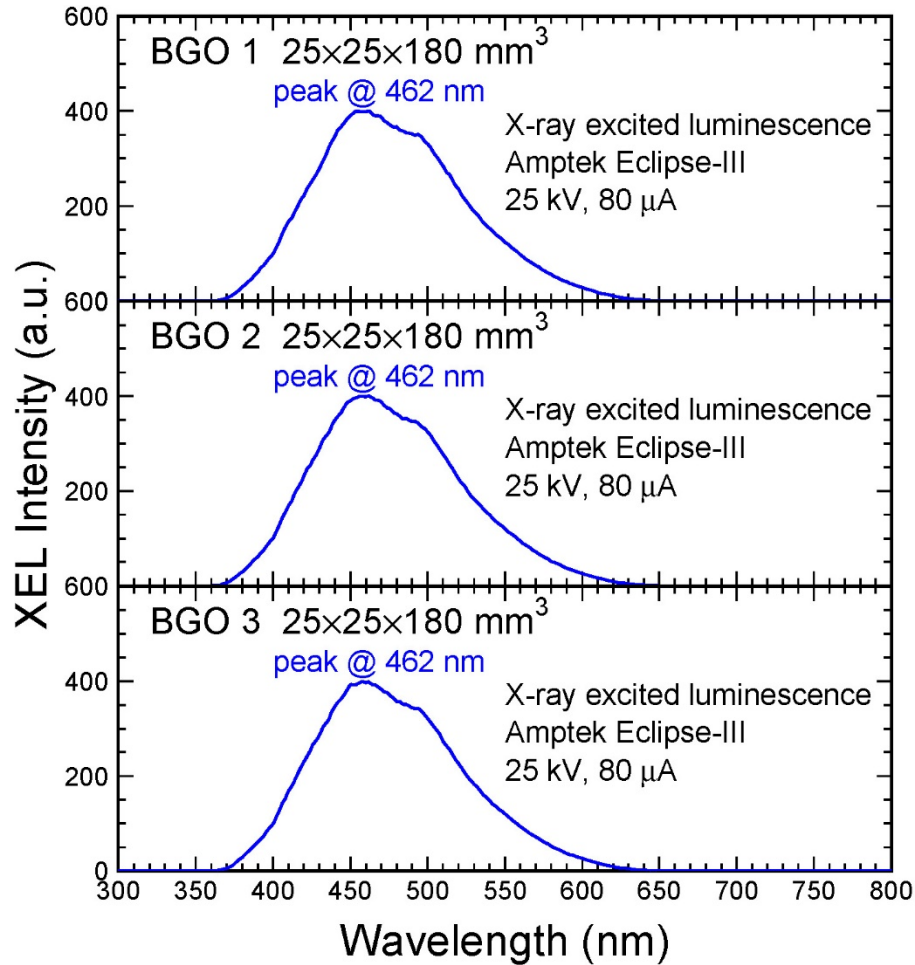
Integrating
sphere

LT and TT (at crystal center) spectra
measured for each sample

PMT

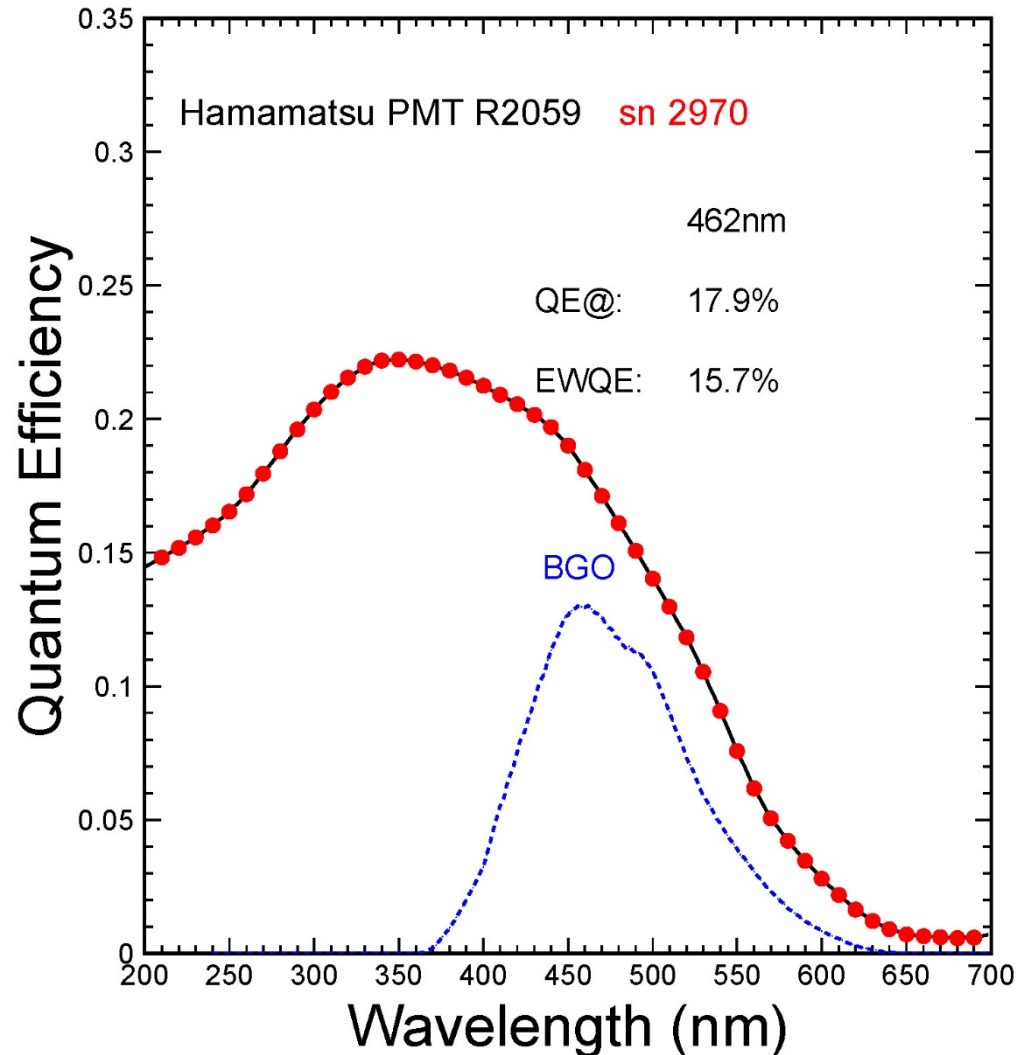
XEL and LT Spectra, TT and EWLT: BGO

XEL peaked at ~462 nm
TT measured at the crystal center



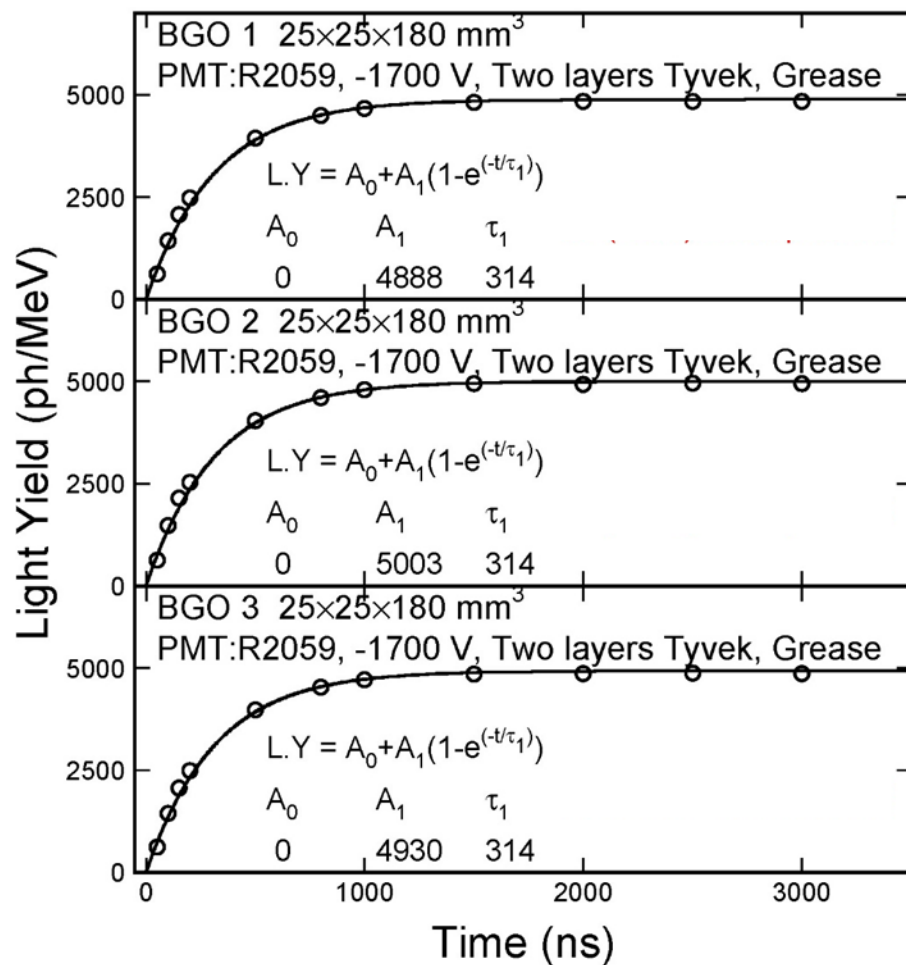
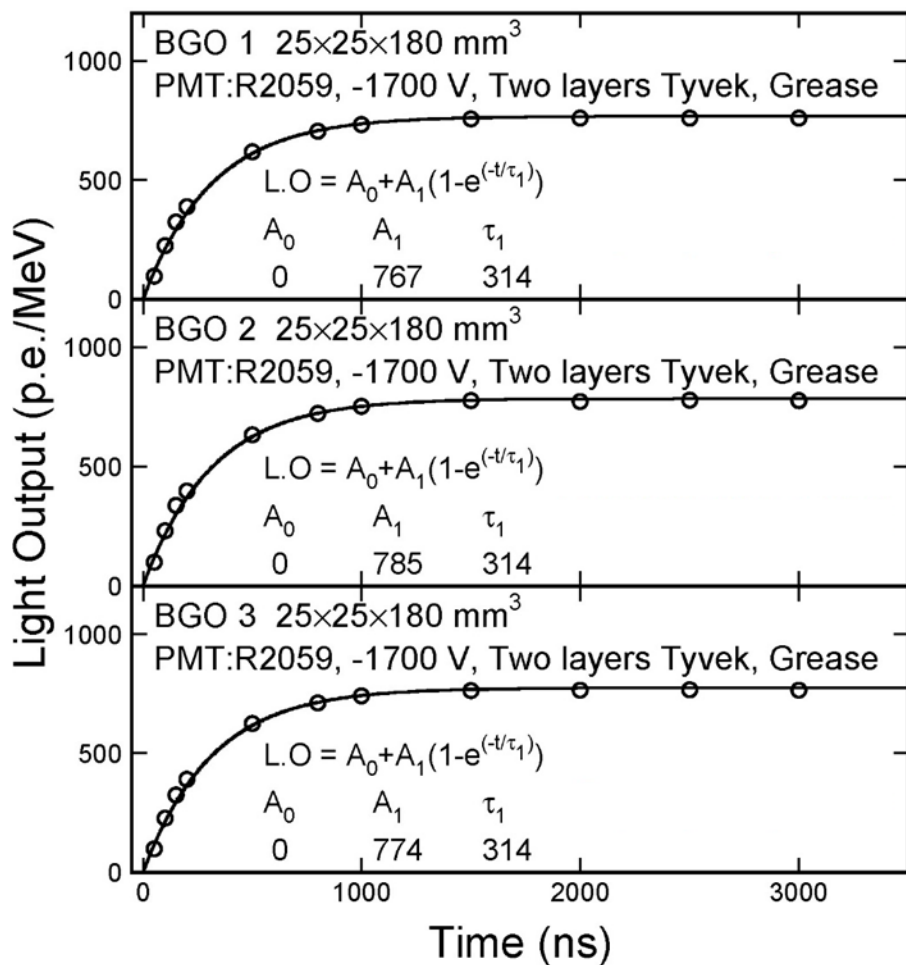
EWQE: BGO

EWQE of 15.7%
used to convert
light output (LO)
in p.e./MeV to
light yield (LY) in
photons/MeV.
Both are
sample/wrapping/
coupling
dependent.



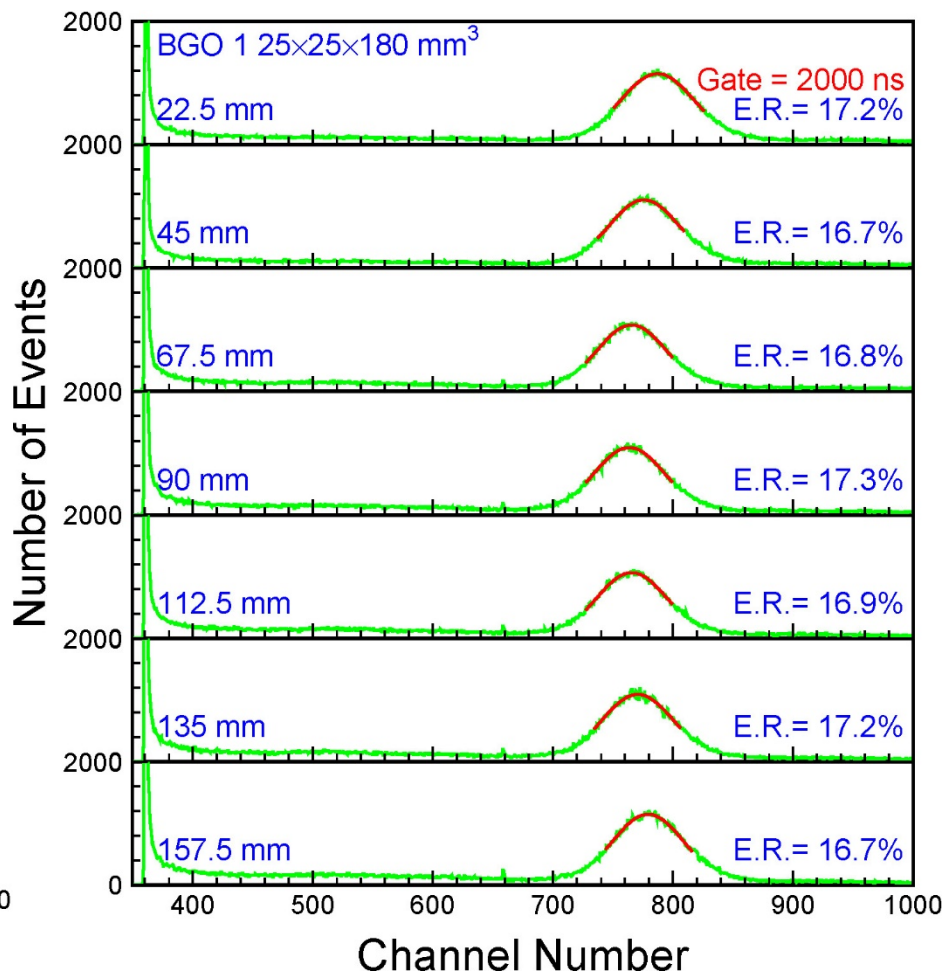
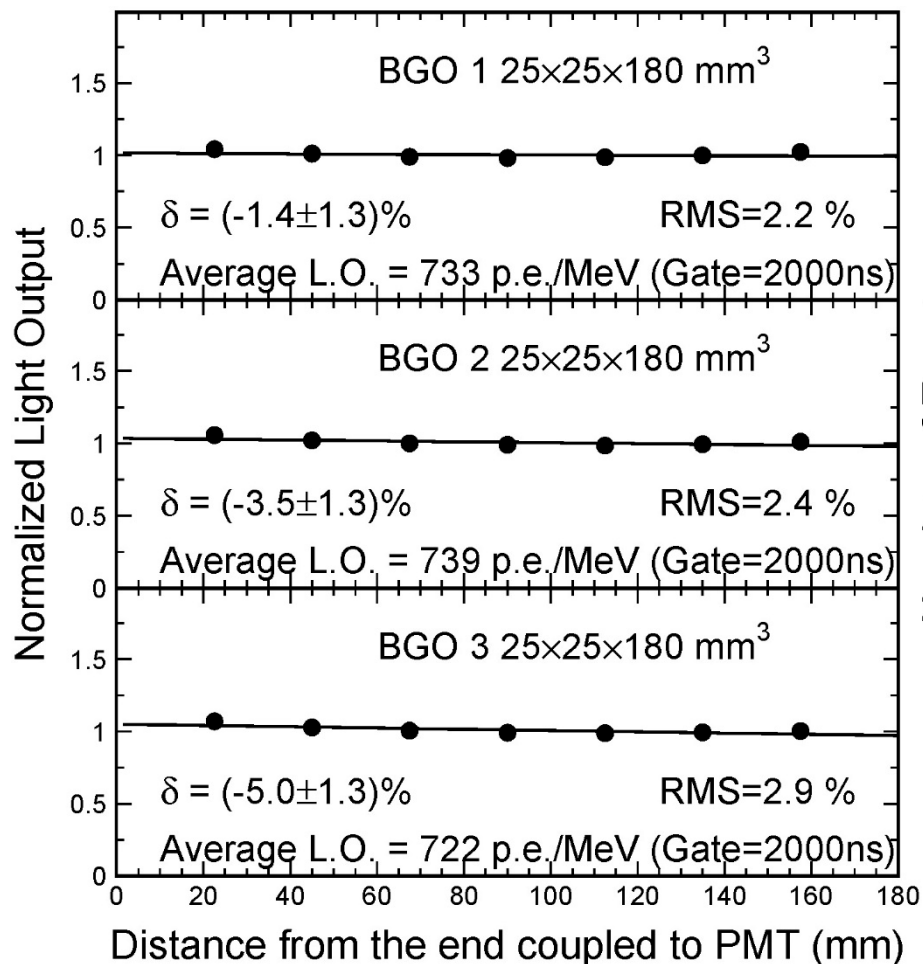
LO/LY and Decay Kinetics: BGO

BGO shows 314 ns decay time with LO and LY of 775 p.e./MeV and 4,940 ph/MeV in 2,000 ns



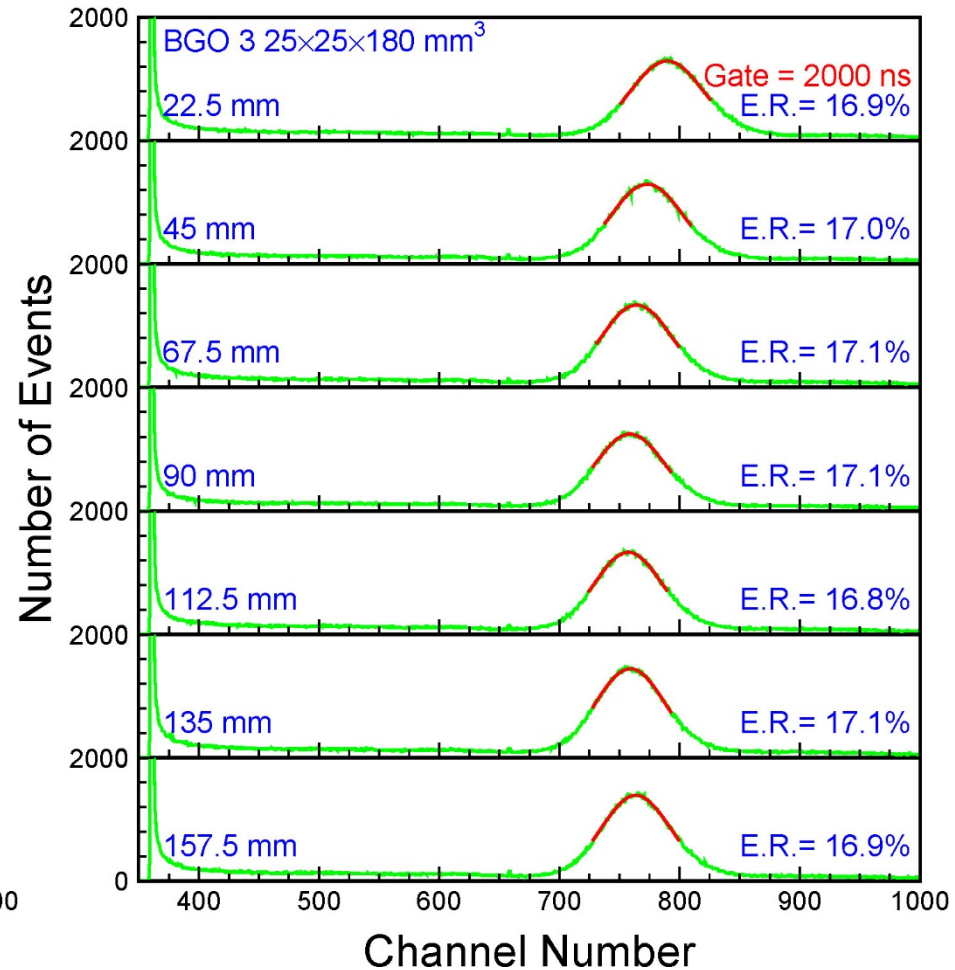
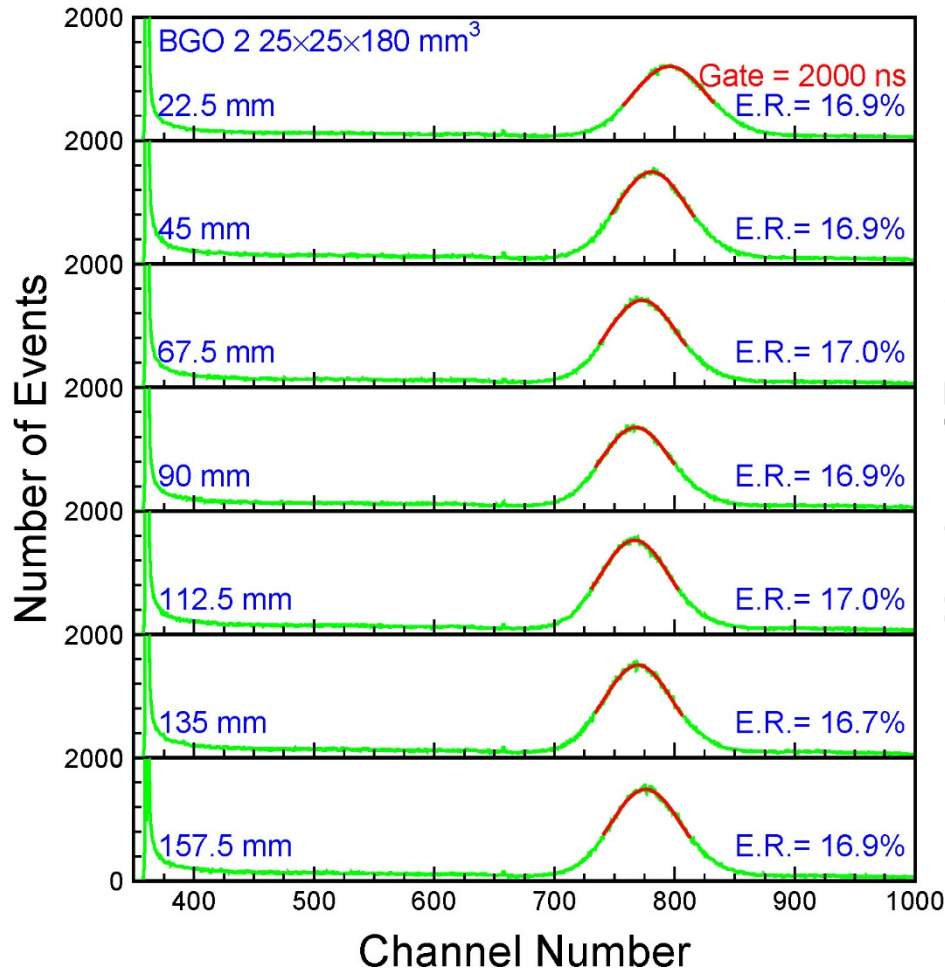
LRU: All Three and PHS: BGO-1

BGO 1/2/3 shows LRU rms of 2.2%/2.4%/2.9%
average LO: 733/739/722 p.e./MeV for BGO-1/2/3



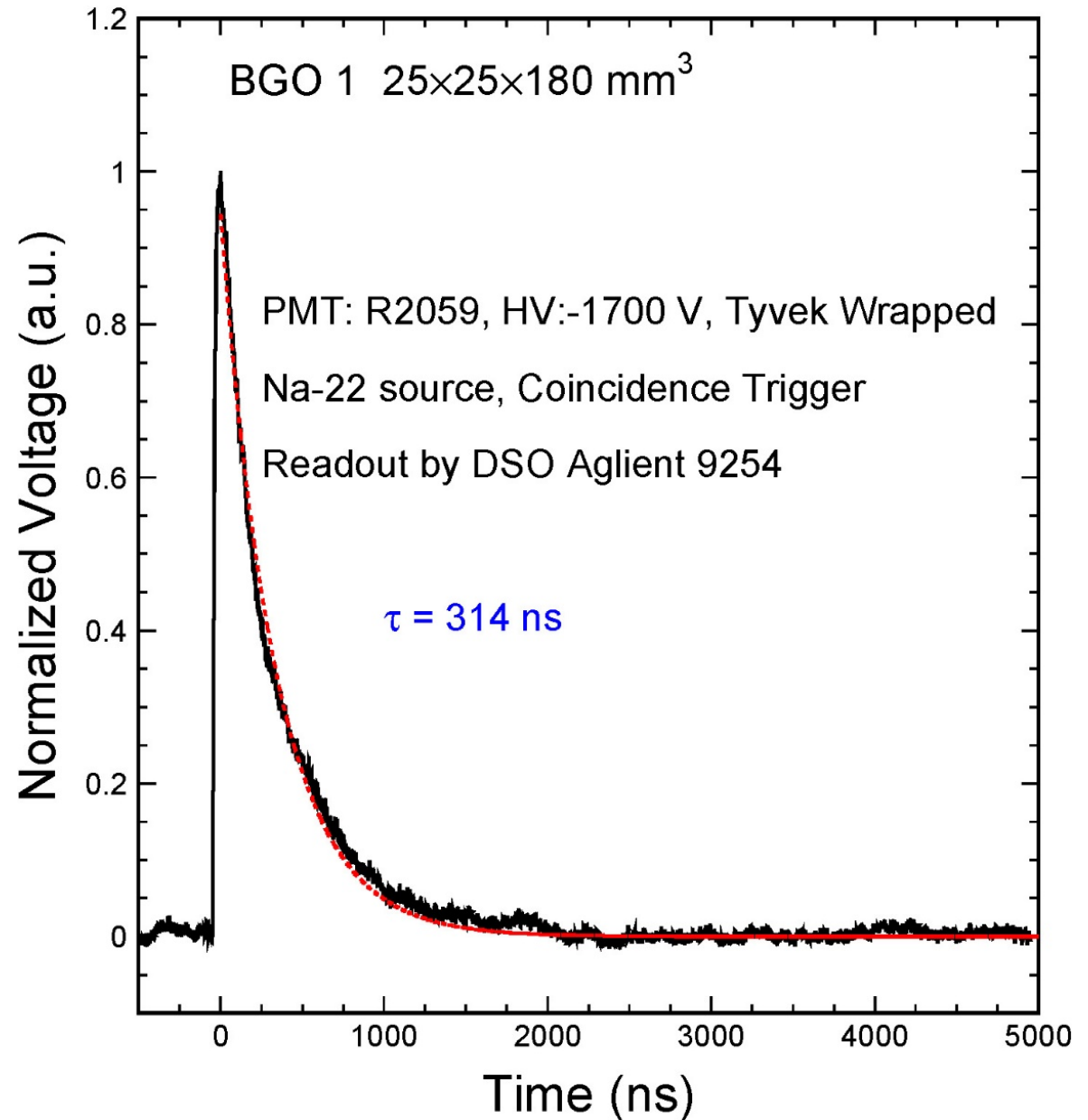
PHS: BGO-2,3

BGO 2 shows the highest light output and the best energy resolution



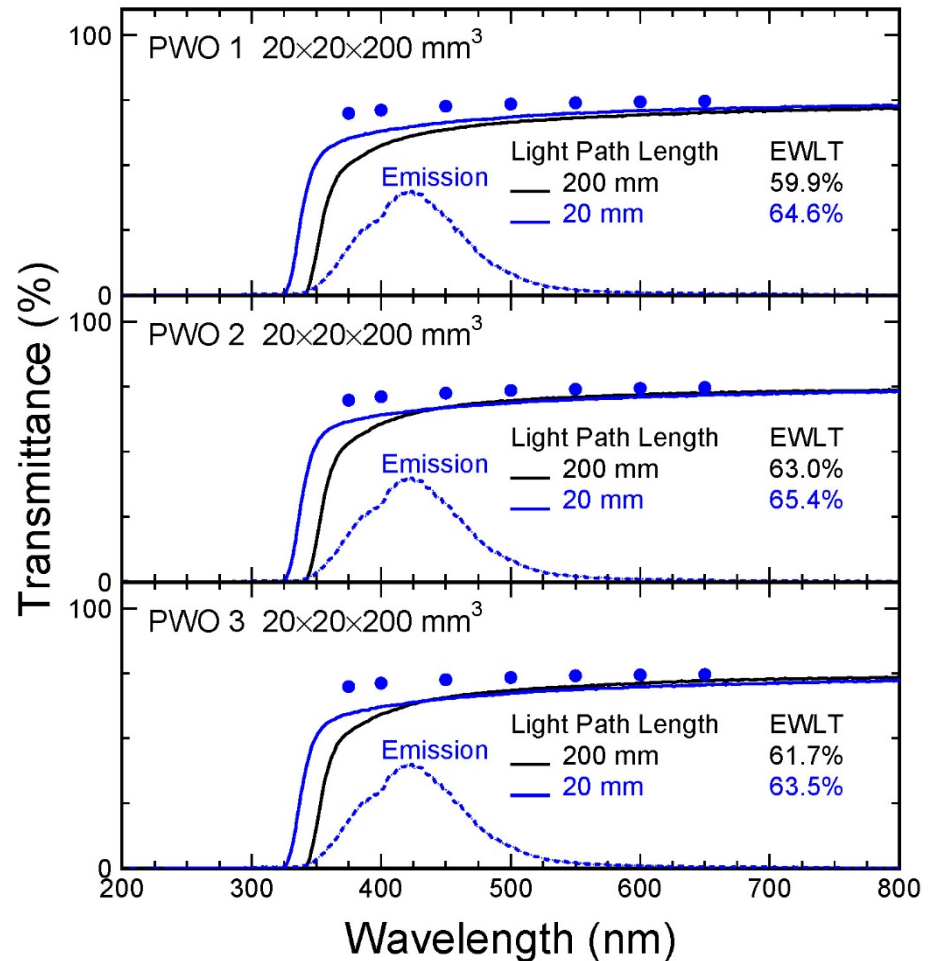
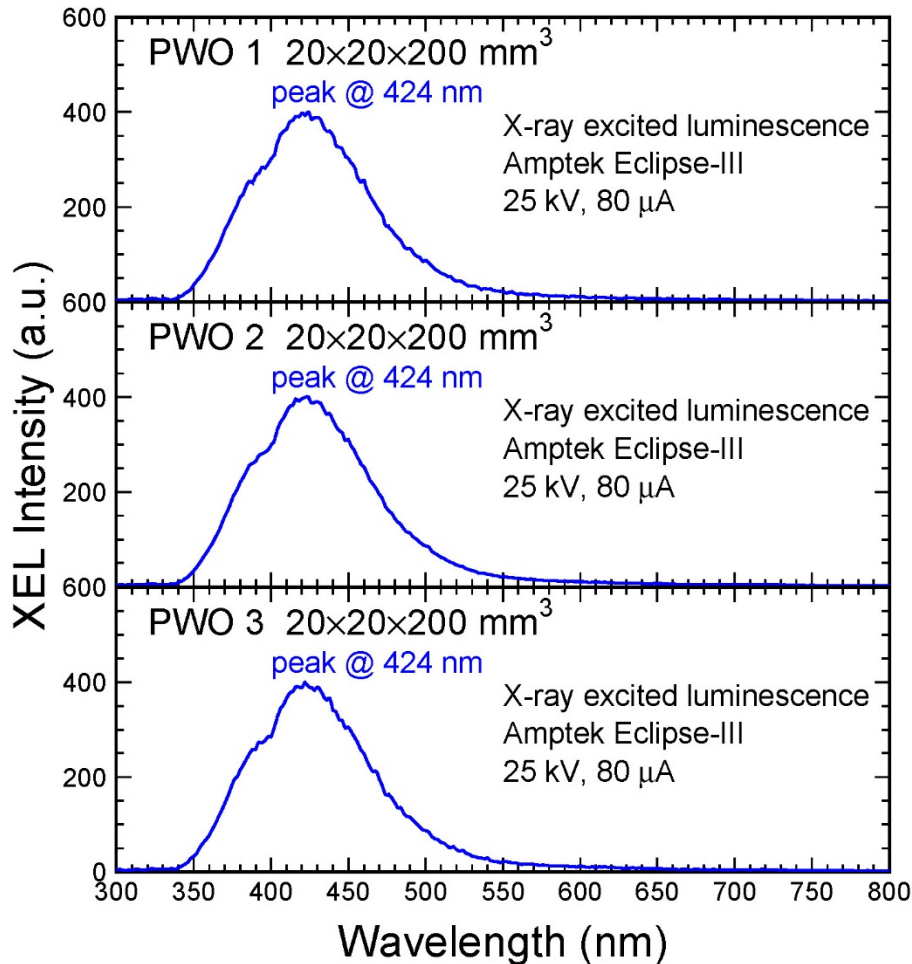
Pulse Shape Measured by DSO: BGO

Decay
time of
314 ns
observed



XEL and LT Spectra, TT and EWLT: PWO

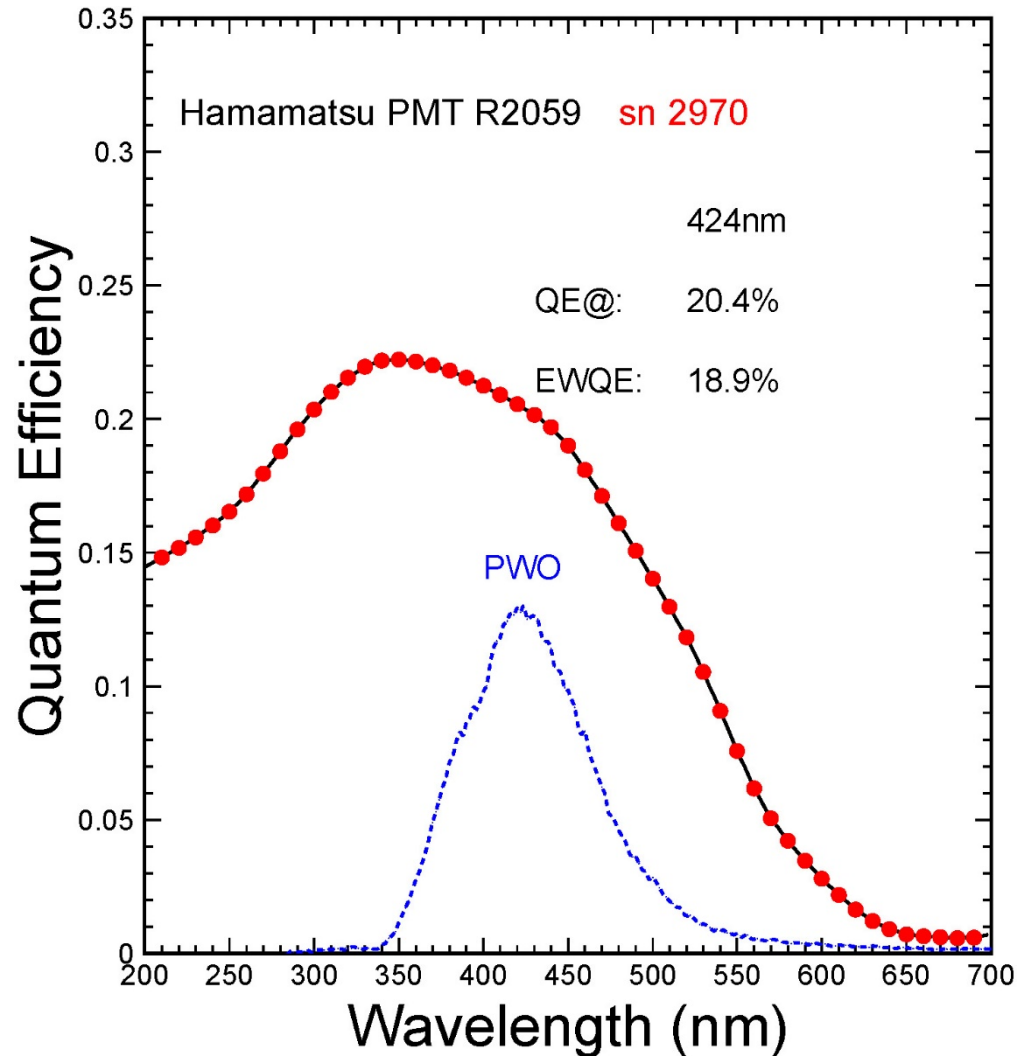
XEL peaked at ~424 nm
TT measured at the crystal center



EWQE: PWO

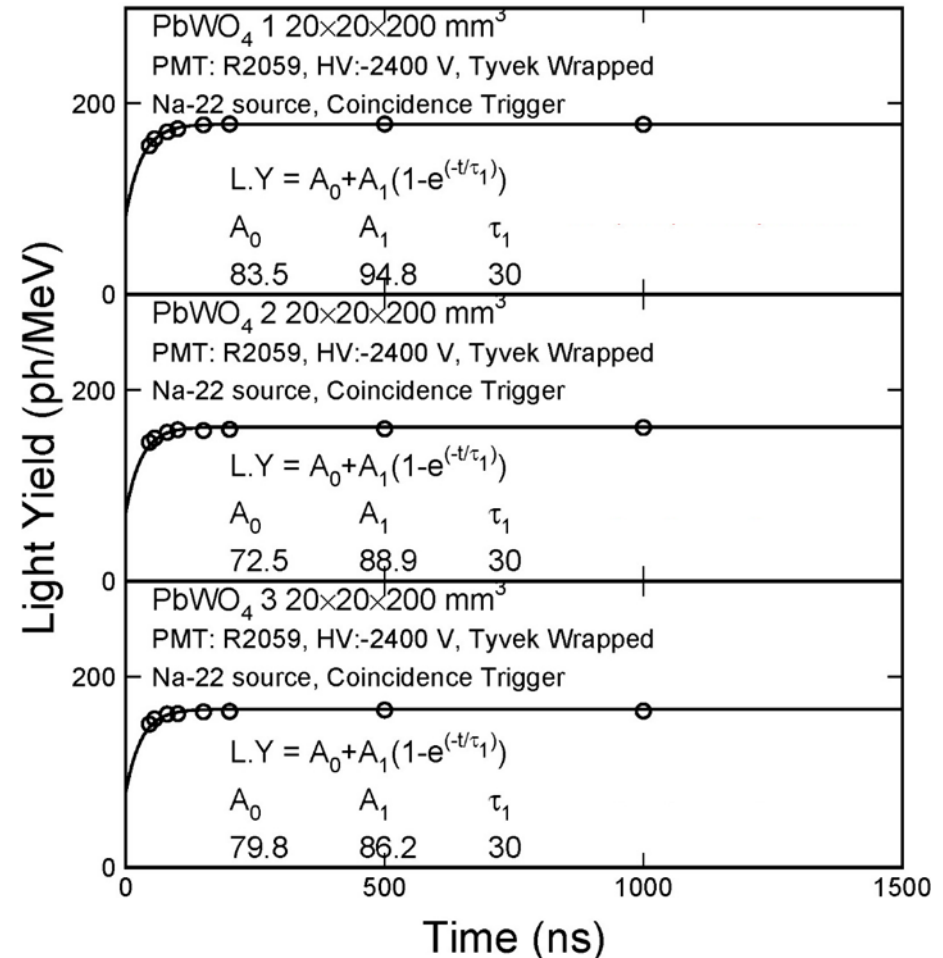
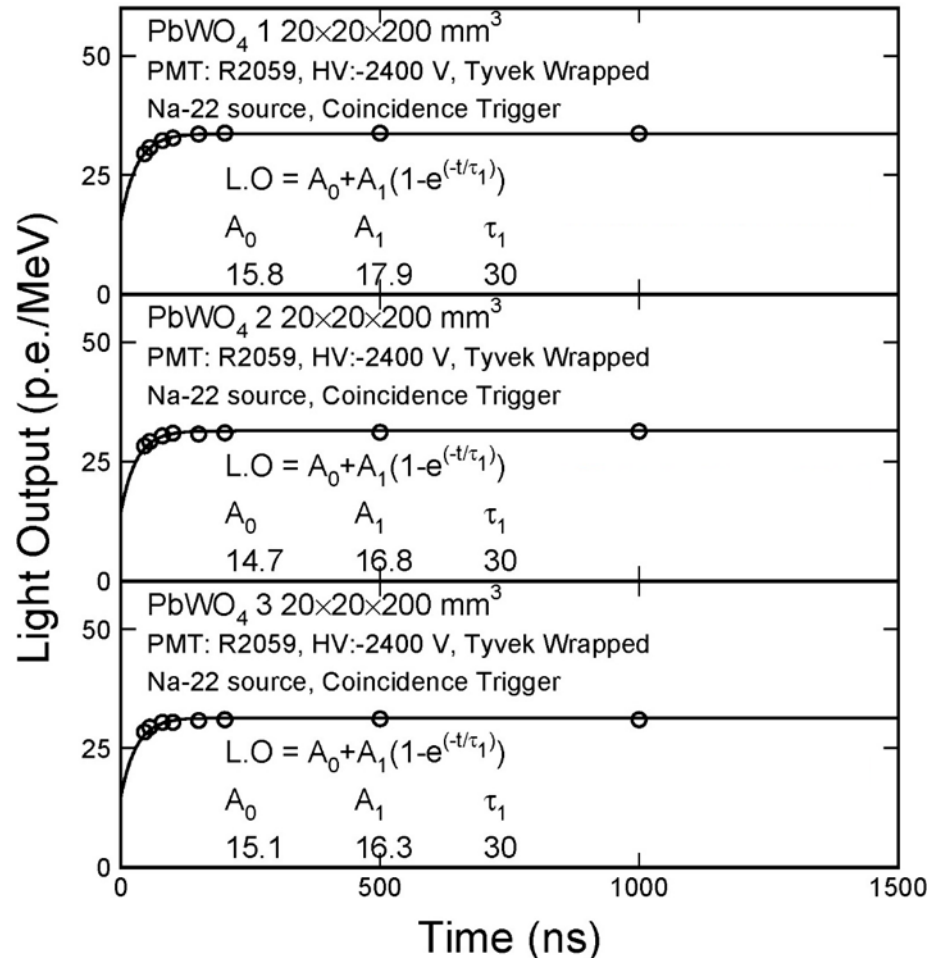
EWQE of 18.9%
used to convert
light output (LO)
in p.e./MeV to
light yield (LY) in
photons/MeV.

Both are
sample/wrapping/
coupling
dependent.



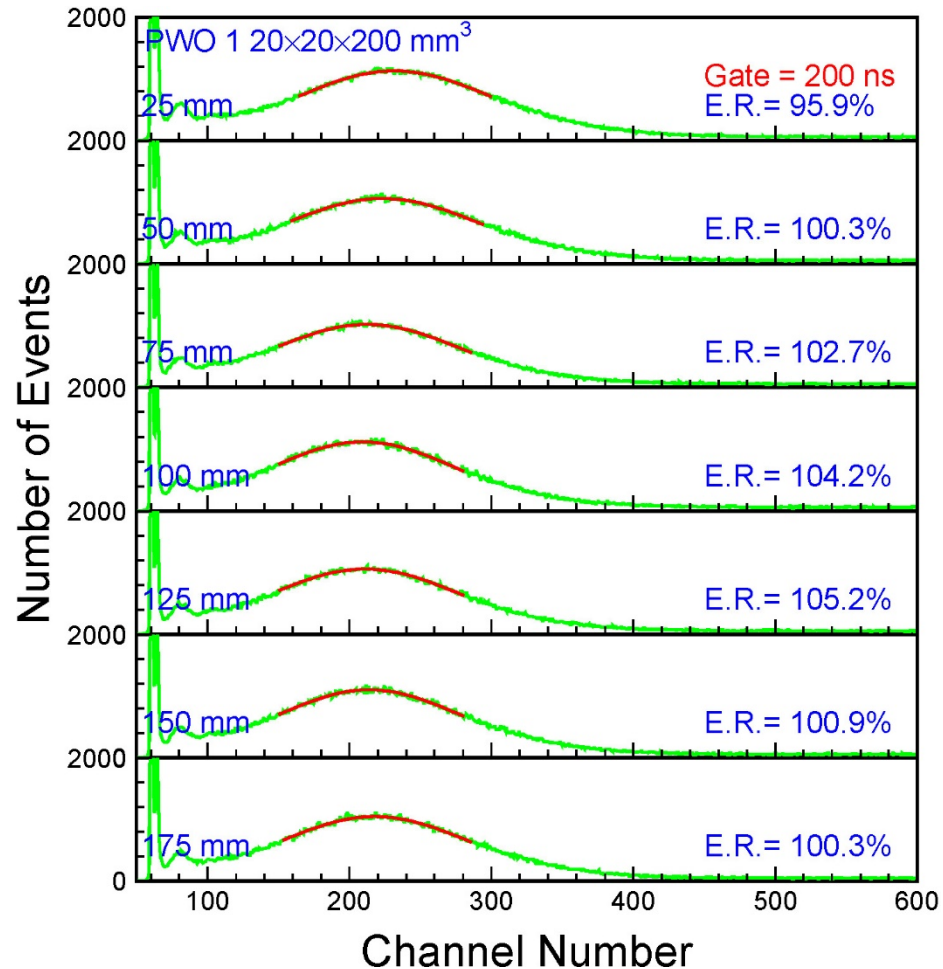
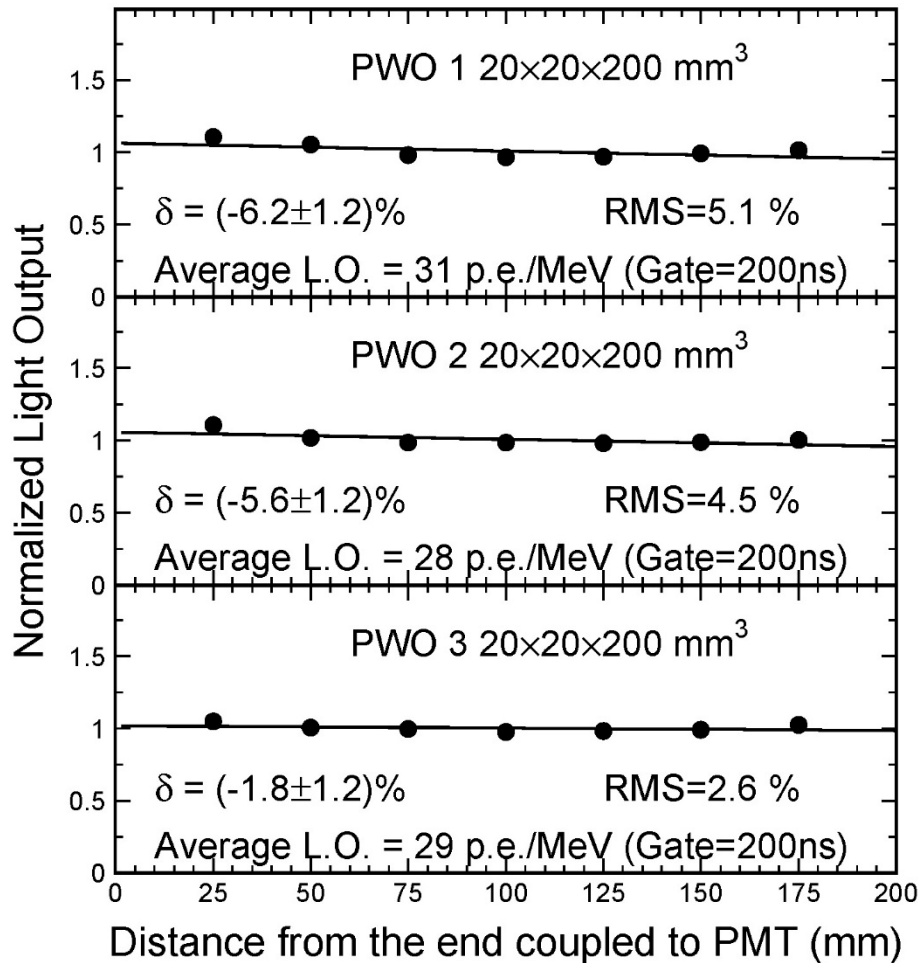
LO/LY and Decay Kinetics: PWO

PWO shows a fast light and a slow light of 30 ns decay with LO and LY of 32.2 p.e./MeV and 168 ph/MeV in 200 ns



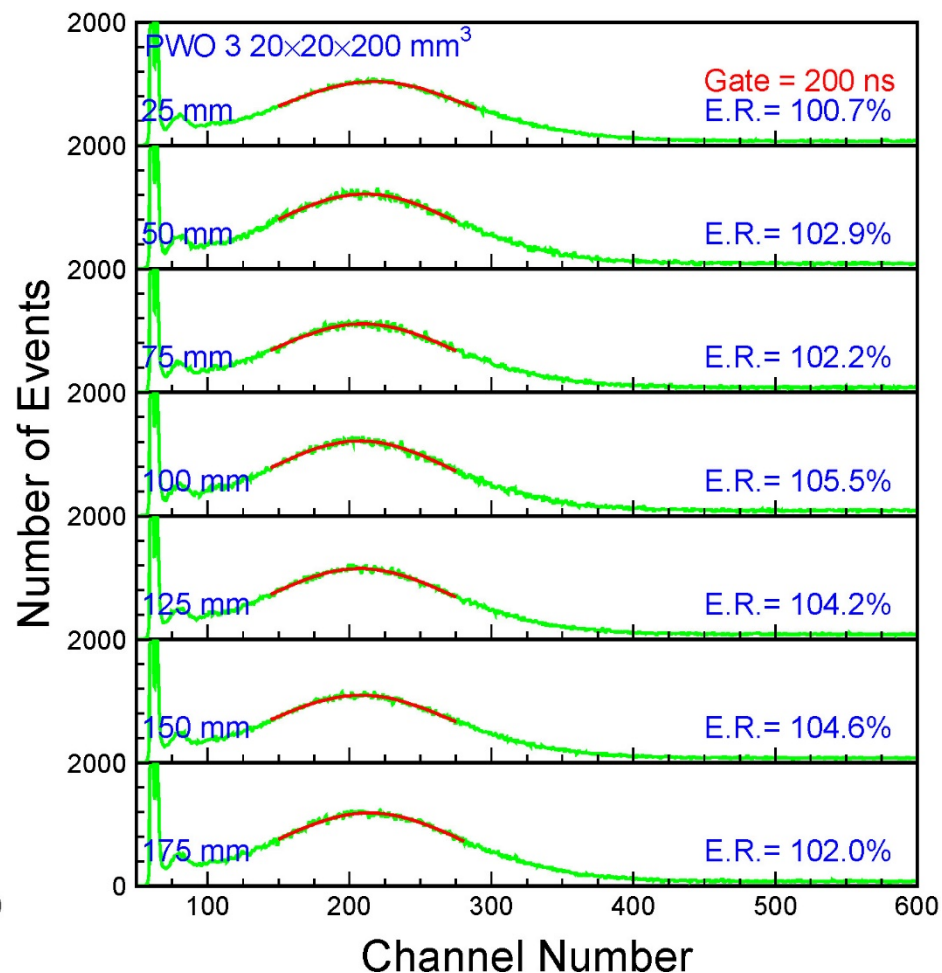
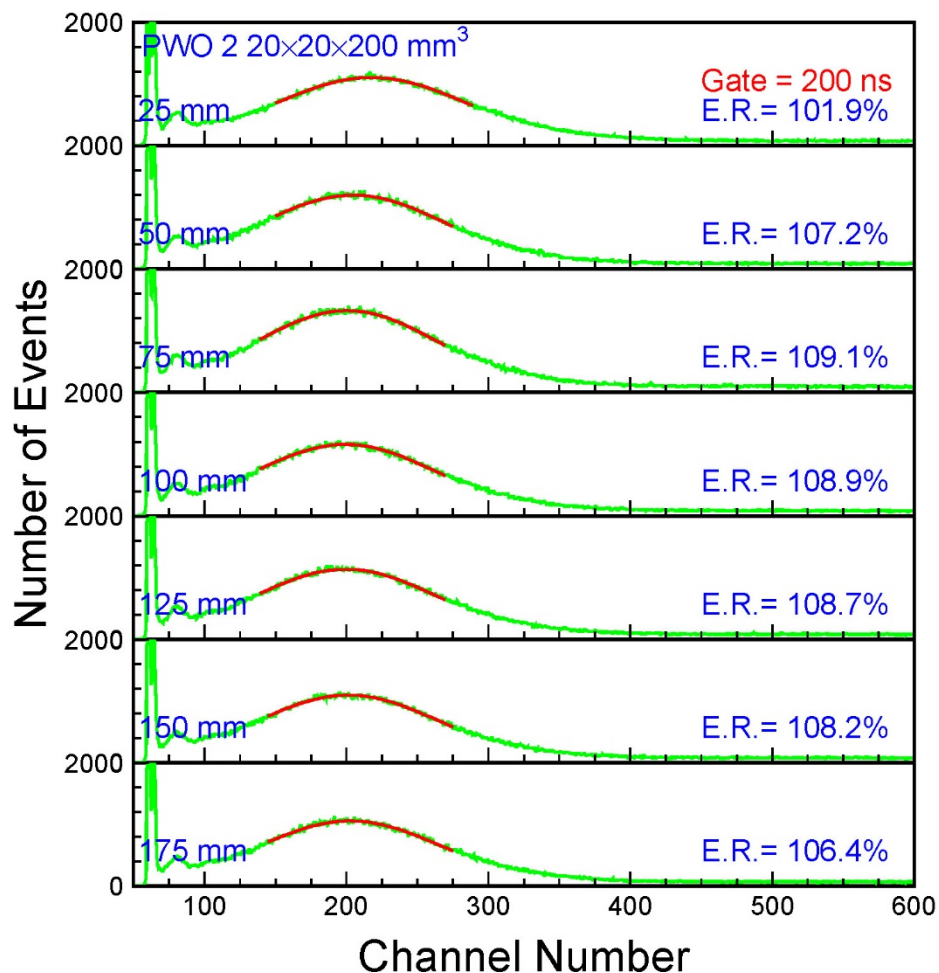
LRU: All Three and PHS: PWO-1

PWO 1/2/3 shows LRU rms of 5.1%/4.5%/2.6%
Average LO: 31/28/29 p.e./MeV for PWO-1/2/3



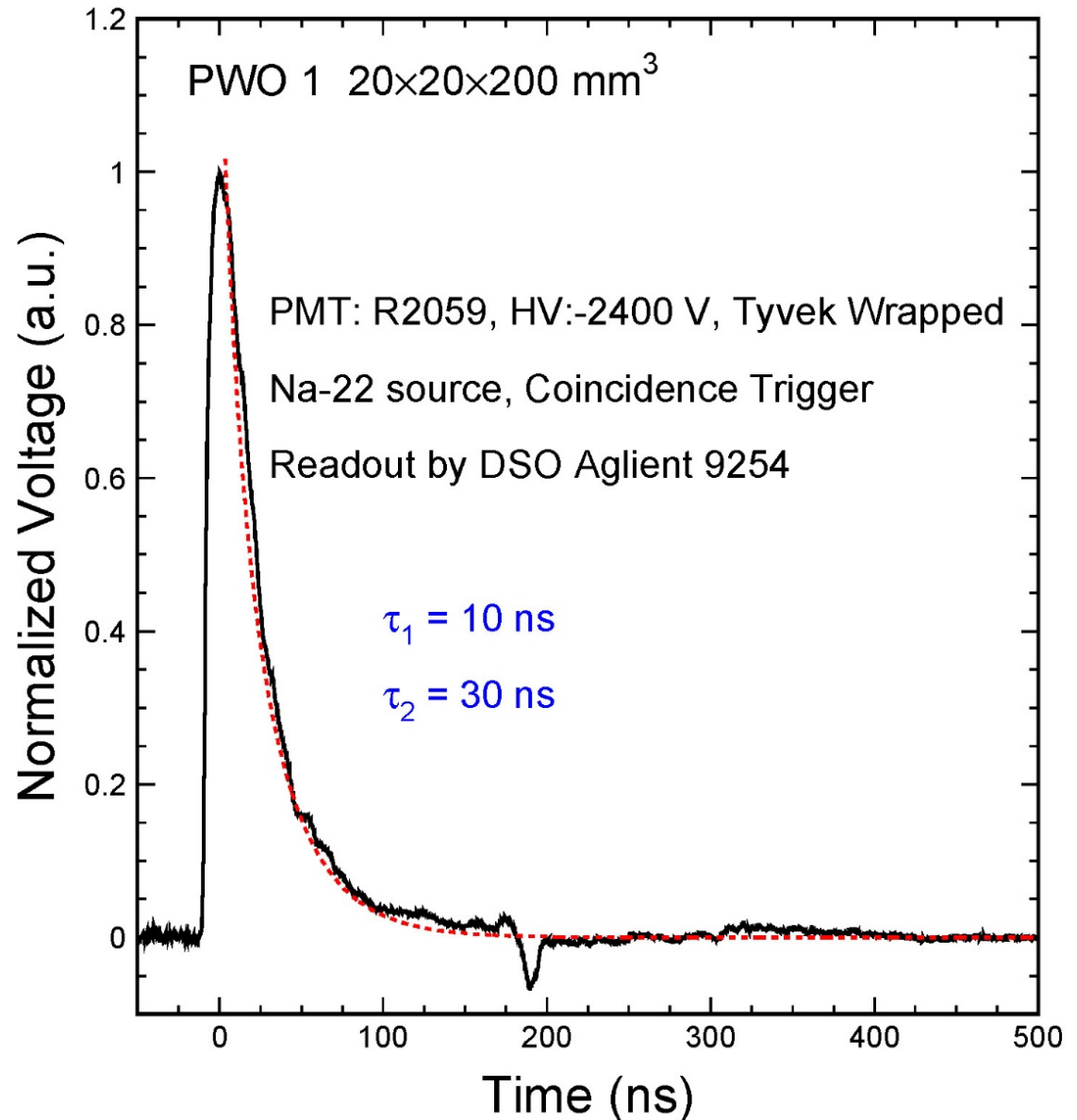
PHS: PWO-2,3

PWO 1 shows the highest light output and the best energy resolution



Pulse Shape Measured by DSO: PWO

Two
decay
time of 10
and 30 ns
observed



Summary: EWLT, LO, ER and LRU

LO & ER: Average of 7 points with 2,000/200 ns gate for BGO/PWO

BGO	EWLT (%)	Light Output (p.e./MeV)	Energy Resolution (%)	Light Response Uniformity (%)
BGO-1	72.2	733	17.0	2.2
BGO-2	73.8	739	16.9	2.4
BGO-3	74.6	722	17.0	2.9
Ave	73.5	731	17.0	2.5
rms/Ave (%)	1.4	1.0	0.2	12
PWO	EWLT (%)	Light Output (p.e./MeV)	Energy Resolution (%)	Light Response Uniformity (%)
PWO-1	59.9	31	101.4	5.1
PWO-2	63.0	28	107.2	4.5
PWO-3	61.7	29	103.2	2.6
Ave	61.5	29	103.9	4.1
rms/Ave (%)	2.1	3.6	2.4	26

Summary

Three each BGO and PWO crystals of 18 and 20 cm long respectively were received from University of Michigan. Their XEL, LT, TT and PHS spectra, EWQE, LO, LY, τ and LRU were measured at Caltech HEP Crystal Lab.

BGO/PWO show consistent XEL peaked at 462/424 nm.

BGO/PWO crystals show average 731/29 p.e./MeV and 4,660/155 photons/MeV after taking out EWQE values of 15.7%/18.9%. While BGO crystals show a single decay time of 314 ns, PWO crystals show two components with decay time of 10 and 30 ns.

Three BGO samples show a much better consistency than three PWO samples.

Acknowledgements: DOE HEP Award DE-SC0011925