



Photo-luminescence and Decay at 22, -35 and -60 °C for Eight LYSO Samples

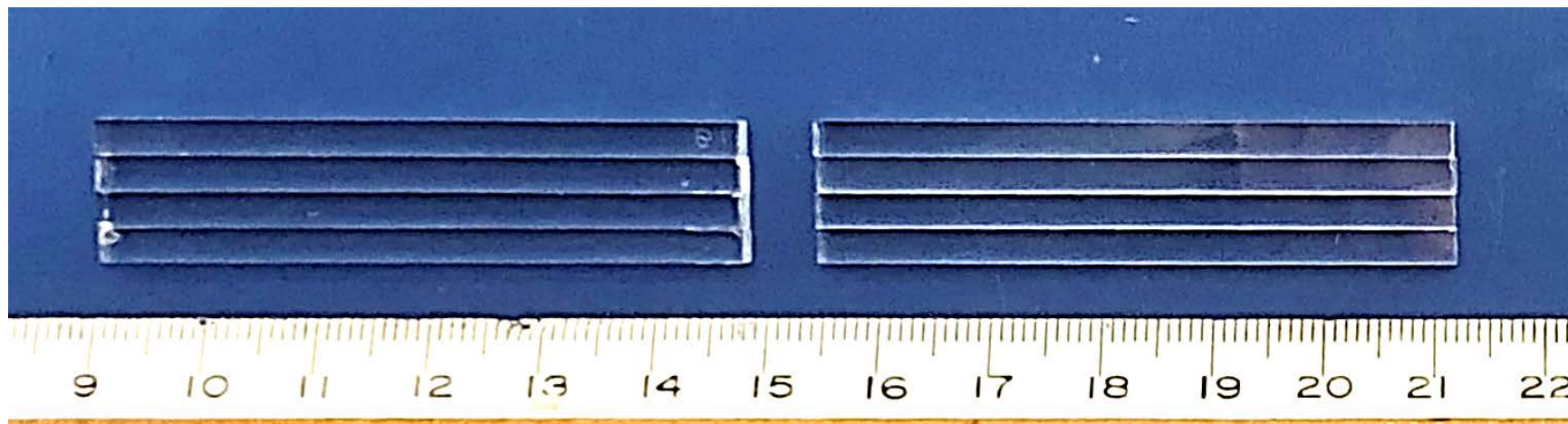
Chen Hu, Liyuan Zhang, Ren-Yuan Zhu, Jason Trevor,
Adi Bornheim, Nan Lu, Maria Spiropulu,

California Institute of Technology

July 22, 2020



LYSO Bars from Eight Vendors



ID	Dimension (mm ³)	#	Polishing
BTL LYSO bar-1,8	3.12x3.75x57	8	All faces
Received on Dec 4 th , 2019. Poor surface quality observed for some samples			

Experiments

Excitation, emission and decay of photo-luminescence (PL) measured at 22, -35 and -60 °C with Edinburgh FLS920 fluorescence spectrometer

LT/LO/Decay/CTR and RIN reported on 1/22/20 and 3/25/20, respectively

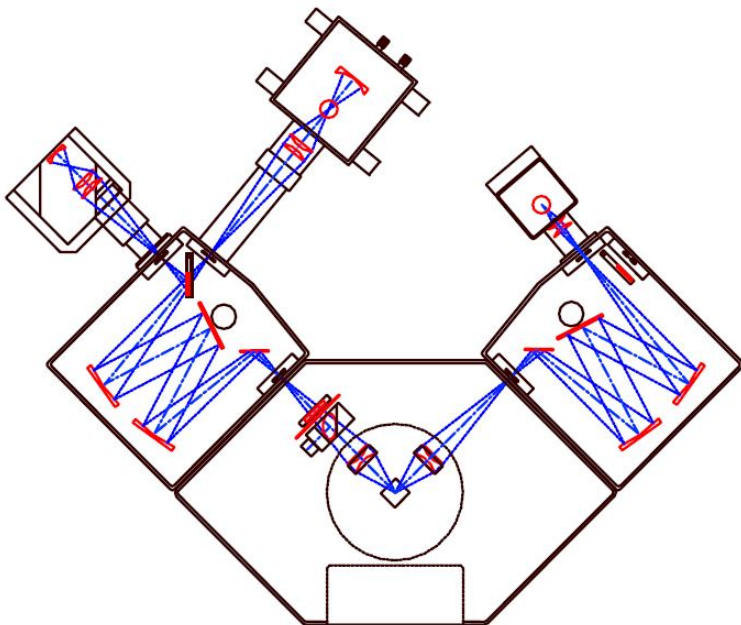


PL and Decay with LN Cooling



Edinburgh FLS920 fluorescence spectrometer

- A Xe900 continuous xenon lamp;
- A nF920 ns flash-lamp;
- Single photon counting PMT and TCSPC;
- Oxford cryostat OptistatDN: 77.2-500K;
- A homemade sample holder for BTL LYSO;
- Excitation, PL emission and decay: at RT, and at -35 and -60 °C with LN.





Measurement Procedure



Excitation, emission and decay time: one sample per day

	Task	Procedure
9:30 am – 10:30 am	Change Sample 295 K measurement	Change sample → Start pumping → 295 K measurement → Stop pumping
10:30 am – 11:00 am	LN filling	2 nd person required for safety
11:00 am – 12:00 pm	238 K measurement	At each temperature: Wait 30 min at the target temperature Ex Spectrum (Em=430 nm): 5 min Em Spectrum (Ex=356 nm): 5 min Decay Profile (Ex356, Em430): 20 min
12:00 pm – 1:00 pm	213 K measurement	

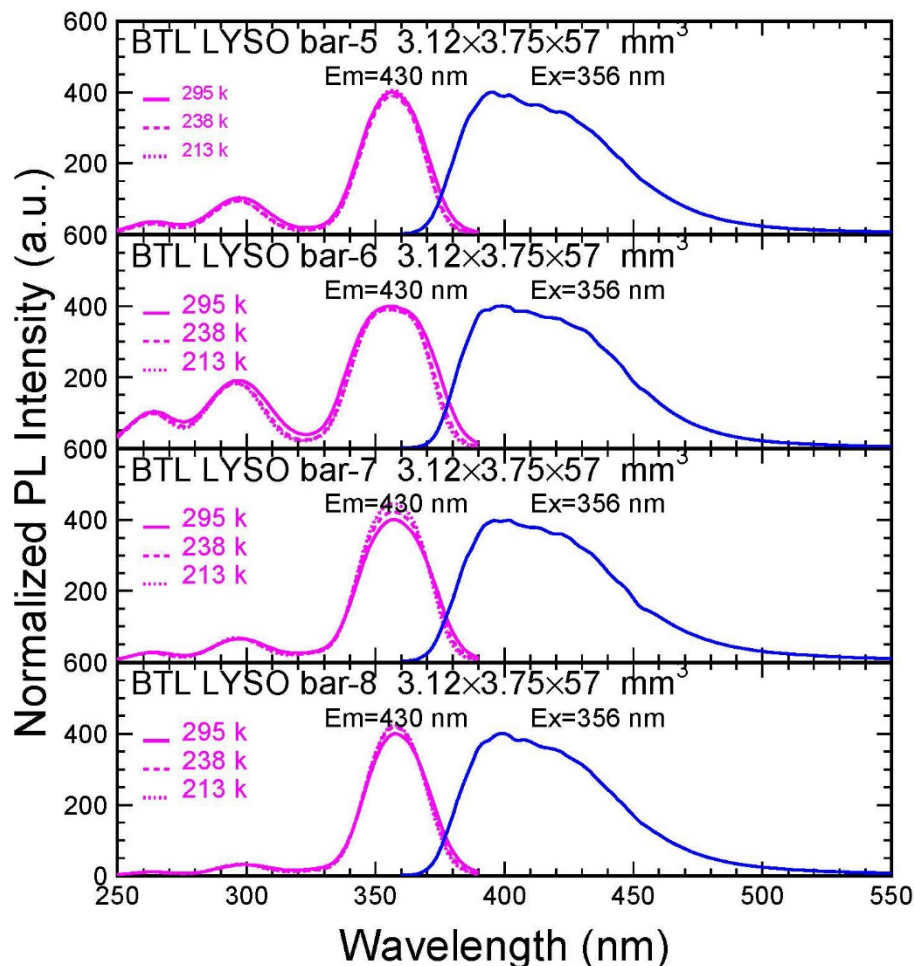
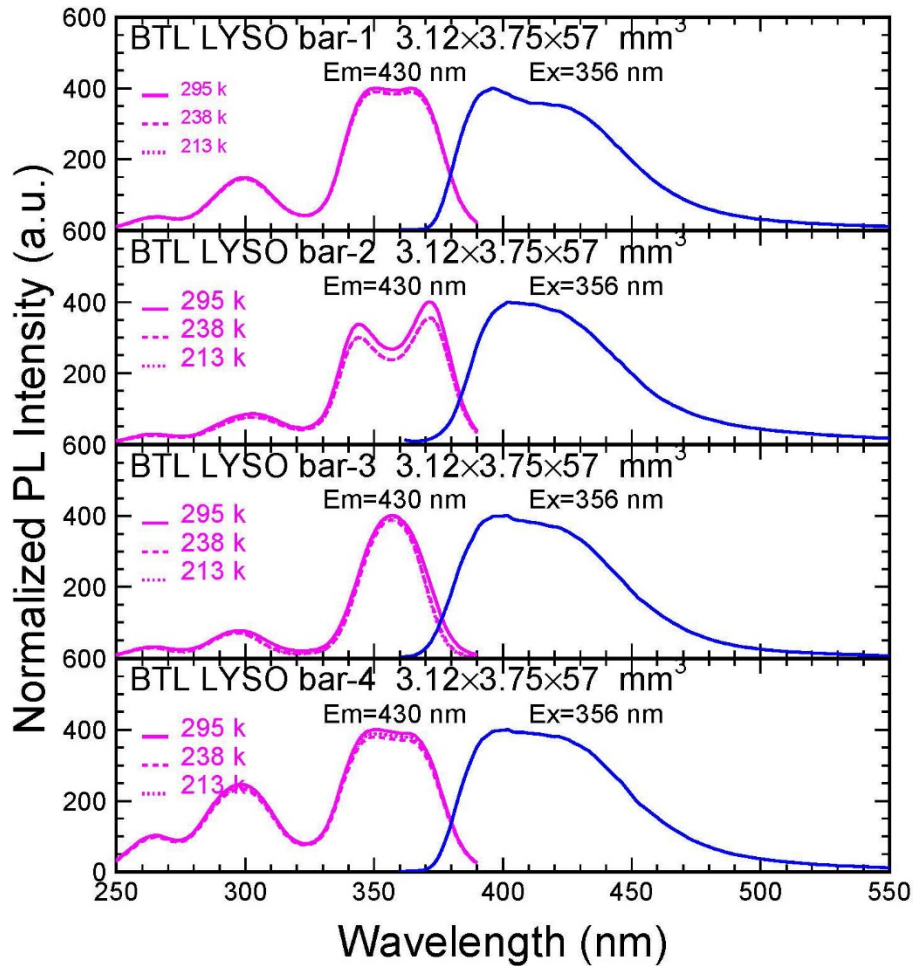
PL intensity depends on sample surface/configuration
Comparison can be made for a fixed surface/configuration



Excitation and PL Emission @295 K

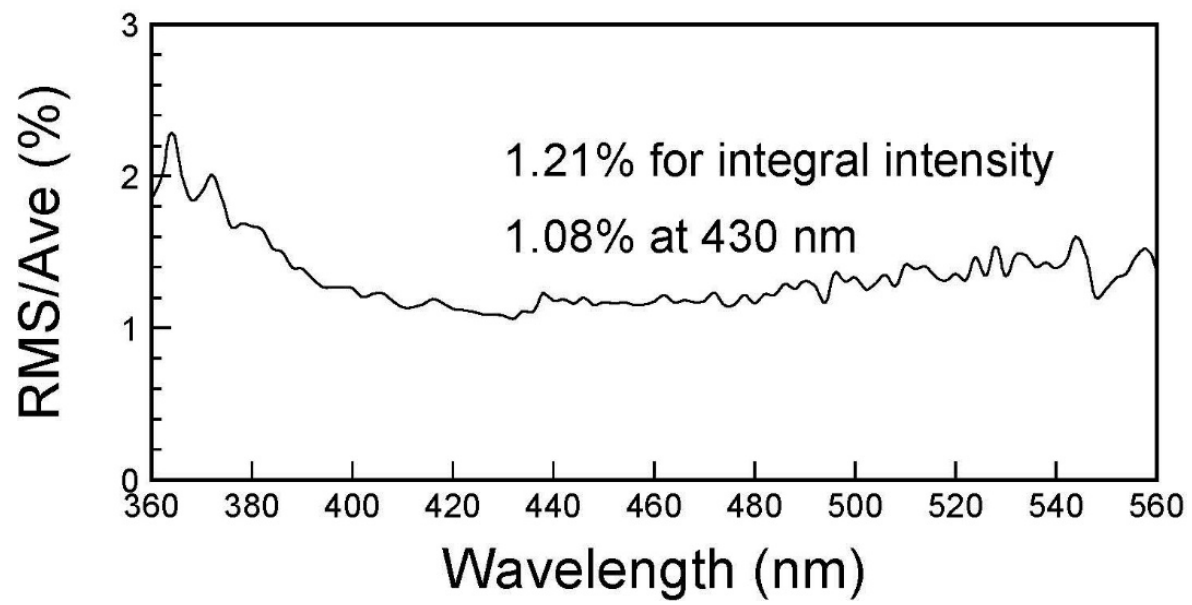
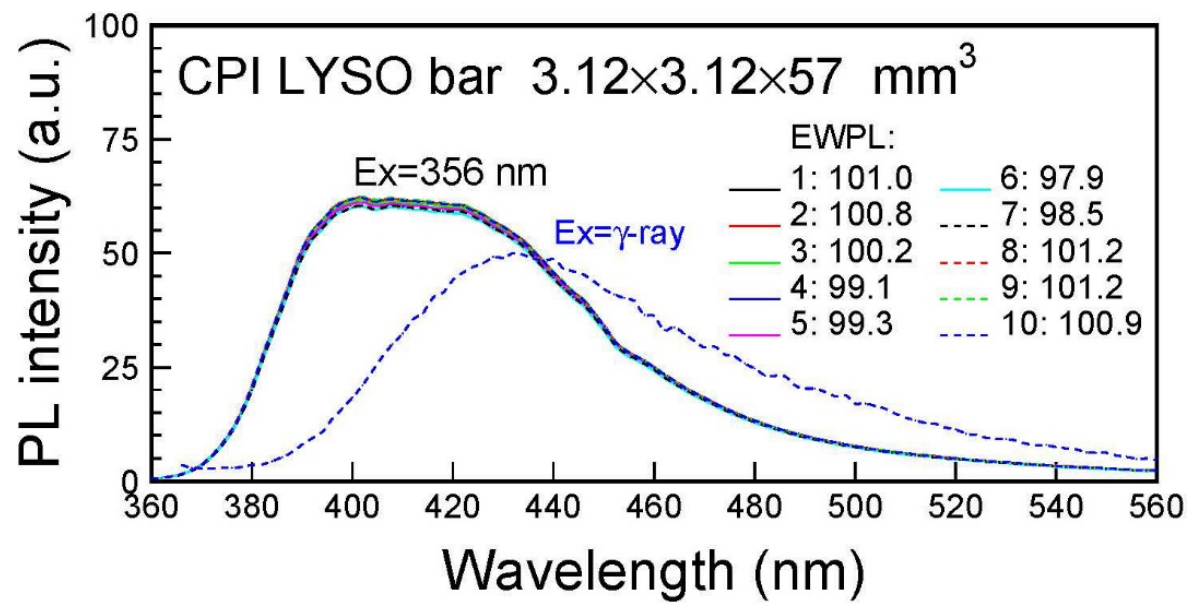


Consistent emission for all LYSO samples
Samples 1, 2, 4 and 6 show broader excitation





Systematic Uncertainty: PL intensity



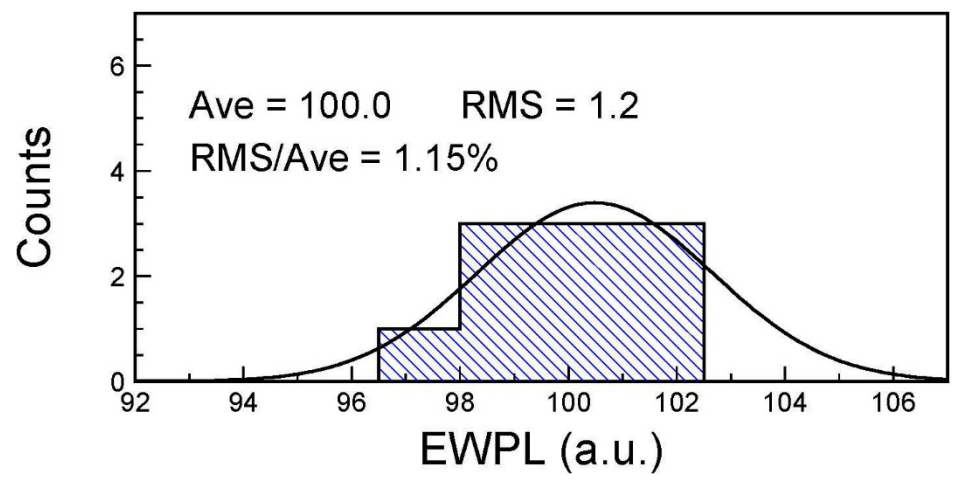
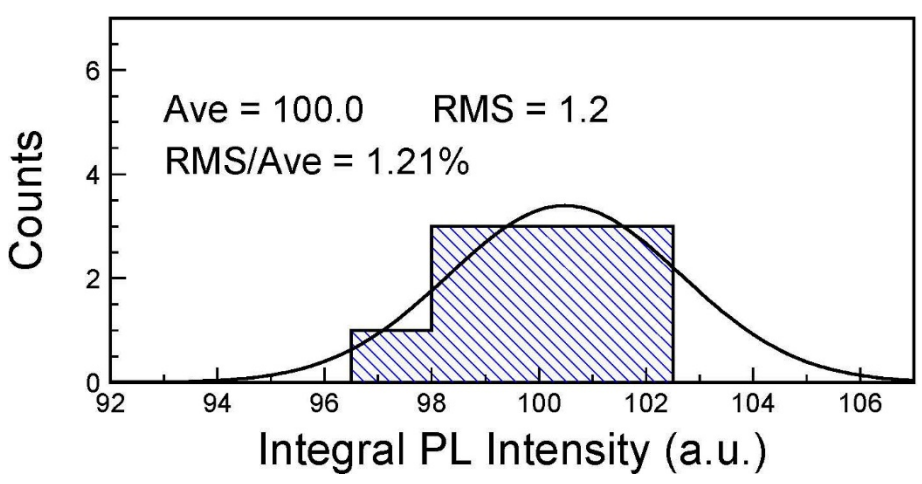
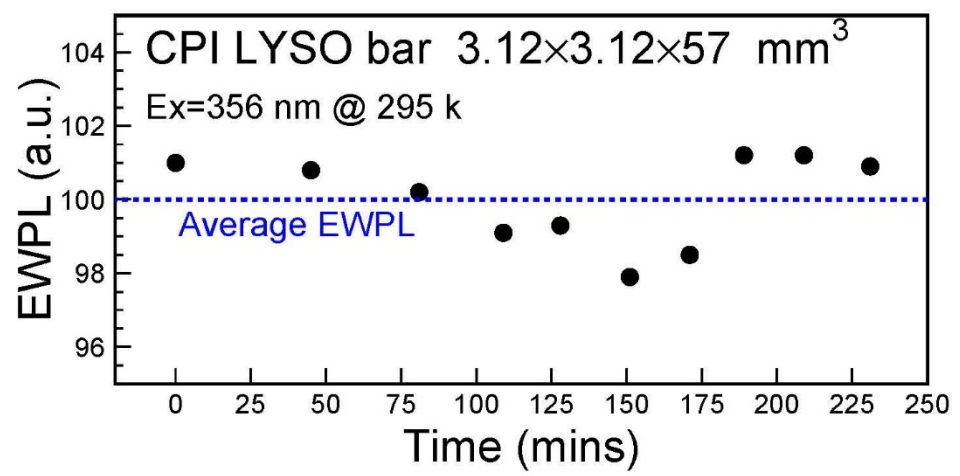
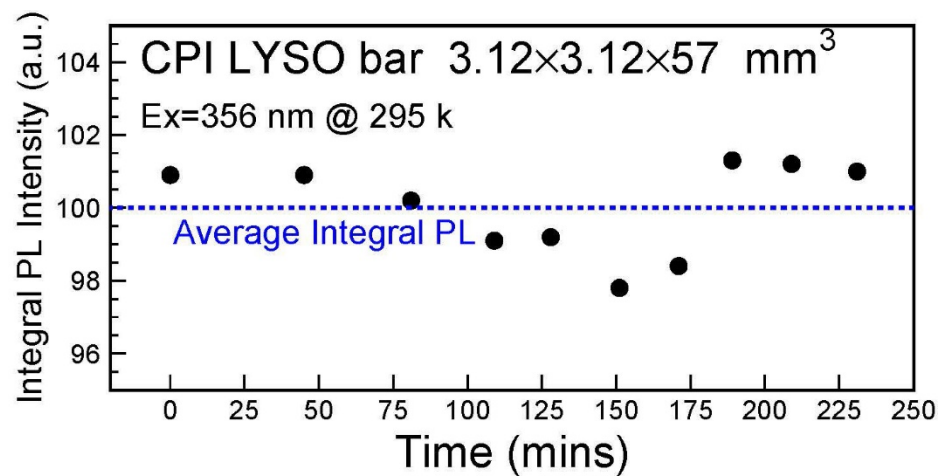
Uncertainty of PL intensity and EWPL (radioluminescence weighted PL intensity): 1.2% determined with ten measurements for a fixed configuration



Uncertainty: PL Intensity & EWPL



1.2% for both integral and EWPL intensities

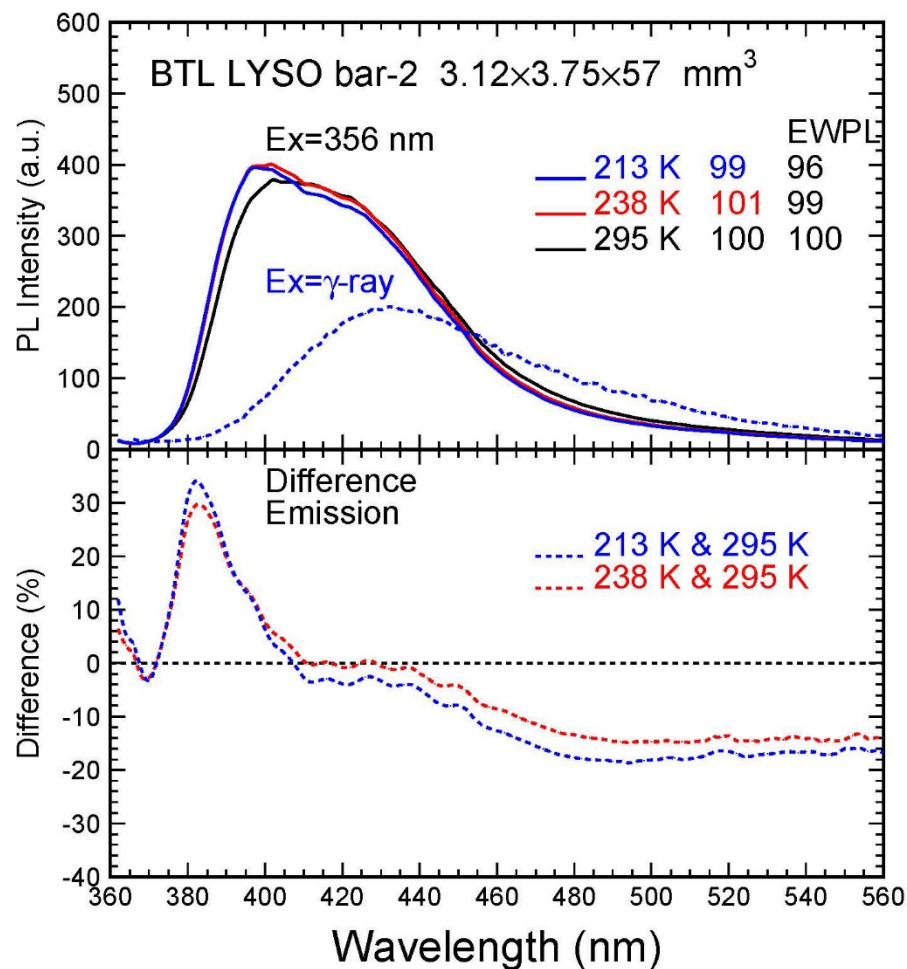
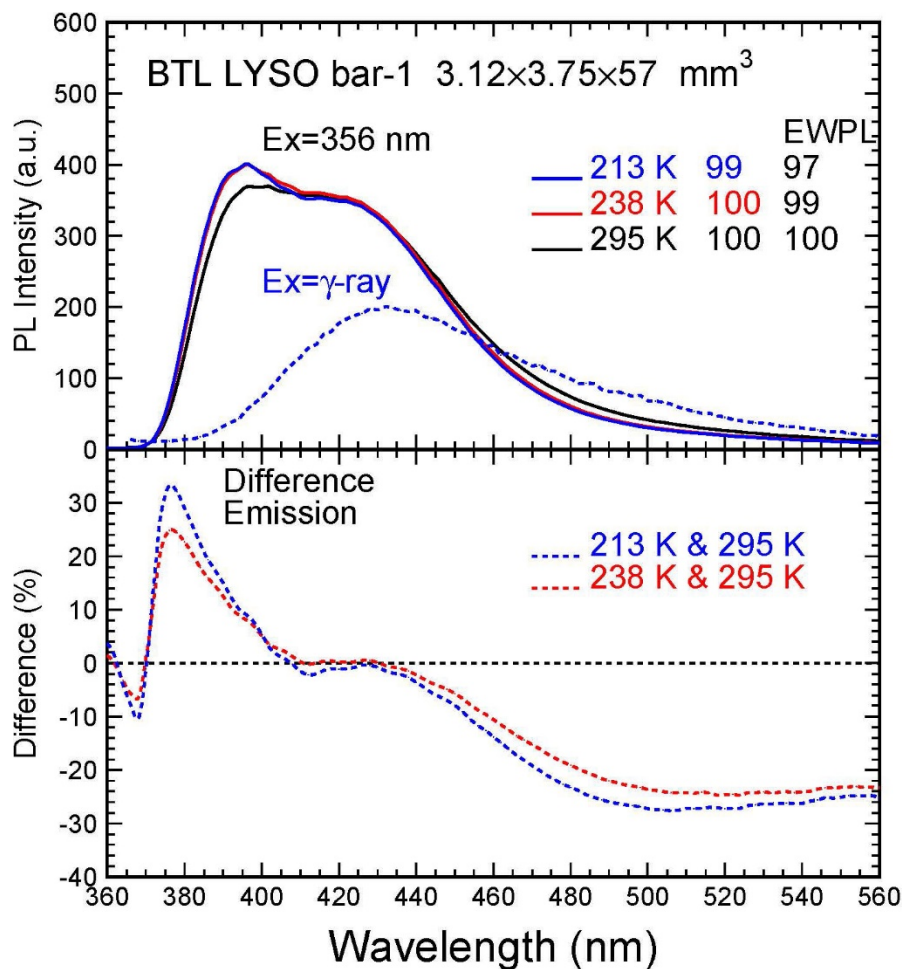




Temperature Dependent PL Intensity for BTL LYSO Vendors 1 and 2



PL shape varies, not much in total and EWPL intensity

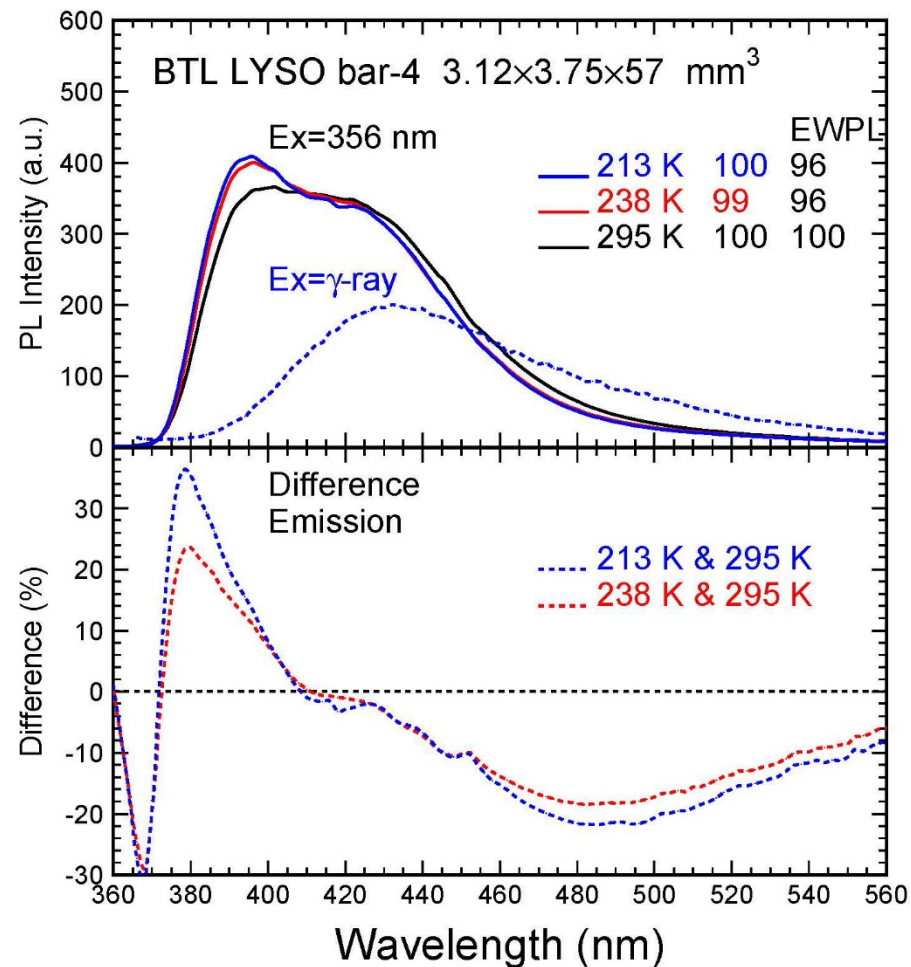
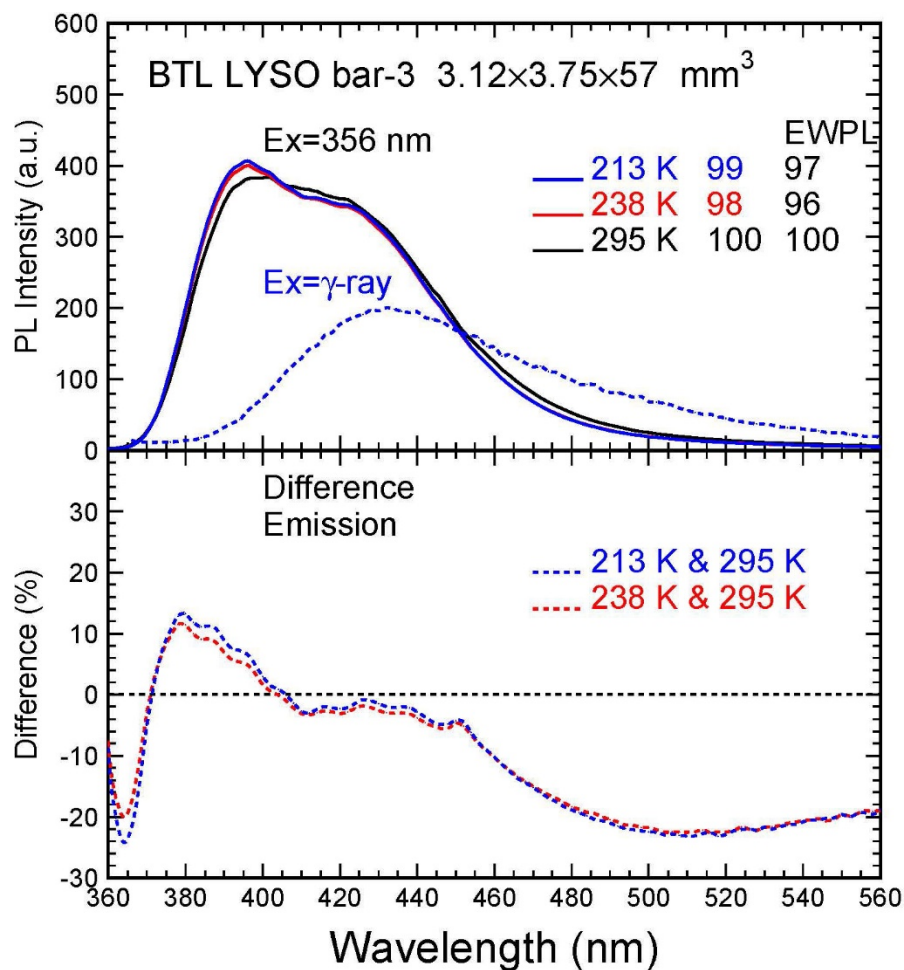




Temperature Dependent PL Intensity for BTL LYSO Vendors 3 and 4



PL shape varies, not much in total and EWPL intensity

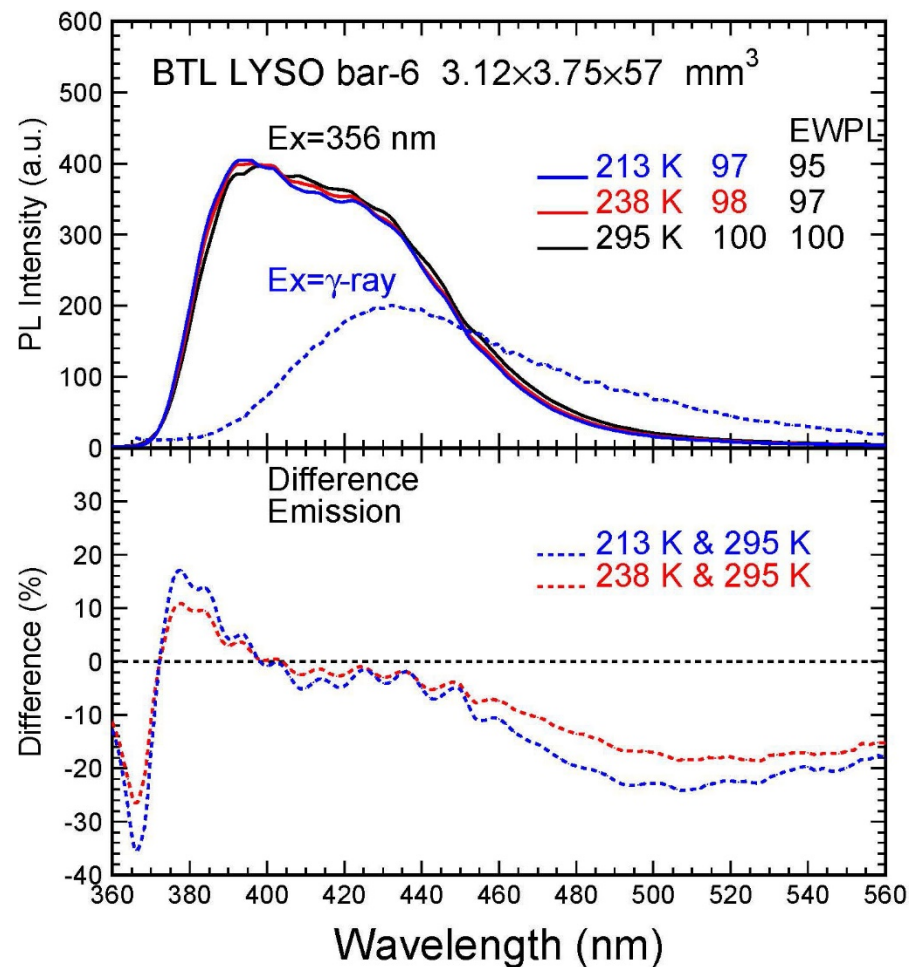
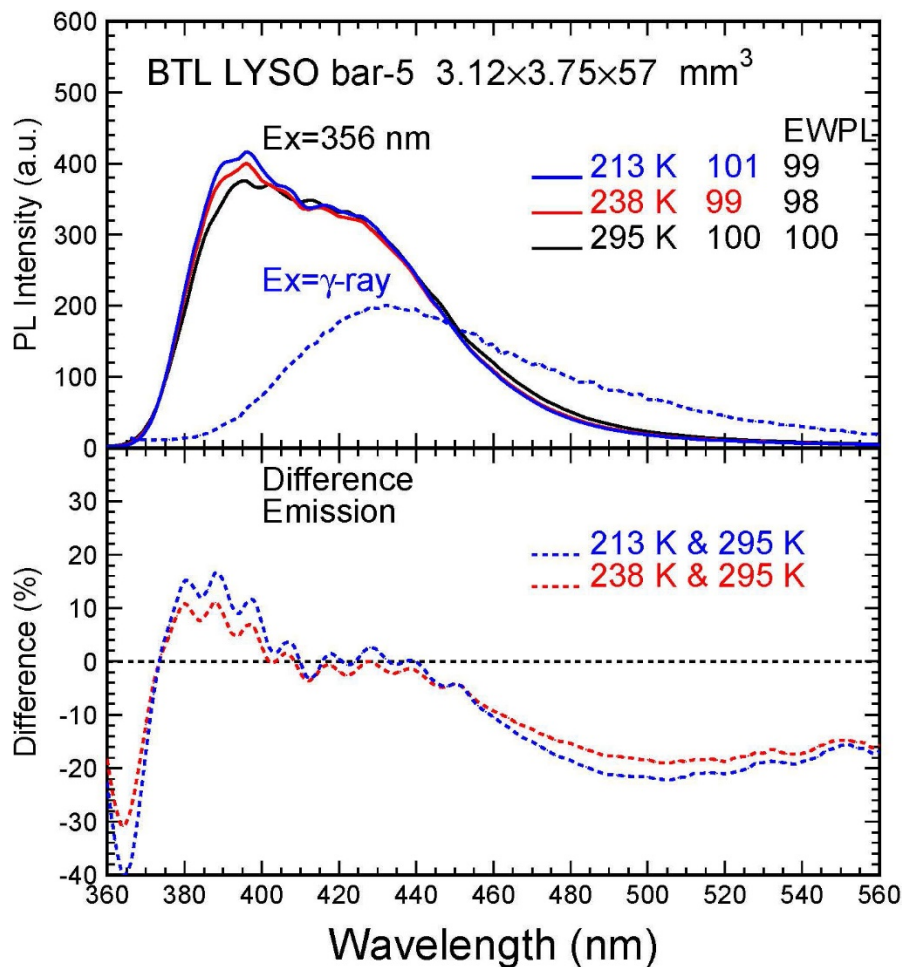




Temperature Dependent PL Intensity for BTL LYSO Vendors 5 and 6



PL shape varies, not much in total and EWPL intensity

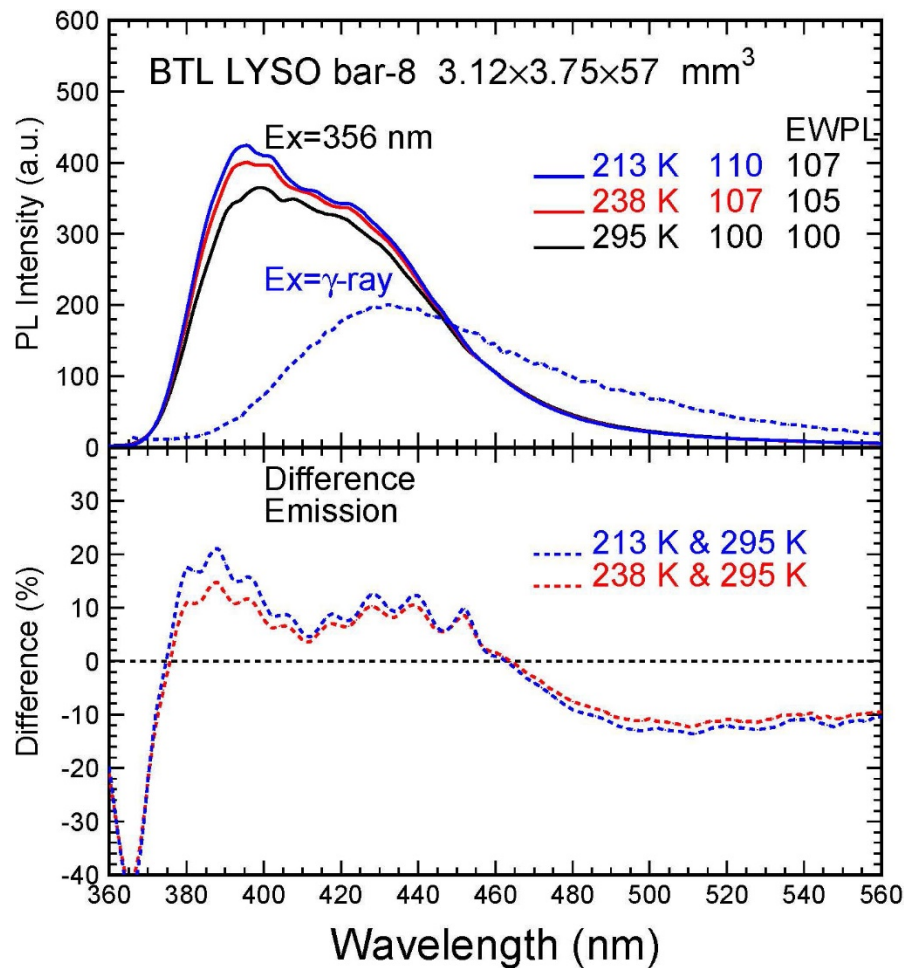
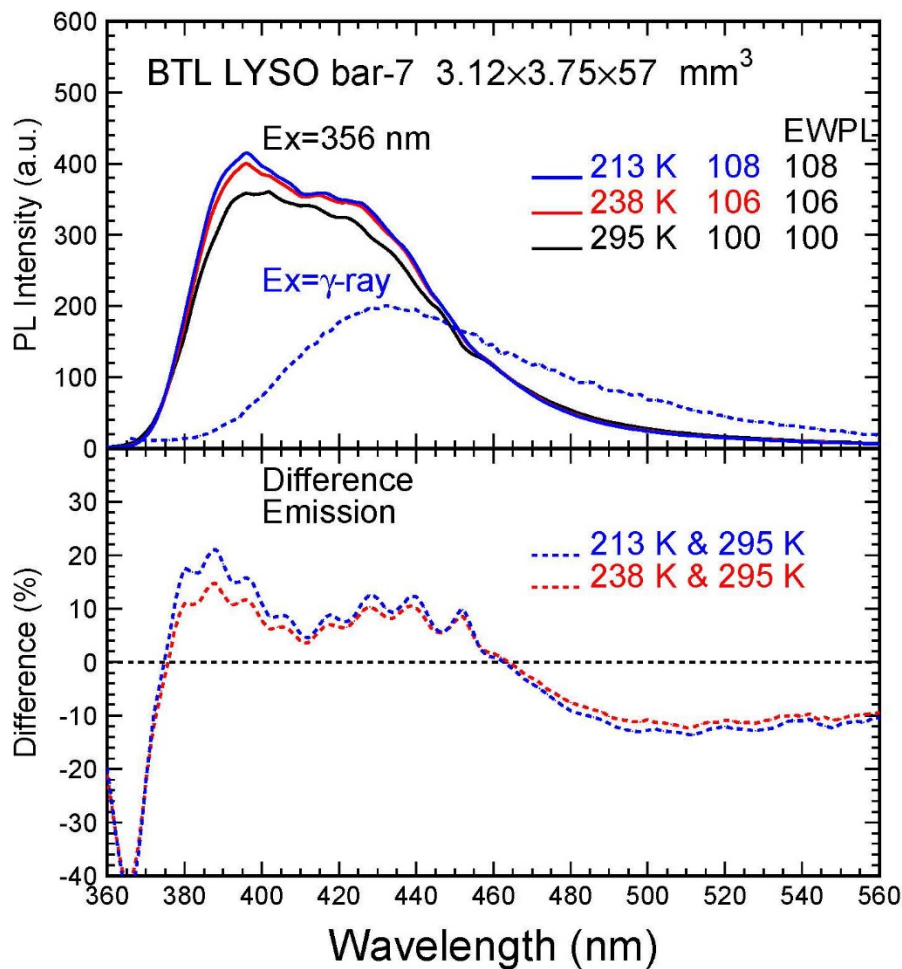




Temperature Dependent PL Intensity for BTL LYSO Vendors 7 and 8



PL shape varies, not much in total and EWPL intensity

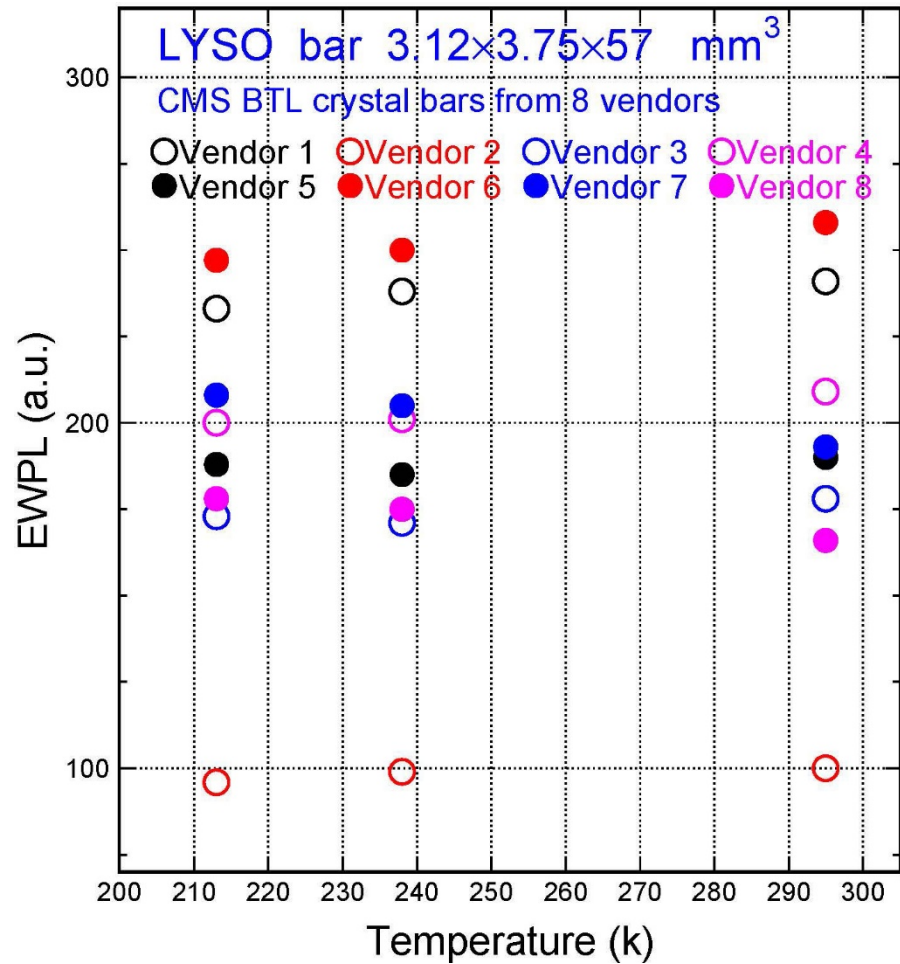
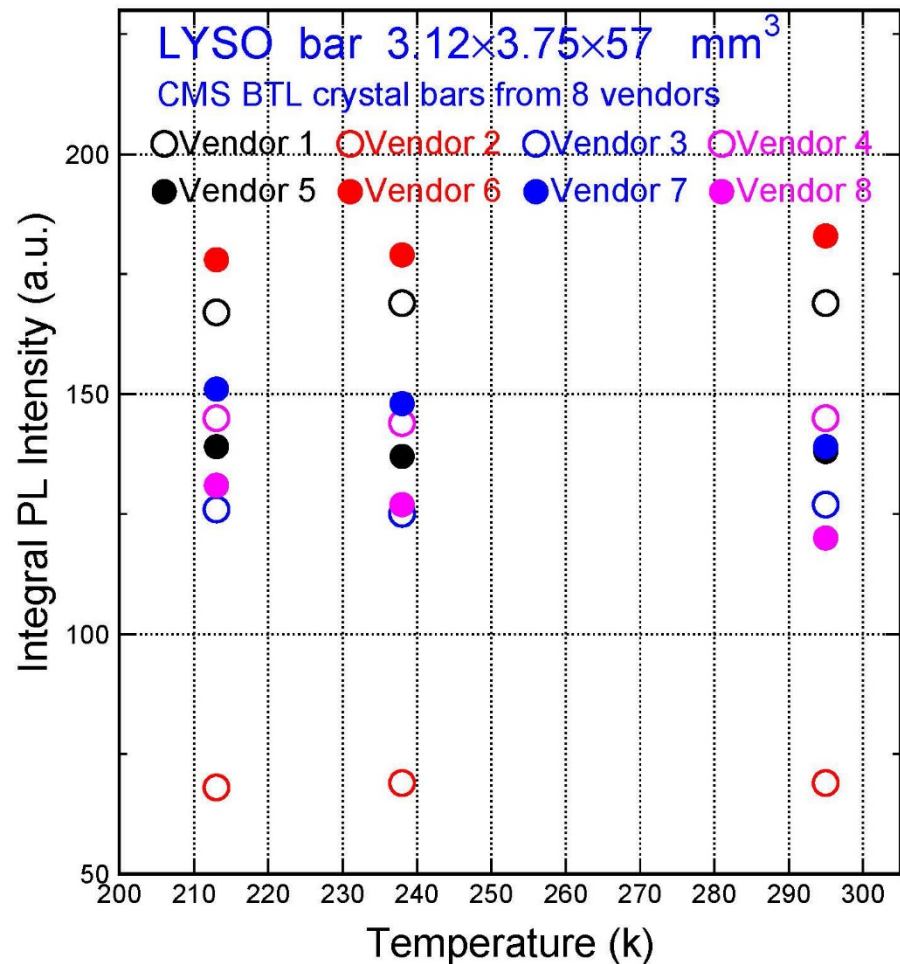




Integral PL/EWPL Intensity



Large divergence in PL/EWPL compared to 5.6% in LO





LT/LO/ τ /CTR @ 1/20/20



Light output measured with Teflon block wrapping and an air gap coupling to a PMT R1306 with triggers provided by a Na-22 source at the crystal center (Reported In the BTL Sensor meeting, 1/22/2020)

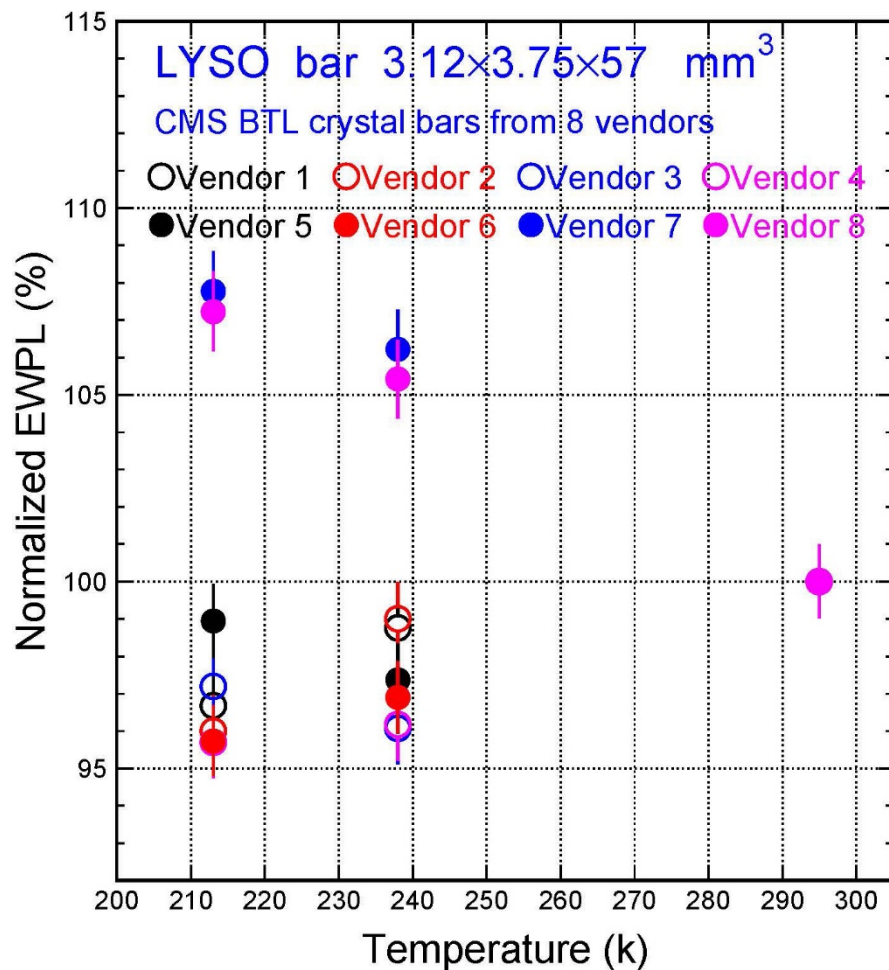
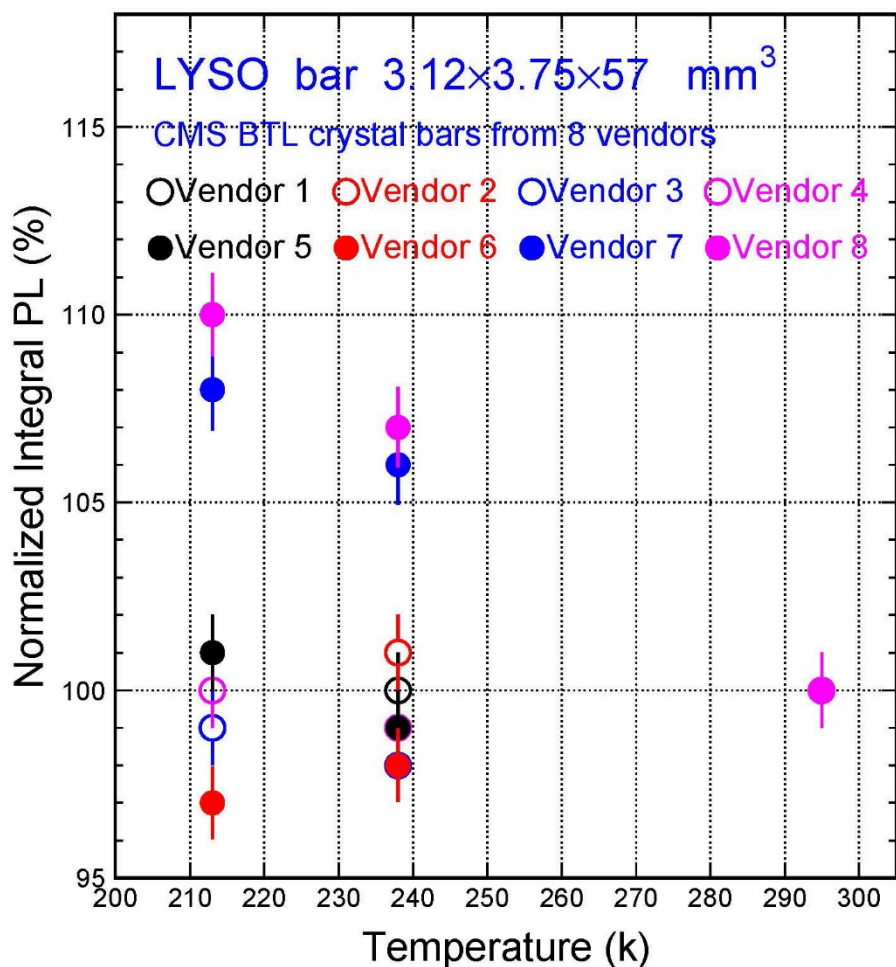
ID	EWLT (%)	T% @ 420 nm	200ns E.R. (%)	200ns L.O. (p.e./MeV)	2000ns L.O. (p.e./MeV)	LO(200)/LO(2000)	Decay Time (ns)	τ /LO(200)	Corrected CTR (ps)
1	62.0	78.6	13.9	1100	1134	97.0%	44.5	0.040	43.5
2	63.7	80.2	14.0	1207	1240	97.3%	45.0	0.037	42.3
3	73.3	84.5	13.6	1118	1135	98.5%	41.1	0.037	43.1
4	60.6	76.5	16.4	983	1029	95.5%	46.2	0.047	47.7
5	70.8	81.4	13.7	1141	1160	98.4%	41.3	0.036	43.1
6	65.0	78.0	14.9	1145	1177	97.3%	45.1	0.039	43.5
7	68.9	82.8	14.2	1137	1163	97.8%	42.9	0.038	44.2
8	60.8	75.6	15.6	1057	1076	98.2%	39.0	0.037	42.2
Ave	65.6	79.7	14.5	1111	1139	97.5%	43.1	0.039	43.7
RMS	6.9%	3.6%	6.5%	5.6%	5.3%	0.9%	5.4%	8.5%	3.7%
Systematic Uncertainty	0.5%	0.5%	1.7%	0.7%	1.0%	1.0%	3%	3%	1.4%



Normalized PL/EWPL Intensity



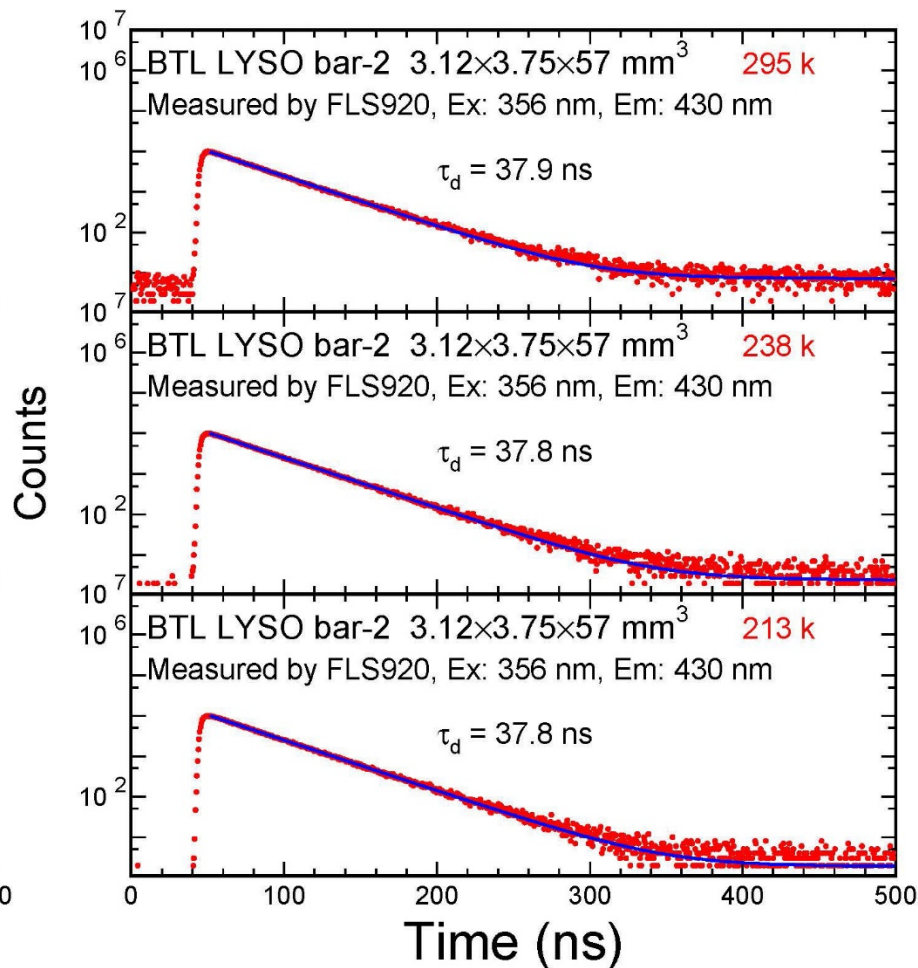
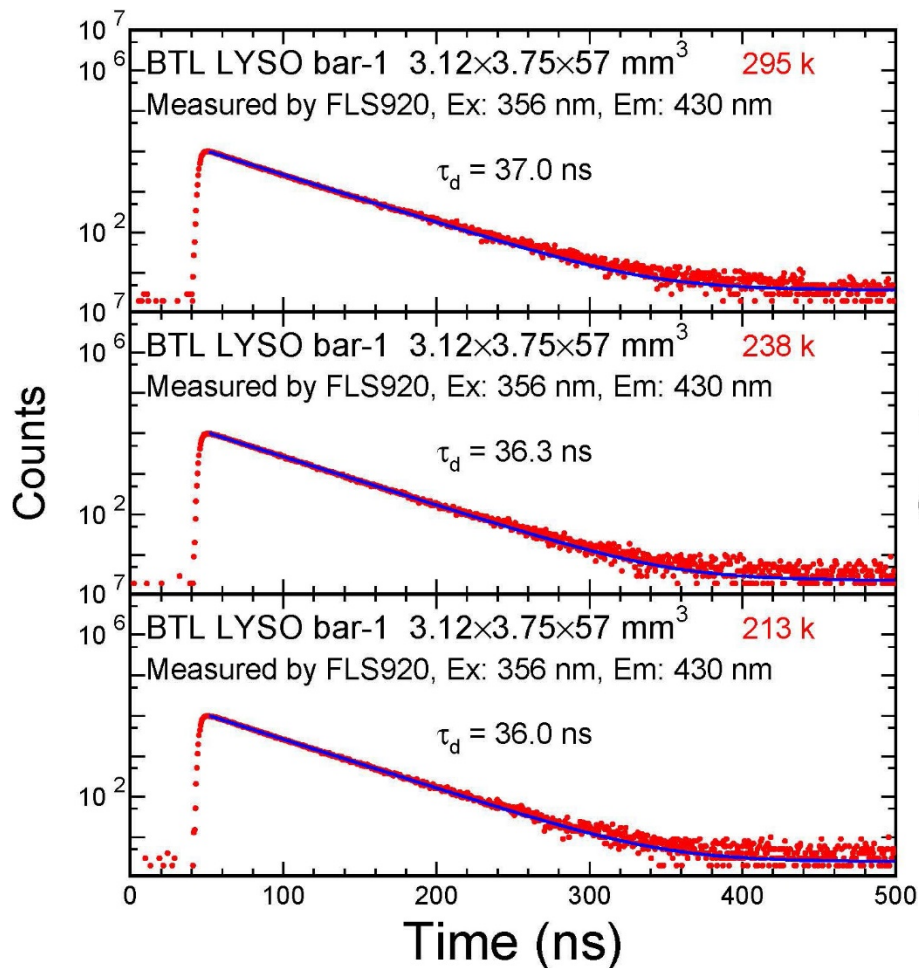
Vendors 7 and 8 show higher PL intensity at low temperatures
Discussion with vendors would help for a better understanding





Temperature Dependent Decay Profile for BTL LYSO Vendors 1 and 2

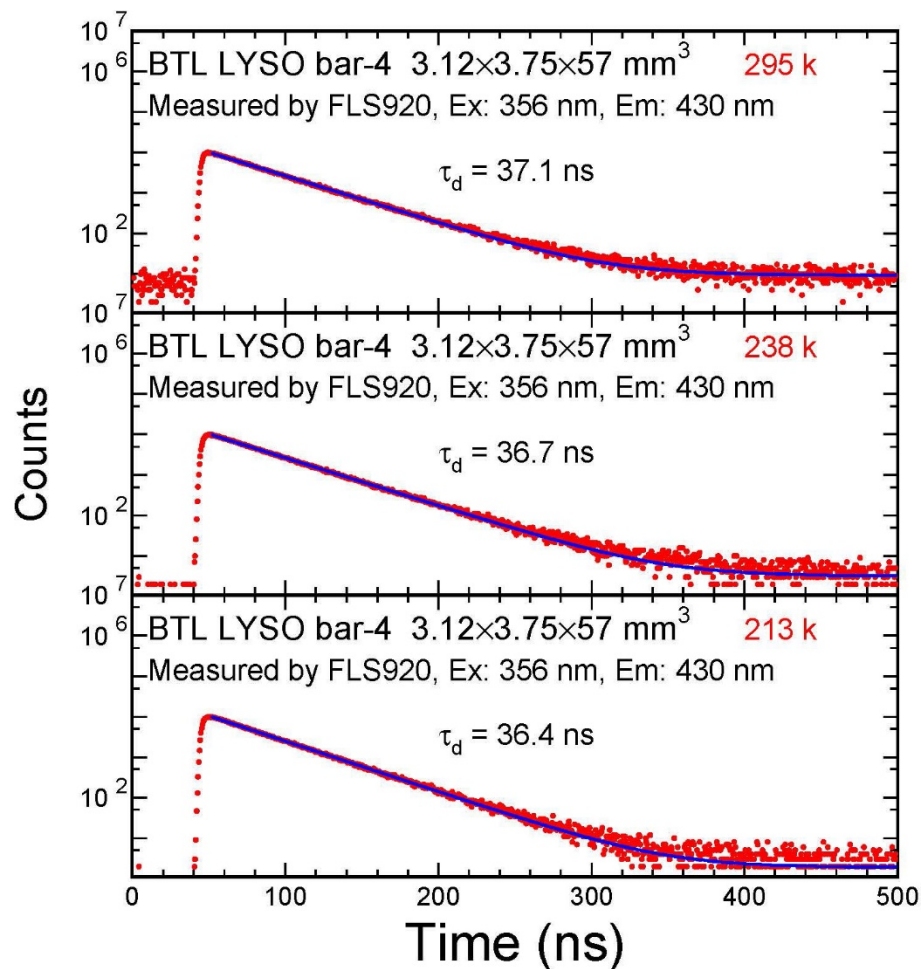
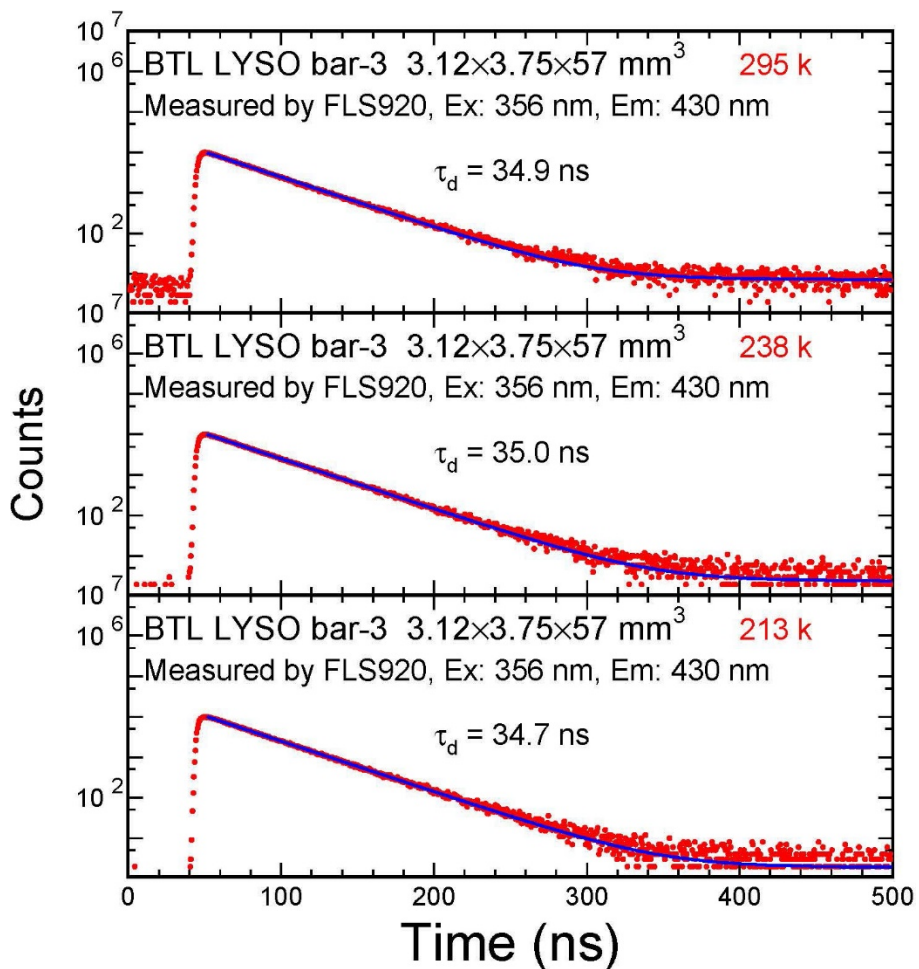
A small variation of decay time at low temperature





Temperature Dependent Decay Profile for BTL LYSO Vendors 3 and 4

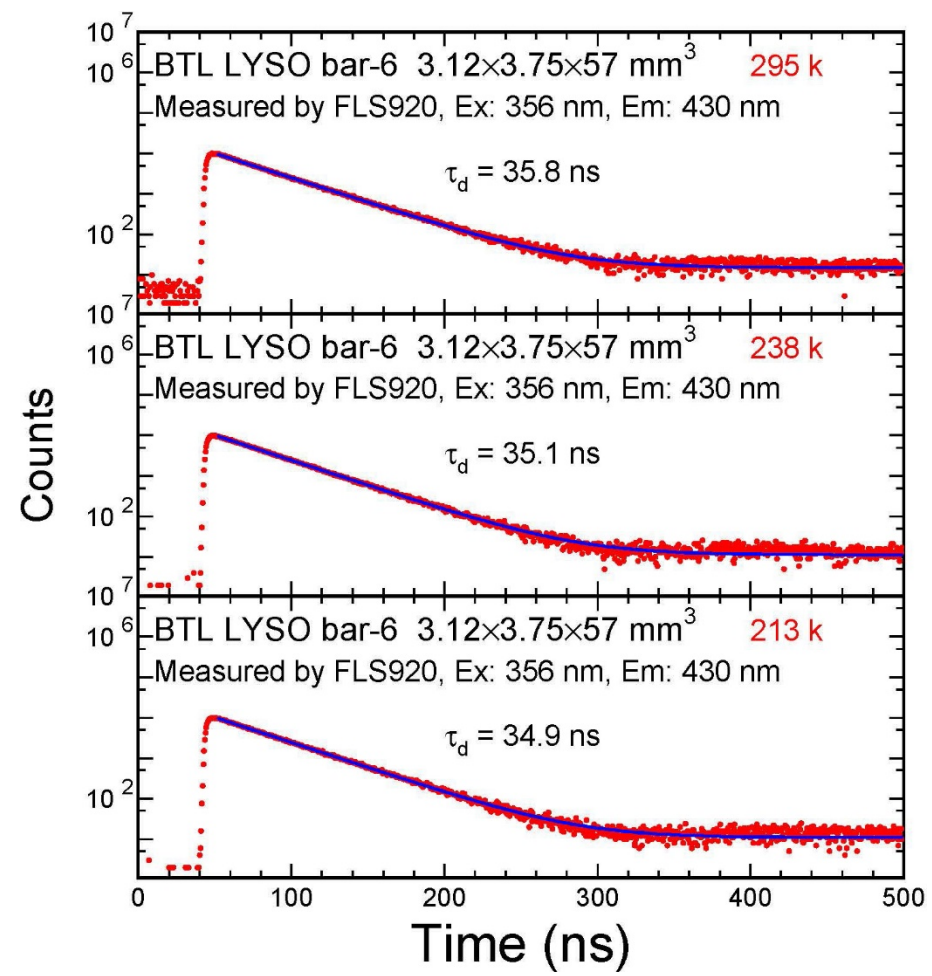
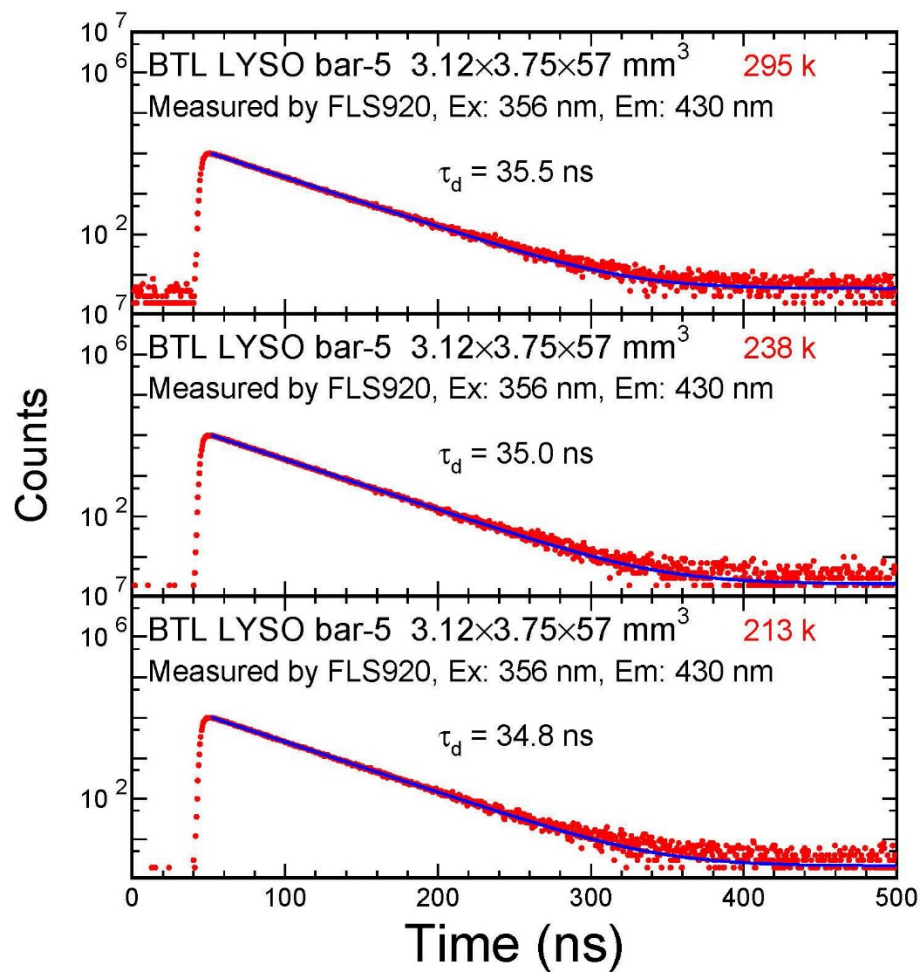
A small variation of decay time at low temperature





Temperature Dependent Decay Profile for BTL LYSO Vendors 5 and 6

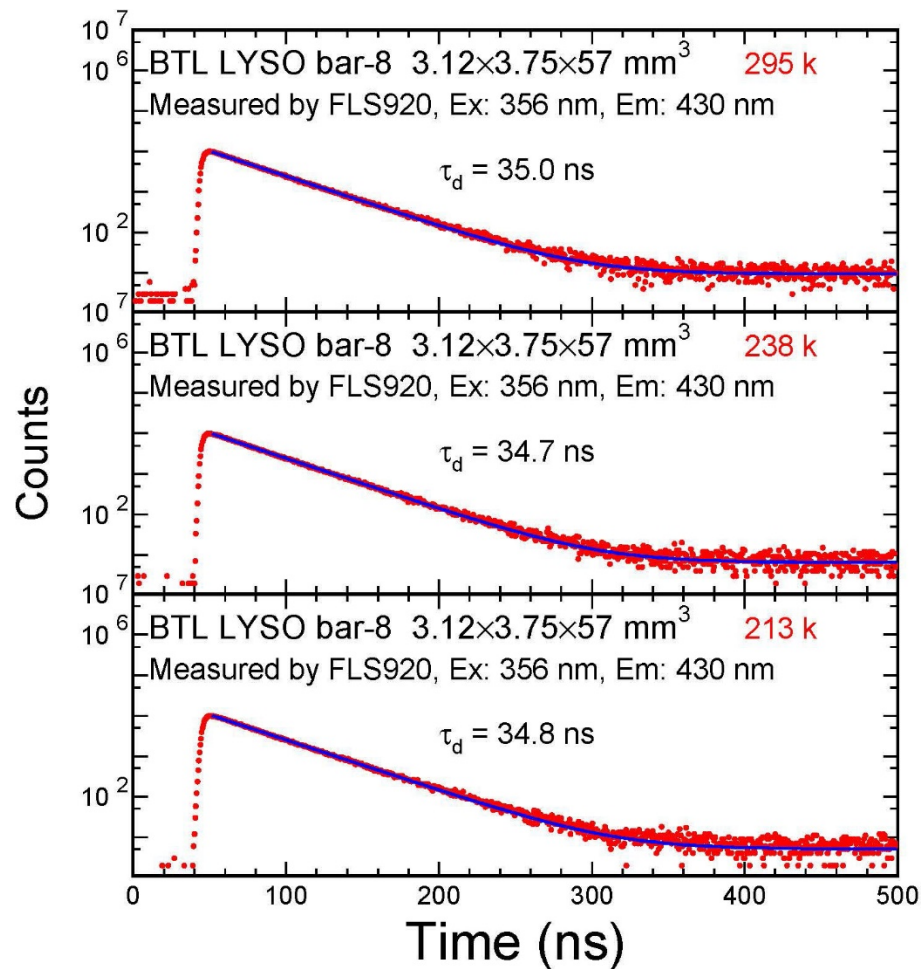
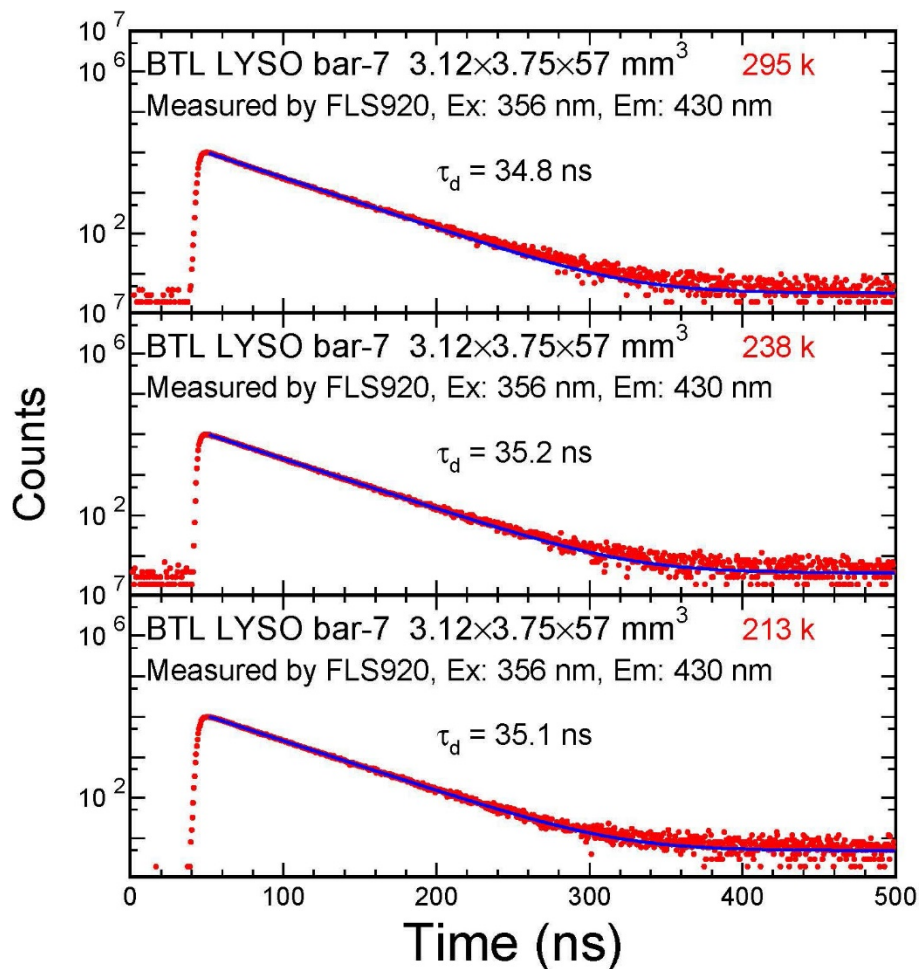
A small variation of decay time at low temperature





Temperature Dependent Decay Profile for BTL LYSO Vendors 7 and 8

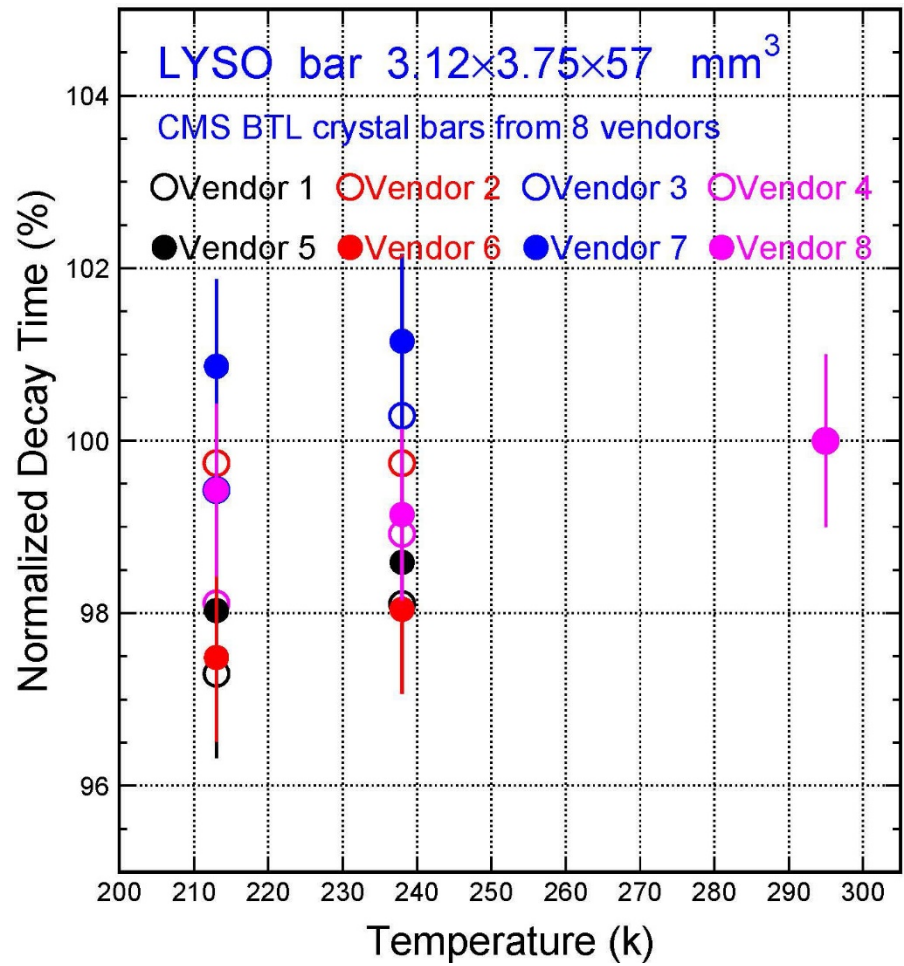
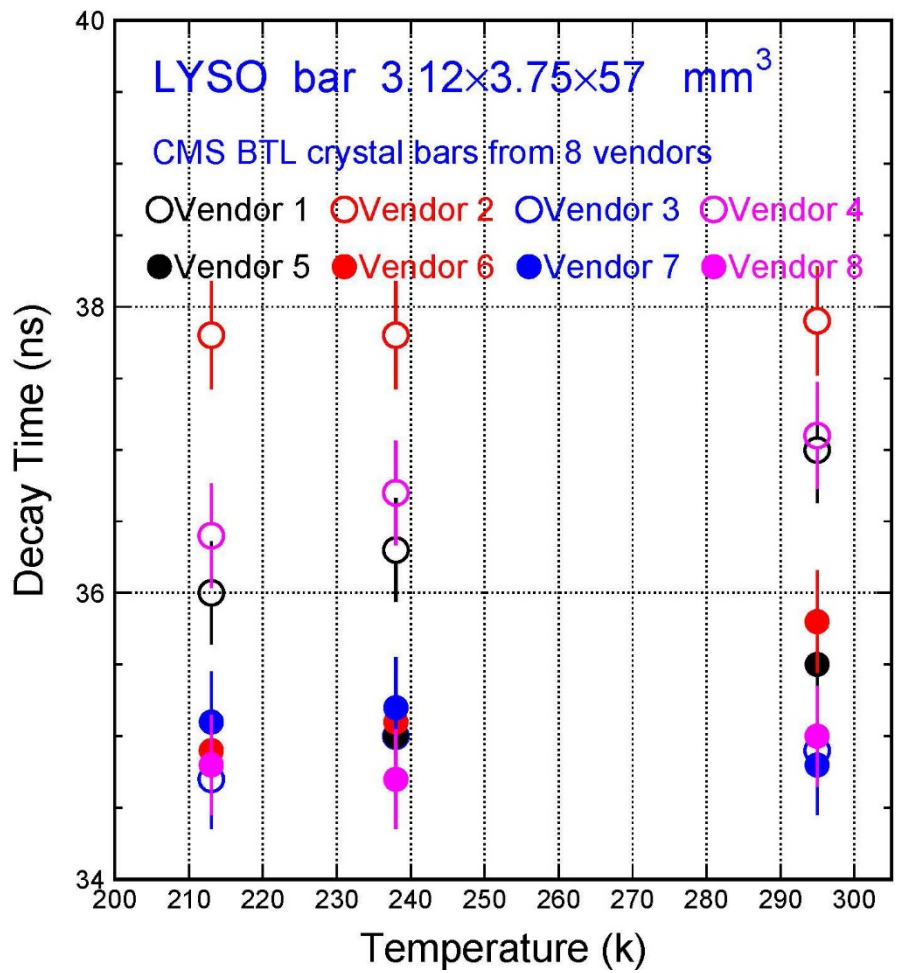
A small variation of decay time at low temperature





Decay Time & Normalized to RT

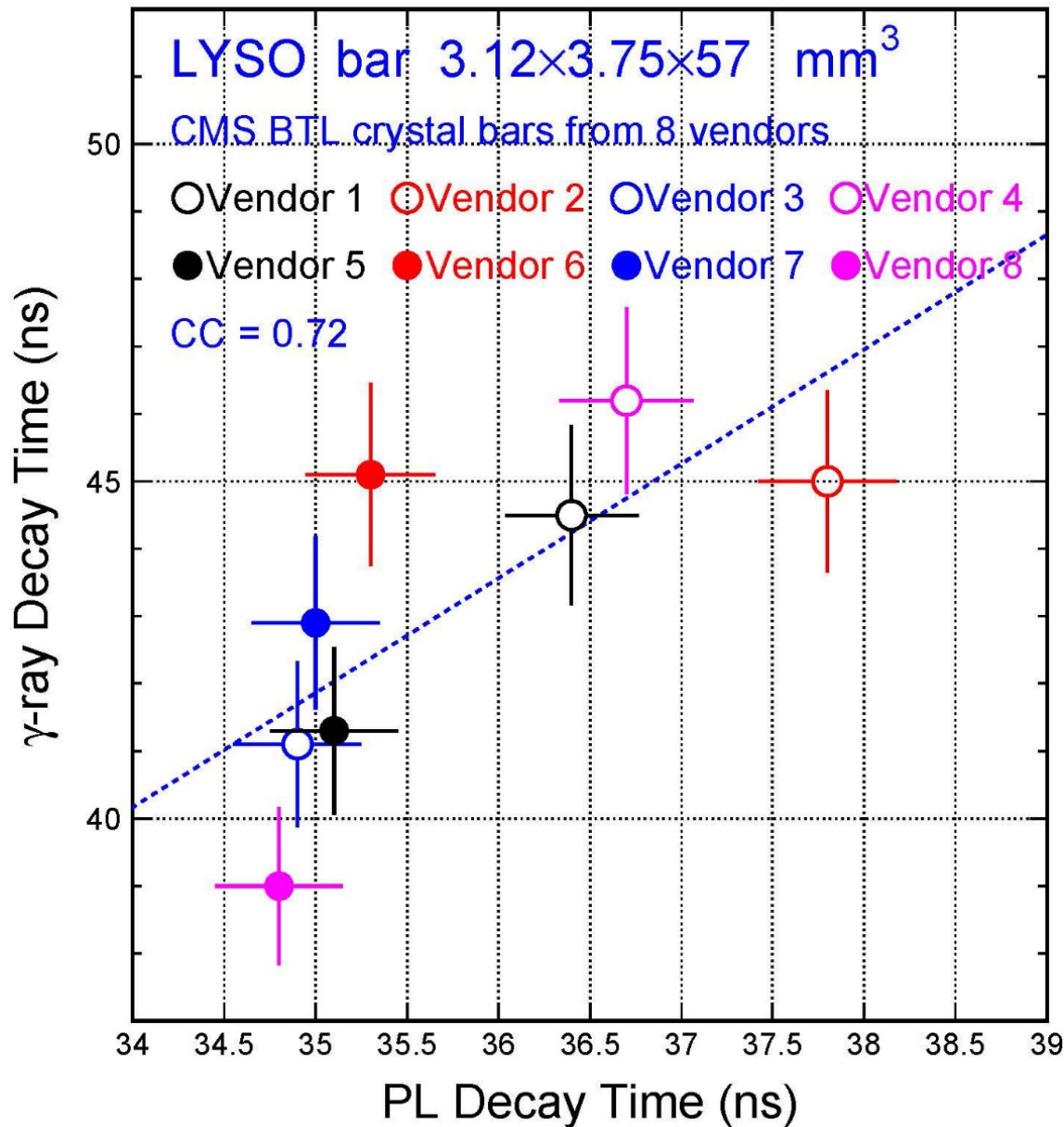
Average decay time decreases slightly at low temperature



Decay Time: PL vs. RL



Good correlation between decay time measured for PL and radio-luminescence





Summary

- Excitation, emission and decay of photo-luminescence (PL) were measured with Edinburgh FLS920 fluorescence spectrometer for 8 LYSO samples at 22, -35 and -60 °C.
- No significant PL/EWPL intensity variation observed at low temperature. To be understood: samples 7 and 8 show an increase of PL/EWPL intensity at low temperature.
- Average decay time shows a small decrease at low temperature. A good correlation is observed between the decay time of PL and radio-luminescence.
- **Conclusion: BTL LYSO crystals work well at -35 and -60 °C.**
- A TID experiment up to 5 Mrad is currently going on for eight BTL LYSO samples.
- A TF:n (8597) experiment is expected to start on 9/3/20 at LANSCE. Samples are needed at LANSCE in late August.

Acknowledgements: DOE HEP Award DE-SC001192