Report on Slow Suppression in La Doped BaF_2 Crystals

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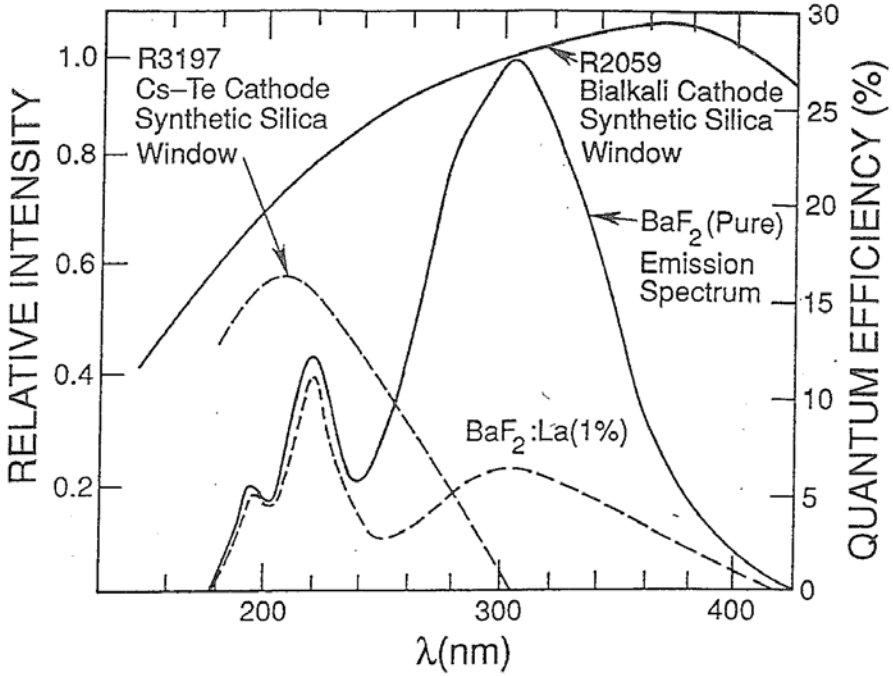
Mu2e Calorimeter Group Meeting

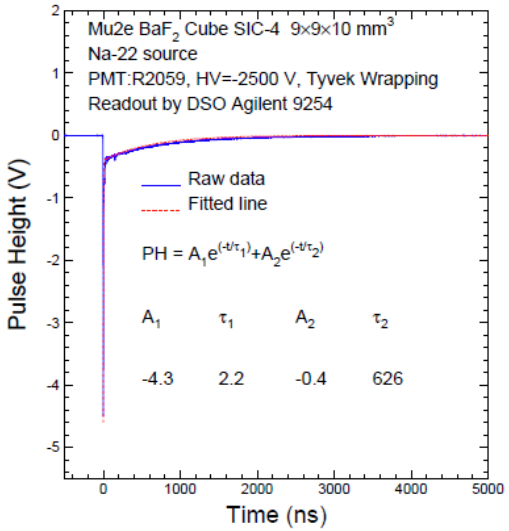
BaF_2 for Mu2e Calorimeter

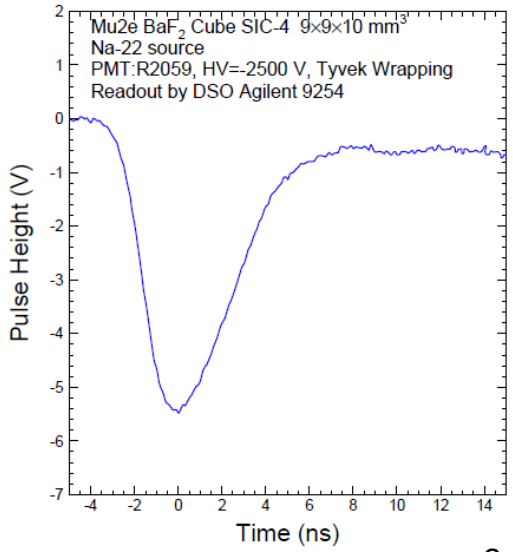
"On Quality Requirements to the Barium Fluoride-Crystals" *NIMA* **340** (1994) 442-457

The light output of the BaF_2 fast component at 220 nm with sub-ns decay time is sufficient for the Mu2e experiment.

R&D on going in two directions for Spectroscopic selection of the fast component: (1) solar blind photo-detector; and
(2) selective doping.



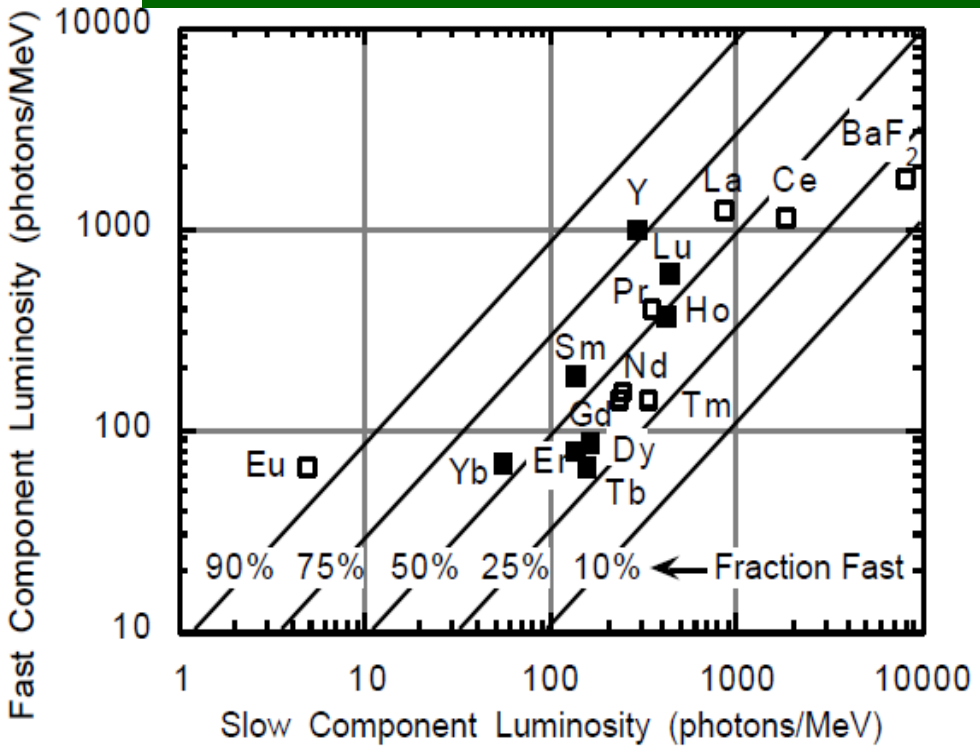


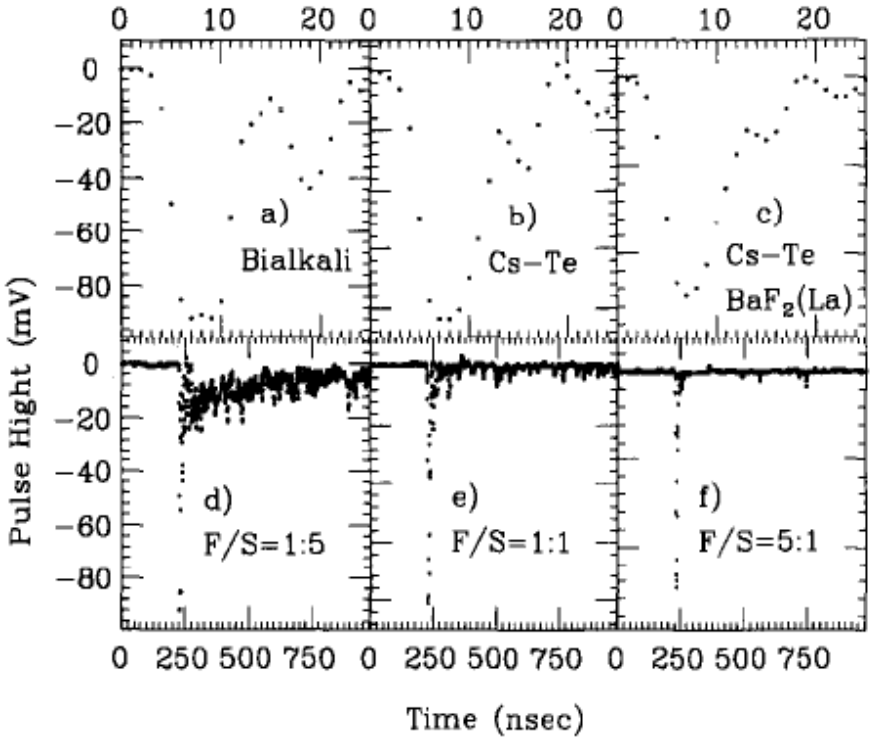


Slow Suppression: Doping and Readout

RE doping is effective in improving the F/S ratio for $Ba_{0.9}R_{0.1}F_2$ powders

B.P. SOBOLEV et al., "SUPPRESSION OF BaF2 SLOW COMPONENT OF X-RAY LUMINESCENCE IN NON-STOICHIOMETRIC Ba0.9R0.1F2 CRYSTALS (R=RARE EARTH ELEMENT)," *Proceedings of The Material Research Society: Scintillator and Phosphor Materials,* pp. 277-283, 1994.

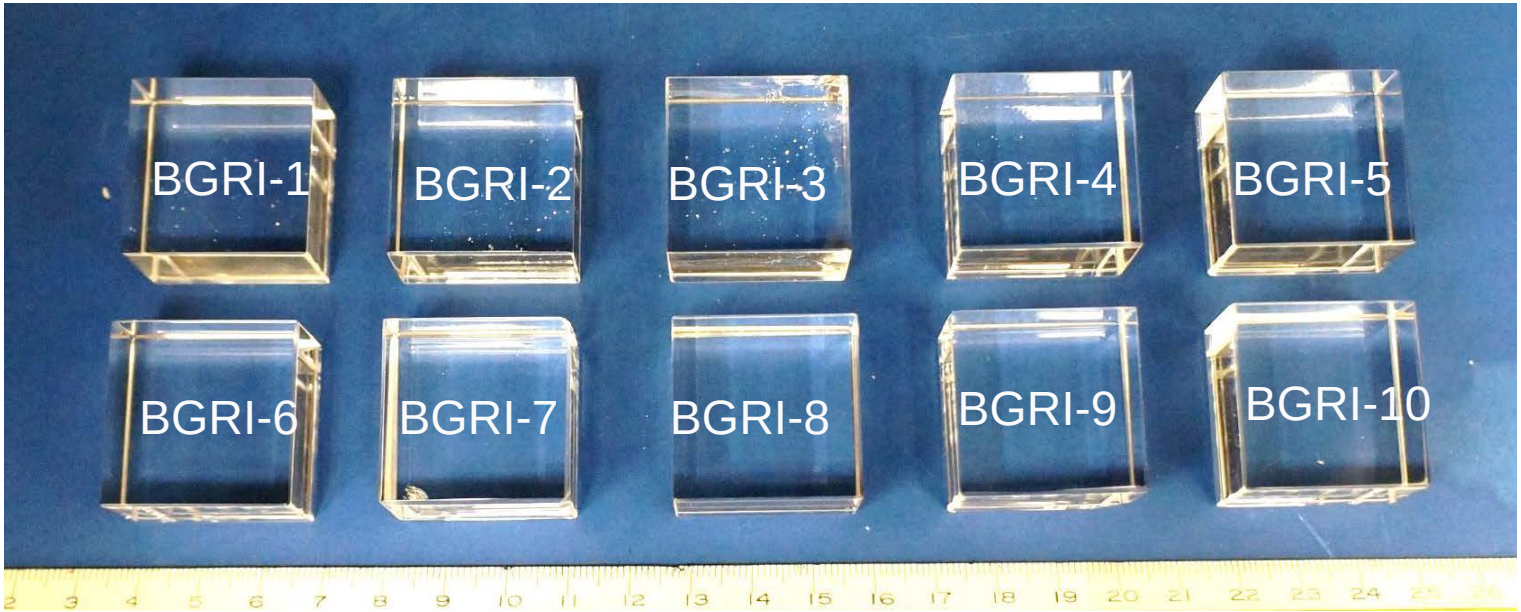




The 1st batch of La doped samples was received last week

Z. Y. Wei, R. Y. Zhu, H. Newman, and Z. W. Yin, "Light Yield and Surface-Treatment of Barium Fluoride-Crystals," *Nucl Instrum Meth B,* vol. 61, pp. 61-66, Jul 1991.

Ten La Doped BaF_2 Samples from BGRI

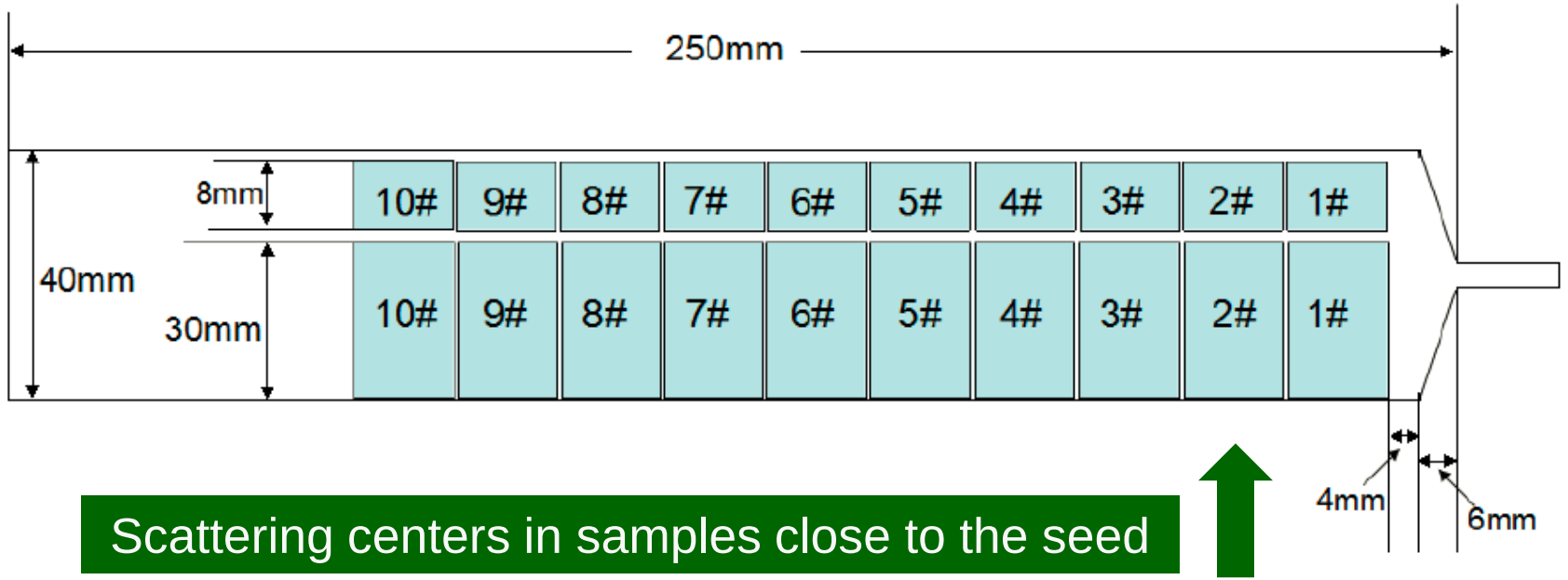


ID	Dimension (mm^3)	Polishing
BaF_2-La BGRI 1 -10	30x30x20	All faces

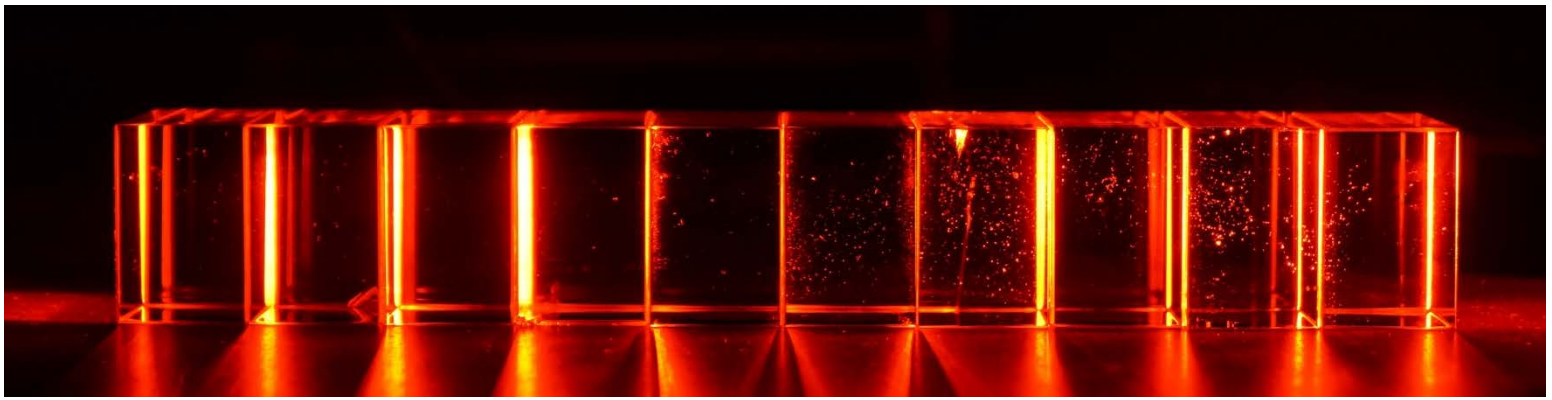
Experiments

- Properties measured at room temperature : Transmittance, LO and Decay Kinetics

Sample Locations in the Ingot

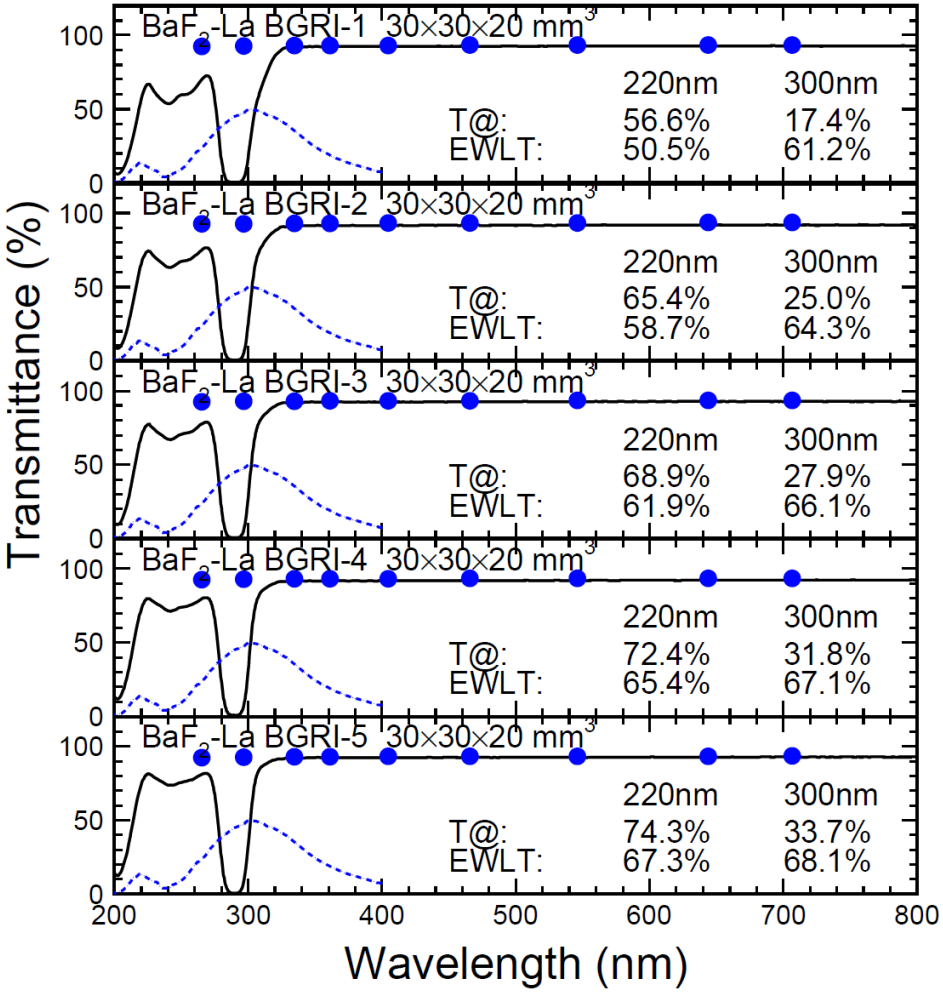


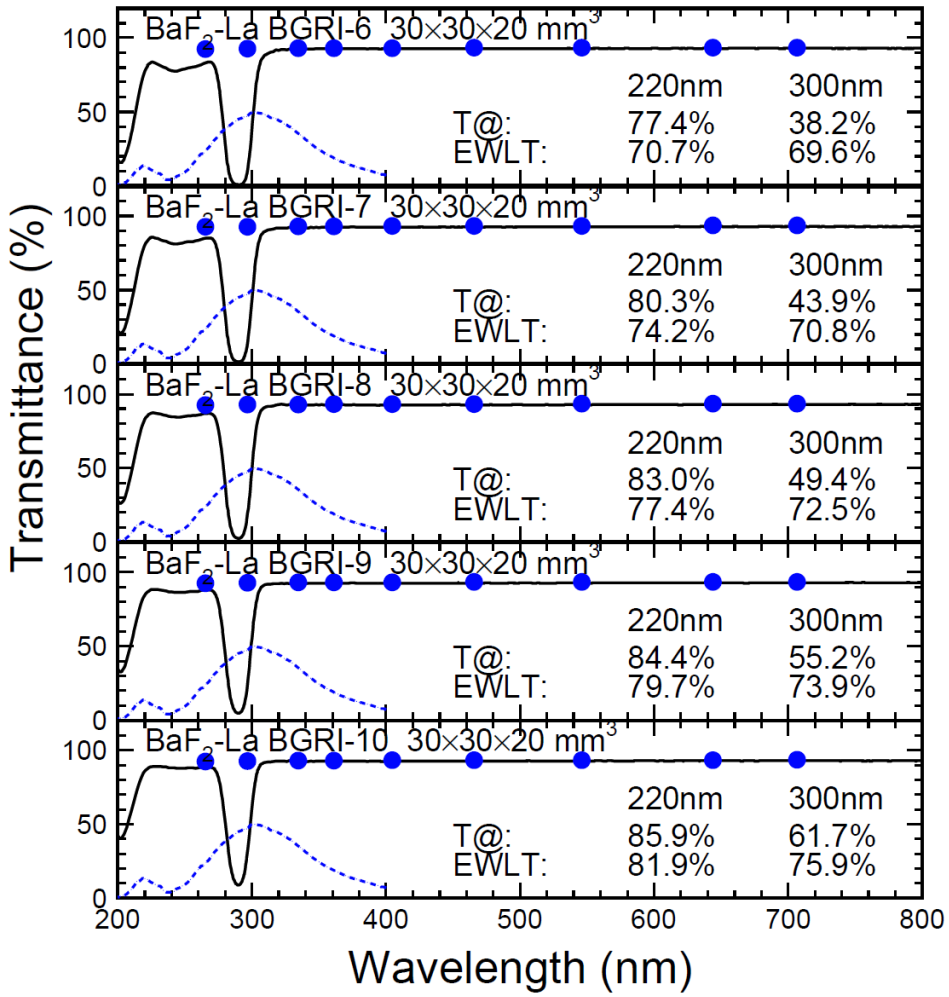
Scattering centers in samples close to the seed



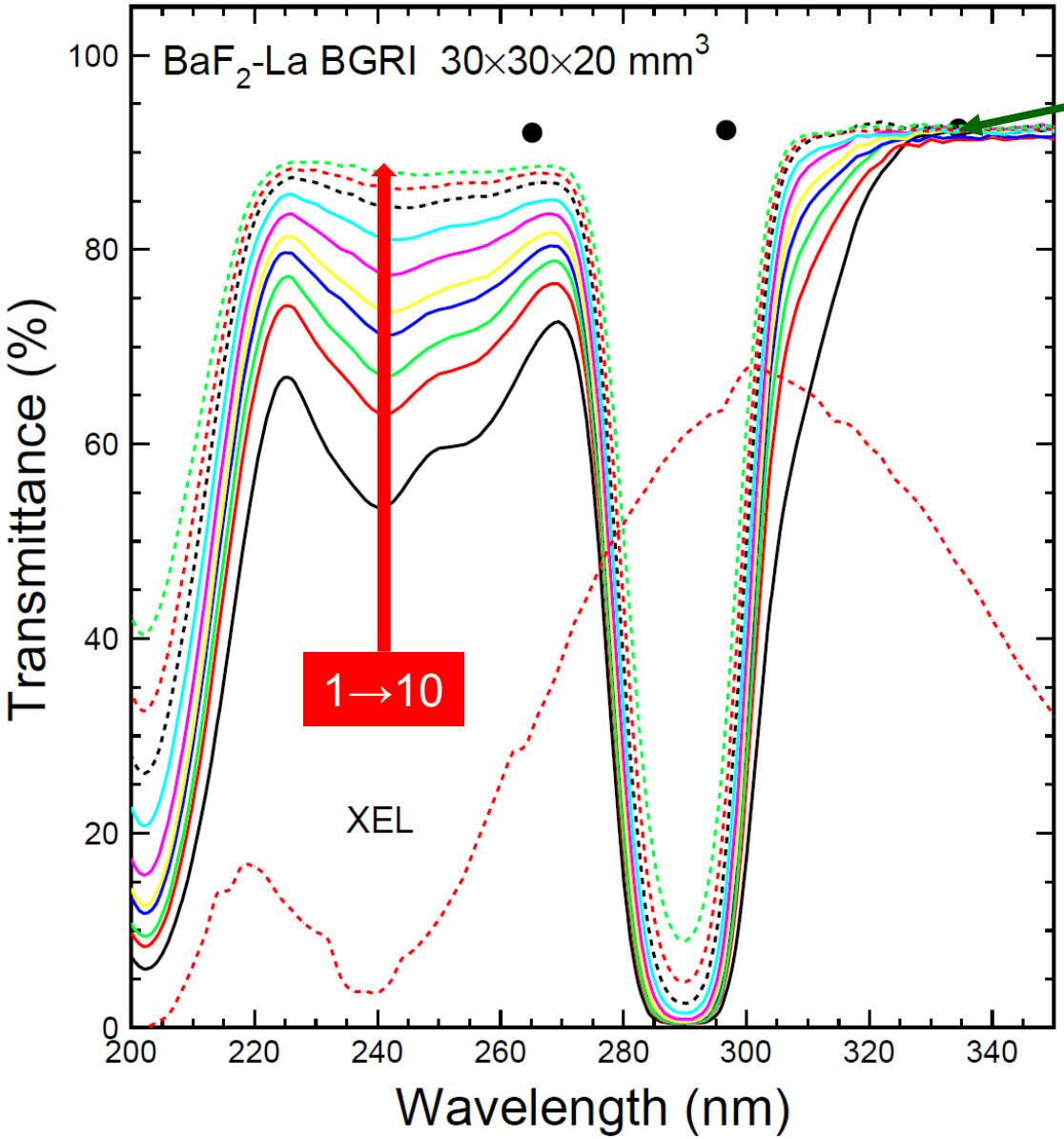
Transmittance Along 2 cm Path

Two absorption bands observed at 203 and 290 nm





La-Induced Absorption Bands



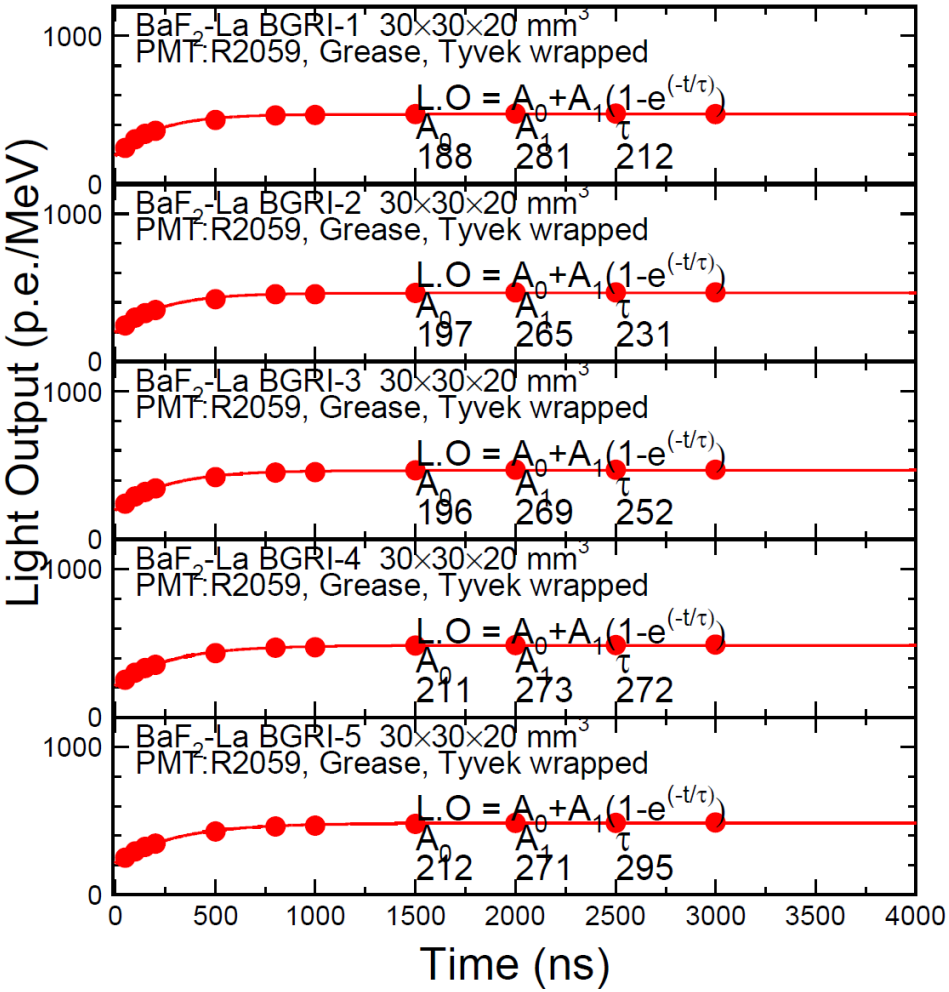
Theoretical Limit

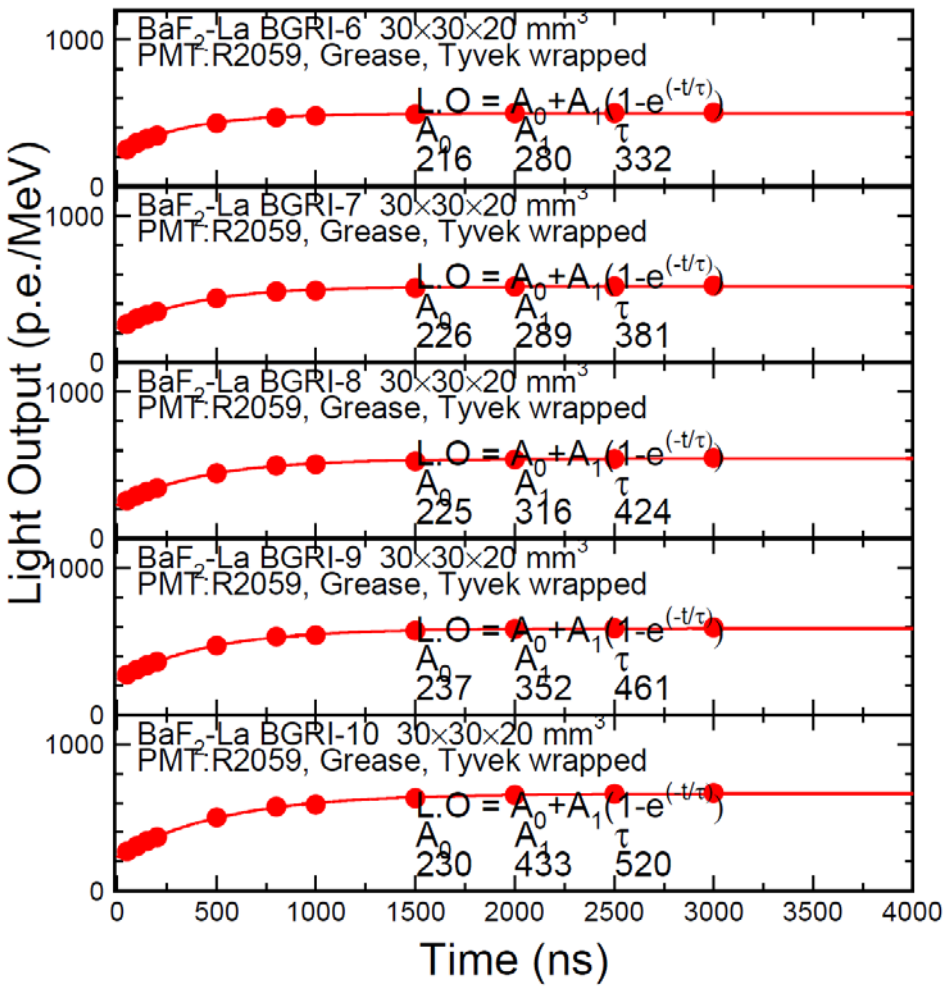
Absorption bands reduce both fast and slow components, but improve the overall Fast/Slow ratio.

The doping effect is reduced from the seed to the tail, indicating a large segregation coefficient of La in BaF_2

Light Output and Decay Kinetics

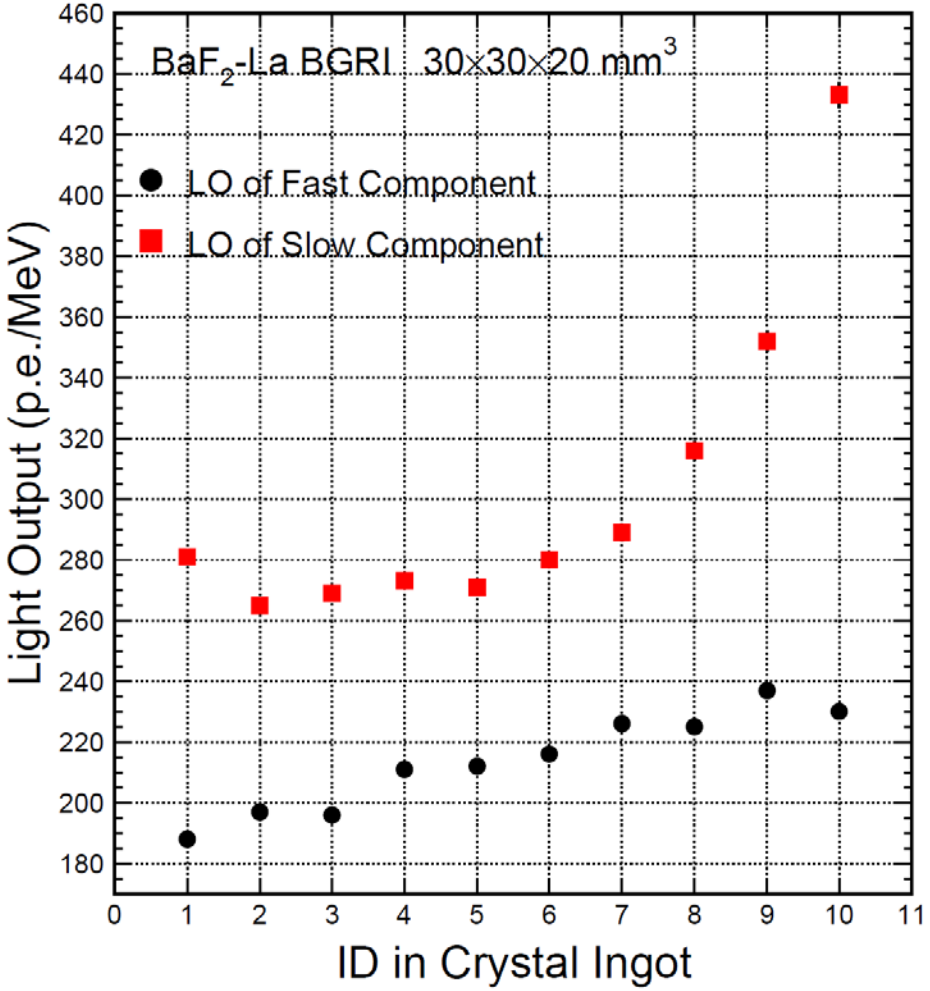
La doping reduces also the slow decay time constant

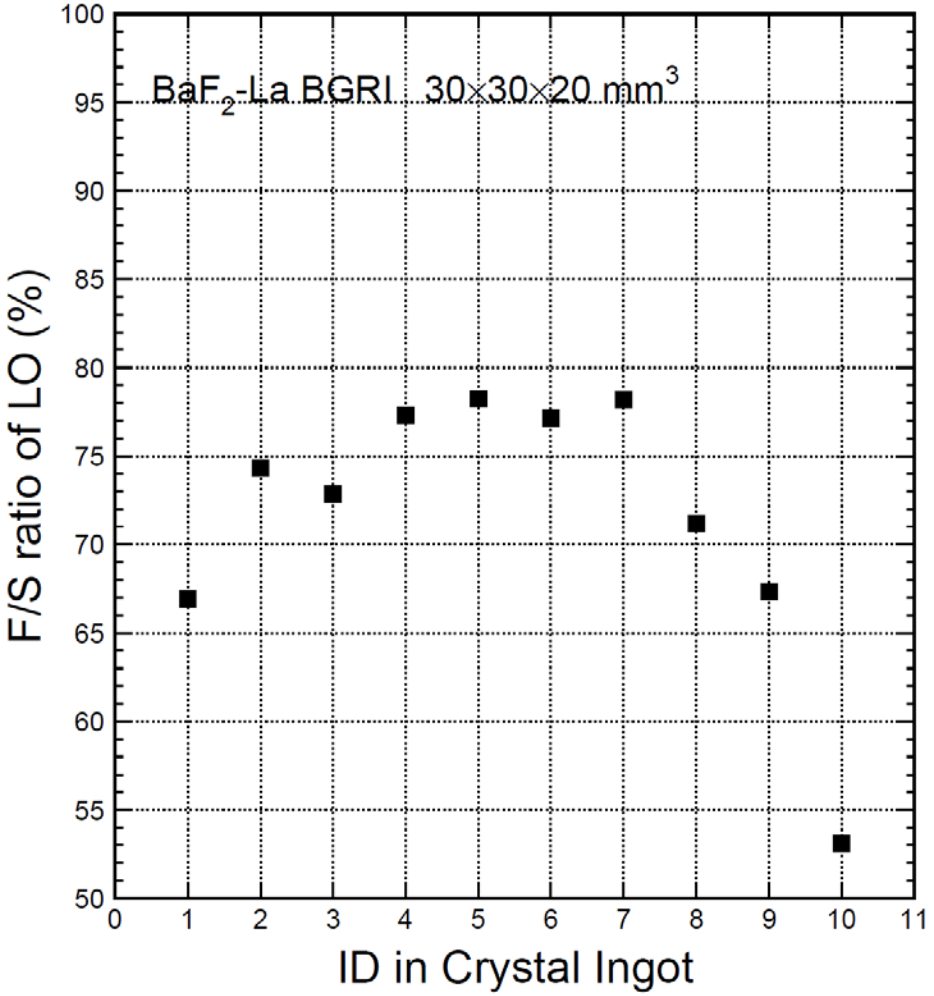




Light Output & F/S Ratio

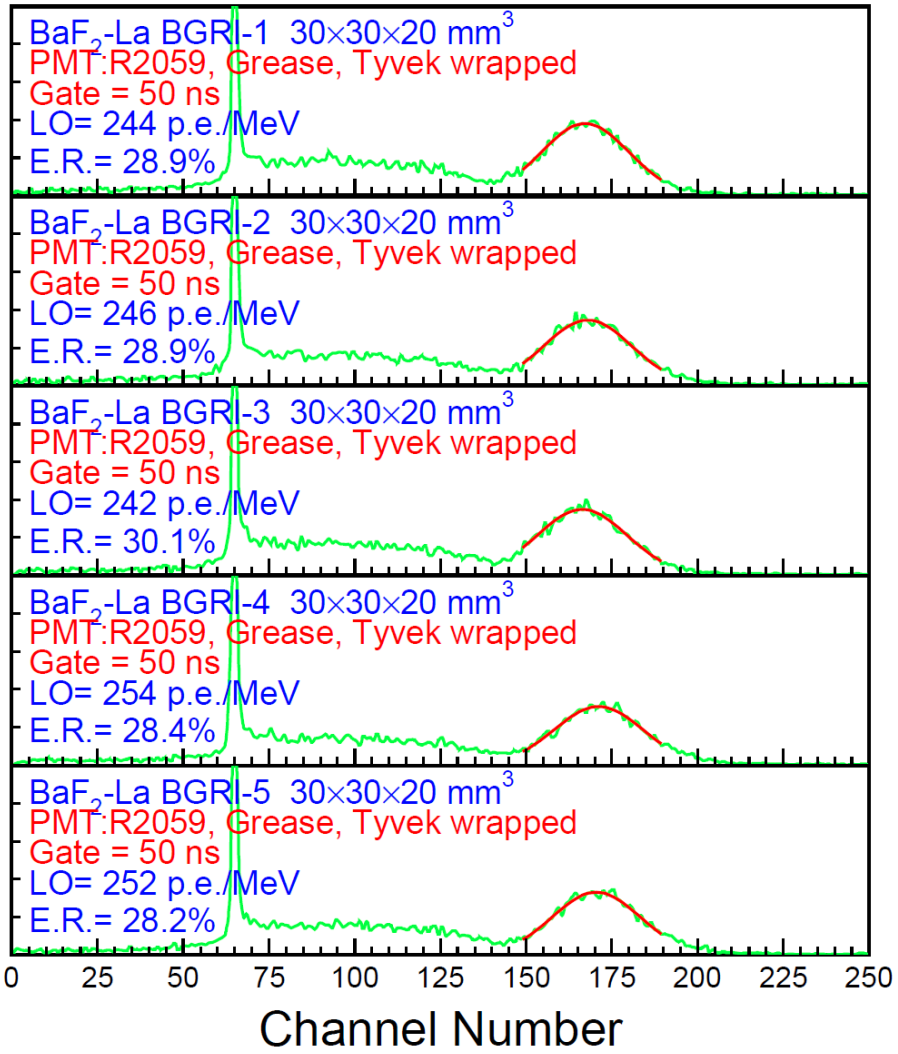
The largest F/S ratio observed in the middle of the ingot

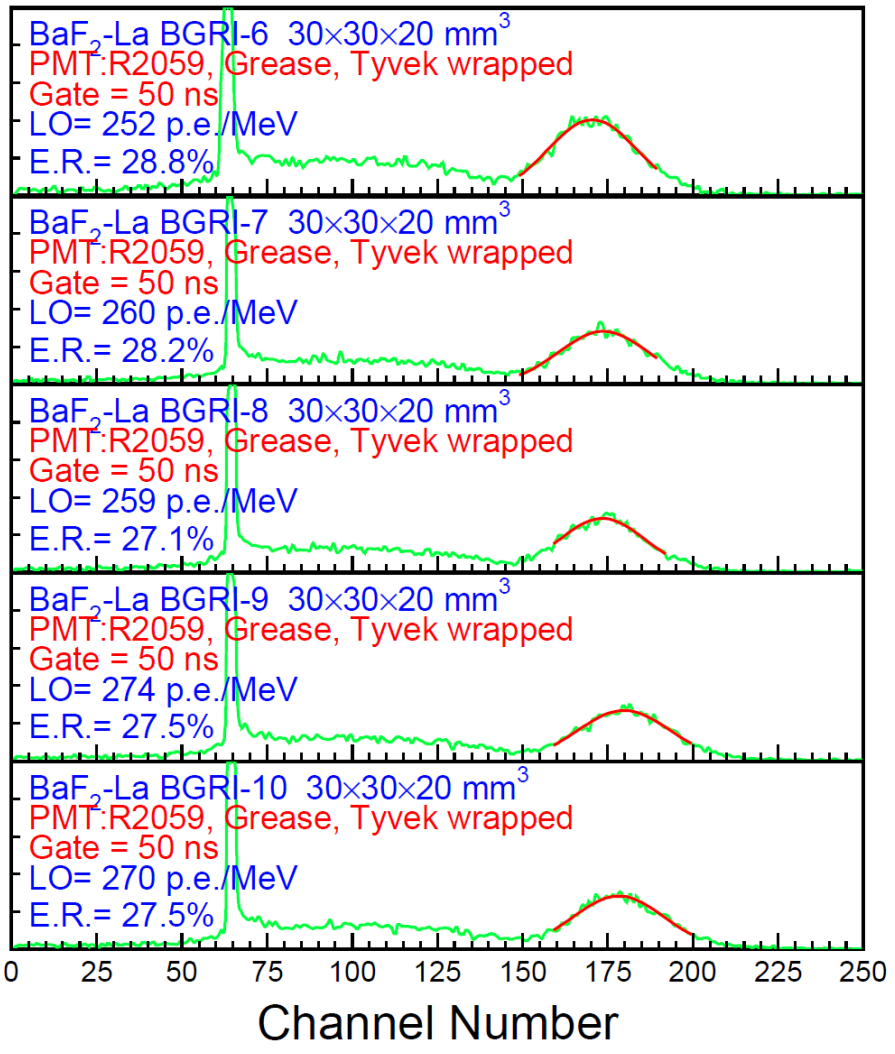




LO and PHS for 50 ns Gate

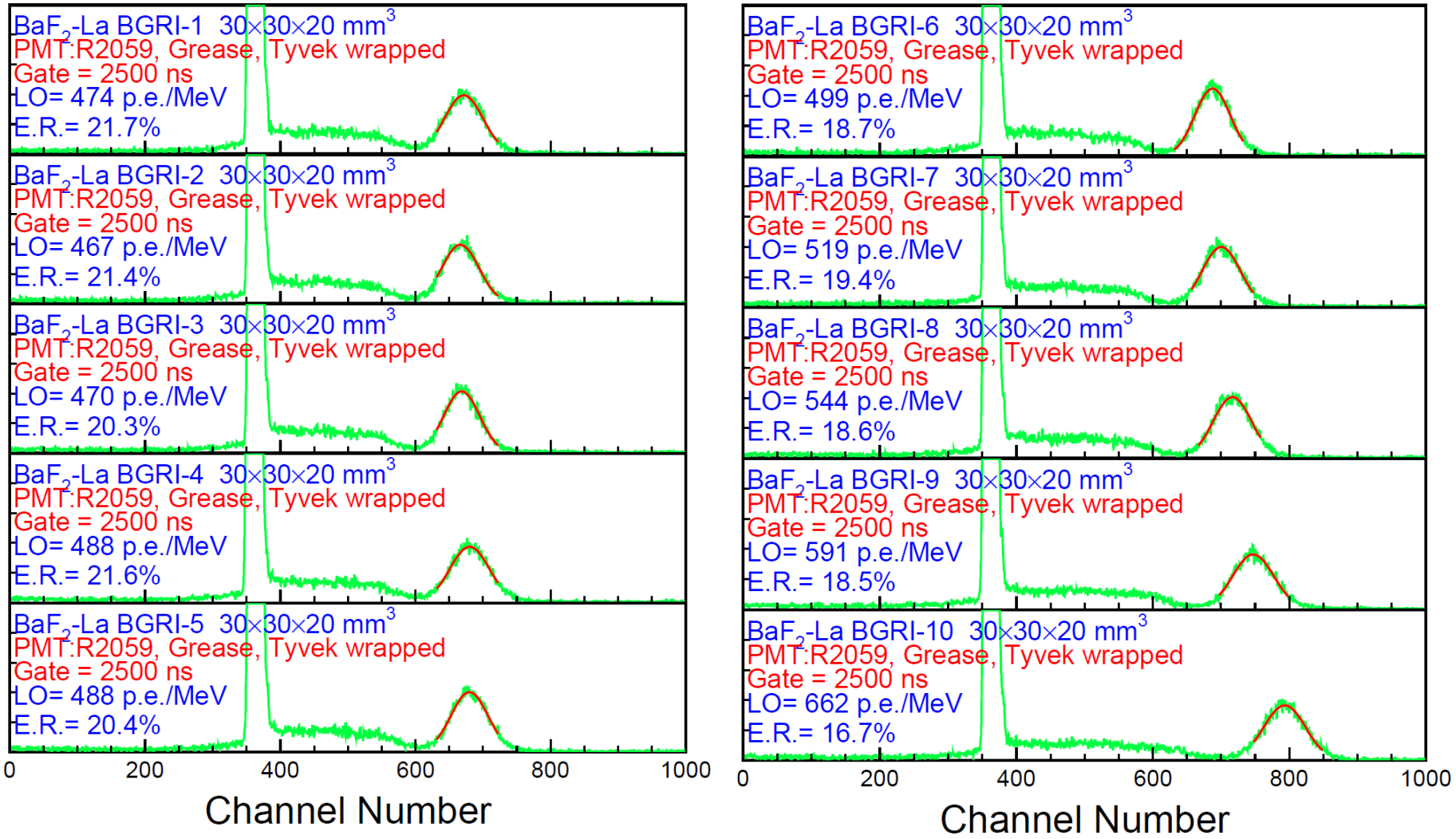
11% variation of light output





LO and PHS for 2500 ns Gate

40% Variation of light output



Transmittance & LO Data

A factor of four increase in the F/S ratio observed with not much variation of light in 50 ns gate

ID	Dimension (mm^3)	EWLT of Fast Component (%)	EWLT of Slow Component (%)	LO of Fast Component (p.e./MeV)	LO of Slow Component (p.e./MeV)	F/S Ratio of LO (%)	LO of 50 ns Gate (p.e./MeV)	LO of 2500 ns Gate (p.e./MeV)
1	30x30x20	50.5	61.2	188	281	66.9	244	474
2	30x30x20	58.7	64.3	197	265	74.3	246	467
3	30x30x20	61.9	66.1	196	269	72.9	242	470
4	30x30x20	65.4	67.1	211	273	77.3	254	488
5	30x30x20	67.3	68.1	212	271	78.2	252	488
6	30x30x20	70.7	69.6	216	280	77.1	252	499
7	30x30x20	74.2	70.8	226	289	78.2	260	519
8	30x30x20	77.4	72.5	225	316	71.2	259	544
9	30x30x20	79.7	73.9	237	352	67.3	274	591
10	30x30x20	81.9	75.9	230	433	53.1	270	662
BaF_2 ST	30x30x30	-	-	161	869	18.5	237	1026

Summary

- The 1st batch of ten samples cut from a La doped BaF_2 ingot was received from BGRI.
- Two absorption bands at 203 and 290 nm are observed, which reduce slightly the fast and significantly the slow component respectively.
- The La-induced absorption weakens from the seed to the tail, indicating a larger than one segregation coefficient of La in BaF_2.
- La doping reduces also the slow scintillation decay time.
- A factor of four improvement in the F/S ratio is observed in La doped samples with bi-alkali cathode readout.
- The light response uniformity of La-doped long BaF_2 crystals depends also on the spectral response of the photo-detector, but is expected to be small.
- Next step: investigation on light output, response uniformity and radiation hardness for La-doped long BaF_2 crystals.