A Study on Type III PWO Samples

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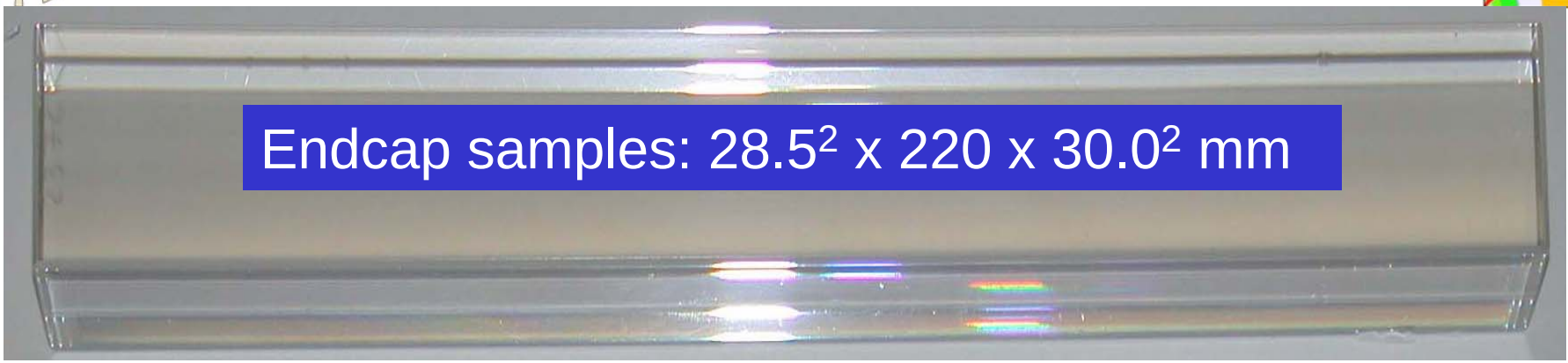
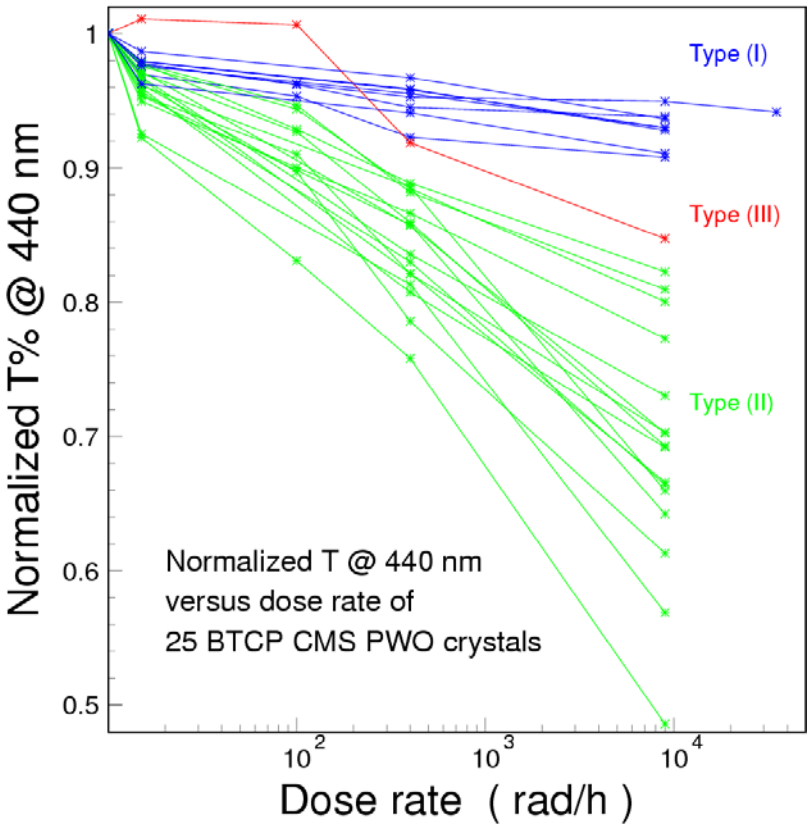
One Type III found in 20 BTCP Samples





Type I: 2456, 2466 & 2467.

Type III: 2465.

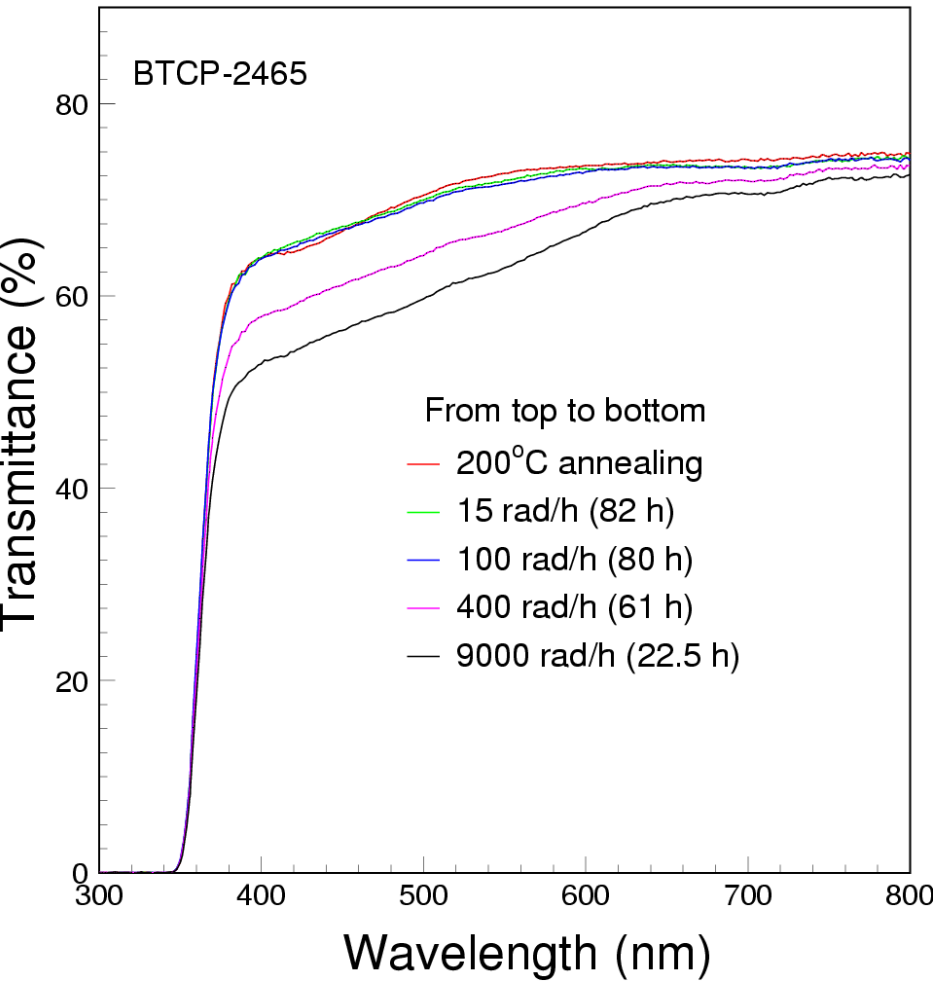
Type II: All others.

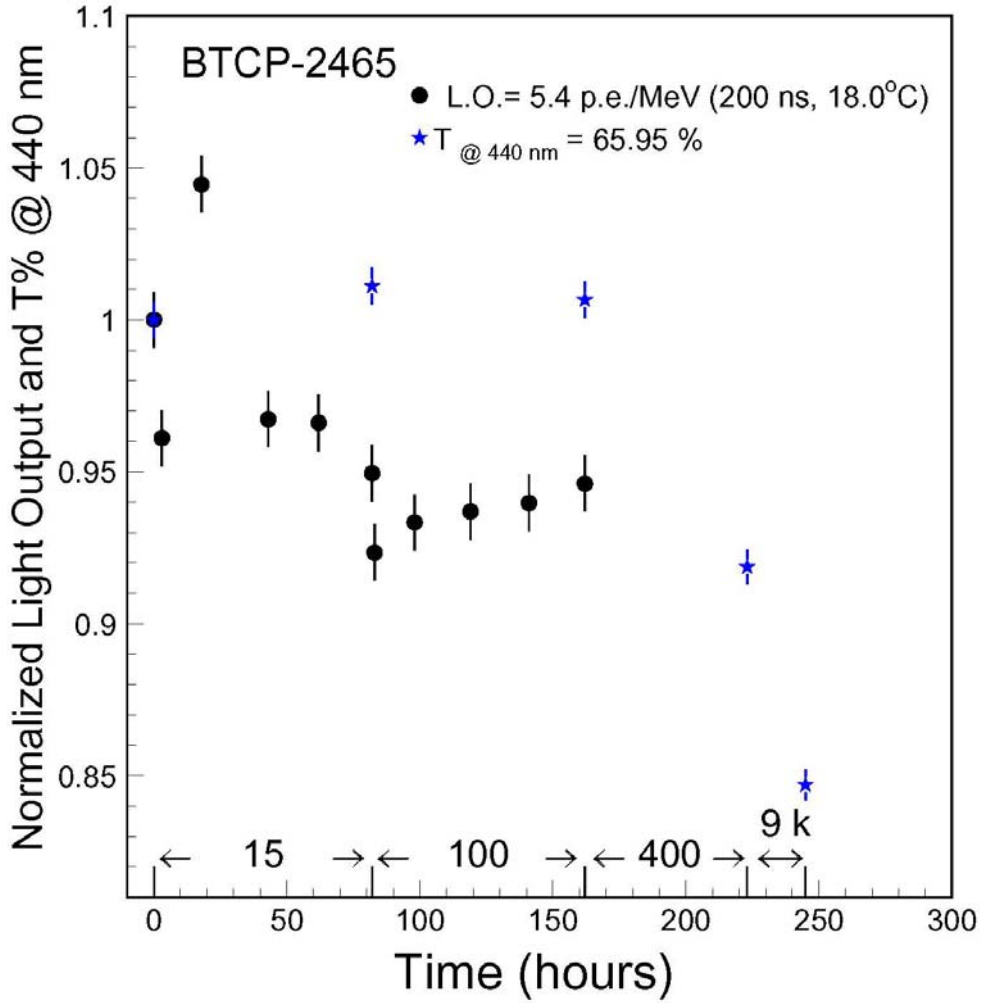
Type III: preexisting bleachable intrinsic color center at 420 nm after 200 degree annealing causes LO increase under irradiation.

Rebecchi found 8 in 150 tested

Type III (BTCP-2465): LT & LO

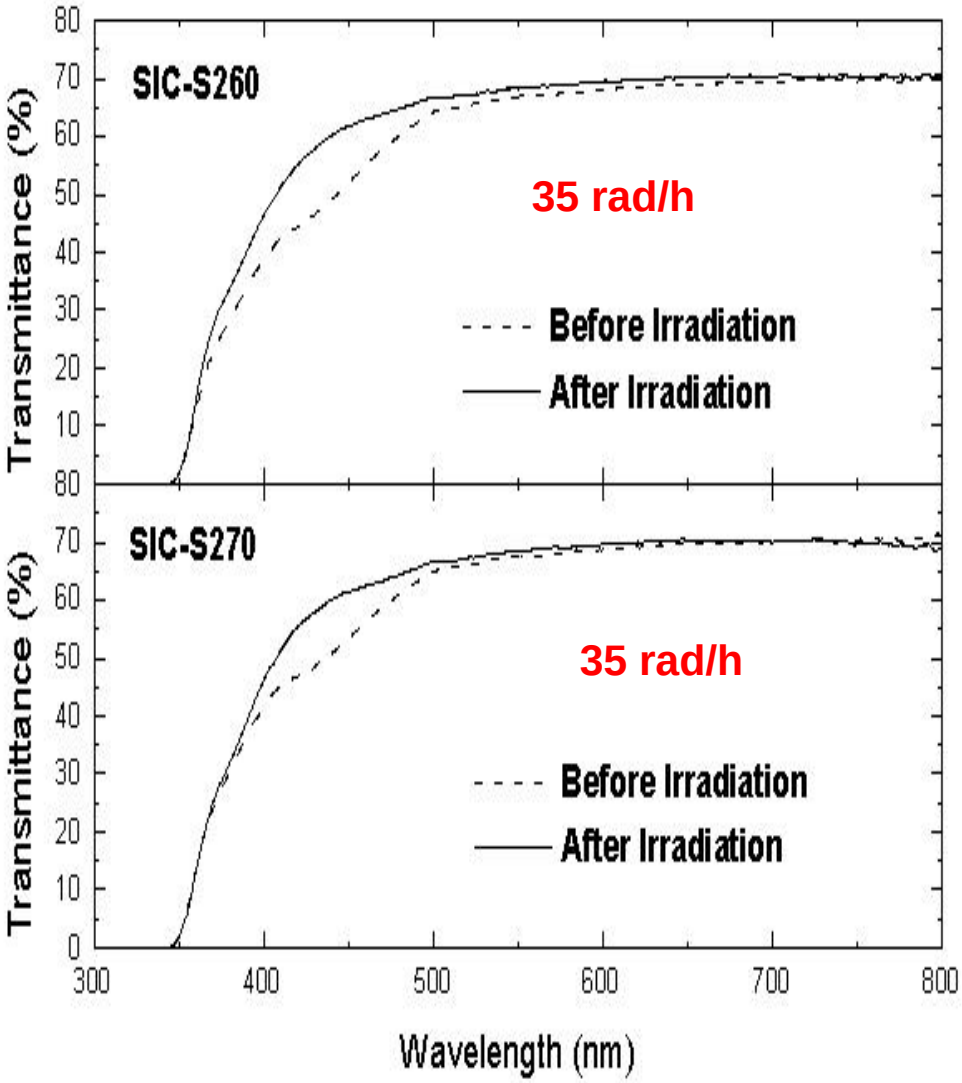
This anomalous behavior may cause confusion for monitoring with 440 nm light

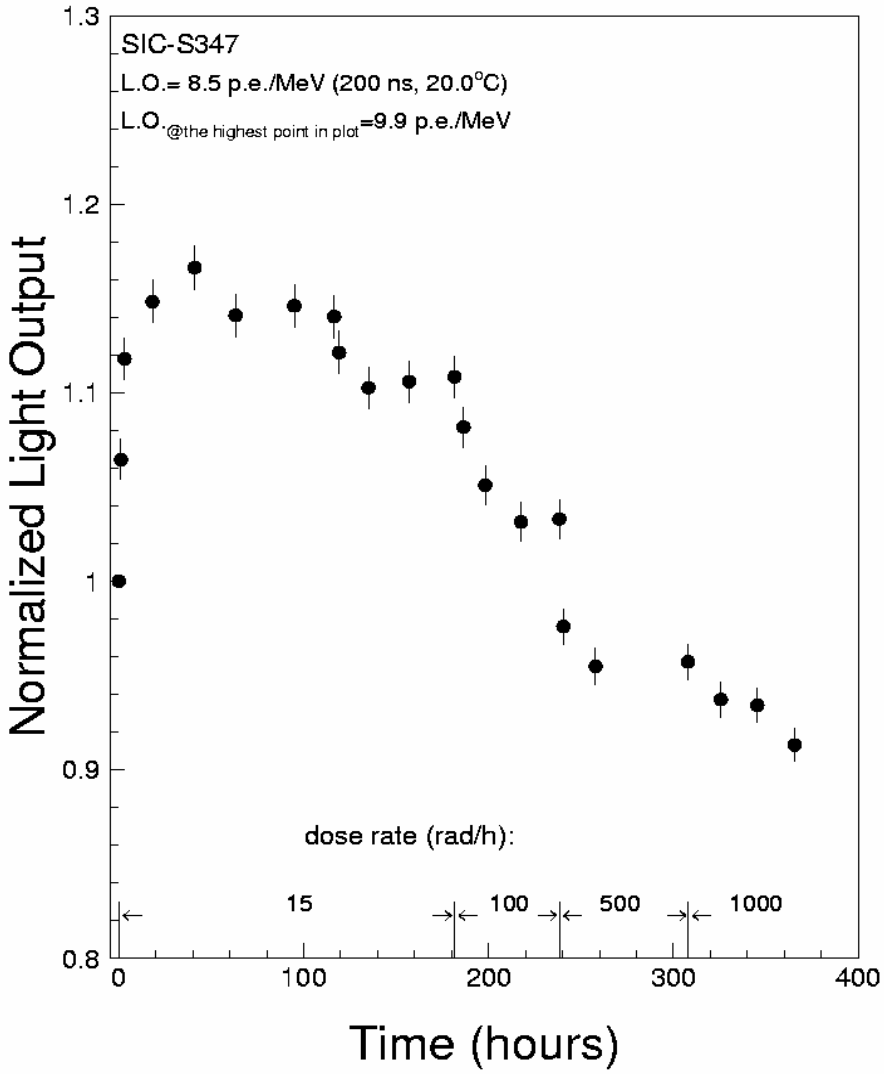




Early Type III Crystals from SIC

Similar behavior was observed in SIC samples in 1999





Investigation on SIC Samples (I)

Two anomalous samples were cut to pieces

Crystal ID: NO.4-1-20 Dopant: Y/150 at ppm

The length of seed is 20.0 mm, thickness of 1, 2, 3, 4 is 5.0 mm.

Dimension of AB, CD, EF, GH and IJ is: 25.0 x 25.0 x 44.3 mm^3

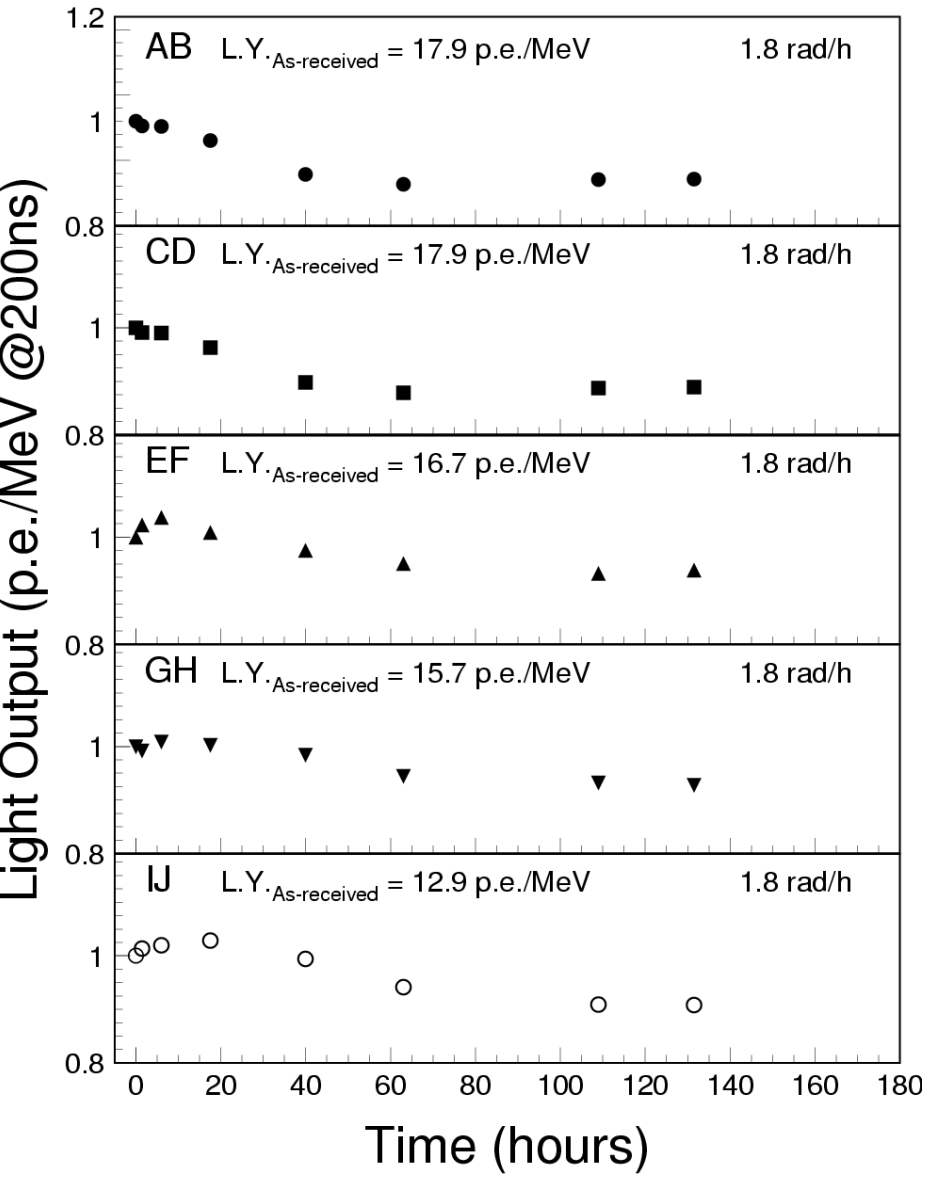
Crystal ID: B13 Dopant: Y/150 at ppm

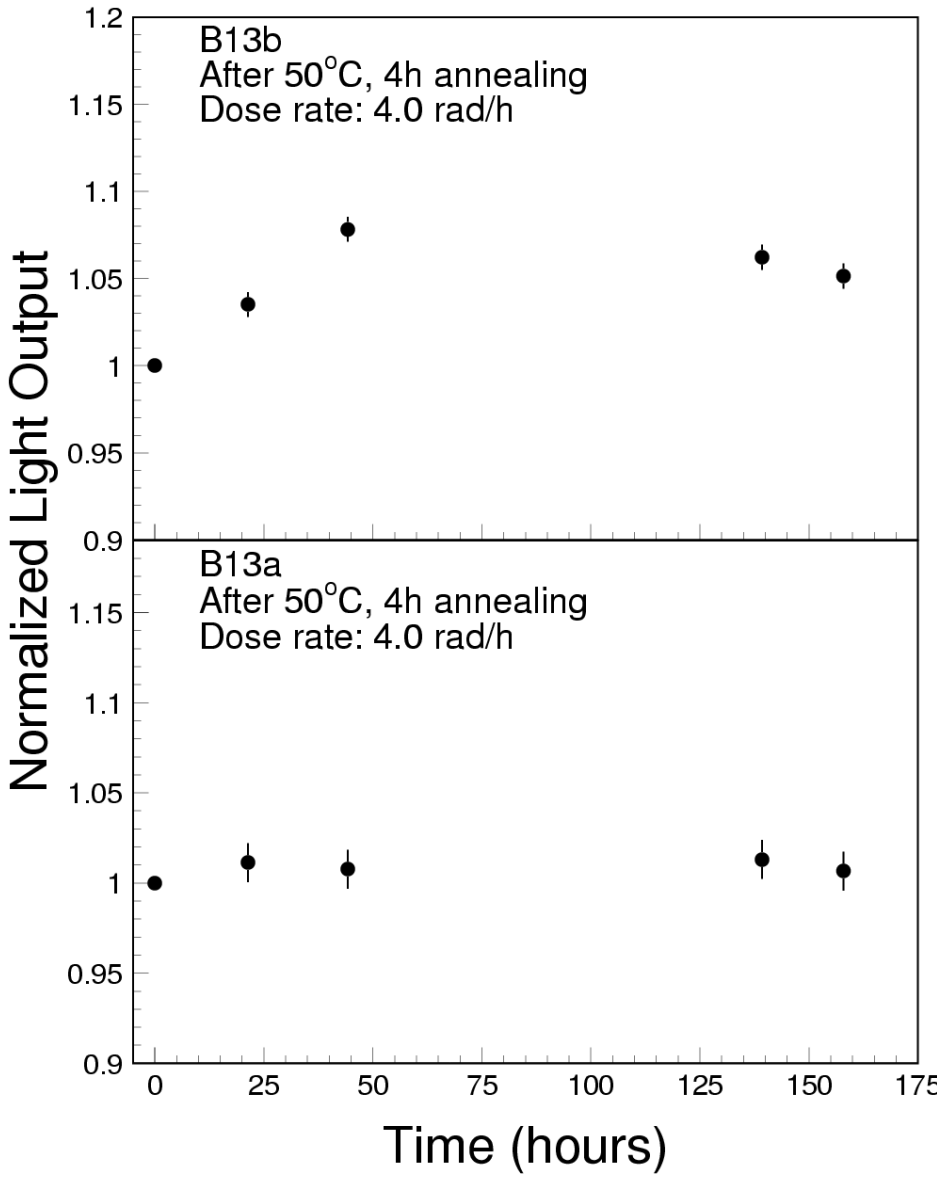
Dimension of B13a: 22.0 x 22.0 x 177.0 x 25.0 x 25.0 mm^3

Dimension of B13b: 22.0 x 22.0 x 50.0 x 23.0 x 23.0 mm^3

Investigation on SIC Samples (II)

Anomaly was found at the tail end: impurity related?





Investigation on SIC Samples (III)

GDMS on SIC PWO(Y) Samples (ppmw)

by Shiva Technology West (November, 1999)

	4-1-20-2/3			4-1-20-AB/EF/IJ	
Element	Seed/Tail 1	Seed/Tai 2	Seed/Tail 3	Seed/Middle/Tail 4	Tail 5
Na	0.2/0.8	0.2/2.3	0.4/0.8	0.2/0.8/1.9	0.8
Si	0.5/0.2	0.7/1.3	0.5/1.2	0.5/0.4/0.1	0.05
K	0.3/1.8	0.4/2.9	0.7/1.2	0.5/0.9/2.0	1.3
Ca	0.9/<0.05	0.6/0.08	0.12/0.15	0.8/0.6/0.2	0.15
Cu	0.04/0.2	0.04/0.4	0.3/0.35	0.08/0.1/0.54	0.23
As	0.15/0.35	0.1/0.6	0.5/0.5	0.14/0.16/0.6	0.54
Y	40/45	40/50	30/35	40/40/60	50
Nb	<0.05	<0.05	<0.05	<0.05	<0.05
Mo	0.3/0.55	0.3/0.9	0.6/0.8	0.2/0.5/0.8	1.0
Sb	<0.05	<0.05	<0.05	<0.05	<0.05
Ba	0.1/0.1	0.1/0.1	<0.05/0.06	0.3/0.15/0.07	0.1
La	<0.01	<0.01	<0.01	<0.01	<0.01
Eu	<0.05	<0.05	<0.05	<0.05	<0.05
TC†	3.8/2.1	4.9/4.6	4.4/3.4	5.3/4.0/2.5	4.3

†: Total contamination, excluding Y.

Impurity segregation:

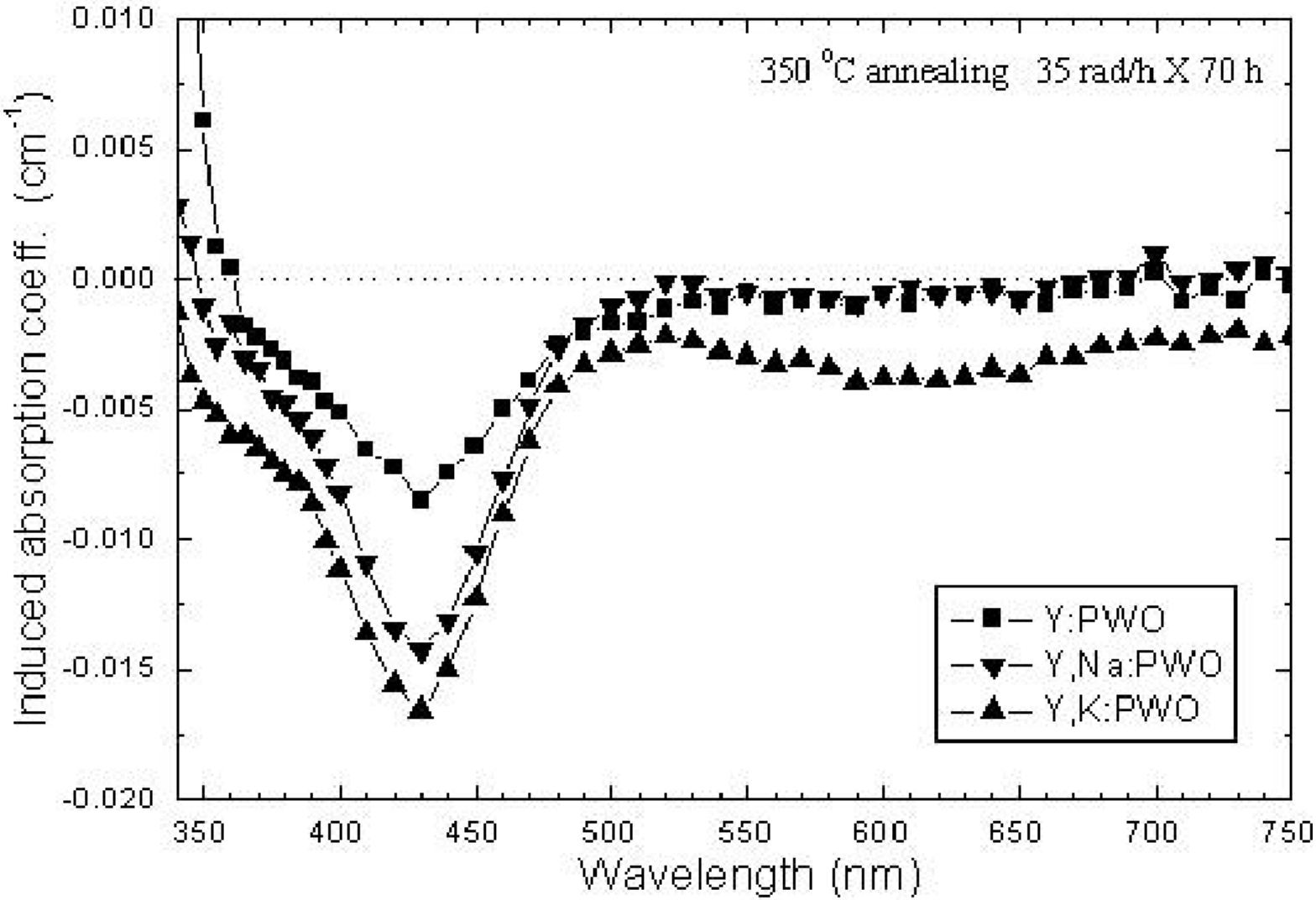
Na, K, Cu, As, Mo: <1;

Ca, Ba: >1;

Y: slightly less, but close to 1.

Investigation on SIC Samples (IV)

20 ppm doping with K or Na enhances 420 nm absorption



Summary of SIC Investigation

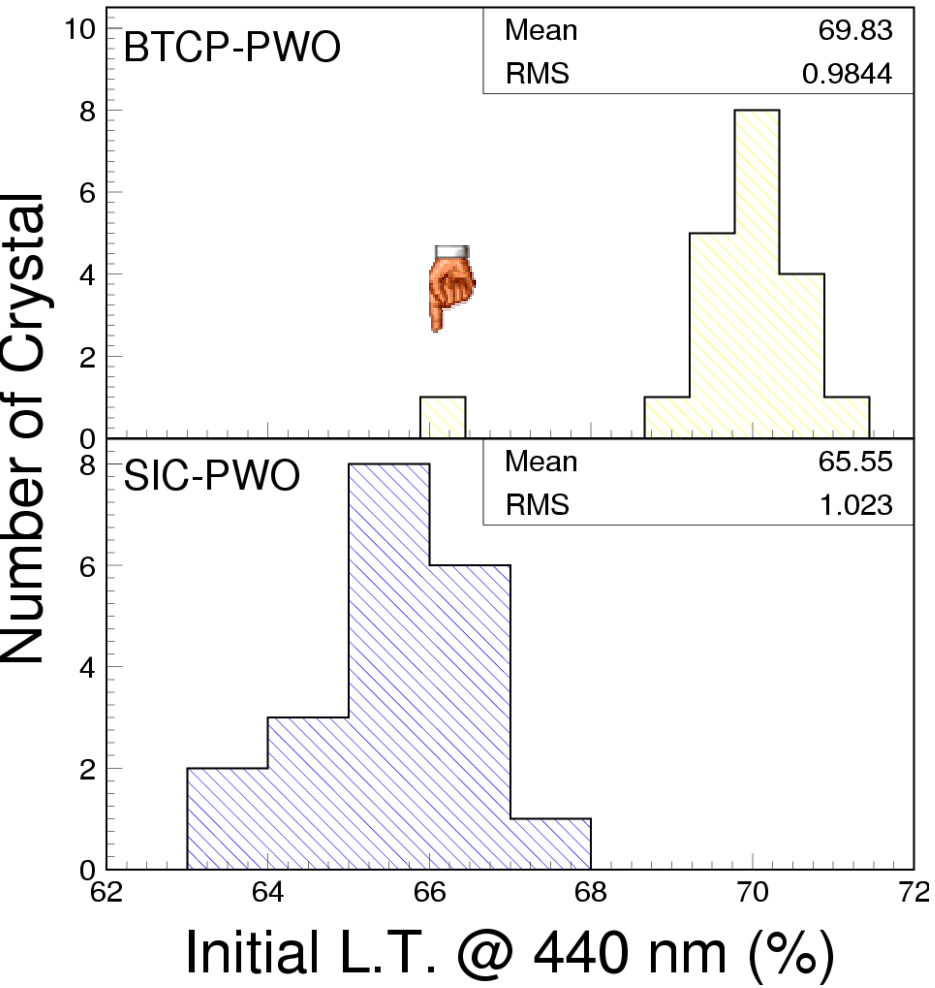
Calor2002 Proceedings World Scientific (2002) 190.

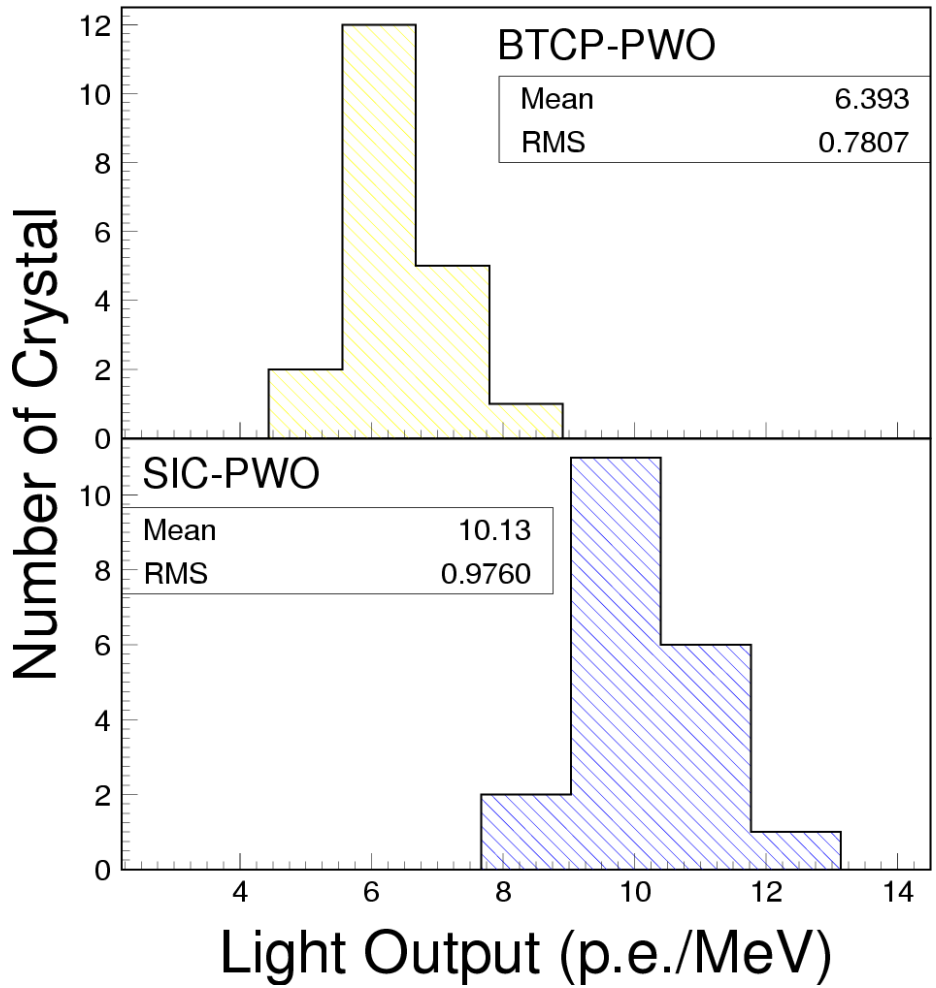
- PWO light yield increase under irradiation (instability) may be explained by preexisting color center at 420 nm which is bleachable by PWO's scintillation light.
- This CC concentrates at the tail end, and is enhanced by Na or K doping.
- Mono-valent impurities with segregation coefficient less than 1, such as Na and K are harmful.
- **SOLUTION**: raw material purification.

L.T. and L.O.: 20 Sample Comparison

BTCP:higher L.T., partly due to birefringence

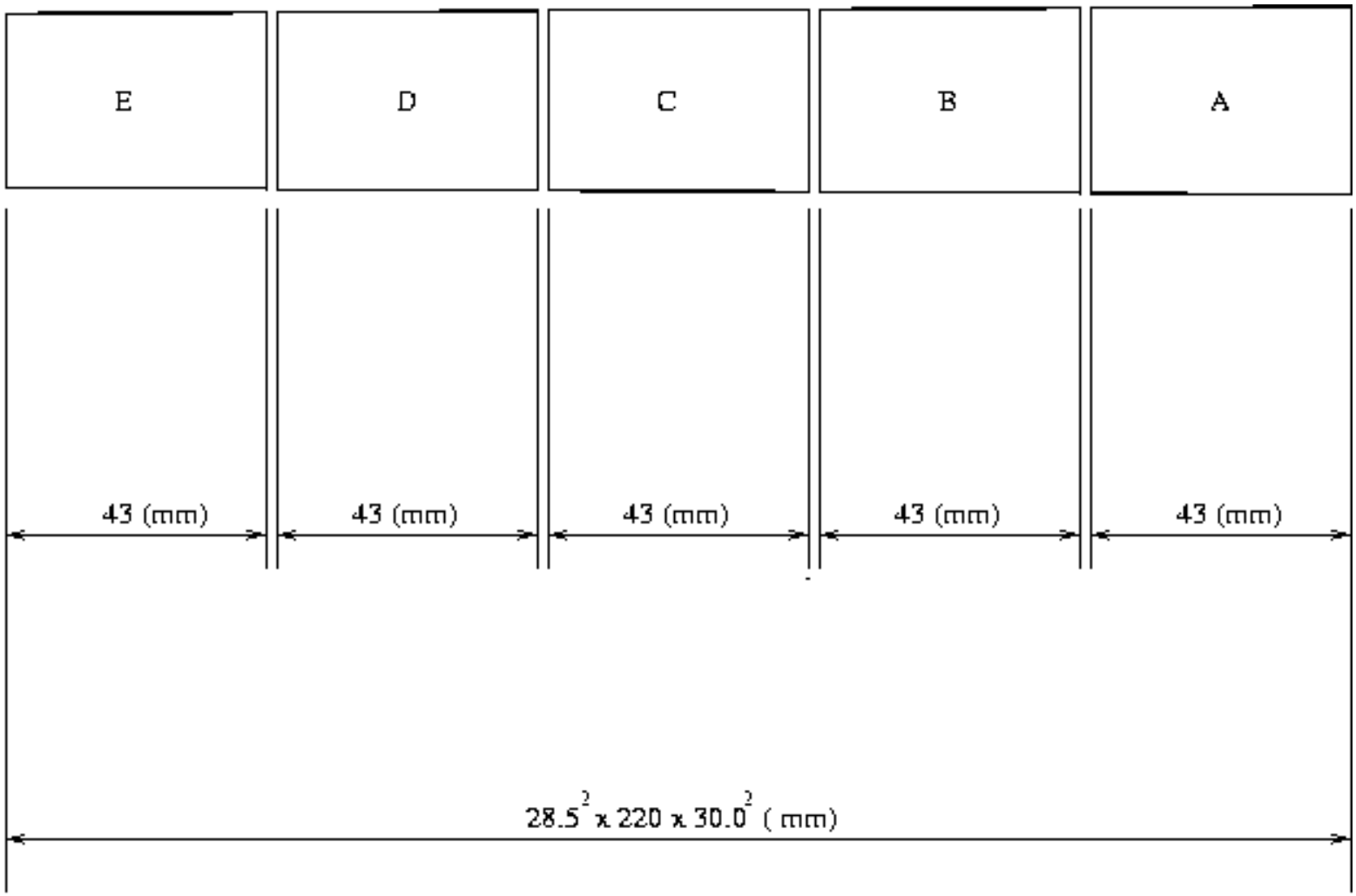
SIC: 58% more light, the reason is unclear!





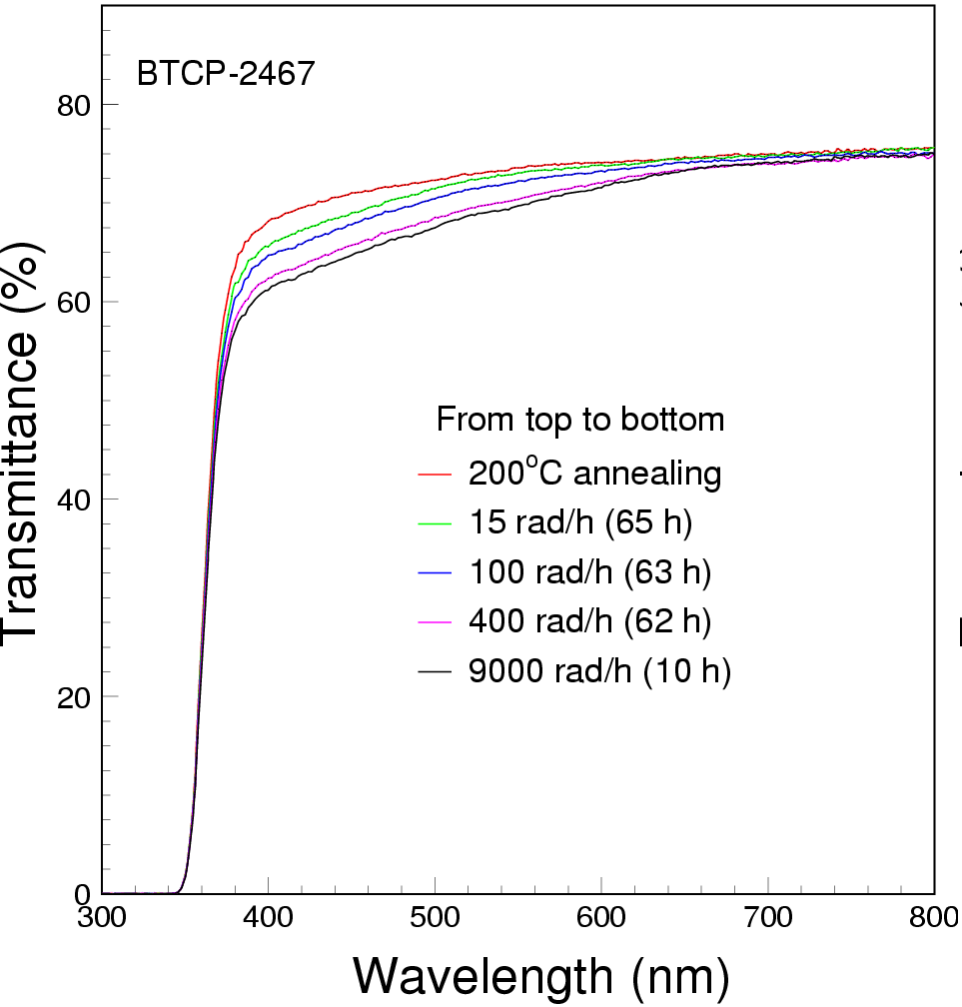
Investigation on BTCP Samples (I)

Three samples cut to 5 pieces: 4.3 cm each:
Type I: 2467, Type II: 2436, Type III: 2465

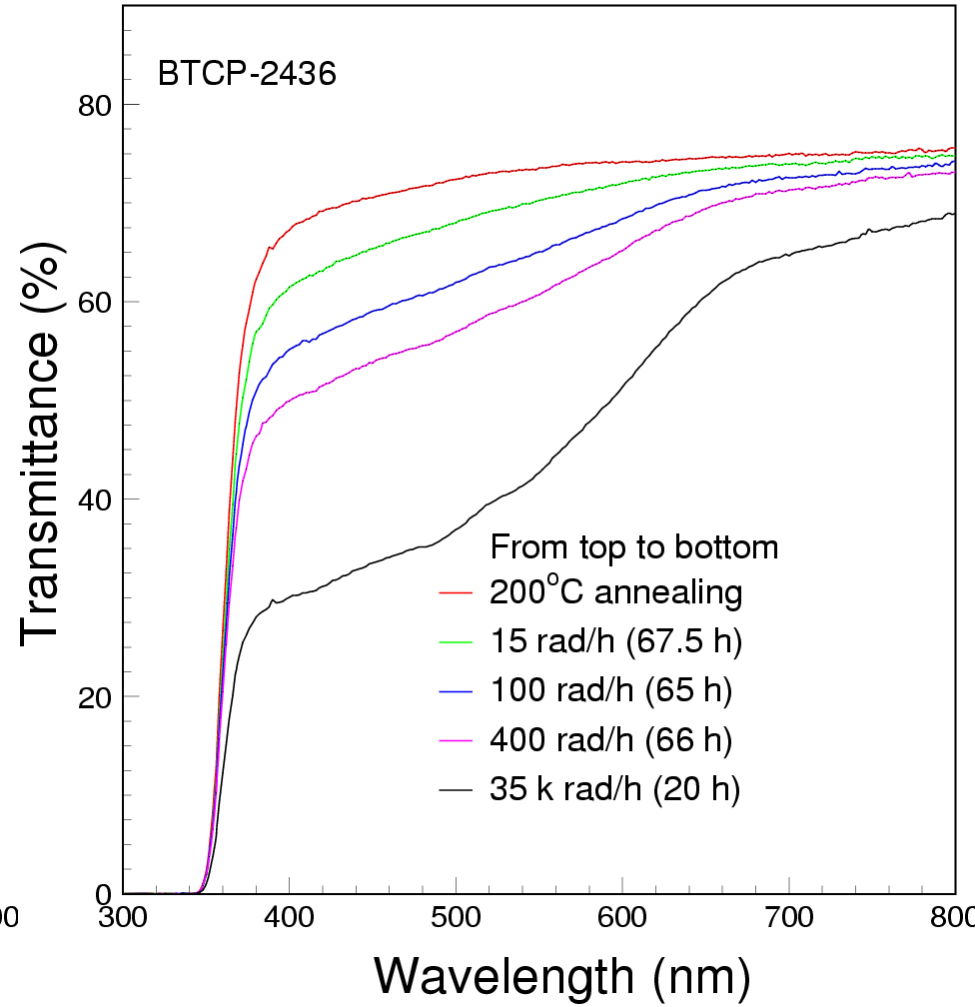


Investigation on BTCP Samples (II)

A good type I sample



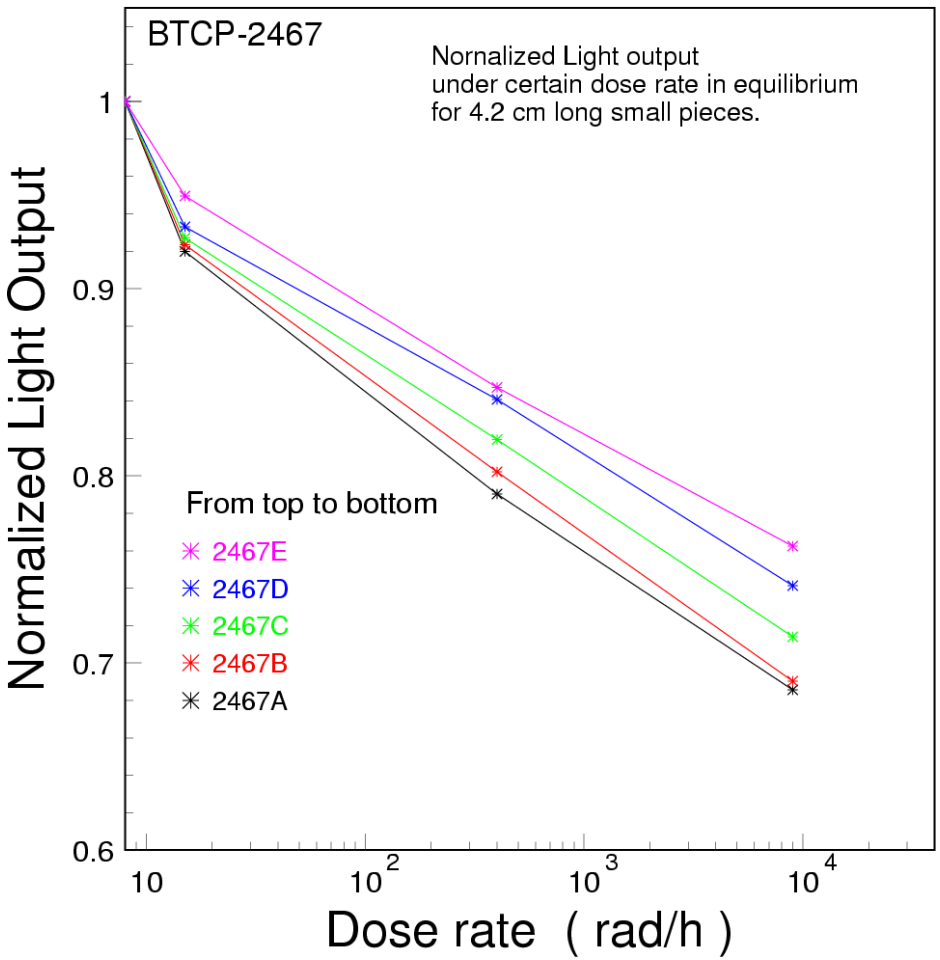
A typical type II sample



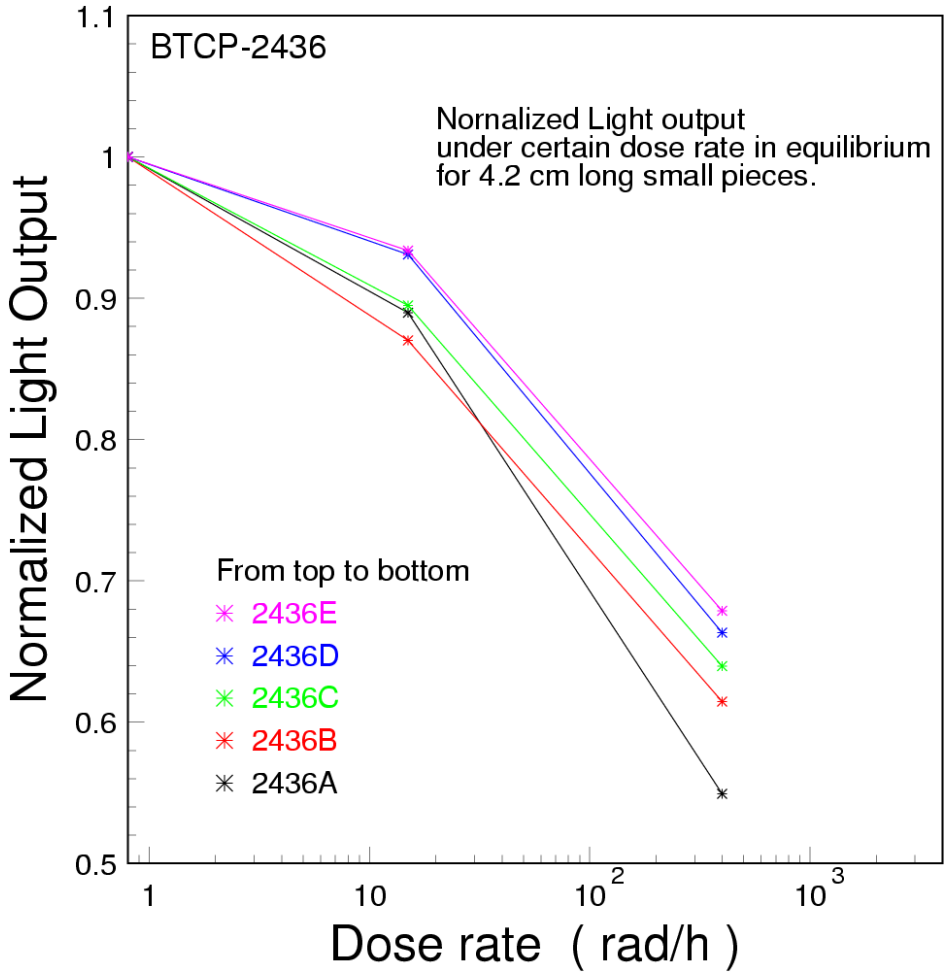
Investigation on BTCP Samples (III)

Light Output Degradation

Type I Sample

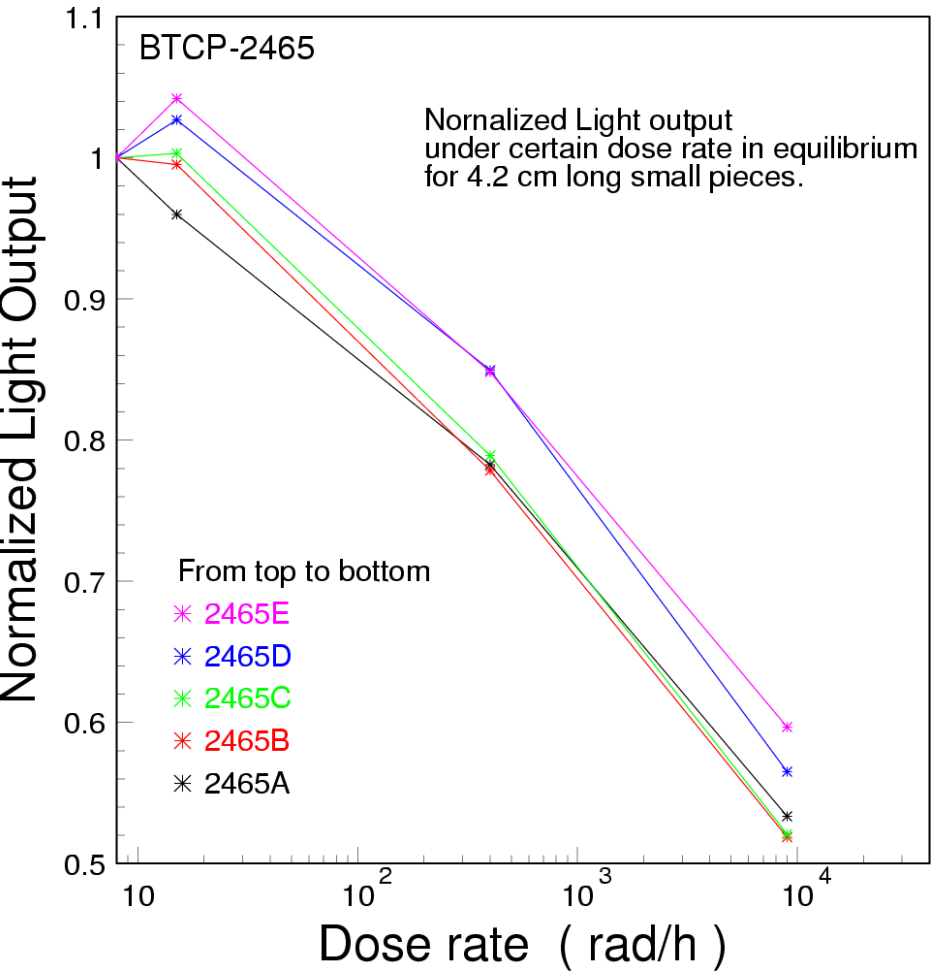


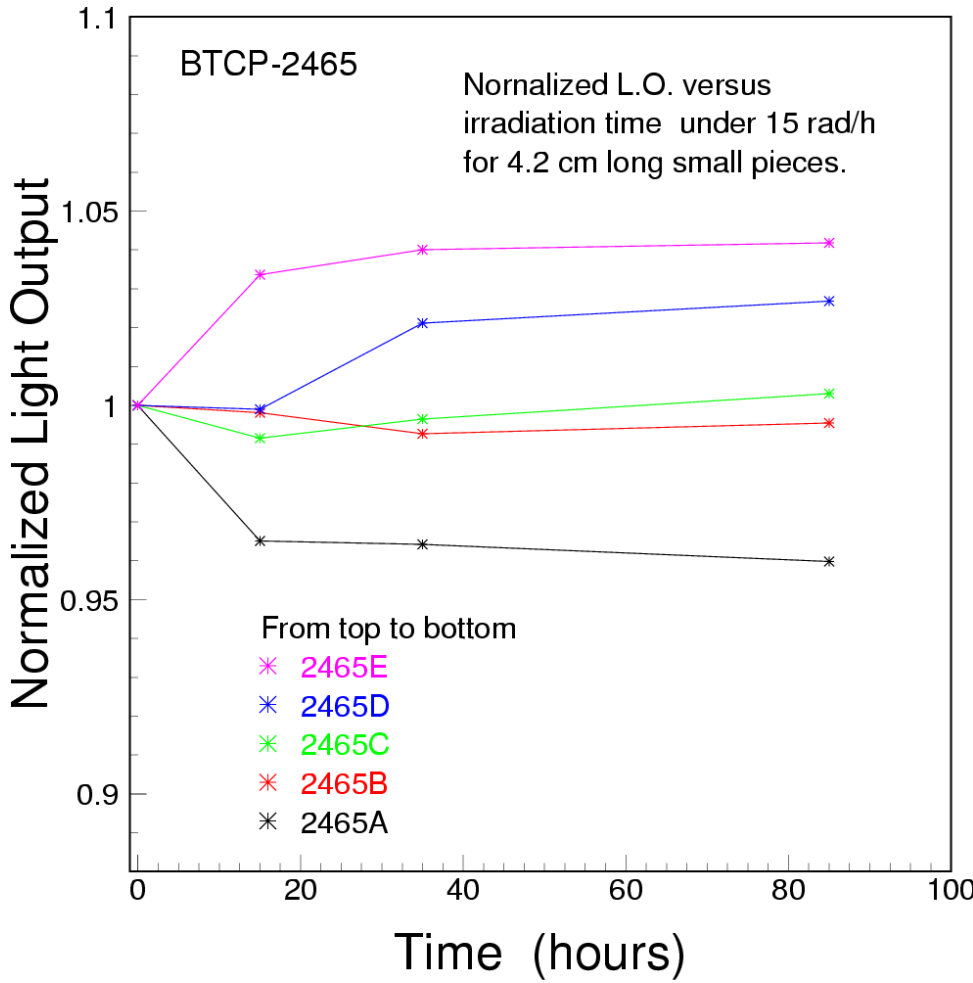
Type II Sample



Investigation on BTCP Samples (IV)

Anomaly is shown also at the Tail end (E and D)





Investigation on BTCP Samples (V)

GDMS on BTCP PWO(Y/Nb/La) Samples (ppmw)

by Shiva Technology (November, 2003)

Element	2467 Seed/Tail	2436 Seed/Tail	2465 Seed/Middle/Tail
Na	0.95/0.98	2.5/5.2	3.8/3.4/5.2
Si	<0.05	<0.05	<0.05
K	0.36/0.58	0.45/0.90	0.71/0.56/1.6
Ca	2.4/1.8	1.3/0.9	1.7/1.3/1.2
Cu	<0.05	<0.05	<0.05
As	<0.05	<0.05	<0.05
Y	71/74	94/120	98/83/100
Nb	0.06/0.11	0.07/<0.05	<0.05/0.27/0.26
Mo	0.2/0.23	0.33/0.38	0.37/0.37/0.41
Sb	<0.05	<0.05	<0.05
Ba	1.7/1.5	1.5/1.2	5.3/1.7/2.5
La	250/140	200/130	280/160/150
Eu	0.6/0.5	0.8/1.4	1.1/0.53/0.3
TC†	6.4/5.7	7.0/10	13/7.9/11

†: Total contamination, excluding Y, Nb and La.

Impurity segregation:

Na, K, Nb, Mo: <1;

Ca, Ba, La: >1;

Y: slightly less, but close to 1.

BTCP PWO is triple doped with Y/Nb/La!!!

Summary

- Early investigation on anomalous SIC samples indicates that the preexisting CC, causing light output increase under irradiation, is caused by contamination of mono-valent impurities.
- Investigation on BTCP samples yields similar conclusion. QC at BTCP on raw materials seems the solution.
- BTCP samples are triple doped with Y, Nb and La. To be understood: whether excessive La doping is the origin of low light yield!!!