Dense Scintillating Crystals and Glasses for HEP Dual Readout Calorimeter

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Dec. 4, 2007
Dual Readout Calorimeter Biweekly Meeting

- Double and Triple Doped $PbWO_4$
- Doped $CdWO_4$
- Gd_2O_3 and La_2O_3 glasses

Existing Studies for Doped $PbWO_4$

R&D work to increase the fast scintillation light of PWO for medical PET applications were conducted during 2000 ~ 2005.

- It is well known that scintillation properties of $PbWO_4$ crystals can be drastically changed by doping at ~100 ppm level.

- **Some of the doped PWO crystals they developed can be used in a dual readout calorimeter.**

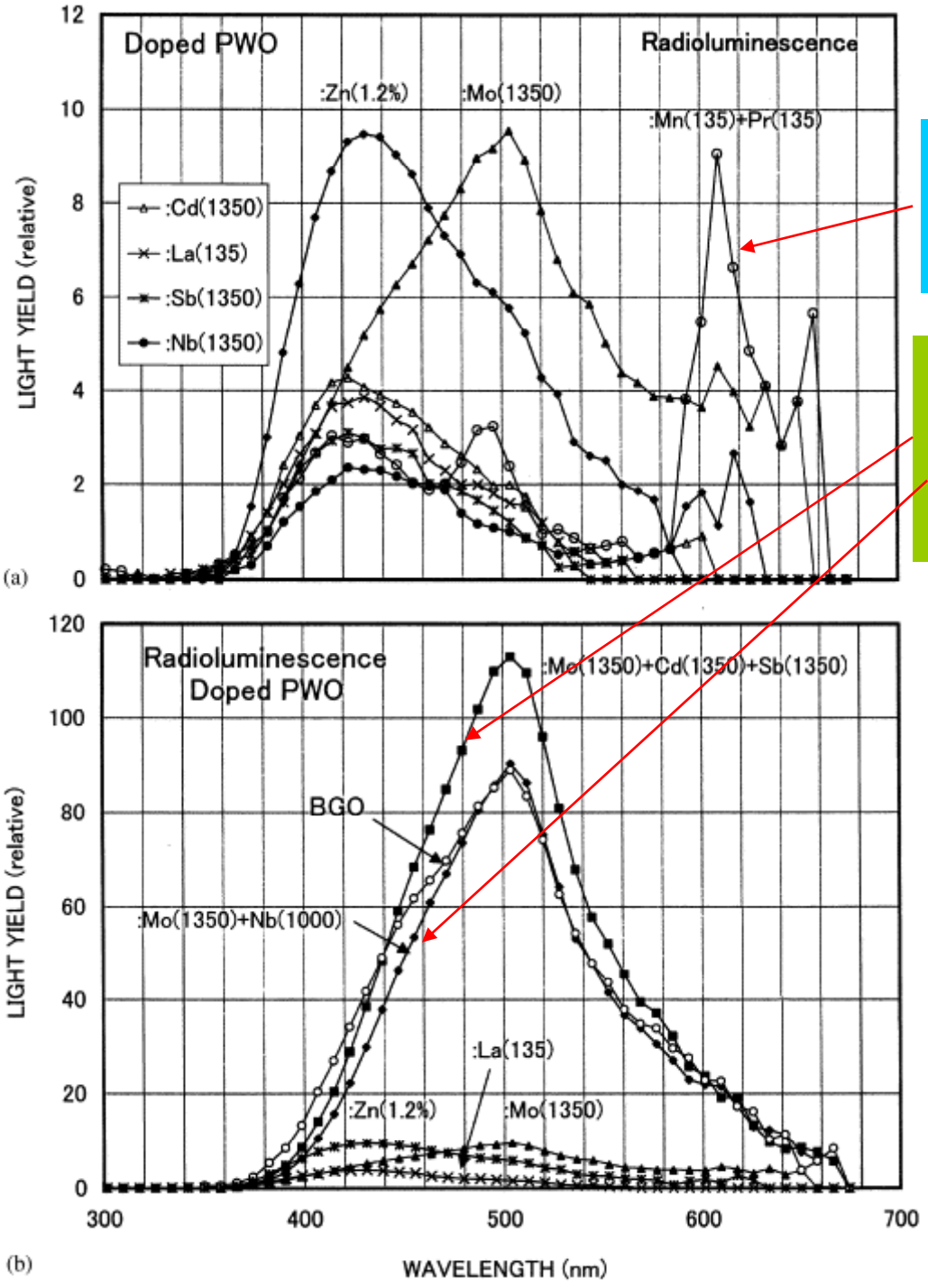
References

Nuclear Instruments and Methods in Physics Research A 540 (2005) 381–394
Nuclear Instruments and Methods in Physics Research A 486 (2002) 170–175

M. Kobayashi, KEK
Y. Usuki, Furukawa Co., Kannondai, Tsukuba 305-0856, Japan
M. Ishii, SIT, Shonan Institute of Technology, Fujisawa 251-8511, Japan
M. Nikl, Institute of Physics ASCR, Cukrovarnicka 10, 16200 Prague, Czech Republic

Nuclear Instruments and Methods in Physics Research A 486 (2002) 196–200
by SIC, CIT, BNL

Emission Spectrum of $PbWO_4$



PWO:Mn, Pr emission spectrum is in the region of 580 – 680 nm. The doping level required is only 135 ppm.

The spectra of scintillation light of
PWO: Mo,Cd,Sb and
PWO:Mo,Nb
are very similar to BGO

Remark

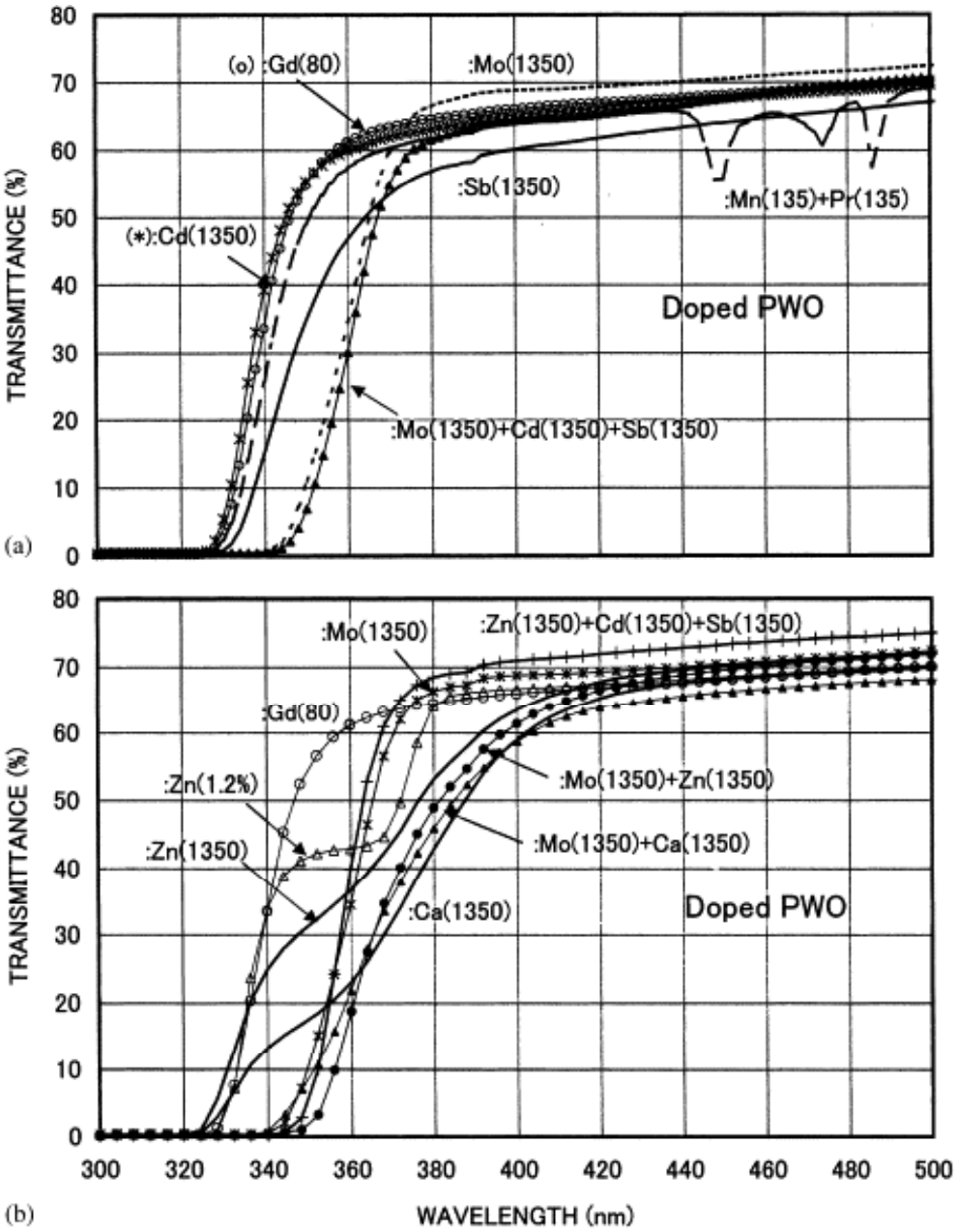
Since total light yield of PWO crystals is <10% of BGO, the ratio

(Cherenkov light)/(scintillation light)

should be higher in PWO crystals

PWO can be a much better crystal for dual readout calorimeter than BGO if wavelength filter is used to separate the scintillation and Cherenkov light components.

Light Transmision Spectrum of Doped $PbWO_4$



The transmission spectra of all kinds of doped PWO crystals are sufficient for transmitting Cherenkov light

PWO:Mn, Pr and PWO: Mo,Cd,Sb

are transparent for

wavelength > 380 nm

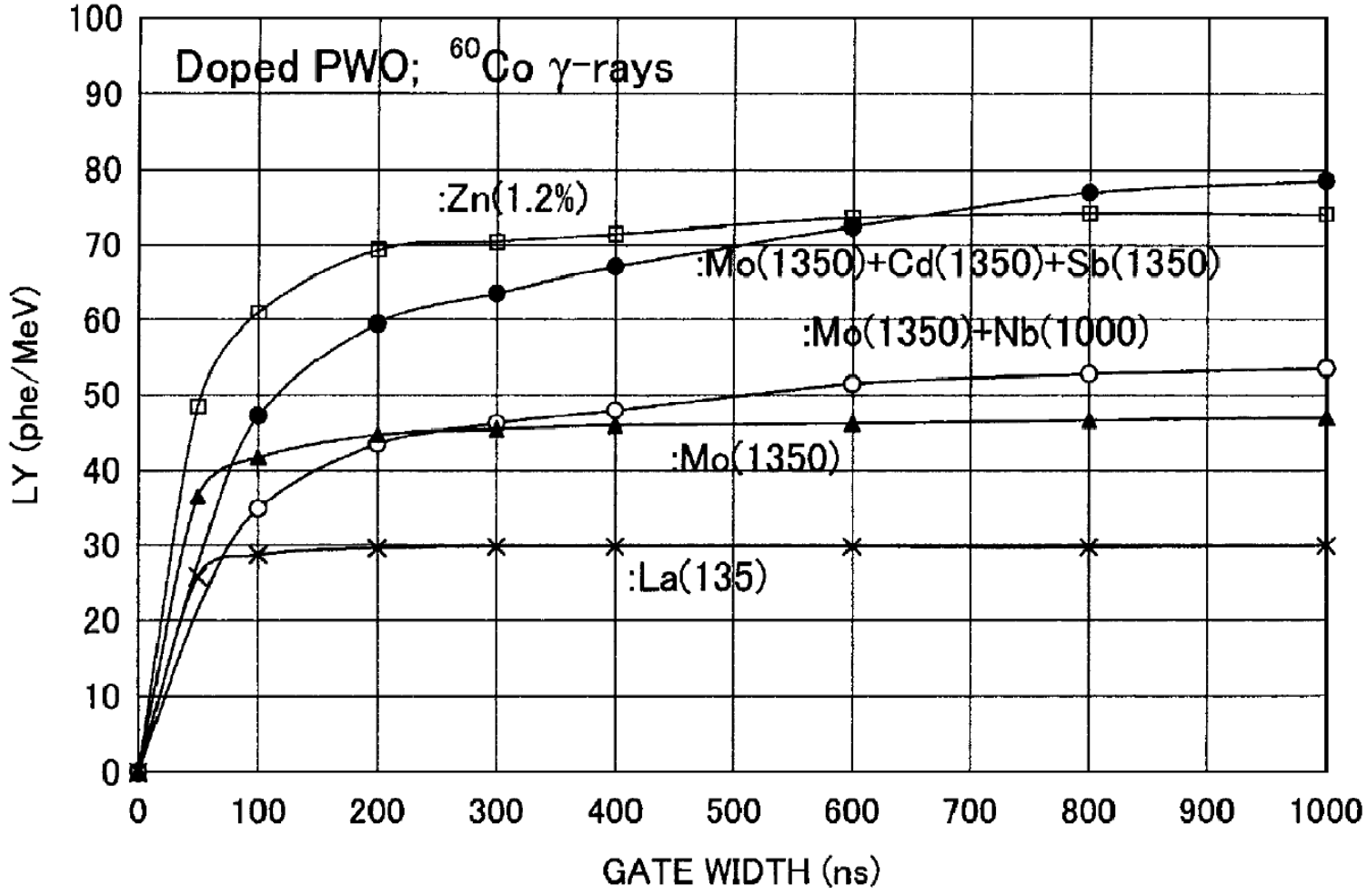
PWO:Mn, Pr without scintillation light below 580 ns is an idea crystal for a dual readout calorimeter.

The decay time of Pr doped scintillator is typically a few μs

Depedence of Light Yield on Gate Width

The light collection time of PWO:Mo, Nb and PWO: Mo,Cd,Sb are about what we want (not too slow nor too fast)

Separating cherenkov from scintillation light seems to be feasible



Doped $CdWO_4$

CWO is a traditional scintillation crystal for X-ray imaging with high light yield and slow decay time. Its density is very high

The fact it contains cadmium makes it interesting for a hadron calorimeter

If long decay time is acceptable, CWO can be a good candidate for a calorimeter with scintillation light only readout

If the 5 μs decay time is too long, then one needs to do some thing to shorten it.

Scintillator	Density (g/cm^3)	Wavelength (nm)	τ (ns)	γ's/MeV
$Bi_4Ge_3O_{12}$	7.1	410	300	8000
$CdWO_4$	7.9	495	5000	16000
$PbWO_4$	8.3	430	20	200~500

Reference

" Modification of scintillation characteristics of CdWO4 by doping with different ions"
M. Kobayashi, Y. Usuki, M. Ishii, M. Itoh
Radiation Measurements 38 (2004) 375 – 379

Dense Glasses

There is a recent paper about GdO and LaO base dense scintillating glasses.

Reference
"Terbium-activated heavy scintillating glasses"
Journal of Luminescence, v 128, n 1, Jan. 2008, 99-104

Jie Fu (Ohara Inc., Sagamihara, Japan)
M Kobayashi (KEK)
J.M. Parker (Sheffiled U, UK)

This paper was intended for slow X-ray imaging. But it shows the optical glass giant Ohara Inc. is developing dense scintillating glasses based on similar formulation as the Shanghai glasses.

Ohara claim: Density up to 6 g/cm^3 is possible with 40 mol% of GdO or LaO

Conclusions

R&D on PWO doping done by a Japanese group lead by KEK and by Shanghai Institute of Ceramics have both proved PWO crystals can be doped to produce slower scintillation light with longer wavelength

CWO may be another interesting crystal to explore for ILC calorimeter

We should have more confident about the dense scintillator based on GdO since now Ohara Inc. is also interested in it