TD1401 EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

SCINTILLATORS:

new ways to fast emission

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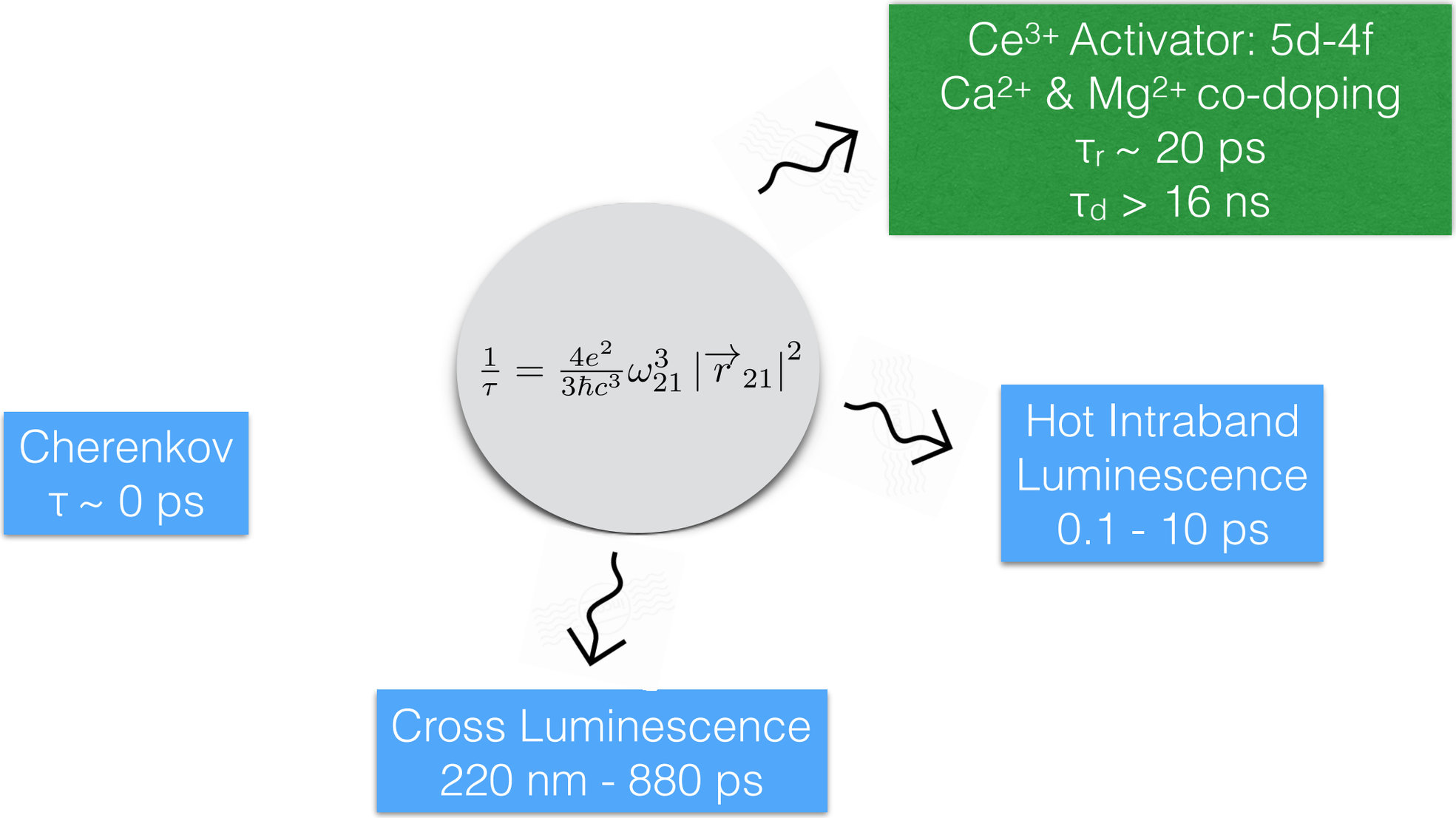
IEEE, Strasbourg 2016

N52-4 Light production in scintillators and nanocrystals during the first 5 ns under pulsed x-rays excitation

MOTIVATION

New source of prompt photons for 10 ps TOF



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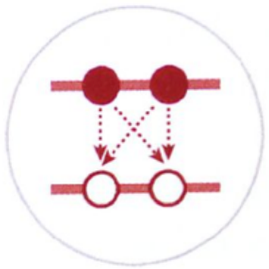
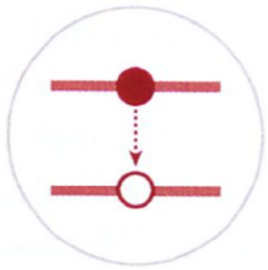


Bi-excitons
stables at 300 K



Excitons
stable at 300 K

Ce^{3+} Activator: 5d-4f
Ca^{2+} & Mg^{2+} co-doping
τ_r ~ 20 ps
τ_d < 16 ns

$$\frac{1}{\tau} = \frac{4e^2}{3\hbar c^3}\omega_{21}^3 \left|\overrightarrow{r}_{21}\right|^2$$

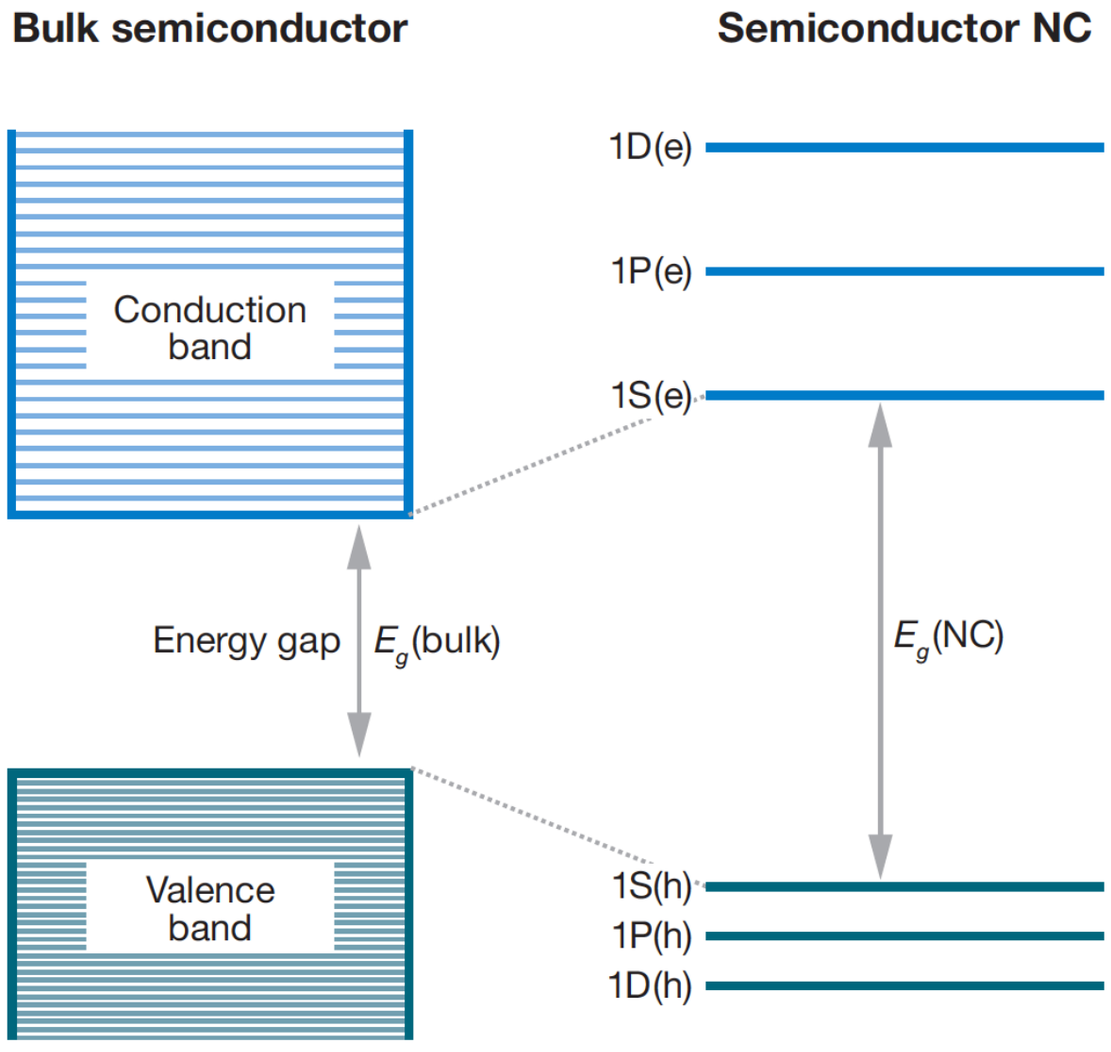
Cherenkov
τ ~ 0 ps

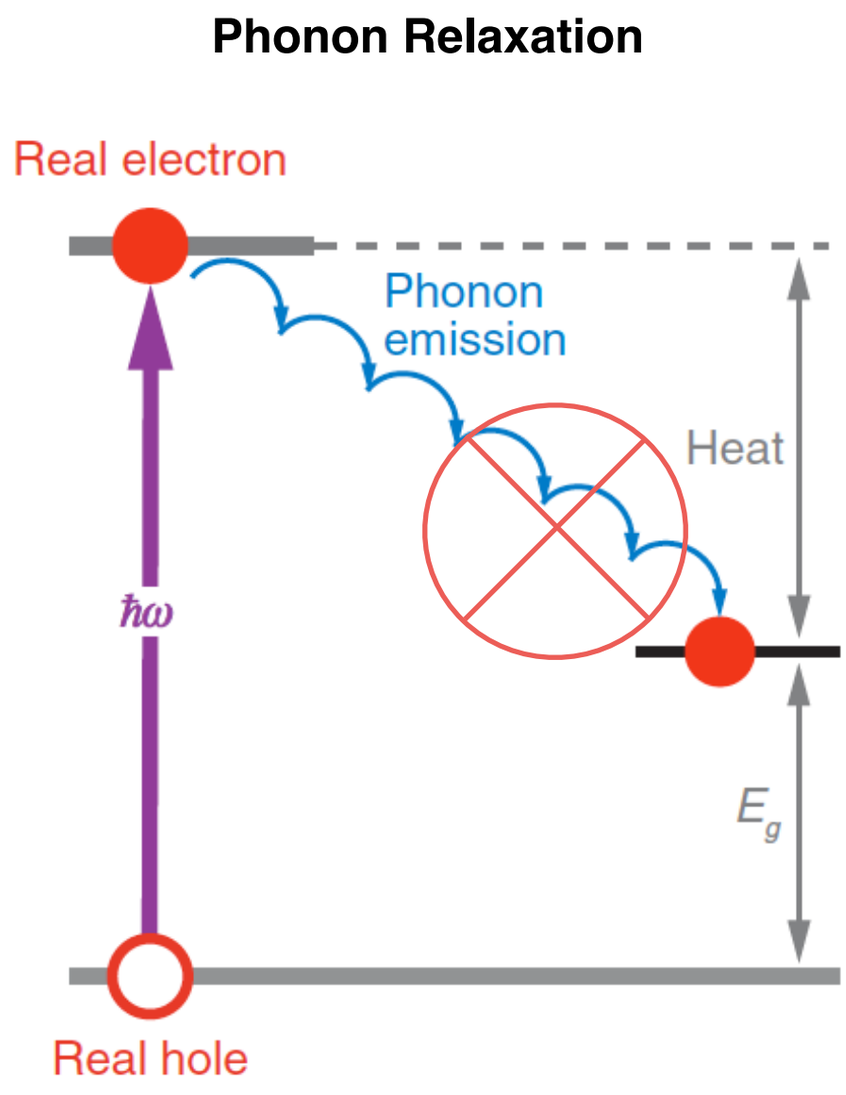
Hot Intraband
Luminescence
0.1 - 10 ps

Cross Luminescence
220 nm - 880 ps

Relaxation scheme in nanocrystals

$$a \sim \lambda_B \longrightarrow QUANTUM\ CONFINEMENT$$

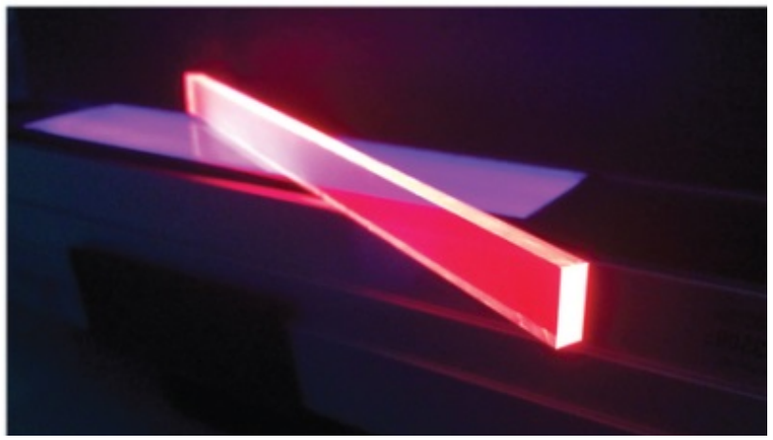




V. Klimov, *Annu. Rev. Phys. Chem,* 58, pp. 635-73, 2007.

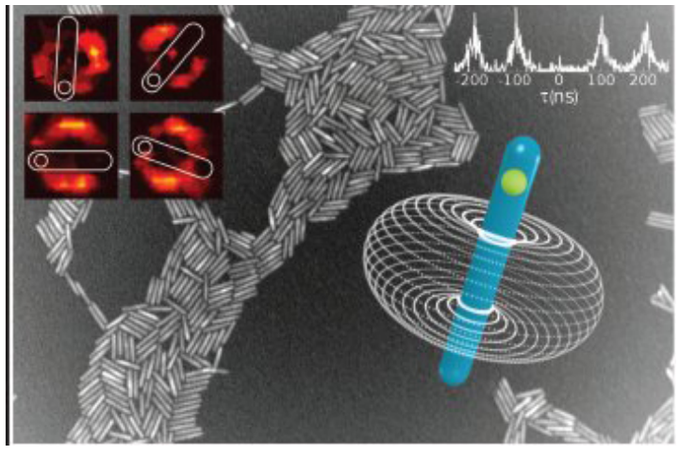
Nanocrystals Applications

Solar cells



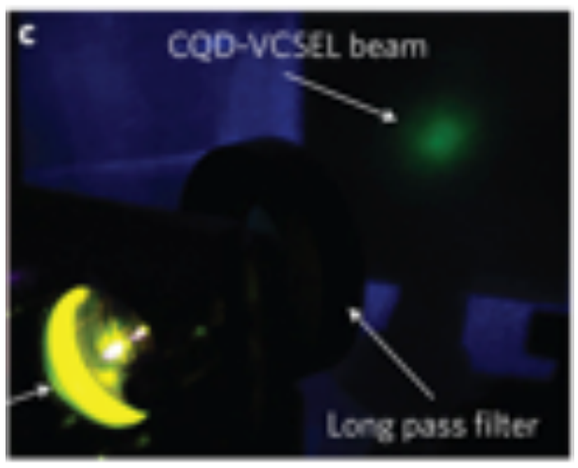
Nat. Photonics, 2014, **8**, 392

Quantum emitters



Appl. Phys. Lett. 2010 **96**, 033101

Lasing



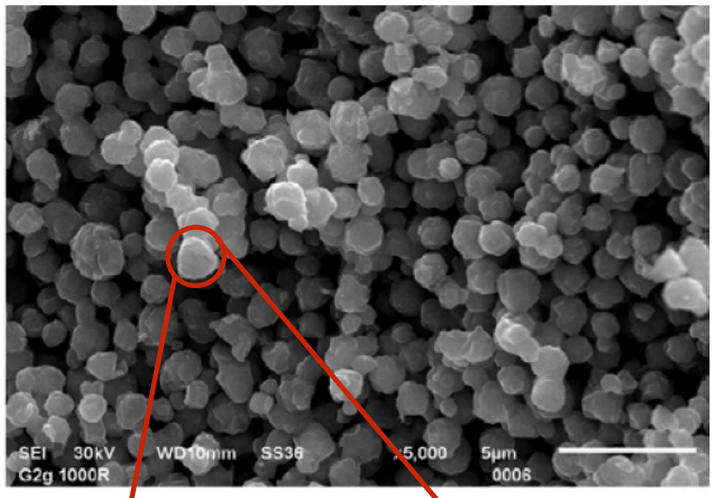
Nat. Nano. 2012 **7**, 335

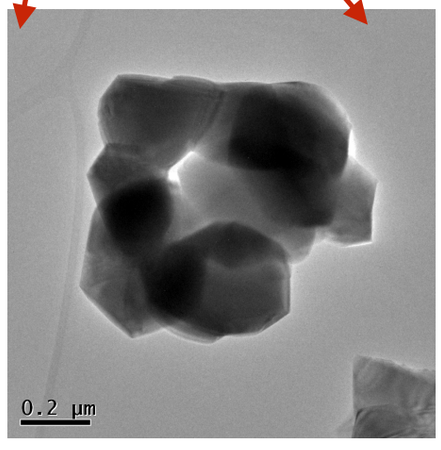
Radiation Detectors

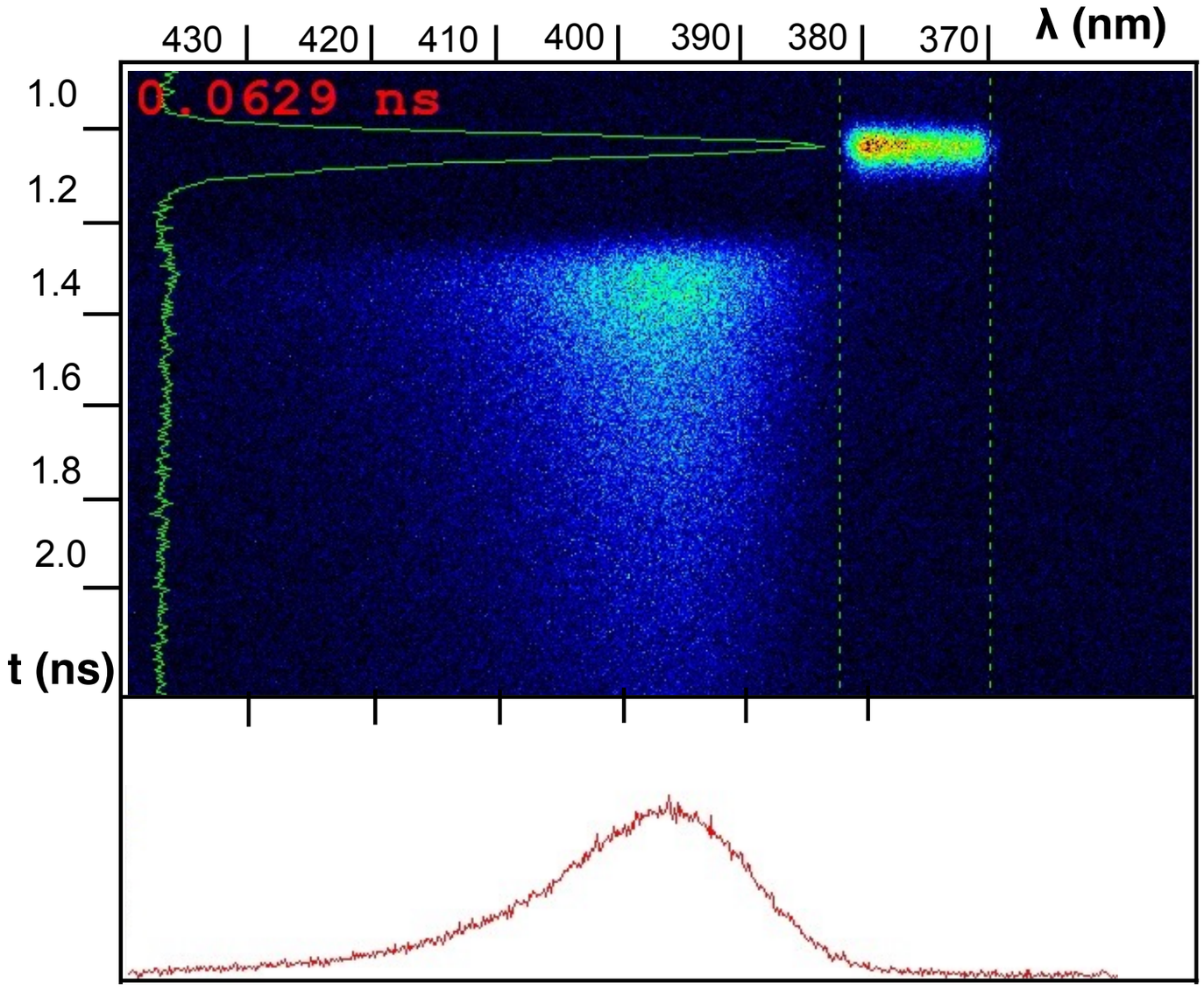
?

ZnO:Ga nanocrystals in a PS host

in collaboration with Institute of Physics AS CR and Technical University in Prague (M. Nikl, V. Čuba groups)





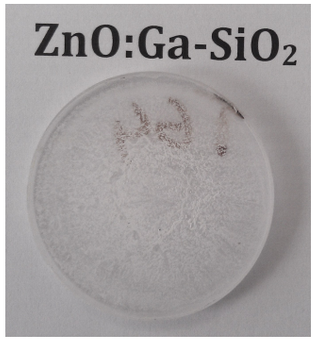


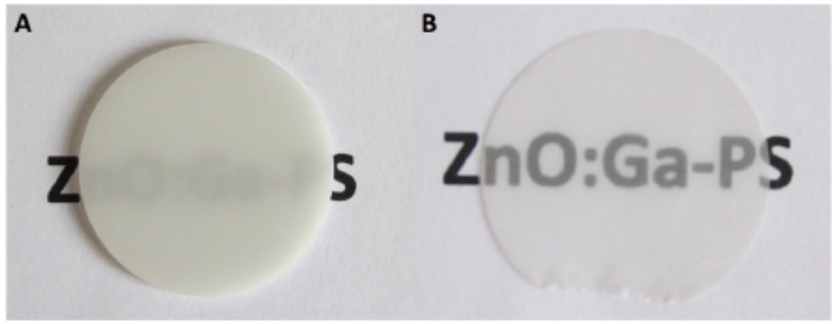
L. Procházková *et al*, *Opt. Materials,* 47, 67 (2015).

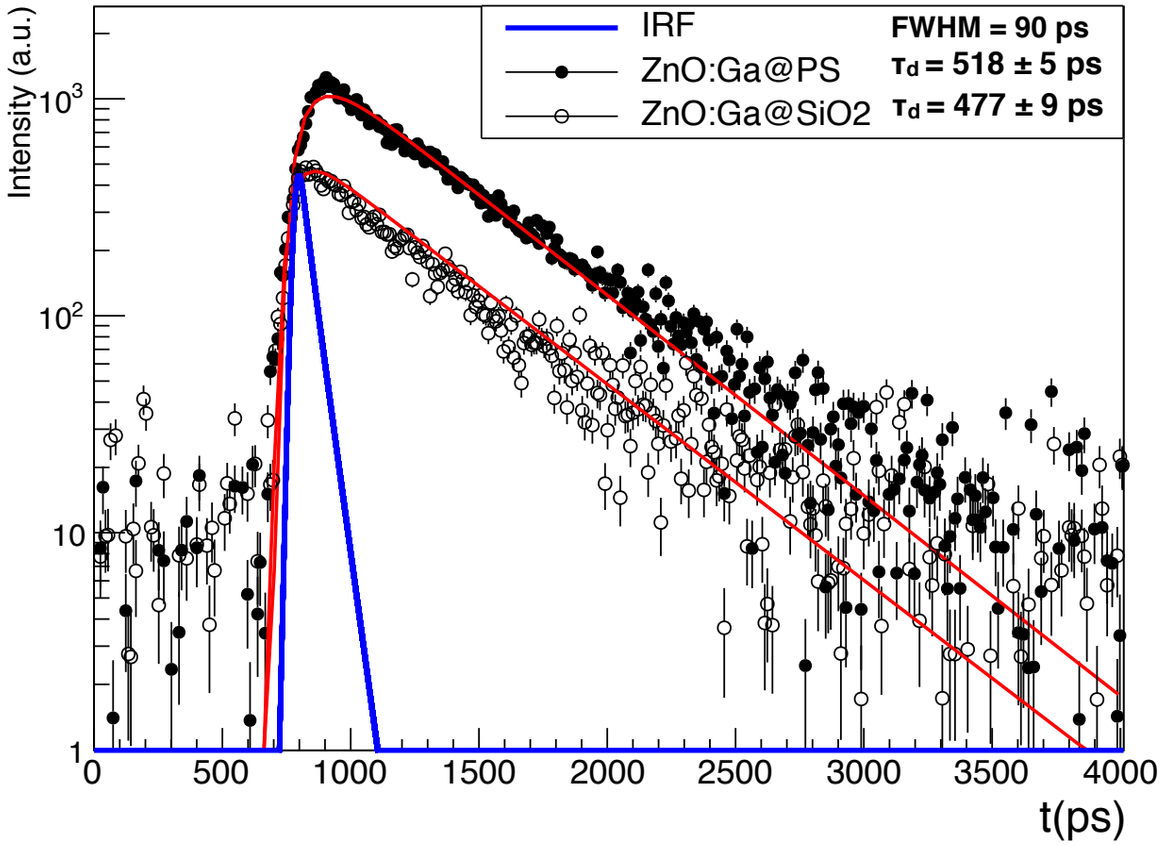
H. Burešová *et al*, *Opt. Express* 24(14), 15289 (2016).

R. M. Turtos *et al*, *pss RRL 1–5,* 2016, DOI 10.1002/pssr.201600288

ZnO:Ga nanocomposites







L. Procházková *et al*, *Radiat. Meas.* 90, 59 (2016).

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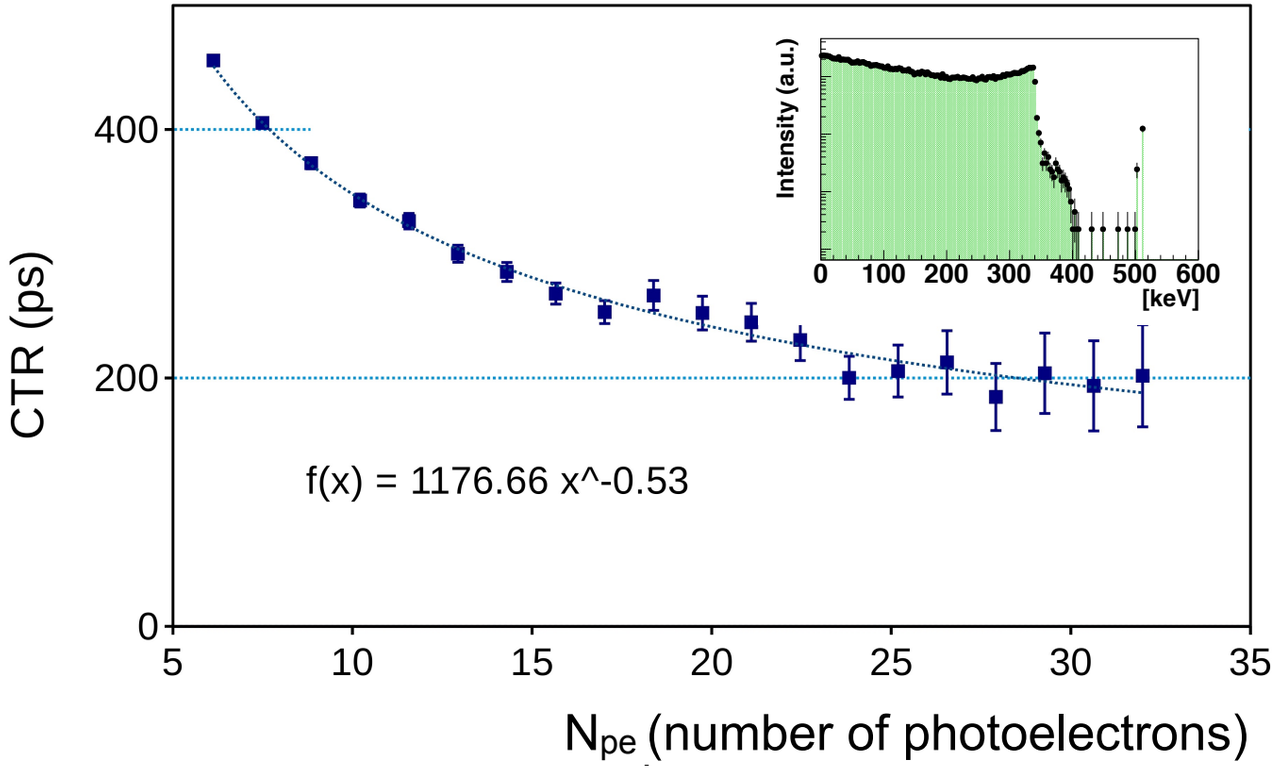
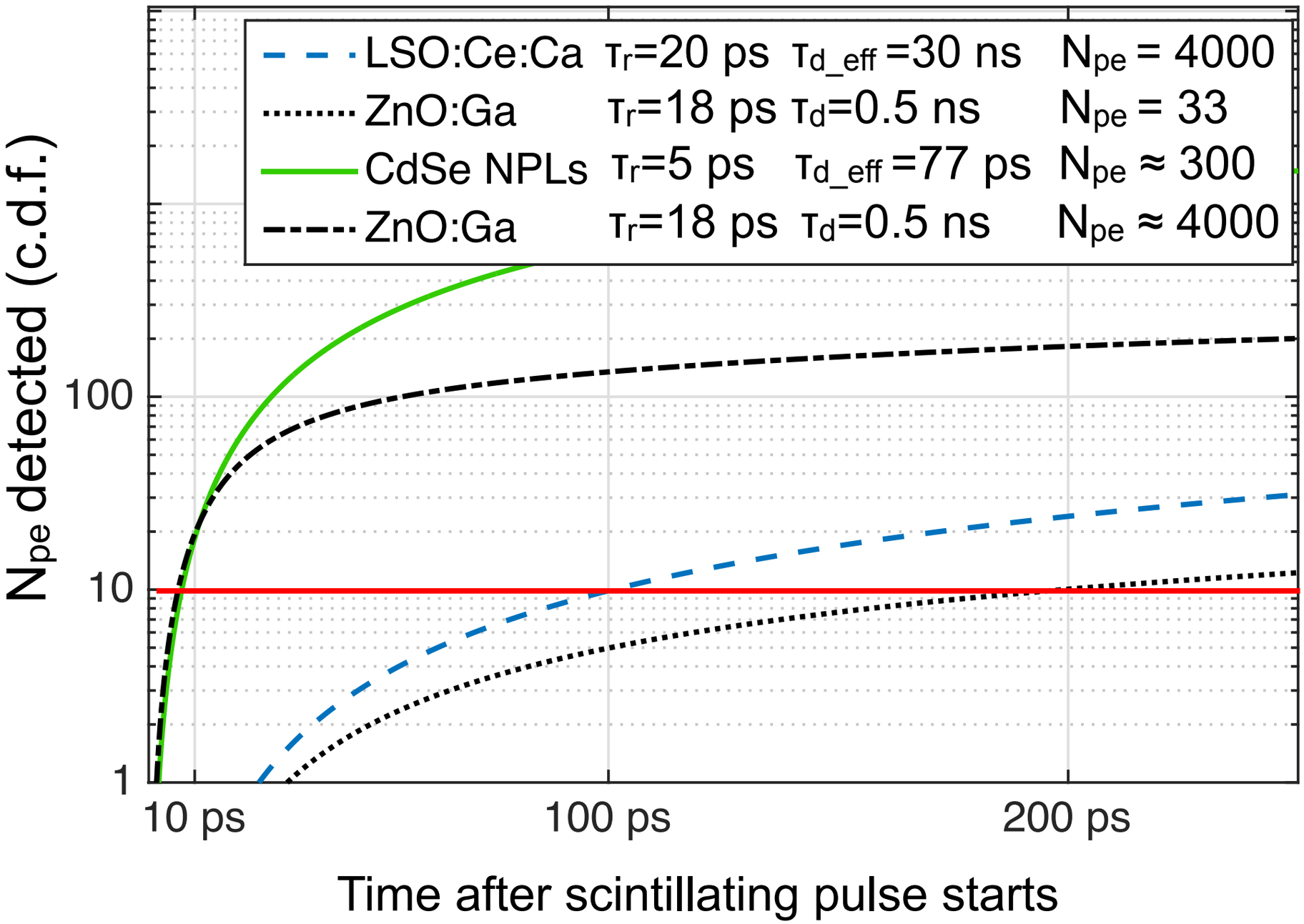


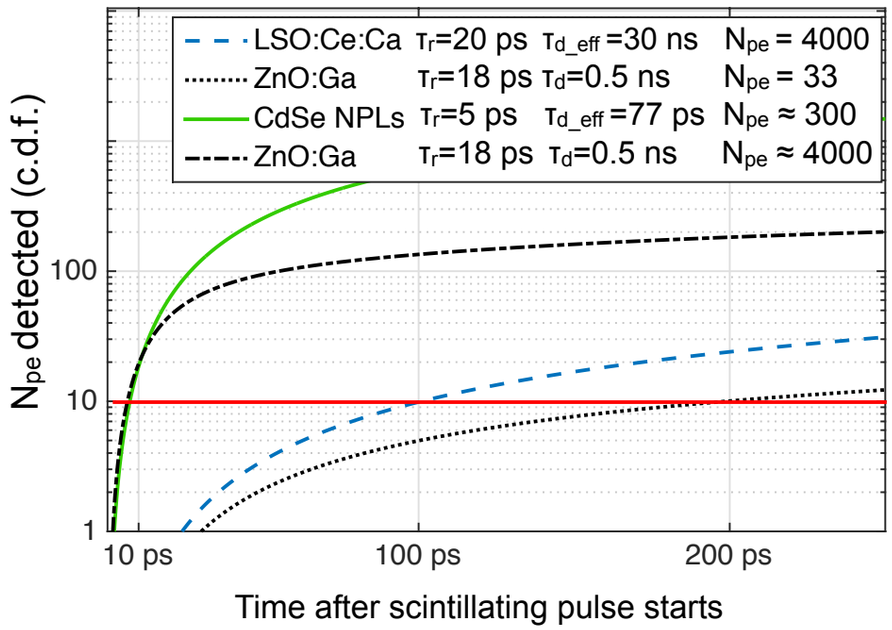
R. M. Turtos *et al*, *pss RRL*, 2016, *in press*.

Nanocrystals for fast timing?

CTR = 200 ps with 30 photoelectrons detected



Transfer the highly localised properties of nanocrystals to a block material



Stopping power

Energy transfer and quantum efficiency

Light transport & extraction

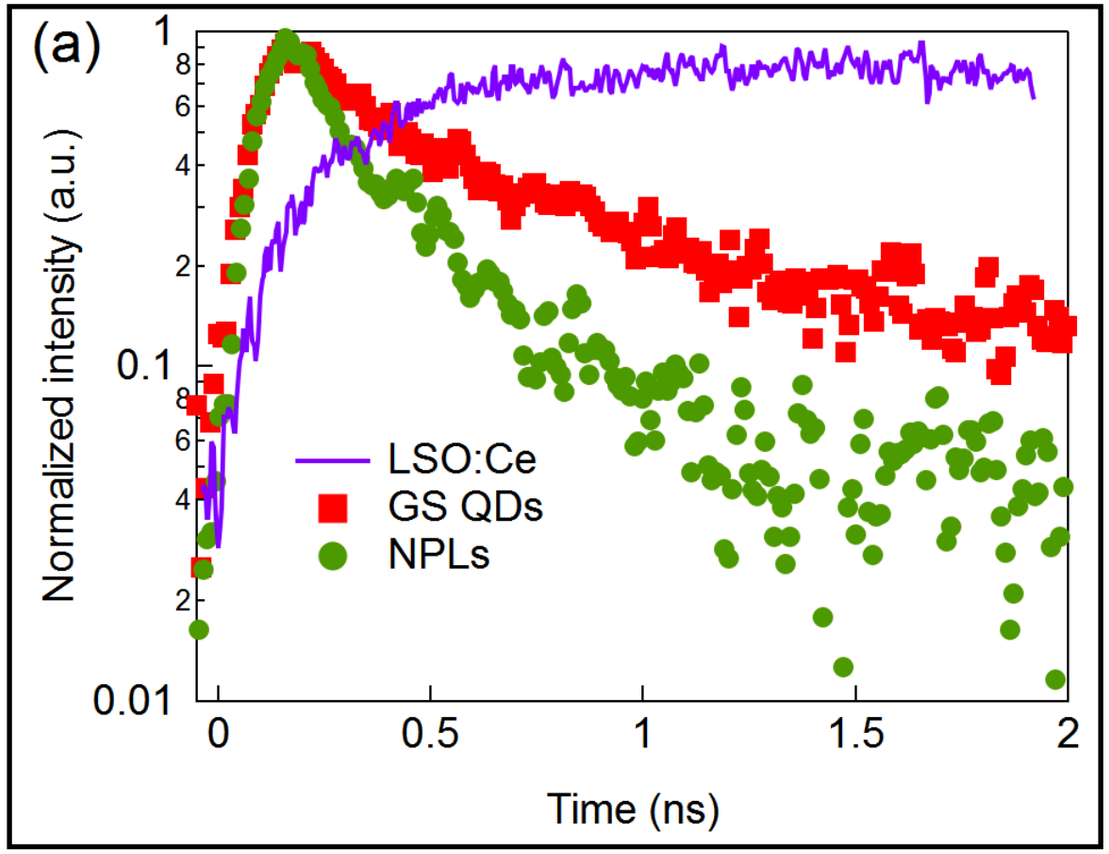
CONCLUSIONS

Auger suppressed NCs are a promising source of prompt photons under ionizing radiation:

$\tau_{eff_CdSe\ NPLs}$ ~ 77 ps

$\tau_{eff_CdSe/CdS\ QDs}$ ~ 849 ps

$\tau_{eff_ZnO:Ga}$ = 500 ps



From nanocrystals to a block material: a new generation of ultrafast scintillators?

THANKS!!

ACKNOWLEDGMENTS

Fast Advanced Scintillator Timing