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Intrinsic Luminescence Peculiarities in CaF_2 Nanoparticles upon the High-Energy Excitation

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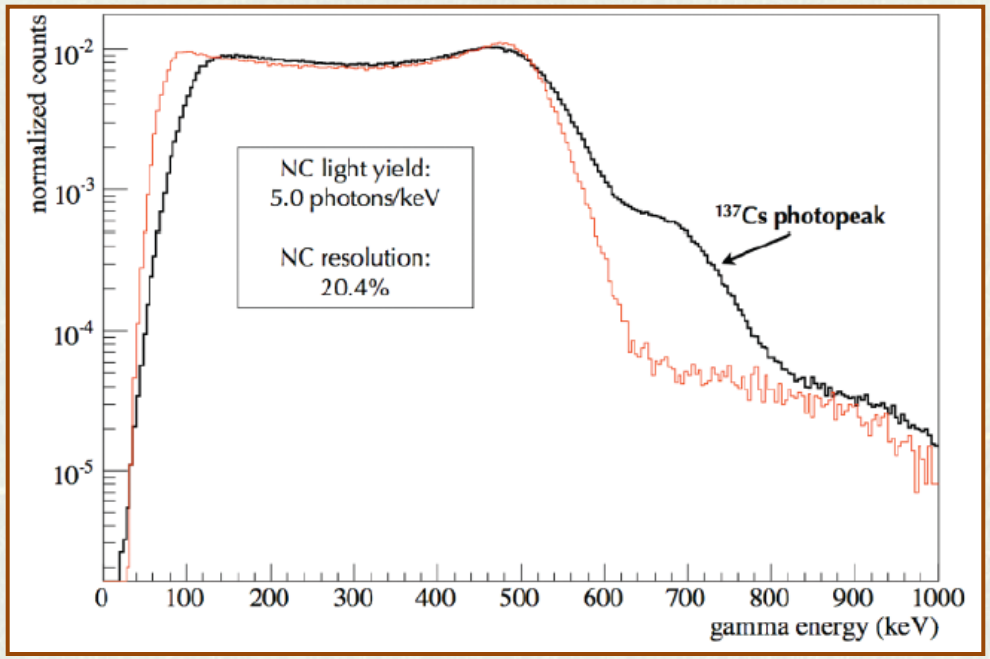
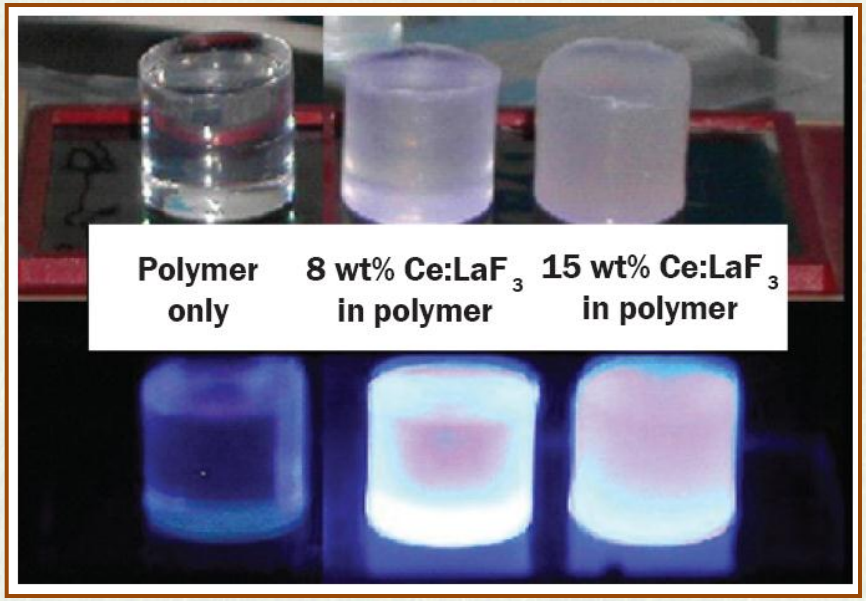
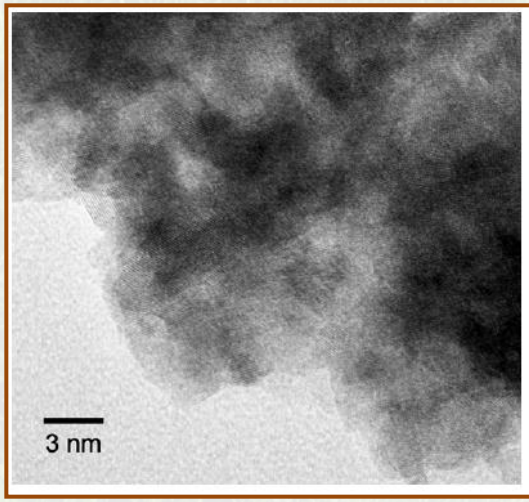
1. Nanoscintillators, Application area

1.1. Volume nanocomposite scintillators

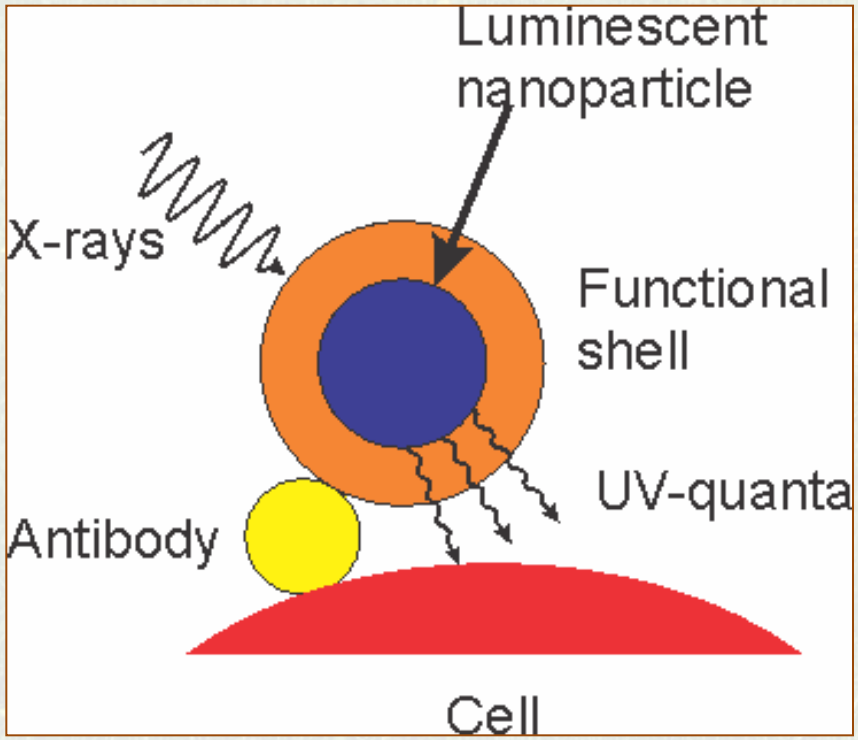


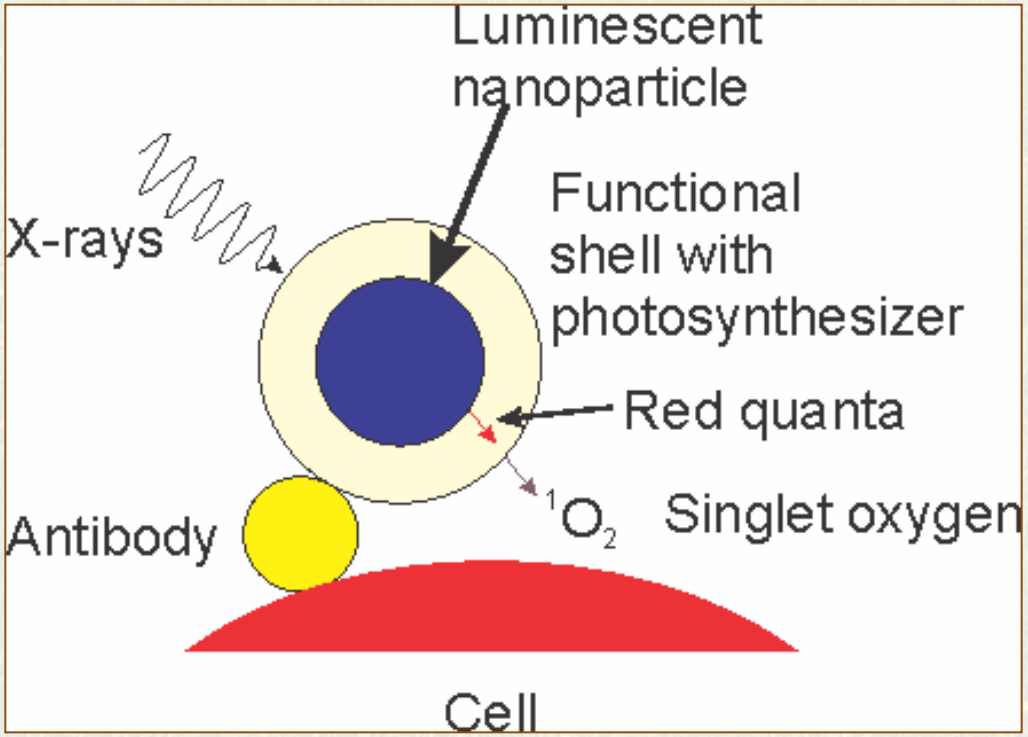


R. E. Del Sesto, E. A. McKigney. et al. Development of nanocomposite scintillators / Materials Research Highlight, 2007



1.2. Medicine. Radiotherapy and photodynamic therapy



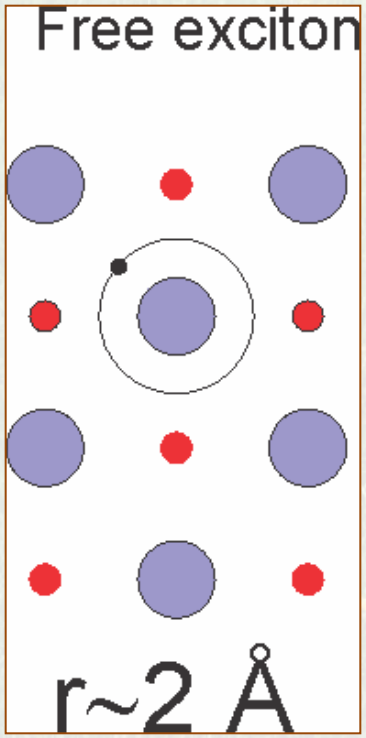


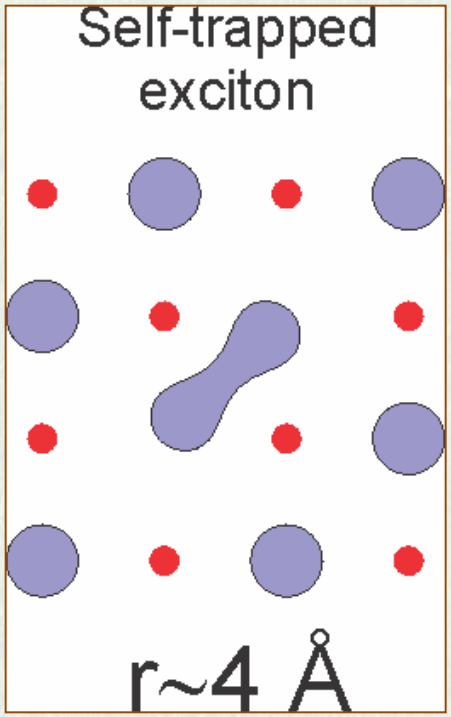
2. Electronic excitations and size effects in nanoparticles

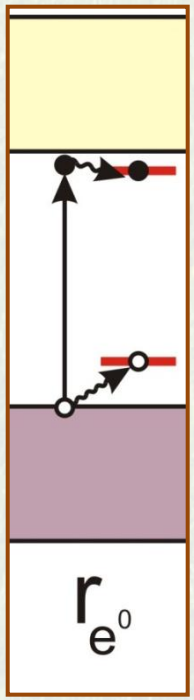
2.1. Radius of electron excitations and confinement effect

Optical creation

of self-trapped excitons



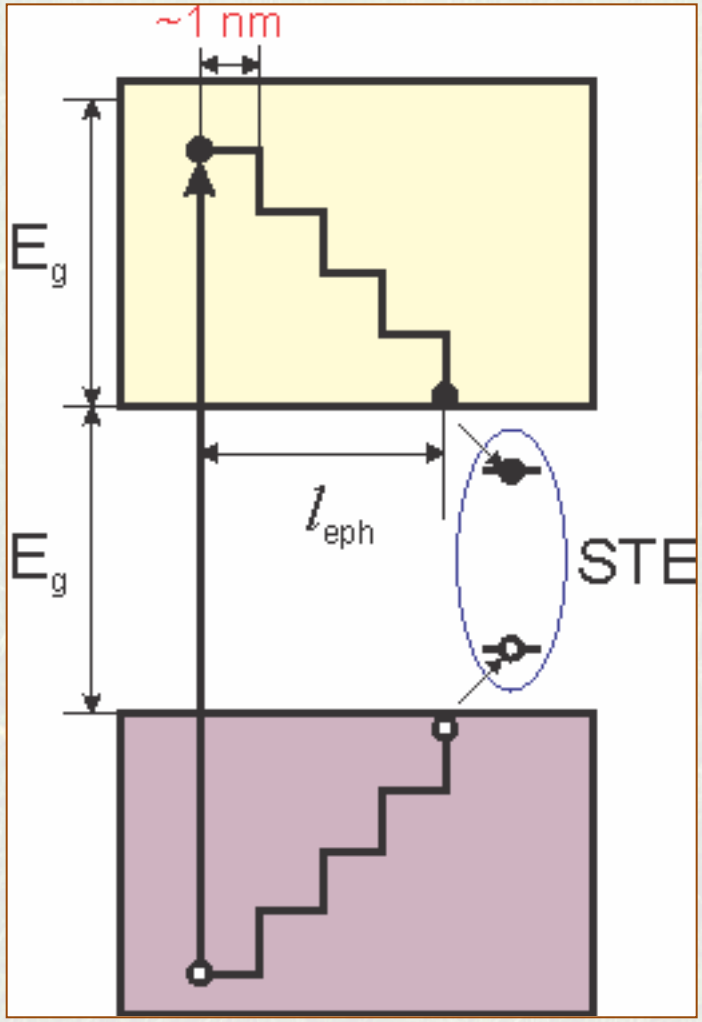




$r \ll a \approx 5$ nm

2.2. Electron phonon interaction termaliazation length

Recombinational creation of excitons



$E < E_g$

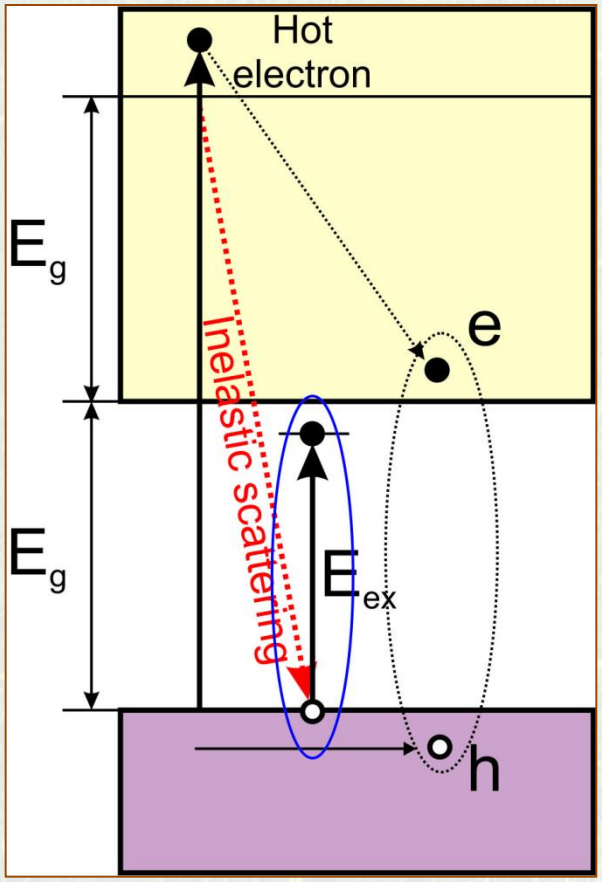
$E_e = 5$ eV

$h\nu_{ph} = 0.1$ eV

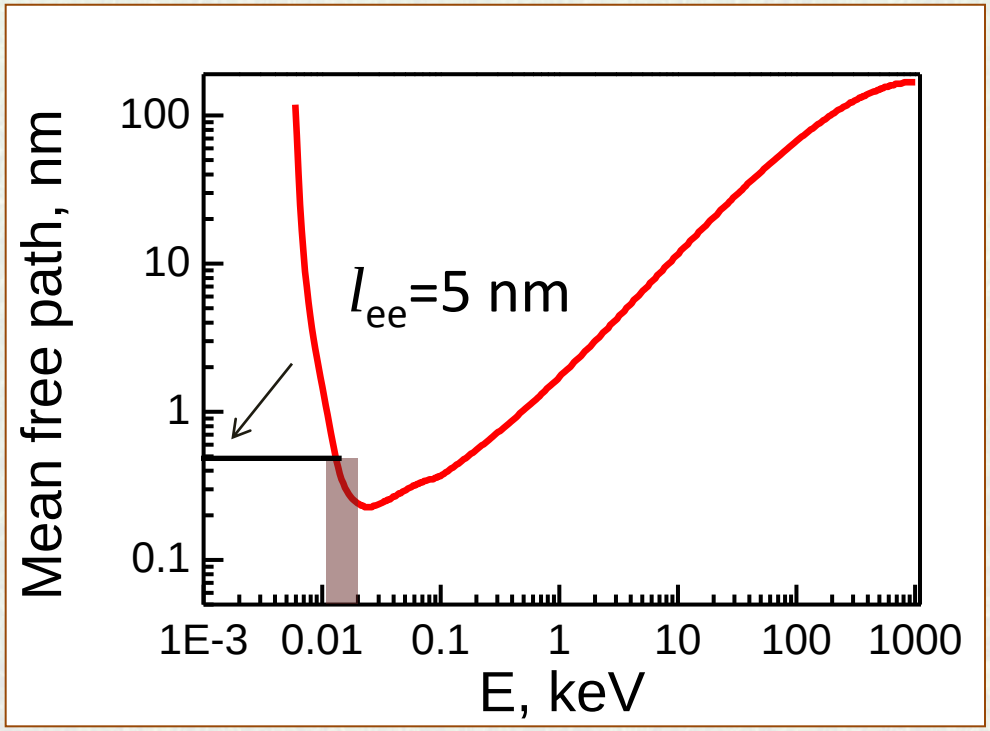
$S = 100$

$l_{eph} \sim 50$ nm

2.3. Electron - electron scattering. Multiplication of electron excitation



Universal curve of electron-electron scattering

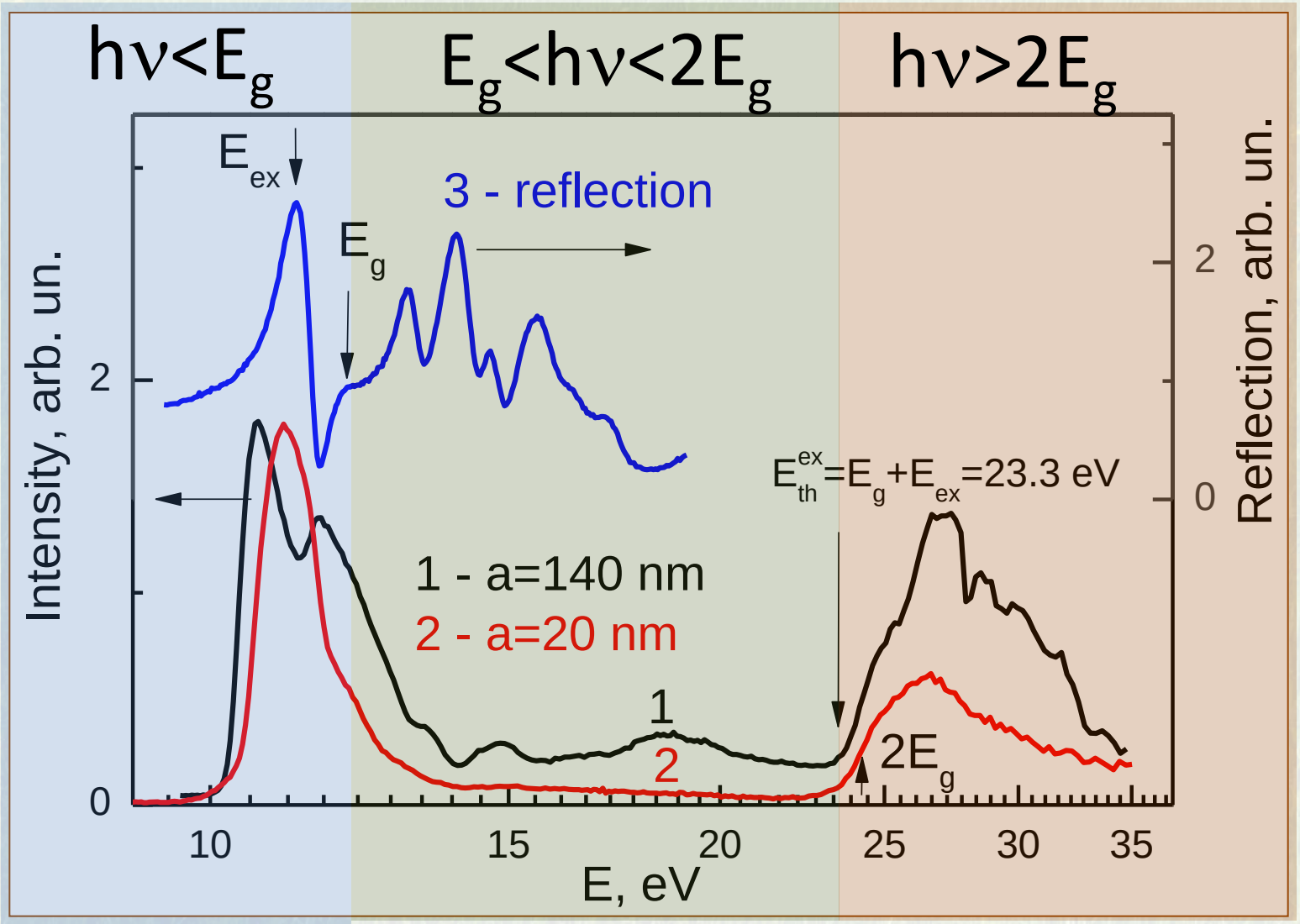


3. Luminescence parameters of CaF_2

SUPERLUMI (HASYLAB, DESY) experiment

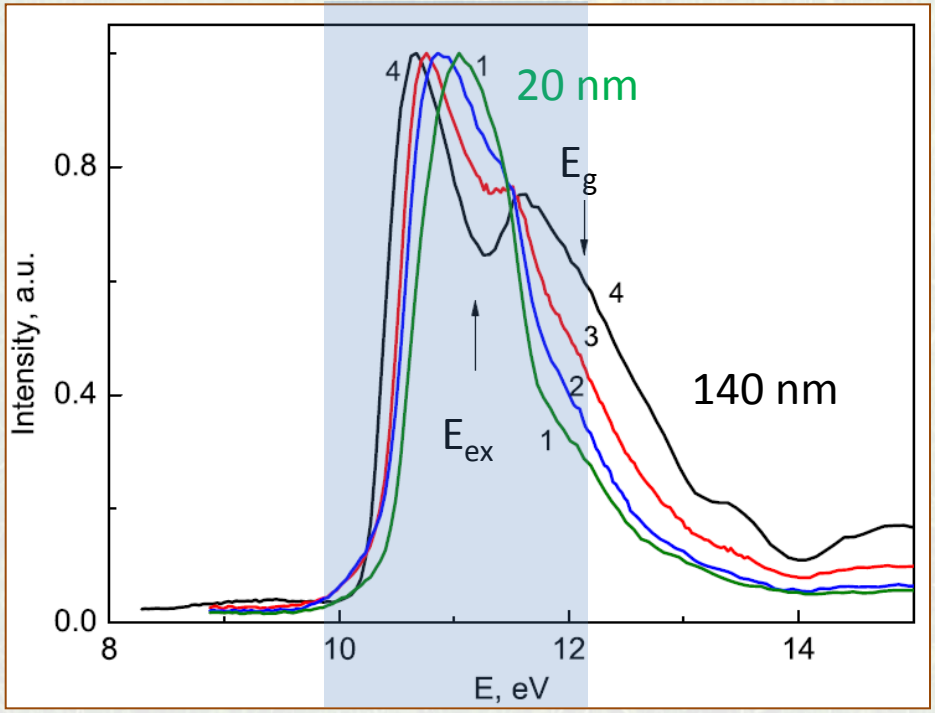
3.1. Excitation spectra of CaF2 nanoparticles (powders)

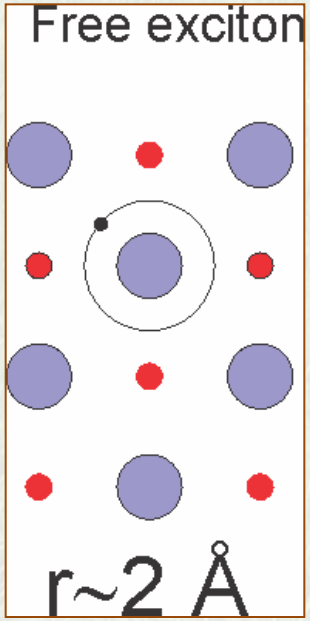
The normalised STE luminescence excitation spectra (λ_{em}=300 nm) at 300K.

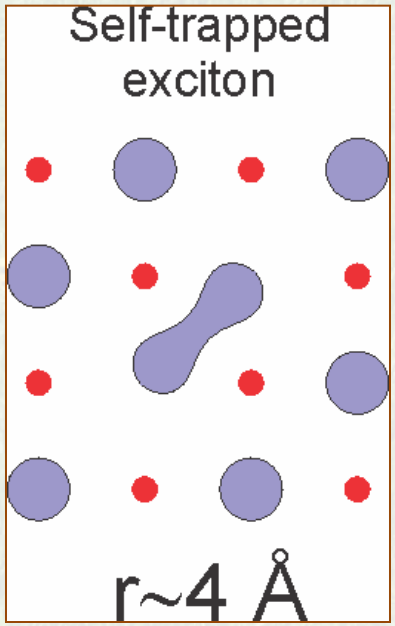


3.2. Range of optical creation of excitons

STE excitation luminescence spectra (λ_{em}=300 nm) for CaF_2 nanoparticles of various sizes at 300K. Curves: 1–20 nm; 2–37 nm; 3–50 nm; 4–140 nm.





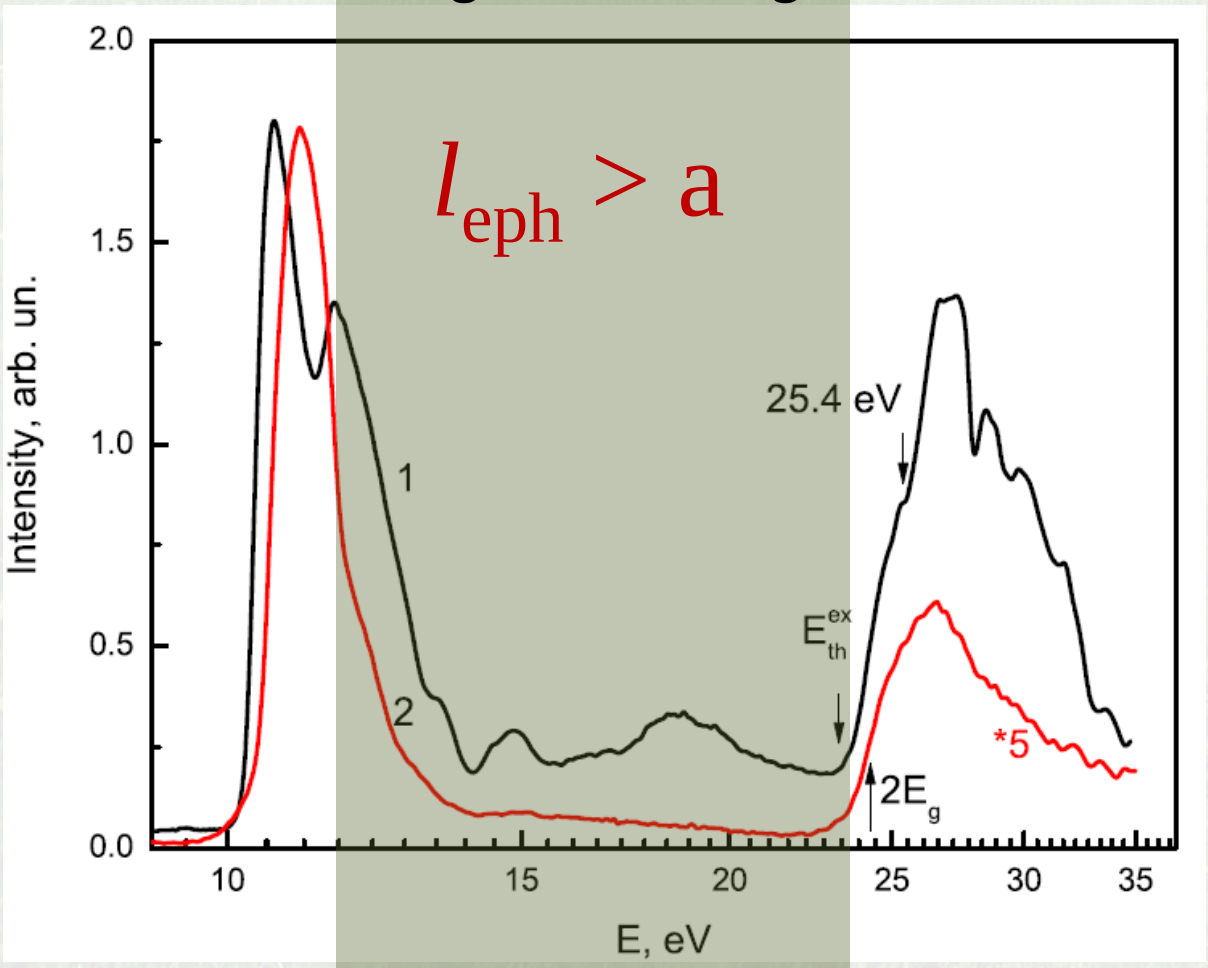


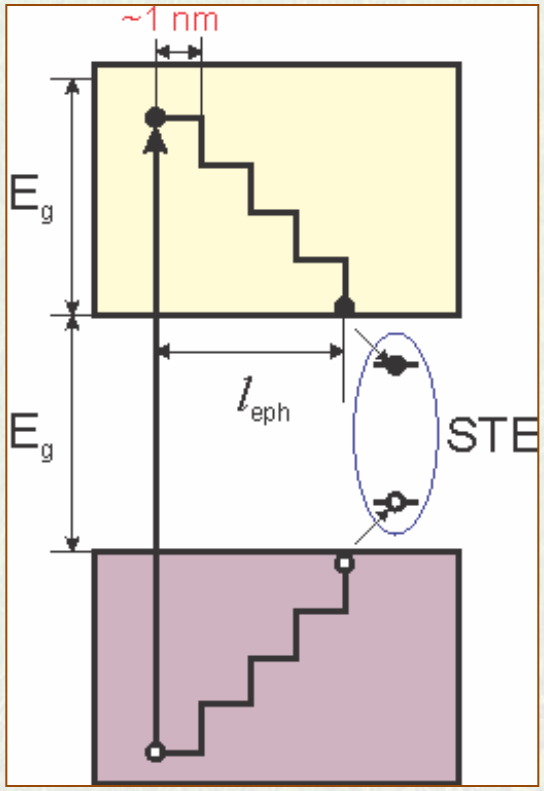
$r << a \approx 5$ nm

3.3. Band to band excitation $E_g<h\nu<2E_g$

The normalised STE luminescence excitation spectra (λ_{em}=300 nm) for nanoparticles of 140 nm (1) and 20 nm (2) sizes at 300K.

$E_g<h\nu<2E_g$

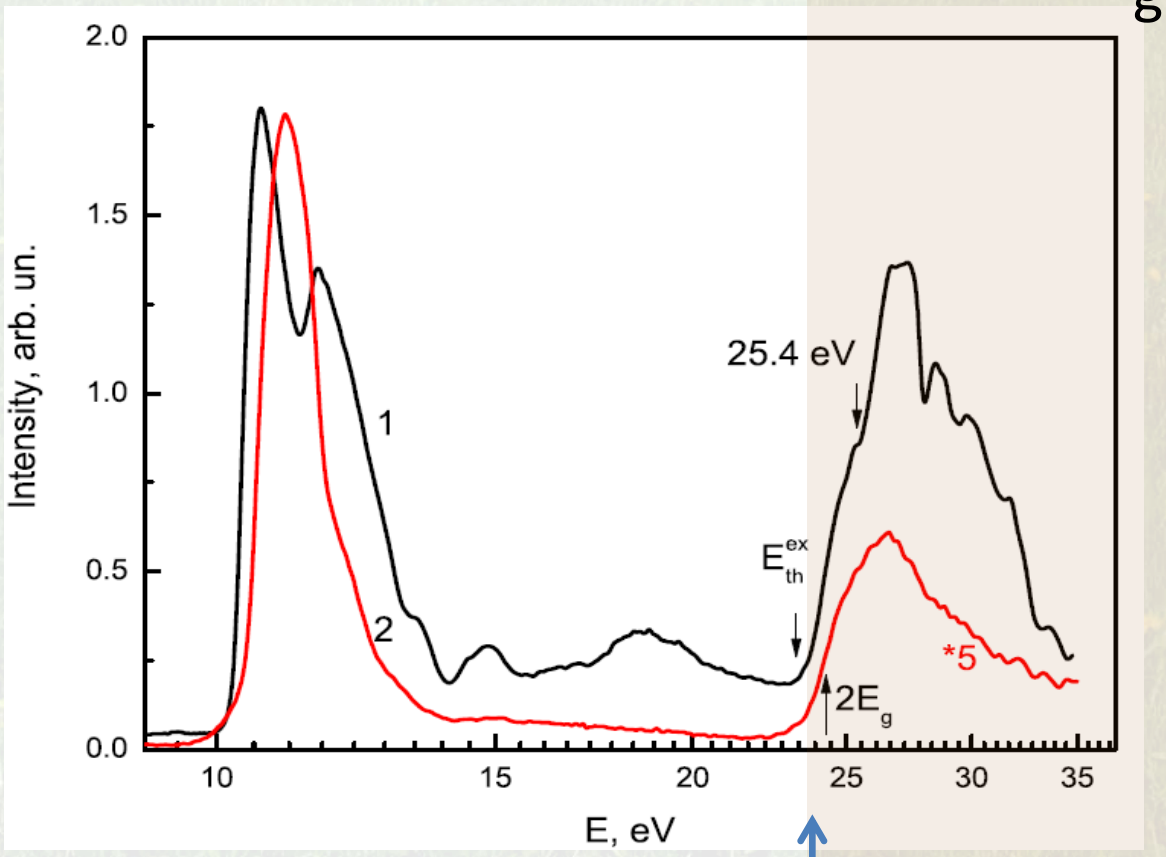


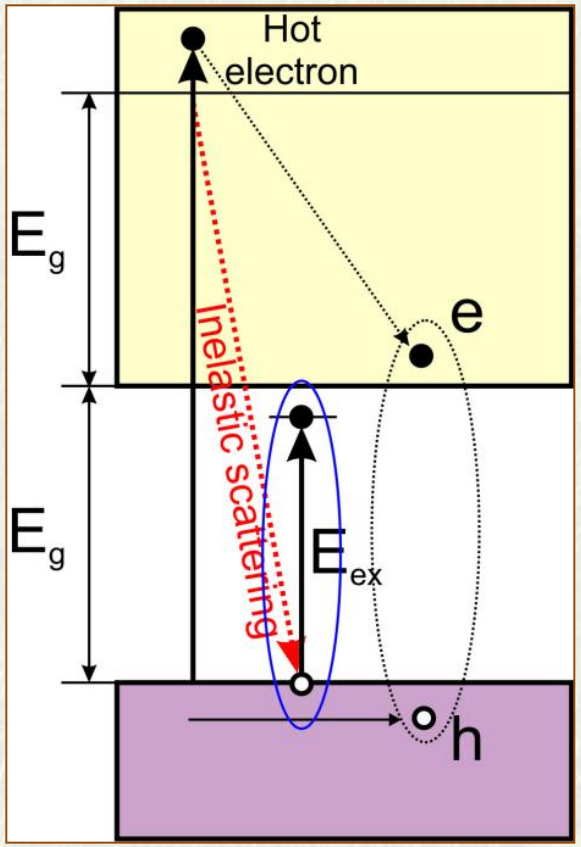


3.4. Multiplication of electron excitations ($h\nu > 2E_g$)

The normalised STE luminescence excitation spectra (λ_{em}=300 nm) for nanoparticles of 140 nm (1) and 20 nm (2) sizes at 300K.

$h\nu > 2E_g$



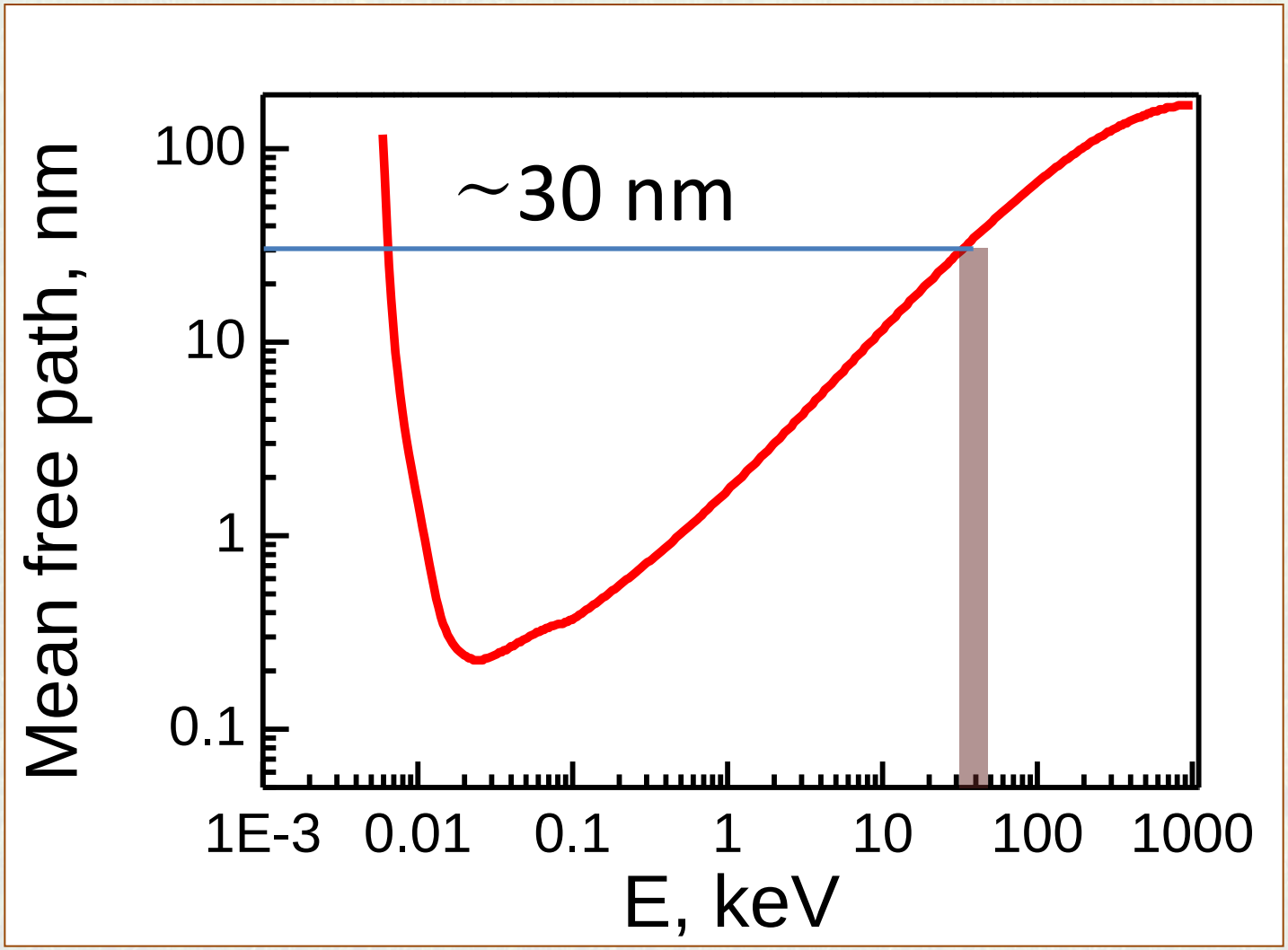


$E_{th} = E_g + E_{ex} = 23.3$ eV

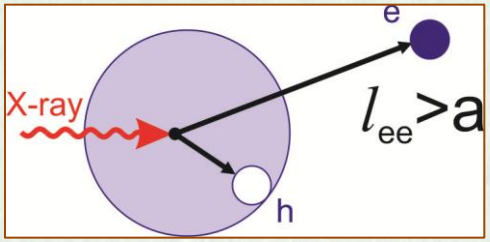
4. X-ray excited luminescence of CaF_2 nanoparticles

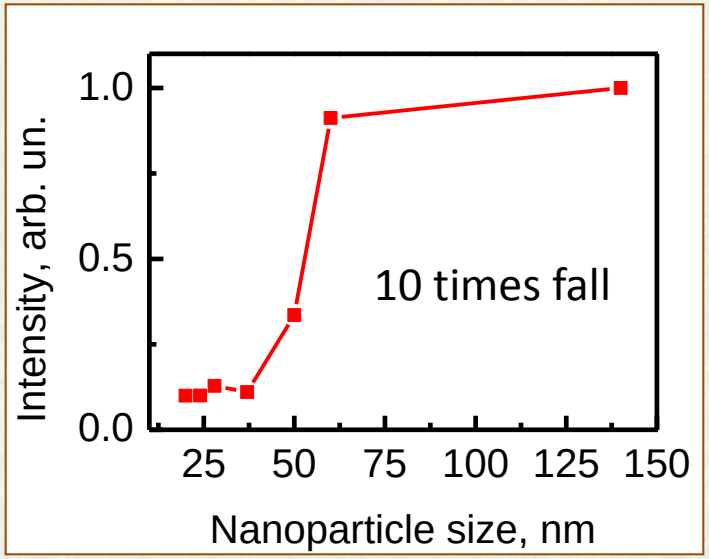
4.1. Photoelectron mean free path

Universal curve of electron-electron scattering

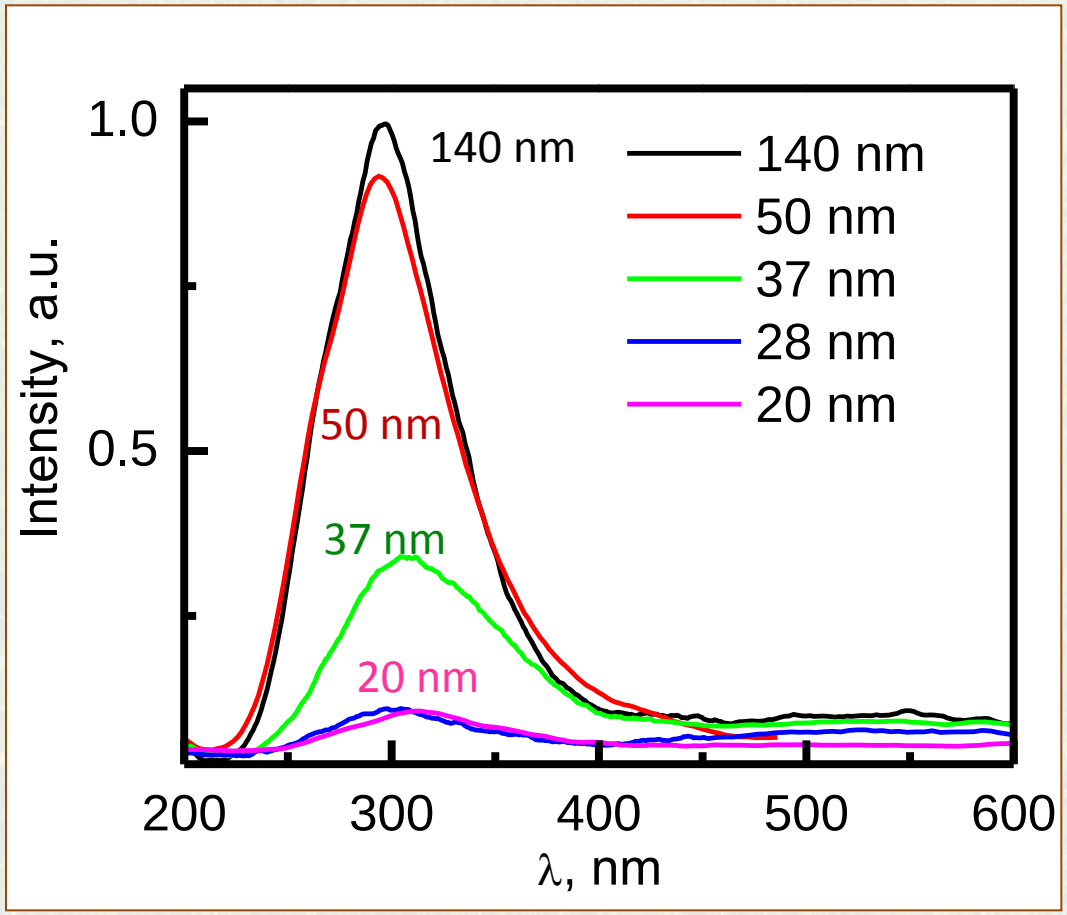


4.2. Intensity and decay time

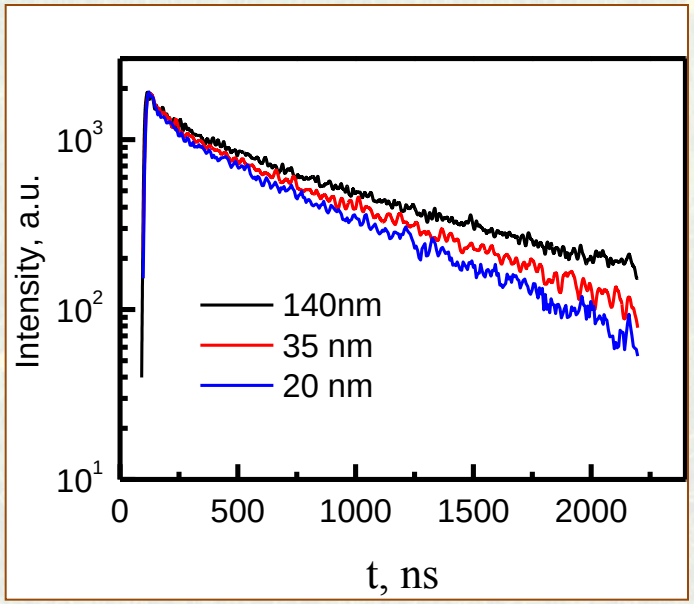




Intensity dependence for X-ray excited luminescence



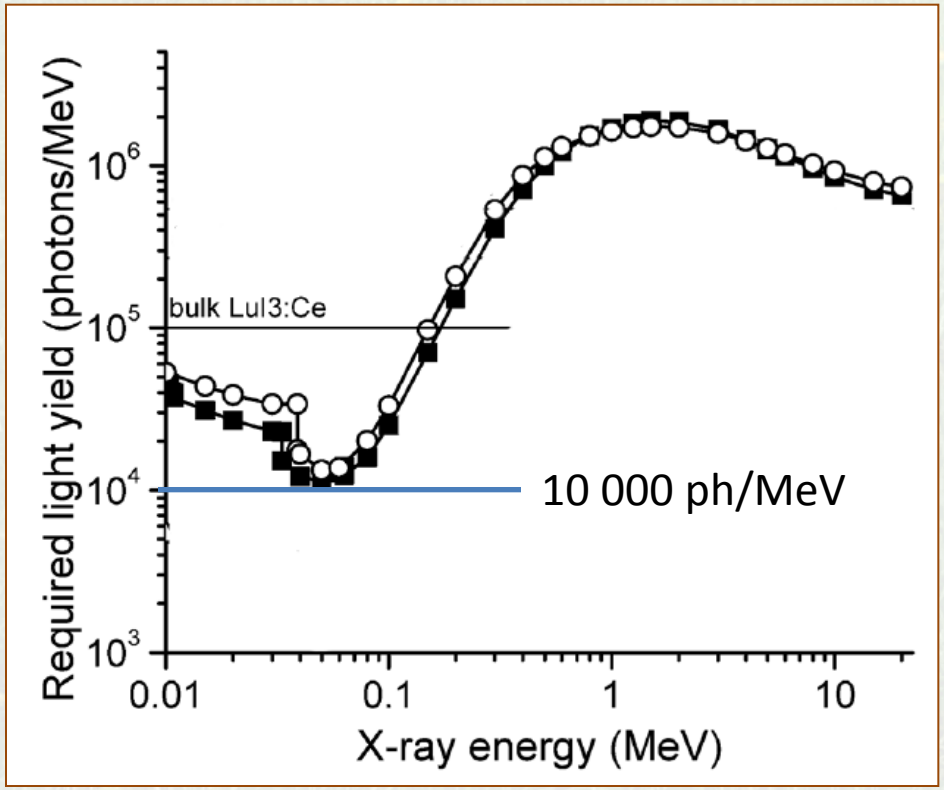
X-ray excited luminescence spectra of CaF_2 nanoparticles of various size at 300 K.

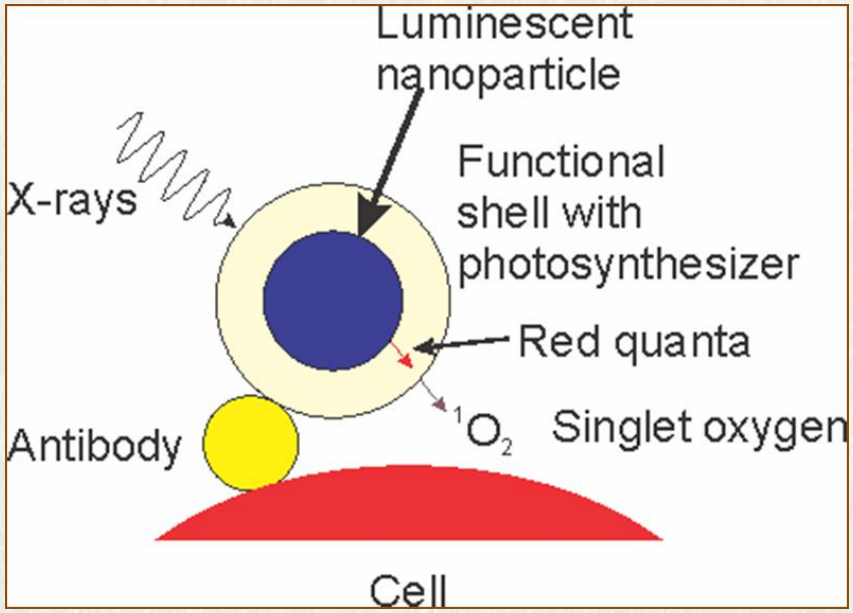


Decay kinetics curves upon the excitation by X-ray quanta

Conclusions

Conclusion 1
Nanoscitillators and photodynamic therapy





Nicole Y. Morgan et al. Radiat Res. 2009 171(2): 236–244. doi:10.1667/RR1470.1.

Conclusion 2
Nanoscitillators and nanocomposite scintillator

Nanoscintillators of 50 – 100 nm of size
large light yield
large scattering of light 2000 ph/Mev

Nanoscintillators of 5 - 20 nm of size
small light yield
small scattering of light 200 ph/Mev

Nanoparticles from materials which demonstrates large light yield more than 50 000 ph/Mev is suitable

Thank you!