# Study of $CeF_3$ nanoscintillators

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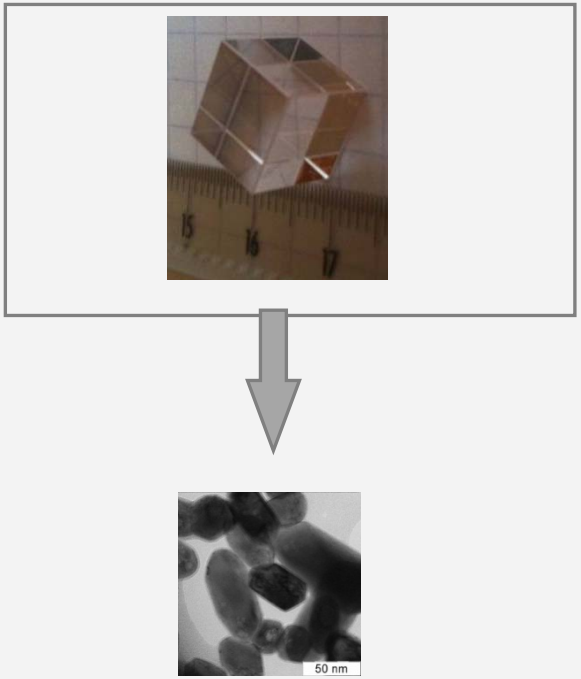
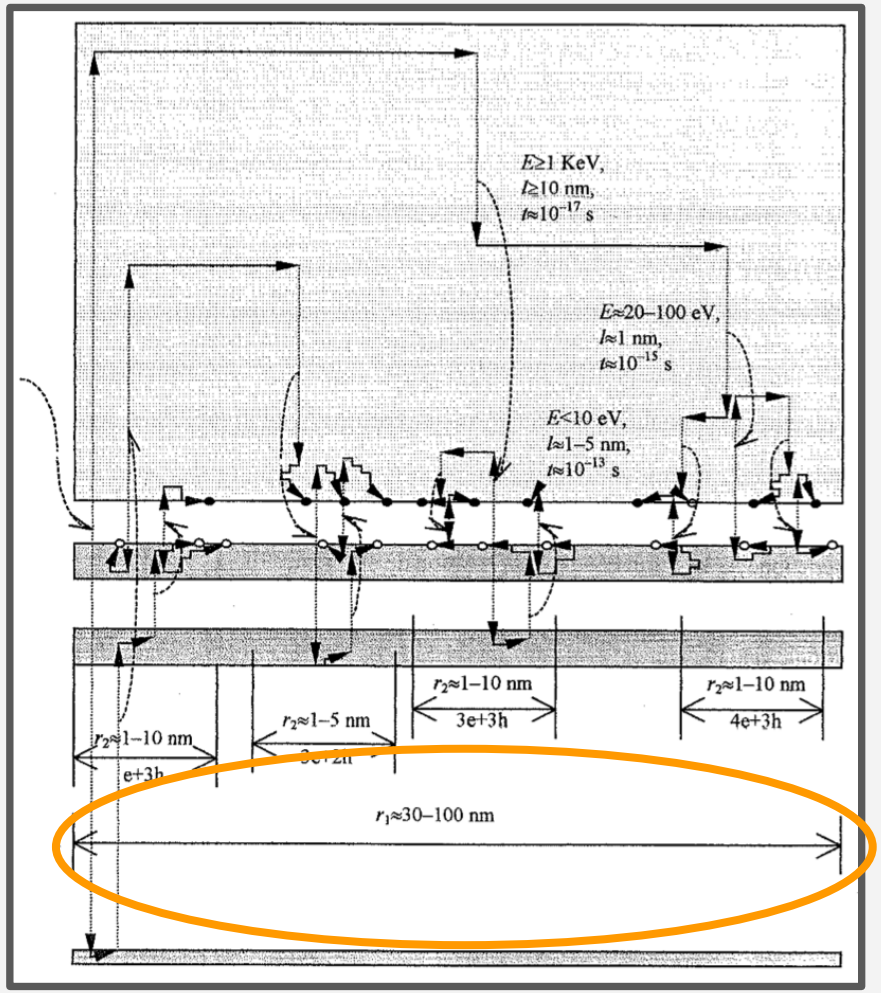
# Introduction

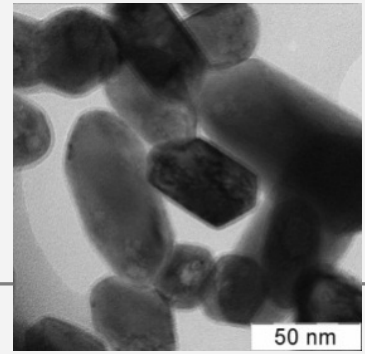



**Migration distance bigger than the NP…**




A.N. Belsky, J. of Elec. Spect. And Rel. Phen. 1996

# Introduction




- Material selected: $CeF_3$
  - Model material (Moses et al, J. of Luminescence, 1994)
    (Auffray et al, NIM, 1996)
    (Wojtowicz, PRB, 1994)
  - Cerium is not a dopant → Energy band
  - Fast decays → studies made in DESY

- Different kind of nanoparticle (NP) samples presented as white powders
  ⇨ All obtained by **soft chemistry**

# Nanoparticles samples as powder form

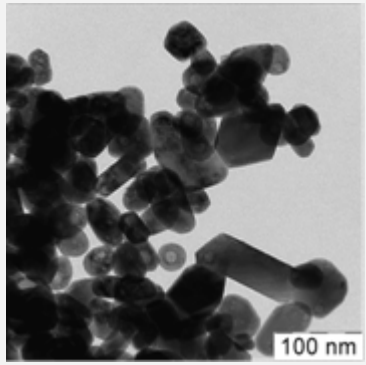
**With calcination: ≈ 60nm**
**(S. Mishra, IRC Lyon) – Type A**

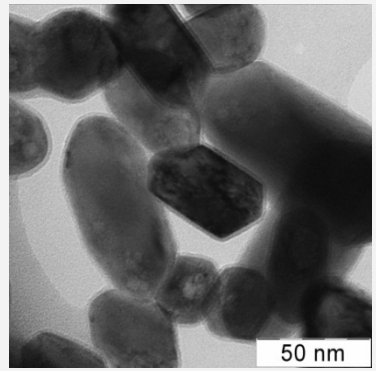
- **Advantages:**
  - Well crystalized (XRD)
- **Drawbacks:**
  - Presence of $CeO_2$ (calcination)
  - No access to small particles (calcination phase)
  - "Complicated" precursors

*Two samples: different conditions for calcination*

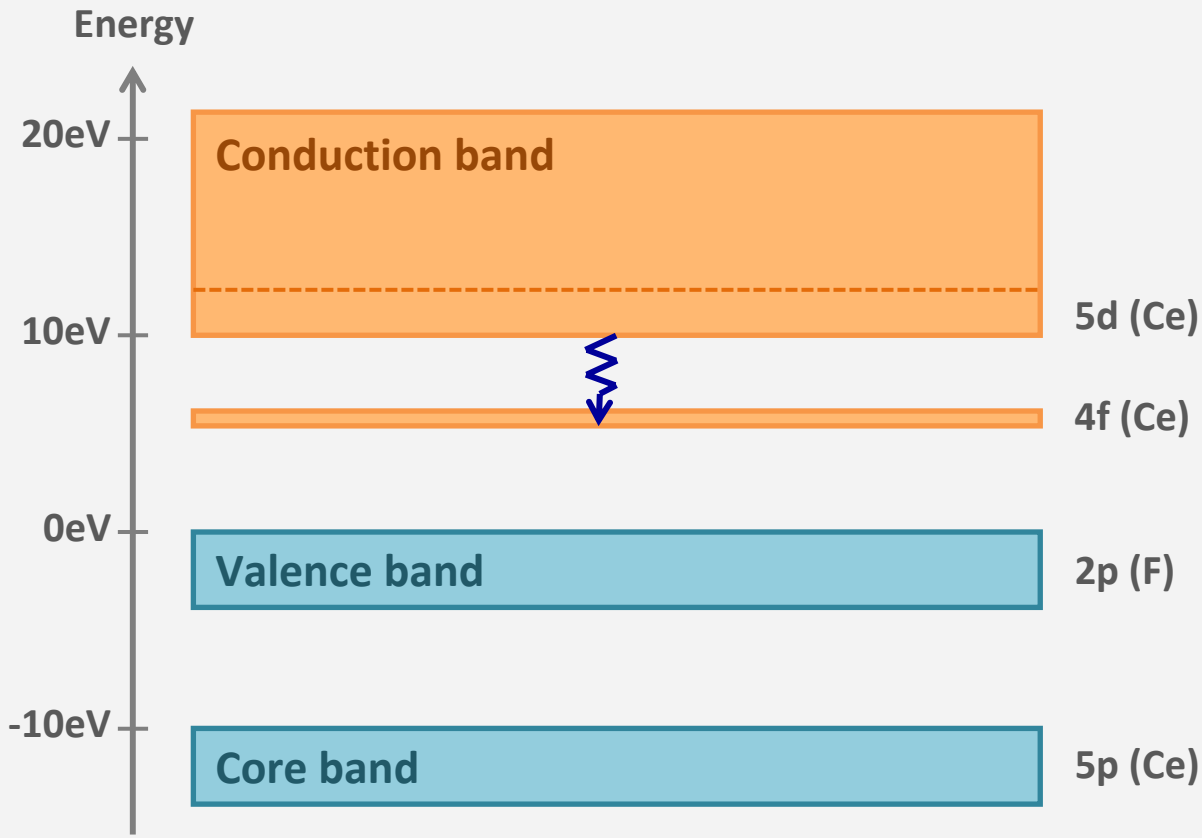
**Without calcination: ≈ 30-100nm**
**(A. Vanetsev, Moscow) – Type B**

- **Advantages:**
  - No $CeO_2$ → More efficient
  - Access to several compositions
- **Drawbacks:**
  - Polydisperse sample:

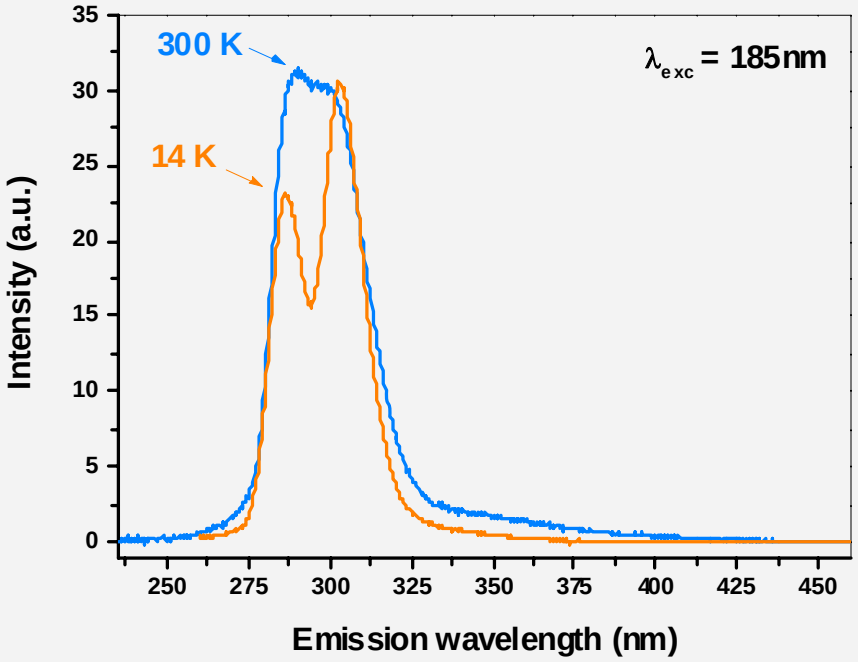


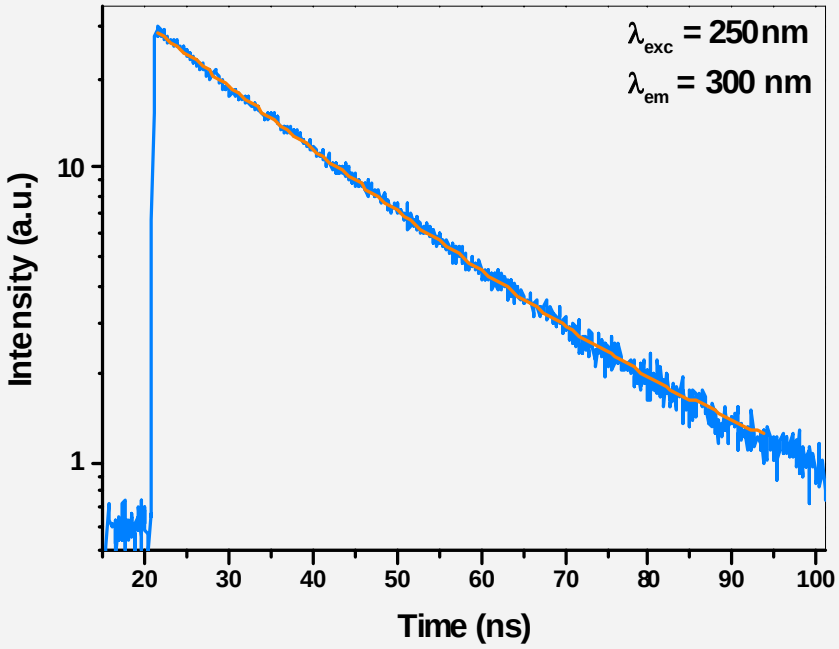



# Energy band structure of bulk $CeF_3$



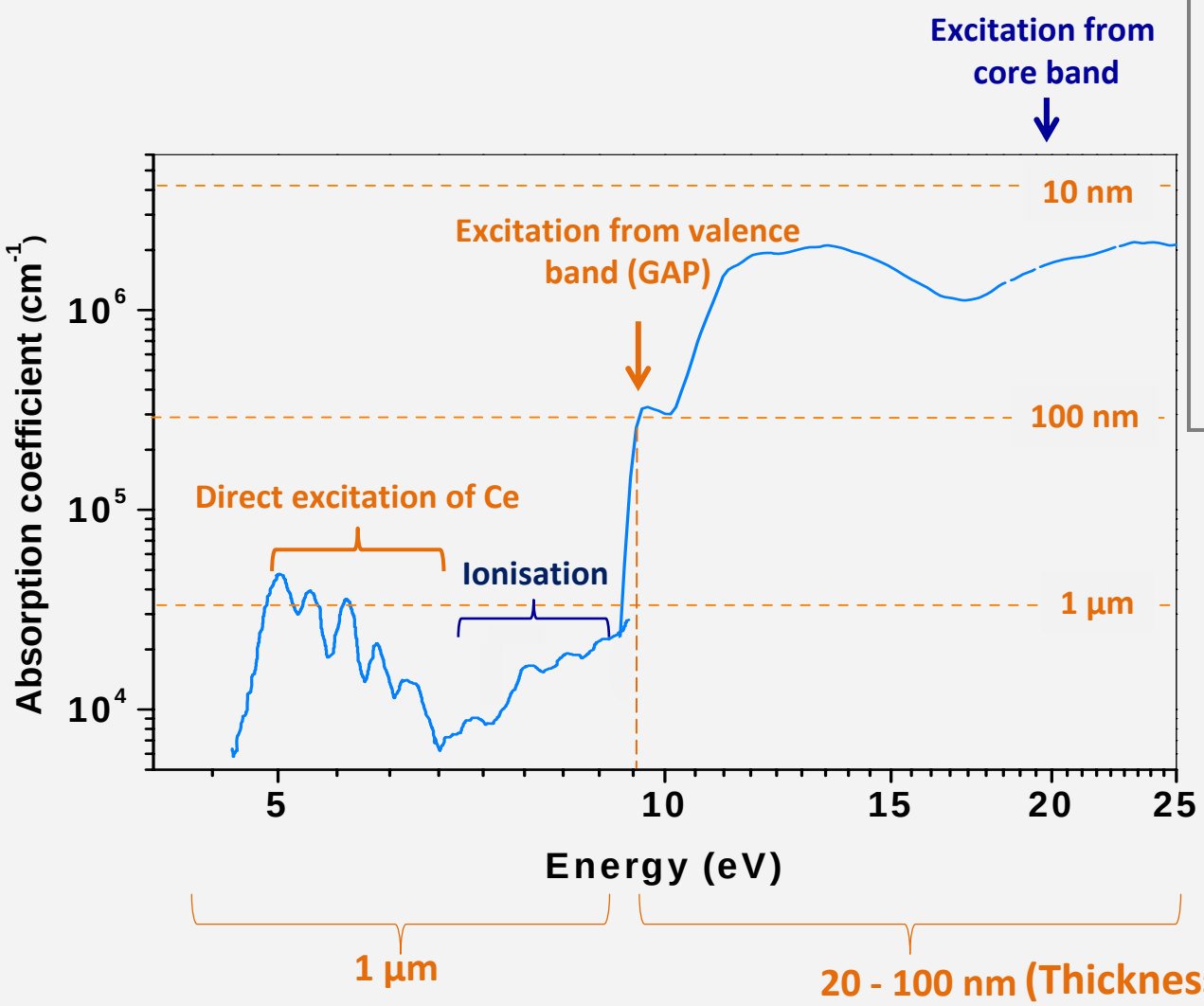
# Emission characteristics of $CeF_3$ as bulk

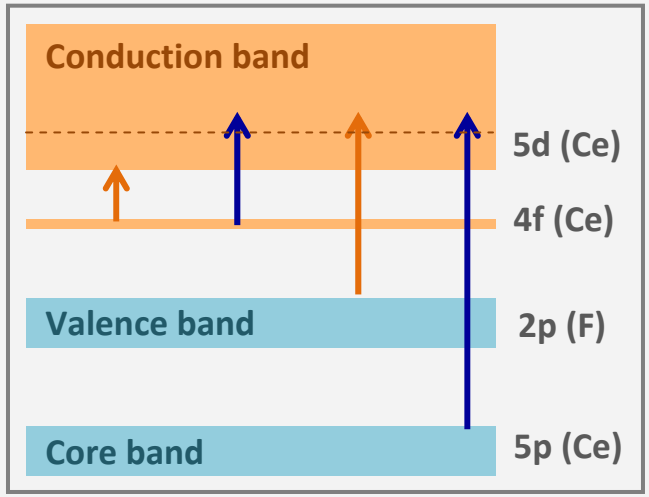



- Emission at **300 nm** → Cerium in a "normal" site
- **5d → 4f :** Electric dipole allowed transition → **fast kinetic**
- Exponential decay **τ ≈ 20ns**

# Absorption in $CeF_3$

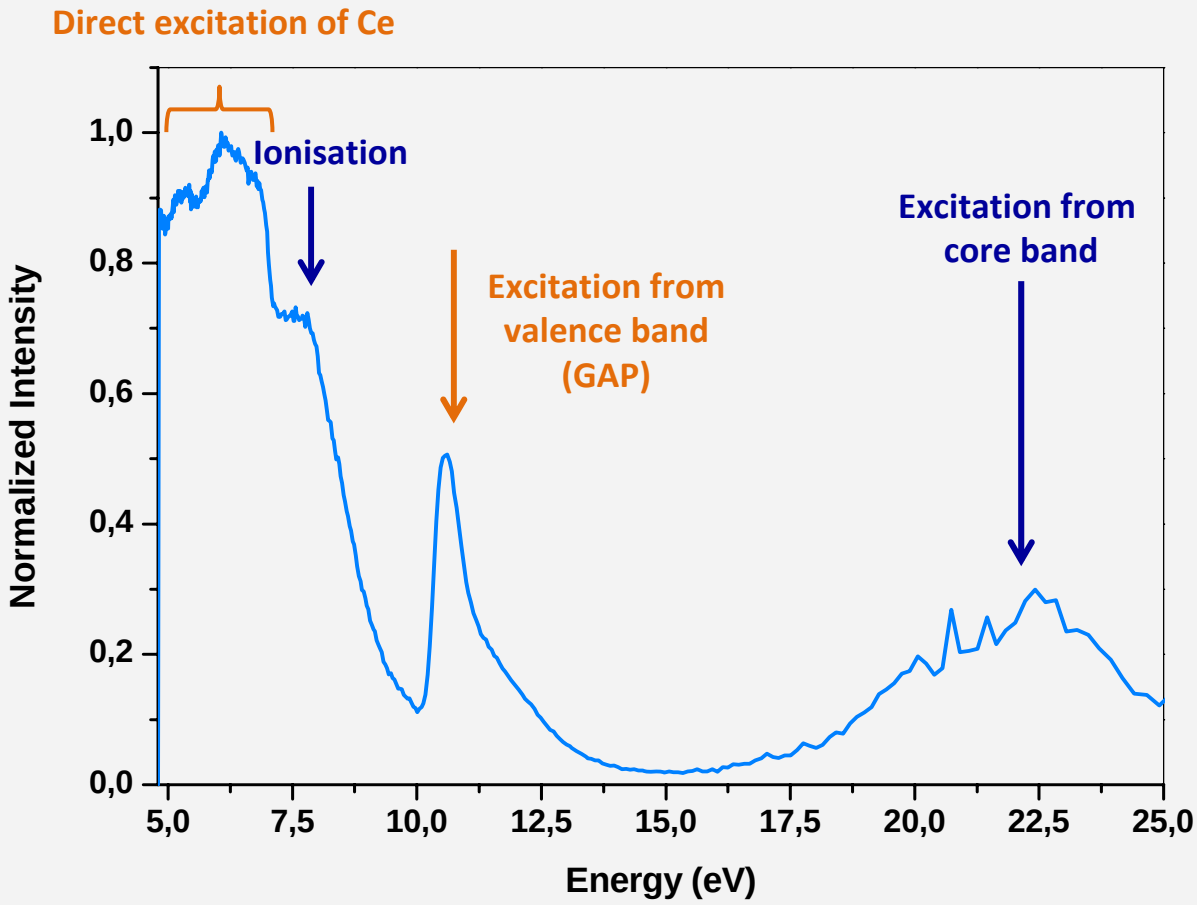



→ 95% of the signal absorbed in 1 µm

LPCML

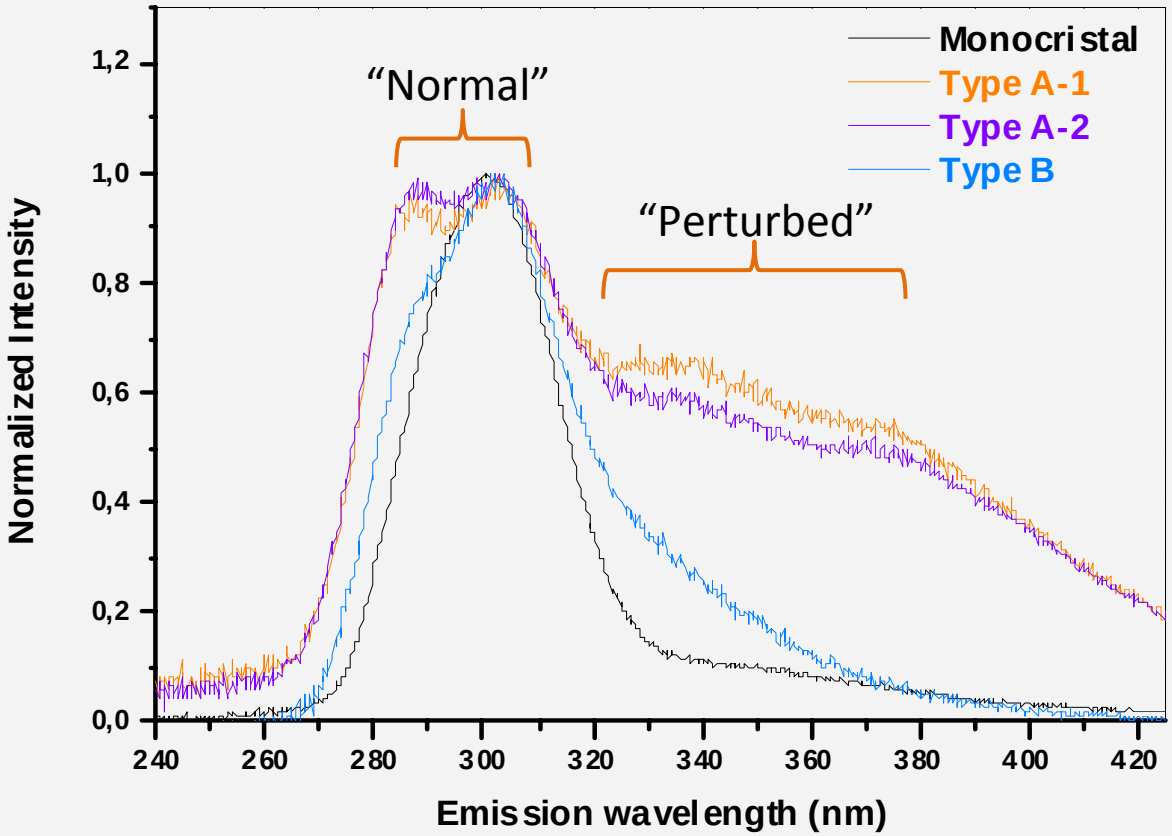
# Excitation spectrum of $CeF_3$ as bulk




- **Perturbed** signal (saturation, surface effects,…)
- Excitation in the GAP: **narrow peak**

# Emission spectrum for NP samples

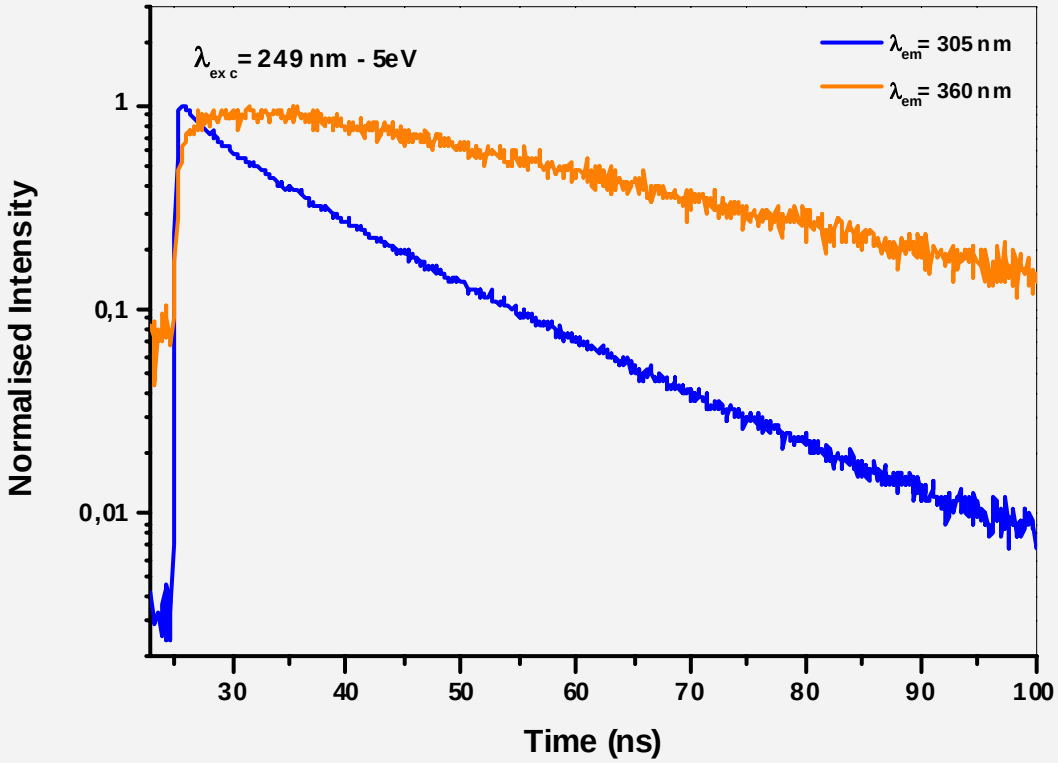
## Direct excitation of the Ce




Cerium is located in **both sites** : "normal" (≈300nm) and "perturbed" (≈350nm)

# Drawback of perturbed Ce presence

- Transfer: normal Ce -> perturbed Ce

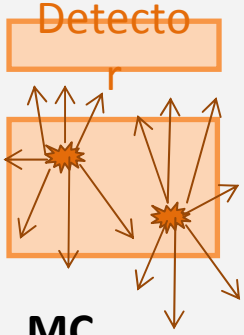



- τ ~ 15 ns for normal Ce
- τ ~ 37 ns for perturbed Ce
- Quenching of the "normal" emission
- Delay for the emission of "perturbed" Ce

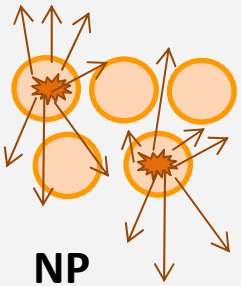
- Supplementary acceleration of the emission for samples containing perturbed Ce (at low energy excitation)

# Excitation spectra: a comparison between bulk and NP

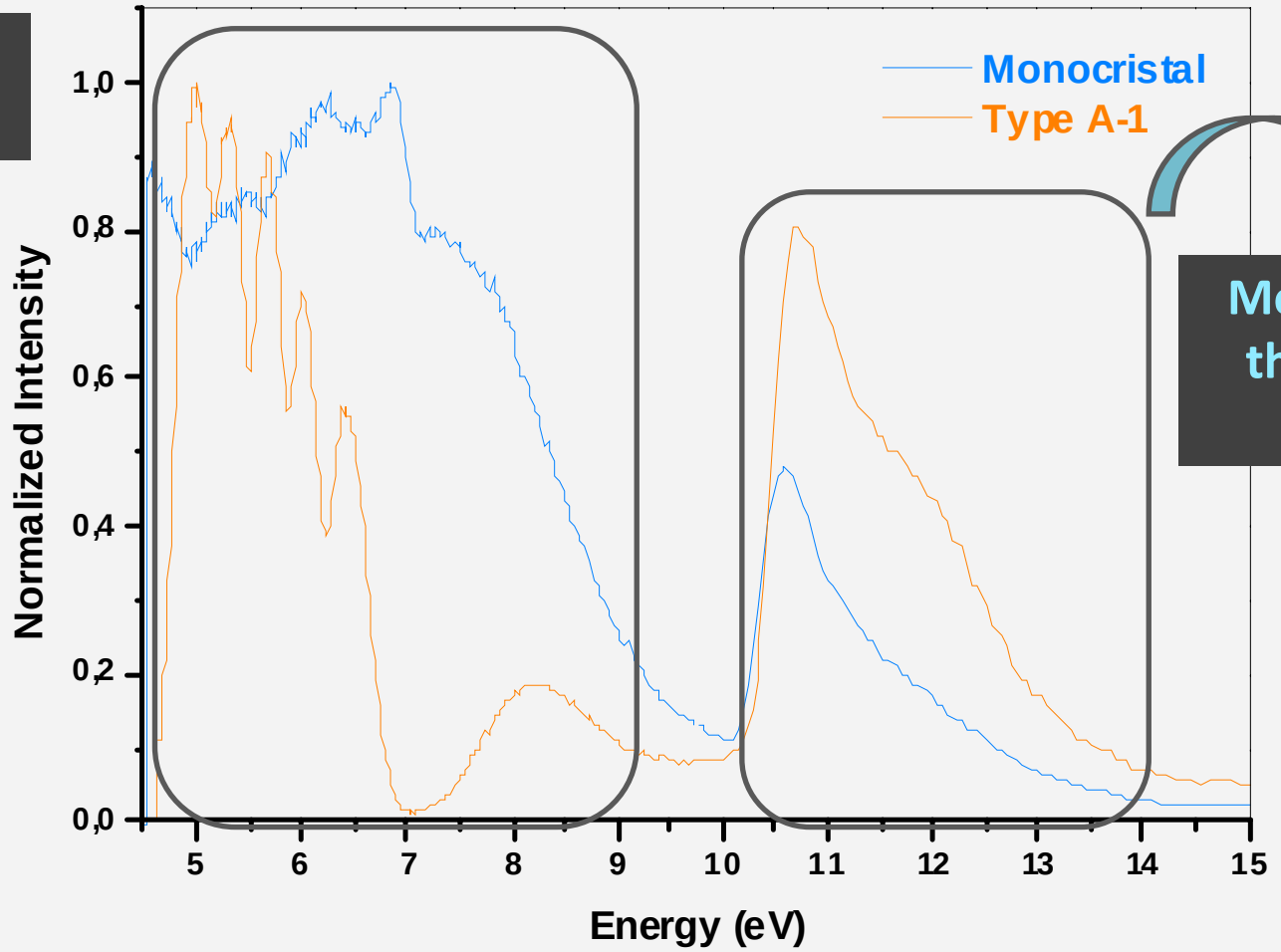
No more saturation




MC

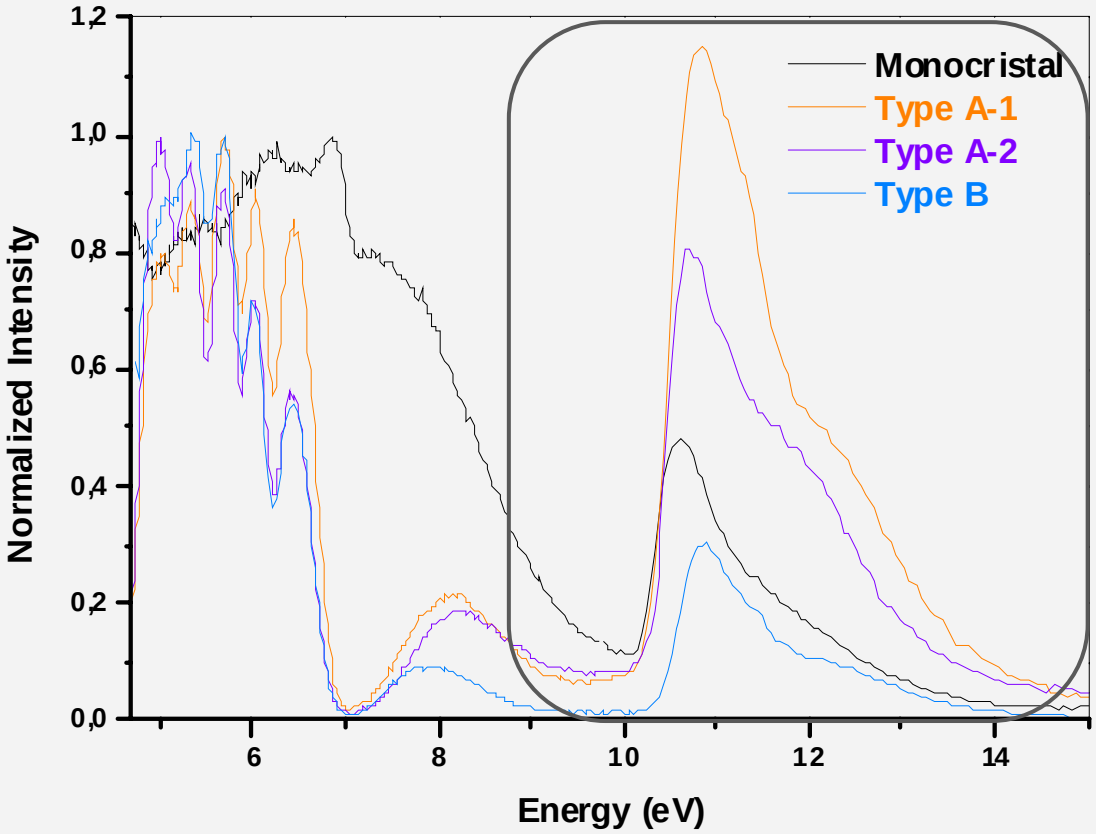


NP



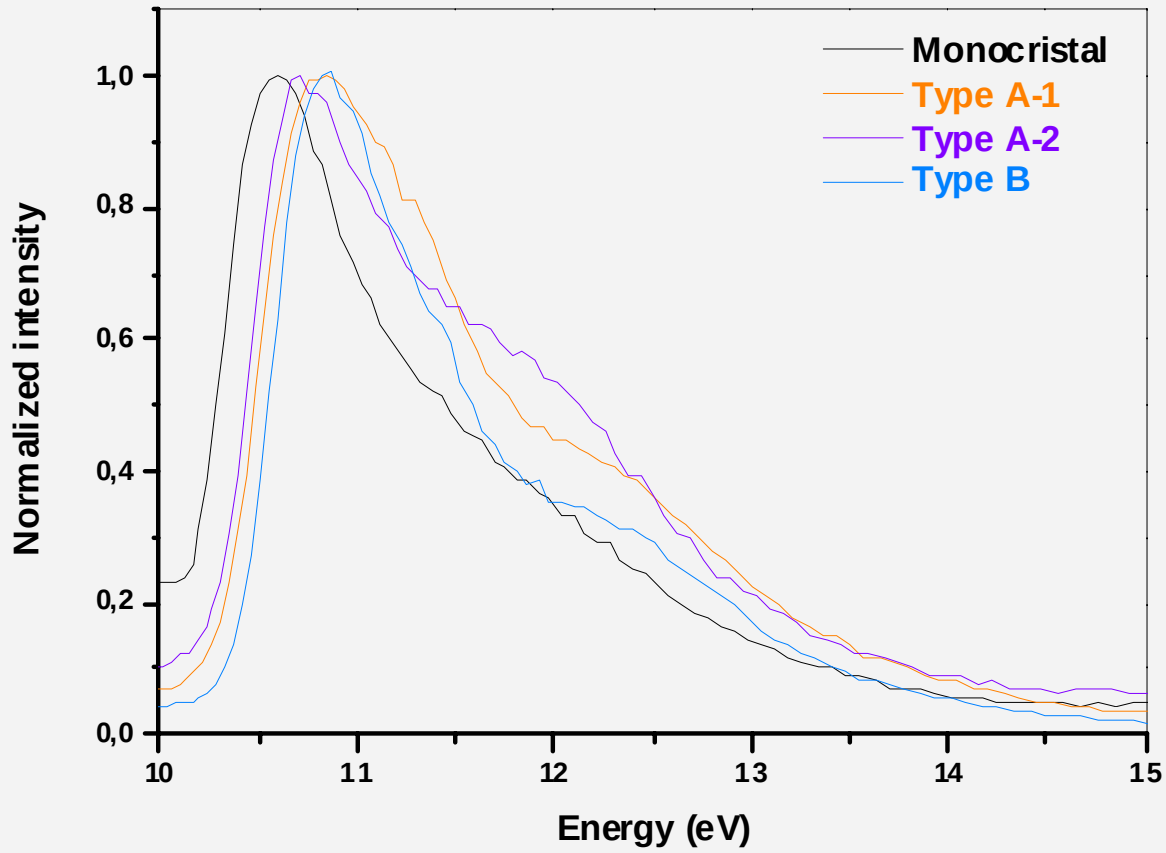

Modification of the band GAP excitation

# Excitation spectra for Nanoparticles




- For all NP samples:
  - No more saturation
  - Modification of the band GAP excitation

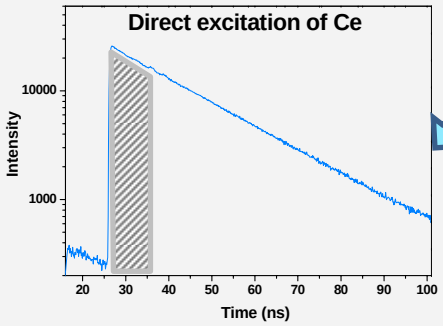
# Zoom on the excitation spectra

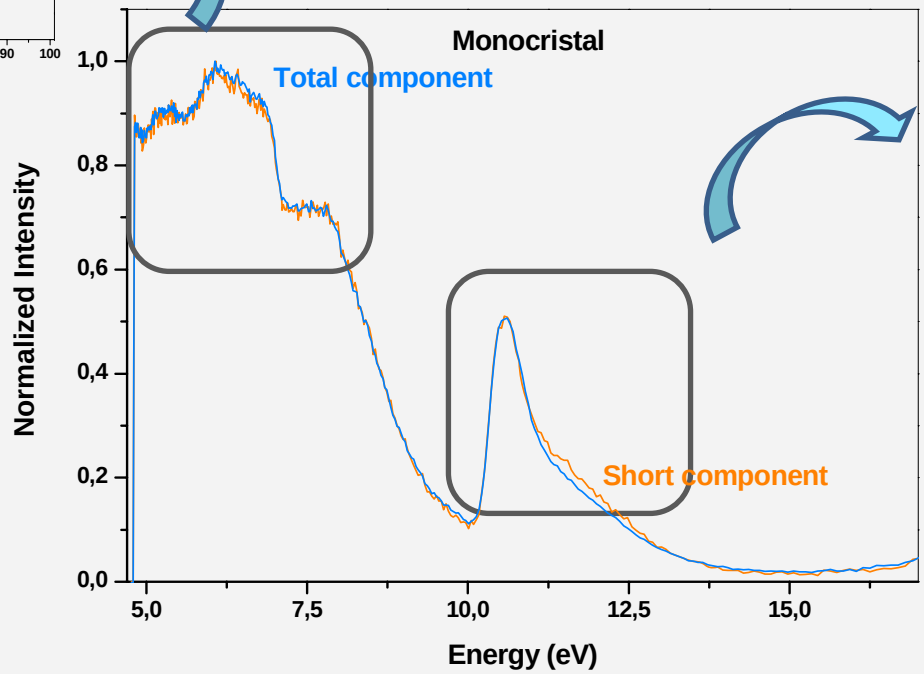


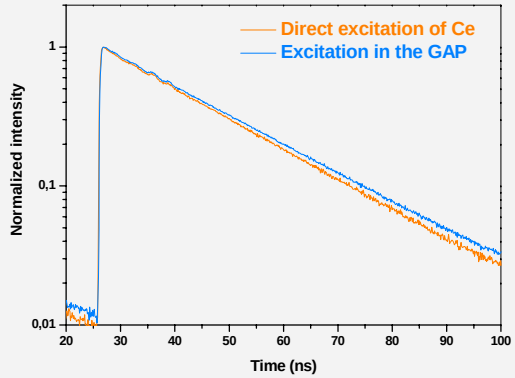

- Excitation in the GAP: shift of the maximum
- Broadening of the band → electron mobility confinement ?
  → sensitivity to absorption for NP

# ”Short” and “total” components in the bulk

## Time resolved spectroscopy:

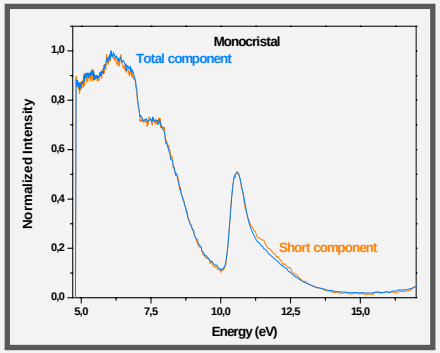


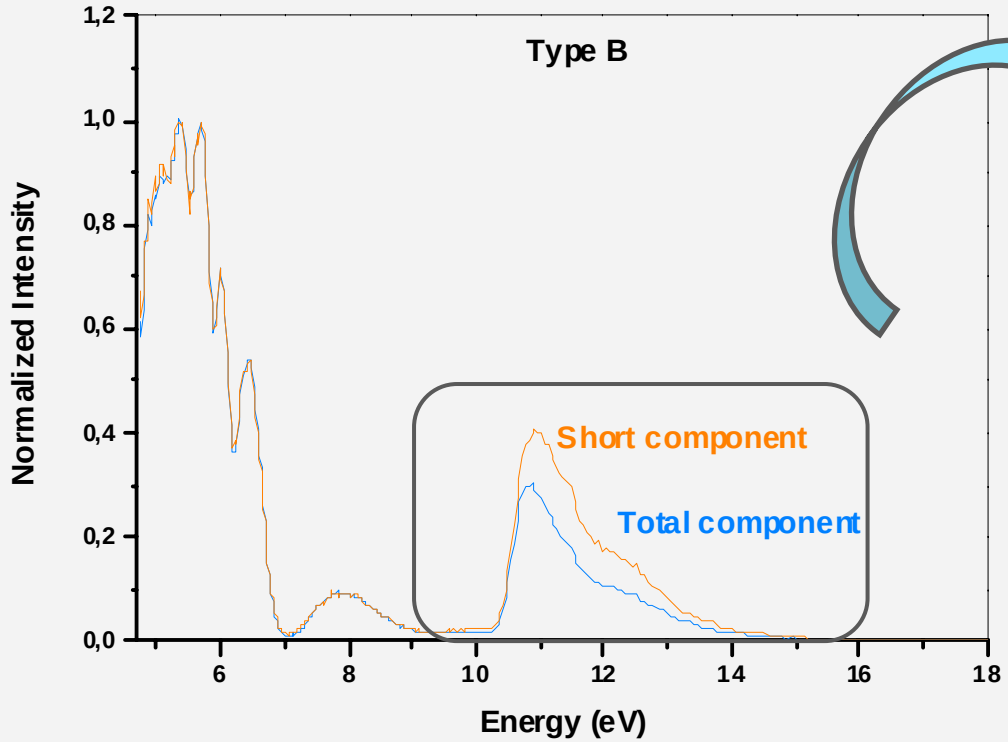



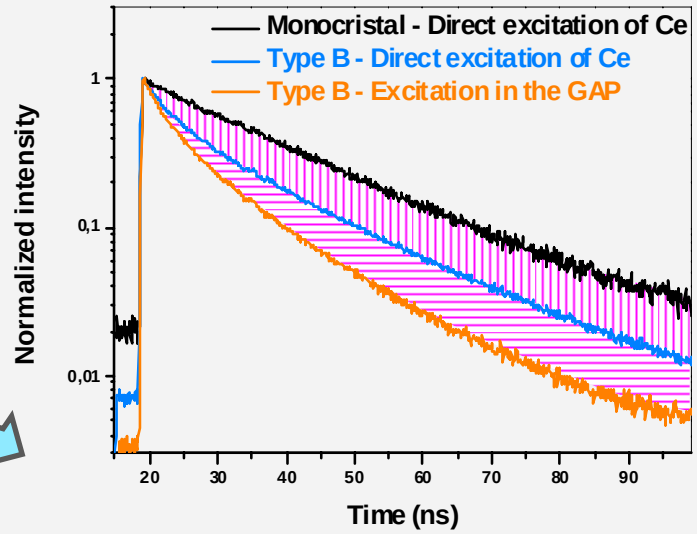




## Short component when excited in the GAP

# What about the nanoparticles ?



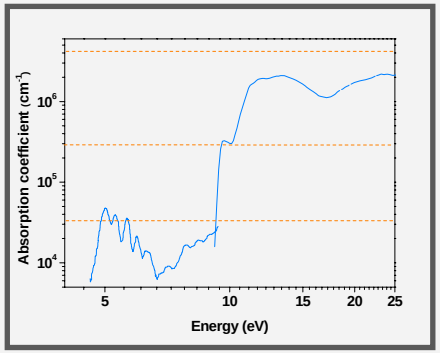



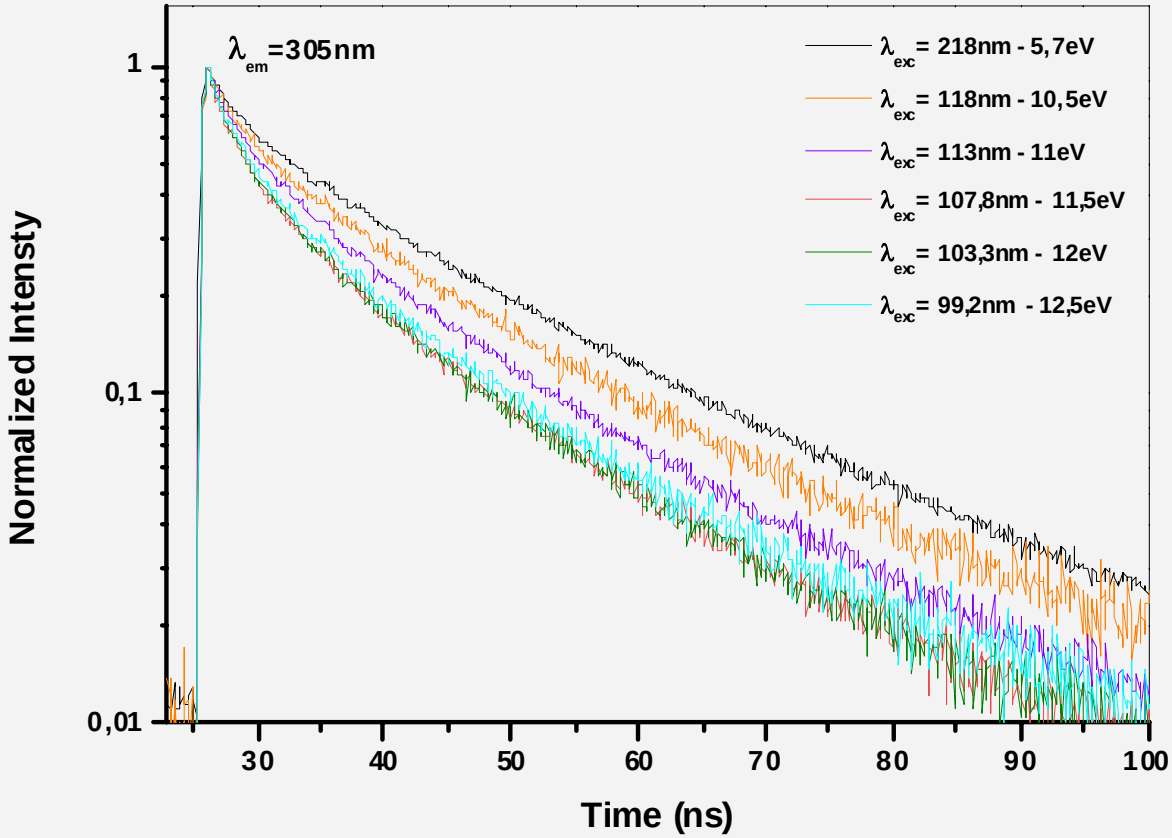




Acceleration due to surface effects

Acceleration of the process? Quenching?

# What about the nanoparticles ?

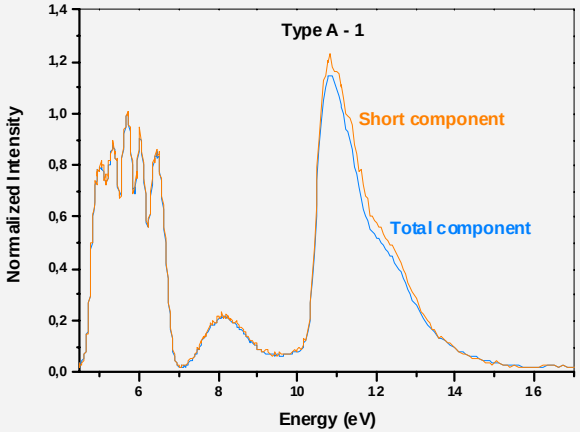


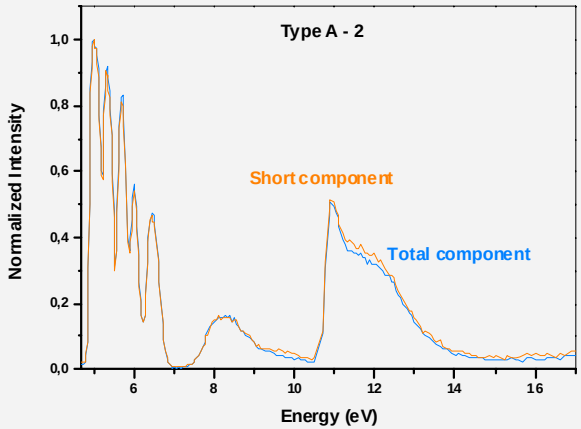



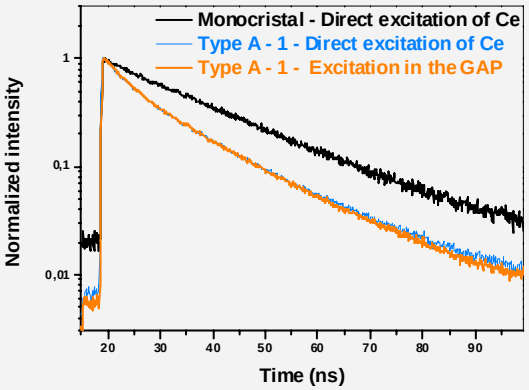

- Acceleration of the emission process when the excitation energy increases
- Problem: **the absorption also increases** in this range
  -> excitation of the surface atoms (killing centers)

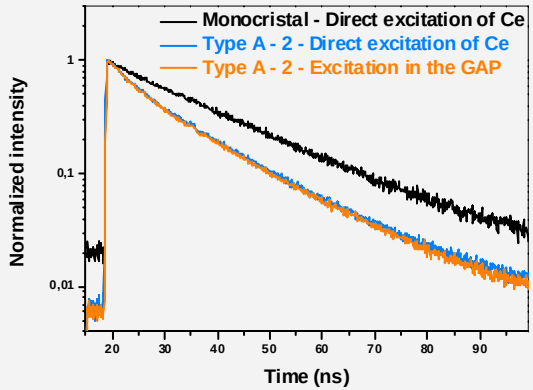
**What about other samples?**

# What about the nanoparticles ?



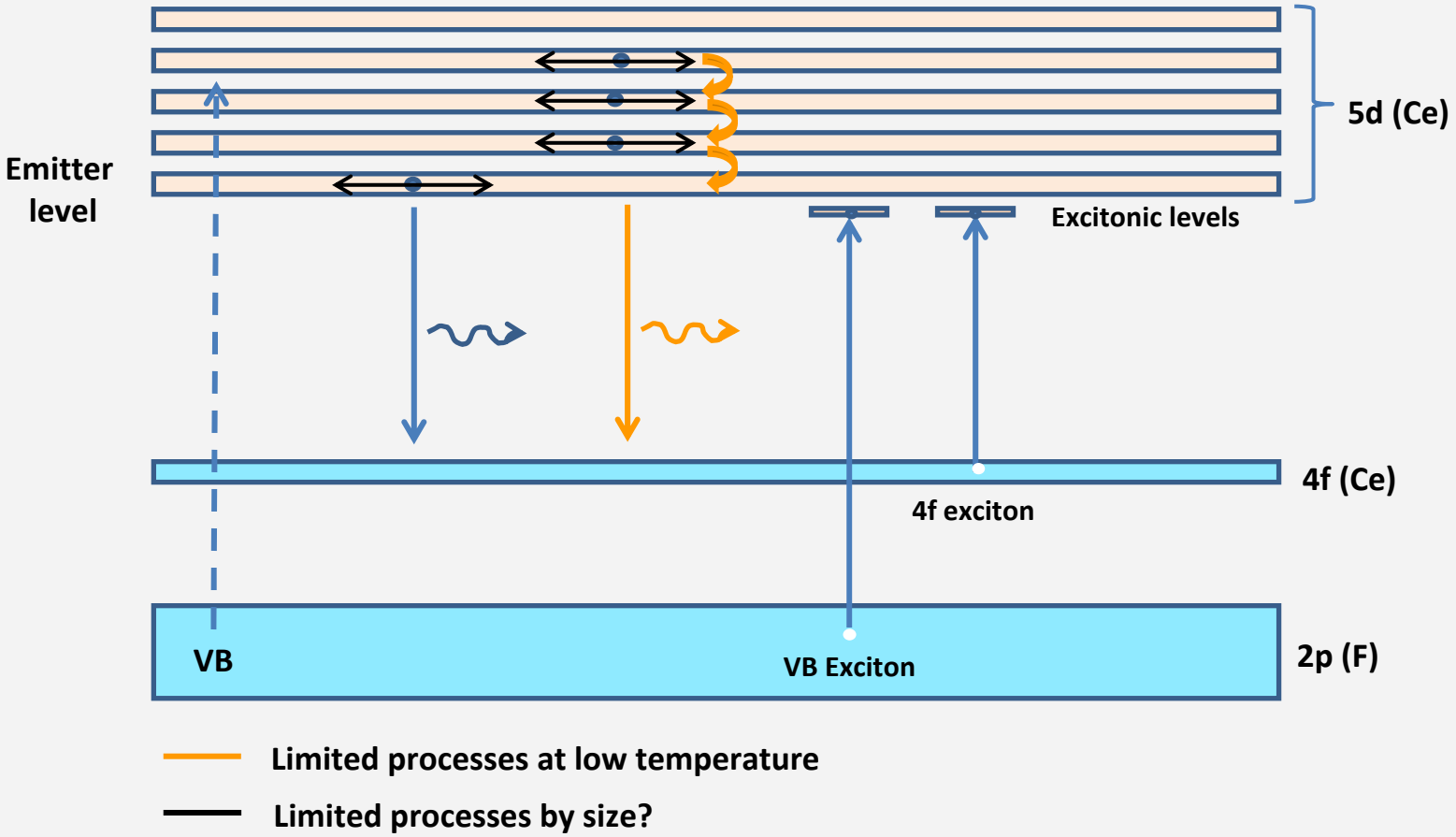




- **The same trend: Acceleration of the emission processes when excited in the GAP**

# What can be the other(s) cause(s) of quenching?




- **At low temperature:** processes requiring phonons are limited
- Spatial localization of the e/h pairs by studying **$LaF_3$:Ce decay curves**

# Conclusion

- **What are we doing now?**
  - **Study of $LaF_3$:Ce samples with different concentrations of Ce**
  - **Study at low temperatures**

  **=> To find the role of "electron confinement" in the nanoparticle**

- **Principal results presented**
  - **In the excitation spectra:**
    - **Shift** of the excitation in the band GAP
    - **Broadening** of the band GAP excitation
  - **In the decay curves:**
    - Acceleration of the emission when excited in the GAP

  => Several possible explanations

- **Next step:**
  - **Measurement of the quantum yield of every sample:**
    - Under light excitation
    - Under X-ray excitation
    - Under electron excitation

# Thank you for your attention…