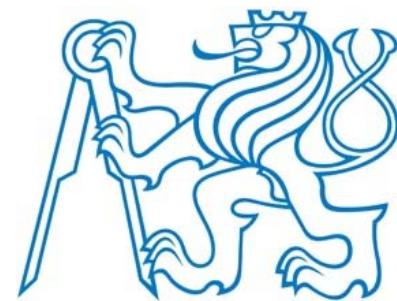


Novel ultrafast halide nanoscintillators

Ascimat workshop

13th April 2018

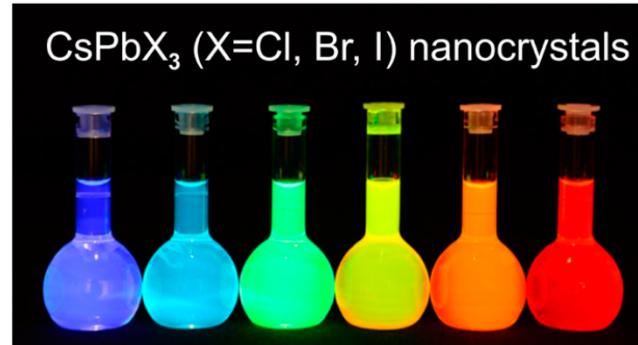
Kateřina Tomanová



Czech Technical University in Prague

CsPbX_3 nanocrystals

- $X = \text{Cl}, \text{Br}, \text{I}$
- Cubic perovskite crystal structure
- Excellent photoluminescence properties:
 - High quantum yield (up to 90 %)
 - Narrow emission line widths
 - Short radiative lifetimes (1 – 29 ns)
- Emission spectra are tunable over the entire visible spectral region
- Optoelectronic applications (LEDs, displays, photovoltaics)

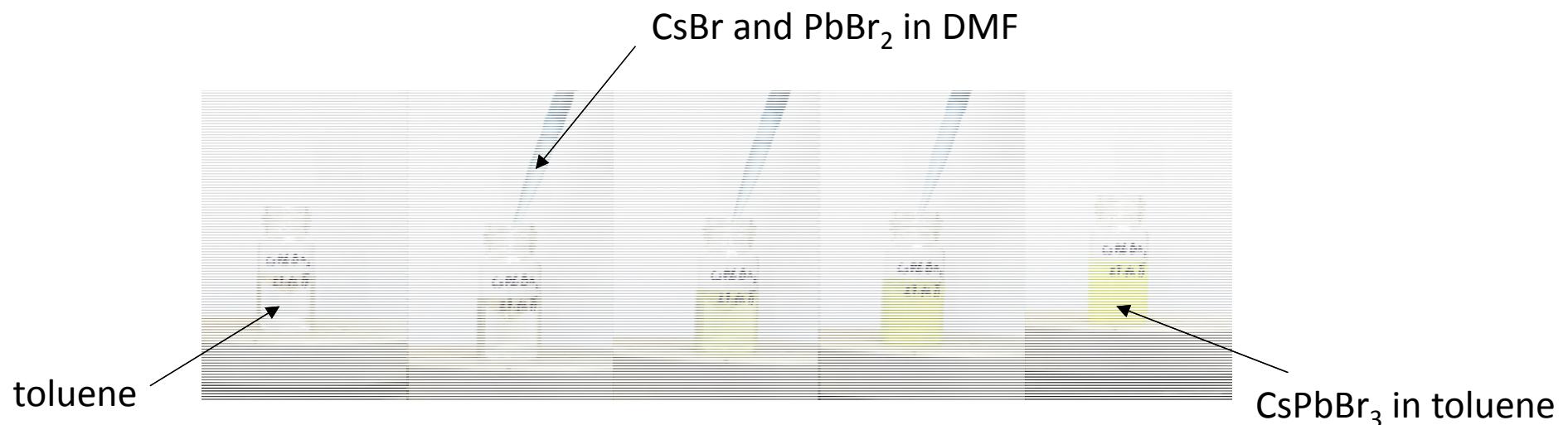


Protesescu et al., 2015

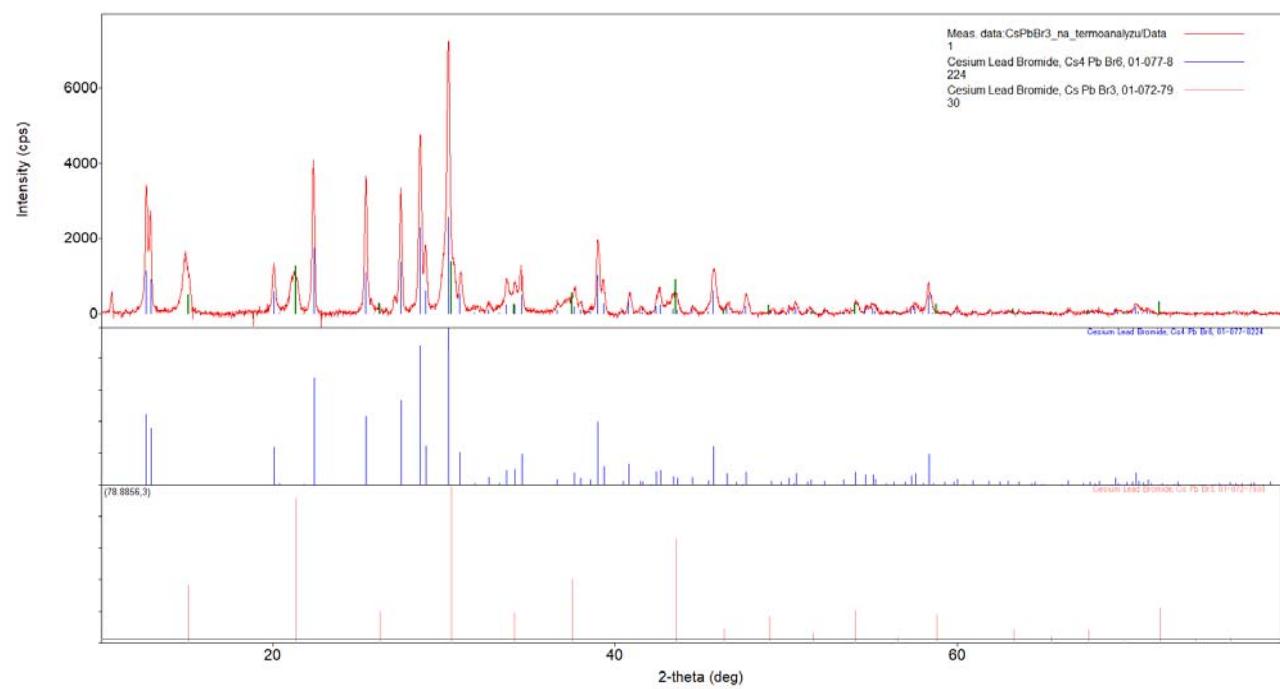
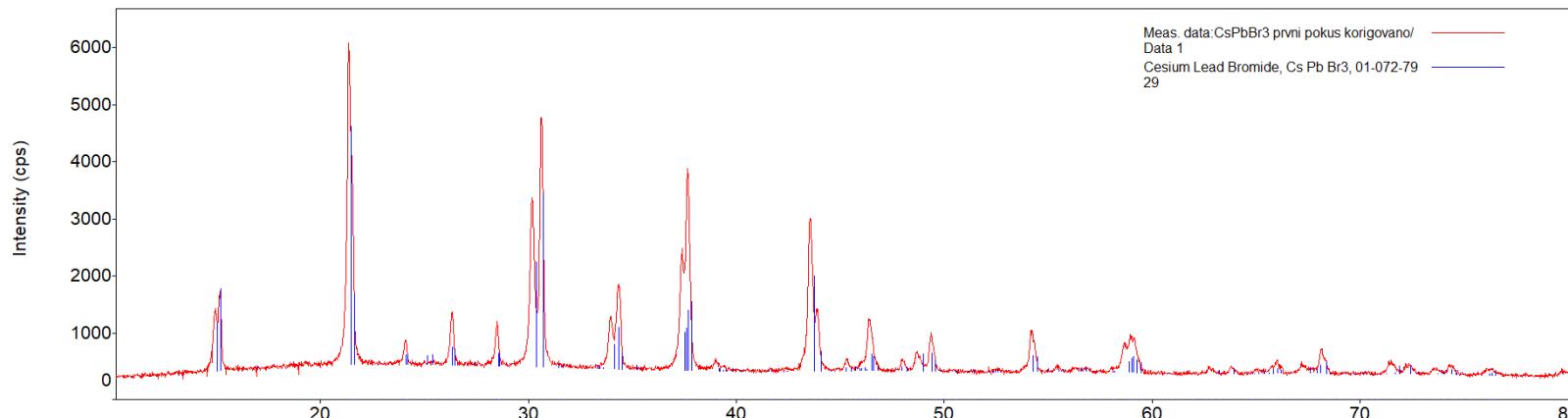
Ref.: L. Protesescu, et al., 2015, *Nano Lett.* **15**, 3692–3696, DOI: 10.1021/nl5048779

Method - CsPbBr_3

- Supersaturated recrystallization at room temperature (alternative to hot injection method) – Liu et al., 2016
- Solution of CsBr and PbBr_2 in DMF (dimethylformamide) with ligands (oleic acid, oleylamine) added dropwise into toluene

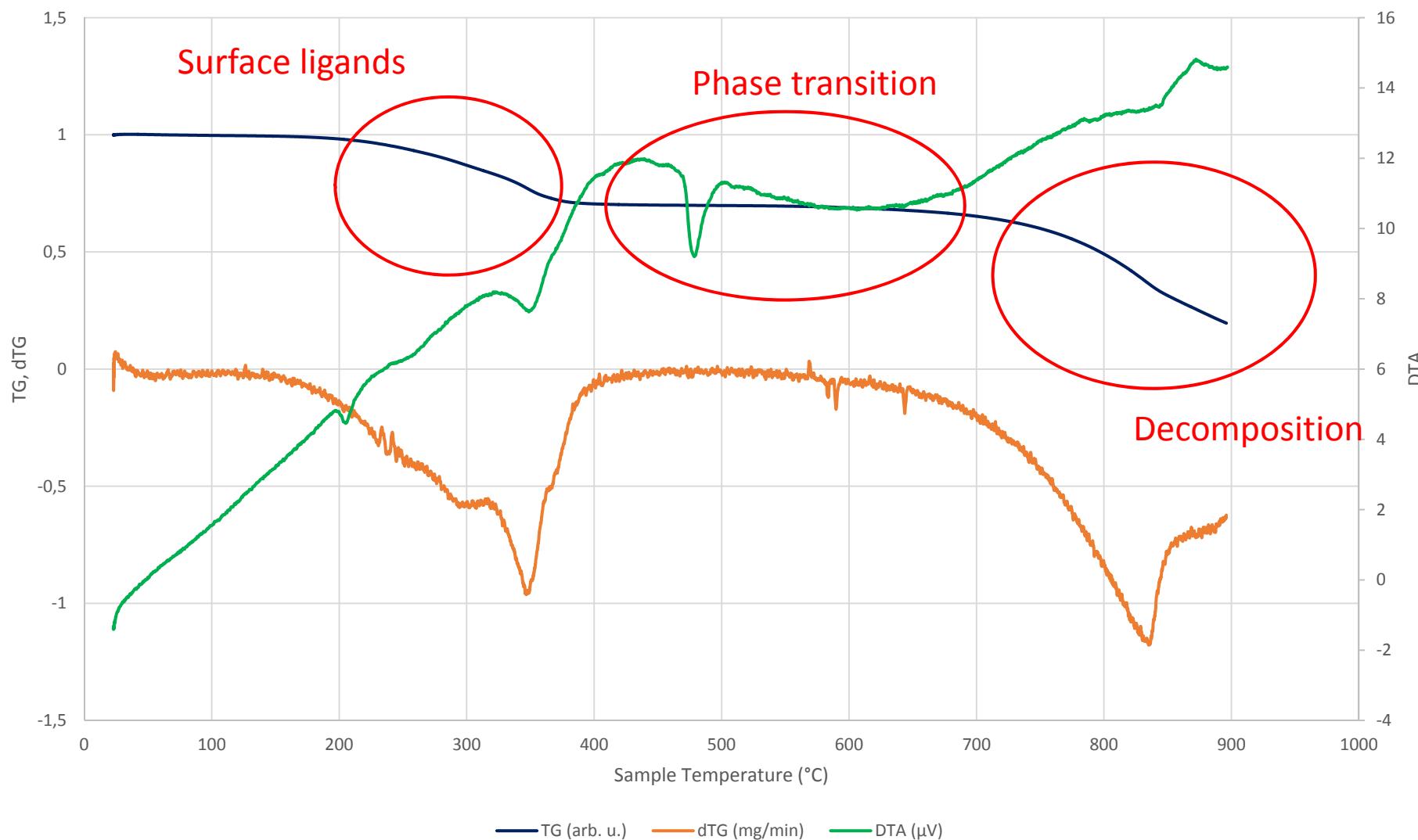


First experiments – results (XRD)



Small changes in reaction conditions results in the mixture of $\text{CsPbBr}_3 + \text{Cs}_4\text{PbBr}_6$

First experiments – results (TG, DTA)



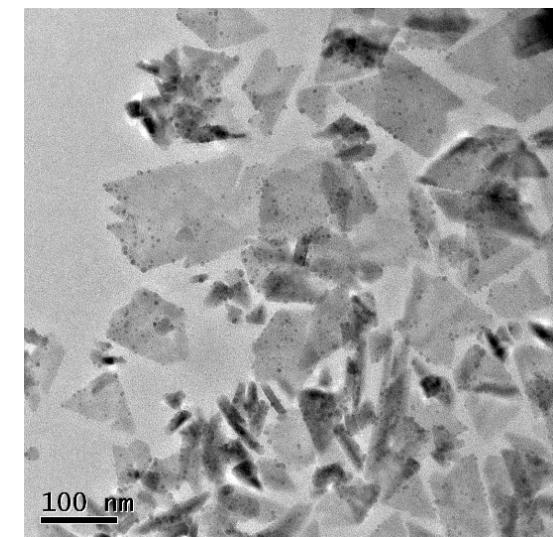
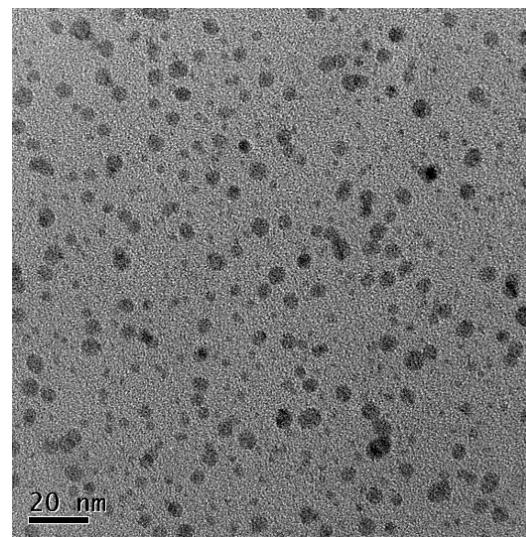
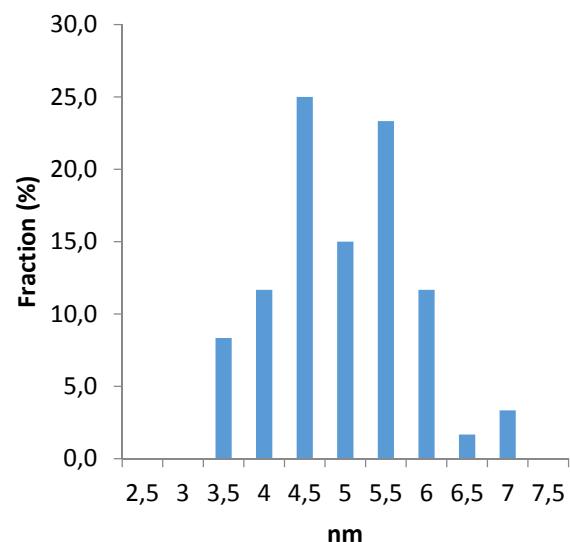
First experiments – results (TEM)

- Size distribution
- Bohr diameter ~ 7 nm

Colloidal part

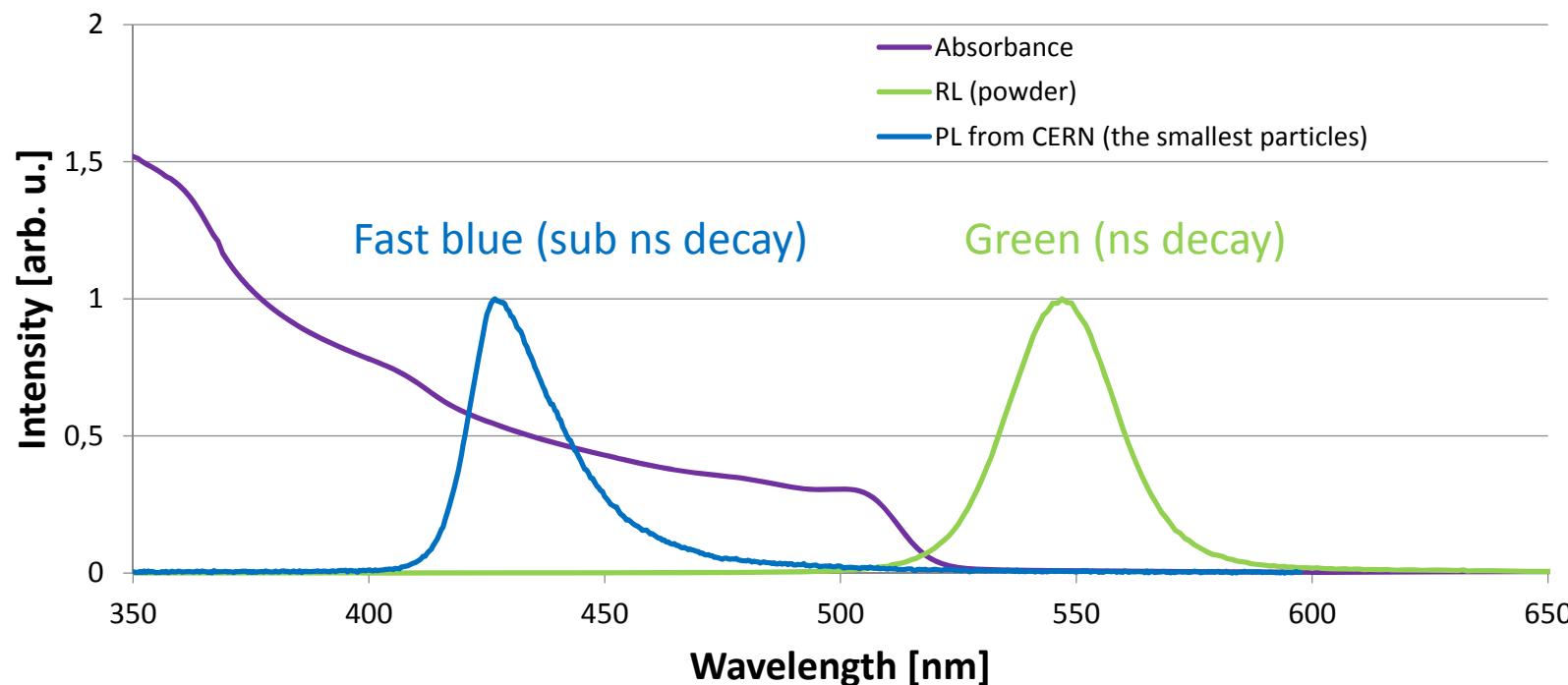


Mixed sample



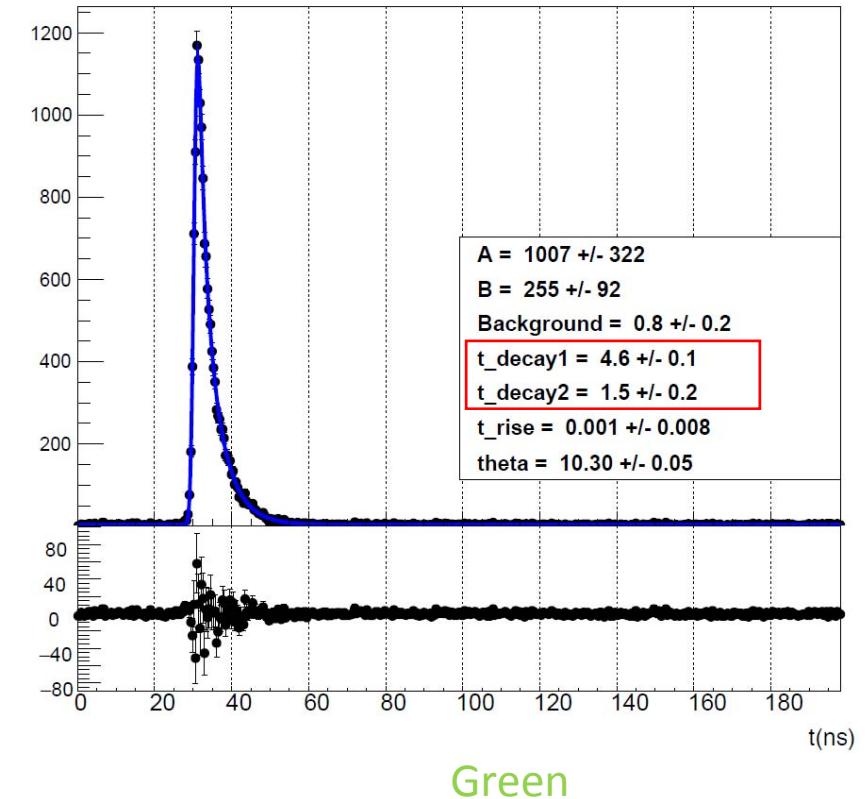
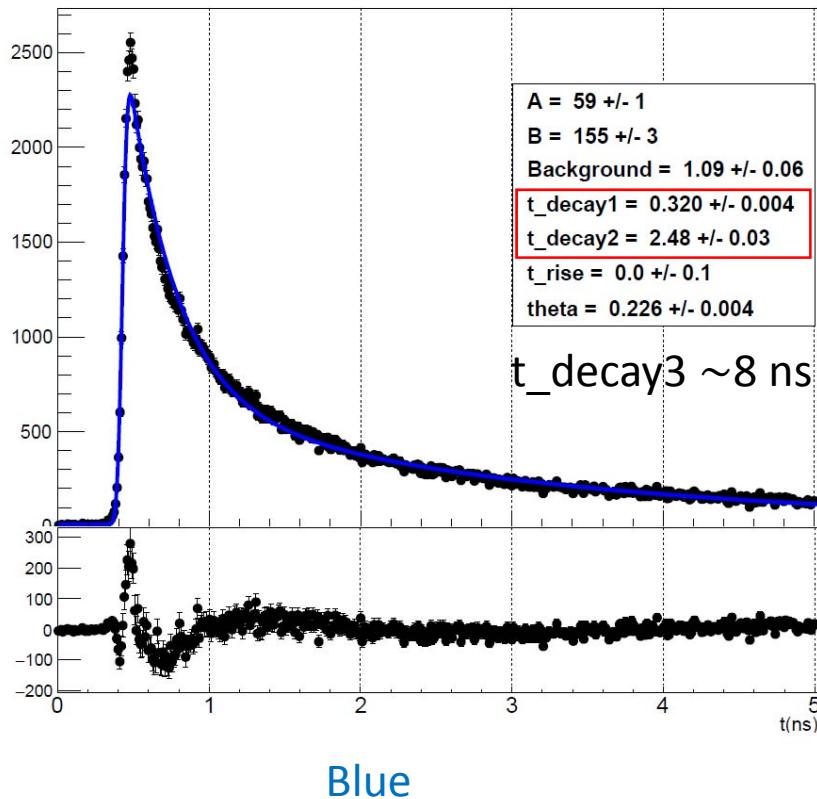
First experiments – results (RL, PL)

- PL was measured on a drop-casted film of the colloidal solution (the smallest particles)
- RL measured on the powder (the biggest particles) – setup for RL measurement of colloids is prepared for next samples



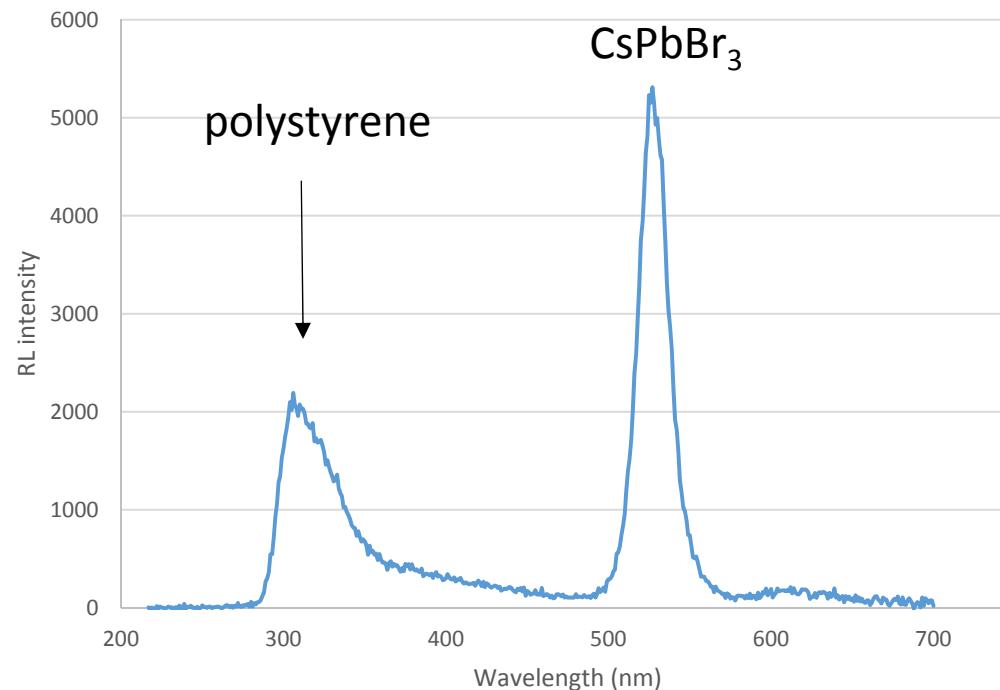
First experiments – results (PL decay)

- Photoluminescence under laser excitation (372 nm)
- Measured at CERN by Rosana Martinez Turtos
- Blue vs. green emmission (blue: fast component – 320 ps!)



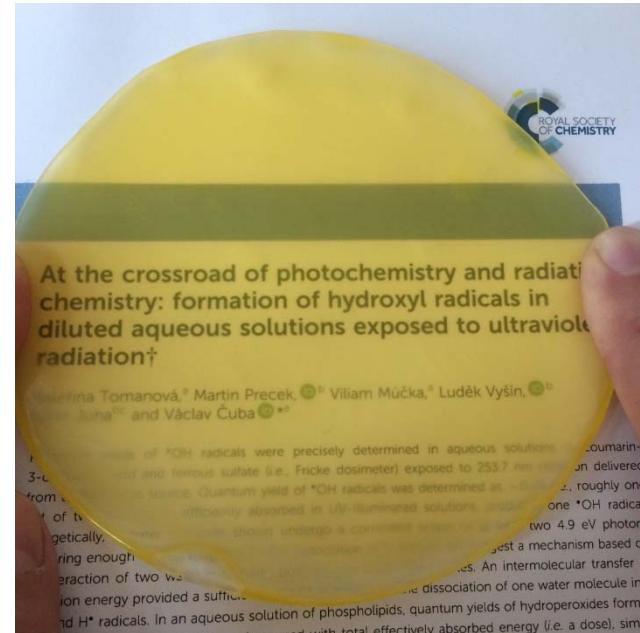
Embedding in polystyrene

- Embedding in polystyrene via polymerization of colloidal solution of CsPbBr_3 in styrene
- Stripping of surface ligands quenched the RL intensity
- PL decay times are a mixture of several components, 1.6 ns up to 450 ns (measured by Rosana Martinez Turtos at Lyon – ILM, Christoph Dujardin)



Outlooks

- Disadvantages:
 - CsPbBr₃ is soluble in water
 - Sensitive to air
 - Colloidal solution unstable
- How to solve them:
 - Core-shell – either silica coating or embedding in polymer matrix
 - Thin films

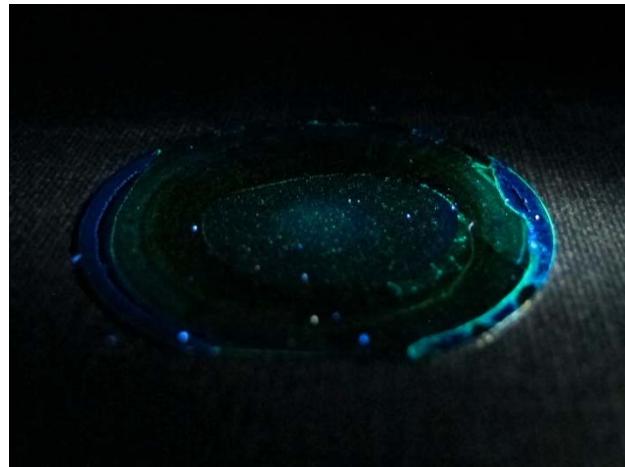


At the crossroad of photochemistry and radiative chemistry: formation of hydroxyl radicals in diluted aqueous solutions exposed to ultraviolet radiation†

Katerina Tománová,^a Martin Precek,^a Viliam Múčka,^a Luděk Vyšin,^a Lukáš Štěpánek,^a and Václav Čuba^{a,*b}

Quantum yields of *OH radicals were precisely determined in aqueous solutions of phospholipids, coumarin-3-carboxylic acid and ferrous sulfate (i.e. Fricke dosimeter) exposed to 253.7 nm UV radiation delivered from a low-pressure mercury source. Quantum yield of *OH radicals was determined at ~ 0.01 , roughly one-tenth of total energy efficiently absorbed in UV-illuminated solutions. Formation of one *OH radical is energetically, kinetically and thermodynamically feasible. We propose a mechanism based on the interaction of two water molecules with a photon. An intermolecular transfer of energy provided a sufficient energy for the dissociation of one water molecule into H⁺ and H^{*} radicals. In an aqueous solution of phospholipids, quantum yields of hydroperoxides formed with total effectively absorbed energy (i.e. a dose), similar

Mixed sample
embedded in polystyrene



Thin film
of the colloidal sample
(UV excitation)

Conclusions

- CsPbBr₃ are prospectively excellent nanoscintillators
- The fastest component has decay time of **320 ps** (first set of experiments)
- Next generation of samples – to concentrate on preparation of the blue emitting smallest particles
- After separation of the blue emission – stabilization of the particles (polystyrene, SiO₂ core-shell, thin films)