Rare earth based materials as solar spectra converters for photolvoltaics applications

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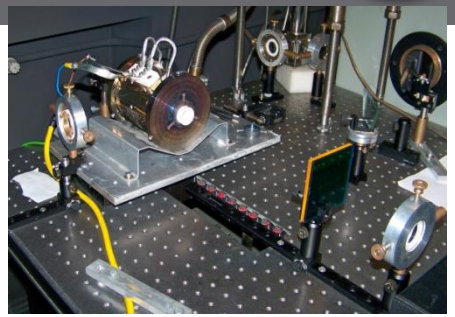
Main work areas

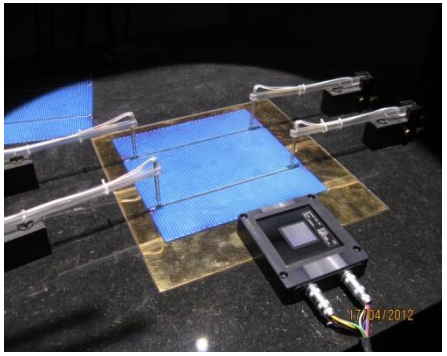
Warsaw University of Technology
Institute of Microelectronics and Optoelectronics

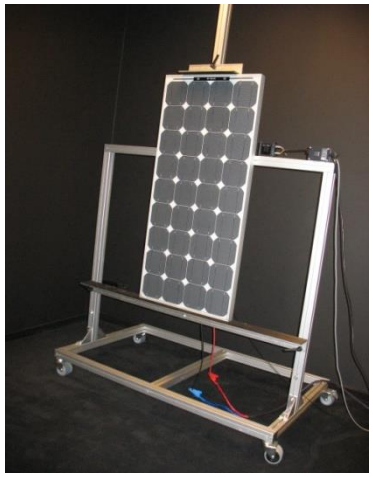
- Characterisation of optical properties of rare earths complexes and their application potential as solar spectra converters
- Charactarisation of electrical and mechanical properties of PV modules in cooperation with number of polish-based companies
- Design and monitoring of PV systems
- Popularization of PV
- Commercial tests of PV modules according to the IEC 61215 and IEC 61646

Main equipment

- Spectroscopic lab
- PhotoEmission ss300b and cell measurement system SS I-V CT-01
- Climatic Chamber - 1450H 40/4G
- Outdoor measurement system

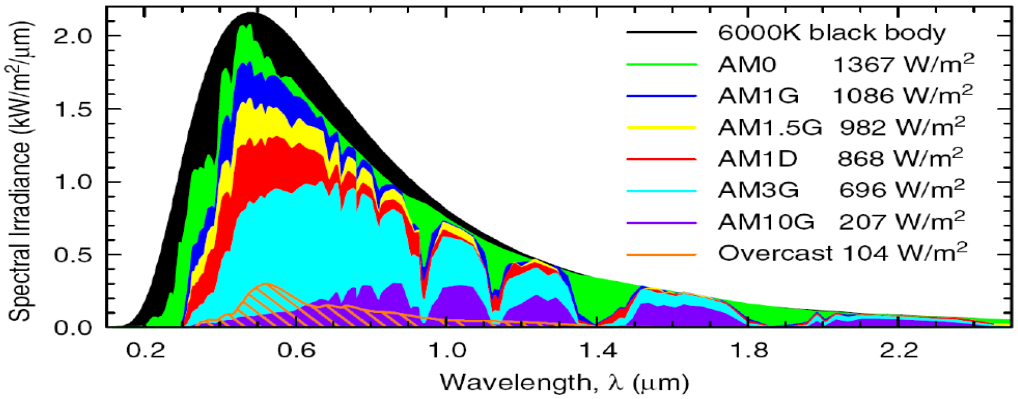




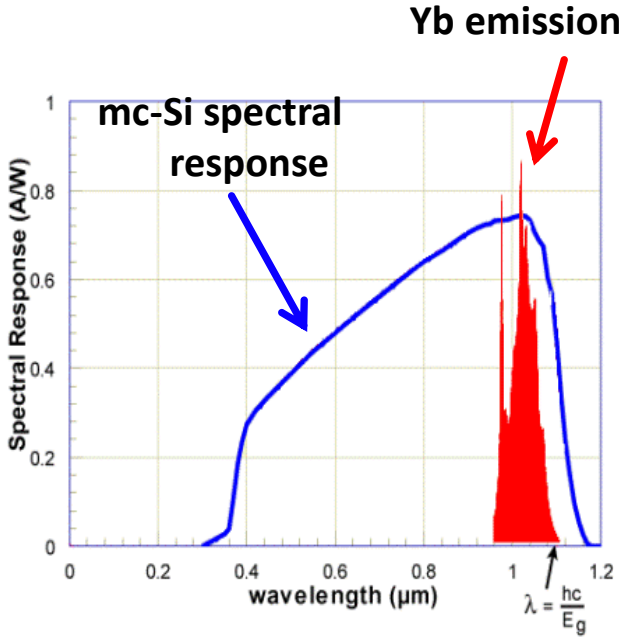


Assumptions and objectives

- Desired result: Re^{3+} ions activated nanoparticles for spectrum changing layer
- Ability to absorb light in 300-488 nm range
- Emission via down-conversion process

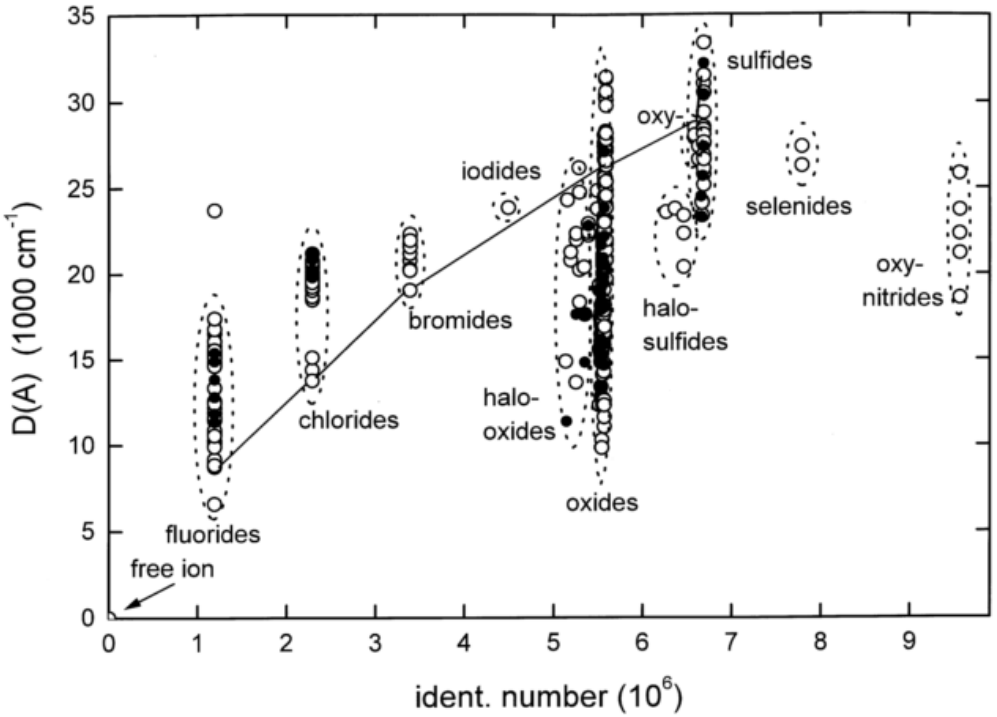


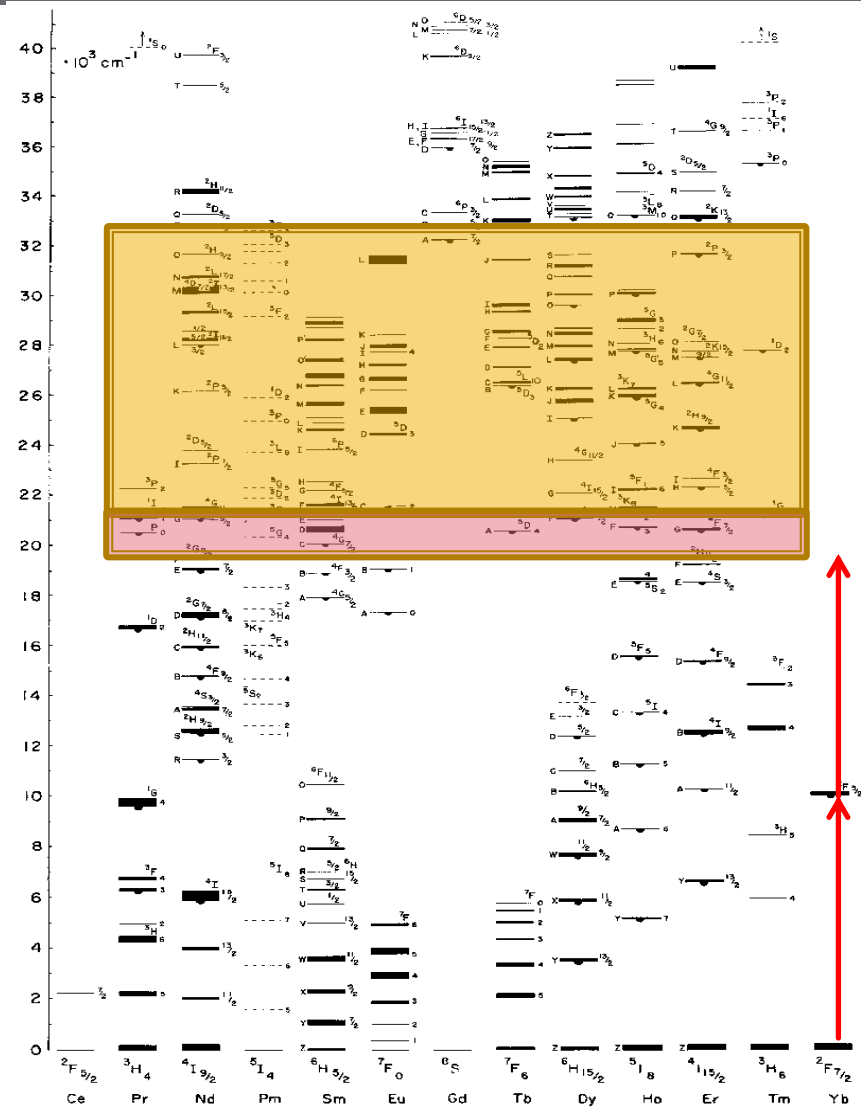
Air Mass spectrum	Total int. [W/m²]	DC potential <0.55 μm [W/m²]	UC potential 1.15-2.21 μm [W/m²]
AM1.5G	982	149 (32%)	164 (35%)
AM3G	696	75 (22%)	139 (42%)
AM10G	207	7 (8%)	74 (85%)
Overcast	166	31 (36%)	18 (21%)



Sensibilisation of Pr^{3+} with Ce^{3+}

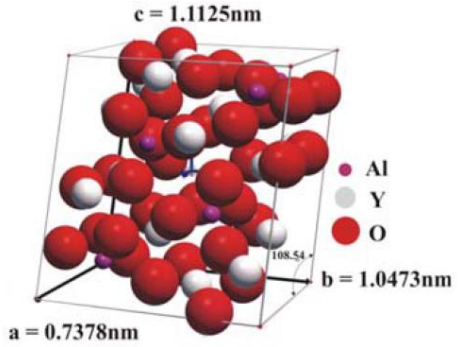
- The main problem - narrow absorption lines of f-f transitions

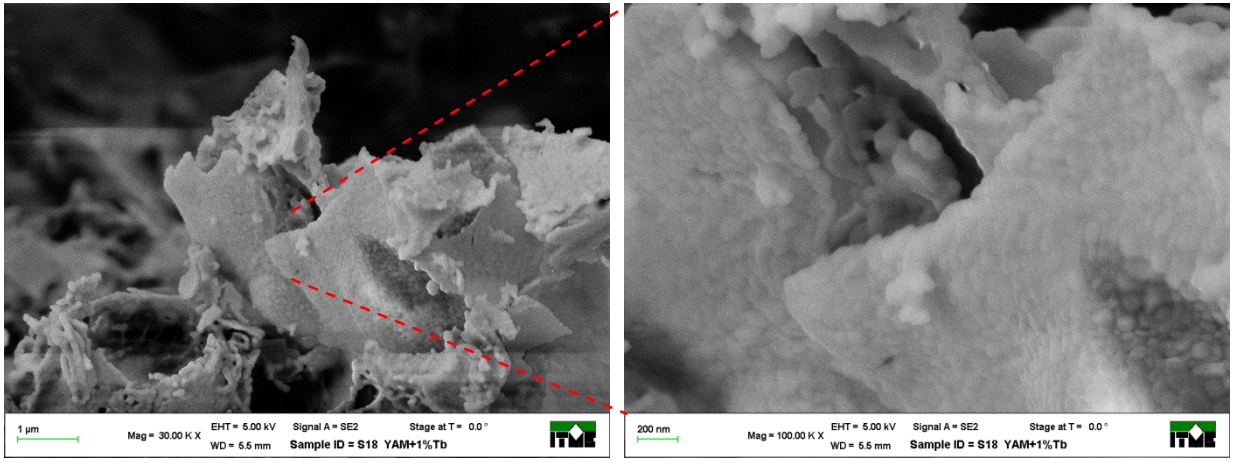


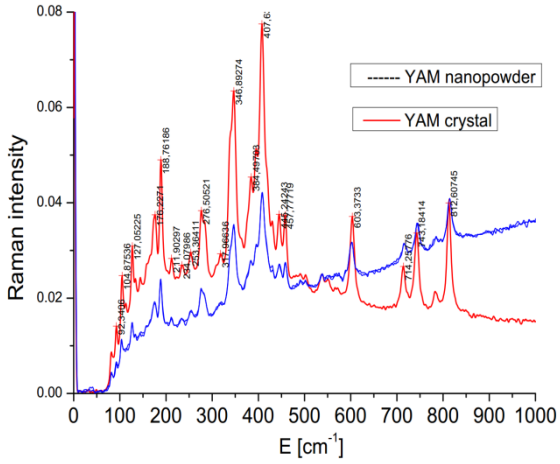


Achieved results

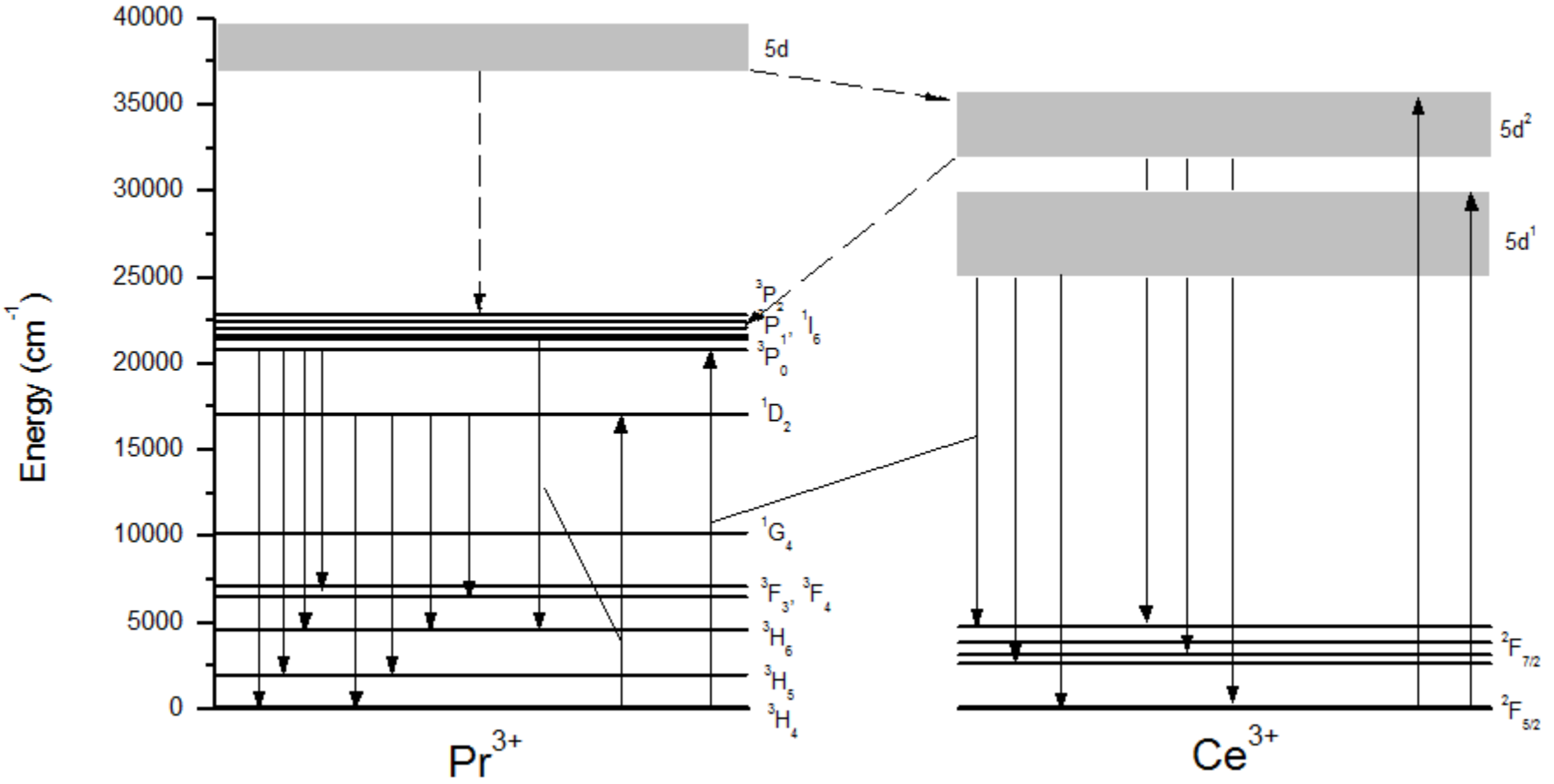
- Host material :**YAM** (Yttrium Aluminium Monoclinic) $Y_4Al_2O_9$ nanopowders and crystals
- Yttrium ions substituted with Re^{3+} ions
- Max. phonon level of 812 cm^{-1}
- Samples:
  - YAM:Ce^{3+} +Pr^{3+}
  - YAM:Tb^{3+}+Yb^{3+}







Sensibilisation of Pr^{3+} with Ce^{3+}



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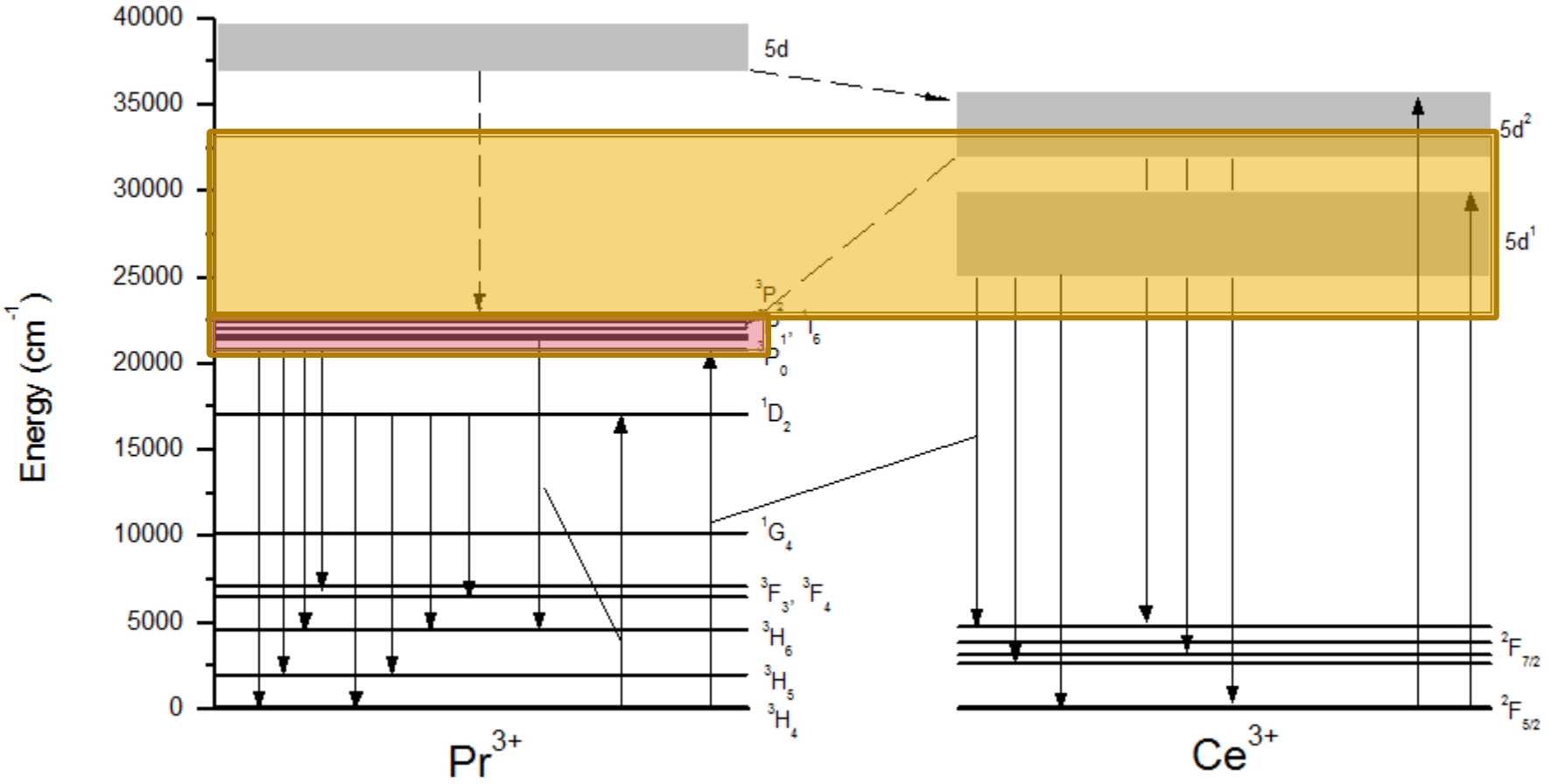
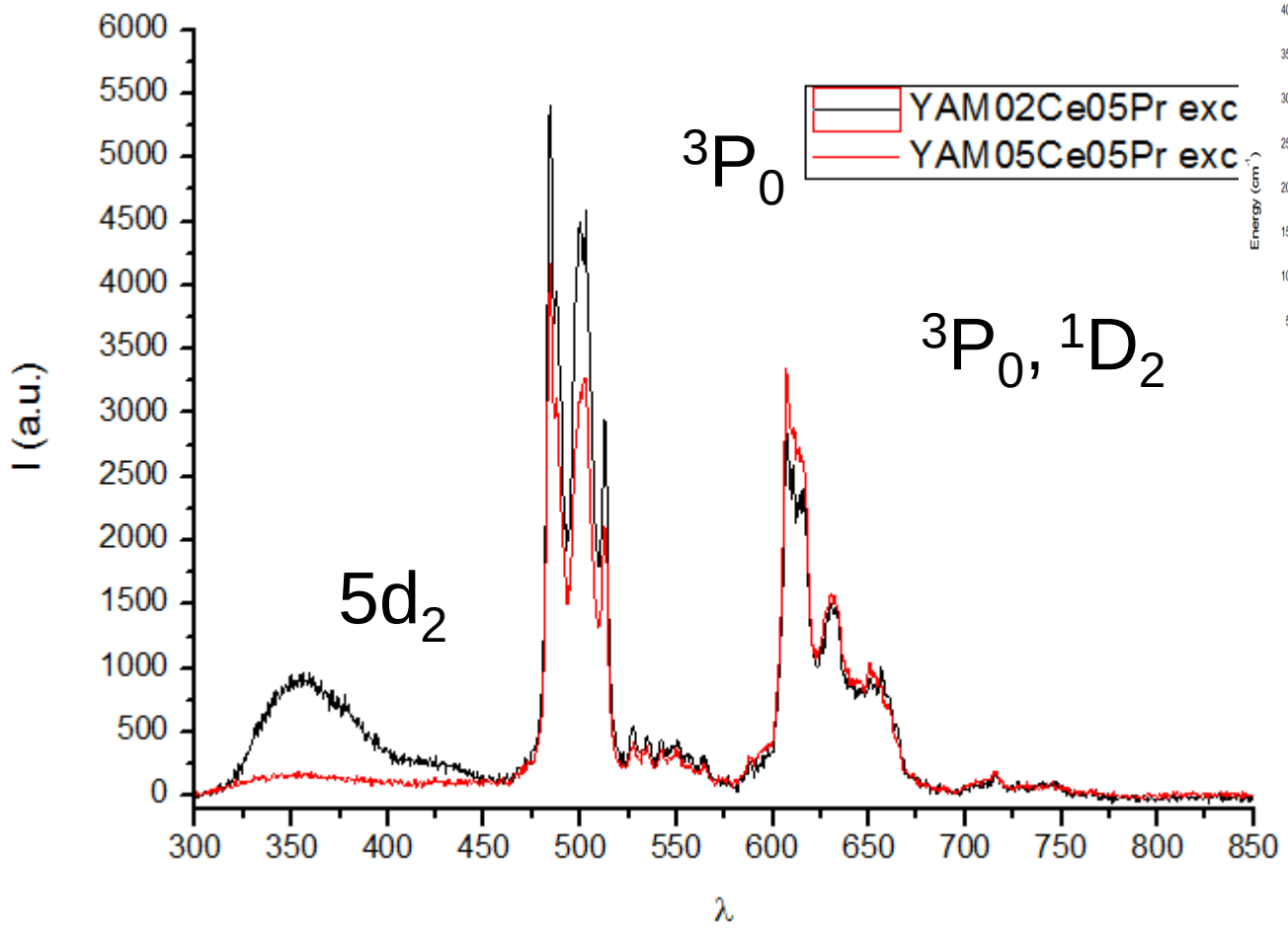
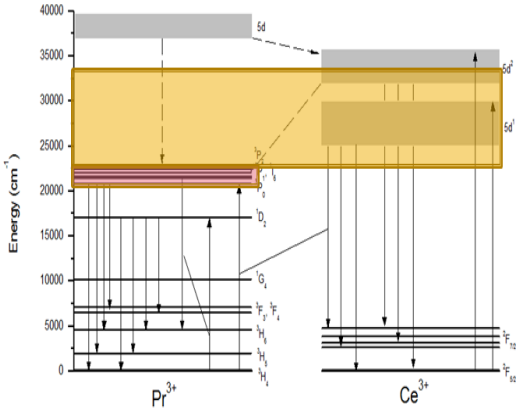


Sensibilisation of Pr^{3+} with Ce^{3+}

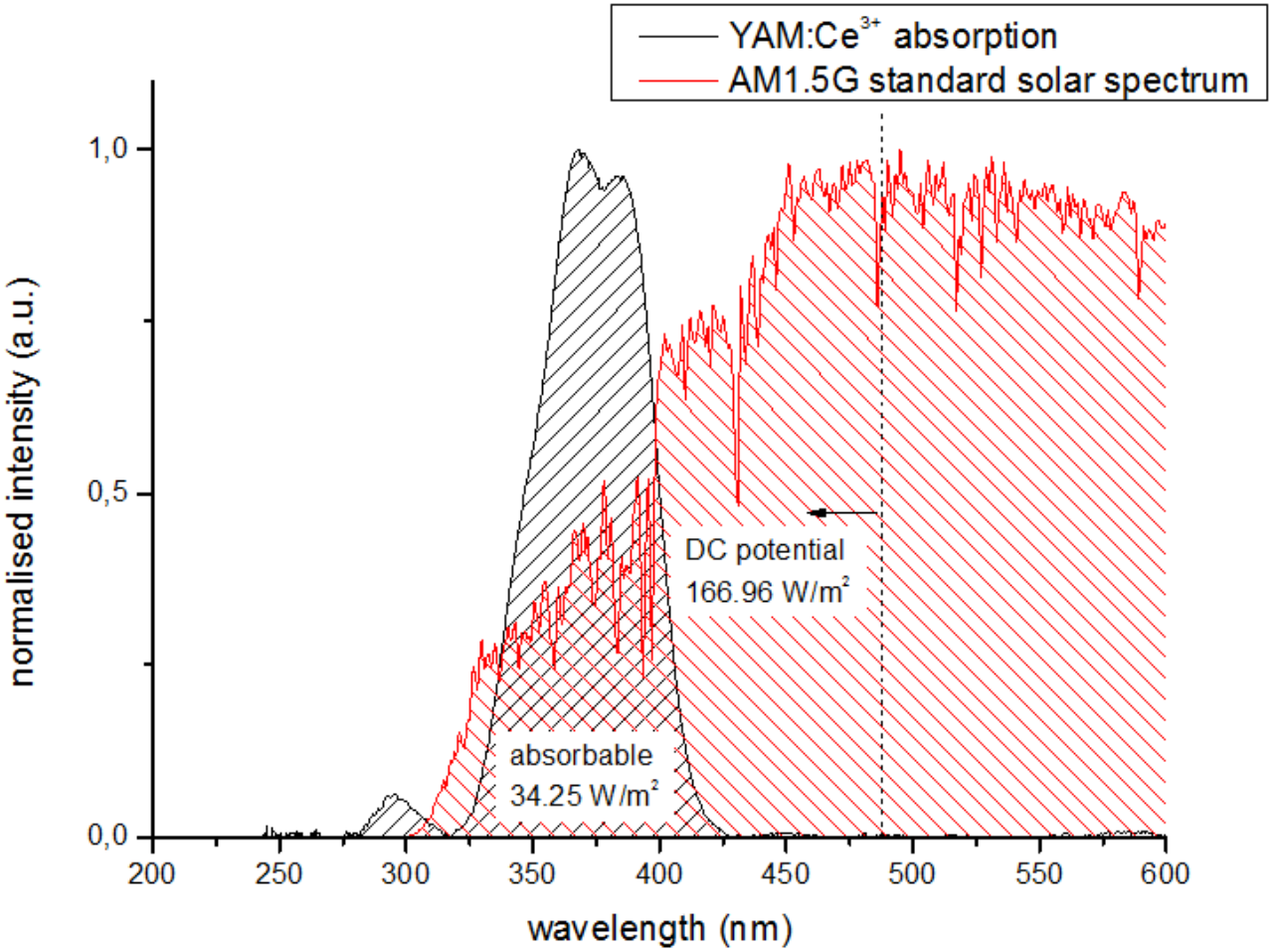
- Emission at λexc=265 nm (5d level of Pr^{3+})

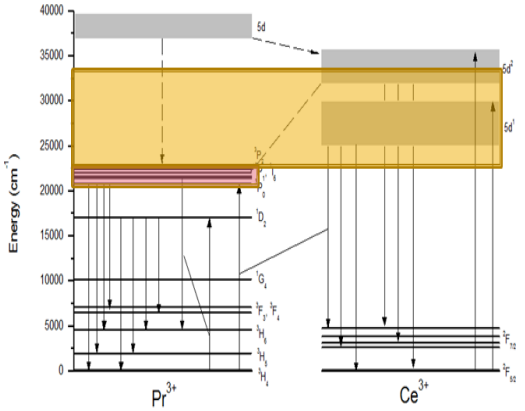




Sensibilisation of Pr^{3+} with Ce^{3+}

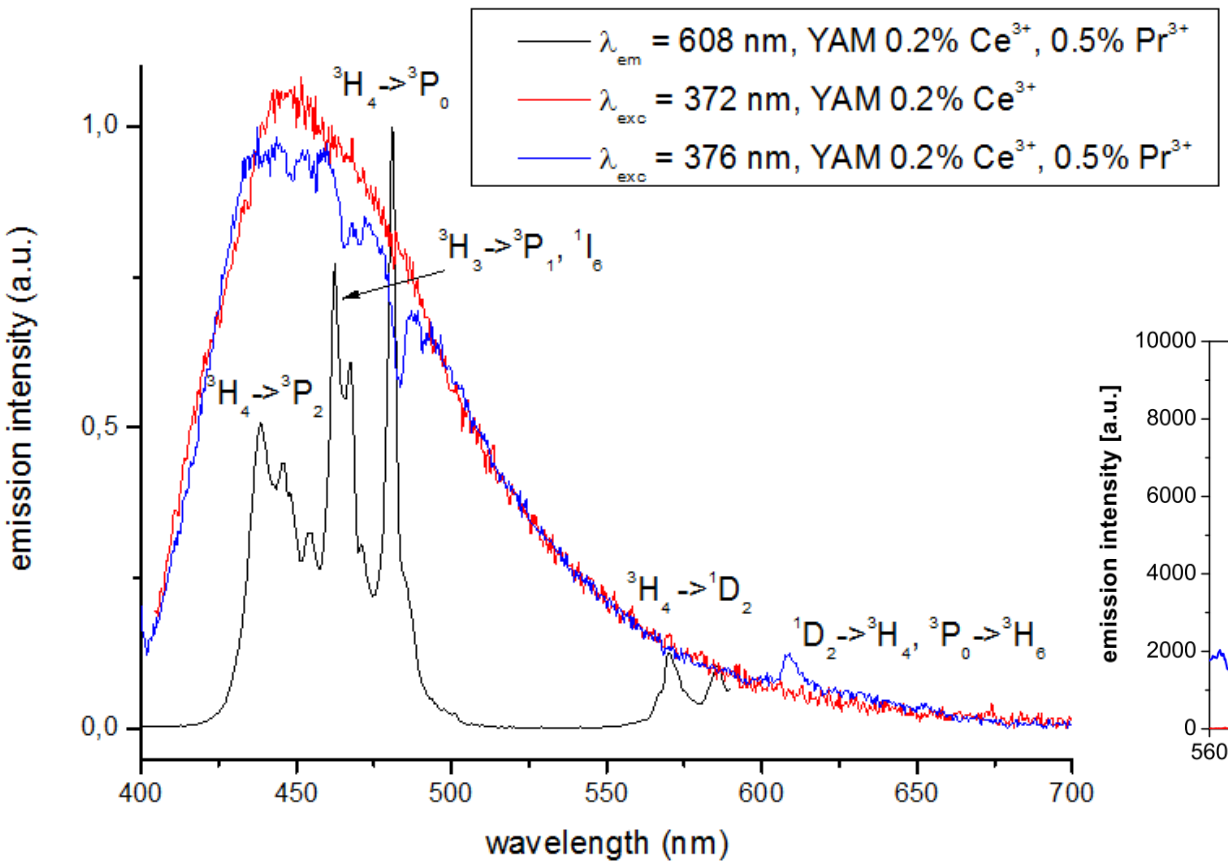
- YAM:Ce^{3+} and AM1.5G spectrum

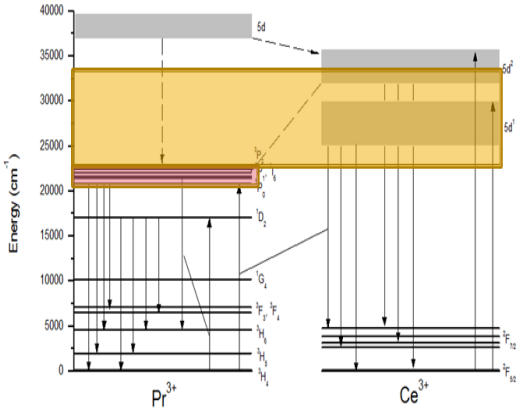


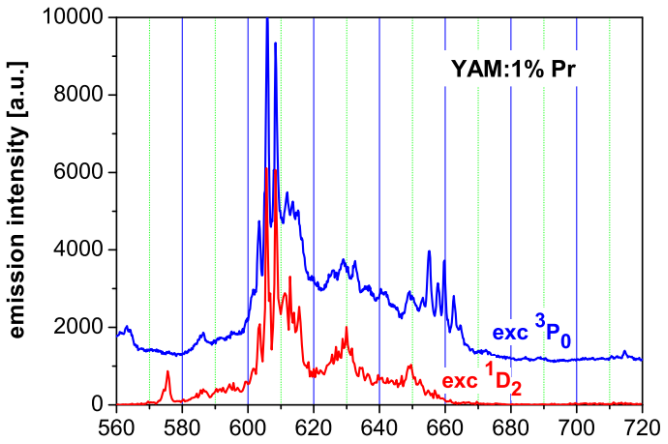


Sensibilisation of Pr^{3+} with Ce^{3+}

- Good overlap of Ce^{3+} emission and Pr^{3+} $^3P_0$ absorption

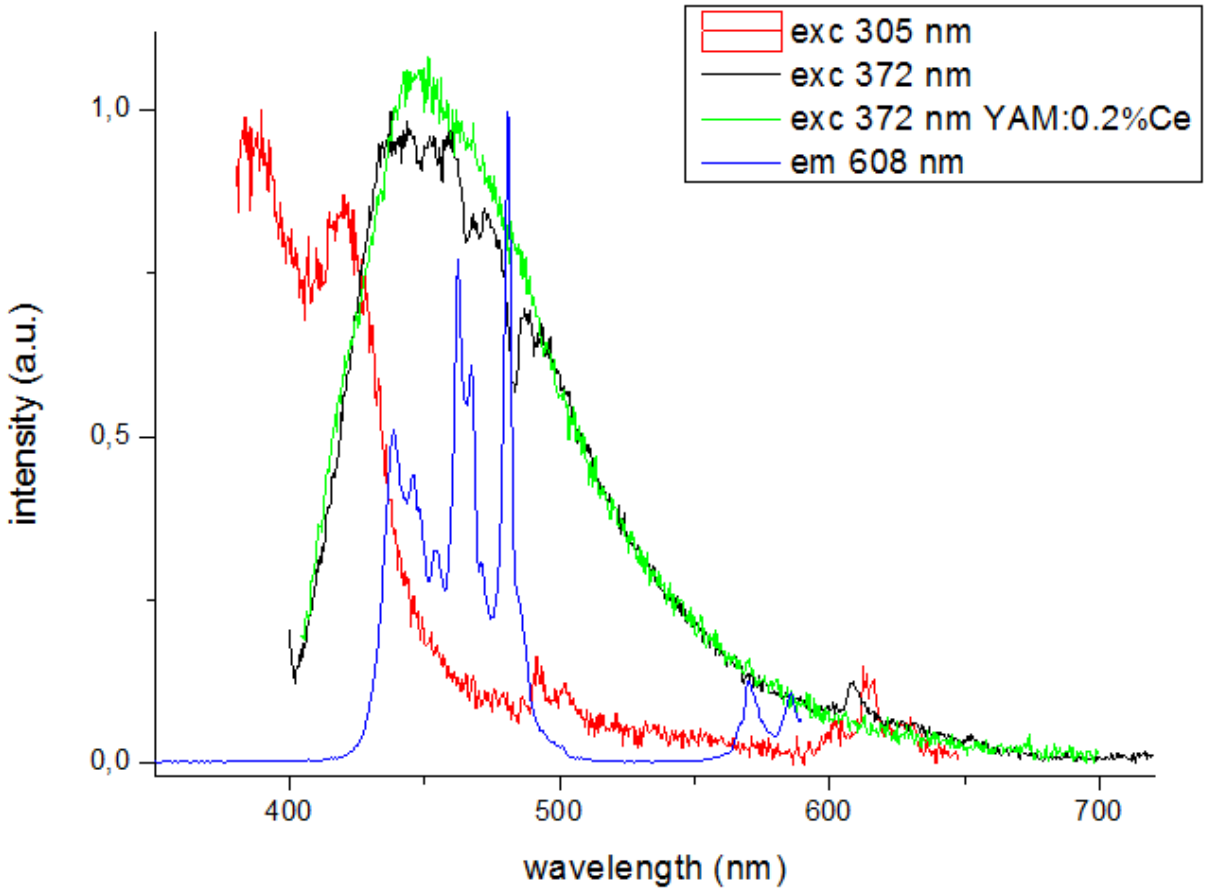


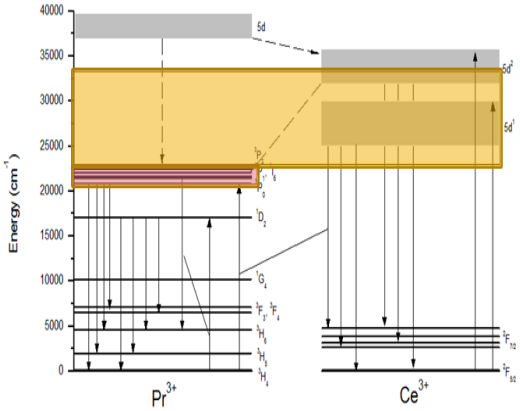




Sensibilisation of Pr^{3+} with Ce^{3+}

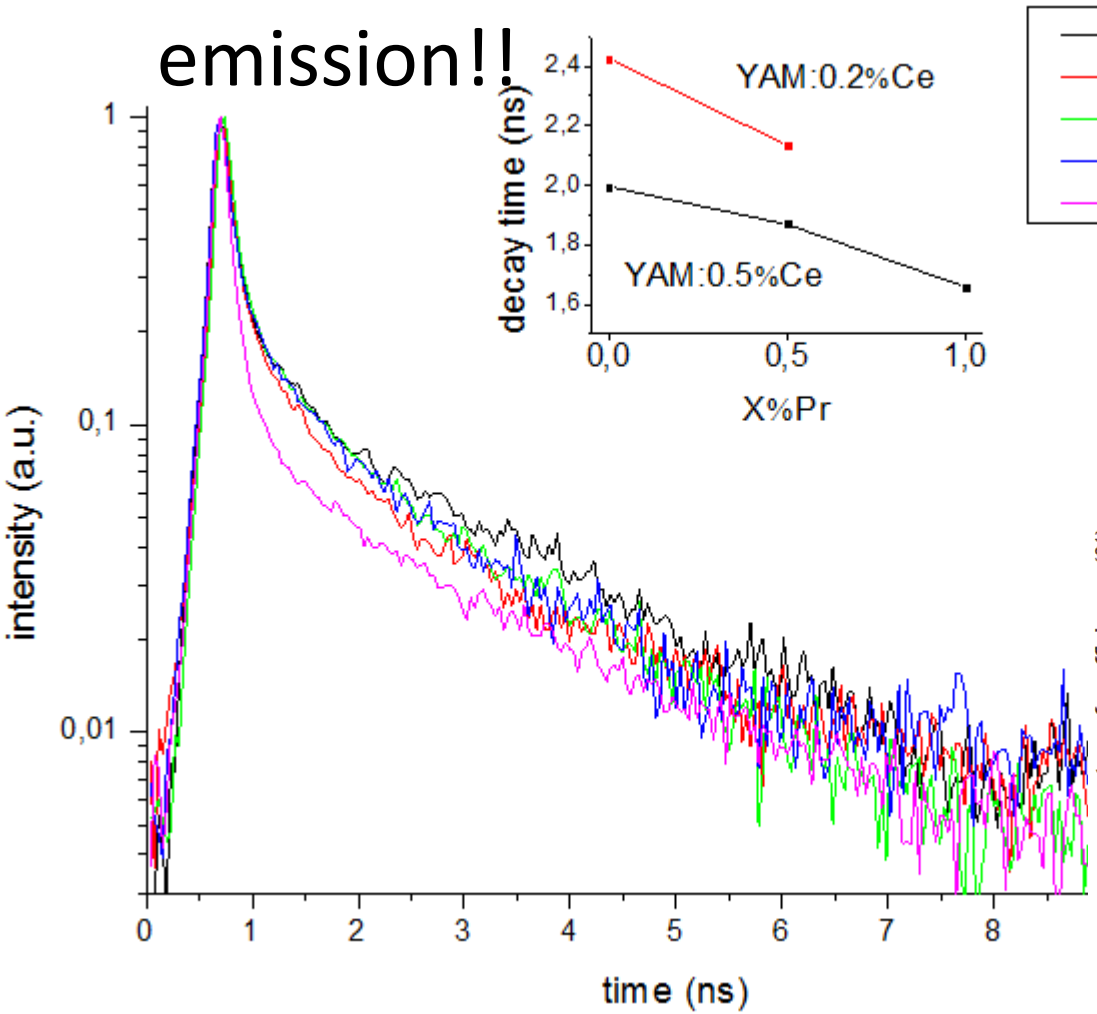
- Emission spectrum at 305 nm excitation clearly shows emission from Pr^{3+} ^3P

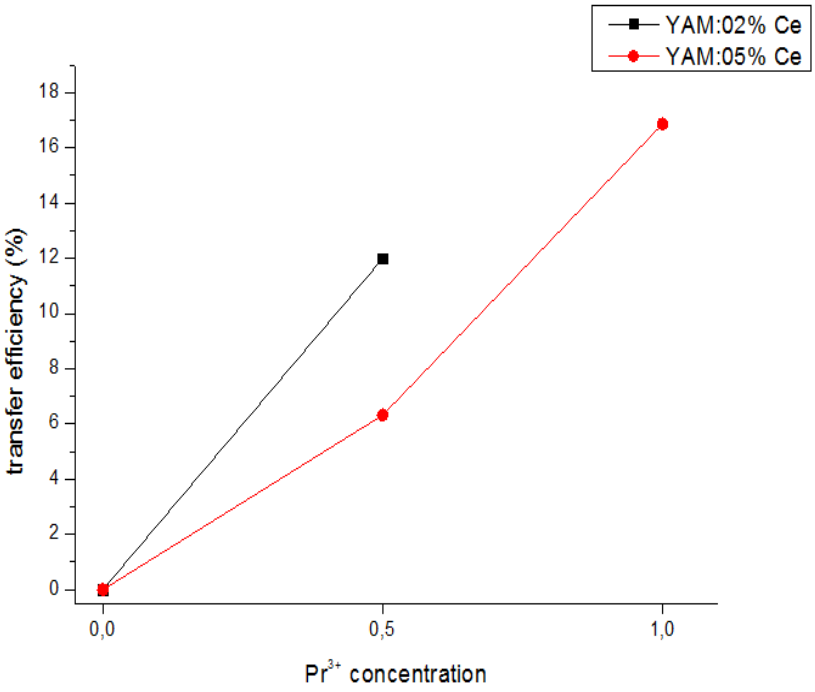




Sensibilisation of Pr^{3+} with Ce^{3+}

- Extremely short decay times of Ce^{3+} emission!!





Conclusions

- We characterised the YAM:Ce^{3+}+Pr^{3+} system
- Cerium 5d levels in YAM:Ce^{3+} are located in advantegous range from point of view of solar down-converters
- Emission spectrum of the cerium ions strongly overlaps with excitation spectrum of the Pr^{3+} $^3P_0$ level
- We proved existence of energy transfer from Ce to Pr in this system, resulting in both $^3P_0$ and $^1D_2$ level emissions
- We observed unusually short luminescence decay times