

SUPPLEMENTARY INFORMATION

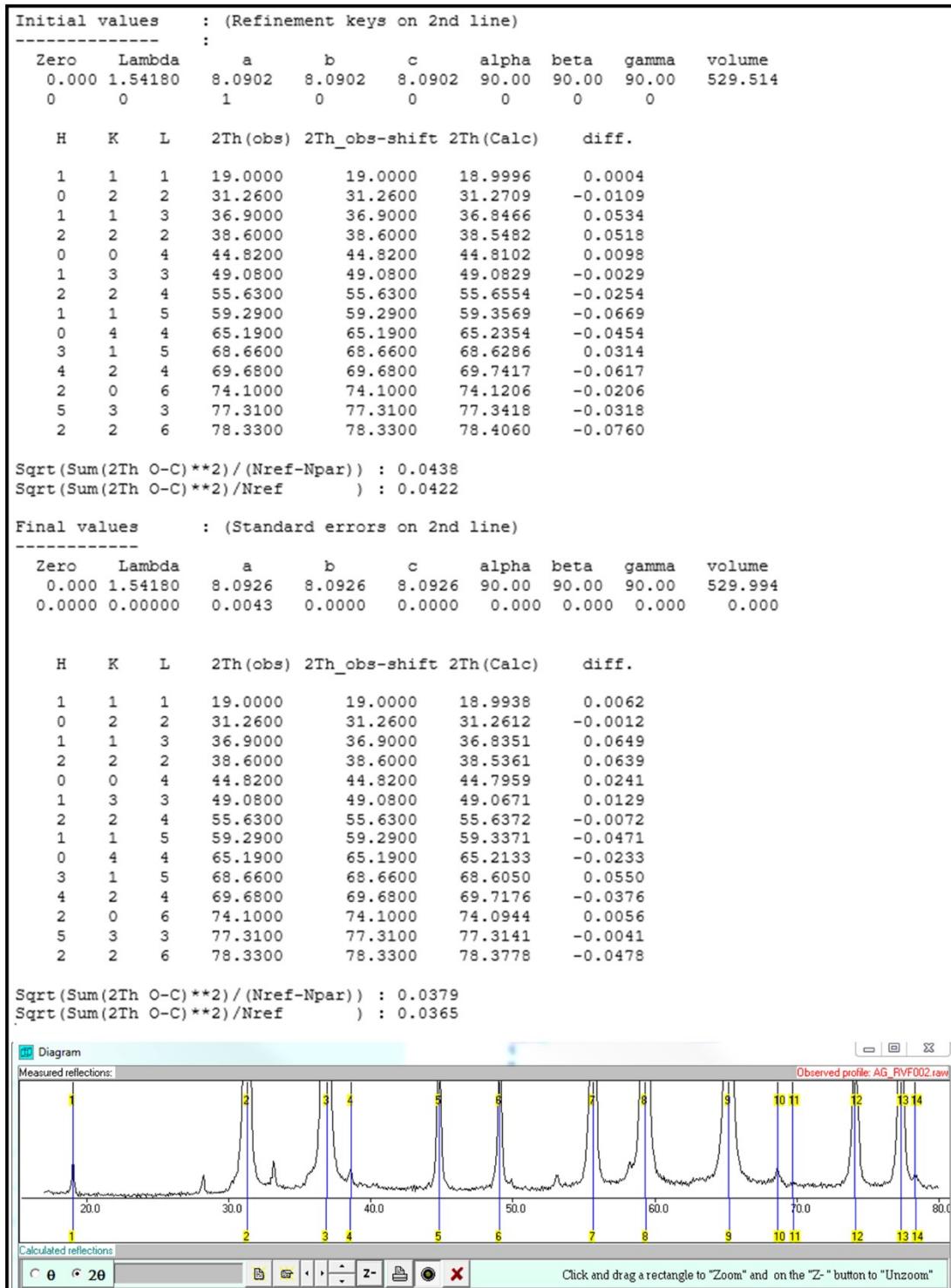


Figure S1: The full cell parameters obtained from the indexed patterns for ZnAl_2O_4 .

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Initial values      : (Refinement keys on 2nd line)
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Zero   Lambda      a       b       c       alpha   beta    gamma   volume
0.000  1.54180   8.0880  8.0880  8.0880  90.00   90.00   90.00   529.083
0       0           1       0       0       0       0       0       0

H     K     L     2Th(obs) 2Th_obs-shift 2Th(Calc)      diff.
1     1     1     19.0800   19.0800   19.0048   0.0752
0     2     2     31.2900   31.2900   31.2796   0.0104
1     1     3     36.8500   36.8500   36.8570  -0.0070
0     0     4     44.8200   44.8200   44.8230  -0.0030
2     2     4     55.7000   55.7000   55.6719   0.0281
1     1     5     59.3500   59.3500   59.3746  -0.0246
0     4     4     65.2000   65.2000   65.2554  -0.0554
3     1     5     68.6600   68.6600   68.6499   0.0101
2     0     6     74.1800   74.1800   74.1441   0.0359
5     3     3     77.3700   77.3700   77.3667   0.0033

Sqrt(Sum(2Th O-C)**2) / (Nref-Npar)) : 0.0360
Sqrt(Sum(2Th O-C)**2)/Nref          ) : 0.0342

Final values      : (Standard errors on 2nd line)
-----
Zero   Lambda      a       b       c       alpha   beta    gamma   volume
0.000  1.54180   8.0867  8.0867  8.0867  90.00   90.00   90.00   528.831
0.0000 0.00000   0.0050  0.0000  0.0000  0.000   0.000   0.000   0.000

H     K     L     2Th(obs) 2Th_obs-shift 2Th(Calc)      diff.
1     1     1     19.0800   19.0800   19.0078   0.0722
0     2     2     31.2900   31.2900   31.2847   0.0053
1     1     3     36.8500   36.8500   36.8630  -0.0130
0     0     4     44.8200   44.8200   44.8305  -0.0105
2     2     4     55.7000   55.7000   55.6815   0.0185
1     1     5     59.3500   59.3500   59.3850  -0.0350
0     4     4     65.2000   65.2000   65.2670  -0.0670
3     1     5     68.6600   68.6600   68.6623  -0.0023
2     0     6     74.1800   74.1800   74.1578   0.0222
5     3     3     77.3700   77.3700   77.3813  -0.0113

Sqrt(Sum(2Th O-C)**2) / (Nref-Npar)) : 0.0368
Sqrt(Sum(2Th O-C)**2)/Nref          ) : 0.0349

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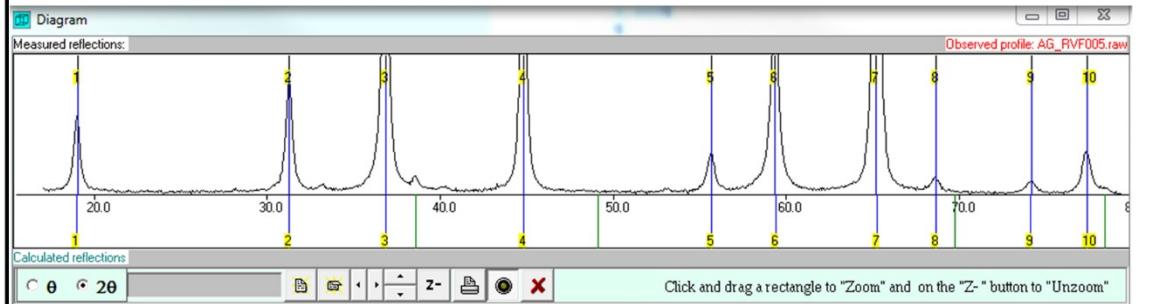


Figure S2: The full cell parameters obtained from the indexed patterns for ZnAl₂O₄:Eu³⁺.

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Initial values      : (Refinement keys on 2nd line)
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Zero    Lambda      a        b        c        alpha   beta    gamma   volume
0.000 1.54180    8.0900   8.0900   8.0900   90.00   90.00   90.00   529.475
0       0           1         0         0         0         0         0         0

H     K     L     2Th(obs) 2Th_obs-shift 2Th(Calc)      diff.

0     2     2     31.2700    31.2700   31.2717   -0.0017
3     1     1     36.8500    36.8500   36.8476   0.0024
0     0     4     44.8600    44.8600   44.8113   0.0487
3     1     3     49.1000    49.1000   49.0842   0.0158
2     2     4     55.6100    55.6100   55.6569   -0.0469
1     1     5     59.3400    59.3400   59.3585   -0.0185
0     4     4     65.2400    65.2400   65.2372   0.0028
2     0     6     74.1100    74.1100   74.1227   -0.0127
5     3     3     77.3700    77.3700   77.3440   0.0260

Sqrt(Sum(2Th O-C)**2)/(Nref-Npar)) : 0.0274
Sqrt(Sum(2Th O-C)**2)/Nref          ) : 0.0258

Final values      : (Standard errors on 2nd line)
-----
:
Zero    Lambda      a        b        c        alpha   beta    gamma   volume
0.000 1.54180    8.0898   8.0898   8.0898   90.00   90.00   90.00   529.445
0.0000 0.00000    0.0033   0.0000   0.0000   0.000   0.000   0.000   0.000

H     K     L     2Th(obs) 2Th_obs-shift 2Th(Calc)      diff.

0     2     2     31.2700    31.2700   31.2723   -0.0023
3     1     1     36.8500    36.8500   36.8483   0.0017
0     0     4     44.8600    44.8600   44.8123   0.0477
3     1     3     49.1000    49.1000   49.0852   0.0148
2     2     4     55.6100    55.6100   55.6581   -0.0481
1     1     5     59.3400    59.3400   59.3597   -0.0197
0     4     4     65.2400    65.2400   65.2386   0.0014
2     0     6     74.1100    74.1100   74.1244   -0.0144
5     3     3     77.3700    77.3700   77.3458   0.0242

Sqrt(Sum(2Th O-C)**2)/(Nref-Npar)) : 0.0274
Sqrt(Sum(2Th O-C)**2)/Nref          ) : 0.0258

Diagram
Measured reflections:
Calculated reflections
Observed profile: AG_RVF003.raw
Click and drag a rectangle to "Zoom" and on the "Z-" button to "Unzoom"

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Figure S3: The full cell parameters obtained from the indexed patterns for MgAl₂O₄.

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Initial values      : (Refinement keys on 2nd line)
-----
Zero    Lambda      a        b        c        alpha   beta    gamma   volume
0.000 1.54180    8.0900   8.0900   8.0900   90.00   90.00   90.00   529.475
0       0           1         0         0         0         0         0         0

H     K     L      2Th(obs) 2Th_obs-shift 2Th(Calc)      diff.

1     1     1      19.0300   19.0300   19.0000   0.0300
0     2     2      31.2900   31.2900   31.2717   0.0183
3     1     1      36.8200   36.8200   36.8476  -0.0276
0     0     4      44.7900   44.7900   44.8113  -0.0213
2     2     4      55.6600   55.6600   55.6569   0.0031
3     3     3      59.3900   59.3900   59.3585   0.0315
0     4     4      65.1800   65.1800   65.2372  -0.0572
5     3     3      77.3700   77.3700   77.3440   0.0260

Sqrt(Sum(2Th O-C)**2)/(Nref-Npar)) : 0.0325
Sqrt(Sum(2Th O-C)**2)/Nref          ) : 0.0304

Final values      : (Standard errors on 2nd line)
-----
Zero    Lambda      a        b        c        alpha   beta    gamma   volume
0.000 1.54180    8.0896   8.0896   8.0896   90.00   90.00   90.00   529.402
0.0000 0.00000    0.0040   0.0000   0.0000   0.0000   0.0000   0.0000   0.000

H     K     L      2Th(obs) 2Th_obs-shift 2Th(Calc)      diff.

1     1     1      19.0300   19.0300   19.0009   0.0291
0     2     2      31.2900   31.2900   31.2732   0.0168
3     1     1      36.8200   36.8200   36.8493  -0.0293
0     0     4      44.7900   44.7900   44.8135  -0.0235
2     2     4      55.6600   55.6600   55.6597   0.0003
3     3     3      59.3900   59.3900   59.3615   0.0285
0     4     4      65.1800   65.1800   65.2406  -0.0606
5     3     3      77.3700   77.3700   77.3483   0.0217

Sqrt(Sum(2Th O-C)**2)/(Nref-Npar)) : 0.0327
Sqrt(Sum(2Th O-C)**2)/Nref          ) : 0.0306

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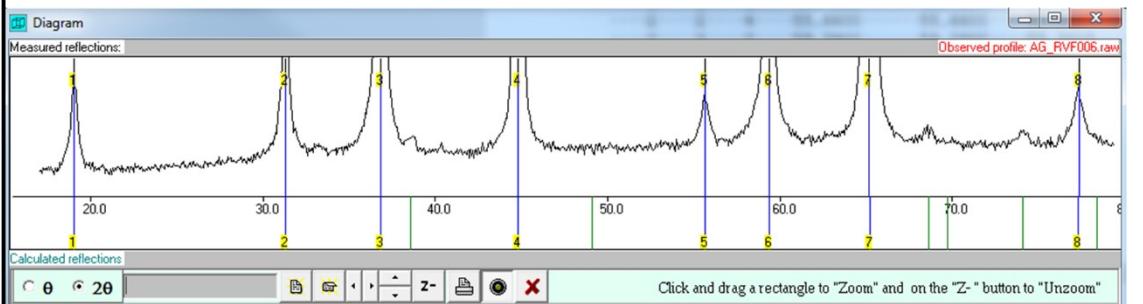


Figure S4: The full cell parameters obtained from the indexed patterns for MgAl₂O₄:Eu³⁺.

Table S1: Data fits of emission and excitation spectra of ZAOE and MAOE

ZAOE									
Emission					Excitation				
Position (cm ⁻¹)	Position (nm)	FWHM (cm ⁻¹)	Intensity (cm ⁻¹)	Energy (eV)	Position (cm ⁻¹)	Position (nm)	FWHM (cm ⁻¹)	Intensity (cm ⁻¹)	Energy (eV)
14178.7	705	211.8	0.683	1.758	18901.4	529	706,0	0.172	2.343
14398.0	695	339.5	0.727	1.785	21582.9	463	701,6	0.657	2.676
15340.8	652	550.7	0.658	1.902	23701.6	422	679,4	1.370	2.939
16156.6	619	425.2	7.160	2.003	25328.5	395	937,1	1.460	3.140
16664.7	600	146.2	0.277	2.066	26243.7	381	748,5	0.299	3.254
16881.4	592	302.9	0.859	2.093	35392.7	283	6959	41.48	4.388
17237.0	580	309.7	0.439	2.137					
MAOE									
Emission					Excitation				
Position (cm ⁻¹)	Position (nm)	FWHM (cm ⁻¹)	Intensity (cm ⁻¹)	Energy (eV)	Position (cm ⁻¹)	Position (nm)	FWHM (cm ⁻¹)	Intensity (cm ⁻¹)	Energy (eV)
14159.9	706	179.2	1.590	1.756	19262.0	519	823.0	0.293	2.388
14324.8	698	421.2	3.180	1.776	22087.4	453	730.2	0.863	2.738
15299.0	654	471.2	1.910	1.897	24278.7	412	698.5	1.310	3.010
16152.8	619	443.9	21.42	2.003	25998.4	385	916.9	2.200	3.,223
16664.7	600	143.3	0.816	2.066	26849.7	372	923.8	0.846	3.329
16874.1	593	292.5	2.670	2.092	36929.9	271	7450	53.79	4.579
17213.8	581	312.8	1.370	2.134					

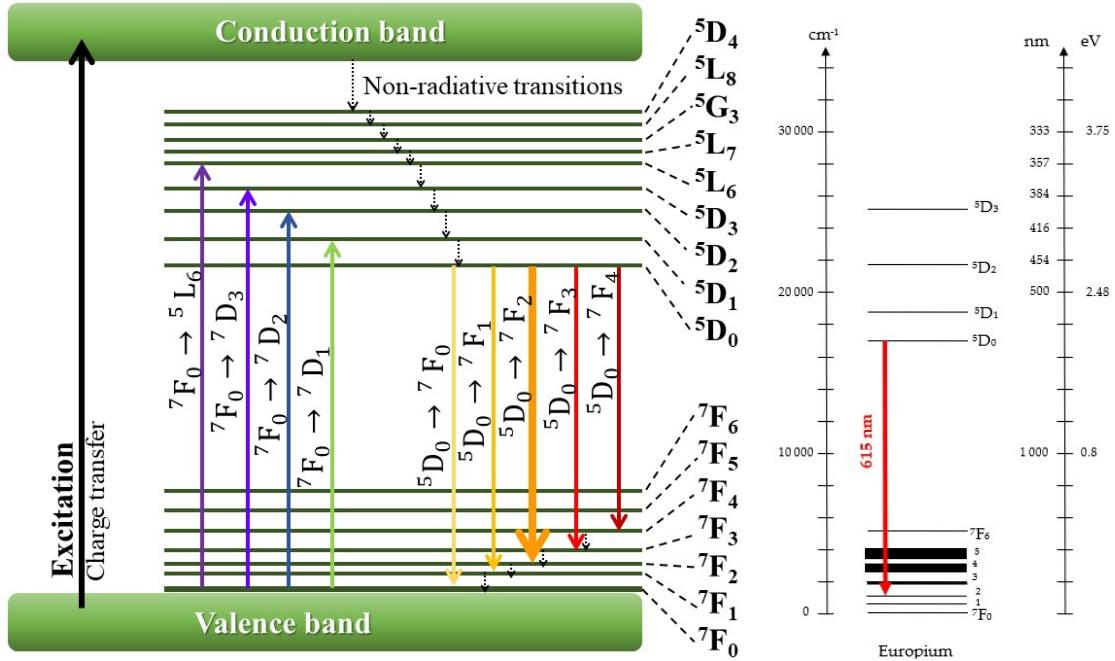


Figure S5: Energy level diagram of Eu^{3+} . Based on M. Dimitrievska et. al. [1]

Table S2a: Spectral parameters of EuDS samples

Sample	Judd-Ofelt Intensity Parameters					
	$\Omega_2 (10^{-20} \text{ cm}^2)$	$\Omega_4 (10^{-20} \text{ cm}^2)$	Radiative Transition Probabilities			${}^5\text{D}_0 \rightarrow {}^7\text{F}_J (\text{J} = 1, 2, 4)$
			$A_1 (\text{s}^{-1})$	$A_2 (\text{s}^{-1})$	$A_4 (\text{s}^{-1})$	
ZAOE	8.651	4.459	78.97	434.26	110.81	
MAOE	8.261	4.679	72.20	373.86	104.50	

Table S2b: Spectral parameters of EuDS samples

Sample	$\tau_{rad} (\text{ms})$	Branching Ratio				Stimulated emission		
		${}^5\text{D}_0 \rightarrow {}^7\text{F}_J (\text{J} = 1, 2, 4)$			$\sigma_1 (10^{-22} \text{ cm}^2)$	$\sigma_2 (10^{-22} \text{ cm}^2)$	$\sigma_4 (10^{-22} \text{ cm}^2)$	
		β_1	β_2	β_4				
ZAOE	1.56	12.7%	69.6%	17.8%	1.12	7.81	3.14	
MAOE	1.77	13.1%	67.9%	19.0%	1.11	7.04	3.46	

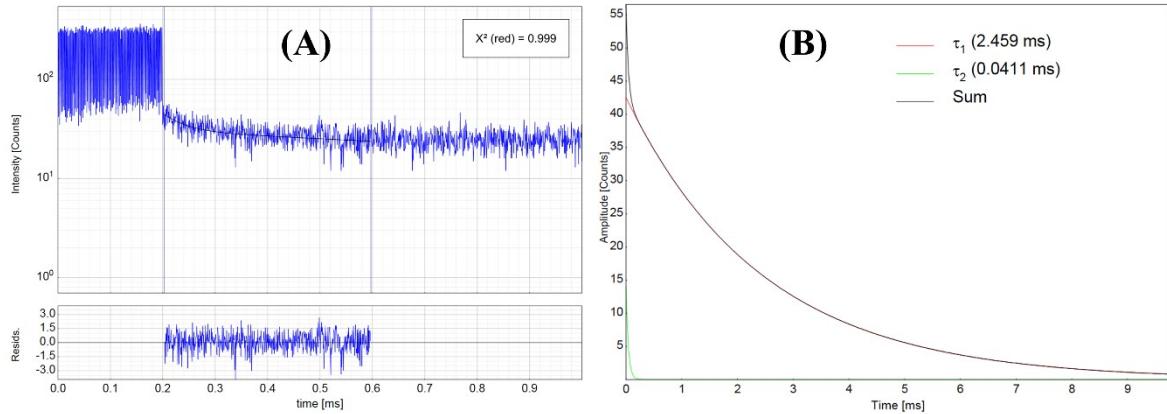


Figure S6. ZAOE. (A) TCSPC fitting and residual. (B) Fitted decay and exponential components.

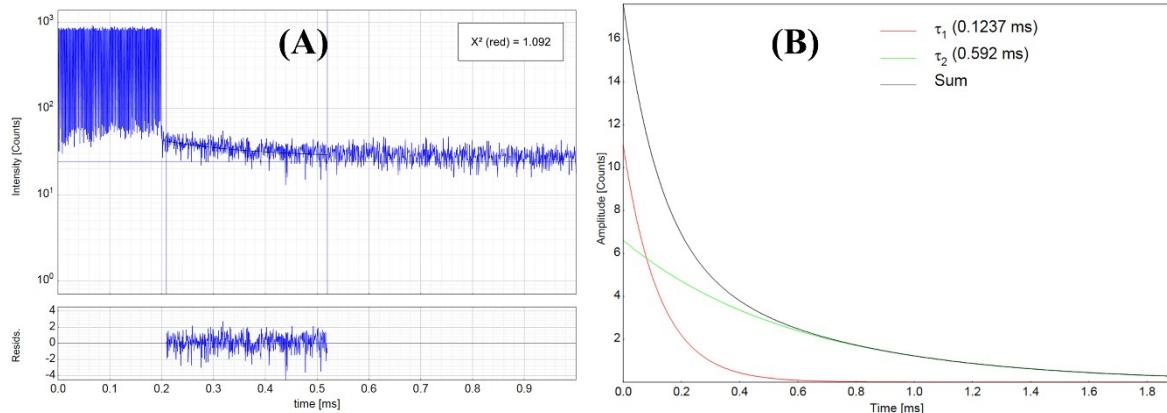


Figure S7. ZAOE-AgMPCS. (A) TCSPC fitting and residual. (B) Fitted decay and exponential components.

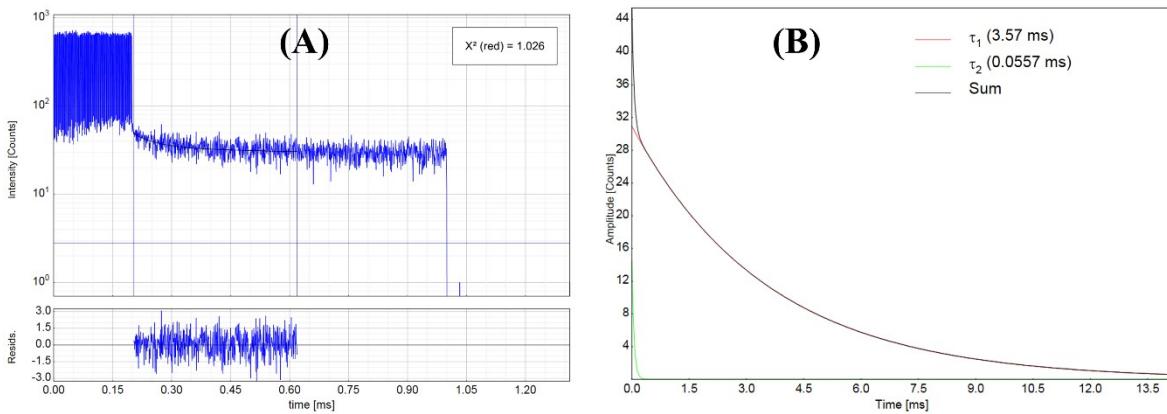


Figure S8. MAOE. (A) TCSPC fitting and residual. (B) Fitted decay and exponential components.

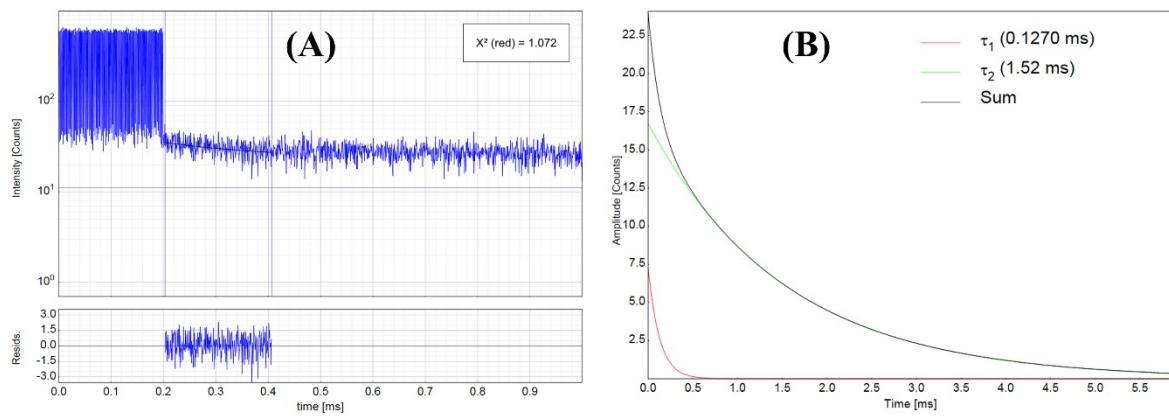


Figure S9. MAOE-AgMPCS. (A) TCSPC fitting and residual. (B) Fitted decay and exponential components.

Reference

- [1] M. Dimitrievska, T.B. Ivetić, A.P. Litvinchuk, A. Fairbrother, B.B. Miljević, G.R. Šrbac, A. Pérez Rodríguez, S.R. Lukić-Petrović, *J. Phys. Chem. C* **120** (2016) 18887–18894.