In[382]:=

```
Charting`$InteractiveHighlighting = False
```

Out[382]=

```
False
```

In[383]:=

```
ClearAll[λ]
```

LASER dataset for the samples A, B, C, D and perovskite

In[384]:=

```
titles = {"Sample A", "Sample B", "Sample C", "Sample D", "Perovskite"};
data =
  Dataset[Import[ToString@StringForm["/Users/giovannigravili/Library/Mobile
            Documents/com~apple~CloudDocs/LM
            MANO/Notebooks/NP/esperimento/LASER/laser_``.txt", #],
          "Table", "HeaderLines" → 0, "FieldSeparators" → "\t",
          "NumberPoint" → ".", CharacterEncoding → "UTF8"]][
       All, Range[1, 2]][All, <|"λ (nm)" → 1, "I" → 2|>] & /@
   {"sample_A", "sample_B", "sample_C",
    "sample_D",
    "perovskite2"};
```

In[386]:=

```
data = Transpose[{#[All, "λ (nm)"], #[All, "I"]} // Normal] & /@ data;
```

In[387]:=

```
lamPk = FindPeaks[#, 100, Automatic, 0.1] & /@
    (TimeSeriesResample@TimeSeries[#2, {#1}] &@@@
      (Transpose[#] & /@ data)) // Normal;
```

In[388]:=

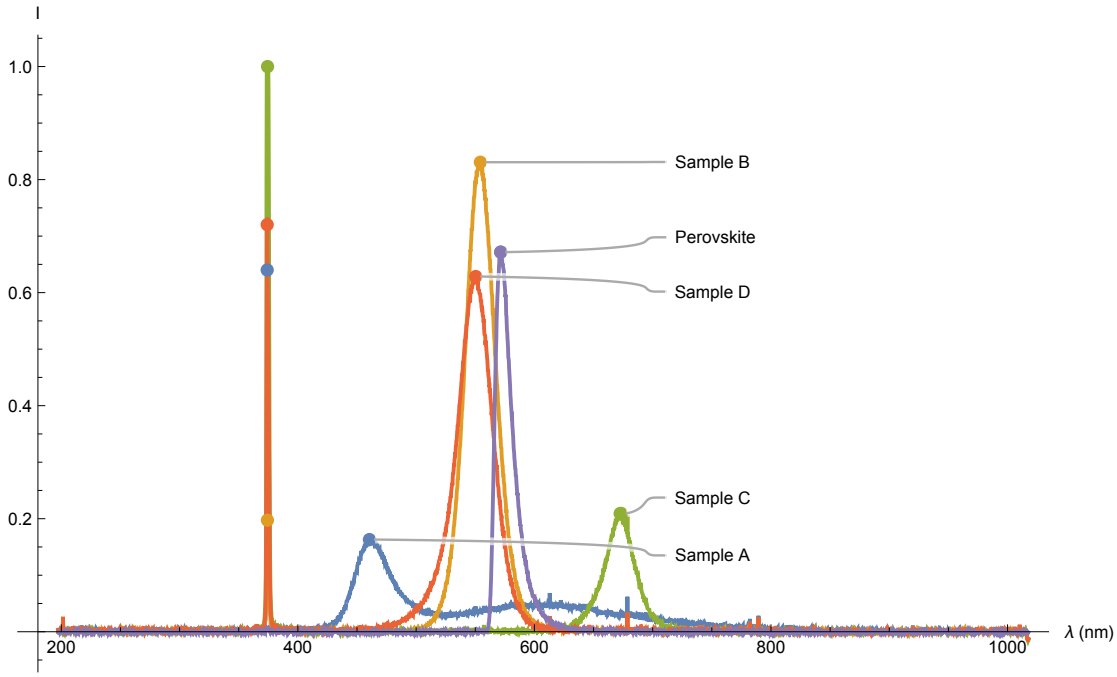
```
Rule @@@ Transpose[{titles, Column@Flatten@Take[#, All, 1] & /@ lamPk}] //
  Association // Dataset
```

Out[388]=

Sample A	374.073 460.5
Sample B	374.278 554.3
Sample C	374.38 672.472 673.291
Sample D	374.073 550.409
Perovskite	571.504

In[389]:=
```
ListLinePlot[data, PlotRange → All, AxesLabel → {"λ (nm)", "I"}] // Show[#,
   ListPlot[lamPk, PlotLabels → titles], ImageSize → Large, PlotRange → All] &
```

Out[389]=



In[390]:=
```
lamIntervals = {{400, 530}, {500, 650}, {600, 750}, {450, 650}, {550, 650}};
valsInt =
  Cases[#1, {x_, y_} /; #2[[1]] ≤ x ≤ #2[[2]] &@@@ Transpose[{data, lamIntervals}];
```

In[392]:=
```
fitFn = NonlinearModelFit[#1, A e^(-((λ-μ)^2)/(2 σ^2)), {A, {μ, #2}, σ}, λ] &@@@
   Transpose[{valsInt, {460.5, 554.3, 672.47, 550.4, 571.5}}];
```

In[393]:=
```
{Show[Plot[#1[λ], {λ, #3[[1]], #3[[2]]}, ImageSize → Medium, PlotLabel → #4],
     ListPlot[#2, PlotStyle → {Orange, PointSize[Small]}], PlotRange → All],
    Column[{#1["ANOVATable"], "", #1["ParameterTable"]}]} &@@@
  Transpose[{fitFn, valsInt, lamIntervals, titles}] // TableForm
```

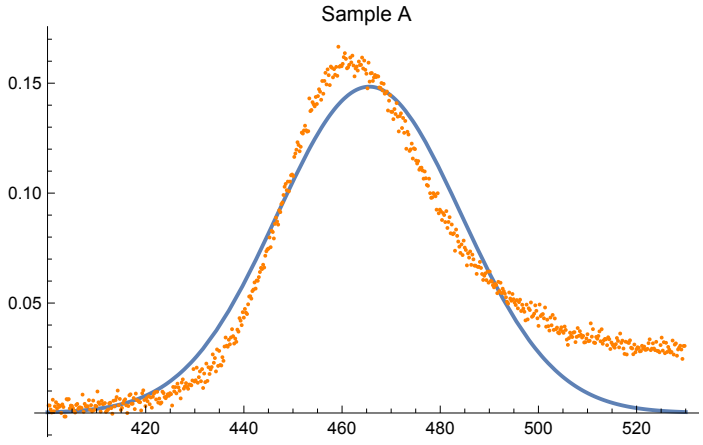
General : Exp[−828.781] is too small to represent as a normalized machine number; precision may be lost.

General : Exp[−2613.35] is too small to represent as a normalized machine number; precision may be lost.

General : Exp[−750.007] is too small to represent as a normalized machine number; precision may be lost.

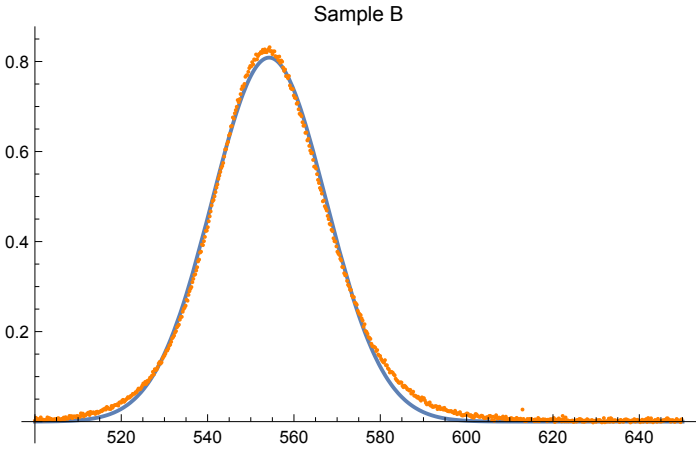
General : Further output of General::munfl will be suppressed during this calculation.

Out[393]//TableForm=



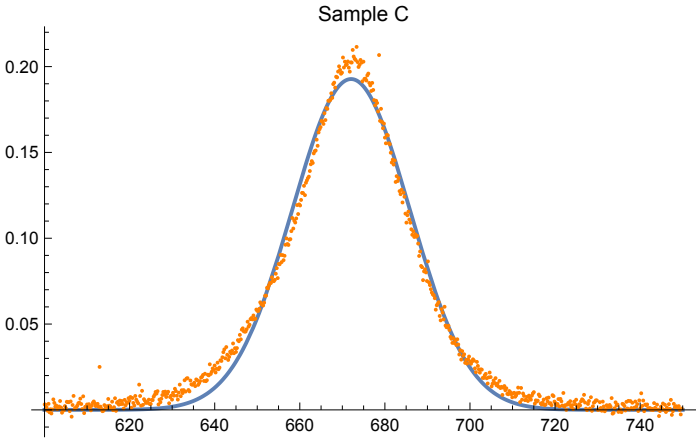
	DF	SS	MS
Model	3	3.33954	1.11318
Error	588	0.142996	0.00024319
Uncorrected Total	591	3.48254	
Corrected Total	590	1.47775	

	Estimate	Standard Error	t-Statistic	P-Value
A	0.148411	0.00155118	95.6765	0.
μ	465.551	0.226788	2052.8	0.
σ	18.7921	0.226815	82.8519	0.



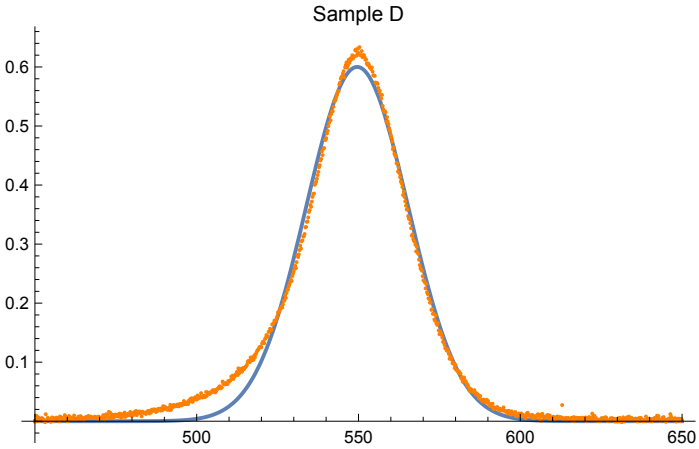
	DF	SS	MS
Model	3	68.4555	22 .8185
Error	664	0.122707	0.000184799
Uncorrected Total	667	68.5782	
Corrected Total	666	45.7676	

	Estimate	Standard Error	t-Statistic	P-	Value
A	0.808636	0.00162721	496.945	0.	
μ	554.26	0.0307381	18 031.7	0.	
σ	13.2287	0.0307377	430.374	0.	



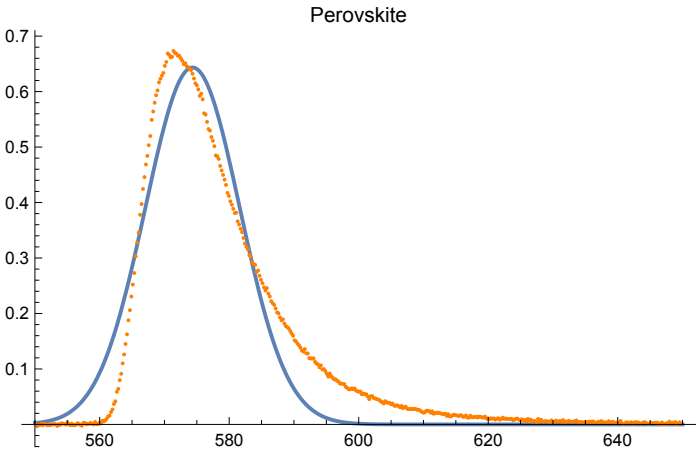
	DF	SS	MS
Model	3	3.95992	1.31997
Error	651	0.0298337	0.0000458
Uncorrected Total	654	3.98976	
Corrected Total	653	2.54211	

	Estimate	Standard Error	t-Statistic	P-	Value
A	0.192741	0.000803042	240.013	0.	
μ	672.052	0.0663241	10 132.9	0.	
σ	13.786	0.0663233	207.861	0.	



	DF	SS	MS
Model	3	44.8615	14.9538
Error	891	0.282091	0.0003166
Uncorrected Total	894	45.1436	
Corrected Total	893	30.961	

	Estimate	Standard Error	t-Statistic	P-	Value
A	0.600014	0.00195221	307.352	0.	
μ	549.599	0.0590979	9299.8	0.	
σ	15.7305	0.0590969	266.181	0.	



	DF	SS	MS
Model	3	23.804	7.93468
Error	439	1.16107	0.0026448
Uncorrected Total	442	24.9651	
Corrected Total	441	17.4937	

	Estimate	Standard Error	t-Statistic	P-	Value
A	0.643393	0.00830639	77.4576	3.85314	
μ	574.345	0.10877	5280.35	0.	
σ	7.29657	0.108786	67.0728	7.79074	

UV dataset for the samples A, B, C, D

In[394]:=
```
titles = {"Sample A", "Sample B", "Sample C", "Sample D"};
data =
  Dataset[Import[ToString@StringForm["/Users/giovannigravili/Library/Mobile
            Documents/com~apple~CloudDocs/LM
            MANO/Notebooks/NP/esperimento/uvNewCorrect/sample``.txt",
          #], "Table", "HeaderLines" → 0, "FieldSeparators" → "\t",
        "NumberPoint" → ".", CharacterEncoding → "UTF8"]][All, Range[1, 2]][
    All, <|"λ (nm)" → 1, "I" → 2|>] & /@ {"A", "B", "C", "D"};
```

In[396]:=
```
data = Transpose[{#[All, "λ (nm)"], #[All, "I"]} // Normal] & /@ data;
```

In[397]:=
```
lamPk = FindPeaks[#, 50, Automatic, 0.05] & /@
    (TimeSeriesResample@TimeSeries[#2, {#1}] &@@@
      (Transpose[#] & /@ data)) // Normal;
```

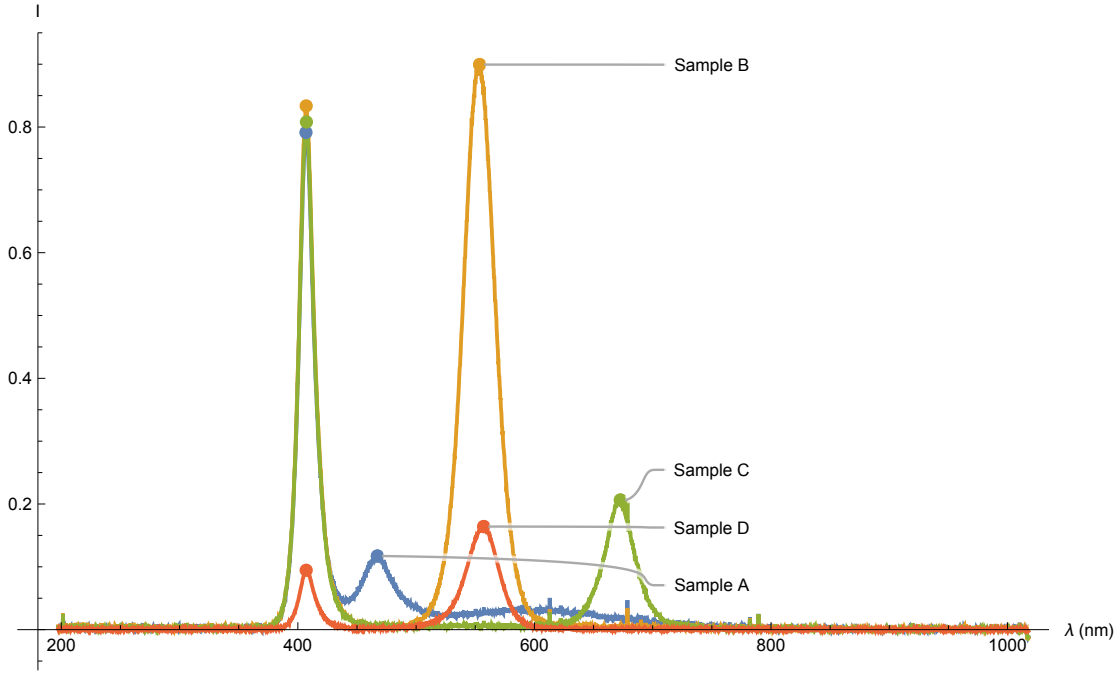
In[398]:=
```
Rule @@@ Transpose[{titles, Column@Flatten@Take[#, All, 1] & /@ lamPk}] //
  Association // Dataset
```

Out[398]=

Sample A	406.842 467.259
Sample B	407.046 553.686
Sample C	407.251 672.677
Sample D	407.046 557.167

In[399]:=
```
ListLinePlot[data, PlotRange → All, AxesLabel → {"λ (nm)", "I"}] // Show[#,
   ListPlot[lamPk, PlotLabels → titles], ImageSize → Large, PlotRange → All] &
```

Out[399]=



In[400]:=
```
lamIntervals = {{440, 500}, {480, 650}, {600, 750}, {500, 650}};
valsInt =
  Cases[#1, {x_, y_} /; #2[[1]] ≤ x ≤ #2[[2]] & @@@ Transpose[{data, lamIntervals}];
```

In[402]:=
```
fitFn = NonlinearModelFit[#1, A e^-((λ-μ)^2/(2 σ^2)), {A, {μ, #2}, σ}, λ] & @@@
  Transpose[{valsInt, {467.25, 553.68, 672.47, 557.4}}]
```

Out[402]=

$$\left\{\text{FittedModel}\left[0.106529\ e^{-0.00153351\ (-\ll 19\gg+\lambda)^2}\right],\ \text{FittedModel}\left[0.875347\ e^{-0.00256873\ (-\ll 18\gg+\lambda)^2}\right],\right.$$
$$\left.\text{FittedModel}\left[0.191232\ e^{-0.00237737\ (-\ll 18\gg+\lambda)^2}\right],\ \text{FittedModel}\left[0.157592\ e^{-0.00236518\ (-\ll 18\gg+\lambda)^2}\right]\right\}$$

In[403]:=
```
{Show[Plot[#1[λ], {λ, #3[[1]], #3[[2]]}, ImageSize → Medium, PlotLabel → #4],
     ListPlot[#2, PlotStyle → {Orange, PointSize[Small]}], PlotRange → All],
   Column[{#1["ANOVATable"], "", #1["ParameterTable"]}]} & @@@
  Transpose[{fitFn, valsInt, lamIntervals, titles}] // TableForm
```

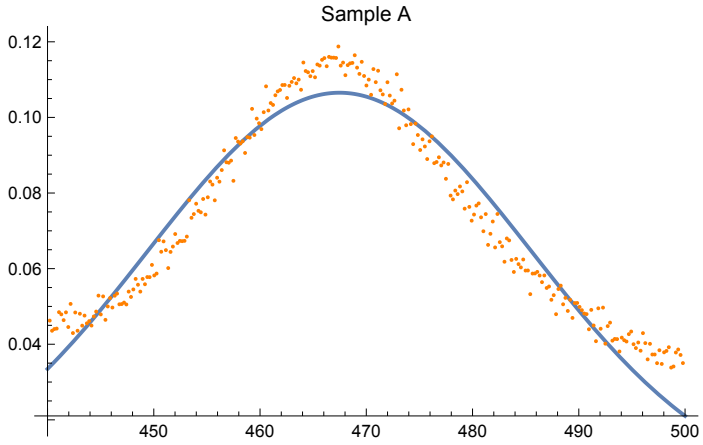
General : Exp[−1422.88] is too small to represent as a normalized machine number; precision may be lost.

General : Exp[−2189.75] is too small to represent as a normalized machine number; precision may be lost.

General : Exp[−4855.1] is too small to represent as a normalized machine number; precision may be lost.

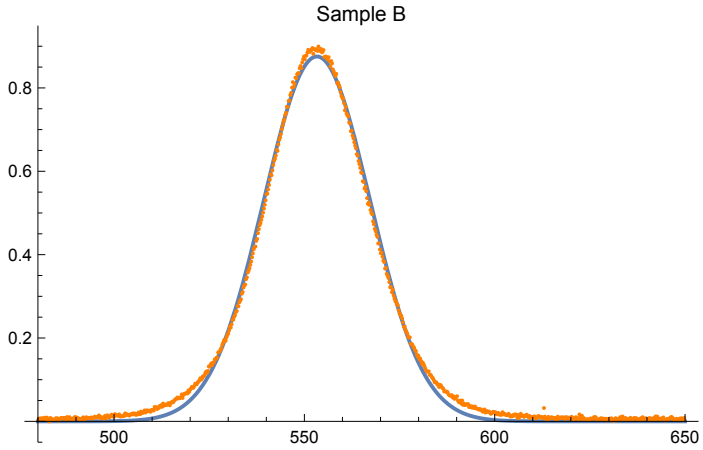
General : Further output of General::munfl will be suppressed during this calculation.

Out[403]//TableForm=



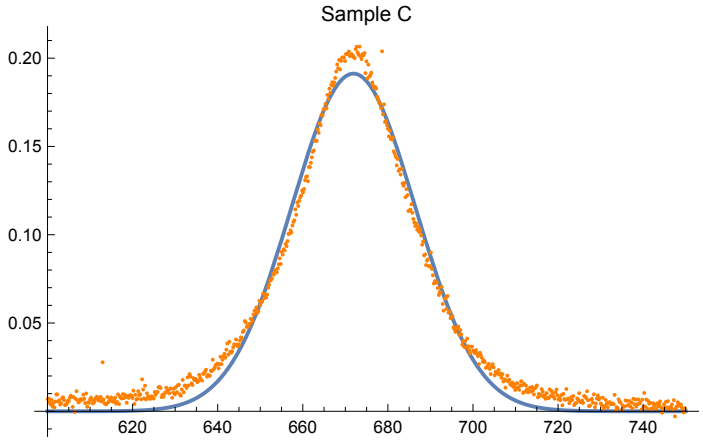
	DF	SS	MS
Model	3	1.61686	0.538954
Error	269	0.0121337	0.00004510
Uncorrected Total	272	1.629	
Corrected Total	271	0.182624	

	Estimate	Standard Error	t-Statistic	P-	Value
A	0.106529	0.000721465	147.656	1.7627	
μ	467.477	0.145401	3215.09	0.	
σ	18.0569	0.176268	102.44	1.5823	



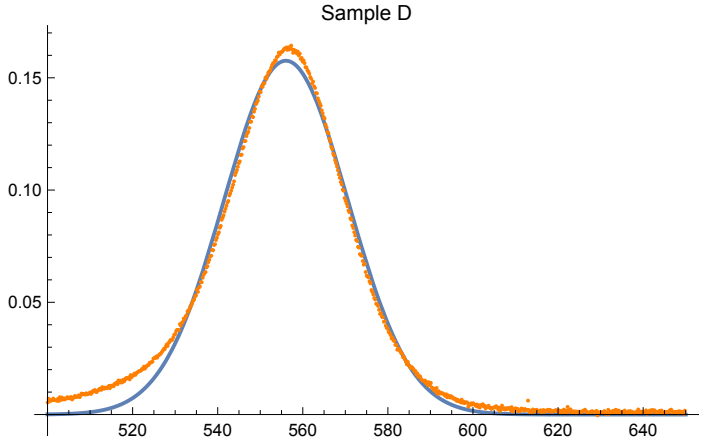
	DF	SS	MS
Model	3	84.6172	28.2057
Error	754	0.171484	0.000227432
Uncorrected Total	757	84.7887	
Corrected Total	756	57.893	

	Estimate	Standard Error	t-Statistic	P-	Value
A	0.875347	0.00175761	498.033	0.	
μ	553.295	0.0323471	17104.9	0.	
σ	13.9517	0.0323466	431.317	0.	



	DF	SS	MS
Model	3	4.10082	1.36694
Error	651	0.039738	0.00006104
Uncorrected Total	654	4.14056	
Corrected Total	653	2.48463	

	Estimate	Standard Error	t-Statistic	P-	Value
A	0.191232	0.000903615	211.63	0.	
μ	671.905	0.0791273	8491.44	0.	
σ	14.5023	0.0791263	183.28	0.	



	DF	SS	MS
Model	3	2.85658	0.952194
Error	664	0.0145978	0.0000219
Uncorrected Total	667	2.87118	
Corrected Total	666	1.77811	

	Estimate	Standard Error	t-Statistic	P-	Value
A	0.157592	0.000535448	294.318	0.	
μ	556.035	0.057043	9747.66	0.	
σ	14.5396	0.0570424	254.891	0.	

In[404]:=

```
selVal = Cases[First@data, {x_, y_} /; 300 ≤ x ≤ 900];
```

In[405]:=

$$\text{fiti} = \text{NonlinearModelFit}\left[\text{selVal}, A_1\, e^{-\frac{(\lambda-\mu_1)^2}{2\sigma_1^2}} + A_2\, e^{-\frac{(\lambda-\mu_2)^2}{2\sigma_2^2}} + A_3\, e^{-\frac{(\lambda-\mu_3)^2}{2\sigma_3^2}},\ \{A_1, \{\mu_1, 406\}, \sigma_1, A_2, \{\mu_2, 467.25\}, \sigma_2, A_3, \{\mu_3, 600\}, \sigma_3\}, \lambda\right];$$

In[406]:=

```
{Show[Plot[fiti[λ], {λ, 300, 900},
    ImageSize → Large, PlotRange → All, PlotLabel → "Sample A"],
   ListPlot[selVal, PlotStyle → {Orange, PointSize[Small]}], PlotRange → All],
  Column[{fiti["ANOVATable"], "", fiti["ParameterTable"]}]} // TableForm
```

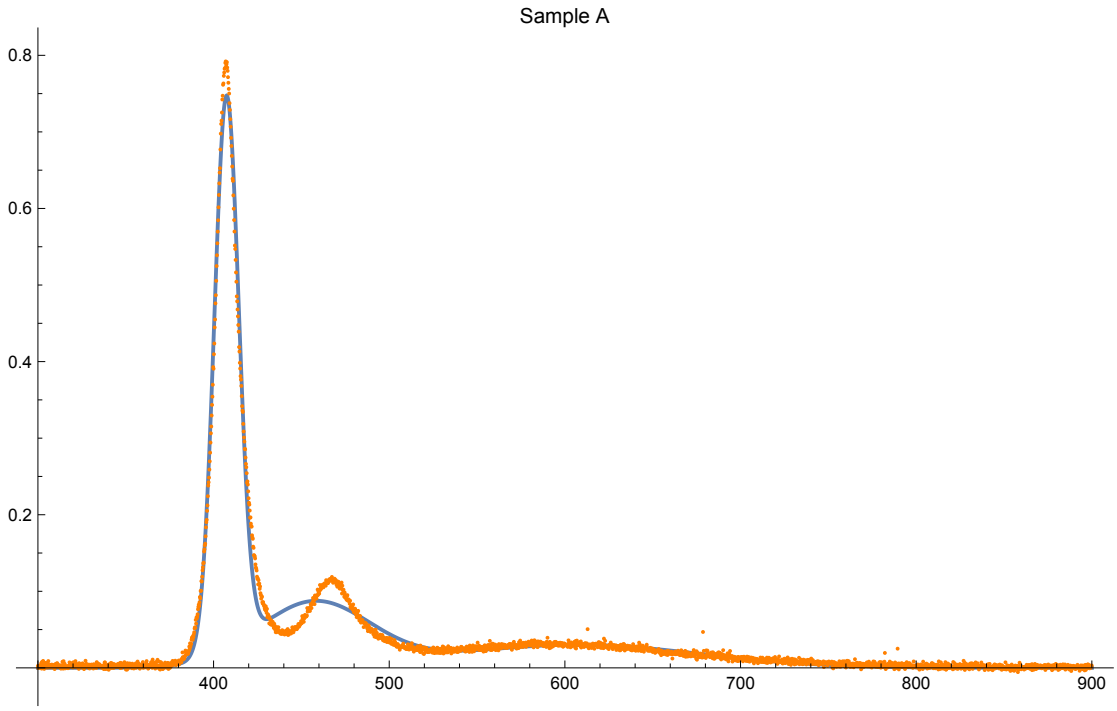
General : 0.721808 2.52765 $\times 10^{-308}$ is too small to represent as a normalized machine number; precision may be lost.

General : Exp[−709.51] is too small to represent as a normalized machine number; precision may be lost.

General : Exp[−710.752] is too small to represent as a normalized machine number; precision may be lost.

General : Further output of General::munfl will be suppressed during this calculation.

Out[406]//TableForm=



	DF	SS	MS
Model	9	35.2949	3.92165
Error	2655	0.31184	0.000117454
Uncorrected Total	2664	35.6067	
Corrected Total	2663	30.6546	

	Estimate	Standard Error	t-Statistic	P-Value	
A_1	0.721808	0.0020422	353.446	0.	
μ_1	407.373	0.0199268	20 443.5	0.	
σ_1	6.95133	0.0245919	282.668	0.	
A_2	0.0842021	0.000954082	88.2545	0.	
μ_2	457.219	0.520148	879.017	0.	
σ_2	32.0018	0.635717	50.3396	0.	
A_3	0.0301523	0.000588465	51.2389	0.	
μ_3	606.328	2.20443	275.05	0.	
σ_3	70.8791	2.38818	29.6792	2.04606	$\times 10^{-167}$

Green, red and UV LEDs spectra

In[407]:=
```
titles = {"Green LED", "Red LED", "UV LED"};
data =
  Dataset[Import[ToString@StringForm["/Users/giovannigravili/Library/Mobile
            Documents/com~apple~CloudDocs/LM
            MANO/Notebooks/NP/esperimento/LEDs/``LedTxt.txt", #],
          "Table", "HeaderLines" → 0, "FieldSeparators" → "\t",
          "NumberPoint" → ".", CharacterEncoding → "UTF8"]][All, Range[1, 2]][
      All, <|"λ (nm)" → 1, "I" → 2|>] & /@ {"green", "red", "uv"};
```

In[409]:=
```
data = Transpose[{#[All, "λ (nm)"], #[All, "I"]} // Normal] & /@ data;
```

In[410]:=
```
lamPk = FindPeaks[#, 100, Automatic, 0.05] & /@
    (TimeSeriesResample@TimeSeries[#2, {#1}] & @@@
      (Transpose[#] & /@ data)) // Normal;
```

In[411]:=
```
Rule @@@ Transpose[{titles, Column@Flatten@Take[#, All, 1] & /@ lamPk}] //
  Association // Dataset
```

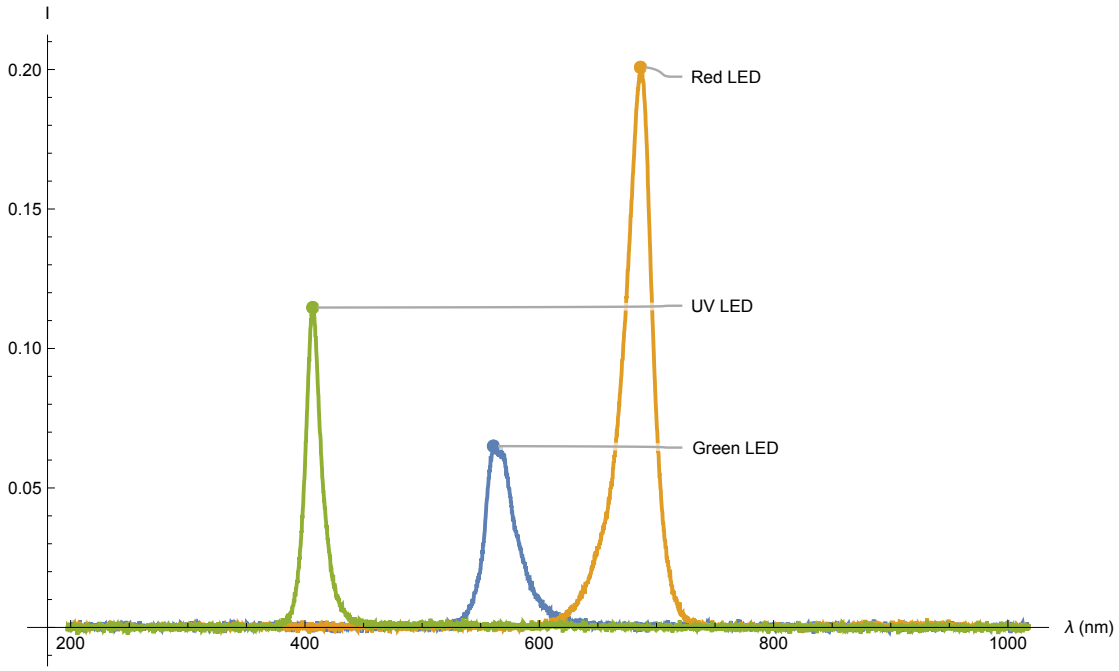
Out[411]=

Green LED	560.854
Red LED	686.398
UV LED	406.637

In[412]:=

```
ListLinePlot[data, PlotRange → All, AxesLabel → {"λ (nm)", "I"}] // Show[#,
   ListPlot[lamPk, PlotLabels → titles], ImageSize → Large, PlotRange → All] &
```

Out[412]=



In[413]:=

```
lamIntervals = {{500, 650}, {580, 800}, {360, 450}};
valsInt =
  Cases[#1, {x_, y_} /; #2[[1]] ≤ x ≤ #2[[2]] & @@@ Transpose[{data, lamIntervals}];
```

In[415]:=

```
fitFn = NonlinearModelFit[{#1, A e^-((λ-μ)^2/(2 σ^2))}, {A, {μ, #2}, σ}, λ] & @@@
  Transpose[{valsInt, {560.9, 686.4, 406.6}}]
```

Out[415]=

$$\left\{\text{FittedModel}\left[0.0623024\ e^{-0.00275522\ (-\ll 18 \gg +\lambda)^2}\right],\ \text{FittedModel}\left[0.183749\ e^{-0.00299913\ (-\ll 18 \gg +\lambda)^2}\right],\ \text{FittedModel}\left[0.10579\ e^{-0.00947149\ (-\ll 18 \gg +\lambda)^2}\right]\right\}$$

In[416]:=

```
{Show[Plot[#1[λ], {λ, #3[[1]], #3[[2]]}, ImageSize → Medium, PlotLabel → #4],
    ListPlot[#2, PlotStyle → {Orange, PointSize[Small]}], PlotRange → All],
   Column[{#1["ANOVATable"], "", #1["ParameterTable"]}]} &@@@
 Transpose[{fitFn, valsInt, lamIntervals, titles}] // TableForm
```

General : Exp[−1155.2] is too small to represent as a normalized machine number; precision may be lost.

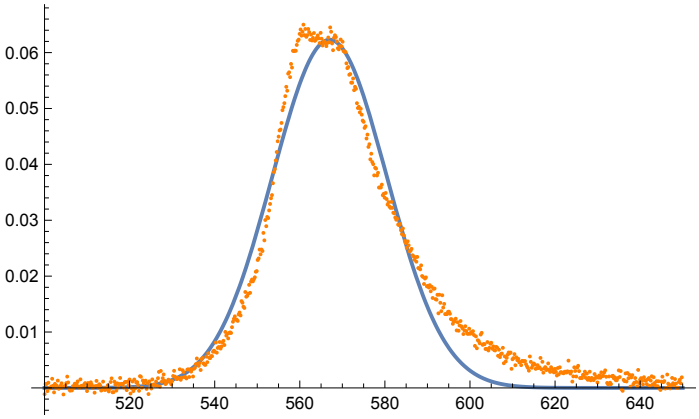
General : Exp[−3532.45] is too small to represent as a normalized machine number; precision may be lost.

General : Exp[−1063.13] is too small to represent as a normalized machine number; precision may be lost.

General : Further output of General::munfl will be suppressed during this calculation.

Out[416]//TableForm=

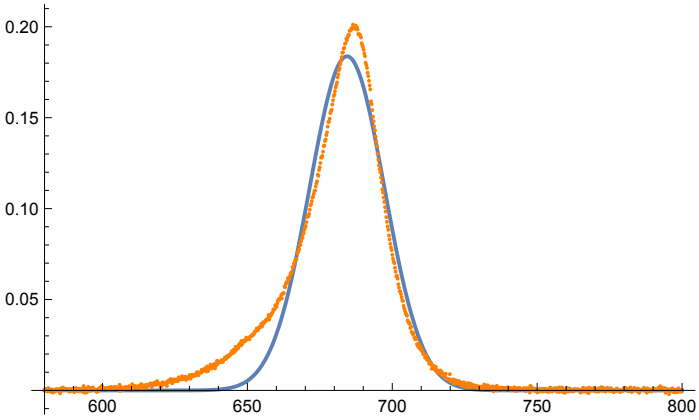
Green LED



	DF	SS	MS
Model	3	0.412719	0.137573
Error	664	0.00884482	0.000013
Uncorrected Total	667	0.421563	
Corrected Total	666	0.26772	

	Estimate	Standard Error	t-Statistic	P-	Valu
A	0.0623024	0.000433495	143.721	0.	
μ	567.	0.108231	5238.78	0.	
σ	13.4712	0.10823	124.469	0.	

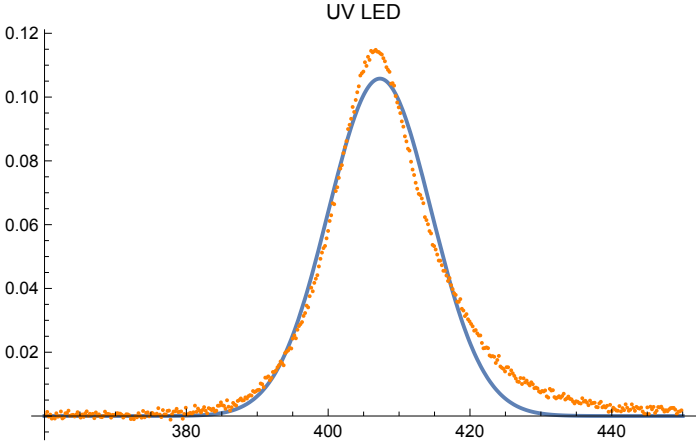
Red LED



	DF	SS	MS
Model	3	3.36313	1.12104
Error	954	0.0776968	0.0000814
Uncorrected Total	957	3.44083	
Corrected Total	956	2.59732	

	Estimate	Standard Error	t-Statistic	P-	Value
A	0.183749	0.00110745	165.92	0.	
μ	684.39	0.0898578	7616.37	0.	
σ	12.9118	0.0898569	143.693	0.	

UV LED



	DF	SS	MS
Model	3	0.665053	0.221684
Error	412	0.00903571	0.0000219
Uncorrected Total	415	0.674089	
Corrected Total	414	0.451651	

	Estimate	Standard Error	t-Statistic	P-Value
A	0.10579	0.000744038	142.184	0.
μ	407.296	0.0590058	6902.65	0.
σ	7.26567	0.0590055	123.136	0.

Calculation of the concentration

In[496]:=
```
λ = UnitConvert[672.84 nm , "SIBase"]
```
Out[496]=
6.7284×10^{-7} m

In[497]:=
```
c = c // UnitConvert[#, "SIBase"] & // N
```
Out[497]=
2.99792×10^{8} m/s

In[498]:=
```
ν = UnitConvert[c / λ, "SIBase"]
```
Out[498]=
4.45563×10^{14} per second

In[499]:=
```
m0 = UnitConvert[ electron PARTICLE [ mass ], "SIBase"]
```
Out[499]=
$9.109383632 \times 10^{-31}$ kg

In[500]:=
```
meCdS = 0.21 m0
```
Out[500]=
1.91297×10^{-31} kg

In[501]:=
```
meCdSe = 0.13 m0
```
Out[501]=
1.18422×10^{-31} kg

In[502]:=
```
mhCdS = 0.8 m0
mhCdSe = 0.45 m0
```
Out[502]=
7.28751×10^{-31} kg

Out[503]=
4.09922×10^{-31} kg

In[504]:=
```
h = UnitConvert[ h , "SIBase"] // N
```
Out[504]=
6.62607×10^{-34} kg m^2/s

In[505]:=
```
e = UnitConvert[ electron PARTICLE [ electric charge ], "SIBase"] // N
```
Out[505]=
$$-1.60218 \times 10^{-19}\ \text{s A}$$

In[506]:=
```
r = UnitConvert[3 nm , "SIBase"] // N
```
Out[506]=
$$3. \times 10^{-9}\ \text{m}$$

In[507]:=
```
egCdS = UnitConvert[2.45 eV , "SIBase"]
```
Out[507]=
$$3.92533 \times 10^{-19}\ \text{kg m}^2/\text{s}^2$$

In[508]:=
```
egCdSe = UnitConvert[1.74 eV , "SIBase"]
```
Out[508]=
$$2.78779 \times 10^{-19}\ \text{kg m}^2/\text{s}^2$$

In[509]:=
```
b = UnitConvert[0.24 eV , "SIBase"]
```
Out[509]=
$$3.84522 \times 10^{-20}\ \text{kg m}^2/\text{s}^2$$

In[510]:=
```
eq = h ν == (x egCdS + (1 - x) egCdSe - b x (1 - x)) +
     h^2/(8 e r^2) (1/(x meCdS + (1 - x) meCdSe) + 1/(x mhCdS + (1 - x) mhCdSe))
```
Out[510]=
$$2.95233 \times 10^{-19}\ \text{kg m}^2/\text{s}^2 == (1-x)\, x \left(-3.84522 \times 10^{-20}\ \text{kg m}^2/\text{s}^2\right) + \left(-3.806 \times 10^{-32}\ \text{kg}^2\text{m}^2/(\text{s}^3\text{A})\right) \left(\frac{1}{(1-x)\left(1.18422 \times 10^{-31}\ \text{kg}\right) + x\left(1.91297 \times 10^{-31}\ \text{kg}\right)} + \frac{1}{(1-x)\left(4.09922 \times 10^{-31}\ \text{kg}\right) + x\left(7.28751 \times 10^{-31}\ \text{kg}\right)}\right) + (1-x)\left(2.78779 \times 10^{-19}\ \text{kg m}^2/\text{s}^2\right) + x\left(3.92533 \times 10^{-19}\ \text{kg m}^2/\text{s}^2\right)$$

In[511]:=
```
eqn = eq /. Quantity[a_, b_] :> QuantityMagnitude[Quantity[a, b]] // Simplify;
```

In[512]:=
```
NSolve[eqn, x, Reals, WorkingPrecision → 10]
```
Out[512]=
$$\{\{x \to -1.348837209\}, \{x \to 2.555383712 \times 10^{6}\}\}$$

Calculations debugging

In[513]:=
```
h ν
```
Out[513]=
$$2.95233 \times 10^{-19}\ \mathrm{kg\,m^2/s^2}$$

In[514]:=
```
(x egCdS + (1 - x) egCdSe - b x (1 - x)) /. {x → 0.9}
```
Out[514]=
$$3.77697 \times 10^{-19}\ \mathrm{kg\,m^2/s^2}$$

In[515]:=
```
h^2 / (8 e r^2)
```
Out[515]=
$$-3.806 \times 10^{-32}\ \mathrm{kg^2 m^2/(s^3 A)}$$

In[516]:=
```
(1 / (x meCdS + (1 - x) meCdSe) + 1 / (x mhCdS + (1 - x) mhCdSe)) /. {x → 0.9}
```
Out[516]=
$$6.86949 \times 10^{30}\ /\mathrm{kg}$$

In[517]:=
```
h^2 / (8 e r^2) (1 / (x meCdS + (1 - x) meCdSe) + 1 / (x mhCdS + (1 - x) mhCdSe)) /. {x → 0.9} //
 ScientificForm
```
Out[517]//ScientificForm=
$$-2.61453 \times 10^{-1}\ \mathrm{kg\,m^2/(s^3 A)}$$

In[518]:=