



# Estimating the Spectral Reflectance of Fluorescent Offset Papers for Varying Illuminants

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- Introduction and motivation
- Basic assumption
- Classification of paper fluorescence
- Development of scalable model spectra
- Estimating the spectral reflectance
- Results and conclusion

- FWAs? – Fluorescent Whitening Agents (FWAs) are added to offset papers to increase paper brightness
  - FWAs absorb UV-radiation between 250 and 400nm and emit radiation within 380 and 480nm
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- **Effect** – Appearance and measurement of fluorescent papers depends on the UV-amount in the source illuminating a fluorescent offset paper
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- **Problem** – Ambiguity and misunderstandings in colour measurements as well as in the visual assessment of colour proofs and production prints

- Sources – for measurement and visual assessment
- Differing UV-characteristics are caused by different sources or special design characteristics
- Discrepancies between measurements, actually perceived colours and D50-colorimetry



LEDs



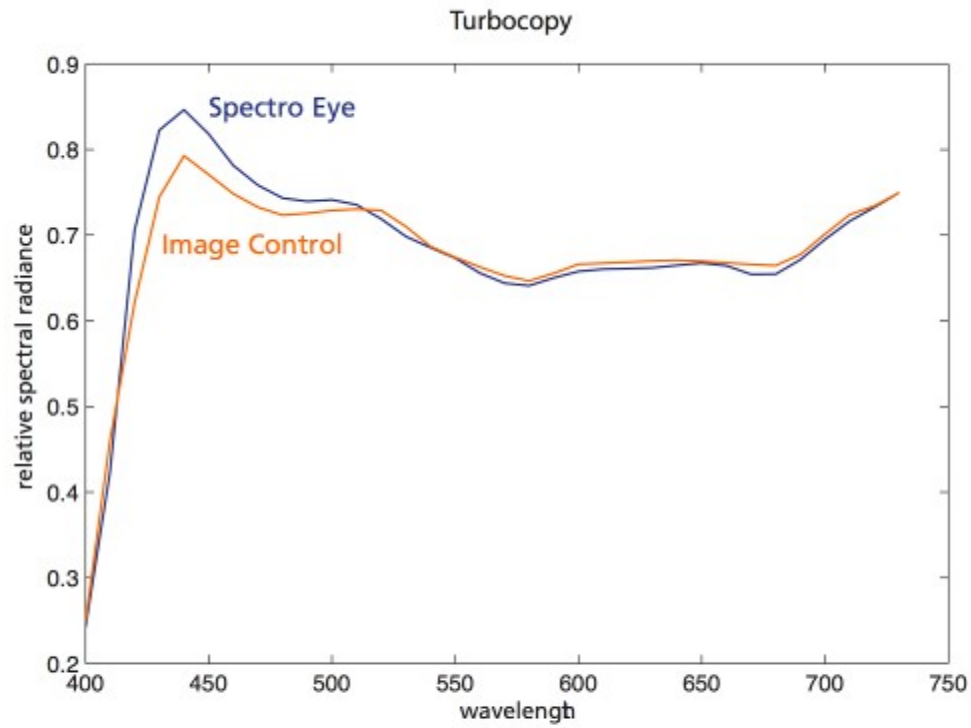
Tungsten sources



Xenon sources

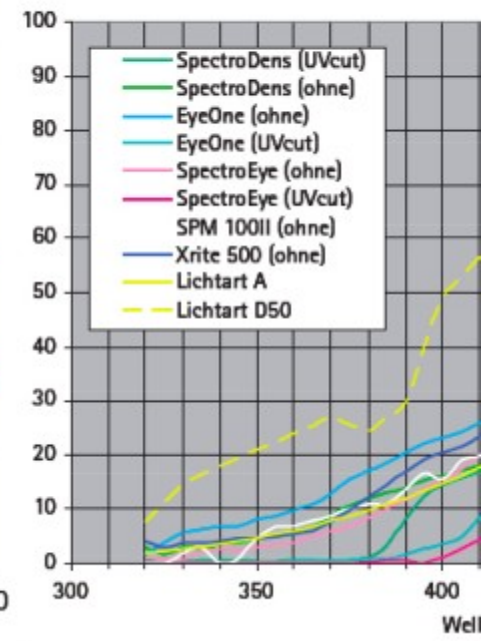
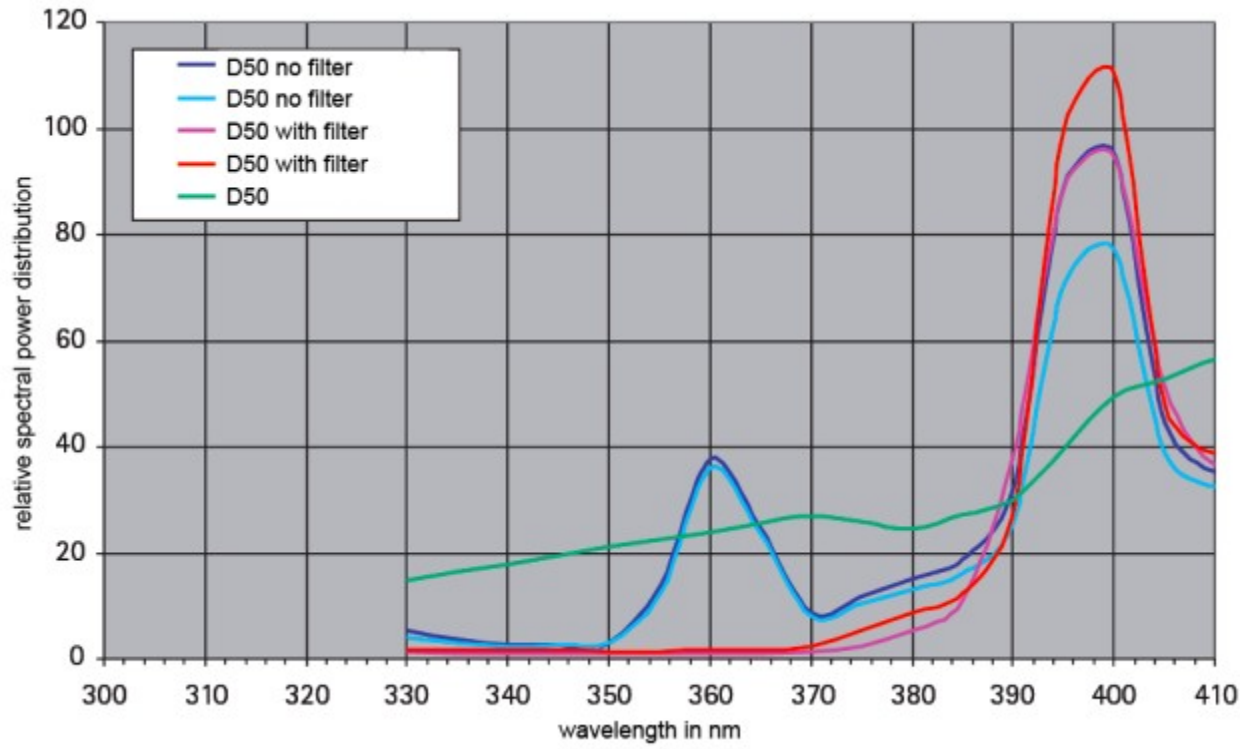


Fluorescent tubes

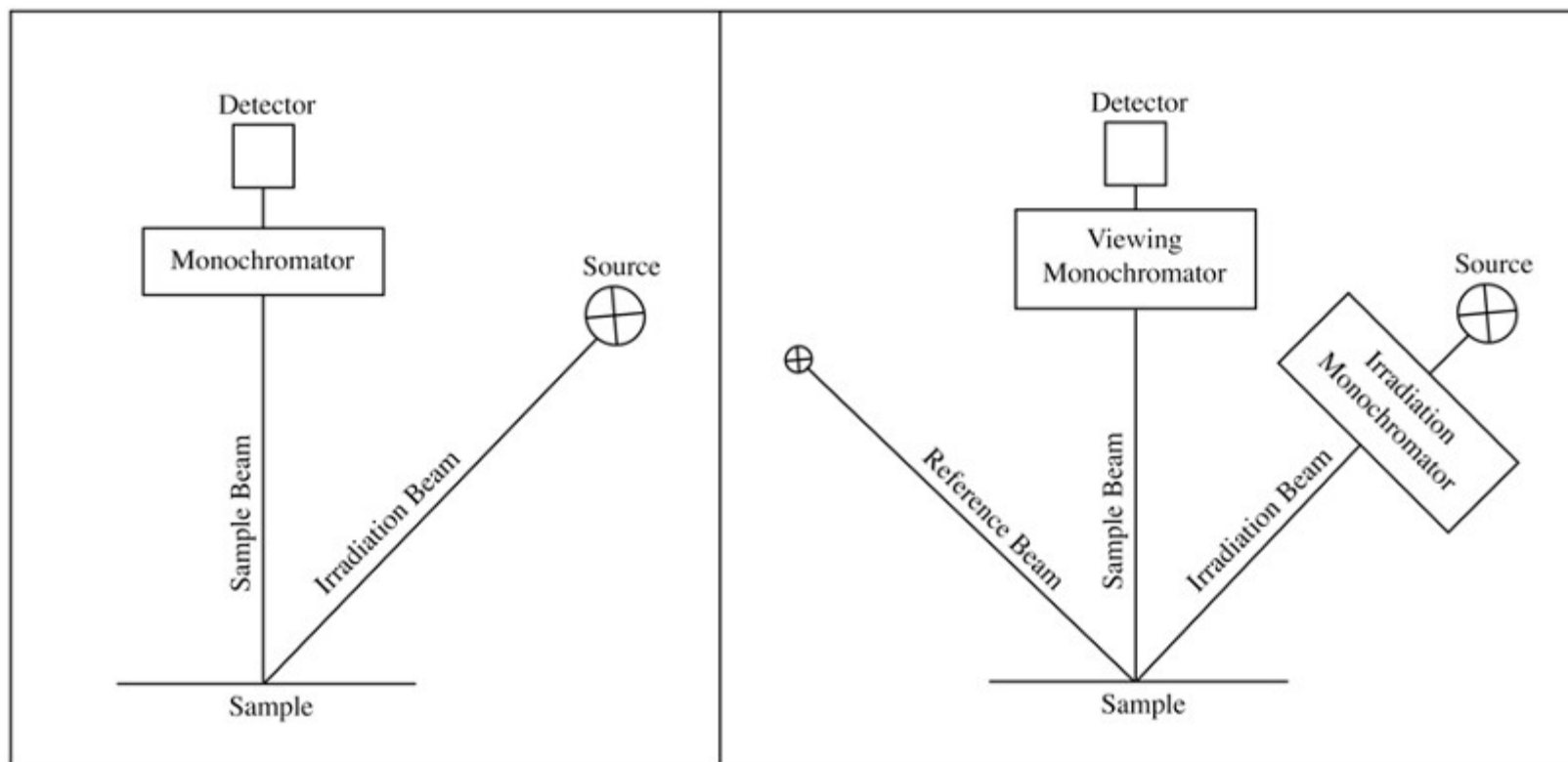


	L*	a*	b*	
Spectro Eye	85,88	-0,34	-8,29	
Image Control	86,07	-1,27	-4,84	Delta E
Delta	-0,19	0,93	-3,45	3,58

- Spectral reflection of a fluorescent offset paper measured with a GretagMacbeth SpectroEye and a Heidelberg ImageControl

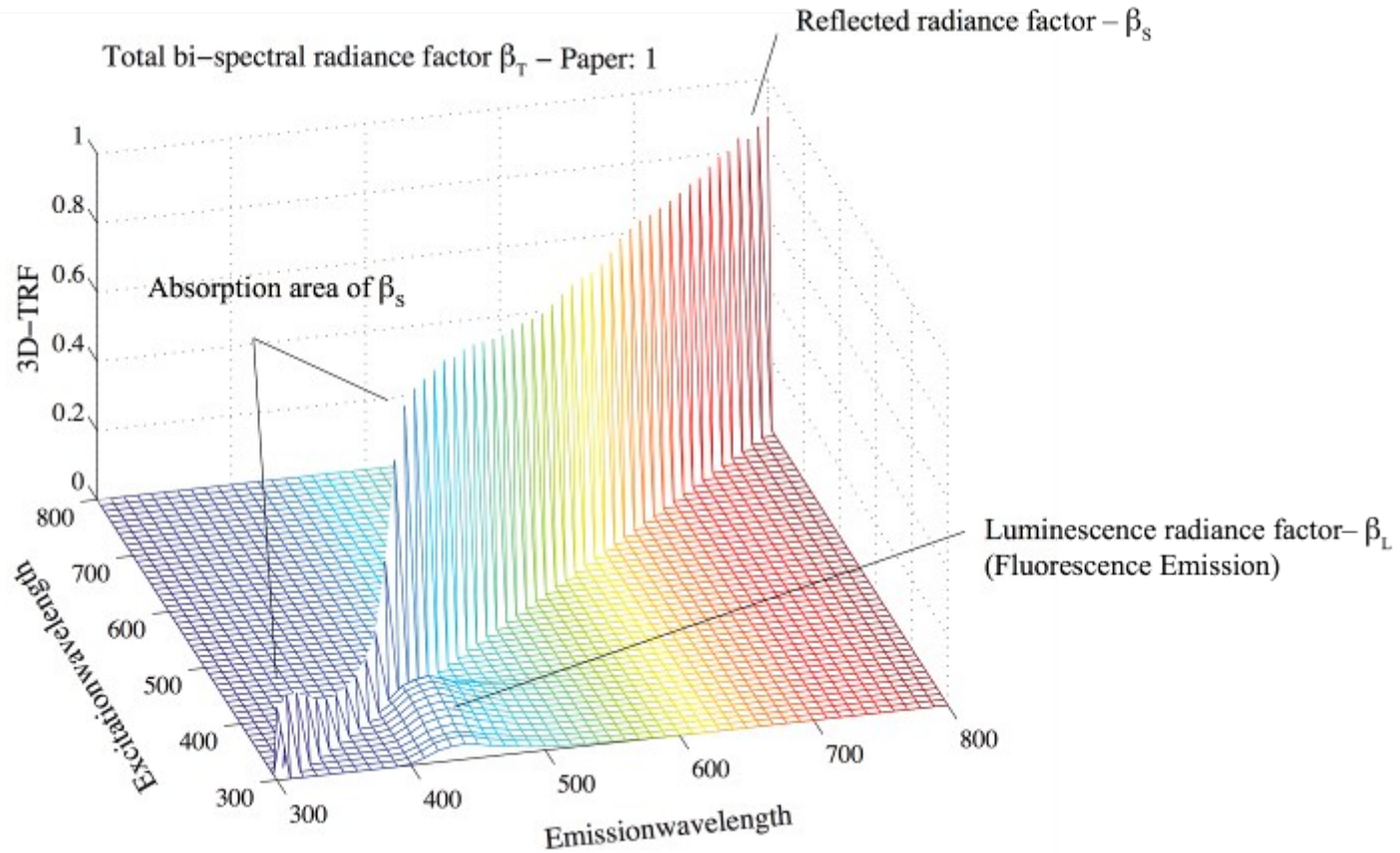


- Relative spectral power distribution of the UV-range of four commercially available viewing booth (left) five common hand held



Single-monochromator setup

Schematic design of the BAM 2MM double monochromator setup



- Total bi-spectral radiance factor – basic fluorescence characteristics are

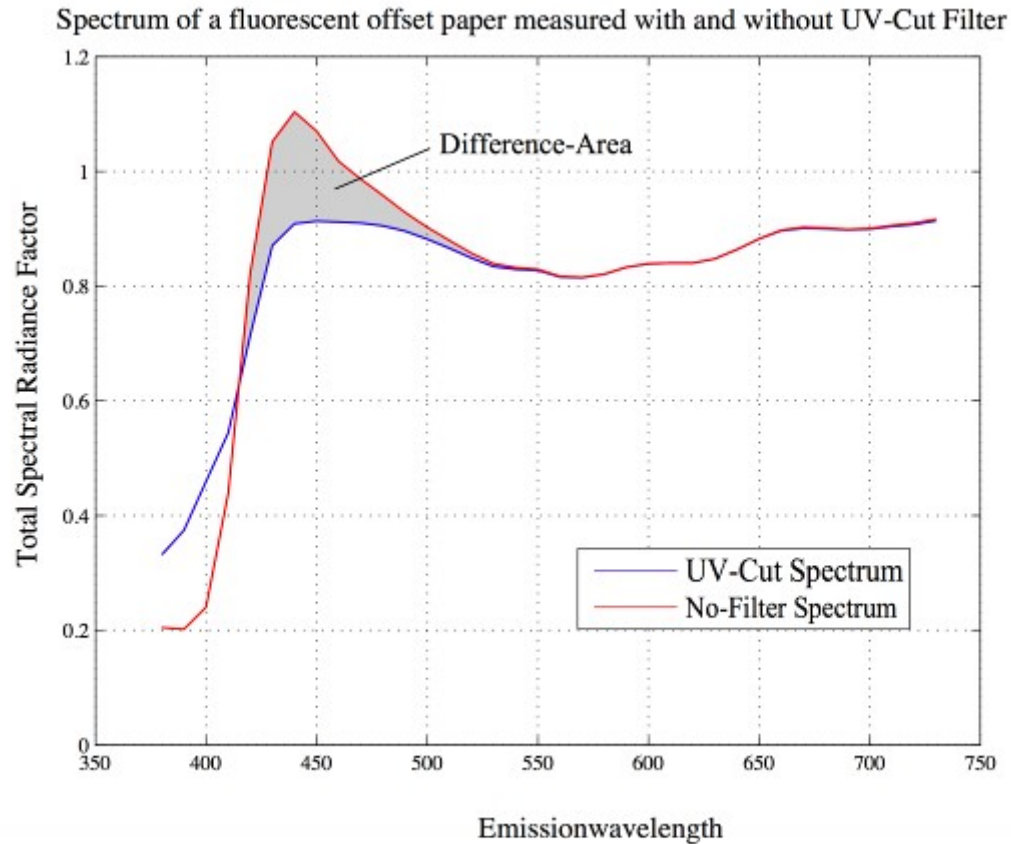


## Assumption

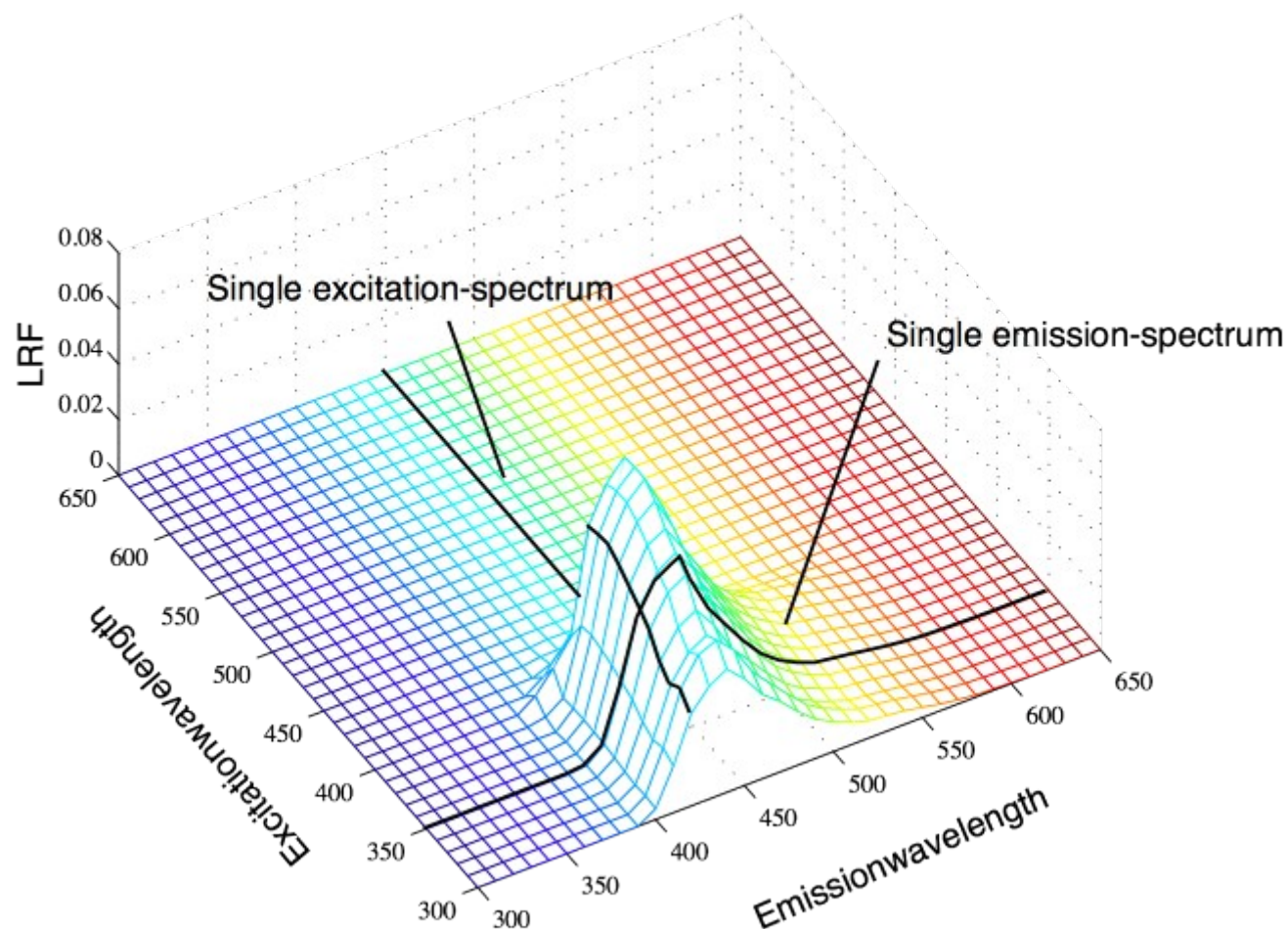
- Similar shapes of fluorescent characteristics – only varying in overall intensity
- Development of scalable model spectra
- Classification of paper fluorescence allows to scale model spectra

## Approach

- Classification of 80 commercially available offset papers
- Selection of 8 offset papers covering the range from lowest to highest degree of fluorescence and conduct bi-spectral measurements
- Calculation of model spectra

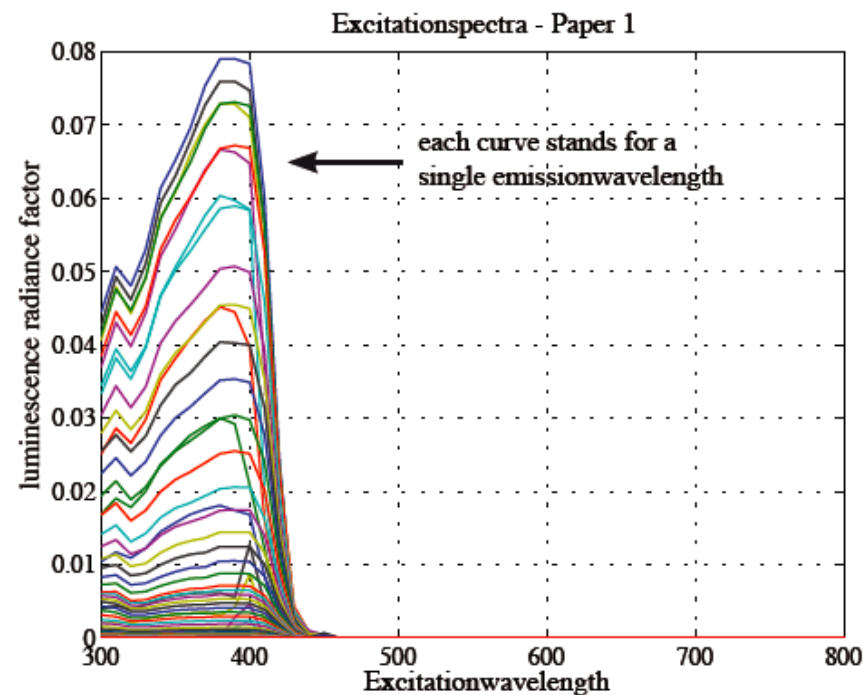
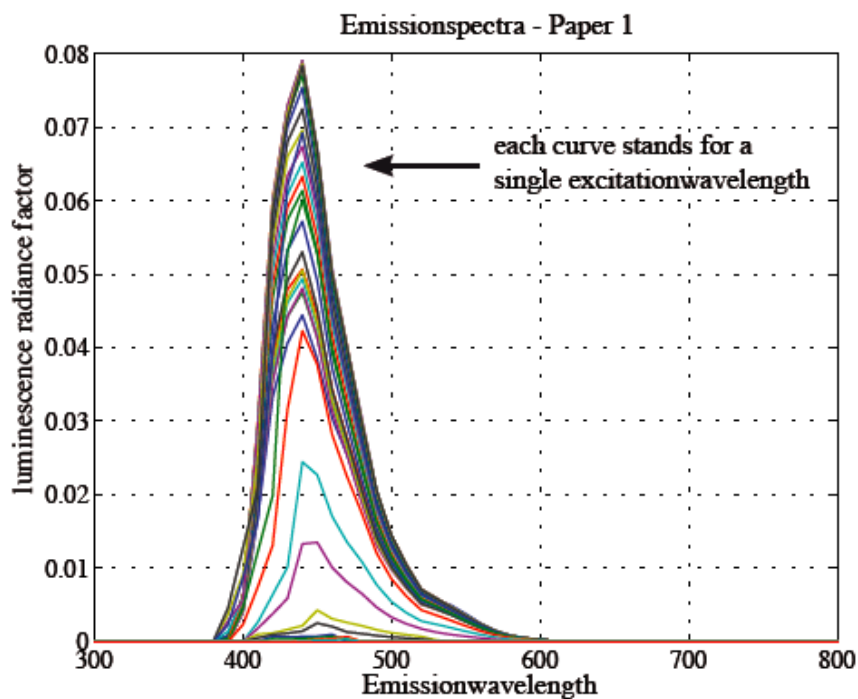


- Fluorescence Identifier – Difference area between UV-Cut- and No-Filter measurement; the larger the difference area the larger the degree of paper fluorescence

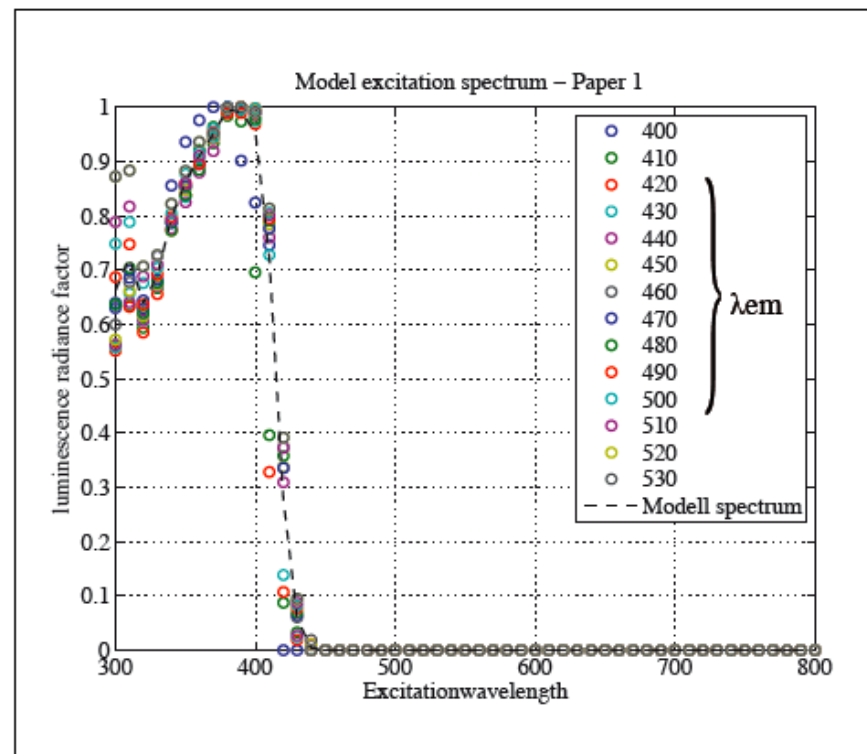
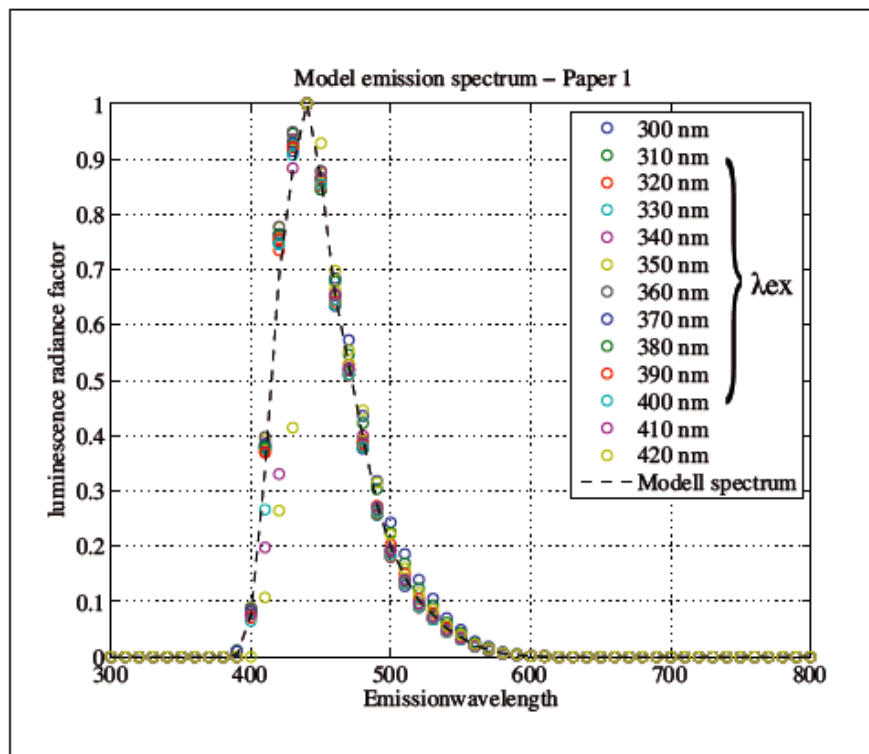


- Analysing the fluorescence emission of all reference offset papers and calculate model spectra – model emission/excitation spectrum and scaling vector

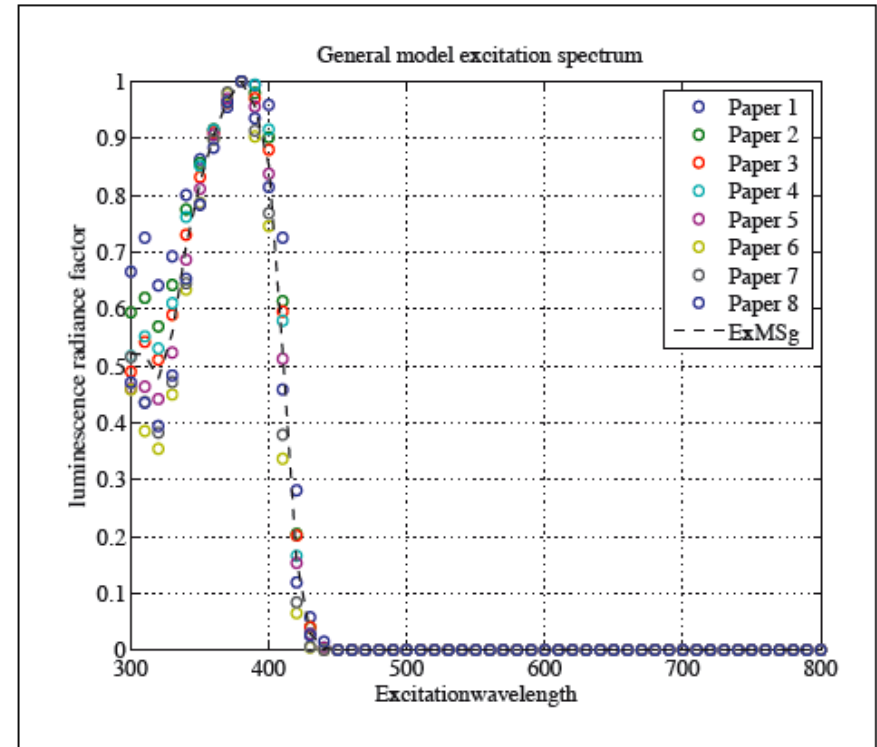
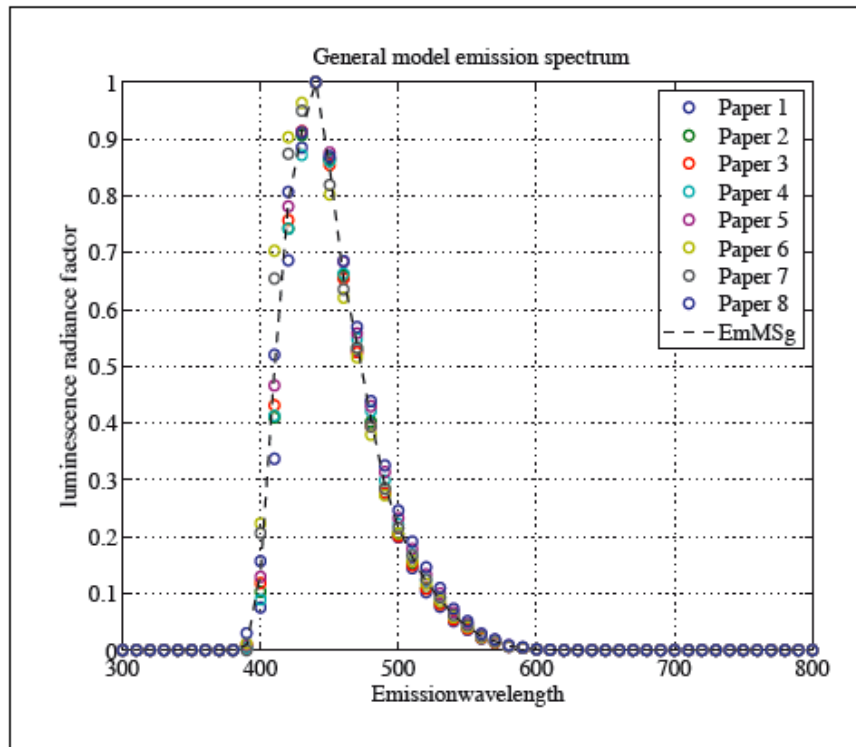
- Step one – Emission and excitation spectra for one offset paper



- Step two – Model emission (EmMS) and model excitation (ExMS) spectrum for one offset paper



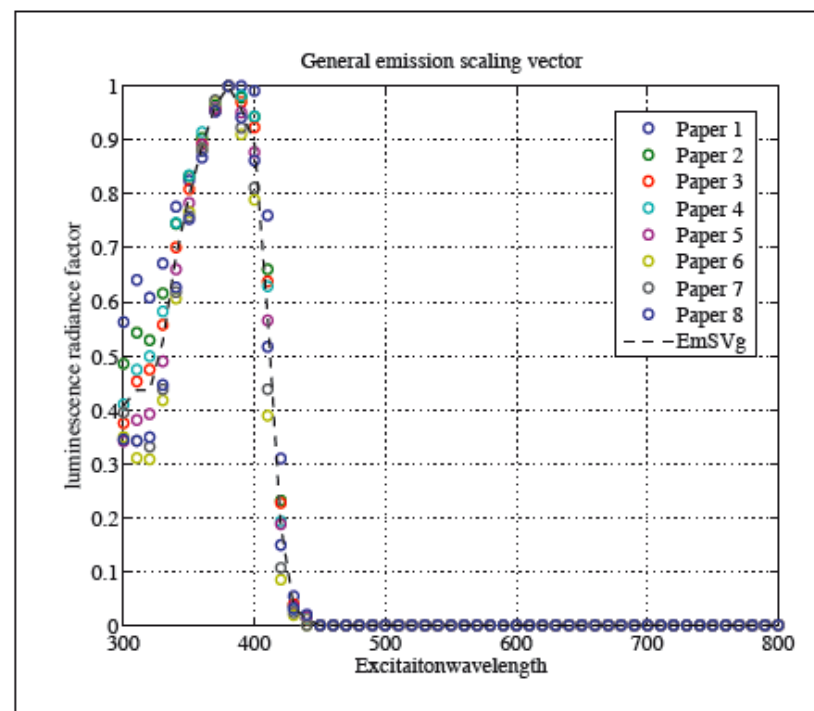
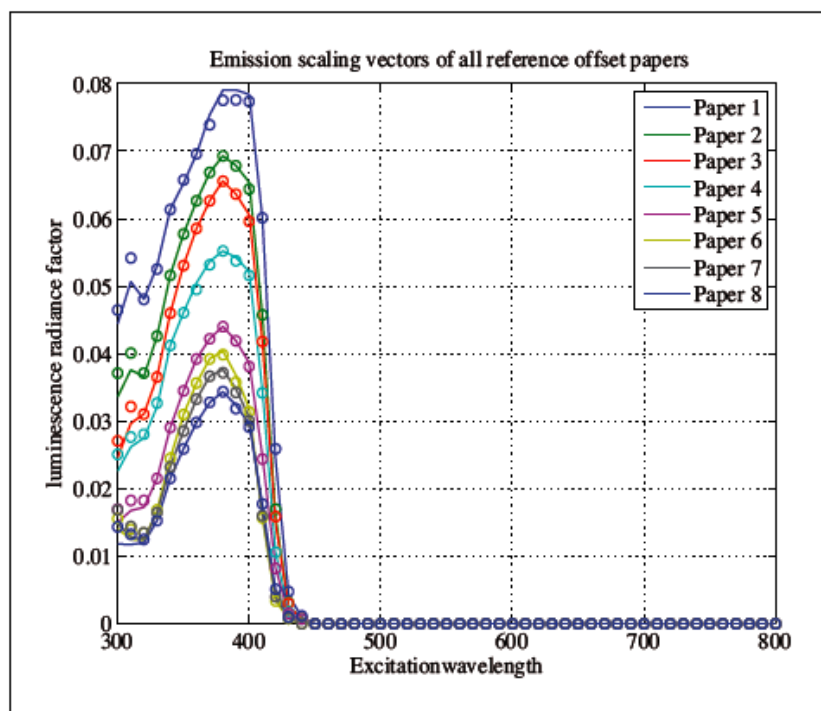
- Step three – General model emission (EmMSg) and general model excitation (ExMSg) spectrum for all selected offset papers



Left: dashed line = General model emission spectrum, o = normalised EmMS for all offset papers

Right: dashed line = General model excitation spectrum, o = normalised ExMS for all offset papers

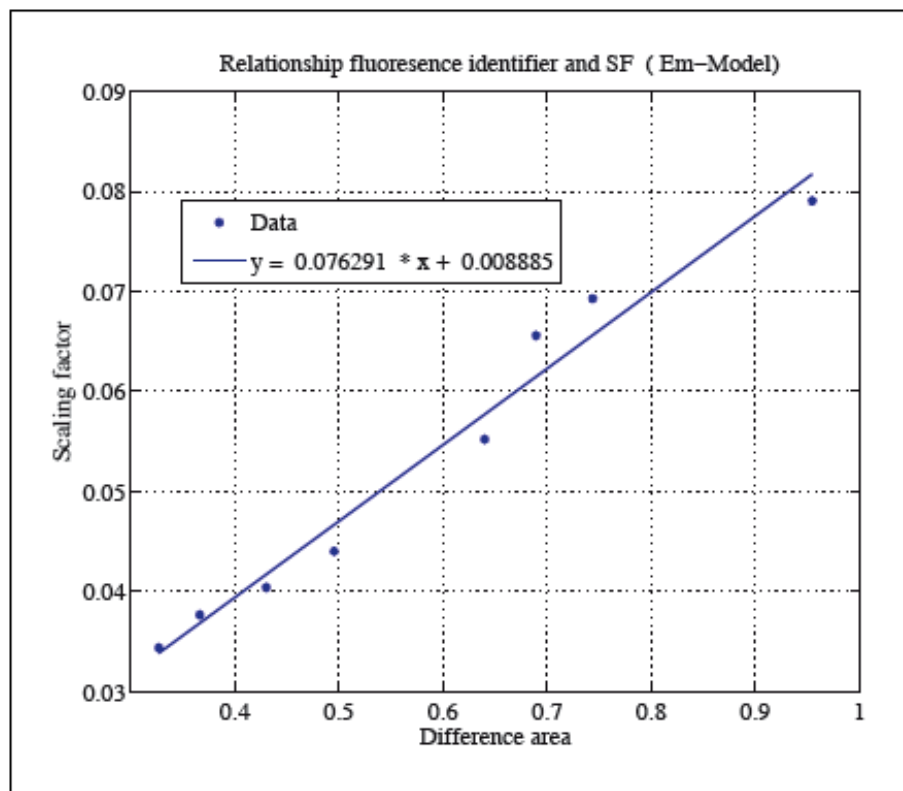
- Step four – Emission scaling vectors (EmSV) of all offset papers and general emission scaling vector (EmSVg)



Left: Emission scaling vector of all offset papers

Right: dashed line = General emission scaling vector, o = normalised EmSV for all offset papers

- Step five – Connecting with the fluorescence identifier – difference area

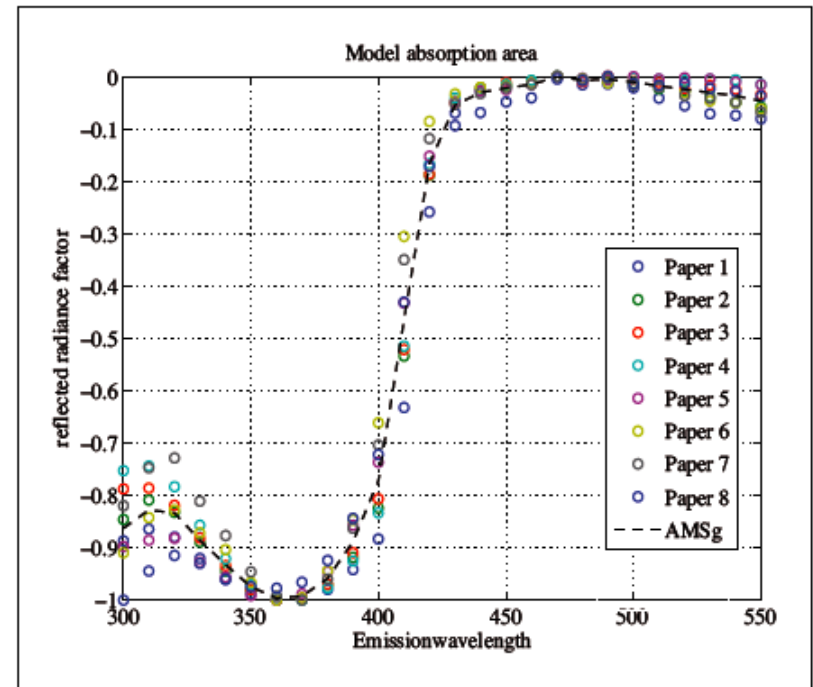
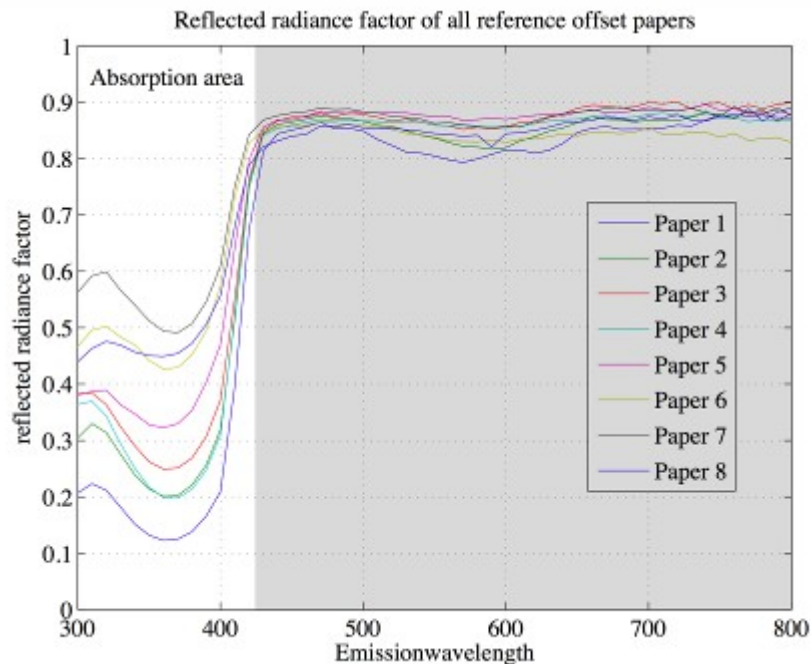


$$SF = x \cdot \text{diffarea} + y$$

- For Pre-Scaling the scaling-vector



- Analysing the absorption area of all reference offset papers and calculate model absorption spectrum (AbMS) representing the general shape of the absorption area



Left: Absorption area of all offset papers

Right: dashed line = Absorption modell spectrum, o = normalised absorption spectra of all offset papers

- Reconstruction of fluorescence emission

$$\begin{bmatrix} \beta_{L(\lambda_{em_i} \lambda_{ex_i})} & \cdots & \beta_{L(\lambda_{em_i} \lambda_{ex_n})} \\ \vdots & \ddots & \vdots \\ \beta_{L(\lambda_{em_i} \lambda_{ex_i})} & \cdots & \beta_{L(\lambda_{em_i} \lambda_{ex_i})} \end{bmatrix} = \begin{bmatrix} \text{EmMSg}_{\lambda_{em_i}} \\ \vdots \\ \text{EmMSg}_{\lambda_{em_i}} \end{bmatrix} \left( \begin{bmatrix} \text{EmSVg}_{\lambda_{ex_n}} \\ \vdots \\ \text{EmSVg}_{\lambda_{ex_n}} \end{bmatrix} \cdot (x \cdot \text{diffarea}) + y \right)^T$$

Emission-Model

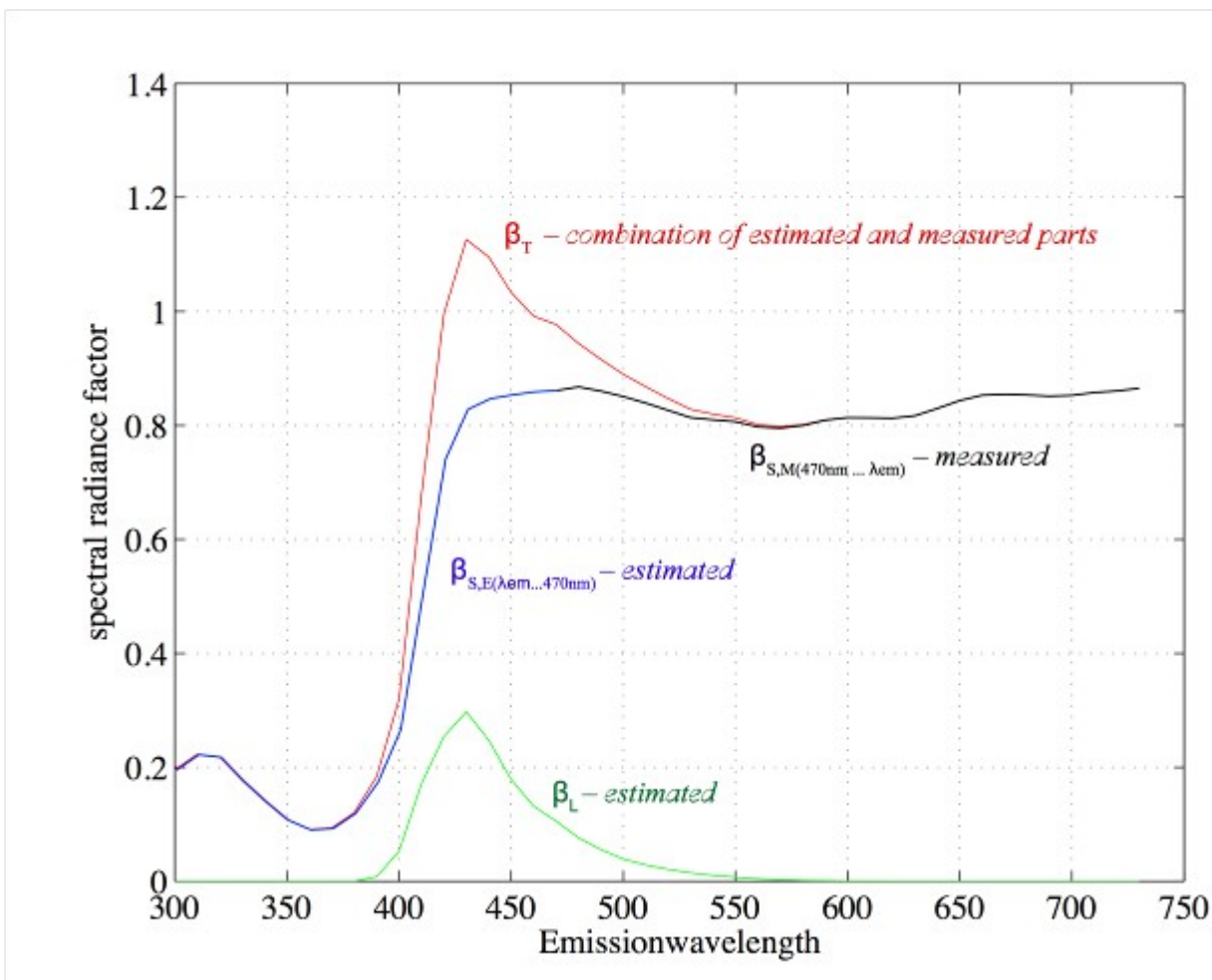
$$\begin{bmatrix} \beta_{L(\lambda_{em_i} \lambda_{ex_i})} & \cdots & \beta_{L(\lambda_{em_i} \lambda_{ex_n})} \\ \vdots & \ddots & \vdots \\ \beta_{L(\lambda_{em_i} \lambda_{ex_i})} & \cdots & \beta_{L(\lambda_{em_i} \lambda_{ex_i})} \end{bmatrix} = \begin{bmatrix} \text{ExMSg}_{\lambda_{ex_n}} \\ \vdots \\ \text{ExMSg}_{\lambda_{ex_n}} \end{bmatrix} \left( \begin{bmatrix} \text{ExSVg}_{\lambda_{em_i}} \\ \vdots \\ \text{ExSVg}_{\lambda_{em_i}} \end{bmatrix} \cdot (x \cdot \text{diffarea}) + y \right)^T$$

Excitation-Model

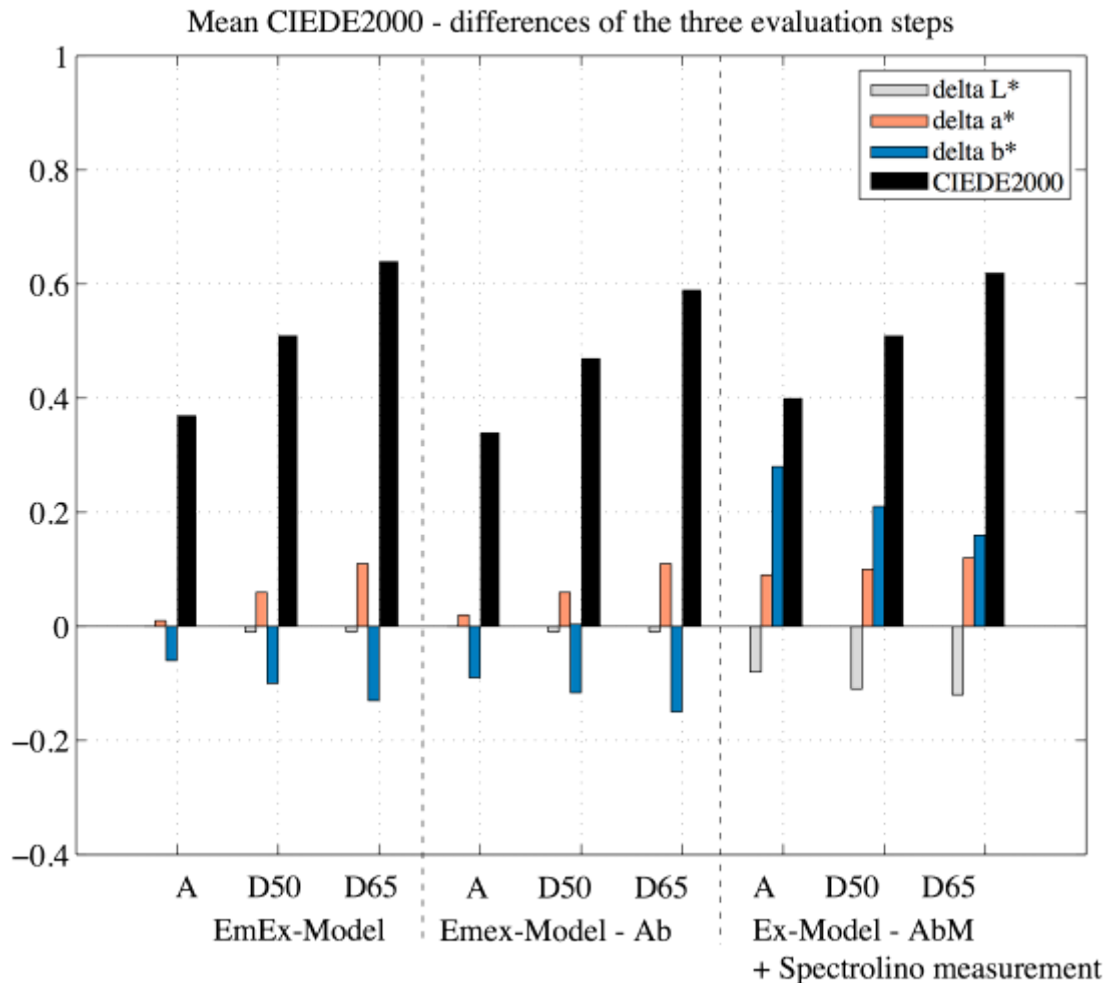
- Reconstruction of absorption area

$$\beta_{S,E(\lambda_{em_n} - 470\text{nm})} = \begin{bmatrix} \text{AbMS}_{em_n} \\ \vdots \\ \text{AbMS}_{470\text{nm}} \end{bmatrix} \cdot ((x \cdot \text{Diffarea}) + y + 1) \cdot \beta_{S,M(470\text{nm})}$$

Absorption-Model



- Estimated spectral reflectance and originally measured parts of  $\beta_T$   
addition of estimated and measured parts



- Evaluation in three steps – 1. Find best fluorescence model – 2. Best fluorescence model plus absorption model – 3. Estimated parts added to Spectrolino-data

## Results

- Model spectra representing the fluorescent characteristics of offset papers
- Classification method to determine the degree of paper fluorescence
- Both allows estimating source-independent fluorescence characteristics

## Notes

- Limited Group of substrates (unprinted)
- Dependency on the spectrophotometer used for the classification

## Nevertheless

- Effect of white point adaption on visual match between differently-fluorescing media
- How behave other substrate groups?

**Thank you for your attention!**