Welcome

DIN Workshop on Image Technology 2005

Stefan Jäger 19.4.05

VOLKSWAGEN AG

Multispectral CIELAB camera for the evaluation of automobile color coatings

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Agenda

- Motivation
- Project Objectives
- Challenges
- System Overview
- Colorimetric and Spectral Accuracy
- Summary and Outlook

Motivation

- **Improve color accuracy and the aesthetic appearance**
  The quality of the surface is a crucial part for the overall quality impression of an industrial product like an automobile

- **Reduce quality costs**
  Quality costs are a notable part of the production expenses. In the production process costs for sorting and rectification arise. Quality problems discovered at the consumer will occur as costs for warrenty and anullment. Additionally the loss of confidence and credability should not be neglected

- **Need for process control with 100% sample size**
  No current color measurement system for the automobile industry offers automated spectral multi-angle color measurement for our needs

Improve surface quality while reducing quality costs

Motivation

Example of mismatching colors

Rear Bumper in „reflex silver“ too light compared to car body

Motivation

Example of mismatching colors (2)

Fuel flap in „reflex silver“ too dark

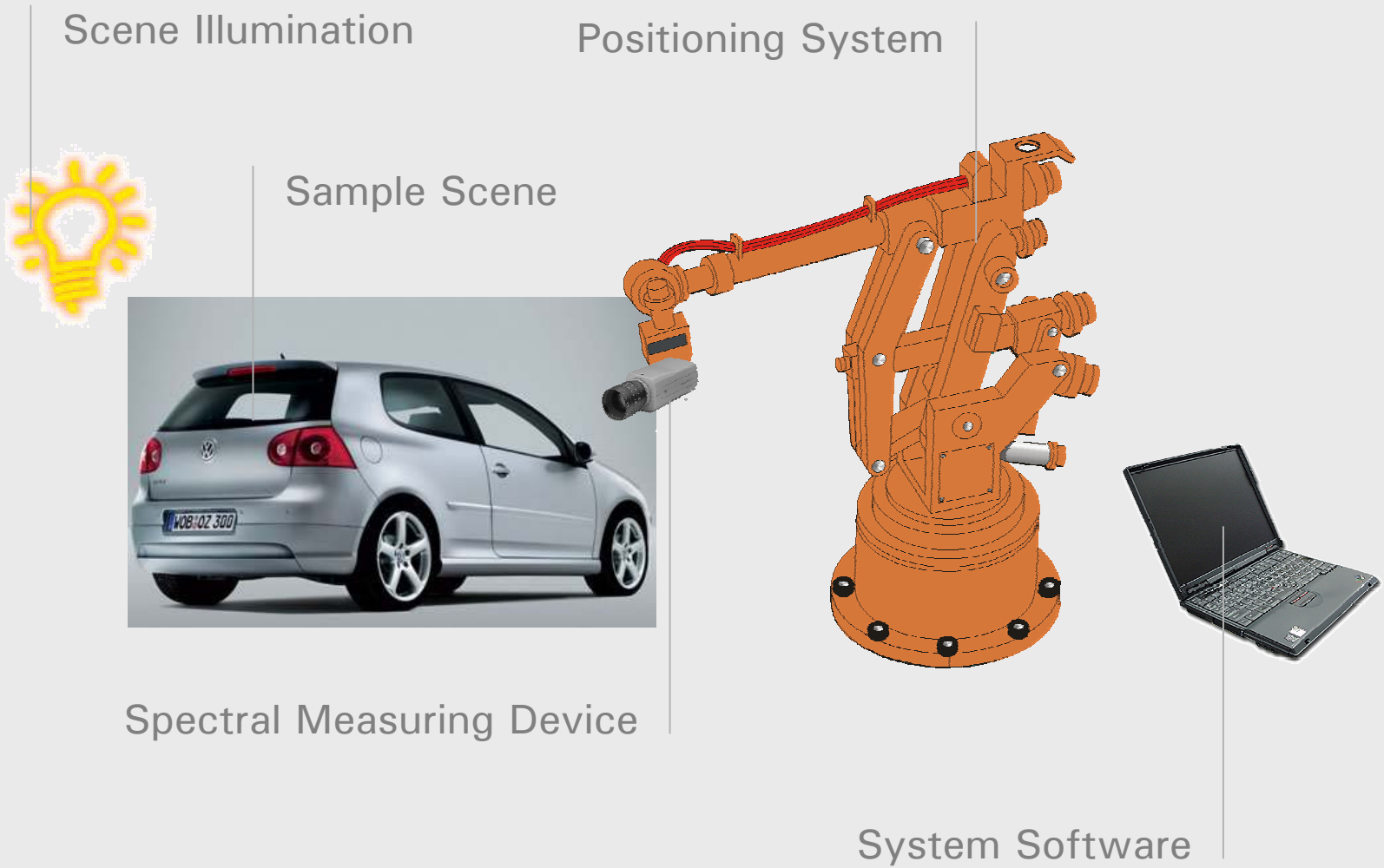
Project Objectives

- **Design of a spectral color measurement system**
  Intended for a process control with a sample size close to 100%
- **Measurement and evaluation of a sample as a whole**
  Realizing a high spacial resolution in comparison to commonly used color measurement equipment in the automobile industry, namely the X-Rite MA68II. Evaluate areas of interest, i.e. connection zone of attachment part and car body
- **Matching attachment parts and car bodies early**
  Decide at an early stage, even before shipping from the supplier to the assembly line, if the parts comply with the specifications of the customer
- **Gaining knowledge and experience**
  Generally in the field of spectral imaging in industrial enviroments. In addition the production process monitored can be understood more thorougly

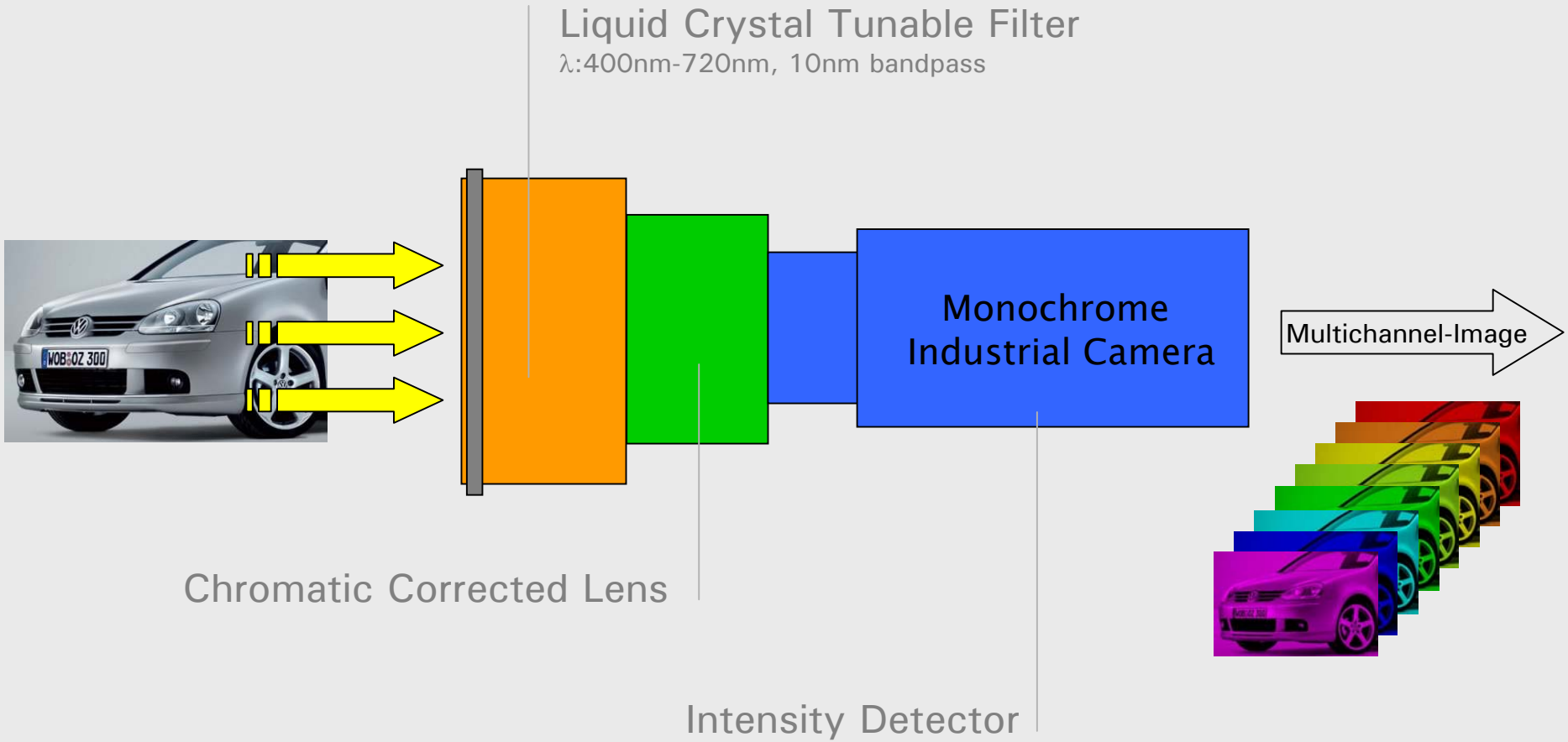
Challenges

- **Samples are not plane surfaces**
  Evaluating curved and bended objects like bumpers and rear-mirror casings
- **Effect colors are observer-illumination angle dependent**
  Metallics and pearls have to be measured with multiple geometries *(15°, 25°, 45°, 75°, 110°)*
- **Constraints of production process must be considered**
  Integration in production line, time constraints for imaging and calculation
- **Reconstruction of spectra is not trivial**
  Algorithms have to be adopted and adapted to the specific needs of the project

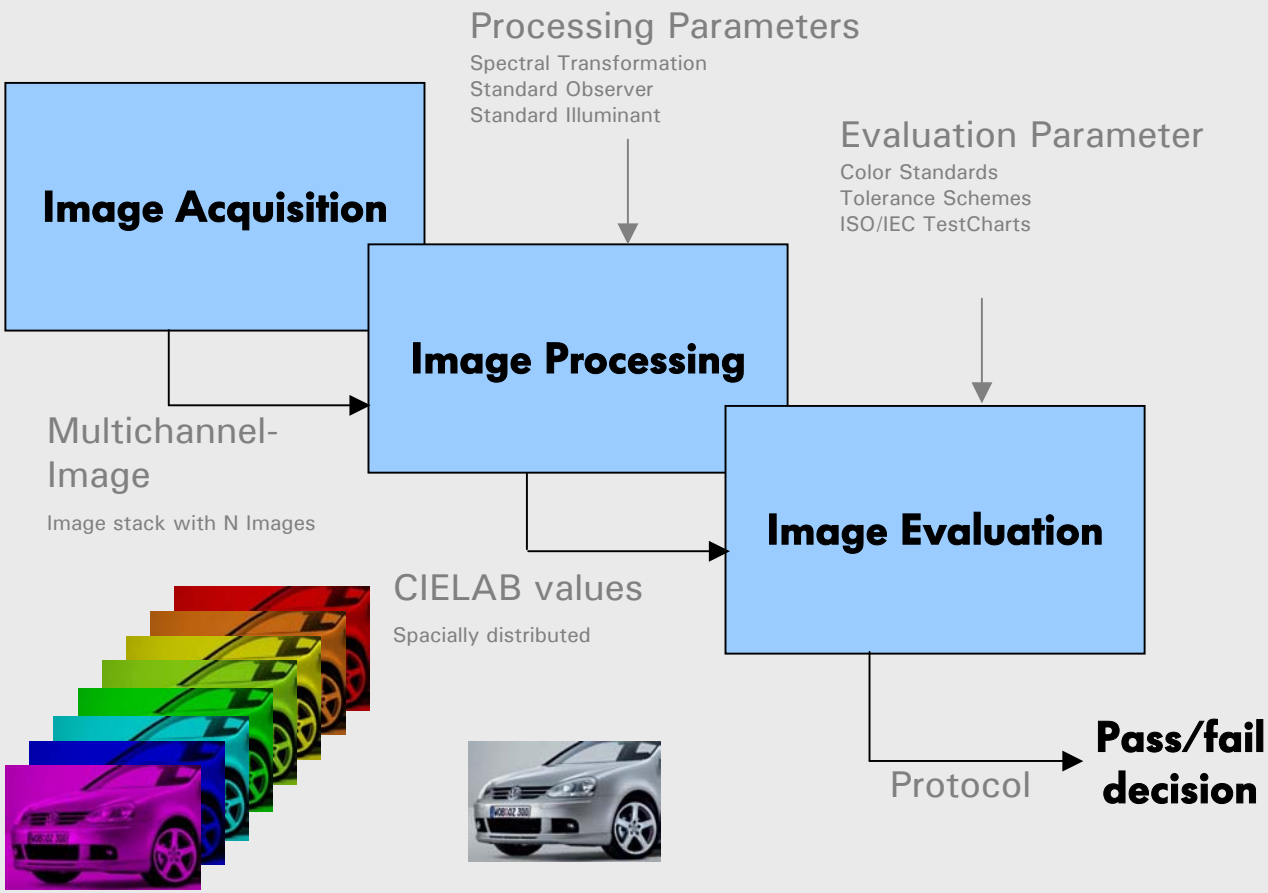
System Overview – Measurement Station



System Overview – Spectral Measuring Device



System Overview – Measurement Process



System Overview – Transformation Determination

Reference System:
Set of reflectances
(reflectance vectors of patches)

Correllation of data

Transformation

Reconstruct reflectance vectors from camera response vectors

Multispectral Measuring Device:
Set of camera responses
(intensity vectors of patches)

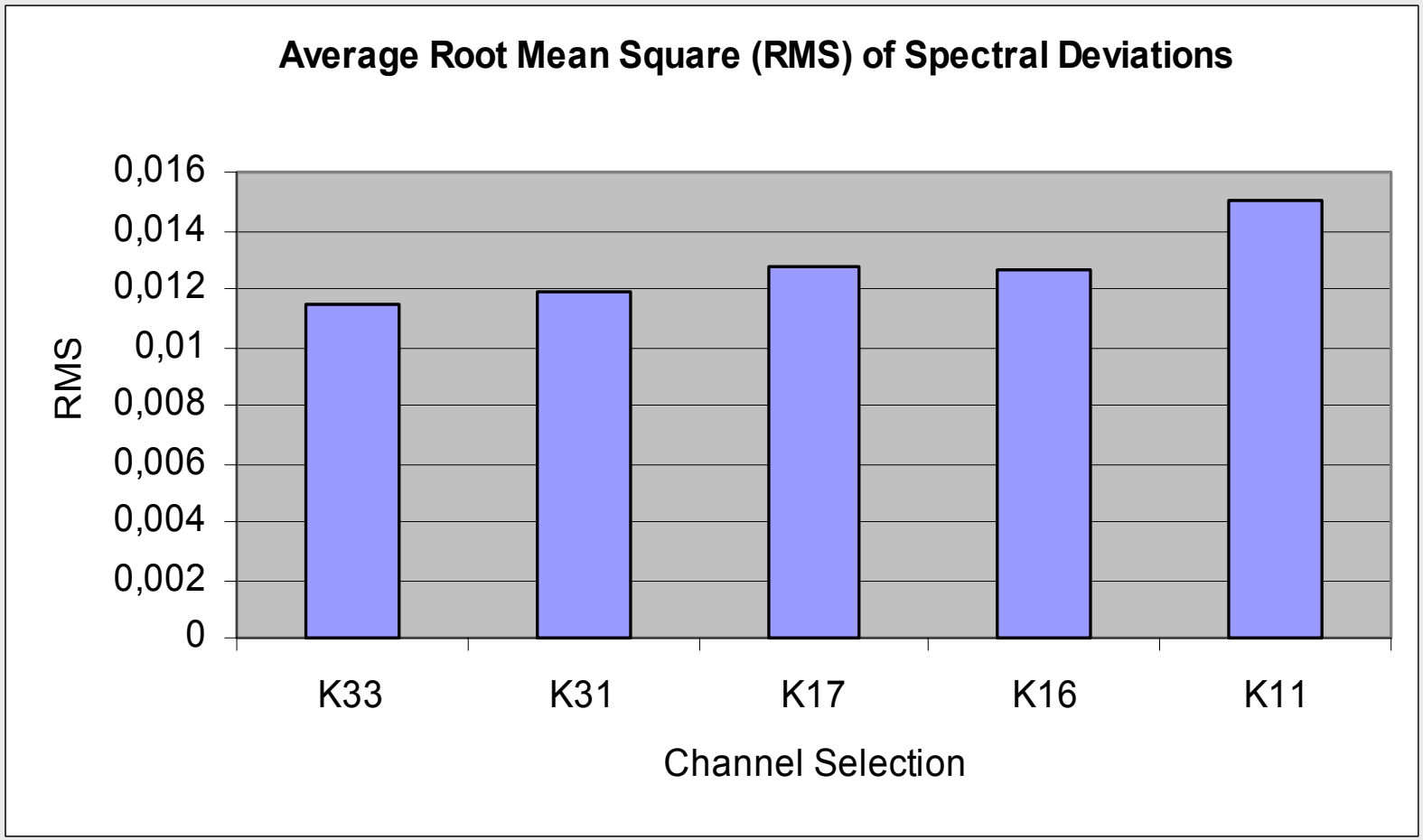
System Accuracy – Evaluation Approach

- **Select error metrics**
  - Spectral: Root Mean Square of differences at spectral sample points
  - Colorimetric: CIE‘s dE Formula with different illuminants (10° Observer)

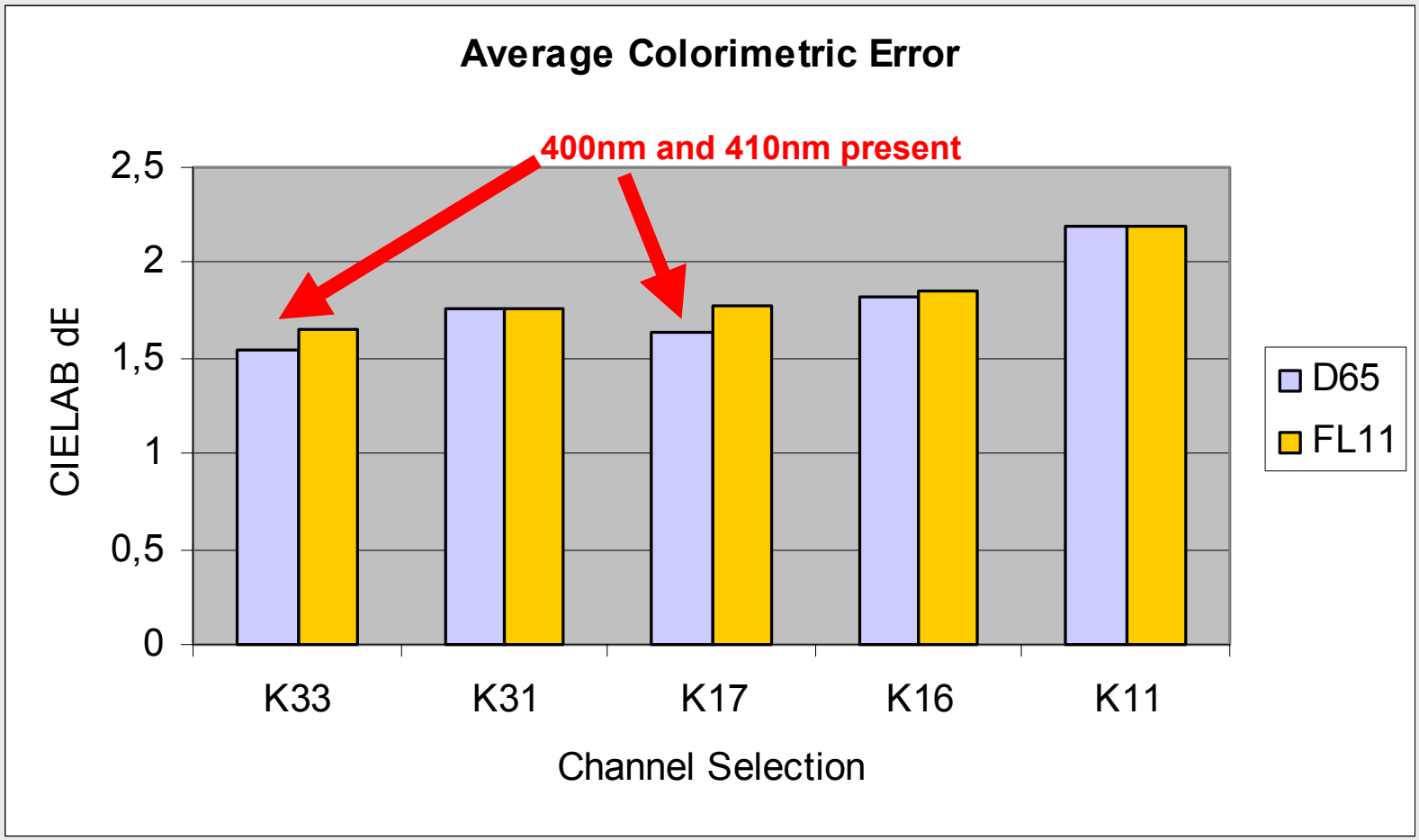
- **Select verification set of colors**
  Colors are spectrally imaged and compared with data from a reference spectral measuring device (380nm-730nm)

- **Define channel sets for acquisition**
  Reduction of acquisition and processing time. Short wavelenghts need extensive exposure time.
  - K33: 400-720nm 10nm steps
  - K31: 420-720nm 10nm steps
  - K17: 400-720nm 20nm steps
  - K16: 420-720nm 20nm steps
  - K11: 420-720nm 30nm steps

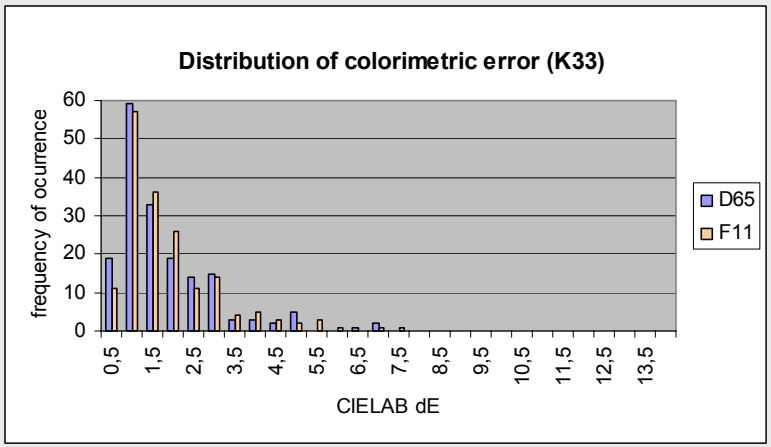
System Accuracy – Spectral Results

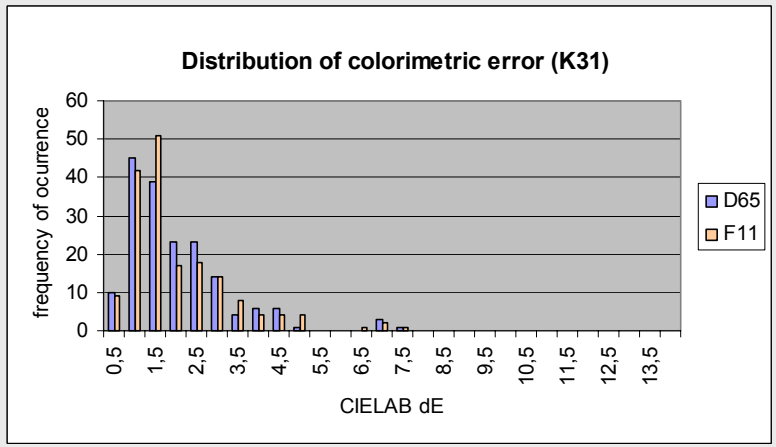


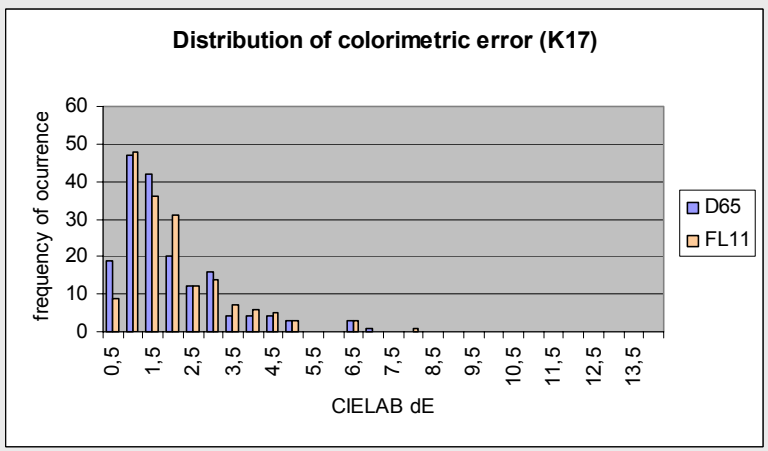
System Accuracy – Colorimetric Results

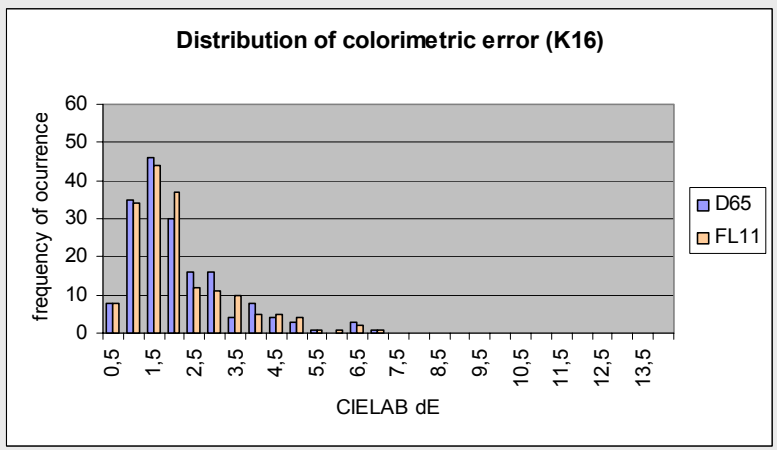


System Accuracy – Colorimetric Results









Summary and Outlook

- **Weak correllation of spectral and colorimetric error**
  Non-linear behavior of observer sensitivity and spectral distribution of sample illumination
- **Improvement potentials for spectral reconstruction**
  Different options for reconstruction, use of optimized equipment (e.g. pelletier cooled camera, improved filter, improved lens system)
- **Improvement of colorimetric accurracy**
  Additional step for colorimetric regression can be introduced

Promising approach for absolute color measurement as well as for color measurement relative to a defined physical standard

Thank you….

Discussion

and

Questions