



DevCon 2016

Colour vision deficiency transforms with iccMAX

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Outline

- Introduction and motivation
- CVD simulation and Daltonization
- Packaging transforms in ICC profiles
- CVD simulation in ICC v4
- CVD simulation and Daltonization in iccMAX
- Conclusions

Introduction

- Anomalous colour vision is generally caused by mutations in cone photopigments. Most colour-deficient observers have difficulty in distinguishing between red and green.
- Colour vision deficiencies include:
- Protanopia and protoanomaly (absent or modified peak wavelength or sensitivity of long-wavelength cone)
- Deuteranopia and deuteranomaly (middle-wavelength cone)
- Tritanopia and tritanomaly (short-wavelength cone)



Photo: Whitemay [Getty]

Introduction

- Designers often need to check that an image or graphic will be adequately clear to a CVD observer, by 'simulating' the effect of the colour vision loss.
- A 'Daltonization' algorithm may be applied to improve the colour visibility of the image to a CVD observer



Deuteranopia
simulation, Adobe
Photoshop



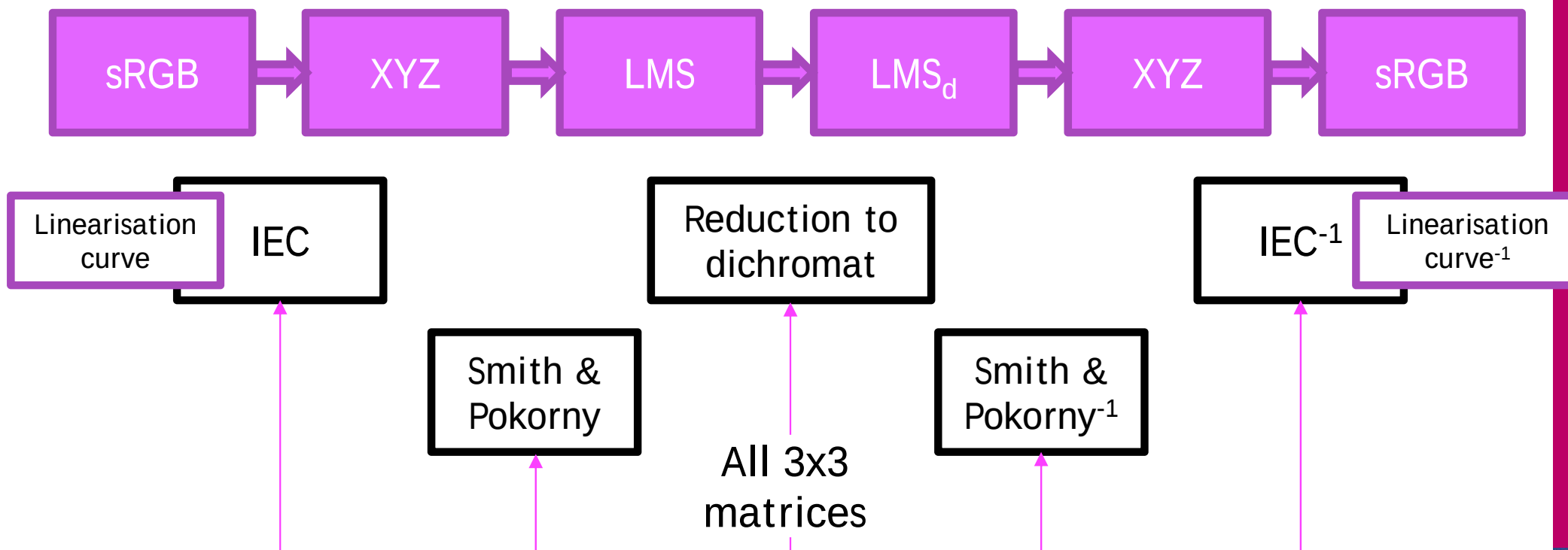
Daltonization to
enhance red-green
difference

Motivation

- Algorithms for CVD simulation and Daltonization have been published
- Tools that implement CVD simulation algorithms have also been implemented and are widely available on the web and in applications (e.g. Adobe Photoshop)
- The goal of this work is to provide profiles encoding such algorithms so that it is possible to transform images within a colour-managed workflow

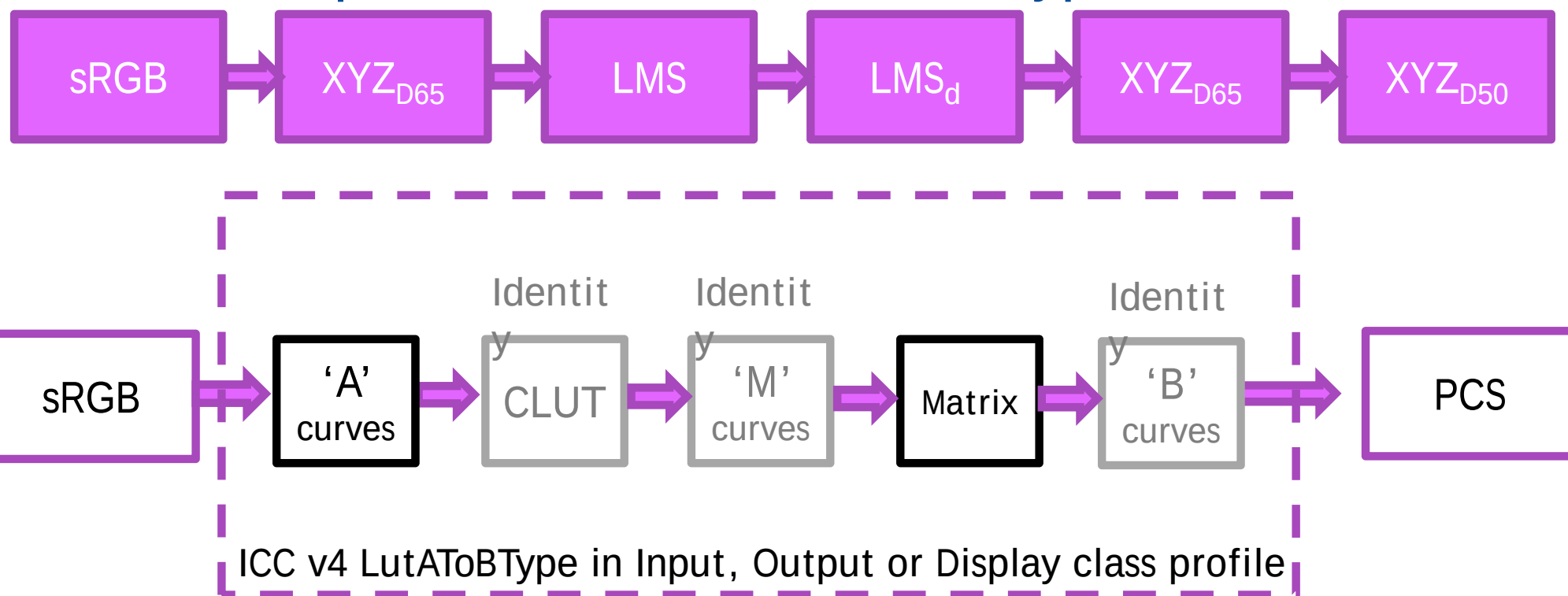
Dichromat simulation

Viénot, Brettel and Mollon (1999)



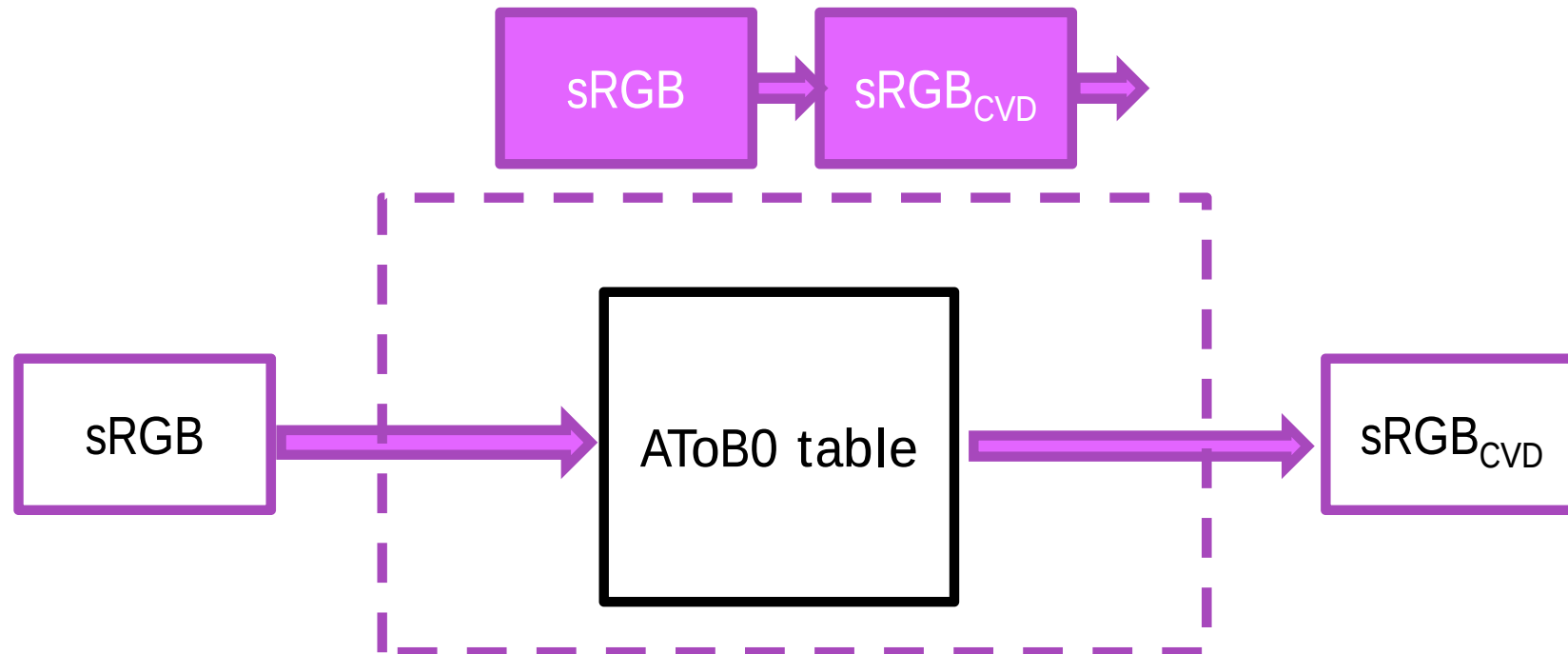
Dichromat simulation

■ ICC v4 implementation as LutAToBType



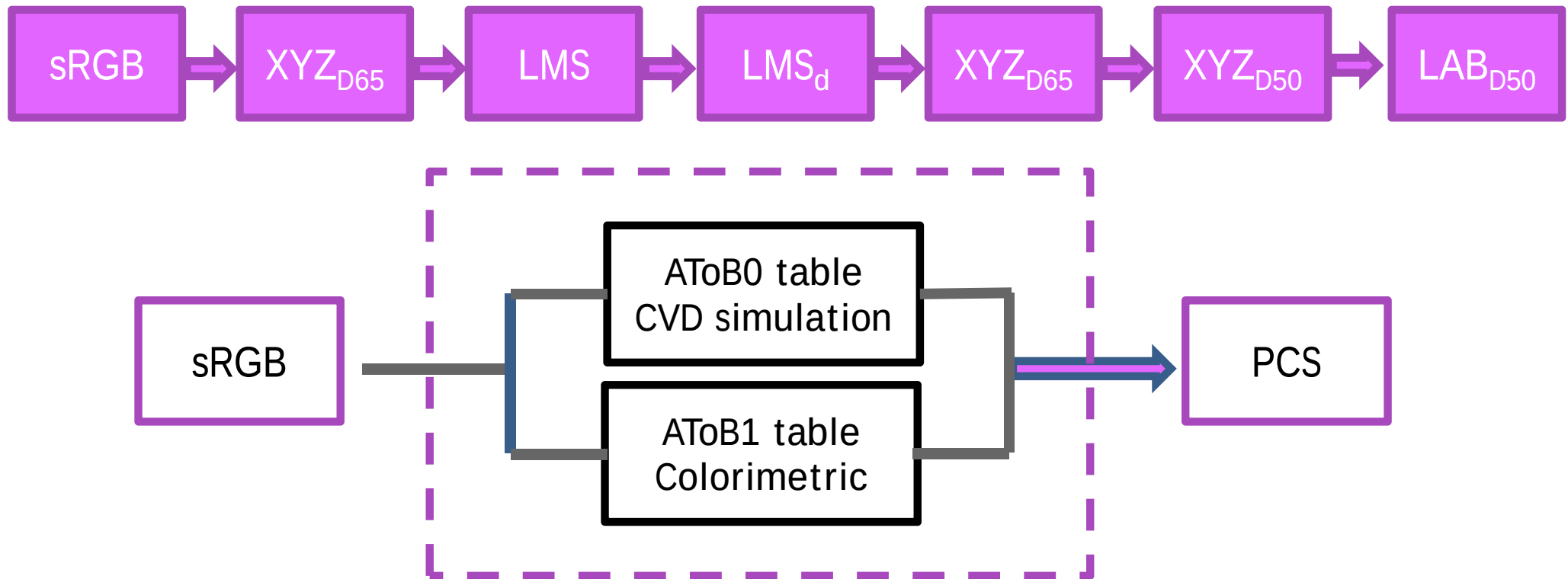
Dichromat simulation

- ICC v4 Device Link profile implementing RGB colourmap (Viénot et al)



Dichromat simulation

- Simulation implemented as ICC v4 Input profile

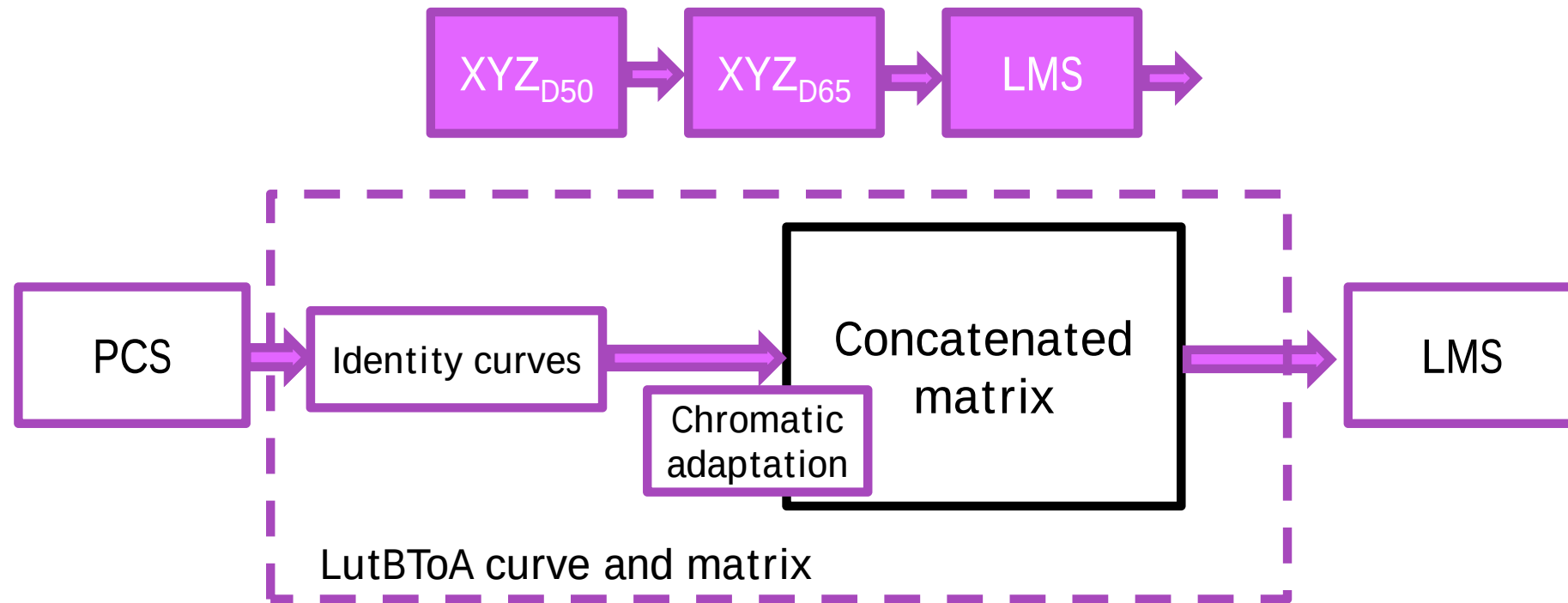


- iccMAX features of interest in CVD transforms
 - Spectral processing
 - Alternate PCS colorimetry, alternate illuminants and observers
 - Extended transform functionality
 - Transform elements can be combined in any number and sequence
 - Programmable transforms



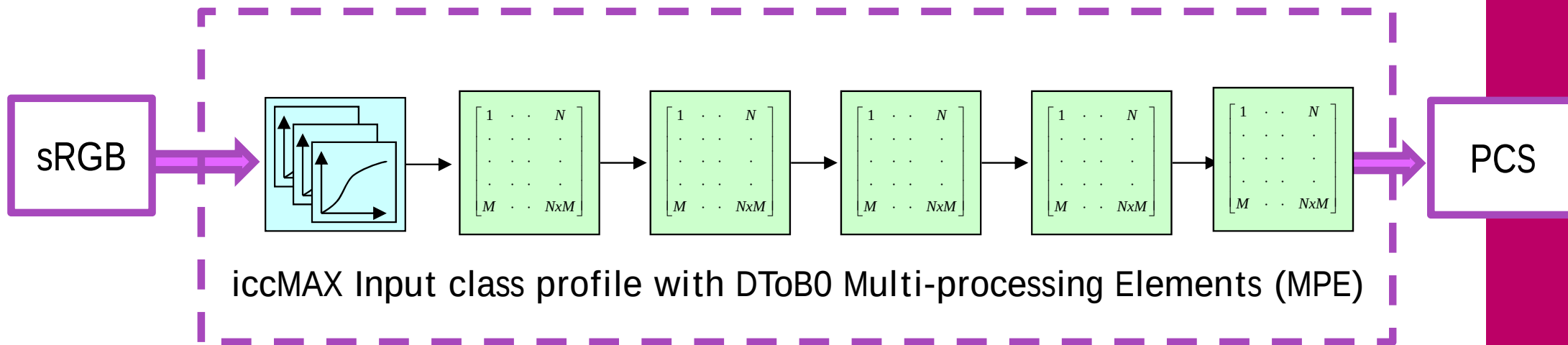
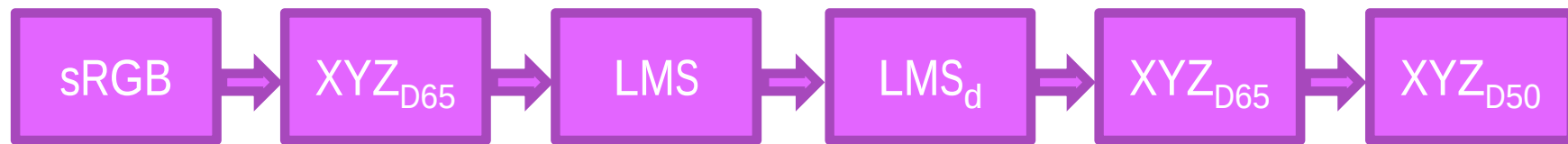
LMS profile

- iccMAX adds 'LMS' colour space



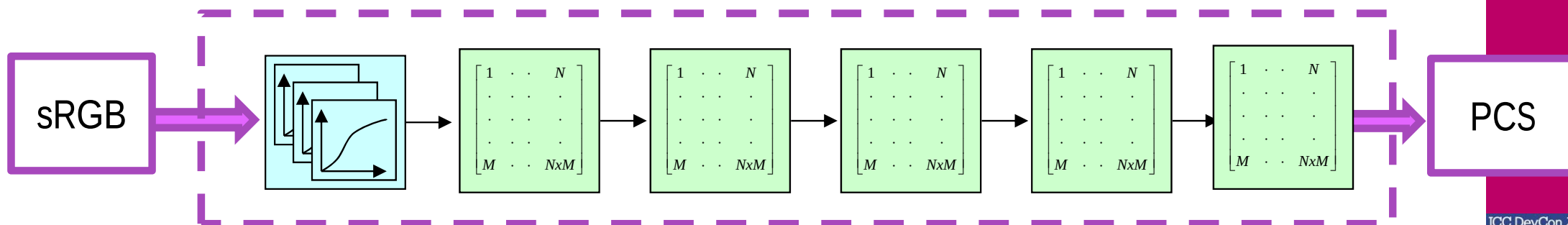
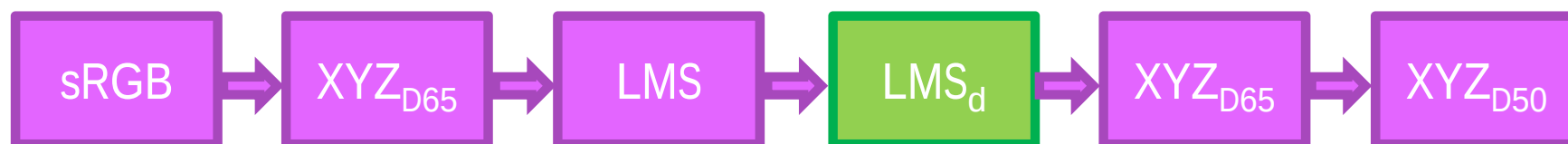
Dichromat simulation

- Simulation implemented as MPE element in iccMAX profile



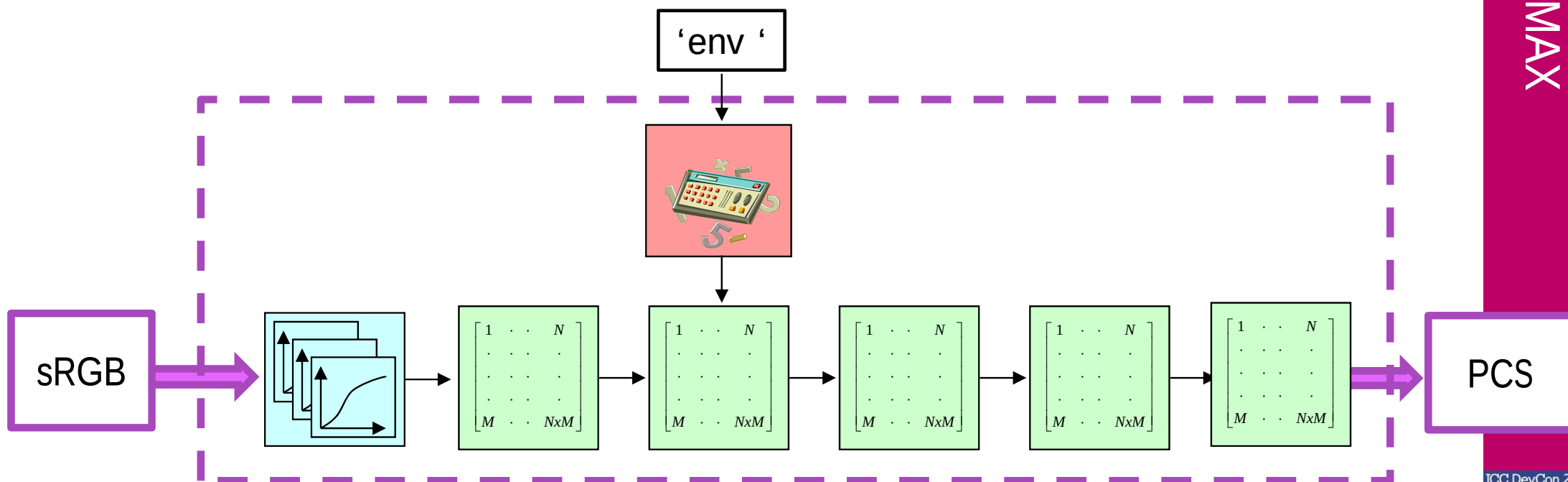
Anomalous CVD simulation

- Encoding each stage of the transform as a separate element makes it possible to modify as needed
 - E.g. we can modify the LMSd matrix to define an anomalous deuteranope or protanope



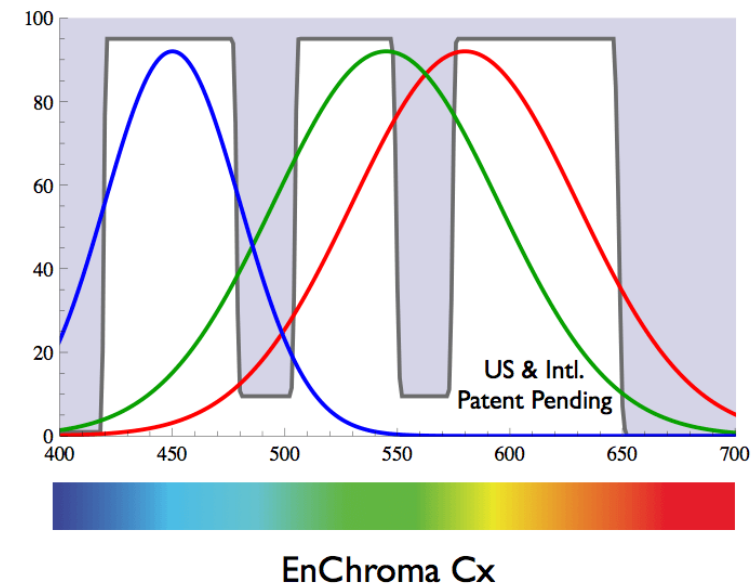
Anomalous CVD simulation

- Using a run-time variable, we can parameterize the transform to reflect the degree of deficiency



Daltonization

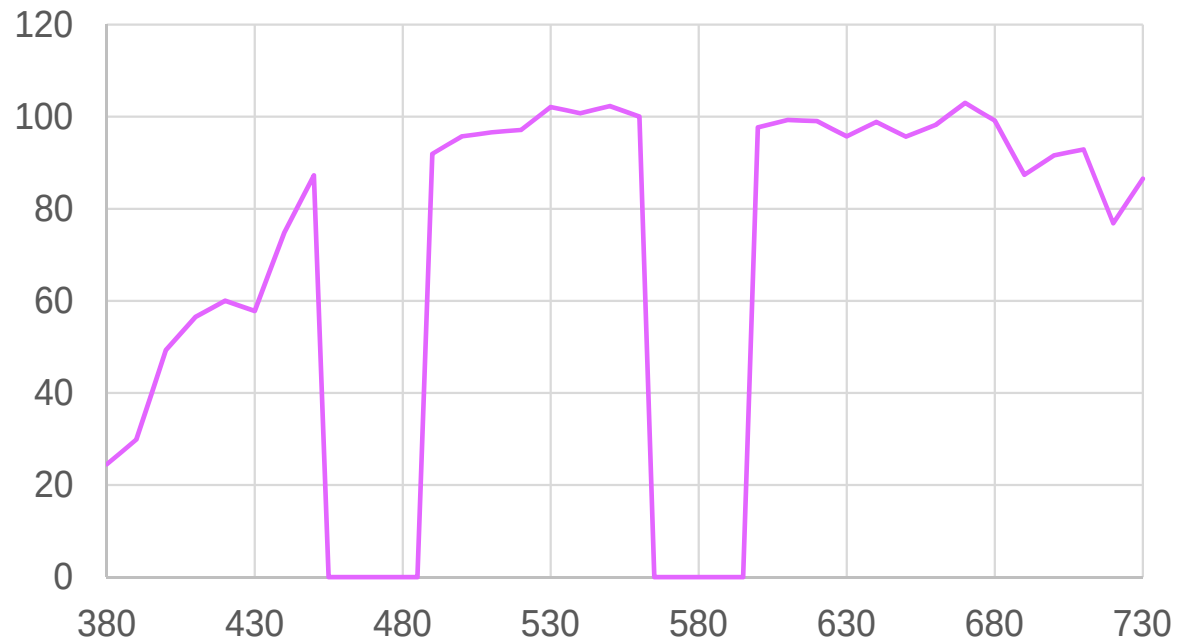
- One approach is to create a 'notch' filter with stop-bands at selected wavelengths that enhance red-green differences



Daltonization

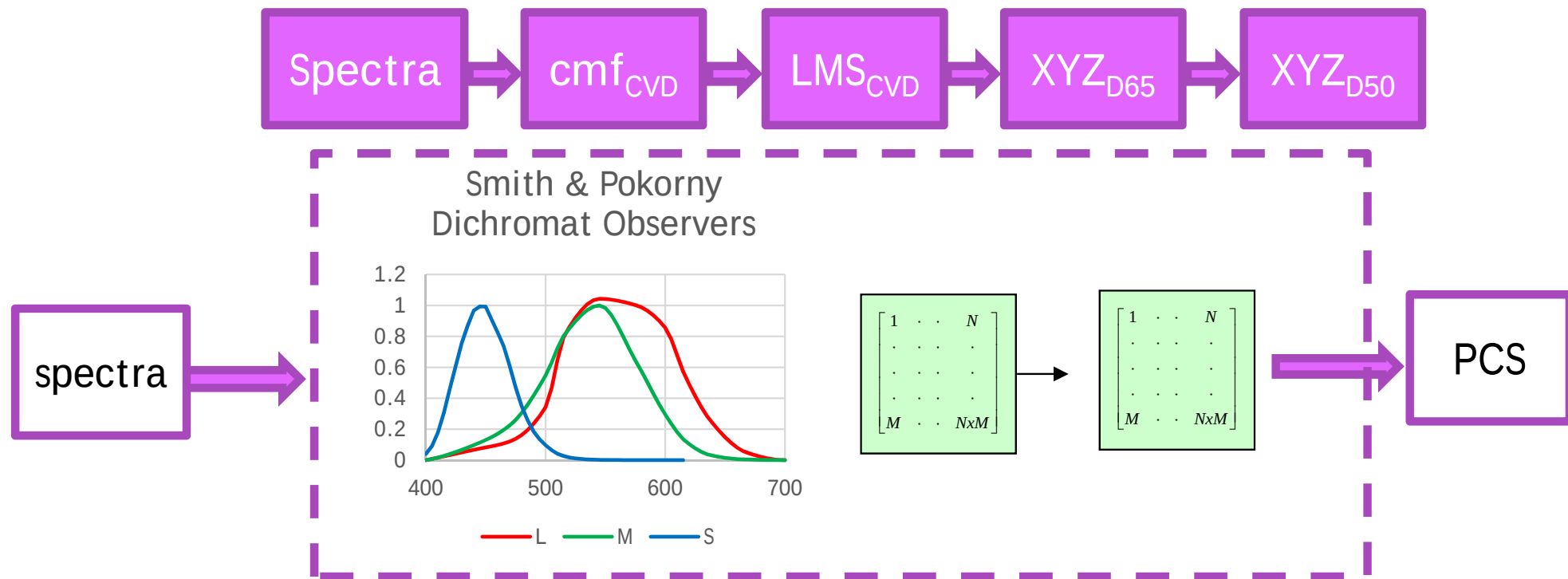
- Implementation as iccMAX custom illuminant in Named Color profile

- Applied to spectral input data
- PCS can be Spectral or Colorimetric



CVD observer response

- Implemented as iccMAX profile with custom observer



Other iccMAX projects

- Daltonization transform (Kotera et al) implemented as iccMAX MPE transform including calc element
- Daltonization or simulation transform generated at run-time based on individual observer
 - Colour vision test app (similar to Ishihara) identifies type and degree of deficiency
 - Run-time parameters passed to MPE calc element to select or compute custom daltonization or simulation transform

Evaluation

- v4 simulation profiles, comparison with Viénot et al test data
 - Good benchmark as training and test values provided



Viénot et al test colours



Viénot et al simulation



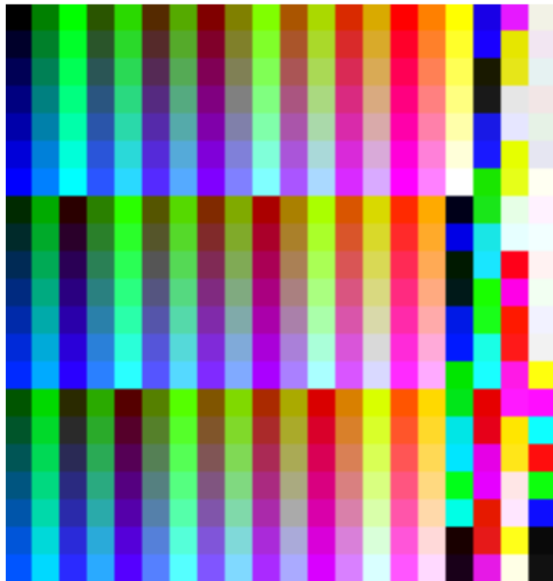
CVDlink-protan.icc $\Delta\text{RGB} = 0$



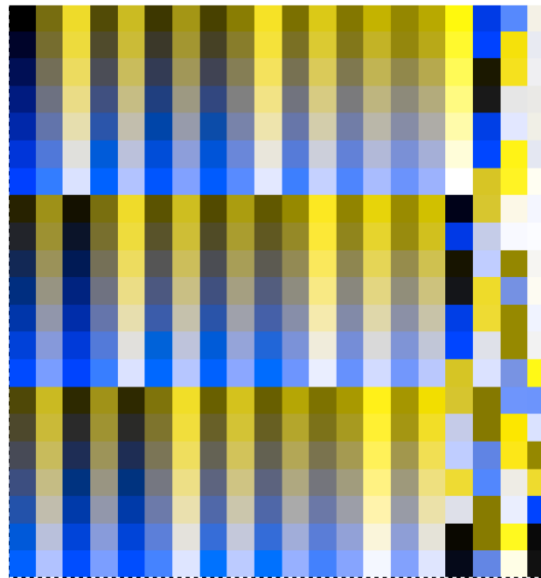
CVDlut-protan.icc $\Delta\text{RGB} = 8.06$

Evaluation

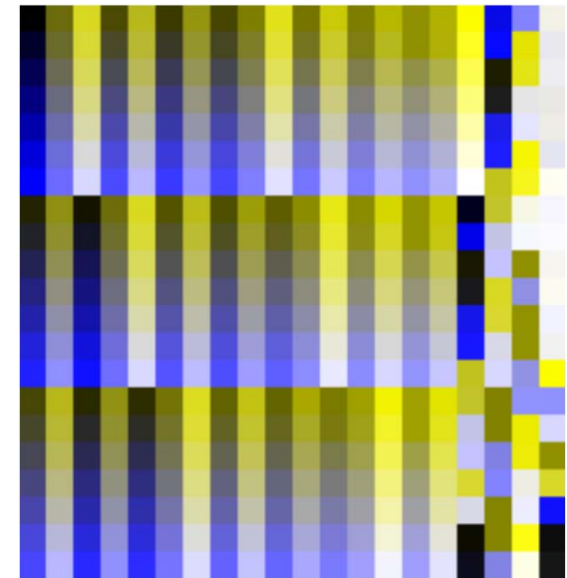
- Simulation profiles, comparison with Adobe Photoshop CVD soft proofing tool



RGB test target



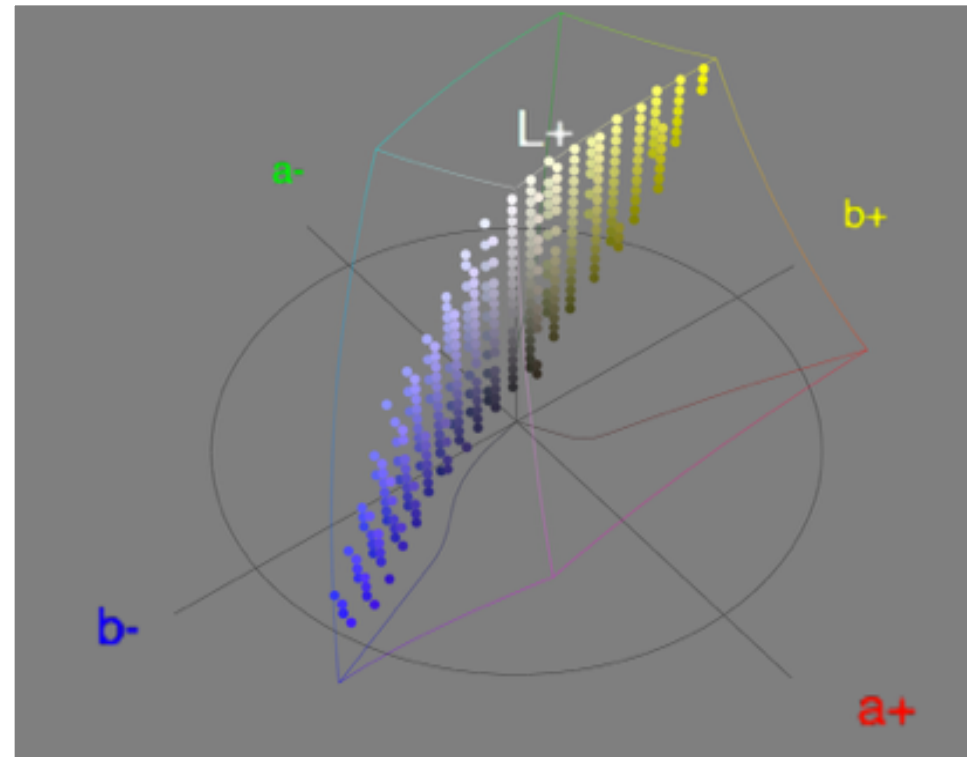
Photoshop simulation



CVDcolormap-d.icc

Evaluation

- Gamut of dichromat simulation profile
 - Dichromat gamut more or less reduced to plane as predicted by CVD research



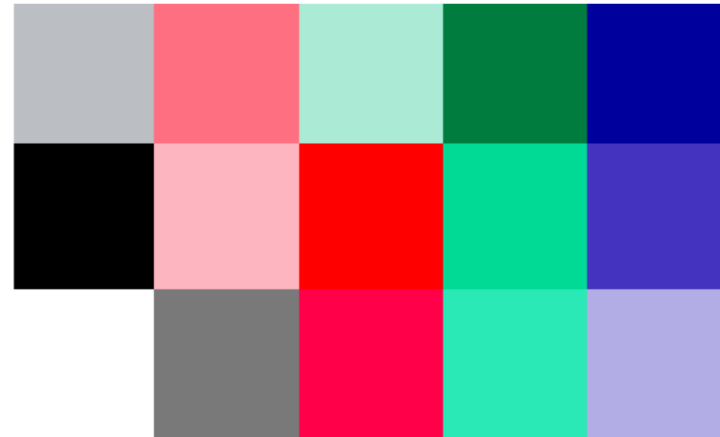
v4 CVDcolormap-deutan.icc

Evaluation

- iccMAX notch filter for Daltonization



Test reflectances
(converted to sRGB)



Test reflectances with
notch filter applied
(converted to sRGB)

Conclusions

- ICC profiles can encode a wide range of different transforms
- Provides a useful toolkit for CVD researchers and developers
- iccMAX extends the possibilities for implementing CVD transforms
- Binary ICC profiles and XML representations will be available to download at www.color.org/