Proposal for calibration target for medical color display systems

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Why calibration?

Stability of state-of-the-art display systems

- A lot of effort is being spent on guaranteeing stability and quality of digital pathology scanners (and other modalities or image processing algorithms that produce color medical images)

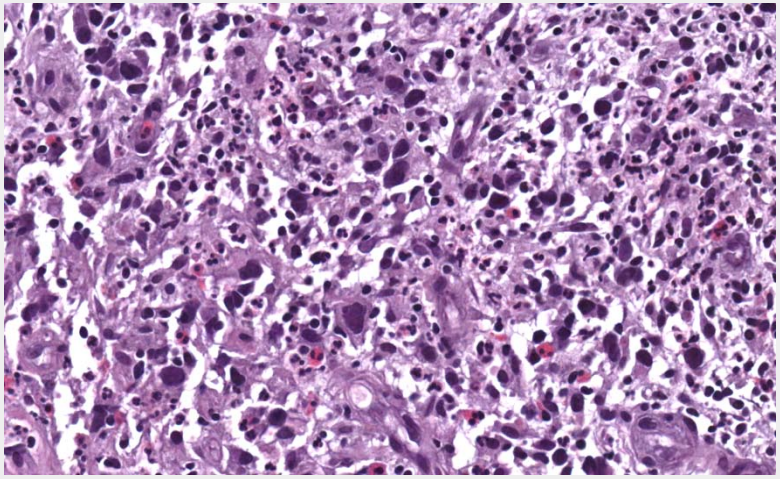
- However, today's (consumer) display systems suffer from substantial instabilities and inconsistencies over time and display area

  - Uniformity center to corner
  - Luminance change with aging
  - White point variation
  - Color shift with aging
  - Different distribution of colors

Non-Uniformity of Display Degrades Image

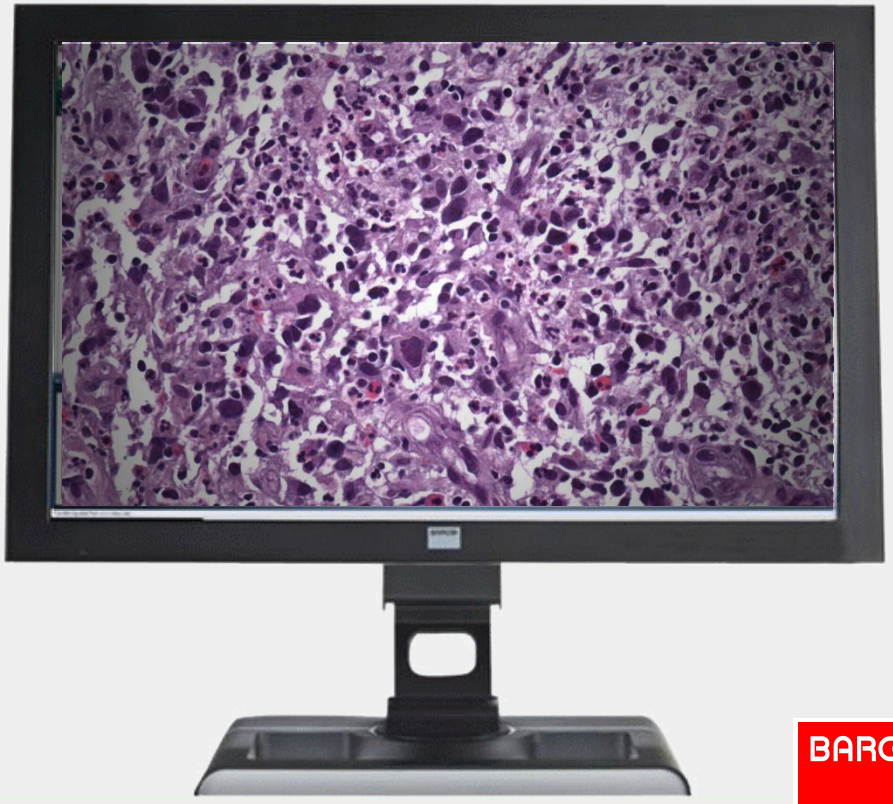
uniformity

(scanner image even corner to corner)



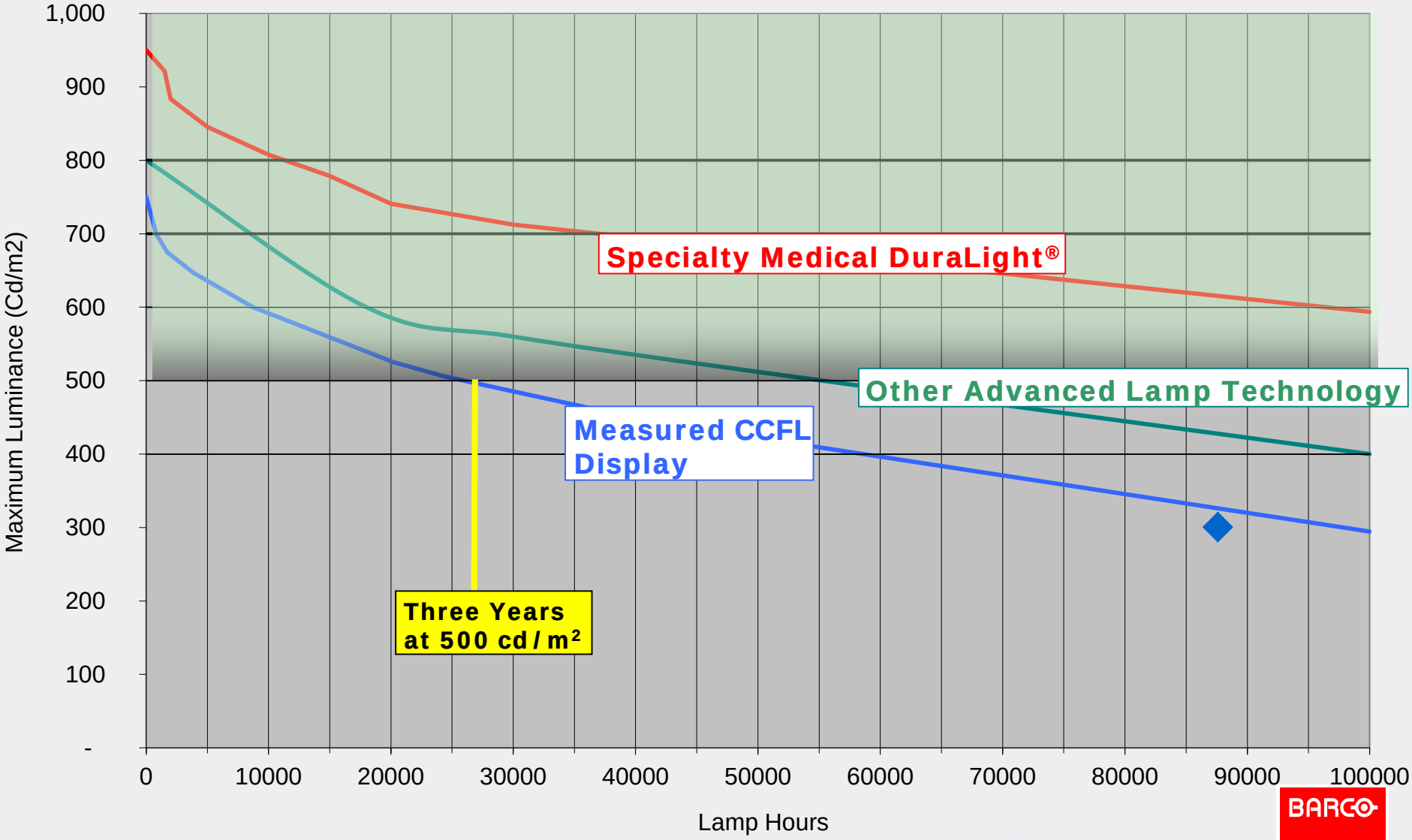
non-uniformity

(center brighter & corners darker)



Images Courtesy of Dr. Cucoranu, UPMC

Display's maximum luminance declines. Unless stabilized, older displays will be dimmer



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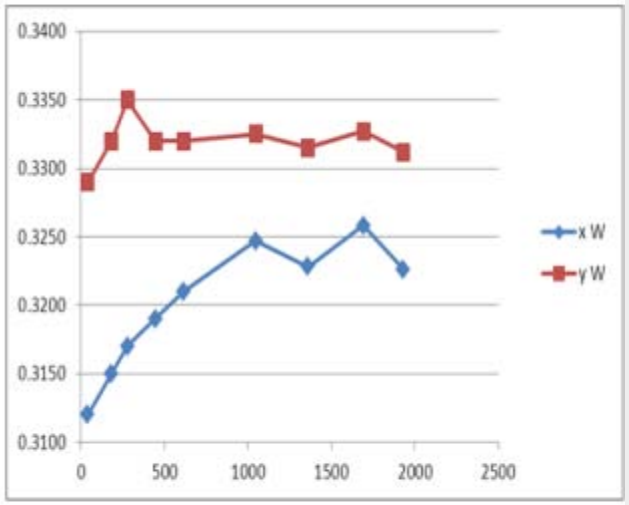
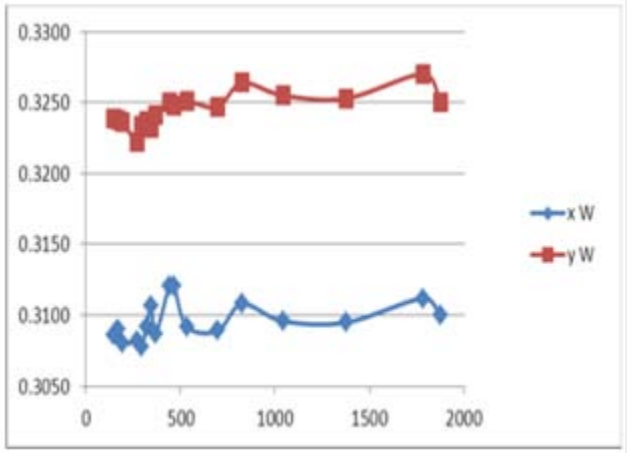
Color point stability of displays over time

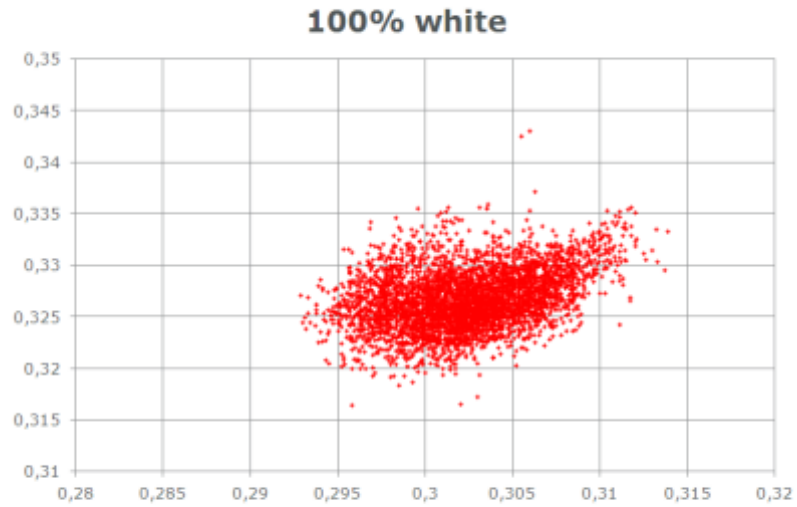
CCFL backlight



LED backlight



White point variation of color displays

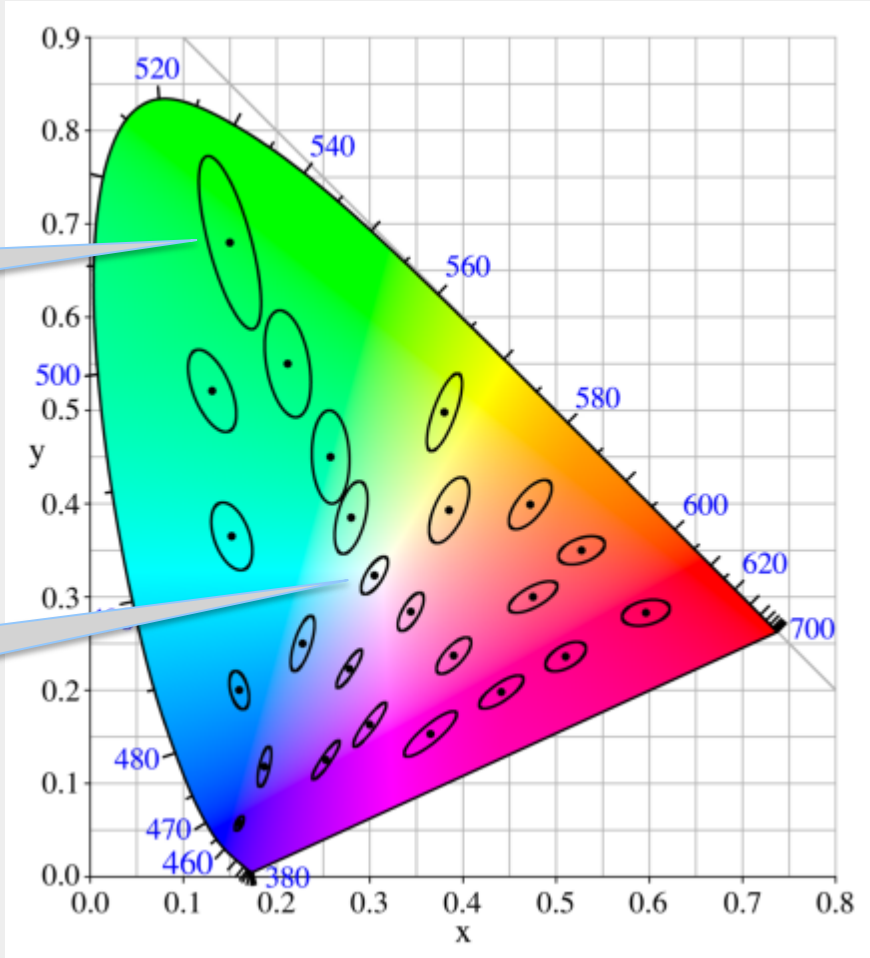


(x,y)-coordinates of 4355 color displays during manufacturing measured with Minolta CA-210

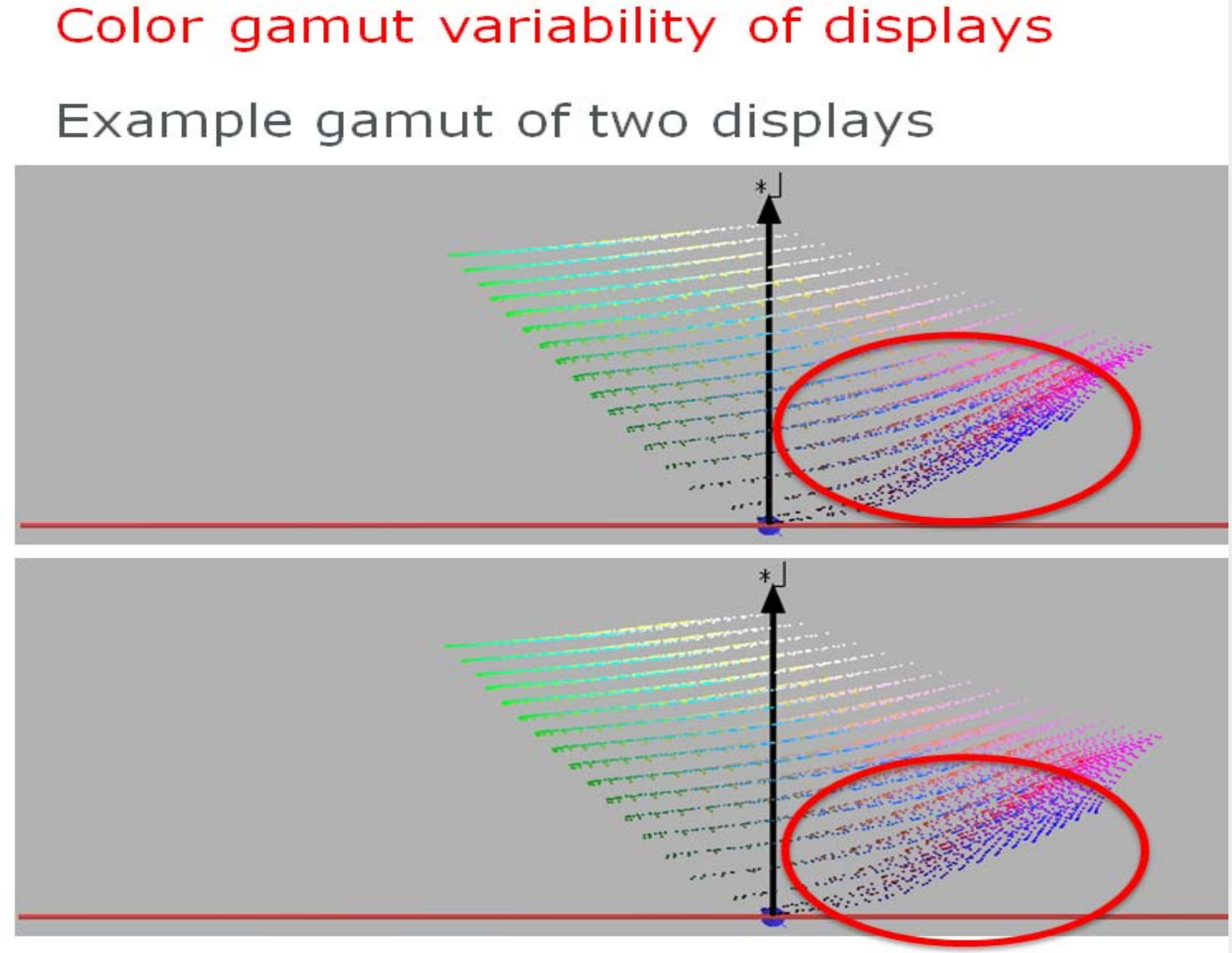
Displays choose how to arrange colors: How should colors be arranged?

Some differences need to be quite large to be noticed

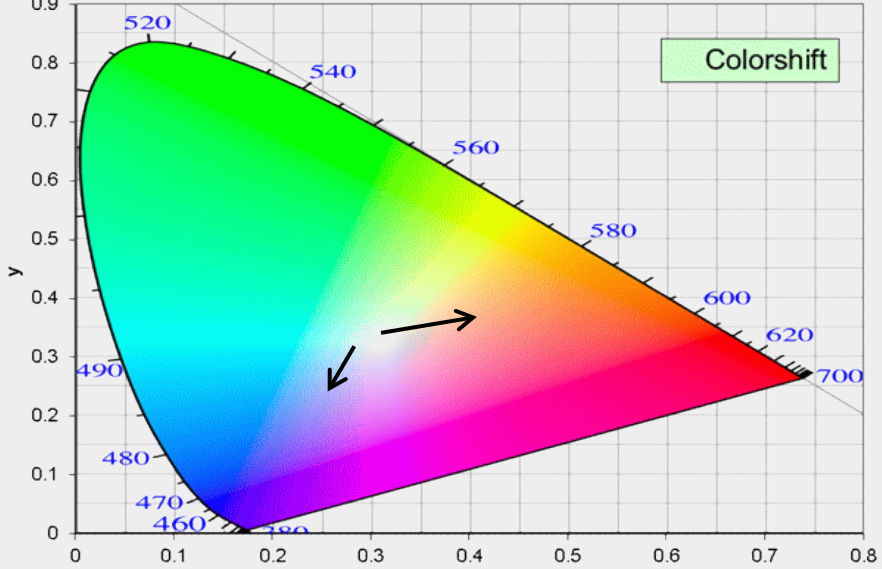
Our eye more readily discerns other differences



Arrange colors in consistent fashion spread out colors in useful way



Color shift of display: aging light source, optics



new display

Aged LED
(less red&green)

Aged CCFL
(less blue)

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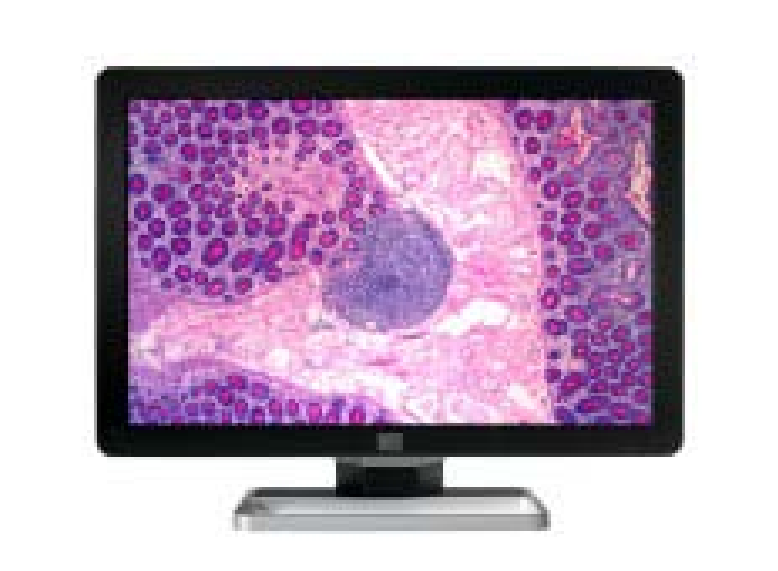
Expectations of a medical display

- After some variation has been compensated, and some remains

- Good clinical performance must still be possible:
  On the same display over time
    - Eg. one could see a pathology today on a particular display, but not anymore six months from now.
  - In between display systems of the same type or of other type
    - Eg. in a reading room full of display systems one could see a subtle pathology on one display but not on another display.



Proposal for calibration target for color medical displays

Color Calibration proposed based on perceptual optimization, not absolute

- Key points:

  - Absolute calibration does not allow for technical advances and limits every display to the worst display that can be accepted

  - Different (color) modalities seem to have different (clinical) requirements

  - spacing things evenly *gives applications best palette*
  - visibility of image value differences independent of location in gamut

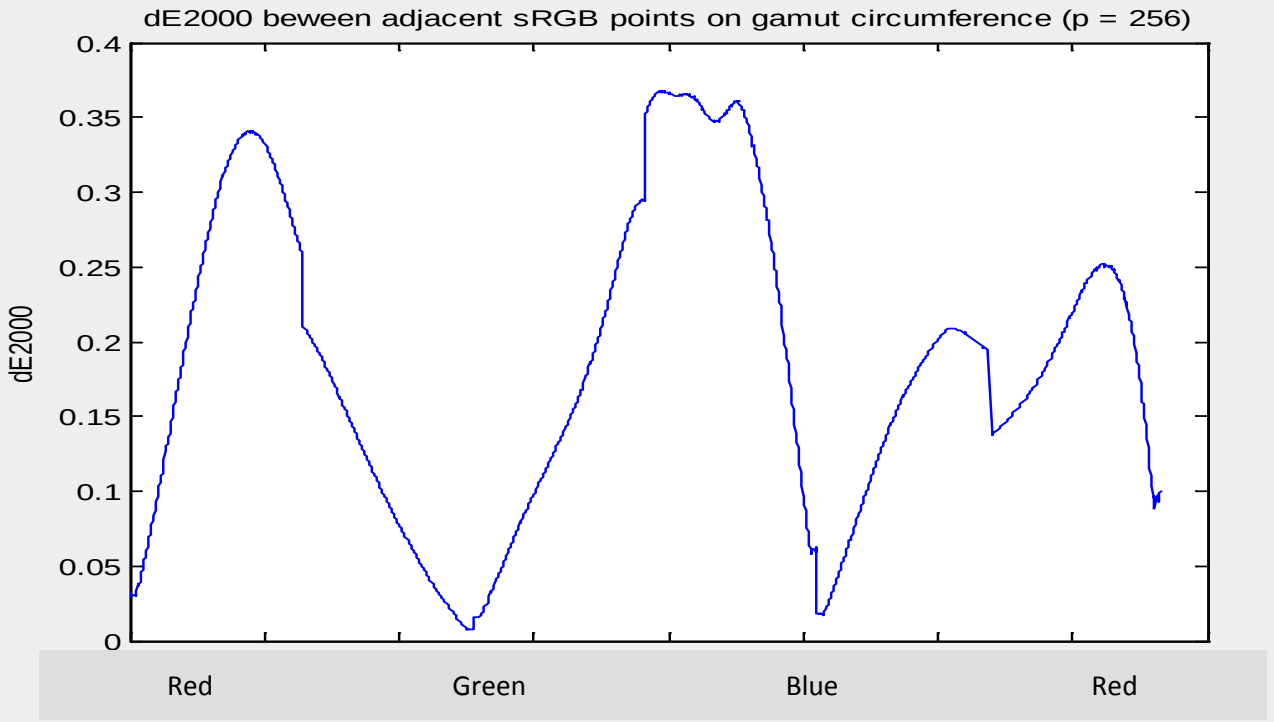
  - Therefore making sure that the display behaves perceptually linear both for greyscale and color seems a good choice.

Proposed calibration target

- Complying with DICOM GSDF for greyscale curve
  - permit simultaneous or sequential use with radiology images
  - accomodate large range of luminances (100-2000 nit)
- Not reducing the native luminance, contrast and color gamut of the display
- Aiming for DeltaE2000 perceptual (color) uniformity for the color behavior within the gamut
  - make differences equally important
  - promote efficient storage of images
- We have the intention to work towards an open industry standard as we have done with DICOM GSDF.

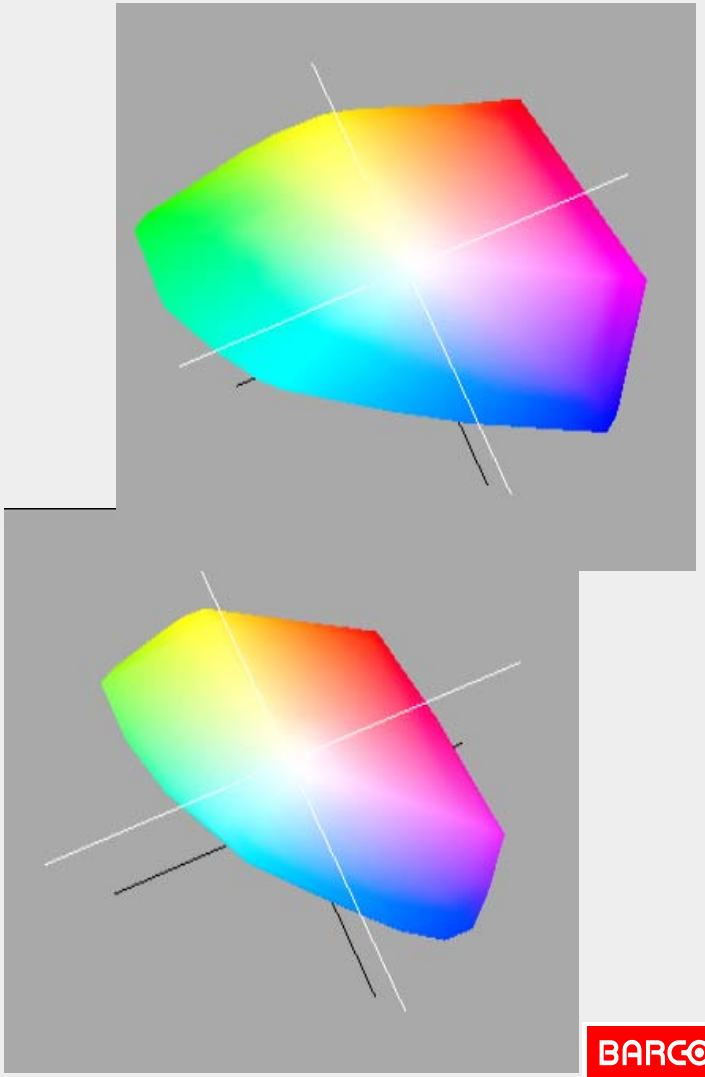
Why not sRGB?

- sRGB is very limiting {80 cd/m2, not in line with evolution of primaries expected soon} and not perceptually uniform
- difference between adjacent hues more or less noticeable as measured by delta-E
- more useful steps available if steps are similar size



Correctly utilize wider gamuts

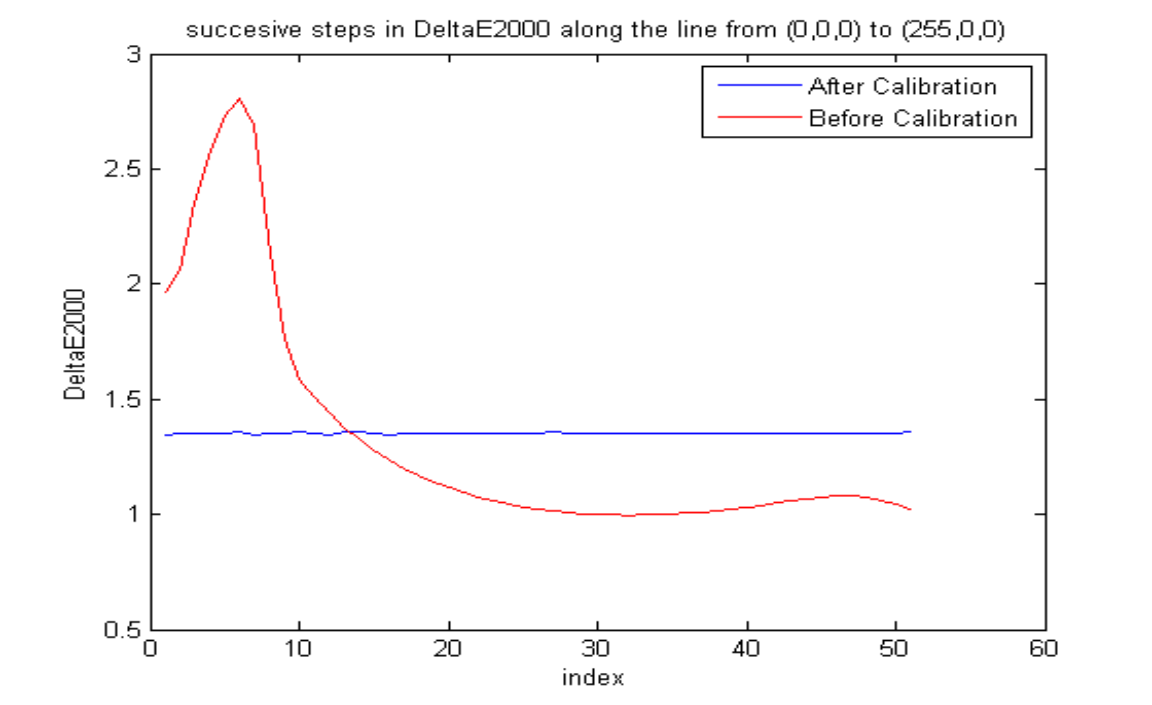
- Large increase in gamut only slightly increases number of perceived shades of saturation
- Handle individual variation and aging
- Different display designs may have only wide gamut in red or green
- DeltaE2000 perceptual approach optimally distributes colors so as to equally value all image color differences



Results that can be achieved

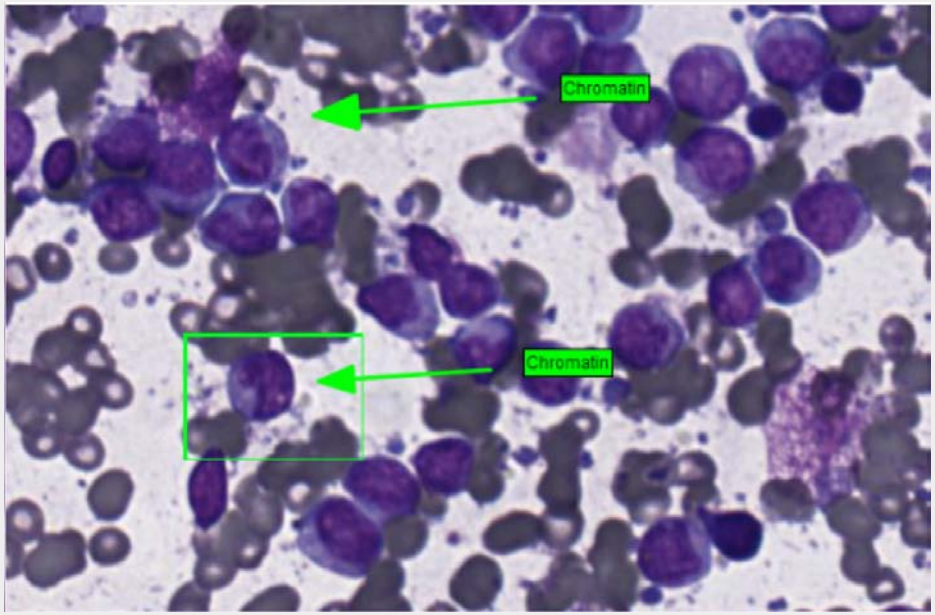
Calibration results (1)

- Subtle color tint targets are much better visible on calibrated display vs. a standard sRGB or DICOM GSDF calibrated display
- Calculations of deltaE2000 confirm improved uniformity of the display



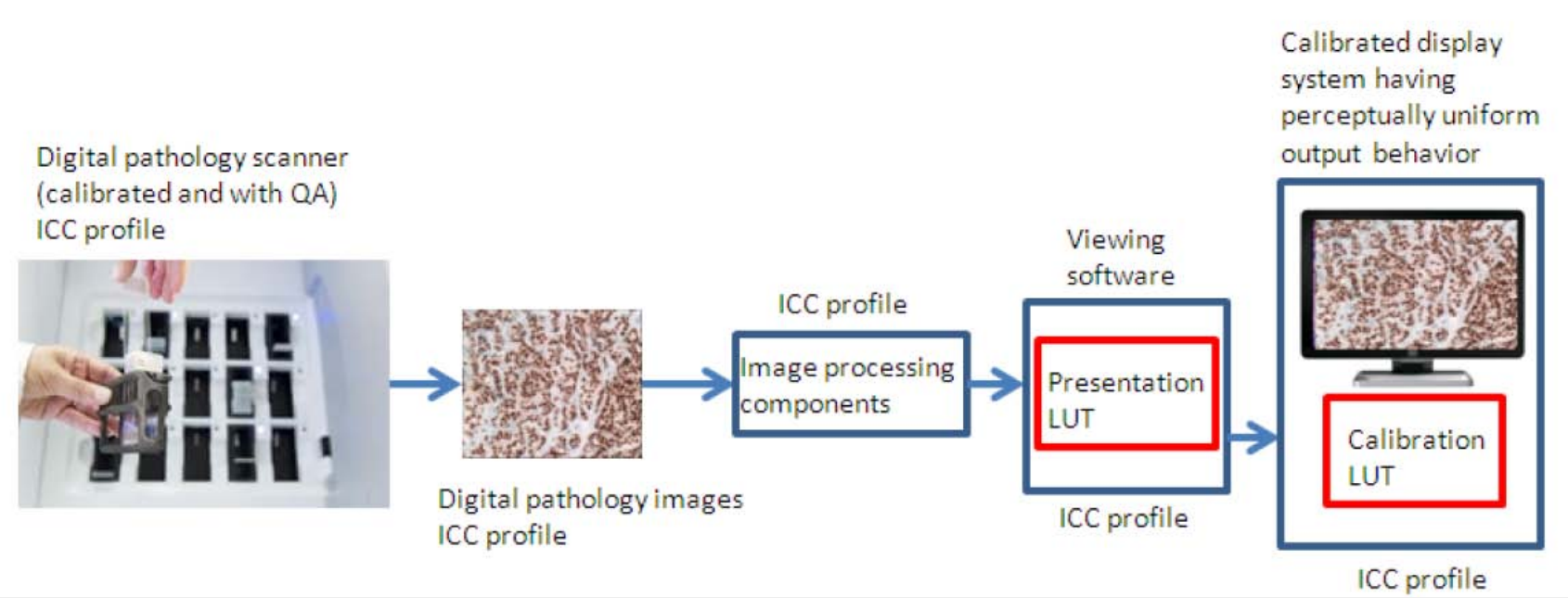
Calibration results (2)

- Visual inspection of pathology images shows that details such as cell core and chromatin are better visible on calibrated displays
- Calculations confirm that indeed these features have higher perceived contrast

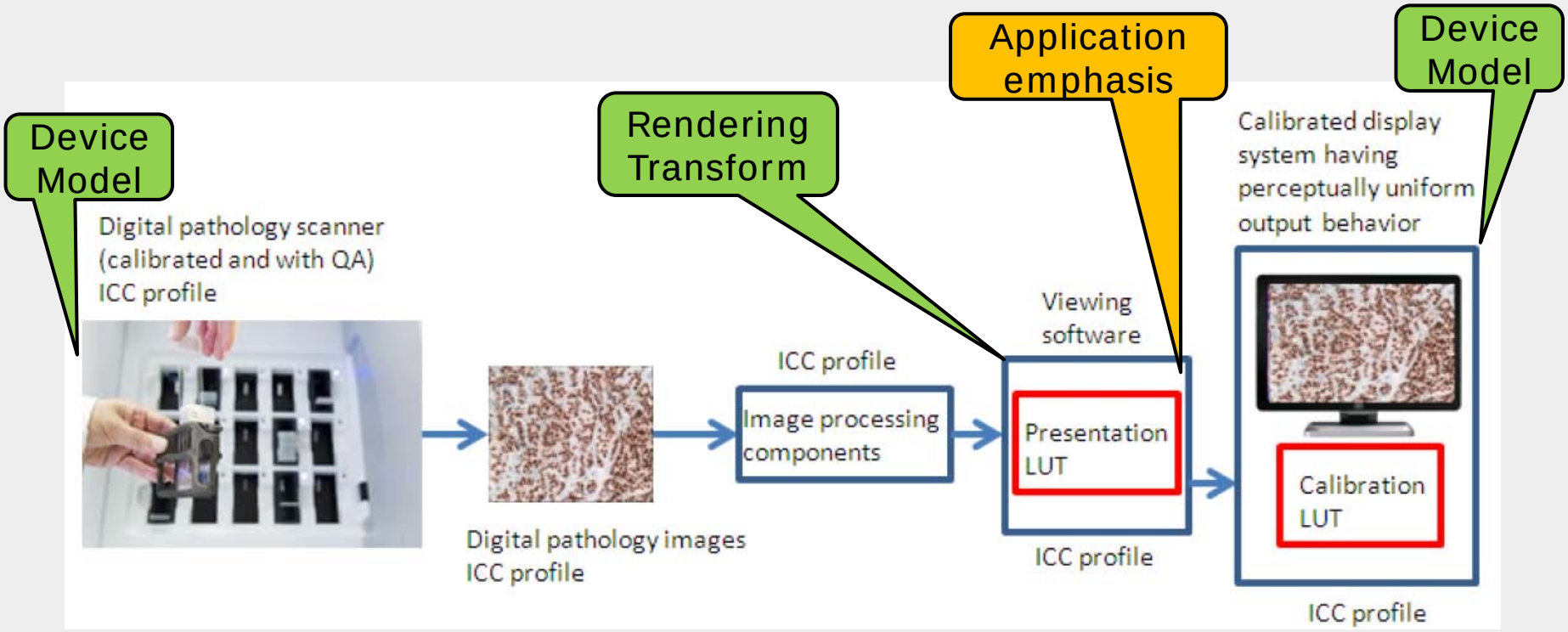


Discussion

- We would appreciate a discussion about how such a calibration practically could be integrated in the ICC platform
- Would this color workflow require a new rendering intent?



Discussion



-> Barco would like to work together to prepare a *flexible* imaging chain that enables *interchangeable* and *unequal* components

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