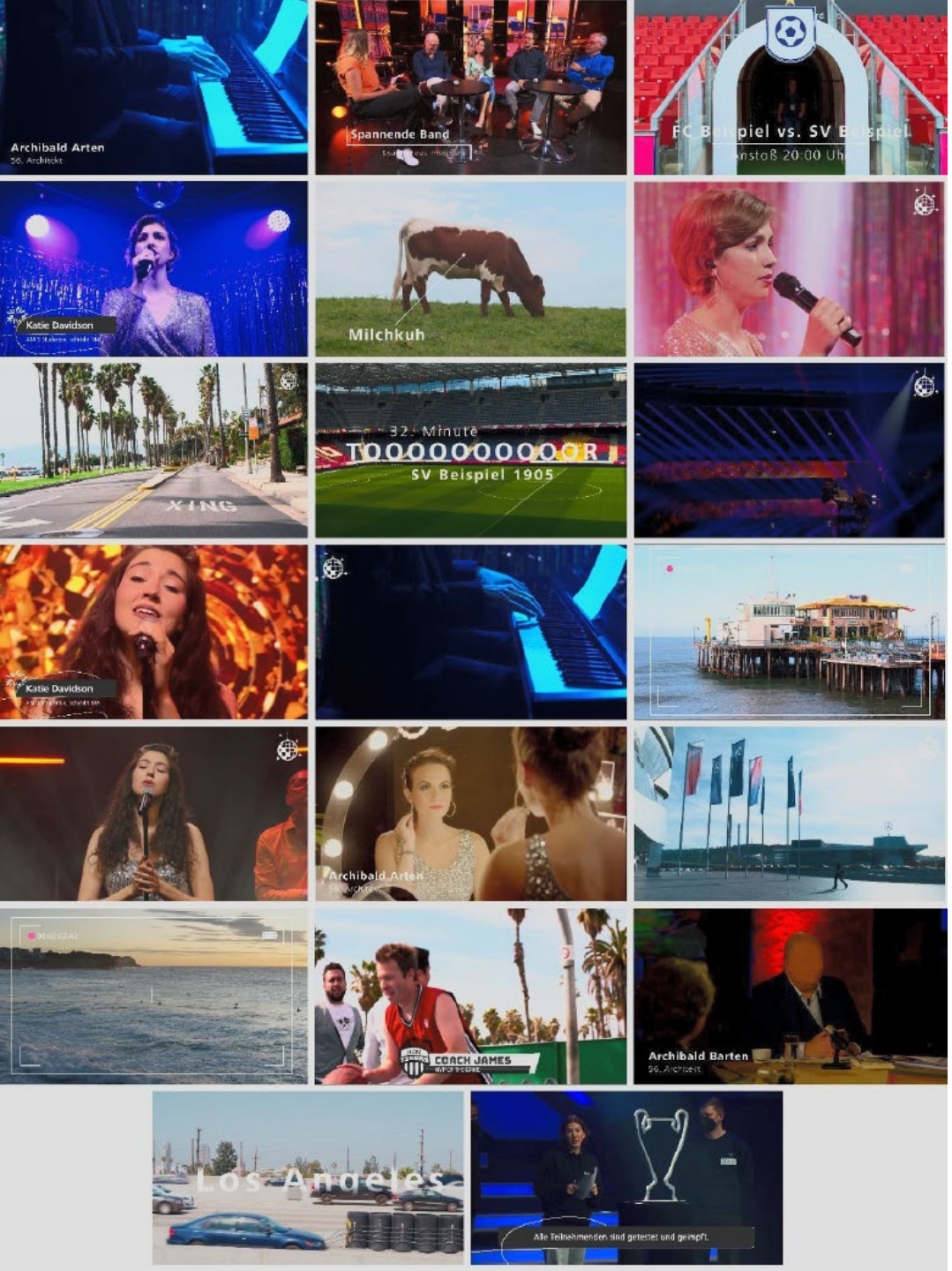


Perception of graphic overlays in High Dynamic Range

A USER STUDY ON BRIGHTNESS PREFERENCES FOCUSING ON HDR BROADCAST CONTENT

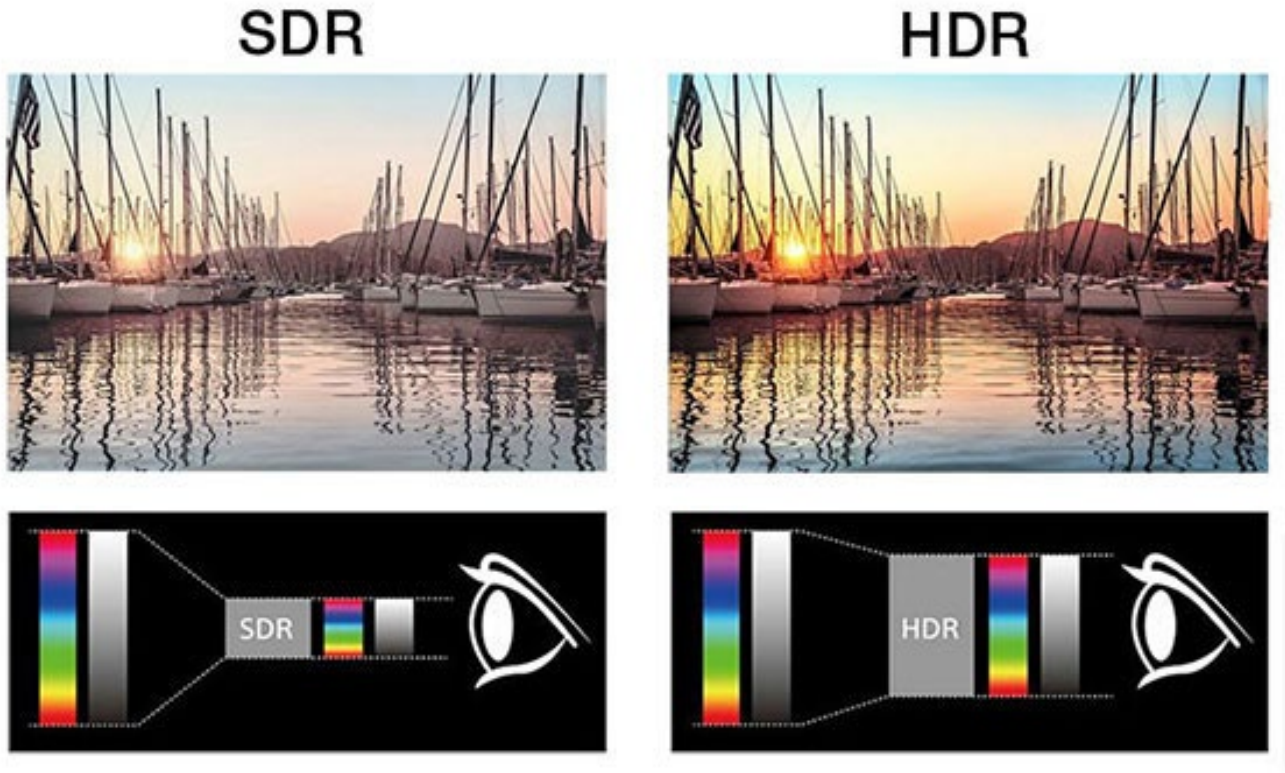
HOCHSCHULE DER MEDIEN

MASTER'S THESIS PRISKA MERBITZ-ZAHRADNIK | AUDIOVISUAL MEDIA | STUTTGART MEDIA UNIVERSITY | 2024

Agenda

- Motivation and Objectives
- Methods
- Results
- Limitations
- Further research
- Conclusions

High Dynamic Range

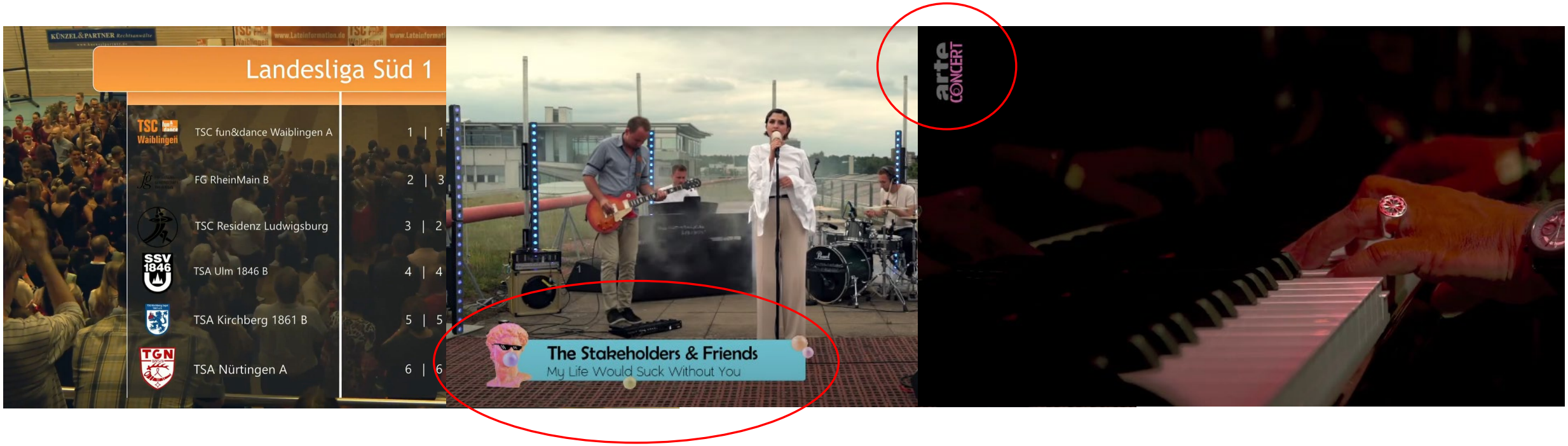


https://www.sony.de/electronics/support/articles/00161421

- increased dynamic range
- increased colour gamut
- SDR: 0.1 – 100 cd/m²
- HDR: 0.0005 – 10 000 cd/m²

Motivation and Objectives

- Graphically effect overlays, scoreboards, lower thirds, station logos, …



Motivation and Objectives

- Graphically effect overlays, scoreboards, lower thirds, station logos, …
- Integrate graphics in a non-distracting or disruptive, but an aesthetically pleasing way
- SDR: preferred luminance for graphics between 90 % and 100 % video level
  - Assumption made in advance based on SDR reference white level
- Hypothesis for HDR: Graphics perception change due to the increased dynamic range of the content → luminance that viewers prefer and want changes

Motivation and Objectives

- Topic remains largely untreated or superficial (in publicly available sources)
  - Graphics white level is recommended to be the same as reference white level: 203 cd/m²
    (ITU BT.2408 Guidance for operational practices in HDR television production, 2023, p.5 & 25)
  - “für Schriften im Speziellen haben sich Leuchtdichten von 100 –400 cd/m² bewährt”
    (Deutsche TV-Plattform e.V., 2022, p. 25)
  - “mindestens 200 cd/m² für Schriften und Logos” (ZDF, 2023)
  - No acceptance of material with texts or graphics “die ohne dramaturgischen Grund Leuchtdichten von weit über 400 nits [cd/m²] erzielen” (Witte, 2022, p.24)
- How does the human perception really behave in this case?

Motivation and Objectives

Research questions:

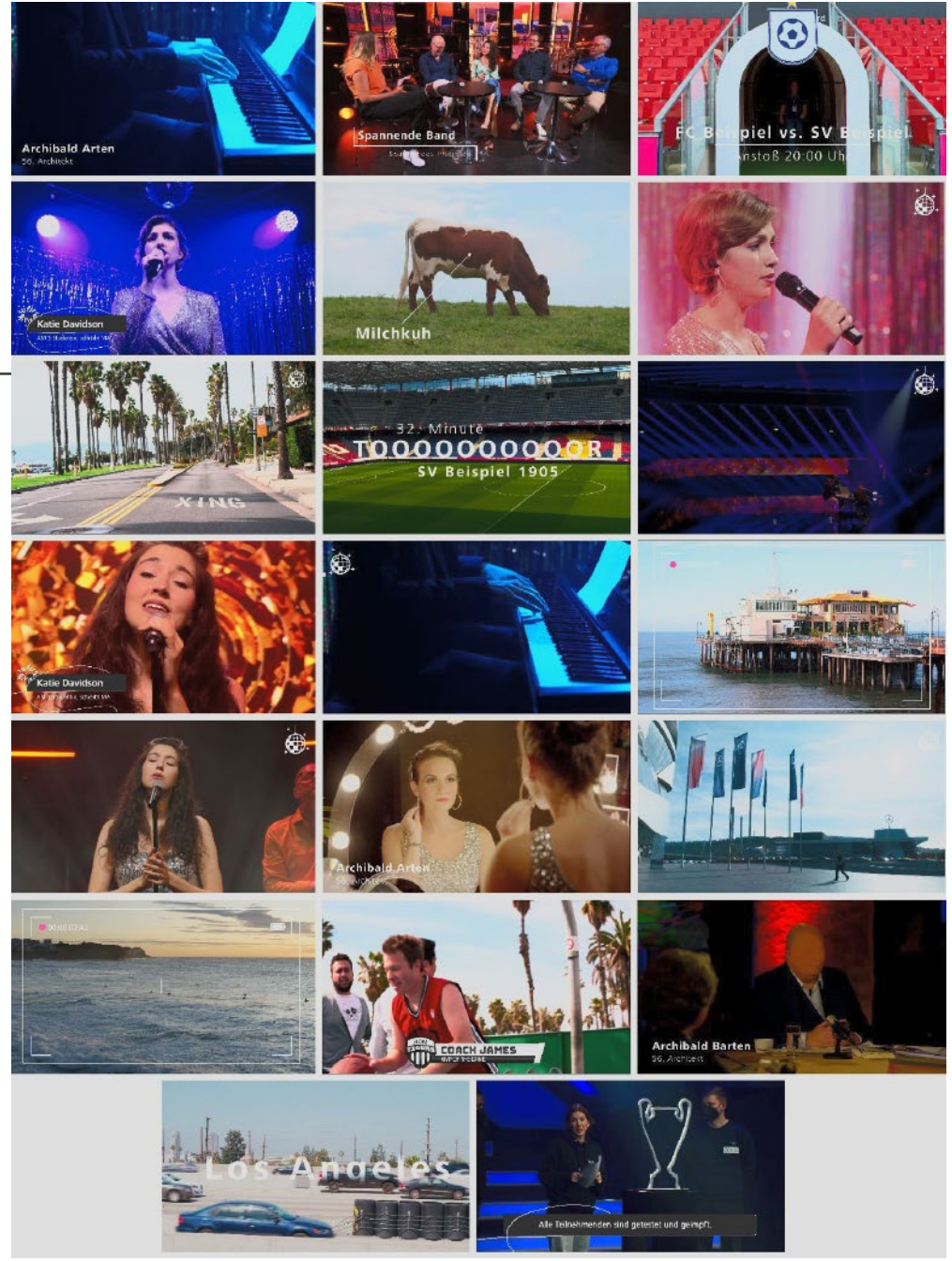
1. Does HDR influence the perception of graphic overlays and can differences be identified compared to SDR?
2. Can a recommendation be made whether the grading of graphics in HDR could be based on one of the methods of calculating average luminance discussed in this thesis?

Methods

- Two studies: SDR and HDR
  - SDR: 2.4 Gamma / BT.709 / Reference White: 100 cd/m²
  - HDR: ST2084 / BT.2020 / Reference White: 203 cd/m²
- Same clips with the same graphics and same participants for both HDR and SDR
  - 20 clips from different contexts (factual footage, sports or show context subjectively selected)
- Focus is on the luminance of the graphics
  - Prevention of perceptual effects such as Helmholtz-Kohlrausch
    (more saturated colours appear brighter, although the luminance is the same as with less saturated colours)

Methods

- Used sequences with graphics
  - Partially changed in this illustrations for legal reasons
- Disco ball in the style of a station logo
- Animated texts, lower thirds, camera overlay
- Sequences are very different
  - Try to avoid harsh light changes and extreme show lighting within a sequence in order not to stress the participants



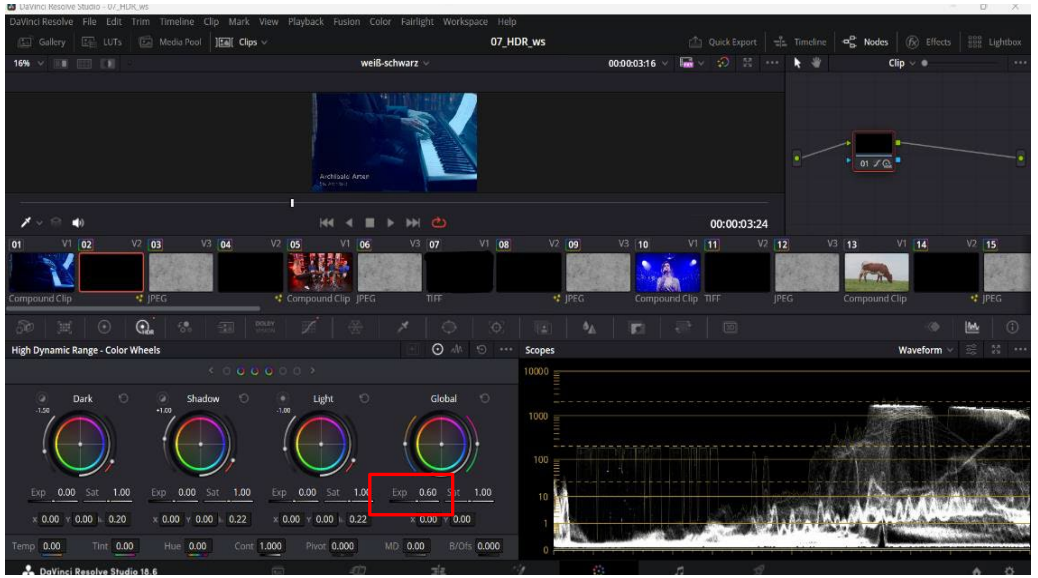
Methods

- Studies set up on a 55-inch LG OLED 4K TV
  - TV shows video feed with graphics
- Room was darkened, wall behind the TV was additionally illuminated
  - According to ITU BT.2100 total of 5 cd/m² is achieved
    (Image parameter values for high dynamic range television for use in production and international programme exchange)
- Keyboard connected to the PC

Viewpoint of the study participants

Methods

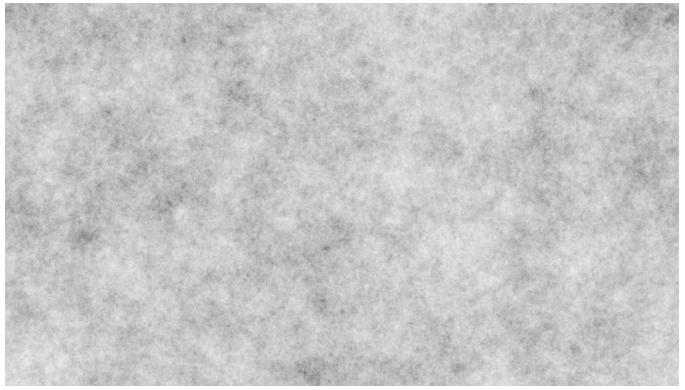
- 30 participants from age 21 to 75
- Their task: adjusting the graphics so that they appeared white, not glaring or grey
- Intentional decision for *Method of Adjustment*
  - No influence, e.g. through predefined brightness levels
  - Graphics start at different levels of luminance
  - 15 Participants: bright, dark, bright, …
  - 15 Participants: dark, bright, dark, …



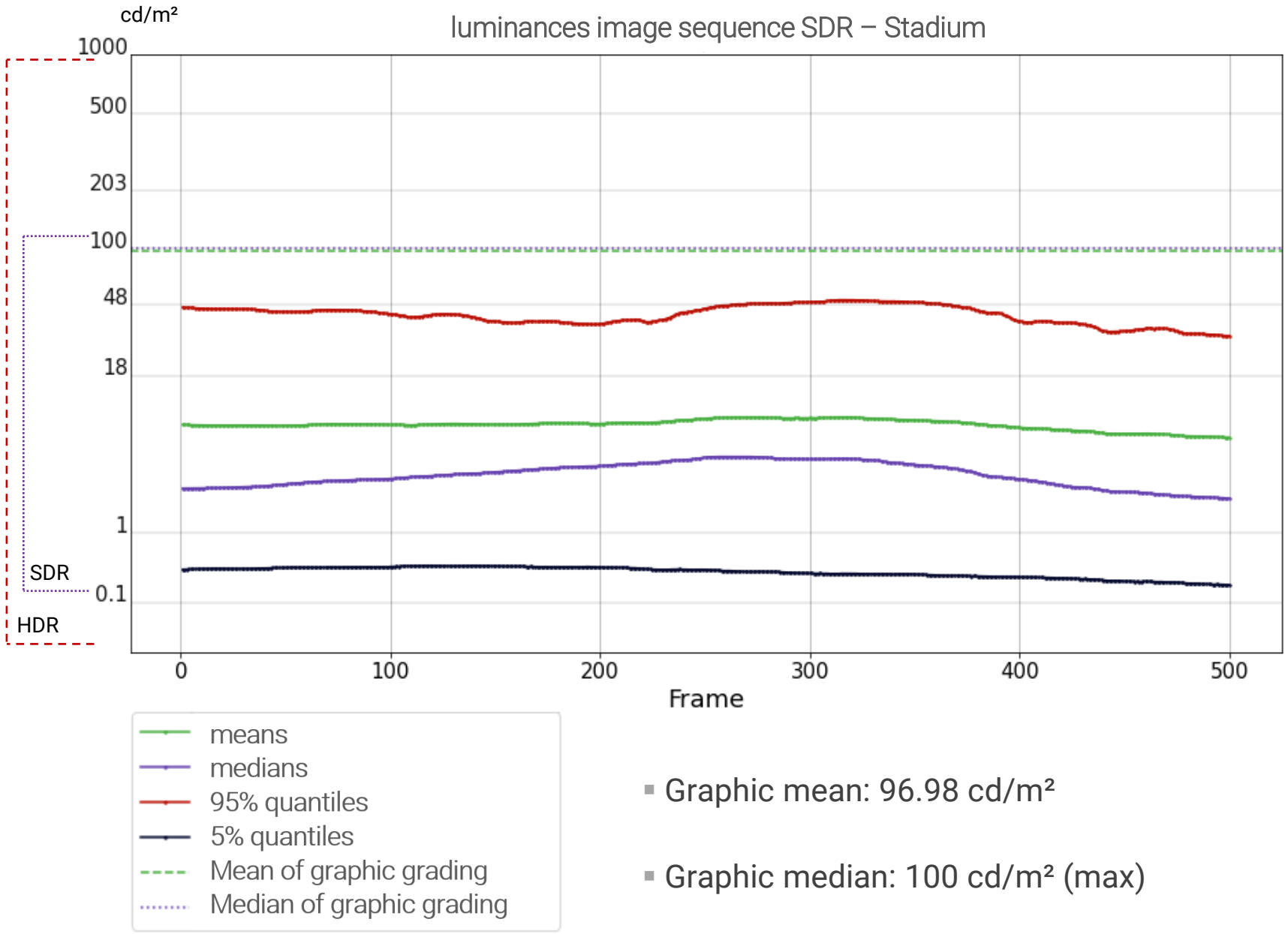
Viewpoint of the study director

Methods

- Clips with graphics 10 seconds long, but looped
- TV used can only display a range up to 1000 cd/m²
- Calculations for image sequences (executed in Python):
  - Mean – mathematical average of the luminance
  - Median – the point where 50 % of all values are above and below
  - 95%-quantile – 95 % of all values are below, 5 % above
  - 5%-quantile – 5 % of all values are above, 95 % below

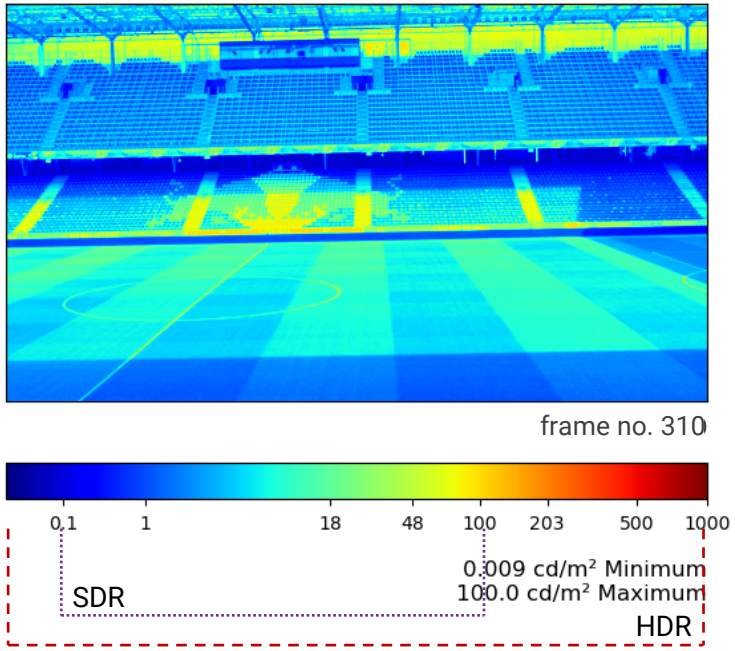


18 cd/m² 1/f-noise for adaptation



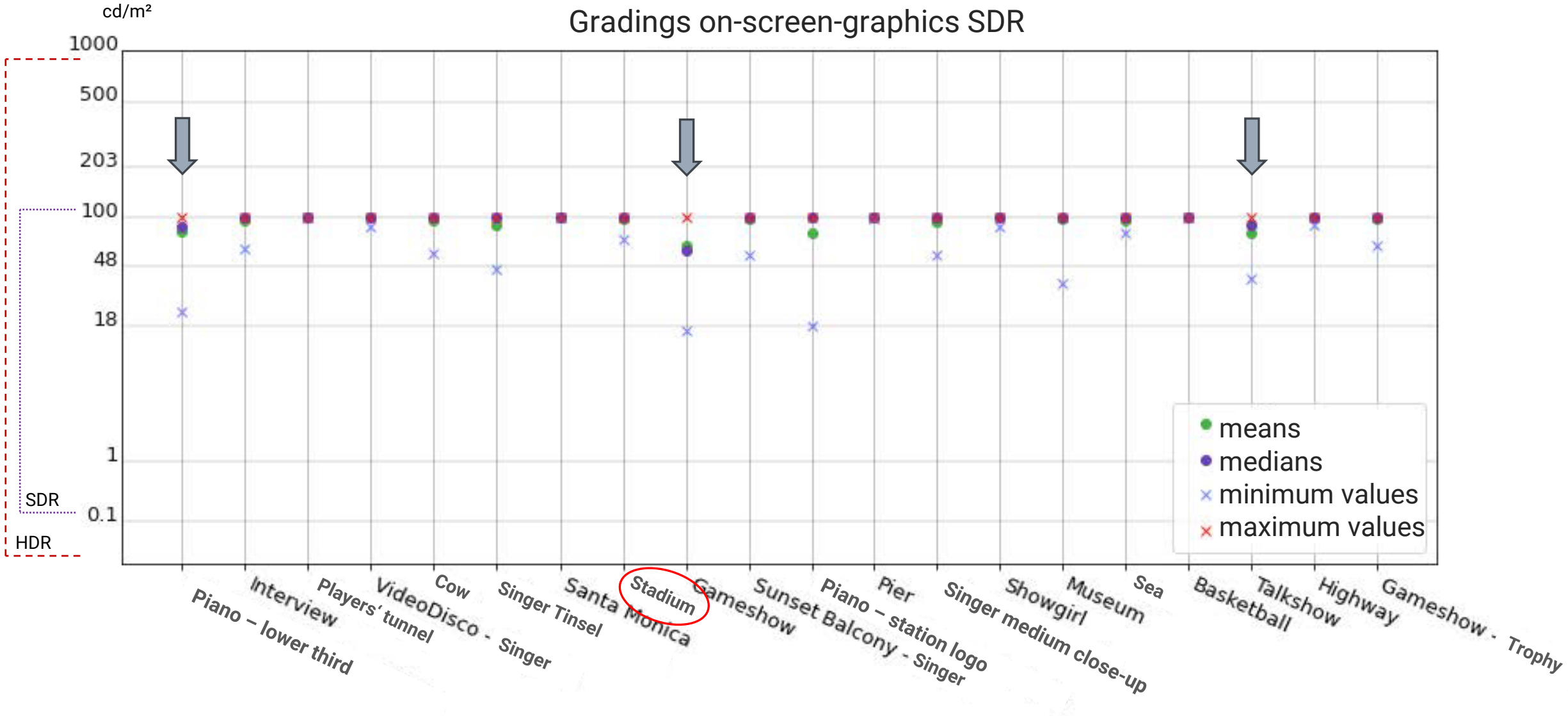
- Graphic:

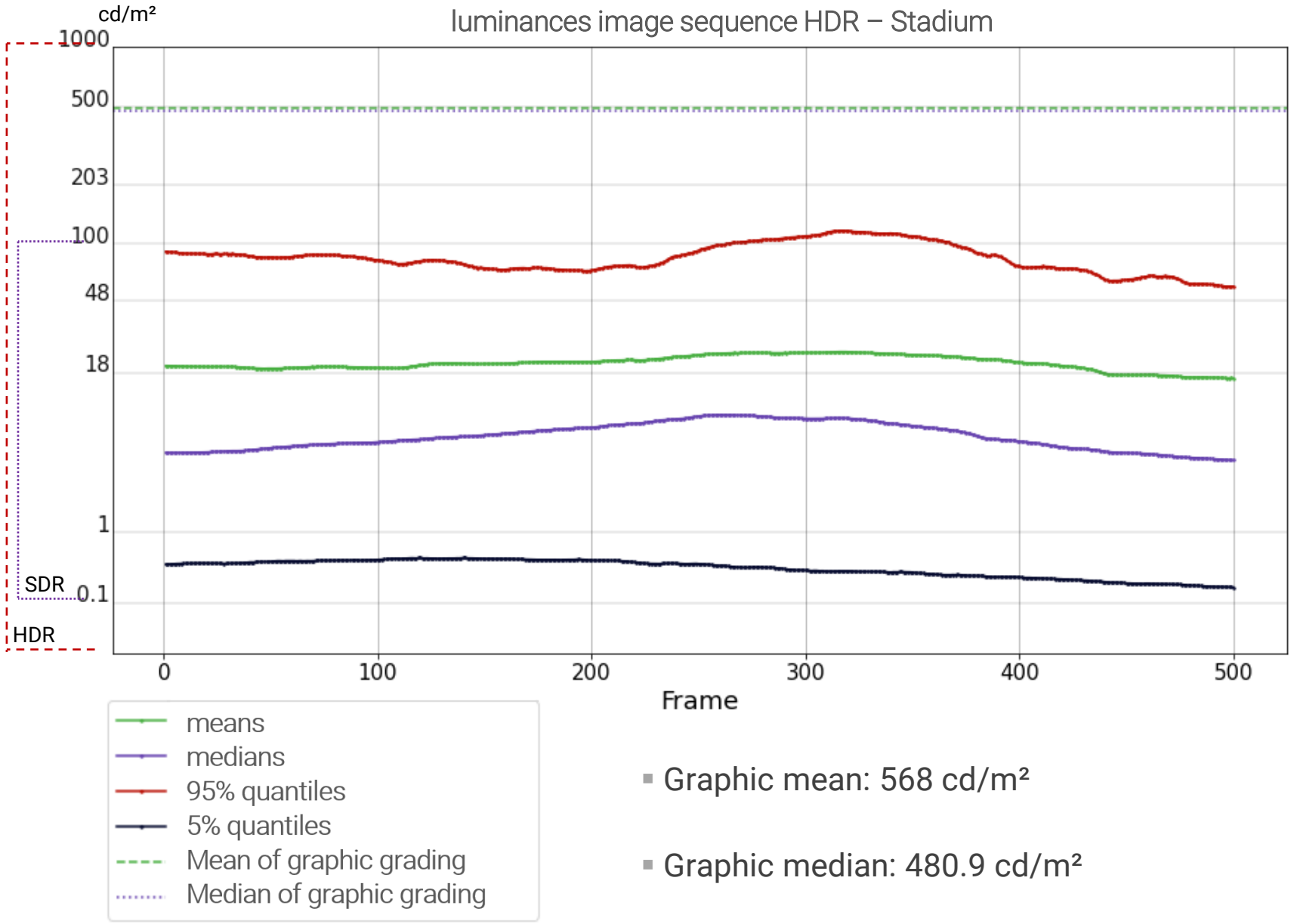
  Title over the complete image



- Graphic mean: 96.98 cd/m²
- Graphic median: 100 cd/m² (max)

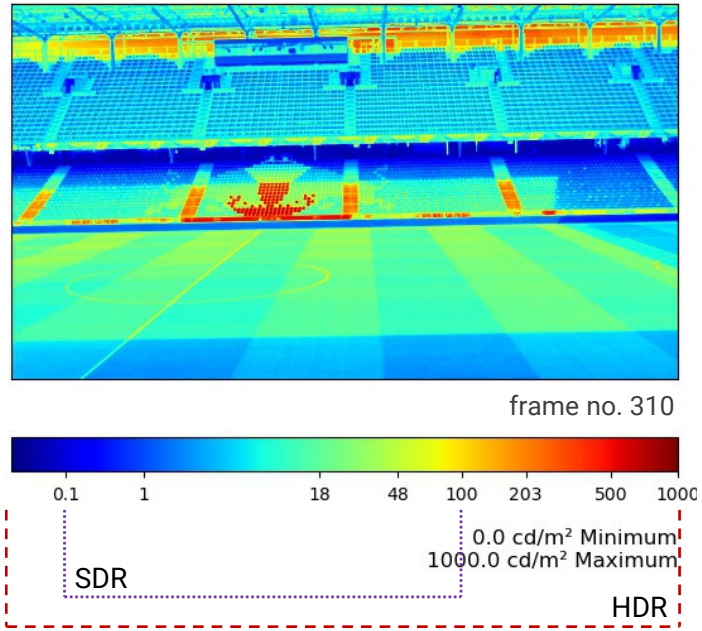
Gradings on-screen-graphics SDR



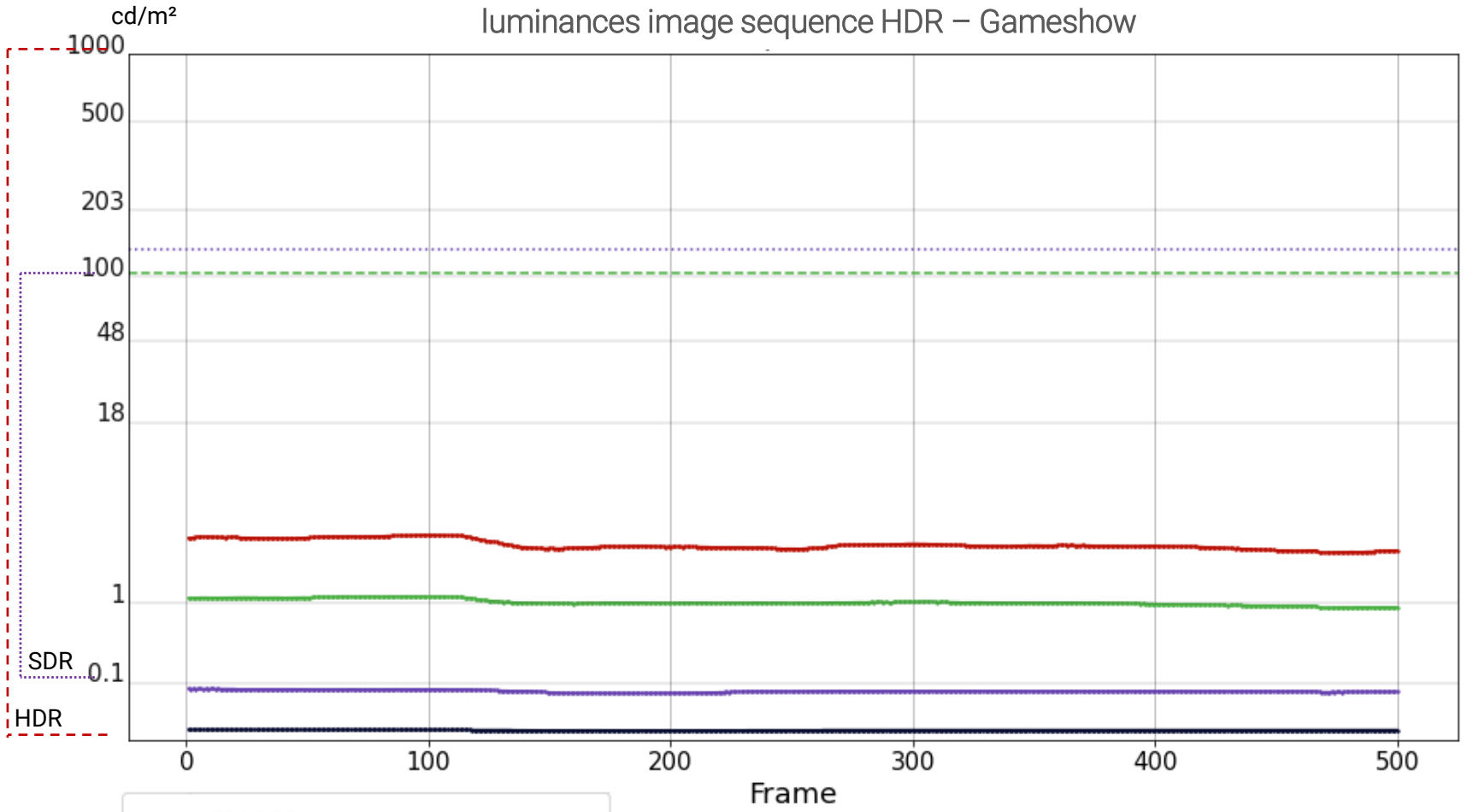


- Graphic:

  Title over the complete image

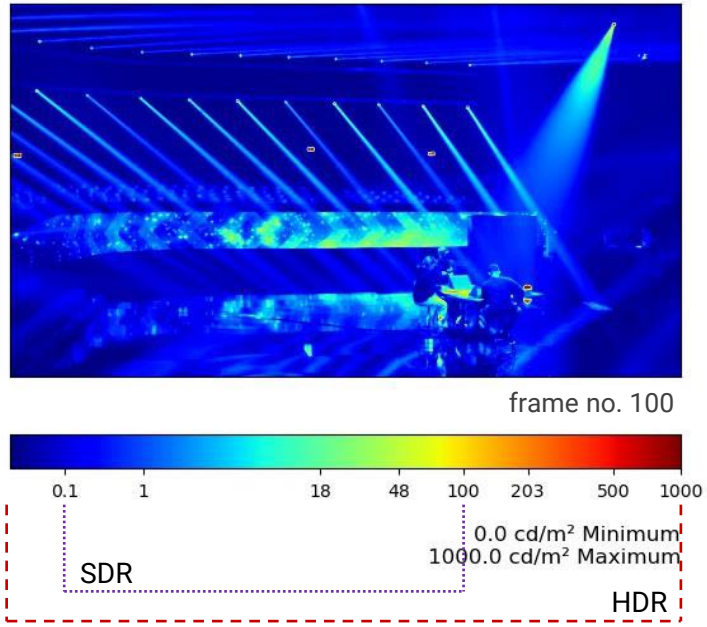


- Graphic mean: 568 cd/m²
- Graphic median: 480.9 cd/m²

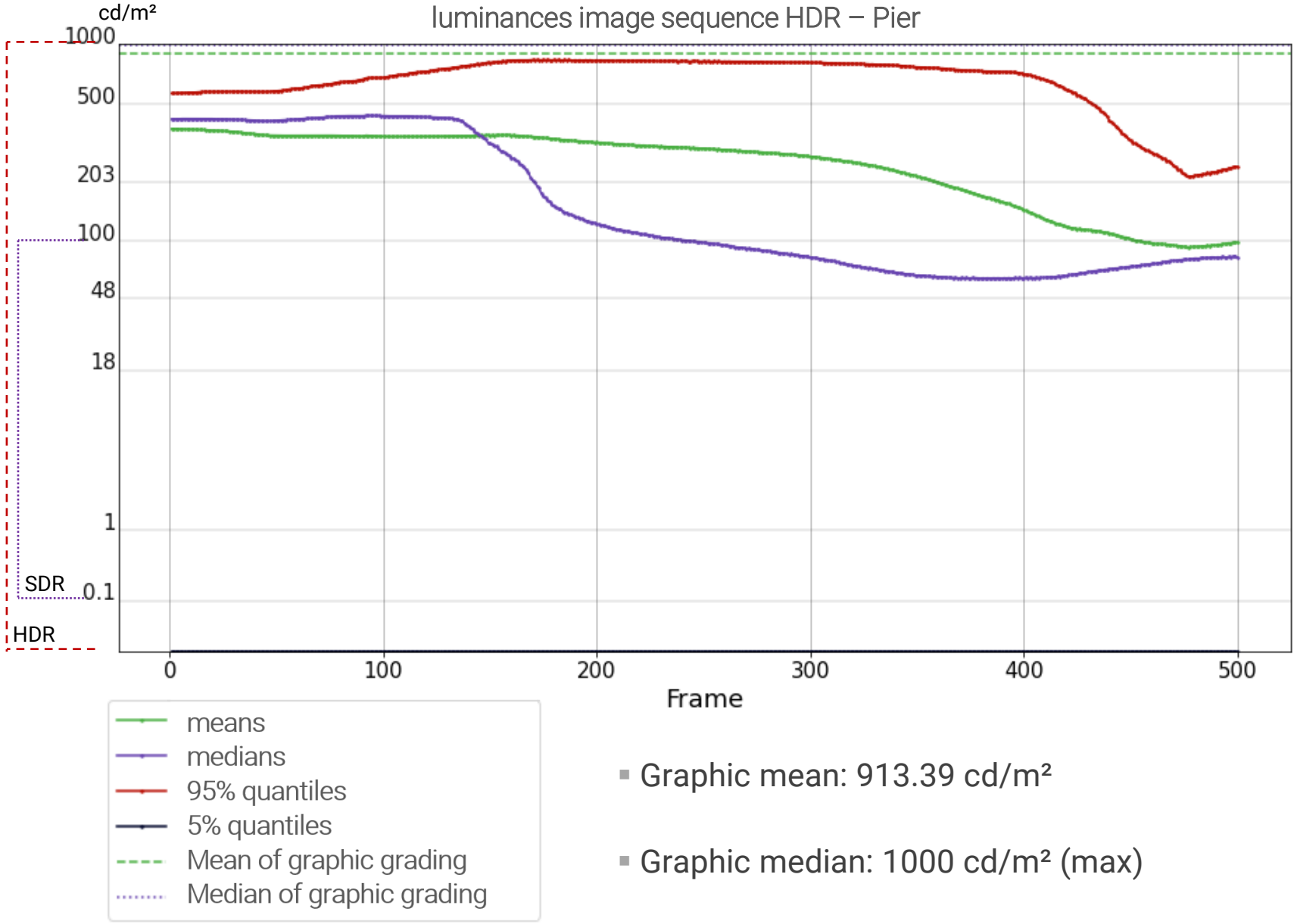


- Graphic:

  Station logo (top right)

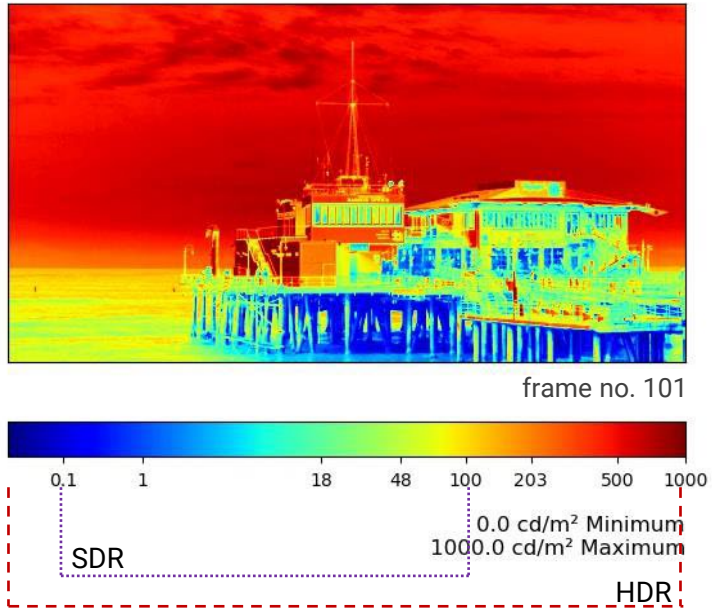


- Graphic mean: 154.9 cd/m²
- Graphic median: 135.96 cd/m²
- Darkest grading of the entire study: 3.46 cd/m²

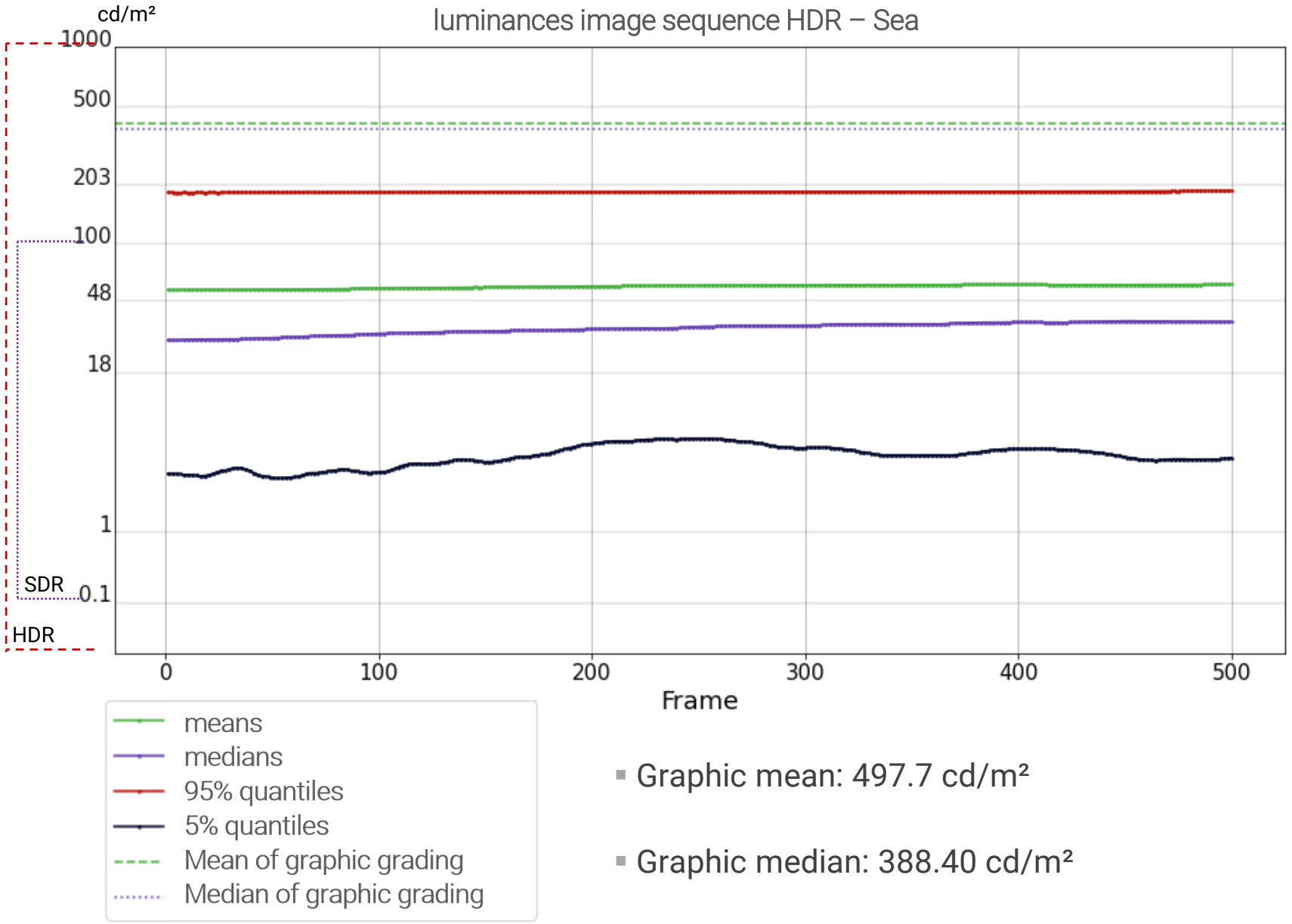


- Graphic:

  Camera overlay



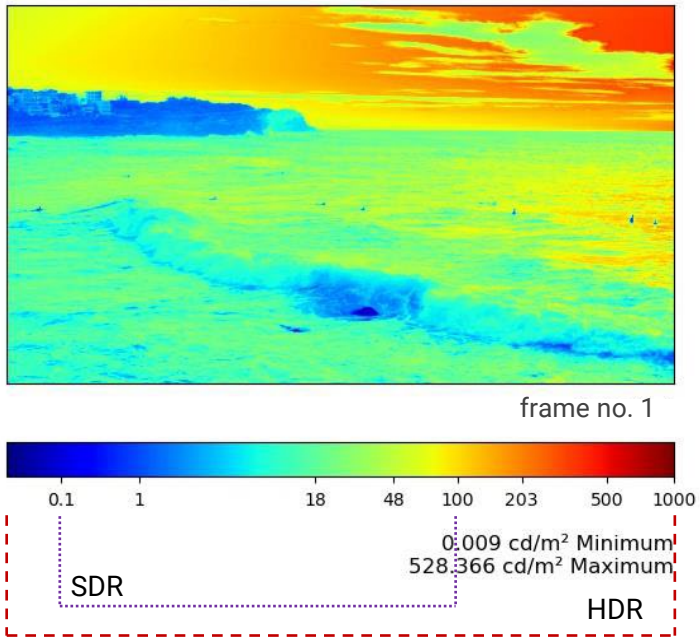
- Graphic mean: 913.39 cd/m²
- Graphic median: 1000 cd/m² (max)

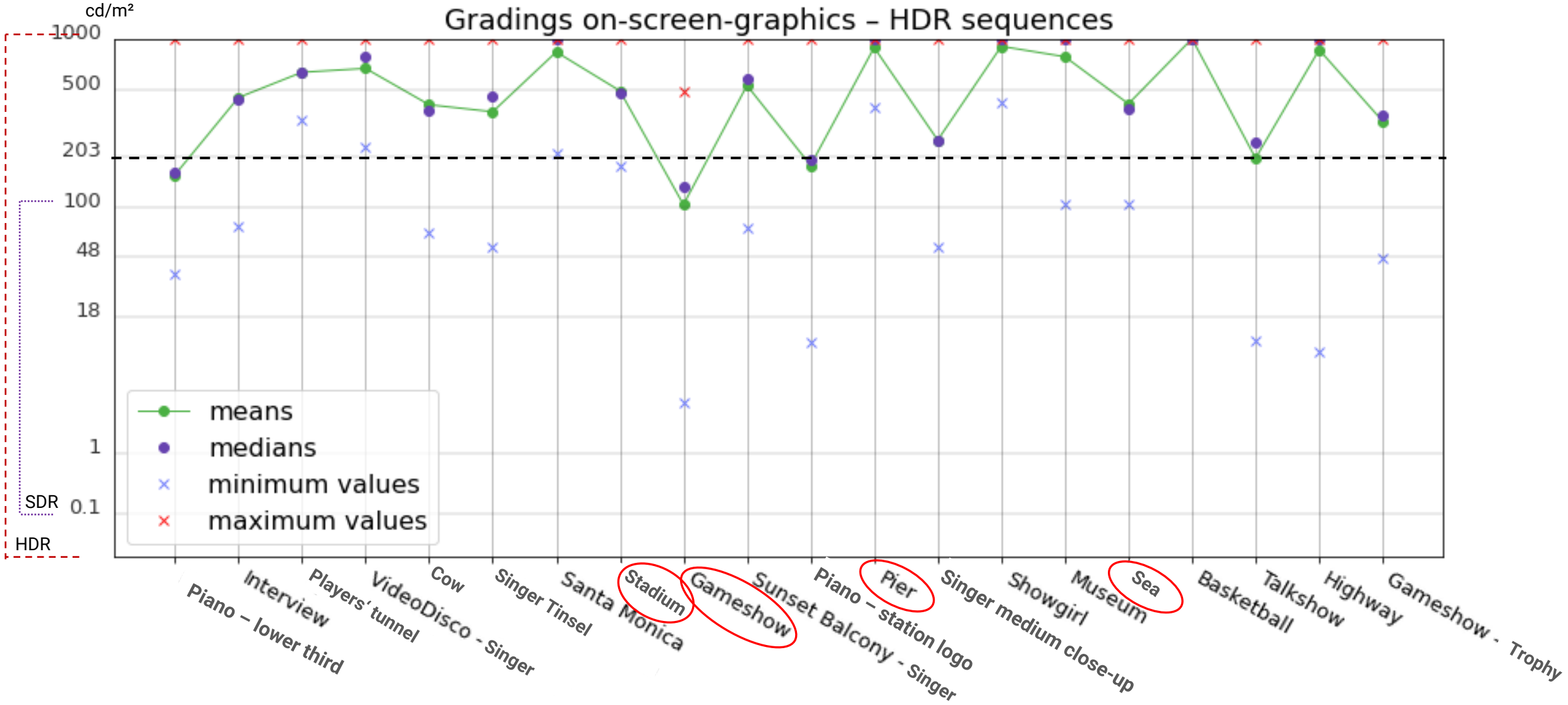


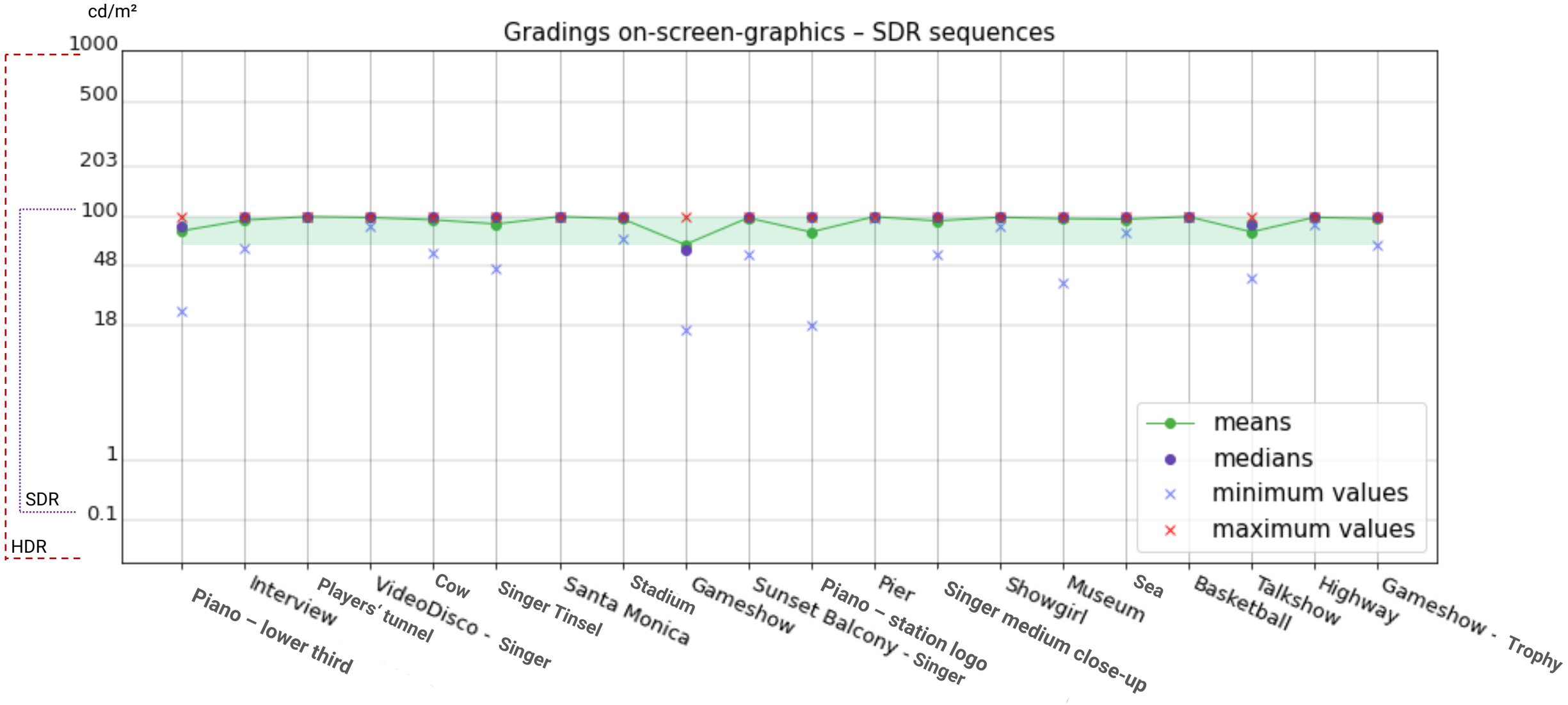
- Graphic mean: 497.7 cd/m²
- Graphic median: 388.40 cd/m²

- Graphic:

  Camera overlay




Gradings on-screen-graphics – HDR sequences
cd/m²
1000
500
203
100
48
18
1
0.1
SDR
HDR
means
medians
minimum values
maximum values
Piano – lower third
Interview
Players' tunnel
VideoDisco - Singer
Cow
Singer Tinsel
Santa Monica
Stadium
Gameshow
Sunset Balcony - Singer
Piano – station logo
Pier
Singer medium close-up
Showgirl
Museum
Sea
Basketball
Talkshow
Highway
Gameshow - Trophy


cd/m²
Gradings on-screen-graphics – SDR sequences
1000
500
203
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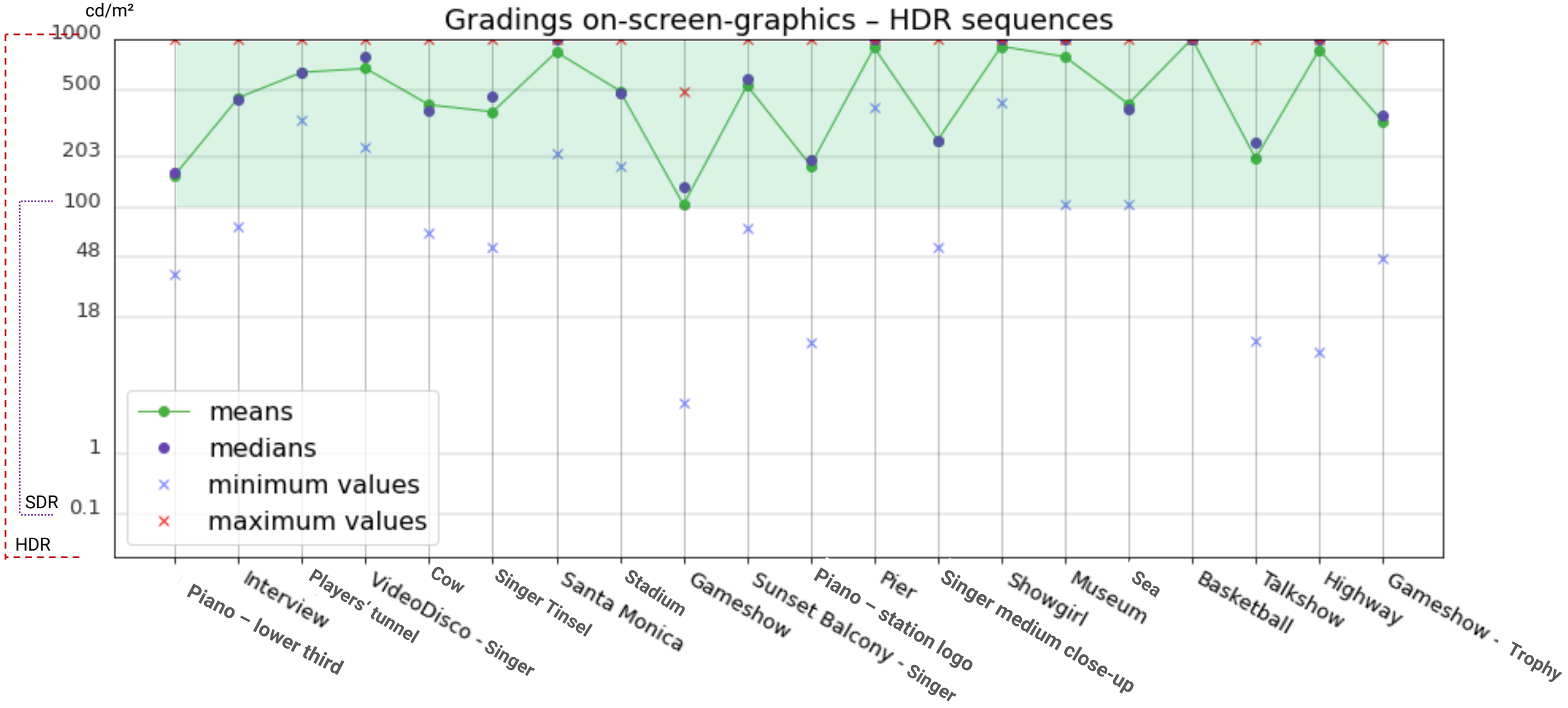
Gradings on-screen-graphics – HDR sequences
cd/m²
1000
500
203
100
48
18
1
0.1
SDR
HDR
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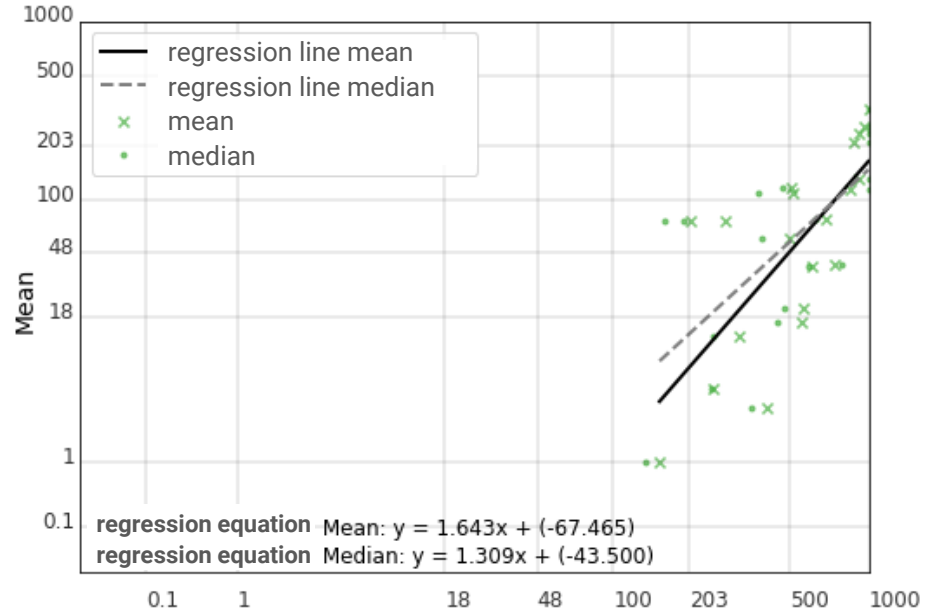
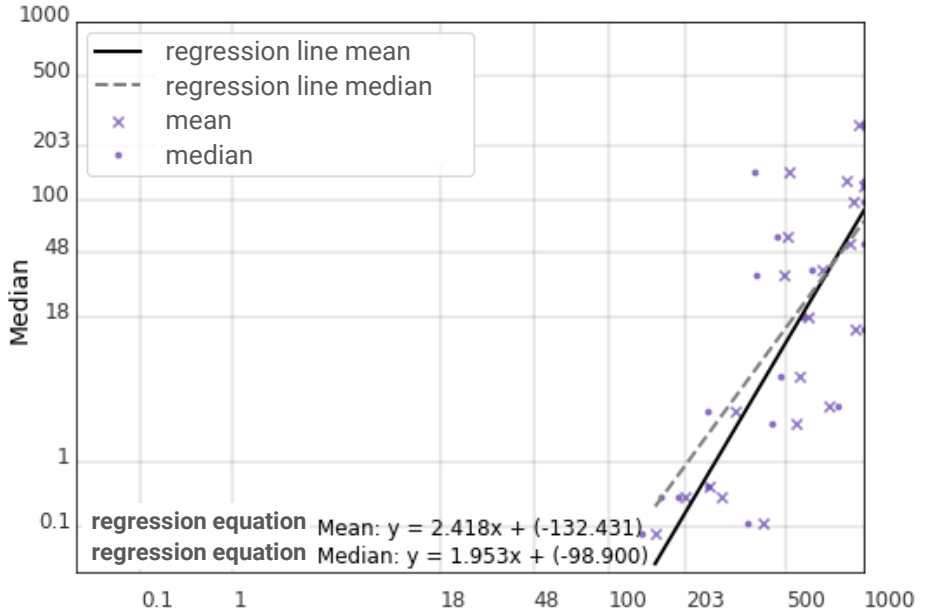
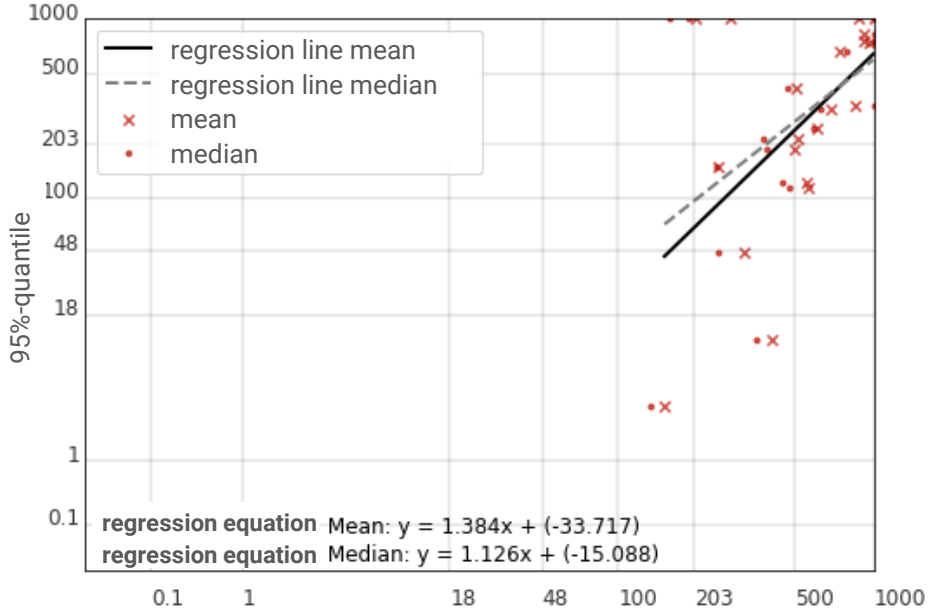
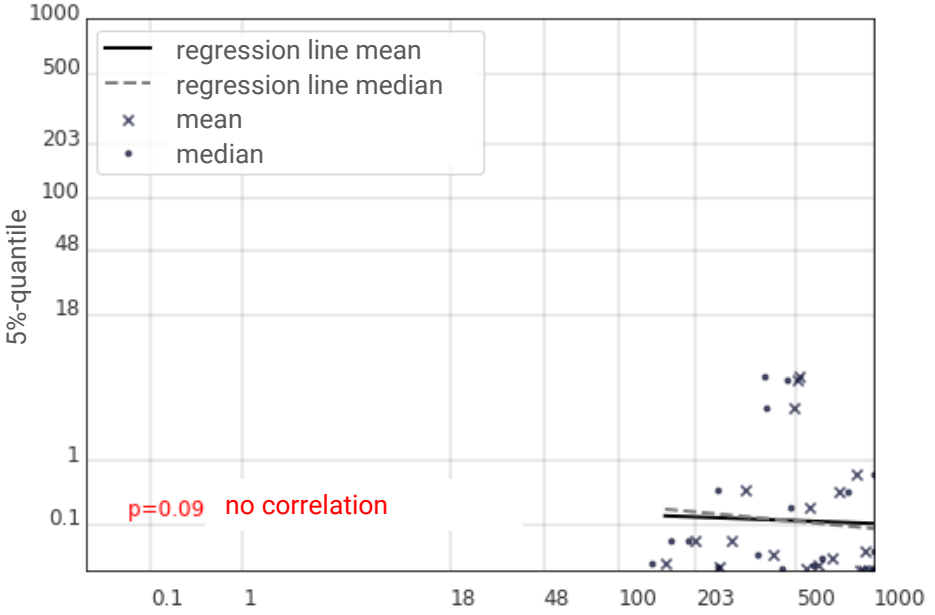
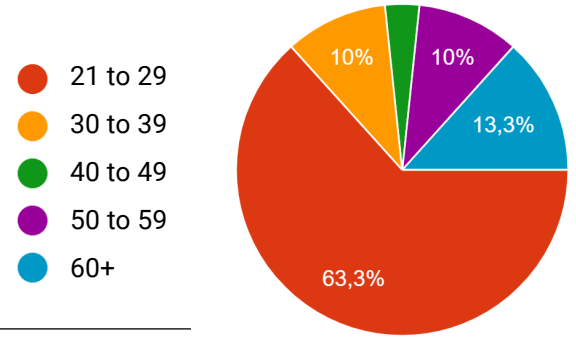

regression line mean
regression line median
mean
median
Mean
1000
500
203
100
48
18
1
0.1
regression equation Mean: y = 1.643x + (-67.465)
regression equation Median: y = 1.309x + (-43.500)
0.1
1
18
48
100
203
500
1000


regression line mean
regression line median
mean
median
Median
1000
500
203
100
48
18
1
0.1
regression equation Mean: y = 2.418x + (-132.431)
regression equation Median: y = 1.953x + (-98.900)
0.1
1
18
48
100
203
500
1000


regression line mean
regression line median
mean
median
95%-quantile
1000
500
203
100
48
18
1
0.1
regression equation Mean: y = 1.384x + (-33.717)
regression equation Median: y = 1.126x + (-15.088)
0.1
1
18
48
100
203
500
1000


regression line mean
regression line median
mean
median
5%-quantile
1000
500
203
100
48
18
1
0.1
p=0.09 no correlation
0.1
1
18
48
100
203
500
1000

Limitations



- 30 participants with an uneven distribution among the individual groups of people
  - Most participants (63.3 %) between the ages of 21 and 29
- Results are clipped due to the display maxing out at 1000 cd/m²
- Ambient and background lighting for the study is measured based on the ITU BT.2100

  (also recommended for viewers (Chalmers & Debattista, 2017, p. 52))
  - Same applies to the size of and the distance from the display
  - Real-life viewing conditions differ greatly

Further research

- Factors chrominance, colour and WCG should be examined and with a more diverse selection of graphics
- Important Topics:
  - Perceptual effects and how these effects influence the perception of graphics in HDR
  - Brand colours
  - Tonemapping

Conclusions – Research questions

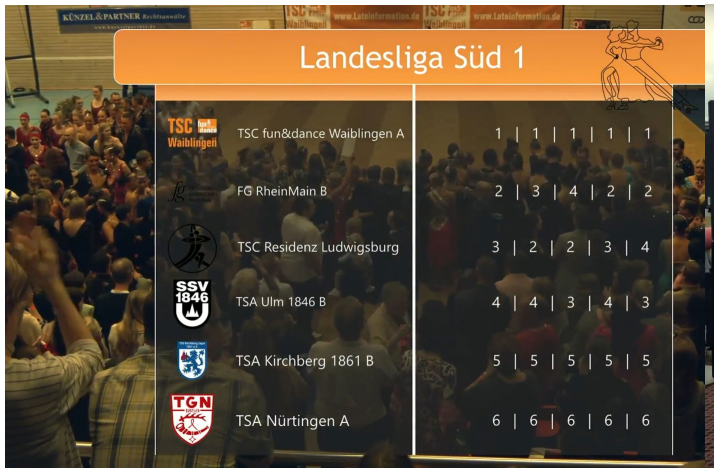
1. **Does HDR influence the perception of graphic overlays and can differences be identified compared to SDR?**
   - Minimum values show that glare can play a major role
     (viewers getting blinded by the graphics)
   - Maximum values provide indications that the visual clipping point of 1000 cd/m² was still not enough
     - (Daly et al., 2013) : Viewer satisfaction increases equally with the luminance of the highlights or diffuse white
     - As the luminances of the moving image material increase, the desired luminances of the graphic overlays would also increase due to the correlation established

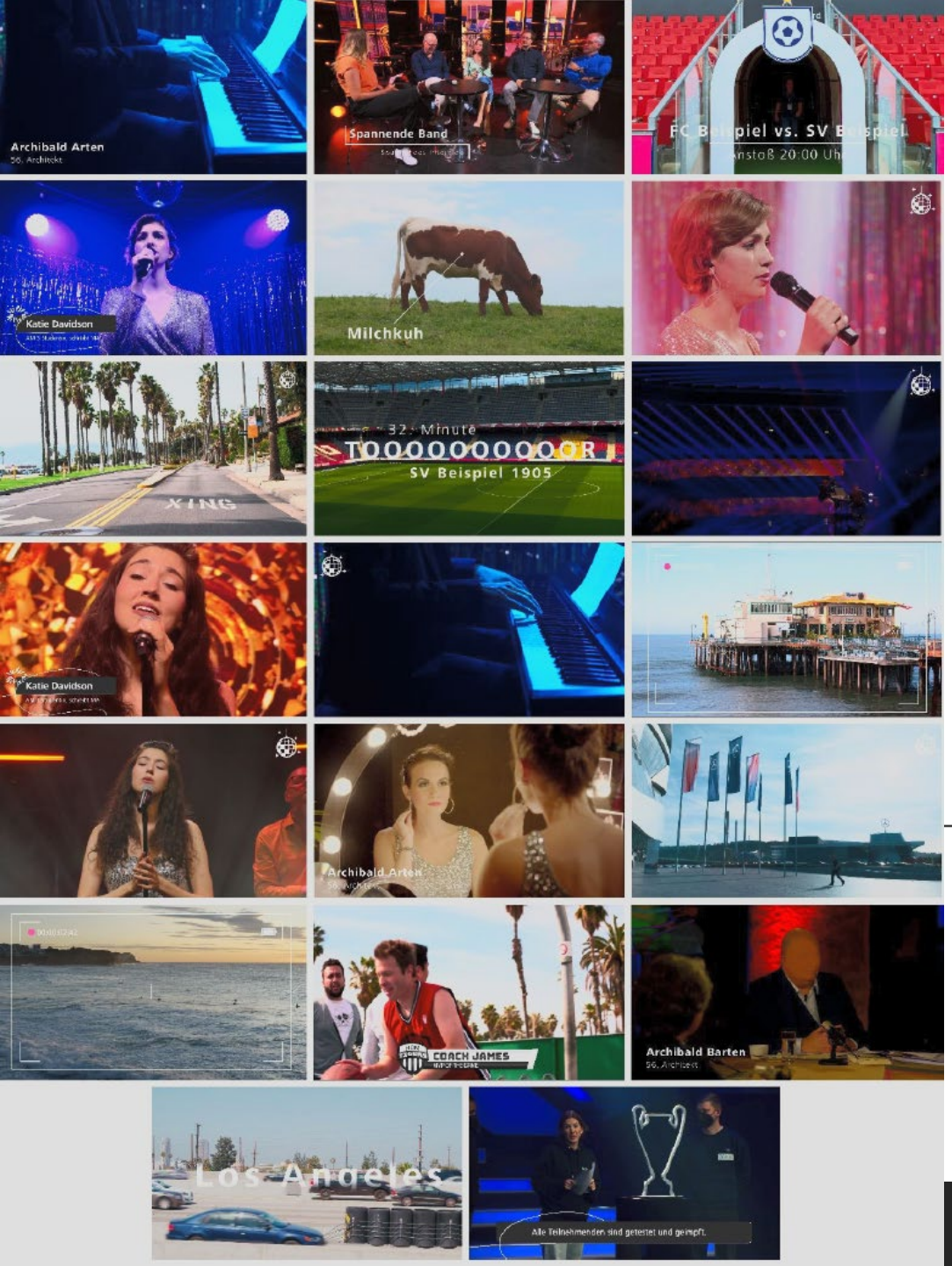
Conclusions – Research questions

2. **Can a recommendation be made whether the grading of graphics in HDR could be based on one of the methods of calculating average luminance discussed in this thesis?**
   - A statistically significant correlation is clearly present, most strongly between mean grading and mean of the image sequence

Conclusions

- There is an issue in HDR that does not exist in this way in SDR
- You have to adjust on-screen-graphics in HDR





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Supervisor Prof. Dr. Jan Fröhlich

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