

# Video Tone Mapping

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# Video Tone Mapping

- How do HDR videos behave when applying a TMO for each frame?

# Video Tone Mapping



Sigmoid TMO

# Video Tone Mapping



Sigmoid TMO

# Video Tone Mapping



Adaptive Logarithmic TMO

# Video Tone Mapping

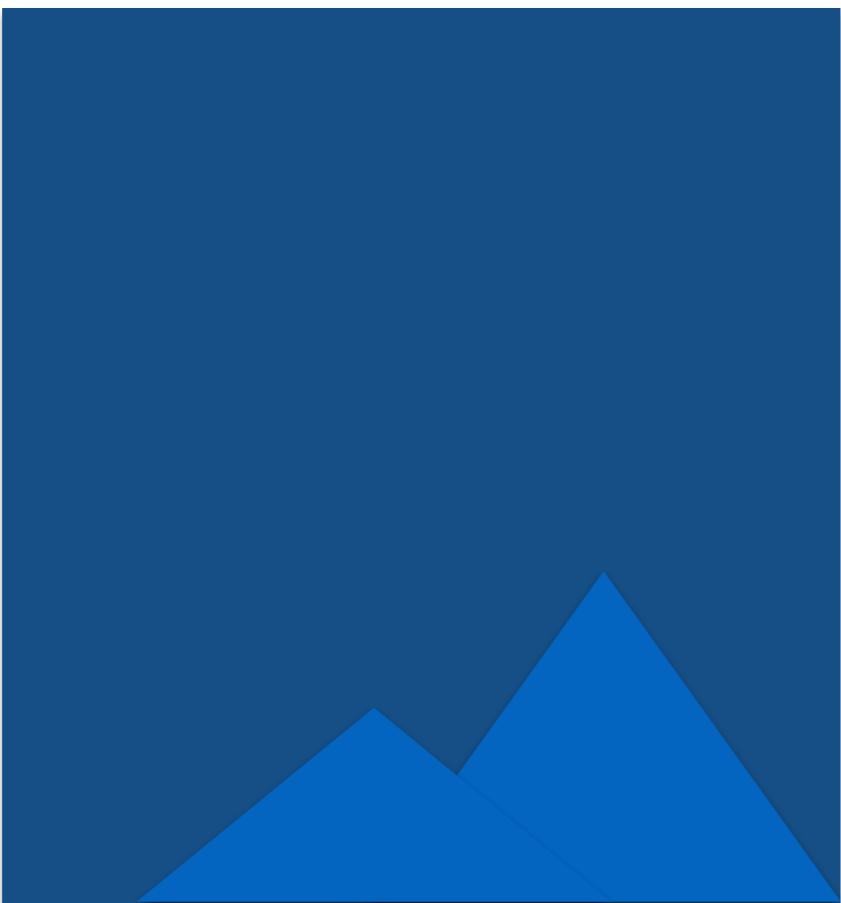


Adaptive Logarithmic TMO

# Video Tone Mapping

- The application of a TMO per frame may lead to temporal flicker
- Why?
  - Global statistics may suddenly change:
    - A bright area appears in the frame
    - A bright area disappears from the frame

# Video Tone Mapping

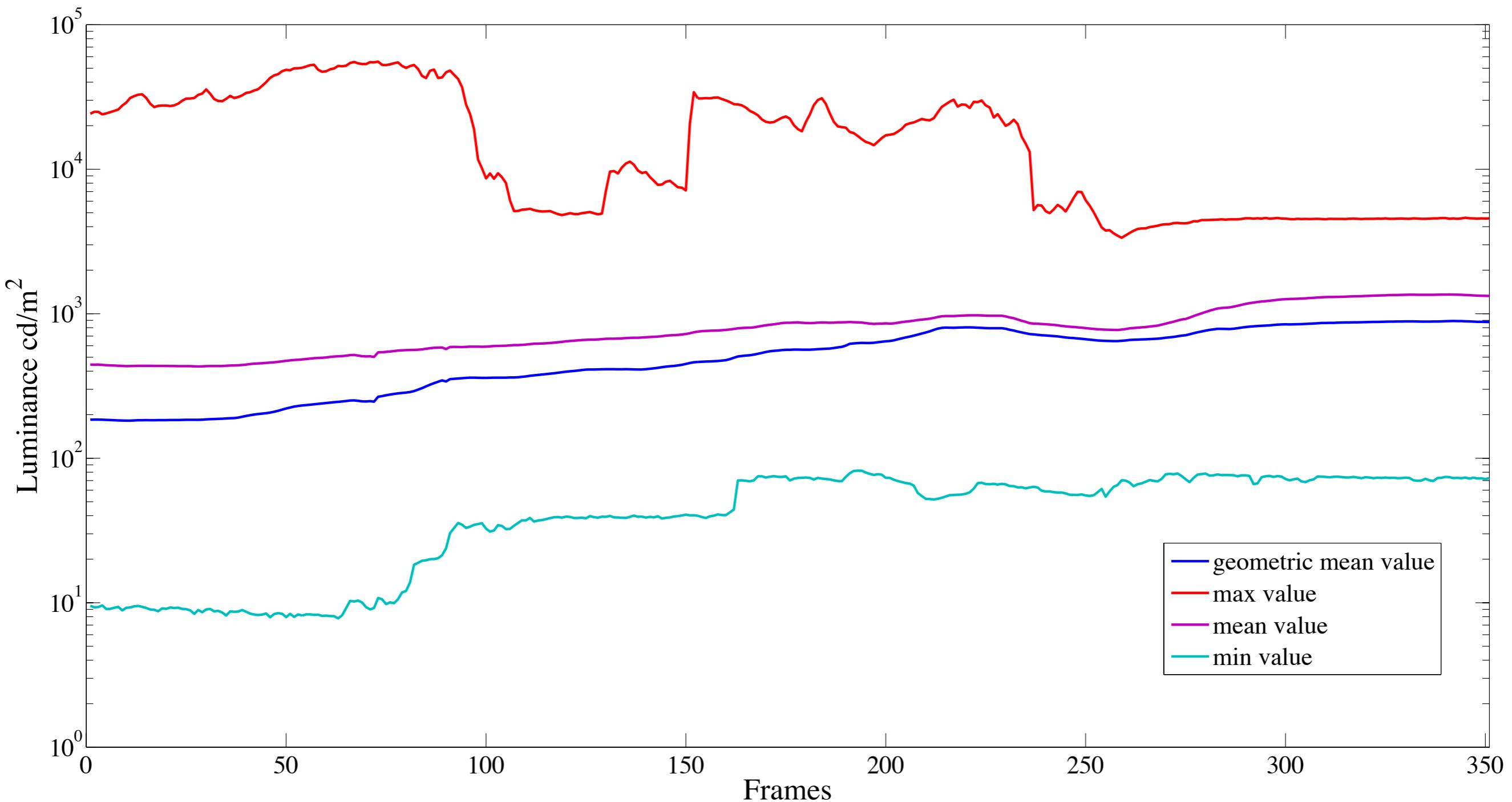


Frame t

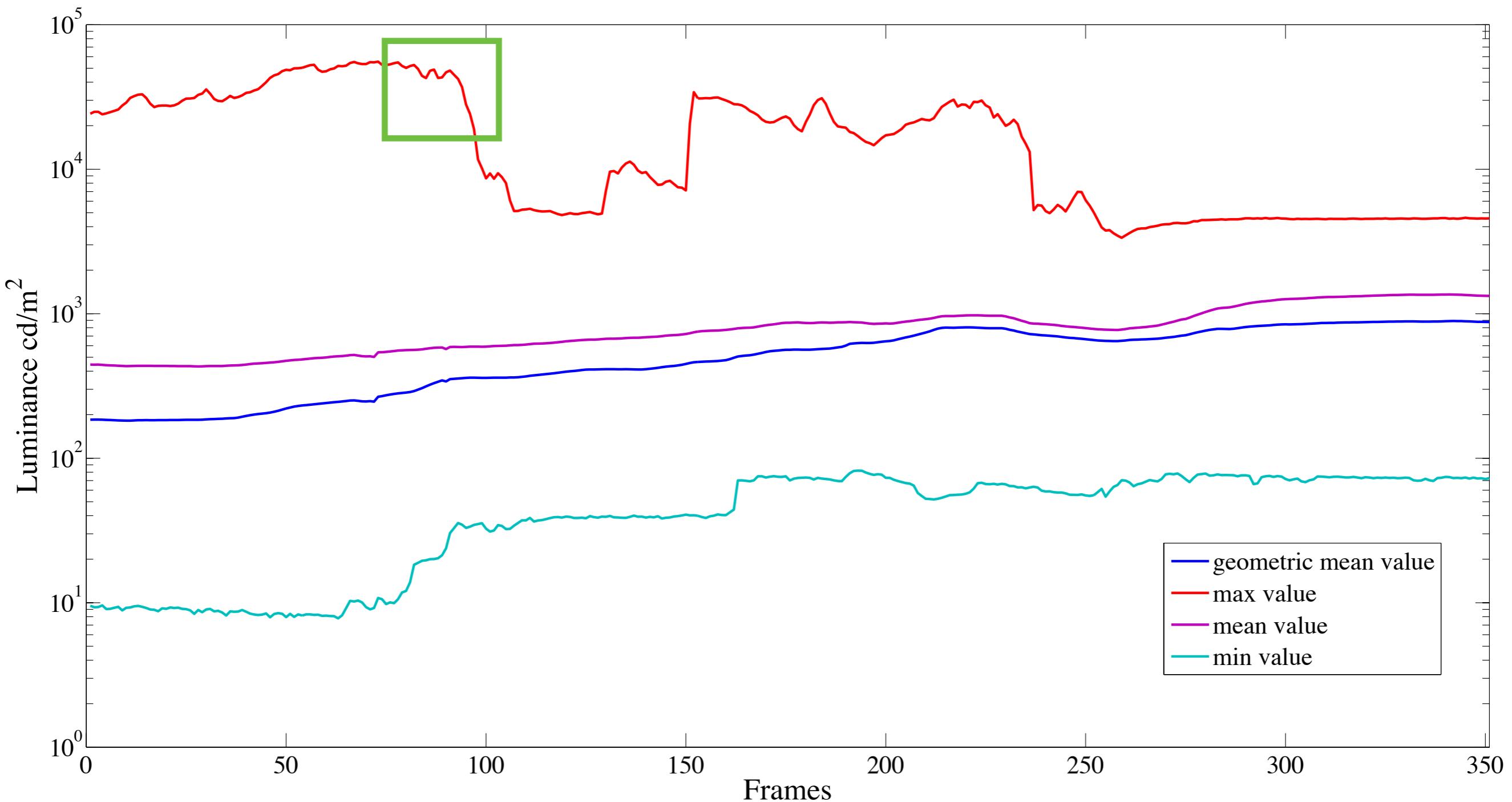


Frame t + 1

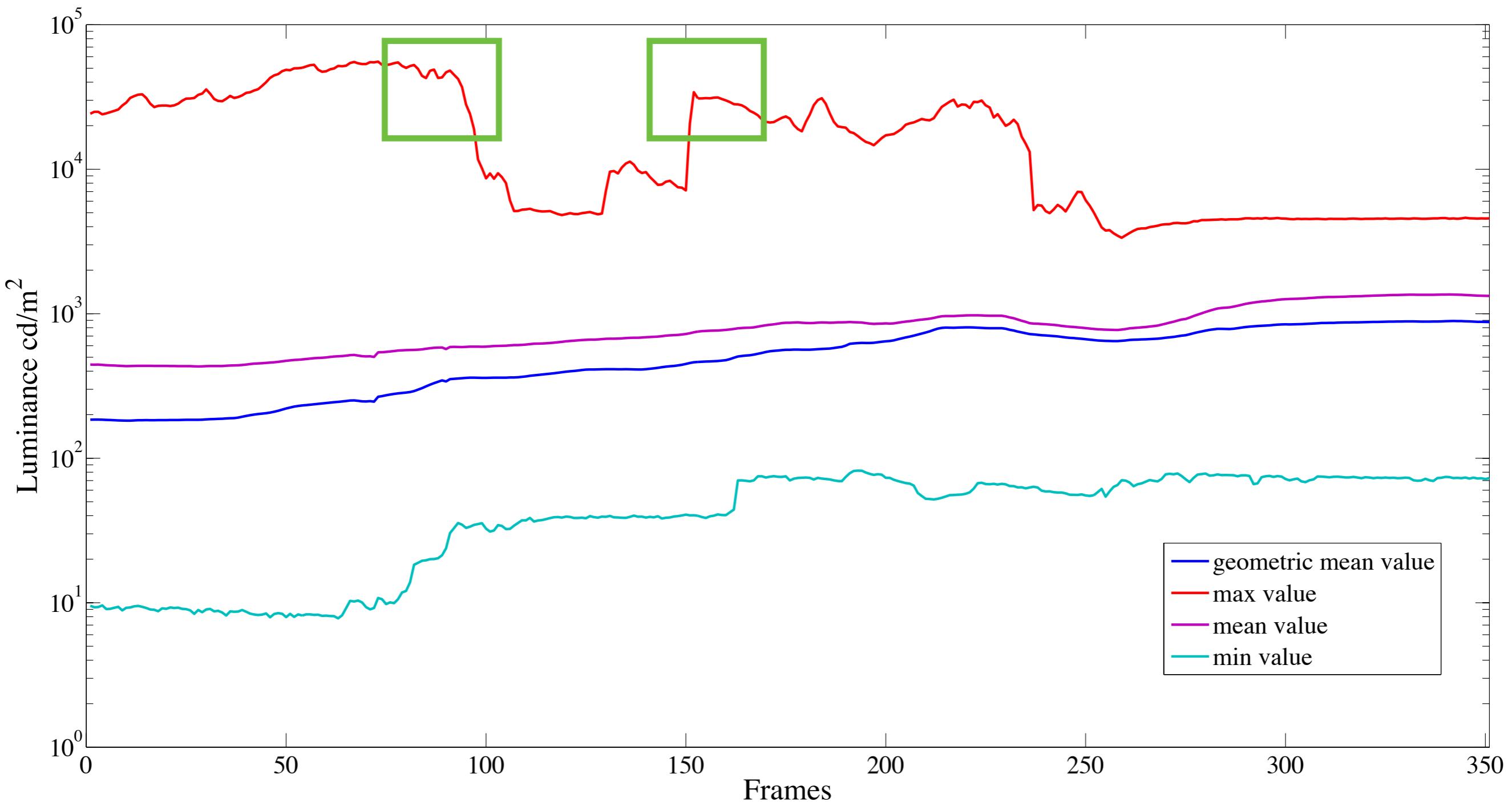
# Video Tone Mapping



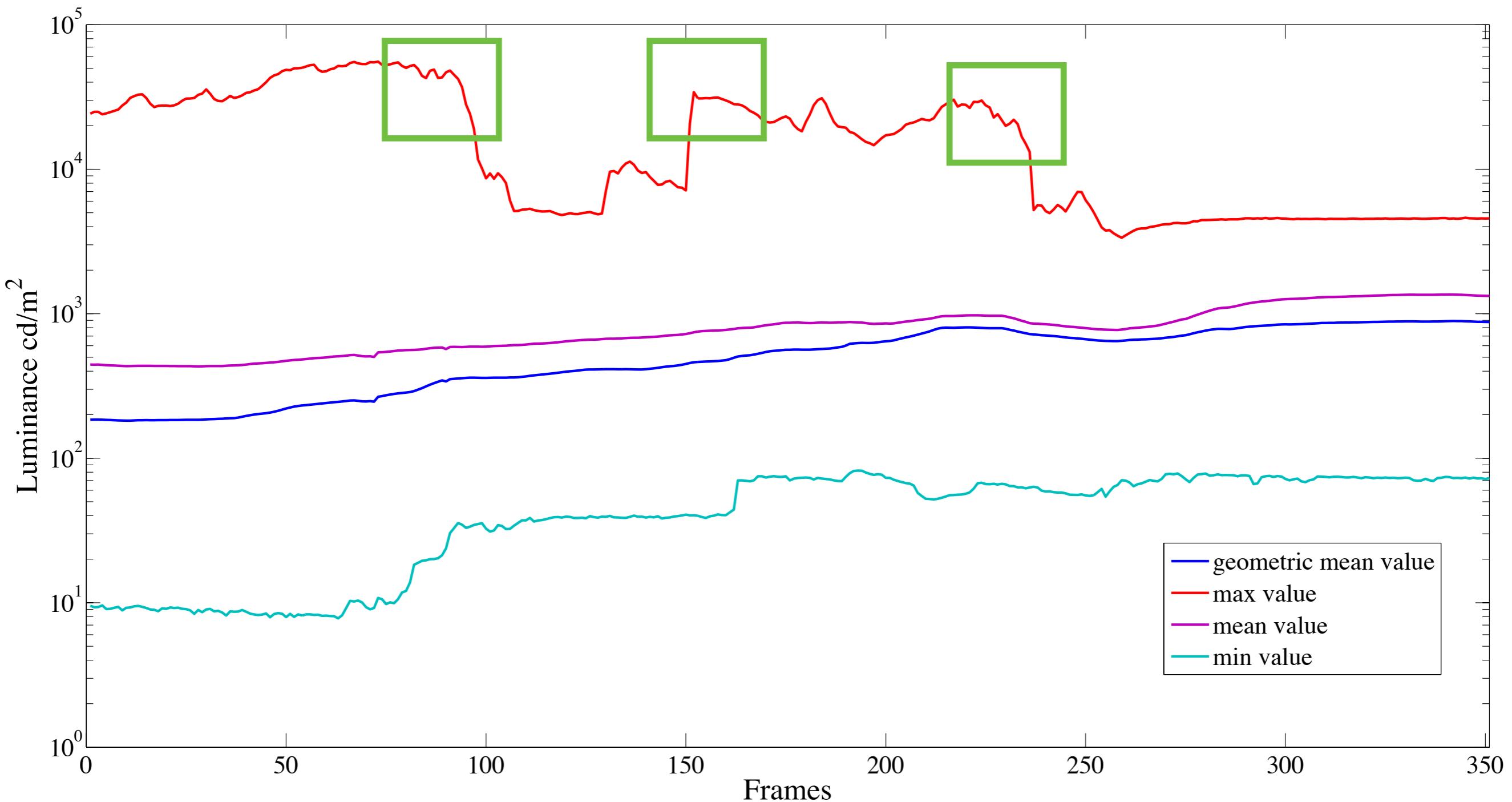
# Video Tone Mapping



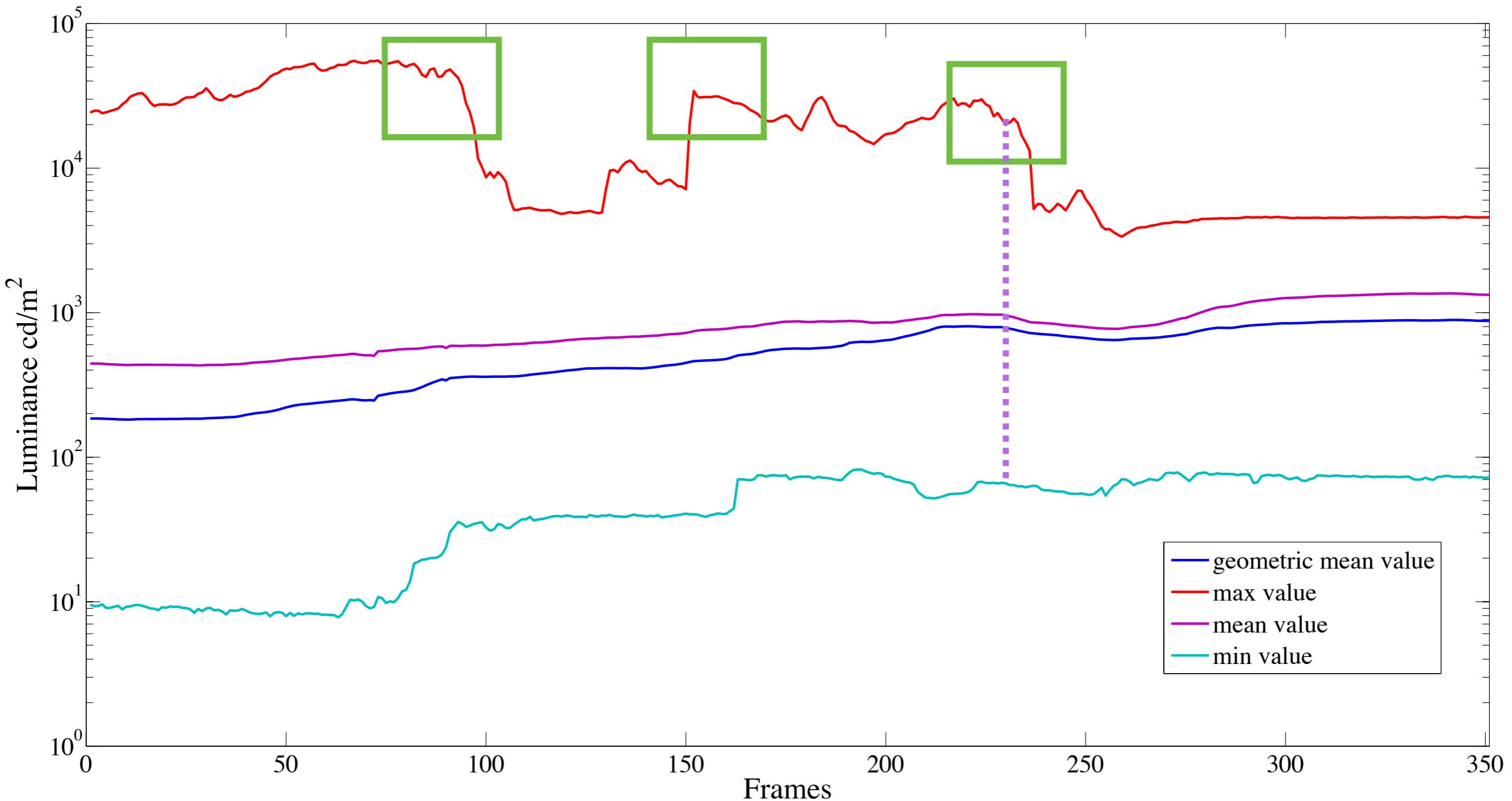
# Video Tone Mapping



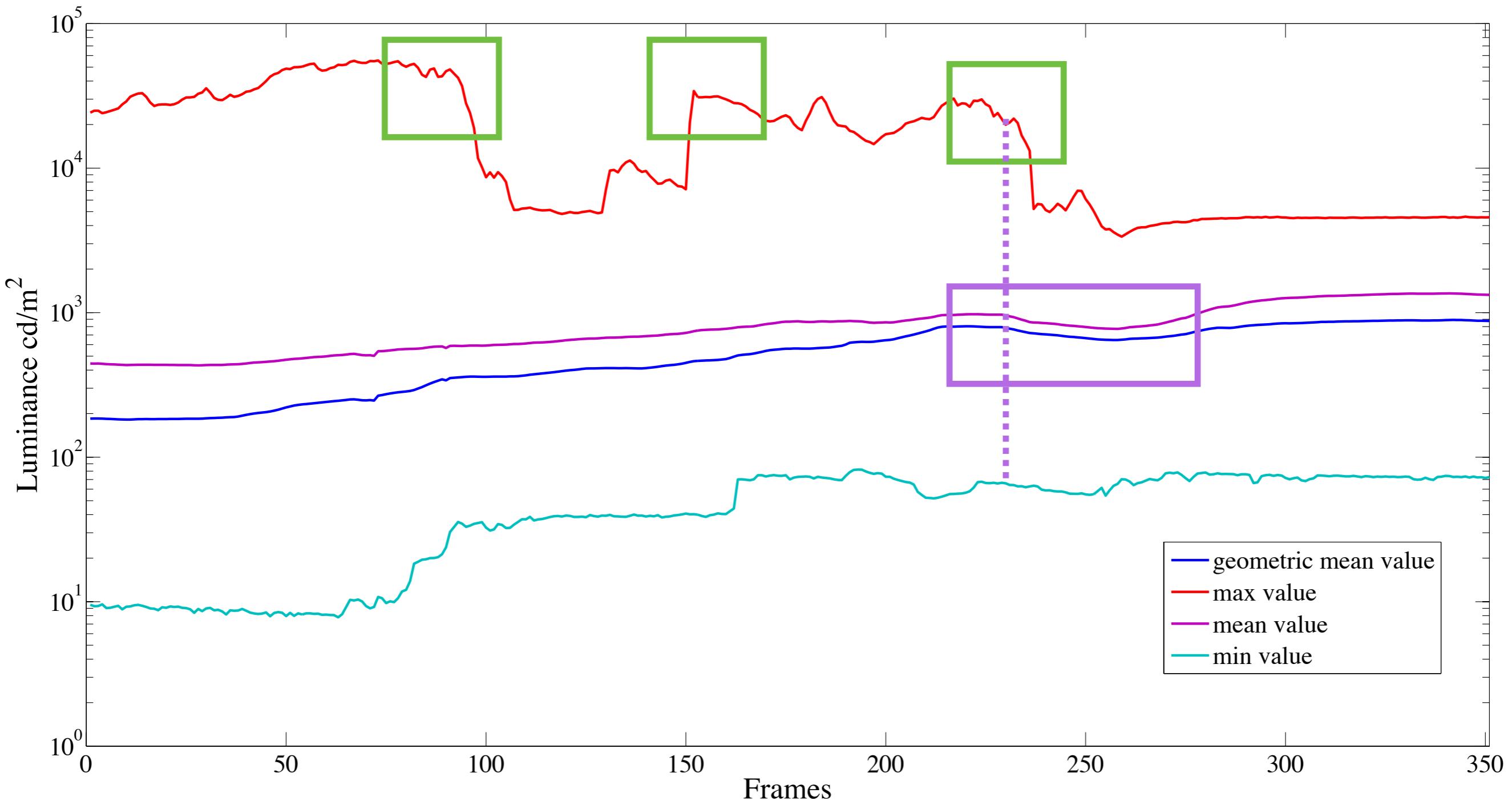
# Video Tone Mapping



# Video Tone Mapping



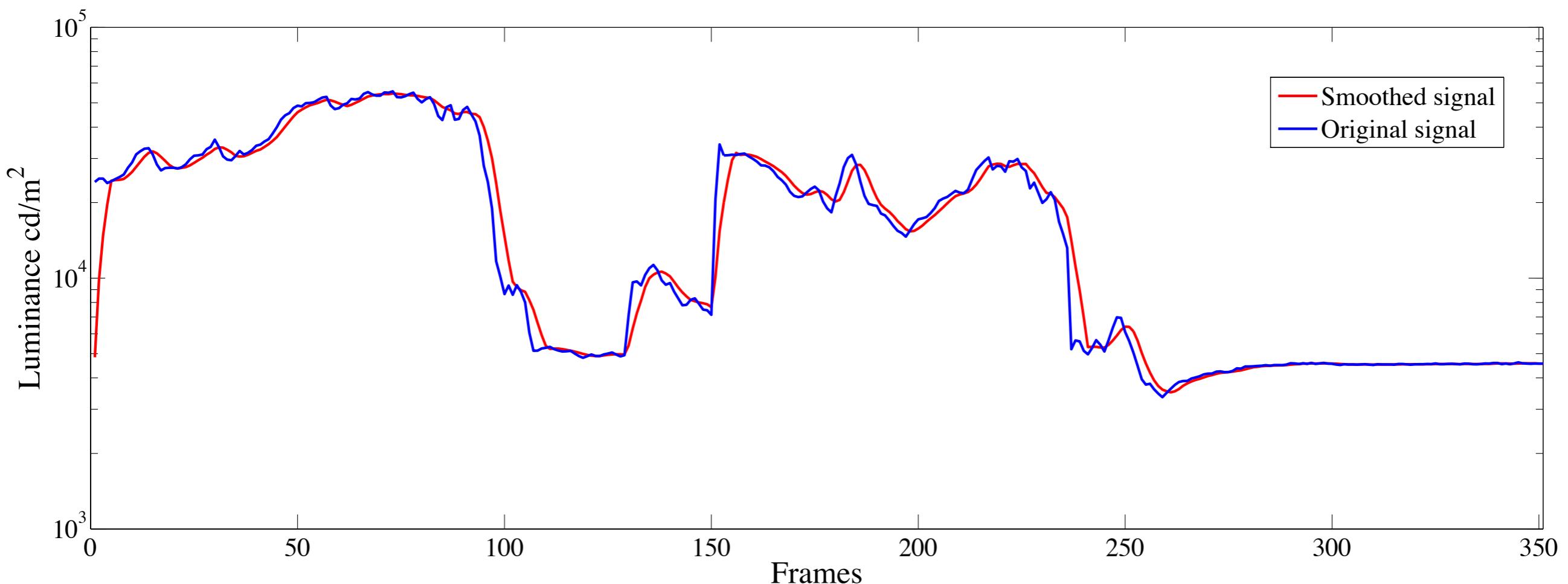
# Video Tone Mapping



# Statistics Smoothing

- How to solve temporal flickering?
- An idea is to smooth global statics with an 1D low pass filter: box, Gaussian, etc.
- **Note:** edges need to be smoothed not preserved in the temporal domain!

# Statistics Smoothing



# Statistics Smoothing

- Smoothing can reduce temporal flicker but:
  - smoothing is ad-hoc solution for each TMO:
    - derived statics need to smoothed separately  
[Kiser et al. 2012]

# Statistics Smoothing

$$a = 0.18 \times 2^{2\frac{B-A}{A+B}}$$

$$A = L_{w,\max} - \bar{L}_w$$

$$B = \bar{L}_w - L_{w,\min}$$

$$L_d(\mathbf{x}) = \frac{L_m(\mathbf{x}) \left( 1 + \frac{L_m(\mathbf{x})}{L_{\text{white}}^2} \right)}{1 + L_m(\mathbf{x})}$$

$$L_m(\mathbf{x}) = \frac{a}{\bar{L}_w} L_w(\mathbf{x})$$

Smoothing for each derived statistic:

$$A_t = (1 - \alpha_A)A_{t-1} + \alpha_A A \quad \alpha_A \in [0, 1]$$

$$B_t = (1 - \alpha_B)B_{t-1} + \alpha_B B \quad \alpha_B \in [0, 1]$$

$$a_t = (1 - \alpha_a)a_{t-1} + \alpha_a a \quad \alpha_a \in [0, 1]$$

# Statistics Smoothing



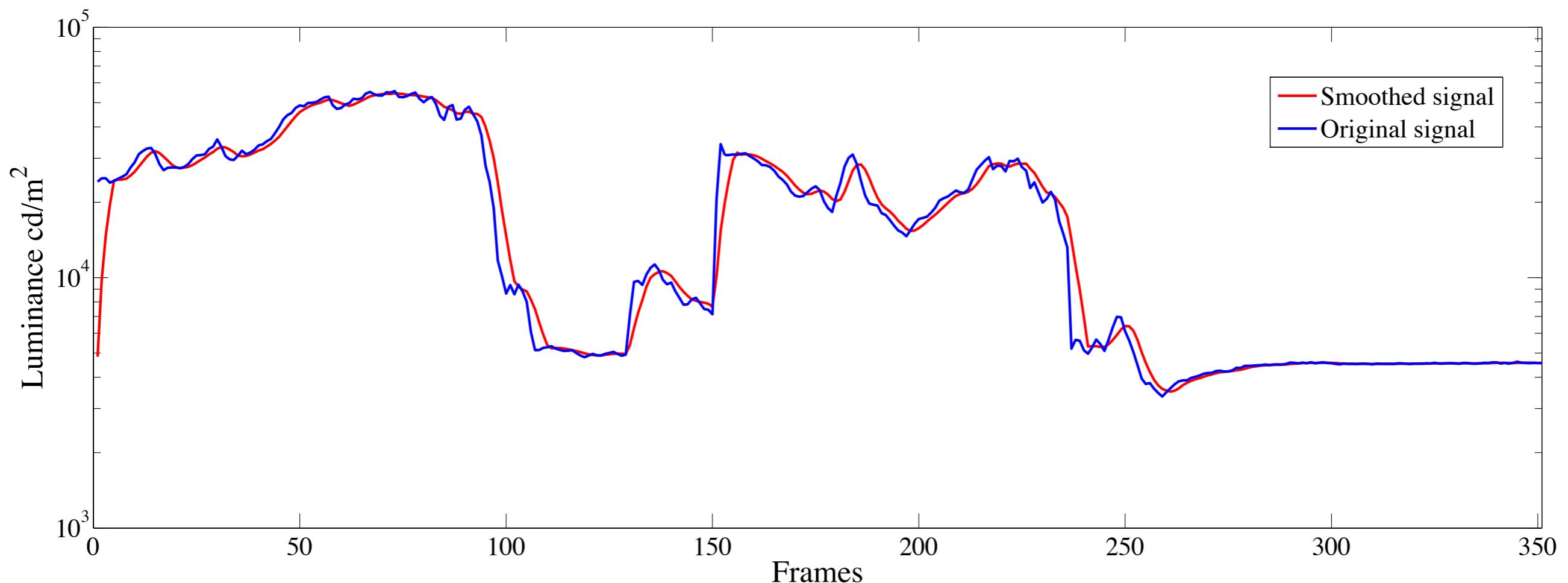
# Statistics Smoothing



# Global Overall Statistics

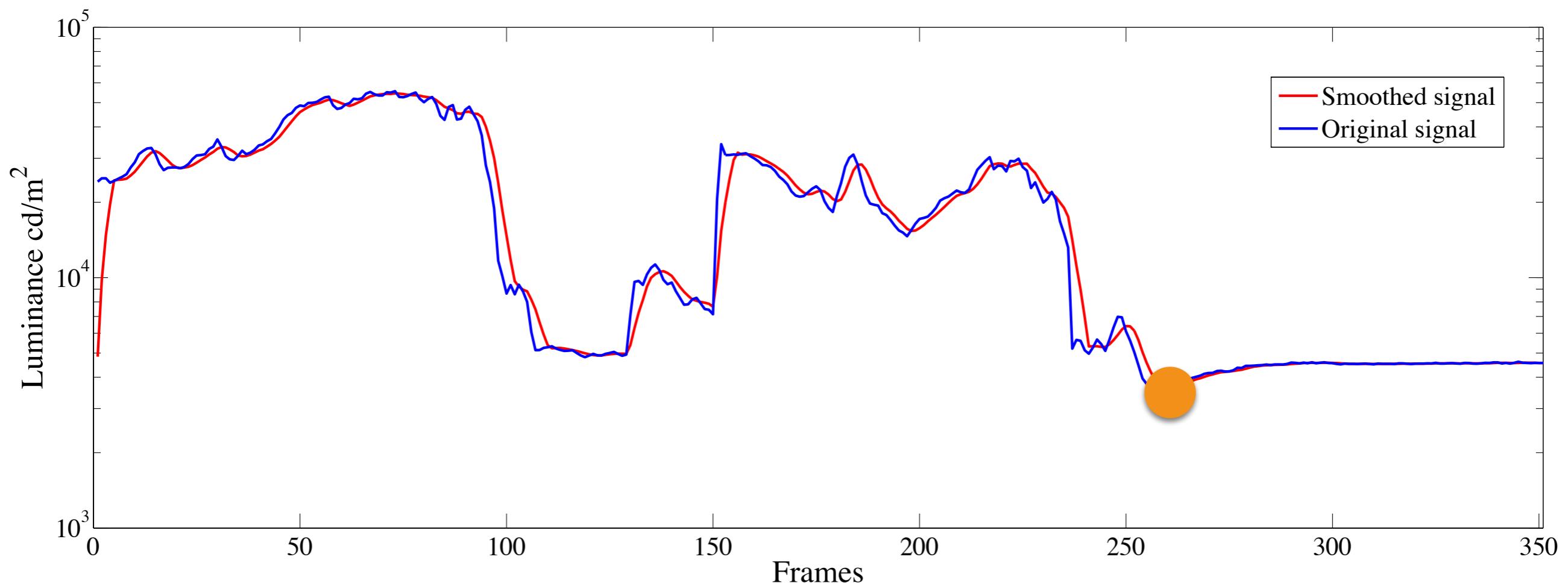
- Another solution is to compute statistics over all frames of a continuous cut [Kang et al. 2003]
- **Issues:**
  - Cuts need to be identified
  - Bright/Dark problem
  - Full analysis of the sequence —> no real-time

# Global Overall Statistics



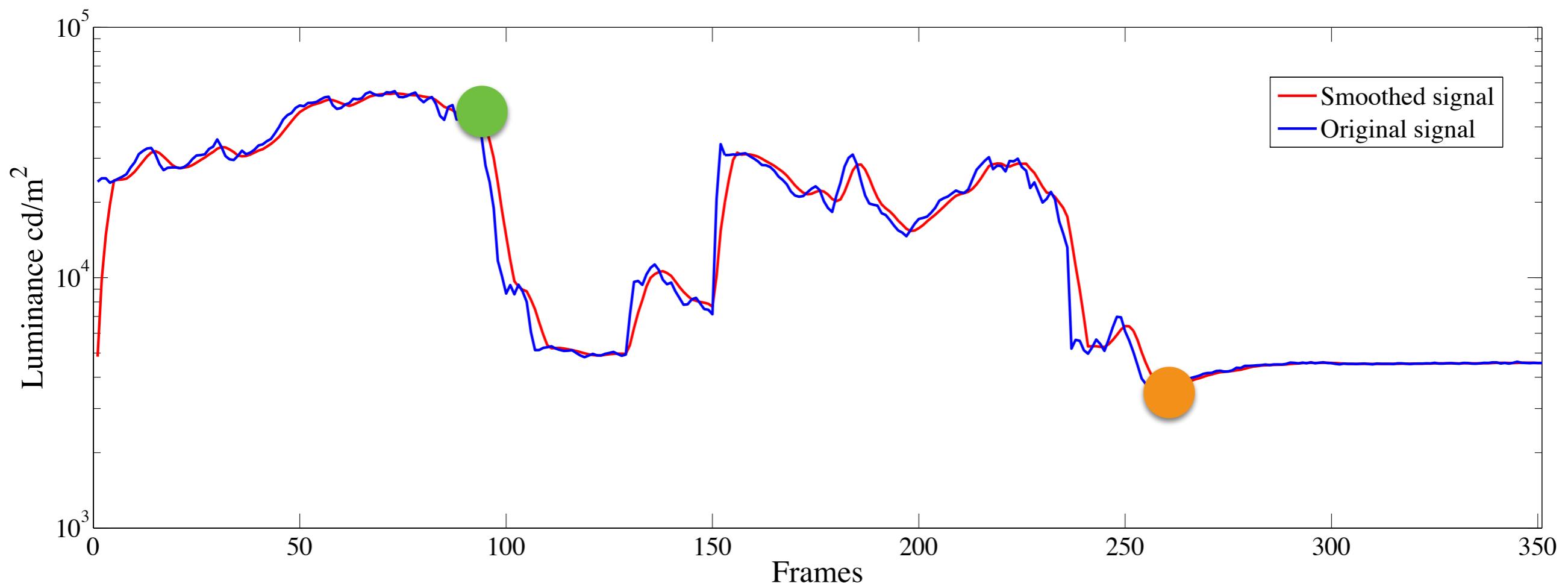
Tone mapping frame 259

# Global Overall Statistics



Tone mapping frame 259

# Global Overall Statistics



Tone mapping frame 259

# Global Overall Statistics



Frame 259

# Global Overall Statistics



Frame 259

# Temporal Coherency

- OK, temporal flickering can be reduced but...
  - This has to be carried for each TMO —> no general solution
  - Not preserved:
    - perception consistency of an object
    - the overall temporal brightness

# Temporal Coherency

- The scene and display brightness match needs to be ensured [Boitard et al. 2012]
- How?

$$\frac{\bar{L}_w}{\bar{L}_{w,\max}} = \frac{\bar{L}_d}{\bar{L}_{d,\max}}$$

$$L'_d(\mathbf{x}) = L_d(\mathbf{x}) \frac{\bar{L}_w \times \bar{L}_{d,\max}}{\bar{L}_{w,\max} \times \bar{L}_d}$$

- **Note:** the sequence needs to be fully analyzed

# Temporal Coherency



# Temporal Coherency



# Motion Vectors Method

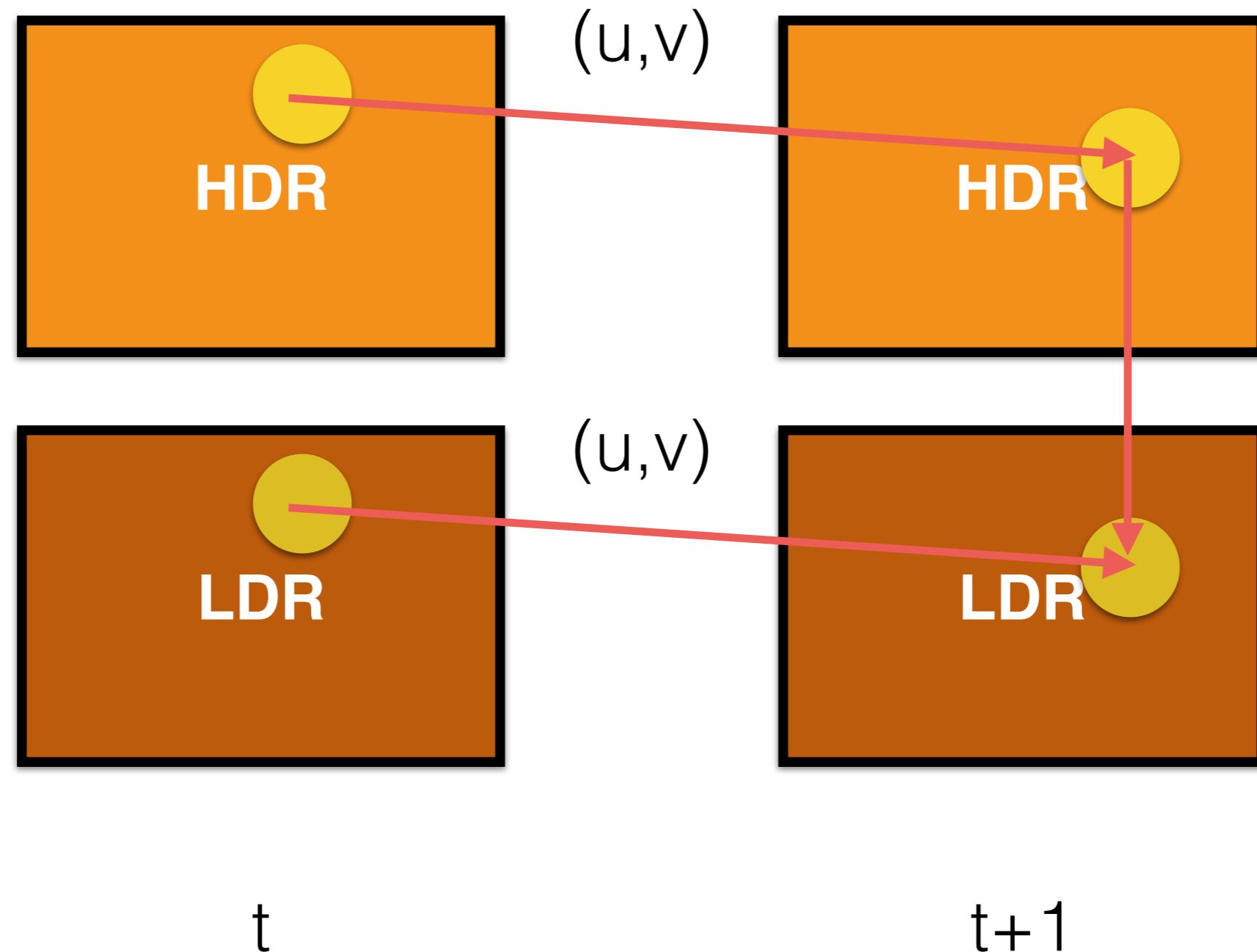
- Motion vectors,  $(u, v)$ , between HDR frames:

$$L_w(x, y, t) = L_w(x + u, y + v, t + 1)$$

- These vectors are used to add a constraint:

$$C = \sum_x \sum_y \left( L_d(x, y, t) - L_d(x + u, y + v, t + 1) \right)^2$$

# Motion Vectors Method



# Motion Vectors Method



# Motion Vectors Method



# Current Trends

- The new trend is a spatio-temporal edge-aware filter [Aydin et al. 2015]
  - Exploiting backward and forward optical flow

# Questions?