A Model of Local Adaptation

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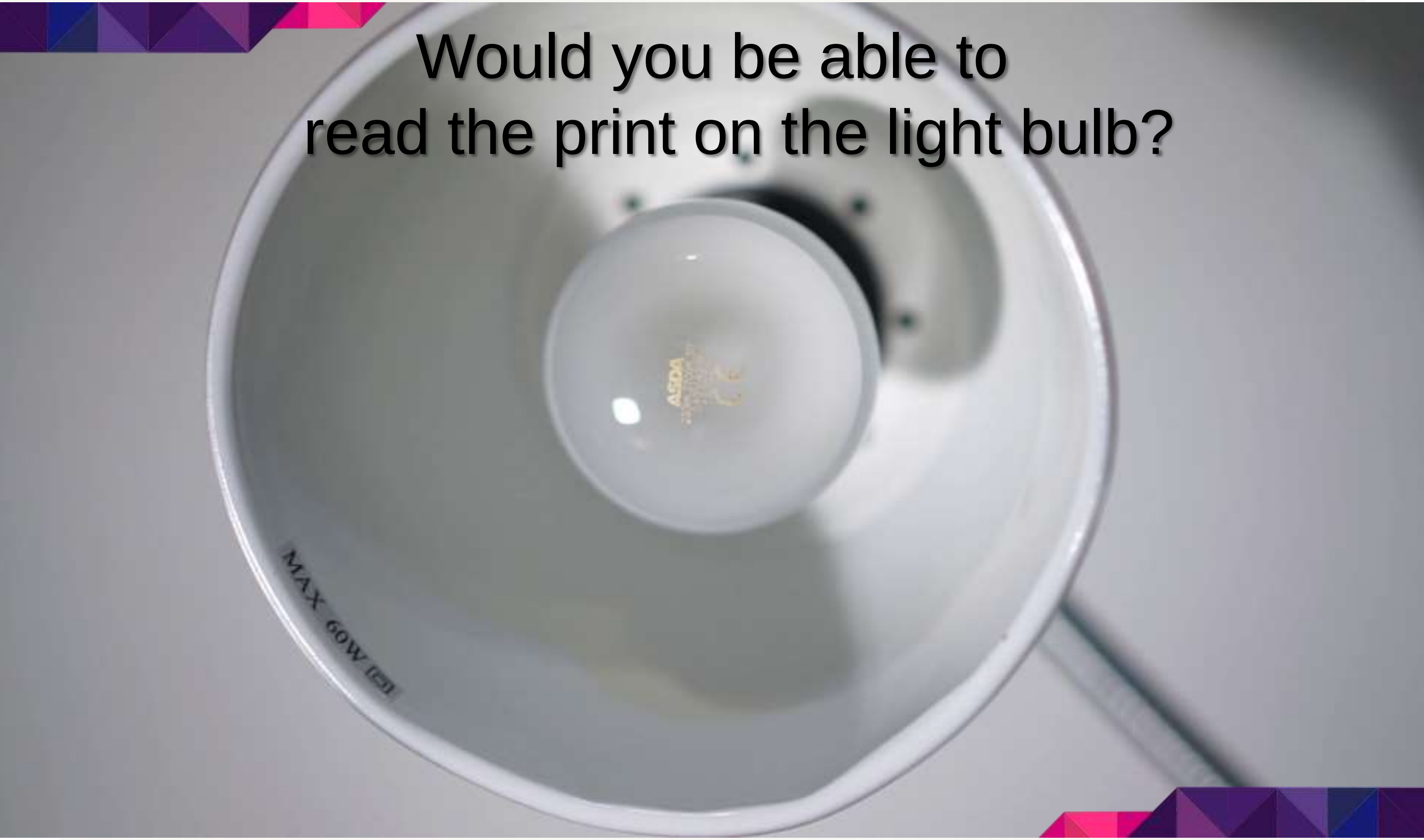
SIGGRAPH ASIA 2015 KOBE

Contrast Perception

Would you be able to
read the print on the light bulb?

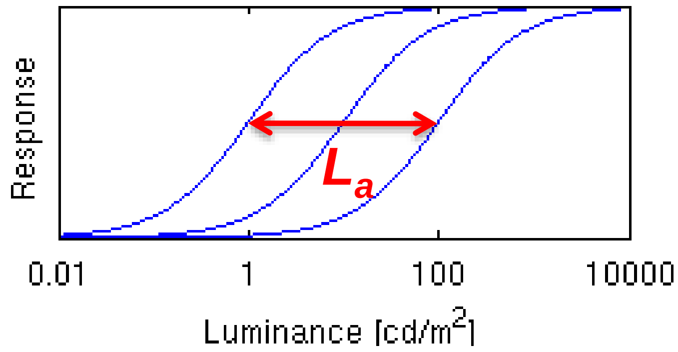


Contrast Perception

Contrast Perception

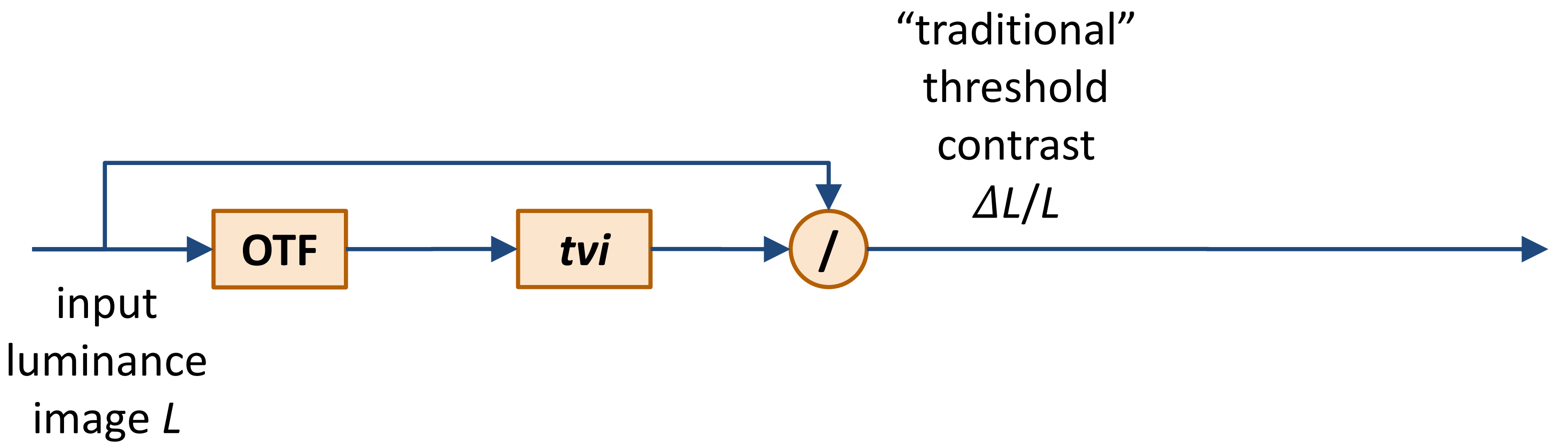
Previous Models of Adaptation

- Physiology and psychophysics
  - Naka-Rushton: $R = k\dfrac{L^n}{L^n + \sigma(L_a)^n}$
    - requires “adaptation luminance” L_a

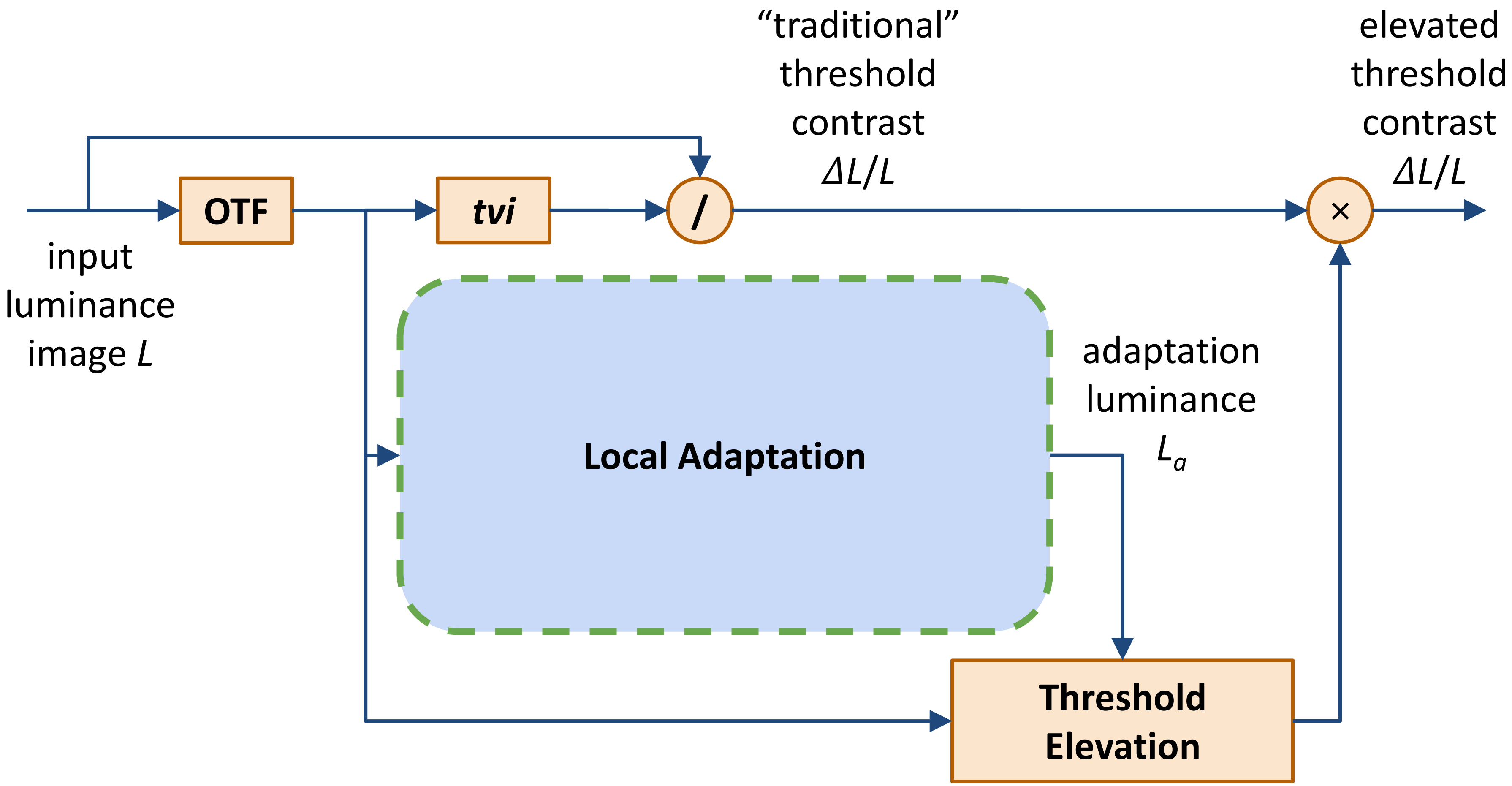


- Ad hoc models used in computer graphics
  - Naka-Rushton model with adaptation luminance = ?
    - global average luminance
    - local per-pixel luminance
    - local average computed in 1° Gaussian window

Basic Contrast Detection Model



Our Adaptation Model



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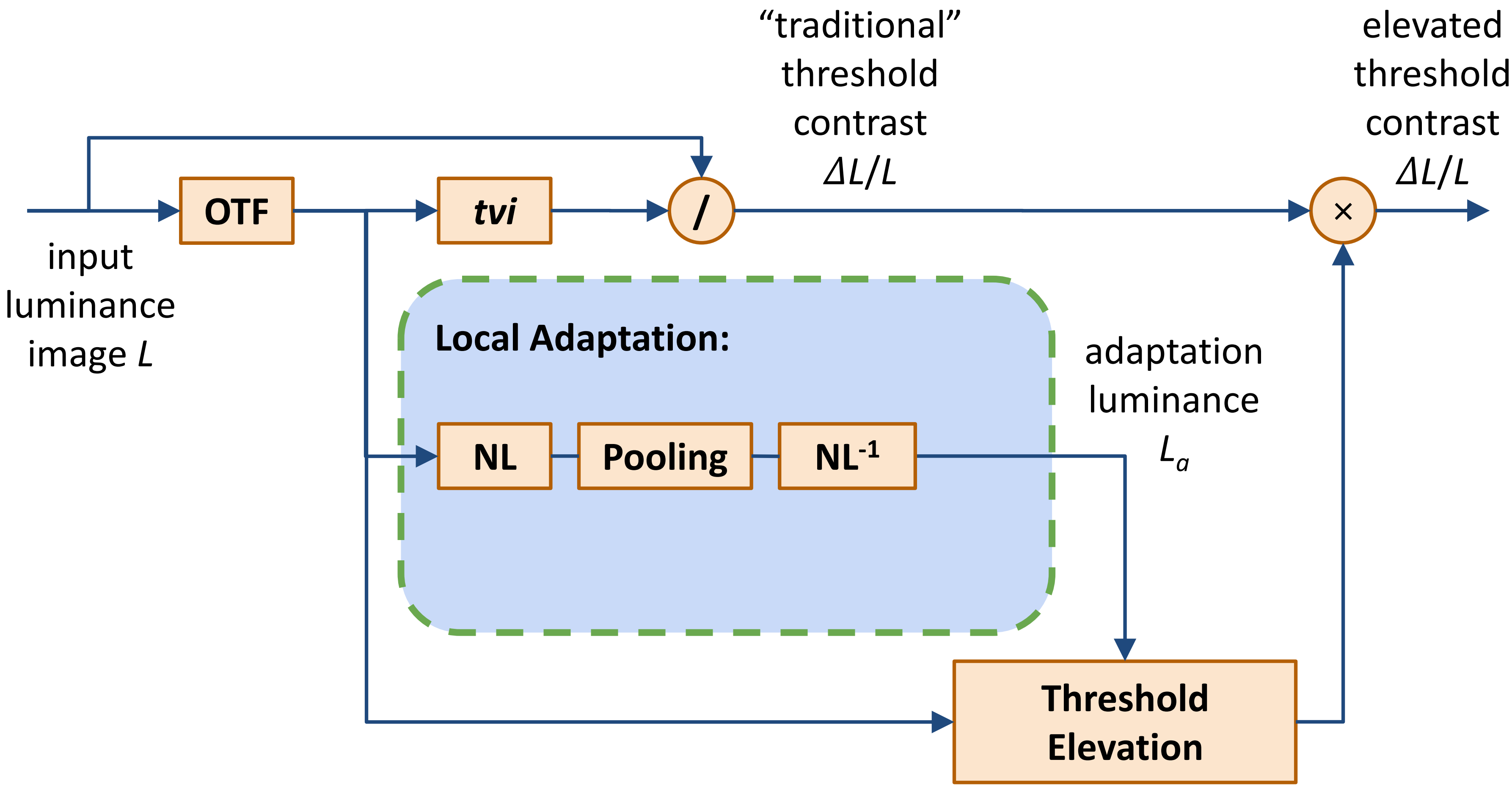

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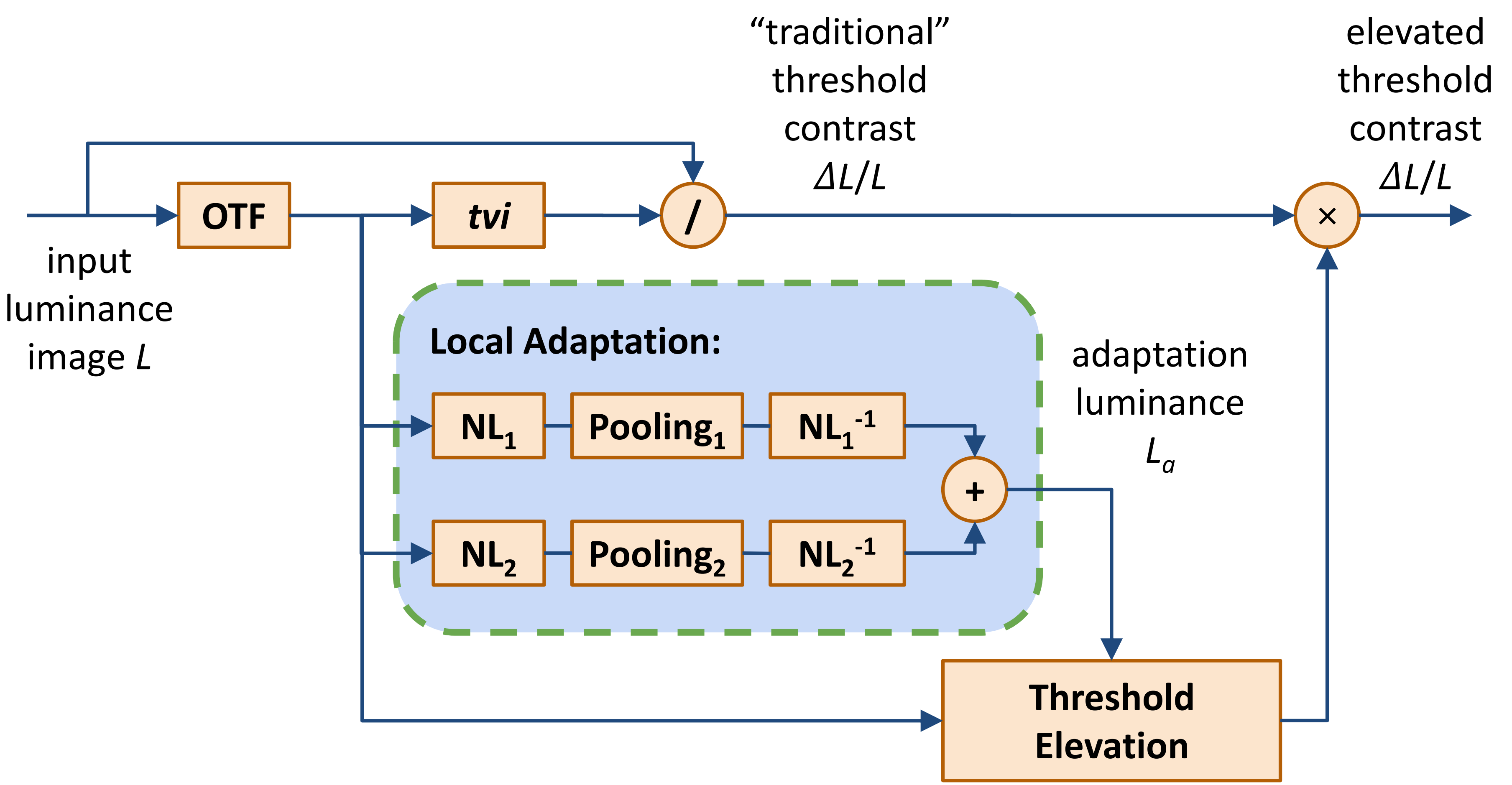

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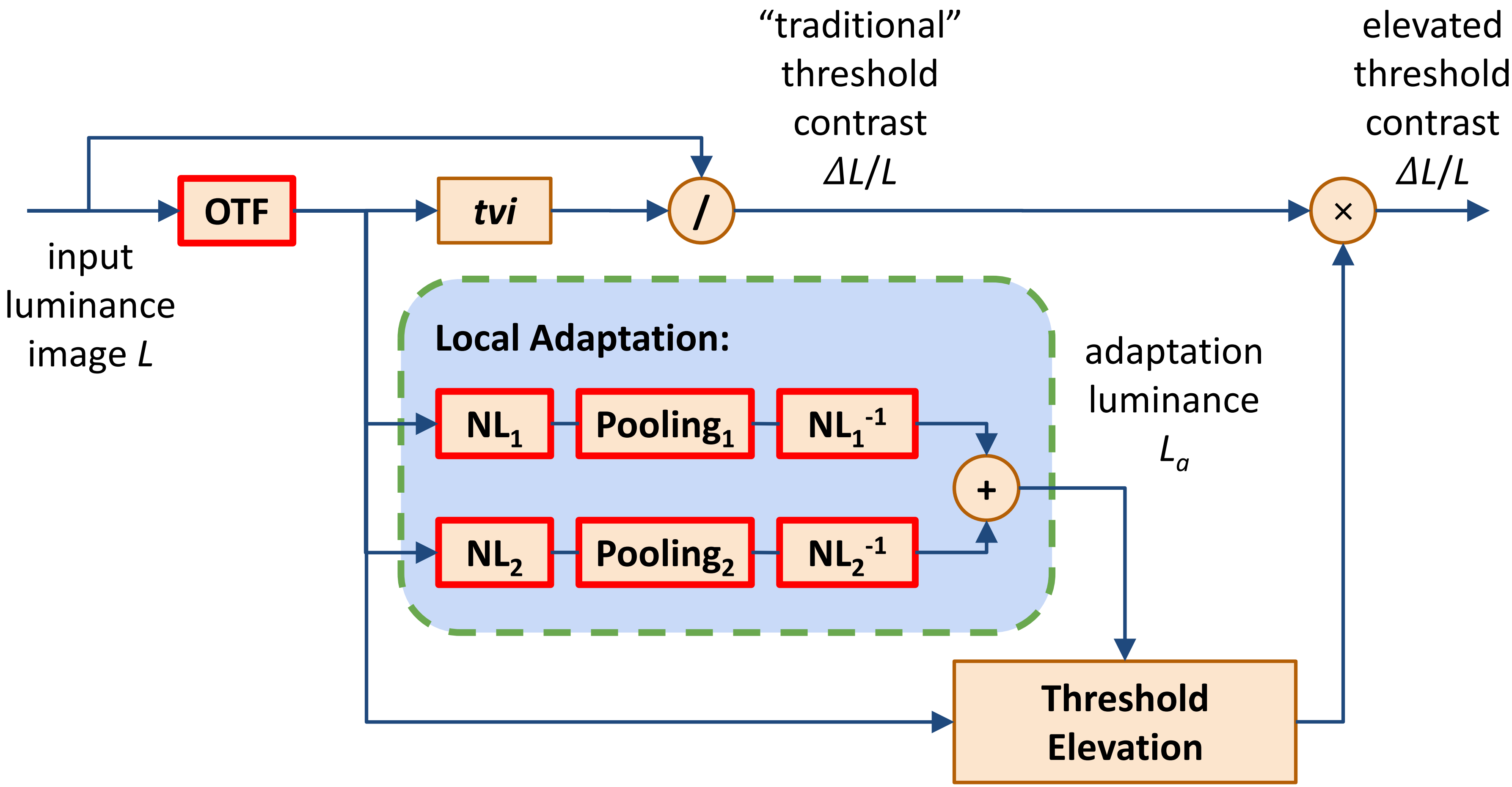
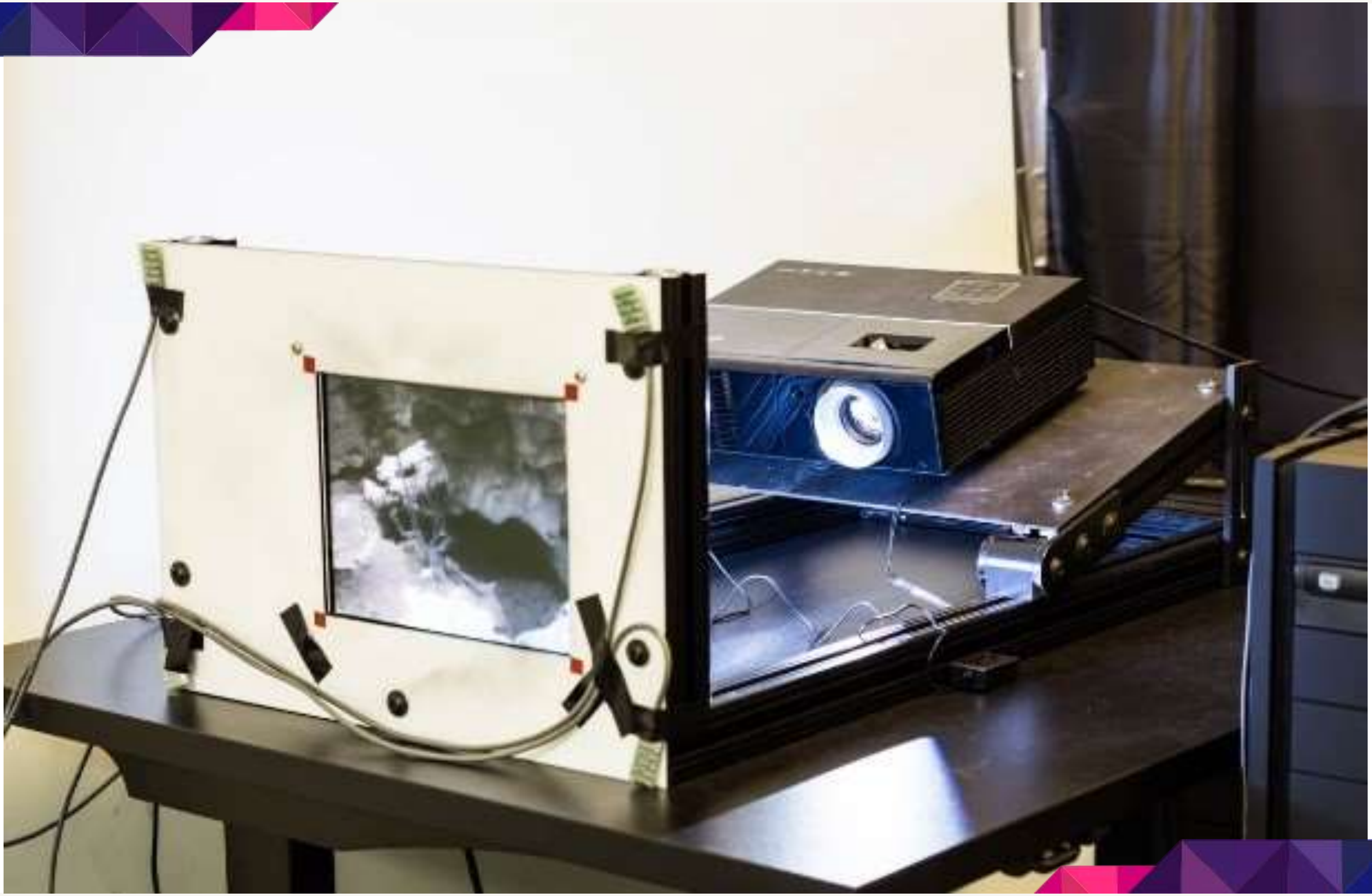
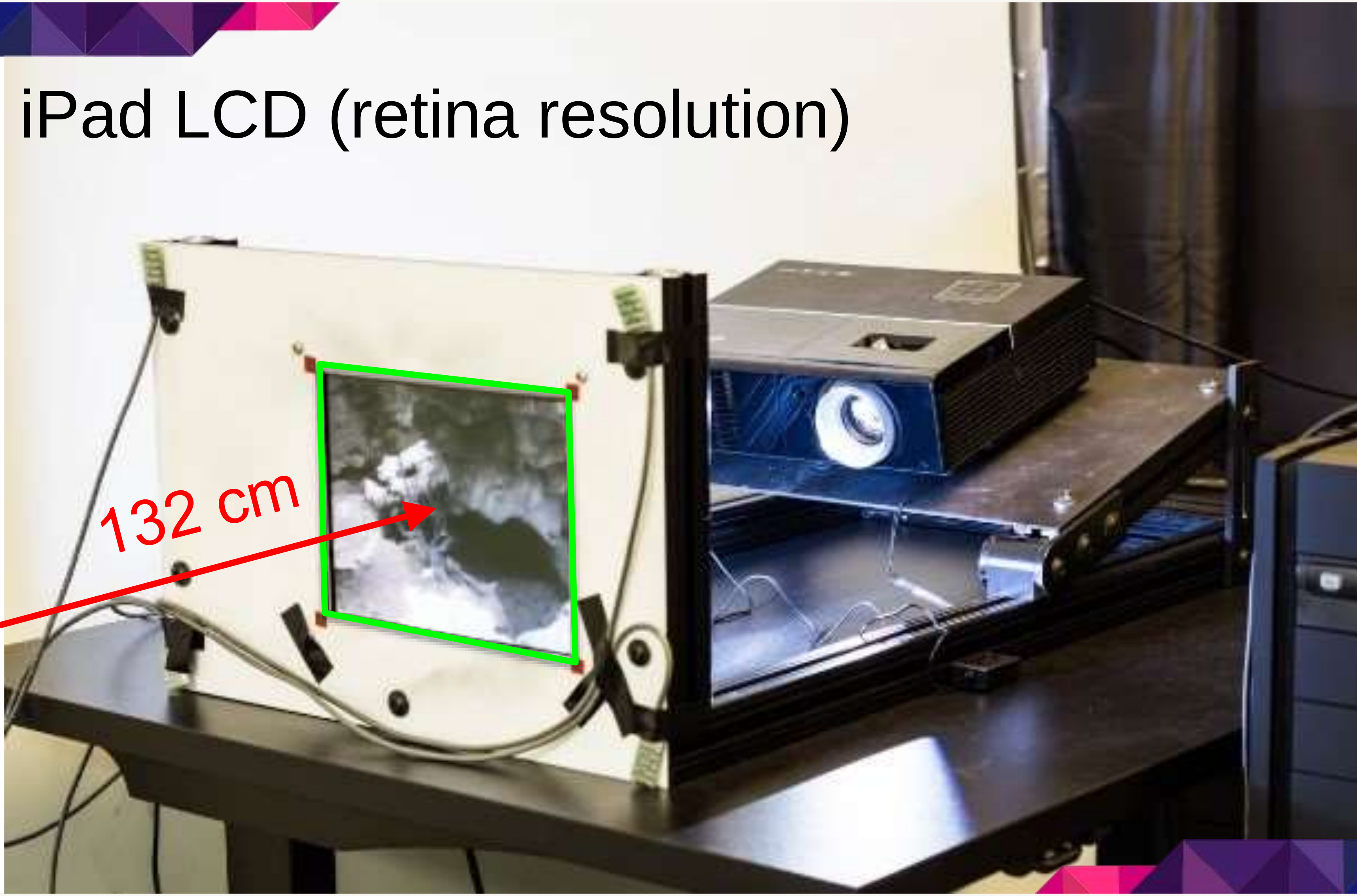


High Dynamic Range Display



High Dynamic Range Display

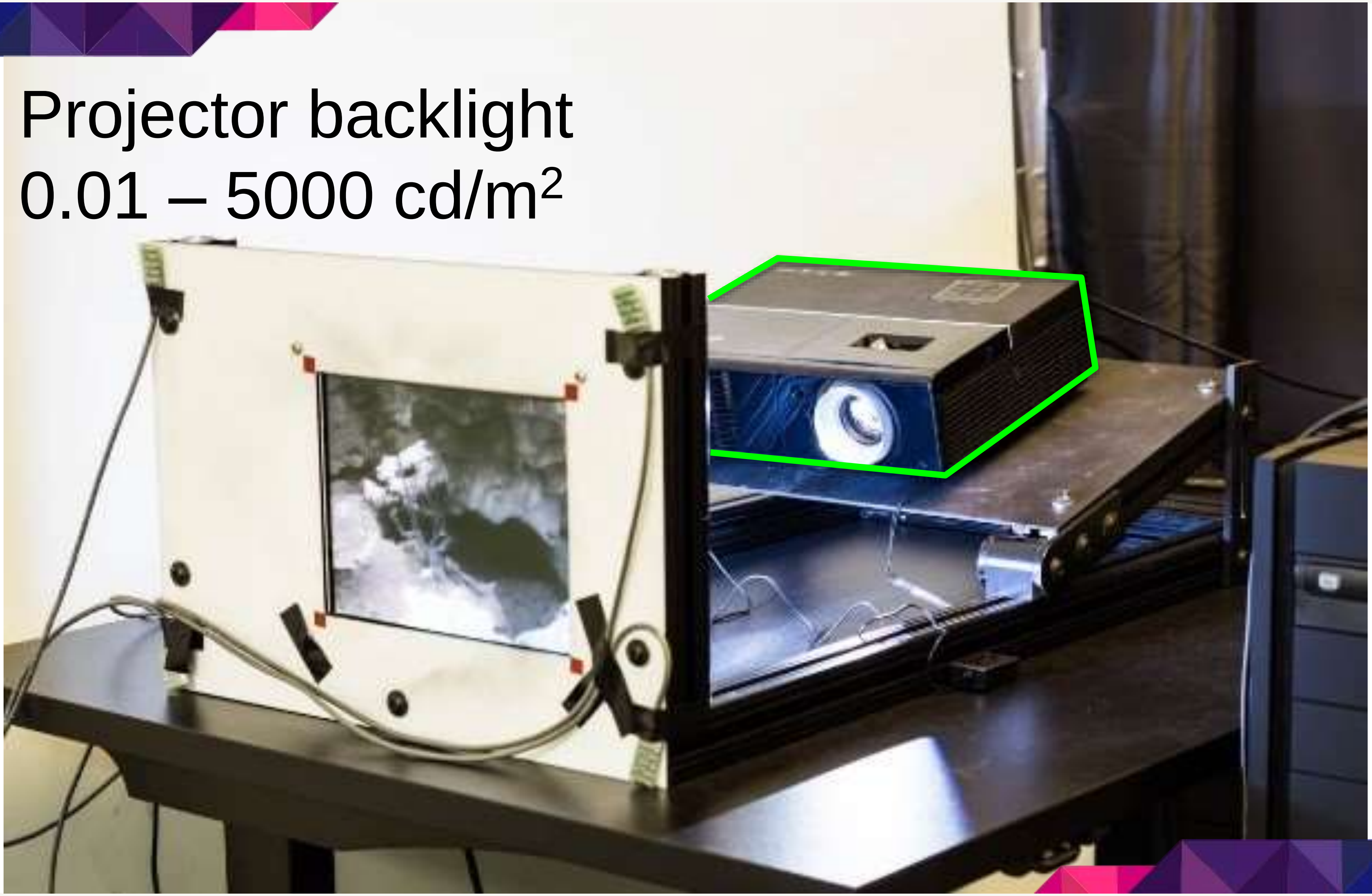
iPad LCD (retina resolution)



High Dynamic Range Display

Projector backlight

0.01 – 5000 cd/m^2



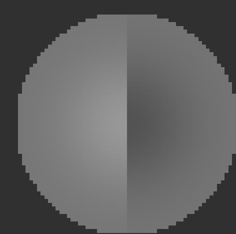
Experiments: Baseline Adaptation

1. Adapt

similar to [Hood et al. 1979]

Experiments: Baseline Adaptation

2. Flash 200 ms



similar to [Hood et al. 1979]

Experiments: Baseline Adaptation

3. Orientation of the edge?

similar to [Hood et al. 1979]

Experiments: Baseline Adaptation

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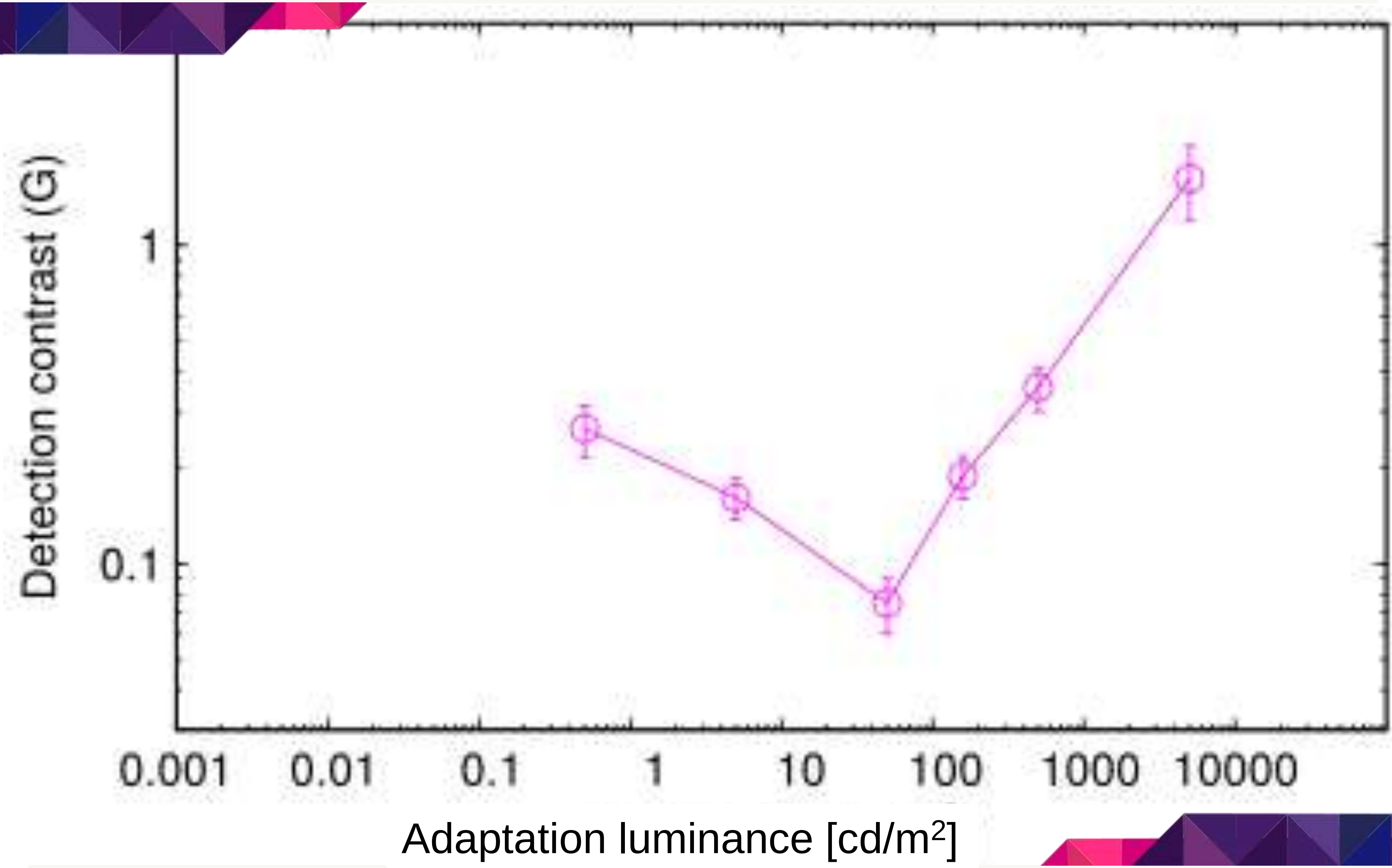
 or  ?

similar to [Hood et al. 1979]

Experiments: Baseline Adaptation



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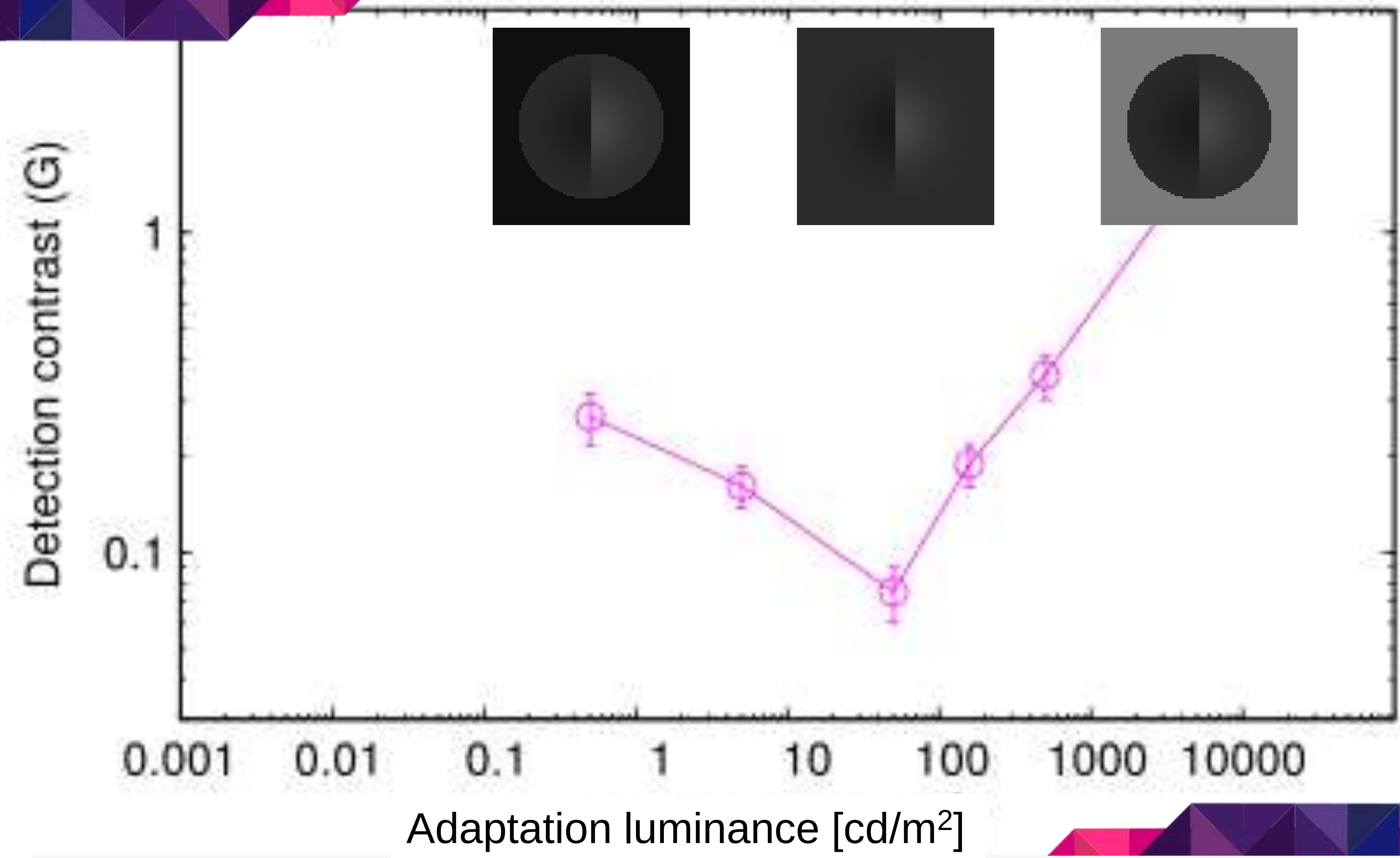

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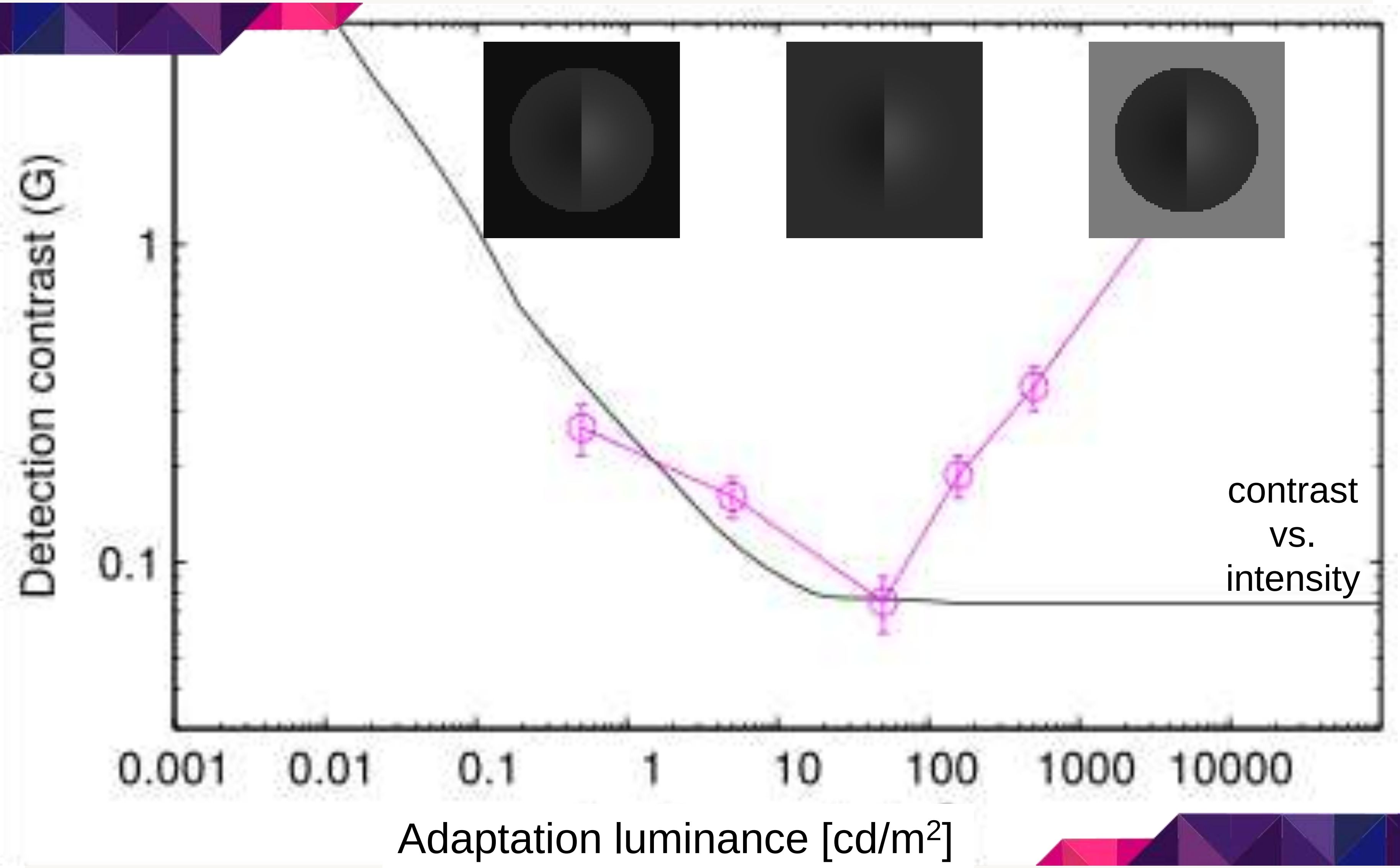

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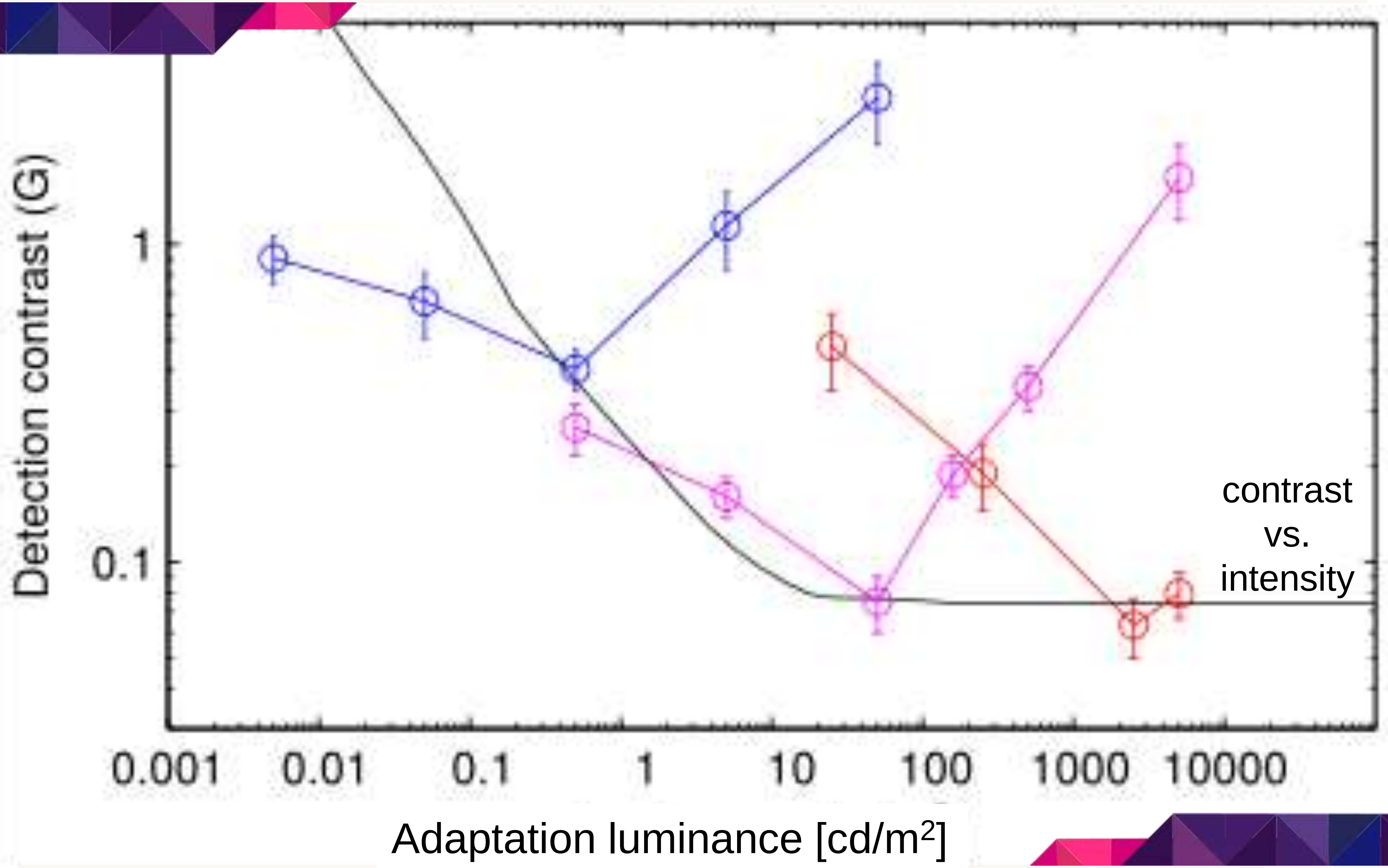

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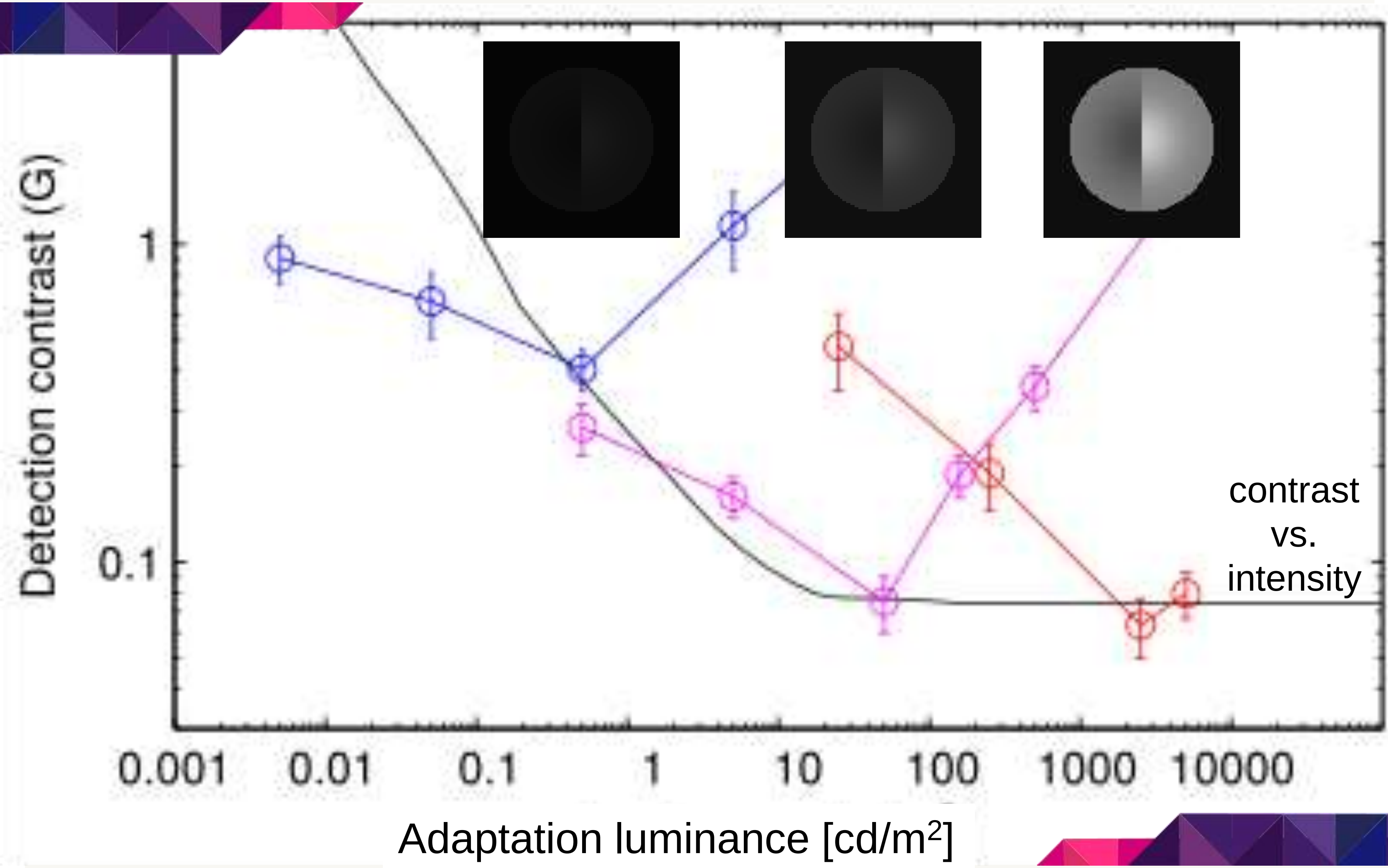
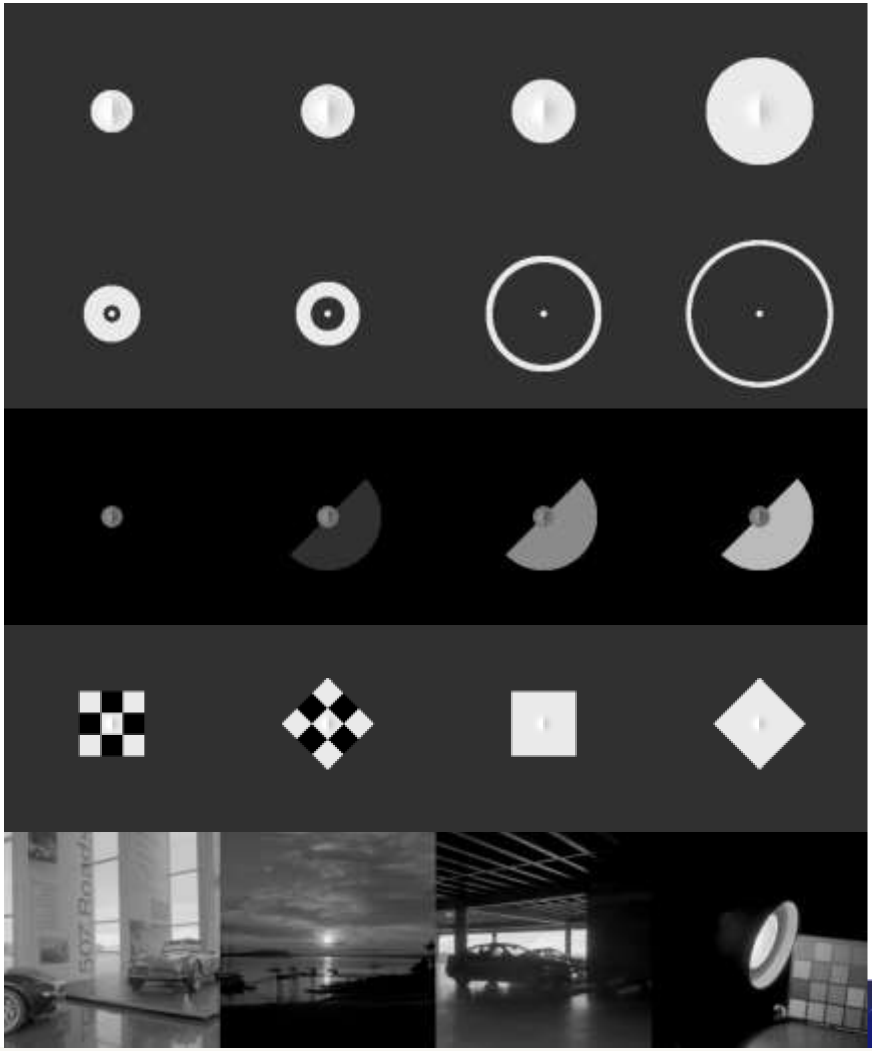


Experiments: Adaptation Patterns

- Extent of pooling
- Long-range effects
- Pooling non-linearity
- Radial symmetry & contrast masking
- Natural images



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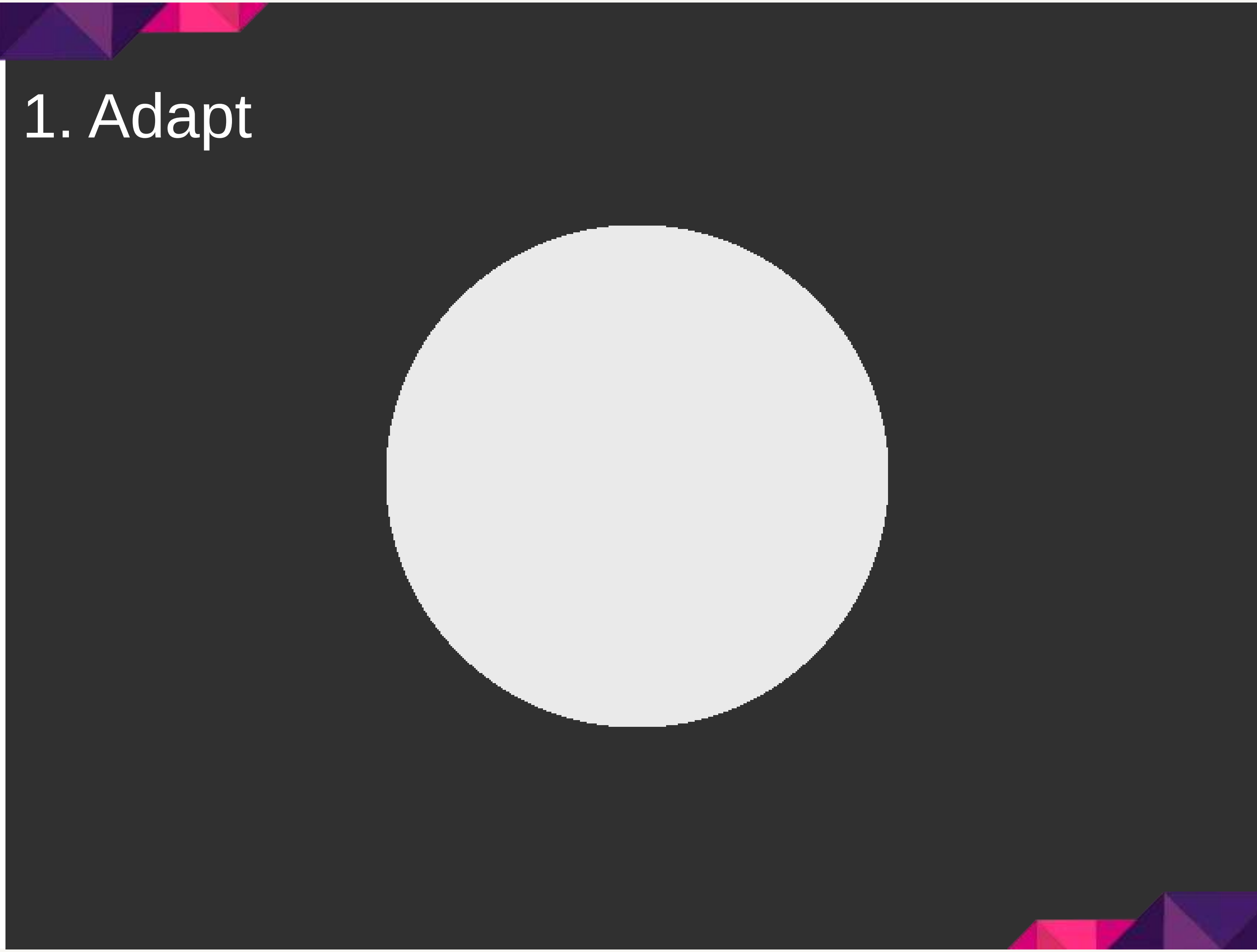

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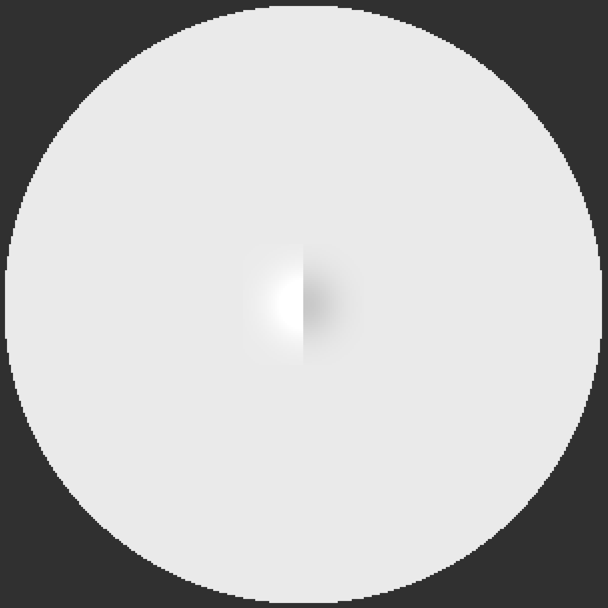

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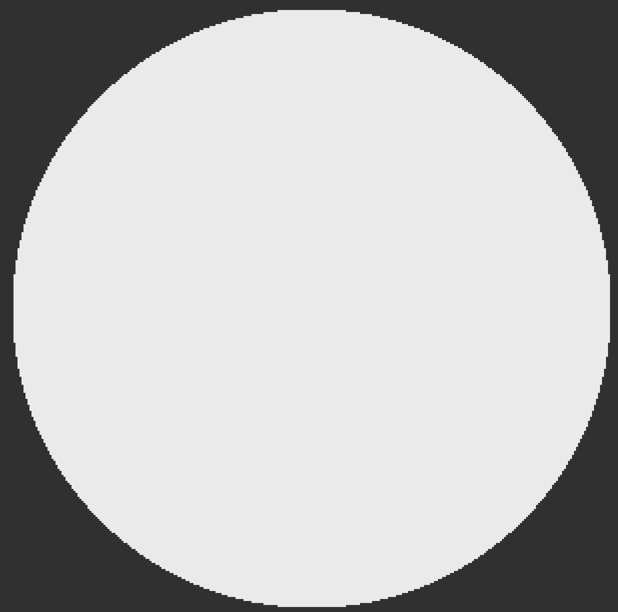
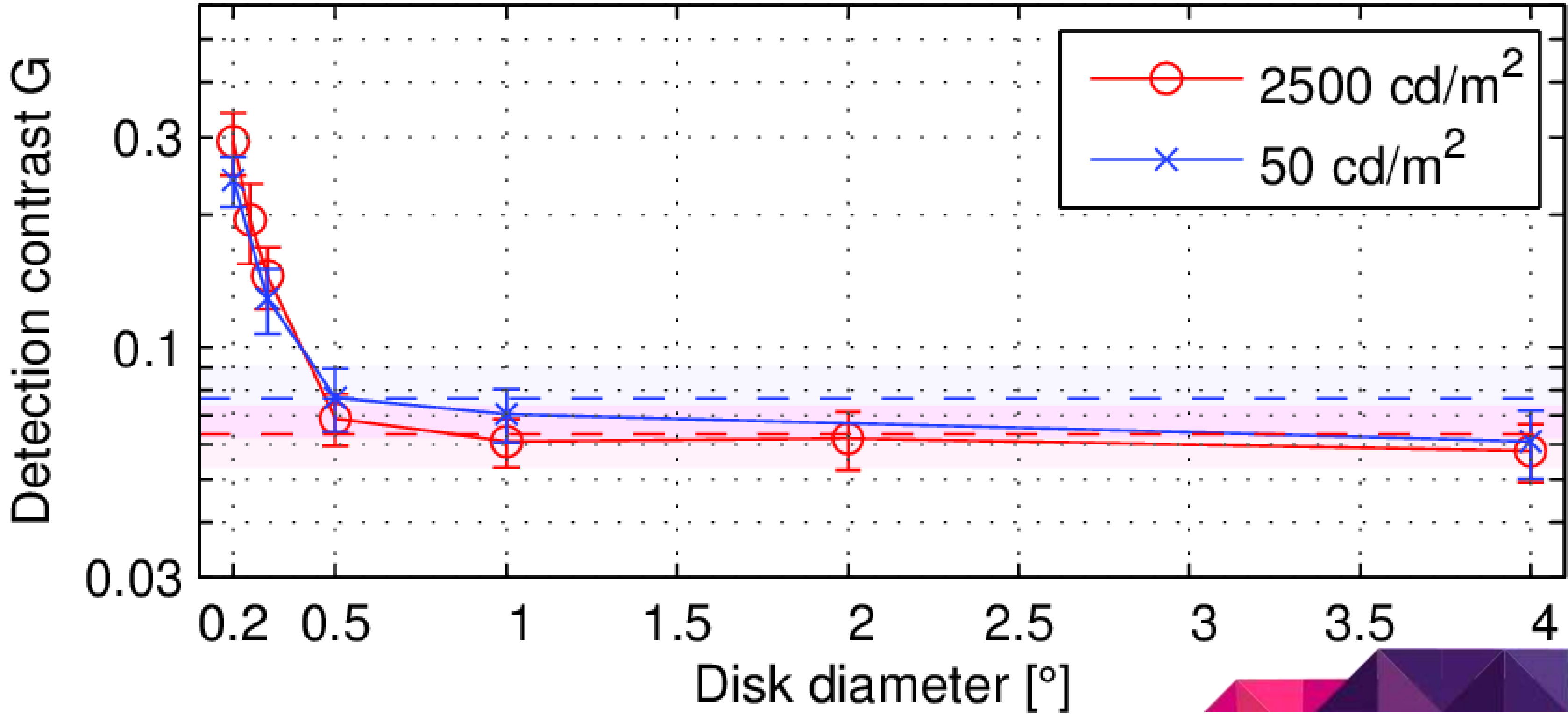


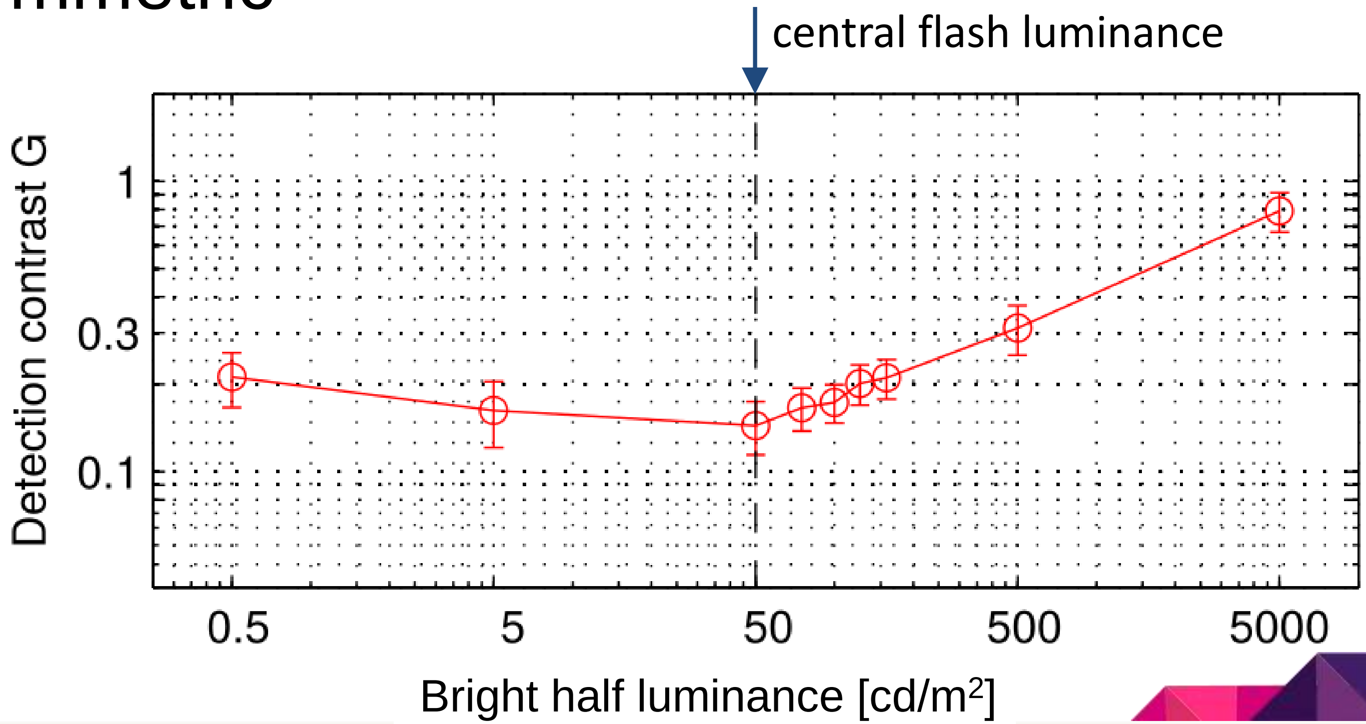
Experiments: Extent of pooling

- Detection contrast levels off at 0.5°



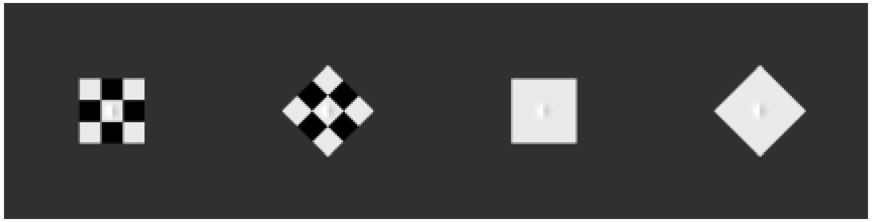
Experiments: Pooling non-linearity

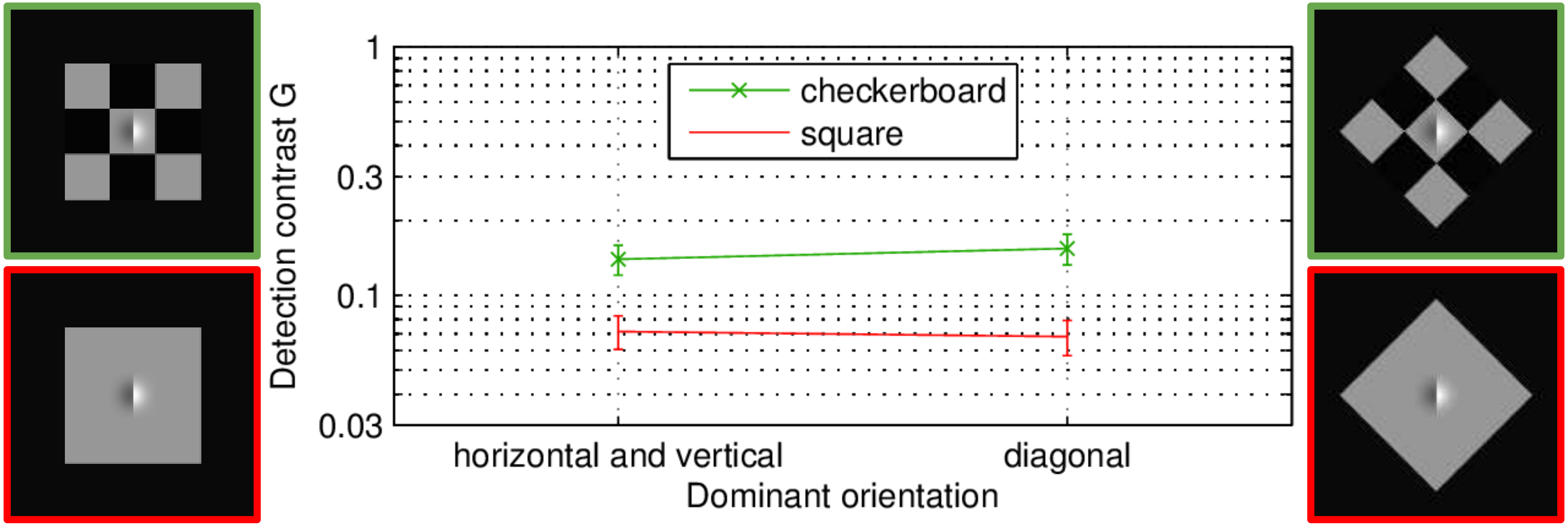
- Not linear
- Not logarithmic
- Asymmetric



Experiments: Radial symmetry

- Rotation makes no difference





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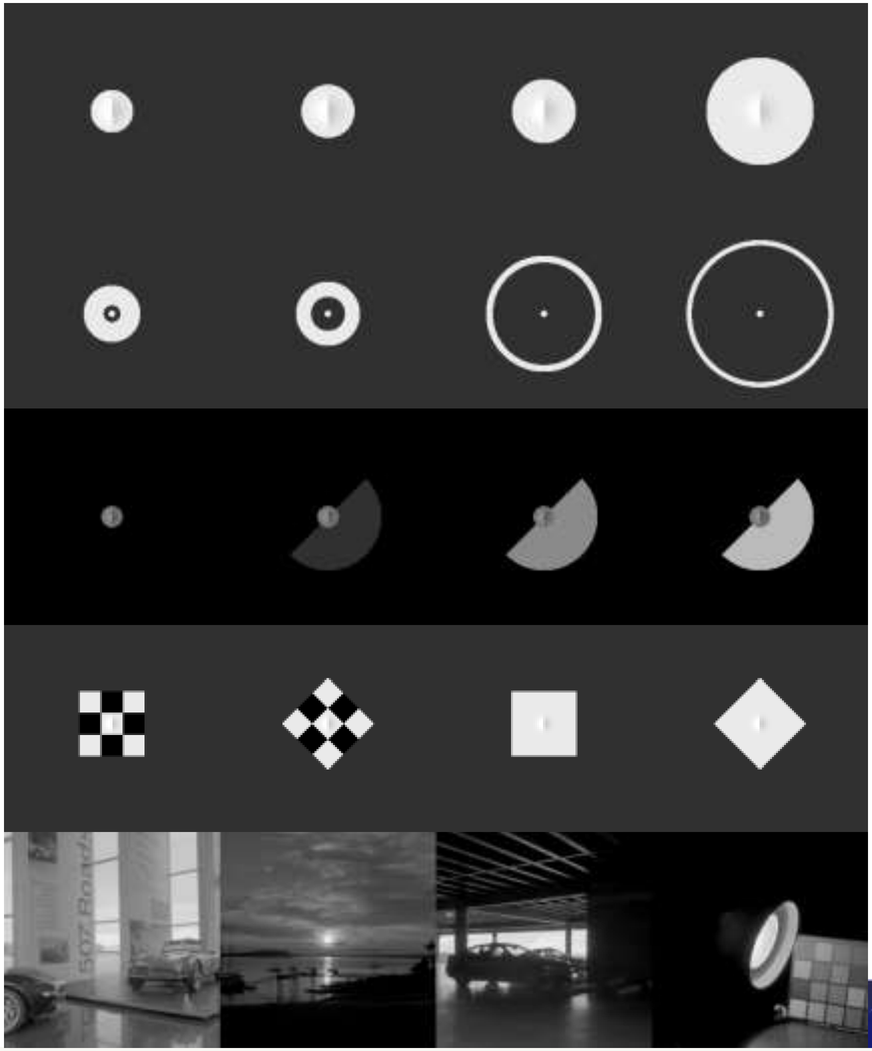
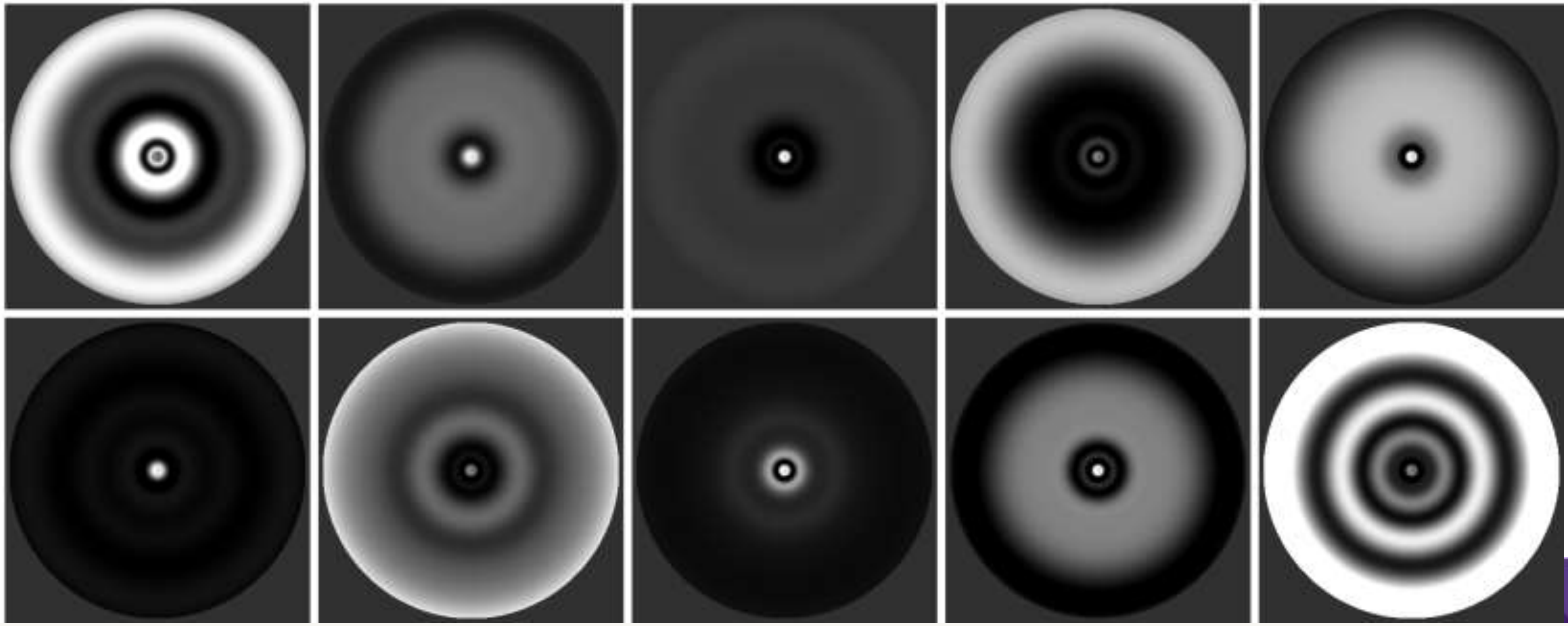


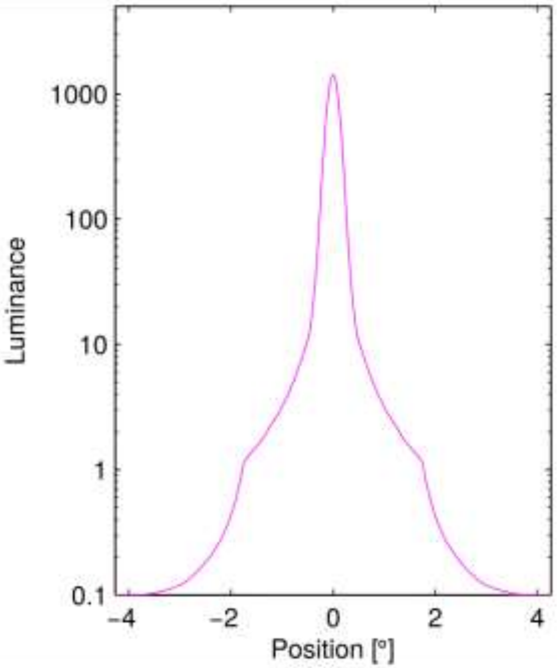
Model Fitting and Cross-validation

- General model → 56 specific candidate models
- Model fitting using parallel genetic optimization
- Cross-validation: maximally differentiating stimuli

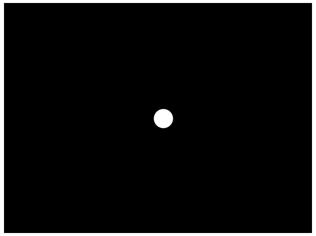


Our Best Adaptation Model

- Wider support at lower luminance
  - due to non-linearities
  - adaptation site shifts to postreceptoral mechanisms [Dunn et al. 2007]



- Complex pooling mechanism
  - cross-validated to avoid overfitting
  - more complex than known retinal pooling
  - receptive fields in LGN or visual cortex?



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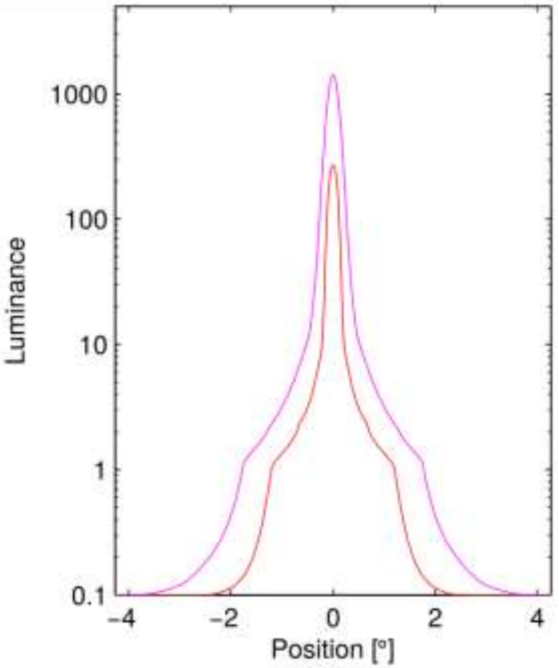

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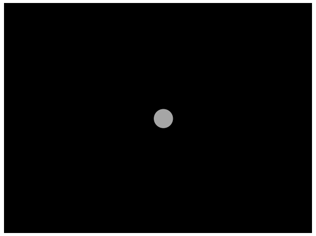

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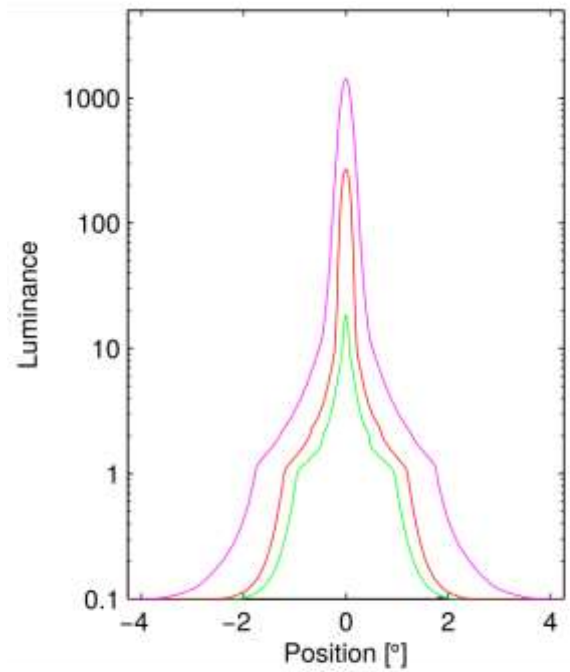

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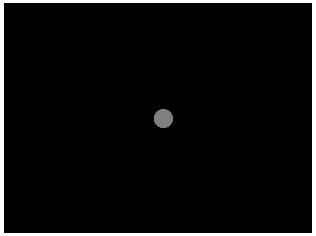

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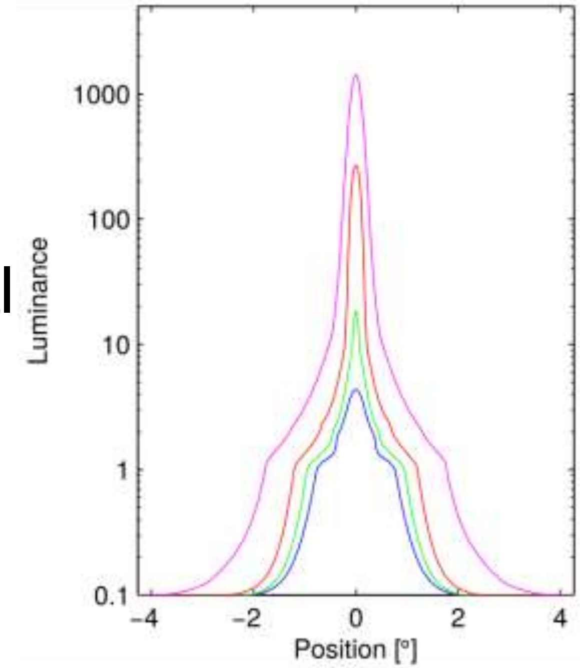

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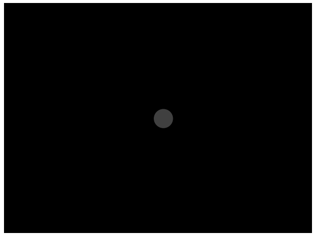

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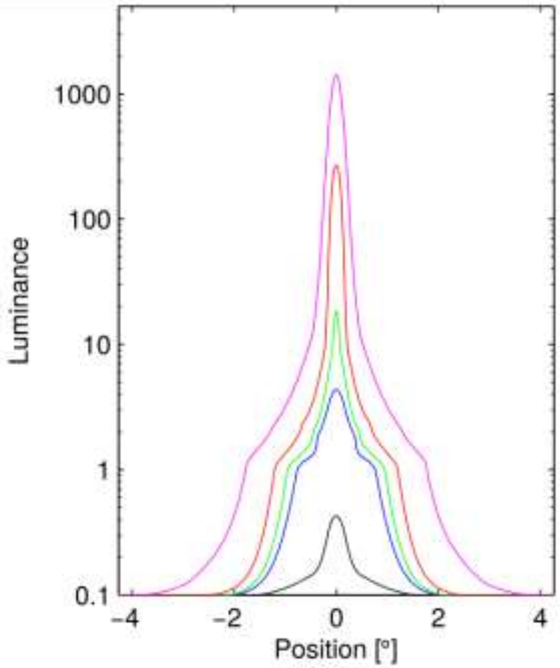

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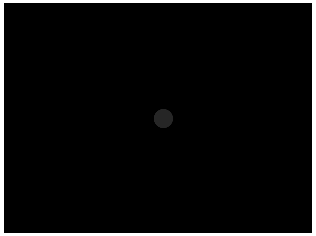
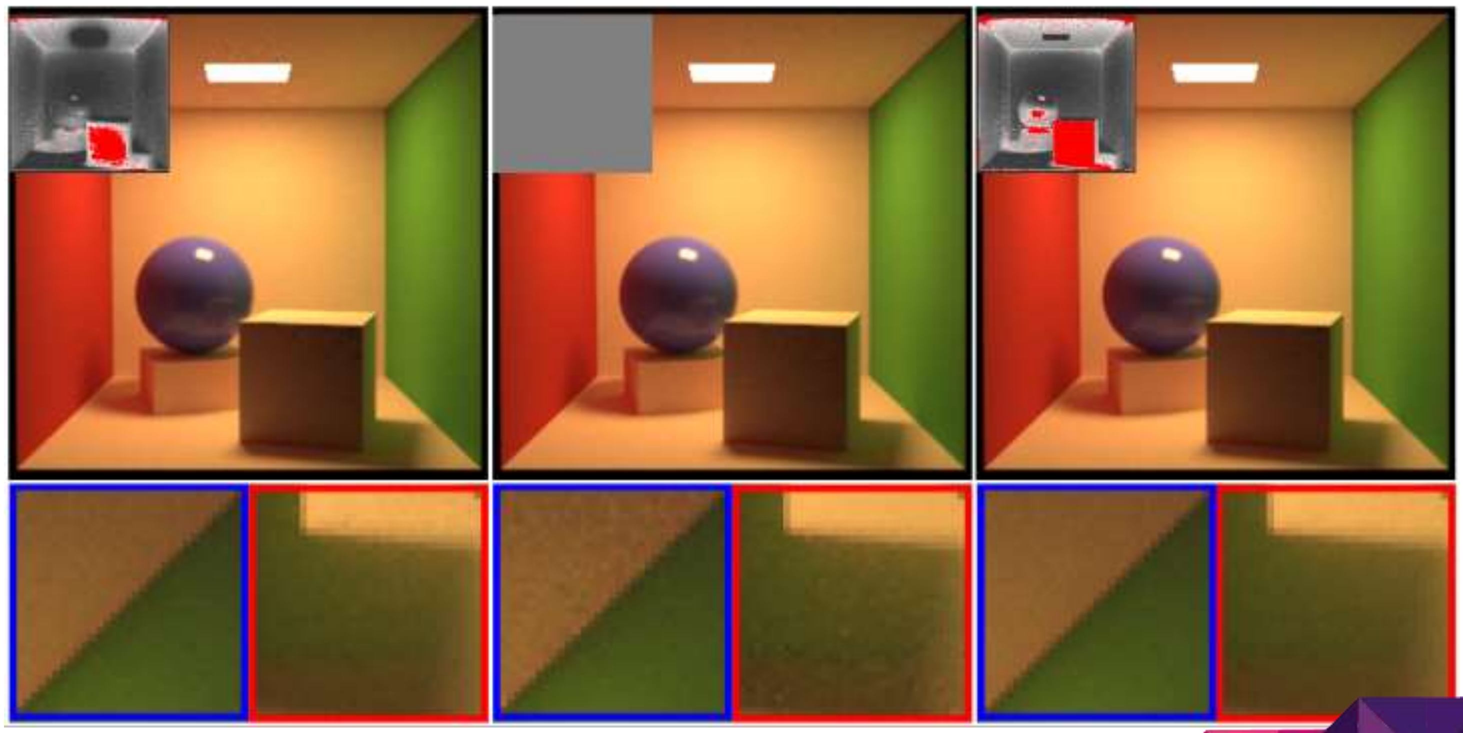


Application: Adaptive Rendering

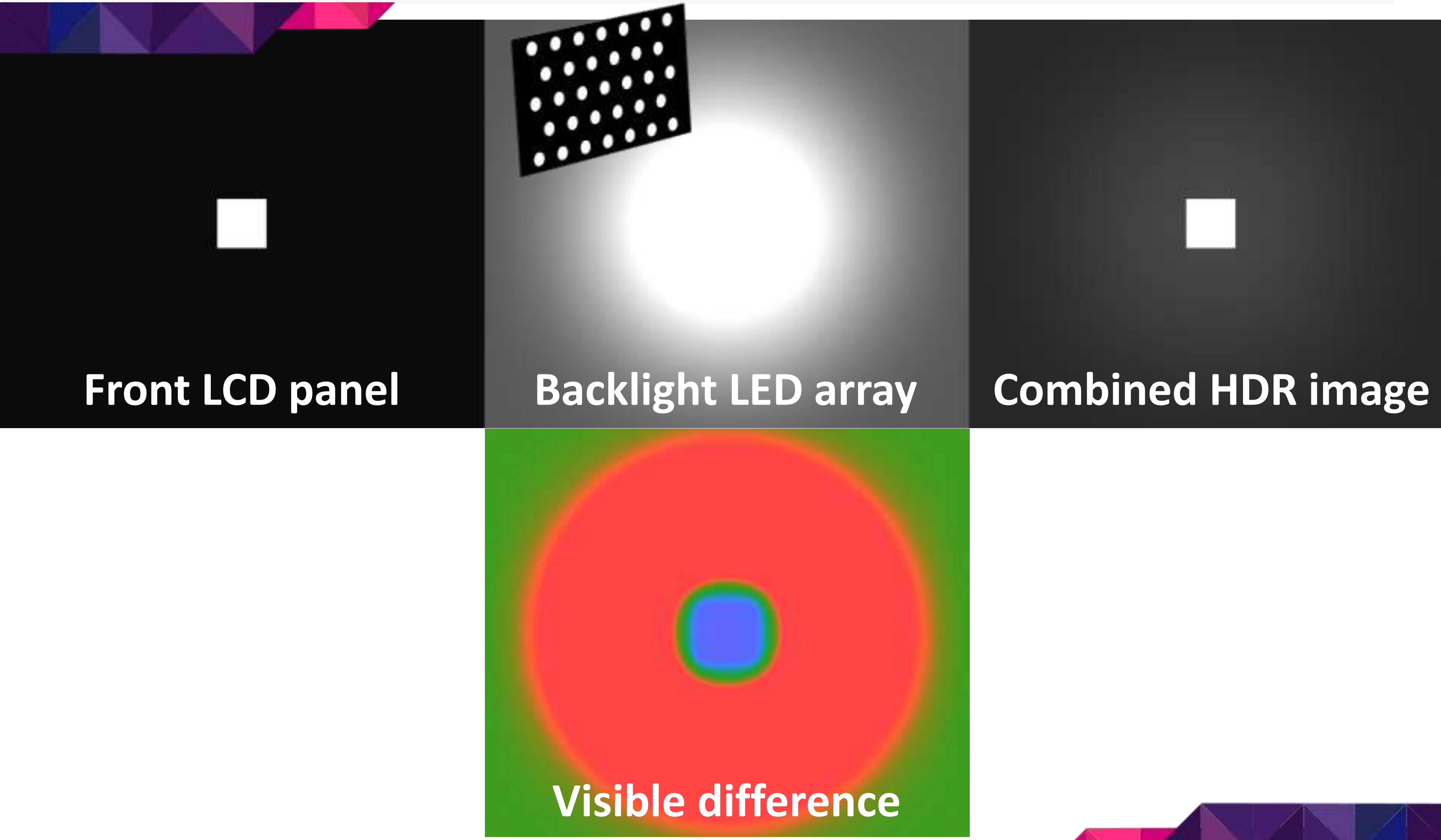
- Adaptive sampling until noise contrast undetectable

Our method | Non-adaptive equal time | Weber adaptive equal quality – 30% slower

Sample density



Application: HDR Display Design



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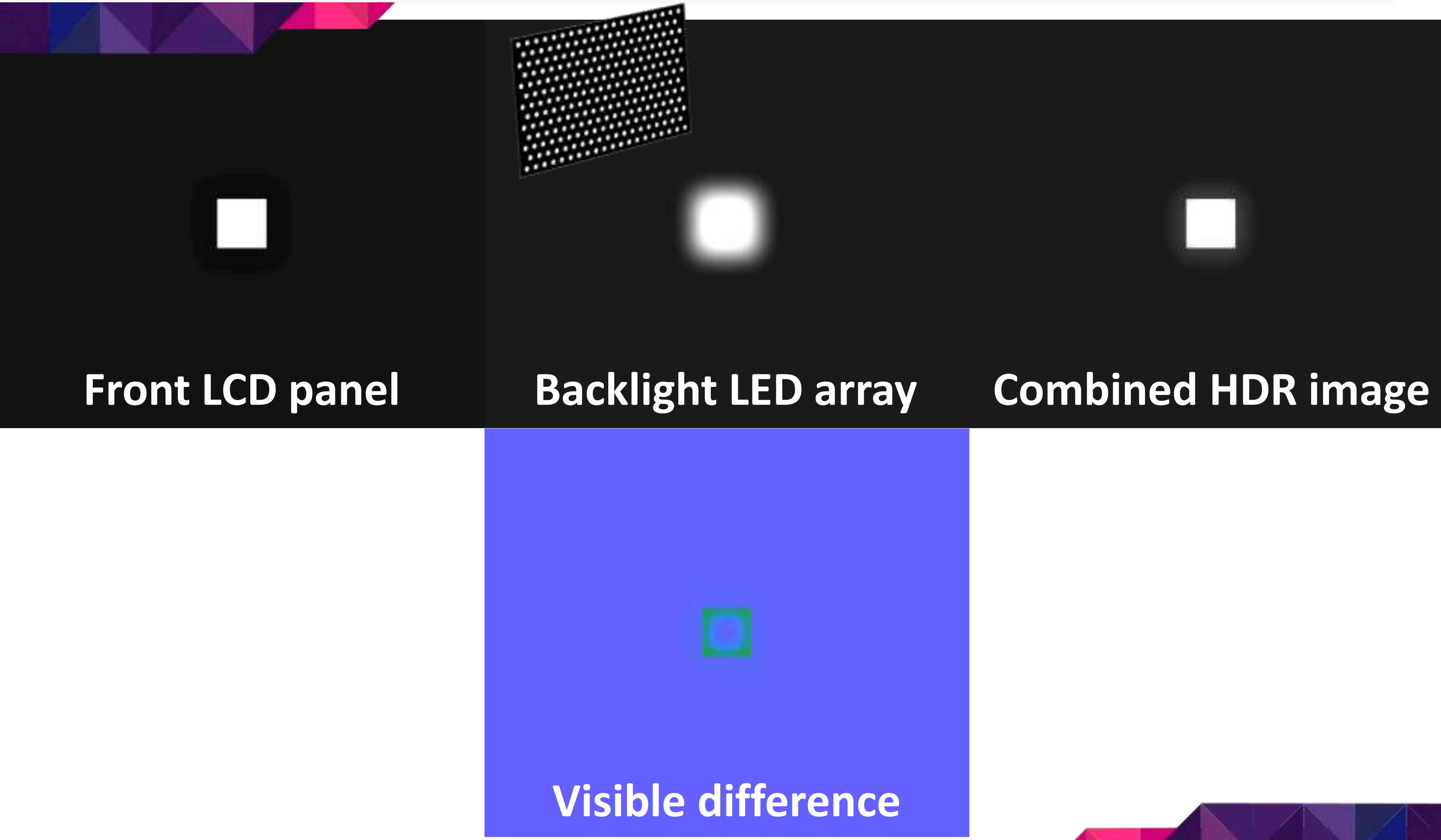

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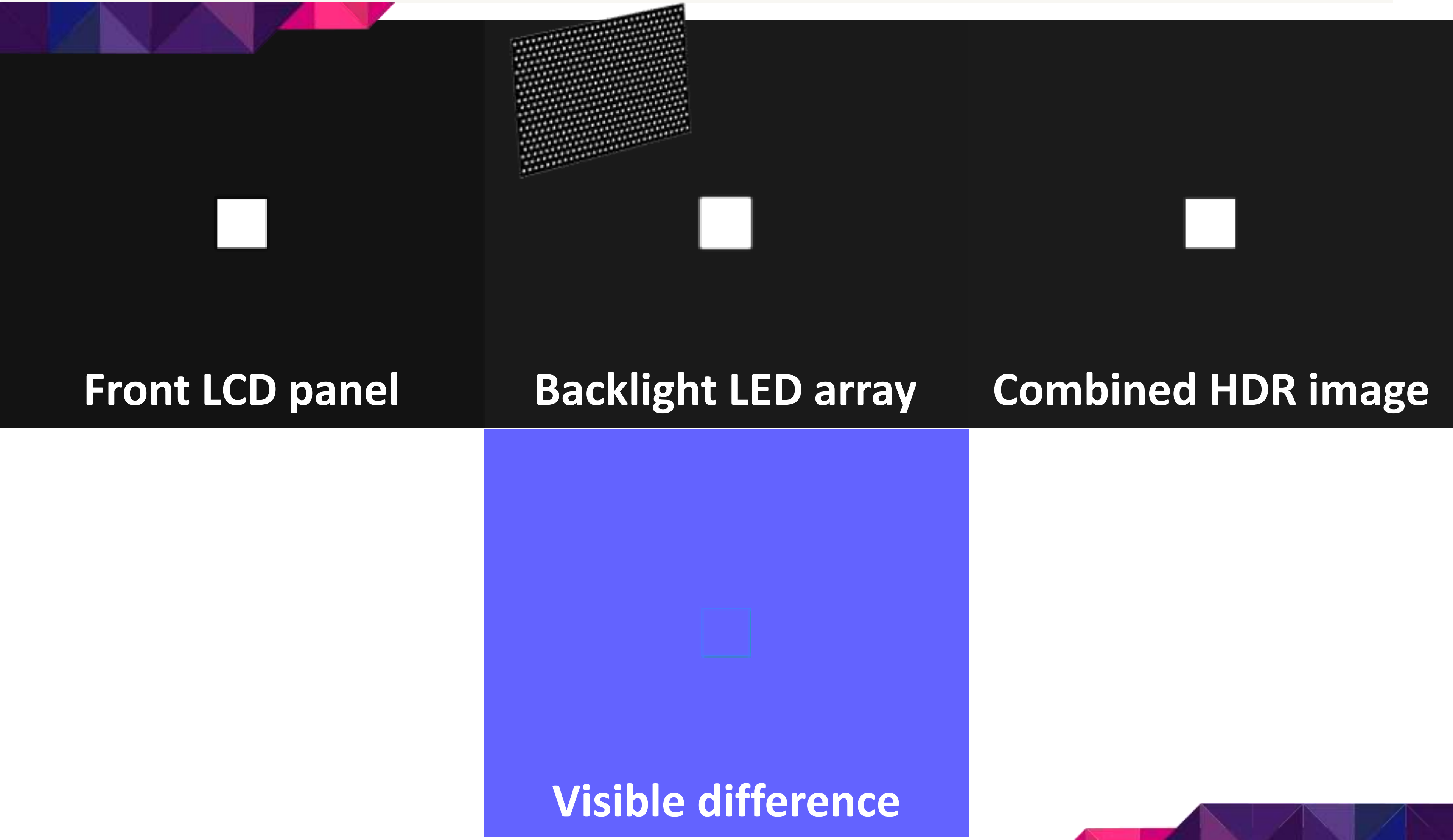

Application: Dynamic Range

Application: Dynamic Range

Application: Afterimages

Application: Gaze-dependent TM

Summary of Contributions

- **General model**
  - local adaptation luminance
  - contrast detection threshold
- **Experiment**
  - contrast detection while adapted to various patterns
- **Analysis**
  - interpretation of results of individual sets of patterns
  - model fitting to all patterns
  - cross-validation using maximally differentiating patterns
- A selection of **applications**

Thanks! Questions?

Source code available at
http://localadapt.pvangorp.be/

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