

The Comparison of Illumination Maps Technique in Computer Graphics Software

Edward A. Kopylov

Moscow State University

Andrei B. Khodulev, Vladimir L. Volevich

Keldysh Institute of Applied Mathematics RAS

Moscow, Russia

Illumination Maps: VRML



International Conference Graphicon 1998,
Moscow, Russia, <http://www.graphicon.ru/>

TESTS

```
graph TD; TESTS[TESTS] --- CUBE["CUBE  
(analytic test)"]; TESTS --- SPHERE["SPHERE  
(analytic test)"]; TESTS --- TEST_E["TEST-E  
(practical test)"];
```

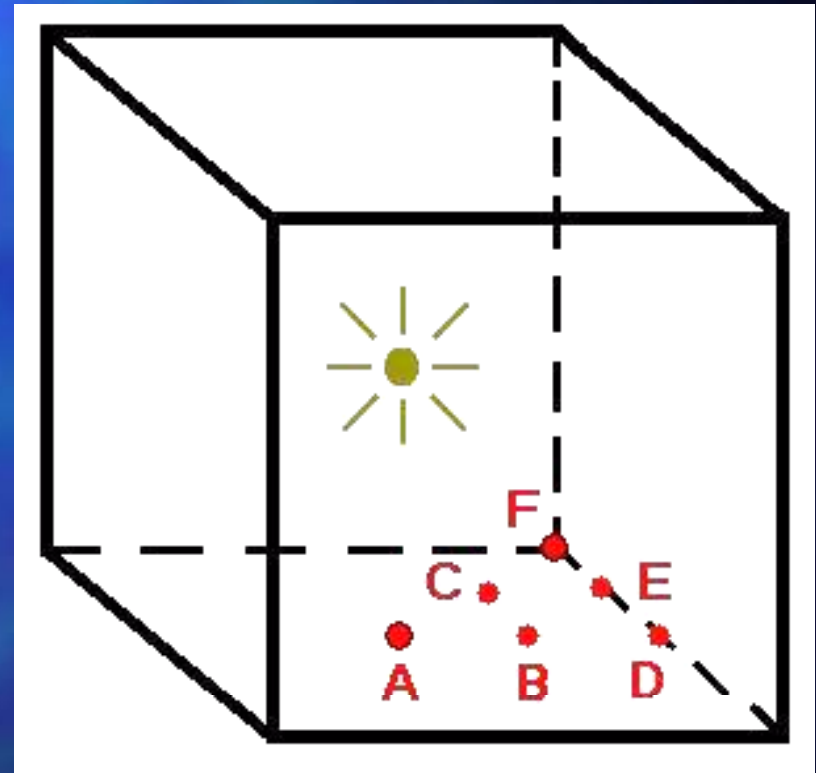
CUBE
(analytic test)

SPHERE
(analytic test)

TEST-E
(practical test)

CUBE

- $10 \times 10 \times 10$ m
- 50000 cd
- illumination = 2000 lux
- white color
- diffuse reflectivity = $2/3$

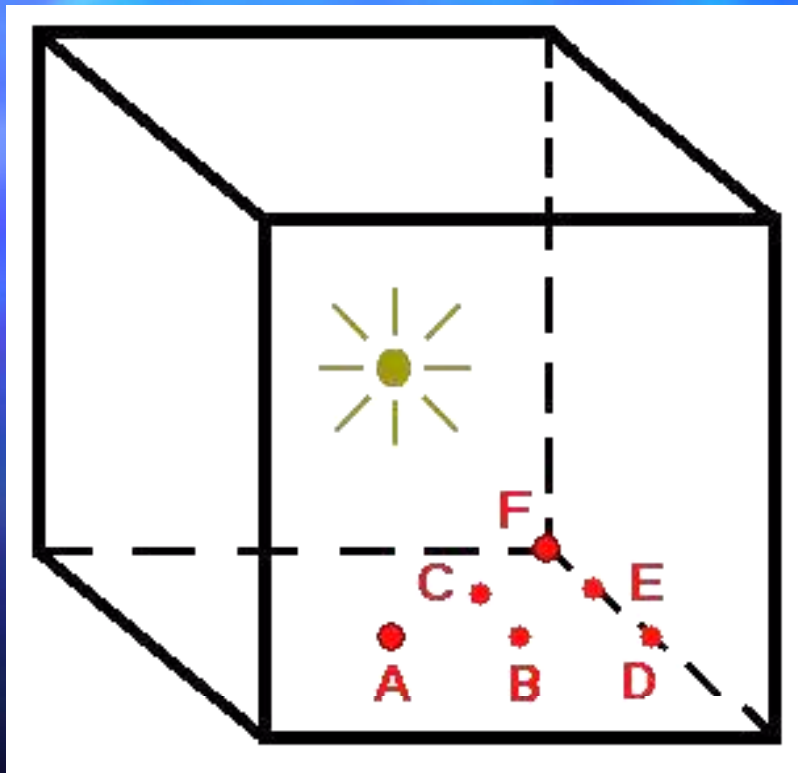


CUBE: energy transfer equation

$$Illum(p) = \int_{\Omega} \frac{Lum(q) \cdot \cos(\alpha) \cdot \cos(\beta)}{r^2(p, q)} dA(q)$$

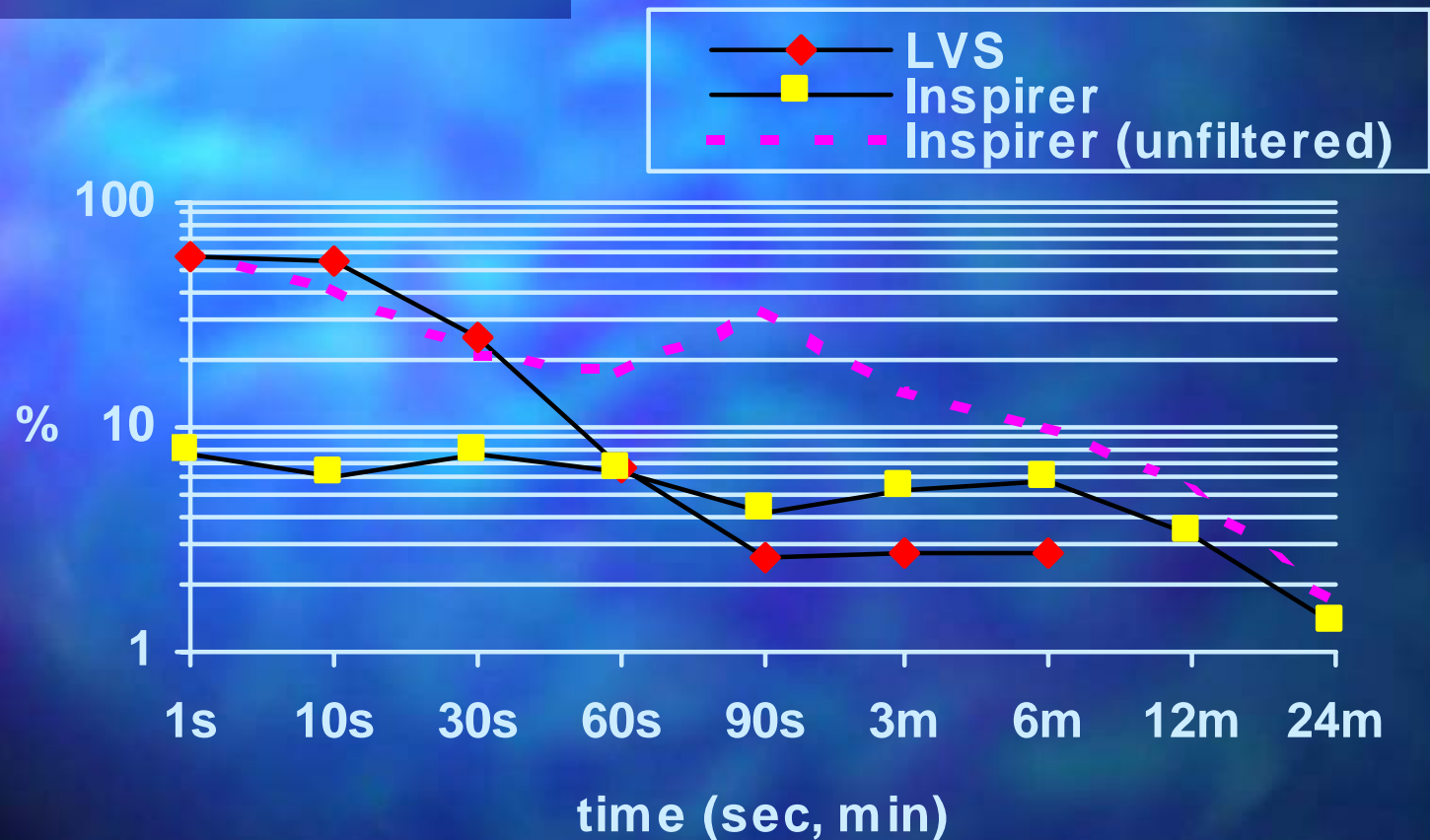
- $Illum(p)$ - is unknown luminance in some point P
- $lum(q)$ - is luminance at point Q
- Ω - integral spans over all surfaces in a scene
- α, β - are angles between normals in P, Q and PQ segment
- $r(p, q)$ - is Euclidean distance between P and Q
- $dA(q)$ - is differential area element at point Q

Theoretical luminance values for cube

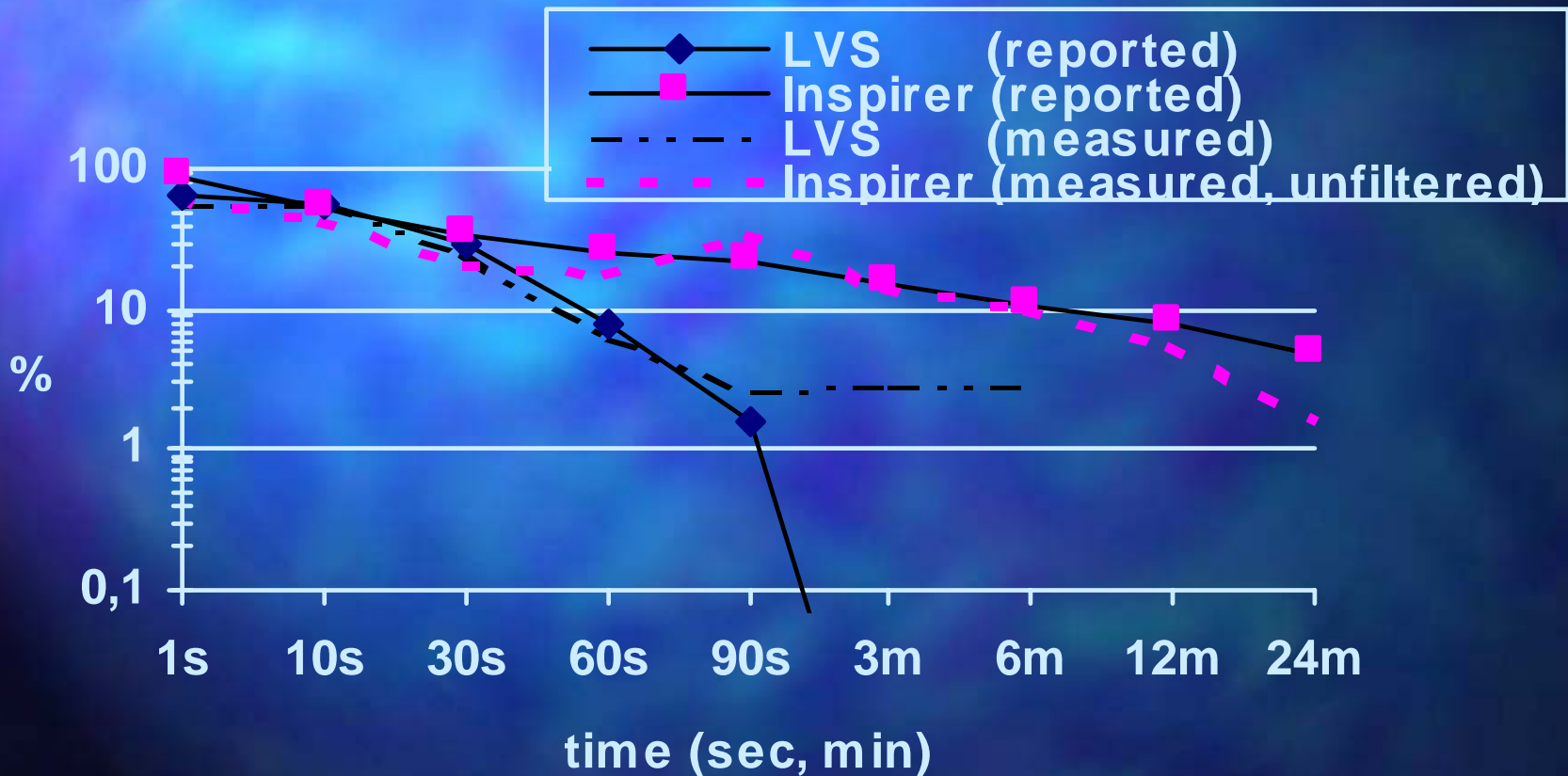


- $A = 892.8 \text{ (cd/m}^2\text{)}$
- $B = 768.7 \text{ (cd/m}^2\text{)}$
- $C = 686.6 \text{ (cd/m}^2\text{)}$
- $D = 565.1 \text{ (cd/m}^2\text{)}$
- $E = 522.4 \text{ (cd/m}^2\text{)}$
- $F = 388.4 \text{ (cd/m}^2\text{)}$
- $A - 1/25$
- $B, C, D, F - 4/25$
- $E - 8/25$

CUBE: Measured error vs. time



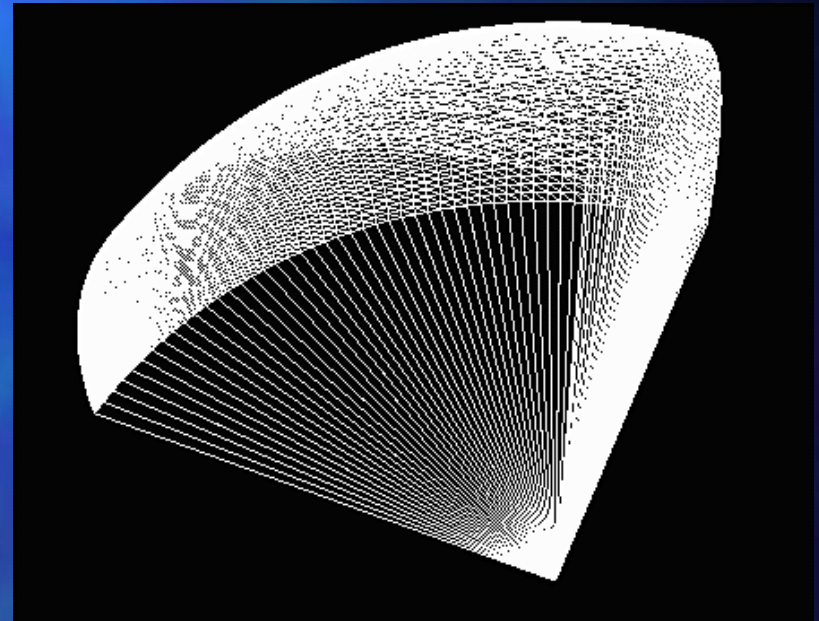
CUBE: Reported error vs. time



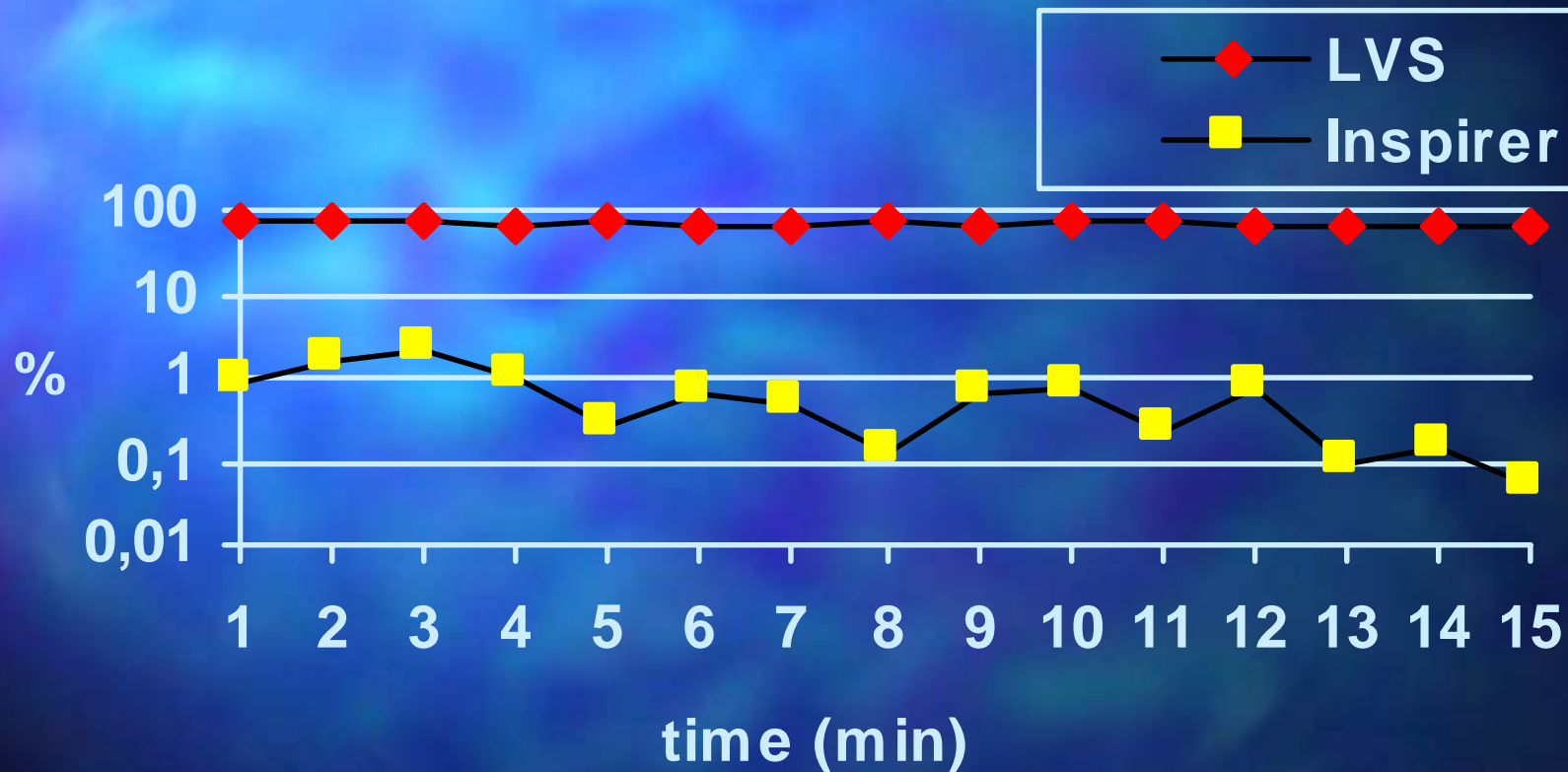
SPHERE: diffuse-specular-diffuse energy transfer.

- a diffuse sphere
- 3 mirror coordinate planes
- exact ambient illuminance
- form-factor is the same for all pairs of points

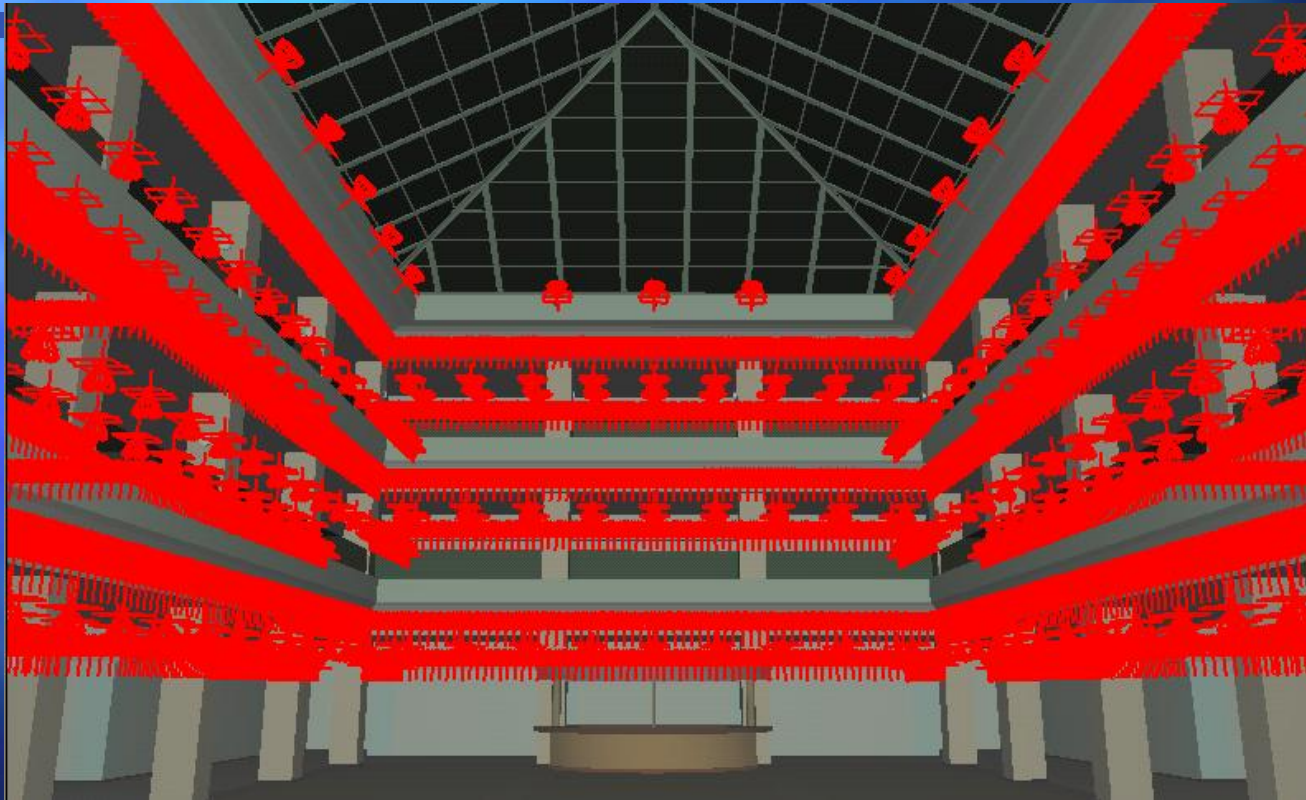
- total illuminance in the center of sphere octant = 1353.247 lux



SPHERE: Simulation error vs. time



TEST-E: Practical test



- about 10000 triangles
- 2626 luminaires for 3 types of photometric data

International Conference Graphicon 1998,
Moscow, Russia, <http://www.graphicon.ru/>



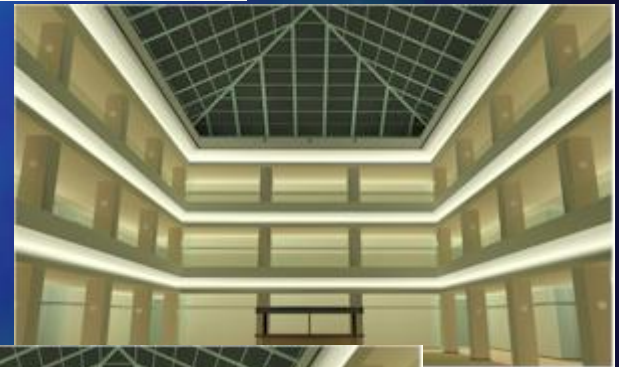
■ 1 min



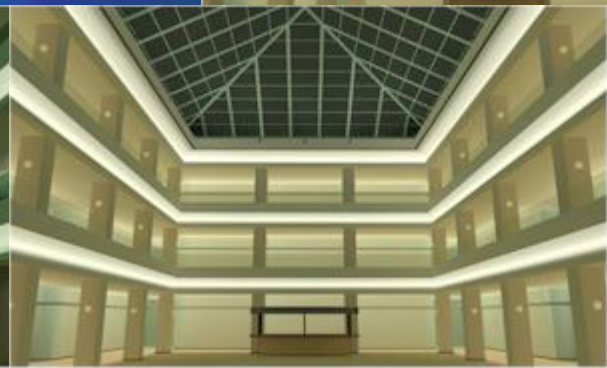
■ 8 min
Inspirer



■ 64 min



■ 68 hours
LVS



NOTE

- Inspirer reports progress in form of error estimation
- LVS produces progress reports in terms of initial energy. For example, 33.44% left means that 33.44% of initial energy still unshot. The actual accuracy level is unknown

Note about shadows



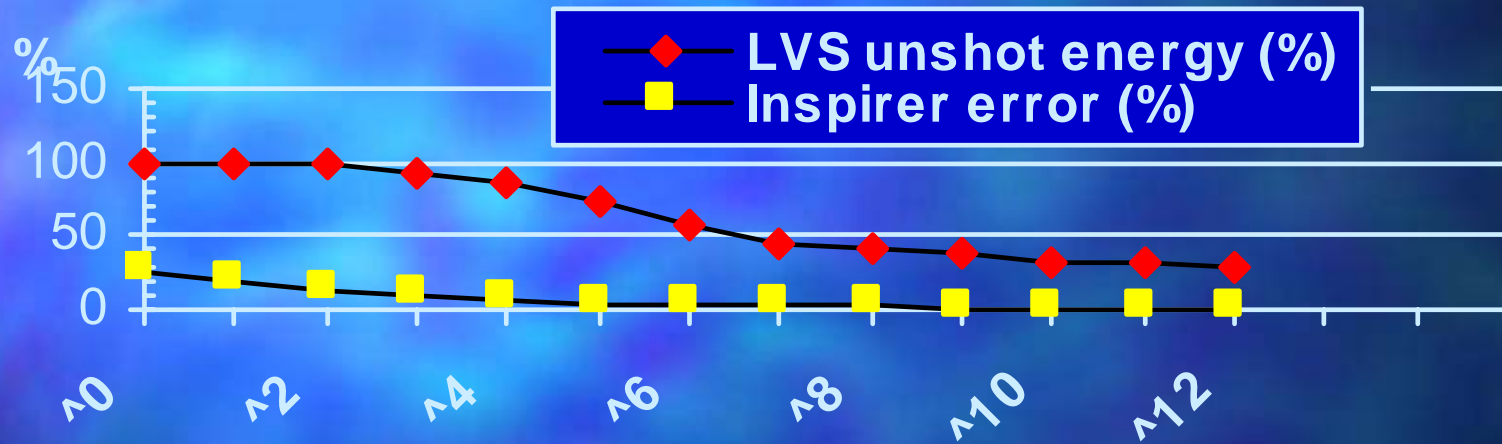
LVS



Inspirer

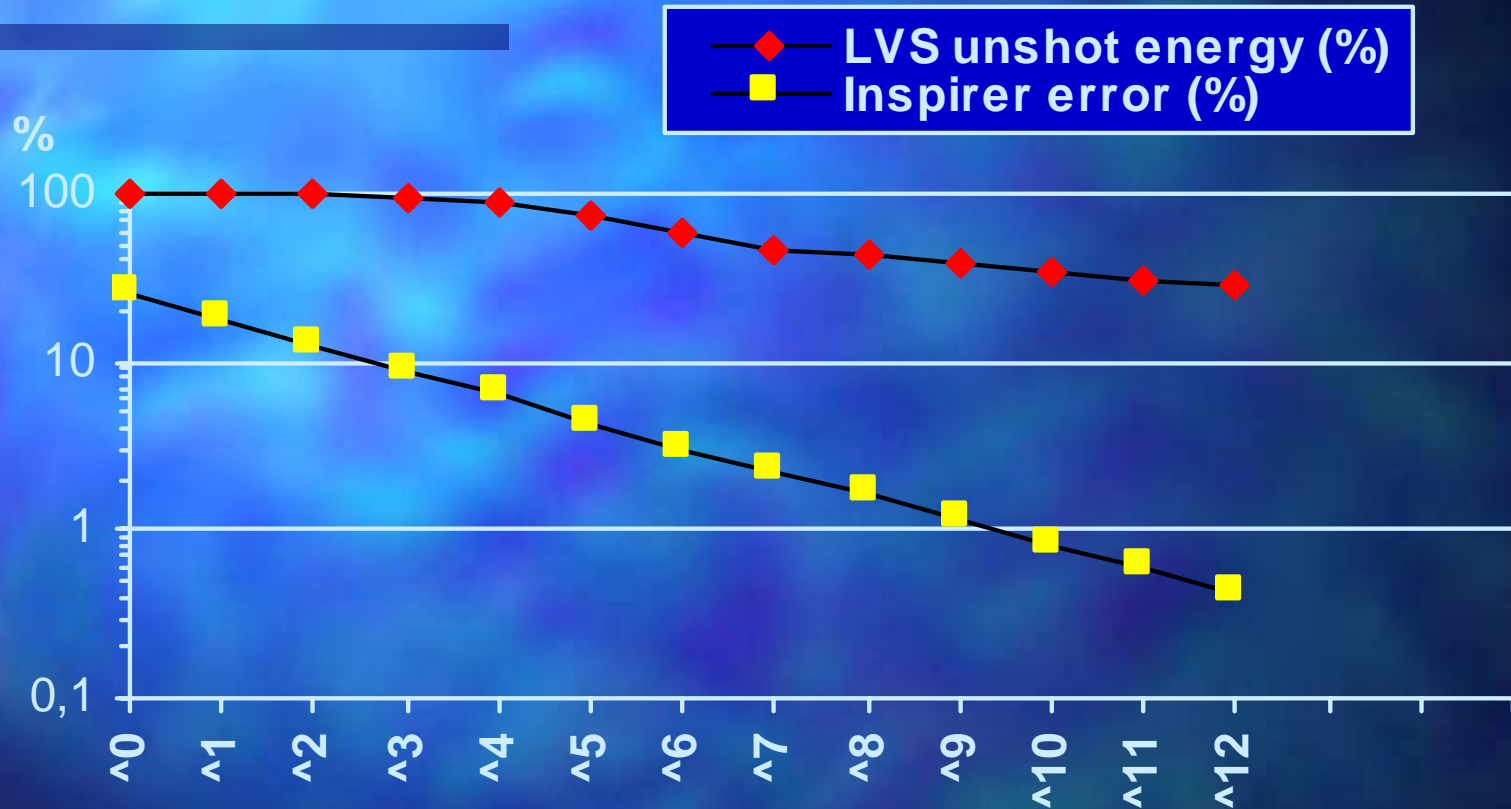
- incomplete calculation at this step for LVS

Reported progress vs. time



time (min) expressed by powers of 2: 1min, 2min, 4min, 8min ...

logarithmic scale



time (min) expressed by powers of 2: 1min, 2min, 4min, 8min...

■ logarithm of error is changed linearly with logarithm of time

Analysis of convergence speed

$$d(f, g) = \sqrt{\frac{1}{N} \sum_{i=1}^N (f_i - g_i)^2}$$

$$d_{rel}(f, g) = \frac{d(f, g)}{\|f\|}$$

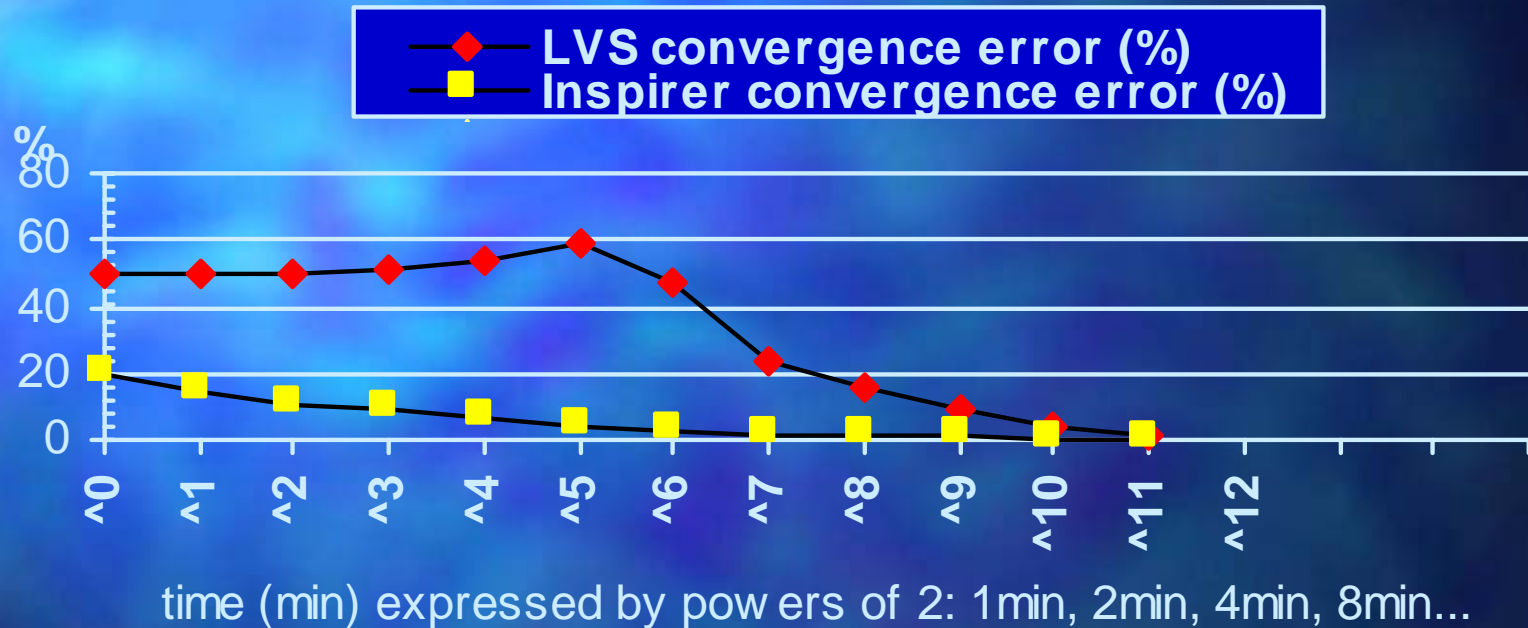
N - number of pixels

f - color component of reference image

g - color component of compared with

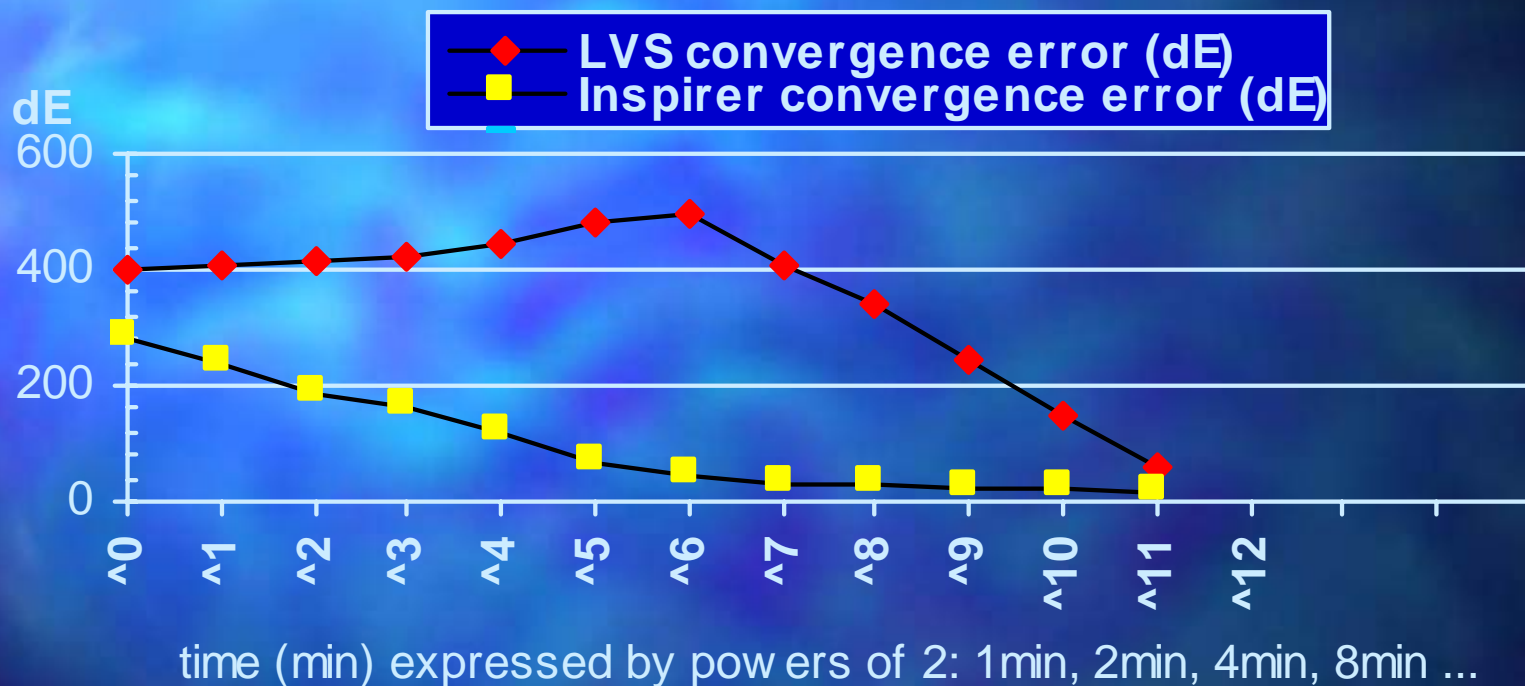
- This comparison is based on calculation of a distance (L2 in RGB) between intermediate images and some reference image
- 2^{12} minutes (about 68.5 hours)

Convergence of images to reference one vs. time



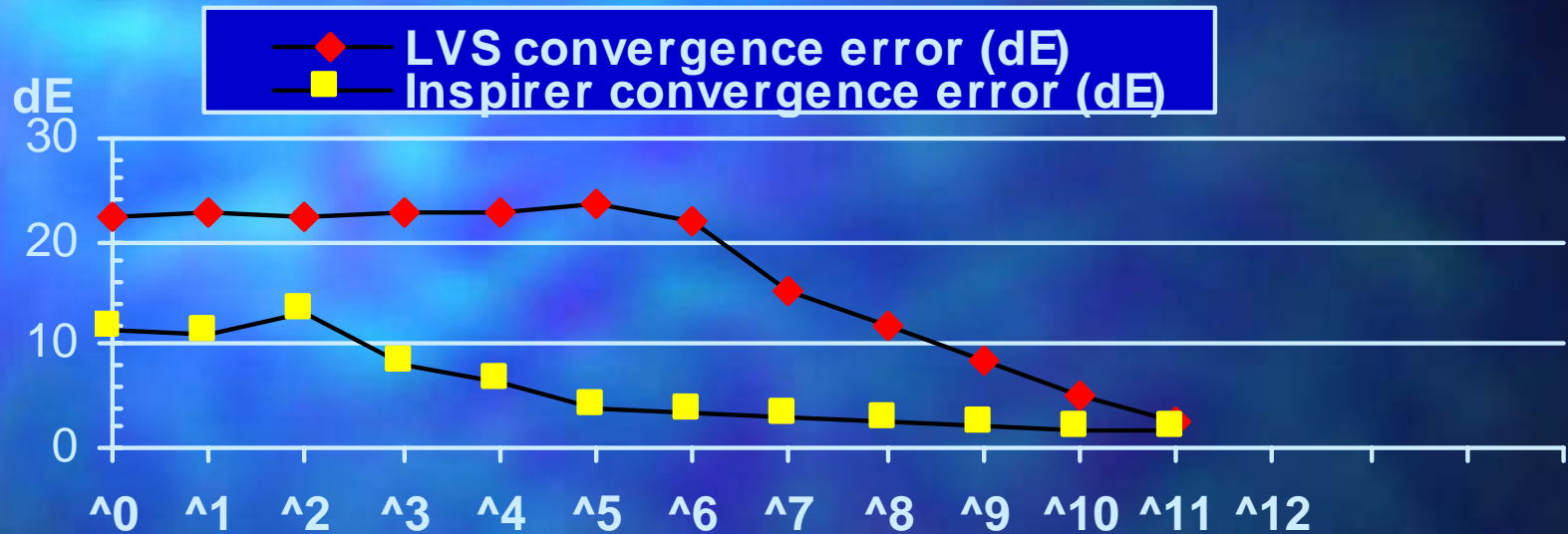
■ L2 metric in RGB

Convergence of images to reference one vs. time



■ Euclid metric in Lab CIE 1976

Convergence of images to reference one vs. time



time (min) expressed by powers of 2: 1min, 2min, 4min, 8min ...

■ Euclid metric in Lab CIE 1995

International Conference Graphicon 1998,
Moscow, Russia, <http://www.graphicon.ru/>