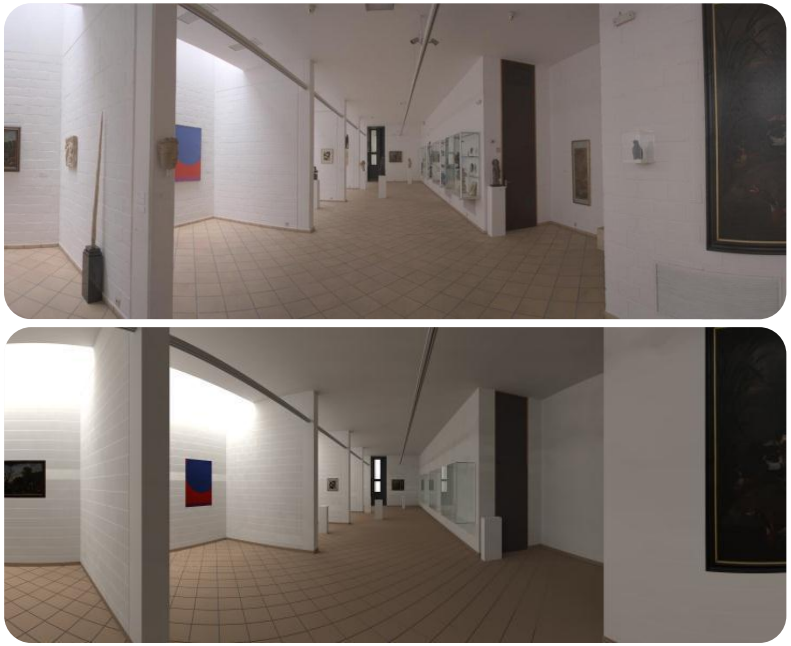
Potential of image-based lighting (IBL) pictures for subjective lighting quality evaluations

a comparison with real world luminances and physically based renderings (PBR)



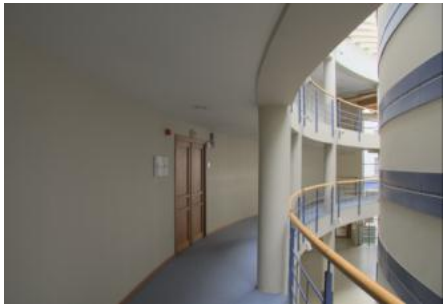
11th International Radiance Workshop
Copenhagen, 12-14 September 2012

Coralie Cauwerts, Eng. in arch. | FNRS Research Fellow
Université catholique de Louvain, Belgium

A numerical comparison of luminances :

< HDR pictures

(captured in four real rooms)



< PBR

(light source =
Perez sky generated with gendaylit)

< IBL pictures

(light source =
sky captured simultaneously to indoor pictures)

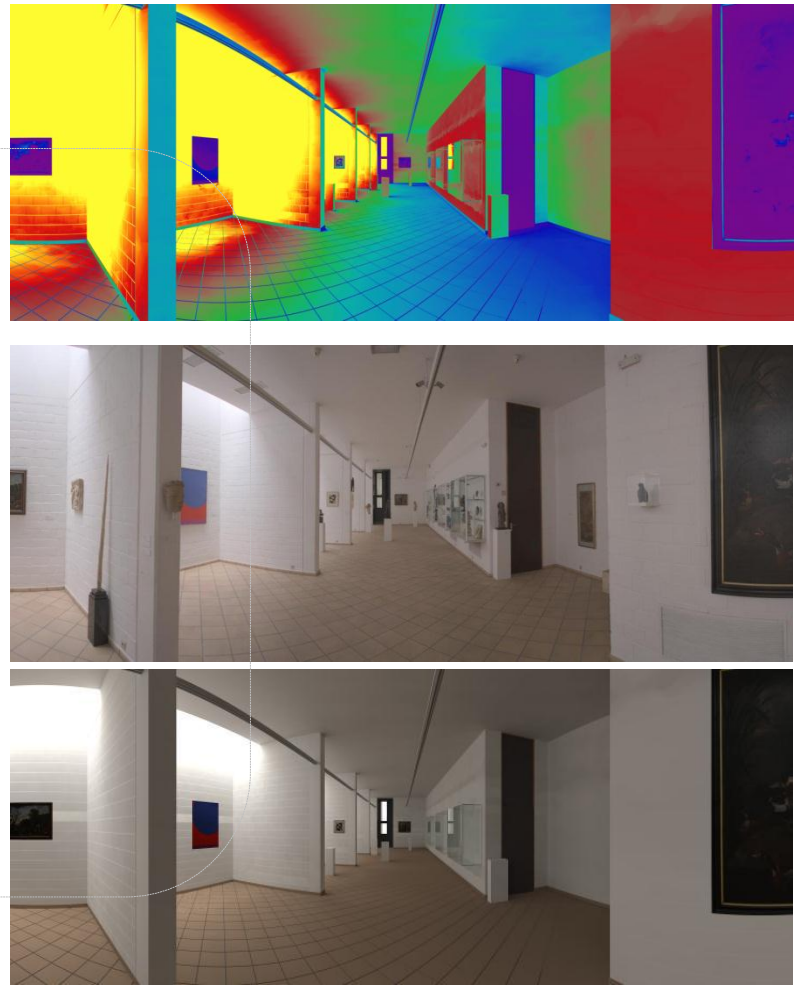
Context

Luminance maps

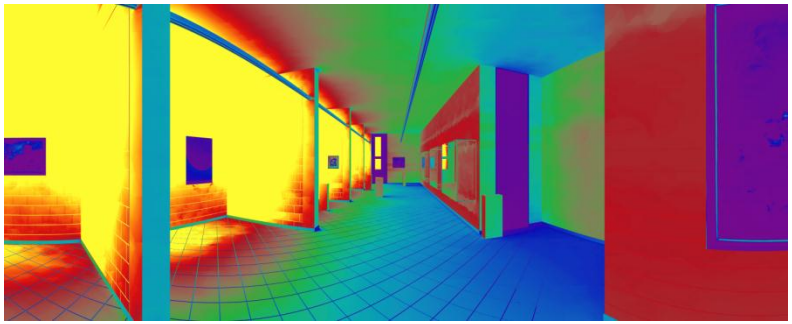
Luminance comparison

Conclusions

To continue …



Context



→ A PhD work

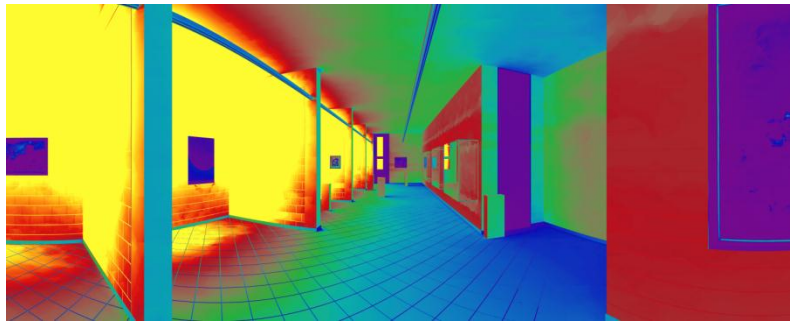
→ AIM : Evaluation of the potential of Radiance pictures for subjective lighting quality evaluations of daylit spaces, as well as the interest of :

- 3D displays *(trying to reproduce binocular vision)*
- panoramic images *(capturing a wide visual field without introducing distortion)*
- HDR displays *(producing wider range of luminances)*

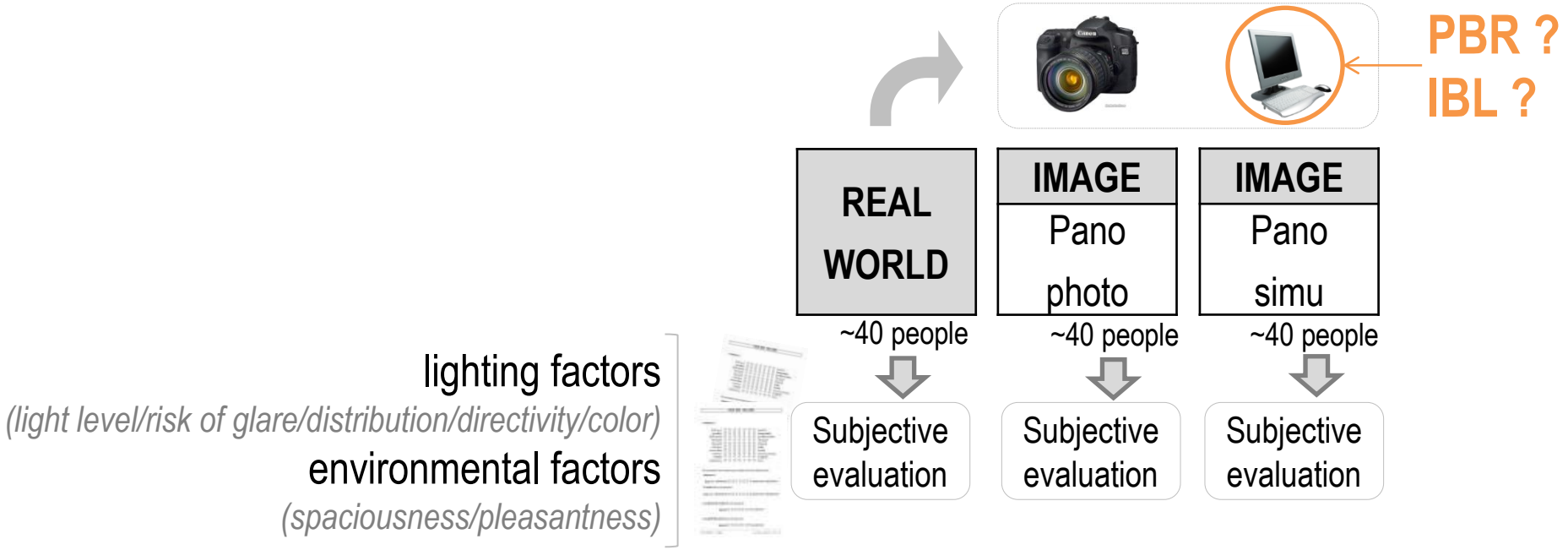
to evaluate :

- lighting *light level/risk of glare/distribution/directivity/color*
- environmental factors *spaciousness/pleasantness*

Context



Interest of Radiance renderings for subjective lighting assessment



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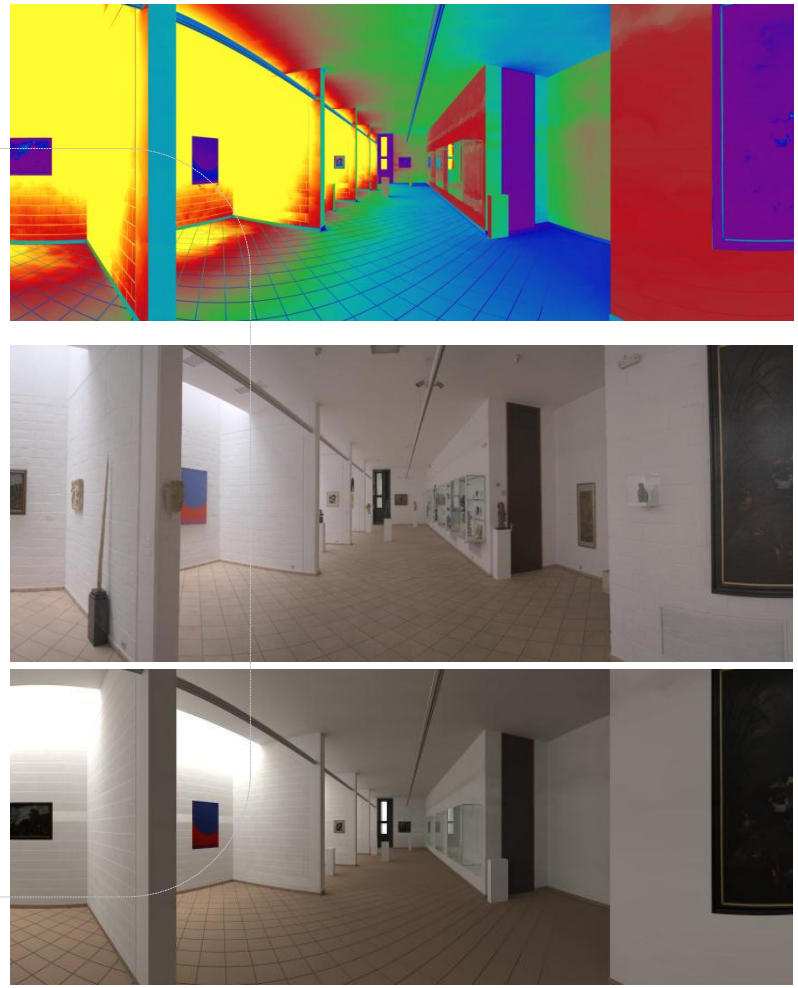
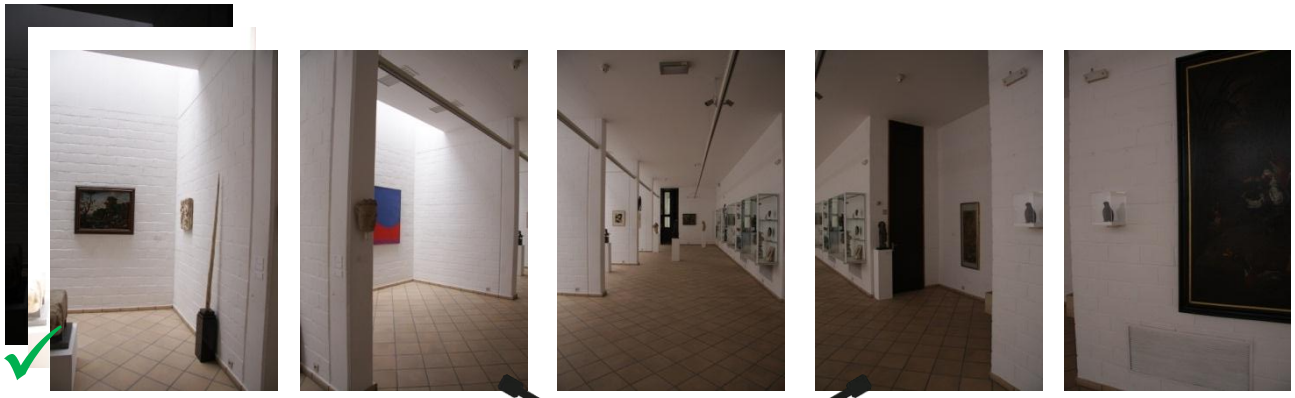
To continue …



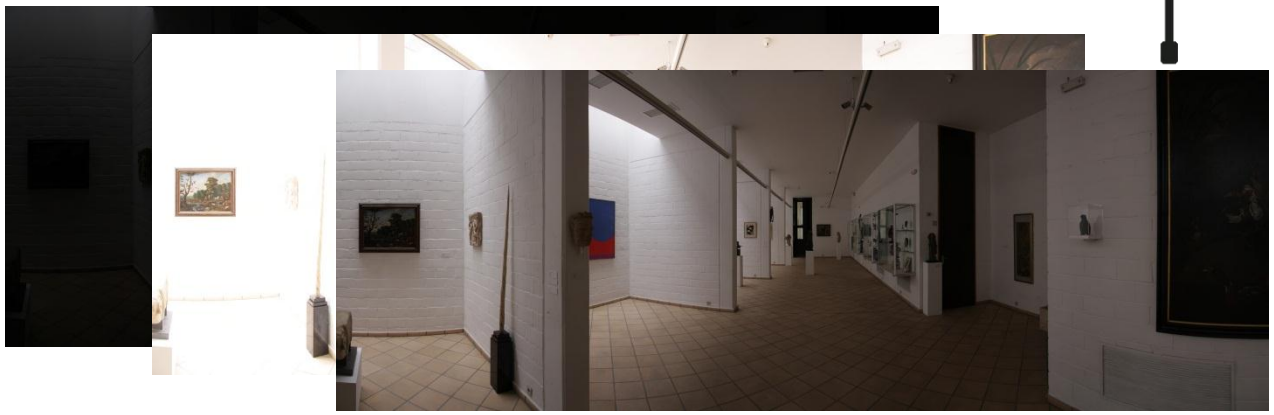
STEP I-a : HDR PICTURES in the REAL WORLD

To cover a large visual field and capture luminances of real world :
HDR panoramic pictures



SIGMA 4.5mm F2.8 EX DC HSM Fisheye
> low resolution of the pano picture

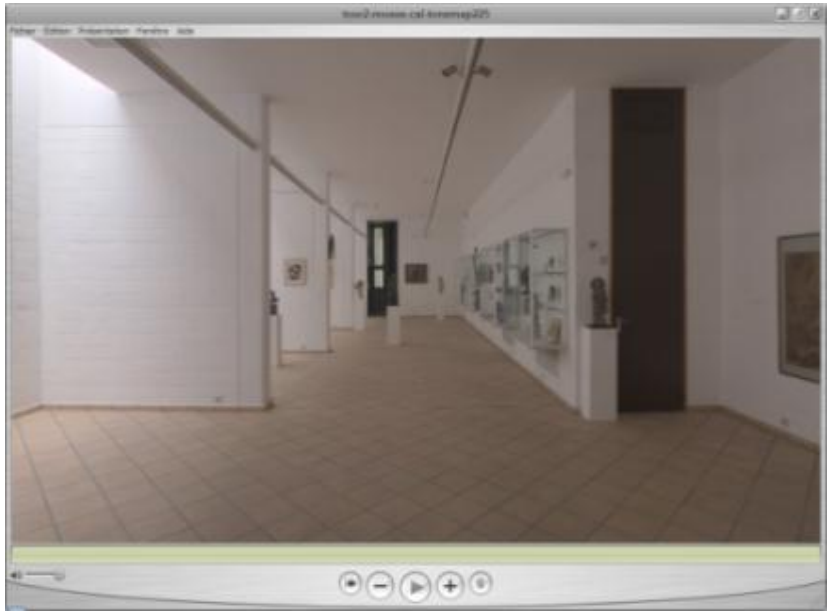
Rotation around the
entrance point



LDR panorama
< in PTGui Pro

STEP I-a : HDR PICTURES in the REAL WORLD

Multiple LDR panorama
fused into a HDR picture
< *hdrgen* command in Radiance
< response curves (< WebHDR)
+ calibration < luminancemeter

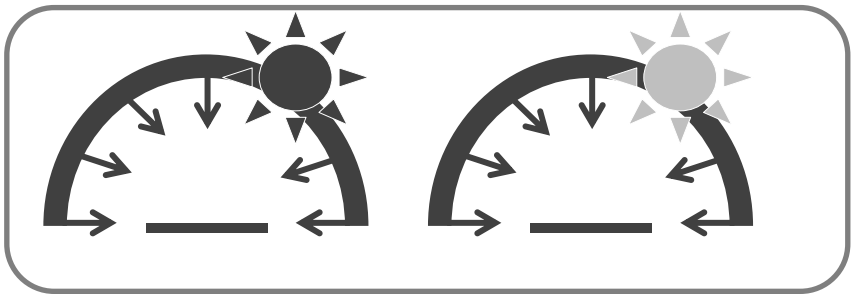


Tone-mapped HDR pictures
< photographic tone mapping
operator (Reinhard et al. 2002)
< litterature
< pre-tests

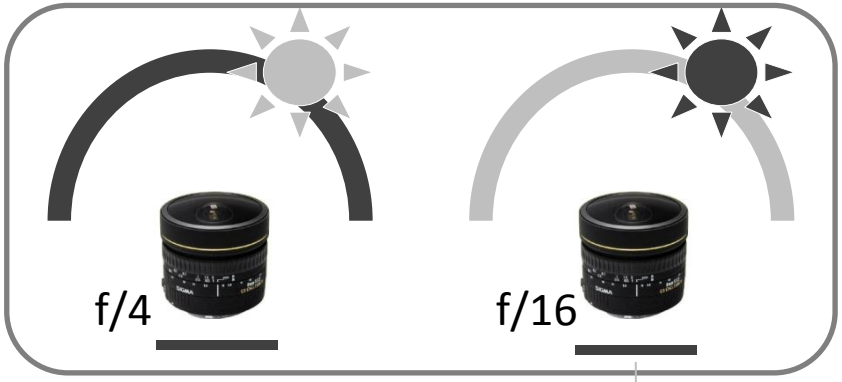
QuickTime panoramic picture
< PTguiPro

STEP I-b : Ext. global/diffus horiz. illuminance
HDR pictures of the sky

@ 5min. intervals



Global horiz. illuminance
Diffuse horiz. illuminance



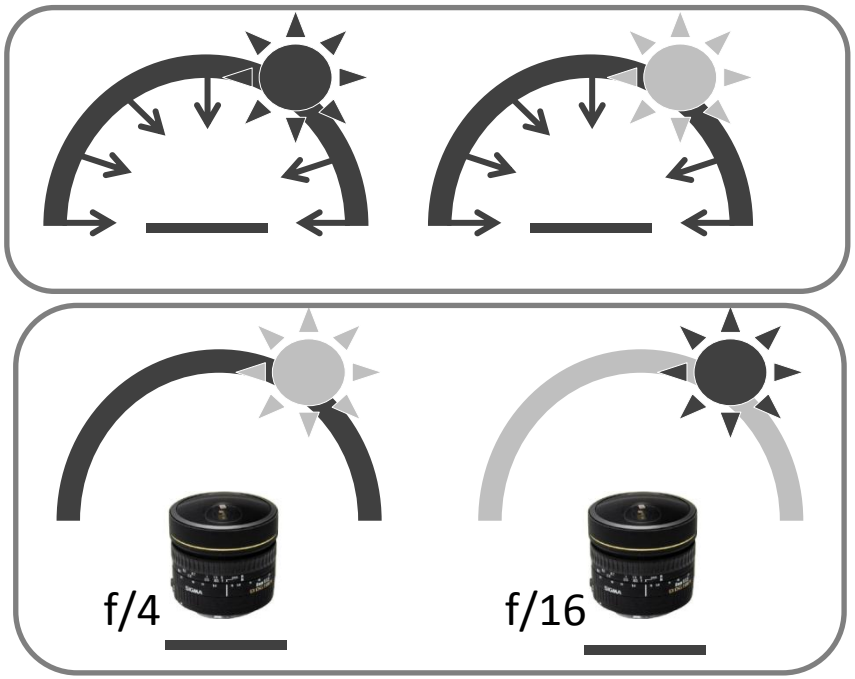
Series of LDR pictures
(sky + sun)

< Debevec 2002, Inanici 2009

Neutral density filter
< Stumpfel et al., 2004

STEP I-b : Ext. global/diffus horiz. illuminance
HDR pictures of the sky

@ 5min. intervals



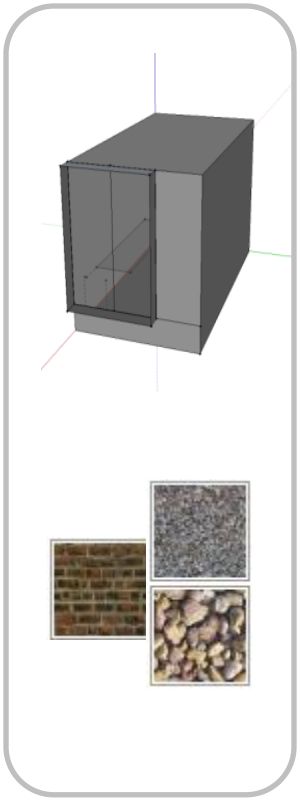
Global horiz. Illuminance
Diffuse horiz. illuminance

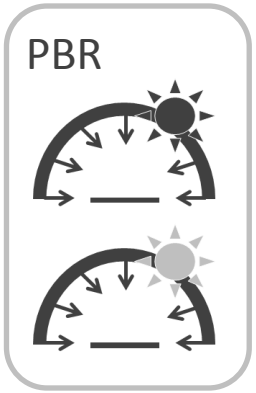
Series of LDR pictures
(sky + sun)

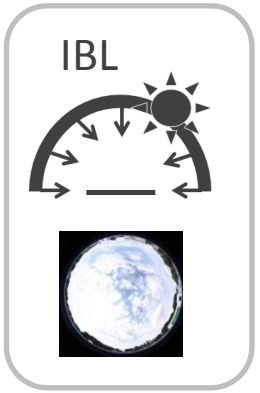
< Debevec 2002, Inanici 2009

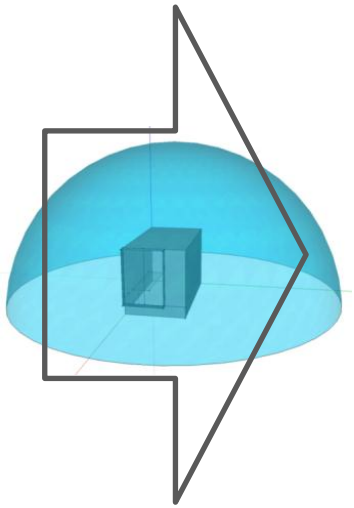
- HDR pictures (sky + sun)
- Filter correction
- Vignetting correction (SIGMA 4.5mm F2.8 EX DC HSM Fisheye)
- Combination of the 2 pictures
- Calibration < horiz. illum. measurement

STEP II : Simulations









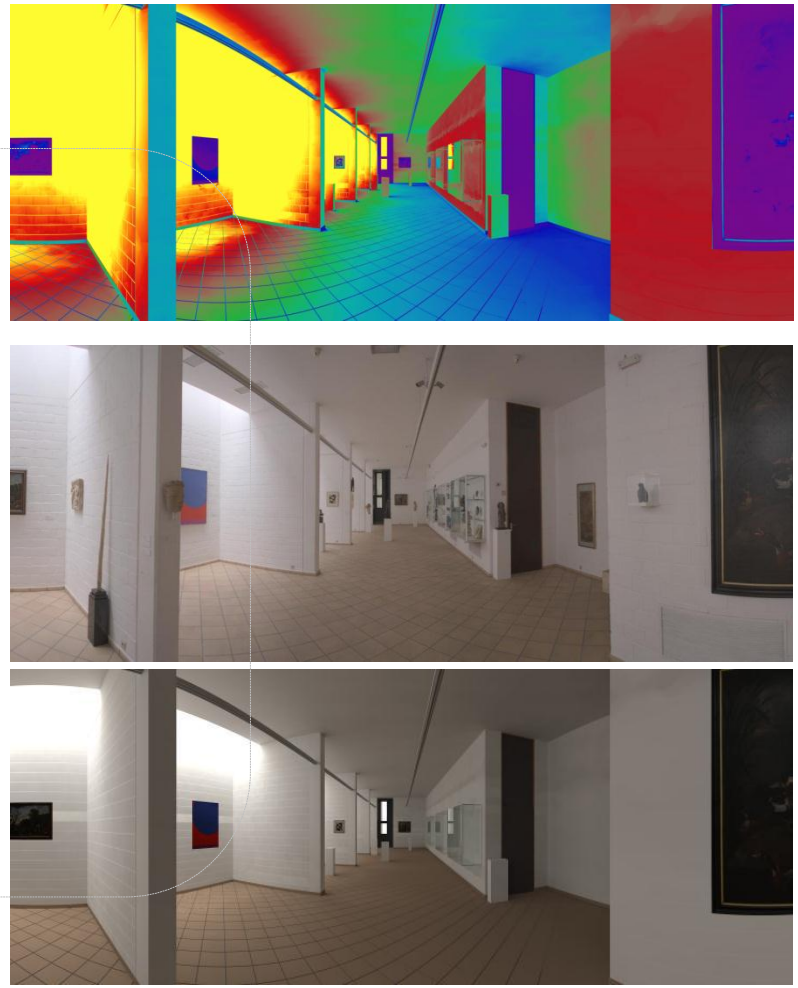
Context

Luminance maps

Luminance comparison

Conclusions

To continue …



Luminance comparison

Encountered difficulties :

How to compare photograph and virtual images ?

= geometrical misalignement

Luminance comparison

- *Visual comparison of luminance maps*

- *Calculation of the relative error (PBR vs. REAL & IBL vs. REAL)*
  - ~~*Pixel to pixel comparison*~~

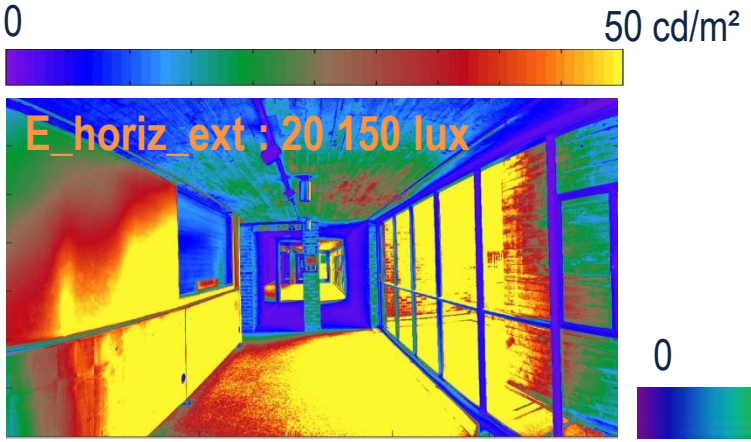
    → *Problems due to geometrical misalignment*
  - *10-pixels to 10-pixels comparison*

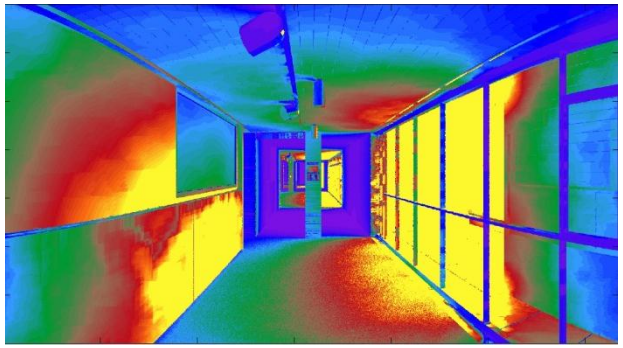
    → *Reduce the error due to geometrical misalignement*

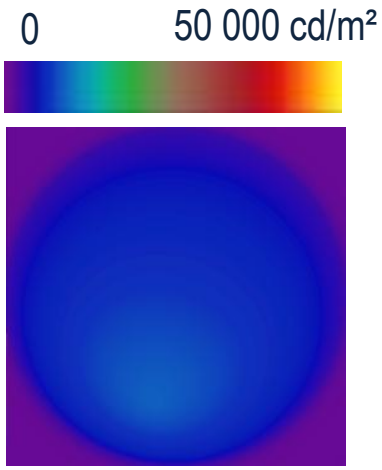
    → *Quick visual identification of regions with large relative errors*
  - *Surface to surface comparison*
  - *Comparison in the visual field*

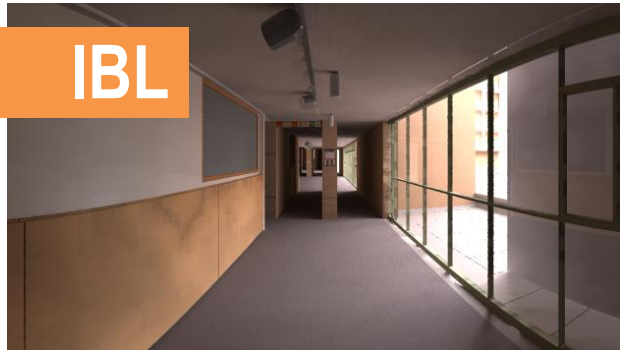
    → *Numerical value easier to compare*

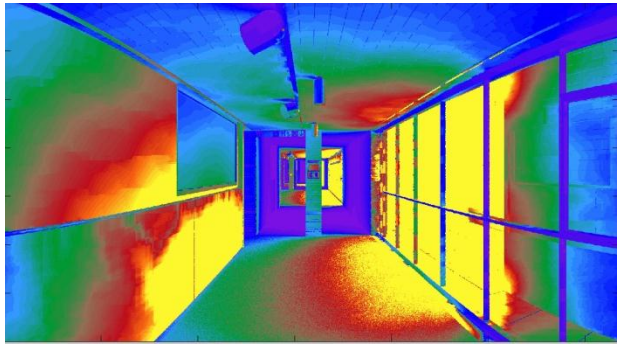
OVERCAST SKY - Luminances (cd/m²)

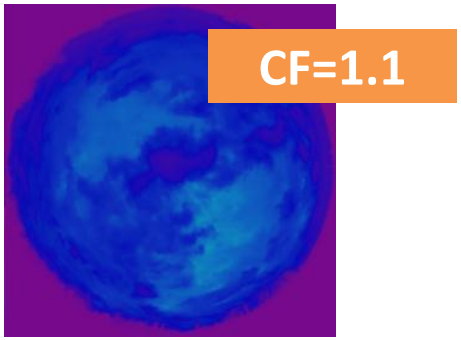












→Distributions of luminances are globally similar

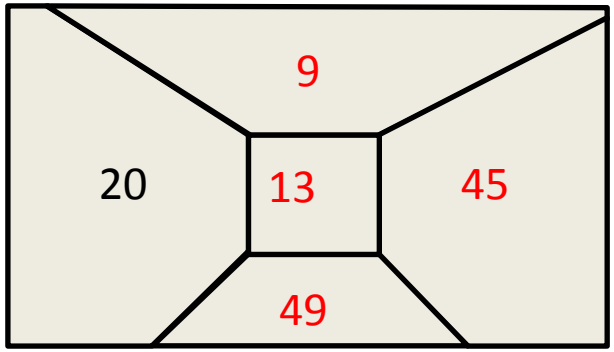
OVERCAST SKY - Relative errors (%)

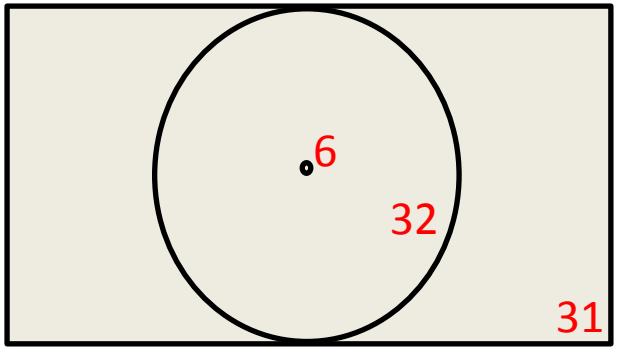
10-pixels to 10-pixels comparison

Surface to surface comparison

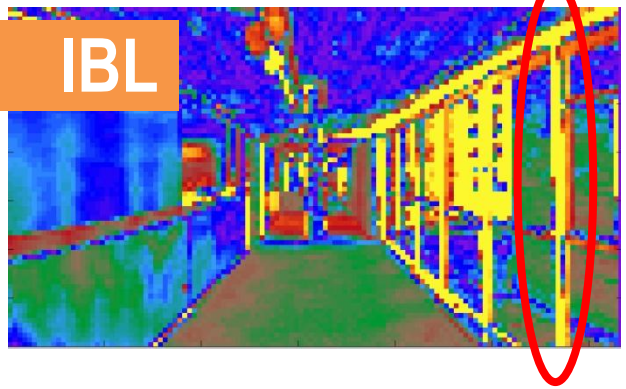
Comparison in the visual field

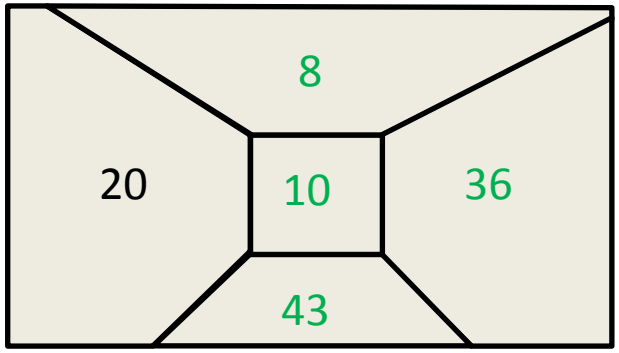
PBR

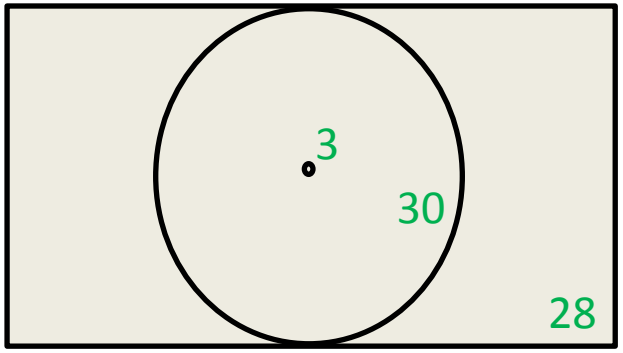




IBL







(10p/10p) → Quick visual identification of - regions with large relative error
- geometrical misalignement

(s/s) → IBL (MRE=24%) slightly better than PBR (MRE=27%)

(vf/vf) → IBL (MRE=20%) slightly better than PBR (MRE=23%)

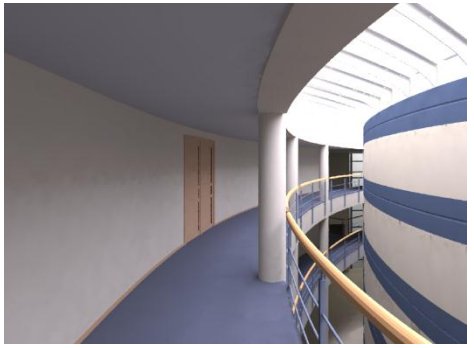
OVERCAST SKY - Renderings

REAL



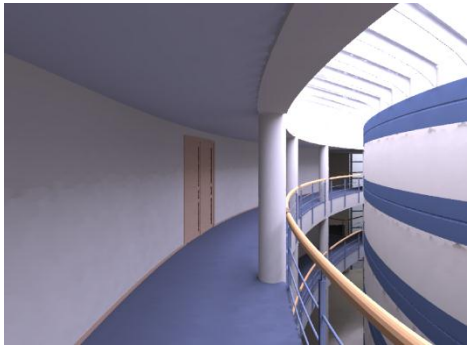
PBR



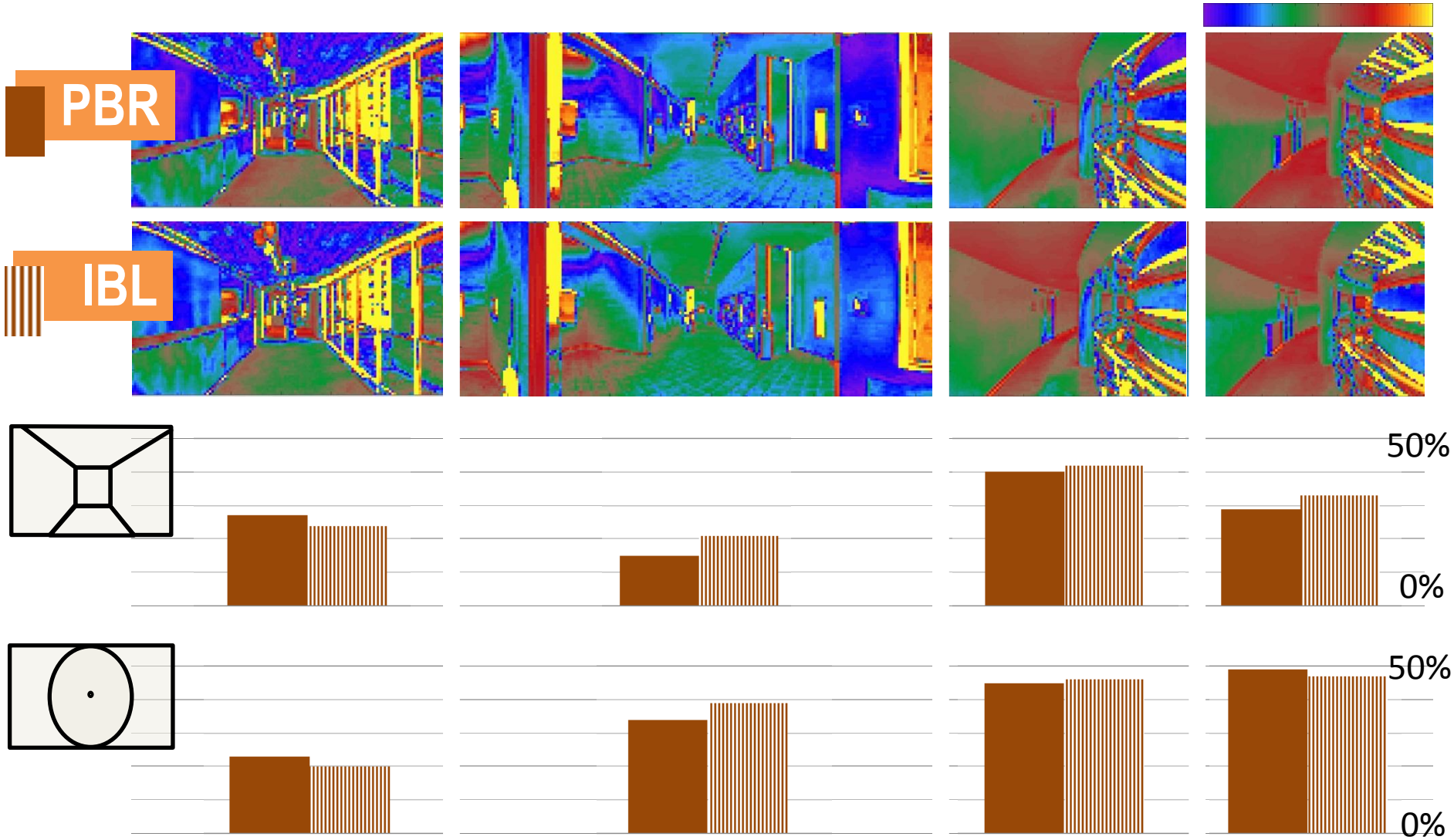


IBL





OVERCAST SKY - Relative errors (%)



→ Large MRE but a part is due to : - geometrical misalignement
- hypotheses on textures/materials

→ Difference between PBR and IBL is not large (< 10%)

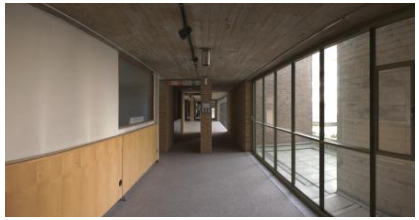
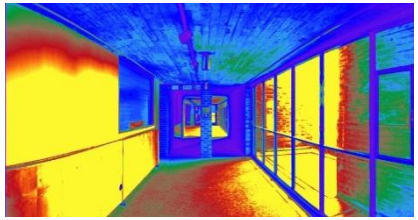
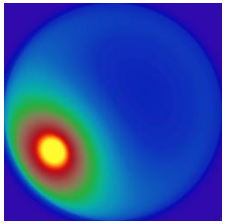
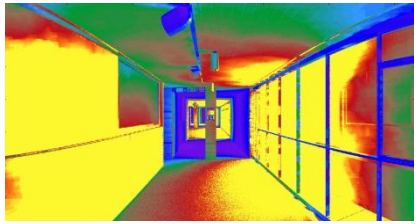
PARTLY CLOUDY SKY – Luminances (cd/m²)

Encountered difficulties :

HDR pictures of sunny sky

< problem to capture luminances of the sun ?

PARTLY CLOUDY SKY – Luminances (cd/m²)

REAL SPACE		
2012.03.09 11:50 AM Eh=71700 lux		
PBR (< gendaylit)		
		
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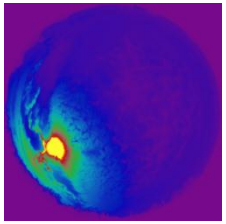
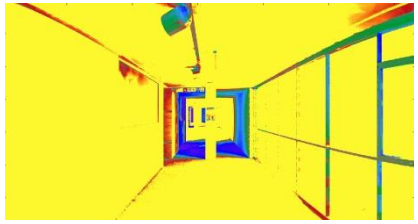
		

0 50 000 cd/m²

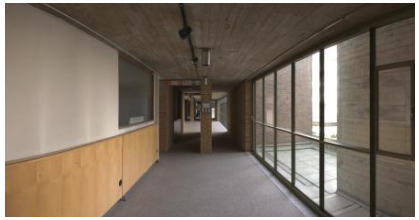
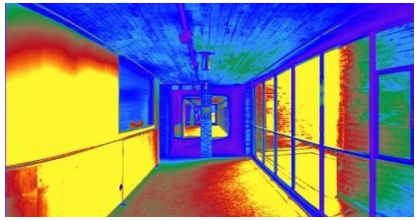
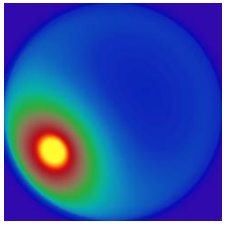
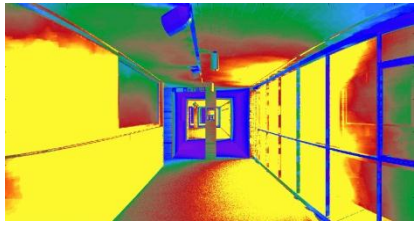
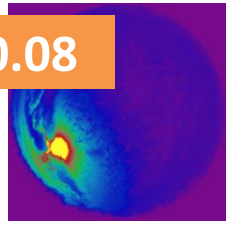
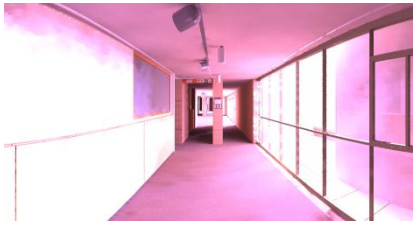
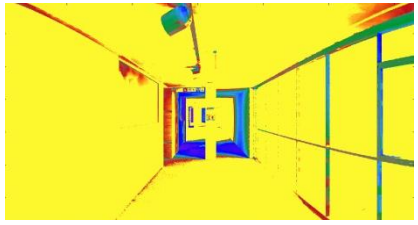
0 50 cd/m²

PARTLY CLOUDY SKY – Luminances (cd/m²)

Determination of the calibration factor (CF)

Comparison between :
- measured horiz. illum.
- horiz. illum. calculated < IBL with non-calibrated HDR sky picture

CF=0.08

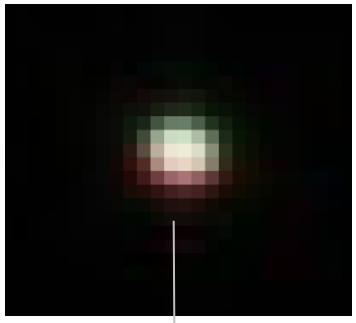
REAL SPACE		
2012.03.09 11:50 AM Eh=71700 lux		
PBR (< gendaylit)		
		
IBL calib#1		
		

0 50 000 cd/m²

0 50 cd/m²

PARTLY CLOUDY SKY – Luminances (cd/m²)

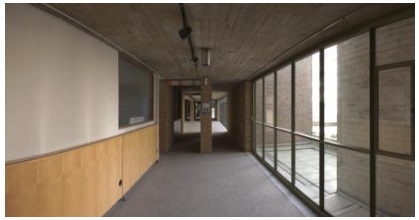
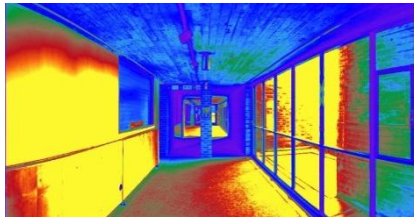
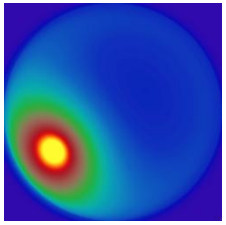
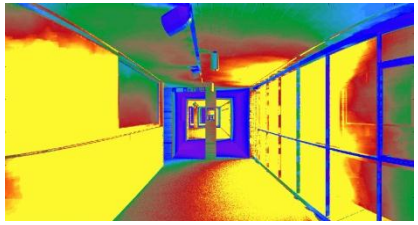
Problem to capture luminances of the sun ?



Shortest exposure with filter : no white pixel

CF=0.08

Problem to combine sky vault picture and sun picture ?

REAL SPACE		
2012.03.09 11:50 AM Eh=71700 lux		
PBR (< gendaylit)		
		
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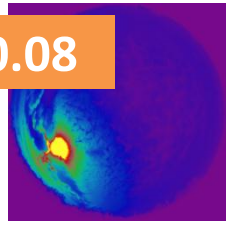
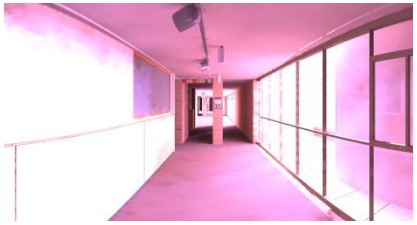
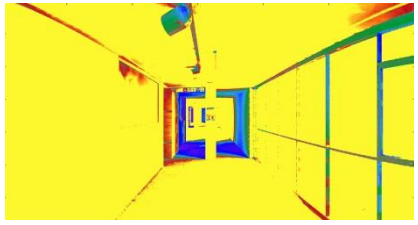
		

0 50 000 cd/m²

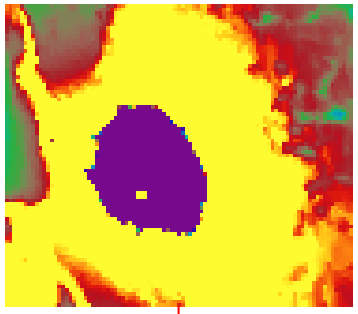
0 50 cd/m²

PARTLY CLOUDY SKY – Luminances (cd/m²)

A temporary solution to fix the problem …

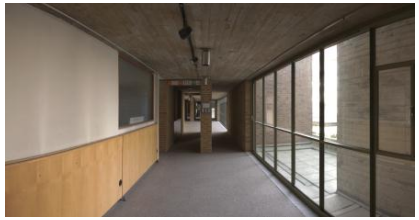
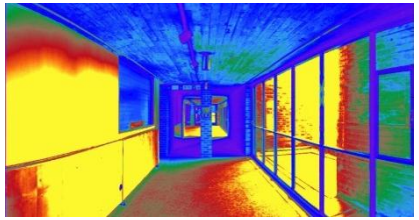
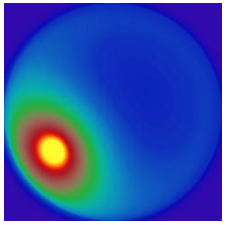
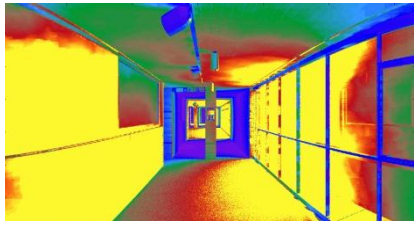
Removing luminances > 200 000 cd/m²

\+ a direct sun source



CF=0.08

CF=0.98

REAL SPACE		
2012.03.09 11:50 AM Eh=71700 lux		
PBR (< gendaylit)		
		
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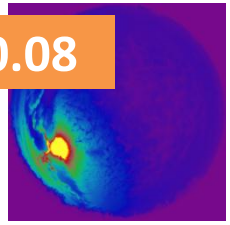	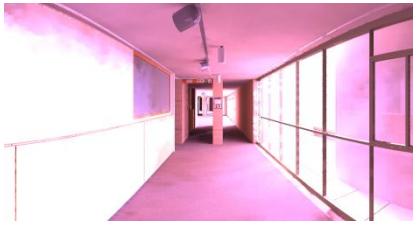	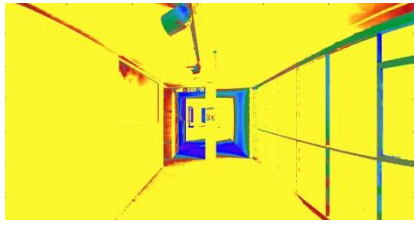
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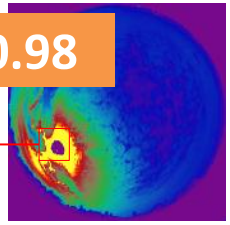
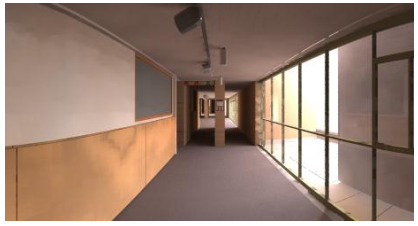
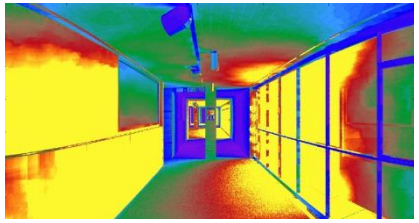
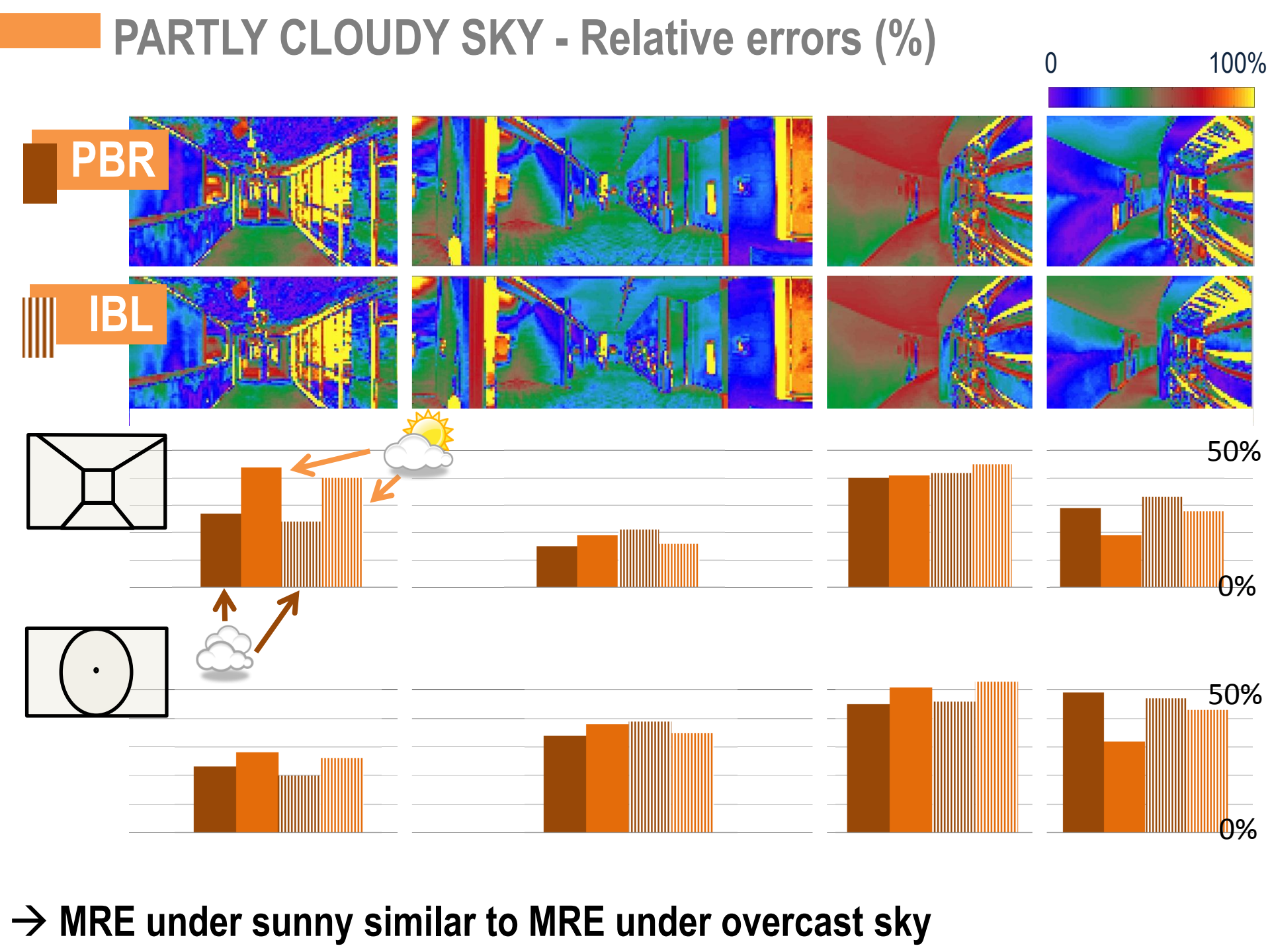
		

0 50 000 cd/m²

0 50 cd/m²

PARTLY CLOUDY SKY - Relative errors (%)



→ MRE under sunny similar to MRE under overcast sky

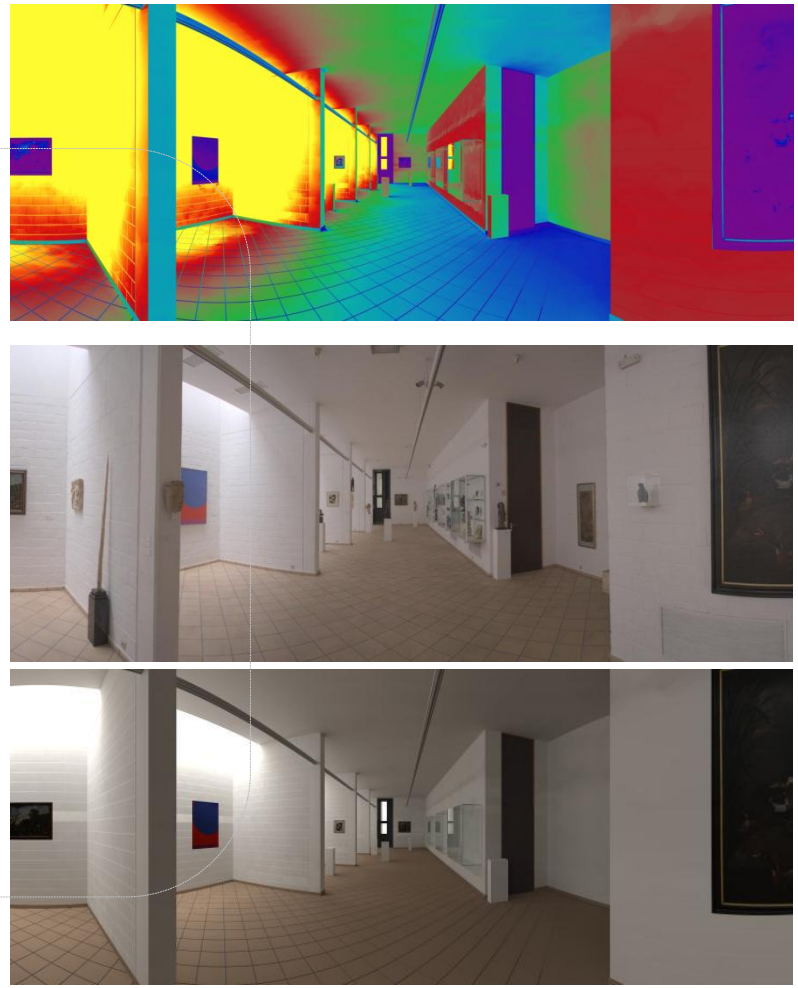
Context

PBR vs. IBL

Luminance comparison

Conclusions

To continue …



Conclusions

Difficulties to capture sunny skies < HDR techniques
Under an overcast sky, IBL ~ PBR
A large part of the error is due to geometrical misalignement

PBR : (+) gives good results
(+) procedure simpler than IBL
(+) 20% faster than IBL rendering

IBL : could be interesting with less complex room (single aperture) in which a HDR vertical fisheye picture taken outside the window could be used as a light source in order to take into account vegetation, surroundings…

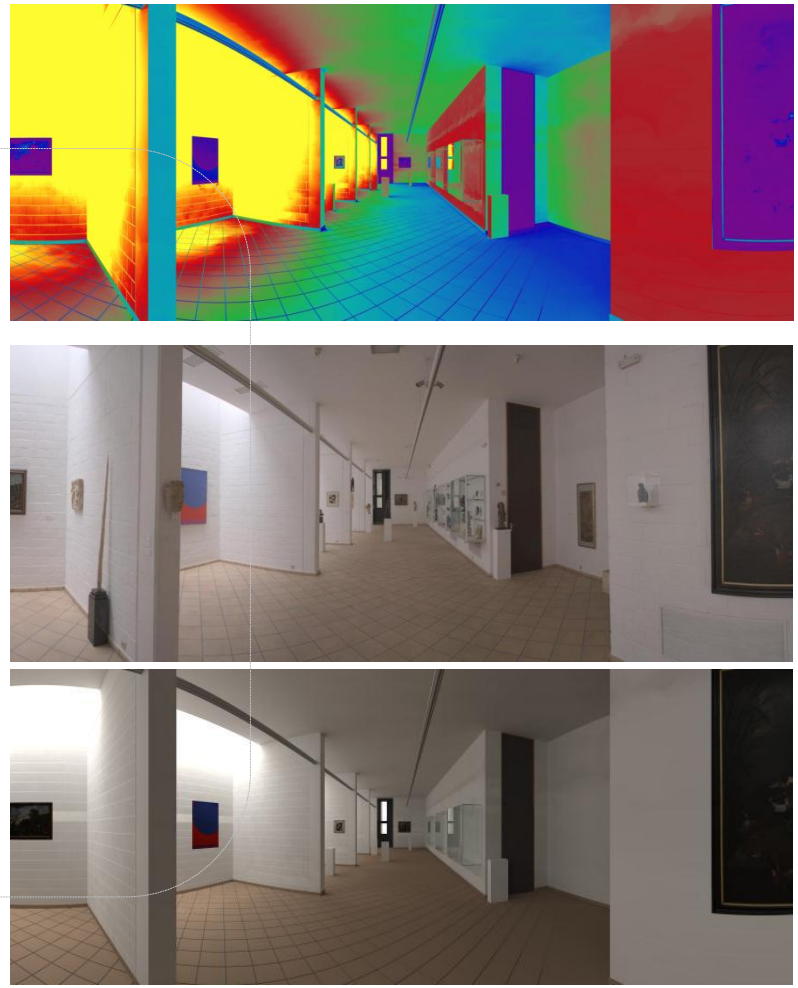
Conclusions

My way to compare pictures of real scenes and computer generated images = a simple approach

To go further in the comparison :

- Adding a mask ? (Karner et al., 1996)
- Using a perceptual metric ? (Rushmeier et al., 1995)

Context
PBR vs. IBL
Luminance comparison
Conclusions
To continue …

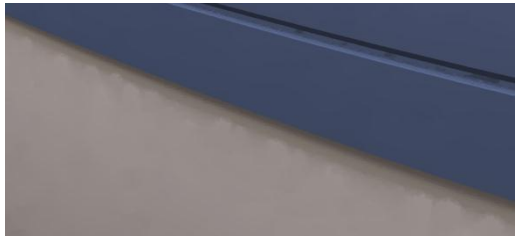


To continue …

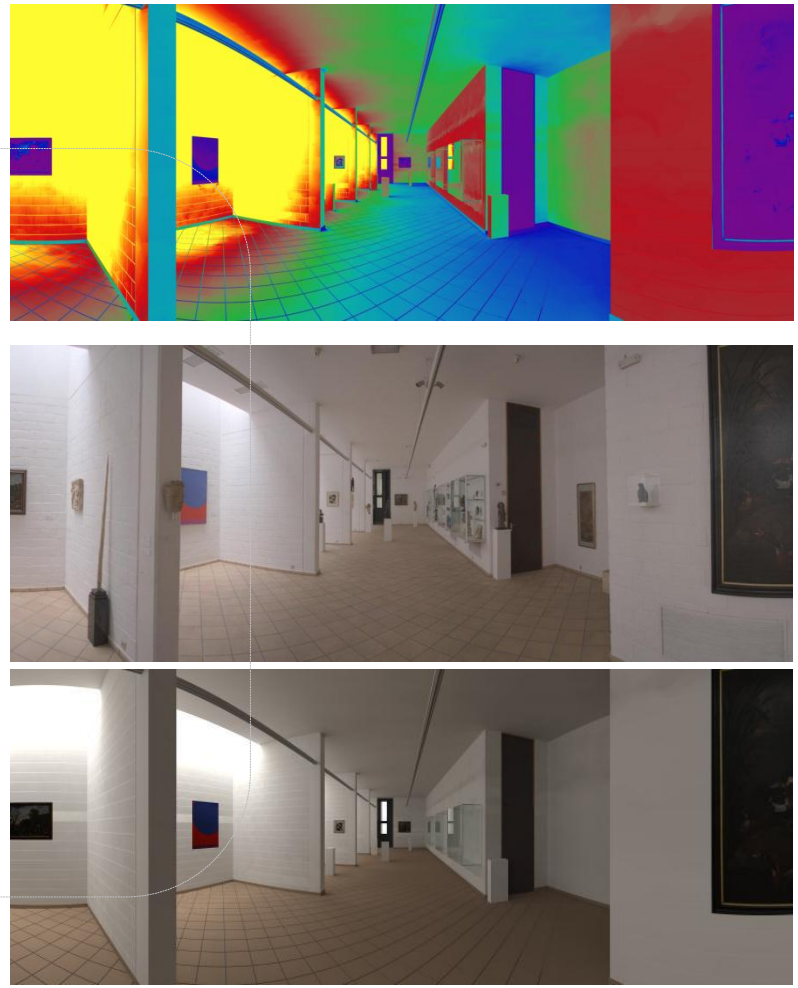
In the frame of this study on subjective lighting perceptions : PBR

Improve the method to capture HDR pictures of sunny sky…

Improve Radiance parameters in order to get a better quality rendering



Any question, suggestion ?



coralie.cauwerts@uclouvain.be