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GDCE 11

# LIGHTING IN CRYISIS 2

# CRYENGINE LIGHTING HISTORY

10 years of evolution

3 generations of engines

4 games and visual benchmarks



# CRYENGINE 1 – FAR CRY



# FAR CRY – LIGHTING

Baked lighting for terrain and static meshes

- + Higher performance for outdoor environments
- Low resolution
- Limited to static objects
- Fixed sun position

# FAR CRY – SHADOWS



Outdoor baked shadows

# FAR CRY – SHADOWS

Sun shadow map for dynamic objects

- + Smooth shadows
- Limited view distance

# FAR CRY – SHADOWS



Sun shadow map for dynamic objects

# FAR CRY – SHADOWS

## Stencil shadows for point lights

- + Raycast shadow volume
- + Very sharp shadows
- No smooth shadows

# FAR CRY – SHADOWS



Stencil shadows for point lights

# FAR CRY – SHADOWS



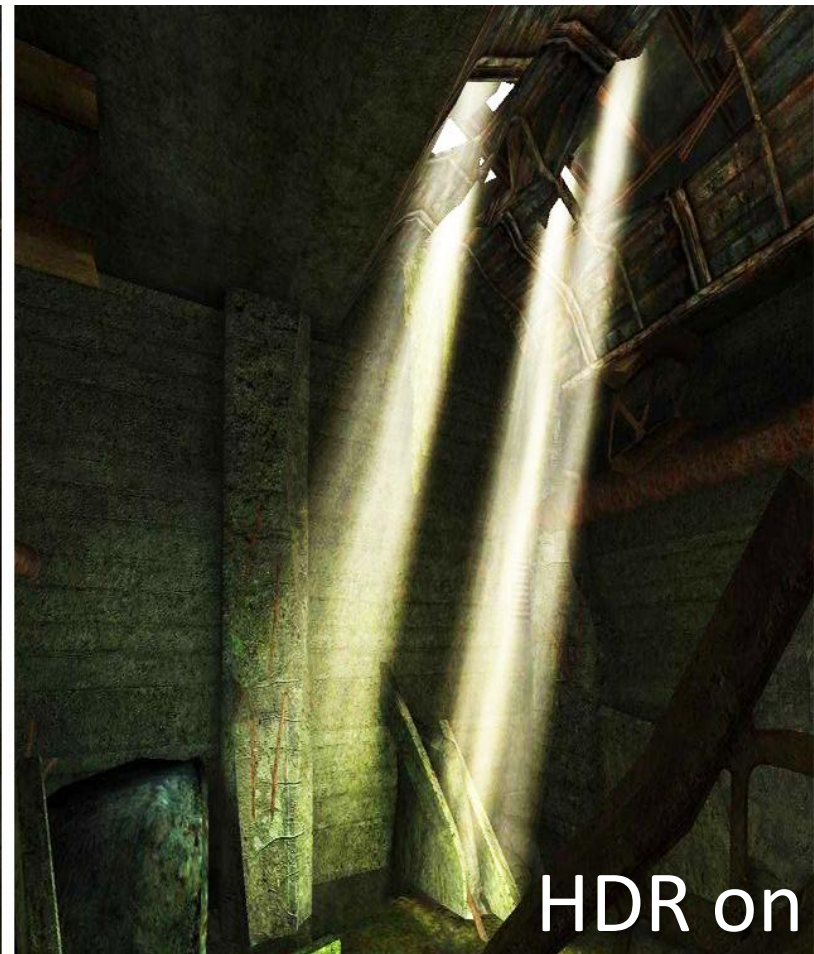
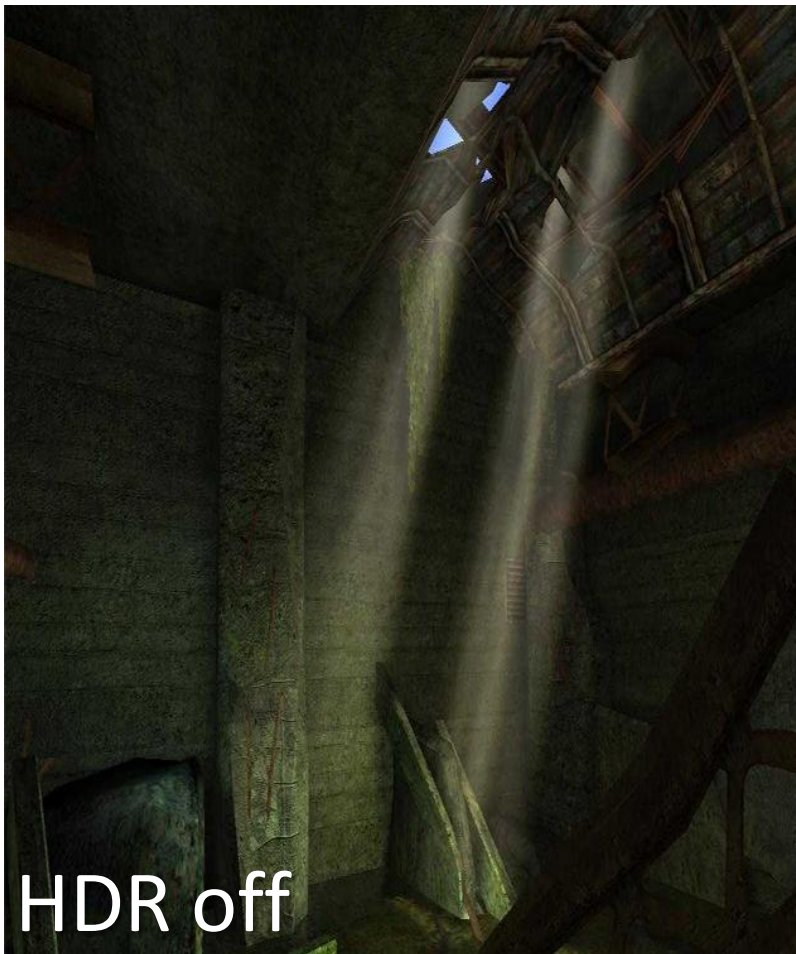
Indoor baked shadows

# FAR CRY – HDR

## High Dynamic Range Rendering

- + First iteration and one of first games in market using HDR
- + Much higher precision for the lighting information
- + Higher contrast/lighting ratio
- Levels and assets not tweaked for HDR

# FAR CRY – HDR



# FAR CRY - COLORGRADING

Highly saturated and cartoony color palette

User selected color theme

# FAR CRY - COLORGRADING



# FAR CRY - COLORGRADING



# FAR CRY - COLORGRADING



# CRYENGINE 2 – CRYISIS



Crysis, PC, 2007

# CRYENGINE 2 – CRYISIS



Crysis, PC, 2007

# CRYSIS LIGHTING

## Realtime lighting

- + HDR Rendering
- + Dynamic time of day
- + Cascaded sun shadow map
- + Ambient occlusion
- Very limited amount of light sources
- Flat ambient lighting

# CRYSIS - HDR

## HDR Rendering

- + Better reproduction of luminance variations
- + Believable implementation of eye adaption
- Level mostly tweaked for HDR only

# CRYSIS - HDR



# CRYSIS - HDR

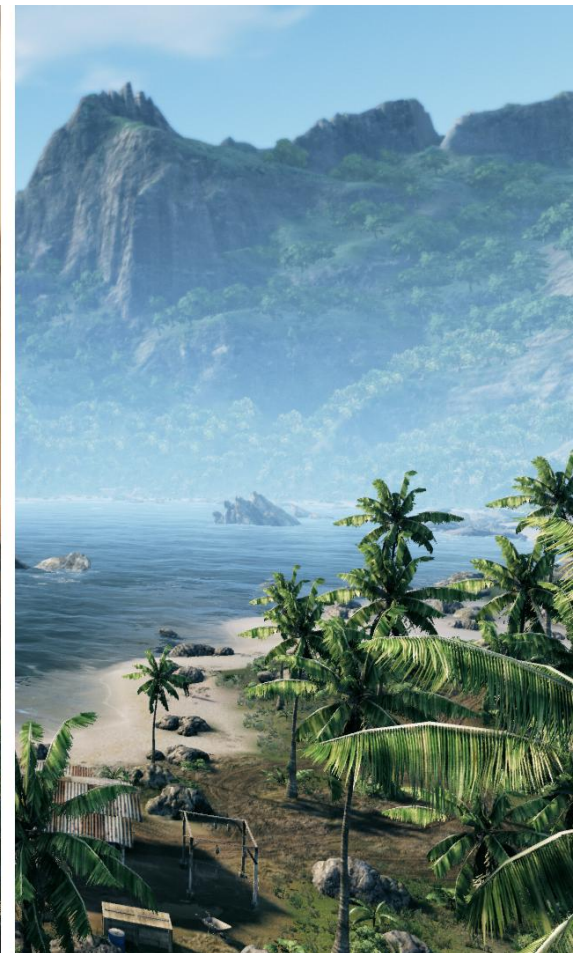
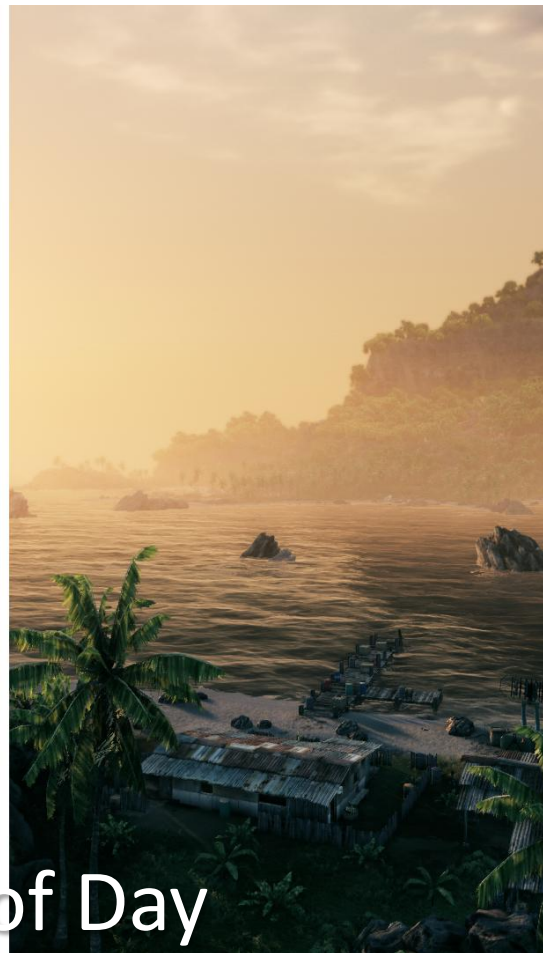


# CRYSIS – TIME OF DAY

Dynamic time of day with procedural HDR skybox

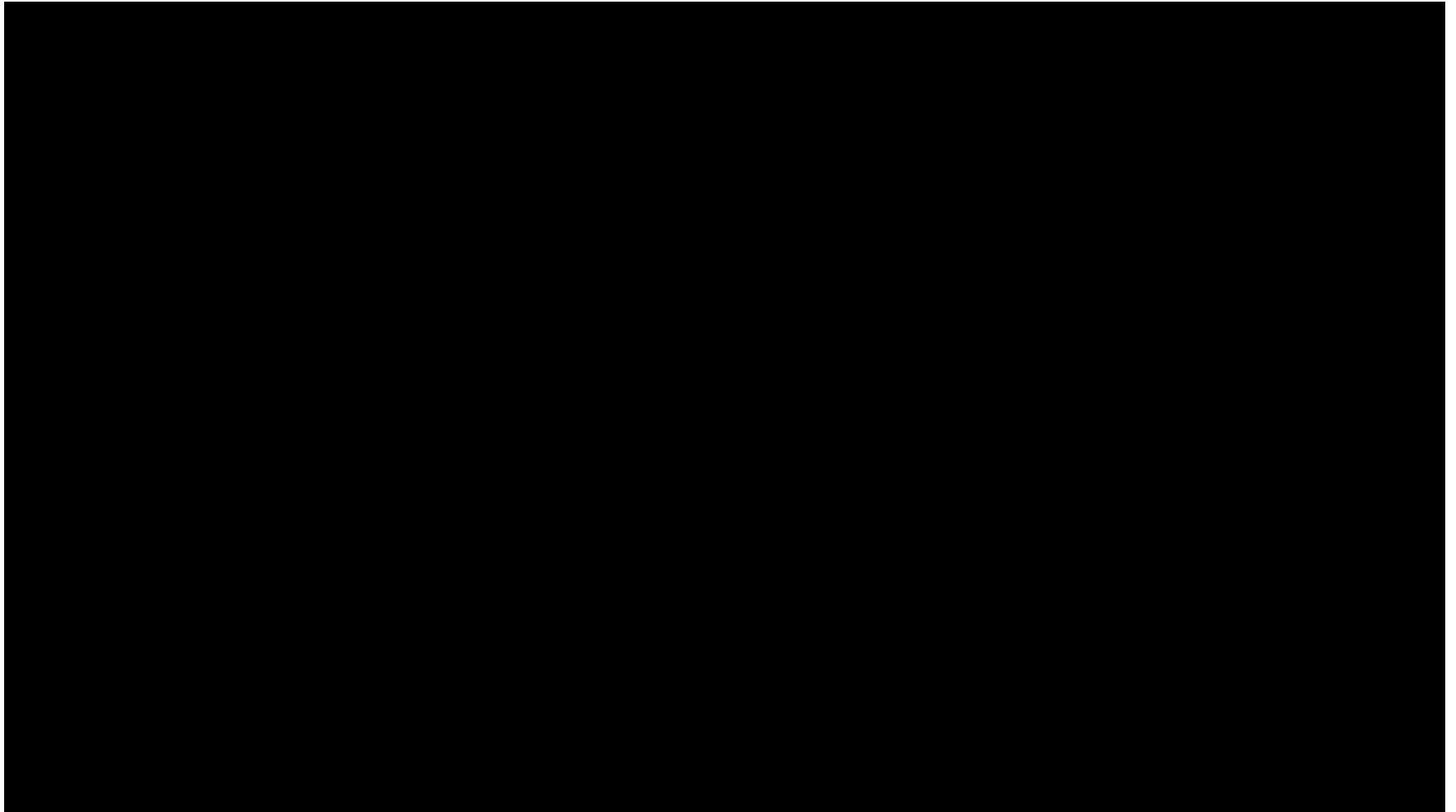
- + Full control on sun, ambient, fog, skybox, etc.
- + 100 parameters
- complex to handle (dawn and sunset transitions)

# CRYSIS – TIME OF DAY



Dynamic Time of Day

# CRYSIS – TIME OF DAY



# CRYSIS – SHADOWS

## Sun Cascaded Shadow Map

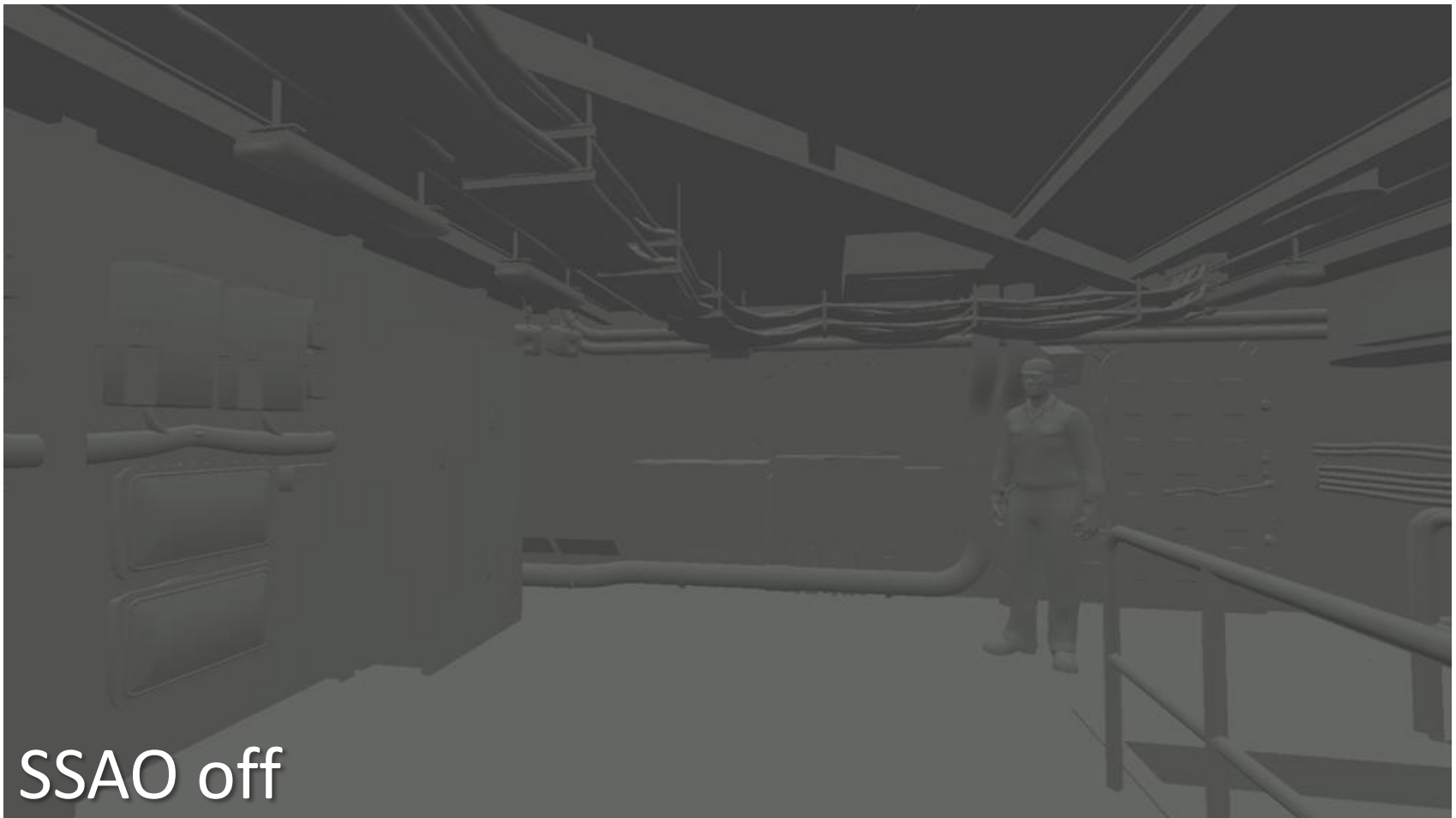
- + Large view distance for shadows
- + Higher resolution near the player's camera
- Lack of macro detail for self-shadowing (characters)

# CRYSIS – SSAO

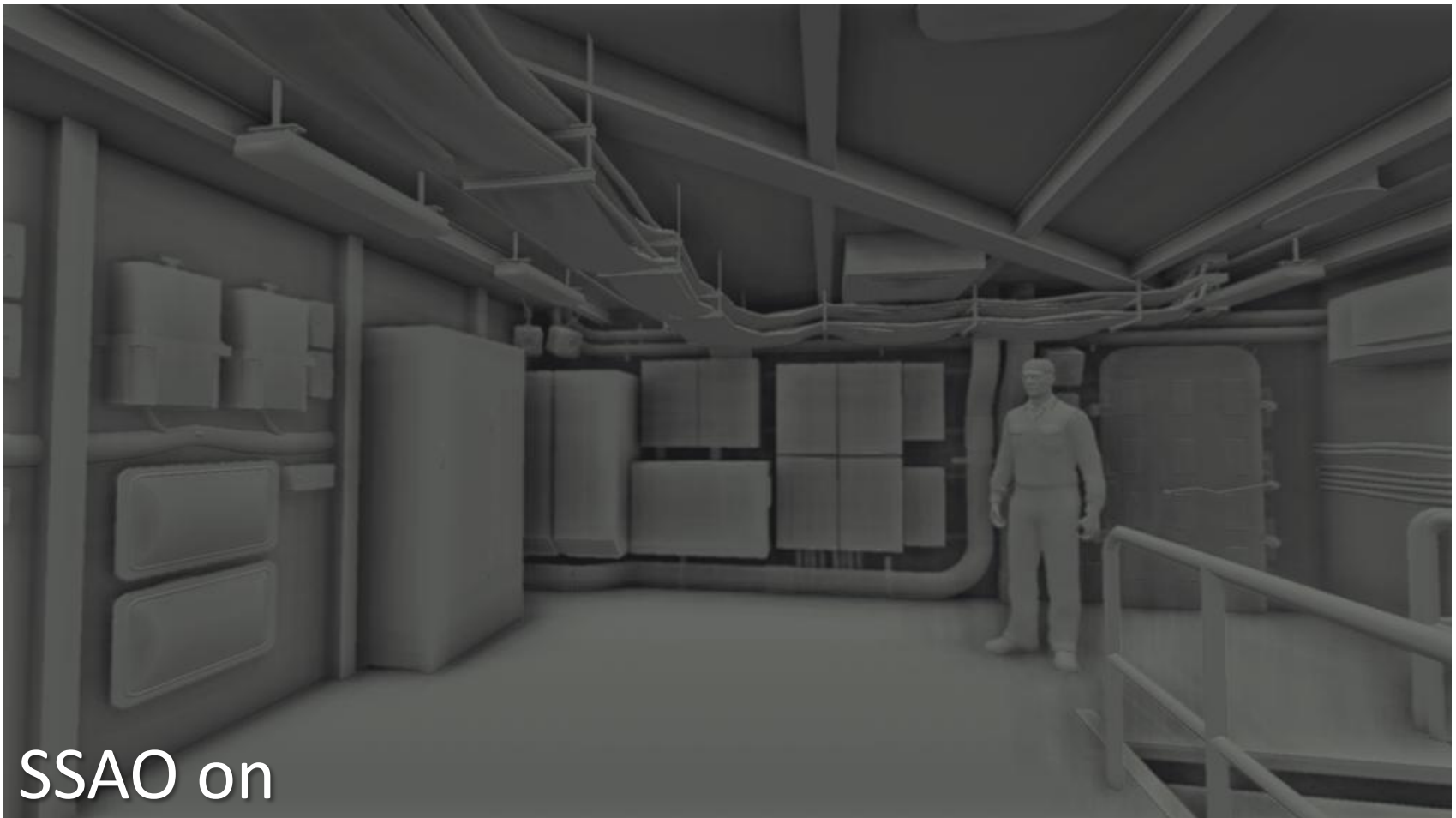
## Screen Space Ambient Occlusion

- + Gray scaled approximation of indirect lighting
- + Light accessibility approximated in screen space
- + Replacement for Ambient Occlusion baking via vertex colors
- Limited number of samples - blocky artifacts

# CRYSIS – SSAO



# CRYSIS – SSAO



# CRYSIS – TERRAIN AO

## Terrain Ambient Occlusion

- + Simulate sky accessibility for terrain and vegetation

# CRYSIS – TERRAIN AO



# CRYSIS – TERRAIN AO



# CRYSIS – LIGHTING PIPELINE



# CRYSIS – LIGHTING PIPELINE



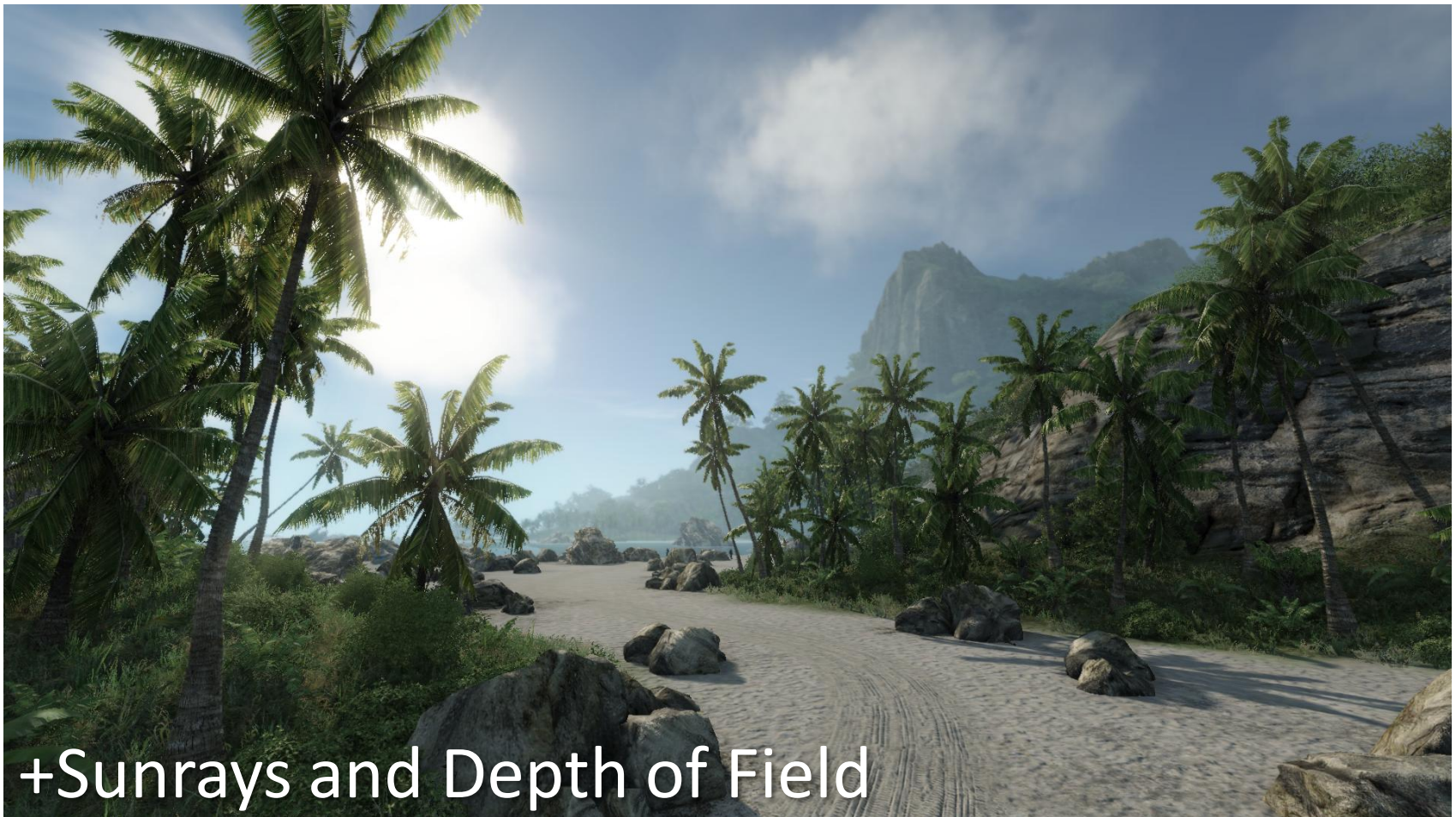
# CRYSIS – LIGHTING PIPELINE



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# CRYSIS – LIGHTING PIPELINE



# CRYENGINE 3 – CRYISIS 2



Crysis 2, PC – Xbox 360 - PS3, 2011

# CRYENGINE 3 – CRYISIS 2



Crysis 2, PC – Xbox 360 - PS3, 2011

# CRYENGINE 3 – CRYISIS 2 [SOUSA 2011]

## New challenges

- + Multi-platform
- + urban environments

## No lead platform

- + carefully picked changes

## Scalable multi-platform technology

- + DX9, DX11, Xbox 360, PS3
- + Multithreaded, better streaming, etc.



# TECHNOLOGICAL CHALLENGES

## Jungle style environment

- + Single key light (sun)
- + Minimal asset variation
- + Mostly glossy reflections
- Alpha testing performance hit



## Urban environment

- Complex lighting conditions
- A lot more assets and material variation
- Reflections everywhere



# TECHNICAL HIGH LEVEL GOALS

## Requirements

- + Improved lighting, particularly ambient lighting
- + Many lights
- + No limits on shadow casting lights
- + Reflections literally everywhere
- + Material variation flexibility
- + Minimal performance/memory footprint

# PHYSICALLY BASED RENDERING

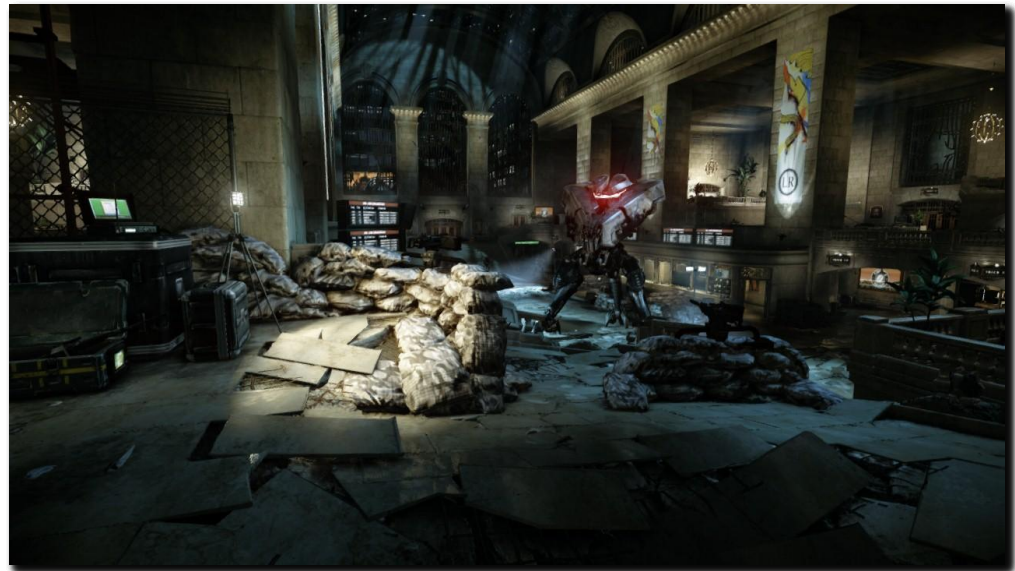
Linear Correct HDR Rendering

Minimal G-Buffer: Depth and Normals

Deferred Lighting

- + Ambient, Light Probes
- + GI, SSDO, RLR, Many lights
- + Physically Based Shading

HDR / LDR Post Processing



# HDR & LINEAR CORRECTNESS

HDR [Reinhard 2010]

- + Precision, range
- + Physically based Post Processing

Linear Correctness [Gritz 2008]

- + All computations in same space



# LIGHTING REQUIREMENTS

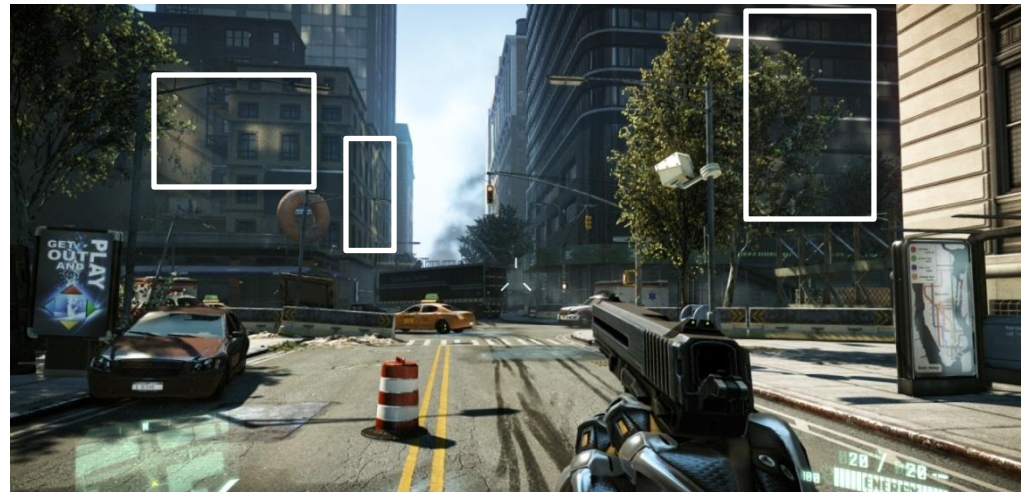
## Urban environment

- + Physically based lighting and materials
- + Scriptable sun position for every action bubble
- Low sun not optimal for lighting ratio inside the city
- Moving sun not optimal for gameplay and player leading
- + Long range shadows
- + Large amount of lights for interiors and night settings

# LIGHTING REQUIREMENTS

Windows reflections

Dappled lighting



# MULTIPLATFORM LIGHTING

Similar shading quality on all platforms

- + Identical output range
- + Similar colorgrading and postFX (DoF and colorgrading)

# MULTIPLATFORM LIGHTING

## Differences between platforms

- Higher view distance and level of detail on PC
- Global Illumination on PC only
- Advanced DX9 and DX11 features on PC only
- Lights flagged as PC only in certain interiors
- Most projectors and key lights cast shadows on PC

# MULTIPLATFORM LIGHTING



# MULTIPLATFORM LIGHTING



PC DX9 (High spec)

# MULTIPLATFORM LIGHTING



# MULTIPLATFORM LIGHTING

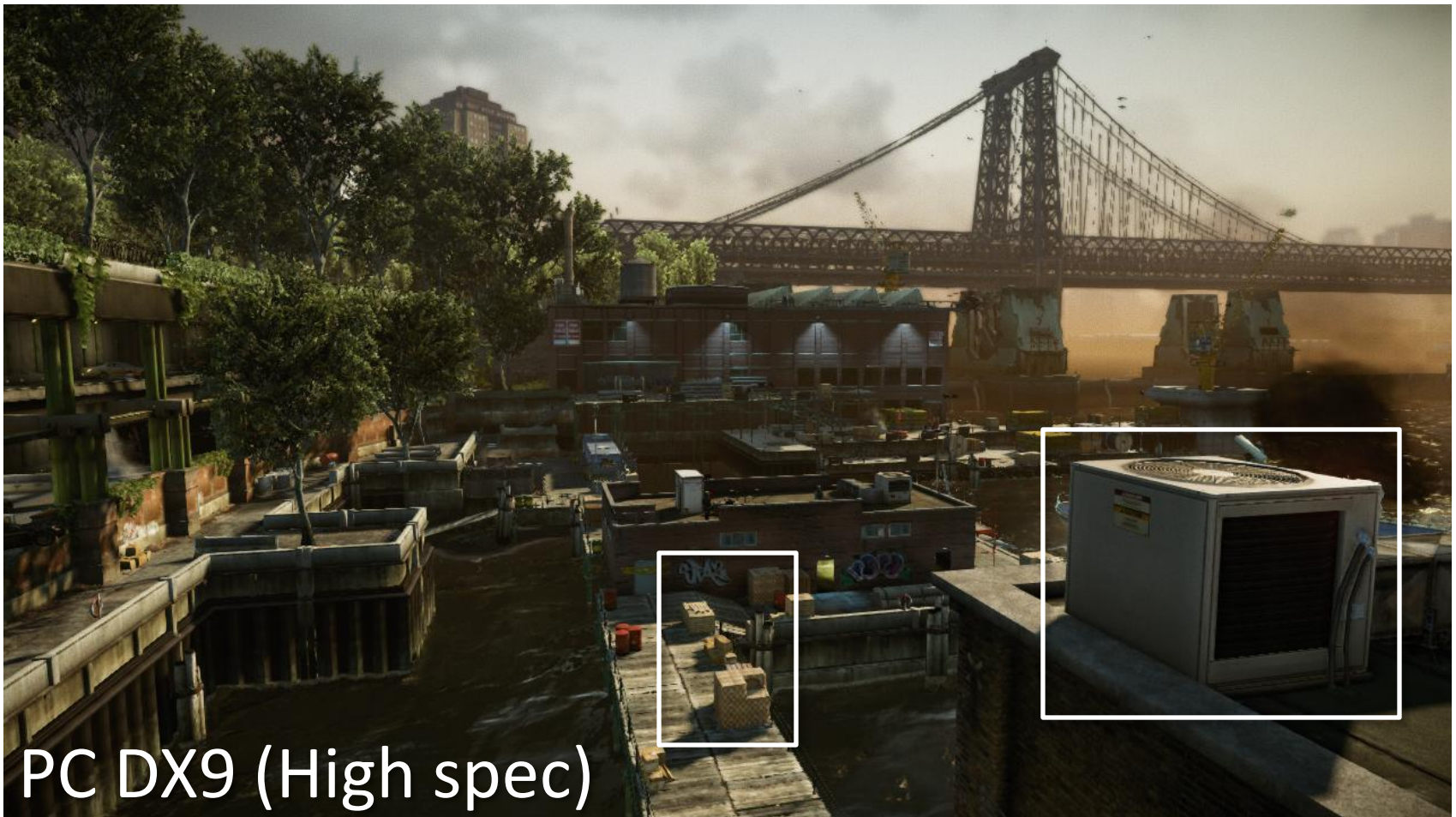


# MULTIPLATFORM LIGHTING



Xbox 360

# MULTIPLATFORM LIGHTING

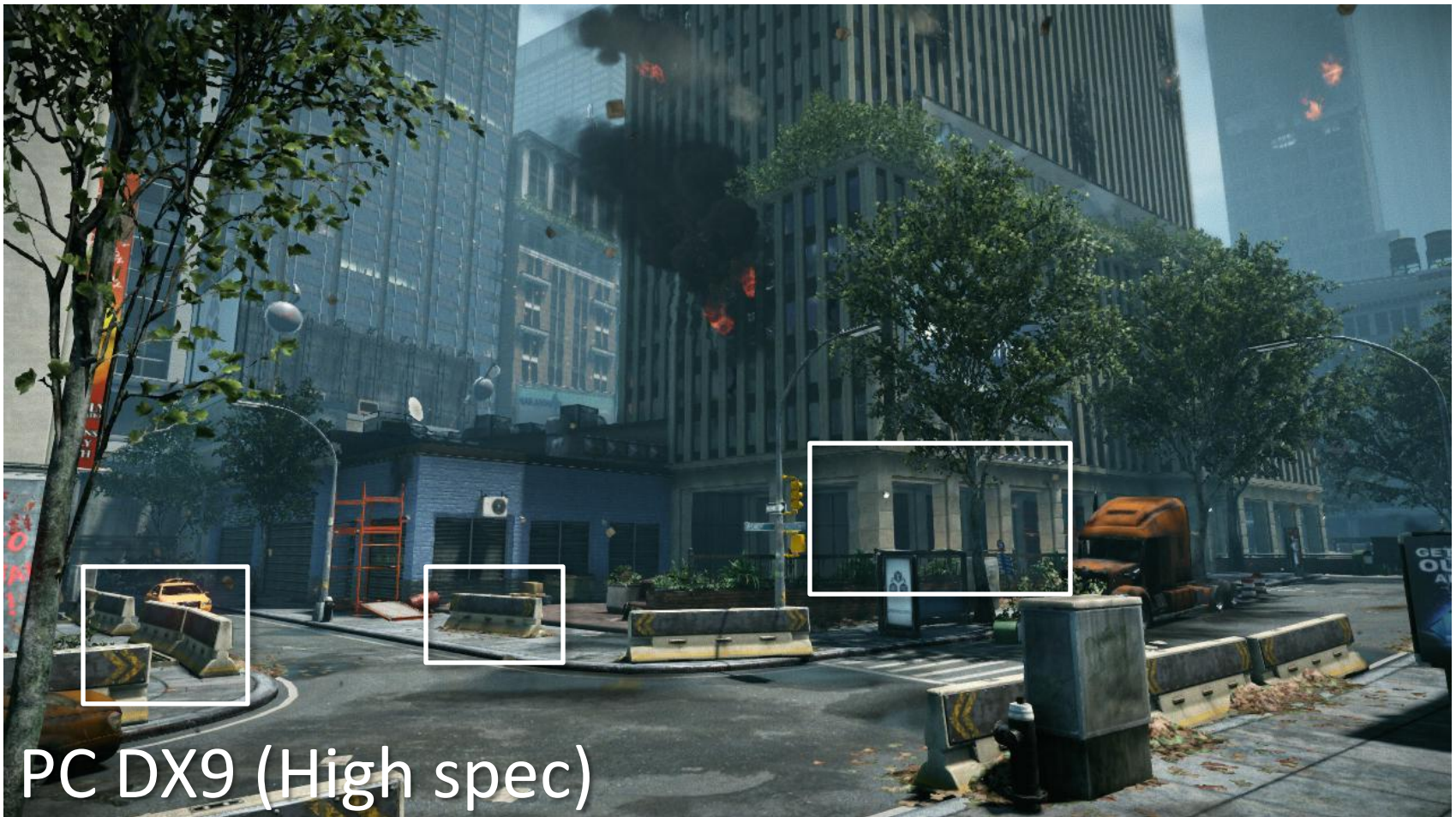


PC DX9 (High spec)

# MULTIPLATFORM LIGHTING



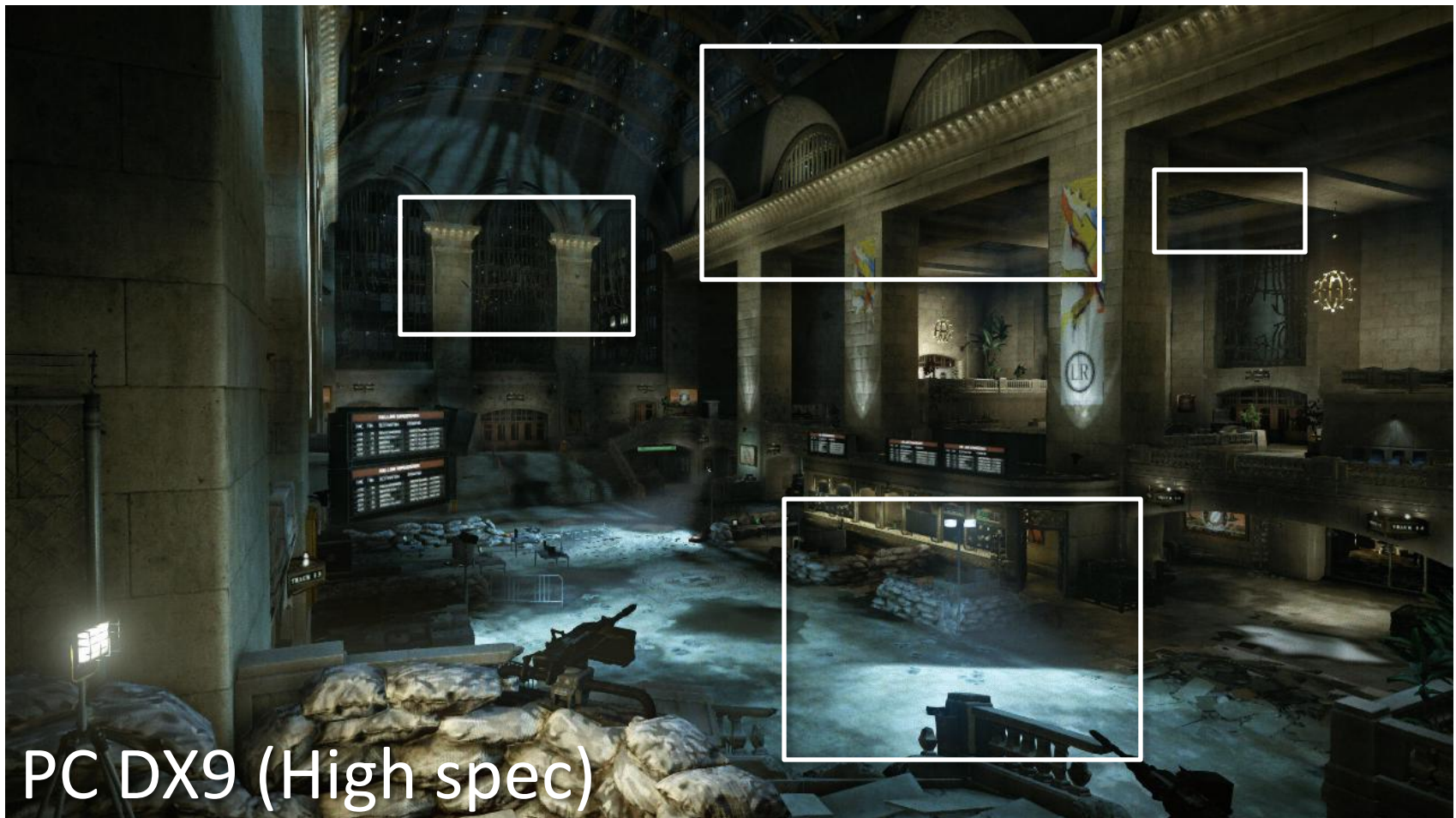
# MULTIPLATFORM LIGHTING



# MULTIPLATFORM LIGHTING



# MULTIPLATFORM LIGHTING



# DEFERRED LIGHTING

- + No need to re-render the geometry for every light
- + Higher performance
- + Higher amount of lights
- Forward pass still needed for shading

# DEFERRED LIGHTS

Point lights with shadow casting abilities

- + Spherical volume
- + Projector lights with projection texture

# LIGHT LEAKING

No occlusion available for deferred lights

- Occlusion volume manually placed by designers
- Box or arbitrary convex volumes
- Possible precision issues on console

# LIGHT LEAKING



Light Clipping off

# LIGHT LEAKING



Light Clipping on

# LIGHT LEAKING



# LIGHT LEAKING



Light Clipping on

# LIGHT LEAKING



# LIGHT LEAKING



# GLOBAL ILLUMINATION

Simulate several light bounces

- + Treat every lit surface as a possible secondary light source within a 3D light grid approach
- + Possible simulation of multiple bounces

# GLOBAL ILLUMINATION

## Limits of the current implementation

- Sun light dependant
- GI leaking and occlusion issues (Fix: light clipping volumes)
- PC only
- Lighting incoherence when using multiple bounces

## Mostly visible with colored bounces

- Limited use in a dull urban environment

# GLOBAL ILLUMINATION



# GLOBAL ILLUMINATION



# GLOBAL ILLUMINATION LEAKING



# GLOBAL ILLUMINATION LEAKING



# SHADOWS

Similar approach as in Crysis

- + Cascaded sun shadow map
- + Shadow map for point lights
- Possible shadow map acne, especially on console



# SUN SHADOWS



PC DX9 High Spec

# POINT LIGHT SHADOWS



PC DX9 High Spec

# SHADOWS MAP ACNE



# SHADOWS MAP ACNE



# IMAGE-BASED LIGHTING

## Environment HDR Light Probes

- + Accurate diffuse and specular lighting
- Hand-placed probes
- + HDR source, encoded into RGBM
- + G-Buffer material glossiness used for picking MIP level
- + Sphere volume, linearly blended into accumulation buffers
- + No more per-material environment map
- Problematic generation



# IMAGE-BASED LIGHTING



# IMAGE-BASED LIGHTING

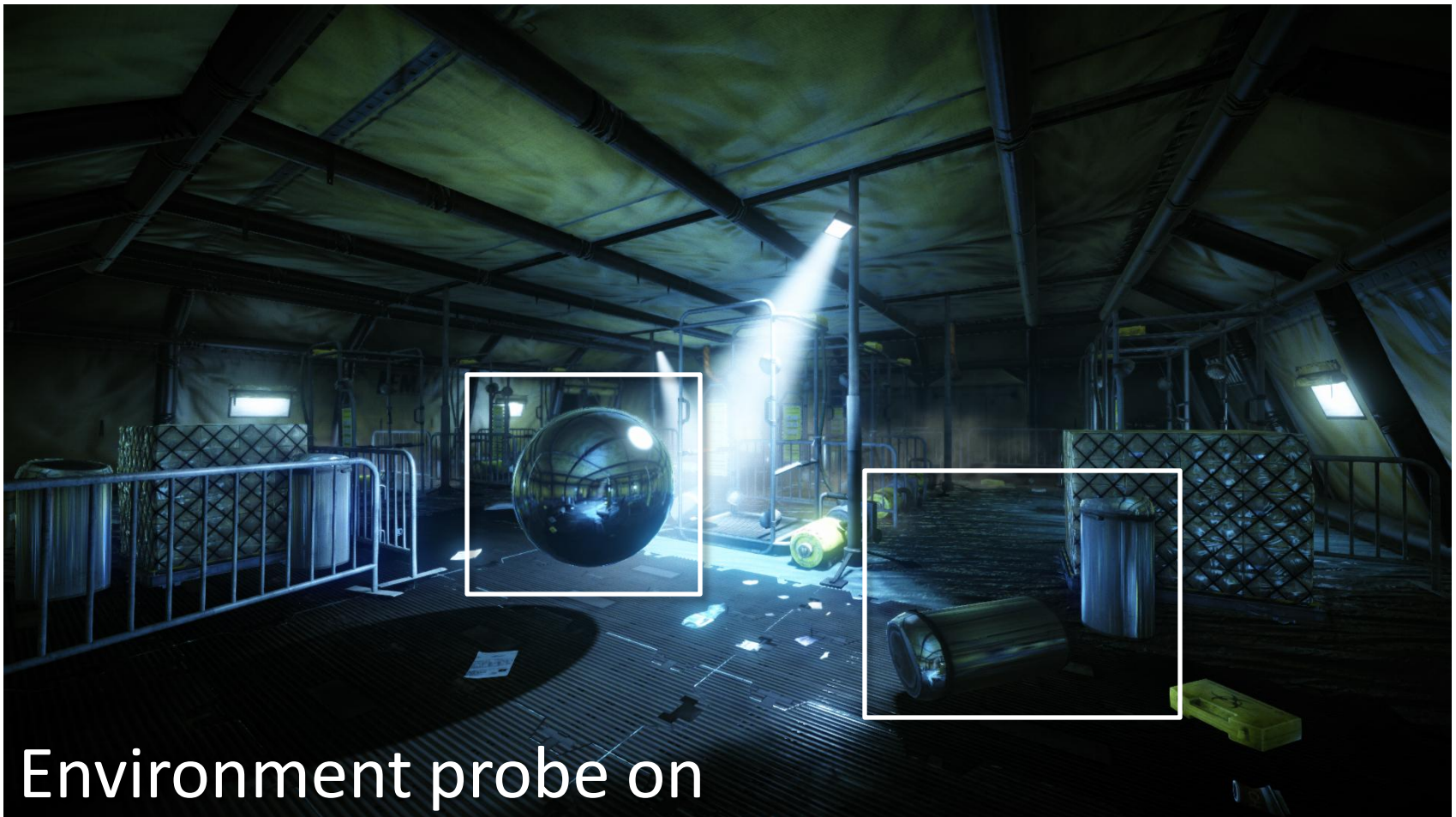


# IMAGE-BASED LIGHTING



Environment probe off

# IMAGE-BASED LIGHTING



Environment probe on

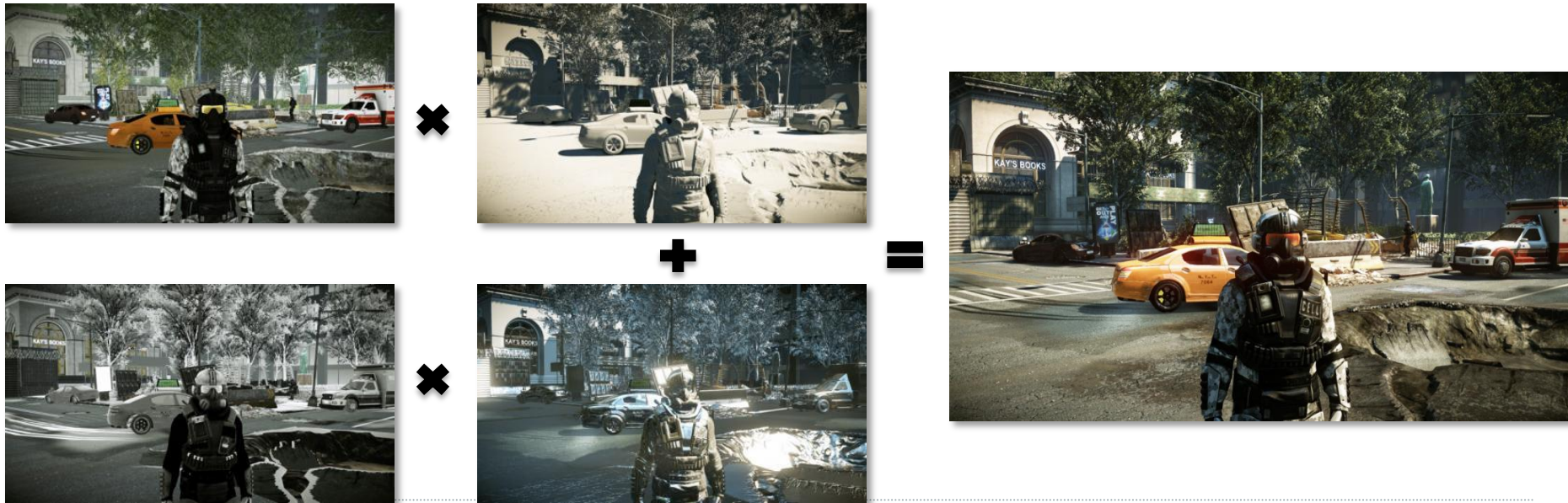
# SHADING PASSES



# SHADING PASSES

Read accumulated lighting and apply material properties

- + Diffuse, Specular, Emissive, Glow, Glossiness, Fresnel, etc
- Difficult maintenance of thousands of materials



# DEFERRED LIGHTING BUDGET

Target framerate: 30 fps  $\Leftrightarrow$  33.33 ms/frame

Entire Deferred lighting budget: 4-8 ms

- + Ambient: 1.5 ms
- + Cubemap: 0.5 - ... ms (art dependent)
- + SSAO – GI: 2 ms
- + Lights: 0 - ... ms (art dependent)

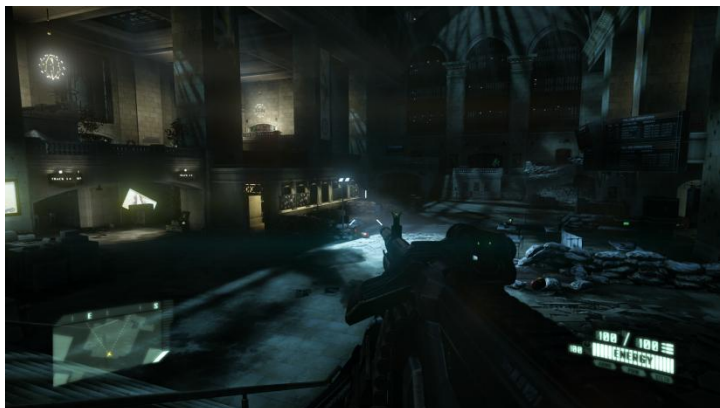
Light covering the entire screen: 1 ms

Light casting shadows: +3 ms

# CENTRAL STATION LIGHTING

## Blackout in Central Station

- + Dynamic lights in action
- + Gameplay affecting lighting
- + Material switching in realtime



# CENTRAL STATION LIGHTING

More than 200 lights on PC

- + Most projectors casting shadows

More than 100 lights on console

- + Running at 30 fps on console
- + Deferred lighting cost of 7-9 ms on console
- Limited amount of shadow casting light on console,  
compensated by Ambient Occlusion

# CENTRAL STATION LIGHTING



# CENTRAL STATION LIGHTING



# CENTRAL STATION LIGHTING



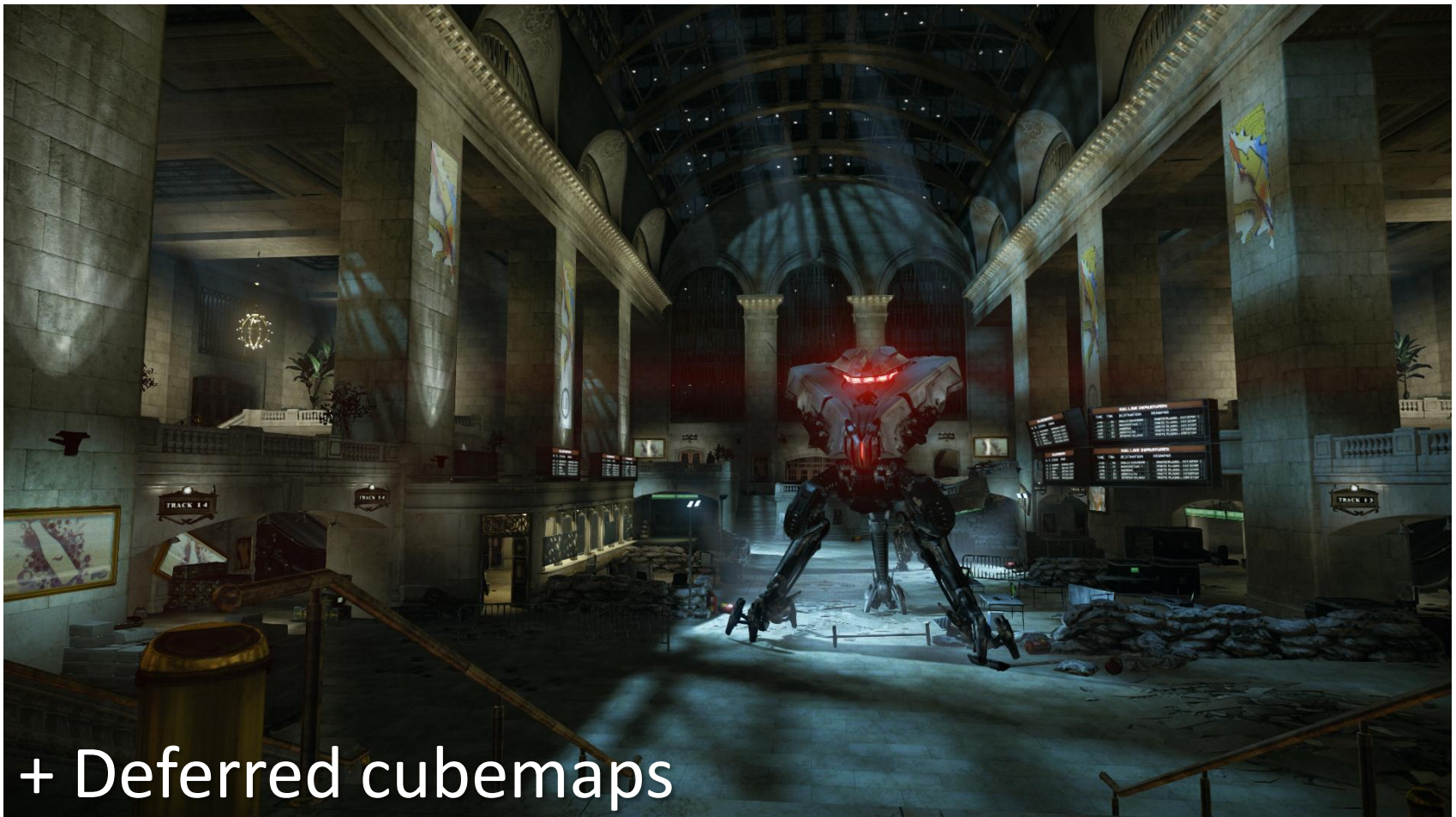
# CENTRAL STATION LIGHTING



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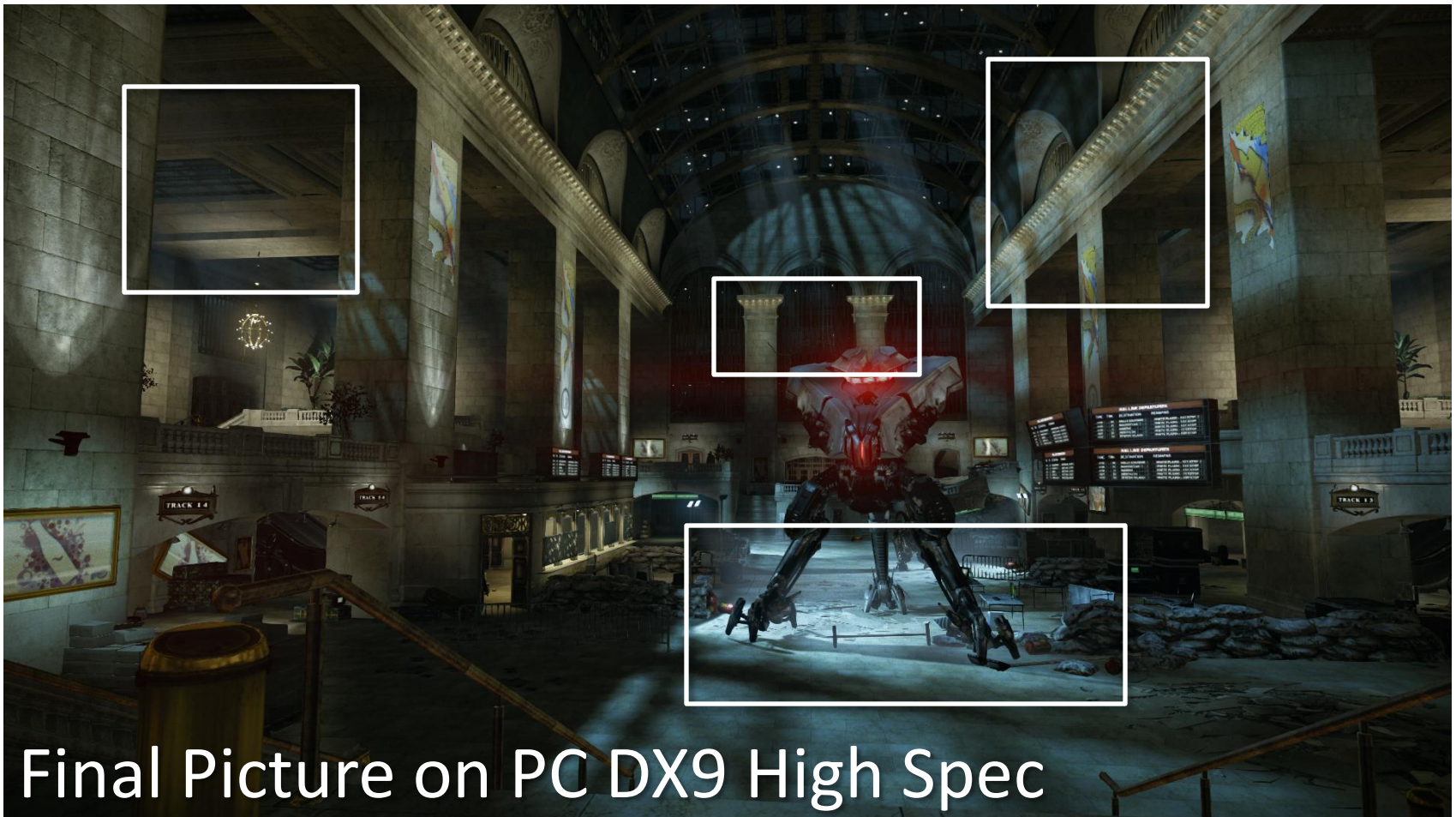
# CENTRAL STATION LIGHTING



# CENTRAL STATION LIGHTING



# CENTRAL STATION LIGHTING



# CENTRAL STATION LIGHTING



Deferred lighting coverage on Xbox 360

# CENTRAL STATION LIGHTING



# COLORGRADING

Colorgrading system based on color look up table

- + All static adjustment filters from PhotoShop available such as curves, color balance, hue/saturation, photofilter, etc.
- + Scripted colorgrading based on mission flow

# COLORGRADING

## Art Direction

- + No typical “next gen” colorgrading
- + Strong control over the color palette with textures and lighting
- Lack of visual identity?

## Intelligent control over color and contrast

- + Tonemapping for contrast adjustment
- + Slight color balance for split toning and color harmony

# ALIEN ATMOSPHERE



# ULTRA UPGRADE [SOUSA 2011]

## New DirectX 9 and 11 lighting features

- + Screen Space Directional Occlusion (DX9)
- + Real Time Local Reflection (DX9)
- + Shadows with variable penumbra (DX11)
- + Improved tone mapping (DX9)

# SSDO



# SSDO



SSAO

# SSDO



# SSDO



# SSDO



# SSDO



# RLR



Real Time Local Reflection off

# RLR



Real Time Local Reflection on

# RLR



# RLR

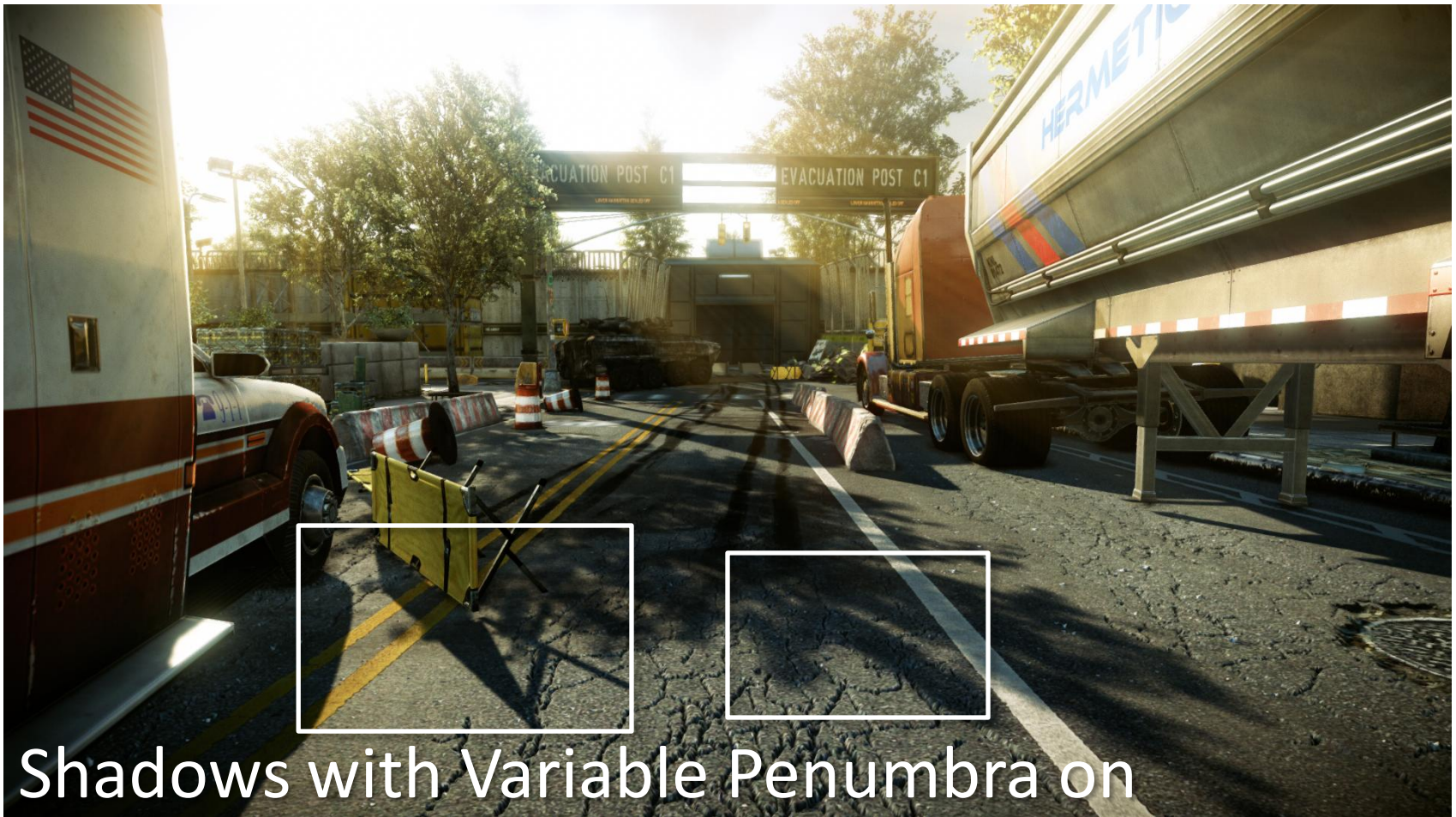


Real Time Local Reflection on

# SHADOWS PENUMBRA



# SHADOWS PENUMBRA



# tone mapping



# TONE MAPPING



# FUTURE OF LIGHTING

Bigger, better, faster

- + Global Illumination
- + Realtime reflections
- + Volumetric effects

# SPECIAL THANKS

Tiago Sousa, Carsten Wenzel, Nicolas Schulz

Nick Kasyan, Vaclav Kyba & RnD team

Magnus Larbrant & Art Team of Crysis 2

Chris Auty & the Design Team of Crysis 2

Crytek Team

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# QUESTIONS

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