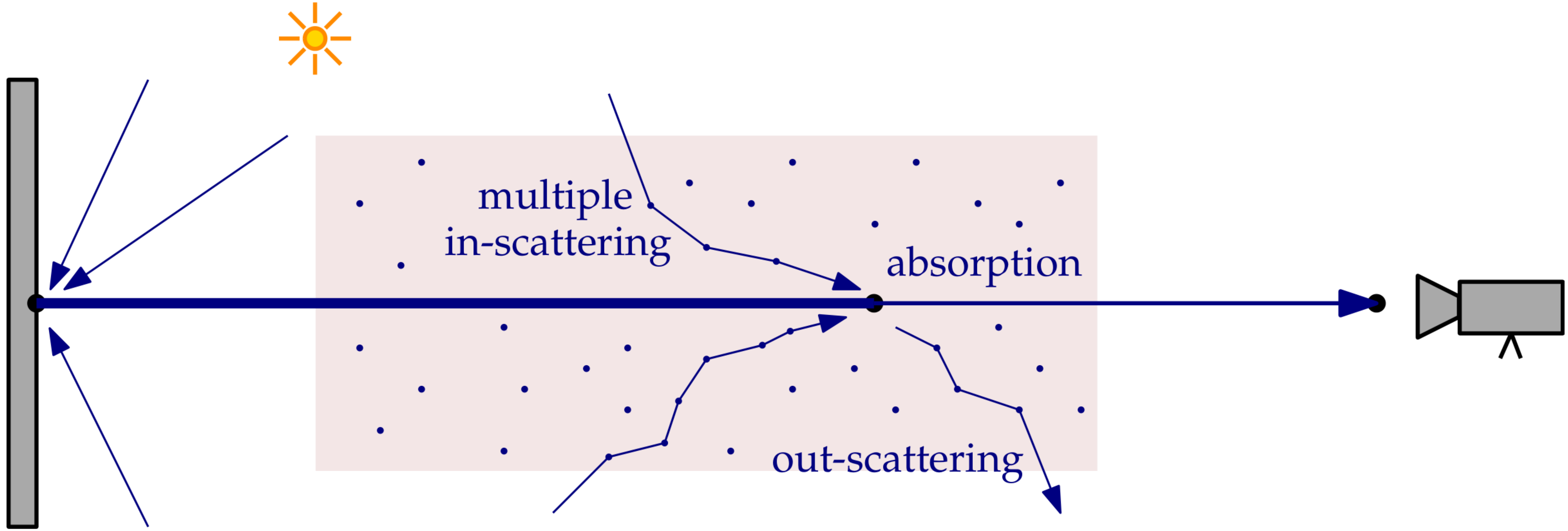
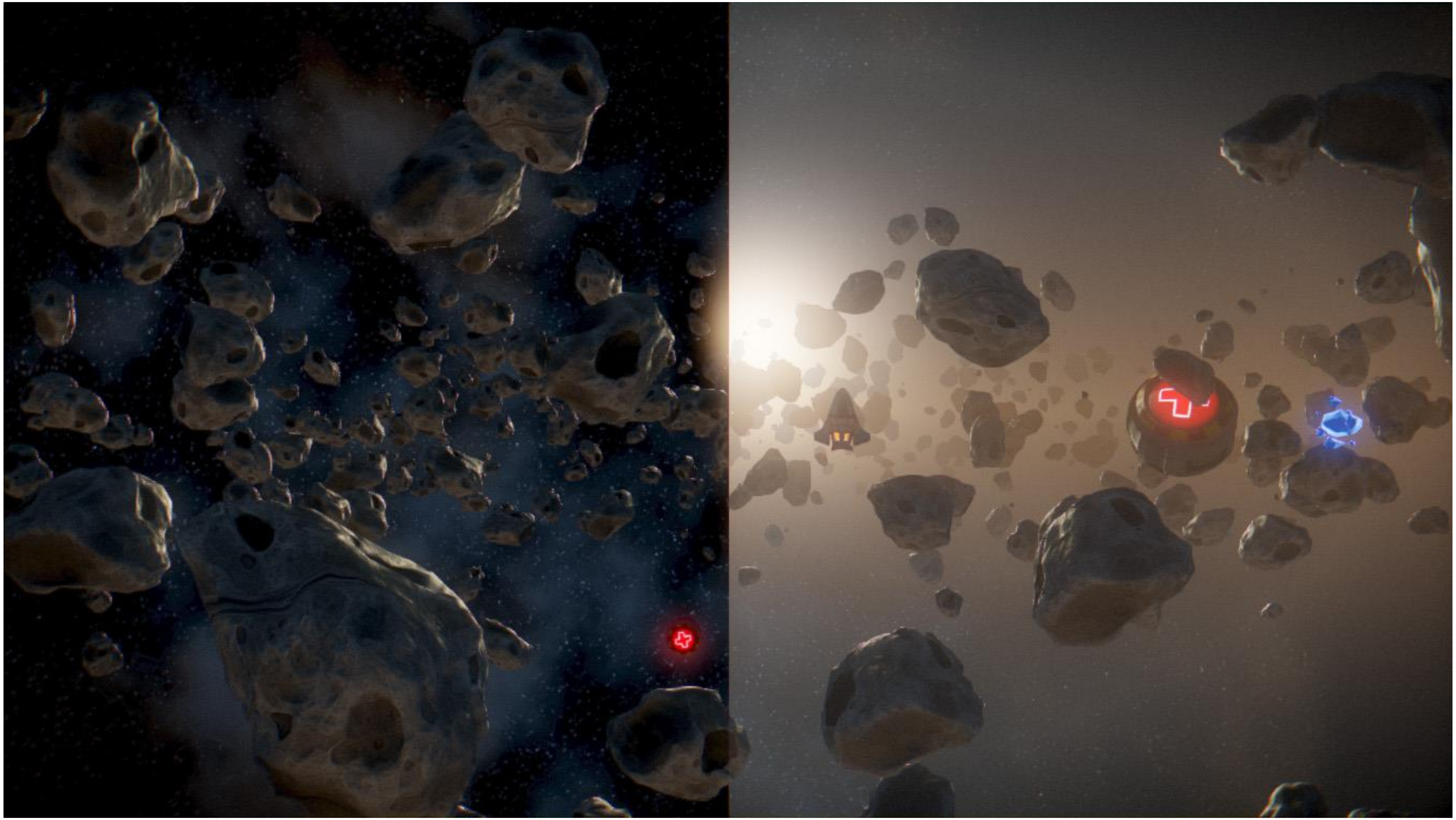
Real-Time Light Transport in Analytically Integrable Quasi-Heterogeneous Media

Tomáš Iser,
Charles University

Photo by Robin Röcker on Unsplash

Participating medium





Picture from http://indus3.org/atmospheric-effects-in-games/

Existing approaches

Existing approaches

- Empirical alpha blending

Picture from http://silenthill.wikia.com/wiki/File:Sh2pc_2011-01-02_17-30-28-55.jpg

Existing approaches

- Empirical alpha blending
- Single-scattering light shafts [Mitchell, 2007], [Wronski, 2014]

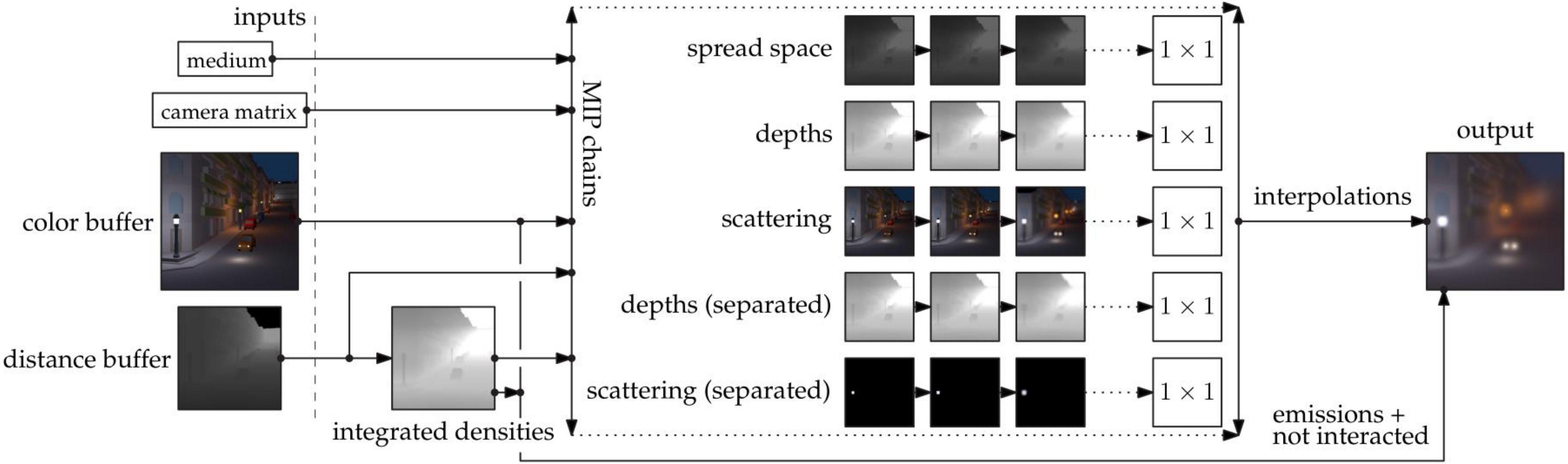
Photo by Matthew Kalapuch on Unsplash

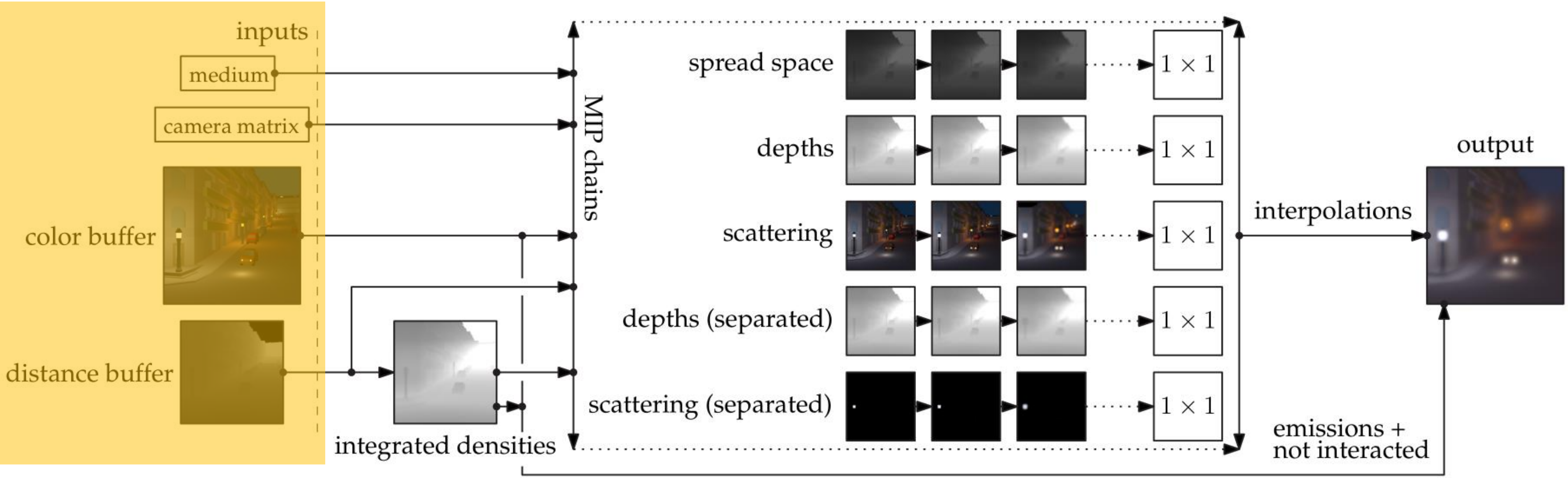
Existing approaches

- Empirical alpha blending
- Single-scattering light shafts [Mitchell, 2007], [Wronski, 2014]
- Multiple scattering in homogeneous media [Elek et al., 2013]

The new approach


Inhomogeneous Media


inputs
medium
camera matrix
color buffer
distance buffer
integrated densities
MIP chains
spread space
depths
scattering
depths (separated)
scattering (separated)
1 × 1
1 × 1
1 × 1
1 × 1
1 × 1
interpolations
output
emissions +
not interacted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Input

color buffer

~ radiance

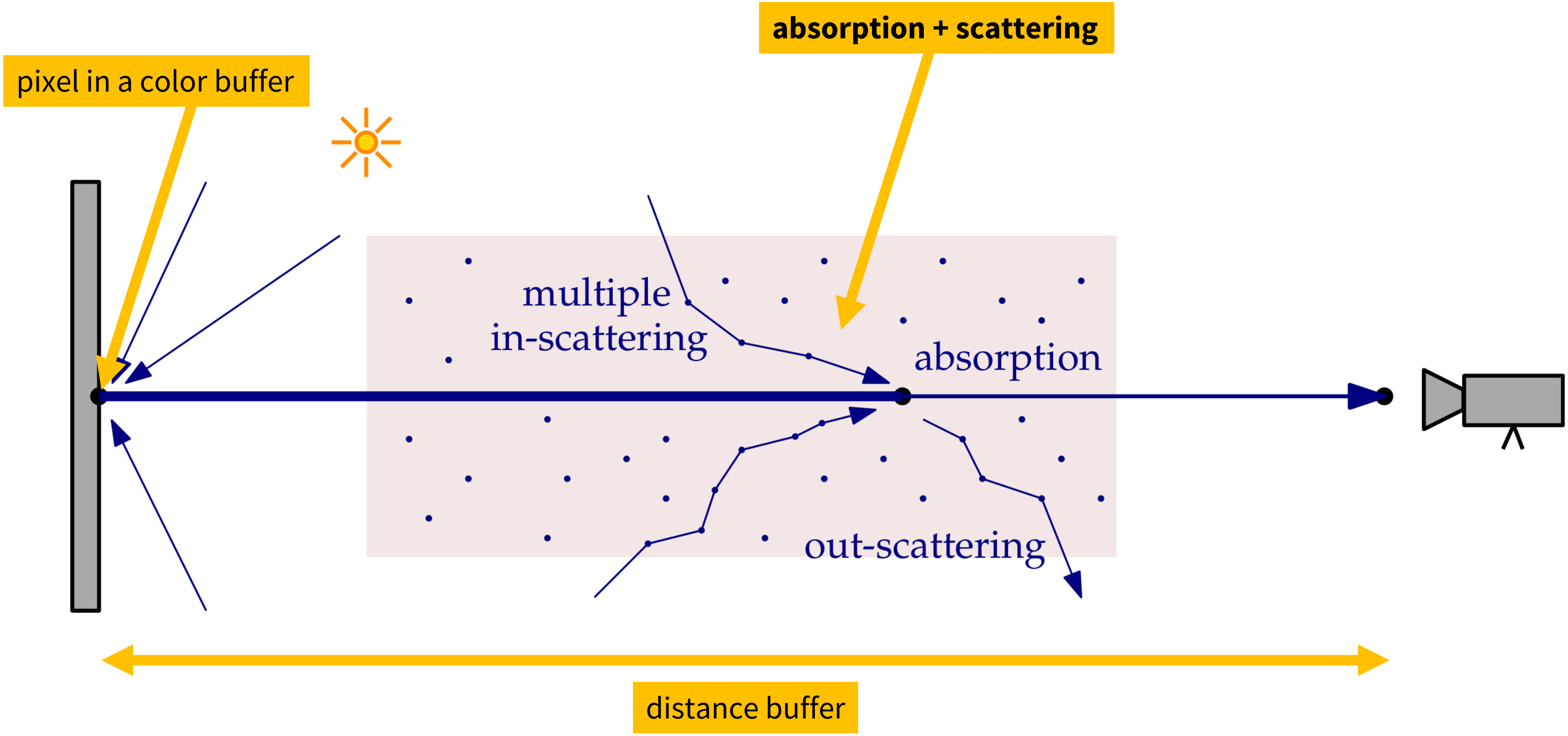
~ how far the photons travel

distance buffer

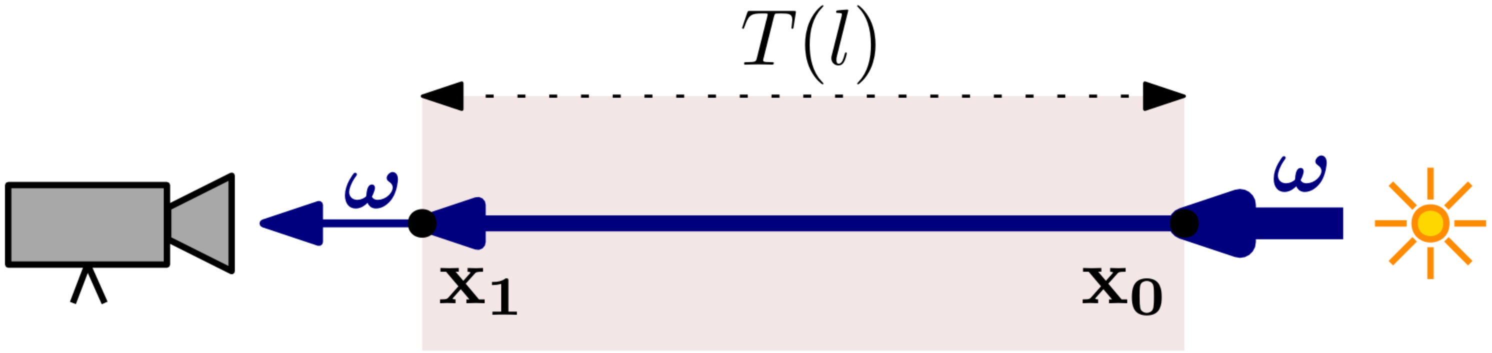
Let's add the physics...

- Absorption
- Scattering

Light path I

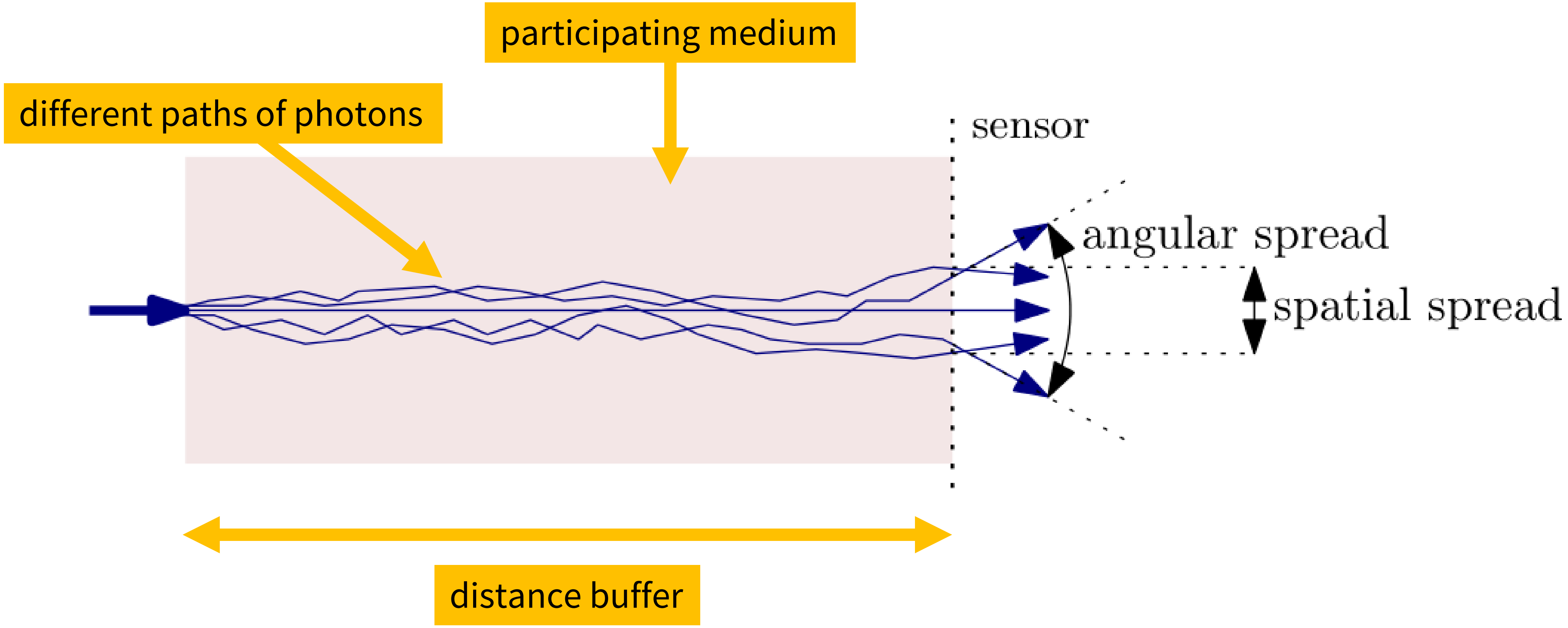

absorption + scattering
pixel in a color buffer
multiple
in-scattering
absorption
out-scattering
distance buffer

Absorption

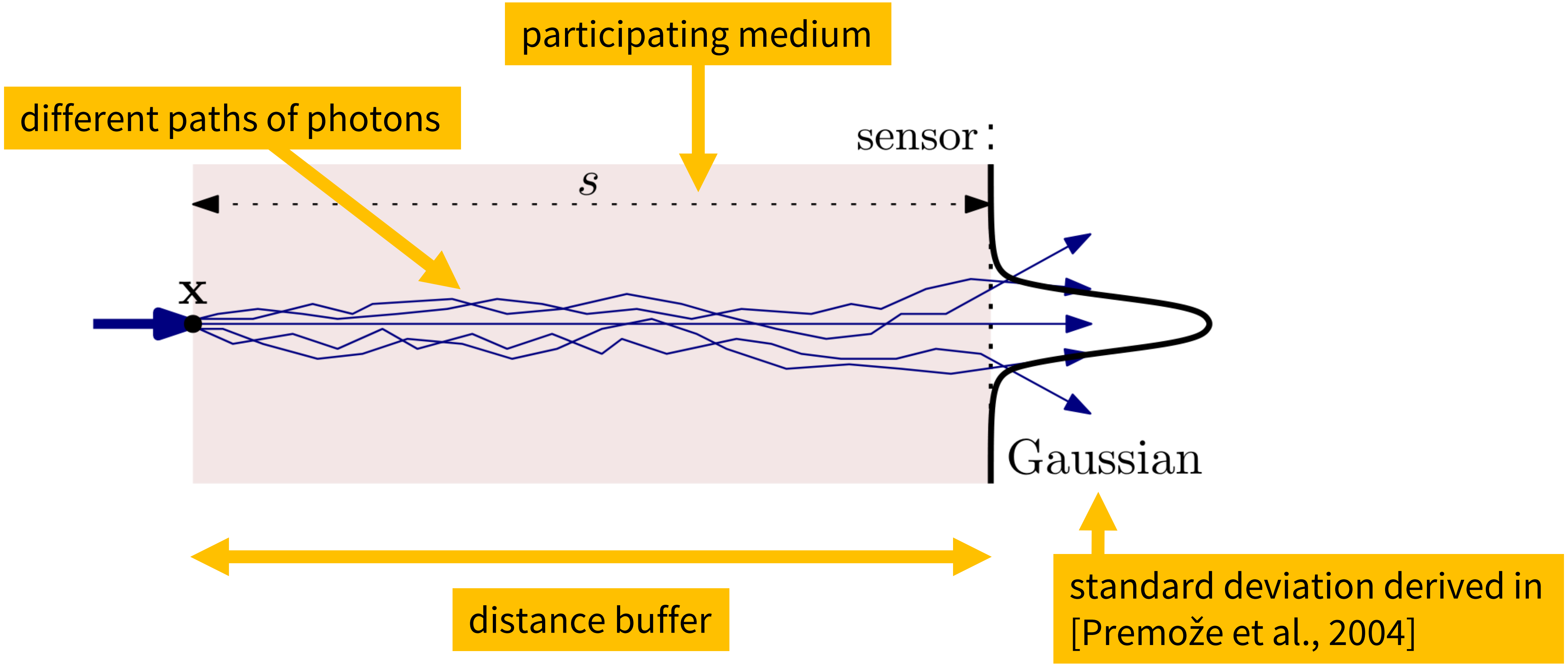


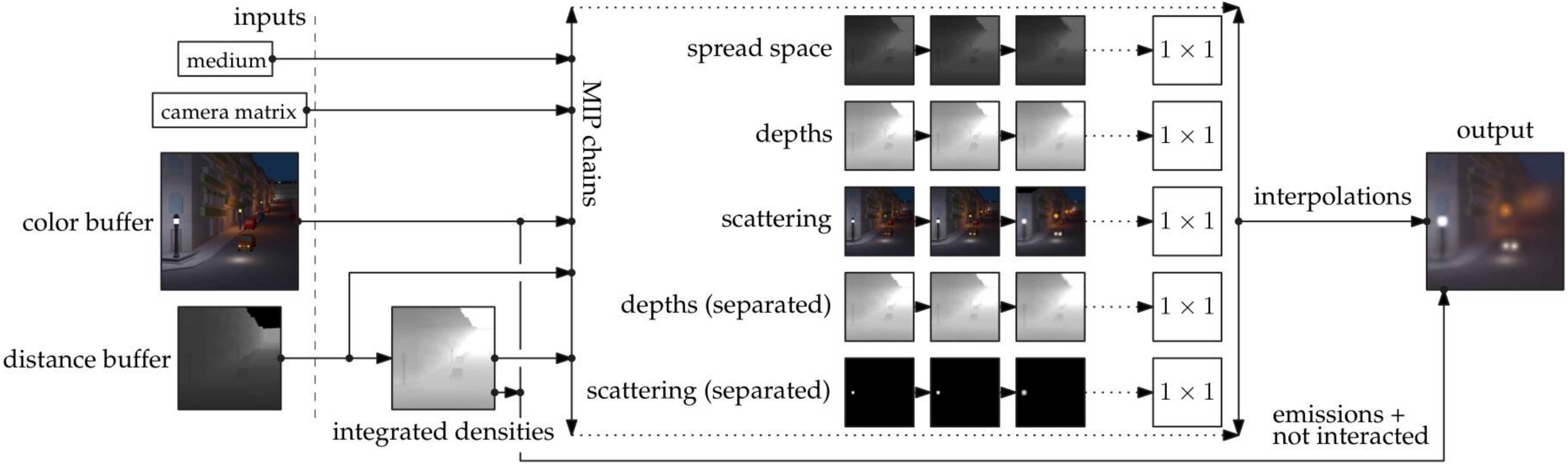
Beer–Lambert law

Scattering


participating medium
different paths of photons
sensor
angular spread
spatial spread
distance buffer

Scattering


participating medium
different paths of photons
sensor
s
x
Gaussian
distance buffer
standard deviation derived in [Premože et al., 2004]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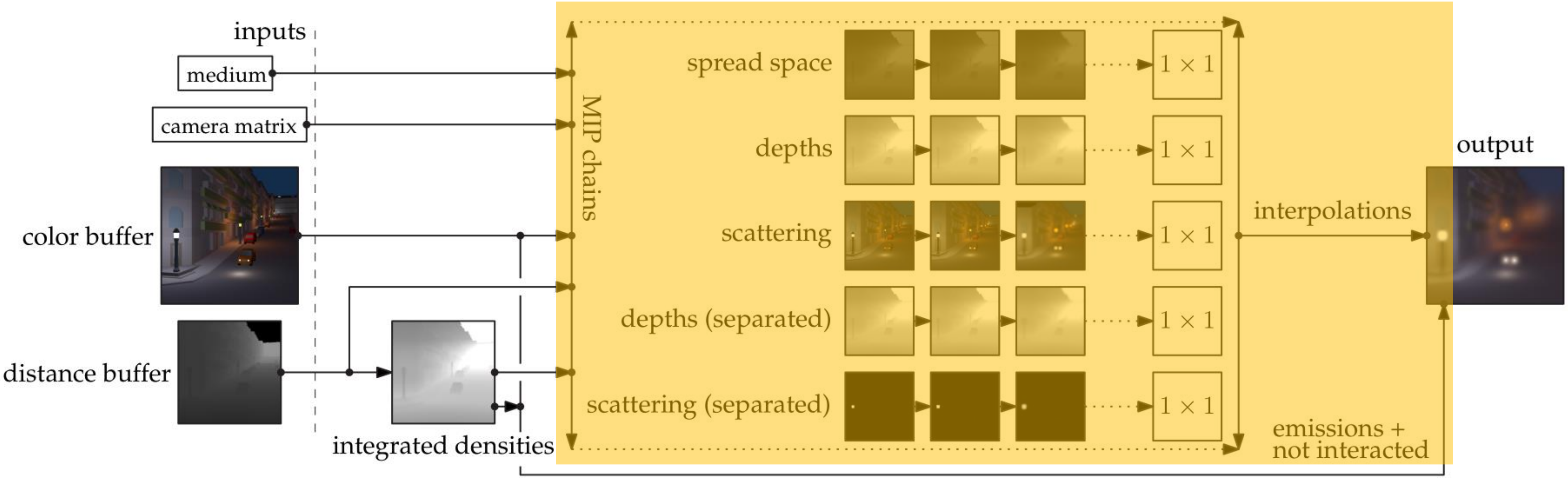
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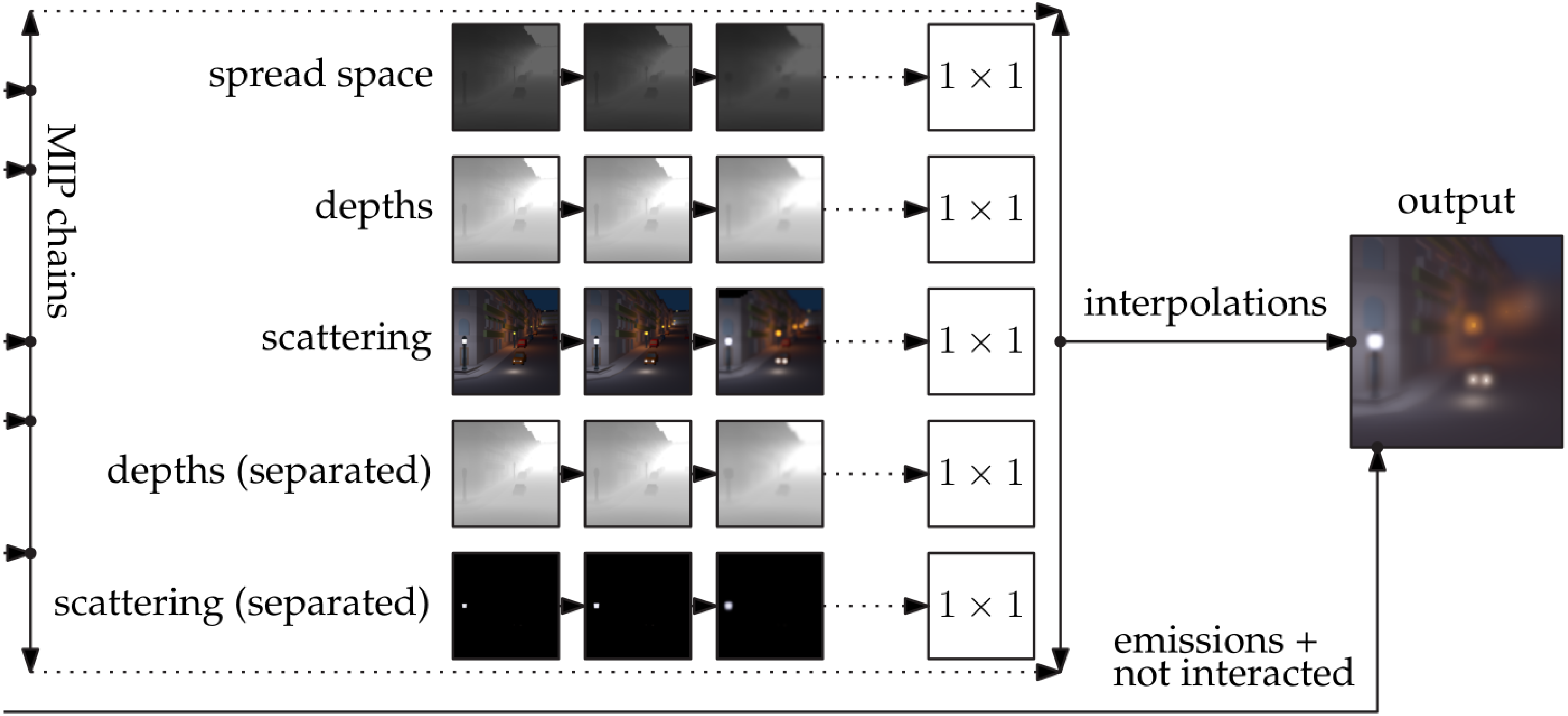
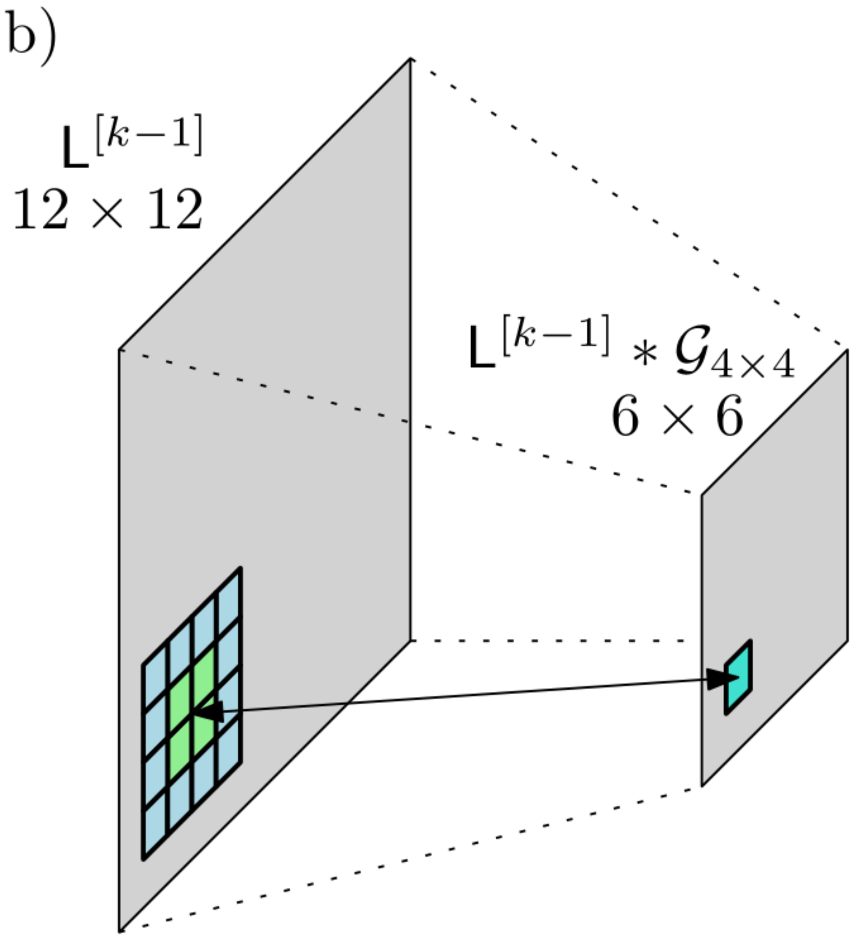
output

Gaussian blurring

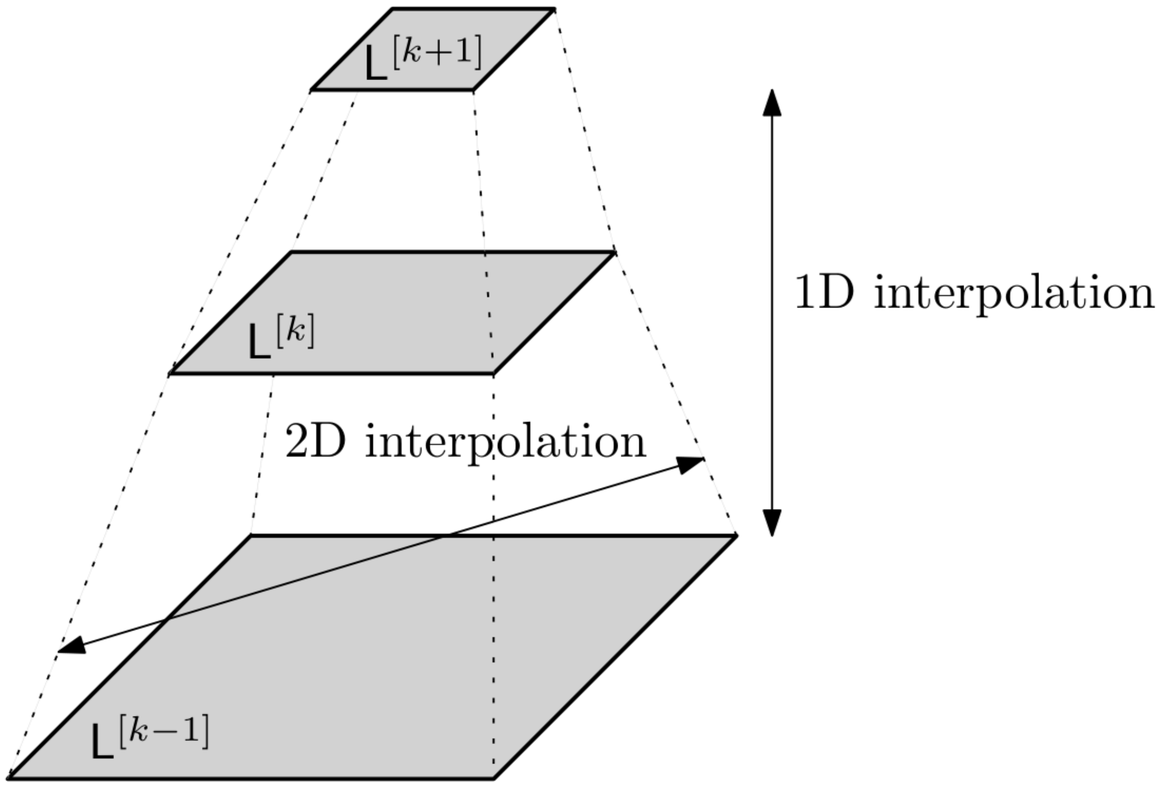


Gaussian blurring

Gaussian blurred MIP maps:



Interpolating the final pixel:



Not enough

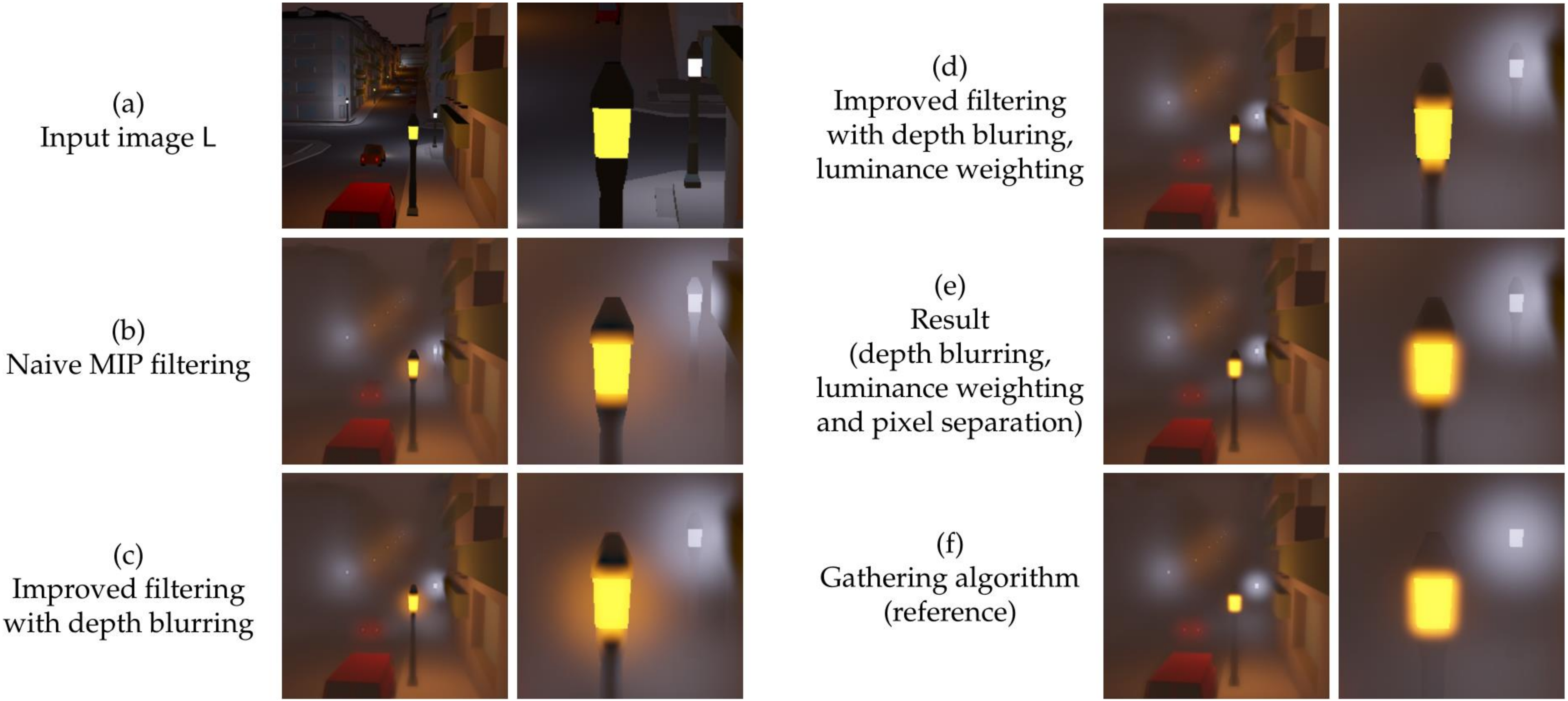
(a)
Input image L

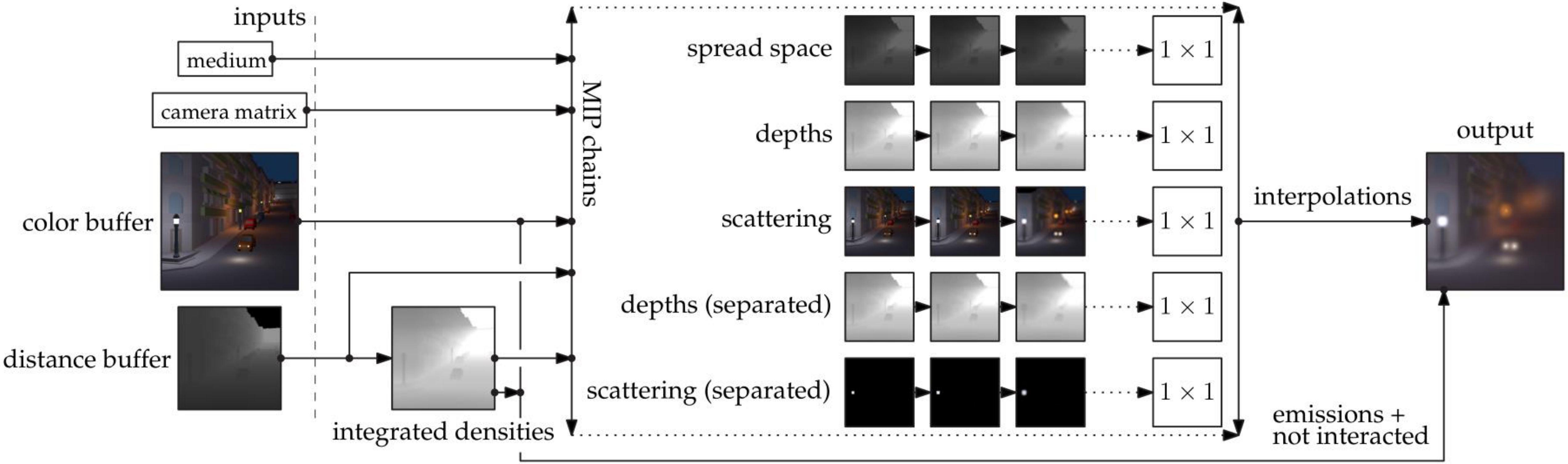
(b)
Naive MIP filtering

Not correct!

Additional tricks

- Depth blurring & luminance weighting [Elek et al., 2013]
- New contribution: separating radiance from bright pixels


(a)
Input image L
(b)
Naive MIP filtering
(c)
Improved filtering
with depth blurring
(d)
Improved filtering
with depth bluring,
luminance weighting
(e)
Result
(depth blurring,
luminance weighting
and pixel separation)
(f)
Gathering algorithm
(reference)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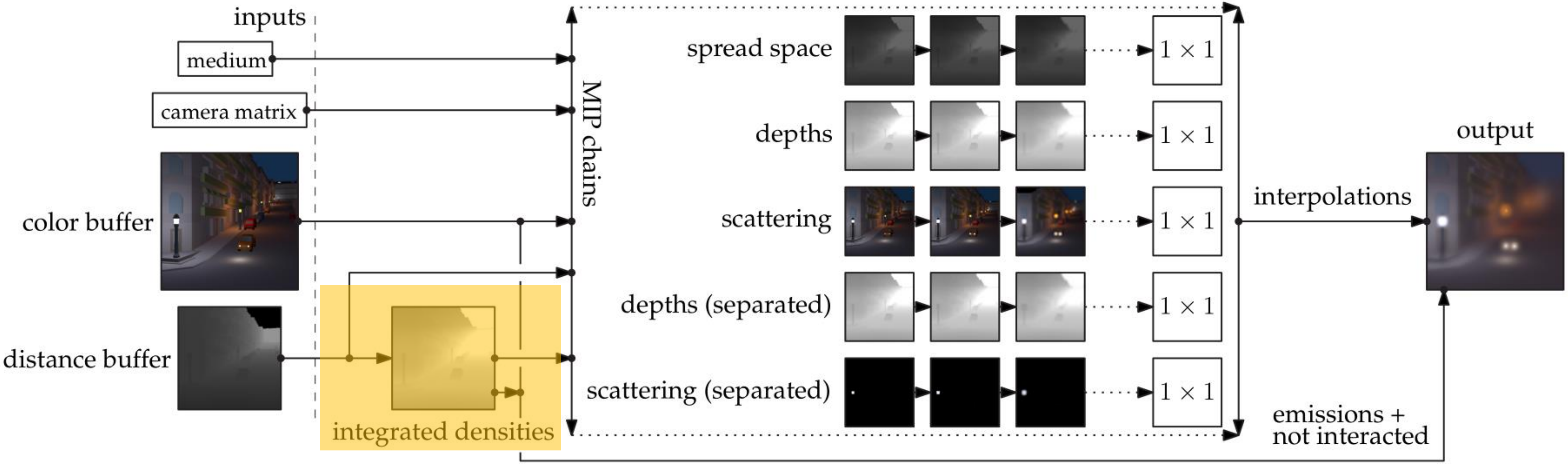
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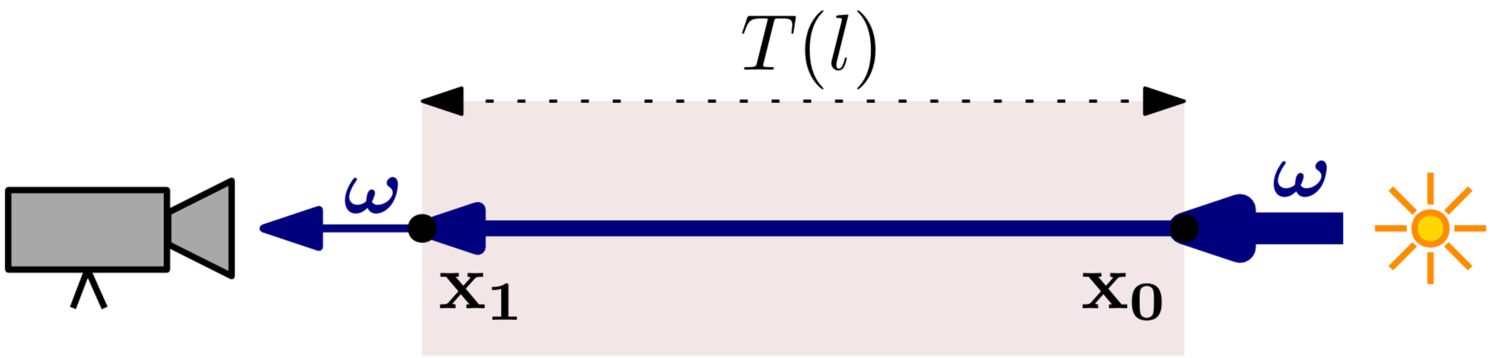
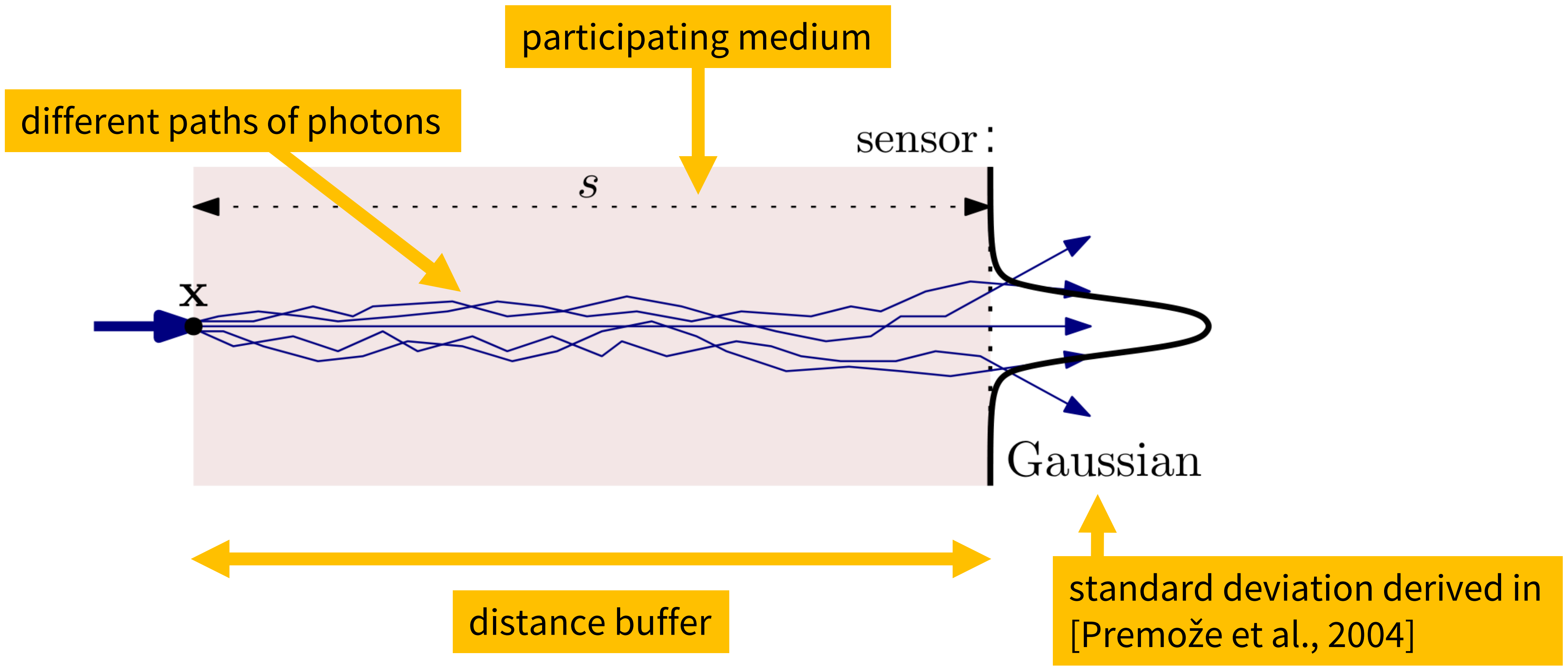
Absorption



Beer–Lambert law

Scattering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different paths of photons
sensor
s
x
Gaussian
distance buffer
standard deviation derived in [Premože et al., 2004]

Integrated densities

- Ray marching (slow!)
- Quasi-heterogeneous media (analytically integrated, fast!):
  - constant function,
  - exponential function,
  - spherical function,
  - etc.
  - + combinations of the above!

Video available online:
https://youtu.be/fMeeHaHzcnY

Performance

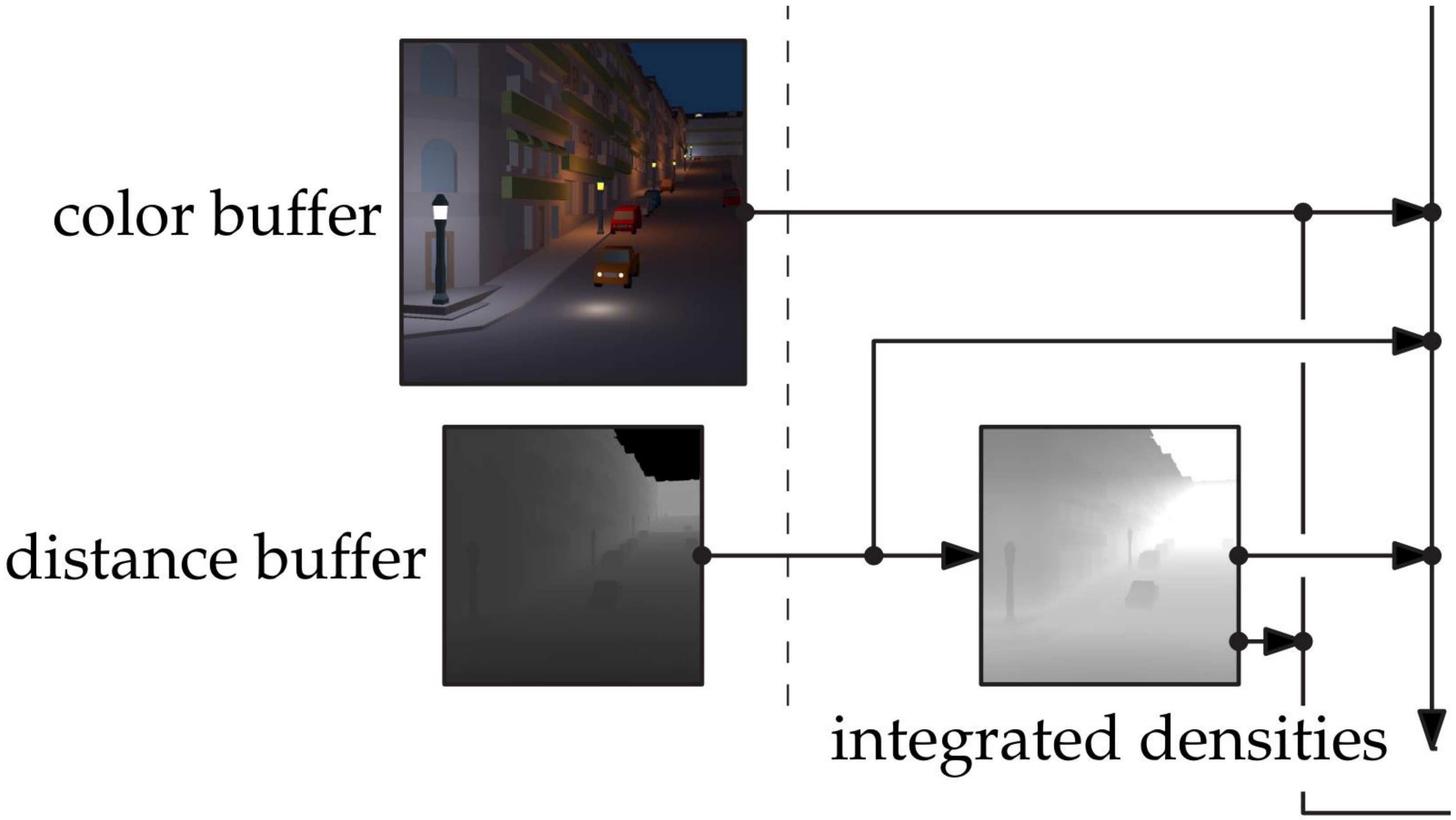
Resolution	Filter size	Interpolation technique			Separation (optional)
		Linear-bilinear	Linear-bicubic	Cubic-bicubic	Linear-bicubic
1280×720	2×2	0.9 ms	1.1 ms	1.6 ms	+0.6 ms
	4×4	1.9 ms	♡ 2.1 ms	2.6 ms	+1.0 ms
	6×6	3.7 ms	3.9 ms	4.3 ms	+2.3 ms
1920×1080	2×2	2.0 ms	2.5 ms	3.4 ms	+1.2 ms
	4×4	4.3 ms	♡ 4.8 ms	5.6 ms	+2.1 ms
	6×6	8.3 ms	8.7 ms	9.7 ms	+3.6 ms

Physically-based approach reproducing multiple-scattering glow effects in media.
Works on the standard outputs of a deferred shading pipeline in a few milliseconds.

Tomáš Iser, tomasiser@gmail.com
Charles University, Supervised by Oskar Elek

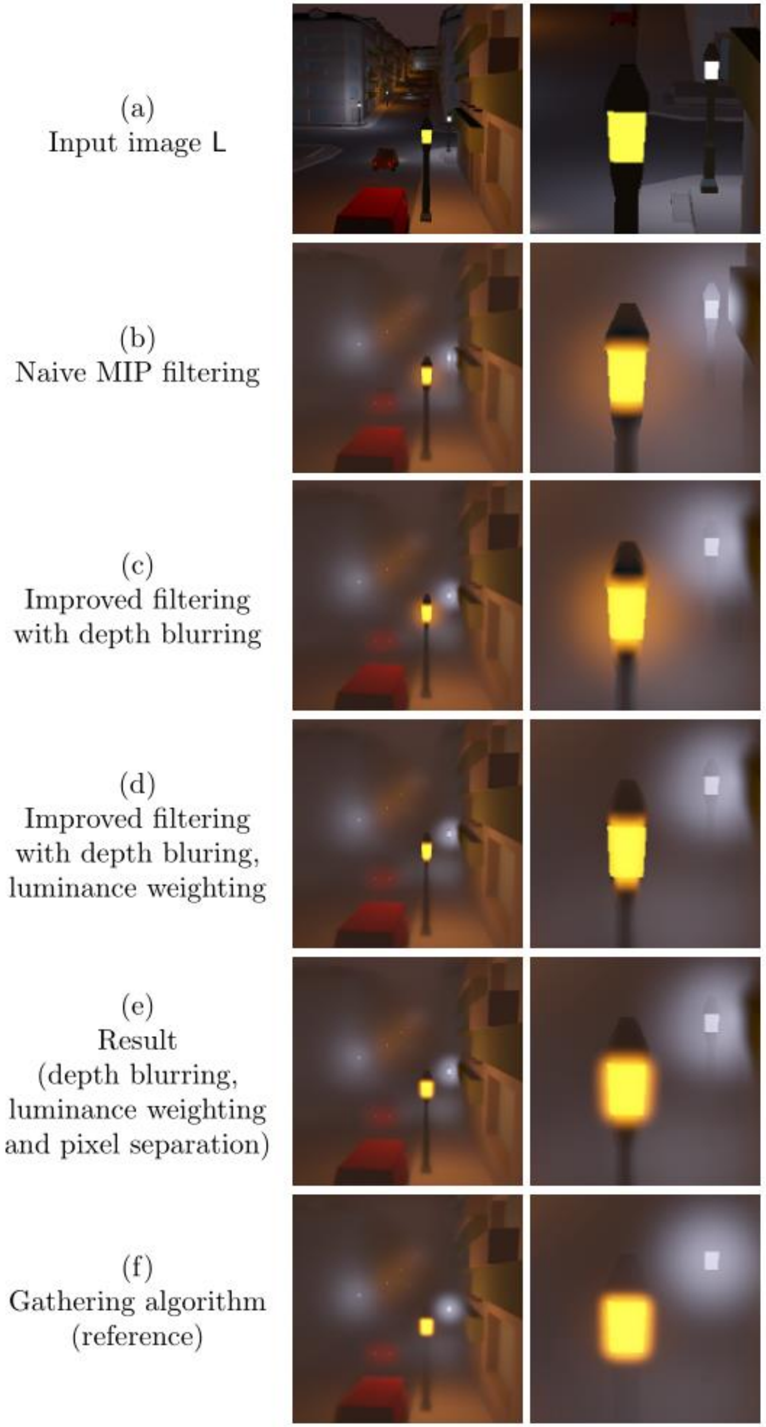
Our solution

Integrating the densities



Additional tricks

- Simply interpolating the final colors is <u>not enough</u>!
- We also need additional tricks:
  - depth blurring,
  - luminance weighting,
  - bright pixel separation.



Additional tricks

- Simply interpolating the final colors is <u>not enough</u>!
- We also need additional tricks:
  - depth blurring,
  - luminance weighting,
  - bright pixel separation.
- We need multiple MIP chains!