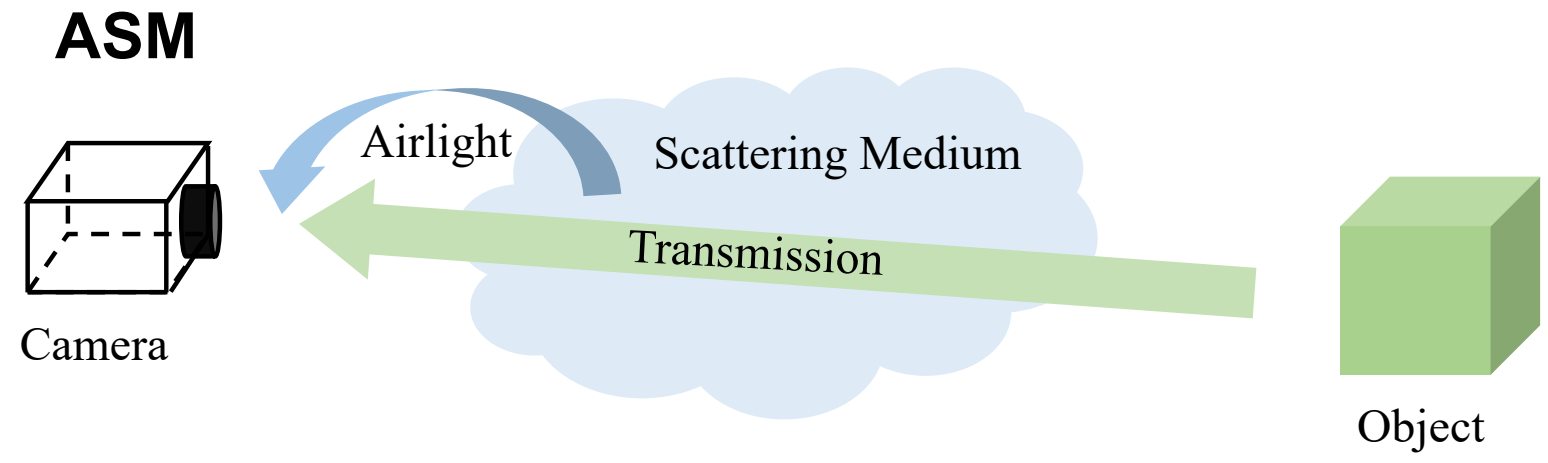


# SynFog: A Photo-realistic Synthetic Fog Dataset based on End-to-end Imaging Simulation for Advancing Real-World Defogging in Autonomous Driving

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## Motivations



- Fail to consider accurate global illumination and the actual imaging process.
- Disparity between synthetic and real-world foggy images, limited robustness.

## Contributions

### End-to-end foggy image simulation pipeline:

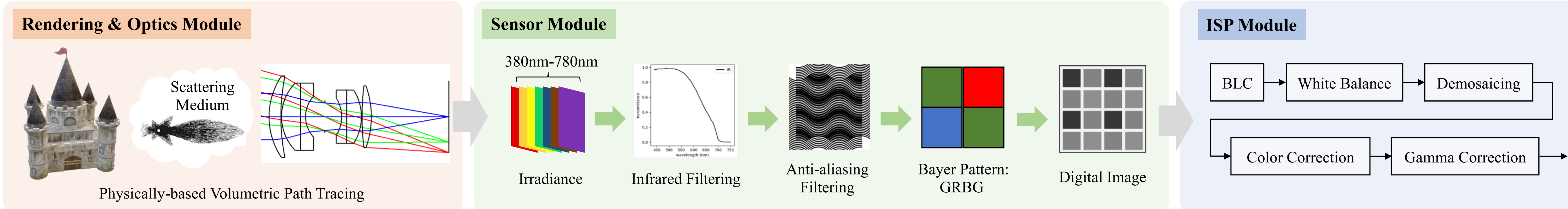
- Accurate light transportation in scattering medium
- Physical characteristics of optics and sensor

### SynFog dataset:

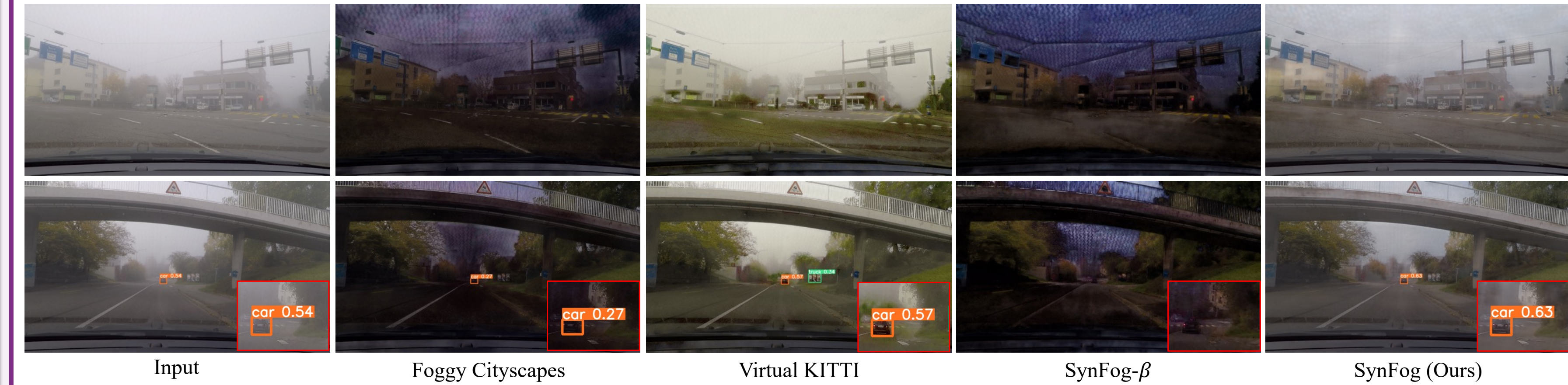
- Both skylight and active lighting conditions
- Three levels of fog density
- Pixel-accurate depth data and segmentation labels



## End-to-end Foggy Image Simulation Pipeline

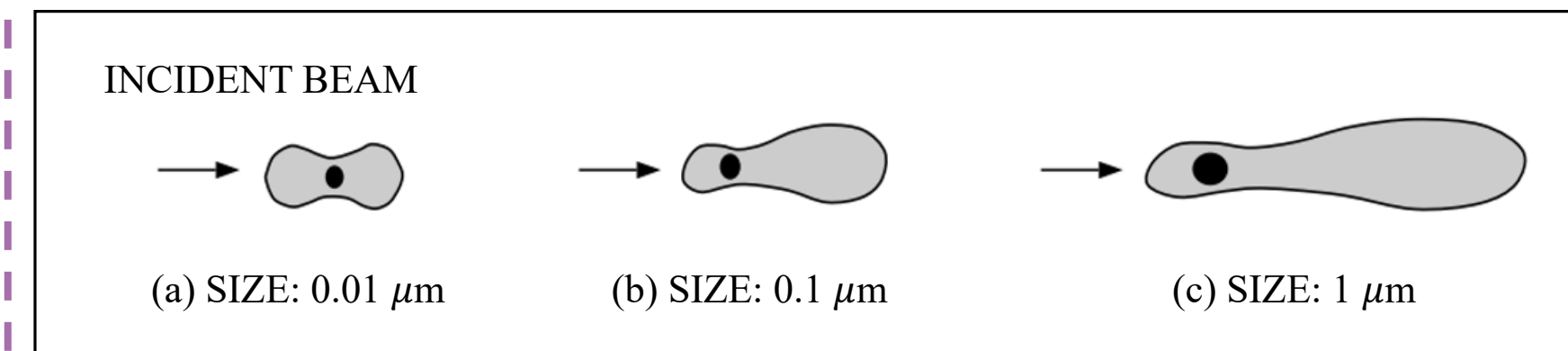


## Transferability across the Real-to-Virtual Gap



## Foggy Scene Rendering

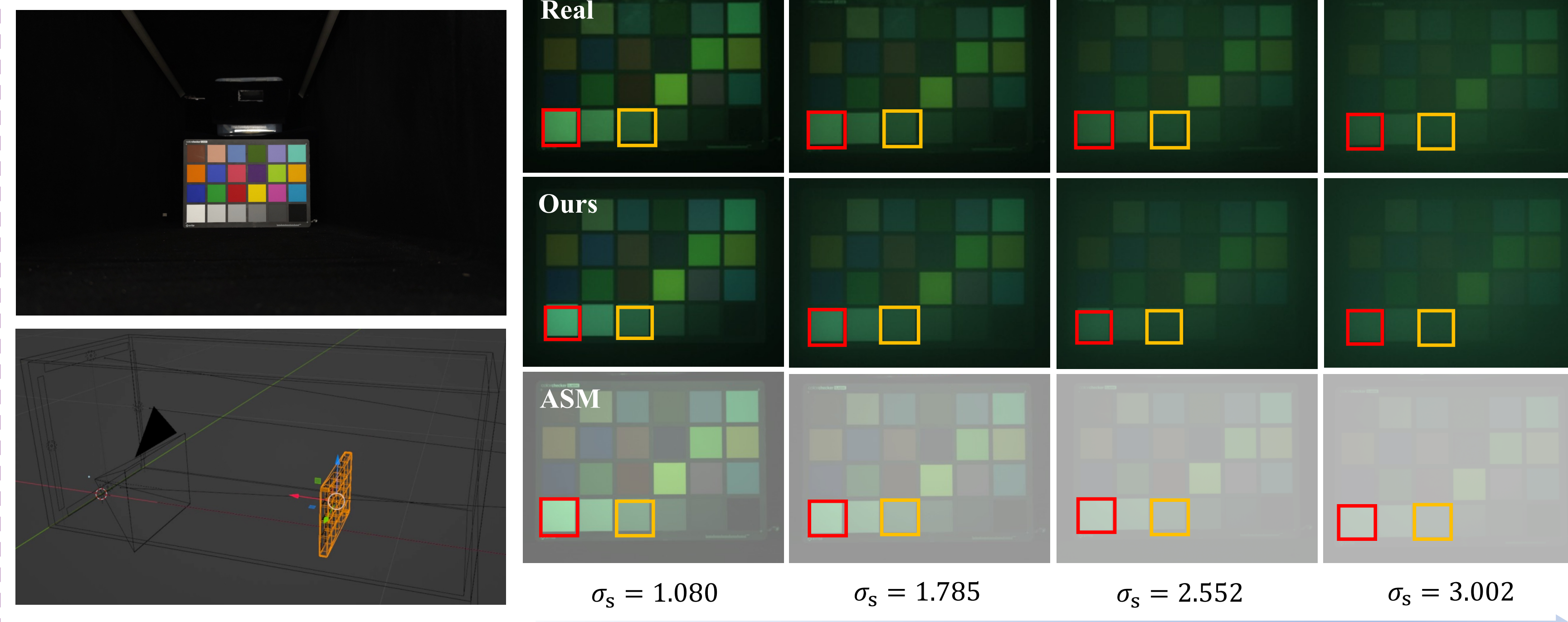
CONDITION	PARTICLE TYPE	RADIUS ( $\mu\text{m}$ )	CONCENTRATION ( $\text{cm}^{-3}$ )
AIR	Molecule	$10^{-4}$	$10^{19}$
HAZE	Aerosol	$10^{-2} - 1$	$10^3 - 10$
FOG	Water Droplet	1 - 10	100 - 10
CLOUD	Water Droplet	1 - 10	300 - 10
RAIN	Water Drop	$10^2 - 10^4$	$10^{-2} - 10^{-5}$



Henyey and Greenstein Phase Function:

$$p_{\text{HG}}(\cos \theta) = \frac{1}{4\pi} \frac{1 - g^2}{(1 + g^2 + 2g(\cos \theta))^{3/2}}$$

## Validation



Training Set	O-Haze [2]			Foggy Zurich [11]	Foggy Driving [40]	BeDDE [56]
	PSNR $\uparrow$	SSIM $\uparrow$	DHQI [14] $\uparrow$	DHQI [14] $\uparrow$	DHQI [14] $\uparrow$	DHQI [14] $\uparrow$
Foggy Cityscapes	14.46	0.5737	43.40	52.06	51.55	36.07
Virtual KITTI	13.90	0.5315	42.80	50.94	47.46	33.42
<b>SynFog</b>	<b>15.43</b>	<b>0.6116</b>	<b>44.46</b>	<b>54.16</b>	<b>52.07</b>	<b>43.28</b>

Method	Training Set	FZ [11]	STF [5]	Experimental setting	
		mAP (%)	mAP (%)	mAP (%)	mAP (%)
AECRNet	Foggy Cityscapes	69.7	54.8	AECRNet+SynFog(w/o noise) 69.5 54.7	
	Virtual KITTI	68.9	53.3	AECRNet+SynFog(w/ noise) <b>71.5</b> <b>55.5</b>	
	<b>SynFog</b>	<b>71.5</b>	<b>55.5</b>		
DehazeFormer	Foggy Cityscapes	67.9	54.9		
	Virtual KITTI	68.5	53.1		
	<b>SynFog-beta</b>	59.7	<b>55.3</b>		
	<b>SynFog</b>	<b>69.7</b>	<b>55.3</b>		

