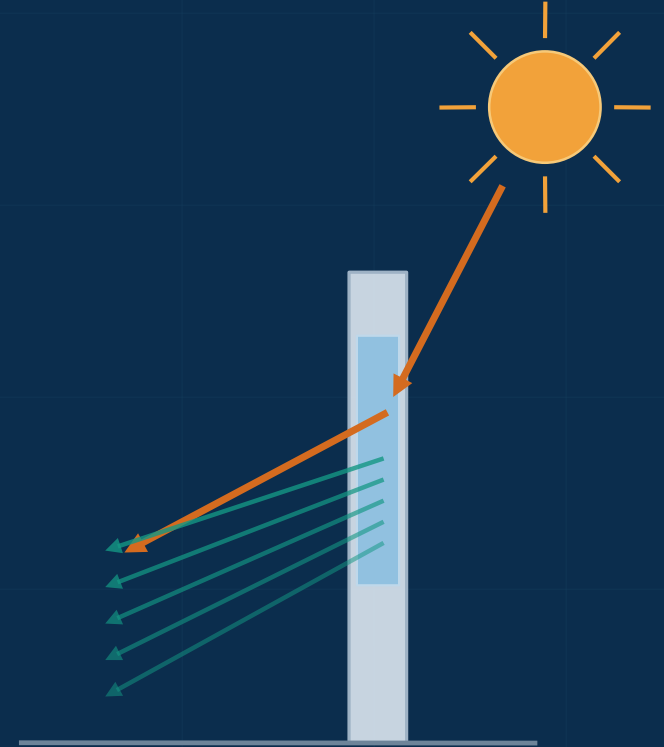


An Enhanced Imageless Method for Annual Daylight Glare Calculation with Complex Fenestration Systems

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coarse background explicit compact sources

No annual HDR image rendering

Annual glare is a compact-source problem

$$\text{DGP}_{i,t} = 5.87 \times 10^{-5} E_{v,i,t} + 0.0918 \log_{10} \left(1 + \frac{G_{i,t}}{E_{v,i,t}^{1.87}} \right) + 0.16$$

SATURATION TERM

Vertical eye illuminance

Broad-field accuracy and total flux are important.

E_v

CONTRAST TERM

Localized glare sources

Peak luminance · visible solid angle
· Guth position

$L^2 \Omega / P^2$

a Viewpoint V1



b Viewpoint V2



Every annual state needs a directional field for each observer.

Preserving luminous flux is not enough: source luminance and angular extent must also be preserved.

SIMPLIFIED / SCREENING

1

Illuminance- or class-based methods

DGPs · adaptive zones · GLANCE-type workflows

Strength Very fast annual and spatial screening using E_v or glare classes.

Limitation Limited source luminance, solid-angle, and position information when contrast dominates.

COARSE MATRIX / IMAGELESS

2

Low-resolution directional methods

Jones dcglare and related matrix workflows

Strength Reusable annual matrices provide excellent computational efficiency.

Limitation Compact sources may be smoothed, and redirected light cannot be considered.

ADAPTIVE RECONSTRUCTION

3

Adaptive luminance-field methods

Raytraverse

Strength Adaptive directional and solar sampling avoids a uniformly dense image grid.

Limitation

- Repeated refinement becomes costly for sharp TensorTree peaks, many solar positions, and many views.
- It is difficult to catch the very small light source such as specular reflection light

Complementary CFS source treatments: high-resolution BSDFs · photon mapping · data-driven BSDFs · peak extraction

EIGCM keeps broad sky and interreflected transport on MF1 window patch, while reconstructing high-intensity compact solar sources only where their physical angular structure matters.

1 Source-specific reconstruction

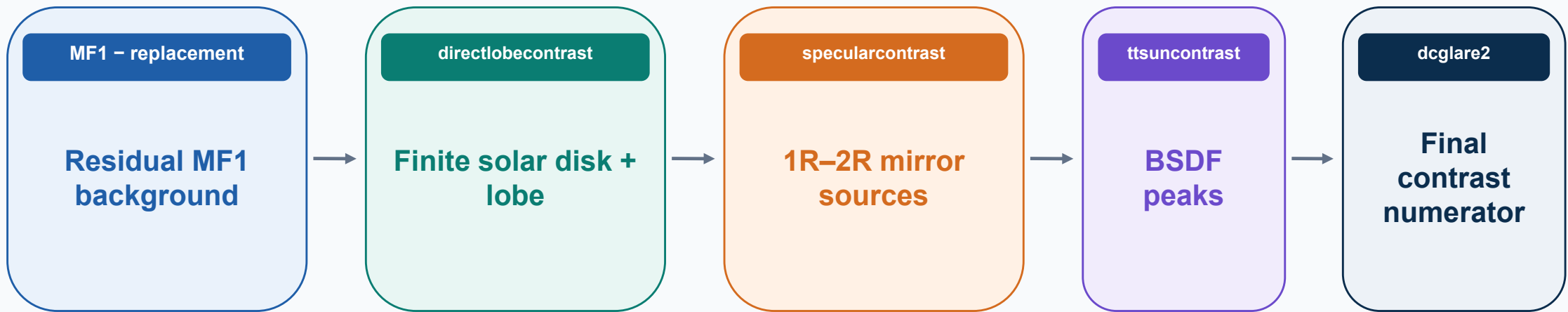
Dedicated solvers for finite solar disks, transmission/refraction lobes, 1R–2R mirror images, and BSDF/aBSDF peaks.

2 Matched subtraction and replacement

Remove each explicitly reconstructed source from the MF1 field before adding its resolved contrast and illuminance.

Resulting principle: adaptive resolution by source physics, not by a uniformly dense angular grid.

$$G_{i,t} = \sum_{g=1}^{N_g} C_{g,i,t} [\mathbf{L}_{g,i,\cdot,t}^{\text{tot},c} - \mathbf{L}_{g,i,\cdot,t}^{\text{rep},c}] + G_{\odot,i,t}^{0R} + G_{dl,i,t} + G_{mir,i,t}^{1:2R} + G_{BSDF,i,t}$$

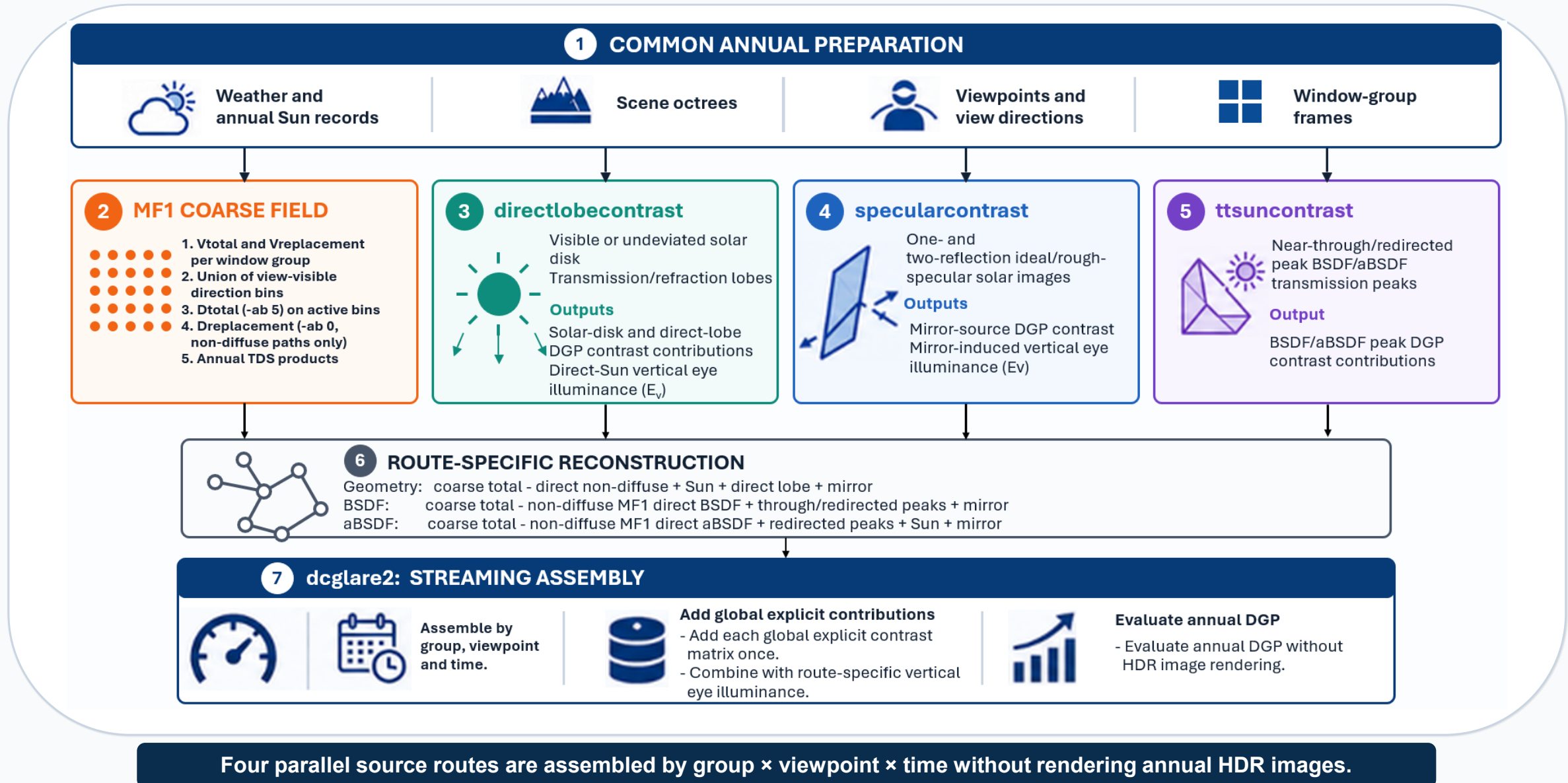


Complete coarse field – matched coarse source + resolved source once

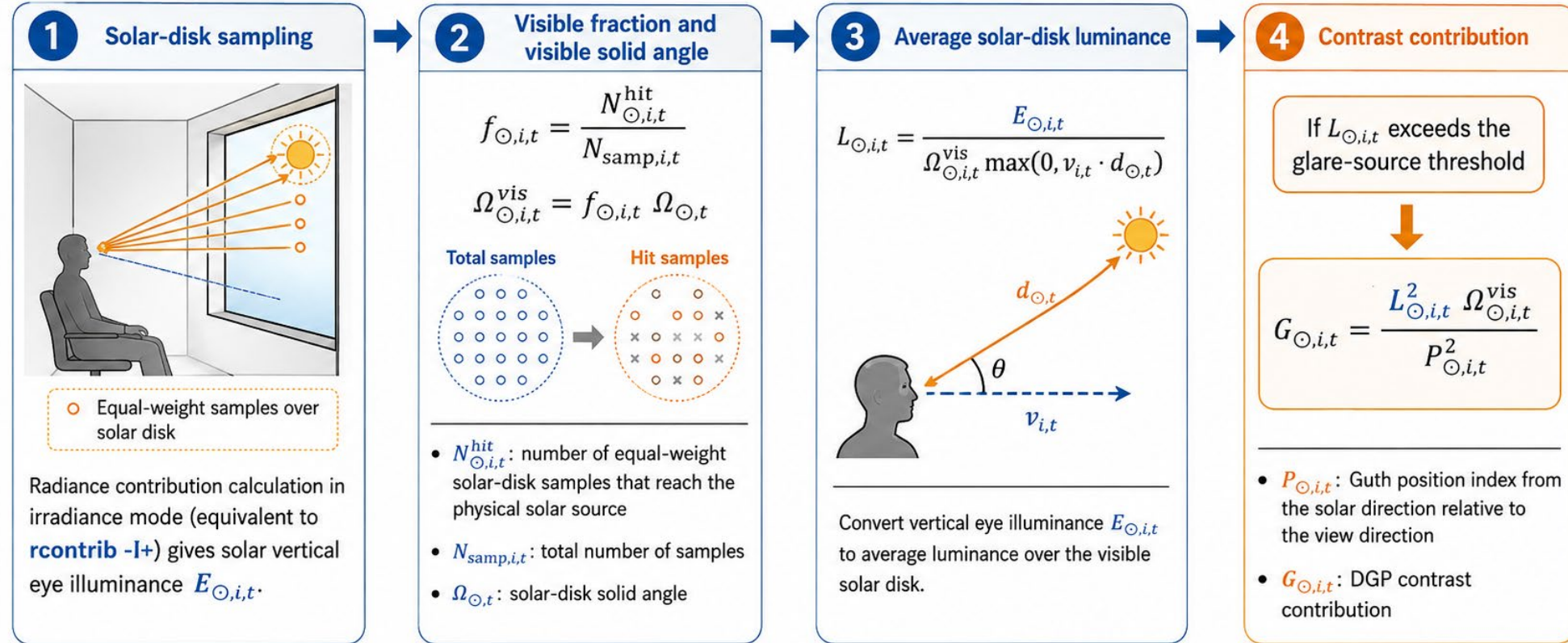
The operator $\mathcal{C}$ maps the residual MF1 luminance distribution to the DGP contrast numerator.

Annual multi-view EIGCM workflow

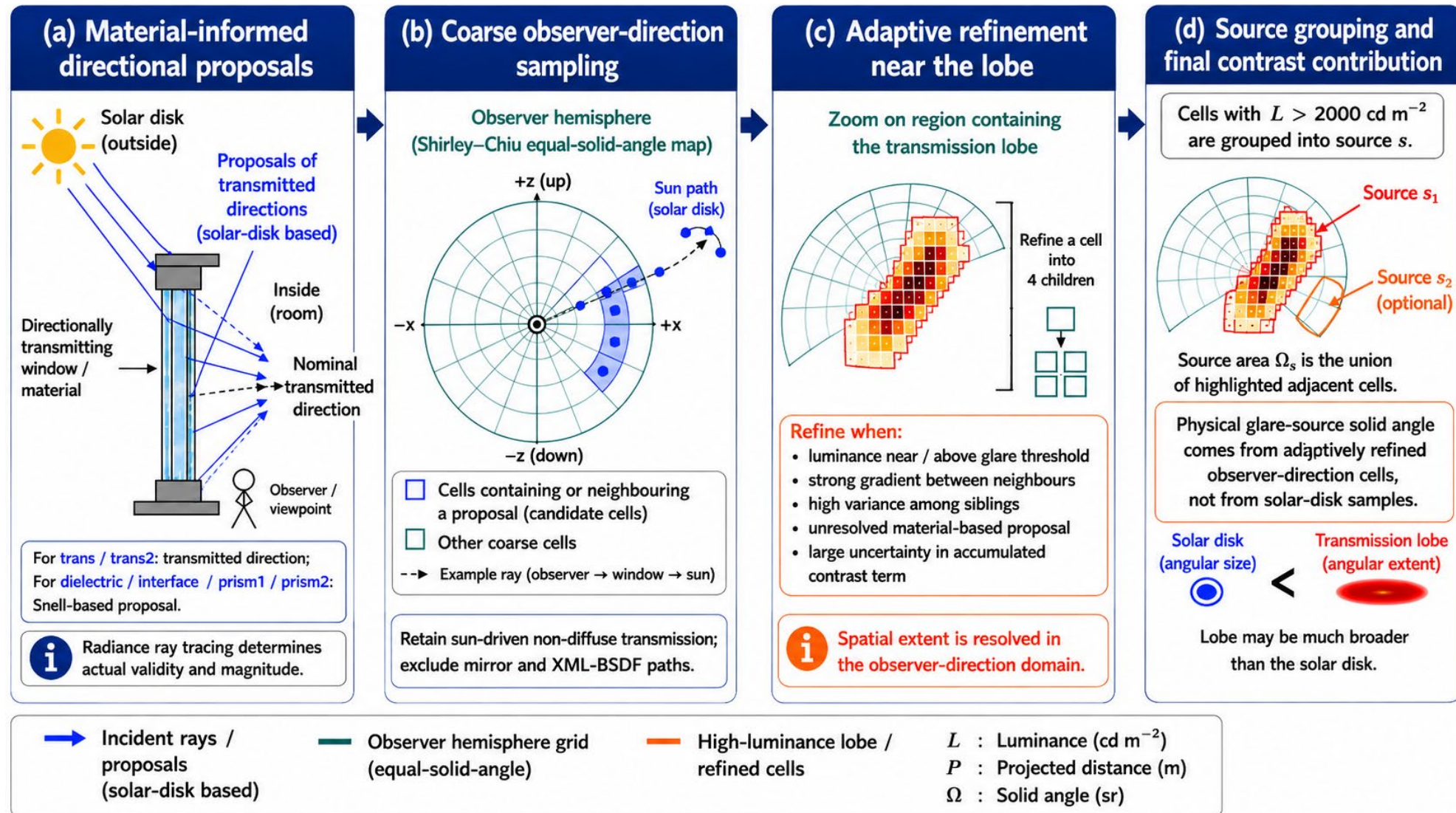
METHOD



Visible or undeviated transmitted solar disk

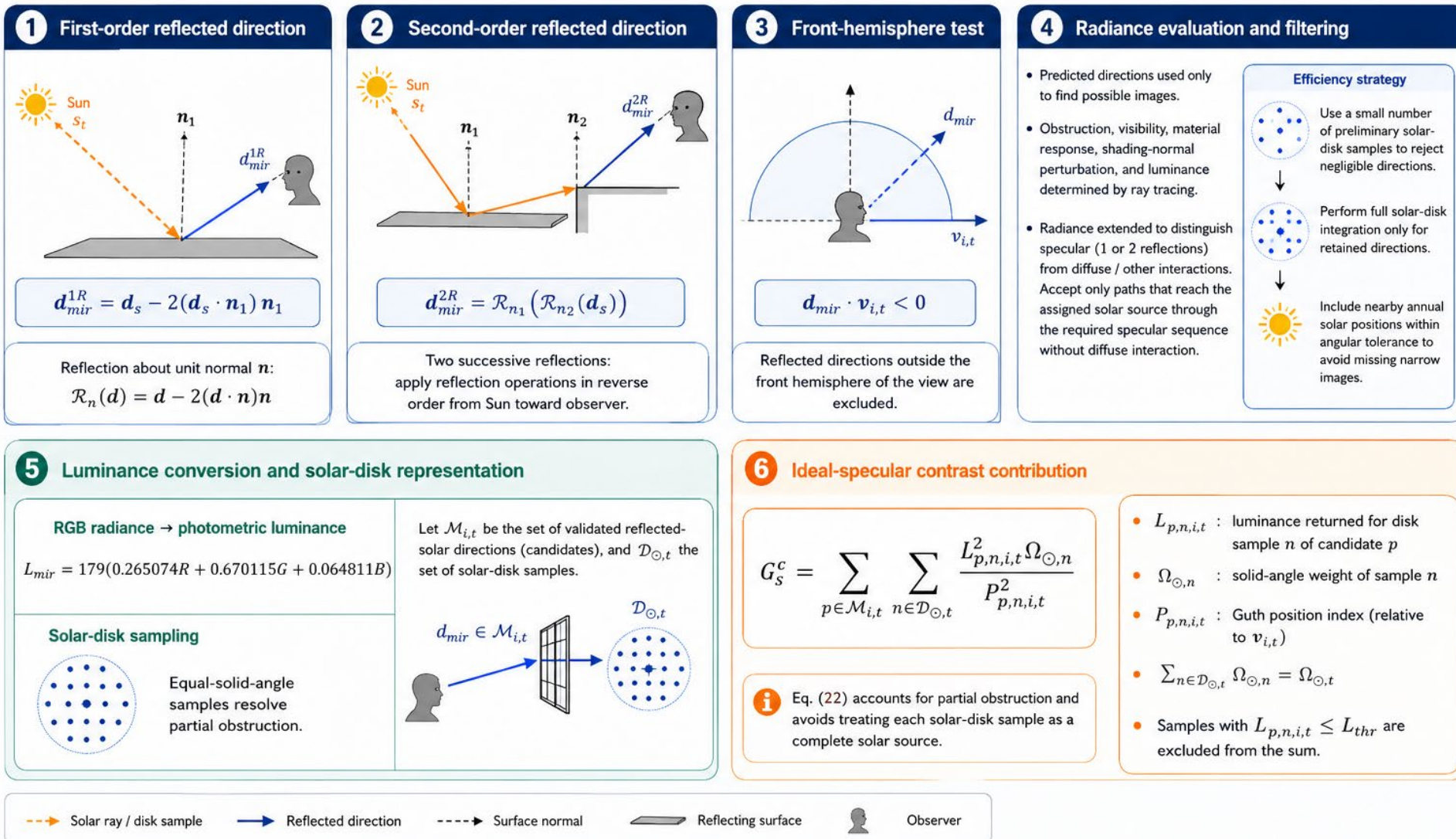


Sample visibility determines Ω^{vis} ; $E_{\odot,i,t}$ gives average source luminance; if bright enough, the source contributes $G_{\odot,i,t}$ to DGP.



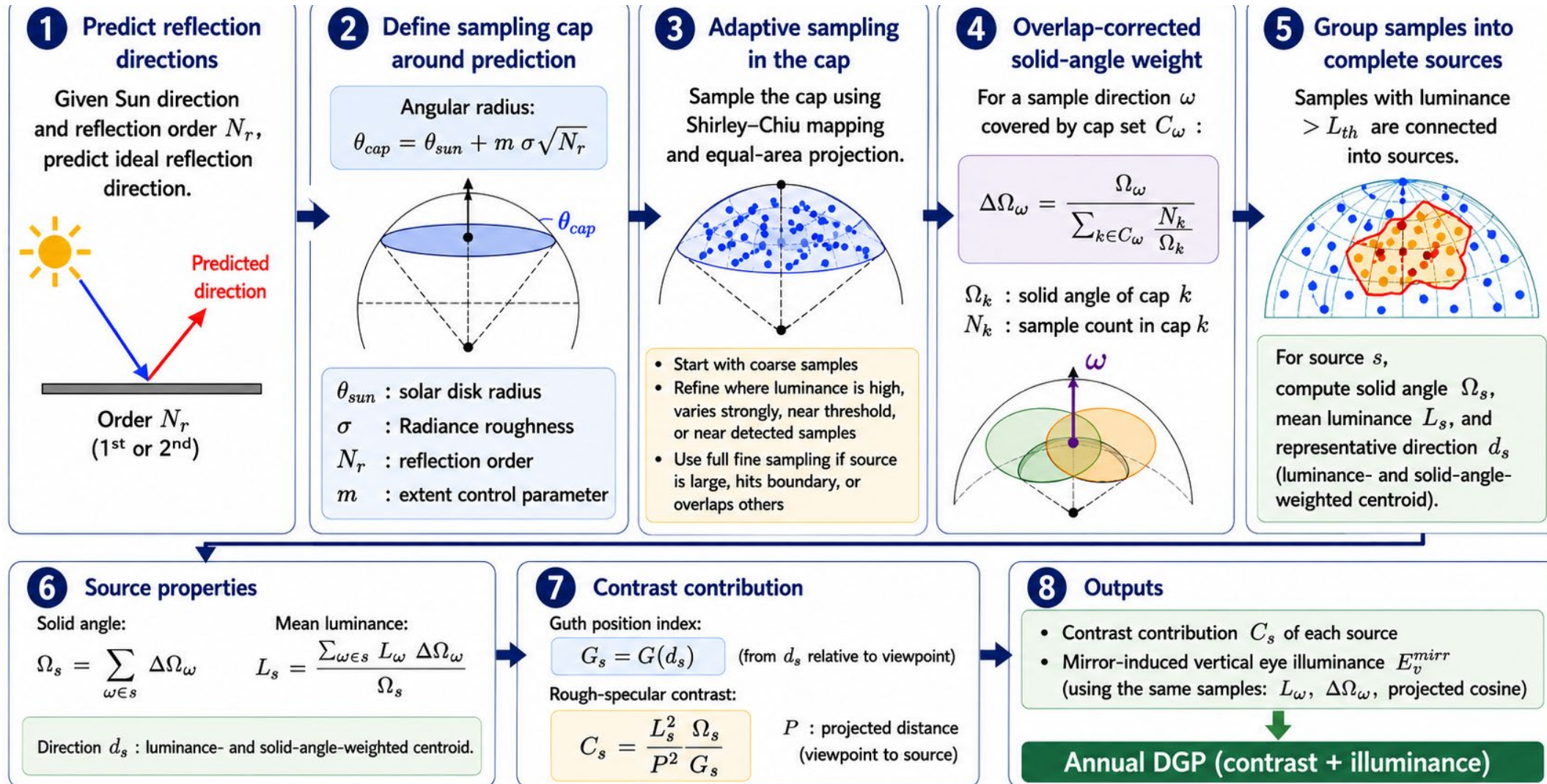
Material physics proposes candidate directions; Radiance determines the actual lobe, and adaptive observer-direction cells determine its physical solid angle.

specularcontrast: first- and second-order ideal reflections



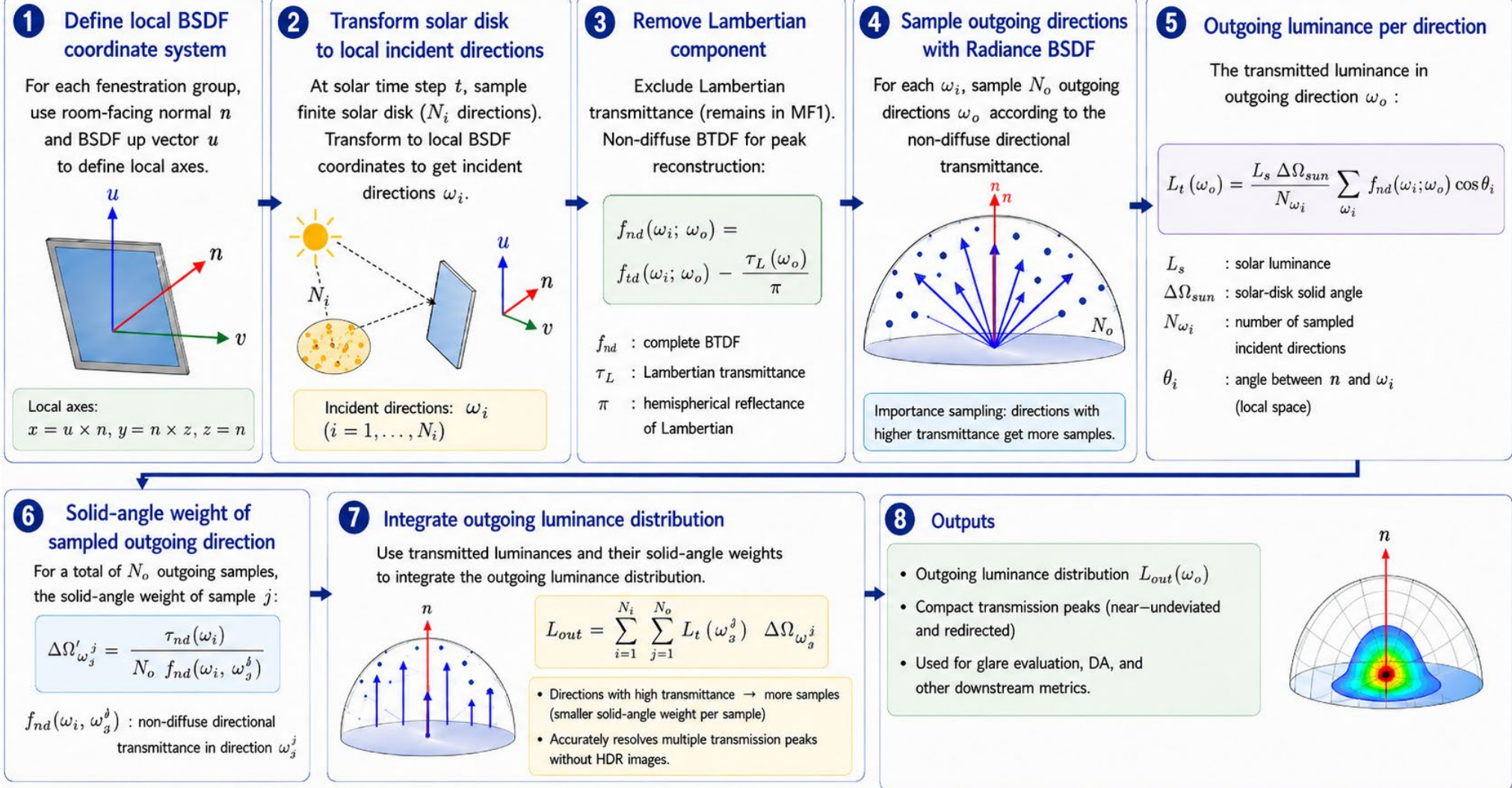
Path search is separated from annual solar evaluation; the same validated samples provide both contrast and mirror-induced vertical eye illuminance.

specularcontrast: first- and second-order rough reflections



Path search is separated from annual solar evaluation; the same validated samples provide both contrast and mirror-induced vertical eye illuminance.

ttsuncontrast: compact BSDF and aBSDF transmission peaks

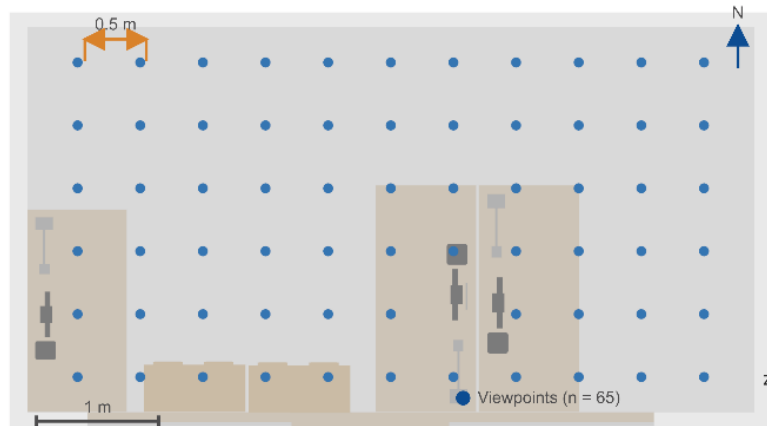


BSDF-guided importance sampling resolves multiple peaks without HDR images; outgoing directions, luminances, and weights are reused across viewpoints.

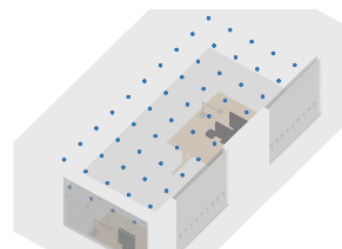
Test model and viewpoint sampling

VALIDATION

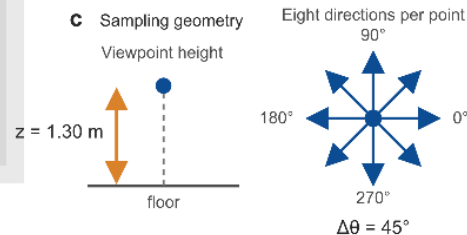
a Spatial distribution



b Three-dimensional context



c Sampling geometry



a Viewpoint V1



b Viewpoint V2



Representative annual views V1 and V2

65

locations

$\times 8$

horizontal directions

= 520

viewpoint-direction combinations

1.30 m

eye height

0.5 m

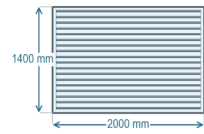
horizontal grid

Weather: Shanghai · full annual validation at V1/V2 · multi-view HDR reference on 21 Mar, 21 Jun, and 22 Dec

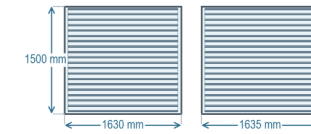
Four fenestration systems stress different source types

VALIDATION

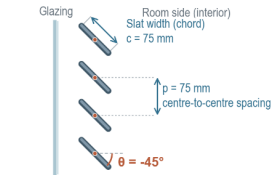
a West-facing window blind
18 horizontal metal slats, embedded within the window reveal



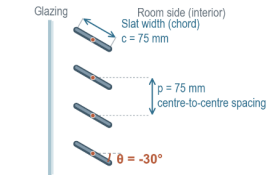
b South-facing window blinds
20 slat levels per window; two adjacent window openings



c West blind section

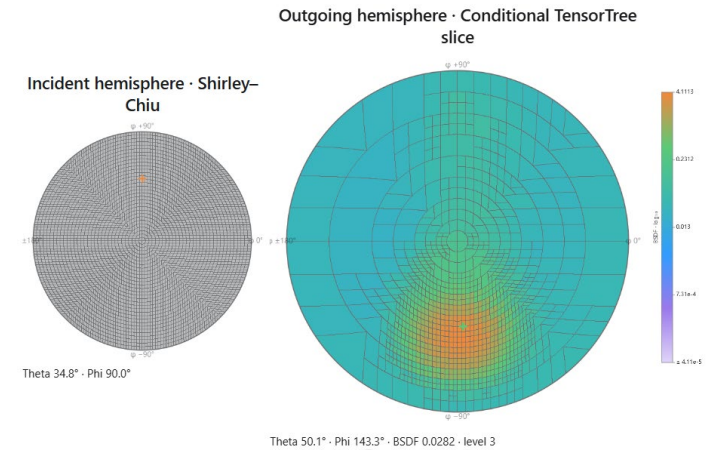


d South blind section



Shared geometry: c = 75 mm (slat width); p = 75 mm (vertical centre spacing).
Slat thickness is exaggerated for visibility; the Radiance polygons are planar.

Specular Venetian blind geometry



PDRF conditional TensorTree distribution

C1 Specular Venetian blinds

Directional solar reflection from slats

C2 Prismatic daylight redirector

Concentrated and redirected TensorTree peaks

C3 Electrochromic glazing

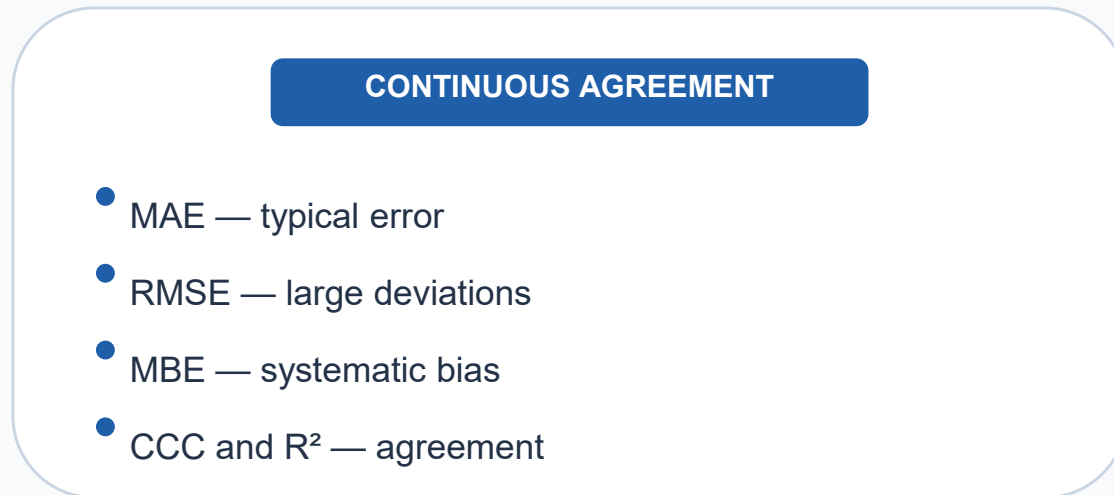
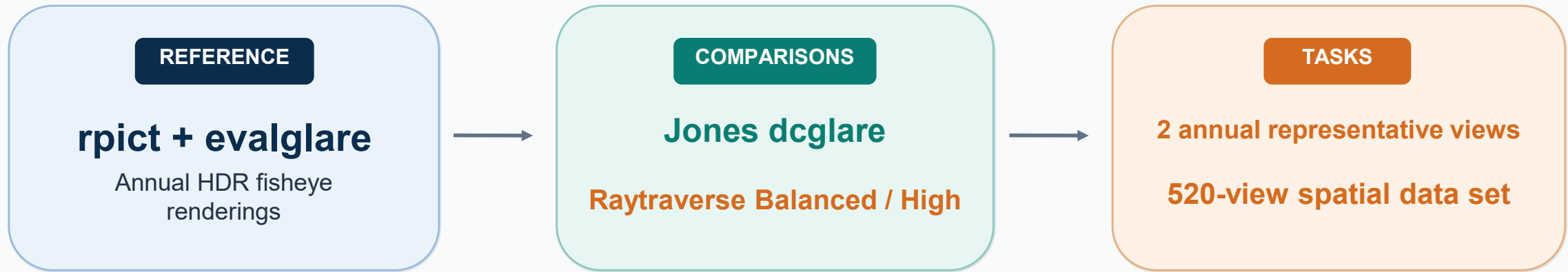
Darkest state: 1% visible transmittance

C4 Blinds + frosted glazing

Coupled mirror reflection and rough transmission

C1: mirror sources · C2: BSDF peaks · C3: low-transmittance saturation regime · C4: specular + finite rough-transmission lobe

Blind settings: RGB reflectance 0.70, specularity 0.21; west slats -45° , south slats -30° .

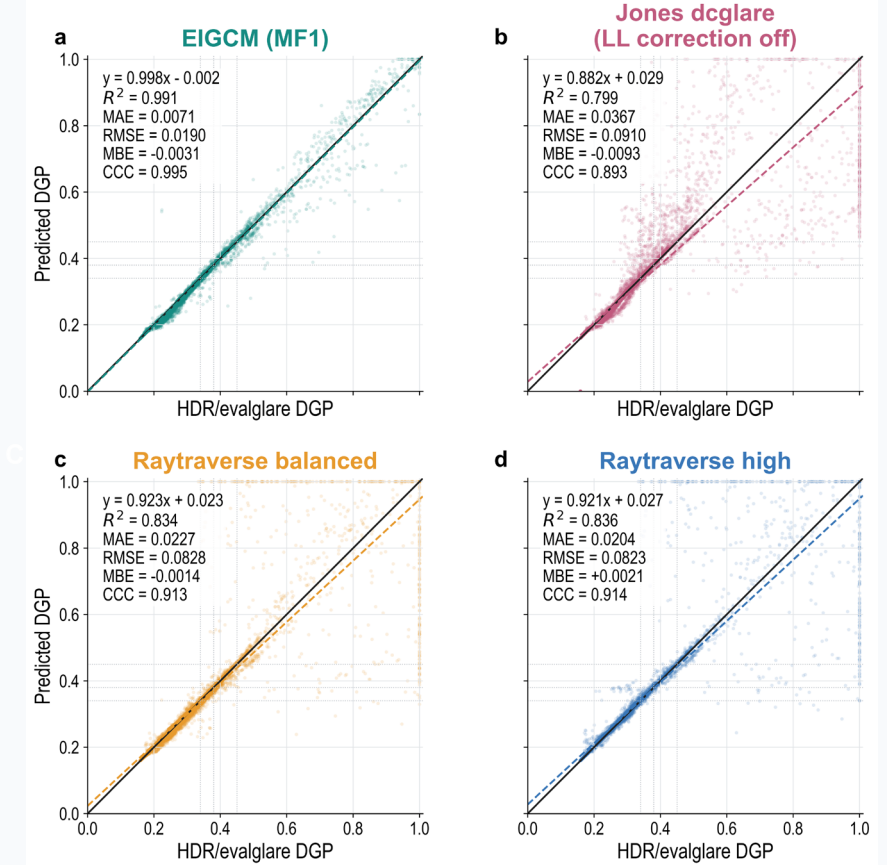


The evaluation tests both ordinary agreement and rare high-glare failures.

C1 · Specular Venetian blinds: two-view annual results

RESULTS

Method	MAE	RMSE	CCC	F2 score
EIGCM (MF1)	0.0071	0.0190	0.995	0.983
Jones dcglare	0.0367	0.0910	0.893	0.959
Raytraverse balanced	0.0227	0.0828	0.913	0.950
Raytraverse high	0.0204	0.0823	0.914	0.975



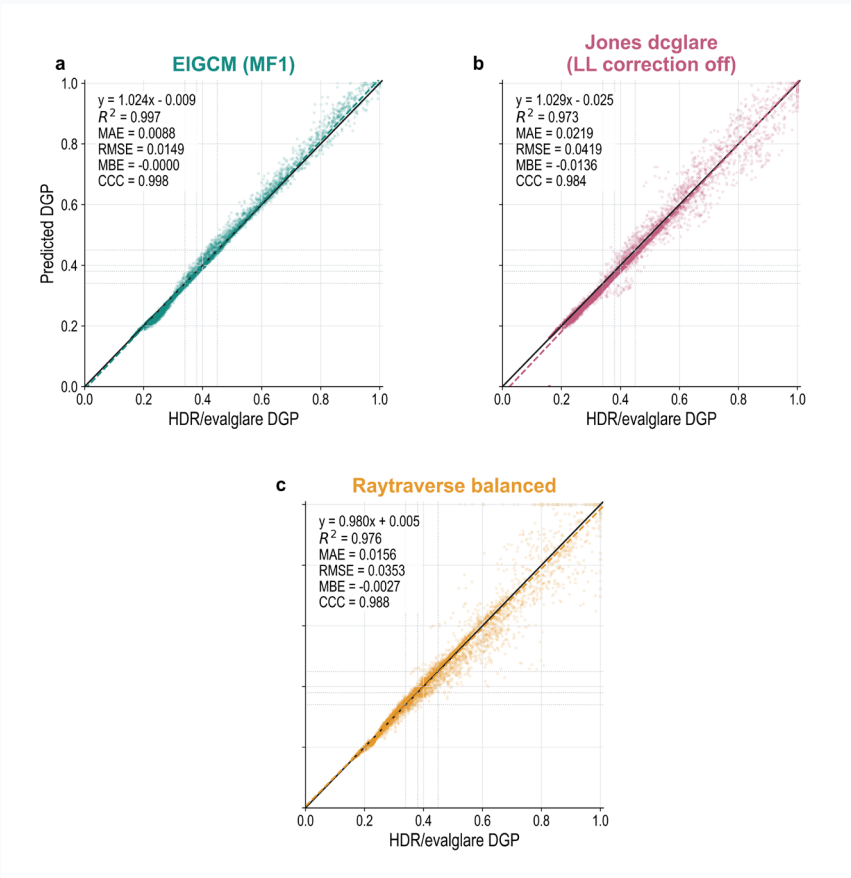
C1 SVB

Event detection (Recall / Precision): EIGCM 0.983 / 0.982 · dcglare 0.980 / 0.883 · Balanced 0.946 / 0.967 · High 0.978 / 0.962

EIGCM gives the smallest errors; higher Raytraverse sampling improves event detection but not the large-error tail.

C2 · Prismatic daylight redirector: two-view annual results

Method	MAE	RMSE	CCC	F2 score
EIGCM (MF1)	0.0088	0.0149	0.998	0.982
Jones dcglare	0.0219	0.0419	0.984	0.944
Raytraverse balanced	0.0156	0.0353	0.988	0.963
Not evaluated	n/a	n/a	n/a	n/a



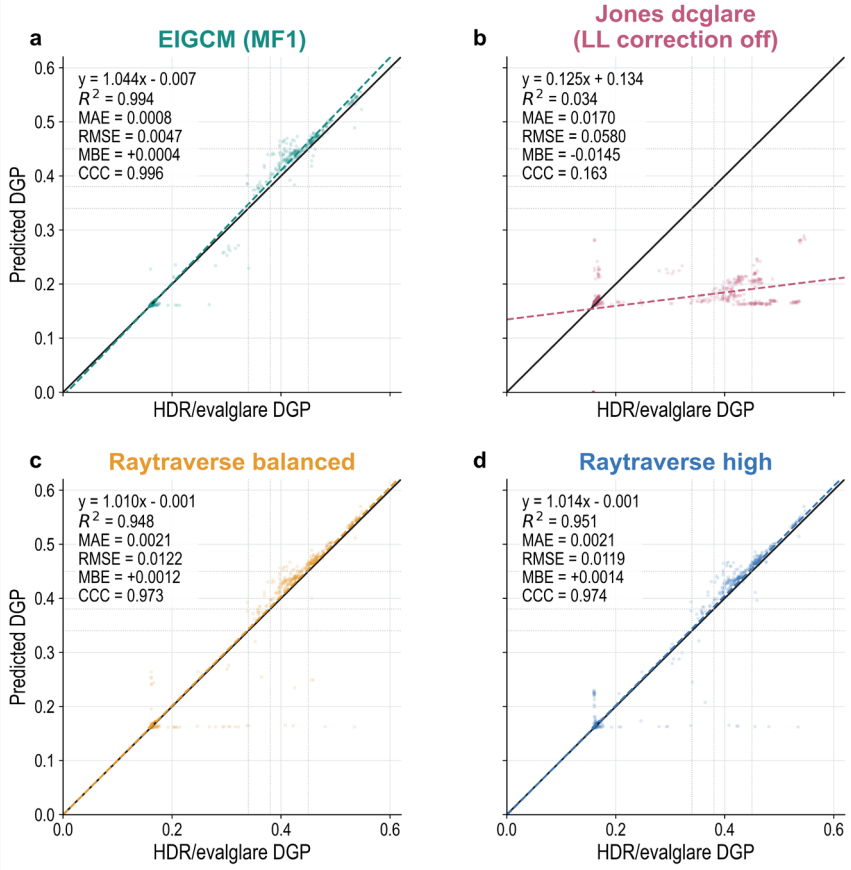
C2 PDFR

Event detection (Recall / Precision): EIGCM 0.980 / 0.989 · dcglare 0.932 / 0.996 · Raytraverse balanced 0.963 / 0.966

The broad TensorTree peak is comparatively forgiving, yet EIGCM retains the best DGP agreement and F2 score.

C3 · Electrochromic glazing: two-view annual results

Method	MAE	RMSE	CCC	F2 score
EIGCM (MF1)	0.0008	0.0047	0.996	0.991
Jones dcglare	0.0170	0.0580	0.163	0.000
Raytraverse balanced	0.0021	0.0122	0.973	0.970
Raytraverse high	0.0021	0.0119	0.974	0.973



C3 ECG

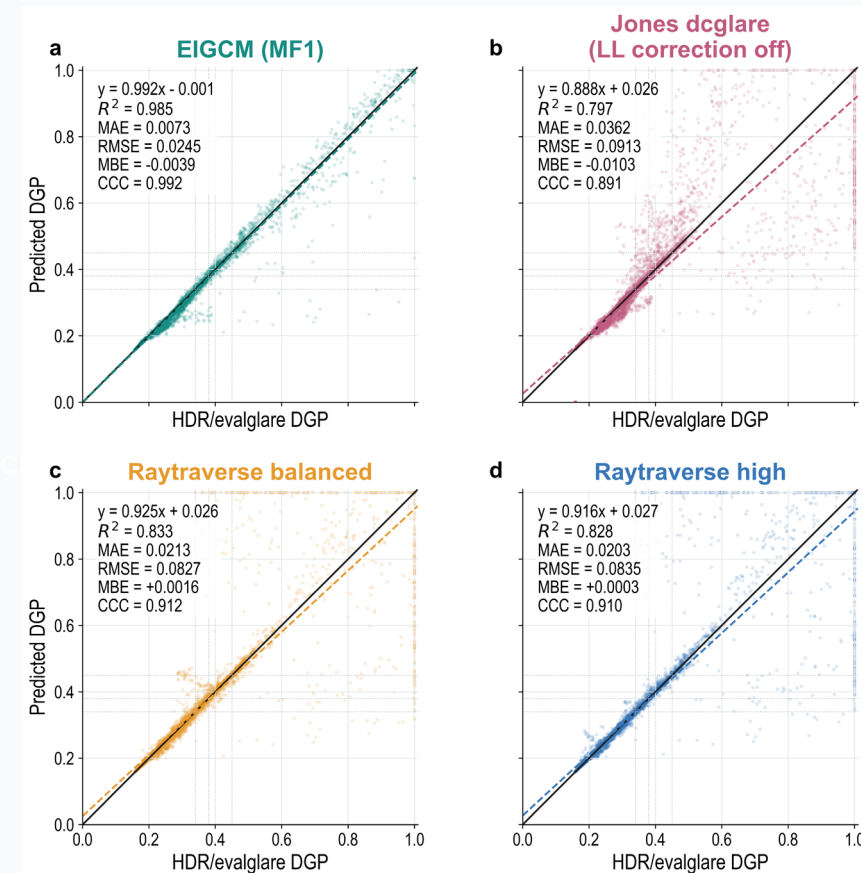
Event detection (Recall / Precision): EIGCM 1.000 / 0.955 · dcglare 0.000 / 0.000 · Balanced 0.974 / 0.953 · High 0.978 / 0.954

EIGCM preserves the low-transmittance response; Jones dcglare misses the ECG glare events in this case.

C4 · Specular blinds + frosted glazing: two-view results

RESULTS

Method	MAE	RMSE	CCC	F2 score
EIGCM (MF1)	0.0073	0.0245	0.992	0.973
Jones dcglare	0.0362	0.0913	0.891	0.960
Raytraverse balanced	0.0213	0.0827	0.912	0.955
Raytraverse high	0.0203	0.0835	0.910	0.968



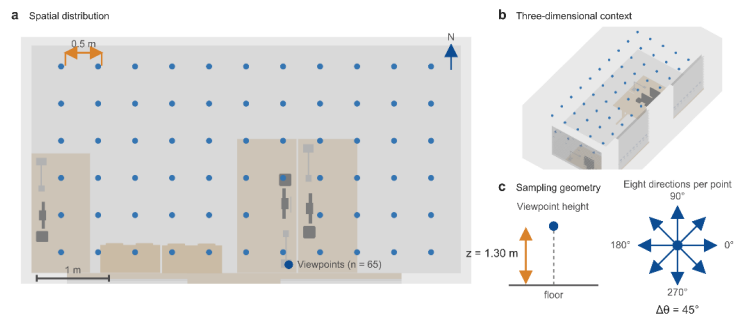
C4 SVB-FG

Event detection (Recall / Precision): EIGCM 0.970 / 0.985 · dcglare 0.974 / 0.908 · Balanced 0.963 / 0.926 · High 0.969 / 0.967

EIGCM best resolves the coupled mirror-reflection and rough-transmission source family.

Spatial robustness over 520 viewpoint–direction combinations

RESULTS



65 locations × 8 directions

Aggregate EIGCM range

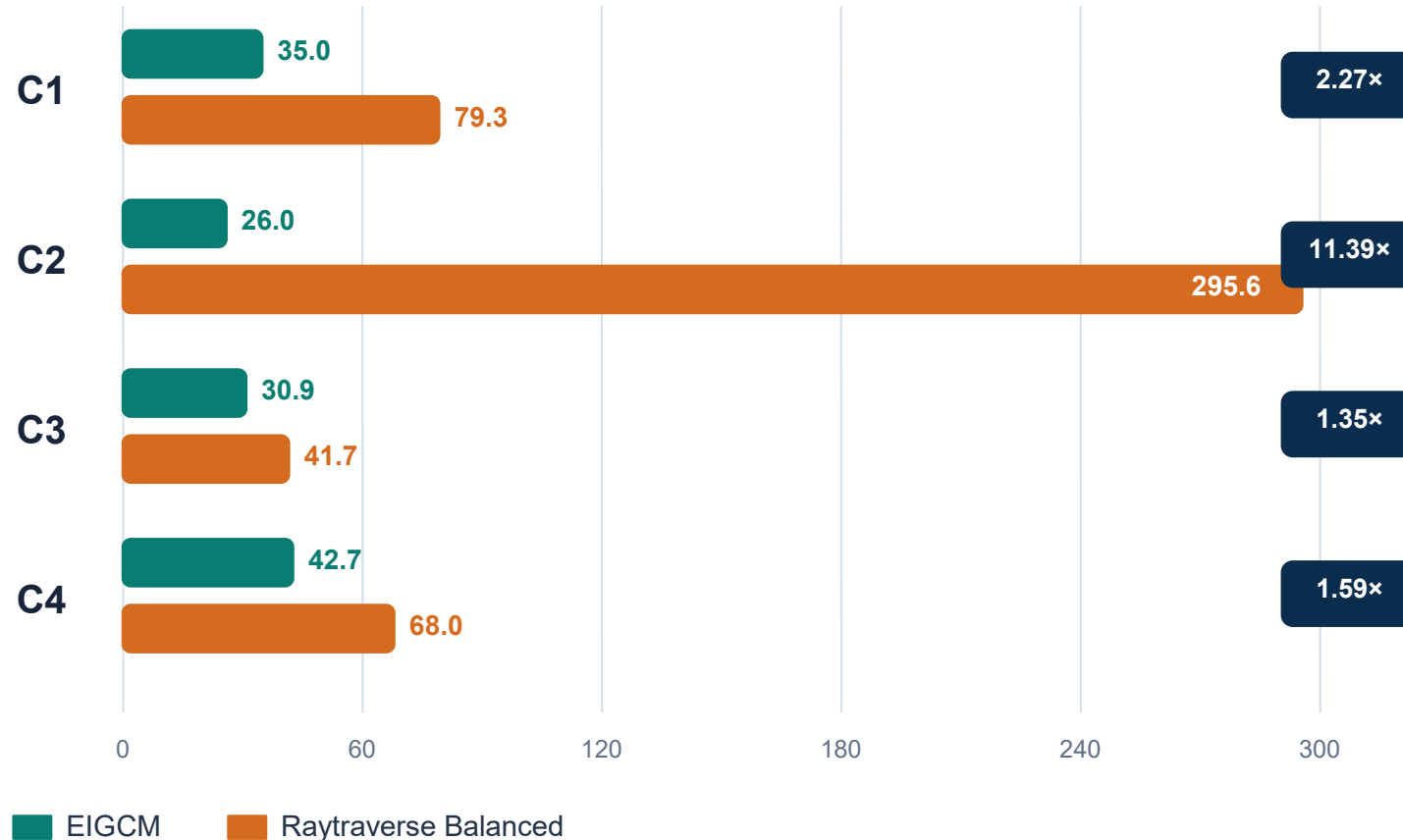
MAE 0.0008 – 0.0075

RMSE 0.0053 – 0.0179

Case	MAE	RMSE	CCC	F ₂
C1 · SVB	0.0066	0.0179	0.995	0.928
C2 · PDRF	0.0075	0.0150	0.997	0.959
C3 · ECG	0.0008	0.0053	0.996	0.996
C4 · SVB–FG	0.0055	0.0137	0.997	0.960

The representative-view advantage was retained spatially; EIGCM had the narrowest typical and upper-tail errors in all four cases.

520-view computation time (minutes)



Single viewpoints

1.17–7.52× faster

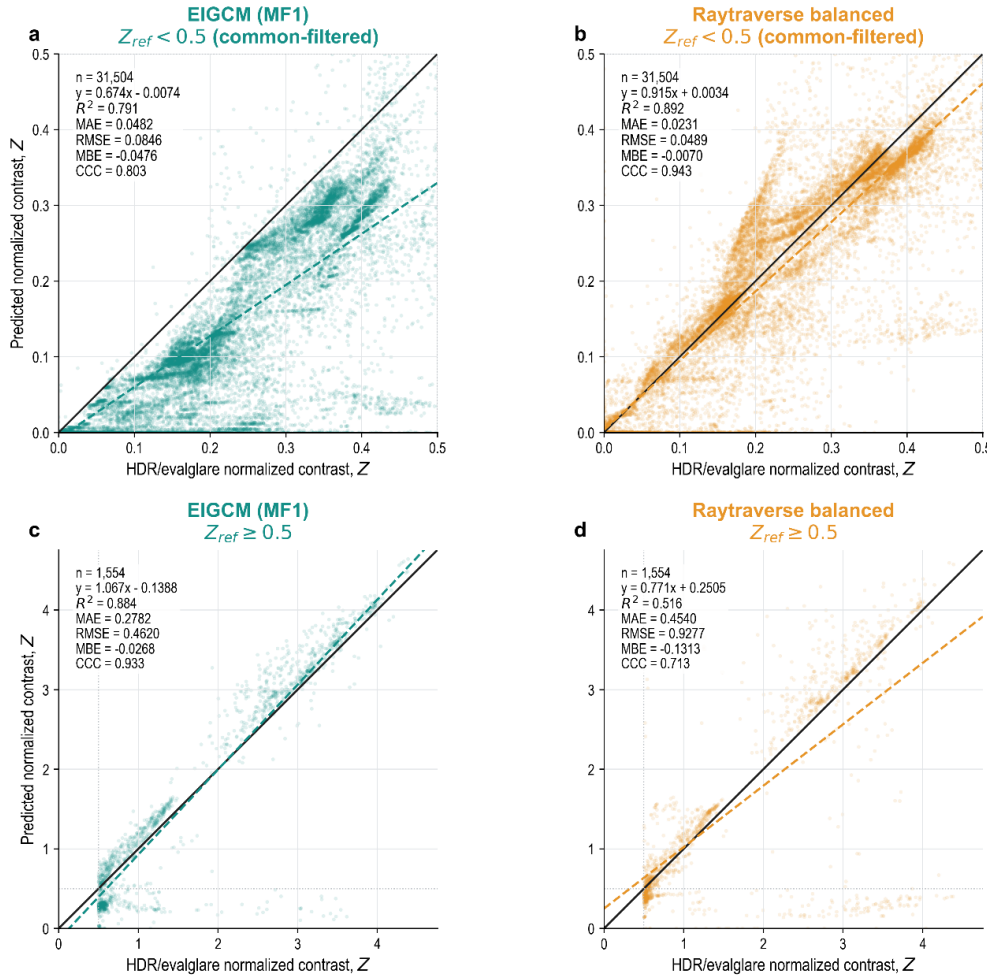
than Raytraverse Balanced

Why C2 benefits most

- TensorTree loaded and cached once
- Only active solar peaks are sampled
- View-independent BSDF work is reused

dcglare was fastest, but accuracy was not reliable when compact-source contrast dominated.

The methods fail in different regimes

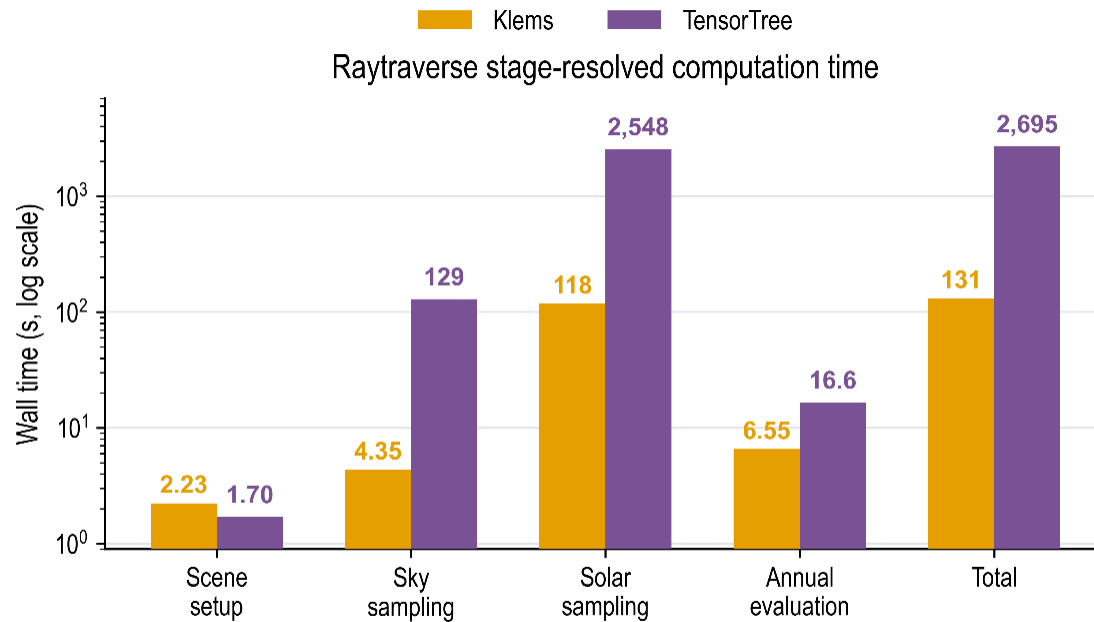


The low-contrast row retains the common sample set for which both predictions are below 0.5; the high-contrast row includes all valid samples.

INTERPRETATION

- Raytraverse is strong for broad, smooth, low-contrast distributions.
- Its main weakness here is a small number of large tail errors when compact sources are smoothed or missed.
- EIGCM is strongest when compact sources make the contrast term large.
- Its MF1 background can be less accurate for broad, smoothly varying contrast.

dcglare can perform well when E_v and the saturation term dominate.



Total runtime: Klems = 131.1 s; TensorTree = 2695.4 s (20.6×)

Raytraverse total runtime: Klems 131.1 s → TensorTree 2695.4 s (20.6×)

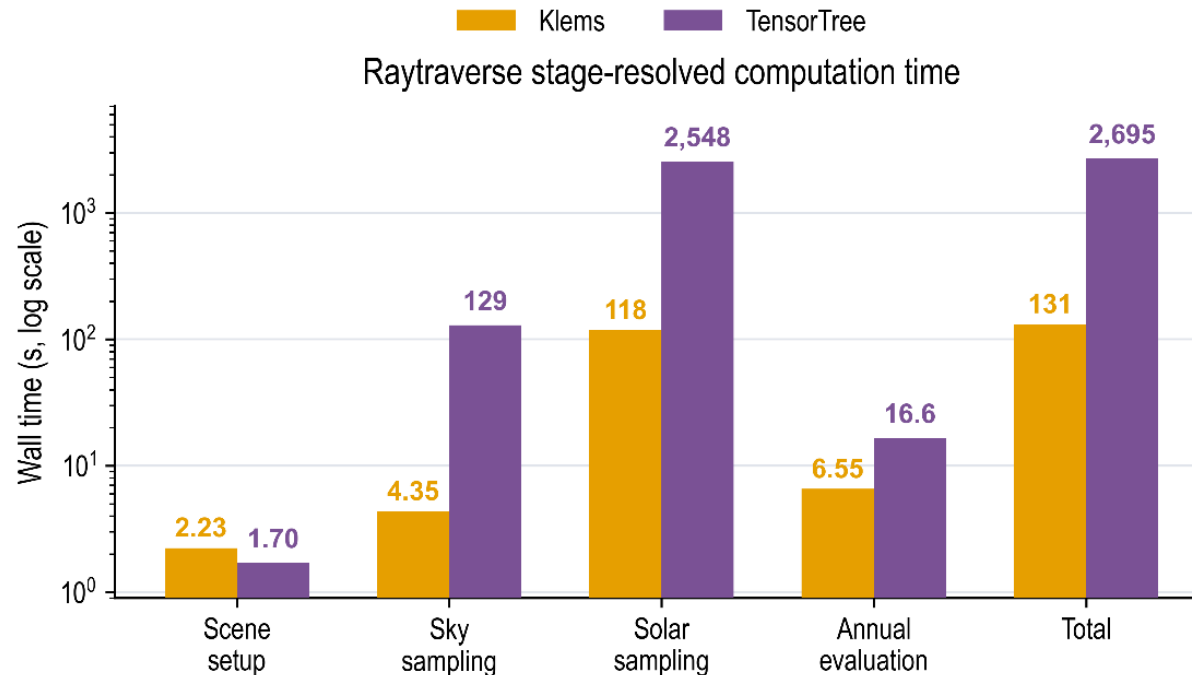
CURRENT BOUNDARIES

- Explicit mirror paths are limited to selected first- and second-order reflections.
- Diffuse effects and higher-order specular transport remain in the MF1 field.
- A small number of C1 multi-view glare events were still missed.
- The 520-view HDR reference covered three representative days, not a full year.

EIGCM efficiency comes from cached optics and targeted solar-peak evaluation, not from approximating every interaction.

Why TensorTree increased Raytraverse runtime

BACKUP



Total runtime: Klems = 131.1 s; TensorTree = 2695.4 s (20.6×)

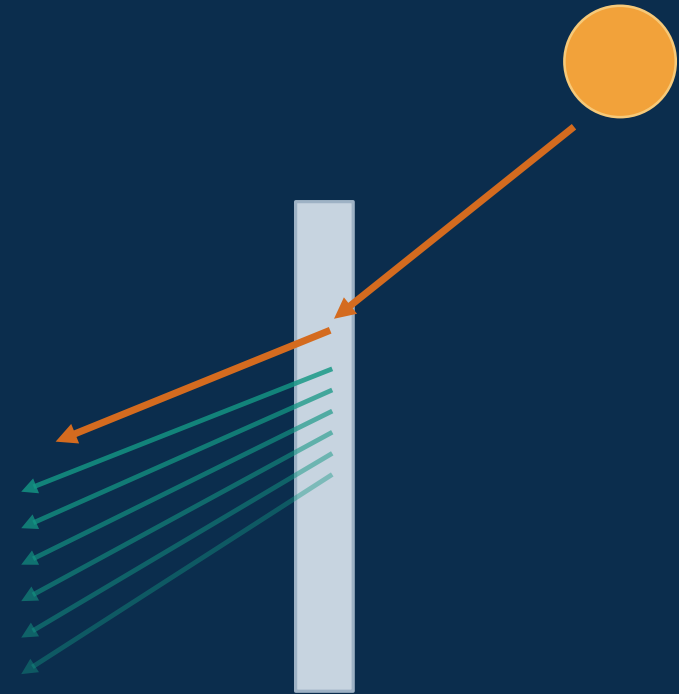
20.6× TOTAL RUNTIME

- Klems: fixed matrix-index lookup.
- TensorTree: hierarchical variable-resolution traversal.
- Adaptive sky and solar sampling repeat many BSDF queries and ray traces.
- ttsuncontrast caches the BSDF and samples only active non-diffuse solar peaks.

1. **EIGCM achieved the best balance of accuracy and efficiency.** It showed the closest agreement with the reference and reduced errors for compact glare sources. *dcglare* was faster but less reliable when contrast dominated DGP.
2. **Raytraverse was much slower for TensorTree BSDFs**, especially in multi-view analysis, due to repeated adaptive sampling and ray-tracing evaluations.
3. **The performance of *dcglare* depended on the dominant DGP component.** It performed well when vertical eye illuminance dominated, but was less reliable for compact, contrast-dominated glare sources.

Thank you

Questions & discussion



Yongqing Zhao

Radiance Workshop 2026

Backup slides follow