

DN DIMM introduction : Turbulence round the clock

C-DIMM : Final validation vs DIMM & SHIMM



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Whole-column site characterization stops at dawn. The r_0 [1], θ_0 and τ_0 that qualify a site — and set the budget of an adaptive-optics or free-space-optical link — are measured on a star through the whole air mass, and they exist for the night alone. Daytime monitors read the ground layer only. Yet the links work in daylight, through the whole column.

DNDIMM (Day/Night DIMM) measures the whole air mass by day as well as by night, on a star, unattended, from a light instrument that lives outdoors with no dome. Its one departure from a classical DIMM: two independent 80 mm telescopes 200 mm apart instead of two holes in a mask. We report 300+ h over 25 days, 38K simultaneous (r_0 , θ_0 , τ_0) triples, and the diurnal cycle they describe.

1 Two telescopes, like C-DIMM

The DNDIMM uses **two complete 80 mm telescopes 200 mm apart**, each with its own filter, focuser and camera, hardware-triggered together, on a mount with absolute encoders.

- **Photon budget.** A full apochromatic objective per channel, with minimal optical aberration to deliver good CoG even under degraded SNR.
- **Focus per channel.** Independent autofocus keeps both images the same size even with a large temperature spread.
- **Redundant measurements.** r_0 with T and L axis, θ_0 and τ_0 with two OTA. Their agreement is the instrument’s own referee. High speed sampling is 1 ms at 400 frames/s, 12 000 frames per 30 s point; with hardware sync’ing. A supervisor acquires, re-centres, re-focuses and recovers from faults with no operator.

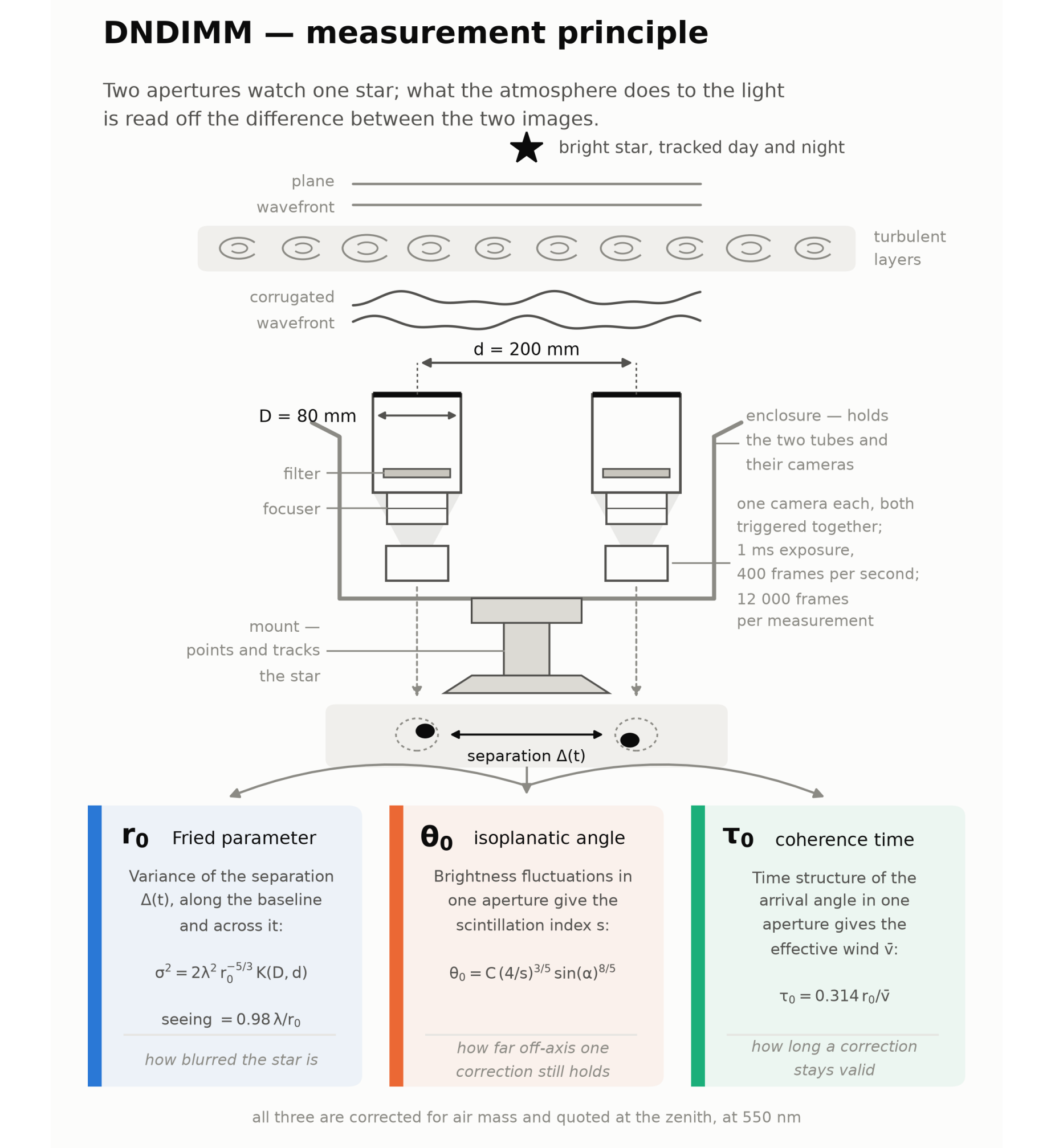


Fig. 1 — Measurement principle. Two apertures, one star, one mount: $\Delta(t)$ and the per-channel series yield r_0 , θ_0 and τ_0 .

2 Observables (airmass corrected 550nm)

r_0 — differential variances of $\Delta(t)$ along and across the baseline [3]:
$$\sigma^2 = 2\lambda^2 r_0^{-5/3} (0.179 D^{-1/3} - k d^{-1/3})$$

θ_0 — aperture-filtered scintillation index per channel, $s = 2s_T - s_{2T}$ [5]:
$$\theta_0 = C(D, \lambda, h_0) \cdot (4/s)^{3/5} \cdot \sin(\alpha)^{8/5}$$

C absorbs the aperture-filtered Fresnel integral; single layer at $h_0 = 10$ km, rescaled to 550 nm as $\lambda^{6/5}$.

τ_0 — temporal structure function of one channel's arrival angle, read at $1 - e^{-1}$; effective wind $\bar{v}$ through the von Kármán correction ($L_0 = 25$ m [7]), then
$$\tau_0 = 0.314 \cdot r_0 / \bar{v} \quad [2]$$

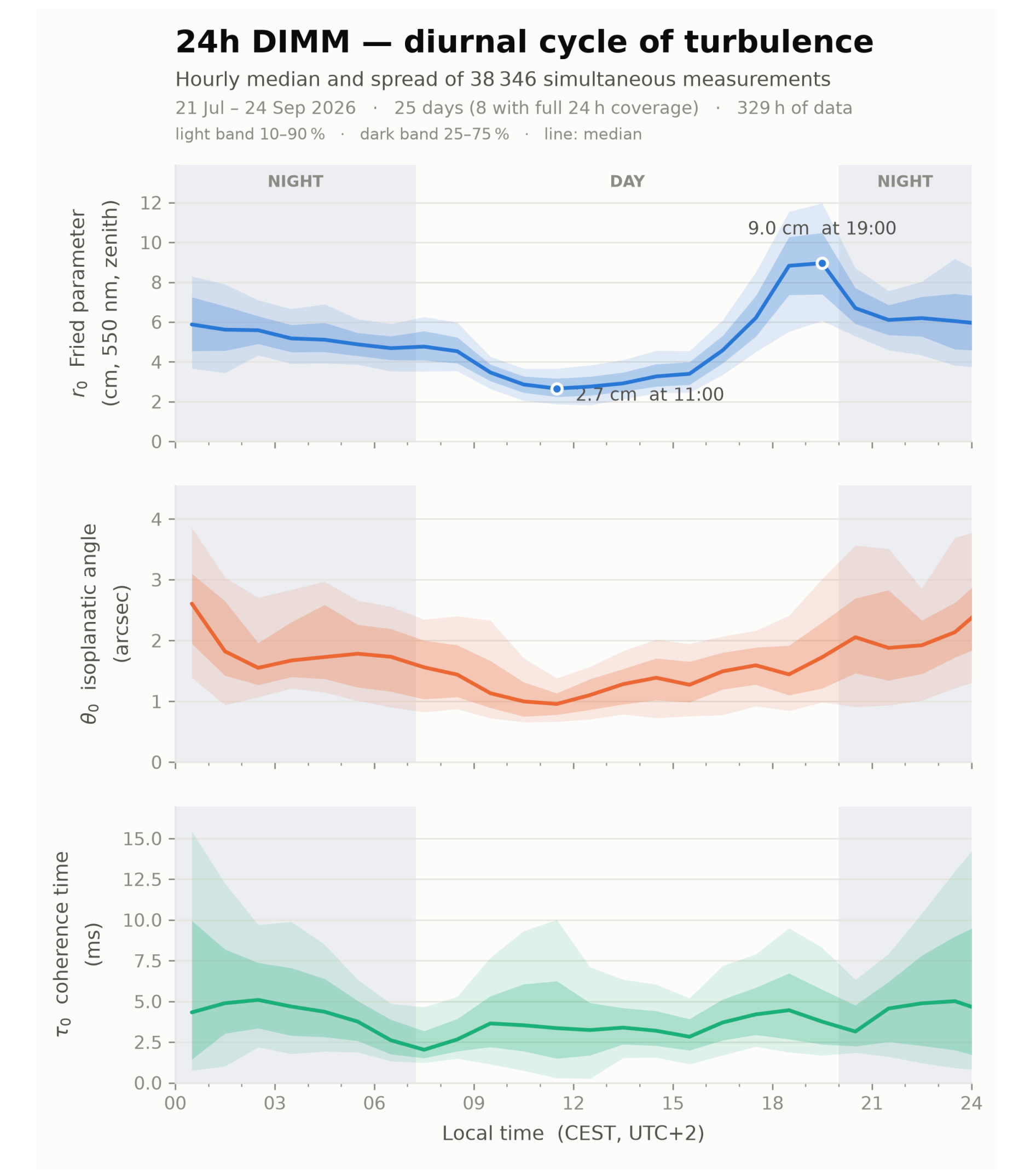


Fig. 2 — Diurnal cycle. Hourly median, interquartile (dark) and 10–90 % (light) bands over the campaign, against local time. Shaded columns are night, set by the measured sky background.

3 Campaign and results

17 days between 21 July and 23 September 2026, four covering a full 24 h; 200 h; >26 000 (r_0 , θ_0 , τ_0) triples. Day and night are separated by the measured sky background, not by an almanac.

Parameter	Median	25–75 %	Hourly
r_0 (cm)	4.92	3.65 – 6.53	2.7 – 9.5
seeing (")	2.31	1.74 – 3.14	1.19 – 4.39
θ_0 (")	1.01	0.67 – 1.49	0.58 – 1.75
τ_0 (ms)	1.48	0.89 – 2.29	0.82 – 1.97

r_0 collapses to 2.7 cm at local noon and peaks at 9.5 cm at 19:00, an hour before sunset; the nocturnal plateau sits at 5–6 cm. θ_0 follows r_0 . τ_0 stays between 1 and 2 ms with no day–night contrast: the wind aloft ignores the solar cycle.

4 Does the ground layer show?

What a direction prints on the seeing is the **local ground layer** — the first tens of metres the line of sight grazes. Here that is houses 15–40 m away, whose roofs, driveways and pool decks release the day’s heat into the beam; and the relief: 431 m on a valley side, horizon 0.1–1.4° to the east where the ground falls away, 18.6° at azimuth 280° where it rises. On this site the two are not separable: the built-up sectors are the rising ones.

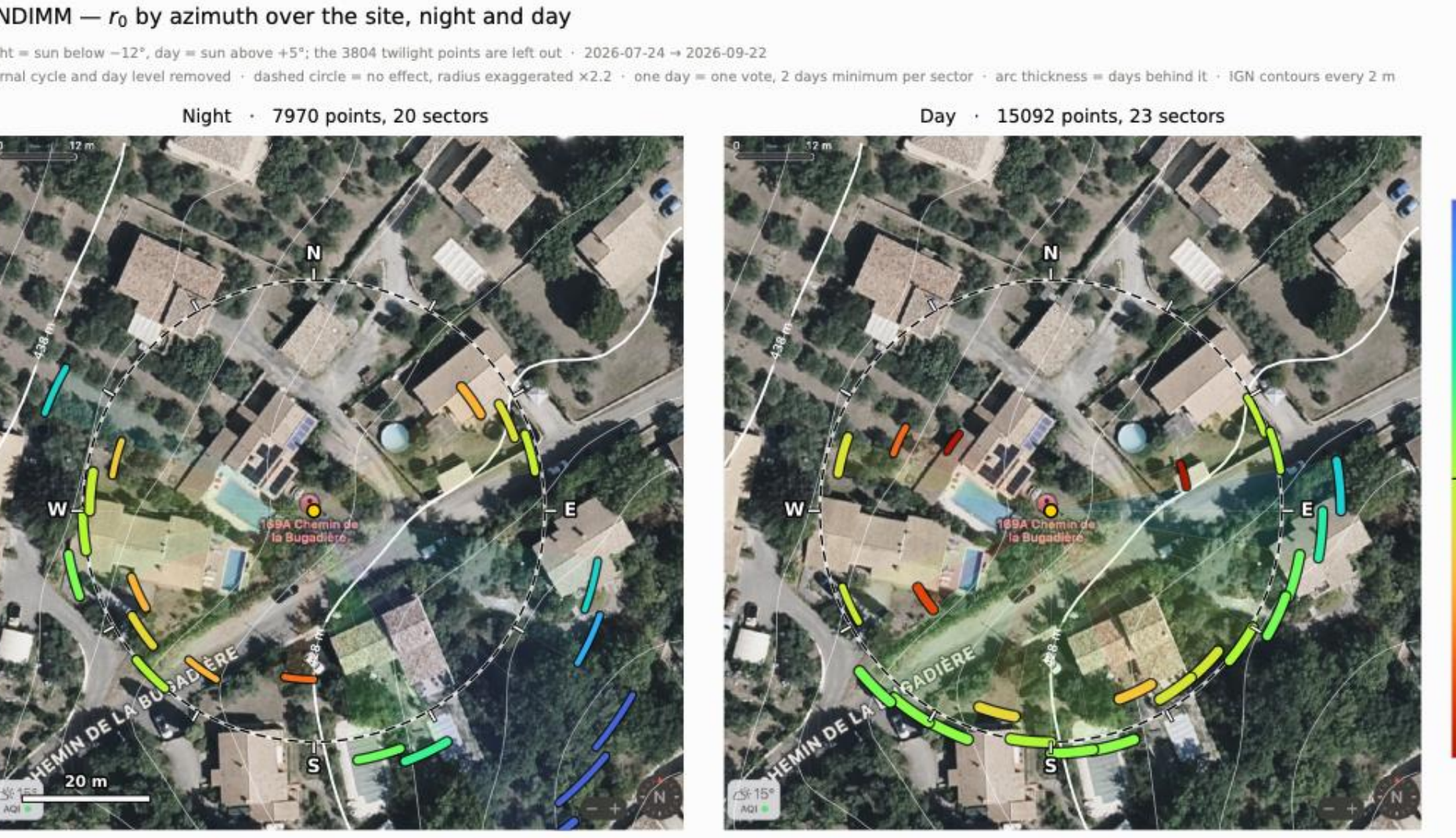


Fig. 3 — r_0 by azimuth in 10° sectors over the site, night (left) and day (right), relative to the median of the same half-hour of the same day; one day, one vote, arc thickness = days behind it. Red degraded → blue better, radius $\times 2.2$; contours every 2 m.

5 Miratlas C-DIMM scientific validation vs DIMM and SHIMM

DNDIMM’s two-tube head is inherited from the **C-DIMM** — two 50 mm tubes 200 mm apart, deployed on more than 60 sites — qualified before being pushed into daylight.

- **Against itself.** Two C-DIMM v3 side by side at OHP, Oct. 2025: r_0 and θ_0 agree to a few per cent.
- **Against a legacy DIMM.** Celestron C11, 79 mm / 200 mm mask, 0.4"/pixel against 3", three nights, Dec. 2025 (Fig. 5): slope 0.984, $r^2 = 0.935$, mean relative error 9.9 %, r_0 2–13 cm.
- **Against a different principle.** ESA’s Turbo 1 SHIMM [6], 3 m away on a rooftop in Barcelona, Jan. 2026: $r^2 = 0.865$, mean relative error 8.4 %, r_0 5–14 cm.

Two principles, one r_0 — within the ~10 % two seeing monitors can be expected to agree to [8].

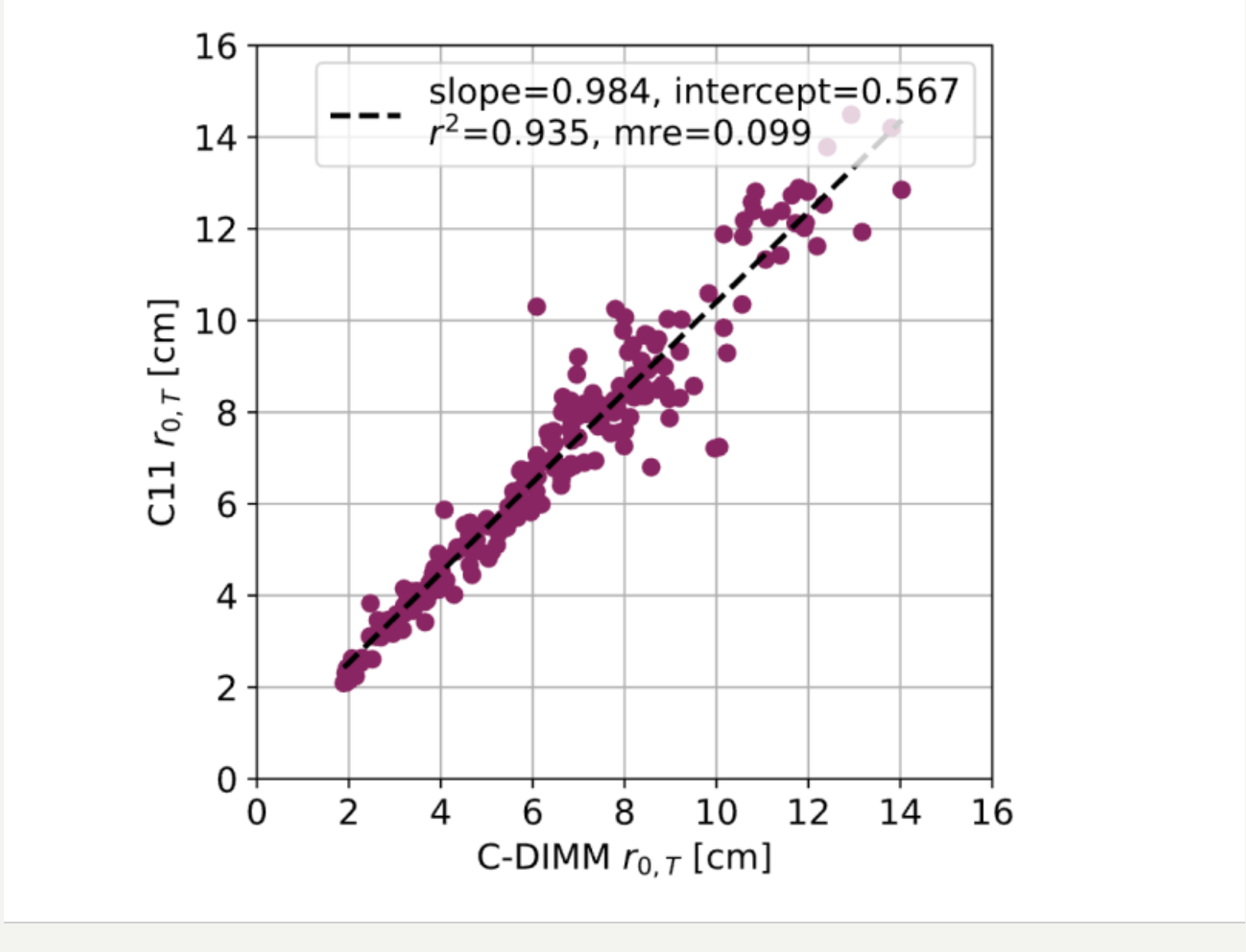


Fig. 5 — C-DIMM against a legacy DIMM (C11, 79 mm / 200 mm mask), transverse r_0 , three nights, Dec. 2025: slope 0.984, $r^2 = 0.935$, mre 9.9 %.

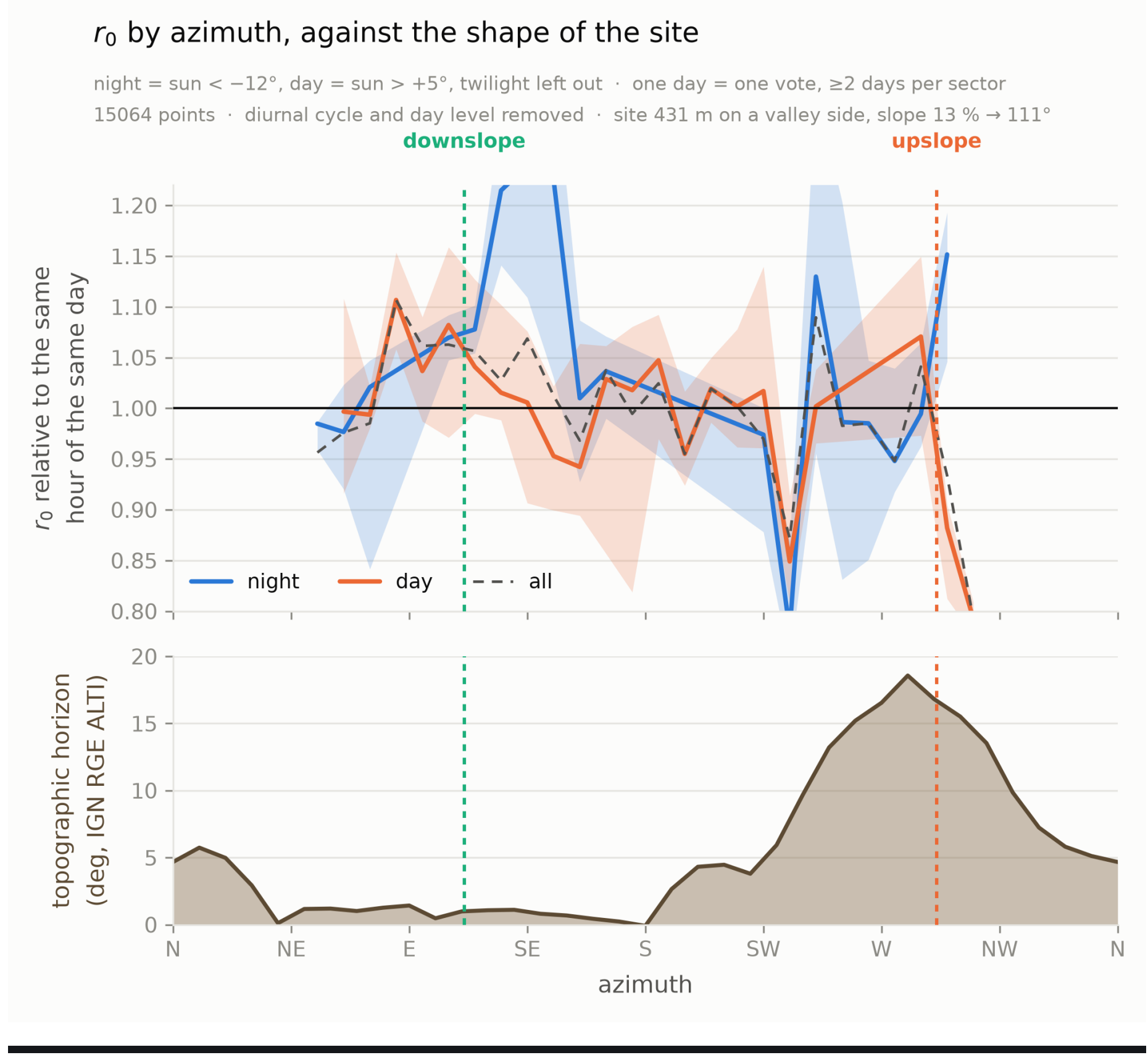


Fig. 4 — The same r_0 by azimuth, night and day, as curves; below, the topographic horizon seen from the instrument.

[1] Fried, D. L. 1966, J. Opt. Soc. Am. 56, 1372. [2] Roddier, F. 1981, Progress in Optics 19, 281. [3] Sarazin, M. & Roddier, F. 1990, A&A 227, 294. [4] Tokovinin, A. 2002, PASP 114, 1156. [5] Aristidi, E., Ziad, A., Chabé, J., et al. 2019, MNRAS 486, 915. [6] Perera, S., Wilson, R. W., Butterley, T., et al. 2021, MNRAS 501, 3042. [7] Ziad, A., Conan, R., Tokovinin, A., et al. 2000, Applied Optics 39, 5415. [8] Tokovinin, A. 2023, Atmosphere 14, 1694.

