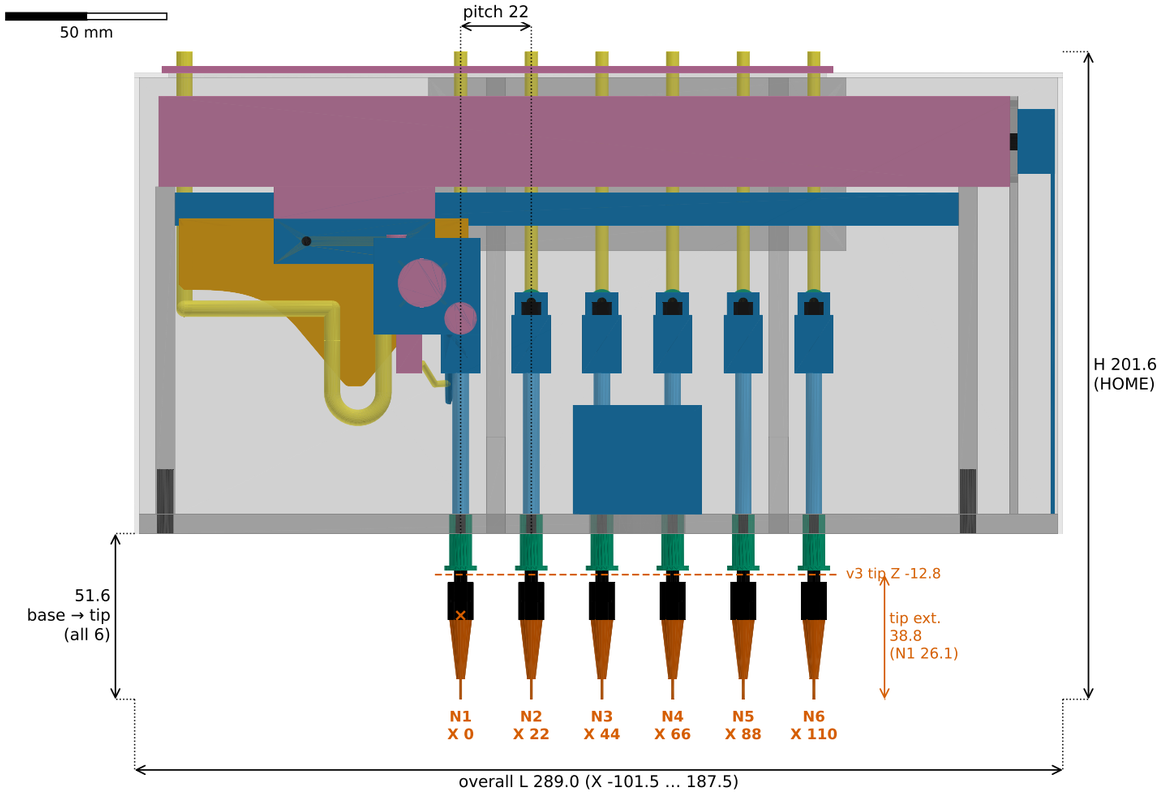
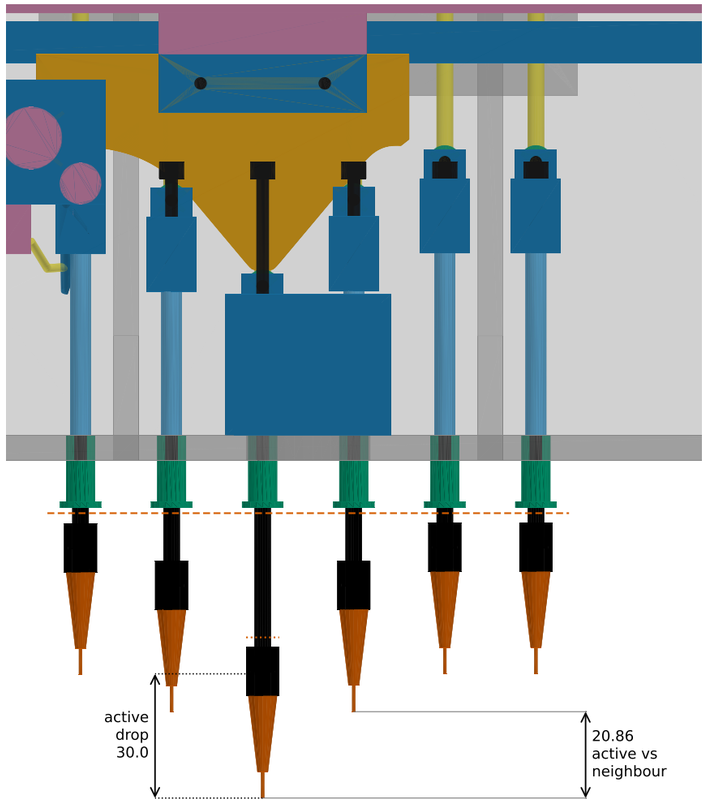
Head (linear cam) — General arrangement (HOME and N3 active)

FRONT (from −Y) — HOME (carriage c = −33), all needles up; panels translucent

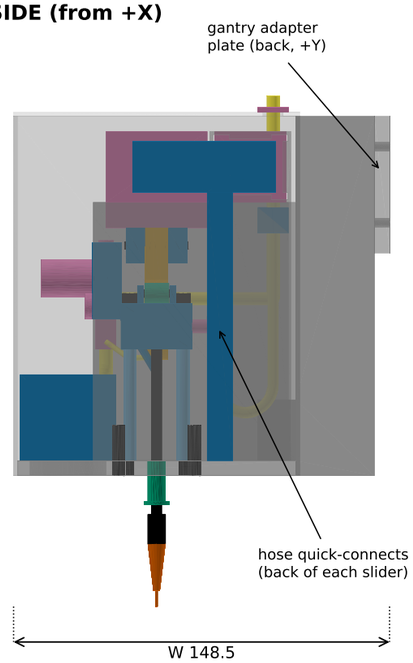


FRONT — N3 active (c = 44), X −15…125 close-up

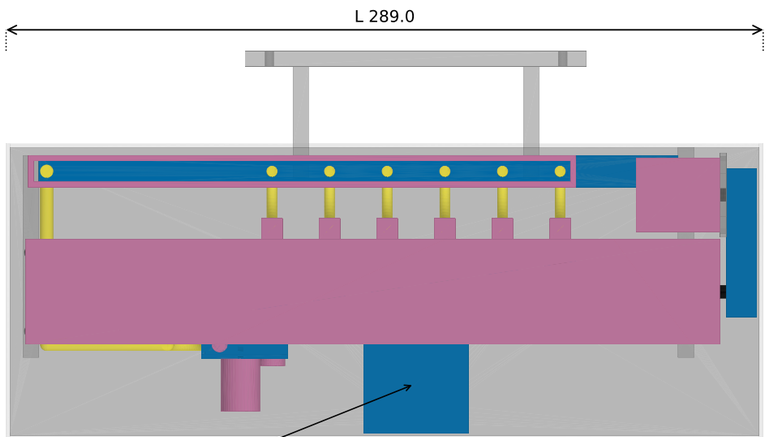


N2/N4 down 9.25 / 9.14; dashed = v3 tip Z -12.8

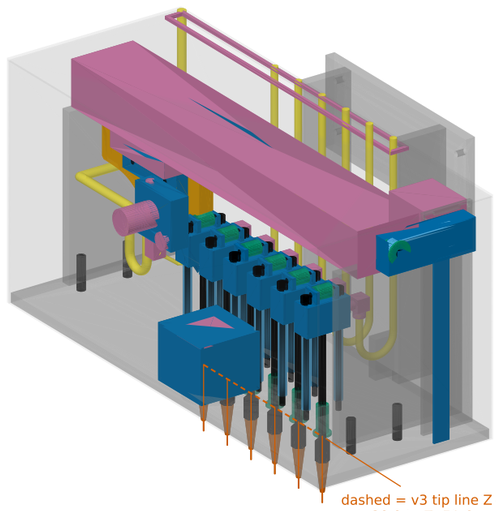
SIDE (from +X)



TOP (from +Z), top panel translucent



ISO (HOME) — tube extension on all 6



- alu sheet: base, panels, ribs (translucent)
- Delrin cam plates; FR4 feed wheel
- printed: sliders, hanger, comb, feeder
- rollers, pulleys; custom guide bushings
- steel: rods, axles, 304 tube, Luer adapter
- std 0.25 in Luer tip (all 6)
- springs, belt
- REF: slide, NEMA 11, fittings, camera
- PU hoses, feeder bundle

KEY DATA (linear_cam_short_v3 model)

- Envelope HOME 289.0 L × 148.5 W × 201.6 H (incl. enclosure, ribs, adapter plate)
- Nozzle (all 6): 304 tube + custom bushing + Luer adapter + std 0.25 in tip. Tips -51.6 up / -81.6 active (v3: -12.8 / -42.8; N1 2.5 in -25.5) → ext. 38.8
- 1×6 single lane, pitch 22, X 0 … 110
- Slide stroke 150, carriage travel 143 (HOME c = -33, BEFORE N1 — not past N6)
- Drive: NEMA 11 → GT2 16T 1:1 (folded) → T6×6 screw; not self-locking: hold powered
- Mass 2.20 kg (v3 model, 2 in needles); nozzle-stack delta TBD
- Gantry: needle row centre X 55 = carriage centre line; mount Y = 420 + local y

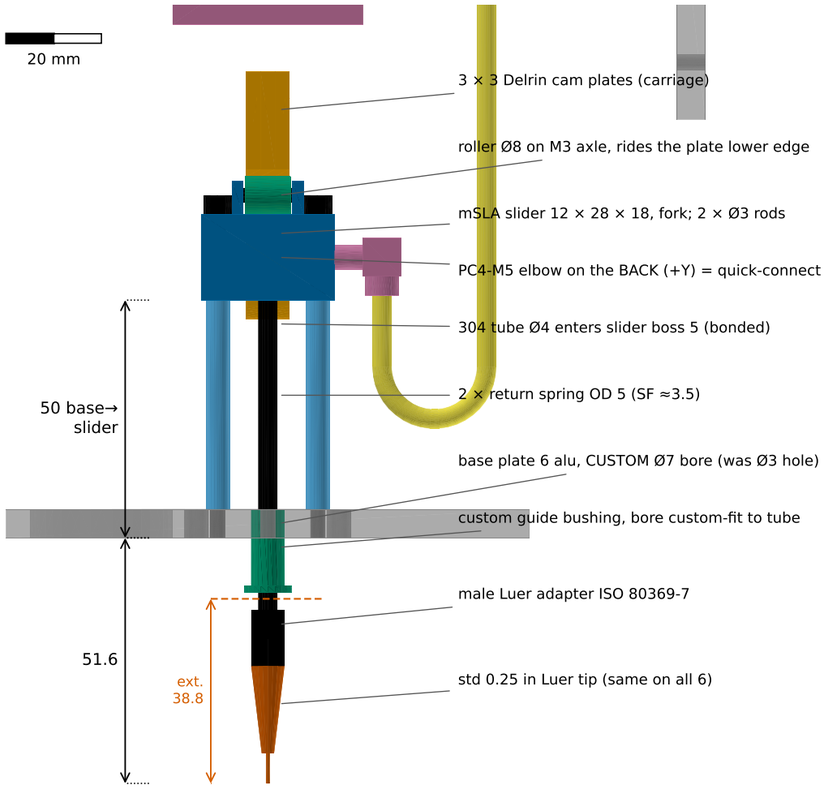
OSSO head linear_cam_short_v3 engineering review drawing r2	**REV B DATE 2026-10-29**	**REVIEW — not for fab**
Sheet 1/5 General arrangement (HOME and N3 active)	Units mm · metric (M3/M5) views to scale bar · 3rd-angle	Source: linear_cam_short_v3 model.py TBD = not in model / calc data

Head (linear cam) — Station section N3 and the tube + bushing nozzle stack (all 6 stations)

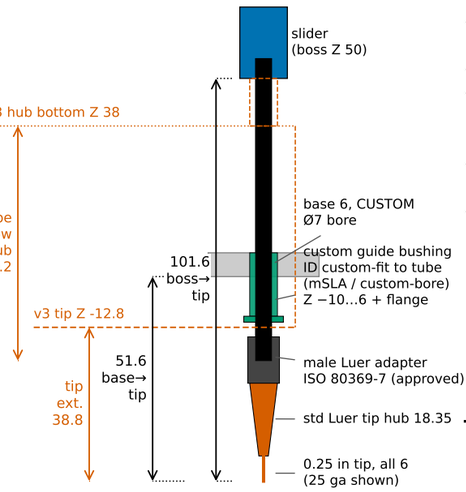
DESIGN NOTE — removable Luer tip (verbatim)
The nozzle tip is a removable standard Luer-lock tip so the gauge can be fine-tuned per need. The supply tube can have a larger ID than the needle. Tip shapes may evolve with testing, and Luer allows quick swaps to other tools, for example an air dispersion head.

NOZZLE STACK ON THE LINEAR HEAD (decision r2; drawn, not yet in model.py)
- Every station: standard-stock 304 tube → custom guide bushing → approved Luer adapter → std 0.25 in tip. Same length on all 6; no 0.5 in variant.
- Boss face = slider bottom, Z 50. Stack below boss 101.6 vs 62.8 in v3 (hub 12 + 2 in needle). Tips: v3 -12.8 → -51.6 up, -42.8 → -81.6 active. Extension 38.8 (N1 26.1, was 2.5 in); tube runs 59.2 below the v3 hub.
- Active drop stays 30 (cam). Run-14 used 45 on cam_head_v3: does not carry over.
- Bushing: custom part (mSLA or custom-bore), ID custom-fit to the tube stock as-measured, so the tube can stay standard stock. Sits in a CUSTOM Ø7 base bore, Z -10…6 + flange: gaps +3.7 (HOME, adapter) / +14.0 (active, slider). Bushing ID/OD fit: TBD (custom-fit).
- Rods Ø3 at Y ±10.5: tube-to-rod gap 7.0, bushing-to-rod 5.5; adapter Ø10 collar at 22 pitch leaves 12 between stations.
- Runout: plan up-camera nozzle-offset calibration after every tip swap (run 14: ≈0.1–0.2 mm mechanical; ≤0.05 needs calibration).
- No theta: rotation only on the rotation plate (tray carrier, X 420).
- N1 (ball feeder): chute exits into the Luer HUB side port (Z 41). The tube + adapter has no side port, and a 25 ga tip ID 0.25 = ball Ø0.25 → N1 ball path with this stack is TBD (conflict).
- Tip deflections below were computed at the cam_head_v3 free length 84.6; here the active tip is ≈ 81.6 below the base: TBD.
- Board Z, soft limits, interlock, T ≥ 462 (run 14): TBD — re-sweep.

STATION N3 (HOME) — side view of the X 44 ± 11 slice, nozzle stack drawn



NOZZLE STACK detail (all 6, to scale)
v3 hub + needle dashed



Tip gauge table, 0.25 in tips (run-14 nozzle_calc.json)

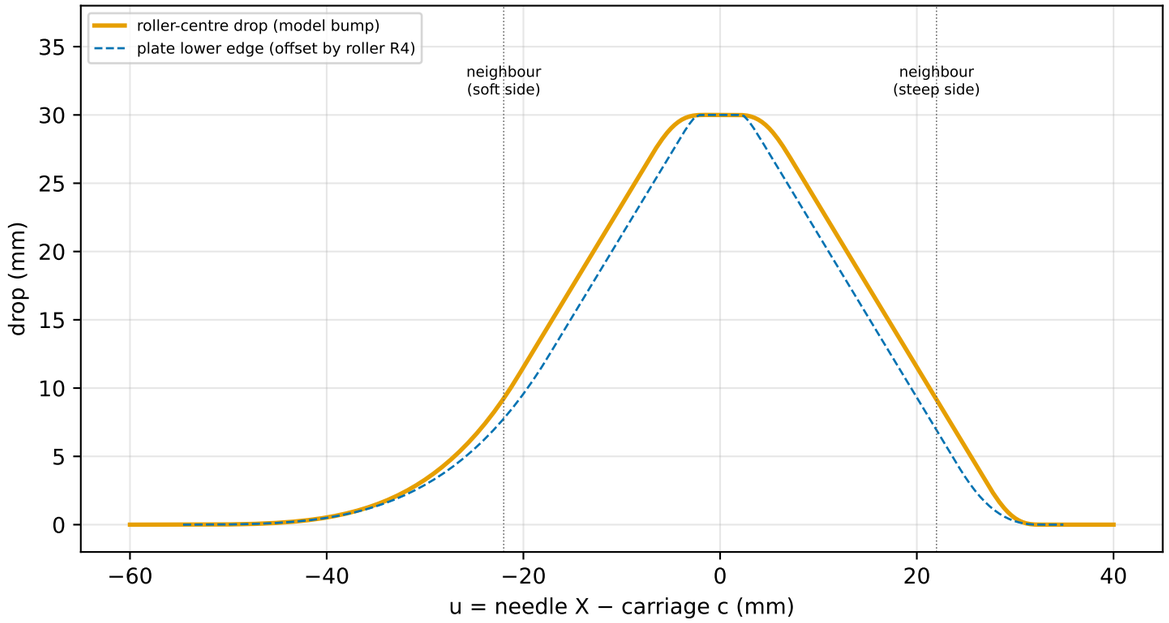
Gauge	Use	OD/ID	defl µm cant/guided
27	0402 (fine)	0.42/0.2	54 / 45
25	0402	0.52/0.25	37 / 27
23	0603/0805	0.65/0.33	29 / 20
22	0603/0805	0.72/0.41	27 / 18
21	1206/SOT/SOIC	0.82/0.51	26 / 16
20	1206/SOT/SOIC	0.91/0.61	25 / 16
18	QFN/SOIC large	1.27/0.84	23 / 14
15	QFN large	1.65/1.36	22 / 13
14	QFN large	1.83/1.54	22 / 12

- alu sheet: base, panels, ribs (translucent)
- Delrin cam plates; FR4 feed wheel
- printed: sliders, hanger, comb, feeder
- rollers, pulleys; custom guide bushings
- steel: rods, axles, 304 tube, Luer adapter
- std 0.25 in Luer tip (all 6)
- springs, belt
- REF: slide, NEMA 11, fittings, camera

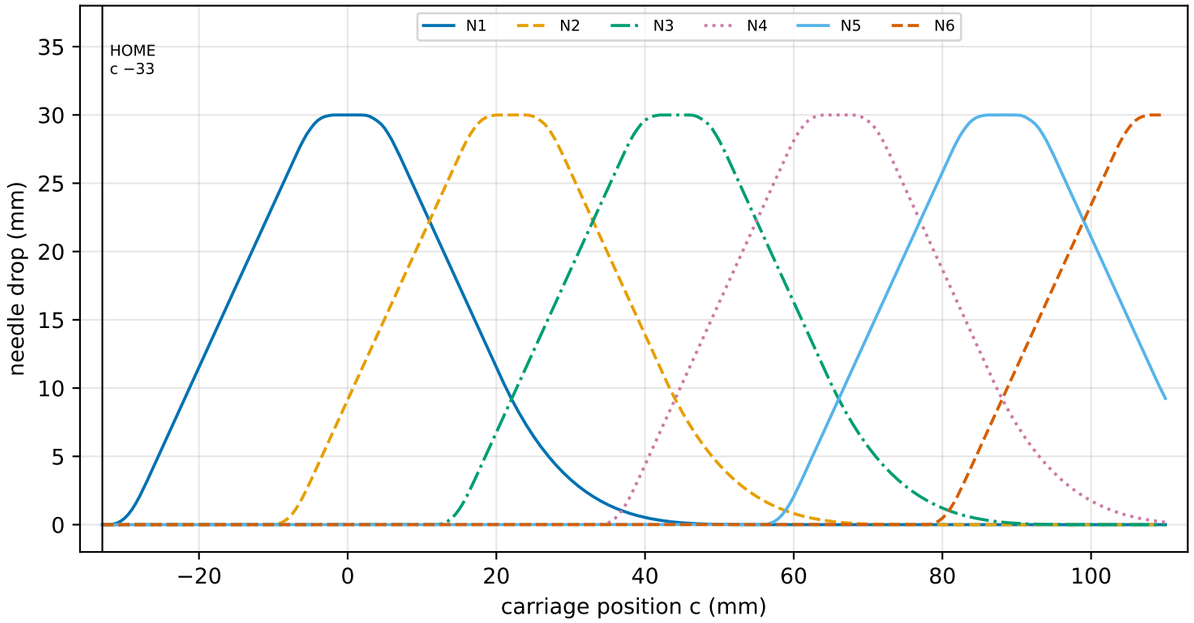
OSSO head linear_cam_short_v3 engineering review drawing r2	**REV B DATE 2026-10-29**	**REVIEW — not for fab**
Sheet 2/5 Station section N3 and the tube + bushing nozzle stack (all 6 stations)	Units mm · metric (M3/M5) views to scale bar · 3rd-angle	Source: linear_cam_short_v3 model.py TBD = not in model / calc data

Head (linear cam) — Cam profile, needle selection and kinematics

Cam bump (model): peak 30, dwell ±1.5, max flank 50°, steep run 32.3 / soft run 53.6



Needle drop vs carriage (model drop(), real plate edge); travel 143 of 150 stroke



Selection at each station (_sweep.json, 84 poses, 0 clashes, 0 floating)

Station	c	active	max other	gap	decision ≤17 / ≥23	concept ≥20
N1	0	30.0	9.14	20.86	≤17 ✓ / ≥23 ✗	✓
N2	22	30.0	9.25	20.75	≤17 ✓ / ≥23 ✗	✓
N3	44	30.0	9.25	20.75	≤17 ✓ / ≥23 ✗	✓
N4	66	30.0	9.25	20.75	≤17 ✓ / ≥23 ✗	✓
N5	88	30.0	9.25	20.75	≤17 ✓ / ≥23 ✗	✓
N6	110	30.0	9.25	20.75	≤17 ✓ / ≥23 ✗	✓
HOME	-33	—	0.00	—	all up ✓	✓

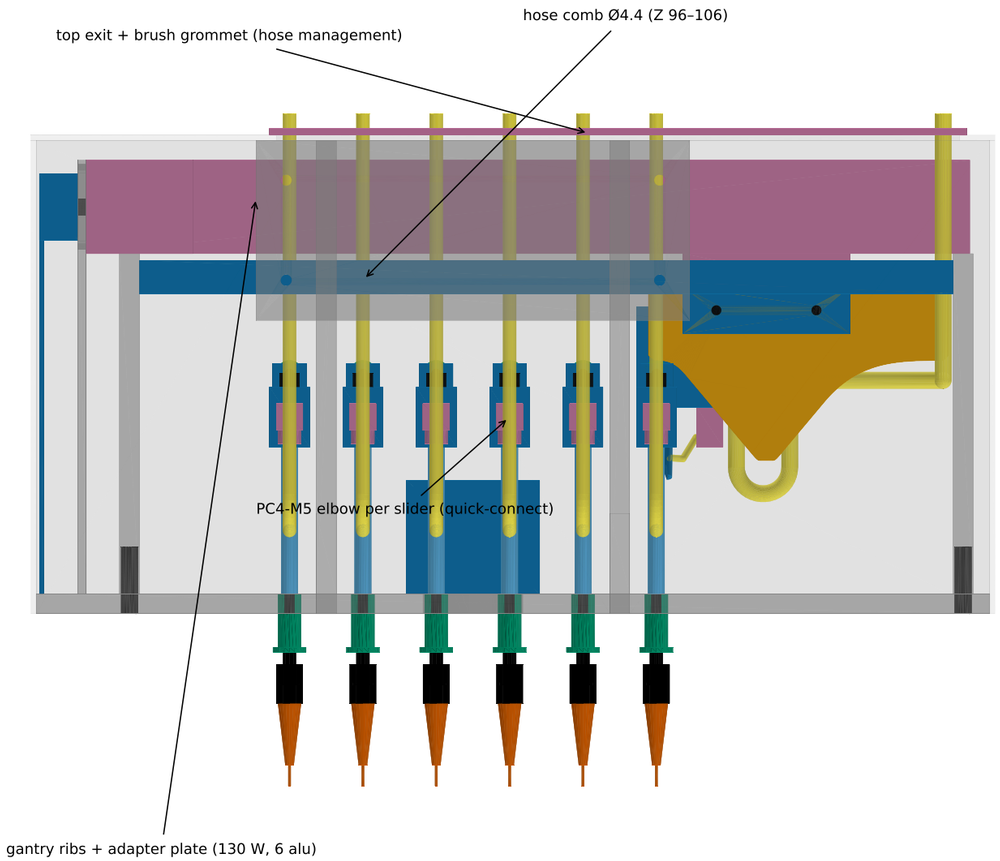
KINEMATICS AND DRIVE
- Pitch 22 (decision said 25 'or whatever v3 uses'): v3 = 22.
- Bump: v3 = 30 peak, 50° asymmetric, ≈86 long. The 84 / 40 / 45° bump is the 250-stroke BASELINE concept (LINEAR_CAM_CONCEPT.md), not v3.
- Neighbour 9.25 ≤ 17 ✓, but active-vs-other gap 20.75 < 23 decision (≥ 20 concept requirement met; ≥ 20.2 with ±0.5 error).
- N±2 needles move 0.18 (concept said ≤ 0.1).
- Stroke: standard 150 slide, travel 143 (spare 7). '≈250 stroke / 220 compressed / 300 total' = baseline; v3 body L 289 incl. belt cover.
- HOME c = −33 BEFORE N1 (steep flank faces the row). Decision says HOME past N6: concept → ≈ +21 travel (soft tail longer) - conflict.
- Tap: none on the plate; dither ±1 at c ≈ N6 + 2.5 (concept).
- Drive (concept calc): axial ≈ 9.5 N; T6×6 η 0.5 ≈ 18 mN·m; NEMA 11 ≈ 60 mN·m @ 900 rpm → margin ≈ 3.1×. Back-drive ≈ 2.3 mN·m → hold powered (reduced current).
- Speed (concept): 90 mm/s, 1 m/s²: one station ≈ 0.33 s, full ≈ 1.7 s.
- Hoses: length constant 163.6, min bend R 11 (PU 4×2.5 ≥ 10 ✓).
- Feeder bundle: const 60.6, R 8, R/D 1.6 (< 5 → flag).
- Springs 44 long at rest / 14 active: ≈0.05 N/mm, free ≈74 (v1 note); rate, solid height and part number TBD.

CARRY-OVER OF RUN-14 MACHINE NUMBERS (computed on cam_head_v3 — NOT valid here)
- +88.9 body raise: TBD. Here the stack would lower tips by 38.8; board-touch Z (run 10: 316.4 with 2 in needles) becomes ≈ 355.2 by arithmetic only; the soft limit, tray interlock (335) and keep-outs need a new sweep (TBD).
- 'N4 down only at T ≥ 462' tray rule: TBD for this head (no run-14 sweep with the linear head).
- Run-14 HOME 0-hit sweep and min gaps: TBD (re-run with linear head + stack).

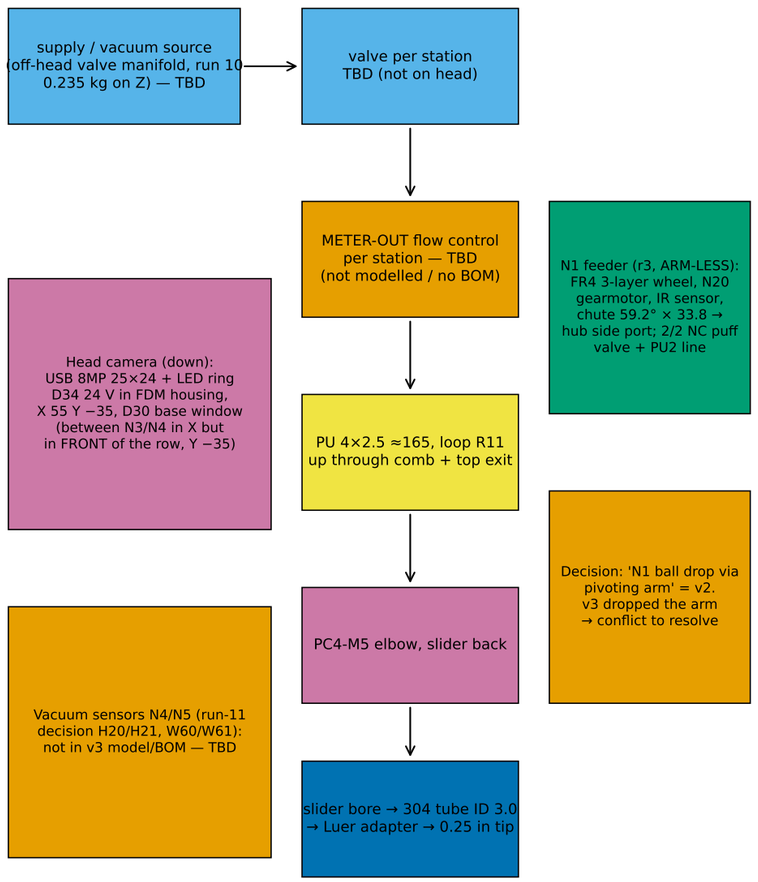
OSSO head linear_cam_short_v3 engineering review drawing r2	**REV B DATE 2026-10-29**	**REVIEW — not for fab**
Sheet 3/5 Cam profile, needle selection and kinematics	Units mm · metric (M3/M5) views to scale bar · 3rd-angle	Source: linear_cam_short_v3 model.py TBD = not in model / calc data

Head (linear cam) — Interfaces: pneumatics, hoses, N1 feeder, camera, gantry, machine reach

BACK (from +Y): quick-connects, hose loops, comb, top exit; panels translucent



Pneumatics per station (schematic)



Machine reach (X travel 160–425, row centre = carriage)

Needle	offset	X range	board 200	plate X 420
N1	-55	105–370	✓	✗
N2	-33	127–392	✓	✗
N3	-11	149–414	✓	✗
N4	+11	171–436	✓	✓
N5	+33	193–458	✓	✓
N6	+55	215–480	✗	✓

- N6 can't reach board X 200 (run 10: left wall hits).
- Only N4/N5/N6 reach the rotation plate + up camera at X 420 (tray carrier, Y T+14 / T−16).
- Board-touch Z with run-14 stack: TBD (sheet 3).

alu sheet: base, panels, ribs (translucent)

printed: sliders, hanger, comb, feeder

steel: rods, axles, 304 tube, Luer adapter

springs, belt

REF: slide, NEMA 11, fittings, camera

PU hoses, feeder bundle

INTERFACE NOTES / TBD

- Gantry: 2 ribs + 6 alu adapter plate (X 55 ± 65, Y 86–92) bolt to the existing Z slide plate; 4 × Ø3.4 holes at X 55 ± 56, Z 100/130 (model). Fastener spec and stiffness TBD.
- Hoses: one PU 4×2.5 per station from a back elbow; constant-length rolling loop; comb + brush-grommet top exit is the hose-management feature (✓ decision).
- Meter-out flow control on every station (decision): not in the model or the v3 BOM — location (manifold vs head top) and part TBD.
- Harness: NEMA 11, N20 feeder motor, IR sensor, puff valve, camera USB, LED 24 V, optional vibe motor → feeder flex bundle + top exit. Head HOME/limit switch: none modelled (v1 issue 7) — TBD.
- Rotation plate + up camera are on the tray carrier at X 420 (run 11/12) — no head hardware; no theta on the head (decision).
- Mass on the X carriage (run 10): head 2.197 kg, Z-moving 3.01 kg; run-14 stack delta TBD.

OSSO head linear_cam_short_v3 engineering review drawing r2	**REV B DATE 2026-10-29**	**REVIEW — not for fab**
Sheet 4/5 Interfaces: pneumatics, hoses, N1 feeder, camera, gantry, machine reach	Units mm · metric (M3/M5) views to scale bar · 3rd-angle	Source: linear_cam_short_v3 model.py TBD = not in model / calc data

Head (linear cam) — BOM (quantities only) and open items

BOM — BOM_linear_cam_short_v3.csv (no prices) + nozzle / decision additions (orange)

Item	Qty	Process / source
base_plate	1	laser-cut 6 alu
upright_A / upright_B_motor_saddle	2	laser-cut 6 alu
gantry_rib_LASERCUT_6alu L/R	2	laser-cut 6 alu
gantry_adapter_plate_LASERCUT_6alu	1	laser-cut 6 alu
motor_face_plate_slotted_LASERCUT_3alu	1	laser-cut 3 alu
belt_cover_FDM	1	FDM PETG
hose_comb	1	FDM PETG
cam_hanger	1	FDM PETG-CF
cam_plate_L1..L3	3	laser-cut 3 alu, ramp edges [...]
slider N1..N6	6	mSLA tough resin (forks)
feeder_housing / lid / chute / guide_ring	4	mSLA tough resin
feeder_wheel_FR4 L1..L3	3	FR4 1.0, laser-cut (fibre/UV) or [...]
vision_head_cam_housing_FDM	1	FDM PETG black
head panel front/back/left/right/top	5	laser-cut 1.5 alu
linear slide 150 stroke, T6x6 screw, NEMA11	1	purchased
GT2 16T pulley	2	purchased
GT2 6 mm closed belt	1	purchased
guide rod D3 steel	12	purchased
stop collar D3	12	purchased
roller bearing + M3 axle	6	purchased
compression spring (2 per station, SF ~3.5 on return [...]	12	purchased
PC4-M5 elbow + PU 4x2.5 hose ~165	6	purchased
N20 gearmotor 15 mm	1	purchased
IR reflective sensor	1	purchased
2/2 NC micro puff valve + PU2 air line	1	purchased
feeder fill plug	1	purchased
OPTIONAL coin vibration motor D10x2.7	1	purchased
feeder flex bundle (loop + fixed leg)	1	purchased
top-exit brush grommet	1	purchased
M5x20 flat head, M3x25	4+2	purchased
USB 8MP camera board 25x24	1	purchased
LED ring D34 24V	1	purchased
304 SS tube 4.0 × 0.5 × 76.2, standard stock	6	ADD — proposal / TBD
Male Luer-lock adapter ISO 80369-7 (approved)	6	ADD — proposal / TBD
Luer-lock tip 0.25 in, std (all 6 stations)	6	ADD — proposal / TBD
Custom guide bushing, ID custom-fit to tube stock (mSLA / custom-bore)	6	ADD — proposal / TBD
Base plate: custom Ø7 bore ×6 (was Ø3)	mod	ADD — proposal / TBD
Meter-out flow control (per station)	6	ADD — proposal / TBD
Vacuum sensor N4/N5 (XGZP6847A class)	2	ADD — proposal / TBD
Head HOME switch / flag	TBD	ADD — proposal / TBD

OPEN ITEMS / CONFLICTS (model v3 vs decisions)

1 **Nozzle stack lowers tips 38.8**

Tips -51.6 up / -81.6 active (all 6); board-touch Z, soft limits, tray interlock and the T ≥ 462 rule: TBD - re-sweep. Stack not yet in model.py.

2 **N1 ball path vs Luer stack**

Feeder chute targets the Luer HUB side port; tube/adapter has no port; 25 ga ID 0.25 = ball Ø0.25.

3 **N1 ball drop: arm vs arm-less**

Decision = pivoting arm (v2). v3 uses the r3 arm-less wheel + chute + puff.

4 **HOME side**

v3 HOME before N1 (c −33); decision HOME past N6 costs ≈ +21 travel (concept).

5 **Selection margin**

Active vs other 20.75 < 23 decision (≥20 met). Pitch 22, peak 30, 50° (not 25 / 40 / 45°).

6 **Stroke / length**

v3: 150 slide, travel 143, L 289. '≈250 / 220 / 300' figures are the baseline concept.

7 **Meter-out flow control**

Required per station; not in model or BOM. Also valves / vacuum source TBD.

8 **No head HOME switch**

No switch / flag modelled for the carriage (v1 issue 7).

9 **Feeder bundle R/D 1.6**

Below 5–10× for continuous flex: high-flex silicone or longer loop.

10 **N6 / X 420 reach**

N6 can't reach board X 200; only N4–N6 reach the plate at X 420.

11 **Camera 'centre gap'**

No gap in a uniform 22 pitch; camera sits at X 55 in front of the row (Y −35). FoV / focus with tips at -51.6: TBD.

12 **No hot-air station**

v2 station E not in v3 (v3 doc).

13 **Mass**

2.197 kg with 2 in needles; nozzle-stack delta TBD.

OSSO head linear_cam_short_v3 engineering review drawing r2	**REV B DATE 2026-10-29**	**REVIEW — not for fab**
Sheet 5/5 BOM (quantities only) and open items	Units mm · metric (M3/M5) views to scale bar · 3rd-angle	Source: linear_cam_short_v3 model.py TBD = not in model / calc data