



Big Space-Time Antenna

Supports, joints and parts — insulation between the copper spheres, the rods and the Merkaba



DESIGN
v13 (checked)

SPHERES
ID 500 / 800 / 1300, 1.5 mm
Cu

DRIVE
 ≤ 5 kV, ~ 1.4 MHz

PARTS
21 plastic + copper

Double-check and changes

Design v14 (file STA_Assembly_v14.blend, checked) · Joints_explained_v6 · previous: v5 (design v13)

New in v6 (design v14): stronger clamping, as requested

#	CHANGE	WHY
A	New P21 counter-ring Ø180 × 10 mm (PP) between the 1300 sphere and the flanged nut. Tower A's spigot is 10 mm longer; nut + jack sit 10 mm lower.	The copper wall is now clamped between two equal Ø180 rings (base ring inside, counter-ring outside). Tilting forces pass straight through instead of bending the thin copper around a small Ø48 nut.
B	Bottom T-cup disc Ø80 instead of Ø60.	The 500 wall is gripped from both sides out to Ø80 (cradle Ø108 outside) - more margin against tilting. Still far from the Merkaba.

Re-checked after the change: 120 solid parts, **0 overlaps**, nothing inside the copper, no edge through a wall, nothing touching the Merkaba.

Double-check results (v4, design v13) - kept

#	PROBLEM FOUND	CORRECTION
1	P11 collet cap had no internal thread - it collided with the slider's M14 stem (527 mm ³ overlap)	Internal M14 × 1 thread (7.5 mm) + closing cone that squeezes the 4 slotted fingers of the stem onto the rod
2	P14, P8, P10, P11 : inside threads / bores were hexagonal (found by you)	Only the outside is hexagonal; all bores and threads are round (already fixed in v3, kept)
3	P14 top nut : hex corners of its spherical seat sank 0.16 mm into the 500 copper	Seat face kept exactly on the sphere R251.5
4	P1 / P4 spigots : the plain Ø19.8 section reached 1 mm past the copper and collided with the nut P7 and with P2's socket	Plain section ends inside the copper wall; the M18 thread starts right at the outer surface
5	P1 / P4 spokes : their outer ends passed THROUGH the copper bowl (the bowl rises towards the base ring)	Spoke underside now 0.5 mm above the bowl at its highest point
6	Instructions : the "multimeter method" for the 3 mm gap cannot work any more (with the T-cups the Merkaba cannot reach the copper within the jack travel)	New method: 3 mm gauges during assembly + reference mark on the rod (see the jack page)

How it was checked: (a) every pair of the 119 solid parts tested for overlapping material: **0 overlaps**; (b) every point of every part tested against the copper walls: **nothing inside the copper** except through the 20 mm holes; (c) every edge sampled for passing through a wall: **0**; (d) no support touches the Merkaba sheets: **0**; (e) all numbers in this PDF compared with the model.

What was new in v3 (design v12) - unchanged

- T-cups** in the 500 sphere instead of the triangular socket cups: a flat 5 mm PTFE disc, no socket at all. The 10 mm tip tube slides in a 10.3 mm bore: centres the Merkaba, free to move up/down, free to rotate.
- Non-rotating height jack**: a HEX slider that cannot turn + an adjusting wheel (1 turn = 1 mm) + lock ring + collet. The rod and Merkaba move straight up/down, they never rotate.
- Top lead-in fittings** (14 mm hole + funnel) pre-mounted on every upper hemisphere, and **screw-in centring inserts** (8.3 / 10.3 mm) added after the hemisphere is down. Easy assembly, no levering of the rods.
- Lead-in chamfers** on top of every bore along the bottom rod path.

Materials and how to make each part

Can it be 3D printed? Which material / process for each part

MATERIAL	PARTS	HOW TO MAKE IT	WHY
PTFE (Teflon), virgin	P3, P6, P12-P20 (liners, T-cups, nut 500, lead-in fittings, funnel rings, centring inserts)	CNC lathe from PTFE rod. PTFE CANNOT be 3D printed (it does not melt and flow). All these parts are round and simple to turn.	Lowest loss at 1.4 MHz, best insulator, slides well on copper. Used everywhere near the rod and the Merkaba tips.
Polypropylene (PP)	P1, P4 (tower bodies), P2, P5 (cradles)	Towers: 3D print in ONE piece - best: HP Multi Jet Fusion PP (any online print service). Also FDM PP or ASA. Cradles: CNC lathe from PP rod, or print.	Very low loss at RF, strong, does not absorb water. Avoid PLA (creeps under 40 kg) and nylon (absorbs water).
POM-C (acetal, Delrin)	P7-P11 (jack)	CNC lathe; hex parts from hex bar or milled	Precise threads, slides smoothly, strong. Outside all spheres, so its slightly higher loss does not matter.
Copper	C1-C3	8 mm Cu-ETP rod, 10 × 1 mm EN 1057 tube	see parts list at the end



Overview



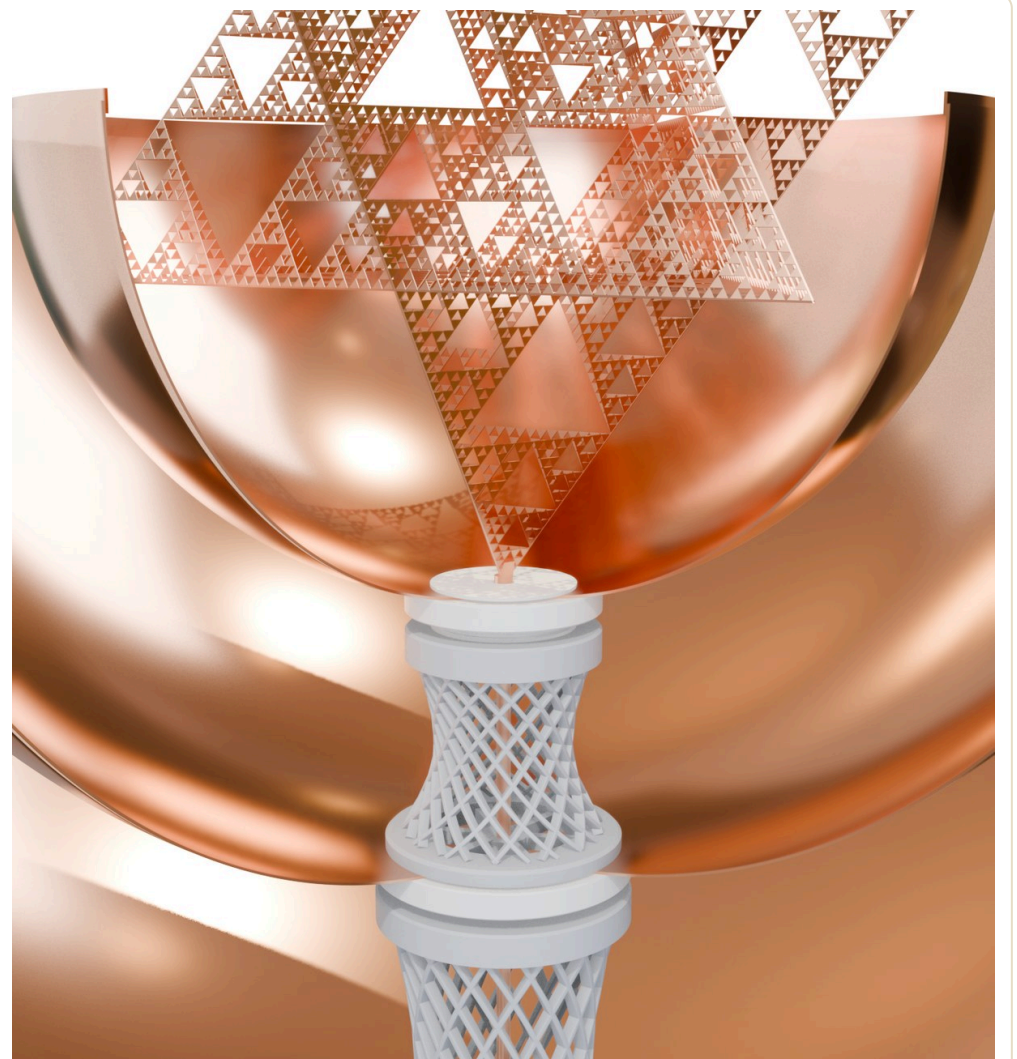
Lower hemispheres, Merkaba, rods and all supports (upper hemispheres removed)



Bottom pole, cut open: Tower A (25 cm) and Tower B (15 cm) screwed together through the 800, the jack below the big sphere



Top pole, cut open: lead-in fittings + centring inserts on the 1300 and 800, T-disc + nut + insert on the 500



The Merkaba's bottom tip: 10 × 1 tube sliding in the PTFE T-cup, 3 mm from the 500 sphere

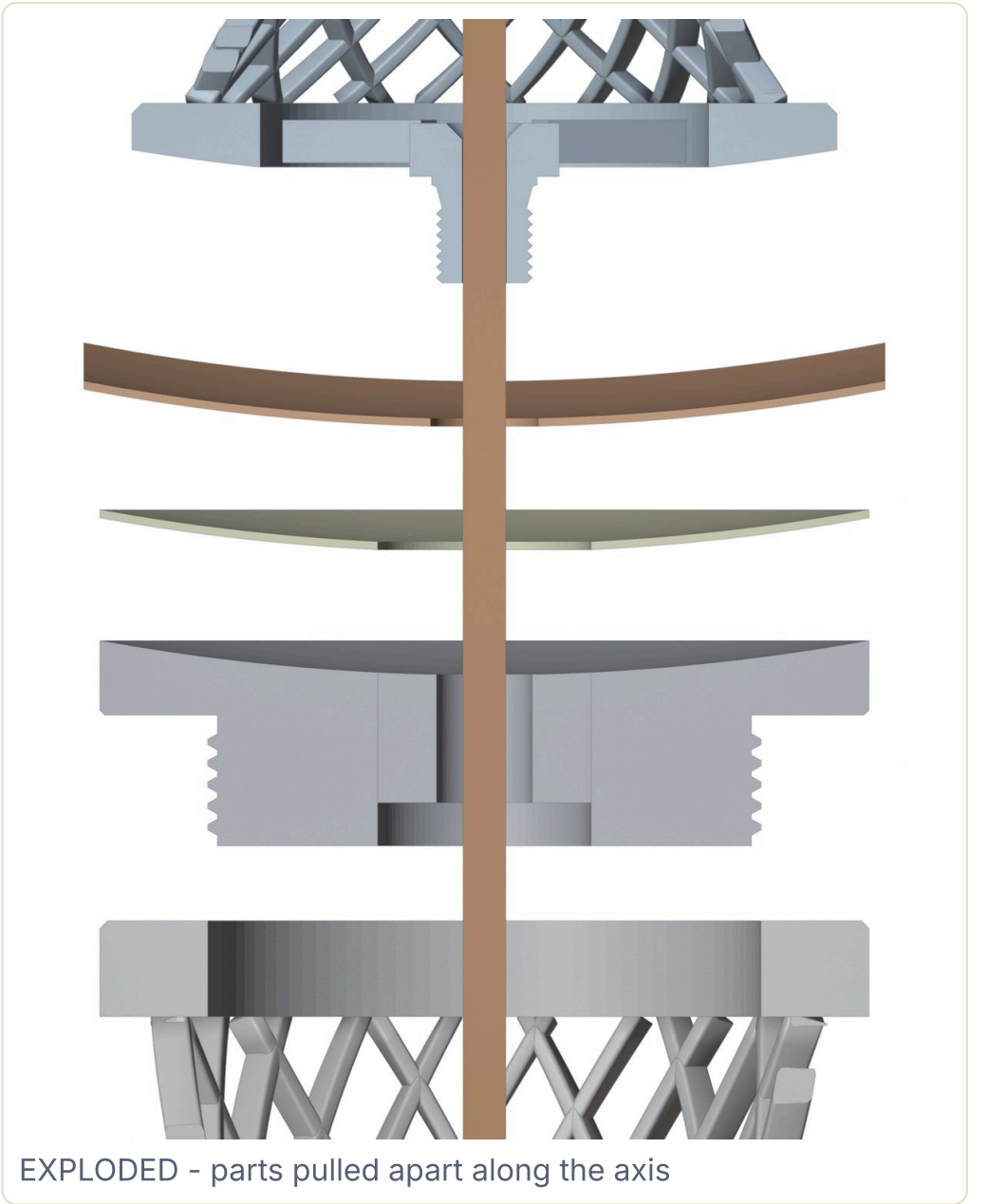
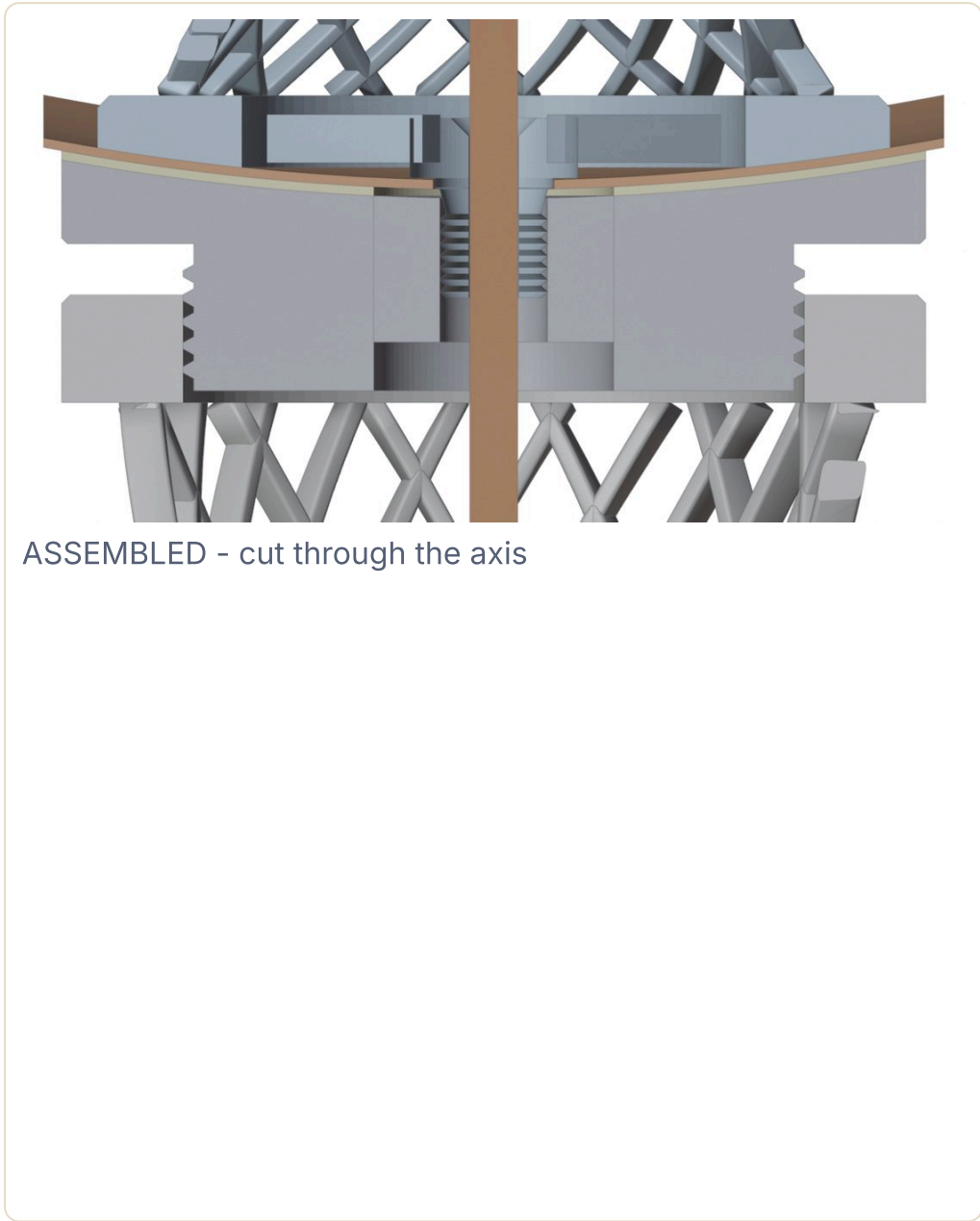
Where the five joints are



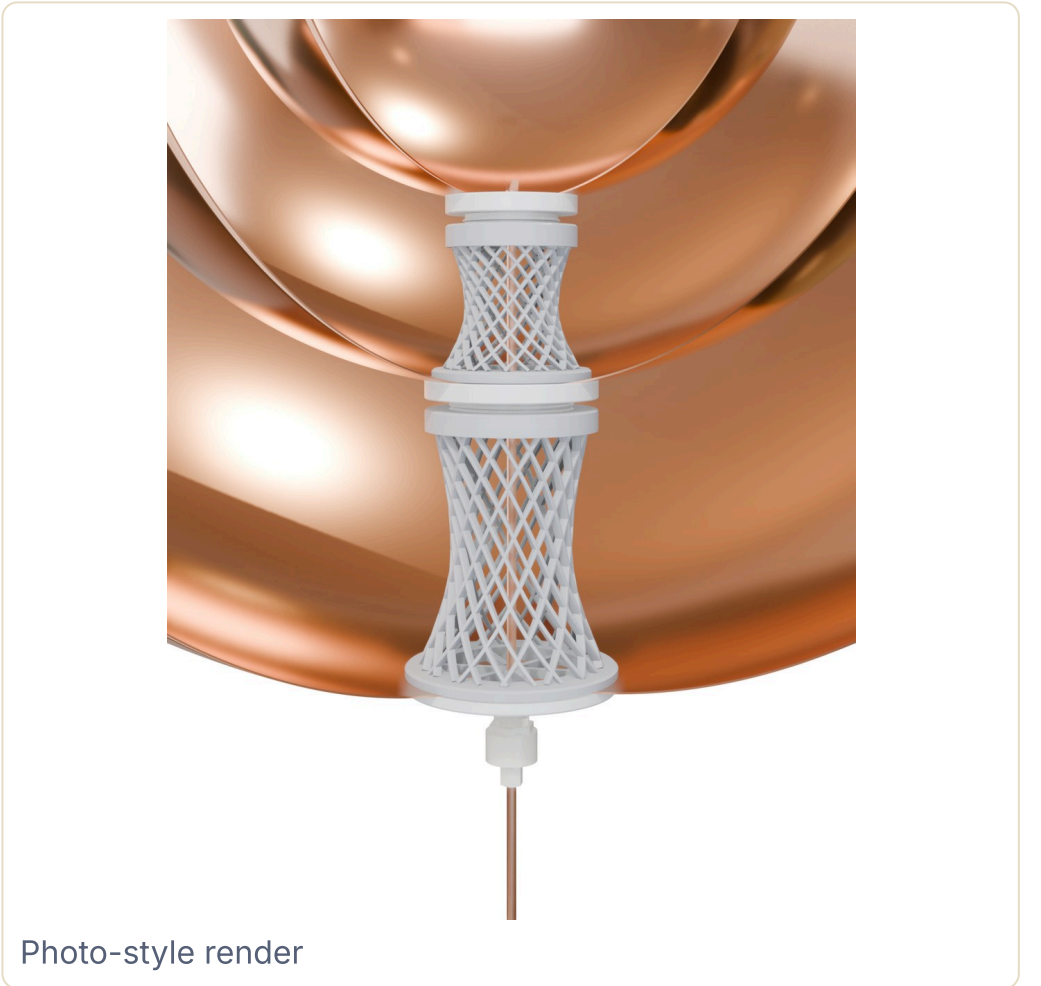
JOINT	WHERE	WHAT IT DOES
J1	bottom of the 800	Tower B screws into Tower A through the 20 mm hole - clamps the 800
J2	bottom of the 1300 (outside)	flanged nut locks Tower A to the 1300 + the Merkaba height jack
J3	bottom of the 500	T-cup screws into Tower B - clamps the 500, guides the bottom tip tube
J4	top of the 500	T-disc + nut clamp the 500; centring insert guides the top tip tube
J5	top of the 800 and 1300	lead-in fitting + funnel ring (pre-mounted), centring insert on the rod

J1 - bottom of the 800 sphere: Tower B screws into Tower A

Tower B's spigot (M18 × 2) goes down through the 20 mm hole and screws into the socket in the centre of Tower A's cradle. Tightening clamps the 800 wall between Tower B's hub (inside) and the cradle + PTFE liner (outside). The cradle itself screws in Tower A's top ring for 8.5 mm of height adjustment.

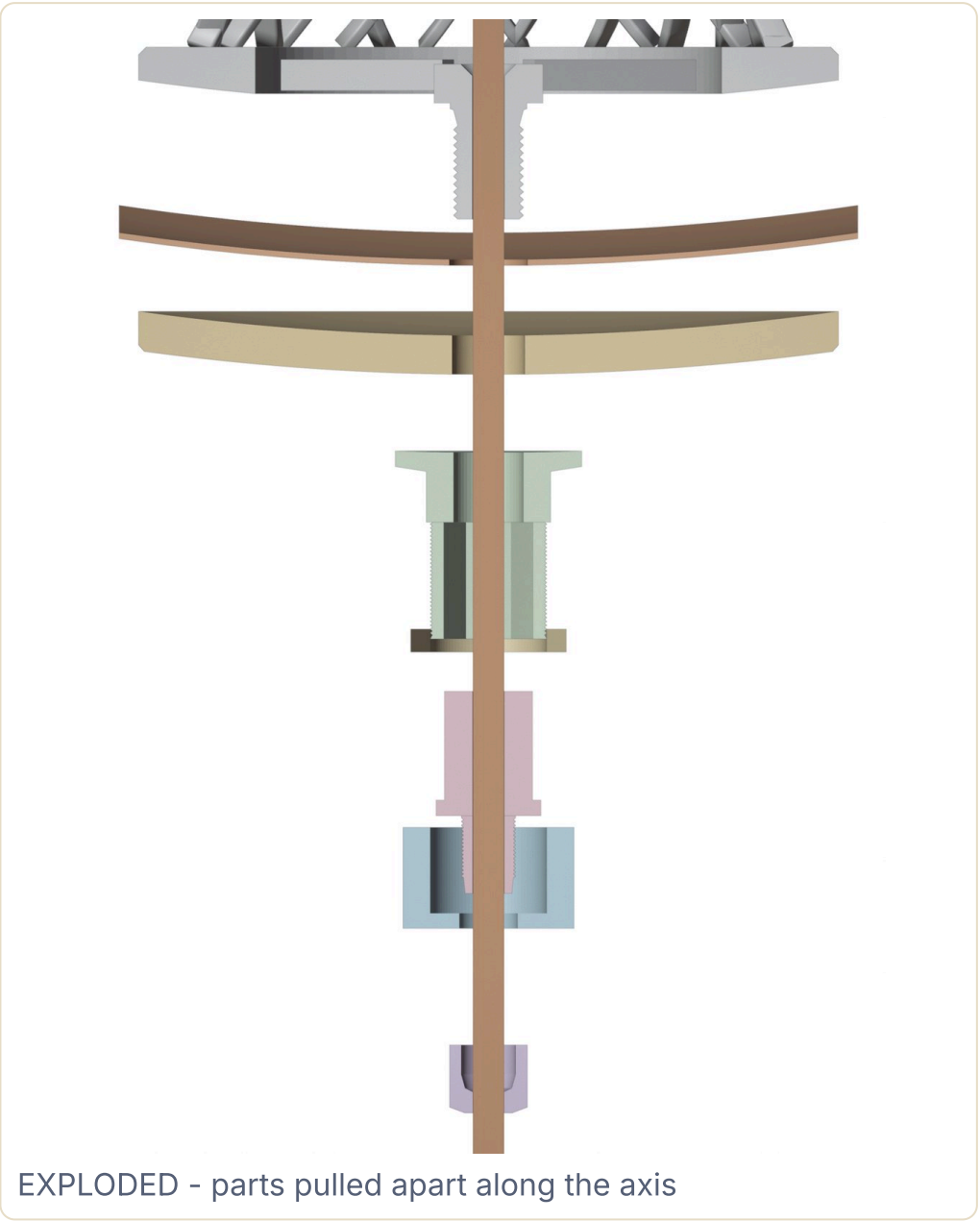
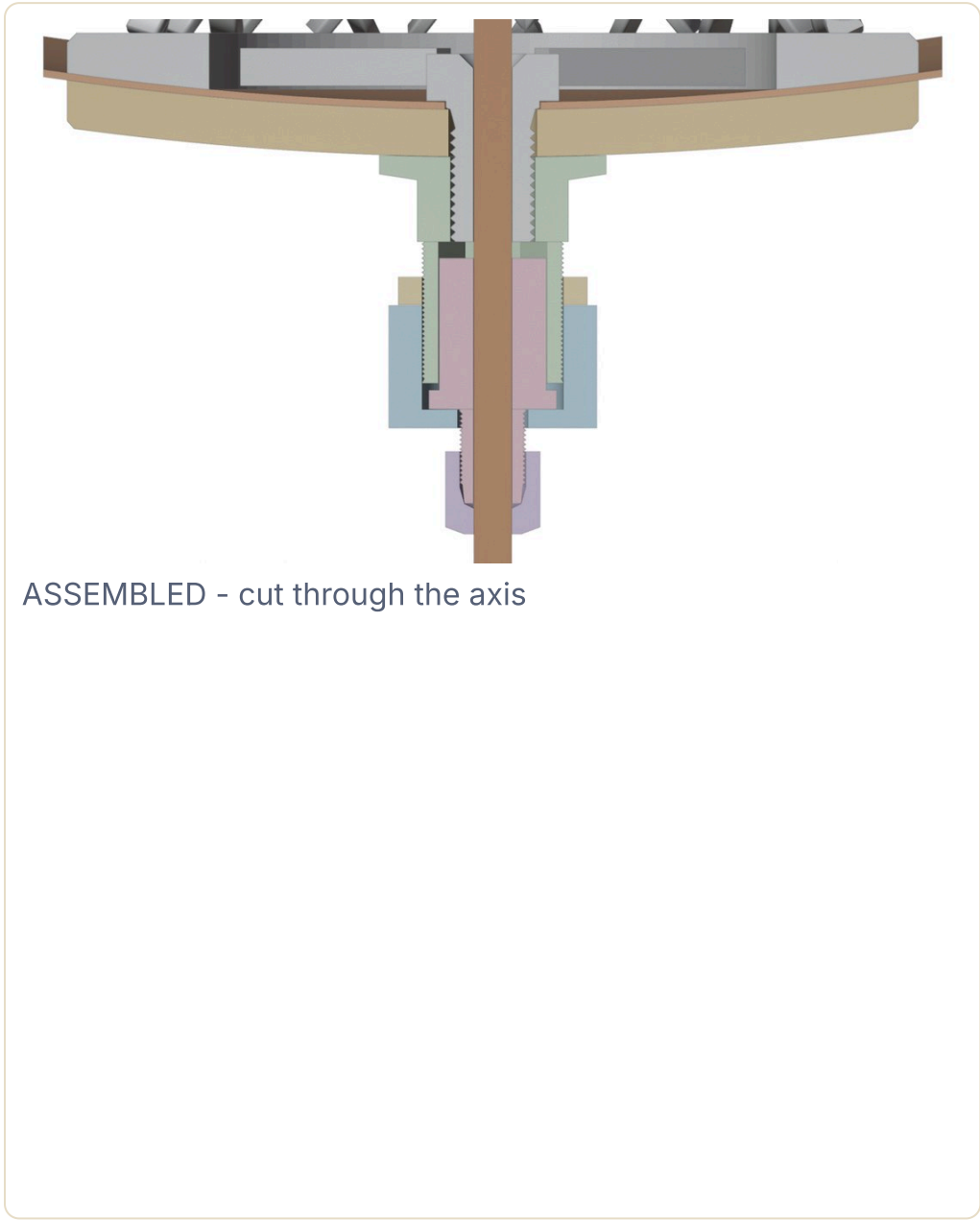


- | | | |
|---|---|--------------------|
|  | 1 | Tower B body |
|  | 2 | Copper sphere wall |
|  | 3 | Tower A PTFE liner |
|  | 4 | Tower A cradle |
|  | 5 | Tower A body |
|  | 6 | 8 mm copper rod |



J2 - bottom of the 1300 sphere: counter-ring, Tower A nut + Merkaba height jack

The 180 mm counter-ring (P21) sits under the copper, matching Tower A's 180 mm base ring inside; the flanged nut screws onto Tower A's spigot from below and clamps the copper between the two rings. Under it hangs the jack housing (same part). See the next pages for how the jack works.

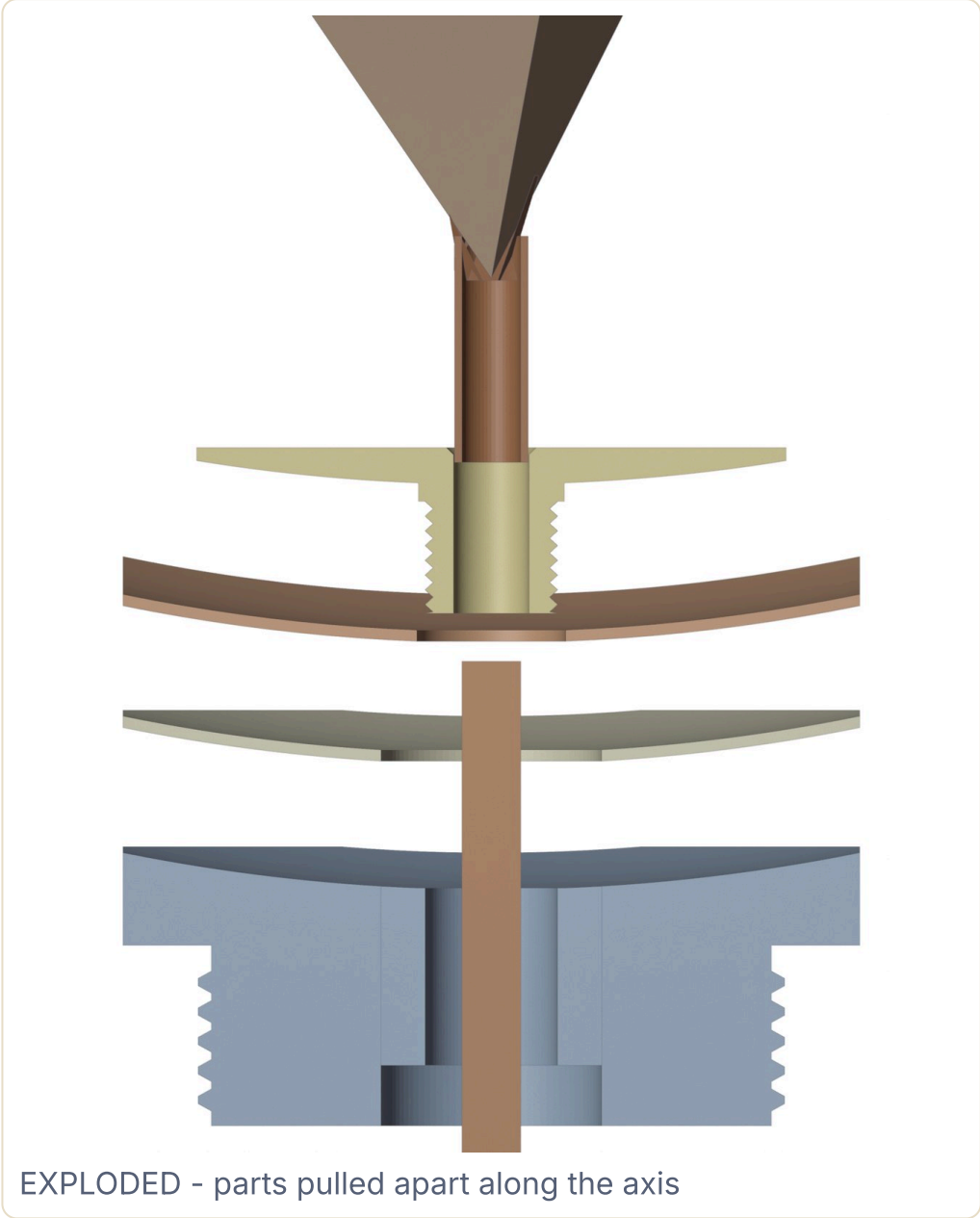
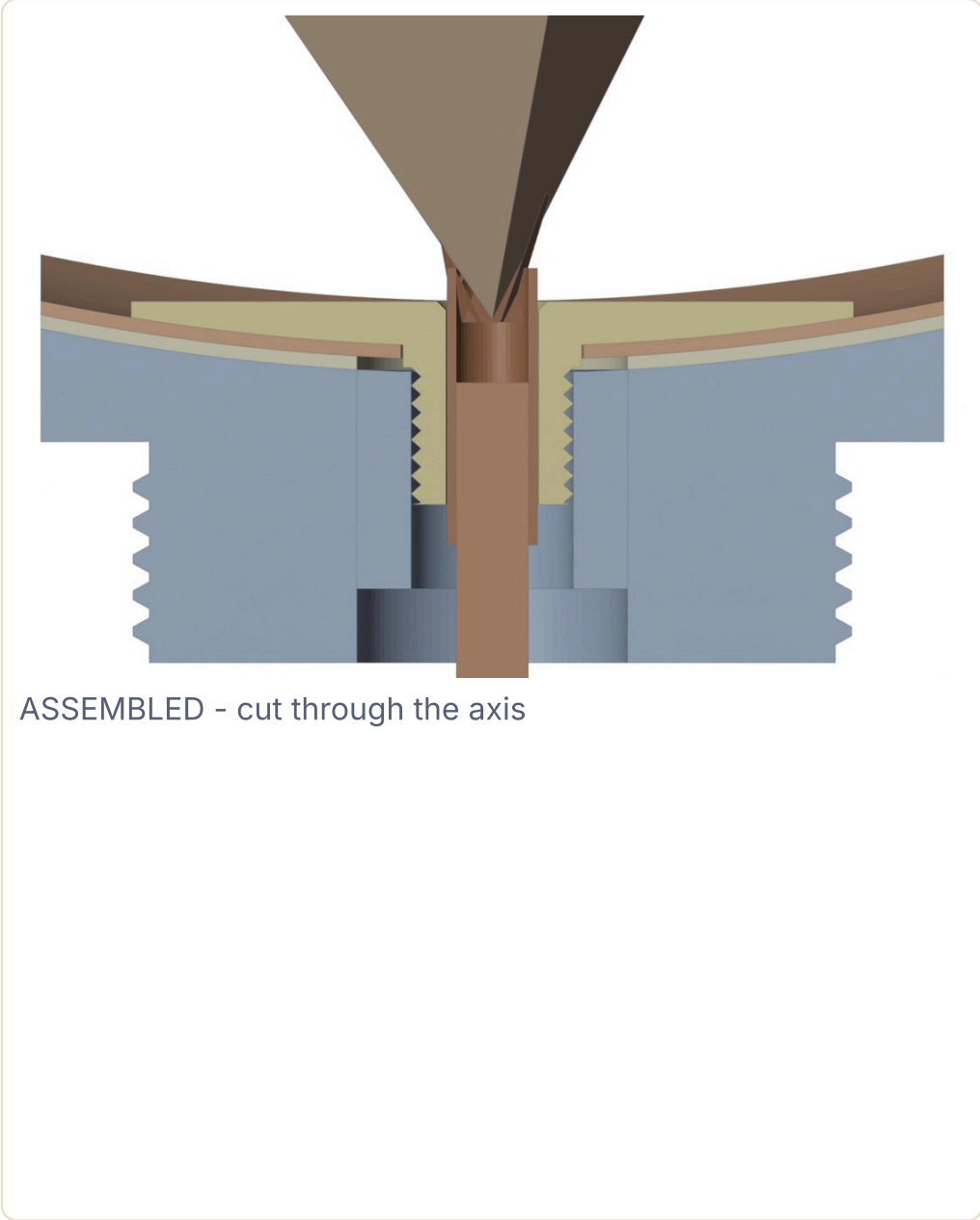


- | | | |
|---|---|----------------------------|
|  | 1 | Tower A body |
|  | 2 | Copper sphere wall |
|  | 3 | Counter-ring 180 (PP) |
|  | 4 | Flanged nut + jack housing |
|  | 5 | Lock ring |
|  | 6 | Jack slider (hex) |
|  | 7 | Adjusting cap (wheel) |
|  | 8 | Collet cap |
|  | 9 | 8 mm copper rod |

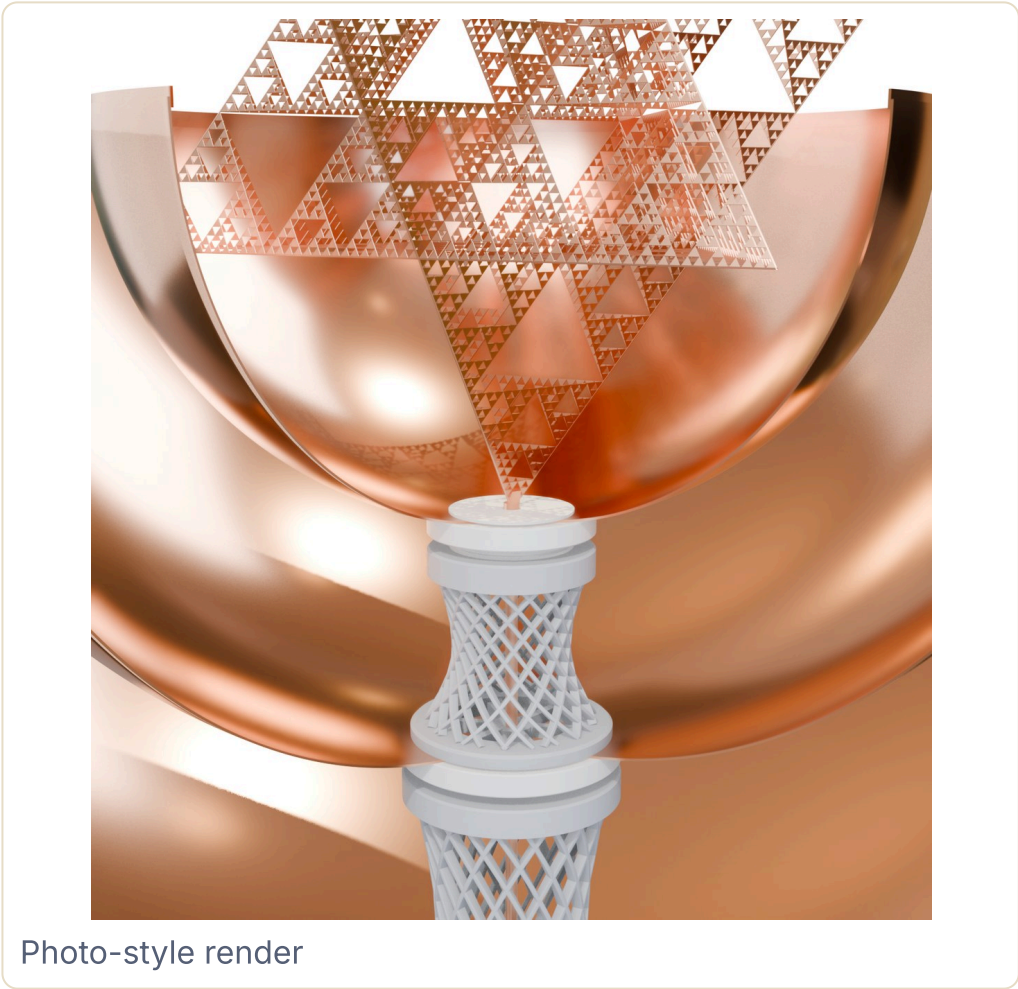


J3 - bottom of the 500 sphere: T-cup

The flat PTFE T-cup sits inside the 500. Its neck (M18 × 2) goes through the hole into Tower B's cradle socket and clamps the 500. The 10 mm tip tube slides in its 10.3 mm bore: the tip is centred sideways but free to move up/down and to rotate. Nothing touches the Merkaba faces.



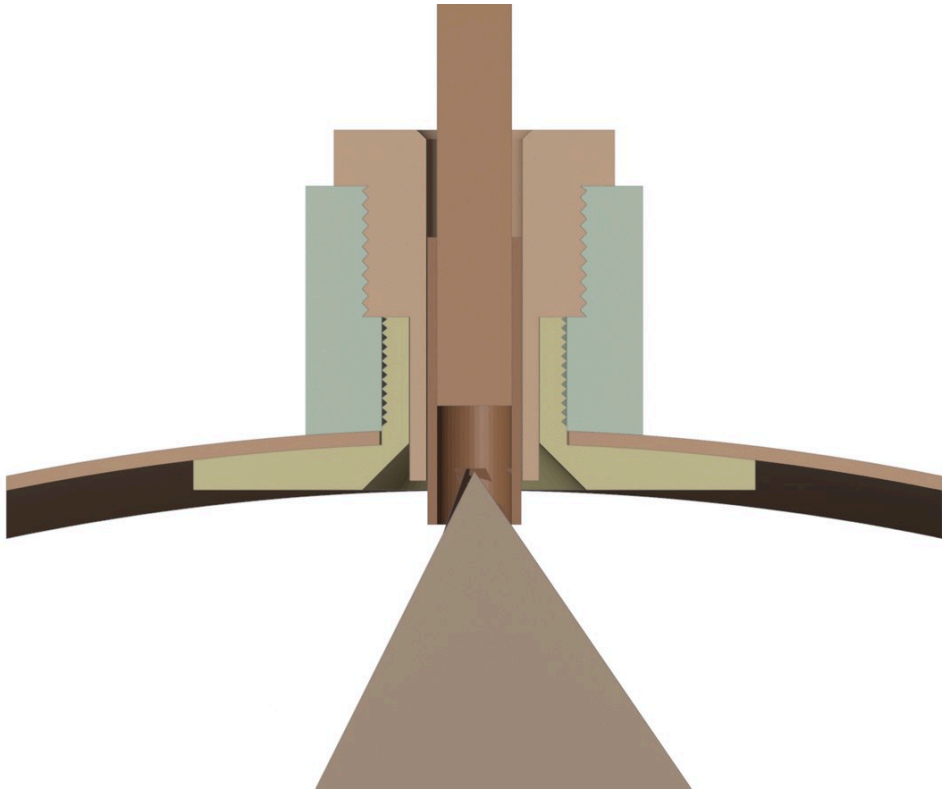
- | | | |
|---|---|-------------------------|
|  | 1 | Merkaba (Sierpinski) |
|  | 2 | 10×1 copper tube + tabs |
|  | 3 | Bottom T-cup (PTFE) |
|  | 4 | Copper sphere wall |
|  | 5 | Tower B PTFE liner |
|  | 6 | Tower B cradle |
|  | 7 | 8 mm copper rod |



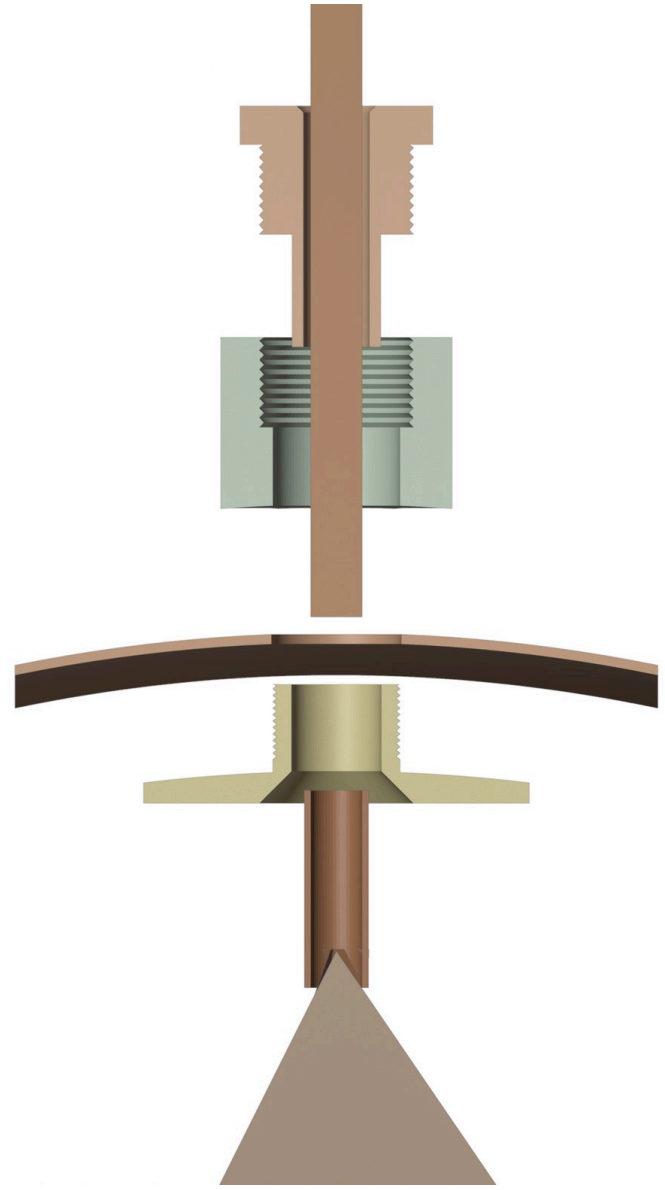


J4 - top of the 500 sphere: T-disc, nut and centring insert

The T-disc (14 mm lead-in hole + funnel) and its nut are mounted on the upper 500 hemisphere BEFORE assembly. After the hemisphere is down, the centring insert slides down the rod and screws into the nut; its 10.3 mm pilot bore centres the top tip tube.



ASSEMBLED - cut through the axis



EXPLODED - parts pulled apart along the axis

- | | | |
|--|---|-------------------------|
| | 1 | Merkaba (Sierpinski) |
| | 2 | 10×1 copper tube + tabs |
| | 3 | Top T-disc (PTFE) |
| | 4 | Copper sphere wall |
| | 5 | Top nut 500 |
| | 6 | Centring insert 10.3 |
| | 7 | 8 mm copper rod |

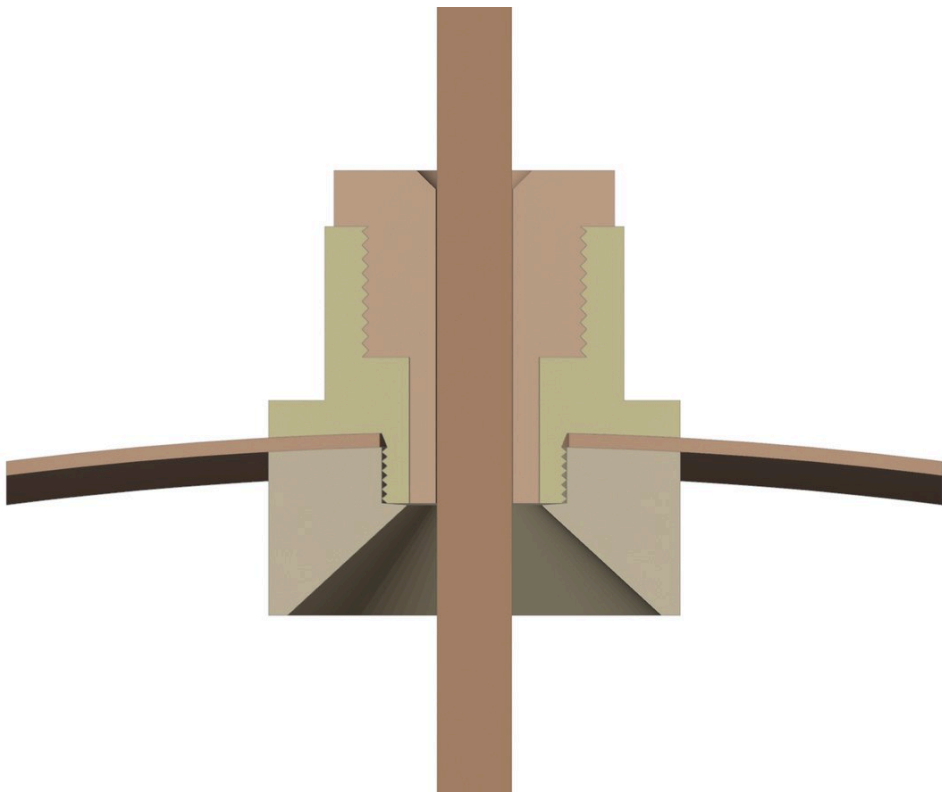


Photo-style render

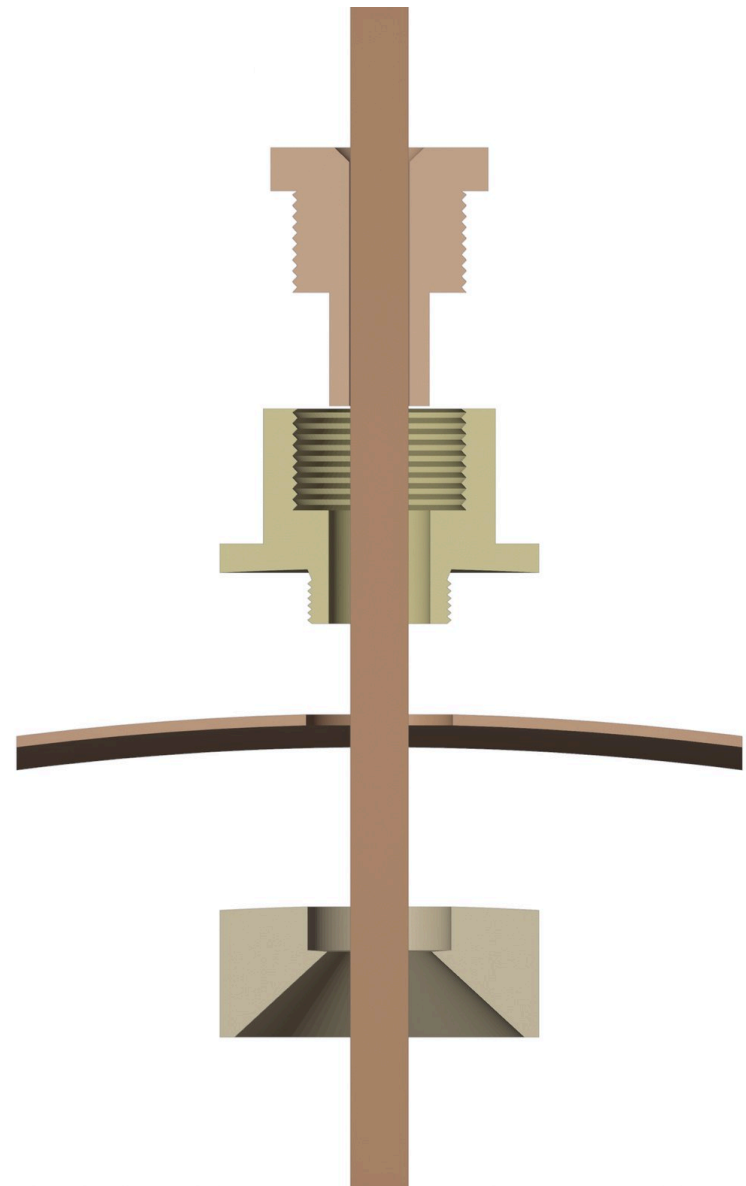


J5 - top of the 800 (and the 1300, identical)

Lead-in fitting (outside) + funnel ring (inside) are screwed together on the loose upper hemisphere BEFORE assembly: 14 mm hole, 40 mm funnel. After the hemisphere is down, the 8.3 mm centring insert slides down the rod and screws into the fitting.



ASSEMBLED - cut through the axis



EXPLODED - parts pulled apart along the axis

- | | | |
|---|---|---------------------|
|  | 1 | Funnel ring 800 |
|  | 2 | Copper sphere wall |
|  | 3 | Lead-in fitting 800 |
|  | 4 | Centring insert 8.3 |
|  | 5 | 8 mm copper rod |

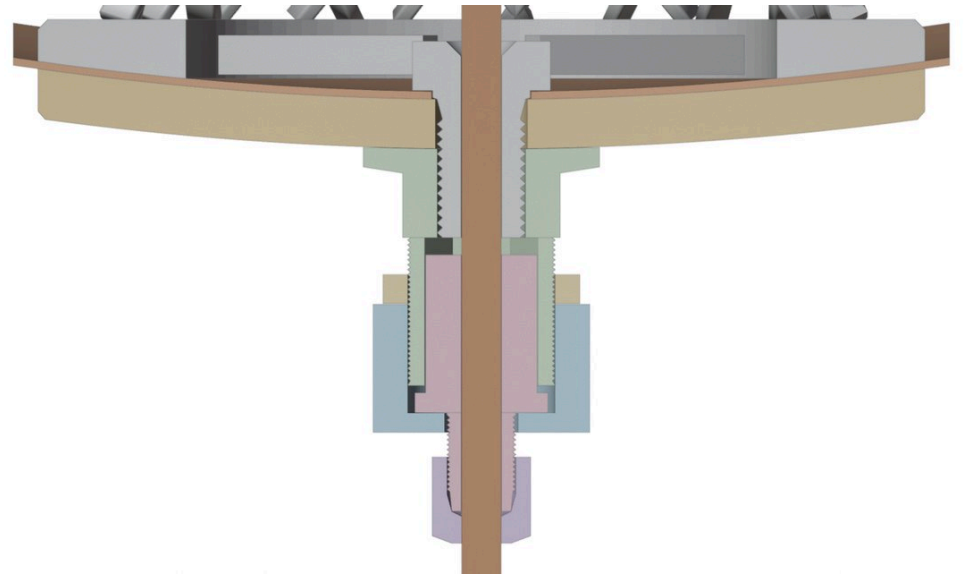


Photo-style render

How the height jack works (step by step)



The jack under the big sphere (photo-style render)



Cut view: green = housing (with the nut), pink = HEX slider, blue = adjusting wheel, beige = lock ring, violet = collet cap

1. **The housing (P7)** hangs under the big sphere, part of the flanged nut. Inside it has a **hexagonal hole**, outside a fine thread $M30 \times 1$.
2. **The slider (P8)** is hexagonal: it slides up and down in the housing but **can never rotate**. The 8 mm rod passes through it.
3. **The collet cap (P11)** squeezes the slider's slotted stem onto the rod. No glue - loosen it any time to slide or turn the rod/Merkaba by hand, then tighten.
4. **The adjusting wheel (P9)** is screwed on the housing's outer thread. The slider's flange rests on its floor (the Merkaba's weight keeps it there).
5. **Turn the wheel:** it moves up or down **1 mm per turn** ($1/4$ turn = 0.25 mm). The slider, rod and Merkaba follow **straight up/down without rotating** - the hexagon prevents it. Travel: +3.5 mm up / about -4 mm down.
6. **Lock:** turn the lock ring (P10) down against the wheel.

Setting the 3 mm gap: during assembly (500 upper half not yet on) place the three 3 mm PTFE gauges between the lower side tips and the 500 sphere, lower the Merkaba onto them, raise the wheel until the Merkaba just lifts off (gauges slide out freely), lock. Then **scribe a reference mark on the bottom rod** exactly at the lower face of the collet cap and write down the wheel position. With everything closed you can always come back to this height, or move it in exact steps (1 turn = 1 mm).

Note: the old multimeter method does not work with the T-cups - the Merkaba cannot reach the copper within the jack travel.

Assembly order

- 1. Bench, upper hemispheres:** mount P13 + P14 on the upper 500; P16 + P18 on the upper 800; P17 + P19 on the upper 1300 (hand-tight). Their 14 mm holes + funnels make the later lowering easy.
- 2. Merkaba spine:** solder the 10 × 1 tubes on both tips (straight, on the tip axis - use a jig), solder the two 8 mm rods into the tubes.
- 3. Big sphere on its stand:** lower 1300 hemisphere; Tower A (P1) inside on the pole; flanged nut + jack (P7) screwed from below. Cradle P2 + liner P3 on Tower A.
- 4. 800 lower hemisphere** on the cradle; Tower B (P4) inside, screw its spigot through the hole into P2 - the 800 is now clamped. Cradle P5 + liner P6 on Tower B.
- 5. 500 lower hemisphere** on P5; put the bottom T-cup (P12) inside and screw it into P5 - the 500 is clamped.
- 6. Lower the Merkaba spine** from above: the bottom rod finds every bore by itself (lead-in chamfers) down through P12, P4, P2, P1, P7, P8; the bottom tube enters P12. Place the 3 mm gauges, tighten the collet P11, set the height with the wheel P9, lock P10, remove the gauges.
- 7. Upper 500:** lower it over the top rod - the funnel of P13 catches it, 3 mm play, nothing is levered. Join the equator. Slide insert P15 down the rod and screw it into P14: the top tube is centred.
- 8. Upper 800:** lower, join, screw in insert P20. **Upper 1300:** lower, join, screw in insert P20.
- 9. Final check:** the reference mark on the rod is at the collet cap, the lock ring is tight.

The parts, one by one

P1 · Tower A body (25 cm, 1300 to 800)

qty 1



Polypropylene (PP) · 3D print, ONE piece: HP Multi Jet Fusion PP (best) or FDM PP / ASA

Base ring	OD 180 / ID 120 × 12 mm, underside spherical R650 (sits in the 1300 bowl)
Hub + spokes	hub OD 28 × 10, 6 spokes 6 × 8 mm to the base ring
Spigot (male)	plain OD 19.8 through the 20 mm hole, then M18 × 2 thread, 24 mm long (passes the P21 counter-ring)
Bore	Dia 8.4 through, 3 × 45 deg lead-in chamfer on top
Spirals	13 clockwise + 21 counter-clockwise, twist 110 deg, waist dia ~95
Strut section	1 : 4 : 9 rounded rectangle = 3.2 × 7.2 mm, corner R0.8, 7.2 side radial
Top ring	OD 144 × 18, INTERNAL thread dia 104 × 4 (custom) for the cradle
Height	base ring top to top-ring bottom 198 mm (pole to pole with cradle 248.5)

P2 · Tower A cradle

qty 1



Polypropylene (PP) · CNC lathe from PP rod (or 3D print PP)

Cradle ring	OD 144, top face CONCAVE spherical R403.0 (= sphere R401.5 + 1.5 liner)
Height thread (male)	dia 104 × 4 custom (root dia 100), 20 mm long - screws into P1 top ring
Centre socket (female)	M18 × 2, 22 mm deep, receives the P4 spigot
Adjustment	8.5 mm height travel
Height	~38 mm

P3 · Tower A liner

qty 1



PTFE (virgin) · CNC lathe, or press-formed from 1.5 mm PTFE sheet

Shape	spherical ring, 1.5 mm thick, R401.5 / R403.0
Size	OD 144 / ID 40

P4 · Tower B body (15 cm, 800 to 500)

qty 1



Polypropylene (PP) · 3D print, ONE piece: HP Multi Jet Fusion PP (best) or FDM PP / ASA

Base ring	OD 132 / ID 84 × 12 mm, underside spherical R400 (sits in the 800 bowl)
Hub + spokes	hub OD 28 × 10, 6 spokes 6 × 8 mm
Spigot (male)	plain OD 19.8, then M18 × 2, 14 mm - screws into P2 socket
Bore	Dia 8.4 through, 3 × 45 deg lead-in chamfer on top
Spirals	13 + 21, twist 110 deg
Strut section	1 : 4 : 9 = 2.6 × 5.85 mm, corner R0.65
Top ring	OD 108 × 18, INTERNAL thread dia 79.6 × 4 (custom)
Height	base ring top to top-ring bottom 99 mm (pole to pole with cradle 148.5)

P5 · Tower B cradle

qty 1



Polypropylene (PP) · CNC lathe from PP rod (or 3D print PP)

Cradle ring	OD 108, top face CONCAVE spherical R253.0 (= R251.5 + 1.5 liner)
Height thread (male)	dia 79.6 × 4 custom (root 76), 20 mm
Centre socket (female)	M18 × 2, 22 mm deep, receives the P12 T-cup neck
Adjustment	8.5 mm

P6 · Tower B liner

qty 1



PTFE (virgin) · CNC lathe, or press-formed from 1.5 mm sheet

Shape	spherical ring 1.5 mm, R251.5 / R253.0
Size	OD 108 / ID 30

P7 · Flanged nut + jack housing (ONE part)

qty 1



POM-C (acetal / Delrin) · CNC lathe + hex broach/EDM (or mill) for the hex bore

Flange	dia 48 × 4, face spherical R661.6 (seats on the P21 counter-ring)
Nut body	dia 32, INTERNAL M18 × 2 - screws onto the P1 spigot
Housing	OUTER thread M30 × 1, 30 mm long
Hex bore	across flats 20.0 (+0.1), 30 mm deep (the drawing shows dia 23.2 = across corners)
Note	dia 18 in the drawing = internal thread M18 × 2 (drawn at major dia)
Total height	~48 mm

P8 · Jack slider (cannot rotate)

qty 1



POM-C · CNC lathe from hex bar AF 19.6 (or mill)

Hex body	across flats 19.6 (-0.05), 28 mm long - slides in the P7 hex bore
Flange	hex 23.4 AF x 4 mm - rests on the P9 floor
Collet stem	M14 × 1, 16 mm, 4 slots 1.5 wide x 12 deep, 10 deg taper at the end
Bore	dia 8.3 through

P9 · Adjusting cap = height wheel

qty 1

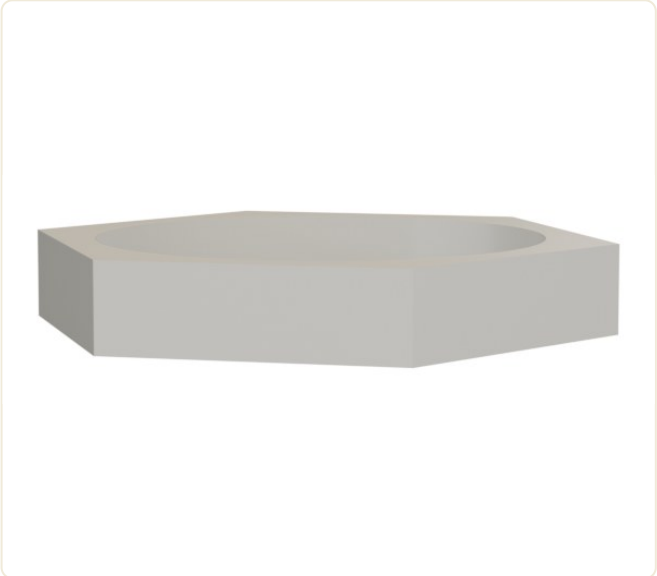
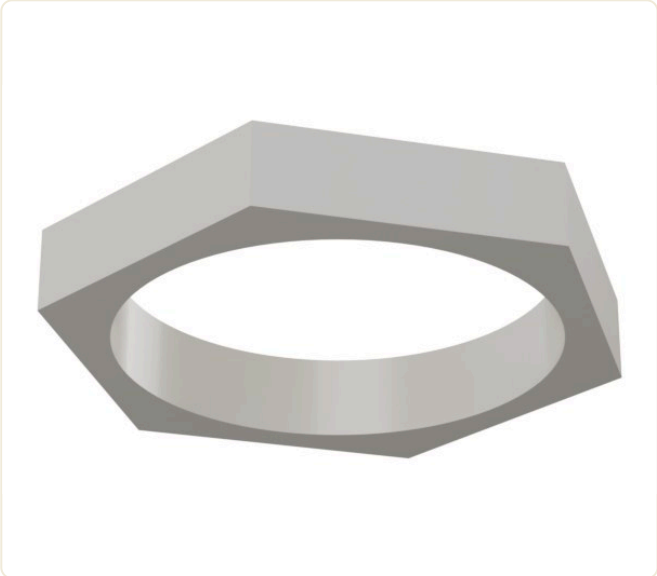


POM-C · CNC lathe, knurled outside

Outside	dia 44 knurled, height 26
Thread	INTERNAL M30 × 1 (ONE TURN = 1 mm)
Floor	4 mm thick, hole dia 15 for the collet stem

P10 · Lock ring

qty 1

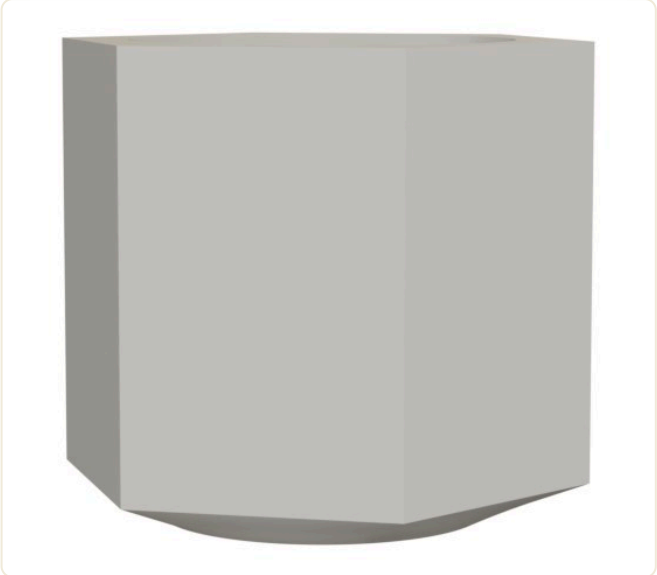


POM-C · CNC lathe / hex bar

Thread	INTERNAL M30 × 1
Outside	hex ~35 AF x 6 mm

P11 · Collet cap

qty 1



POM-C · CNC lathe / hex bar

Thread	INTERNAL M14 × 1, 7.5 mm long
Closing cone	from dia 14.1 to dia 12.1 over 3.6 mm (~16 deg), matches the stem end - squeezes the 4 fingers
Outside	hex 17.3 AF x 17.5
Bore	dia 8.1 at the end

P12 · Bottom T-cup (500, inside)

qty 1



PTFE (virgin) · CNC lathe

Disc	dia 80 × 5 mm at the pole, outer face spherical R250 (inside of the 500)
Bore	dia 10.3 H9 - sliding fit on the 10 mm tip tube, 1 × 45 deg chamfer on the Merkaba side
Neck	plain dia 19.8 through the hole, then M18 × 2, 15 mm - into P5 socket
Clearance	5 mm to the nearest Merkaba edge, 4 mm to the tube solder

P13 · Top T-disc (500, inside)

qty 1

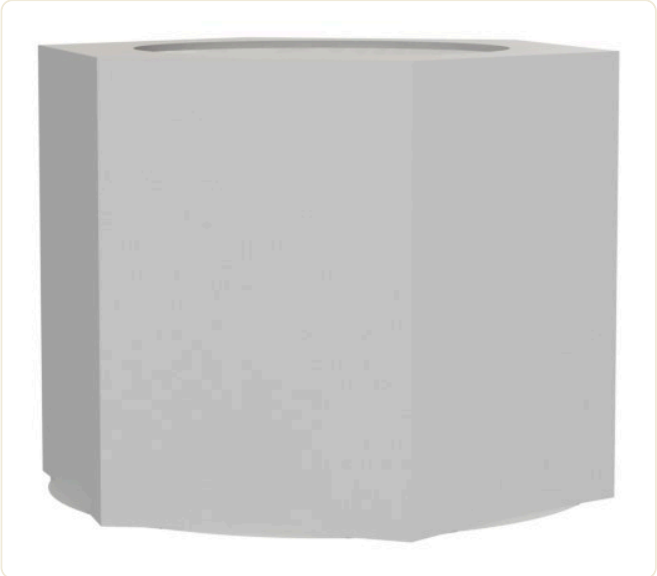
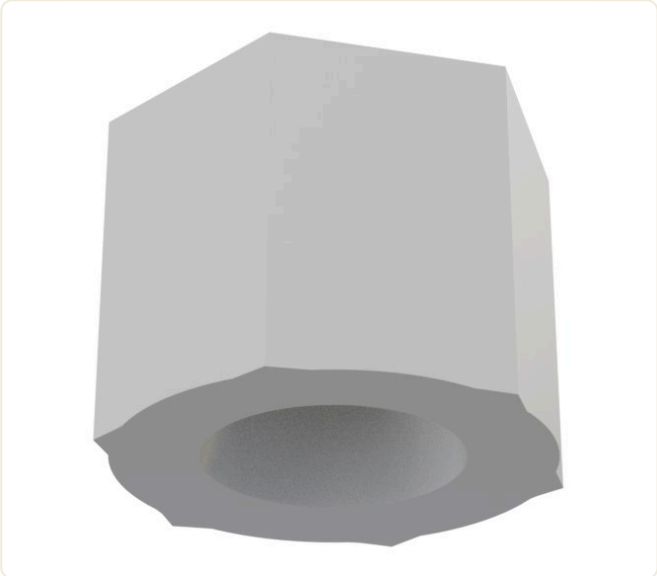


PTFE (virgin) · CNC lathe

Disc	dia 60 × 5 mm, outer face spherical R250
Lead-in hole	dia 14 with 45 deg funnel to dia 24 (catches the rod)
Neck	M20 × 1 (major dia 19.8), 11 mm

P14 · Top nut 500 (outside)

qty 1



PTFE (virgin) · CNC lathe / hex bar

Lower thread	INTERNAL M20 × 1, 12 mm (on the P13 neck)
Upper thread	INTERNAL M24 × 1.5, 14 mm (for P15)
Outside	hex ~31 AF, face spherical R251.5
Height	~27 mm

P15 · Centring insert 10.3 (500)

qty 1



PTFE (virgin) · CNC lathe, knurled head

Bore	dia 10.3 H9 - slides down the rod and over the tube
Pilot	dia 13.8, reaches down into the T-disc
Thread	M24 × 1.5, 14 mm
Head	dia 30 × 6 knurled, 1 × 45 deg chamfer in the bore

P16 · Top lead-in fitting 800 (outside)

qty 1



PTFE (virgin) · CNC lathe

Flange	dia 44 × 4, face spherical R401.5
Spigot	dia 19.8 through the hole with M20 × 1 at the inner end
Neck	dia 32, INTERNAL M24 × 1.5, 14 mm (for P20)
Lead-in hole	dia 14

P17 · Top lead-in fitting 1300 (outside) qty 1



PTFE (virgin) · CNC lathe

Same as P16

but flange face spherical R651.5

P18 · Funnel ring 800 (inside) qty 1



PTFE (virgin) · CNC lathe

Thread	INTERNAL M20 × 1 (on the P16 spigot)
Top face	spherical R400 (inside of the 800)
Funnel	from dia 40 down to dia 14
Outside	dia 44 × 18

P19 · Funnel ring 1300 (inside)

qty 1



PTFE (virgin) · CNC lathe

Same as P18but top face spherical R650

P21 · Counter-ring 180 (outside, under the 1300)

qty 1



Polypropylene (PP) · CNC lathe from PP plate, or 3D print PP	
Ring	OD 180 / ID 18.8 × 10 mm
Top face	CONCAVE spherical R651.5 - follows the outside of the 1300 sphere
Bottom face	spherical R661.5 - the flanged nut P7 seats here
Job	matches the 180 mm base ring of Tower A inside: the copper is clamped between two equal rings

P20 · Centring insert 8.3 (800 and 1300)

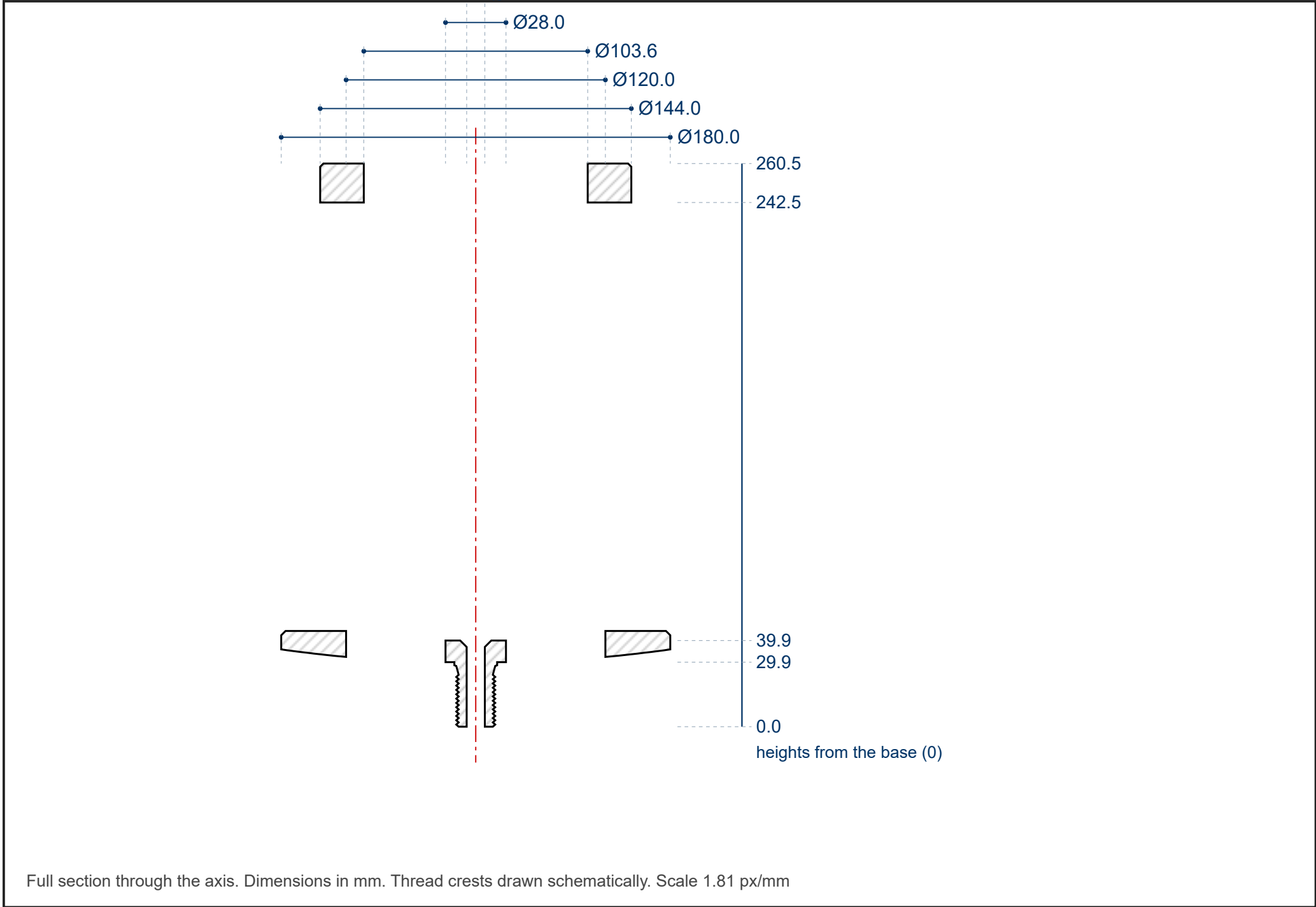
qty 2



PTFE (virgin) · CNC lathe, knurled head

Bore	dia 8.3 H9 on the 8 mm rod
Pilot	dia 13.8, reaches the funnel ring
Thread	M24 × 1.5, 14 mm
Head	dia 30 × 6 knurled

Technical drawing · P1 · Tower A body (25 cm, 1300 to 800)

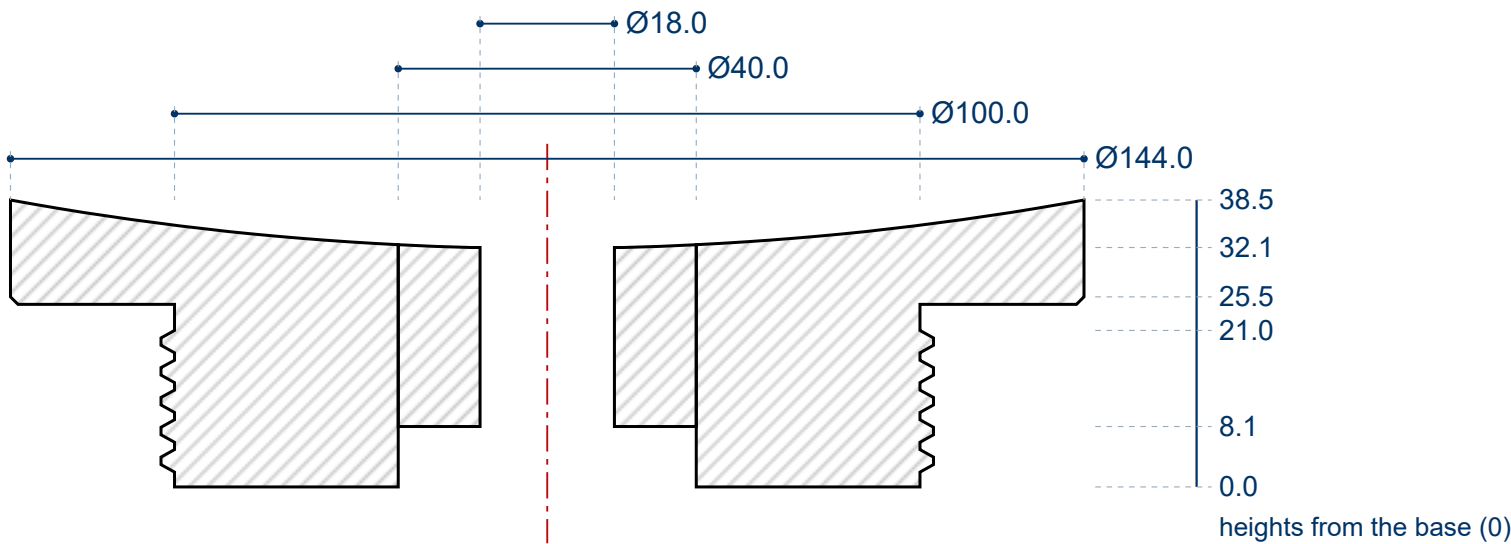


Part P1 - Tower A body (25 cm, 1300 to 800)	Qty 1	Material Polypropylene (PP)
Process 3D print, ONE piece: HP Multi Jet Fusion PP (best) or FDM PP / ASA		
Base ring	OD 180 / ID 120 × 12 mm, underside spherical R650 (sits in the 1300 bowl)	
Hub + spokes	hub OD 28 × 10, 6 spokes 6 × 8 mm to the base ring	
Spigot (male)	plain OD 19.8 through the 20 mm hole, then M18 × 2 thread, 24 mm long (passes the P21 counter-ring)	
Bore	Dia 8.4 through, 3 × 45 deg lead-in chamfer on top	
Spirals	13 clockwise + 21 counter-clockwise, twist 110 deg, waist dia ~95	
Strut section	1 : 4 : 9 rounded rectangle = 3.2 × 7.2 mm, corner R0.8, 7.2 side radial	
Top ring	OD 144 × 18, INTERNAL thread dia 104 × 4 (custom) for the cradle	
Height	base ring top to top-ring bottom 198 mm (pole to pole with cradle 248.5)	

Lattice not drawn in the section (only base ring, hub/spigot and top ring are turned profiles). Spirals and spokes: see the spec table and the part views. STL file: STL_parts_v14 folder.

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P2 · Tower A cradle

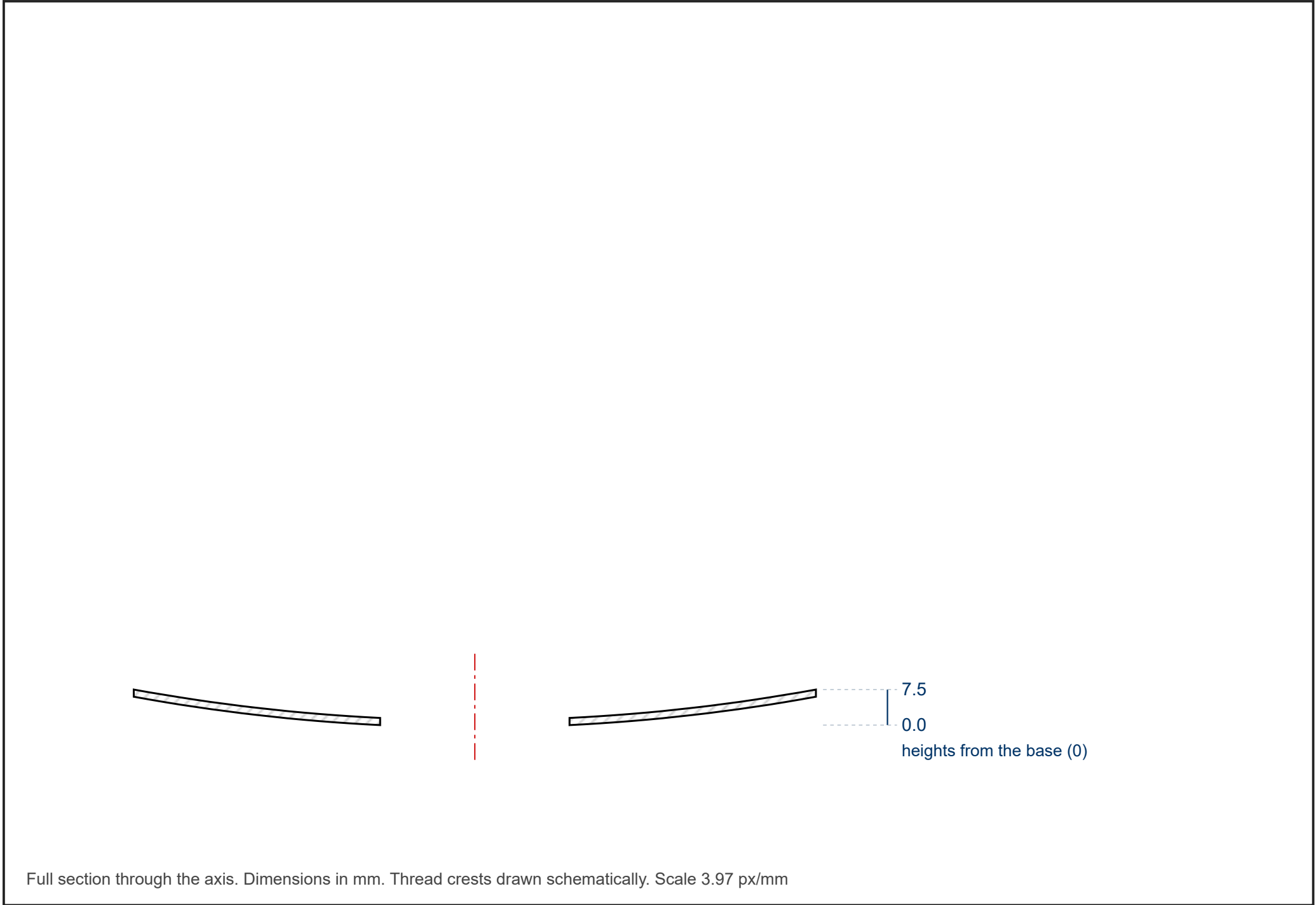


Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 3.97 px/mm

Part P2 - Tower A cradle	Qty 1	Material Polypropylene (PP)
Process CNC lathe from PP rod (or 3D print PP)		
Cradle ring	OD 144, top face CONCAVE spherical R403.0 (= sphere R401.5 + 1.5 liner)	
Height thread (male)	dia 104 × 4 custom (root dia 100), 20 mm long - screws into P1 top ring	
Centre socket (female)	M18 × 2, 22 mm deep, receives the P4 spigot	
Adjustment	8.5 mm height travel	
Height	~38 mm	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

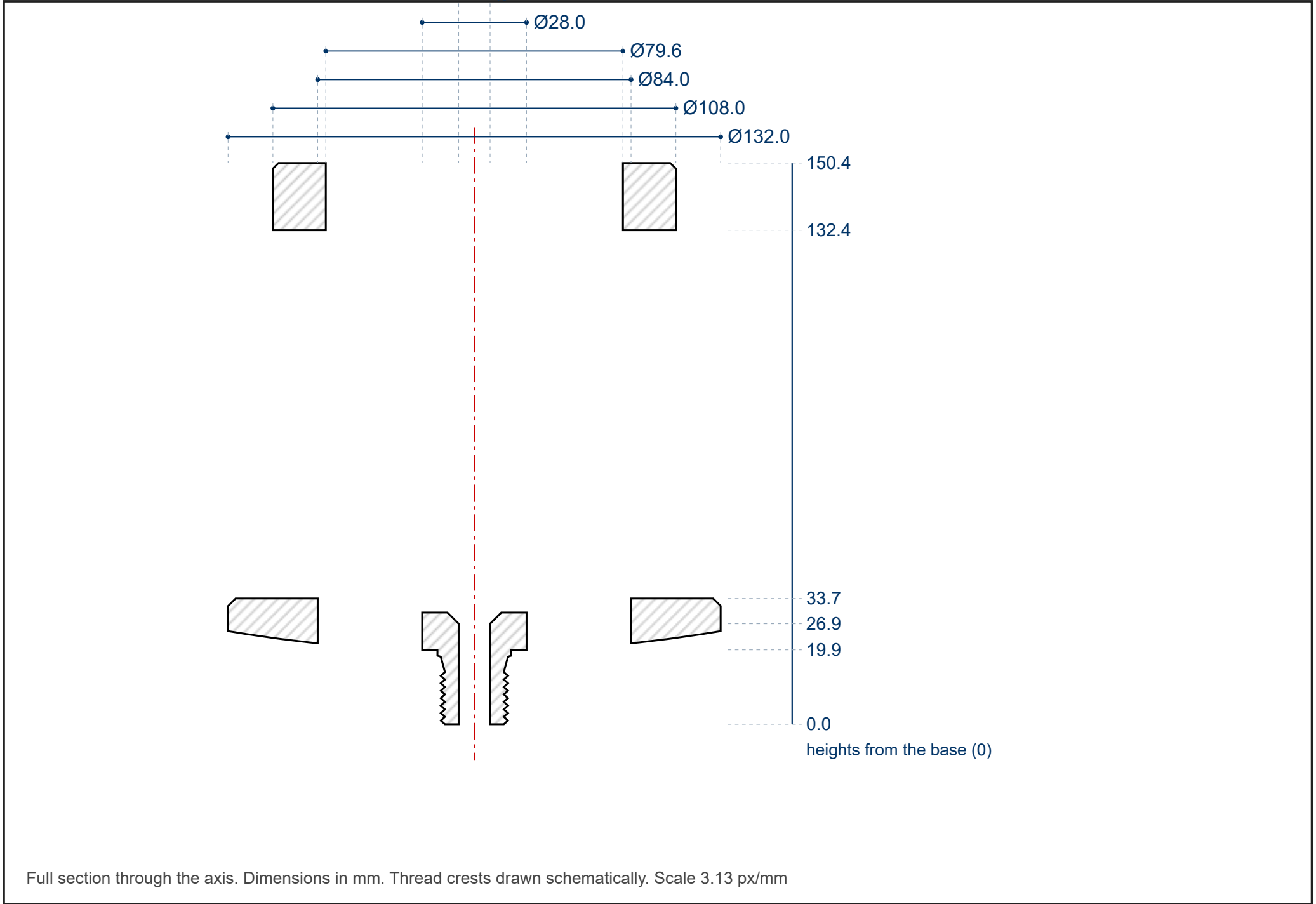
Technical drawing · P3 · Tower A liner



Part P3 - Tower A liner	Qty 1	Material PTFE (virgin)
Process CNC lathe, or press-formed from 1.5 mm PTFE sheet		
Shape	spherical ring, 1.5 mm thick, R401.5 / R403.0	
Size	OD 144 / ID 40	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P4 · Tower B body (15 cm, 800 to 500)

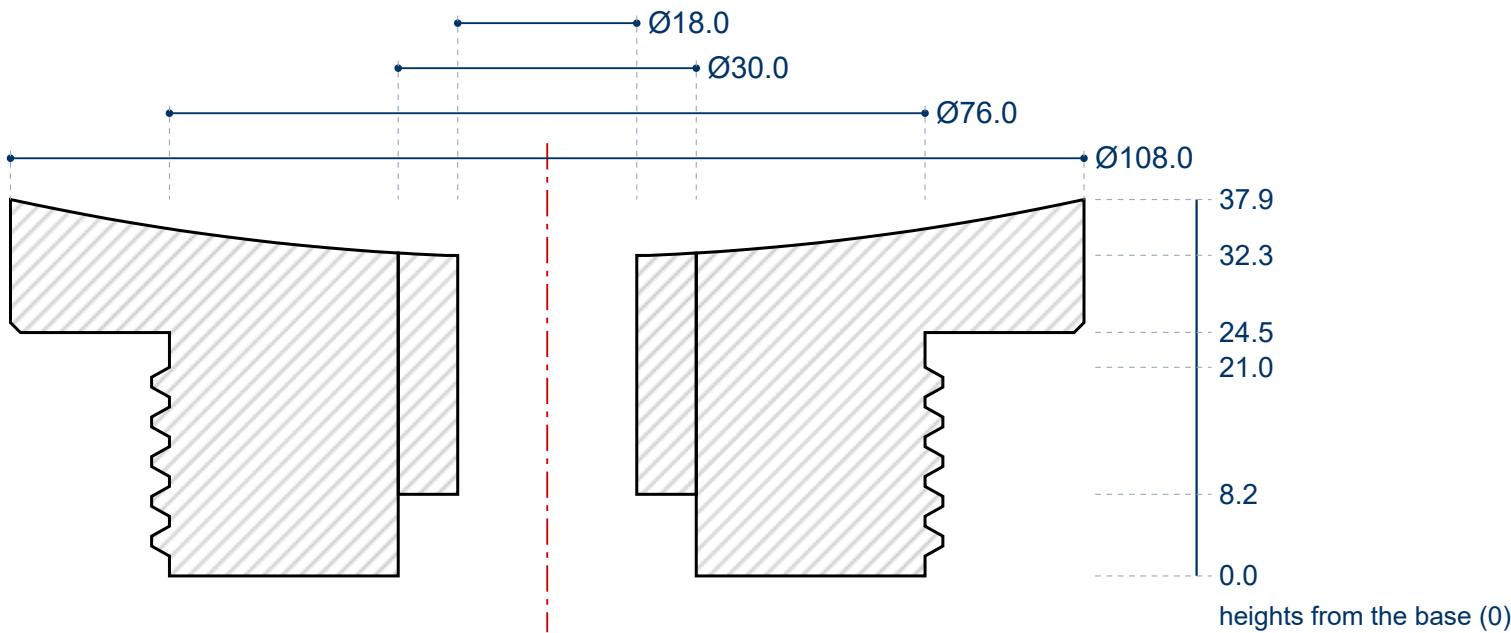


Part P4 - Tower B body (15 cm, 800 to 500)	Qty 1	Material Polypropylene (PP)
Process 3D print, ONE piece: HP Multi Jet Fusion PP (best) or FDM PP / ASA		
Base ring	OD 132 / ID 84 × 12 mm, underside spherical R400 (sits in the 800 bowl)	
Hub + spokes	hub OD 28 × 10, 6 spokes 6 × 8 mm	
Spigot (male)	plain OD 19.8, then M18 × 2, 14 mm - screws into P2 socket	
Bore	Dia 8.4 through, 3 × 45 deg lead-in chamfer on top	
Spirals	13 + 21, twist 110 deg	
Strut section	1 : 4 : 9 = 2.6 × 5.85 mm, corner R0.65	
Top ring	OD 108 × 18, INTERNAL thread dia 79.6 × 4 (custom)	
Height	base ring top to top-ring bottom 99 mm (pole to pole with cradle 148.5)	

Lattice not drawn in the section (only base ring, hub/spigot and top ring are turned profiles). Spirals and spokes: see the spec table and the part views. STL file: STL_parts_v14 folder.

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P5 · Tower B cradle

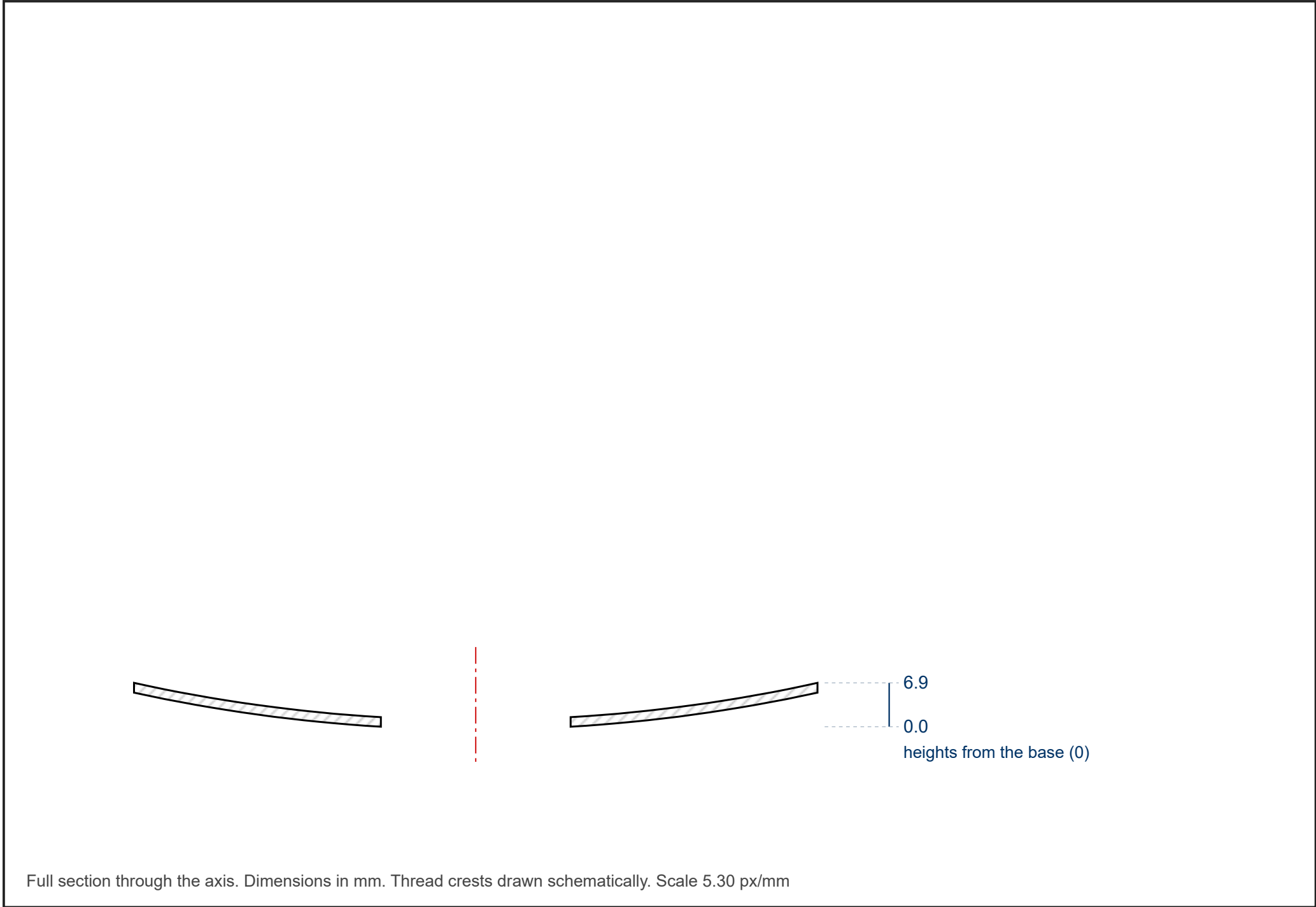


Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 5.30 px/mm

Part P5 - Tower B cradle	Qty 1	Material Polypropylene (PP)
Process CNC lathe from PP rod (or 3D print PP)		
Cradle ring	OD 108, top face CONCAVE spherical R253.0 (= R251.5 + 1.5 liner)	
Height thread (male)	dia 79.6 × 4 custom (root 76), 20 mm	
Centre socket (female)	M18 × 2, 22 mm deep, receives the P12 T-cup neck	
Adjustment	8.5 mm	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

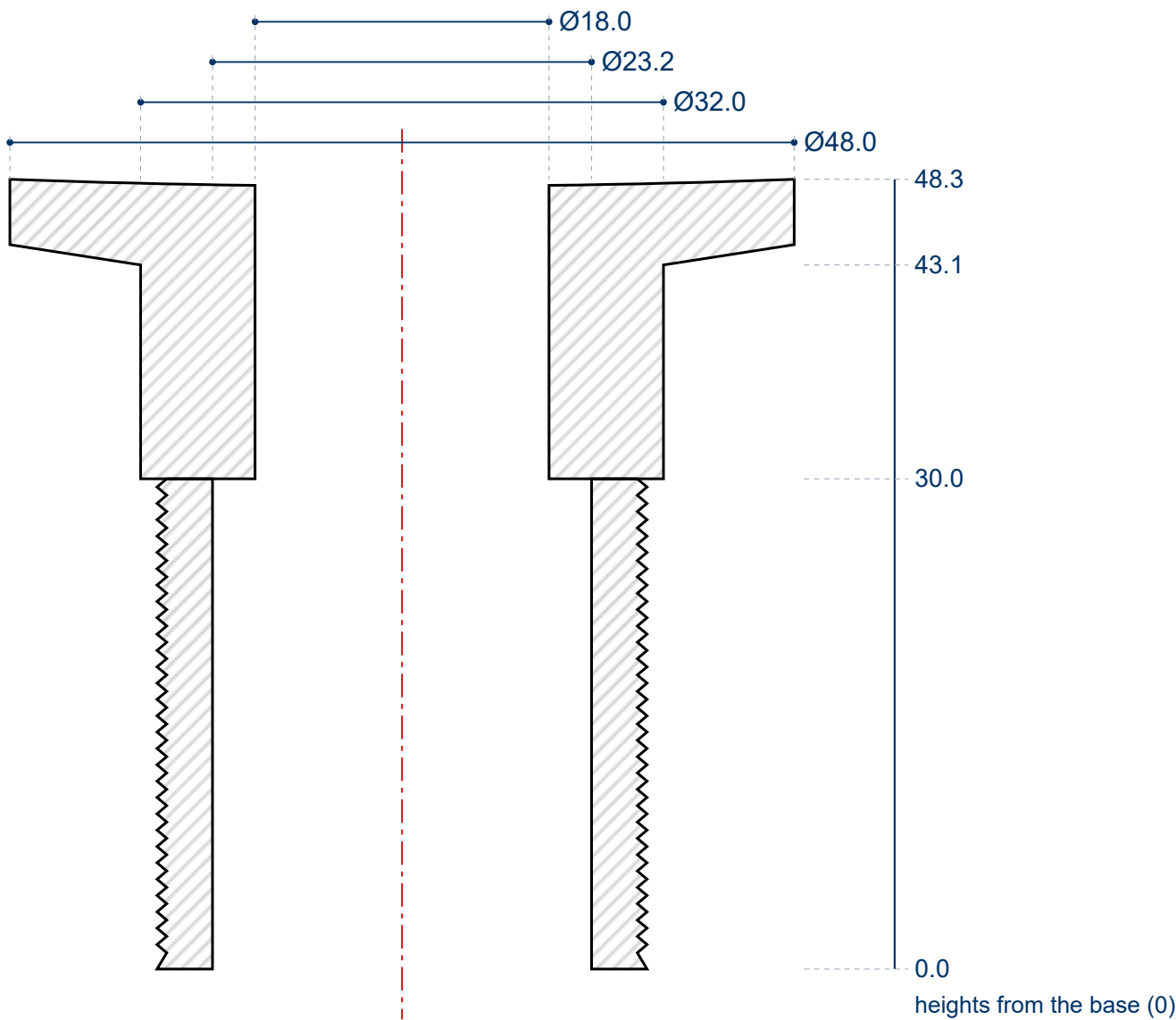
Technical drawing · P6 · Tower B liner



Part P6 - Tower B liner	Qty 1	Material PTFE (virgin)
Process CNC lathe, or press-formed from 1.5 mm sheet		
Shape	spherical ring 1.5 mm, R251.5 / R253.0	
Size	OD 108 / ID 30	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

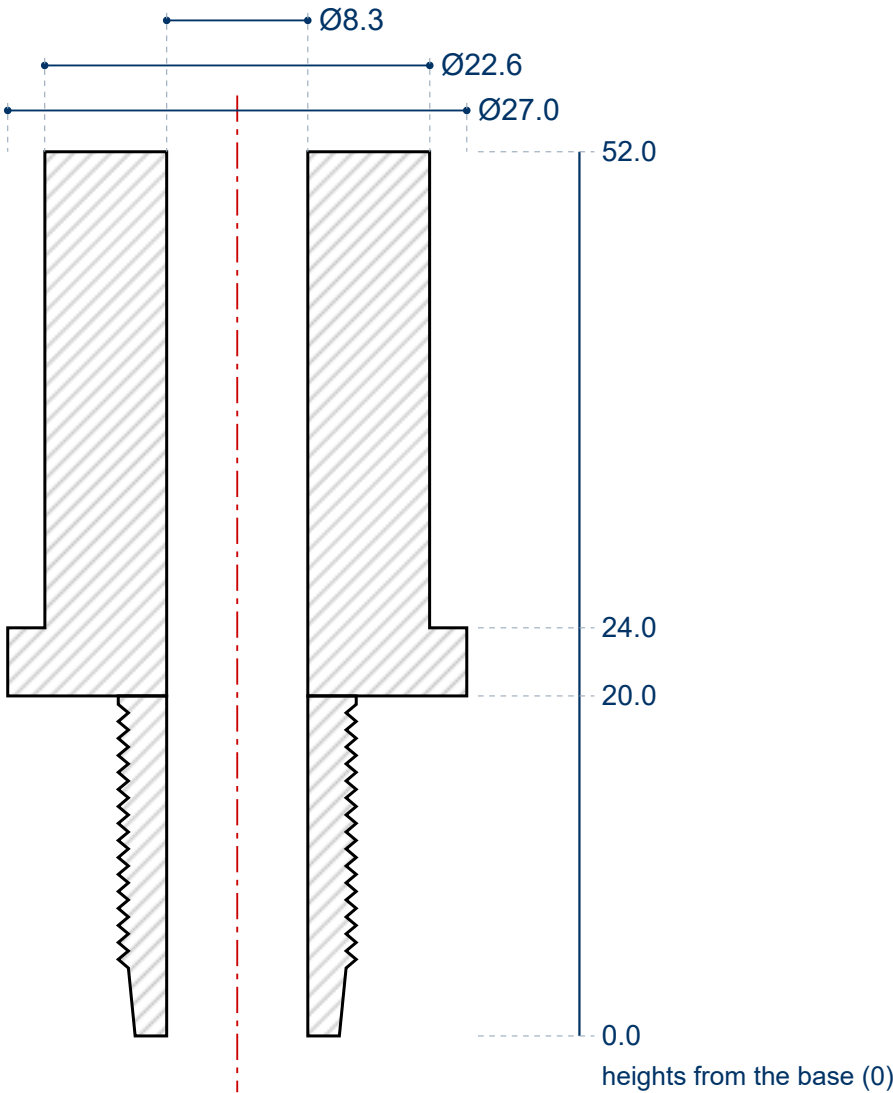
Technical drawing · P7 · Flanged nut + jack housing (ONE part)



Part P7 - Flanged nut + jack housing (ONE part)	Qty 1	Material POM-C (acetal / Delrin)
Process CNC lathe + hex broach/EDM (or mill) for the hex bore		
Flange	dia 48 × 4, face spherical R661.6 (seats on the P21 counter-ring)	
Nut body	dia 32, INTERNAL M18 × 2 - screws onto the P1 spigot	
Housing	OUTER thread M30 × 1, 30 mm long	
Hex bore	across flats 20.0 (+0.1), 30 mm deep (the drawing shows dia 23.2 = across corners)	
Note	dia 18 in the drawing = internal thread M18 × 2 (drawn at major dia)	
Total height	~48 mm	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P8 · Jack slider (cannot rotate)

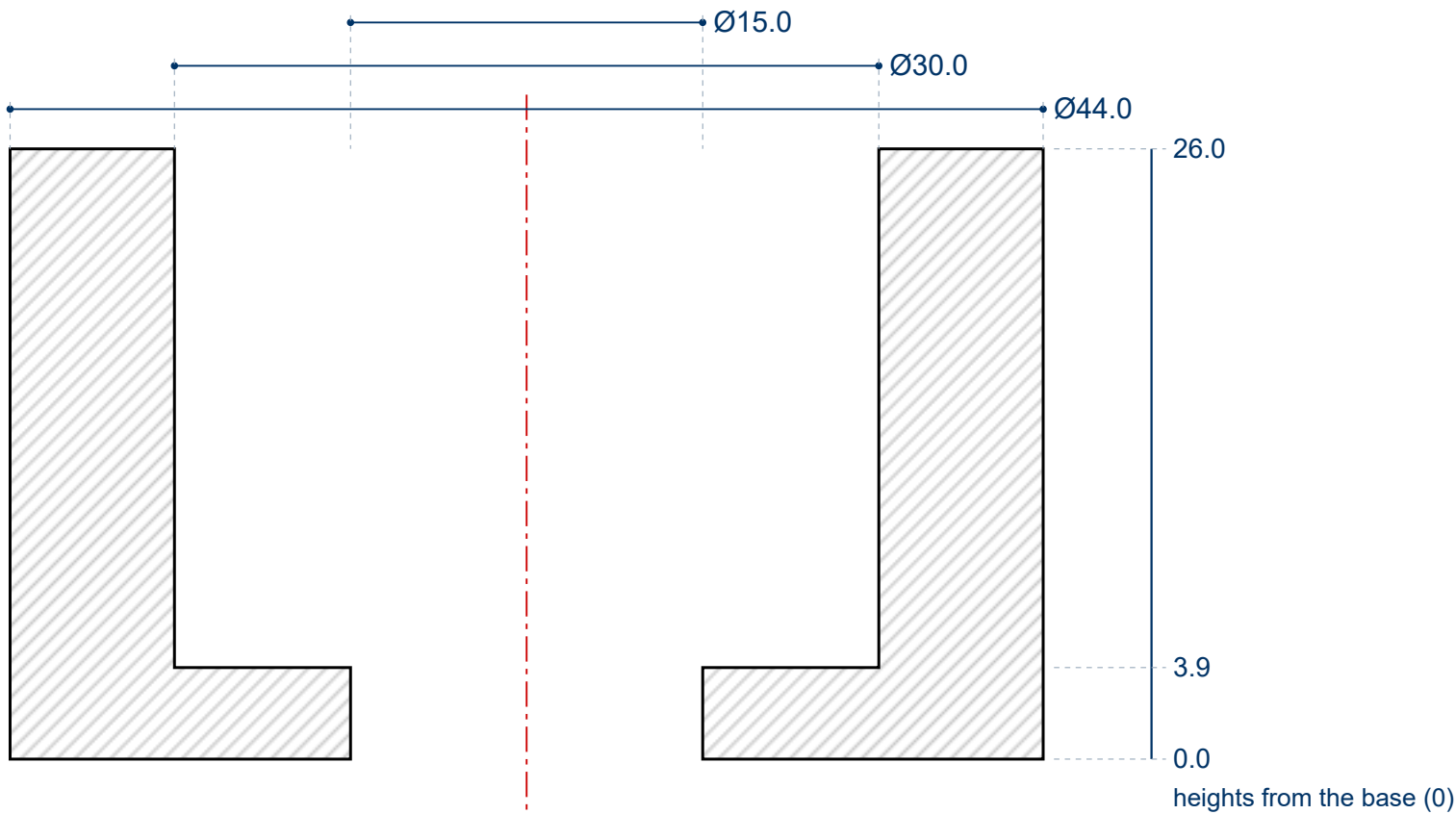


Full section through the axis. Dimensions in mm. Thread crests drawn schematically. HEX OUTSIDE: the outer diameter shown is across the corners; bores and threads are rounded

Part P8 - Jack slider (cannot rotate)	Qty 1	Material POM-C
Process CNC lathe from hex bar AF 19.6 (or mill)		
Hex body	across flats 19.6 (-0.05), 28 mm long - slides in the P7 hex bore	
Flange	hex 23.4 AF x 4 mm - rests on the P9 floor	
Collet stem	M14 × 1, 16 mm, 4 slots 1.5 wide x 12 deep, 10 deg taper at the end	
Bore	dia 8.3 through	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P9 · Adjusting cap = height wheel

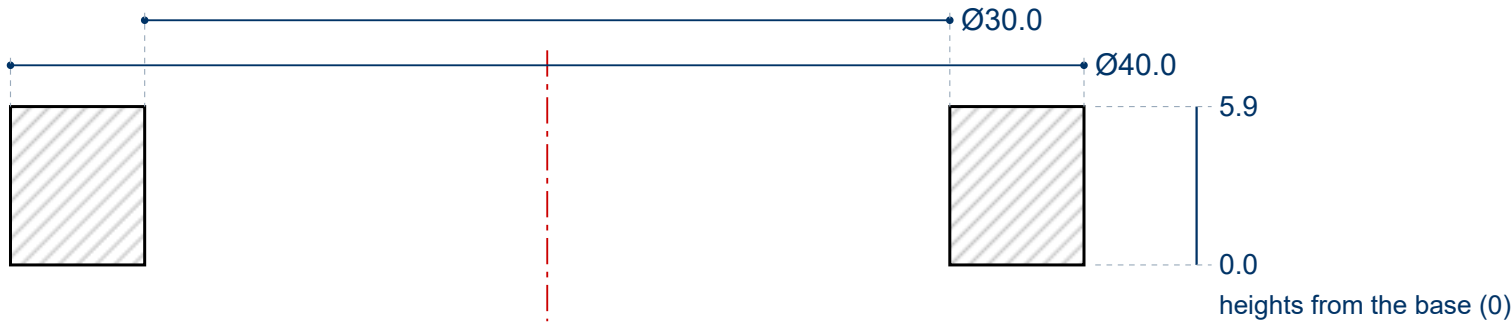


Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 13.00 px/mm

Part P9 - Adjusting cap = height wheel		Qty 1	Material POM-C
Process CNC lathe, knurled outside			
Outside	dia 44 knurled, height 26		
Thread	INTERNAL M30 × 1 (ONE TURN = 1 mm)		
Floor	4 mm thick, hole dia 15 for the collet stem		

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P10 · Lock ring

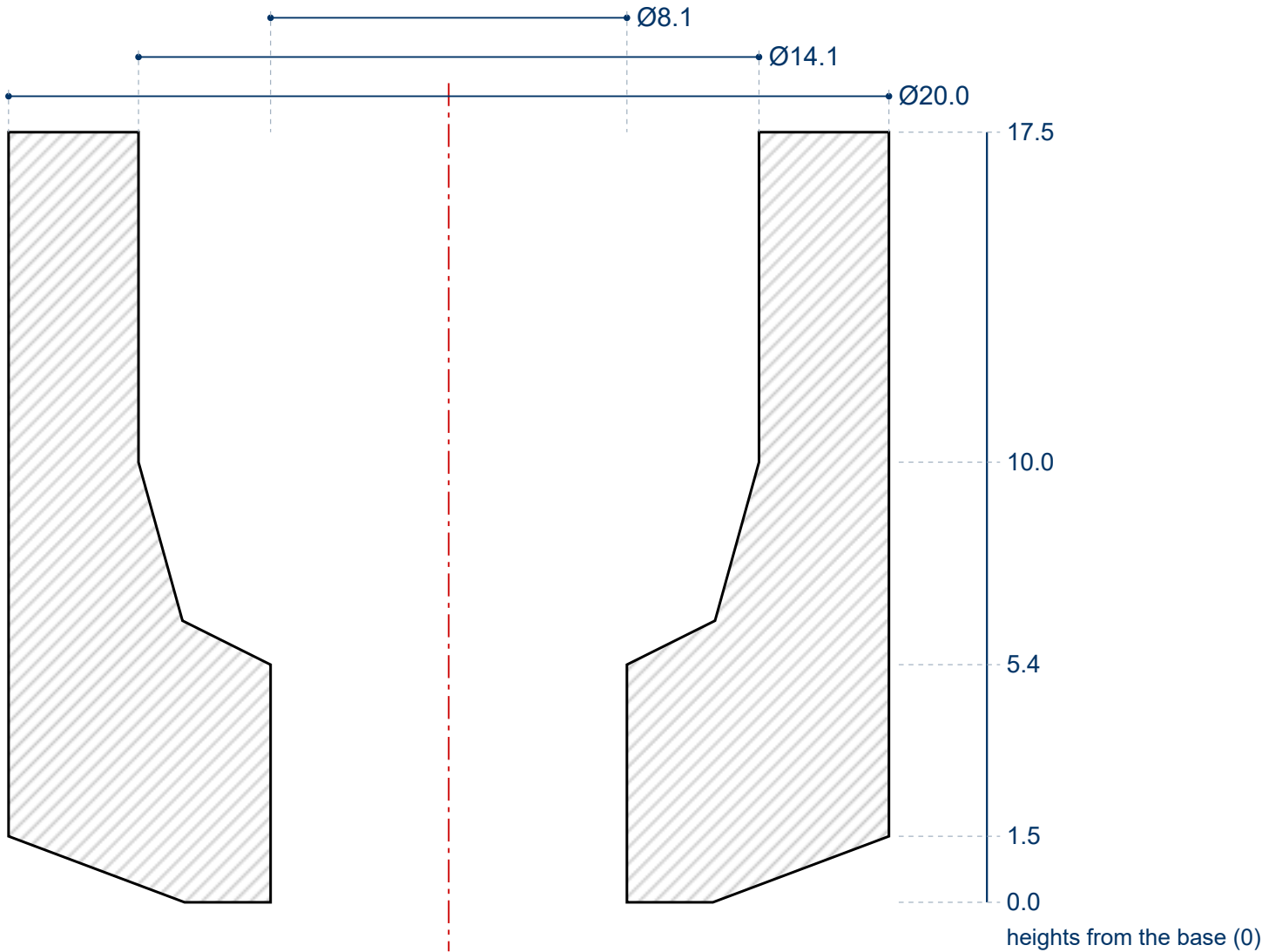


Full section through the axis. Dimensions in mm. Thread crests drawn schematically. HEX OUTSIDE: the outer diameter shown is across the corners; bores and threads are rounded.

Part P10 - Lock ring	Qty 1	Material POM-C
Process CNC lathe / hex bar		
Thread	INTERNAL M30 × 1	
Outside	hex ~35 AF x 6 mm	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P11 · Collet cap

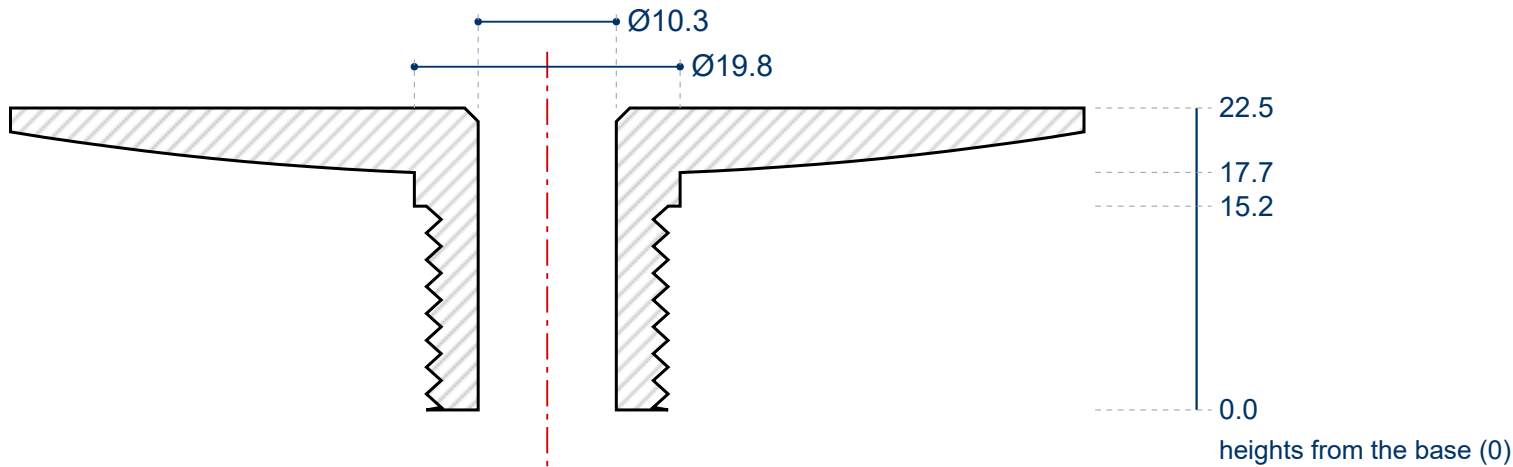


Full section through the axis. Dimensions in mm. Thread crests drawn schematically. HEX OUTSIDE: the outer diameter shown is across the corners; bores and threads are rounded.

Part P11 - Collet cap	Qty 1	Material POM-C
Process CNC lathe / hex bar		
Thread	INTERNAL M14 × 1, 7.5 mm long	
Closing cone	from dia 14.1 to dia 12.1 over 3.6 mm (~16 deg), matches the stem end - squeezes the 4 fingers	
Outside	hex 17.3 AF x 17.5	
Bore	dia 8.1 at the end	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P12 · Bottom T-cup (500, inside)

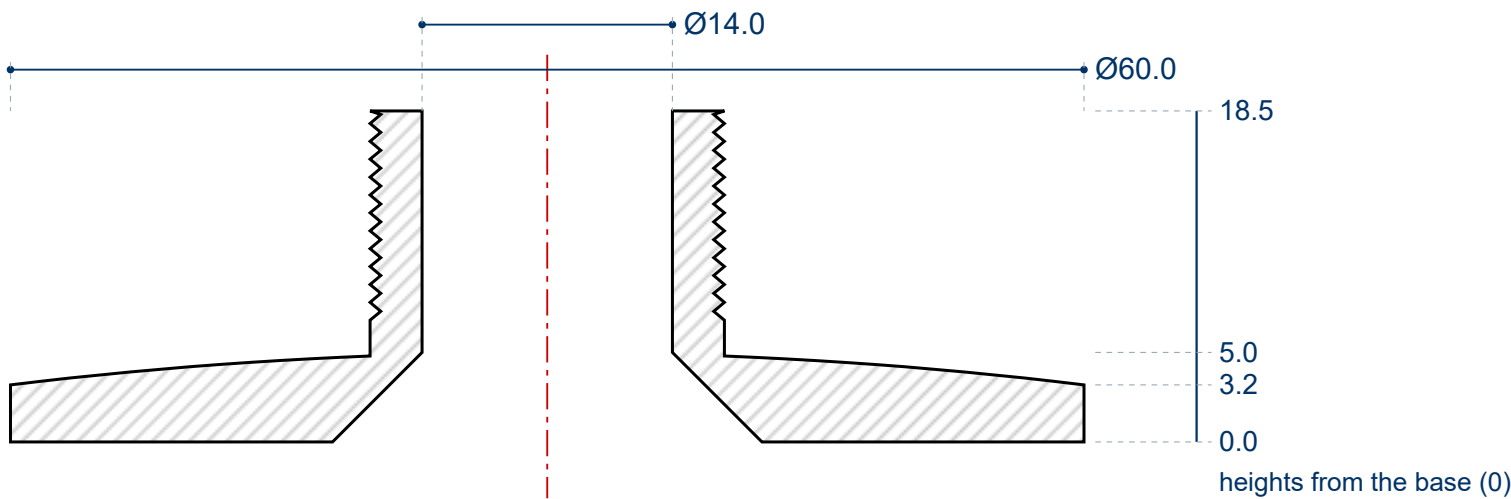


Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 7.15 px/mm

Part P12 - Bottom T-cup (500, inside)	Qty 1	Material PTFE (virgin)
Process CNC lathe		
Disc	dia 80 × 5 mm at the pole, outer face spherical R250 (inside of the 500)	
Bore	dia 10.3 H9 - sliding fit on the 10 mm tip tube, 1 × 45 deg chamfer on the Merkaba side	
Neck	plain dia 19.8 through the hole, then M18 × 2, 15 mm - into P5 socket	
Clearance	5 mm to the nearest Merkaba edge, 4 mm to the tube solder	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

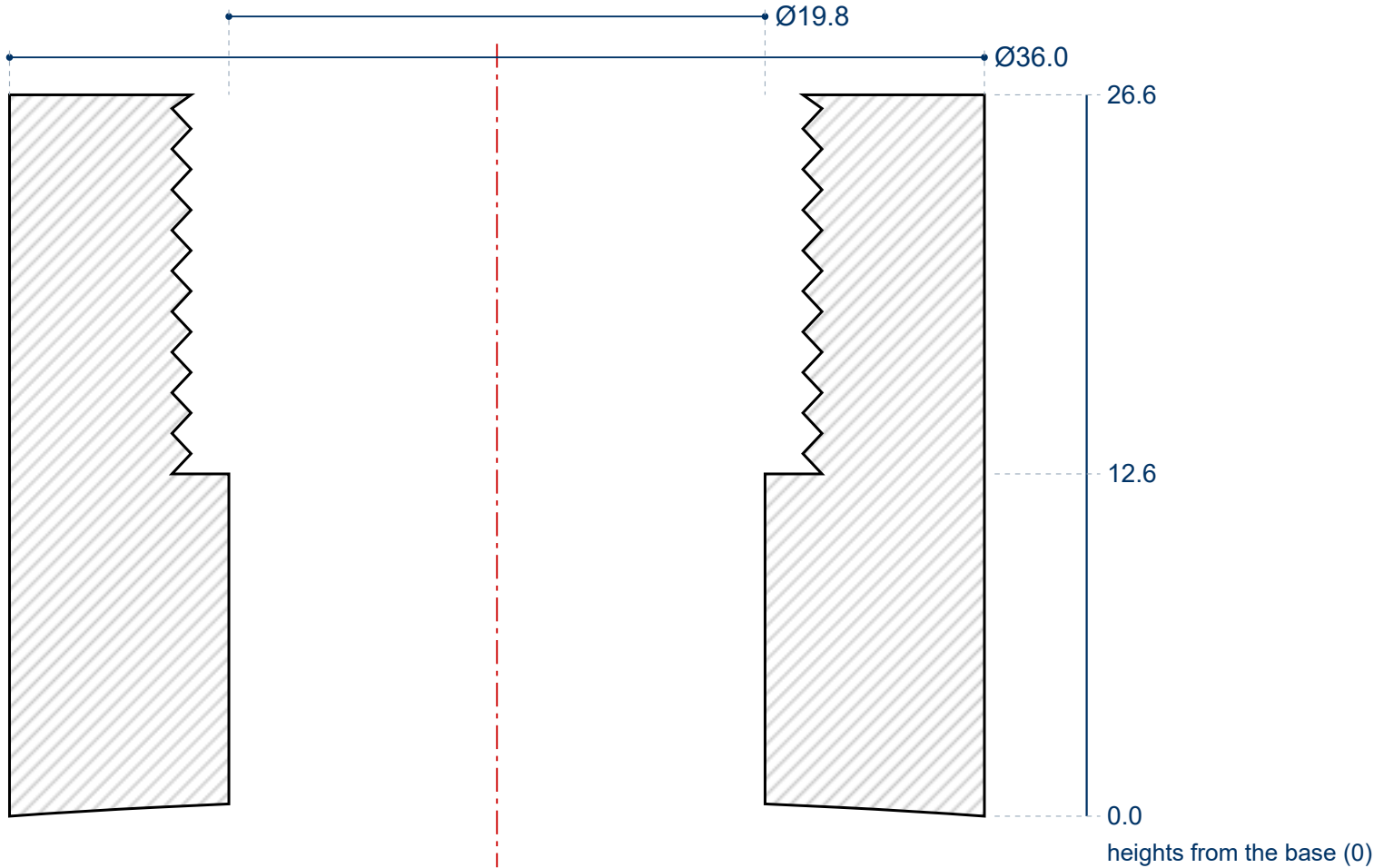
Technical drawing · P13 · Top T-disc (500, inside)



Part P13 - Top T-disc (500, inside)	Qty 1	Material PTFE (virgin)
Process CNC lathe		
Disc	dia 60 × 5 mm, outer face spherical R250	
Lead-in hole	dia 14 with 45 deg funnel to dia 24 (catches the rod)	
Neck	M20 × 1 (major dia 19.8), 11 mm	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P14 · Top nut 500 (outside)

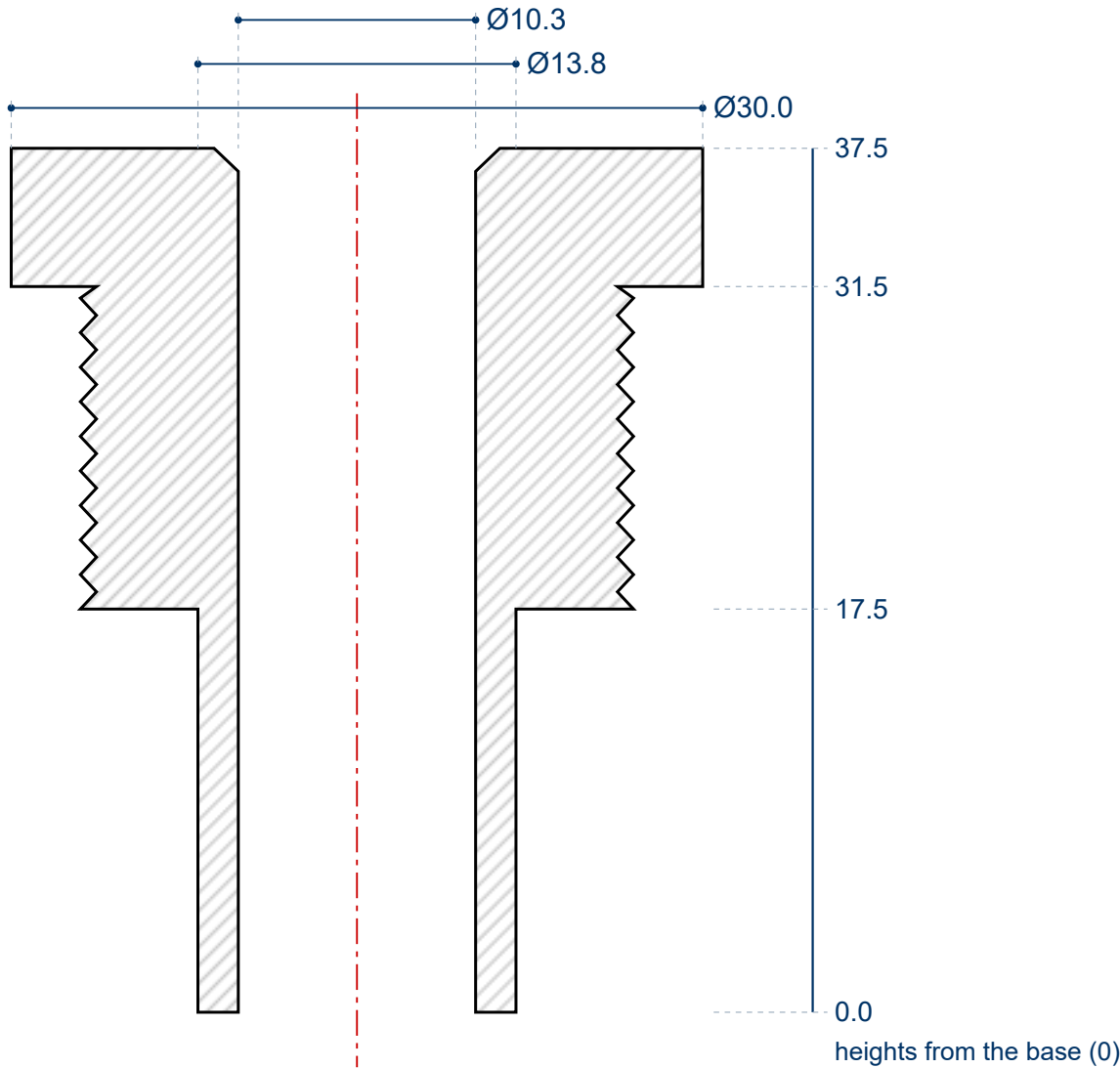


Full section through the axis. Dimensions in mm. Thread crests drawn schematically. HEX OUTSIDE: the outer diameter shown is across the corners; bores and threads are rounded.

Part P14 - Top nut 500 (outside)	Qty 1	Material PTFE (virgin)
Process CNC lathe / hex bar		
Lower thread	INTERNAL M20 × 1, 12 mm (on the P13 neck)	
Upper thread	INTERNAL M24 × 1.5, 14 mm (for P15)	
Outside	hex ~31 AF, face spherical R251.5	
Height	~27 mm	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P15 · Centring insert 10.3 (500)

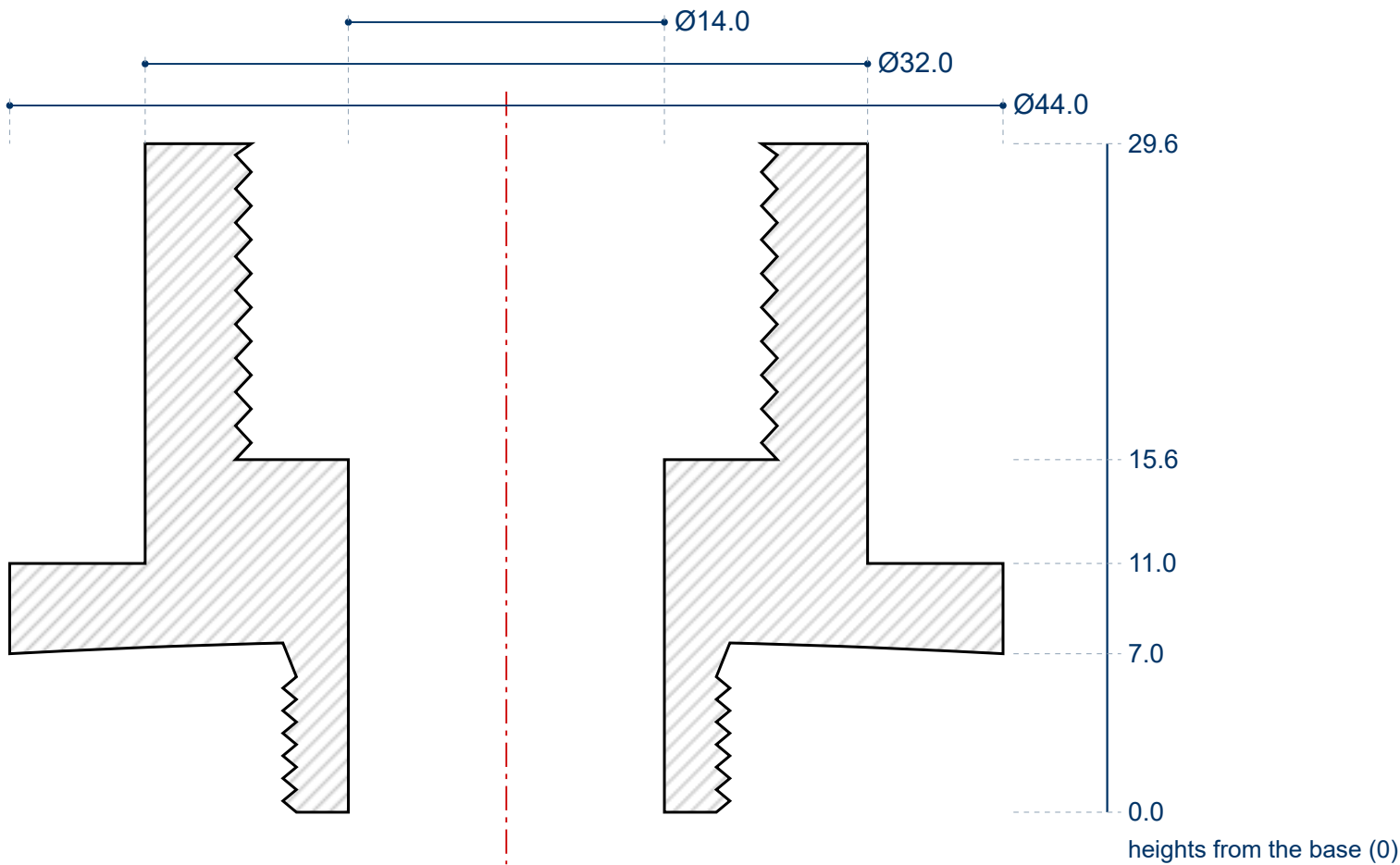


Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 12.57 px/mm

Part P15 - Centring insert 10.3 (500)		Qty 1	Material PTFE (virgin)
Process CNC lathe, knurled head			
Bore	dia 10.3 H9 - slides down the rod and over the tube		
Pilot	dia 13.8, reaches down into the T-disc		
Thread	M24 × 1.5, 14 mm		
Head	dia 30 × 6 knurled, 1 × 45 deg chamfer in the bore		

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

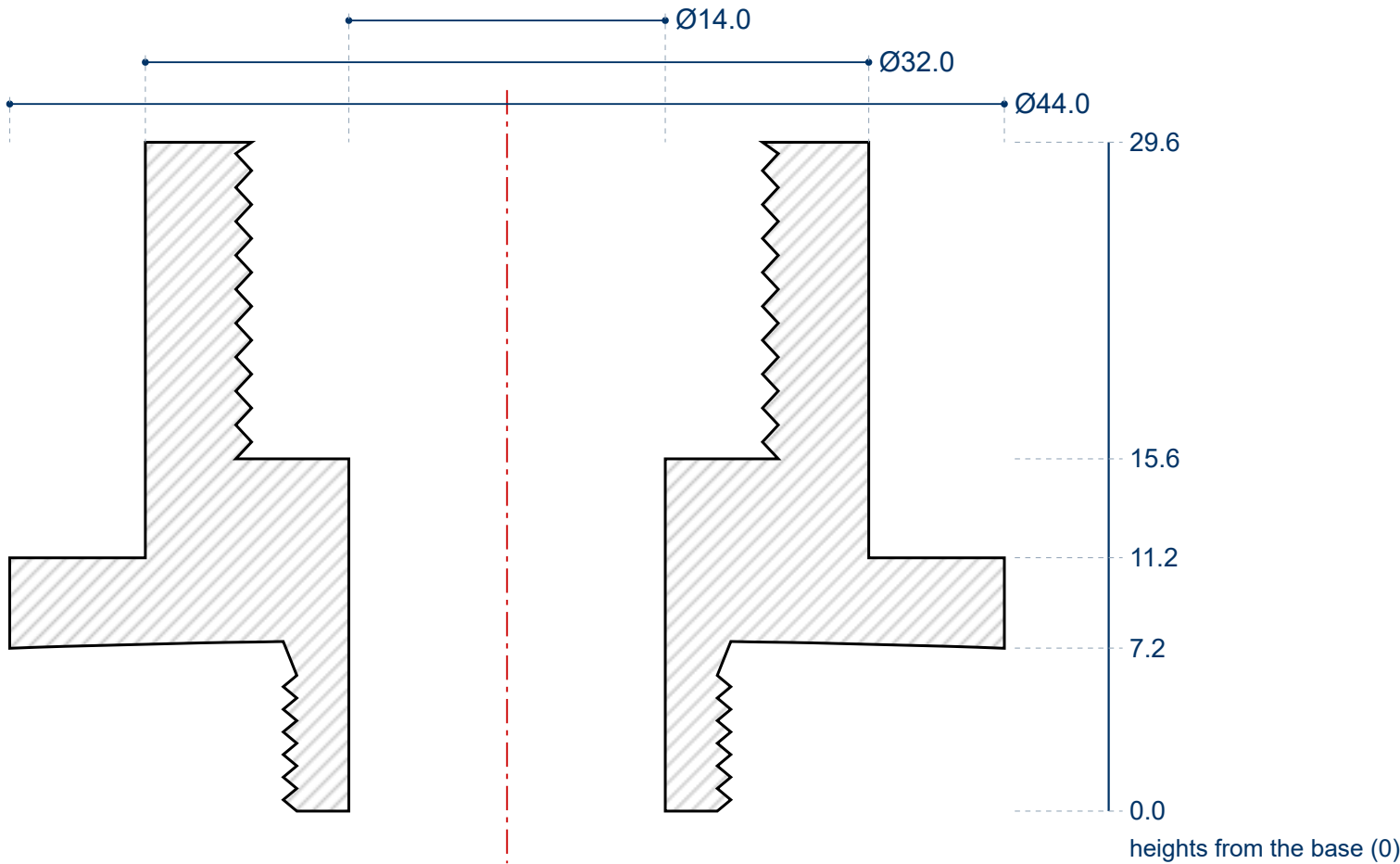
Technical drawing · P16 · Top lead-in fitting 800 (outside)



Part P16 - Top lead-in fitting 800 (outside)		Qty 1	Material PTFE (virgin)
Process CNC lathe			
Flange	dia 44 × 4, face spherical R401.5		
Spigot	dia 19.8 through the hole with M20 × 1 at the inner end		
Neck	dia 32, INTERNAL M24 × 1.5, 14 mm (for P20)		
Lead-in hole	dia 14		

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P17 · Top lead-in fitting 1300 (outside)



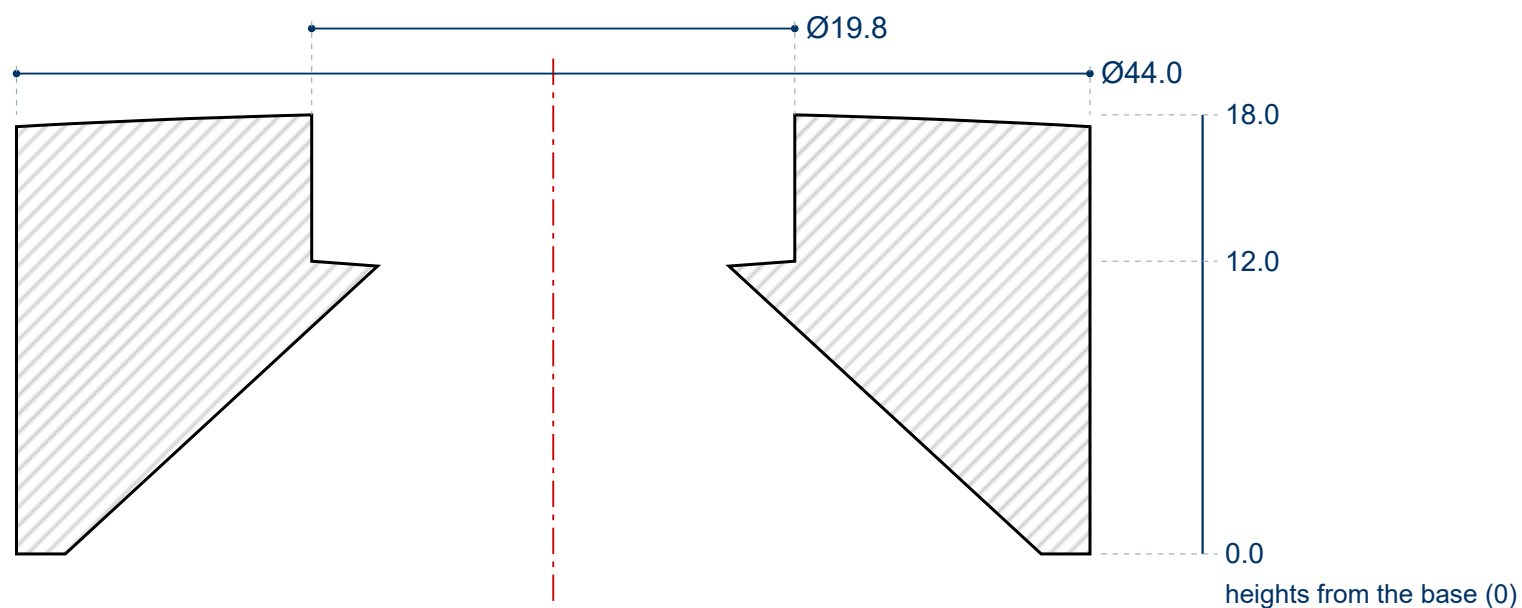
Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 13.00 px/mm

Part P17 - Top lead-in fitting 1300 (outside)	Qty 1	Material PTFE (virgin)
Process CNC lathe		

Same as P16 but flange face spherical R651.5

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P18 · Funnel ring 800 (inside)



Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 13.00 px/mm

Part P18 - Funnel ring 800 (inside)	Qty 1	Material PTFE (virgin)
Process CNC lathe		
Thread	INTERNAL M20 × 1 (on the P16 spigot)	
Top face	spherical R400 (inside of the 800)	
Funnel	from dia 40 down to dia 14	
Outside	dia 44 × 18	

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.



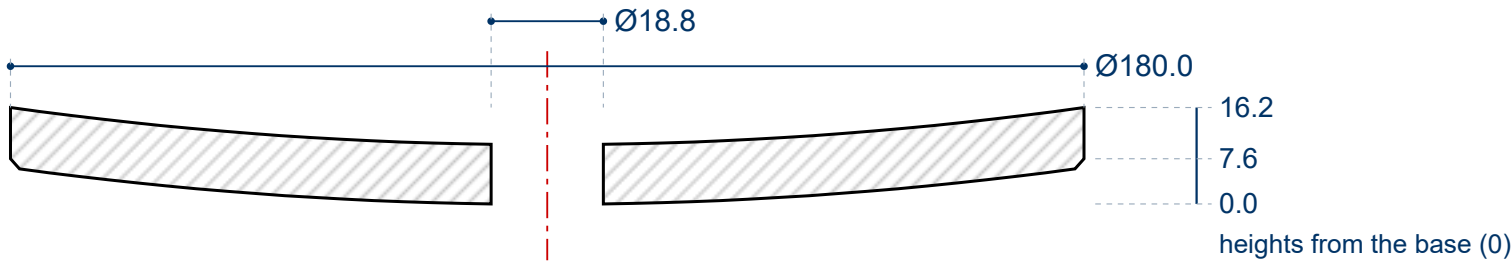
Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 13.00 px/mm

Part P19 - Funnel ring 1300 (inside)	Qty 1	Material PTFE (virgin)
Process CNC lathe		

Same as P18 but top face spherical R650

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P21 · Counter-ring 180 (outside, under the 1300)



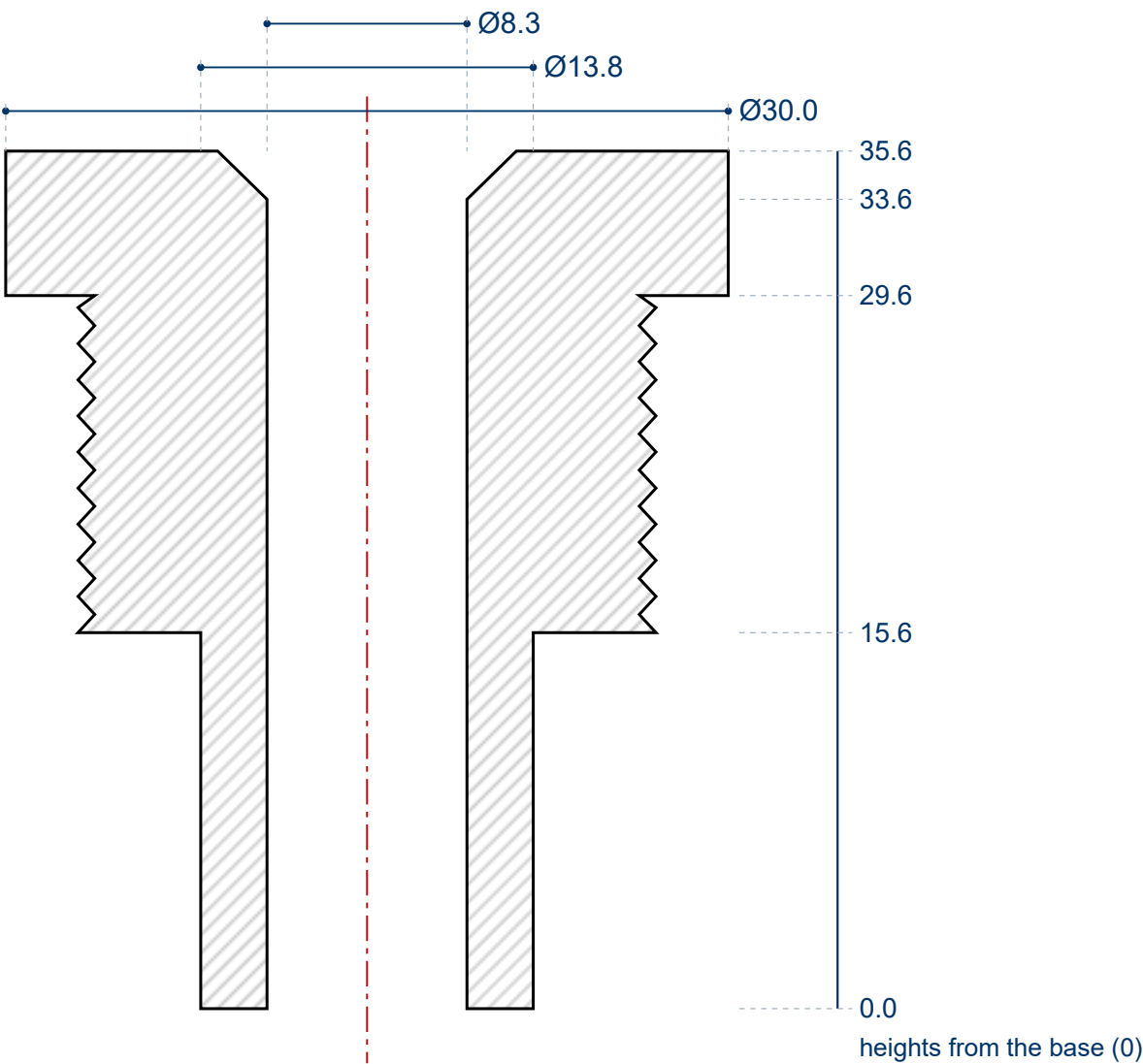
Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 3.18 px/mm

Part P21 - Counter-ring 180 (outside, under the 1300)	Qty 1	Material Polypropylene (PP)
Process CNC lathe from PP plate, or 3D print PP		

Ring	OD 180 / ID 18.8 × 10 mm
Top face	CONCAVE spherical R651.5 - follows the outside of the 1300 sphere
Bottom face	spherical R661.5 - the flanged nut P7 seats here
Job	matches the 180 mm base ring of Tower A inside: the copper is clamped between two equal rings

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Technical drawing · P20 · Centring insert 8.3 (800 and 1300)



Full section through the axis. Dimensions in mm. Thread crests drawn schematically. Scale 13.23 px/mm

Part P20 - Centring insert 8.3 (800 and 1300)		Qty 2	Material PTFE (virgin)
Process CNC lathe, knurled head			
Bore	dia 8.3 H9 on the 8 mm rod		
Pilot	dia 13.8, reaches the funnel ring		
Thread	M24 × 1.5, 14 mm		
Head	dia 30 × 6 knurled		

General tolerances ISO 2768-m. Bores marked H9 = sliding fits. Break all sharp edges 0.3 mm. Threads to ISO metric unless marked custom. Dimensions in mm.

Parts list (BOM) - for outsourcing

ID	PART	QTY	MATERIAL	PROCESS / NOTE
P1	Tower A body (25 cm, 1300 to 800)	1	Polypropylene (PP)	3D print, ONE piece: HP Multi Jet Fusion PP (best) or FDM PP / ASA
P2	Tower A cradle	1	Polypropylene (PP)	CNC lathe from PP rod (or 3D print PP)
P3	Tower A liner	1	PTFE (virgin)	CNC lathe, or press-formed from 1.5 mm PTFE sheet
P4	Tower B body (15 cm, 800 to 500)	1	Polypropylene (PP)	3D print, ONE piece: HP Multi Jet Fusion PP (best) or FDM PP / ASA
P5	Tower B cradle	1	Polypropylene (PP)	CNC lathe from PP rod (or 3D print PP)
P6	Tower B liner	1	PTFE (virgin)	CNC lathe, or press-formed from 1.5 mm sheet
P7	Flanged nut + jack housing (ONE part)	1	POM-C (acetal / Delrin)	CNC lathe + hex broach/EDM (or mill) for the hex bore
P8	Jack slider (cannot rotate)	1	POM-C	CNC lathe from hex bar AF 19.6 (or mill)
P9	Adjusting cap = height wheel	1	POM-C	CNC lathe, knurled outside
P10	Lock ring	1	POM-C	CNC lathe / hex bar
P11	Collet cap	1	POM-C	CNC lathe / hex bar
P12	Bottom T-cup (500, inside)	1	PTFE (virgin)	CNC lathe
P13	Top T-disc (500, inside)	1	PTFE (virgin)	CNC lathe
P14	Top nut 500 (outside)	1	PTFE (virgin)	CNC lathe / hex bar
P15	Centring insert 10.3 (500)	1	PTFE (virgin)	CNC lathe, knurled head
P16	Top lead-in fitting 800 (outside)	1	PTFE (virgin)	CNC lathe
P17	Top lead-in fitting 1300 (outside)	1	PTFE (virgin)	CNC lathe
P18	Funnel ring 800 (inside)	1	PTFE (virgin)	CNC lathe
P19	Funnel ring 1300 (inside)	1	PTFE (virgin)	CNC lathe
P21	Counter-ring 180 (outside, under the 1300)	1	Polypropylene (PP)	CNC lathe from PP plate, or 3D print PP
P20	Centring insert 8.3 (800 and 1300)	2	PTFE (virgin)	CNC lathe, knurled head
C1	Copper rod, solid, Cu-ETP - dia 8 mm x 798 mm	2	copper	top and bottom rod
C2	Copper tube EN 1057 - 10 × 1 mm, piece ~46 mm	2	copper	25 mm above the tip + 5.7 mm over the apex + 15 mm slit into 3 tabs
C3	Solder - Sn96.5Ag3.5 or Sn60Pb40 + flux	1	solder	tabs to tip, rod into tube

Send to the machine shop: this PDF + the STL files in the folder **STL_parts_v14** (one file per part, in millimetres).
Send to the 3D print service: P1 and P4 STL files, material PP (HP MJF), fully dense.