SolarScope Design & Build

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Inspiration

- I hadn’t been specifically interested in Solar Viewing
- Attending the Hall Place Outreach was impressed with the SolarScopes that Andy and Rita demonstrated
- Researched different models on the internet and selected a
- Researched the Elevation, Optical and construction requirements to build one

SolarScope Models

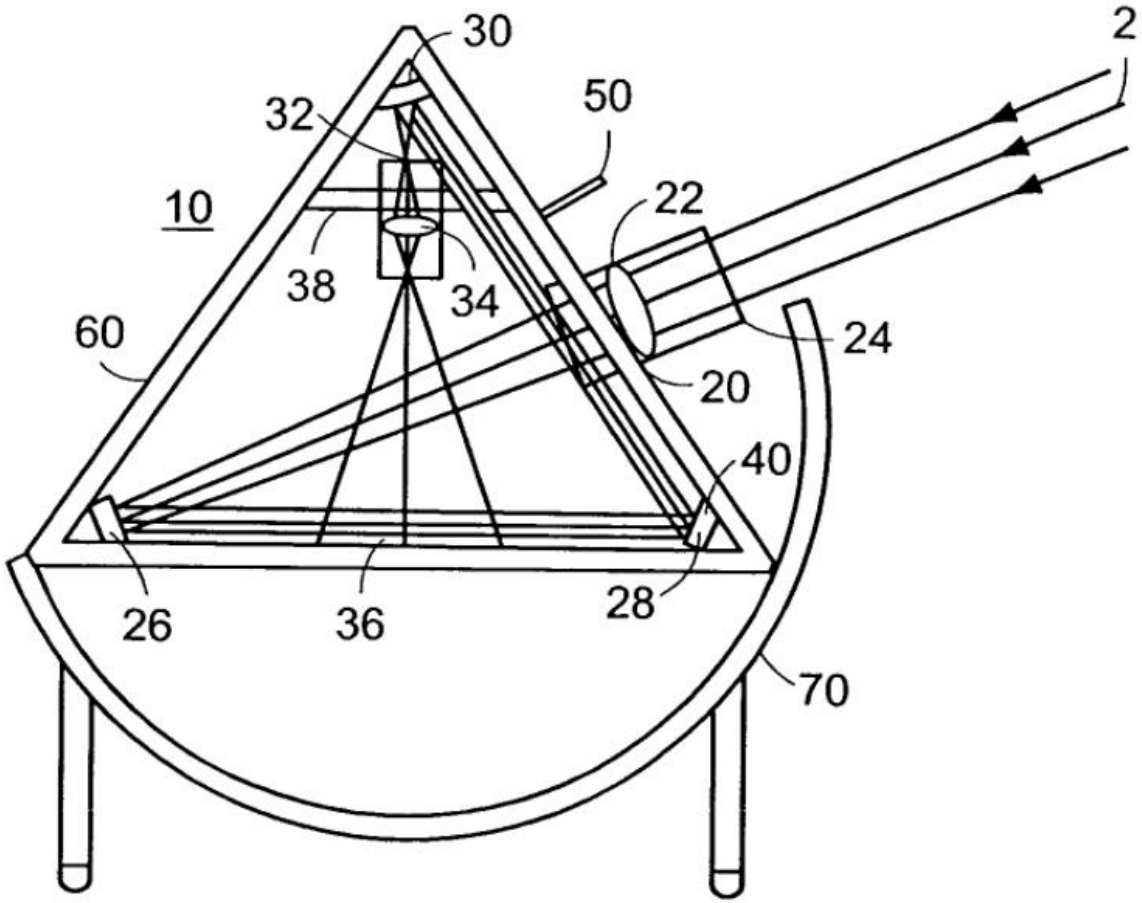
WOODEN FOLDED SUNSPOTTER
KEPLERIAN TELESCOPE

Comparison of Wooden and Card Models

- YouTube comparison by Wayne Schmidt
- Sunspotter on the left (fuzzy)
- SolarScope on the right (clear)

Selection Process – Sunspotter Model

- The wooden model was rejected due to:
  - Need to bend the cradle shape
  - The tricky multiple light paths to align
  - Fuzzy image from the YouTube Comparison

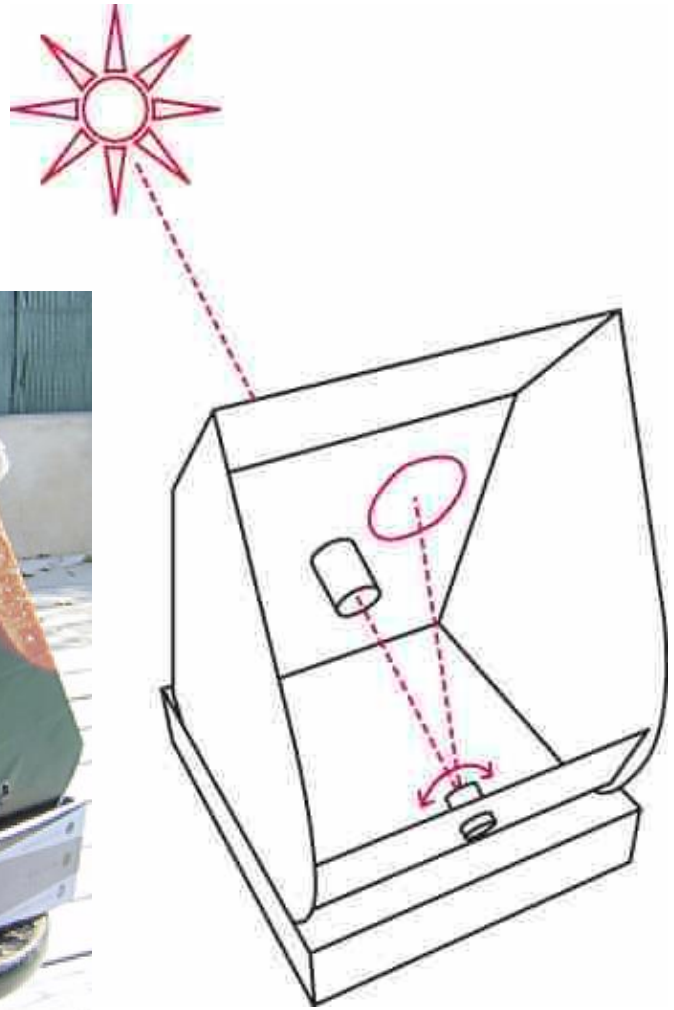


Selection Process – Card Models

- I felt that the Smaller model was a little too small though effective all the same and had items that could be incorporated
- The larger model was selected because more than one person could view relatively easier

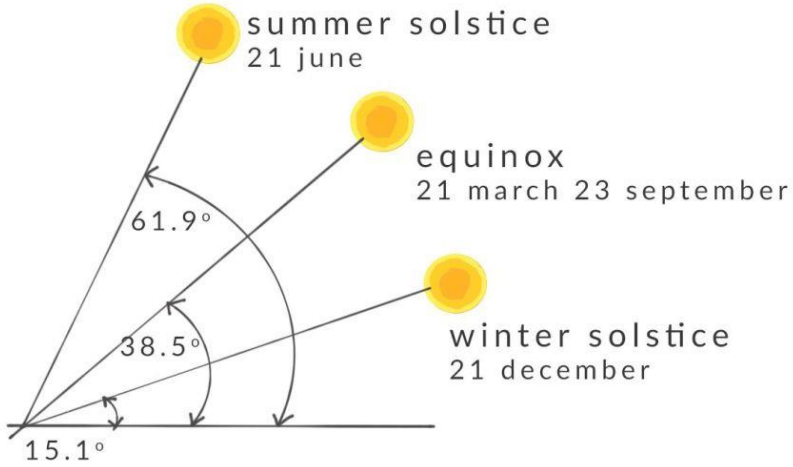
SolarScope Basic Function

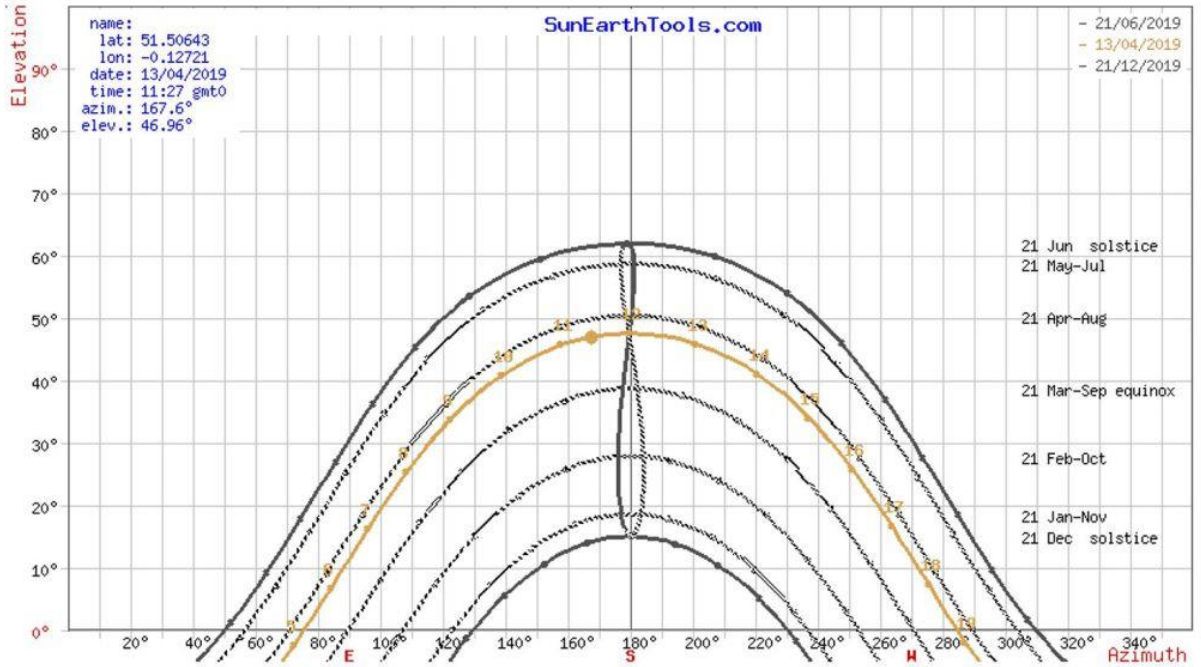
- The SolarScope employs a light gathering tube that holds a primary lens that is focused onto a reflecting lens and the image of the Solar disc is displayed on the white inside of the rear back panel



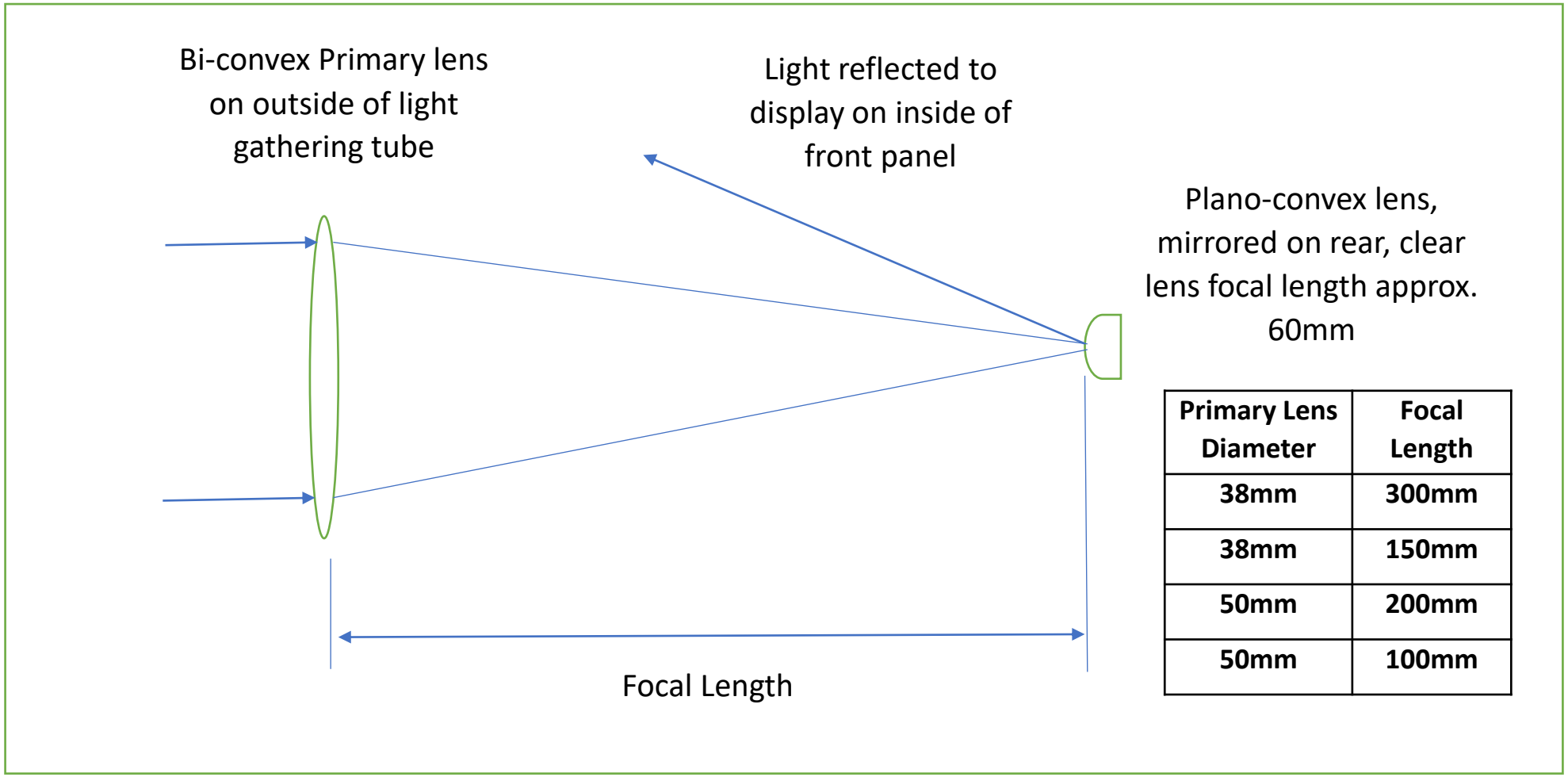
Design Considerations

- To build an effective SolarScope it must be enabled to adjust for elevation of the Sun at different times of the year and each day.
- The diagram indicates the maximum elevation at principal times of the year at a location in London with Lat: 51.50643 N, Lon: 0.12721 W which gives maximum elevation of the Sun between 15 degrees and 62 degrees.
- These diagrams were taken from: https://www.firstinarchitecture.co.uk/building-fabric-03-sunlight-and-solar-gain/ to determine a range of altitudes that the SolarScope would need to be able to cover.
- It is intended that the device would be made of plywood.





Light Path, Focal Length & Primary Lens Choice



Primary Lens Diameter	Focal Length
38mm	**300mm**
38mm	**150mm**
50mm	**200mm**
50mm	**100mm**

Light Gathering Tube & Focussing Possibilities

- The light gathering tube houses the bi-convex at the outer end.
- The tube needs to have a means of moving in and out to enable the light to be focussed on the inside of the front panel via the plano-convex reflecting lens.
- One suggestion is a fairly coarse groove with guide bearing but difficult to find or make one
- Item 3 seemed to be the best approach and a modified version of this idea was used.

Possible Primary Lens Focus Assemblies

1 Rack Pinion Design 1.25” R&P Telescope Focuser
Conclusion: overkill and difficult to focus as adjuster would be too close to back panel

2 M42 Variable Extension Tube T2-Extension
Conclusion: the desired length could be accomplished but the short thread length would be a problem to fix to a wooden panel

3 1.5” BSP Tank Adaptor
Conclusion: Ample screw thread length To fit through panel and fitting flange Grommet would lock an internal light tube holding the primary lens

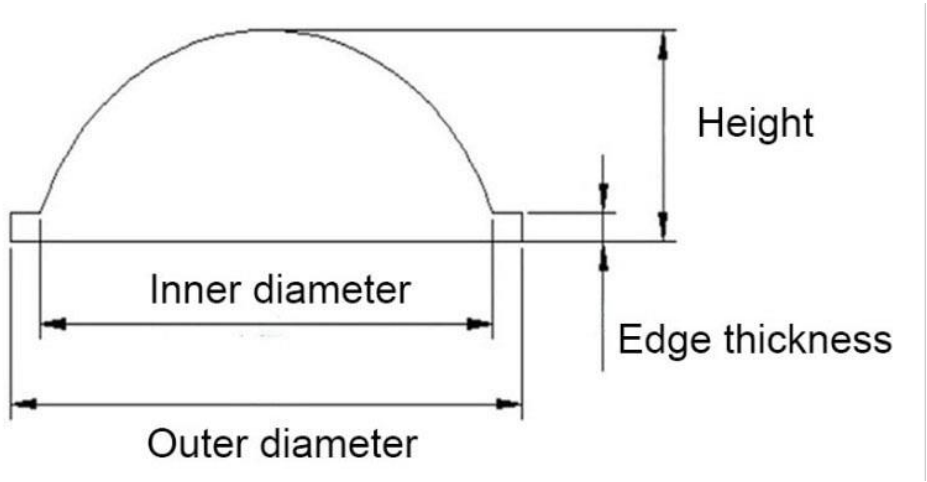
ALL THESE OPTIONS DISCARDED DUE TO IMPRACTICALITY IN USE

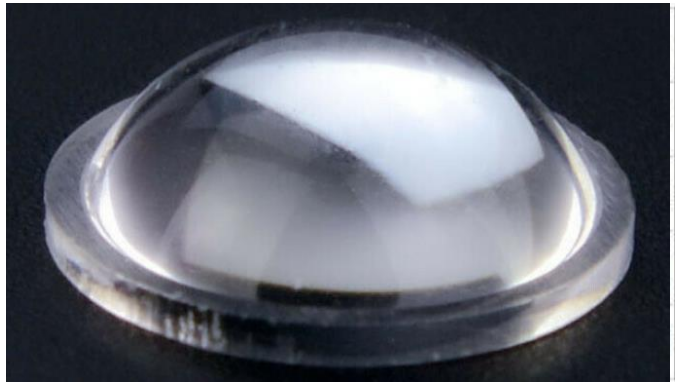
Plano-Convex Reflecting Lens 1

- A Plano-convex lens had been in possession for many years and this project offered a use for it.
- As a proof of concept a 22mm brass plumbing fitting was adapted to fix to a front panel. The bottom of the lens would fit into the chamfered fitting and two flanges were adapted to provide a fixing to a plate (here simulated with a folded envelope) that will ultimately be used to fix into slots in the side panel assembly.
- The rear of the lens could be mirrored with say Rust-oleum
- Advice when presenting this at CMHASD was that the mirroring should be on the front of the lens to prevent distortion of the reflected image that might occur if the light passed through the lens twice.
- THIS IDEA WAS EVENTUALLY DISCARDED AS FOCAL LENGTH OF THE LENS WAS TOO LONG.

Plano-Convex Reflecting Lens 2

- Rita felt that the convex of the previous lens was too shallow a curve so it may be replaced by a more rounded lens as illustrated and used in LED torches
- Smaller lens sizes offer a small focal length so need to understand impact on reflected solar image. Focal length of around 8mm was needed and an alternative found.





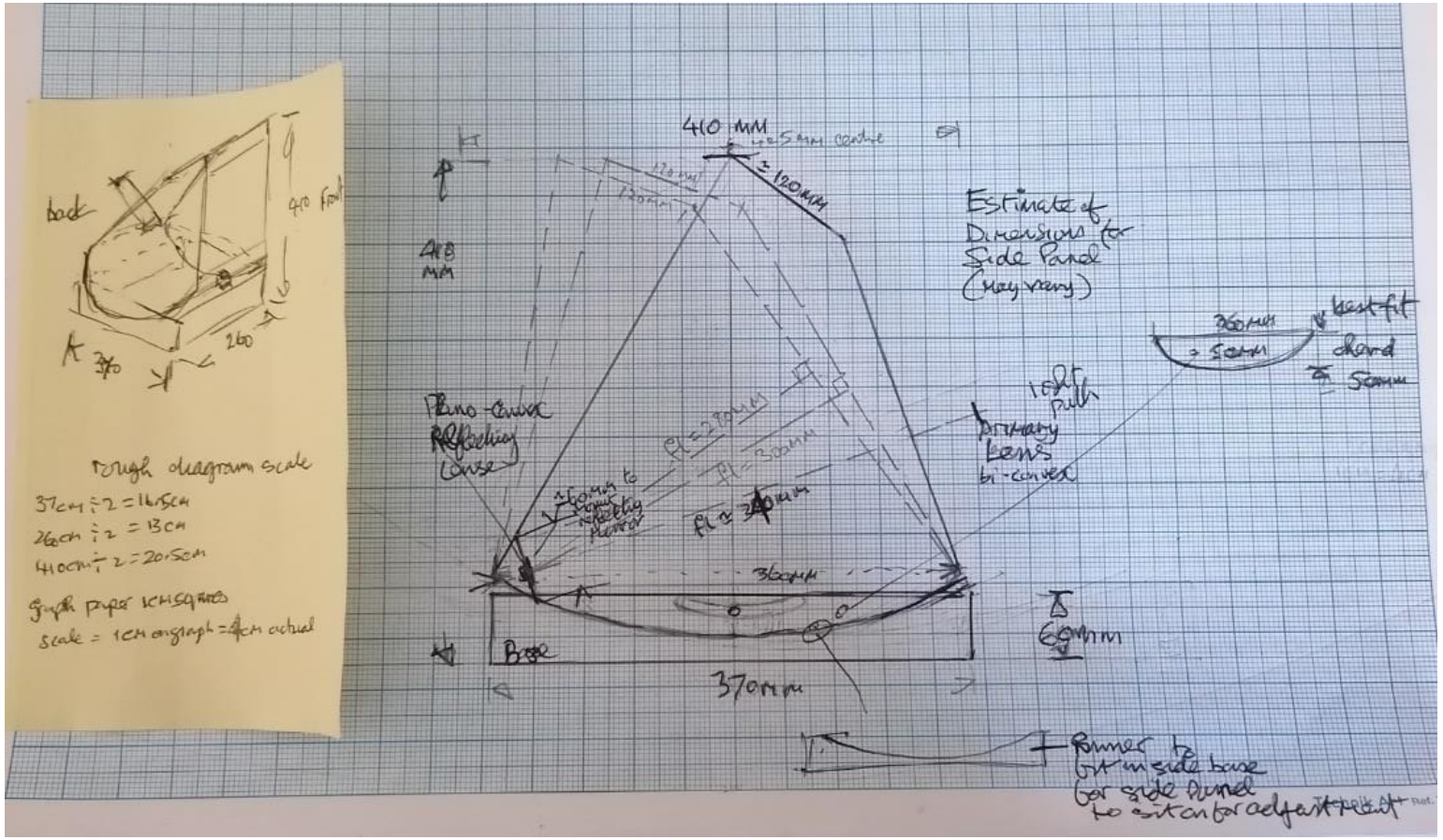
Outer diameter (mm	12.5	15	18	19.8	20.2	22	23	24	27.5	28	30	32	34	35	38	39	40
Inner diameter (mm)	10	13	16	18.5	17.8	20	21	22.5	25	25	27.5	24	31.5	32	35.8	36.9	36
Height (mm)	3.6	6	7	7.5	8.1	7	8.2	10.4	10.2	9.8	9.8	7.8	21	16	19.5	15.5	16
Edge thickness (mm)	1.4	1.5	2.4	1.5	2.8	3	1.6	2.1	2.7	3	2.6	2.4	3	3	2.5	2.5	2.5
Focal length (mm)	10	10	14.5	14	13	27	18	14	16.5	25	25	21	11	17	16	19	22

Summary & Discussion at End of Original Presentation

- This is a work in progress and I have come up with many ideas to build a SolarScope based on the proprietary model
- Ultimately a finished design will be documented and the documentation donated to the Society for others to build their own if they wish
- The following are slides that cover follow up action on design and build and finished device.

Draft Outline Diagram of Side Panel

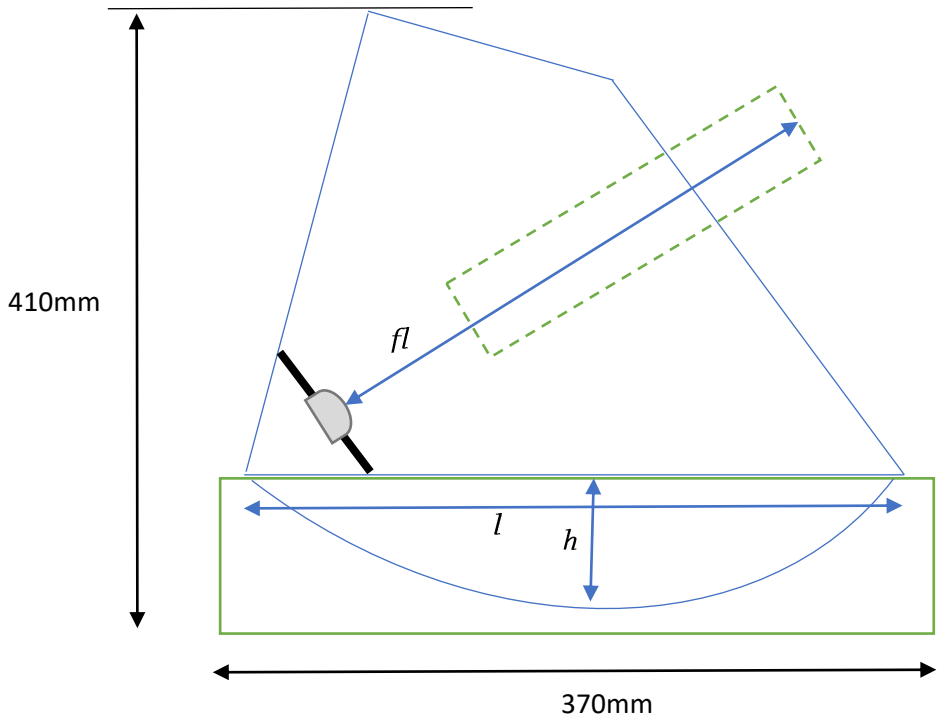
- The dimensions are approximate from the pictures and memory
- The light path must be at 90 degrees to the back panel
- The effect of making the Front panel more upright shortens the focal length required for the light gathering tube
- A radius slot on each side panel with a connecting rod across will help guide for elevation adjustment and keep top and bottom sections together – later discarded
- Rita provided measurements from and my Son drew it up on AutoCad



Side Elevation Schematic & Calculations for Radius of Curved Arc of Chord at Bottom end

- Approximate Dimensions - Side length - 370mm; Height - 410mm; Width - 260mm
- Formula for Radius for Arc = $(4*h^2 + l^2)/(8*h)$
- Various values were calculated as below to get a usable curve (the last from a measurement of the proprietary device
- A schematic from Rita gave better definition of the side panel and base unit dimensions.

h mm	l mm	Radius mm
10	360	1625
20	360	820
30	360	555
40	360	425
50	360	349
105	300	160

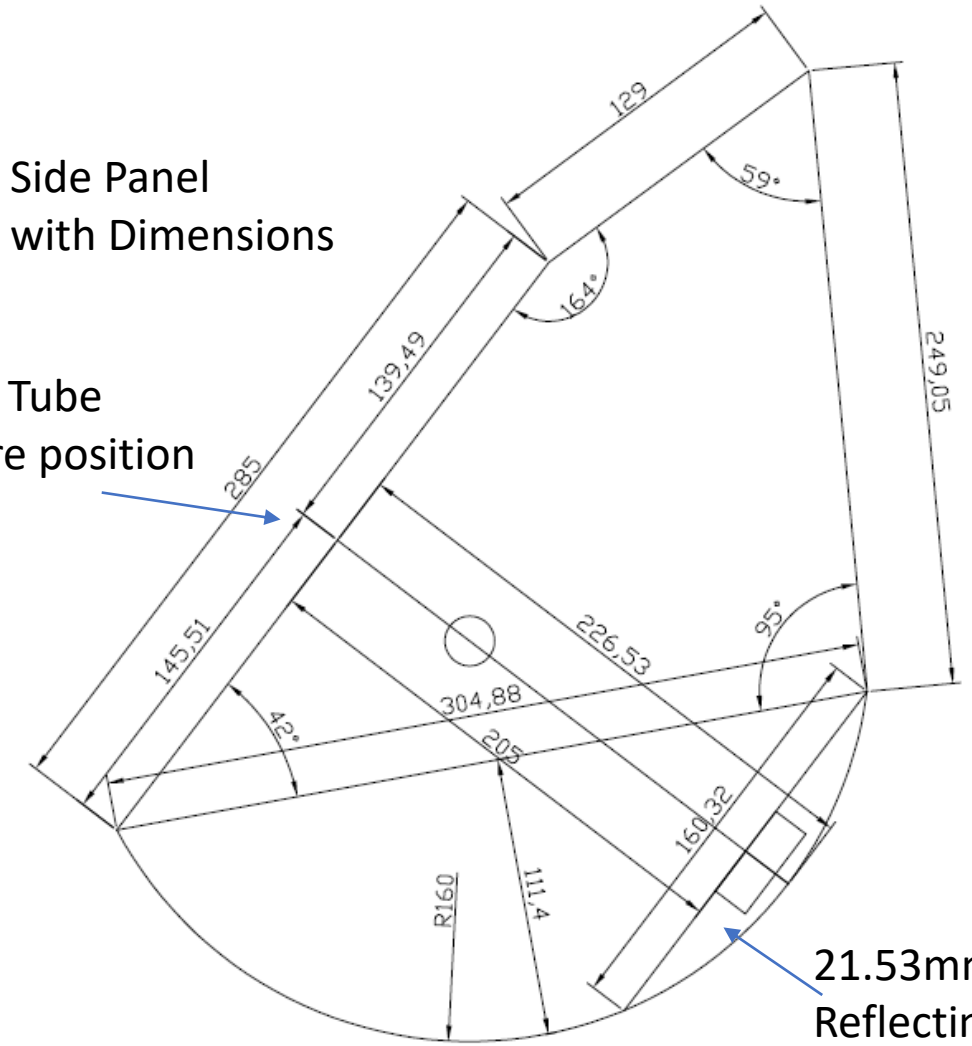


Elevation Adjustment, Use & Transportation

- The two side panels will have convex curved bottom edges and fit into matching concave curved guide battens fixed to each side of the base unit
- This arrangement will also enable the assembly to be easily tilted up to align with the Sun at whatever time of year the device is used
- A pair of D shaped handles screwed into each side of the base unit and through to the curved guide battens will help to keep the battens in place and aid transportation
- Felt pads fixed to each corner of the bottom panel will protect from table scratches and allow easy rotational adjustment
- An arrangement of a curved guide at the bottom of the side panels with a rod passing though both sides of the base and side panels will keep top and base together for transport – Idea discarded

Side Panel Schematic Diagrams in AutoCad 1

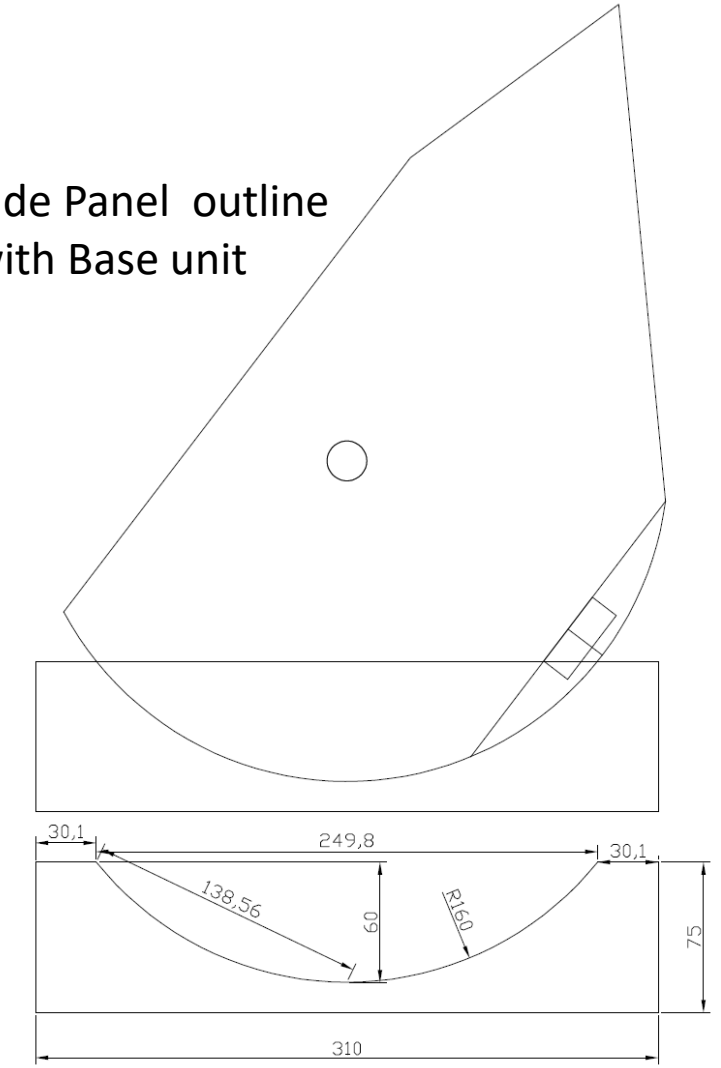
Side Panel
with Dimensions



Light Tube
centre position

21.53mm Space for
Reflecting lens fixing

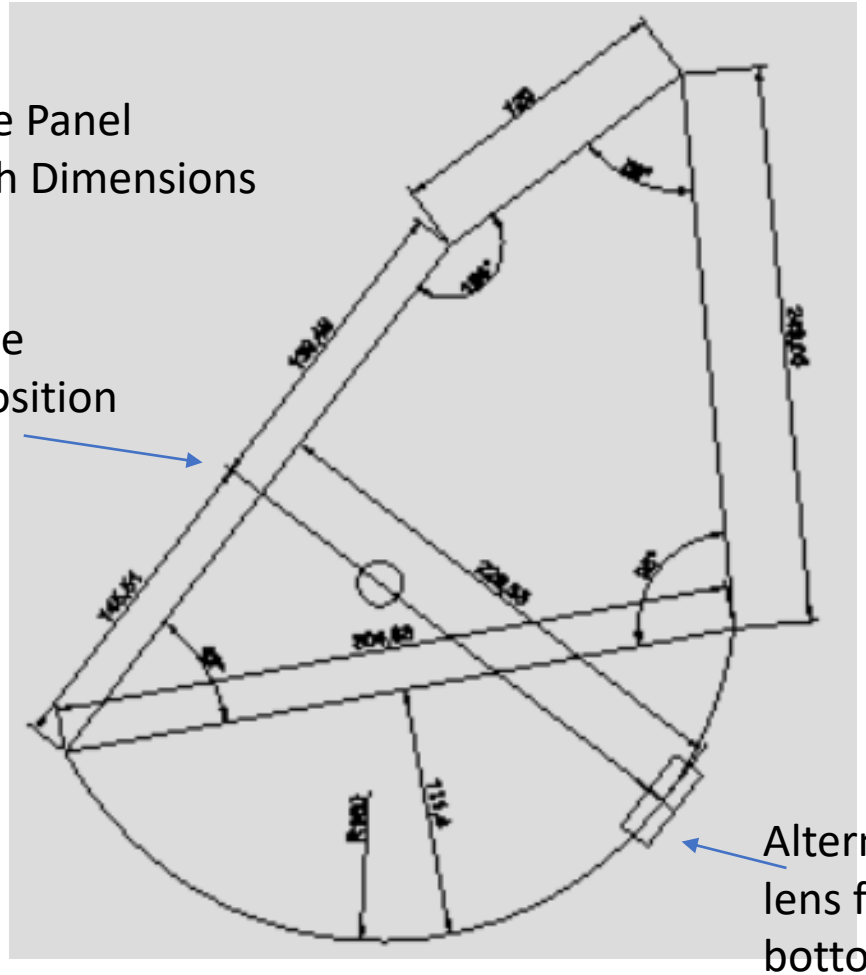
Side Panel outline
with Base unit



Base unit
Dimensions

Side Panel Schematic Diagrams in AutoCad 2

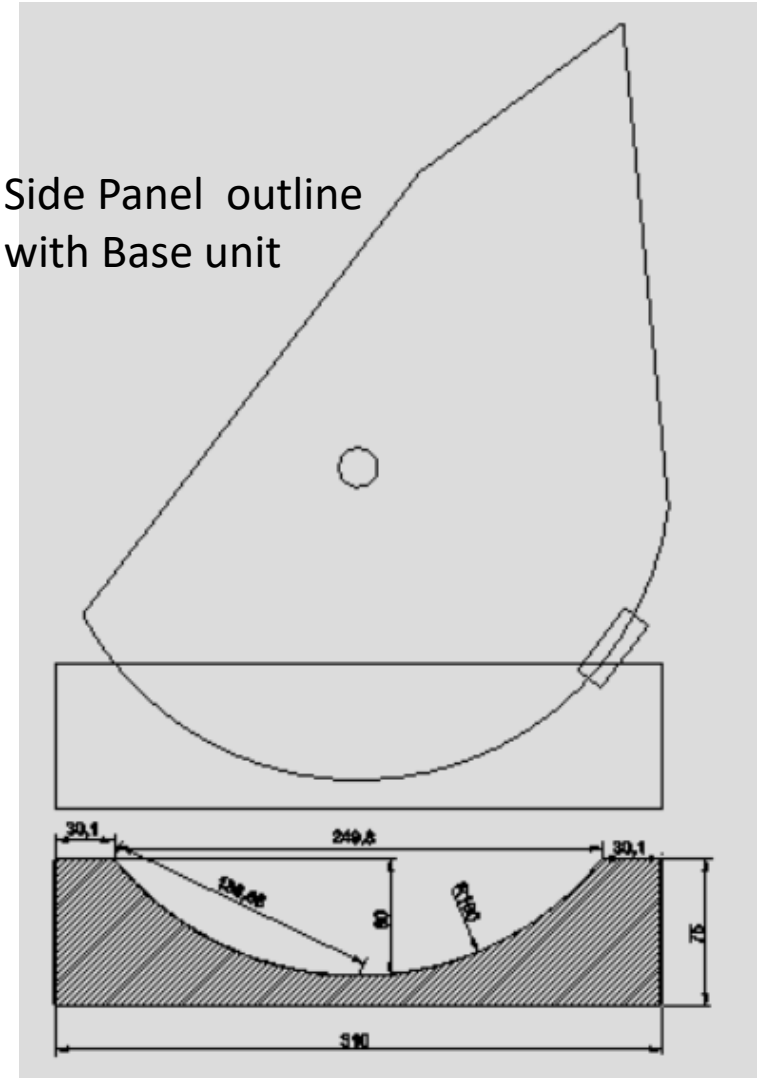
Side Panel
with Dimensions



Light Tube
centre position

Alternate Reflecting
lens fixing direct to
bottom front panel

Side Panel outline
with Base unit



Base unit
Dimensions

Side Panel Carrier Schematic Diagram in Cad

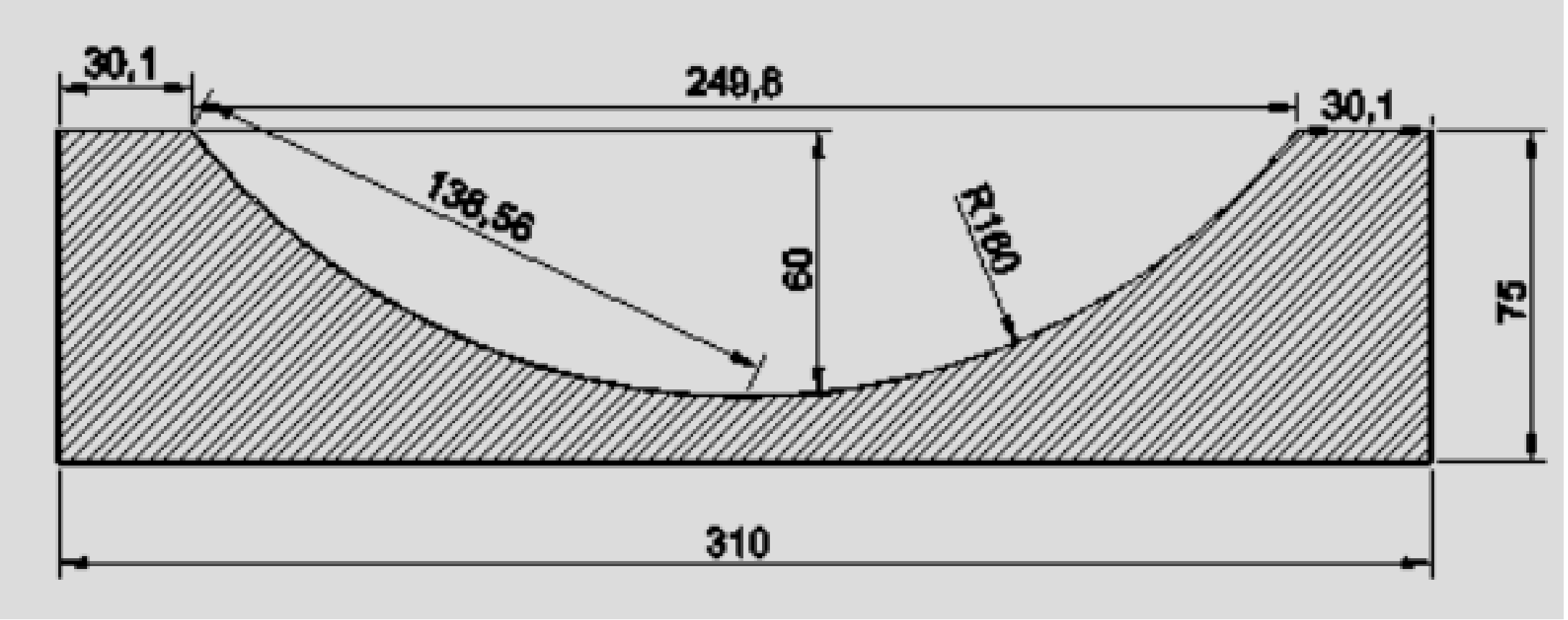
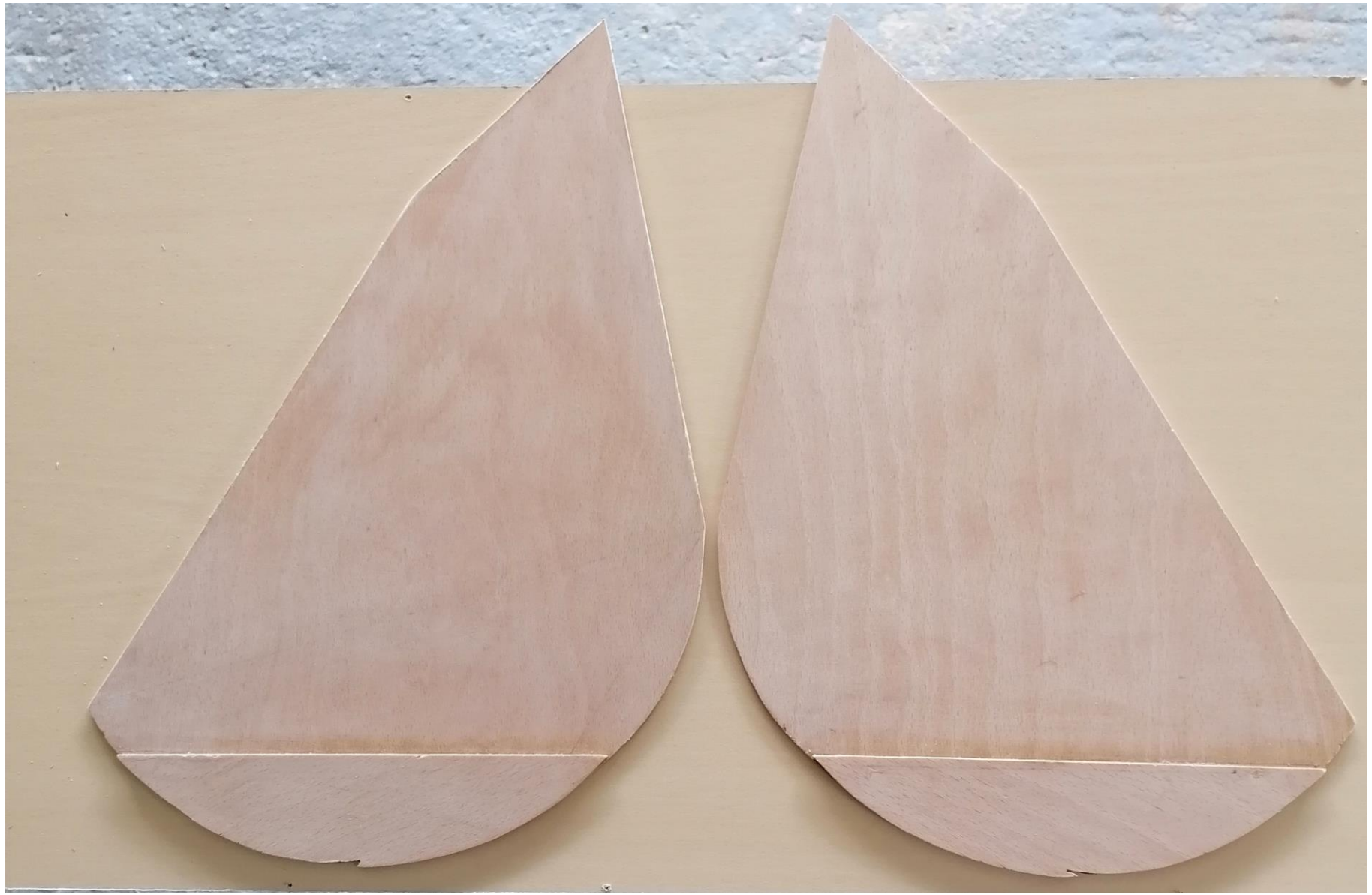


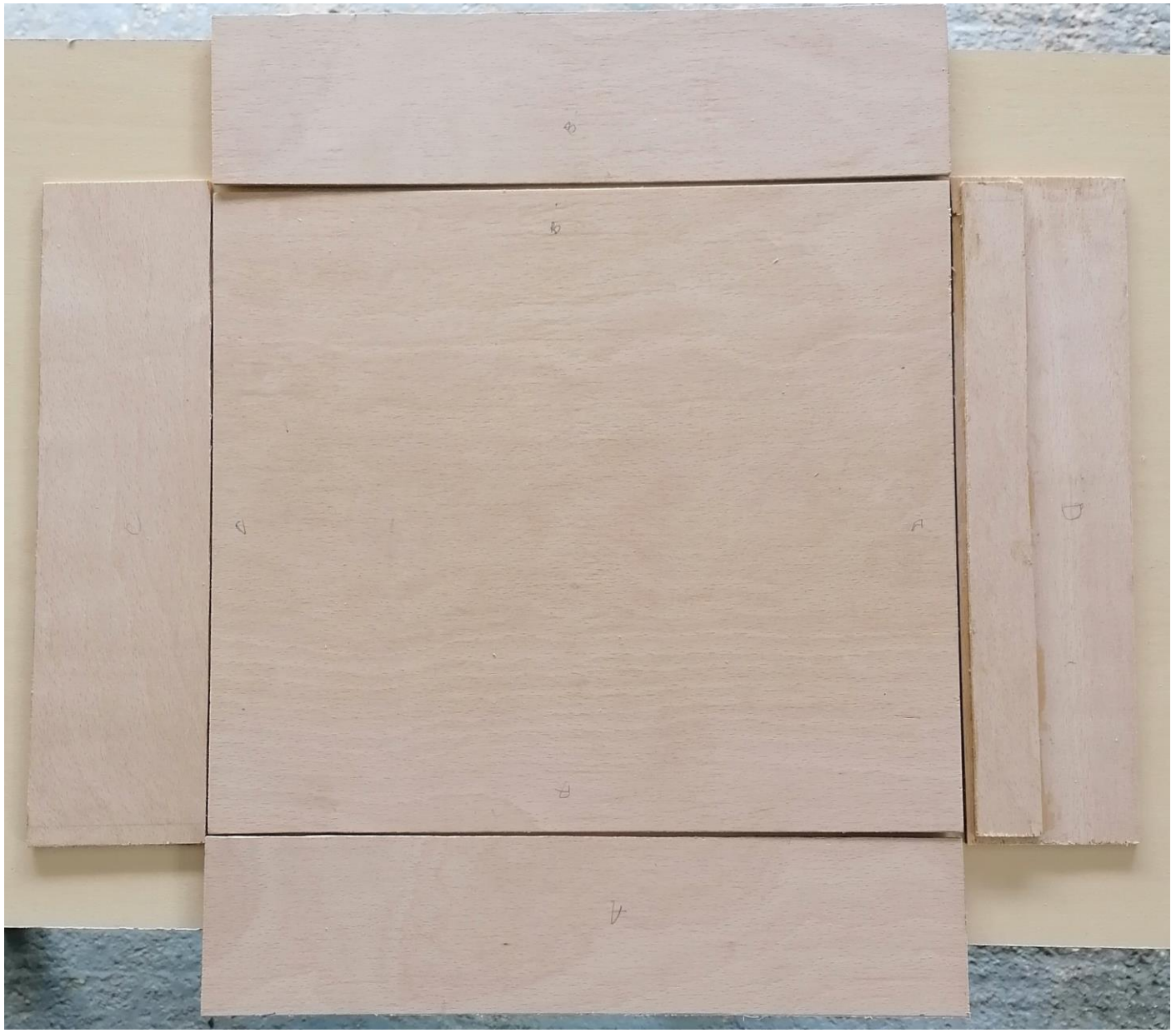
Image Section Side Panels

- The side panels of the image section cut to size and fitted with a glued chord shaped section to provide a wider runner for adjustment of viewing angle.
- These were the first sections made so that they could be used as templates to cut the support runner sections to be fixed to the base side panels.



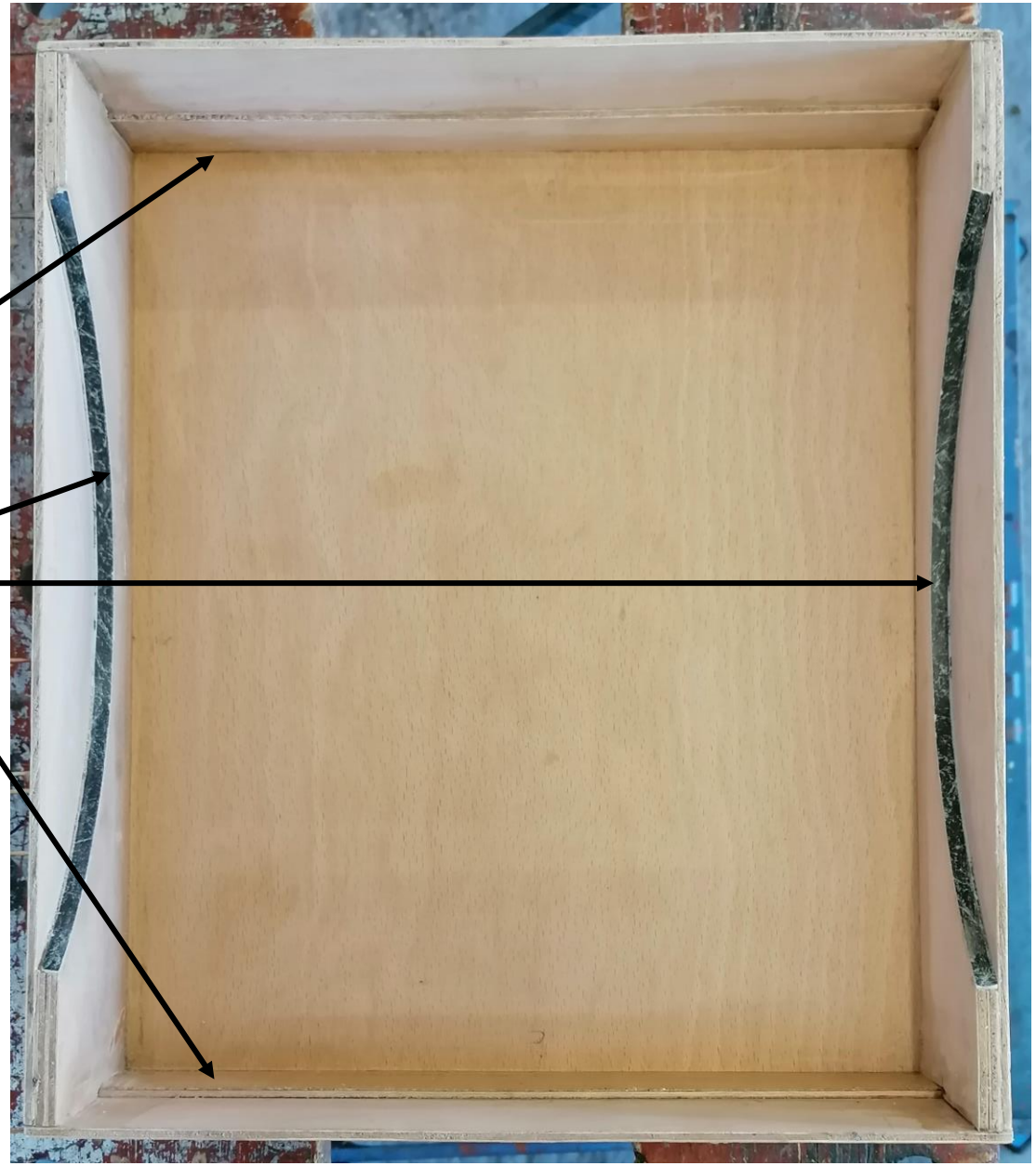
Base Panel Sections

- The whole unit is mainly made from 4mm Plywood and the image shows the base panels after cutting to size.
- All Sides overlap the base panel.
- The sides of the Front and Back overlap the side panels to give extra strength and an additional section has been glued to the back panel (at the right).



Base Unit Assembled

- Base panels were glued and pinned and clamped in place to set. The strengtheners and base side panel carriers fitted with worktop edging strip (Melamine) secured with high power impact adhesive.
- Wooden handles for carrying to be fitted to the base unit front and back panels through the strengtheners.



Base Side Panel Carrier Marking

- The side panels of the Image section were used as templates so that the curvatures could be matched as near as possible.
- There were four sections to cut – two for each side.
- Once marked up the middle of the chord shape on the side panel carrier material was screwed together to prevent movement during cutting.
- A coarse cut was made to remove the bulk of the chord area and the rest removed carefully with a router like bit.

Base Side Panel Carriers Finished to Match Image Unit Side Panel Curvature

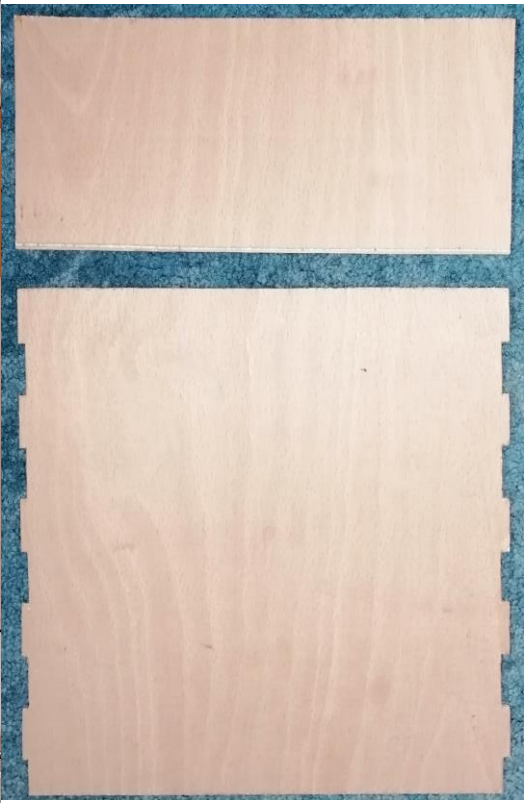
- After cutting and final shaping and sanding this shows checking that the curvatures matched.
- Here one set of Base Side Panel Carriers are clamped into the Workmate and the corresponding side placed on it and free standing.

Both Image Side Panels Placed in the Carriers

- Here, Both Image Side Panels are shown placed into the Base Side Panel and Carriers, free standing on the Workmate top.
- At this stage the Base items were clamped together for checking before the corresponding base side panel and carrier sets were glued together.

Back Panel Jointing

- The top and rear panels were made from the same plywood largely because of the weight and that they were straight and available.
- The edges were fixed in a dovetail fashion to the side panels to provide a robust unit.
- Back and Side Panel jointing scheme with joints completed.



Interim Assembly Check

- Interim Assembly Check
- The top section prior to cross supports fitting.
- The bottom section with handles fitted.

Top Section Cross Supports

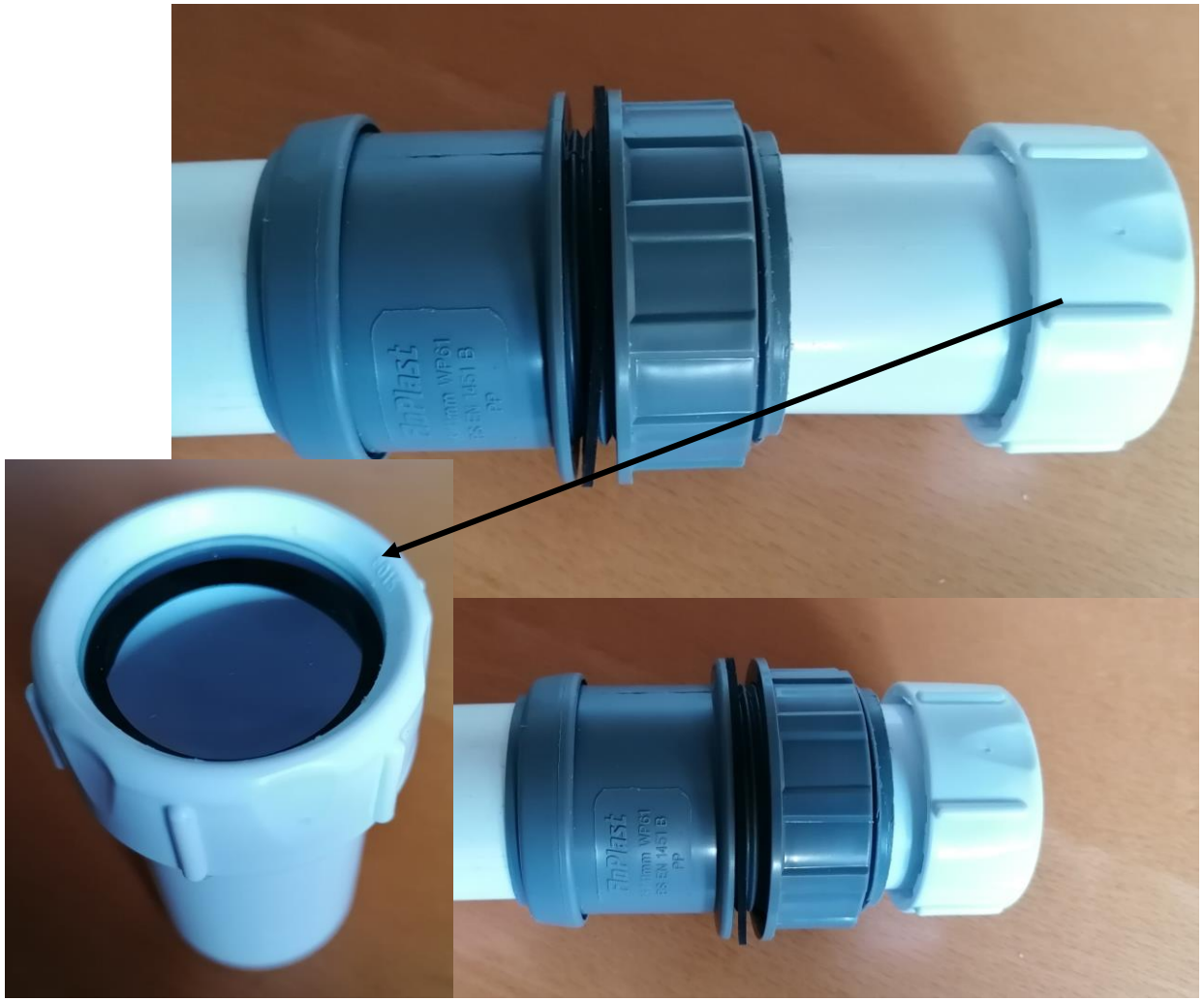
- Cross Support curved Rebate support (bottom right).
- Top Section Cross Supports fitted.
- Sanding to be done.
- Assembly check.

Light Tube Fitting

- Interim Assembly Check
- The top section with most cross supports fitted.
- The curvature of the front part of the top side panels was found to cause binding on the carriers of the base unit so the curvature was reduced to enable smooth elevation.

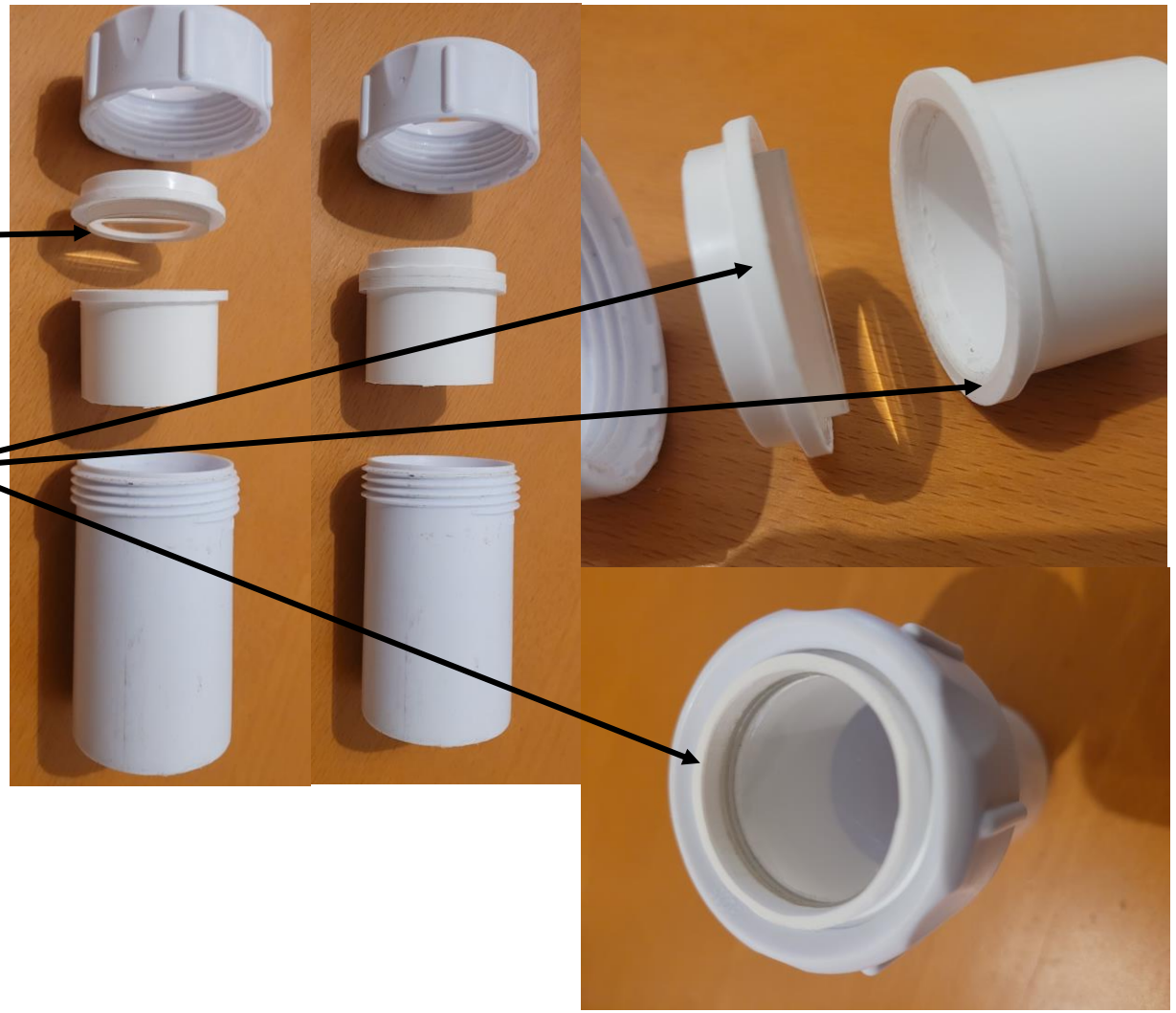
Chosen Light Tube Assembly and Focuser 1

- The Light Tube & Focuser assembly was made out of a tank adaptor with a 1.5” push fit “light tube” from some old waste pipe that was cut to size. The washer was discarded and the excess thread cut off to give up to 1cm additional travel
- The focuser was made from a 1.25” sink waste that almost fitted the screw end of the tank adaptor which was neither regular waste sizes. It is shown positioned at either end of its travel.
- The inside of the screw fitting was coated with two layers of heavy-duty Sellotape to provide a snug no-creep focussing arrangement.
- Lens Mounting in the Focuser Tube securely holds a 38mm diameter bi-convex lens.
- Focal lengths of 200mm, 250mm and 300mm were tried with this lens diameter and type.
- The lens used depends on the focusing range of the light tube to enable correct focusing on the reflecting mirror. 250mm and 300mm worked reasonably well.



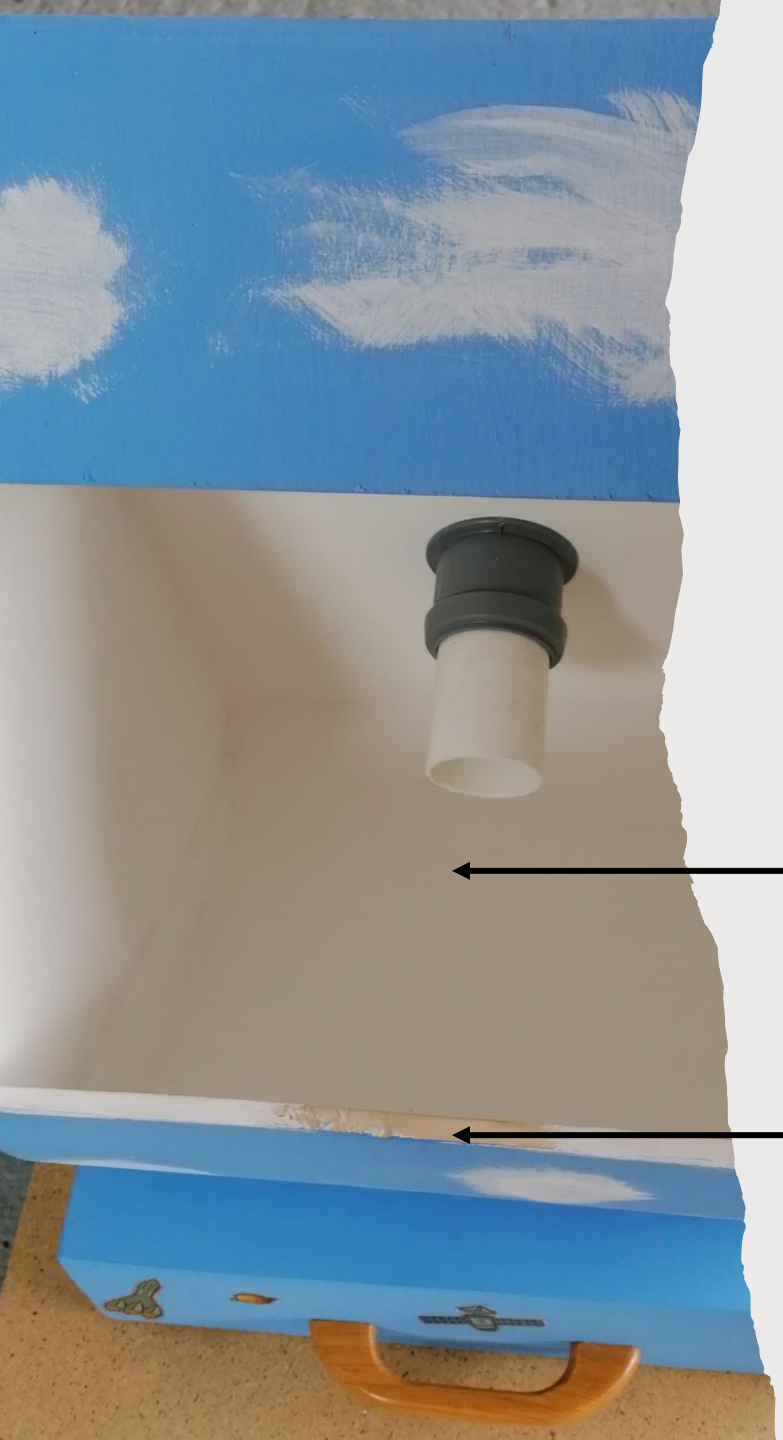
Chosen Light Tube Assembly and Focuser 2

- To provide for flexibility in type of lenses used an alternate Lens Mounting in the Focuser Tube securely was designed.
- This holds a 31mm diameter Achromatic glass OPTI Media 569 OAL 30mm diameter bi-convex lens with a focal length of 250mm, taken from the “Der Sonnen Projektor” with its Reflecting Mirrors (see Slide 3).
- The Lens holder section was made from two plastic stop ends rebated at the openings to receive the lens and then cut to shape and length to fit the light tube and locking fitting.
- TESTS WITH THE 38MM BI-CONVEX LENSES AT 300MM AND 250MM FOCAL LENGTHS WERE DISCARDED DUE TO POORLY RESOLVED IMAGES



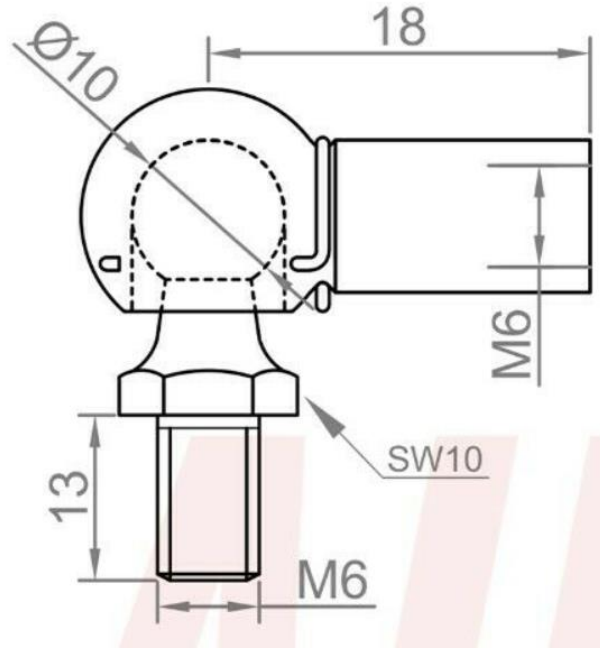
Decorated Unit

- Bright emulsion colours used plus decorative stickers for the outside.
- White inside had six coats of emulsion applied with a pad then smoothed with fine sandpaper and cleaned to give a smooth surface to reflect on with minimal brush marks.
- Unpainted area is where the reflector mirrors would be sited and painted after final design of Reflecting Mirror assembly (see slides 33 to 38).



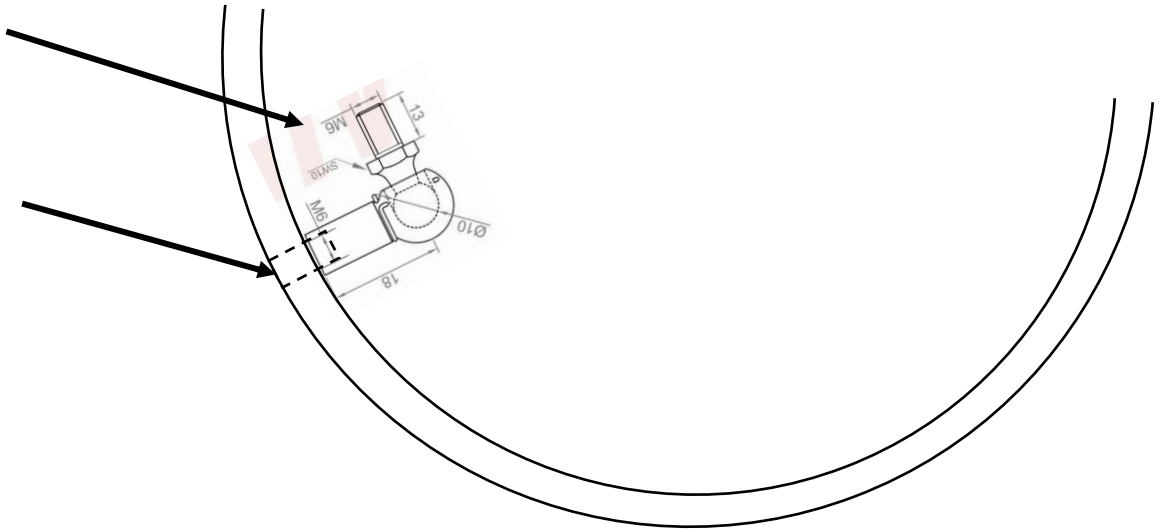
Reflecting Mirror Panel Mount Design 1

- To provide for flexibility in movement a M6 Ball joint was chosen to enable three-dimensional adjustment to send the Solar image to the required position on the back panel of the SolarScope.
- The female thread is screwed through the body.
- The male thread is used to attach the reflecting mirror assembly.



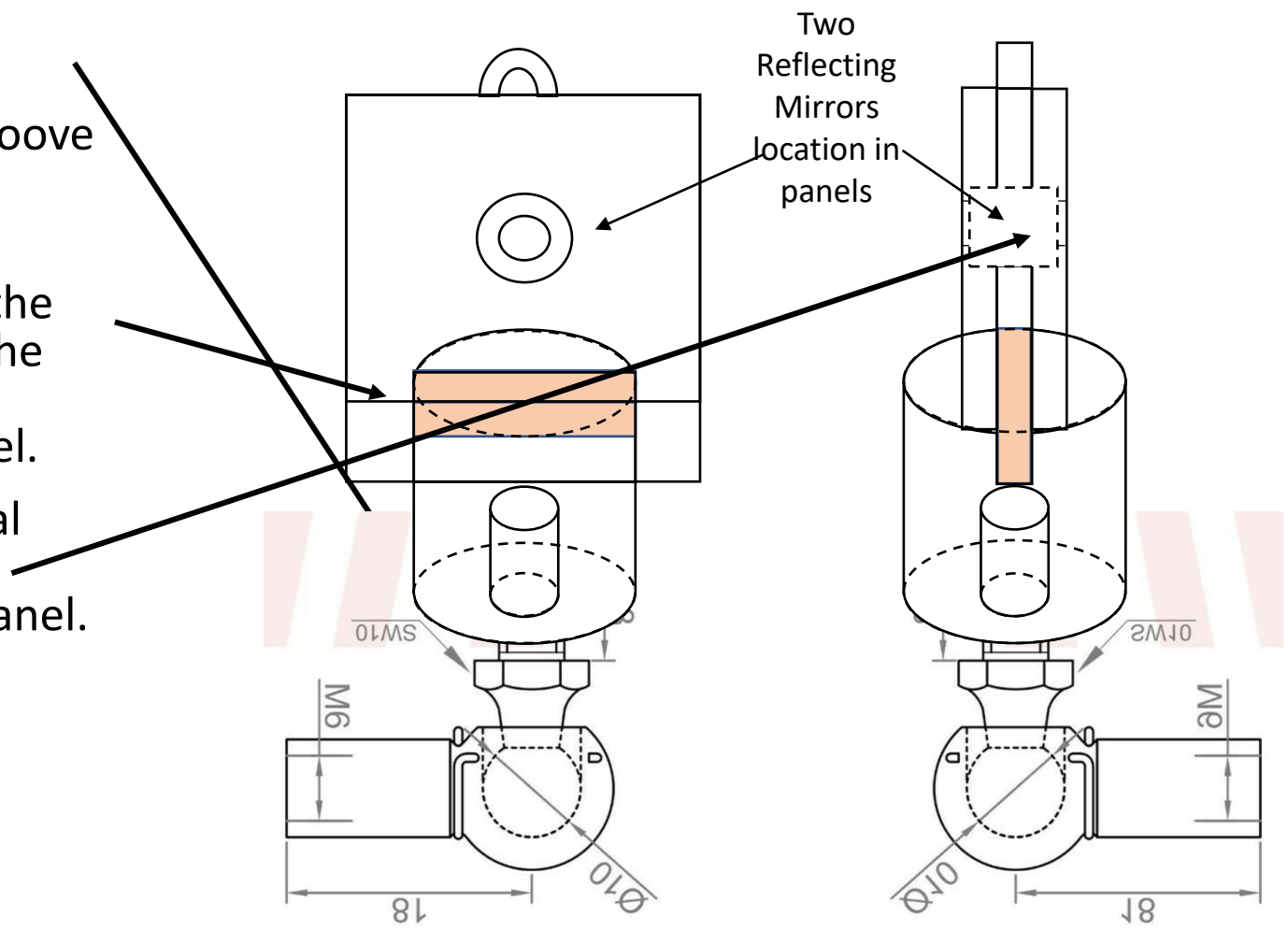
Reflecting Mirror Panel Mount Design 2

- To provide for flexibility in movement a M6 Ball joint was chosen to enable three-dimensional adjustment to send the Solar image to the back panel of the SolarScope.
- The male thread is used to attach the reflecting mirror assembly.
- The female thread is screwed through the body.
- The position of the hole to fix the Ball joint is determined from overall dimensions of the Reflecting mirror plate to give desired placement of the Solar image on the back panel.



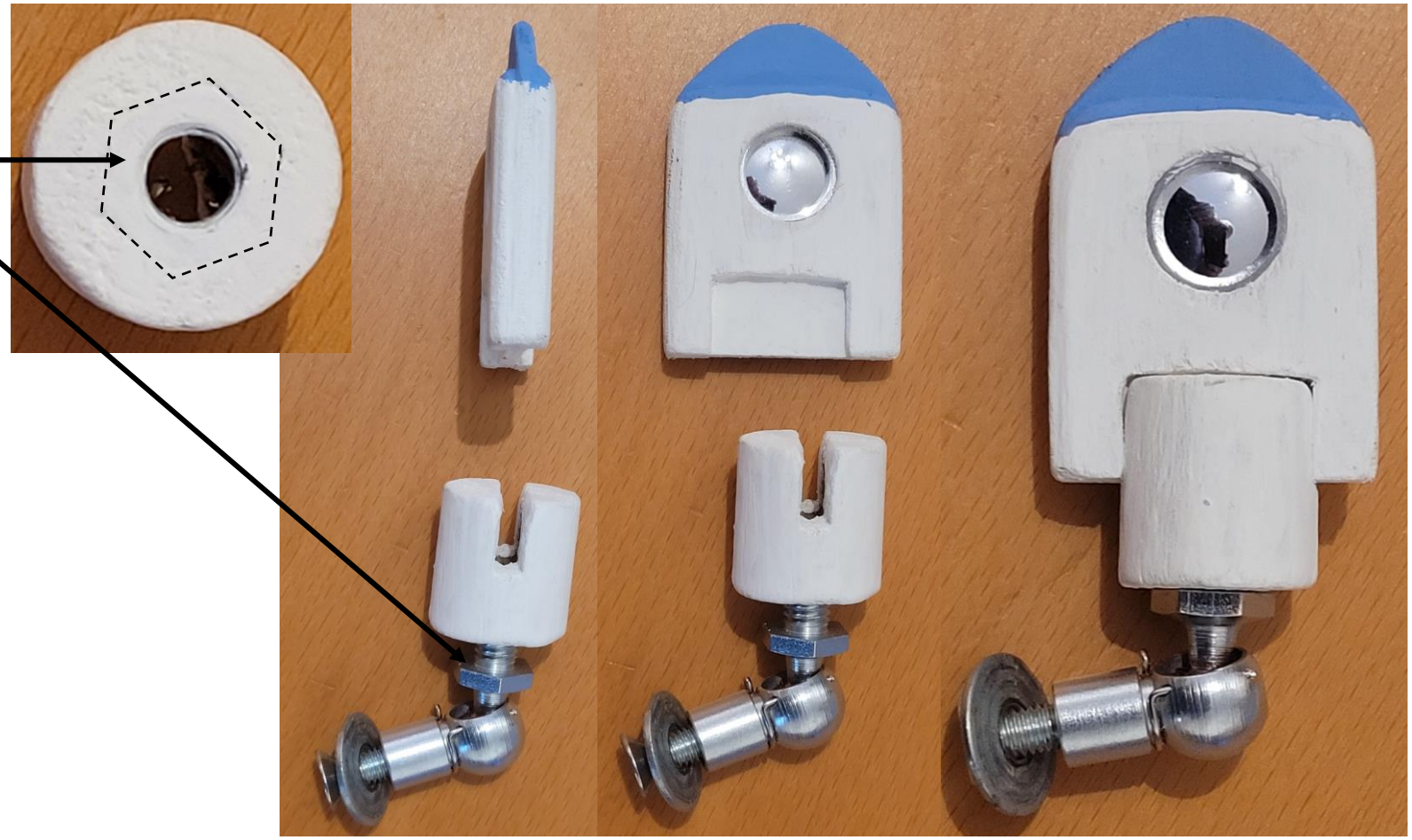
Reflecting Mirror Panel Mount Design 3

- Short length of a broom handle with fixing to the ball joint male thread to attach the reflecting mirror assembly shown.
- The reflecting mirror panel slots into a groove cut into the top of the “dowel”.
- The Reflecting mirror panel made from a triple layer of 4mm plywood as used for the SolarScope body. The central section of the panel slots into the groove and have stabilizing sections to fit against the dowel.
- Two Reflecting mirrors with different focal lengths (-10.2mm and -14.0mm) 16mm diameter mounted back-to-back in the panel.
- This arrangement allows the panel to be rotated to use either mirror and tilted.



Reflecting Mirror Panel Mount Assembly

- Embedded Nut (outlined) in the dowel mount base to receive the Ball joint M6 thread
- Images of the components in mid assembly
- Final assembly ready to fit into the Solarscope

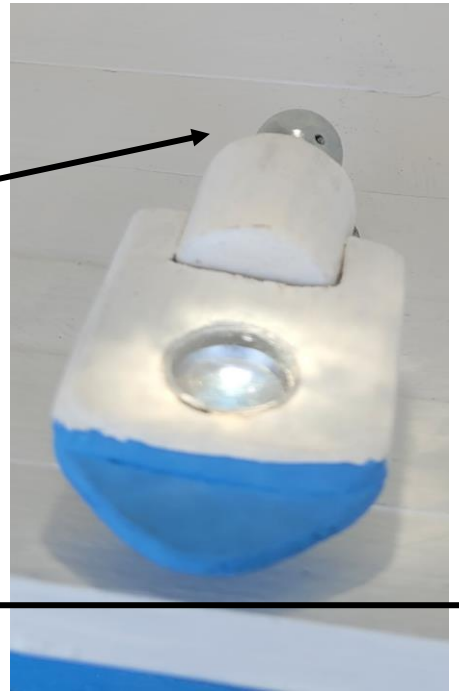


Solarscope with Donation Label 22/12/2022

Final Unit – So How did it Work

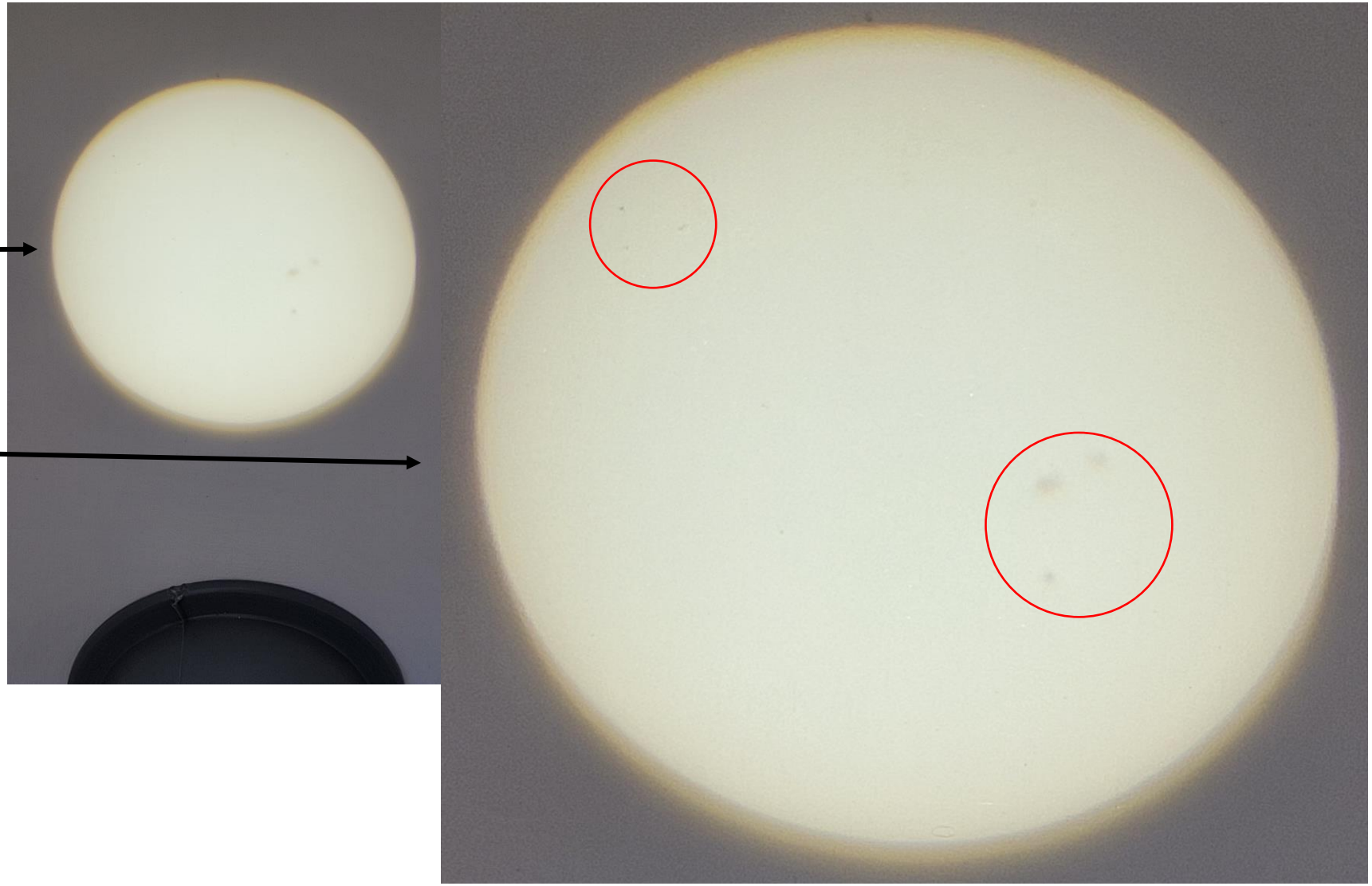
Reflecting Mirror Assembly In Position

- Reflecting Mirror Adjusting Panel on Ball Joint
- Video Clip of Solar Disk Image and adjusting the Reflecting Mirror Panel (taken on a windy 9th November 2022 hence movement).

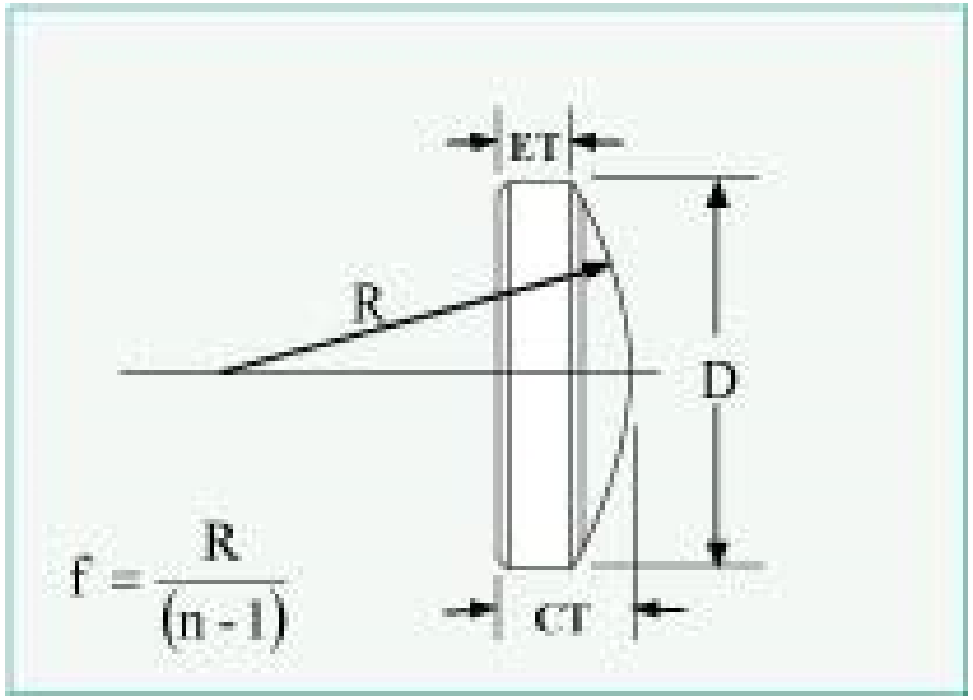


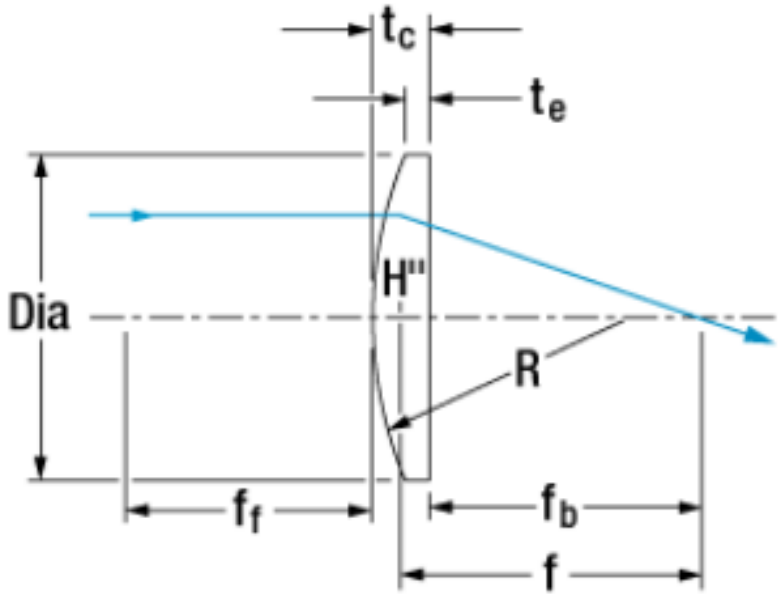
Solar Images Images Achieved

- Image of the Reflected Solar Disk
- Enlarged image showing Sun Spot Groups (ringed)



Plano Convex Reflecting Lens Formulae





Dia: Diameter
f: Focal Length
f_f: Front Focal Length
f_b: Back Focal Length
R: Radius
t_c: Lens Thickness
t_e: Edge Thickness
H'': Back Principal Plane