Designing the Full Moon Theatre

francesco.anselmo@aaschool.ac.uk

Architectural Association
School of Architecture

Gourgoubès, France / 43.854464 N, 3.659107 E
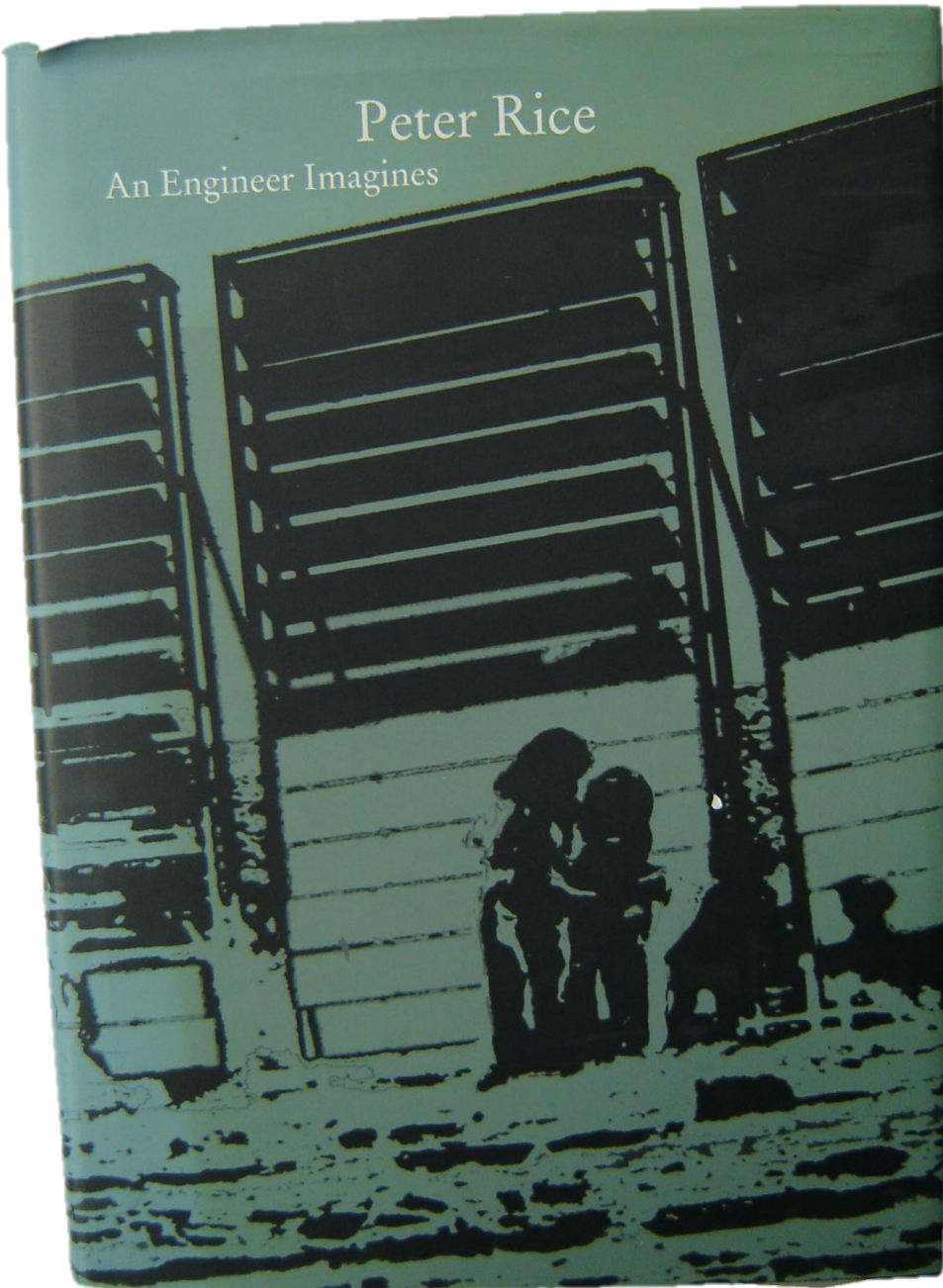
Peter Rice
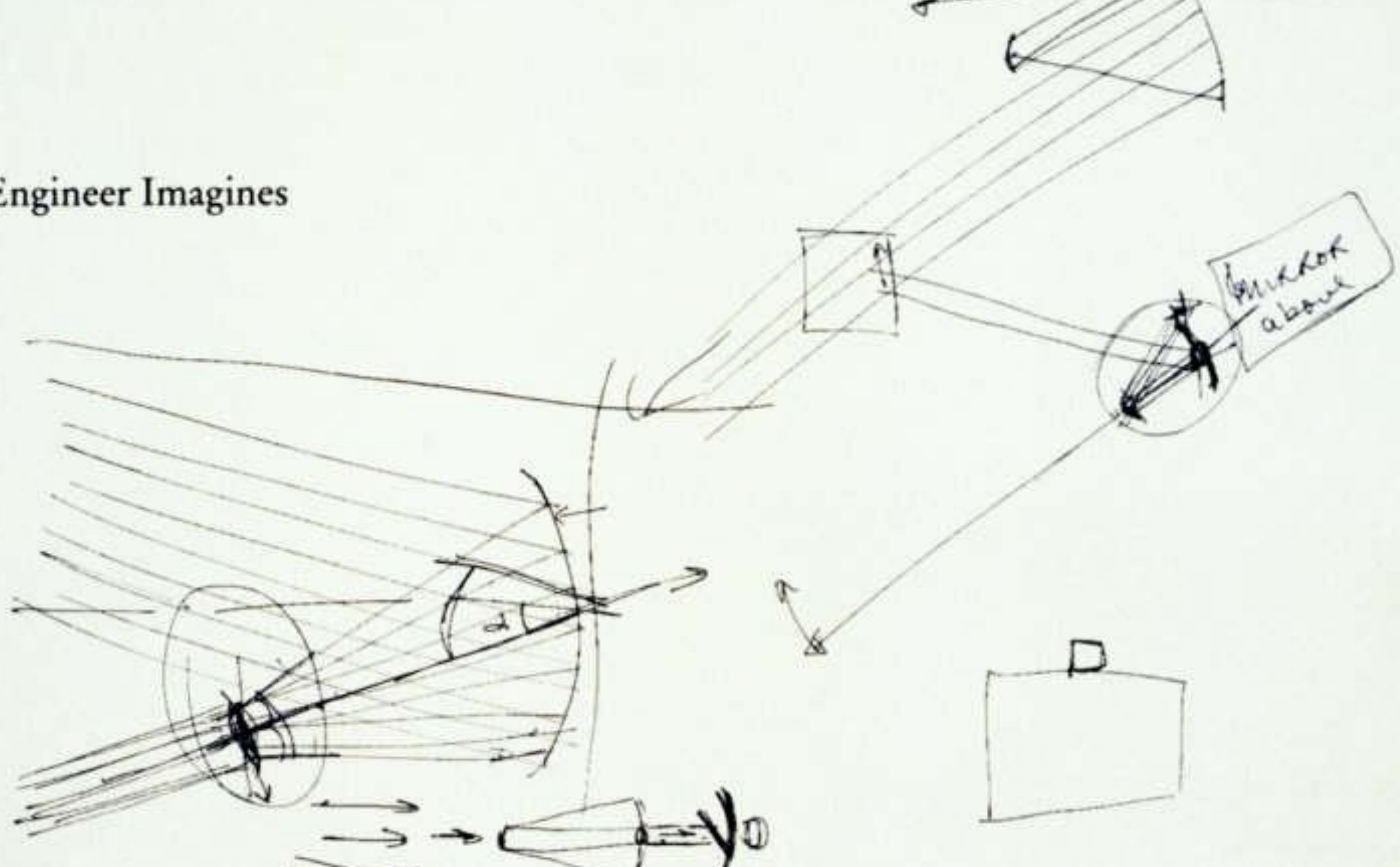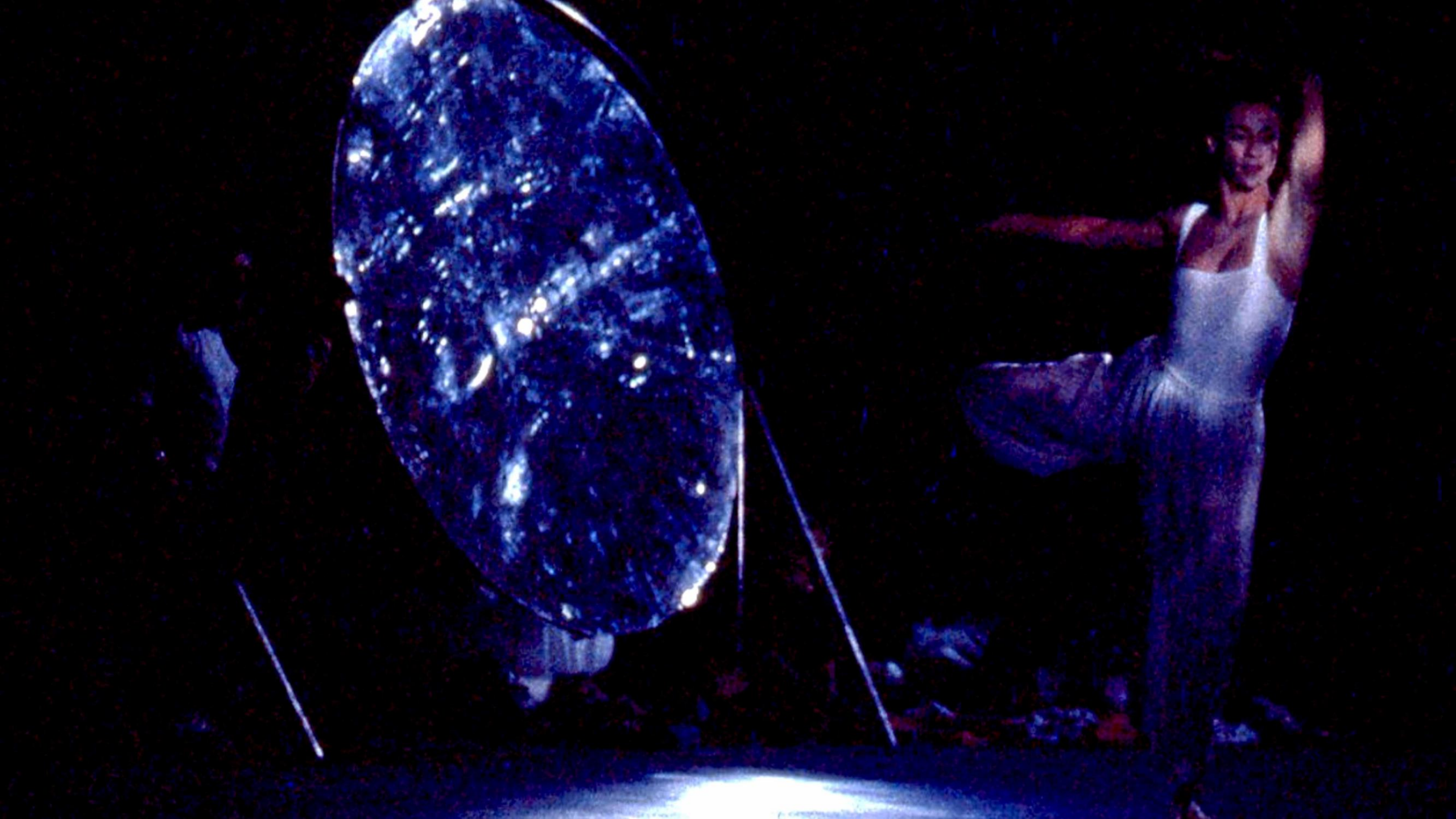Humbert Camerlo

Peter Rice

An Engineer Imagines

An Engineer Imagines

THE SITE

Latitude	:	43° 44' North of Equator
Longitude	:	3° 07' East of Greenwich

Maximum altitude of full moon :

June	19°
May and July	29°
April and August	40°

Maximum azimuthal movement of moon in one hour	:	18 degrees
Maximum altitudinal movement of moon in one hour	:	9 degrees

End of astronomical twilight :

June 21st	22:52
July 21st	22:16
August 21st	21:20

|		
Albedo (reflectance)	:	0.07
Magnitude of full moon	:	$-12^m.5$
Luminance of full moon	:	$4{,}000 \ \mathrm{cd/m^2}$
Luminous intensity of full moon	:	3.8×10^{16} candelas
Extraterrestial illuminance from full moon:		0.26 lux
Illuminance at sea level, normal to full moons rays :		0.19 lux

Spectral Data

For wavelengths in visible spectrum and near infra-red (< 2000 nanometres) spectral content of moonlight approximately equal to spectral content of sunlight Moonlight very slightly yellower than sunlight.

For wavelengths in far infra-red (> 2000 nanometres) moon absorbs all radiation

Surface temperature of
new moon   :   90 K

Surface temperature of
full moon   :   390 K
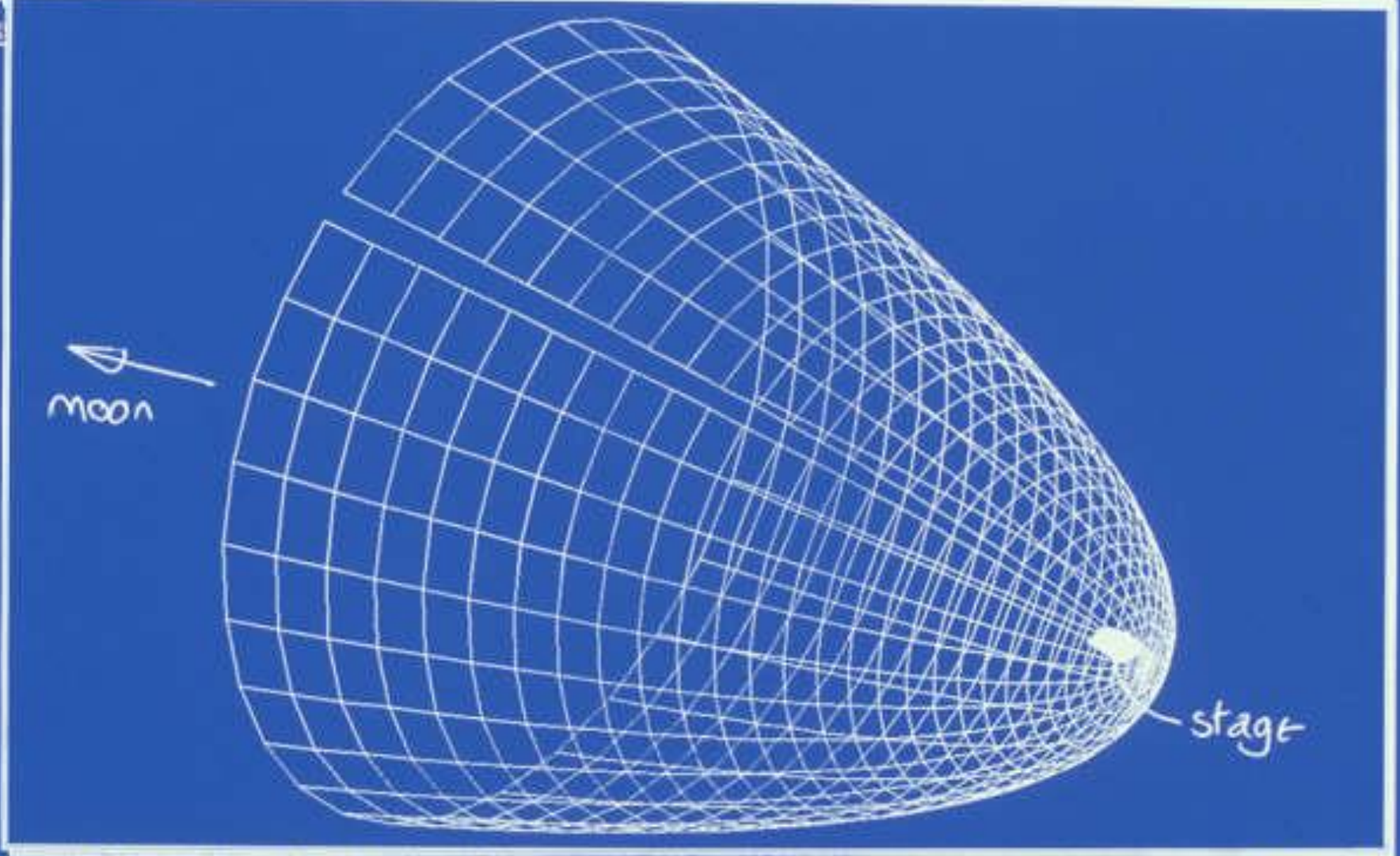
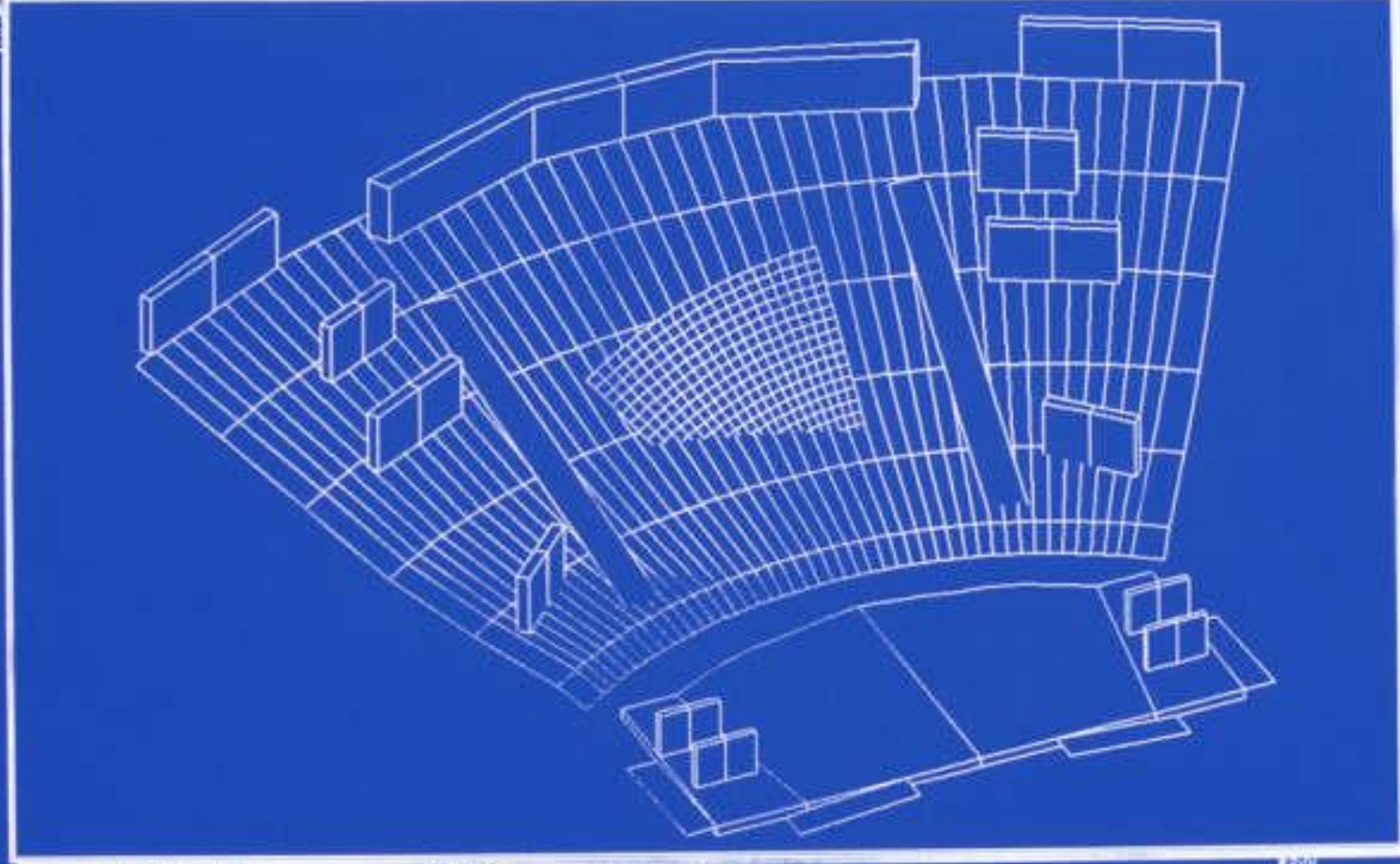Palm Canvas

moon

stage

b-7sun03 42444-08 31 1 ''
screen
b-7sun03 42444-08 32 1 ''
screen

Progres   Plane   Hidden   Colour   Touchup
Toggles   Plot   Draw over Node Nos Thick col

(Menu) (Help) (Draw) (New view) (Freeze)

Data read from a4433.vie
Data read from rub.top
Data read from stage.top

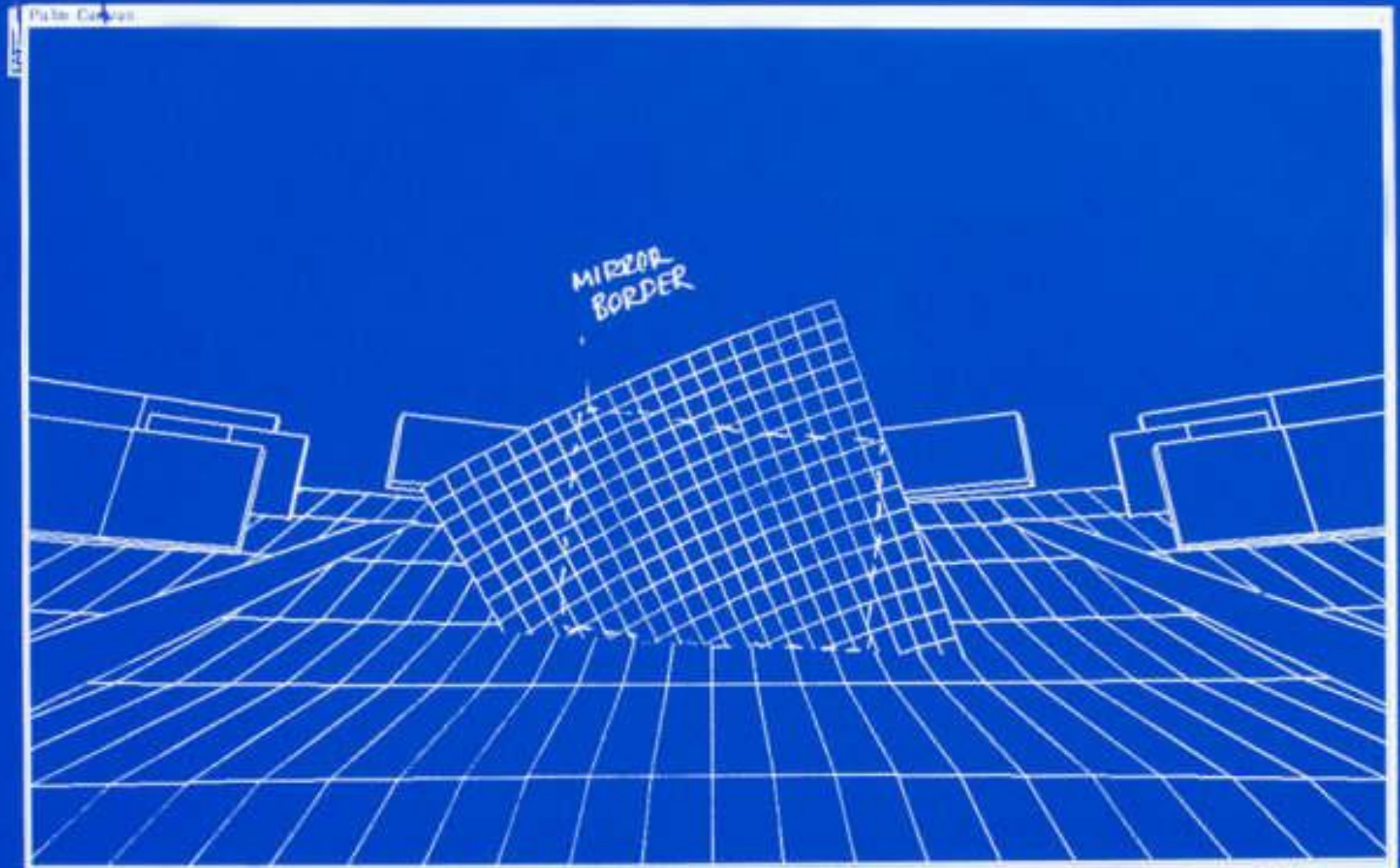Pala Canvas

[3]   Done   textedi
b-7sun03 42444-00 37 % screen
b-7sun03 42444-00 38 % ''
screen

Program   Glass   window   Colour   Touchup
Toggles   Plot   Draw over Node Nos Thick col Set sects Dot lines

(Menu) (Help) (Draw) (New view) (Freeze)

Can't auto scale - view angle set.

Ouverture « *Allegro* »

Sur la mécanique céleste , le système terre lune,
« Le songe de Kepler »

1ᵉʳ Mouvement « *Dans l'urgence* »

La lumière pure, La frange visible, Le spectre
lunaire du soleil, premières images en lumière
de lune magnifiée. reproduction d'images peintes
Ateliers de Gourgoubès (1987) Odeillo (1990)
Théâtre de la Pleine Lune (1991 -2006)
« Les trois musiciens »

2ᵉᵐᵉ Mouvement « *à l'Aventure !* »

De l'idée à la création du concept
Peter Rice et Humbert Camerlo
Création du Conseil Arts et Sciences
du « Théâtre de la Pleine Lune »
Les Ateliers . La « soft-technology ».
Recherches et expérimentation.

3ᵉᵐᵉ Mouvement «*La résonance planétaire* »

Lyon, Dublin, Paris, Londres, Rome,
Barcelone, Madrid, Montréal, New York,
Lima, Santiago, Buenos Aires, Sydney, Hobart !
La tournée mondiale pour
« La Fondation Théâtres de Pleine Lune
« TheFull Moon Theatres Foundation»

Final « *ombre et lumière* »

Quels sites d'implantation ?
Les lieux européens antiques de spectacle?
La stratégie du Théâtre Vivant ?

Le Théâtre de la pleine Lune

Présenté
à Saint Romain en Gal

'The project is not a problem we can solve quickly. It's not part of the modern misconception that we all have so little time to live, that if something is not done by tomorrow, then it is not worth doing. The Full-Moon Theatre is a project of many life-times.'

-    Peter Rice, 'An Engineer Imagines'

ARCHITECTURAL ASSOCIATION
SCHOOL OF ARCHITECTURE
VISITING SCHOOL

- Incorporate, develop and build on existing research to **design and construct a site-specific open air Full Moon Theatre**, equipped with locally digitally fabricated moonlight reflectors.

- **Stage a test performance rehearsal** that will be fully illuminated by the light of the moon, without using electricity.

- Create an online "**Full Moon Theatre Library**" which will include all the tools, documentation and techniques developed during the workshop that anyone could use to stage a Full Moon Theatre performance anywhere in the world in the future.

Hooke Park, UK / 50.790342 N, -2.674989 E

THE SITE

Latitude   :   43° 44' North of Equator

Longitude   :   3° 07' East of Greenwich

Maximum altitude of full moon :   June   19°
                                  May and July   29°
                                  April and August   40°

Maximum azimuthal movement of
moon in one hour   :   18 degrees

Maximum altitudinal movement
of moon in one hour   :   9 degrees

End of astronomical twilight   :   June 21st   22:52
                                      July 21st   22:16
                                      August 21st   21:28
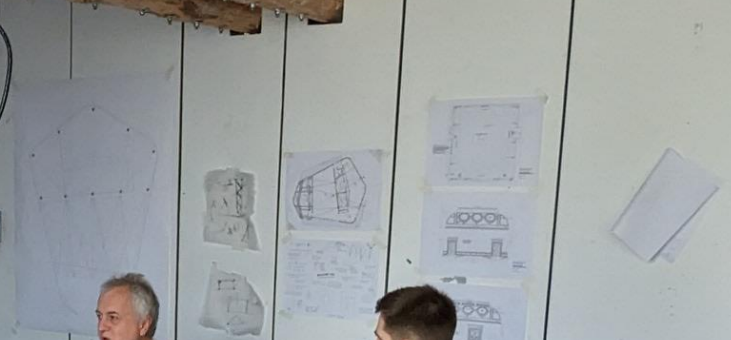
Full Moon Theatre
Planning, designing, building and performing

- Time planning
- Site layout planning
- Reflector design
- Site design
- Site simulation / validation
- Reflectors fabrication
- Reflectors assembling
- Theatre construction
- Performing

FMT event planning and site layout

- Planning the day
  - Approximately 4 days 4 times per year, weather permitting
    - Full moon
    - Clear sky
    - Moon not too low, not too high in the sky
    - Moon at night
- Planning the site
  - Reflectors/audience orientation towards south (northern hemisphere)
  - Stage facing north (northern hemisphere)
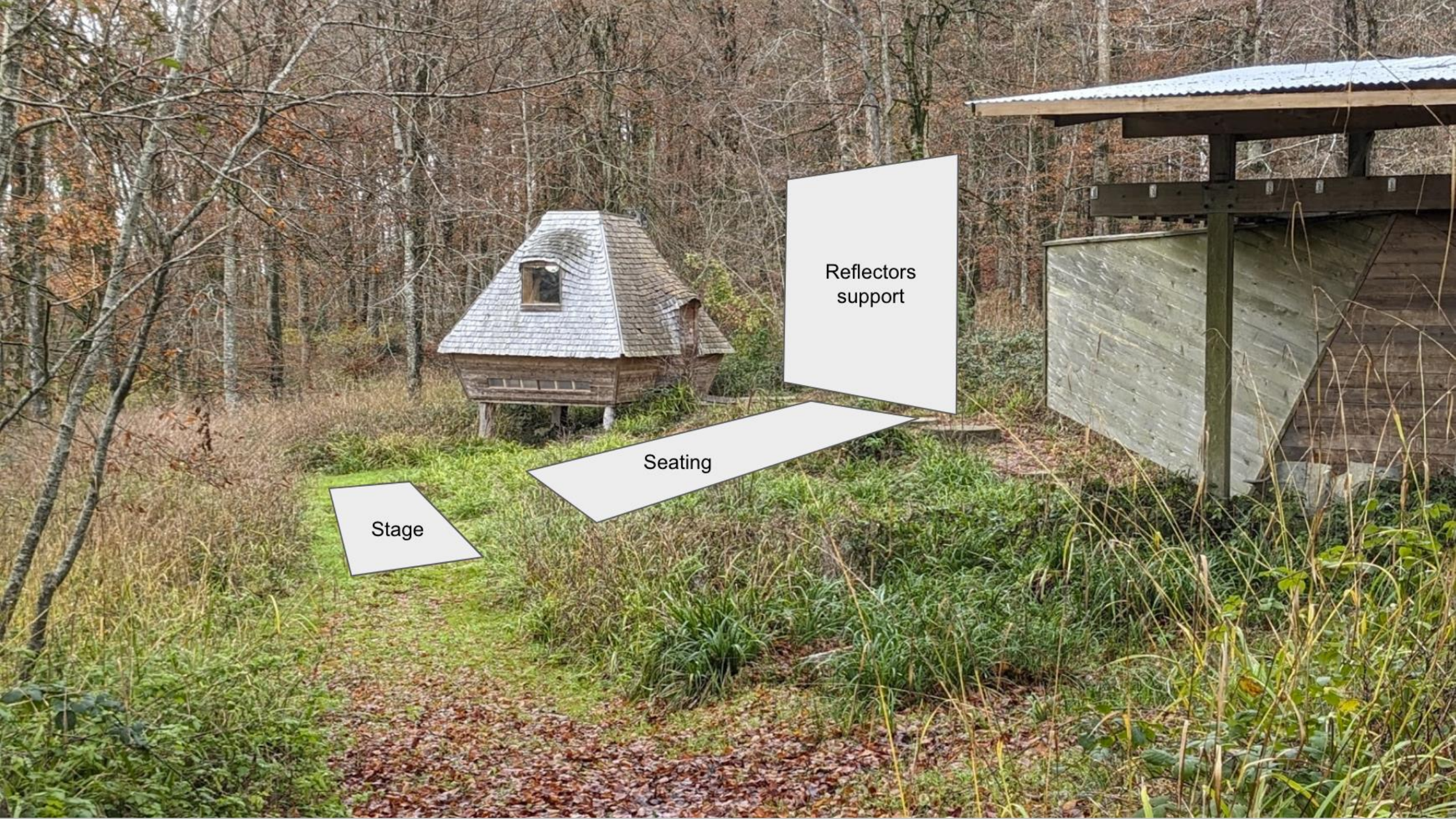
Reflectors support

Seating

Stage

https://moonphases.co.uk/moon-calendar

MOON
PHASES

HOME   MOON PHASES   **CALENDAR**   TOOLS   ABOUT   CONTACT

Moon Calendar

Use the dropdown below to select any given calendar month and year to see that particular month's Moon Phases (don't forget to press the yellow "Go" button). The 8 Phases of the Moon are clearly displayed on the relevant day of the month. Clicking a calendar day reveals the % illumination, diameter and Moon Sign in the Moon Phase summary box (top left corner of the page).

| March ▼ | 2023 ▼ | Go > |

‹   MARCH 2023   ›

MON	TUES	WED	THUR	FRI	SAT	SUN
		1 Waxing Gibbous	2	3	4	5
6 Full Moon	7	8	9 Waning Gibbous	10	11	12
13 Third Quarter	14	15	16 Waning Crescent	17	18	19

MOON PHASE FOR
TODAY, SAT 4TH MAR

‹   ›

WAXING GIBBOUS

91% / 0.49

Leo

▲   **NEXT**   ▼
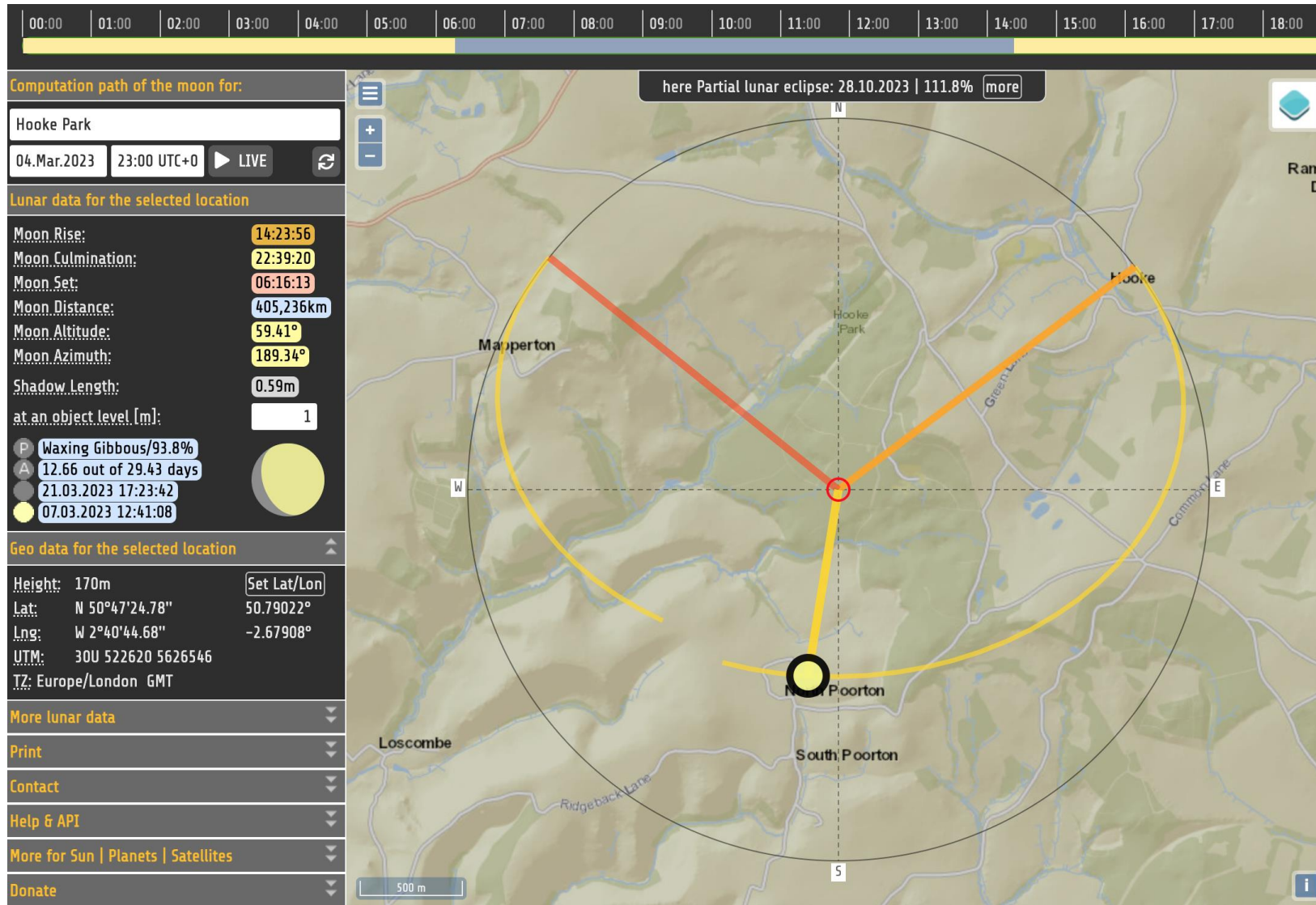### MOONRISE & MOONSET

14:10   **06:08**

Times above are based upon your current location:
LONDON, GB
Change Location

MOON PHASE CALENDAR
MARCH 2023

00:00 | 01:00 | 02:00 | 03:00 | 04:00 | 05:00 | 06:00 | 07:00 | 08:00 | 09:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00

Computation path of the moon for:

Hooke Park

04.Mar.2023 | 23:00 UTC+0 | ▶ LIVE

Lunar data for the selected location

Moon Rise: 14:23:56
Moon Culmination: 22:39:20
Moon Set: 06:16:13
Moon Distance: 405,236km
Moon Altitude: 59.41°
Moon Azimuth: 189.34°

Shadow Length: 0.59m
at an object level [m]: 1

P Waxing Gibbous/93.8%
A 12.66 out of 29.43 days
⬤ 21.03.2023 17:23:42
⬤ 07.03.2023 12:41:08

Geo data for the selected location

Height: 170m | Set Lat/Lon
Lat: N 50°47'24.78" 50.79022°
Lng: W 2°40'44.68" -2.67908°
UTM: 30U 522620 5626546
TZ: Europe/London GMT

More lunar data
Print
Contact
Help & API
More for Sun | Planets | Satellites
Donate

here Partial lunar eclipse: 28.10.2023 | 111.8% more

Type / to search

Overview | Repositories 5 | Projects | Packages | Teams | People 1 | Settings

Full Moon Theatre

👥 1 follower   📍 United Kingdom   🔗 https://fullmoontheatre.org   ⭕ theatredelapleinelune   f Theatredepleinelune

Unfollow

README.md

Full Moon Theatre

The aim of this organisation is to create an online "Full Moon Theatre Library" which will include all the tools, documentation and techniques that anyone could use to stage a Full Moon Theatre performance anywhere in the world in the future.

Contribution Guidelines

Contributing is simple!

You can contribute by forking our repositories and creating pull requests including your suggested designs, new features and bugfixes in the various repositories.

Useful resources

- Full Moon Theatre website
- Articles
  - THE FULL MOON THEATRE, by Peter Rice Ove Arup & Partners RFR on archiframe

👁 View as: **Public** ▾

You are viewing the README and pinned repositories as a public user.

Get started with tasks that most successful organizations complete.

Discussions

Set up discussions to engage with your community!

Turn on discussions

People

Invite someone

Full Moon Theatre Planning

This notebook is designed to help planning Full Moon Theatre events.

We start by importing the required external Python libraries.

In [118…

```python
%matplotlib inline
import matplotlib
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import pylunar
import geopy
from geopy.geocoders import Nominatim
from datetime import datetime, timedelta
from os.path import join
import math
from moon.jupyter_ui import JupyterUi
```

We then select a location, the starting and ending dates for the Full Moon Theatre workshop and the target moment for the performance event.

The location should be indicated with the syntax "Location name, Country Code", for instance "Montpellier, FR".

In [119…

```python
# LOCATION_NAME = "Montpellier, FR"
LOCATION_NAME = "Hooke Park, UK"
# LOCATION_NAME = "La Grange, Causse de la Selle, FR"
# LOCATION_NAME = "Théâtre de Verdure, Pl. des Aires, 13500 Martigues"
# LOCATION_NAME = "Saint-Roman-de-Codières, Occitanie"
```

We use the Nominatim service to derive the latitude and longitude of the selected location.

We can now use the `pylunar` library to identify the dates and times of the Full Moons over the next year.

In [123...

```python
moon_info = pylunar.MoonInfo(latitude_dms, longitude_dms)

now_year = int(datetime.strftime(datetime.now(),'%Y'))
now_month = int(datetime.strftime(datetime.now(),'%m'))
now_day = int(datetime.strftime(datetime.now(),'%d'))
# date initialisation
startDate = datetime(now_year, now_month, now_day)-timedelta(days=28)
endDate = datetime(now_year+1, now_month, now_day)

while startDate <= endDate:
    moon_info.update(startDate)
    time_to_full_moon = moon_info.time_to_full_moon()
    startDate += timedelta(days=int(time_to_full_moon+1))
    moon_info.update(startDate)
    full_moon = moon_info.next_four_phases()[3]
    full_moon_date = full_moon[1]
    day_of_the_week = datetime(full_moon[1][0], full_moon[1][1], full_moon[1][2]).strftime('%A')
    moon_info.update(datetime(full_moon[1][0], full_moon[1][1], full_moon[1][2], 23, 0))
    print(full_moon, day_of_the_week, "%d.2" % moon_info.azimuth(), "%d.2" % moon_info.altitude())
```

```
('full_moon', (2023, 8, 31, 1, 35, 33.888811)) Thursday 145.2 26.2
('full_moon', (2023, 9, 29, 9, 57, 29.345159)) Friday 150.2 39.2
('full_moon', (2023, 10, 28, 20, 24, 0.492493)) Saturday 156.2 51.2
('full_moon', (2023, 11, 27, 9, 16, 16.659315)) Monday 138.2 59.2
('full_moon', (2023, 12, 27, 0, 33, 10.338242)) Wednesday 123.2 56.2
('full_moon', (2024, 1, 25, 17, 53, 57.068241)) Thursday 136.2 55.2
('full_moon', (2024, 2, 24, 12, 30, 22.256625)) Saturday 142.2 43.2
('full_moon', (2024, 3, 25, 7, 0, 16.416796)) Monday 149.2 29.2
('full_moon', (2024, 4, 23, 23, 48, 55.940077)) Tuesday 162.2 22.2
('full_moon', (2024, 5, 23, 13, 53, 5.253559)) Thursday 160.2 10.2
('full_moon', (2024, 6, 22, 1, 7, 48.966103)) Saturday 152.2 5.2
('full_moon', (2024, 7, 21, 10, 17, 4.647682)) Sunday 153.2 11.2
('full_moon', (2024, 8, 19, 18, 25, 44.062308)) Monday 156.2 21.2
('full_moon', (2024, 9, 18, 2, 34, 24.104429)) Wednesday 144.2 36.2
```

https://github.com/fullmoontheatre/fmt_planning

```python
TARGET_MOMENT = (2023, 10, 28, 23, 0, 0) # format: (YEAR, MONTH, DAY, HOUR, MINUTES, SECONDS)
START_DAY = [2023, 10, 26] # format: [YEAR, MONTH, DAY]
END_DAY = [2023, 10, 28] # format: [YEAR, MONTH, DAY]

moon_info = pylunar.MoonInfo(latitude_dms, longitude_dms)
moon_info.update(TARGET_MOMENT)
print("Target Moon's azimuth:", moon_info.azimuth())
print("Target Moon's altitude:", moon_info.altitude())
print("Target Moon's age (days):", moon_info.age())
print("Target Moon's fractional phase:", moon_info.fractional_phase())
print("Target Moon's phase name:", moon_info.phase_name())
print("Target Moon's magnitude (measure of the brightness of a celestial object):", moon_info.magnitude())
print("Distance of target Moon's from Earth:", moon_info.earth_distance(), "km")
print("Next four Moon phases:", moon_info.next_four_phases())
```

```
Target Moon's azimuth: 156.55337260727157
Target Moon's altitude: 51.48679241644569
Target Moon's age (days): 14.211730042770796
Target Moon's fractional phase: 0.9997474211255863
Target Moon's phase name: WANING_GIBBOUS
Target Moon's magnitude (measure of the brightness of a celestial object): -12.72
Distance of target Moon's from Earth: 365075.8837129292 km
Next four Moon phases: [('last_quarter', (2023, 11, 5, 8, 36, 45.365642)), ('new_moon', (2023, 11, 13, 9, 27, 22.32
332)), ('first_quarter', (2023, 11, 20, 10, 49, 50.355023)), ('full_moon', (2023, 11, 27, 9, 16, 16.659326))]
```

We can visualise the Moon's phase using the `moon` library

```python
ui = JupyterUi(size=(300,300))
time_format = "%Y-%m-%d"
hour_format = "%H:%M"
target_date = datetime(TARGET_MOMENT[0], TARGET_MOMENT[1], TARGET_MOMENT[2]).strftime(time_format)
ui.set_moon_phase(date = target_date) #defaults to today's date
print(ui.moon_datetime_info)
ui.show()
```

```
{'time': '28 Oct 2023 21:00 UT', 'phase': 99.99, 'age': 14.128, 'diameter': 1938.2, 'distance': 369790, 'j2000':
{'ra': 2.1702, 'dec': 14.1622}, 'subsolar': {'lon': 4.099, 'lat': -0.321}, 'subearth': {'lon': 4.403, 'lat': -1.3},
'posangle': 341.907}
```
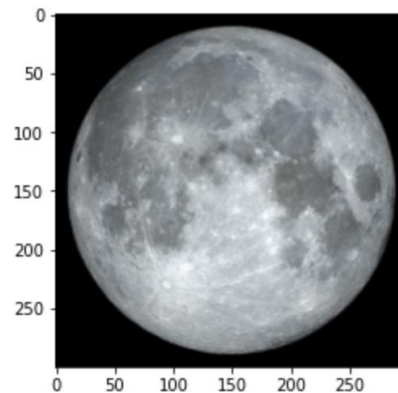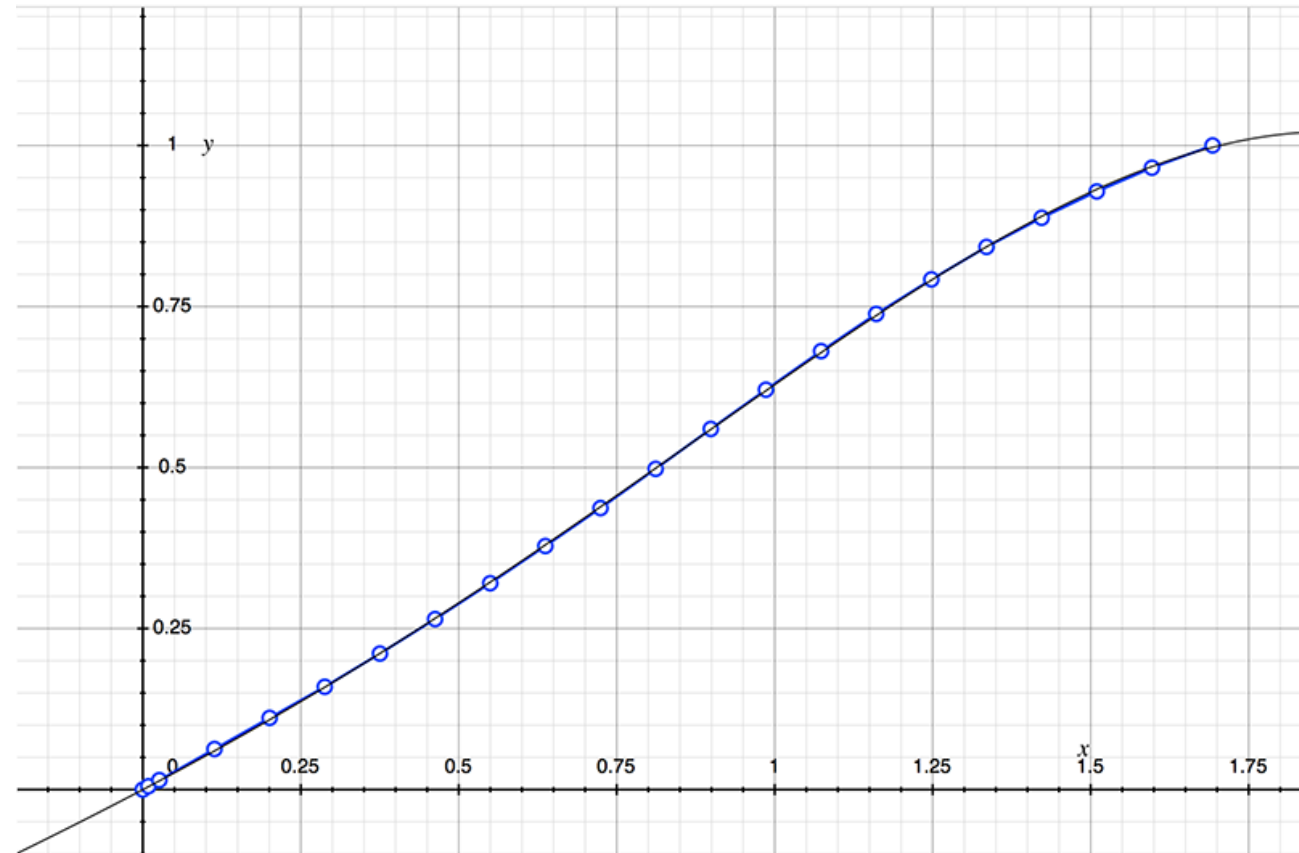
Moon path diagram - Hooke Park, UK - from 2023-10-26 00:00 to 2023-10-28 23:59
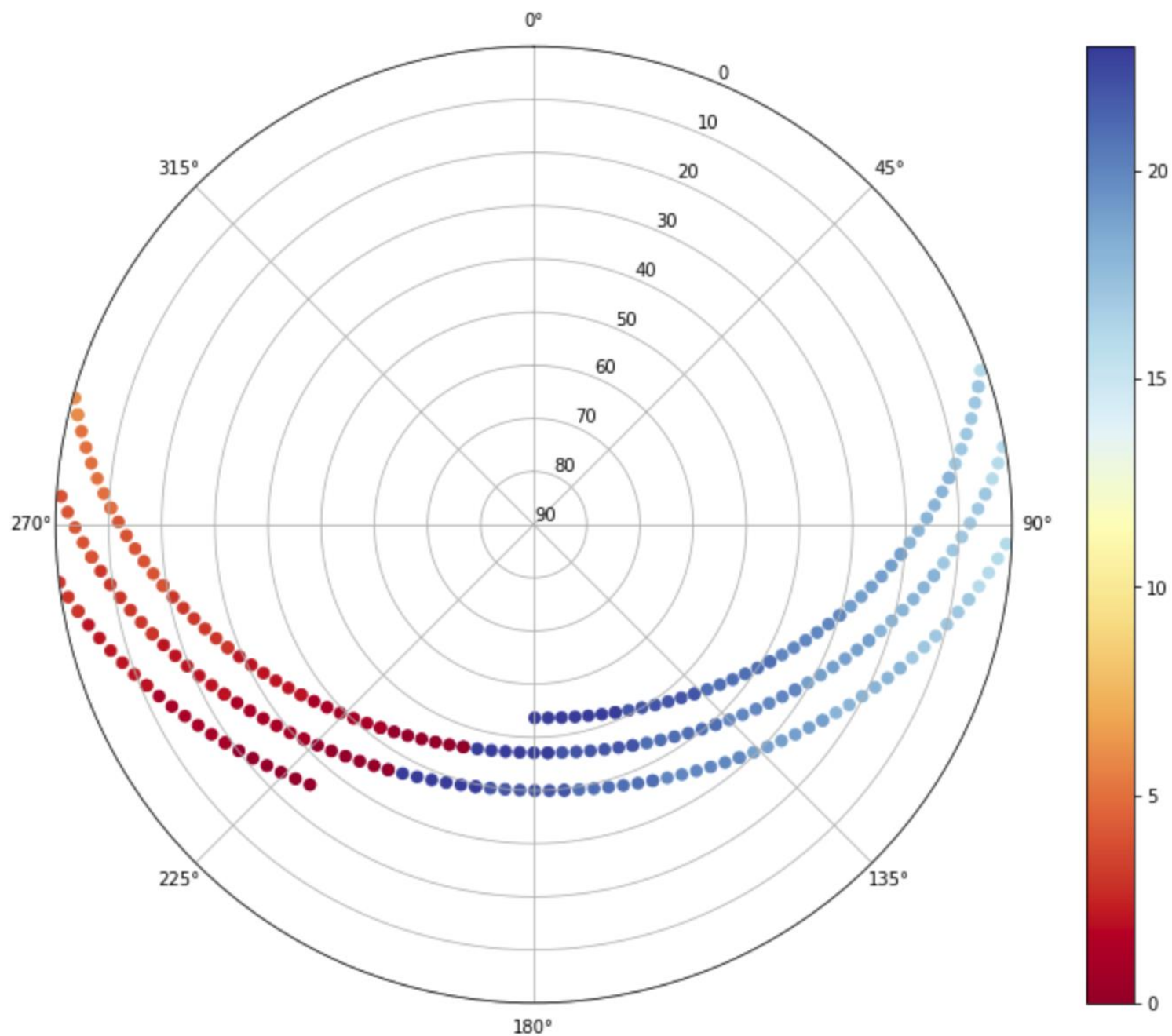
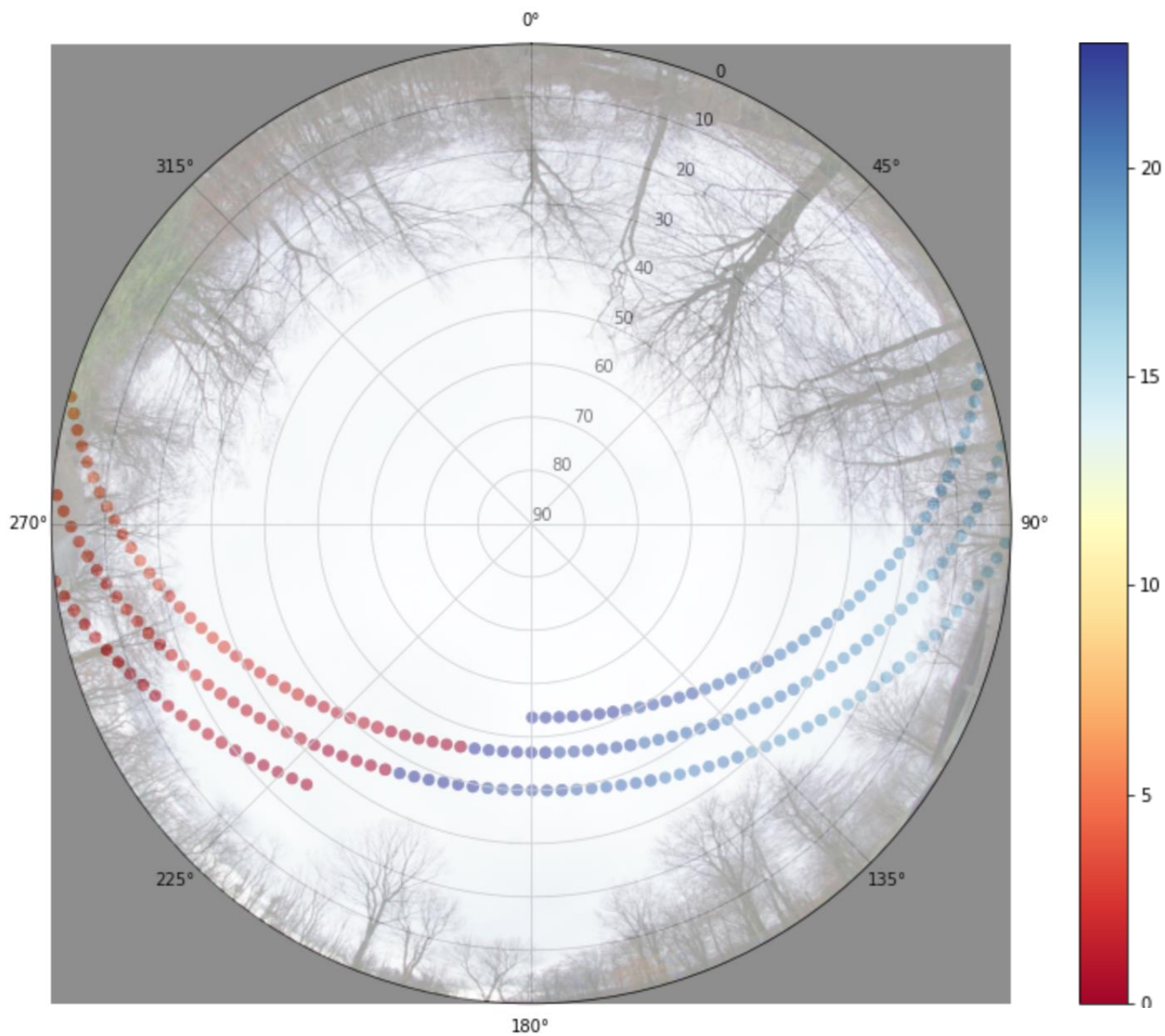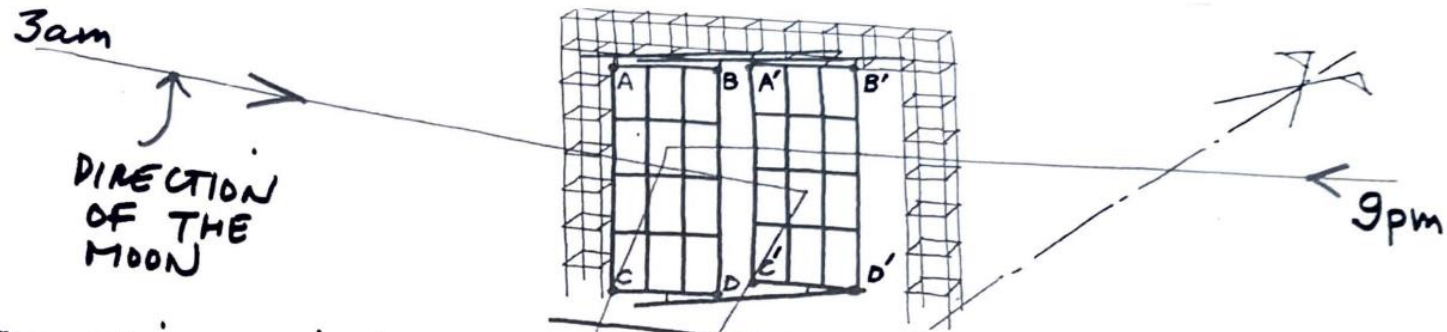$y = 0.5165x + 0.1106x^2 + 0.0617x^3 - 0.0601x^4$

http://www.paulbourke.net/dome/fisheyecorrect/

Moon path diagram - Hooke Park, UK - from 2023-10-26 00:00 to 2023-10-28 23:59

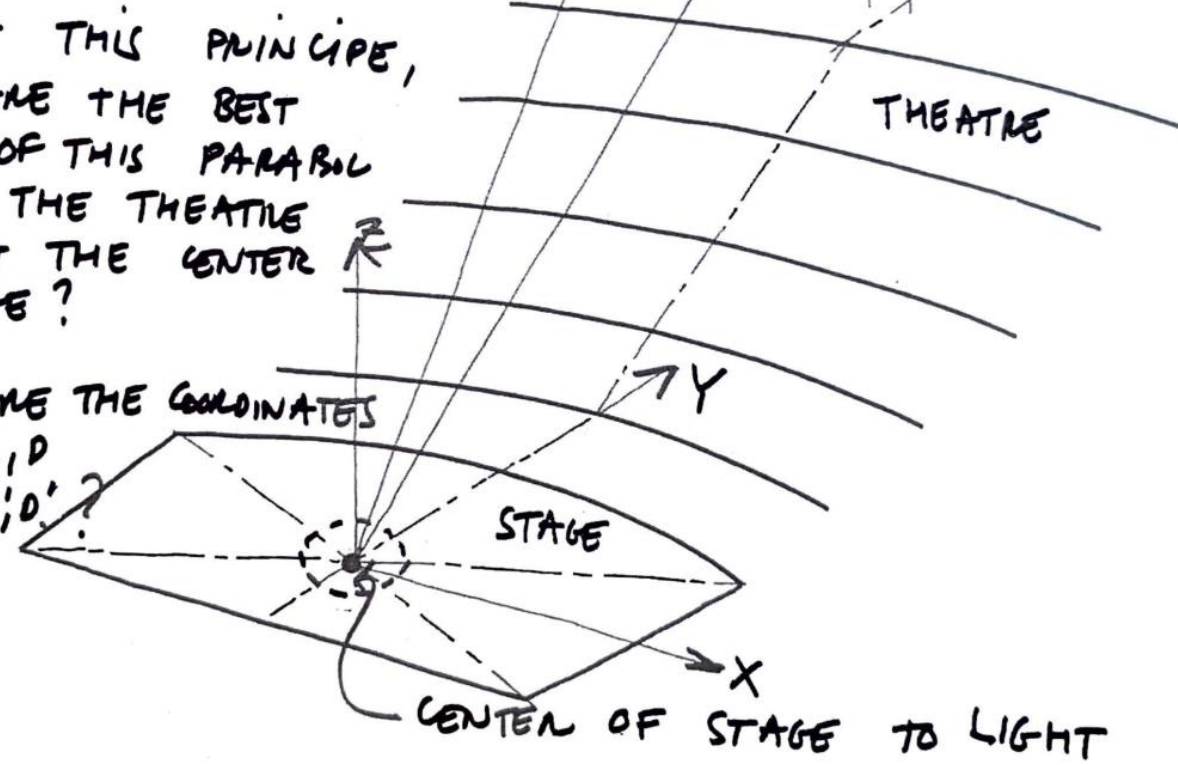# FMT reflectors and site design

3am

DIRECTION
OF THE
MOON

9pm

A B A' B'
C D C' D'

THEATRE

TO TEST THIS PRINCIPE,
WHAT ARE THE BEST
PLACE OF THIS PARABOL
BEHIND THE THEATRE
TO LIGHT THE CENTER
OF STAGE ?

WHAT ARE THE COORDINATES
OF A, B, C, D
AND A', B', C', D' ?

Z

Y

X

STAGE

CENTER OF STAGE TO LIGHT

Copernic

Copernic

Copernic
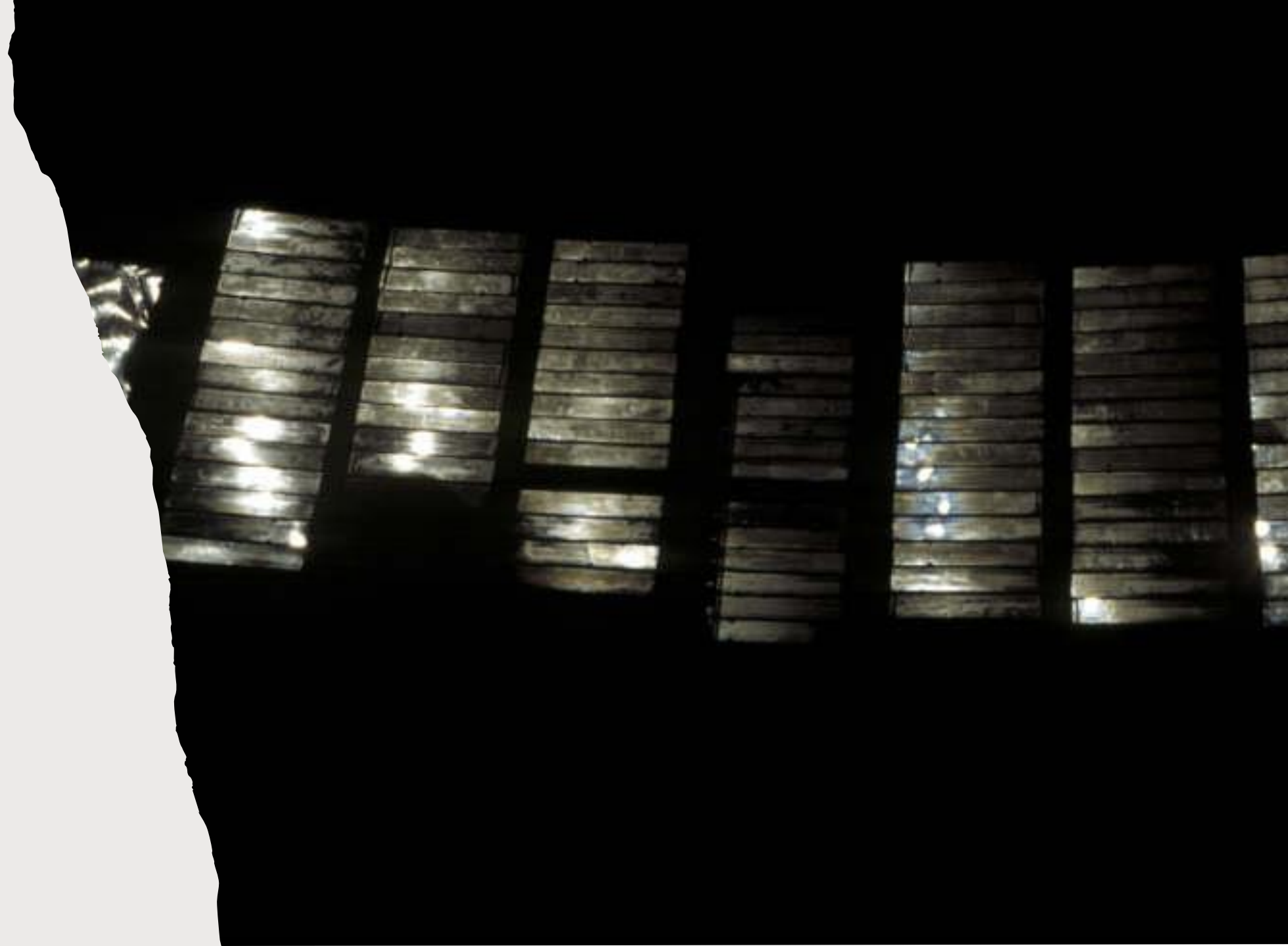
Kepler

Kepler

Archimedes

Archimedes

Galileo

ARE THE RAILS CAN BE STRAIGHT?

HORIZONTAL DIRECTION RAILS

A   B

A'   B'

PARABOL AT 9pm

PARABOL AT 3pm

THIS DRAWING IS JUST A PRINCIPE DRAWING THE DIRECTION OF PARABOL CAN BE FALSE

C   D

C'   D'

VERTICAL DIRECTION RAIL
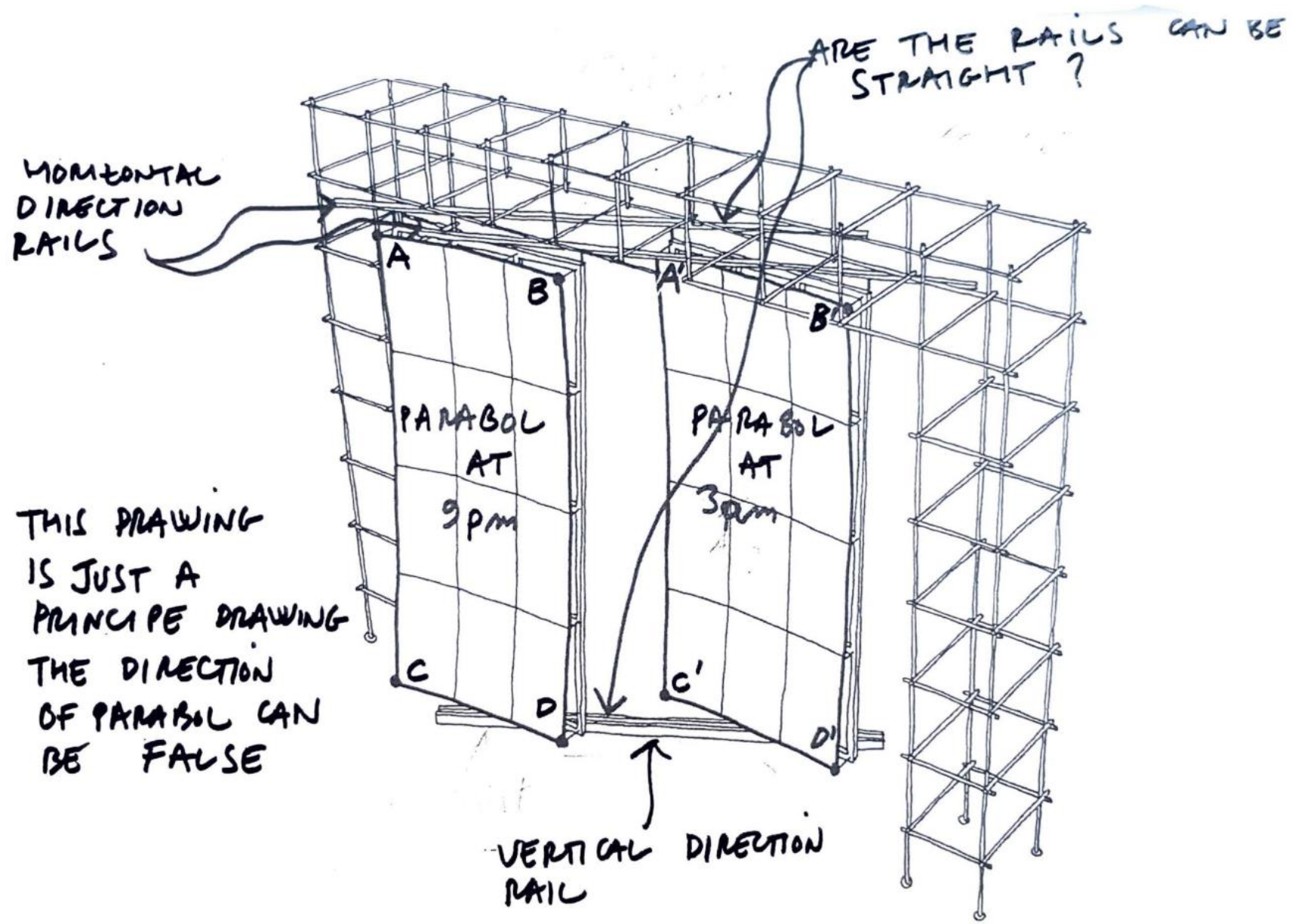
Galileo

Tycho

new reflector 2023

Aristarchus

FreeCAD 0.20

Combo View

Model | Tasks

Labels & Attributes

- arm_left
- side_left_bottom_part
- side_left_centre_part
- side_left_joint_1
- side_left_joint_2
- M12-Nut028
- M12x80-Screw028
- head_bottom
- head_top
- Page
- 12mm_panel_1
- 12mm_panel_2

Property	Value
Base	
Label	12mm_panel_1
Group	[Ortho001 (Ortho_arm...
Drawing view	
Page Res...	/Users/francesco.anse...
Template	/Applications/FreeCA...
Editable ...	[]

View | Data

aristarchus_parametric : 1*   aristarchus_parametric : 12mm_pan...

Report view

07:46:11 Sketch Sketch has partially redundant constraints!
07:46:11 Start Editing Sketch
07:47:24 Sketch Sketch has partially redundant constraints!
07:47:24 Recompute failed! Please check report view.
07:47:24 Recompute failed! Please check report view.

Python console

```
>>> Gui.runCommand('Std_ToggleVisibility',0)
>>> Gui.runCommand('Std_ToggleVisibility',0)
>>> # Gui.Selection.clearSelection()
>>> # Gui.Selection.addSelection('aristarchus_parametric','Page001')
>>> Gui.runCommand('Std_ToggleVisibility',0)
>>>
```

Preselected: aristarchus_parametric.Page001. (0.000000 mm, 0.000000 mm, 0.000000 mm)

Gesture   7704.00 mm x 5778.00 mm

https://github.com/fullmoontheatre/reflectors

fullmoontheatre / reflectors

<> Code   Issues   Pull requests   Actions   Projects   Wiki   Security   Insights   Settings

reflectors Public

Edit Pins   Unwatch 1   Fork 0   Star 0

main   1 branch   0 tags

Go to file   Add file   <> Code

pisuke initial reflectors designs   20775d1 4 days ago   3 commits

archimedes/photos	initial reflectors designs	4 days ago
aristarchus	initial reflectors designs	4 days ago
aryabhata/photos	initial reflectors designs	4 days ago
copernic/photos	initial reflectors designs	4 days ago
galileo	initial reflectors designs	4 days ago
kepler	initial reflectors designs	4 days ago
tycho/photos	initial reflectors designs	4 days ago
LICENSE	Initial commit	4 days ago
README.md	Update README.md	4 days ago

README.md

FMT reflectors

About

Full Moon Theatre reflector designs

☐ Readme
⚖ CC0-1.0 license
⎍ Activity
☆ 0 stars
👁 1 watching
⑂ 0 forks

Report repository

Releases

No releases published
Create a new release

Packages

No packages published
Publish your first package

Ladybug Tools

TOOLS   RESOURCES ▾   PRODUCTS ▾   ABOUT ▾

Tools

———

We are the developers of Ladybug, Honeybee, Butterfly, Dragonfly, and EPWMap
We also contribute to open-source projects including Design Explorer and the Glazing + Winter Comfort Tool.

LADYBUG   **HONEYBEE**   **DRAGONFLY**   **BUTTERFLY**

———

Browse the features of each application using the web of interoperability below.

Double click an image to read more. Press Ctrl + Click to pan. Press Ctrl + Scroll to zoom.

1 :: Analyze Data

LB Surface Ray Tracing

Get a ray tracing visualization of direct sunlight rays reflected off of _source_geo and subsequently bouncing through a set of context_ geometries.

_

Examples where this visualization could be useful include understading the reflection of light by a light shelf or testing to see whether a parabolic glass or metal building geometry might focus sunlight to dangerous levels at certain times of the year.

_

Note that this component assumes that all sun light is reflected specularly (like a mirror) and, for more detailed raytracing analysis with diffuse scattering, the Honeybee Radiance components should be used.

-

0 {0,0

FMT simulation and validation

≡ README.md   ✎

genmoonlight

A python script to generate a Radiance file description of the moon at a specific location, date and time.

Installation of dependencies

```
python3 -m pip install -r requirements.txt
```

Options

```
#                                                        _ _        _   _
#     __ _  ___ _ __  _ __ ___   ___   ___  _ __ | (_) __ _| |_ | |_
#    / _` |/ _ \ '_ \| '_ ` _ \ / _ \ / _ \| '_ \| | |/ _` | __|| '_ \| _|
#   | (_| |  __/ | | | | | | | | (_) | (_) | | | | | | (_| | |  | | | | |_
#    \__, |\___|_| |_|_| |_| |_|\___/ \___/|_| |_|_|_|\__, |_| |_|\__|
#    |___/                                            |___/

usage: genmoonlight.py [-h] [-a LATITUDE] [-o LONGITUDE] [-m MERIDIAN]
                       [-d DATE] [-t TIME]

optional arguments:
  -h, --help            show this help message and exit
  -a LATITUDE, --latitude LATITUDE
                        latitude
  -o LONGITUDE, --longitude LONGITUDE
                        longitude
  -m MERIDIAN, --meridian MERIDIAN
                        meridian
  -d DATE, --date DATE  date - format: YYYY-MM-DD
  -t TIME, --time TIME  time - format: HH:MM
```

```
$ ./genmoonlight.py -a 50.790707850000004 -o -2.6816552948061627 -m 0 -d 2023-10-28 -t 23:00
```

```
#                                              _ _      _   _
#    __ _  ___ _ __  _ __ ___   ___   ___  _ _ | (_) __ _| |_ | |_
#   / _` |/ _ \ '_ \| '_ ` _ \ / _ \ / _ \| '_ \| | |/ _` | '_ \| __|
#  | (_| |  __/ | | | | | | | | (_) | (_) | | | | | | (_| | | | | |_
#   \__, |\___|_| |_|_| |_| |_|\___/ \___/|_| |_|_|_|\__, |_| |_|\__|
#   |___/                                              |___/

# Moon data for 2023-10-28 23:00
# Location - latitude: 50.790707850000004 | longitude: -2.6816552948061627
# Target Moon's azimuth: 156.55337260727157
# Target Moon's altitude: 51.48679241644569
# Target Moon's angular size: 0.5461606174045139
# Target Moon's age (days): 14.211730042770796
# Target Moon's fractional phase: 0.9997474211255863
# Target Moon's phase name: WANING_GIBBOUS
# Distance of target Moon's from Earth: 365075.8837129292 km

# Lunar altitude  51.48679241644569 deg, azimuth 156.55337260727157 deg
# lunar age 14.211730042770796 days, disc illum fraction 0.9997474211255863, angular disc size 0.546

void light lunar
0
0
3 16.371726561054125 15.592120534337262 13.253302454186672

lunar source moon
0
0
4 0.2477670055152368 -0.571279794378561 0.7824646365892849 0.5461606174045139
```
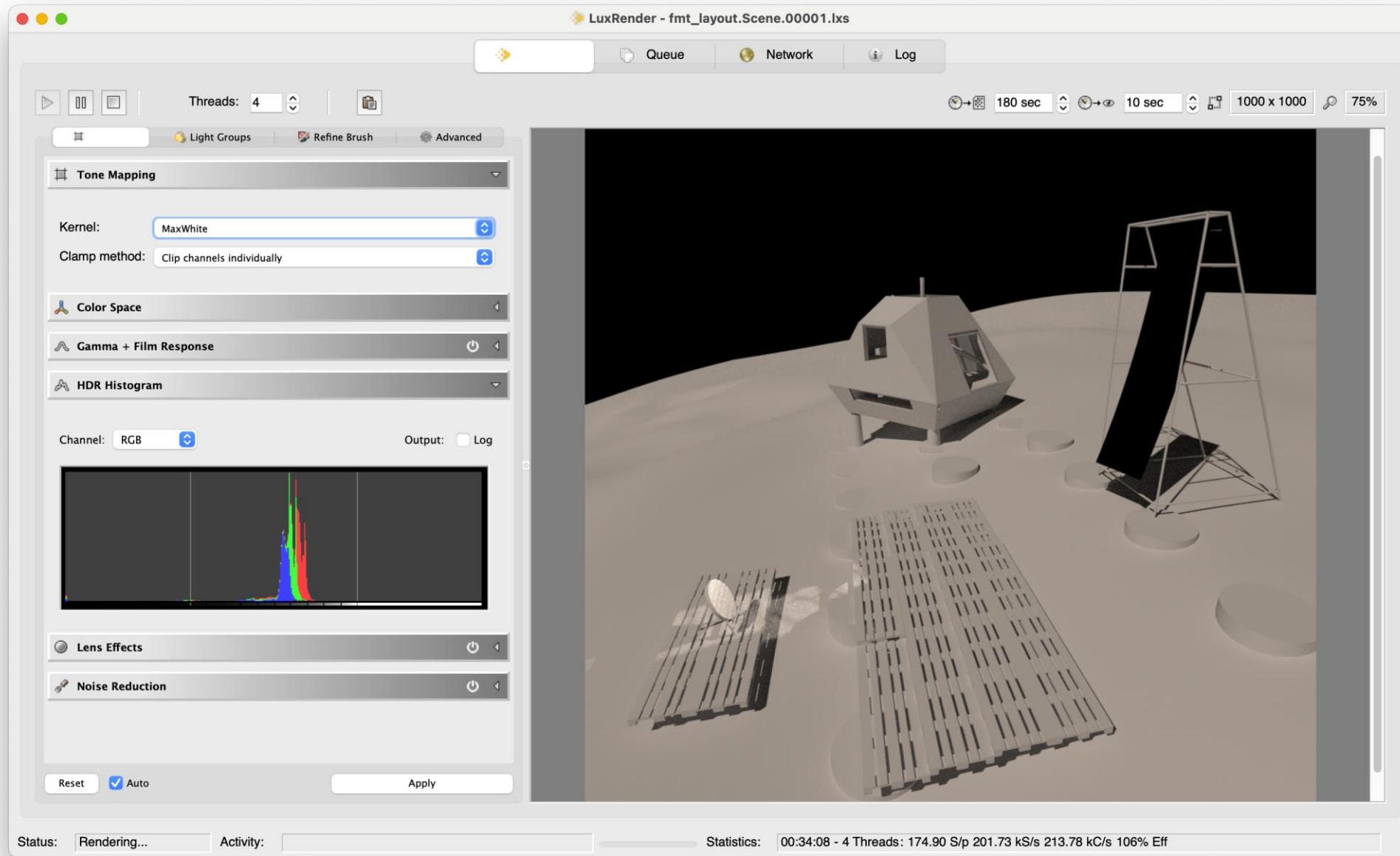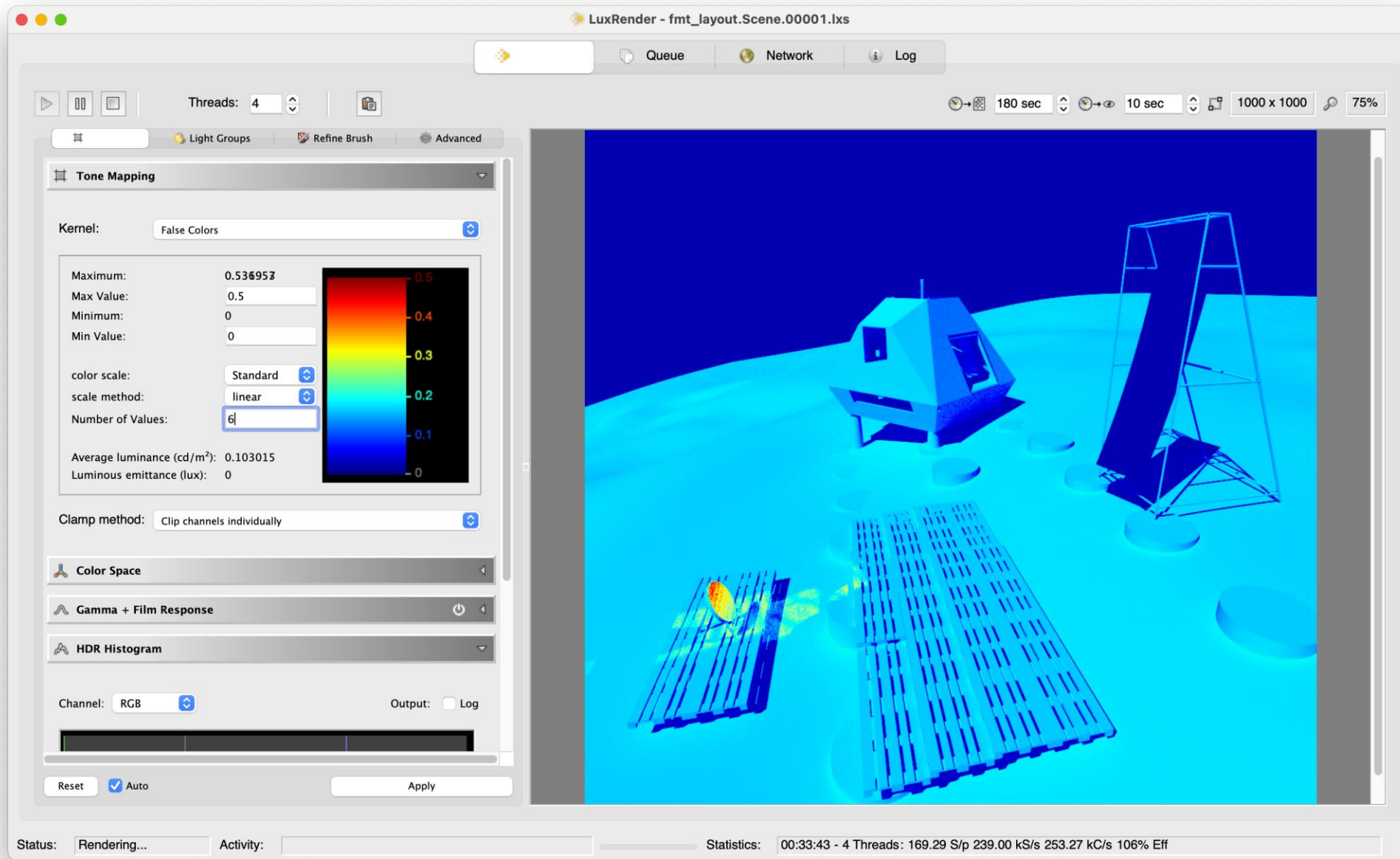
FMT reflector simulation and validation - Radiance
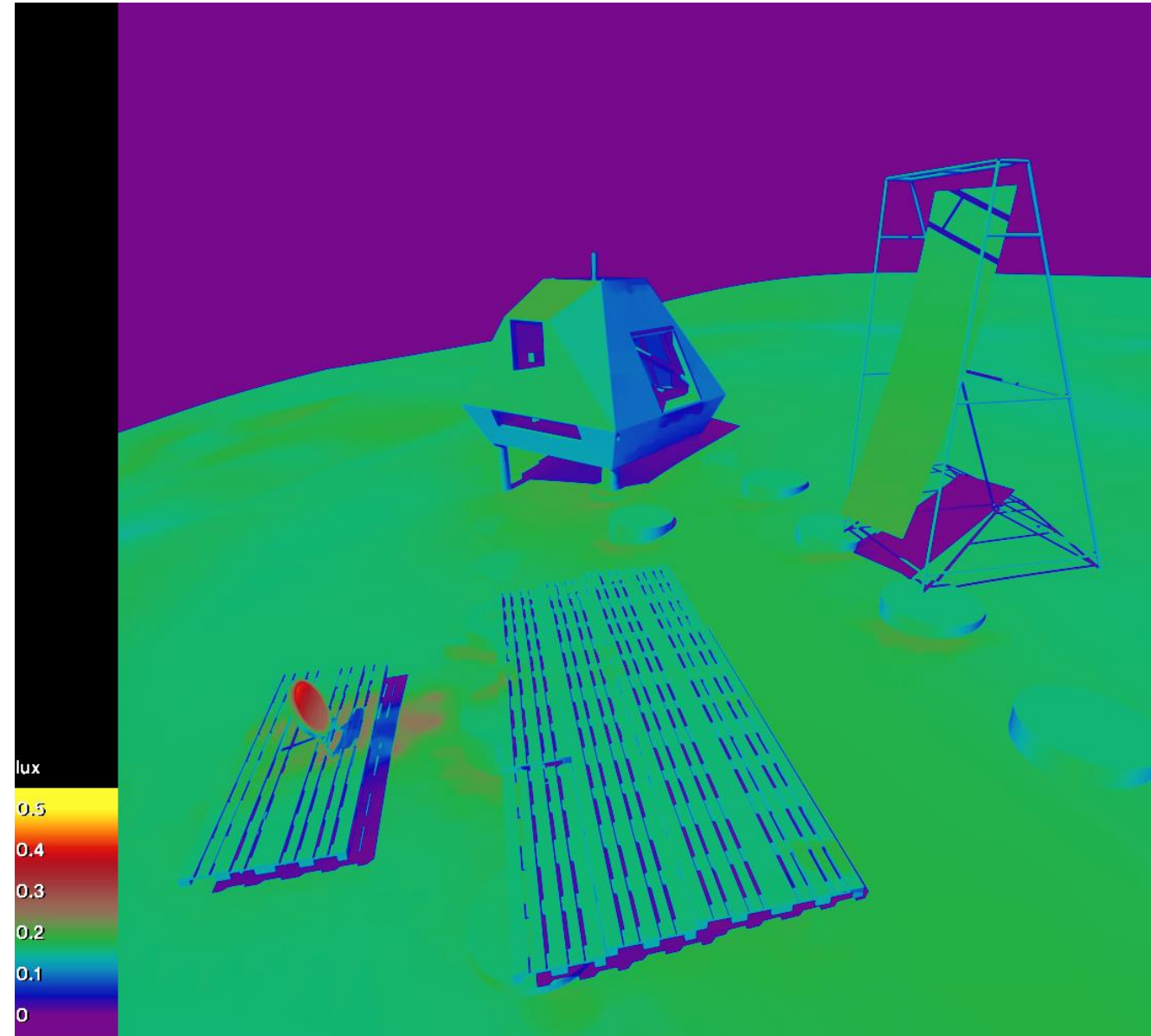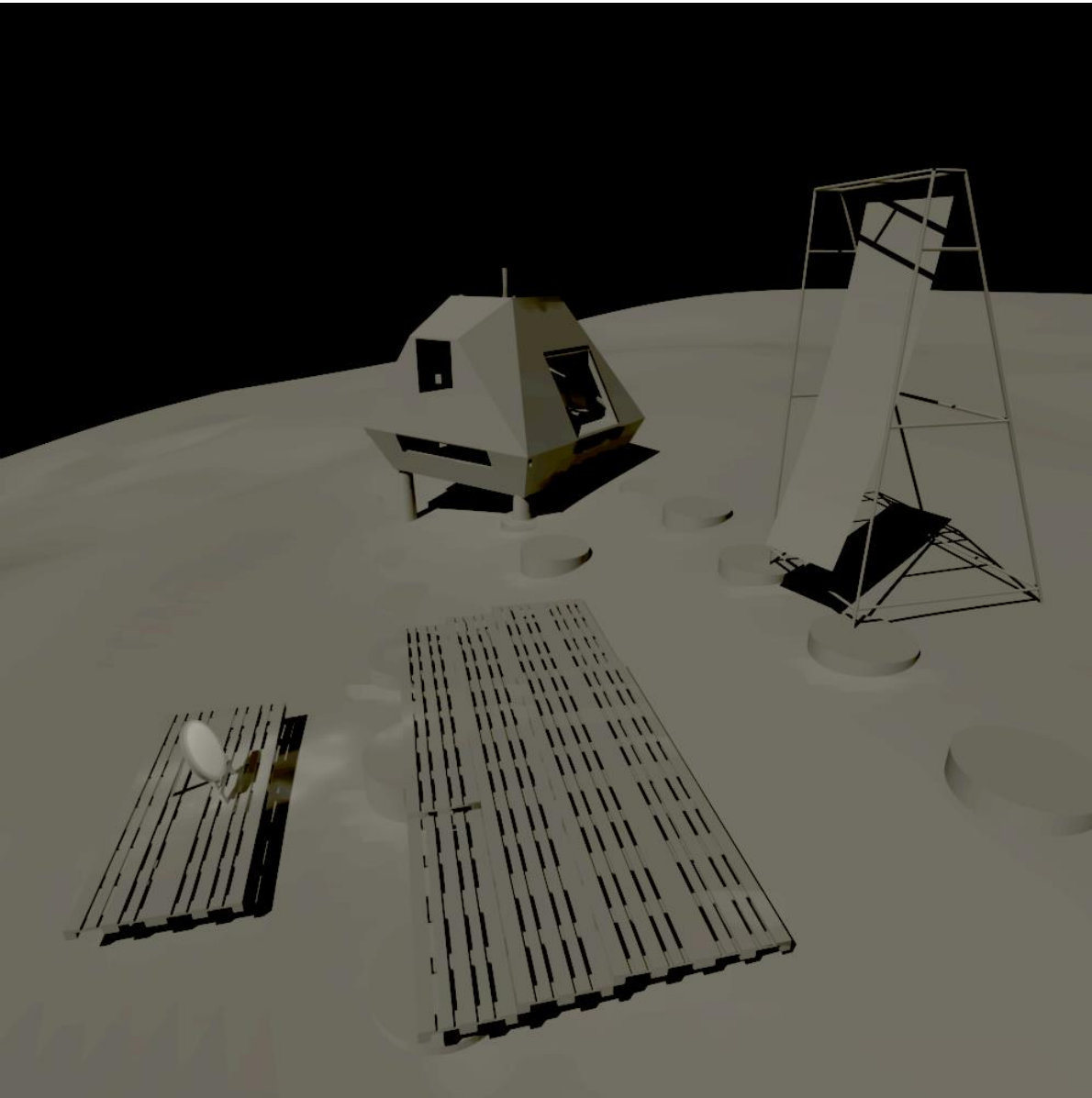
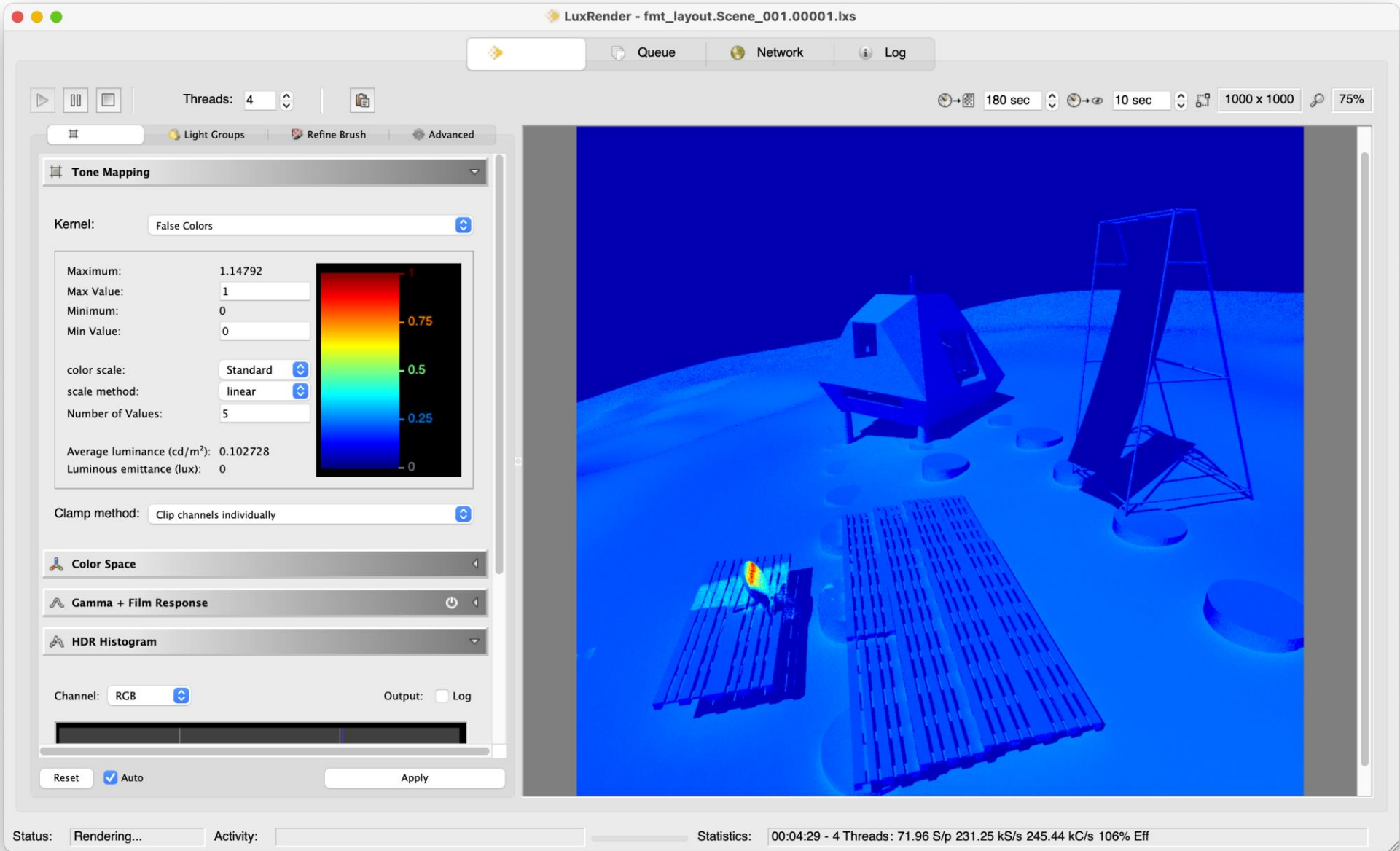# FMT reflector simulation and validation - LuxRender

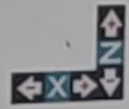# FMT reflector simulation and validation - LuxRender
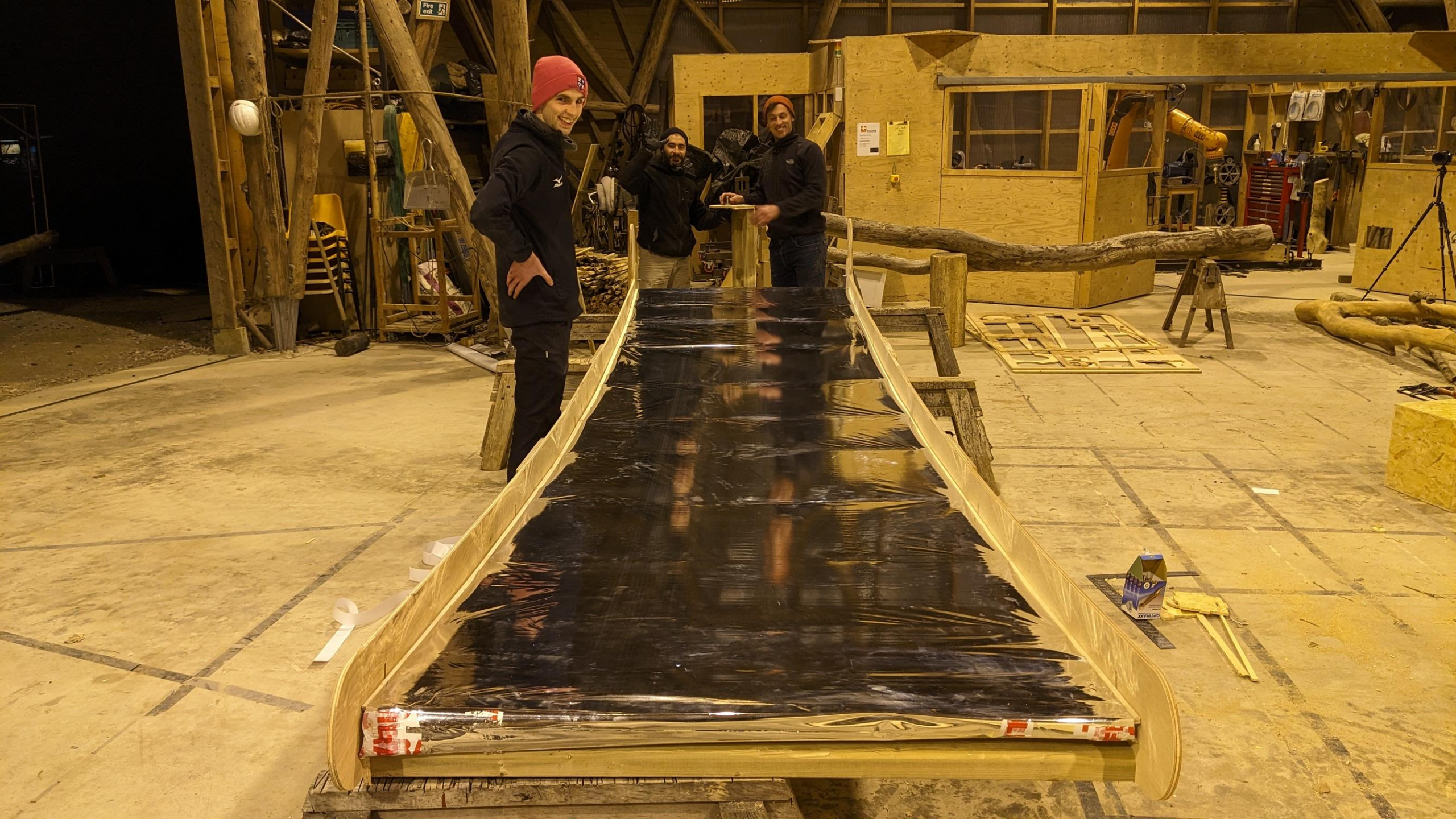
FMT reflector CNC fabrication

https://fullmoontheatre.org/

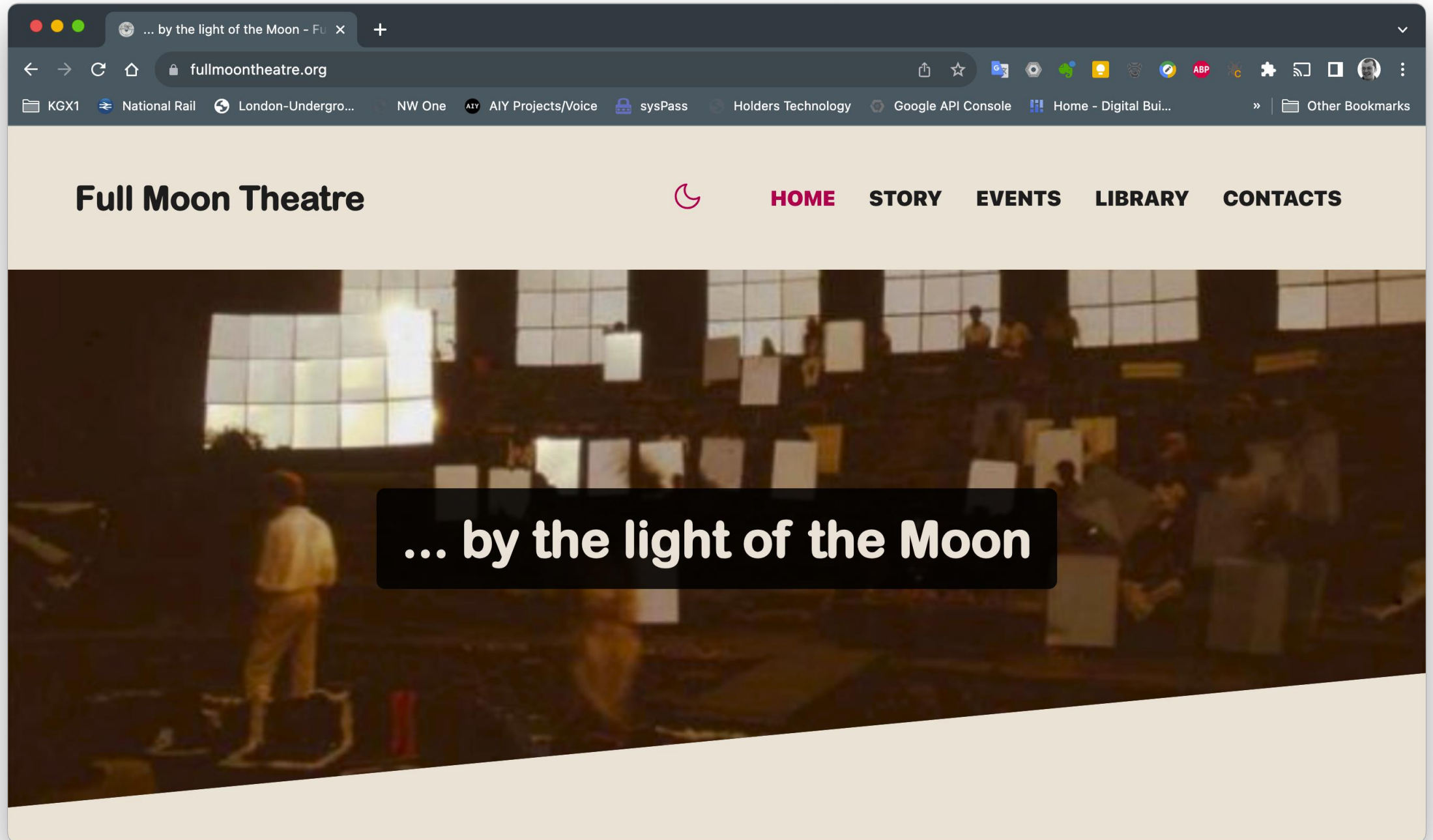# Thank you!

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Architectural Association
School of Architecture