Task 1: Data Retrieval and Parsing

Retrieving and plotting Gamma Ray Spectrometer(GRS) data. The data is collected for a duration of 18 months at an interval of 32 seconds from 1998 to 1999 at an altitude of ~30km and ~100km.

In [1]:
```python
# Importing libraries to download required data
import urllib.request
import time
import struct
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

Retrieving the corresponding .dat and .lbl file

Before parsing through the .dat files which hold the correspoding GRS data, the files are downloaded from the following url https://pds-geosciences.wustl.edu/lunar/lp-l-grs-3-rdr-v1/lp_2xxx/grs/ using the **urllib.request** module within Python. The files are stored locally, following the naming convention **{year}_{day}_grs.dat** and **{year}_{day}_grs.lbl**

The datasets for the years 1998 and 1999 have been downloaded separately inorder to minimize the overhead.

In [ ]:
```python
# Downloading GRS data from the specified URL for the year 1998

url = 'https://pds-geosciences.wustl.edu/lunar/lp-l-grs-3-rdr-v1/lp_2xxx/grs/'

start = time.time()
data_not_found = 0
label_not_found = 0

for year in range(1998, 1999):
    for day in range(1, 367):
        if day < 100:
            if day < 10:
                temp_day = "00" + str(day)
            else:
                temp_day = "0" + str(day)
            data_file_name = f'{year}_{temp_day}_grs.dat'
            label_file_name = f'{year}_{temp_day}_grs.lbl'
        else:
            data_file_name = f'{year}_{day}_grs.dat'
            label_file_name = f'{year}_{day}_grs.lbl'
        url_data = url + data_file_name
        url_label = url + label_file_name
        try:
            urllib.request.urlretrieve(url_data, data_file_name)
        except:
            print(f"Data file for {data_file_name} could not be retrieved.")
            data_not_found += 1
        try:
            urllib.request.urlretrieve(url_label, label_file_name)
        except:
            print(f"Label file for {label_file_name} could not be retrieved.")
            label_not_found += 1

end = time.time()

print("Total time taken to retrive all data and label files: {:.4f} seconds".format(end-start))
print(f"Total .dat files not found {data_not_found}")
print(f"Total .lbl files not found {label_not_found}")
```

In [ ]:
```python
# Downloading GRS data from the specified URL for the year 1999

url = 'https://pds-geosciences.wustl.edu/lunar/lp-l-grs-3-rdr-v1/lp_2xxx/grs/'

start = time.time()
data_not_found = 0
label_not_found = 0

for year in range(1999, 2000):
    for day in range(1, 367):
        if day < 100:
            if day < 10:
                temp_day = "00" + str(day)
            else:
                temp_day = "0" + str(day)
            data_file_name = f'{year}_{temp_day}_grs.dat'
            label_file_name = f'{year}_{temp_day}_grs.lbl'
        else:
            data_file_name = f'{year}_{day}_grs.dat'
            label_file_name = f'{year}_{day}_grs.lbl'
        url_data = url + data_file_name
        url_label = url + label_file_name
        try:
            urllib.request.urlretrieve(url_data, data_file_name)
        except:
            print(f"Data file for {data_file_name} could not be retrieved.")
            data_not_found += 1
        try:
            urllib.request.urlretrieve(url_label, label_file_name)
        except:
            print(f"Label file for {label_file_name} could not be retrieved.")
            label_not_found += 1

end = time.time()

print("Total time taken to retrive all data and label files: {:.4f} seconds".format(end-start))
print(f"Total .dat files not found {data_not_found}")
print(f"Total .lbl files not found {label_not_found}")
```

Parsing .dat files

The .dat files are parsed in accordance with the instructions and format specified in the respective .lbl file. To illustrate, we first parse the **1998_270_grs.dat** file which denotes the GRS data collected on Day 270 of 1998 by the Lunar Prospector. After parsing through the .dat file, a **Pandas Dataframe** is created which is used to plot and perform further calculations.

In [2]:
```python
filename = "./Task1/1998_270_grs.lbl"
datafilename = "./Task1/1998_270_grs.dat"

# Define the record format for the label file
label_format = [
    ("PDS_VERSION_ID", "23s"),
    ("RECORD_TYPE", "23s"),
    ("RECORD_BYTES", "23s"),
    ("FILE_RECORDS", "23s"),
    ("^TABLE", "23s"),
    ("DATA_SET_NAME", "59s"),
    ("DATA_SET_ID", "33s"),
    ("PRODUCT_ID", "23s"),
    ("PRODUCT_TYPE", "23s"),
    ("PRODUCT_VERSION_ID", "23s"),
    ("SPACECRAFT_NAME", "23s"),
    ("INSTRUMENT_NAME", "23s"),
    ("TARGET_NAME", "23s"),
    ("START_TIME", "23s"),
    ("STOP_TIME", "23s"),
    ("SPACECRAFT_CLOCK_START_COUNT", "23s"),
    ("SPACECRAFT_CLOCK_STOP_COUNT", "23s"),
    ("PRODUCT_CREATION_TIME", "23s")
]

# Define the record format for the data file
data_format = [
    ("accepted_spectrum", "512f"),
    ("rejected_spectrum", "512f"),
    ("deadtime", "f"),
    ("overload", "f"),
    ("grs_temperature", "f"),
    ("earth_received_time", "f"),
    ("spacecraft_altitude", "f"),
    ("subspacecraft_latitude", "f"),
    ("subspacecraft_longitude", "f")
]

# Open the data file for reading
with open(filename, "r") as f:
    label = {}
    for line in f:
        # Ignoring all comments in the .lbl file.
        if line.strip() and not line.startswith("#"):
            # Splitting lines and reading values for corresponding labels
            parts = line.split("=", 1)
            if len(parts) == 2:
                key = parts[0].strip()
                value = parts[1].strip()
                label[key] = value

# Read the data file
with open(datafilename, "rb") as f:
    # Parse each data record in the file
    data = []
    for i in range(int(label["FILE_RECORDS"])):
        record = {}
        for field, format in data_format:
            bytes = f.read(struct.calcsize(format))
            value = struct.unpack(format, bytes)[0]
            # Separate condition for accepted and rejected spectrum as they 512 data items.
            if field == "accepted_spectrum" or field == "rejected_spectrum":
                value = struct.unpack(format, bytes)
            record[field] = value
        data.append(record)

data_size = len(data)

# Print some information from the label and data
print("Data Set Name:", label["DATA_SET_NAME"])
print("Product ID:", label["PRODUCT_ID"])
print("Start Time:", label["START_TIME"])
print("Stop Time:", label["STOP_TIME"])
print("Number of Records:", len(data))

df = pd.DataFrame(data)
df.to_csv("./Task1/1998_270_grs.csv", index = False)
df
```

```
Data Set Name: "LP MOON GAMMA RAY SPECTROMETER 3 RDR V1.0"
Product ID: "1998_270_GRS"
Start Time: 1998-270T00:00:00
Stop Time: 1998-270T23:59:59
Number of Records: 2434
```

Out[2]:

	accepted_spectrum	rejected_spectrum	deadtime	overload	grs_temperature	earth_received_time	spacecraft_altitude	subspacecraft_lat
0	(64.02674102783203, 13.172483444213867, 7.3601...	(64.02674102783203, 13.172483444213867, 7.3601...	0.036275	19240.0	-29.462872	270.000458	94.548889	-65.0
1	(71.24832153320312, 16.329853057861328, 6.2006...	(71.24832153320312, 16.329853057861328, 6.2006...	0.036379	19470.0	-29.462872	270.000824	94.397430	-66.6
2	(75.33775329589844, 14.223711013793945, 2.8263...	(75.33775329589844, 14.223711013793945, 2.8263...	0.036232	19333.0	-29.462872	270.001190	94.250351	-68.3
3	(66.99480438232422, 13.69210147857666, 2.24435...	(66.99480438232422, 13.69210147857666, 2.24435...	0.035954	19481.0	-29.244972	270.001556	94.106232	-69.9
4	(83.07652282714844, 18.389801025390625, 8.6971...	(83.07652282714844, 18.389801025390625, 8.6971...	0.036298	19235.0	-29.027073	270.001953	93.965805	-71.5
...	...	...	...	...	...	...	...	
2429	(75.26776885986328, 13.090079307556152, 6.5458...	(75.26776885986328, 13.090079307556152, 6.5458...	0.038344	20041.0	-29.027073	270.998230	90.229843	-39.7
2430	(75.17789459228516, 12.126038551330566, 2.8355...	(75.17789459228516, 12.126038551330566, 2.8355...	0.038190	19712.0	-29.027073	270.998596	90.314163	-38.0
2431	(79.4575424194336, 14.664920806884766, 3.31126...	(79.4575424194336, 14.664920806884766, 3.31126...	0.038392	19890.0	-29.027073	270.998993	90.410225	-36.4
2432	(67.12801361083984, 14.736181259155273, 4.6537...	(67.12801361083984, 14.736181259155273, 4.6537...	0.038206	19701.0	-29.027073	270.999359	90.507782	-34.7
2433	(67.05589294433594, 12.82453727722168, 3.32525...	(67.05589294433594, 12.82453727722168, 3.32525...	0.038266	19466.0	-28.594601	271.000092	90.725143	-31.5

2434 rows × 9 columns

Visualising the data of 1998_270_grs.dat file

The column **sum_accepted_spectrum** has been added.

In [3]:
```python
# Finding the sum of all accepted_spectrums, and inserting an additional column in the dataframe.

data = pd.read_csv("./Task1/1998_270_grs.csv")
sum_accepted_spectrum = []
for i in range(data_size):
    temp = data["accepted_spectrum"][i].lstrip("(").rstrip(")").split(",")
    temp = [float(j.strip()) for j in temp]
    sum_accepted_spectrum.append(sum(temp))
data["sum_accepted_spectrum"] = sum_accepted_spectrum
data
```

Out[3]:

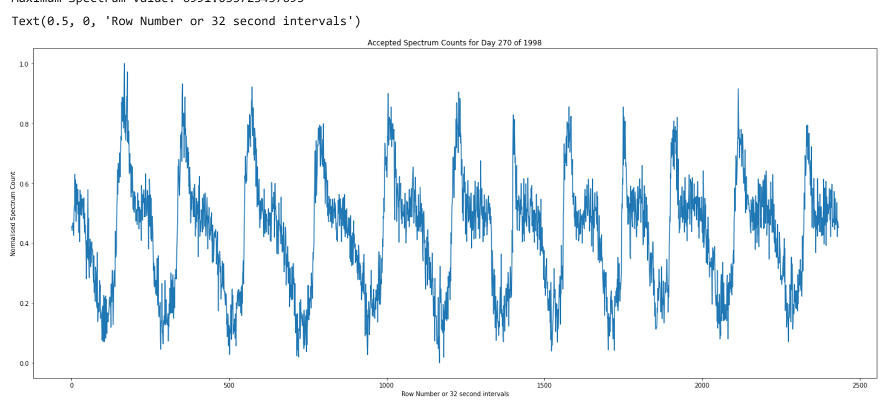
	accepted_spectrum	rejected_spectrum	deadtime	overload	grs_temperature	earth_received_time	spacecraft_altitude	subspacecraft_lat
0	(64.02674102783203, 13.172483444213867, 7.3601...	(64.02674102783203, 13.172483444213867, 7.3601...	0.036275	19240.0	-29.462872	270.000458	94.548889	-65.0
1	(71.24832153320312, 16.329853057861328, 6.2006...	(71.24832153320312, 16.329853057861328, 6.2006...	0.036379	19470.0	-29.462872	270.000824	94.397430	-66.6
2	(75.33775329589844, 14.223711013793945, 2.8263...	(75.33775329589844, 14.223711013793945, 2.8263...	0.036232	19333.0	-29.462872	270.001190	94.250351	-68.3
3	(66.99480438232422, 13.69210147857666, 2.24435...	(66.99480438232422, 13.69210147857666, 2.24435...	0.035954	19481.0	-29.244972	270.001556	94.106232	-69.9
4	(83.07652282714844, 18.389801025390625, 8.6971...	(83.07652282714844, 18.389801025390625, 8.6971...	0.036298	19235.0	-29.027073	270.001953	93.965805	-71.5
...	...	...	...	...	...	...	...	
2429	(75.26776885986328, 13.090079307556152, 6.5458...	(75.26776885986328, 13.090079307556152, 6.5458...	0.038344	20041.0	-29.027073	270.998230	90.229843	-39.7
2430	(75.17789459228516, 12.126038551330566, 2.8355...	(75.17789459228516, 12.126038551330566, 2.8355...	0.038190	19712.0	-29.027073	270.998596	90.314163	-38.0
2431	(79.4575424194336, 14.664920806884766, 3.31126...	(79.4575424194336, 14.664920806884766, 3.31126...	0.038392	19890.0	-29.027073	270.998993	90.410225	-36.4
2432	(67.12801361083984, 14.736181259155273, 4.6537...	(67.12801361083984, 14.736181259155273, 4.6537...	0.038206	19701.0	-29.027073	270.999359	90.507782	-34.7
2433	(67.05589294433594, 12.82453727722168, 3.32525...	(67.05589294433594, 12.82453727722168, 3.32525...	0.038266	19466.0	-28.594601	271.000092	90.725143	-31.5

2434 rows × 10 columns

In [8]:
```python
from sklearn.preprocessing import MinMaxScaler

# Normalising the data for plotting.
scaler = MinMaxScaler()
np_data = np.array(data["sum_accepted_spectrum"])
np_data = np_data.reshape(-1,1)
scaled_data = scaler.fit_transform(np_data)
print(f"Normalized Values: {scaled_data}")

print(f"Minimum Spectrum Value:" , min(data["sum_accepted_spectrum"]))
print(f"Maximum Spectrum Value:", max(data["sum_accepted_spectrum"]))

plt.figure(figsize = (25, 10))
plt.plot(scaled_data)
plt.title("Accepted Spectrum Counts for Day 270 of 1998")
plt.ylabel("Normalised Spectrum Count")
plt.xlabel("Row Number or 32 second intervals")
```

```
Normalized Values: [[0.45497323]
 [0.45532941]
 [0.44181099]
 ...
 [0.46832142]
 [0.45991979]
 [0.45269049]]
Minimum Spectrum Value: 5310.273548566736
Maximum Spectrum Value: 6991.033723437693
```

Out[8]: `Text(0.5, 0, 'Row Number or 32 second intervals')`



Creating a Pandas Dataframe to store all GRS data

In [7]:
```python
# Determining the .dat and .lbl files available locally.

import os

directory = './Task1'  # Replace with your directory path
files = os.listdir(directory)

dat_files = []
lbl_files = []
for file in files:
    if file.endswith('.dat'):
        dat_files.append(file)
    elif file.endswith('.lbl'):
        lbl_files.append(file)
```

In [ ]:
```python
data = []

# Iterating through all .dat and .lbl files.
for i in dat_files:
    if i[:-4] + ".lbl" in lbl_files:
        filename = f"./Task1/{i[:-4]}.lbl"
        datafilename = f"./Task1/{i}"
    else:
        continue

    # Define the record format for the label file
    label_format = [
        ("PDS_VERSION_ID", "23s"),
        ("RECORD_TYPE", "23s"),
        ("RECORD_BYTES", "23s"),
        ("FILE_RECORDS", "23s"),
        ("^TABLE", "23s"),
        ("DATA_SET_NAME", "59s"),
        ("DATA_SET_ID", "33s"),
        ("PRODUCT_ID", "23s"),
        ("PRODUCT_TYPE", "23s"),
        ("PRODUCT_VERSION_ID", "23s"),
        ("SPACECRAFT_NAME", "23s"),
        ("INSTRUMENT_NAME", "23s"),
        ("TARGET_NAME", "23s"),
        ("START_TIME", "23s"),
        ("STOP_TIME", "23s"),
        ("SPACECRAFT_CLOCK_START_COUNT", "23s"),
        ("SPACECRAFT_CLOCK_STOP_COUNT", "23s"),
        ("PRODUCT_CREATION_TIME", "23s")
    ]

    # Define the record format for the data file
    data_format = [
        ("accepted_spectrum", "512f"),
        ("rejected_spectrum", "512f"),
        ("deadtime", "f"),
        ("overload", "f"),
        ("grs_temperature", "f"),
        ("earth_received_time", "f"),
        ("spacecraft_altitude", "f"),
        ("subspacecraft_latitude", "f"),
        ("subspacecraft_longitude", "f")
    ]

    # Open the data file for reading
    with open(filename, "r") as f:
        label = {}
        for line in f:
            # Ignoring all comments in the .lbl file.
            if line.strip() and not line.startswith("#"):
                # Splitting lines and reading values for corresponding labels
                parts = line.split("=", 1)
                if len(parts) == 2:
                    key = parts[0].strip()
                    value = parts[1].strip()
                    label[key] = value

    # Read the data file
    with open(datafilename, "rb") as f:
        for i in range(int(label["FILE_RECORDS"])):
            record = {}
            for field, format in data_format:
                bytes = f.read(struct.calcsize(format))
                value = struct.unpack(format, bytes)[0]
                # Separate condition for accepted and rejected spectrum as they 512 data items.
                if field == "accepted_spectrum" or field == "rejected_spectrum":
                    value = struct.unpack(format, bytes)
                record[field] = value
            data.append(record)

df = pd.DataFrame(data)
df.head()
df.info()
df.to_csv("./Task1/cumulative_grs_data.csv", index = False)
```

Task Complete

The specified .dat files have been retrieved, and have been parsed using the respective .lbl files. Furthermore, a plot illustrating the **accepted_spectrum_count** for **Day 270** of **1998** has been plotted, which demonstrates the count of spectrum count for every 32 seconds

Kindly note that certain outputs while fetching the data have been cleared. Only necessary outputs have been displayed