

SLAPS Data

October 7, 2021

Load CSV Data to pandas dataframe and clean the data

```
[1]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

# open file
f = open("TEST.csv", "r")
df = pd.read_csv(f, dtype = object)

# trim excess rows and convert non-numerics to NaNs
df = df.apply(pd.to_numeric, errors='coerce')
df.drop(columns = df.columns[17:], inplace = True)
df.dropna(axis = 'index', inplace = True) # drop any rows with any NaNs

# set type of each column
dtype = {'ti':np.int64, 'e':np.int64, 'st':np.int64, 'pr':np.float64,
        'te':np.float64, 'a':np.float64, 'Vs':np.float64, 'Vb':np.float64,
        'c':np.float64, 'po':np.int64, 'Sa':np.int64, 'Ax':np.int64,
        'Ay':np.int64, 'Az':np.int64, 'Gx':np.int64,
        'Gy':np.int64, 'Gz':np.int64}
df = df.astype(dtype)

# check for any reported errors (if none, drop the error column)
if (df.e.max() == 0):
    df.drop(columns = 'e', inplace = True)
else:
    print("Errors: ", df.e.unique())

# show beginning of df
df.head()
```

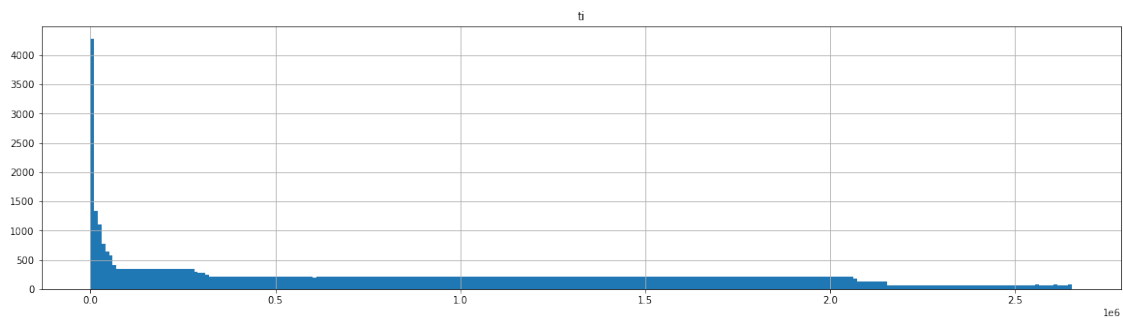
```
[1]:   ti  st      pr    te    a    Vs    Vb    c  po  Sa  Ax  Ay  Az  \
0  474   0 100698.71 23.27 135.93 0.13 0.89 1.1   0  93 -54  22 1261
1  506   4 100698.71 23.27 135.93 0.09 0.89 1.2   0   0 -74  16 1264
2  642   1 100699.28 23.30 135.89 0.11 0.89 0.9   0   0 -72  22 1268
3  777   1 100701.99 23.33 135.66 0.10 0.89 1.1   0   0 -77  13 1248
4  912   1 100700.53 23.34 135.78 0.11 0.88 1.4   0   0 -75   7 1268
```

	Gx	Gy	Gz
0	19	8	-110
1	28	2	-101
2	24	4	-105
3	24	5	-110
4	22	12	-111

Histogram of times to illustrate that there are a bunch of small times

```
[2]: time_per_bin_ms = 10000
num_bins = int(df.ti.max()/time_per_bin_ms)
df.hist(column = 'ti', bins = num_bins, figsize = (20,5))
ti_count = pd.cut(df['ti'], bins = num_bins)
ti_count.value_counts()
```

```
[2]: (-2495.75, 10167.377]      4279
(10167.377, 20177.755]      1337
(20177.755, 30188.132]      1112
(30188.132, 40198.509]       771
(40198.509, 50208.887]       639
...
(2242481.528, 2252491.906]      69
(2352595.679, 2362606.057]      69
(2422668.321, 2432678.698]      69
(2202440.019, 2212450.396]      69
(2392637.189, 2402647.566]      69
Name: ti, Length: 265, dtype: int64
```



Now we set about correcting the strange times. To do this, we will compute the mean delta time and round it to an int. First, we visualze the data to determine which delta t's correspond to the average

```
[3]: # most common delta-t for measurements, essentially avg timestep between
      ↳ measurements
      # median is taken because of extreme values when arduino resets from large time
```

```

del_ts = df[['ti']].diff(periods = 1, axis = 'index')
hd_offset = 750 # offset from head and tail of data
h_offset = 1550 # offset from head of data
t_offset = 750 # offset from tail of data
sorted_dts = (del_ts['ti'])[1:].sort_values()
middle_dts = sorted_dts[hd_offset-1:sorted_dts.size-hd_offset-1]
corrected_dts = sorted_dts[h_offset-1:sorted_dts.size-t_offset-1]

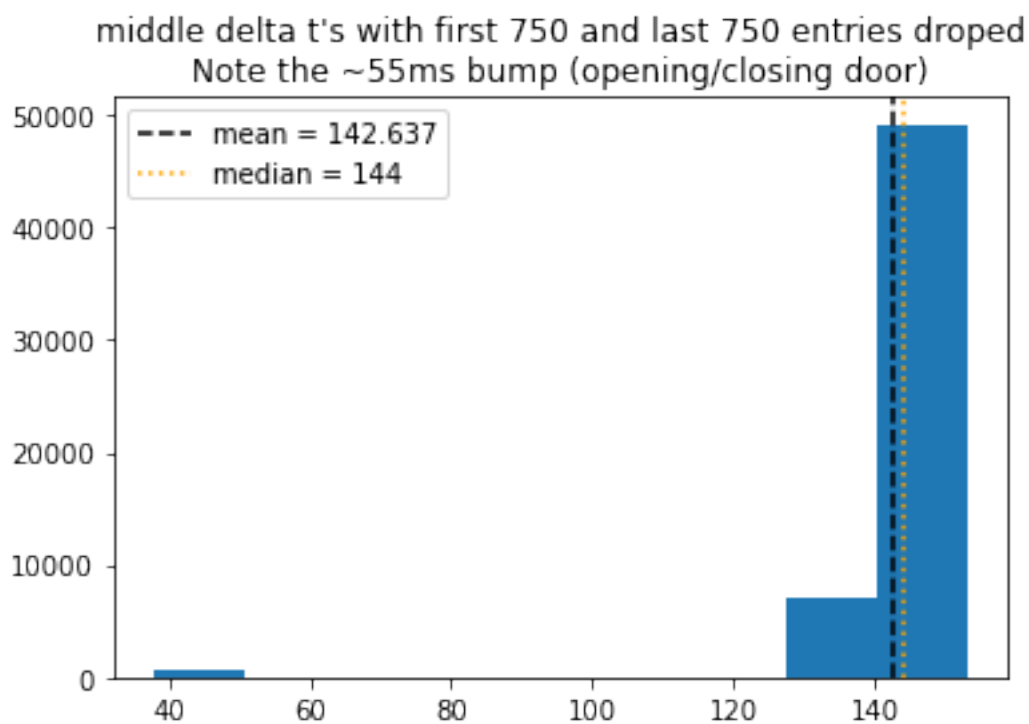
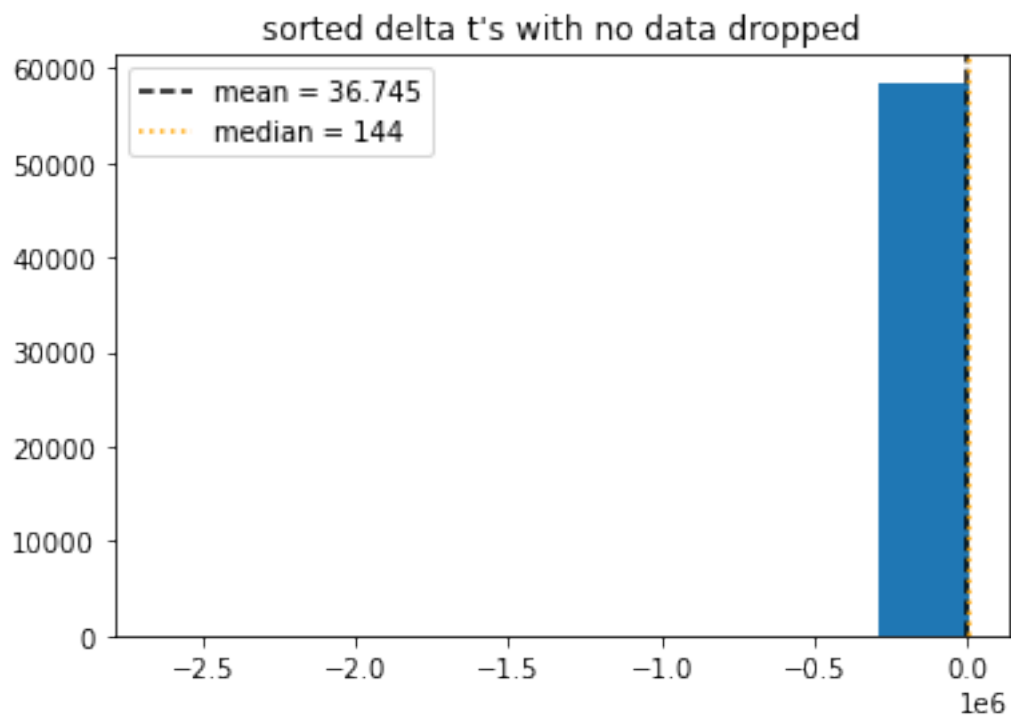
plt.figure()
plt.title('sorted delta t\'s with no data dropped')
plt.hist(sorted_dts, bins = 9)
plt.axvline(x = sorted_dts.mean(), ls = '--', c = 'k', label = f'mean = {round(sorted_dts.mean(),3)}')
plt.axvline(x = sorted_dts.median(), ls = ':', c = 'orange', label = f'median = {round(sorted_dts.median())}')
plt.legend()

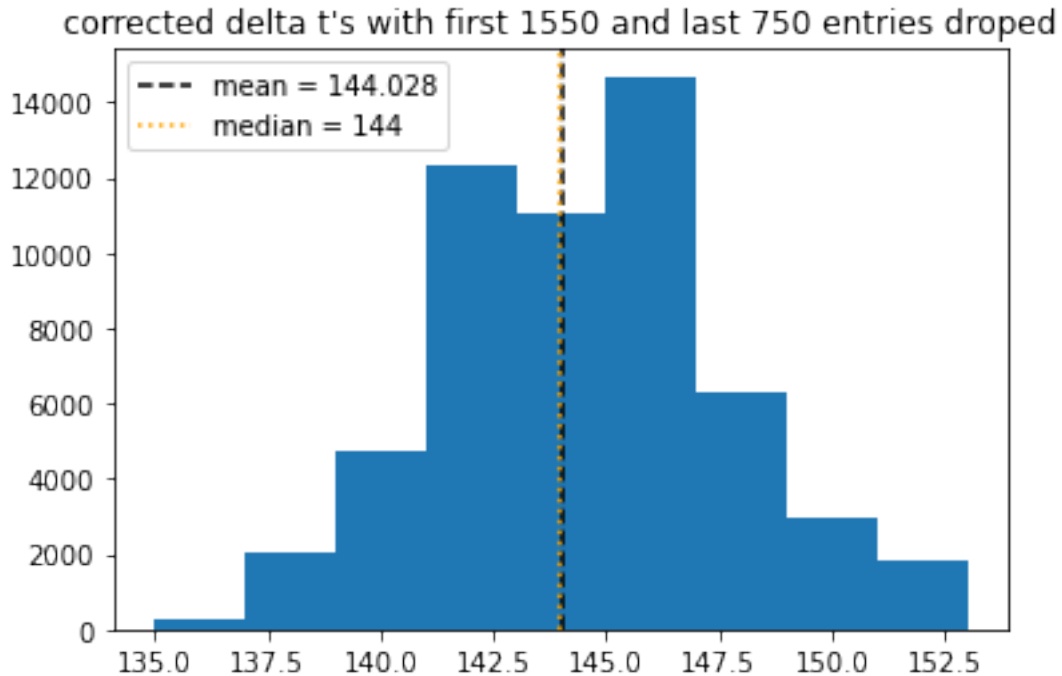
plt.figure()
plt.title(f'middle delta t\'s with first {hd_offset} and last {hd_offset} entries dropped\nNote the ~55ms bump (opening/closing door)')
plt.hist(middle_dts, bins = 9)
plt.axvline(x = middle_dts.mean(), ls = '--', c = 'k', label = f'mean = {round(middle_dts.mean(),3)}')
plt.axvline(x = middle_dts.median(), ls = ':', c = 'orange', label = f'median = {round(middle_dts.median())}')
plt.legend()
print("")

plt.figure()
plt.title(f'corrected delta t\'s with first {h_offset} and last {t_offset} entries dropped')
plt.hist(corrected_dts, bins = 9)
plt.axvline(x = corrected_dts.mean(), ls = '--', c = 'k', label = f'mean = {round(corrected_dts.mean(),3)}')
plt.axvline(x = corrected_dts.median(), ls = ':', c = 'orange', label = f'median = {round(corrected_dts.median())}')
plt.legend()

mdt = round(corrected_dts.mean())

```





Now that we have a reasonable mean delta t for regular memory writes, we will look at the trends over time while the door is open.

```
[4]: # get only rows where the door is open
open_st = 3
open_df = df.loc[df['st'] == open_st]

# disable a warning quickly because it won't make any problems (probably)
pd.options.mode.chained_assignment = None
open_df['ti_c'] = np.arange(0, len(open_df)*mdt, mdt)
pd.options.mode.chained_assignment = 'warn' # default = 'warn'

plt.figure()
plt.title('Raw power data vs time (ms)')
x = open_df.ti_c
y = open_df.po
plt.plot(x, y, label = 'Raw power data')
plt.axhline(y = y.mean(), ls = '--', c = 'k', label = f'mean = {round(y.
    ↪mean(),3)}')
plt.legend()

window_length_s = 60
plt.figure()
plt.title(f'Rolling average power over {window_length_s}s vs time (ms)')
x = open_df.ti_c
```

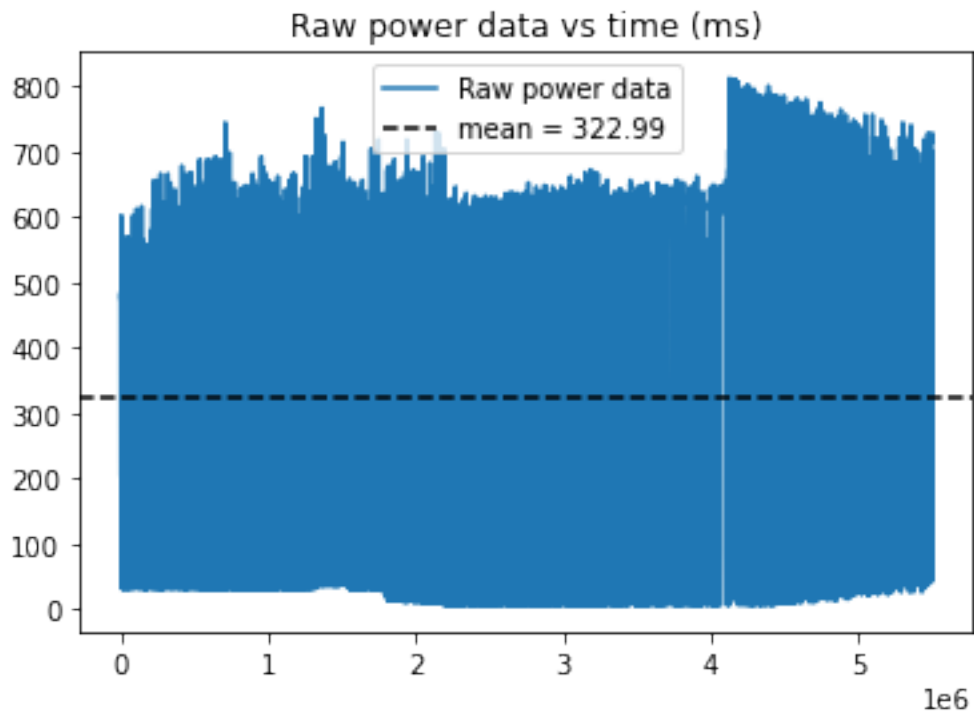
```

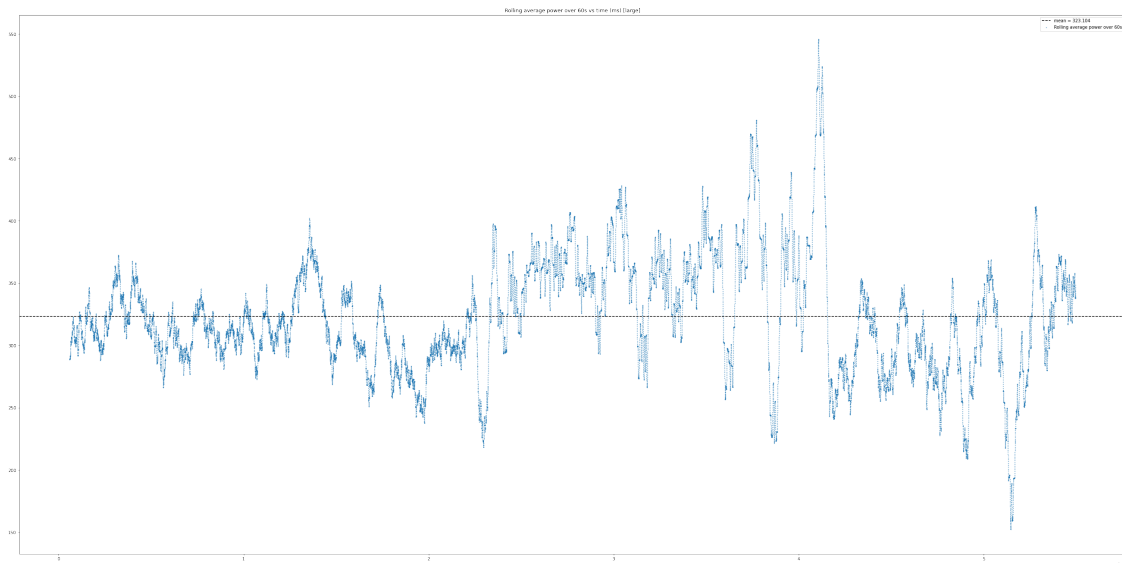
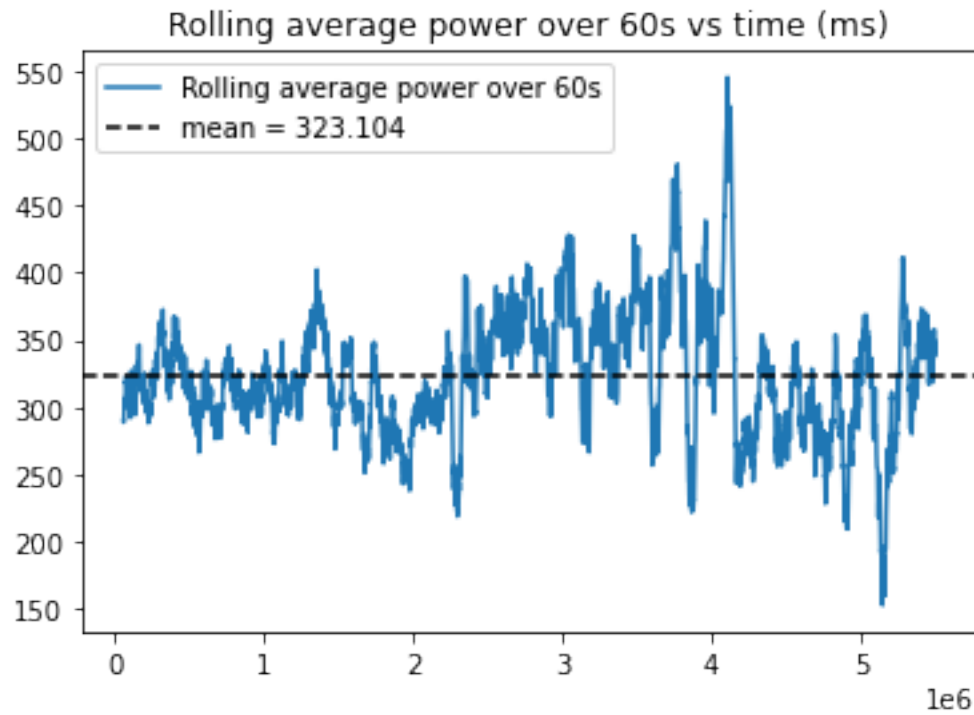
y = open_df.po.rolling(window=round(window_length_s*1000/mdt)).mean()
plt.plot(x, y, label = f'Rolling average power over {window_length_s}s')
plt.axhline(y = y.mean(), ls = '--', c = 'k', label = f'mean = {round(y.
    ↳mean(),3)}')
plt.legend()

# larger plot with same settings as above
plt.figure(figsize = (46,23))
plt.title(f'Rolling average power over {window_length_s}s vs time (ms) [large]')
plt.scatter(x, y, s = 3, linewidth = 0, label = f'Rolling average power over_
    ↳{window_length_s}s')
plt.axhline(y = y.mean(), ls = '--', c = 'k', label = f'mean = {round(y.
    ↳mean(),3)}')
plt.legend()

```

[4]: <matplotlib.legend.Legend at 0x7f7cfcce1790>





Now we use the mean power, mean delta t, number of timesteps to estimate total energy produced during the open stage

```
[5]: open_mean_po_W = open_df.po.mean()/1000
open_num_ts = len(open_df)
```

```

open_time_s = open_num_ts*mdt/1000
open_energy_Wh = open_mean_po_W*open_time_s/3600

total_mean_po_W = df.po.mean()/1000
total_num_ts = len(df)
total_time_s = total_num_ts*mdt/1000
total_energy_Wh = total_mean_po_W*total_time_s/3600

other_energy_Wh = total_energy_Wh-open_energy_Wh

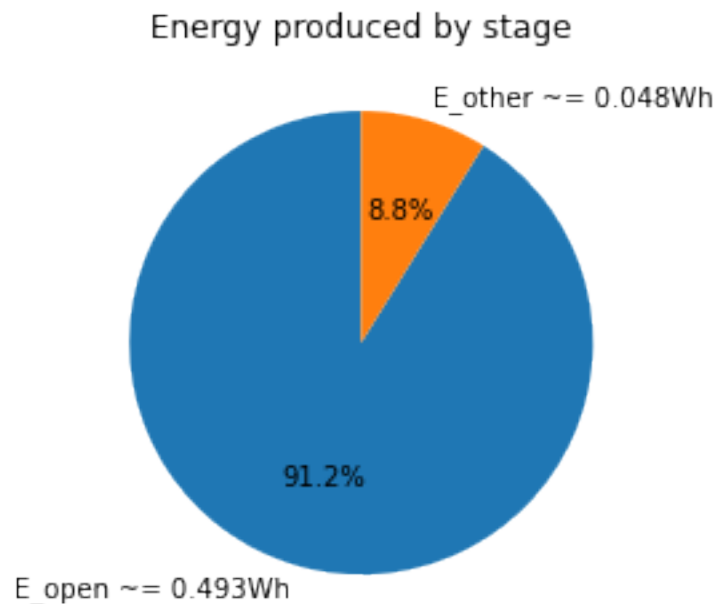
print(f'Energy produced during open stage ~= {round(open_energy_Wh,3)}Wh')
print(f'Energy produced during all other stages ~=␣
↪{round(other_energy_Wh,3)}Wh')
print(f'Total energy produced during all stages ~=␣
↪{round(total_energy_Wh,3)}Wh')

labels = f'E_open ~= {round(open_energy_Wh,3)}Wh', f'E_other ~=␣
↪{round(other_energy_Wh,3)}Wh'
sizes = [open_energy_Wh/total_energy_Wh, other_energy_Wh/total_energy_Wh]

plt.figure()
plt.title("Energy produced by stage")
plt.pie(sizes, labels=labels, autopct='%1.1f%%', startangle=90)
plt.show()

```

Energy produced during open stage ~= 0.493Wh
 Energy produced during all other stages ~= 0.048Wh
 Total energy produced during all stages ~= 0.541Wh



Make plot of power and altitude over time to visualize the mission.

```
[11]: pd.options.mode.chained_assignment = None
df['ti_c'] = np.arange(0, len(df)*mdt, mdt)
pd.options.mode.chained_assignment = 'warn' # default = 'warn'

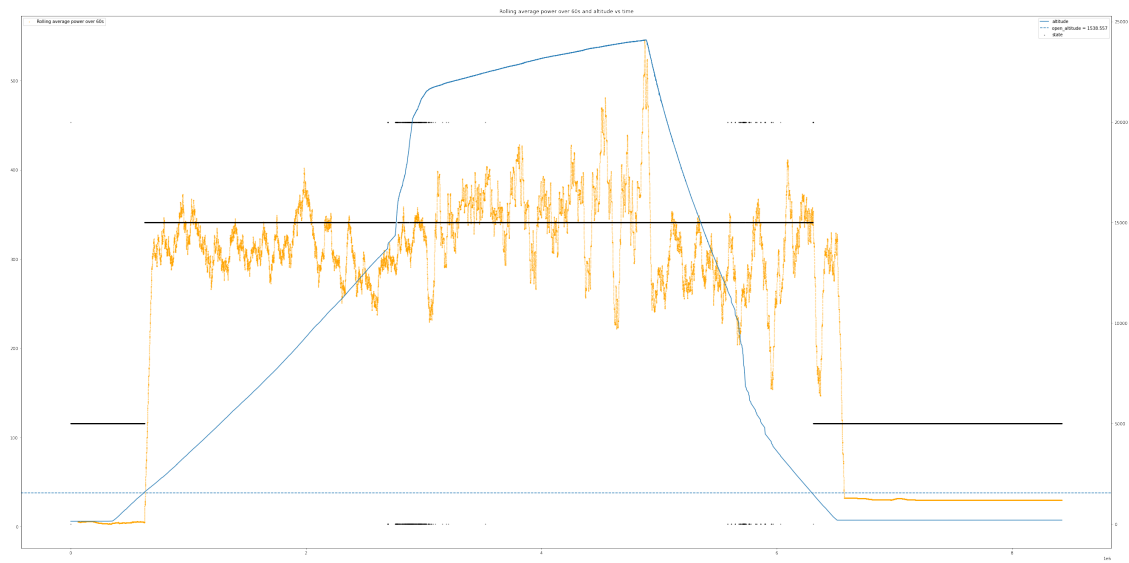
# Power and altitude vs time
window_length_s = 60
x = df.ti_c
y = df.po.rolling(window=round(window_length_s*1000/mdt)).mean()
fig, ax = plt.subplots(figsize = (46,23))
plt.title(f'Rolling average power over {window_length_s}s and altitude vs time')
ax.scatter(x, y, s = 3, c = 'orange', linewidth = 0, label = f'Rolling average_
↳power over {window_length_s}s')
ax.legend(loc = 'upper left')

# values from open pressure, local pressure, and BMP_280 source code to get_
↳exact open altitude used to trigger payload
LOCAL_P_MBAR = 1023.37
OPEN_PRESSURE = 85000
open_altitude = 44330*(1.0-(OPEN_PRESSURE/100/LOCAL_P_MBAR)**0.1903)

ax2 = ax.twinx()
ax2.plot(x, df.a, label = f'altitude')
ax2.axhline(y = open_altitude, ls = '--', label = f'open_altitude =_
↳{round(open_altitude,3)}')

ax2.scatter(x, df.st*5000, s = 3, c = 'k', alpha = 1, linewidth = 0, label =_
↳f'state')
ax2.legend(loc = 'upper right')
```

```
[11]: <matplotlib.legend.Legend at 0x7f7cfd683430>
```



[]: