What is this competition all about?

- Given seismic signals we are asked to predict the time until the onset of laboratory earthquakes.
- The training data is a single sequence of signal and seems to come from one experiment alone.
- In contrast the test data consists of several different sequences, called segments, that may correspond to different experiments. The regular pattern we might find in the train set does not match those of the test segments.
- For each test data segment with its corresponding seg_id we are asked to predict it's single time until the lab earthquake takes place.

What is an earthquake in the lab?

Presently, I don't know how an earthquake in the laboratory works. So I've googled around and found this video that shows how such a lab looks like. If you like, feel free to take a look at it. I'm still on my journey to understand the problem.

In [25]:
```
from IPython.display import YouTubeVideo
YouTubeVideo('m_dBwwDJ4uo')
```

Out[25]:

In the end we can see that the probes that are used are put under some kind of **normal pressure but there is a shear stress working on it as well**. Then, after some time, the probe splits. If you take a look at the additional material given, you can see that we have:

3 kind of plates

- 2 plates left and right that are under normal pressure: Forces are acting with 90 degree on the plate, pushing the two plates together.
- In the middle we find a third plate which is separated by some granular material. This plate moves downwards with constant velocity.

I'm not sure if I understand this right, but it seems that this granular material is the "rock" that can split and load again to produce this kind of lab earthquakes in repetitive cycles. Even though the train set contains continuous data it contains several such splits (earthquakes).

Loading Packages

In [26]:
```
# access kaggle datasets
!pip install kaggle

# math operations
!pip install numpy==1.15.0

# machine learning
!pip install catboost
```

```
Requirement already satisfied: kaggle in /usr/local/lib/python3.6/dist-packages (1.5.2)
Requirement already satisfied: urllib3<1.23.0,>=1.15 in /usr/local/lib/python3.6/dist-package
s (from kaggle) (1.22)
Requirement already satisfied: six>=1.10 in /usr/local/lib/python3.6/dist-packages (from kagg
le) (1.11.0)
Requirement already satisfied: certifi in /usr/local/lib/python3.6/dist-packages (from kaggl
e) (2018.11.29)
Requirement already satisfied: python-dateutil in /usr/local/lib/python3.6/dist-packages (fro
m kaggle) (2.5.3)
Requirement already satisfied: requests in /usr/local/lib/python3.6/dist-packages (from kaggl
e) (2.18.4)
Requirement already satisfied: tqdm in /usr/local/lib/python3.6/dist-packages (from kaggle)
(4.28.1)
Requirement already satisfied: python-slugify in /usr/local/lib/python3.6/dist-packages (from
kaggle) (2.0.1)
Requirement already satisfied: chardet<3.1.0,>=3.0.2 in /usr/local/lib/python3.6/dist-package
s (from requests->kaggle) (3.0.4)
Requirement already satisfied: idna<2.7,>=2.5 in /usr/local/lib/python3.6/dist-packages (from
requests->kaggle) (2.6)
Requirement already satisfied: Unidecode>=0.04.16 in /usr/local/lib/python3.6/dist-packages
(from python-slugify->kaggle) (1.0.23)
Requirement already satisfied: numpy==1.15.0 in /usr/local/lib/python3.6/dist-packages (1.15.
0)
Requirement already satisfied: catboost in /usr/local/lib/python3.6/dist-packages (0.12.2)
Requirement already satisfied: numpy>=1.11.1 in /usr/local/lib/python3.6/dist-packages (from
catboost) (1.15.0)
Requirement already satisfied: six in /usr/local/lib/python3.6/dist-packages (from catboost)
(1.11.0)
Requirement already satisfied: enum34 in /usr/local/lib/python3.6/dist-packages (from catboos
t) (1.1.6)
Requirement already satisfied: pandas>=0.19.1 in /usr/local/lib/python3.6/dist-packages (from
catboost) (0.22.0)
Requirement already satisfied: pytz>=2011k in /usr/local/lib/python3.6/dist-packages (from pa
ndas>=0.19.1->catboost) (2018.9)
Requirement already satisfied: python-dateutil>=2 in /usr/local/lib/python3.6/dist-packages
(from pandas>=0.19.1->catboost) (2.5.3)
```

In [0]:
```
# data preprocessing
import pandas as pd

# math operations
import numpy as np

# machine learning
from catboost import CatBoostRegressor, Pool

# data scaling
from sklearn.preprocessing import StandardScaler

# hyperparameter optimization
from sklearn.model_selection import GridSearchCV

# support vector machine model
from sklearn.svm import NuSVR, SVR

# kernel ridge model
from sklearn.kernel_ridge import KernelRidge

# data visualization
import matplotlib.pyplot as plt
```

Import Dataset from Kaggle

In [28]:
```
# Colab's file access feature
from google.colab import files

# retrieve uploaded file
uploaded = files.upload()

# print results
for fn in uploaded.keys():
  print('User uploaded file "{name}" with length {length} bytes'.format(
      name=fn, length=len(uploaded[fn])))

# then move kaggle.json into the folder where the API expects to find it.
!mkdir -p ~/.kaggle/ && mv kaggle.json ~/.kaggle/ && chmod 600 ~/.kaggle/kaggle.json
```

Choose Files No file chosen

Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving kaggle.json to kaggle.json
User uploaded file "kaggle.json" with length 62 bytes
```

In [29]:
```
# list competitions
!kaggle competitions list
```

```
ref                                             deadline             category            rewar
d  teamCount  userHasEntered
----------------------------------------------  -------------------  ---------------  --------
-  ---------  --------------
digit-recognizer                                2030-01-01 00:00:00  Getting Started  Knowledg
e       2617           False
titanic                                         2030-01-01 00:00:00  Getting Started  Knowledg
e       9973            True
house-prices-advanced-regression-techniques     2030-01-01 00:00:00  Getting Started  Knowledg
e       4136            True
imagenet-object-localization-challenge          2029-12-31 07:00:00  Research         Knowledg
e         33           False
competitive-data-science-predict-future-sales   2019-12-31 23:59:00  Playground           Kudo
s       2293            True
two-sigma-financial-news                        2019-07-15 23:59:00  Featured         $100,00
0       2897           False
LANL-Earthquake-Prediction                      2019-06-03 23:59:00  Research          $50,00
0       1012            True
tmdb-box-office-prediction                      2019-05-30 23:59:00  Playground       Knowledg
e         56           False
dont-overfit-ii                                 2019-05-07 23:59:00  Playground            Swa
g        183           False
gendered-pronoun-resolution                     2019-04-22 23:59:00  Research          $25,00
0        115           False
histopathologic-cancer-detection                2019-03-30 23:59:00  Playground       Knowledg
e        571           False
petfinder-adoption-prediction                   2019-03-28 23:59:00  Featured          $25,00
0       1024           False
vsb-power-line-fault-detection                  2019-03-21 23:59:00  Featured          $25,00
0        830            True
microsoft-malware-prediction                    2019-03-13 23:59:00  Research          $25,00
0       1558           False
humpback-whale-identification                   2019-02-28 23:59:00  Featured          $25,00
0       1777           False
elo-merchant-category-recommendation            2019-02-26 23:59:00  Featured          $50,00
0       3612           False
quora-insincere-questions-classification        2019-02-26 23:59:00  Featured          $25,00
0       4037           False
ga-customer-revenue-prediction                  2019-02-15 23:59:00  Featured          $45,00
0       1104           False
reducing-commercial-aviation-fatalities         2019-02-12 23:59:00  Playground            Swa
g        160            True
pubg-finish-placement-prediction                2019-01-30 23:59:00  Playground            Swa
g       1534           False
```

In [30]:
```
# download earthquake dataset
!kaggle competitions download -c LANL-Earthquake-Prediction
```

```
sample_submission.csv: Skipping, found more recently modified local copy (use --force to forc
e download)
test.zip: Skipping, found more recently modified local copy (use --force to force download)
train.csv.zip: Skipping, found more recently modified local copy (use --force to force downlo
ad)
```

In [31]:
```
# unzip training data for usage
!ls
!unzip train.csv.zip
!ls
```

```
catboost_info  sample_submission.csv  train.csv
sample_data    test.zip               train.csv.zip
Archive:  train.csv.zip
replace train.csv? [y]es, [n]o, [A]ll, [N]one, [r]ename: y
  inflating: train.csv
catboost_info  sample_submission.csv  train.csv
sample_data    test.zip               train.csv.zip
```

Exploratory Data Analysis

Let's get familiar with the data!

Training data

The total size of the train data is almost 9 GB and we don't want to wait too long just for a first impression, let's load only some rows:

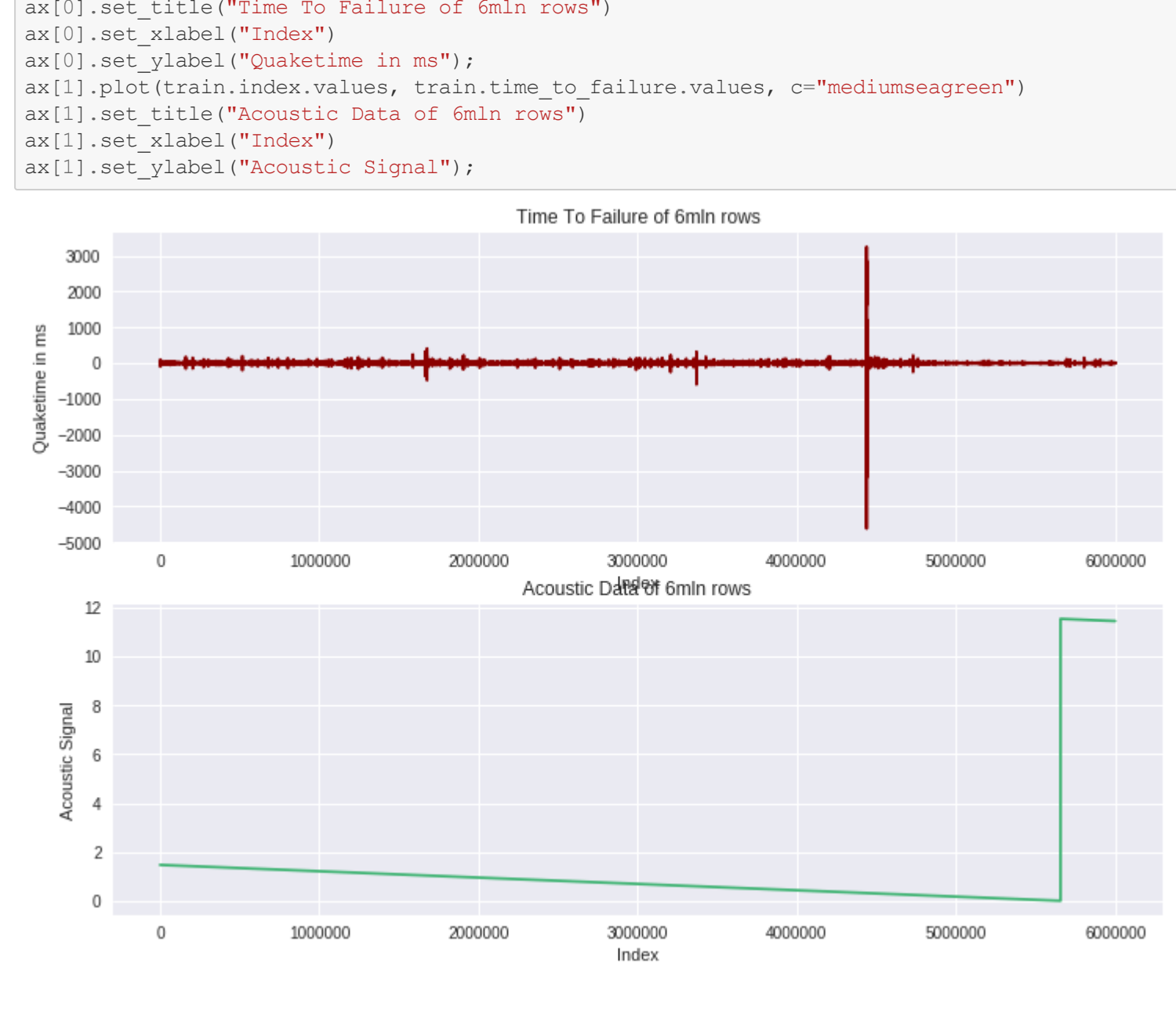
In [32]:
```
# extract training data into a dataframe for further manipulation
train = pd.read_csv('train.csv', nrows=6000000, dtype={'acoustic_data': np.int16, 'time_to_fail
ure': np.float64})

# print first 10 entries
train.head(10)
```

Out[32]:

	acoustic_data	time_to_failure
0	12	1.4691
1	6	1.4691
2	8	1.4691
3	5	1.4691
4	8	1.4691
5	8	1.4691
6	9	1.4691
7	7	1.4691
8	-5	1.4691
9	3	1.4691

We see two columns: **acoustic_data** and **time_to_failure.** The former is the seismic singal and the latter corresponds to the the time (in seconds) until the next laboratory earthquake takes place.

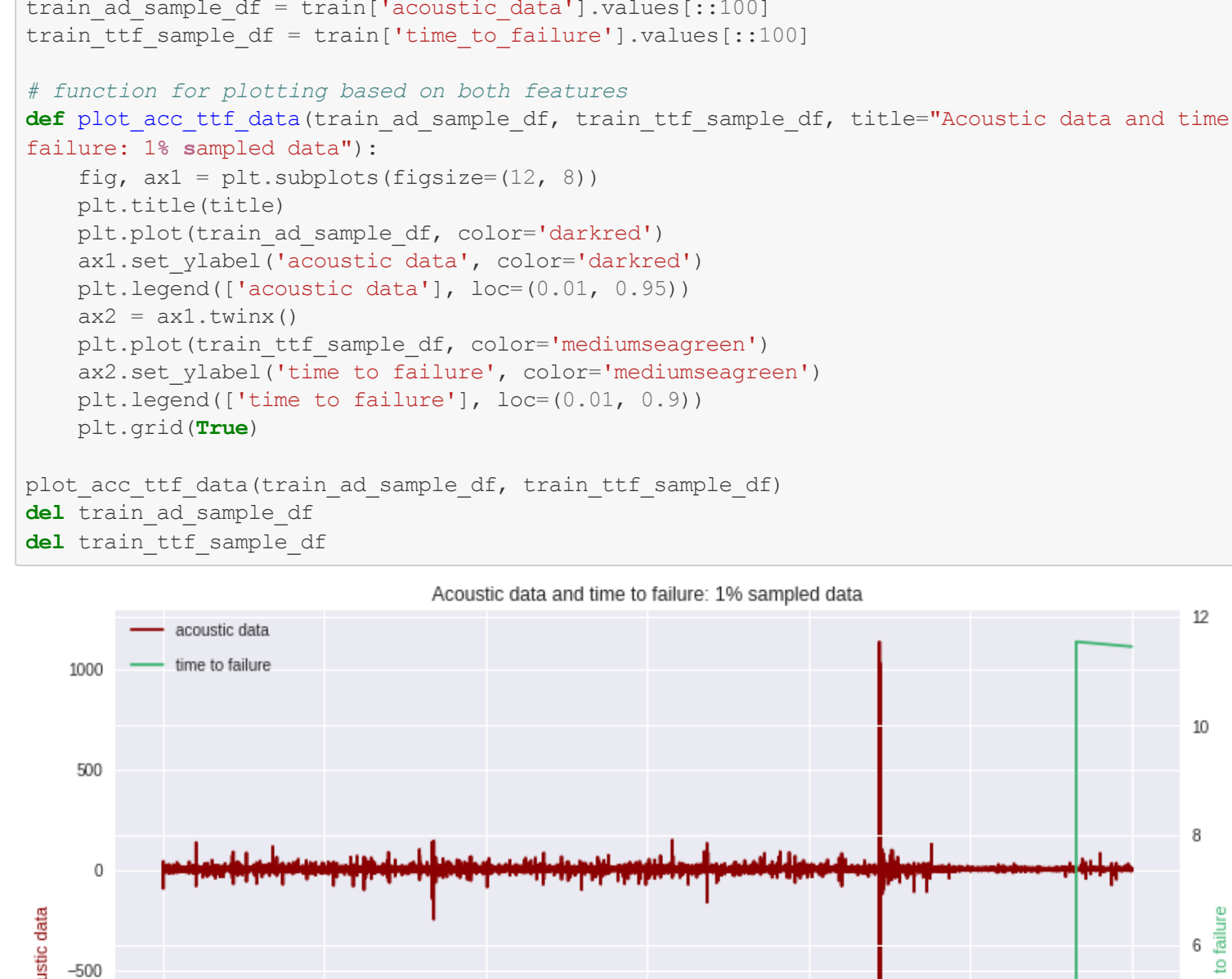
In [33]:
```
fig, ax = plt.subplots(2,1, figsize=(12,8))
ax[0].plot(train.index.values, train.acoustic_data.values, c="darkred")
ax[0].set_title("Time To Failure of 6mln rows")
ax[0].set_xlabel("Index")
ax[0].set_ylabel("Quaketime in ms");
ax[1].plot(train.index.values, train.time_to_failure.values, c="mediumseagreen")
ax[1].set_title("Acoustic Data of 6mln rows")
ax[1].set_xlabel("Index")
ax[1].set_ylabel("Acoustic Signal");
```



Observations:

- We can see only one time in 6mln rows when quaketime goes to 0. This is a timepoint where an earthquake in the lab occurs.
- There are many small oscillations until a heavy peak of the signal occurs. Then it takes some time with smaller oscillations and the earthquake occurs.

In [34]:
```
# visualize 1% of samples data, first 100 datapoints
train_ad_sample_df = train['acoustic_data'].values[::100]
train_ttf_sample_df = train['time_to_failure'].values[::100]

# function for plotting based on both features
def plot_acc_ttf_data(train_ad_sample_df, train_ttf_sample_df, title="Acoustic data and time to
failure: 1% sampled data"):
    fig, ax1 = plt.subplots(figsize=(12, 8))
    plt.title(title)
    plt.plot(train_ad_sample_df, color='darkred')
    ax1.set_ylabel('acoustic data', color='darkred')
    plt.legend(['acoustic data'], loc=(0.01, 0.95))
    ax2 = ax1.twinx()
    plt.plot(train_ttf_sample_df, color='mediumseagreen')
    ax2.set_ylabel('time to failure', color='mediumseagreen')
    plt.legend(['time to failure'], loc=(0.01, 0.9))
    plt.grid(True)

plot_acc_ttf_data(train_ad_sample_df, train_ttf_sample_df)
del train_ad_sample_df
del train_ttf_sample_df
```



Feature Engineering

In [0]:
```
## Feature Engineering and signifiance of these statistical features

# let's create a function to generate some statistical features based on the training data
def gen_features(X):
    strain = []
    strain.append(X.mean())
    strain.append(X.std())
    strain.append(X.min())
    strain.append(X.max())
    strain.append(X.kurtosis())
    strain.append(X.skew())
    strain.append(np.quantile(X,0.01))
    strain.append(np.quantile(X,0.05))
    strain.append(np.quantile(X,0.95))
    strain.append(np.quantile(X,0.99))
    strain.append(np.abs(X).max())
    strain.append(np.abs(X).mean())
    strain.append(np.abs(X).std())
    return pd.Series(strain)
```

In [0]:
```
train = pd.read_csv('train.csv', iterator=True, chunksize=150_000, dtype={'acoustic_data': np.i
nt16, 'time_to_failure': np.float64})

X_train = pd.DataFrame()
y_train = pd.Series()
for df in train:
    ch = gen_features(df['acoustic_data'])
    X_train = X_train.append(ch, ignore_index=True)
    y_train = y_train.append(pd.Series(df['time_to_failure'].values[-1]))
```

In [37]:
```
X_train.describe()
```

Out[37]:

	0	1	2	3	4	5	6	7
count	4195.000000	4195.000000	4195.000000	4195.000000	4195.000000	4195.000000	4195.000000	4195.000000
mean	4.519475	6.547788	-149.190942	163.522288	68.297997	0.125830	-11.224603	-2.184779
std	0.256049	8.503939	265.087984	272.930331	70.532565	0.477901	14.106852	2.346558
min	3.596313	2.802720	-5515.000000	23.000000	0.648602	-4.091826	-336.000000	-39.000000
25%	4.349497	4.478637	-154.000000	92.000000	28.090227	-0.040779	-14.000000	-3.000000
50%	4.522147	5.618798	-111.000000	123.000000	45.816625	0.085620	-10.000000	-2.000000
75%	4.693350	6.880904	-79.000000	170.000000	78.664202	0.253930	-6.000000	-1.000000
max	5.391993	153.703569	-15.000000	5444.000000	631.158927	4.219429	-2.000000	0.000000

Implement Catboost Model

In [38]:
```
# model #1 - Catboost

train_pool = Pool(X_train, y_train)
m = CatBoostRegressor(iterations=10000, loss_function='MAE', boosting_type='Ordered')
m.fit(X_train, y_train, silent=True)
m.best_score_
```

Out[38]:
```
{'learn': {'MAE': 1.7804224713035586}}
```

Not a great score, given the leaderboard's top 5 are in the mid 1.3 to 1.4

Implement Support Vector Machine + Radial Basis Function Kernel

In [39]:
```
# model #2 - Support Vector Machine w/ RBF + Grid Search

from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import GridSearchCV
from sklearn.svm import NuSVR, SVR


scaler = StandardScaler()
scaler.fit(X_train)
X_train_scaled = scaler.transform(X_train)

parameters = [{'gamma': [0.001, 0.005, 0.01, 0.02, 0.05, 0.1],
               'C': [0.1, 0.2, 0.25, 0.5, 1, 1.5, 2]}]
               #'nu': [0.75, 0.8, 0.85, 0.9, 0.95, 0.97]}]

reg1 = GridSearchCV(SVR(kernel='rbf', tol=0.01), parameters, cv=5, scoring='neg_mean_absolute_e
rror')
reg1.fit(X_train_scaled, y_train.values.flatten())
y_pred1 = reg1.predict(X_train_scaled)

print("Best CV score: {:.4f}".format(reg1.best_score_))
print(reg1.best_params_)
```

```
Best CV score: -2.1722
{'C': 2, 'gamma': 0.02}
```