In [1]:
```
# https://www.kaggle.com/janiobachmann/credit-fraud-dealing-with-imbalanced-datasets
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
from scipy.stats import binned_statistic

import tensorflow as tf
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.manifold import TSNE
from sklearn.decomposition import PCA, TruncatedSVD
import matplotlib.patches as mpatches
import time

# Classifier Libraries
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier, VotingClassifier
from sklearn.preprocessing import MinMaxScaler, StandardScaler, RobustScaler
from sklearn import svm


from mlxtend.feature_selection import SequentialFeatureSelector
import collections

from sklearn.cluster import KMeans
from sklearn.metrics import confusion_matrix



from sklearn.naive_bayes import GaussianNB


# Other Libraries
from sklearn.model_selection import train_test_split
from sklearn.pipeline import make_pipeline
from sklearn.model_selection import cross_val_score

from sklearn.metrics import precision_score, recall_score, f1_score, roc_auc_score, accuracy_score, c
lassification_report
from collections import Counter
from sklearn.model_selection import KFold, StratifiedKFold


from sklearn.metrics import roc_curve
from sklearn.model_selection import cross_val_predict


import warnings

import copy
warnings.filterwarnings("ignore")
```

In [2]:
```
file_location = "./data/creditcard.csv"
```

In [3]:
```
df = pd.read_csv(file_location)
```

In [4]:
```
df.head()
```

Out[4]:

	Time	V1	V2	V3	V4	V5	V6	V7	V8	V9	...	V21	V22	
0	0.0	-1.359807	-0.072781	2.536347	1.378155	-0.338321	0.462388	0.239599	0.098698	0.363787	...	-0.018307	0.277838	-0.11
1	0.0	1.191857	0.266151	0.166480	0.448154	0.060018	-0.082361	-0.078803	0.085102	-0.255425	...	-0.225775	-0.638672	0.1(
2	1.0	-1.358354	-1.340163	1.773209	0.379780	-0.503198	1.800499	0.791461	0.247676	-1.514654	...	0.247998	0.771679	0.9(
3	1.0	-0.966272	-0.185226	1.792993	-0.863291	-0.010309	1.247203	0.237609	0.377436	-1.387024	...	-0.108300	0.005274	-0.1(
4	2.0	-1.158233	0.877737	1.548718	0.403034	-0.407193	0.095921	0.592941	-0.270533	0.817739	...	-0.009431	0.798278	-0.1(

5 rows × 31 columns

In [5]:
```
df.describe()
```

Out[5]:

	Time	V1	V2	V3	V4	V5	V6	V7	
count	284807.000000	2.848070e+05	2.848070e+05	2.848070e+05	2.848070e+05	2.848070e+05	2.848070e+05	2.848070e+05	2.8480
mean	94813.859575	3.919560e-15	5.688174e-16	-8.769071e-15	2.782312e-15	-1.552563e-15	2.010663e-15	-1.694249e-15	-1.927(
std	47488.145955	1.958696e+00	1.651309e+00	1.516255e+00	1.415869e+00	1.380247e+00	1.332271e+00	1.237094e+00	1.1943
min	0.000000	-5.640751e+01	-7.271573e+01	-4.832559e+01	-5.683171e+00	-1.137433e+02	-2.616051e+01	-4.355724e+01	-7.3216
25%	54201.500000	-9.203734e-01	-5.985499e-01	-8.903648e-01	-8.486401e-01	-6.915971e-01	-7.682956e-01	-5.540759e-01	-2.0862
50%	84692.000000	1.810880e-02	6.548556e-02	1.798463e-01	-1.984653e-02	-5.433583e-02	-2.741871e-01	4.010308e-02	2.2358
75%	139320.500000	1.315642e+00	8.037239e-01	1.027196e+00	7.433413e-01	6.119264e-01	3.985649e-01	5.704361e-01	3.2734
max	172792.000000	2.454930e+00	2.205773e+01	9.382558e+00	1.687534e+01	3.480167e+01	7.330163e+01	1.205895e+02	2.0007

8 rows × 31 columns

In [6]:
```
df.isnull().sum()
```

Out[6]:
```
Time      0
V1        0
V2        0
V3        0
V4        0
V5        0
V6        0
V7        0
V8        0
V9        0
V10       0
V11       0
V12       0
V13       0
V14       0
V15       0
V16       0
V17       0
V18       0
V19       0
V20       0
V21       0
V22       0
V23       0
V24       0
V25       0
V26       0
V27       0
V28       0
Amount    0
Class     0
dtype: int64
```

Class column determines if transaction is Fraudulent

In [7]:
```
df['Class'].value_counts()
```

Out[7]:
```
0    284315
1       492
Name: Class, dtype: int64
```

Determine percentage of Fraudlent and Crediable Transactions

In [8]:
```
def get_percentage(value, total):
    return round((value / total) * 100, 2)
```

In [9]:
```
def print_transaction_percentage(df):
    CREDIBLE = 0
    FRAUDULENT = 1
    total_transactions = len(df['Class'])
    total_credible_transactions = df['Class'].value_counts()[CREDIBLE]
    total_fraud_transactions = df['Class'].value_counts()[FRAUDULENT]
    print("Credible Transactions: "+ str(get_percentage(total_credible_transactions, total_transactio
ns)))
    print("Fraudulent Transactions: "+ str(get_percentage(total_fraud_transactions, total_transaction
s)))
```

In [10]:
```
print_transaction_percentage(df)
```

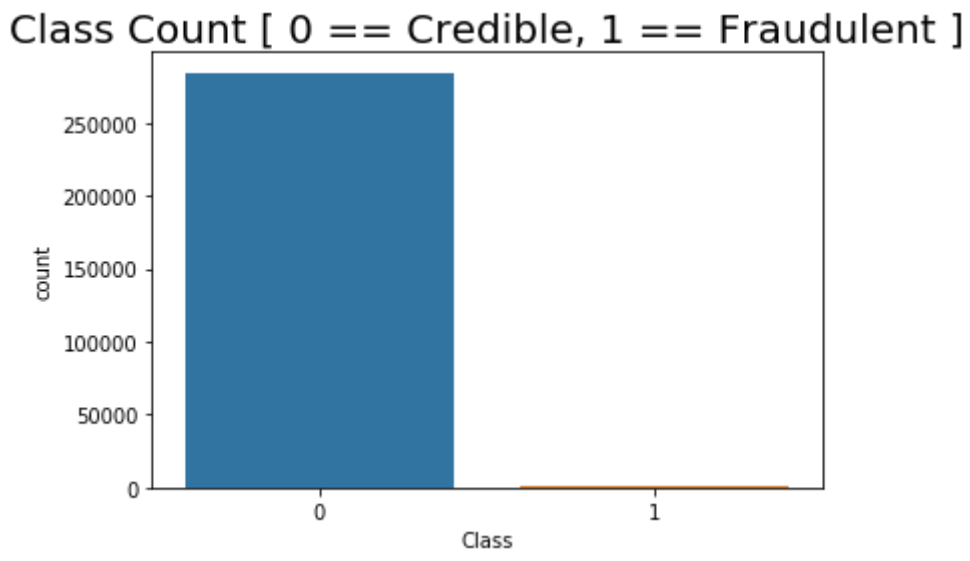
```
Credible Transactions: 99.83
Fraudulent Transactions: 0.17
```

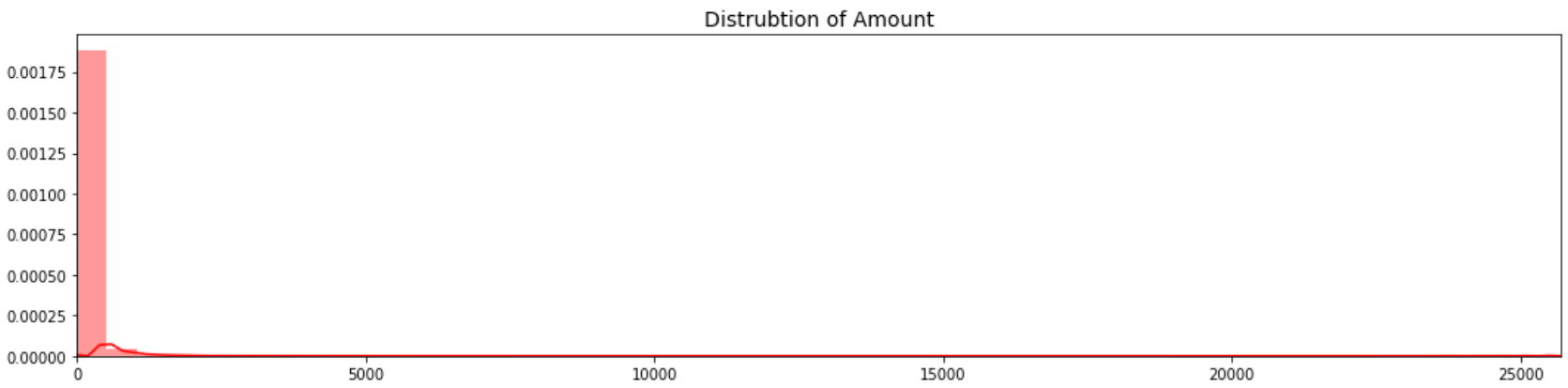
In [11]:
```
def plot_count(df, title, col):
    sns.countplot(col, data=df)
    plt.title(title, fontsize=20)
```

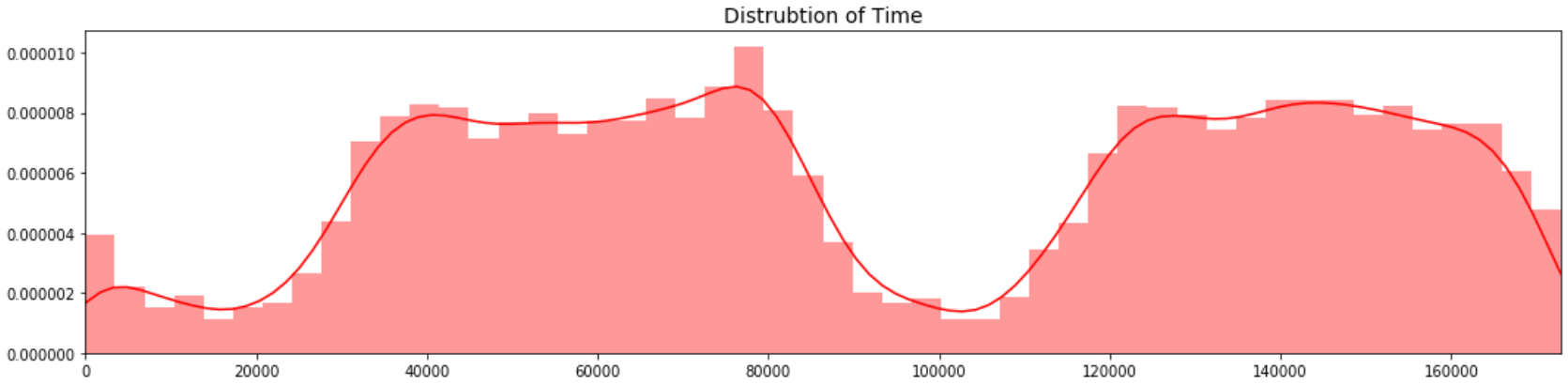
In [12]:
```
def create_distributed_plot(sub_df, title):
    f, ax = plt.subplots(1, 1, figsize=(18,4))
    col_array_vals = sub_df.values
    sns.distplot(col_array_vals, ax=ax, color='r')
    ax.set_title(title, fontsize=14)
    ax.set_xlim([min(col_array_vals), max(col_array_vals)])
```

In [ ]:
```
```

In [13]:
```
plot_count(df, 'Class Count [ 0 == Credible, 1 == Fraudulent ]', 'Class')
create_distributed_plot(df['Amount'], 'Distrubtion of Amount')
create_distributed_plot(df['Time'], 'Distrubtion of Time')
plt.show()
```







In [ ]:
```
```

In [14]:
```
bins_amount = 100
```

In [15]:
```
# equal sized bins
df['bin_time'] = pd.cut(df['Time'], bins=bins_amount, labels=False )
```

In [16]:
```
df['bin_time'].unique()
```

Out[16]:
```
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16,
       17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33,
       34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50,
       51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67,
       68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84,
       85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99])
```

In [17]:
```
len(df['bin_time'].unique())
```

Out[17]:
```
100
```

In [30]:
```
df['bin_amount'] = pd.cut(df['Amount'], bins=100, labels=False )
```

In [32]:
```
df['bin_amount'].unique()
```

Out[32]:
```
array([ 0,  1,  5,  4,  2,  3, 14,  6,  9, 30, 11,  7, 15, 10,  8, 23, 13,
       20, 28, 19, 16, 12, 17, 27, 25, 50, 18, 22, 46, 29, 76, 21, 34, 24,
       73, 45, 26, 32, 38, 31, 99, 39])
```

In [ ]:

In [33]:
```
df.drop(['Amount', 'Time'], axis=1, inplace=True )
```

In [ ]:

In [34]:
```
df.head(10)
```

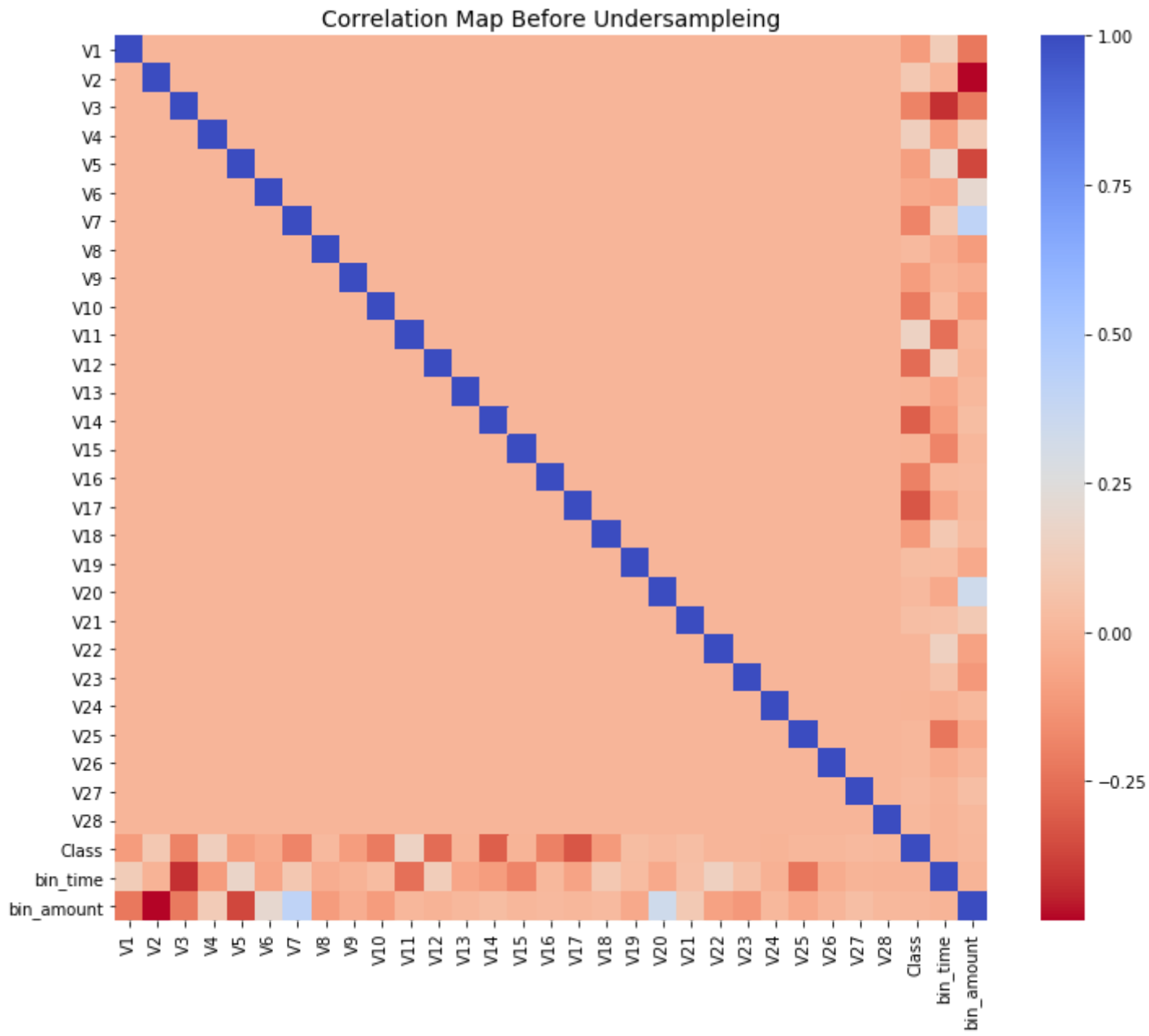
Out[34]:

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	...	V22	V23
0	-1.359807	-0.072781	2.536347	1.378155	-0.338321	0.462388	0.239599	0.098698	0.363787	0.090794	...	0.277838	-0.110474
1	1.191857	0.266151	0.166480	0.448154	0.060018	-0.082361	-0.078803	0.085102	-0.255425	-0.166974	...	-0.638672	0.101288
2	-1.358354	-1.340163	1.773209	0.379780	-0.503198	1.800499	0.791461	0.247676	-1.514654	0.207643	...	0.771679	0.909412
3	-0.966272	-0.185226	1.792993	-0.863291	-0.010309	1.247203	0.237609	0.377436	-1.387024	-0.054952	...	0.005274	-0.190321
4	-1.158233	0.877737	1.548718	0.403034	-0.407193	0.095921	0.592941	-0.270533	0.817739	0.753074	...	0.798278	-0.137458
5	-0.425966	0.960523	1.141109	-0.168252	0.420987	-0.029728	0.476201	0.260314	-0.568671	-0.371407	...	-0.559825	-0.026398
6	1.229658	0.141004	0.045371	1.202613	0.191881	0.272708	-0.005159	0.081213	0.464960	-0.099254	...	-0.270710	-0.154104
7	-0.644269	1.417964	1.074380	-0.492199	0.948934	0.428118	1.120631	-3.807864	0.615375	1.249376	...	-1.015455	0.057504
8	-0.894286	0.286157	-0.113192	-0.271526	2.669599	3.721818	0.370145	0.851084	-0.392048	-0.410430	...	-0.268092	-0.204233
9	-0.338262	1.119593	1.044367	-0.222187	0.499361	-0.246761	0.651583	0.069539	-0.736727	-0.366846	...	-0.633753	-0.120794

10 rows × 31 columns

In [35]:
```
def show_correlation_matrix(data, title):
    f, ax = plt.subplots(1, 1, figsize=(12,10))
    # Entire DataFrame
    corr = data.corr()
    sns.heatmap(corr, cmap='coolwarm_r', ax=ax)
    ax.set_title(title, fontsize=14)
```

In [36]:
```
show_correlation_matrix(df, 'Correlation Map Before Undersampleing')
```



In [37]:
```
# shuffle
df = df.sample(frac=1)
```

In [38]:
```
# Creating a balanced df
fraud_df = df.loc[df['Class'] == 1]
crediable_df = df.loc[df['Class'] == 0][:len(fraud_df)]
balanced_df = pd.concat([fraud_df, crediable_df]).sample(frac=1, random_state = 50)
```

In [39]:
```
len(balanced_df)
```

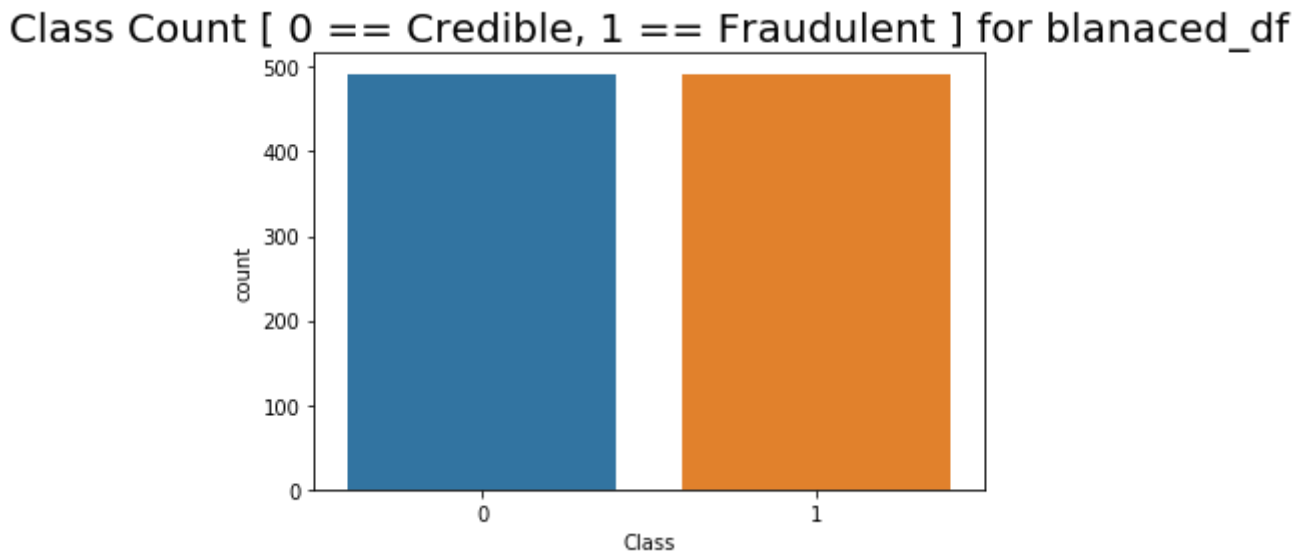
Out[39]: 984

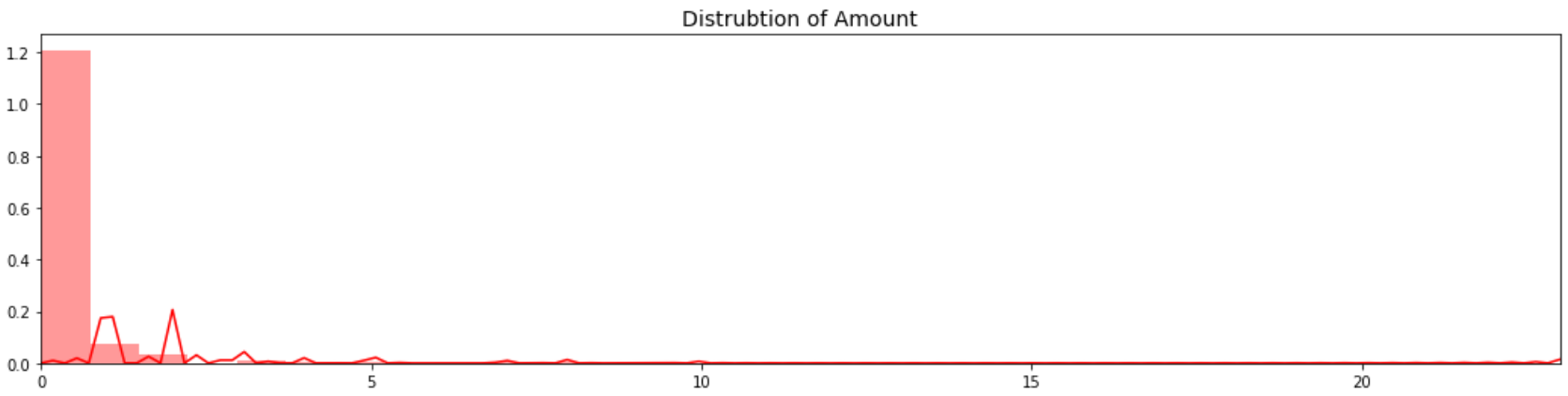
In [40]:
```
print_transaction_percentage(balanced_df)
```

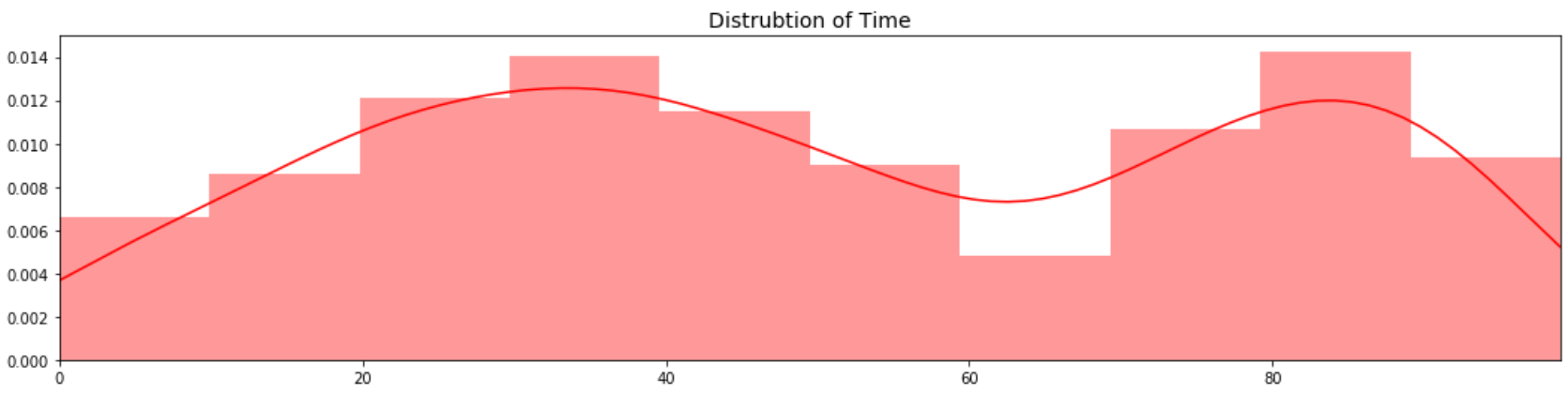
```
Credible Transactions: 50.0
Fraudulent Transactions: 50.0
```

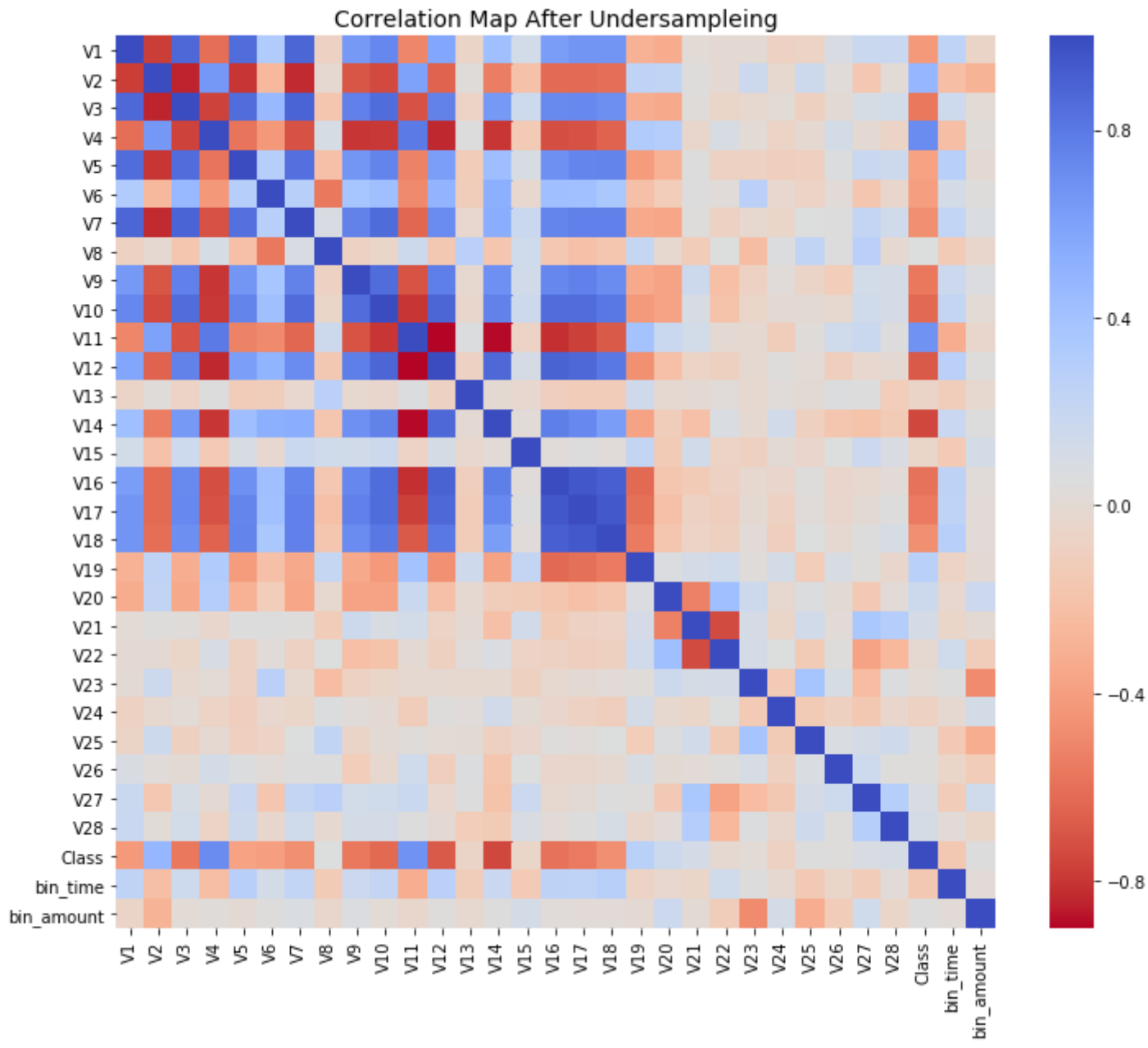
In [ ]:

In [41]:
```
plot_count(balanced_df, 'Class Count [ 0 == Credible, 1 == Fraudulent ] for blanaced_df', 'Class')
create_distributed_plot(balanced_df['bin_amount'], 'Distrubtion of Amount')
create_distributed_plot(balanced_df['bin_time'], 'Distrubtion of Time')
show_correlation_matrix(balanced_df, 'Correlation Map After Undersampleing')
plt.show()
```









In [ ]:
```
```

In [ ]:

In [ ]:

In [42]:
```
def filter_relative_features(data, target, start):
    cor = data.corr()
    cor_target = abs(cor[target])
    relevant_features = cor_target[cor_target>start]
    return relevant_features
```

In [43]:
```
def get_columns_from_series(s):
    result = []
    for i,r in s.items():
        result.append(i)
    return result
```

In [44]:
```
filtered_features_based_on_overall_correlation = filter_relative_features(balanced_df, 'Class', 0.5)
```

In [45]:
```
filtered_features_based_on_overall_correlation = get_columns_from_series(filtered_features_based_on_o
verall_correlation)
```

In [46]:
```
# excluding target feature
filtered_features_based_on_overall_correlation.remove('Class')
```

In [47]:
```
# Shallow feature correlation shows 9.
# Will now use backward feature selection to determine the best features per model
# Will use this size for and this feature selection to determine the best possible features
size_of_filtered_featured_based_on_correlation = len(filtered_features_based_on_overall_correlation)
```

In [ ]:

In [48]:
```
random_forest = RandomForestClassifier(n_estimators=20)
```

In [49]:
```
naive_bayes = GaussianNB()
```

In [ ]:

In [50]:
```
supervised = {
    naive_bayes.__class__.__name__ : naive_bayes,
    random_forest.__class__.__name__ : random_forest,
}
```

In [51]:
```
supervised
```

Out[51]:
```
{'GaussianNB': GaussianNB(priors=None, var_smoothing=1e-09),
 'RandomForestClassifier': RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gin
i',
                       max_depth=None, max_features='auto', max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=20, n_jobs=None,
                       oob_score=False, random_state=None, verbose=0,
                       warm_start=False)}
```

In [52]:
```
balanced_df_features = balanced_df.drop('Class', axis=1)
balanced_df_target_feature_only = balanced_df['Class']
```

In [ ]:

In [ ]:

In [53]:
```
def get_backward_selected_features(amount_of_selected_features, m, df_with_features, df_with_target_f
eature):
#     Uses the backward feature selection approach
    feature_selector = SequentialFeatureSelector(m,
           k_features=amount_of_selected_features,
           forward=False,
           verbose=2,
           scoring='roc_auc',
           cv=4)
    features = feature_selector.fit(df_with_features, df_with_target_feature)
    filtered_features = df_with_features.columns[list(features.k_feature_idx_)]
    return list(filtered_features)
```

In [54]:
```
def get_filtered_features_by_model(amount_of_selected_features, supervised, df_with_features, df_with
_target_feature):
    filtered_features_by_model = {}
    for modelName, modelObj in supervised.items():
        filtered_features_by_model[modelName+"_backward_selected_features"] = get_backward_selected_f
eatures(amount_of_selected_features, modelObj, df_with_features, df_with_target_feature)
    return filtered_features_by_model
```

In [55]:
```
filtered_features_by_correlation = get_filtered_features_by_model(
    size_of_filtered_featured_based_on_correlation,
    supervised,
    balanced_df_features, balanced_df_target_feature_only )
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  30 out of  30 | elapsed:    0.4s finished

[2019-11-17 17:12:45] Features: 29/9 -- score: 0.9564743208407693[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  29 out of  29 | elapsed:    0.3s finished

[2019-11-17 17:12:45] Features: 28/9 -- score: 0.9583911692775464[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  28 out of  28 | elapsed:    0.3s finished

[2019-11-17 17:12:46] Features: 27/9 -- score: 0.9602997554365789[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  27 out of  27 | elapsed:    0.3s finished

[2019-11-17 17:12:46] Features: 26/9 -- score: 0.9619274241522904[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  26 out of  26 | elapsed:    0.3s finished

[2019-11-17 17:12:46] Features: 25/9 -- score: 0.9628362747042105[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  25 out of  25 | elapsed:    0.3s finished

[2019-11-17 17:12:47] Features: 24/9 -- score: 0.9642491241985591[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  24 out of  24 | elapsed:    0.3s finished

[2019-11-17 17:12:47] Features: 23/9 -- score: 0.9655545640822262[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  23 out of  23 | elapsed:    0.3s finished

[2019-11-17 17:12:47] Features: 22/9 -- score: 0.9668517416881486[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  22 out of  22 | elapsed:    0.2s finished

[2019-11-17 17:12:47] Features: 21/9 -- score: 0.9678680018507502[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  21 out of  21 | elapsed:    0.2s finished

[2019-11-17 17:12:48] Features: 20/9 -- score: 0.969181704012162[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  20 out of  20 | elapsed:    0.2s finished

[2019-11-17 17:12:48] Features: 19/9 -- score: 0.9698674730649747[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  19 out of  19 | elapsed:    0.2s finished

[2019-11-17 17:12:48] Features: 18/9 -- score: 0.970735012228171[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  18 out of  18 | elapsed:    0.2s finished

[2019-11-17 17:12:48] Features: 17/9 -- score: 0.9721478617225197[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  17 out of  17 | elapsed:    0.2s finished

[2019-11-17 17:12:48] Features: 16/9 -- score: 0.9732054332738449[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  16 out of  16 | elapsed:    0.2s finished

[2019-11-17 17:12:49] Features: 15/9 -- score: 0.9738581532156785[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  15 out of  15 | elapsed:    0.2s finished

[2019-11-17 17:12:49] Features: 14/9 -- score: 0.9742547425474255[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  14 out of  14 | elapsed:    0.2s finished

[2019-11-17 17:12:49] Features: 13/9 -- score: 0.9746843809901514[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  13 out of  13 | elapsed:    0.1s finished

[2019-11-17 17:12:49] Features: 12/9 -- score: 0.9752792649877717[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
```

```
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  12 out of  12 | elapsed:    0.1s finished

[2019-11-17 17:12:49] Features: 11/9 -- score: 0.9755932315420716[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  11 out of  11 | elapsed:    0.1s finished

[2019-11-17 17:12:49] Features: 10/9 -- score: 0.9760889682067553[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed:    0.1s finished

[2019-11-17 17:12:49] Features: 9/9 -- score: 0.9764194593165443[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  30 out of  30 | elapsed:    4.9s finished

[2019-11-17 17:12:55] Features: 29/9 -- score: 0.976312049705863[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  29 out of  29 | elapsed:    4.7s finished

[2019-11-17 17:12:59] Features: 28/9 -- score: 0.9780058166435324[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  28 out of  28 | elapsed:    4.6s finished

[2019-11-17 17:13:04] Features: 27/9 -- score: 0.9748331019895564[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  27 out of  27 | elapsed:    4.4s finished

[2019-11-17 17:13:08] Features: 26/9 -- score: 0.9767003767598652[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  26 out of  26 | elapsed:    4.1s finished

[2019-11-17 17:13:12] Features: 25/9 -- score: 0.9774687685901249[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  25 out of  25 | elapsed:    3.6s finished

[2019-11-17 17:13:16] Features: 24/9 -- score: 0.9766177539824179[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  24 out of  24 | elapsed:    3.6s finished

[2019-11-17 17:13:20] Features: 23/9 -- score: 0.9775431290898274[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  23 out of  23 | elapsed:    3.6s finished

[2019-11-17 17:13:23] Features: 22/9 -- score: 0.9782371604203848[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  22 out of  22 | elapsed:    3.8s finished

[2019-11-17 17:13:27] Features: 21/9 -- score: 0.9766260162601625[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  21 out of  21 | elapsed:    3.1s finished

[2019-11-17 17:13:30] Features: 20/9 -- score: 0.9782784718091083[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  20 out of  20 | elapsed:    3.1s finished

[2019-11-17 17:13:33] Features: 19/9 -- score: 0.9769647696476965[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  19 out of  19 | elapsed:    3.0s finished

[2019-11-17 17:13:36] Features: 18/9 -- score: 0.9767995240928018[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  18 out of  18 | elapsed:    2.7s finished

[2019-11-17 17:13:39] Features: 17/9 -- score: 0.9784685041972371[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.2s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  17 out of  17 | elapsed:    2.7s finished

[2019-11-17 17:13:42] Features: 16/9 -- score: 0.9783528323088109[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  16 out of  16 | elapsed:    2.1s finished

[2019-11-17 17:13:44] Features: 15/9 -- score: 0.9795508625817966[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
```

```
[Parallel(n_jobs=1)]: Done  15 out of  15 | elapsed:    2.1s finished

[2019-11-17 17:13:46] Features: 14/9 -- score: 0.9778653579218719[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  14 out of  14 | elapsed:    1.8s finished

[2019-11-17 17:13:48] Features: 13/9 -- score: 0.9779397184215746[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  13 out of  13 | elapsed:    1.6s finished

[2019-11-17 17:13:49] Features: 12/9 -- score: 0.9789064049177078[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  12 out of  12 | elapsed:    1.5s finished

[2019-11-17 17:13:51] Features: 11/9 -- score: 0.9794186661378809[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  11 out of  11 | elapsed:    1.4s finished

[2019-11-17 17:13:52] Features: 10/9 -- score: 0.9800961729129487[Parallel(n_jobs=1)]: Using backend
SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.1s remaining:    0.0s
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed:    1.3s finished

[2019-11-17 17:13:53] Features: 9/9 -- score: 0.9788733558067287
```

In [ ]:

In [56]:
```
filtered_features_by_correlation
```

Out[56]:
```
{'GaussianNB_backward_selected_features': ['V4',
  'V6',
  'V7',
  'V13',
  'V14',
  'V19',
  'V23',
  'V25',
  'bin_time'],
 'RandomForestClassifier_backward_selected_features': ['V4',
  'V7',
  'V13',
  'V14',
  'V17',
  'V18',
  'V21',
  'V26',
  'V27']}
```

In [ ]:

In [57]:
```
filtered_features_by_correlation['filtered_correlation_selected_features']  = filtered_features_based
_on_overall_correlation
```

In [58]:
```
# This is the set a features I will test the balanced data set on
filtered_features_by_correlation
```

Out[58]:
```
{'GaussianNB_backward_selected_features': ['V4',
  'V6',
  'V7',
  'V13',
  'V14',
  'V19',
  'V23',
  'V25',
  'bin_time'],
 'RandomForestClassifier_backward_selected_features': ['V4',
  'V7',
  'V13',
  'V14',
  'V17',
  'V18',
  'V21',
  'V26',
  'V27'],
 'filtered_correlation_selected_features': ['V3',
  'V4',
  'V9',
  'V10',
  'V11',
  'V12',
  'V14',
  'V16',
  'V17']}
```

In [ ]:

In [59]:
```
models_to_test = supervised
```

In [ ]:

In [60]:
```
def create_confustion_matrix_and_score(correlation_name, model_name, model_to_test, X_test, y_test, f
iltered_features, version):
    score = model_to_test.score(X_test, y_test)
    y_predicted = model_to_test.predict(X_test)

    cm = confusion_matrix(y_test, y_predicted)

    accuray_score_data = accuracy_score(y_test, y_predicted)
    classification_report_data = classification_report(y_test, y_predicted)
    recall_score_data = recall_score(y_test, y_predicted)
    percision_score_data = precision_score(y_test, y_predicted)
    f1_score_data = f1_score(y_test, y_predicted)
    roc_auc_score_data = roc_auc_score(y_test, y_predicted)

    figure = plt.figure(figsize=(10,7))
    sns.heatmap(cm, annot=True)
    title =  "VERSION: " +version
    title += "\nModel used: "
    title += model_to_test.__class__.__name__
    title += "\nScore: "
    title += str(roc_auc_score_data)
    title += "\nCorelation Name : "
    title += correlation_name
    title += "\nFiltered Features Used: "
    title += str(filtered_features)
    plt.title(title)
    plt.xlabel("Predicted")
    plt.ylabel("True")
    file_name = 'version_'+version+'confusion_matrix_'+str(model_to_test.__class__.__name__)+"_correl
ation_name_"+correlation_name+".jpg"
    figure.savefig(file_name)
    return {
        'cm' : cm,
        'title' : title,
        'file_name' : file_name,
        'model_name' : model_name,
        'correlation_name' : correlation_name,
        'model' : model_to_test,
        'score' : score,
        'accuray_score_data' : accuray_score_data,
        'classification_report_data' : classification_report_data,
        'recall_score_data' : recall_score_data,
        'percision_score_data' : percision_score_data,
        'f1_score_data' : f1_score_data,
        'roc_auc_score_data' : roc_auc_score_data
    }
```

In [ ]:

In [ ]:

In [61]:
```
def test_models_by_feature_list(correlation_name,
                                list_of_filtered_features,
                                model_name,
                                model_to_test,
                                X_train,
                                X_test,
                                y_train,
                                y_test, version):

    model_to_test.fit(X_train, y_train)
    training_score = cross_val_score(model_to_test, X_train, y_train, cv=5)
    data = create_confustion_matrix_and_score(correlation_name, model_name, model_to_test, X_test, y_
test, list_of_filtered_features, version)
    data['training_score'] = training_score
    model_pred = cross_val_predict(model_to_test, X_train, y_train, cv=5)
    roc_auc_score_corss_validation = roc_auc_score(y_train, model_pred)
    data['roc_auc_score_corss_validation']  = roc_auc_score_corss_validation
    data['roc_curve_data'] = roc_curve(y_train, model_pred)
    return data
```

In [ ]:

In [62]:
```
def test_data(data_frame, version):

    results  = []

    for correlation_name, list_of_filtered_features in filtered_features_by_correlation.items():

        df_with_high_correlated_features = data_frame[list_of_filtered_features]

        df_target = data_frame['Class']

        X_train, X_test, y_train, y_test = train_test_split(df_with_high_correlated_features, df_targ
et,test_size=.2)

        for model_name, model_to_test in models_to_test.items():
            res = test_models_by_feature_list(correlation_name,
                                                                list_of_filtered_features,
                                                                model_name,
                                                                model_to_test,
                                                                X_train,
                                                                X_test,
                                                                y_train,
                                                                y_test, version)
            results.append(res)
        plt.show()
    return results
```

In [ ]:
```
```

In [63]:
```
def graph_roc_curve_multiple(data):
    fpr, tpr, thresold = data['roc_curve_data']
    plt.title('ROC Curve \n 2 Classifiers', fontsize=18)
    plt.plot(fpr, tpr, label=data['model_name']+'_'+data['correlation_name']+'{:.4f}'.format(data['ro
c_auc_score_data']))
    plt.plot([0, 1], [0, 1], 'k--')
    plt.axis([-0.01, 1, 0, 1])
    plt.xlabel('False Positive Rate', fontsize=16)
    plt.ylabel('True Positive Rate', fontsize=16)
    plt.annotate('Minimum ROC Score of 50% \n (This is the minimum score to get)', xy=(0.5, 0.5), xyt
ext=(0.6, 0.3),
                 arrowprops=dict(facecolor='#6E726D', shrink=0.05),
                 )
    plt.legend()
```

In [64]:
```
def create_roc_cruve(results):
    plt.figure(figsize=(16,8))
    for i, d in enumerate(results):
        graph_roc_curve_multiple(d)
    plt.show()
```

In [65]:
```
def print_result(d):
    CM = d['cm']
    TP = CM[0][0]
    FN = CM[0][1]
    FP = CM[1][0]
    TN = CM[1][1]

    # Sensitivity, hit rate, recall, or true positive rate
    TPR = TP/(TP+FN)
    # Specificity or true negative rate
    TNR = TN/(TN+FP)
    # Precision or positive predictive value
    PPV = TP/(TP+FP)
    # Negative predictive value
    NPV = TN/(TN+FN)
    # Fall out or false positive rate
    FPR = FP/(FP+TN)
    # False negative rate
    FNR = FN/(TP+FN)
    # False discovery rate
    FDR = FP/(TP+FP)

    model_and_feature_used = 'Model and Feature used: '+ d['title']
    TN = "TN: " + str( np.round(TN, 2) )
    FN = "FN: " + str( np.round(FN, 2) )
    TP = "TP: " + str( np.round(TP, 2) )
    FP = "FP: " + str( np.round(FP, 2) )
    TPR = "TPR: " + str( np.round(TPR, 2) )
    TNR = "TNR: " + str( np.round(TNR, 2) )
    PPV = "PPV: " + str( np.round(PPV, 2) )
    NPV = "NPV: " + str( np.round(NPV, 2) )
    FPR = "FPR: " + str( np.round(FPR, 2) )
    FNR = "FNR: " + str( np.round(FNR, 2) )
    FDR = "FDR: " + str( np.round(FDR, 2) )
    Recall_Score = 'Recall Score: {:.2f}'.format(d['recall_score_data'])
    Precision_Score = 'Precision Score: {:.2f}'.format(d['percision_score_data'])
    F1_Score = 'F1 Score: {:.2f}'.format(d['f1_score_data'])
    Accuracy_Score = 'Accuracy Score: {:.2f}'.format(d['accuray_score_data'])



    line =  TN +', '+ FN +', '+ TP +', '+ FP +', '+ TPR +', '+ TNR +', '+ PPV +', '+ NPV +', '+ FPR +
', '+ FNR +', '+ FDR +', '+ Recall_Score +', '+ Precision_Score +', '+ F1_Score +', '+ Accuracy_Score

    print('---' * 10)
    print( model_and_feature_used )
    print( TN )
    print( FN )
    print( TP )
    print( FP )
    print( TPR )
    print( TNR )
    print( PPV )
    print( NPV )
    print( FPR )
    print( FNR )
    print( FDR )
    print( Recall_Score )
    print( Precision_Score )
    print( F1_Score )
    print( Accuracy_Score )
    print(line)
    print('---' * 10)
```

In [66]:
```
def print_all(results):
    for i, d in enumerate(results):
        print_result(d)
```

In [67]:
```
def show_all_confusion_matrix(results):
    stack_results = copy.deepcopy(results)
    fig, ax = plt.subplots(3, 2,figsize=(30,30))
    r = 0;
    c = 0;

    while (r < 3):
        while(c < 2):
            d = stack_results.pop()
            sns.heatmap(d['cm'], ax=ax[r][c], annot=True, cmap=plt.cm.copper, square=True, linewidths
=0.1, annot_kws={"size":30})
            ax[r, c].set_title(d['title'], fontsize=16)
            ax[r, c].set_xticklabels(['', ''], fontsize=100, rotation=90)
            ax[r, c].set_yticklabels(['', ''], fontsize=100, rotation=360)
            c = c + 1
        c = 0
        r = r + 1

    plt.show()
```

In [ ]:

In [68]:
```
def determine_max_correlation(cm1, cm1Index , cm2, cm2Index):

    correct_credible_transactions_cm1 = cm1[0][0]
    incorrect_fraudulent_transactions_cm1 = cm1[0][1]
    incorrect_credible_transactions_cm1 = cm1[1][0]
    correct_fraudulent_transactions_cm1 = cm1[1][1]

    correct_credible_transactions_cm2 = cm2[0][0]
    incorrect_fraudulent_transactions_cm2 = cm2[0][1]
    incorrect_credible_transactions_cm2 = cm2[1][0]
    correct_fraudulent_transactions_cm2 = cm2[1][1]

#     Misclassifying fradulent transactions has the highest bussiness cost
    if(incorrect_fraudulent_transactions_cm1 > incorrect_fraudulent_transactions_cm2):
        return cm2Index
    elif(incorrect_fraudulent_transactions_cm1 < incorrect_fraudulent_transactions_cm2):
        return cm1Index

#     Checking count for in correct credible transactions
    if(incorrect_credible_transactions_cm1 > incorrect_credible_transactions_cm2):
        return cm2Index
    elif(incorrect_credible_transactions_cm1 < incorrect_credible_transactions_cm2):
        return cm1Index

#  Who has the most correct credible transactions
    if(correct_credible_transactions_cm1 > correct_credible_transactions_cm2):
        return cm1Index
    elif(correct_credible_transactions_cm1 < correct_credible_transactions_cm2):
        return cm2Index

    if(correct_fraudulent_transactions_cm1 > correct_fraudulent_transactions_cm2):
        return cm1Index
    elif(correct_fraudulent_transactions_cm1 < correct_fraudulent_transactions_cm2):
        return cm2Index

    return cm2Index
```

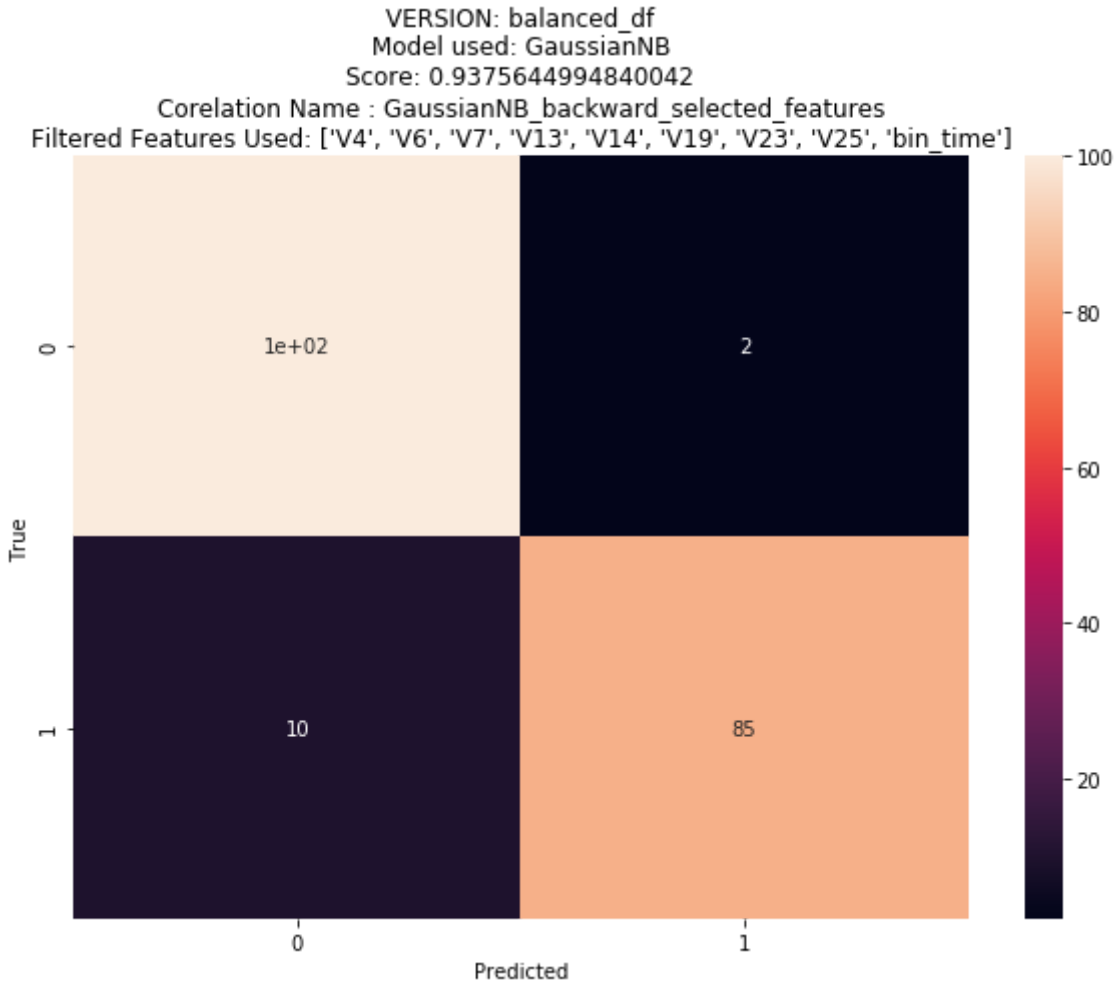
In [69]:
```
def get_best_result(res):
    maxResultIndex = 0
    initCm = res[0]['cm']
    for i, r in enumerate(res):
        maxResultIndex = determine_max_correlation(res[maxResultIndex]['cm'], maxResultIndex, r['cm'
], i)
    print("MAX_RESULT_INDEX: "+ str(maxResultIndex))
    return res[maxResultIndex]
```

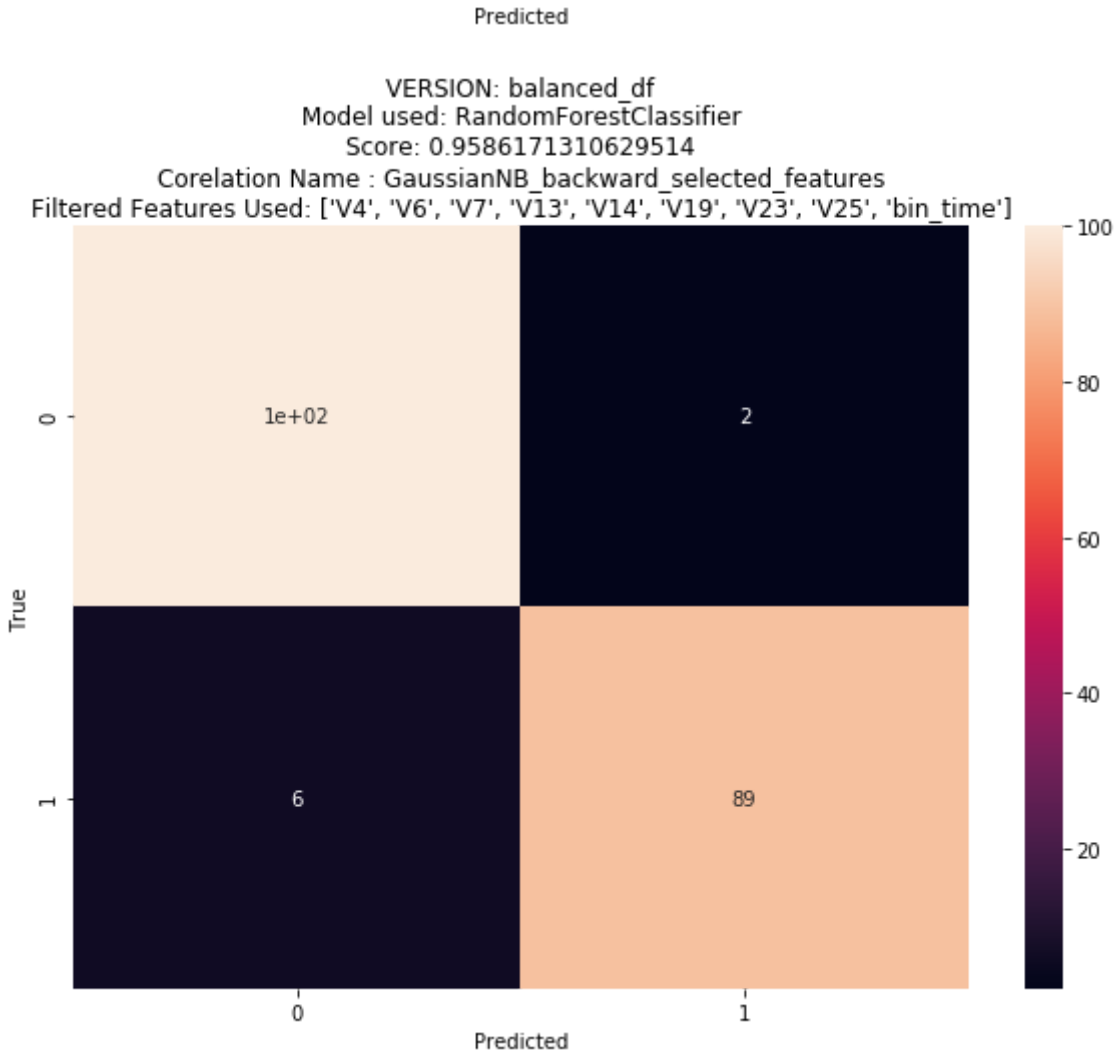
In [ ]:

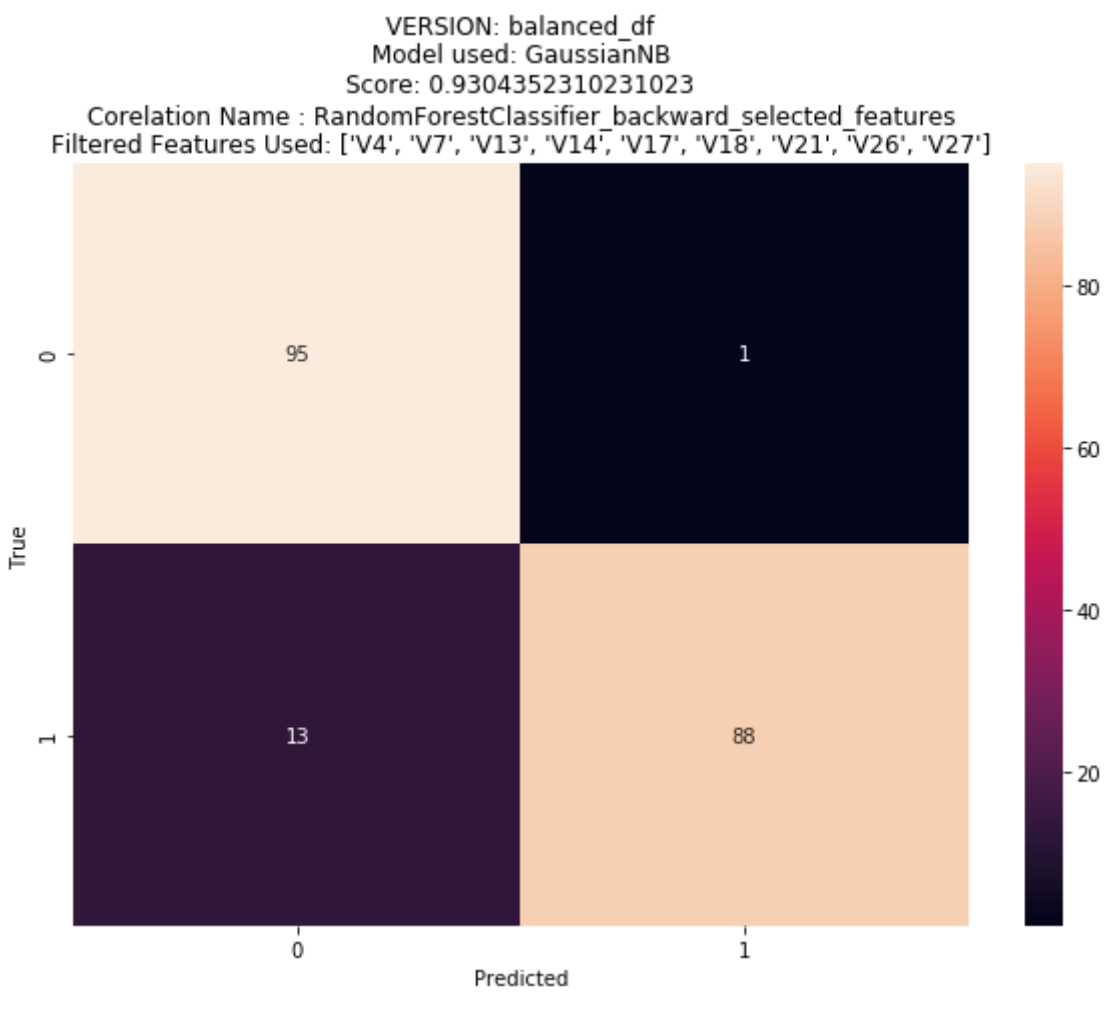
In [ ]:

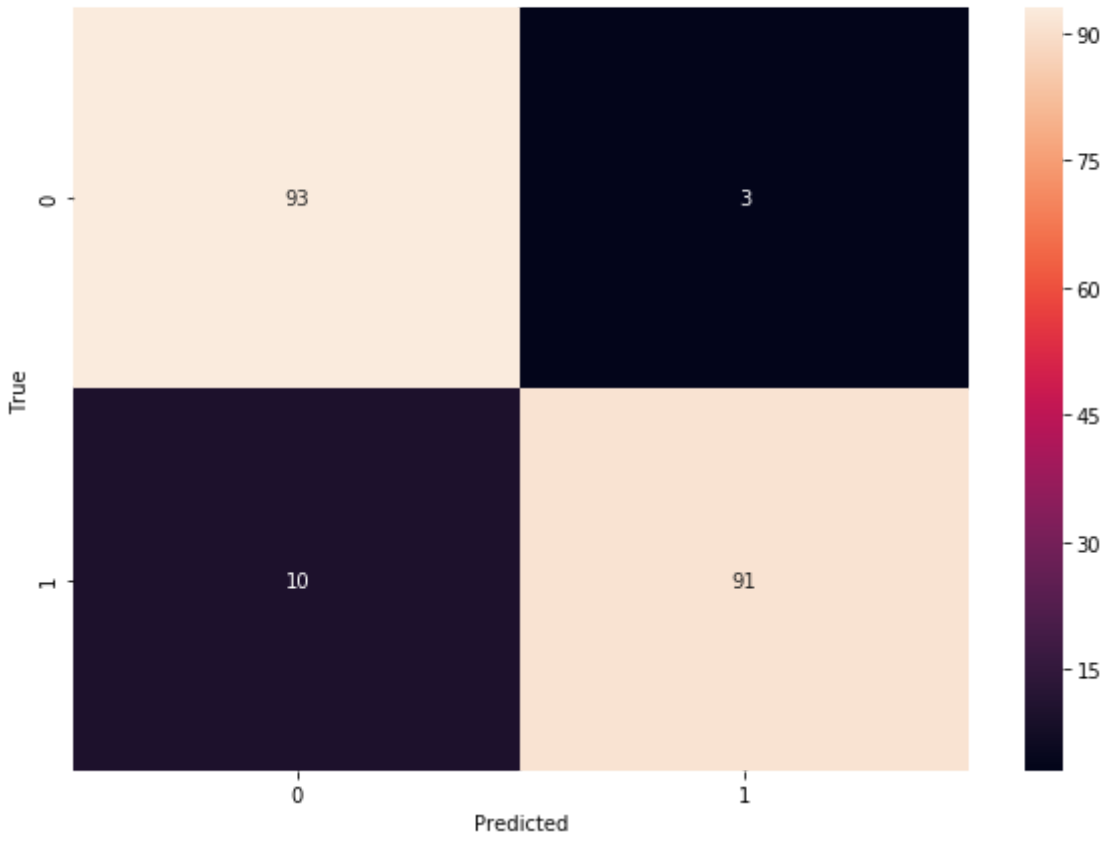
In [70]:
```
version = "balanced_df"
```

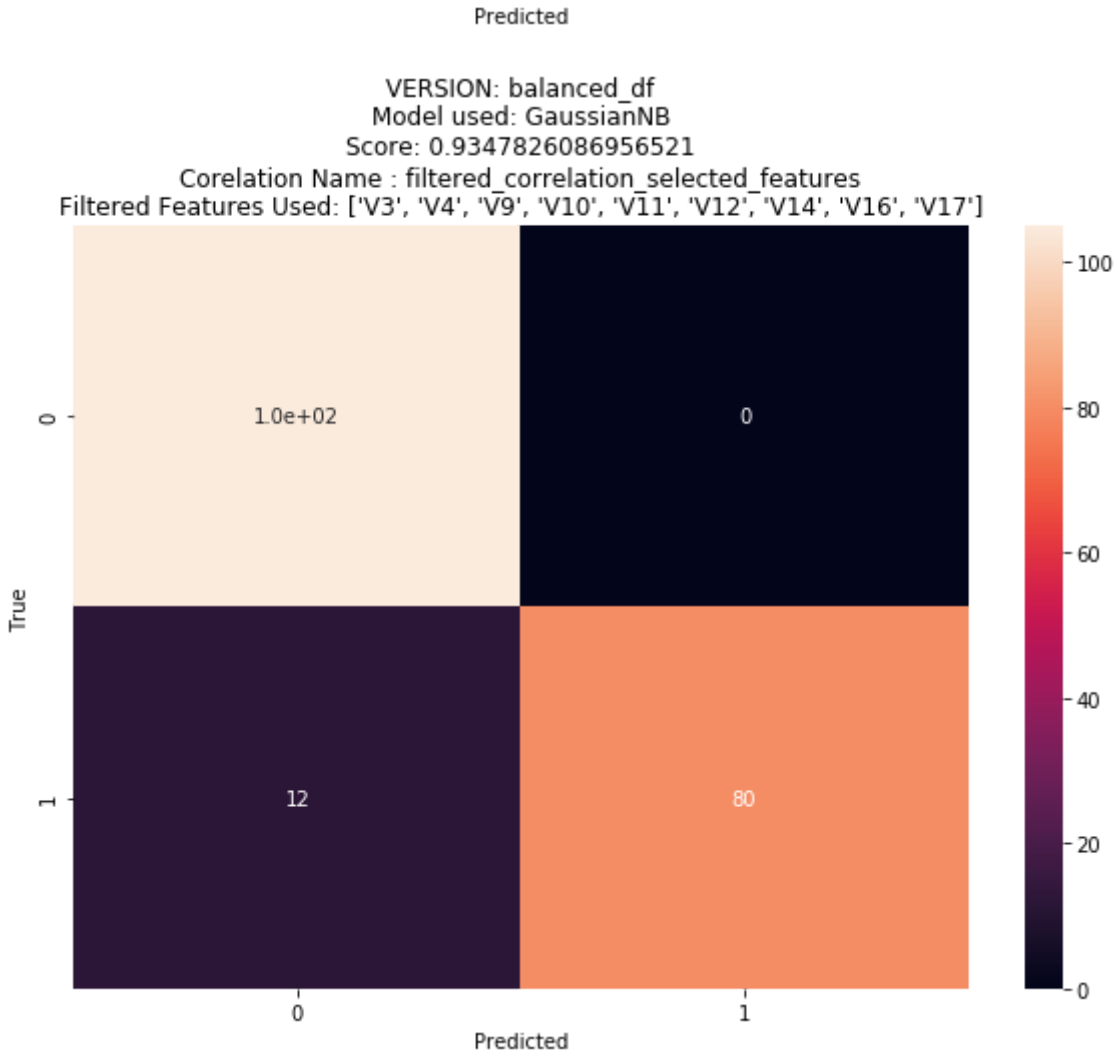
In [71]:
```
results = test_data(balanced_df, version)
```

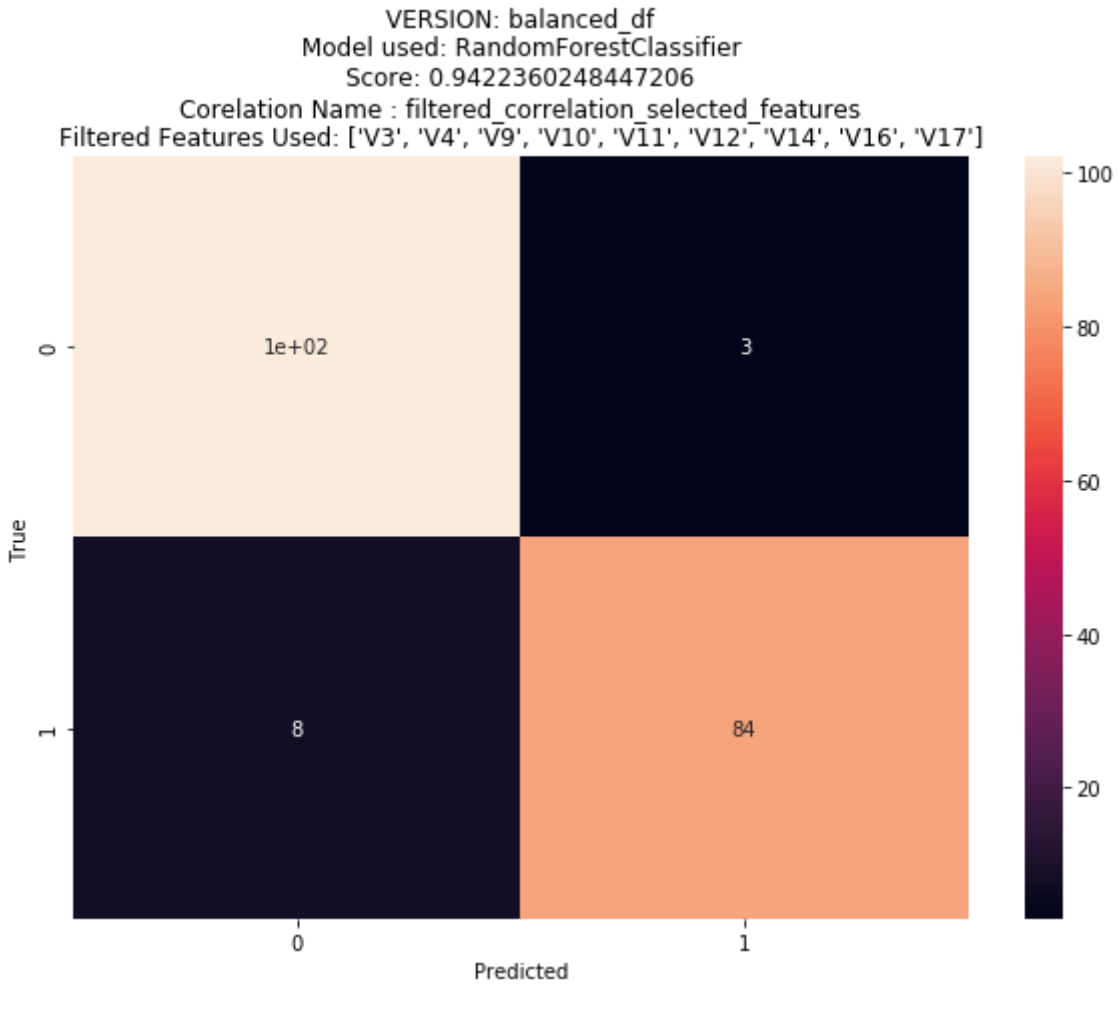

VERSION: balanced_df
Model used: GaussianNB
Score: 0.9375644994840042
Corelation Name : GaussianNB_backward_selected_features
Filtered Features Used: ['V4', 'V6', 'V7', 'V13', 'V14', 'V19', 'V23', 'V25', 'bin_time']
1e+02
2
10
85
True
Predicted
0
1
100
80
60
40
20


VERSION: balanced_df
Model used: RandomForestClassifier
Score: 0.9586171310629514
Corelation Name : GaussianNB_backward_selected_features
Filtered Features Used: ['V4', 'V6', 'V7', 'V13', 'V14', 'V19', 'V23', 'V25', 'bin_time']
1e+02
2
6
89
True
Predicted
0
1
100
80
60
40
20

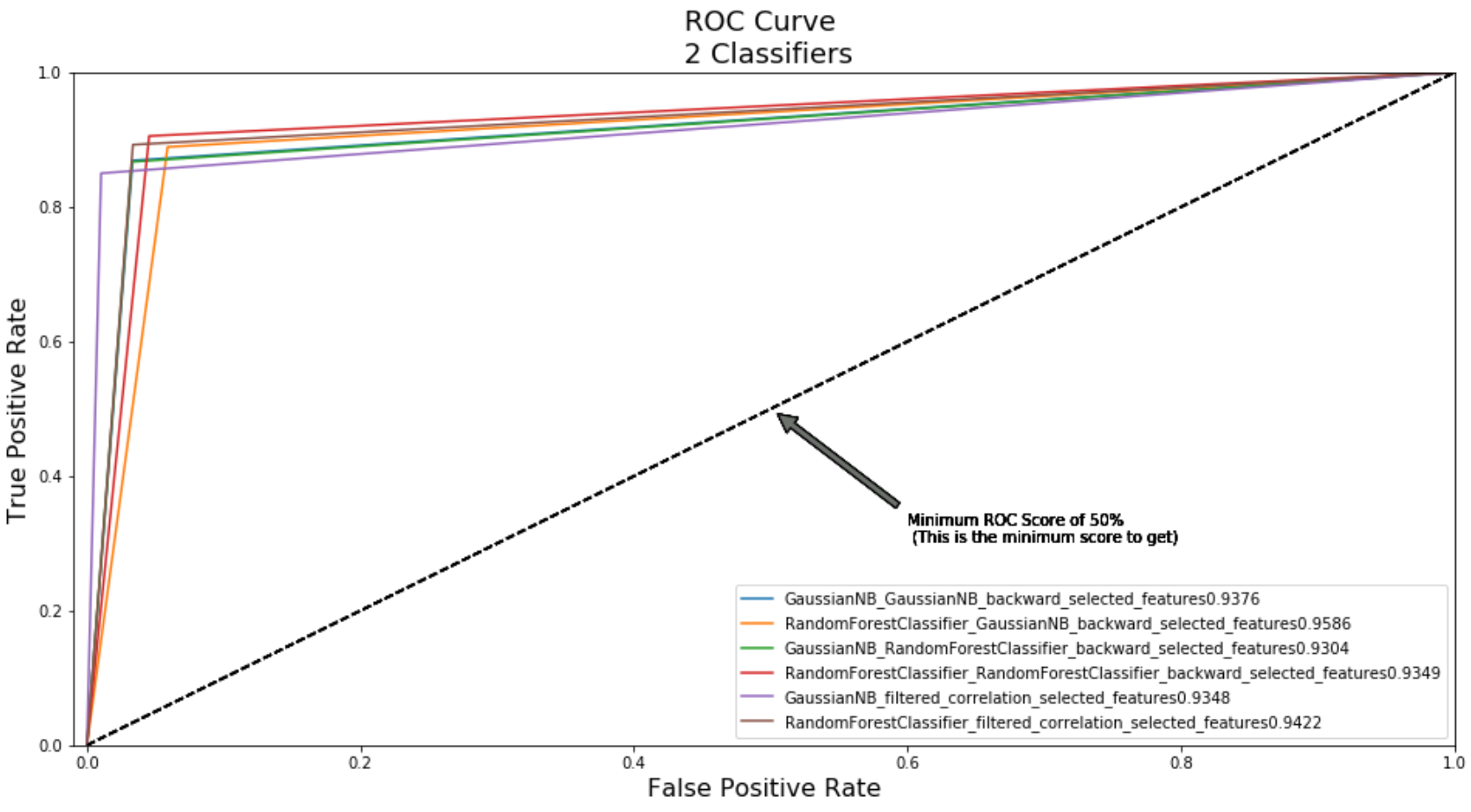

VERSION: balanced_df
Model used: GaussianNB
Score: 0.9304352310231023
Corelation Name : RandomForestClassifier_backward_selected_features
Filtered Features Used: ['V4', 'V7', 'V13', 'V14', 'V17', 'V18', 'V21', 'V26', 'V27']
95
1
13
88
True
Predicted
0
1
80
60
40
20


VERSION: balanced_df
Model used: RandomForestClassifier
Score: 0.9348700495049505
Corelation Name : RandomForestClassifier_backward_selected_features
Filtered Features Used: ['V4', 'V7', 'V13', 'V14', 'V17', 'V18', 'V21', 'V26', 'V27']
93
3
10
91
True
Predicted
0
1
90
75
60
45
30
15

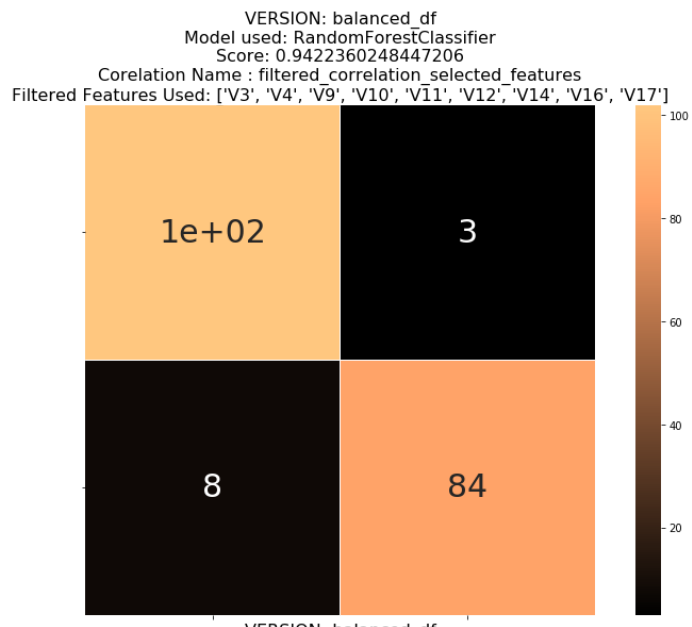

VERSION: balanced_df
Model used: GaussianNB
Score: 0.9347826086956521
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
1.0e+02
0
12
80
True
Predicted
0
1
100
80
60
40
20
0

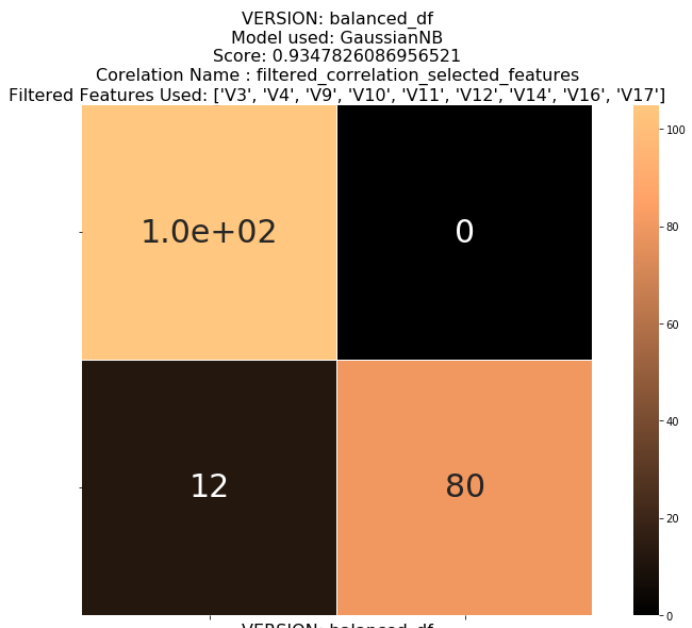

VERSION: balanced_df
Model used: RandomForestClassifier
Score: 0.9422360248447206
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
1e+02
3
8
84
True
Predicted
0
1
100
80
60
40
20

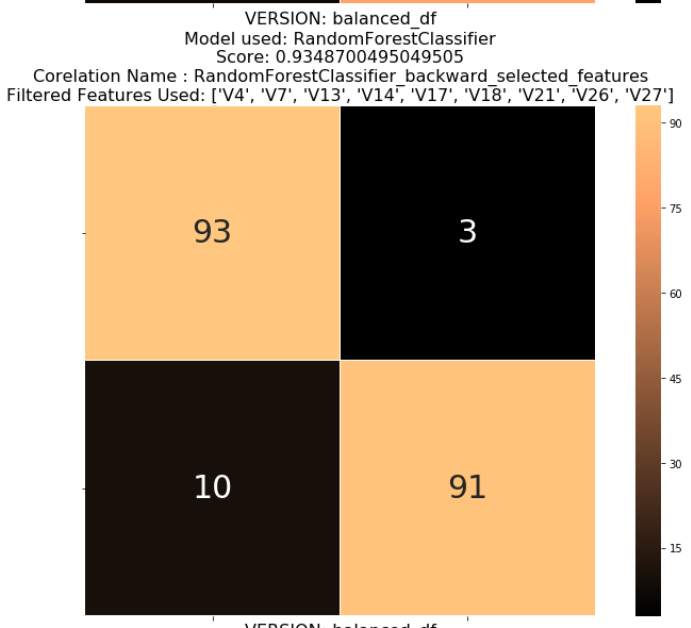
In [72]:
```
create_roc_cruve(results)
```

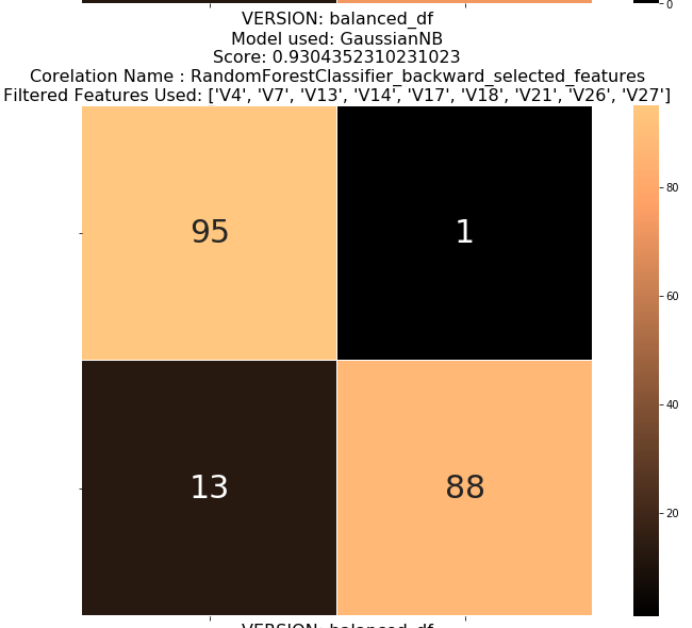


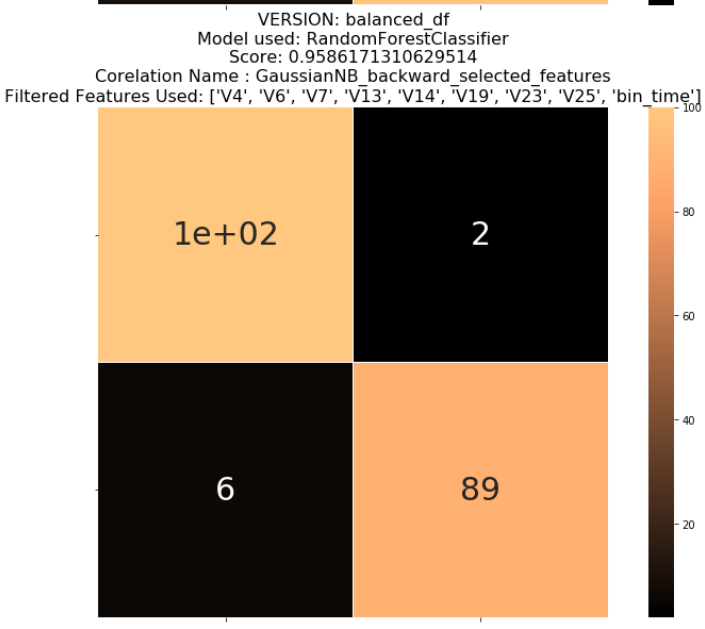
In [73]:
```
show_all_confusion_matrix(results)
```

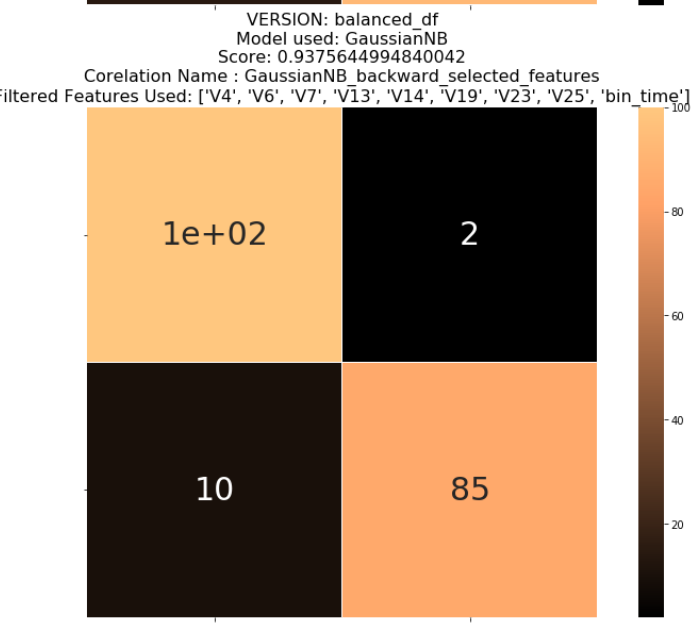












In [74]:
```
print_all(results)
```

```
------------------------------
Model and Feature used: VERSION: balanced_df
Model used: GaussianNB
Score: 0.9375644994840042
Corelation Name : GaussianNB_backward_selected_features
Filtered Features Used: ['V4', 'V6', 'V7', 'V13', 'V14', 'V19', 'V23', 'V25', 'bin_time']
TN: 85
FN: 2
TP: 100
FP: 10
TPR: 0.98
TNR: 0.89
PPV: 0.91
NPV: 0.98
FPR: 0.11
FNR: 0.02
FDR: 0.09
Recall Score: 0.89
Precision Score: 0.98
F1 Score: 0.93
Accuracy Score: 0.94
TN: 85, FN: 2, TP: 100, FP: 10, TPR: 0.98, TNR: 0.89, PPV: 0.91, NPV: 0.98, FPR: 0.11, FNR: 0.02, FD
R: 0.09, Recall Score: 0.89, Precision Score: 0.98, F1 Score: 0.93, Accuracy Score: 0.94
------------------------------
------------------------------
Model and Feature used: VERSION: balanced_df
Model used: RandomForestClassifier
Score: 0.9586171310629514
Corelation Name : GaussianNB_backward_selected_features
Filtered Features Used: ['V4', 'V6', 'V7', 'V13', 'V14', 'V19', 'V23', 'V25', 'bin_time']
TN: 89
FN: 2
TP: 100
FP: 6
TPR: 0.98
TNR: 0.94
PPV: 0.94
NPV: 0.98
FPR: 0.06
FNR: 0.02
FDR: 0.06
Recall Score: 0.94
Precision Score: 0.98
F1 Score: 0.96
Accuracy Score: 0.96
TN: 89, FN: 2, TP: 100, FP: 6, TPR: 0.98, TNR: 0.94, PPV: 0.94, NPV: 0.98, FPR: 0.06, FNR: 0.02, FD
R: 0.06, Recall Score: 0.94, Precision Score: 0.98, F1 Score: 0.96, Accuracy Score: 0.96
------------------------------
------------------------------
Model and Feature used: VERSION: balanced_df
Model used: GaussianNB
Score: 0.9304352310231023
Corelation Name : RandomForestClassifier_backward_selected_features
Filtered Features Used: ['V4', 'V7', 'V13', 'V14', 'V17', 'V18', 'V21', 'V26', 'V27']
TN: 88
FN: 1
TP: 95
FP: 13
TPR: 0.99
TNR: 0.87
PPV: 0.88
NPV: 0.99
FPR: 0.13
FNR: 0.01
FDR: 0.12
Recall Score: 0.87
Precision Score: 0.99
F1 Score: 0.93
Accuracy Score: 0.93
TN: 88, FN: 1, TP: 95, FP: 13, TPR: 0.99, TNR: 0.87, PPV: 0.88, NPV: 0.99, FPR: 0.13, FNR: 0.01, FD
R: 0.12, Recall Score: 0.87, Precision Score: 0.99, F1 Score: 0.93, Accuracy Score: 0.93
------------------------------
------------------------------
Model and Feature used: VERSION: balanced_df
Model used: RandomForestClassifier
Score: 0.9348700495049505
Corelation Name : RandomForestClassifier_backward_selected_features
Filtered Features Used: ['V4', 'V7', 'V13', 'V14', 'V17', 'V18', 'V21', 'V26', 'V27']
TN: 91
FN: 3
TP: 93
FP: 10
TPR: 0.97
TNR: 0.9
PPV: 0.9
NPV: 0.97
FPR: 0.1
FNR: 0.03
FDR: 0.1
Recall Score: 0.90
Precision Score: 0.97
```

```
F1 Score: 0.93
Accuracy Score: 0.93
TN: 91, FN: 3, TP: 93, FP: 10, TPR: 0.97, TNR: 0.9, PPV: 0.9, NPV: 0.97, FPR: 0.1, FNR: 0.03, FDR:
0.1, Recall Score: 0.90, Precision Score: 0.97, F1 Score: 0.93, Accuracy Score: 0.93
------------------------------
------------------------------
Model and Feature used: VERSION: balanced_df
Model used: GaussianNB
Score: 0.9347826086956521
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
TN: 80
FN: 0
TP: 105
FP: 12
TPR: 1.0
TNR: 0.87
PPV: 0.9
NPV: 1.0
FPR: 0.13
FNR: 0.0
FDR: 0.1
Recall Score: 0.87
Precision Score: 1.00
F1 Score: 0.93
Accuracy Score: 0.94
TN: 80, FN: 0, TP: 105, FP: 12, TPR: 1.0, TNR: 0.87, PPV: 0.9, NPV: 1.0, FPR: 0.13, FNR: 0.0, FDR:
0.1, Recall Score: 0.87, Precision Score: 1.00, F1 Score: 0.93, Accuracy Score: 0.94
------------------------------
------------------------------
Model and Feature used: VERSION: balanced_df
Model used: RandomForestClassifier
Score: 0.9422360248447206
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
TN: 84
FN: 3
TP: 102
FP: 8
TPR: 0.97
TNR: 0.91
PPV: 0.93
NPV: 0.97
FPR: 0.09
FNR: 0.03
FDR: 0.07
Recall Score: 0.91
Precision Score: 0.97
F1 Score: 0.94
Accuracy Score: 0.94
TN: 84, FN: 3, TP: 102, FP: 8, TPR: 0.97, TNR: 0.91, PPV: 0.93, NPV: 0.97, FPR: 0.09, FNR: 0.03, FD
R: 0.07, Recall Score: 0.91, Precision Score: 0.97, F1 Score: 0.94, Accuracy Score: 0.94
------------------------------
```

In [75]:
```
best_result = get_best_result(results)
```

```
MAX_RESULT_INDEX: 4
```

In [76]:
```
print_result(best_result)
```

```
------------------------------
Model and Feature used: VERSION: balanced_df
Model used: GaussianNB
Score: 0.9347826086956521
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
TN: 80
FN: 0
TP: 105
FP: 12
TPR: 1.0
TNR: 0.87
PPV: 0.9
NPV: 1.0
FPR: 0.13
FNR: 0.0
FDR: 0.1
Recall Score: 0.87
Precision Score: 1.00
F1 Score: 0.93
Accuracy Score: 0.94
TN: 80, FN: 0, TP: 105, FP: 12, TPR: 1.0, TNR: 0.87, PPV: 0.9, NPV: 1.0, FPR: 0.13, FNR: 0.0, FDR:
0.1, Recall Score: 0.87, Precision Score: 1.00, F1 Score: 0.93, Accuracy Score: 0.94
------------------------------
```

In [77]:
```
print("Best result from test data: ")
print(best_result['title'])
```

```
Best result from test data:
VERSION: balanced_df
Model used: GaussianNB
Score: 0.9347826086956521
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
```

In [78]:
```
results
```

Out[78]:

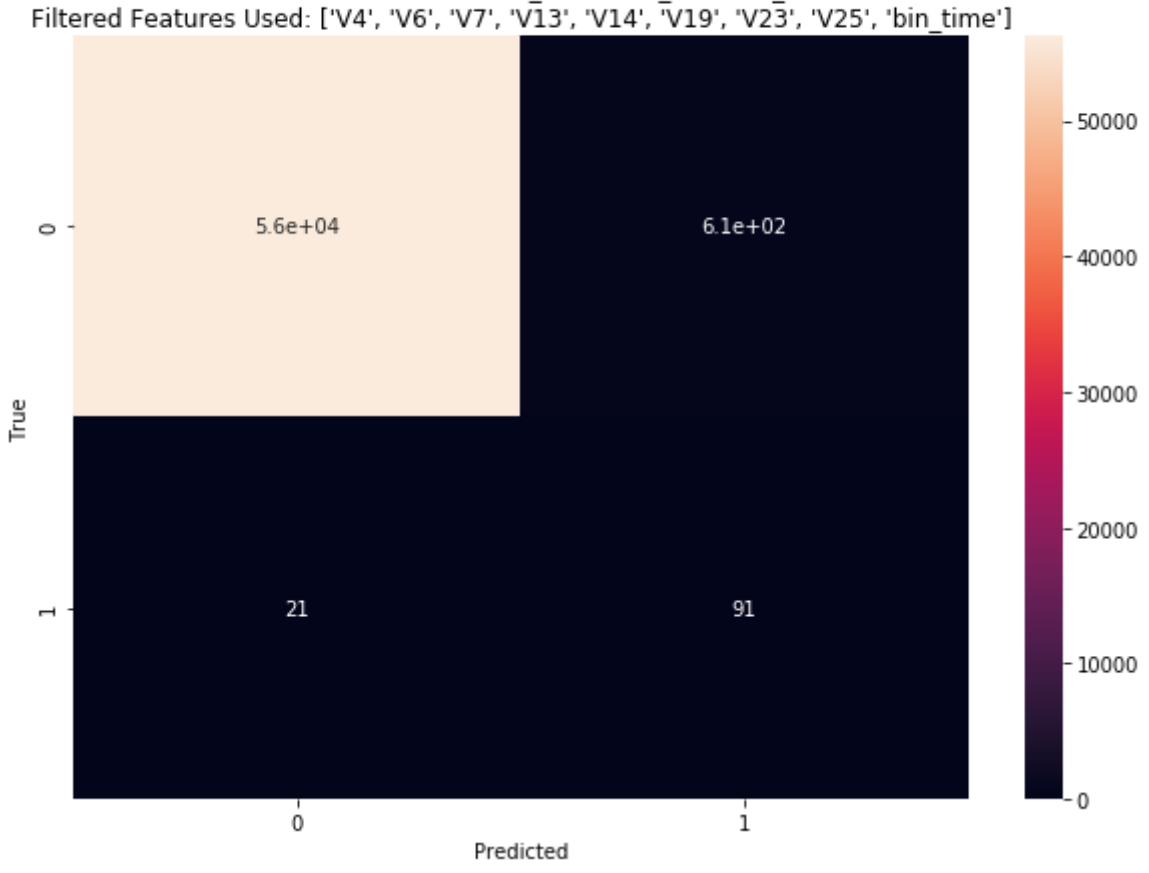
```
[{'cm': array([[100,   2],
               [ 10,  85]]),
  'title': "VERSION: balanced_df\nModel used: GaussianNB\nScore: 0.9375644994840042\nCorelation Name
: GaussianNB_backward_selected_features\nFiltered Features Used: ['V4', 'V6', 'V7', 'V13', 'V14', 'V
19', 'V23', 'V25', 'bin_time']",
  'file_name': 'version_balanced_dfconfusion_matrix_GaussianNB_correlation_name_GaussianNB_backward_
selected_features.jpg',
  'model_name': 'GaussianNB',
  'correlation_name': 'GaussianNB_backward_selected_features',
  'model': GaussianNB(priors=None, var_smoothing=1e-09),
  'score': 0.9390862944162437,
  'accuray_score_data': 0.9390862944162437,
  'classification_report_data': '              precision    recall  f1-score   support\n\n
0       0.91      0.98      0.94       102\n           1       0.98      0.89      0.93        95\n
\n   micro avg       0.94      0.94      0.94       197\n   macro avg       0.94      0.94      0.94
197\nweighted avg       0.94      0.94      0.94       197\n',
  'recall_score_data': 0.8947368421052632,
  'percision_score_data': 0.9770114942528736,
  'f1_score_data': 0.9340659340659342,
  'roc_auc_score_data': 0.9375644994840042,
  'training_score': array([0.93037975, 0.91772152, 0.92993631, 0.89171975, 0.91719745]),
  'roc_auc_score_corss_validation': 0.91784214945424,
  'roc_curve_data': (array([0.        , 0.03333333, 1.        ]),
   array([0.        , 0.86901763, 1.        ]),
   array([2, 1, 0]))},
 {'cm': array([[100,   2],
               [  6,  89]]),
  'title': "VERSION: balanced_df\nModel used: RandomForestClassifier\nScore: 0.9586171310629514\nCor
elation Name : GaussianNB_backward_selected_features\nFiltered Features Used: ['V4', 'V6', 'V7', 'V1
3', 'V14', 'V19', 'V23', 'V25', 'bin_time']",
  'file_name': 'version_balanced_dfconfusion_matrix_RandomForestClassifier_correlation_name_Gaussian
NB_backward_selected_features.jpg',
  'model_name': 'RandomForestClassifier',
  'correlation_name': 'GaussianNB_backward_selected_features',
  'model': RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
              max_depth=None, max_features='auto', max_leaf_nodes=None,
              min_impurity_decrease=0.0, min_impurity_split=None,
              min_samples_leaf=1, min_samples_split=2,
              min_weight_fraction_leaf=0.0, n_estimators=20, n_jobs=None,
              oob_score=False, random_state=None, verbose=0,
              warm_start=False),
  'score': 0.9593908629441624,
  'accuray_score_data': 0.9593908629441624,
  'classification_report_data': '              precision    recall  f1-score   support\n\n
0       0.94      0.98      0.96       102\n           1       0.98      0.94      0.96        95\n
\n   micro avg       0.96      0.96      0.96       197\n   macro avg       0.96      0.96      0.96
197\nweighted avg       0.96      0.96      0.96       197\n',
  'recall_score_data': 0.9368421052631579,
  'percision_score_data': 0.978021978021978,
  'f1_score_data': 0.956989247311828,
  'roc_auc_score_data': 0.9586171310629514,
  'training_score': array([0.94303797, 0.91139241, 0.91082803, 0.91082803, 0.91082803]),
  'roc_auc_score_corss_validation': 0.9150972033843571,
  'roc_curve_data': (array([0.        , 0.05897436, 1.        ]),
   array([0.        , 0.88916877, 1.        ]),
   array([2, 1, 0]))},
 {'cm': array([[95,  1],
               [13, 88]]),
  'title': "VERSION: balanced_df\nModel used: GaussianNB\nScore: 0.9304352310231023\nCorelation Name
: RandomForestClassifier_backward_selected_features\nFiltered Features Used: ['V4', 'V7', 'V13', 'V1
4', 'V17', 'V18', 'V21', 'V26', 'V27']",
  'file_name': 'version_balanced_dfconfusion_matrix_GaussianNB_correlation_name_RandomForestClassifi
er_backward_selected_features.jpg',
  'model_name': 'GaussianNB',
  'correlation_name': 'RandomForestClassifier_backward_selected_features',
  'model': GaussianNB(priors=None, var_smoothing=1e-09),
  'score': 0.9289340101522843,
  'accuray_score_data': 0.9289340101522843,
  'classification_report_data': '              precision    recall  f1-score   support\n\n
0       0.88      0.99      0.93        96\n           1       0.99      0.87      0.93       101\n
\n   micro avg       0.93      0.93      0.93       197\n   macro avg       0.93      0.93      0.93
197\nweighted avg       0.94      0.93      0.93       197\n',
  'recall_score_data': 0.8712871287128713,
  'percision_score_data': 0.9887640449438202,
  'f1_score_data': 0.9263157894736842,
  'roc_auc_score_data': 0.9304352310231023,
  'training_score': array([0.93081761, 0.89808917, 0.92356688, 0.9044586 , 0.92993631]),
  'roc_auc_score_corss_validation': 0.9170896949029941,
  'roc_curve_data': (array([0.        , 0.03282828, 1.        ]),
   array([0.        , 0.86700767, 1.        ]),
   array([2, 1, 0]))},
 {'cm': array([[93,  3],
               [10, 91]]),
  'title': "VERSION: balanced_df\nModel used: RandomForestClassifier\nScore: 0.9348700495049505\nCor
elation Name : RandomForestClassifier_backward_selected_features\nFiltered Features Used: ['V4', 'V
7', 'V13', 'V14', 'V17', 'V18', 'V21', 'V26', 'V27']",
  'file_name': 'version_balanced_dfconfusion_matrix_RandomForestClassifier_correlation_name_RandomFo
restClassifier_backward_selected_features.jpg',
  'model_name': 'RandomForestClassifier',
  'correlation_name': 'RandomForestClassifier_backward_selected_features',
  'model': RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
```

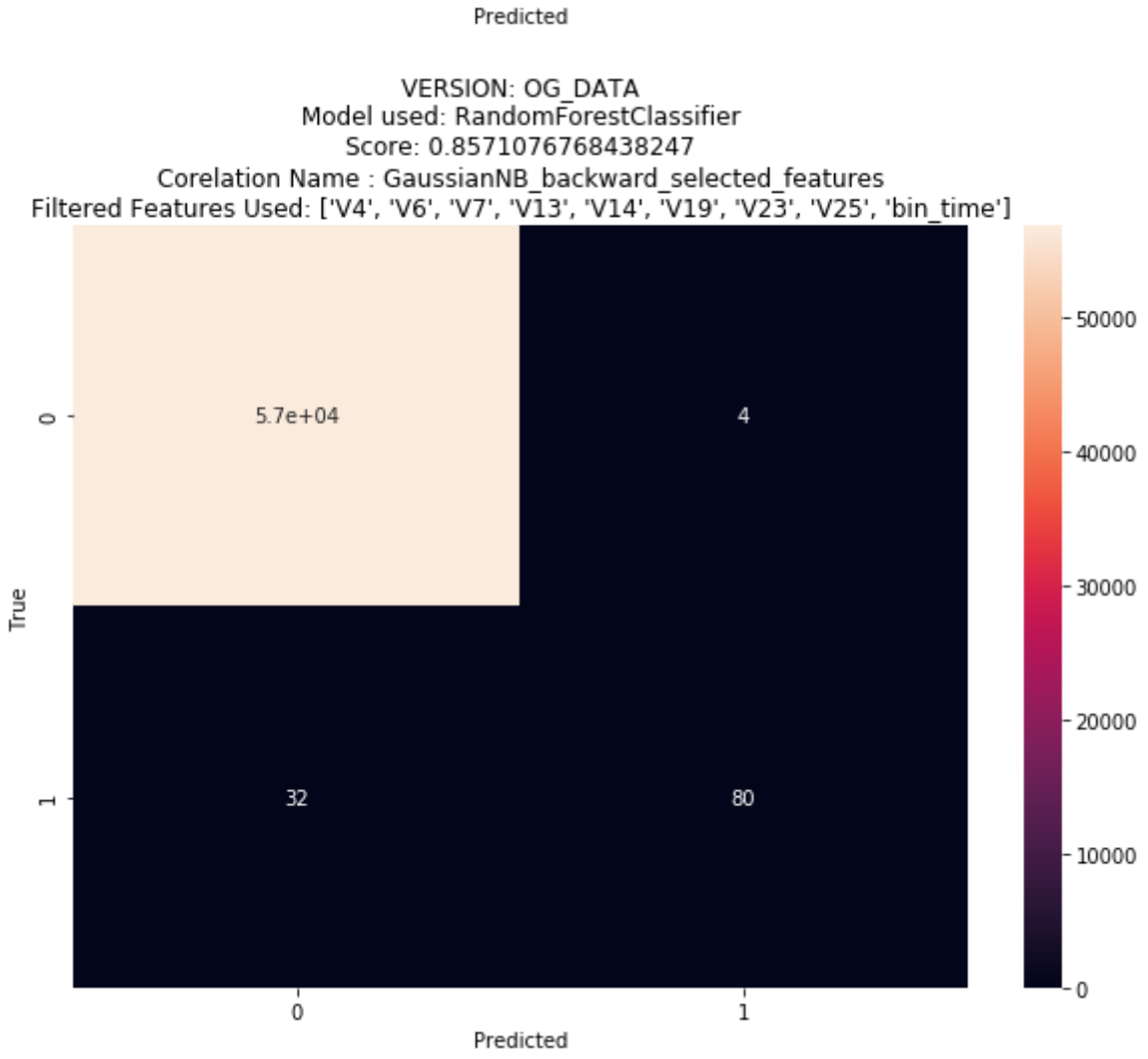
```
              max_depth=None, max_features='auto', max_leaf_nodes=None,
              min_impurity_decrease=0.0, min_impurity_split=None,
              min_samples_leaf=1, min_samples_split=2,
              min_weight_fraction_leaf=0.0, n_estimators=20, n_jobs=None,
              oob_score=False, random_state=None, verbose=0,
              warm_start=False),
  'score': 0.934010152284264,
  'accuray_score_data': 0.934010152284264,
  'classification_report_data': '              precision    recall  f1-score   support\n\n
0       0.90      0.97      0.93        96\n           1       0.97      0.90      0.93       101\n
\n   micro avg       0.93      0.93      0.93       197\n   macro avg       0.94      0.93      0.93
197\nweighted avg       0.94      0.93      0.93       197\n',
  'recall_score_data': 0.900990099009901,
  'percision_score_data': 0.9680851063829787,
  'f1_score_data': 0.9333333333333335,
  'roc_auc_score_data': 0.9348700495049505,
  'training_score': array([0.94339623, 0.92356688, 0.94267516, 0.92356688, 0.91719745]),
  'roc_auc_score_corss_validation': 0.9299581492676122,
  'roc_curve_data': (array([0.        , 0.04545455, 1.        ]),
   array([0.        , 0.90537084, 1.        ]),
   array([2, 1, 0]))},
 {'cm': array([[105,   0],
        [ 12,  80]]),
  'title': "VERSION: balanced_df\nModel used: GaussianNB\nScore: 0.934782606956521\nCorelation Name
: filtered_correlation_selected_features\nFiltered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11',
'V12', 'V14', 'V16', 'V17']",
  'file_name': 'version_balanced_dfconfusion_matrix_GaussianNB_correlation_name_filtered_correlation
_selected_features.jpg',
  'model_name': 'GaussianNB',
  'correlation_name': 'filtered_correlation_selected_features',
  'model': GaussianNB(priors=None, var_smoothing=1e-09),
  'score': 0.9390862944162437,
  'accuray_score_data': 0.9390862944162437,
  'classification_report_data': '              precision    recall  f1-score   support\n\n
0       0.90      1.00      0.95       105\n           1       1.00      0.87      0.93        92\n
\n   micro avg       0.94      0.94      0.94       197\n   macro avg       0.95      0.93      0.94
197\nweighted avg       0.95      0.94      0.94       197\n',
  'recall_score_data': 0.8695652173913043,
  'percision_score_data': 1.0,
  'f1_score_data': 0.9302325581395349,
  'roc_auc_score_data': 0.9347826086956521,
  'training_score': array([0.90506329, 0.92405063, 0.9044586 , 0.92356688, 0.93630573]),
  'roc_auc_score_corss_validation': 0.9198320413436692,
  'roc_curve_data': (array([0.        , 0.01033592, 1.        ]),
   array([0.  , 0.85, 1.  ]),
   array([2, 1, 0]))},
 {'cm': array([[102,   3],
        [  8,  84]]),
  'title': "VERSION: balanced_df\nModel used: RandomForestClassifier\nScore: 0.9422360248447206\nCor
elation Name : filtered_correlation_selected_features\nFiltered Features Used: ['V3', 'V4', 'V9', 'V
10', 'V11', 'V12', 'V14', 'V16', 'V17']",
  'file_name': 'version_balanced_dfconfusion_matrix_RandomForestClassifier_correlation_name_filtered
_correlation_selected_features.jpg',
  'model_name': 'RandomForestClassifier',
  'correlation_name': 'filtered_correlation_selected_features',
  'model': RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
              max_depth=None, max_features='auto', max_leaf_nodes=None,
              min_impurity_decrease=0.0, min_impurity_split=None,
              min_samples_leaf=1, min_samples_split=2,
              min_weight_fraction_leaf=0.0, n_estimators=20, n_jobs=None,
              oob_score=False, random_state=None, verbose=0,
              warm_start=False),
  'score': 0.9441624365482234,
  'accuray_score_data': 0.9441624365482234,
  'classification_report_data': '              precision    recall  f1-score   support\n\n
0       0.93      0.97      0.95       105\n           1       0.97      0.91      0.94        92\n
\n   micro avg       0.94      0.94      0.94       197\n   macro avg       0.95      0.94      0.94
197\nweighted avg       0.95      0.94      0.94       197\n',
  'recall_score_data': 0.9130434782608695,
  'percision_score_data': 0.9655172413793104,
  'f1_score_data': 0.9385474860335196,
  'roc_auc_score_data': 0.9422360248447206,
  'training_score': array([0.91772152, 0.94303797, 0.93630573, 0.94267516, 0.93630573]),
  'roc_auc_score_corss_validation': 0.929454134366925,
  'roc_curve_data': (array([0.        , 0.03359173, 1.        ]),
   array([0.    , 0.8925, 1.    ]),
   array([2, 1, 0]))}]
```

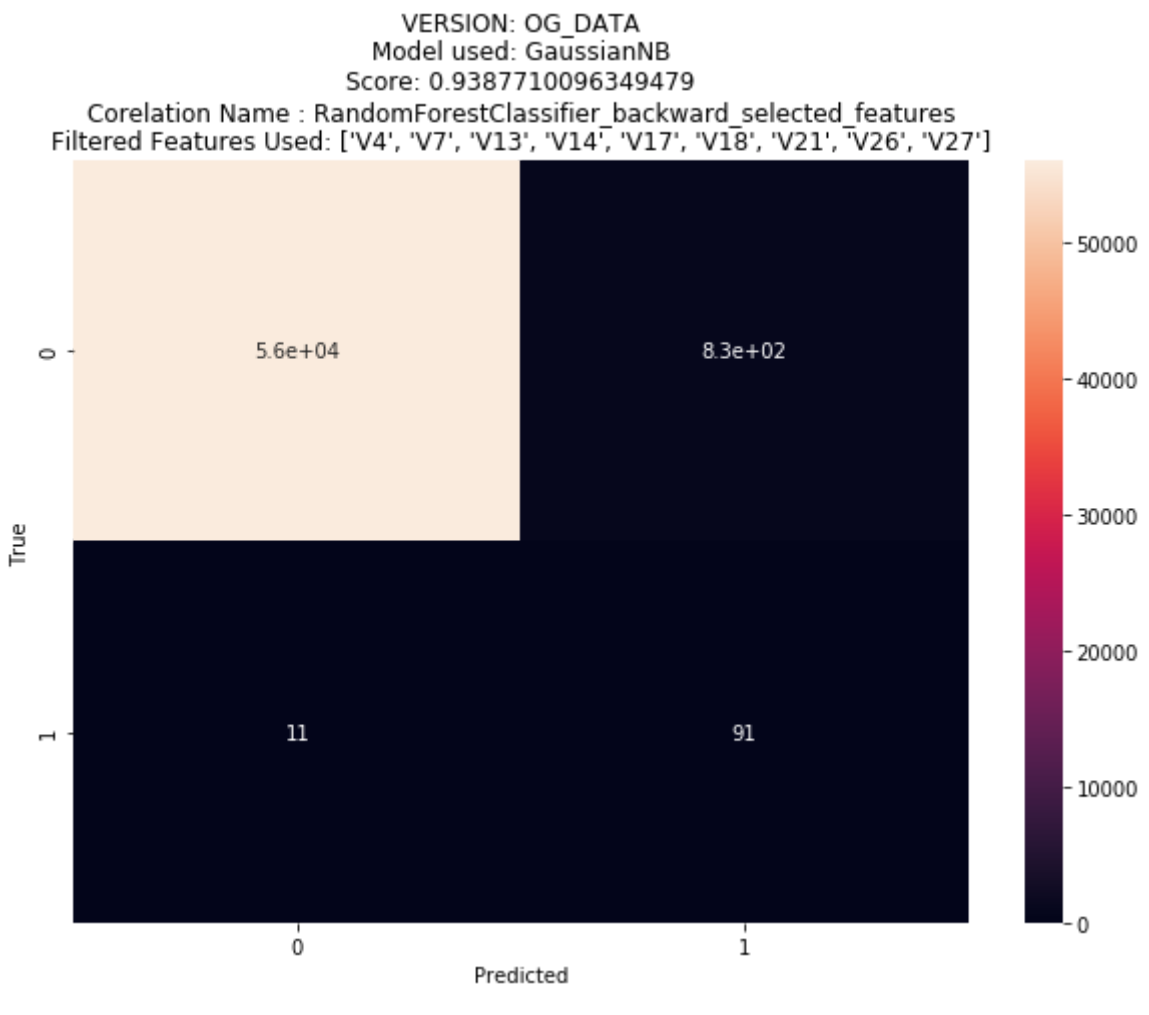

In [ ]:

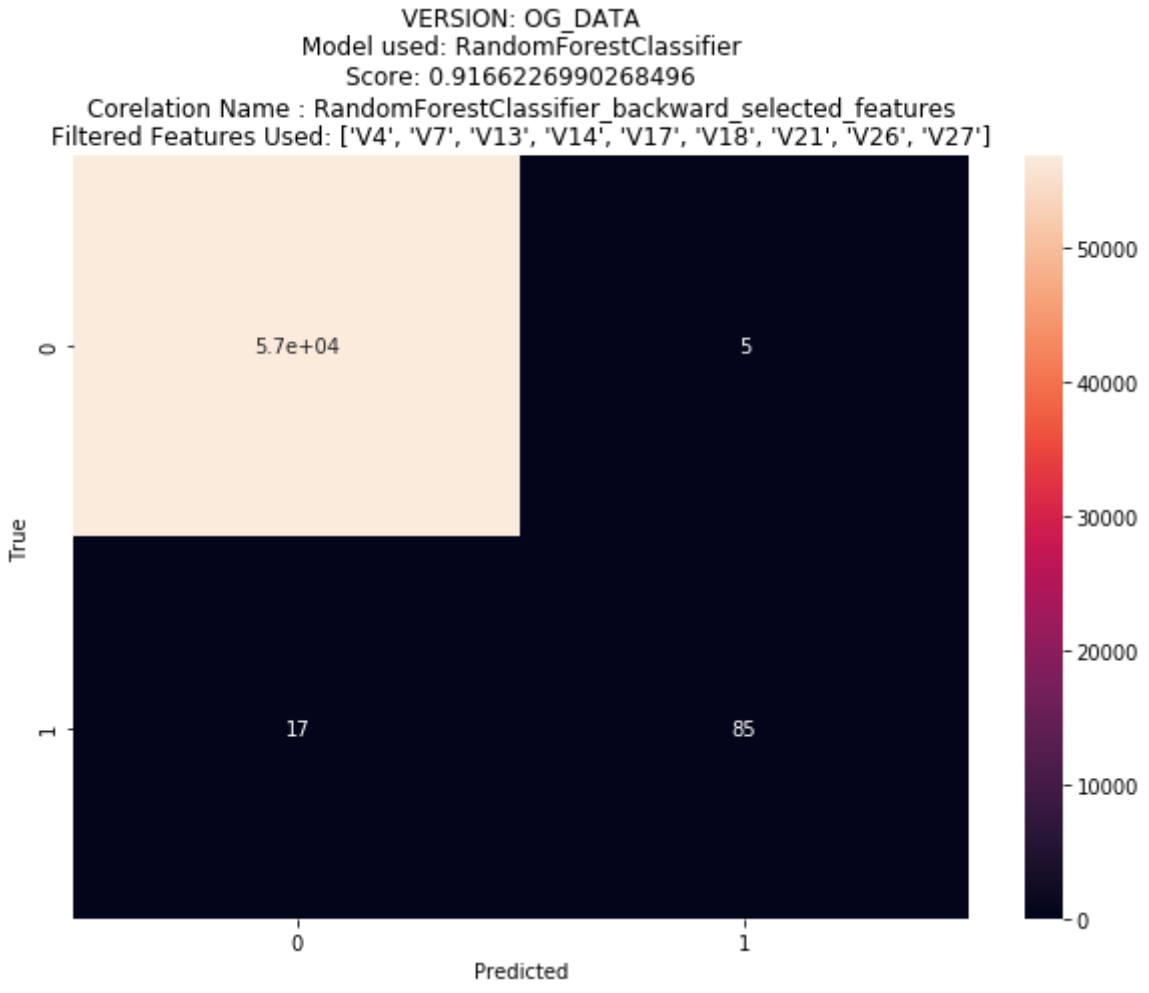
In [ ]:

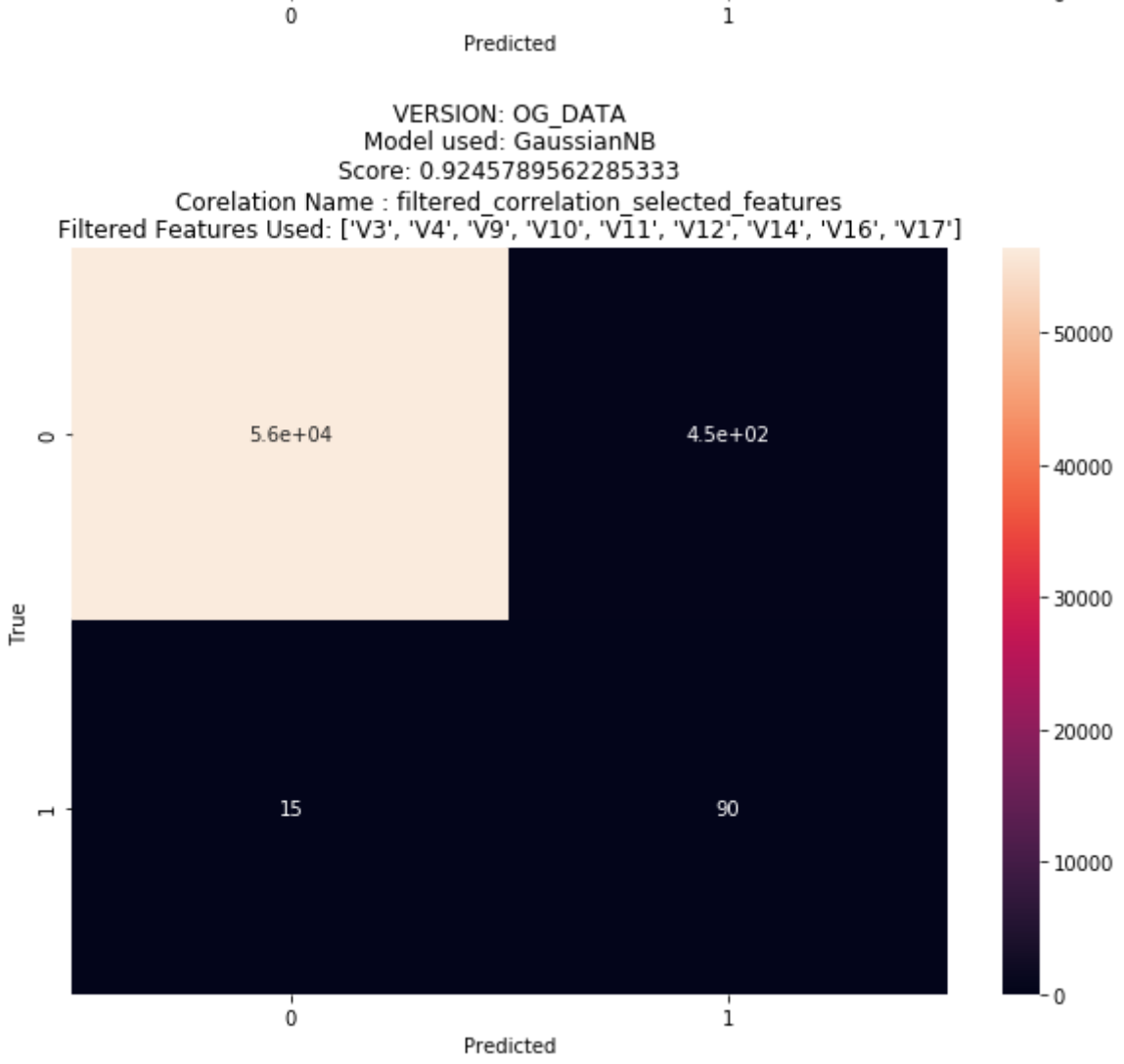
In [79]:
```
results_based_off_og = test_data(df, "OG_DATA")
```

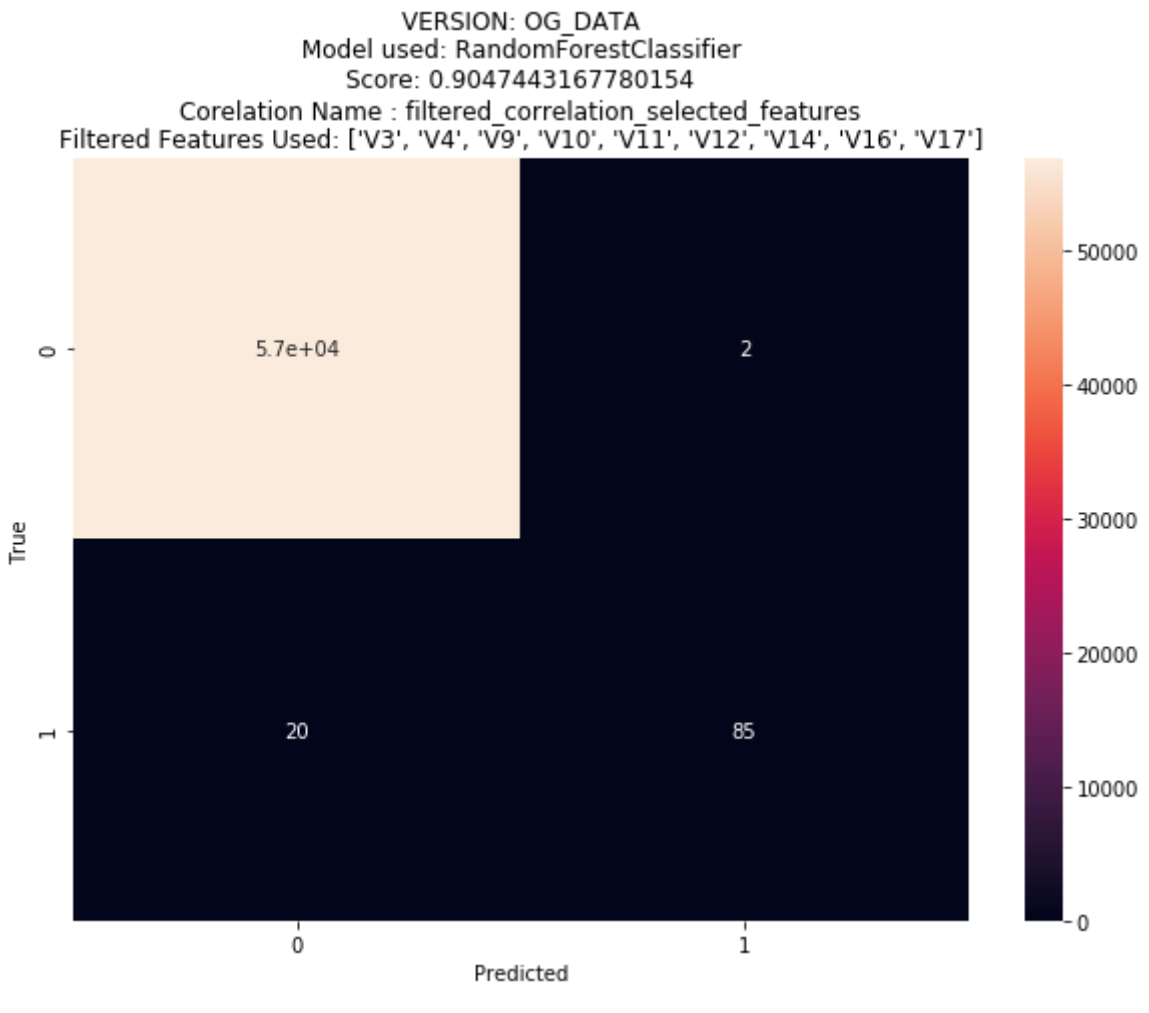

VERSION: OG_DATA
Model used: GaussianNB
Score: 0.9009201846965699
Corelation Name : GaussianNB_backward_selected_features
Filtered Features Used: ['V4', 'V6', 'V7', 'V13', 'V14', 'V19', 'V23', 'V25', 'bin_time']
5.6e+04
6.1e+02
21
91
True
Predicted
0
1
50000
40000
30000
20000
10000
0


VERSION: OG_DATA
Model used: RandomForestClassifier
Score: 0.8571076768438247
Corelation Name : GaussianNB_backward_selected_features
Filtered Features Used: ['V4', 'V6', 'V7', 'V13', 'V14', 'V19', 'V23', 'V25', 'bin_time']
5.7e+04
4
32
80
True
Predicted
0
1
50000
40000
30000
20000
10000
0

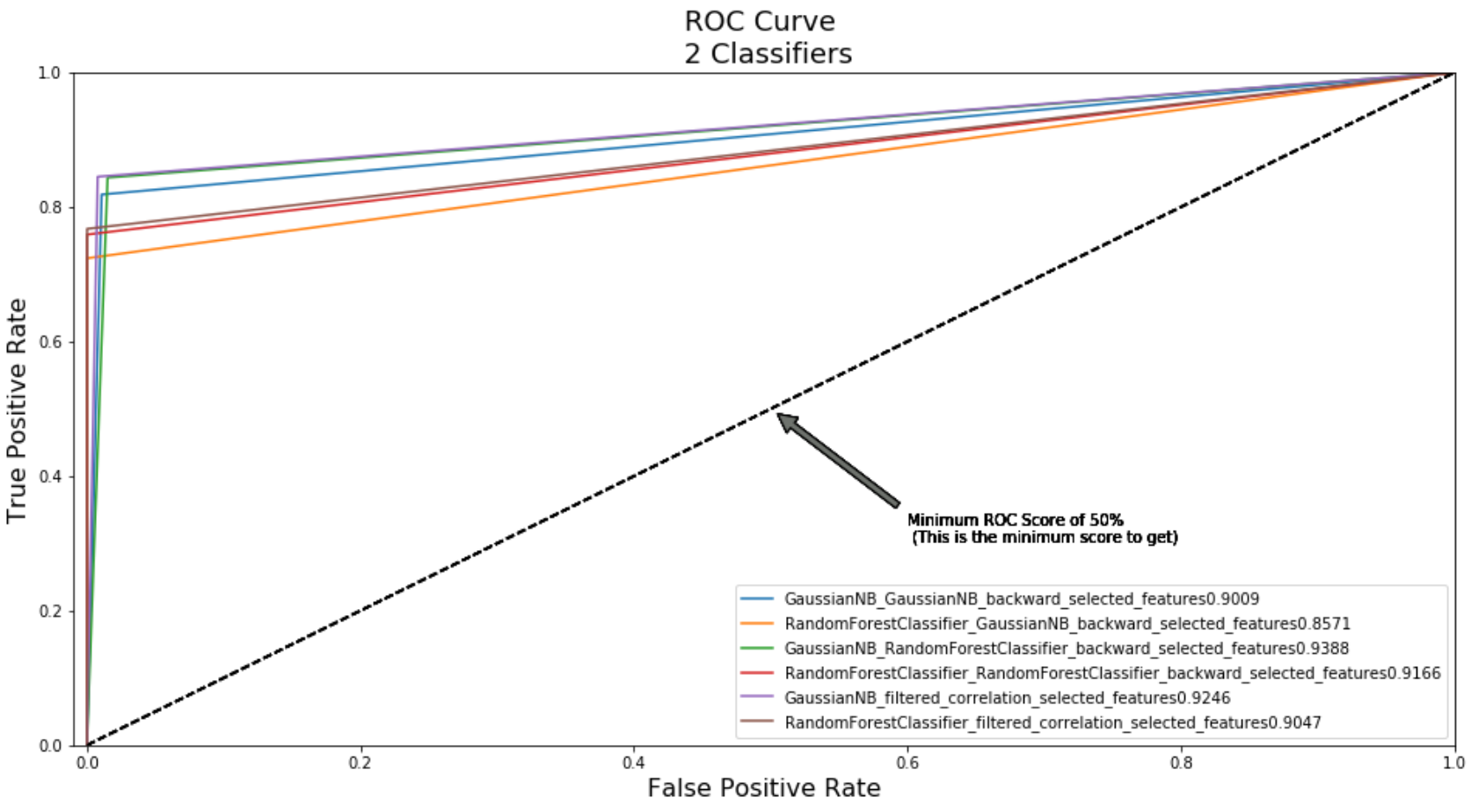

VERSION: OG_DATA
Model used: GaussianNB
Score: 0.9387710096349479
Corelation Name : RandomForestClassifier_backward_selected_features
Filtered Features Used: ['V4', 'V7', 'V13', 'V14', 'V17', 'V18', 'V21', 'V26', 'V27']
5.6e+04
8.3e+02
11
91
True
Predicted
0
1
50000
40000
30000
20000
10000
0


VERSION: OG_DATA
Model used: RandomForestClassifier
Score: 0.9166226990268496
Corelation Name : RandomForestClassifier_backward_selected_features
Filtered Features Used: ['V4', 'V7', 'V13', 'V14', 'V17', 'V18', 'V21', 'V26', 'V27']
5.7e+04
5
17
85
True
Predicted
0
1
50000
40000
30000
20000
10000
0

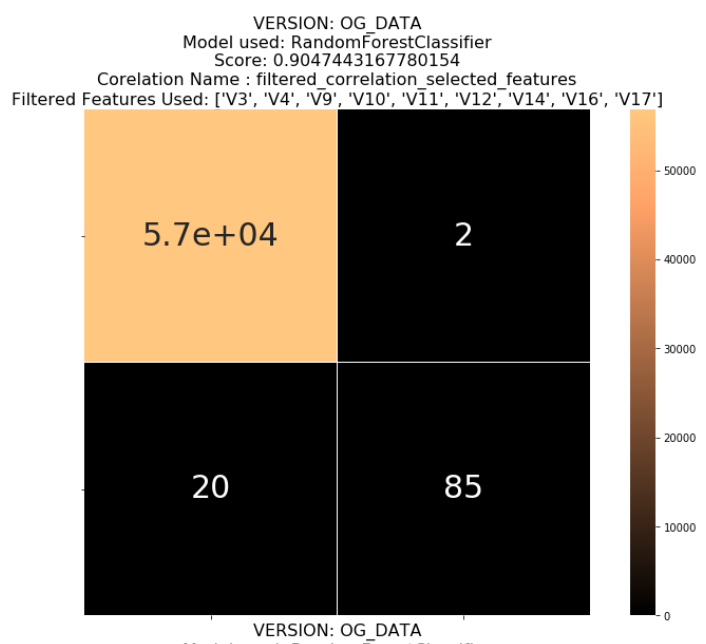

VERSION: OG_DATA
Model used: GaussianNB
Score: 0.9245789562285333
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
5.6e+04
4.5e+02
15
90
True
Predicted
0
1
50000
40000
30000
20000
10000
0

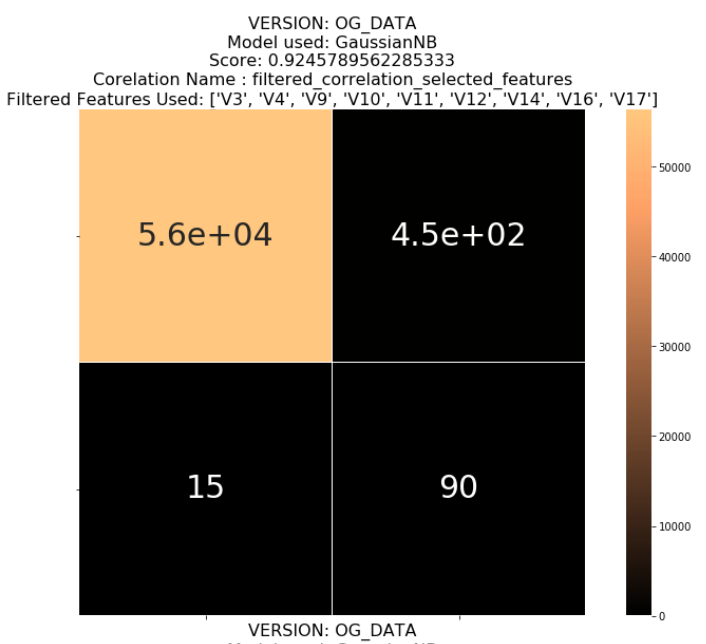

VERSION: OG_DATA
Model used: RandomForestClassifier
Score: 0.9047443167780154
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
5.7e+04
2
20
85
True
Predicted
0
1
50000
40000
30000
20000
10000
0

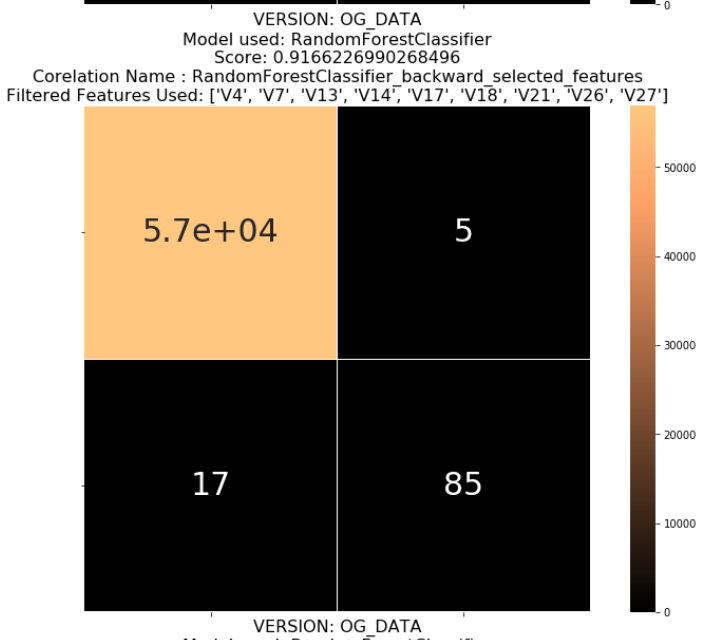
In [80]:
```
create_roc_cruve(results_based_off_og)
```

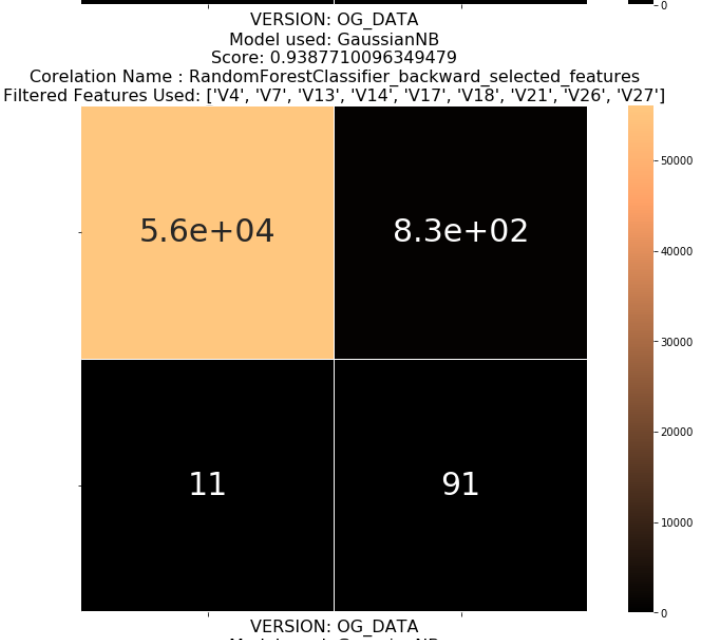


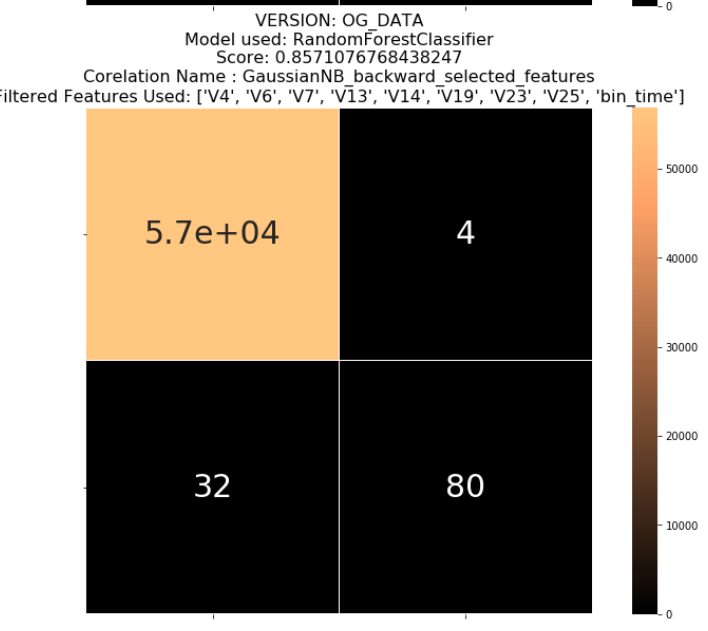
In [81]:
```
show_all_confusion_matrix(results_based_off_og)
```

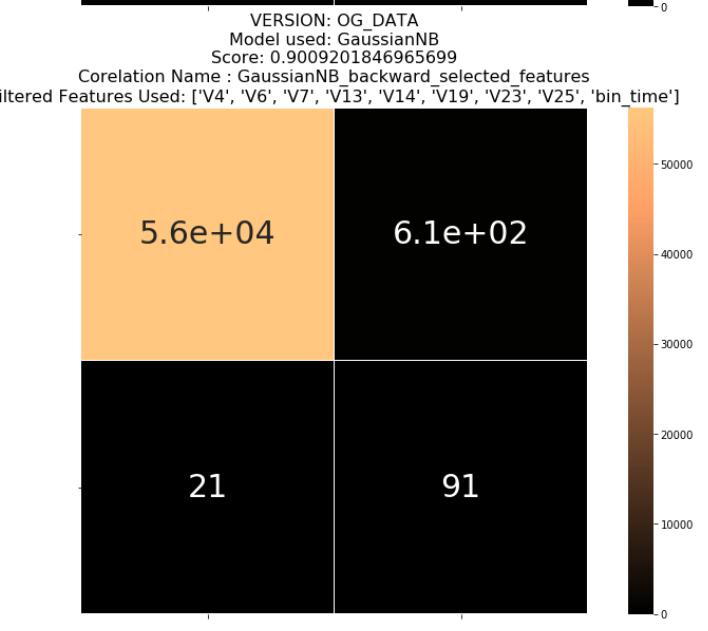












In [82]:
```
print_all(results_based_off_og)
```

```
------------------------------
Model and Feature used: VERSION: OG_DATA
Model used: GaussianNB
Score: 0.9009201846965699
Corelation Name : GaussianNB_backward_selected_features
Filtered Features Used: ['V4', 'V6', 'V7', 'V13', 'V14', 'V19', 'V23', 'V25', 'bin_time']
TN: 91
FN: 606
TP: 56244
FP: 21
TPR: 0.99
TNR: 0.81
PPV: 1.0
NPV: 0.13
FPR: 0.19
FNR: 0.01
FDR: 0.0
Recall Score: 0.81
Precision Score: 0.13
F1 Score: 0.22
Accuracy Score: 0.99
TN: 91, FN: 606, TP: 56244, FP: 21, TPR: 0.99, TNR: 0.81, PPV: 1.0, NPV: 0.13, FPR: 0.19, FNR: 0.01,
FDR: 0.0, Recall Score: 0.81, Precision Score: 0.13, F1 Score: 0.22, Accuracy Score: 0.99
------------------------------
------------------------------
Model and Feature used: VERSION: OG_DATA
Model used: RandomForestClassifier
Score: 0.8571076768438247
Corelation Name : GaussianNB_backward_selected_features
Filtered Features Used: ['V4', 'V6', 'V7', 'V13', 'V14', 'V19', 'V23', 'V25', 'bin_time']
TN: 80
FN: 4
TP: 56846
FP: 32
TPR: 1.0
TNR: 0.71
PPV: 1.0
NPV: 0.95
FPR: 0.29
FNR: 0.0
FDR: 0.0
Recall Score: 0.71
Precision Score: 0.95
F1 Score: 0.82
Accuracy Score: 1.00
TN: 80, FN: 4, TP: 56846, FP: 32, TPR: 1.0, TNR: 0.71, PPV: 1.0, NPV: 0.95, FPR: 0.29, FNR: 0.0, FD
R: 0.0, Recall Score: 0.71, Precision Score: 0.95, F1 Score: 0.82, Accuracy Score: 1.00
------------------------------
------------------------------
Model and Feature used: VERSION: OG_DATA
Model used: GaussianNB
Score: 0.9387710096349479
Corelation Name : RandomForestClassifier_backward_selected_features
Filtered Features Used: ['V4', 'V7', 'V13', 'V14', 'V17', 'V18', 'V21', 'V26', 'V27']
TN: 91
FN: 831
TP: 56029
FP: 11
TPR: 0.99
TNR: 0.89
PPV: 1.0
NPV: 0.1
FPR: 0.11
FNR: 0.01
FDR: 0.0
Recall Score: 0.89
Precision Score: 0.10
F1 Score: 0.18
Accuracy Score: 0.99
TN: 91, FN: 831, TP: 56029, FP: 11, TPR: 0.99, TNR: 0.89, PPV: 1.0, NPV: 0.1, FPR: 0.11, FNR: 0.01,
FDR: 0.0, Recall Score: 0.89, Precision Score: 0.10, F1 Score: 0.18, Accuracy Score: 0.99
------------------------------
------------------------------
Model and Feature used: VERSION: OG_DATA
Model used: RandomForestClassifier
Score: 0.9166226990268496
Corelation Name : RandomForestClassifier_backward_selected_features
Filtered Features Used: ['V4', 'V7', 'V13', 'V14', 'V17', 'V18', 'V21', 'V26', 'V27']
TN: 85
FN: 5
TP: 56855
FP: 17
TPR: 1.0
TNR: 0.83
PPV: 1.0
NPV: 0.94
FPR: 0.17
FNR: 0.0
FDR: 0.0
Recall Score: 0.83
Precision Score: 0.94
```

```
F1 Score: 0.89
Accuracy Score: 1.00
TN: 85, FN: 5, TP: 56855, FP: 17, TPR: 1.0, TNR: 0.83, PPV: 1.0, NPV: 0.94, FPR: 0.17, FNR: 0.0, FD
R: 0.0, Recall Score: 0.83, Precision Score: 0.94, F1 Score: 0.89, Accuracy Score: 1.00
------------------------------
------------------------------
Model and Feature used: VERSION: OG_DATA
Model used: GaussianNB
Score: 0.9245789562285333
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
TN: 90
FN: 454
TP: 56403
FP: 15
TPR: 0.99
TNR: 0.86
PPV: 1.0
NPV: 0.17
FPR: 0.14
FNR: 0.01
FDR: 0.0
Recall Score: 0.86
Precision Score: 0.17
F1 Score: 0.28
Accuracy Score: 0.99
TN: 90, FN: 454, TP: 56403, FP: 15, TPR: 0.99, TNR: 0.86, PPV: 1.0, NPV: 0.17, FPR: 0.14, FNR: 0.01,
FDR: 0.0, Recall Score: 0.86, Precision Score: 0.17, F1 Score: 0.28, Accuracy Score: 0.99
------------------------------
------------------------------
Model and Feature used: VERSION: OG_DATA
Model used: RandomForestClassifier
Score: 0.9047443167780154
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
TN: 85
FN: 2
TP: 56855
FP: 20
TPR: 1.0
TNR: 0.81
PPV: 1.0
NPV: 0.98
FPR: 0.19
FNR: 0.0
FDR: 0.0
Recall Score: 0.81
Precision Score: 0.98
F1 Score: 0.89
Accuracy Score: 1.00
TN: 85, FN: 2, TP: 56855, FP: 20, TPR: 1.0, TNR: 0.81, PPV: 1.0, NPV: 0.98, FPR: 0.19, FNR: 0.0, FD
R: 0.0, Recall Score: 0.81, Precision Score: 0.98, F1 Score: 0.89, Accuracy Score: 1.00
------------------------------
```

In [83]:
```
best_result = get_best_result(results_based_off_og)
```

```
MAX_RESULT_INDEX: 5
```

In [84]:
```
print_result(best_result)
```

```
------------------------------
Model and Feature used: VERSION: OG_DATA
Model used: RandomForestClassifier
Score: 0.9047443167780154
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
TN: 85
FN: 2
TP: 56855
FP: 20
TPR: 1.0
TNR: 0.81
PPV: 1.0
NPV: 0.98
FPR: 0.19
FNR: 0.0
FDR: 0.0
Recall Score: 0.81
Precision Score: 0.98
F1 Score: 0.89
Accuracy Score: 1.00
TN: 85, FN: 2, TP: 56855, FP: 20, TPR: 1.0, TNR: 0.81, PPV: 1.0, NPV: 0.98, FPR: 0.19, FNR: 0.0, FD
R: 0.0, Recall Score: 0.81, Precision Score: 0.98, F1 Score: 0.89, Accuracy Score: 1.00
------------------------------
```

In [85]:
```
print("Best result from test data: ")
print(best_result['title'])
```

```
Best result from test data:
VERSION: OG_DATA
Model used: RandomForestClassifier
Score: 0.9047443167780154
Corelation Name : filtered_correlation_selected_features
Filtered Features Used: ['V3', 'V4', 'V9', 'V10', 'V11', 'V12', 'V14', 'V16', 'V17']
```

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]: