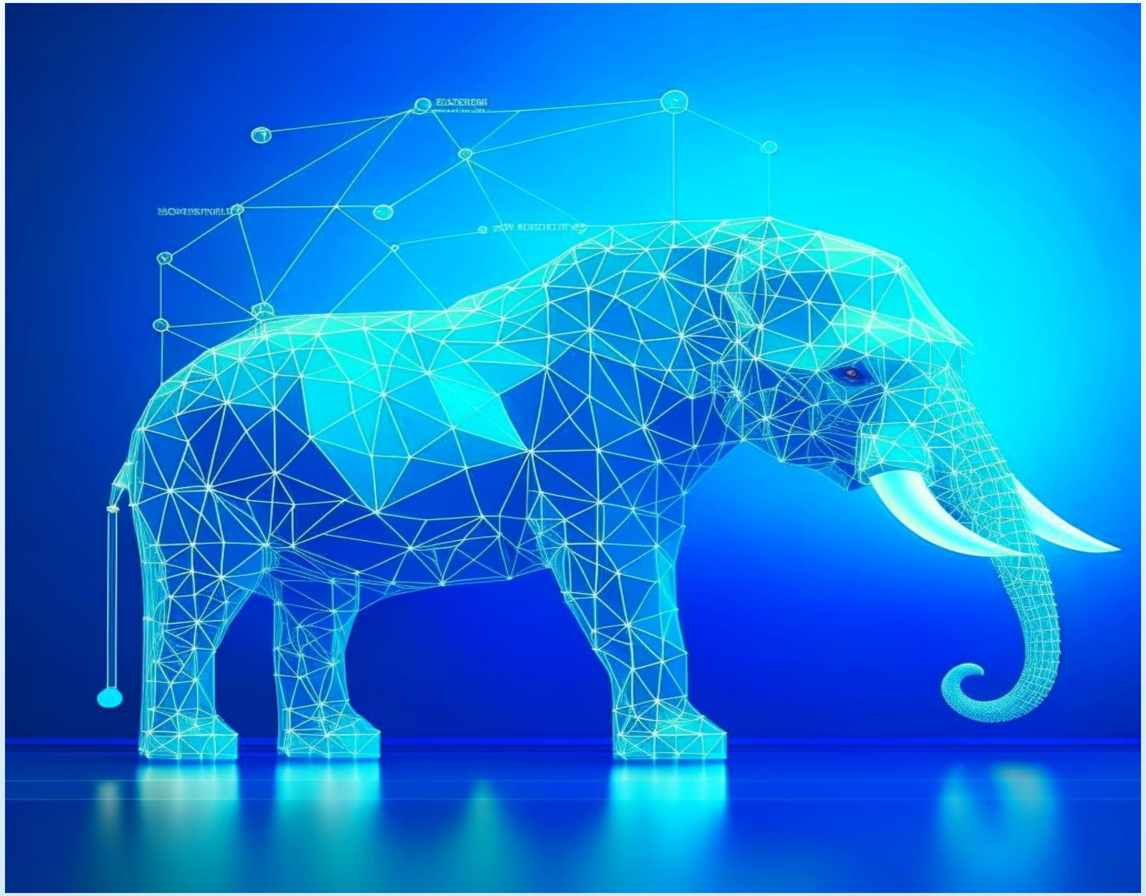
ML in PostgreSQL



Using models:

- Binary Classification
- Multi Classification
- Regression

Using framework:

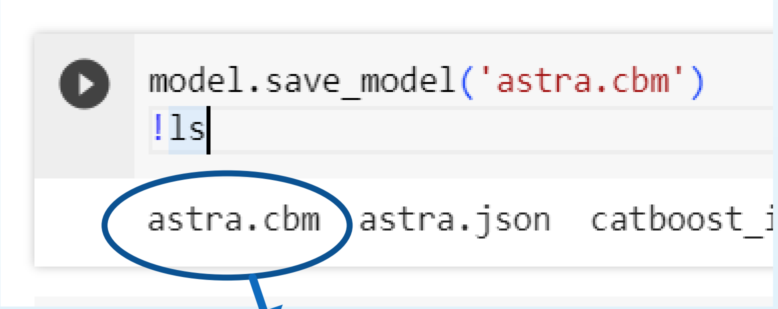
CatBoost: https://catboost.ai/

only prediction

ML process:

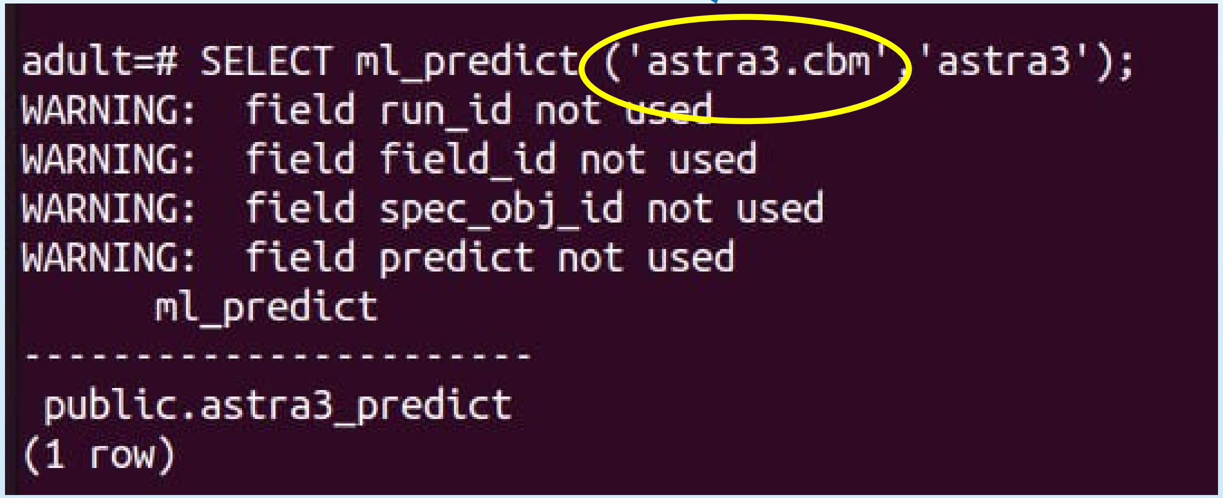
1. Training model
2. Save model to database server

3. prediction



```
model.save_model('astra.cbm')
!ls
```

```
astra.cbm  astra.json  catboost_i
```

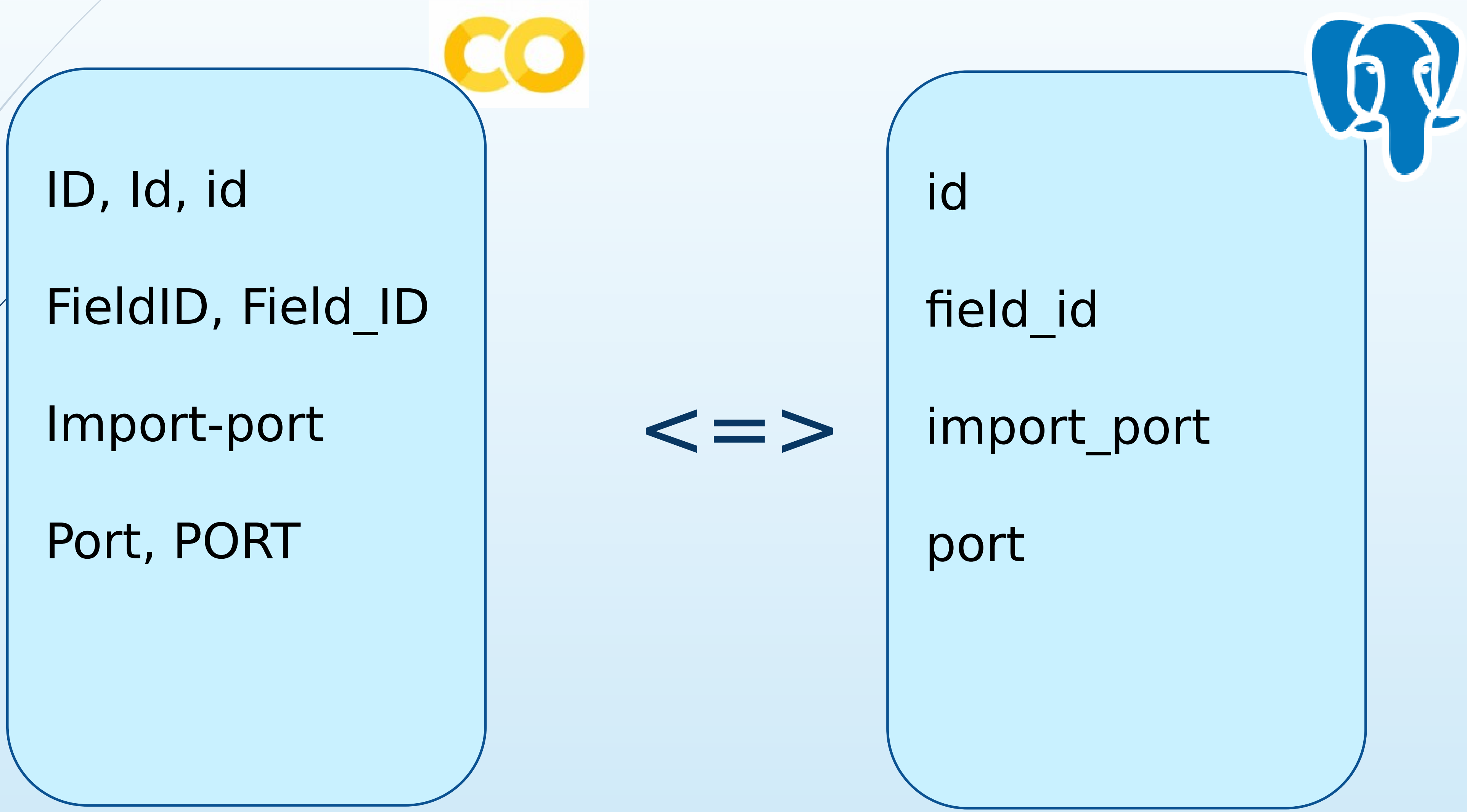


```
adult=# SELECT ml_predict('astra3.cbm','astra3');
WARNING:  field run_id not used
WARNING:  field field_id not used
WARNING:  field spec_obj_id not used
WARNING:  field predict not used
      ml_predict
----------------------
 public.astra3_predict
(1 row)
```

Installation

- git clone https://github.com/akalend/pg_ml.git
- export PG_HOME=/usr/local/pgsql   //where is main postgres folder
- wget https://github.com/catboost/catboost/releases/download/v1.2.2/libcatboostmodel.so
- mv libcatboostmodel.so $PG_HOME/lib
- cd pg_ml
- export PG_CONFIG=$PG_HOME/bin/pg_config
- export LD_LIBRARY_PATH=$PG_HOME/lib
- USE_PGXS=1 make
- sudo su
- export PATH=$PATH:$PG_HOME/bin
- USE_PGXS=1 make install
- chown postgres model.cbm
- [optional] cp model.cbm $PG_HOME/data

DataFrame columns convert to PostgreSQL fields



ID, Id, id

FieldID, Field_ID

Import-port

Port, PORT

<=>

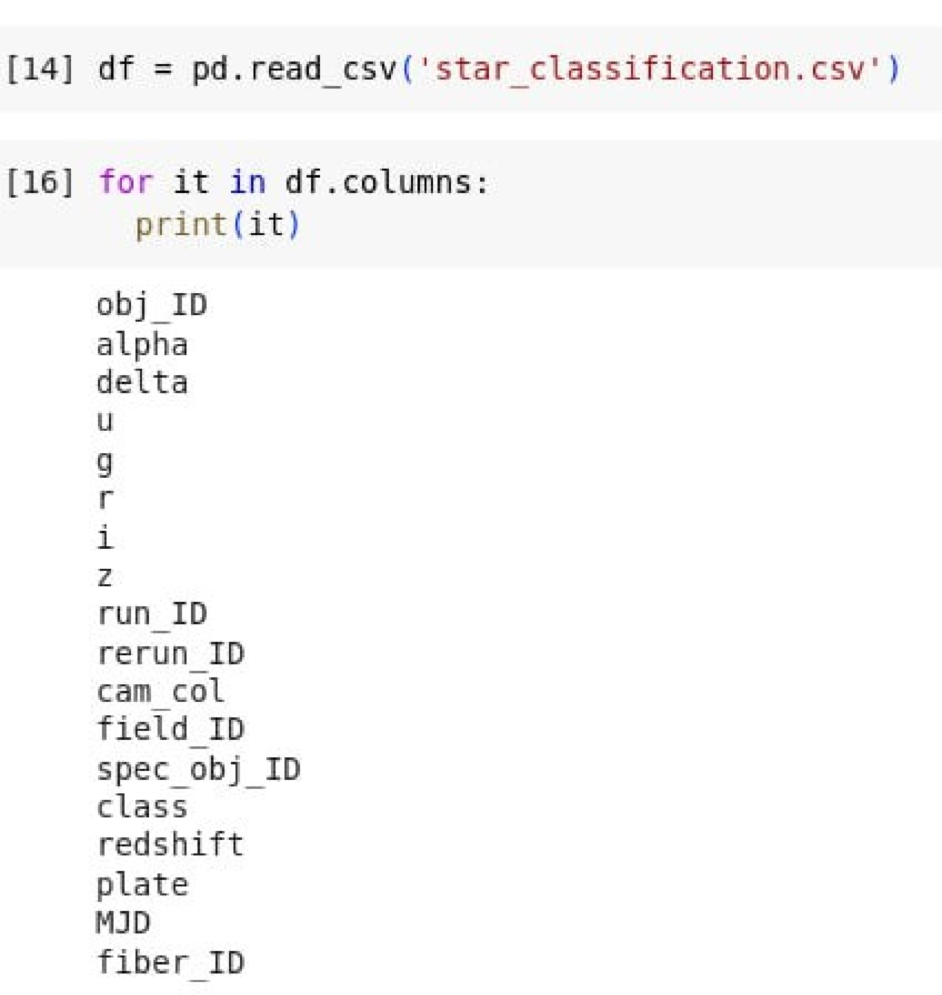
id

field_id

import_port

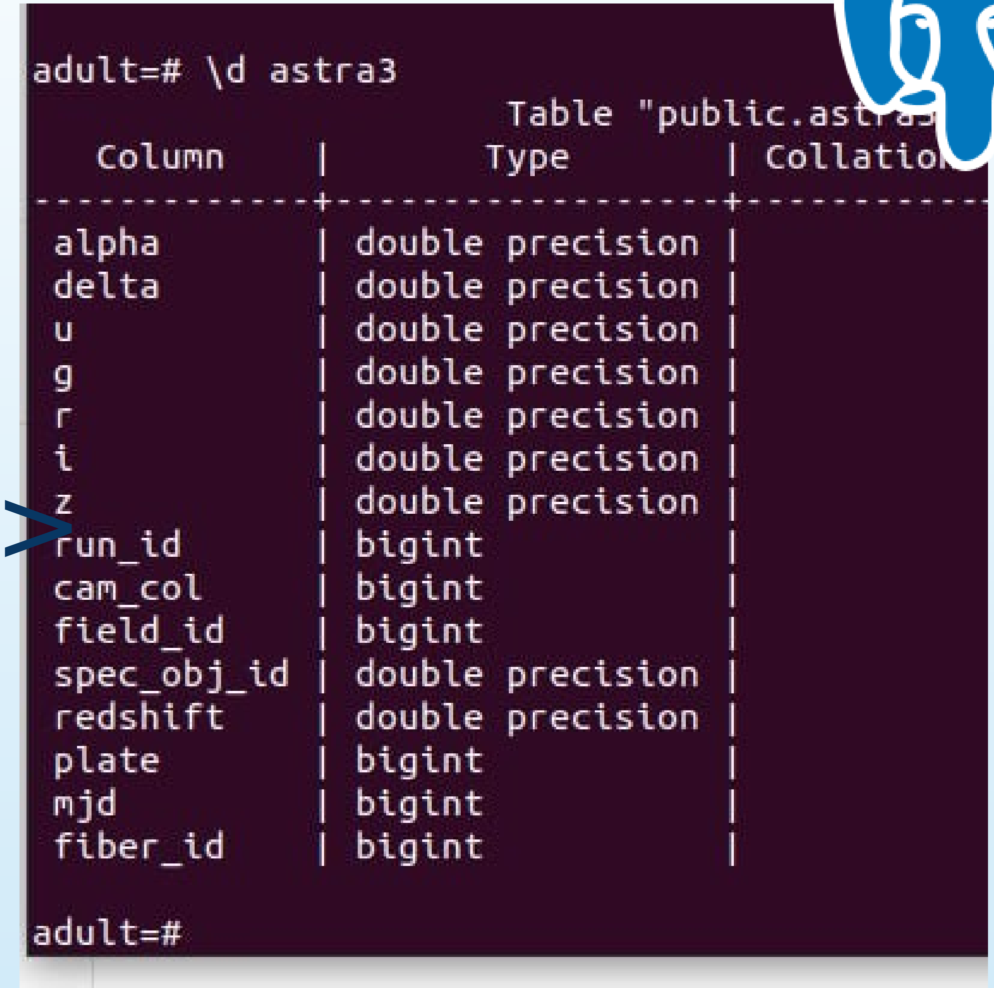
port

DataFrame columns and PostgreSQL fields



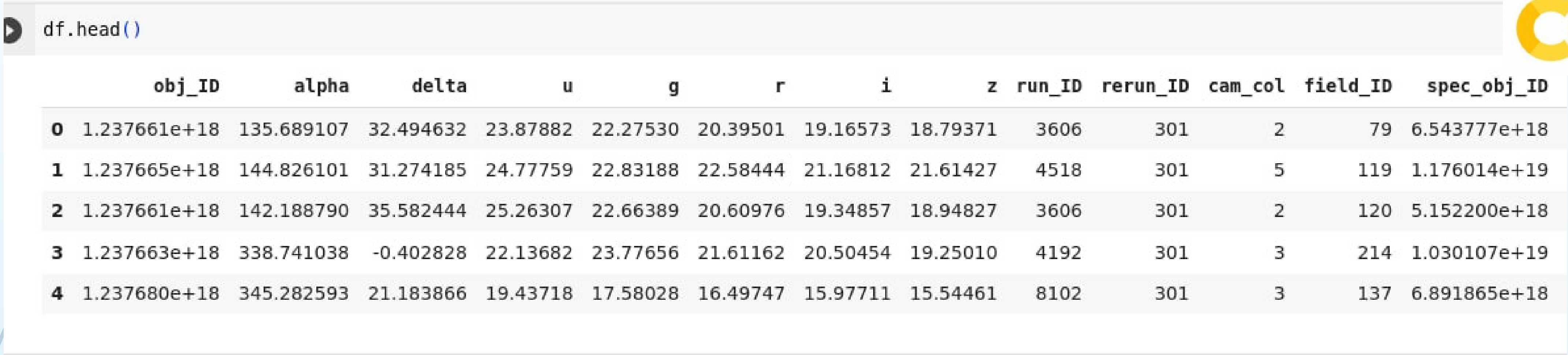
```
[14] df = pd.read_csv('star_classification.csv')

[16] for it in df.columns:
       print(it)

     obj_ID
     alpha
     delta
     u
     g
     r
     i
     z
     run_ID
     rerun_ID
     cam_col
     field_ID
     spec_obj_ID
     class
     redshift
     plate
     MJD
     fiber_ID
```

<=>



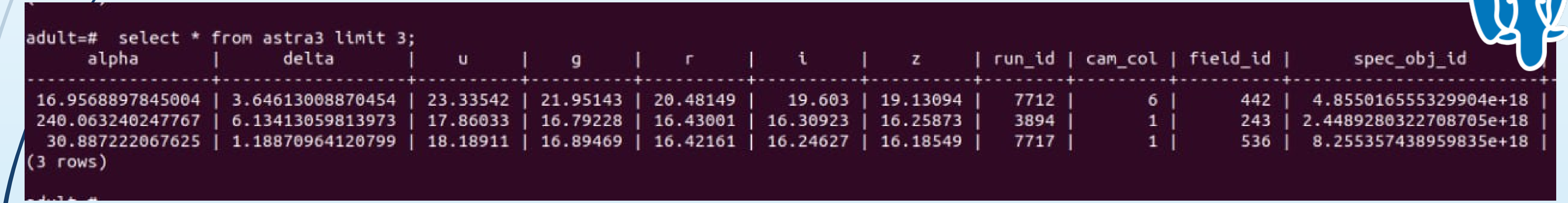
```
adult=# \d astra3
                         Table "public.astra3
   Column     |        Type        | Collatio
--------------+--------------------+-----------
 alpha        | double precision |
 delta        | double precision |
 u            | double precision |
 g            | double precision |
 r            | double precision |
 i            | double precision |
 z            | double precision |
 run_id       | bigint           |
 cam_col      | bigint           |
 field_id     | bigint           |
 spec_obj_id  | double precision |
 redshift     | double precision |
 plate        | bigint           |
 mjd          | bigint           |
 fiber_id     | bigint           |

adult=#
```

DataFrame columns and PostgreSQL fields



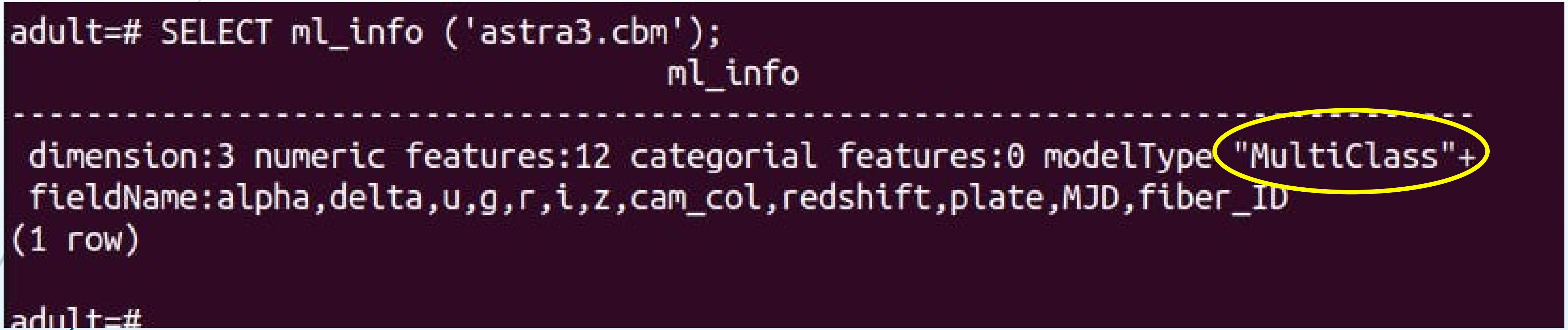
```
df.head()
```

	obj_ID	alpha	delta	u	g	r	i	z	run_ID	rerun_ID	cam_col	field_ID	spec_obj_ID
0	1.237661e+18	135.689107	32.494632	23.87882	22.27530	20.39501	19.16573	18.79371	3606	301	2	79	6.543777e+18
1	1.237665e+18	144.826101	31.274185	24.77759	22.83188	22.58444	21.16812	21.61427	4518	301	5	119	1.176014e+19
2	1.237661e+18	142.188790	35.582444	25.26307	22.66389	20.60976	19.34857	18.94827	3606	301	2	120	5.152200e+18
3	1.237663e+18	338.741038	-0.402828	22.13682	23.77656	21.61162	20.50454	19.25010	4192	301	3	214	1.030107e+19
4	1.237680e+18	345.282593	21.183866	19.43718	17.58028	16.49747	15.97711	15.54461	8102	301	3	137	6.891865e+18



```
adult=#  select * from astra3 limit 3;
      alpha       |       delta       |    u     |    g     |    r     |    i     |    z     | run_id | cam_col | field_id |      spec_obj_id
------------------+-------------------+----------+----------+----------+----------+----------+--------+---------+----------+-----------------------+-
 16.9568897845004 | 3.64613008870454 | 23.33542 | 21.95143 | 20.48149 |   19.603 | 19.13094 |   7712 |       6 |      442 |  4.85501655329904e+18 |
 240.063240247767 | 6.13413059813973 | 17.86033 | 16.79228 | 16.43001 | 16.30923 | 16.25873 |   3894 |       1 |      243 | 2.4489280322708705e+18 |
  30.887222067625 | 1.18870964120799 | 18.18911 | 16.89469 | 16.42161 | 16.24627 | 16.18549 |   7717 |       1 |      536 |  8.255357438959835e+18 |
(3 rows)
```

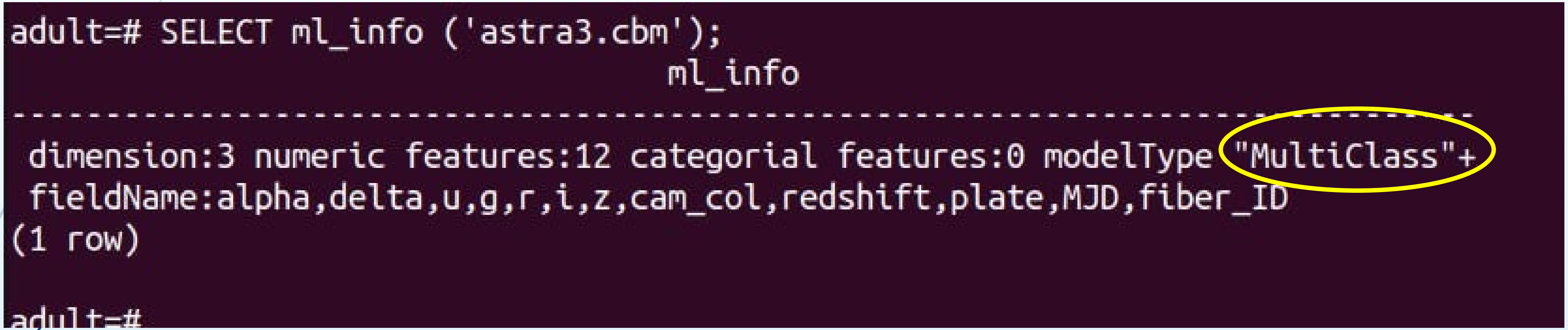
Information about model



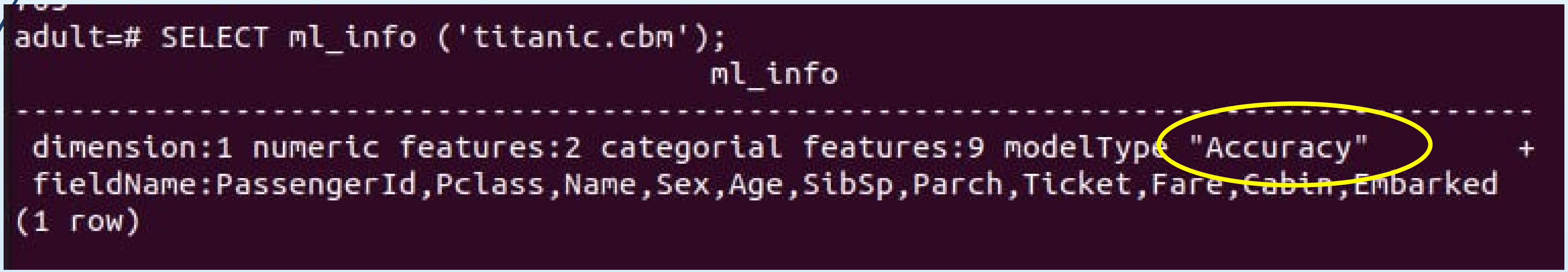
```
adult=# SELECT ml_info ('astra3.cbm');
                                    ml_info
--------------------------------------------------------------------------------
 dimension:3 numeric features:12 categorial features:0 modelType "MultiClass"+
 fieldName:alpha,delta,u,g,r,i,z,cam_col,redshift,plate,MJD,fiber_ID
(1 row)

adult=#
```

- Dimension result (How many classes)
- Feature count (categorical and float)
- Type of model
- Fields name

Information about model

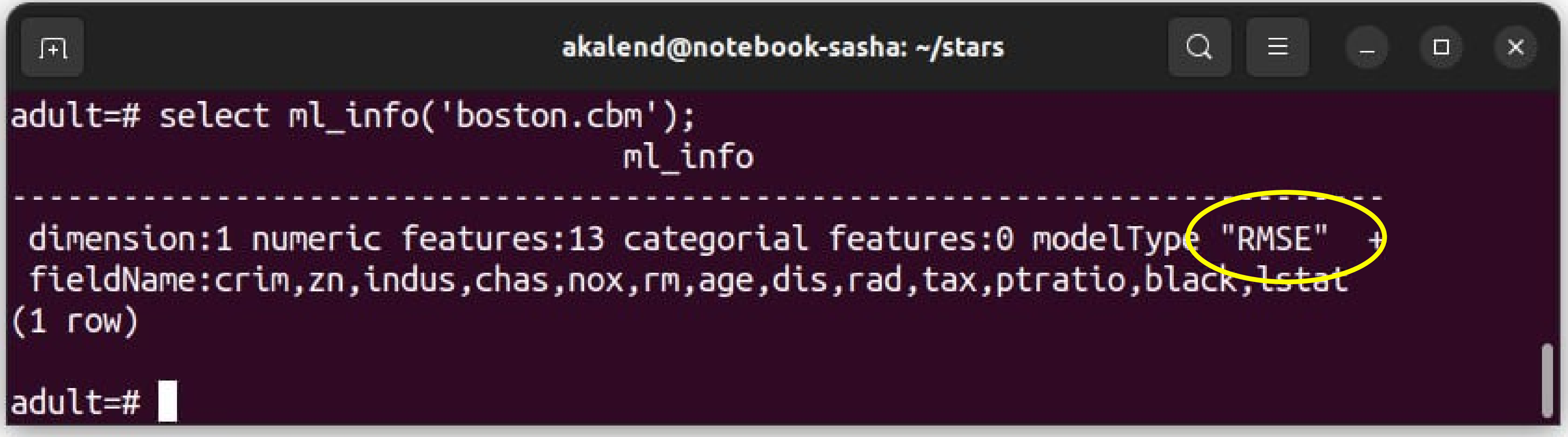


```
adult=# SELECT ml_info ('astra3.cbm');
                                        ml_info
------------------------------------------------------------------------------------------
 dimension:3 numeric features:12 categorial features:0 modelType "MultiClass"+
 fieldName:alpha,delta,u,g,r,i,z,cam_col,redshift,plate,MJD,fiber_ID
(1 row)

adult=#
```



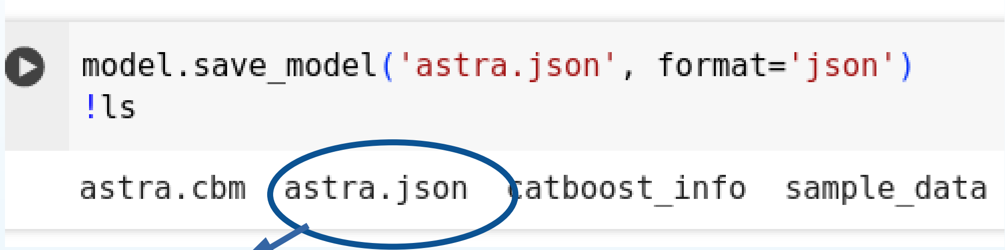
```
adult=# SELECT ml_info ('titanic.cbm');
                                        ml_info
-------------------------------------------------------------------------------------------
 dimension:1 numeric features:2 categorial features:9 modelType "Accuracy"      +
 fieldName:PassengerId,Pclass,Name,Sex,Age,SibSp,Parch,Ticket,Fare,Cabin,Embarked
(1 row)
```

Model information



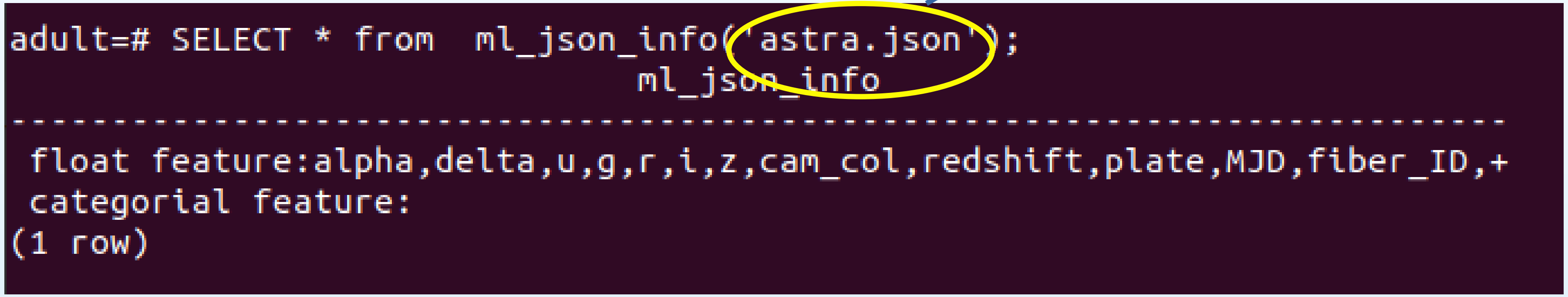
```
adult=# select ml_info('boston.cbm');
                                ml_info
------------------------------------------------------------------------
 dimension:1 numeric features:13 categorial features:0 modelType "RMSE"  +
 fieldName:crim,zn,indus,chas,nox,rm,age,dis,rad,tax,ptratio,black,lstat
(1 row)

adult=# 
```

More information



```
model.save_model('astra.json', format='json')
!ls
```

```
astra.cbm  astra.json  catboost_info  sample_data
```



```
adult=# SELECT * from  ml_json_info('astra.json');
                              ml_json_info
-------------------------------------------------------------------------
 float feature:alpha,delta,u,g,r,i,z,cam_col,redshift,plate,MJD,fiber_ID,+
 categorial feature:
(1 row)
```

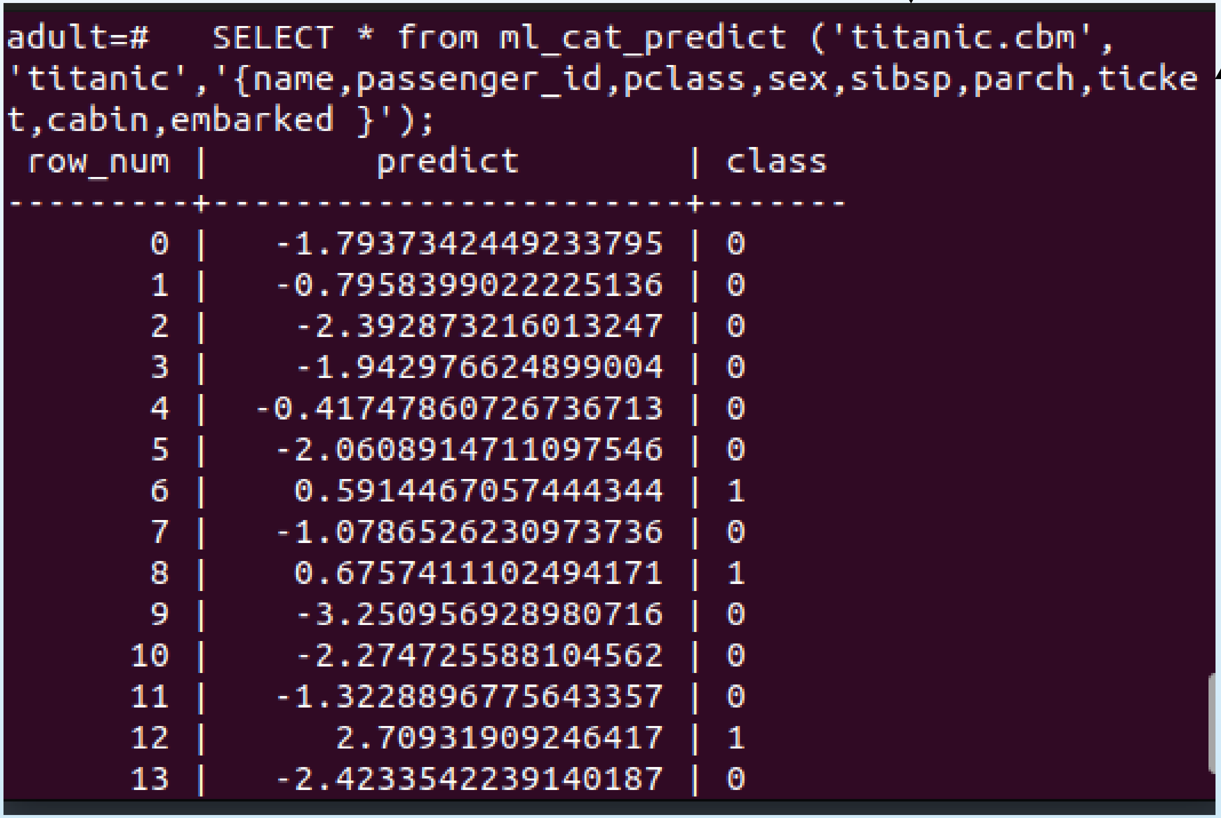
Categorical Feature list
Float Feature count list

Prediction of model (recordset)

Path to model file

Table name

Categorical field list

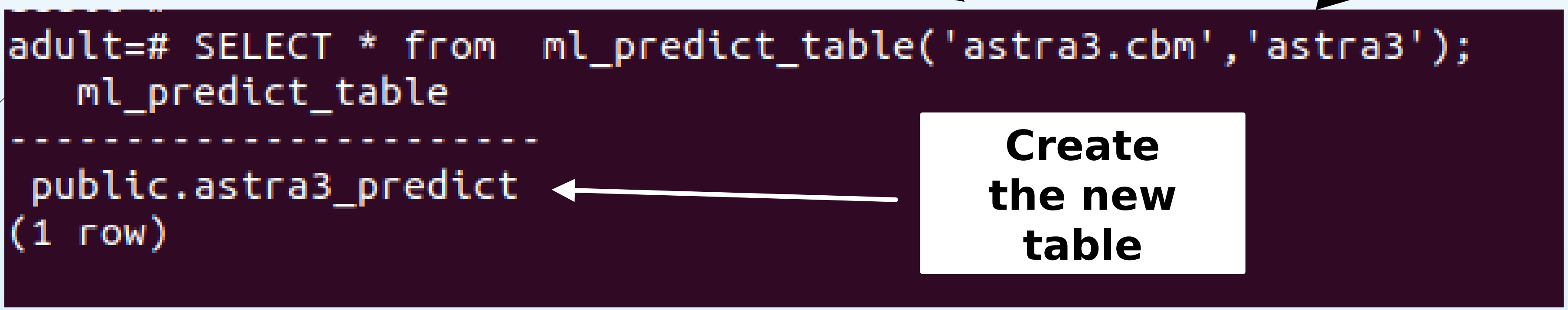


```
adult=#   SELECT * from ml_cat_predict ('titanic.cbm',
'titanic','{name,passenger_id,pclass,sex,sibsp,parch,ticke
t,cabin,embarked }');
 row_num |         predict         | class
---------+-------------------------+-------
       0 |   -1.7937342449233795 | 0
       1 |   -0.7958399022225136 | 0
       2 |    -2.392873216013247 | 0
       3 |    -1.942976624899004 | 0
       4 |  -0.41747860726736713 | 0
       5 |   -2.0608914711097546 | 0
       6 |    0.5914467057444344 | 1
       7 |   -1.0786526230973736 | 0
       8 |    0.6757411102494171 | 1
       9 |    -3.250956928980716 | 0
      10 |    -2.274725588104562 | 0
      11 |   -1.3228896775643357 | 0
      12 |      2.70931909246417 | 1
      13 |   -2.4233542239140187 | 0
```

Prediction of model (result table)

Path to model file

Table name



```
adult=# SELECT * from  ml_predict_table('astra3.cbm','astra3');
   ml_predict_table
------------------------
 public.astra3_predict
(1 row)
```

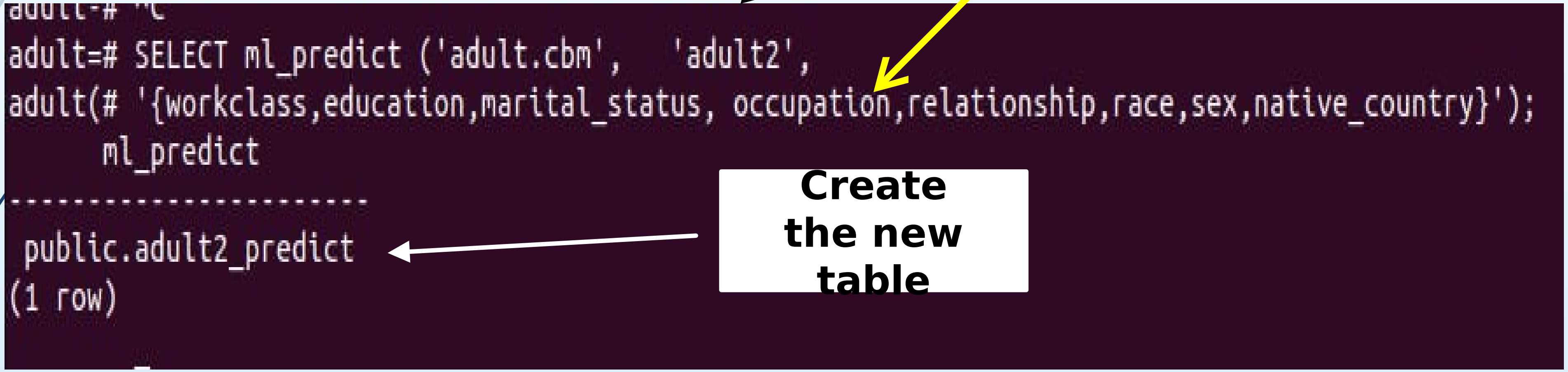
Create the new table

Prediction of model (table)

Path to model file

Table name

List of categorical fields

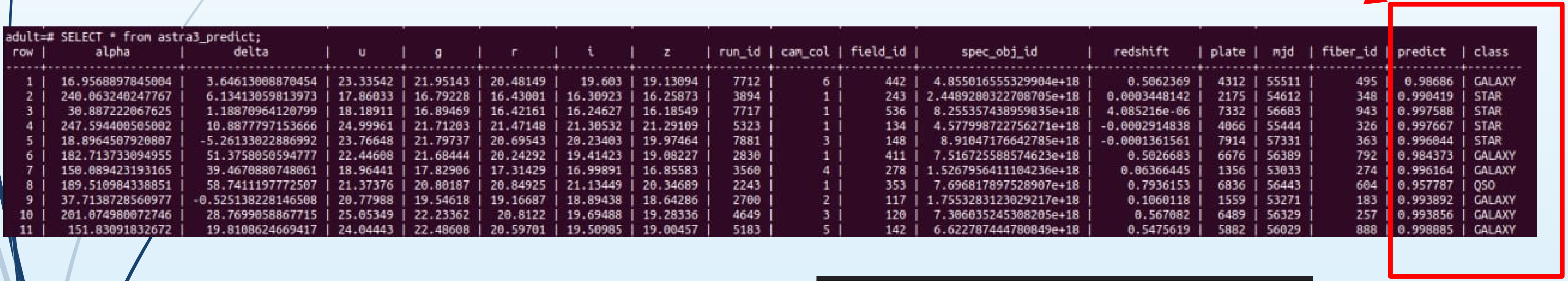


```
adult=# ^C
adult=# SELECT ml_predict ('adult.cbm',   'adult2',
adult(# '{workclass,education,marital_status, occupation,relationship,race,sex,native_country}');
      ml_predict
-----------------------
 public.adult2_predict
(1 row)
```

Create the new table

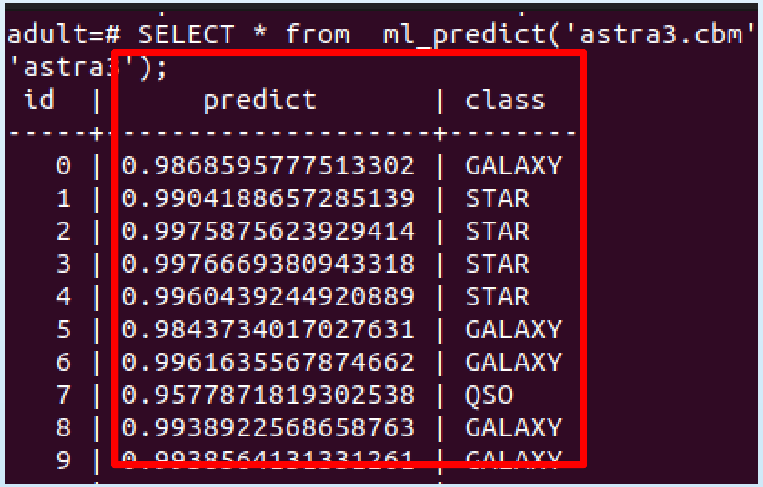
Prediction results

SELECT * FROM {table}_predict;



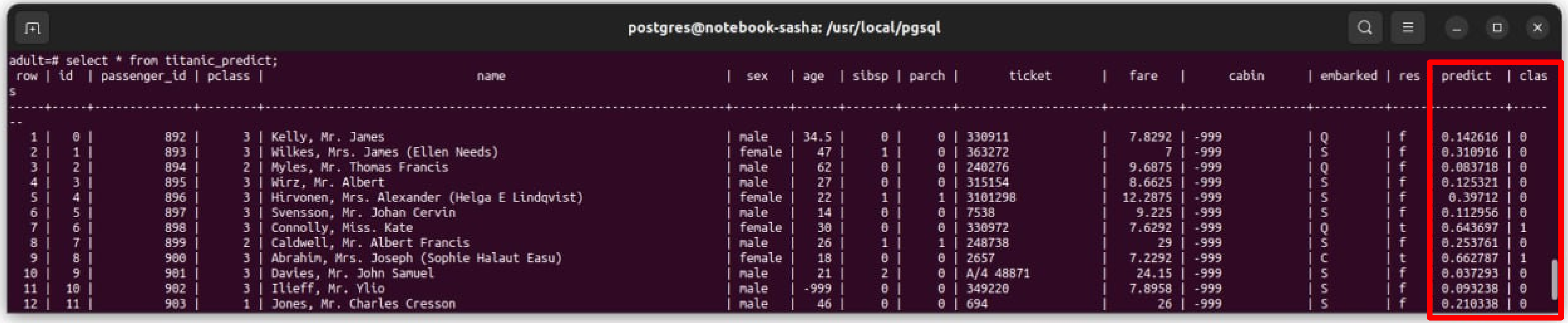
```
adult=# SELECT * from astra3_predict;
 row |       alpha      |       delta       |    u     |    g     |    r     |    i     |    z     | run_id | cam_col | field_id |      spec_obj_id      |    redshift    | plate |  mjd  | fiber_id | predict  | class
-----+------------------+-------------------+----------+----------+----------+----------+----------+--------+---------+----------+-----------------------+----------------+-------+-------+----------+----------+--------
   1 | 16.9568897845004 |  3.64613008870454 | 23.33542 | 21.95143 | 20.48149 |   19.603 | 19.13094 |   7712 |       6 |      442 | 4.855016555329904e+18 |      0.5062369 |  4312 | 55511 |      495 |  0.98686 | GALAXY
   2 | 240.063240247767 |  6.13413059813973 | 17.86033 | 16.79228 | 16.43001 | 16.30923 | 16.25873 |   3894 |       1 |      243 | 2.4489280322708705e+18 |  0.0003448142 |  2175 | 54612 |      348 | 0.990419 | STAR
   3 |  30.887222067625 |  1.18870964120799 | 18.18911 | 16.89469 | 16.42161 | 16.24627 | 16.18549 |   7717 |       1 |      536 |  8.25535743895983 5e+18 |  4.085216e-06 |  7332 | 56683 |      943 | 0.997588 | STAR
   4 | 247.594400505002 |  10.8877797153666 | 24.99961 | 21.71203 | 21.47148 | 21.30532 | 21.29109 |   5323 |       1 |      134 | 4.577998722756271e+18 | -0.0002914838 |  4066 | 55444 |      326 | 0.997667 | STAR
   5 | 18.8964507920807 | -5.26133022886992 | 23.76648 | 21.79737 | 20.69543 | 20.23403 | 19.97464 |   7881 |       3 |      148 |  8.91047176642785e+18 | -0.0001361561 |  7914 | 57331 |      363 | 0.996044 | STAR
   6 | 182.713733094955 |  51.3758050594777 | 22.44608 | 21.68444 | 20.24292 | 19.41423 | 19.08227 |   2830 |       1 |      411 | 7.516725588574623e+18 |      0.5026683 |  6676 | 56389 |      792 | 0.984373 | GALAXY
   7 | 150.089423193165 |  39.4670880748061 | 18.96441 | 17.82906 | 17.31429 | 16.99891 | 16.85583 |   3560 |       4 |      278 | 1.5267956411104236e+18 |    0.06366445 |  1356 | 53033 |      274 | 0.996164 | GALAXY
   8 | 189.510984338851 |  58.7411197772507 | 21.37376 | 20.80187 | 20.84925 | 21.13449 | 20.34689 |   2243 |       1 |      353 | 7.696817897528907e+18 |      0.7936153 |  6836 | 56443 |      604 | 0.957787 | QSO
   9 | 37.7138728560977 |-0.525138228146508 | 20.77988 | 19.54618 | 19.16687 | 18.89438 | 18.64286 |   2700 |       2 |      117 | 1.7553283123029217e+18 |     0.1060118 |  1559 | 53271 |      183 | 0.993892 | GALAXY
  10 | 201.074980072746 |  28.7699058867715 | 25.05349 | 22.23362 |  20.8122 | 19.69488 | 19.28336 |   4649 |       3 |      120 | 7.306035245308205e+18 |      0.567082 |  6489 | 56329 |      257 | 0.993856 | GALAXY
  11 |  151.83091832672 |  19.8108624669417 | 24.04443 | 22.48608 | 20.59701 | 19.50985 | 19.00457 |   5183 |       5 |      142 | 6.622787444780849e+18 |     0.5475619 |  5882 | 56029 |      888 | 0.998885 | GALAXY
```

SELECT * FROM ml_predict(…);

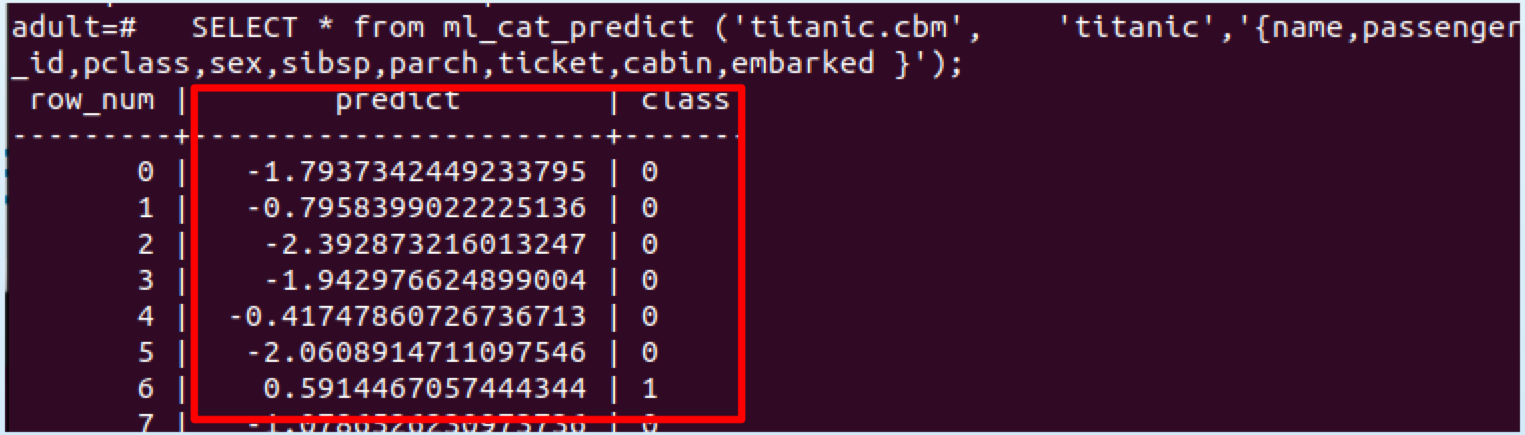


```
adult=# SELECT * from  ml_predict('astra3.cbm'
'astra3');
 id  |      predict       | class
-----+--------------------+--------
   0 | 0.9868595777513302 | GALAXY
   1 | 0.9904188657285139 | STAR
   2 | 0.9975875623929414 | STAR
   3 | 0.9976669380943318 | STAR
   4 | 0.9960439244920889 | STAR
   5 | 0.9843734017027631 | GALAXY
   6 | 0.9961635567874662 | GALAXY
   7 | 0.9577871819302538 | QSO
   8 | 0.9938922568658763 | GALAXY
   9 | 0.9938564131331261 | GALAXY
```

Binary classification

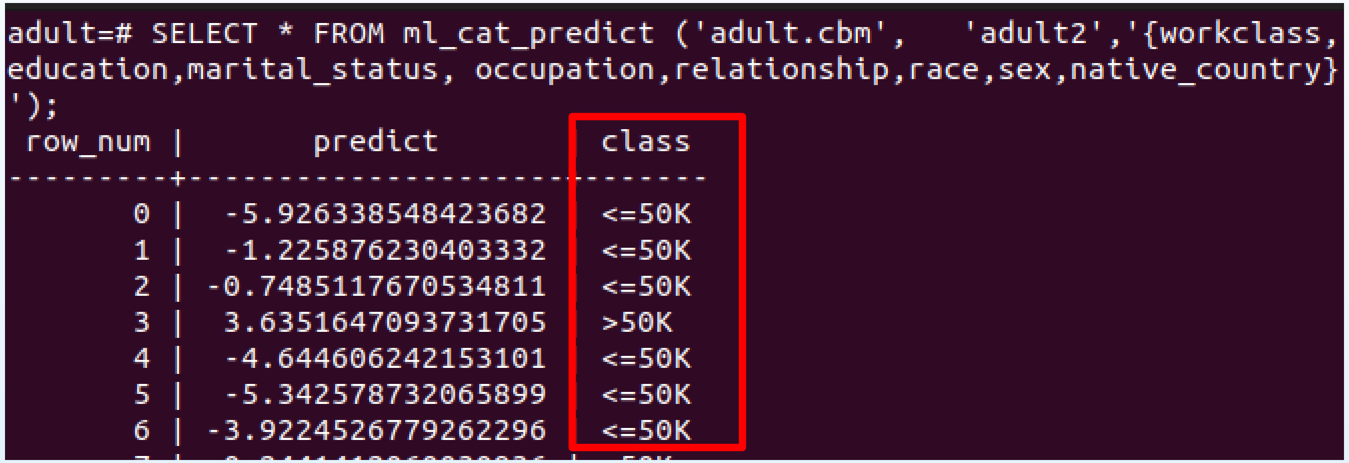


```
adult=# select * from titanic_predict;
 row | id  | passenger_id | pclass |                       name                       | sex    | age  | sibsp | parch |       ticket        |   fare   |      cabin      | embarked | res   predict  | clas
s
-----+-----+--------------+--------+--------------------------------------------------+--------+------+-------+-------+---------------------+----------+-----------------+----------+-----------------+-----
--
   1 |   0 |          892 |      3 | Kelly, Mr. James                                 | male   | 34.5 |     0 |     0 | 330911              |   7.8292 | -999            | Q        | f     0.142616 | 0
   2 |   1 |          893 |      3 | Wilkes, Mrs. James (Ellen Needs)                 | female |   47 |     1 |     0 | 363272              |        7 | -999            | S        | f     0.310916 | 0
   3 |   2 |          894 |      2 | Myles, Mr. Thomas Francis                        | male   |   62 |     0 |     0 | 240276              |   9.6875 | -999            | Q        | f     0.083718 | 0
   4 |   3 |          895 |      3 | Wirz, Mr. Albert                                 | male   |   27 |     0 |     0 | 315154              |   8.6625 | -999            | S        | f     0.125321 | 0
   5 |   4 |          896 |      3 | Hirvonen, Mrs. Alexander (Helga E Lindqvist)     | female |   22 |     1 |     1 | 3101298             |  12.2875 | -999            | S        | f      0.39712 | 0
   6 |   5 |          897 |      3 | Svensson, Mr. Johan Cervin                       | male   |   14 |     0 |     0 | 7538                |    9.225 | -999            | S        | f     0.112956 | 0
   7 |   6 |          898 |      3 | Connolly, Miss. Kate                             | female |   30 |     0 |     0 | 330972              |   7.6292 | -999            | Q        | t     0.643697 | 1
   8 |   7 |          899 |      2 | Caldwell, Mr. Albert Francis                     | male   |   26 |     1 |     1 | 248738              |       29 | -999            | S        | f     0.253761 | 0
   9 |   8 |          900 |      3 | Abrahim, Mrs. Joseph (Sophie Halaut Easu)        | female |   18 |     0 |     0 | 2657                |   7.2292 | -999            | C        | t     0.662787 | 1
  10 |   9 |          901 |      3 | Davies, Mr. John Samuel                          | male   |   21 |     2 |     0 | A/4 48871           |    24.15 | -999            | S        | f     0.037293 | 0
  11 |  10 |          902 |      3 | Ilieff, Mr. Ylio                                 | male   | -999 |     0 |     0 | 349220              |   7.8958 | -999            | S        | f     0.093238 | 0
  12 |  11 |          903 |      1 | Jones, Mr. Charles Cresson                       | male   |   46 |     0 |     0 | 694                 |       26 | -999            | S        | f     0.210338 | 0
```

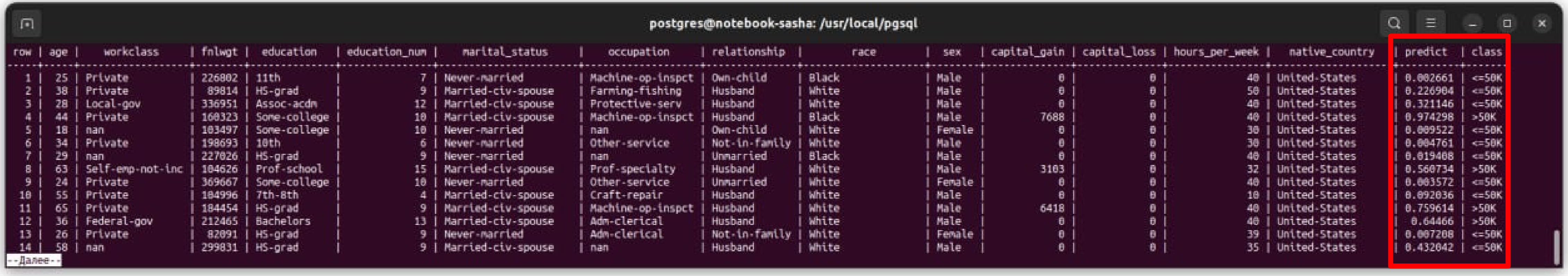


```
adult=#   SELECT * from ml_cat_predict ('titanic.cbm',    'titanic','{name,passenger
_id,pclass,sex,sibsp,parch,ticket,cabin,embarked }');
 row_num |        predict         | class
---------+------------------------+-------
       0 |    -1.7937342449233795 | 0
       1 |    -0.7958399022225136 | 0
       2 |     -2.392873216013247 | 0
       3 |     -1.942976624899004 | 0
       4 |   -0.41747860726736713 | 0
       5 |    -2.0608914711097546 | 0
       6 |     0.5914467057444344 | 1
       7 |    -1.0780320230975736 | 0
```

Binary classification



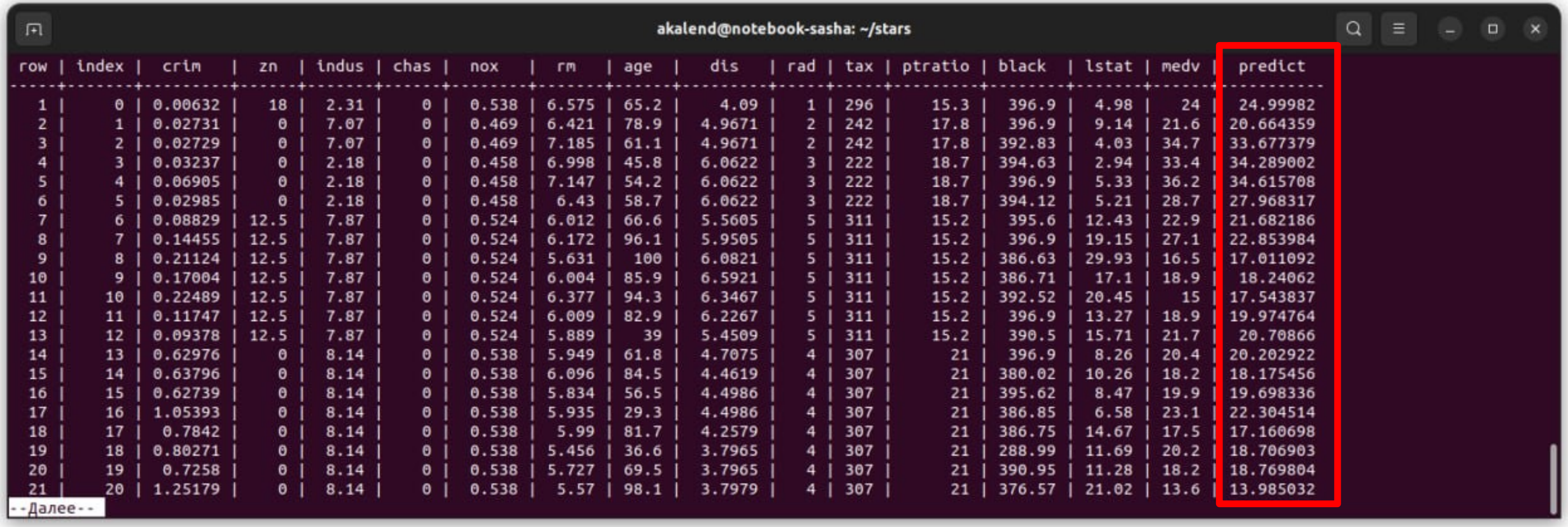
```
adult=# SELECT * FROM ml_cat_predict ('adult.cbm',   'adult2','{workclass,
education,marital_status, occupation,relationship,race,sex,native_country}
');
 row_num |       predict       | class
---------+---------------------+-------
       0 |  -5.926338548423682 | <=50K
       1 |  -1.225876230403332 | <=50K
       2 | -0.7485117670534811 | <=50K
       3 |  3.6351647093731705 | >50K
       4 |  -4.644606242153101 | <=50K
       5 |  -5.342578732065899 | <=50K
       6 | -3.9224526779262296 | <=50K
```



postgres@notebook-sasha: /usr/local/pgsql

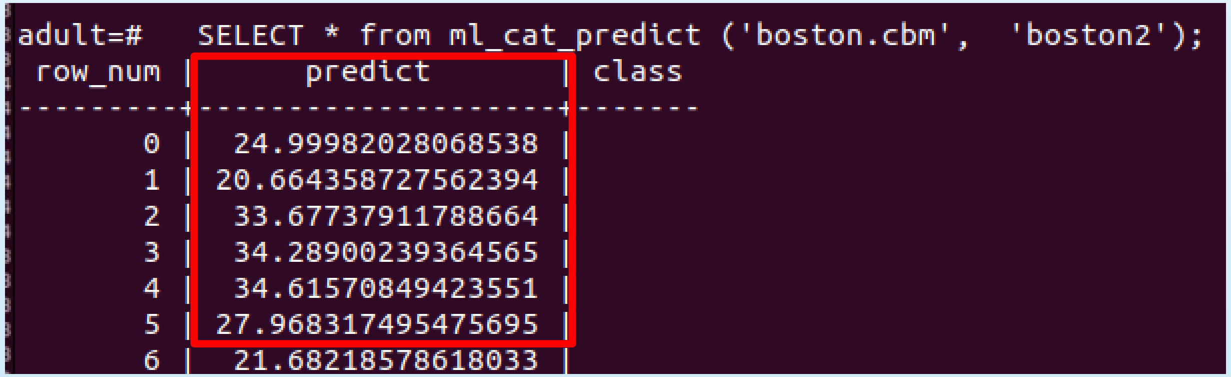
```
row | age |    workclass     | fnlwgt |  education   | education_num |    marital_status     |     occupation     | relationship |        race        |  sex   | capital_gain | capital_loss | hours_per_week |   native_country   | predict  | class
----+-----+------------------+--------+--------------+---------------+-----------------------+--------------------+--------------+--------------------+--------+--------------+--------------+----------------+--------------------+----------+-------
  1 |  25 | Private          | 226802 | 11th         |             7 | Never-married         | Machine-op-inspct  | Own-child    | Black              | Male   |            0 |            0 |             40 | United-States      | 0.002661 | <=50K
  2 |  38 | Private          |  89814 | HS-grad      |             9 | Married-civ-spouse    | Farming-fishing    | Husband      | White              | Male   |            0 |            0 |             50 | United-States      | 0.226904 | <=50K
  3 |  28 | Local-gov        | 336951 | Assoc-acdm   |            12 | Married-civ-spouse    | Protective-serv    | Husband      | White              | Male   |            0 |            0 |             40 | United-States      | 0.321146 | <=50K
  4 |  44 | Private          | 160323 | Some-college |            10 | Married-civ-spouse    | Machine-op-inspct  | Husband      | Black              | Male   |         7688 |            0 |             40 | United-States      | 0.974298 | >50K
  5 |  18 | nan              | 103497 | Some-college |            10 | Never-married         | nan                | Own-child    | White              | Female |            0 |            0 |             30 | United-States      | 0.009522 | <=50K
  6 |  34 | Private          | 198693 | 10th         |             6 | Never-married         | Other-service      | Not-in-family | White             | Male   |            0 |            0 |             30 | United-States      | 0.004761 | <=50K
  7 |  29 | nan              | 227026 | HS-grad      |             9 | Never-married         | nan                | Unmarried    | Black              | Male   |            0 |            0 |             40 | United-States      | 0.019408 | <=50K
  8 |  63 | Self-emp-not-inc | 104626 | Prof-school  |            15 | Married-civ-spouse    | Prof-specialty     | Husband      | White              | Male   |         3103 |            0 |             32 | United-States      | 0.560734 | >50K
  9 |  24 | Private          | 369667 | Some-college |            10 | Never-married         | Other-service      | Unmarried    | White              | Female |            0 |            0 |             40 | United-States      | 0.003572 | <=50K
 10 |  55 | Private          | 104996 | 7th-8th      |             4 | Married-civ-spouse    | Craft-repair       | Husband      | White              | Male   |            0 |            0 |             10 | United-States      | 0.092036 | <=50K
 11 |  65 | Private          | 184454 | HS-grad      |             9 | Married-civ-spouse    | Machine-op-inspct  | Husband      | White              | Male   |         6418 |            0 |             40 | United-States      | 0.759614 | >50K
 12 |  36 | Federal-gov      | 212465 | Bachelors    |            13 | Married-civ-spouse    | Adm-clerical       | Husband      | White              | Male   |            0 |            0 |             40 | United-States      |  0.64466 | >50K
 13 |  26 | Private          |  82091 | HS-grad      |             9 | Never-married         | Adm-clerical       | Not-in-family | White             | Female |            0 |            0 |             39 | United-States      | 0.007208 | <=50K
 14 |  58 | nan              | 299831 | HS-grad      |             9 | Married-civ-spouse    | nan                | Husband      | White              | Male   |            0 |            0 |             35 | United-States      | 0.432042 | <=50K
--Далее--
```

Regression



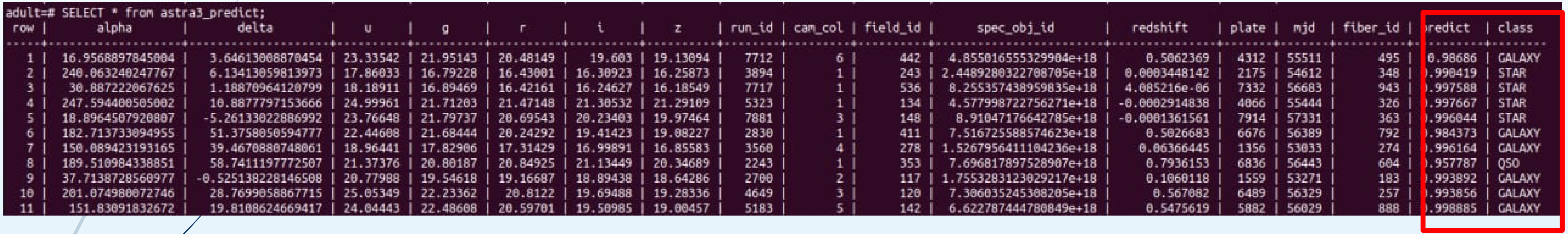
akalend@notebook-sasha: ~/stars

```
 row | index |  crim   |  zn  | indus | chas |  nox  |  rm   | age  |  dis   | rad | tax | ptratio | black  | lstat | medv |  predict
-----+-------+---------+------+-------+------+-------+-------+------+--------+-----+-----+---------+--------+-------+------+-----------
   1 |     0 | 0.00632 |   18 |  2.31 |    0 | 0.538 | 6.575 | 65.2 |   4.09 |   1 | 296 |    15.3 |  396.9 |  4.98 |   24 |  24.99982
   2 |     1 | 0.02731 |    0 |  7.07 |    0 | 0.469 | 6.421 | 78.9 | 4.9671 |   2 | 242 |    17.8 |  396.9 |  9.14 | 21.6 | 20.664359
   3 |     2 | 0.02729 |    0 |  7.07 |    0 | 0.469 | 7.185 | 61.1 | 4.9671 |   2 | 242 |    17.8 | 392.83 |  4.03 | 34.7 | 33.677379
   4 |     3 | 0.03237 |    0 |  2.18 |    0 | 0.458 | 6.998 | 45.8 | 6.0622 |   3 | 222 |    18.7 | 394.63 |  2.94 | 33.4 | 34.289002
   5 |     4 | 0.06905 |    0 |  2.18 |    0 | 0.458 | 7.147 | 54.2 | 6.0622 |   3 | 222 |    18.7 |  396.9 |  5.33 | 36.2 | 34.615708
   6 |     5 | 0.02985 |    0 |  2.18 |    0 | 0.458 |  6.43 | 58.7 | 6.0622 |   3 | 222 |    18.7 | 394.12 |  5.21 | 28.7 | 27.968317
   7 |     6 | 0.08829 | 12.5 |  7.87 |    0 | 0.524 | 6.012 | 66.6 | 5.5605 |   5 | 311 |    15.2 |  395.6 | 12.43 | 22.9 | 21.682186
   8 |     7 | 0.14455 | 12.5 |  7.87 |    0 | 0.524 | 6.172 | 96.1 | 5.9505 |   5 | 311 |    15.2 |  396.9 | 19.15 | 27.1 | 22.853984
   9 |     8 | 0.21124 | 12.5 |  7.87 |    0 | 0.524 | 5.631 |  100 | 6.0821 |   5 | 311 |    15.2 | 386.63 | 29.93 | 16.5 | 17.011092
  10 |     9 | 0.17004 | 12.5 |  7.87 |    0 | 0.524 | 6.004 | 85.9 | 6.5921 |   5 | 311 |    15.2 | 386.71 |  17.1 | 18.9 |  18.24062
  11 |    10 | 0.22489 | 12.5 |  7.87 |    0 | 0.524 | 6.377 | 94.3 | 6.3467 |   5 | 311 |    15.2 | 392.52 | 20.45 |   15 | 17.543837
  12 |    11 | 0.11747 | 12.5 |  7.87 |    0 | 0.524 | 6.009 | 82.9 | 6.2267 |   5 | 311 |    15.2 |  396.9 | 13.27 | 18.9 | 19.974764
  13 |    12 | 0.09378 | 12.5 |  7.87 |    0 | 0.524 | 5.889 |   39 | 5.4509 |   5 | 311 |    15.2 |  390.5 | 15.71 | 21.7 |  20.70866
  14 |    13 | 0.62976 |    0 |  8.14 |    0 | 0.538 | 5.949 | 61.8 | 4.7075 |   4 | 307 |      21 |  396.9 |  8.26 | 20.4 | 20.202922
  15 |    14 | 0.63796 |    0 |  8.14 |    0 | 0.538 | 6.096 | 84.5 | 4.4619 |   4 | 307 |      21 | 380.02 | 10.26 | 18.2 | 18.175456
  16 |    15 | 0.62739 |    0 |  8.14 |    0 | 0.538 | 5.834 | 56.5 | 4.4986 |   4 | 307 |      21 | 395.62 |  8.47 | 19.9 | 19.698336
  17 |    16 | 1.05393 |    0 |  8.14 |    0 | 0.538 | 5.935 | 29.3 | 4.4986 |   4 | 307 |      21 | 386.85 |  6.58 | 23.1 | 22.304514
  18 |    17 |  0.7842 |    0 |  8.14 |    0 | 0.538 |  5.99 | 81.7 | 4.2579 |   4 | 307 |      21 | 386.75 | 14.67 | 17.5 | 17.160698
  19 |    18 | 0.80271 |    0 |  8.14 |    0 | 0.538 | 5.456 | 36.6 | 3.7965 |   4 | 307 |      21 | 288.99 | 11.69 | 20.2 | 18.706903
  20 |    19 |  0.7258 |    0 |  8.14 |    0 | 0.538 | 5.727 | 69.5 | 3.7965 |   4 | 307 |      21 | 390.95 | 11.28 | 18.2 | 18.769804
  21 |    20 | 1.25179 |    0 |  8.14 |    0 | 0.538 |  5.57 | 98.1 | 3.7979 |   4 | 307 |      21 | 376.57 | 21.02 | 13.6 | 13.985032
--Далее--
```

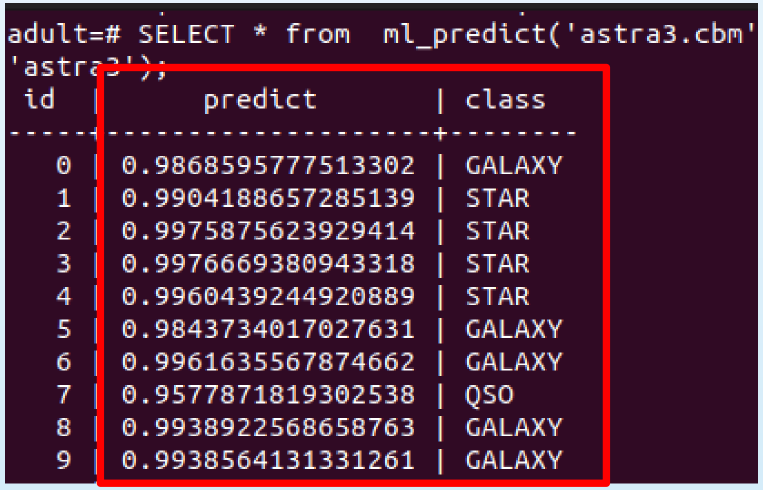


```
adult=#   SELECT * from ml_cat_predict ('boston.cbm',  'boston2');
 row_num |       predict       | class
---------+---------------------+-------
       0 |   24.99982028068538 |
       1 |  20.664358727562394 |
       2 |   33.67737911788664 |
       3 |   34.28900239364565 |
       4 |   34.61570849423551 |
       5 |  27.968317495475695 |
       6 |   21.68218578618033 |
```

Multi classification

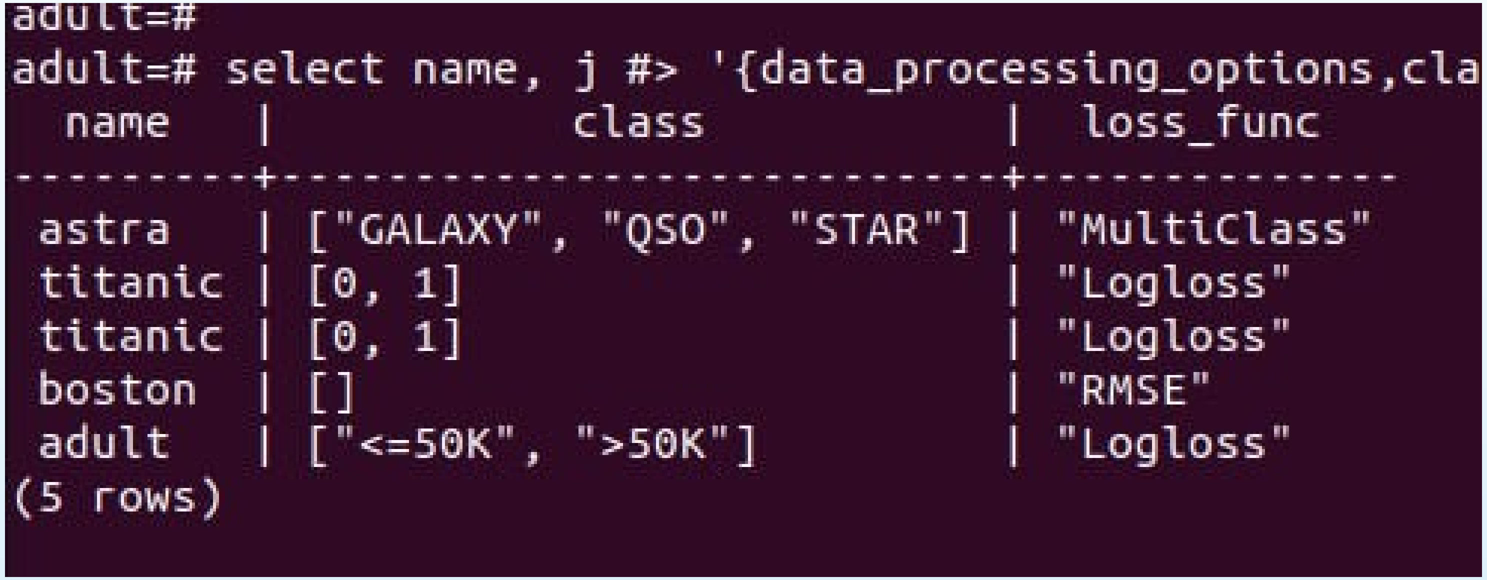


```
adult=# SELECT * from astra3_predict;
 row |      alpha       |       delta        |    u     |    g     |    r     |    i     |    z     | run_id | cam_col | field_id |      spec_obj_id      |   redshift    | plate |  mjd  | fiber_id | predict  | class
-----+------------------+--------------------+----------+----------+----------+----------+----------+--------+---------+----------+-----------------------+---------------+-------+-------+----------+----------+--------
   1 | 16.9568897845004 |   3.64613008870454 | 23.33542 | 21.95143 | 20.48149 |   19.603 | 19.13094 |   7712 |       6 |      442 | 4.85501655532990 4e+18 |     0.5062369 |  4312 | 55511 |      495 |  0.98686 | GALAXY
   2 | 240.063240247767 |   6.13413059813973 | 17.86033 | 16.79228 | 16.43001 | 16.30923 | 16.25873 |   3894 |       1 |      243 | 2.448928032270870 5e+18 |  0.0003448142 |  2175 | 54612 |      348 | 0.990419 | STAR
   3 |  30.887222067625 |   1.18870964120799 | 18.18911 | 16.89469 | 16.42161 | 16.24627 | 16.18549 |   7717 |       1 |      536 |  8.255357438959835e+18 |  4.085216e-06 |  7332 | 56683 |      943 | 0.997588 | STAR
   4 | 247.594400505002 |   10.8877797153666 | 24.99961 | 21.71203 | 21.47148 | 21.30532 | 21.29109 |   5323 |       1 |      134 |  4.577998722756271e+18 | -0.0002914838 |  4066 | 55444 |      326 | 0.997667 | STAR
   5 | 18.8964507920807 |  -5.26133022886992 | 23.76648 | 21.79737 | 20.69543 | 20.23403 | 19.97464 |   7881 |       3 |      148 |   8.91047176642785e+18 | -0.0001361561 |  7914 | 57331 |      363 | 0.996044 | STAR
   6 | 182.713733094955 |   51.3758050594777 | 22.44608 | 21.68444 | 20.24292 | 19.41423 | 19.08227 |   2830 |       1 |      411 |  7.516725588574623e+18 |     0.5026683 |  6676 | 56389 |      792 | 0.984373 | GALAXY
   7 | 150.089423193165 |   39.4670880748061 | 18.96441 | 17.82906 | 17.31429 | 16.99891 | 16.85583 |   3560 |       4 |      278 | 1.5267956411104236e+18 |    0.06366445 |  1356 | 53033 |      274 | 0.996164 | GALAXY
   8 | 189.510984338851 |   58.7411197772507 | 21.37376 | 20.80187 | 20.84925 | 21.13449 | 20.34689 |   2243 |       1 |      353 |  7.696817897528907e+18 |     0.7936153 |  6836 | 56443 |      604 | 0.957787 | QSO
   9 | 37.7138728560977 | -0.525138228146508 | 20.77988 | 19.54618 | 19.16687 | 18.89438 | 18.64286 |   2700 |       2 |      117 | 1.7553283123029217e+18 |     0.1060118 |  1559 | 53271 |      183 | 0.993892 | GALAXY
  10 | 201.074980072746 |   28.7699058867715 | 25.05349 | 22.23362 |  20.8122 | 19.69488 | 19.28336 |   4649 |       3 |      120 |  7.306035245308205e+18 |      0.567082 |  6489 | 56329 |      257 | 0.993856 | GALAXY
  11 |  151.83091832672 |   19.8108624669417 | 24.04443 | 22.48608 | 20.59701 | 19.50985 | 19.00457 |   5183 |       5 |      142 |  6.622787444780849e+18 |     0.5475619 |  5882 | 56029 |      888 | 0.998885 | GALAXY
```



```
adult=# SELECT * from  ml_predict('astra3.cbm',
'astra3');
 id  |         predict         | class
-----+-------------------------+--------
   0 | 0.9868595777513302 | GALAXY
   1 | 0.9904188657285139 | STAR
   2 | 0.9975875623929414 | STAR
   3 | 0.9976669380943318 | STAR
   4 | 0.9960439244920889 | STAR
   5 | 0.9843734017027631 | GALAXY
   6 | 0.9961635567874662 | GALAXY
   7 | 0.9577871819302538 | QSO
   8 | 0.9938922568658763 | GALAXY
   9 | 0.9938564131331261 | GALAXY
```

Inner data model



```
adult=#
adult=# select name, j #> '{data_processing_options,cla
  name   |             class              |  loss_func
---------+--------------------------------+--------------
 astra   | ["GALAXY", "QSO", "STAR"] | "MultiClass"
 titanic | [0, 1]                         | "Logloss"
 titanic | [0, 1]                         | "Logloss"
 boston  | []                             | "RMSE"
 adult   | ["<=50K", ">50K"]              | "Logloss"
(5 rows)
```