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# **CosmoPhotoz Documentation**

*Release*

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## Installation

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The package can be installed using the PyPI and pip.

```
$ pip install -U CosmoPhotoz
```

Or if the tarball or repository is downloaded, distutils can be

```
$ python setup.py install
```

The PyPI package page can be accessed at [PyPI](#)

### 1.1 Requirements

This will only run on Python  $\geq 2.7$  or  $\geq 3.3$  as seaborn does not work on Python  $\leq 2.6$ .





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## Introduction

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This package provides user-friendly interfaces to perform fast and reliable photometric redshift estimation. The code makes use of generalized linear models, more specifically the Gamma family.

The methodology and test cases of the software will be accessible in the future via an article on Astronomy and Computing. The documentation will be updated when it has been submitted to arXiv.

The problem to be solved is to estimate the redshift of a galaxy based on its multi-wavelength photometry. Such a problem will become increasingly apparent with the new set of instruments to begin observing in the near future, e.g. LSST. They will detect more sources than they can carry out follow up spectroscopy on, and so machine learning techniques must be used.

The gamma family that originates from the wider set of generalized linear models, is a distribution that reproduces positive and continuous observables. We show that this technique requires much smaller training sizes and computational execution time to estimate values of redshift from the multi-wavelength photometry, than conventional methods such as neural networks. Despite the less strict requirements of the model, the fits are similar and sometimes better than the other techniques used.

This package allows you to train a GLM on a sample of known redshifts and then estimate the photometric redshifts of a sample for which you have no redshifts.



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**Examples**

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### 3.1 PHAT0

We first show the usage of GLMs to fit synthetic redshifts. We have a dataset that has both magnitudes and redshifts for each object.

```
%matplotlib inline
from CosmoPhotoz.photoz import PhotoSample
```

Make an instance of the PhotoSample class and define the filename of your sample

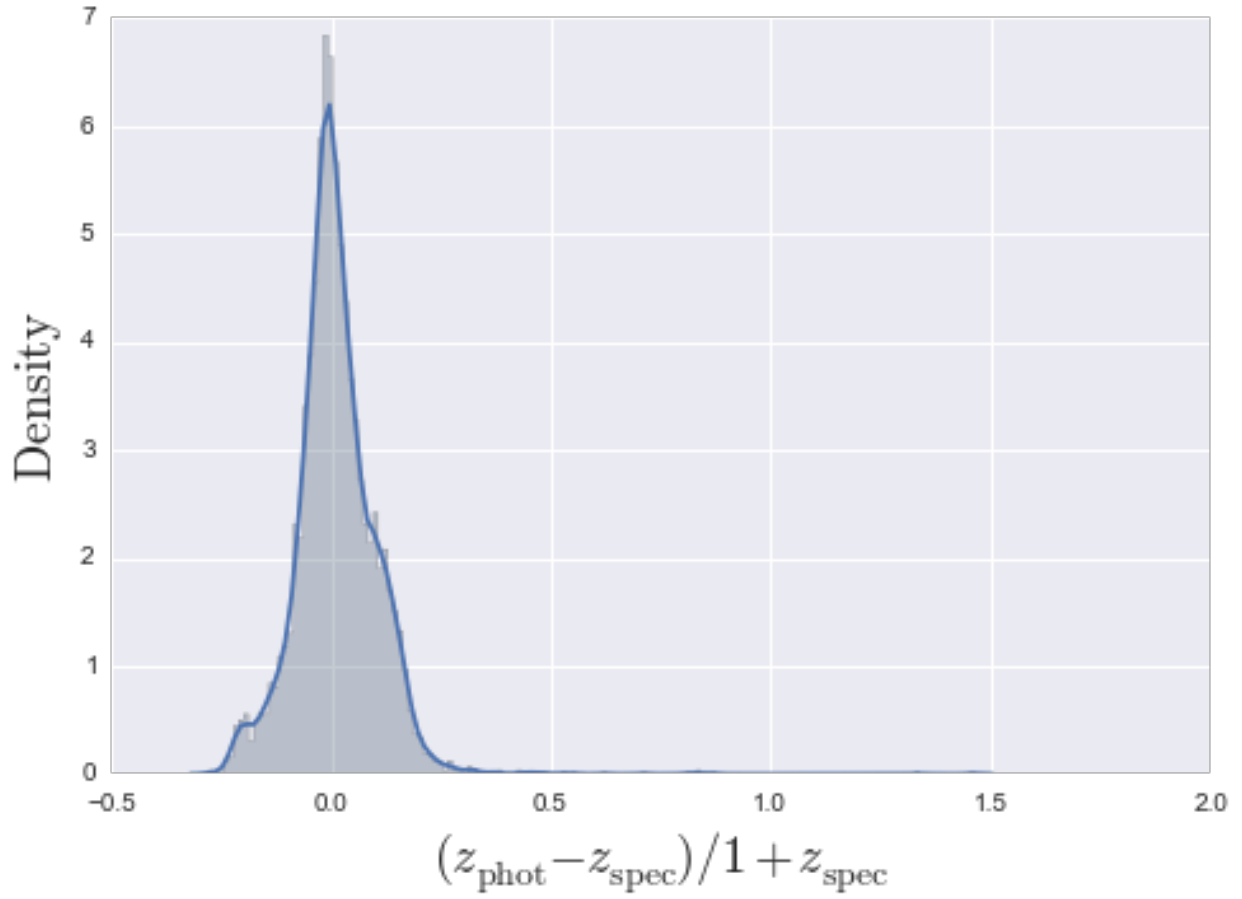
```
PHAT0 = PhotoSample(filename="../data/PHAT0.csv", family="Gamma", link="log")
```

Let's specify the number of PCAs we want to fit and the size of the training sample

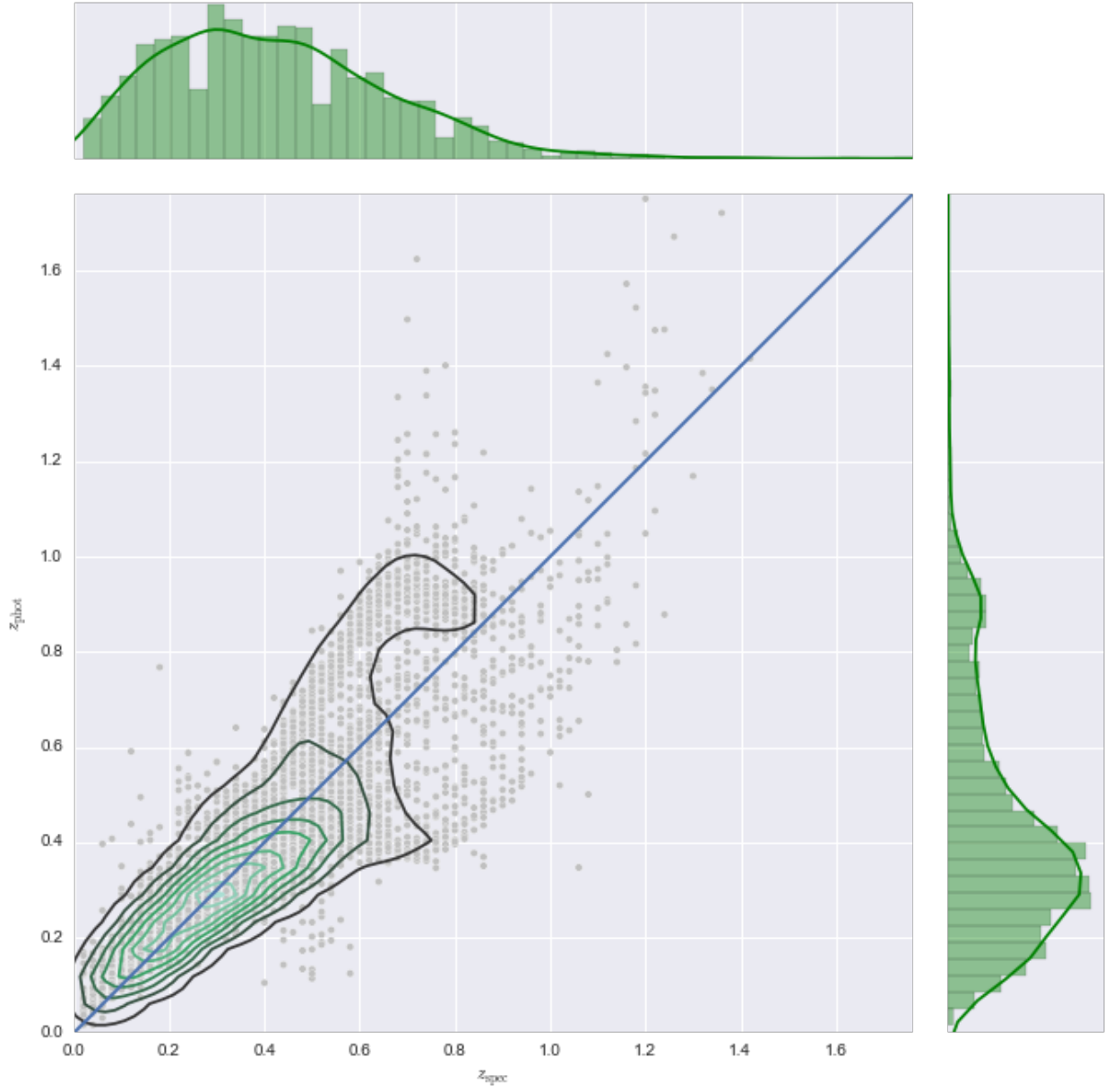
```
PHAT0.num_components = 5
PHAT0.test_size = 5000
```

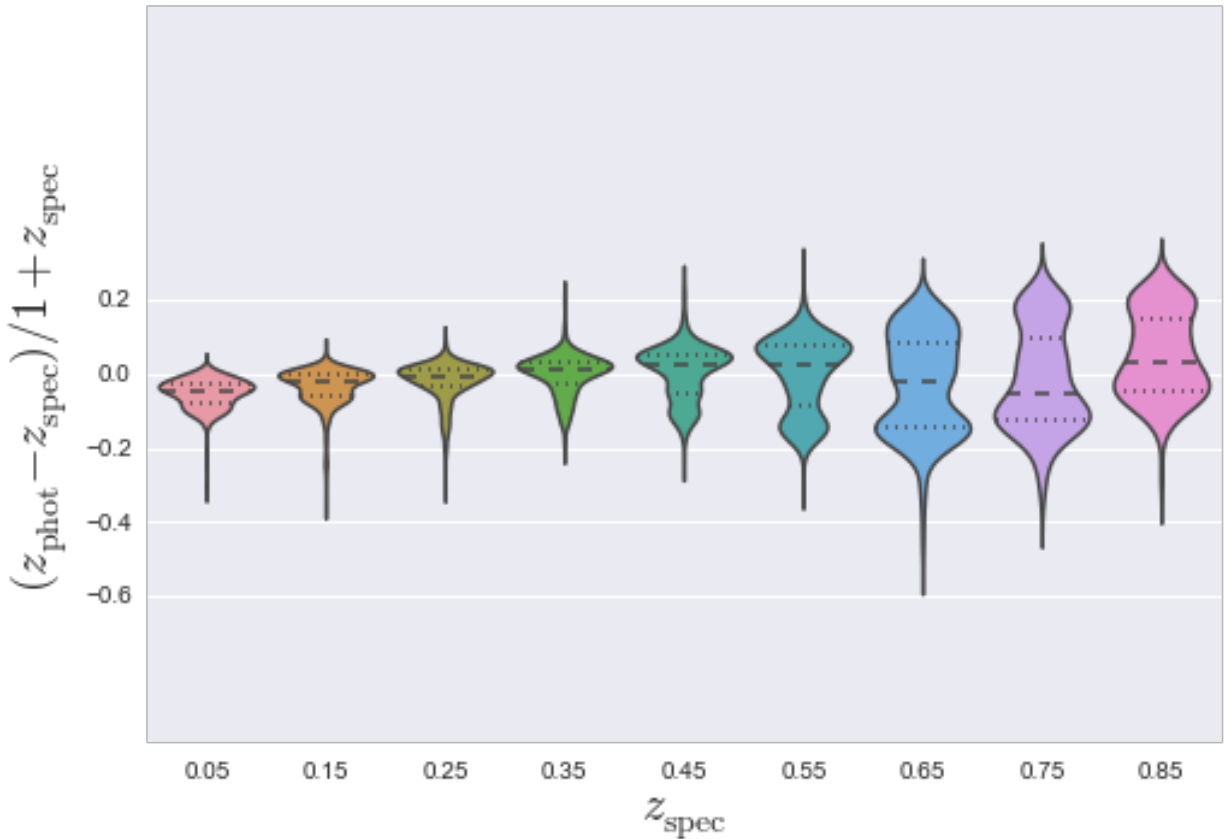
Now run the PCA decomposition and GLM fitting

```
PHAT0.run_full()
```



<matplotlib.figure.Figure at 0xb1a11a2c>





## 3.2 Real Data

We now show you how to use a dataset to train your GLM model and then how to fit it to a separate testing dataset. We also show that you can use the Quantile family rather than a Gamma family.

```
SDSS = PhotoSample(filename_train="../data/SDSS_train.csv", filename_test="../data/SDSS_test.csv", f
```

We note that the training set contains redshift, but the test dataset does not contain a redshift field. We run each step independently to show you the innards of `run_all()` work. Utilising the library in an object-oriented manner allows you to interact in a more easier manner when investigating such things as the training sample size. See later for an example.

Applying the GLM to the SDSS

1. We run principle component analysis to ensure that each component is orthogonal (independent and identically distributed).

```
SDSS.do_PCA()
print("PCA has decided to use {0} components".format(SDSS.num_components))
```

```
PCA has decided to use 4 components
```

2. First we ensure the datasets are resplit after PCA and carry out the GLM fitting.

```
SDSS.split_sample(random=False)
SDSS.do_GLM()
```

## QuantReg Regression Results

```

=====
Dep. Variable:          redshift   Pseudo R-squared:          0.8158
Model:                 QuantReg   Bandwidth:                 0.008182
Method:                Least Squares   Sparsity:                 0.08200
Date:                  Tue, 19 Aug 2014   No. Observations:        10000
Time:                  15:05:54       Df Residuals:            9984
                                           Df Model:                15
=====

```

|                 | coef    | std err | t       | P> t  | [95.0% Conf. Int.] |        |
|-----------------|---------|---------|---------|-------|--------------------|--------|
| Intercept       | 0.3156  | 0.000   | 692.656 | 0.000 | 0.315              | 0.317  |
| PC1             | 0.0493  | 0.000   | 385.097 | 0.000 | 0.049              | 0.050  |
| PC2             | -0.0322 | 0.001   | -43.416 | 0.000 | -0.034             | -0.031 |
| PC1:PC2         | 0.0045  | 0.000   | 21.331  | 0.000 | 0.004              | 0.005  |
| PC3             | 0.2093  | 0.002   | 103.342 | 0.000 | 0.205              | 0.213  |
| PC1:PC3         | -0.0213 | 0.000   | -45.427 | 0.000 | -0.022             | -0.020 |
| PC2:PC3         | 0.0409  | 0.001   | 28.324  | 0.000 | 0.038              | 0.044  |
| PC1:PC2:PC3     | -0.0096 | 0.000   | -25.380 | 0.000 | -0.010             | -0.009 |
| PC4             | 0.2813  | 0.006   | 46.342  | 0.000 | 0.269              | 0.293  |
| PC1:PC4         | -0.0003 | 0.002   | -0.213  | 0.831 | -0.003             | 0.003  |
| PC2:PC4         | -0.2007 | 0.006   | -31.264 | 0.000 | -0.213             | -0.188 |
| PC1:PC2:PC4     | 0.0321  | 0.002   | 19.469  | 0.000 | 0.029              | 0.035  |
| PC3:PC4         | -0.0806 | 0.012   | -6.999  | 0.000 | -0.103             | -0.058 |
| PC1:PC3:PC4     | 0.0108  | 0.002   | 4.640   | 0.000 | 0.006              | 0.015  |
| PC2:PC3:PC4     | -0.0591 | 0.008   | -7.600  | 0.000 | -0.074             | -0.044 |
| PC1:PC2:PC3:PC4 | 0.0175  | 0.002   | 9.303   | 0.000 | 0.014              | 0.021  |

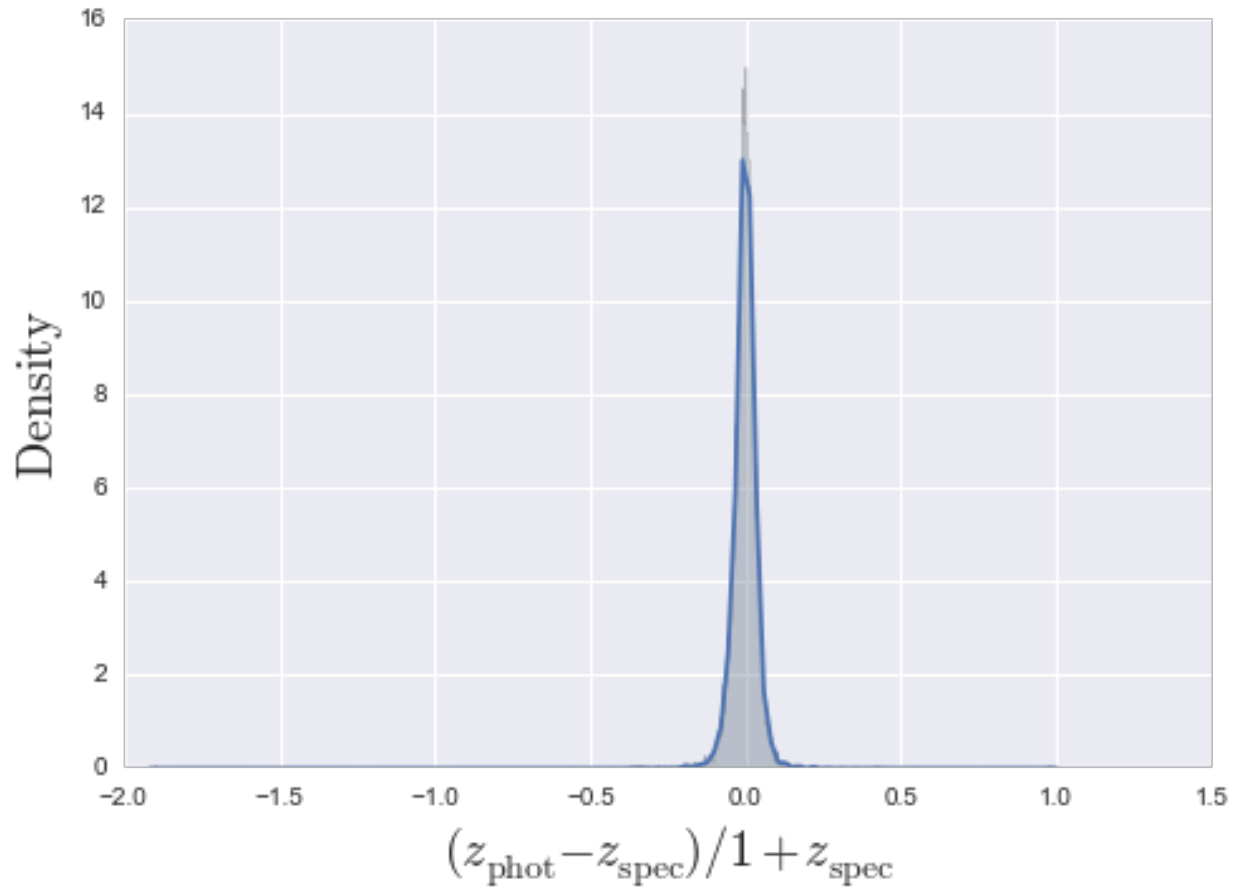
```

=====

```

## 3. Make a 1 dimensional KDE plot of the number of outliers.

```
SDSS.make_1D_KDE()
```

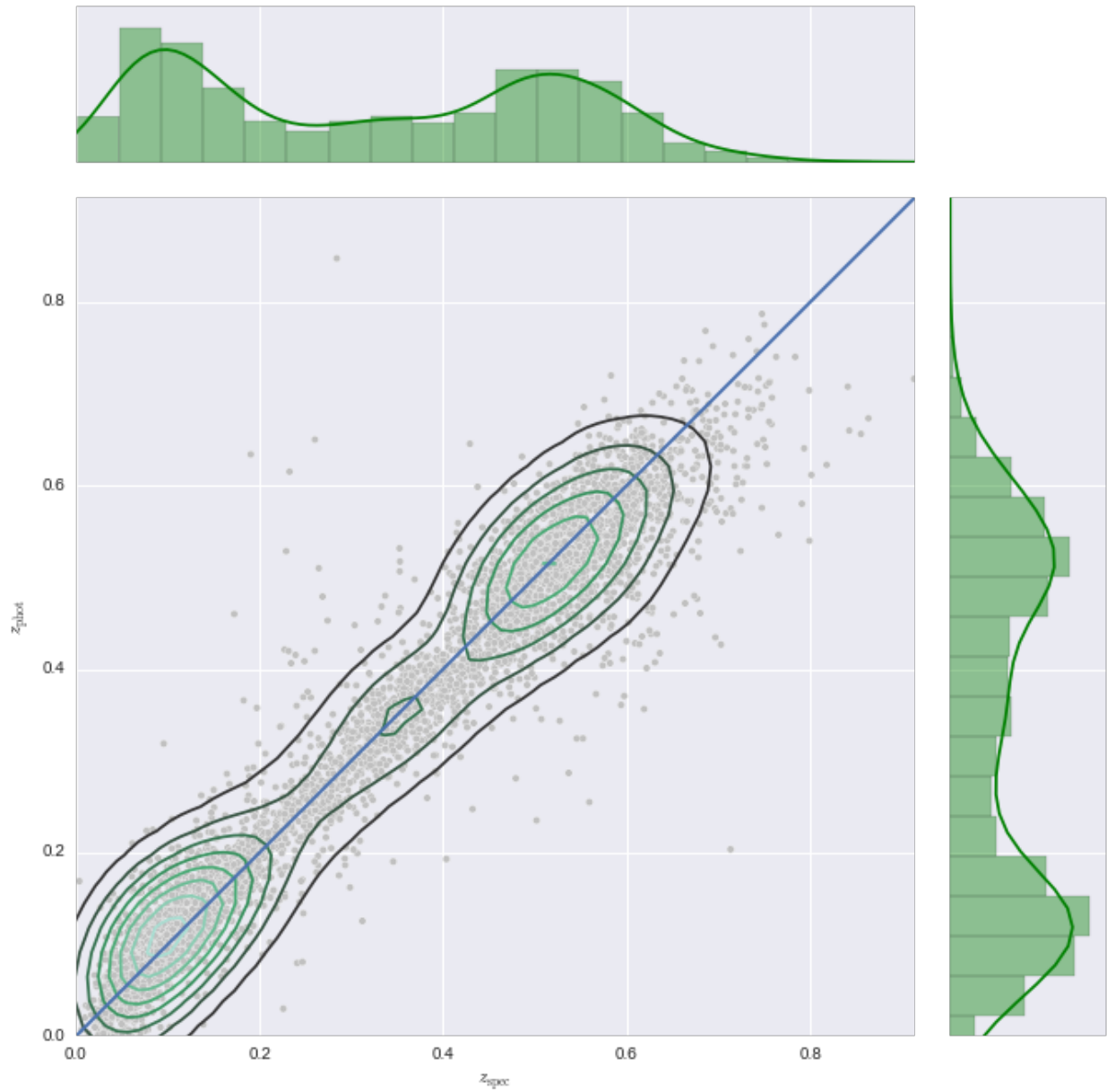


#### 4. Make a 2D KDE plot

```
SDSS.make_2D_KDE()
```

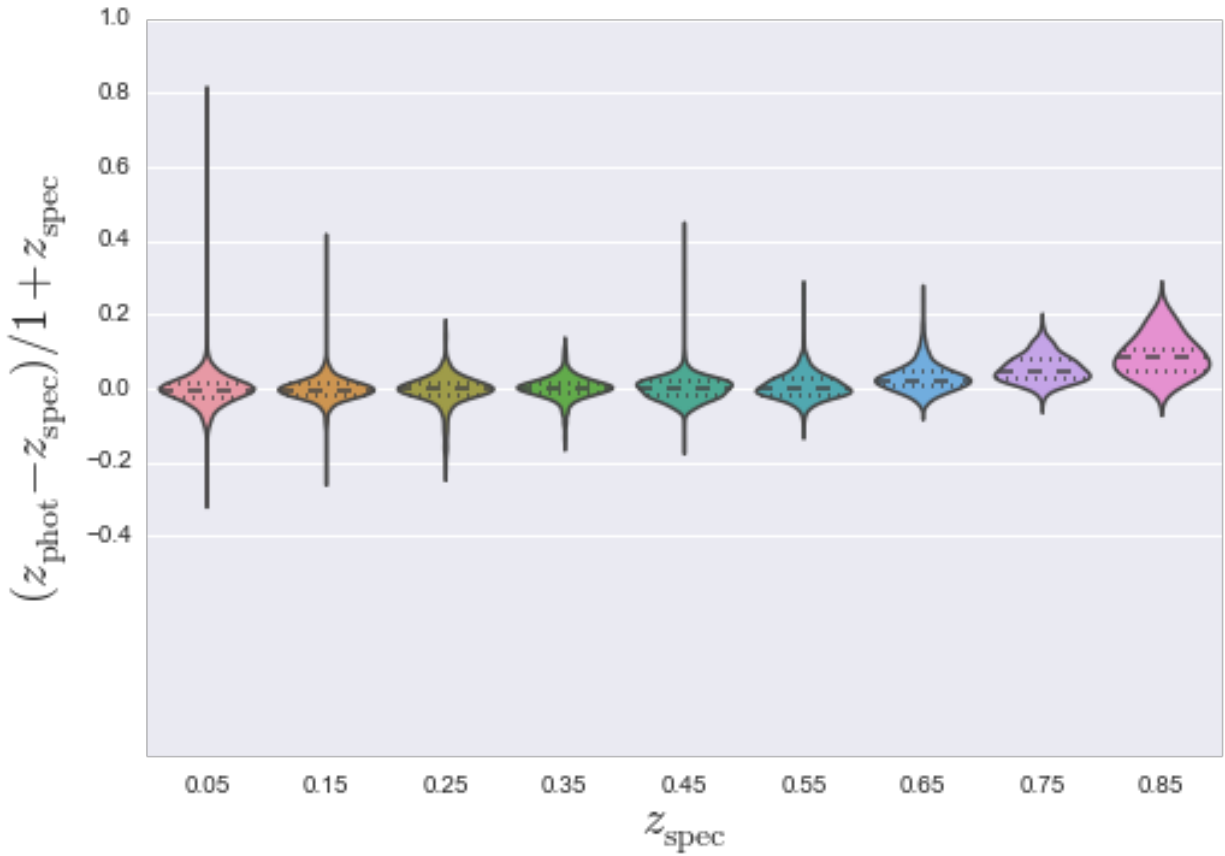
```
<matplotlib.figure.Figure at 0xb15ae30c>
```





### 5. Make a violin plot

```
SDSS.make_violin()
```



### Abuse of Object-Orientation

Imagine that we want to investigate how the catastrophic error evolves with the size of the sample used to train the Generalised Linear Model. This can be easily carried out in an object-oriented way, in comparison to functional forms.

```
import numpy as np          # for arrays
import matplotlib.pyplot as plt # for plotting

# Load a full dataset
SDSS = PhotoSample(filename="../data/SDSS_nospec.csv", family="Gamma", link="log")

# Definitions
train_size = np.array([100, 500, 1000, 5000, 10000])
catastrophic_error = []

# Run over training sizes
for i in range(len(train_size)):

    # User defined
    SDSS.test_size = train_size[i]

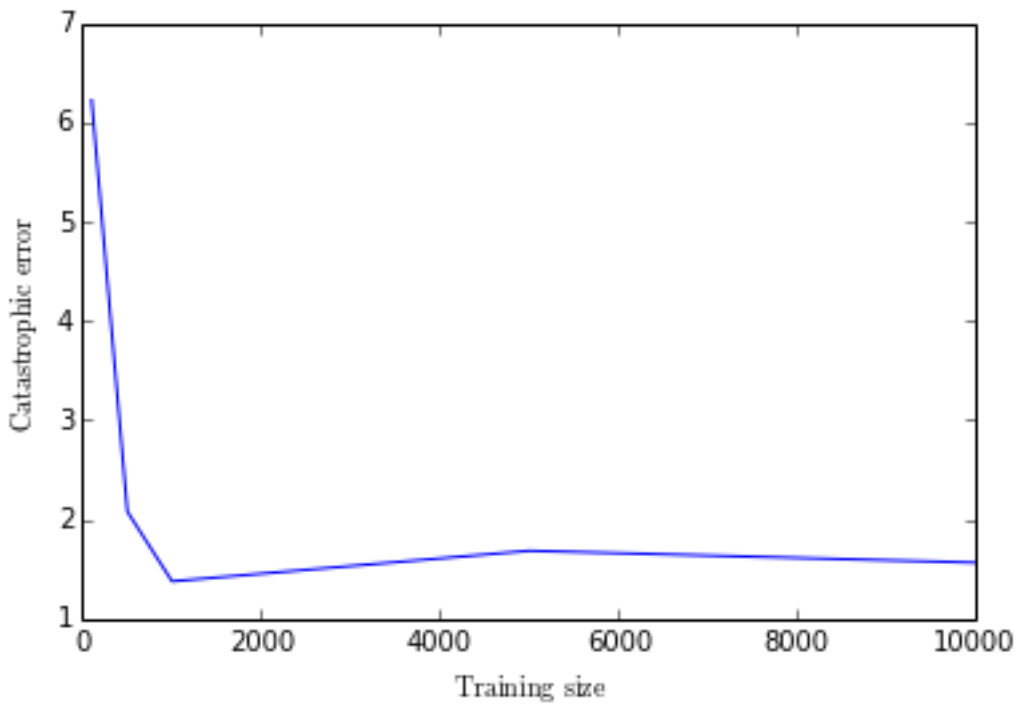
    # This can also be placed in a method to make cleaner
    SDSS.do_PCA()
    SDSS.split_sample(random=True)
    SDSS.do_GLM()

    # Collect the output
    catastrophic_error.append(SDSS.catastrophic_error)
```

```
# Make nicer for MPL
catastrophic_error = np.array(catastrophic_error)

# Define the figure for plotting
fig = plt.figure(0)
ax = fig.add_subplot(111)
ax.errorbar(train_size, catastrophic_error)
ax.set_xlabel(r"$\rm Training\, size$")
ax.set_ylabel(r"$\rm Catastrophic\, error$")

plt.show()
```





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**CosmoPhotoz package**

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**4.1 CosmoPhotoz.photoz module**

**4.2 CosmoPhotoz.run\_glm module**



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## Indices and tables

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