# Investigating the Optical Properties of Galaxies in the direction of Clusters; Art of Photometric Redshifts toward ALMA.

**Chi-Chun Lung**

**Department of Science**

**National Taipei University of Education**

**Primary supervisor: Prof. Yasuhiro Hashimoto**

**Secondary supervisor: Prof. Sébastien Foucaud**

# Outline

- Motivation
- What is the photo-Z
- GIGO in the photo-Z
- Methods
- Results
- Summary
- Future

# Why Photo-Z ?

- We need **redshifts** for a variety of important extragalactic study.
- But, spectroscopic redshifts are bad because…

  --time consuming

  --low completeness

  --bright objects only
- Photo-Z is good because...

  --needs less time

  --higher completeness

  --can go much fainter

# What is ALMA


- ALMA (Atacama Large Milimeter Array)
- Locate: Chile
- Antenna: 12m-telescope*54
  7m-telescope*12
- Wide wavelength coverage.

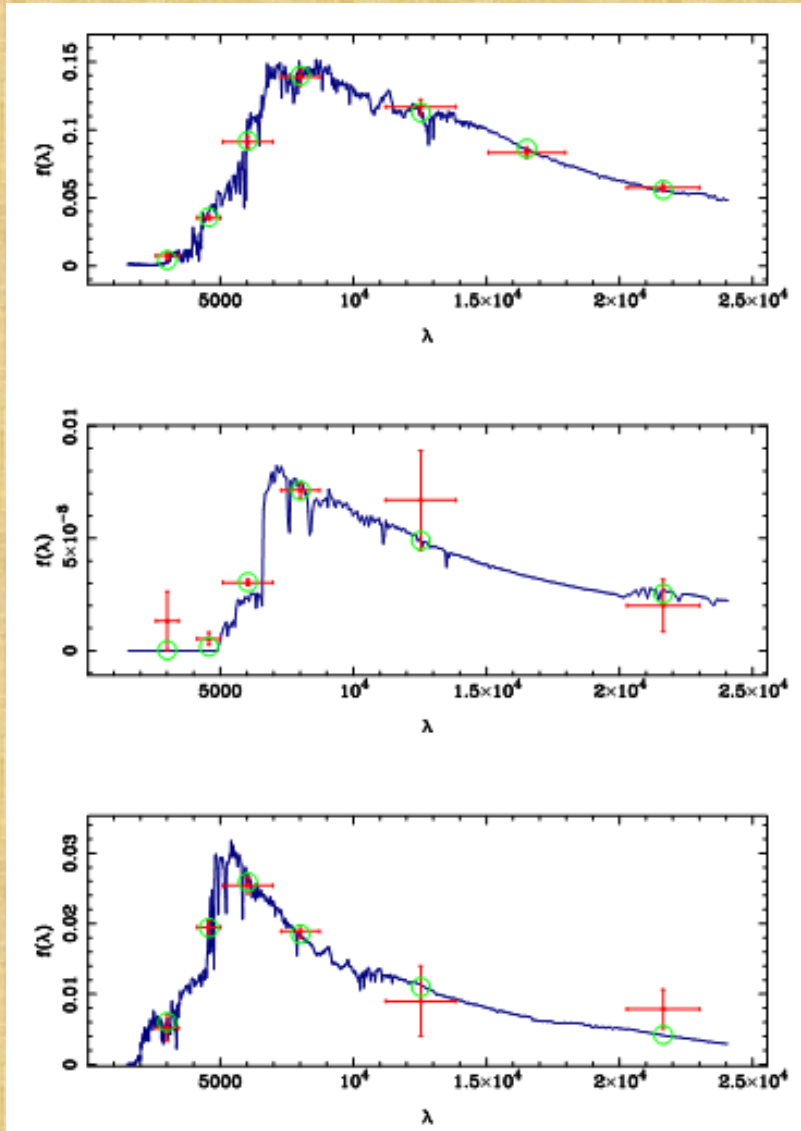
| Band | Frequency Range GHz |
|---|---|
| 1 | 31.3-45.0 |
| 2 | 67-90 |
| 4 | 125-163 |
| 5 | 163-211 |
| 6 | 211-275 |
| 7 | 275-373 |
| 8 | 383-500 |
| 9 | 602-720 |
| 10 | 787-950 |

# Why we need Photo-Z for ALMA?

- In theory, using a wide wavelength coverage of ALMA, we can do blind observation.
- In practice, it is still difficult that to do blind redshift.
- To make efficient ALMA observation, we need **redshift**.

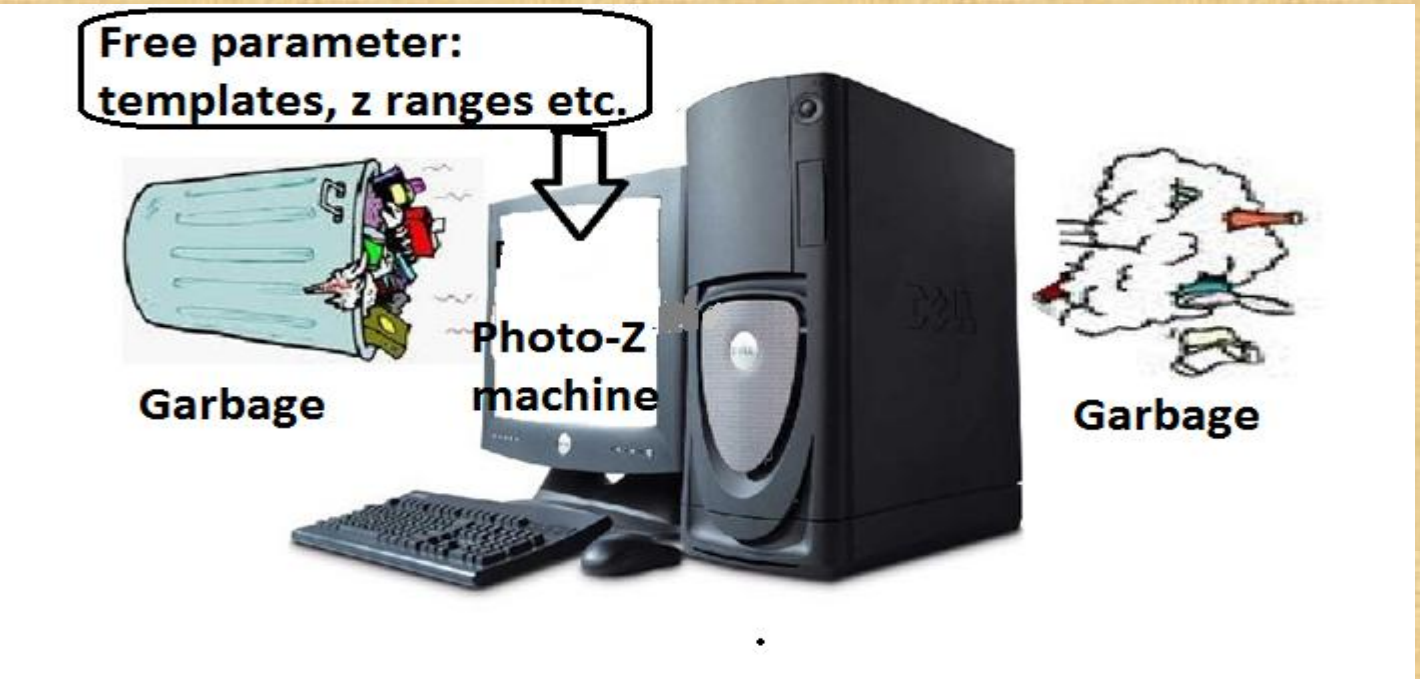
# Photo-Z in Nut Shell

- The technique was developed in the 1960s.
- In photometric redshifts (photo-Zs), you fit your spectroscopic templates to your photometric observations.



# Difficulty in using Photo-Z
# (We need to use Photo-Z very carefully)

- GIGO (garbage in, garbage out!)
- Many Free parameters (e.g. templates, reddening laws, redshifts, age, metalicity, normalization.)
- **Degeneracy (no unique solution)**



# Methods

- Use public Photo-Z codes (e.g. Hyper-Z , EAZY...)
- Use archival data (e.g. SDSS, UKIDSS ...)
- Use the archival photo-Z, calibrate codes.
- Explore the parameter space and understand the behavior of the code.
- Evaluate errors in photo-Z estimates.
- Produce the accurate photo-Zs.

# Major Public Photo-Z Codes

| **Code** | **Reference** |
|---|---|
| **HyperZ** | **Bolzonella et al. (2000)** |
| BPZ-1 | Benítez (2000); Coe et al. (2006) |
| EAZY | Brammer et al. (2008) |
| GOODZ | Dahlen et al. (2005, 2007) |
| Le Phare | Ilbert et al. (2006) |
| Zebra | Feldmann et al. (2006) |
| ANNZ | Collister & Lahav (2004) |

# And More…

| Code | Reference |
|---|---|
| BPZ-2 | Benítez (2000); Benítez 2010 (in prep.) |
| GALEV, GALaxy EVolution | Kotulla et al. (2009) |
| LRT | Assef et al. (2008, 2010) |
| Template Repair | Adelman-McCarthy et al. (2007) |
| ZEBRA-2 | Feldmann et al. (2006) |
| Nearest-Neighbour Fit | Abazajian et al. (2009) |
| Regression Trees | Carliles et al. (2010) |
| Neural Network | - |

# Hyperz

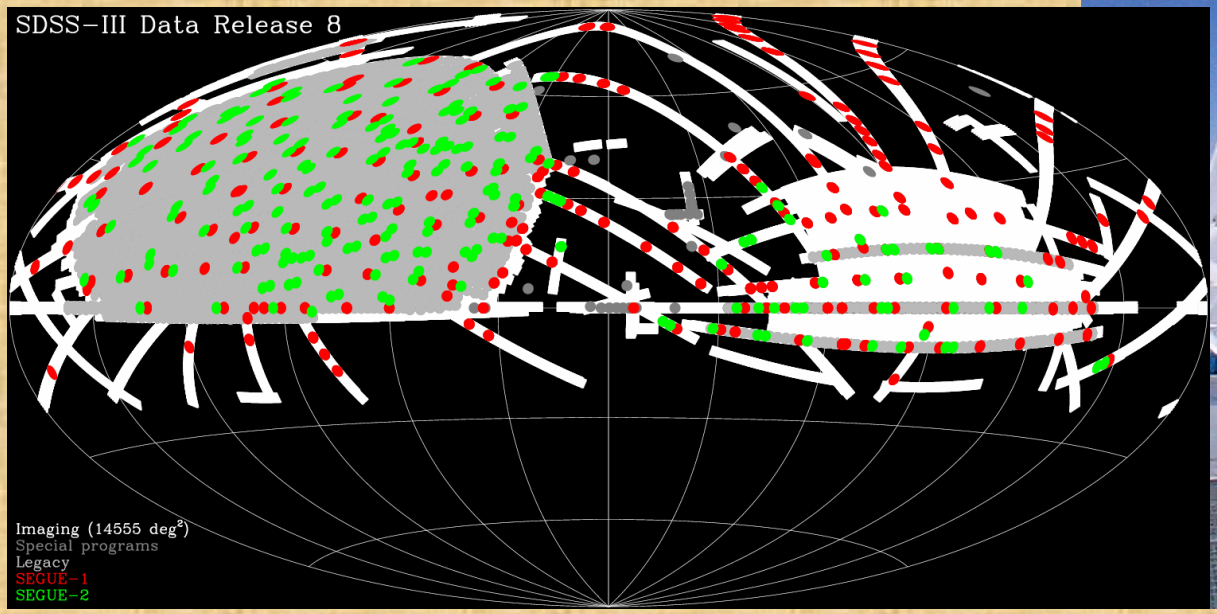
- We can just choose the best template to fit data.

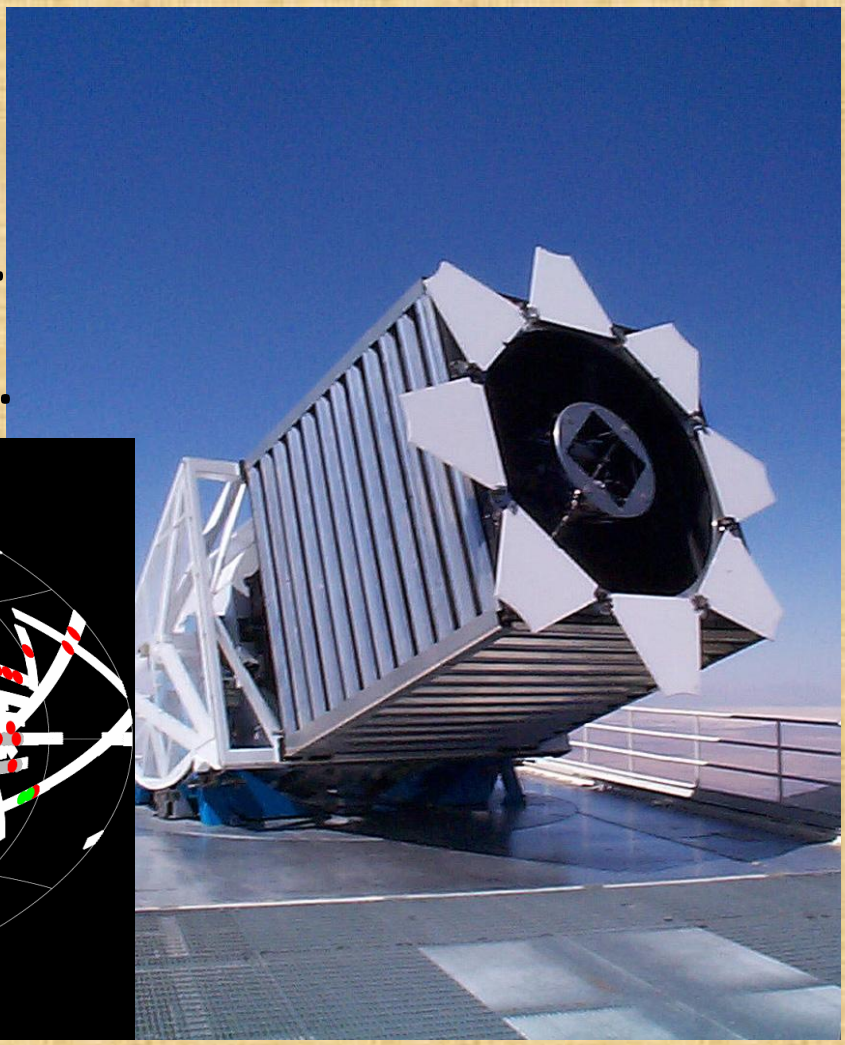
  --template: BC (Bruzual and Charlot, 1993)

  CWW (Coleman, Wu, and Weedman, 1980)
- Prior : no prior.
- Training: no training.

# Archival data--SDSS (Sloan Digital Sky Survey)

- Telescope: 2.5m
- Position: New Mexico, USA
- Sky coverage: 14555 sq. deg.
- DR8 release at January 2011.



# Request of SDSS Catalog

- Catalog: Galaxy
- Field selection

  --center (Abell1758)

  RA: 203.0625°

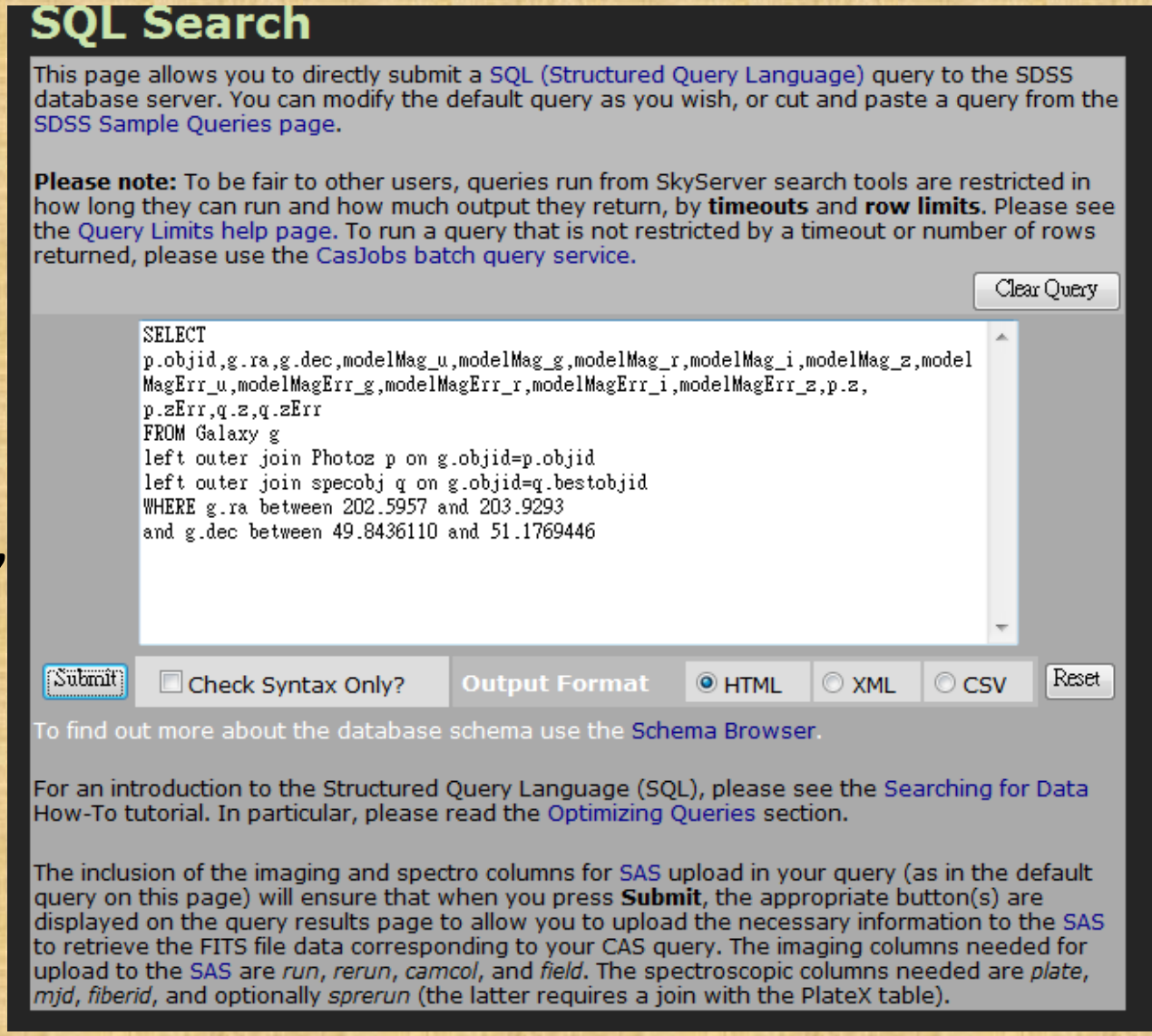
  Dec: 50.5102778°

  Field size: 40 arcmins* 40 arcmins

---> With those limit, I got 22491 galaxies.

# SDSS SQL

- Example from SQL, our data setting is in which I typed in, such as magnitude type, catalog files, field range……



# SDSS SQL

- This data is output from SQL search.

Your SQL command was:

```
SELECT p.objid,g.ra,g.dec,modelMag_u,modelMag_g,modelMag_r,modelMag_i,modelMag_z,modelMagErr_u,modelMagErr_g,modelMagErr_r,modelMagErr_i,modelMagErr_
FROM Galaxy g
left outer join Photoz p on g.objid=p.objid
left outer join specobj q on g.objid=q.bestobjid
WHERE g.ra between 202.5957 and 203.9293
and g.dec between 49.8436110 and 51.1769446
```

| objid | ra | dec | modelMag_u | modelMag_g | modelMag_r | modelMag_i | modelMag_z | modelMagErr_u | modelMagErr_g | modelMagErr_r | modelMagErr_i | modelMagErr_z | z | zErr | z | zErr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1237658206127063470 | 202.61893535 | 49.85076233 | 24.280882 | 25.127274 | 22.233809 | 21.607811 | 22.325918 | 0.940404 | 0.576727 | 0.159253 | 0.141425 | 0.772415 | 0.433628 | 0.185002 | 0 | 0 |
| 1237658206127063503 | 202.64091445 | 49.86026596 | 22.652988 | 21.812693 | 21.235392 | 20.975134 | 20.452393 | 0.339007 | 0.065819 | 0.068089 | 0.083324 | 0.200125 | 0.234215 | 0.072747 | 0 | 0 |
| 1237658206127063746 | 202.59702759 | 49.86654552 | 23.32292 | 23.381905 | 22.309504 | 22.183277 | 21.030251 | 0.700541 | 0.304392 | 0.212668 | 0.299569 | 0.400573 | 0.50878 | 0.165009 | 0 | 0 |

- http://skyserver.sdss3.org/dr8/en/

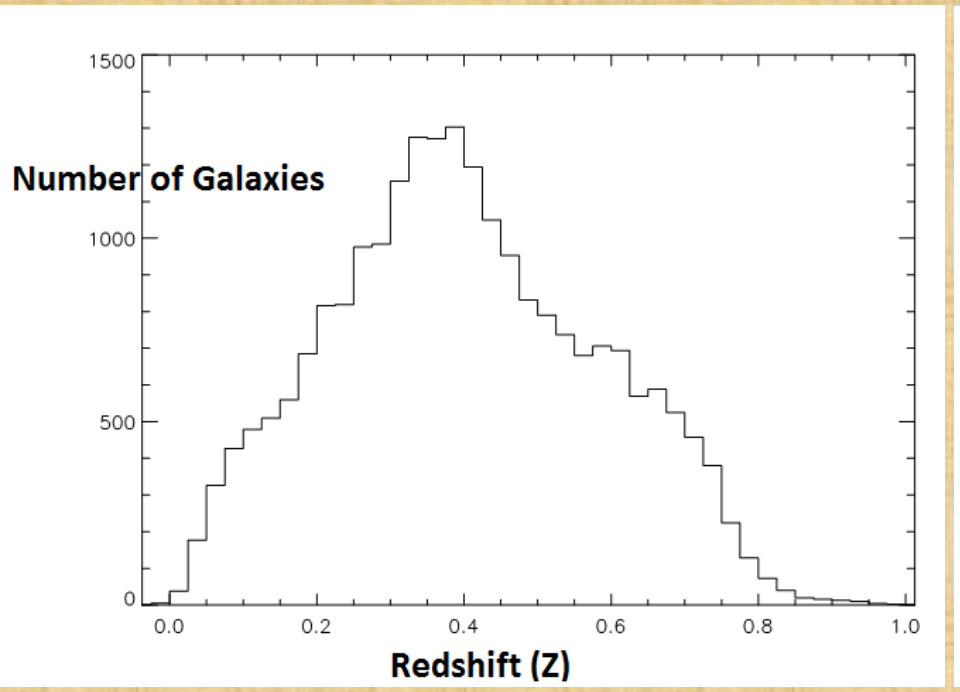
# Parameter Space to Explore

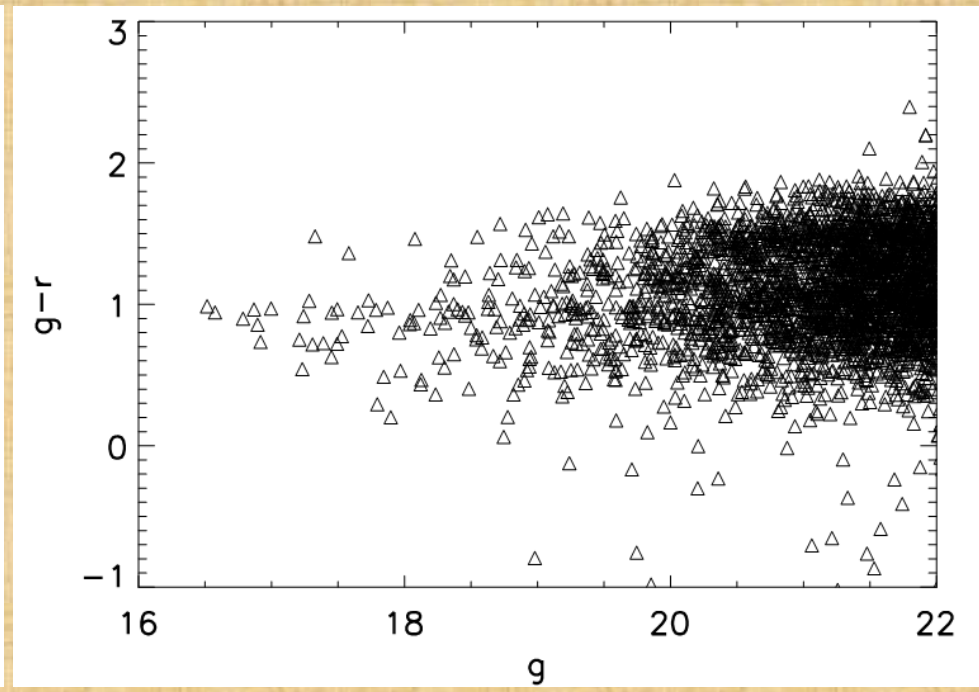
- Templates (Burst, Sa, Scd…)
- Probability Cuts (1st redshift, 2nd redshift)
- Reddening Laws (Allen, Seaton…)
- Z Ranges (z: 0-1)
- SDSS Photo-Z's Cut [(|errorZ-Z|)/Z<0.3]
- Z Steps (initial z step)
- Number of the Bands (ugriz, ugri, griz…)
- Magnitude Types (petrosian, psf , model…)

# Strategy

| | Templates | Reddening Laws | Probability cuts | SDSS cuts | Magnitude types | Number of Band | Z steps | Z ranges |
|---|---|---|---|---|---|---|---|---|
| **Reference** | CWW-ALL | 2 | 80-50 | 0.3 | Model | UGRIZ | 0.025 | 0-1 |
| **Changing templates** | CWW-ALL, CWW-E, BC-E,BC-ALL | | | | | | | |
| **Changing Reddening Laws** | | 0, 1,2 | | | | | | |
| **Changing Probability cuts** | | | 95-30, 90-40, 80-50, 50-50 | | | | | |
| **Changing SDSS cuts** | | | | 0.3, 0.5, 1 | | | | |
| **Changing Magnitude types** | | | | | Model, PSF, Petro | | | |
| **Changing Number of Band** | | | | | | UGRIZ, GRIZ, UGRI | | |
| **Changing Z steps** | | | | | | | 0.05, 0.025 | |
| **Changing Z ranges** | | | | | | | | 0-1, 0-2 |

# Input SDSS Catalog

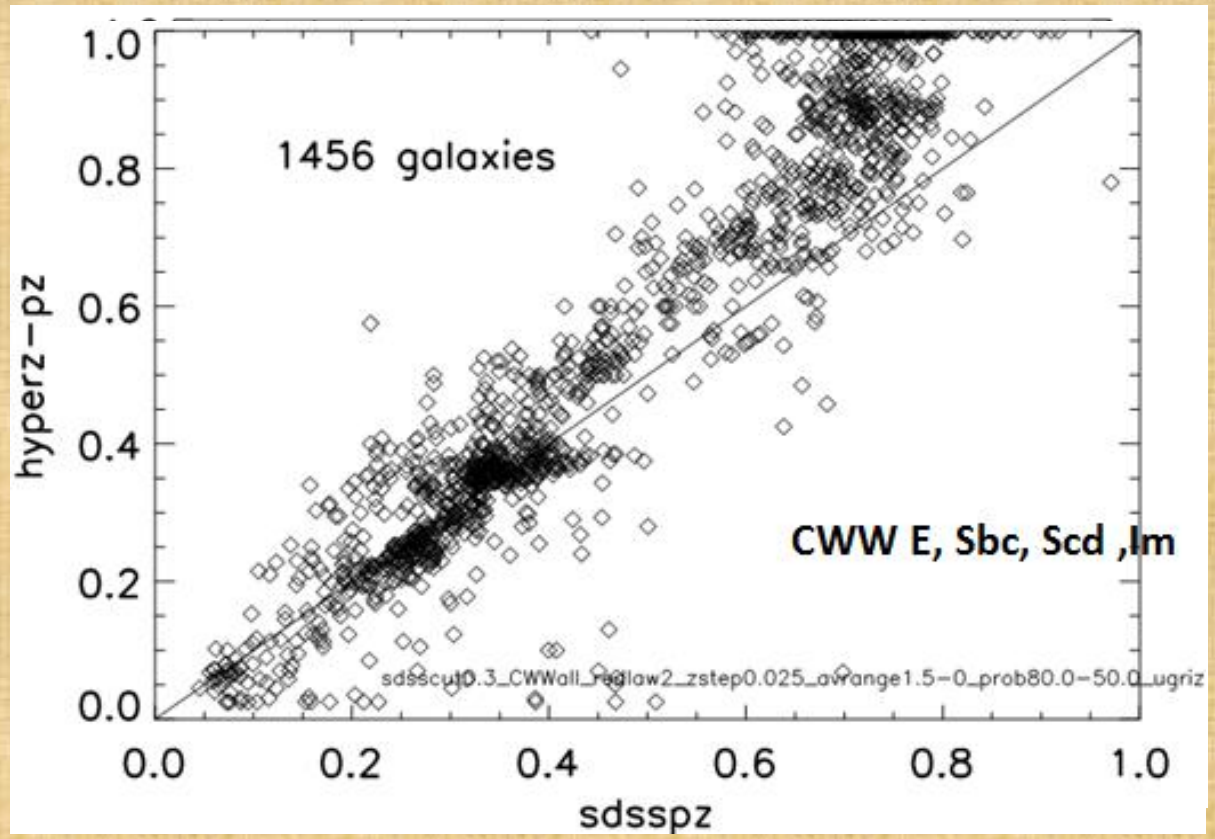


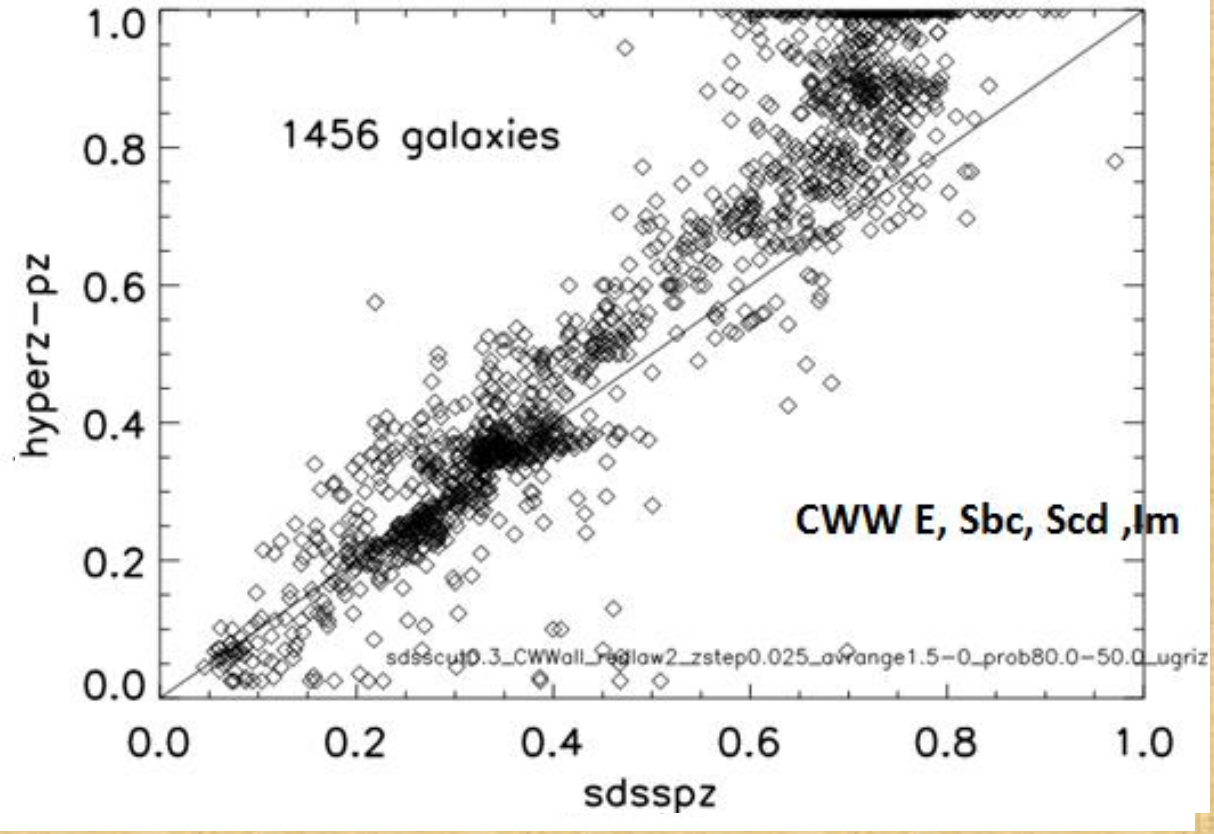
# Reference Data

- Template: CWW E, Sbc, Scd, Im
- Probability cut = $1^{st}$ redshift >80%, $2^{nd}$ redshift<50%
- SDSS Photo-Z's cut ($\Delta z/z$)<0.3
- Magnitude type: Model
- Reddening Law= Seaton
- Z steps = 0.025
- Z ranges : 0-1
- Filters : ugriz

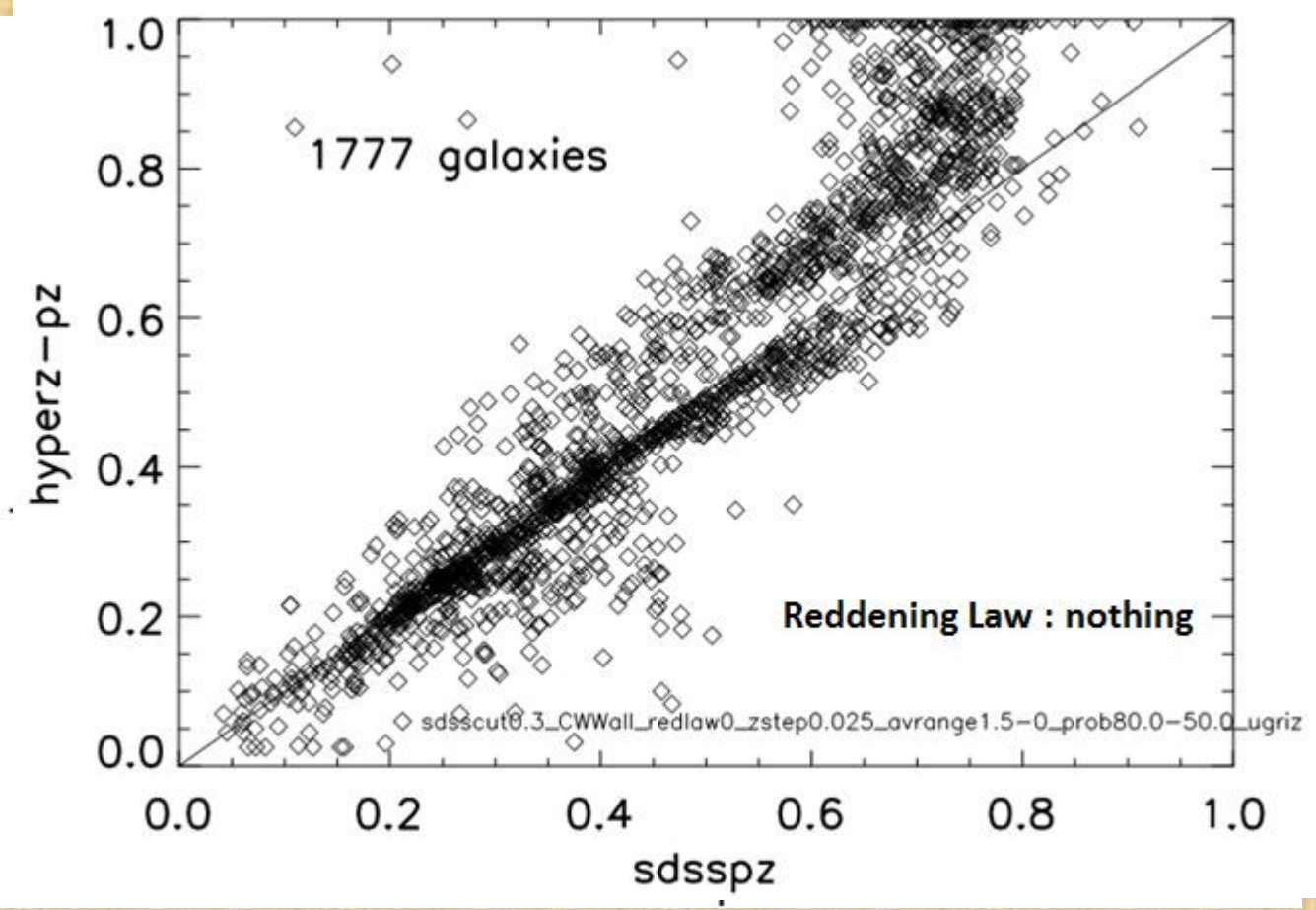
# Changing templates--CWW



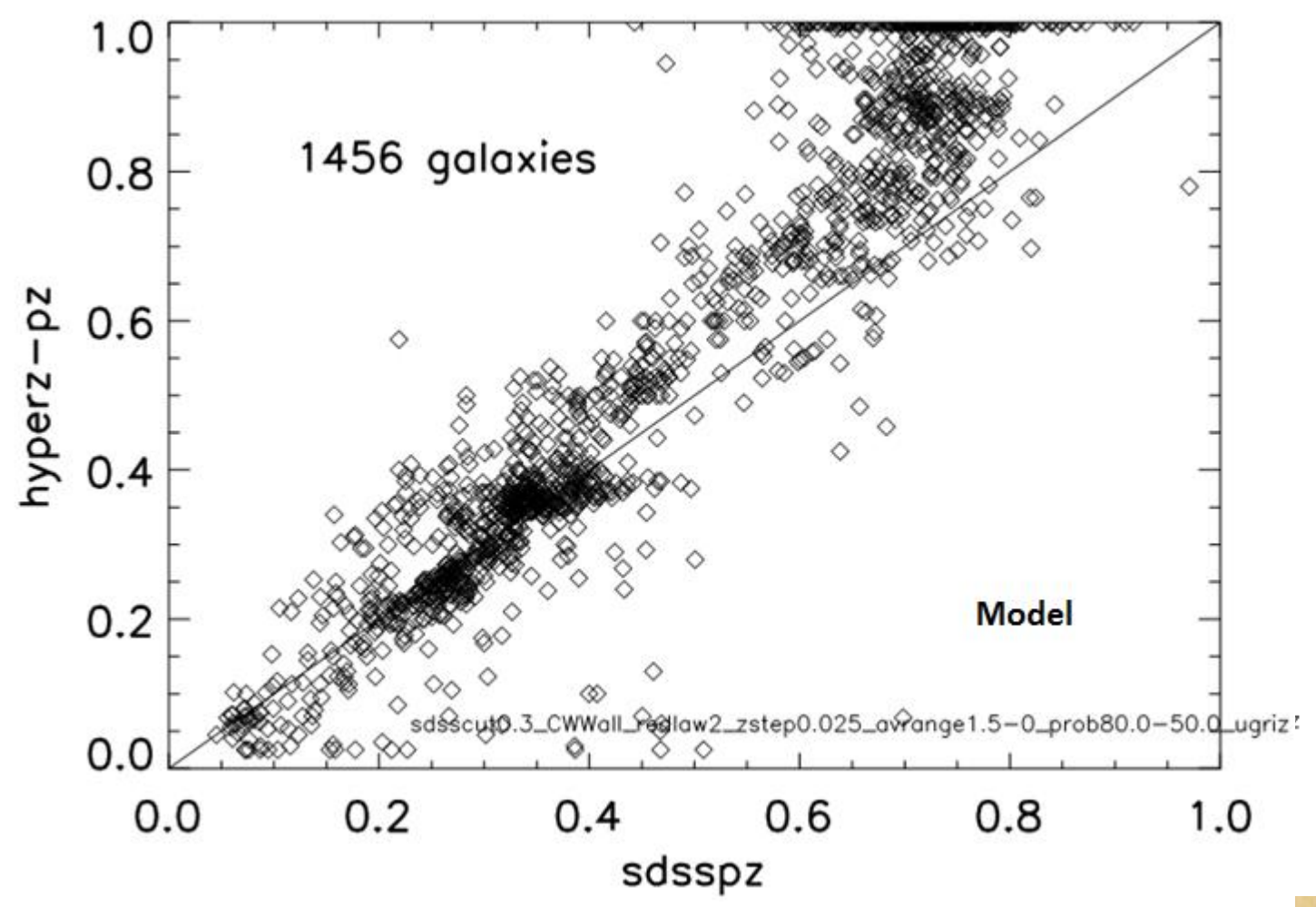
# Changing templates-- BC V.S. CWW



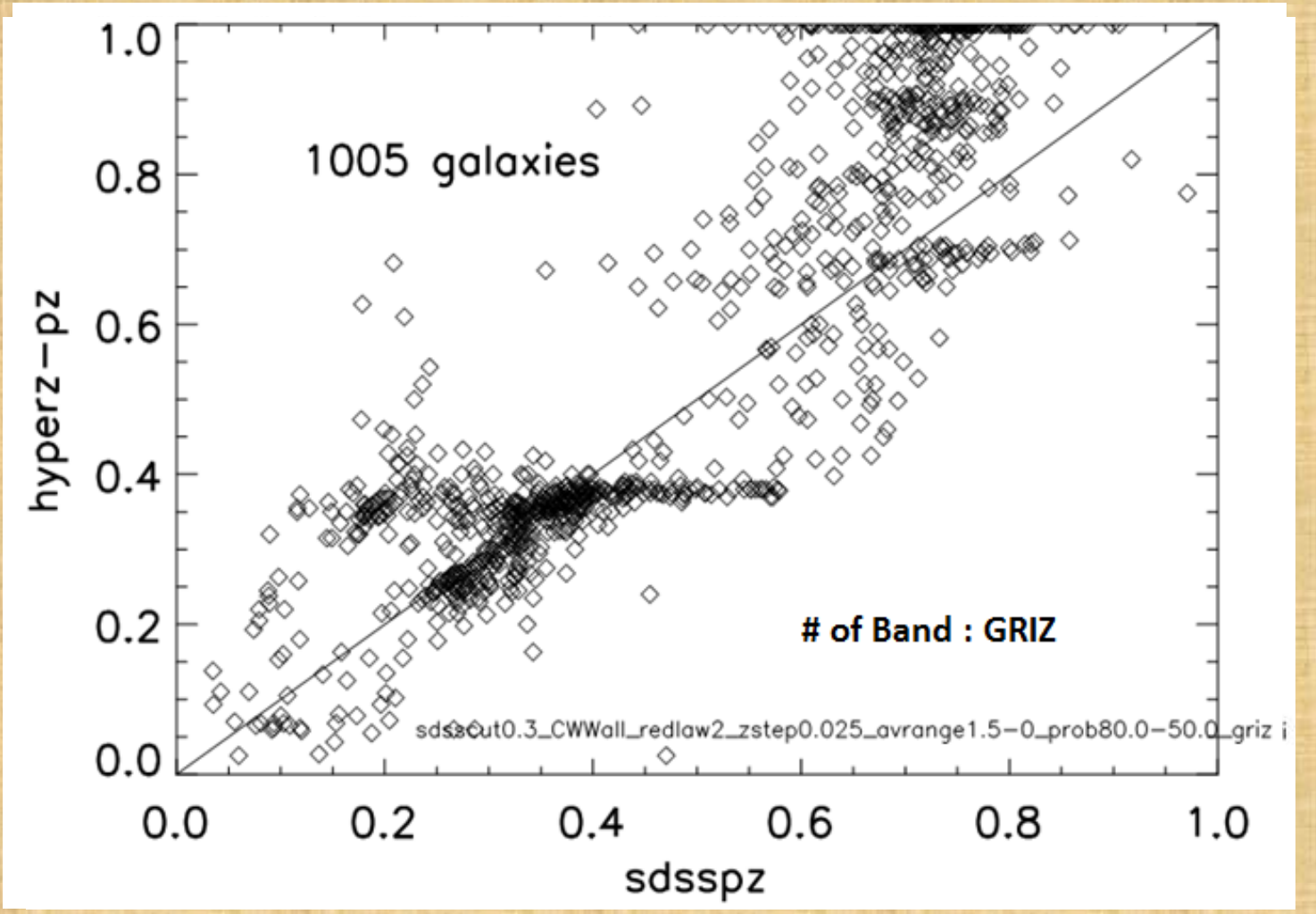
# Changing Reddening Laws



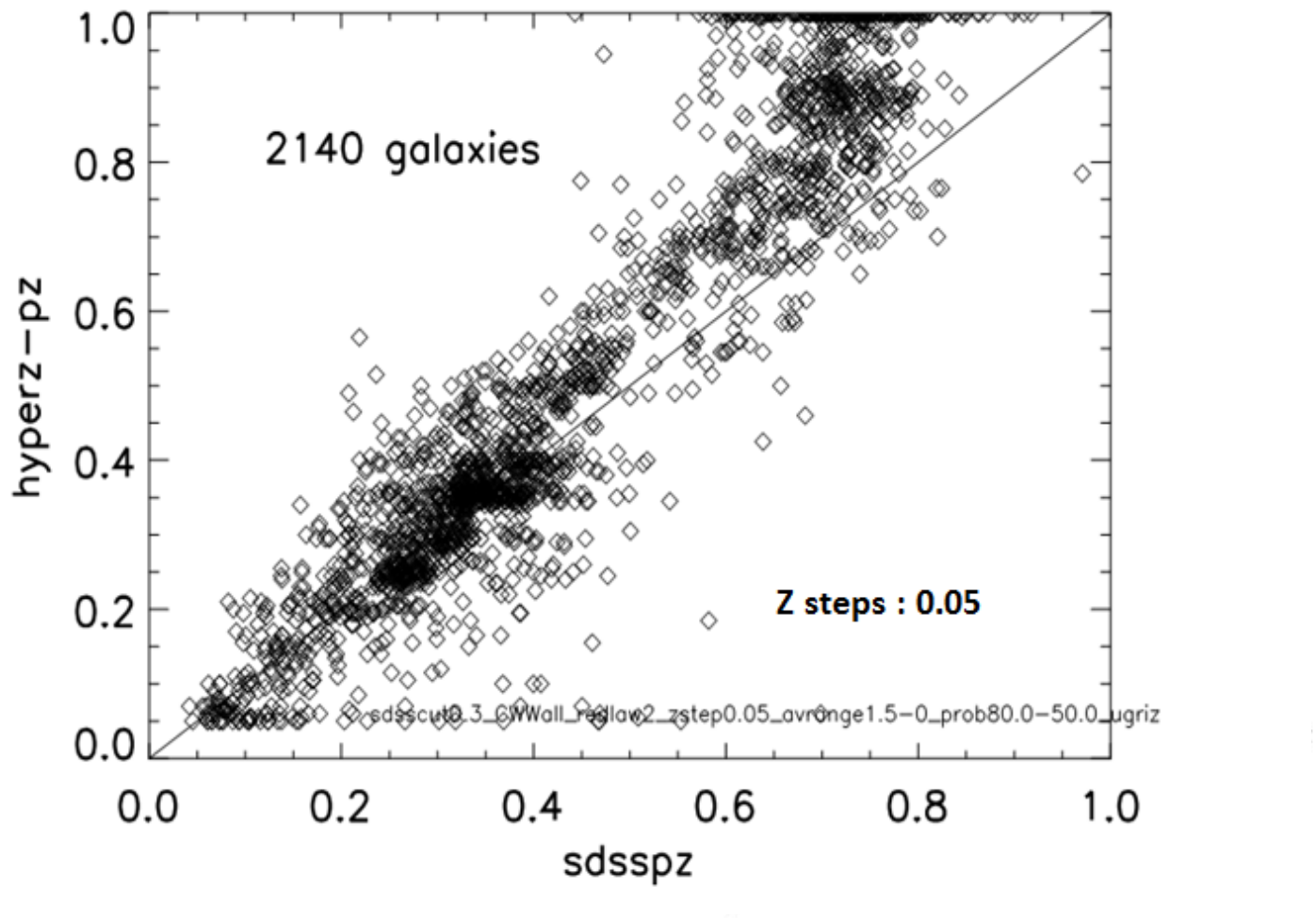
# Changing Magnitude types



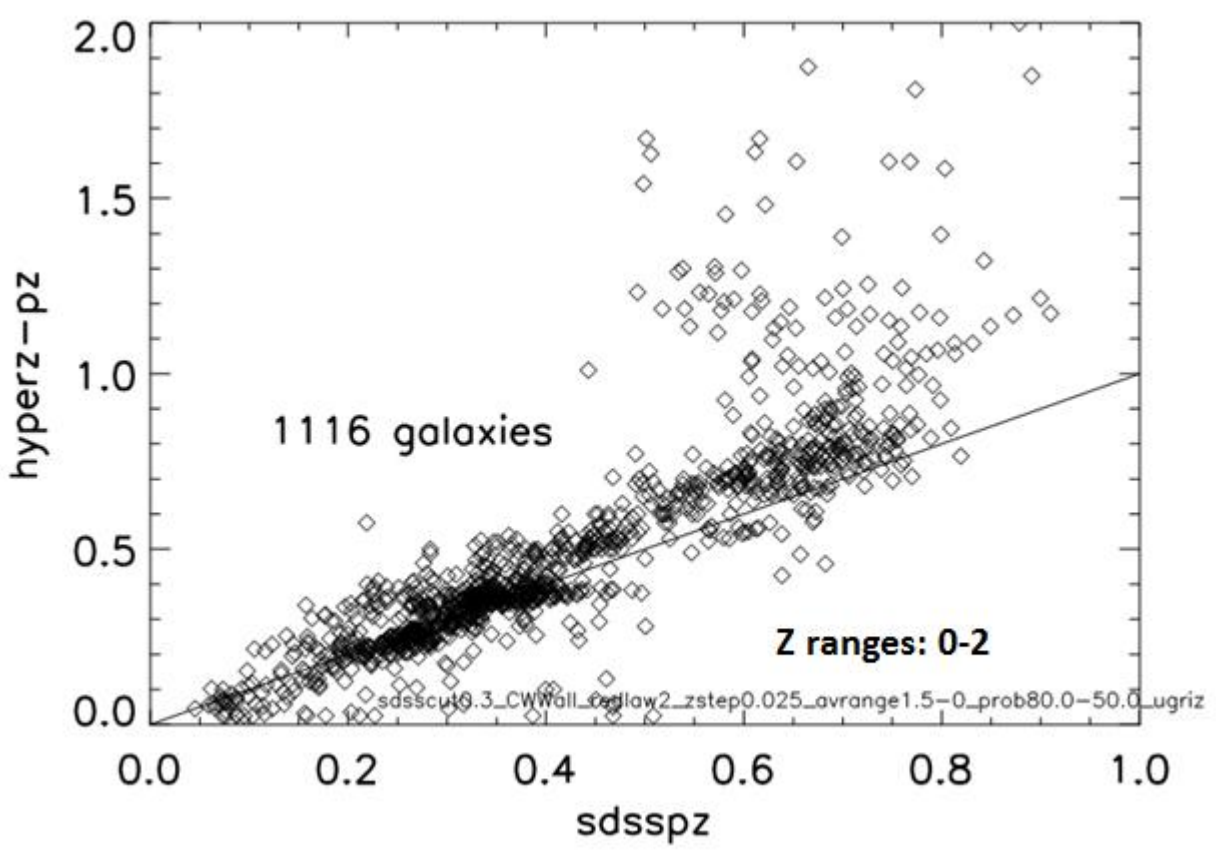
# Changing Number of Bands



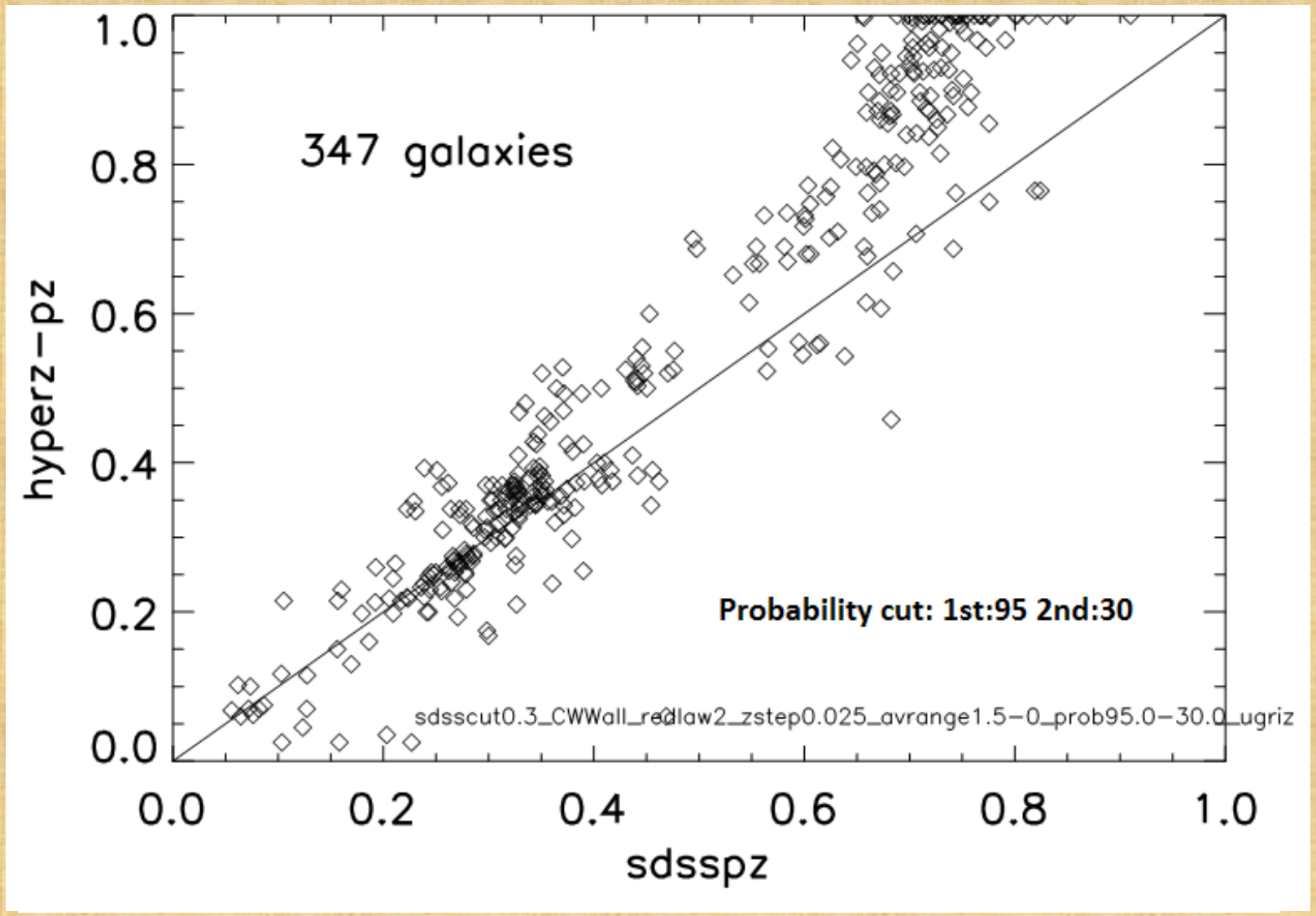
# Changing Z steps



# Changing Z ranges

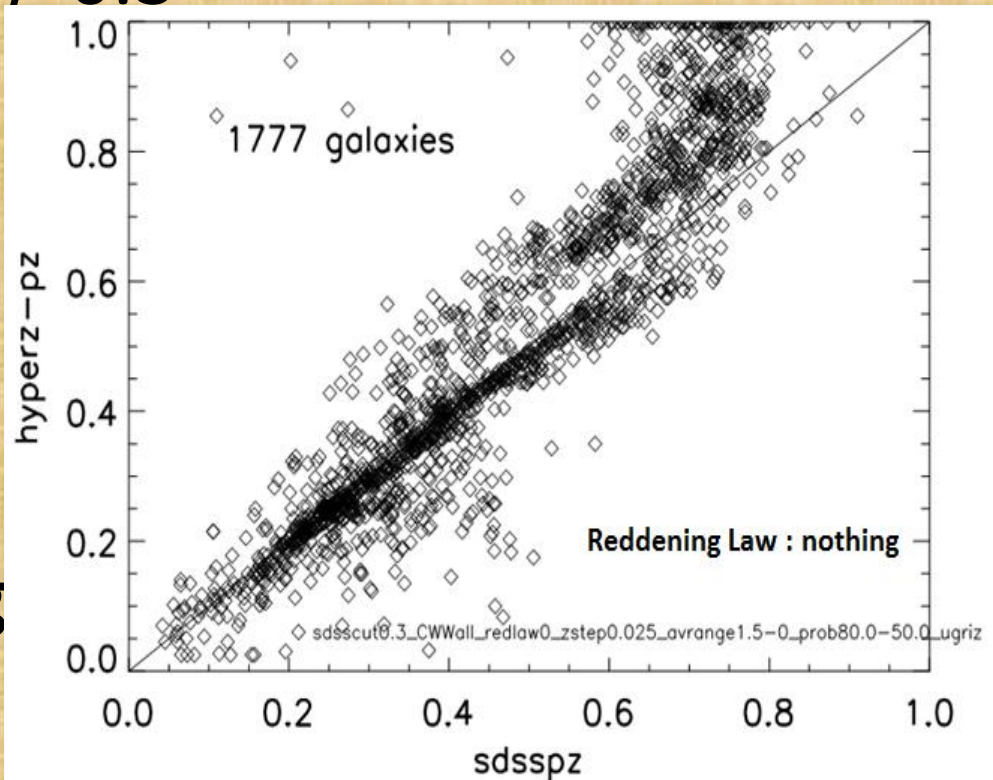


# Changing Probability Cuts



# Best fit

- Probability cut = 1st redshift >80%, 2nd redshift<50%
- Template: CWW E, Sbc, Scd, Im
- SDSS Photo-Z's cut (Δz/z)<0.3
- Magnitude type: Model
- Z steps = 0.025
- Z ranges : 0-1
- Band : ugriz
- Reddening Law: **nothing**



# Summary

- Need photo-Z code has to be used cautiously.
- If we change some template, the parameter is opened more, the output might be worse.
- If we change reddening law, it is better that there are no setting reddening law.
- If we change different magnitude type, the model magnitude is still the best fit.

- If we plus value of z steps, it will shows the steps.
- If we change z ranges, some of worse data might be out of SDSS range.
- If we clean by probability, Hyper-Z generated photo-Z agrees with SDSS photo-Z reasonably ($\Delta$ z=0.05).

# Future Work

- More quantitative analysis.
- Compare to Spectroscopic redshifts.
- More test other codes (EAZY, Le Phare, Bpz…)
- Includes NIR-bands (UKIDSS J, H, K band)
- Other telescopes (**ALMA**, Subaru, CFHT…)
- Cluster membership analysis.
- Luminosity Function.