RAIL: a platform for photometric redshift production and research Overview and Tutorial

LINCC Tech Talk, Nov 13 2024

Tianqing Zhang on behalf of RAIL team

The goal of the tutorial

- Understand a basic background of photometric redshift, and its relation to other topics in DESC
- Understand how RAIL is designed and its basic functionality
- Install RAIL or use RAIL in a pre-installed environment
- Get some photo-z results and make some plots!
- Basic understanding of the RAIL pipeline

Photometric redshift

For LSST, we determine most galaxies' distance (redshift) by photometric information – photometric redshift (photo-z).

Photometric information: magnitude of a reference band, and colors (difference in magnitude between two bands)

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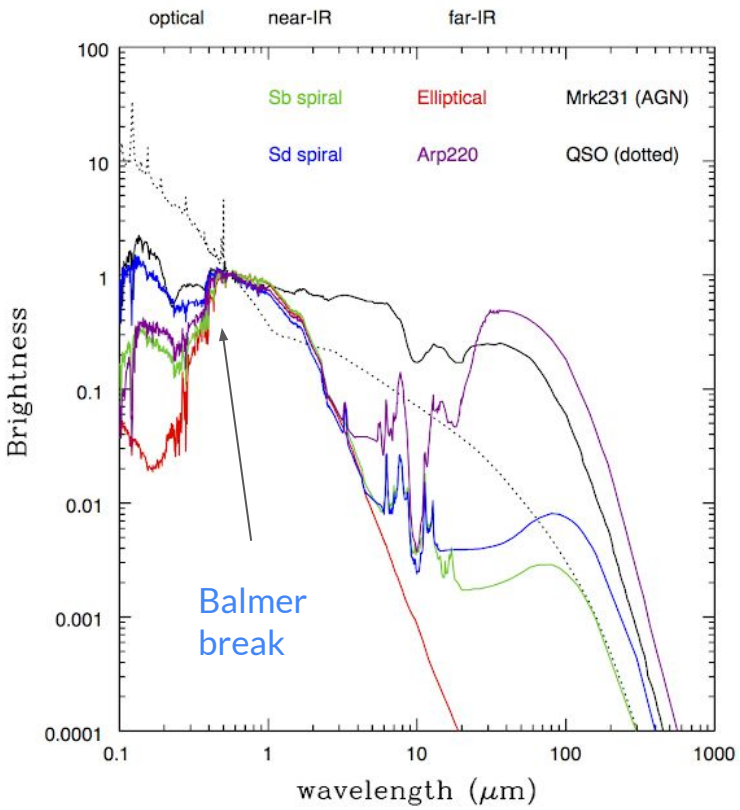
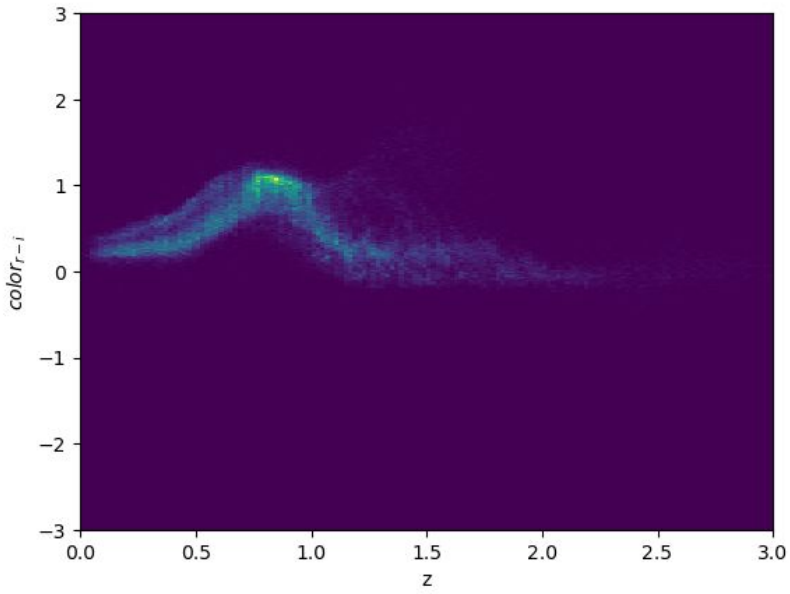
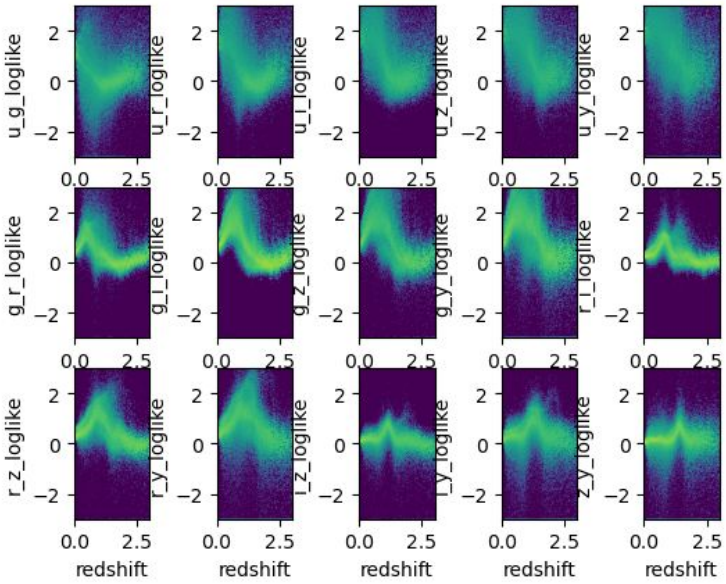
Colors in visible/IR bands are sensitive to redshift because the ~3600A Balmer break traverse through 400-1200 nm from z=0~2



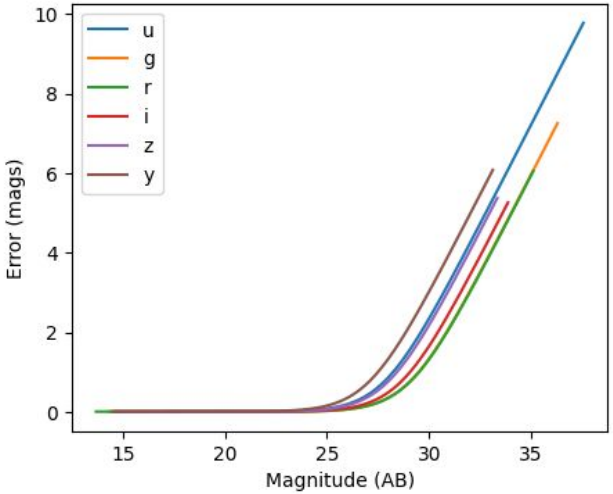
Credit: CANDLES, spectra of different objects

Redshift information from color





Photometric uncertainties



Photometric uncertainties blow up for dim objects

Quoting photo-z performance without stating what sample or limiting magnitude you are using is not useful

The challenges in photo-z studies

There are dozens of photo-z methods, categorized by whether they are data-driven or physics-driven (Salvato et al., Newman et al.). **They are written in different languages, expecting different format of input/output, different treatment of corner cases.**

This makes it very challenging to

1. Compare multiple methods on the same dataset (bias, variance, outliers, speed)
2. Efficiently produce photo-z products
3. Save configuration of multiple runs
4. Ensure safeguards are implemented

RAIL is designed to solve these issues.

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B. The bulge and disk structure
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RAIL: Redshift Assessment Infrastructure Layers

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Developers of the RAIL package: DESC pipeline scientists, LINCC frameworks scientists and engineers, DESC in-kind contributors, etc.

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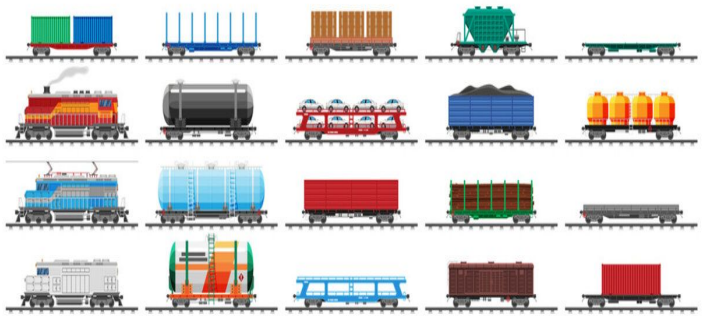
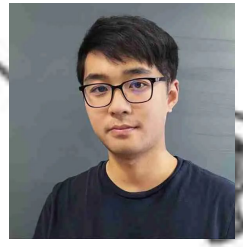


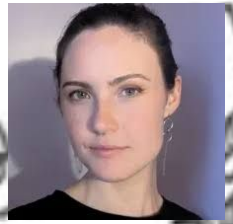
The RAIL Team

John-Franklin Crenshaw

Drew Oldag



Tianqing Zhang



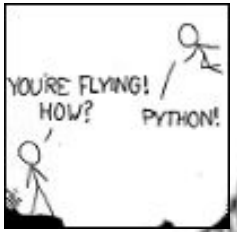
Olivia Lynn

Qianjun Hang

Luca Tortorelli

Eric Charles

Sam Schmidt



Alex Malz

Ziang Yan

Jan Luca van den Busch

And many others

TASK 1: Install RAIL / Use the NERSC environment

Installation how-to: https://rail-hub.readthedocs.io/en/latest/source/installation.html

Developer installation:

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git clone https://github.com/LSSTDESC/rail.git

cd rail

conda env create -f environment.yml -n [env]  # or mamba env create, which is much faster

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RAIL stages: getting photo-z's

Model
RAIL Stage
Data

	Name	Functionality	Examples
1.	Informer	Training/Preparing a photo-z model	Spec-z X photometry → Tree-Pz informer → Tree model
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Available photo-z methods

Template fitting

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LePhare paper rail_lephare

Machine Learning

CMNN paper rail_cmnn: Color-Matched Nearest Neighbor

FlexZBoost paper rail_flexzboost: xgboost

GPz paper rail_gpz: sparse Gaussian process

TPz paper rail_tpz: Tree PZ

PZFlow rail_pzflow: normalizing flow

SciKit Learn methods: KNN, Neural Net, RF, etc

Hybrid

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DNF

Image-based ML

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Summarizers

Naive Stacking: Stack p(z)

NZ_DIR direct calibration n(z)

SOM: somoclu, SOMpz

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RAIL Stages: creating mock data

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Available engine and degraders

Engines

Pzflow engine

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Noisifier

Photometric error model (add noise to photometry)

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RAIL Namespace stuff

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- But all RAIL packages share the same name space
  - A namespace is a system that has a unique name for each and every object in Python
- RAIL namespace is organized in the following way:
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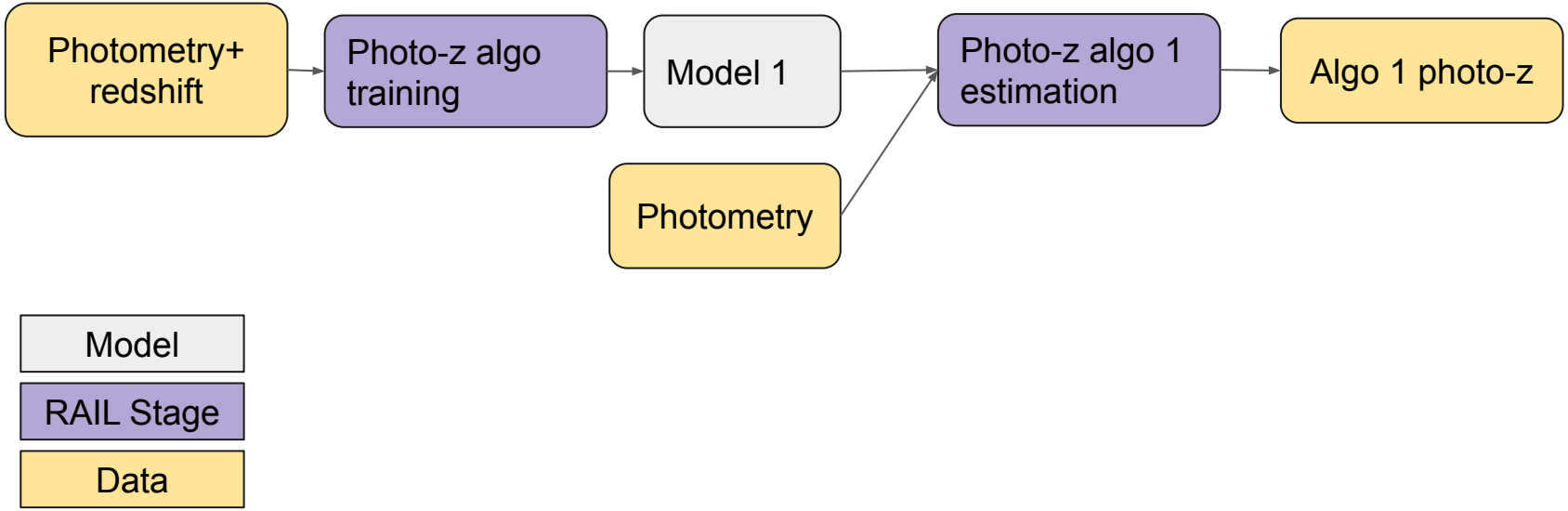
TASK 2: GET SOME PHOTO-Z

Go to RAIL_estimation_demo.ipynb

RAIL pipeline

You can put multiple RAIL stages together to form a pipeline, as long as they can be represented by a Directed Acyclic Graph (meaning, no loop)



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Pipeline YAML files

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log_dir: ./log
modules: rail
output_dir: .
resume: false
site:
  max_threads: 2
  name: local
stages:
- classname: GPzInformer
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```

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> ceci [ceci_config.yml]

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  aliases:
    model: model_inform_gpz
  bands:
  - HSCg_cmodel_dered
  - HSCr_cmodel_dered
  - HSCi_cmodel_dered
  - HSCz_cmodel_dered
  - HSCy_cmodel_dered
  config: null
  csl_binwidth: 0.1
  csl_method: normal
  err_bands:
  - g_cmodel_magerr
  - r_cmodel_magerr
  - i_cmodel_magerr
  - z_cmodel_magerr
  - y_cmodel_magerr
  gpz_method: VC
  hdf5_groupname: ''
  hetero_noise: true
  input: None
  learn_jointly: true
  log_errors: true
  mag_limits:
    HSCg_cmodel_dered: 27.88
    HSCi_cmodel_dered: 26.6
    HSCr_cmodel_dered: 27.05
    HSCy_cmodel_dered: 25.64
    HSCz_cmodel_dered: 26.6
  max_attempt: 100
  max_iter: 200
  model: model/estimator/model_gpz.pkl
  n_basis: 50
  name: inform_gpz
```

The RAIL Tutorial

DESC Sprint week @ SLAC Fall 2024

TQ, Eric on behalf of the RAIL team

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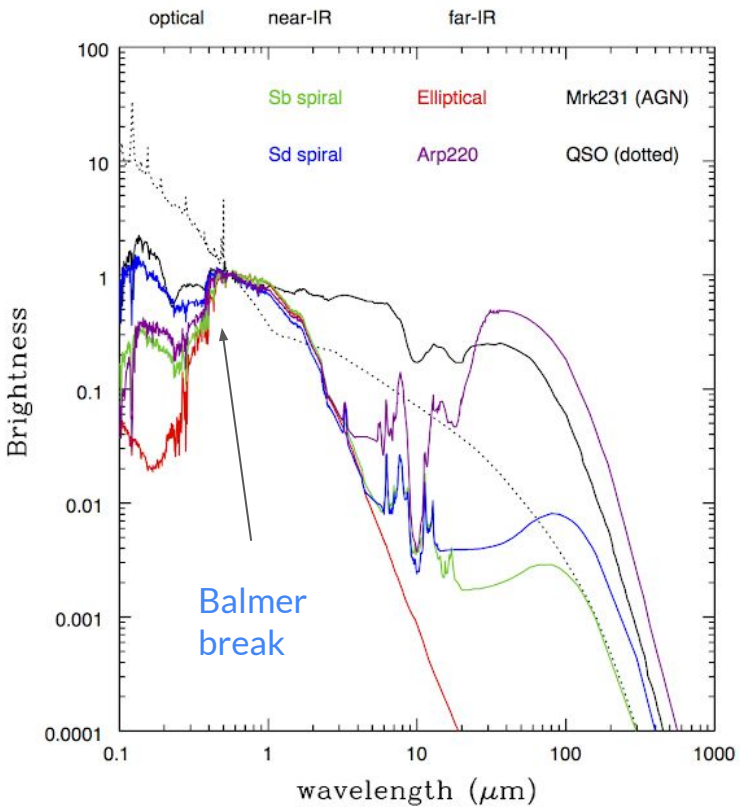

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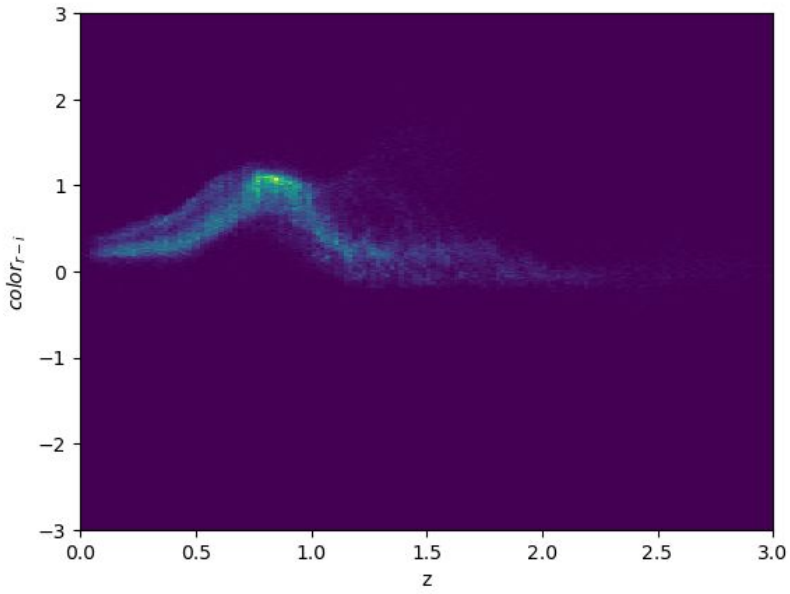

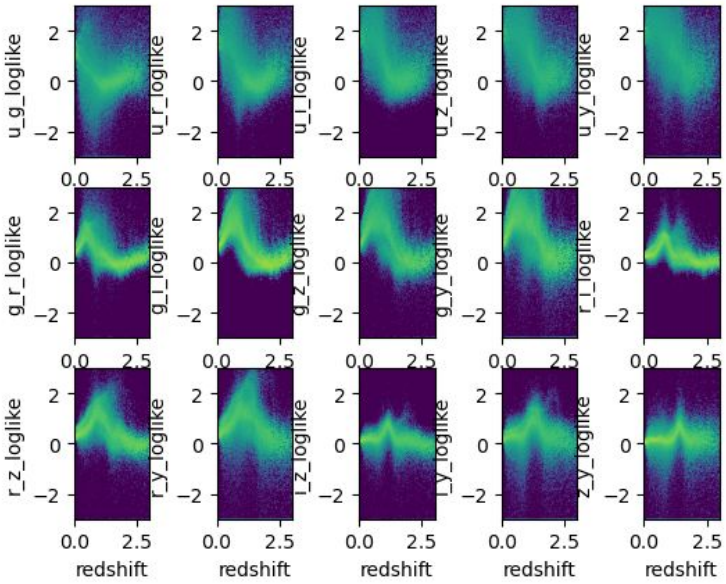

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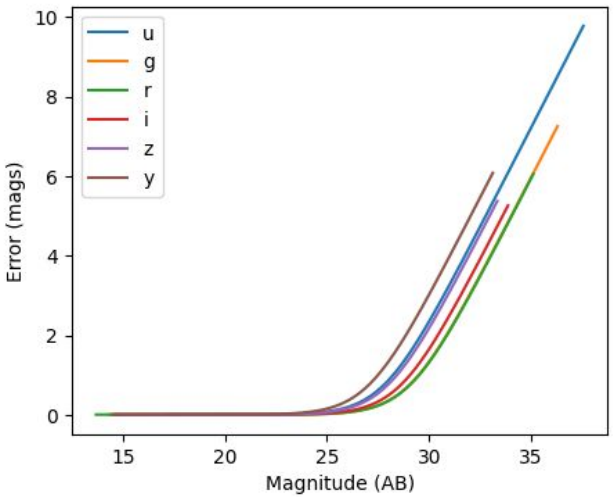

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*Slide borrowed from Eric Charles

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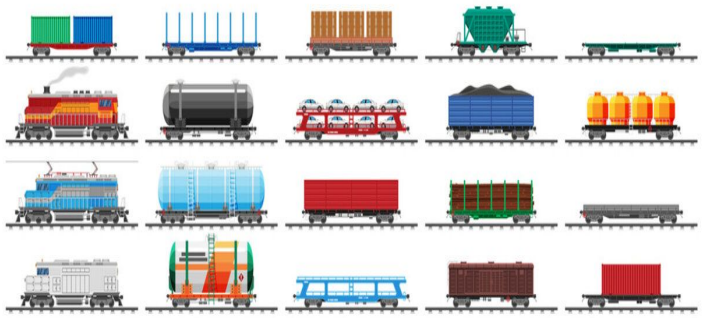

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Log in NERSC:

```
python /global/common/software/lsst/common/miniconda/start-kernel-cli.py
desc-python-bleed
```

Or initialize a RAIL notebook in `desc-python-bleed`

Pull the example from rail-hub:

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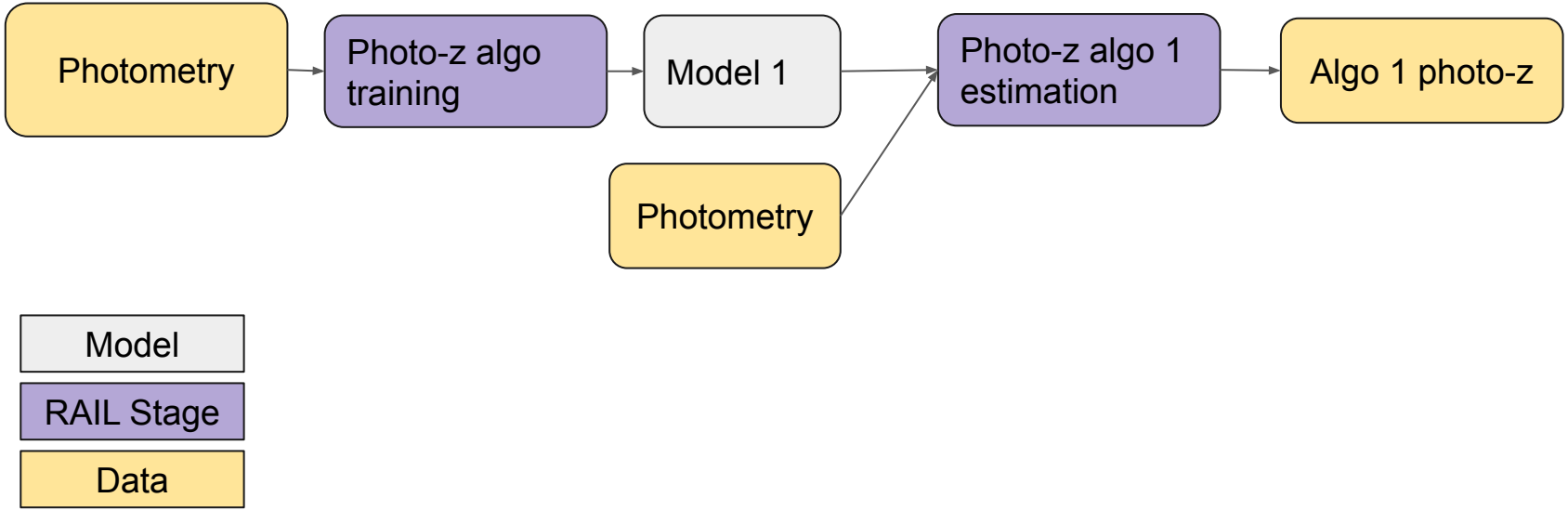

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  config: null
  csl_binwidth: 0.1
  csl_method: normal
  err_bands:
  - g_cmodel_magerr
  - r_cmodel_magerr
  - i_cmodel_magerr
  - z_cmodel_magerr
  - y_cmodel_magerr
  gpz_method: VC
  hdf5_groupname: ''
  hetero_noise: true
  input: None
  learn_jointly: true
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