All aboard! RAIL <3 TVS SN

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LINCC Frameworks

LINCC Tech Talk

LINCC Frameworks

- Stands for LSST Interdisciplinary Network For Collaboration And Computing
- Schmidt Futures Foundation-funded collaboration between
  UW, CMU, LSSTC, U Pitt, and NOIRLab
- Enables LSST science by developing scalable and productionised software/algorithms in collaboration with professional software engineers
- Activities include workshops, hack weeks, and incubators

Highlights of first LINCC Tech Talk

LINCC Frameworks Collaboration

Additional venues for collaboration:

- Workshops - Work with LSST Science Collaborations to identify areas of need.
    - Data to Software to Science Workshop (March 2022)
    - Whitepaper summary of DSS: arXiv:2208.02781
- Hackweeks - Provide tutorials and training in any new tools / frameworks.
- Incubators - Scientists work with team to get their science applications working (open proposal process).
- LINCC Frameworks members joining Science Collaborations.

Workshop: From Data to Software to Science with the Rubin Observatory LSST

Workshop goals:

1. Enabling *interactive development* of exciting scientific use cases for early LSST data, and identifying the common computational/technical challenges and enabling technologies associated with them.
2. Promoting the development of a broad and inclusive community of researchers engaged with LINCC Frameworks.

Paper: https://arxiv.org/abs/2208.02781

	Cross-matching	Photo-z	Selection functions	Time series	Image reprocessing	Image analysis
Cosmology	✓✓	✓✓	✓✓	✓✓	✓	✓
Extragalactic static	✓✓	✓✓	✓✓		✓✓	✓
Extragalactic transient	✓✓	✓✓	✓	✓✓	✓	✓
Extragalactic variable	✓✓	✓	✓	✓✓	✓	✓
Local Universe transient & variable	✓✓		✓	✓✓		
Local Universe static	✓✓		✓✓		✓	✓
Solar system	✓		✓✓	✓✓	✓	✓✓

Table 1. Table highlighting the connection between scientific and technical areas discussed at the workshop. Rows are science areas while columns are for infrastructure capabilities. A double checkmark (✓✓) signifies that some infrastructure capability is essential to enable a particular scientific area, while a single checkmark (✓) signifies that the infrastructure capability would enhance or expand scientific discovery within that area but is not necessary to enable all of it.

Redshift Assessment Infrastructure Layers (RAIL) github.com/LSSTDESC/RAIL

A starting point for a photo-z framework

But first, some context (from DESC PZ onboarding slides)

Schmidt, Malz & Soo, et al. (2020) overview

Motivation

To identify the best photo-*z* PDF estimation code for DESC pipelines

Data

DC1 was a DC2 precursor mock data set

N-body-based cosmological redshifts & photometry

Methods

Controlled comparison of 11+ photo-*z* PDF estimation codes

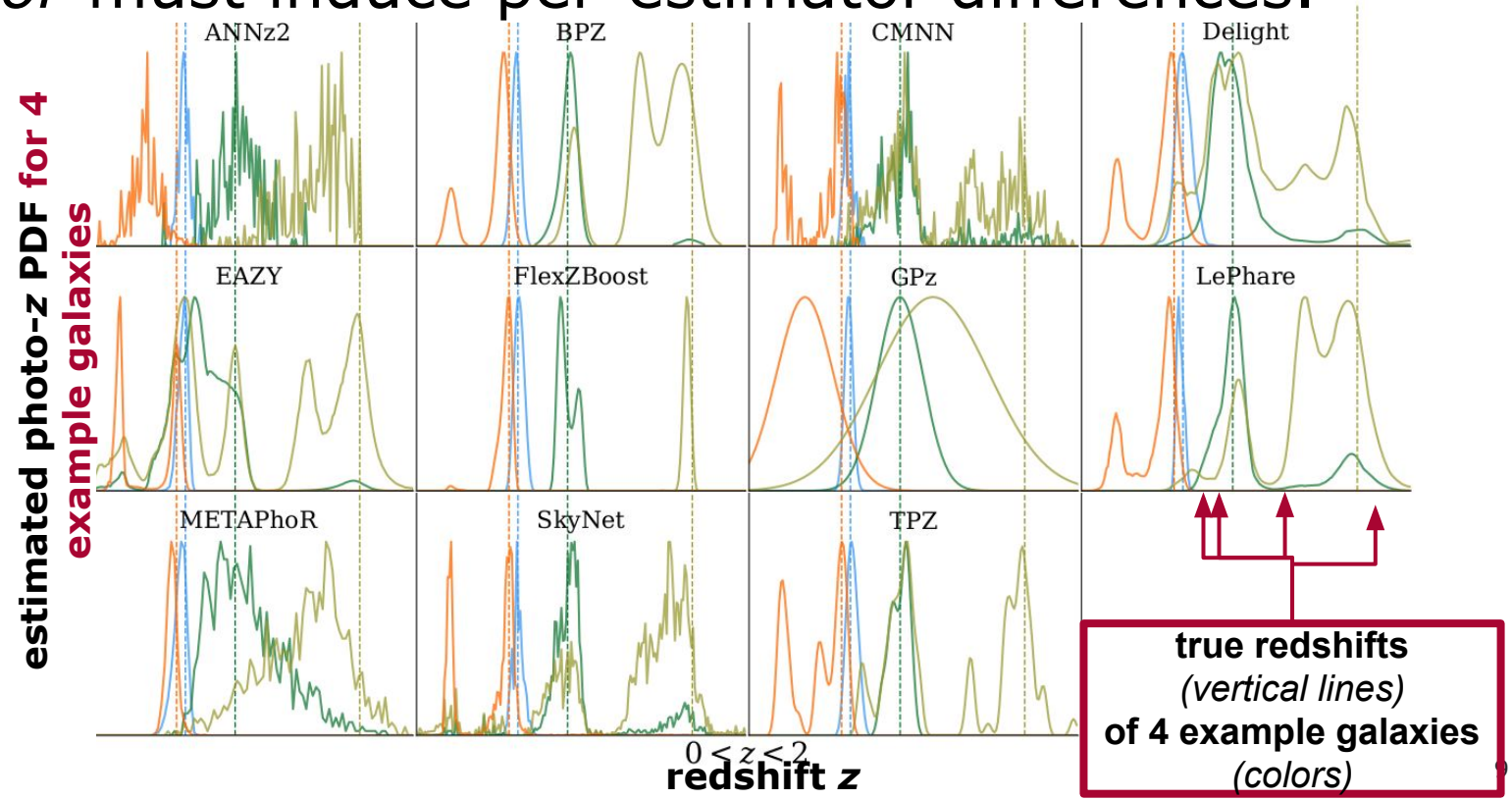
Evaluated performance by all standard metrics (and then some)

Baseline test before introducing realistic conditions

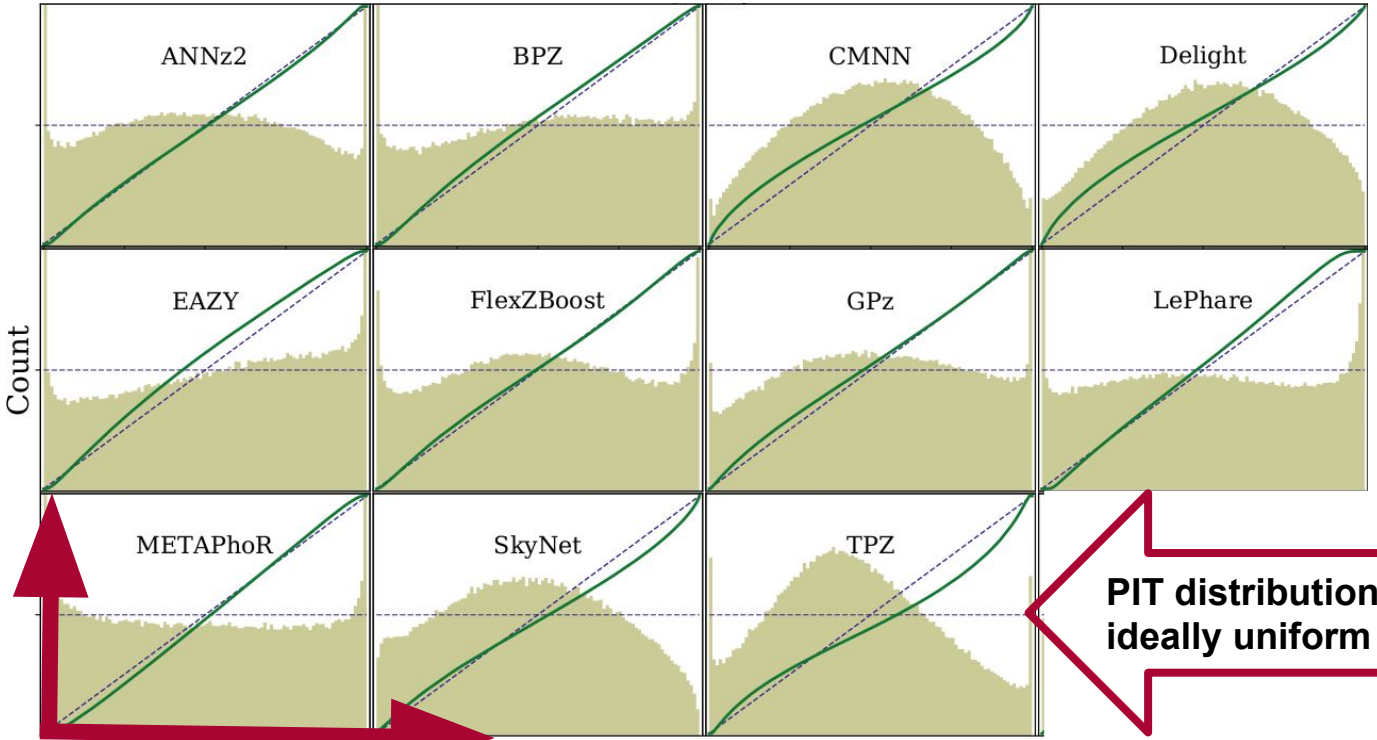
Experimental control: All estimators shared perfect prior information

- A representative training set for machine learning codes
- The true SED templates for model-fitting codes

Under shared prior information, an *implicit prior* must induce per-estimator differences.

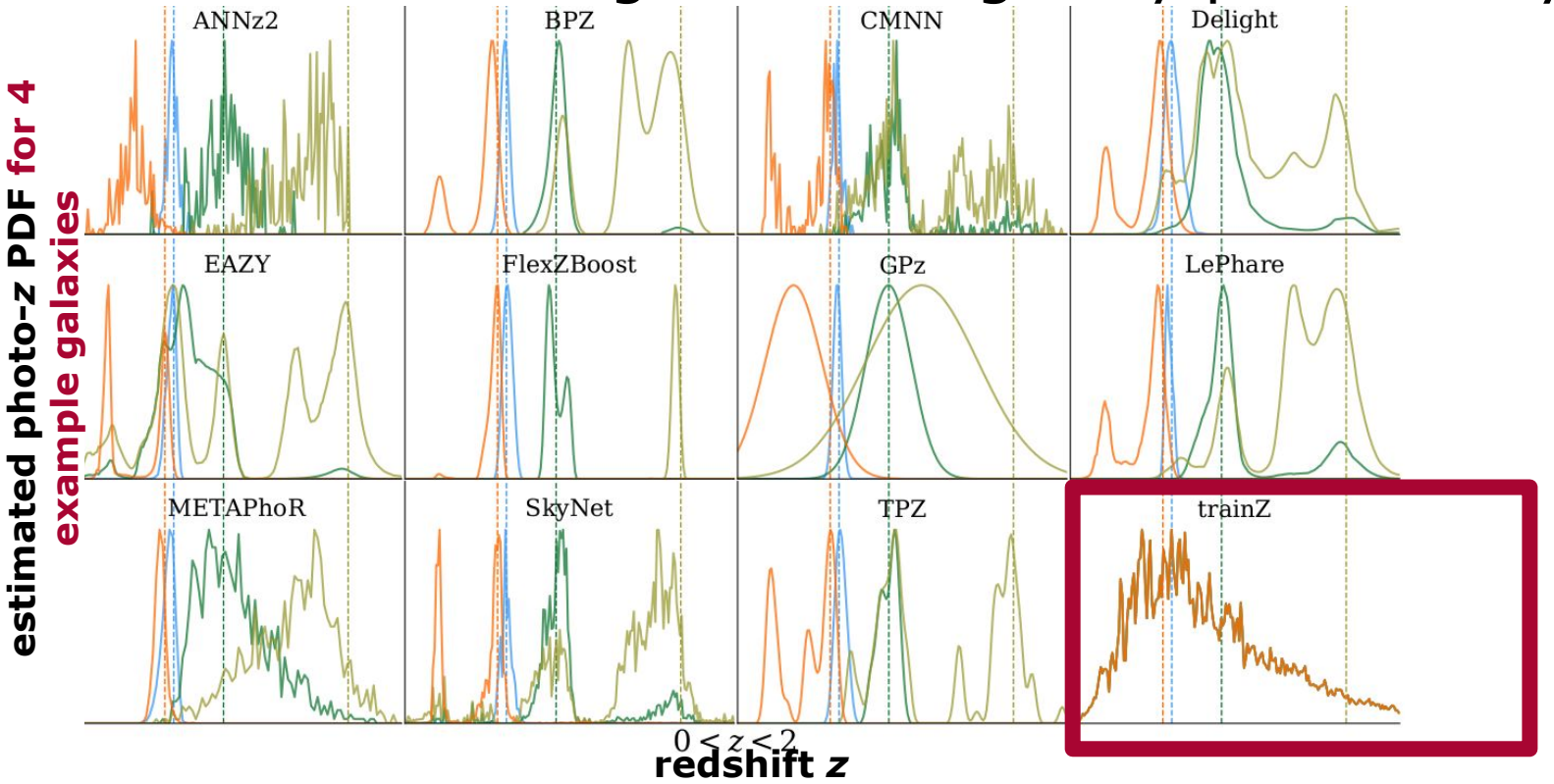


Even under perfect prior information, no method yields perfect photo-*z* PDFs.

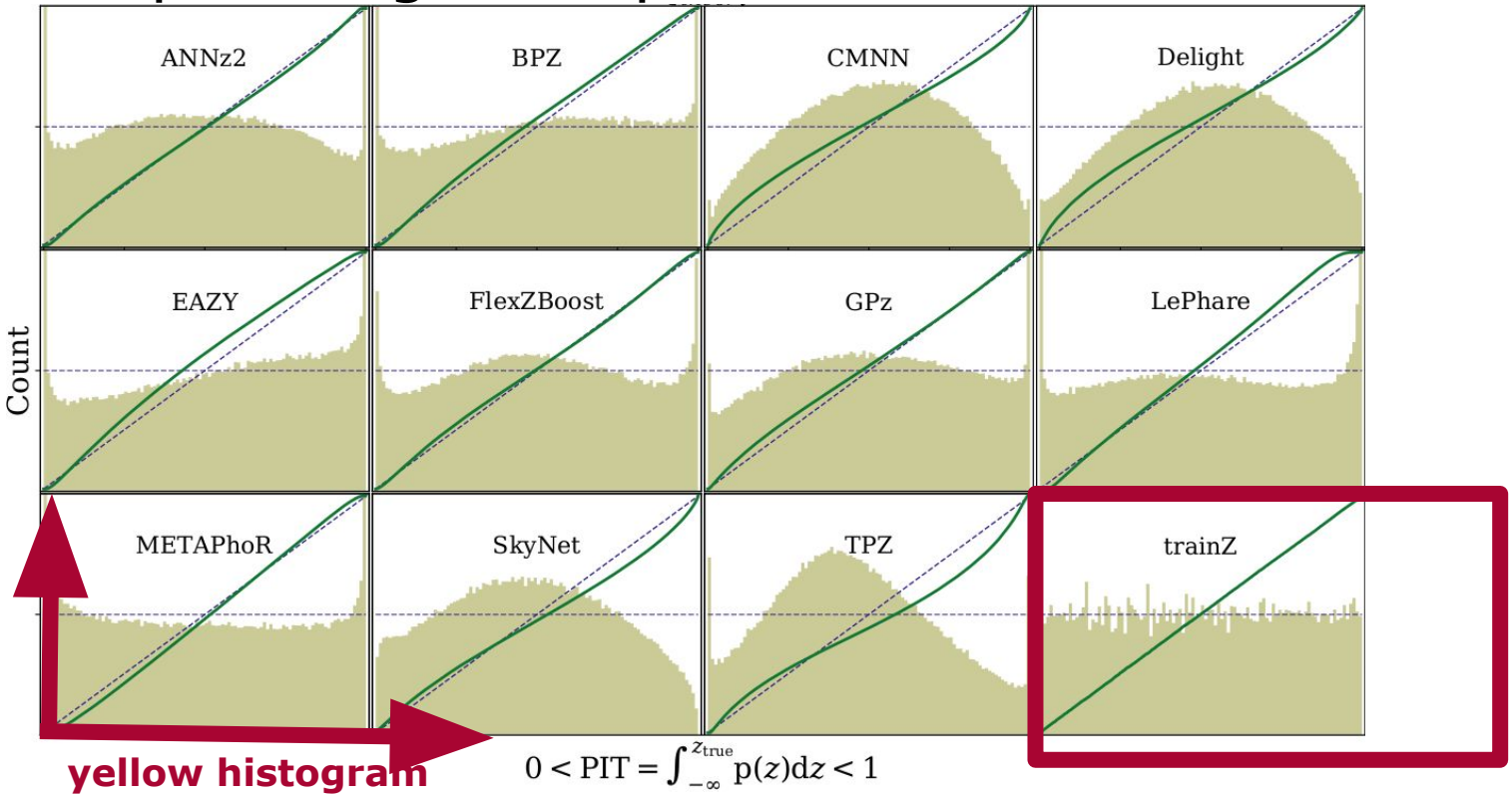


PIT distribution *(yellow histogram)*
ideally uniform *(flat dotted line)*

The experimental control returns the training set redshift distribution regardless of galaxy photometry.



Traditional metrics of photo-*z* PDFs favor the pathological experimental control.



Schmidt, Malz & Soo, et al. (2020) conclusions and next steps

Each photo-*z* posterior estimator is distinguished by its implicit prior. → The implicit prior must be isolated to use photo-*z* posteriors for DESC cosmology.

No photo-*z* posterior estimator is perfect, even with perfect prior information. → We must probe the response of estimators under realistically imperfect prior information.

Traditional metrics of photo-*z* posterior performance are inappropriate. → To evaluate principled metrics, we must compare estimates to true photo-*z* posteriors.

RAIL Structure

The implicit prior must be isolated to use photo-*z* posteriors for DESC cosmology.

We must probe the response of estimators under realistically imperfect prior information.

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RAIL is a modular toolkit for building end-to-end pipelines for estimating and stress-testing photo-z data products.

Major themes:

RAIL's design facilitates controlled experiments to characterize estimators and mitigate shortcomings.

RAIL is designed to be extensible beyond DESC needs.

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RAIL.creation forward models mock data

Generates mock redshifts and photometry *and* the probability space p(z, data) so
- posteriors p(z | data) and
- likelihoods p(data | z) are accessible

Includes both empirical and
- physical modeling back-ends

Supports realistically complex systematics (degradation) modeling, including:
- emission/absorption line confusion,
- magnitude cuts (shortcuts to surveys),
- observing condition/sky variation,
- magnitude errors over time,

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RAIL.estimation establishes a shared API for photo-z (PDF) algorithms

Currently includes
- BPZ, Delight, FlexZBoost, GPz,
- KNN (two implementations),
- pzflow, SOM (two implementations),

Provides straightforward process
- to wrap more estimators

Supports several I/O formats via tables_io
- *with more coming soon!*

(Also includes summarizers of ensemble redshift distribution)

RAIL Structure

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We must probe the response of estimators under realistically imperfect prior information.

To evaluate principled metrics, we must compare estimates to true photo-*z* posteriors.

RAIL.evaluation supports flexible metrics of photo-z (PDF) estimates

Currently includes:

Bias, IQR, MAD, outlier rate,
PIT plus KS, AD, CvM of PIT,
CDE loss *(and more via qp)*

Provides straightforward process to add more metrics

Actively seeking to implement xSC metrics!

LINCCxRAILxTVS SN

Discussion: next steps for making RAIL useful for TVS

(And everyone is invited to join #desc-pz-rail on the LSSTC Slack!)