How to advance cosmology with the data products of machine learning

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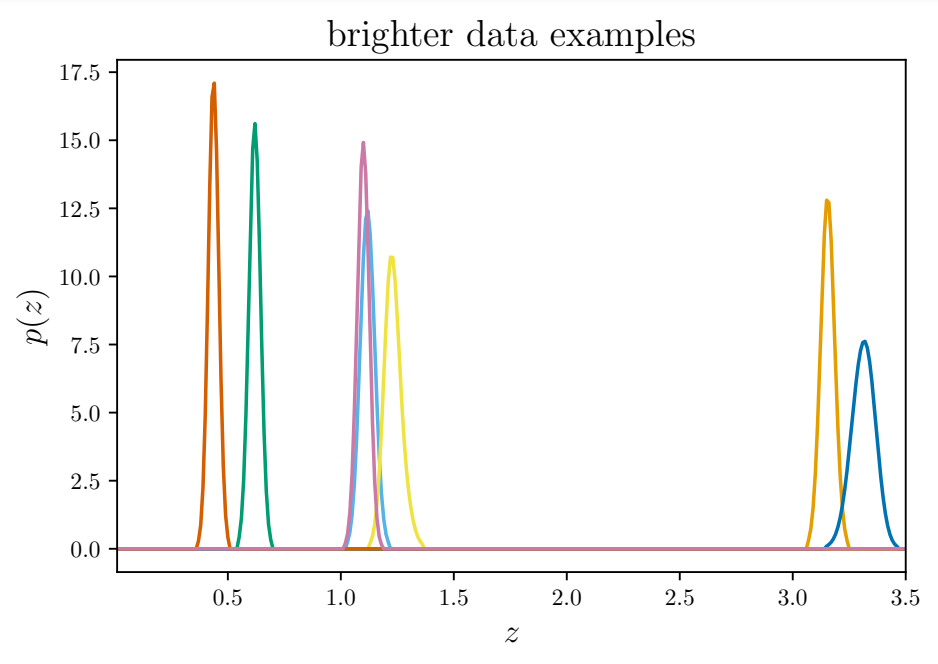
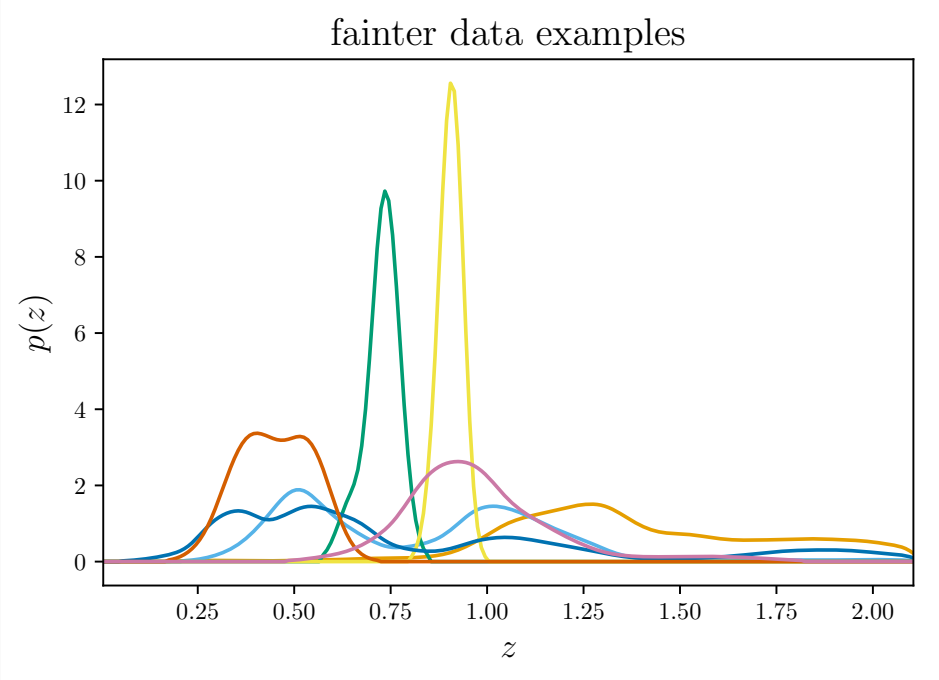
What do cosmologists want from machine learning?

PDFs are more informative than point estimates.





Malz&Marshall+18

Cosmology pipelines are unprepared for photo-z PDFs.

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the stacked estimator of the redshift distribution

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$$\hat{n}(z) \equiv \frac{1}{N} \sum_{i=1}^{N} p_i(z)$$

and statistical independence

$$p(A \cap B) = p(A) \times p(B) \neq p(A) + p(B)$$

are incompatible!

CHIPPR: a model for using photo-z PDFs in inference

Cosmological
Hierarchical
Inference with
Probabilistic
Photometric
Redshifts

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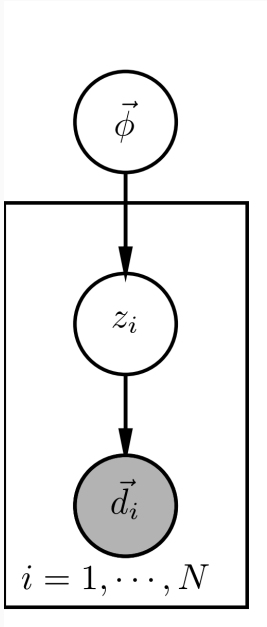

Malz&Hogg(in prep)

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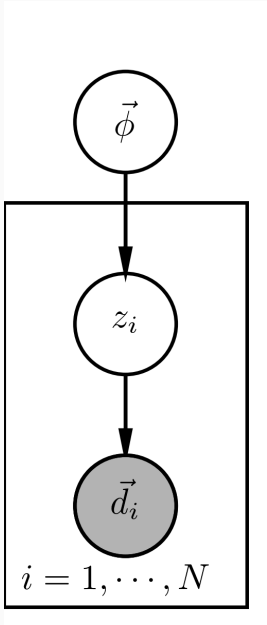

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Malz&Hogg(in prep)

$$p(\vec{\phi} \mid \{\vec{d}_i\}) \propto p(\vec{\phi}) \prod_i^N \int p(z \mid \vec{d}_i, \vec{\phi}^*) \frac{p(z \mid \vec{\phi})}{p(z \mid \vec{\phi}^*)} dz$$

What do cosmologists want from ML?

Cosmologists want ML
to produce photo-z PDFs.

What does machine learning provide to cosmologists?

Photo-z PDFs vary despite shared, perfect training set.

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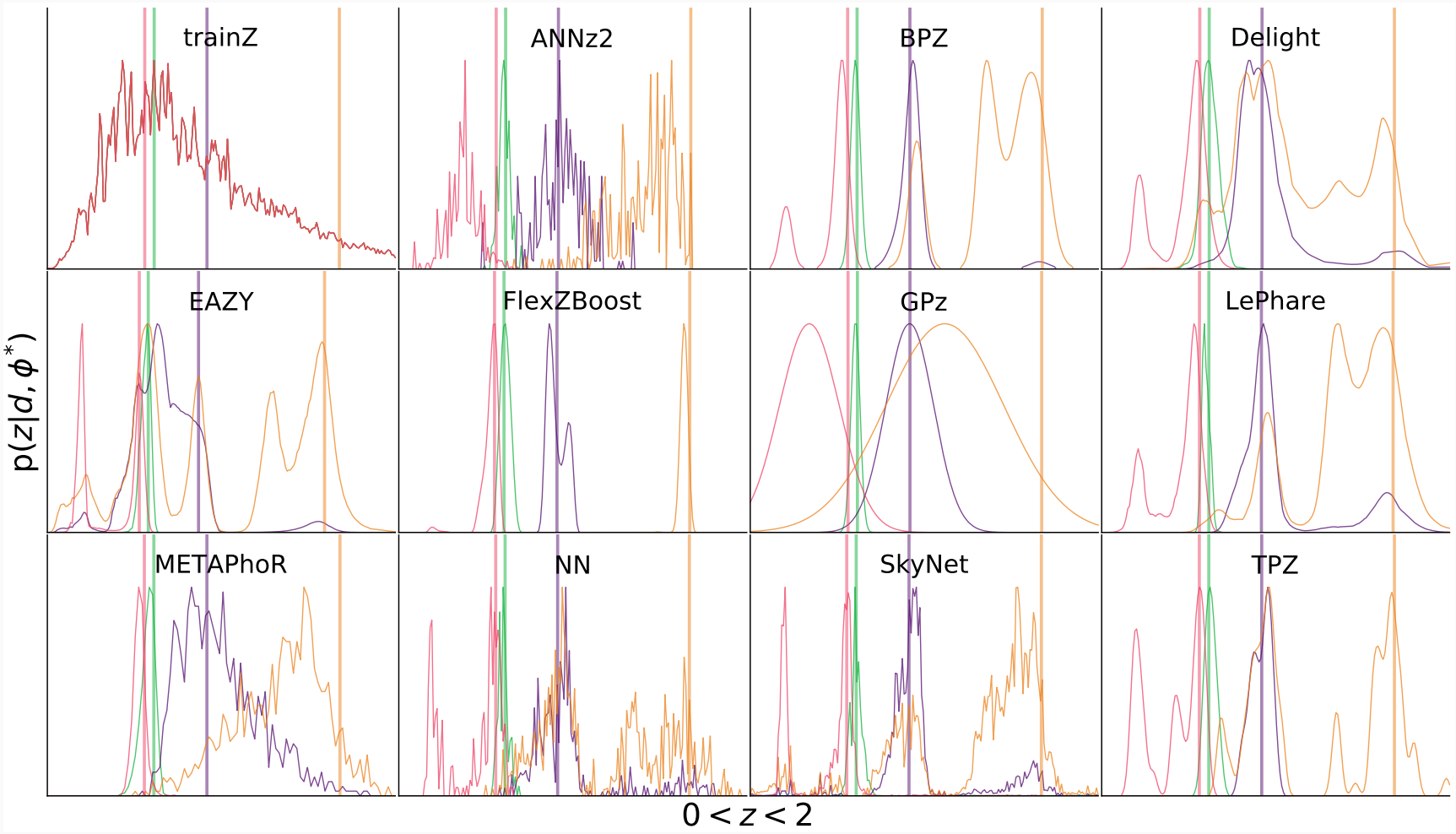

Schmidt&Malz+(in review)

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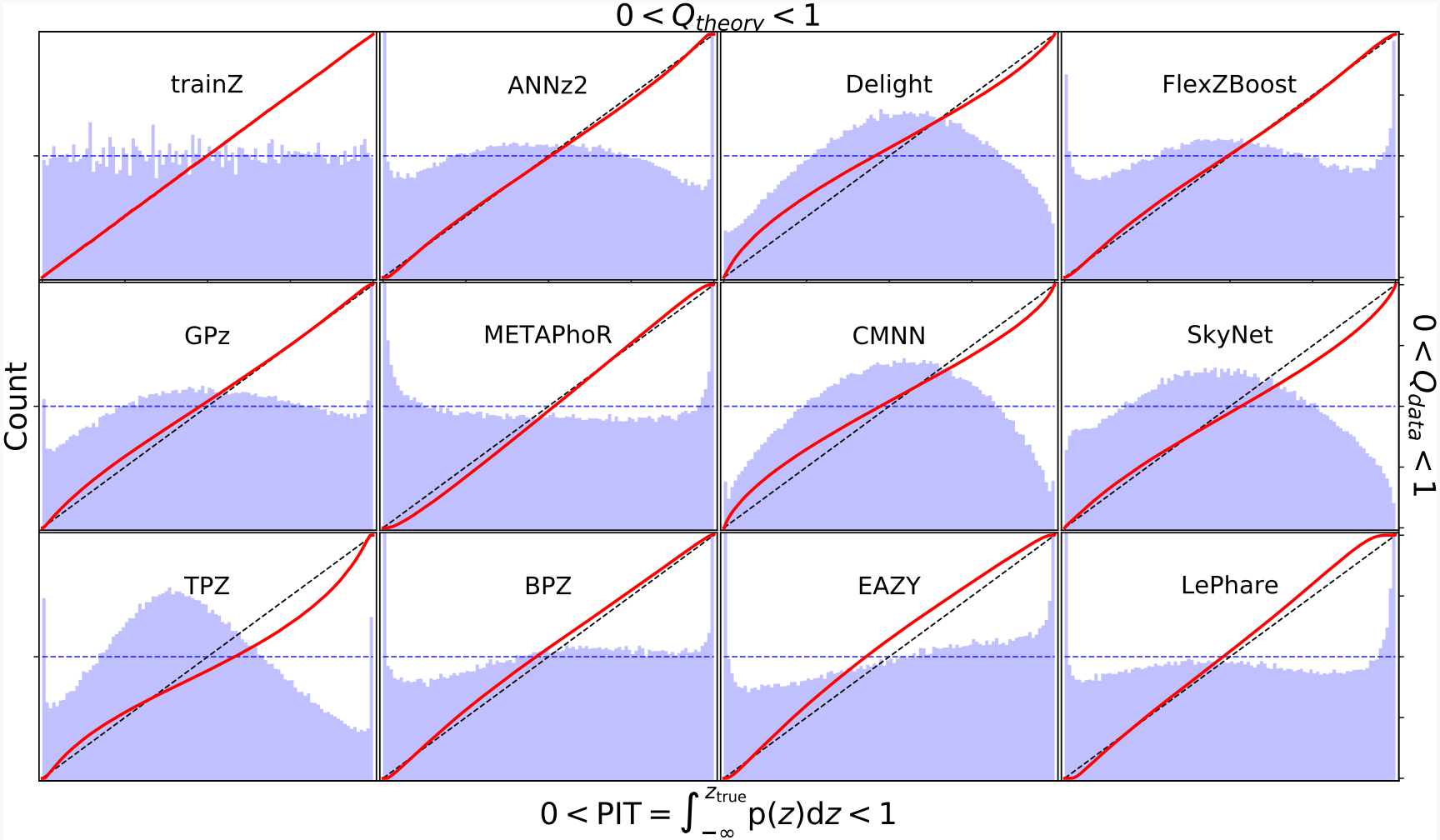

Schmidt&Malz+(in review)

What does ML provide to cosmologists?

ML yields photo-z posteriors weighted by an implicit prior.

What do cosmologists need from machine learning?

Cosmology pipelines are unprepared for the implicit prior.

the stacked estimator of the redshift distribution

$$\hat{n}(z) \equiv \frac{1}{N} \sum_{i=1}^{N} p(z|\vec{d}_i, \vec{\phi}^*)$$

and statistical independence

$$p(A \cap B|C) = p(A|C) \times p(B|C) \neq p(A|C) + p(B|C)$$

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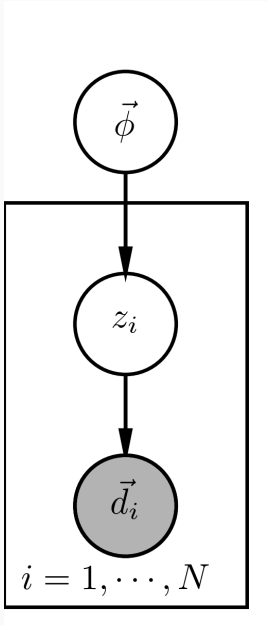

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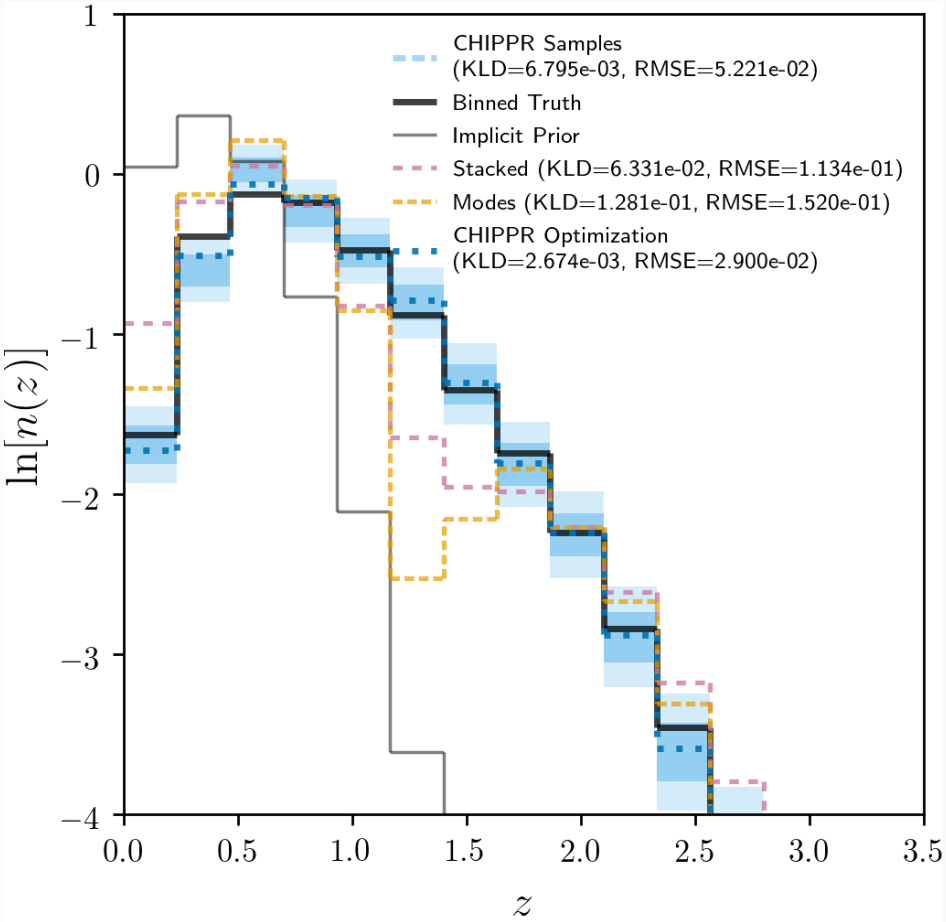
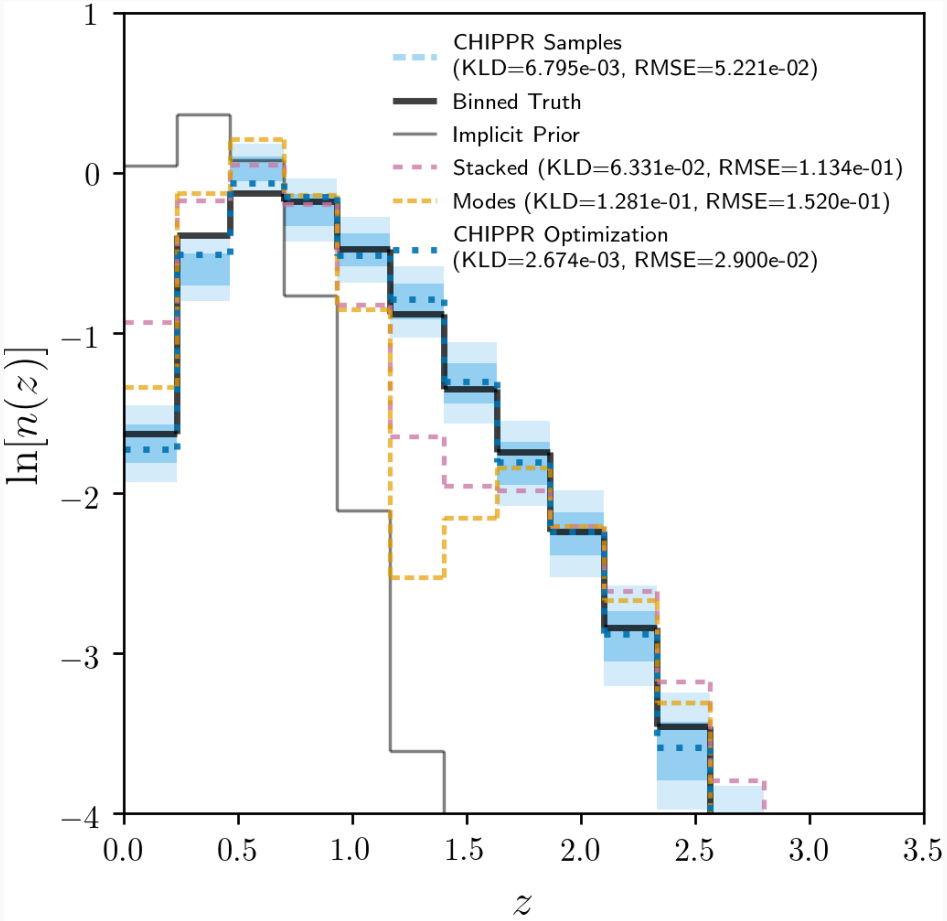
CHIPPR is robust to a nontrivial implicit prior.

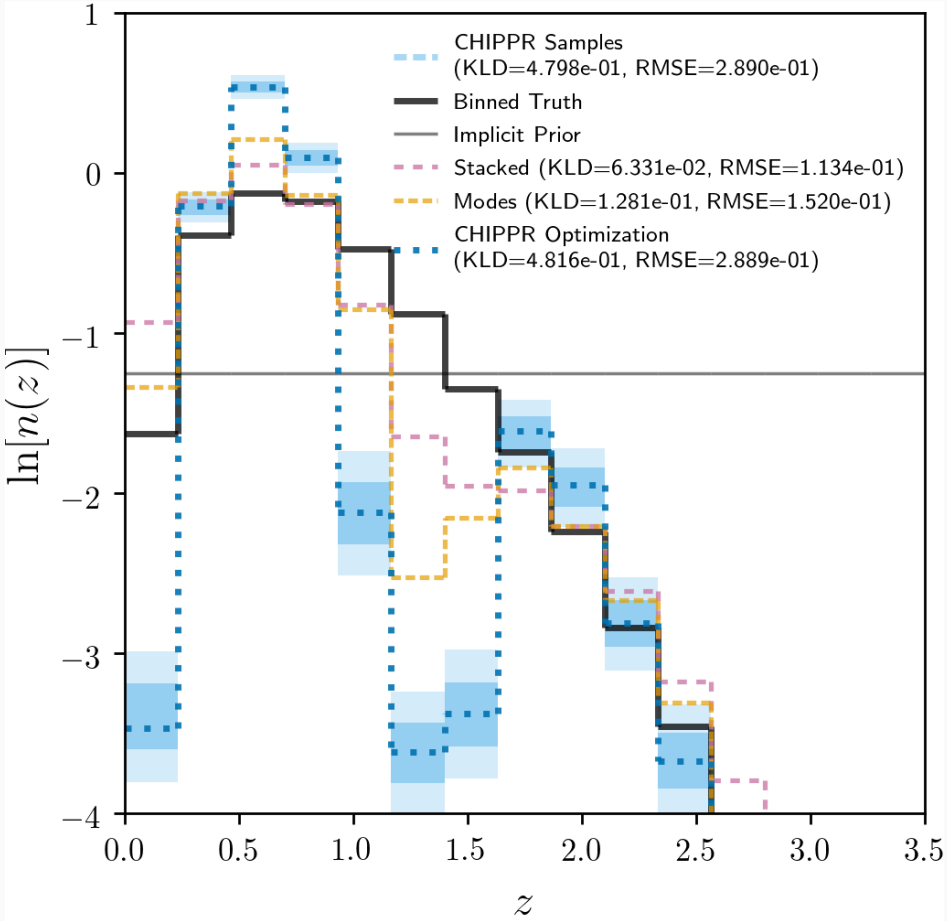


Malz&Hogg(in prep)

`github.com/aimalz/chippr`

Even CHIPPR fails under prior misspecification.





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The implicit prior
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A realistic implicit prior introduces further complications.

- The galaxy catalog may not share a single implicit prior.
- The implicit prior may be derived nondeterministically.
- Retrieving the implicit prior after combining PDFs from multiple ML methods could be impossible.

ML is not a panacea for photo-zs.

What do cosmologists want from ML?

Cosmologists want ML to produce photo-z PDFs.

What does ML provide to cosmologists?

The photo-z PDFs of ML are at best implicit posteriors.

What do cosmologists need from ML?

The implicit prior must be known in order to perform inference.