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# *Improving photo-z estimation under covariate shift with StratLearn*

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# Scientific Rationale

## Covariate shift

Unrepresentative training datasets → $p_S(x) \neq p_T(x)$ but $p_S(y|x) = p_T(y|x)$

→ ML algorithms show **poor generalisation**

Ubiquitous problem in astronomy! Due to **selection effects** (brighter/low redshift objects more likely to be observed)

**GOAL: improve generalisation properties of ML algorithms in presence of covariate shift**

Scientific application:

**Photometric redshift estimation**

- obtain redshifts of several objects at once from imaging (vs spectroscopy, more accurate but more expensive)
- Key in ongoing/future cosmological surveys like Euclid, LSST
- Typically estimated with template fitting or **ML based methods**

# Technical Objectives, Methodologies and Solutions

## → Proposed solution: StratLearn

Code declined for photo-z estimation (applied to weak lensing in arXiv:2401.04687)

- Data partitioned in strata, based on quantiles of **propensity scores**

$$e(x_i) = P(s_i = 1|x_i)$$

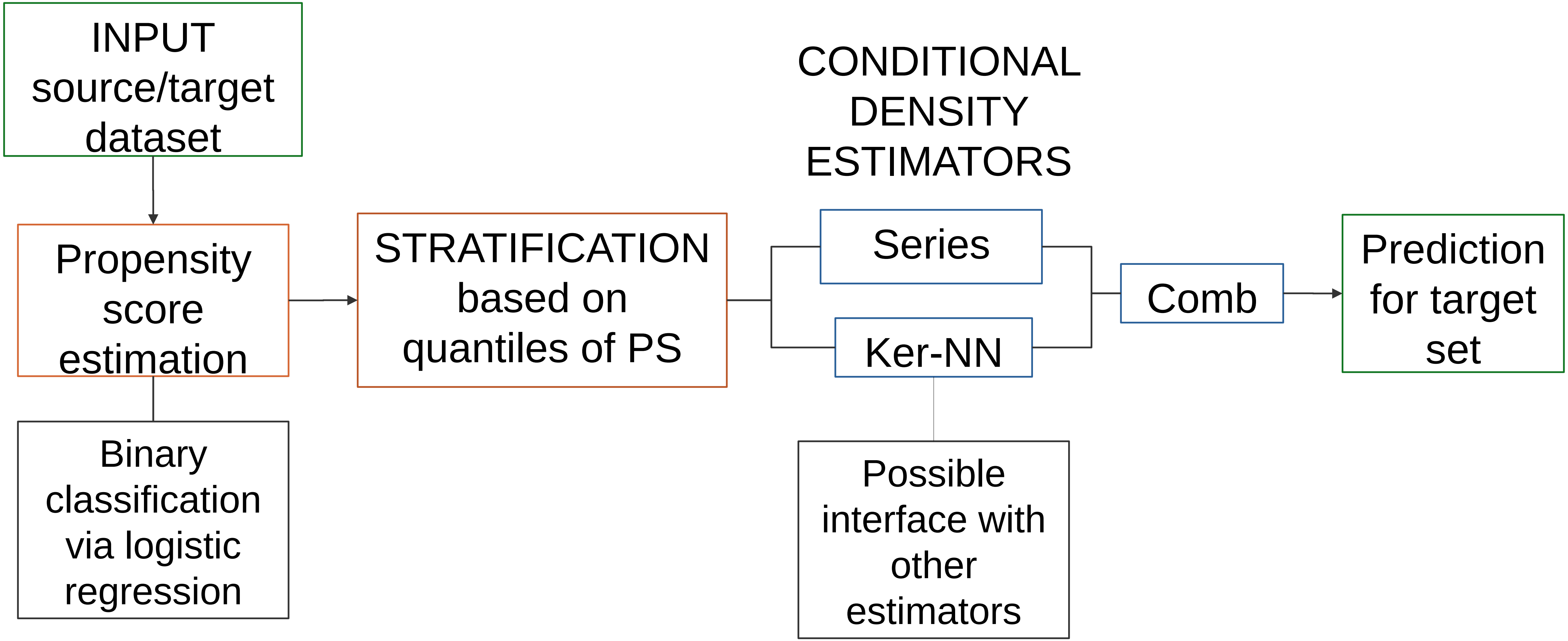
→ Estimated via binary classification with logistic regression

- Conditional density estimators (Series, ker-NN) trained within each stratum, then combined with weighted average

→ Approach is **general and multi-purpose**

→ Can be combined with other estimators/models

# Technical Objectives, Methodologies and  Solutions



INPUT source/target dataset

Propensity score estimation

Binary classification via logistic regression

STRATIFICATION based on quantiles of PS

CONDITIONAL DENSITY ESTIMATORS

Series

Ker-NN

Possible interface with other estimators

Comb

Prediction for target set

# Main Results

Previous milestones:

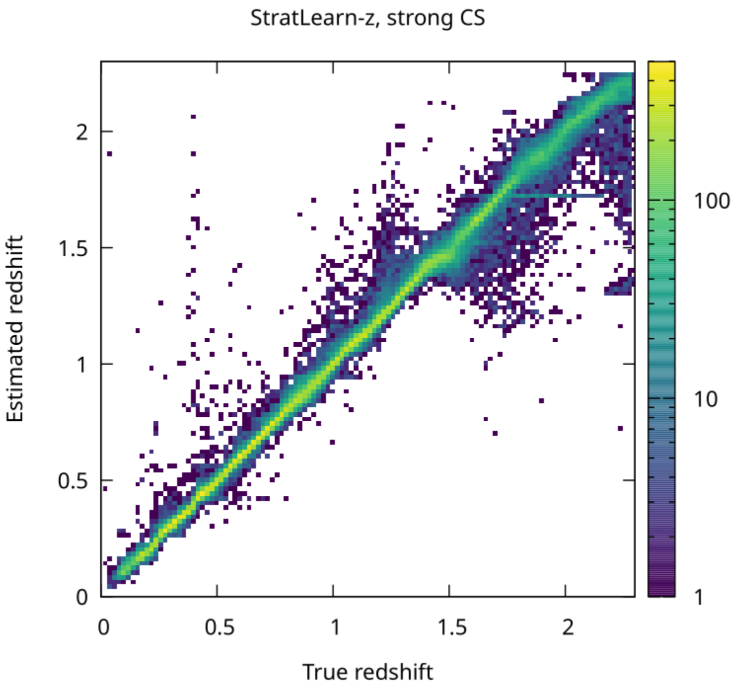
- Original code ported from R to julia → 50x faster KPI
- Code optimisation → 10x faster KPI
- Introduction of yaml parameterfile for easy usage
- Public github repository available at [github.com/chiaramoretti/StratLearn-z](github.com/chiaramoretti/StratLearn-z) KPI

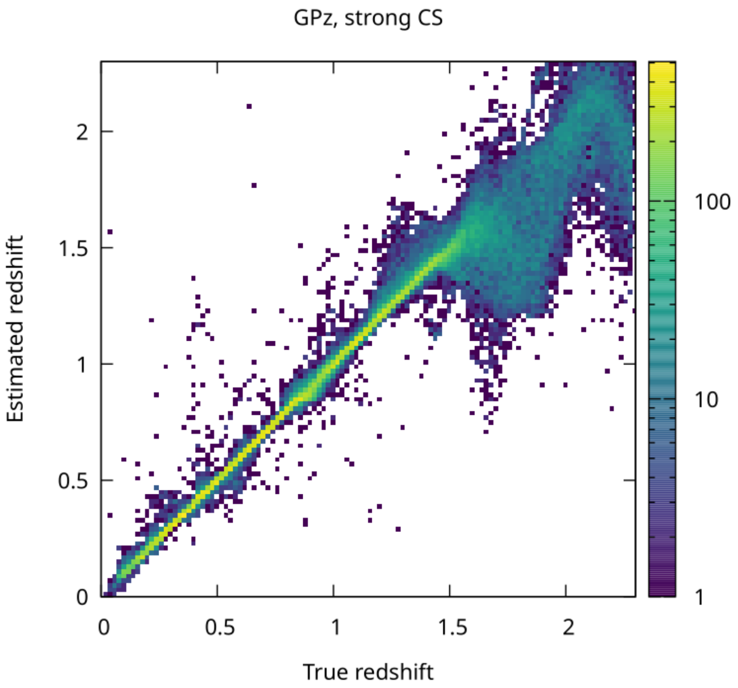
- Generalised to read covariates from input datafile
- Additional script that only performs stratification → **easier combination with external photo-z codes**

# Main Results

Application to simulated dataset (Buzzard flock simulations produced for DES, LSST) with introduced covariate shift

→ 100k objects with *ugrizy* photometry + redshifts
→ CS introduced by performing rejection sampling on the r-band





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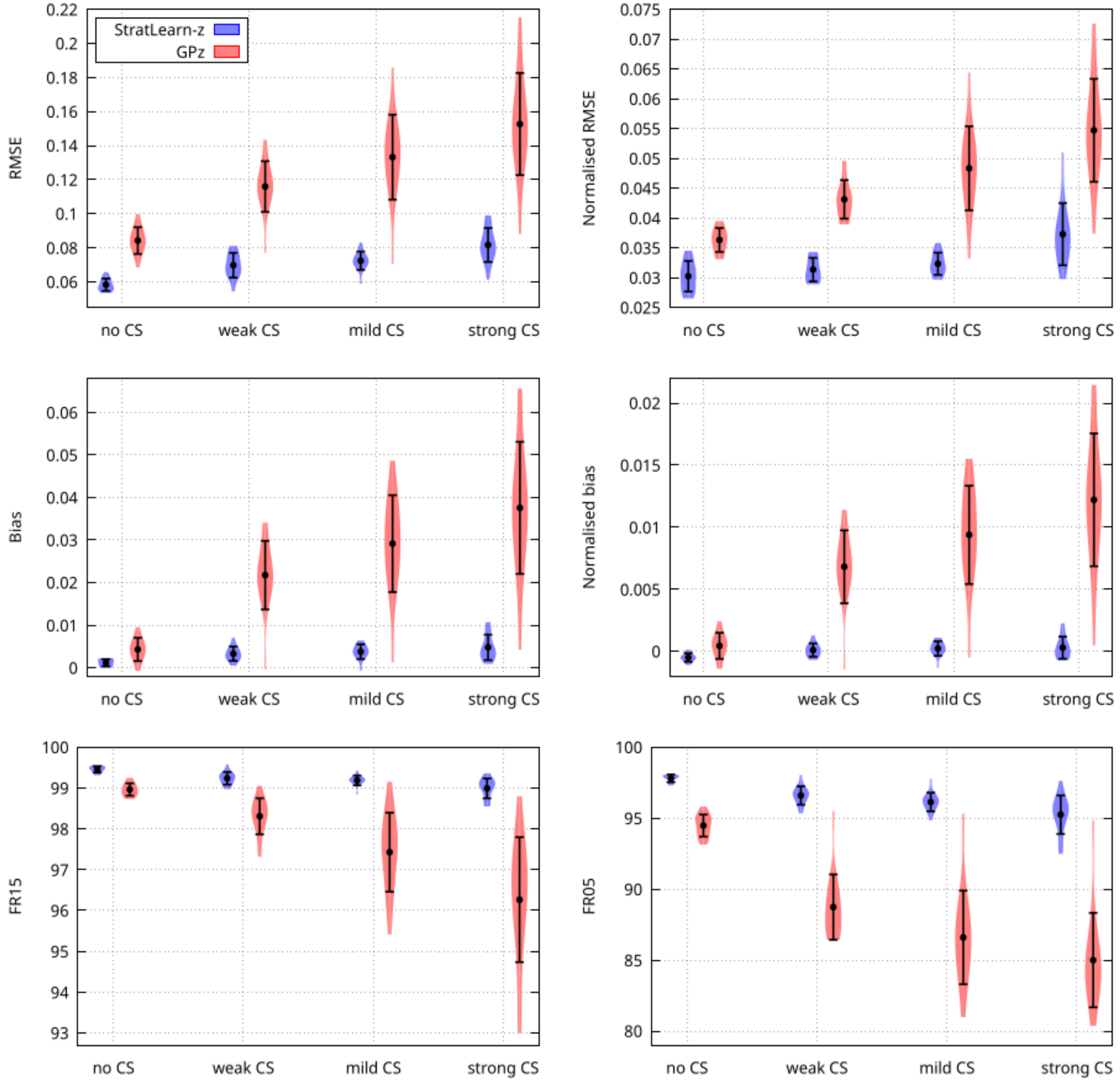
Application to simulated dataset (Buzzard flock simulations produced for DES, LSST) with introduced covariate shift

Comparison with GPz code: **improved results** on all point estimate metrics considered



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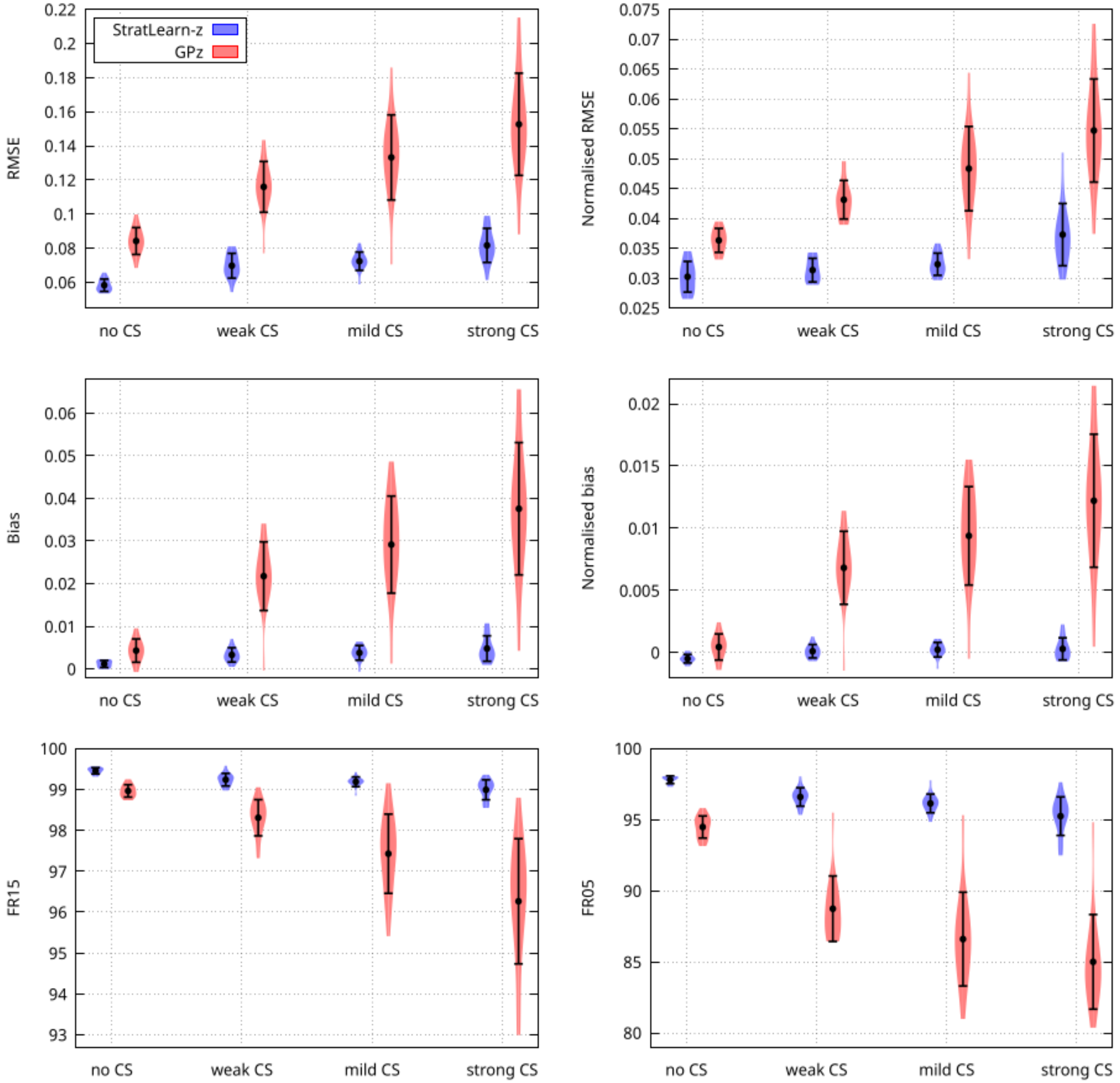
Comparison with GPz code: **improved results** on all point estimate metrics considered

Paper published on OJA [arXiv:2409.20379](https://arxiv.org/abs/2409.20379)

KPI

Poster presentation @ COSMO

KPI

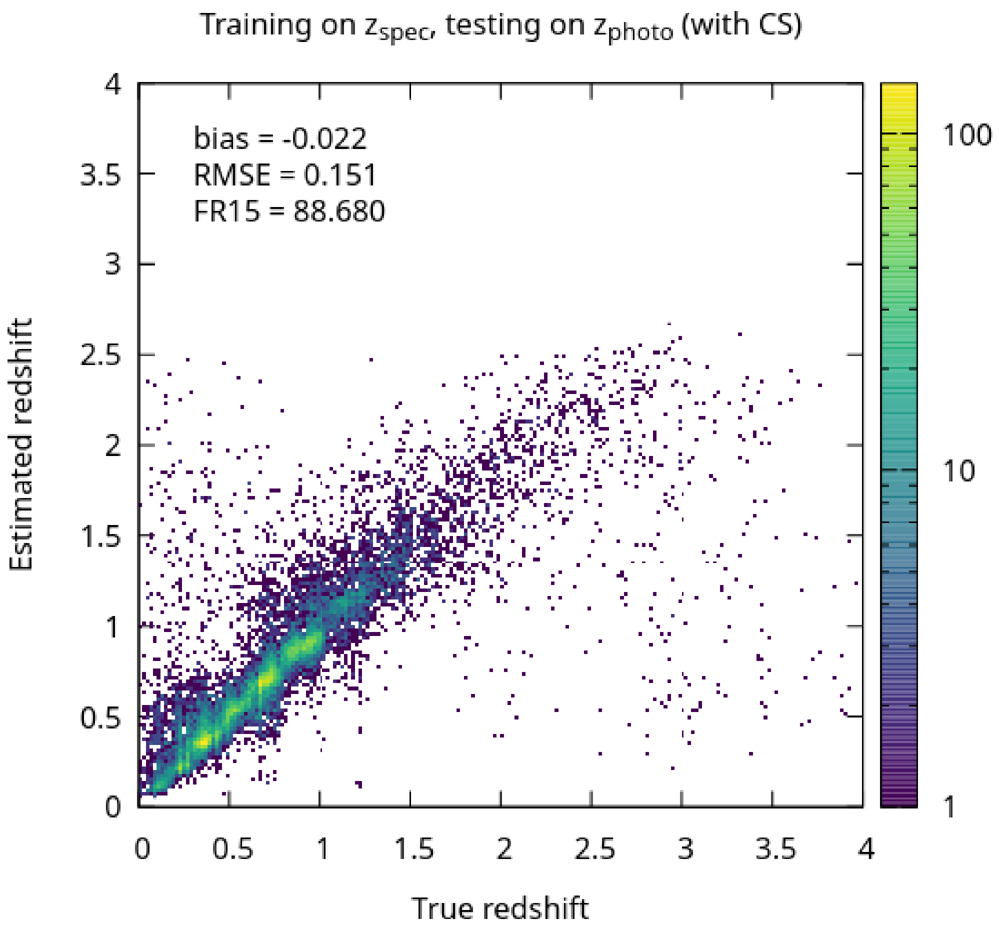


# Main Results & Next Steps

## Ongoing work:

- Application to Euclid-like dataset based on COSMOS field
  → more realistic, used in Euclid photo-z challenge
  → 400k objects, 8 photometric bands *g,r,i,z,Y,J,H,VIS-like*
  → "ground truth" redshift from spectroscopy + 30-band photometry

- First results in place, starting paper writing



# Main Results & Next Steps

## Science applications:

- Application to Euclid-like dataset based on COSMOS field
- Application to Euclid real data (Q1): looking into feasibility

## Code development:

- First step towards parallelisation ✓
  → assessment of scaling properties ongoing
- Combination with more CDEs
- Further optimisation

*Not on spoke funds anymore, so work is ongoing on a best-effort basis*