AHEAD 2020

Integrated activities for the High Energy Astrophysics Domain

Funded by the Horizon 2020
Framework Programme of the
European Union
Grant Agreement No. 871158

WP14.5: automatic redshift determination

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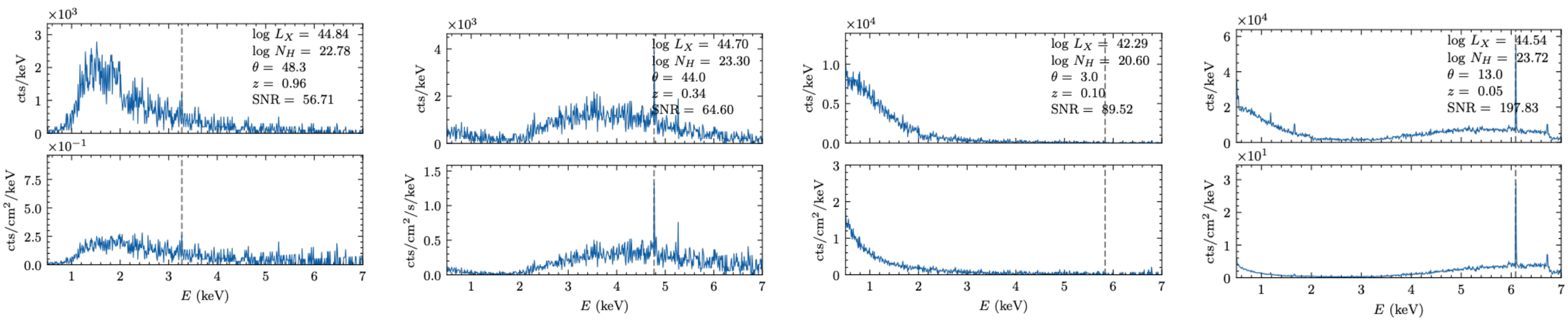
Introduction

- **Task 14.5**: Multi-dimensional source detection, Bayesian source detection, **automatic redshift determination** (NOA, INAF, **IFCA**)

  2) study algorithms for automatic redshift determination of detected sources
- **Deliverable 14.5**: Prototype tools for source detection, **redshift determination**, and automatic extraction and identification of line features, with description of algorithms and tests. (**month 36**)

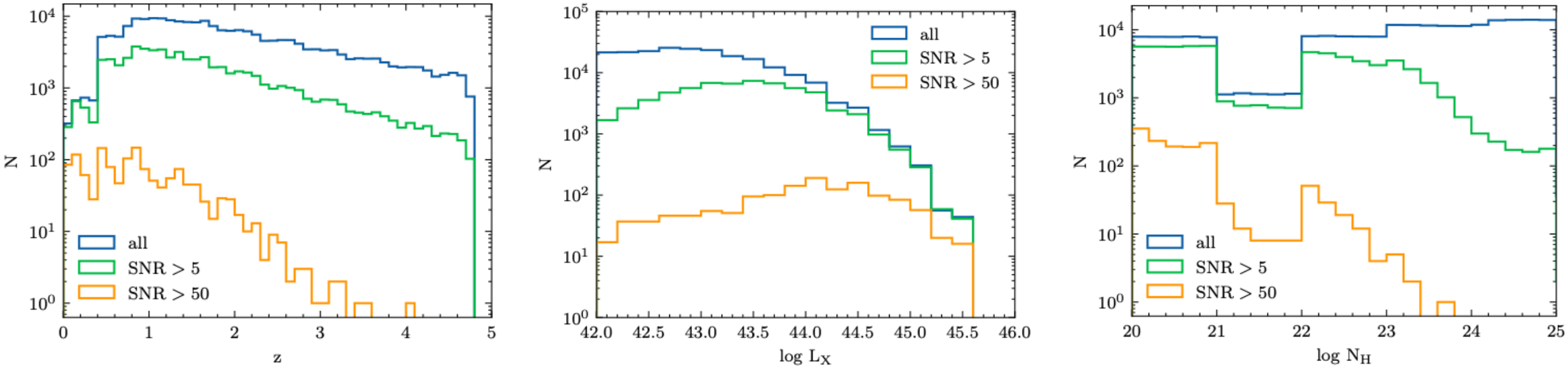
- **Ingredients**:
  - MOP 4 v1.8: X-IFU in focus, target extent ≤1arcmin, not moving target, |b|≥20º: 109 observations in 4y
  - Hexagonal FoV ~5arcmin diameter: 0.0045 deg^2 per observation
    - A total of ~1.23deg^2 in 10y lifetime of the instrument
  - Gilli+07 XRB population synthesis model: unabsorbed and absorbed (Compton-thin and –thick) AGN: ~8400deg^{-2} $\log(NH/cm^{-2})>21$
  - uxclumpy Buchner+19 clumpy torus model
  - Texp=30ks (median MOP 35ks)

Introduction



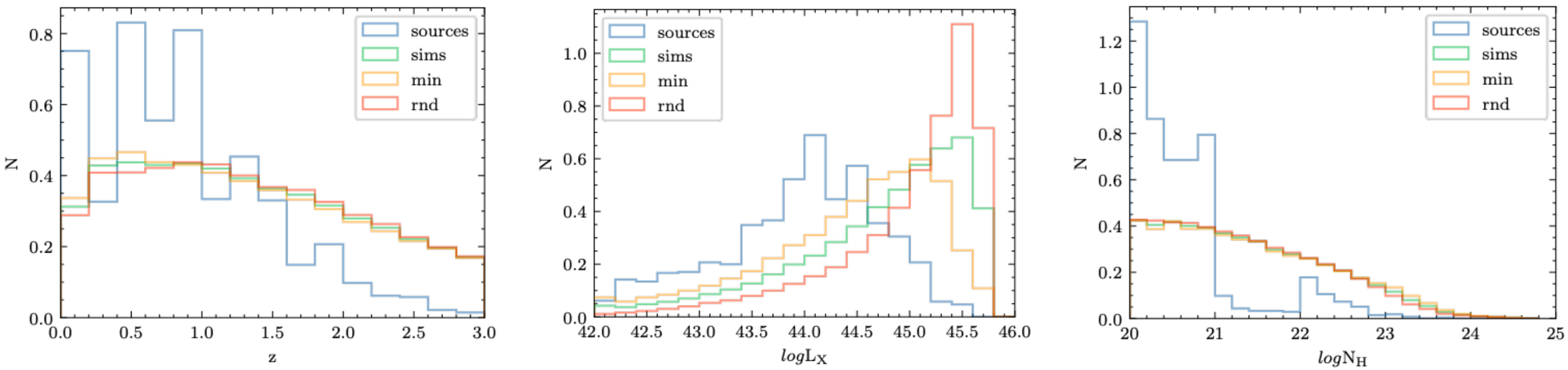
- Gilli+07 XRB population synthesis model: unabsorbed and absorbed (Compton-thin and –thick) AGN: ~8400deg^{-2} log(NH/cm^{-2})>21
- uxclumpy Buchner+19 clumpy torus model
- xspec simulations with on-axis X-IFU response matrix

Test sample



- ~Mimicking source densities
  - 20.0 < log N_H < 25.0
  - 42.0 < log L_X < 48.2
  - 0.05 < z < 4.75
  - 0.0 < θ < 90.0
- **1 378 sources**
  - 25 deg^2 & z < 3.0 & SNR > 50
  - SNR = sqrt(counts) within 0.5 - 7 keV

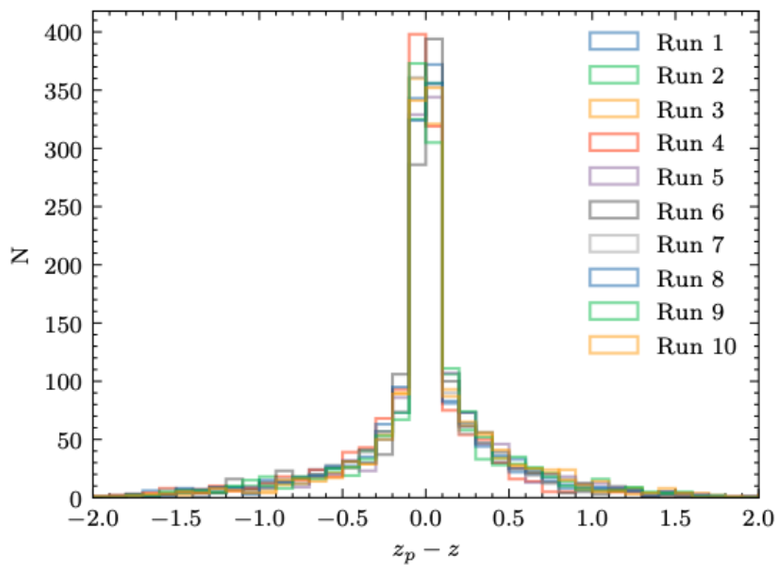
Training sample

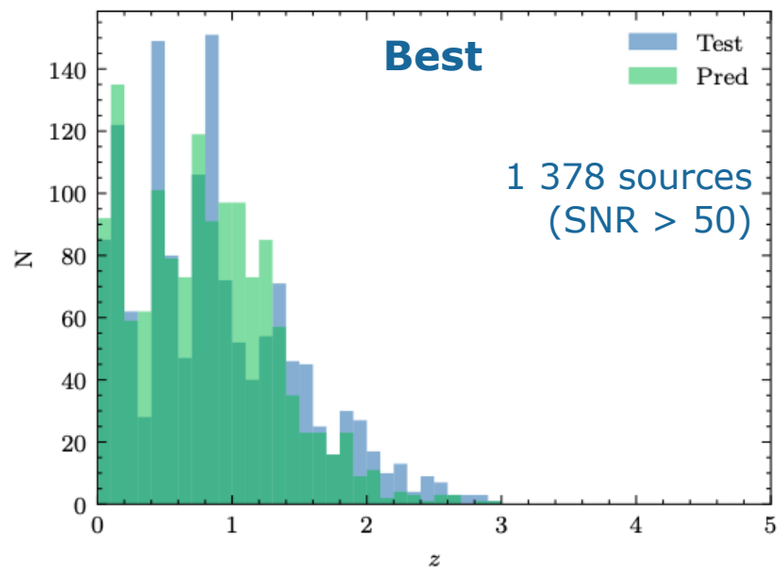


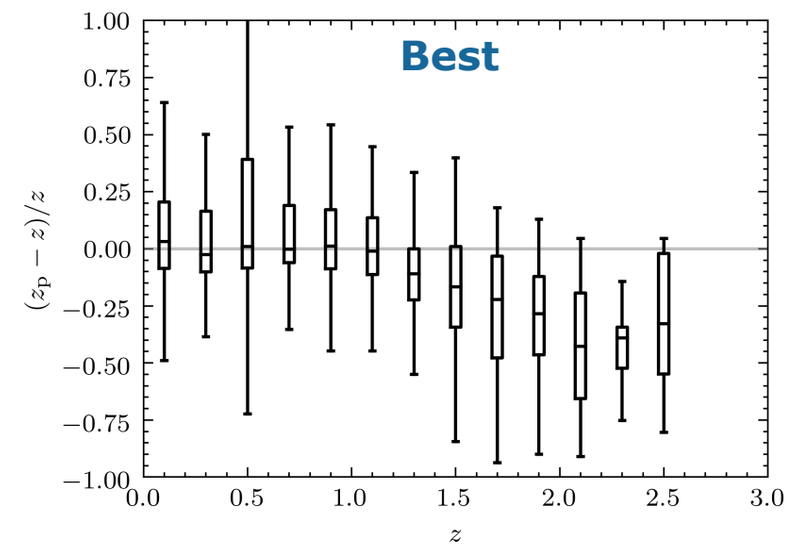
- Increasing the size of the simulated sample
  - $20.0 < \log N_H < 24.5$
  - $42.0 < \log L_X < 45.5$
  - $0.05 < z < 3.00$
  - $0.0 < \theta < 90.0$
- **189k simulations**
  - $z < 3.0$ & SNR > 50
- Learning on counts/keV & unfolded spectra
- **1064 bins in [0.1-12] keV** (28:1 binning~10eV)

Redshift estimates

z*: true *z
z*p: predicted *z



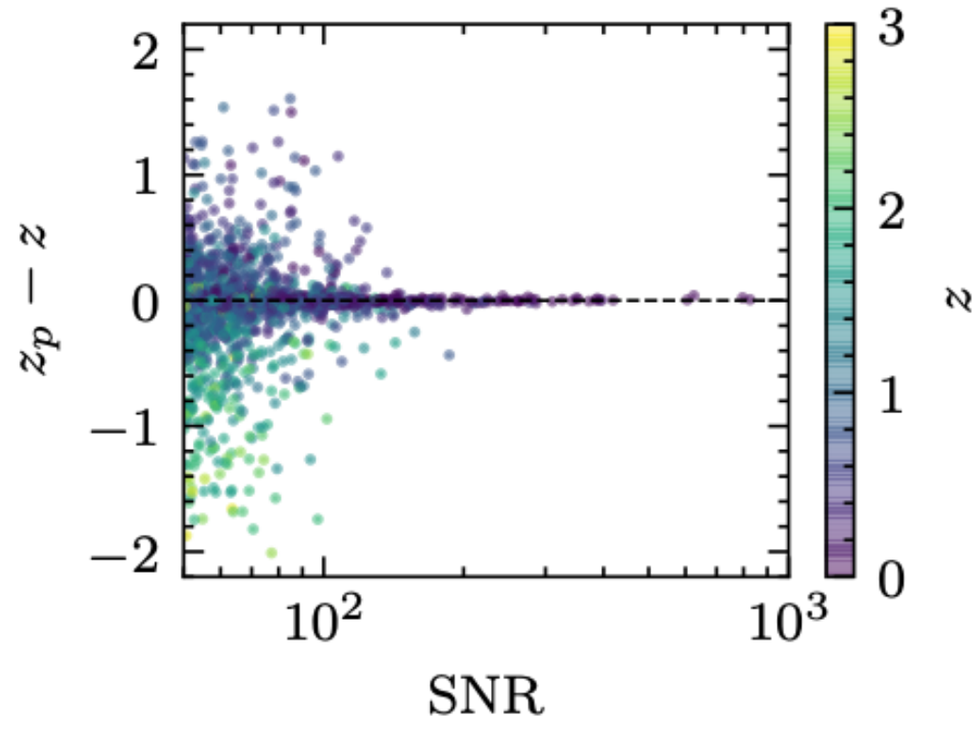


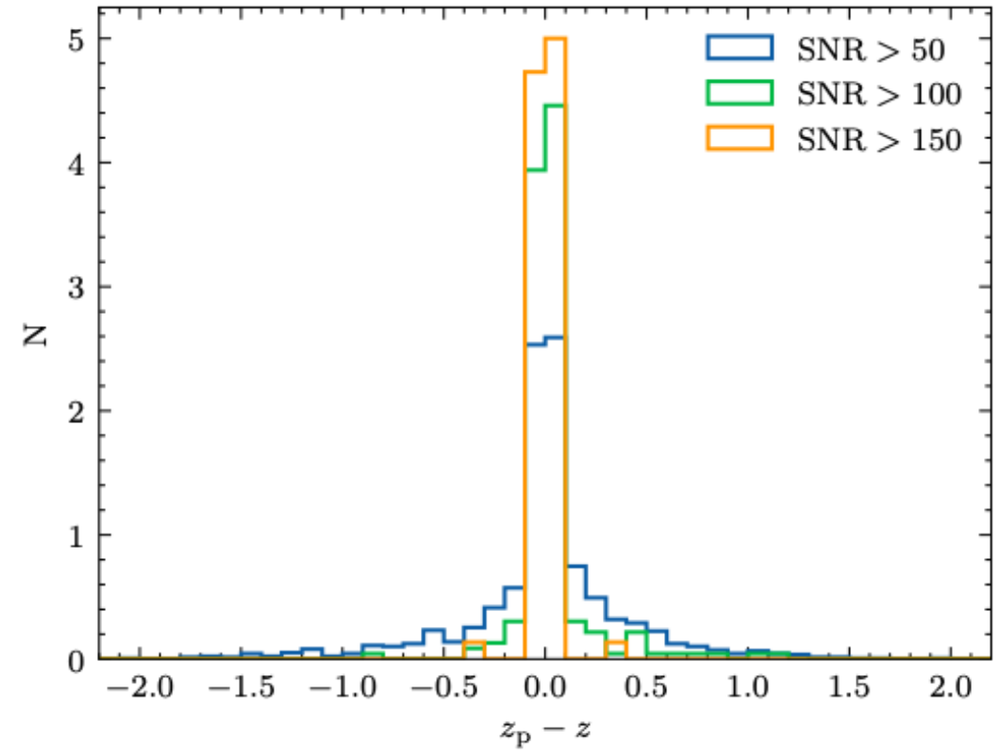


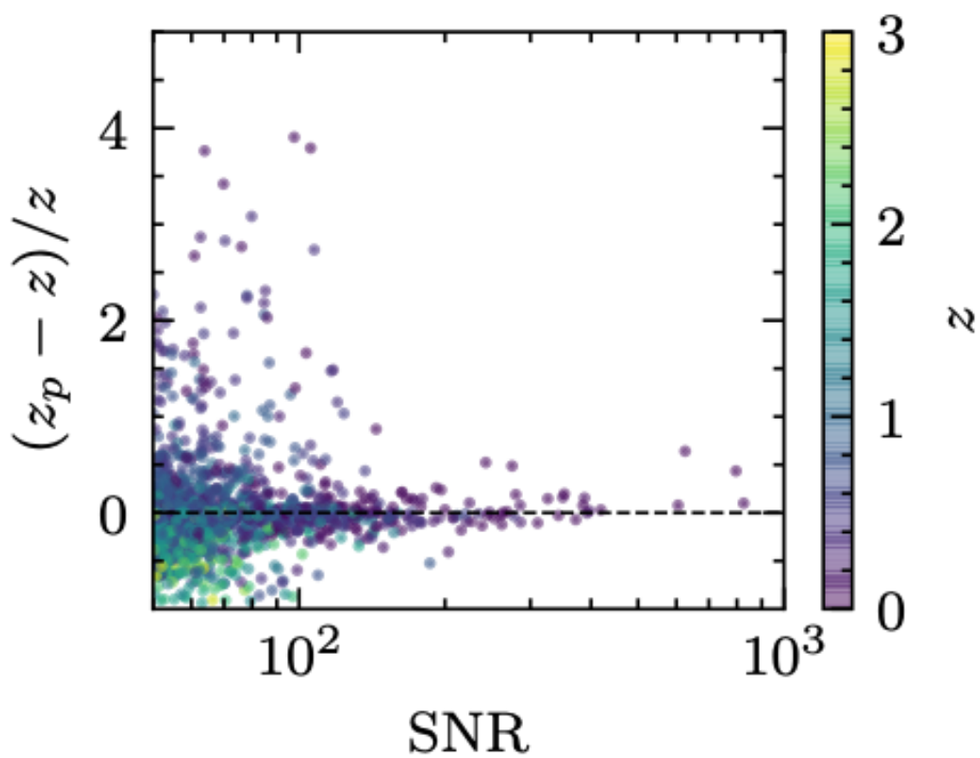
- **Convolutional Neural Networks** (4 conv. + 3 dense layers)
  - Training on the training sample
  - Evaluating results on the test sample
- *k-fold* = 10 (ind. models)
- Mean Absolute Percentage Error MAPE $|z_p - z|/z$ = 0.39 ± 0.03
- **Best** model MAPE = 0.32

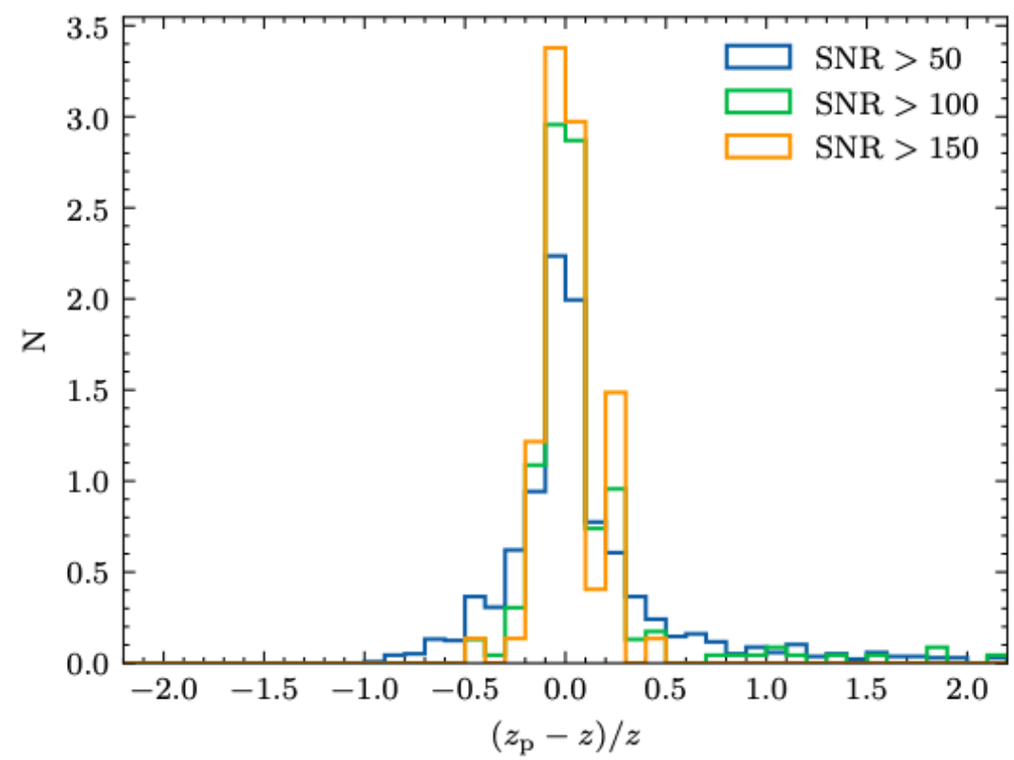
Dependence with SNR

z*: true *z
z*p: predicted *z



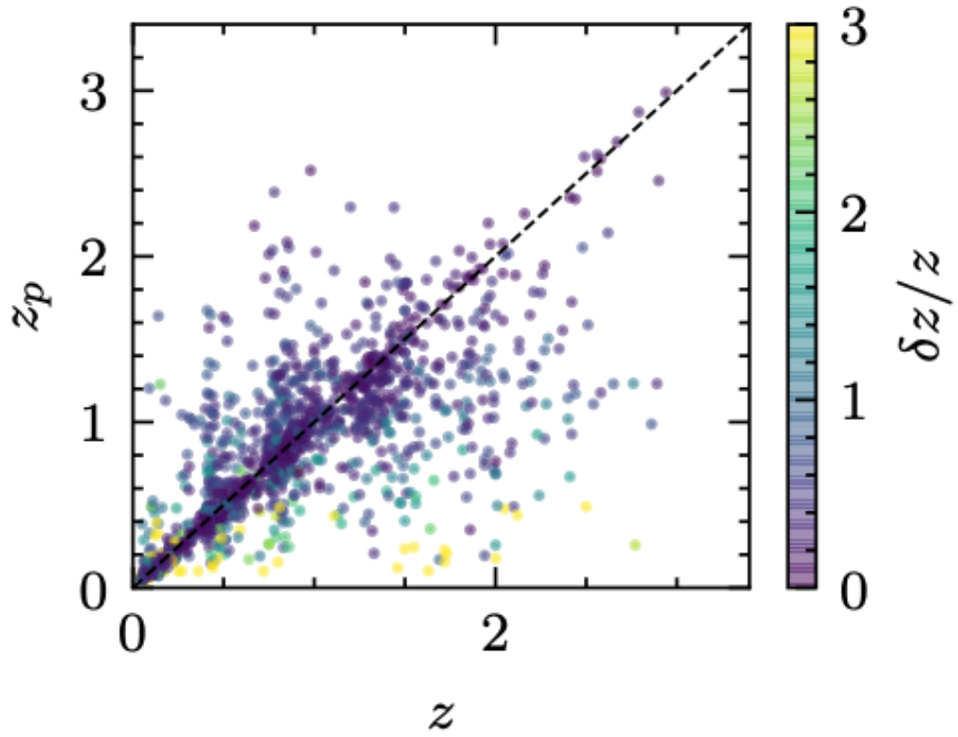


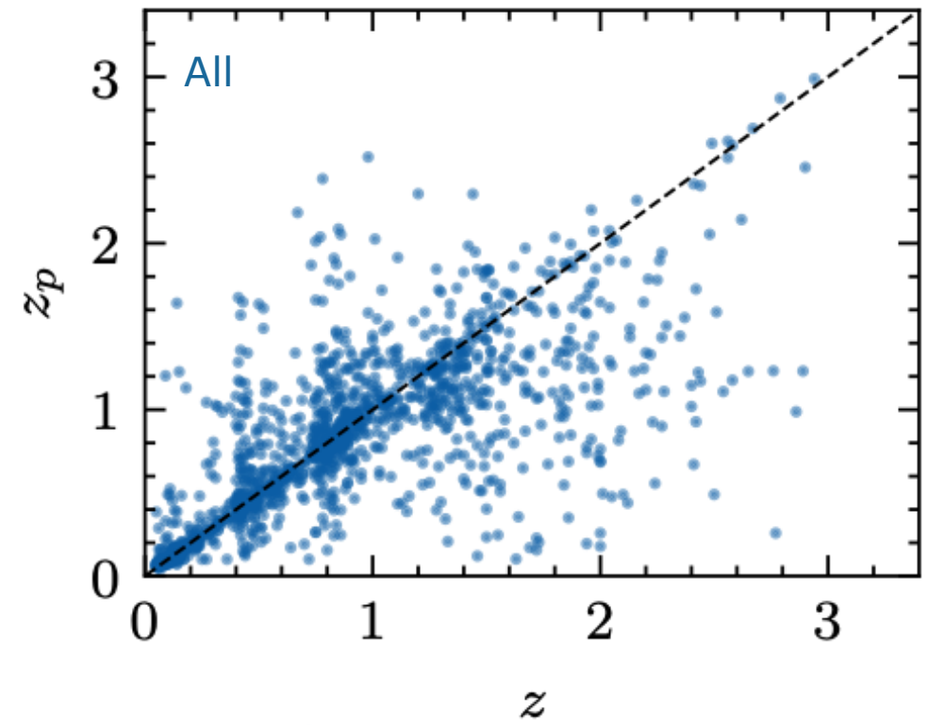




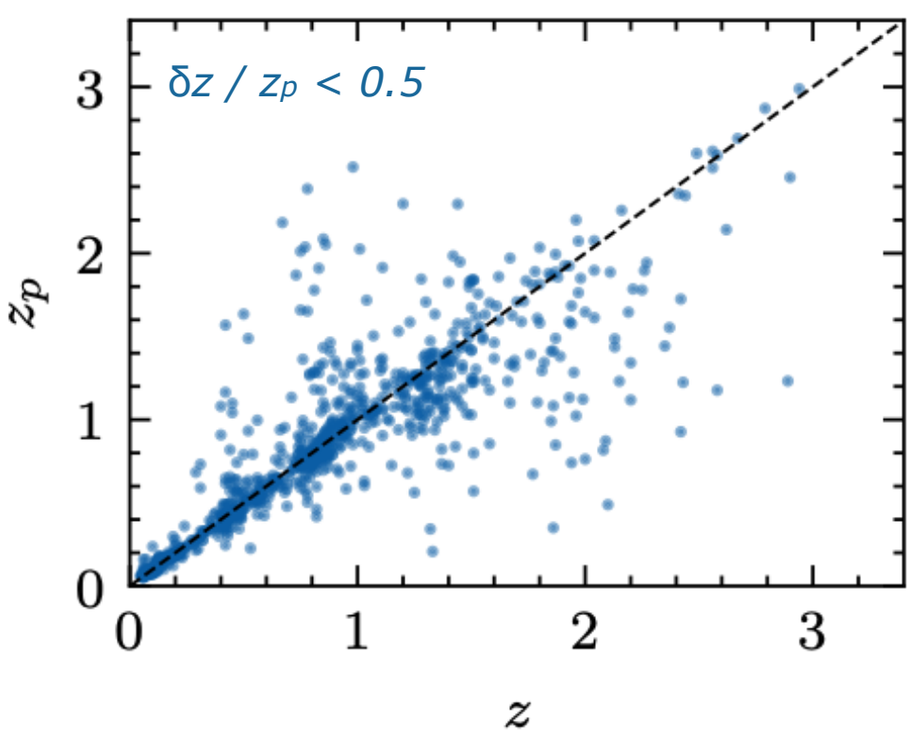
Robustness of the redshift estimates

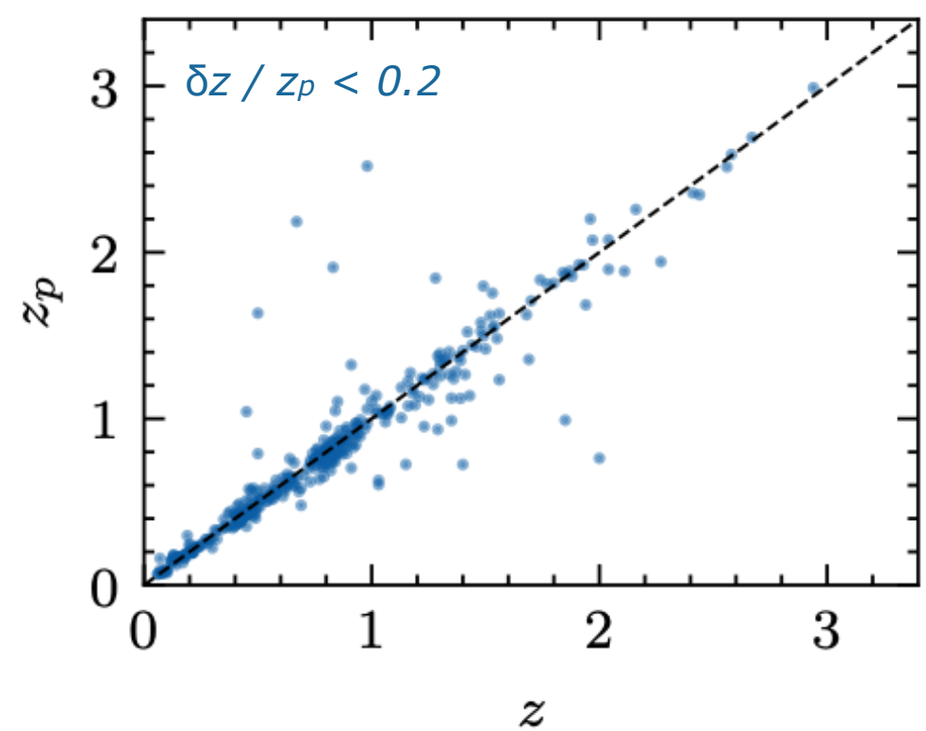
z: true z
z_p: predicted z





$\delta z = \max(z_k) - \min(z_k)$ with $k = 1..10$





Summary

- Aiming at automatic z determination of serendipitous X-IFU detections
- Using just binned spectra ~10eV
- Assuming Gilli+07 CXB synthesis model and clumpy torus model
- Defining samples:
  - Training sample: many more simulated spectra
  - k-fold = 10
  - Test sample: ~following CXB synthesis model
  - z<3 & SNR>50
- Redshift recovery:
  - MAPE $|z_p - z|/z$ = 0.39 ± 0.03
  - Improvement with higher SNR
  - Internal evaluation of accuracy (dispersion of k-fold)
  - Does not appear to depend heavily on presence of Fe K line
- Calculations finished, starting to write paper