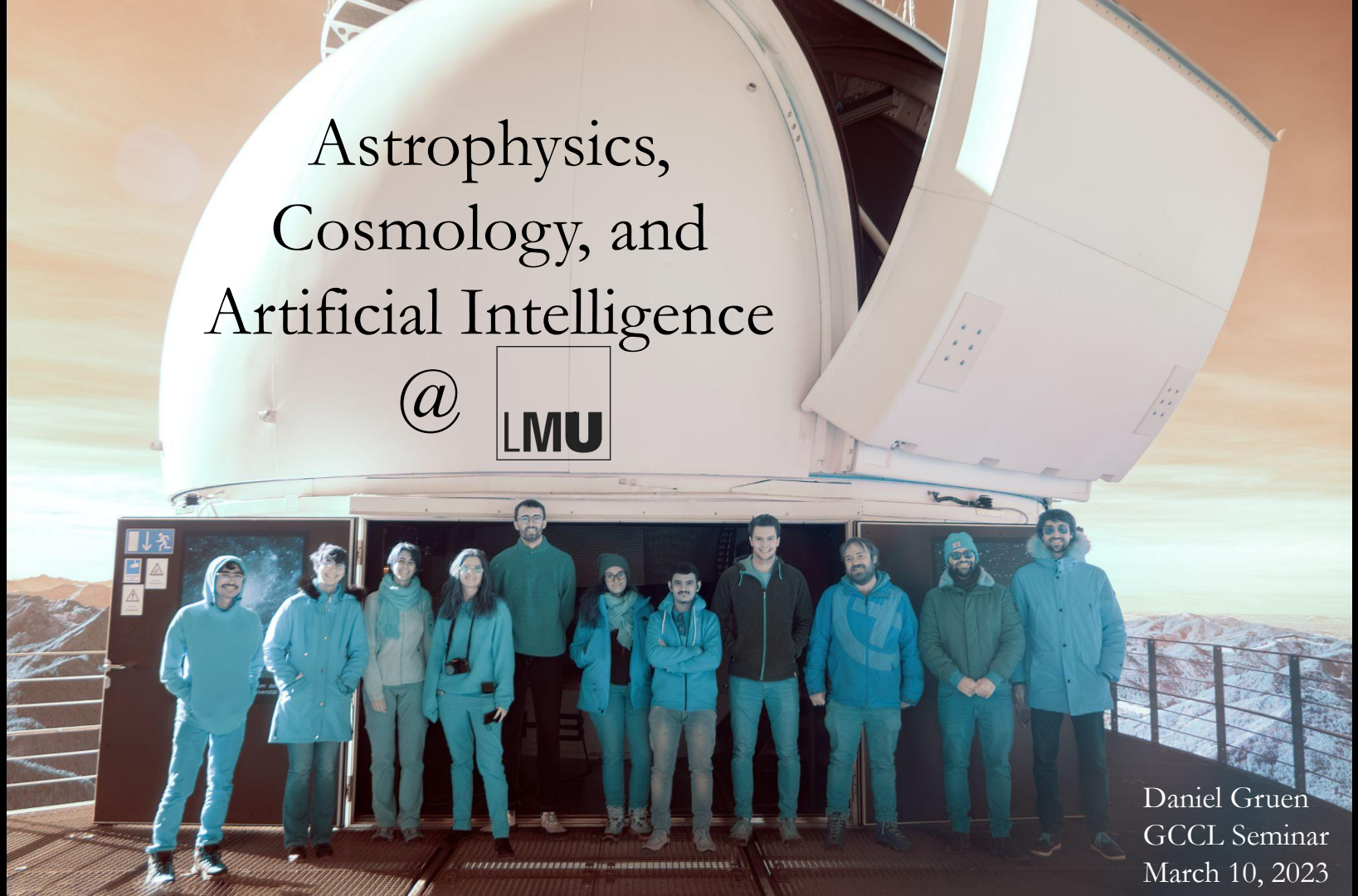
Astrophysics, Cosmology, and Artificial Intelligence @ LMU



Daniel Gruen
GCCL Seminar
March 10, 2023

Measuring and modeling the universe from pixels to cosmology

Modeling and utilizing modern statistics of cosmic structure (higher order, PDF, AI):

Led by Oliver Friedrich

Postdocs:
Michael Walther,
Alexandre Barthelemy (w/ Stella Seitz)

PhD students:
Dylan Britt, Jed Homer, Parth Nayak

M.Sc. students:
Jamal El Kuweiss, Marco Gibietz,
Rintaro Kanaki, Moritz Koch, Alina Stephan

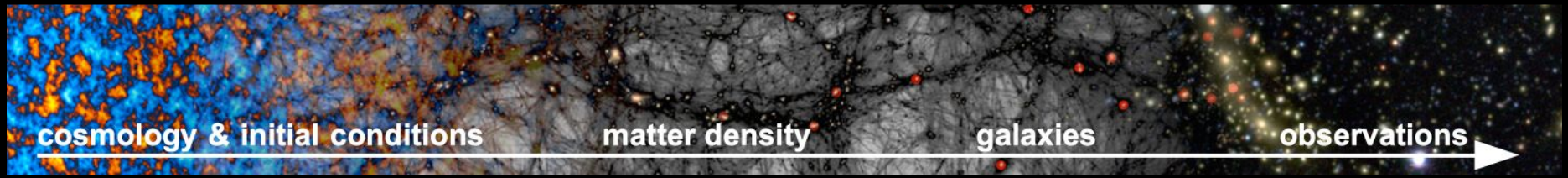
Modeling galaxies, clusters, and their observational data for cosmology:

Led by Daniel Gruen

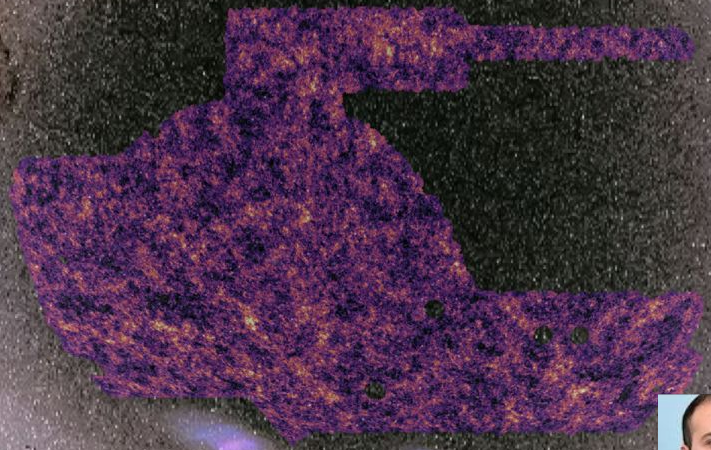
Postdoc:
Luca Tortorelli

PhD students:
Patrick Gebhardt, Yun-Hsin Hsu,
Jamie McCullough, Justin Myles

M.Sc. students:
Shirsh Chhabra, Benjamin Csizi,
Bhashin Thakore



Past Highlight: Dark Energy Survey Three-Year Analyses





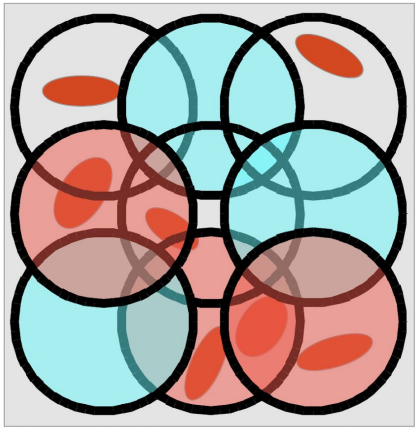


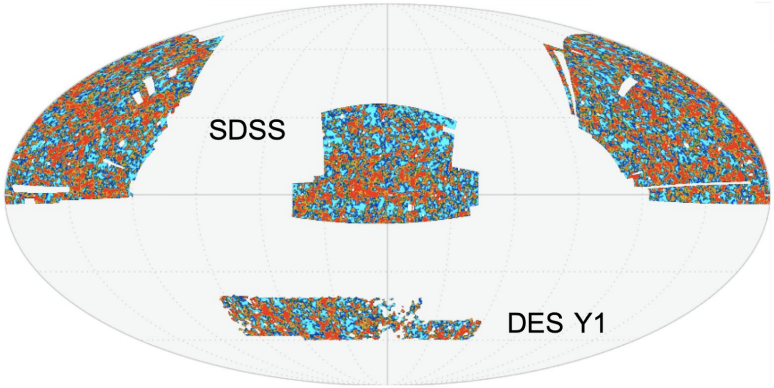


Team members led key parts of the DES Three-Year Weak Lensing analyses:

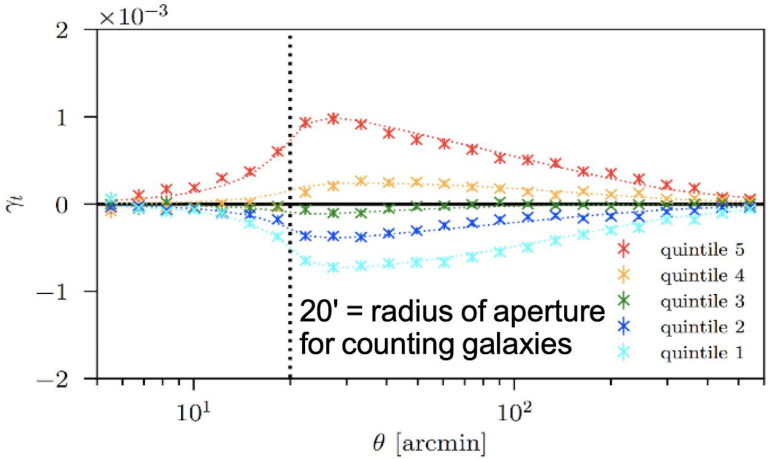
- Development of the redshift calibration methodology (*Buchs*, Davis, *DG* et al.)
- Photometric redshift calibration (*Myles* et al., including *Amon*, *McCullough, DG*)
- Image simulations for shear calibration (MacCrann, Becker, *McCullough, Amon, DG* et al.)
- Covariances (*Friedrich* et al.)
- Cosmic shear (*Amon, DG* et al.)
- *Luca Tortorelli* and *Patrick Gebhardt* are applying some of the things we learned to DES Y6 & LSST

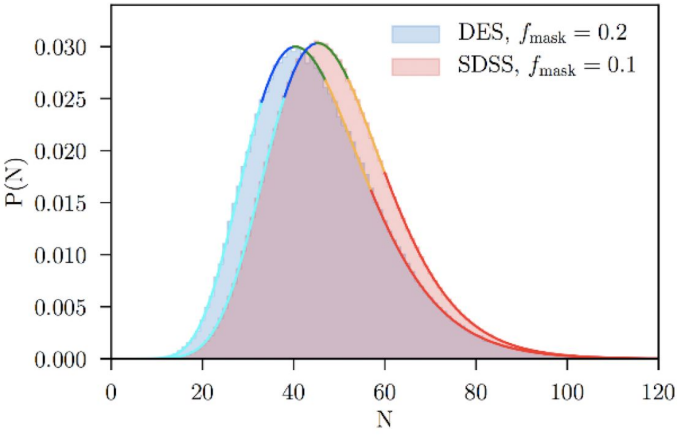
Past Highlight:
Density split statistics in DES and KiDS



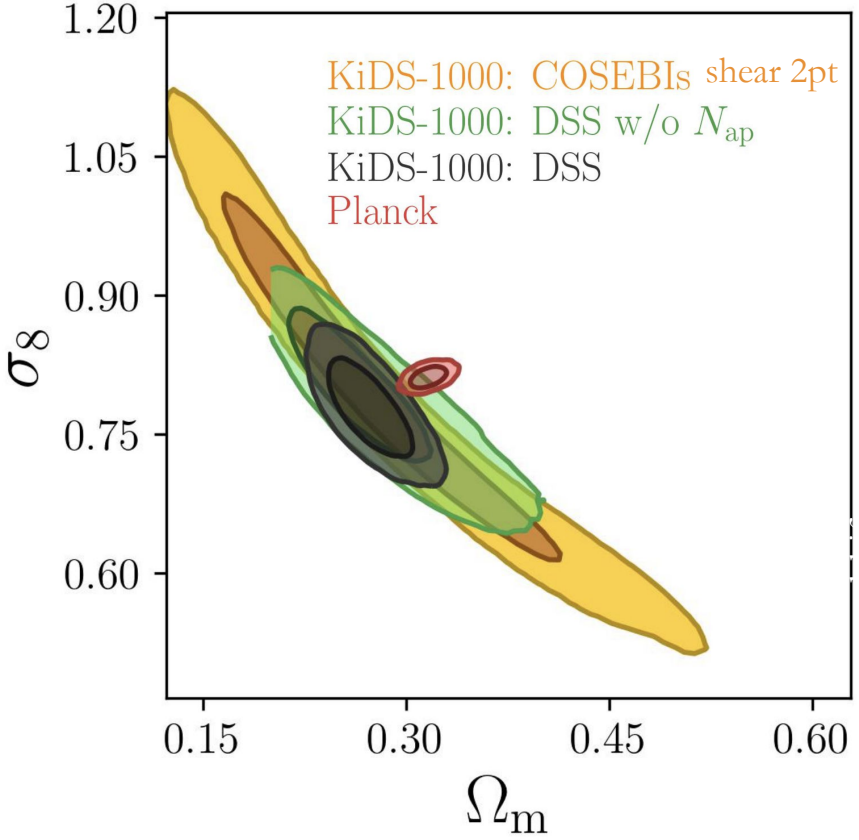


DG, Friedrich 2015;
DG, Friedrich, 2017;
Friedrich, DG, 2017



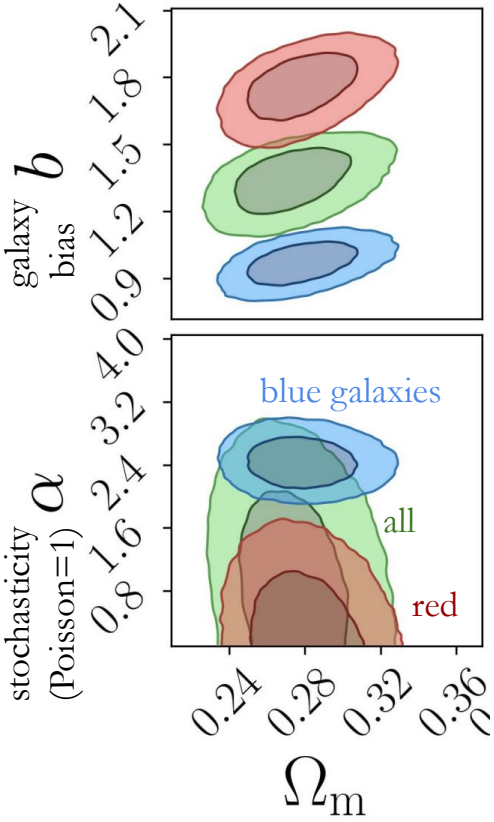


Past Highlight:
Density split statistics in DES and KiDS



Recent KiDS-1000 density split statistics analysis by Pierre Burger (Bonn), Oliver Friedrich et al.

- Methodological improvements
- Competitive cosmological constraints
- Insights on red/blue galaxy-matter connection

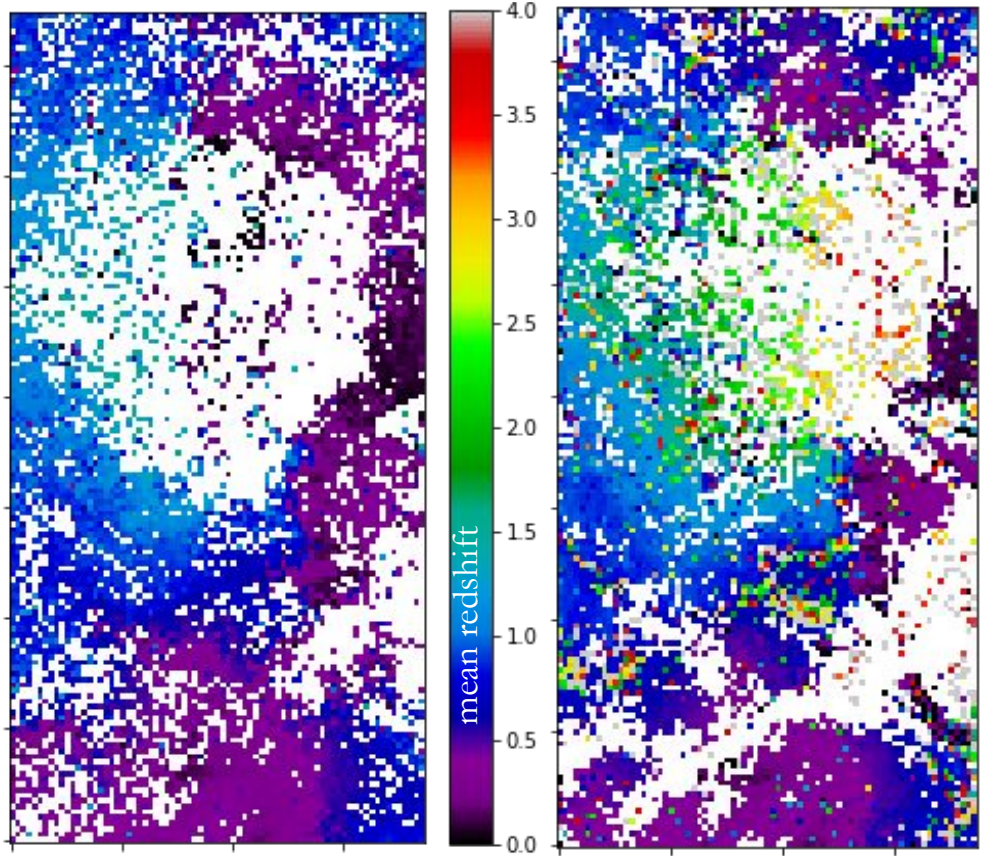


Recent Highlight:
Calibrating the color-redshift relation with massively multiplexed spectroscopy

DESI complete calibration of the color redshift relation (DC3R2)

- ➔ 57% of color space
- ➔ 241k galaxies
- ➔ SV + partial Y1, DESI Operations
- ➔ 2 Additional Dedicated Tiles

McCullough, Gruen+ in prep.



Masters et al. (2015) SOM

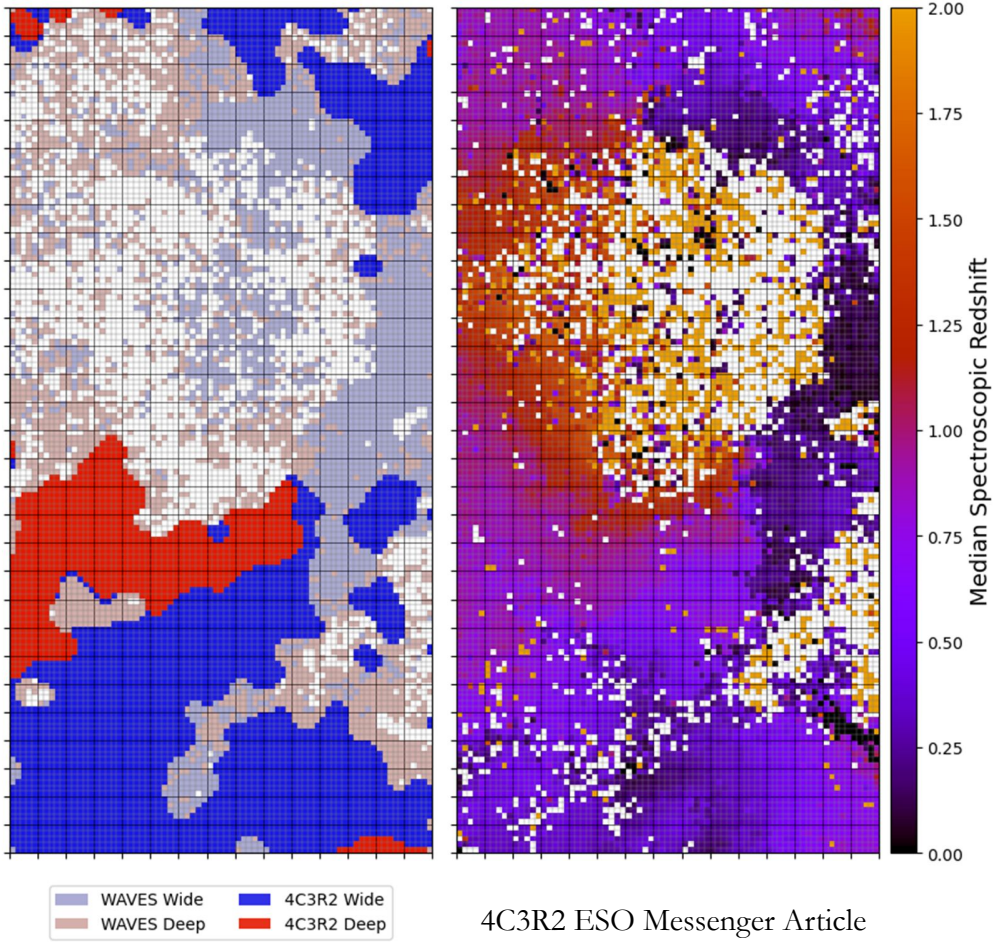
COSMOS Field Spectroscopy,
C3R2 + zCOSMOS + Others

- ➔ 65% of color space
- ➔ 27k galaxies
- ➔ > 1200 hrs of exposure on Keck/VLT/Gemini/ Subaru/LBT

Recent Highlight:
4MOST Complete Calibration of the Color Redshift Relation (4C3R2)

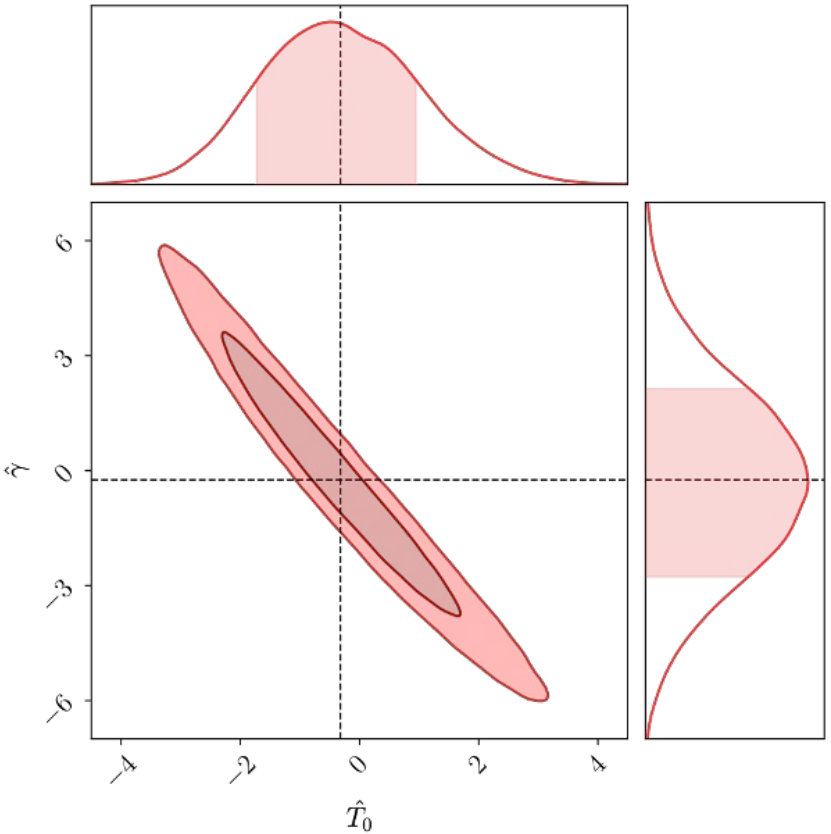
- 980k fiber hour community survey: ~150k galaxies, selected by KiDS-VIKING color
- Coordinated with 4MOST survey WAVES which aims to be complete at low redshift
- 4C3R2 will cover the same fields with high multiplicity of representative targets in complementary color space to z < 1.55

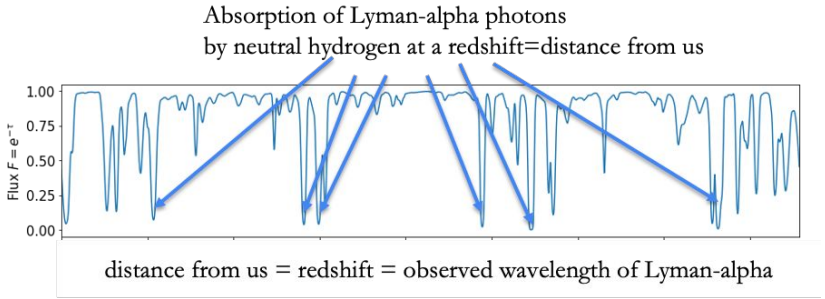
→ in wide, ~45 per cell (Z < 21.4)
→ in deep, ~10 per cell (Z < 22)



4C3R2 ESO Messenger Article
(*Gruen, McCullough+ in press*)

Recent Highlight:
Deep learning insights from Cosmic Structure



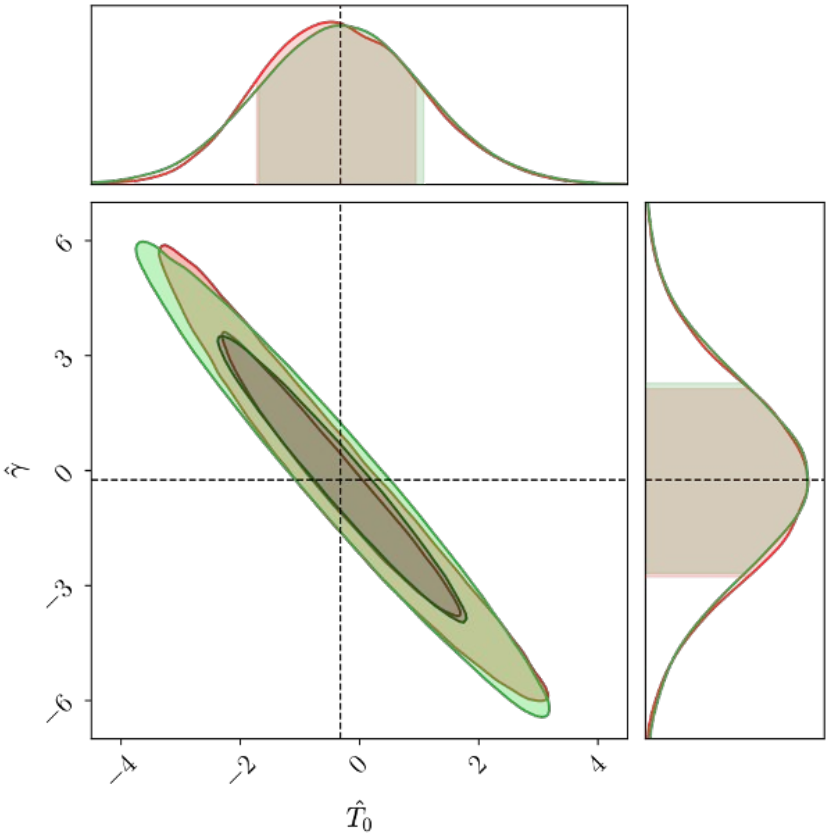


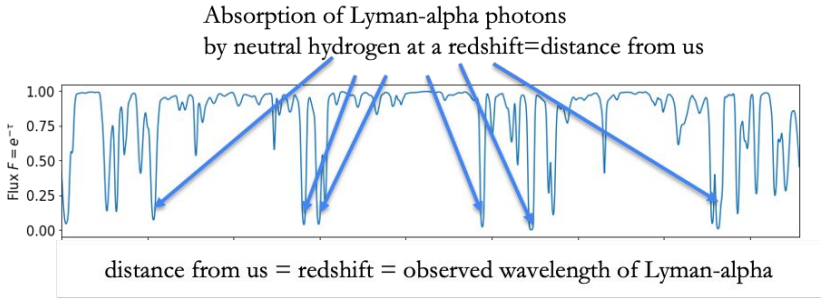
Traditional likelihood analysis of power spectrum
"summary" returns uncertain, degenerate results on
astrophysical parameters of neutral hydrogen gas



Parth Nayak et al. in prep.,
with Michael Walther and Oliver Friedrich

Recent Highlight:
Deep learning insights from Cosmic Structure





Traditional likelihood analysis of power spectrum "summary" returns uncertain, degenerate results on astrophysical parameters of neutral hydrogen gas

Deep Learning / convolutional neural network, applied to the same "summary" is equivalent (that means it is doing as well as possible!)

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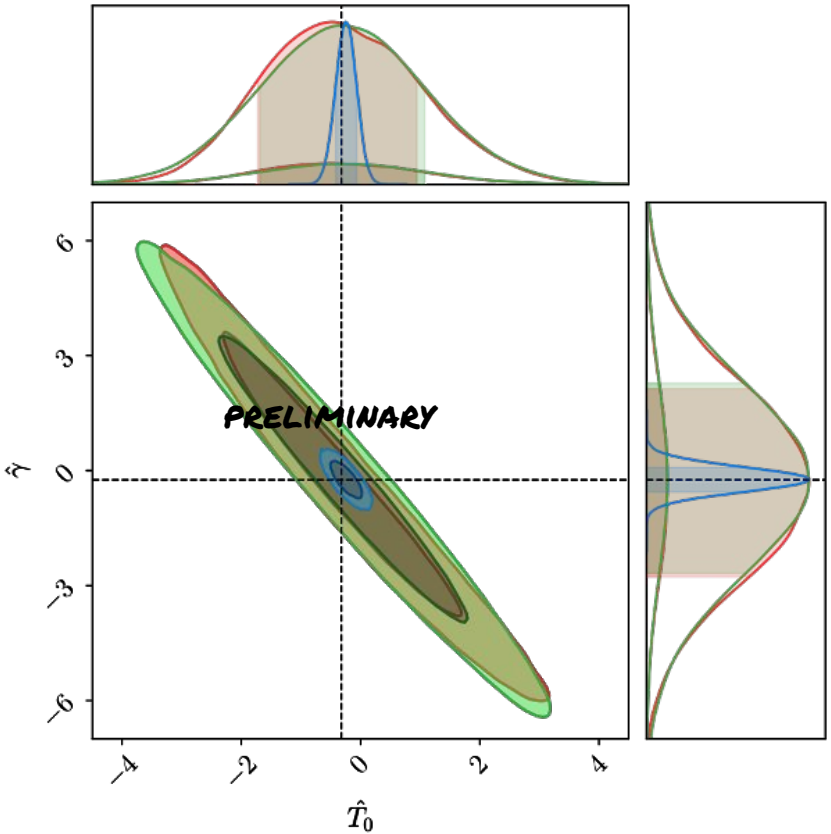
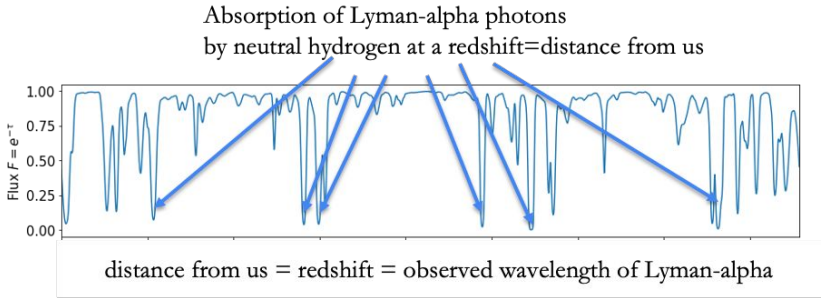
Deep learning insights from Cosmic Structure



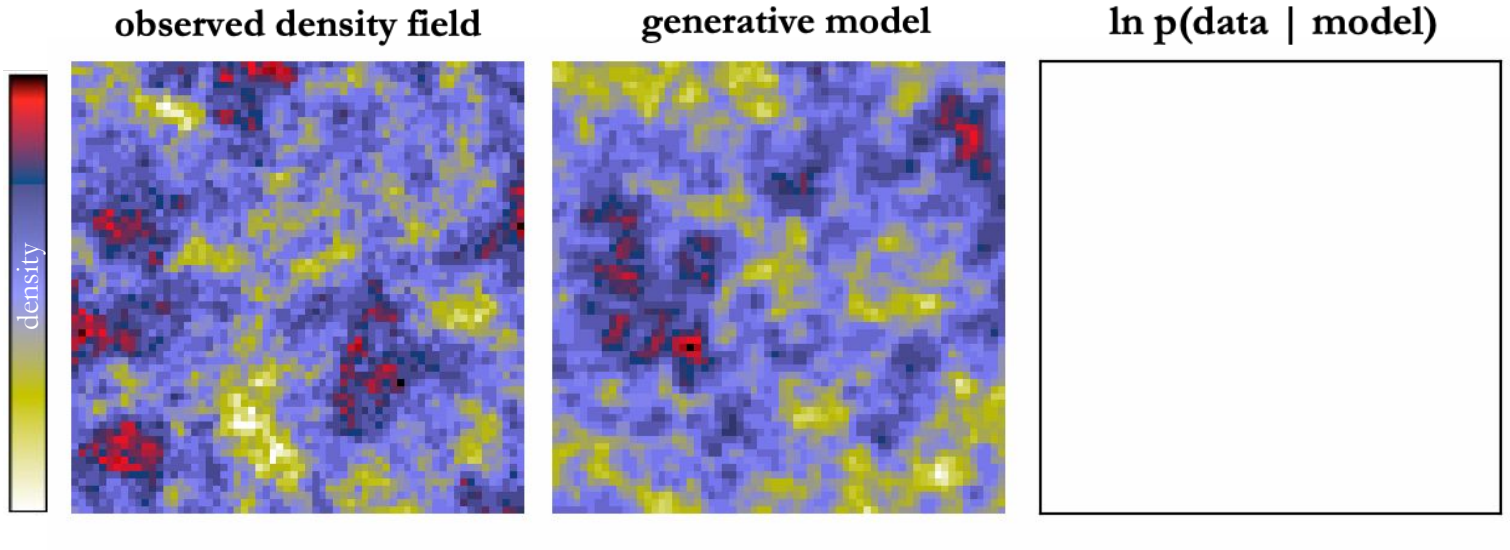


Traditional likelihood analysis of power spectrum "summary" returns uncertain, degenerate results on astrophysical parameters of neutral hydrogen gas

Deep Learning, applied to the same "summary" is equivalent (that means it is doing as well as possible!)

Deep Learning applied to original data is much more constraining. Most of the information on astrophysics is not in the power spectrum!

Recent Highlight:
Generative Models for Bayesian Analysis of Cosmic Structure



Jed Homer with Yun-Hsin Hsu and Oliver Friedrich

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