# Tomasz Kacprzak

Senior Data Scientist, Swiss Data Science Center
Senior Scientist, Cosmology Group, ETH Zurich

Swiss Data Science Center
Paul Scherrer Institute, 5232 Villigen, Switzerland
Email: tomasz.kacprzak@phys.ethz.ch
Website: tomaszkacprzak.github.io

## Employment

2021 - present **Senior Data Scientist**, Swiss Data Science Center
Organizing collaborations for adaptaion of data science in physics, ML for climate science

2017 - present **Senior Scientist**, Institute of Particle Physics and Astrophysics, ETH Zurich
Idea originator and lead advisor for 6 PhD student papers and 8 MSc student papers

2014 - 2017 Post-doctoral research associate, Institute for Astronomy, ETH Zurich
First author of 3 papers, advisor: Prof Alexandre Refregier

## Education

2010 - 2014 **PhD in Physics and Astronomy**, University College London, UK
Advisors: Prof Sarah Bridle, Prof John Shawe - Taylor
Thesis topic: *Statistical problems in Weak Gravitational Lensing*

2009 - 2010 **MSc Machine Learning**, First Class, University College London, UK
Advisors: Prof John Shawe-Taylor, Prof Ofer Lahav
Thesis topic: *Kernel methods for galaxy morphological classification*

## Awards

2023 - 2025 NERSC Exascale Science Applications Program, NESAP for Learning
**Principal Investigator**, algorithmic and technical support (0.5 FTE NERSC post-doc)
Awarded by the National Energy Research Scientific Computing Center, USA

2020 - 2021 Computational production project: *Measuring Dark Energy with Deep Learning*
**Principal Investigator**, value 750'000 GPU-node hours, data at www.cosmogrid.ai
Awarded by the Swiss National Supercomputing Center (CSCS)

2017 - 2019 Grant: *Deep Learning for Observational Cosmology*
**Principal Investigator**, hired staff: Nathanael Perraudin (post-doc), Janis Fluri (PhD)
Awarded by Swiss Data Science Center, 600k CHF (500k GBP)

2019 Workshop: *Artificial Intelligence Methods in Cosmology*, June 9-12
Main applicant and lead organizer, grant value 4.8k CHF (4k GBP)
Awarded by Congressi Stefano Franscini

2018 Preparatory project: *Parallel Deep Learning for Point Spread Function estimation*
Principal Investigator, grant value 1000 GPU node hours
Awarded by Swiss National Supercomputing Centre (CSCS)

## Major scientific achievements

2018 - present Introduction of deep learning to cosmology, from prototypes [1807.08732], first practical measurements [1906.03156], and mature measurements on par with main analysis [2201.07771].

2015 - present Leadership of the simulation-based inference in Dark Energy Survey, using shear peak statistics for the Science Verification [1603.05040] and Year 3 [2110.10135] cosmology constraints.

2016 - present Lead of an independent, full image-level reanalysis of the Dark Energy Survey Year 1 data using simulation-based forward modelling framework Monte Carlo Control Loops [1906.01018].

## Leadership and service

| | |
|---|---|
| 2022 - present | **Simulations Working Group coordinator in the Dark Energy Survey**<br>Coordinating 6 projects led by junior researchers, membership of the Science Committee |
| 2018 - 2019 | **Lead organiser of workshop** *Artificial Intelligence Methods in Cosmology*<br>Monte Verita, Ascona, June 2019, 46 participants, 6 invited speakers |
| 2018 - 2020 | Member of the IPA Institute Council, representative of non-permanent research staff |
| 2017 - 2020 | Coordinator of the Cosmology Seminar at ETH Zurich |
| 2015 - present | Referee for: Nature Astronomy, Physical Review, JCAP, MNRAS, CompAst, and others |
| 2012 | Observing for the Dark Energy Survey at the Blanco Telescope, CTIO, Chile |

## Supervision

**Idea originator and lead advisor for 3 post-doc projects, 7 PhD projects, 13 MSc projects.**
8/13 MSc projects resulted in articles published or accepted to peer-reviewed journals, marked with ↗.

| | |
|---|---|
| 2022 - present | Arne Thomsen, PhD, *Cosmology with deep learning of combined probes in DES* |
| 2022 - present | Virginia Ajani, post-doc, *Peak statistics of combined probes in DES* |
| 2021 - present | Beatrice Moser, PhD, *Evolution of galaxy samples with ABC forward modelling in DES* |
| 2022 - present | Silvan Fischbacher, MSc, PhD, *Redshift requirements for cosmic shear with intrinsic alignment* ↗ |
| 2022 | Gaspard Aymerich, MSc, *Interpretability of deep-learning methods applied to LSS surveys* |
| 2022 | Ting Tan, MSc, *Assessing theoretical uncertainties for cosmological constraints from weak lensing* ↗ |
| 2022 | Dominik Zürcher, PhD, *Dark energy survey year 3 results: Cosmology with peaks* ↗ |
| 2022 | Janis Fluri, PhD, *Full wCDM Analysis of KiDS-1000 Weak Lensing Maps using Deep Learning* ↗ |
| 2018 | Nathanael Perraudin, post-doc data scientist, *Deep learning on the sphere* ↗ |
| 2020 | Timothy Wing Hei Yiu, MSc, *A tomographic spherical mass map emulator of KiDS-1000* ↗ |
| 2020 | Benjamin Suter, MSc, *Cosmology with machine learining and humand -designed statistics* |
| 2019 | Dominik Zürcher, PhD, *Cosmological forecast for non-Gaussian statistics in large-scale surveys* ↗ |
| 2019 | Janis Fluri, PhD, *Cosmological constraints with deep learning from KiDS-450 weak lensing maps* ↗ |
| 2019 | Conrad Schwanitz, MSc, *Interpretability measures for deep learning based on weak lensing maps* |
| 2019 | Sajanth Subramaniam, MSc, *Systematics-invariant cosmological constraints with deep learning* ↗ |
| 2018 | Jörg Herbel, PhD, *Fast Point Spread Function Modeling with Deep Learning* ↗ |
| 2018 | Sandro Marcon, MSc, *Emulation of cosmological mass maps with conditional GANs* ↗ |
| 2018 | Ankit Srivastava, MSc, *Cosmological N-body simulations: a challenge for scalable GANs* ↗ |
| 2018 | Janis Fluri, PhD, *Cosmological constraints from noisy convergence maps through deep learning* ↗ |
| 2018 | Alex Stauffer, MSc, *Approximate Bayesian Computation in cosmology with the ABCpy package* |
| 2018 | Jonathan Rosenthal, MSc, *Generative Temporal Models for Cosmology* |
| 2017 | Janis Fluri, MSc, *Weak lensing peak statistics in the era of large scale cosmological surveys* ↗ |
| 2017 | Andres Rodrigues, MSc, *Fast cosmic web simulations with generative adversarial networks* ↗ |
| 2017 | Jorit Schmelzle, MSc, *Cosmological model discrimination with deep learning* |

## Teaching

| | |
|---|---|
| 2019 - 2020 | Lecturer for UG course *Statistical Methods and Analysis in Experimental Physics*<br>Topical block: Bayesian methods, machine learning, simulations-based inference<br>Tasks: lectures, preparing assignments, leading the tutorials for approx. 50 students |
| 2019 | Lecturer for the UG course *Astrophysics 1*, topical block: *Introduction to Cosmology* |
| 2019 - 2020 | Guest lecturer for UG course *Introduction to Data Science* at University of Zurich<br>Topics: deep learning, convolutional neural networks, generative models |
| 2017 - 2018 | Course coordinator for undergraduate module *Physics 1 and 2*, approx. 300 students<br>Tasks: creation of exercises, preparation of exams and coordination of marking |
| 2016 - 2017 | Teaching assistant for MSc course *Advanced Statistical Methods in Cosmology*<br>Tasks: curriculum development, creating assignments, leading tutorials |
| 2017 | Leader of the tutorial sessions, masters-level module *Cosmological Probes* |

## Selected presentations

| | |
|---|---|
| 2023/06 | *Emerging topics in applications of Optimal Transport*, ITS, ETH Zurich, CH |
| 2023/05 | *ML X Astrophysics Symposium*, Flatiron Insitute, New York, USA, invited talk |
| 2023/03 | *University Observatory Munich Colloquium*, Munich, DE, invited talk + 2-day tutorials |
| 2022/09 | *SDSC internal seminar*, topic: "Accelerated Machine Learning on New HPC Clusters" |
| 2022/07 | *Key Challenges in Galaxy and CMB lensing*, Cambridge, UK, invited guest talk |
| 2022/06 | *Bayesian Deep Learning in Cosmology*, Paris, FR, **invited keynote talk** |
| 2022/06 | *Space Science Data Center Seminar*, Rome, IT, invited seminar talk |
| 2022/04 | *Berkeley ML and Science Forum*, Berkeley, USA, invited seminar talk |
| 2021/10 | *Cosmology seminar*, University of Geneva, CH, invited seminar talk |
| 2021/07 | *Cosmology from Home 2021*, online |
| 2021/05 | *Dark Energy Spectroscopic Instrument: Artificial Intelligence Seminar*, invited talk |
| 2020/10 | *German Center For Cosmological Lensing Seminar*, Bohum, DE |
| 2020/10 | *Institute of Cosmology and Gravitation Colloquium*, Portsmouth, UK, invited talk |
| 2020/01 | *Applied Machine Learning Days: Machine Learning and Space*, Lausanne, CH |
| 2019/12 | *Machine Learning Tools for Research in Astronomy Workshop*, Ringberg, DE |
| 2019/10 | *LSST Dark Energy Science Collaboration*, online |
| 2019/09 | *Cosmology seminar*, SLAC, Stanford, USA, invited talk |
| 2019/08 | *Understanding Cosmological Observations Workshop*, Benasque, ES |
| 2019/07 | *Applied Inverse Problems*, Grenoble, FR, invited panel talk |
| 2019/11 | *8th KIAS workshop on cosmology and structure formation*, Seoul, KR |
| 2019/04 | *IDIAP Research Institute Seminar*, Moriond, CH, invited talk |
| 2018/10 | *Computational Science Seminar*, University of Zurich, CH, invited seminar talk |
| 2018/06 | *Cosmology Seminar*, University College London, UK |
| 2018/04 | *Swiss Data Science Center Project Day*, Bern, CH, invited talk |
| 2017/10 | *Dark Universe*, Munich, Germany |
| 2016/07 | *Celebrating the Century of Gravitational Lensing*, Leiden, NL |
| 2013/06 | *Weak Lensing Beyond The Ordinary*, Nice, FR |
| 2013/08 | *GREAT3 Kickoff meeting*, JPL, Pasadena, USA |

## Publications

Authored 21 papers on own original ideas, including 7 as the lead author. Signigifcantly contributed to 12 papers by students at the ETH Zurich Cosmology Group in a support role, and 33 international collaboration papers. Most important publications are listed firest. Citation count as of 11 Nov 2022 provided by NASA ADS.

Selected papers on own original ideas, lead author or lead advisor:

**CosmoGridV1: a simulated $w$CDM theory prediction for map-level cosmological inference**
T. Kacprzak, J. Fluri, A. Schneider, A Refregier, J Stadel
JCAP 2023, 02, 050, 29, 2209.04662, citations: 7

**DeepLSS: breaking parameter degeneracies in large scale structure with deep learning of combined probes**
T. Kacprzak, J. Fluri
**PhysRevX (impact factor 14.5)**, 2022, 2, 031029, 2203.09616, citations: 6

**A Full wCDM Analysis of KiDS-1000 Weak Lensing Maps using Deep Learning**
J. Fluri, T. Kacprzak, A. Lucchi, A. Schneider, A. Refregier, T. Hofmann
PhysRevD, 2022, 105, 8, 083518, 2201.07771, citations: 14

**Cosmological constraints with deep learning from KiDS-450 weak lensing maps**
J. Fluri, T. Kacprzak, A. Lucchi, A. Refregier, A. Amara, T. Hofmann, A. Schneider
PhysRevD, 2019, 100, 6, 1906.03156, citations: 87

**DeepSphere: Efficient spherical convolutional neural network with HEALPix sampling for cosmology**
N. Perraudin, M. Defferrard, T. Kacprzak, R. Sgier
Astronomy and Computing, 2019, 27, 130, 1810.12186, citations: 68, including in computer science: 161

**Cosmological constraints from noisy convergence maps through deep learning**
J. Fluri, T. Kacprzak, A. Lucchi, A. Refregier, A. Amara, T. Hofmann
PhysRevD, 2018, Vol. 98, 12, 1807.08732, citations: 51

**Cosmological model discrimination with deep learning**
J. Schmelzle, A. Lucchi, T. Kacprzak, A. Amara, R. Sgier, A. Réfrégier, T. Hofmann
unpublished, 1707.05167, citations: 55

**Fast Cosmic Web Simulations with Generative Adversarial Networks**
A. C. Rodriguez, T. Kacprzak, A. Lucchi, A. Amara, R. Sgier, +3 authors
CompAst, 2018, 5, 1, 4, 11, 1801.09070, citations: 71

**Cosmology constraints from shear peak statistics in Dark Energy Survey Science Verification data**
T. Kacprzak, D. Kirk, O. Friedrich, + 84 authors (DES collaboration)
MNRAS, 2016, 463, 4, 1603.05040, citations: 119

**Dark Energy Survey Year 3 results: Cosmology with peaks using an emulator approach**
D. Zürcher, ... T. Kacprzak, + DES Collaboration (102 authors)
MNRAS, 2022, 511, 2, 2075-2104, 2110.10135, citations: 37

**A tomographic spherical mass map emulator of the KiDS-1000 survey using conditional GANs**
T. W. H. Yiu, J. Fluri, T. Kacprzak
JCAP 2022, 12, 013, 40, 2112.12741, citations: 3

**Measurement and calibration of noise bias in weak lensing galaxy shape estimation**
T. Kacprzak, J. Zuntz, B. Rowe, S. Bridle, A. Refregier, A. Amara, L. Voigt, M. Hirsch
MNRAS, 2012, 427, 1203.5049, citations: 82

**Monte Carlo Control Loops for cosmic shear cosmology with DES Year 1**
T. Kacprzak, J. Herbel, A. Nicola, + 53 authors (DES collaboration)
PhysRevD, 2020, 101, 8, 082003, 1906.01018, citations: 16

**Fast Point Spread Function Modeling with Deep Learning**
J. Herbel, T. Kacprzak, A. Amara, A. Refregier, A. Lucchi
JCAP, 2018, 07, 54, 1801.07615, citations: 49

**Redshift requirements for cosmic shear with intrinsic alignment**
S. Fischbacher, T. Kacprzak, J. Blazek, A. Refregier
JCAP 2023, 01, 033, 37, 2207.01627, citations: 1

Selected papers with substantial contribution:

**Dark Energy Survey Year 3 Results: Cosmology from Cosmic Shear and Robustness to Modeling Uncertainty**
L. Secco, ..., T. Kacprzak, + The DES Collaboration (153 authors)
PhysRevD, 2022, 105, 2, 023515, 2105.13544, citations: 164
Role: DES internal reviewer for this paper

**Dark Energy Survey Year 1 results: Cosmological constraints from cosmic shear**
M.A. Troxel, ..., T. Kacprzak, + 134 authors (DES collaboration)
PhysRevD, 2018, 98, 4, 043528, 1708.01538, citations: 505
Role: wrote Im3shape, calibration and testing of shear catalog

**Dark Energy Survey year 1 results: Cosmological constraints from galaxy clustering and weak lensing**
T.M.C. Abbott, ..., T. Kacprzak, + 199 authors (DES collaboration)
PhysRevD, 2018, 98, 4, 043526, 1708.01530, citations: 956
Role: wrote Im3shape, calibration and testing of shear catalog

**Cosmology from cosmic shear with Dark Energy Survey Science Verification data**
The Dark Energy Survey Collaboration (128 authors, alphabetical) + T. Kacprzak
PhysRevD, 2016, 94, 2, 1507.05552, citations: 177
Role: measurement and calibration of the cosmic shear signal, creation of simulations for testing and calibration

**The DES Science Verification weak lensing shear catalogues**
M. Jarvis, E. Sheldon, J. Zuntz, T. Kacprzak, S. L. Bridle + 90 authors (DES collaboration)
MNRAS, 2016, 460, 2, 1507.05603, citations: 184
Role: creation of simulations to test the methods, calibrations for the Im3shape measurement, paper writing

**Cosmic shear measurements with Dark Energy Survey Science Verification data**
M.R. Becker, ..., T. Kacprzak, + 104 authors (DES collaboration)
PhysRevD, 2016, 94, 2, 022002, 1507.05598, citations: 95
Role: wrote Im3shape, calibration and testing of shear catalog

**GREAT3 results - I. Systematic errors in shear estimation and the impact of real galaxy morphology**
R. Mandelbaum, ..., T. Kacprzak, ... (43 authors)
MNRAS, 2015, 450, 3, 2963-3007, 1412.1825, citations: 127
Role: submission to the GREAT3 competition with the Im3shape results

**GALSIM: The modular galaxy image simulation toolkit**
B.T.P. Rowe, ..., T. Kacprzak, ... (15 authors)
Astronomy and Computing, 2015, 10, 121-150, 1407.7676, citations: 276
Role: development of GalSim, extended testing of the convolution module

**Noise bias in weak lensing shape measurements**
A. Refregier, T. Kacprzak, A. Amara, S. Bridle, B. Rowe
MNRAS, 2012, 425, 1951, 1203.5050, citations: 134
Role: idea development, paper writing

**Cosmological Parameter Estimation and Inference using Deep Summaries**
J. Fluri, A. Lucchi, T. Kacprzak, A. Refregier, T. Hofmann
PhysRevD, 2021, 104, 12, 123526, 2107.09002, citations: 7
Role: coordinating the collaboration with computer scientists Aurelien Lucchi and Thomas Hofmann, comments

**Rapid Simulations of Halo and Subhalo Clustering**
Authors: P. Berner, A. Refregier, R. Sgier, T. Kacprzak, L. Tortorelli, P. Monaco
JCAP 2022, 11, 002, 29, 2112.08389
Role: consulting, comments

**The PAU Survey: Measurement of Narrow-band galaxy properties with Approximate Bayesian Computation**
Authors: L. Tortorelli, M. Siudek, B. Moser, T. Kacprzak, ... + 21 authors (The PAUS Collaboration)
JCAP, 2021, 12, 013, 45, 2106.02651, citations: 10
Role: developing the galaxy population model and the Approximate Bayesian Computation engine

**The redshift distribution of cosmological samples: a forward modeling approach**
J. Herbel, T. Kacprzak, A. Amara, A. Refregier, C. Bruderer, A. Nicola
JCAP, 2017, 08, 035, 1603.05040, citations: 19
Role: contribution to model building and algorithms, co-advisor of J. Herbel (PhD student)