



THE UNIVERSITY OF ARIZONA
COLLEGE OF SCIENCE

Arizona Cosmology Lab

Data Science meets Space Science

cosmolab.arizona.edu



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Kinematic Lensing with the Roman Space Telescope (and other experiments)

Tim Eifler

- CCAPP fellow Sept 2009- April 2012
- PD at Penn (2012-2014)
- JPL Research Scientist (2014-2018)
- Faculty UofA since 2018, (tenure '22, full '25, sabbatical, etc)

As Annika said, at some point you realize you became your mum...

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Cosmolab is an entity across Departments of
Astronomy and Physics

Recently moved into our new lab



Experiments/Missions/Datasets

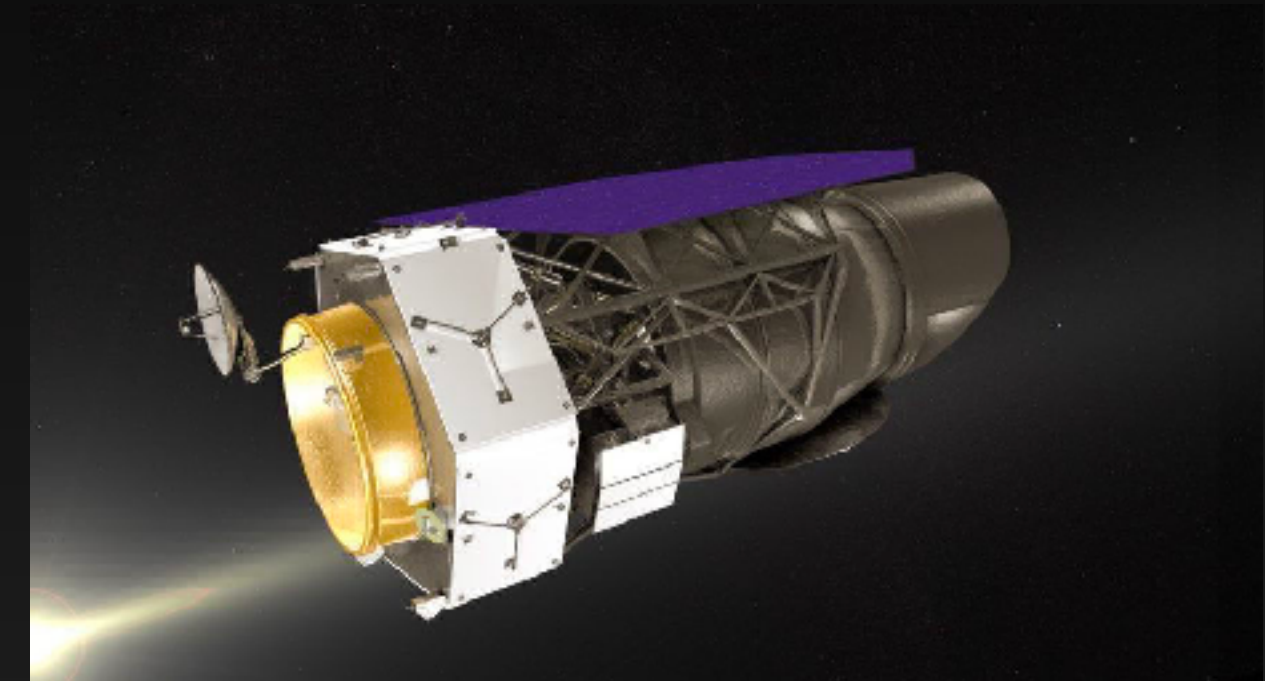
We build models/software for cosmological data analysis
(dark energy, dark matter, neutrino physics, modified gravity, galaxy-halo connection and... many systematics)



DES - completed/ongoing



Rubin Observatory's LSST
Science OP 2026



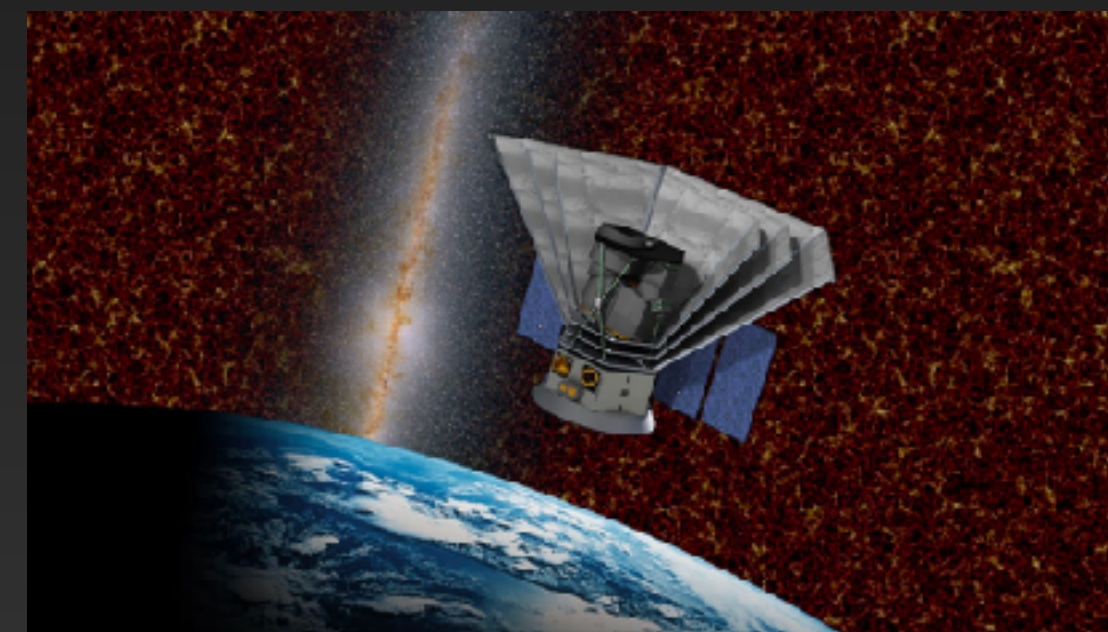
Nancy Grace Roman Space Telescope
- launch 2026



Simons Observatory



DESI - ongoing



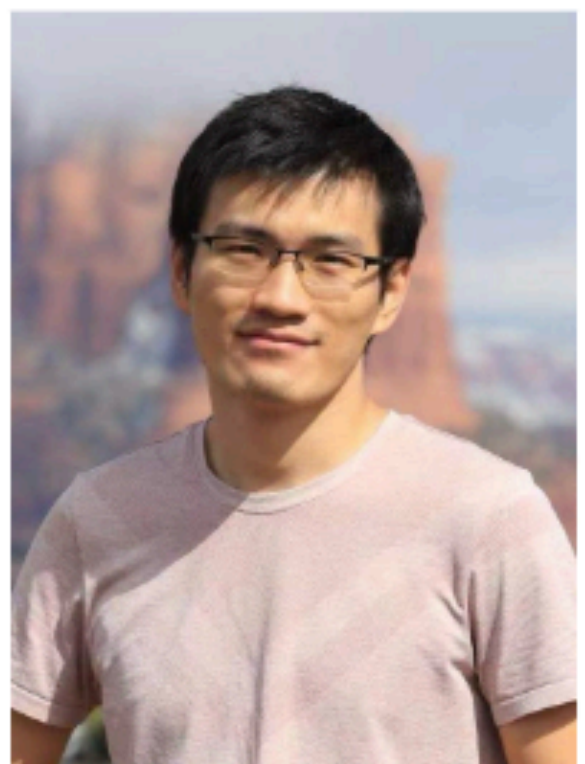
SPHEREx explorer -
launched March 11 2025



Deep Synoptic Array 2000

+we love and use public data of all sorts, e.g. BOSS, KiDS, Planck, ACT, SPT, etc

Roman Kinematic Lensing WFS Team



Jiachuan Xu
UA -> NE



Pranjal R. S.
UA -> JPL



Yu-Hsiu
Huang UA



Lauren
Willett UA



Emily
Macbeth UA



Jiyun Di UA



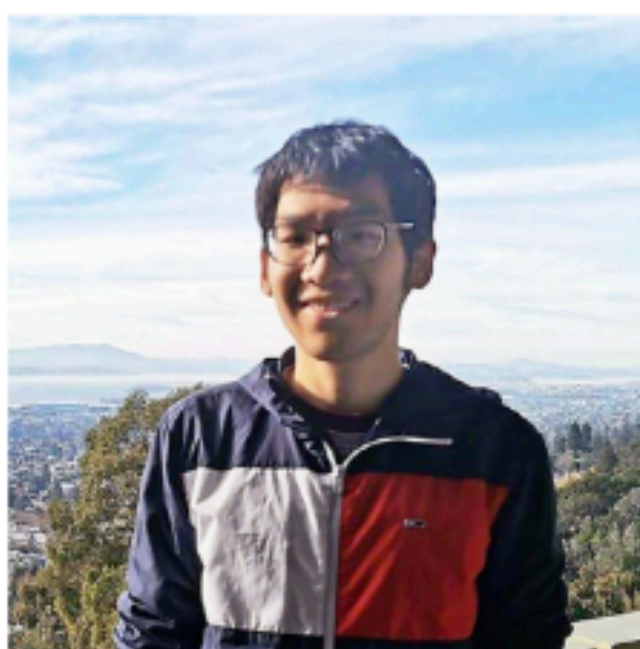
Eason Wang
UA -> CMU



Vic Lloyd, SBU



Fabian Hervas-
Peters (UA)



Yan Lai UA



Eiichi Egami UA



Tim Elfler UA



Elisabeth
Krause (PI) UA



Eric Huff JPL



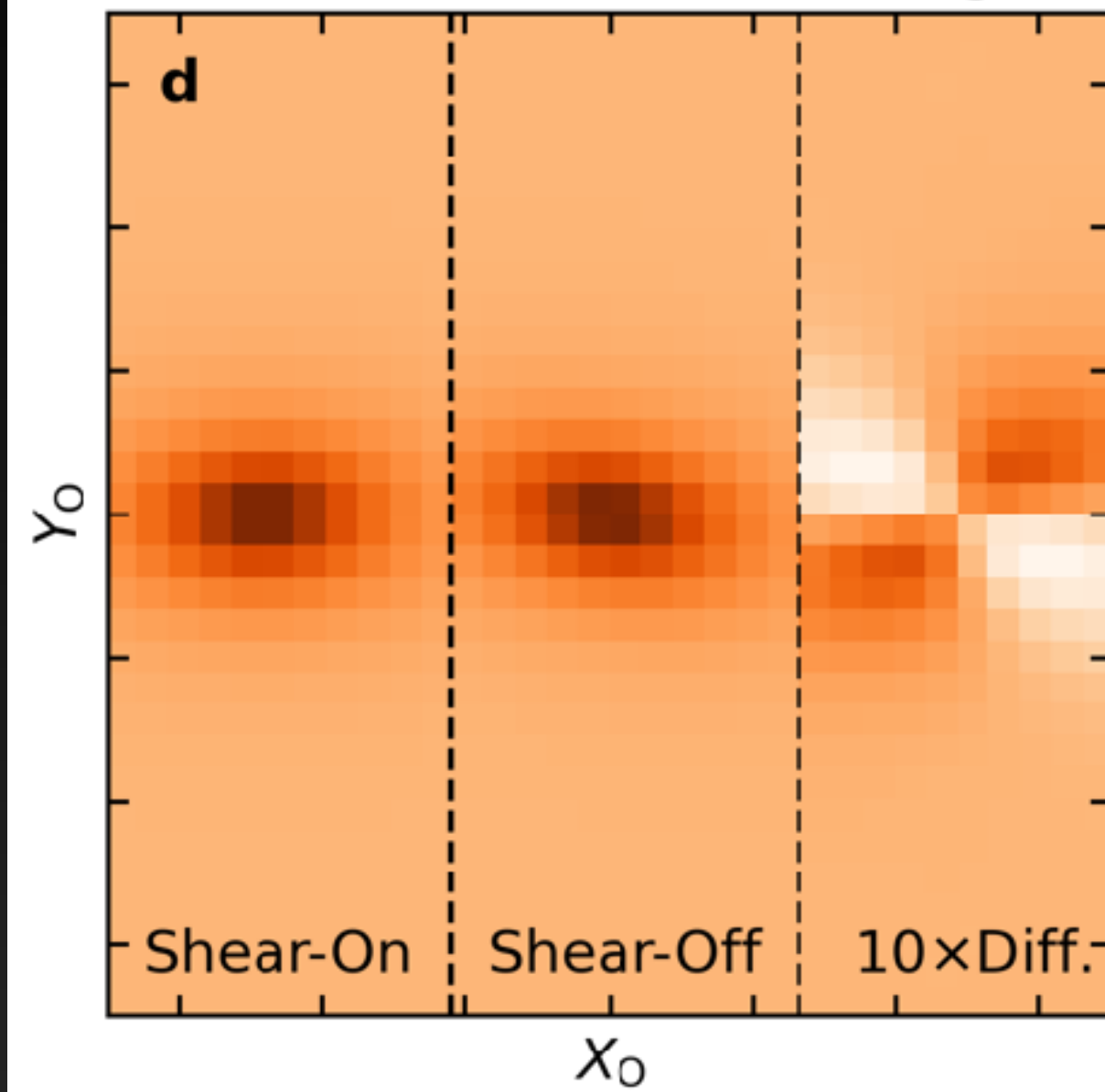
Spencer Everett
Caltech



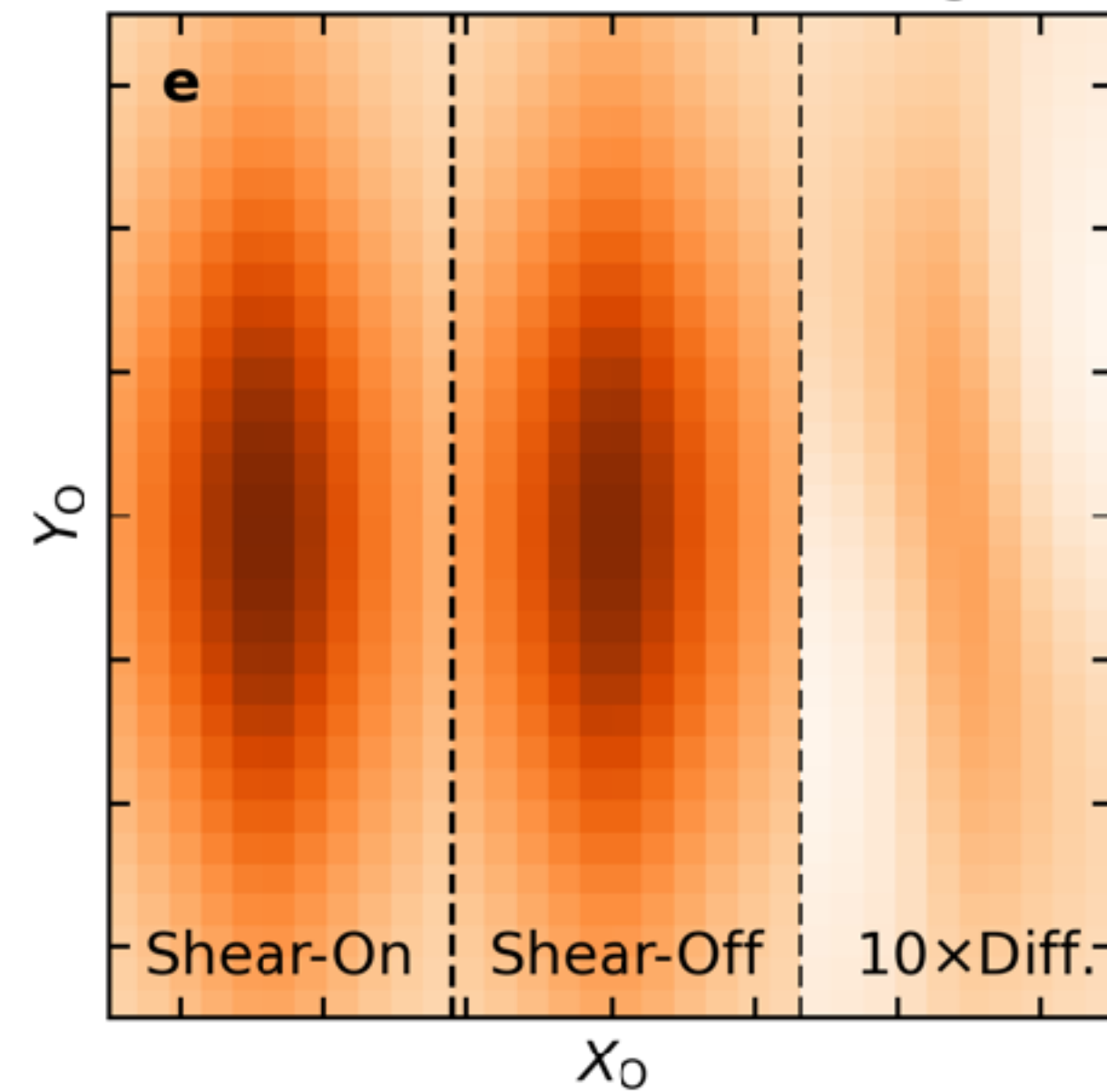
Anoma
Ganguly UA

Kinematic Lensing with the Roman Space Telescope

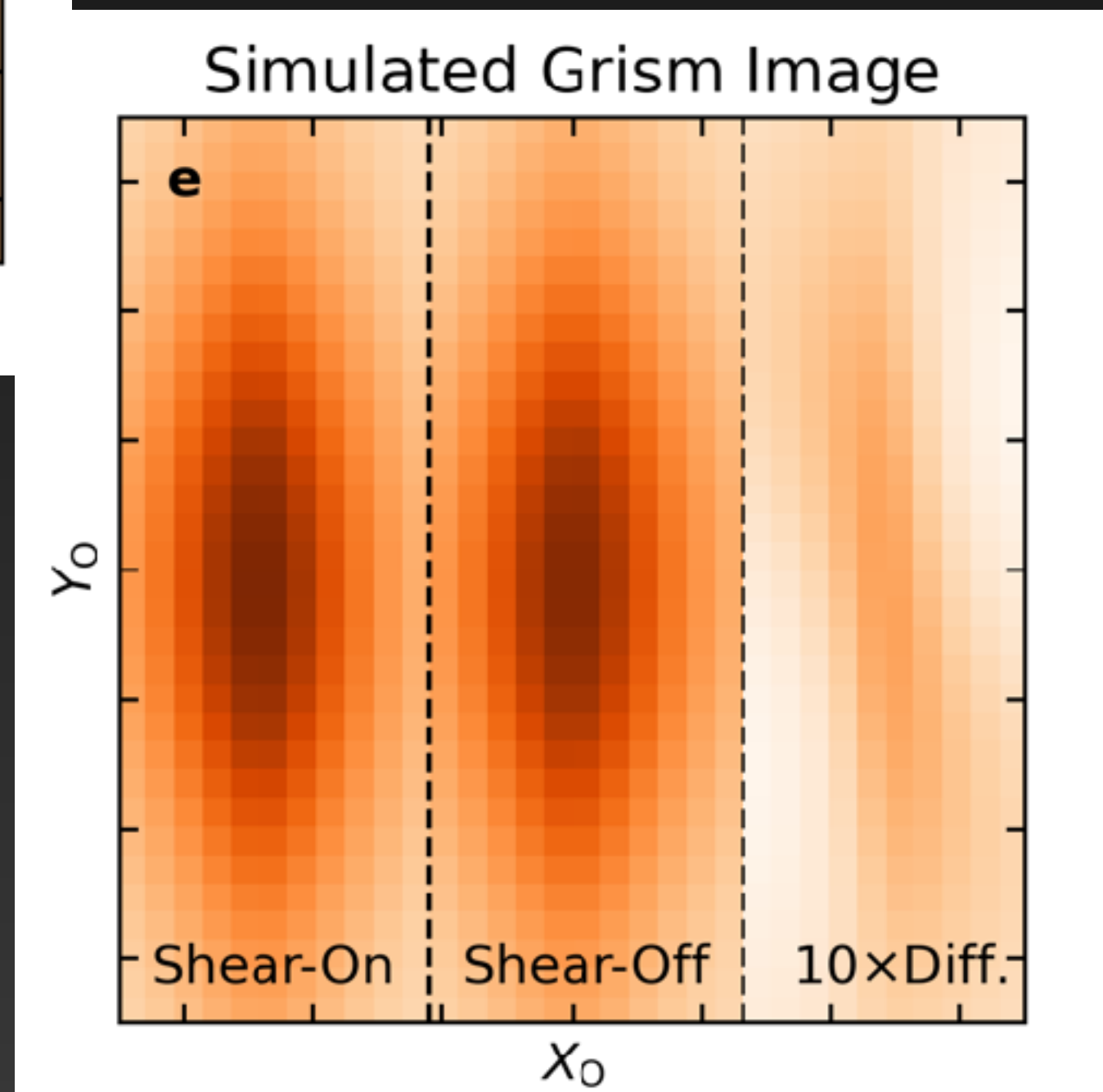
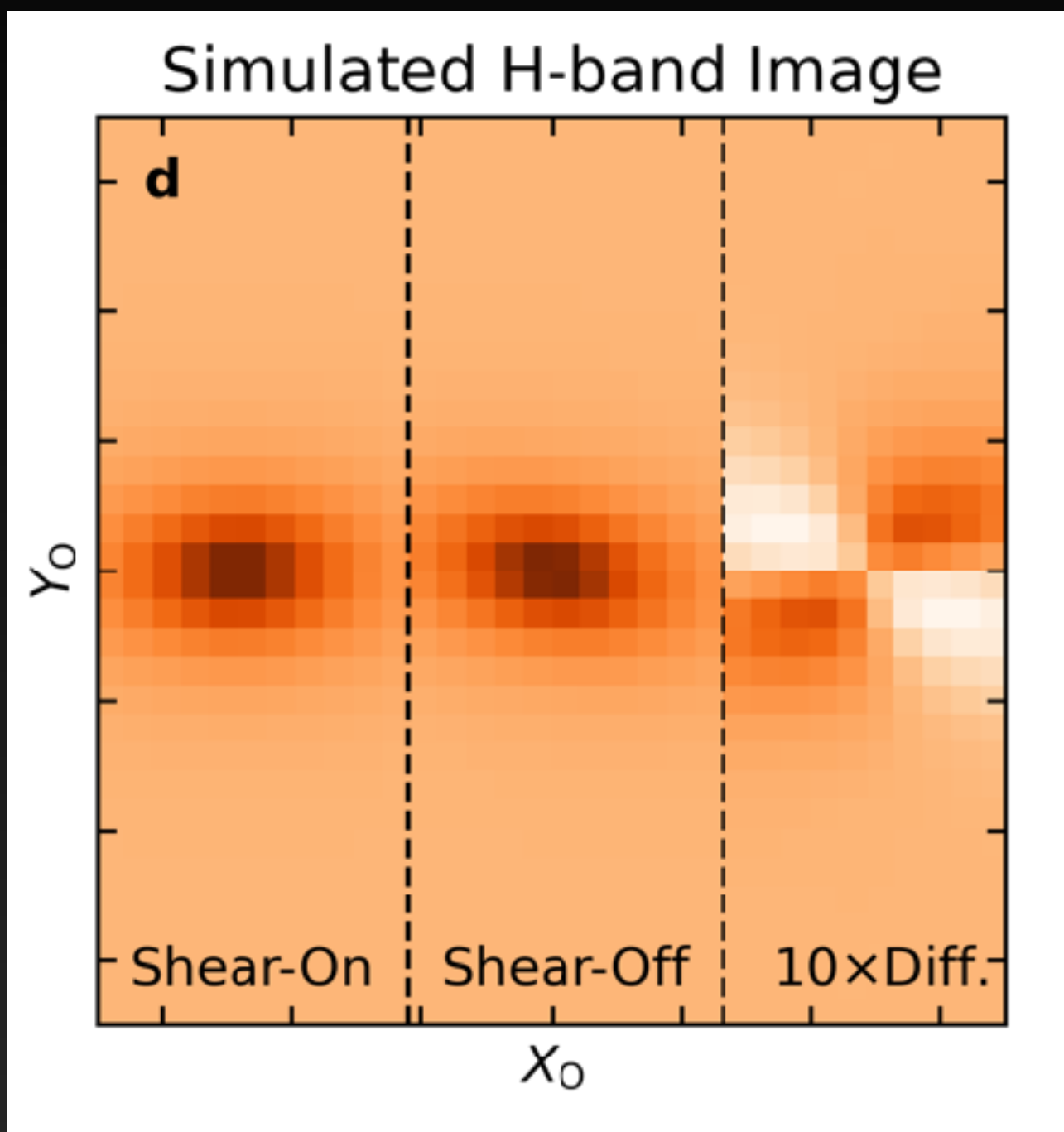
Simulated H-band Image



Simulated Grism Image



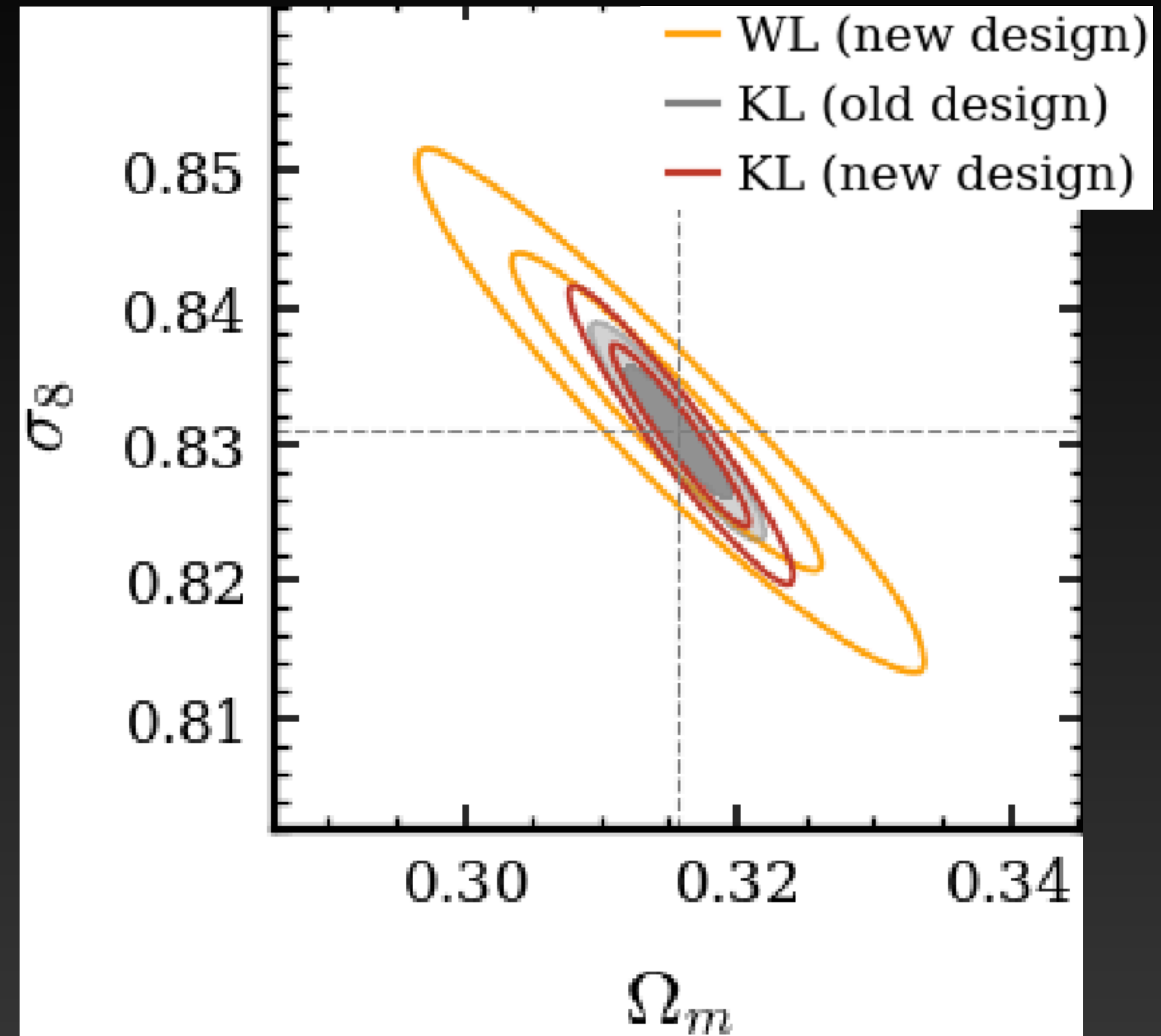
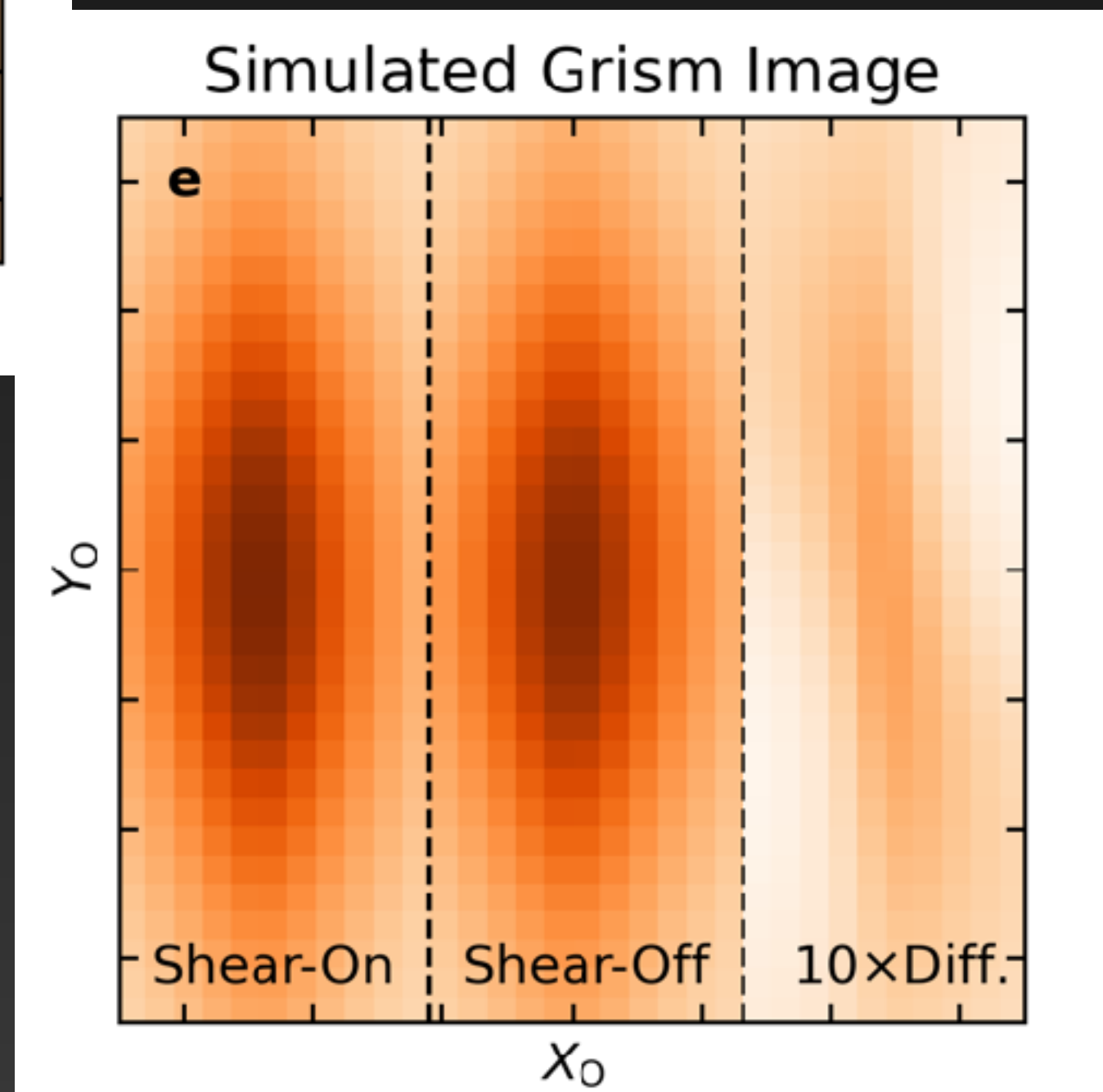
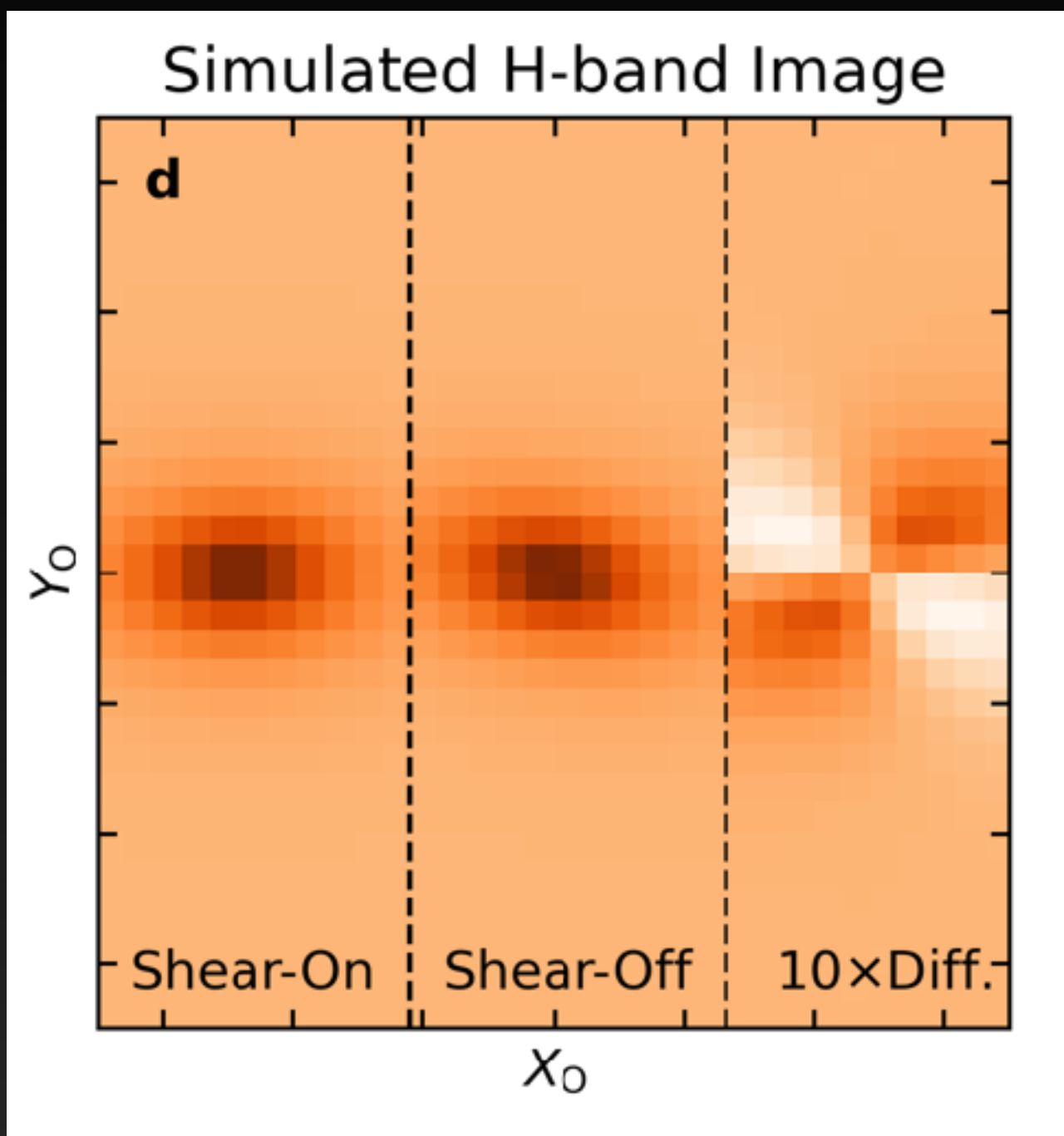
Kinematic Lensing with the Roman Space Telescope



All you need to know about forecasting experiments is

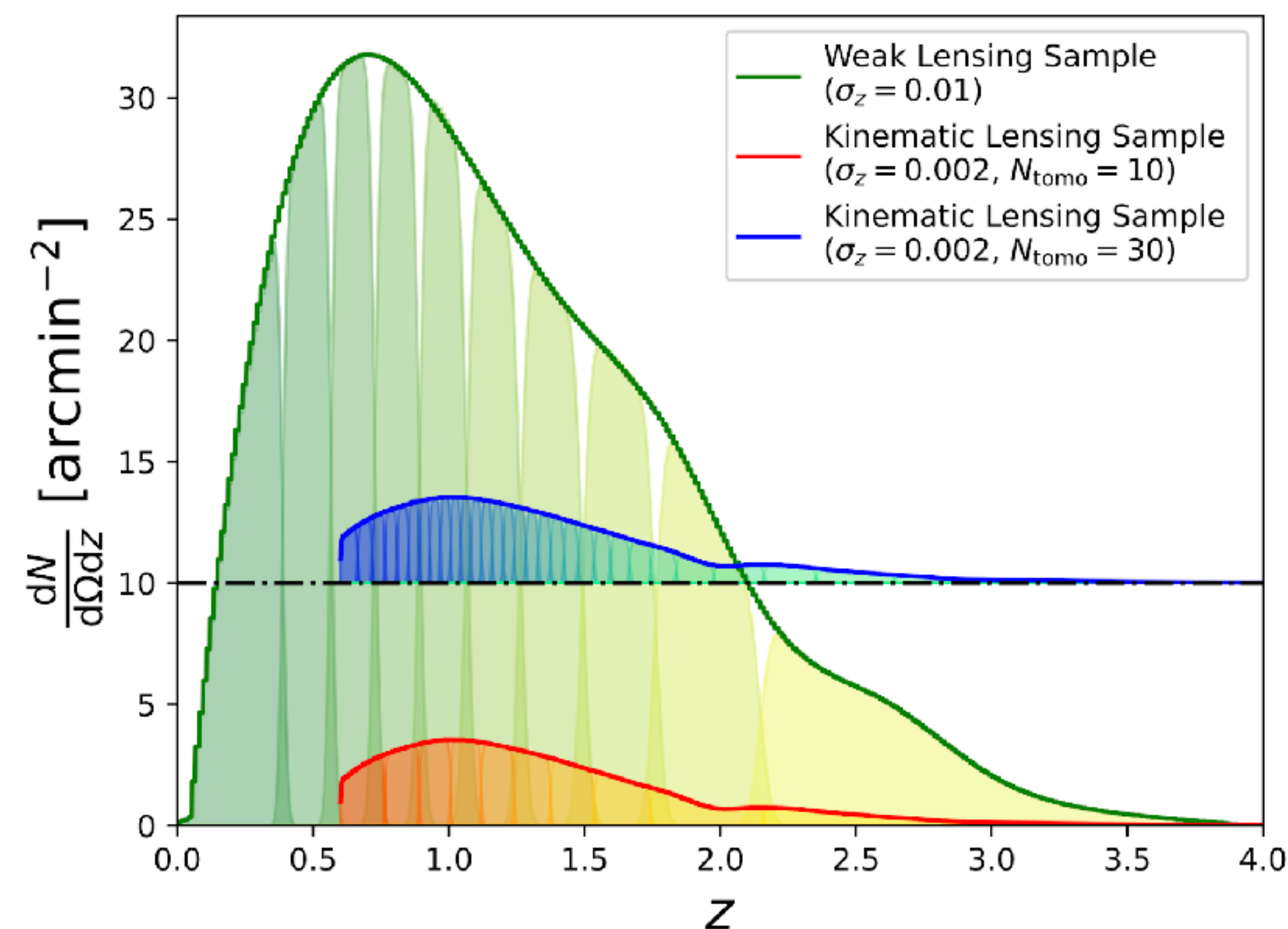
“Smaller contours are always better (unless they are wrong)”

Kinematic Lensing with the Roman Space Telescope



KL with *Roman Space Telescope*

Galaxy sample definition



Obtained from COSMOS and CANDELS

Scenarios Definition:

Reference HLS Imaging

- J+H band combined $S/N > 18$
- Ellipticity error $\sigma_e < 0.2$
- Resolution factor $R > 0.4$

$$n_{\text{gal}}^{\text{WL}} = \frac{51}{\text{arcmin}^2}$$
$$\sigma_e^{\text{WL}} = 0.37$$

Reference HLS Spectroscopy

- At least one of H_α , H_β and $[O_{\text{III}}]$ is resolved within $1 - 2 \mu m$
- Emission flux $> 10^{-16} \text{erg/s/cm}^2$
- Half-light radius $> 0.1''$
- z -band magnitude ≤ 24.5

50%
success
rate

$$n_{\text{gal}}^{\text{KL}} = \frac{4}{\text{arcmin}^2}$$
$$\sigma_e^{\text{KL}} = 0.035$$

**Roman-KL will be exciting already with
Roman Deep Field, so stay tuned!**



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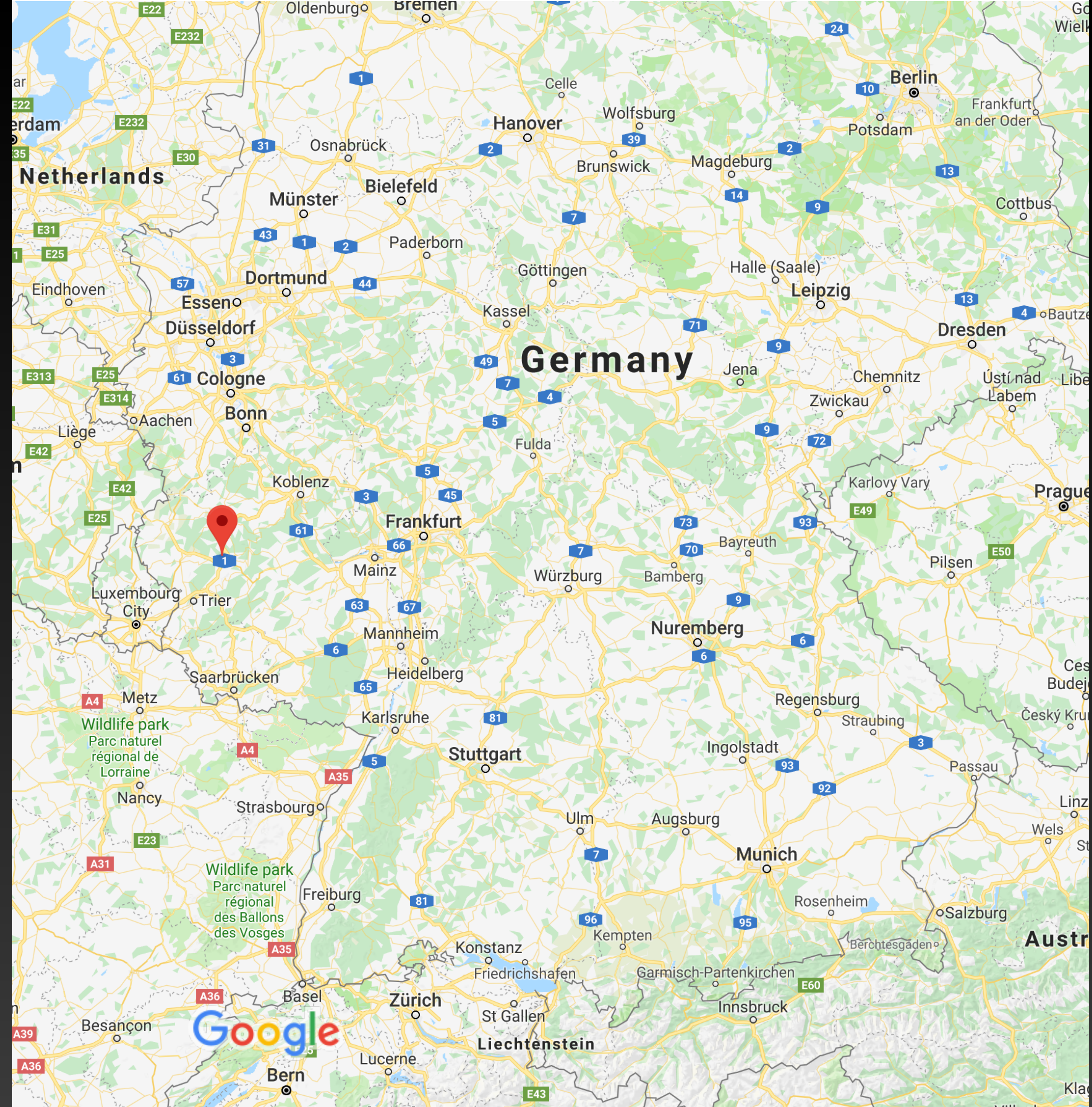
Data Science meets Space Science

How John Beacom fired me from CCAPP (and other stories...)

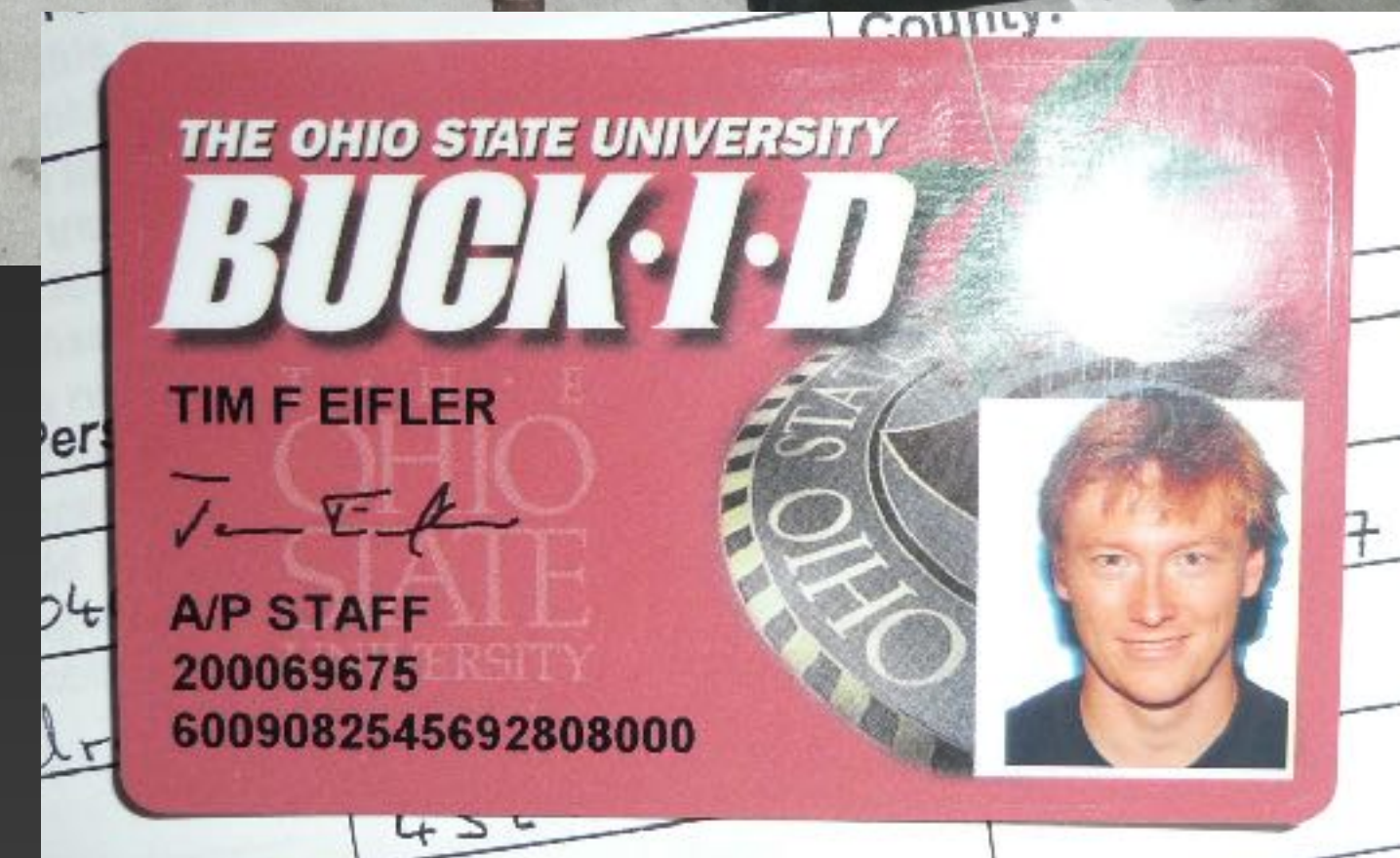
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Pre 2009

- Grew up in the middle of nowhere in the Eifel/Mosel region in Germany
- Undergrad and Grad School at University of Bonn
- Diplom in Physics
- PhD in Astrophysics (Argelander Institute for Astronomy)
- Then moved to the US

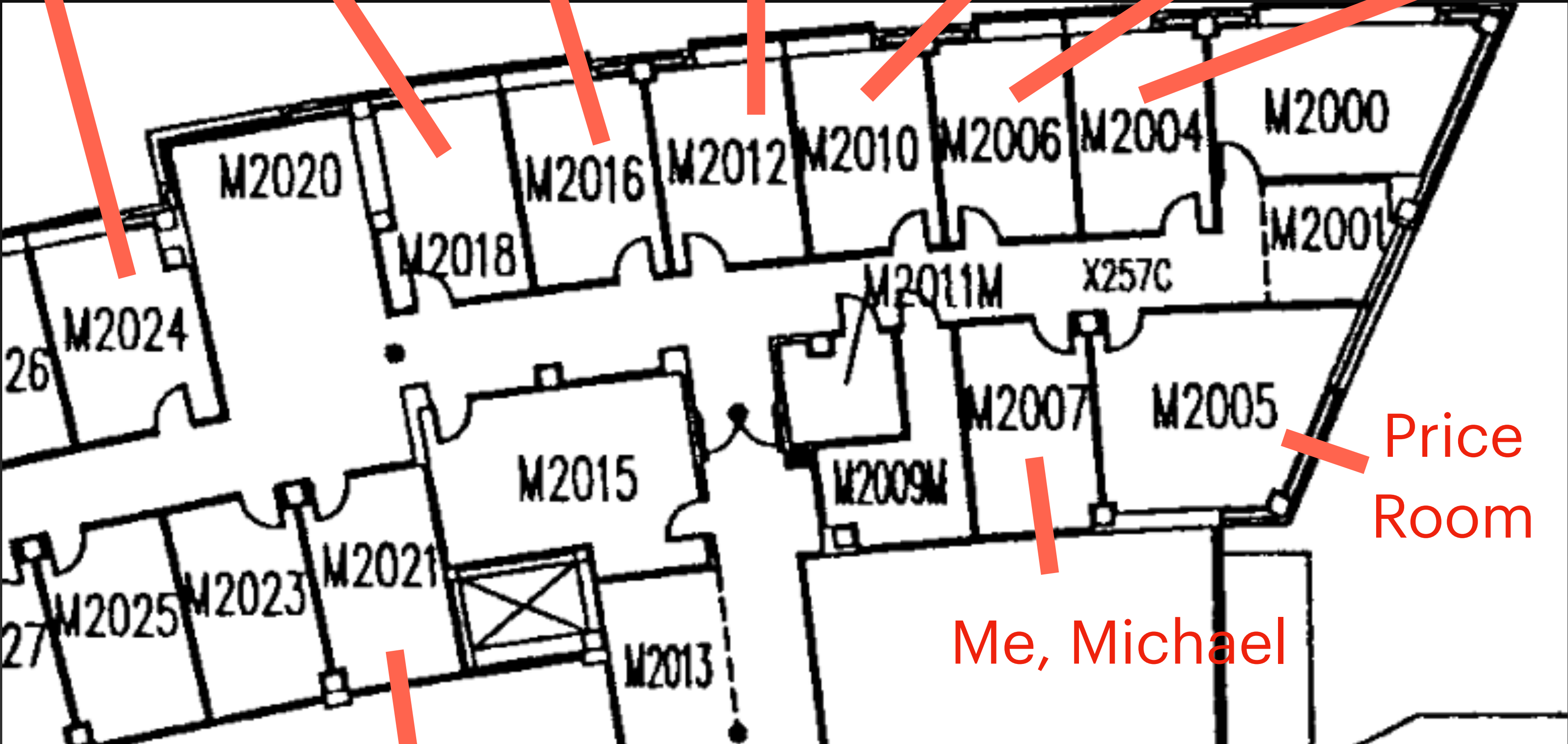


2009 - moved to CCAPP



CCAPP during my ~time

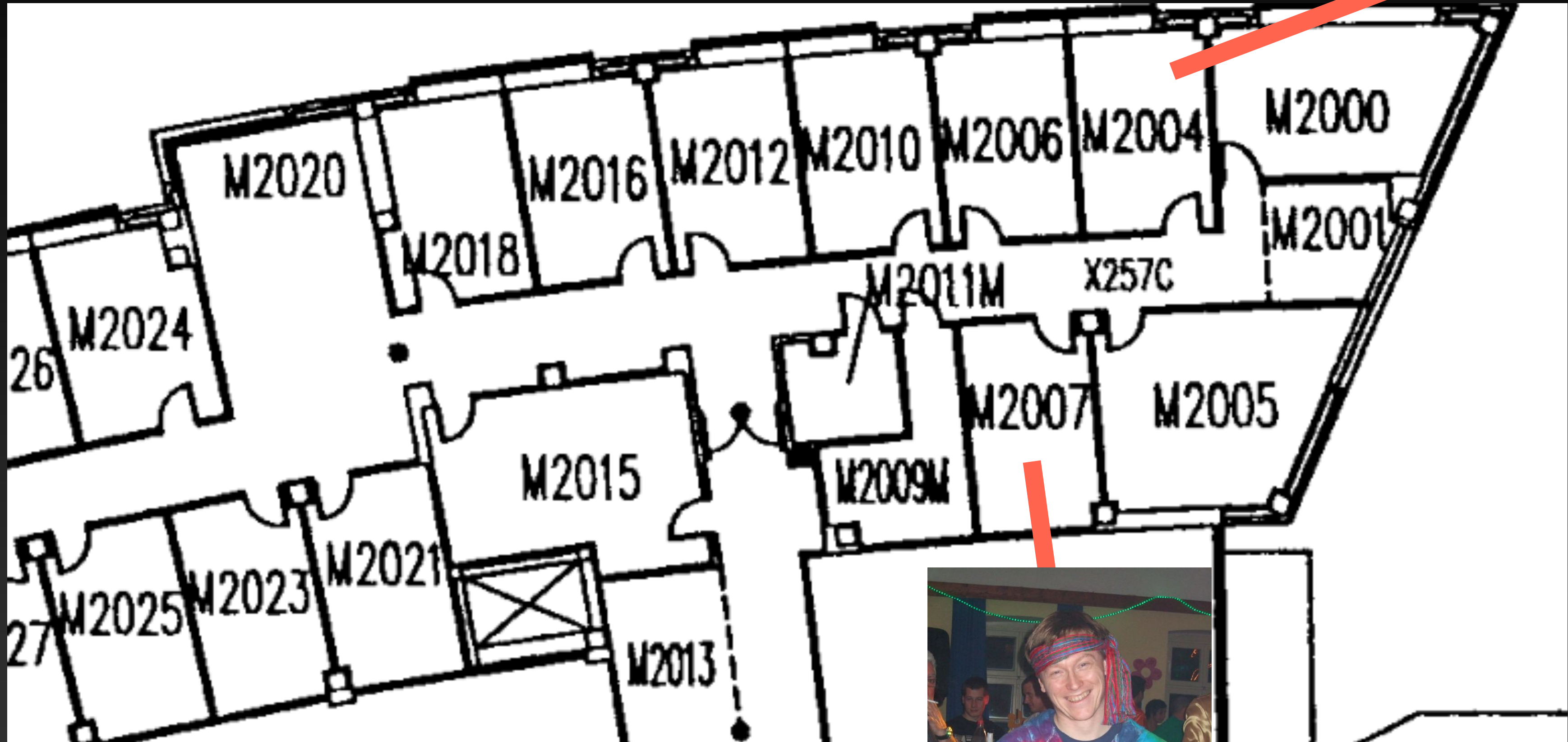
Michael, Carsten Peter, Stelios Kotha, Haojing Coffee Machine (Sometimes Terry) Jenny, Shun Gary Steigman John



Me, Michael

Price Room

Julia, Mandeep



First Impressions - soooooo fancy!!



My Apt - not so fancy...



Life improved quickly though...



Got my first salary+bought furniture ...Thanks to Carsten, who at some point drove to Ikea



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- Really, my German drivers license can just get me an Ohio drivers license??
No driving test, no theory?

But life was very good

- I coded a lot while at CCAPP (early versions of CosmoLike, code that was one of the main DES codes and is now evolving into CoCoA, used in Roman as well)
- Worked within the DES collaboration, made friends there
- Traveled a lot to Pasadena to collaborate
- Coding, Pasadena, DES, coding, Pasadena, DES, rinse repeat...

Took 2 years
to publish
on this...

[Submitted on 11 Feb 2013 ([v1](#)), last revised 17 Mar 2014 (this version, v2)]

Combining Probes of Large-Scale Structure with CosmoLike

Tim Eifler, Elisabeth Krause, Peter Schneider, [Klaus Honscheid](#)

Developing accurate analysis techniques to combine various probes of cosmology is essential to tighten constraints on cosmological parameters and to check for inconsistencies in our model of the Universe. In this paper we develop a joint analysis framework for six different second-order statistics calculated from three tracers of the dark matter density field, namely galaxy position, shear, and magnification. We extend a data compression scheme developed in the context of shear-shear statistics (the so-called COSEBIs) to the other five second-order statistics, thereby significantly reducing the number of data points in the joint data vector. We use CosmoLike, a newly developed software framework for joint likelihood analyses, to forecast parameter constraints for the Dark Energy Survey (DES). The simulated MCMCs cover a five dimensional cosmological parameter space comparing the information content of the individual probes to several combined probes (CP) data vectors. Given the significant correlations of these second-order statistics we model all cross terms in the covariance matrix; furthermore we go beyond the Gaussian covariance approximation and use the halo model to include higher order correlations of the density field. We find that adding magnification information (including cross probes with shear and clustering) noticeably increases the information content and that the correct modeling of the covariance (i.e., accounting for non-Gaussianity and cross terms) is essential for accurate likelihood contours from the CP data vector. We also identify several nulltests based on the degeneracy of magnification and shear statistics which can be used to quantify the contamination of data sets by astrophysical systematics and/or calibration issues.

Second year, I realized: Argh... I have to publish something!!

Astrophysics > Cosmology and Nongalactic Astrophysics

[Submitted on 14 Dec 2010]

Weak lensing statistics from the Coyote Universe

Tim Eifler (CCAPP/OSU)

Analyzing future weak lensing data sets from KIDS, DES, LSST, Euclid, WFIRST requires precise predictions for the weak lensing measures. In this paper we present a weak lensing prediction code based on the Coyote Universe emulator. The Coyote Universe emulator predicts the (non-linear) power spectrum of density fluctuations (P_{δ}) to high accuracy for $k \in [0.002; 3.4] \text{ h/Mpc}$ within the redshift interval $z \in [0; 1]$, outside this regime we extend P_{δ} using a modified Halofit code. This pipeline is used to calculate various second-order cosmic shear statistics, e.g., shear power spectrum, shear-shear correlation function, ring statistics and COSEBIs (Complete Orthogonal Set of EB-mode Integrals), and we examine how the upper limit in k (and z) to which P_{δ} is known, impacts on these statistics. For example, we find that $k_{\text{max}} \sim 8 \text{ h/Mpc}$ causes a bias in the shear power spectrum at $l \sim 4000$ that is comparable to the statistical errors (intrinsic shape-noise and cosmic variance) of a DES-like survey, whereas for LSST-like errors $k_{\text{max}} \sim 15 \text{ h/Mpc}$ is needed to limit the bias at $l \sim 4000$. For the most recently developed second-order shear statistics, the COSEBIs, we find that 9 modes can be calculated accurately knowing P_{δ} to $k_{\text{max}} = 10 \text{ h/Mpc}$. The COSEBIs allow for an EB-mode decomposition using a shear-shear correlation function measured over a finite range, thereby avoiding any EB-mode mixing due to finite survey size. We perform a detailed study in a 5-dimensional parameter space in order to examine whether all cosmological information is captured by these 9 modes with the result that already 7–8 modes are sufficient.

- Surprising, how many people care about requirements

Then I wanted to go on vacation...

Not the short trips to all sorts of National Parks I may or may not have taken while visiting California...but a real trip to see the world.

Philosophy...

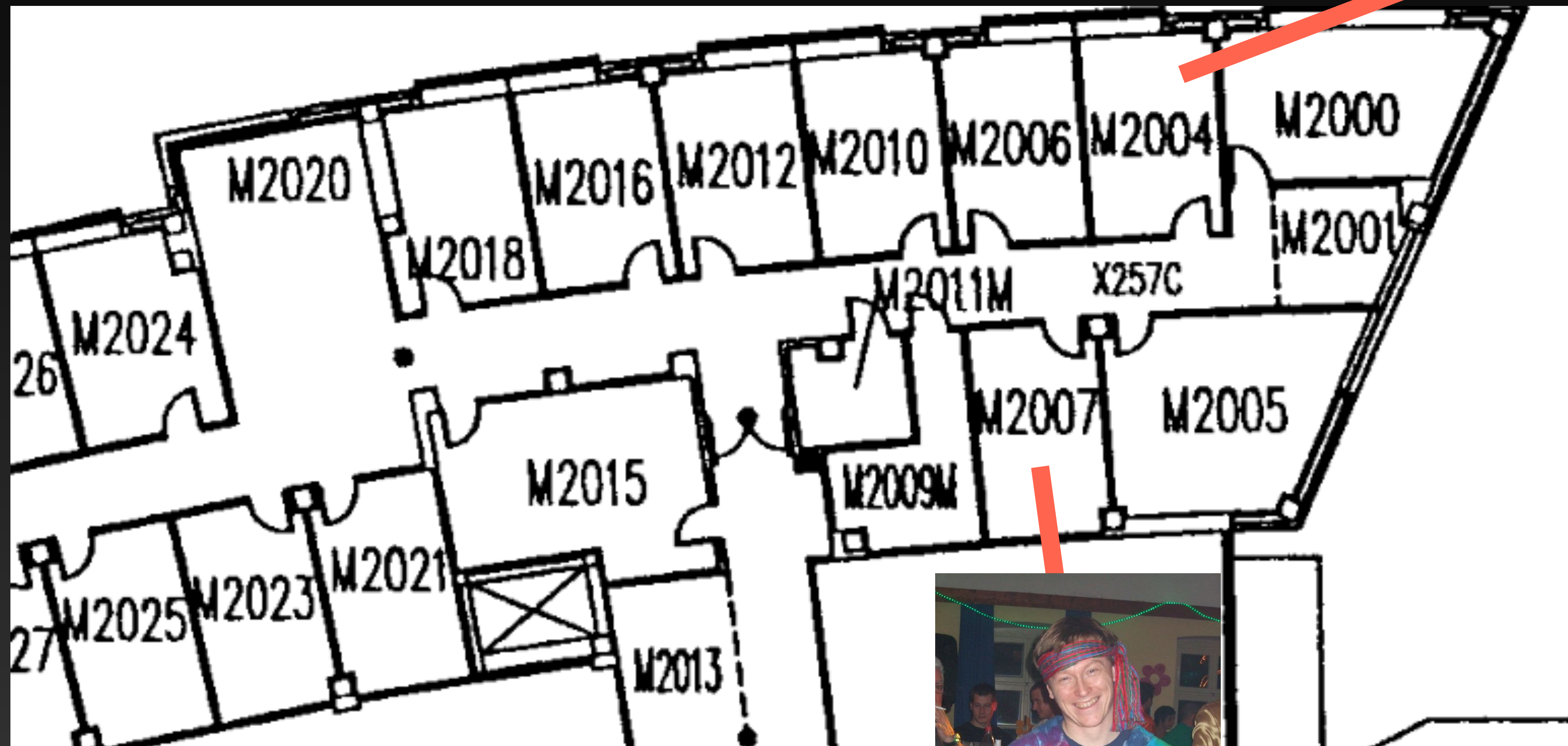
What does vacation actually mean for a scientist?

Is OSU like Germany in terms of vacation? Everyone is so nice after all...

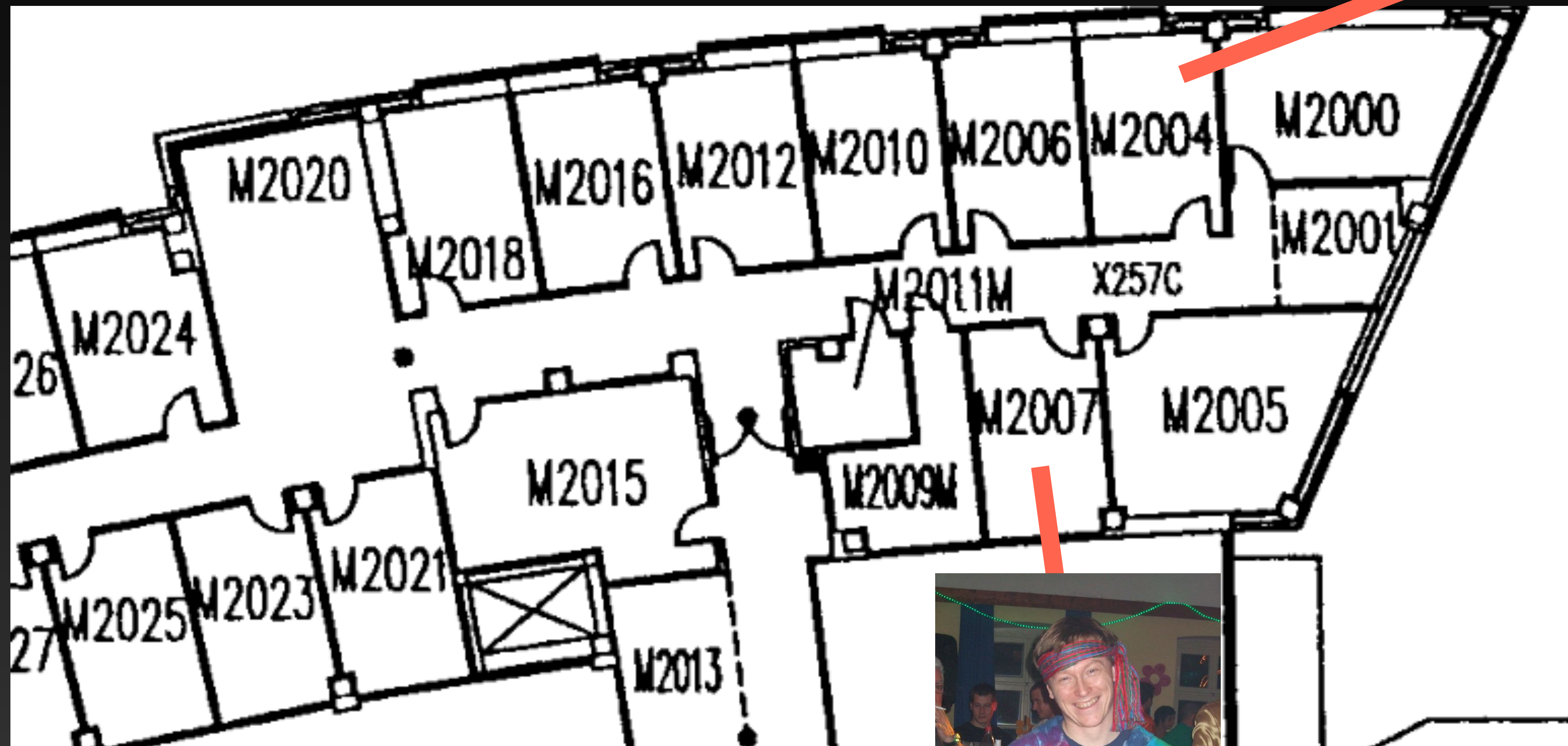
Is it like my Dad, who had 38 paid vacation days at the end of his career?

**Trivia Question: How many vacation days did
a CCAPP fellow have in 2011?**

0

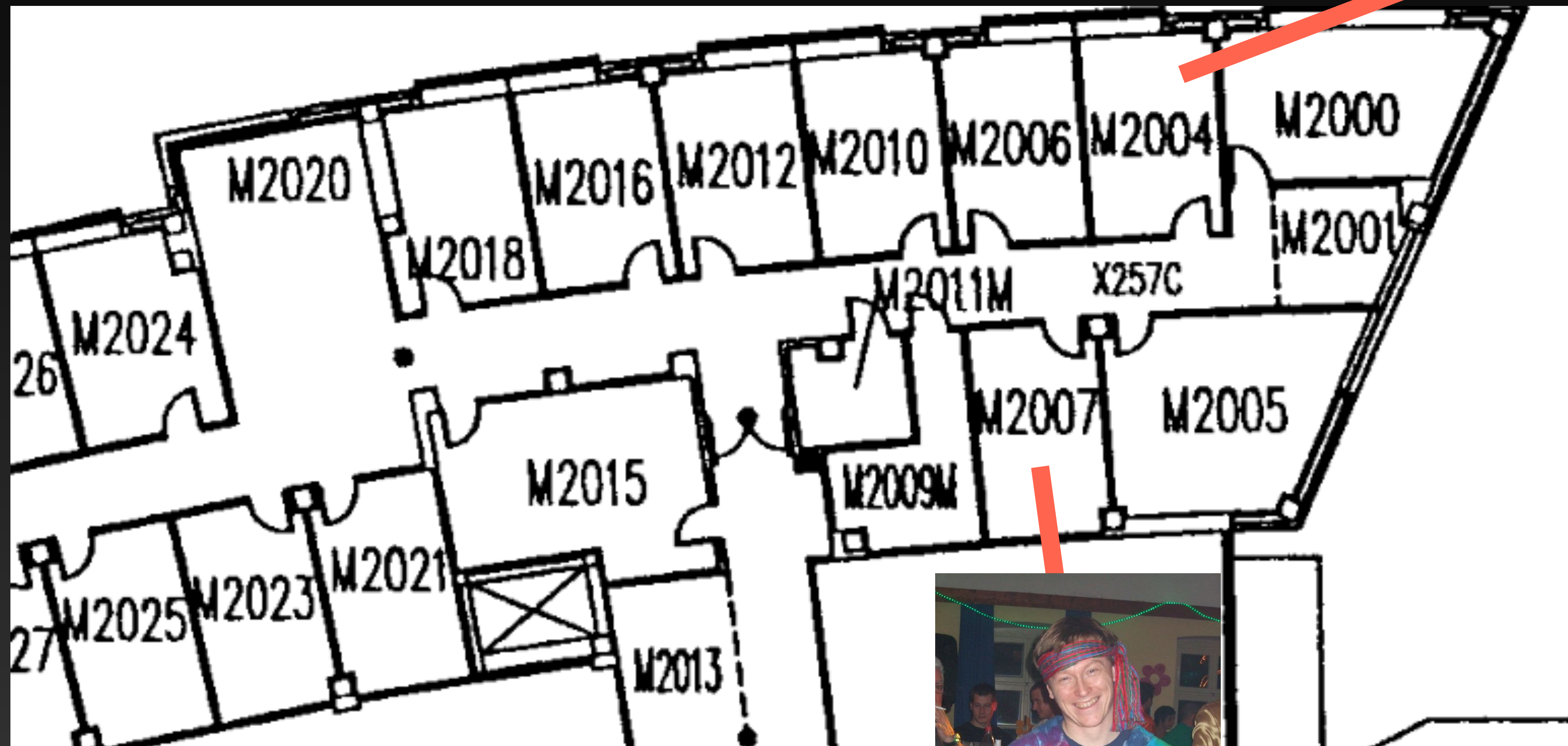


I will look into it.



Mhmm, still looking... apparently you indeed have 0 vacation days





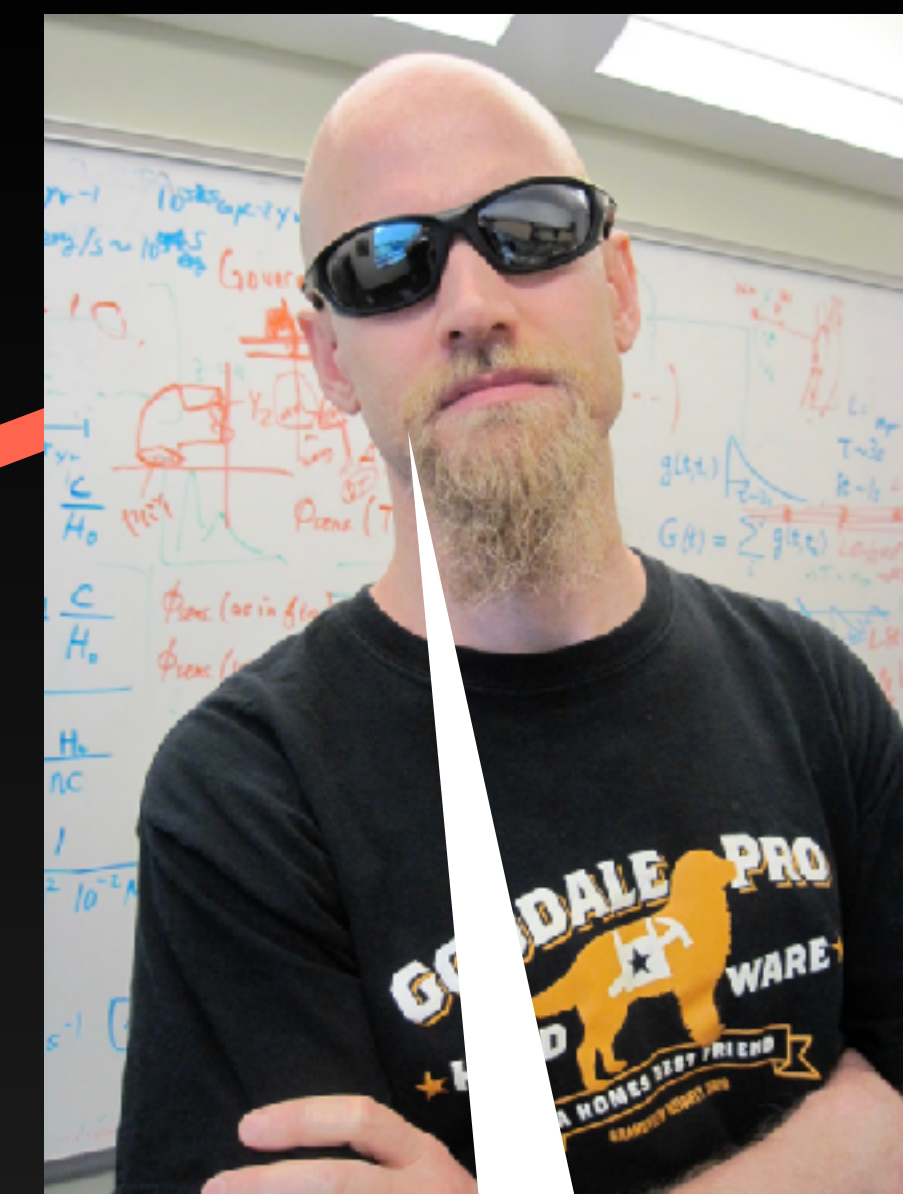
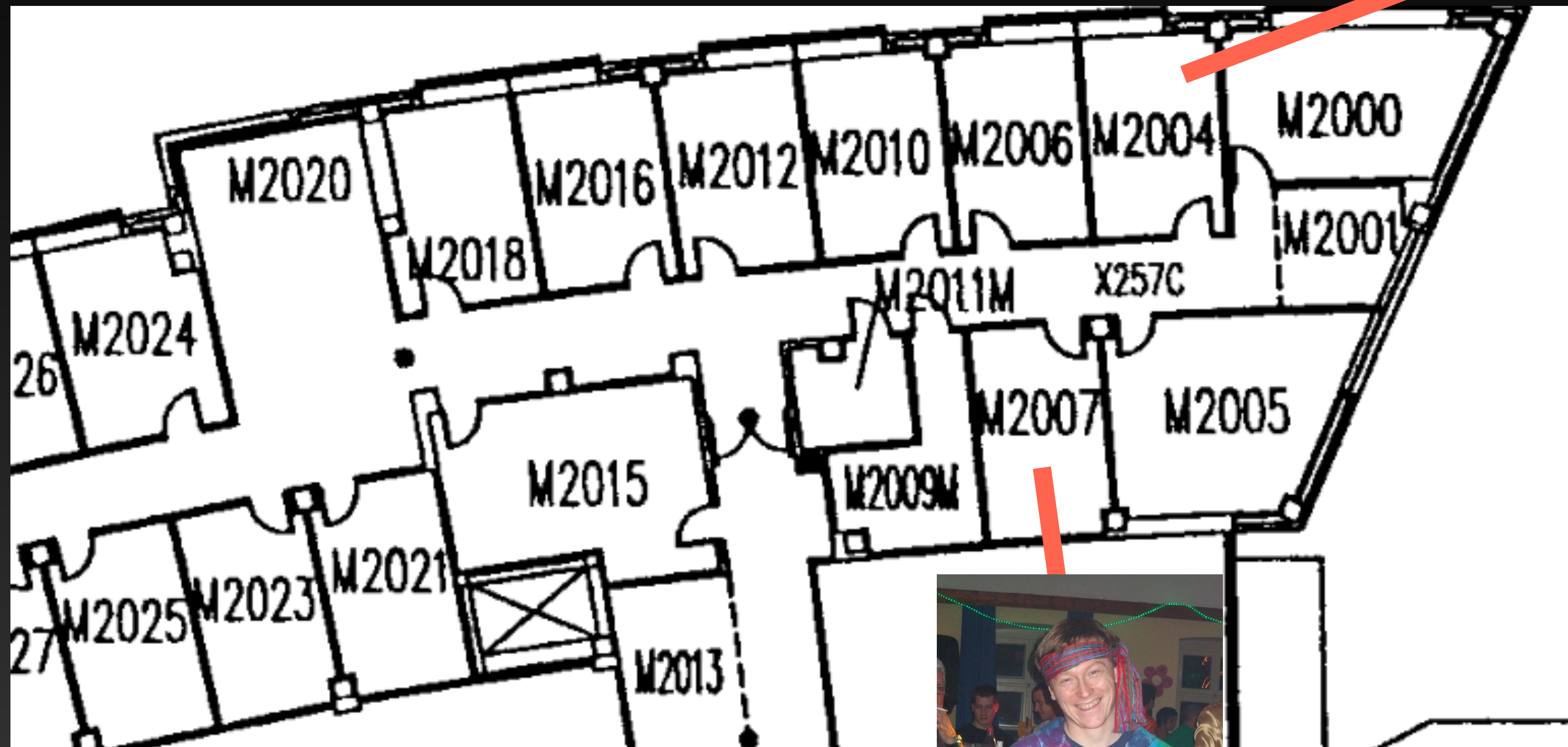
Why the hell did you ask me this...? Now I can't unsee it...



Klaus best described through the entire process...



WTF??



Here's the
solution I came up
with:

You are fired.
And then we can rehire
you... maybe...

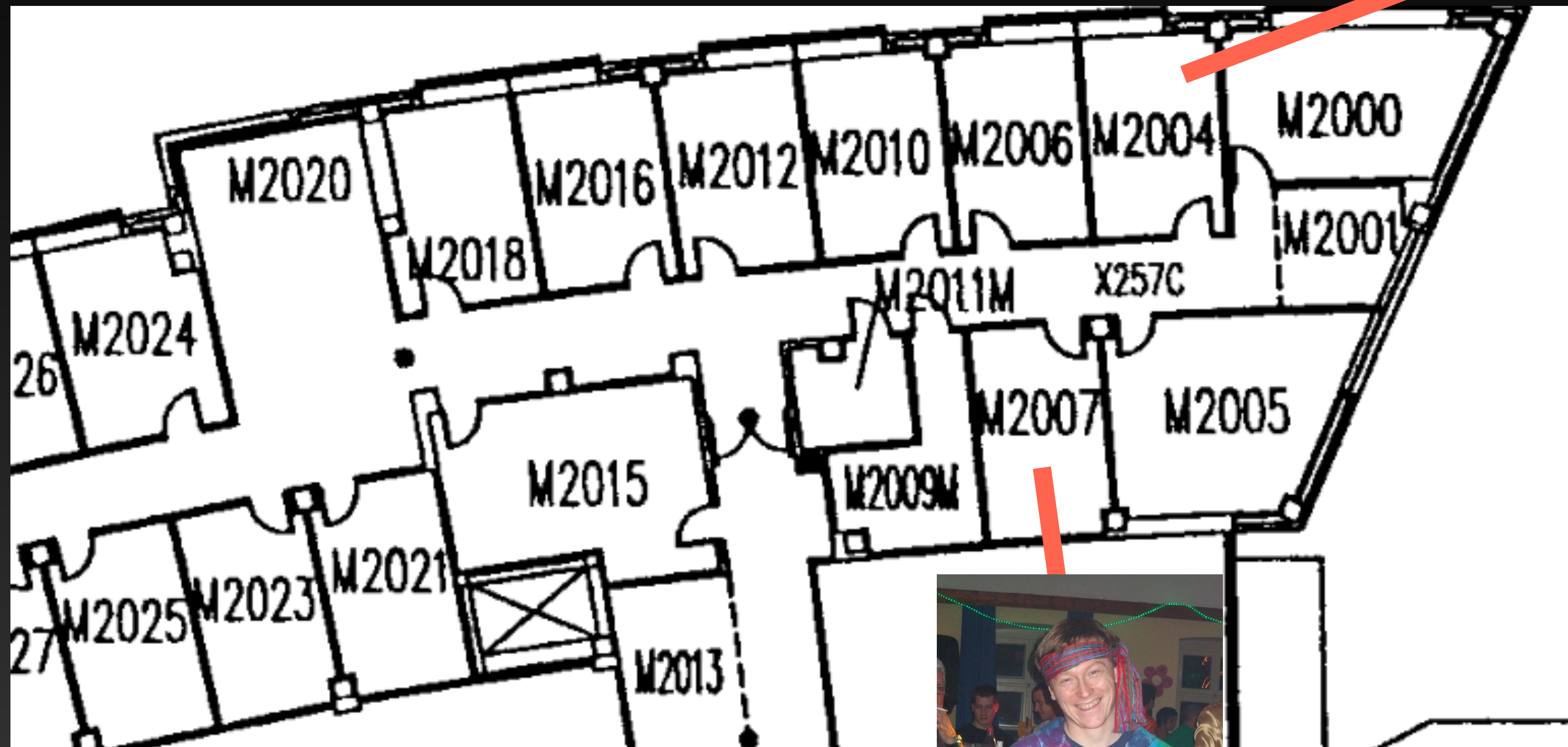


Anyhow... made it to NZ, froze on Glaciers, kayaked in sounds, etc



CCAPP shaped me early in my career and many doors opened because of what I learned/observed here. There's hardly a better place to shape scientists. Thanks!

PS: If you want to know the story how John asked me about Chris, specifically whether he's a nice person... happy to take questions :)



So... this Chris Hirata... He seems smart, but is he actually a nice person?