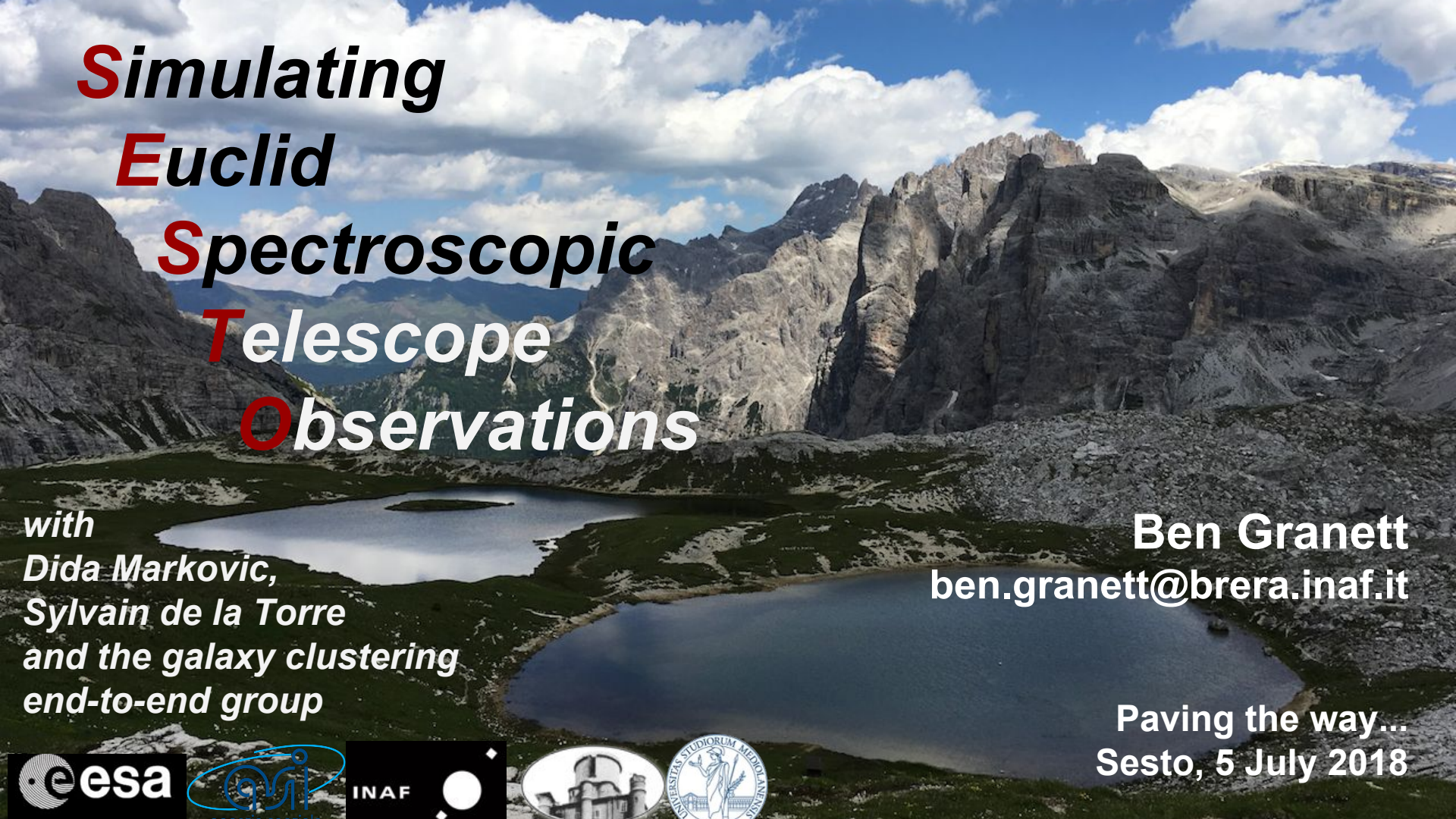


Simulating Euclid Spectroscopic Telescope Observations

with
Dida Markovic,
Sylvain de la Torre
and the galaxy clustering
end-to-end group

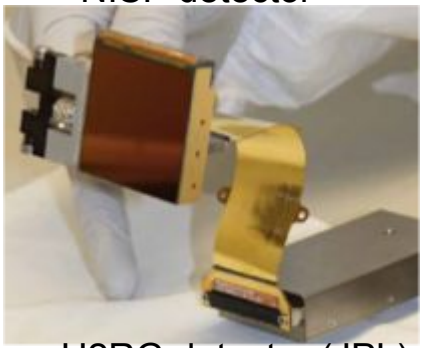
Ben Granett
ben.granett@brera.inaf.it

Paving the way...
Sesto, 5 July 2018

Euclid survey instruments

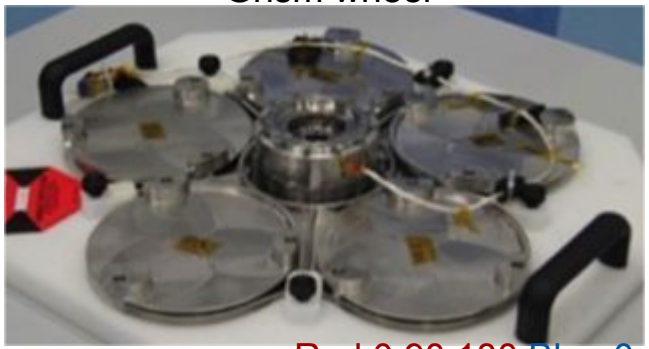
- Near-IR spectrograph (NISP)
  - Pixel scale 0.3 arcsec/pixel
  - Slitless spectrograph
  - Grism dispersion 13.4 A/pixel
- Visible imager (VIS), not presented here

NISP detector

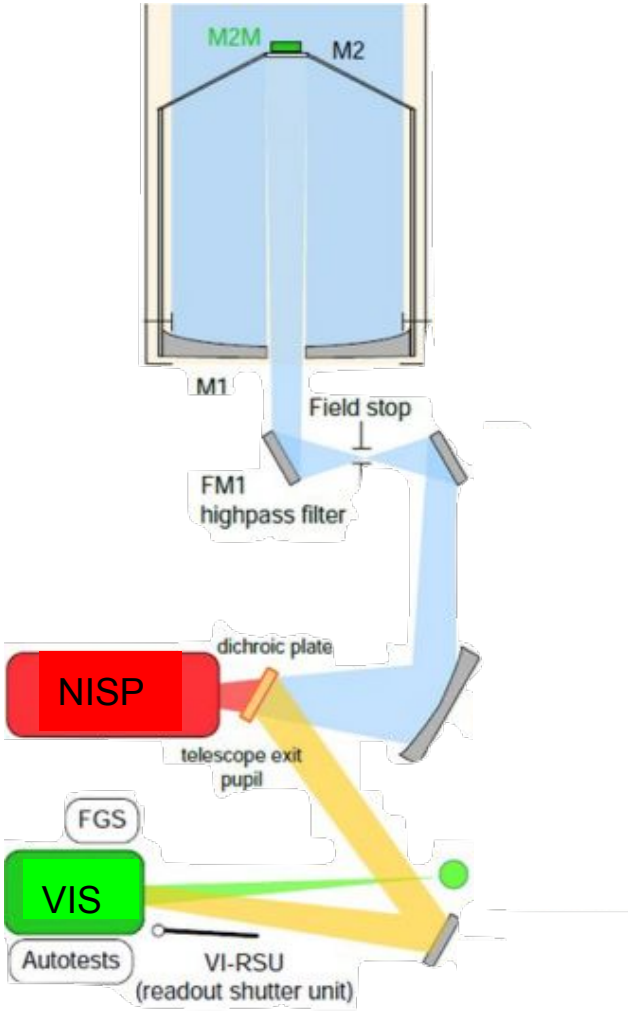


H2RG detector (JPL)

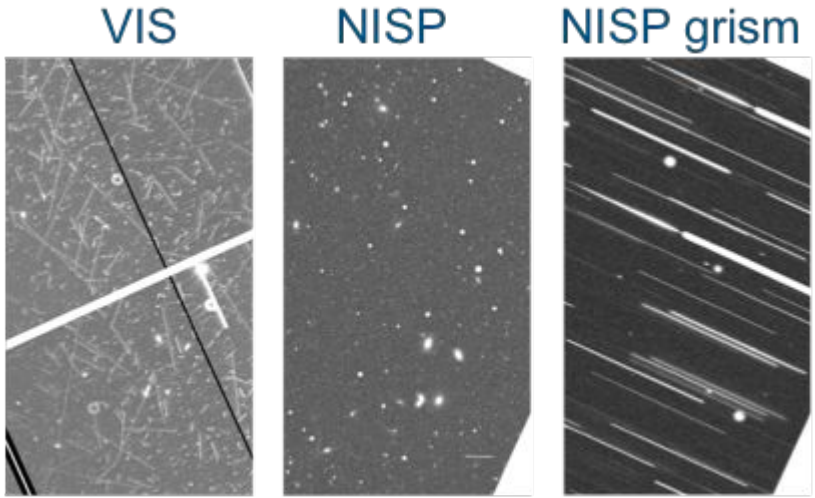
Grism wheel



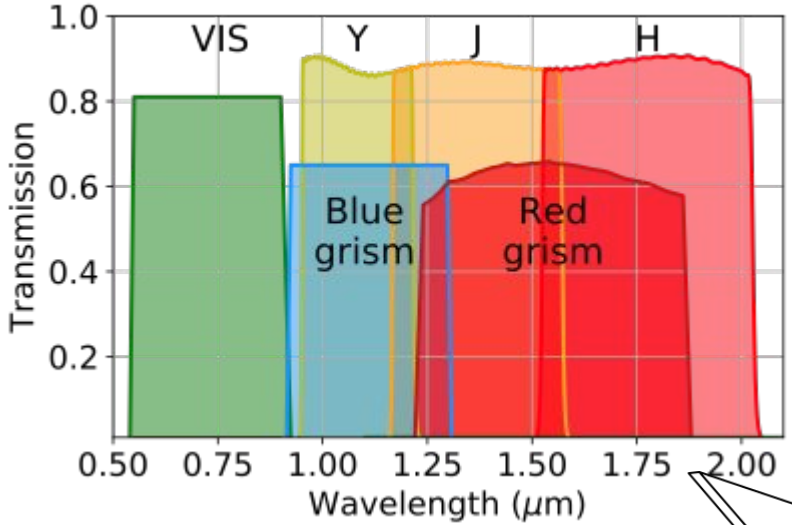
Red 0,90,180 Blue 0

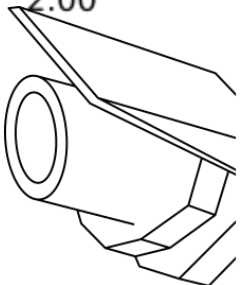


A panchromatic view

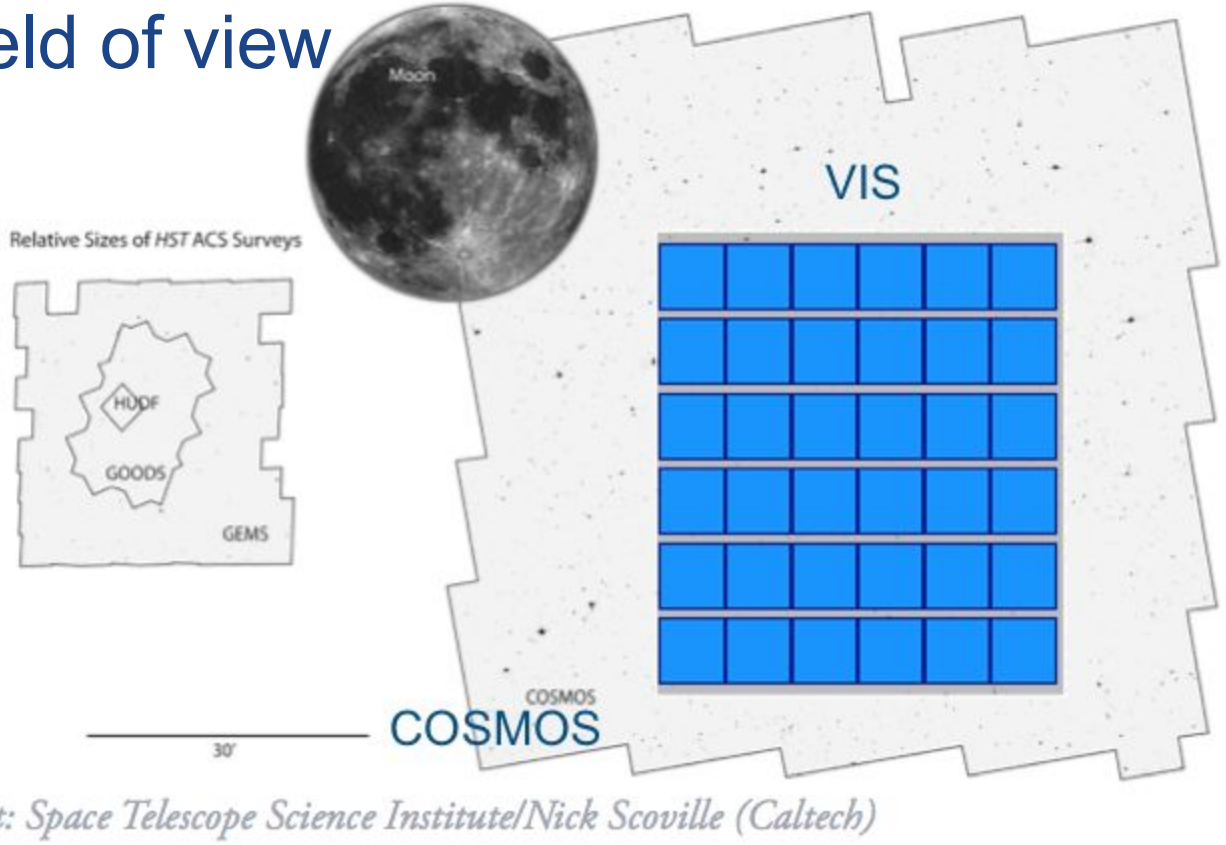


*NISP sim does not include cosmic rays.

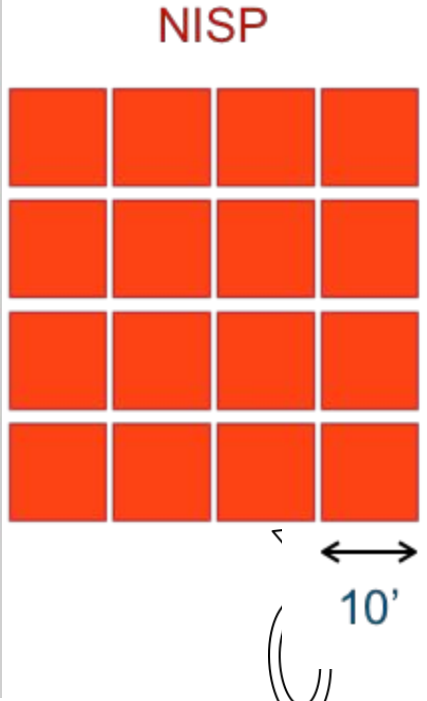




Field of view

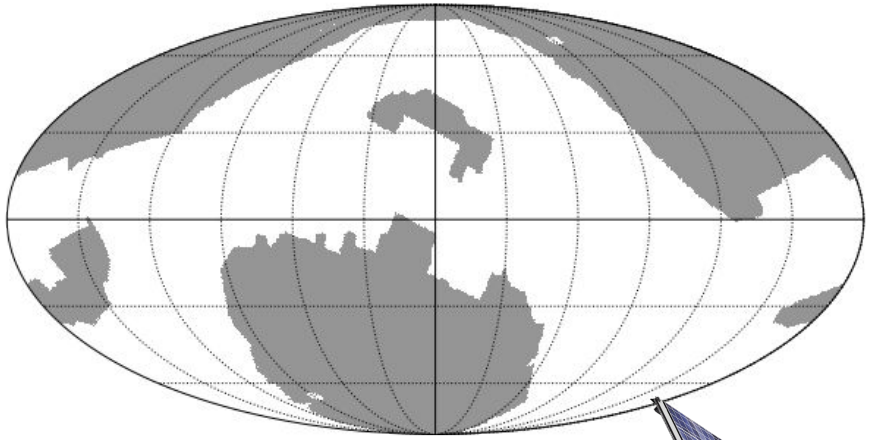


Credit: Space Telescope Science Institute/Nick Scoville (Caltech)



Spectroscopic surveys

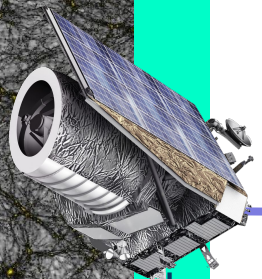
- *Wide*
  - ~ 15 000 sq deg
  - Imaging magnitude limit: H ~ 24
  - Emission line flux limit: ~ 2 x 10^{-16} erg/s/cm^2
  - 4 passes
  - 3 red grism orientations
- *Deep*
  - ~ 40 sq deg
  - H ~ 26
  - Flux ~ 0.2 x 10^{-16} erg/s/cm^2
  - >> 4 passes
  - Red and blue grisms



Reference survey
(Scaramella)

Full Euclid end-to-end

True Universe

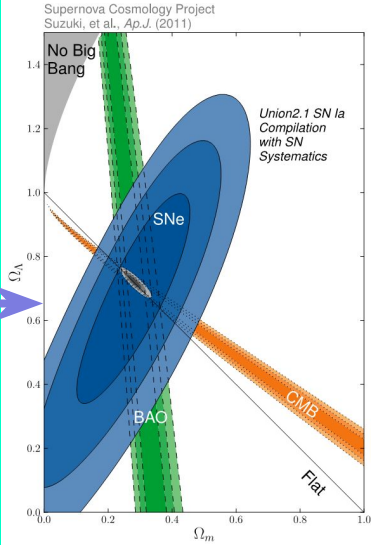


observation

reduction
& redshift
measurement

Galaxy catalogue

science
analysis



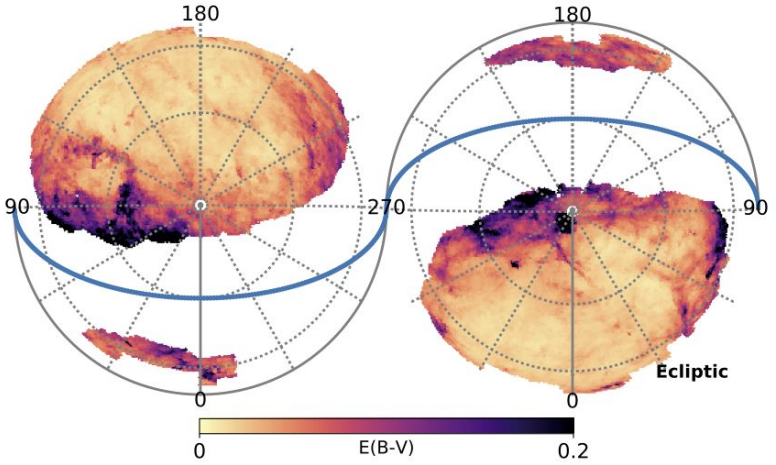
J.Stadel: Flagship

Slide by Dida Markovic

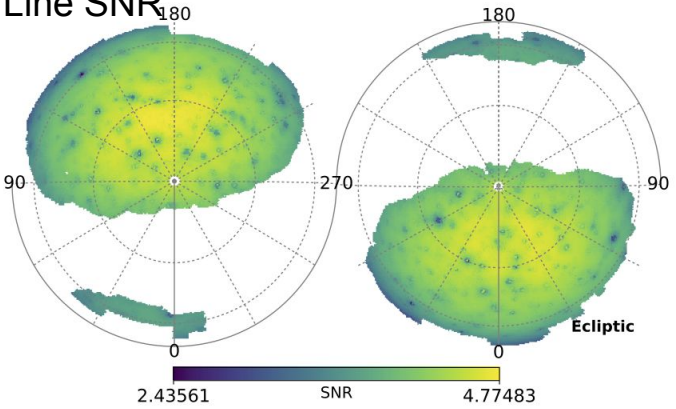
Data systematics

- Foregrounds
  - Zodi
  - Straylight
  - Extinction
- Contamination
  - Spectra overlaps
  - Cosmic rays
  - Persistence
- Redshift measurement
  - Systematic misidentification
  - Spurious detection rate
  - Random error
  - Template bias
- Calibration error
  - Spectrophotometry
  - Wavelengths

MW extinction map E(B-V)

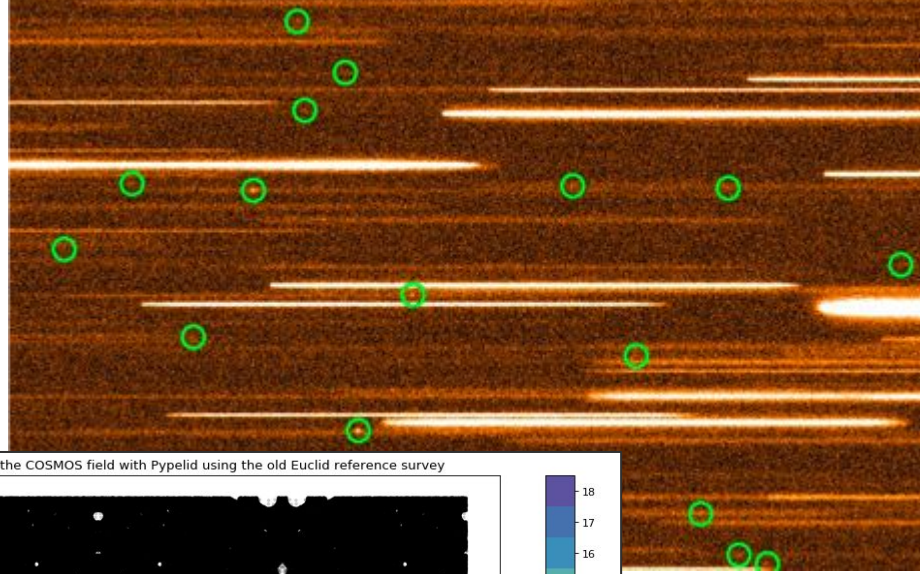


Line SNR



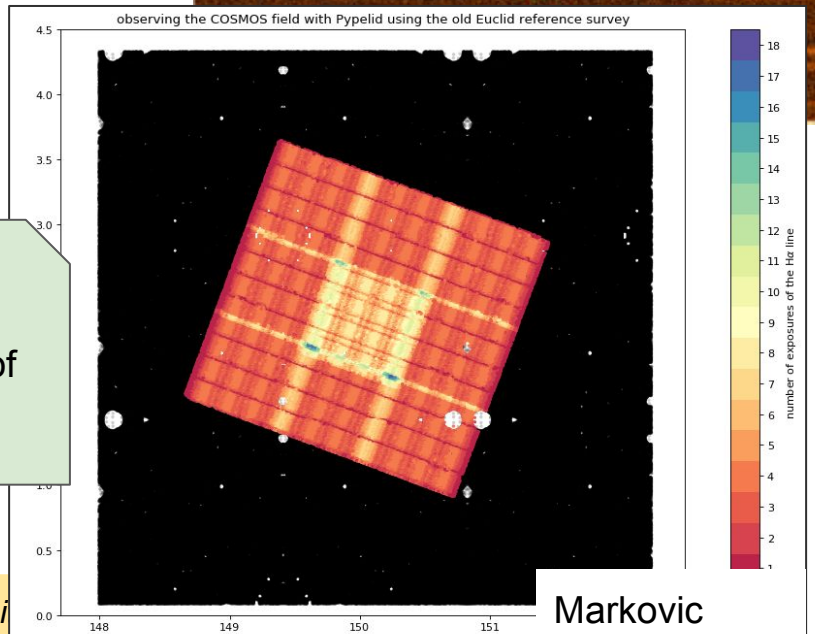
Simulation tools

- Pixel simulations
  - IModel (Garilli et al)
  - TIPS (Zoubian et al)
- Catalog level (bypasses)
  - Pypelid (Granett, Markovic et al)

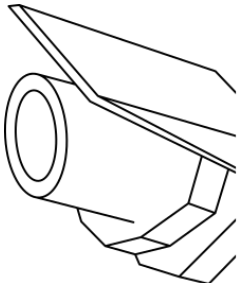


Garilli

⭑ We are developing pypelid to scale up to simulations the size of the Euclid wide survey



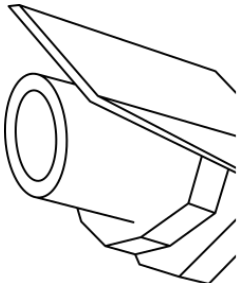
Markovic



Inputs

- Flagship galaxy properties
  - RA, Dec, z
  - mag J, H
  - Flux Ha, Hb, NII, SII, OIII, OII
  - Bulge, disk: scale, fraction, axis ratio

- Foregrounds
  - Stars
  - Zodi
  - Out-field straylight
  - Milky way extinction



Signal and noise

- Emission line signal

$$S = A_{surf}\ t_{exp}\ q \int T(\lambda)\, f_\lambda(\lambda)\ 10^{-0.4A(\lambda)}\ \frac{\lambda}{hc}\ d\lambda$$

Collecting area

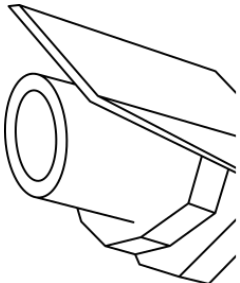
Exposure time

Quantum efficiency

Transmission

Source flux

Milky Way extinction



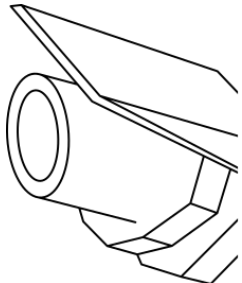
Signal and noise

- Emission line signal

$$S = A_{surf}\ t_{exp}\ q \int T(\lambda)\, f_\lambda(\lambda)\ 10^{-0.4A(\lambda)}\, \frac{\lambda}{hc}\, d\lambda$$

- Noise

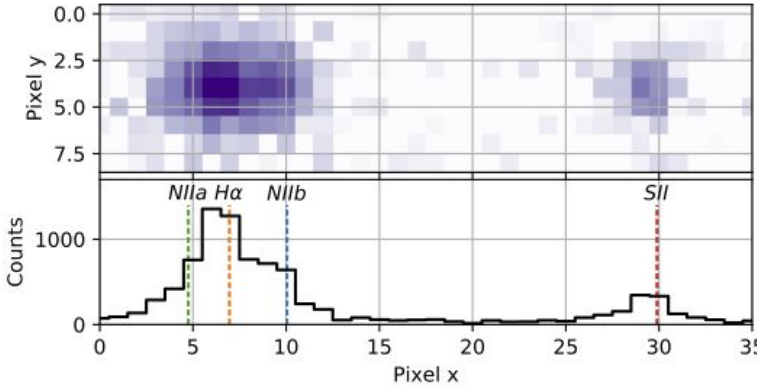
$$\sigma^2 = t_{exp} n_{dark} + \sigma^2_{read} + \sum_i \sigma^2_{diffuse,i}$$

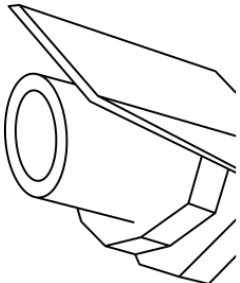


Detection significance

- Simulate noisy emission line spectrum
  - Point-spread function
  - Disk & bulge size
  - Line broadening
  - No continuum
- Do a template fit on the 1D spectrum
- Template-fit amplitude defines SNR:

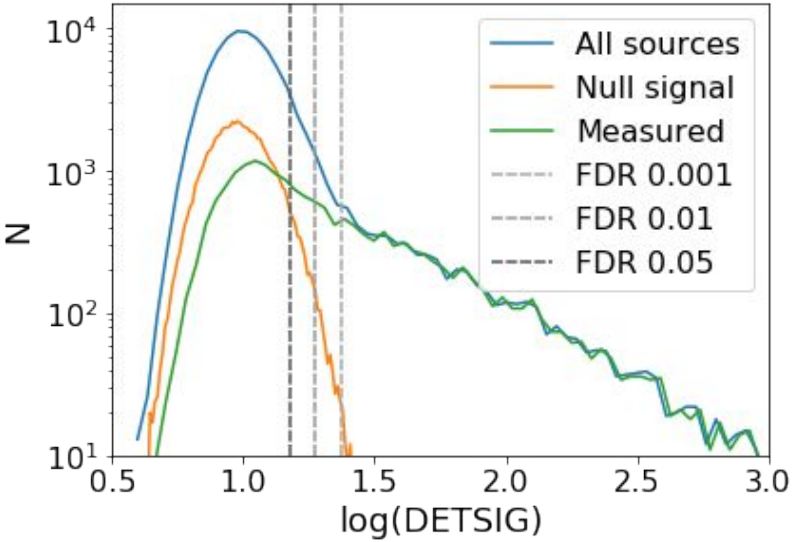
$$a = \frac{\sum d\sigma^{-2}t}{\sum t\sigma^{-2}t}$$

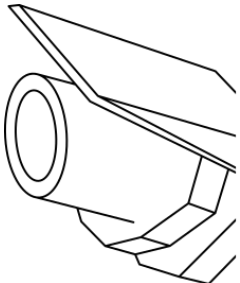




Spurious sources - false detection rate

- The SNR cut will set the false-detection rate
- We can model the distribution by running noise-only spectra
- Model the SNR null distribution:
  - At fixed redshift: Chi2 with one deg of freedom, or
  - Varying redshift: Gumbel distribution

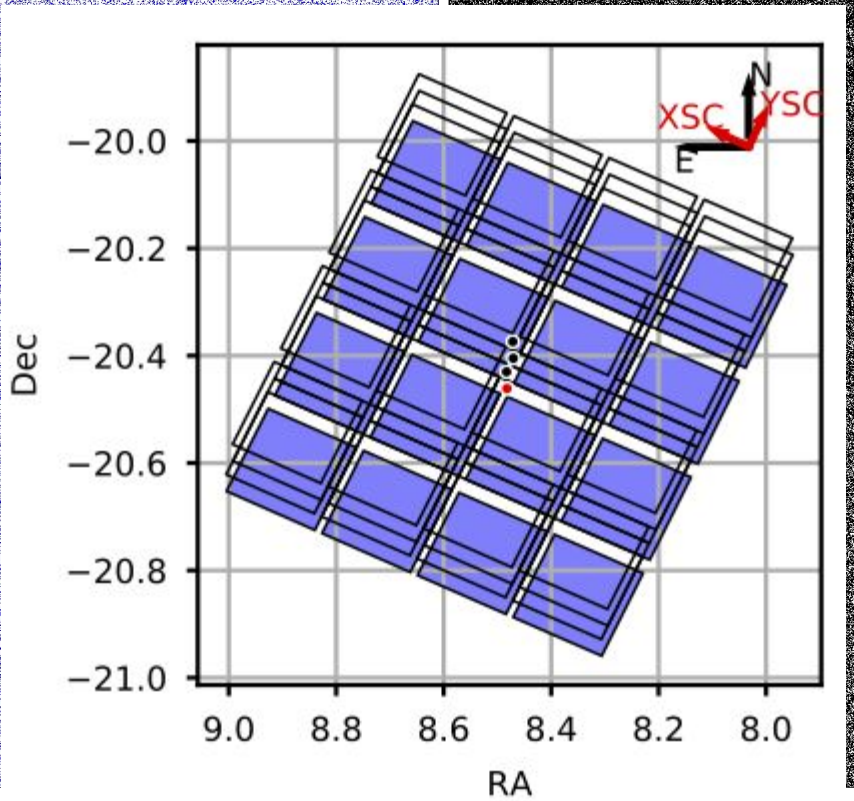




Galaxies

Randoms 8x

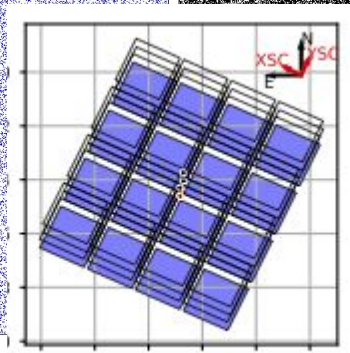
Systematics: tiling pattern



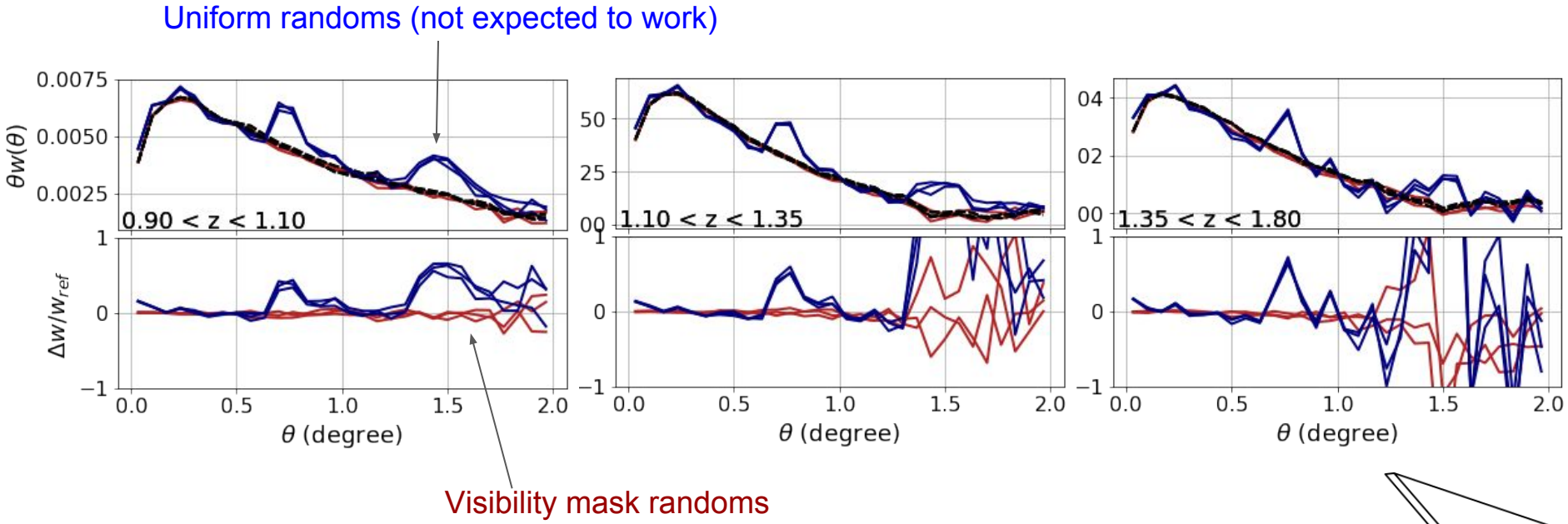
Galaxies

Randoms 8x

Systematics: tiling pattern



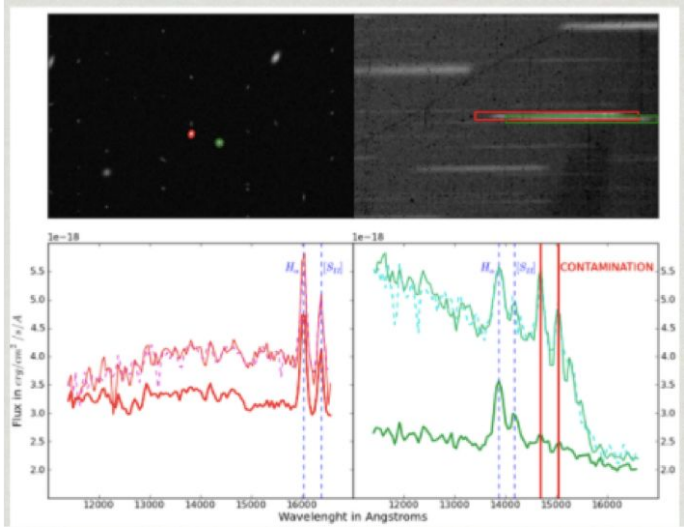
Systematics: tiling pattern

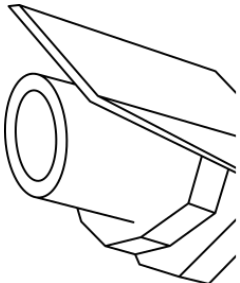


Lines of the same color show different shuffling realizations (shot noise)

Systematics: contamination

- Overlapping spectra contribute to the noise
- Is this an important exclusion effect like SDSS fiber collisions or VIMOS slit constraints?

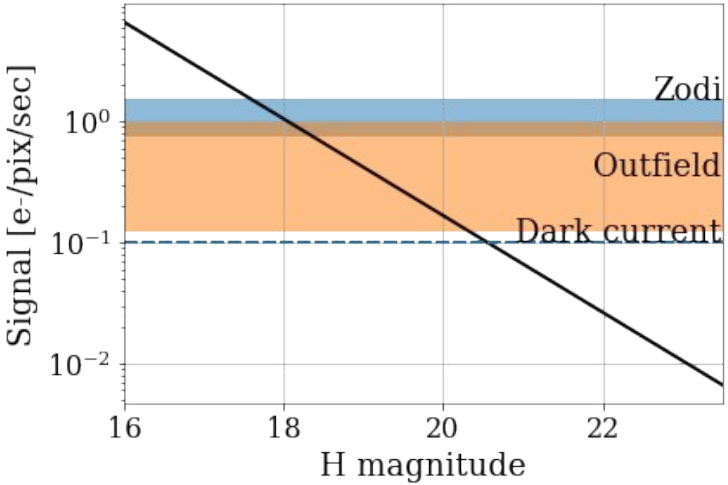


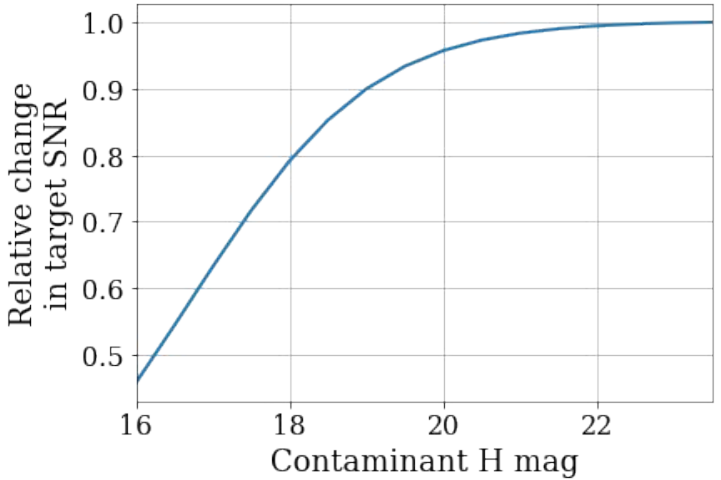


Systematics: contamination

$$SNR = \frac{S}{\sqrt{S + C + N_{sky}}}$$

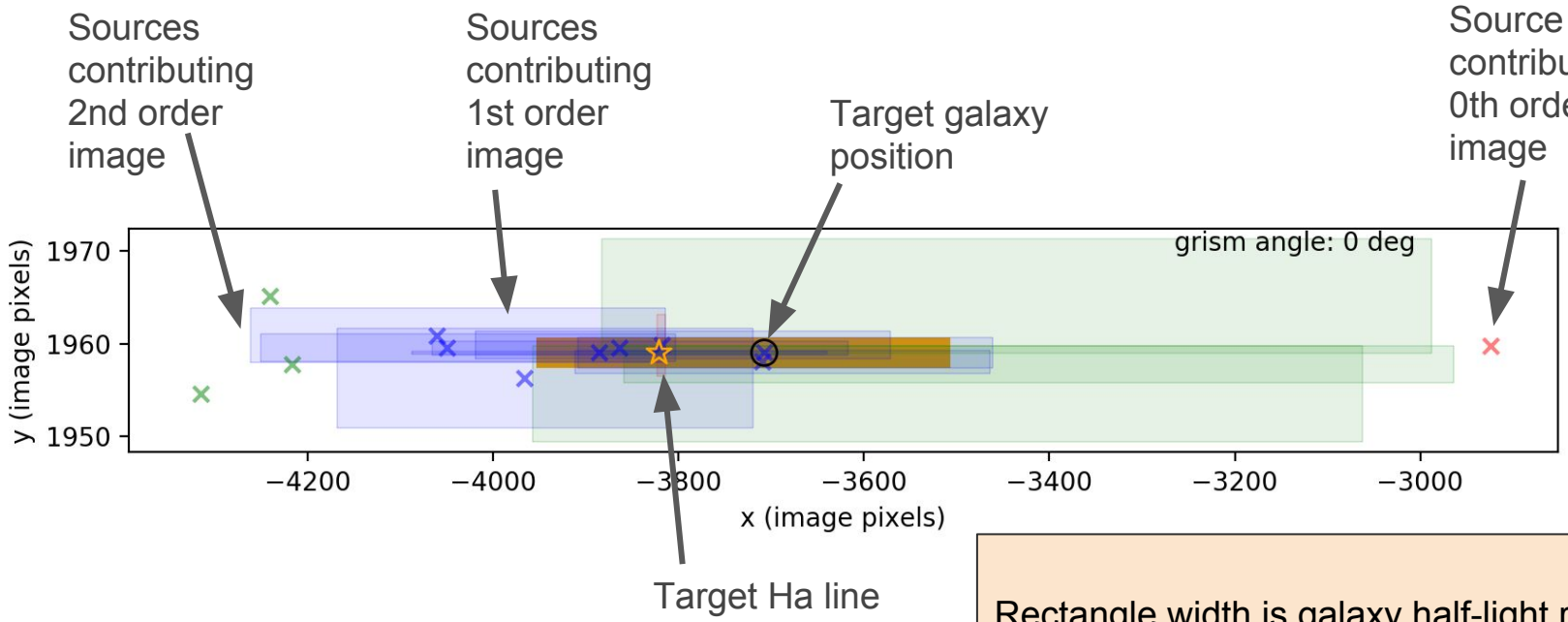
- We are in the $N_{sky} > C$ regime
- The exception is bright galaxies at low redshift





Contamination model

[Based on PROFESS by S. de la Torre]



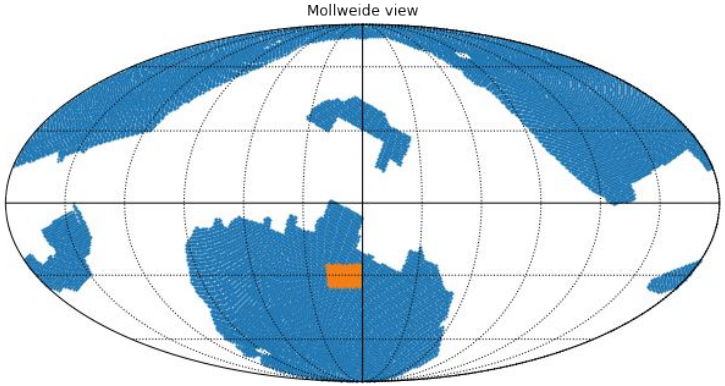
Rectangle width is galaxy half-light radius.

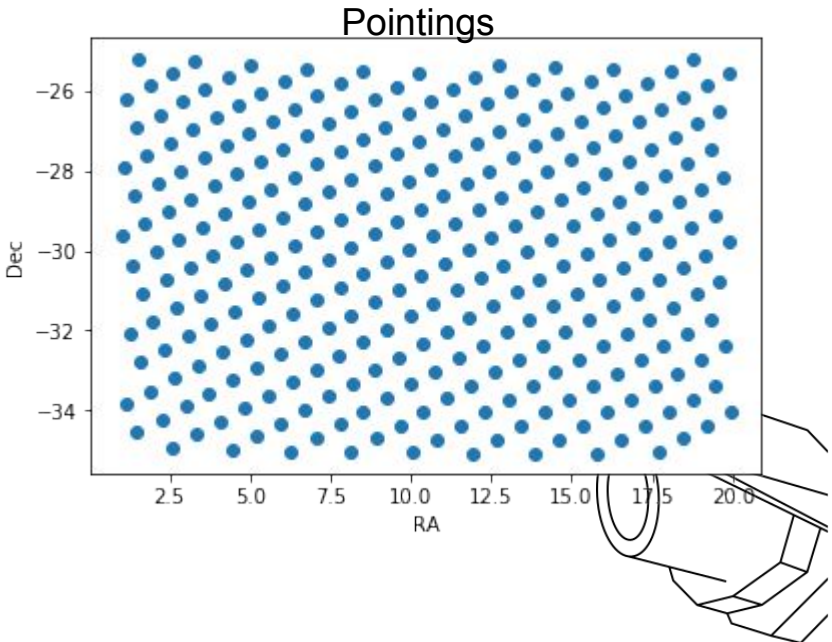
Note aspect ratio is 10:1

Run configurations

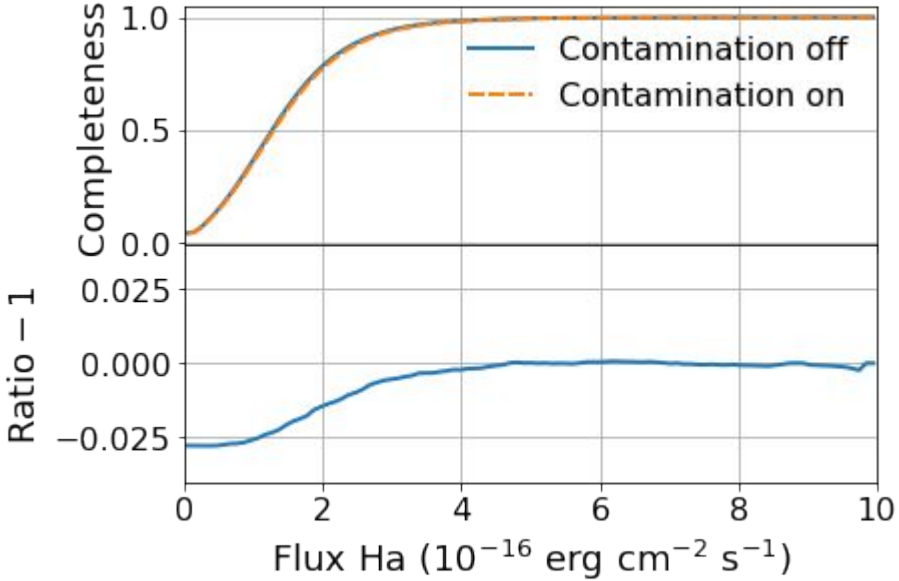
- Flagship 1.5.2
- Selection: H < 24
- 307 pointings ~ 175 sqr deg
- Foregrounds:
  - Zodi
  - Out-field stray light
  - Milky Way extinction

- Pypelid run with contamination on and off
- Detection threshold 5 sigma

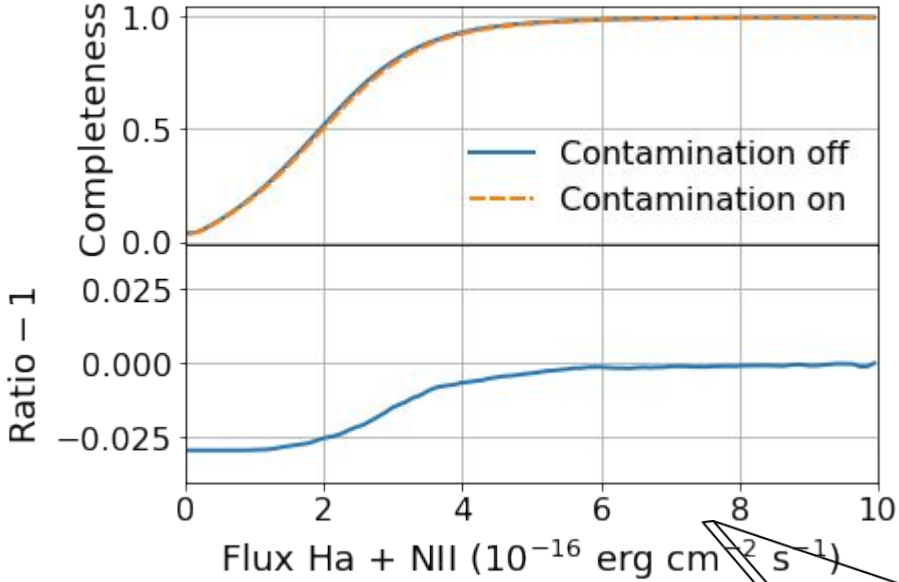




Contamination tests: completeness



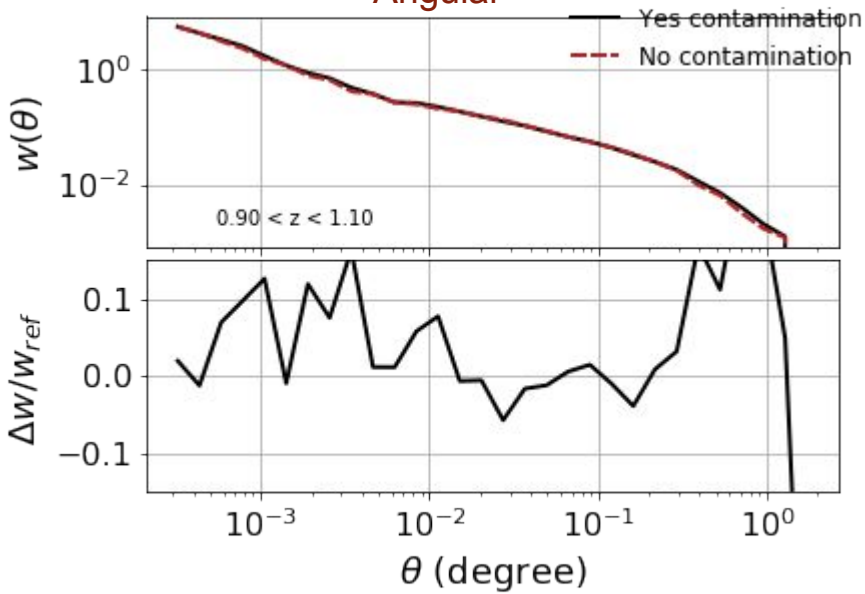
(Flux threshold bins)



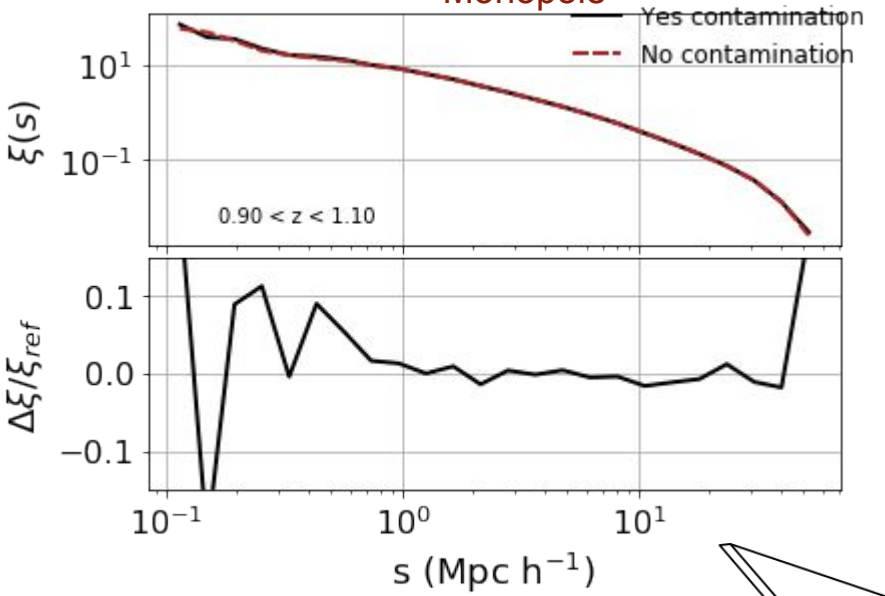
- 5 sigma detection threshold

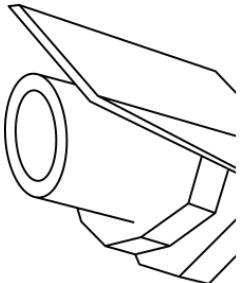
Contamination tests: correlation function

Angular



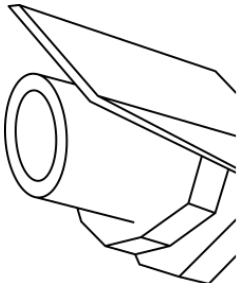
Monopole





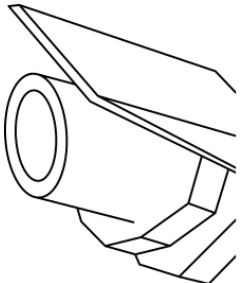
Discussion points - contamination

- Continuum contamination will come from foreground bright galaxies (stars) H<20
- Uncorrelated with target sample 0.9<z<1.8
- What about contamination with line features?
  - This could come from sources at any redshift
  - Depends on OU-SIR decontamination algorithm
  - Insufficient orientations could leave residual contamination features in stacked spectra.



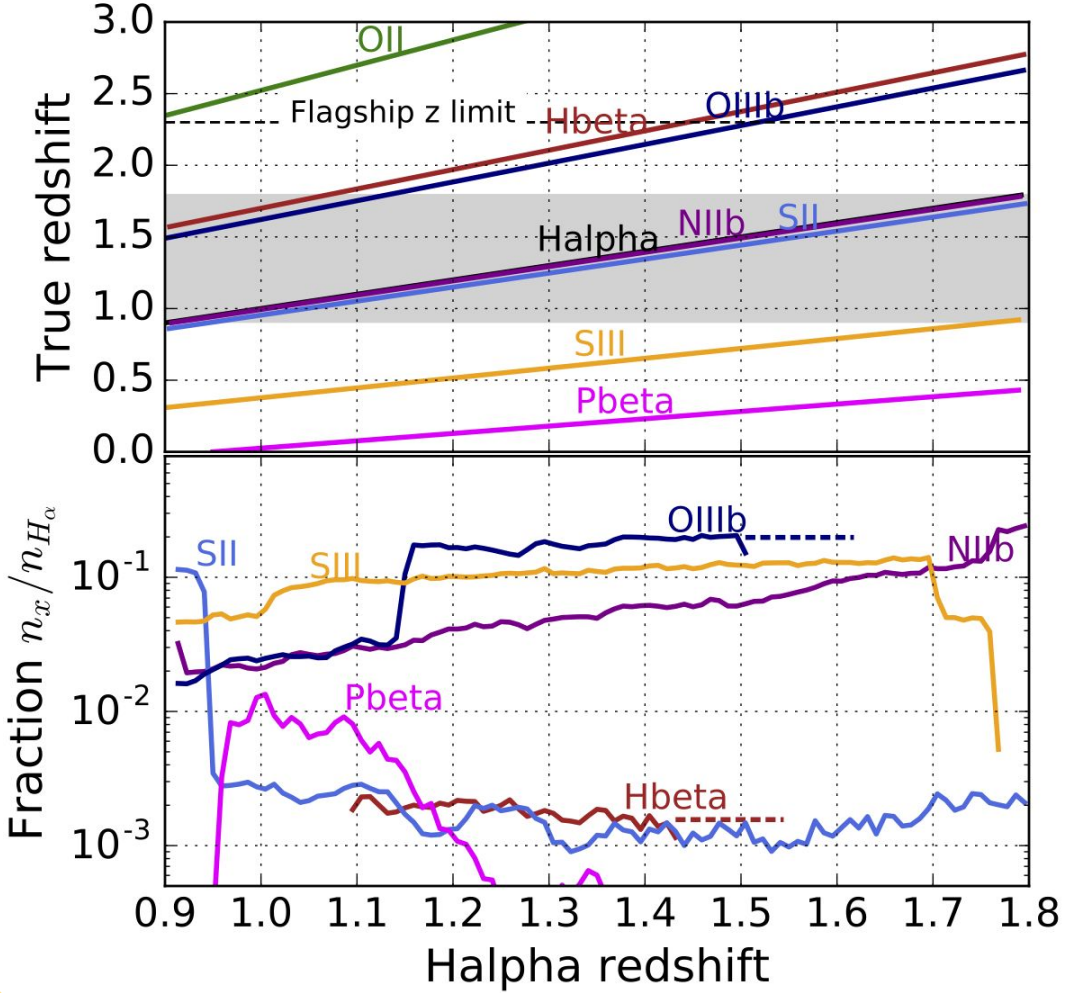
Systematics - redshift measurement error

- Pypelid models the extraction process and runs a template fitter to get a redshift measurement with error
- Includes
  - Spurious line detection
  - Line misidentification
  - Estimation of significance
  - Estimation of the false detection rate by running noise-only spectra
- Not implemented (yet)
  - Redshift priors (eg magnitude, color or size)
  - Wavelength calibration error model

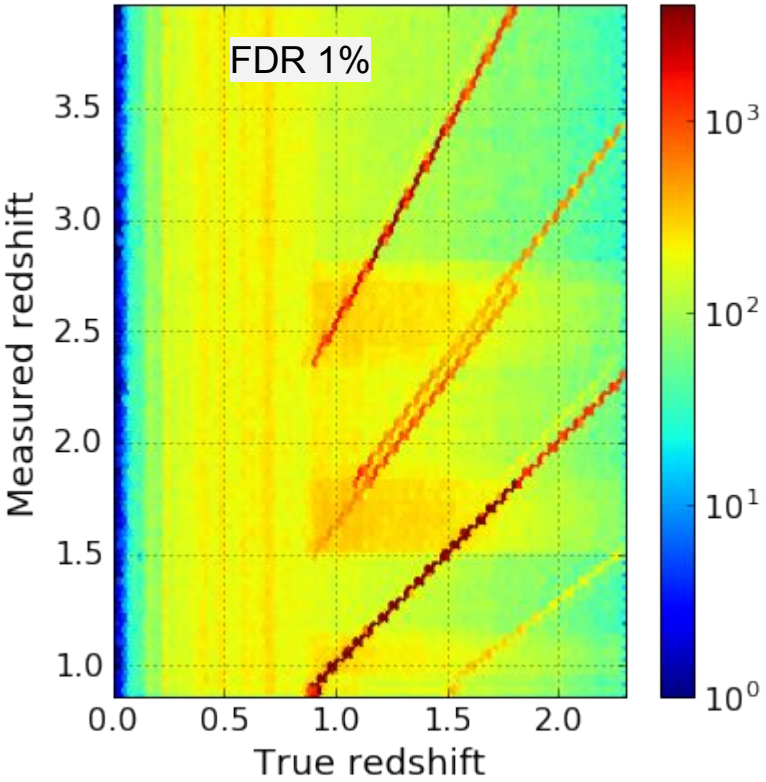


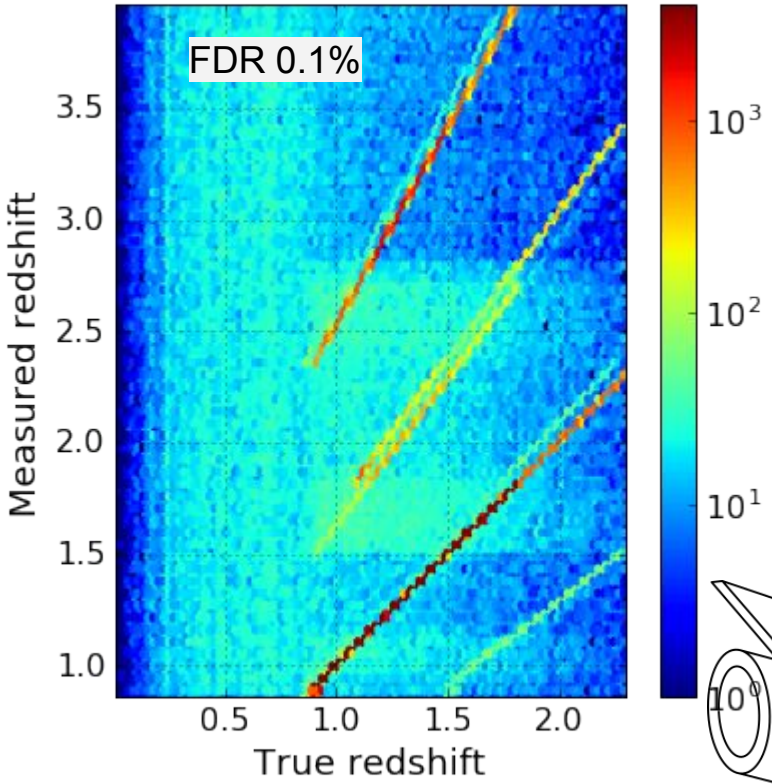
Line misidentification

- Contamination rates estimated from Flagship populations
- Ultimately to be calibrated from the Deep survey

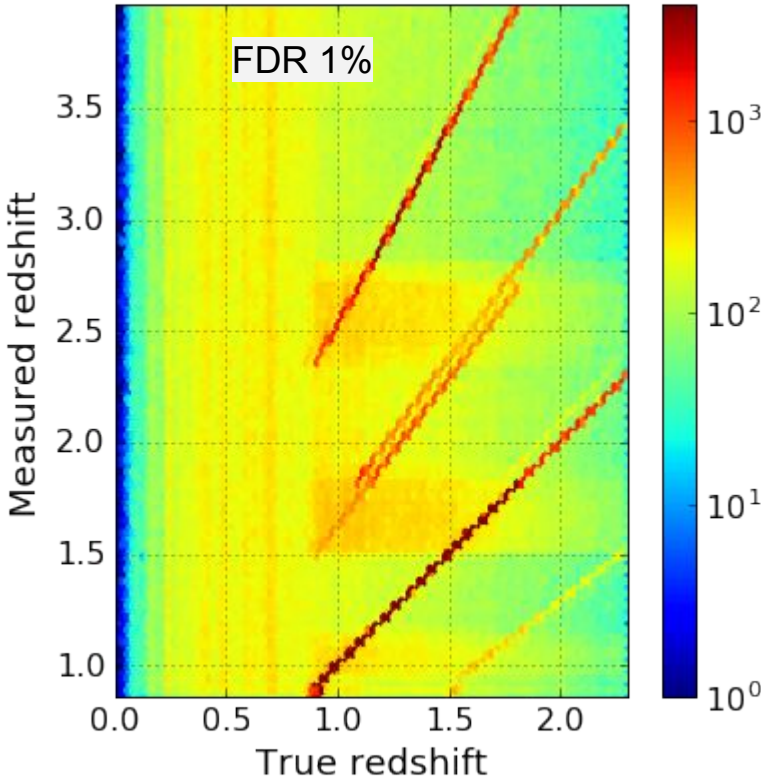


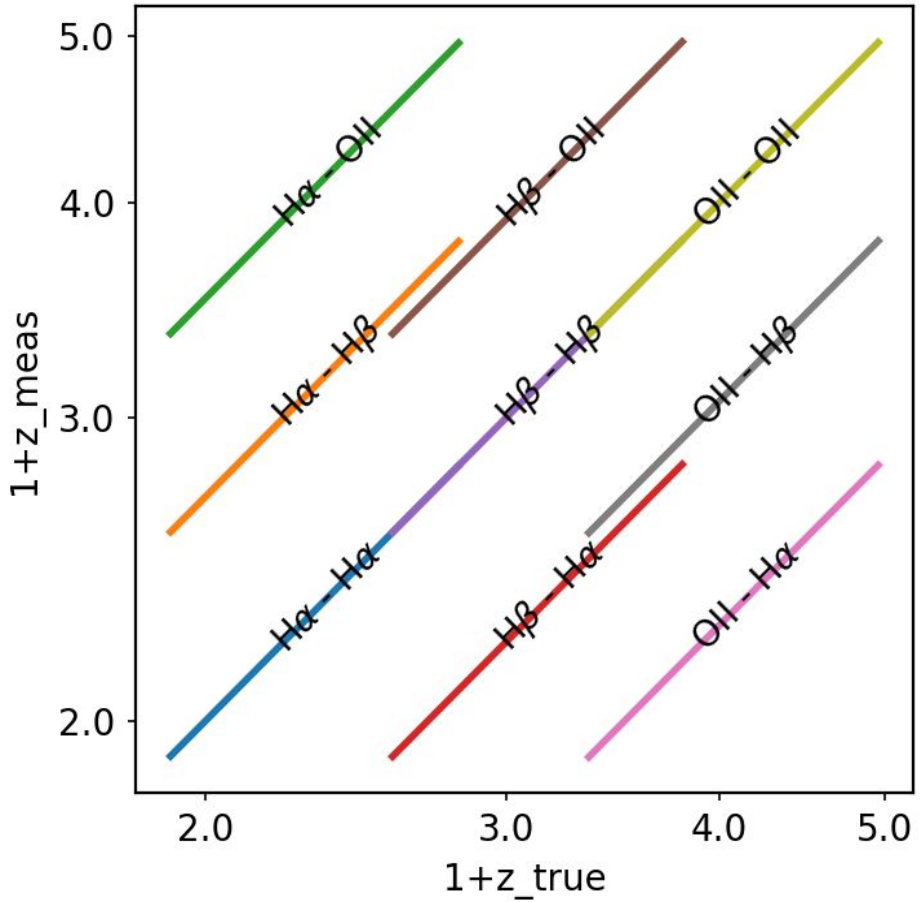
Line misidentification



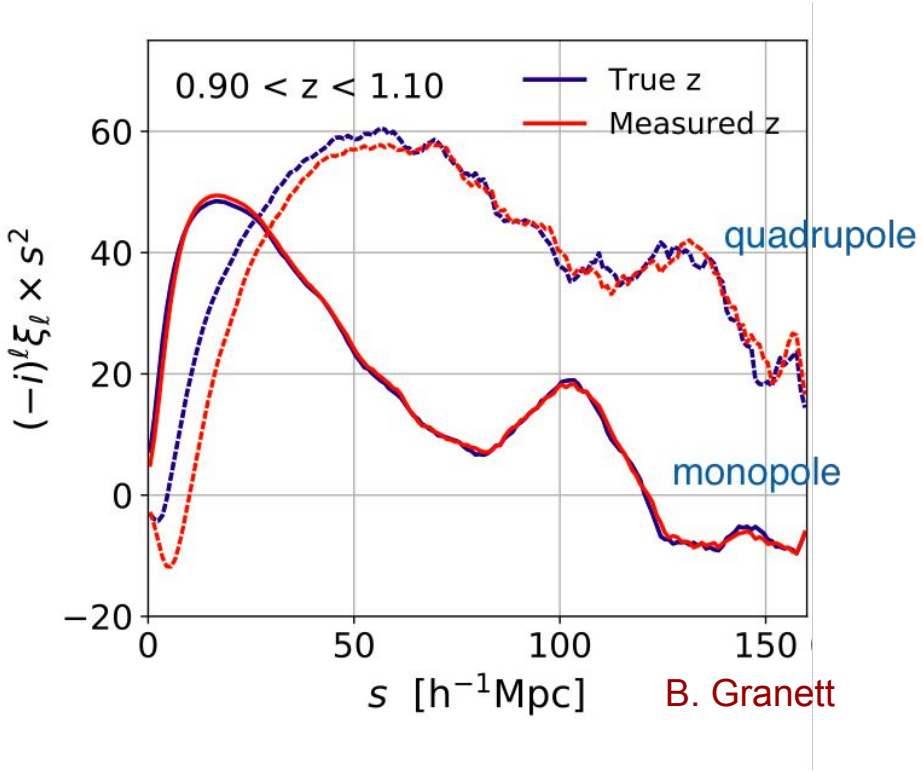


Line misidentification



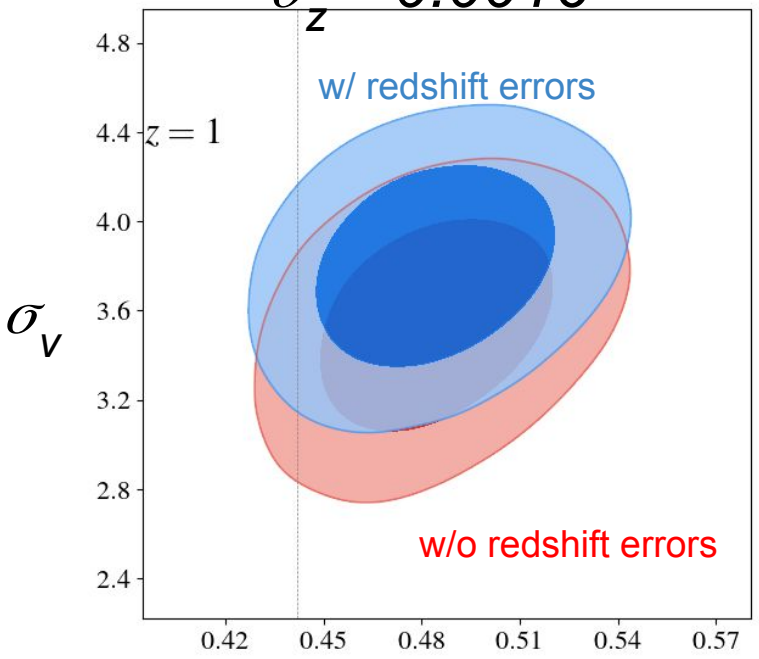


Random redshift error - RSD



B. Granett

$\sigma_z = 0.0016$

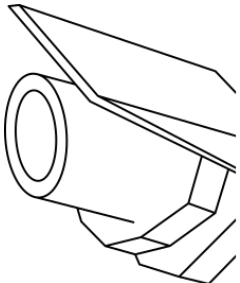


$f\sigma_8(z=1)$

S. de la Torre

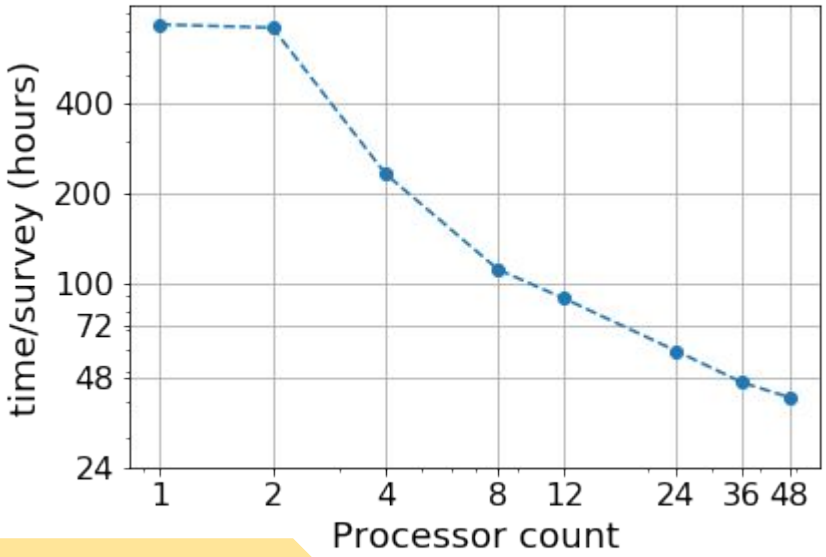
Discussion points - redshift error

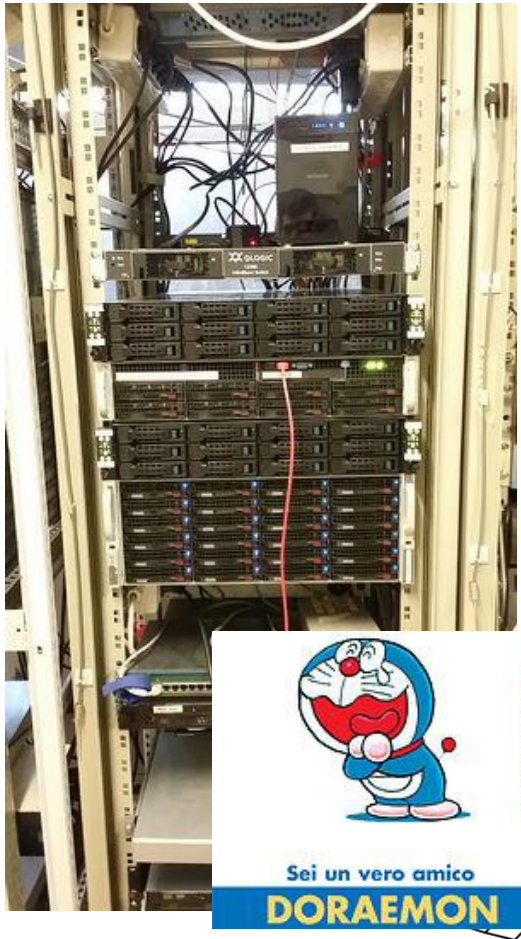
- Line misidentification rates will depend strongly on the priors
  - Magnitude, color, size, ...
  - Line misidentification can be put into the model
- Best fit parameters can change with redshift error, even though we know how to model it perfectly...
  - Information is lost
  - Watch for degeneracies between redshift error and other RSD model parameters
- Correlations between redshift error, galaxy type and environment can be troublesome
  - But we have not seen a strong effect in Flagship



Pypelid performance

- Exposures processed in parallel with MPI
  - There are remaining efficiency issues
- ~100 core-days/survey





SESTO summary

- Current pixel-level simulations are limited to a few pointings
- We are developing algorithms to bypass pixels and model survey systematics at the catalog level
- *pypelid* is our fast and modular survey simulator
- With the Flagship mock we've started looking at systematics for Euclid Wide clustering analyses
  - **Tiling pattern and visibility mask**
  - **Contamination by continuum sources**
  - **Random and systematic redshift error**


More paving to come!