Radial selection issues for primordial non-Gaussianity detection

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Radial issues

• Decoupled from angular selection:
  – One average $N(z)$ for all (simplest possible case).
  – Worry about photo-zs.
  – Wrong redshifts.

• Coupled to angular selection
Need redshifts

• Spectroscopic or photometric redshifts (photo-zs).
• Photo-zs also require spec-zs – for calibration.
• Spec-zs, require photometric pre-selection.

Spectroscopic Issues
• Incompleteness
• Failures (wrong redshifts)
• Sample variance (for photo-z calibration).
Example - Wigglez

When spec-zs go wrong, they go wrong bad

Figure 11. Distribution of values of $(1 + z_1)/(1 + z_2)$ for inconsistent repeat redshifts derived from pairs of spectra with quality flags $Q = 3$ (redshift $z_1$) and $Q \geq 4$ (redshift $z_2$). The vertical lines indicate the ratios expected in the cases where $\text{H}\beta$, $[\text{OIII}]$ and H$\alpha$ are mis-identified as $[\text{OII}]$.

Figure 13. The power spectrum correction factor due to redshift blunders for each of the survey regions analyzed in this paper, for a redshift range $0.3 < z < 0.9$. The measured power spectrum must be divided by this factor in order to obtain an unbiased estimate of the true power spectrum.

Effect is largest at large scales

Blake et al 2010
Radial spec-z issues for photometric surveys

**Issues:**

- Spectroscopic samples are very incomplete
  - Need to apply spectroscopic selection to photometric sample.
- Sample variance of spec. sample.
  - Area of samples is too small.
- Spectroscopic failures (wrong redshifts).

**Case study:**
DES photometry + VVDS-like spec-z’s

4.5 h exposures
8-m telescope

Cunha et al. in prep.
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Cunha, Huterer, Busha & Wechsler 2012
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Cunha et al. in prep.
Radial-Angular correlations
Photometric surveys for theorists

- Collect light from galaxies in several broad-band filters in optical and near-IR.
- grizY (DES) + JK (Vista)
- Use flux in each filter to determine:
  - type: star/gal./QSO
  - gal. type: spiral, elliptical, ...
  - (photometric) redshift
- Also have angular and shape information

Terminology:

magnitude = A – log(flux)
color = magnitude - magnitude
**DES Photometric Calibration**

- Deal with: telescope/camera, atmosphere, seasons, Moon, Milky Way.
- Multiple overlapping tilings with varying orientations + standard stars + ...
- DES: 2 survey tilings/filter/year
- Need contiguous area that overlaps existing surveys.

**DES Goal:** 1% photometry over all survey area (BaO requirement is 2%).
Photometric calibration is complicated

- Deal with: telescope/camera, atmosphere, seasons, Moon, Milky Way – over several years.
- Multiple overlapping tilings with varying orientations + standard stars + ...
- DES: 2 survey tilings/filter/year
- Need contiguous area that overlaps existing surveys.

**DES Goal**: 1% photometry over all survey area (BaO requirement is 2%).
Photometric calibration is complicated

- Mag. limits affect redshift distribution -> coupling between angular and radial effects (problem is worse if using photo-zs).
- Varying colors, affect galaxy types being selected.
  - Different types have different HODs, with different biases.
  - variation in color -> scale-dependent halo bias
- Need to couple radial-angular mask
- Uncertainty in calibration will still be a problem.
Uncertainty in calibration

\[ e_{\text{calib}} = \frac{\delta N}{N} \approx 3 \frac{\delta m}{m} \]

\( N \): Number of galaxies
\( m \): magnitude

Error bars: variations from allocating \( e_{\text{calib}} \) to different \( m \).

Huterer & friends, in prep.
Conclusions

• Spectroscopic selection is a major challenge for upcoming surveys, particularly photometric surveys (because they go deeper).

• Survey calibration on the largest scales is a tough challenge.

• Lots of work to be done before trustworthy constraints can be extracted from large-scale clustering.
An example:

- Template photo-zs.
- Calibration using one field with 1 deg$^2$.
- Weak Lensing shear-shear tomography.

- Difference between true $P(z_s|z_p)$ and that of calibration sample generates biases in cosmology.

$$\Delta P(z_s|z_p) = P(z_s|z_p)_{\text{phot}} - P(z_s|z_p)_{\text{train}}$$
Finedl galaxies are added to the simulation by integrating a resulting catalogn. Once this probability relation has been dem— Behroozi et aln rpqp— Busha et aln rpqqain The served galaxy clustering hConroy et aln rppv— Wetzel and properties that accurately reproduces properties of the obm— matter simulations with galaxies based on halo and subhalo.

This is an algorithm for populating very high resolution dark with the technique known as subhalo abundance matchingn— Cunha, Huterer, Busha & Wechsler. The lightcone output necessary for the ADDGALS puck luminosity function are first assigned to particles in— put luminosity function as measured in Blanton et aln hrppsil but evolves— for each galaxy by drawing from the integrated luminosity function with the appropriate magnitude and den.

When applied to the present simulation, we populate halos larger than u— explicit information about the mass of their host halosn— Thusl— central objects require exm— distribution of satellite galaxies— the completeness limit for a standard halo occupation hHODi.

The advanm— distributionl and attaching it to a simulated dark matter— a list of galaxies with magnitudes and redshiftsl selecting— significant deeper catalogs using simulations of only modest— based on the dark matter halos is the ability to produce sigm— aS c h e c k t e rF u n c t i o n with— .

The figure shows the number of patches as a function of the number of galaxies observed per patch so that the calibration bias will yield a— of dark mattern— .

The survey can observe more galaxies in each patchn then the total number of patches obviously decreases since— typical number of galaxies per observed patch possible with a single pointing of Magellan or VLTp.

The VIMOSoVLT instrument could observe— different telescope apertures based on capabilities of— eric observing area of Magellanp. The number of patches is plotted against the number of galaxies observed per patch for different survey areas:

- 1/4 deg² (black line)
- 1/8 deg² (red line)
- 1/32 deg² (blue line)

The survey calculator interface allows users to input parameters such as survey area, number of galaxies, and observe patches to estimate the number of patches needed for a given survey design. The graph indicates that as the number of galaxies observed per patch increases, fewer patches are required to achieve the desired level of calibration bias, with 95% confidence.

The graph also highlights the expected number of patches needed for surveys with different observing areas. By varying the number of galaxies per patch, users can explore different survey configurations and their impact on the number of patches required. This tool is useful for planning observational campaigns and optimizing resource allocation in astronomical surveys.
• Combination DES (optical)+Vista (IR) yields robust photo-zs.
• LRGs have even better scatter.
• Errors need to be modeled carefully, but $f_{NL}$ requirements weaker than WL.
• For clusters $\sigma_z=0.02$.

Rough numbers:
$\Delta z=0.1 \Rightarrow \Delta d_c = 1-2 \times 10^2 h^{-1} \text{ Mpc over survey redshift range.}$

100 Mpc $\approx$ 3 deg at $z=1$. 
Star/Galaxy separation

- Distribution of stars is not random. Pronounced variation with latitude.
- Classification using colors (magnitudes)
- BAO requirement:
  - Probabilities accurate to 1%
  - Stellar contamination and distribution of misclassified galaxies smaller than 9% over all survey (< 2% on scales < 4 degree)
- Good enough for $f_{NL}$?
The Dark Energy Survey

- Study Dark Energy using 4 complementary techniques:
  I. Cluster Counts
  II. Weak Lensing
  III. Baryon Acoustic Oscillations
  IV. Supernovae

- Two multiband surveys:
  **Main:** $5000 \text{ deg}^2 \approx 5 \text{ (h}^{-1}\text{Gpc)}^3$
  - 300 million galaxies
  - $g, r, i, z, Y$ to 24th mag
  **SNe:** 15 deg$^2$ repeat

- Build new 3 deg$^2$ FoV camera and Data management system in Blanco 4-m telescope
  - Survey 2012-2017 (525 nights)
  - Camera available for community use the rest of the time (70%)

www.darkenergysurvey.org
Observational issues for $f_{nl}$ measurement

- Artificial correlations can mimic $f_{nl}$. For $f_{NL}^{\text{local}}$, separations >100 Mpc (several degrees) are crucial.

- Artificial correlations can be due to:
  - photometric calibration
  - photometric redshifts
  - star/galaxy separation

- Clusters have own selection issues

\[
b(k) = b_G + f_{NL} \frac{\text{const}}{k^2}
\]

Because of $1/k^2$ scale dependence of bias

More relevant for galaxies than clusters