Some Considerations for Southern Wide-Field Spectroscopy (SWFS)

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Summarizing some discussions of an informal study group involving Fermilab, Argonne, and KICP scientists in early 2015

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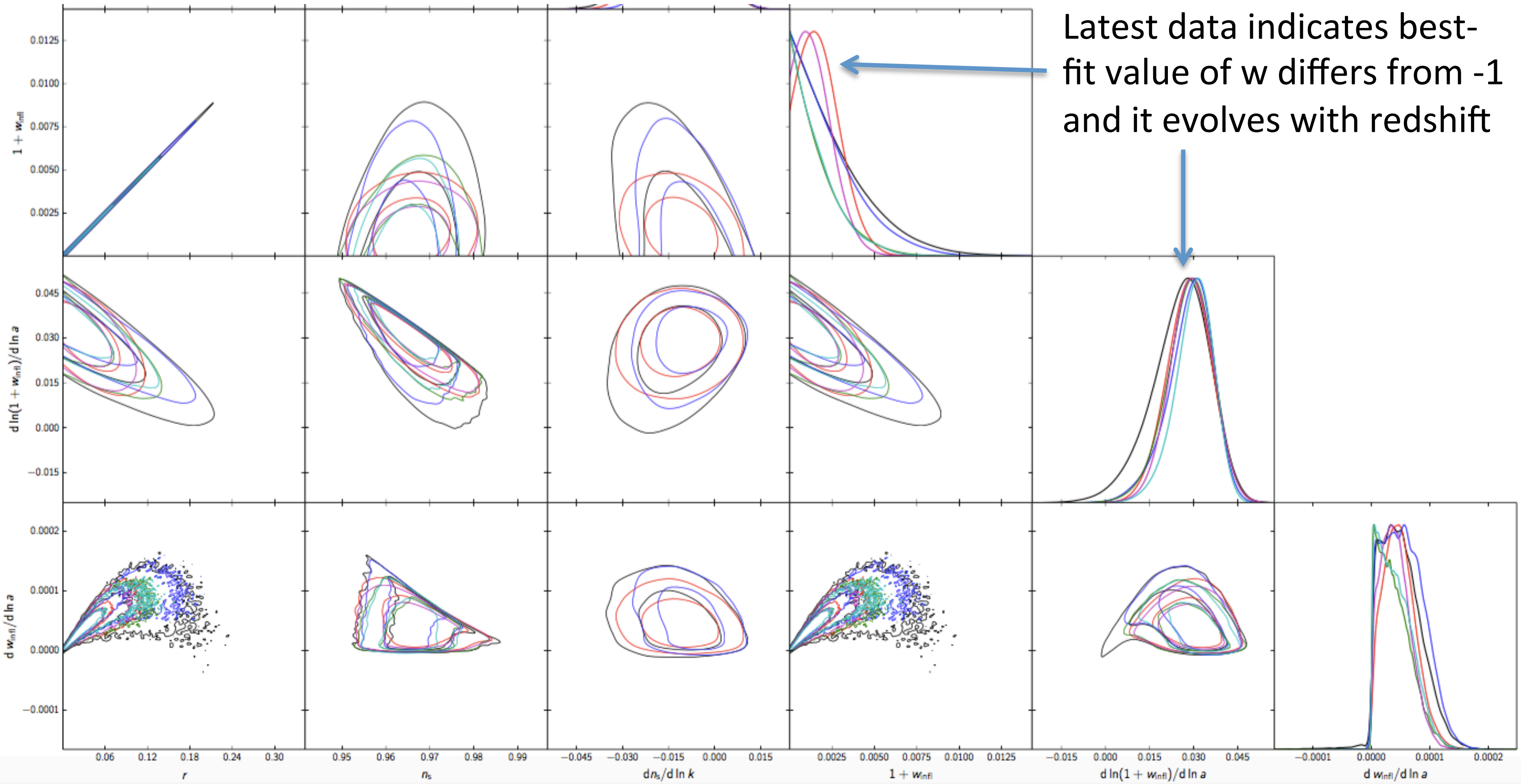
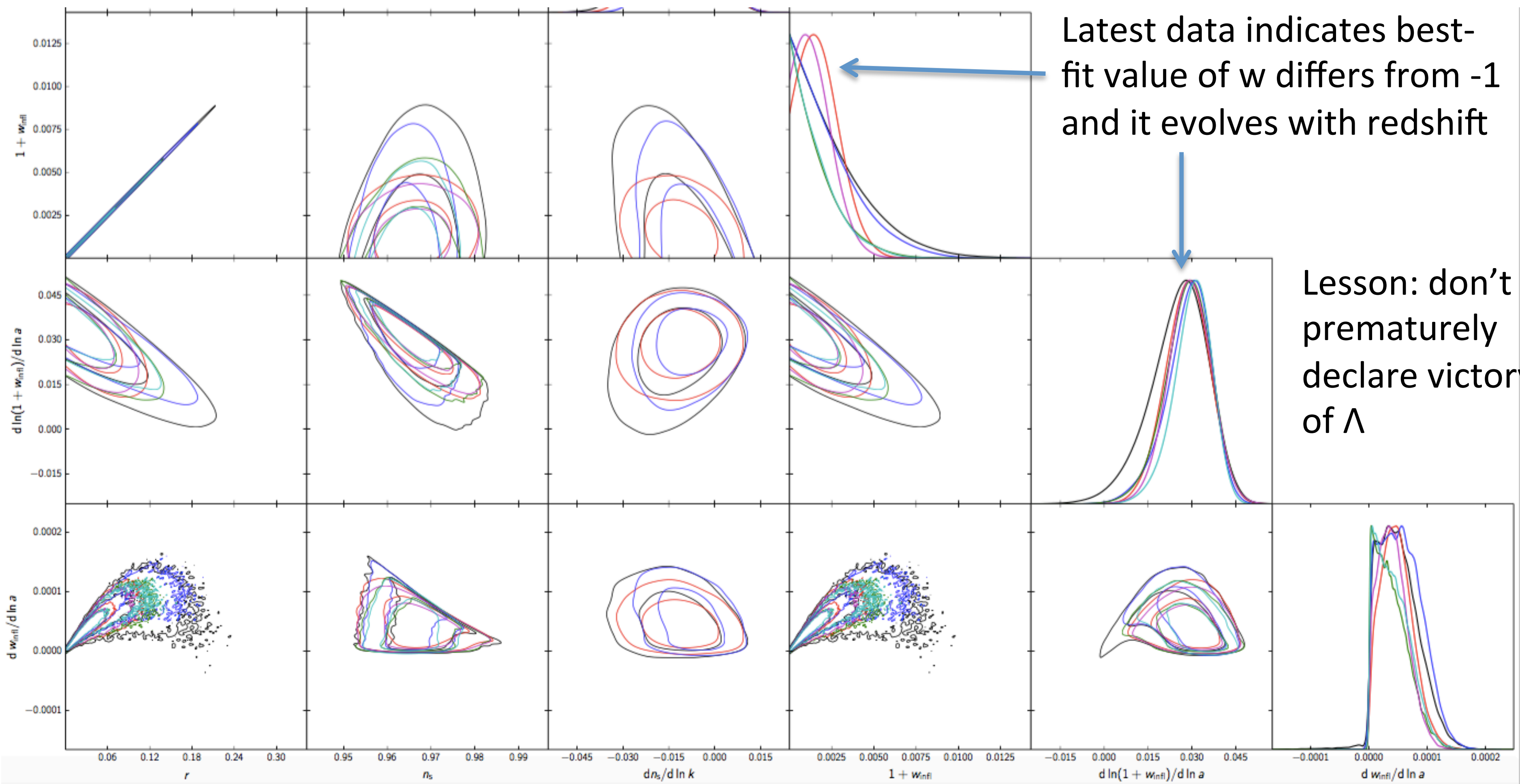


Latest data indicates best-fit value of w differs from -1 and it evolves with redshift

Planck/BICEP constraints on inflaton EOS



Latest data indicates best-fit value of w differs from -1 and it evolves with redshift

Lesson: don't prematurely declare victory of Λ

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Context

- LSST will be an extremely powerful *fast, deep, wide* imaging survey.
- Spectroscopic resources (in principle) in place for *fast* (Gemini, SOAR, robotic, …) and *deep* (6->10->30m) follow-up, but not for a **wide-area, large-scale spectroscopic survey that covers much of the LSST 15,000 sq deg extragalactic footprint**.
- Growing recognition of this in the astronomy community: recommendations and conclusions of the NRC Committee on a Strategy to Optimize the OIR System in the Era of LSST Report earlier this year.
- Depending on options pursued, science case would include but likely go well beyond cosmology.

Optimizing the US Ground-Based Optical And Infrared Astronomy System

- NRC Report (April 2015) commissioned by NSF Astronomy Division, chaired by D. Elmegreen
- Tasked with recommending and prioritizing adjustments to the US ground-based OIR system that will better position the system to address Astro2010 science priorities over the next 10-15 years.
- LSST will produce precise 2d maps of the cosmos.
- SDSS enabled a rich variety of discoveries through its combination of photometric (2d) and spectroscopic (3d) surveys.
- Science reach of LSST could be substantially enhanced by developing for the US community a very wide-field, massively multiplexed spectroscopic capability that can access much of the LSST footprint.

Optimizing the US Ground-Based Optical And Infrared Astronomy System

- **RECOMMENDATION 3. The National Science Foundation should support the development of a wide-field, highly multiplexed spectroscopic capability on a medium- or large-aperture telescope in the Southern Hemisphere to enable a wide variety of science, including follow-up spectroscopy of Large Synoptic Survey Telescope targets. Examples of enabled science are studies of cosmology, galaxy evolution, quasars, and the Milky Way.**
- **CONCLUSION: If the DESI project proceeds as planned, then upon completion of its survey from the KPNO Mayall 4-meter, NSF and DOE could partner to move DESI to the CTIO Blanco 4-meter (if technically feasible) early in the era of LSST operations in order to enable southern wide-field spectroscopic surveys.**
- Question of what science can be done with the 4-m aperture vs needs for larger aperture was beyond scope of the report.

Science Cases for SWFS

- Enhancing/strengthening LSST science + Extending DE science:
  - LSST Photo-z Training +/or Calibration
  - Baryon Acoustic Oscillations
  - Redshift Space Distortions: synergy with LSST Weak Lensing
  - Cross-correlations (e.g. gal-gal lensing, SPT/ACT)
  - Galaxy Clusters (velocity dispersions)
  - SN host galaxies
  - Strong-lens systems
  - Non-Gaussianity?
  - Weak Lensing intrinsic alignment systematics control
- Defining a Stage V DE Project?
- Ultimate 3d map of half the sky: >100 Million spectra
- A large-aperture (>4m) instrument/facility may rest heavily on non-DE science.
- Spec target selection from much deeper, well-calibrated, homogeneous multi-band photometry (i.e., DES, LSST, VHS) leads to higher redshift success rates and enables sculpting of z distributions

Science Flowdown

- From science cases to:
  - Depth (flux limits) → aperture, exposure times
  - Target selection (galaxy types, QSOs, Lya,…)
  - Area (fraction of LSST footprint) → FOV, location
  - Number or number density of targets → multiplexing
  - S/N per target: more than z? → aperture, exposure times
  - Redshift range → wavelength range
  - Spectral features and z precision → spectral resolution R (wide-band imaging: R~5; narrow-band imaging or MKIDS: R~50-100?; spectroscopy: R>1000)

Current Landscape

- DESI on Mayall 4m 2019+
- PFS on Subaru 8m 2018+
- Euclid 2020+
- LSST 2020+
- WFIRST 2024+
- SPHEREx (NASA SMEX)
- 4MOST on VISTA 4m ~2018+?
- Maunakea Spectroscopic Explorer: 10m replacement for CFHT, 3000 fibers, ~2025+

Some Options

- Very broad range of costs and timescales
- Move DESI to Blanco in ~2024+. 20M+ redshifts selected from LSST. Sqrt(2) improvement over DESI, gain from LSST selection & same-sky WL/RSD.
- 4000-fiber WFS w/ existing corrector on Blanco (DESpec redux). 20M+ z's from LSST (or ~2000 fibers w DESI positioners)
- Wide-field, multi-fiber spectrograph for LSST telescope. 15K fibers over 10 sq deg w Echidna technology. On-sky ~2032. Substantially deeper than DESI, wider than PFS. 100M+ z's from LSST.
- Resurrect WFMOS concept on Gemini-S?
- New 8-10m telescope with very wide-field spec. capability and even higher multiplexing. ~2030++.
- Coarser wavelength (lower-resolution) sampling: MKIDS, narrow-band imaging (PAU+). Redshift precision sufficient for photo-z but likely not for BAO, RSD, and non-cosmological astronomy.