Recommendations on the planning for the post SDSS-IV Era

Rene Walterbos, ARC Board Chair

The ARC Board formed an After Sloan-IV Futures Committee[1] to examine prospects for the post SDSS-IV era in terms of science programs, infrastructure changes, modes of operation, and/or management structures that would enable continued productive use of the facilities. A call for white papers was issued in June of 2015. The white papers were asked to address projects or programs that would include future use of the facilities at APO and at Las Campanas Observatory currently in use for SDSS-IV, possibly in concert with other telescopes, including the ARC 3.5-m telescope.

Fifteen white papers were received and evaluated by the Committee. The white papers were not scientific proposals but were intended to gauge the interest and ideas of the ARC and SDSS communities in continuing use of the facilities. The white papers were classified in several strategic areas (with some addressing several of these areas): Infrastructure Improvements; Time Domain Science Applications; APOGEE Projects in various areas of MW science; Follow-up Projects to other Science Missions; Education and Public Outreach; Instrumentation for the ARC 3.5-m Telescope. The Committee addressed in its report the competitiveness of the ARC/SDSS facilities with respect to future surveys with other multi-object spectroscopic facilities that are coming online in the next 3 to 6 years. The Committee reported to the ARC Board during the November 2015 Board meeting. It made several recommendations and suggested a strategy and schedule for moving forward with the development of a post SDSS-IV program. The Board approved the recommendations of the Committee. This document summarizes the main recommendations and includes in the appendix a listing of the white papers that addressed continuing use of existing facilities that we received.

The Committee found sufficient scientific motivation and potential, as evidenced by the white papers received, to recommend that the Board form an After-Sloan-4 (AS4) Steering Committee, charged with developing and executing a call for proposals for the next generation ARC sky survey. The committee outlined several steps required in order to refine a suite of projects that will be scientifically compelling and able to accrue the tens of millions of dollars of foundation, government and institutional support that represent the typical funding level for previous incarnations of SDSS. A formal proposal competition will be necessary to advance the existing ideas to a level competitive with other spectroscopic projects likely to be in full operation in the timeframe of the 2020's. New ideas not presented in the white papers may also be considered in response to the call for proposals.

The committee believes that an effective AS4 call for proposals will require additional groundwork to define some of the key capabilities and related scientific objectives. The Futures Committee will remain active, until the AS4 Steering Committee is created and charged, to coordinate these activities. They include formation of two sub-committees, one tasked with revisiting the issue of robotic fiber positioning, the other with refining

[1] Mike Skrutskie (Chair), Matt Bershady, Mike Blanton, Bruce Gillespie, Suzanne Hawley, Juna Kollmeier, Hans-Walter Rix, Connie Rockosi, Keivan Stassun, Rene Walterbos

the role of spectroscopic surveys in a variety of time-domain arenas. The reports from these subcommittees would inform the call for proposals for AS4. In parallel with the activities of the AS4 Steering Committee, the Futures Committee recommends creating a group charged with issuing a call for proposals that would enable ARC to use its deep prior experience in survey data management to become involved with long-term data curation, both to secure the legacy of previous generations of SDSS and possibly to serve as a more general data archive in the upcoming era of data-rich astronomy. These efforts should begin almost immediately to enable a survey start in 2020, particularly if new instrumentation is fundamental to one or more next-generation surveys.

The Futures Committee recommended the following timeline leading to a completed call for AS4 proposals and an evaluation leading to the definition of a possible AS4 survey plan by the time of the next ARC Board meeting in November 2016:

November 2015 – ARC Board Meeting
Early December 2015 -
Formation of subcommittees pre-requisite to forming a Steering Committee:

- Fiber positioner evaluation
- Time domain science

March 2016 – Subcommittee Reports
March 2016 – Finalize membership of AS4 Steering Committee and separate Data Archive committee
April 2016 – AS4 Call for Proposals, Data archive call for proposals
Spring-Summer 2016 – Proposal preparation period
Mid September 2016 – Proposals due, begin proposal evaluation
November 2016 – AS4 Steering committee and Data archive committee report to Board

The ARC Board approved these steps. We will continue to keep the ARC and SDSS communities involved over the next months as we progress through these milestones.

APPENDIX: List of white papers received.

The white papers are listed by category. Some papers appear in multiple categories and appear in *italics* when listed again. In total 15 responses that addressed ARC and LCO facilities were received.

The "Instruments/Facilities" line is a quick assessment of the major instrumentation and telescopes involved in the white paper, while the "Scope" category gives an indication of time and target demand, plus other restrictions on accommodating other programs.

I. Facility/Infrastructure

1. Authors: N. Drory, N. MacDonald, M. Bershady, K. Bundy, R. Yan, D. Law

Title: A very large IFU system for future Multi-scale surveys of galaxies
Length: 10 pages
Instruments/Facilities: new spectrographs, independent of BOSS/Apogee, possibly both Sloan and du Pont telescopes.
Scale of the project: could fill all the dark time, depends on scope of the survey

2. Authors: N. MacDonald

Title: Efficiency improvements for the SDSS operating model and telescope
Length: 6 pages
Instruments/Facilities: Robotic fiber positioner, coating changes in NIR for Apogee

3. Authors: J. Huehnerhoff, J.A. Lozo, M. Klaene, J. Downey, D. Long, B. Ketzeback

Title: AS4 Robotic Fiber Positioner
Length: 4 pages (plus a longer 15 page draft document available)
Instruments/Facilities: fiber feeding BOSS and APOGEE with robotic fiber positioner

4. Authors: P. Gaulme

Title: A visible high-resolution spectrometer to detect/characterize multiple star systems with the 2.5-m telescope
Length: 3 pages
Instruments/Facilities: Sloan telescope, new R 40,000-70,000 visible wavelength, fiber-fed spectrograph
Scale of the project: not discussed, but would fall in time-domain category and require extensive searches for many years, so could use up all the time.

II. Time Domain

5. Authors: P. Green, S. Anderson, M. Eraclous, A. Myers, M. Agueros, N. Brandt, N. Filiz Ak, A. Georgakakis, P. Hall, F. Hamann, C. Macleod, I. McGreer, A. Merloni, E. Morganson, I. Paris, G. Richards, J. Ruan, J. Runnoe, D. Schneider, Y. Shen, P. Szkody, D. York

Title: After SDSS-IV: All-sky multi-epoch spectroscopy of quasars

Length: 7 pages
Instruments/Facilities: BOSS spectrographs and Sloan 2.5m telescope
Scale of the project: Nominally all of the dark time over 4 years but the project can be flexible in terms of length of the survey, number of targets and accommodating other surveys.

6. Authors: Y. Shen, S. Anderson, A. Barth, N. Brandt, P. Du, X. Fan, P. Green, P. Hall, L. Ho, K. Horne, C. Hu, L. Jiang, C. Kochanek, Y,-R. Li, I. McGreer, A. Myers, D. Schneider, M. Strauss, J. Trump, J.-M. Wang, D. York

Title: Multi-object reverberation mapping: transforming quasar science in the era of time-domain and multi-object spectroscopic surveys
Length: 7 pages
Instruments/Facilities: BOSS and Sloan 2.5m, robotic fiber positioner would be helpful
Scale of the project: 600 hrs/yr dark and grey time on BOSS, reduced cadence in subsequent years, can be scaled back to fewer targets. However, cadence places restrictions on other programs that could be accommodated (many repeated visits to a few fields).

7. Authors: N. Troup, S. Majewski, J. Carlberg, K. Covey, K. Cunha, N. De Lee, F. Hearty, D. Nidever, M. Skrutskie, V. Smith, J. Sobeck, K. Stassun, J. Wisniewki

Title: The APOGEE Time-domain Legacy Survey (ATLaS)
Length: 7 pages
Instruments/Facilities: upgraded APOGEE spectrographs, fiber positioner, Sloan and du Pont telescopes if possible.
Scope of the project: Bright time time-domain survey, radial velocity survey so repeat visits to same fields, following up Kepler and TESS targets, could use all bright time but also accommodate other programs.

III. APOGEE

8. Authors: J. Kauffmann, J. Bally, K. Covey, L. Hillenbrand, C. Román-Zúñiga, M. Skrutskie, H. Arce, A. Ginsburg, F. Nakamura, T. Pillai, N. Da Rio, A Roman-Lopes, K. Stassun, J. Tan, A. Weinberger

Title: SDSS-V: Unbiased views of young stars in the Milky Way
Length: 7 pages
Instruments/Facilities: APOGEE spectrographs, new K-band multi-object spectrograph, Sloan and du Pont telescopes
Scope of the project: 20,000 young stars with APOGEE, North and South best, few hundred nights, can be de-scoped, would not fill all bright time in a 4+ year survey.

9. Authors: M. Brogi, J. Stocke, P. Armitage, T. Brown, C. Huitson

Title: On the use of APOGEE and APO for investigating exoplanet atmospheres
Length: 12 pages
Instruments/Facilities: APOGEE spectrograph, possibly fiber bundles, Sloan telescope, ARC 3.5-m telescope

Scope of the project: This is a "piggy-back program" with few targets, requiring about 60 to 75 hrs per month. Could use single fiber per target or small fiber bundle, could also go on the 3.5m. Current detectable sample is 16 planets each 4 months. Co-observing possible but limited to the fields of the planets.

10. Authors: J. Bird, M. Ness, L. Inno, G. Zasowski, A. Casey, D.W. Hogg, H.-W. Rix, J. Holtzman

Title: Disco: Near field cartography and cosmology with precise stellar distances
Length: 11 pages
Instruments/Facilities: APOGEE spectrographs, Sloan and du Pont, no upgrades required, maybe new detector arrays.
Scope of the project: >200,000 possible targets, comparable in scope to current APOGEE surveys.

7. (Also listed under Time Domain) Authors: N. Troup, S. Majewski, J. Carlberg, K. Covey, K. Cunha, N. De Lee, F. Hearty, D. Nidever, M. Skrutskie, V. Smith, J. Sobeck, K. Stassun, J. Wisniewki

Title: The APOGEE Time-domain Legacy Survey (ATLaS)
Length: 7
Instruments/Facilities: upgraded APOGEE spectrographs, fiber positioner, Sloan and du Pont telescopes if possible.
Scope of the project: Bright time time-domain survey, radial velocity survey so repeat visits to same fields, following up Kepler and TESS targets, could use all bright time but also accommodate other programs.

IV. Follow-up for other projects

11. Authors: N. Clerc, A. Finoguenov, A. Merloni

Title: IFU survey of clusters of galaxies: cosmology and astrophysics
Length: 5 pages
Instruments/facilities: Use BOSS/MaNGA instr, possibly some different fiber bundles, and Sloan 2.5-m telescope
Scope of project: Use MaNGA single large bundle of sets of smaller bundles to observe 1500 or 15,000 X-ray detected clusters. Could use 100% of dark time over 5 years but could be de-scoped in various ways.

12. Authors: K. Nandra, A. Merloni

Title: A complete census of accreting black holes: SDSS follow-up of e-ROSITA AGN
Length: 6 pages
Instruments/facilities: BOSS spectrograph and Sloan telescope
Scope of the project: Similar to currently planned eROSITA followup, will need of order $1/3^{rd}$ of the BOSS fibers over a 5 yr period.

V. Education and Public Outreach only

13. Authors: B. Cherinka, B. Lundgren, K. Masters, N. MacDonald, K. Meredith, J. Raddick, O. Fraser

Title: To boldly go: Engaging in a future of education and public outreach for the Sloan Digital Sky Survey
Length: 6 pages
Instruments/facilities: N/A, plan as supplement to AS4, to integrate and fund EPO systematically

VI. 3.5-m Telescope

14. Authors: P. Gaulme

Title: Adaptive optics, high-resolution spectrometry, and Doppler imaging for the 3.5-m telescope
Length: 3 pages
Instruments/Facilities: ARC 3.5-m telescope, AO system, R 100,000 single fiber spectrograph, also Doppler imager at 519 nm (JIVE)

15. Authors: X. Dai, E. Baron, J. Wisniewki

Title: Target of opportunity Observations for APO telescopes
Length: Abstract only, posted on AS4 wiki
Instruments/Facilities: APO 3.5-m telescope and instruments

9. (Also listed under APOGEE) Authors: M. Brogi, J. Stocke, P. Armitage, T. Brown, C. Huitson

Title: On the use of APOGEE and APO for investigating exoplanet atmospheres
Length: 12 pages
Instruments/Facilities: APOGEE spectrograph, possibly fiber bundles, Sloan telescope, ARC 3.5-m telescope
Scope of the project: This is a "piggy-back program" with few targets, requiring about 60 to 75 hrs per month. Could use single fiber per target or small fiber bundle, could also go on the 3.5m. Current detectable sample is 16 planets each 4 months. Co-observing possible but limited to the fields of the planets.