Lessons learned from SDSS instrument + operations

David Schlegel, Berkeley Lab, 26 Feb 2019
Start-up of a survey is time-critical

SDSS was built as a survey (dedicated single, long-term project), not a facility (mix of smaller projects)

Dedicated surveys have enormous time pressure for commissioning

- SDSS-1 started in 1998, but in fact was commissioning for ~2 years
- SDSS-2,3,4 benefited from pilot surveys ~1 year in advance
- Likewise, DES started in 2012, but commissioned for ~1 year

MSE is both a facility and surveys
Tolerances should work for commissioning
SDSS pointing tolerance < 5” was OK for smooth operations, but we first spent > 1 year looking for Polaris!
Design for the best conditions, not worst

Most effective survey time is photometric, dark sky, good seeing
MSE already designing for this with small fibers

Fiber size optimization
Surveys should dynamically expose to a uniform completeness or S/N depth

(...going to a uniform t_exp is pretty dumb)
SDSS has done this crudely: sequences of exposures until complete
DESI (imaging + spectro) tracks S/N on ~minute timescales
Surveys should dynamically expose

For spectroscopy, continuum sky brightness scales w/ Sun activity
Can be predicted 4 days in advance from radio data
(c.f. Parker Fagrelius thesis, 2018)
Lesson: Shipping & handling is dangerous
Evidence: Shipping of prisms for BOSS spectrographs
Lesson: Believe the data!

Evidence: Sky spectra in SDSS-I was too bright by ~50X, effectively making the 2.5-m telescope as good as a Meade 10”

Underlying problem: LED lights on spectrograph shutter controls (but only when the shutters were open!)

Other lessons: LEDs are in everything (even when they’re not!) Black tape doesn’t block light at > 800 nm
Lesson: Optics can be humidity-sensitive

Evidence: Varying spectral features in SDSS spectra

Underlying problem: Some anti-reflective coatings absorb water, then dissipate on timescales of \(~1\) hour
Lesson: Visual inspections are important

Evidence: Apparent charge-transfer-efficiency issues in some raw spectro images

Underlying problem: Oil-filled lenses in spectrographs had separated into a liquid & a glue, diffraction from air bubbles appeared as an electronics read-out problem (we blamed Connie Rockosi first!)
Lesson: Communication between mountain staff an science team

Evidence: SDSS fiber mapping became unreliable for no apparent reason

Underlying problem: Site maintenance staff replaced light bulbs over the mapping station which had been intentionally removed
Lesson: Don’t just keep taking bad data?

Evidence: Some SDSS plates had terrible sky-subtraction, we kept repeating but still bad

Underlying problem: Observed fields with Jupiter (& Uranus), where scattering off clouds dominated the sky background

Note: A physicist (David Kirkby), not astronomer, figured this out.
Lesson: Airplanes fly overhead

Evidence: Bright “LED light” in a handful of spectra
Lesson: Airplanes fly overhead

Evidence: Bright “LED light” in a handful of spectra

... Plotted in sky coordinates, these lined up
Lesson: **Always** look back at the images

Evidence: Some quasars showed no light in the fibers

Underlying problem: Targeting data had “double images”, and therefore lots of weird-colored, fake QSOs
Lesson: **Always** look back at the images

Not a cluster of high-redshift QSOs (as it was targeted)
Lesson: Some telescope/instrument code needs to run off-line

Evidence: Guiding sometimes worked, sometimes not. Could not reproduce off-line, first attempts actually commanded the telescope in New Mexico!

Underlying problem: Several, one being that we were only guiding on masked (not unmasked) pixels in the images
Lesson: Small problems need follow-up

Evidence: Small issues reported in observing night log

08:40Z Cart 16, plate 4235, BOSS, GSOGTF. Seeing was at about 1.75" per the DIMM. This field was out of focus on gotoField. After focus, fibers 04 and 06 were disabled because they were donuts. With the preCalibs on this plate, the exposures were reversed for the arc and flat, i.e., the arc was 30 seconds; the flat was 4 seconds. So, we did another set of calibs after the first science exposure. We are not sure why this happened. We also did a sos_redo, which did not work. Seeing was about 2.5" at the end of the time on this field per the DIMM.

MJD  b1  r1  b2  r2  Texp  Sum  Plugfile

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Underlying problem: SDSS cartridge #16 was not latching, part of focal plane was very out-of-focus
Lesson: good communication, not more…

SDSS has done well with obvious communication channels
- **obvious mail lists** — day log, night log, infrastructure, pipeline
- **unified ticket system** — for telescope, instrument, software, …, allowing problems to be tracked through different systems
- **no competing communication channels** (Slack, google sheets), very little “off list” communication
- **mail lists, tickets, wiki curated + ported for 20+ years**

Has social media wreck this in the future?

Rapid problem-solving possible because of rapid data
—> SDSS raw + reduced data available within 36 hours

(This is less work than doing it wrong and not having rapid turn-around.)
MSE should expect major instrument upgrades
Balancing marginal costs for telescope aperture vs. instrument drives MSE from 4,000 $\rightarrow$ 40,000 fibers

MSE should expect major instrument upgrades

Telescope cost/fiber $\sim \frac{\$200M}{N_{fiber}}$

Instrument cost/fiber $\sim \$5k$

N_{fibers} $\begin{array}{cccc}
1 & 40 & 400 & 4000 \\
$\$200M$ & $\$50k$ & $\$5k$ & 40,000
\end{array}$
MSE should expect major instrument upgrades

Don’t be sad when that First Light instrument is driven off the mountain.
There’s never enough physical space for instrument upgrades

Operations building, several times re-built for more instruments

SDSS Telescope