AGA0414
Surveys

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A few definitions

What is a survey?

Hard to get a good definition. One could be:

An observation which takes a considerable amount of telescope time.

Two main types:

1. “Pencil beam”: observing one field for a long time, e.g. the Hubble Deep Field
2. “Wide Field Surveys”: observing thousands of square degrees (e.g. SDSS)

Wide-field surveys

2 Main types:

- Photometric surveys: use a specific set of filter to explore a region of sky
- Spectroscopic surveys: use a spectrograph to observe many objects

Astrometric surveys (e.g. Gaia) also give photometric information (and vice-versa, photometric surveys provide astrometric information)

Time-domain surveys (e.g. LSST) are mostly photometric surveys which observe the same field(s) over and over.

Building your own survey

A few steps

- Have one (or more) good science case(s)
- Find (or build) the telescope/instrument that suit your needs
  - A lot of intruments are built to make a survey and then become common use instruments
- Estimate how much time your survey is going to last
  - How many hours are good for your project at that given observatory?
  - Is your survey going to finish in a reasonable time-frame? Will there be other projects which are going to do your science in less time?
- Get prepared
  - “Software” is not “soft”
- Observe
- Publish
- Optional: book your flight to Stockholm to get the Nobel Prize

Step #1: Science Case

<u>Science is your main outcome and it is what gives you direction all the time.</u>

It is undeniable that most of the big surveys, nowadays, are dominated by cosmology (nature of dark matter and dark energy).

Galaxy structure is a (non-negligible) niche.

Mind you: in some cases, observatories have instruments which have completed their primary goal and then open to new surveys. In this case, you match the science to the instrument and not vice-versa.

Step #2: Find telescope/instrument

Normally you use a very fast telescope (or, which is the same, you observe at prime focus).

Adapt your instrument and your observing constraints to the “normal” conditions of a site. It is pointless to adapt to conditions which apply only a small fraction of the time (it increases the duration of the survey).

If the average seeing at your site is ~1”, do not have a camera with a pixel of 0.2” or 1”.

Step #3: Simulate the Survey

You need to have an idea of the pointings of your survey, the observing limits of your telescope and the weather statistics of your observatory.

This helps you to say if a survey lasts “long” or not.

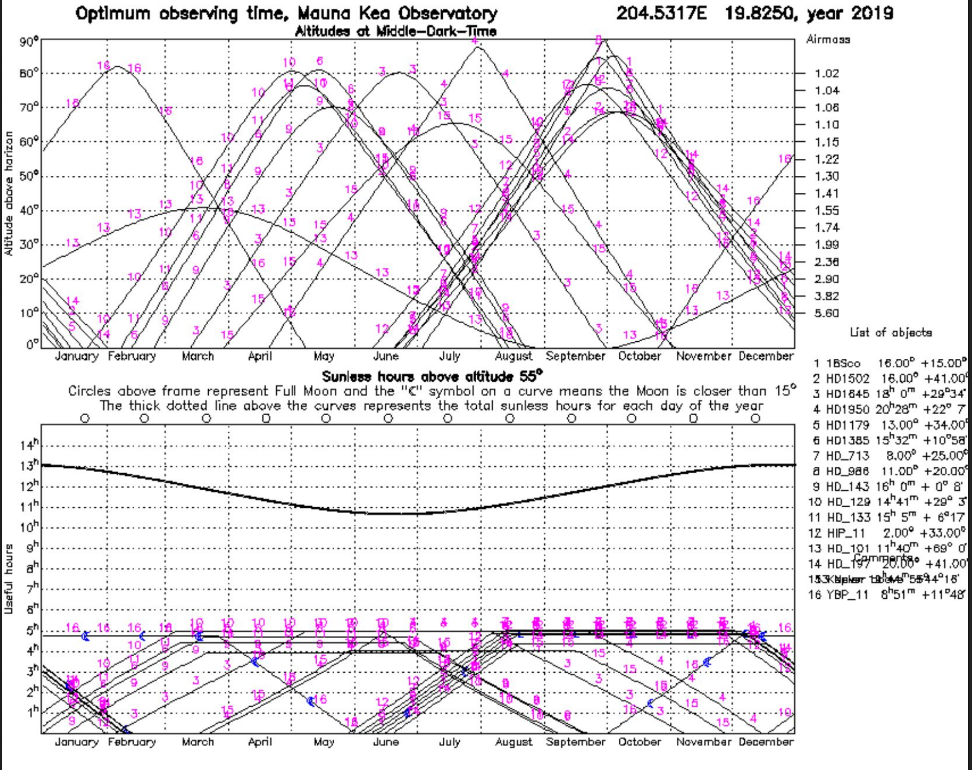
“Long” is a relative term! LSST is expected to last 10 years: is it long? Considering that it is a unique project, with no competitors, it can last as much as it wants.

Step #3: Example *a*

Given 10 stars https://en.wikipedia.org/wiki/Solar_analog :

- When is it the best moment to observe each of them?
- Is there a good date to observe most of them?
- Assume that it takes 20minutes (including overheads) to observe each of them, how long would it take to observe them all?

Starobs



Mode	Starobs
Night	20 March 2019 or date when the local night starts. *Staralt, Startrack only*.
Observatory	Mauna Kea Observatory (Hawaii, USA) Select one above or specify your own site with this format: `Longitude(°E) Latitude(°N) Altitude(metres) UT-offset(hours)` Ex.: `289.2767 -30.2283 2725 -4`

Coordinates	Formats can be any of these:
	`name hh mm ss ±dd mm ss`
	`name hh:mm:ss ±dd:mm:ss`
	`name ddd.ddd dd.ddd`
	`name` must be a single word with no dots, avoid using single numbers. Every entry must be in the same format, do not use different formats with different entries. We recommmend a maximum of 100 targets per submission.

```
18Sco 16 15 37.3 −08 22 06
HD150248 16 41 49.8 −45 22 07
HD164595 18 00 38.9 29 34 19
HD195034 20 28 11.8 22 07 44
HD117939 13 34 32.6 −38 54 26
HD138573 15 32 43.7 10 58 06
HD_71334 08 25 49.5 −29 55 50
HD_98649 11 20 51.8 −23 13 02
HD_143436 16 00 18.8 00 08 13
HD_129357 14 41 22.4 29 03 32
HD_133600 15 05 13.2 06 17 24
HIP_11915 02 33 49.0 −19 36 42.5
HD_101364 11 40 28.5 69 00 31
HD_197027 20 41 54.6 −27 12 57
Kepler-452 19 44 00.9 44 16 39.2
YBP_1194 08 51 00.8 11 48 53
```

Alternatively, you can upload a file with coordinates. You can use the same format as in the TCS catalog. Target names must be single words with no dots.

Browse... No file selected.

Options	Moon distance — Included on plot. Moon coordinates at ~02:00 UT. *Staralt only*. 55°, X=1.2 — Min. elevation (or max. airmass X). *Starobs, Starmult only*. GIF [inline] — Output format
Submit	Retrieve Help

Step #3: Example *a* (ctd.)

Given 10 stars:

- **When is it the best moment to observe each of them?** 18Sco, beginning of October,...
- **Is there a good date to observe most of them?** End of September / Beginning of October is best for 7 out of 16
- **Assume that it takes 20minutes (including overheads) to observe each of them, how long would it take to observe them all?** 16 x 20min = 320min = 5.3h

Step #3: Example *b*

J-PLUS has ~4,000 pointings.

Assuming that each pointing takes about 1h of observing time (including overheads):

- How long would it take to complete the survey (one can assume that the average night at OAJ is 8h long)?
- How long would it take to complete the survey, if only 75% of the time is available because of lunar illumination?
- What if one also adds that the sky has transparency conditions good for J-PLUS for only 50% of the time?
- Are you able to simulate a realistic scenario, taking into account the RA distribution of the sources?

Step #3: Example *b*

J-PLUS has ~4,000 pointings.

Assuming that each pointing takes about 1h of observing time (including overheads):

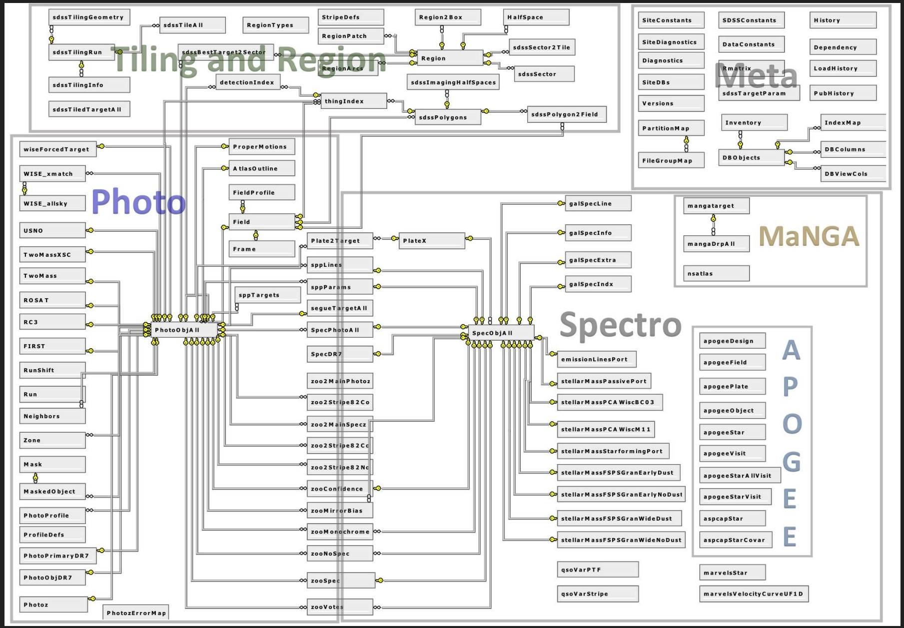
- How long would it take to complete the survey (one can assume that the average night at OAJ is 8h long)? 1h/pointing*4000 pointings=4000h => 4000h / 8h/night = 500nights
- How long would it take to complete the survey, if only 75% of the time is available because of lunar illumination? 500nights * 100 / 75 = 666nights
- What if one also adds that the sky has transparency conditions good for J-PLUS for only 50% of the time? 666nights * 2 = 1333,3nights (=3.6 years)
- Are you able to simulate a realistic scenario, taking into account the RA distribution of the sources?

Step #4: Get prepared

<u>Everything you can do before the beginning of the survey, is time saved before you can start doing science.</u>

Study other surveys. If you can, make a small version of your survey, to get ready.

In particular, make sure you have a complete and easy-to-use database for your data (SDSS is a super-good example).



https://skyserver.sdss.org/dr14/en/help/docs/images/datamodelbest.jpg

Step #5: Observe

Most surveys have automatic systems which allow to keep track of what has been observed and the quality of the observations.

In many cases, it is critical to re-observe what has been observed and ended up being not valid.

Data quality assessment is tough (can be driven by image quality, limiting magnitude, or other issues).

Relaxing your constraints increases the efficiency but it may damage your science.

Avoid changing quality criteria *during* the survey!

Step #6: Publish

When you work on a project by yourself, you do the work and you publish it. The co-authors will be the people who worked with you. It’s nice and easy (most of the times, at least).

In the case of a survey, there are people who stopped doing research to do management or technical work for the survey. You “compensate” their effort by including them in papers.

The larger the collaboration, the more complicated the publication rules will be (at times, with internal refereeing process, even before sending the paper to the journal).

Step #7: Get your Nobel Prize

Nobel Prize has its pros and cons.

The Prize is awarded in December in Stockholm. It is very cold.

The ceremony is very stiff.

The food is extraordinarily good.

The Prize consists of a lot of money (9million Swedish crowns ~ 1 million US$).

A note of wisdom

The real success of a survey is in the amount of people who were not involved in the definition and execution of the project but then use your data for excellent science which you did not think of.

Exercise

Design your dream survey.

What is the main science goal?

What instrument would you use? Does it exist?

From which observatory would you carry it out?

If you could start observing 1st January 2021,when would it end?

A few relevant surveys

The following is a biased selection of relevant surveys.

I have selected projects which have, to my judgement, have had or will have a special impact.

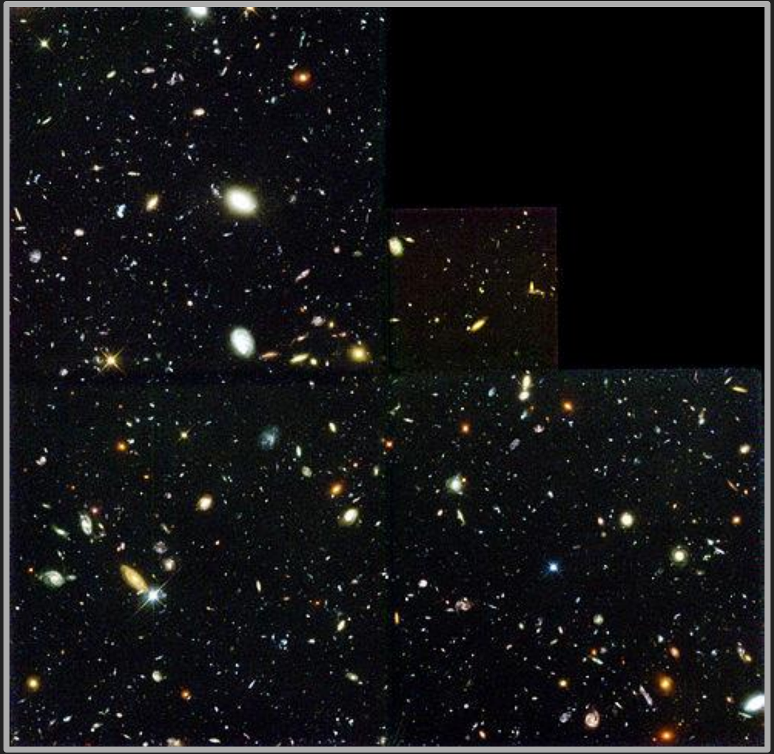
This list is not intended to be complete, nor it is intended to give any particular merit (i.e. the ones which are not listed are not less relevant than the ones listed)

The Hubble Deep Field

The origin of observational cosmology, as we understand it today.

10 days of HST/WFPC2 in 4 filters

https://ui.adsabs.harvard.edu/abs/1996AJ....112.1335W/abstract



ESO/Hamburg Survey

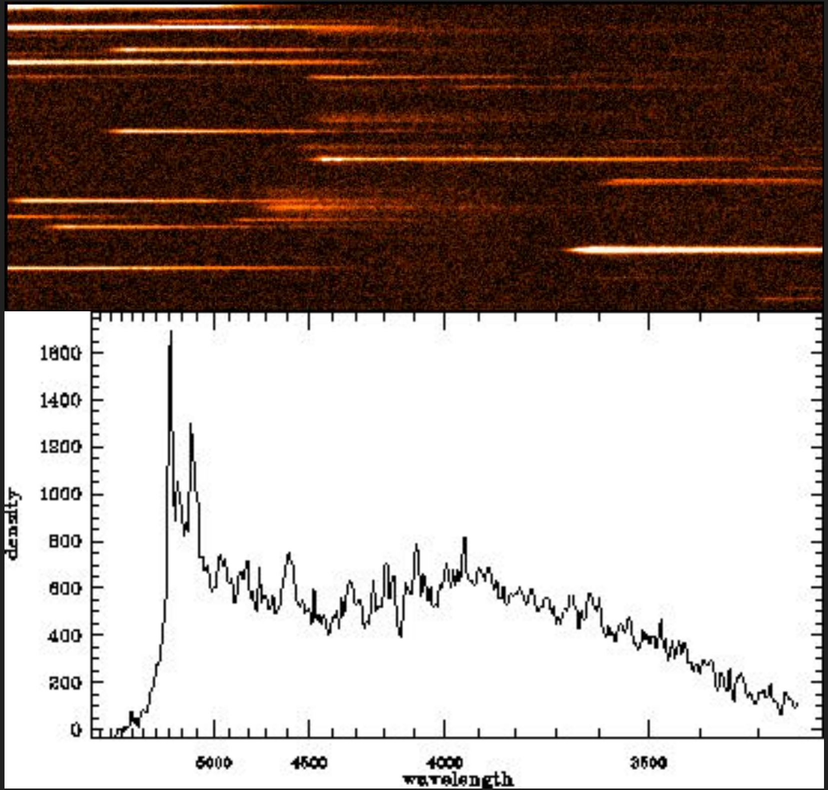
https://www.hs.uni-hamburg.de/DE/For/Exg/Sur/hes/index.html

9000sq.deg.

Prism objective survey

Low-spectral resolution

Schmidt telescope at La Silla

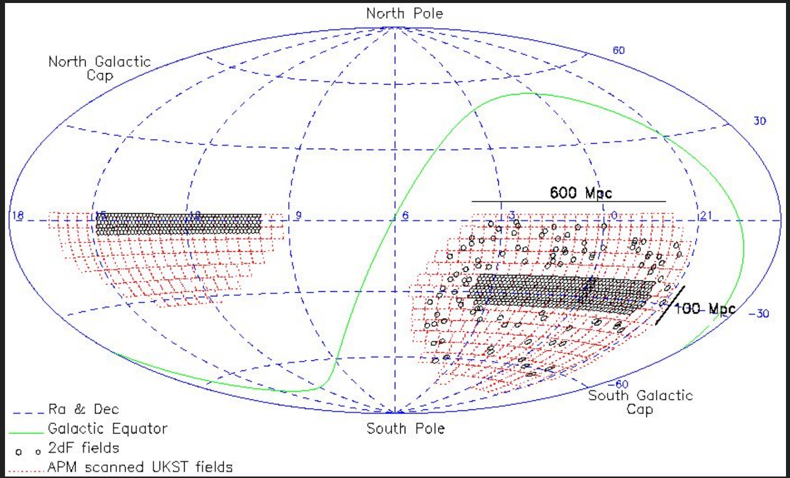


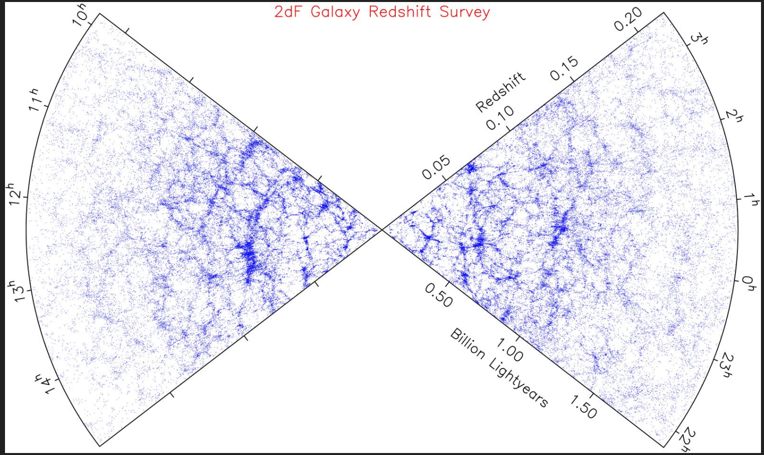
https://www.hs.uni-hamburg.de/EN/For/Exg/Sur/hes/qso_surveys.html

2dF Galaxy Redshift Survey

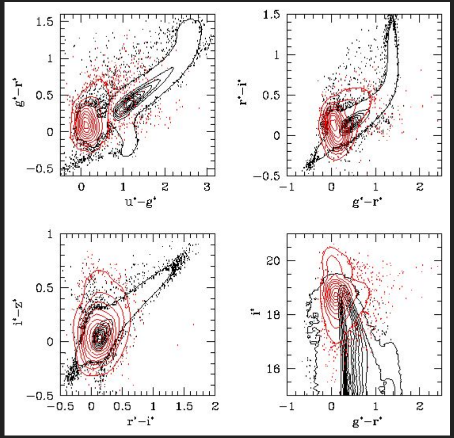
Used the 2degrees Field of view multi-object spectrograph (400 spectra per observation) on the 4m AAT telescope.

http://www.2dfgrs.net/





In black the stellar locus and in red the quasar locus from SDSS EDR



Sloan Digital Sky Survey

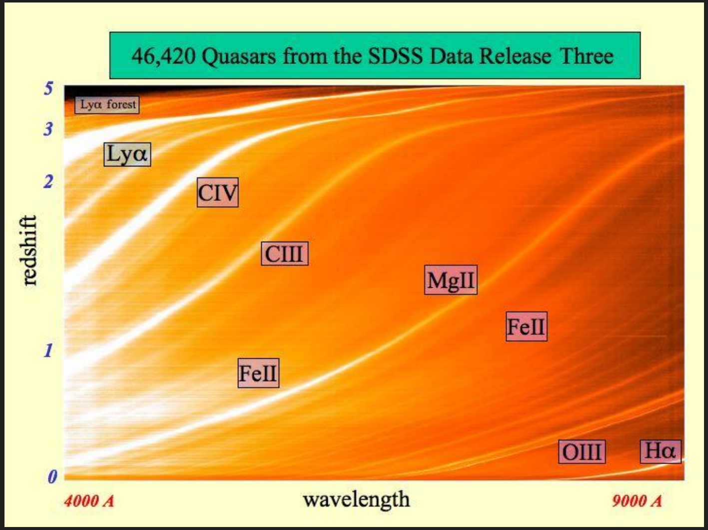
The Mother of All Modern Surveys

Originated as a quasar survey (post-2dF)

In its first incarnation:

- 10,000 sq.deg. photometry (ugriz)
- 8,000 sq.seg. spectroscopy (R~2,000)

https://www.sdss.org/



Sloan Digital Sky Survey

https://www.sdss.org/surveys/

- SDSS I/II (2000-2008)
  - Legacy / Supernova (Stripe 82) / Segue
- SDSS III (2008-2014)
  - APOGEE / BOSS / MARVELS / SEGUE2
- SDSS IV (2014-2020)
  - APOGEE2 / eBOSS / MANGA /
- SDSS V (2020-2025)
  - https://www.sdss.org/future/

New incarnations of SDSS have required the development of new instruments (e.g. the APOGEE or BOSS spectrographs) with respect to the original survey.

LAMOST

Large Sky Area Multi Object Fiber Spectroscopic Telescope

“The Chinese SDSS”

Mostly focused on stars.

http://www.lamost.org/public/?locale=en

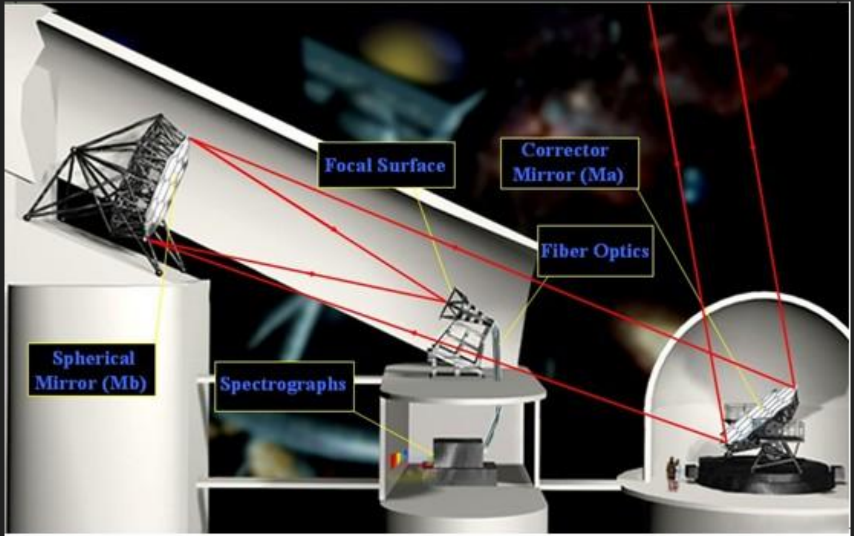


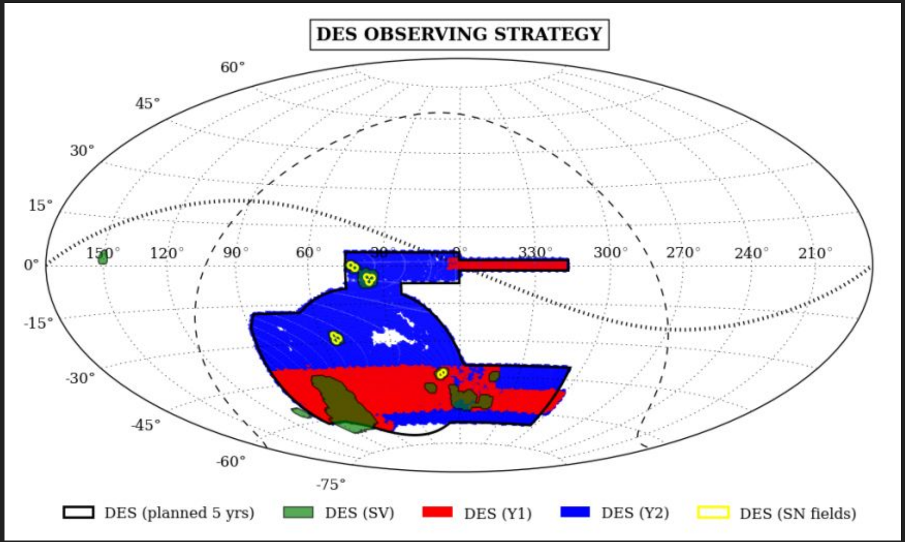
Figure 2 LAMOST overview

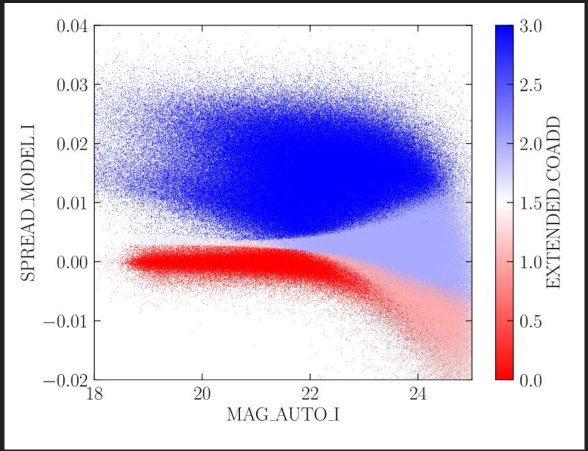
Dark Energy Survey

It has been a photometric cosmological survey carried out with the DECam at the 4m Blanco telescope at CTIO.

The last observations were completed last year.

https://www.darkenergysurvey.org/





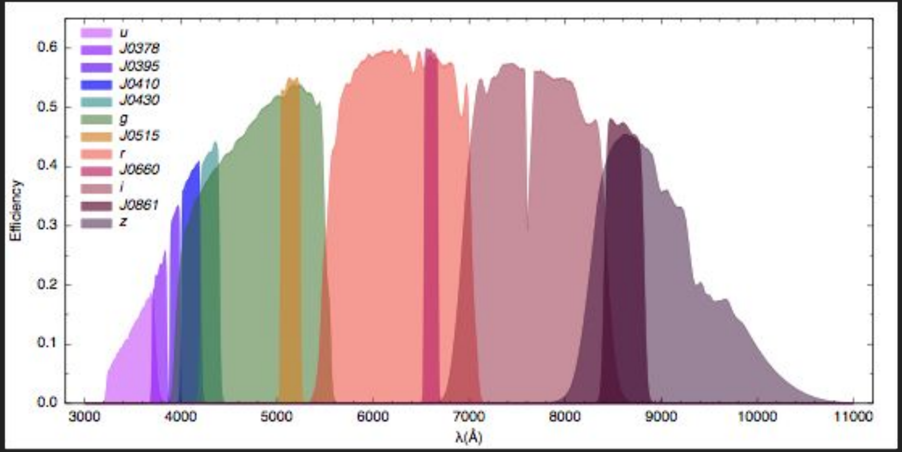
Abbott et al. (2018)

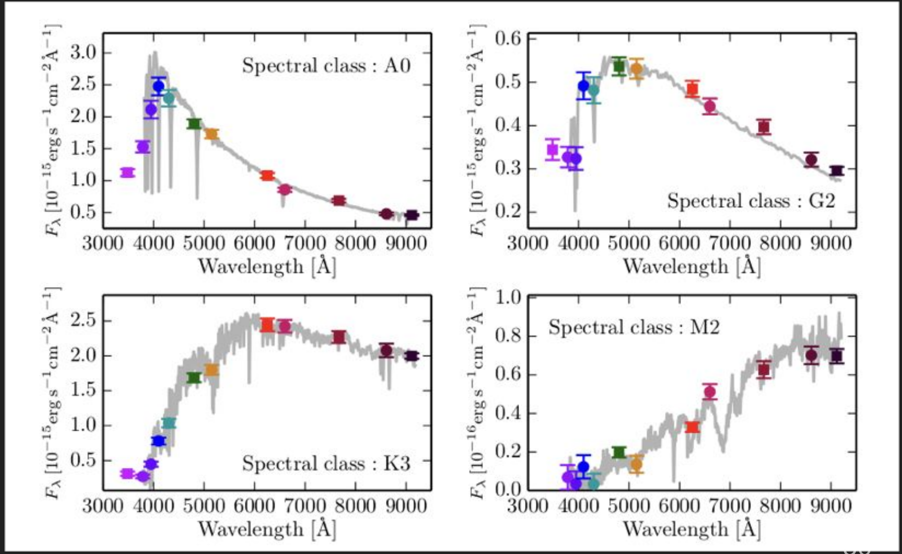
J-PLUS

The Javalambre Photometry of the Local Universe Survey is a photometric (12 filters) survey of the northern extragalactic sky (8,500 sq.deg.), carried out from the Observatorio Astrofísico de Javalambre.

Cenarro et al. (2019)

http://j-plus.es/





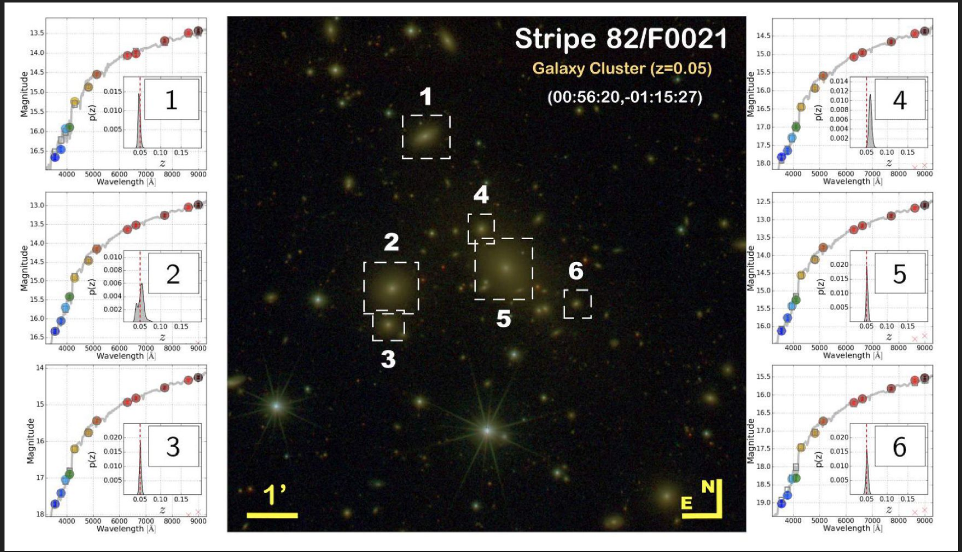
S-PLUS

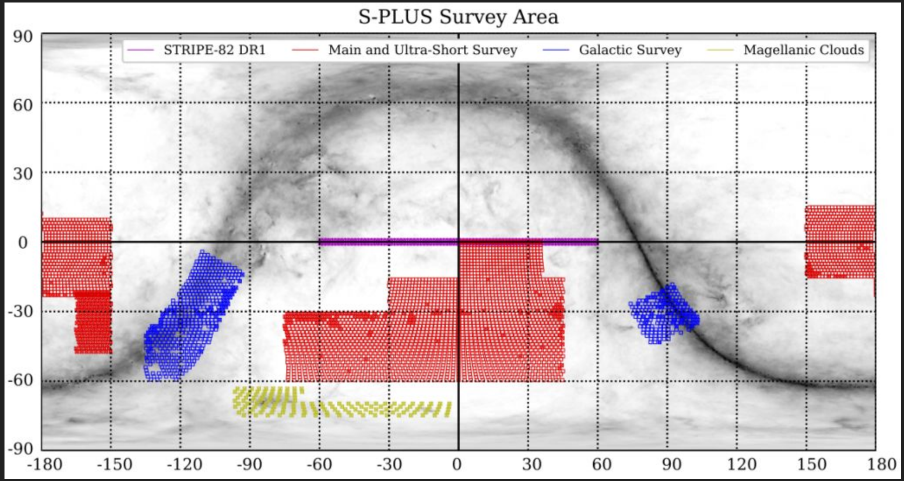
Southern Photometry of the Local Universe Survey

Southern replica of J-PLUS + 5 extra projects (Galactic survey, Variability Survey, Marble Fields, Ultra-Short Survey, Magellanic Clouds Survey)

Mendes de Oliveira et al. (2019)

http://www.splus.iag.usp.br/data/





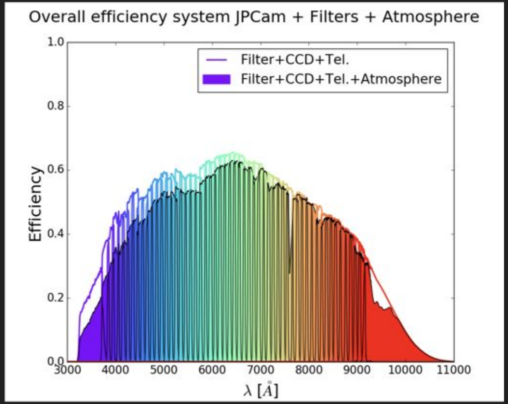
J-PAS

Javalambre Physics of the accelerating universe Astrophysical Survey

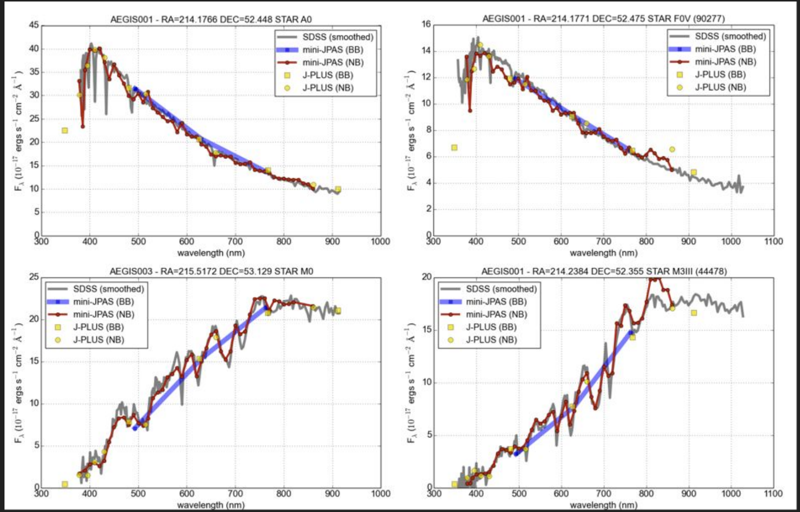
Cosmological photometric survey (8,500sq.deg.; same FoV as J-PLUS)

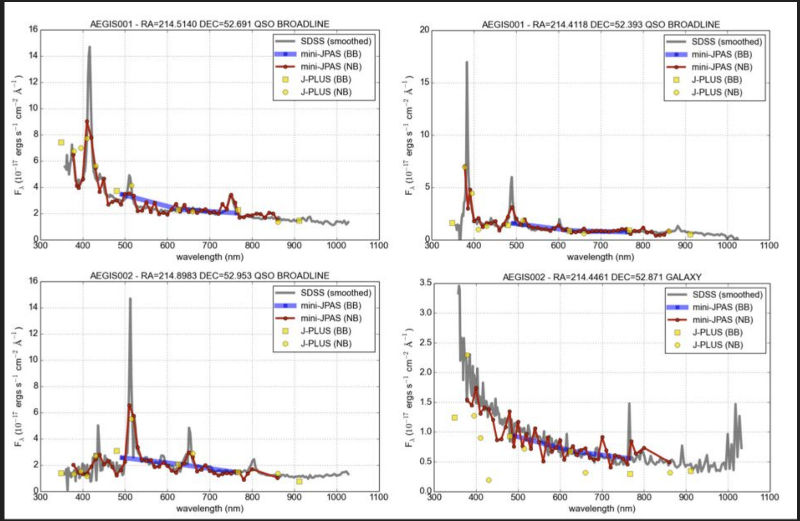
Benitez et al. (2014)

http://www.j-pas.org/



SEDs from the "mini-J-PAS" observations





Vera Rubin Telescope (formerly known as LSST)

Photometric survey with main science cases:

- Near Earth Objects
- Variable Stars
- Cosmology

(in this respect is very similar to PanStarrs)

Dedicated 8m telescope (5sq.deg. FoV) at Cerro Pachon (Chile).

Gaia

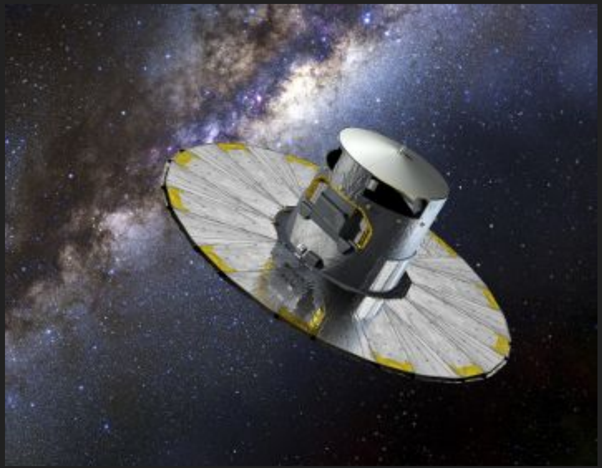
Since Gaia DR2 (25th Apr 2019), it has been producing papers at the same rate as the HST!

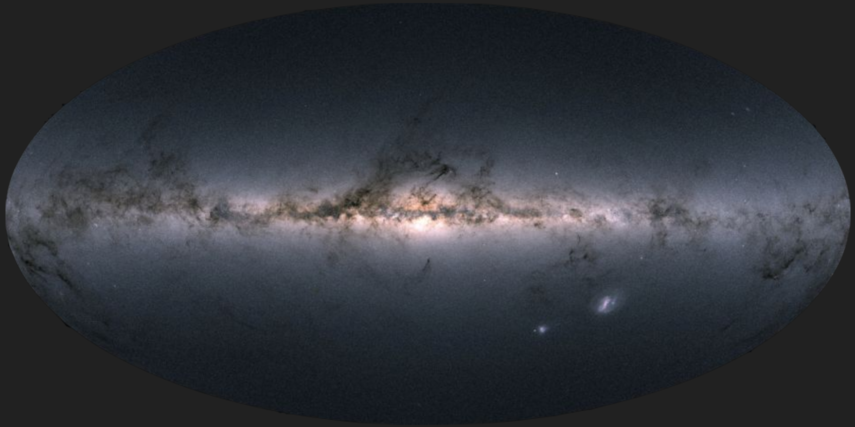
It is (mostly) an astrometric survey

DR2 has:

- 1.8 billion objects
- 1.3 billion parallaxes

https://gea.esac.esa.int/archive/





This is a plot of the catalog, it is not an image!