Galaxy Formation in the era of Large Surveys

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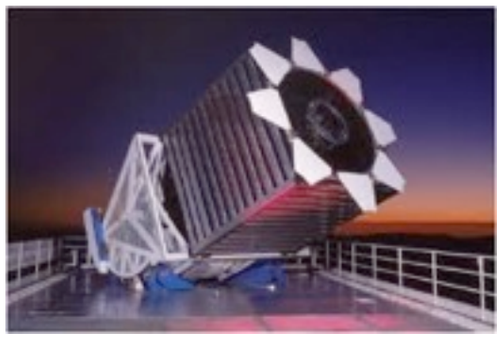
Kavli IPMU
Subaru UM, March 2012

Outline:

1. Thoughts (excitement) about large surveys

2. MaNGA: Resolved spectroscopy for 10k galaxies



Power of large surveys

Rank	Facility	Citations	Participation
1	SDSS → $26M	1892	14.3%
2	Swift	1523	11.5%
3	HST	1078	8.2%
4	ESO	813	6.1%
5	Keck → $200M	572	4.3%

Madrid & Macchetto 2009

Large survey destiny for Subaru?

Only wide-field capability on 8m class telescope

Hyper Suprime Cam (HSC) Prime Focus Spectrograph (PFS)

Proprietary programs always needed and beneficial...
but wouldn't you want 50~100 nights per year?

Experiment mode vs Observatory mode

e.g., WMAP, BigBOSS

- 1-2 specific goals
- some ancillary science
- very high-impact for ~10 publications
- limited community involvement

e.g., SDSS, HSC, PFS

- 3-4 broad topics, many many goals
- vast, unanticipated science
- high-impact for 10s of publications, 100-1000s other publications
- wide community involvement, observing overlap, followup, etc.

Experiment mode vs Observatory mode

Observatory mode: What I learned from DEEP2 and SDSS-III

- Plan observations & software: calibration, reduction, products, database
- Science: Organic development of projects within a framework of rules
- Bottom-up growth: initiative of small (open) teams defines scientific territory
- Maturing projects intersect and interact with each other and team
- Importance of connection with team builders
- Importance of international collaboration and public availability

For more, see e.g., Strauss et al. 2009 white paper

MaNGA

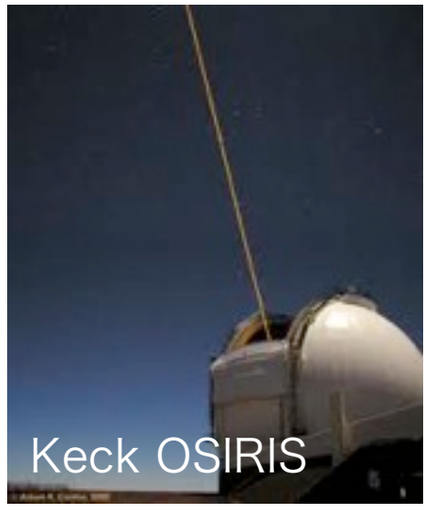
Mapping
Nearby
Galaxies
at APO

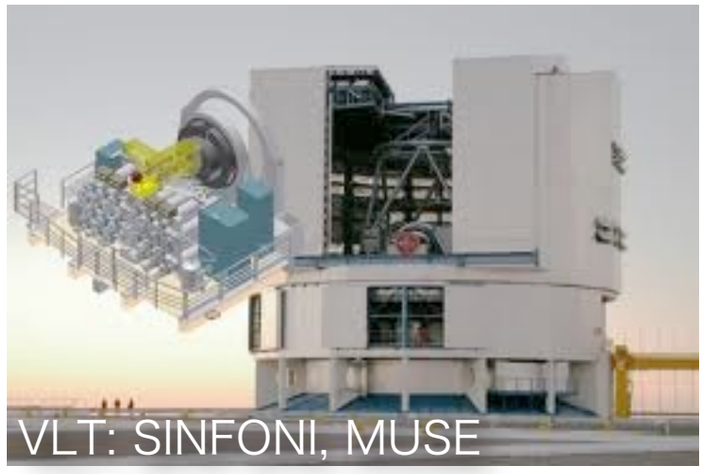
Resolved
spectroscopy
of 10,000
galaxies

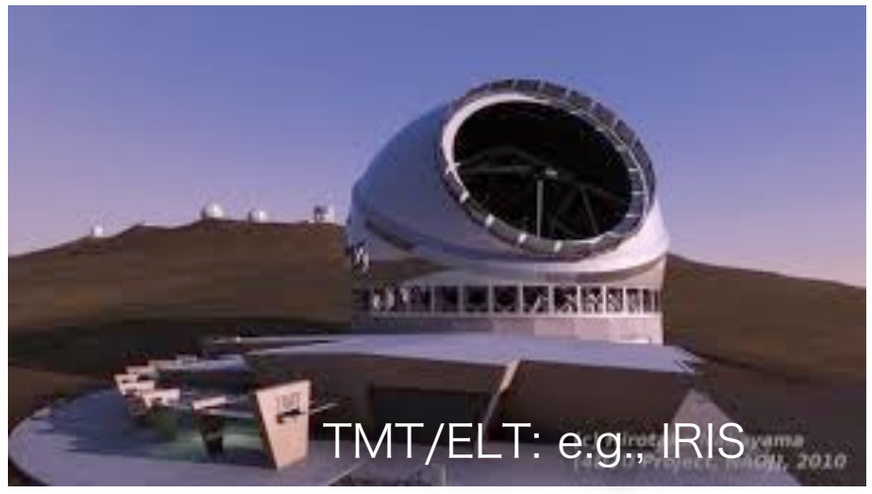
painting by Sonatawind

landscape:

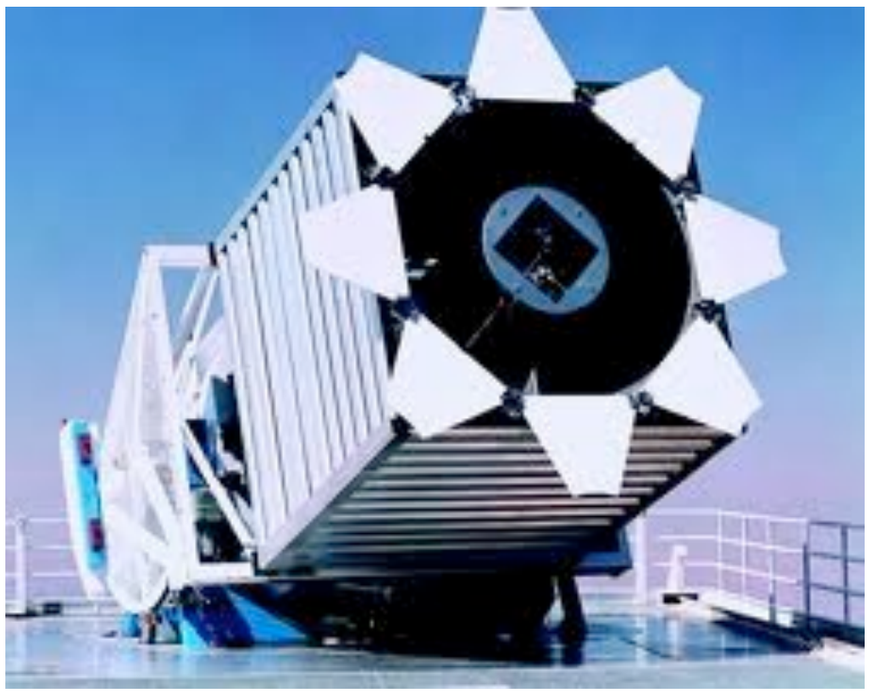
High-z IFUs







We need a z=0 baseline for 2D spectroscopy

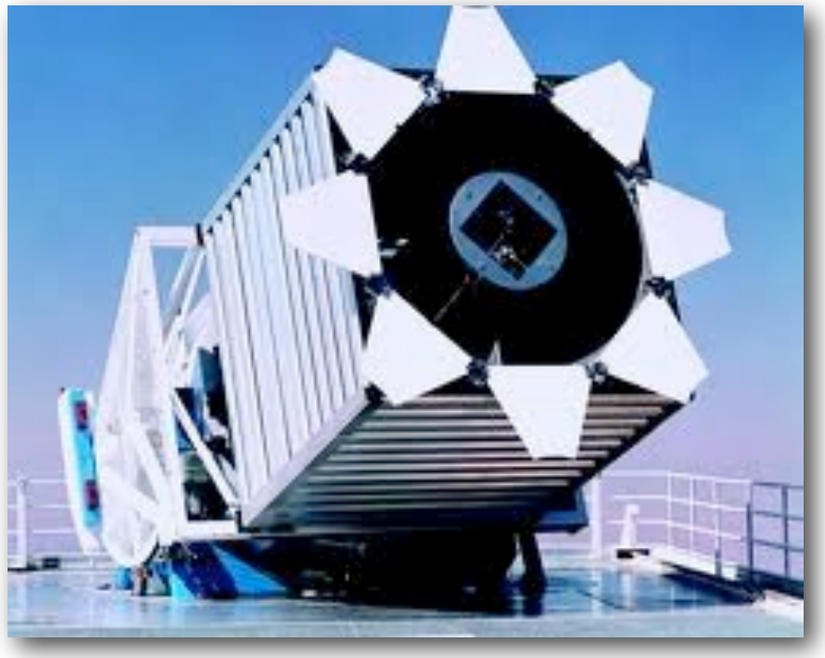


Current & Planned IFU surveys

- SAURON/Atlas3D: ~200 galaxies, huge success
- CALIFA (Calar Alto): 600 galaxies
- Surveys at AAO: ~1000 galaxies

But, SDSS-like low-z mapping is missing...

What is MaNGA?



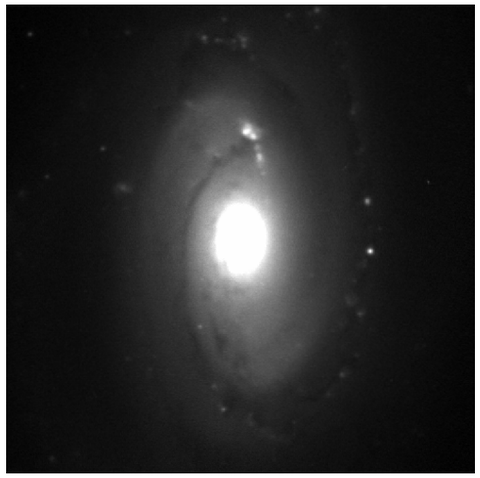
- One of three approved "After-SDSS-III" (AS3) surveys to begin on the Sloan 2.5m in September 2014
- AS3 = MaNGA, eBOSS, APOGEE-2
- MaNGA exploits the existing BOSS instrument (high throughput, pipeline)

- MaNGA will bundle BOSS fibers to create 15-20 IFUs of various sizes
- MaNGA IFU survey of ~10k nearby galaxies

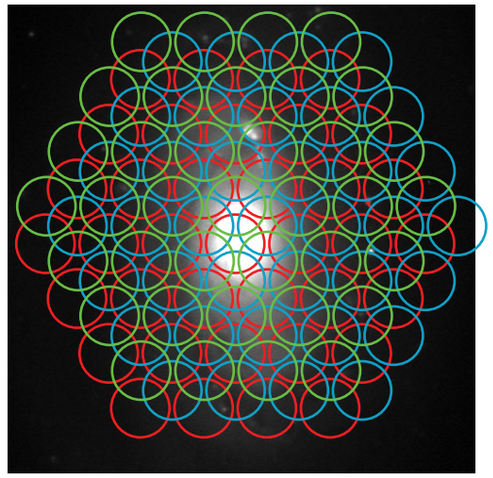
Spectroscopic survey opportunity ahead of PFS

MaNGA:
Resolved spectroscopy of
10,000 nearby galaxies

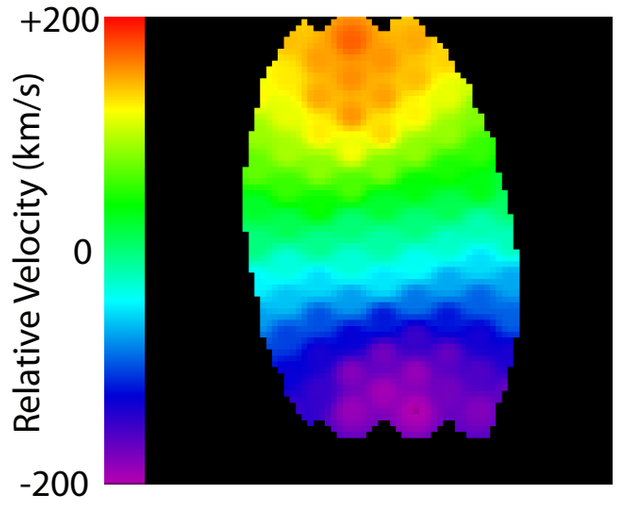
Galactic Archaeology:
Resolved spectroscopy of
one very nearby galaxy



Hα image of NGC 4450



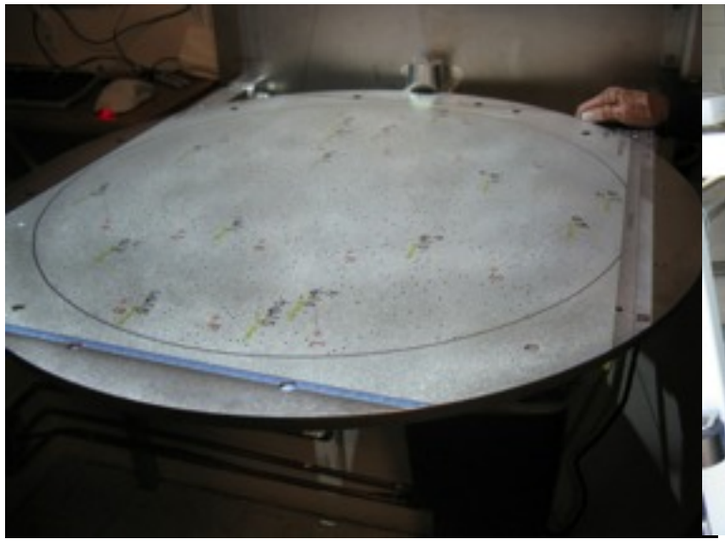
MaNGA fiber bundle
(with 3 dither positions)

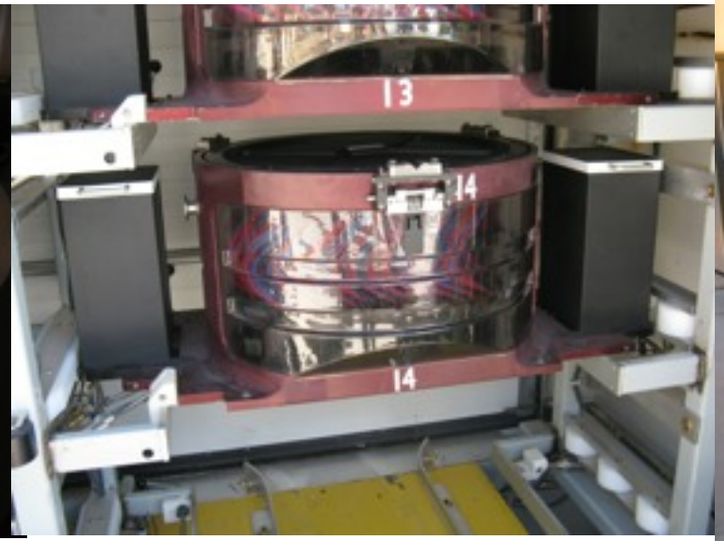


Recovered velocity map

MaNGA Key Science

1. The nature of present-day galaxy growth via merging and gas accretion
2. The processes responsible for terminating star formation in galaxies
3. The formation history of galaxy subcomponents, including the disk, bulge, and dark matter halo





Exposure time: minimum S/N
~ 5-10 at 1.5 Re = 3 hours

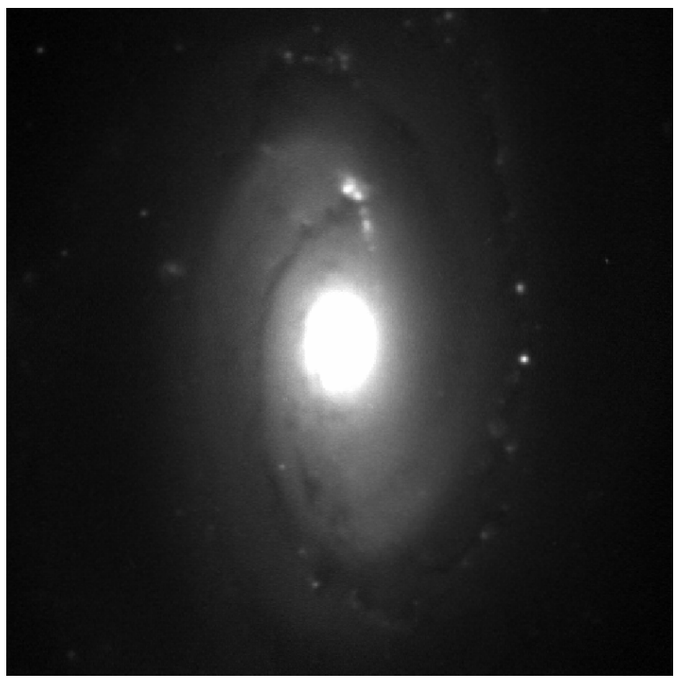
MaNGA: Design Concept

- Plug plates as BOSS does now with single fibers
- 15-20 bundles over 7 deg^2

Spatial resolution = 2” (1-3 kpc)
Spectral resolution = 50-70 km/s (sigma)
Spectral coverage: 3600-10,000 angstroms
Mass-limited sample: log M_{star} > 9
Redshift: 0.005 < z < 0.15

MaNGA Simulations:

Led by Anne-Marie Weijmans & David Law (U.Toronto)



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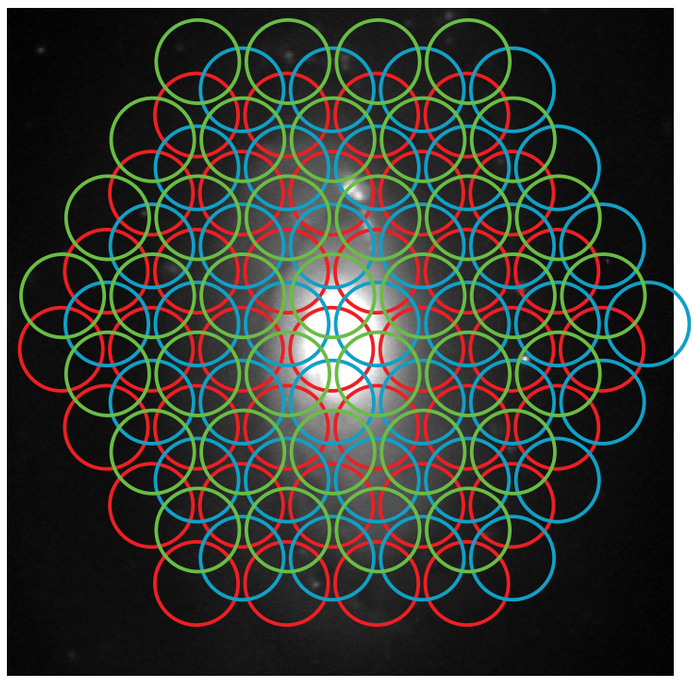
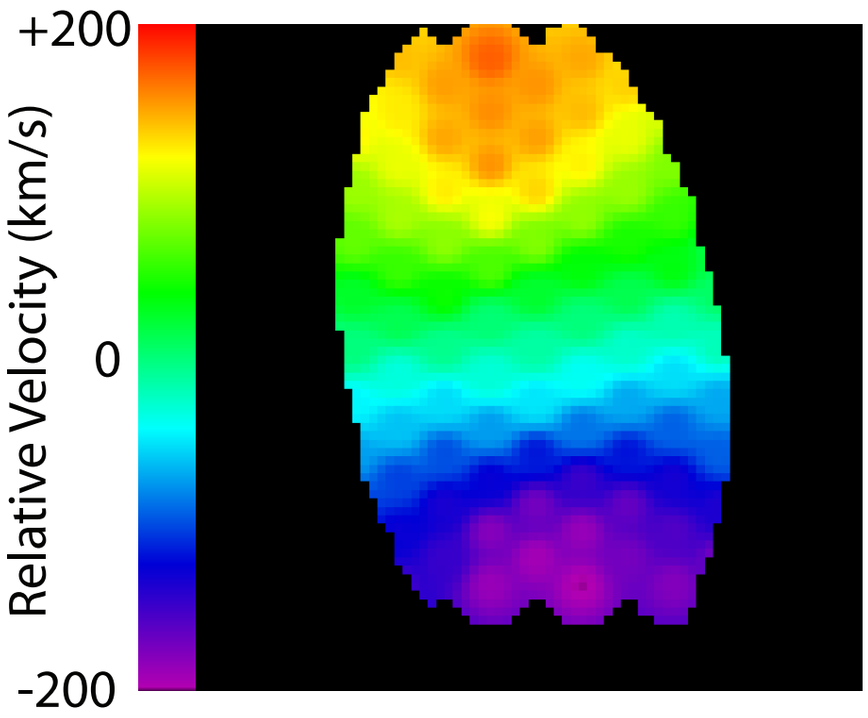


MaNGA fiber bundle
(with 3 dither positions)



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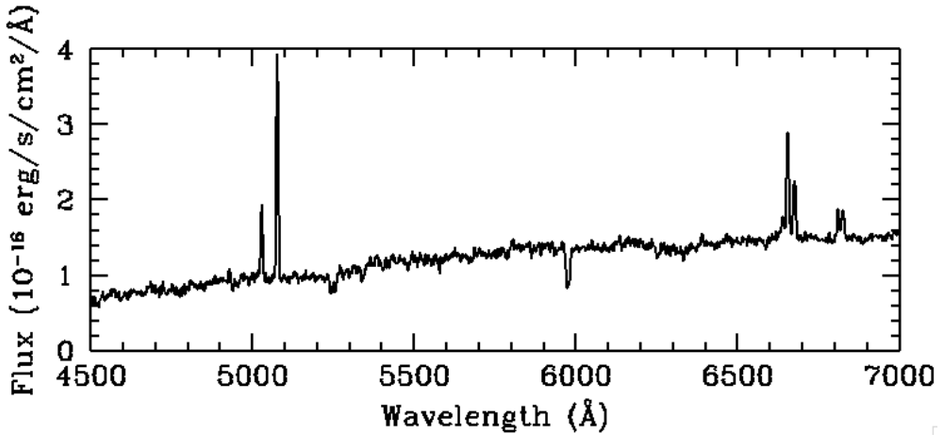
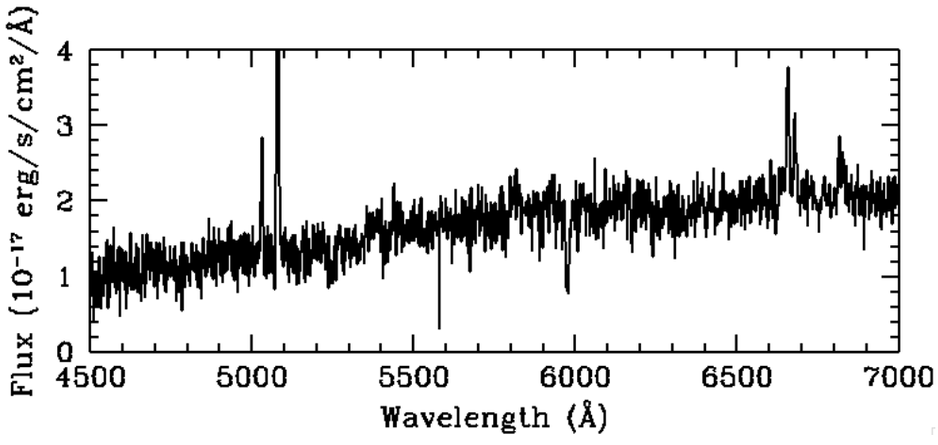


Simulated spectrum (central fiber)

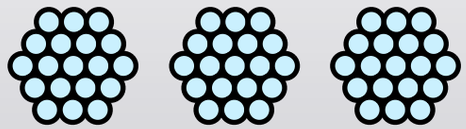


Simulated spectrum (edge fiber)

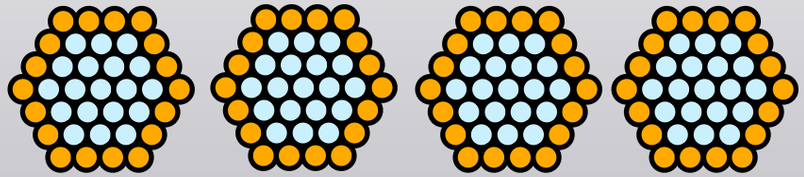
Current bundle size distribution

16 bundles per cartridge
(1017 bundled fibers)
5 cartridges → 80 bundles total

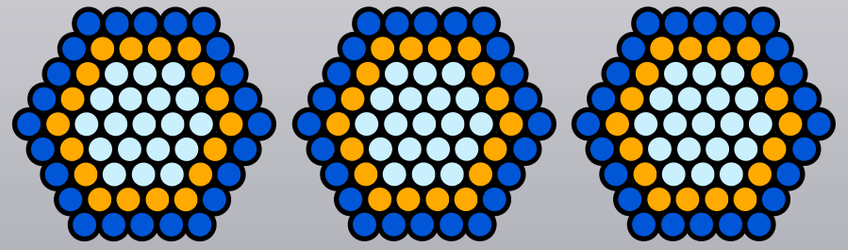
3 bundles x 19 fibers



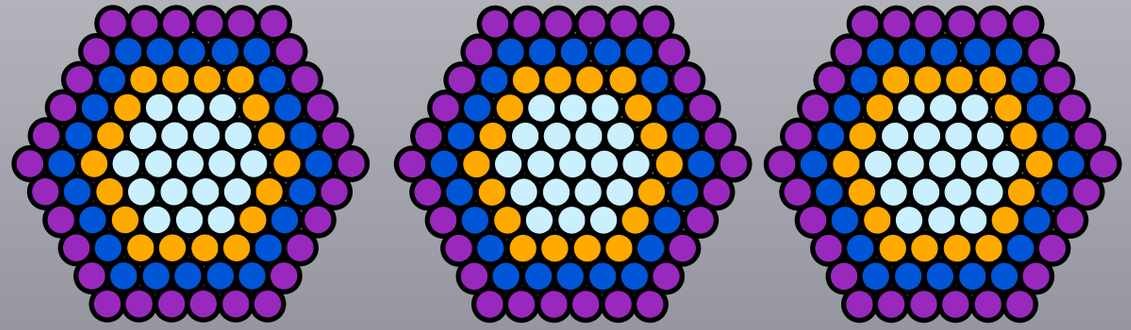
4 bundles x 37 fibers



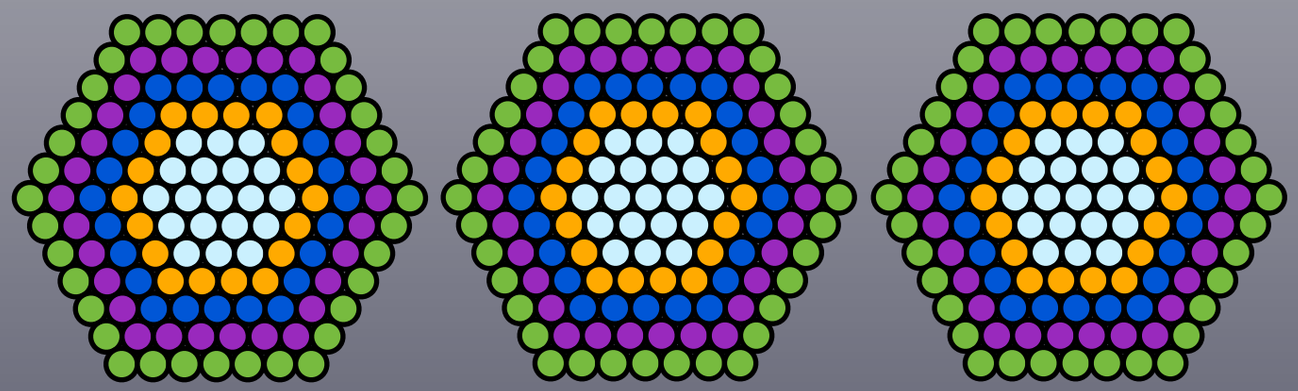
3 bundles x 61 fibers



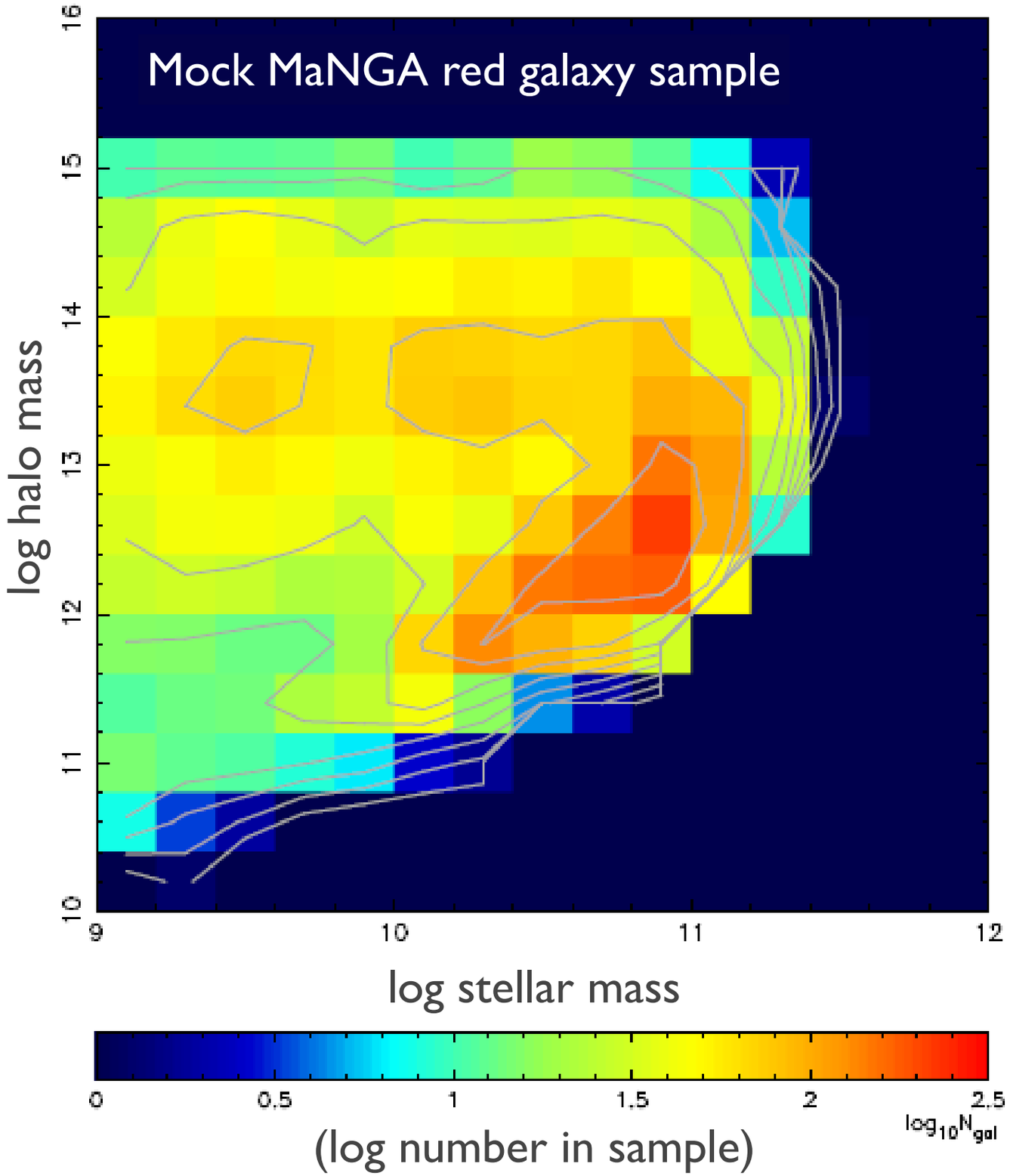
3 bundles x 91 fibers



3 bundles x 127 fibers



Motivation for large samples



plot by Cheng Li

- Goal is 10k sample
- Ability to split by many observables: mass, environment, SFH, kinematic state, morphology, etc.
- Rare populations seen in an unbiased, mass-selected context: e.g., mergers, AGN hosts, outflows
- Statistics of sub-samples (e.g., TF)
- Stacking, especially lensing (e.g., HSC)

... an example of
MaNGA science

Extragalactic Archaeology

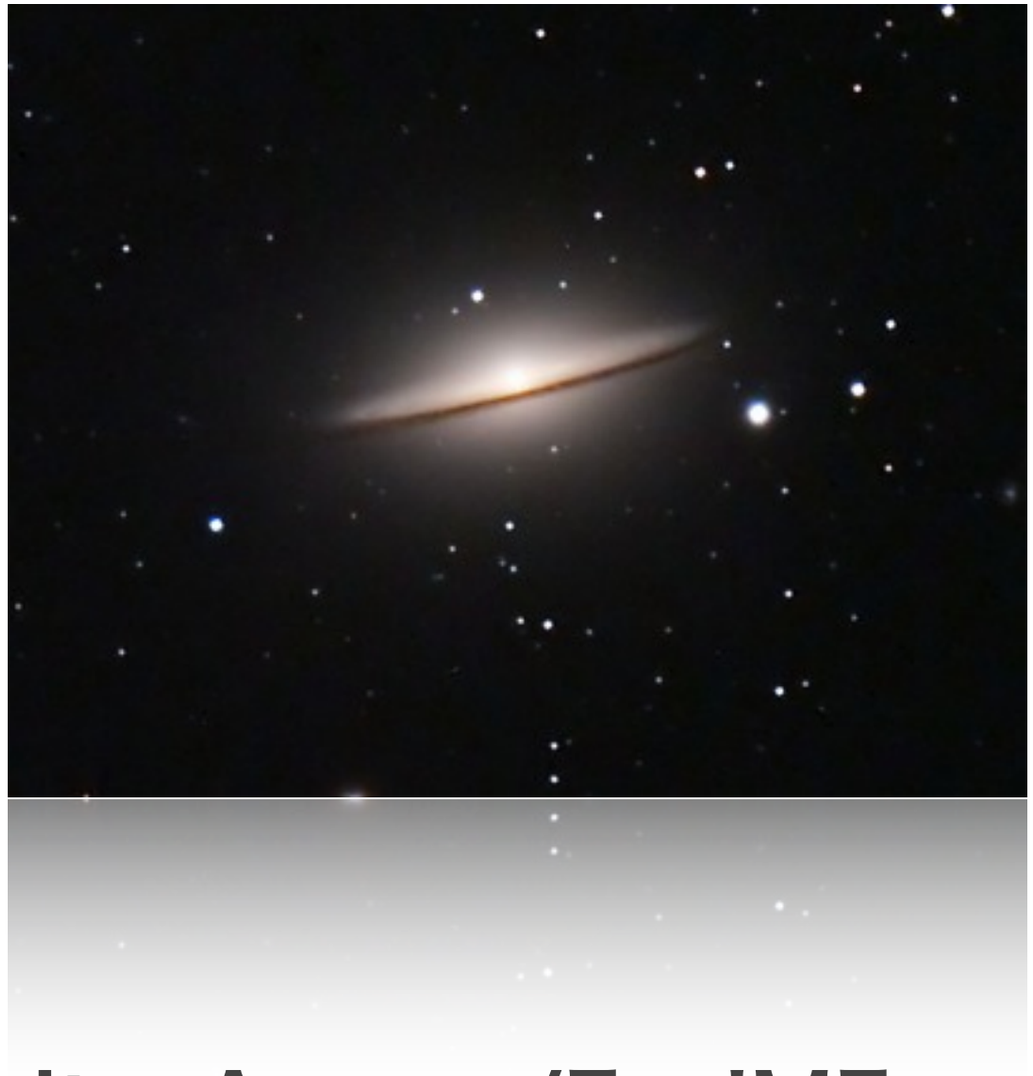
Are galaxies built from the inside out?

Is material accreted on the outskirts at late times?

What is the formation history of different components (disk, bulge, halo, thick disk)?

Importance of halo mass and environment?

... an example of MaNGA science



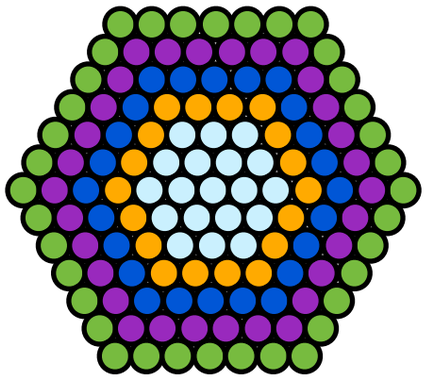
Extragalactic Archaeology

How? Gradients in...

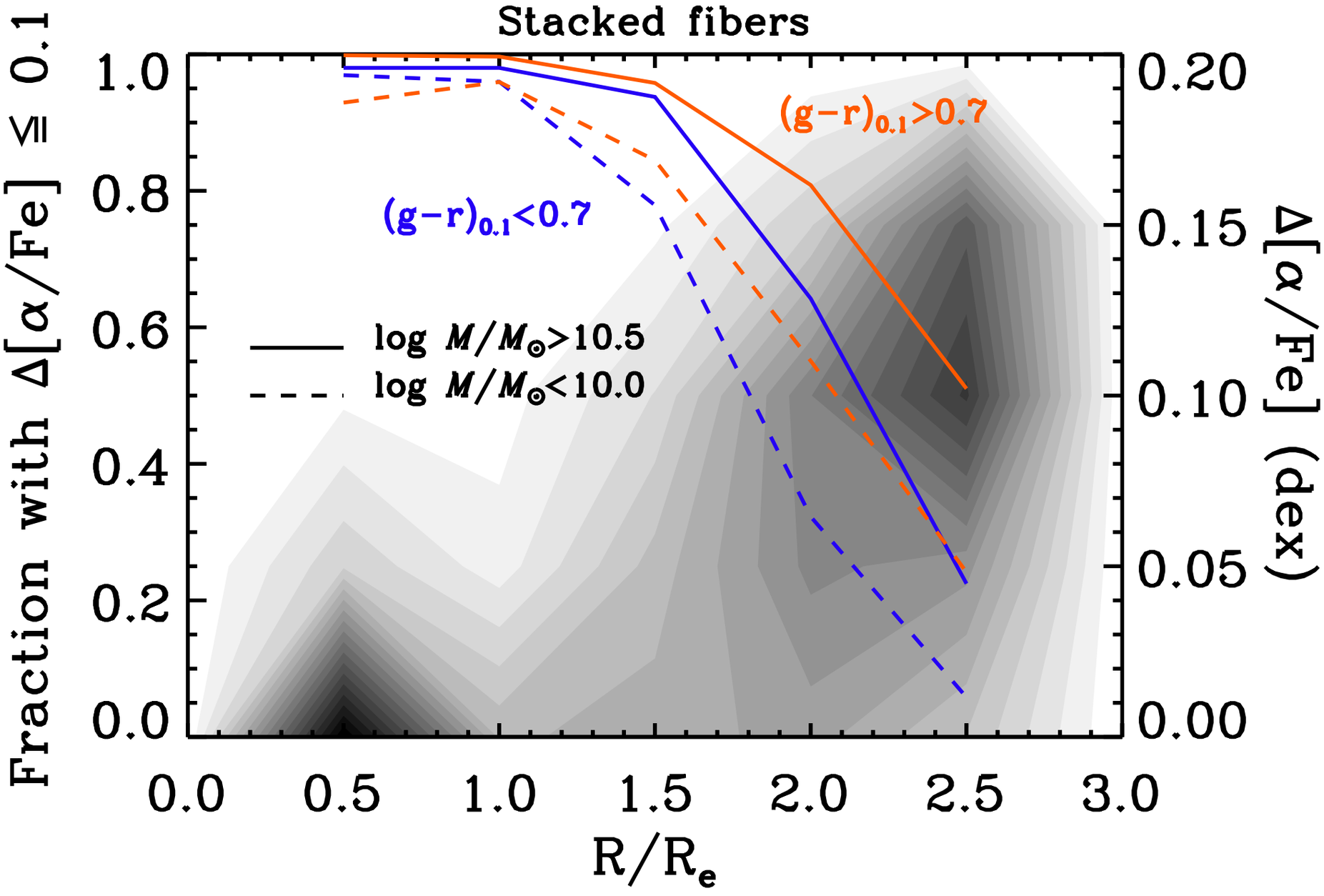
Absorption lines: Metallicity, Age, α/Fe, IMF indicators

Emission lines: SFR, gas phase metallicity, BPT

Kinematic models, gas/stars, isolating kinematic components...



Errors on α/Fe, per MaNGA galaxy, in stacked radial annuli



Management & Costs:

MaNGA: $1M instrument, $3M operations/data yearly = $19M over 6 yr survey

AS3 to follow SDSS-III model - Estimated

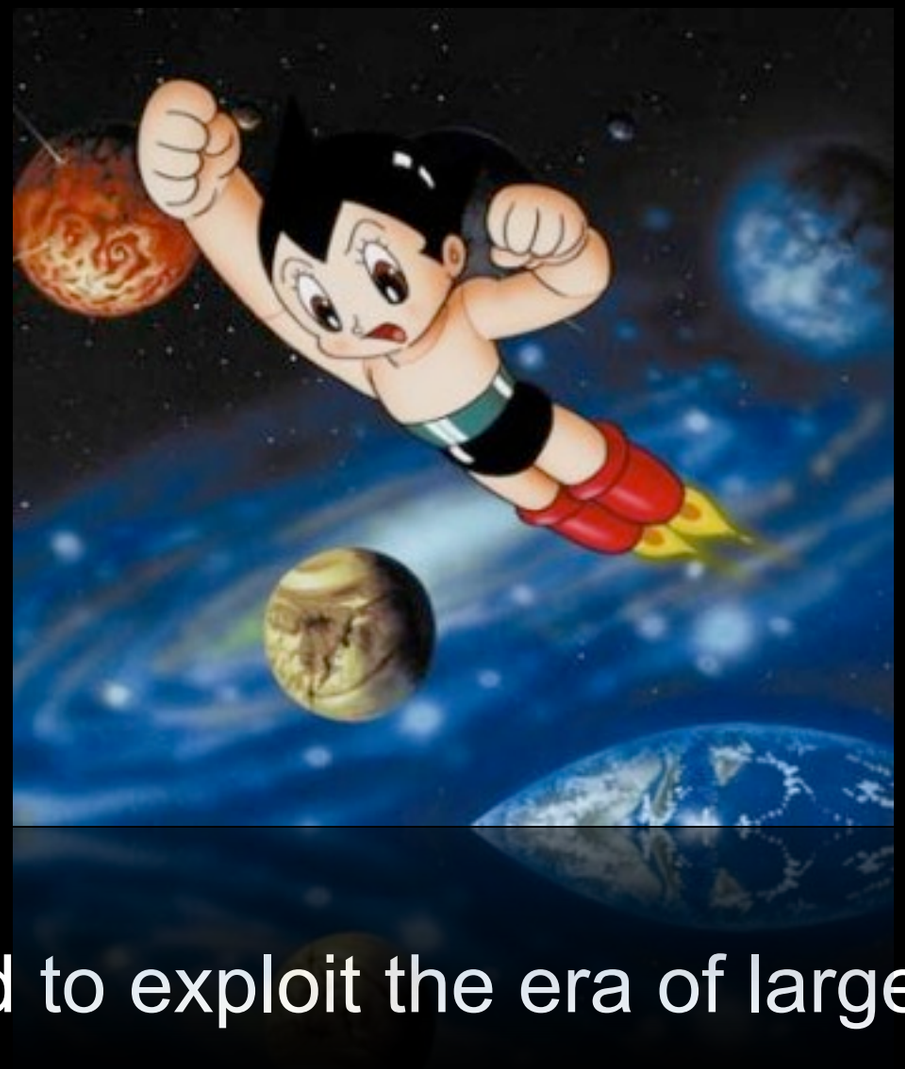
- Institutional buy-in for ~$1M, access to all 3 surveys, Advisory Council
- Individual group buy-in for ~$100k

Access includes APOGEE-2 and APOGEE-South

H-band, R~22,000, 10^5 stars, galactic halo, galactic bulge

Japan Participation Group?

Conclusions



Subaru Users are well poised to exploit the era of large surveys

MaNGA is a spectroscopic opportunity before PFS, development underway

- MaNGA is a bridge from the Milky Way to “Extragalactic Archaeology”
- Your contribution is welcome!
- Interest in a Japan Participation Group for AS3?