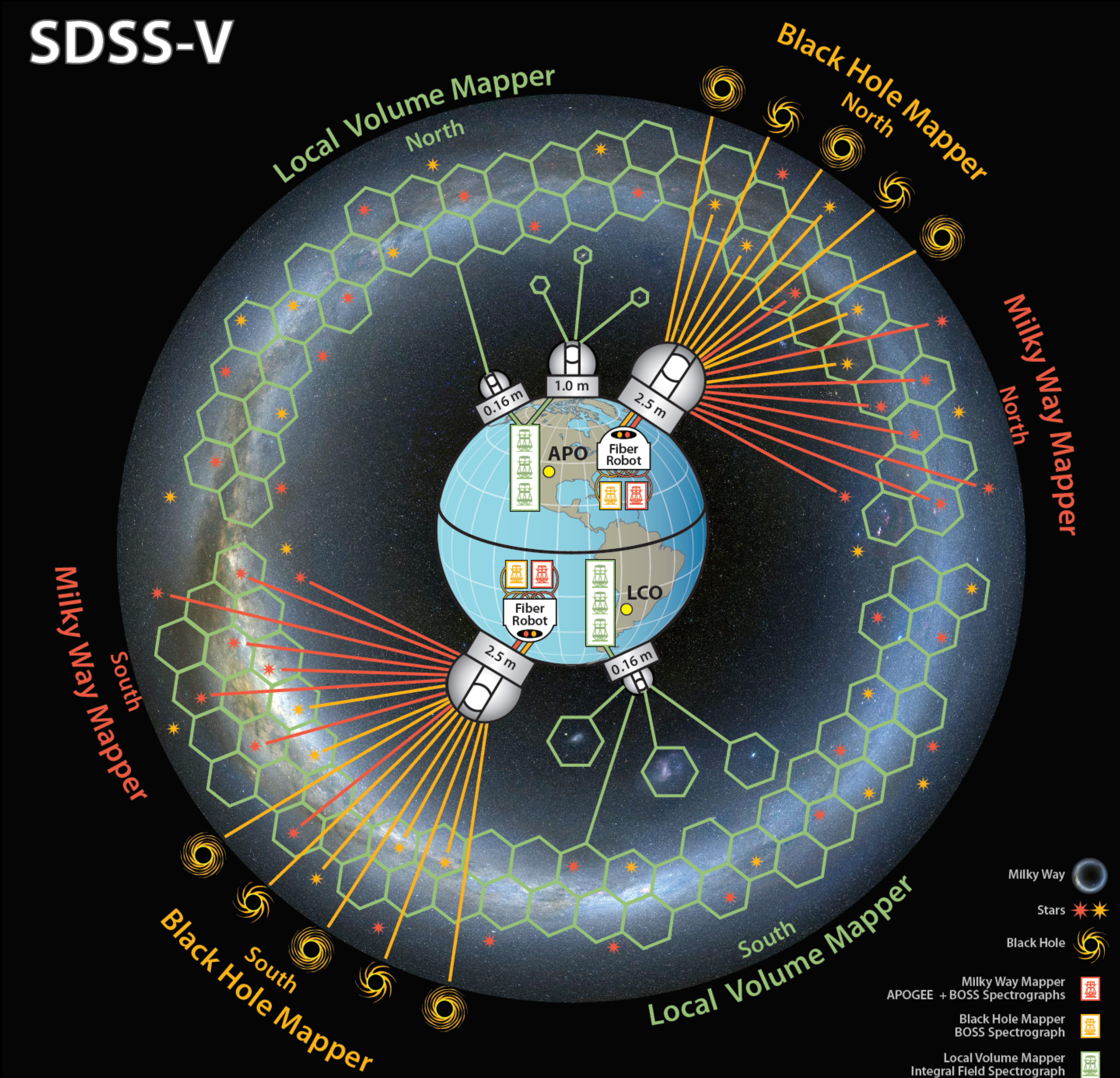
SDSS-V UPDATE


SDSS-V
Local Volume Mapper
North
Black Hole Mapper
North
Milky Way Mapper
North
0.16 m
1.0 m
2.5 m
APO
Fiber Robot
LCO
Fiber Robot
2.5 m
0.16 m
Milky Way Mapper
South
Black Hole Mapper
South
Local Volume Mapper
South
Milky Way
Stars
Black Hole
Milky Way Mapper
APOGEE + BOSS Spectrographs
Black Hole Mapper
BOSS Spectrograph
Local Volume Mapper
Integral Field Spectrograph

SDSS-V's 3 "Mappers"

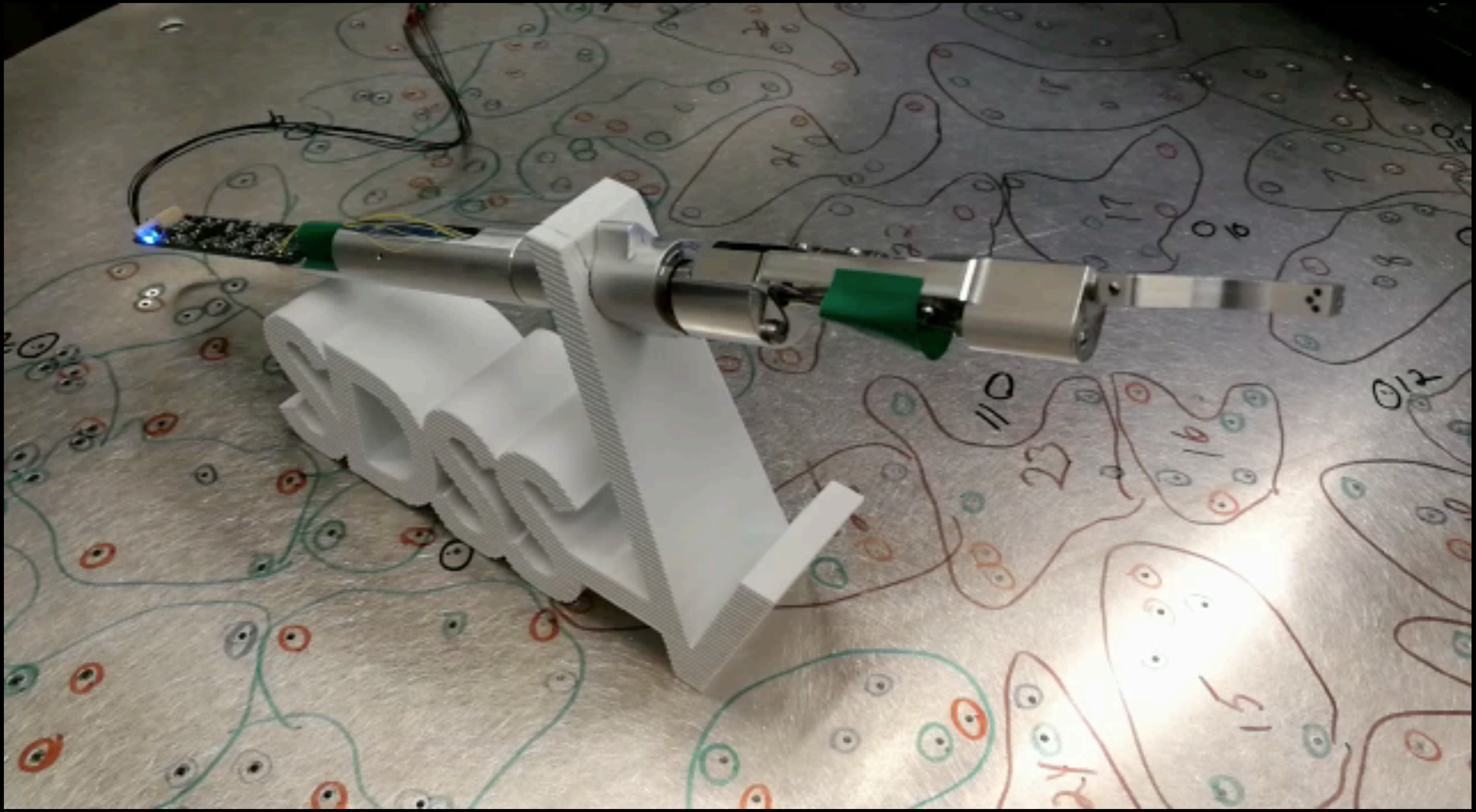
Program	Science Targets	$N_{Objects}$ and/or Sky Area	Primary Spectral Range and Hardware	Primary Science Goals
Milky Way Mapper (MWM)	Stars across the Milky Way	>6M stars; all-sky	IR; APOGEE ($R \sim 22,000$) with fiber-positioning system	Understanding the formation of the Milky Way and the physics of its stars
Black Hole Mapper (BHM)	Primarily supermassive black holes	>400,000 sources; all-sky	Optical; e.g., BOSS ($R \sim 2000$) with fiber-positioning system	Probing black hole growth and mapping the X-ray sky
Local Volume Mapper (LVM)	ISM & stellar populations in the MW, Local Group, and nearby galaxies	>25M contiguous spectra over 3,000 deg^2	Optical; new integral field spectrographs covering 3600-10000Å at $R \sim 4000$	Exploring galaxy formation and regulation by star formation; feedback, enrichment, & ISM physics

Spectroscopic Surveys

Spectroscopic Survey Facilities around the Year 2020								
Survey (facility)	N_{target}	R_{spec}	N_{res}	$\overline{\lambda}[\mu m]$	Ω_{sky}	N_{epoch}	Timeframe	$m_{primary}$
SDSS-V	7×10^6	22,000 2,000	500	1.51-1.7 0.37-1	4π	$4-60$	2020-2024	$m_H \leq 12$ $m_G \leq 18$
Gaia (RVS)	2×10^6	8000	270	0.85-0.87	4π	~ 60	2013-2020	$m_G \leq 12$
Gaia-ESO	0.1×10^6	$17,000$	140	0.55& 0.85	0.02π	~ 1	2013-2018	$m_G \leq 17$
GALAH	0.8×10^6	$28,000$	400	0.40- 0.85	π $\lvert b\rvert \geq 10$	~ 1	2015-2020	$m_G \leq 13$
WEAVE	0.8×10^6	$5,000$& $20,000$	1000	0.37-0.9	$\sim \pi$	$\sim 1-2$	2018-2023	$m_G \leq 19$
DESI	8×10^6	$3,000$	5000	0.36-0.98	$\sim \pi$ $\lvert b\rvert \geq 25$	$\sim 1-2$	2019-2024	$m_G \leq 19$
LAMOST	8×10^6	$1,800$	4000	0.4-0.9	0.5π	~ 1	2010-2020	$m_G \leq 16$
4MOST	10×10^6	$5,000$& $20,000$	1600& 800	0.4-0.9	1.5π	$1-2$	2023-2028	$m_g \leq 21$ $m_V \leq 16$
APOGEE-1& -2	5×10^5	22,000	300	1.51-1.7	0.5π	~ 4	2011-2019	$m_H \leq 12$
PFS	1×10^6	$3,000$	2400	0.4-1.6	0.05π	1	2018-2021	$m_g \leq 22$
MOONS	2×10^6	$5,000$& $20,000$	1000	0.6-1.8	0.05π	1	2020-2025	$m_g \leq 22$ $m_H \leq 17$

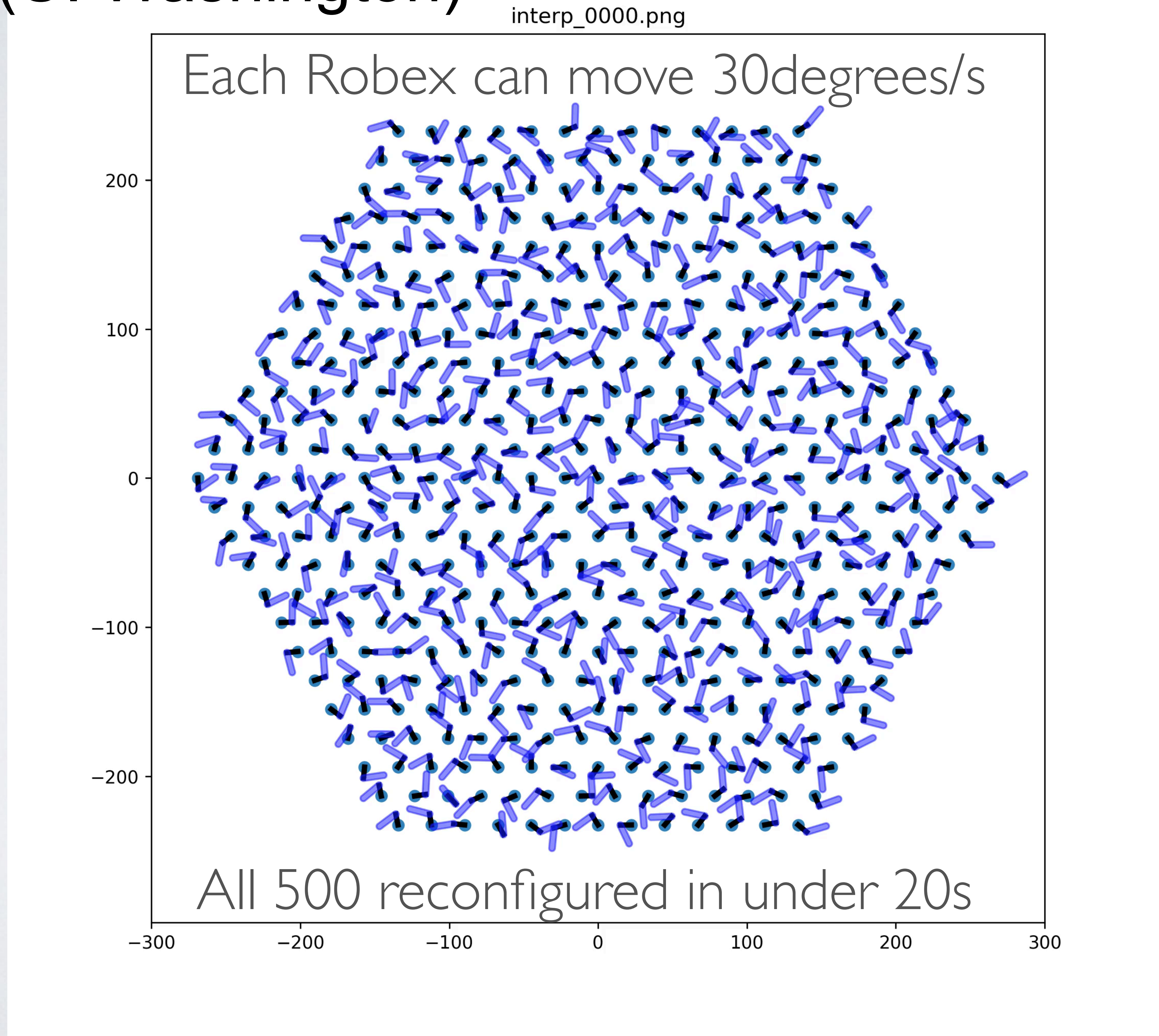
O + IR ; ALL SKY ; TIME DOMAIN!

SDSS-V PROTOTYPE0!

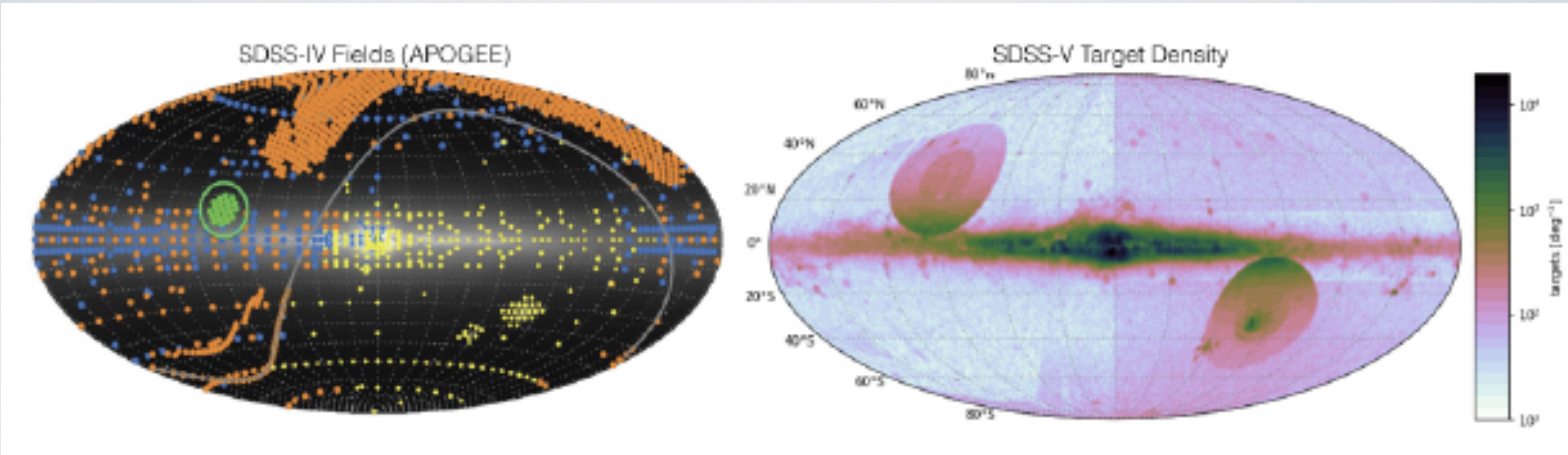


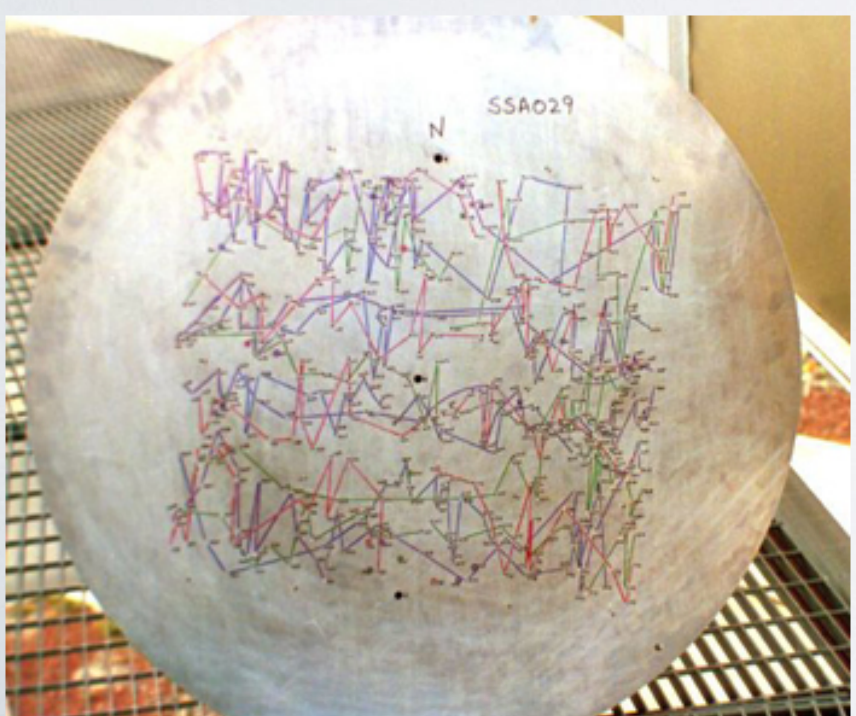
Courtesy J-P Kneib & EPFL Team

Kaiju: A Highly Efficient Collision Avoidance Algorithm for SDSS-V Robotic Fiber Positioners — Conor Sayres (U. Washington)

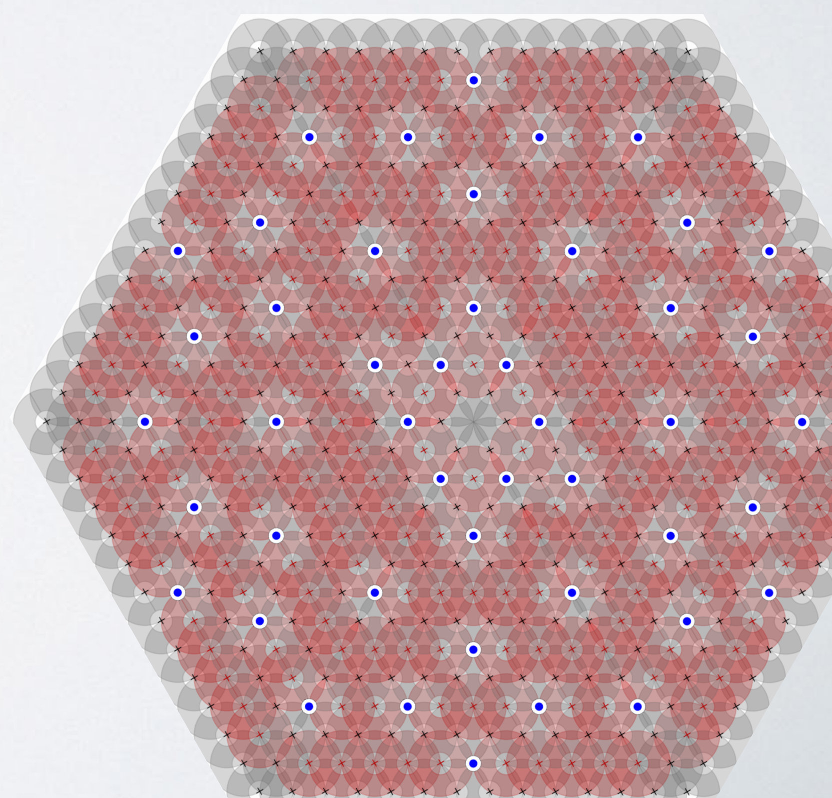


PLATES —> ROBOTS

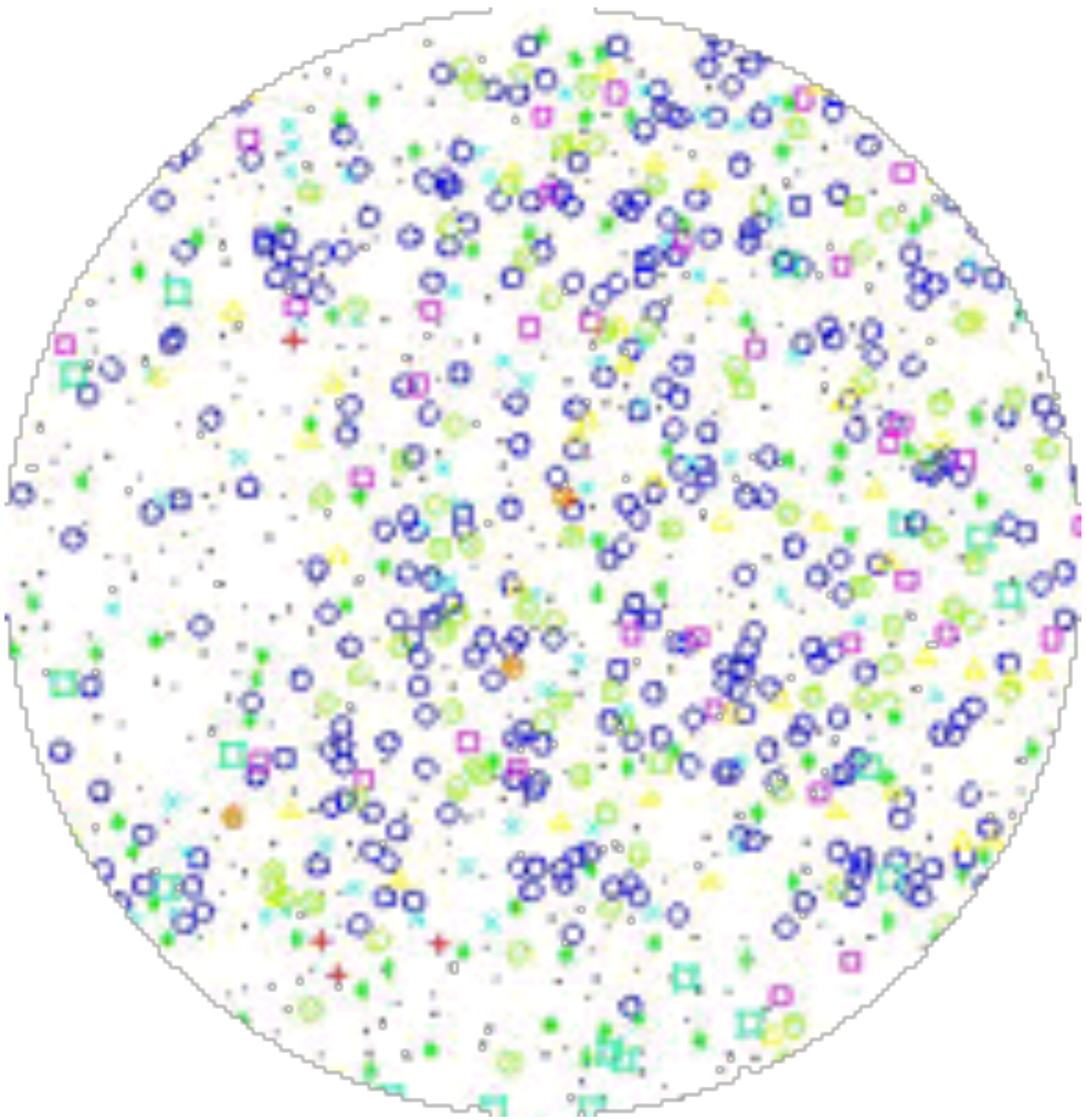


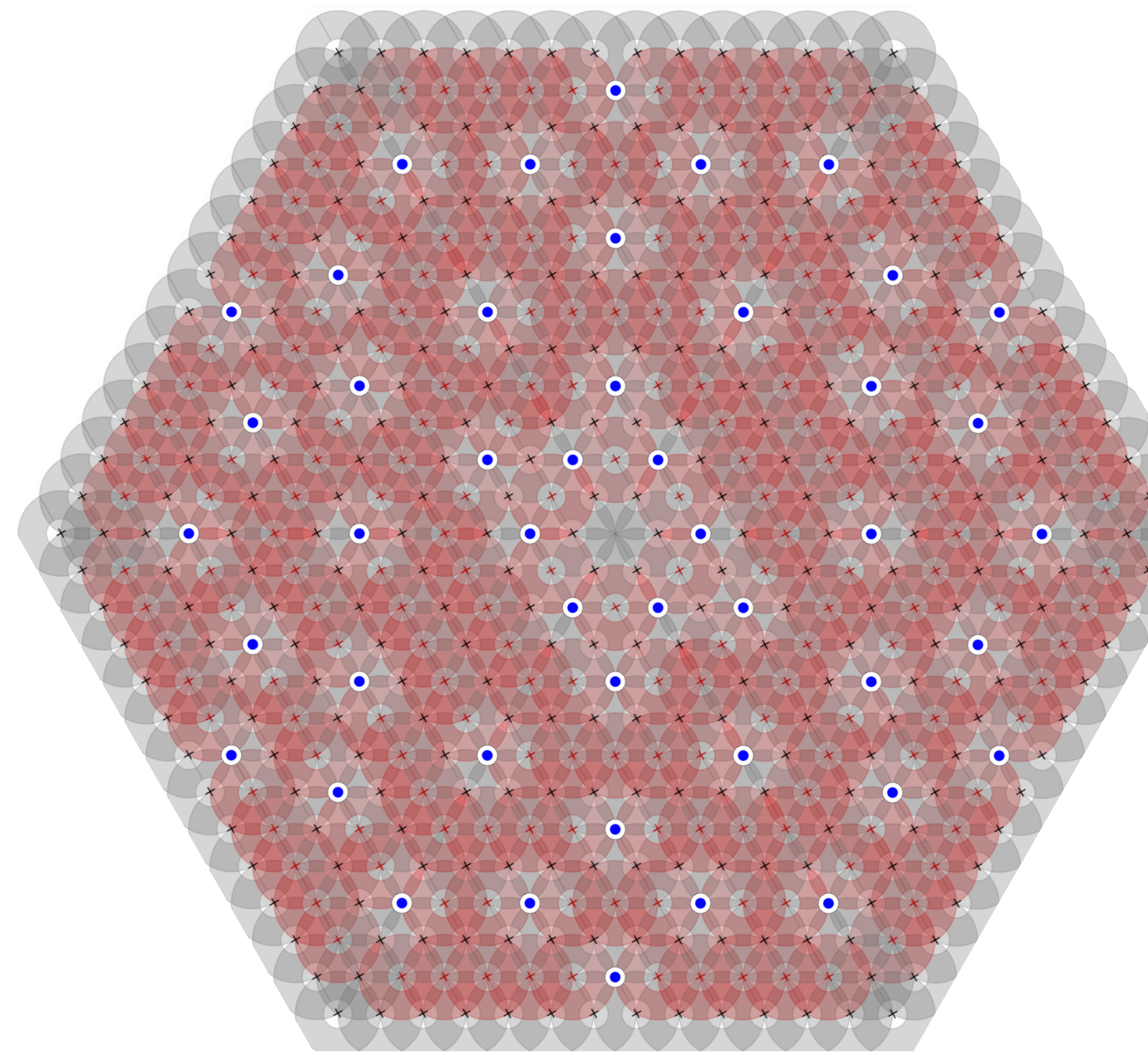


ALL Sky
Dust-Penetrating
Multi-epoch (1-60)
High-quality
spectroscopy



ROBOTIC FIBER POSITIONERS TO FEED SPECTROGRAPHS





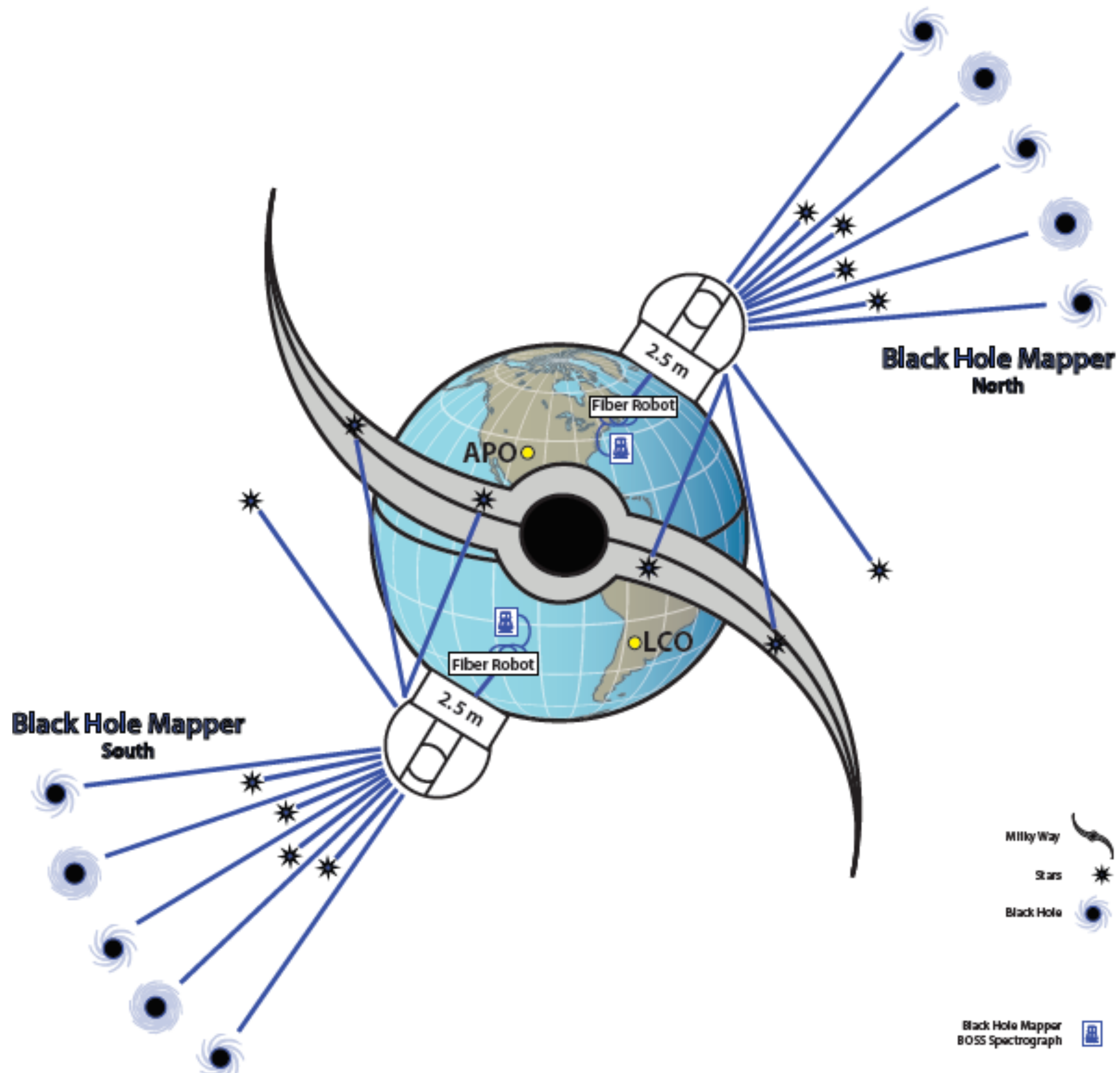
SDSS-V PROTOTYPE I!

- New prototypes tested in December/ January
- Fiber Positioning System successful PDR in November 2018
- Call of Tender for the robots has gone out (today!)

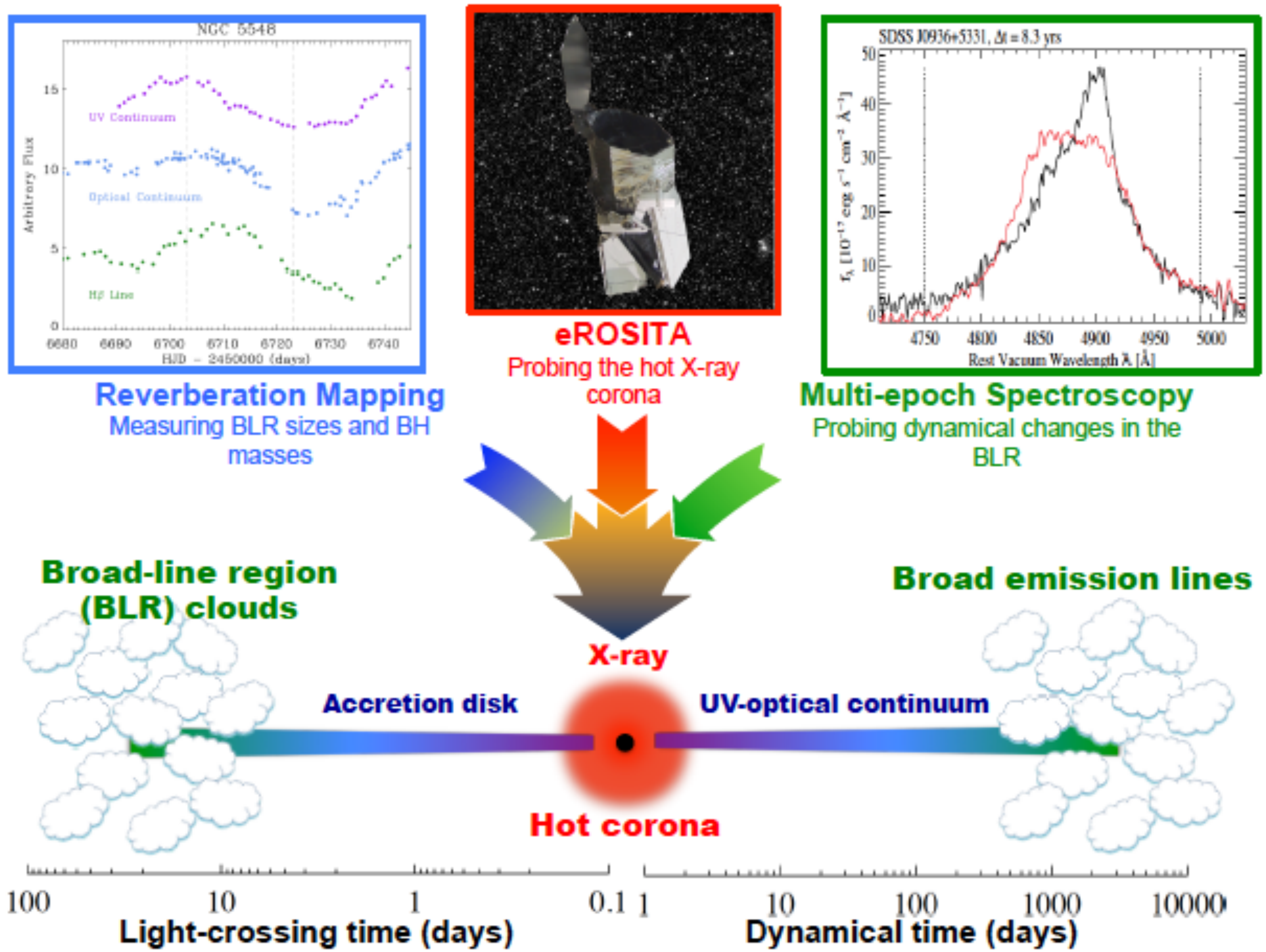
Final design review at the end of Q2!

Ready for "Robot Ridge" in mid-2020 will commission as soon as SDSS-IV completes

BLACK HOLE MAPPER: BHM



BLACK HOLE MAPPER:
UNDERSTANDING BLACK HOLE GROWTH

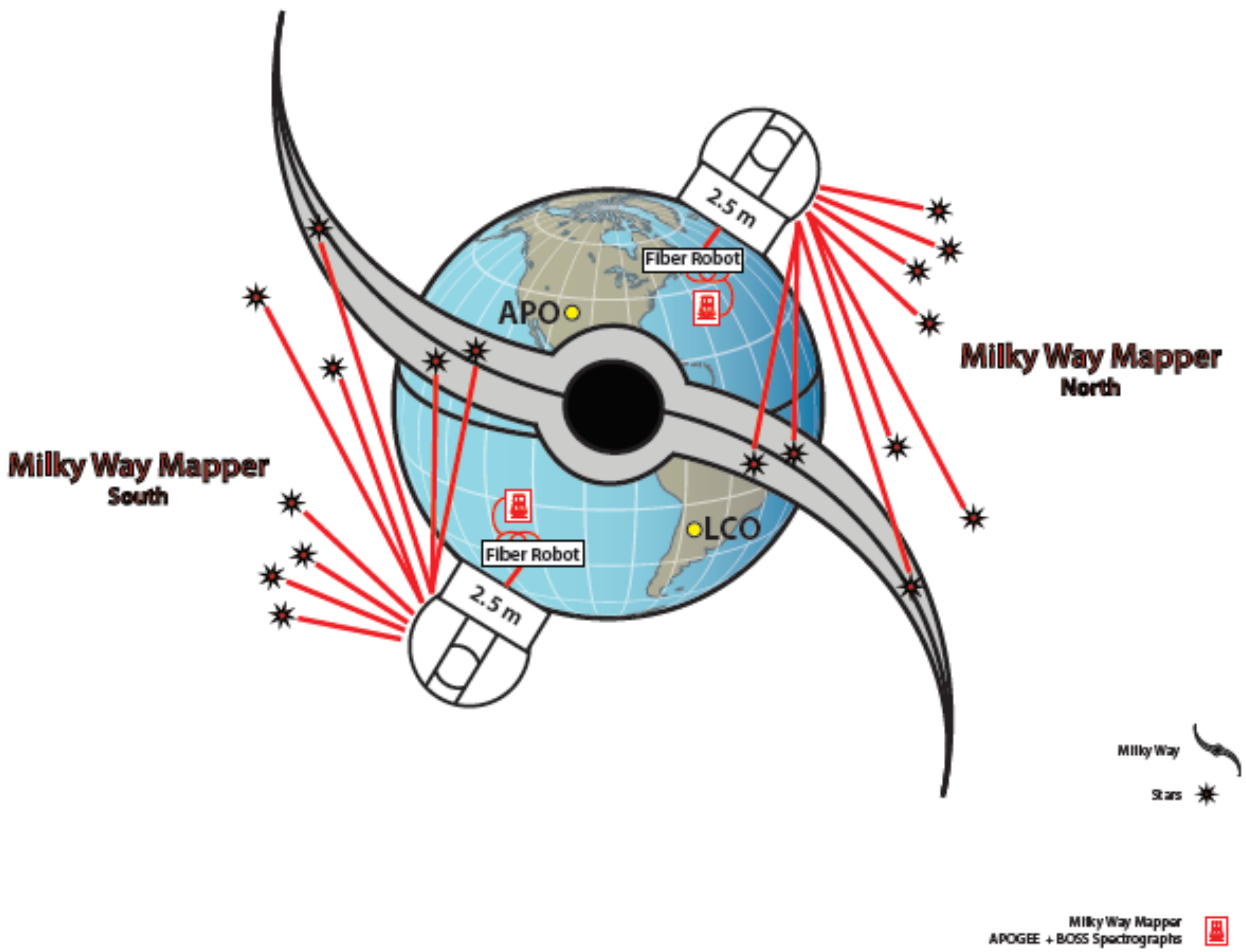


BHM Time-Domain Survey Outline

Spectral time-domain astrophysics of quasars: BH masses, binarity, accretion and events, BLR dynamics, outflows, etc. Broad range of time-sampling/cadence, days to decades.

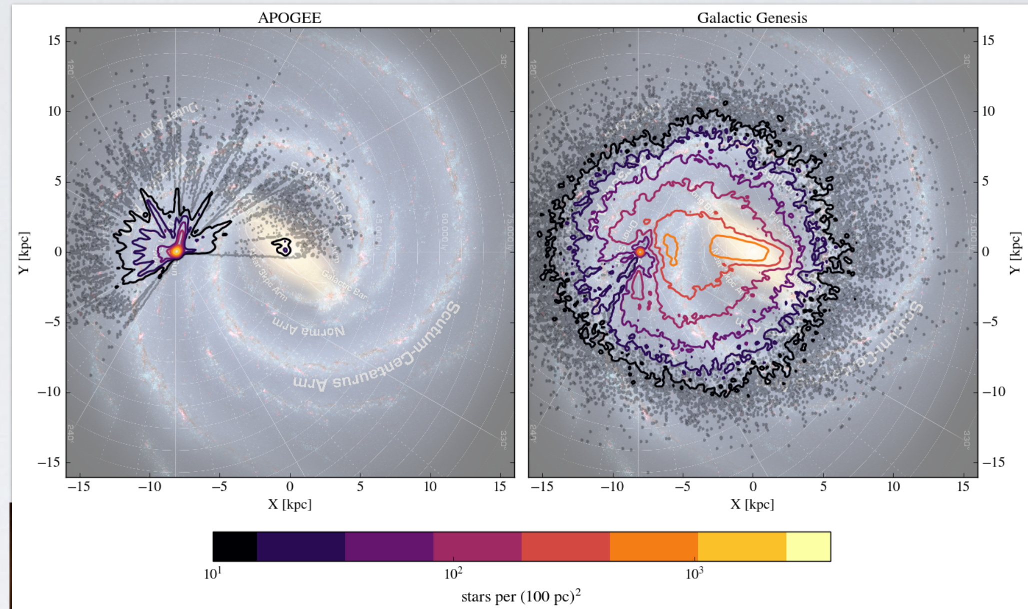
- For >20,000 quasars, 2-3 epochs during AS4 plus earlier-epoch SDSS spectra, sampling ~1-10 year timescales, e.g., transition times of changing look quasars, BAL disappearance and emergence, etc. *(wide/low-cadence tier; ~3000 deg^2).*
- For >2000 quasars, 12 epochs during ~2 years of AS4, probing down to ~1-month to 1-year timescales, adding unfolding BLR structural and dynamical changes *(medium tier; ~300 deg^2)*.
- Reverberation mapping (RM) for ~1000 quasars in 5 fields, >10^2 epochs, sampling down to days to weeks; lags between continuum and BLR emission yield BH masses; premier RM sample at high L, z. (high-cadence tier; ~30 deg^2)

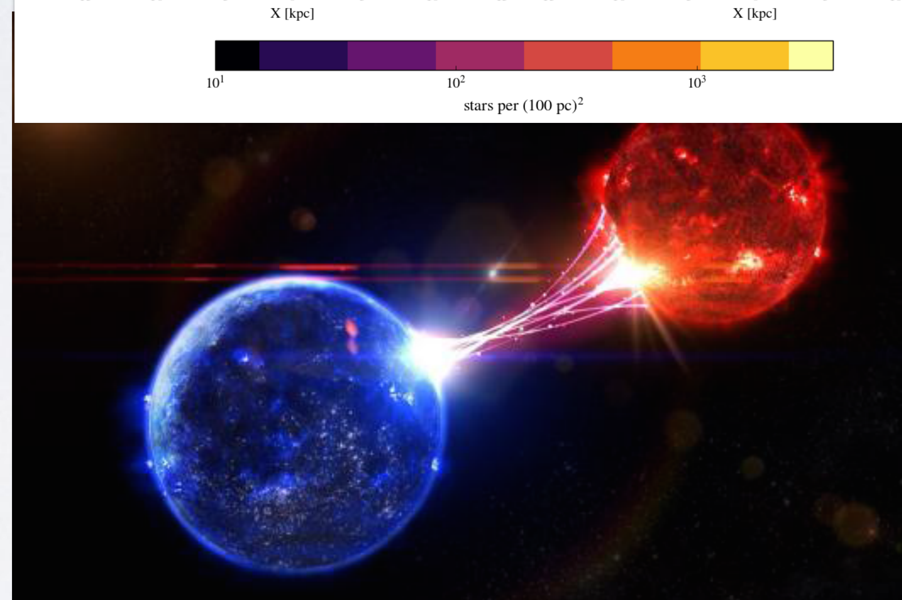
Milky Way Mapper: MWM

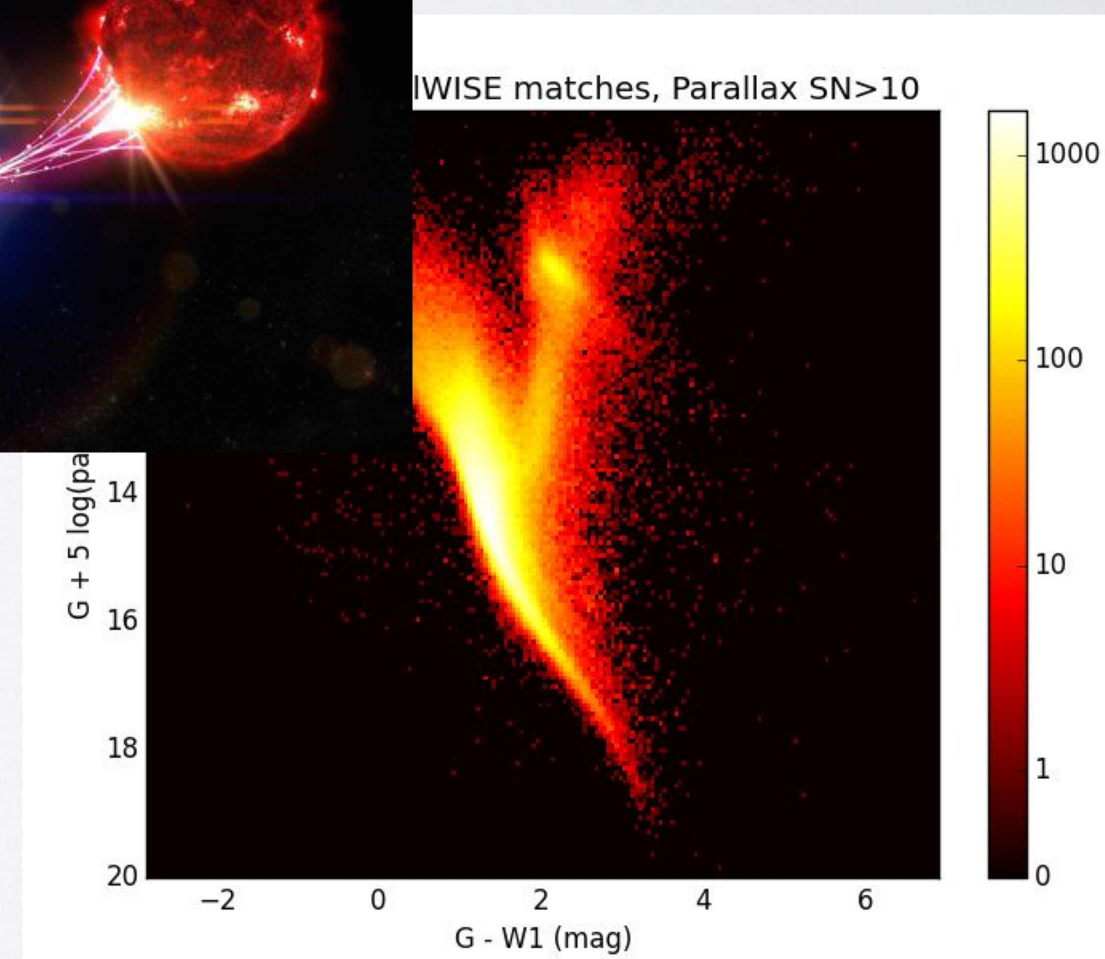


SCIENCE GOALS (GENERAL)

- **1) How did the Milky Way's disk form?**
- **2) How do stars live, evolve, and die (and affect transient/GW universe)?**
- **3) What stars host planets?**
- **4) What IS the stellar multiplicity across the HR diagram? Role of binaries in Stellar Evolution**
- **5) Origin of Supernovae and the heavy elements**



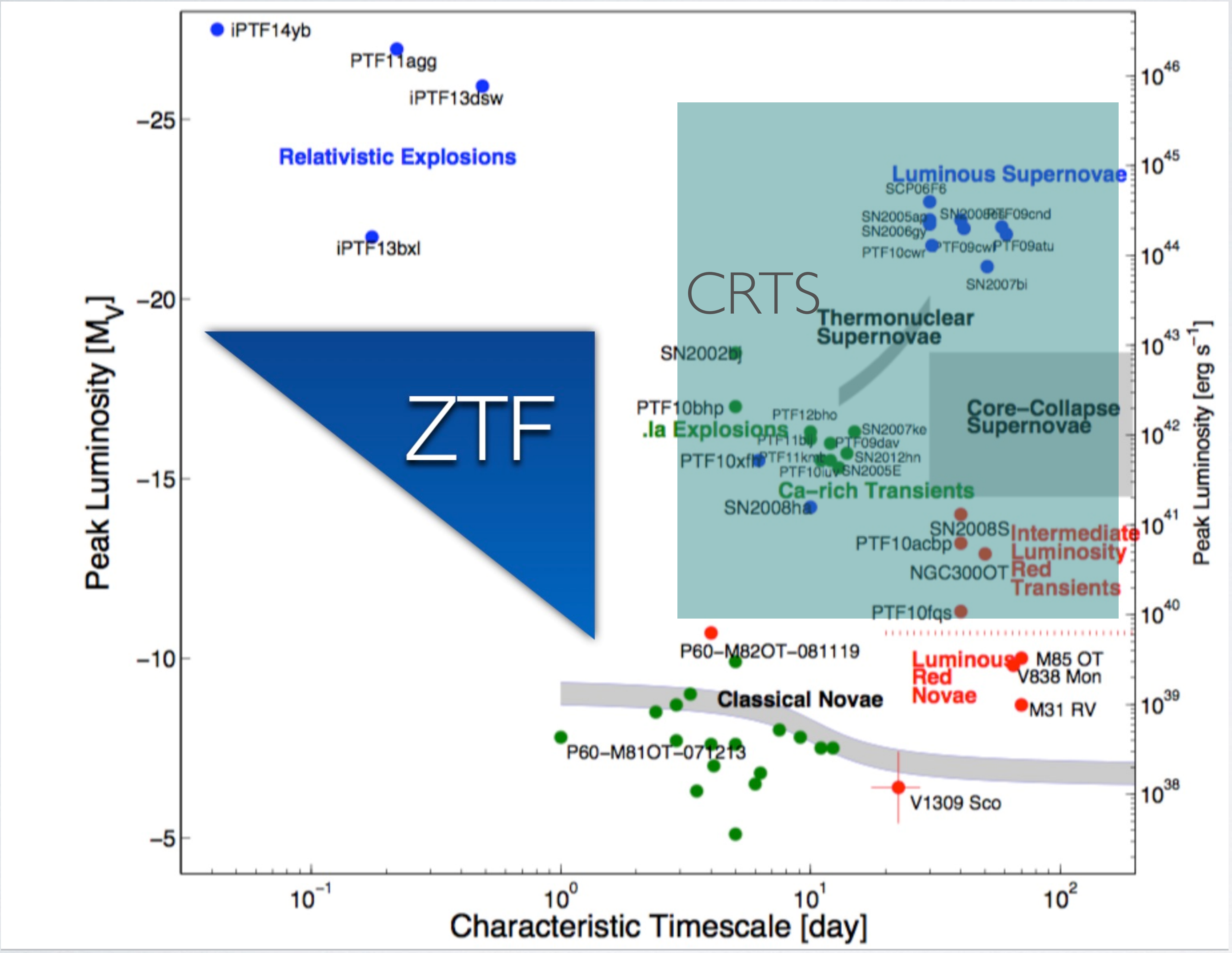




From D. Lang

Galactic Genesis & Stellar Astrophysics Targeting Classes				
Instrument	**Selection**	**$N_{Targets}$**	**N_{Epochs}**	**Comments**
Galactic Genesis Survey: mapping the dusty disk				
APOGEE	$H<11$, $G-H>3.5$	4,800,000	1	dust-extinguished disk
APOGEE	$\|z\|<200$ pc, $H<11$, d<5 kpc	125,000	1	to complete high-res ISM map
Binaries with Compact Objects: enumerating the populations of binaries with white dwarfs, neutron stars, or black holes, selected by variability				
BOSS	PTF, ZTF, *Gaia* variability	30,000	3	binaries with WDs, NSs, and BHs
BOSS	*Gaia* parallaxes	30,000	1	wide WD+MS/RGB binaries
Solar Neighborhood Census: observing all stars within 100 pc, giving the best probe of low-mass stars, whether in single or binary systems				
APOGEE, BOSS	d<100 pc, $G<20$, $H<12$	400,000	2	1000× increase in volume & stars
White Dwarf Chronicle: using white dwarfs and their evolved companions to measure the SFH and age-metallicity relation				
BOSS	$G<20$	300,000	3	15× increase in sample size
TESS Exoplanet Host Candidates: observing all TESS short-cadence targets in the CVZs				
APOGEE	$H\leq 13.3$	300,000	1–8	all short-cadence targets & planet hosts
Binaries Across the Galaxy: measuring environmental dependence of binary fraction in the disk, bulge, halo, and stellar clusters; probing the brown-dwarf desert beyond solar-type stars				
APOGEE	$H<13.4$, $N_{Epoch}\geq 6$ by the start of SDSS-V	60,000	6–18	gives orbits with 24–40 epochs for all targets with long APOGEE baselines
Gaia Astrometric Binaries: characterizing rare systems that have good astrometric orbits but limited other information, from *Gaia*'s sample of > 10 million stars				
APOGEE, BOSS	$d<3$ kpc	200,000	1	rare types of systems
TESS Red Giant Variability: measuring spectroscopic properties for red giants in TESS that have seismic and/or granulation lightcurve signatures				
APOGEE	$H<12.5$	250,000	1	stars with at least 80 days of TESS observation
Massive, Convective Core Stars: combining dynamic and asteroseismic measurements of binary OBAF stars in the TESS CVZs and characterizing their multiplicity				
APOGEE	$H<12$	200,000	2	detection of single vs. binary systems
APOGEE	$H<12$	500	25	>10× increase in current sample size
Young Stellar Objects: quantifying the stellar populations in star-forming regions, including identifying sources of ionizing radiation and characterizing the binary frequency				
APOGEE	$H<12$, $d<1$ kpc	20,000	12	nearby star-formation regions
APOGEE	$H<12$	3,500	8	high-mass star-formation regions
APOGEE	$H<12$, $\|b\|<2°$	10,000	2	massive young stars in the Galactic Plane
APOGEE	$H<13$	10,000	2	Central Molecular Zone

TRANSIENTS!



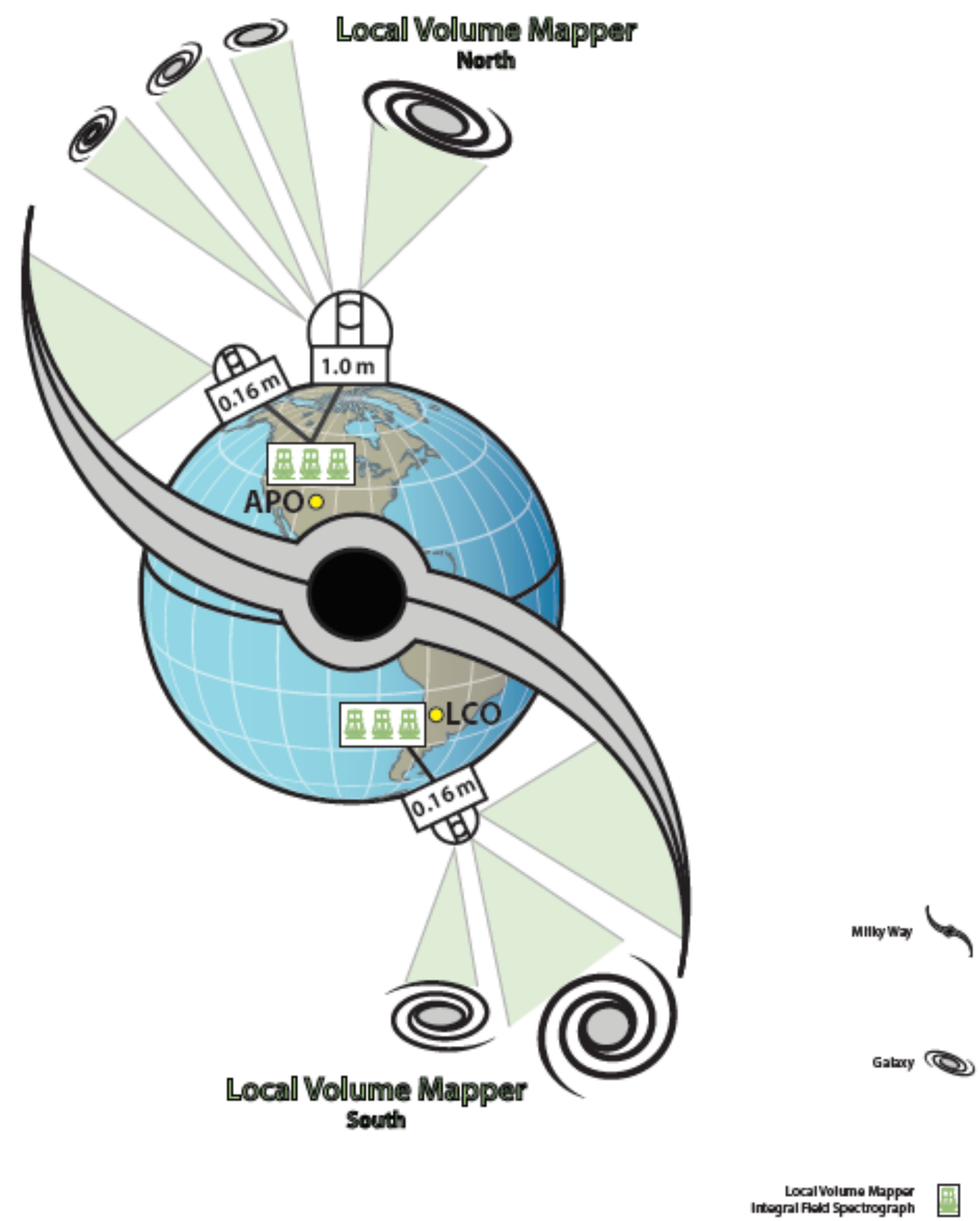
Wouldn't it be nice to settle BASIC questions like: What are Type 1a SNe (and what are they NOT)?

B. Penpraese

Local Volume Mapper: LVM

Using different telescope sizes of and an array of IFU-coupled spectrographs at $R\sim4000$ and 3600-10000Å, we survey

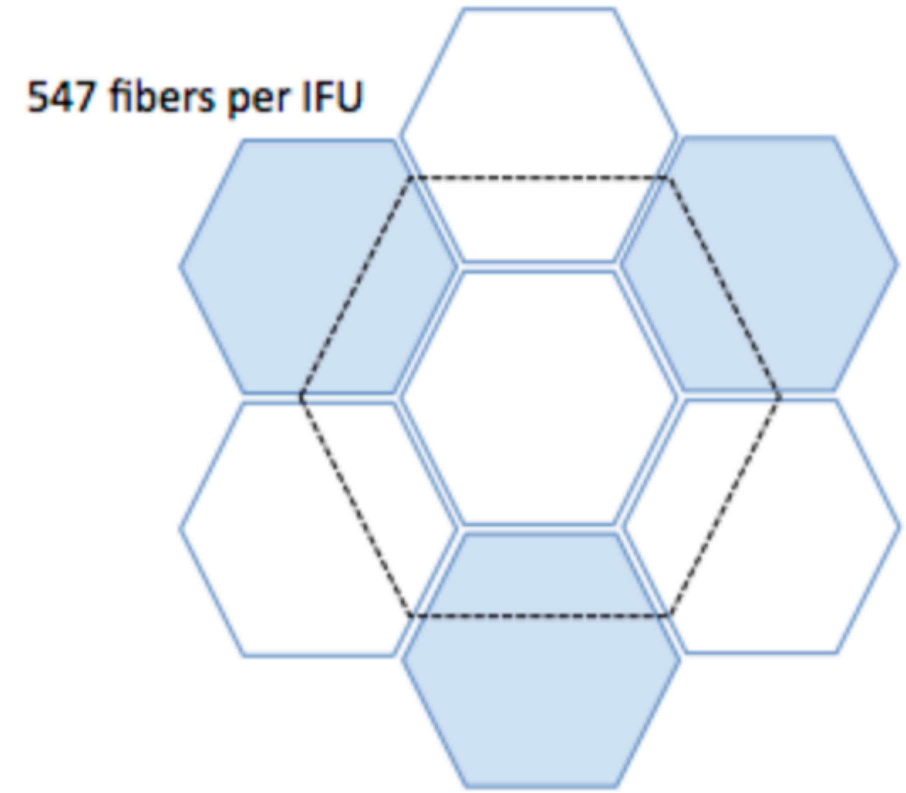
- 2800 sq. deg. in the MW @ 0.1-1 pc resolution,
- 300 sq. deg. in the MW 10x deeper,
- LMC & SMC @ 10 pc resolution,
- M31 & M33 @ 20 pc resolution, and
- 12 nearby galaxies (D≲5 Mpc) @ 50 pc resolution

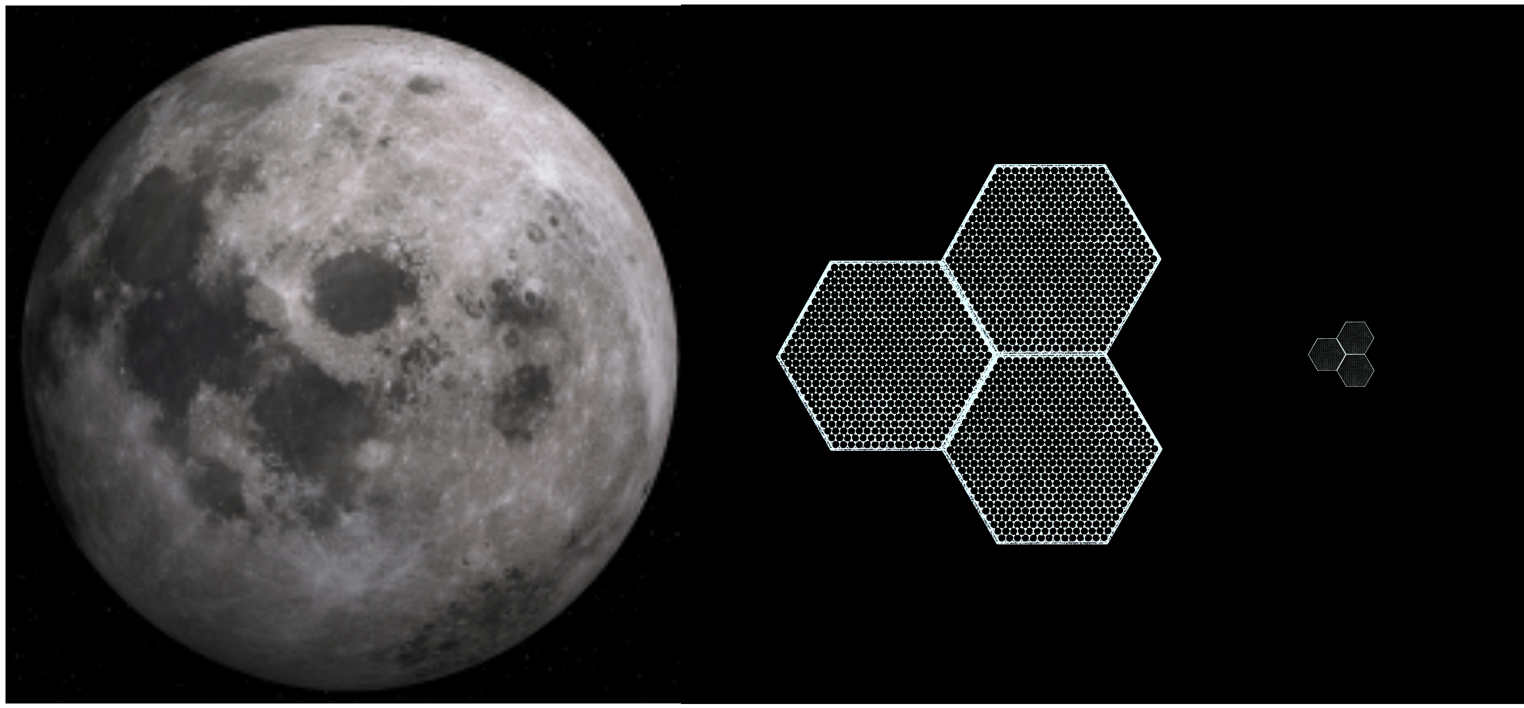


LVM hardware

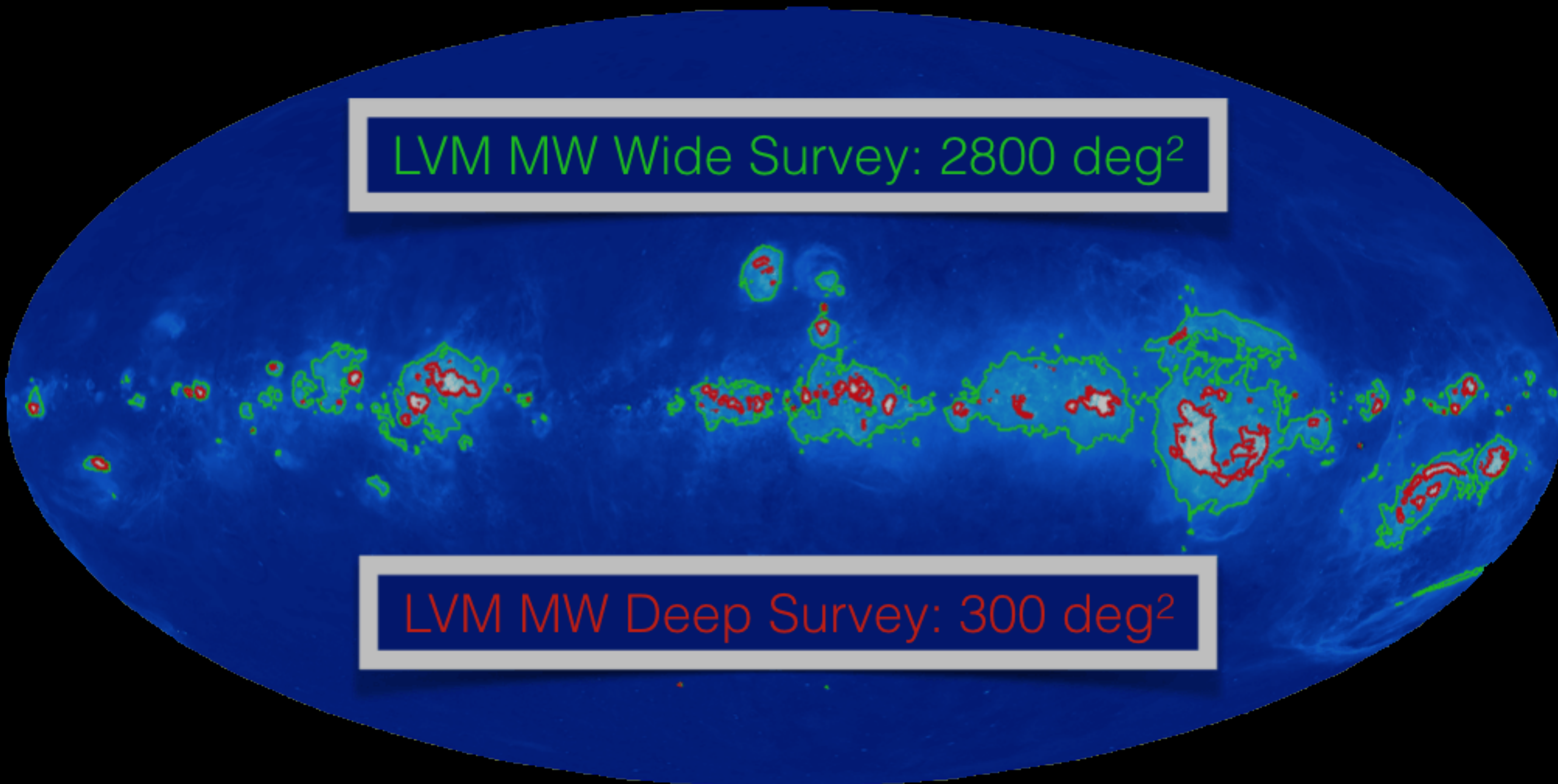
IFU design

- 3 x 547 hexagonal non-abutted lenslet coupled IFUs arrays.
- 309 calibration fibres.
- Based on highly-successful MaNGA design.
- 490 arcmin2 @ 0.16 m
- 12 arcmin2 @ 1 m





OBSERVING GALAXIES AT THE "ENERGY INJECTION SCALE"



Cosmological Zoom-In Observations!

Orion

- M42 0.07 pc / spaxel
- APOGEE stars (yellow)
- Combine information from gas and stars to map the interaction between stars and ISM
- Have Teff, L, Z, [X/H], f_{UV}, (age) for each star
- Gas: temperature, density, kinematics, abundances

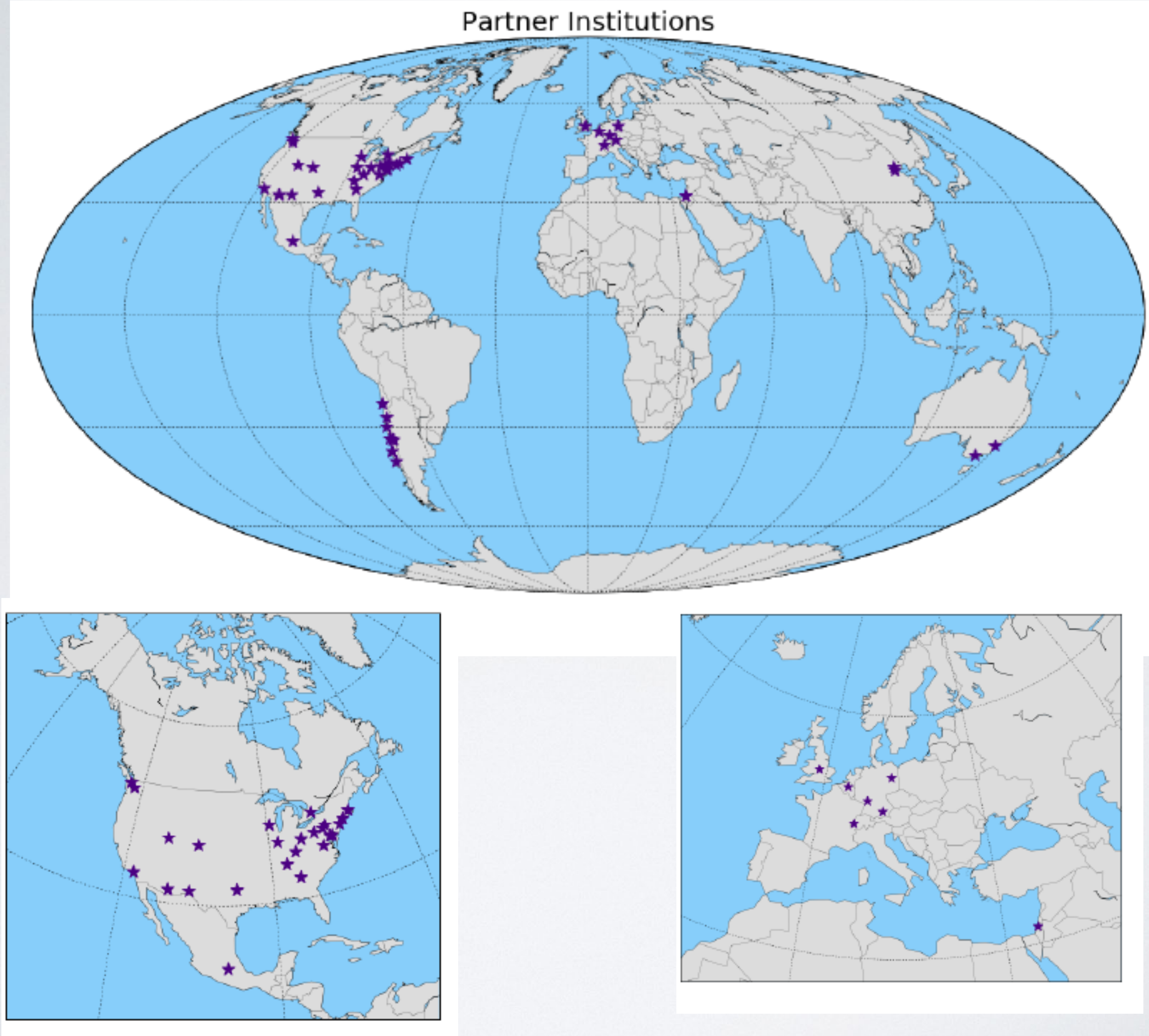
Images: ESO 2.2m

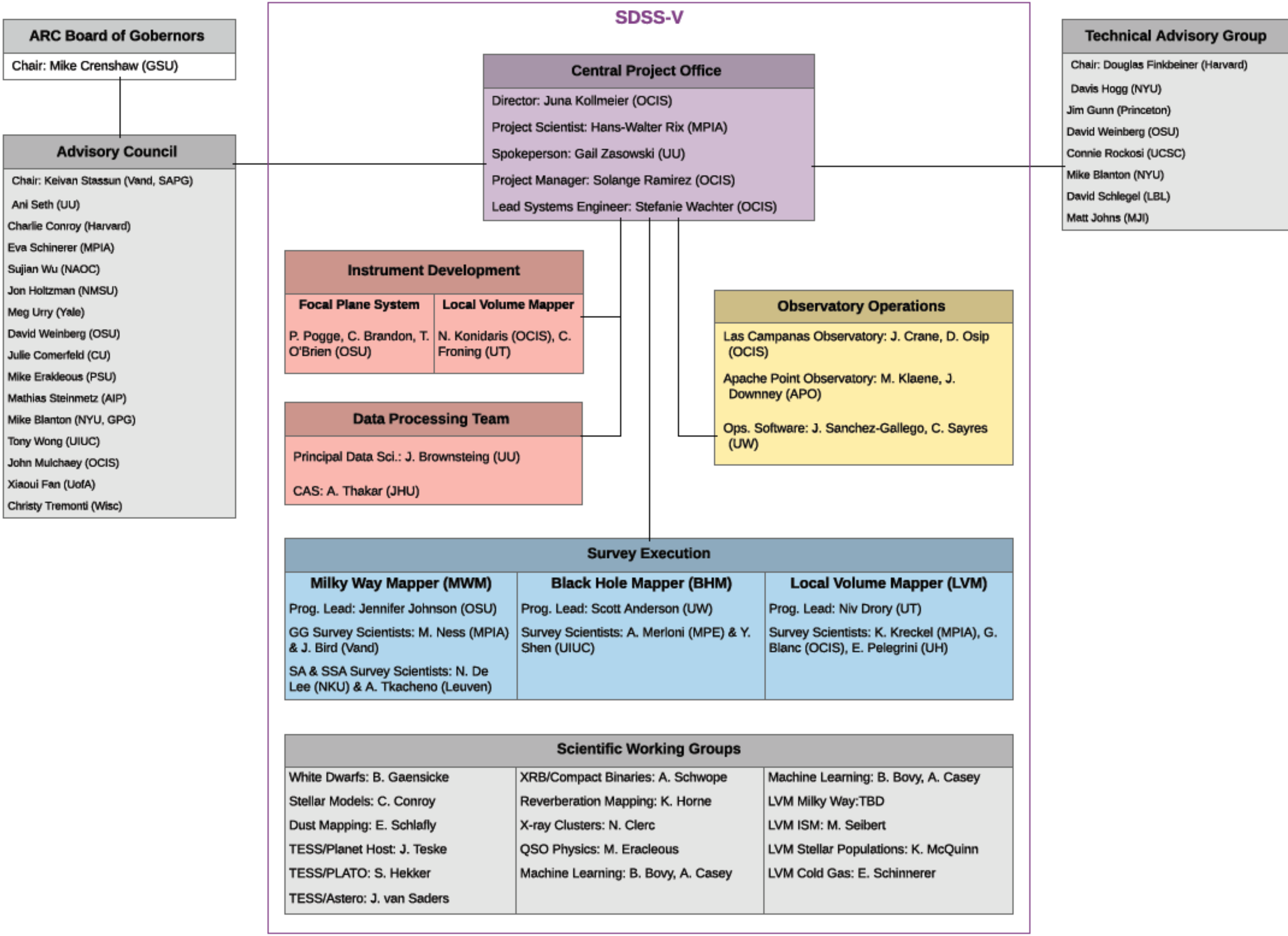
INSTITUTIONAL PARTNERSHIP

GROWTH OF COLLABORATION

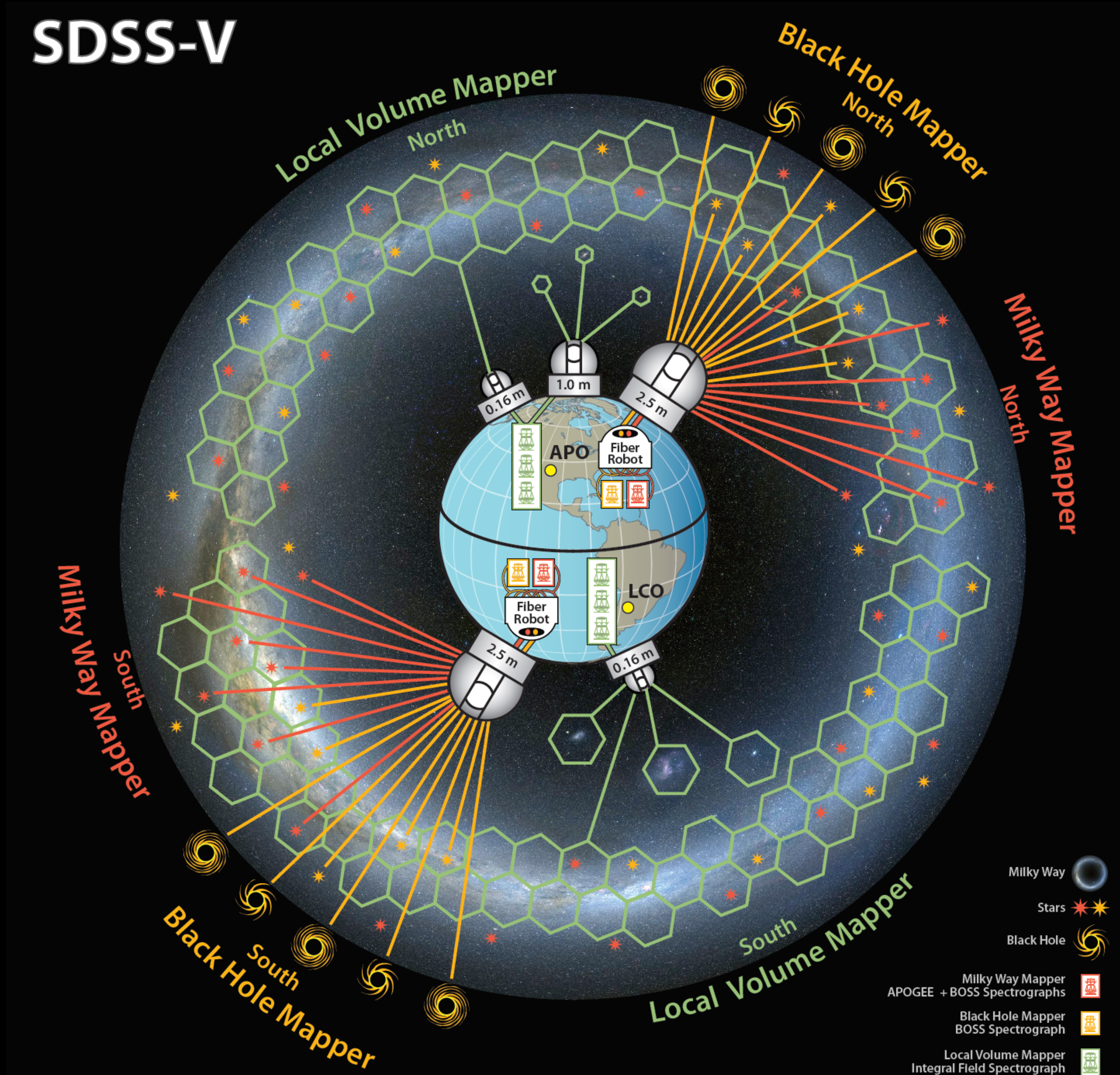
SRK = Investor #1

SDSS Collaboration Matrix	MOU Signed/Out for Signature	MOU in Draft/Iteration	Prospective Institutions
FULL MEMBERS	CU Boulder Harvard MPE MPIA NMSU OSU NAOC Yale CNTAC	Carnegie Wisconsin STSCI UofA JHU UNAM U of Toronto SAO	NOAO INAF
3 Slot Members	AIP PSU Flatiron UIUC	UVA	Caltech MIT
Individual (1/2) slot Members	University of Washington (2) TCU, TAU (2) Vanderbilt, KIAA, U. Warwick, NYU, KU Leuven, Columbia, U. Penn,York University, University of Victoria, U. Pittsburgh, Georgia State	Monash University EPFL ANU	Oxford St. Andrews Nanjing U. SHAO


Partner Institutions



SDSS-V
ARC Board of Gobernors
Chair: Mike Crenshaw (GSU)
Advisory Council
Chair: Keivan Stassun (Vand, SAPG)
Ani Seth (UU)
Charlie Conroy (Harvard)
Eva Schinerer (MPIA)
Sujian Wu (NAOC)
Jon Holtzman (NMSU)
Meg Urry (Yale)
David Weinberg (OSU)
Julie Comerfeld (CU)
Mike Erakleous (PSU)
Mathias Steinmetz (AIP)
Mike Blanton (NYU, GPG)
Tony Wong (UIUC)
John Mulchaey (OCIS)
Xiaoui Fan (UofA)
Christy Tremonti (Wisc)
Central Project Office
Director: Juna Kollmeier (OCIS)
Project Scientist: Hans-Walter Rix (MPIA)
Spokeperson: Gail Zasowski (UU)
Project Manager: Solange Ramirez (OCIS)
Lead Systems Engineer: Stefanie Wachter (OCIS)
Technical Advisory Group
Chair: Douglas Finkbeiner (Harvard)
Davis Hogg (NYU)
Jim Gunn (Princeton)
David Weinberg (OSU)
Connie Rockosi (UCSC)
Mike Blanton (NYU)
David Schlegel (LBL)
Matt Johns (MJI)
Instrument Development
Focal Plane System
P. Pogge, C. Brandon, T. O'Brien (OSU)
Local Volume Mapper
N. Konidaris (OCIS), C. Froning (UT)
Observatory Operations
Las Campanas Observatory: J. Crane, D. Osip (OCIS)
Apache Point Observatory: M. Klaene, J. Downney (APO)
Ops. Software: J. Sanchez-Gallego, C. Sayres (UW)
Data Processing Team
Principal Data Sci.: J. Brownsteing (UU)
CAS: A. Thakar (JHU)
Survey Execution
Milky Way Mapper (MWM)
Prog. Lead: Jennifer Johnson (OSU)
GG Survey Scientists: M. Ness (MPIA) & J. Bird (Vand)
SA & SSA Survey Scientists: N. De Lee (NKU) & A. Tkacheno (Leuven)
Black Hole Mapper (BHM)
Prog. Lead: Scott Anderson (UW)
Survey Scientists: A. Merloni (MPE) & Y. Shen (UIUC)
Local Volume Mapper (LVM)
Prog. Lead: Niv Drory (UT)
Survey Scientists: K. Kreckel (MPIA), G. Blanc (OCIS), E. Pelegrini (UH)
Scientific Working Groups
White Dwarfs: B. Gaensicke
Stellar Models: C. Conroy
Dust Mapping: E. Schlafly
TESS/Planet Host: J. Teske
TESS/PLATO: S. Hekker
TESS/Astero: J. van Saders
XRB/Compact Binaries: A. Schwope
Reverberation Mapping: K. Horne
X-ray Clusters: N. Clerc
QSO Physics: M. Eracleous
Machine Learning: B. Bovy, A. Casey
Machine Learning: B. Bovy, A. Casey
LVM Milky Way:TBD
LVM ISM: M. Seibert
LVM Stellar Populations: K. McQuinn
LVM Cold Gas: E. Schinnerer



SDSS-V
Local Volume Mapper
North
Black Hole Mapper
North
Milky Way Mapper
North
0.16 m
1.0 m
2.5 m
APO
Fiber Robot
LCO
Fiber Robot
2.5 m
0.16 m
Milky Way Mapper
South
Black Hole Mapper
South
Local Volume Mapper
South
Milky Way
Stars
Black Hole
Milky Way Mapper
APOGEE + BOSS Spectrographs
Black Hole Mapper
BOSS Spectrograph
Local Volume Mapper
Integral Field Spectrograph