Chilean AGN/Galaxy Evolution Survey (ChAN·GES)
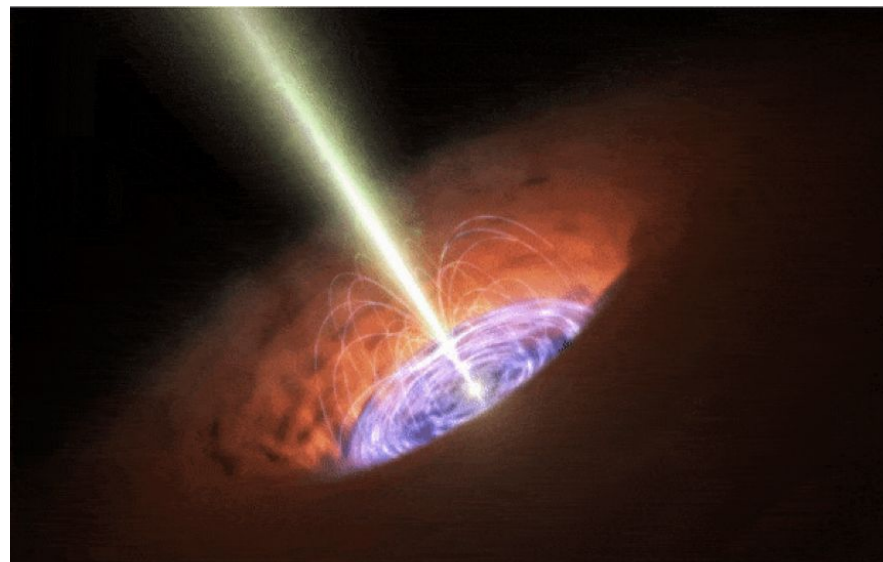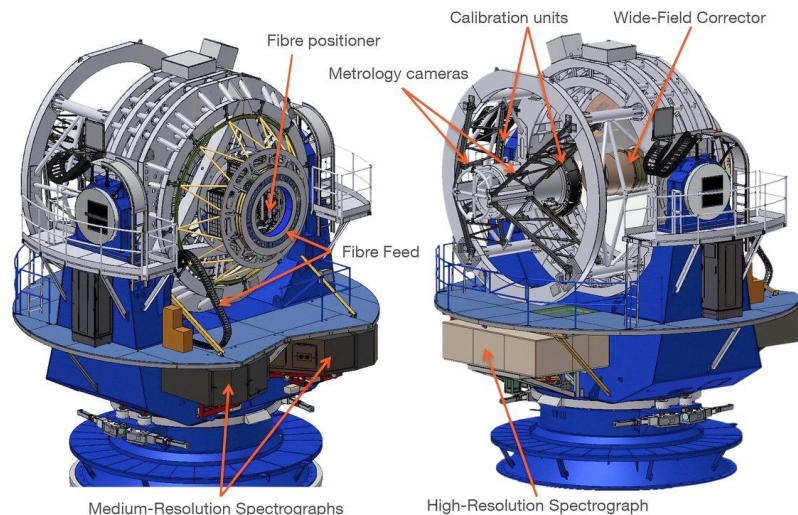

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Motivation

Explore critical portions of AGN discovery space which are still very poorly constrained…

- Characterize <u>faint</u> and <u>redder</u> portions of accretion & BH density functions to at least z~1

  - Trace BH mass growth for AGN with $L/L_{Edd} < 10^{-1}$

  - Locate low-mass BHs => <u>constrain black hole seed models</u>

- Investigate relations between AGN (M_{BH}, L/L_{Edd}, outflows, ...) and host properties (age/SFH, Z, v_{disp}, …)

- Large statistical spectral variability investigation for R<20 AGN, over wide physical parameter space

- Synergy with Chilean involvement in LSST; strong legacy value that will greatly enhance LSST studies

Novel Selection

- Optical/NIR continuum variability + (nuclear) color/SED selection of ~700,000 AGN from ZTF, ATLAS, La Silla-QUEST, DES, VST … eventually from LSST... over 4MOST WIDE/MEDIUM/DEEP footprints.

- Push selection into (redder) host-dominated / contaminated regions of parameter space

- Variability+SED selection highly complementary to the soft X-ray and optical/NIR/MIR color selection where AGN is likely dominant over host
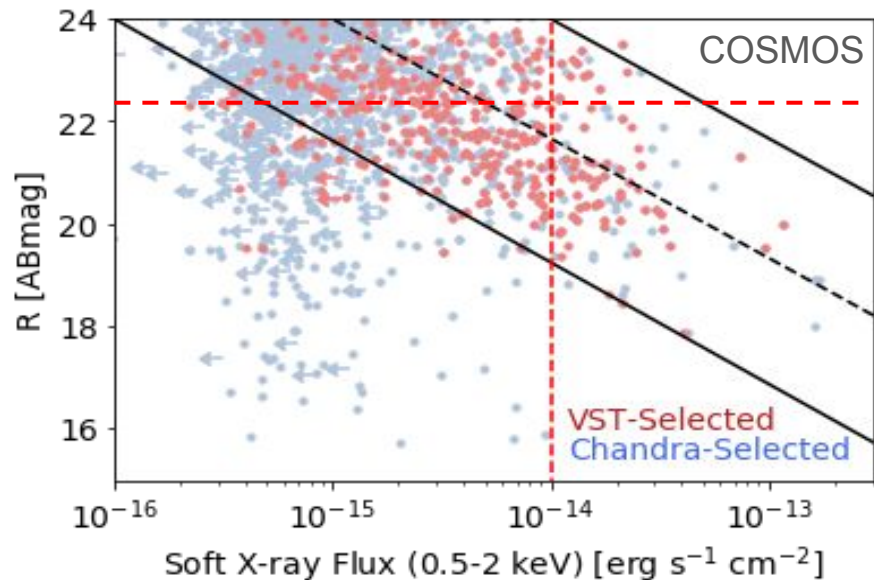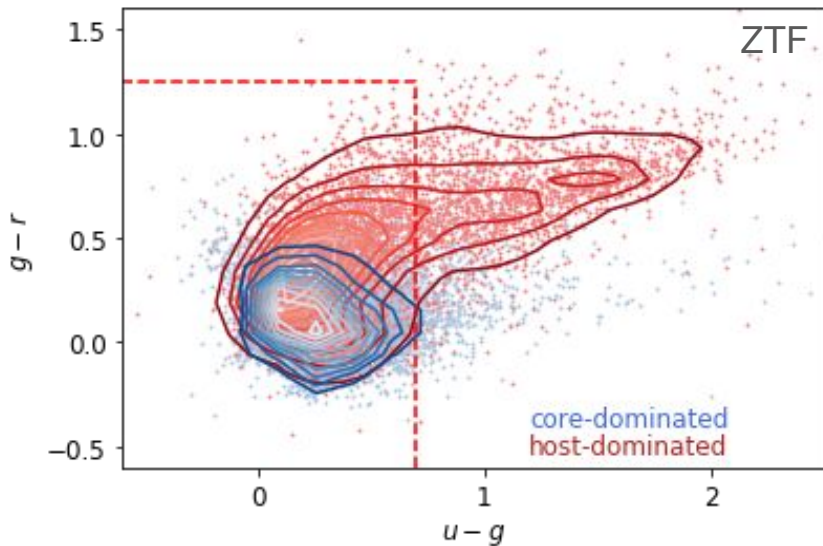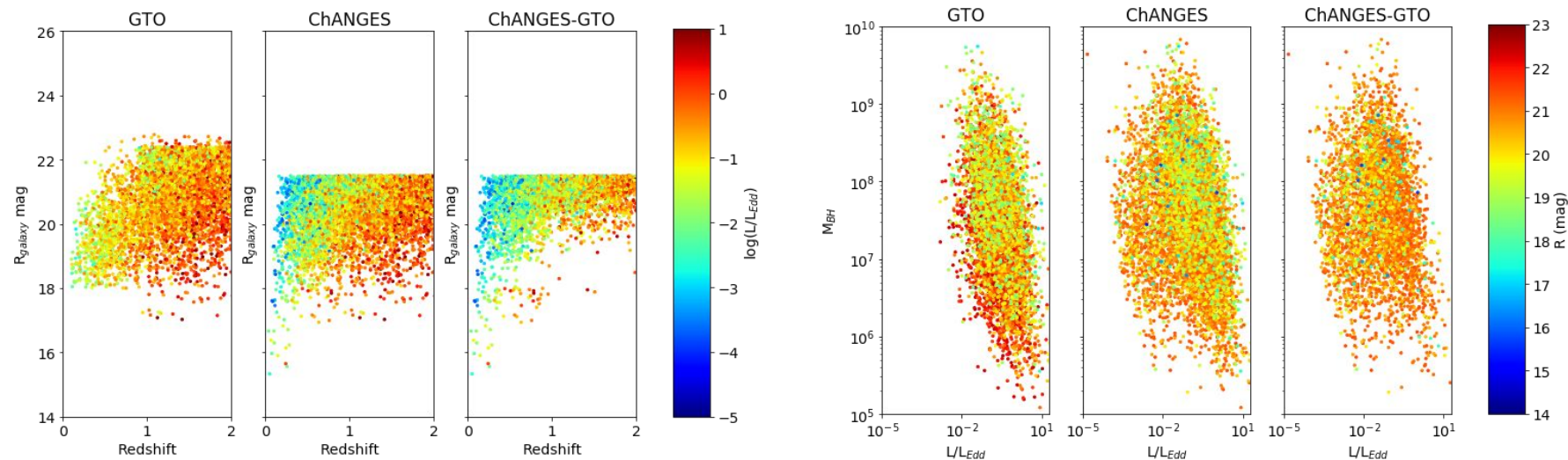
Expectations

Mock simulations (Comparat+19) imply our selection will probe ~1-2 dex lower in AGN accretion rate vs. GTO.

Main sample likely biased against obscured AGN, but y-band variability will select some obscured AGNs, while fainter DDF subsample incorporating all selection methods will enable obscured fraction corrections.

We expect ChANGES to ultimately yield novel constraints on AGN physics, demography, evolution, and host properties out to z~1 and beyond.

Mock catalog comparisons of GTO, full ChANGES and ChANGES-GTO ("GTO removed") selections for WIDE area using simulations from Comparat+19

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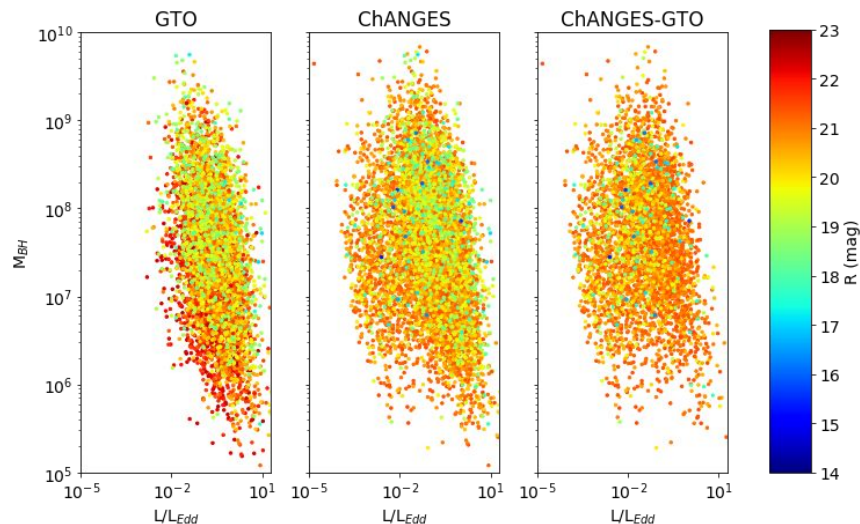

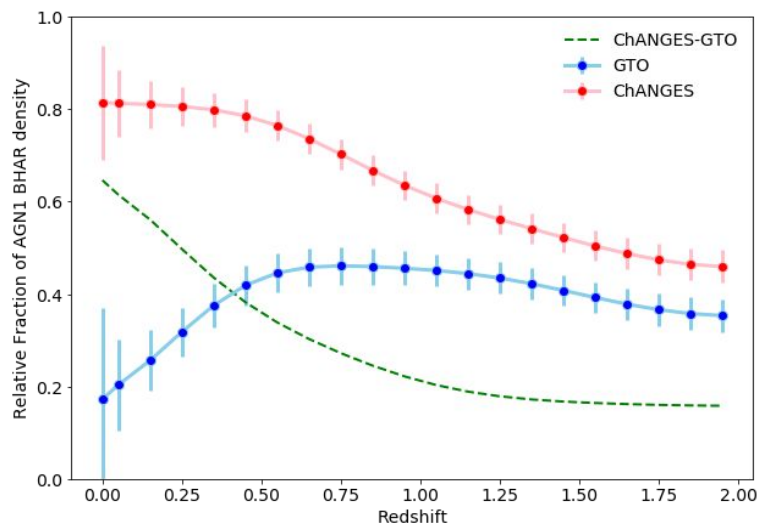Mock catalog comparisons of GTO, full ChANGES and ChANGES-GTO ("GTO removed") selections for WIDE area using simulations from Comparat+19

Key Secondary Goals

- Prioritize rare BH subsamples, which would be difficult/impossible to assemble otherwise.
  => confirm, spectral characterization, trigger follow-up and/or ancillary multi-wavelength studies.

  - **Extreme Variable (EV, >1mag)/Changing-Type AGN (10,000, LRS)**

  - **Tidal Disruption Events (TDEs; 1000 direct, 19,000 hosts, LRS)**

  - **Strongly lensed AGN (1000s, LRS)**

  - **Damped Lyman-α Absorption (~5,000, HRS)**

- **Filler AGN (>10000, >10 epochs, LRS)**

Details

Two phase sample:

- ~Year 1-2 => "**BRIGHT**" sample with surveys in hand (to ~20-21 mag).
- ~Year 3-5 => "**FAINT**" sample based on LSST ($\gtrsim$24.5 mag, DR1+).
  - Absolutely vital to tap into LSST depth and precision difference imaging once available.

Employ "wedding cake" strategy for systematics/completeness + obscured fraction corrections across a variety of indicators:

- **WIDE** (625k AGN): t_{exp}~1.3h => assemble main demographic + variability samples.
- **MEDIUM+DEEP-GAMA** (60k AGN): t_{exp}~5h-8h => parameter completeness/systematics
- **DDFs** (10k AGN): t_{exp}~4h/8h/16h => parameter completeness/systematics/obscured fractions.

Generate massive training set for LSST => critical step for LSST AGN SC RoadMap...

Survey Scope

- target type,
- target density,
- survey area,
- total number of targets,
- magnitude distribution
- High or low spectral resolution
- Required S/N and completeness
- Any special calibration requirements
- Any other operational requirements (e.g. repeat observations)

Survey Scope

Survey regions	RA (deg)	Dec (deg)	Area (deg²)	Range of target density (targets/deg²) Parent => Goal	Range and average t_{exp} (hours)	Magnitude range	Execution Priority (% complete)	Spectrograph (LRS/HRS) Fibre hrs	
WIDE VAR (var+color+lensed)	0<α<360 (minus |b|<10)	-70<δ<+5 (minus |b|<10)	10000	>150 => ~65	1.3	R<21.5	low-to-high (40-90% from z<1 to z>4); Lensed (>90%)	LRS 815,000h	AGN #s, var
WIDE GTO-REPEAT	0<α<360 (minus |b|<10)	-70<δ<+5 (minus |b|<10)	10000	>50 => ~10	0.7	R<20	low: (20%)	LRS 70,000h	GTO AGN var
WIDE TDEs+hosts	0<α<360 (minus |b|<10)	-70<δ<+5 (minus |b|<10)	10000	~2 => ~1.7	0.6-1.3	R<21.5	high: (>80%)	LRS 22,000h	
WIDE QSO absorbers	0<α<360 (minus |b|<10)	-70<δ<+5 (minus |b|<10)	10000	0.5 => 0.5	1.3	R<18.5	high: (>90%)	HRS 6,500h	
MEDIUM-N (var+color+lensed)	157<α<225	-3<δ<+4	545	>150 => ~45	~6	R<21.5	medium: (30%)	LRS 250,000h	AGN #s, var
MEDIUM-S (var+color+lensed)	-30<α<52.5	-36<δ<-27	625						
MEDIUM-N GTO-REPEAT	157<α<225	-3<δ<+4	545	>50 => ~10	~6	R<20	medium: (20%)	LRS 70,000h	GTO AGN var
MEDIUM-S GTO-REPEAT	-30<α<52.5	-36<δ<-27	625						
DEEP (GAMA23)	-21<α<-9	-35<δ<-30	50	>300 => ~200	1-16, ~8	R<22.5	high: (66%)	LRS 80,000h	AGN #s, var
DEEP (ELIAS-S1)	8.95	-43.7	4	~670 => ~670	1-16, ~12	R<22.5	high: (>90%)	LRS 112,000h	AGN #s, var
DEEP (XMMLSS)	35.5	-5.55	4						
DEEP (ECDFS)	53.0	-28.0	4						
DEEP (E-COSMOS)	150.1	+2.5	4						
WIDE FILLER	0<α<360 (minus |b|<10)	-70<δ<+5 (minus |b|<10)	10000	~10-40 => >10	1.3	R<~18	low: (>25%)	LRS 130,000h	
TOTAL								LRS 1,550,000h	
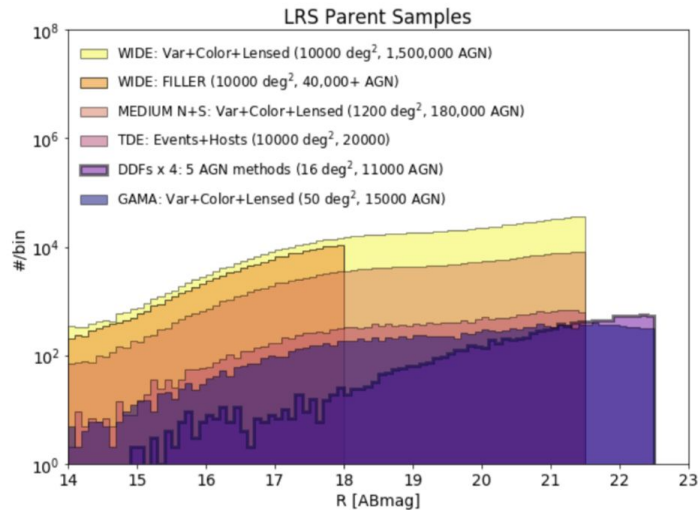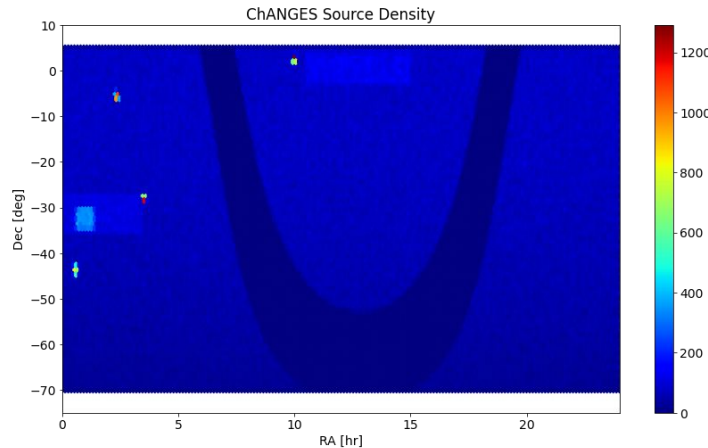
assume airmass<1.25, FLI=0.5, clear; <80% turbulence, <1.2" seeing (except filler)
S/N≳4-7 per Å over >50% of 4MOST spectral range

ChANGES Source Density

LRS Parent Samples

- WIDE: Var+Color+Lensed (10000 deg², 1,500,000 AGN)
- WIDE: FILLER (10000 deg², 40,000+ AGN)
- MEDIUM N+S: Var+Color+Lensed (1200 deg², 180,000 AGN)
- TDE: Events+Hosts (10000 deg², 20000)
- DDFs x 4: 5 AGN methods (16 deg², 11000 AGN)
- GAMA: Var+Color+Lensed (50 deg², 15000 AGN)

Specific spectral quantities we want measured

- Calibrated, cleaned, flagged spectra.
- Redshifts, parametric and non-parametric estimates of line fluxes and shapes; continuum template fits to spectral libraries; associated MCMC error propagation.

Deliverable L2 products to ESO/public

- **Reduced spectra**: Calibrated, cleaned, flagged, etc. (best possible version).
- **Derived spectra products**: Redshifts, parametric and non-parametric estimates of line fluxes and shapes; line luminosities, widths, skew, outflows, continuum template fits to spectral libraries; associated MCMC error propagation.
- **Host galaxy products**: stellar age/SFH, metallicity, kinematics, SFR, stellar mass, extinction, AGN fraction
- **AGN products**: AGN type, continuum slope; M_{BH} and L/L_{Edd} when broad line(s) present;

Extra L2 products

- **Outlier detection:** rogue line-of-sight absorbers, emission lines; cross-check on quality flags
- **Lensed**: redshifts of both lens and source when possible, confirmation "flag"
- **TDEs**: TDE properties if observed, host properties
- **DLAs**: database w/ redshift, N_{HI}
- **AGN**: NLR/BLR decrements/extinction, BPT/ionization info, NLR metallicity; Matched photometry SEDs, spectral variability, AGN variability structure functions

Contributions to IWGs

- Survey Strategy (TA, FEB, PG)
  - 1 Liaison

- Selection Functions (PA, PC, DdC, PL, PSS, ET)
  - 1 Liaison

- L2 Extragalactic Pipeline (PA, MB, IC, YD, EL, FR)
  - Chilingarian Group => spectral fitting pipeline prototype in hand

- L2 Classification Pipeline (PA, MB, IC, YD, EL, FR, PSS)
  - Boquien Group => CIGALE multi-wavelength photometry+spectral fitting => physical properties
  - Sanchez-Saez/Lira/De Cicco => machine-learning classification work