Roman Early-Definition Astrophysics Survey Opportunity:

(1) Survey Name: Obscured AGN - Hiding High Growth at the Cosmic Noon

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(4) Do you support the selection of a Roman Early-Definition Astrophysics Survey (as described in the "Request for Information"; yes/no, with supporting motivation, 10 lines max):

Yes. Roman is poised to make impressive strides forward in the study of dark energy, exoplanet coronography, and time domain. It will also revolutionize our understanding of general astrophysics problems associated with galaxy growth at the cosmic noon. Roman's imaging data products will be unparalleled in sensitivity, spatial resolution, and precision of point spread function (PSF) characterization. However, the combination of deep imaging and grism spectroscopy is required to quantify the factors driving galaxy and black hole growth. Combining imaging and slitless spectroscopy of 24-26 H-band magnitude galaxies is a powerful way to study galaxies and the processes that shape them but needs carefully and efficiently derived calibration products and observing strategies. Developing such techniques requires time and a wide range of skills. The selection of a Roman-Early definition project will facilitate this effort.

(5) Describe the science investigations enabled by the survey (briefly describe: key science drivers and breadth of science areas engaged; datasets; comparison of science with respect to ground/space-based state-of-the-art at time of Roman launch; key differences from, and/or complementarities with, Roman core community surveys; one page max):

Key science drivers: Most bulge-dominated galaxies host black holes with masses that tightly correlate with the masses of their bulges. This may indicate that the black holes regulate galaxy growth, or vice versa, or that they may grow in lock-step. The quest to understand how, when, and where those black-holes formed motivates much of extragalactic astronomy. An important part of the puzzle is the evolution of galaxies with active black holes in their nuclei (active galactic nuclei or AGN), that are fully or partially hidden by dust and gas (extinction > 1 & H mAB > 22). The number density of MIR-selected obscured AGN (Av >1) peaks at a higher redshift (z ~ 2-3) than that of unobscured AGN [1]. At the peak epoch for galaxy and BH growth, the most luminous quasars are also the most dust reddened, and they are major mergers [1-4] (Figure 1). Evolutionary differences between obscured and unobscured sources may be driven by the increased frequency of major mergers of gas rich galaxies at high redshift. Those conclusions come from painstaking ground optical and NIR observations of hundreds MIR-selected AGN. Higher sensitivity spectroscopy that is unaffected by the atmosphere is needed to probe the high z regime and measure the molecular and nebular lines required for significant progress. By targeting obscured quasars and fainter AGN we get a statistically sound handle on their demographics, SFR, and impact of stellar and AGN feedback.
Datasets expected; With Roman's WFI-grism we can efficiently measure ionized and hot molecular gas emission lines, probing star-formation, AGN feedback, and gas flows in and between galaxies and the CGM. Grism spectra will also reveal obscured AGNs based on the high equivalent widths of narrow emission lines (Lya, CIV, and Mg II).
Synergies: Current and future IR, X-ray, and radio campaigns that will find millions of AGN. In the IR the SPHEREx mission [9] will survey the whole sky at a 6" spatial resolution, and will isolate AGN based on their MIR colors. However, given its poor angular resolution, SPHEREx will require follow-up observations. The X-ray eROSITA mission [10] is poised to detect on the order of 10^5 obscured AGN, thousands of which are expected to be the so far elusive Compton-thick AGN with obscuring column densities greater than 10^{24} cm^{-2}. Pinning down the fraction and evolution of those most obscured AGN is essential to our understanding of their evolution. Several ongoing and planned radio projects will reach unprecedented sensitivity levels μJy over wide fields and are complementary in terms of resolution, frequency and observing epochs, facilitating time-domain AGN studies. These surveys will elucidate the role of radio-jetted AGN in shaping the environment of both their host galaxy and the circumgalactic medium. The Jansky-Very Large Array Sky Survey (VLASS) [7,8] , the LOFAR Two-meter Sky Survey (LoTSS) [14], MeerKAT/MIGHTEE [11] surveys will require wide-field, highly multiplexed spectroscopy to distinguish between high- and low-excitation accretion modes via analysis of emission line ratios and to study triggering processes for both radiatively efficient and inefficient AGN in the early Universe. The next generation of X-ray, radio, and imaging wide field/all sky surveys must be leveraged by efficient spectroscopic surveys in the optical and NIR to obtain redshifts, and confirm AGN classifications. Ground-based NIR spectroscopy of such faint sources is inhibited by the rapidly changing atmosphere. Comparison with Roman core surveys: This proposed survey is ~100 deeper than wide field core survey.

(6) Provide a possible observational outline of the survey (as relevant/known, touch upon: survey area covered, possible location, and/or (types of) targets observed; optical element (filters/grism/prism) choices; cadence or other timing constraint (if relevant); depth to be achieved; total time needed including estimated overheads; how the survey leverages the unique observational capabilities of Roman; half-a-page max):

Field name and properties	Spatial coverage and dithering	Sensitivity required using optical element:GRISM
XMM-LSS and COSMOS fields -coverage includes ~μJy Spitzer IRAC (MIR), and radio and imaging with the Very Large Array [5,6,7], + target for Rubin LSST deep drilling fields [5]	Central RA & Dec (J2000) XMM-LSS 02:22:18, -04:49:00 COSMOS 10:00:26, +02:14:01 We will mosaic and dither to account for any bad pixels and gaps between detectors.	We used the https://roman.gsfc.nasa.gov/science/apttables2021/table-grism.html to estimate that a continuum SN of 5 for a 23 magnitude at 1µm, target requires 26 hours of integrations. We will combine 312 five - minute exposures per pointing with 8min overheads per hour of exposure. The exposures will be dithered. Reads with saturated sources will be flagged to mask the saturated sources, spectra obtained from multiple roll-angles will be processed and and combined with reads from other exposures at the same roll angle hours to push the sensitivity limit. We estimate overheads as similar to WFC3 IR grism which has a different guiding technique and may be an overestimate. This will amount to 30h per pointing and 120h for all four pointings for each requested field.

Types of targets of interest: Obscured AGN selected from MIR colors (from IRAC or WISE) and/or X-ray missions like eROSITA. The ~1 degree field is needed to have sufficient statistics at a wide range of obscurations from blue, optically luminous QSOs to Compton Thick AGN.
Cadence: No timing constraints.
The unique capability of slitless spectroscopy with Roman will create a dataset that will allow a broad segment of the astronomical community to pursue a wide range of investigations of galaxy evolution, AGN and star-formation feedback, impacts of galaxy environments on black hole and galaxy growth.

7) Describe specific preparatory activities enabled by early definition (e.g., supporting facility observations, software development work, theoretical/simulation efforts etc.; describe the benefits of conducting these activities early; half-a-page max):

We will support grism emission-line deblending algorithms and explore the use of machine learning techniques employed on large imaging and spectroscopic data sets that appear effective at matching galaxy shapes and spectra [13]. This code was developed specifically to augment the scientific results of spectroscopically-limited galaxy samples and testing it on the faintest, farthest targets using the proposed grism data will benefit multiple surveys.

References:

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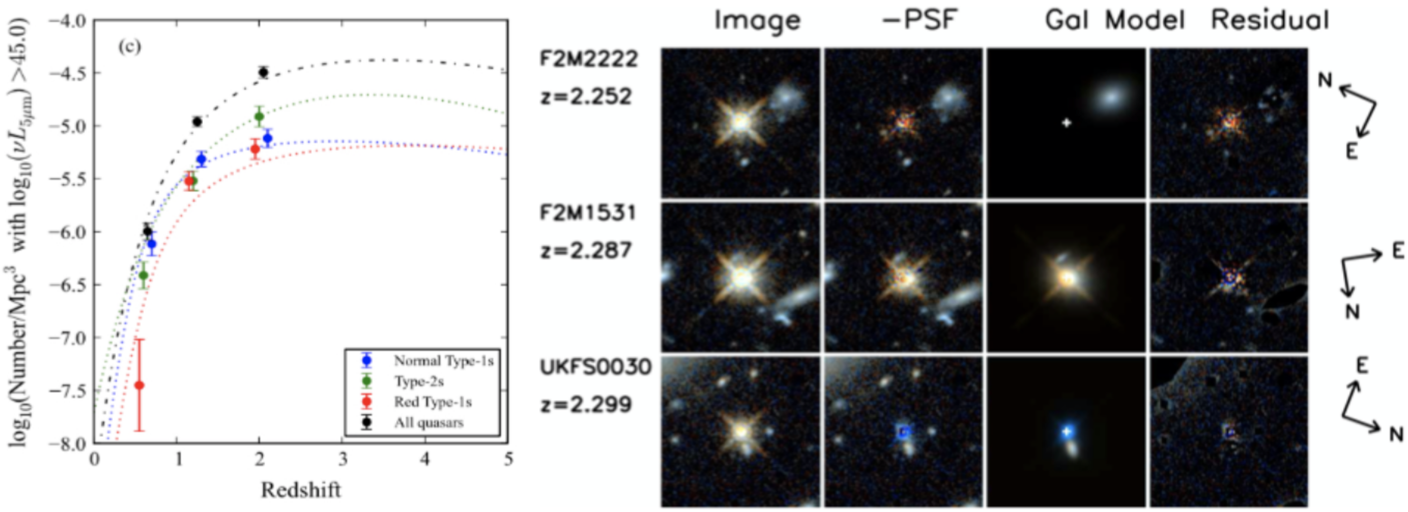

FIGURE 1 (**Left:**) Figure from (Lacy et al., 2015) showing the evolution by type of AGN from a survey of MIR selected AGN. Although only 13 objects of any type at $z \geq 2.8$ were included in this analysis, the difference in evolution between obscured and non-obscured AGN is intriguing and underscores the importance of optical-to-NIR AGN surveys with wide aperture telescopes (for sensitivity), a wide field, and multi-object (for efficient follow up of radio and X-ray deep surveys). (**Right:**) Figure 5 from (Glikman et al., 2015)(reproduced with permission) show HST WFC3/IR images of z 2, luminous, red-quasars that suggest the host galaxies are mergers.