



Legacy Science with Euclid: Active Galactic Nuclei and their Host Galaxies

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WP9: Active Galactic Nuclei

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AGN identification

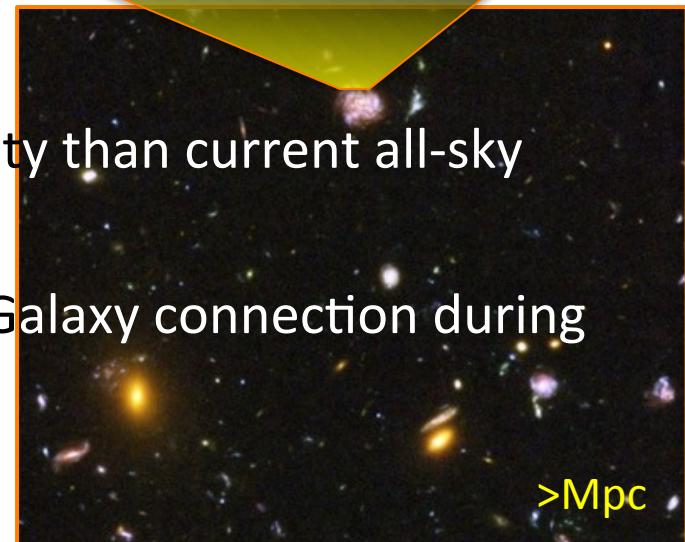
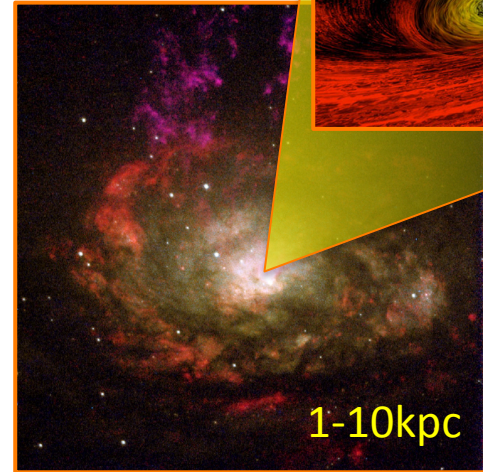
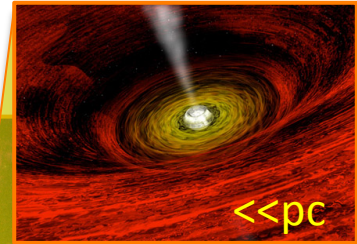
→ AGN Database useable by all other WPs

AGN studies:

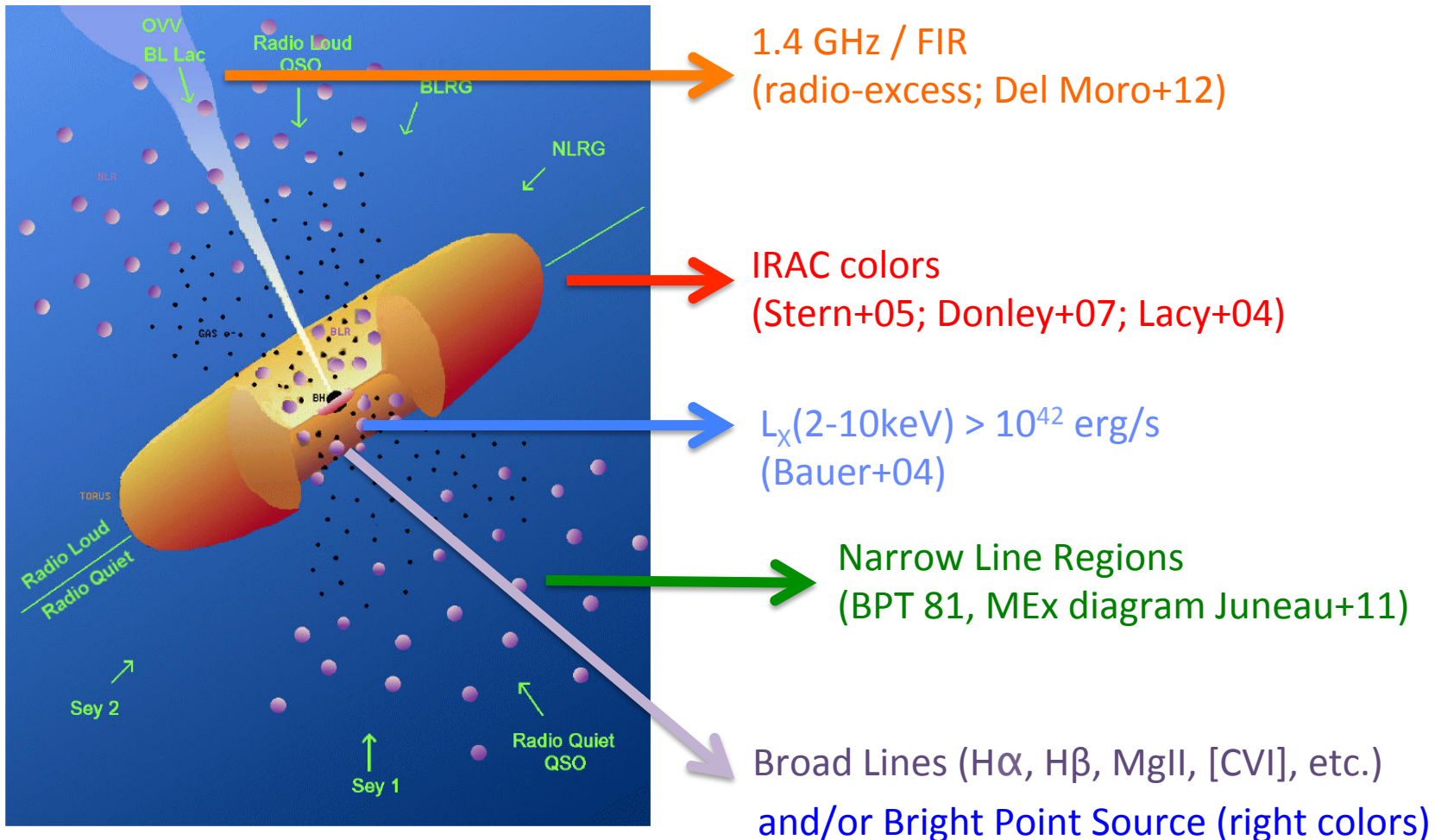
- AGN triggering/feedback
- AGN obscuration
- BH masses, BH growth budget
- Connection with host galaxies
- Connection with environment

Probe of luminous objects with more sensitivity than current all-sky AGN surveys (+ get host galaxy properties!)

Improved understanding of the Black-Hole – Galaxy connection during the peak epoch of activity ($z \sim 2$)



AGN Unification Model

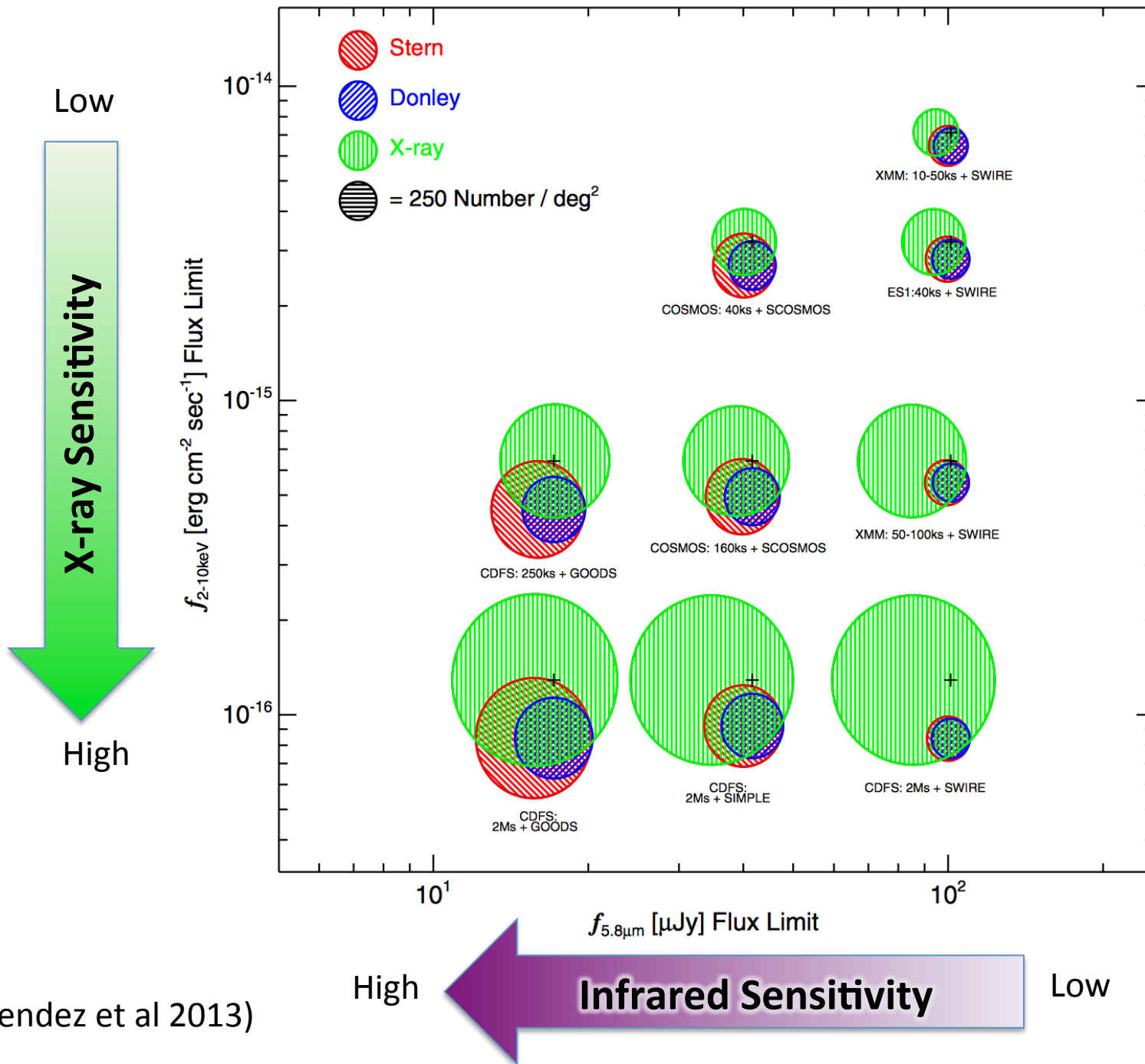


[Antonucci 1984; Urry & Padovani 1995]

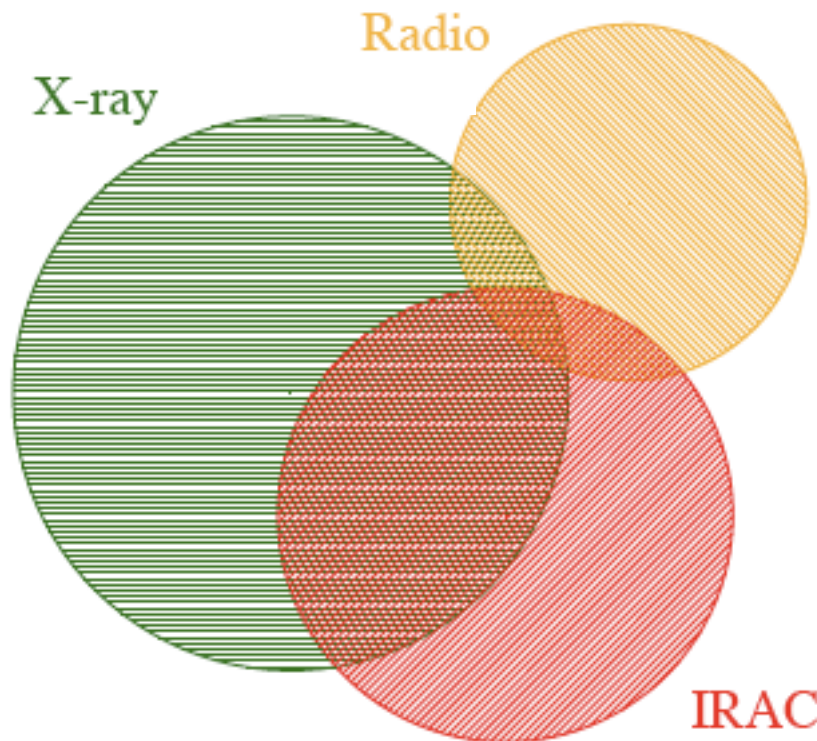
AGN Identification: Pros & Cons

Regime	Advantages	Limitations
Radio (e.g., 1.4 GHz / FIR)	<ul style="list-style-type: none">• Dust insensitive• Can get high resolution in some systems (VLBI)	<ul style="list-style-type: none">• Radio loudness is rare (and not fully understood?)• Limited sensitivity
Mid-IR (IRAC or WISE colors)	<ul style="list-style-type: none">• Both obscured and unobscured AGNs• All sky with WISE (rare populations)	<ul style="list-style-type: none">• Limited sensitivity ($L_x > 10^{43}$ erg/s)• Need contrast with SF in host
Optical (Colors or emission lines [BPT, MEx, etc.])	<ul style="list-style-type: none">• Most sensitive ($L_x < 10^{41}$ erg/s)• Can detect Compton-thick AGNs (geometry)	<ul style="list-style-type: none">• Dust obscuration from host/ Optical elusive cases• Spectroscopy is expensive
X-rays (luminosity or excess)	<ul style="list-style-type: none">• Reliable tracer (> 2 keV)• Intermediate sensitivity (better than mid-IR colors)	<ul style="list-style-type: none">• Compton-thick AGNs (even hard w/ NuSTAR)• Ambiguous at low luminosities ($< 10^{42}$)

(Mendez et al 2013)



AGN Selection Comparison / Overlap



- These AGNs live in different host galaxies!
- → *not* multiple views of the same system
- → different evolutionary paths and/or different points along an evolutionary path? (e.g., Hopkins+2008; Hickox+2009; Alexander & Hickox 2012)

Hickox+ 2009 (also Juneau+ 2013, Menzel+ 2015)

AGN Identification: Methods

- Euclid “internal” identification of AGNs:
 - NIR spectroscopy
 - Broad lines (type 1): a few 10^5 at $0.9 < z < 9$
 - Narrow lines (type 2): ~ 8000 from $[\text{NII}]/\text{H}\alpha$; 2.7×10^4 from $[\text{OIII}]/\text{H}\beta$
 - Imaging
 - Point-sources (w/ OU-PHZ)
 - SED fitting (w/ GAWG-WP1; OU-PHZ)
 - Variability
- Euclid “external” identification of AGNs:
 - Ancillary data (OU-MER?)
 - X-ray (e.g., eROSITA)
 - MIR/FIR? (e.g., WISE)
 - Radio
 - Follow-up surveys

AGN Identification: Challenges

- Limited spectral resolution $R \sim 250$
 - Blending of key emission lines ($H\alpha + [NII]$) (w/ WP2)
- Limited availability of given sets of diagnostic emission lines (for Type 2 AGN)
 - “BPT” lines only at $1.5 < z < 1.8$ (red) or $1 < z < 1.8$ (red+blue)
 - $[NII]/H\alpha$ at $0.9 < z < 1.8$ (red) or $0.4 < z < 1.8$ (red+blue)
 - $[OIII]/H\beta$ at $1.5 < z < 2.7$ (red) or $1.0 < z < 2.7$ (red+blue)
 - Behavior of emission line diagnostics at high redshift? (e.g., Kewley+2013a,b; Juneau+2014, Steidel+2014)
- Heterogeneous selection/detection limits from multi-wavelength AGN studies (X-ray, Infrared, etc.)

AGN Identification: Challenges

- Close collaboration w/ OU-PHZ (AGN WP coord. Salvato):

Q1: Are we using an homogenised classification, or, when possible we go deeper and use more data?

or Q2: How do we take into account the different data depth? How we document that?

TODO:

1) see at which depth you can extend the various methods

2) Check ALLWISE vs. UNWISE

3) Check ability in computing photo for non X-ray AGN.

AGN Identification: Progress

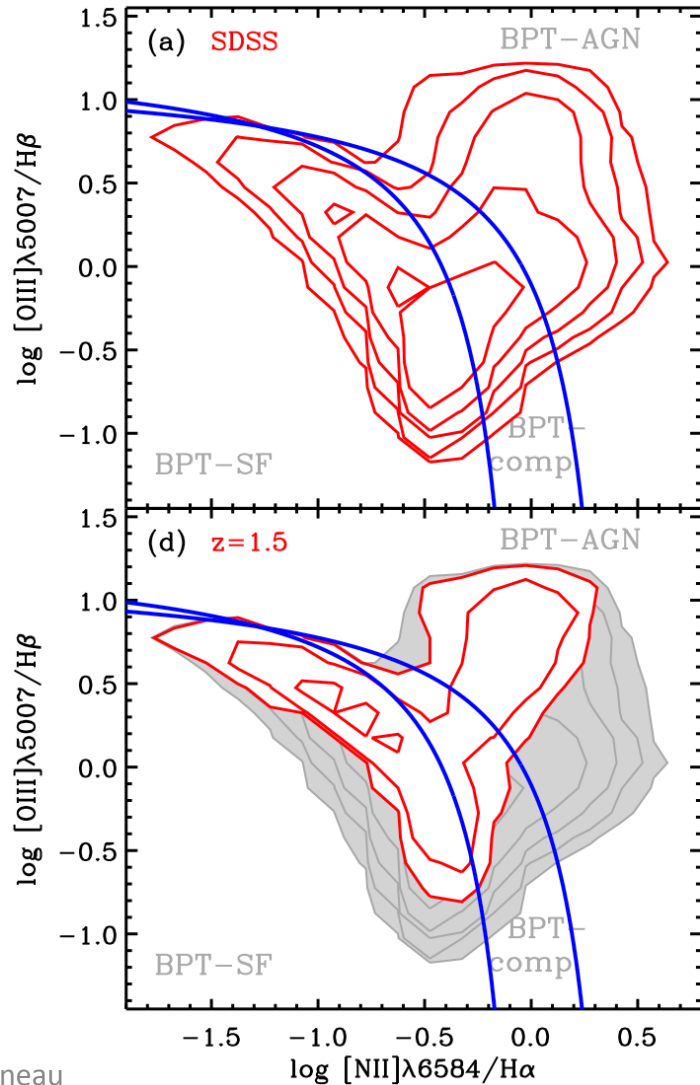
- Close collaboration w/ OU-PHZ (AGN WP coord. Salvato):
 - Already testing/comparing AGN **identification** methods with existing datasets (SDSS, Stripe82-X, XMM-XXL, WISE, AllWISE, ...)
 - Already testing/comparing AGN **photo-z** methods (e.g., SED fitting vs. Machine Learning)
 - Ongoing work on testing emission-line diagnostics at redshift >1
- At OU-PHZ level (required for main mission; coord. Paltani):
 - For proper object classification, we need a spectroscopic training set (ongoing effort in North by Capak+)
 - + need another spec-z sample to verify the accuracy (independent from training set)

Expected Scientific Outcome

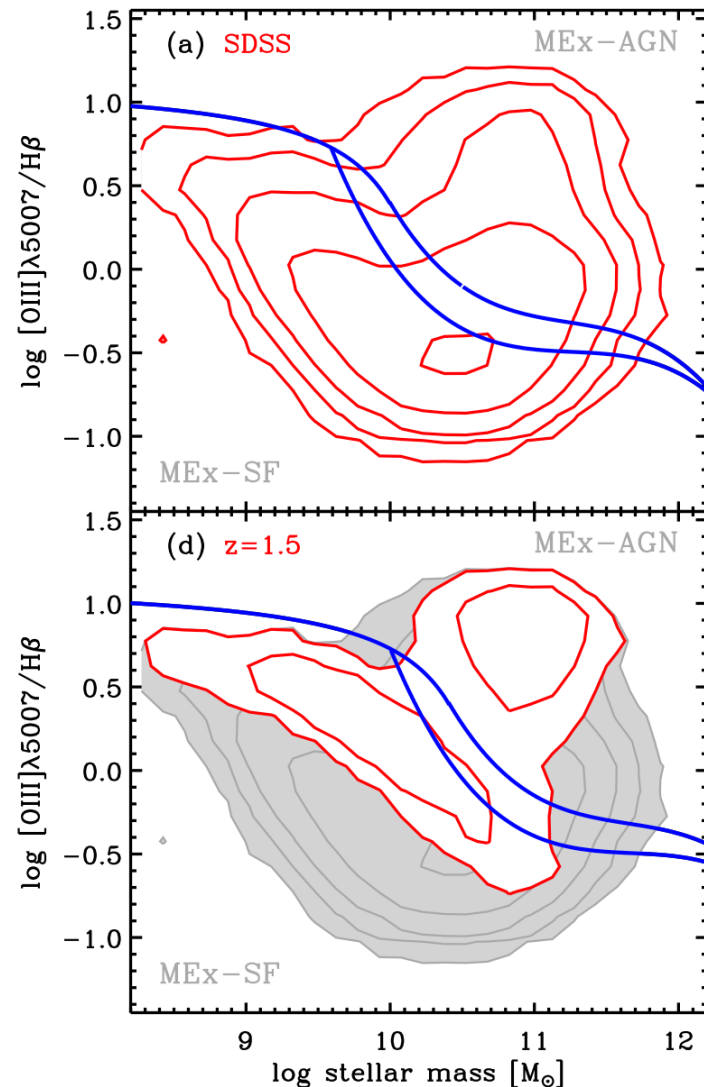
- Key insights into Galaxy Evolution:
 - Black-Hole – Galaxy connection during the peak epoch of activity ($z \sim 2$)
 - First Black Holes (seeds) and their growth across Cosmic time
- Key Euclid advantage: Host galaxy properties such as morphologies (talks by Tasca, Huertas-Company, Duc), and galaxy stellar masses
 - How are BH fueled: galaxy collisions vs. isolated galaxies?
- Large-scale environment/clustering of AGN hosts
 - How are BH fueled: in dense or field environment?
- The most luminous AGNs back to young universe (redshift > 7)
 - The most active growth episodes + earliest supermassive black holes
- **NEEDED:** Multi-wl surveys (eROSITA, WISE, etc.); Close ties with other GAWG WPs and OUs (PHZ and SPE)

Emission-Line Diagnostics

BPT lines at $1 < z < 1.75$ (Deep)



$[\text{OIII}]/\text{H}\beta$ at $1 < z < 2.7$ (Deep)



Updates from AGN Splinter @EC Meeting 2015

Charling Tao

- Variability/Reverberation mapping for cosmology (part of SWG on SNe & Transients); There was a request for an extra survey
- Exact strategy can only be made after we know the cadence for the calibration/deep fields

Marco Mignoli

- [NII]/Ha can be deblended in certain cases, only tested with SF galaxies so far, and only with outdated Euclidized simulations
- Could use the most metal rich galaxies as the closest thing to NL AGN, but no existing simulations of type 1s (BL AGNs)
- Need up-to-date simulations of Euclid spectra including galaxy and AGN spectra

Follow-up w/ spectra from the ground

- Michael Strauss mentioned PFS on Subaru: survey will be mostly along the equatorial
- PFS first light 2017 in lab, survey starting in 2019 and will last for 5 years
- Is OU-EXT exploring relationship with PFS for follow-up?

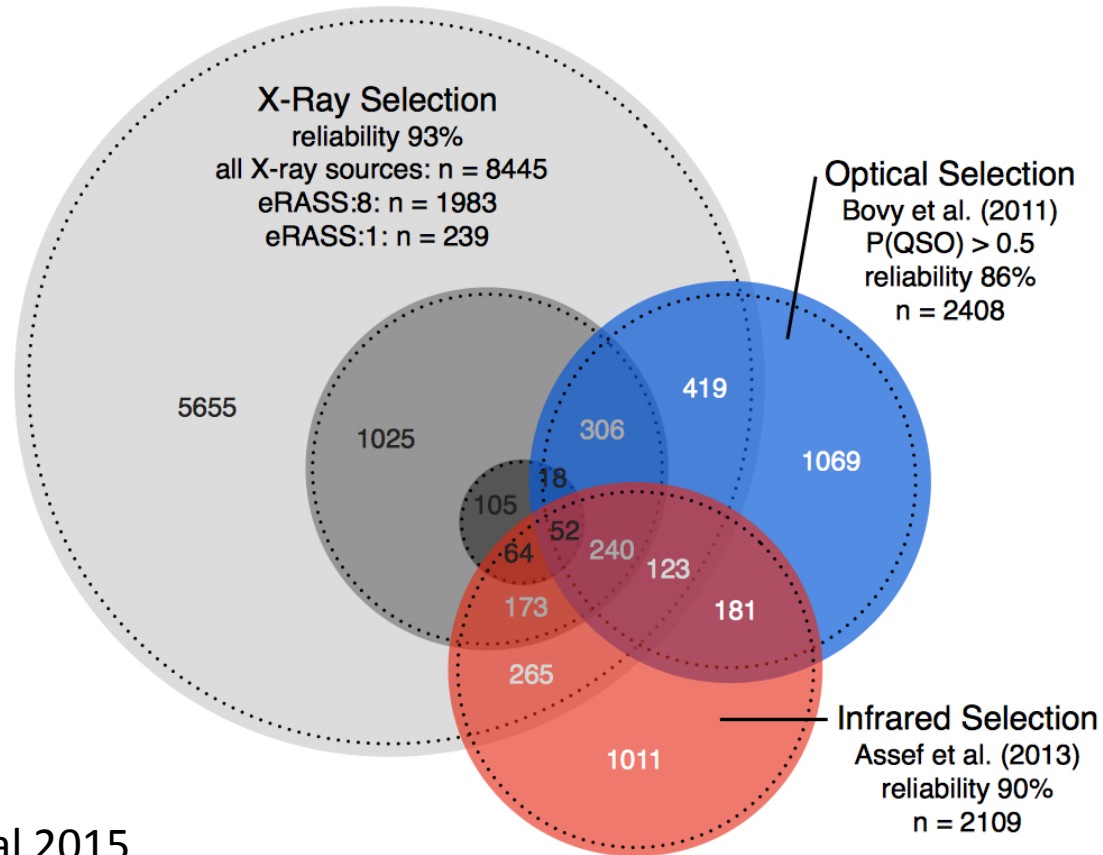
Viola Allevato:

- mock AGN catalogs from semi-empirical models (works with F. Shankar)

Knud Jahnke:

- Need specific questions for diagnostics and/or detectability to send requests for models+sims + Euclidized sims
- Parallel efforts between models and simulations (e.g., Light cones from Durham team), and then compare.
- Define Parameters: e.g., L_{bol} , MBH, (L_{Edd}),

AGN Selection Comparison / Overlap



Menzel et al 2015