Improved Methods to Identify Active Galactic Nuclei

(AKA where are the giant black holes?)

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Black Holes in Galaxies

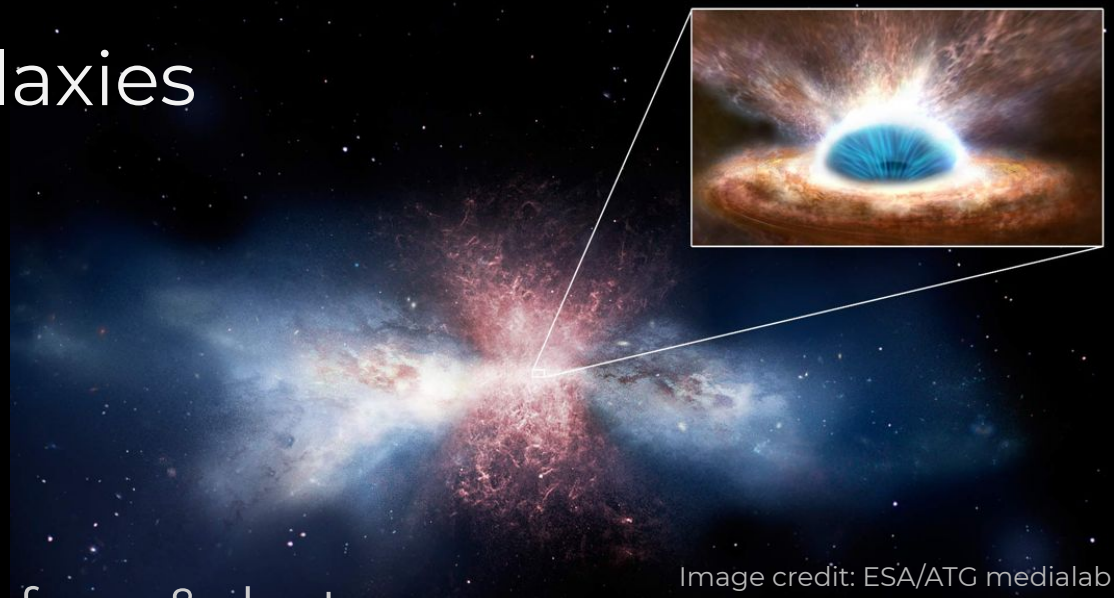

Image credit: ESA/ATG medialab

- Live in galaxy centers
- Feed on a bright disk of gas & dust
- May be “hidden” behind dust & gas clouds
- Create fast winds plowing through galaxies

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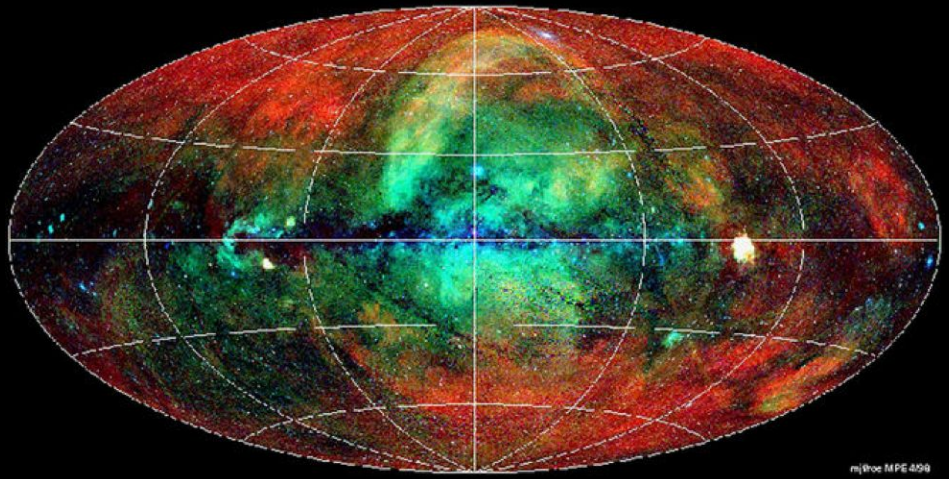
How many *missing* black holes?



1- Measure all energetic X-ray light (“Cosmic X-ray background”)

2- Count known black hole sources

→ *Does not add up !* (deficit at highest X-ray energies)

3- What is missing? A population of “hidden” black holes

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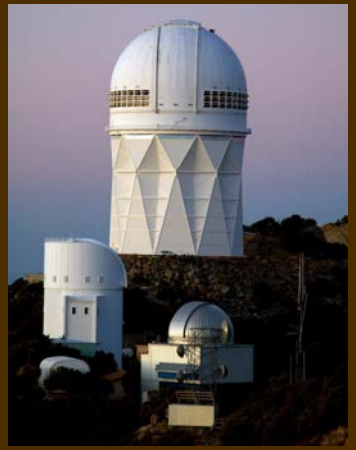
Improved methods to find active black holes

SDSS 2.5m telescope
(APO)

WISE satellite
(NASA)



Mayall 4m & Bok 2.3m
(Kitt Peak, AZ)

Blanco 4m
(Cerro Tololo, Chile)

Joint technique: optical spectroscopy (SDSS) with optical/infrared images from DESI Legacy Surveys to obtain clues (more pieces of the puzzle)

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Photo credits: (1) Fermilab Visual Media Services; (2) NASA/JPL-Caltech; (3 & 4) P. Marenfeld & NOIRLab/AURA/NSF

Improved methods to find active black holes

What's new?

- Started with two established methods normally used separately (optical spectroscopy signatures & infrared-colors) + independent black hole signatures from X-ray data to test them

- Combined them in an iterative process that i**mproved each one separately** but… even **more powerful when combined**

- High data quality from the Legacy Surveys was also key!

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Current spectroscopy coverage (redshift<0.2)

SDSS spectrum
Active Black Hole

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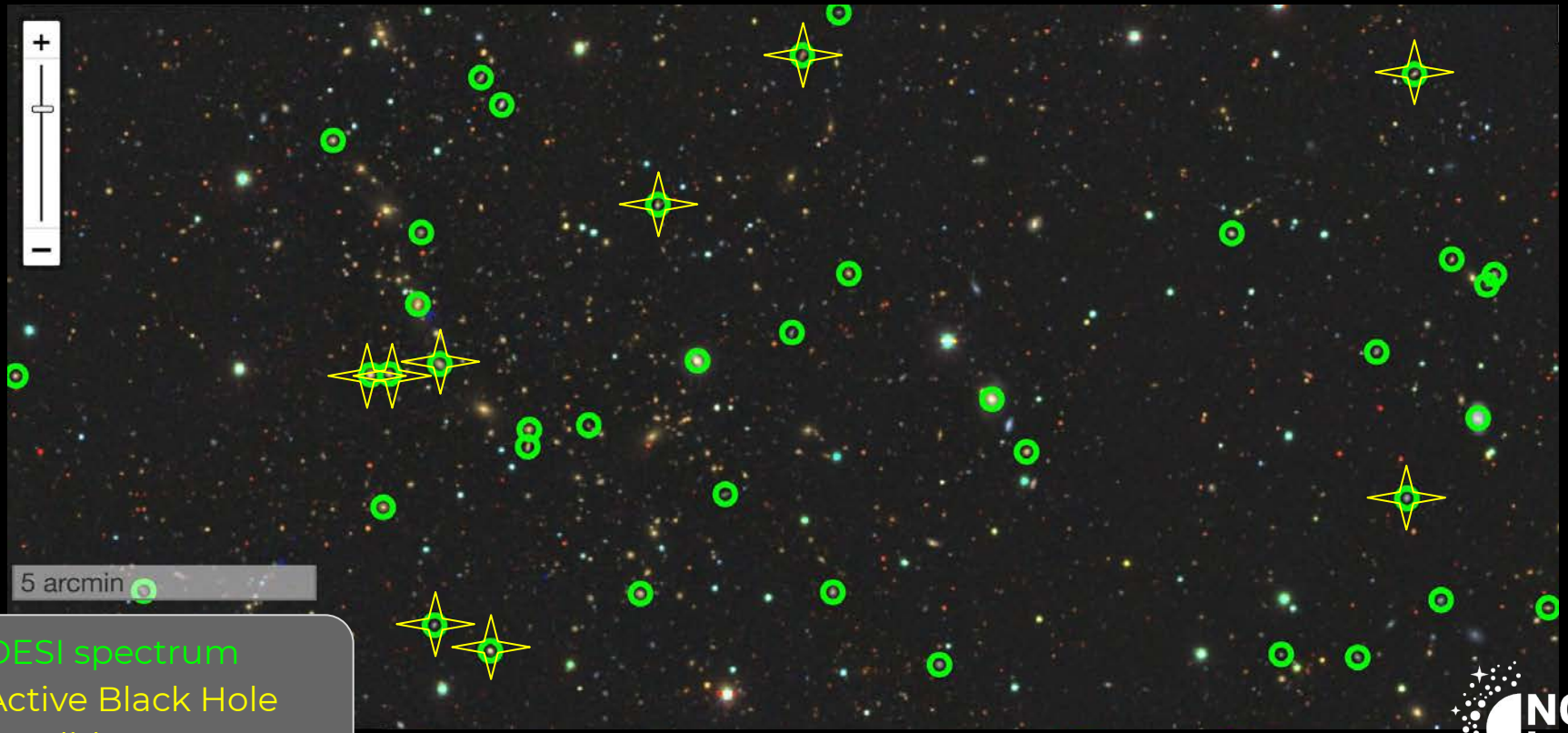
Future spectroscopy coverage (redshift<0.2)



DESI spectrum
Active Black Hole candidate

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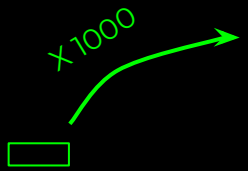
Zooming out!

SDSS sample

colored for active black holes



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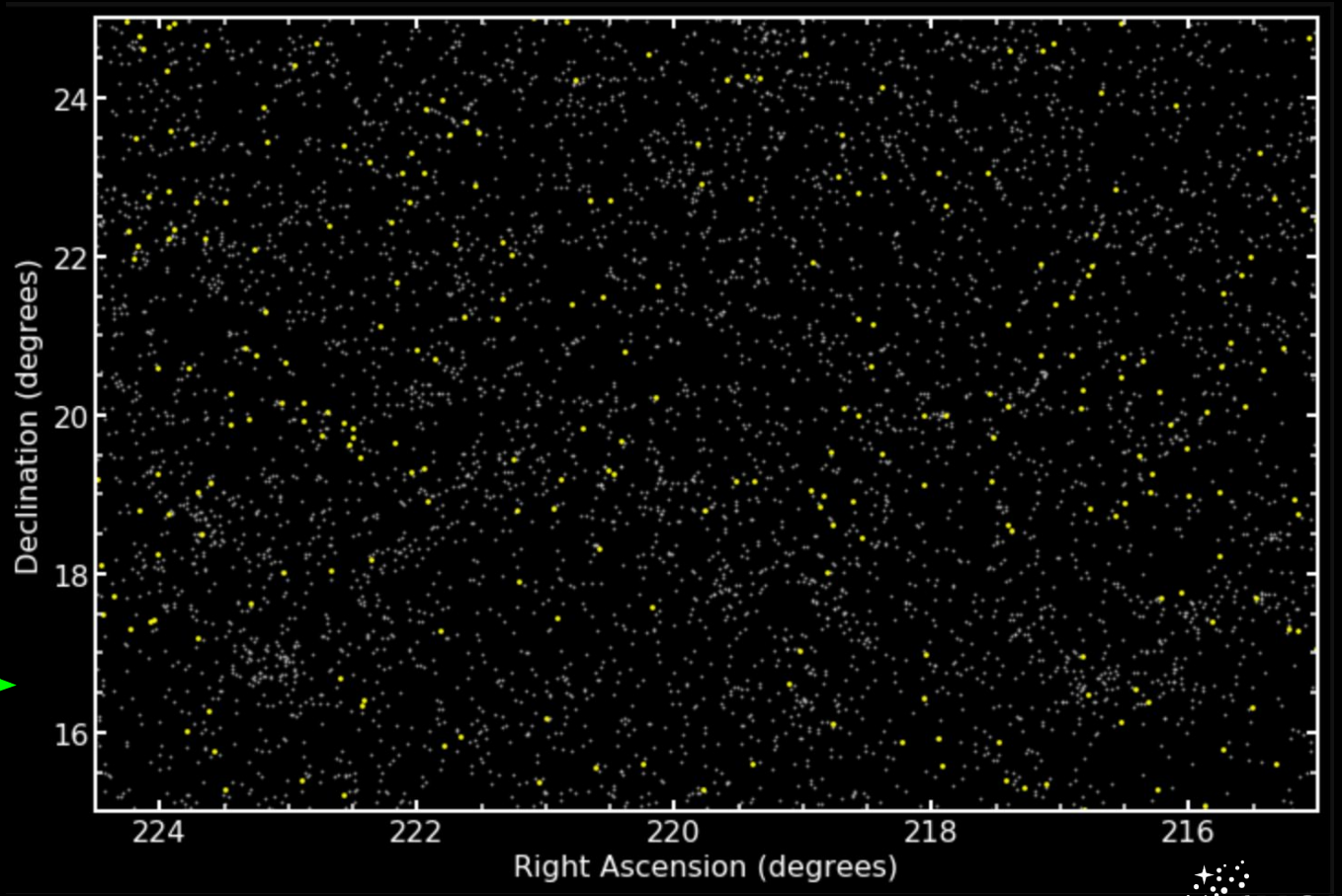

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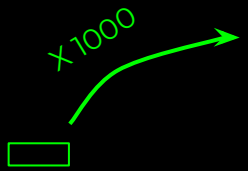
Zooming out!

DESI sample

colored for active

black hole candidates



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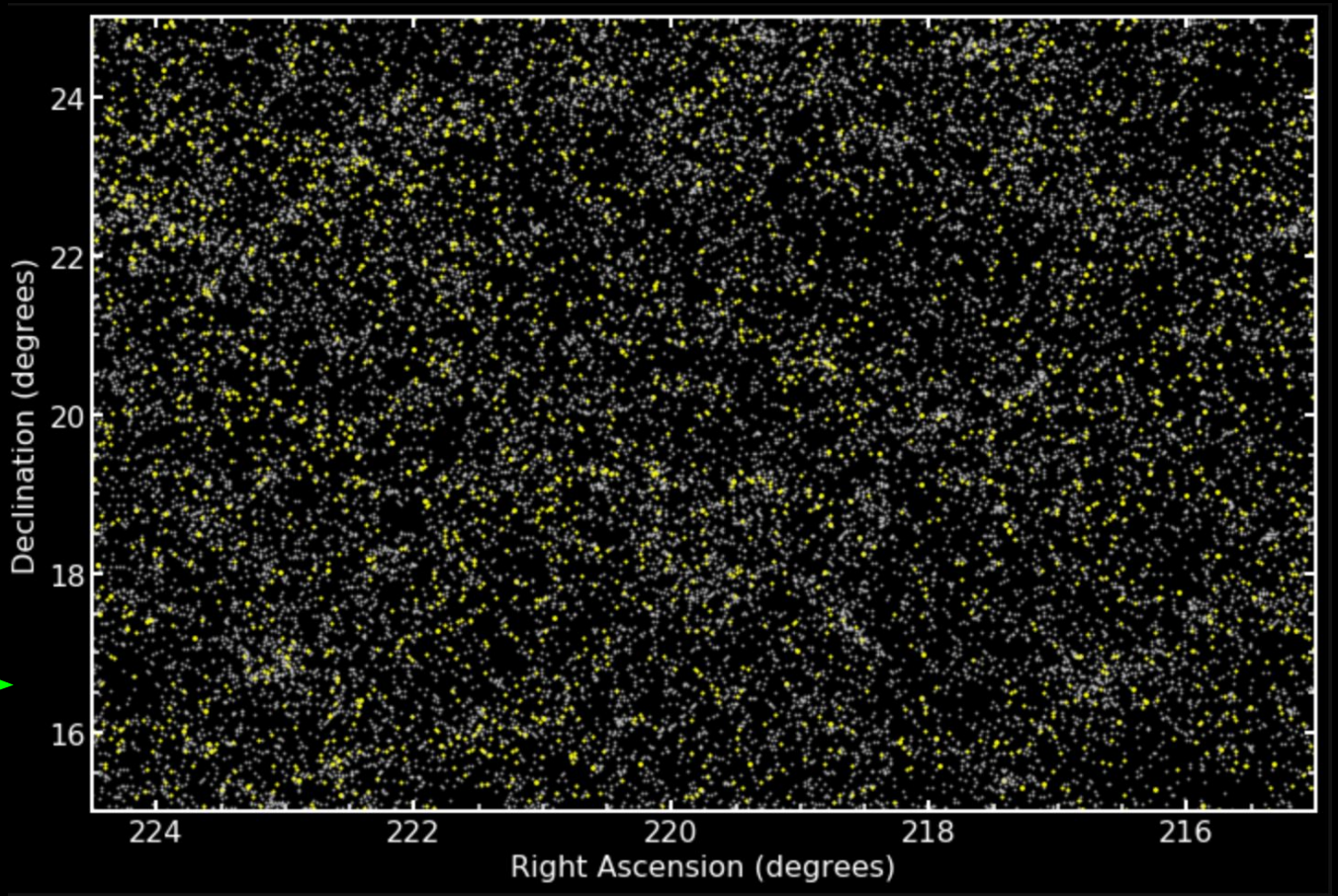

→ Multiply area x 150 for full DESI footprint

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Implications

Think of *active* black holes like light bulbs flickering “on” and “off”...

If the active black holes are confirmed:

- we might find the missing population
- they might spend a large fraction of their time “on”

These findings can impact how we understand:

- the growth of black holes
- their connection to their host galaxies

With our improved method, an exciting path to discovery lies ahead

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Take Away Point

better spectroscopic sampling = more black holes

+ larger survey area = many more black holes

+ improved methods = many, many more black holes

Black holes. Black holes everywhere.

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Take Away Points (longer version)

1. Improved method combining spectroscopy and images (colors) to find active black holes in galaxies (“fine tuning”)

2. Much better census of active black holes including picking up fainter signals (crucial because we can’t study what we can’t find!)

3. Perfectly suited for sky surveys such as DESI; expecting millions of spectroscopic confirmations coming soon (+ new discoveries)!

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