


# **What TMT will (hopefully) tell us about AGNs and SMBHs: beyond first light**

**Yoshiki Matsuoka (Ehime Univ.)**



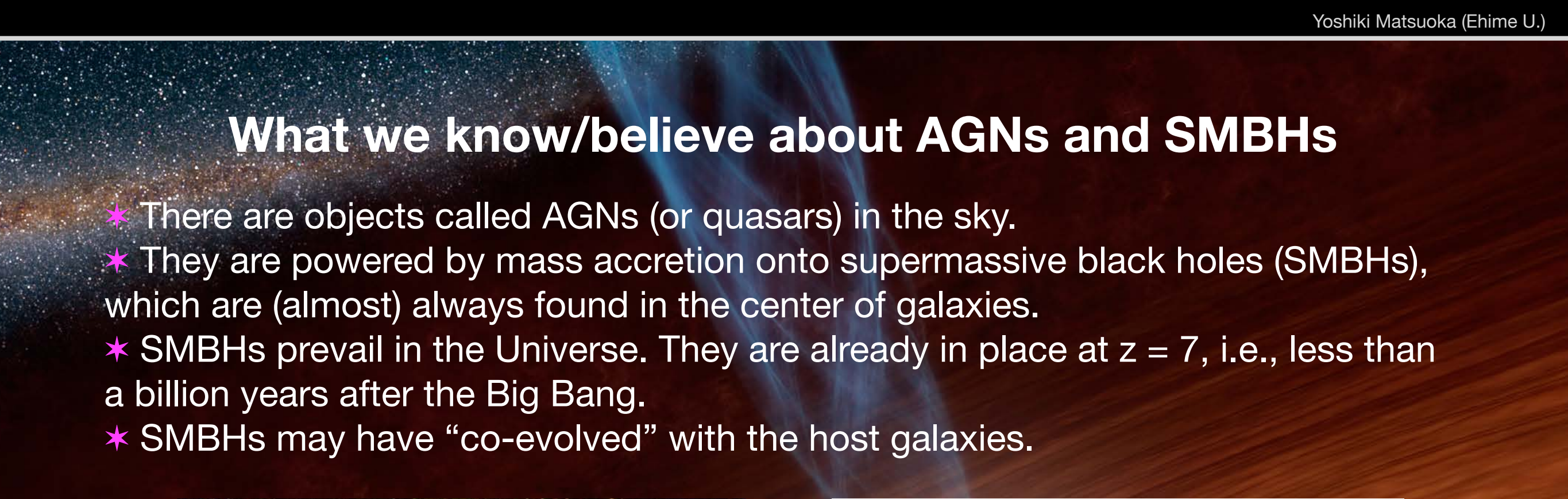
The background of the entire page is a deep space image. At the top center, a bright, glowing spiral galaxy is visible, surrounded by a field of distant stars. In the lower half of the image, the large, white, dome-shaped structure of the TMT telescope is shown. The interior of the dome is illuminated with a warm, yellow light, revealing the complex internal structure and the telescope's primary mirror. The dome is situated on a dark, rocky terrain, likely a mountain peak.

# TMTで切り拓く新しい天文学

TMTサイエンス検討会  
2011年2月

395-page document  
issued in Feb 2011

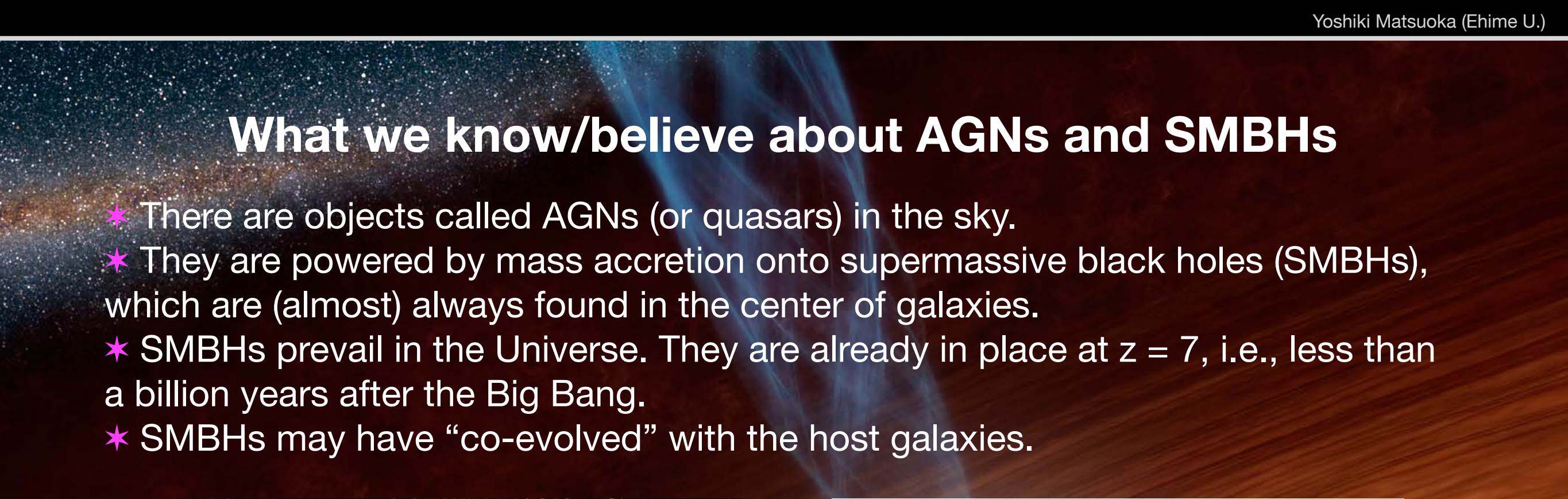


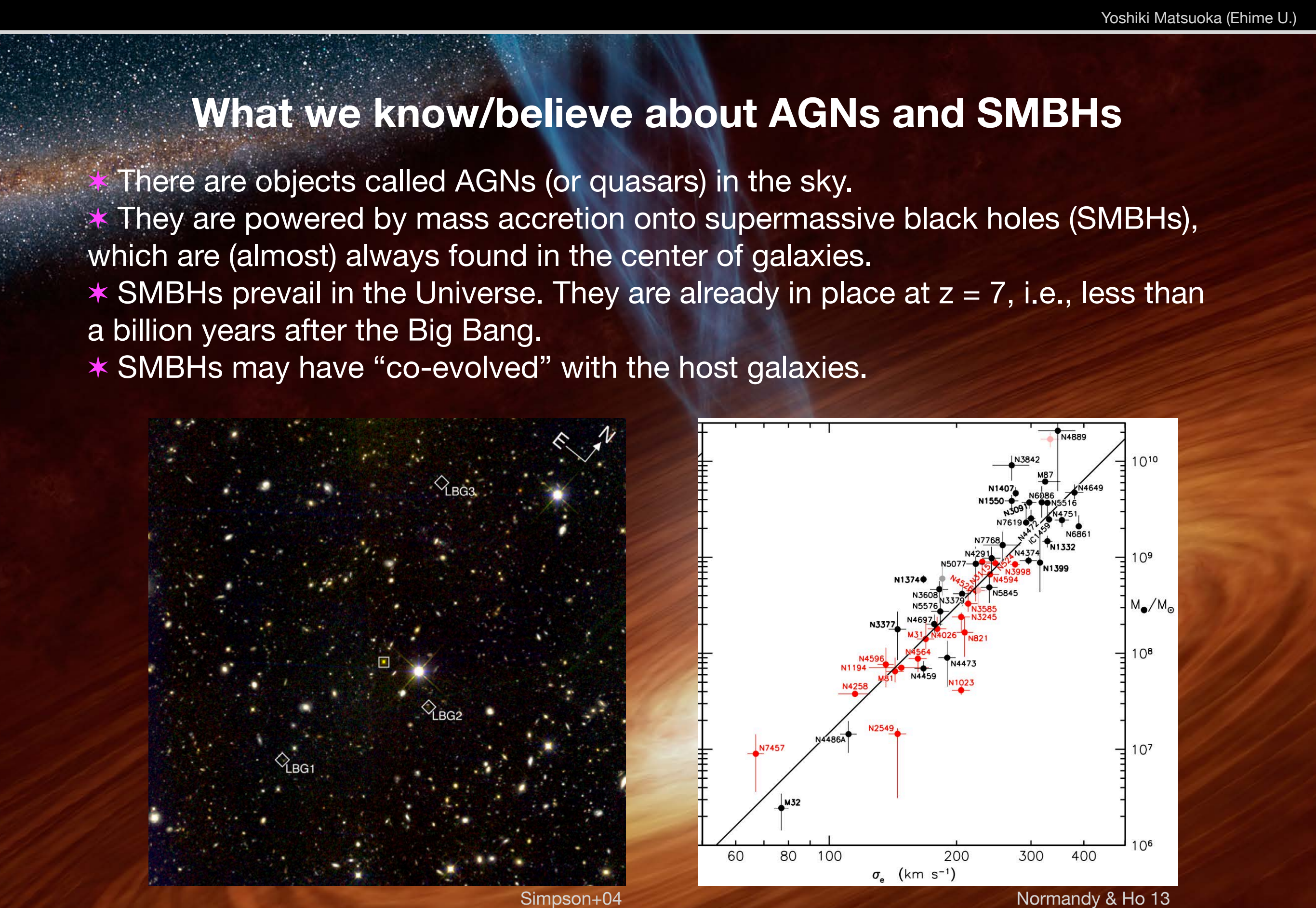
A cosmic background image featuring a deep blue and black star field on the left, transitioning into a vibrant blue and white nebula or galaxy structure on the right. The overall tone is dark and mysterious, typical of astronomical imagery.

Yoshiki Matsuoka (Ehime U.)

## What we know/believe about AGNs and SMBHs

- ★ There are objects called AGNs (or quasars) in the sky.
- ★ They are powered by mass accretion onto supermassive black holes (SMBHs), which are (almost) always found in the center of galaxies.
- ★ SMBHs prevail in the Universe. They are already in place at  $z = 7$ , i.e., less than a billion years after the Big Bang.
- ★ SMBHs may have “co-evolved” with the host galaxies.

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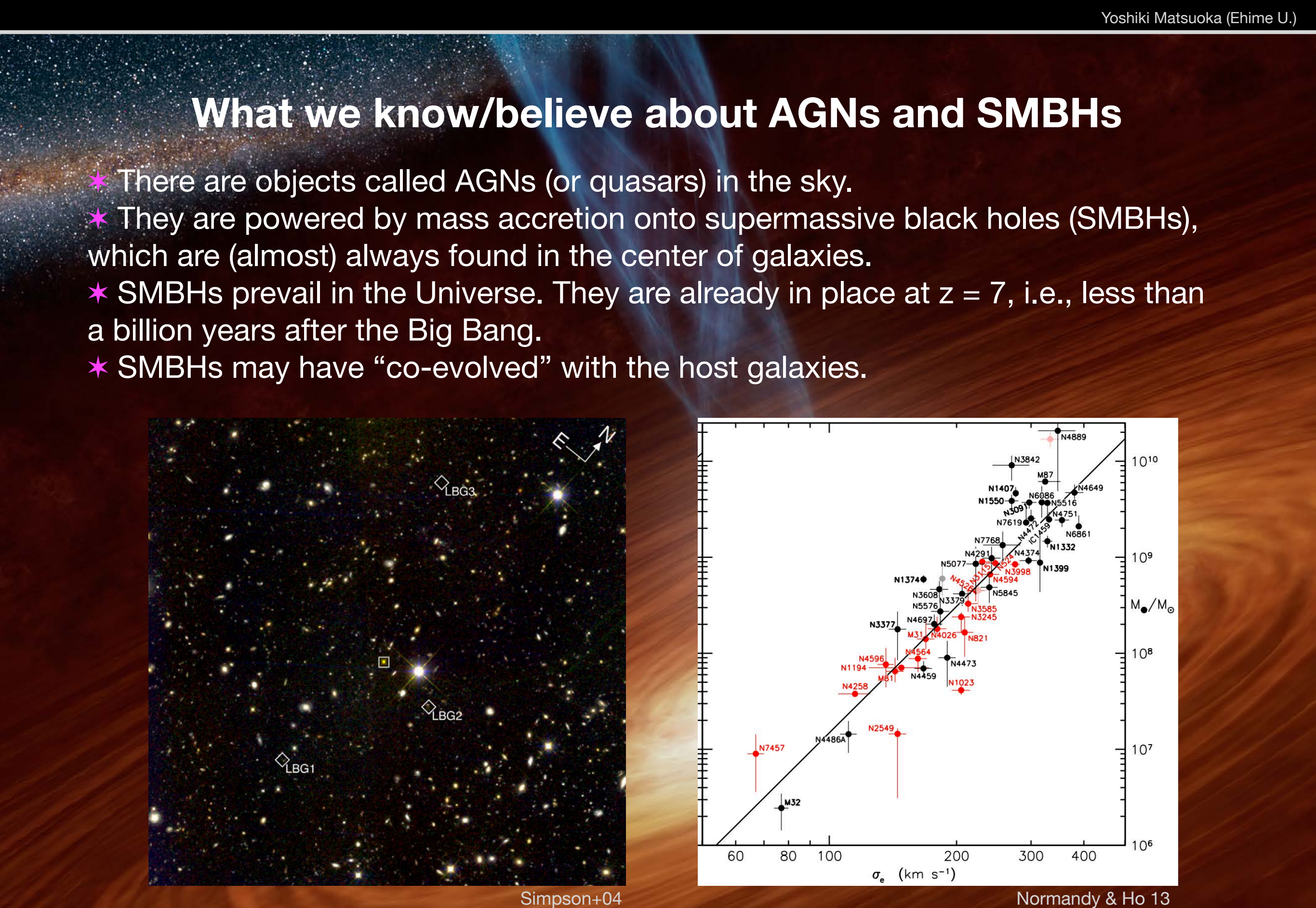


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Simpson+04



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Simpson+04

Normandy & Ho 13



# What we **will** know about AGNs and SMBHs, with **the TMT first-light instruments**

## ★ IRIS + NFIRAOS will:

→ **observe** SMBHs being formed; SMBHs with  $10^7 M_{\text{sun}}$  at  $z = 10$  will be detected in a few hours (if they are shining at the Eddington limit, and not obscured).

→ **find** intermediate-mass black holes (IMBHs) in globular clusters and/or dwarf galaxies, if present (e.g., G1 in M31).

→ **map** the kinematics of ionized/neutral/molecular gas in AGN host galaxies, to look for the signature of the putative “AGN feedback”, with  $\sim 100$  pc resolution even at  $z = 1-2$ .

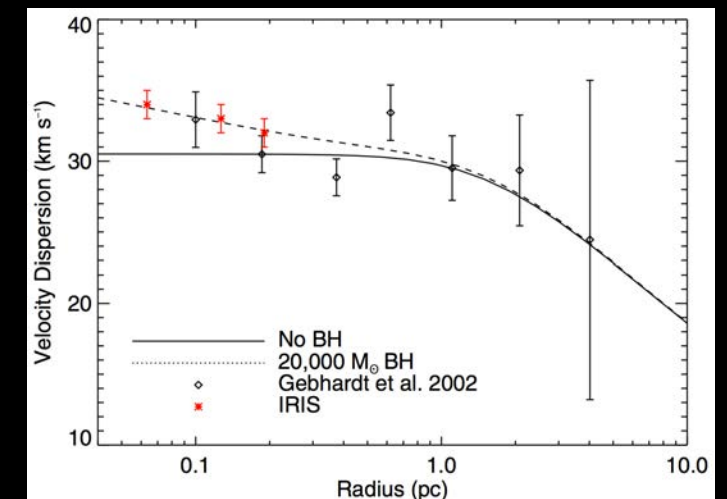
## ★ WFOS will:

→ **identify** a large number of AGNs in optically-faint X-ray sources, as well as in galaxies without significant X-ray emission.

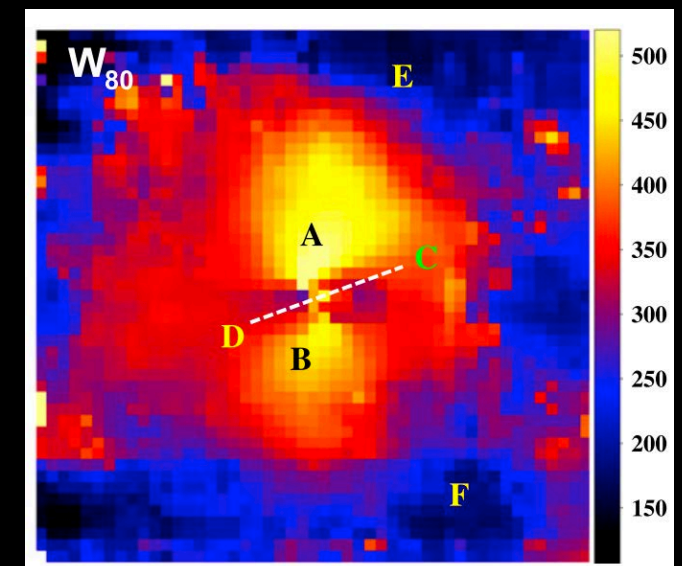
→ **trace** the chemical evolution of galaxy centers close to SMBHs, through measurements of multiple metal emission lines.



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Do+14



Liu+15



# What we **further want to** know about AGNs and SMBHs, with **TMT next-generation instruments**

★ IMBHs in GCs and  
dwarf galaxies

→ *Optical/NIR high-  
resolution spectrograph*

★ AGN torus

★ Energetics of IR  
galaxies

→ *MIR imager + AO*

★ AGN demographics  
at the “cosmic noon”

→ *NIR multi-object  
spectrograph*

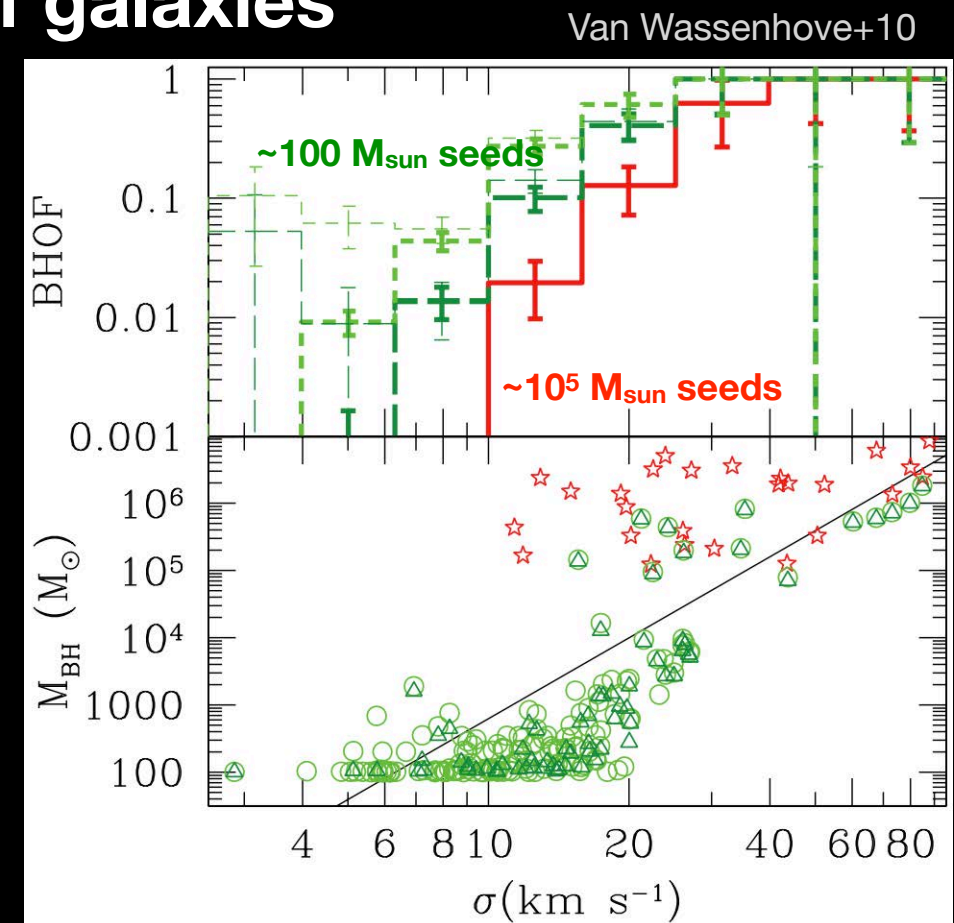




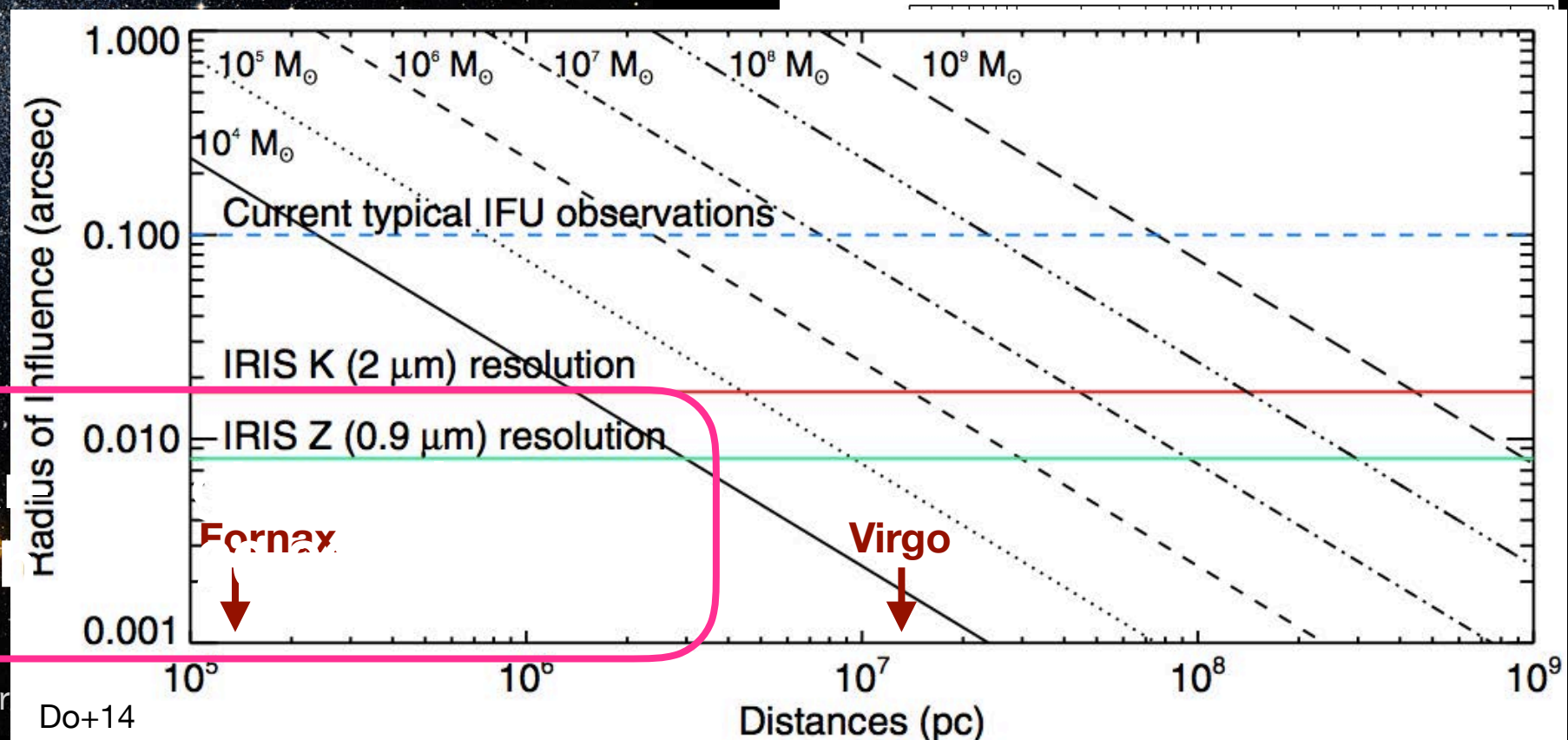
# IMBHs in GCs and dwarf galaxies

## Why do we care?

- SMBH formation
- Origin of the  $M_{\text{BH}} - \sigma_{\text{star}}$  relation



→ Optical/near  
infrared spectrograph

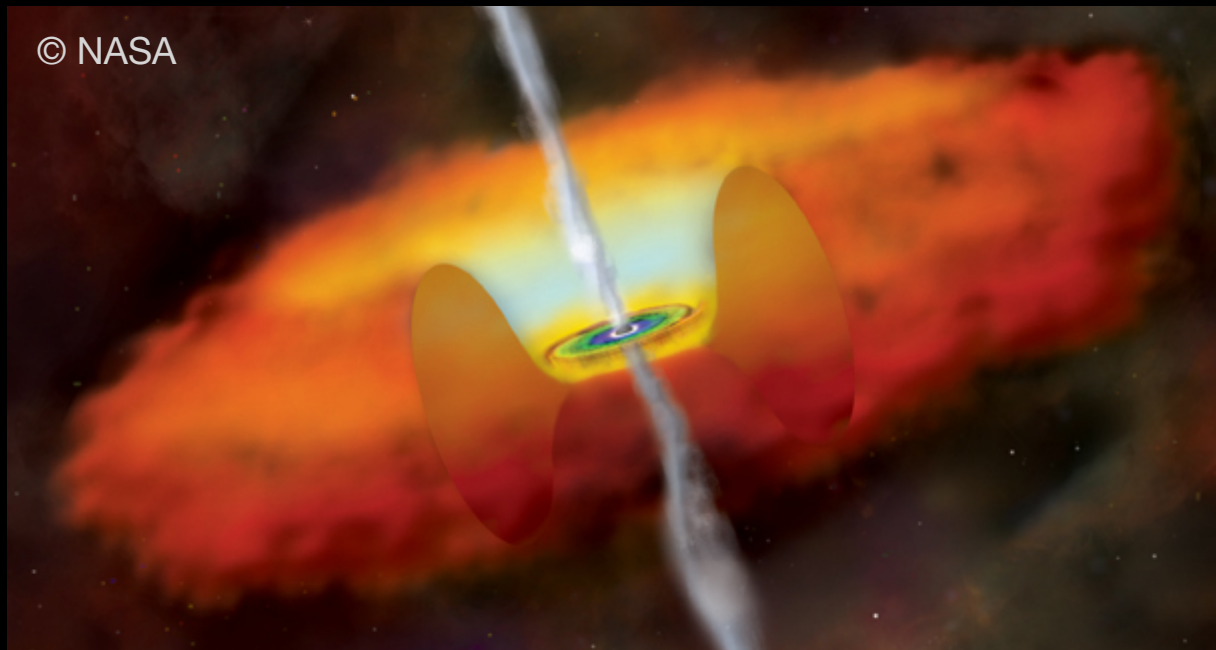


Fornax dSph galaxy (ESO/Digitized Sky Survey)

Do+14

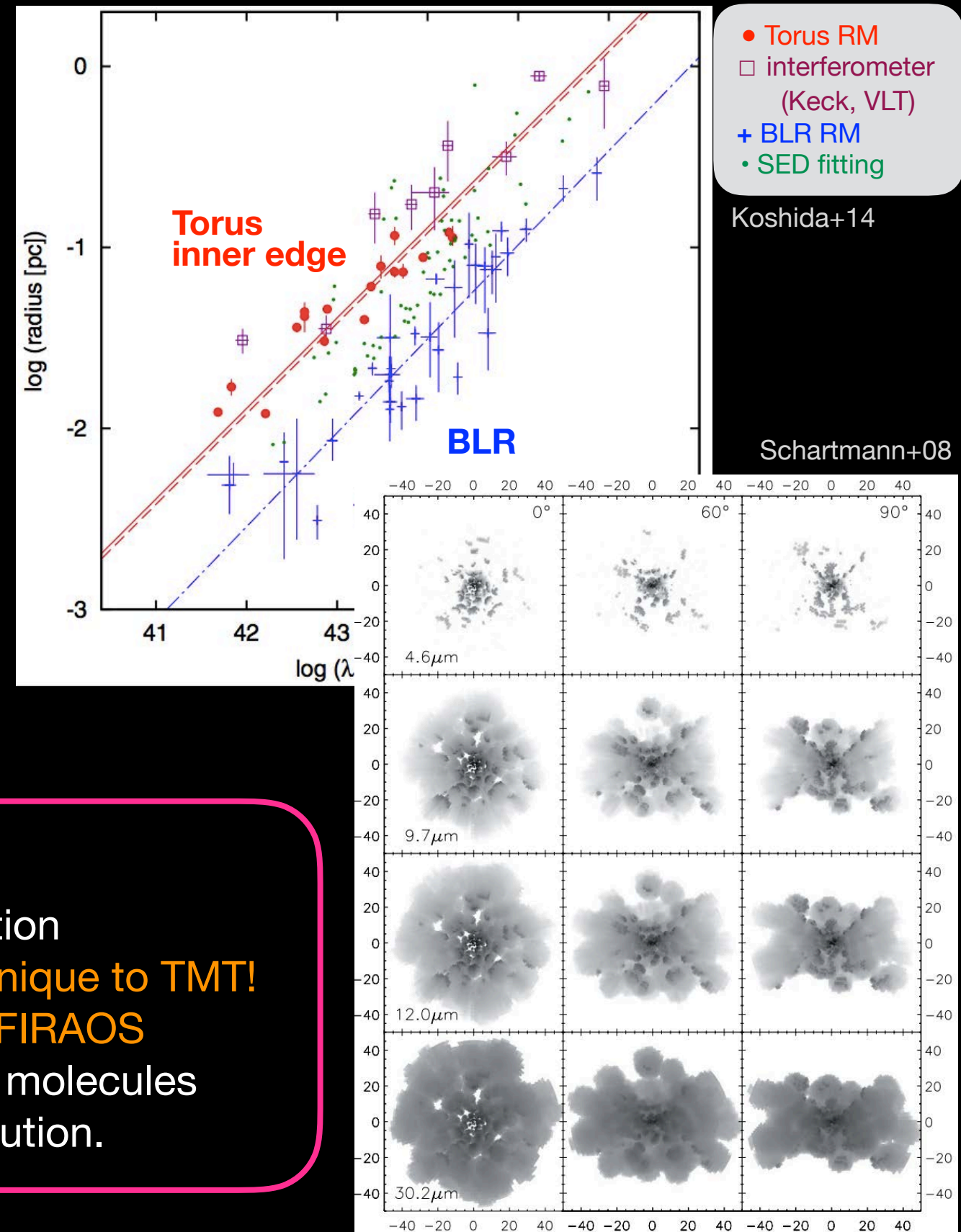


# AGN torus



## Why do we care?

- AGN unification model
- SMBH feeding and feedback



## → Mid-IR imager + AO

- ★ Q-band (20  $\mu\text{m}$ ) imaging with  $\sim 0''.1$  resolution  
 ( $\sim 20$  pc at  $z = 0.01$ ) - **Unique to TMT!**
- ★ Gas kinematics from  $\text{H}_2$  IFS, with **IRIS + NFIRAOS**
- ★ Synergy with **ALMA**, which will probe cold molecules with the CO lines, with similar spatial resolution.



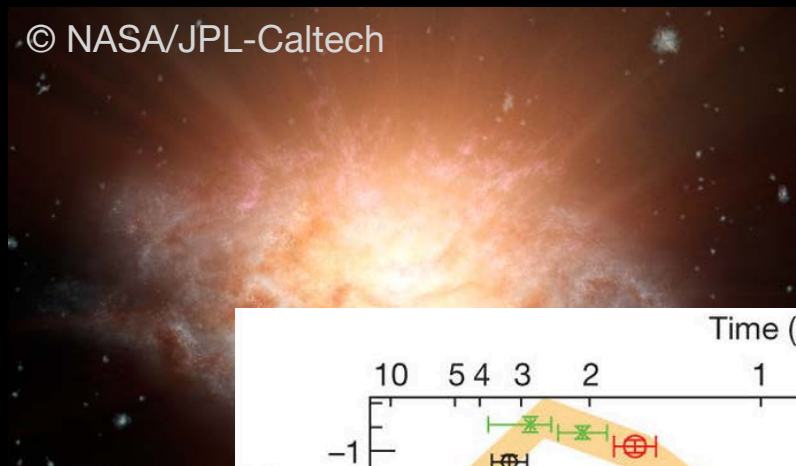
# Energetics of IR galaxies

Imanishi+06,07,11

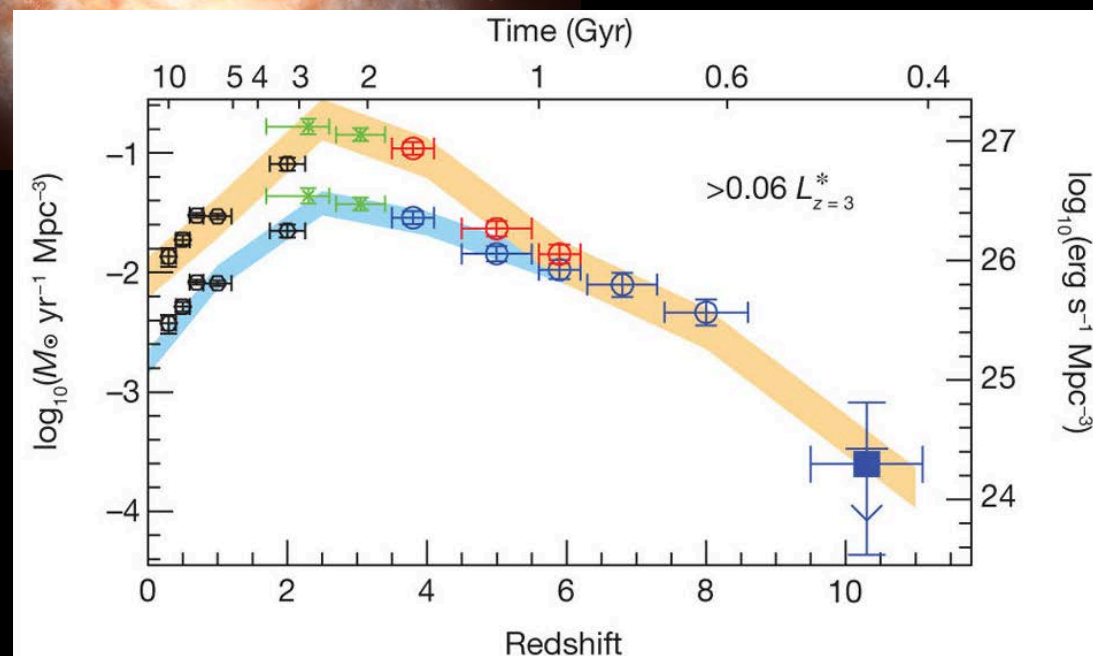
## Why do we care?

- Cosmic SF largely obscured by dust
- Optically-elusive AGNs

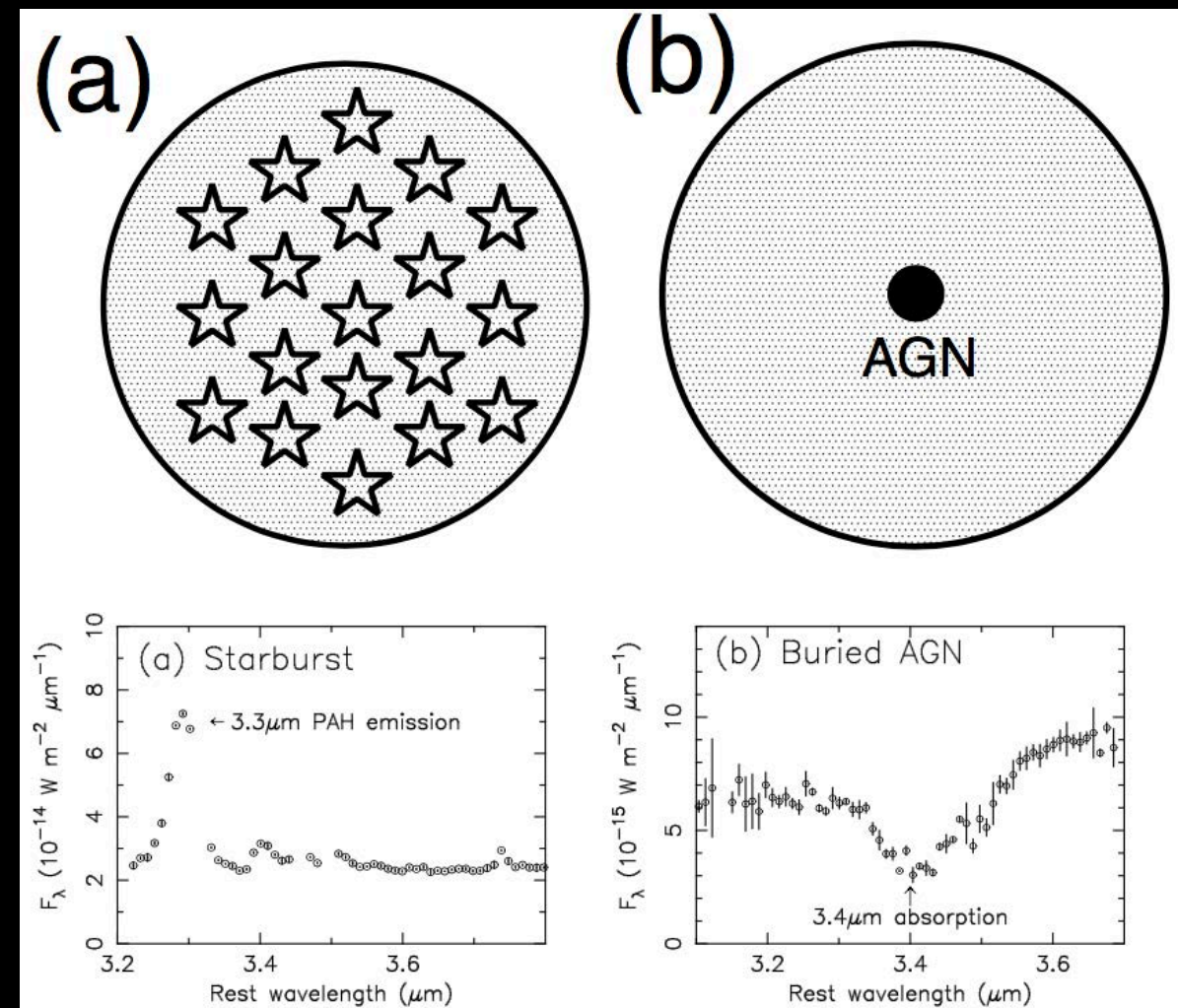
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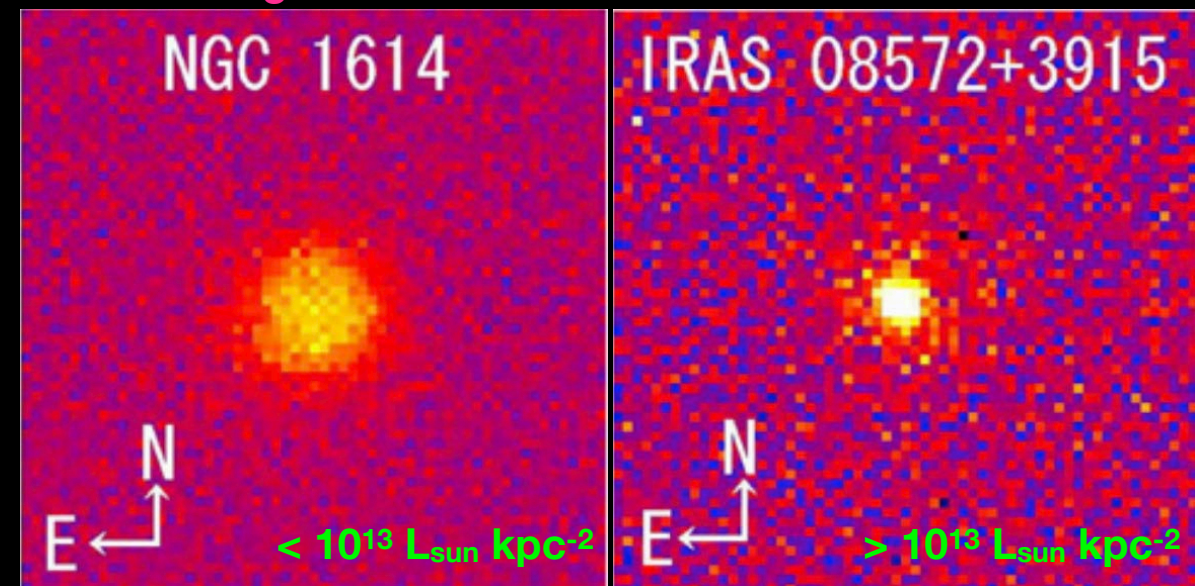
Bouwens+11



→ Mid-IR imager  
+ low-resolution spectrograph



Q-band images with Subaru/COMICS and Gemini/T-ReCS





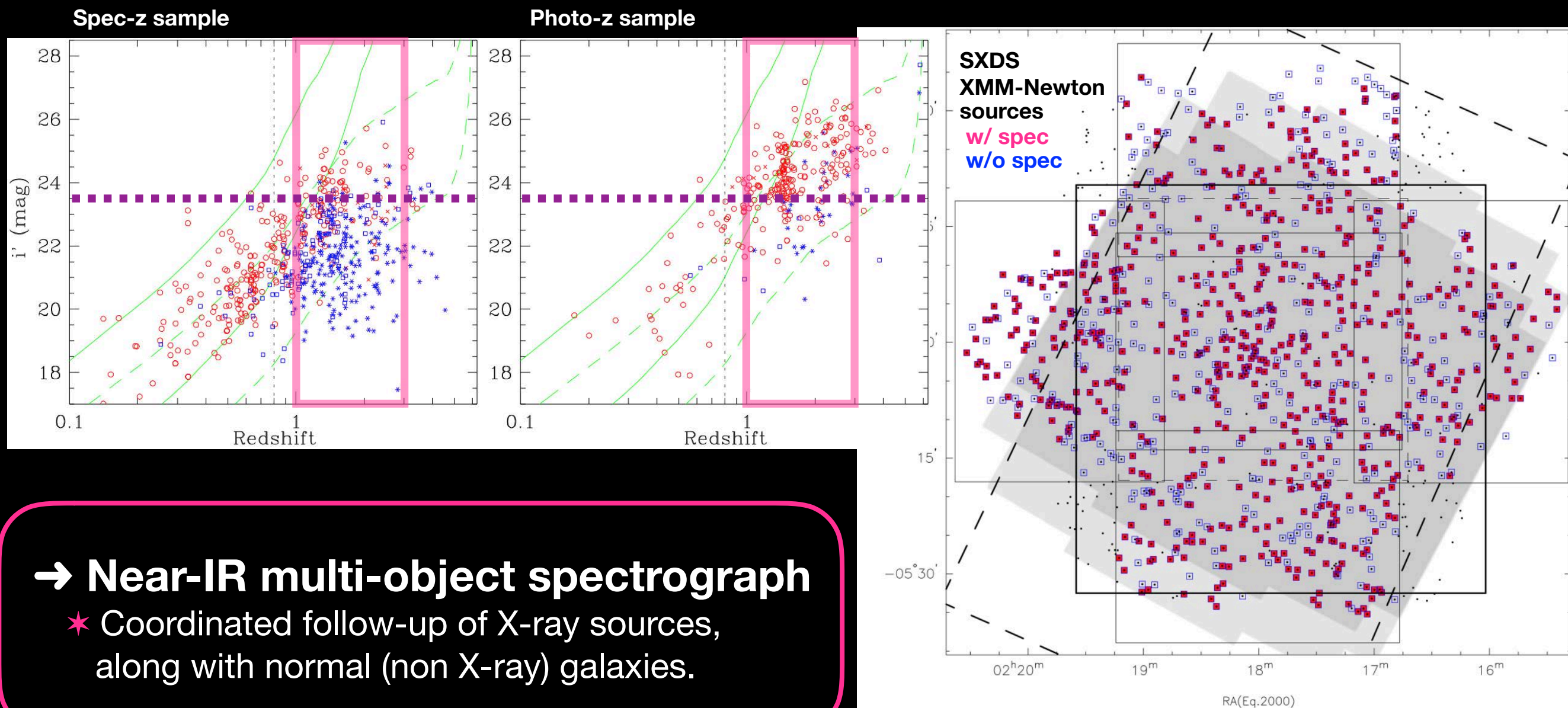
# AGN demographics at (and beyond) the “cosmic noon”

## Why do we care?

- AGN demographics
- SMBH growth throughout the Universe



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## → Near-IR multi-object spectrograph

- ★ Coordinated follow-up of X-ray sources, along with normal (non X-ray) galaxies.

Akiyama+15



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