



Journée SKA-France 2018

November 23rd, 2018

Unveiling radio AGN feedback over cosmic time with SKA

Ivan Delvecchio

Marie Curie Fellow at CEA-Saclay
ivan.delvecchio@cea.fr

On behalf of:

V. Smolčić, G. Zamorani, D.J. Rosario, M. Bondi, S. Marchesi,
T. Miyaji, M. Novak, M.T. Sargent, D.M. Alexander, J. Delhaize,
E. Daddi and the COSMOS team



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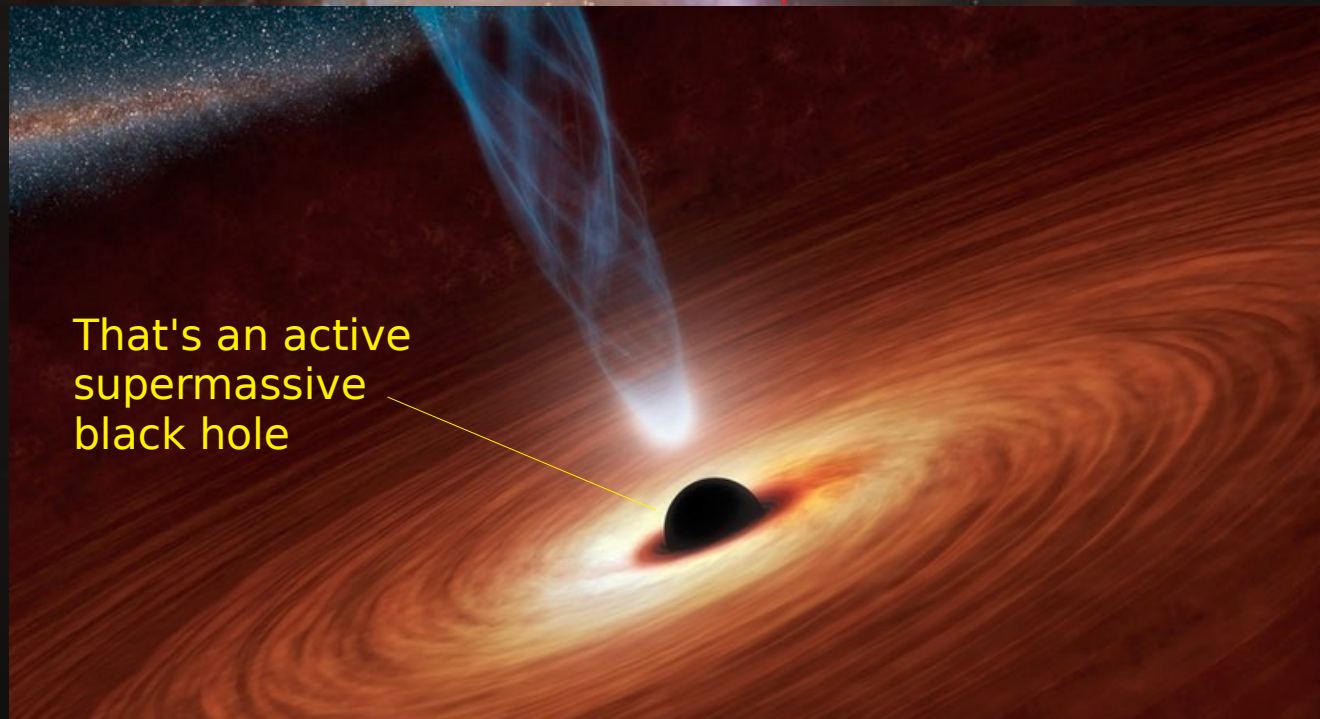
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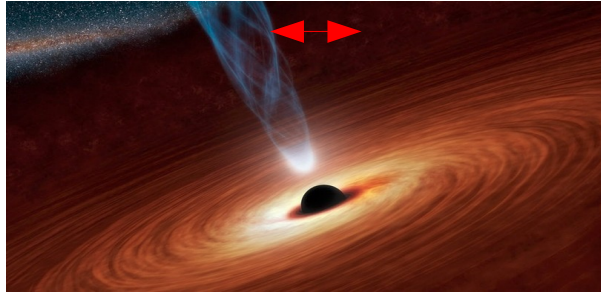
Unveiling radio **AGN** feedback over cosmic time with SKA



That's an active
supermassive
black hole

Active Galactic Nuclei (AGN)

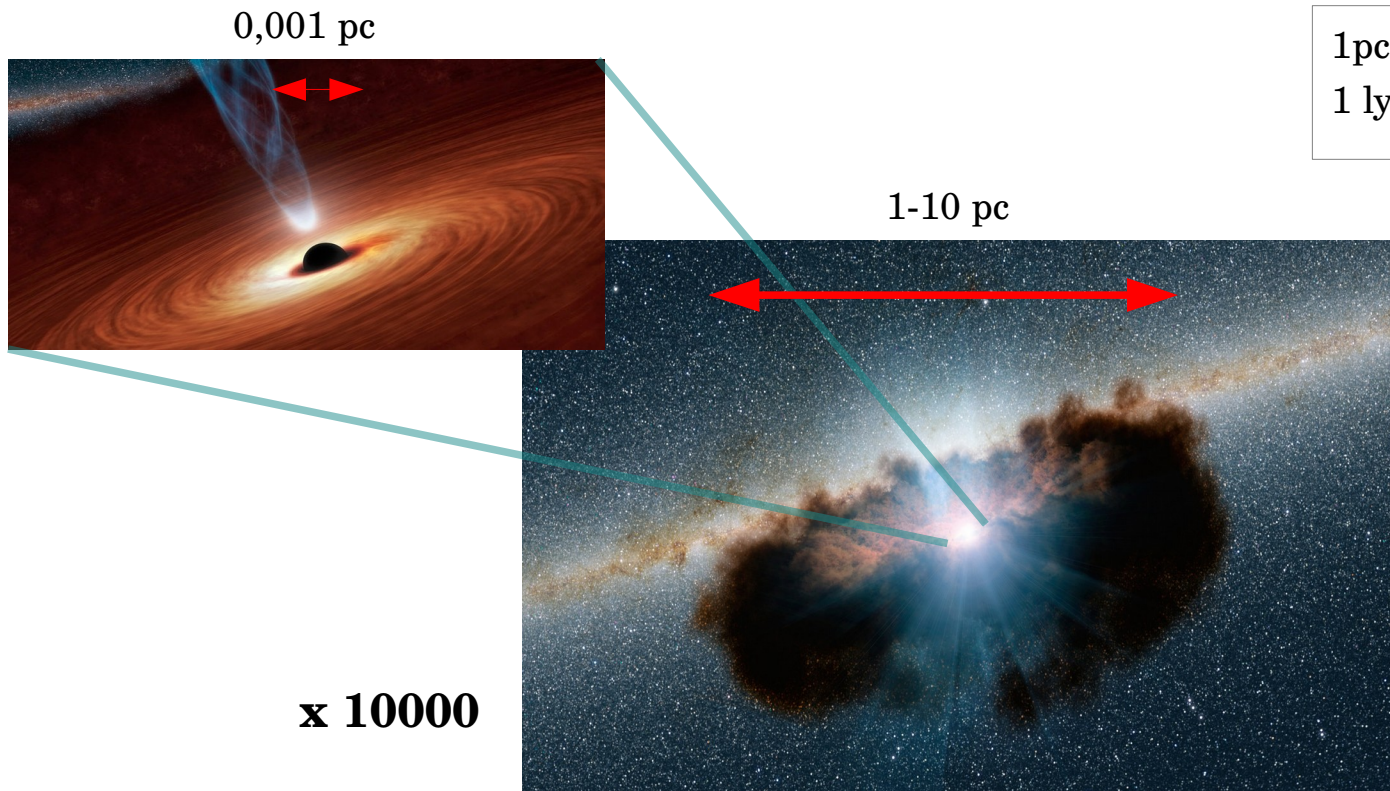
0,001 pc



1pc (parsec) = 3.26 ly (light year)
1 ly = 9460 billion km

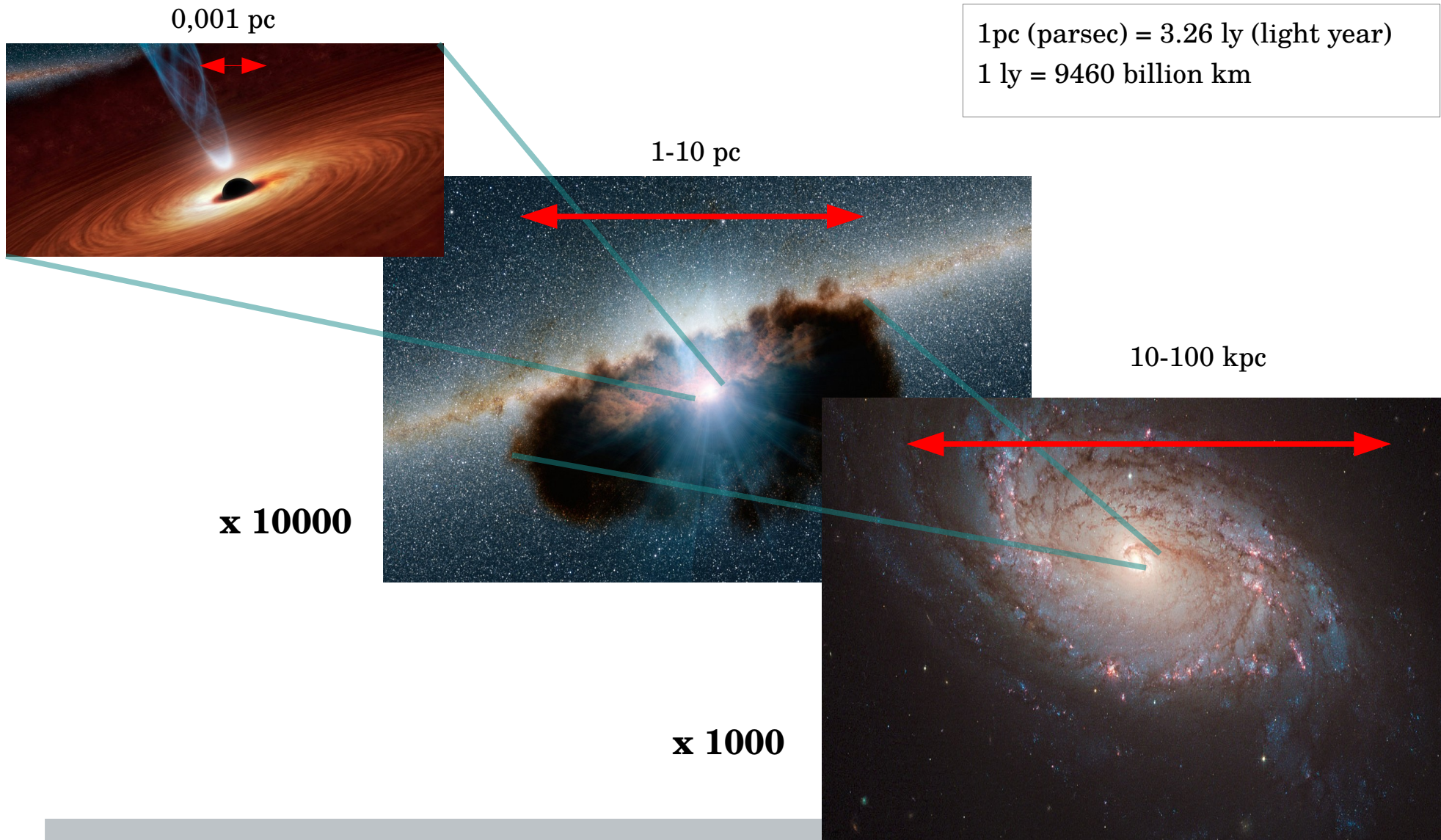
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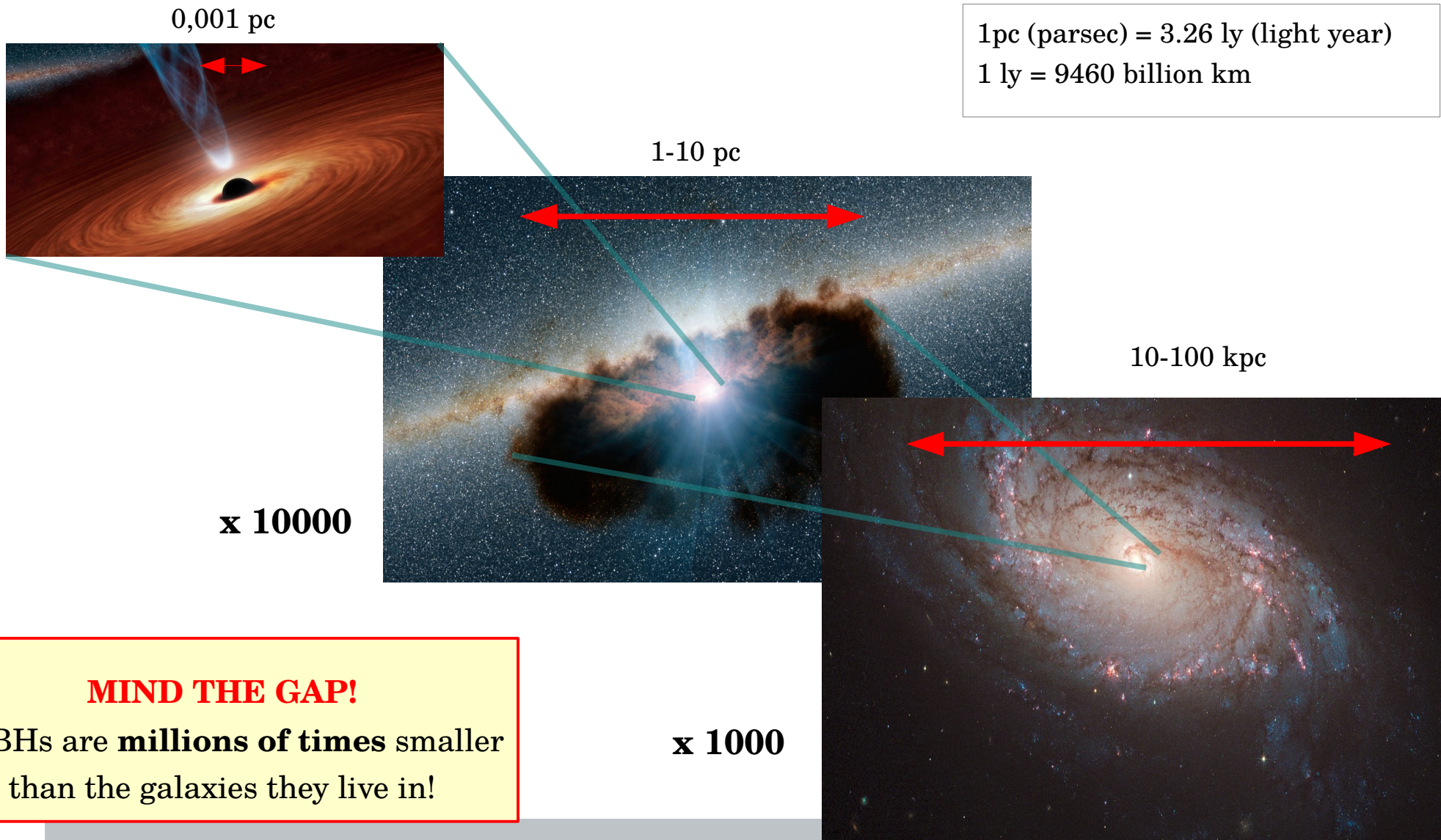
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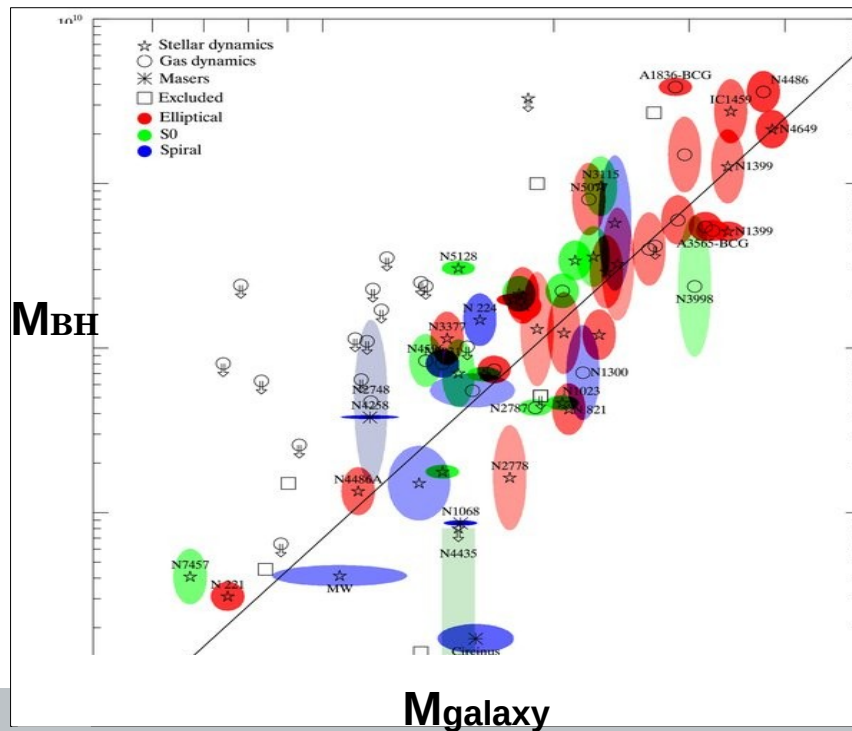


Why do we care about AGN?

- Nearly every galaxy hosts a central SMBH!

Why do we care about AGN?

- Nearly every galaxy hosts a central SMBH!
- Bigger SMBHs live in bigger galaxies! Galaxies and (active) SMBHs know each other



$$M_{galaxy} / M_{BH} \sim 1000$$



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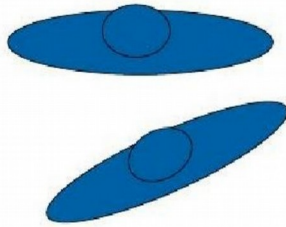
The need for AGN feedback



The need for AGN feedback

Sanders et al. (1988)
Alexander & Hickox (2012)

- Early phase



Galaxy mergers /
Stochastic processes

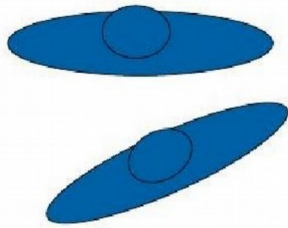
t



The need for AGN feedback

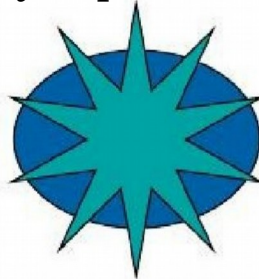
Sanders et al. (1988)
Alexander & Hickox (2012)

- Early phase



Galaxy mergers /
Stochastic processes

- Star forming galaxy
- X-ray / optical AGN



Gas inflow: SMBH
becomes an AGN

"Radiative mode"

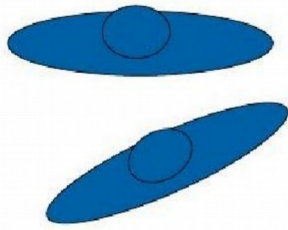


t

The need for AGN feedback

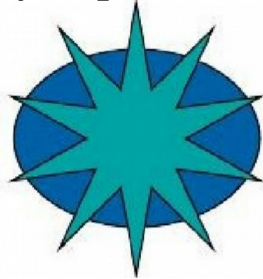
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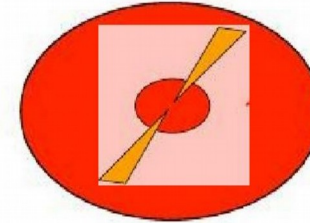
Galaxy mergers /
Stochastic processes

- Star forming galaxy
- X-ray / optical AGN



Gas inflow: SMBH
becomes an AGN

- Red and passive galaxy
- Radio AGN



AGN feedback hampers
galaxy star formation

"Radiative mode"



"Jet mode"



t

The need for AGN feedback

Sanders et al. (1988)

Alexander & Hickox (2012)

Open questions:

- How are radio jets formed?
- Why are jets only seen in a small fraction of galaxies?
- What is the impact of radio AGN feedback onto the galaxy?
 - How does AGN feedback change across cosmic time?

"Radiative mode"



"Jet mode"



t

The need for AGN feedback

Sanders et al. (1988)

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Open questions:

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"Radiative mode"



"Jet mode"



Testing this picture is crucial for understanding how AGN feedback has shaped the evolution of galaxies



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Nearby galaxy = old Universe

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Nearby galaxy = old Universe



Distant galaxy = young Universe





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$$F_{\text{limit}} \propto L / d^2$$



Nearby galaxy = old Universe



Distant galaxy = young Universe





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$$F_{\text{limit}} \propto L / d^2$$



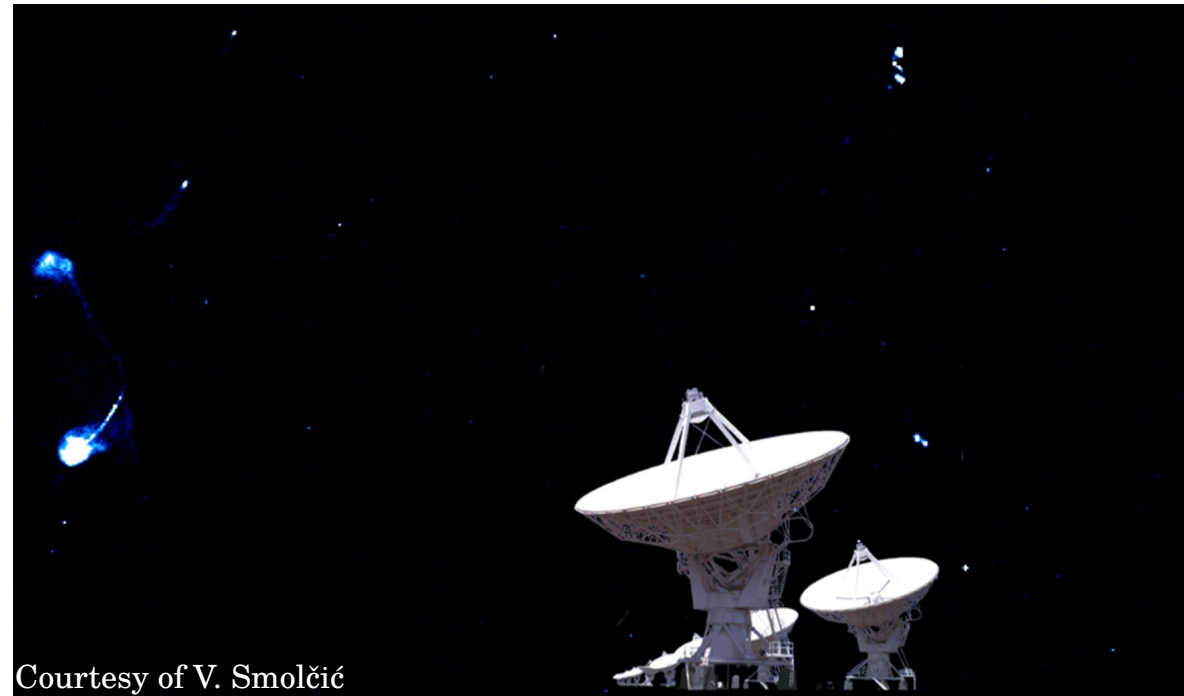
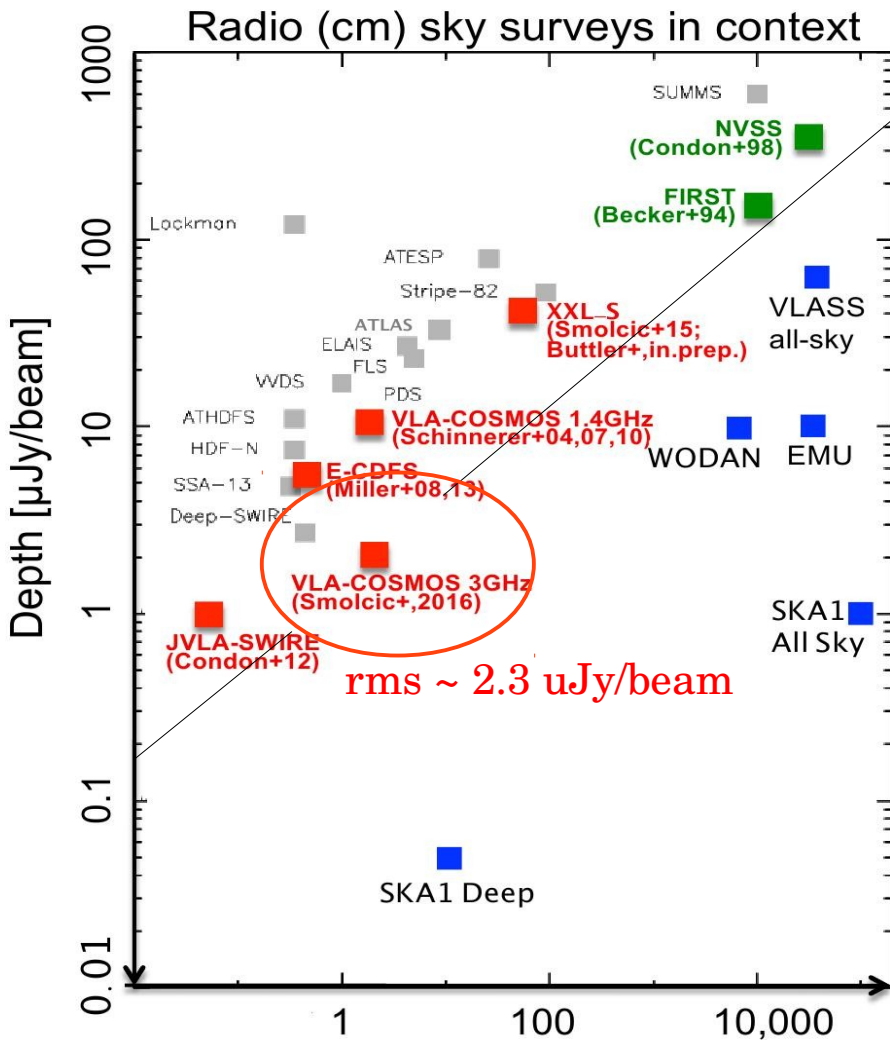
Nearby galaxy = old Universe



Distant galaxy = young Universe



The VLA-COSMOS 3GHz Large Project



Courtesy of V. Smolčić

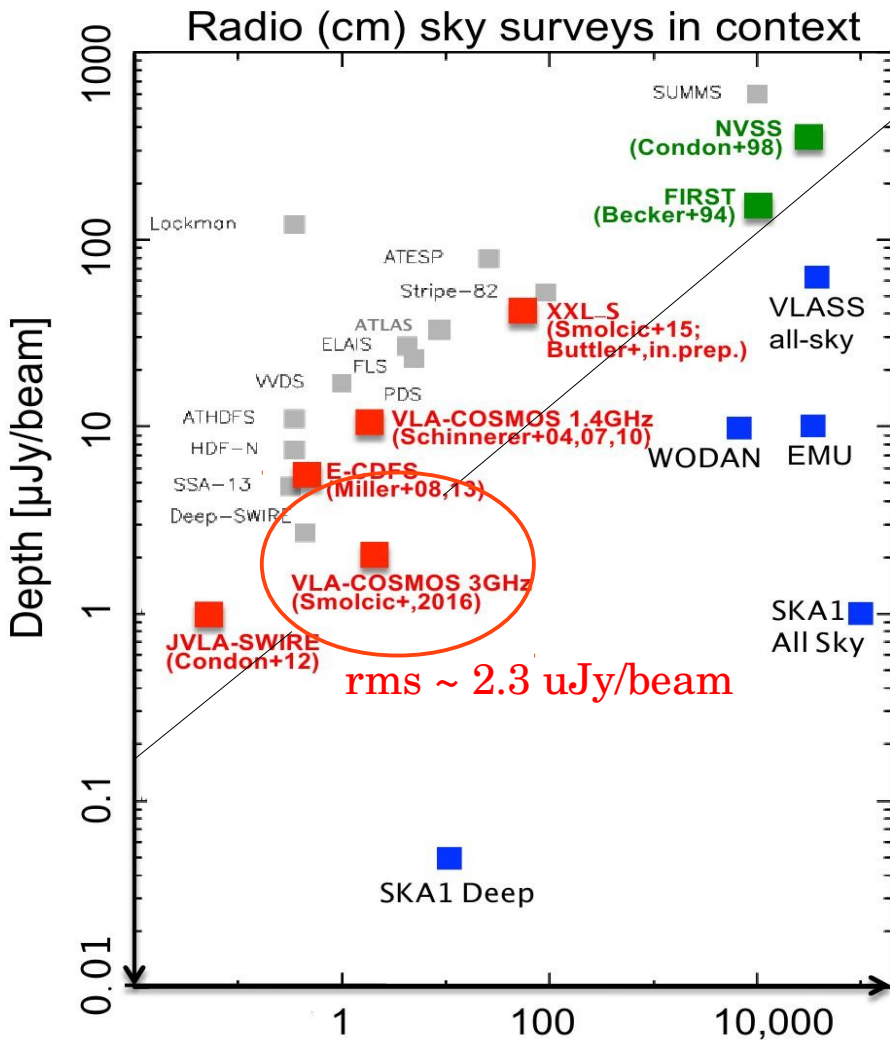
PI: V. Smolčić



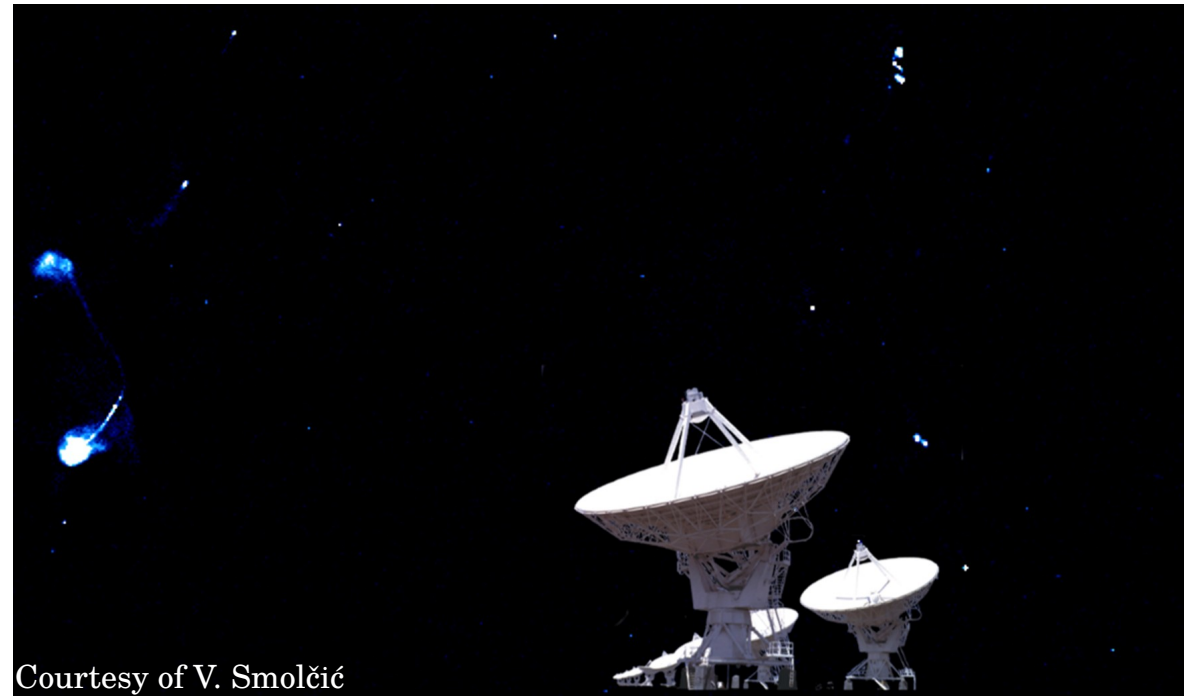
European
Research
Council

The VLA-COSMOS 3GHz Large Project

- 7729 radio sources selected at 3 GHz (10 cm) at 0.75" resolution (Smolčić, Delvecchio et al. 2017)
- Press release on A&A special issue:
<http://cosmos.astro.caltech.edu/news/52>



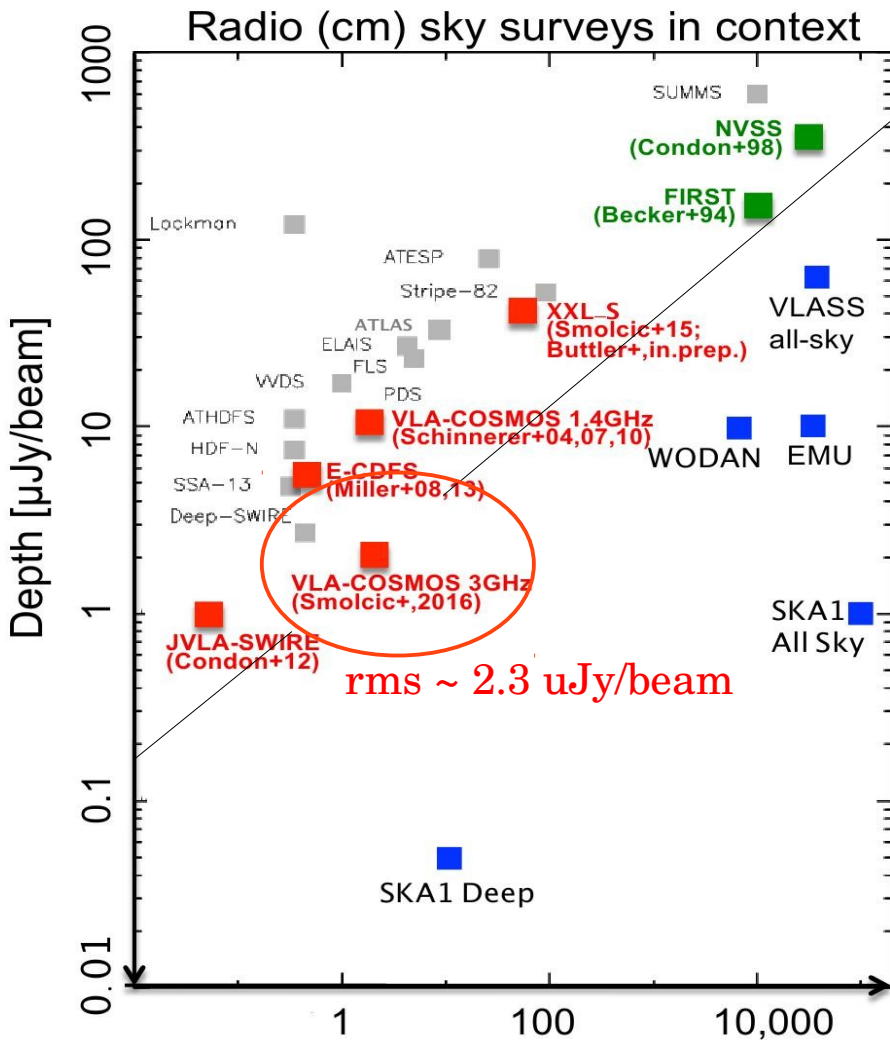
PI: V. Smolčić Area [sq.deg]



Courtesy of V. Smolčić

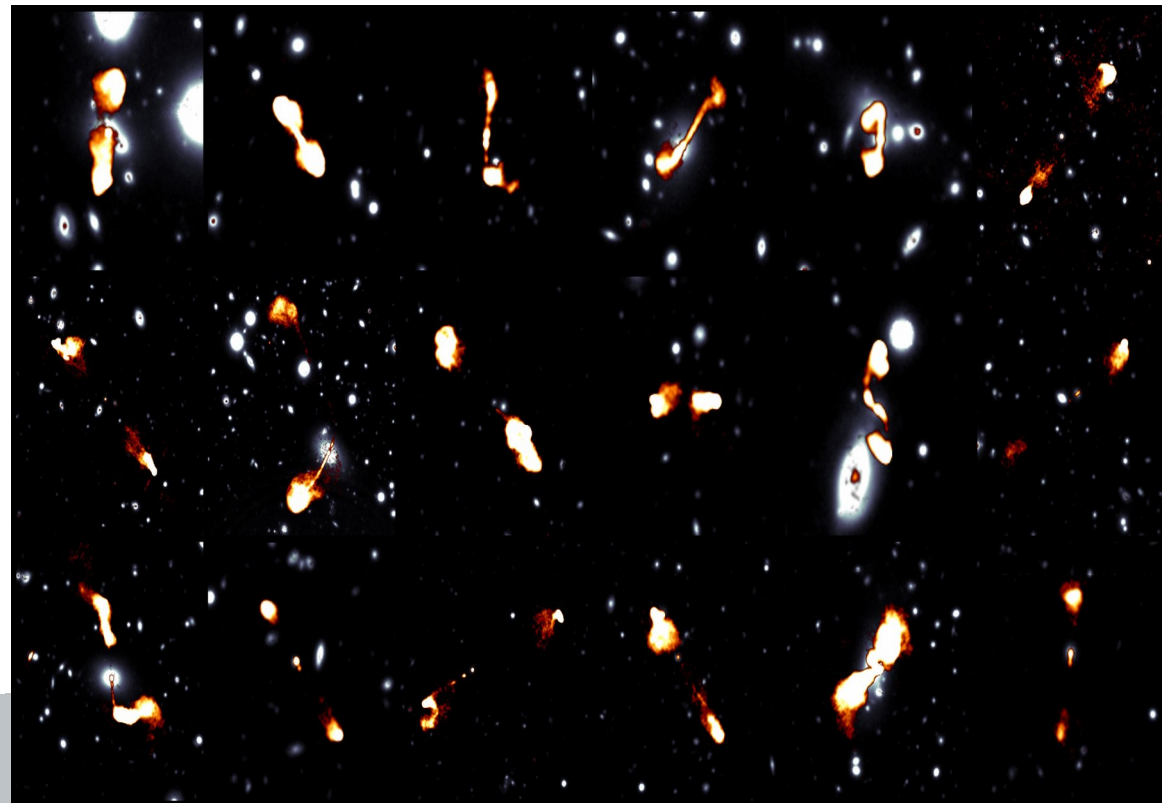
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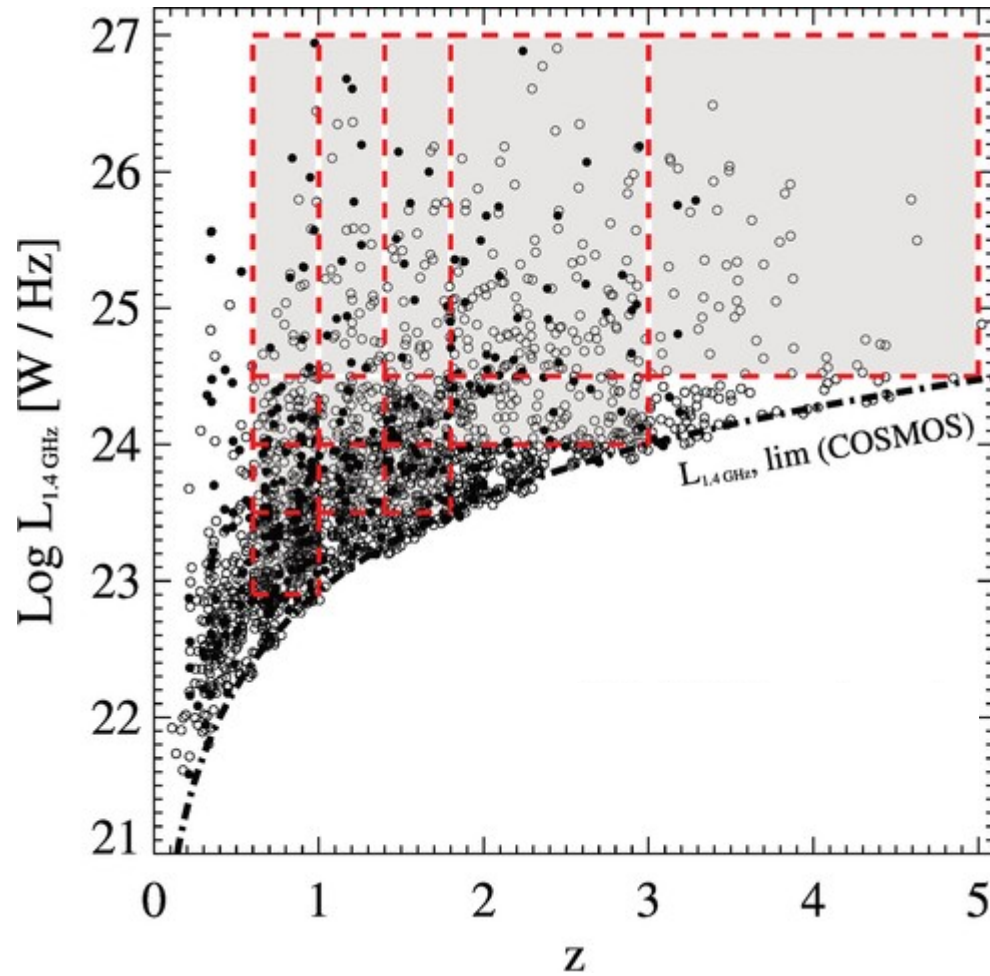


rms ~ 2.3 μ Jy/beam

PI: V. Smolčić Area [sq.deg]



Radio AGN across cosmic time



- Probing >1200 radio AGN across cosmic time

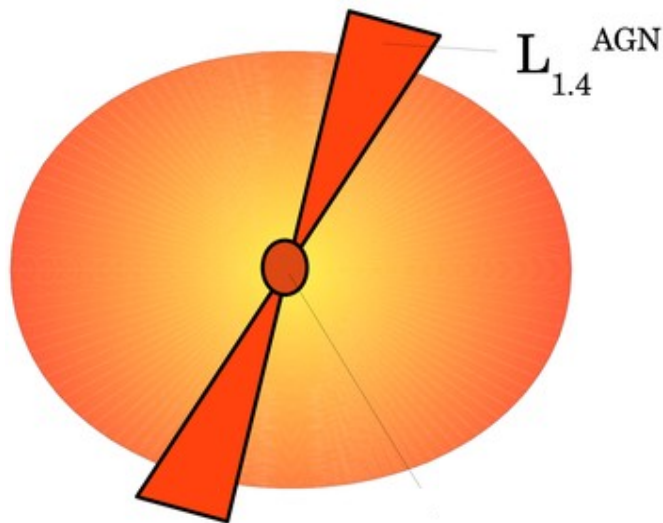
← Cosmic time →

AGN feedback: a simplistic cartoon

Delvecchio et al. (2018)

Nearby Universe

$z \ll 1$

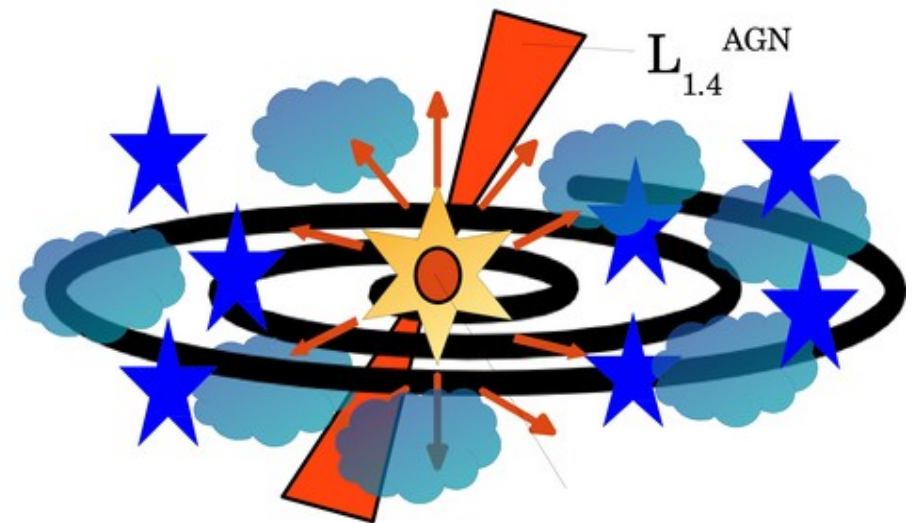


Red and passive
galaxy

Jet mode

Distant Universe

$z > 1.5$



Blue and highly
star-forming galaxy

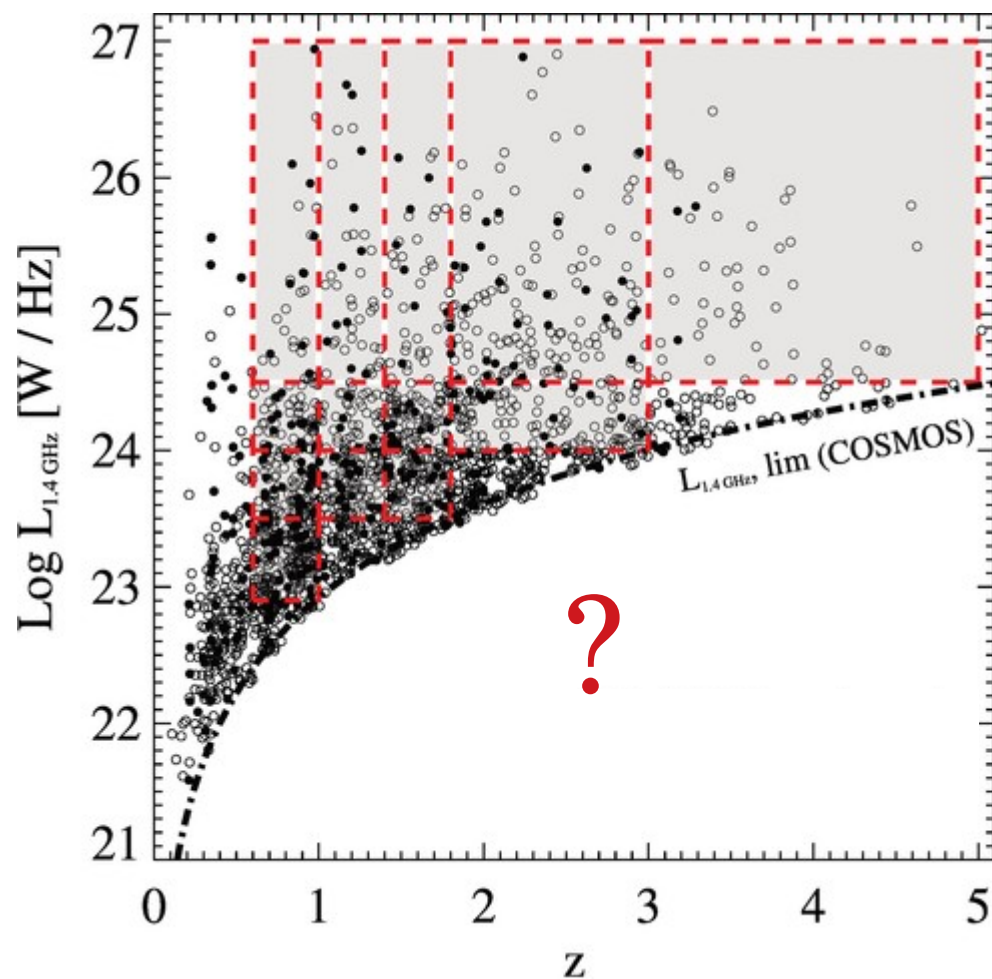
Jet + radiative mode



RADIO (AND NON)
AGN HOST

RADIO AGN

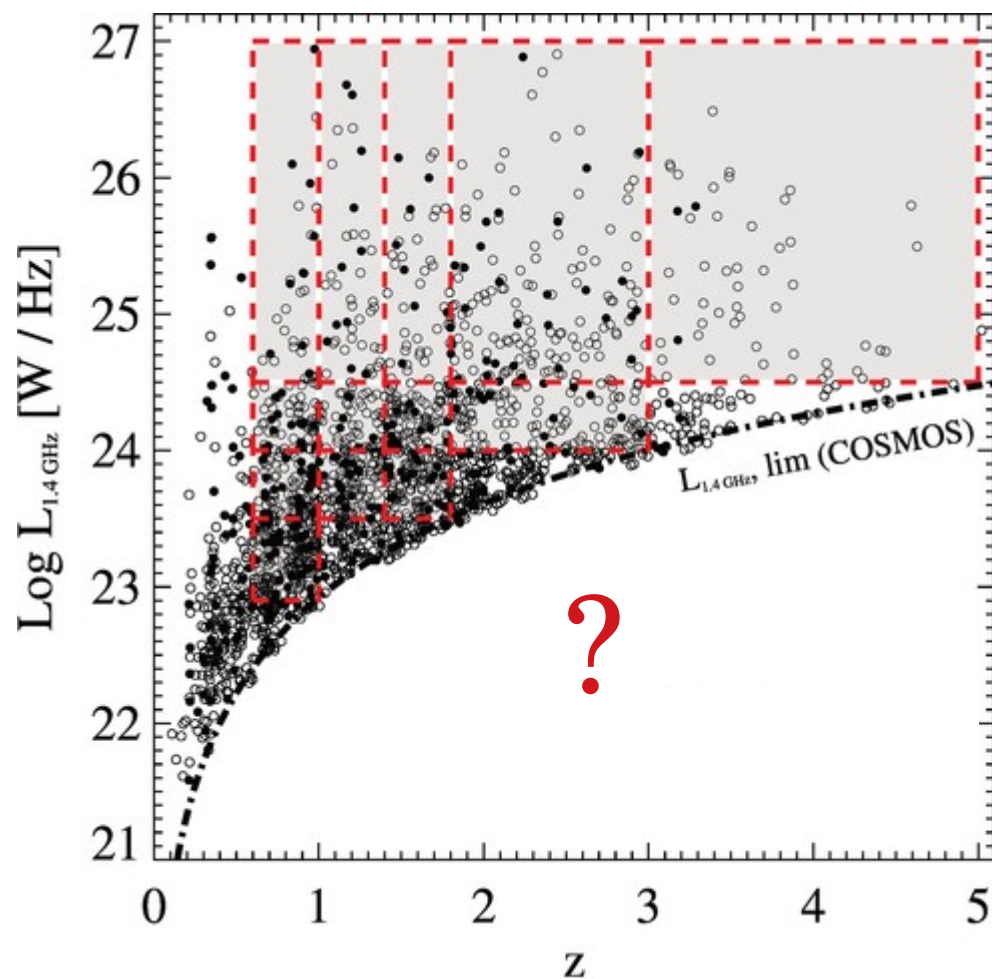
Radio AGN across cosmic time



- Probing >1200 radio AGN across cosmic time
- Many radio faint AGN are being missed in the distant Universe

← Cosmic time →

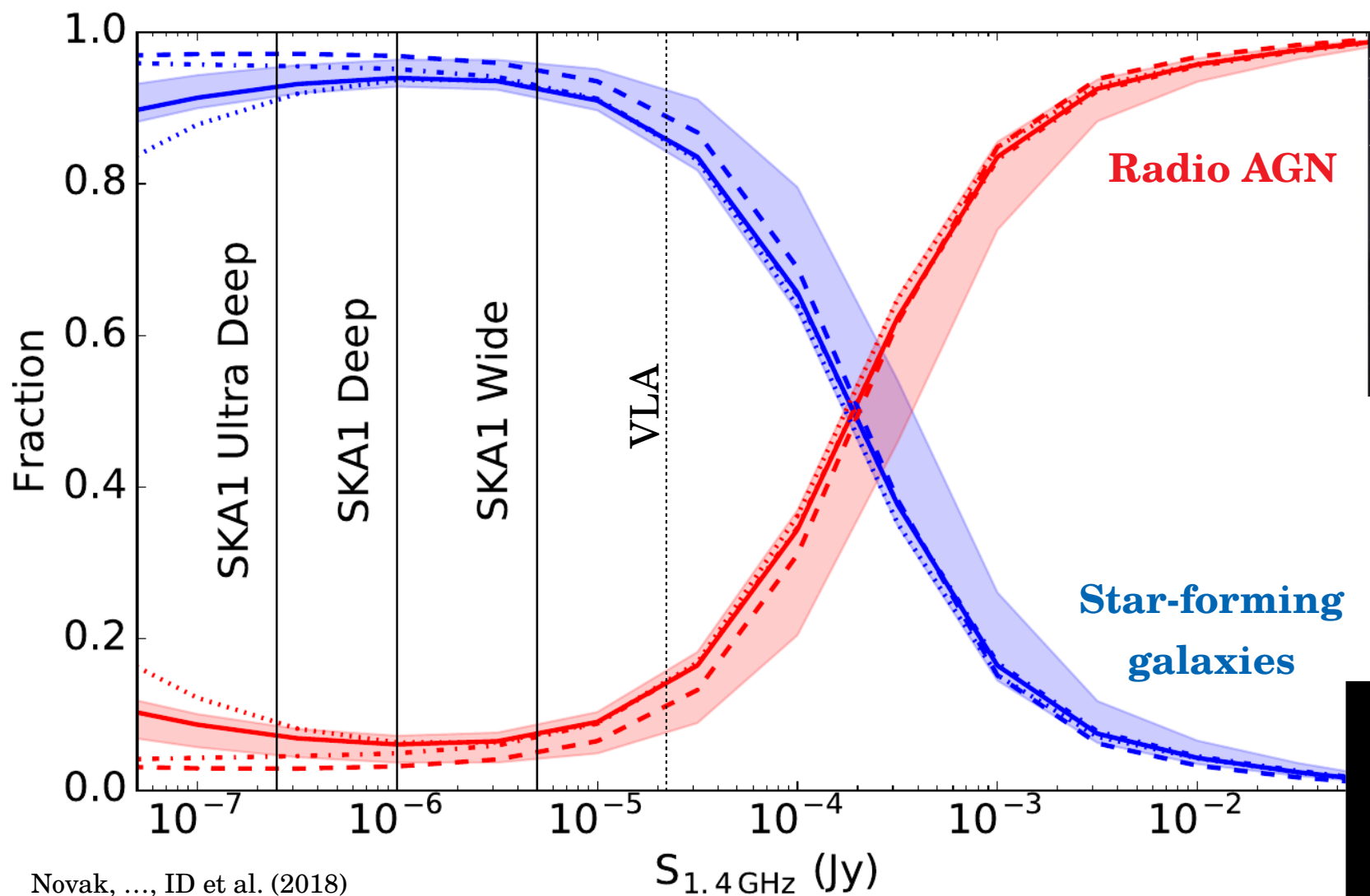
Radio AGN across cosmic time



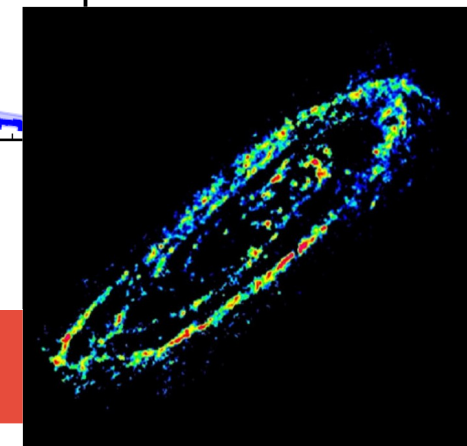
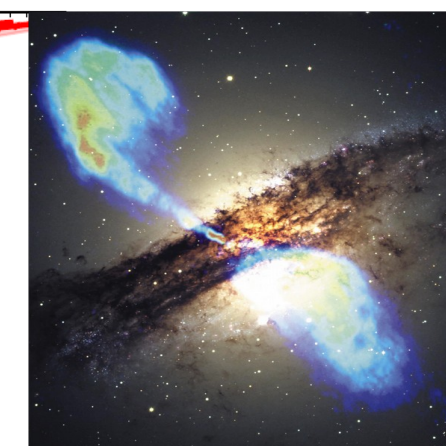
← Cosmic time →

- Probing >1200 radio AGN across cosmic time
- Many radio faint AGN are being missed in the distant Universe
- Model predictions with SKA

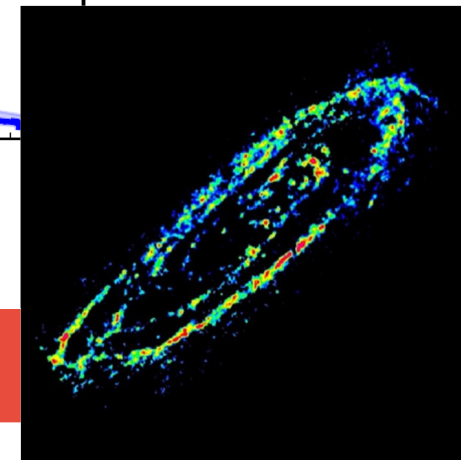
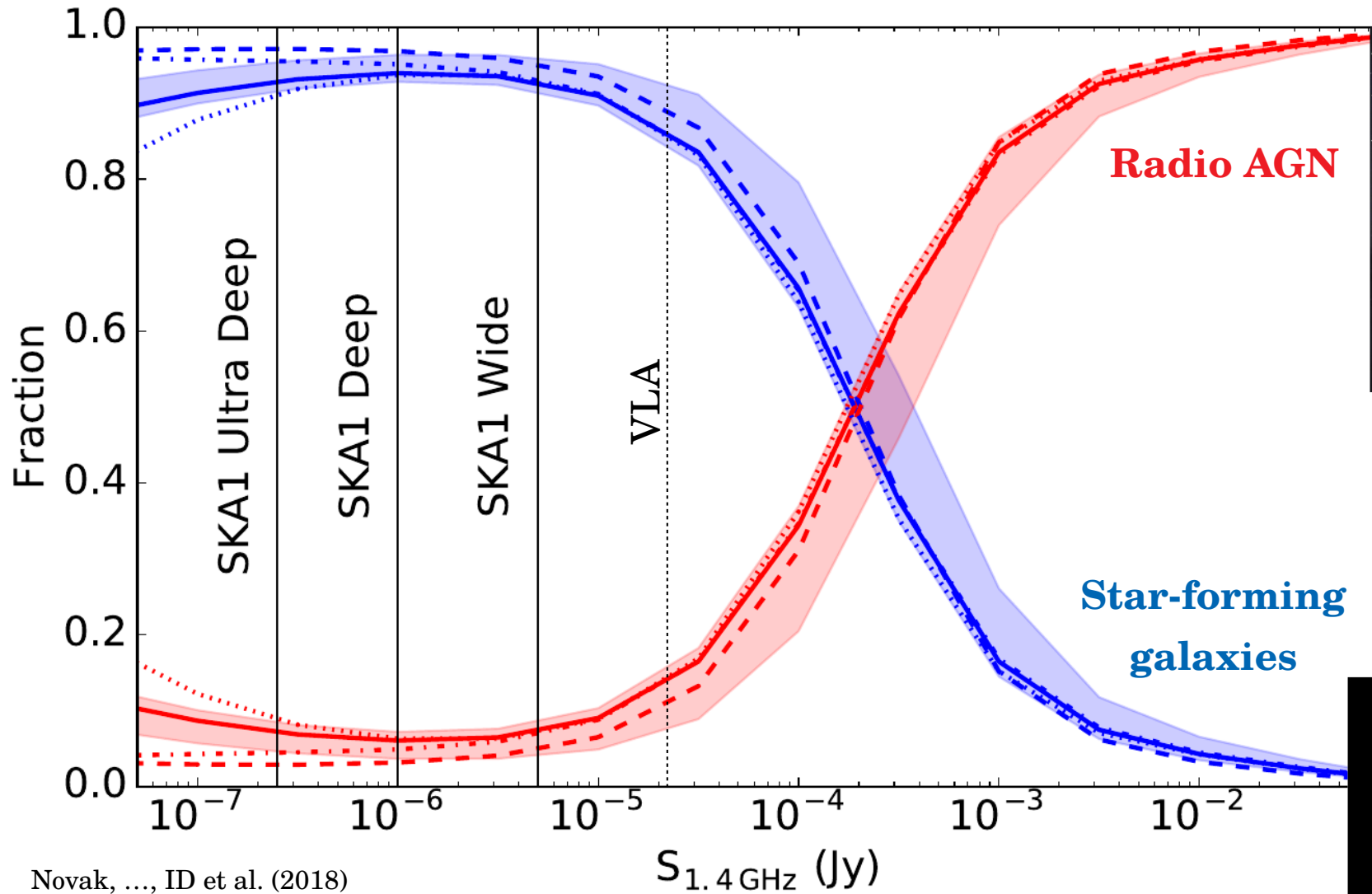
Radio AGN across cosmic time



Novak, ..., ID et al. (2018)

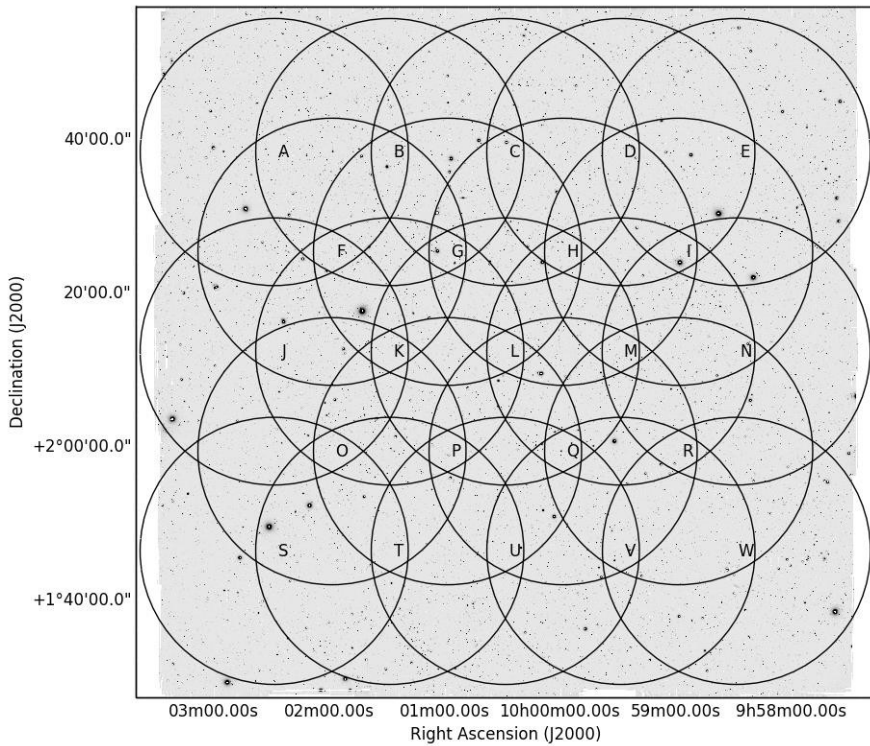


Radio AGN across cosmic time

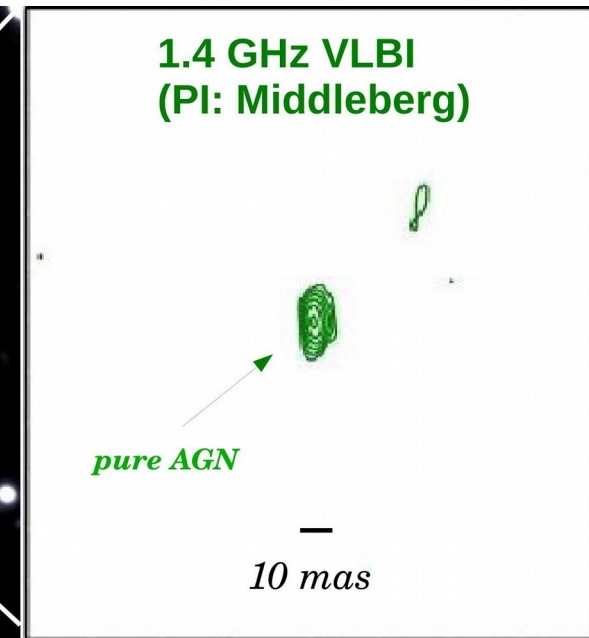
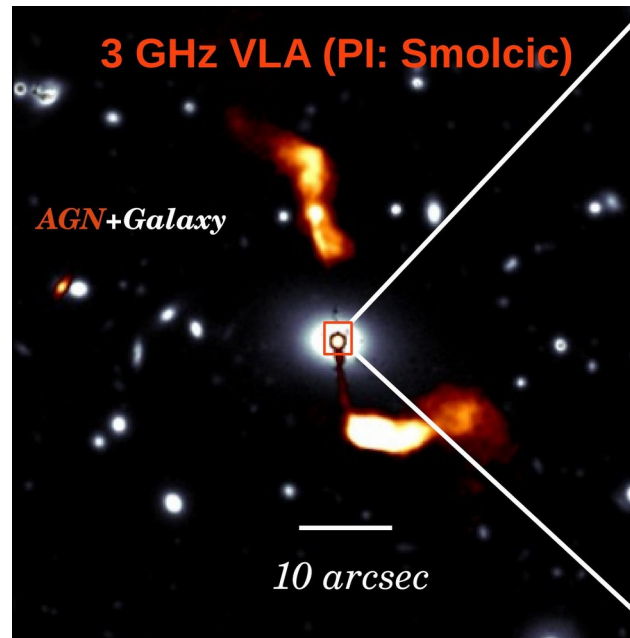


Radio AGN may be washed out by star formation !

Unveiling radio AGN with VLBA

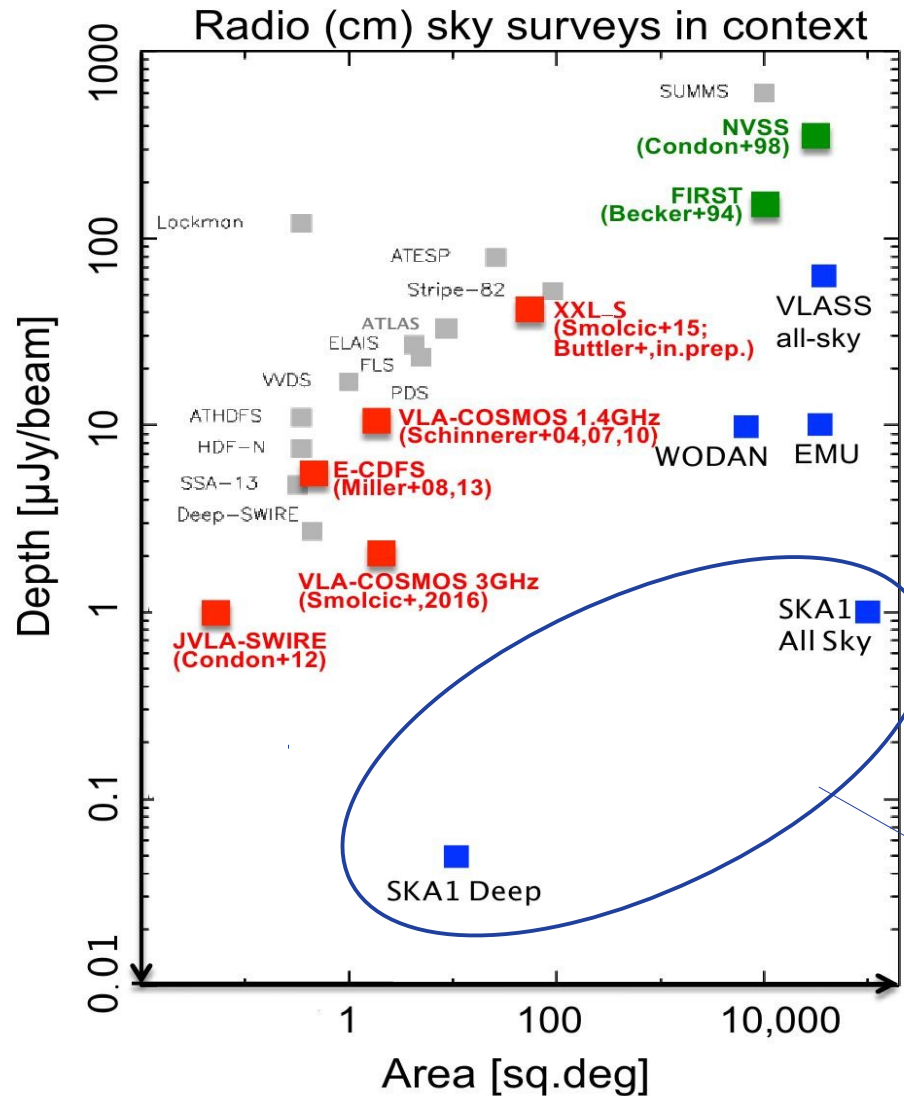


Overcoming galaxy dilution in radio !

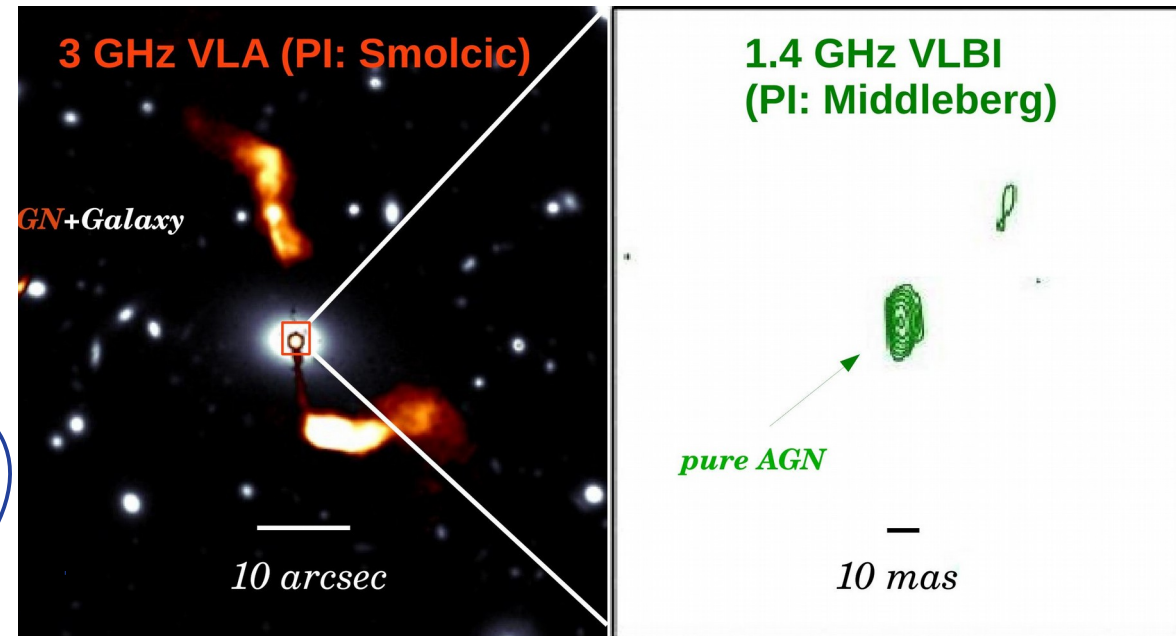


(Courtesy of E. Middleberg and N. Herrera Ruiz)

Unveiling radio AGN with SKA



Overcoming galaxy dilution in radio !



- Taking a full radio AGN census over cosmic time
- Constraining radio AGN feedback and its impact on galaxy evolution

(Courtesy of E. Middleberg and N. Herrera Ruiz)