Galaxienentwicklung

(unter anderem mit Hilfe von Radio/mm-Beobachtungen)

UPPSALA UNIVERSITET

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Credit: NRAO/AUI/NSF, B. Saxton:ALMA (ESO/NAOJ/NRAO); NASA/Hubble

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  (JWST: unser kosmologisches Modell am Prüfstand)

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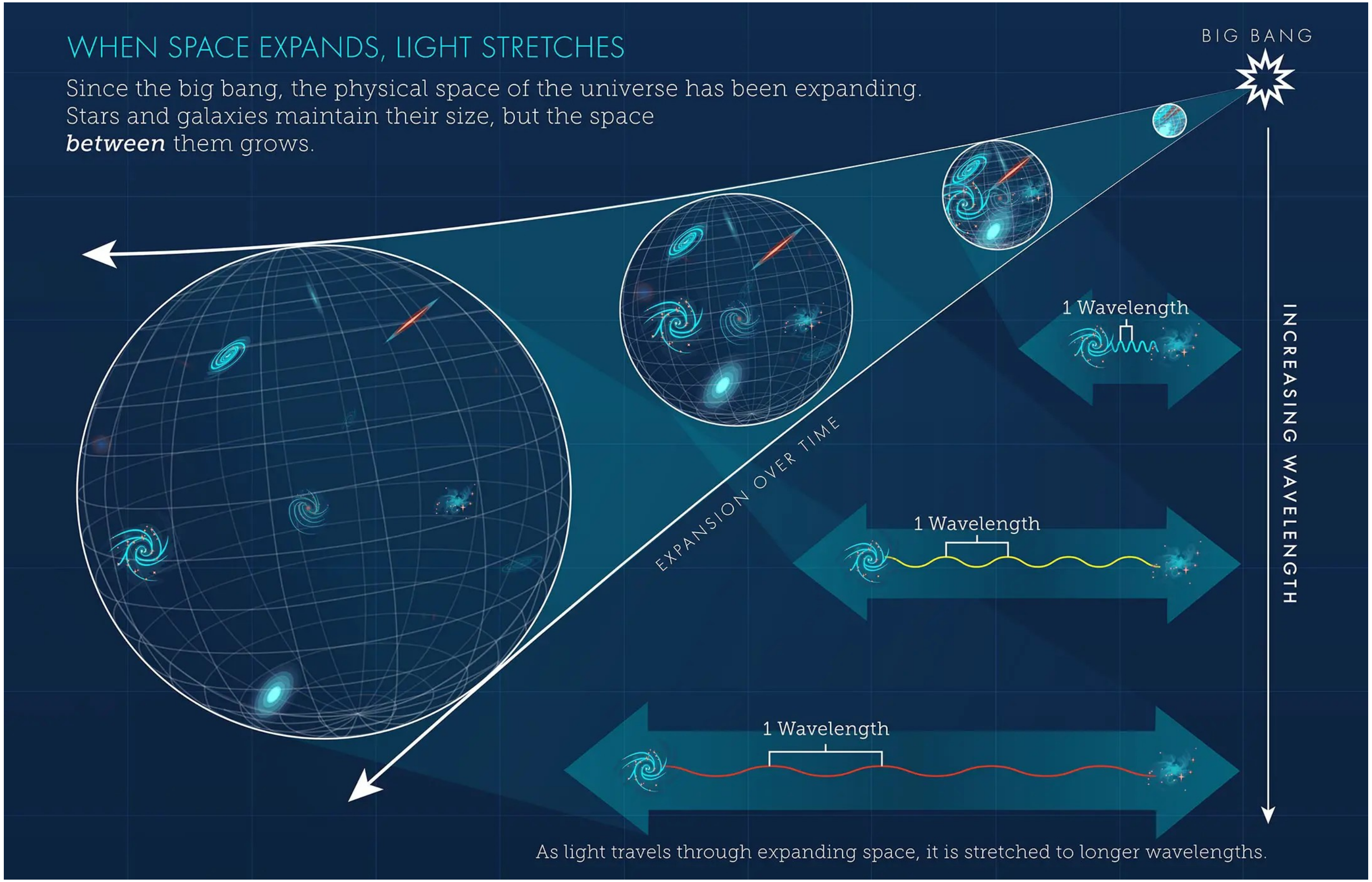
  - Die ersten Galaxien/Quasare und kosmische Reionisation

  - Sternentstehung, Moleküle und Radioastronomie

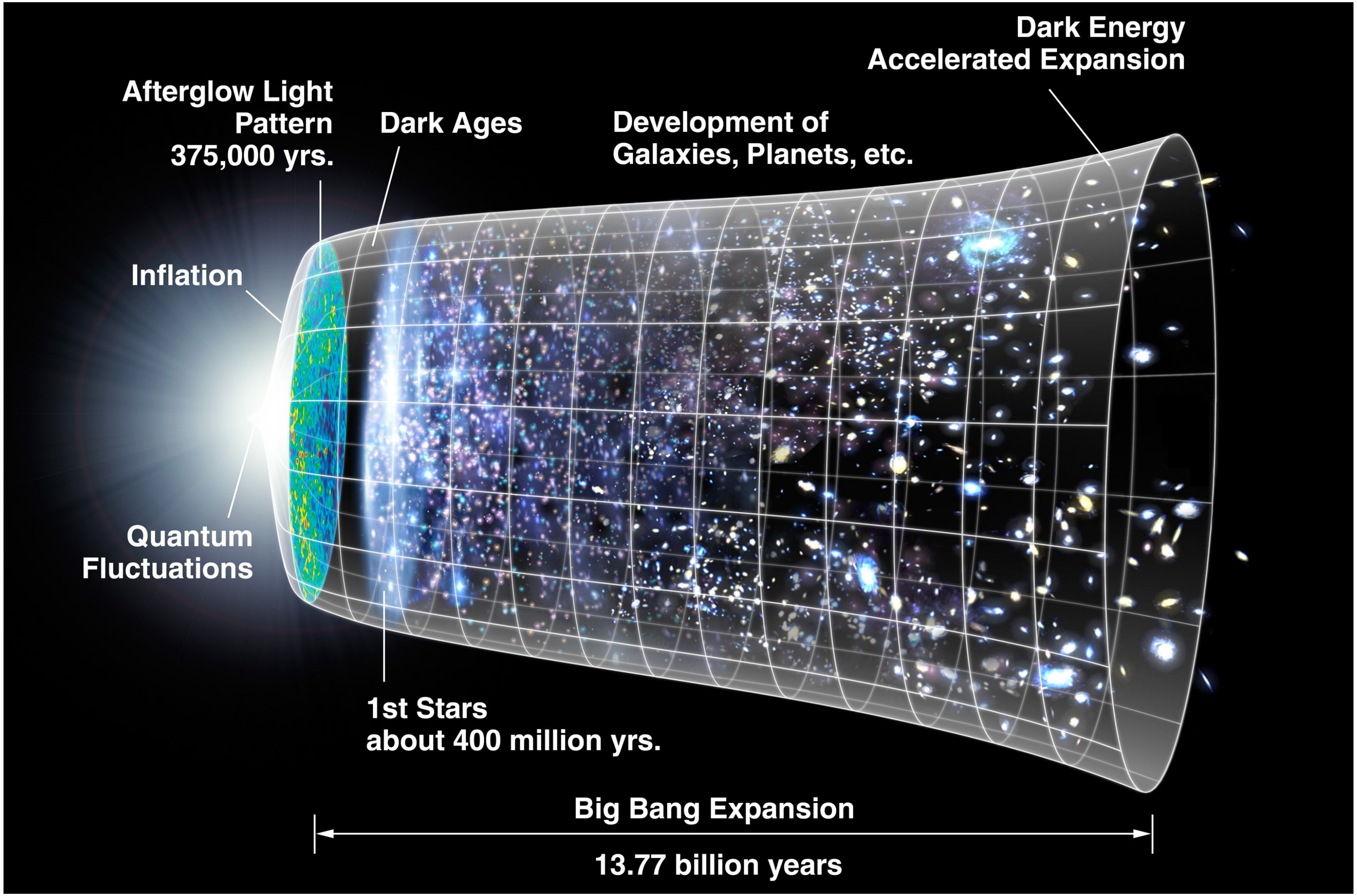
  - Galaxien am Höhepunkt der Sternentstehung

Was ist Rotverschiebung

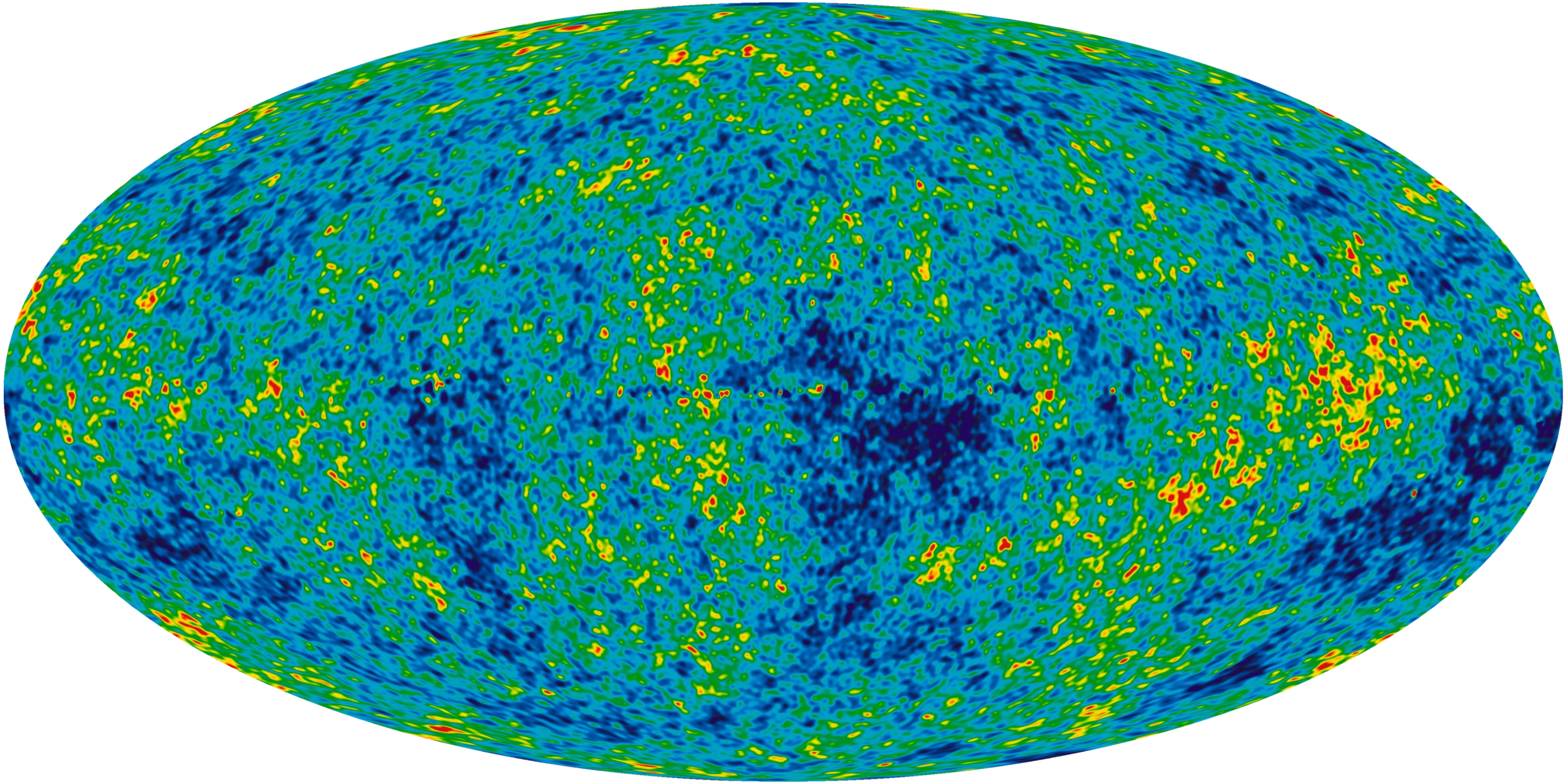


Credit: NASA, ESA, AND L. Hustak (STScI)

Urknall und Expansion des Universums (“Hubble Tension”)



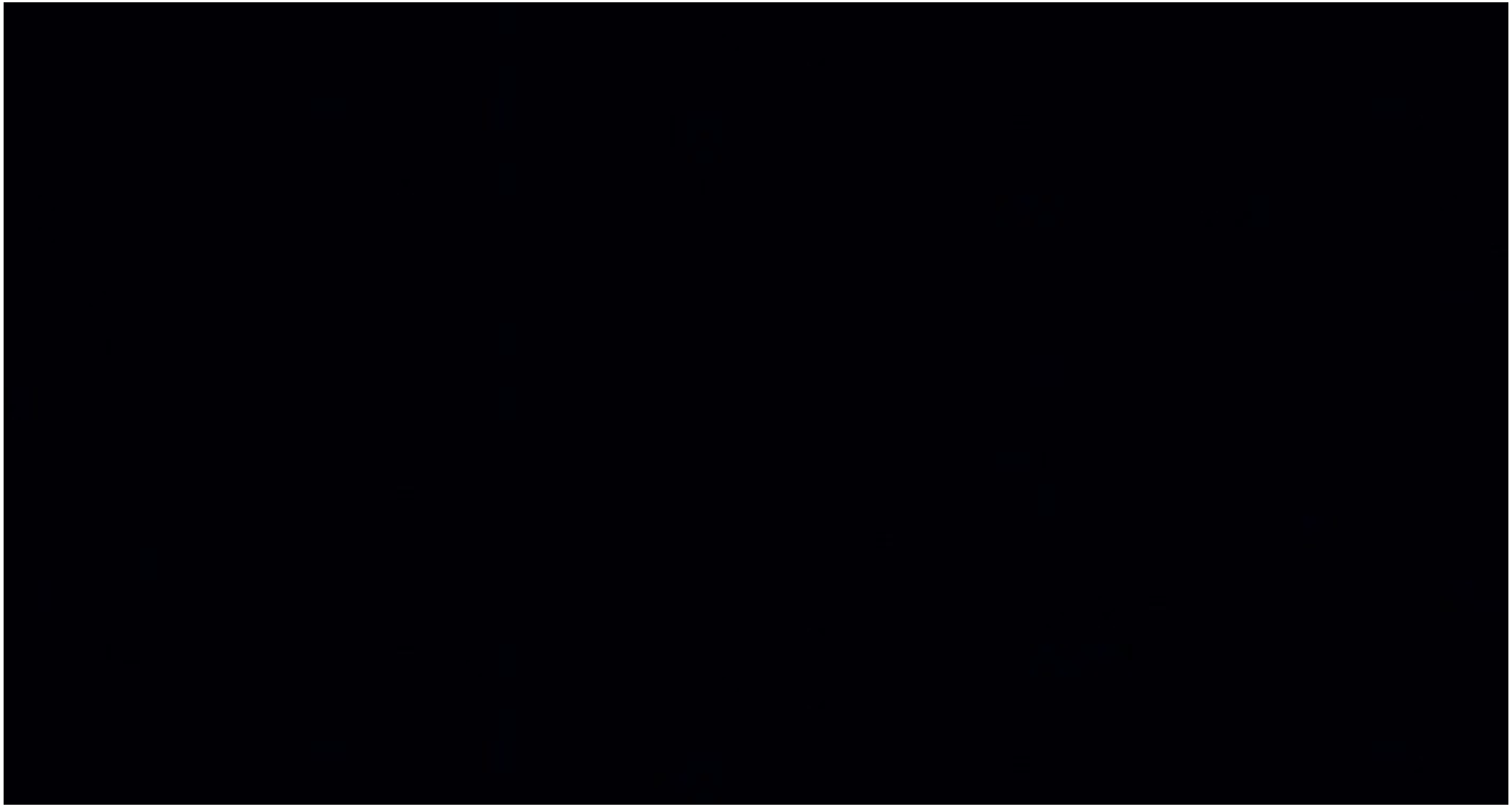
Urknall und Expansion des Universums (“Hubble Tension”)



CMB → Alter und Expansion des Universums (Hubble Konstante)

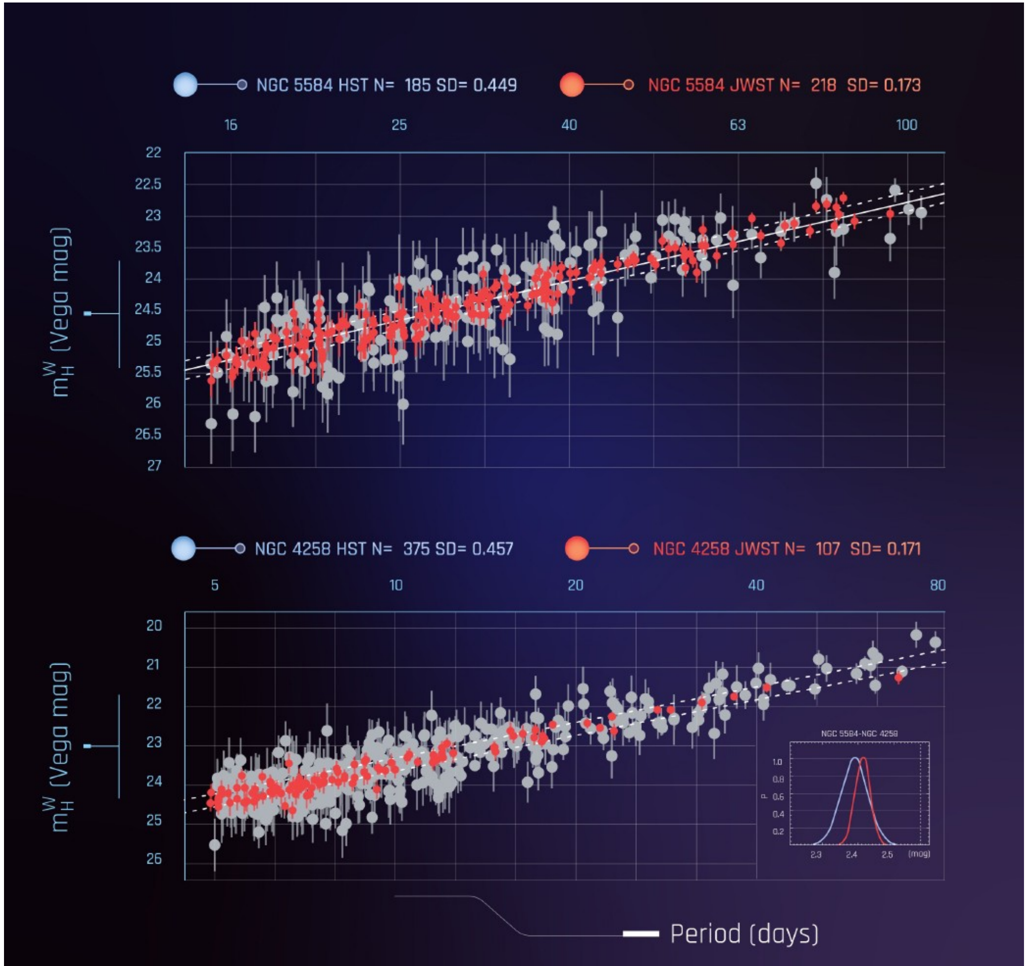
Credit: NASA / WMAP Science Team

Urknall und Expansion des Universums ("Hubble Tension")



Urknall und Expansion des Universums (“Hubble Tension”)

Henrietta Swan Leavitt



Credit: NASA, ESA, CSA, J. Kang (STScI). Science: A. Riess (STScI)

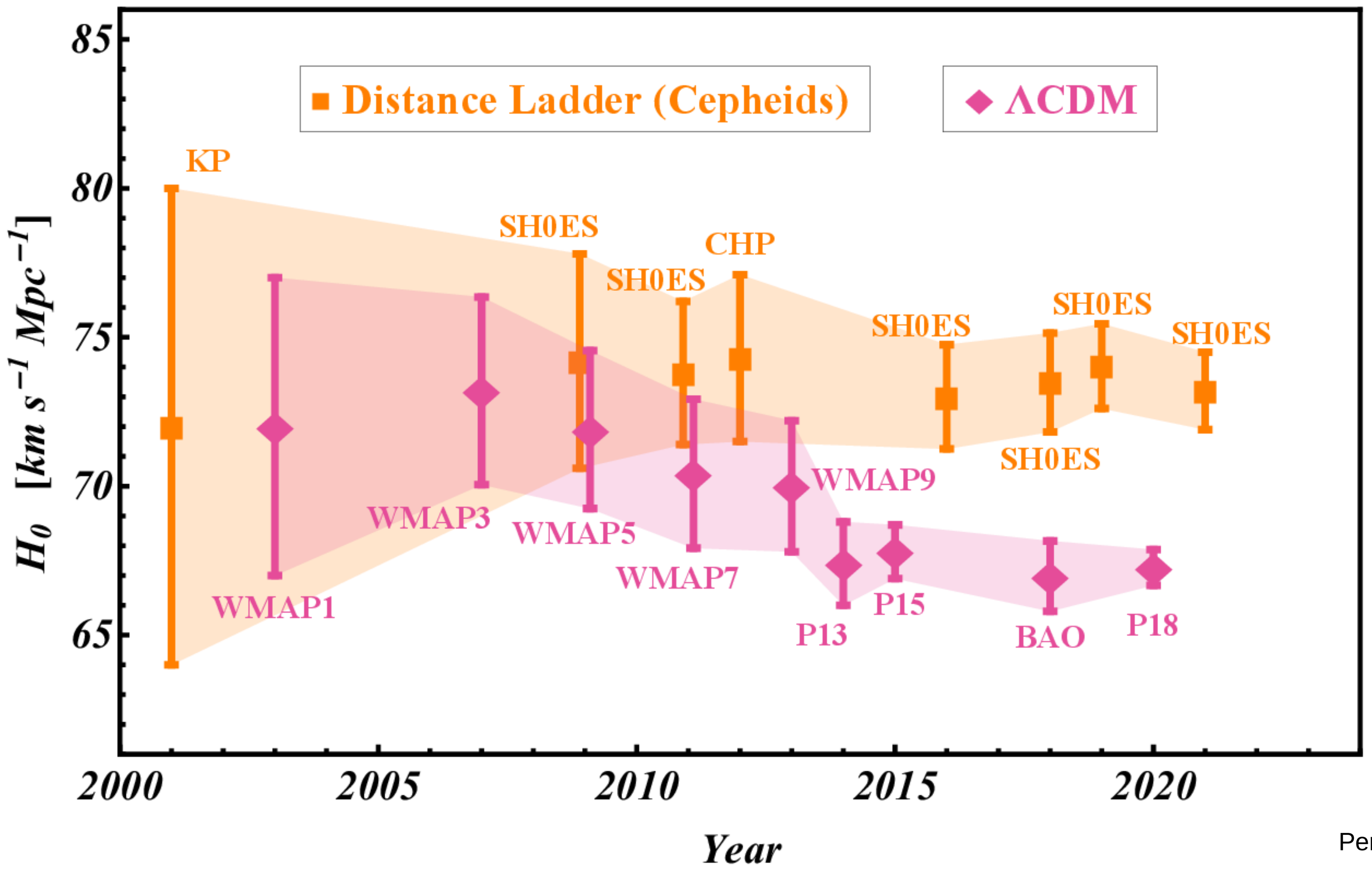
Perioden-Leuchtkraft-Beziehung

→ Entfernungsbestimmung

→ Expansion des Universums

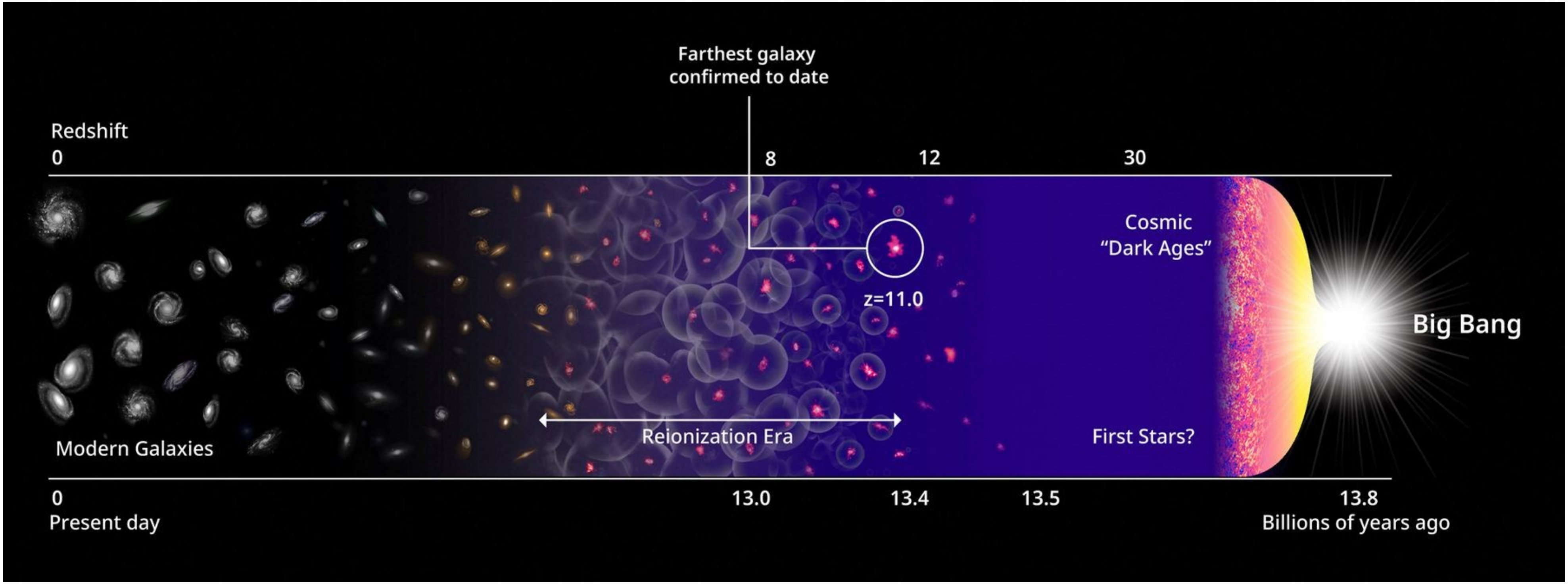
Urknall und Expansion des Universums (“Hubble Tension”)

Hubble Tension



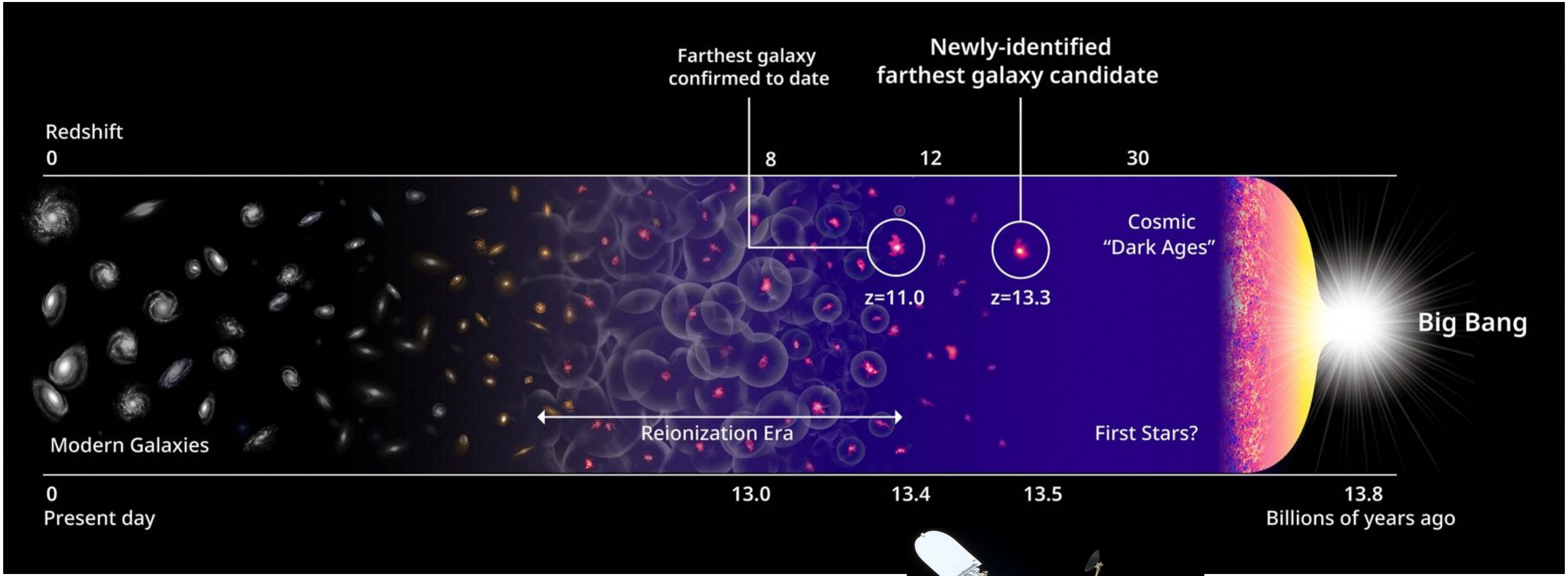
Perivolaropoulos et al. (2021)

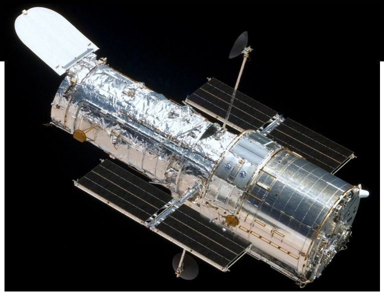
Urknall und Expansion des Universums – Massive Galaxien bei z~11?



NASA, EST and P. Oesch

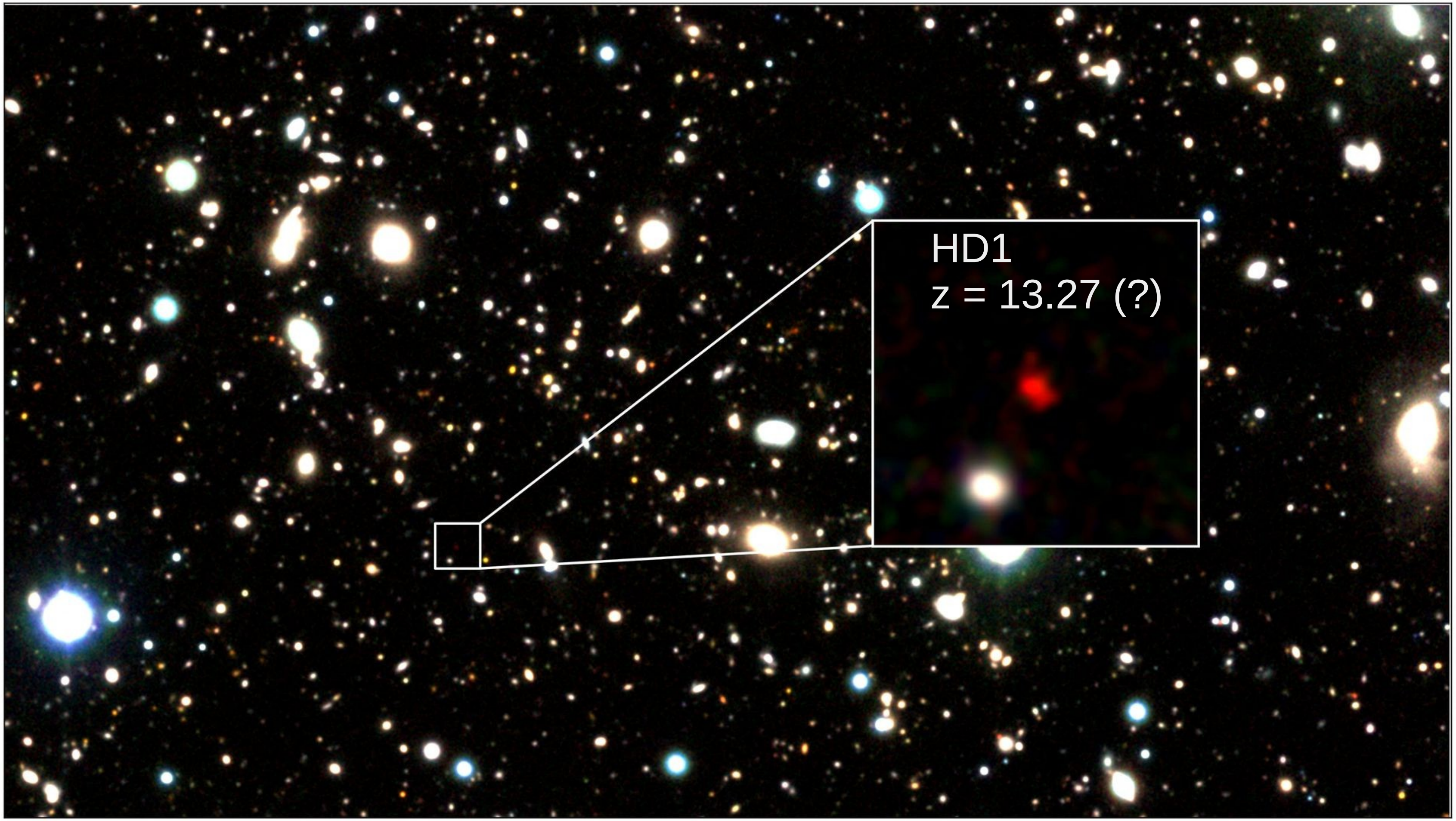
Urknall und Expansion des Universums – Massive Galaxien bei z~13?





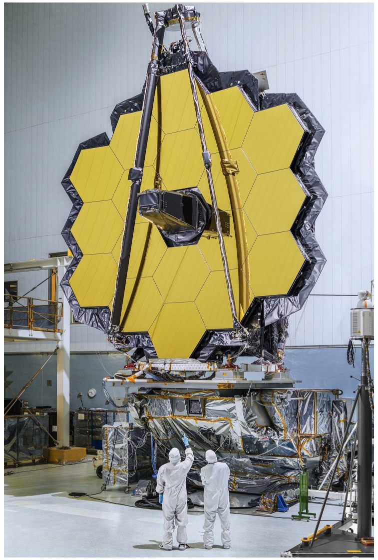
Harikane et al. (2022), NASA, EST and P. Oesch

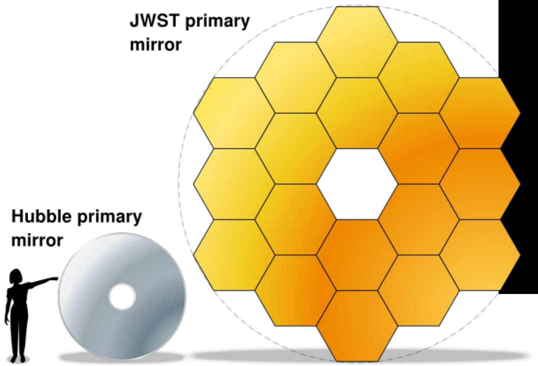
Urknall und Expansion des Universums – Massive Galaxien bei z~13?

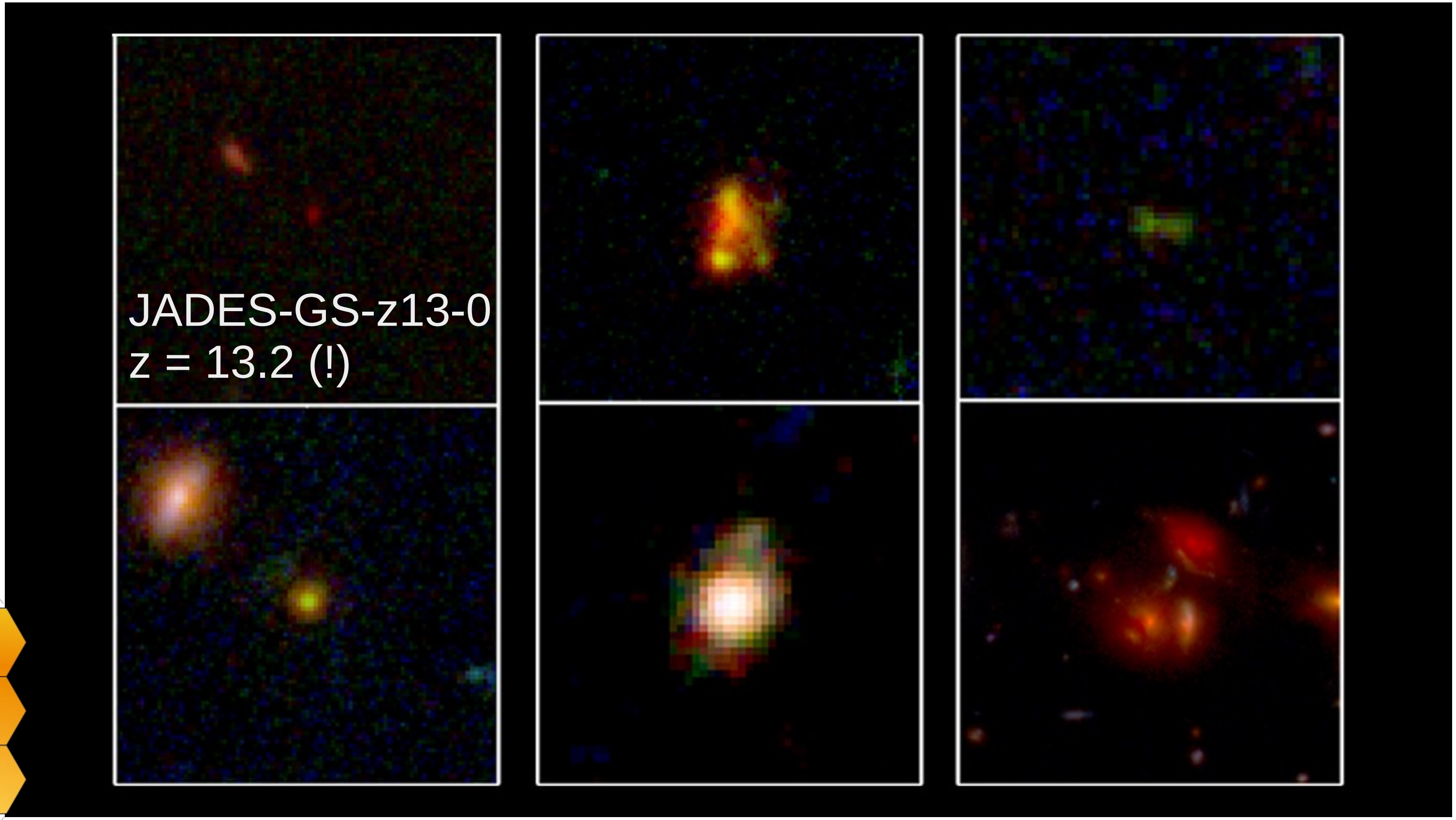


Urknall und Expansion des Universums – Massive Galaxien bei z~13?

JWST Advanced Deep Extragalactic Survey (JADES)







Credit: JADES Collaboration, B.E. Robertson et al./Nature Astronomy

Urknall und Expansion des Universums – eine Alternative

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JWST early Universe observations and ΛCDM cosmology

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Urknall und Expansion des Universums – eine Alternative

ABSTRACT

Deep space observations of the *JWST* have revealed that the structure and masses of very early Universe galaxies at high redshifts ($z \sim 15$), existing at $\sim$0.3 Gyr after the Big Bang, may be as evolved as the galaxies in existence for $\sim$ 10 Gyr. The *JWST* findings are thus in strong tension with the ΛCDM cosmological model. While tired light (TL) models have been shown to comply with the *JWST* angular galaxy size data, they cannot satisfactorily explain isotropy of the cosmic microwave background (CMB) observations or fit the supernovae distance modulus versus redshift data well. We have developed hybrid models that include the tired light concept in the expanding universe. The hybrid ΛCDM model fits the supernovae type 1a data well but not the *JWST* observations. We present a model with covarying coupling constants (CCC), starting from the modified FLRW metric and resulting Einstein and Friedmann equations, and a CCC + TL hybrid model. They fit the Pantheon + data admirably, and the CCC + TL model is compliant with the *JWST* observations. It stretches the age of the Universe to 26.7 Gyr with 5.8 Gyr at $z = 10$ and 3.5 Gyr at $z = 20$, giving enough time to form massive galaxies. It thus resolves the 'impossible early galaxy' problem without requiring the existence of primordial black hole seeds or modified power spectrum, rapid formation of massive population III stars, and super Eddington accretion rates. One could infer the CCC model as an extension of the ΛCDM model with a dynamic cosmological constant.

Urknall und Expansion des Universums

Die Beobachtung von Galaxien (und Sternen) ist letzlich unser Maßstab für die Entwicklung des Universums und des Lebens.

Inhalt

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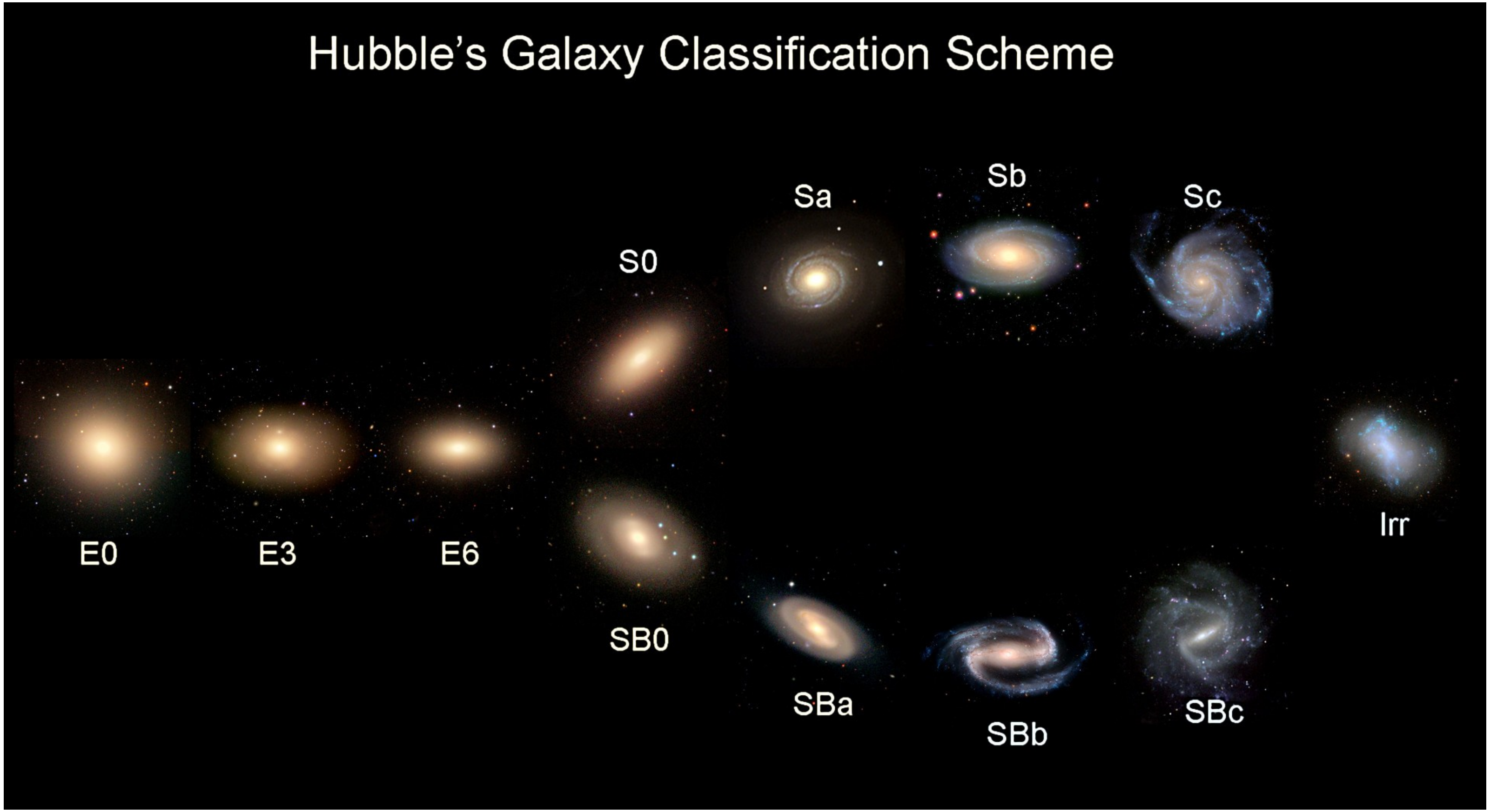
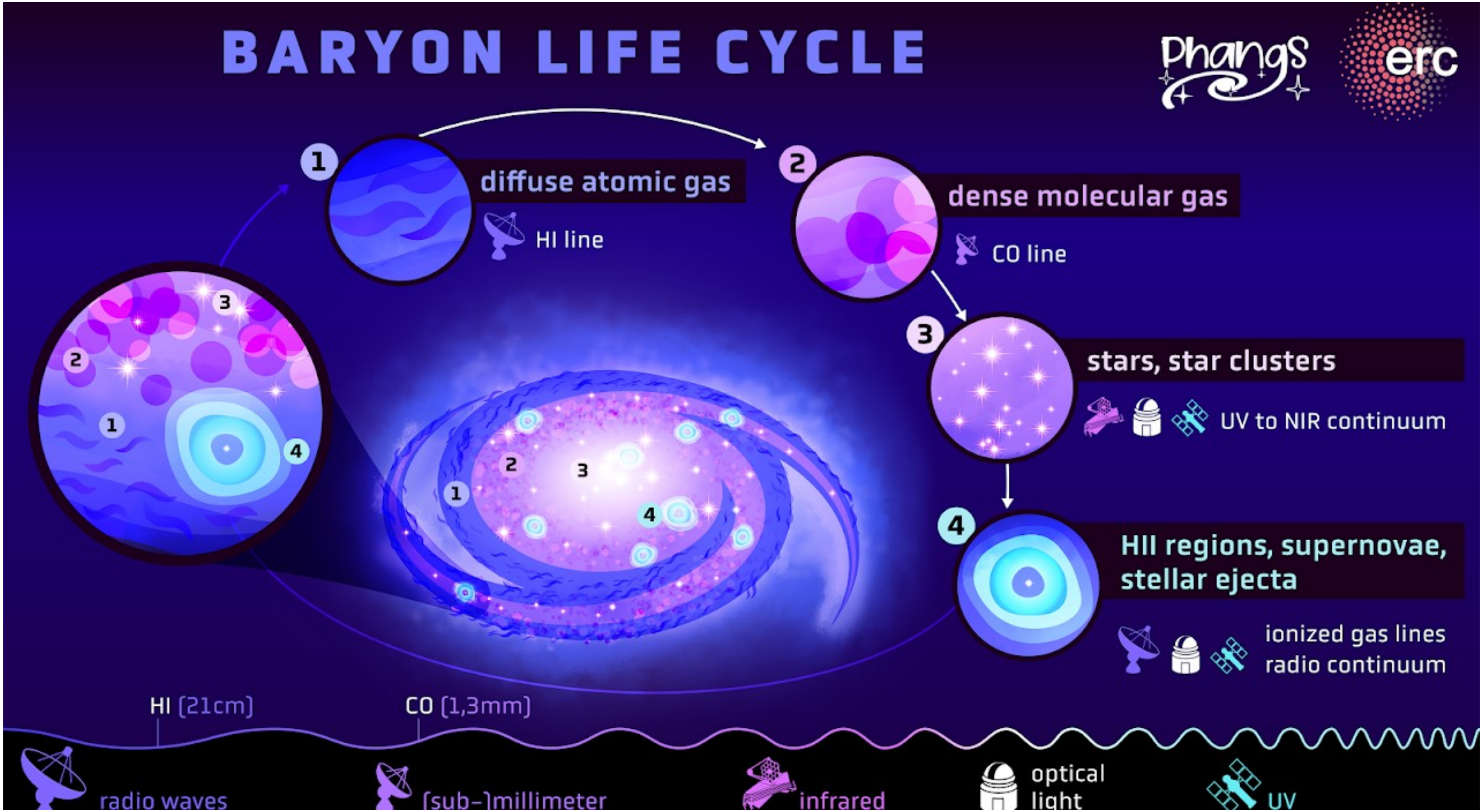
  - Galaxien am Höhepunkt der Sternentstehung

Galaxienentwicklung – Allgemeines zu Galaxien



Credit: Galaxy Zoo

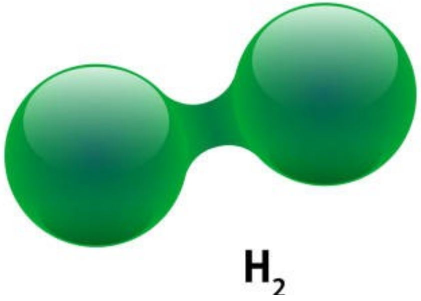
Galaxienentwicklung – Allgemeines zu Galaxien



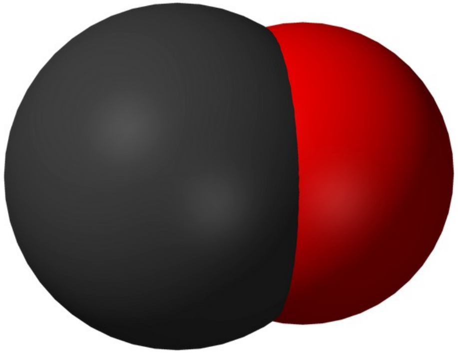
Credit: PHANGS Collaboration

Galaxienentwicklung – Warum CO statt H_2

H_2 kein Dipolmoment



CO zeithäufigstes Molekül mit Dipol



Anregung von Rotationsübergängen ab ca. 5K

Ein paar meiner Lieblingsteleskope

IRAM 30m Teleskop

Ein paar meiner Lieblingsteleskope

Nordic Optical Telescope

Ein paar meiner Lieblingsteleskope

Nobeyama
45m Telekop

Ein paar meiner Lieblingsteleskope

Nobeyama
45m Telekop

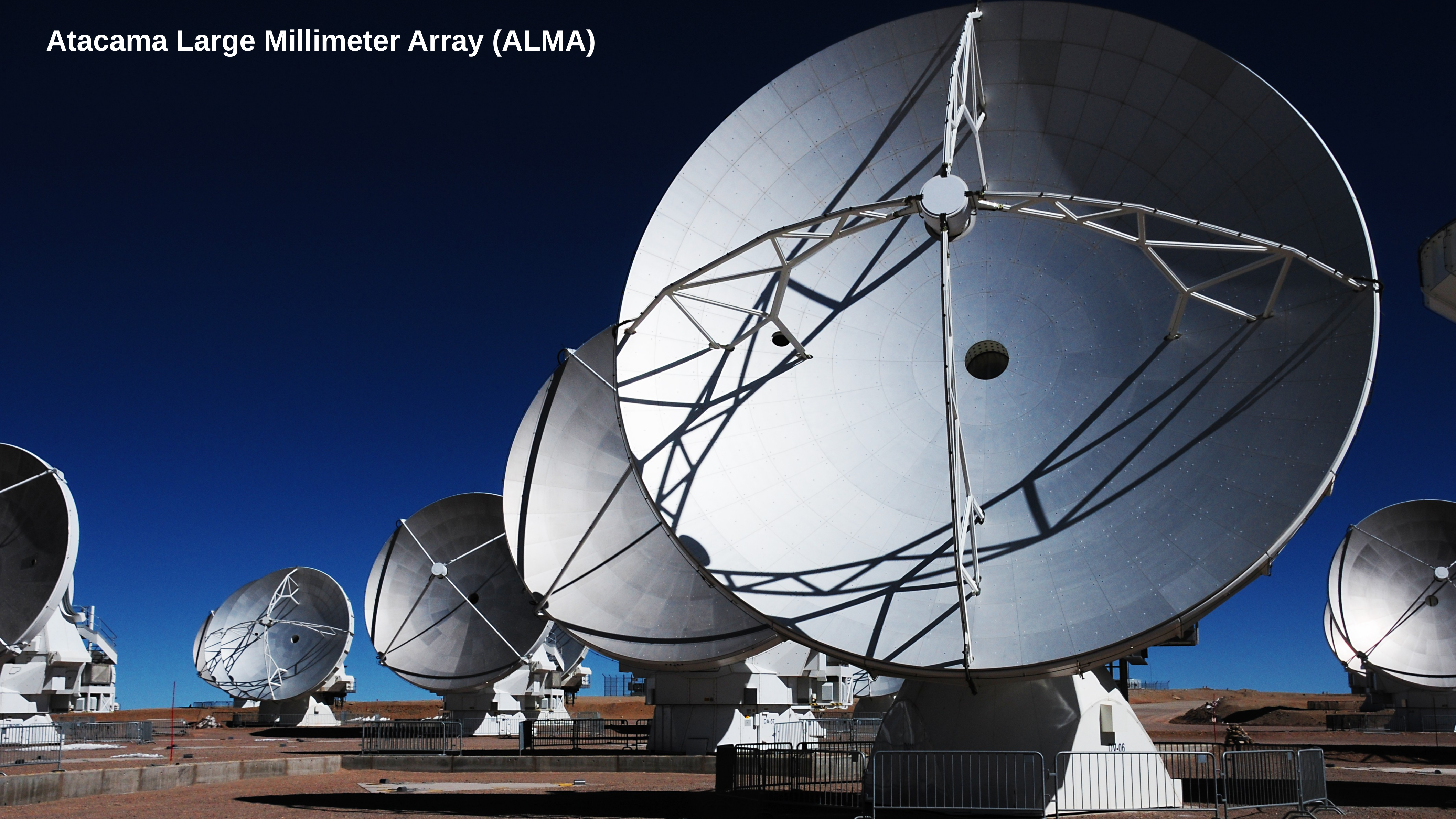

IRAM 30m Teleskop

IRAM 30m Teleskop Control Room

Atacama Pathfinder Experiment (APEX)

APEX Control Room

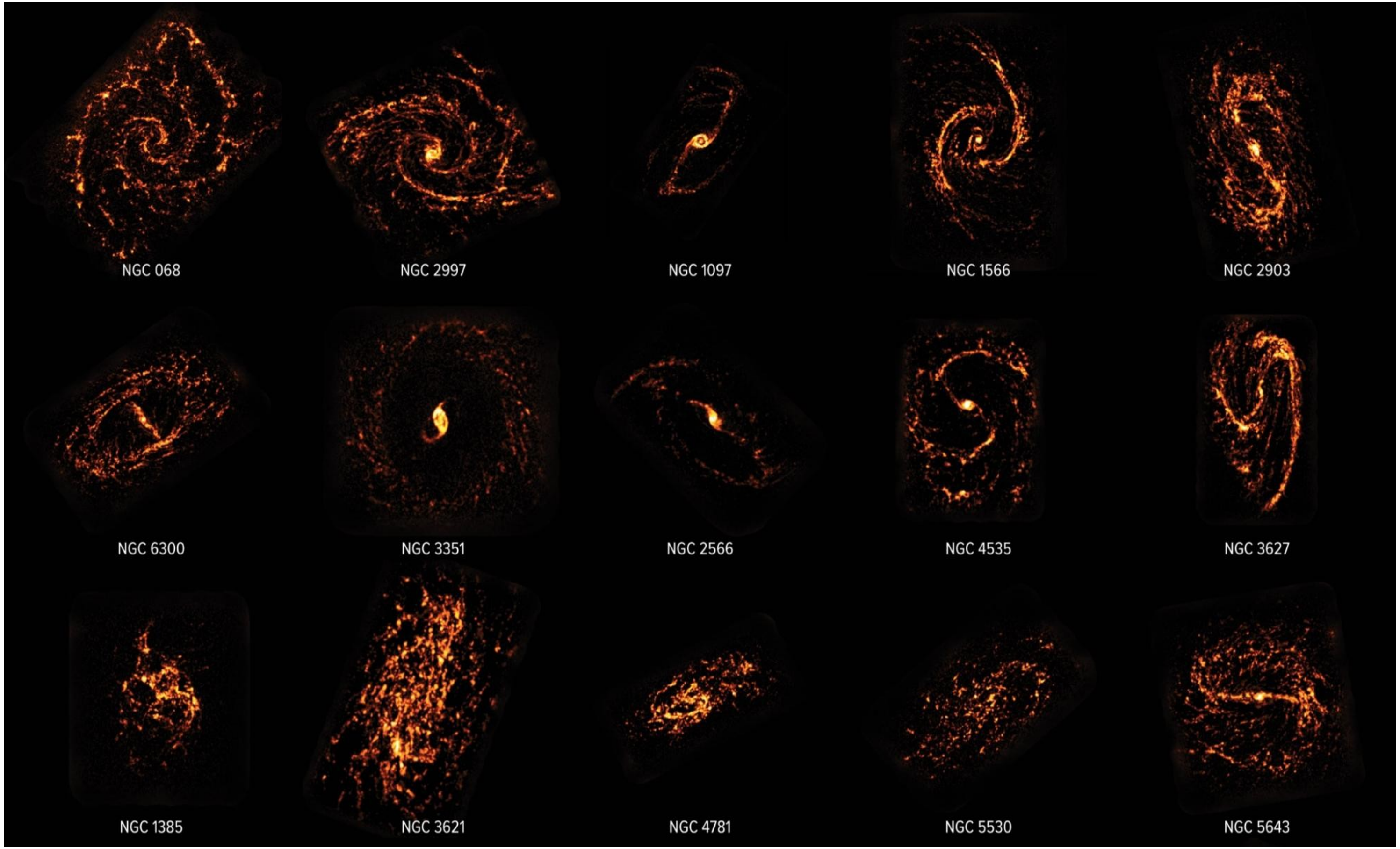
Atacama Large Millimeter Array (ALMA)



Atacama Large Millimeter Array (ALMA)

Galaxienentwicklung – ALMA Daten

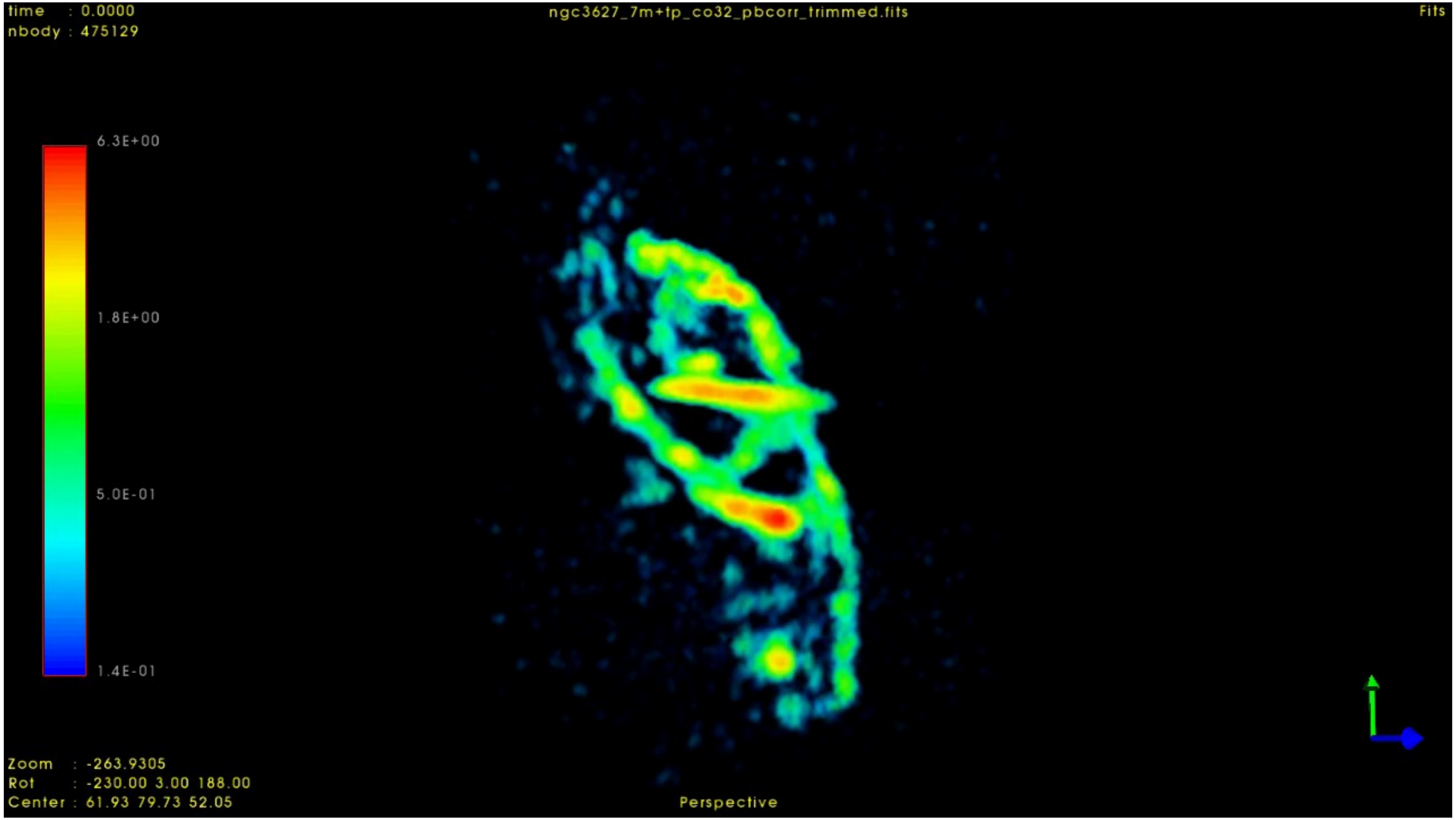
Molekulares Gas: CO (2-1)



Credit: PHANGS Collaboration

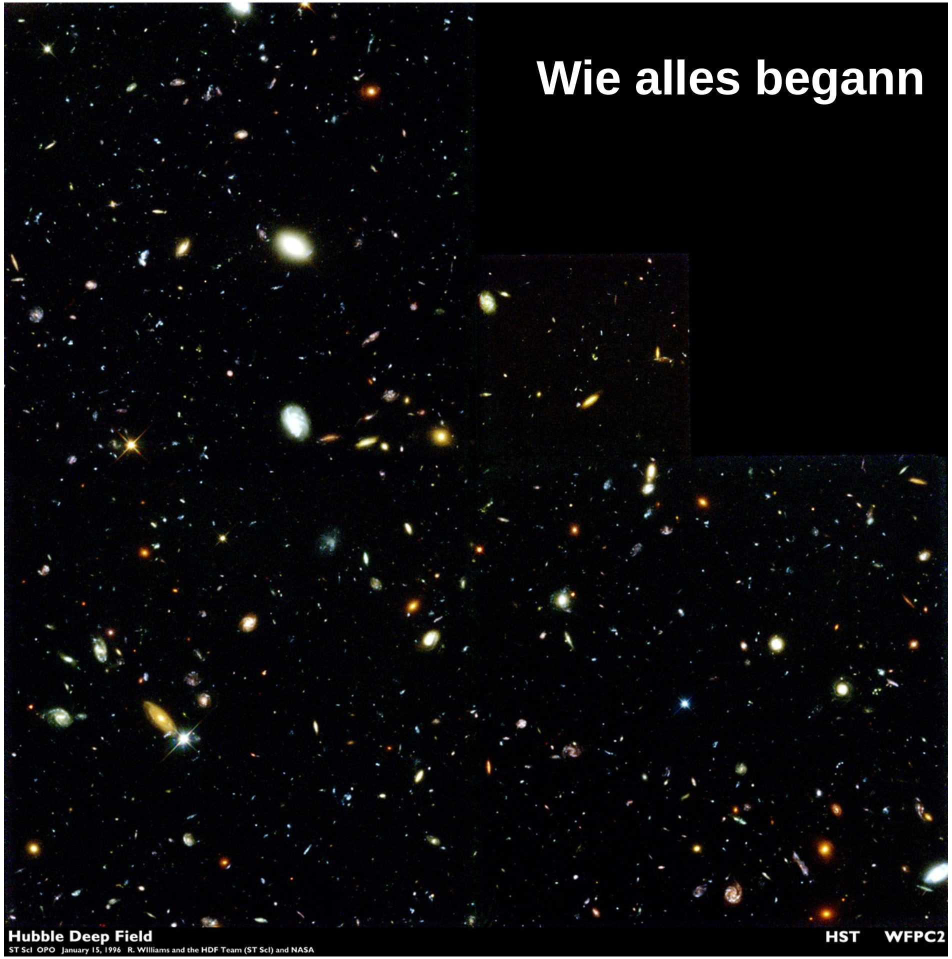
Galaxienentwicklung – ALMA Daten

Molekulares Gas: CO (3-2)



Puschnig et al. (in prep)

Galaxienentwicklung – Hubble Deep Field

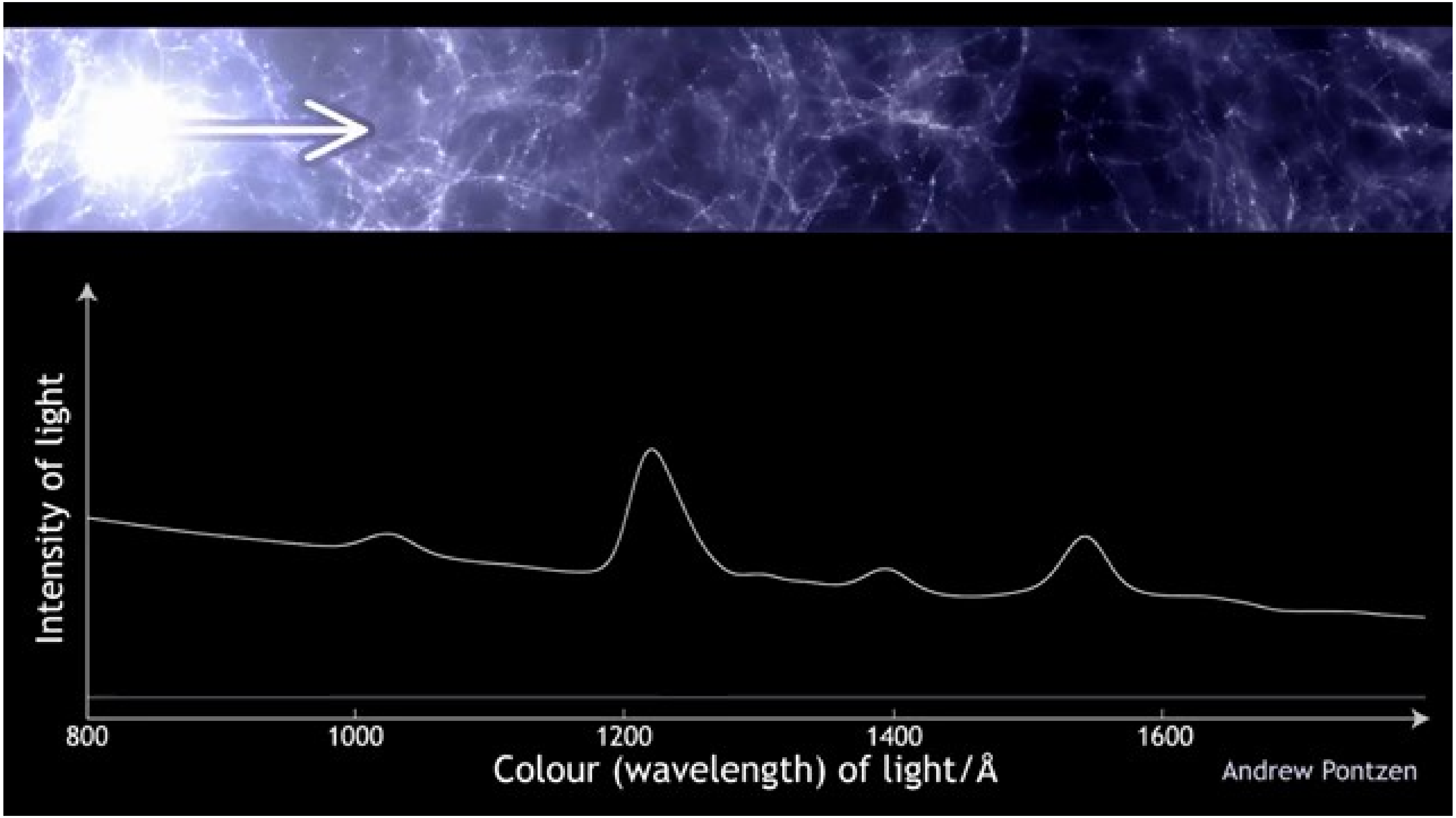


Credit: Robert Williams and the Hubble Deep Field Team (STScI) and NASA/ESA

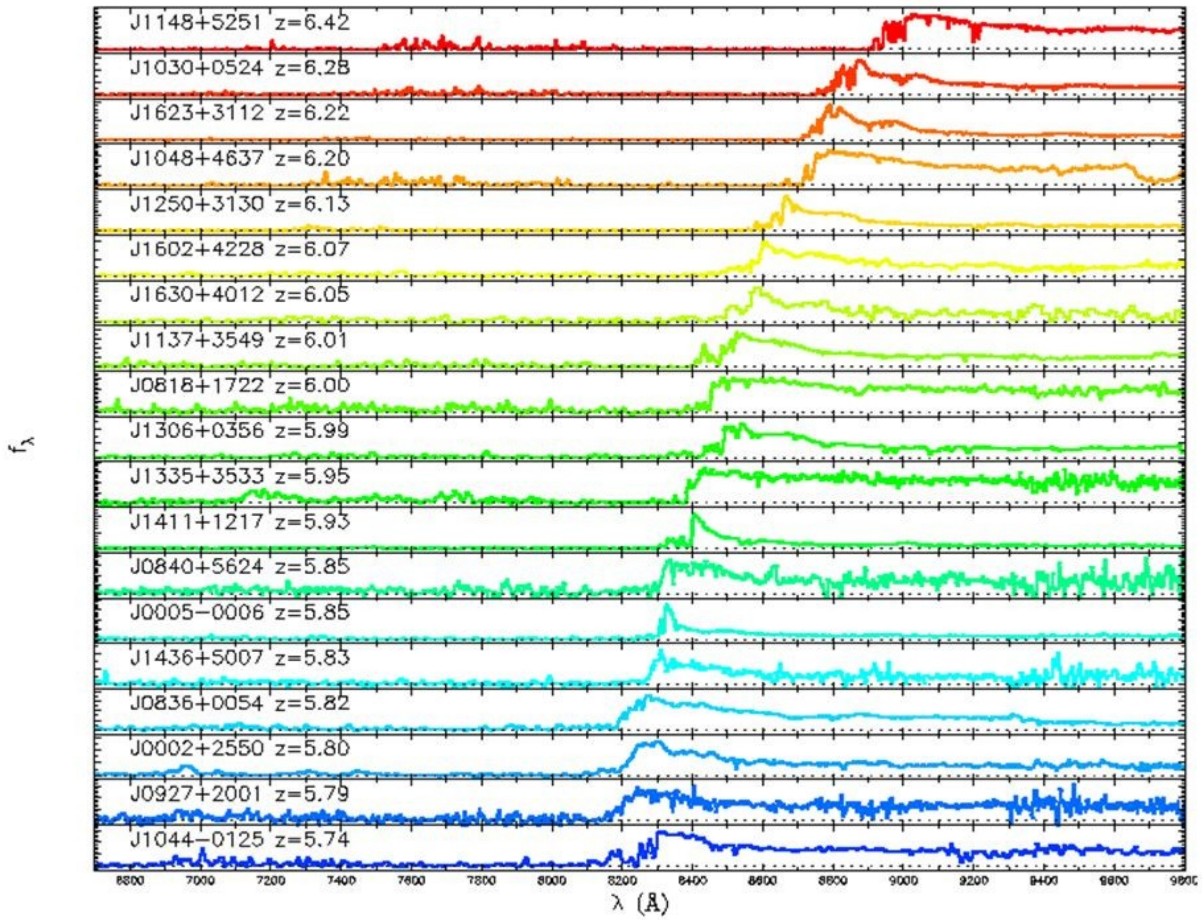
Galaxienentwicklung – Hubble Deep Field

Credit: Robert Williams and the Hubble Deep Field Team (STScI) and NASA/ESA

Galaxienentwicklung – Lyman Alpha Wald



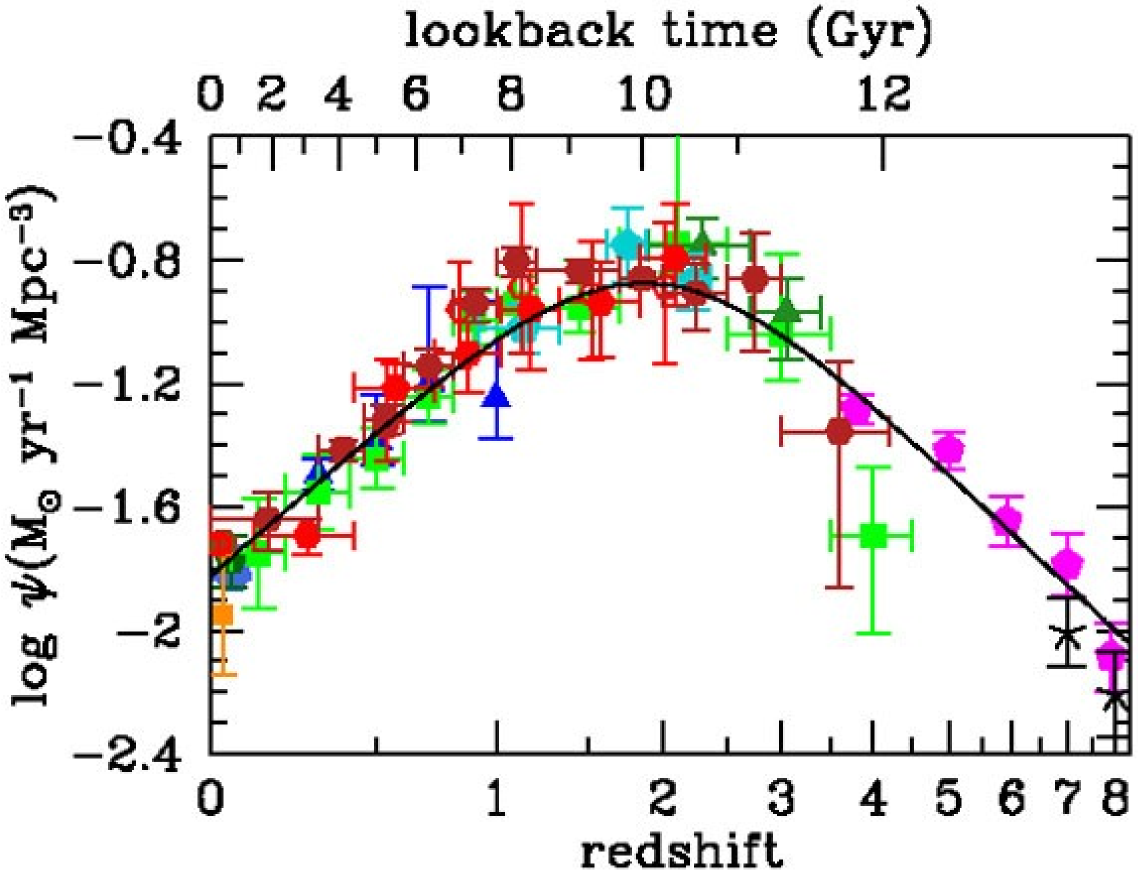
Galaxienentwicklung – Zeitpunkt der kosmischen Reionisation



Wann alles begann:
z~6

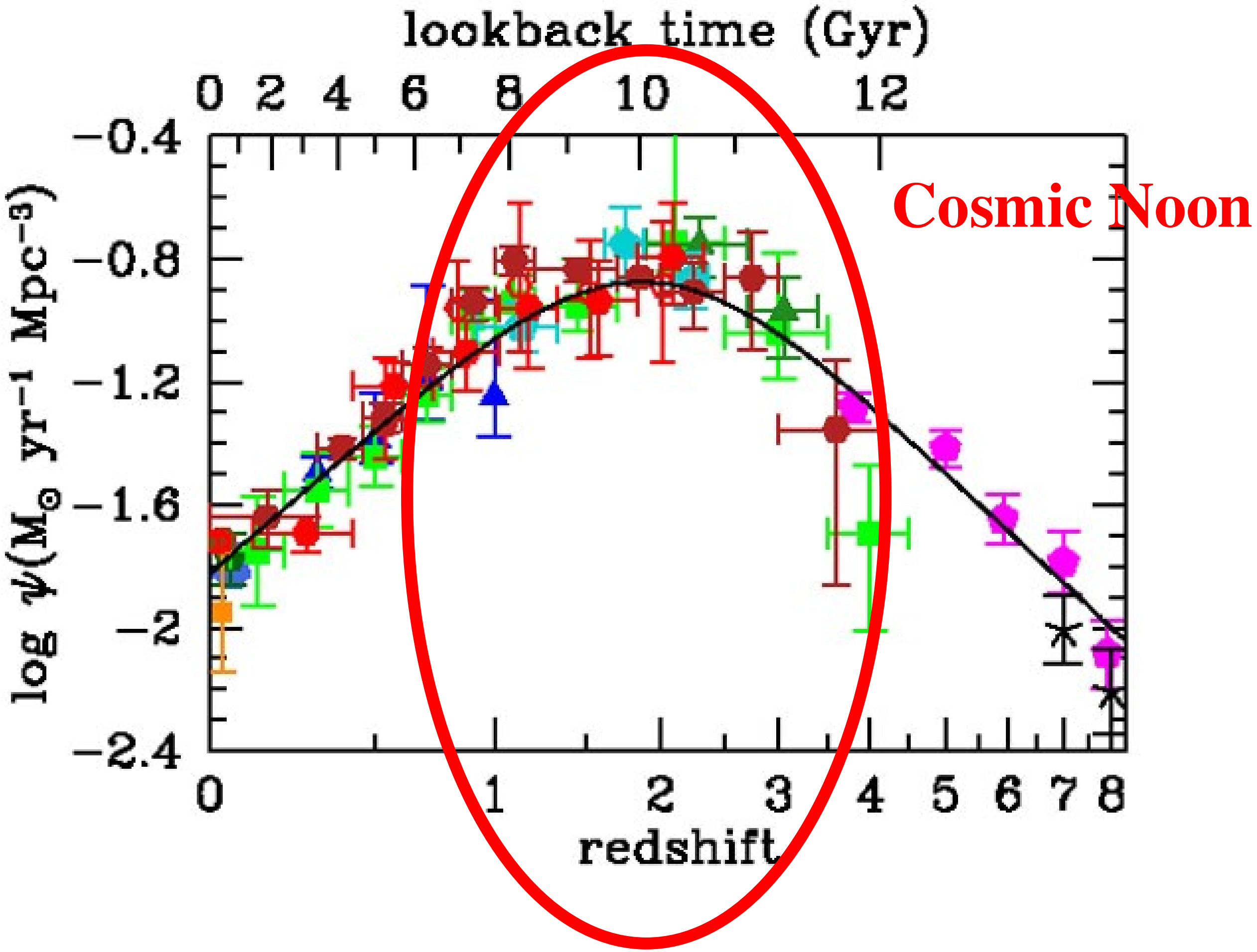
Fan et al. (2006)

Galaxienentwicklung – kosmische Sternentstehungsrate



Madau & Dickinson (2014)

Galaxienentwicklung – kosmische Sternentstehungsrate

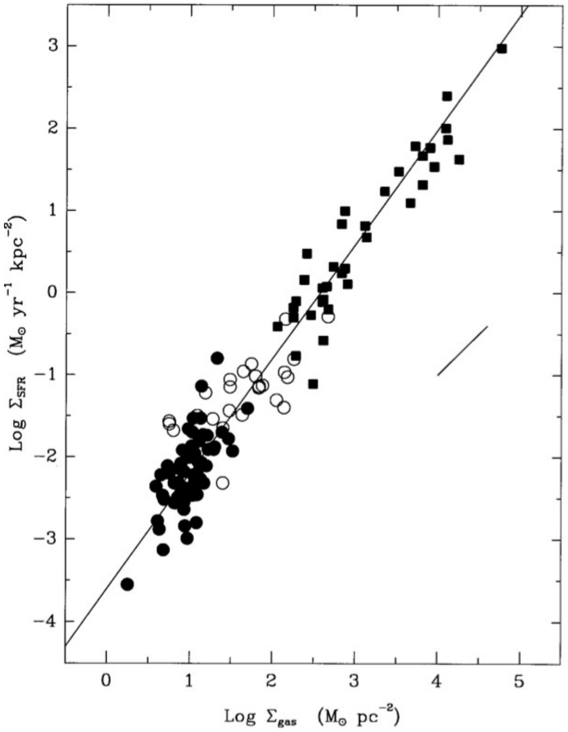


Madau & Dickinson (2014)

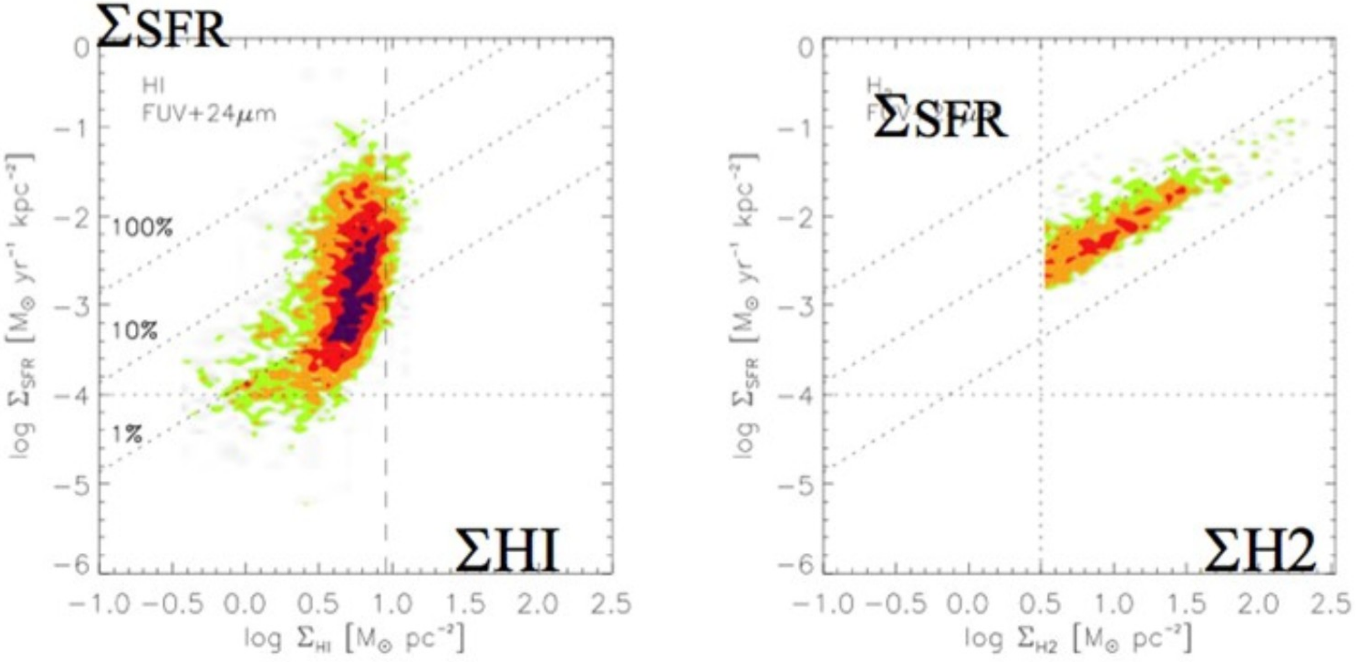
Galaxienentwicklung

Die Hälfte der heute existierenden Sterne entstand vor ca. 10 Milliarden Jahren bei z~1-3.

Sternentstehungsrate vs. molekulares Gas



Kennicutt et al. (1998)

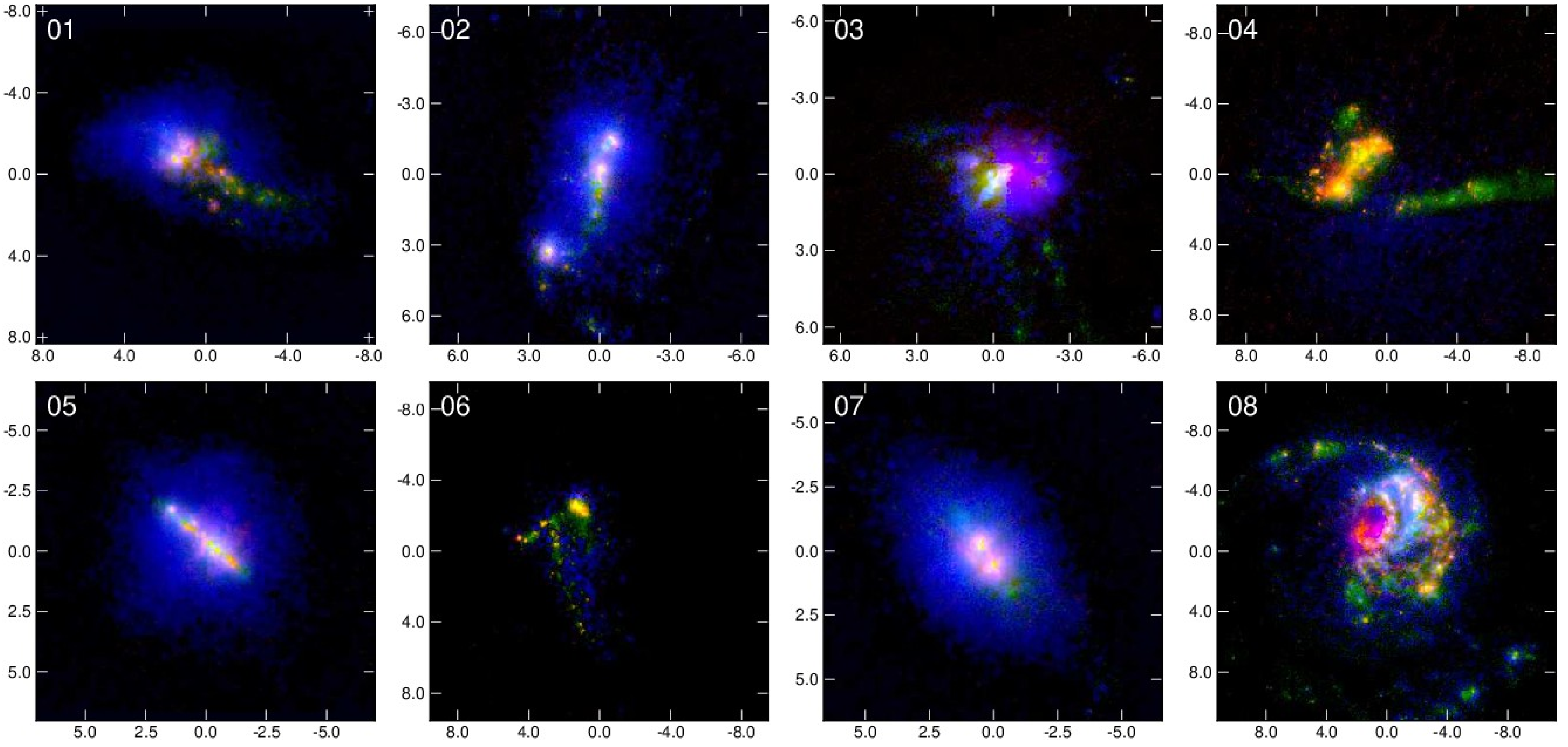


Bigiel et al. (2008)

Eigenschaften von Galaxien bei z~1-3

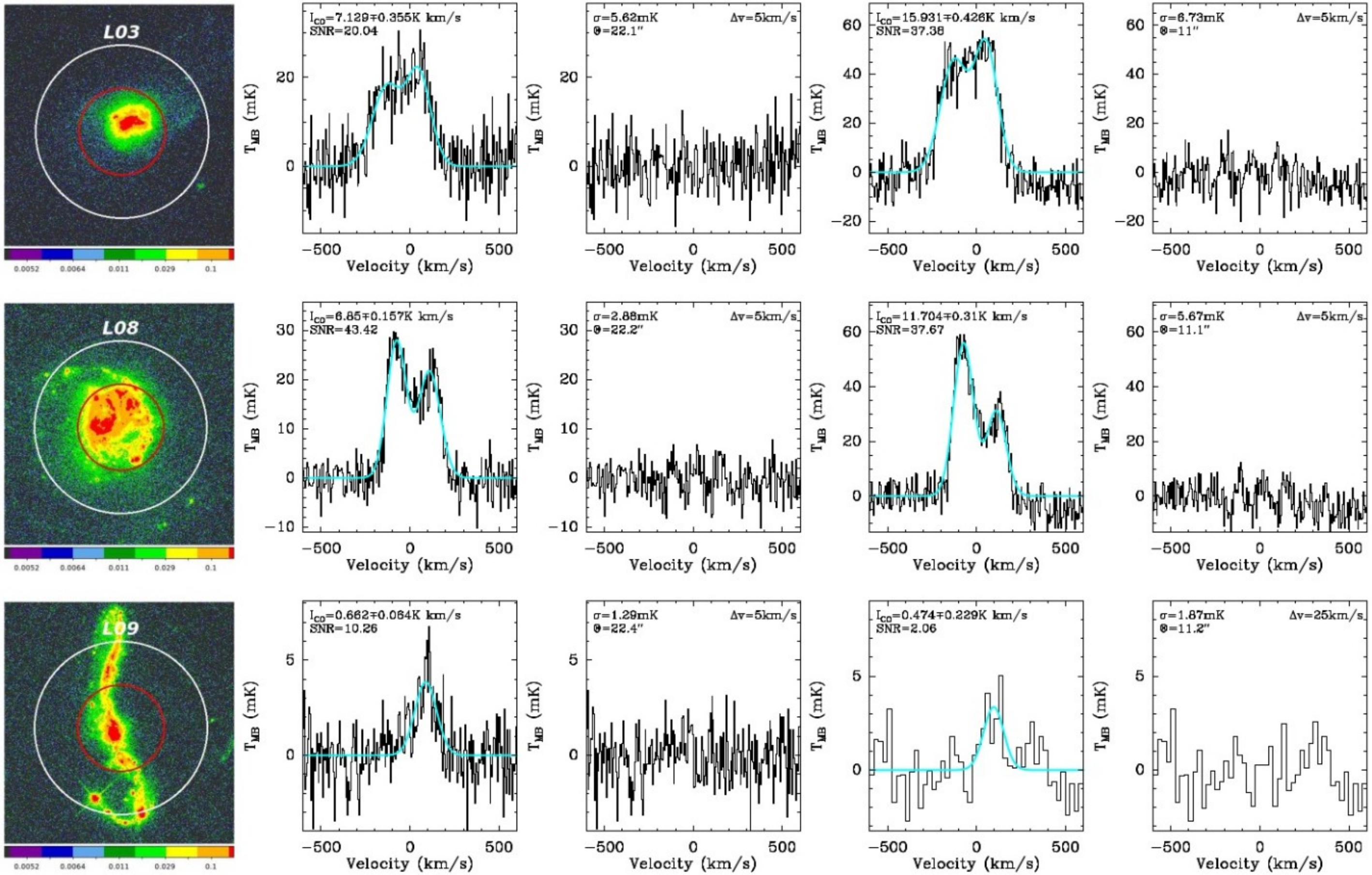
- Massereiche Scheibengalaxien (MW)
- Rotationsgestützt
- Sehr massereiche Super-Sternhaufen (clumpy)
- Sehr grosser Gasanteil
- Sehr hohe Sternentstehungsraten

Lyman Alpha Reference Sample



Galaxienentwicklung – Lokale Galaxien als Laboratorien

Lyman Alpha Reference Sample

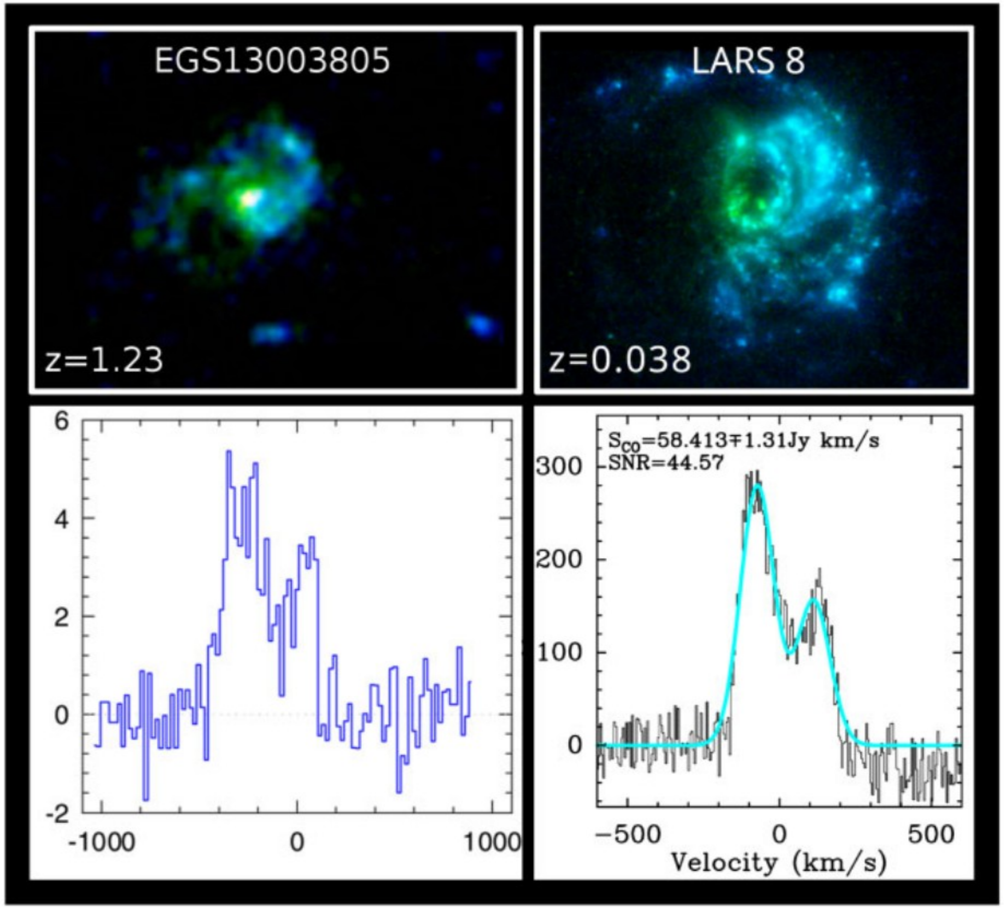


Puschnig et al. (2020)

Galaxienentwicklung – Entstehung von Super-Sternhaufen

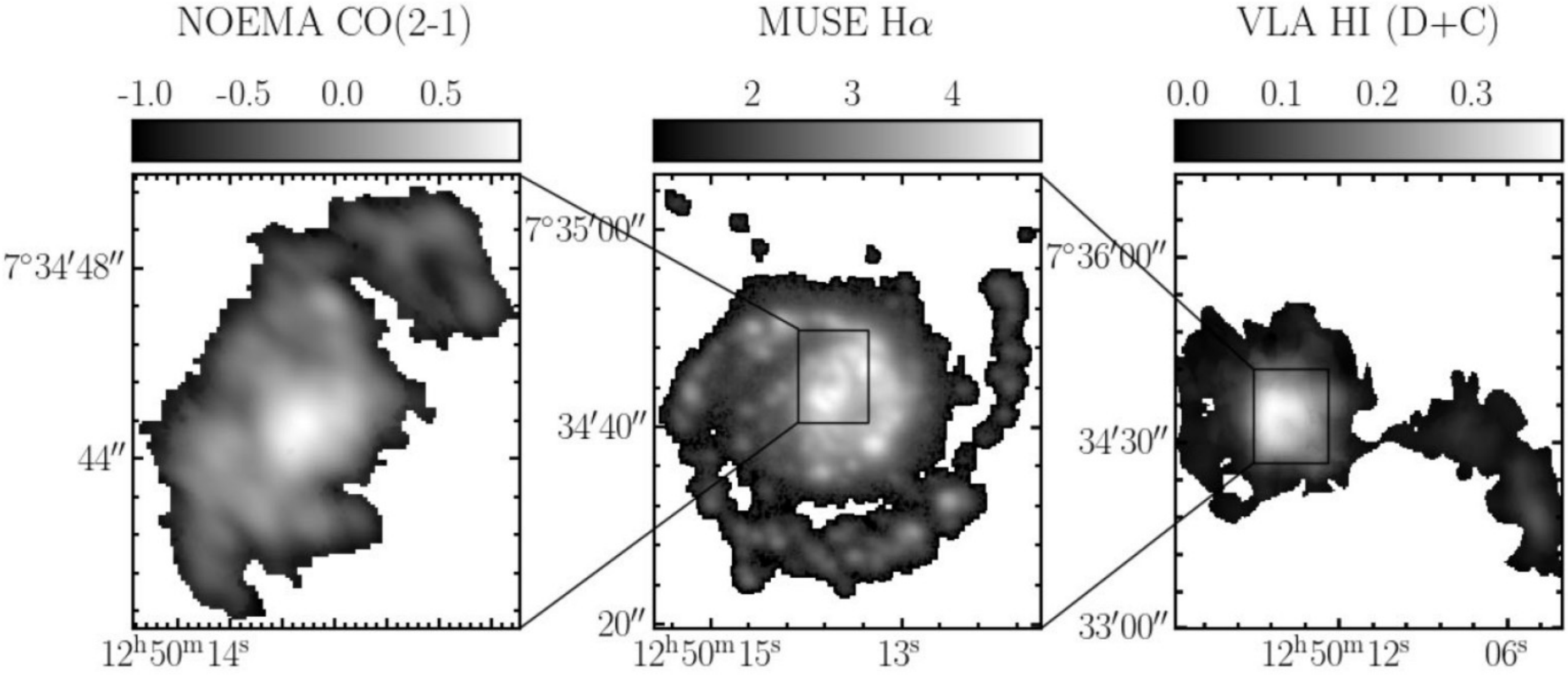
Eigenschaften von Galaxien bei z~1-3:

Fallstudie zur Entstehung massereicher Super-Sternhaufen



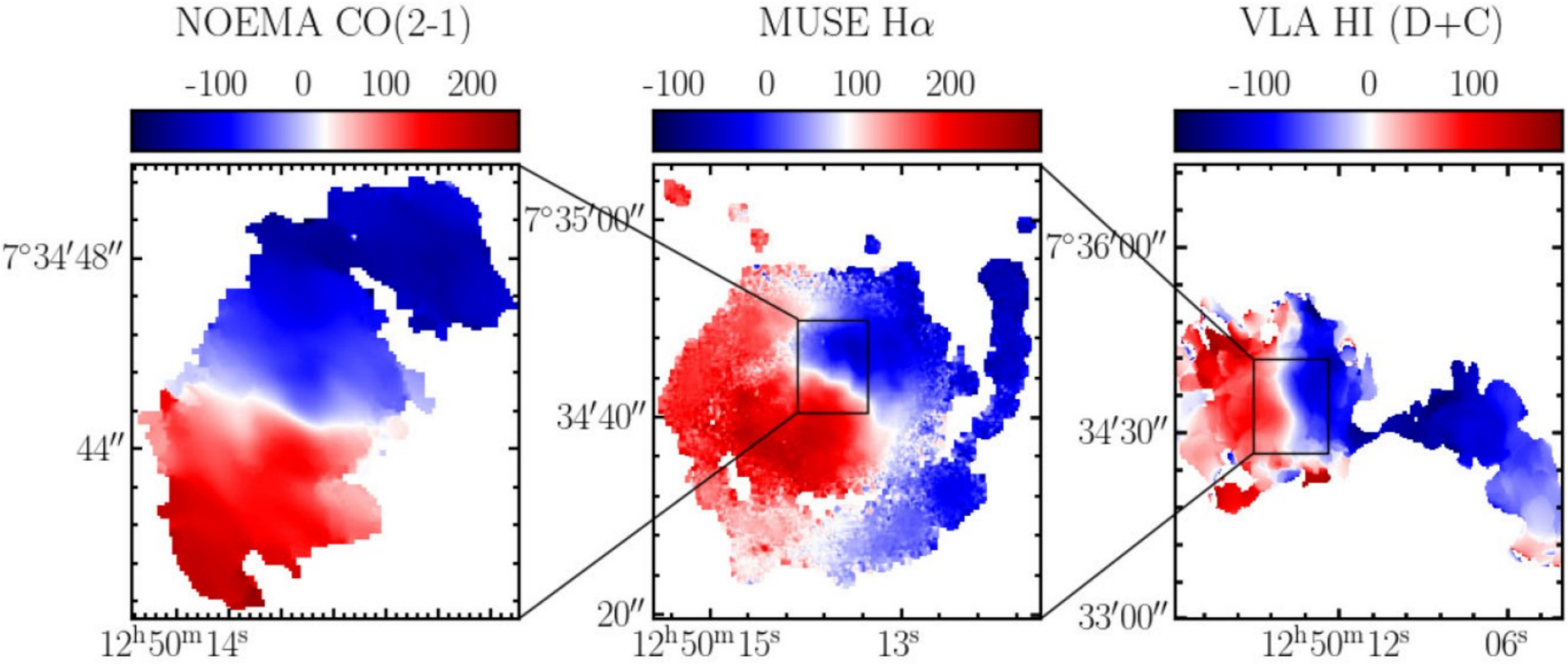
Puschnig et al. (2023)

Galaxienentwicklung – Entstehung von Super-Sternhaufen



Puschnig et al. (2023)

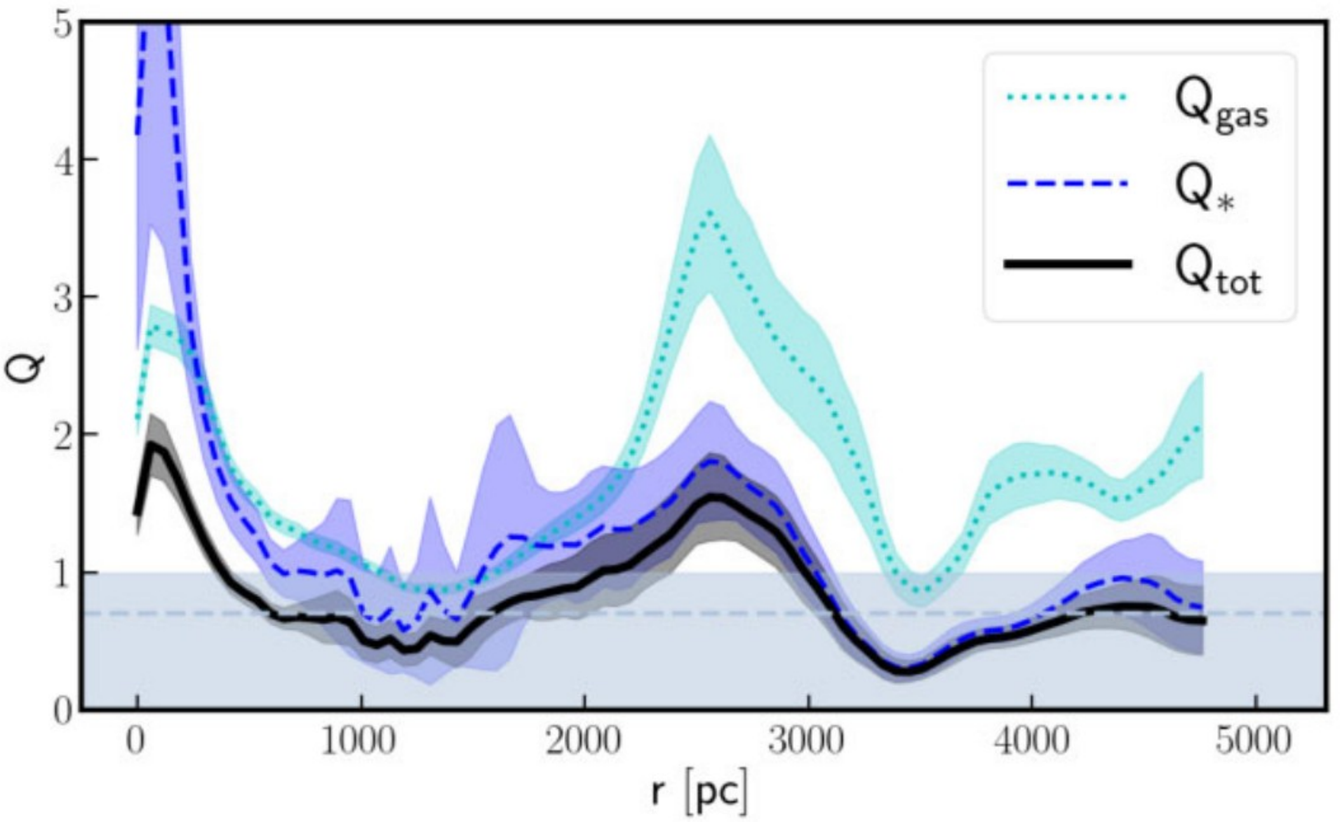
Galaxienentwicklung – Entstehung von Super-Sternhaufen



Puschnig et al. (2023)

Galaxienentwicklung – Entstehung von Super-Sternhaufen

$$Q_g = \frac{\kappa \ \sigma_g}{\pi \ G \ \Sigma_g} > 1$$



Instabil auf großer Skala → Sternentstehung

Puschnig et al. (2023)

Zusammenfassung

- Unser kosmologisches Modell steht durch neue Beobachtungen derzeit unter Druck (Hubble Tension, JADES)
- Limit der kosmischen Reionisation aus Quasarsichtlinien sehr gut bestimmt zu: z~6
- Kosmische Sternentstehungsrate hatte Peak bei z~1-3 (die meisten Sterne heute entstanden zu diesem Zeitpunkt)
- Sterne entstehen aus molekularem Gas: Zusammenhang CO vs. Sternentstehungsrate
- Wir koennen einige ausgesuchte lokale Galaxien als Laboratorien für das frühe Universum verwenden (z.B. LARS –> Entstehung supermassereicher Sternhaufen)


Credit: ESO

Credit: ESO

Danke