J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

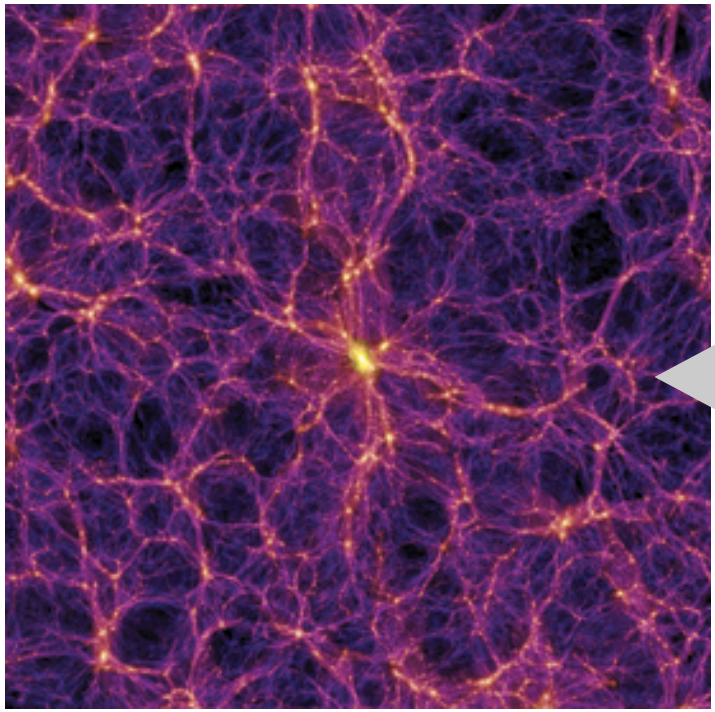
Session 2 Summary
Star formation in the Milky Way, its satellites, and nearby galaxies

J. M. Diederik Kruijssen
MPA

Session 2 Summary

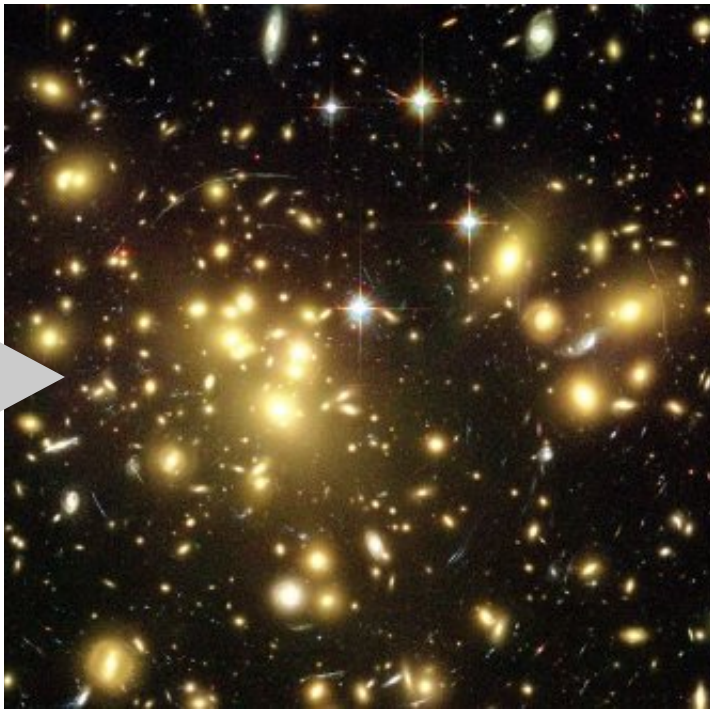
J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Star formation is a fundamental process



Springel+05

star formation



ΛCDM

Galaxy population

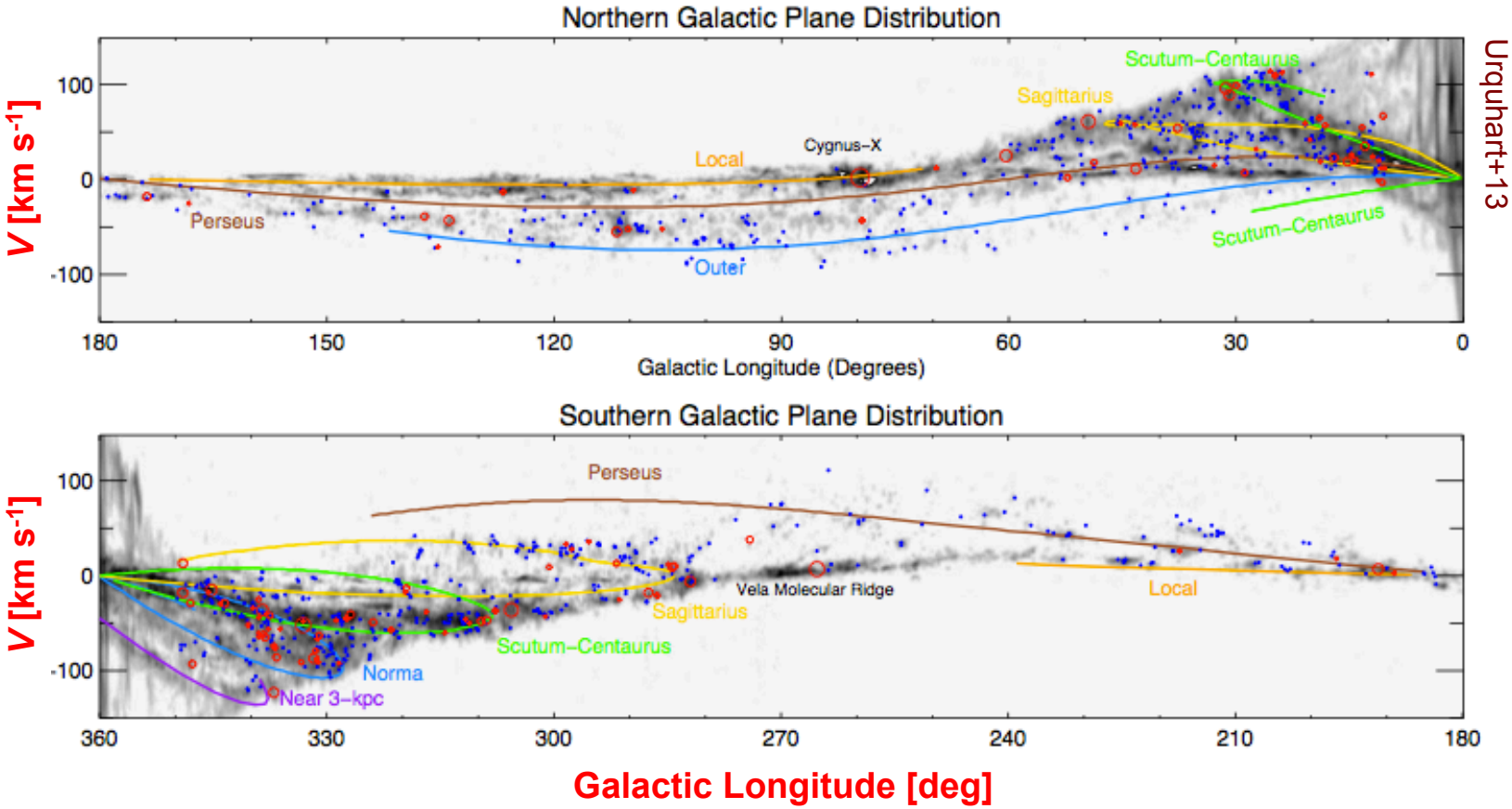
Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Star formation process extremely well-resolved in the MW & SMC/LMC

✧ Provides test & calibration for analytic theories of star formation

Krumholz & McKee 05; Padoan & Nordlund 11,13; Hennebelle & Charbier 12; Hopkins 12,13



Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Formation of stars and massive clusters by cloud-cloud collisions?

Talks by Fukui, Nakamura

- Yasuo Fukui: massive cluster formation by cloud-cloud collisions gives observed age spread of ~0.1 Myr (assuming $\Delta v \sim 20$ km/s)

Session 2 Summary

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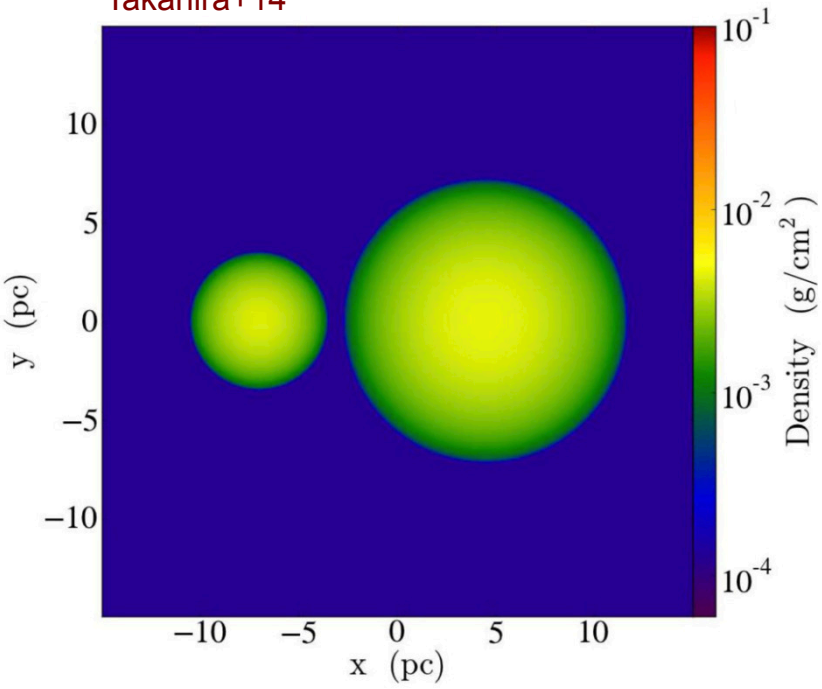
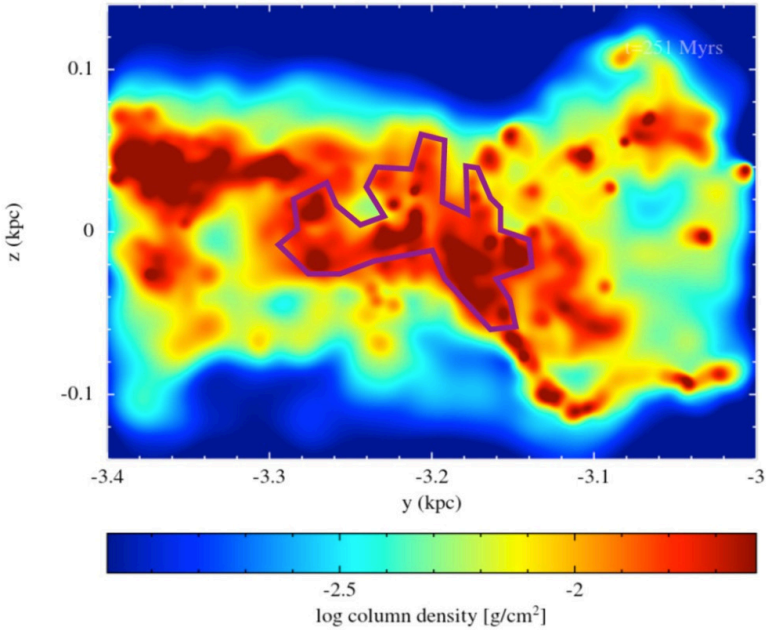
Takahira+14



Dobbs+14



Session 2 Summary

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- What fraction of star formation is caused by cloud-cloud collisions?

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J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

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- What fraction of star formation is caused by cloud-cloud collisions?
- Merger-induced star formation during galaxy formation contributes few %

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Formation of stars and massive clusters by cloud-cloud collisions?

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- What fraction of star formation is caused by cloud-cloud collisions?
- Merger-induced star formation during galaxy formation contributes few %
- Dobbs, Pringle, Duarte-Cabral, arXiv:1411.0840 find:
  - $\Delta v = 3$–6 km/s
  - ‘minor’ mergers dominate
  - little effect on SFR

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Role of cloud-cloud collisions still an open question

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Role of cloud-cloud collisions still an open question

Even Siri doesn’t know…

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

To form a massive cluster it must survive gas removal by feedback

Talks by Motte, Onishi, discussion by Zinnecker
also Longmore+14 PPVI review

- Frédérique Motte: core formation efficiency approaches 100% at 10^6 cm^{-3}

- Is this how massive clusters form?

Session 2 Summary

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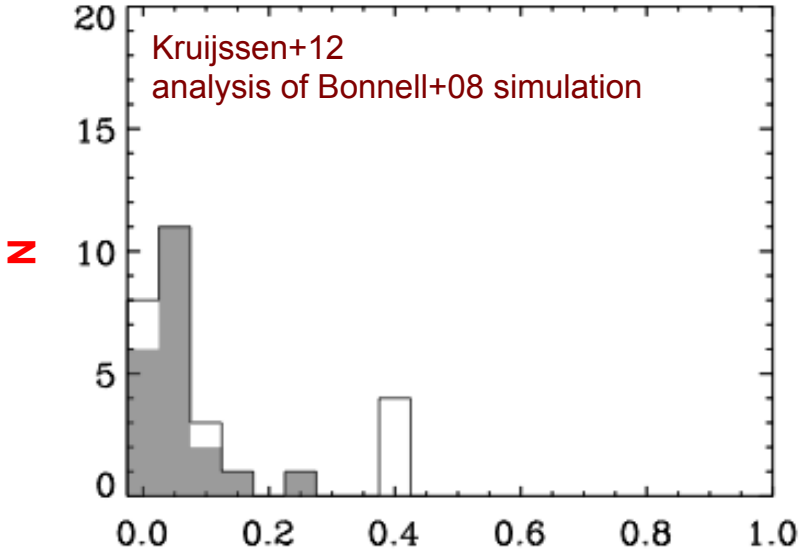
- Is this how massive clusters form?
- Prediction from numerical sims:
  low diffuse gas fraction
  above $10^{5.3}$ cm^{-3}
- Integration across galaxy gives
  # of clusters consistent with the
  observed 5–10% of SF in clusters
  (for the Milky Way)

  Kruijssen 12



Gas fraction =
1 – core formation efficiency

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

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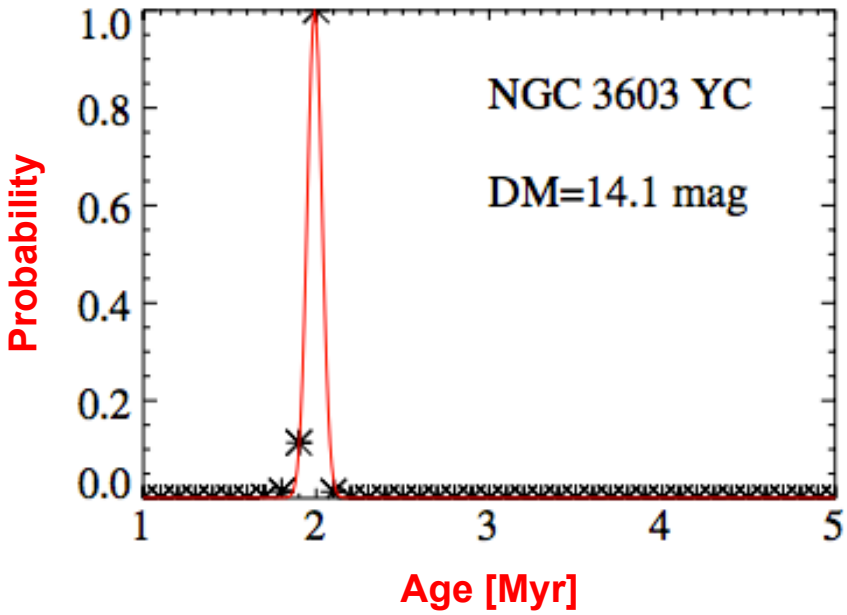
- Is this how massive clusters form?
- Prediction from numerical sims:
  low diffuse gas fraction
  above $10^{5.3}$ cm^{-3}
- Free-fall time of < 0.1 Myr
  Similar to age spread?!

Kudryavtseva+12

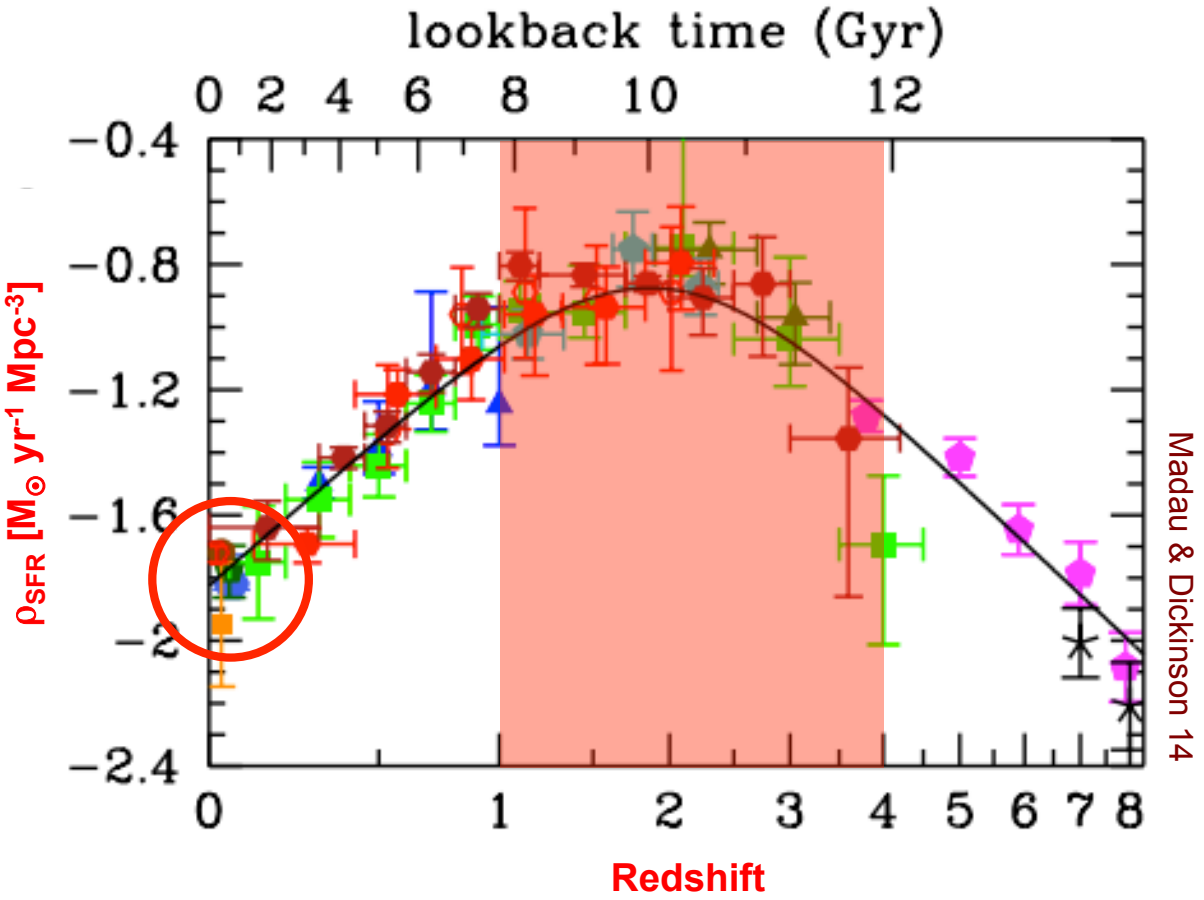


Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Cosmic SFR peaked at redshift z = 2–3

✧ A priori no way of knowing if Galactic constraints are universal

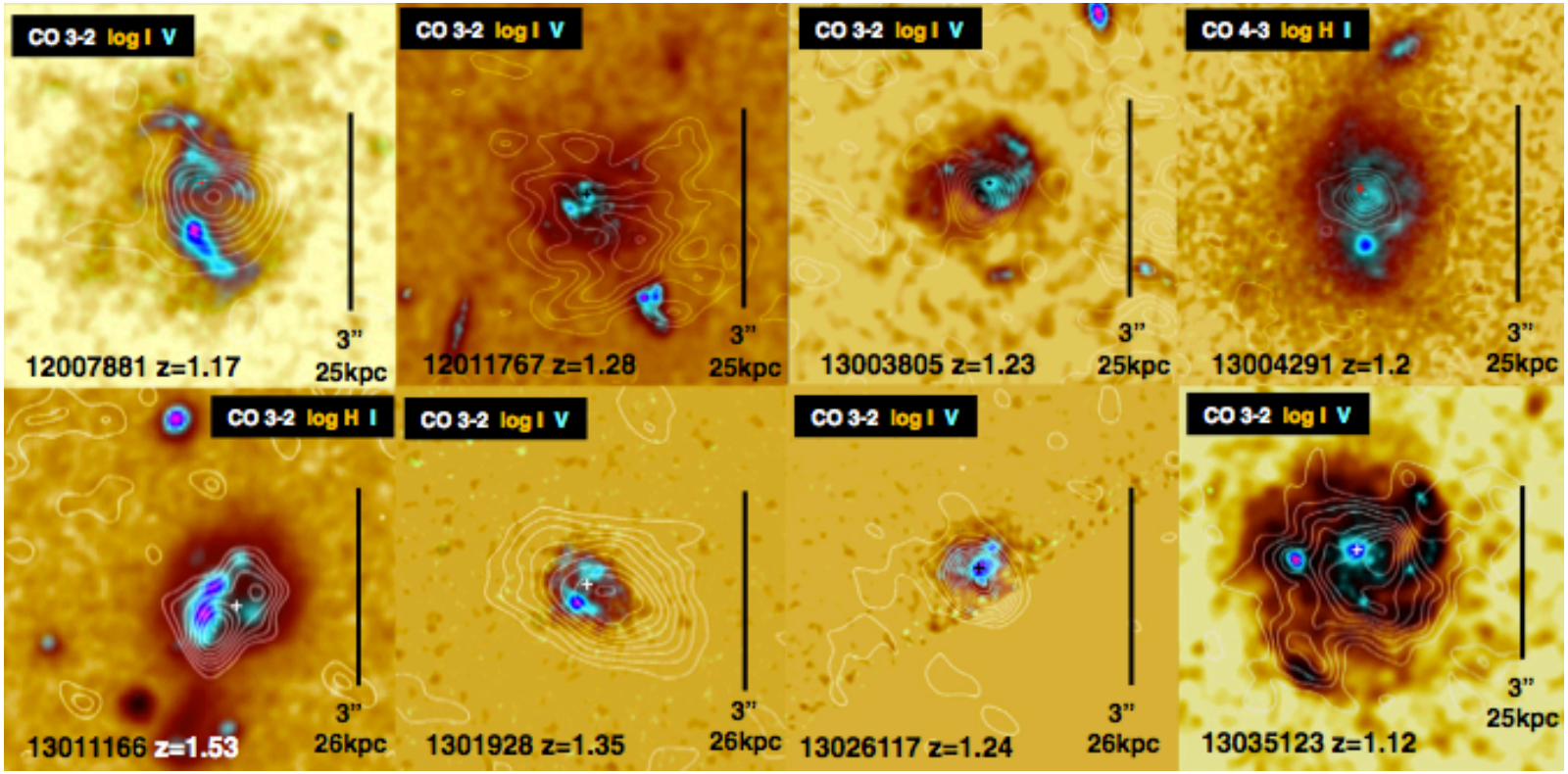


Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Gas properties of high-*z* star-forming galaxies

✧ Gas pressures of $P/k \sim 10^7$ K cm^{-3} (Milky Way has $P/k \sim 10^4$ K cm^{-3})



Tacconi+13

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Connect Galactic studies to extragalactic systems

Talks by Brandl, Könyves, Alves

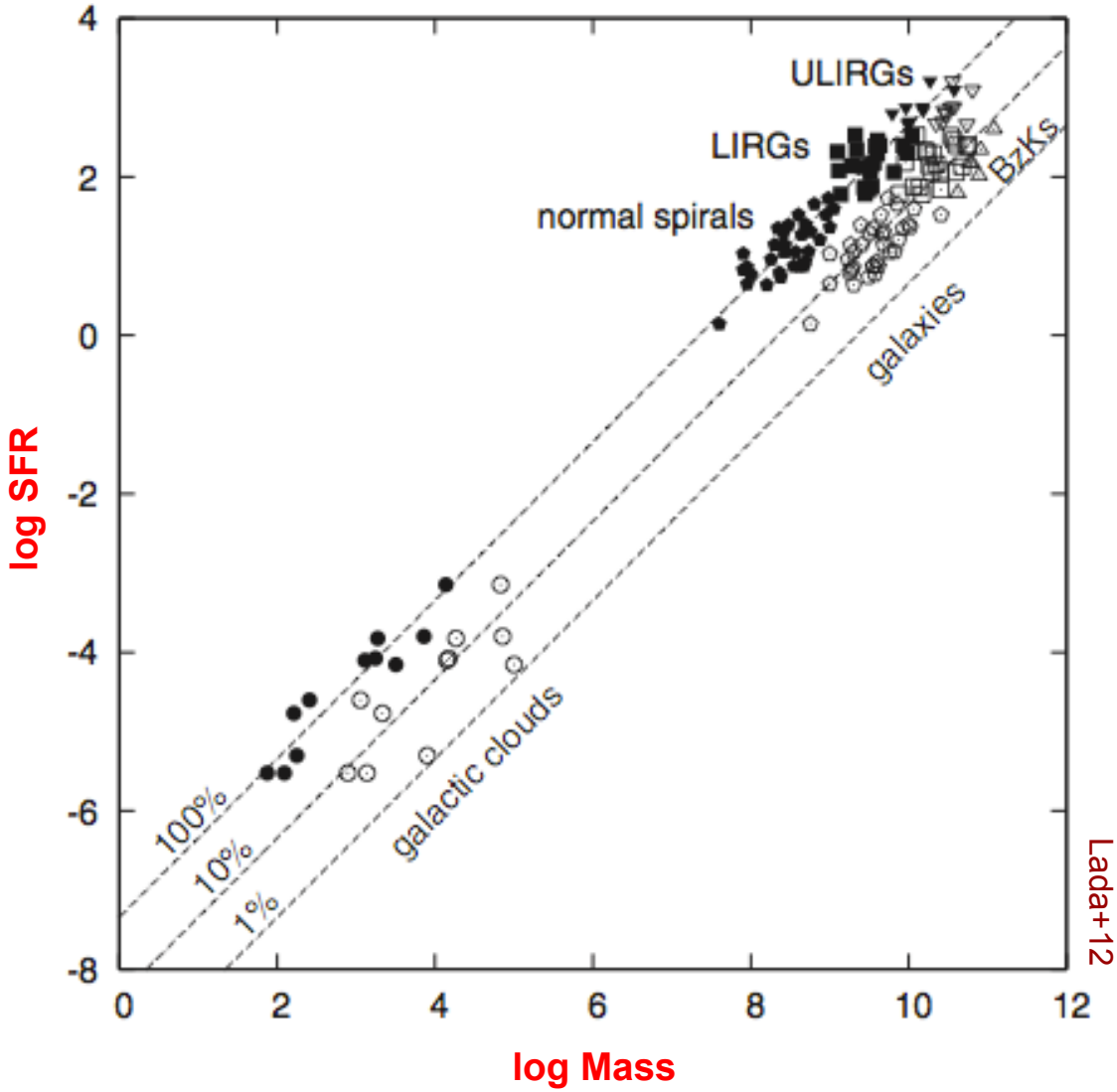
- Bernhard Brandl: Galactic starbursts provide resolved analogue for exgal
- CMZ has the only high-pressure gas that we can resolve into indiv. cores

  Kruijssen & Longmore 13; Rathborne+14
- João Alves: universal (?) dense gas-SFR relation
- Vera Könyves: Aquila fits the same relation

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

The dense gas mass – SFR relation: universal?



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J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

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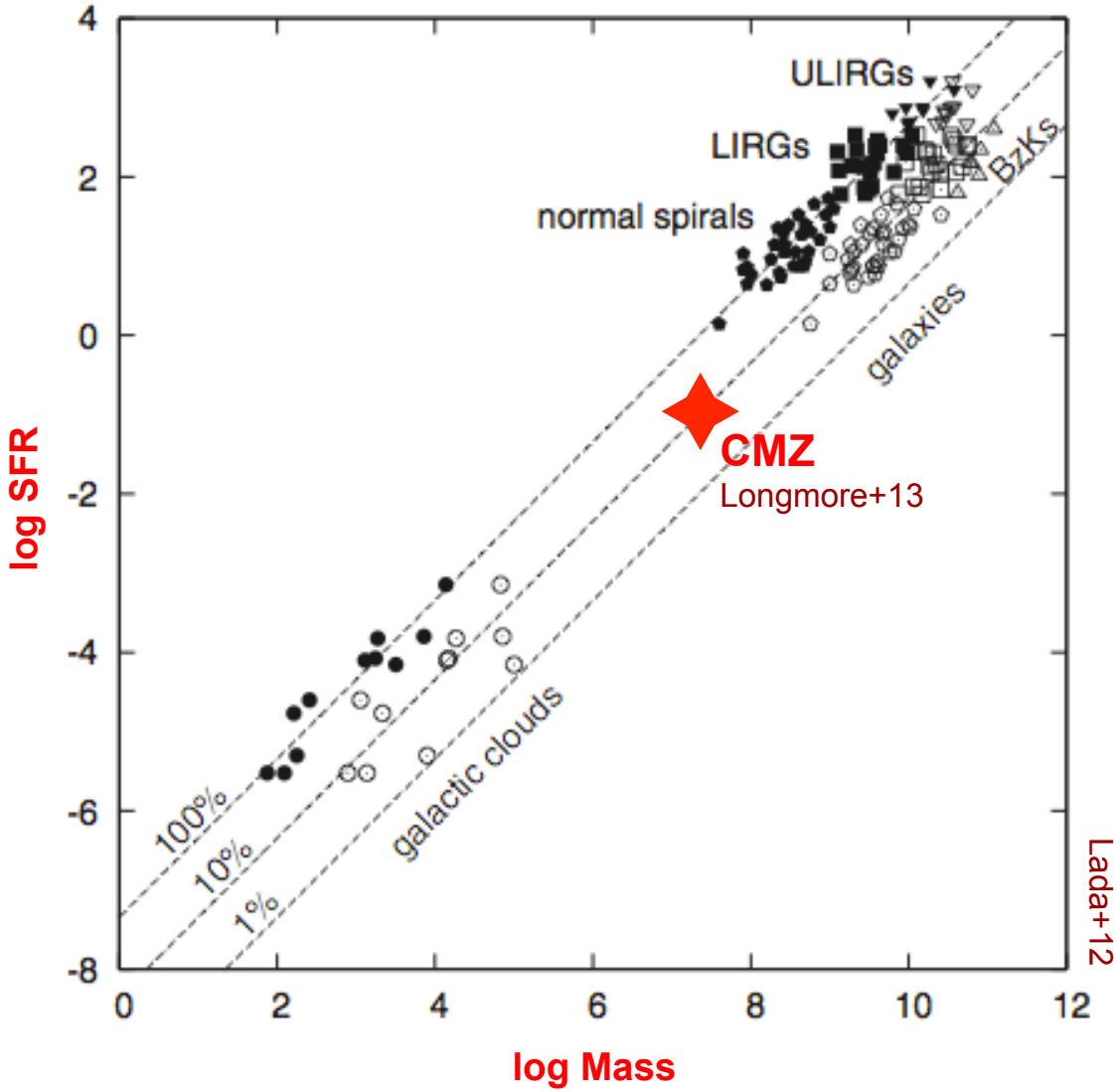
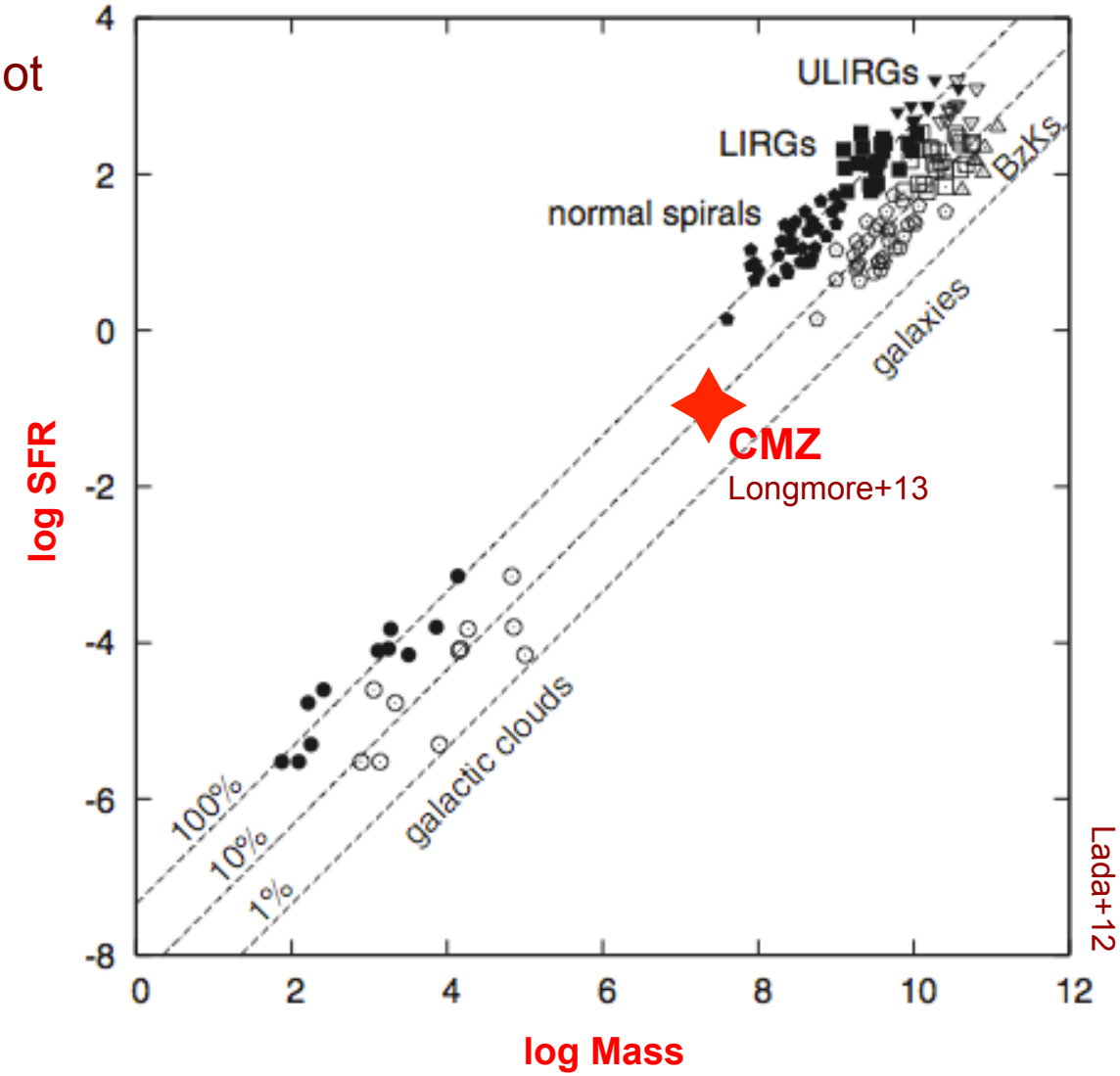


Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

The dense gas mass – SFR relation: universal?

- CMZ deficit due to gas not being self-gravitating
  Kruijssen+14



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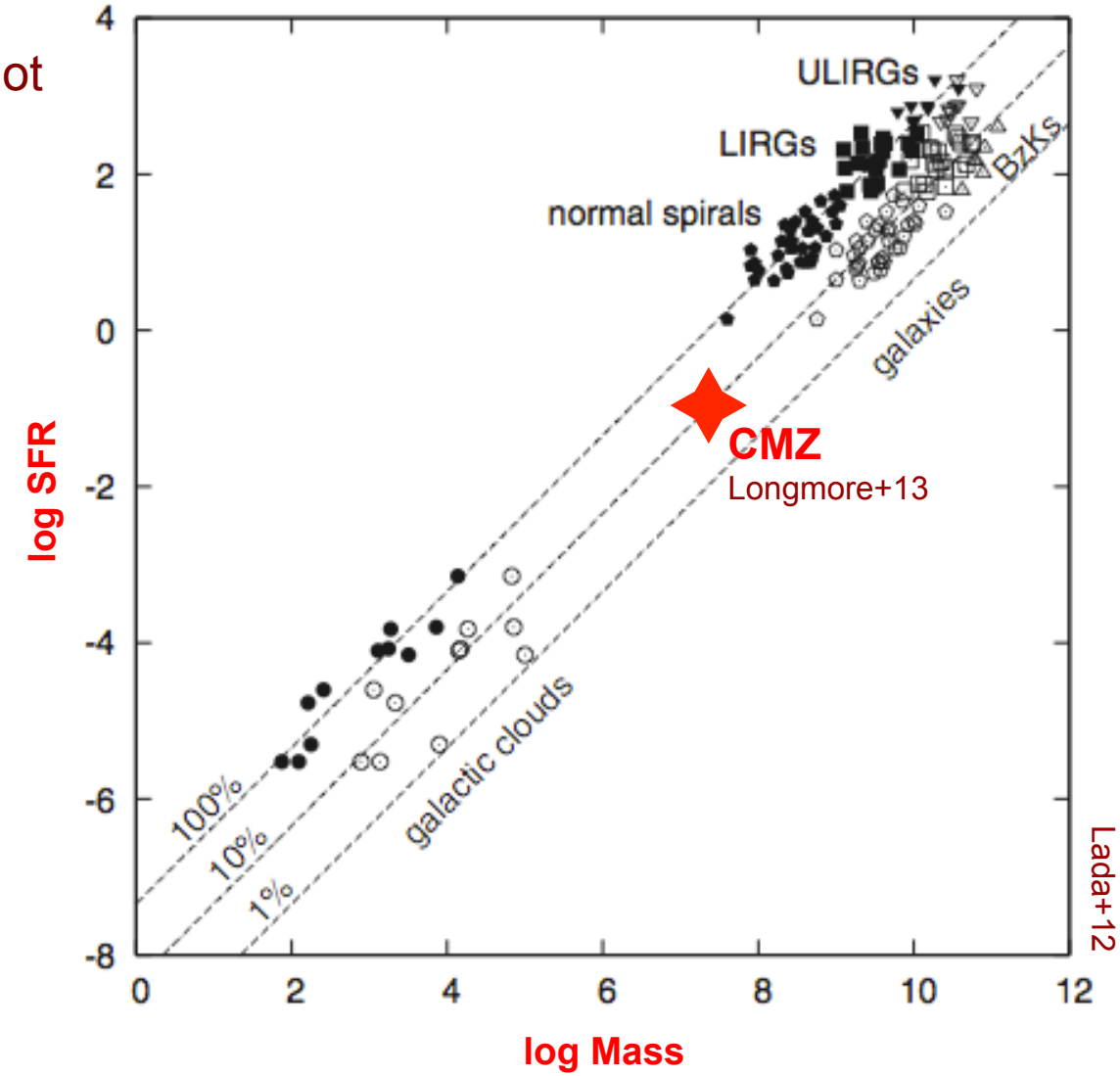

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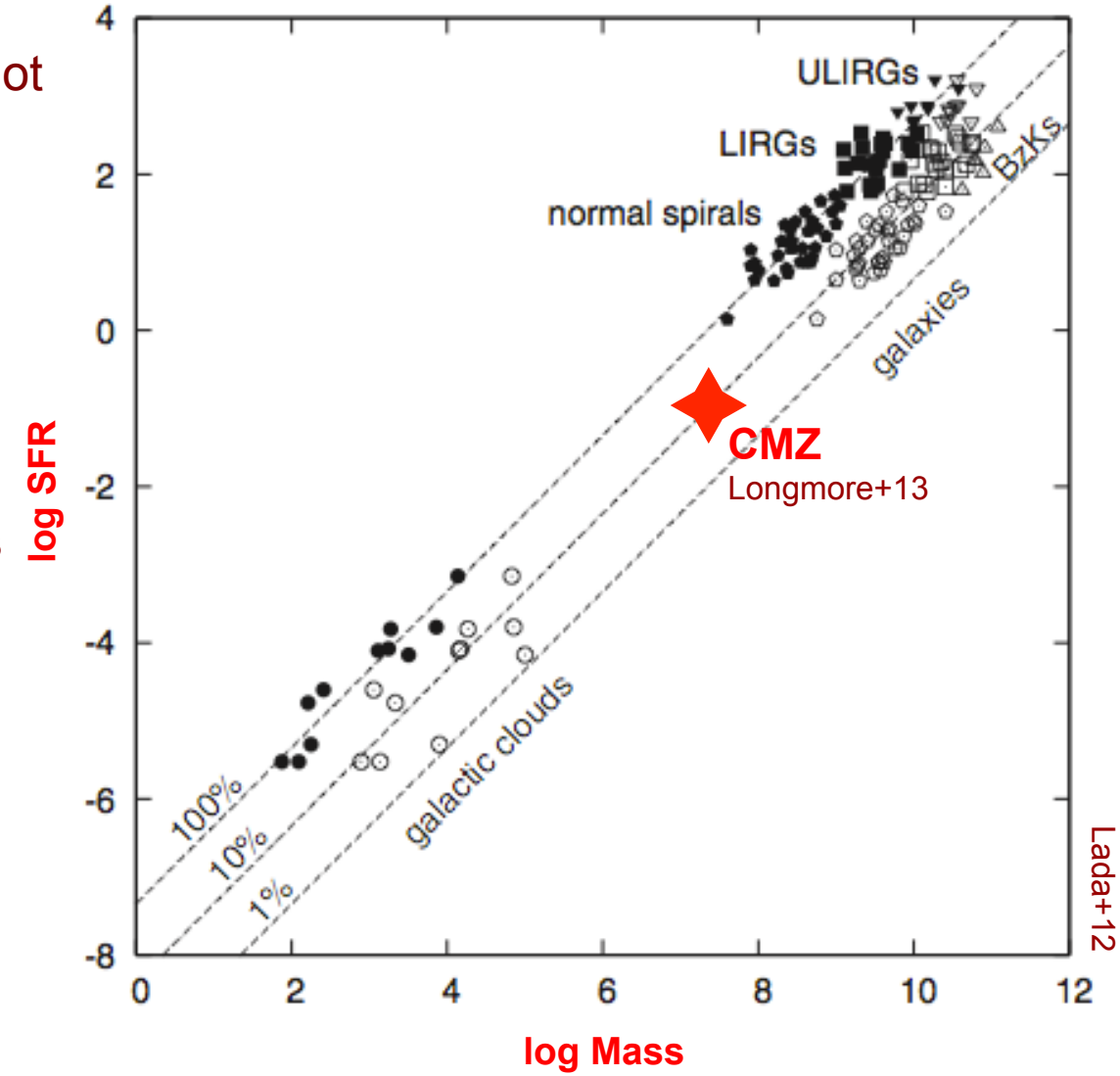

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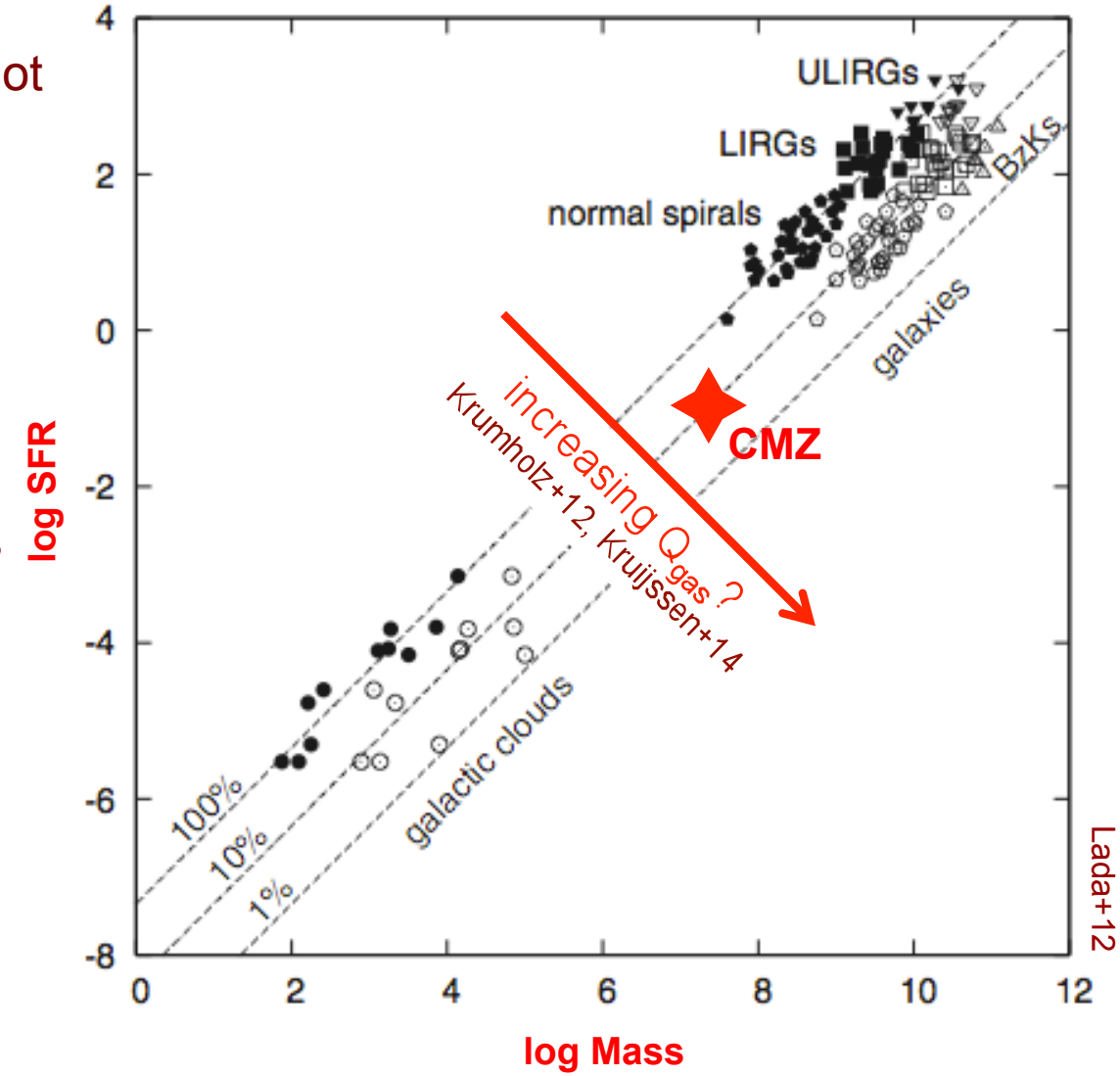

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

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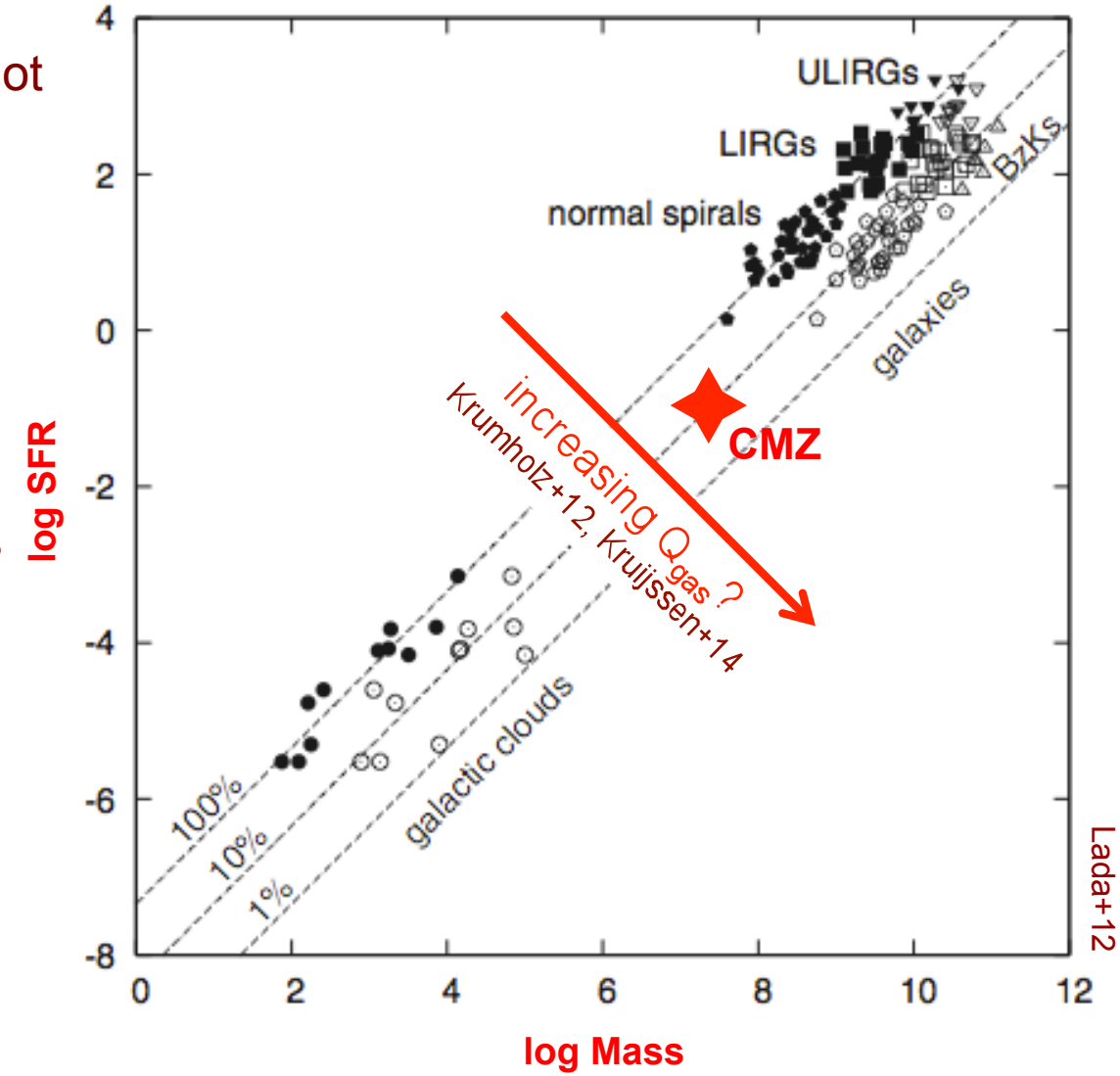
- Star formation relation includes factor Q_{gas}^{-1}?



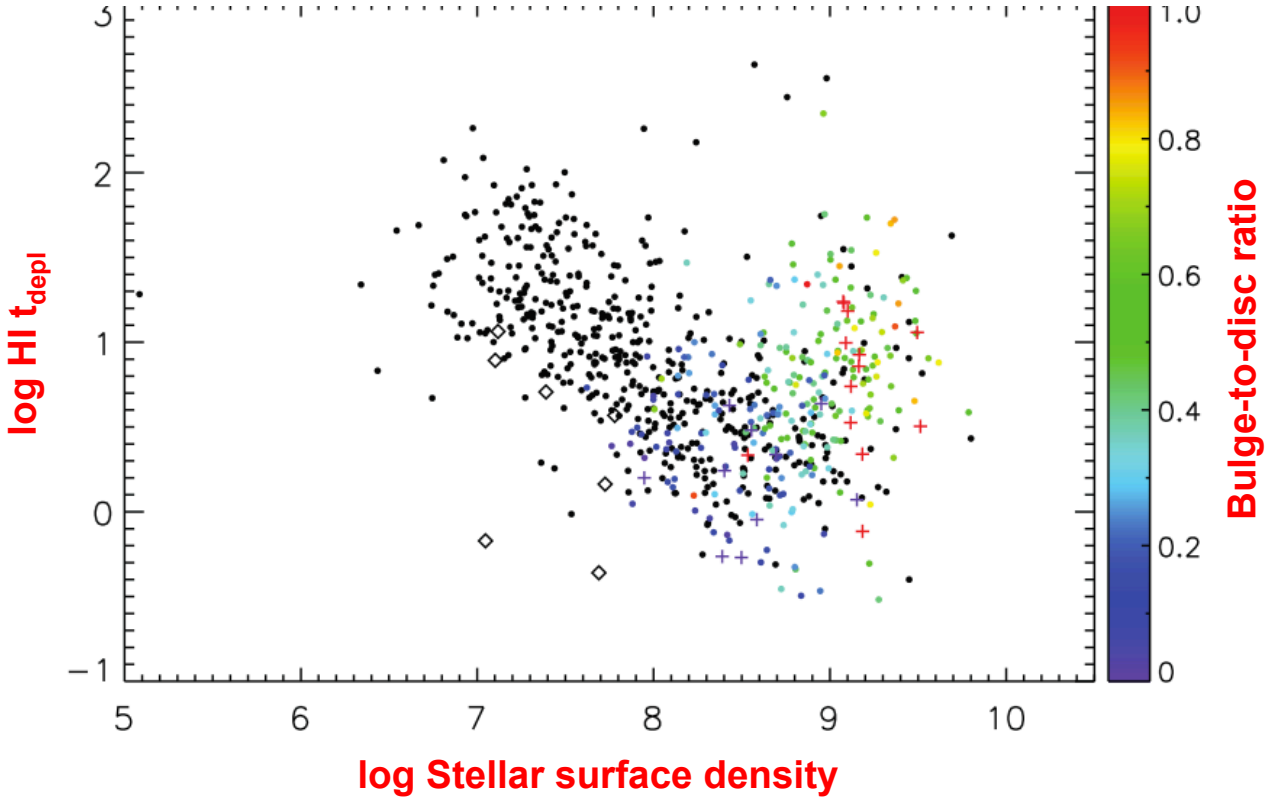
Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Relation to variation of HI depletion time on galaxy morphology?

Talk by Jaskot

Jaskot+ in prep.



✧ Also: (morphological) quenching (Session 3)

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Extragalactic systems show variations with respect to Milky Way

Talks by Scoville, Madden, Cormier, Smith, Gear

- Nick Scoville: short molecular gas depletion time in Arp 220

Session 2 Summary

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  Dust-to-gas ratio increases linearly with metallicity except for low M_* (SFH?)

Session 2 Summary

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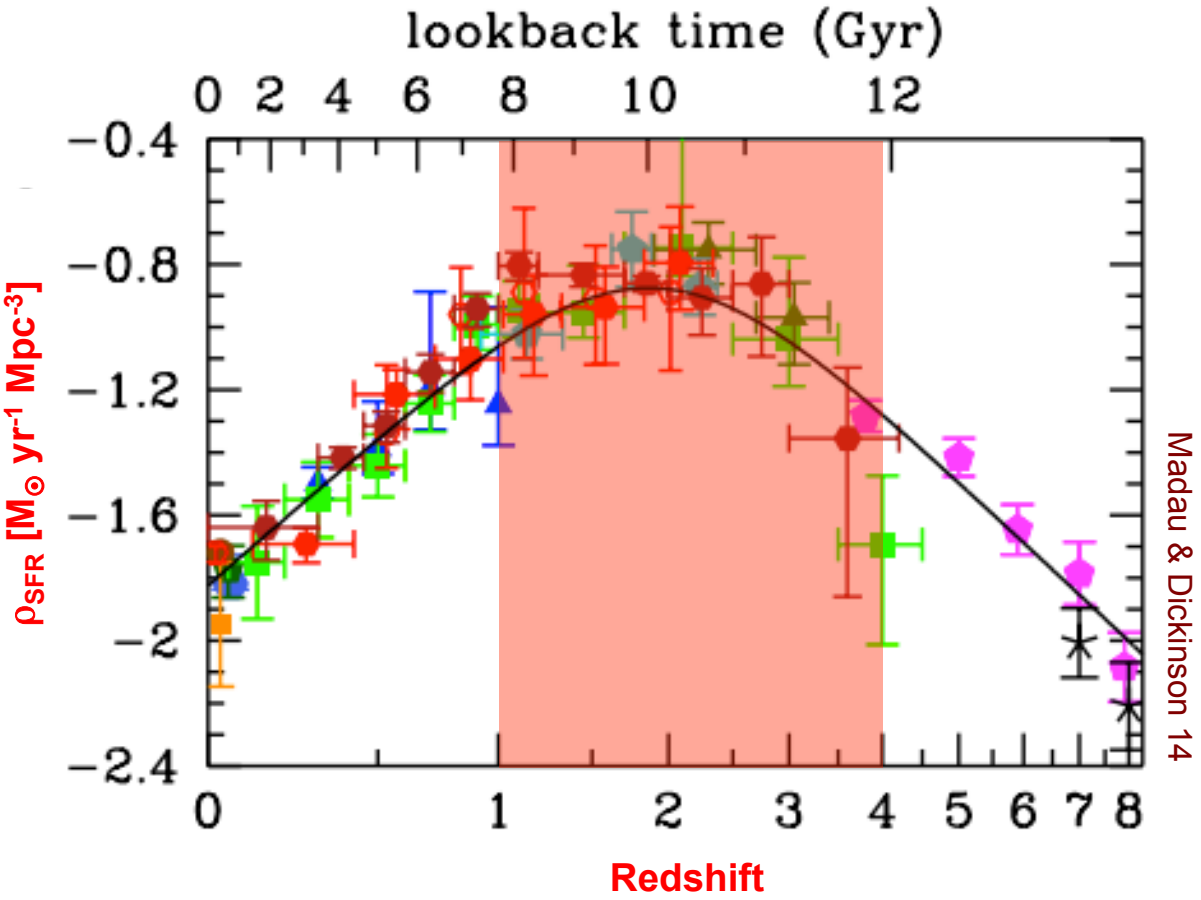
- Diane Cormier: ISM of low-metallicity galaxies more porous (i.e. high HII filling factor) than in the Milky Way
- Walter Gear: be wary of variety of calibrations in heterogeneous samples
  Phil Hopkins: different sample selection criteria also introduce biases

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Cosmic SFR peaked at redshift z = 2–3

✧ This is where detailed & systematic SF studies must eventually go



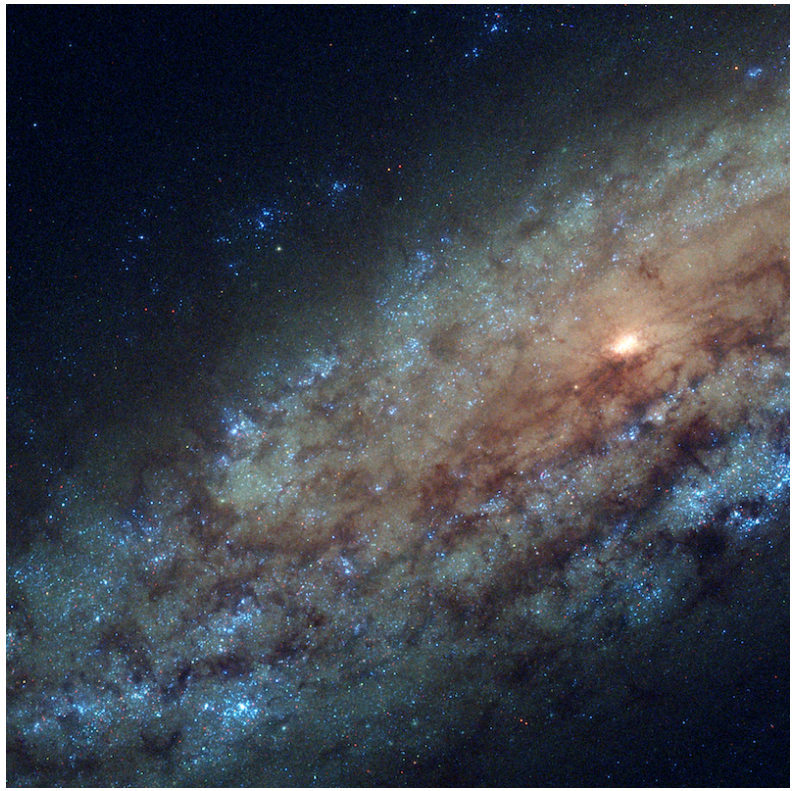
Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

First steps to systematic probing of diverse environs at high resolution

Talks by Calzetti, Zanella

- Stellar populations out to 12 Mpc with LEGUS



Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

First steps to systematic probing of diverse environs at high resolution

Talk by Gear

- Dust in nearby galaxies with Herschel, e.g. HELGA

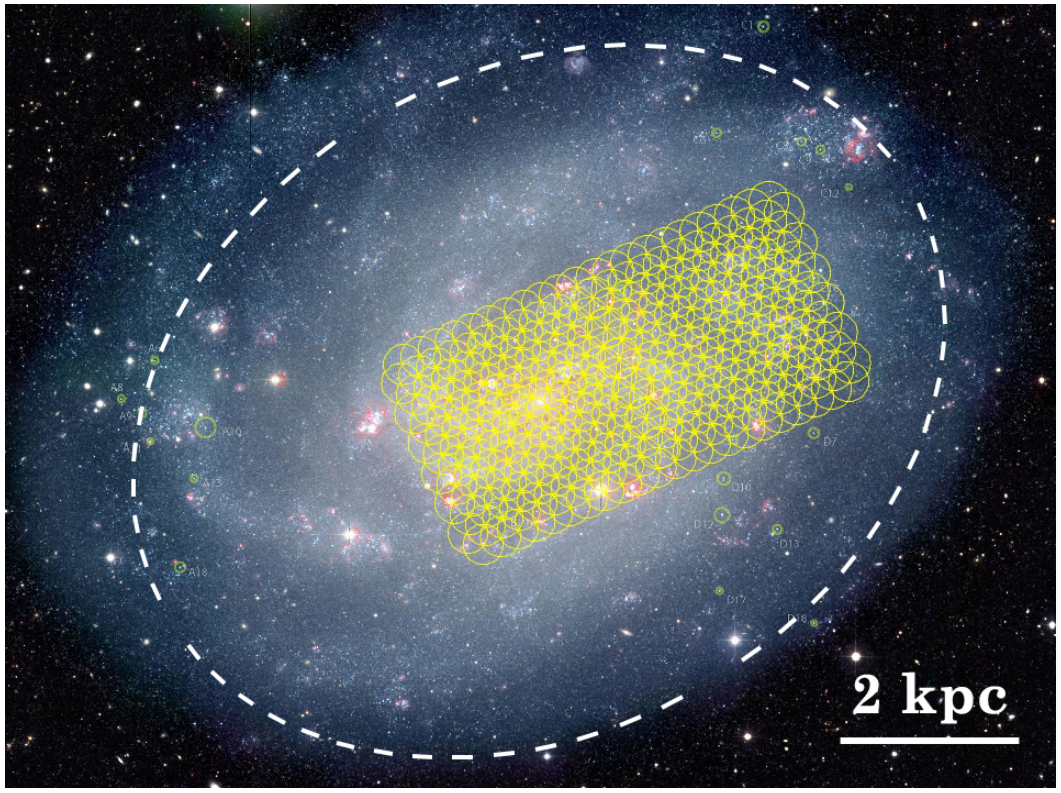
Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

First steps to systematic probing of diverse environs at high resolution

Talks by Scoville, Kruijssen
also Hodge+12

- Gas with ALMA, EVLA



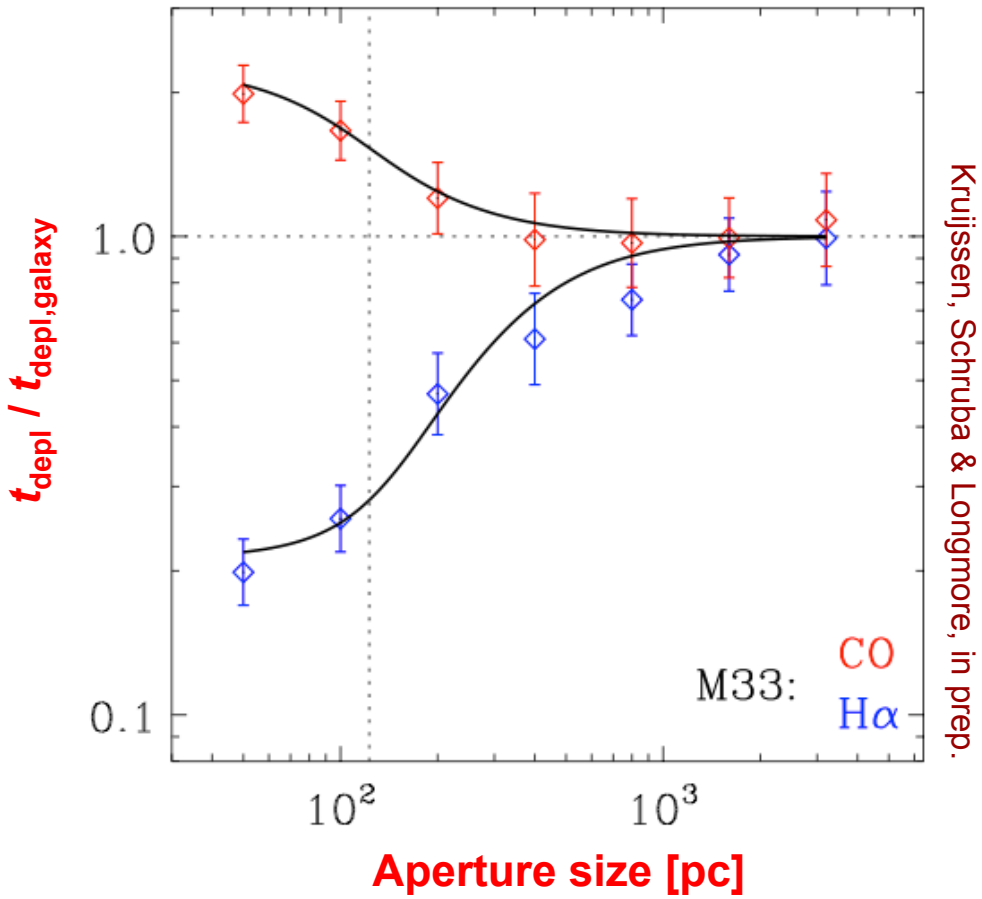
(Schruba & Kruijssen + Longmore, Tacconi, van Dishoeck, Dalcanton)

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

First steps to systematic probing of diverse environs with new methods

✧ Kruijssen & Longmore uncertainty principle

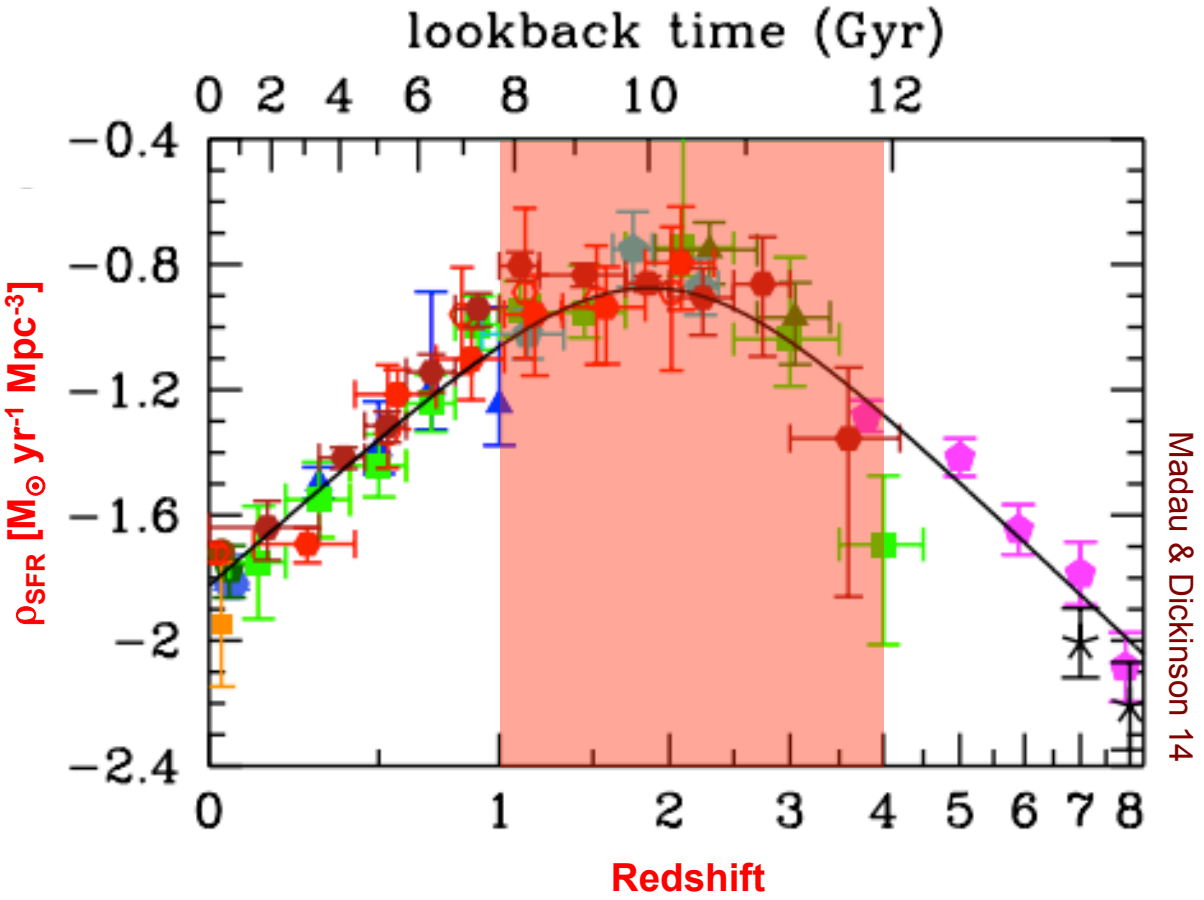


Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Cosmic SFR peaked at redshift z = 2–3

✧ Maybe we can get there sooner rather than later…



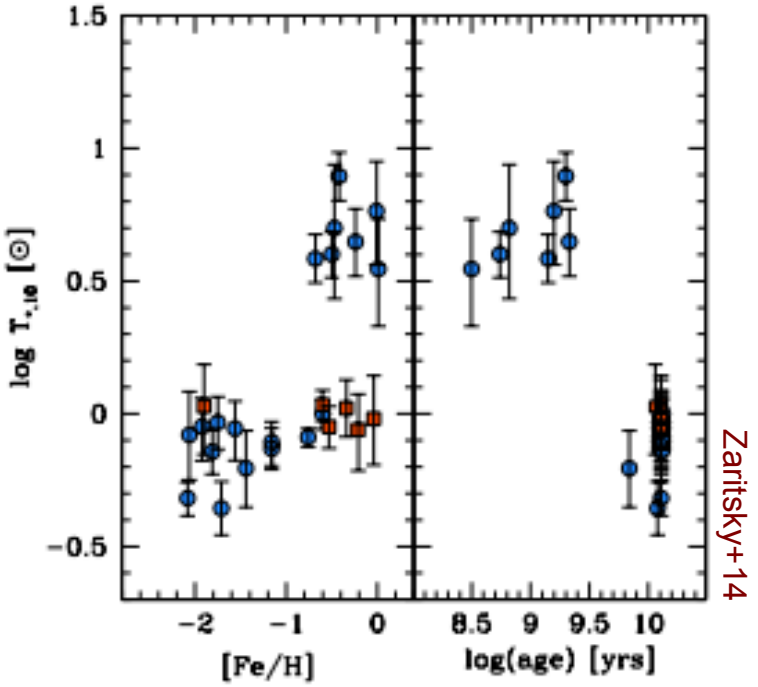
Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Variations of the stellar initial mass function

Talks by Zaritsky, also Chabrier, Hopkins

✧ Does the IMF vary with cosmic history & environment?



Zaritsky+14

Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

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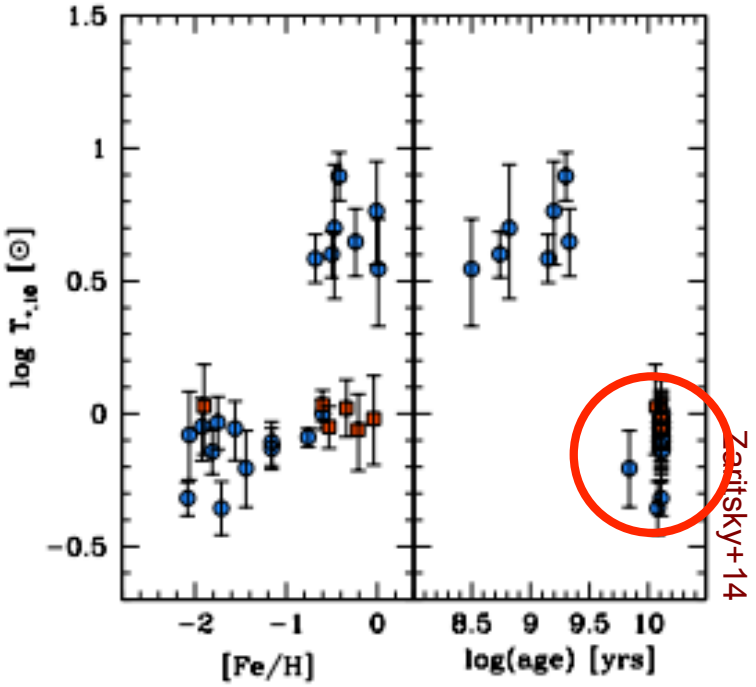

Must correct for 12 Gyr of dynamical evolution:

low-mass stars are preferentially ejected, so M/L decreased by ~0.5 dex

Hénon 69, Kruijssen 09

Session 2 Summary

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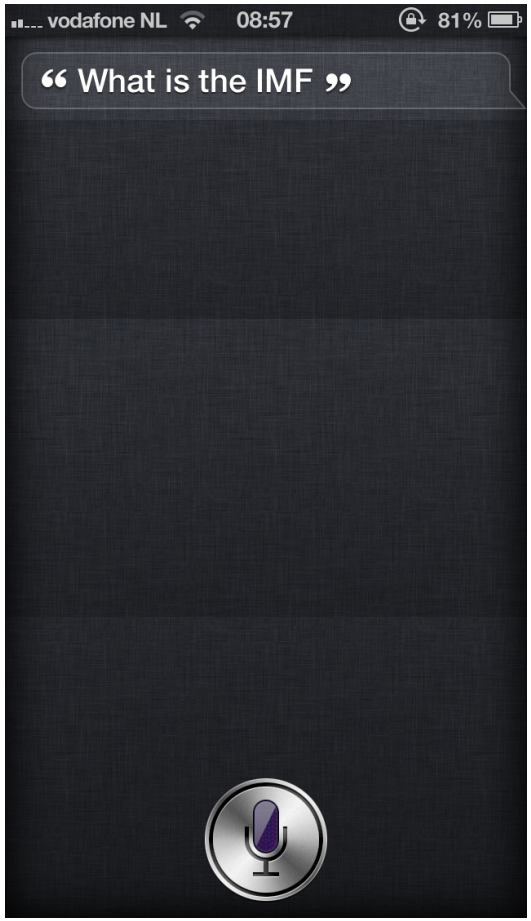
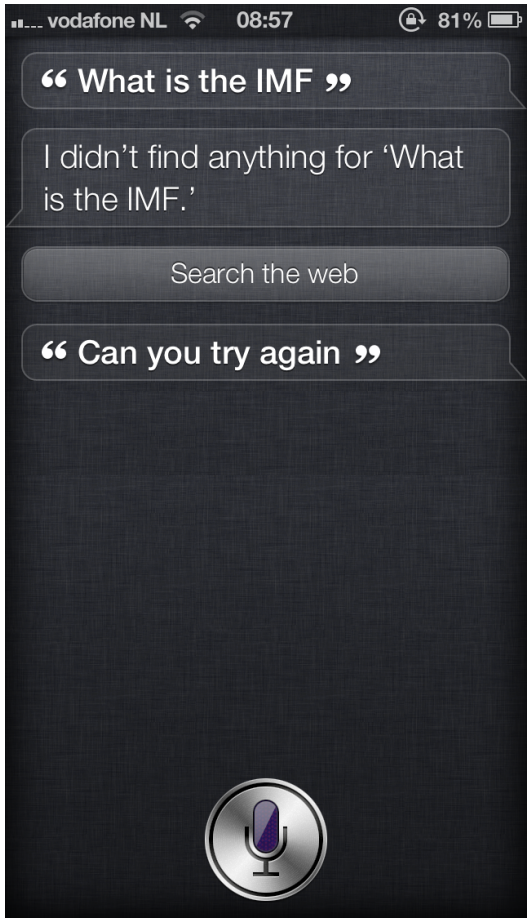
The nature of the IMF – ask Siri for help



Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

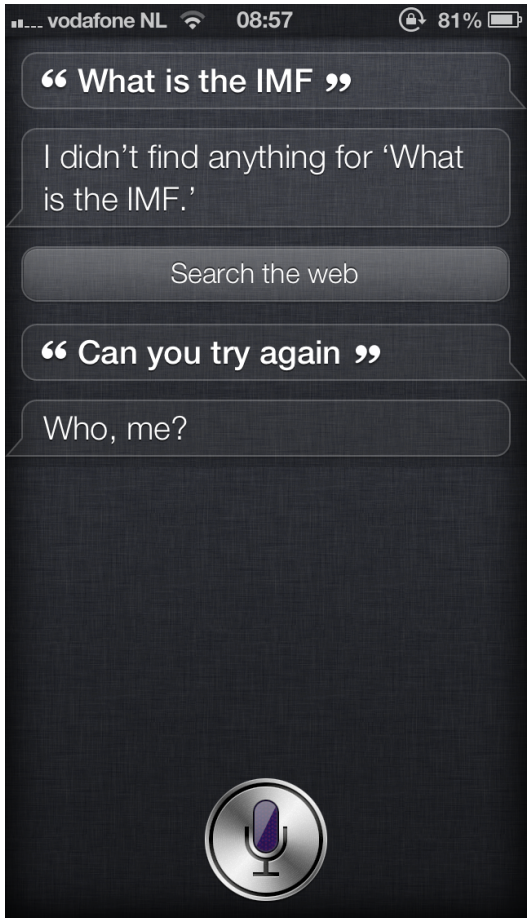
Wait, what? No idea *again*?



Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

That sounds helpful…



Session 2 Summary

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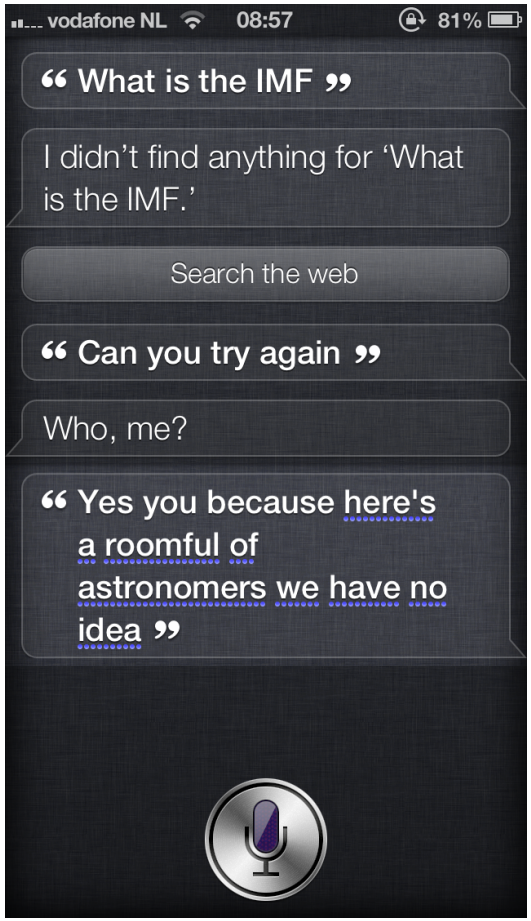
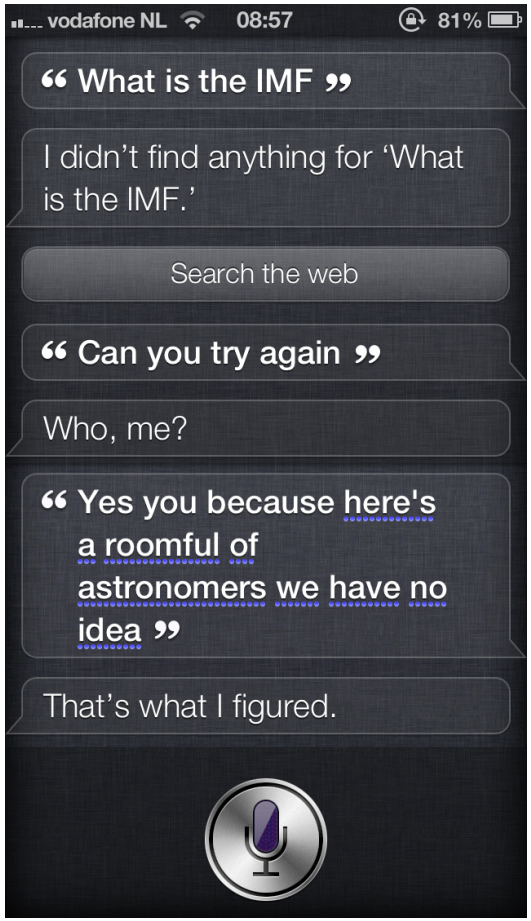
Surely we can convince Siri to try harder…



Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

Unfortunately, Siri doesn't think very highly of astronomers



Session 2 Summary

J. M. Diederik Kruijssen – Max Planck Institute for Astrophysics

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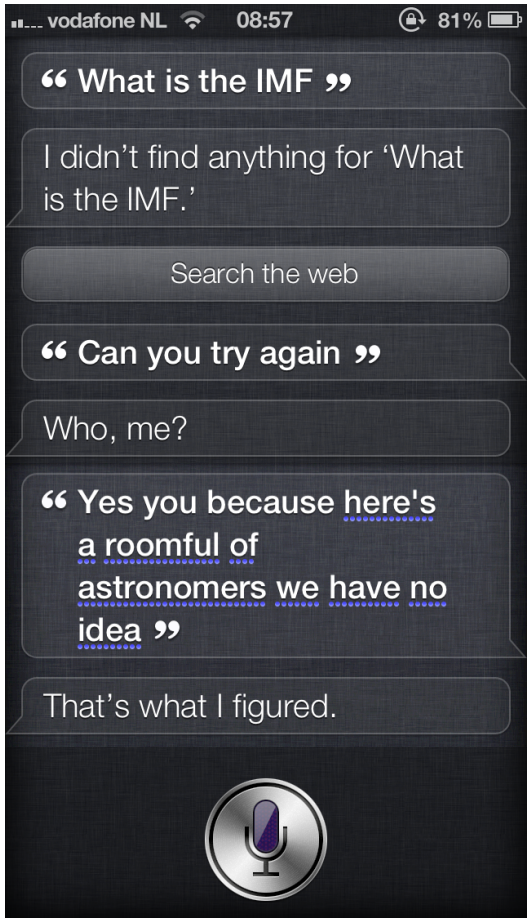

We'll have to solve the problem ourselves…