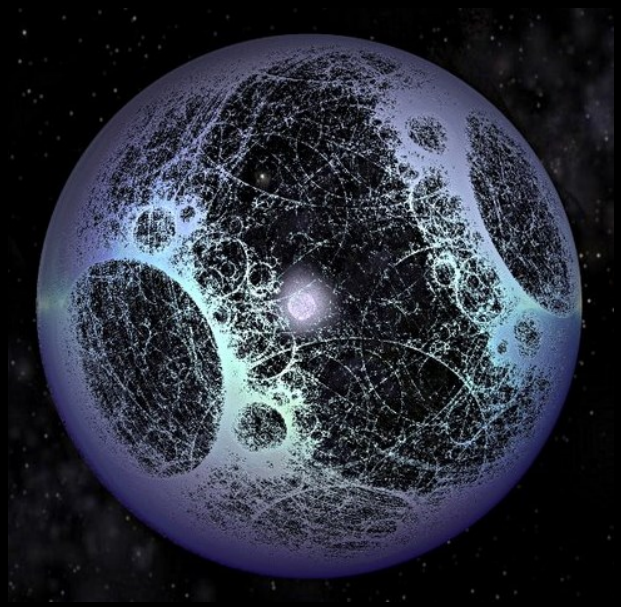
Searching for Extraterrestrial Intelligence Beyond the Milky Way

The first Swedish SETI project



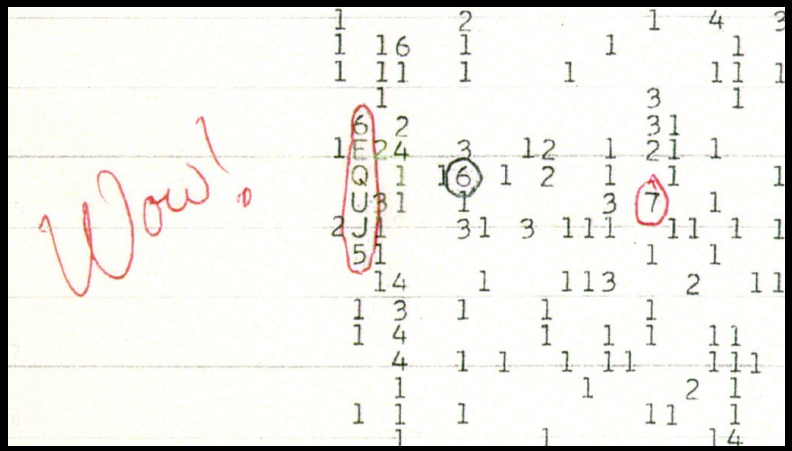
Erik Zackrisson

Department of Astronomy

Oskar Klein Centre

Stockholm University

Searching for Extraterrestrial Intelligence (SETI) – A Brief History I



- 1959 – Cocconi & Morrison (Nature): ”Try the hydrogen frequency (1.42 GHz)”
- 1960 – Project Ozma
- 1961 – Schwartz & Townes (Nature): ”Try optical laser”
- 1977 – The Wow signal

Searching for Extraterrestrial Intelligence (SETI) – A Brief History II

- 1984 – The SETI Institute
- Late 1990s – Optical SETI becomes popular
- 1999 – SETI@home
- 2007 – Allen Telescope Array
- 2012 – SETI Live

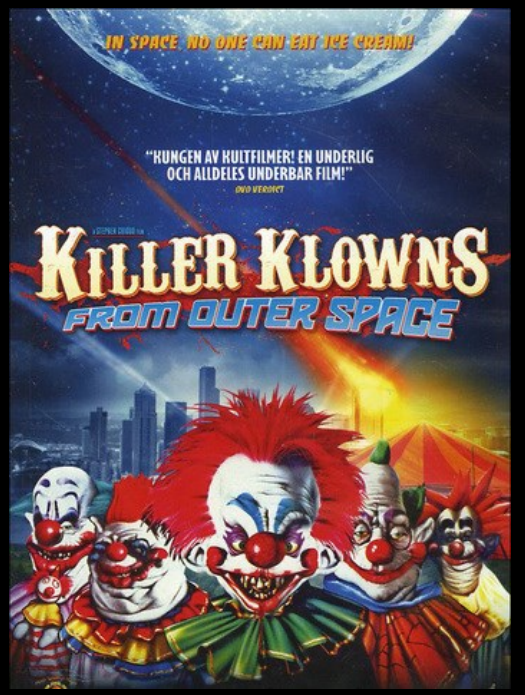
The Fermi Paradox

- No signals from E.T. despite 50 years of SETI
- The Milky Way can be colonized in ~1% of its current age – why are we not already colonized?
- *Where is everybody?*

50+ possible solutions are known (e.g. Brin 1983, Webb 2002)

A Few Possible Explanations

- Everybody is staying at home and nobody is transmitting
  - Virtual worlds more exciting than space exploration?
  - Berserkers → Transmission = Doom
- Wrong search strategy
  - Try artefacts, Bracewell probes, IR laser, internet, DNA, Dyson spheres…
- Intelligent life is extremely rare
  - Try extragalactic SETI



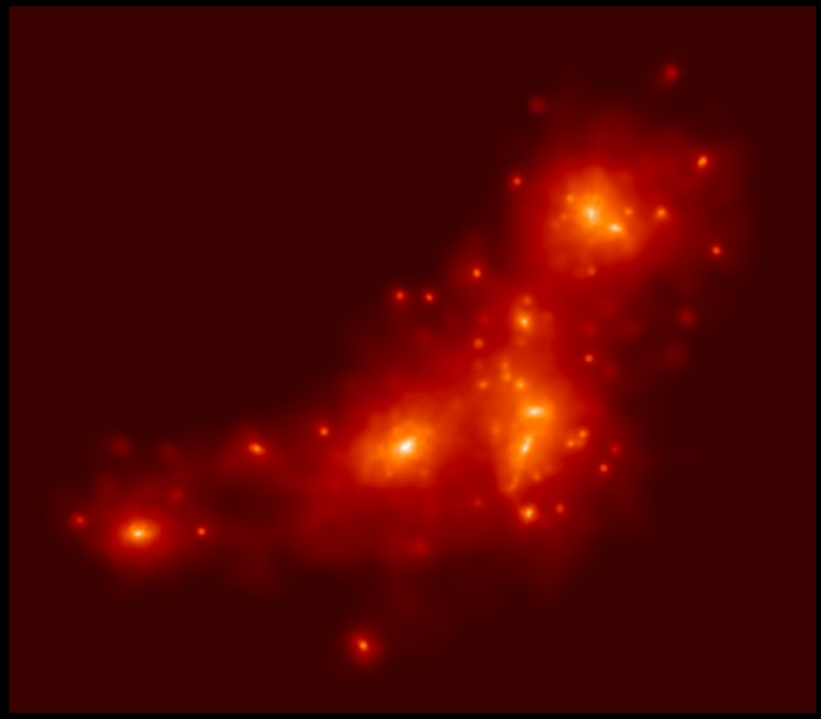
Beyond the Milky Way

- Carl Sagan: ”More stars in the Universe than grains of sand on all the beaches on Earth”
- Stars in Milky Way $\sim 10^{11}$
- Stars in observable Universe $\sim 10^{23}$

Only a handful of extragalactic SETI projects carried out so far!

Earth-like planets in a cosmological context I

Millenium simulation +
Semi-analytic galaxy models +
Metallicity-dependent planet formation $\rightarrow$
The typical Earth-like planet in the local Universe is
$\approx$ 3 Gyr older than Earth!



Erik Zackrisson, Anders Johansen, Juan González (2014, in prep.)

Earth-like planets in a cosmological context II

Earth-like planets around Solar-type stars in the observable Universe: $\sim 10^{18}$

Comparable to grains of sand on the longest beach in Sweden!

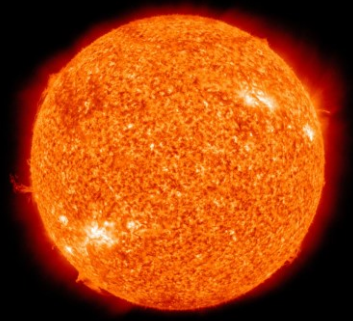
Laholmsbuktens strand –
the longest beach in Sweden (12 km)

Supercivilizations – The Kardashev scale

- Based on the amount of energy that a civilization is able to harness
- Kardashev (1964): Type I, II & III

Nicolai Kardashev

Kardashev type I, II, III



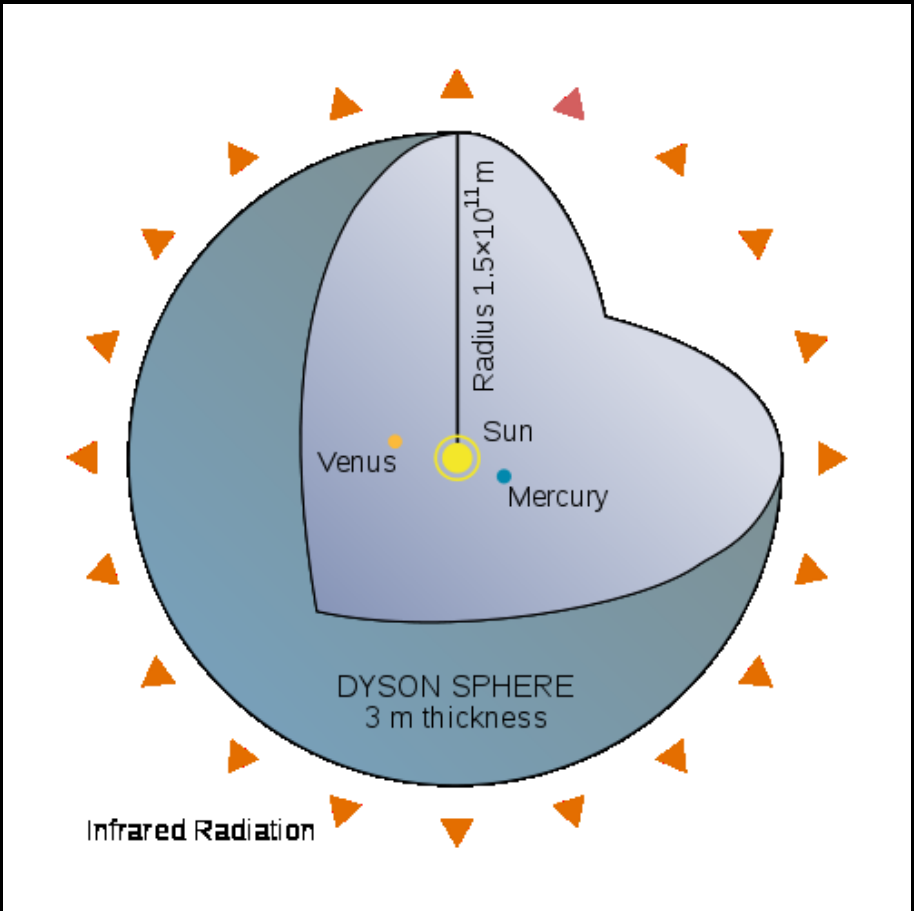
Power consumption:

Type I — Similar to the Solar insolation on Earth ($\sim 10^{17}$ W)

Type II — Similar to the luminosity of their parent star ($\sim 10^{26}$ W for the Sun)

Type III — Similar to the luminosity of their home galaxy ($\sim 10^{37}$ W for the Milky Way)

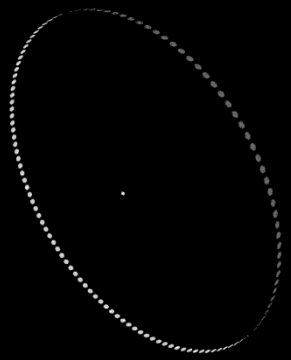
The Dyson Sphere



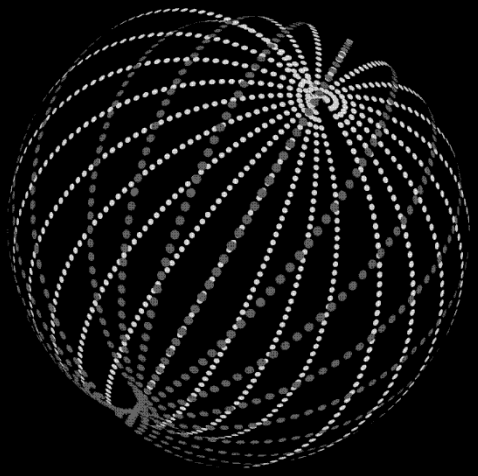
Dimensions envisioned for a Solar system

Dyson sphere made by disassembled planets

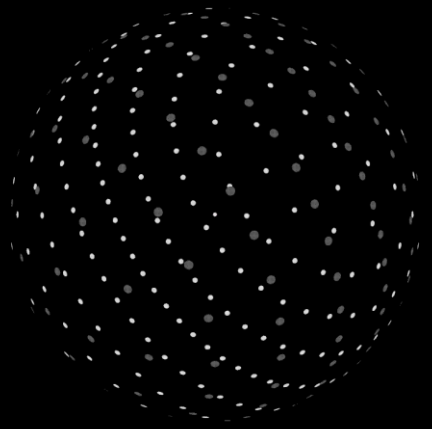
Freeman Dyson



Dyson ring

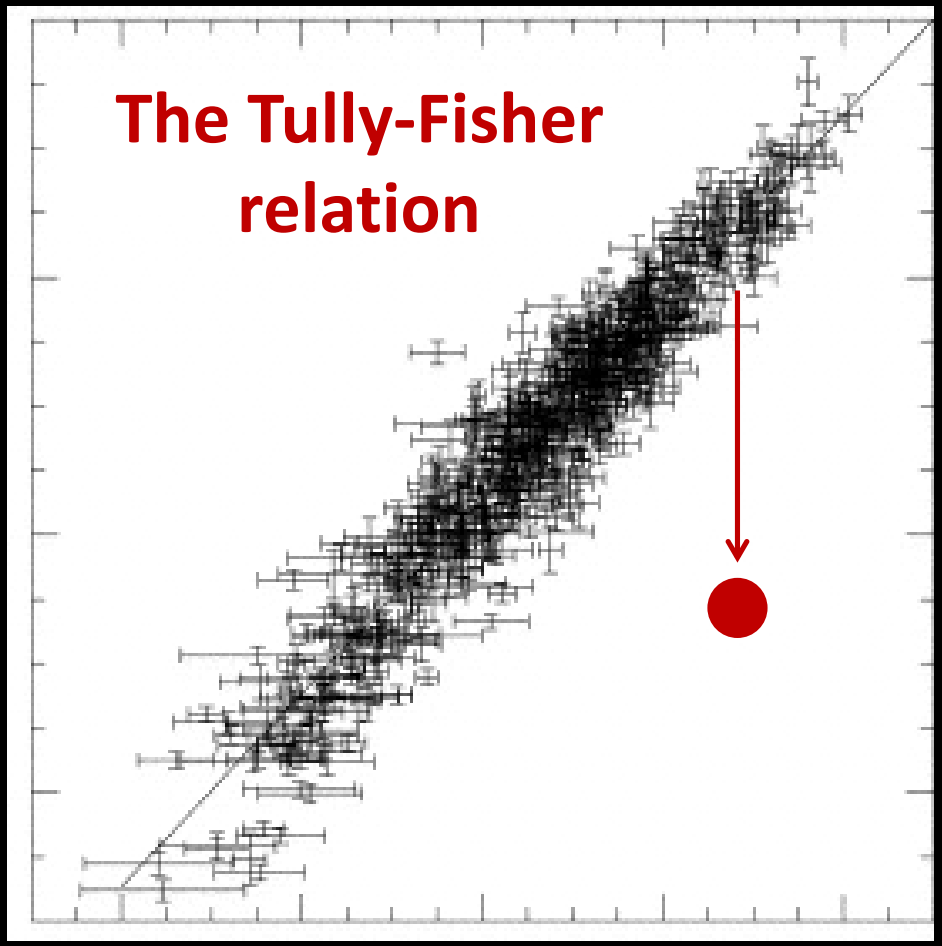


Dyson swarm



Dyson bubble

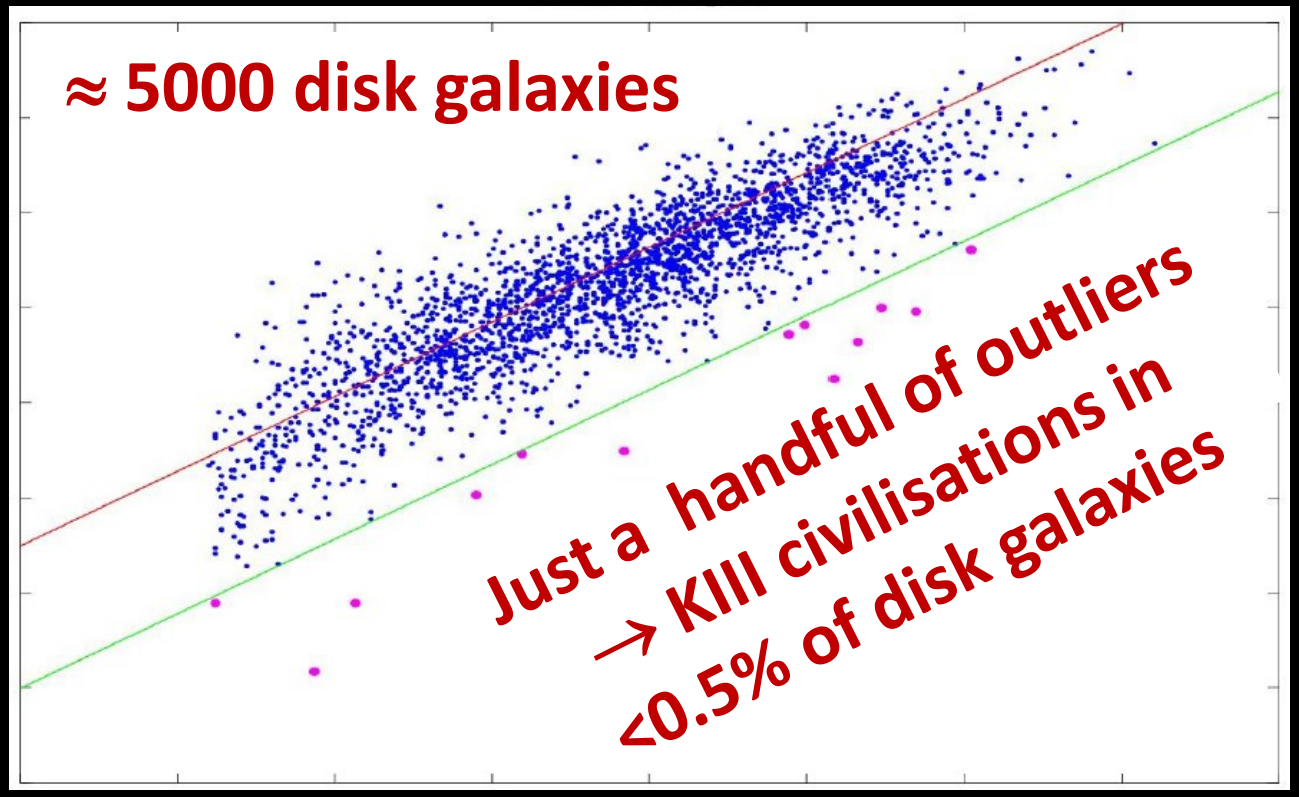
Hunting for Kardashev type III



Galactic-scale colonization using Dyson sphere → Mass unaffected but diminished UV/optical luminosity

Very few disk galaxies deviate from the Tully-Fisher relation → *Kardashev type IIIs must be rare (Annis 1999)*

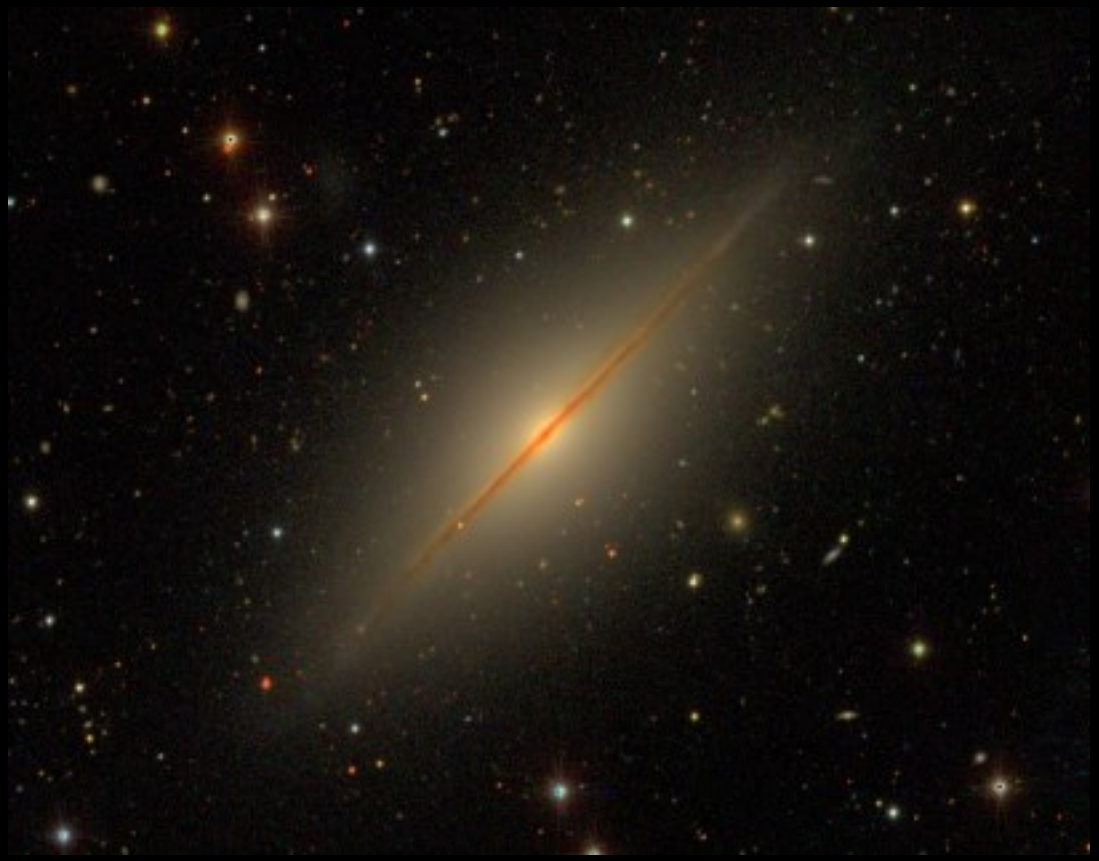
The largests extragalactic SETI project so far!



Per Calissendorff (2013, BSc thesis, SU)

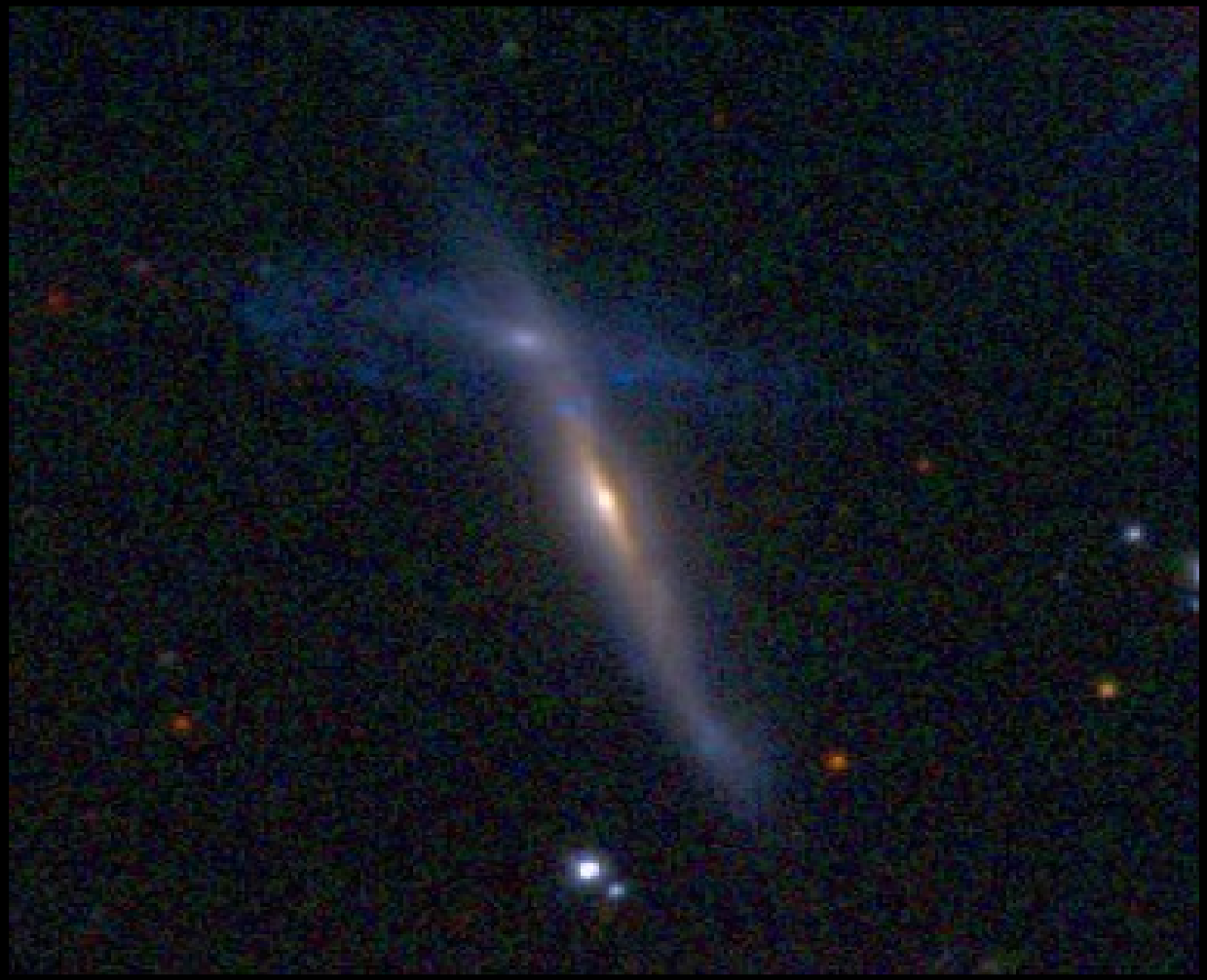
Erik Zackrisson, Per Calissendorff, Saghar Asadi (2014, in prep.)

But what are the outliers?



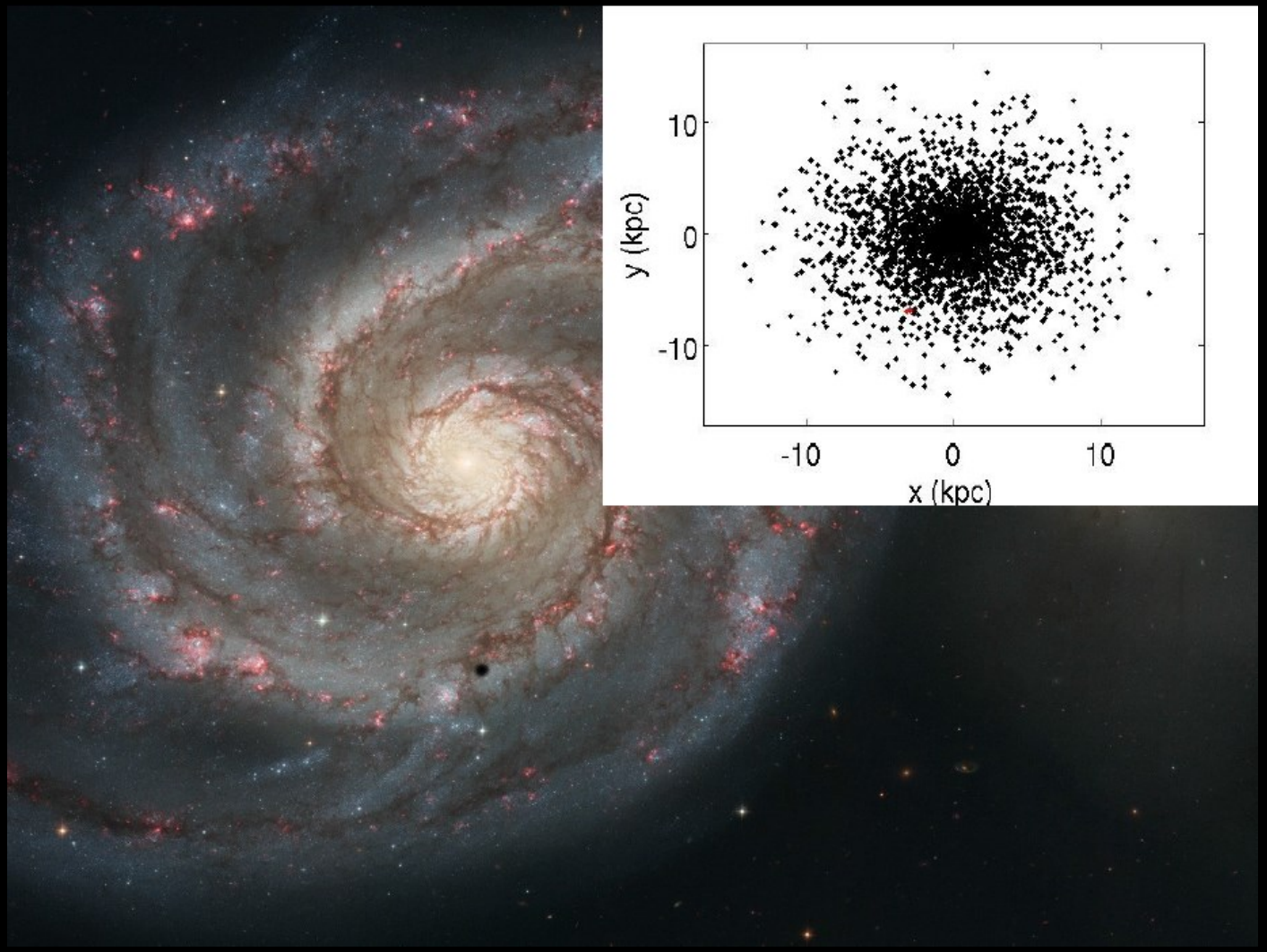
Example I: Edge-on disk incorrectly assigned a lower inclination

But what are the outliers?



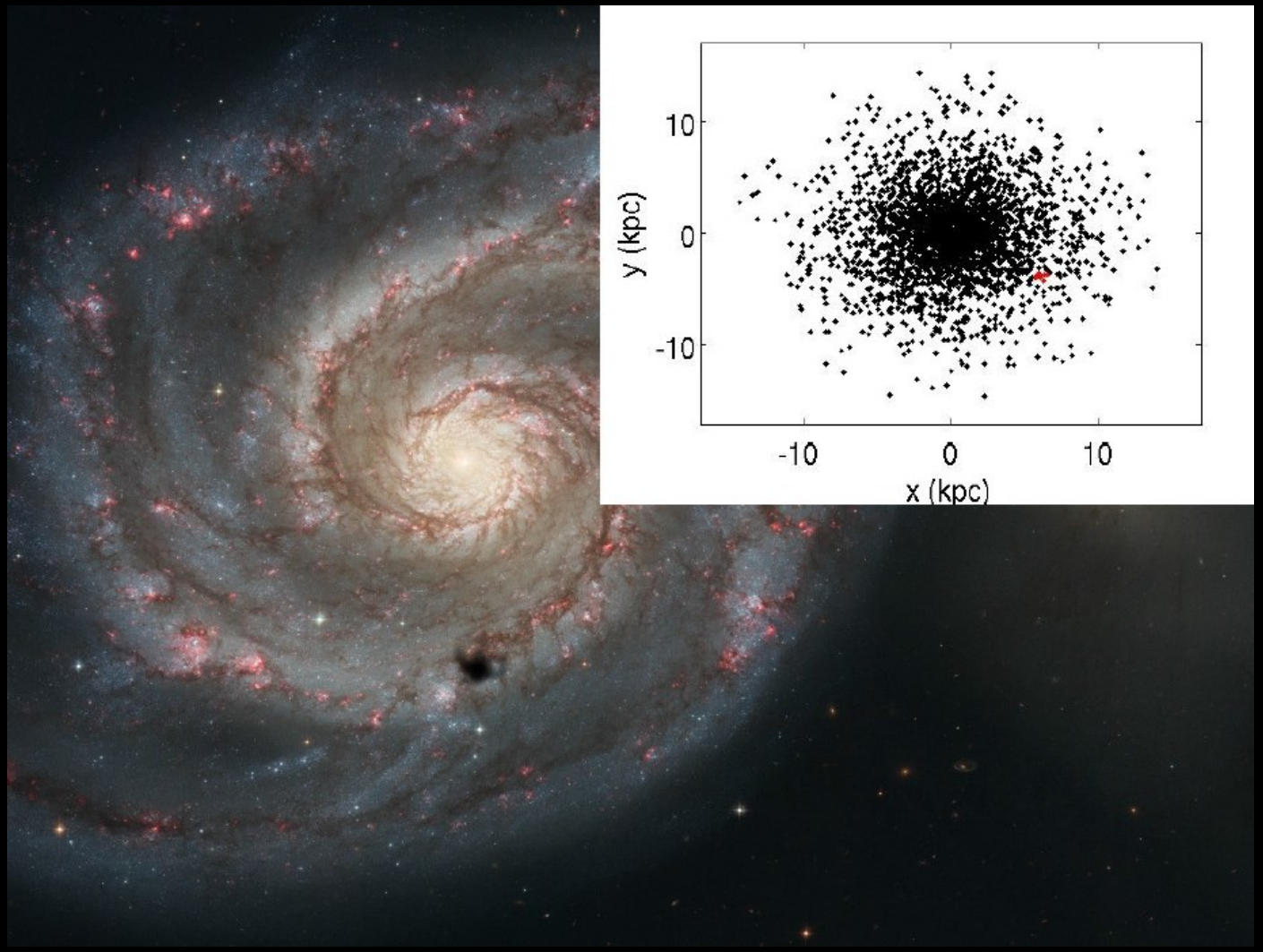
Example II: Two interacting (?) disks incorrectly classified as one object

Colonization using Dyson spheres



Per Calissendorff (2013)

Colonization using Dyson spheres



Per Calissendorff (2013)

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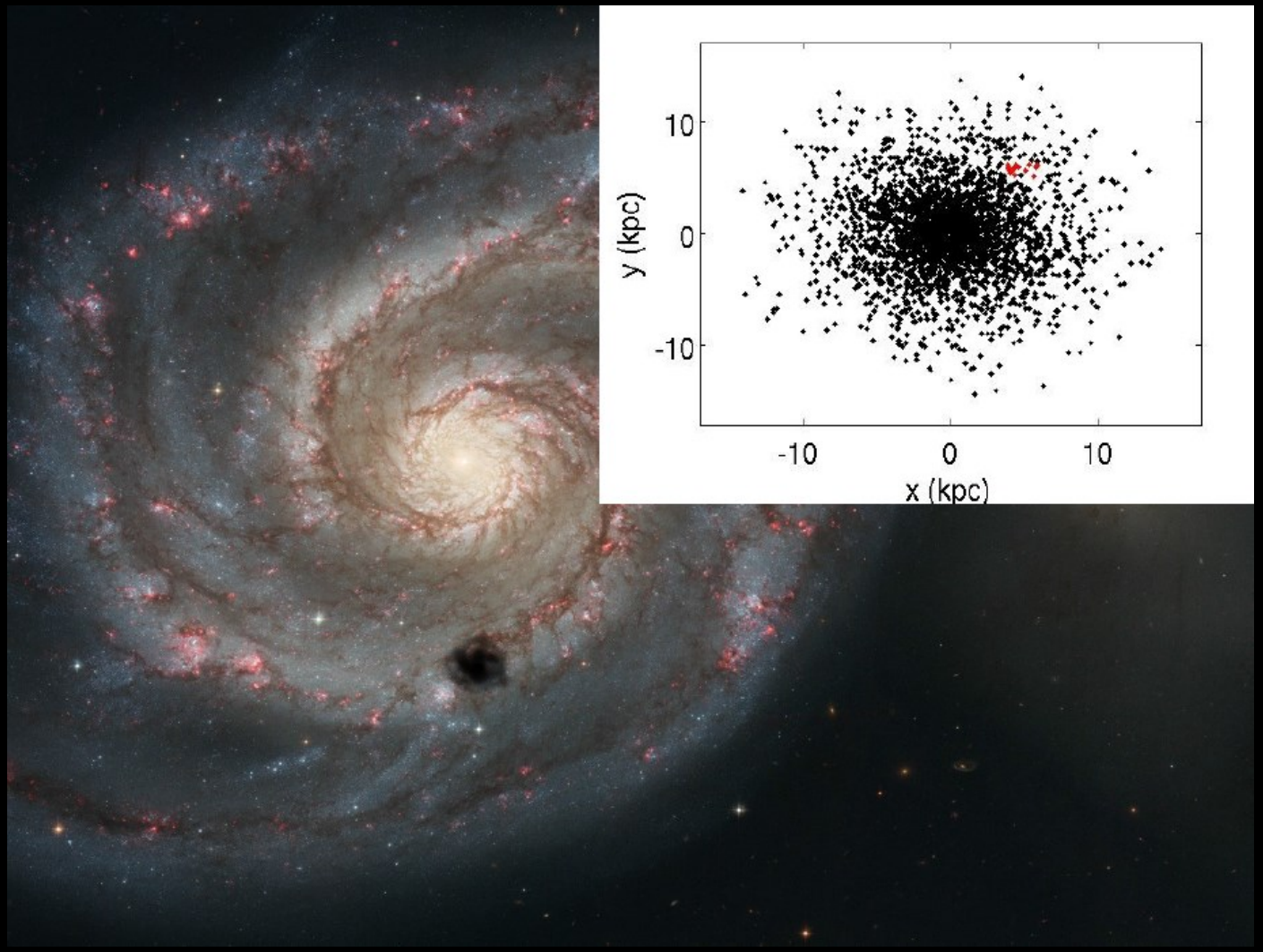
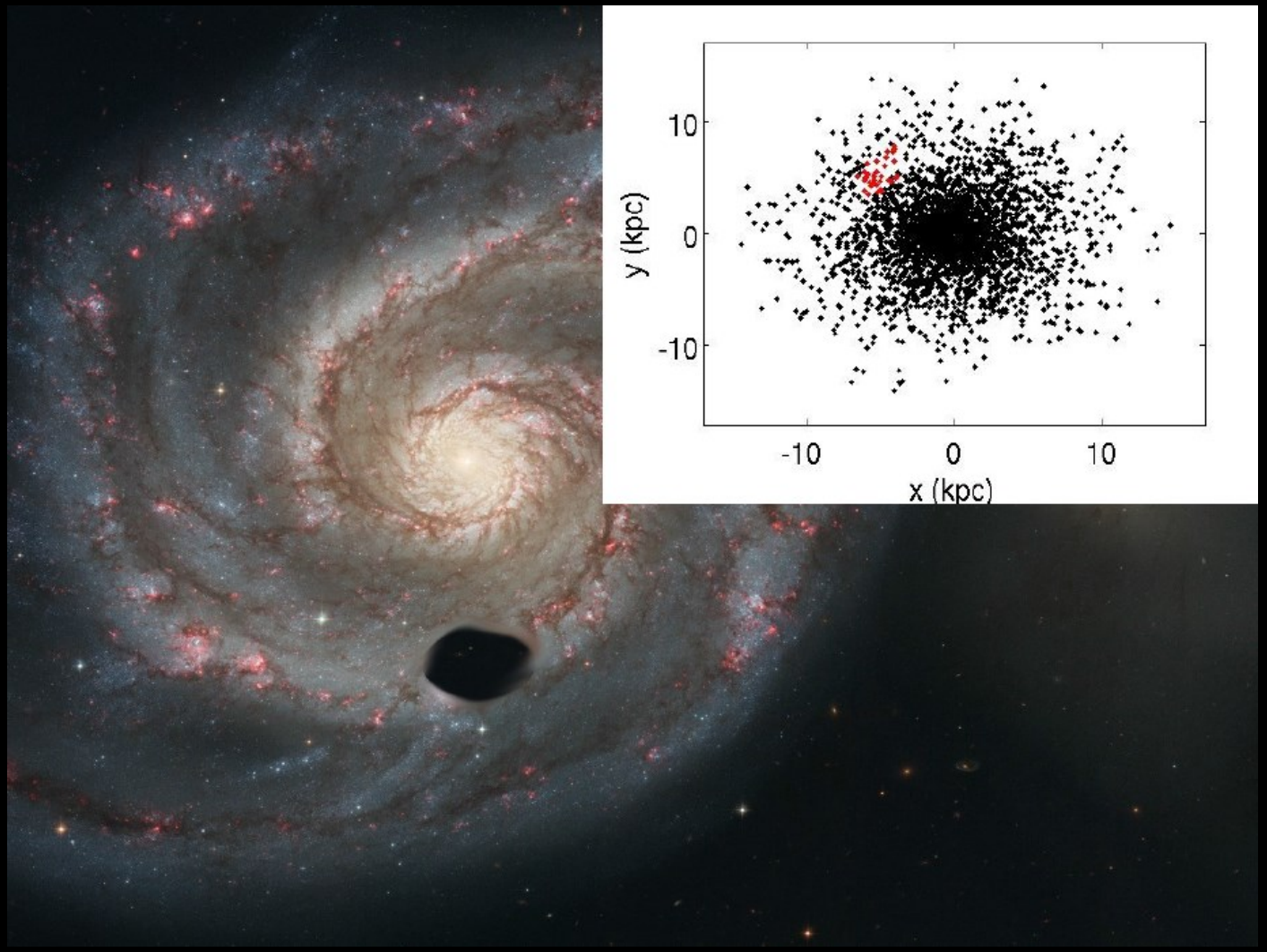


Per Calissendorff (2013)

Colonization using Dyson spheres



Per Calissendorff (2013)

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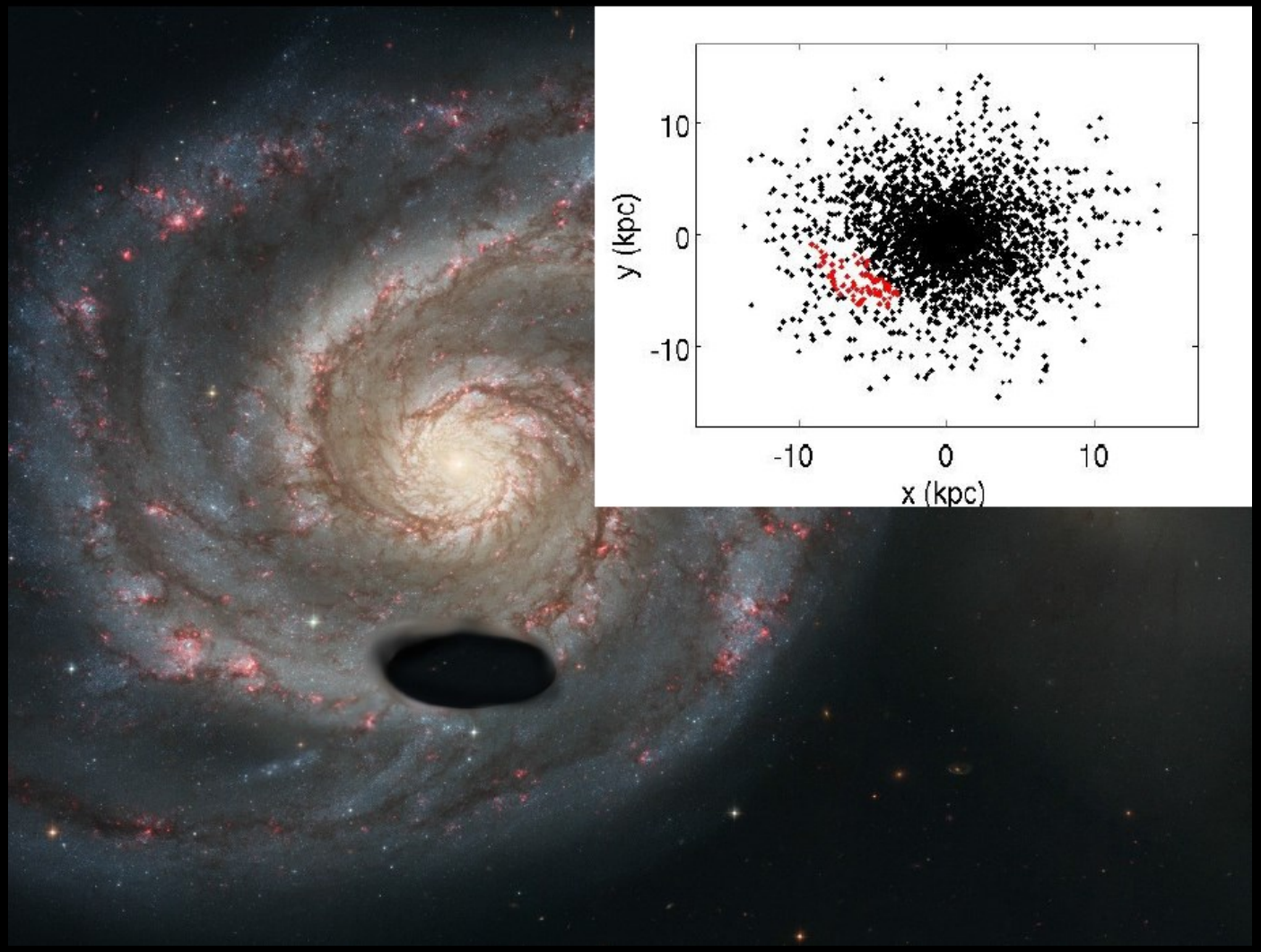

Per Calissendorff (2013)

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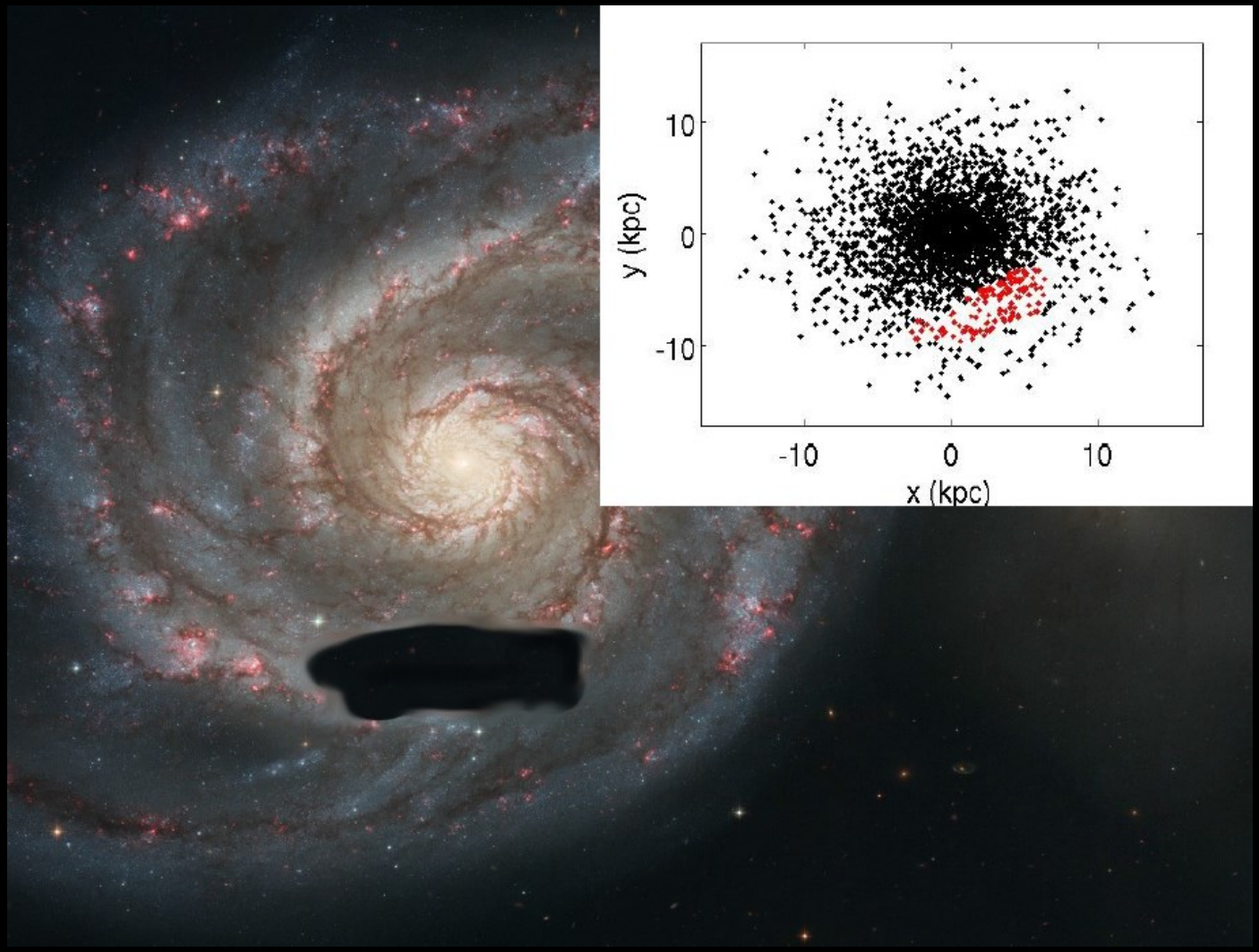

Per Calissendorff (2013)

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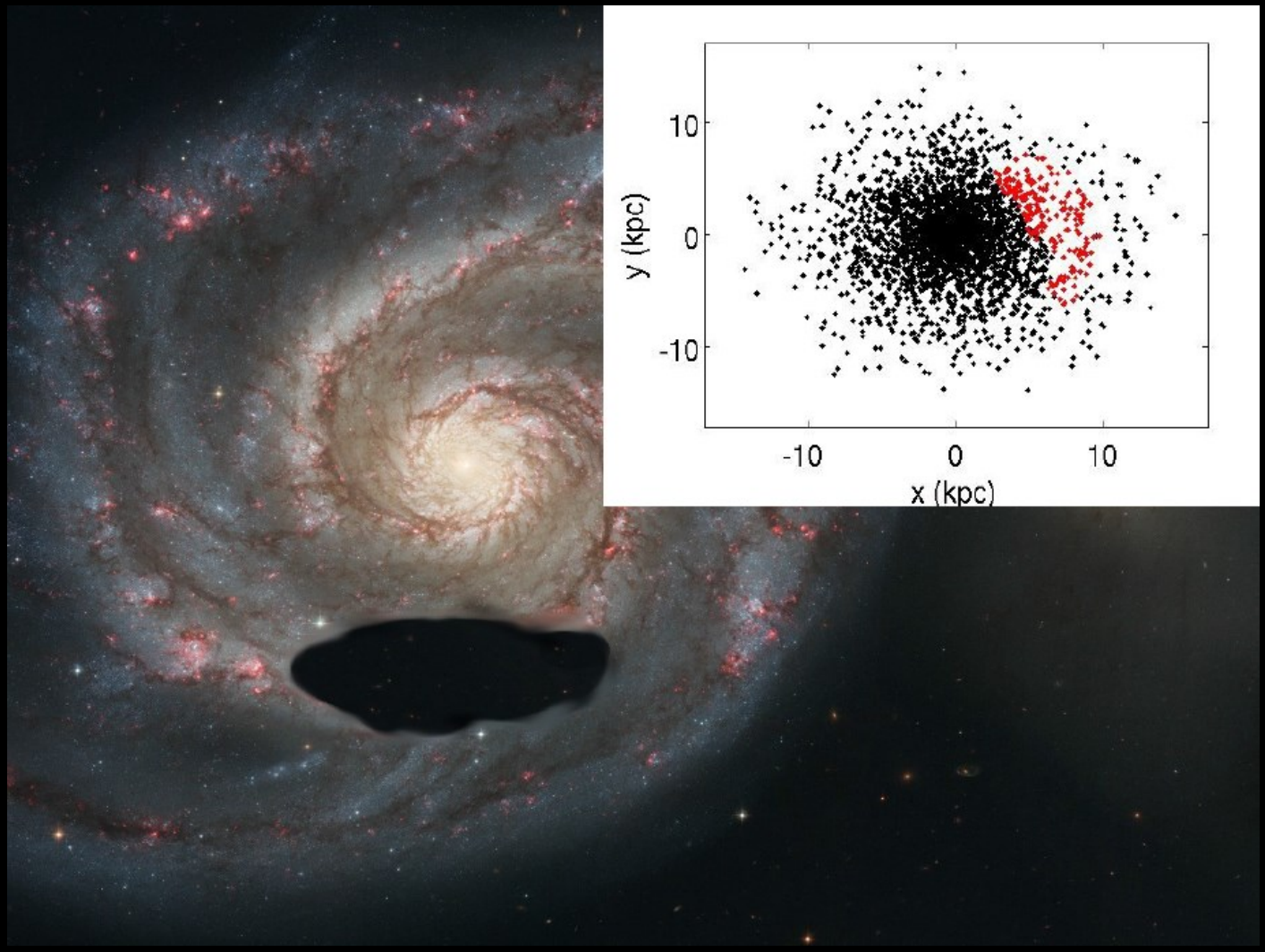

Per Calissendorff (2013)

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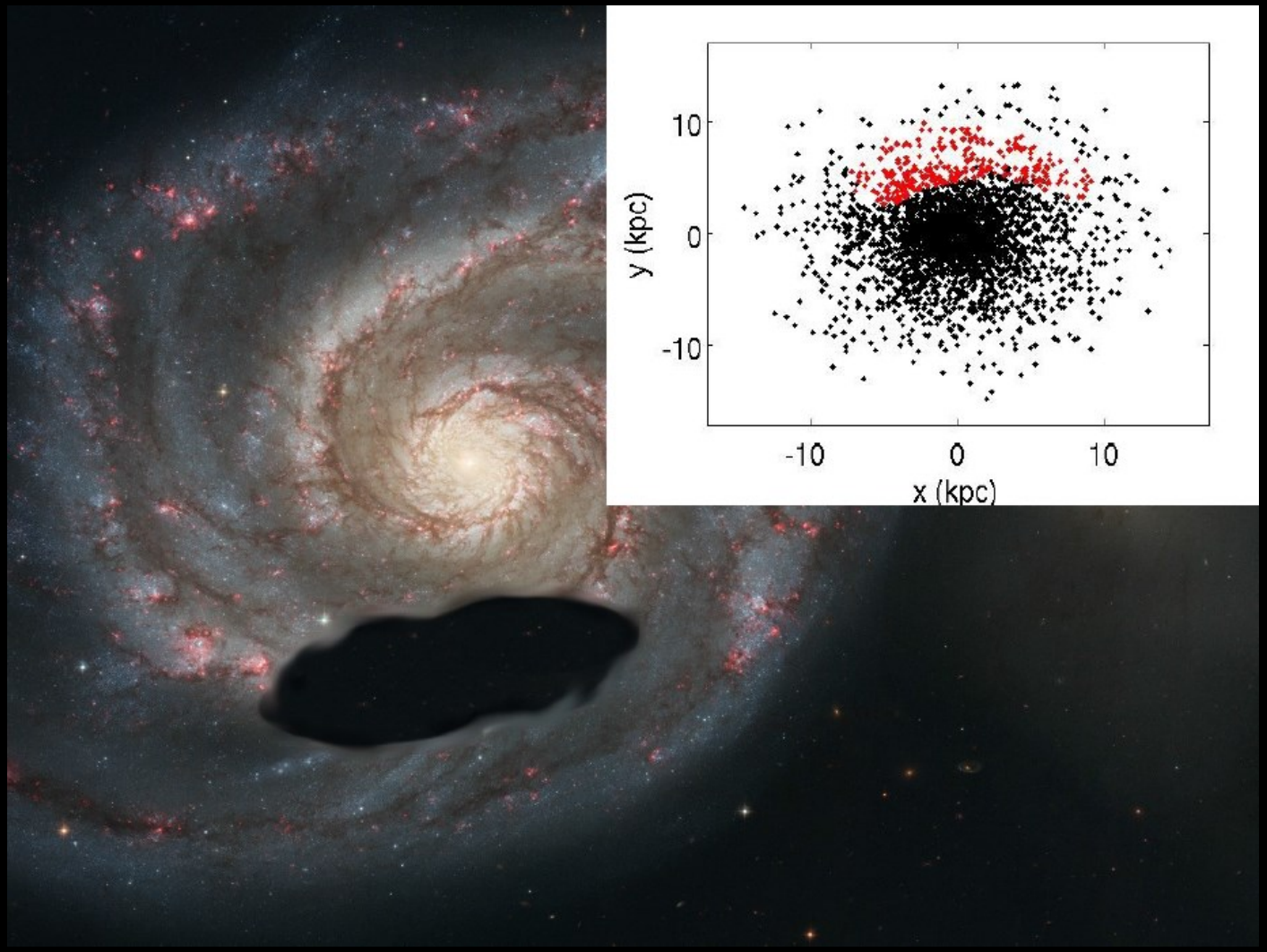

Per Calissendorff (2013)

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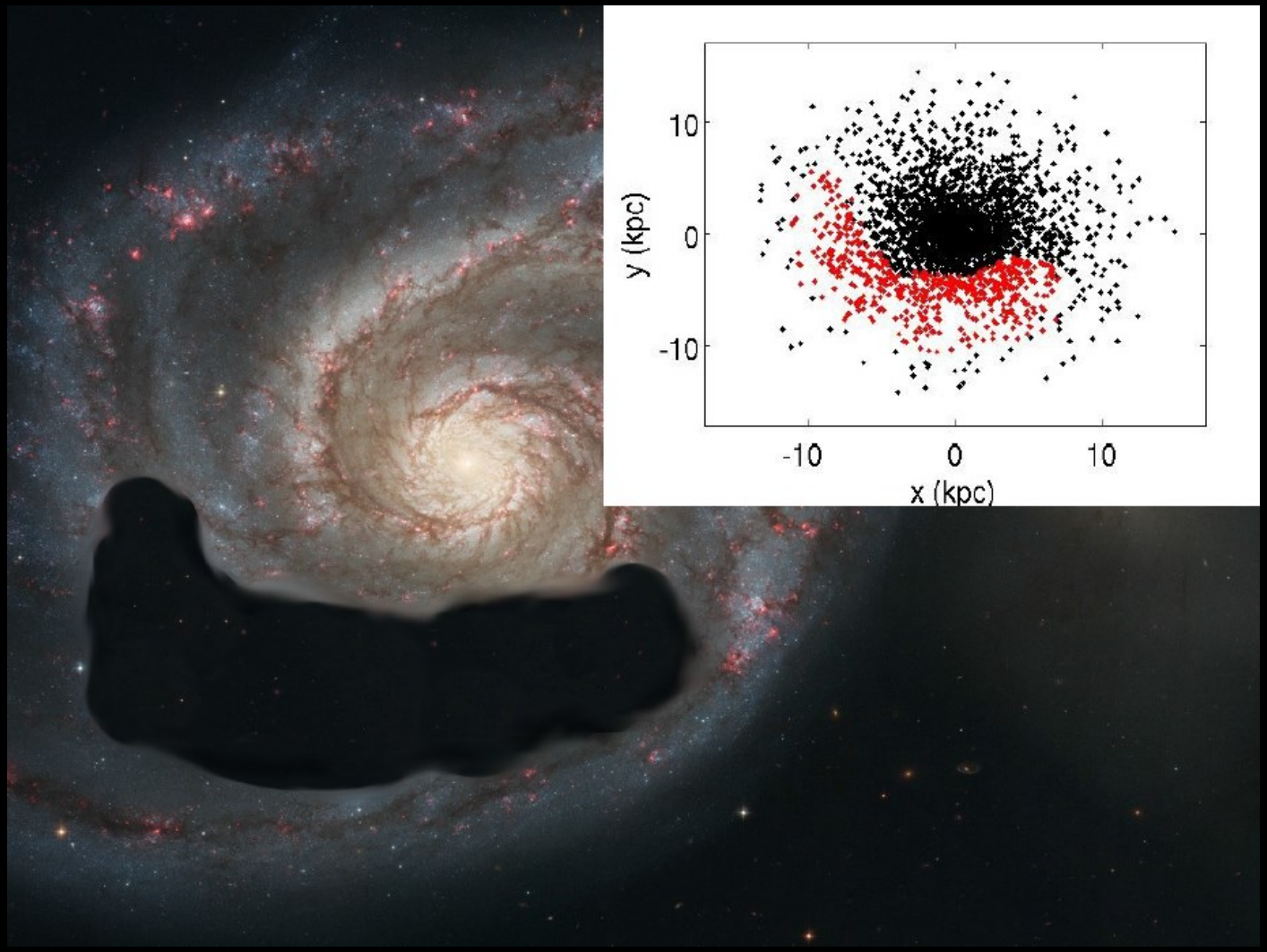

Per Calissendorff (2013)

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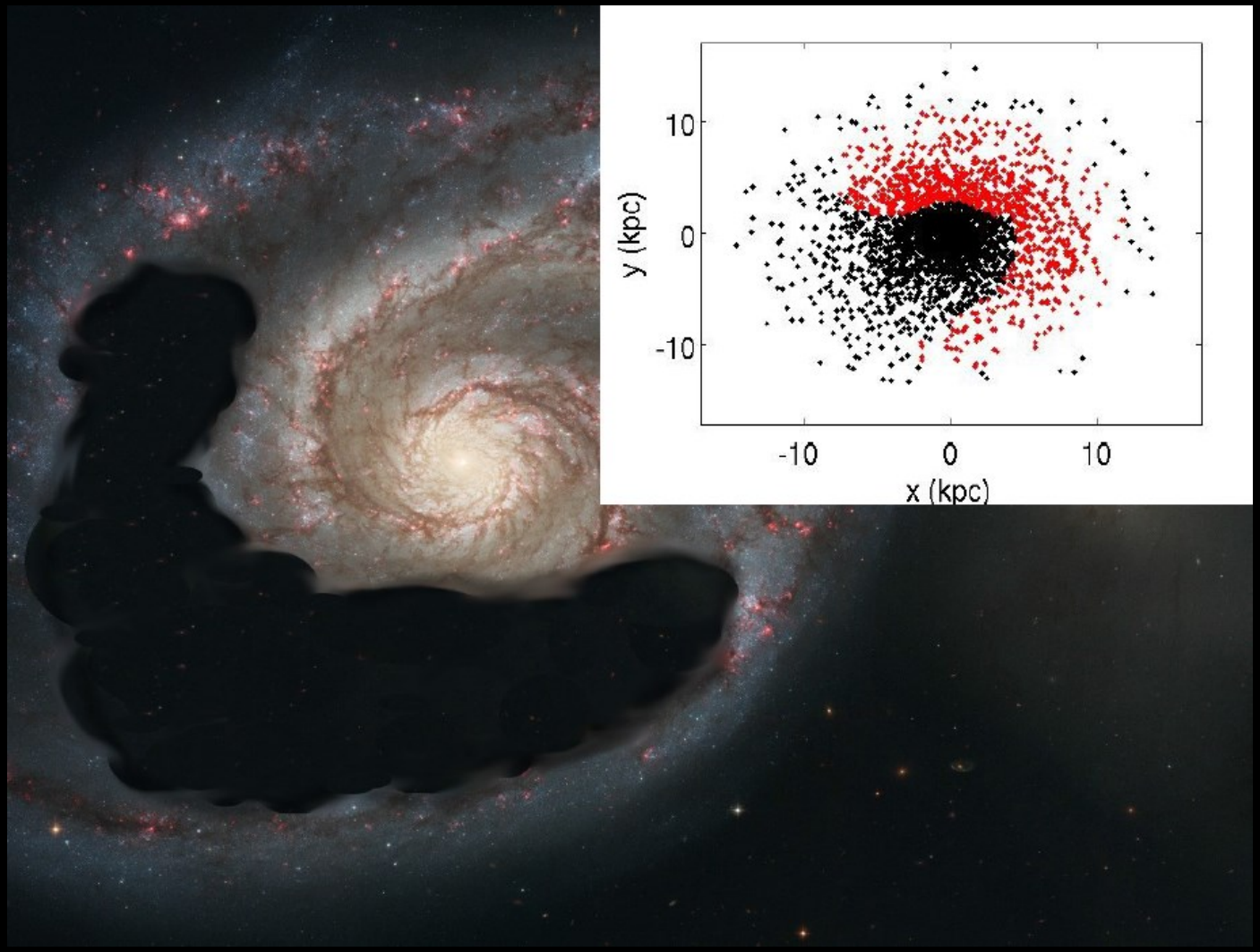

Per Calissendorff (2013)

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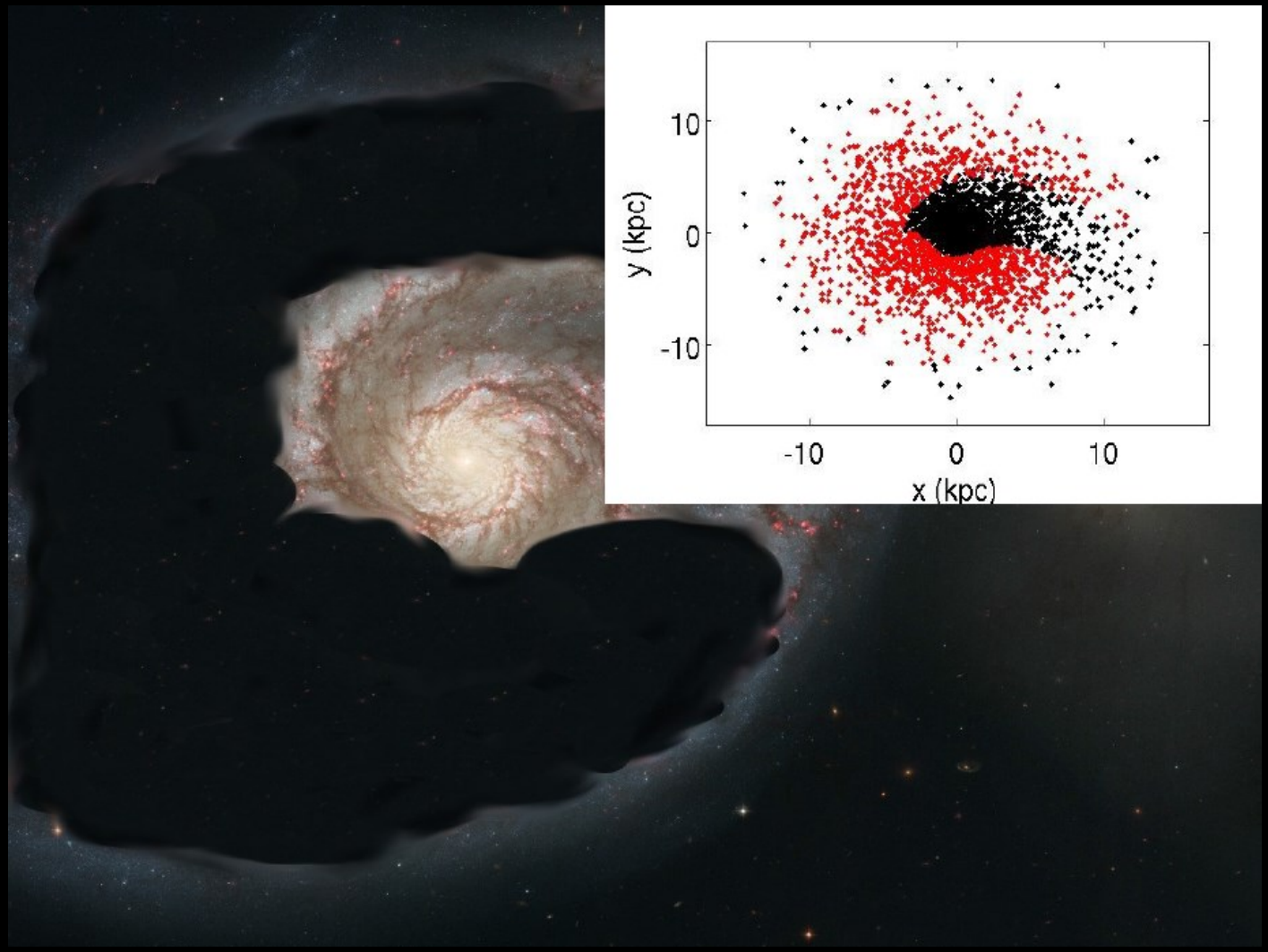

Per Calissendorff (2013)

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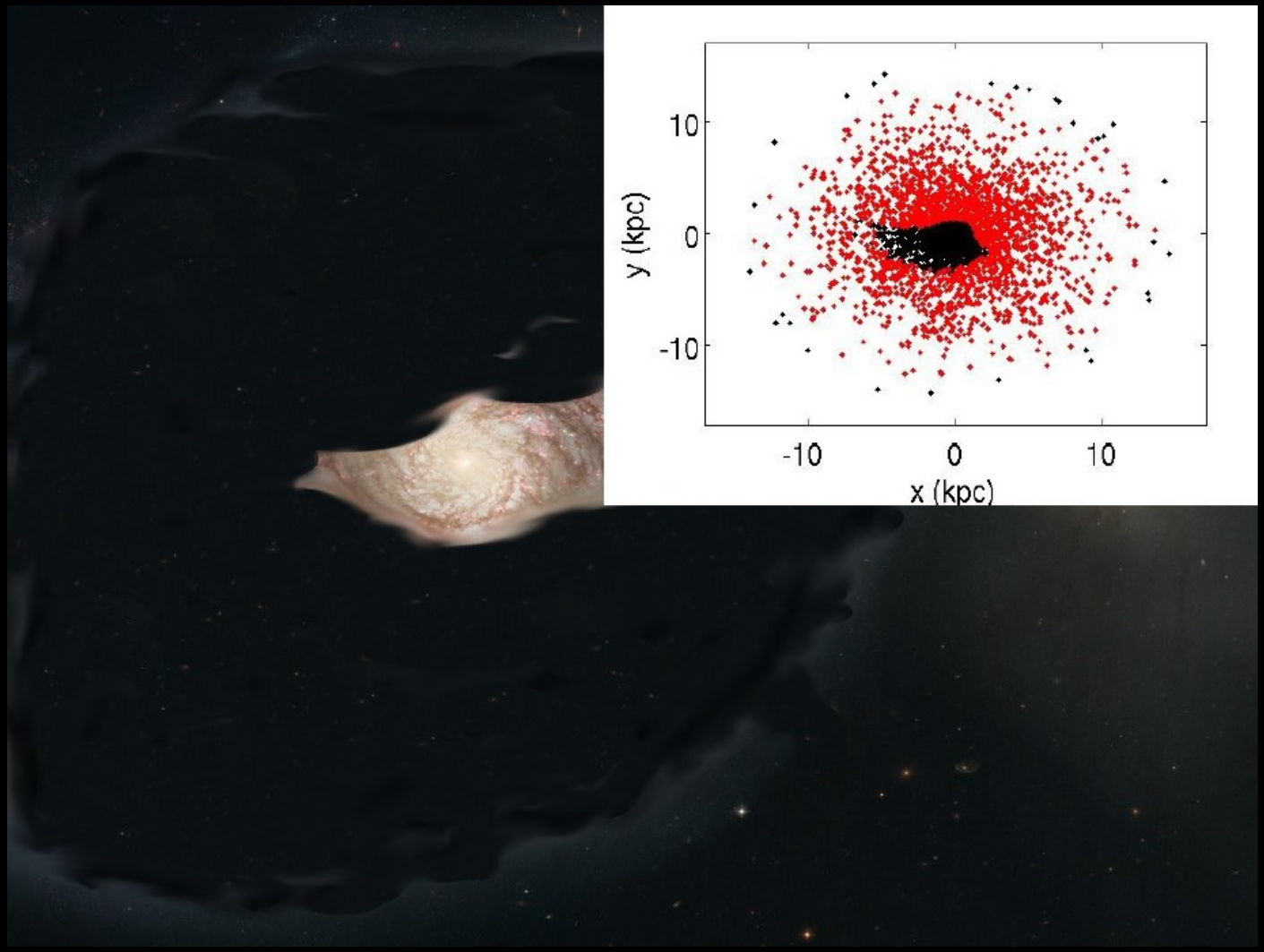

Per Calissendorff (2013)

Complications

- Colonization using Dyson spheres
  - Modified surface brightness profile
  - Misinterpreted axial ratios
- Object not classified as disk galaxy and never enters Tully-Fisher sample?

Summary

- Largest extragalactic Dysonian SETI project yet
- Star-fed Kardashev type III civilizations extremely rare in disk galaxies (<0.5%)
- Some KIII candidates are clearly due to failed measurements or misclassifications
- What are the others? We don’t know yet…