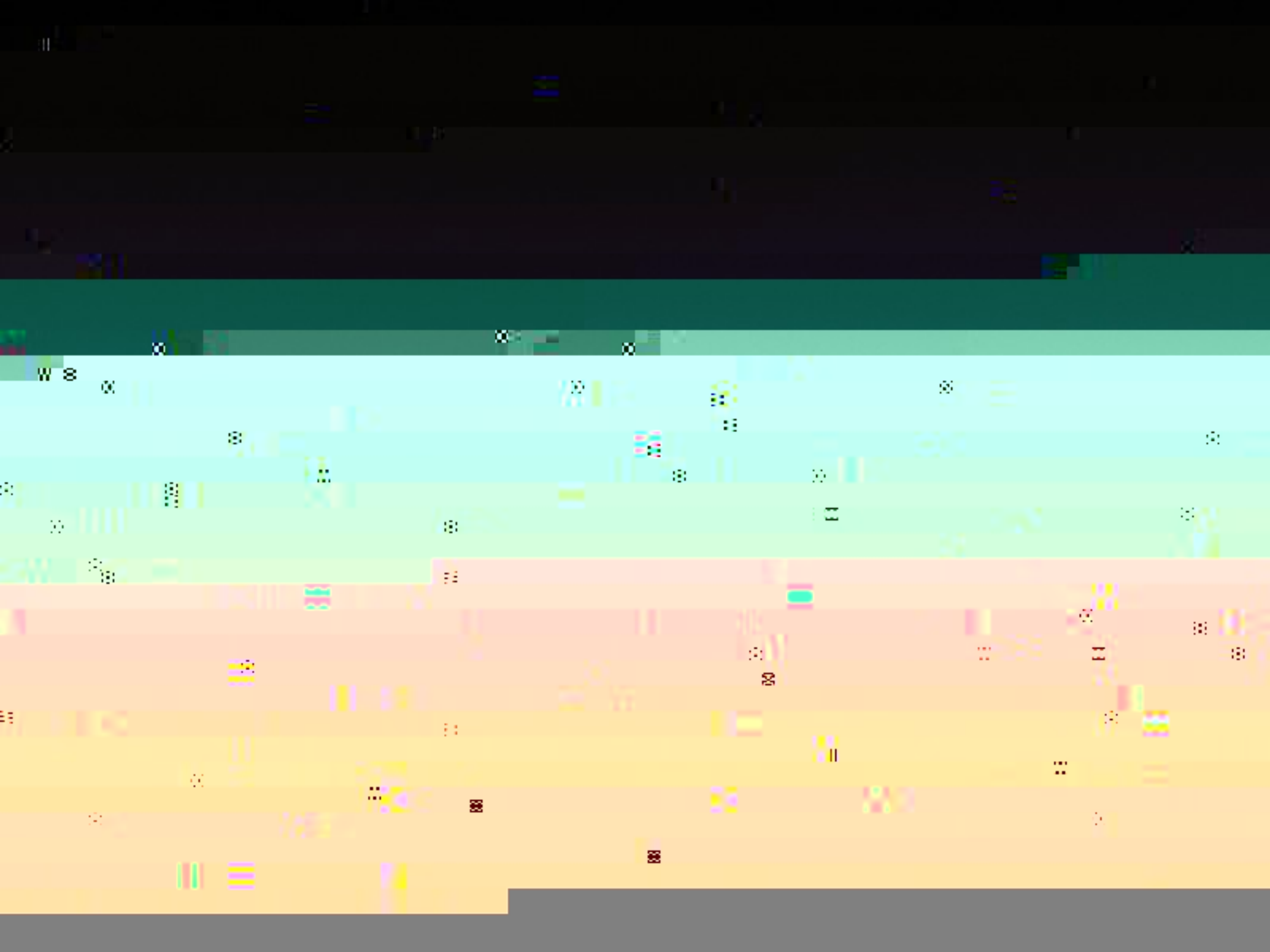
GReCO Seminar@IAP
November 25, 2013

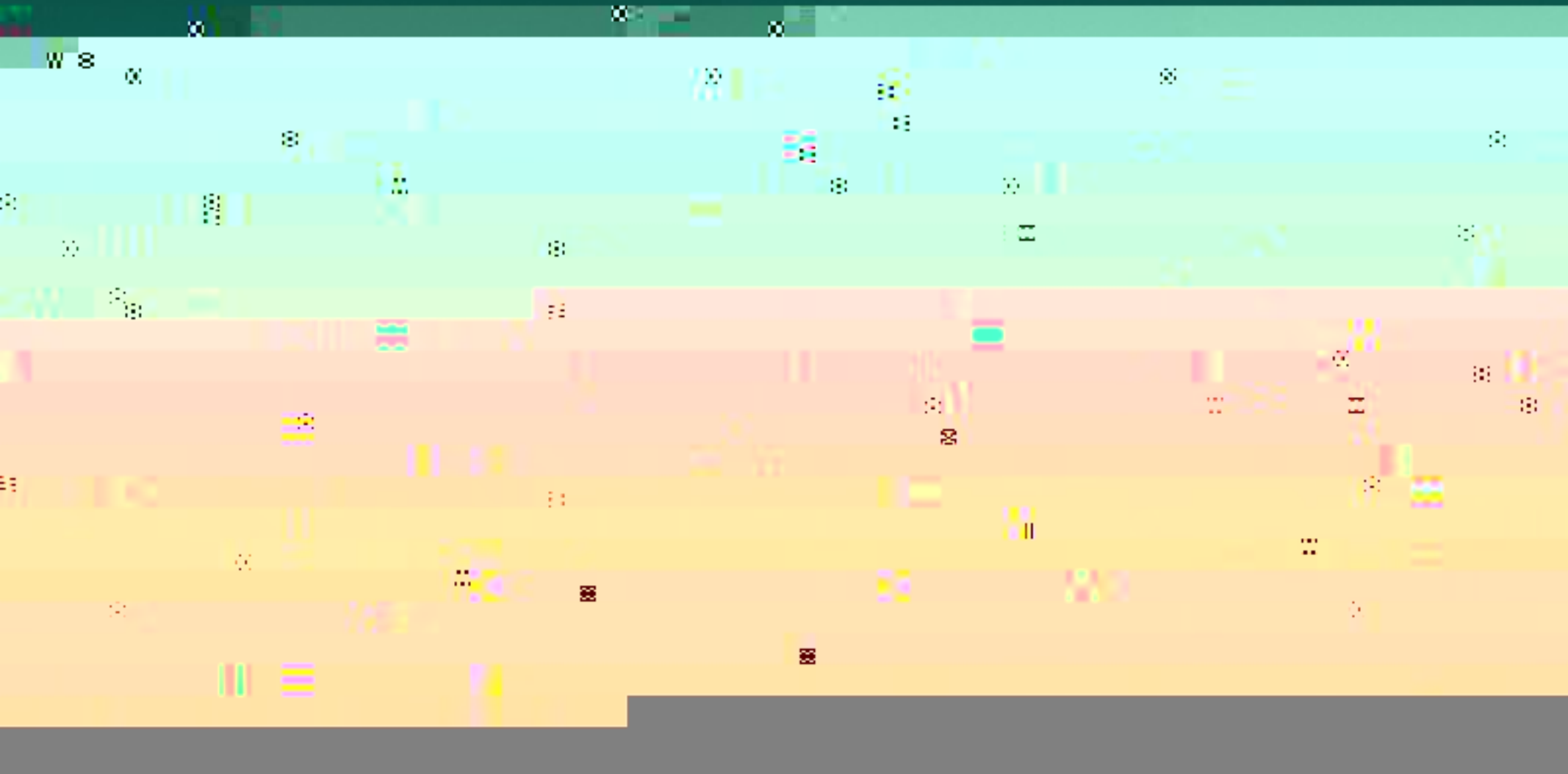
Shin'ichiro Ando

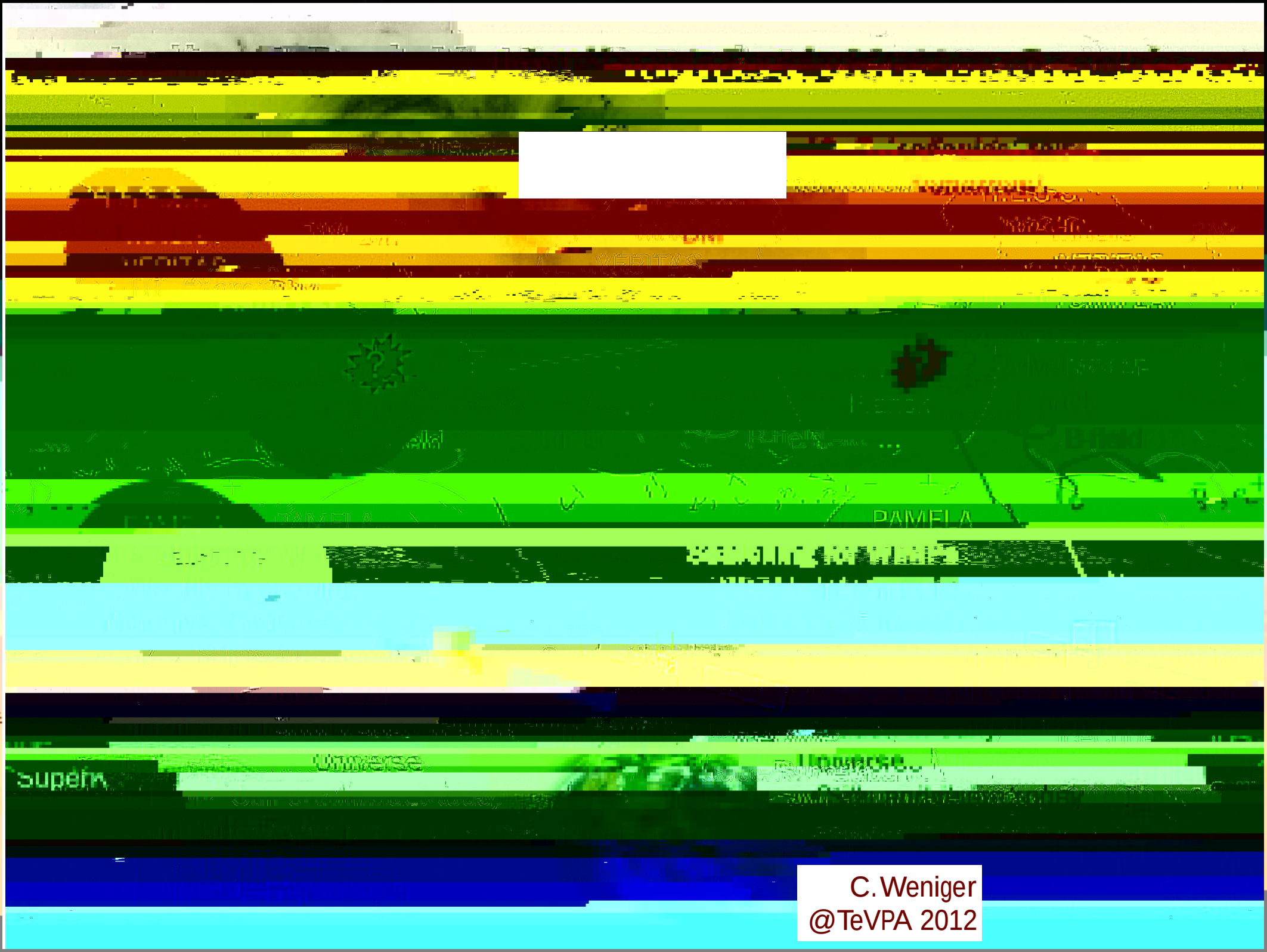
Nonbaryonic dark matter

- Many observations indicate presence of *nonbaryonic dark matter*
  - Galaxy rotation curves, galaxy clusters, gravitational lensing, CMB anisotropy, etc.
- ~80% of total matter in the Universe



Three routes to dark matter





C. Weniger
@TeVPA 2012

Fermi Large Area Telescope (LAT)

- Fermi satellite launched in summer 2008
- Pair conversion detector
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Formulation

- Divided into particle-physics and astrophysical factors
- The former and the latter determine energy and angular distributions, respectively
- Density-square dependence always boost the annihilation; e.g., dark matter subhalos
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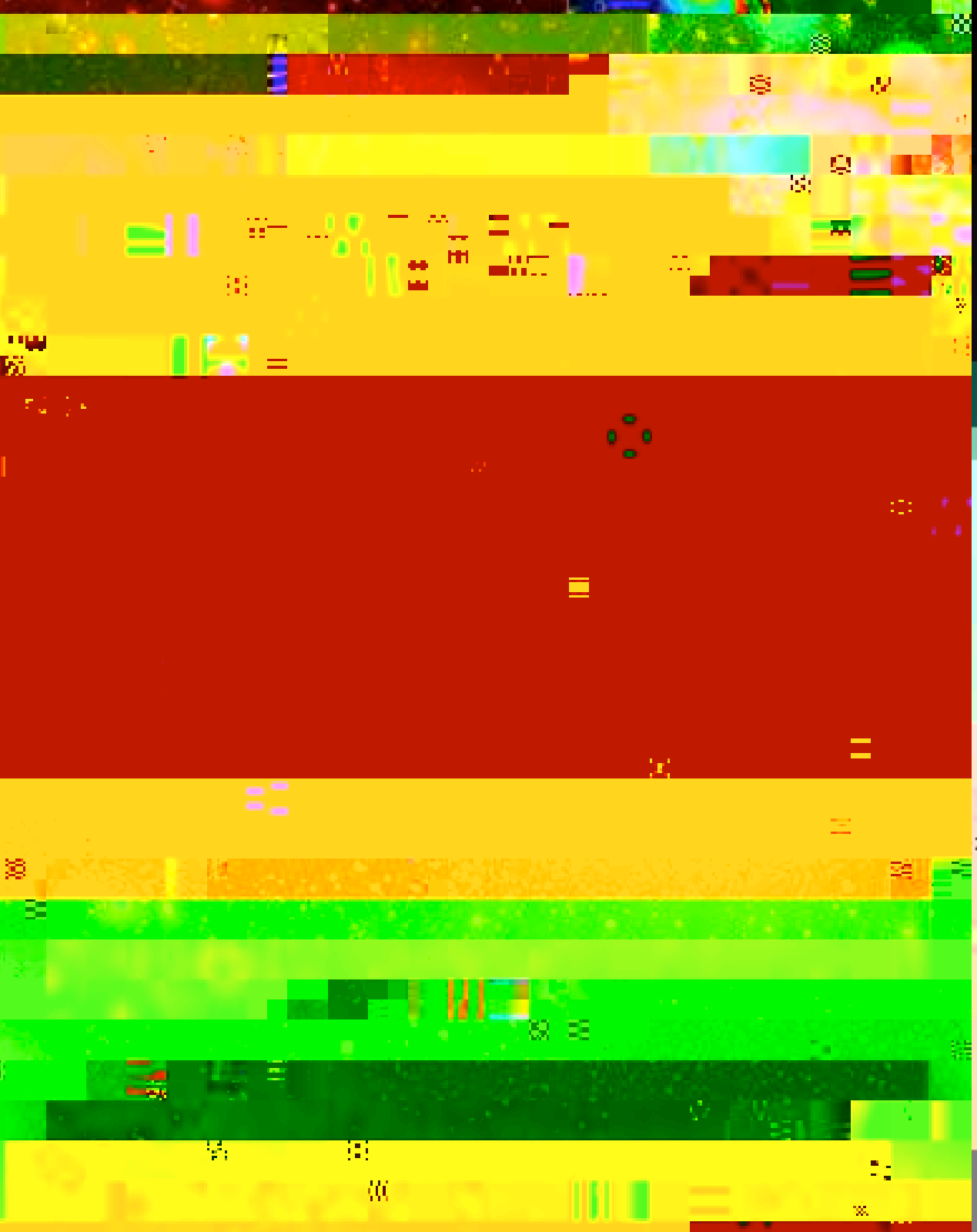
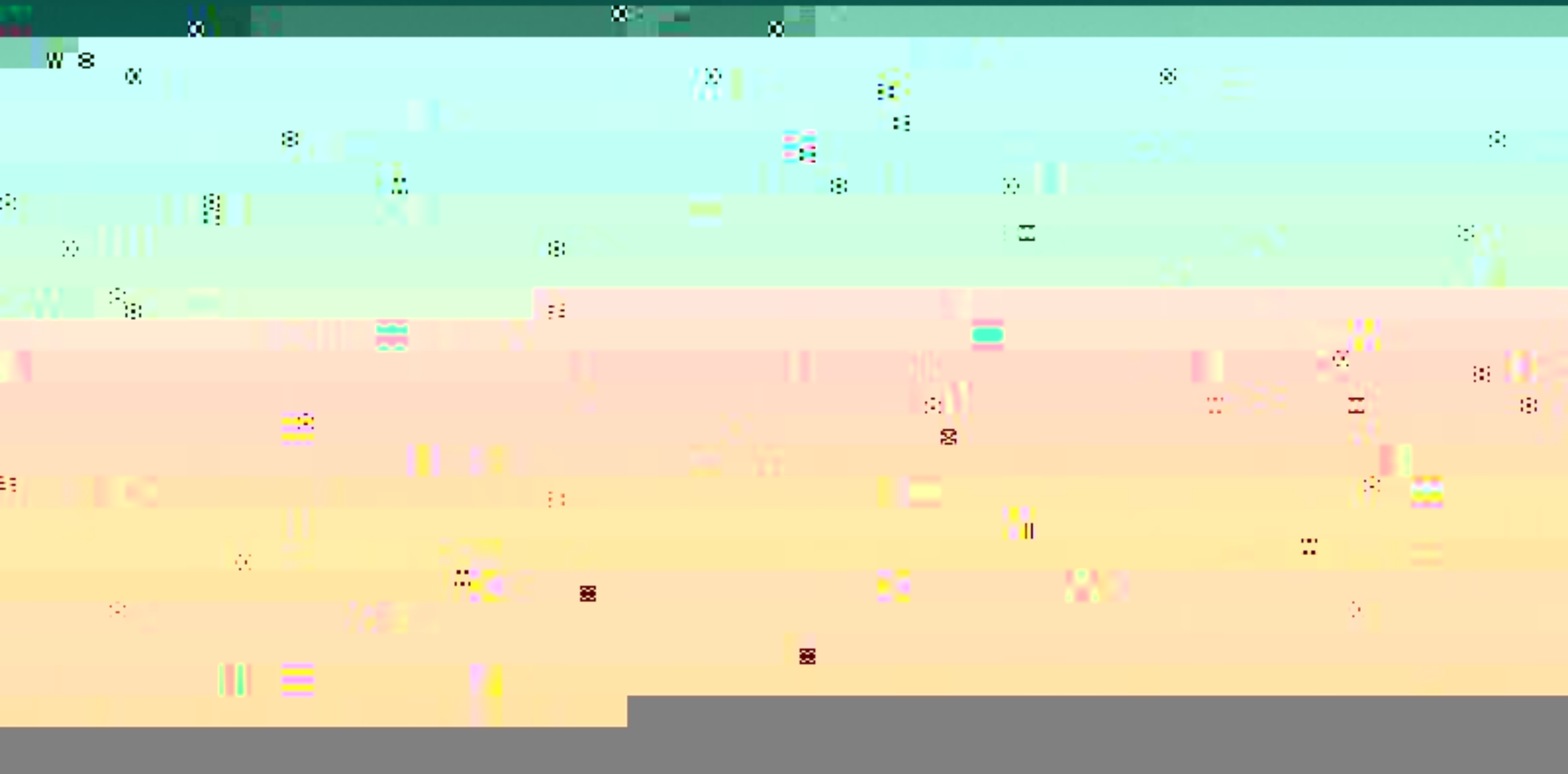


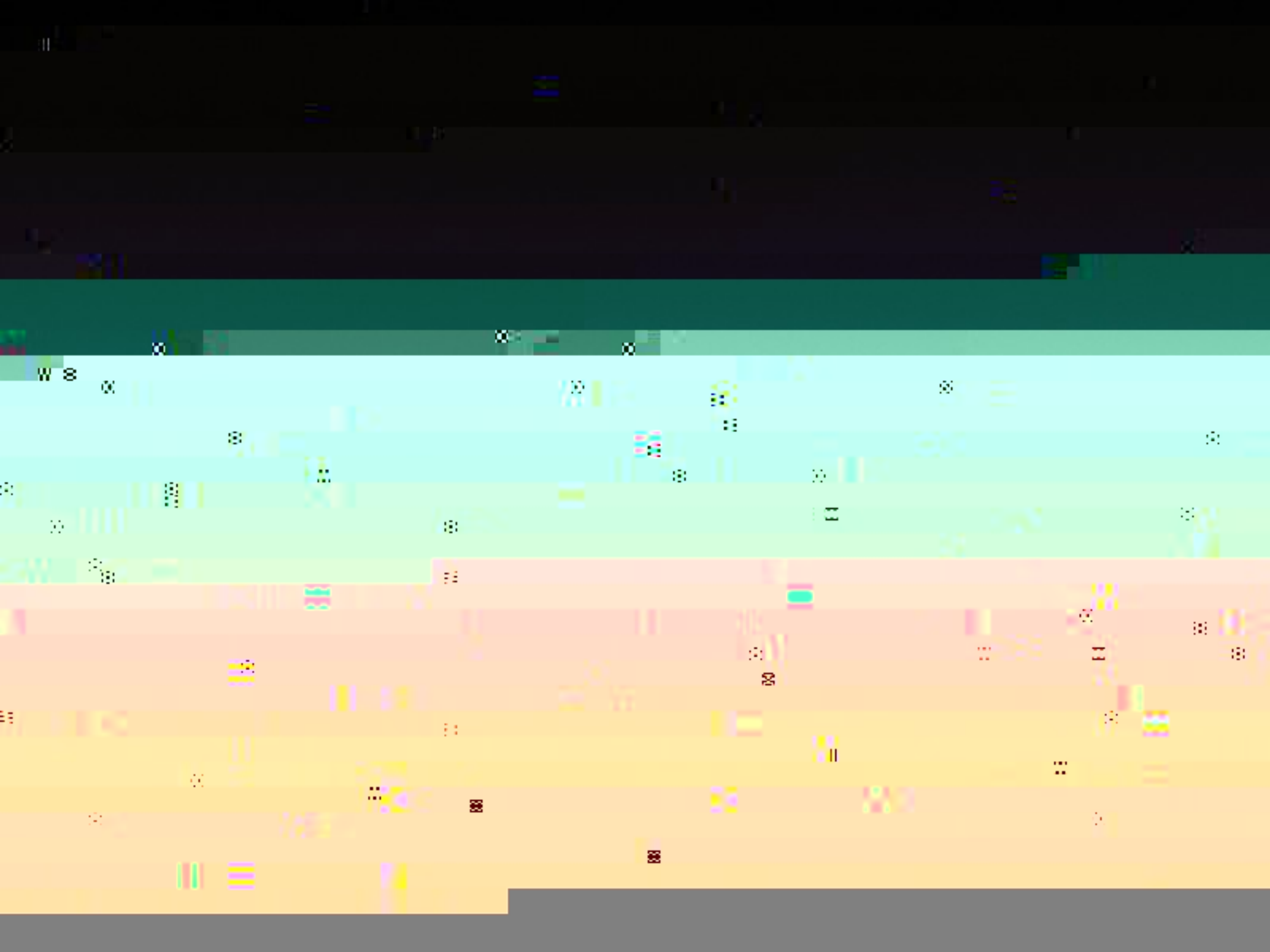
- Numerical simulations imply universal form of density profile: NFW

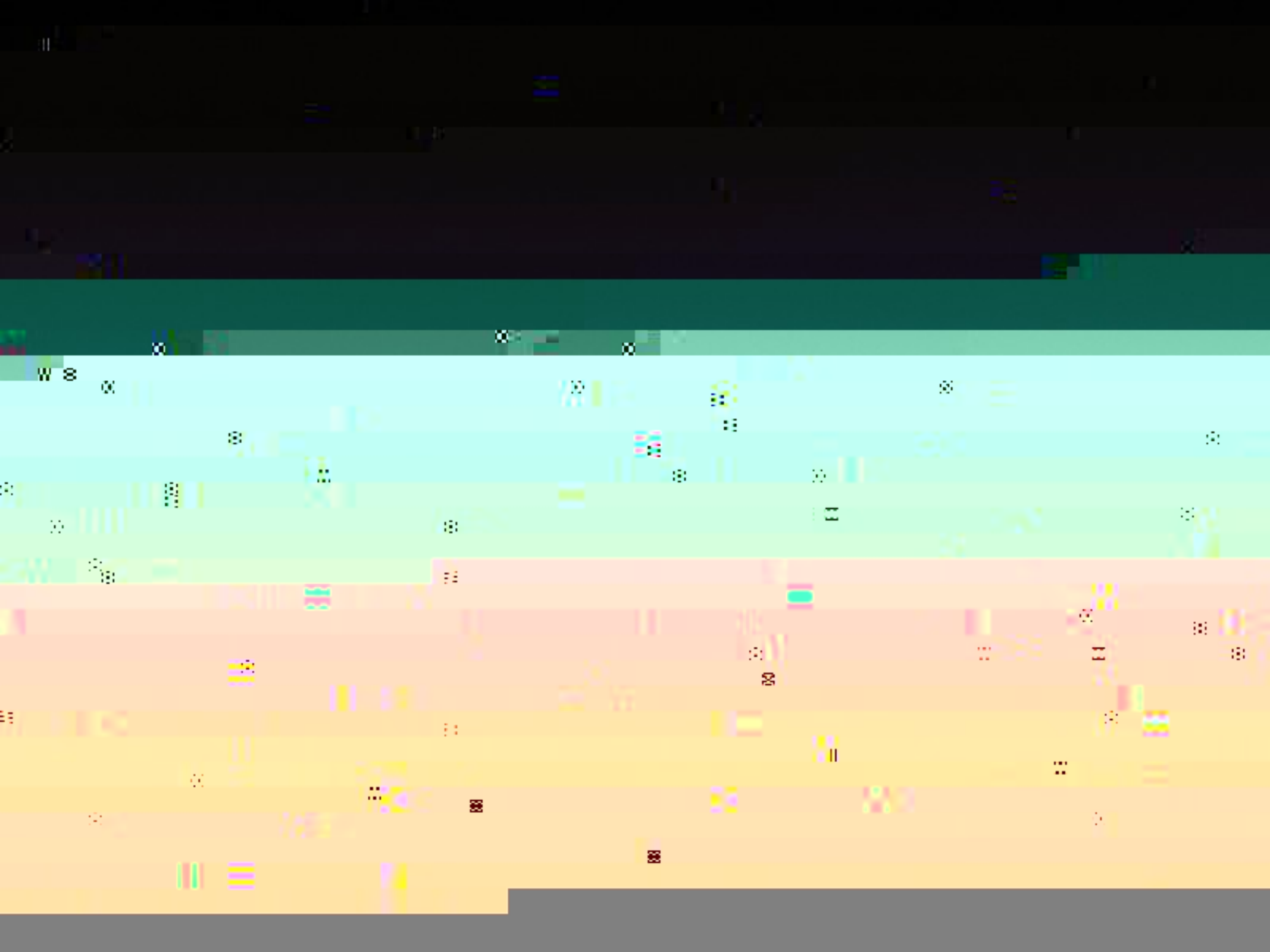
Galactic structures

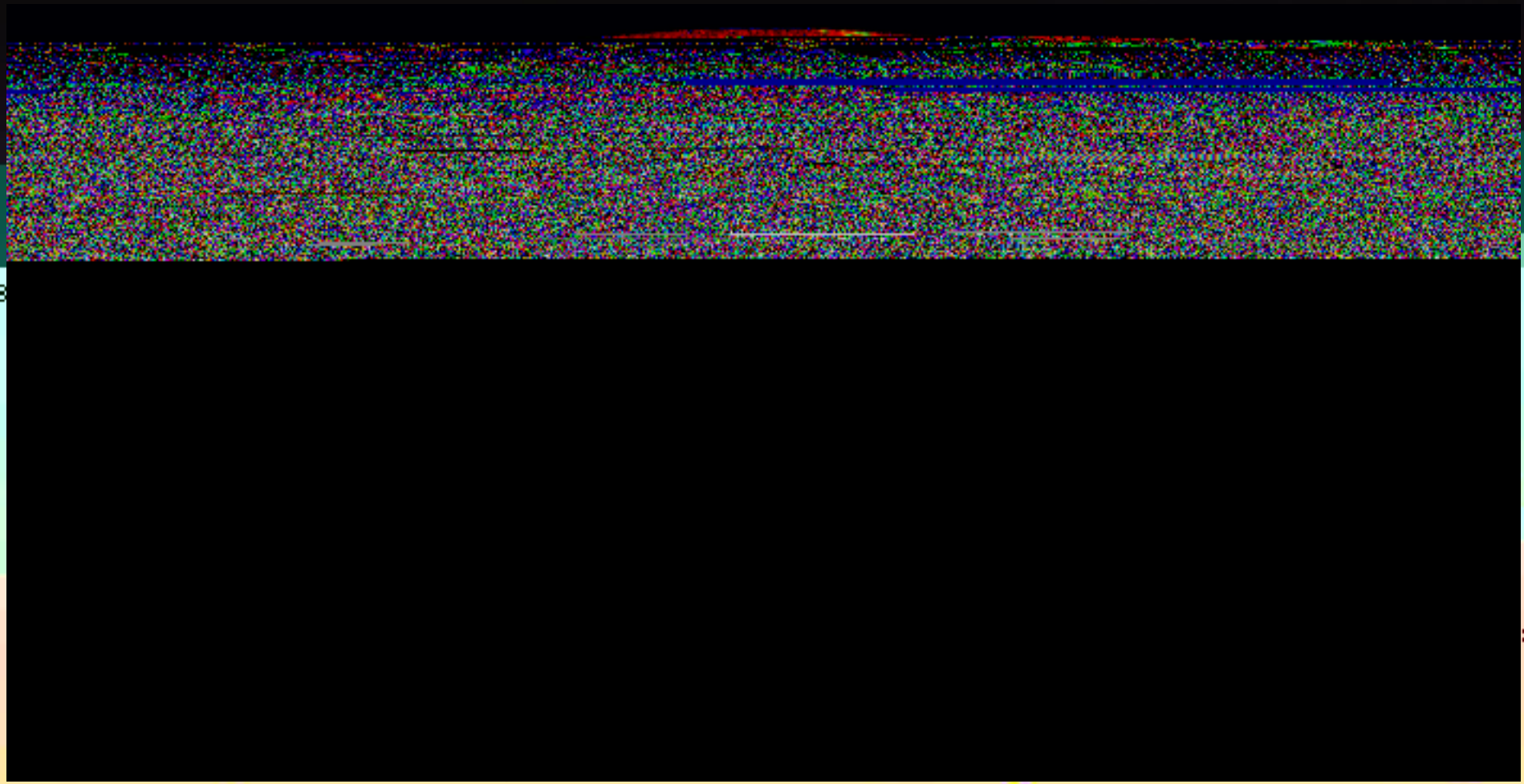


Galactic halo (excluding center and disk)

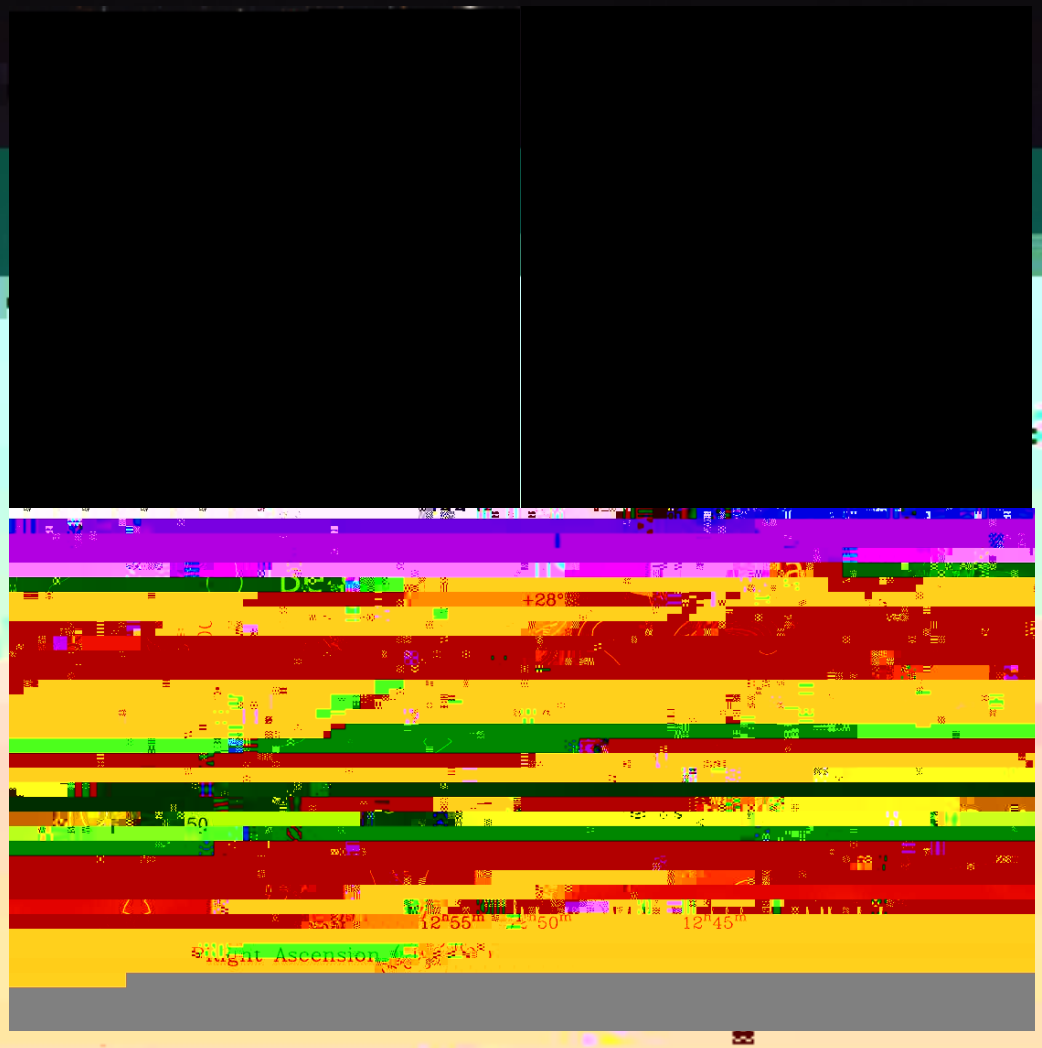
- Large number of expected photons
- Avoid strong Galactic emission from the disk
- Marginalized over parameters for astrophysical backgrounds
  - Height of diffusive CR halo
  - CR source distribution and spectra
  - Column density of ISM gas
  - Diffusion coefficient, etc.
- Full parameter scan yet to be done



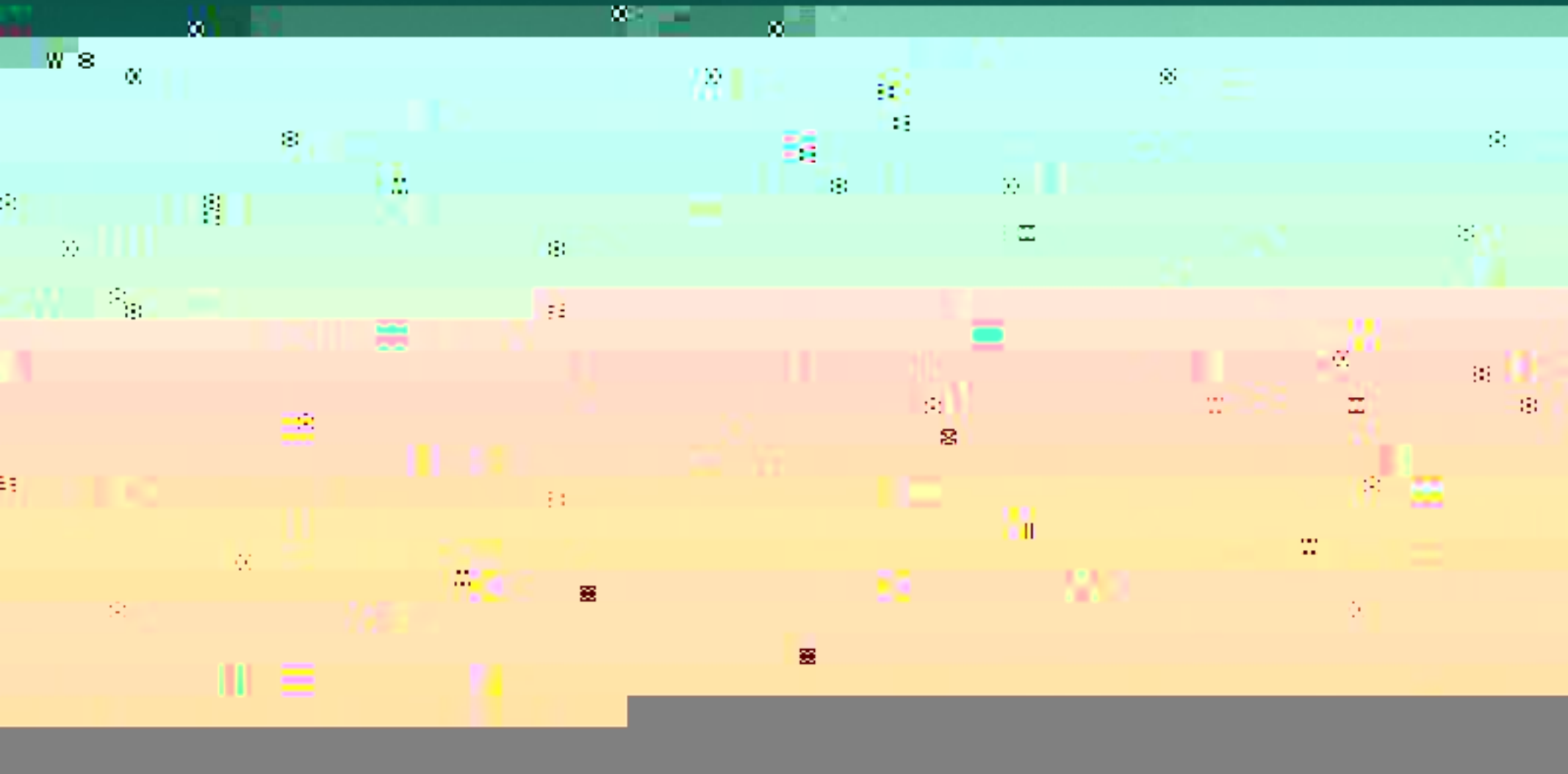


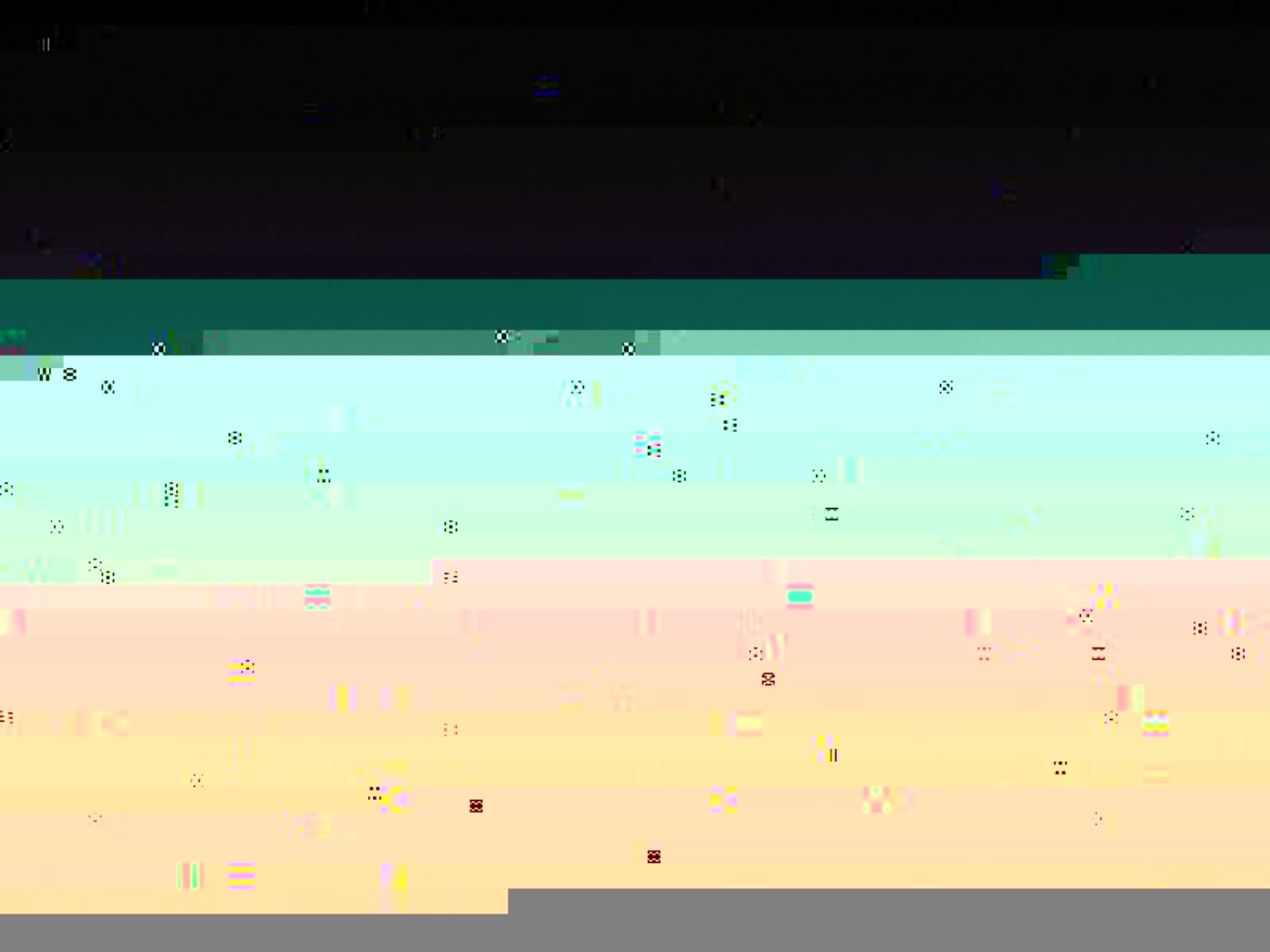


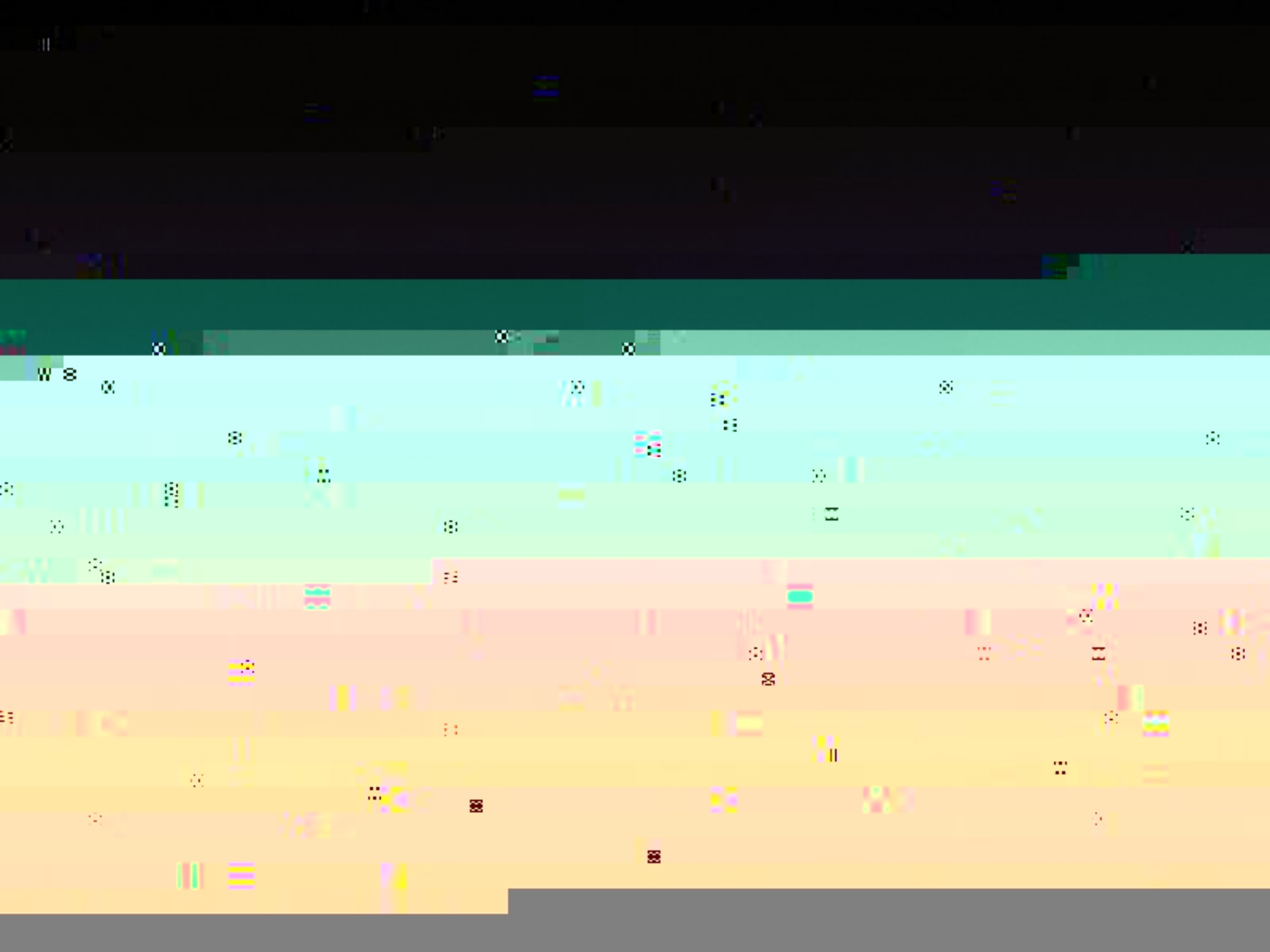
Two important clusters



Cosmic rays in clusters

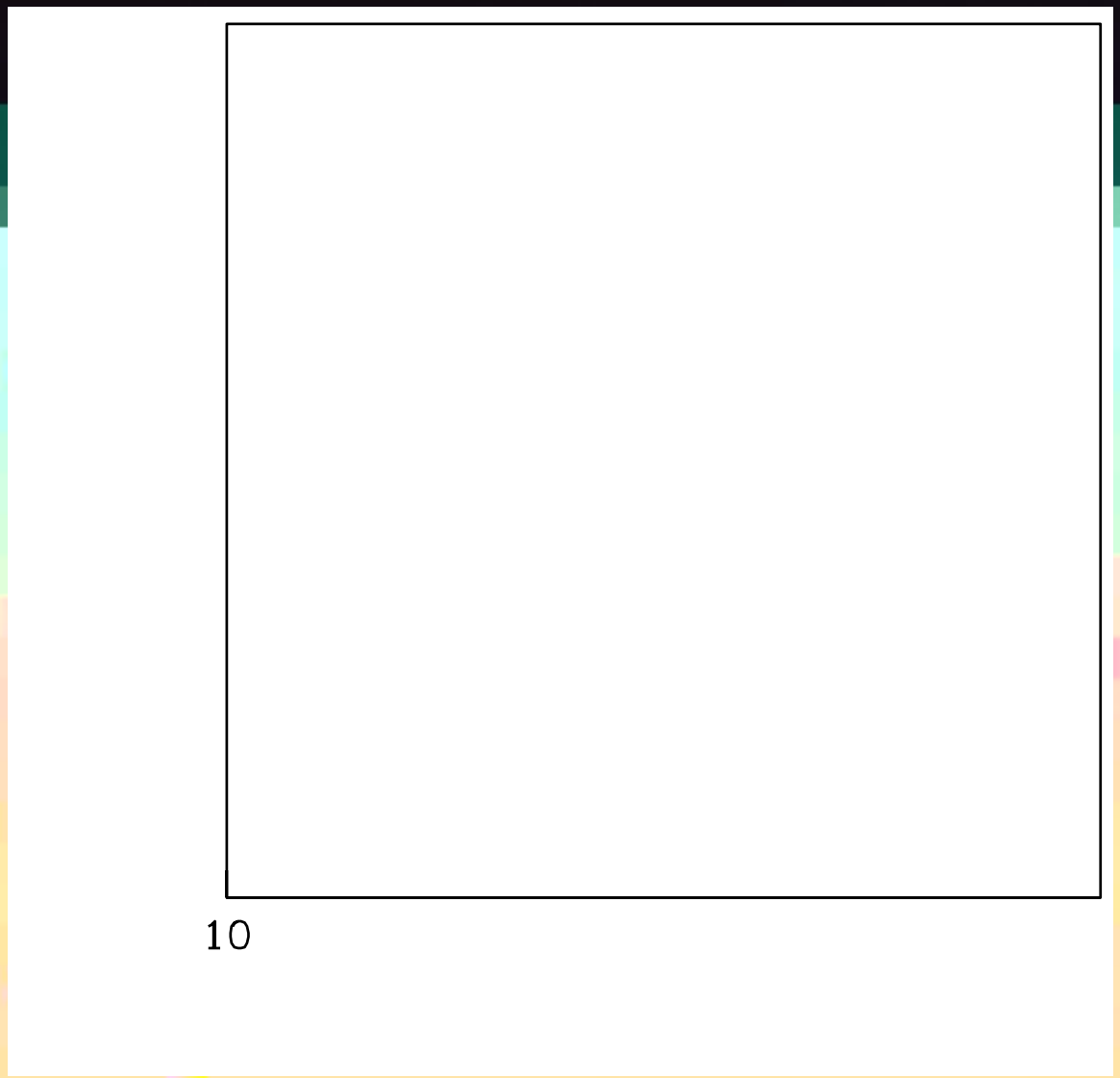






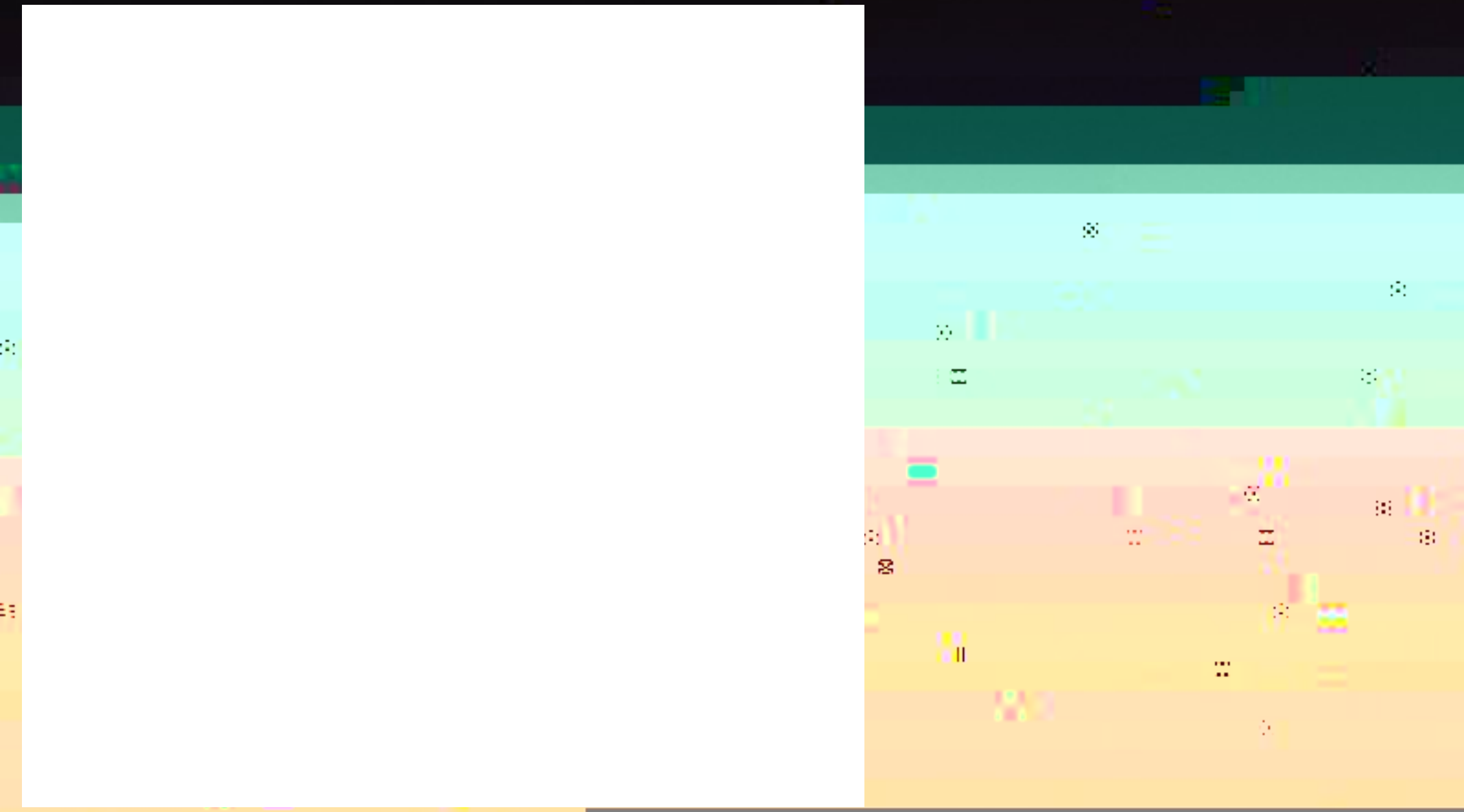
Limits on annihilation cross section from Fornax

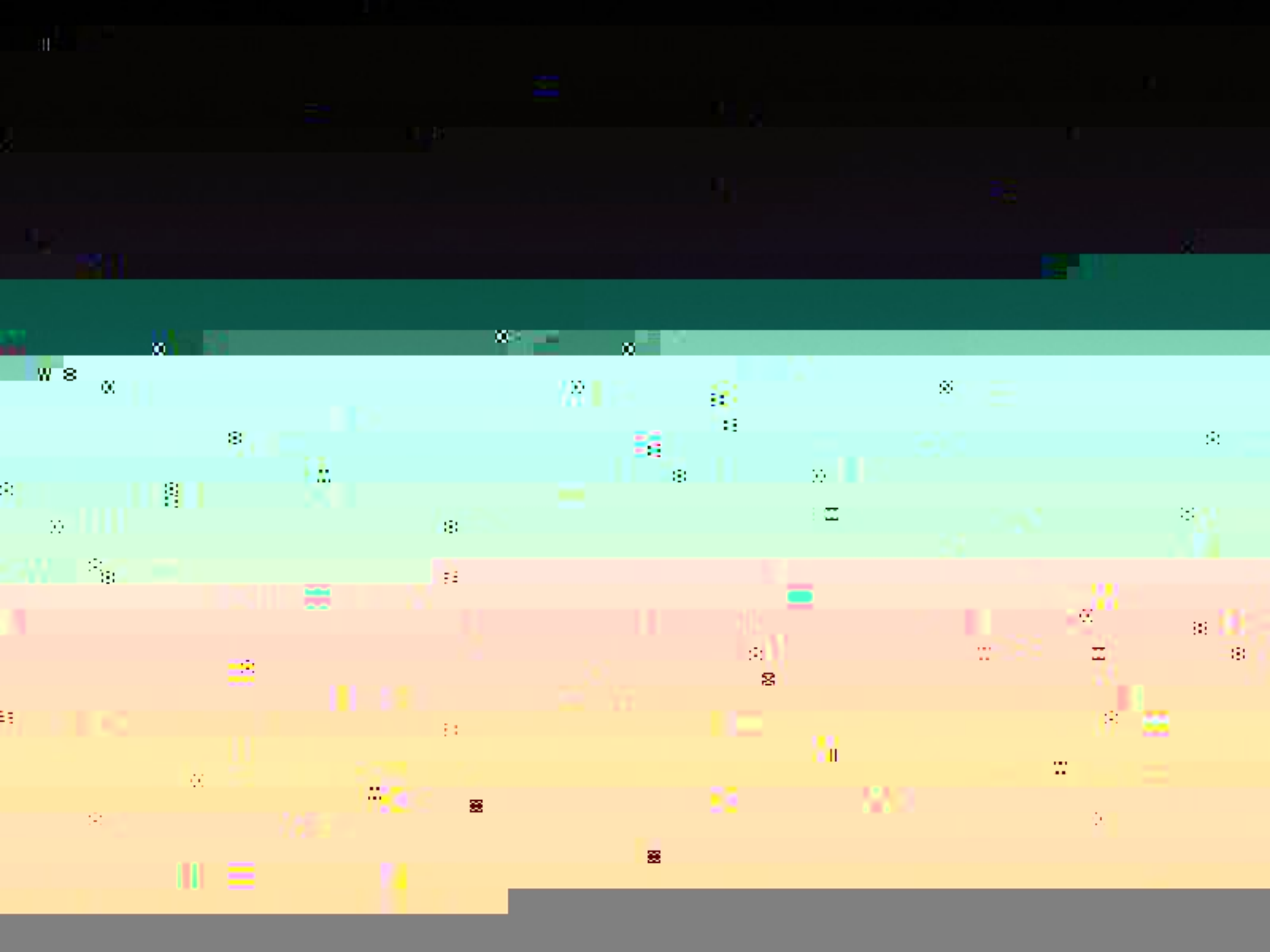
NFW halo with no subhalos



Ando & Nagai, *JCAP* 1207, 017 (2012)

Density profiles of Fornax

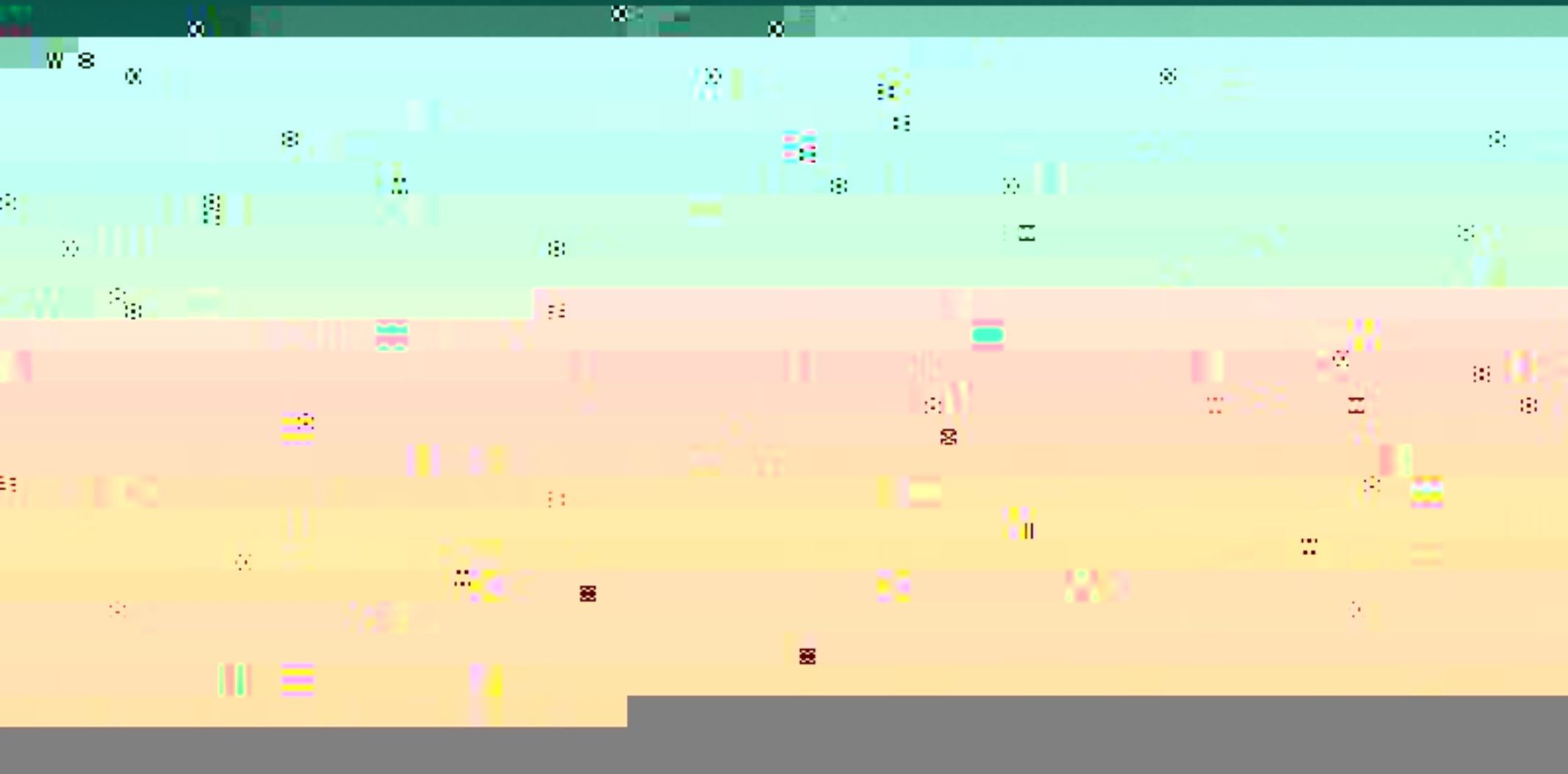


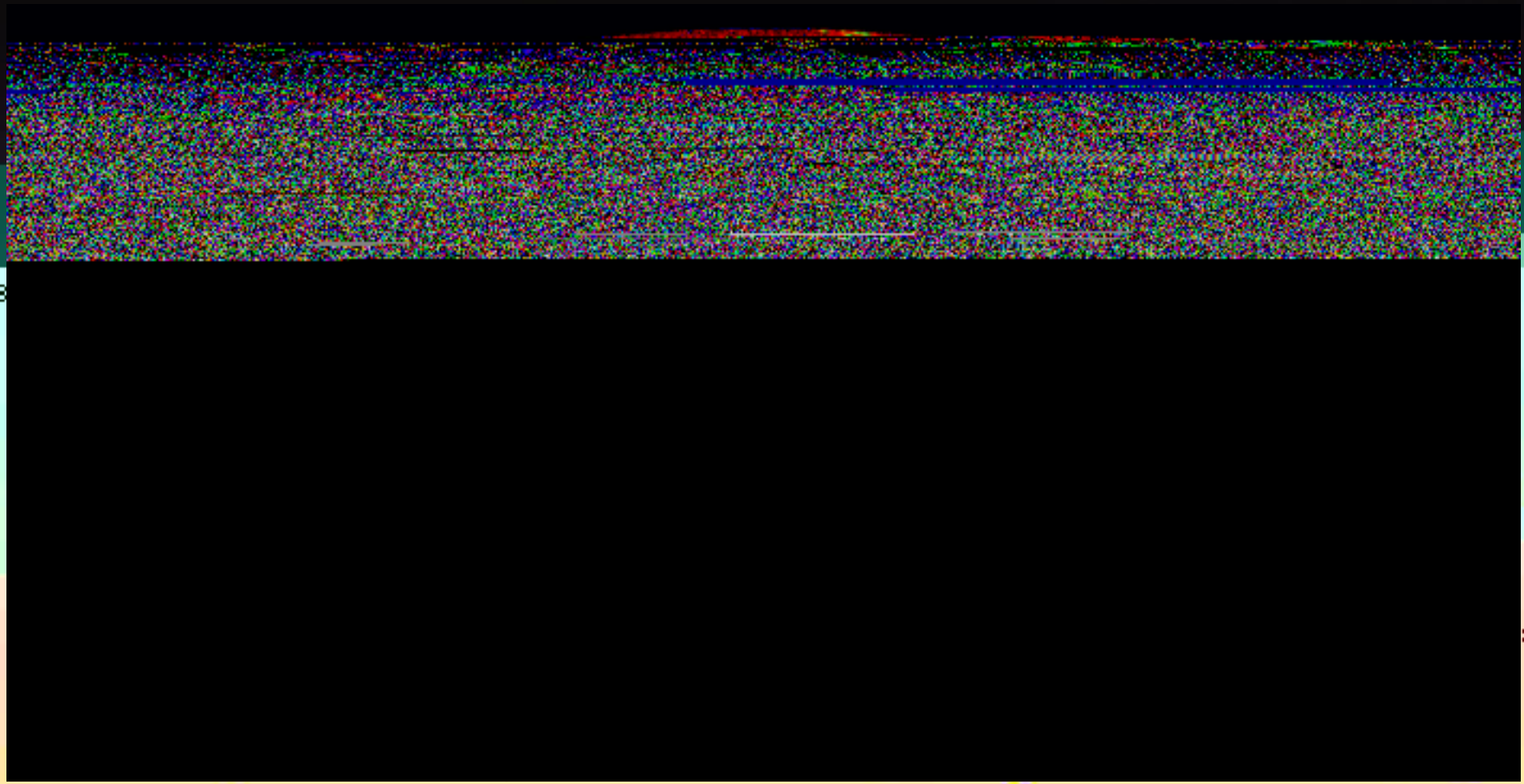


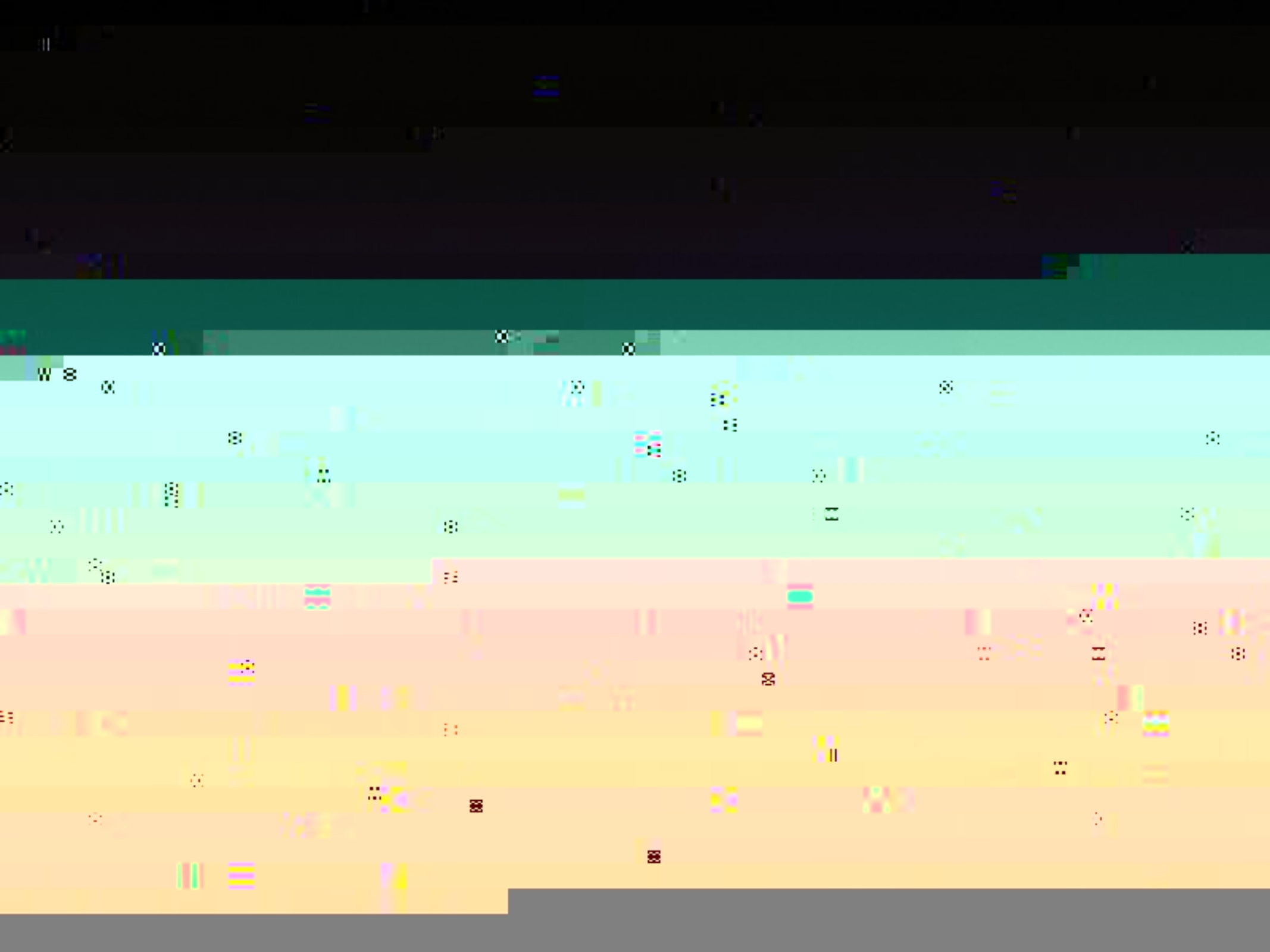
Cross section upper limits

- Limits improve by a factor of
  - 4.1 (NFW)
  - 2.4 (Einasto)
- This is almost independent of mass and annihilation channel
- $\langle \sigma v \rangle < (2\text{–}3)\times10^{-25}$ cm^3/s for low-mass WIMPs

How important is this?: Compare with subhalos



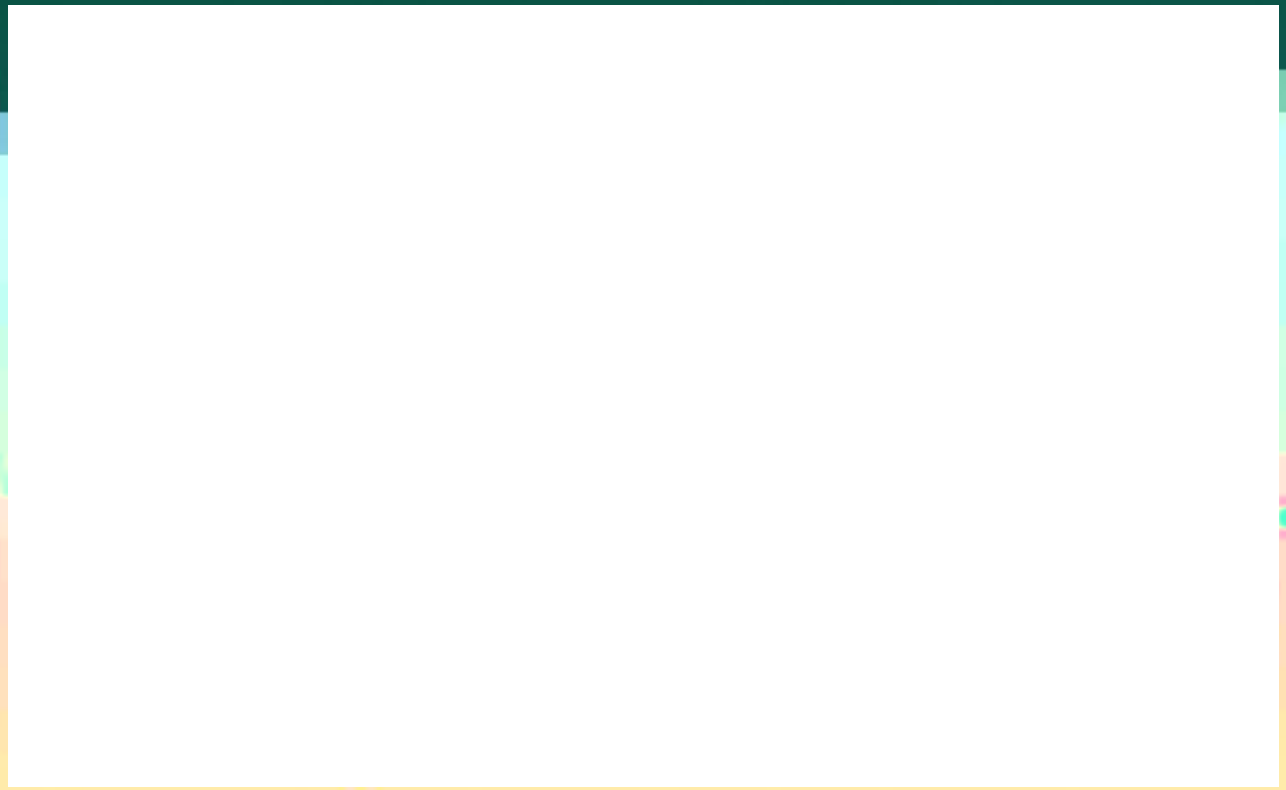




Gamma-ray background anisotropy

- Small-angular power spectrum

Origin of the gamma-ray background



- Contributions from Galactic/extragalactic objects
  - Blazars
  - Radio galaxies
  - Star-forming galaxies, starburst galaxies
  - 50 ! 80% can be explained

Dark matter annihilation?

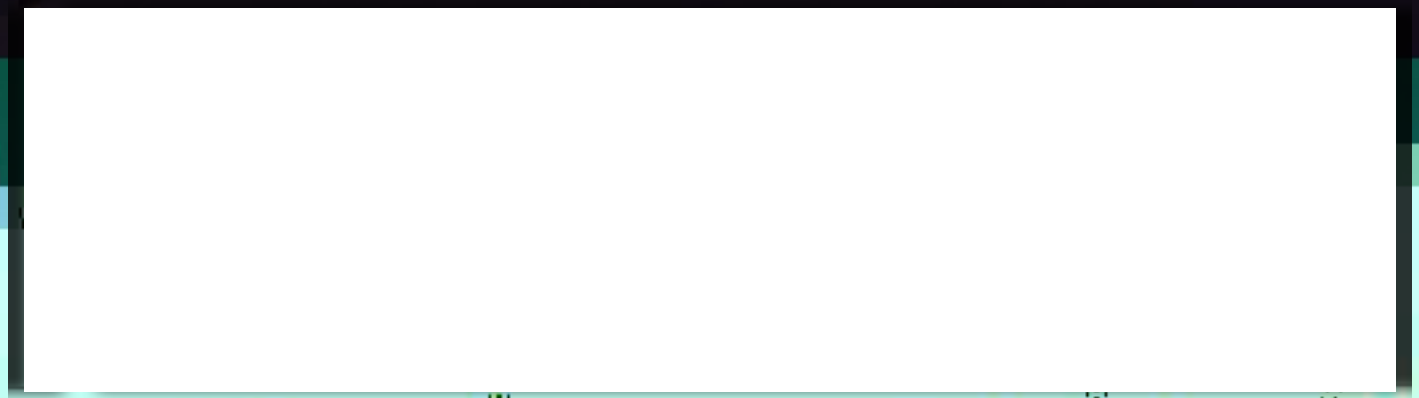
Purpose of this study

Angular power spectrum

- Take spherical harmonic expansion

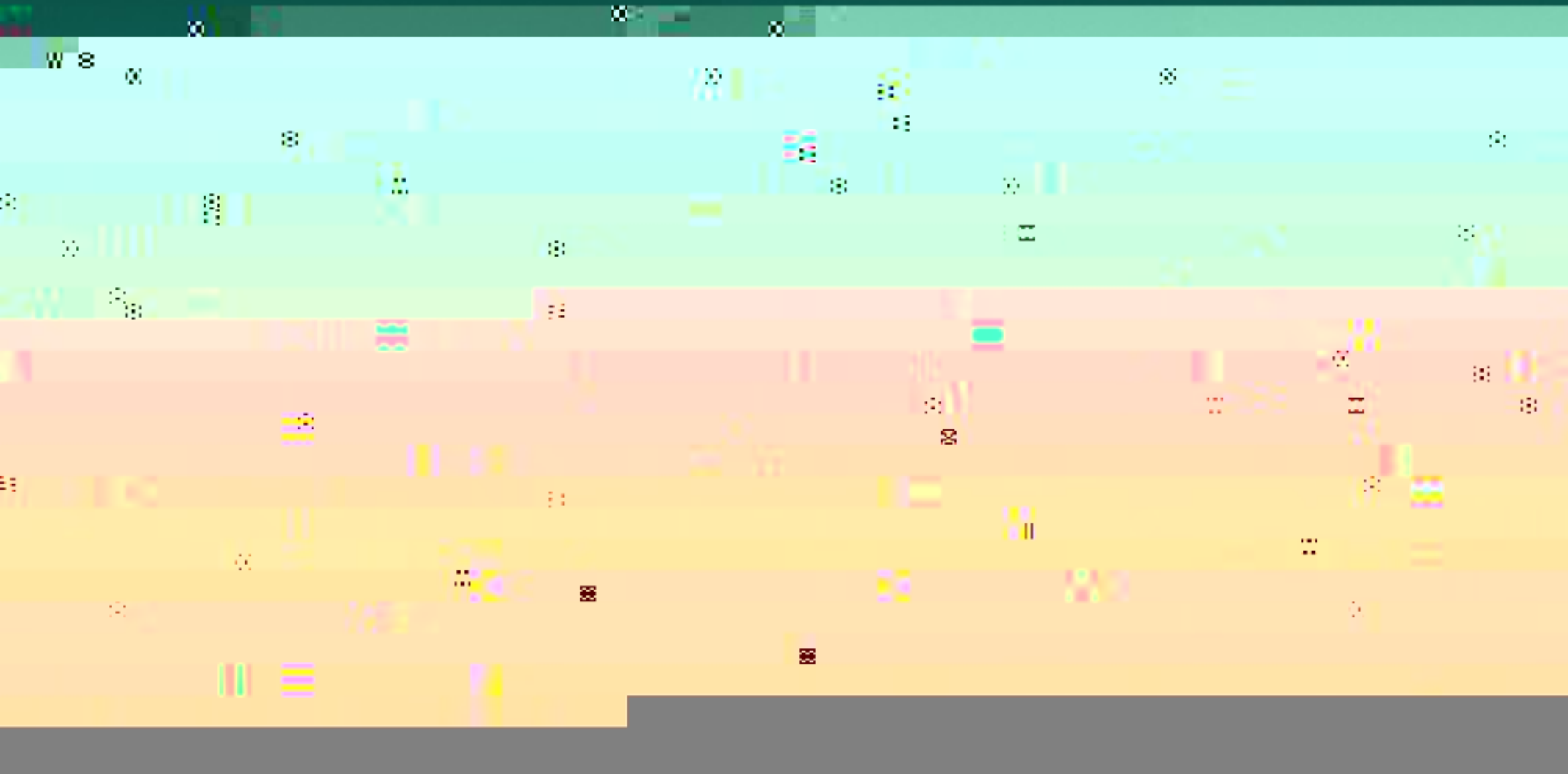
Analytic approach: Mean intensity

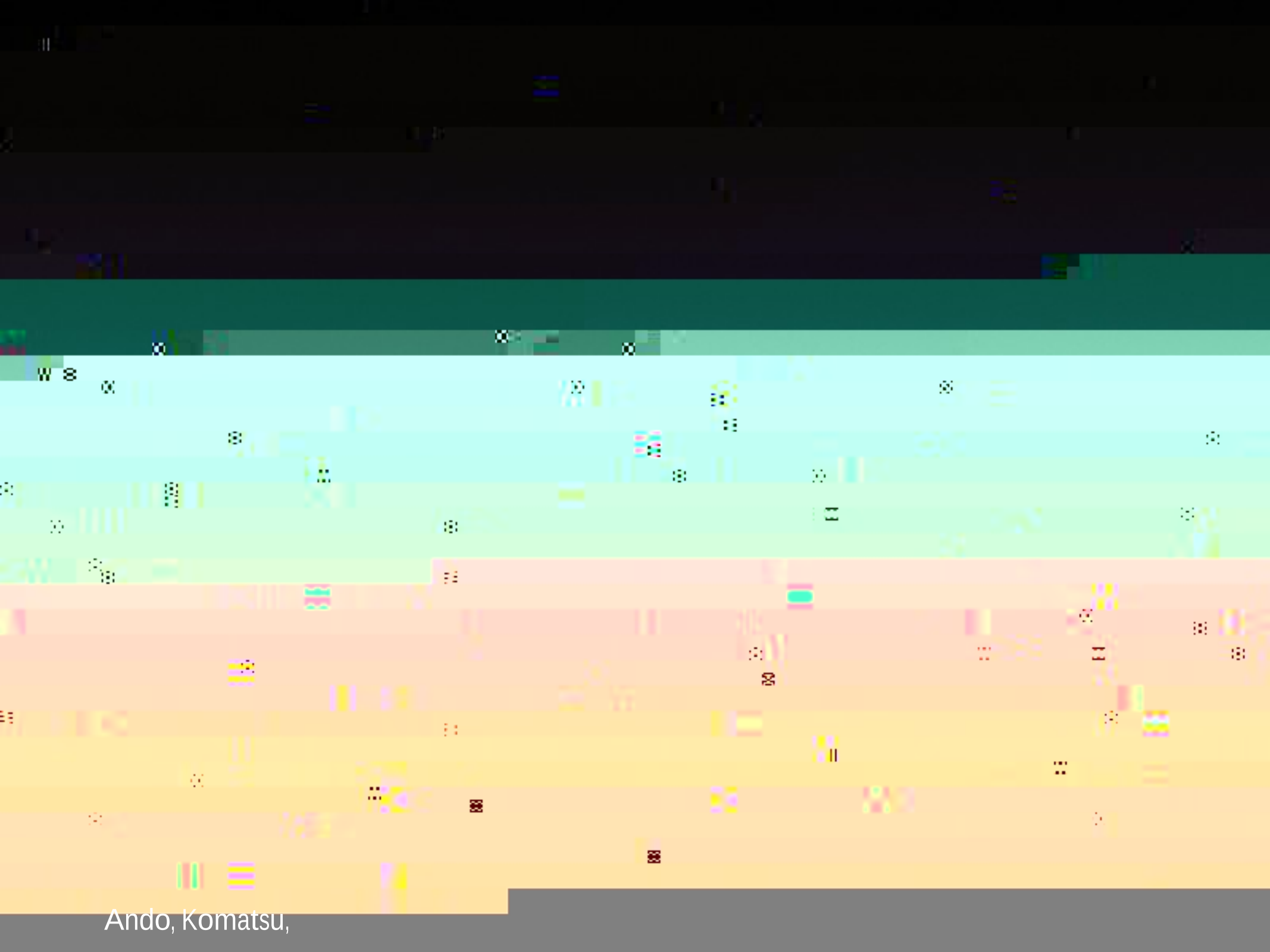
- Assumption: all the matter is contained in spherical halos (halo model)



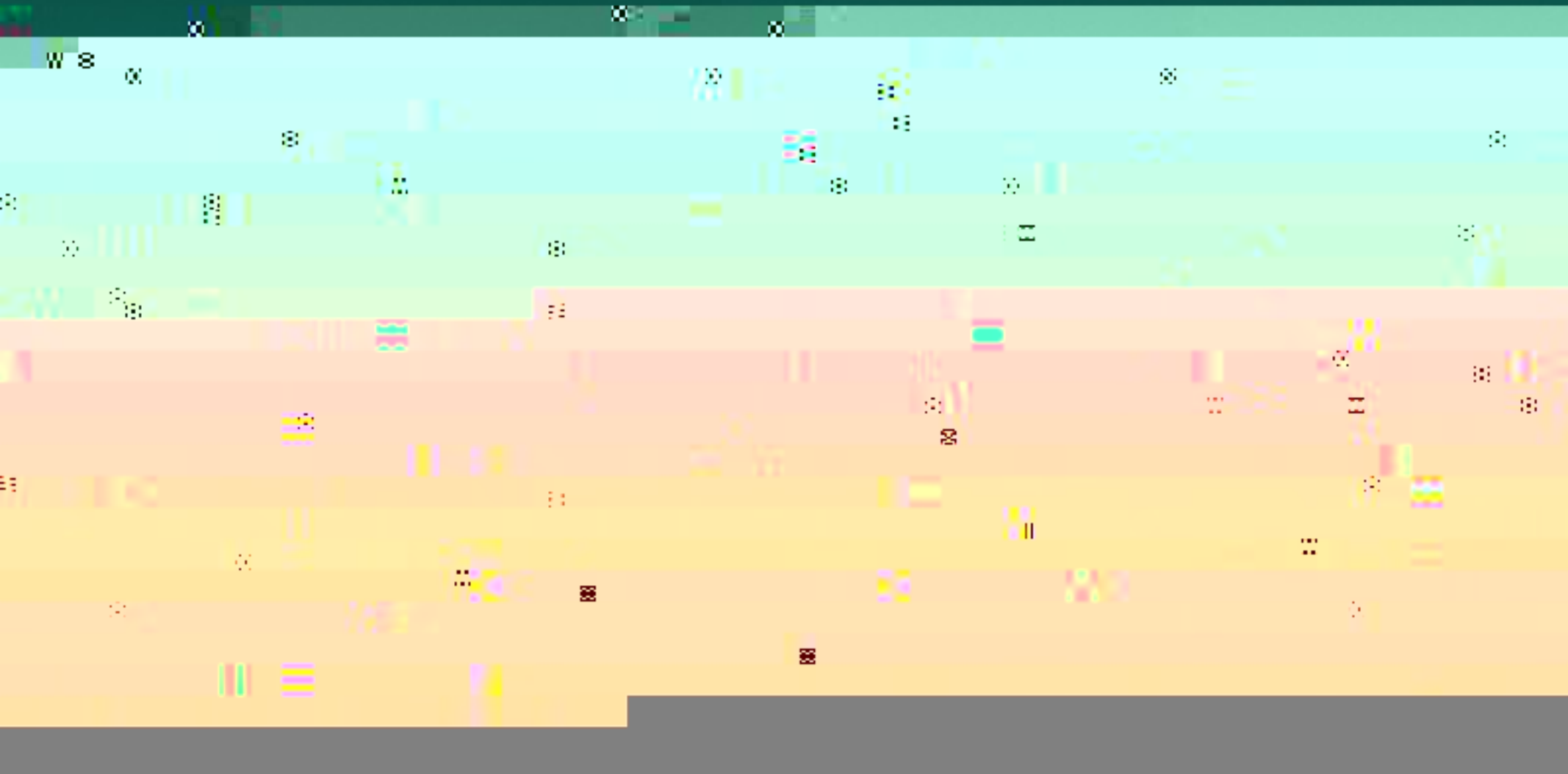
Analytic approach: Angular power spectrum

Result: Angular power spectrum (1)




Ando, Komatsu,

Future: Cross correlation with lensing



Conclusions

- For promising WIMP model of dark matter, WIMPs annihilate in the early