The effects of Small scale CDM Cosmology on Thin Stellar Streams and Globular Clusters

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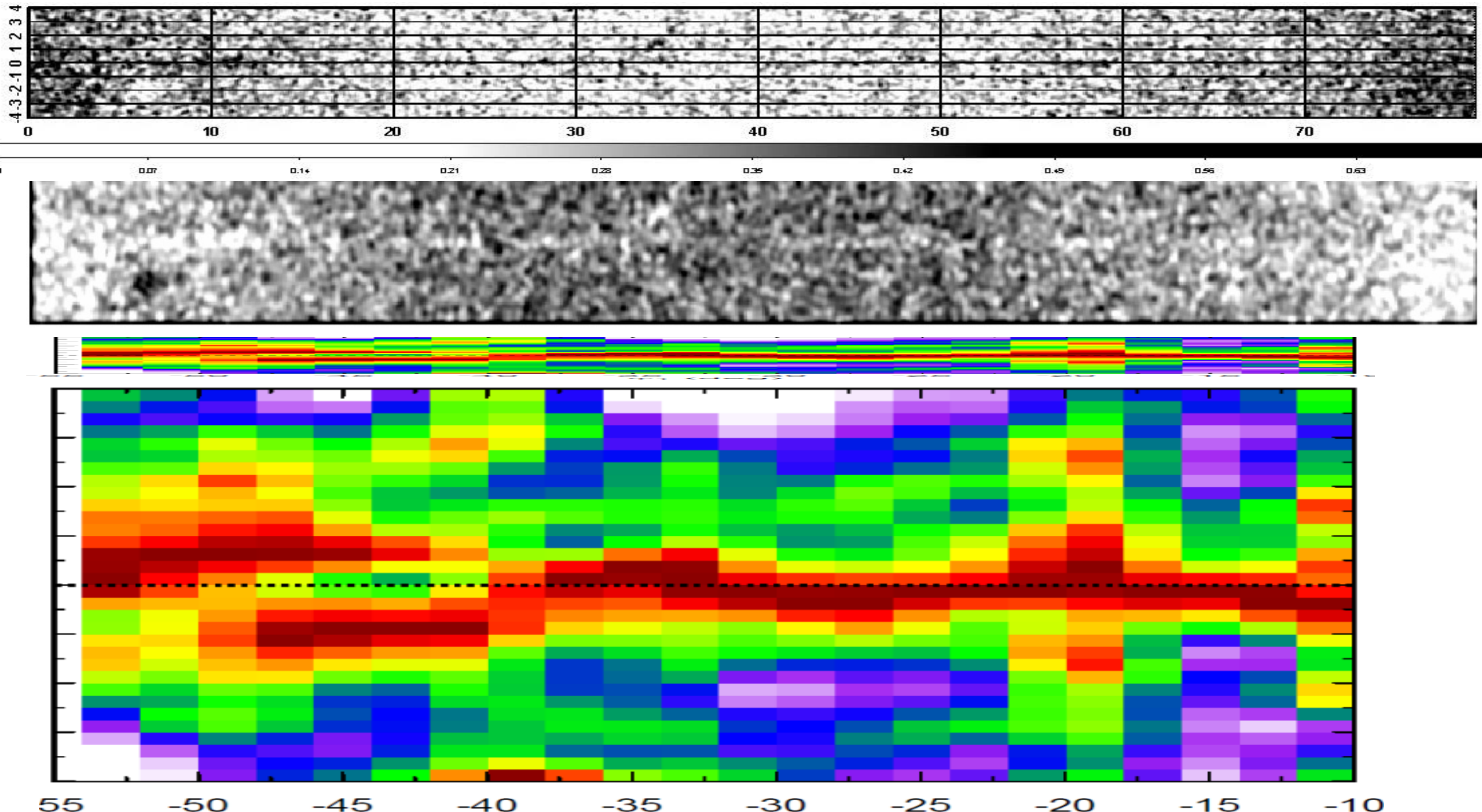
Thin stellar streams

- Streams are fragile (more fragile than low mass sub-halos)
  - MW streams found 15 kpc <R(galactic center) < 100 kpc
  - Baryonic erosion inside ~10 kpc
- About 20 known in the halo to about 35 kpc
  - Only 2 have known globular cluster progenitors
- GD-1 and Pal 5 high quality thin long streams
  - Over-density is about 10-30%
  - S/N per degree is a few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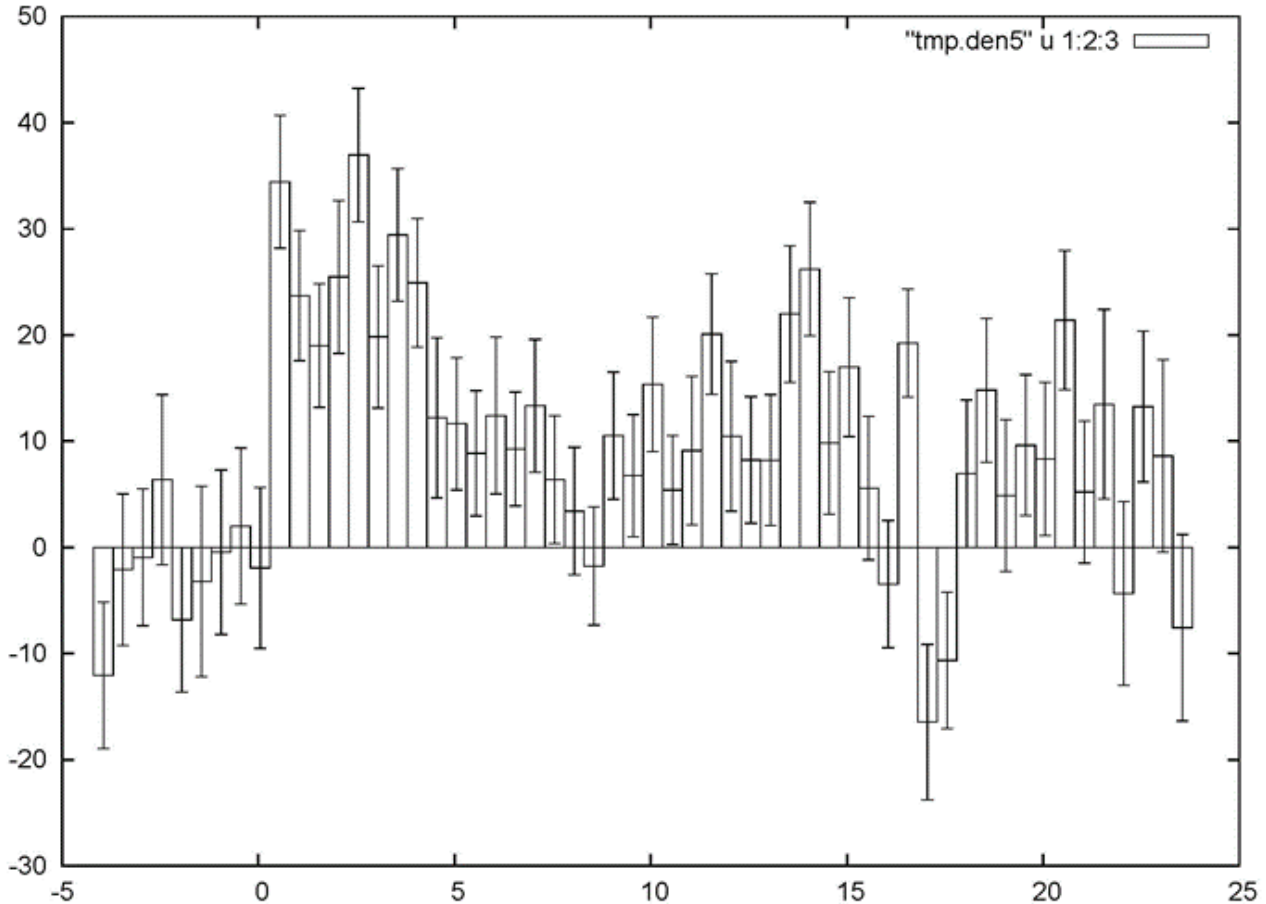
0
10
20
30
40
50
60
70
55
-50
-45
-40
-35
-30
-25
-20
-15
-10

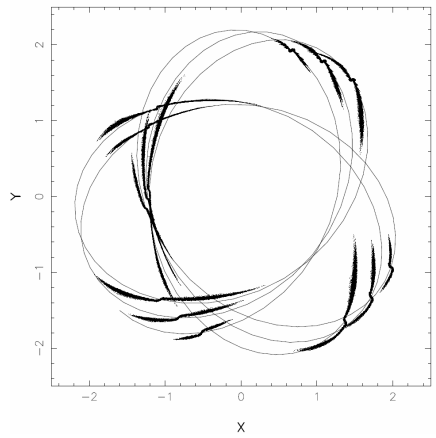
Pal 5



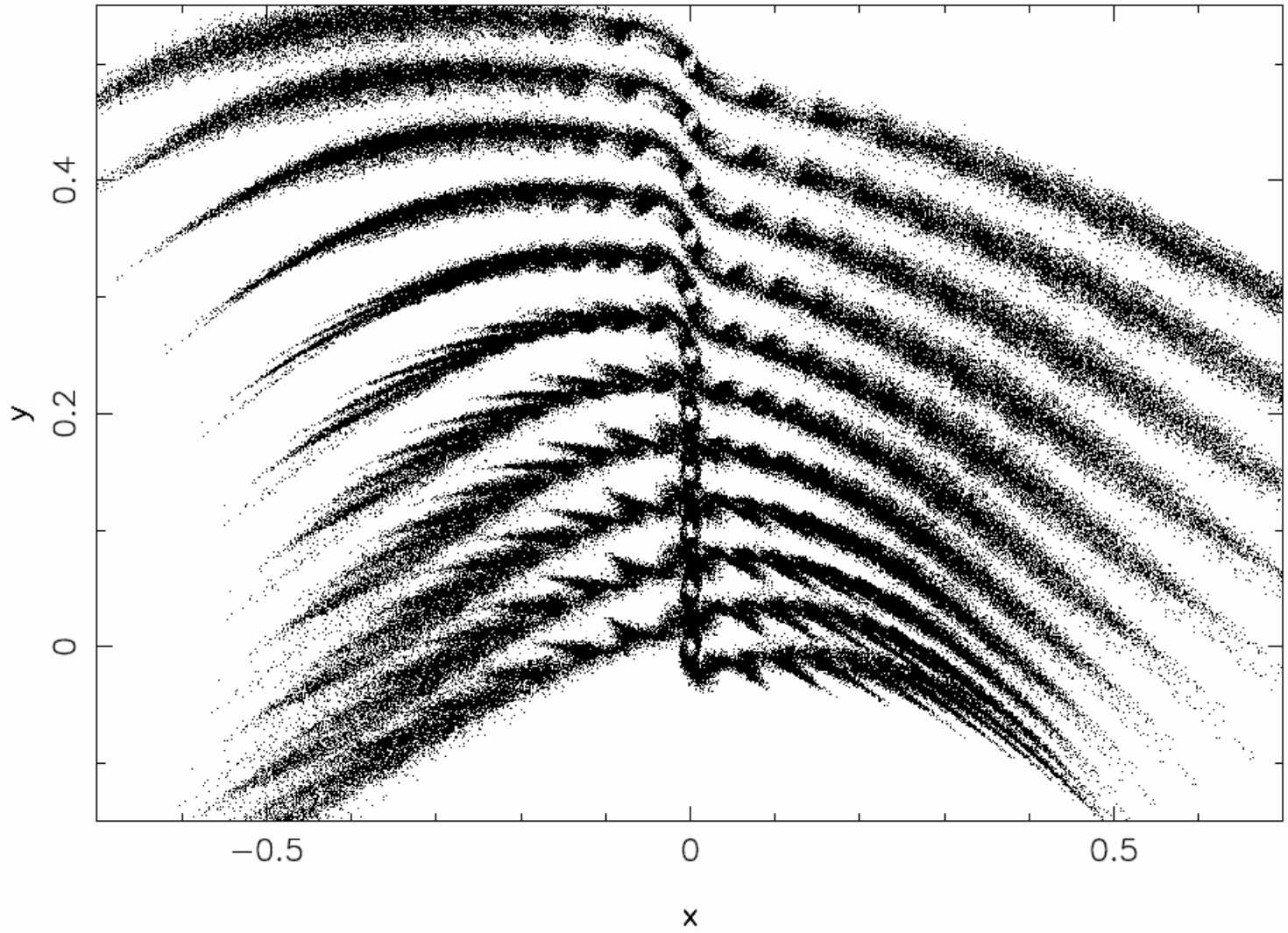
Streams have density variations

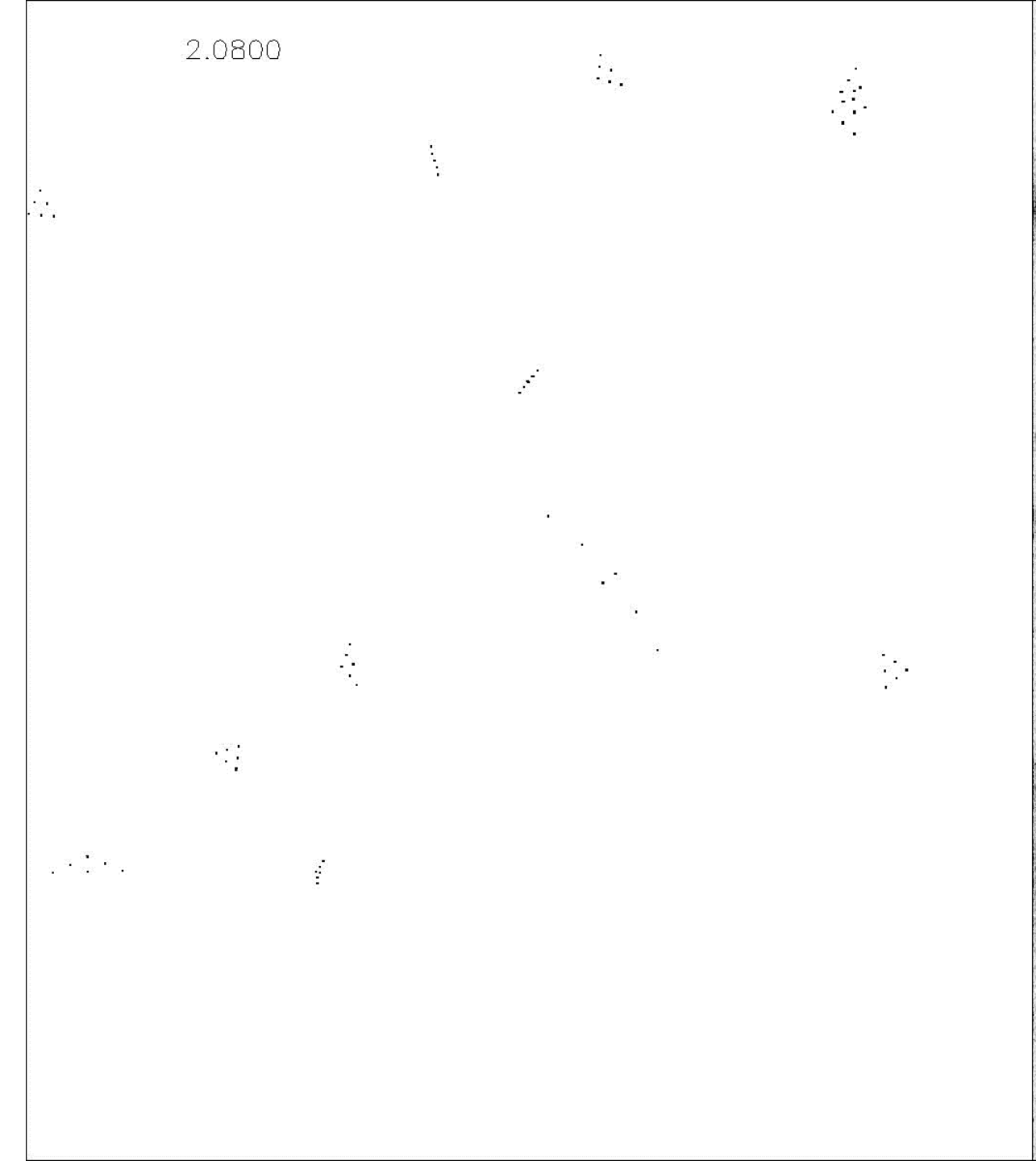
- Streams have variations around mean density with Chi^2/dof~2-3
  - That is, not smooth at very high confidence
- Sub-halos produce gaps, e.g.
  - 10 km/s sub-halo that goes near/through a stream
  - Pulls stars toward the middle dv ~ 2 v_{sh}^2 /v_{orb} ~ 2 * 10*10/200 ~1 km/s
  - Gap width ~ sub-halo ½ mass radius, grows with time
- Gap rate is about 1 gap of kpc size per 10kpc of stream per 10Gyr
  - Numbers go up inversely with size
  - Halos that make gaps are 10^{7-8} M_sun
- Picture is statistically consistent with CDM, not yet compelling

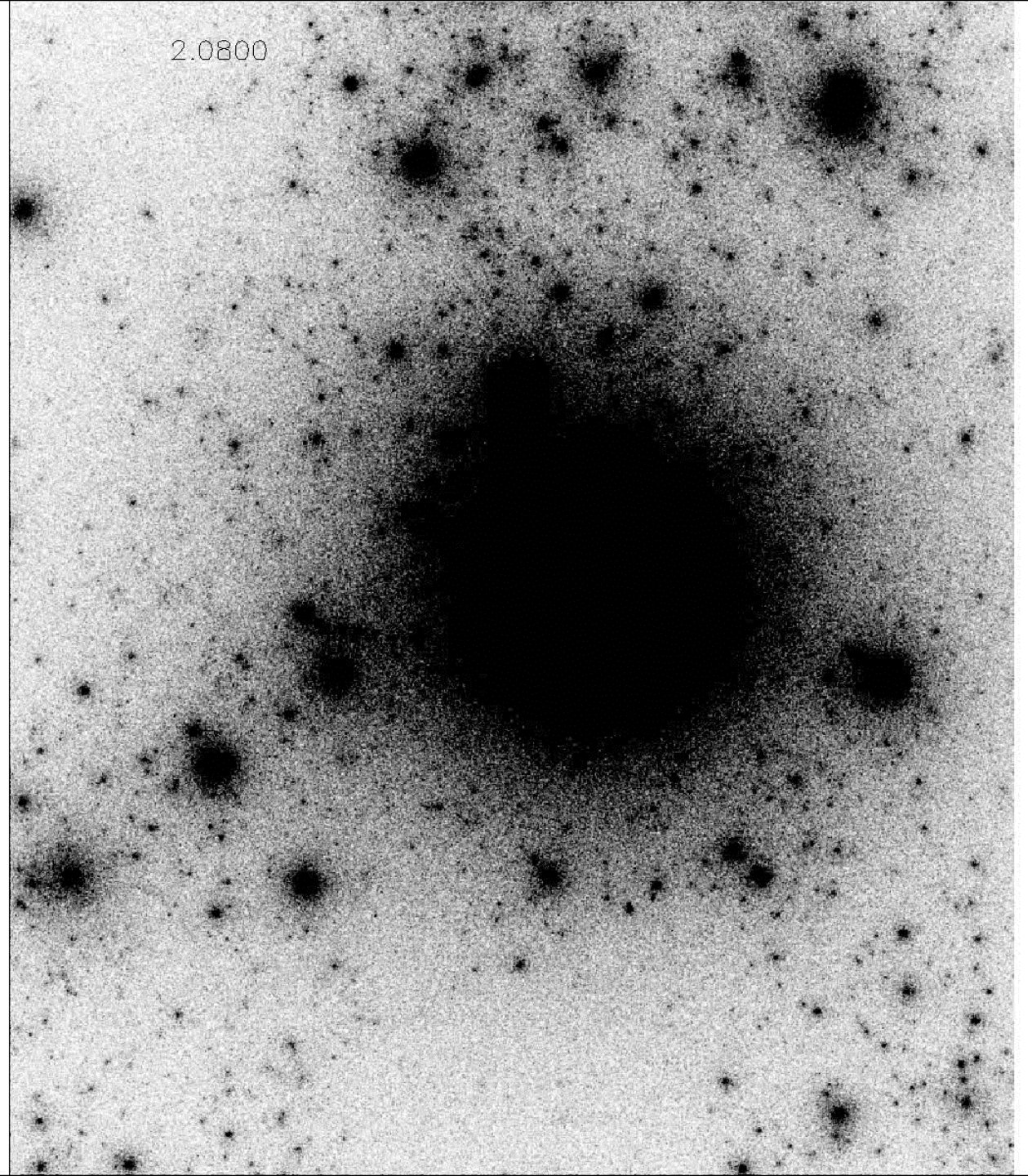
Streams in smooth potentials well understood (top view)

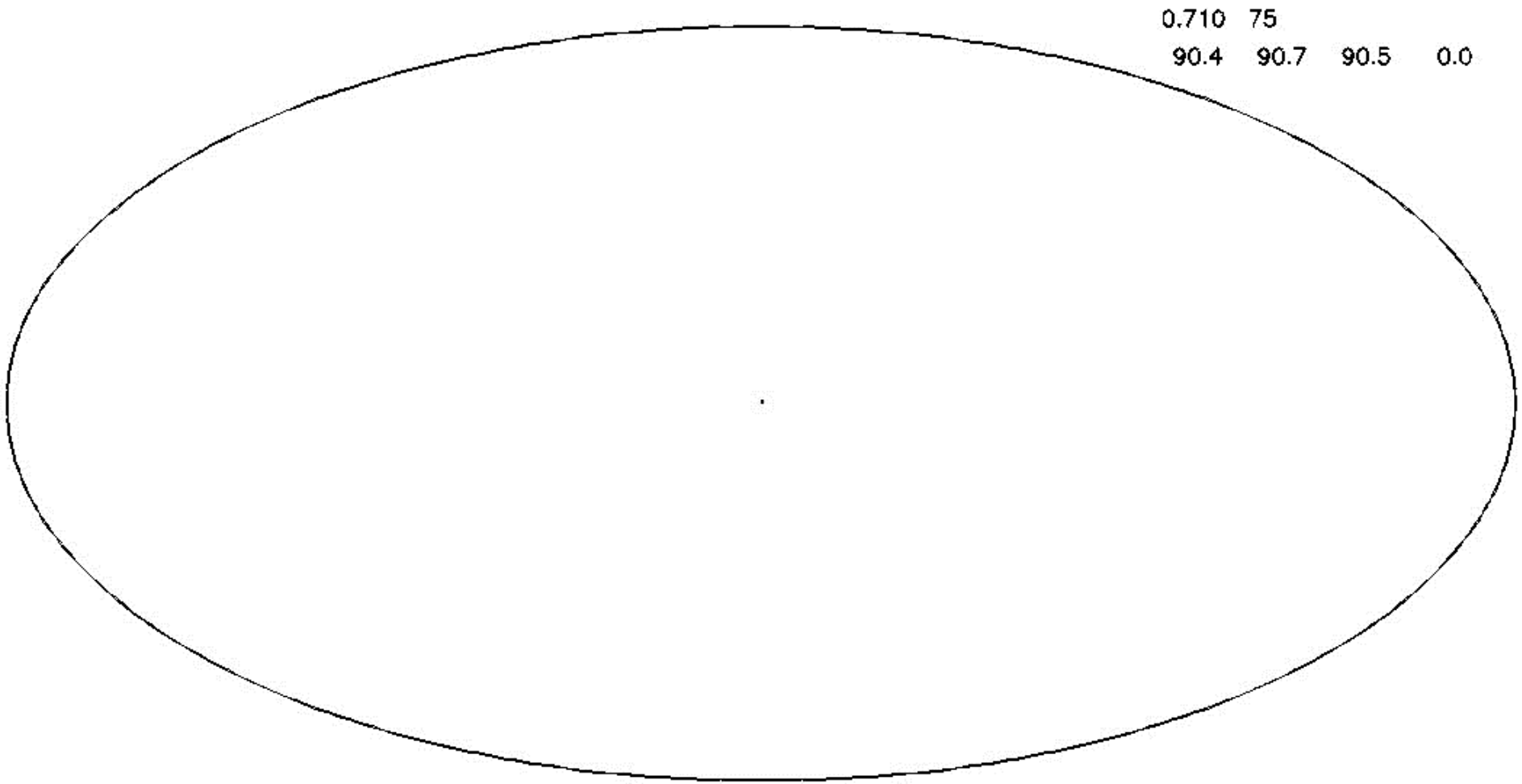


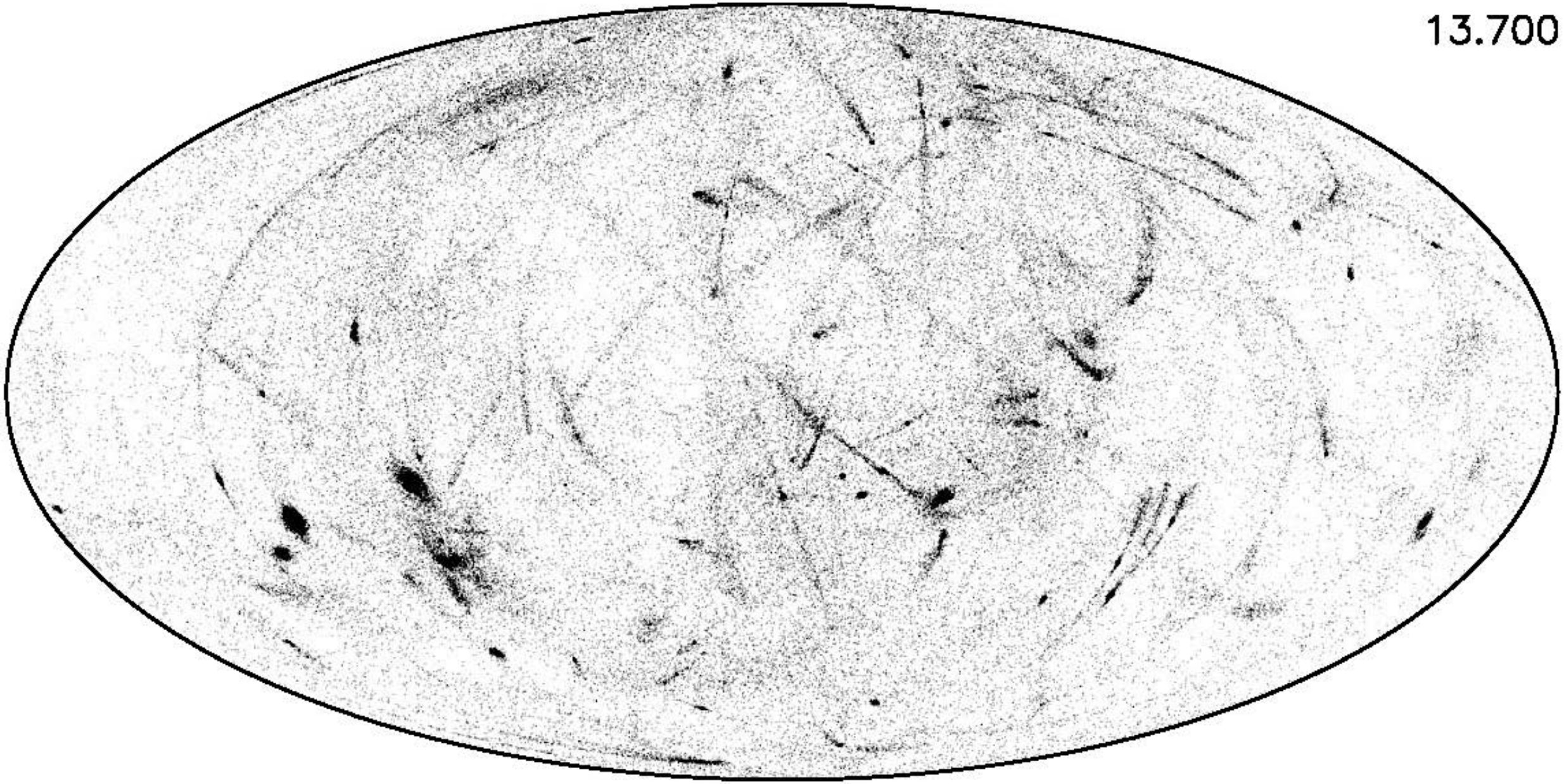
Time

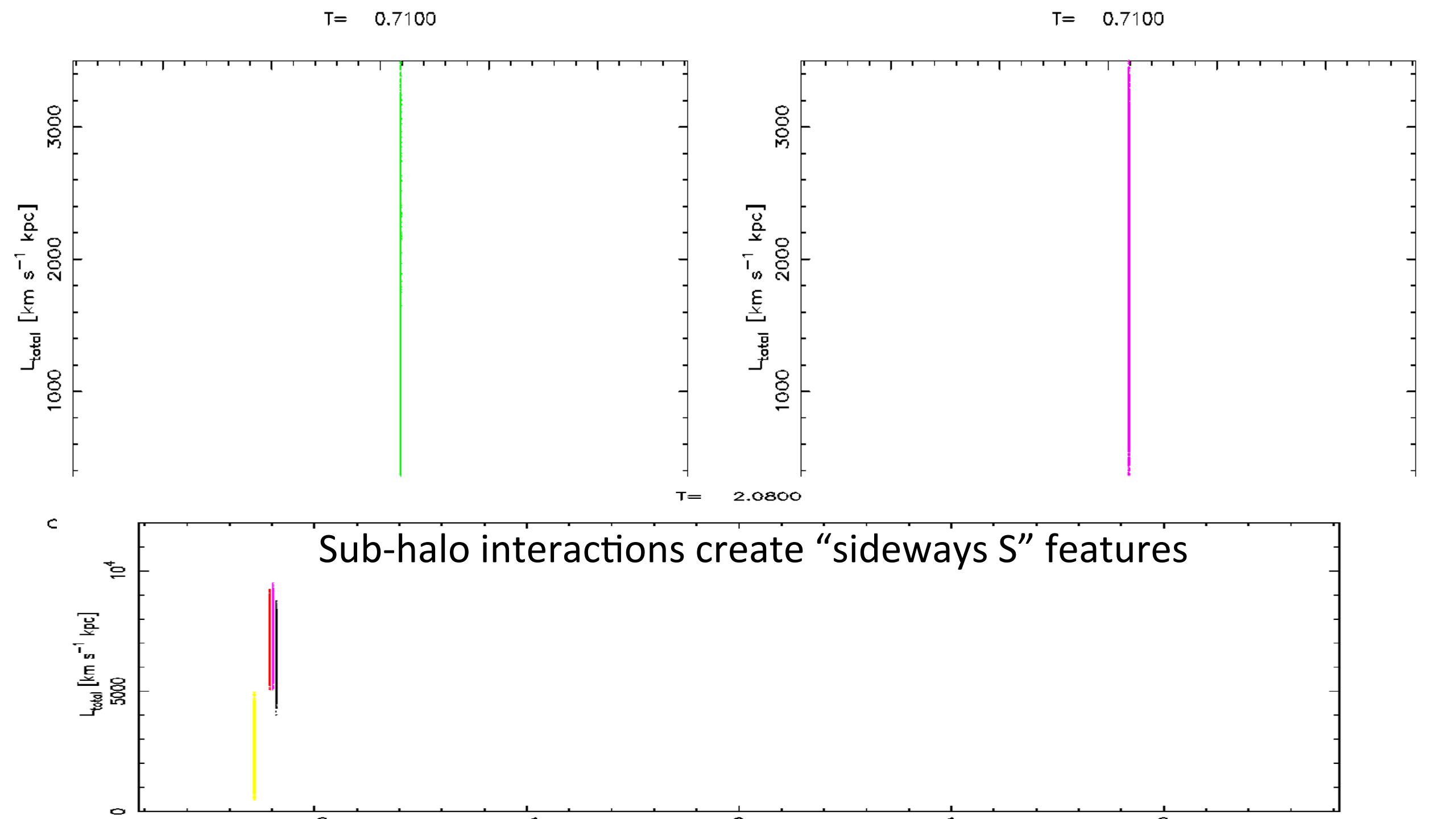



2.0800


2.0800


0.710 75
90.4 90.7 90.5 0.0


13.700


T= 0.7100
T= 0.7100
T= 2.0800
Sub-halo interactions create “sideways S” features
L_{total} [km s^{-1} kpc]
1000
2000
3000
5000
0
10^4

Streams with and without GCs

GCs at High Redshift

CLUSTER AND STREAM COUNTS.

Start	M_c	R_g max	N_0	N_f	Streams
z=3	$3 \times 10^5\,M_\odot$	50 kpc	20	20	18
		100 kpc	67	67	45
z=8	$3 \times 10^5\,M_\odot$	50 kpc	78	0	28
		100 kpc	87	0	29
z=3	$N \propto M^{-1.5}$	35 kpc	50	45	28

- Simulations:
  - z=3 GCs **all retained** (~40% mass loss)
  - Z=8 GCs **all evaporated**
  - Evaporation has only weak mass dependence (tidal driving)
- In the sky: 2 of ~12 (3 of ~20) streams have GCs present
  - Suggests a much larger GC population beyond z=3
  - BBHs and reioinization both due to low metal, >20 M_sun stars