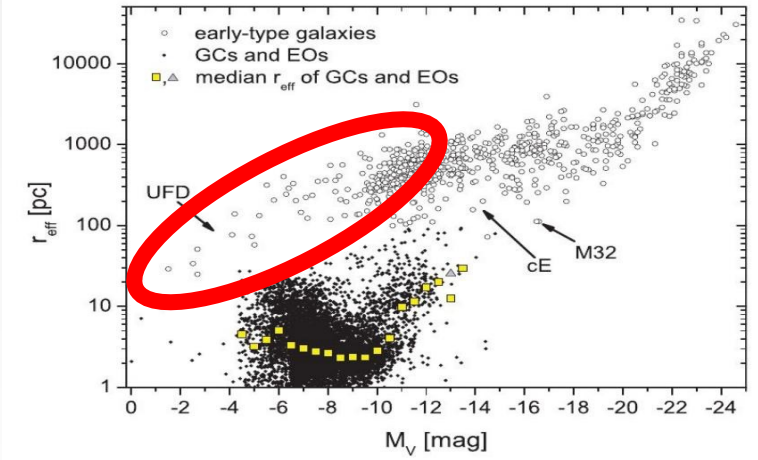
# The Dissolving Star Cluster Model

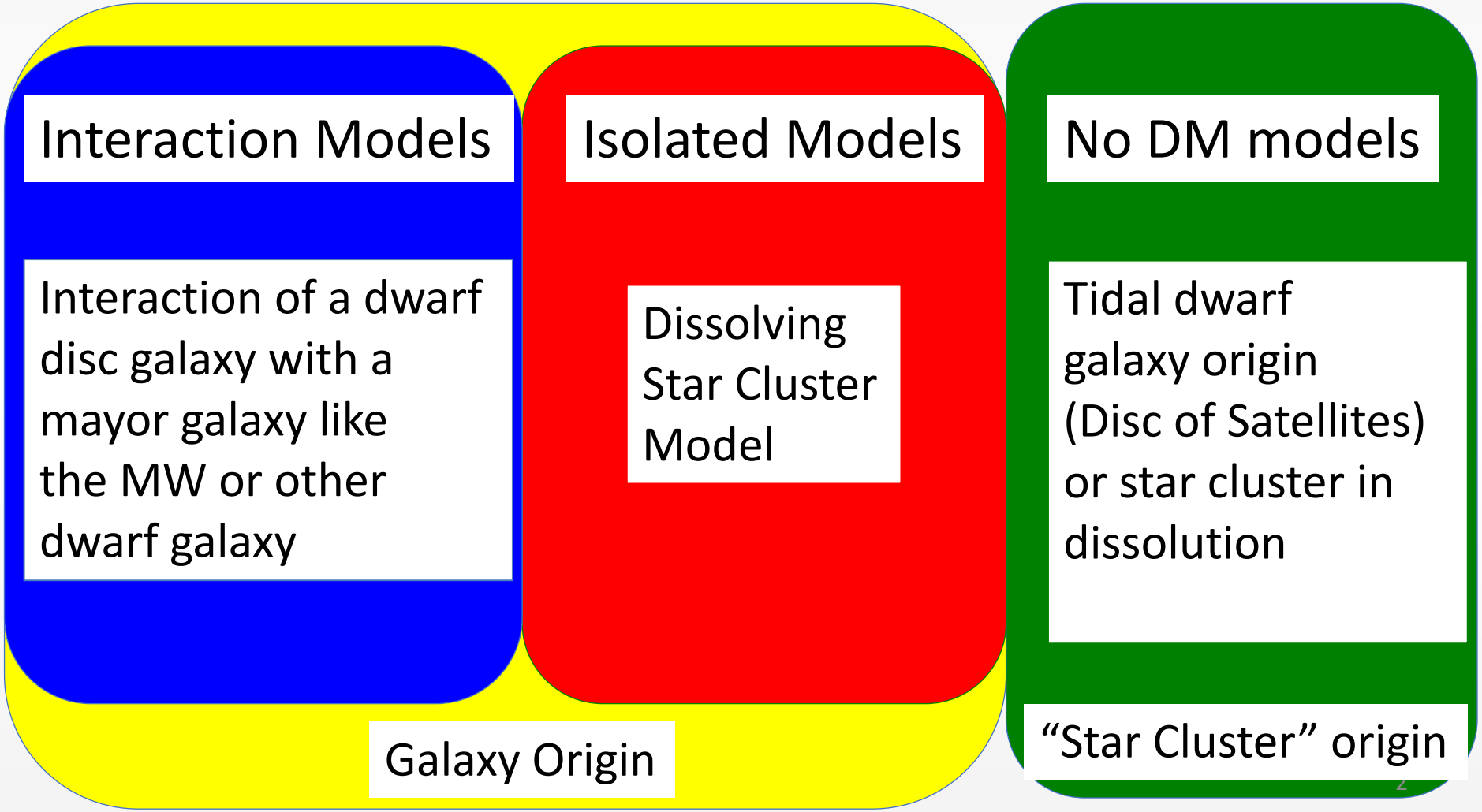
## A formation scenario for dSph galaxies

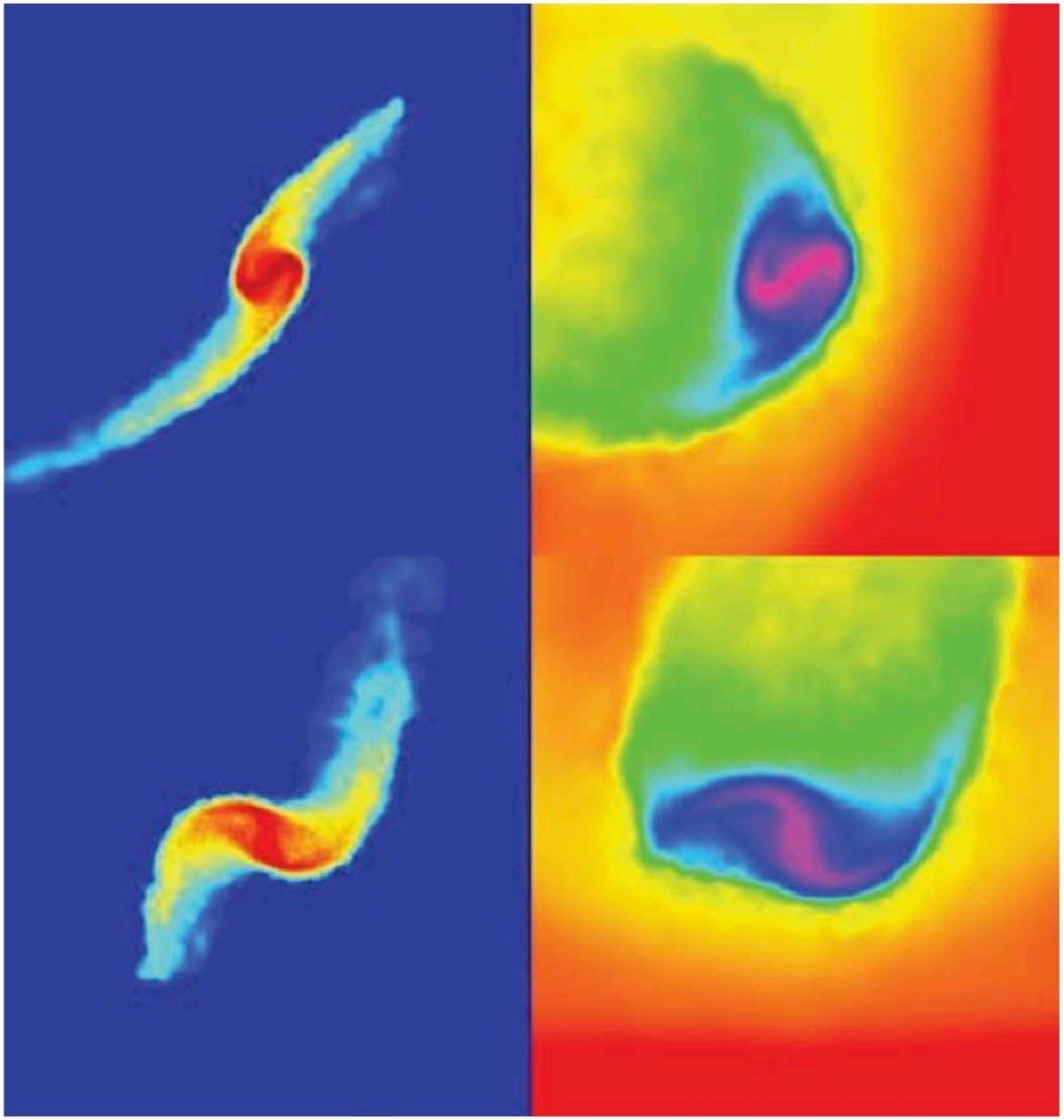

Michael Fellhauer

Universidad de Concepción, Chile

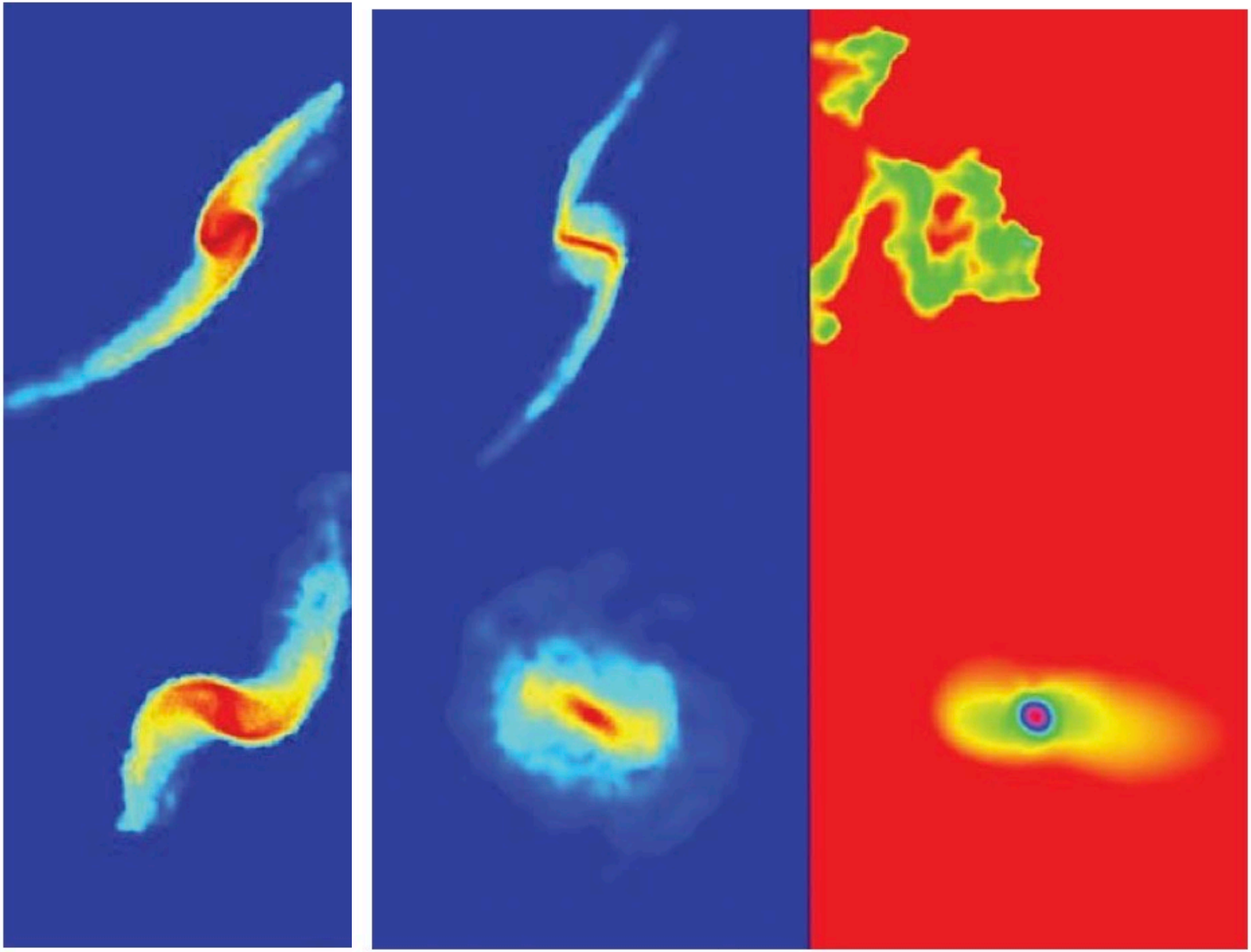



# dSph - different formation scenarios



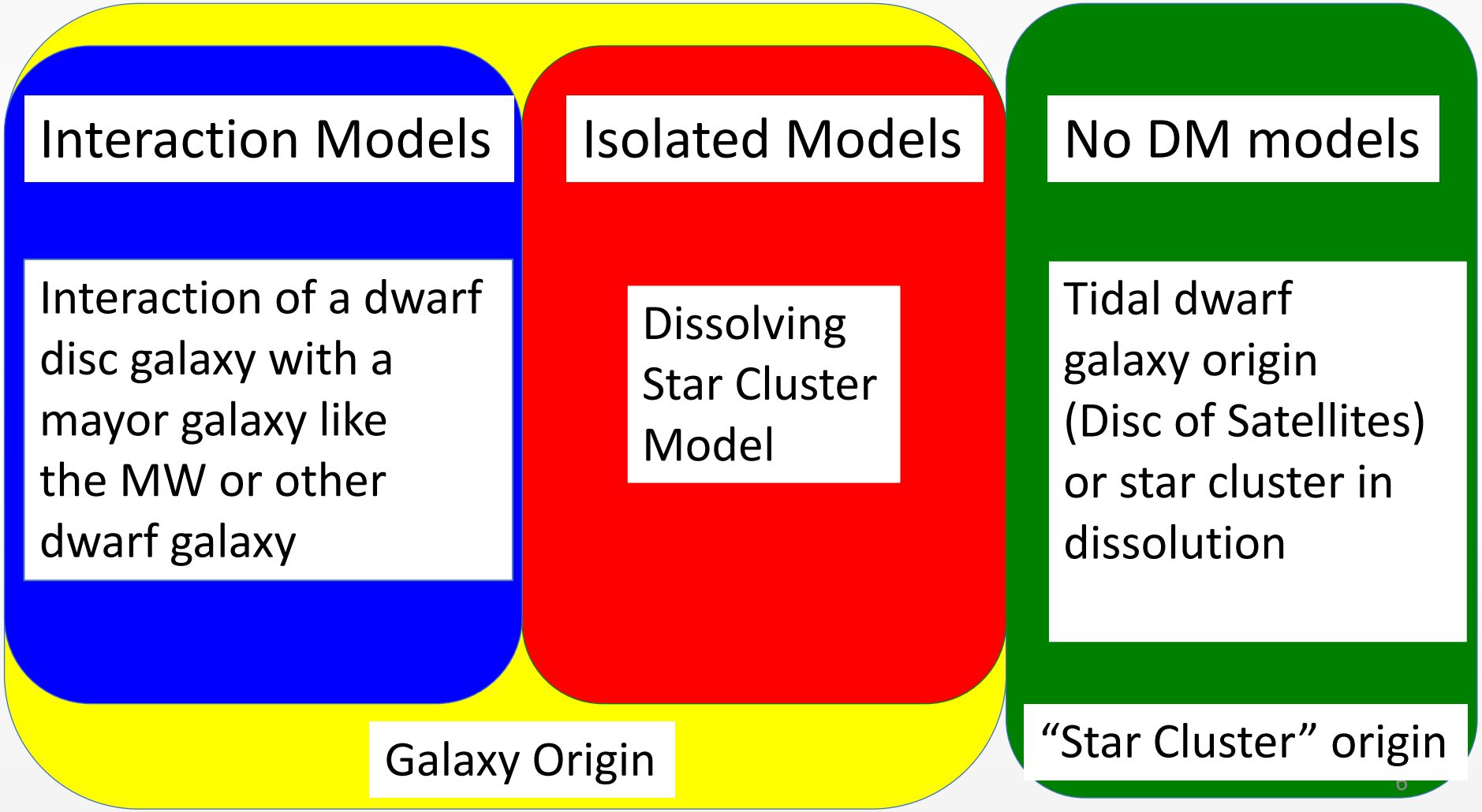


Mayer et al.
2001, 2006



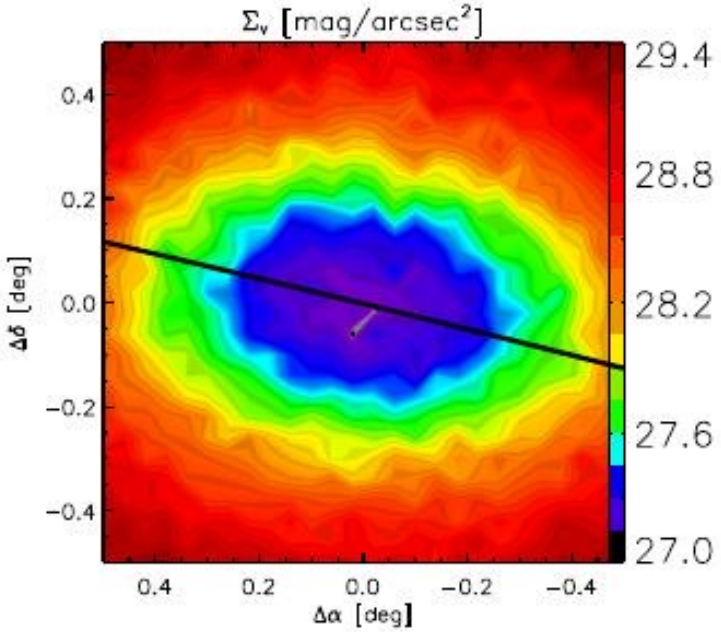

D’Onghia et al. 2009

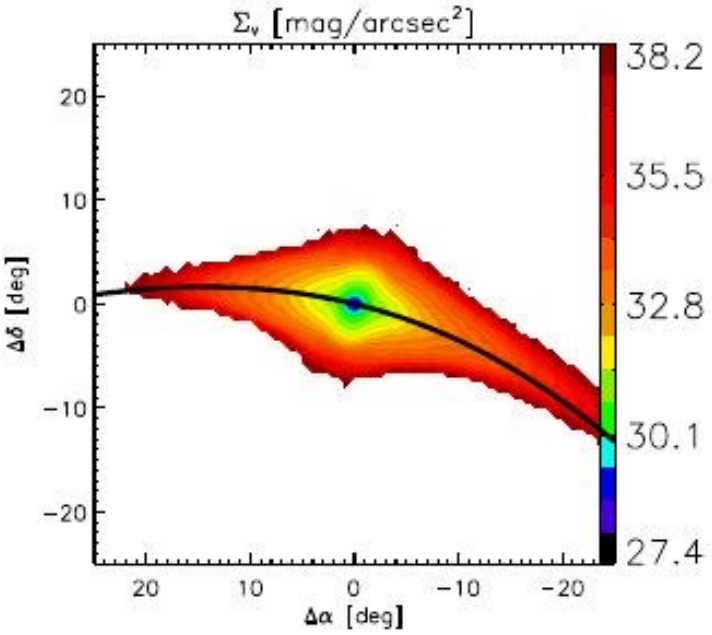
# dSph - different formation scenarios



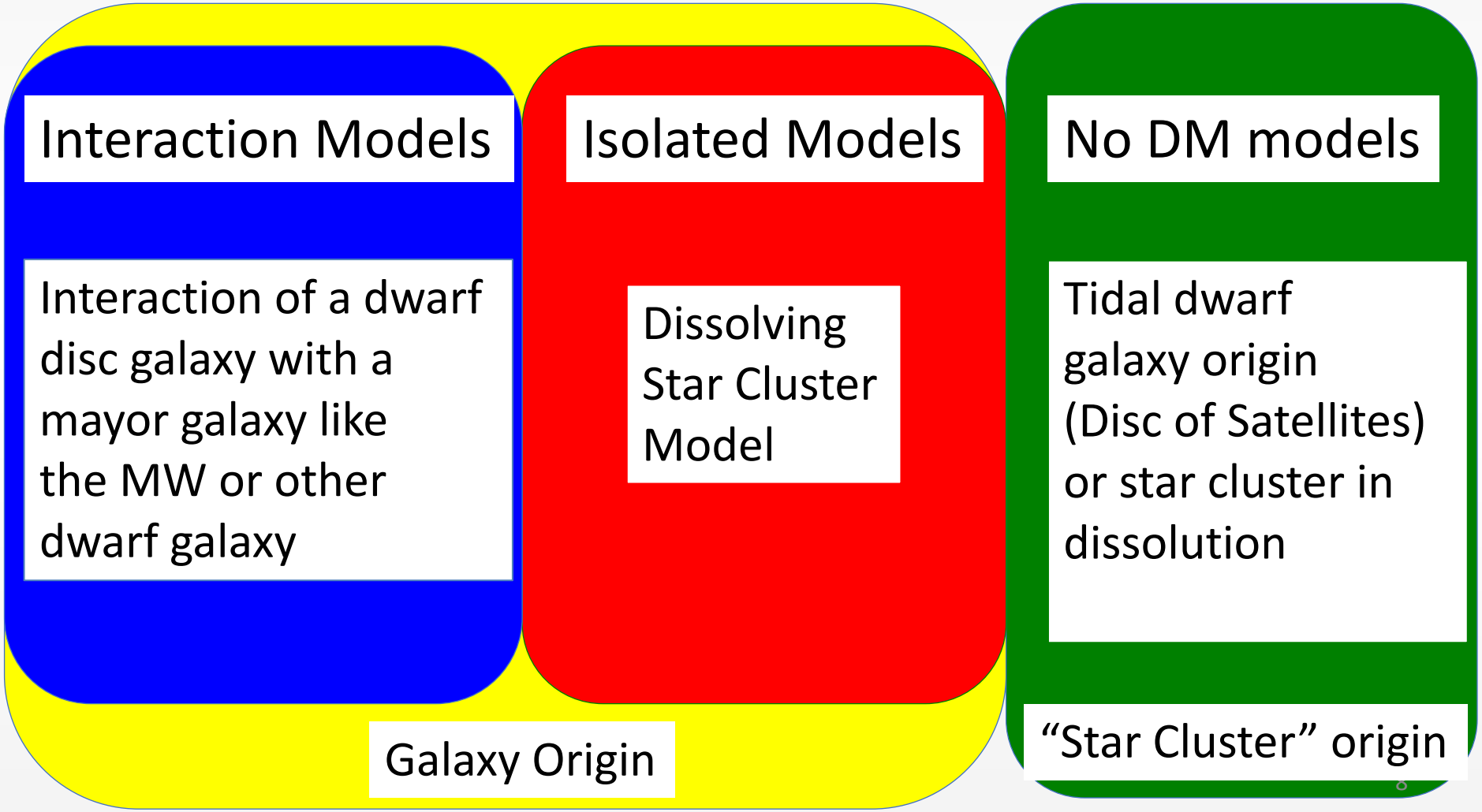
We have so far obtained DM free models for:

- Bootes (Fellhauer et al. 2008)
- Ursa Major II (Smith et al. 2013)
- Hercules (Blaña et al. 2015)
- Segue 1 (Dominguez et al. 2017)
- Canes Venaticii I (Matus Carillo et al. 2020)
- Coma Berenice (Letelier thesis work)

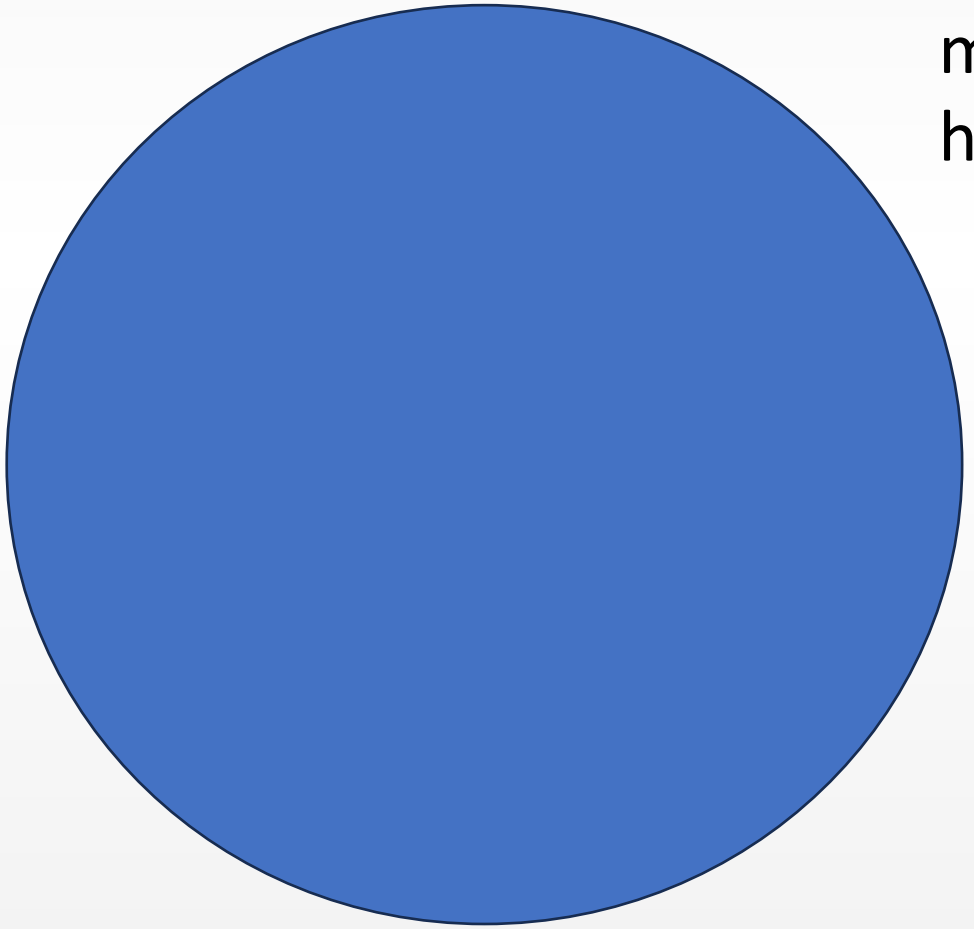


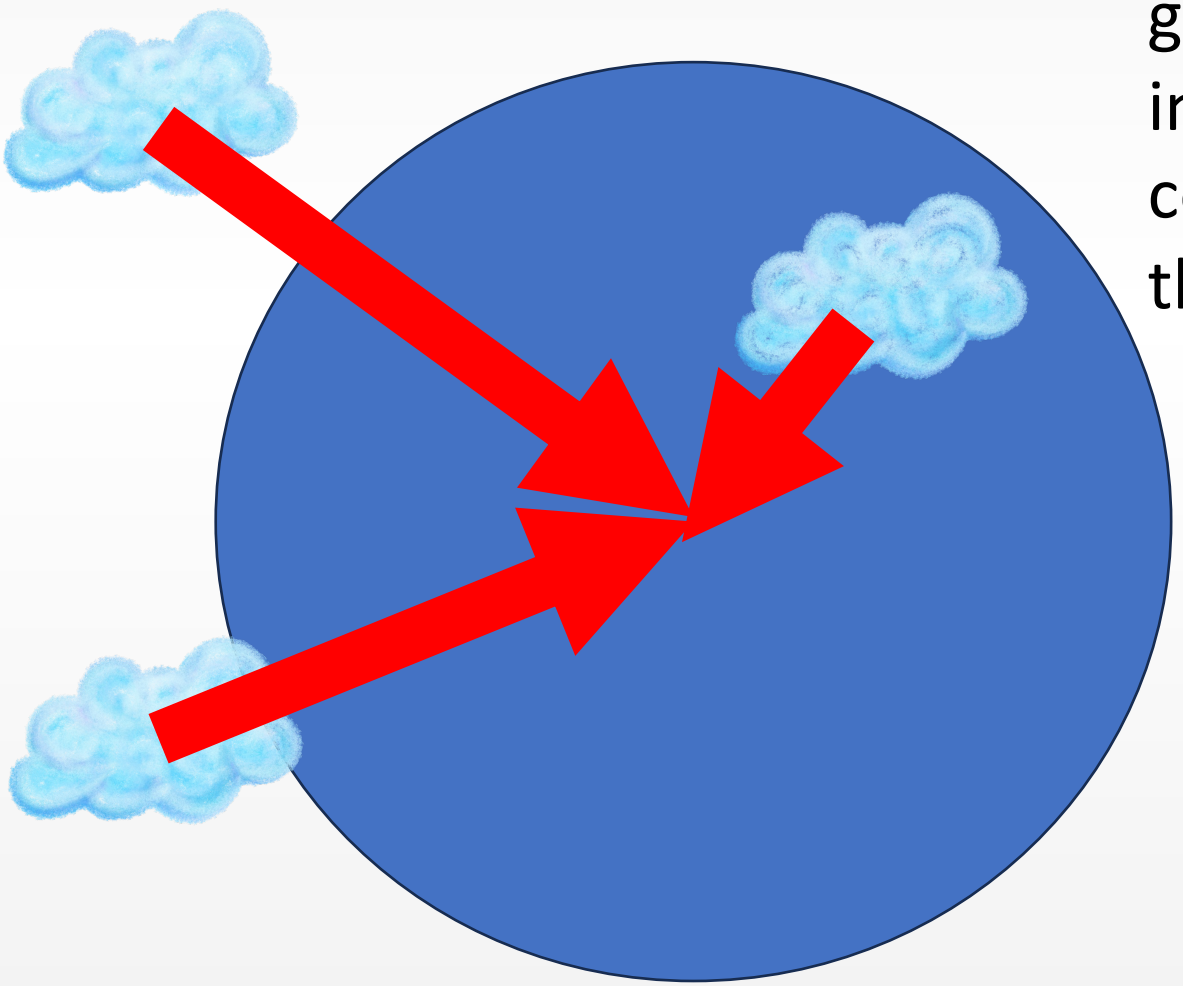
# dSph - different formation scenarios



# Dissolving Star Cluster Model:

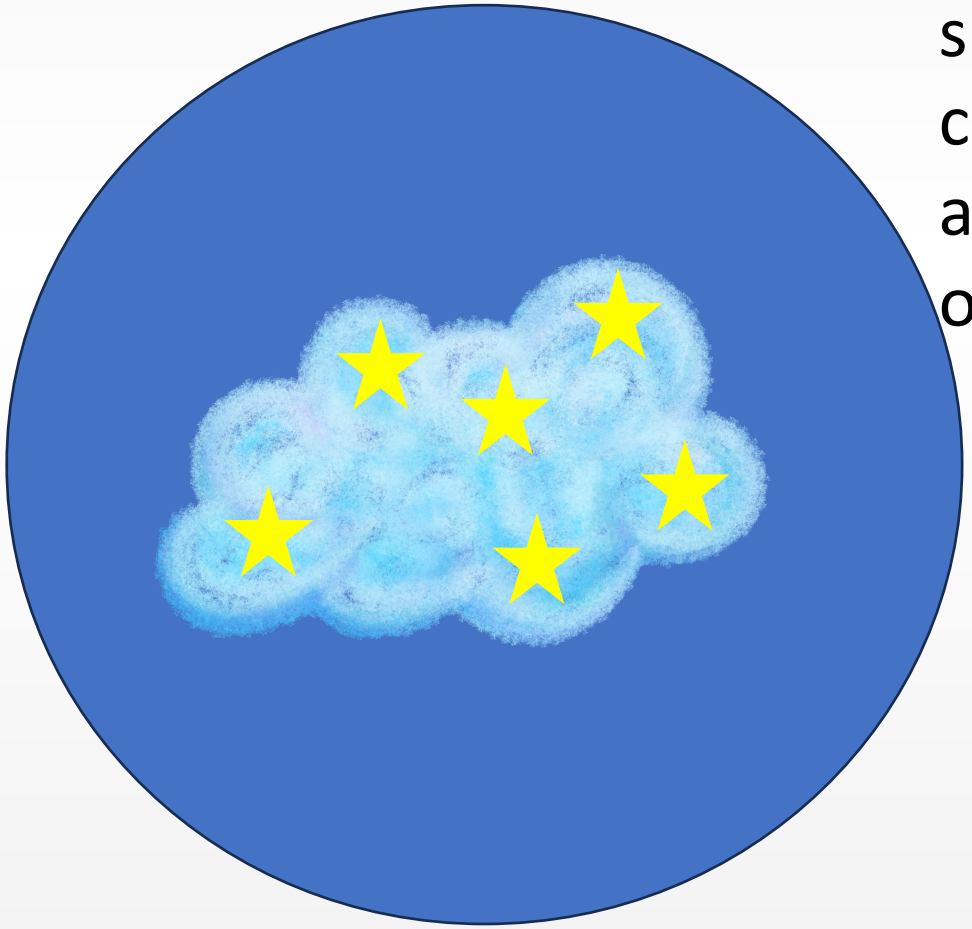


# Dissolving Star Cluster Model:



gas falls into the centre of the halo

# Dissolving Star Cluster Model:



gas forms small clusters and associations of stars

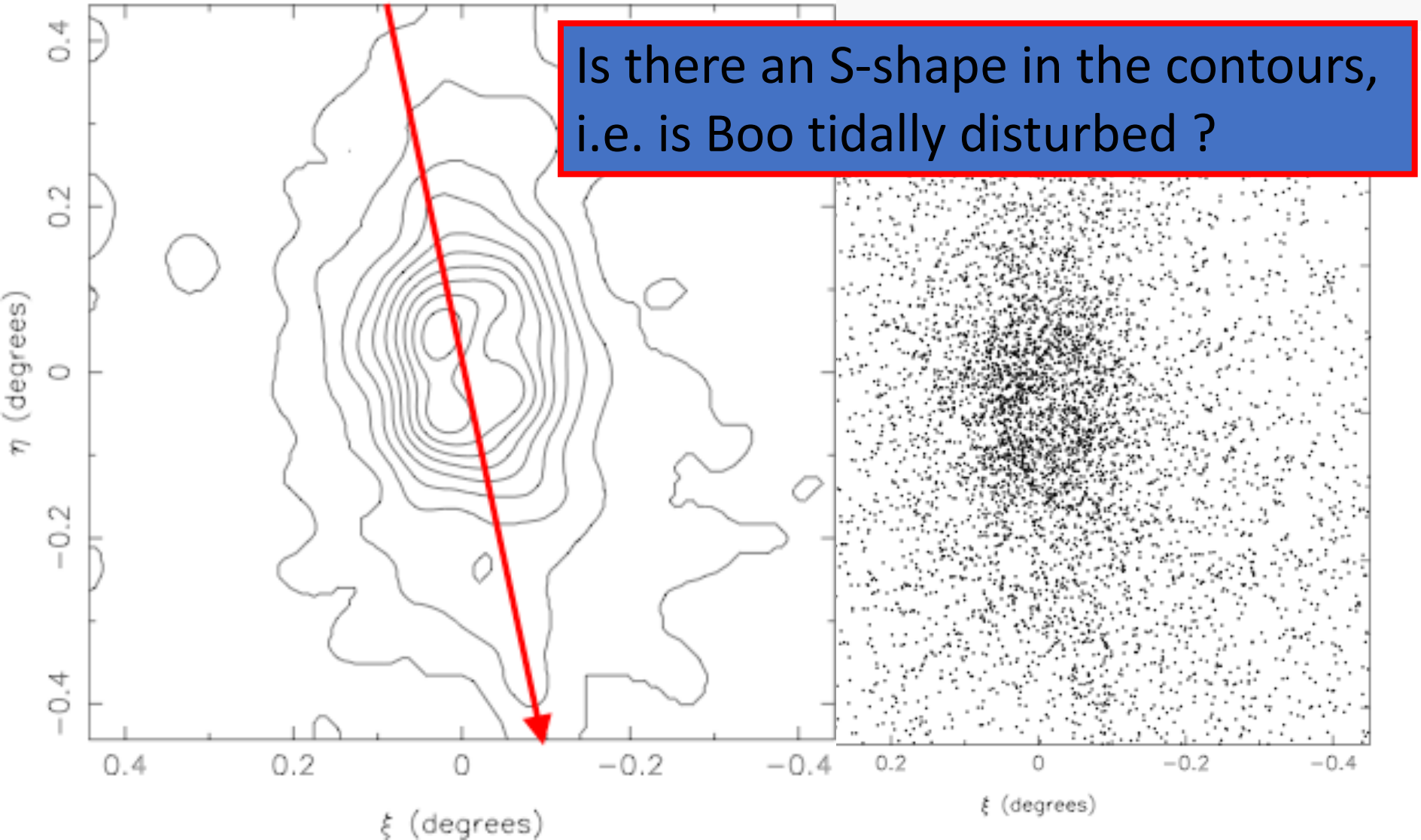
# Dissolving Star Cluster Model:

The clusters orbit the central part of the halo and dissolve

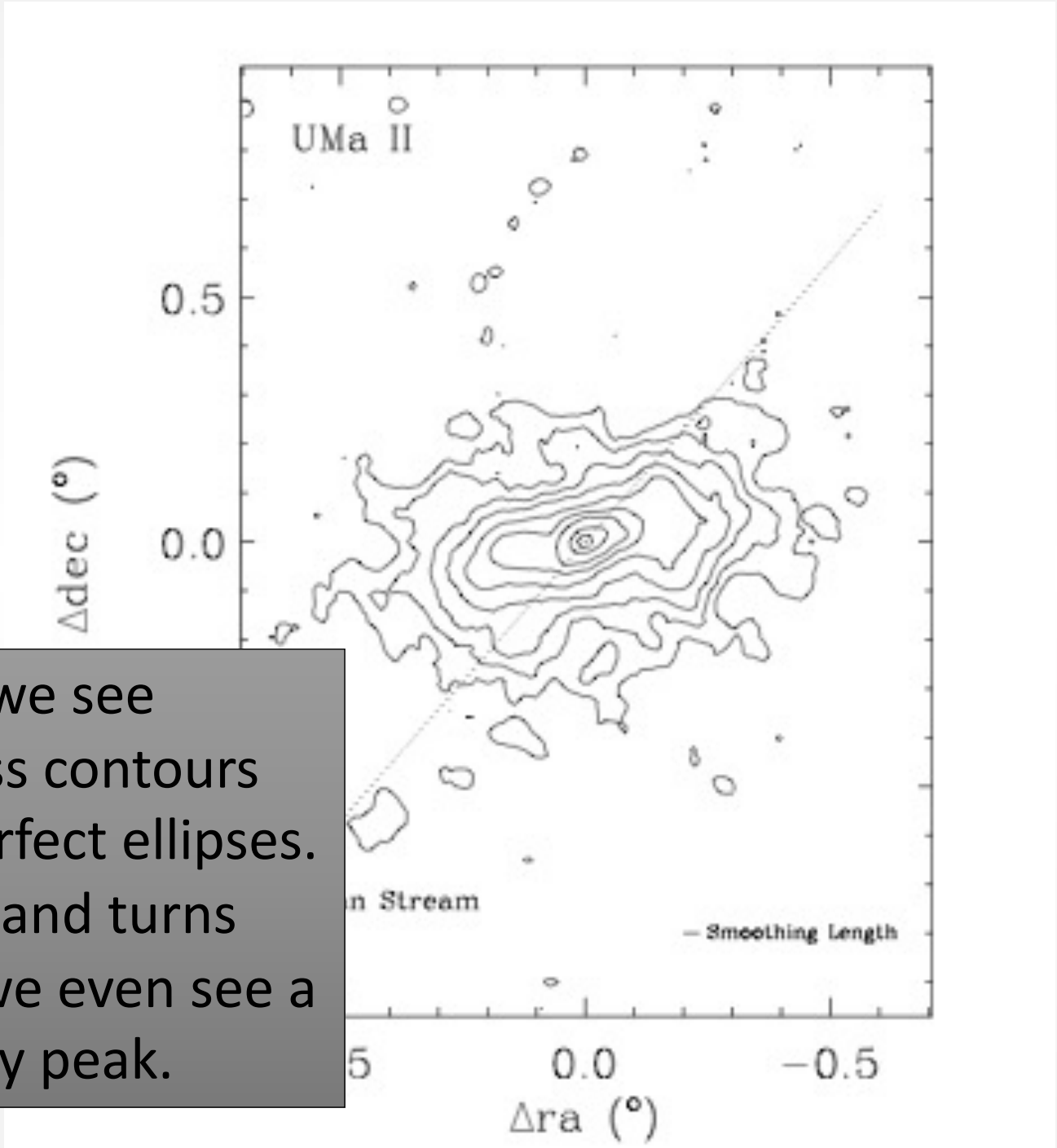
# Dissolving Star Cluster Model:

forming the luminous part of the dSph galaxy

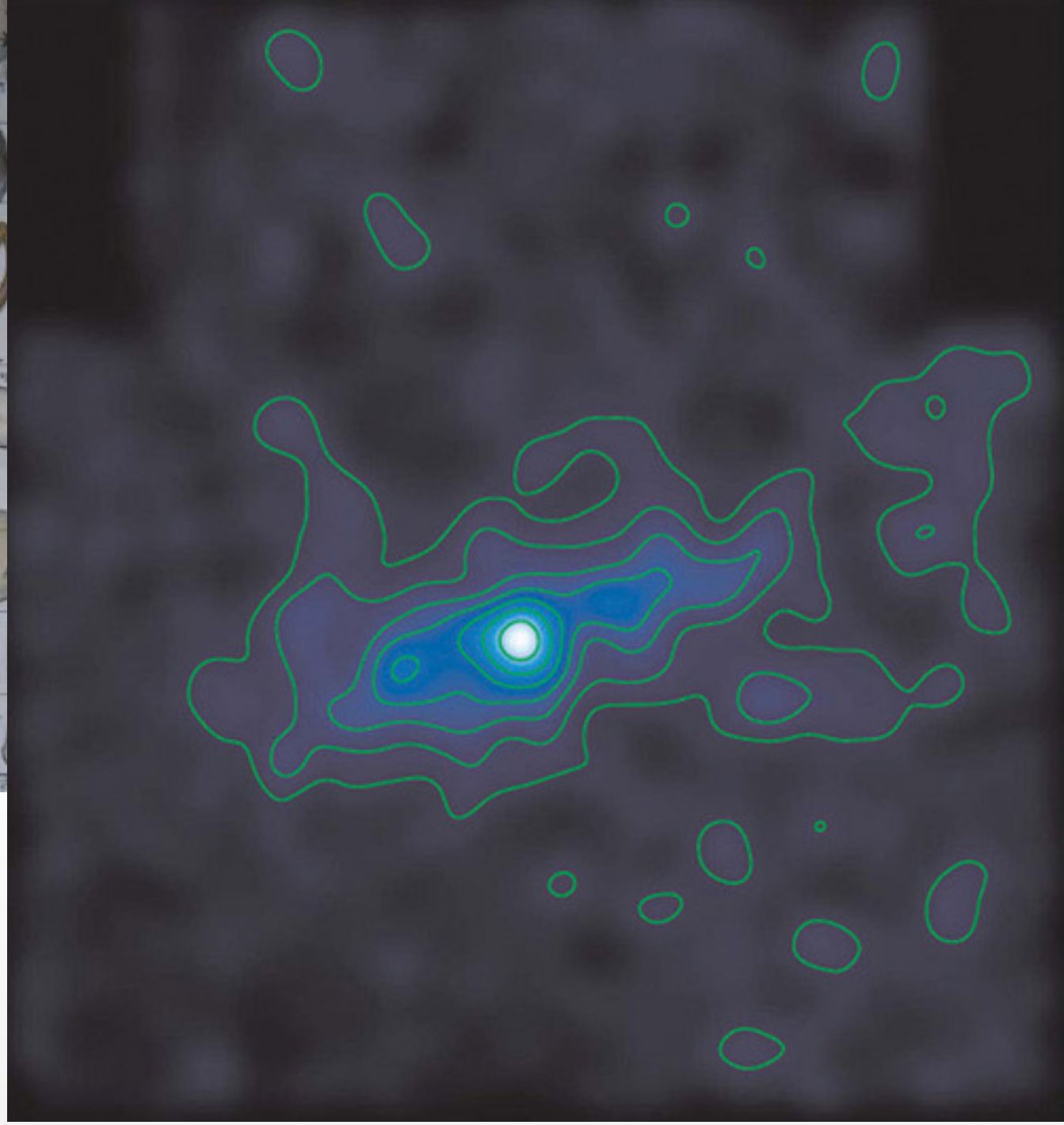
# Bootes I


Is there an S-shape in the contours, i.e. is Boo tidally disturbed ?
0.4
0.2
0
−0.2
−0.4
η (degrees)
0.4
0.2
0
−0.2
−0.4
ξ (degrees)
0.2
0
−0.2
−0.4
ξ (degrees)

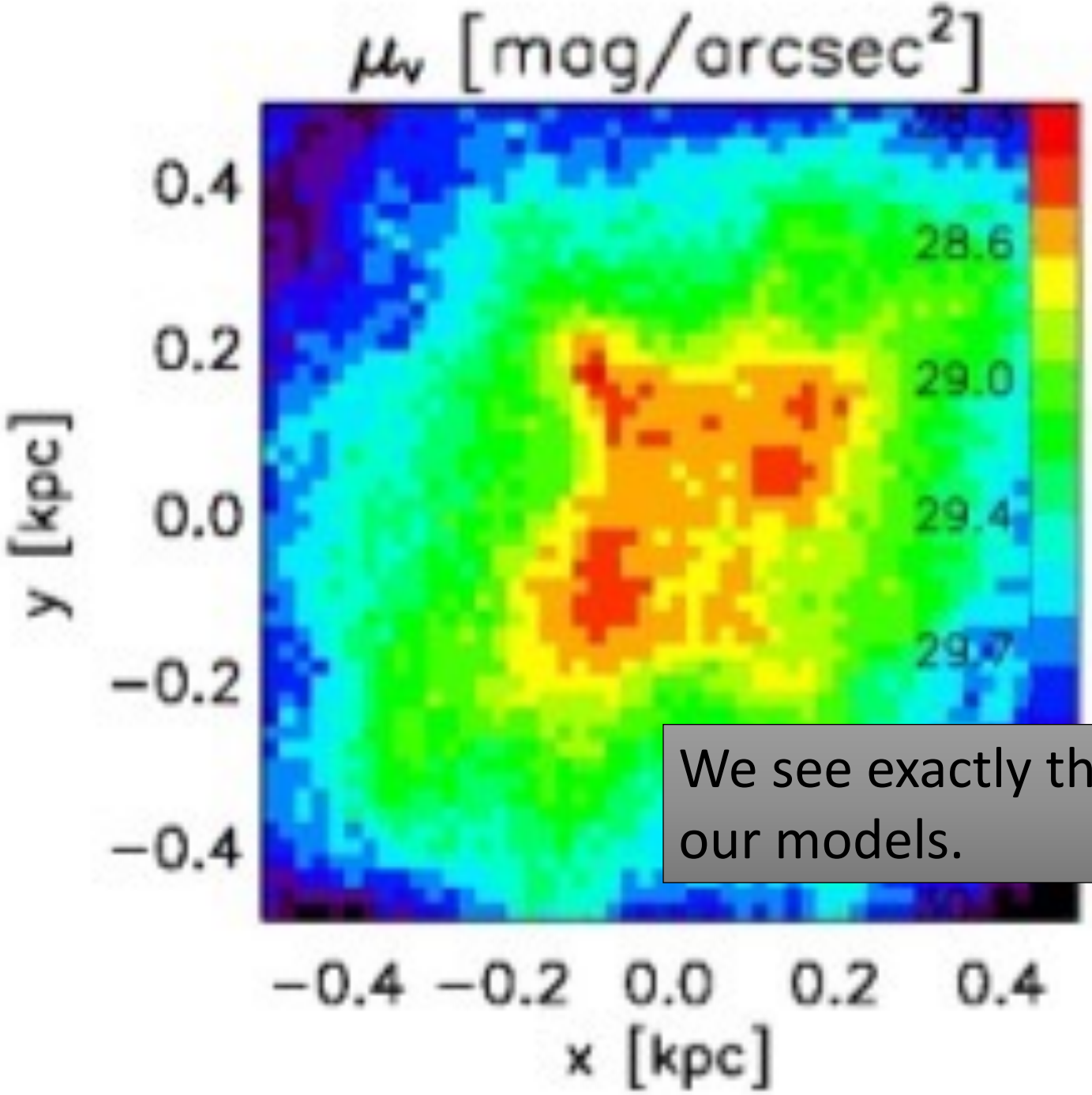
# UrsaMajor II




In dSph galaxies we see surface brightness contours which are not perfect ellipses. They have twists and turns and sometimes we even see a secondary density peak.

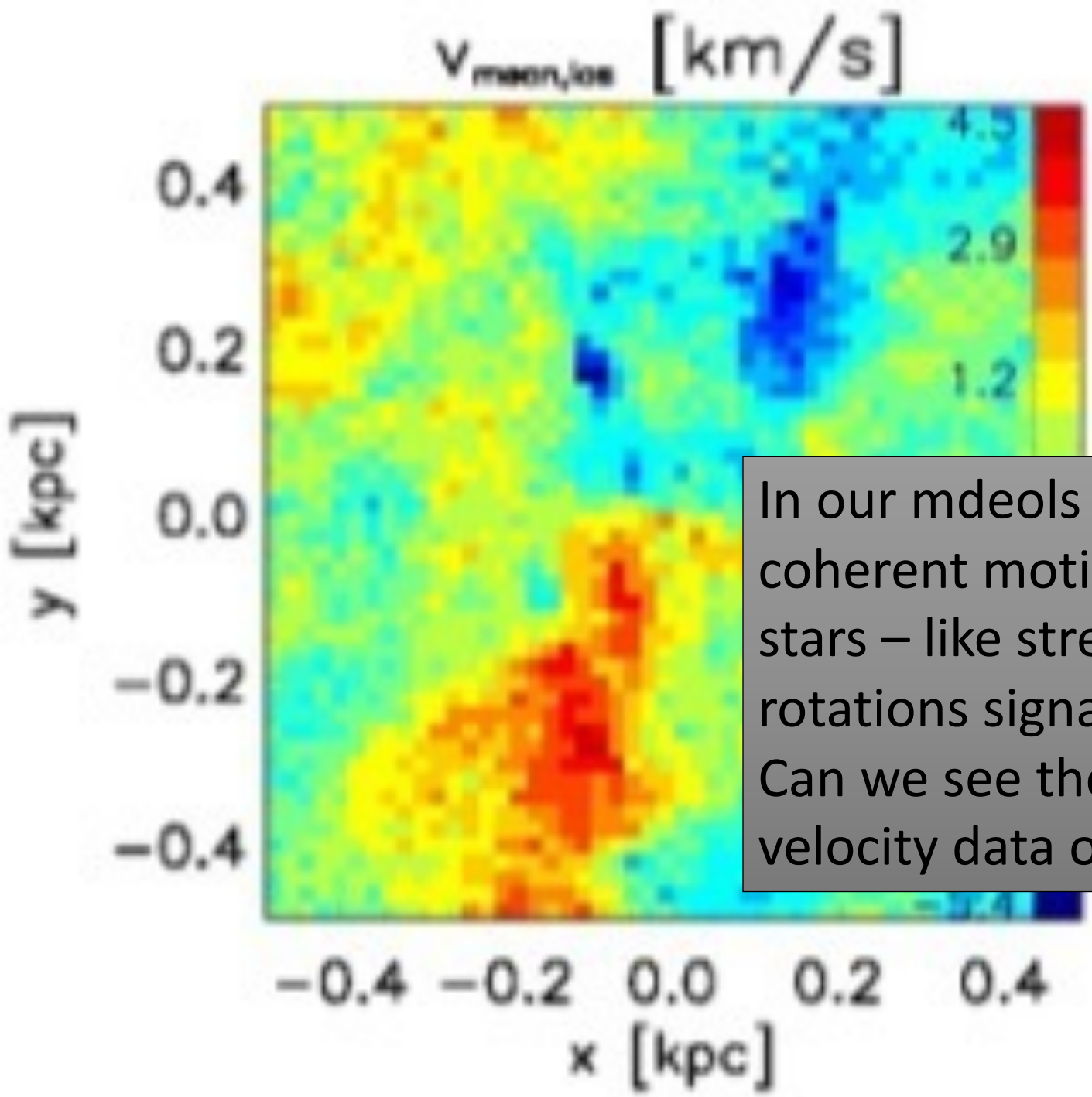


Hercules I




Assmann et al 2013ab

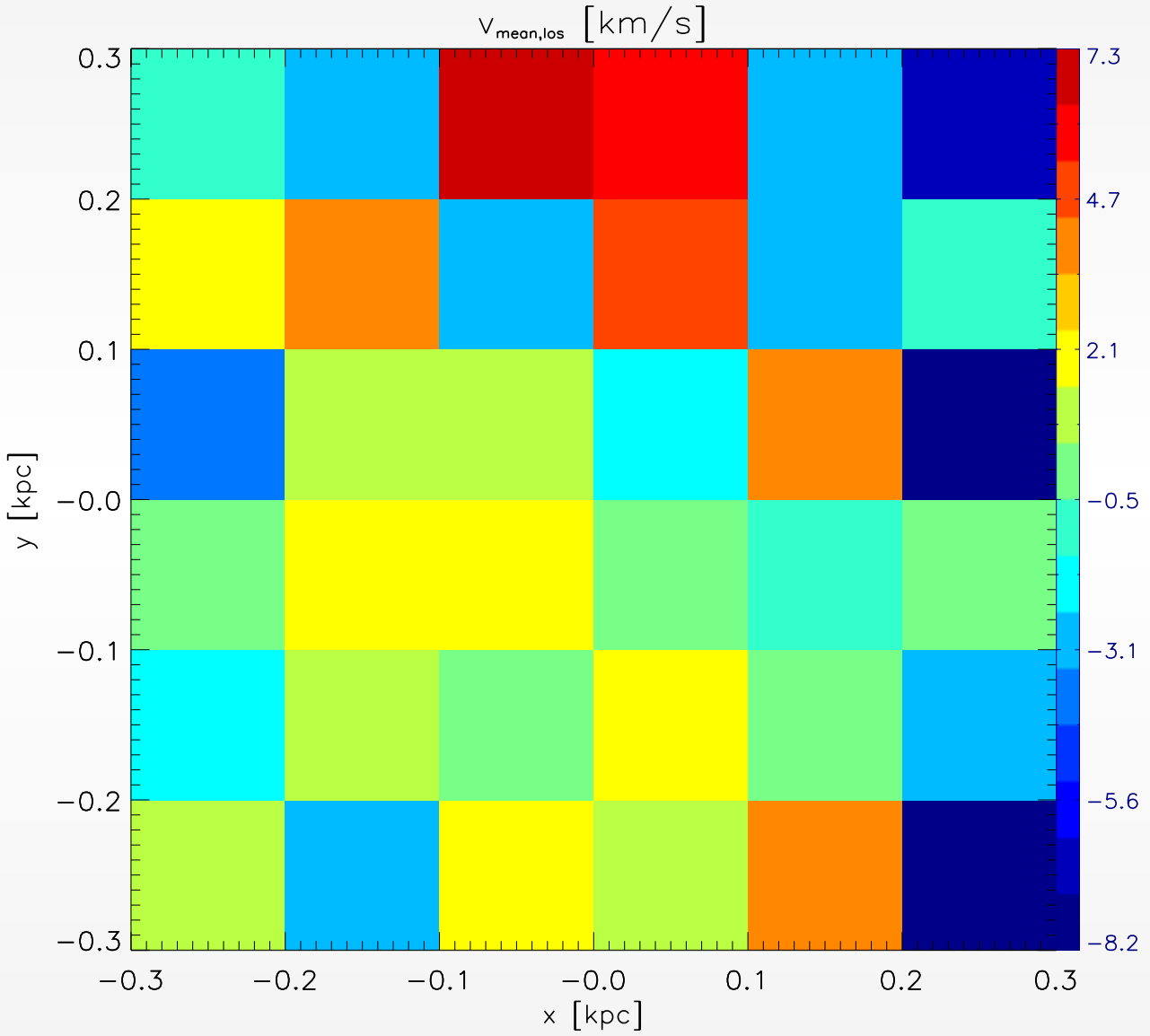
We see exactly the same in our models.



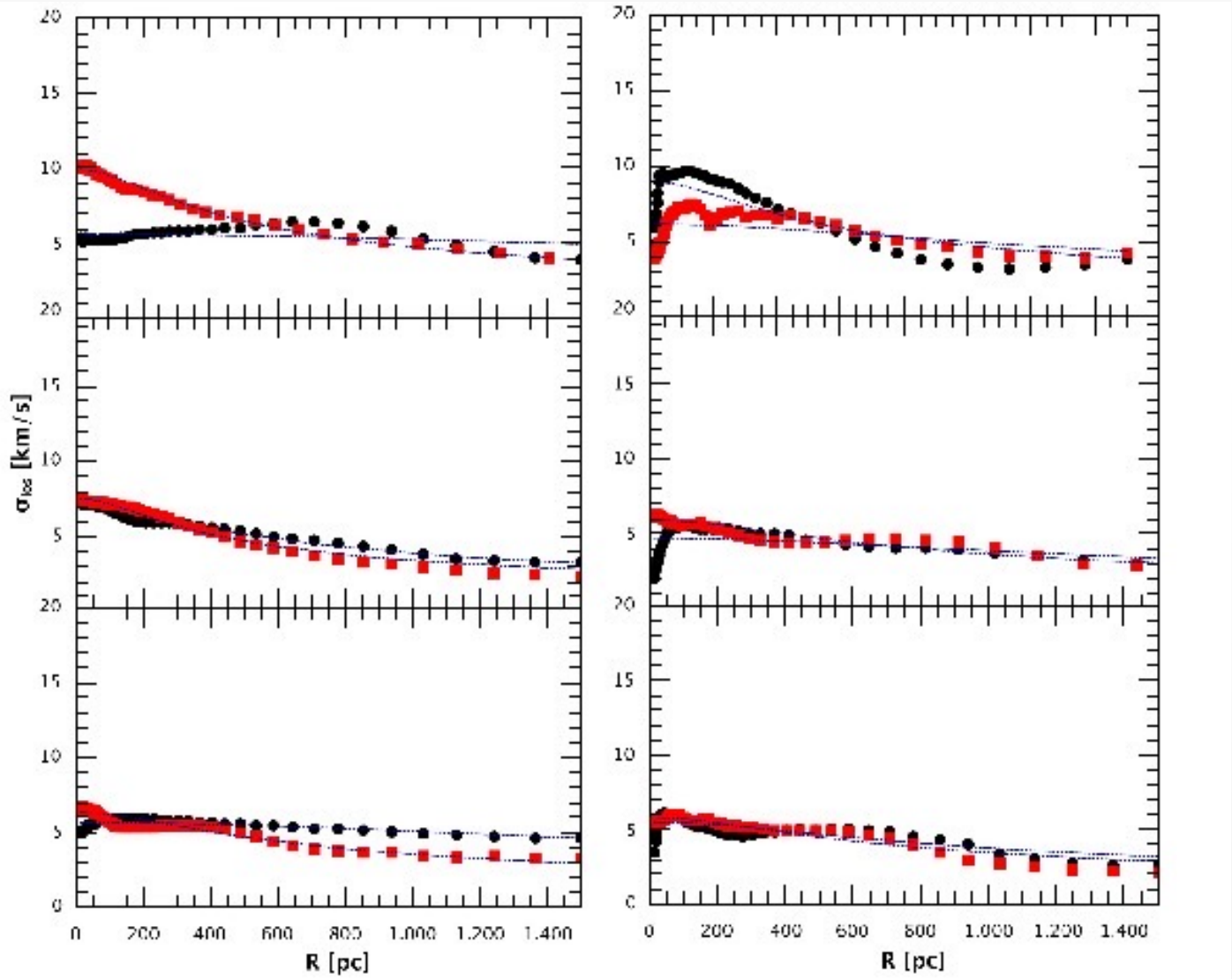

In our mdeols we see signs of coherent motions of many stars – like streams or even rotations signals.
Can we see the same in the velocity data of real dSph?

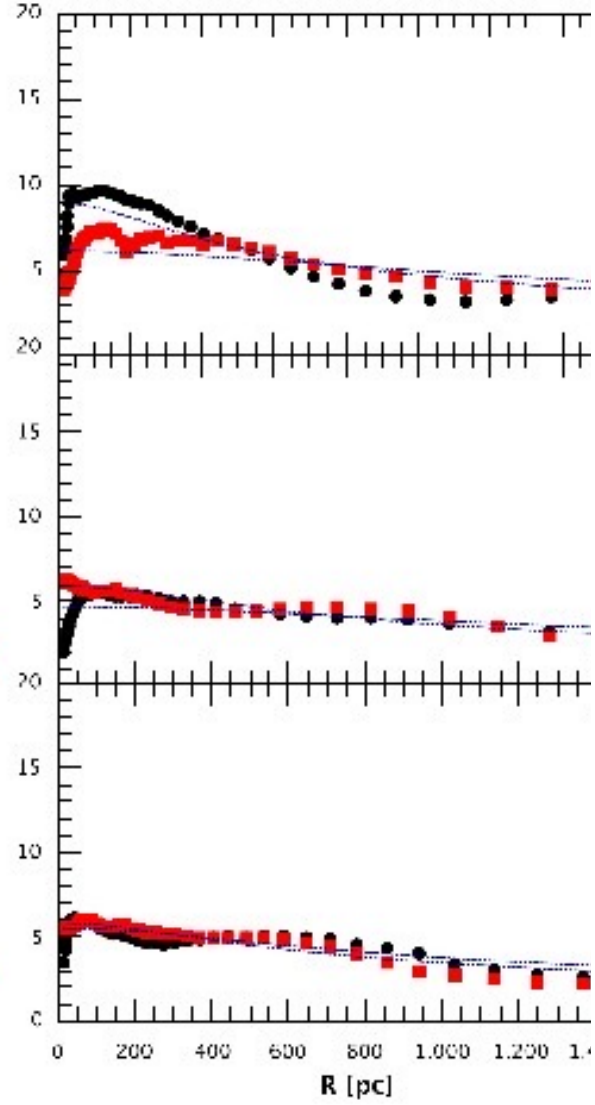
# NO?

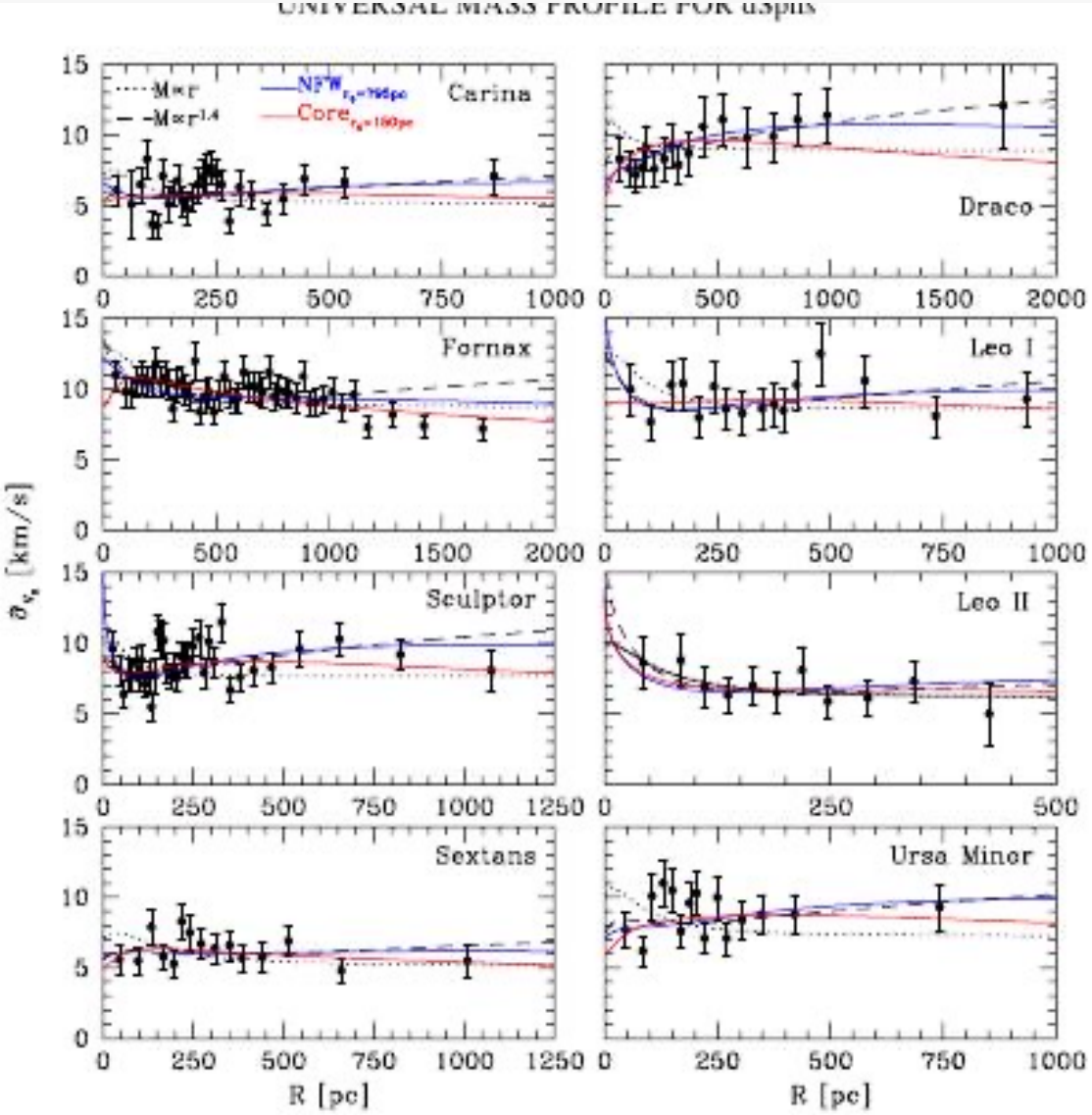
**Fornax**


$V_{mean,los}$ [km/s]
0.3
0.2
0.1
−0.0
−0.1
−0.2
−0.3
y [kpc]
−0.3
−0.2
−0.1
−0.0
0.1
0.2
0.3
x [kpc]
7.3
4.7
2.1
−0.5
−3.1
−5.6
−8.2

# But…



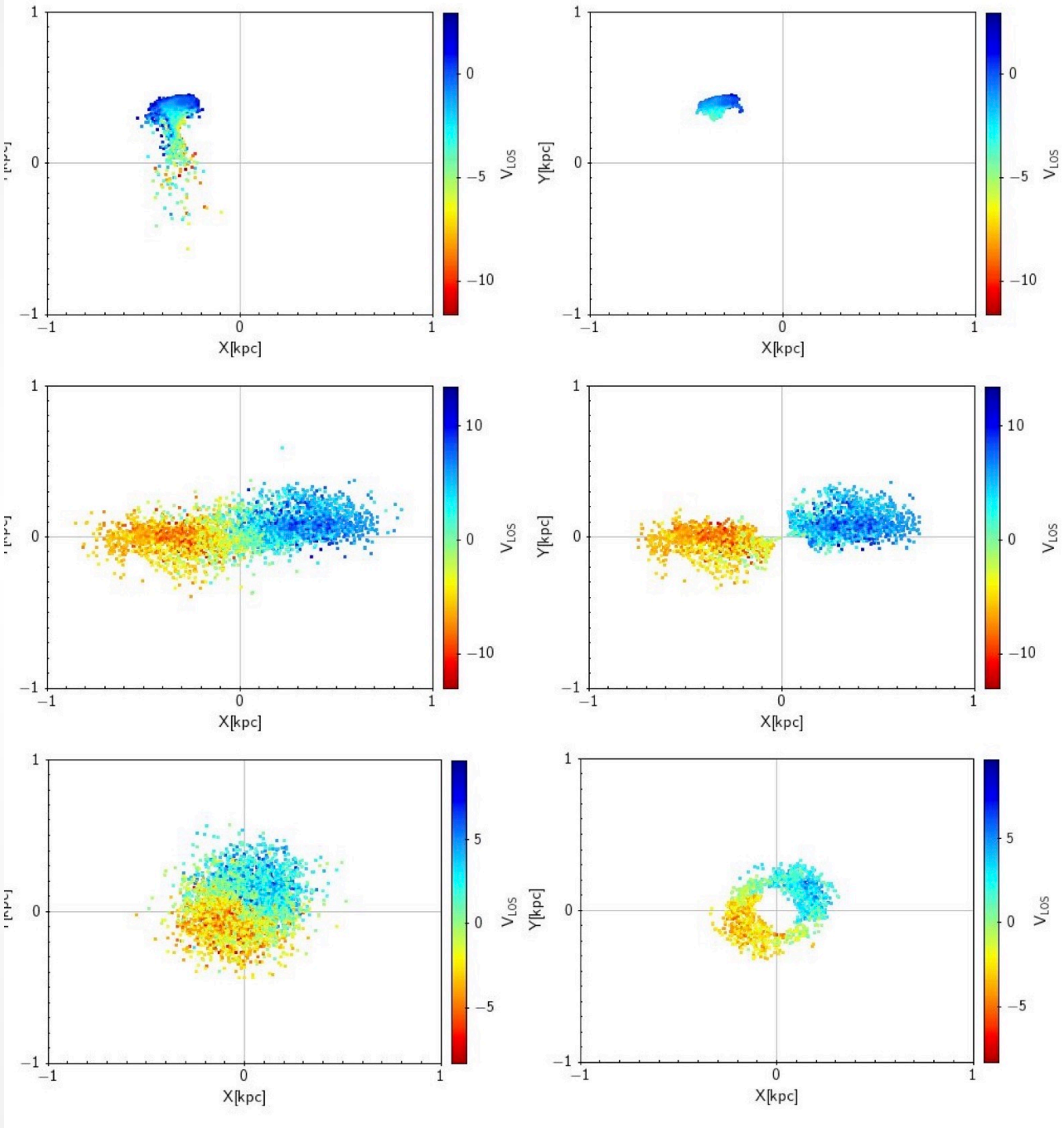

R [pc]

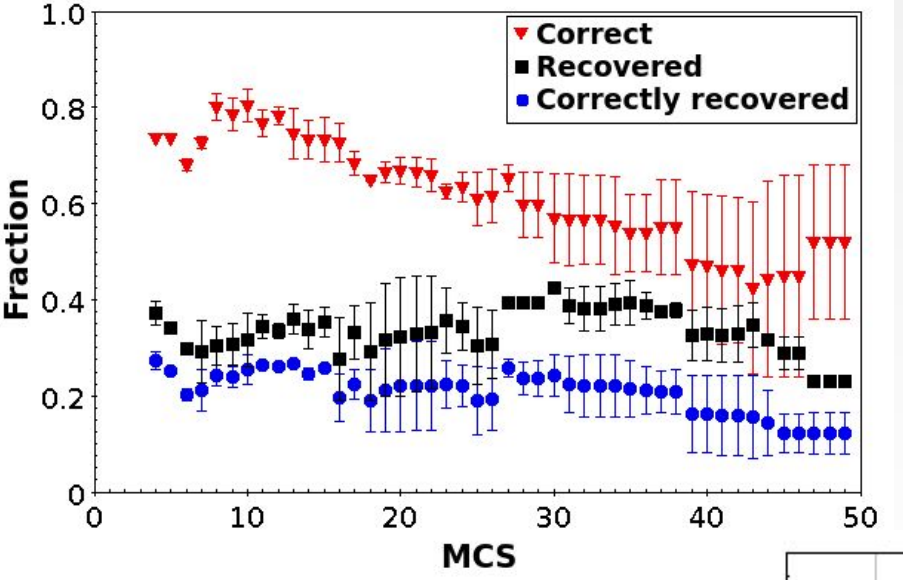

Carina
Draco
Fornax
Leo I
Sculptor
Leo II
Sextans
Ursa Minor
R [pc]
R [pc]

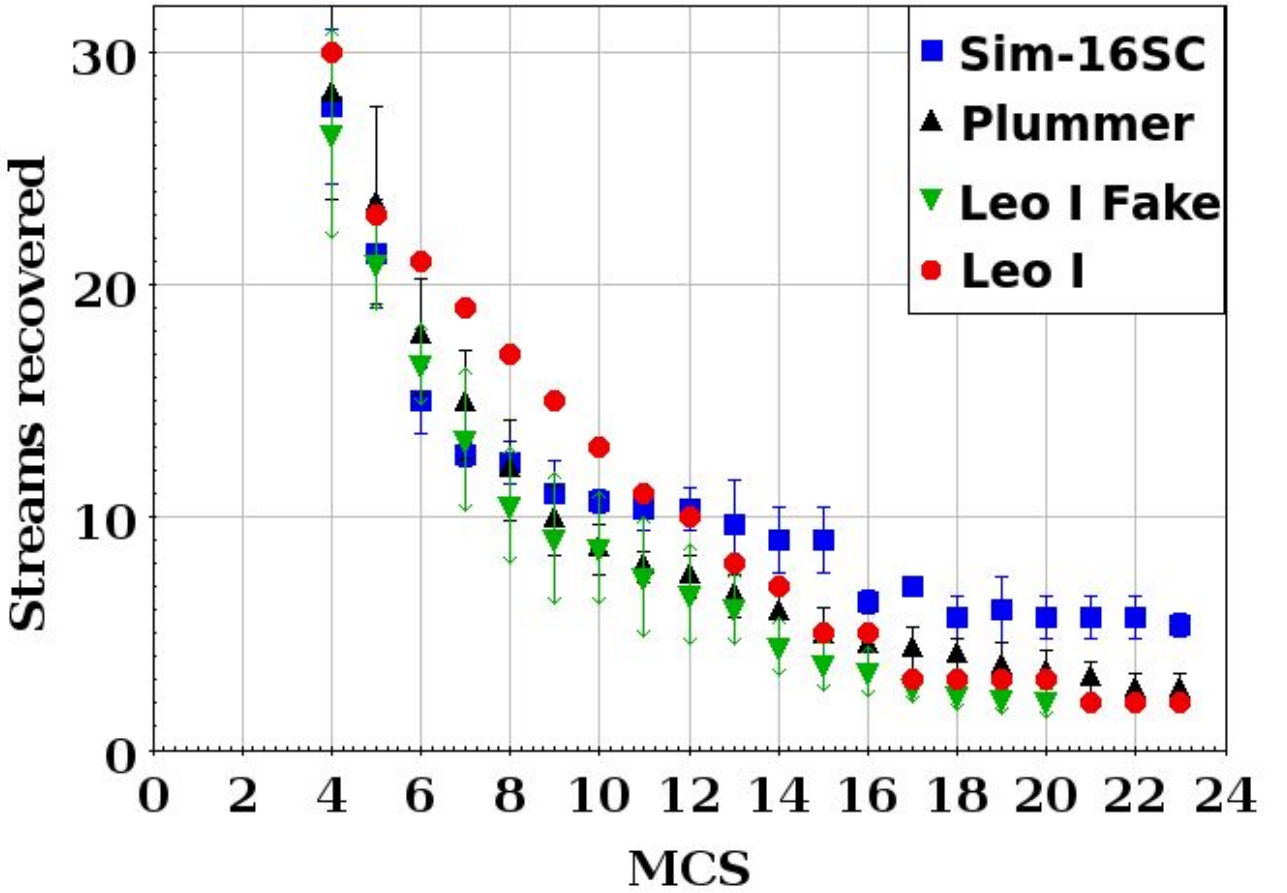
# Beacon

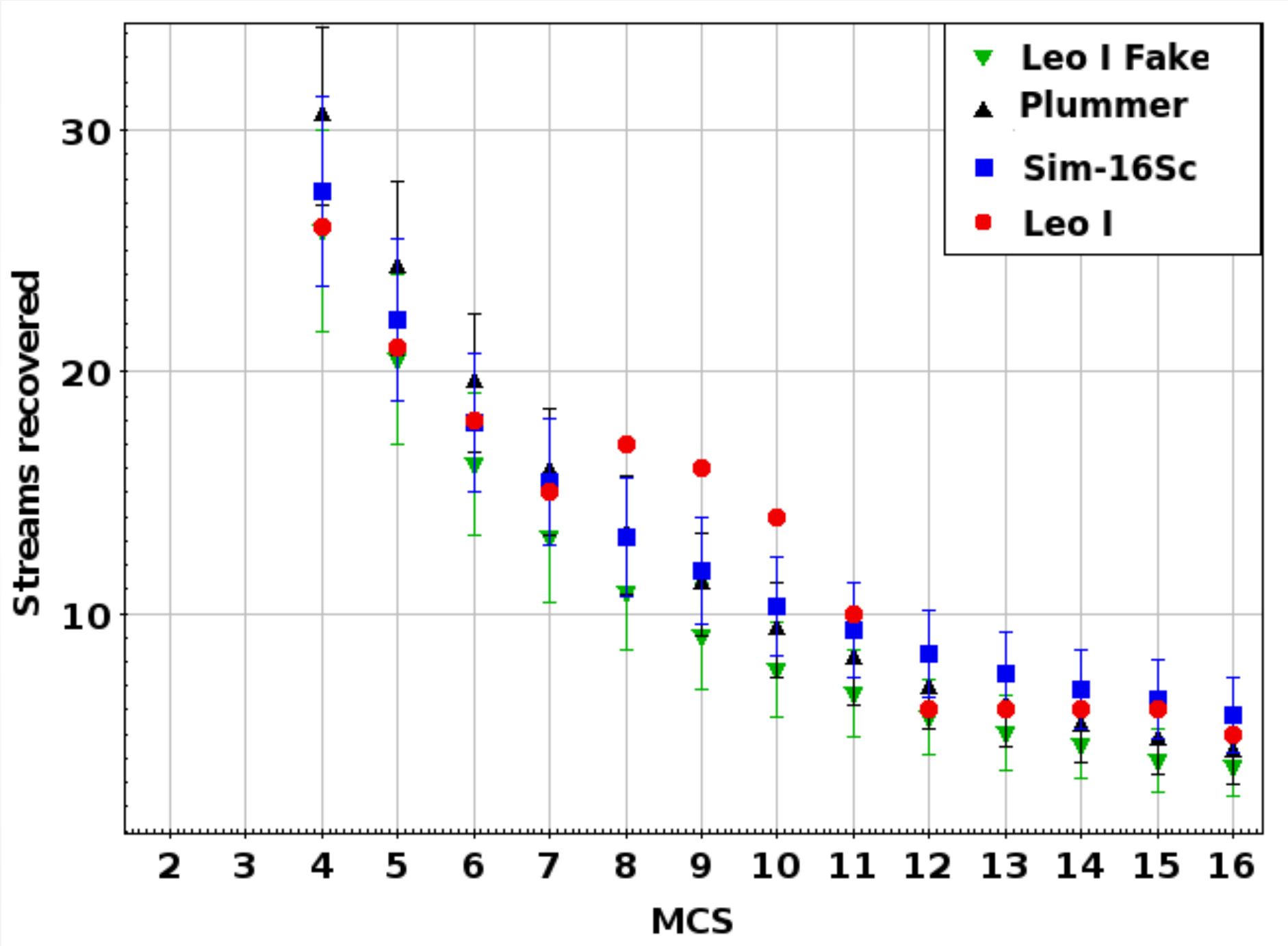
We tried to detect chemo-dynamical stream and patterns with our simulations and with real velocity data from Leo I

Alarcon Jara et al 2023

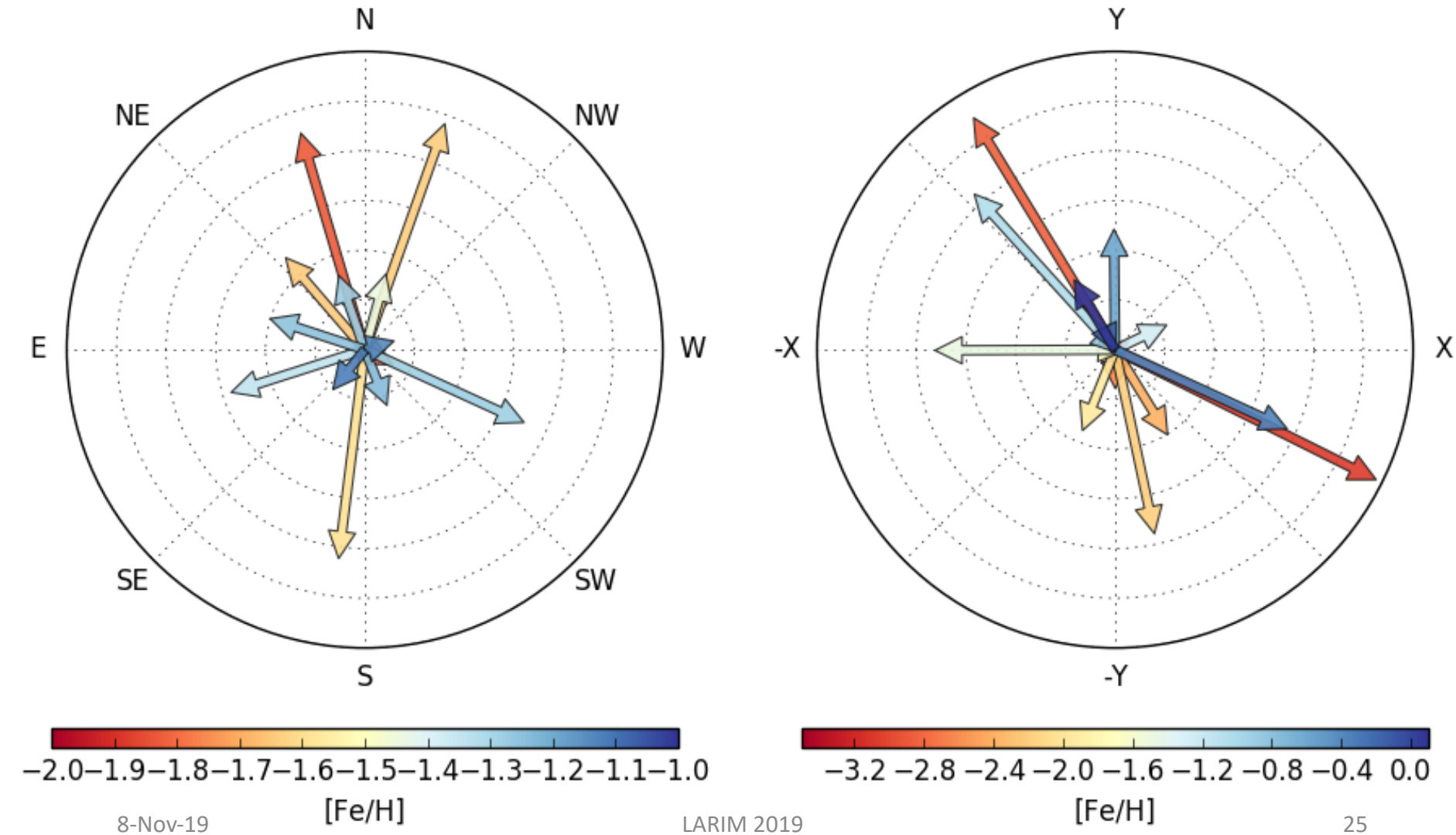


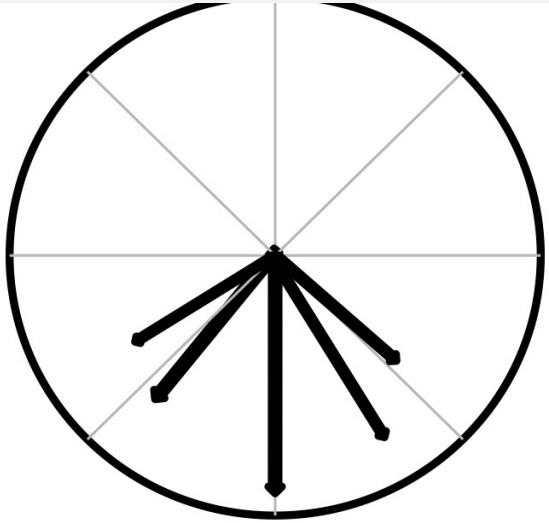

Correct
Recovered
Correctly recovered
Fraction
MCS
0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
50


Sim-16SC
Plummer
Leo I Fake
Leo I
Streams recovered
MCS
0
10
20
30
0
2
4
6
8
10
12
14
16
18
20
22
24

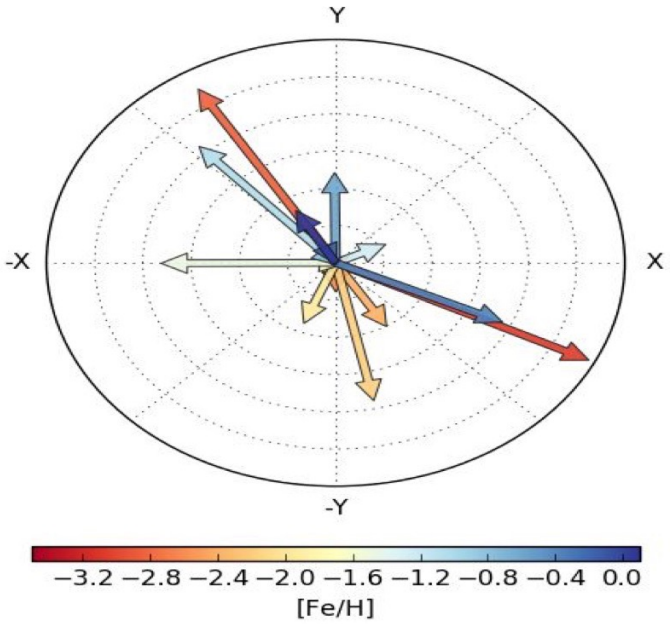

Leo I Fake
Plummer
Sim-16Sc
Leo I
Streams recovered
30
20
10
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
MCS

# Chemo-Kinematics of Leo 1

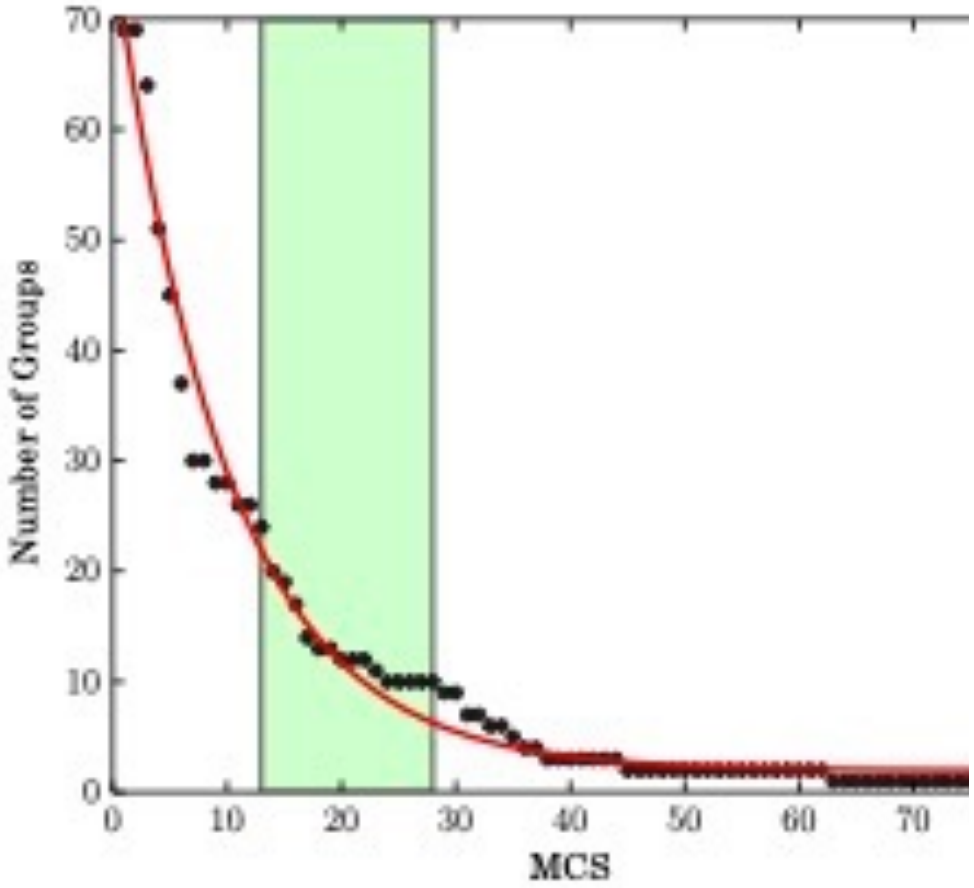




**Destroyed disc models**




**Dissolving star cluster model**



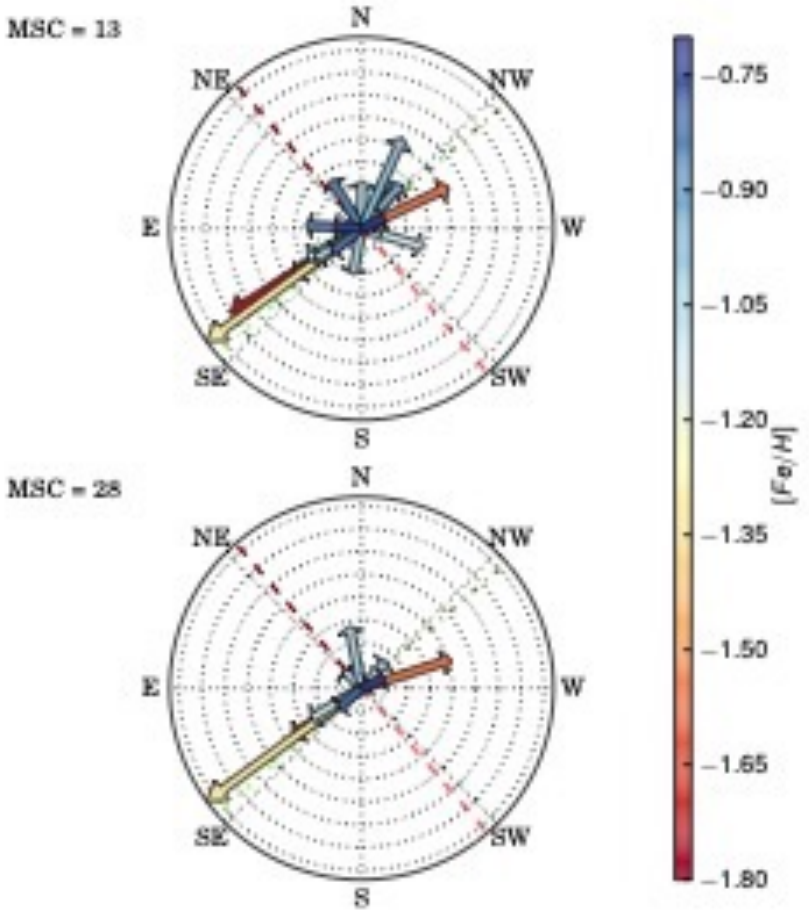
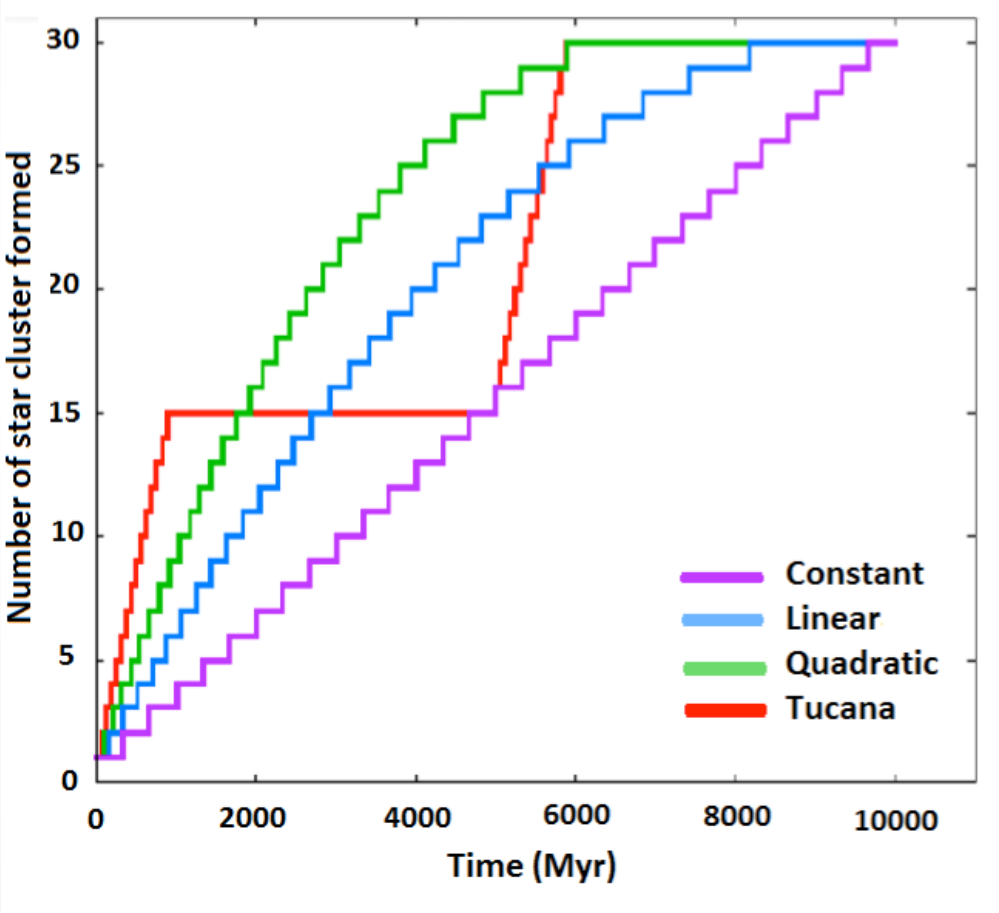
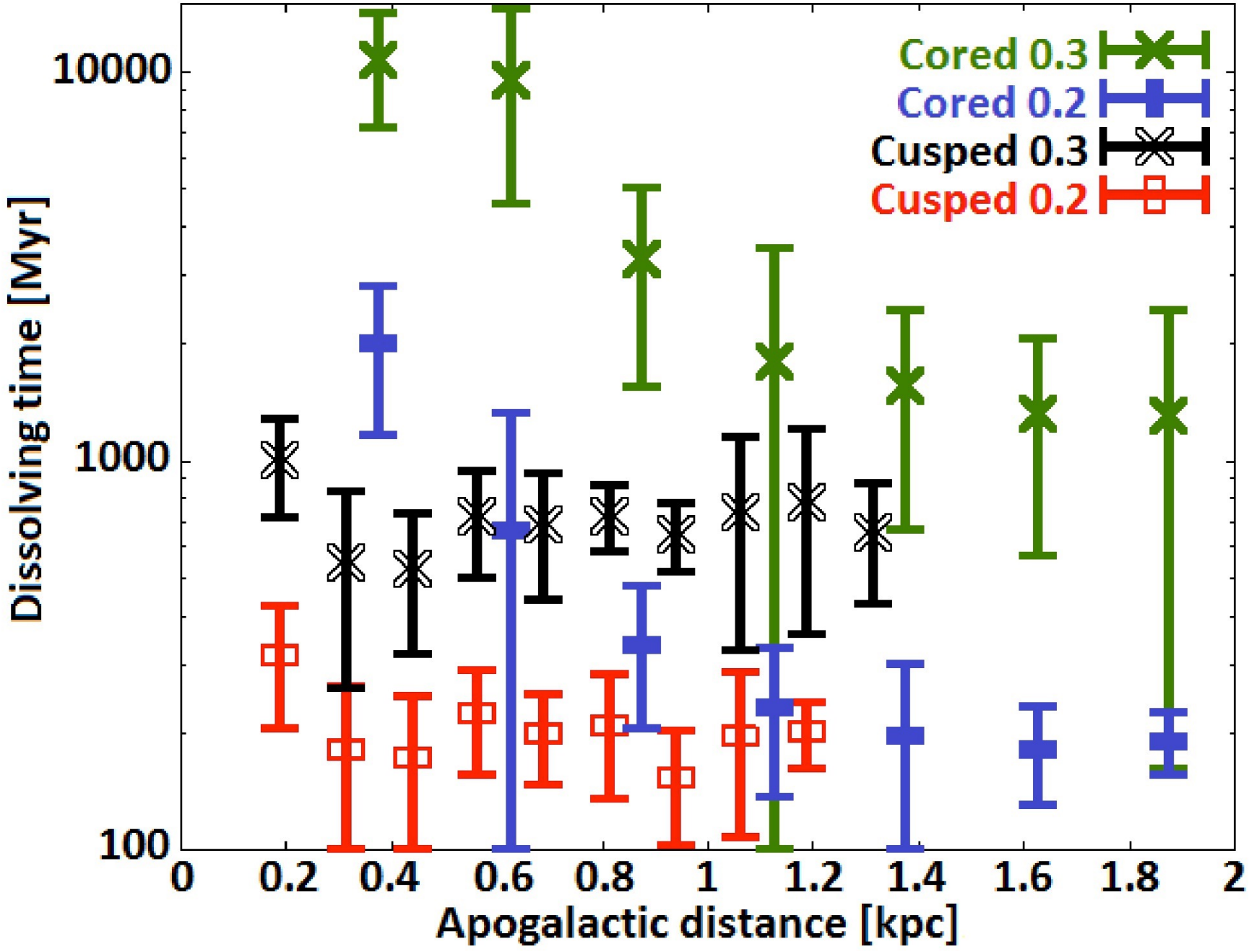



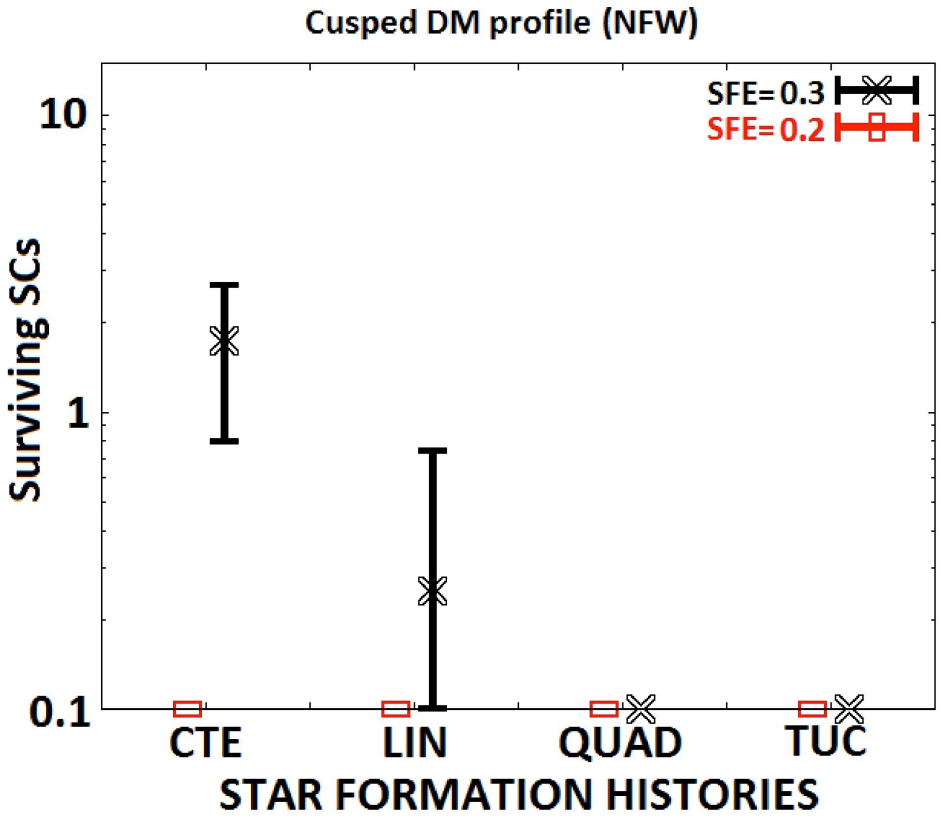

**Figure 5.** Number of resulting circular streams as a function of *minimum cluster size* parameter (MCS). The red line shows an exponential function fitted to the points. The area of the preferred values for MCS is marked in green ($13 < MCS < 28$).

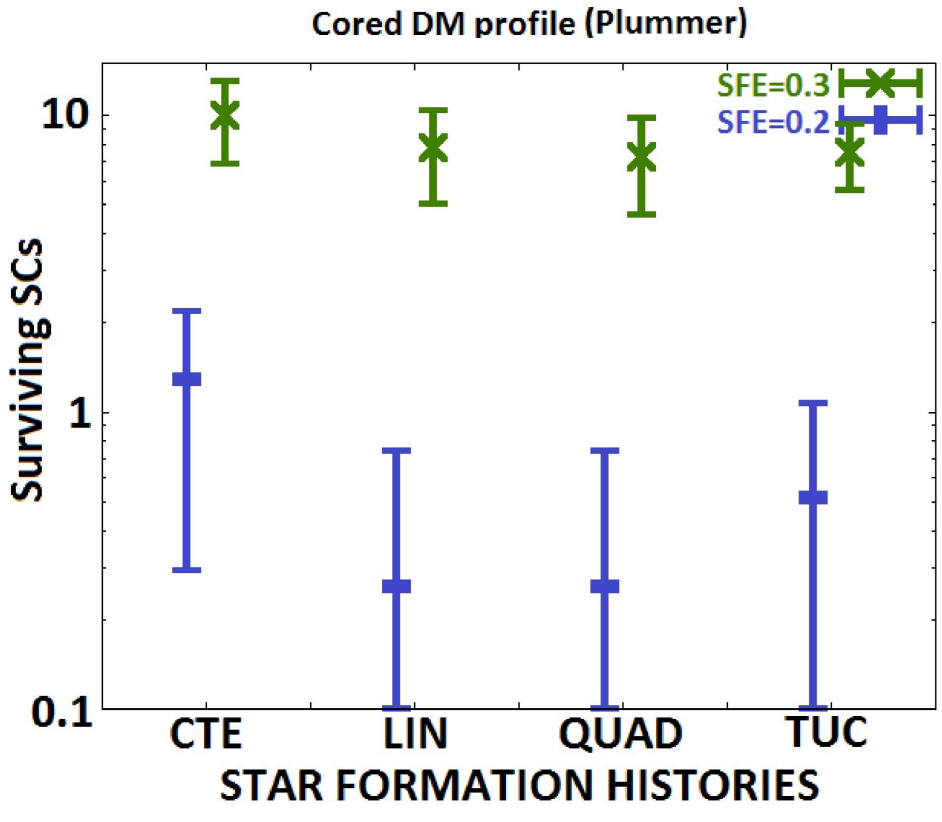
Analysis of Fornax data del Pino et al. 2017

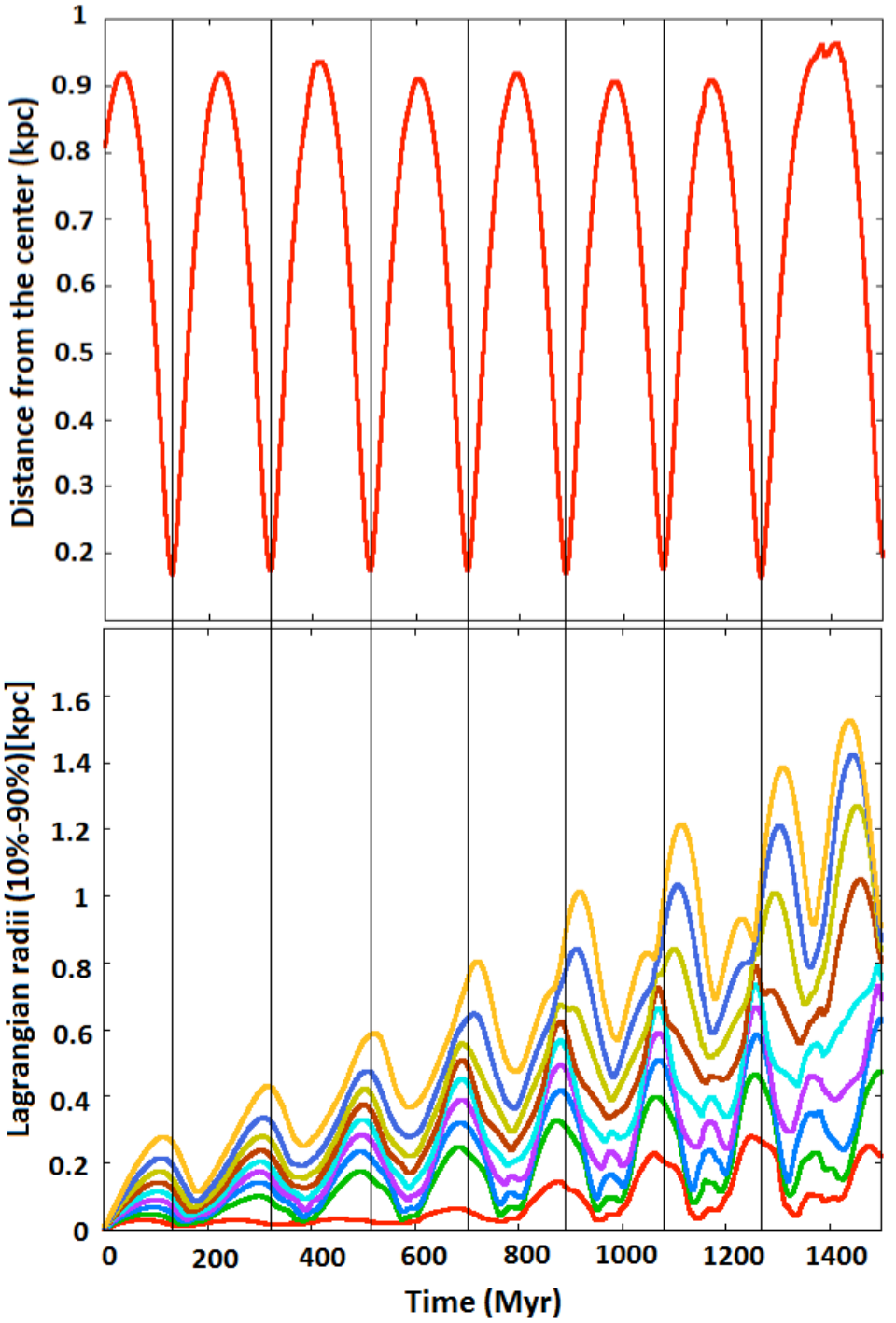
# Star Formation Histories of dSph




Cored 0.3
Cored 0.2
Cusped 0.3
Cusped 0.2
10000
1000
100
Dissolving time [Myr]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Apogalactic distance [kpc]


Cusped DM profile (NFW)
SFE= 0.3
SFE= 0.2
10
1
0.1
Surviving SCs
CTE
LIN
QUAD
TUC
STAR FORMATION HISTORIES

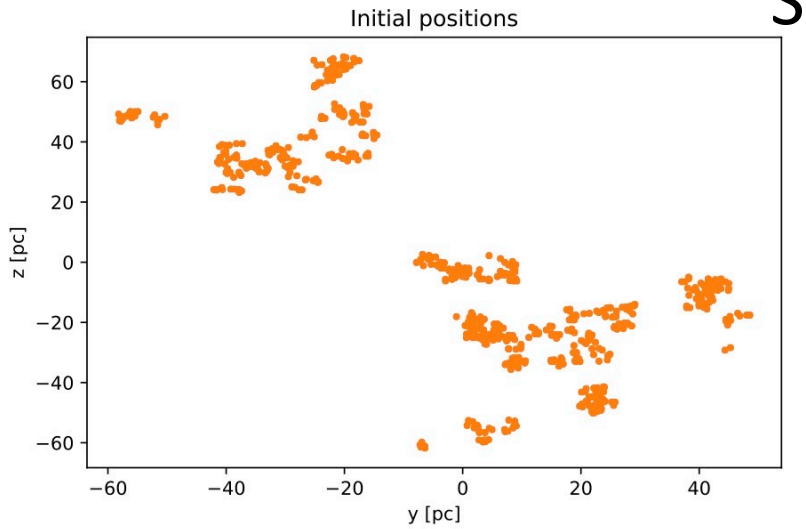

Cored DM profile (Plummer)
SFE=0.3
SFE=0.2
10
1
0.1
Surviving SCs
CTE
LIN
QUAD
TUC
STAR FORMATION HISTORIES

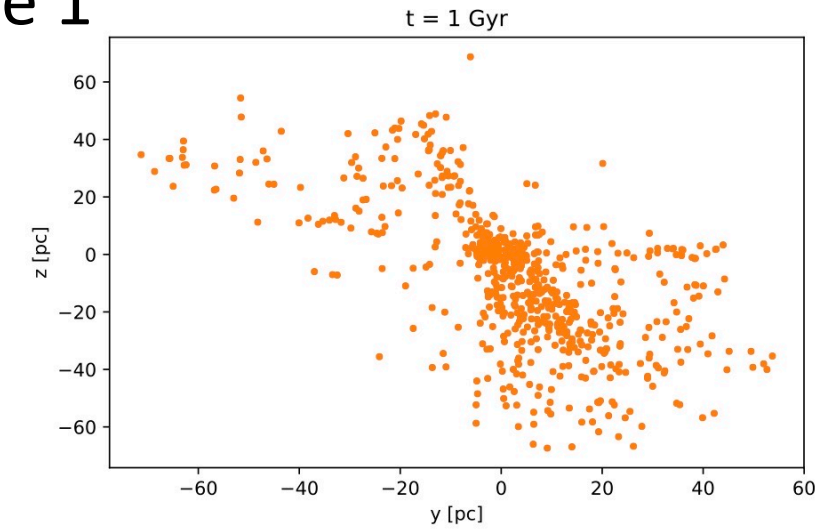

Distance from the center (kpc)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Lagrangian radii (10%-90%)[kpc]
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
1400
Time (Myr)

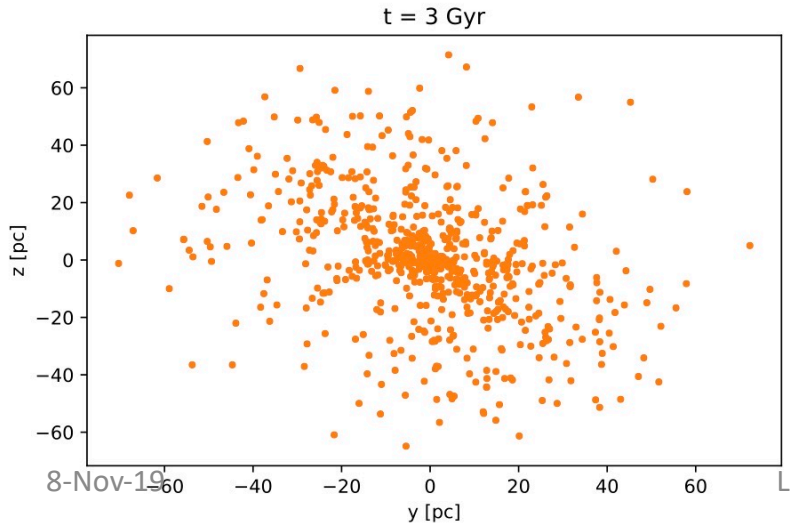
# Formation of Ultra-Faint dSph

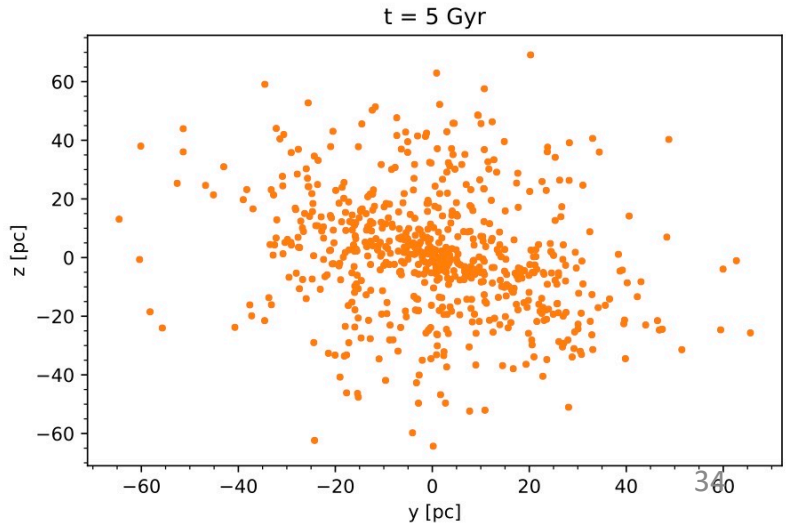
(Aravena et al.)

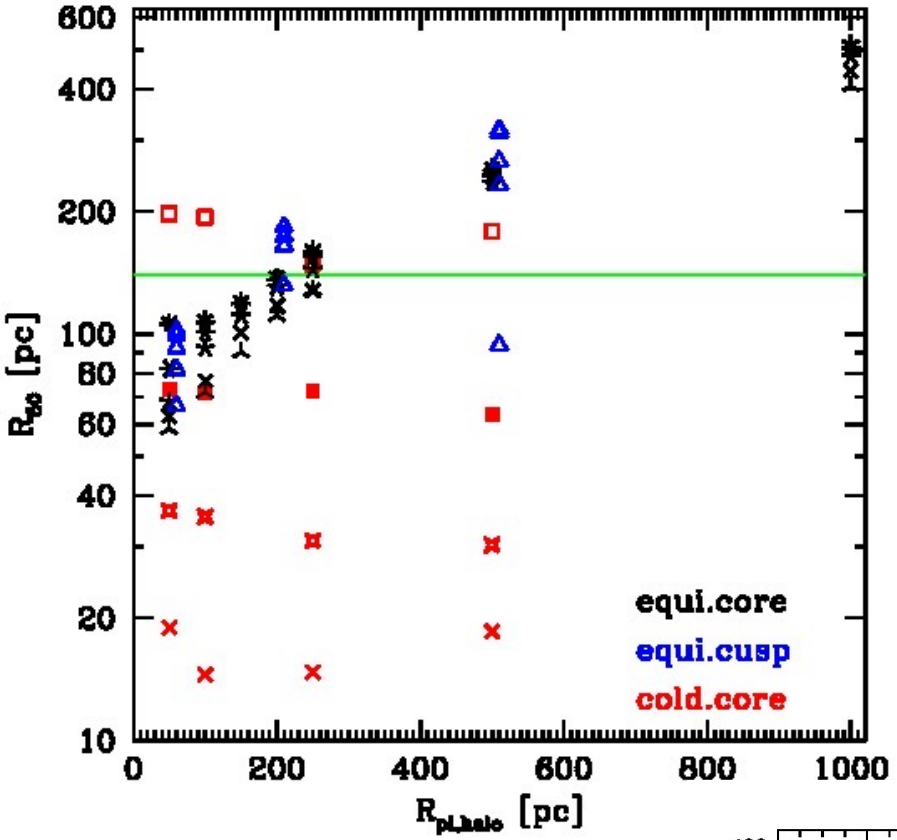
## Segue 1

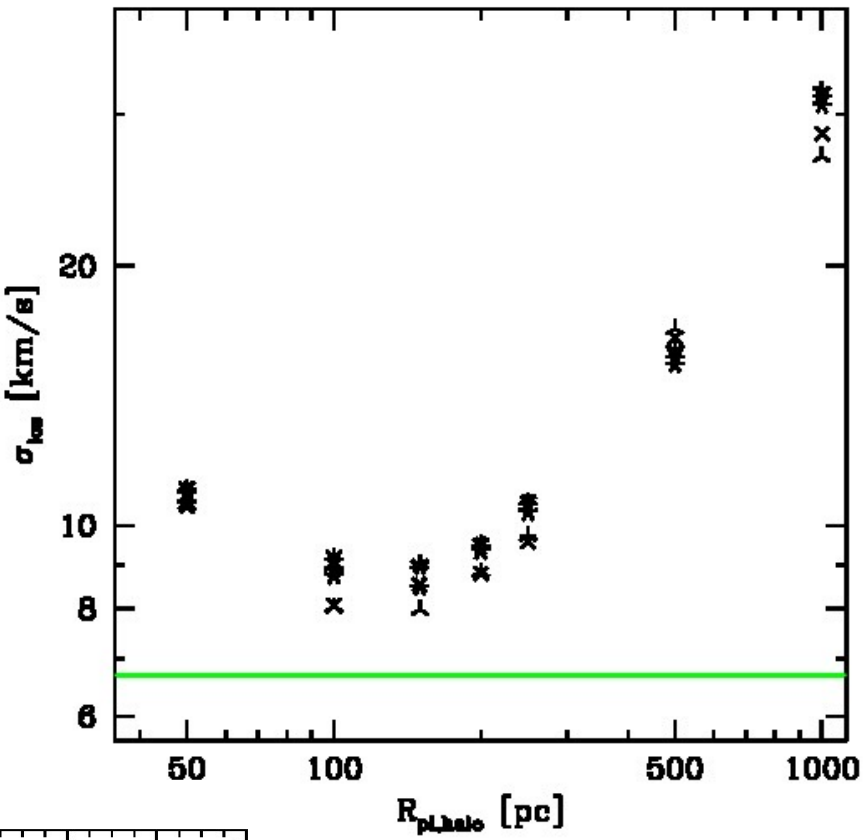


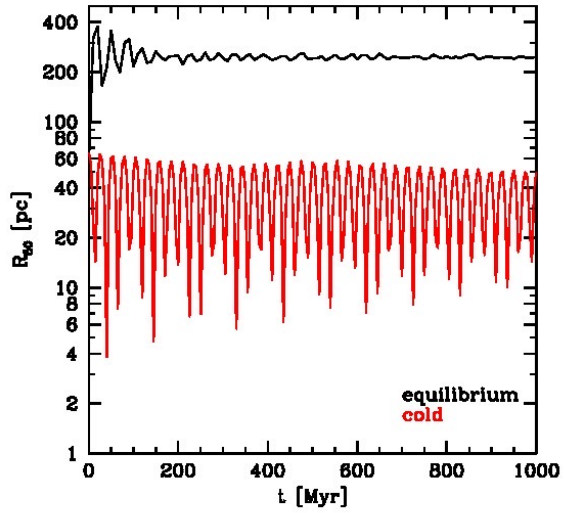




600
400
200
100
80
60
40
20
10
0
200
400
600
800
1000
$R_{pl}$ [pc]
$R_{pl,halo}$ [pc]
equi.core
equi.cusp
cold.core


20
10
8
6
50
100
500
1000
$\sigma_{los}$ [km/s]
$R_{pl,halo}$ [pc]


400
200
100
80
60
40
20
10
8
6
4
2
1
0
200
400
600
800
1000
$R_{pl}$ [pc]
t [Myr]
equilibrium
cold

UMa II

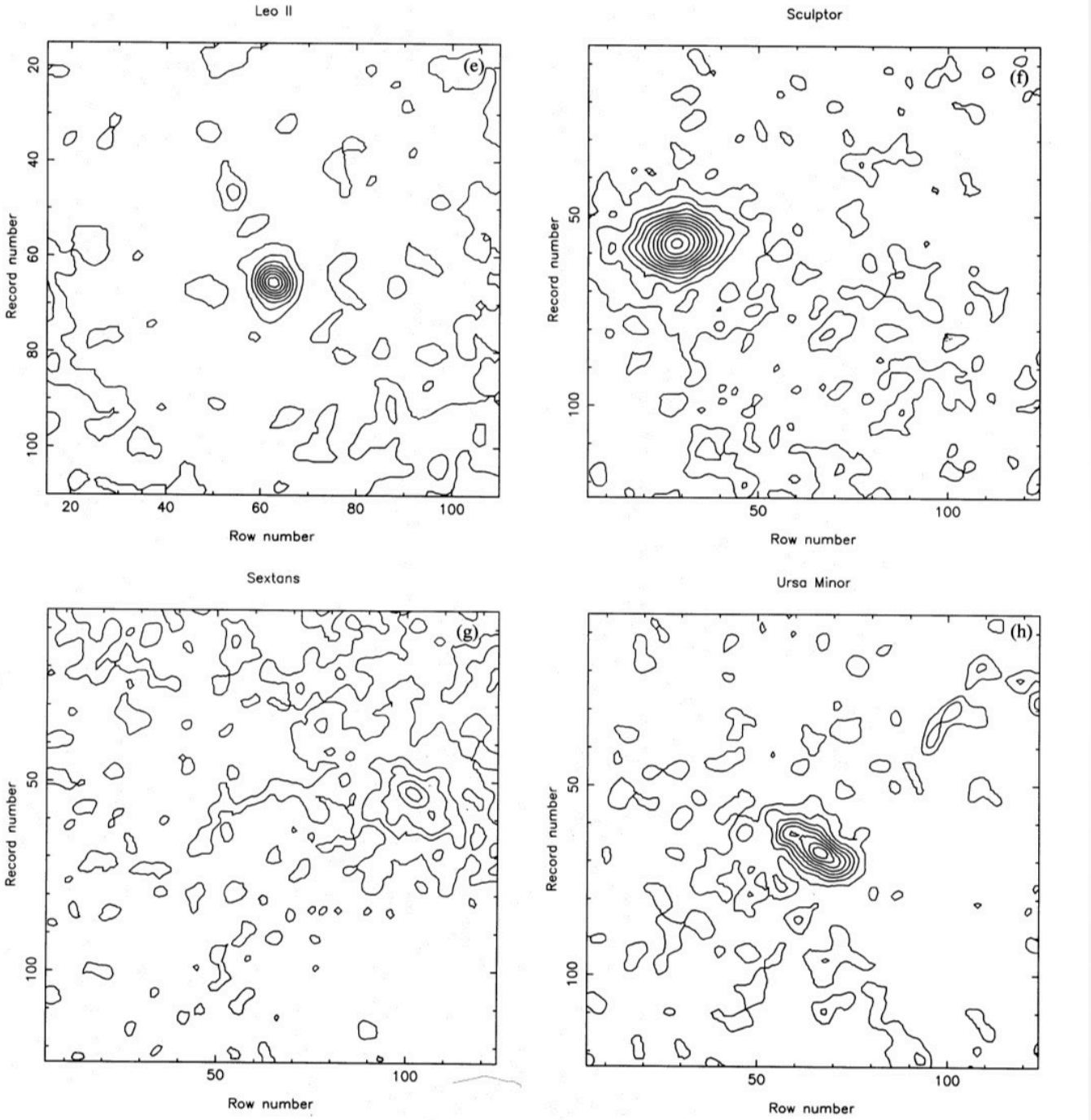
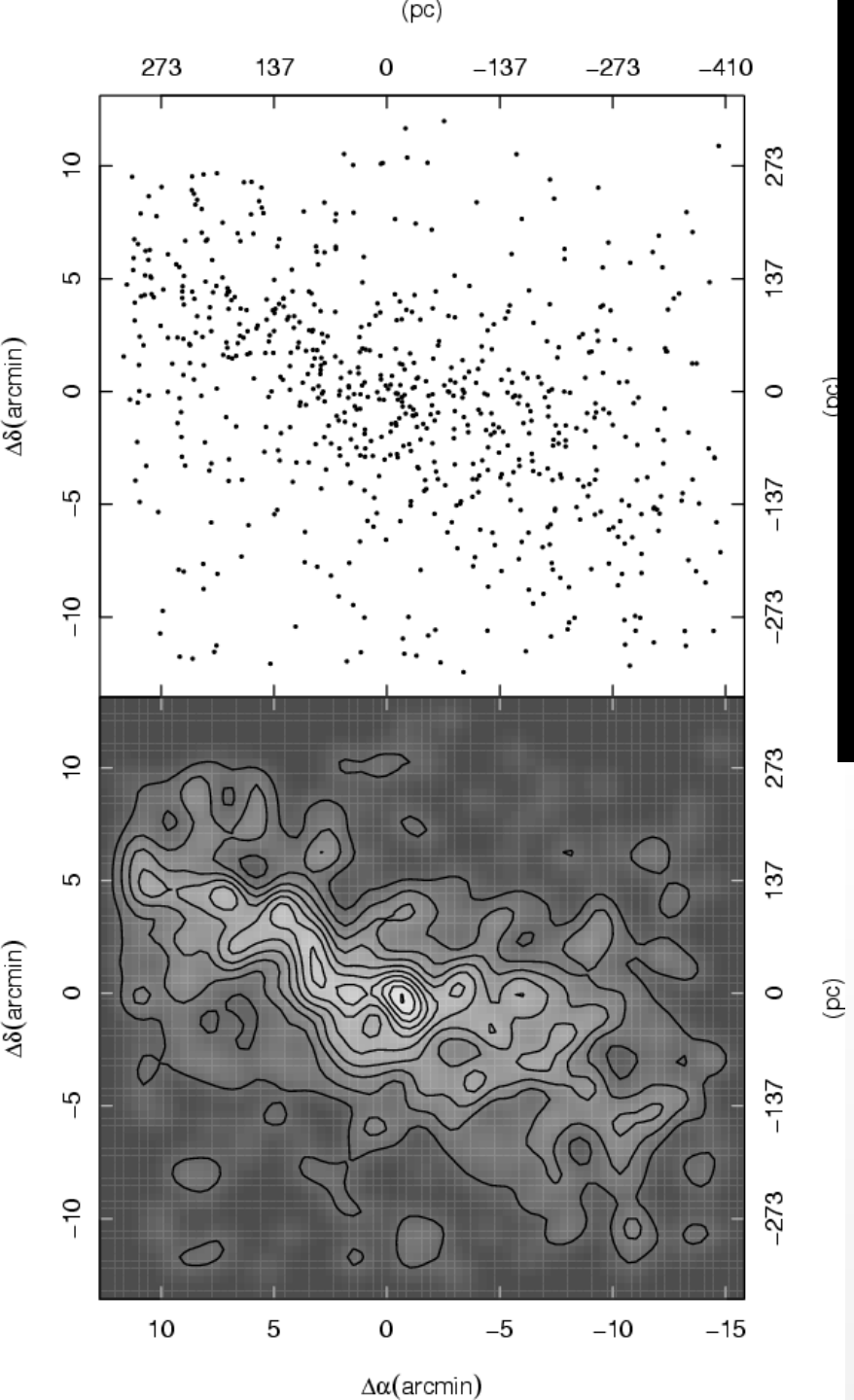
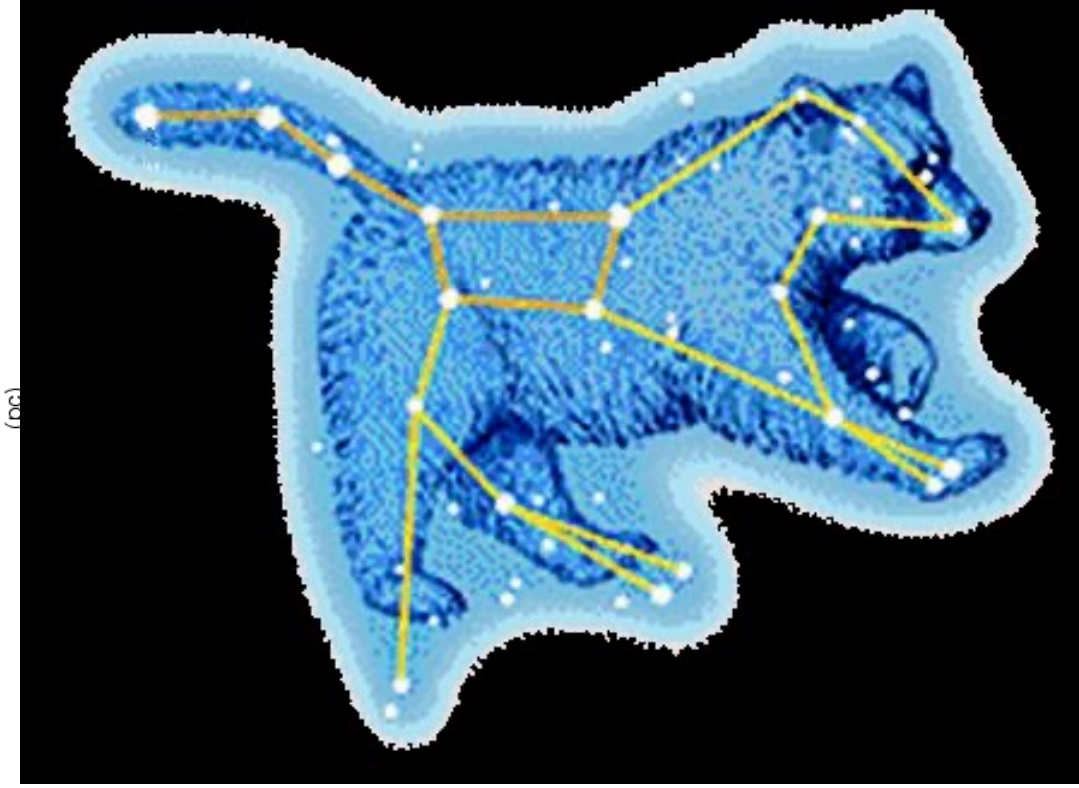



**Figure 1** – *continued*



# UrsaMajor I