Internal Dynamics of Galaxies and Groups

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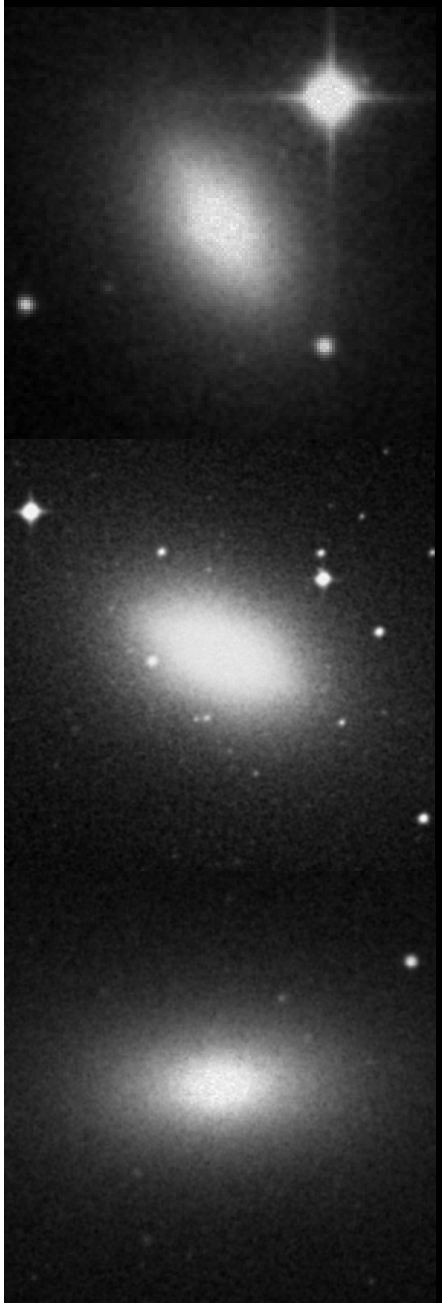
T. Richtler, D. Geisler, M. Gómez (Concepción) S. Zepf (Michigan St), G. Bergond (IAA), R. Sharples (Durham), Y. Schuberth (Bonn), L. Bassino, F. Faifer, J. Forte (La Plata), L. Infante (PUC), K. Rhode (Wesleyan), P. Sánchez-Blázquez (EPFL)	**GCs**

Elliptical galaxy environmental differences



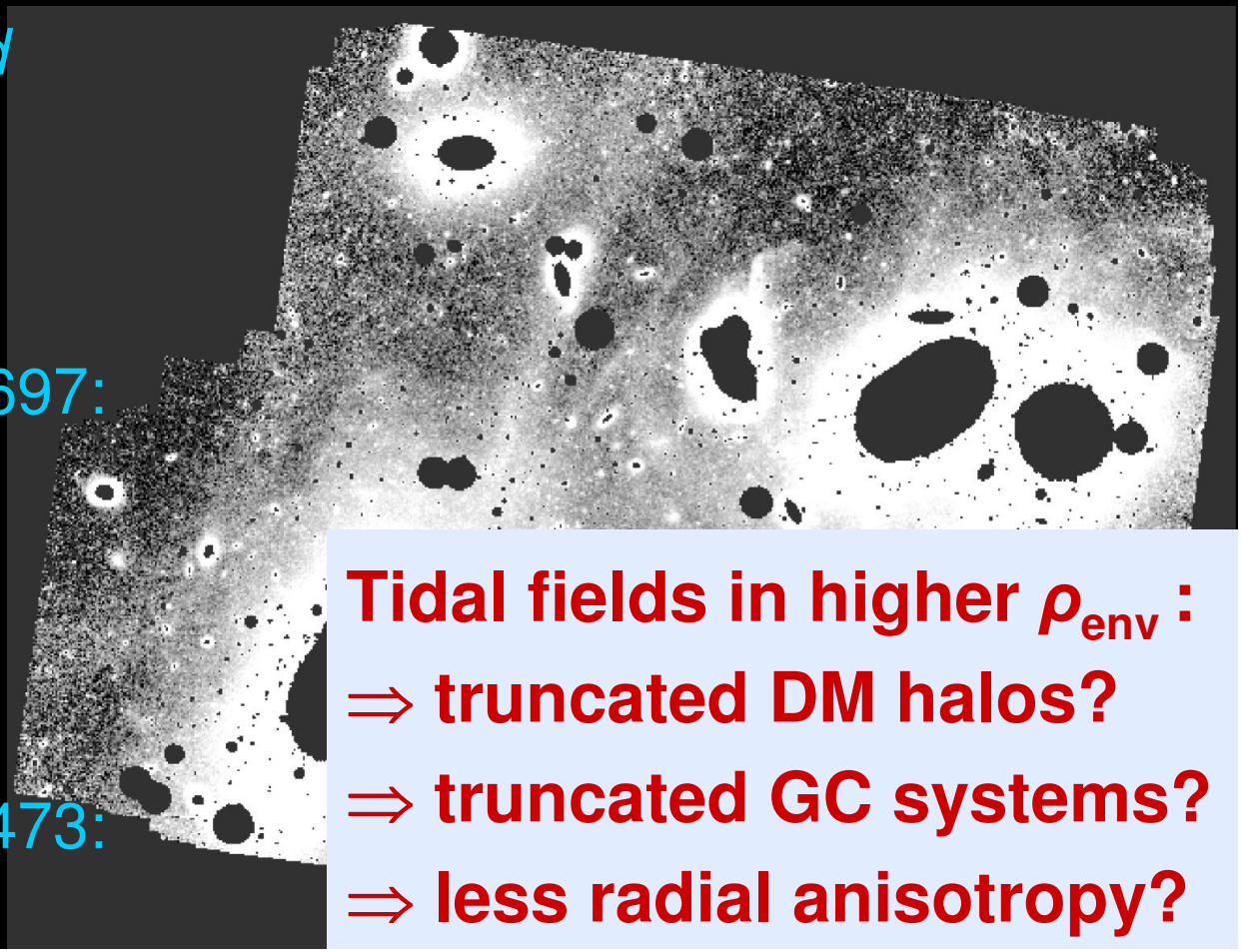
Central properties of ellipticals show only minor dependence on environment

(e.g. Reda et al. 2005)

NGC 821:
isolated

NGC 4697:
group

NGC 4473:
cluster



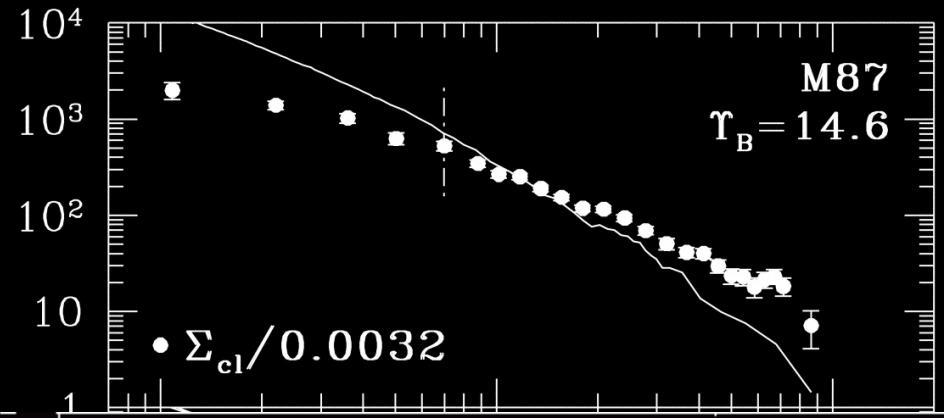
Tidal fields in higher ρ_{env} :

⇒ truncated DM halos?

⇒ truncated GC systems?

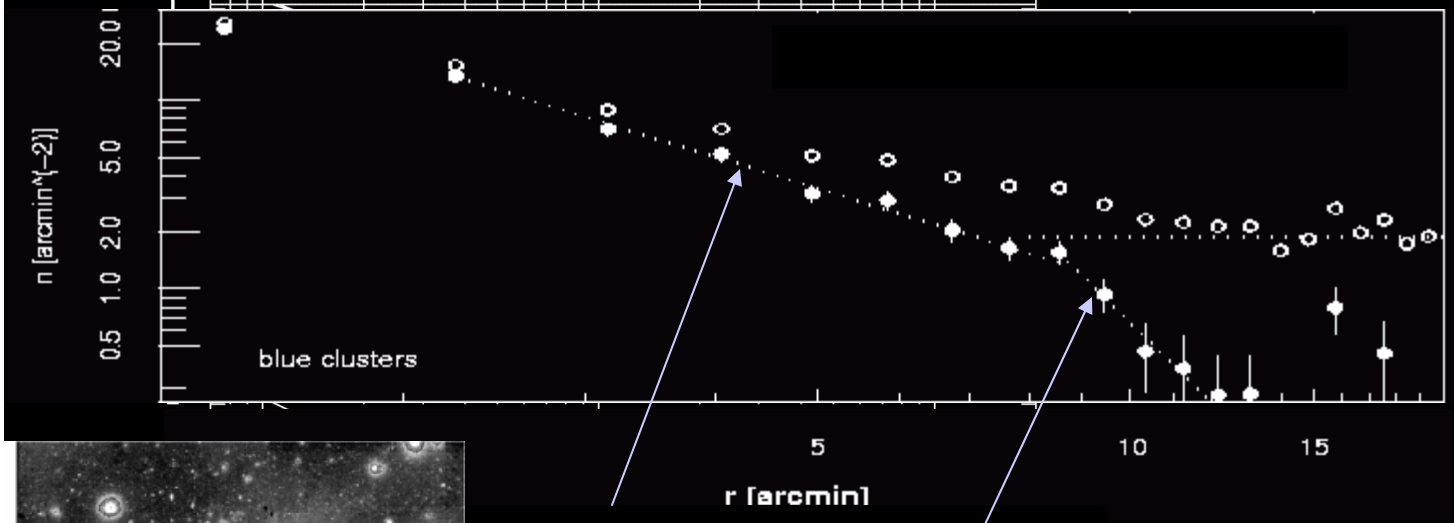
⇒ less radial anisotropy?

GCS surface density profiles

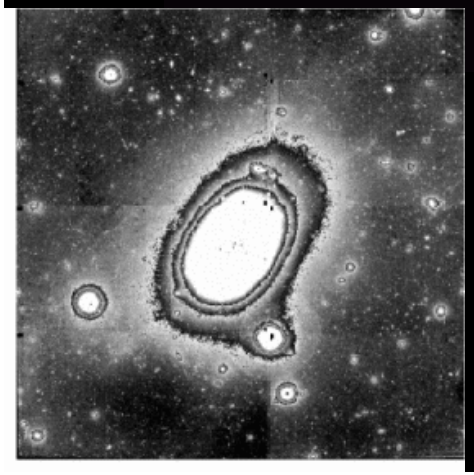


Extended GCSs in BCGs

(McLaughlin 1999)



NGC 4636:
BGG in Virgo infalling group?
(Dirsch et al. 2005)



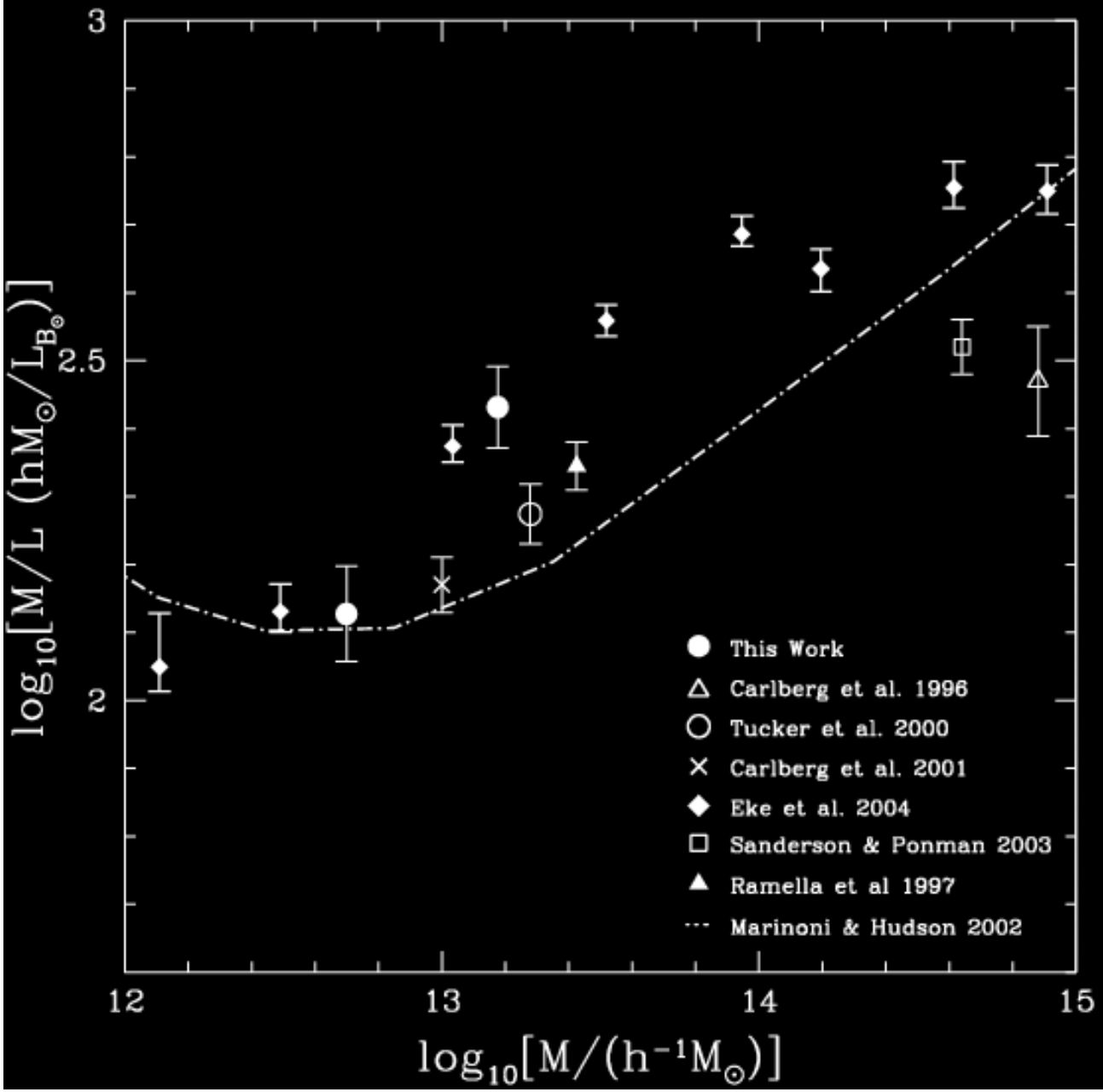
$N \propto R^{-1.5}$

$N \propto R^{-5}$

Stripped halos?:
GCs as proxy for DM

(e.g. Bekki et al. 2005)

Galaxy/group M/L results/predictions



(Parker et al. 2005)

Combined halo probes

- **Planetary Nebulae, Globular Clusters, X-rays**

$\Rightarrow$ Cross-checks for reliability

$\Rightarrow$ Much stronger combined constraints,

e.g., use $M_X(r)$ and find orbit anisotropy from kinematical data

$\Rightarrow$ Cross-correlate stellar+GC pops kinematics

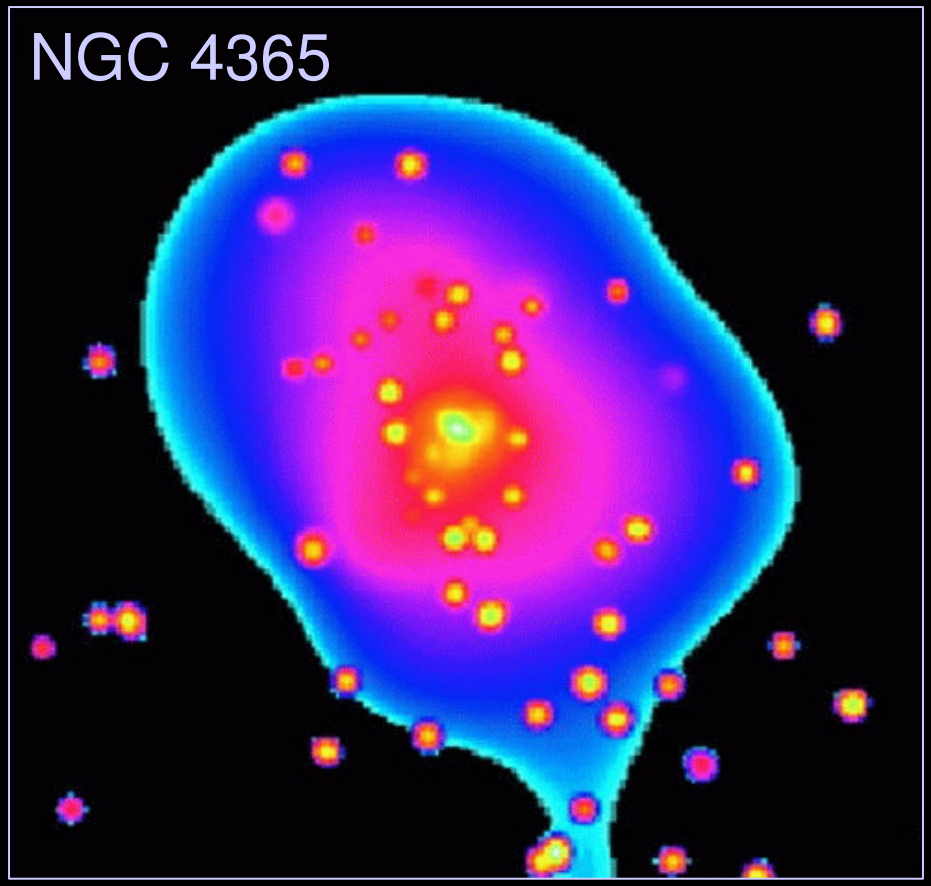
- Long-term PN.Spectrograph program on WHT
  (Douglas et al.)
- Various GCs projects (VLT, Magellan, Gemini)
- *Chandra* archive grant, new *XMM-Newton* data
  (O'Sullivan et al.)

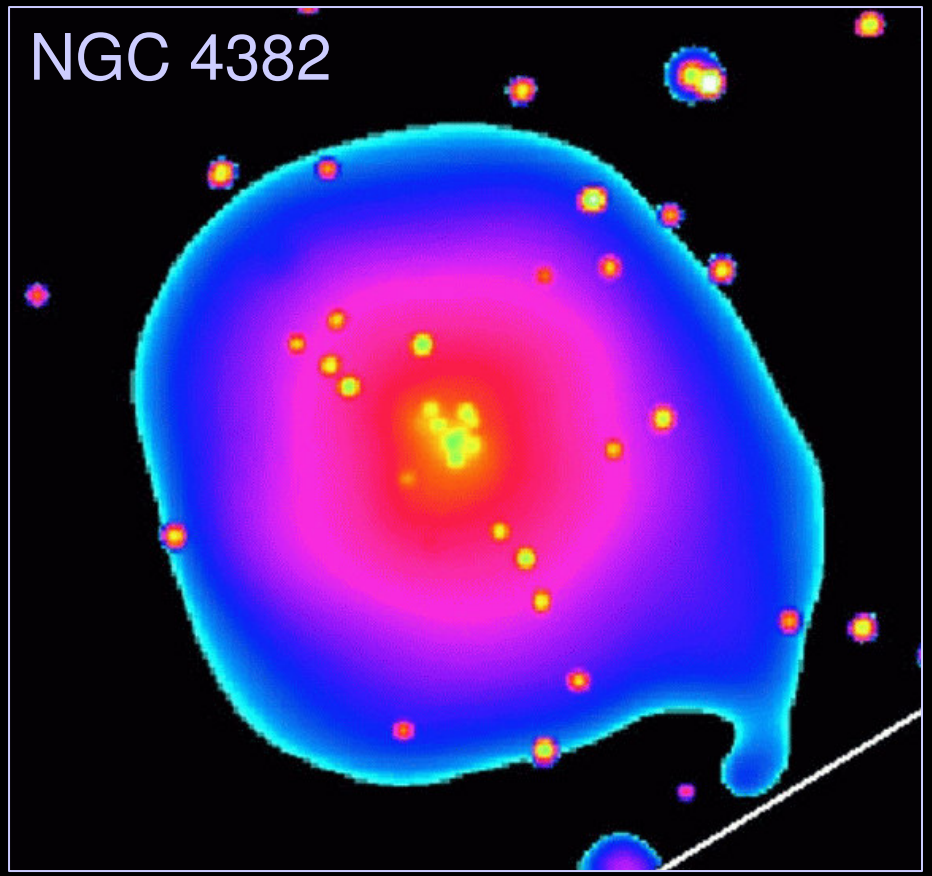
Probing E halos with X-ray emission

Chandra, *XMM-Newton*: large area, high angular resol´n

$\Rightarrow$ determine $T(r)$, subtract pt. sources, check equilibrium

$\Rightarrow$ important to **not** select on L_X (biased mass result!)





Chandra ACIS-S (Sivakoff, Sarazin & Irwin 2003)

Globular Clusters in NGC 1399

D=19 Mpc, M_B=-21.1

Fornax central E1

VLT+FORS2/MXU,

Gemini-S+GMOS:

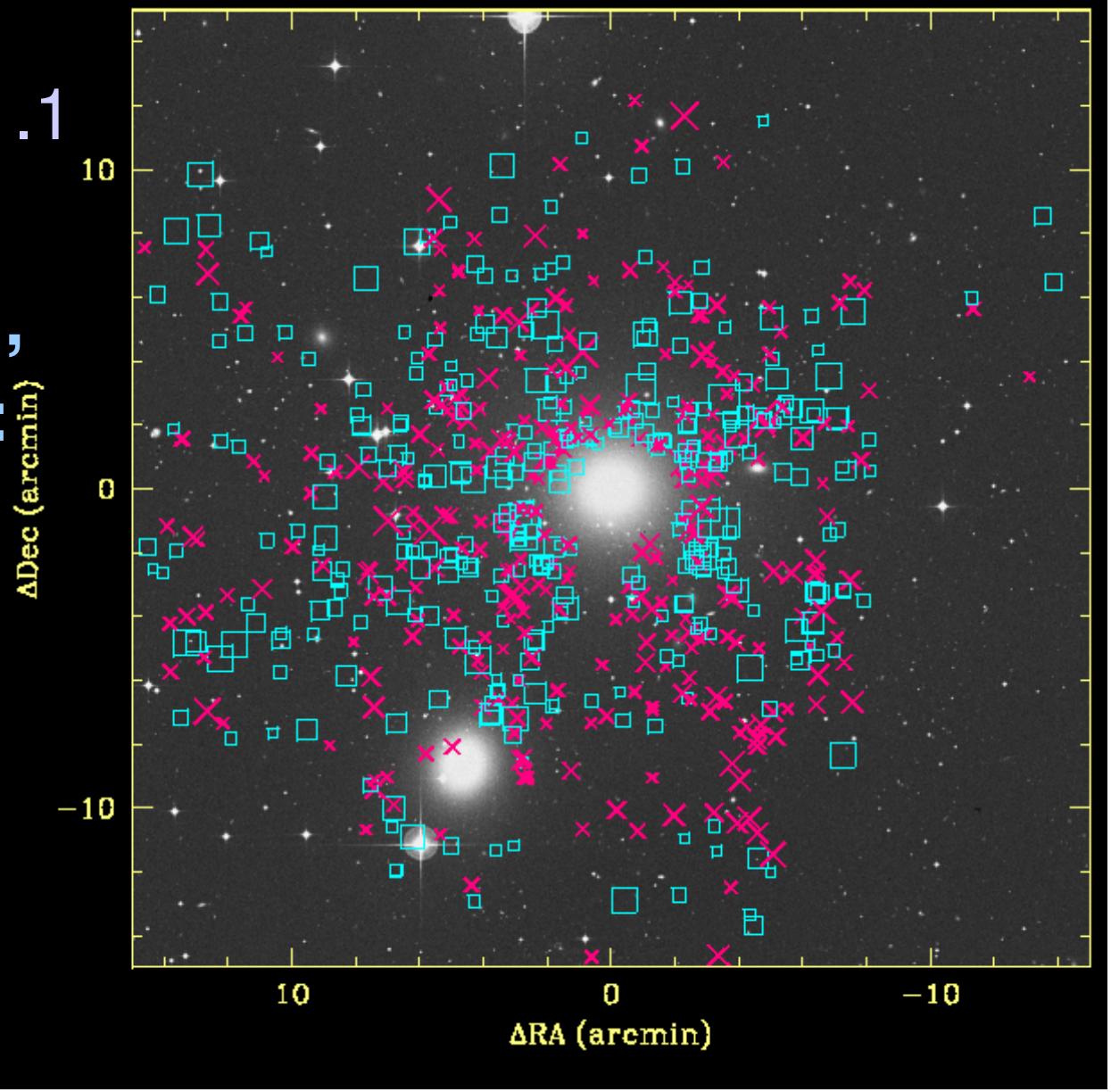
Nov/Dec 2000,

Nov/Dec 2002,

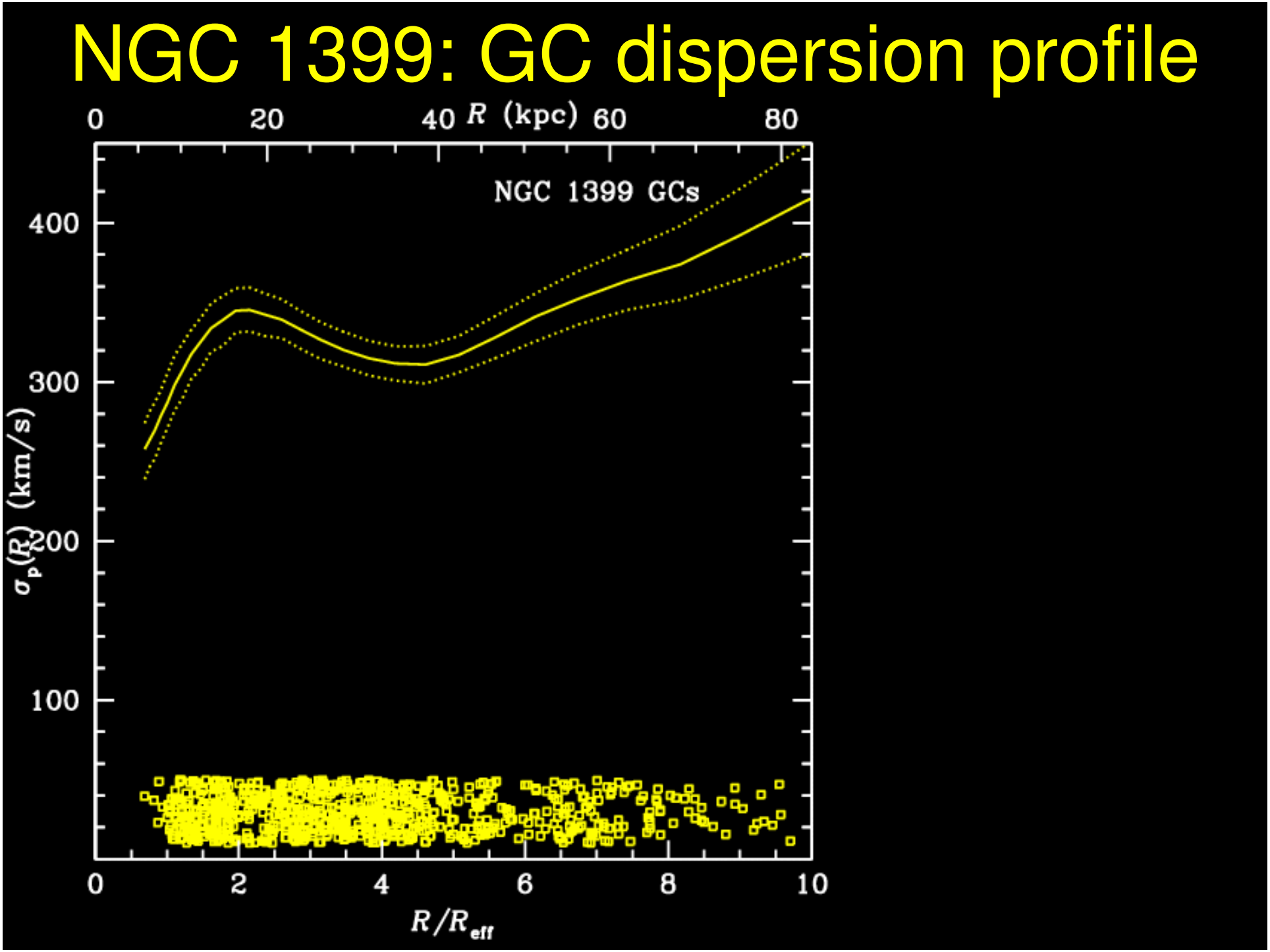
Nov/Dec 2004

(Richtler et al.)

>700 velocities
to 90 kpc,
Δv = 20-100 km/s



NGC 1399: GC dispersion profile



M87: Dispersion profiles

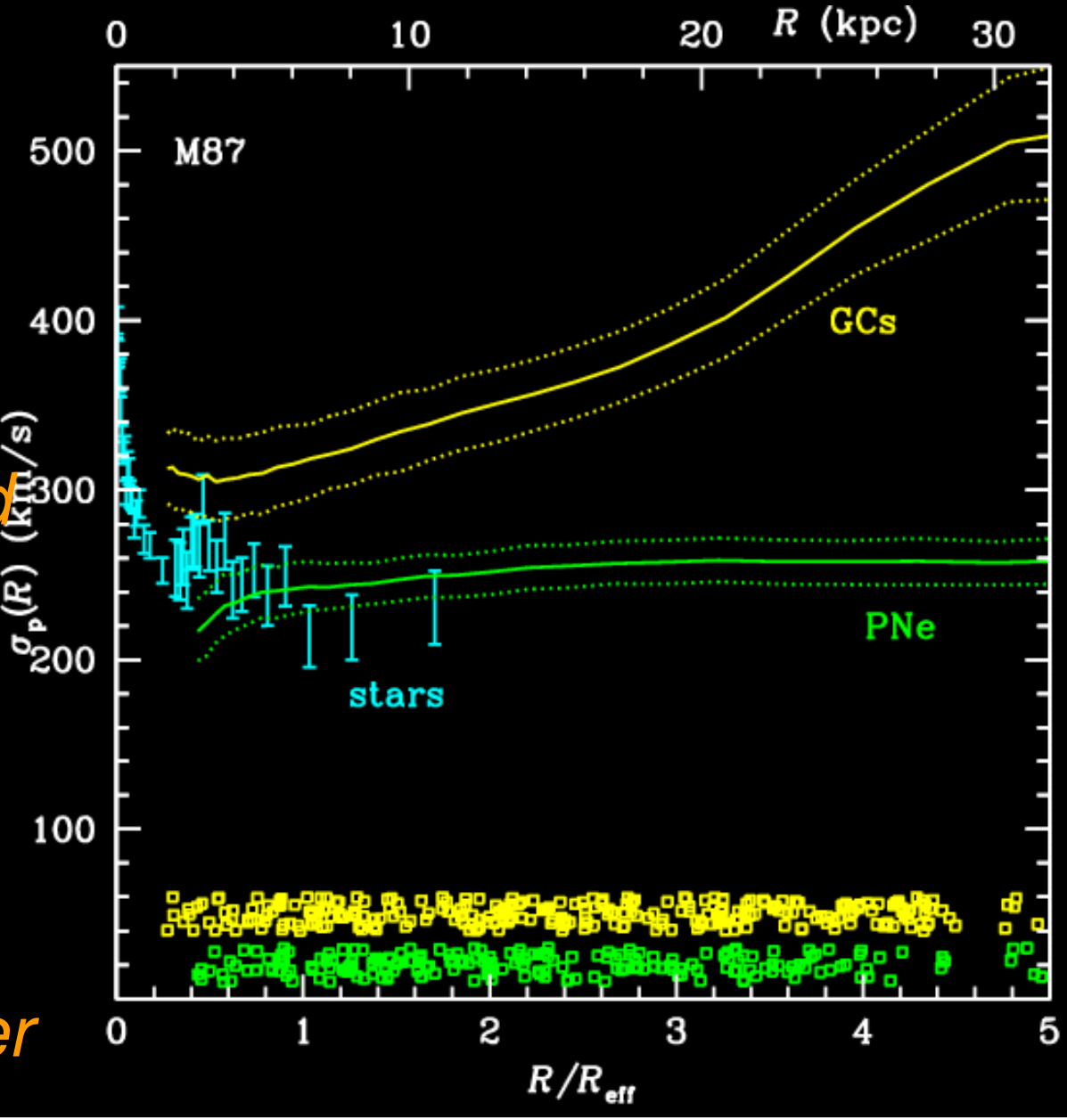
PNe consistent with long-slit data

PN $\sigma_p(R)$ constant or rising with R

dark halo indicated

PNe have lower $\sigma_p(R)$ than GCs (Hanes et al. 2001)

PN, GC orbits differ



M87: Modeled circular velocity profile

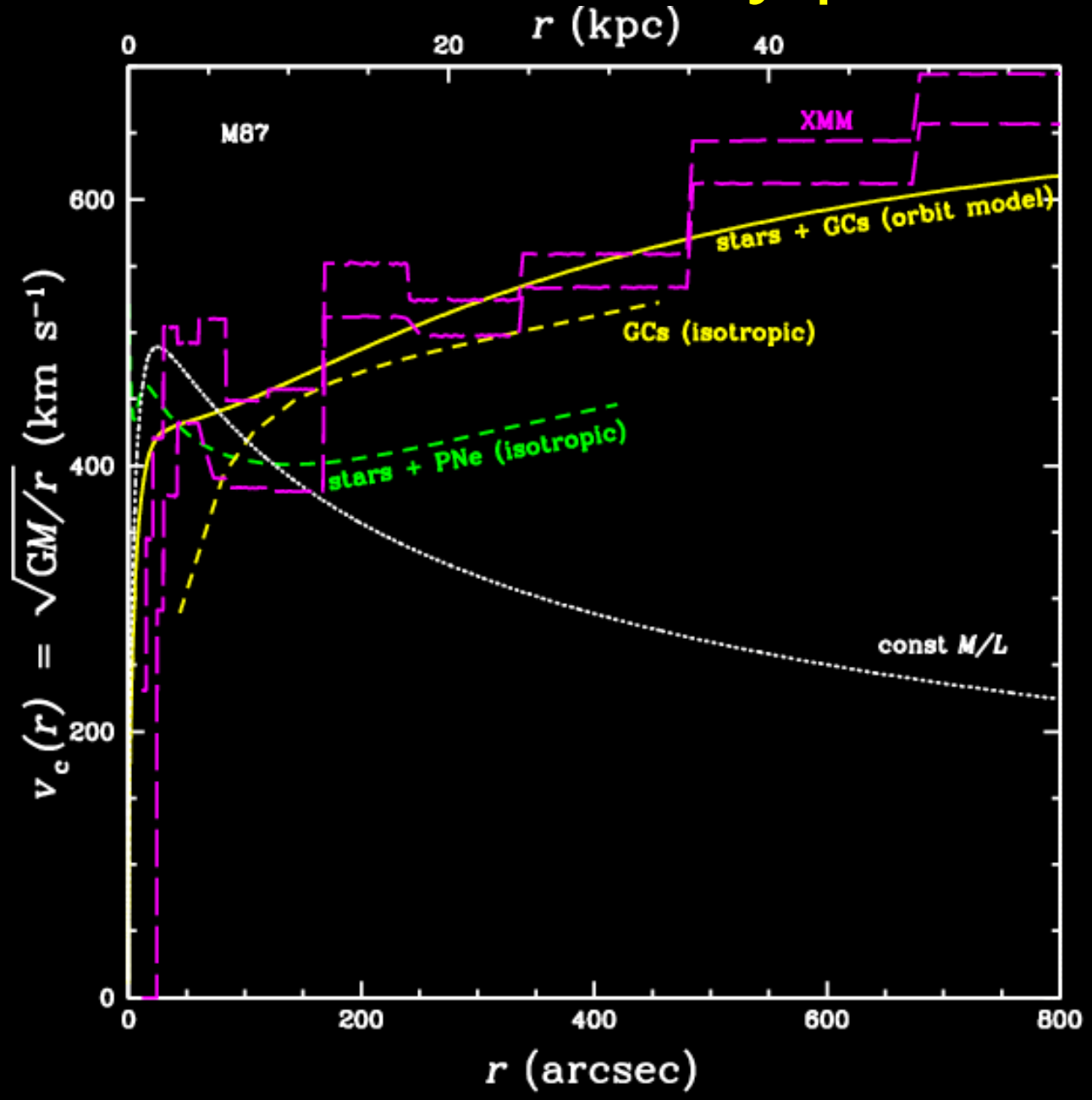
Stars + 234 GCs
(Romanowsky & Kochanek 2001)

XMM-Newton
(Matsushita et al. 2002)

⇒ ***good agreement***

Stars + 200 PNs
(Douglas et al.)

⇒ ***strong stellar anisotropy***



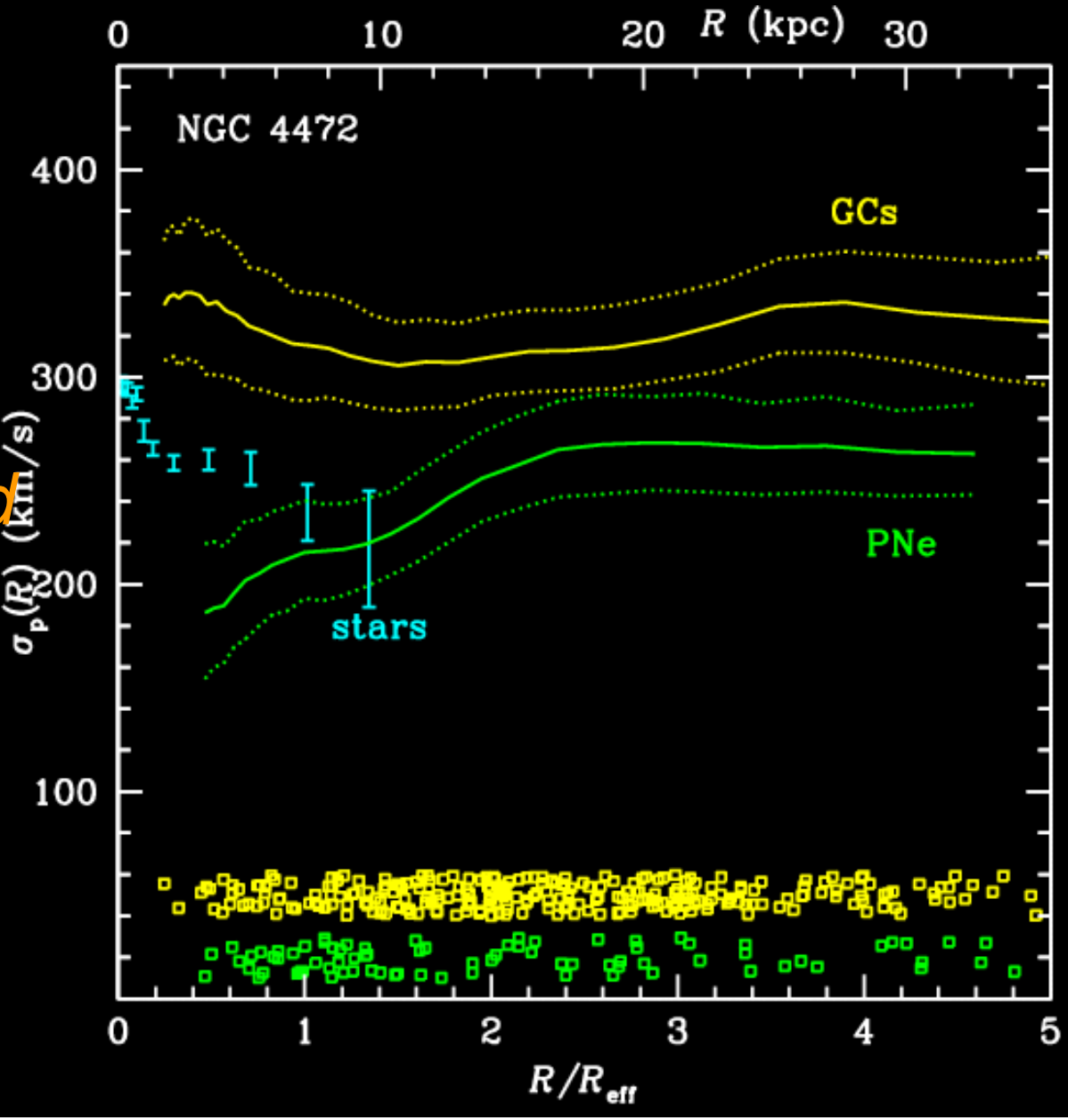
NGC 4472: Dispersion profiles

PNe consistent with long-slit data

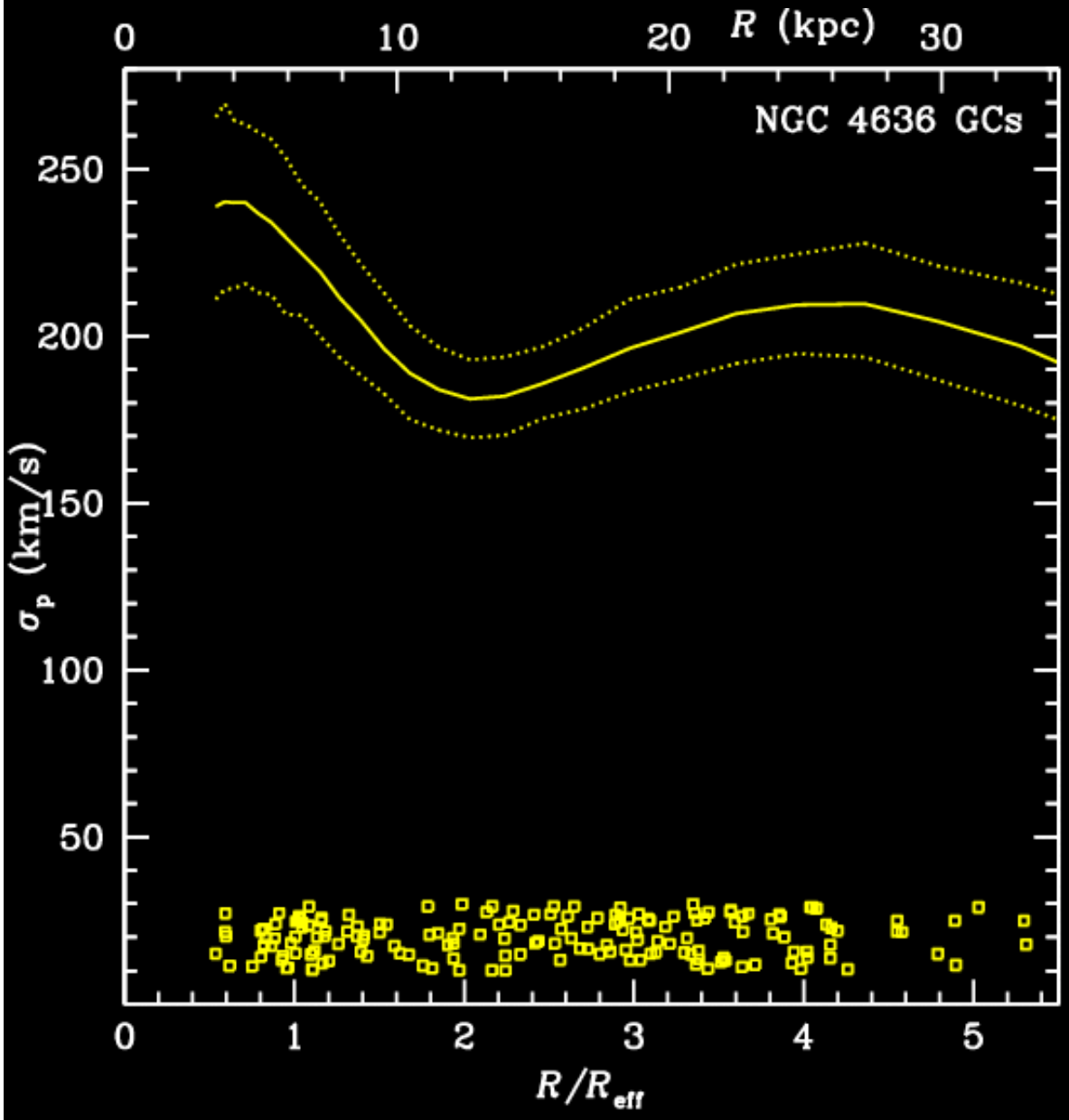
PN $\sigma_p(R)$ constant or rising with R

dark halo indicated

PNe have similar $\sigma_p(R)$ to GCs (Zepf et al. 2000)



NGC 4636: GC dispersion profile



174 GC velocities w/VLT+FORS2/MXU:

roughly constant velocity dispersion

lower halo mass than Chandra results
(Schuberth et al.)

GCs in NGC 1407 (Eri A group)

E1 , M_B = -21.6

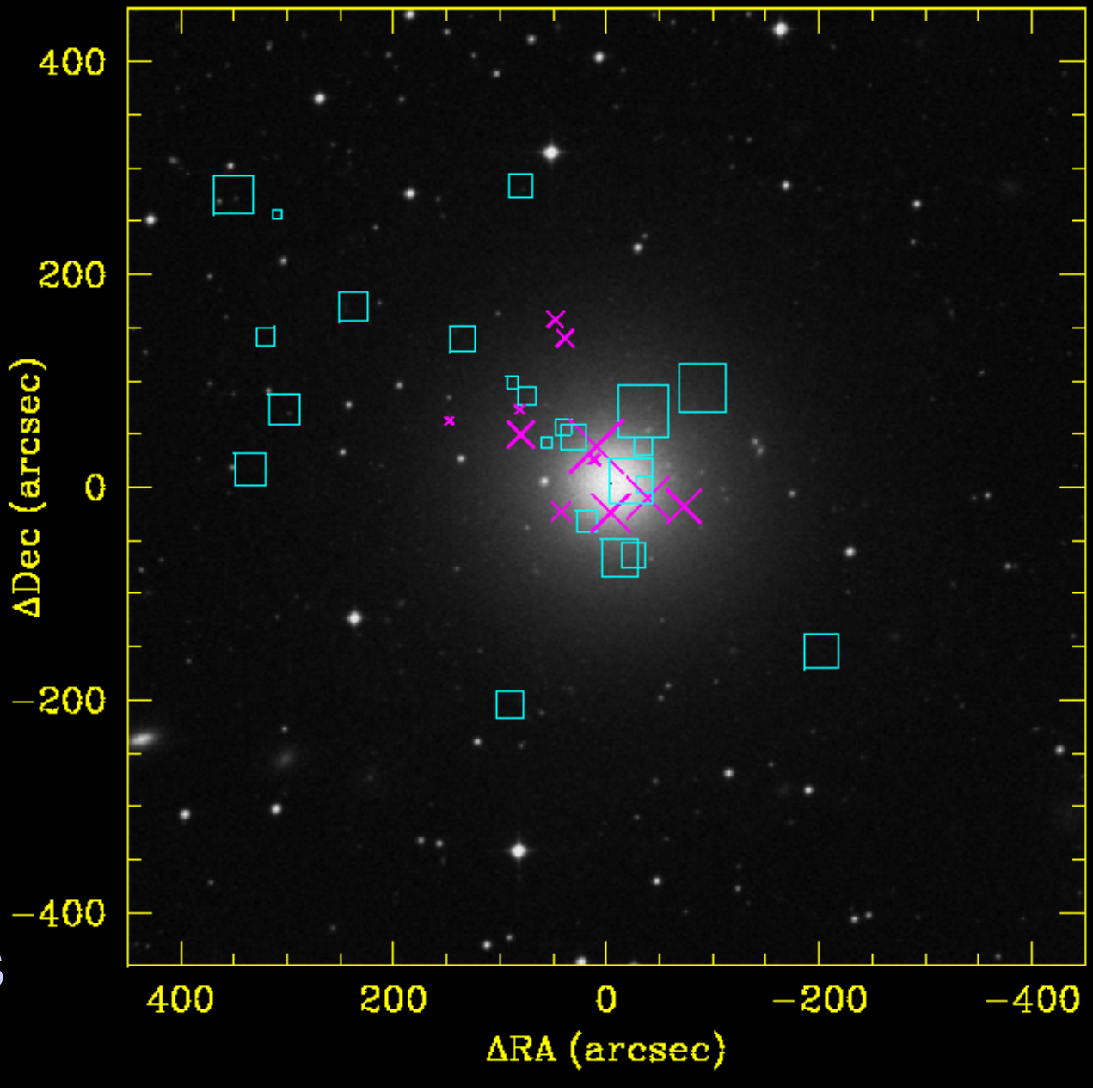
***D* = 27 Mpc**

VLT+FLAMES/ GIRAFFE, Keck+LRIS:

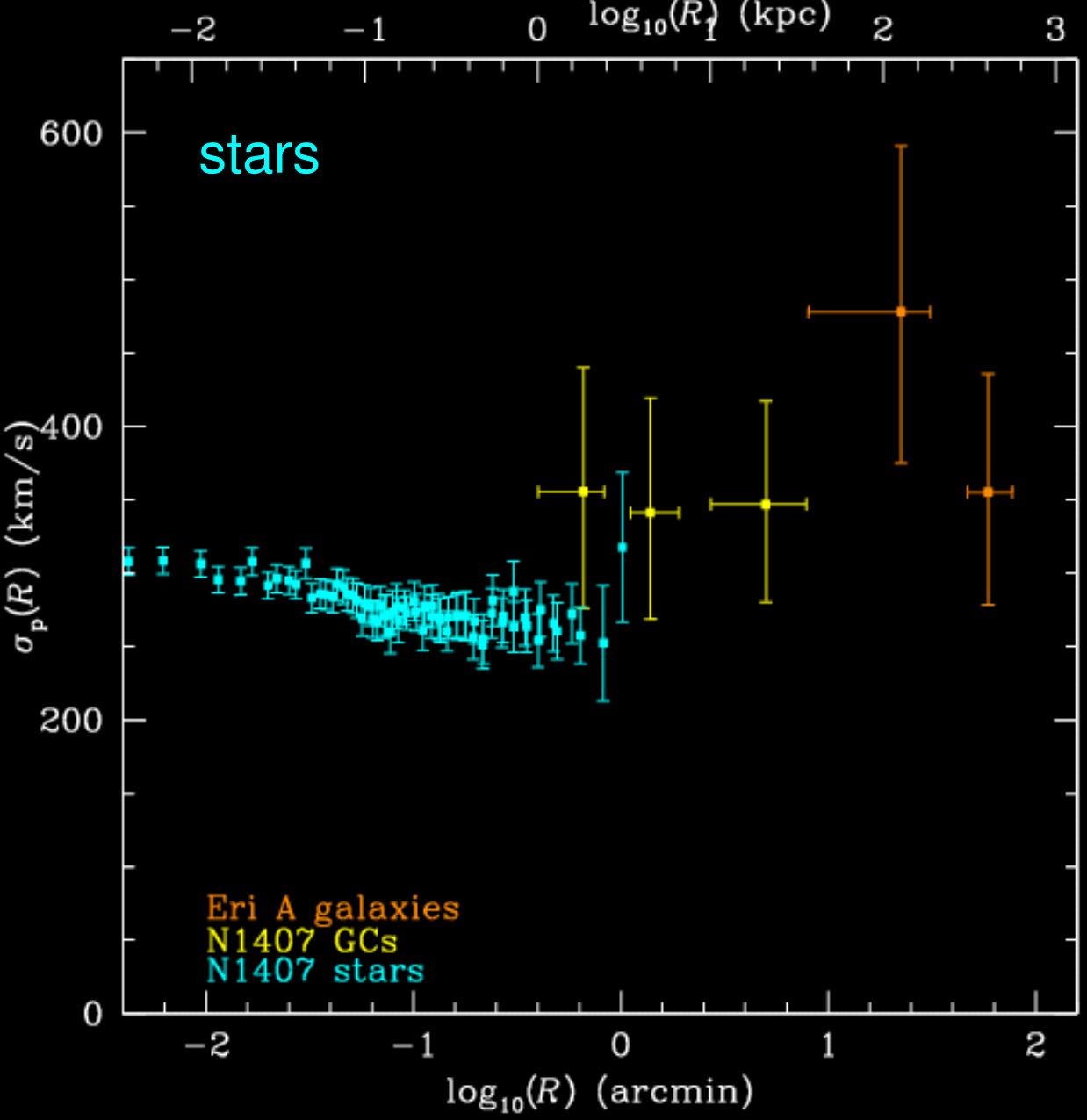
Nov 2004

35 GC velocities

Δv = 15-30 km/s



NGC 1407: GC dispersion profile



PNe in NGC 3379

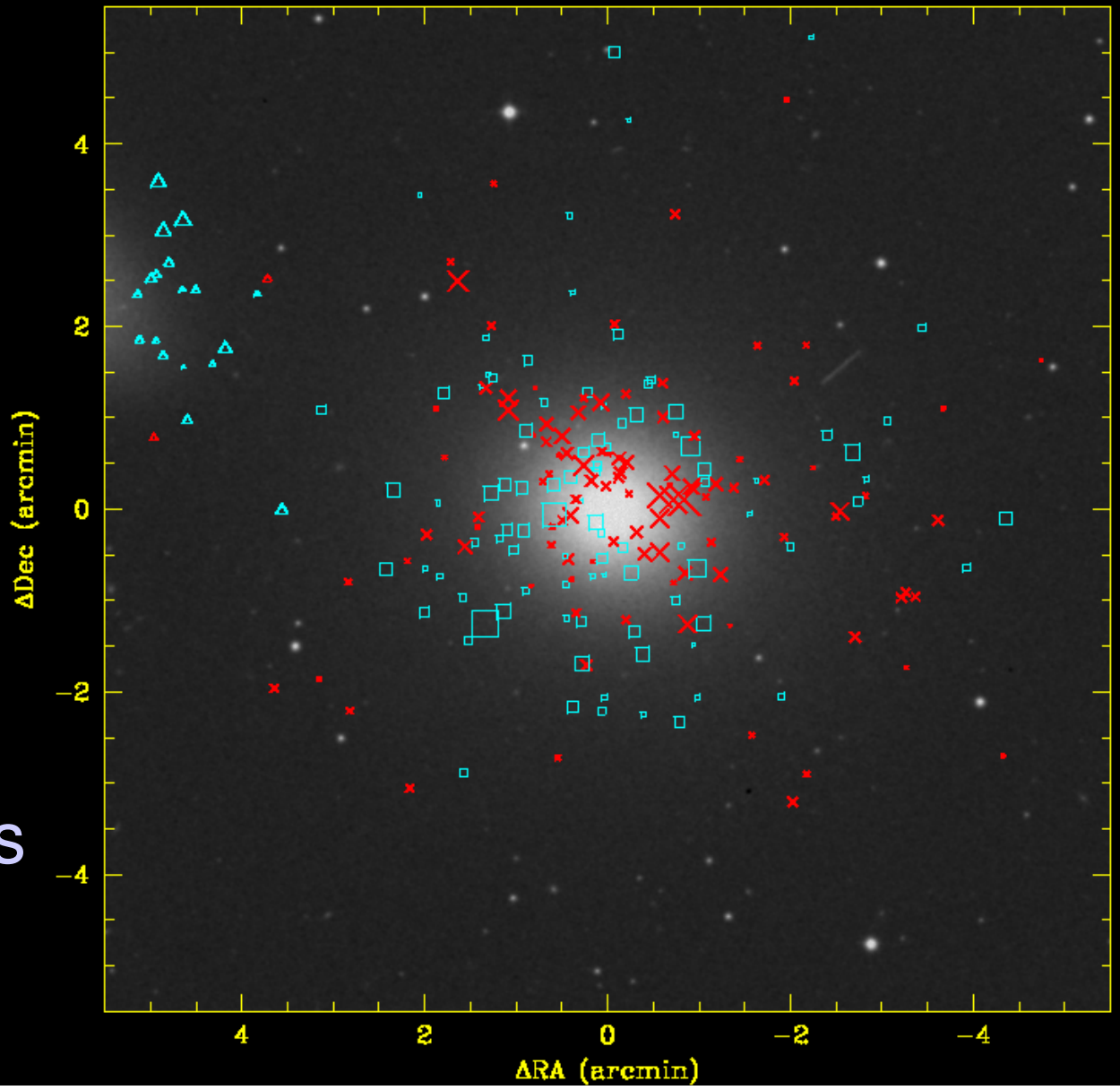
E1 , M_B = -20.0

D = 11 Mpc.

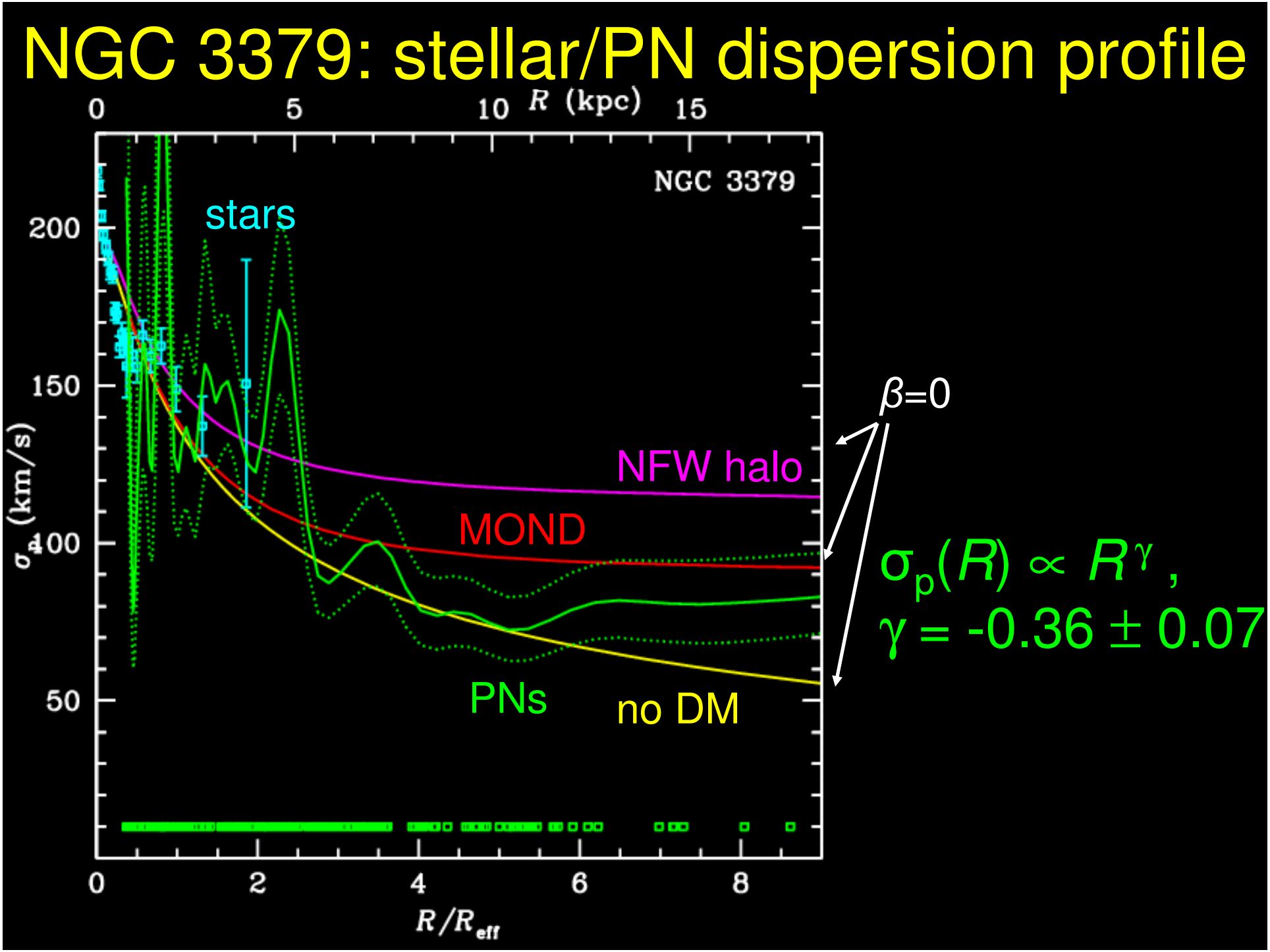
Leo I central

WHT+PN.S:
March 2002
3 hrs :

197 PN velocities
to 7 R_{eff} ,
Δv = 20 km/s



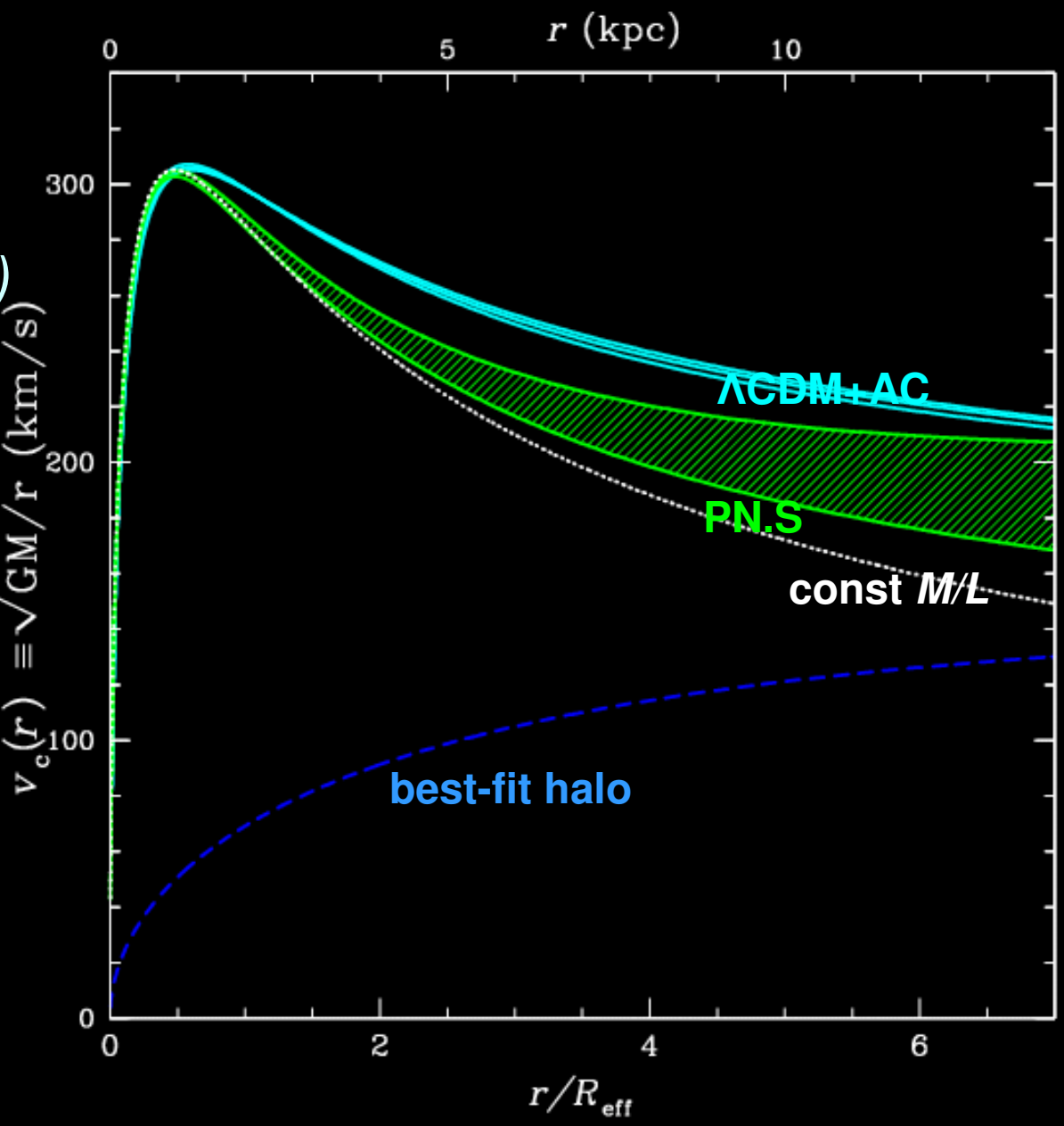
NGC 3379: stellar/PN dispersion profile



NGC 3379 : circular velocity profile

Orbit models include variable anisotropy!
(find β ~ -0.3 → +0.5)

- cumulative *M/L*
  at 5 $R_{\rm eff}$:
  $\Upsilon_{B5} = 7.1 \pm 0.6\ \Upsilon_{B,\odot}$
- DM fraction
  inside $R_{\rm eff}$ ~ 3%



GCs in NGC 3379

E1 , M_B = -19.9

***D* = 10 Mpc**

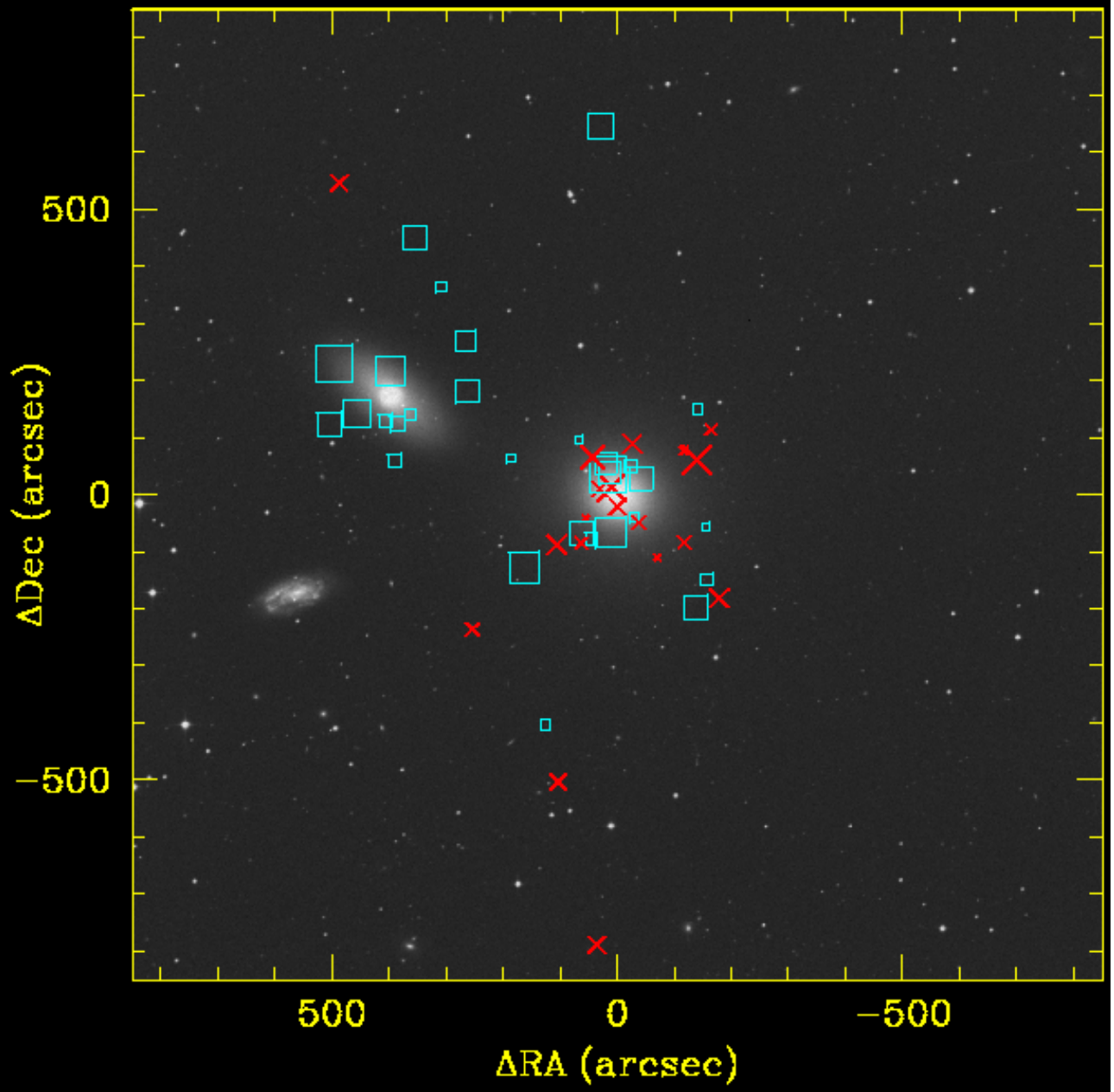
UT2+FLAMES/ GIRAFFE:

May-Jul 2003

5 hours :

34 GC velocities

Δv = 5-15 km/s

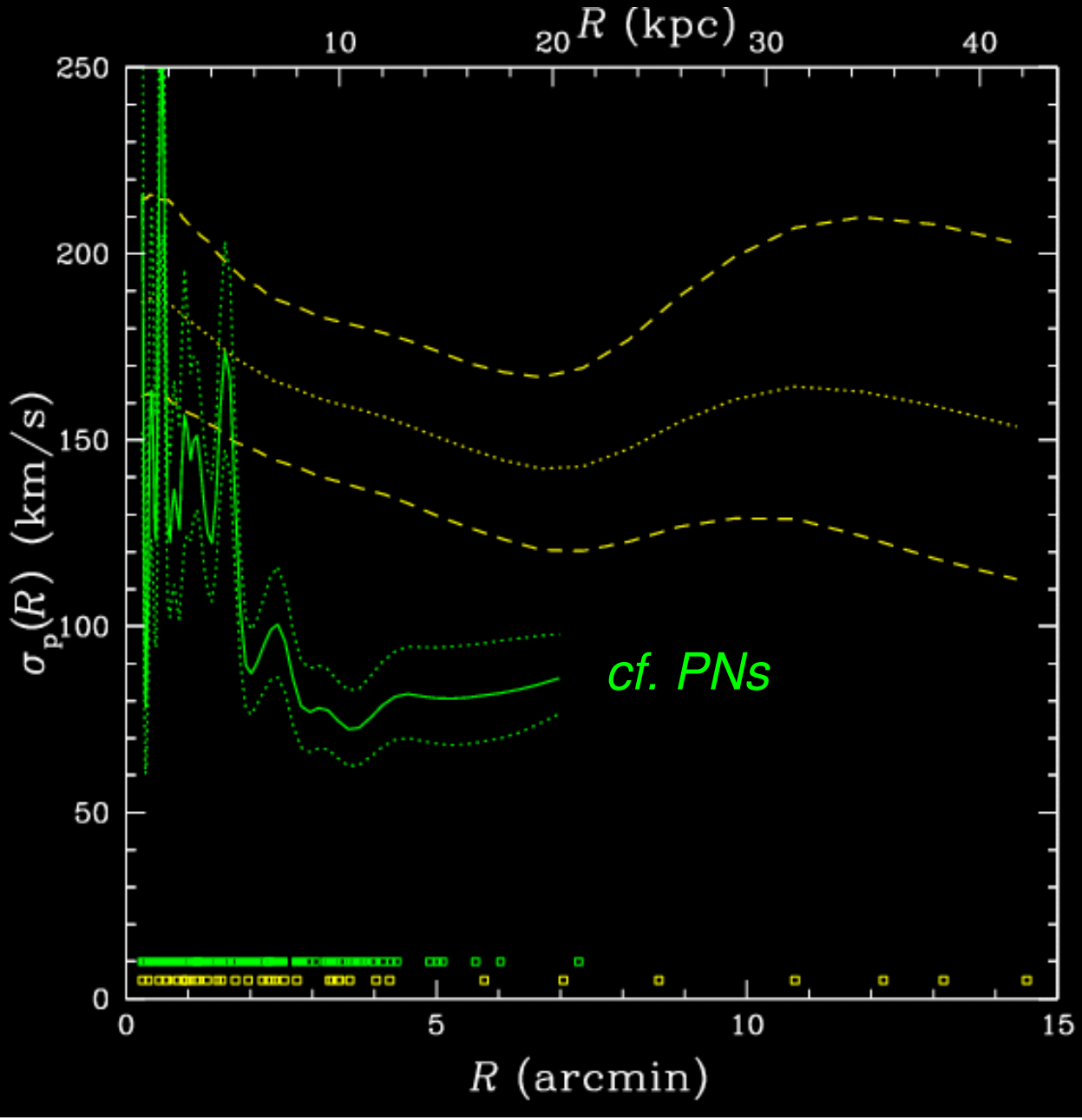


NGC 3379 : GCS dispersion profile

Weakly declining dispersion:

$\sigma_p(R) \propto R^{\gamma}$,
$\gamma = -0.13 \pm 0.12$

Due largely to different N(R) , β(r)



NGC 3379 : GCS dynamics

Model predictions vs. data *(isotropy)*

GCs data

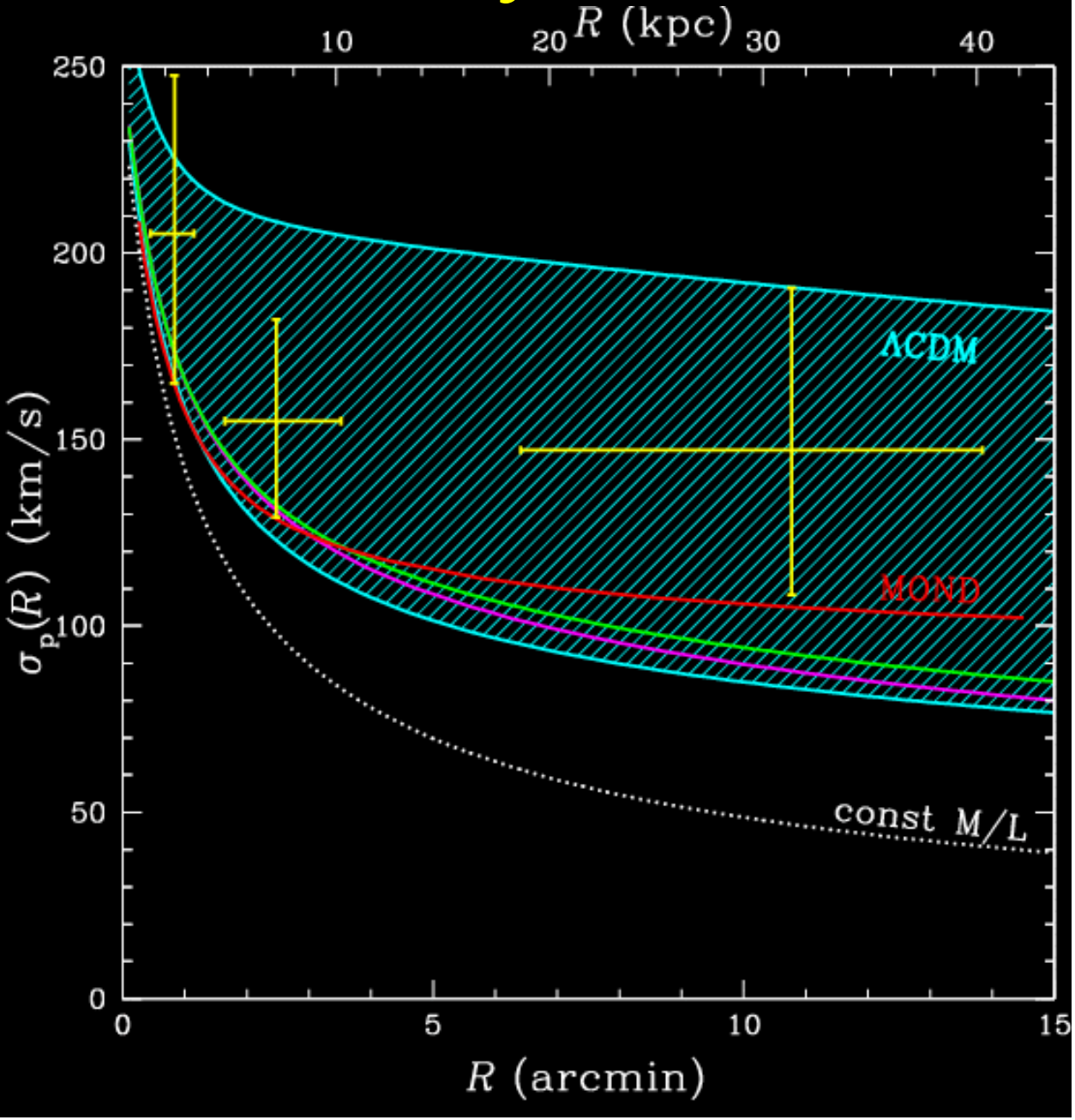
ΛCDM

Best PNs + ΛCDM

Best HI ring + ΛCDM

MOND

const *M/L*

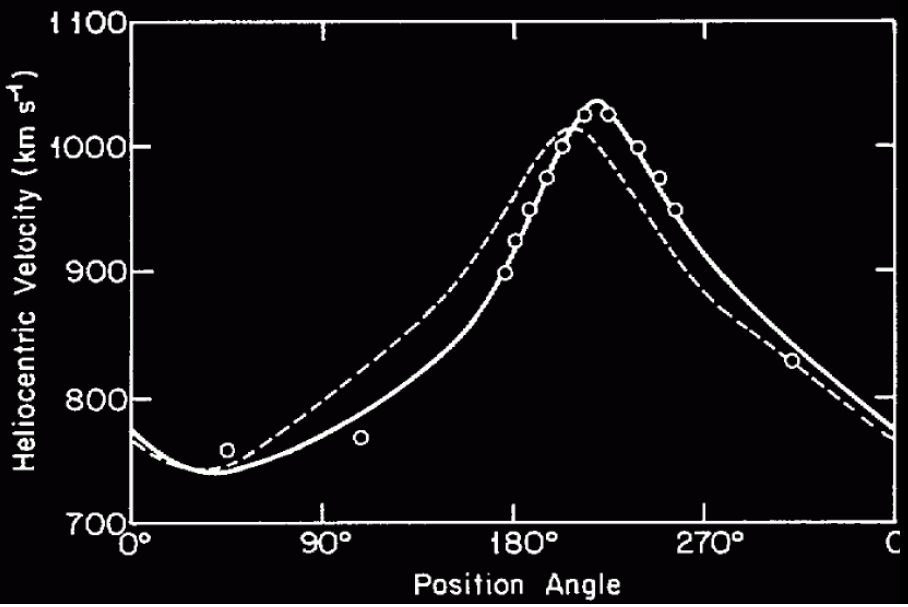


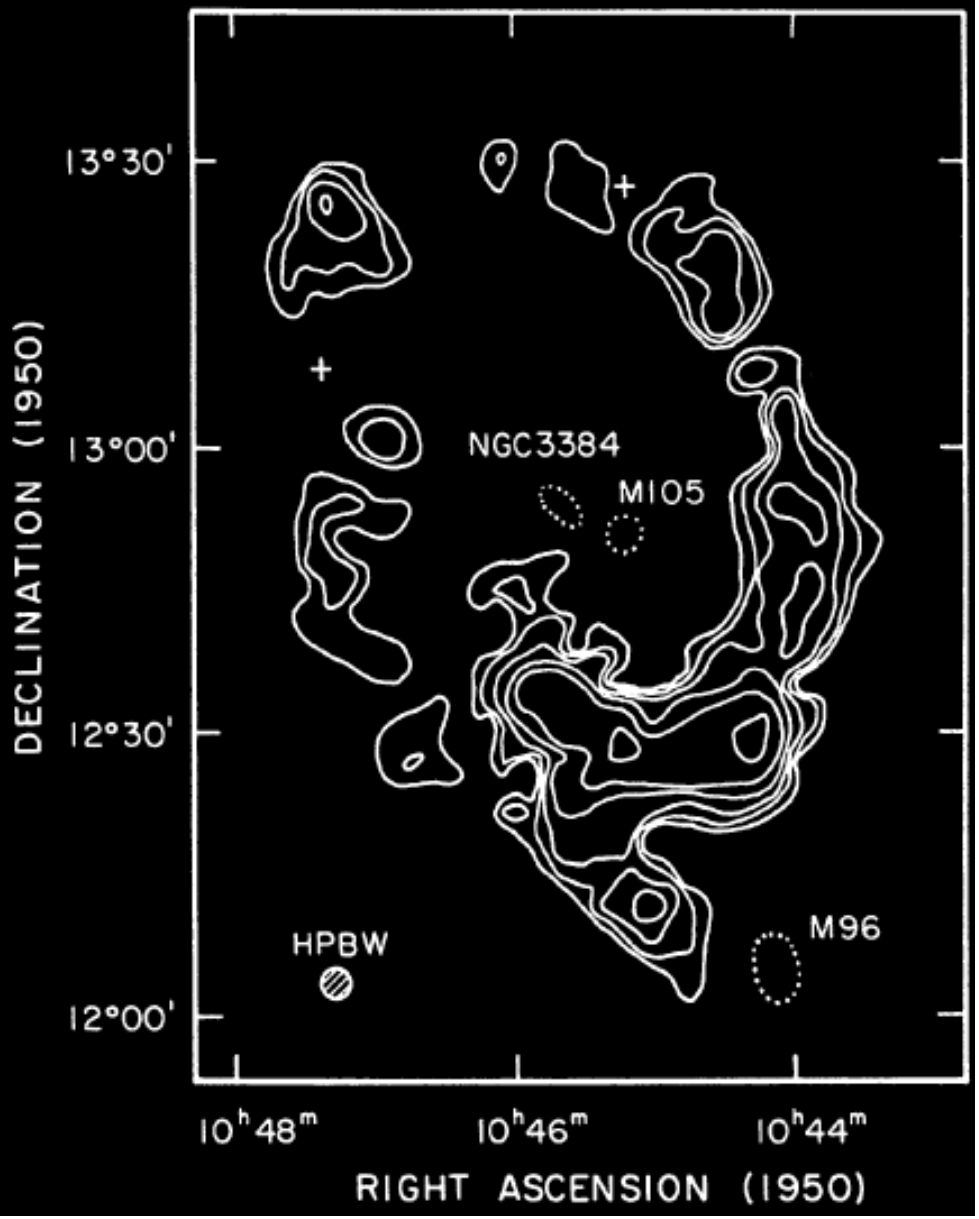
NGC 3379: HI gas ring

Mass measurement
N3379 + N3384:

M/L_B (100 kpc) = 27 ± 5
(Schneider 1985)

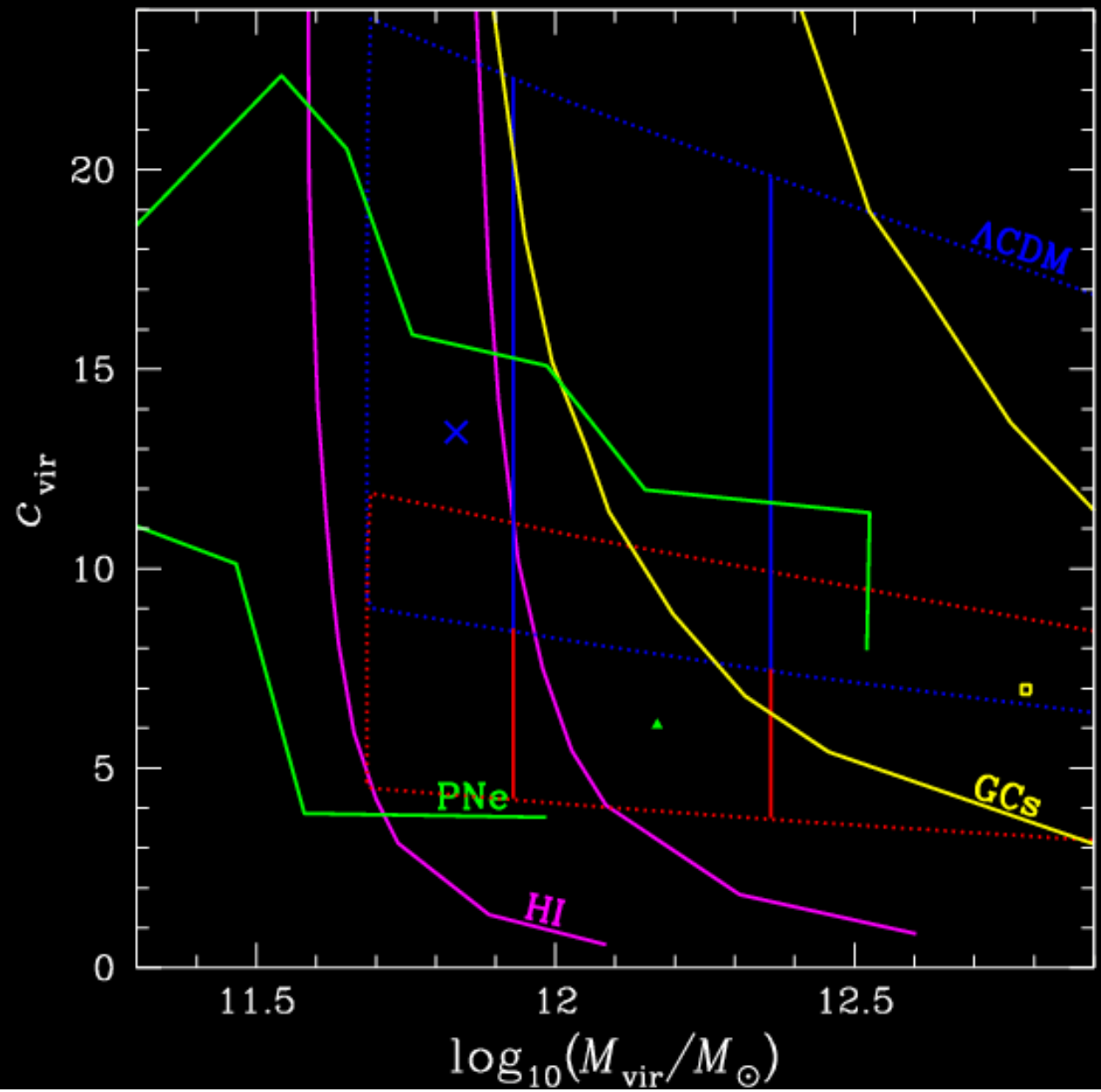
Not consistent with group-mass halo





NGC 3379 : Constraints on halo

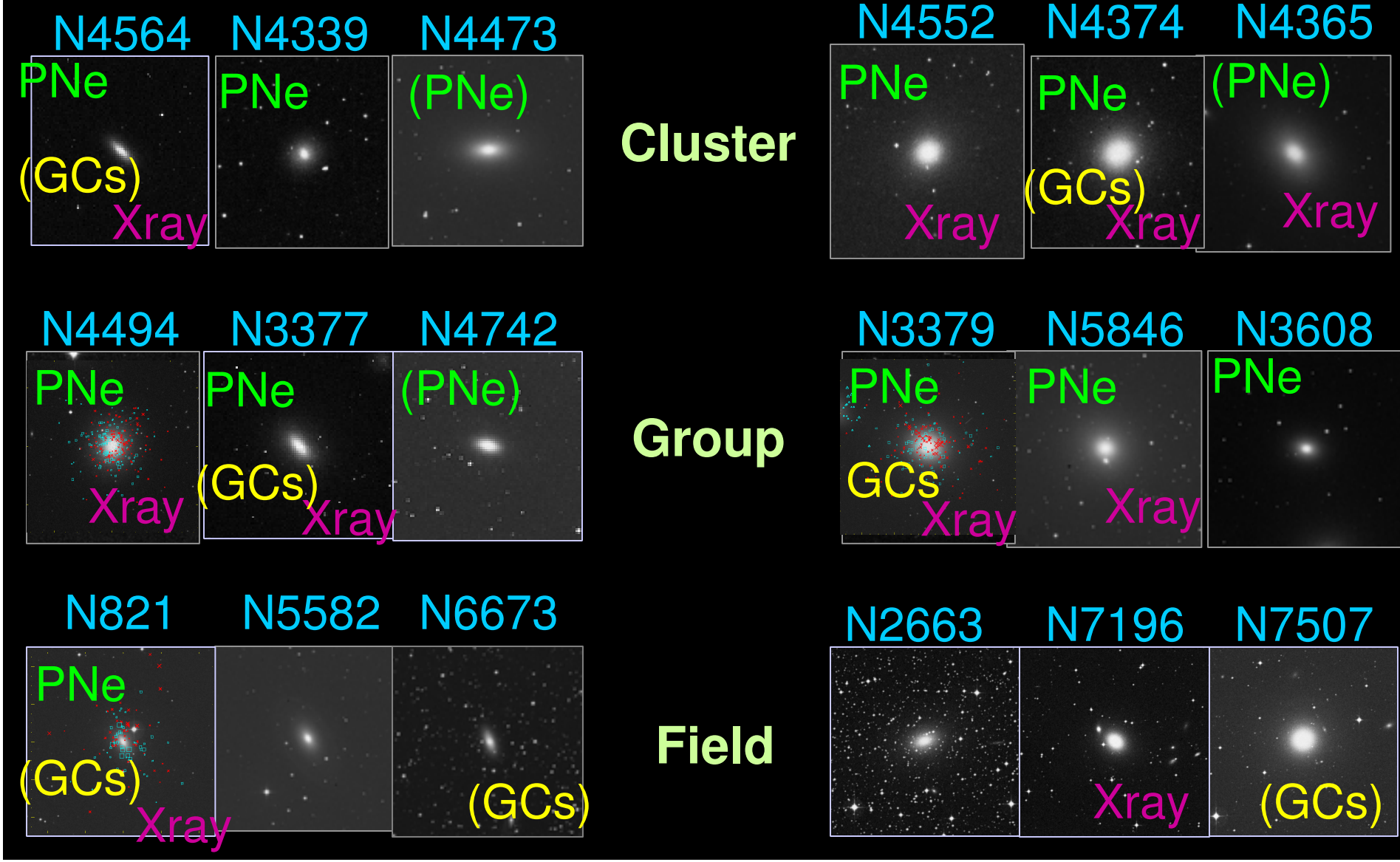
Problem for consensus solution: HI and GCs not consistent



"Ordinary" (~L^*) elliptical galaxy sample

Family 1 ***(disky/faint)***

Family 2 ***(boxy/bright)***



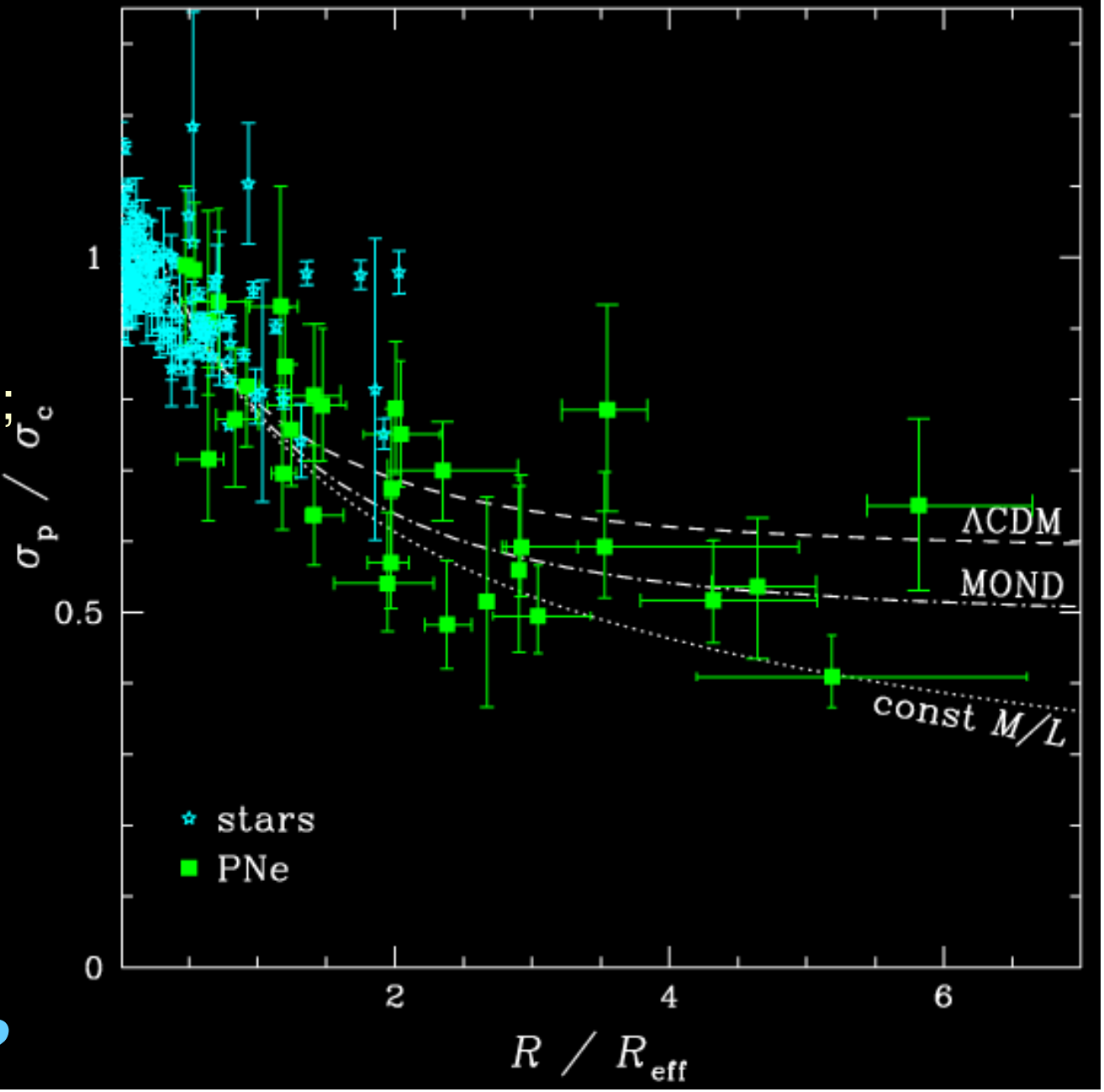
Extended stellar/PN dispersion profiles

5 “normal” (*L**) ellipticals:

$\sigma_p(R)$ declining with R

(Ciardullo et al. 1993; Méndez et al. 2001; Romanowsky et al. 2003; Teodorescu et al. 2005)

Population of ordinary ellipticals with low DM content?



M/L gradient parameter

$\nabla'\Upsilon_\ell$: logarithmic radial gradient of *M/L*

$$\nabla\Upsilon_\ell \equiv \frac{R_{\rm e}}{\Delta r}\left[\left(\frac{M_{\rm d}}{M_*}\right)_{\rm out} - \left(\frac{M_{\rm d}}{M_*}\right)_{\rm in}\right] = \frac{R_e \Delta\Upsilon}{\Upsilon_{\rm in}\Delta r}$$

theoretical quantity *empirical quantity*

$\nabla'\Upsilon_\ell$: independent of bandpass, distance;

insensitive to measurement radii ($r_{\rm in}$, $r_{\rm out}$)

ΛCDM predictions (f_b=0.17, σ_8=0.9)

$\nabla' \Upsilon_\ell$:

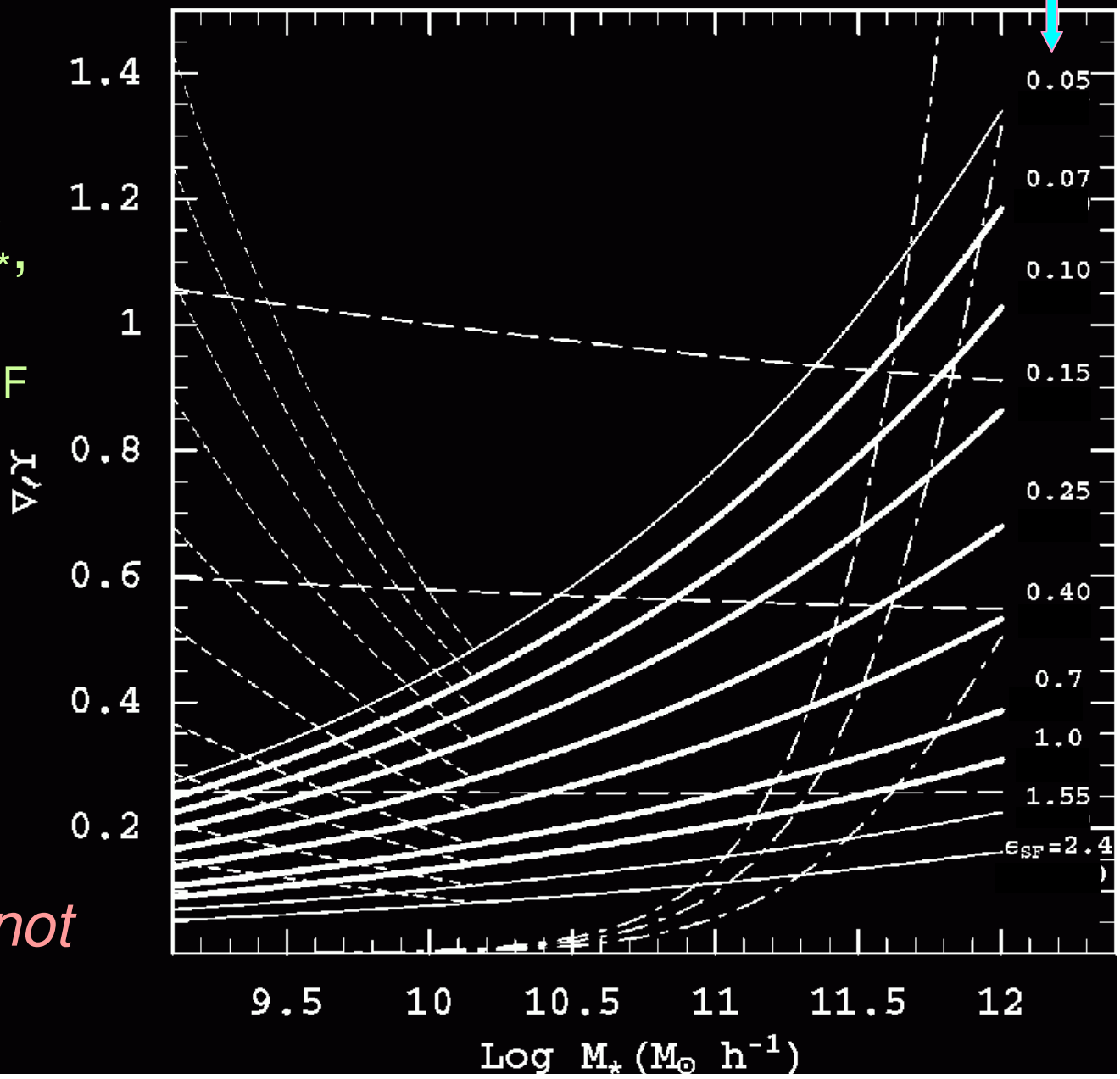
increases with M_*,

decreases with ε_{SF}

Sensitive to

M_*-R_e relation

Valid statistically, not individually



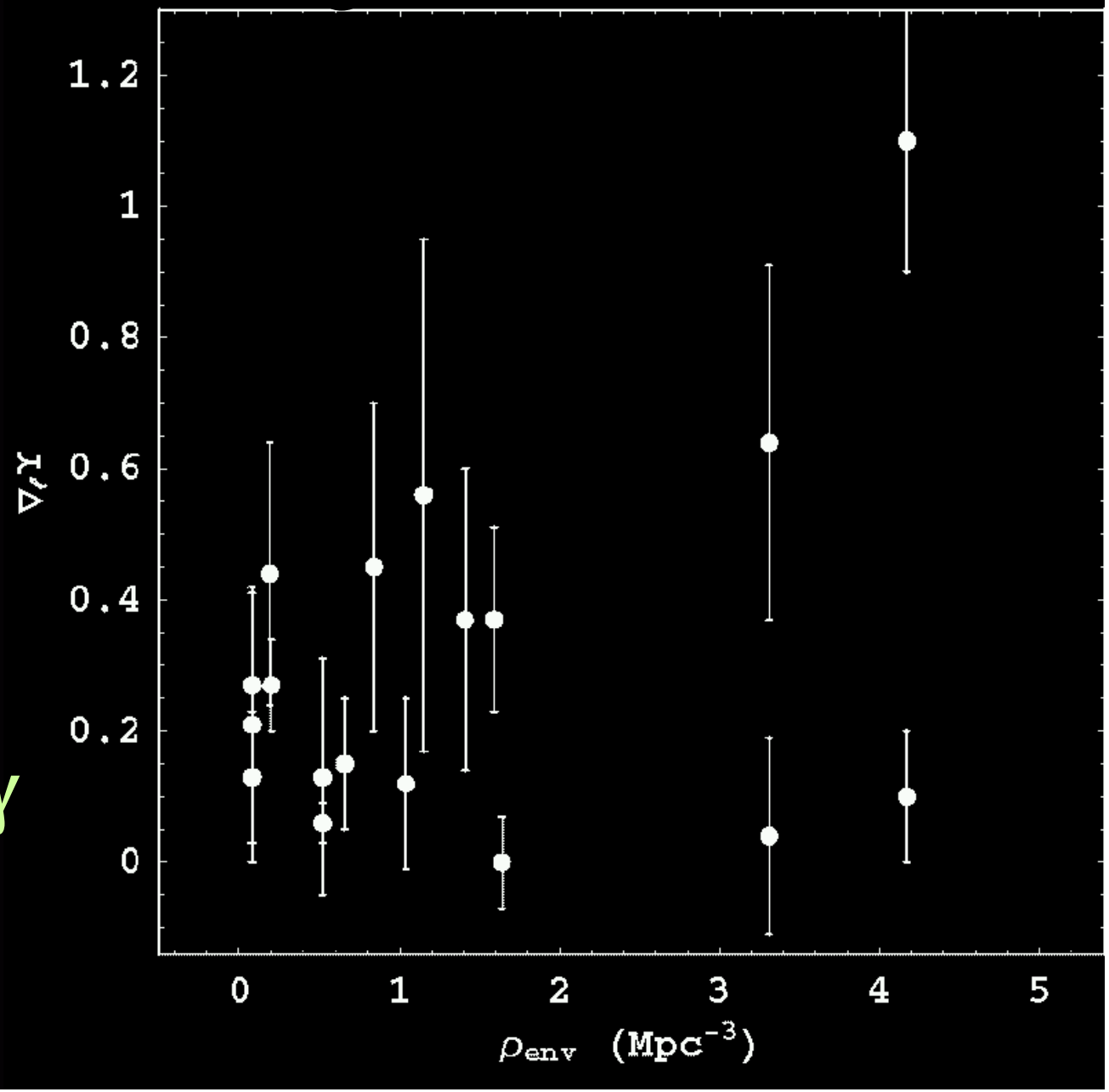
Empirical gradients

Sample of 21 Es, S0s

***M/L* from stars, PNe, GCs**

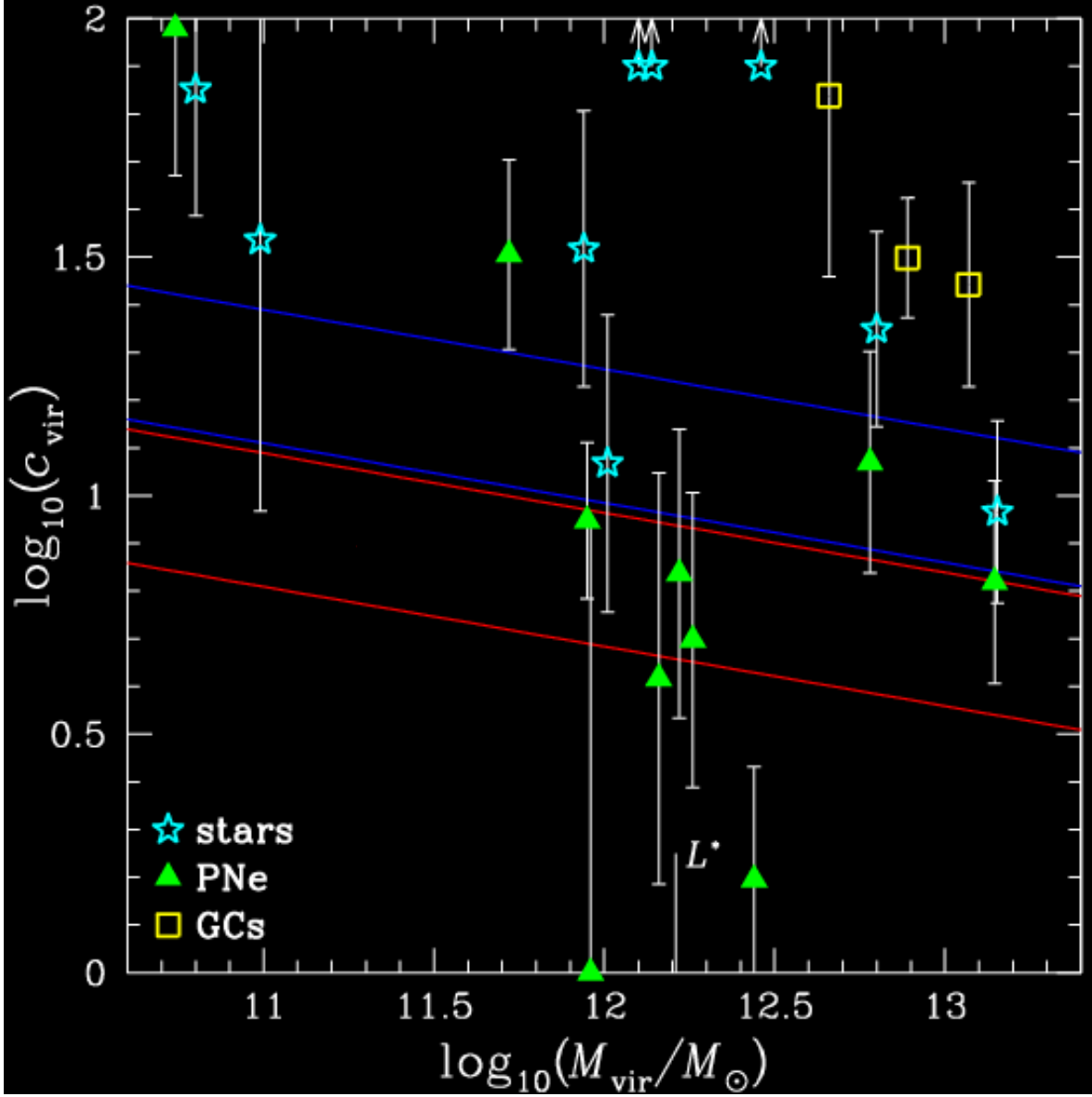
Significant correlations between $\nabla' \Upsilon_\ell$ & M_B , M_* , a_4 , γ

Not with $\rho_{\rm env}$



Low concentration halos?

(after Napolitano et al. 2005)

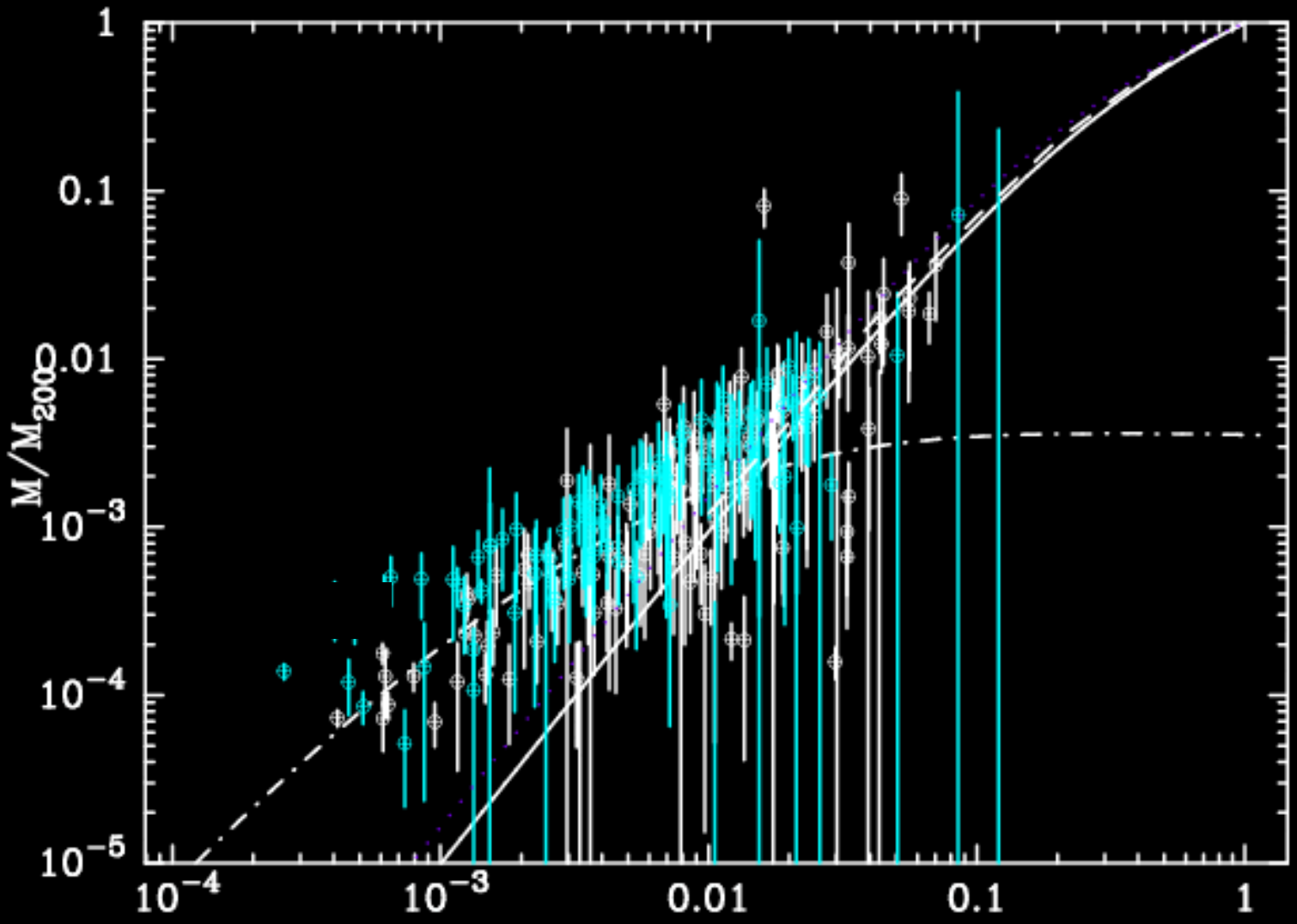


Fits to ∇´Υ data assuming ΛCDM HOD (van den Bosch et al. 2003)

ΛCDM (Bullock et al. 2001)

0.5 $c_{\rm vir}$ (e.g. ΛWDM)

Low concentration halos?



Chandra/XMM galaxy sample:

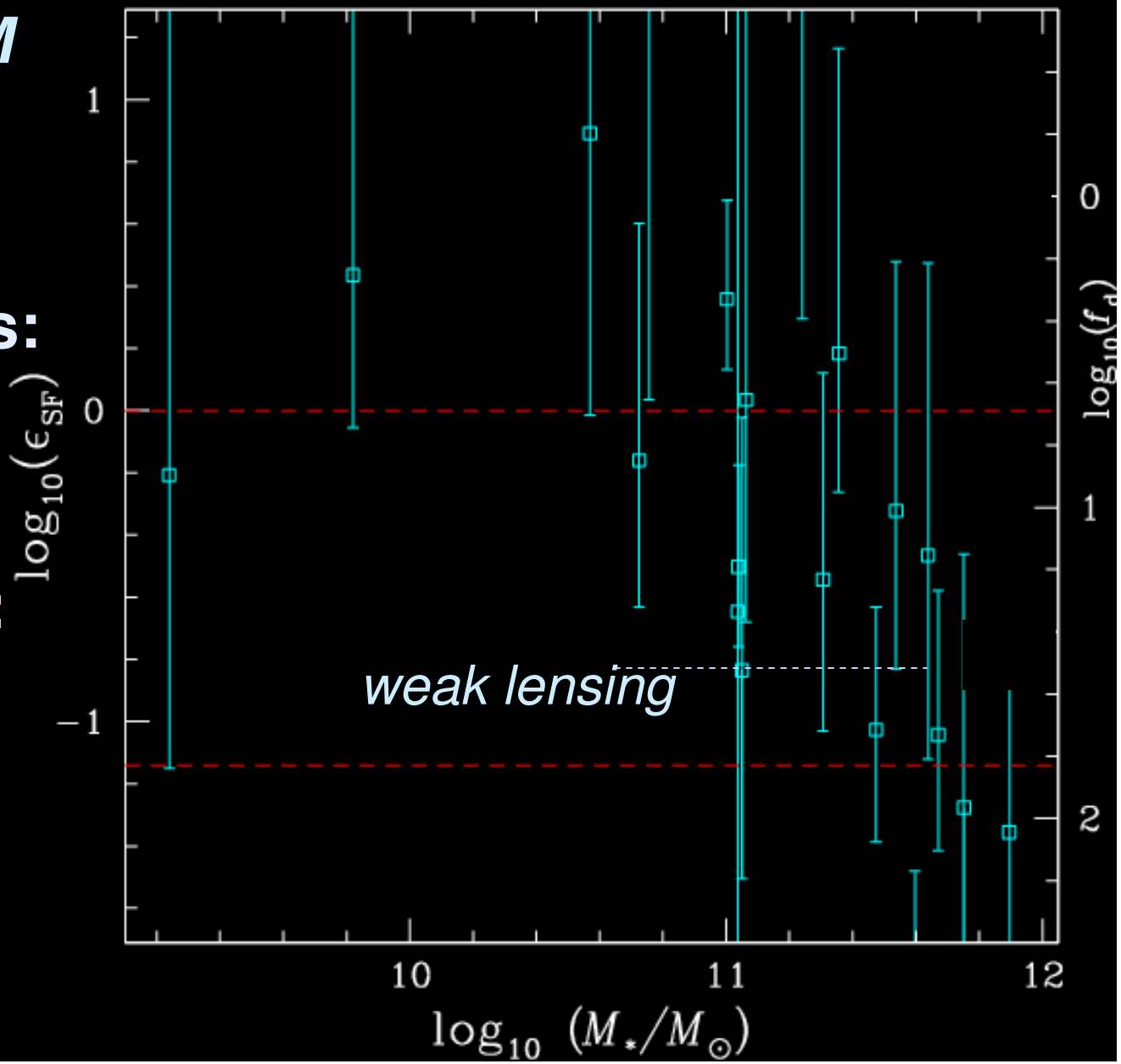
c ~ 2-4 (~ cluster concentrations) (Fukazawa et al. 2006)

Results for star formation efficiency

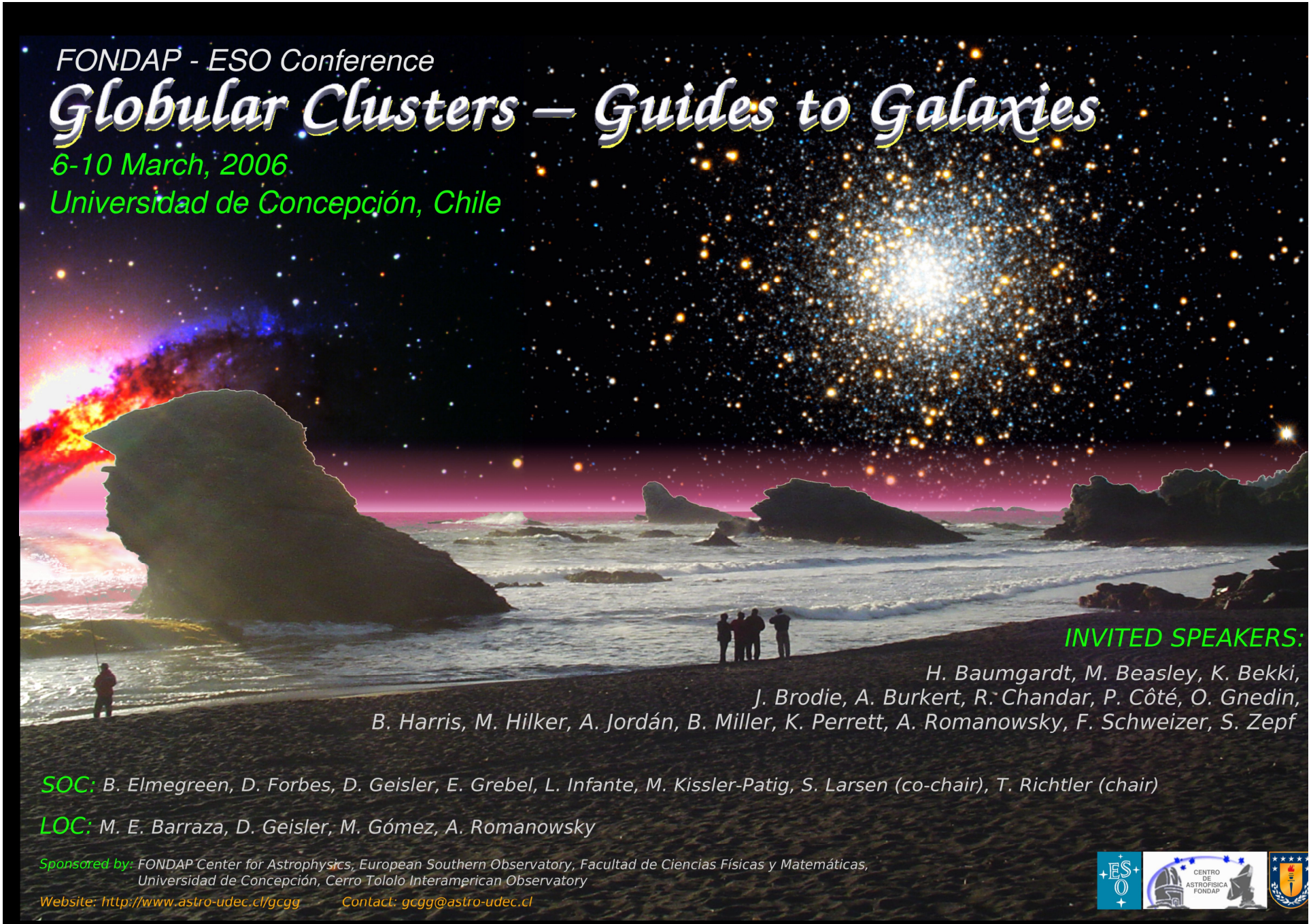
Assuming LCDM concentrations:

Brighter galaxies: reasonable ε_{SF}

Fainter galaxies: some $\varepsilon_{SF} > 1$ ($f_b > 0.17$)




NEXT CONFERENCE:
"GROUPS OF GUANACOS IN THE NEARBY UNIVERSE" ?!



FONDAP - ESO Conference

Globular Clusters – Guides to Galaxies

6-10 March, 2006

Universidad de Concepción, Chile

INVITED SPEAKERS:

H. Baumgardt, M. Beasley, K. Bekki,
J. Brodie, A. Burkert, R. Chandar, P. Côté, O. Gnedin,
B. Harris, M. Hilker, A. Jordán, B. Miller, K. Perrett, A. Romanowsky, F. Schweizer, S. Zepf

SOC: B. Elmegreen, D. Forbes, D. Geisler, E. Grebel, L. Infante, M. Kissler-Patig, S. Larsen (co-chair), T. Richtler (chair)

LOC: M. E. Barraza, D. Geisler, M. Gómez, A. Romanowsky

Sponsored by: FONDAP Center for Astrophysics, European Southern Observatory, Facultad de Ciencias Físicas y Matemáticas, Universidad de Concepción, Cerro Tololo Interamerican Observatory

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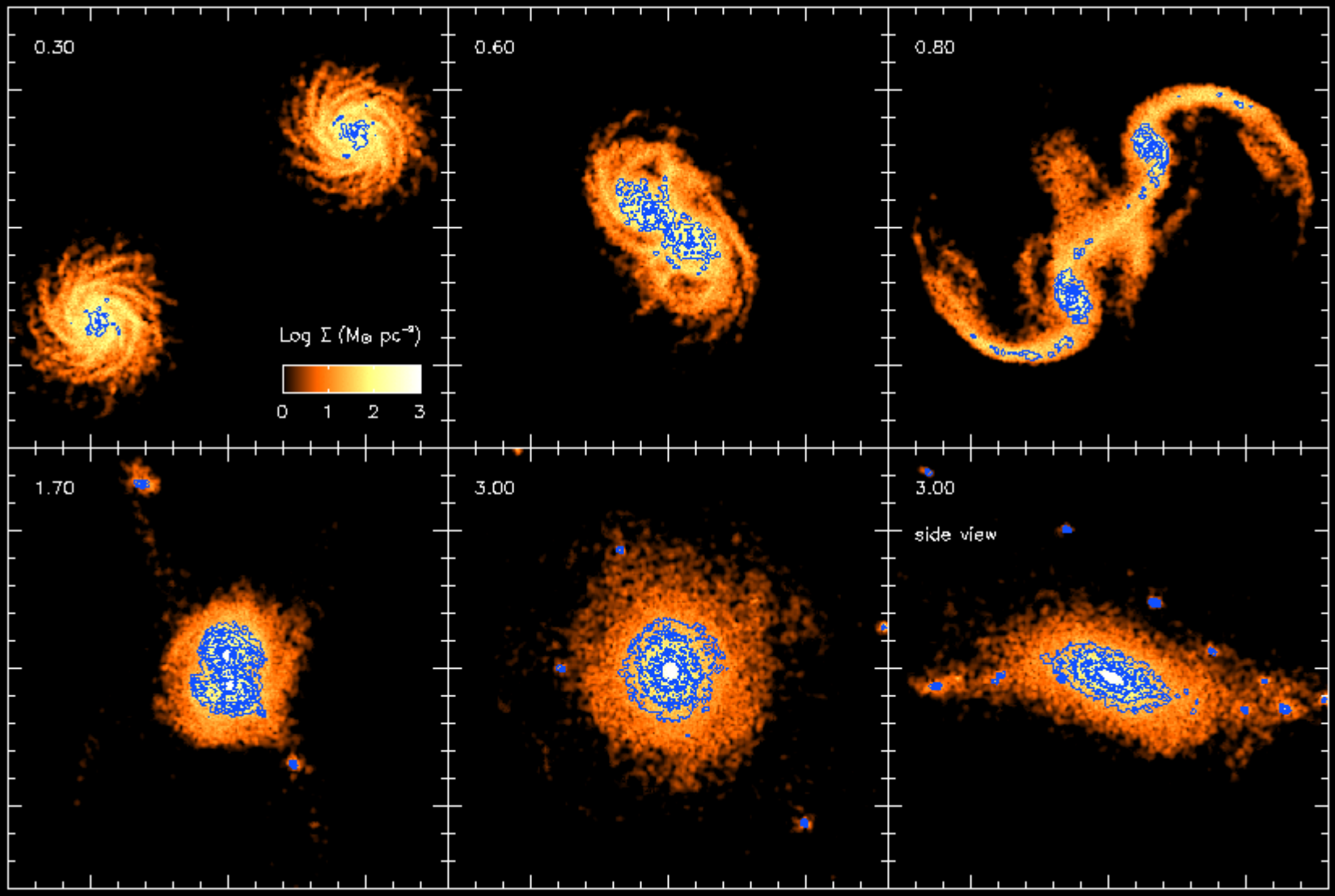
Natural outcome of merger?



Dekel et al. (2005)

Natural outcome of merger?

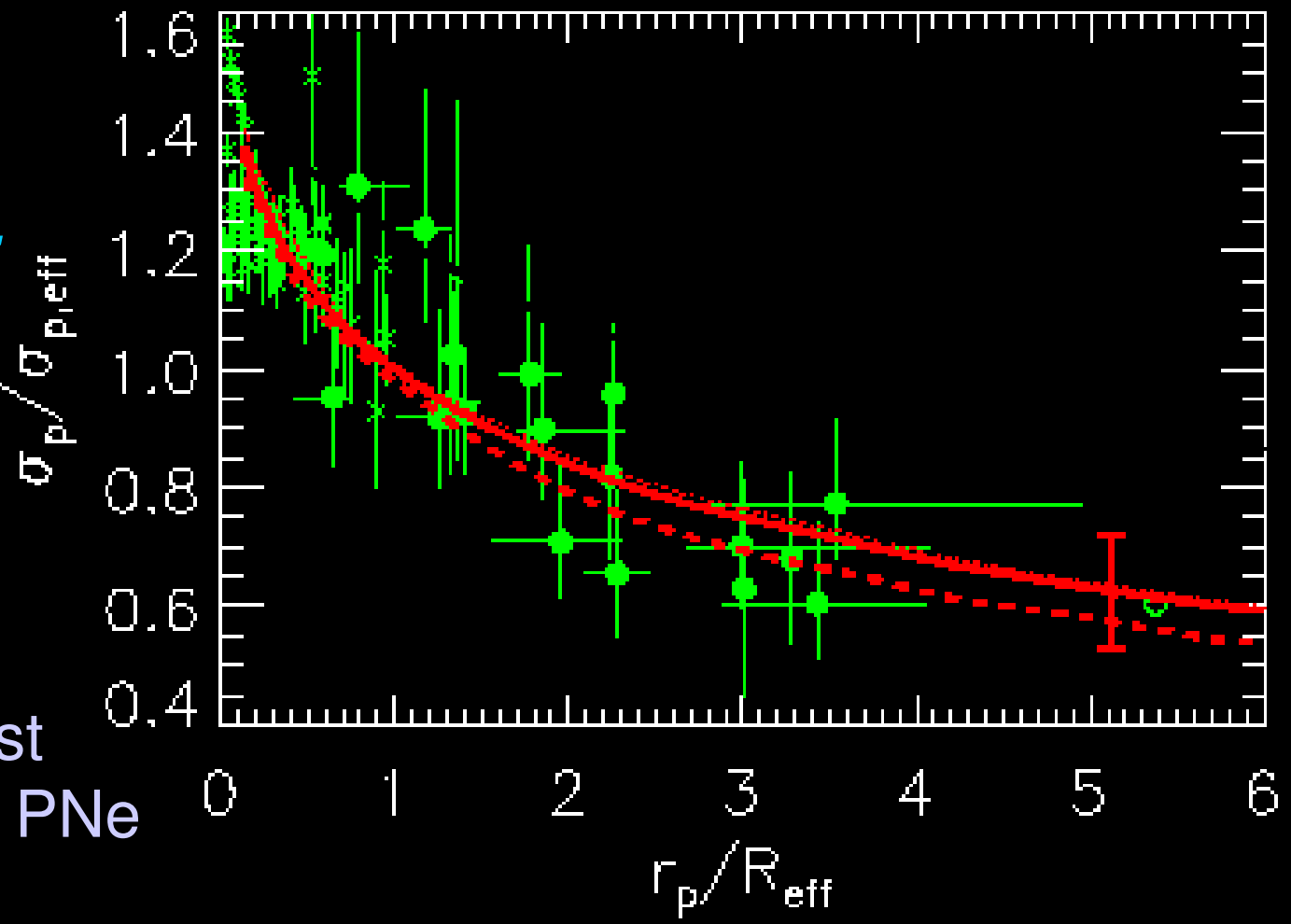
Radial anisotropy, triaxiality can naturally lower projected dispersions

Data may be reproduced ***if:***

Sbc-Sbc 1:1 merger

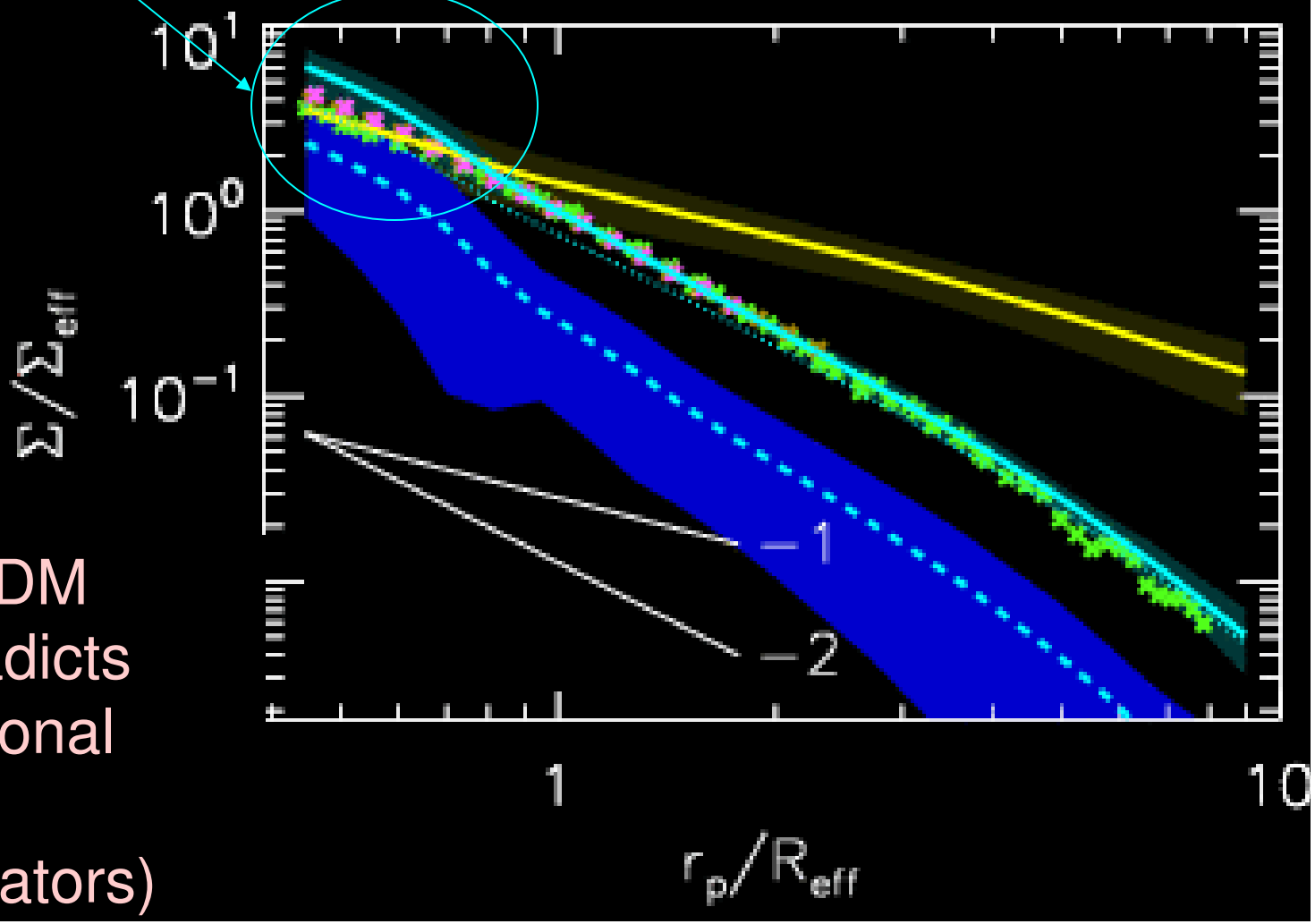
or

recent starburst contaminating PNe



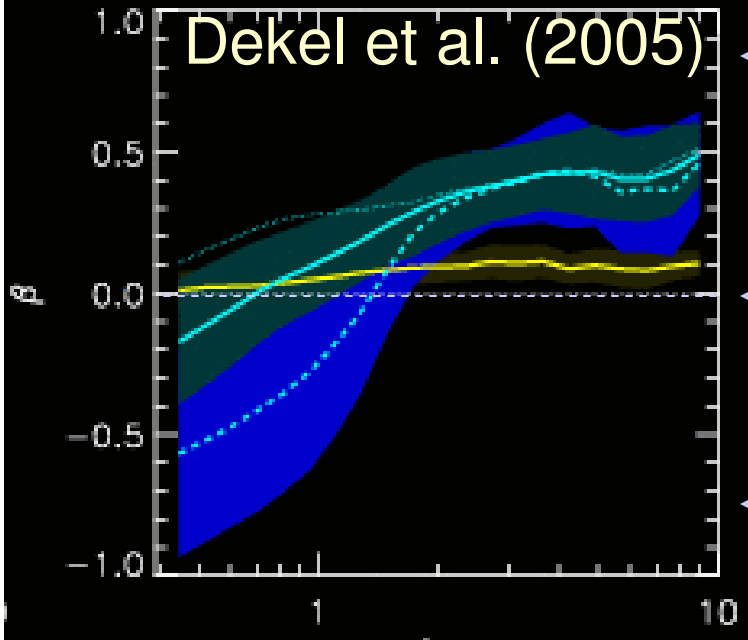
Simulations realistic?

Blue bump from excess baryon cooling :
extra concentration of stars, DM steepens dispersion



~30% central DM fraction contradicts best observational estimate
(~10% fast rotators)

Radial anisotropy?



radial

isotropic

tangential