Discrete dynamical modelling of ω Centauri

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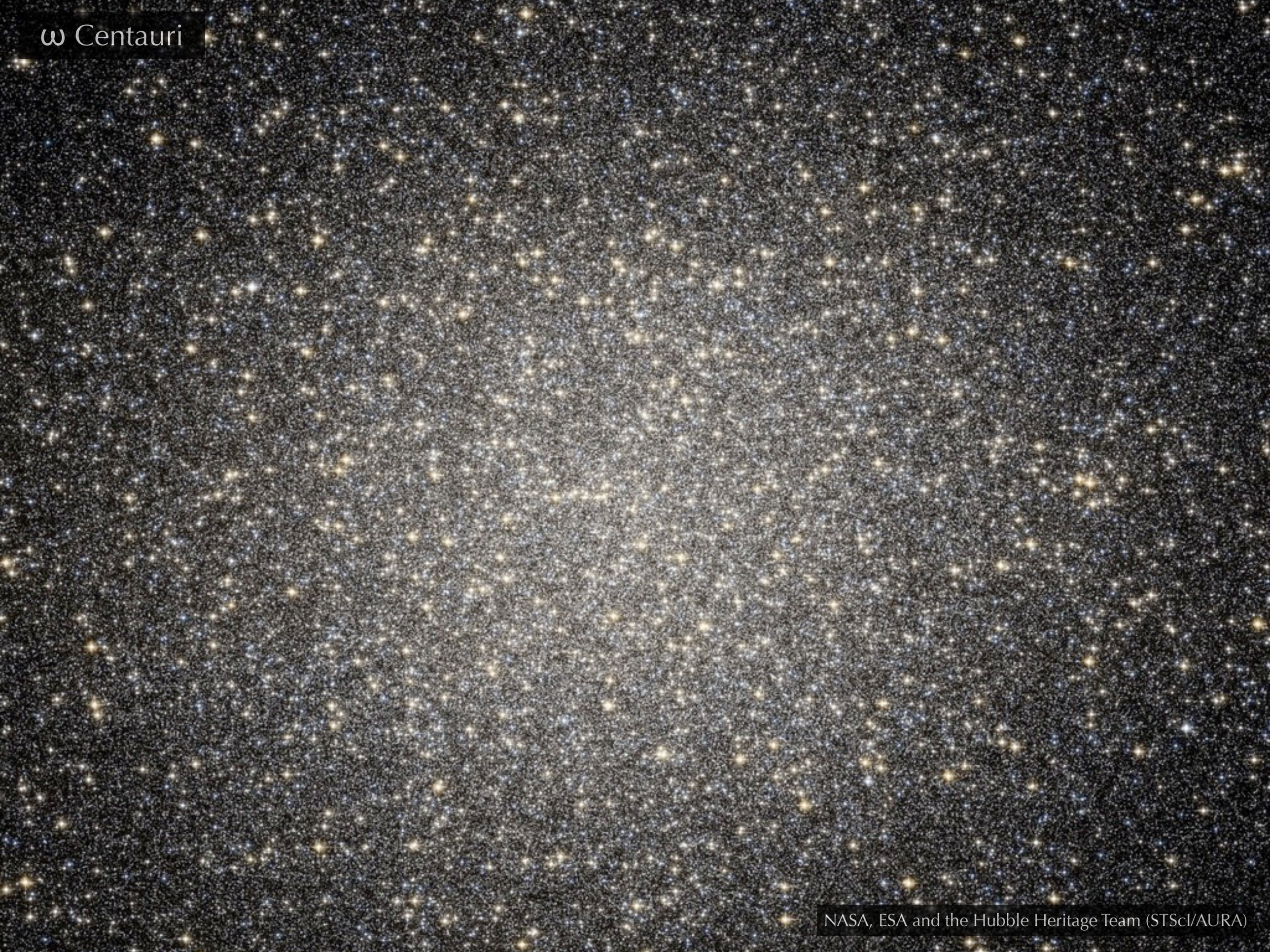
NASA, ESA and the Hubble Heritage Team (STScI/AURA)

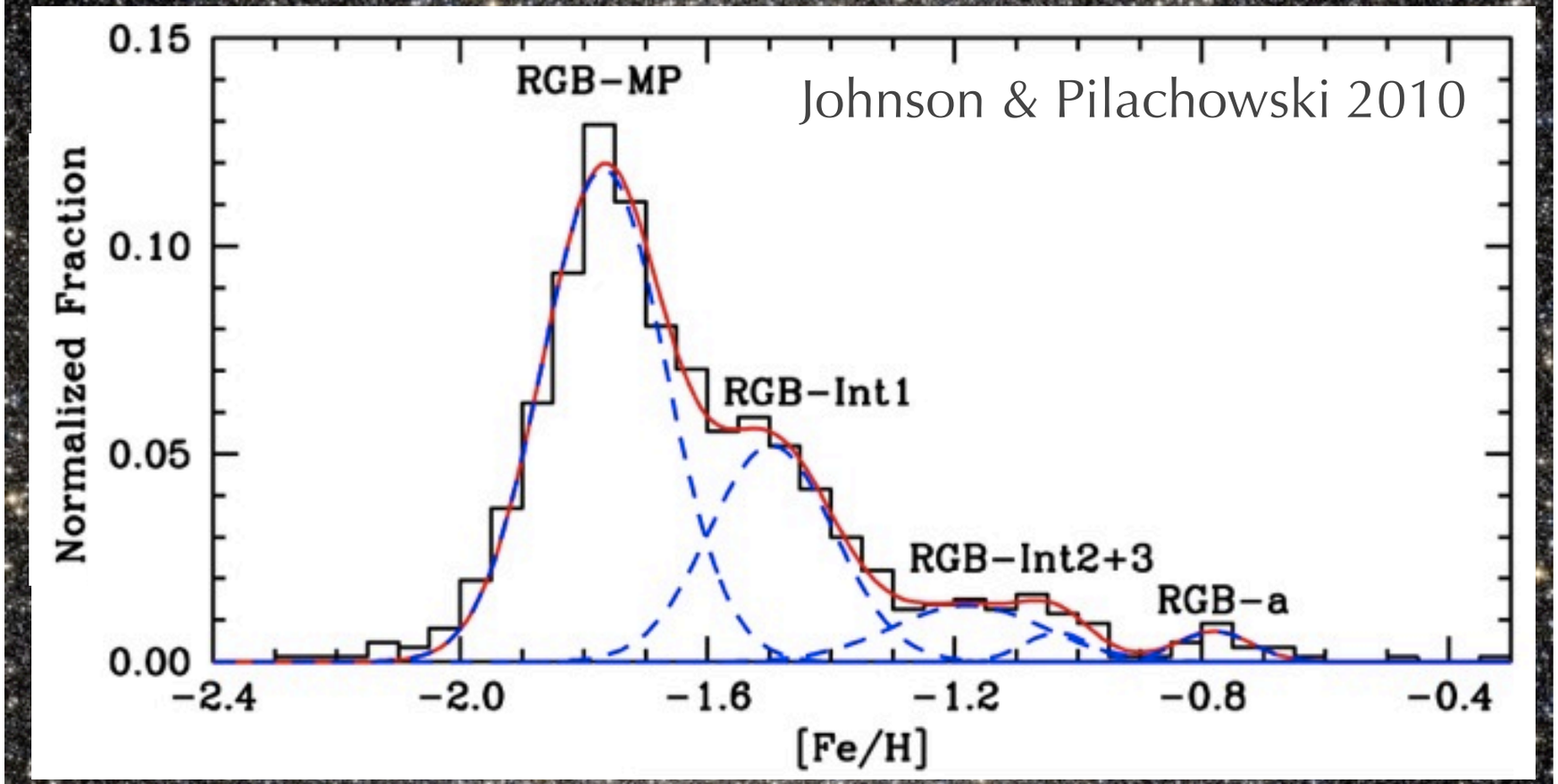
ω Centauri



NASA, ESA and the Hubble Heritage Team (STScI/AURA)

ω Centauri is interesting

ω Centauri



NASA, ESA and the Hubble Heritage Team (STScI/AURA)

- multiple SPs
- IMBH?

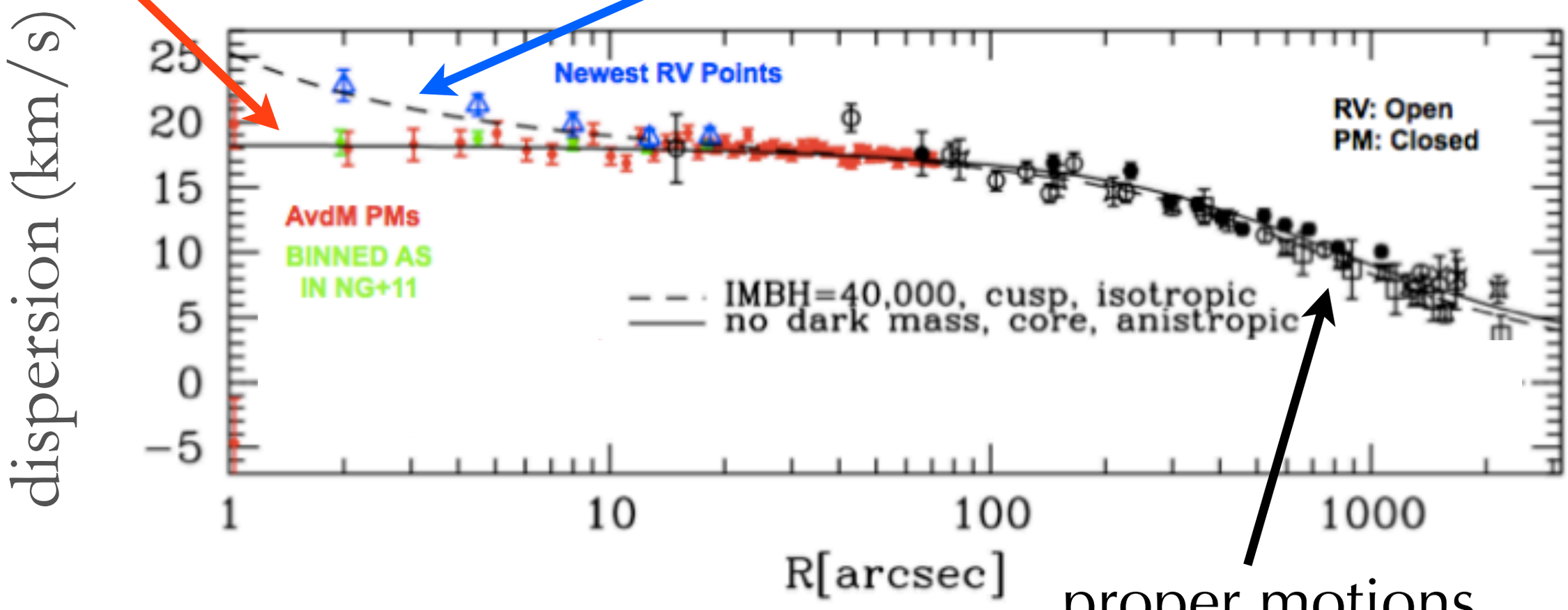
omega centauri intermediate mass black hole

HST proper motions
(no black hole)

Anderson & van der Marel (2010)

line of sight velocities
(black hole)

Noyola et al. (2008, 2010)



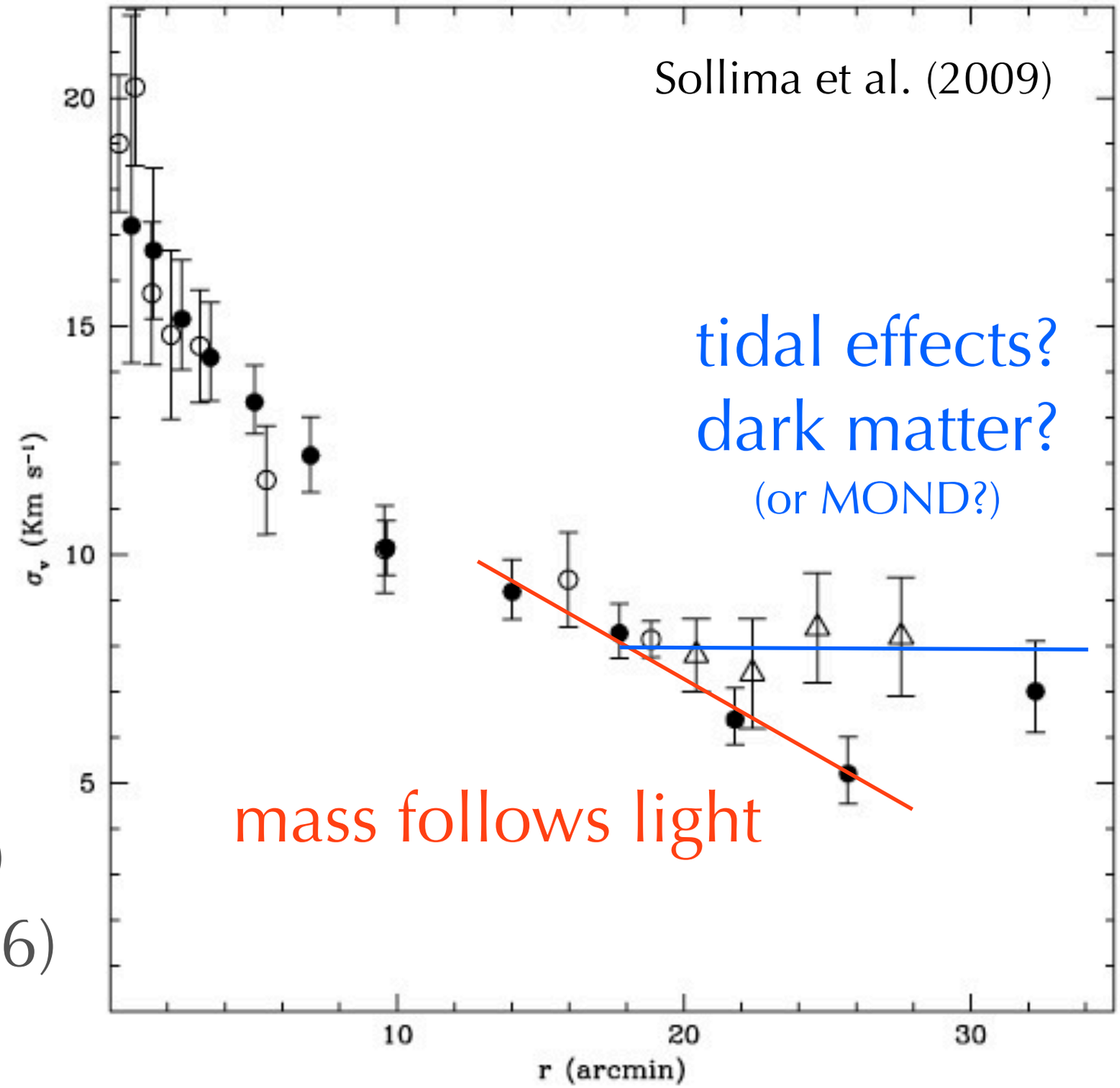
proper motions
line of sight velocities

van de Ven et al. (2006)

ω Centauri is interesting

- multiple SPs
- IMBH?
- dark matter?

omega centauri dispersion profile



- ● Sollima et al. (2009)
- ○ van de Ven et al. (2006)
- △ Scarpa et al. (2003)

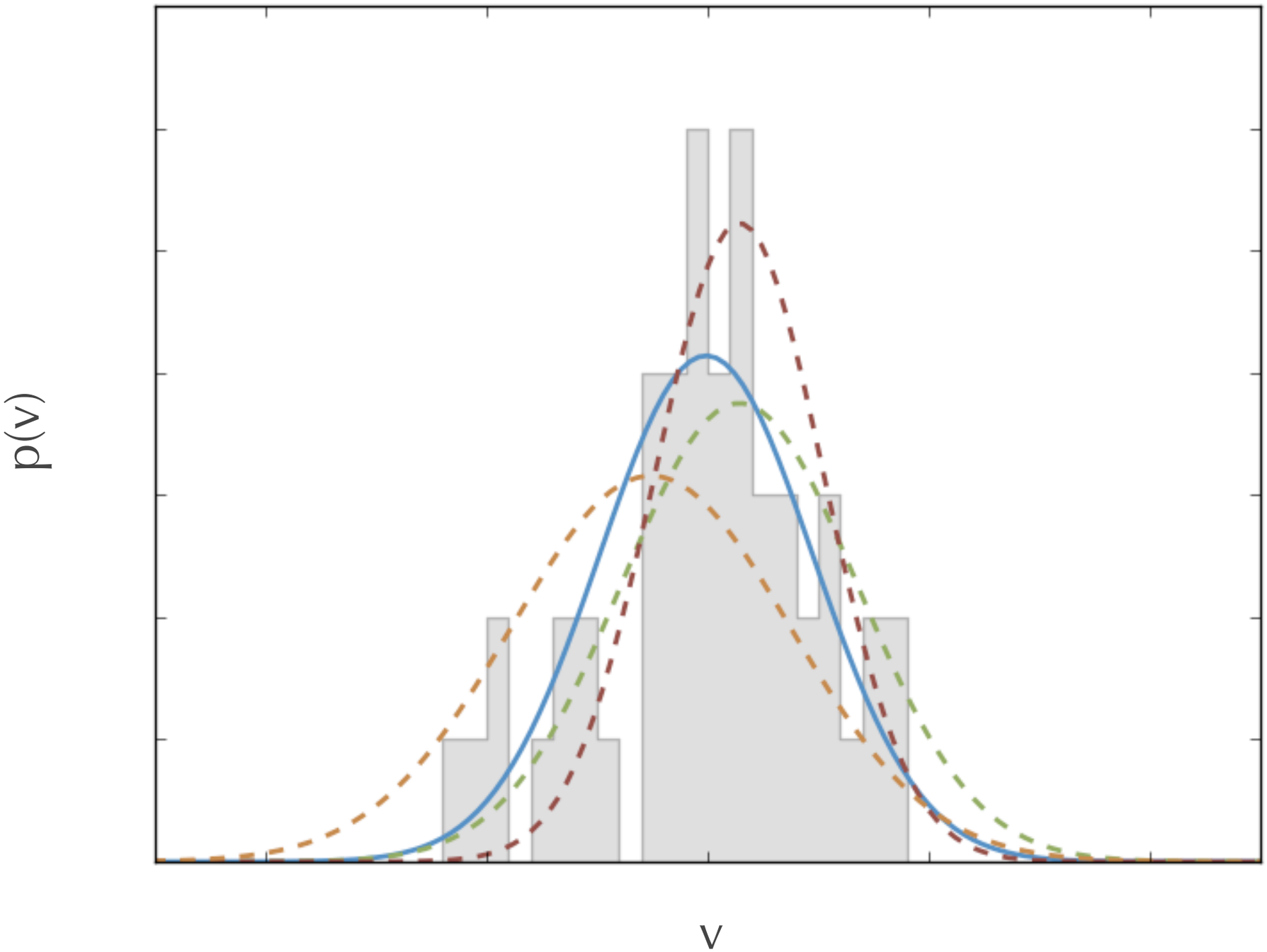
ω Centauri is interesting

- multiple SPs
- IMBH?
- dark matter?

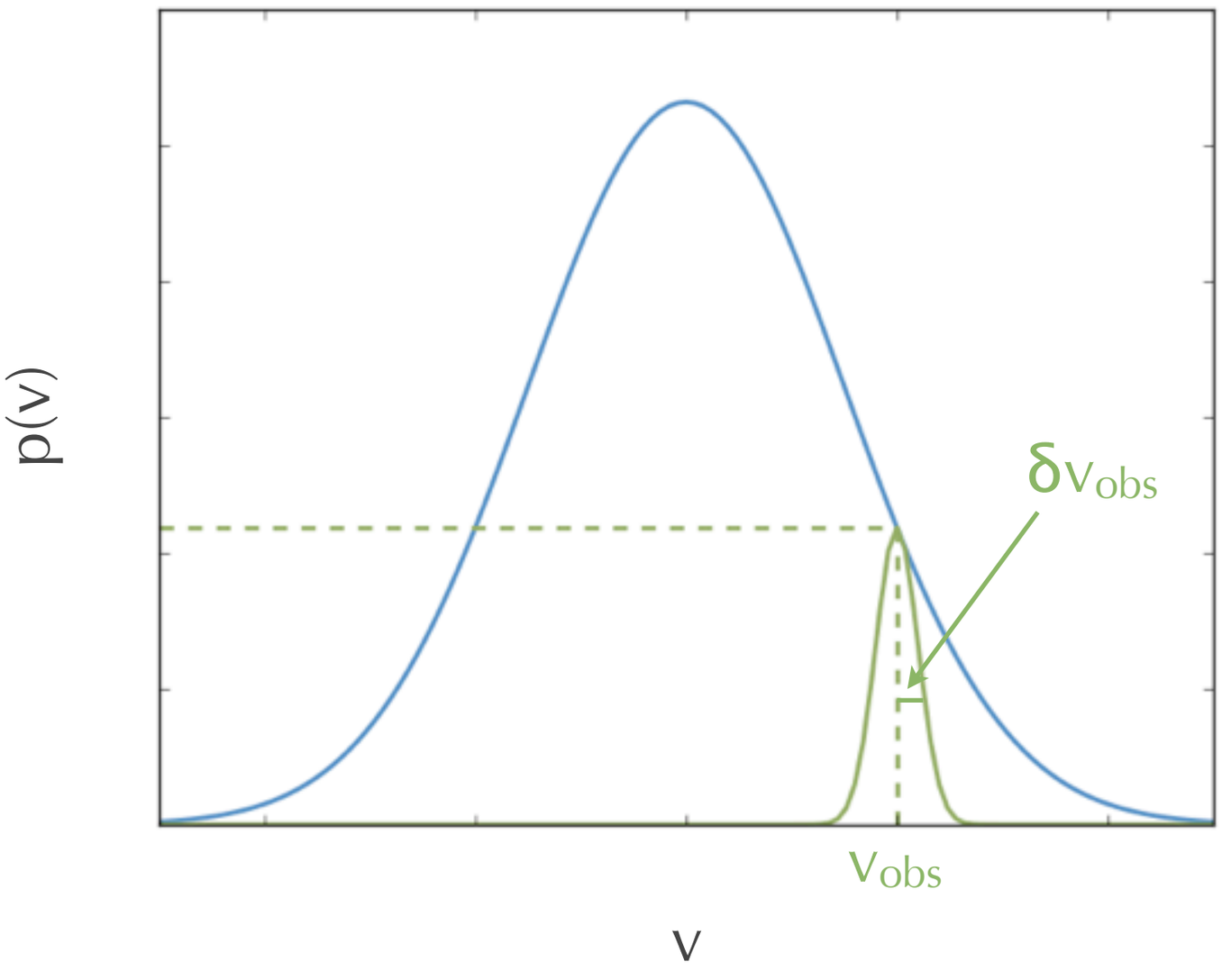
- lots of good data

- need dynamical models

binning matches moments



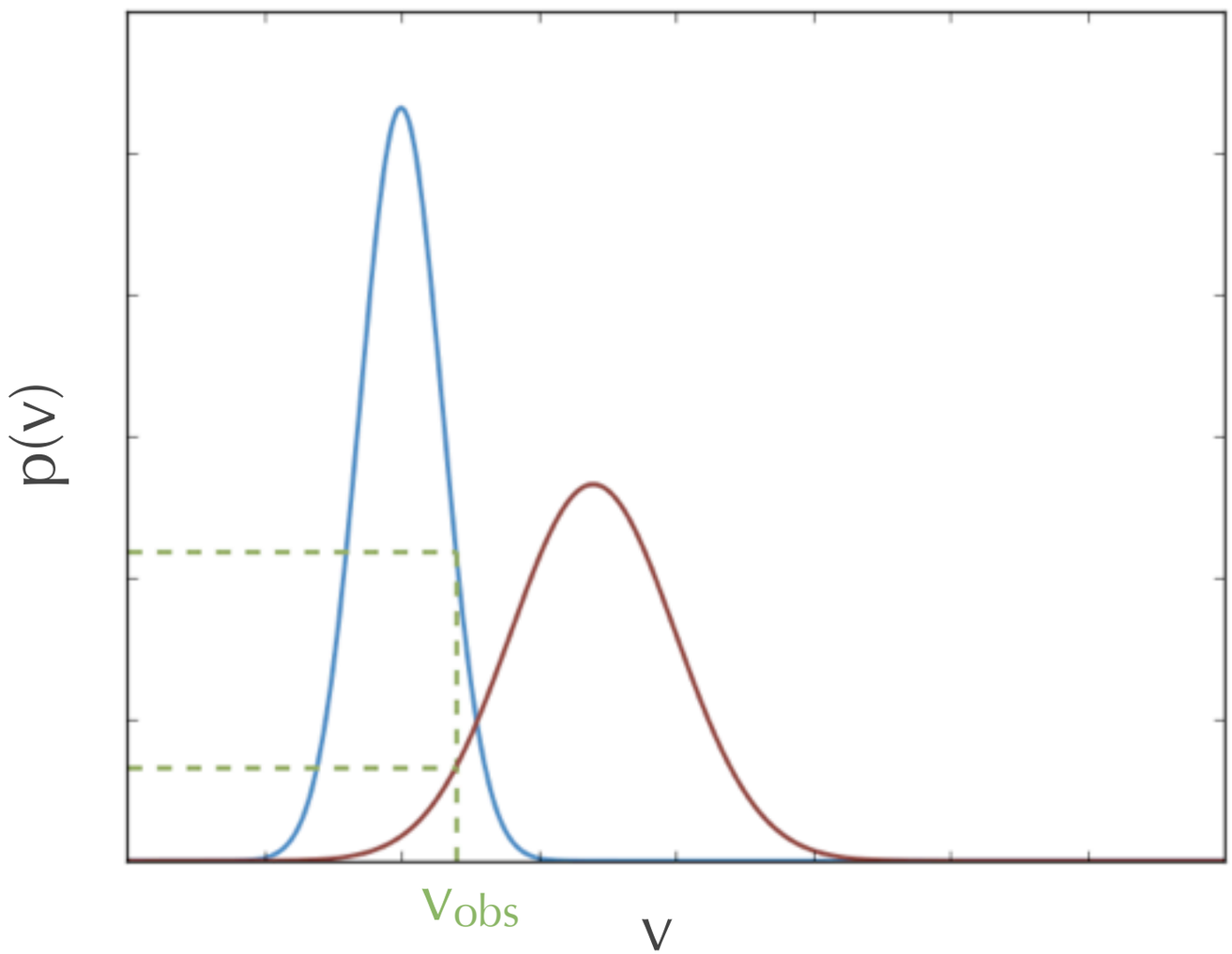
we don’t want to bin at all



p(v_{obs} | model, δv_{obs})

include contamination model

$$m(x',y')\ p(\ v_{obs}\ |\ \text{model}\ )\ +\ (1\text{-}m(x',y'))\ p(\ v_{obs}\ |\ \text{contaminants}\ )$$

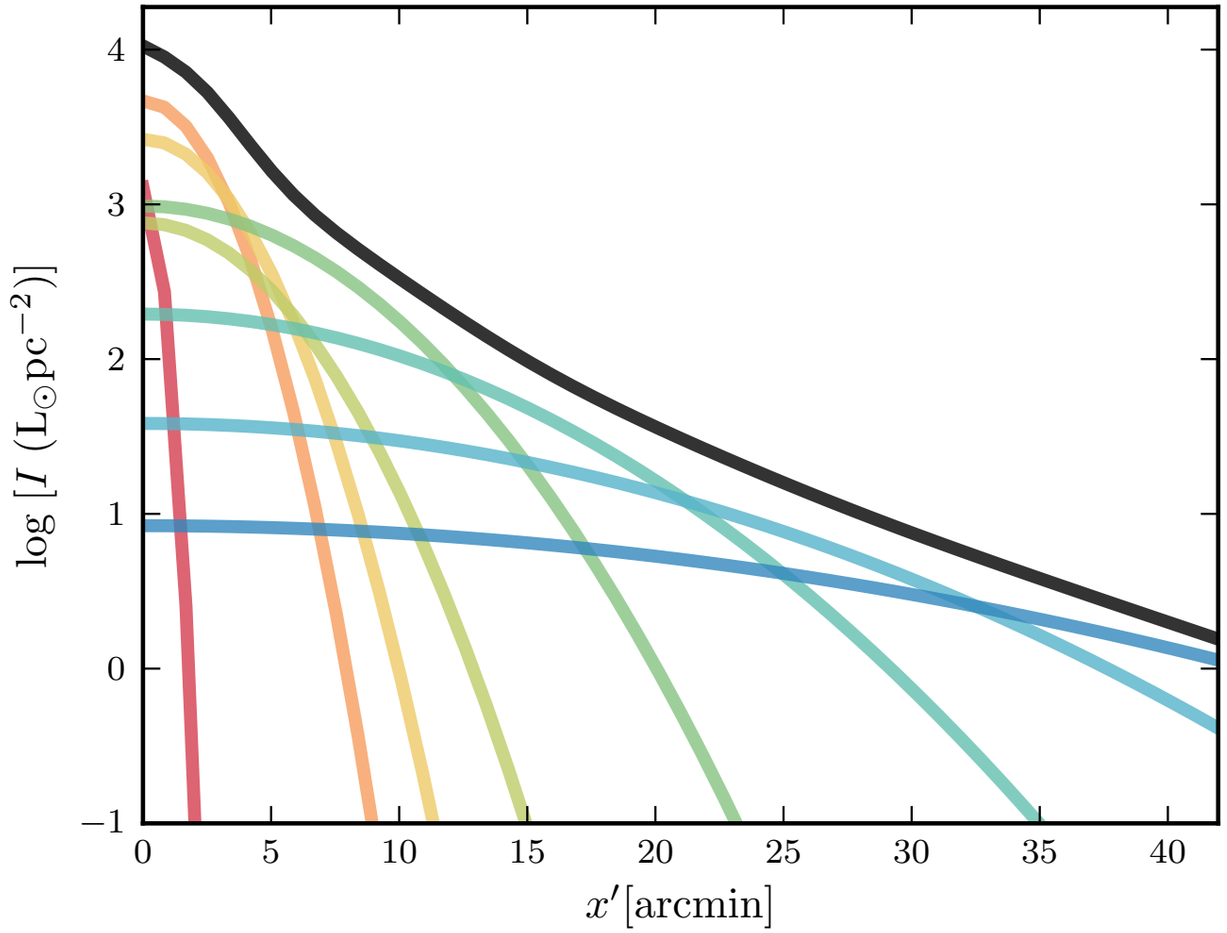


membership fraction

$$m(x',y') = \frac{dN_{cl}(x',y')}{dN_{cl}(x',y') + dN_{bg}(x',y')}$$

$dN_{cl}(x',y') \propto I\,(x',y')$ surface brightness

$dNbg(x',y') = \varepsilon\, dN_0$ $dN_0 = dN_{cl}(0,0)$



we have 5 free parameters

- axisymmetric Jeans models

- anisotropy: $\lambda = -\ln(\langle v_z^2 \rangle / \langle v_R^2 \rangle)$
- shape: q
- stellar mass-to-light ratio: Υ
- distance: d
- contamination fraction: ε

+

emcee MCMC Foreman-Mackey et al. (2013)

line-of-sight velocities

van de Ven et al. (2006)

Suntzeff & Kraft (1996)

Mayor et al. (1997)

Reijns et al. (2006)

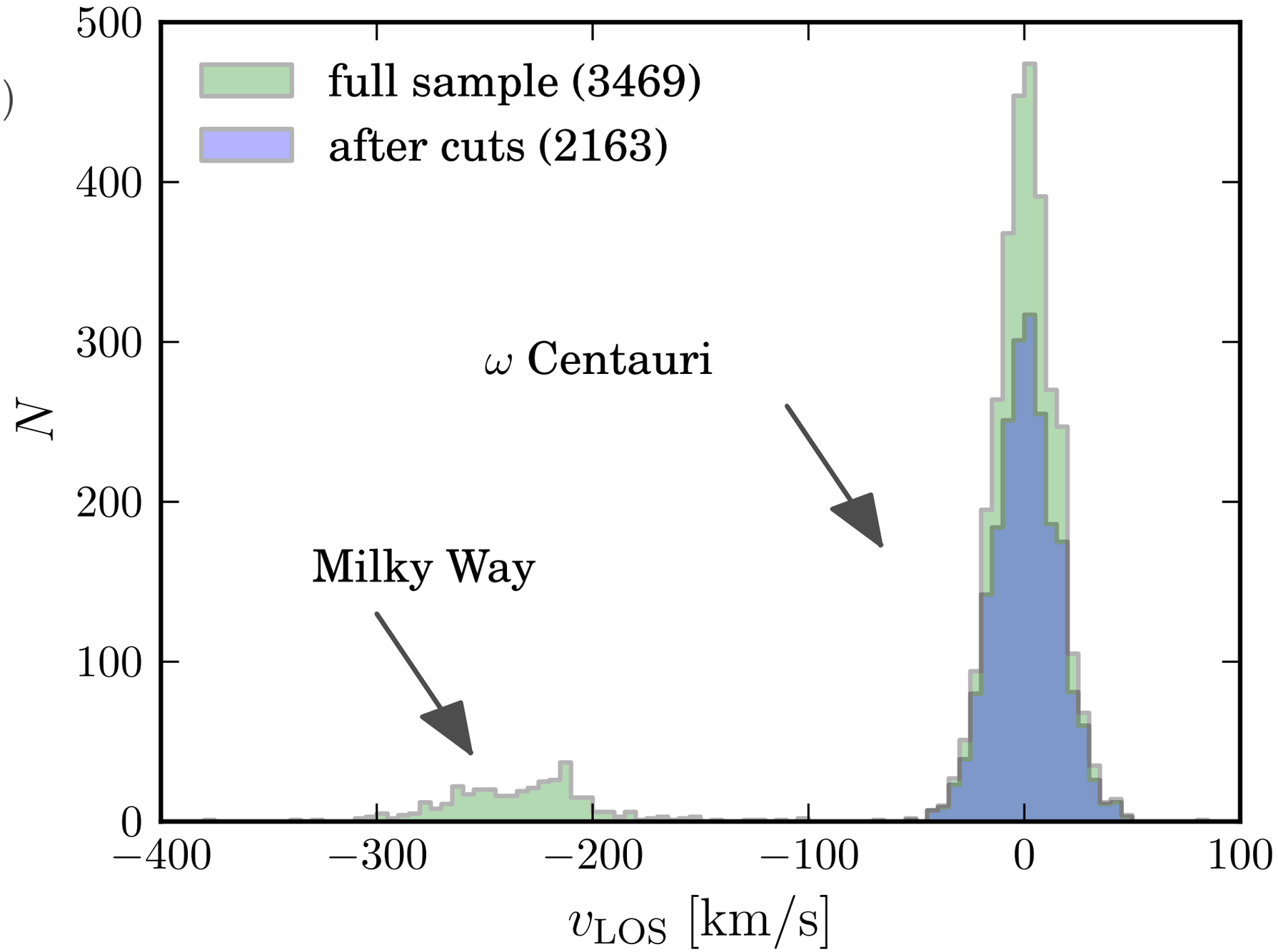
Karl Gebhardt

intermediate & full

sigma clip outliers

& cut on error

clean



proper motions

van de Ven et al. (2006)

van Leeuwen et al. (2000)

full

cut on error &

cut blended stars

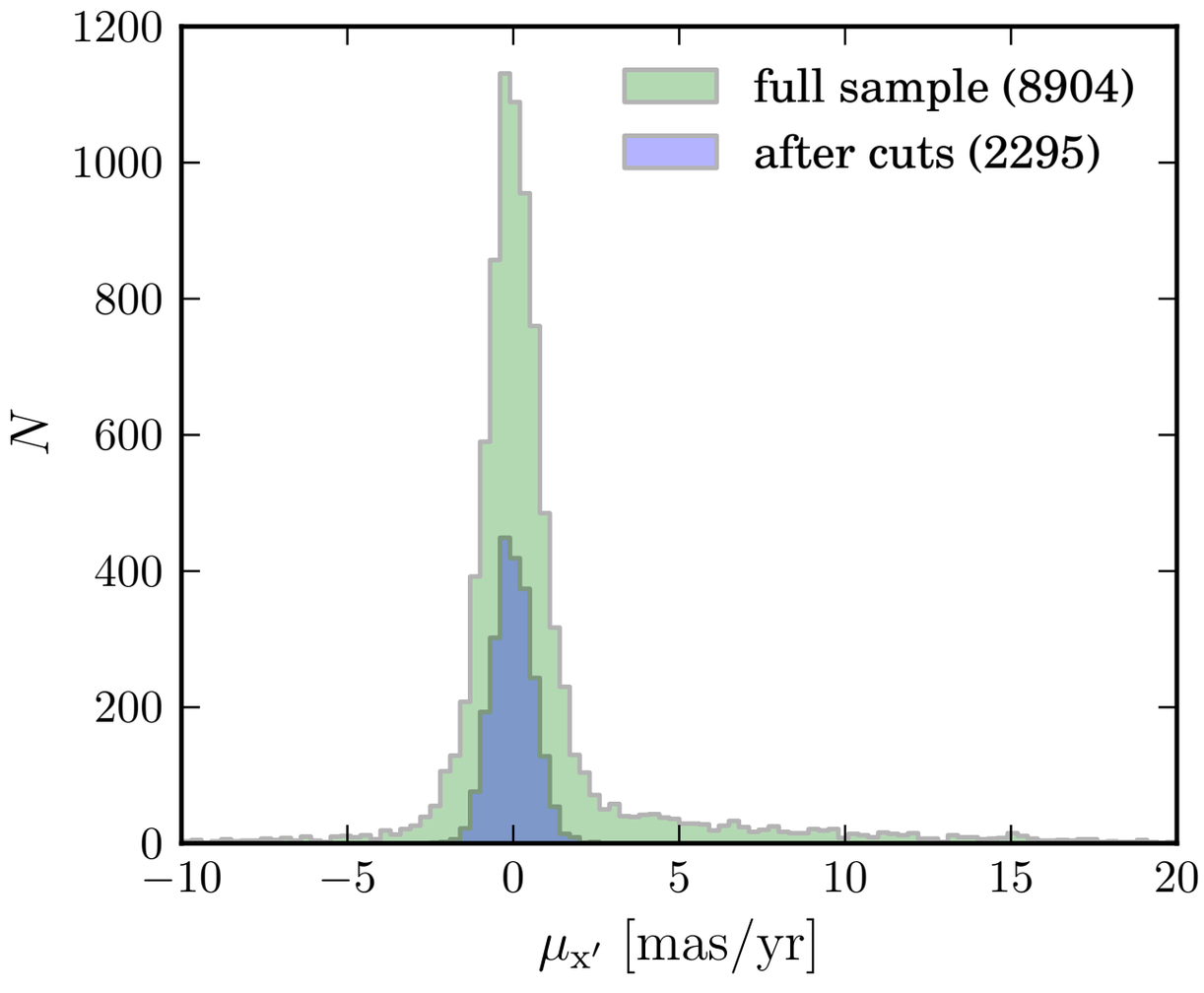
intermediate

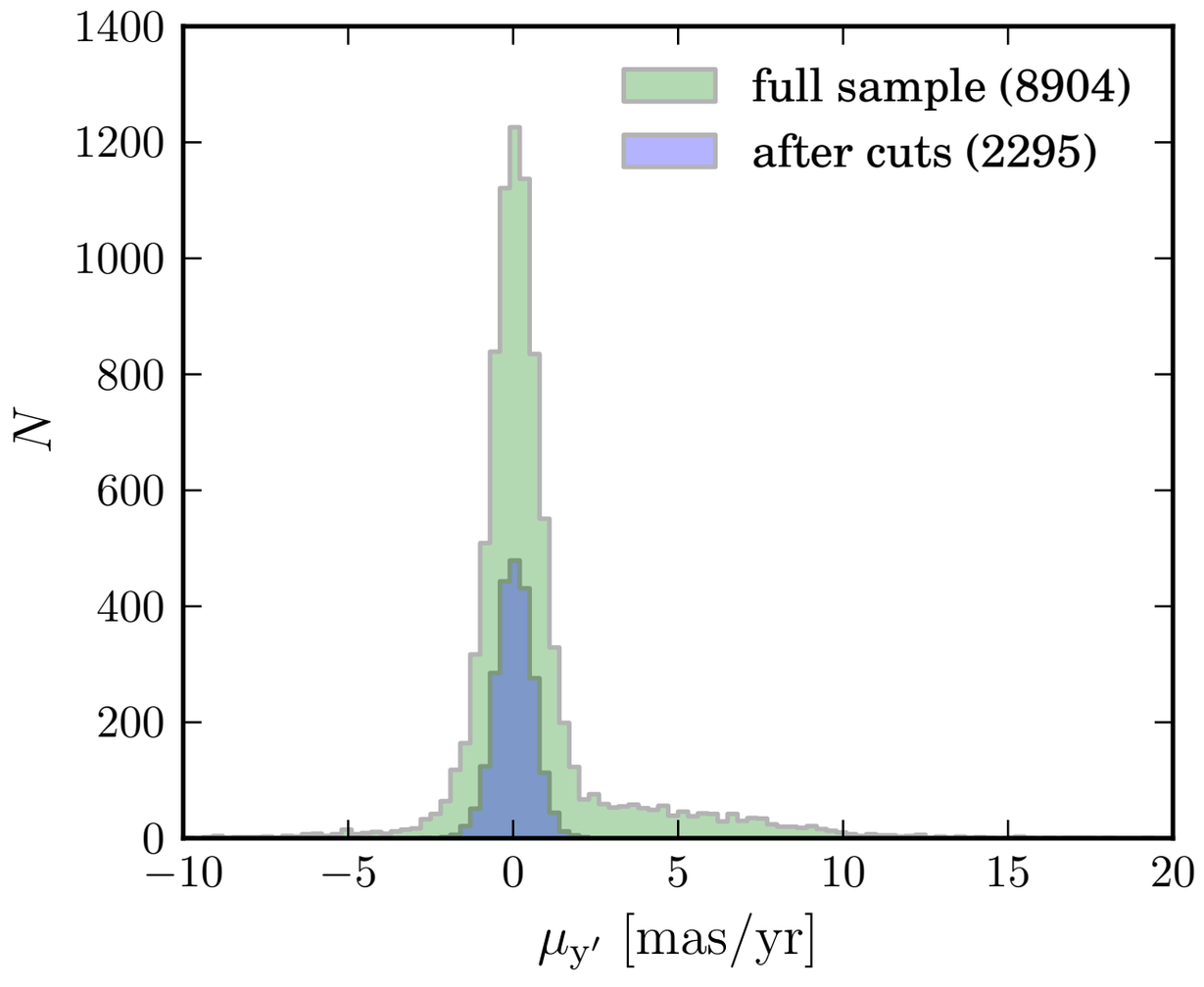
cut on error &

cut blended stars

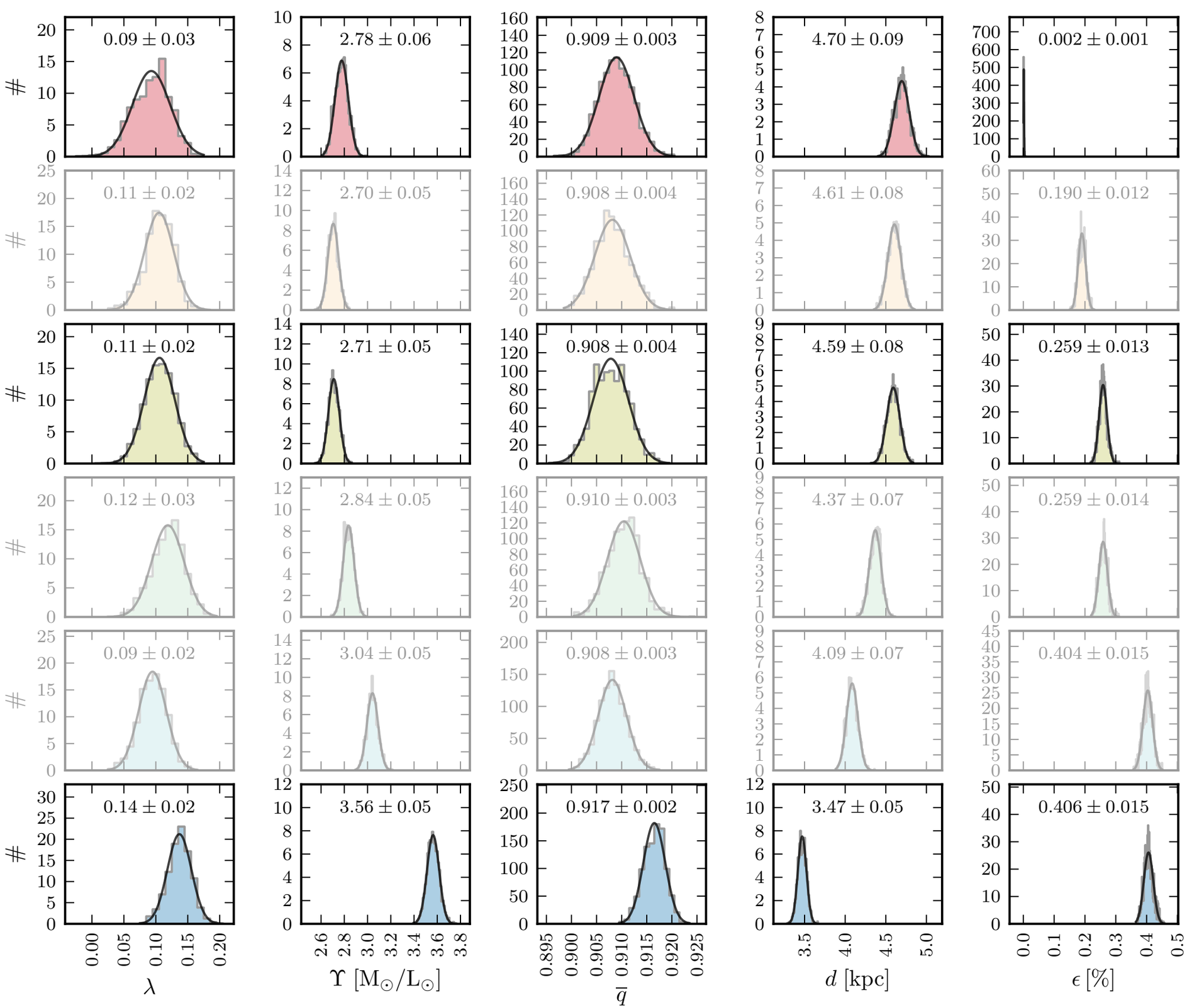
& cut outliers

clean





results



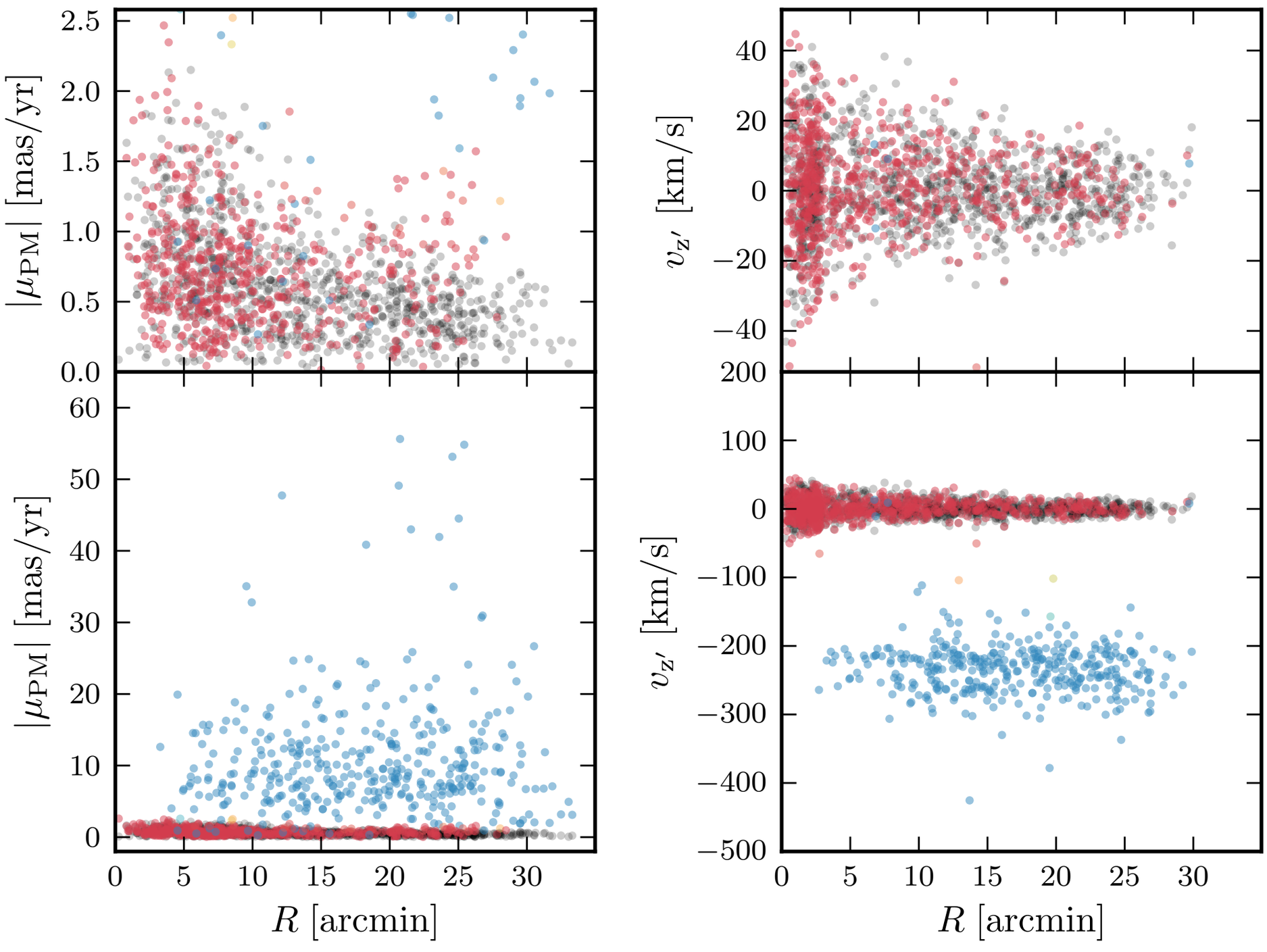
✓ clean
(all cuts)

✓ intermediate
(cut bad PM stars)

✗ full
(no cuts)

"best" model

$$P(cl) = \frac{m\ L_{cl}}{m\ L_{cl} + (1\text{-}m)\ L_{bg}}$$



these models are fast

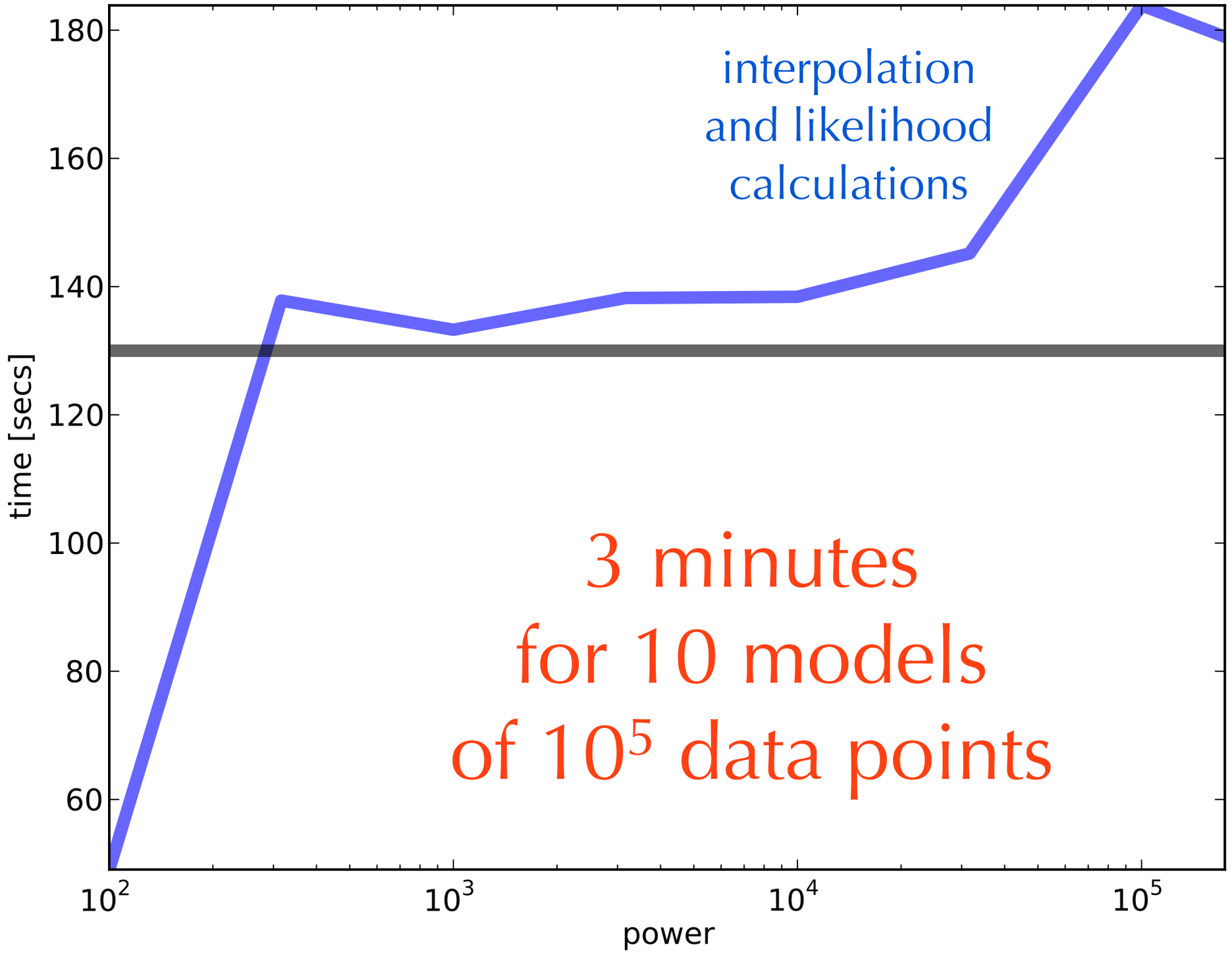
- < 250 stars
  - N model moments

- > 250 stars
  - 250 model moments (polar grid)
  - N moment interpolations

- N likelihoods

these models are fast

200 models on 20 CPUS = 10 models on 1 CPU



what next?

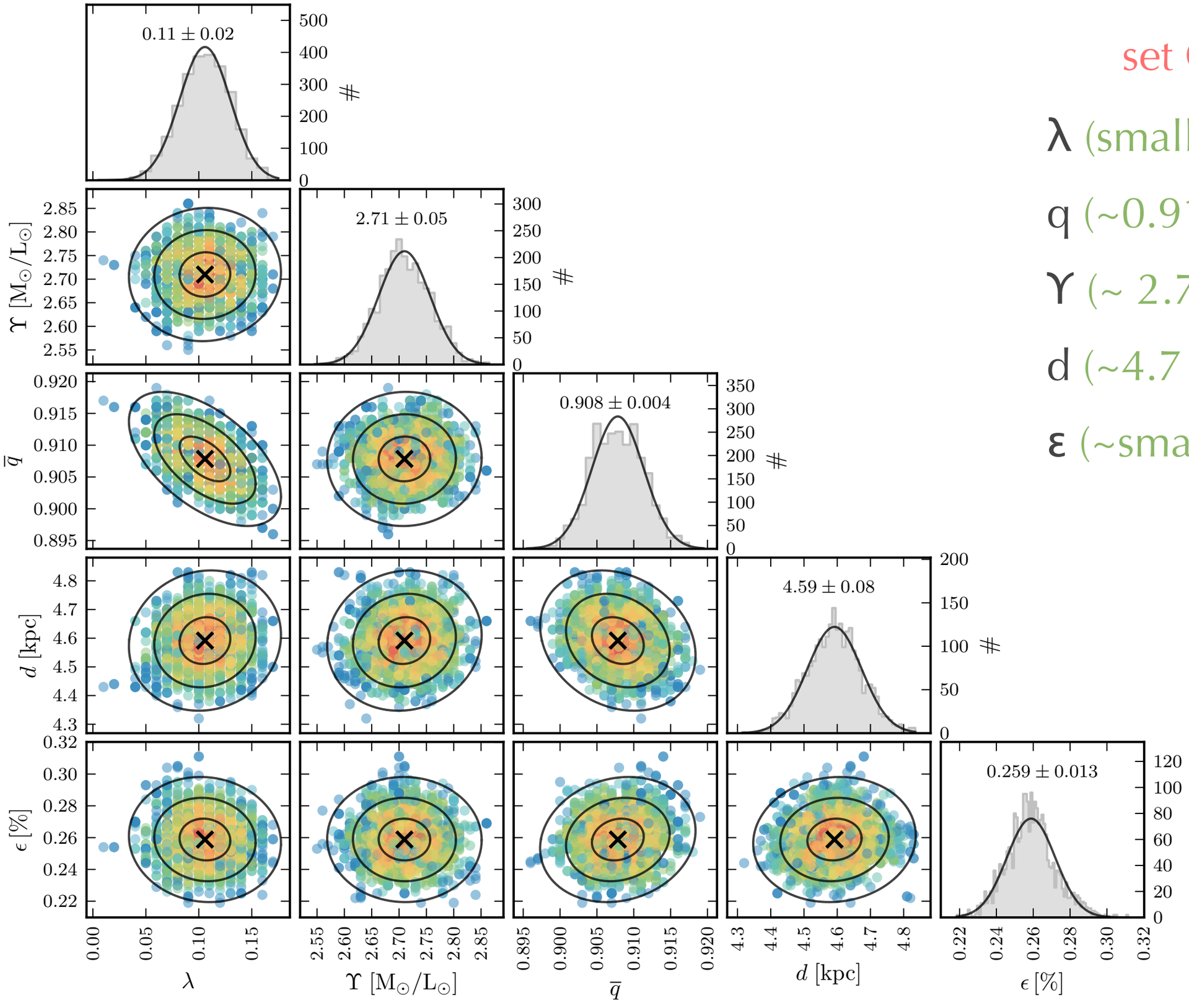
- ω Centauri
  - IMBH?
  - DM halo
  - chemical tagging
    - better background models
    - discrete Schwarzschild
- Local Group dSphs and GCs
- Milky Way

summary

- high quality and quantity data sets in the LG
- analysis usually involves binning
- we are implementing discrete modelling of discrete datasets
- initial study of ω Centauri is encouraging
- accurate data uncertainties are vital

extra slides

parameter distributions for cleaned dataset



set C

λ (small)

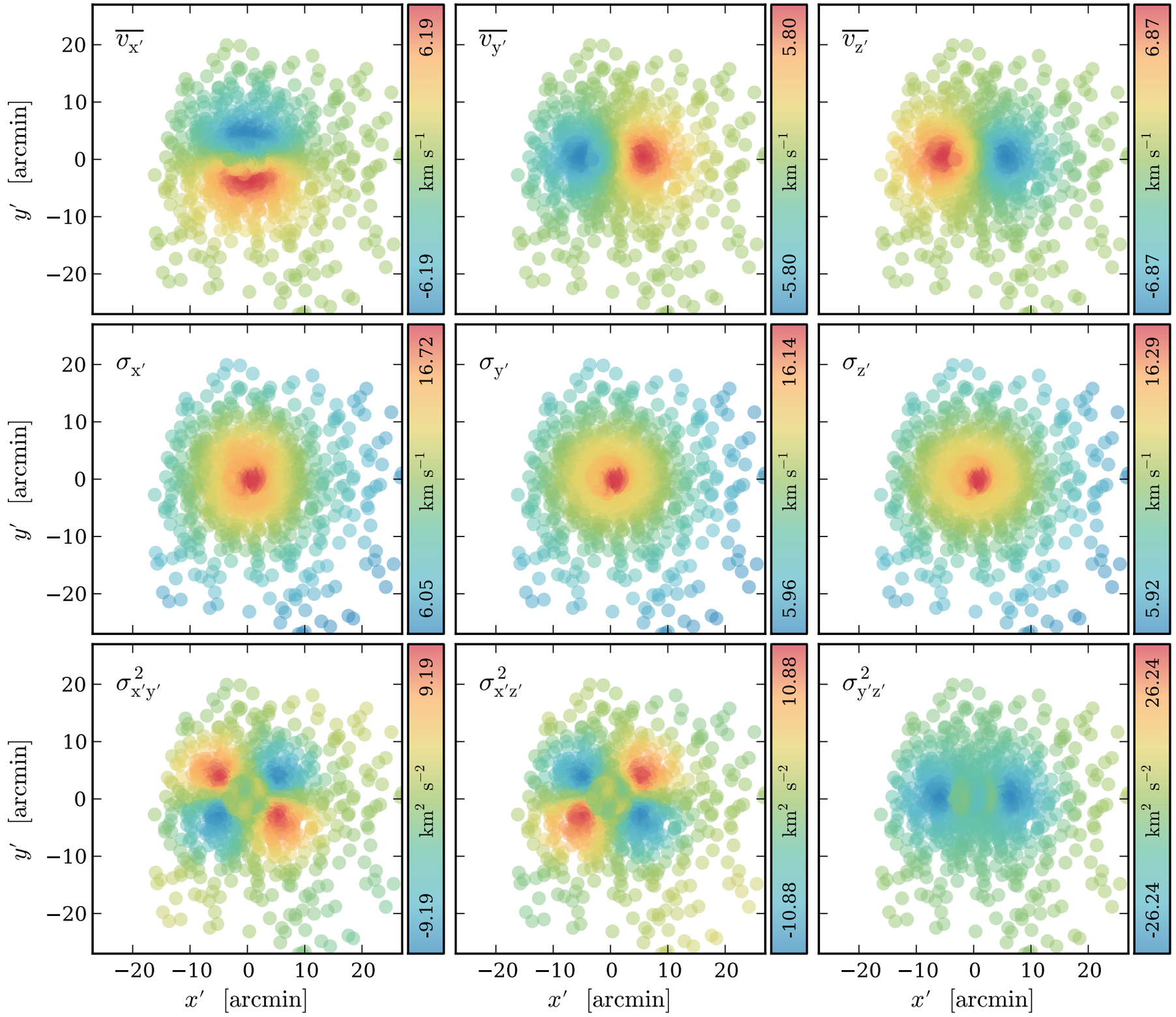
q (~0.91)

ϒ (~ 2.7)

d (~4.7 kpc)

ε (~small)

“best” model


$\overline{v_{x'}}$
$\overline{v_{y'}}$
$\overline{v_{z'}}$
$\sigma_{x'}$
$\sigma_{y'}$
$\sigma_{z'}$
$\sigma^2_{x'y'}$
$\sigma^2_{x'z'}$
$\sigma^2_{y'z'}$
6.19
-6.19
5.80
-5.80
6.87
-6.87
16.72
6.05
16.14
5.96
16.29
5.92
9.19
-9.19
10.88
-10.88
26.24
-26.24
km s^{-1}
km^2 s^{-2}
y' [arcmin]
x' [arcmin]
20
10
0
−10
−20

fair sampling of models