Open Cluster Dynamics via Fundamental Plane

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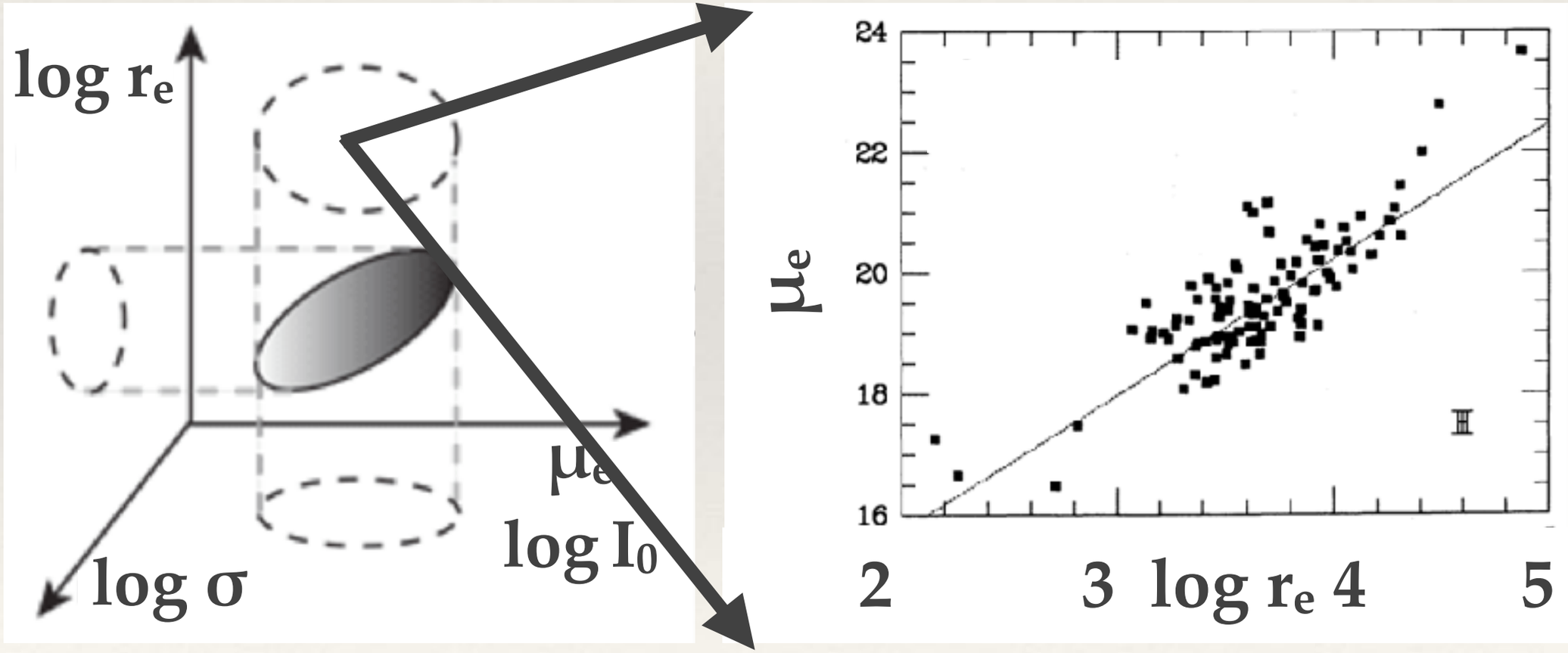
Motivations

- Stars form in star clusters (Lada & Lada 2003)
  - 70% of O-type stars in star clusters (Gies 1987)
  - 50% of field O stars are runaways (de Wit et al. 2005)
- Dissolved and Survived (a few hundreds Myr)
  - External: galactic spiral arms, giant molecular clouds
  - Internal: stellar encounter, relaxation
  - Dynamics of open clusters

The Fundamental Plane (FP)

- A relationship between 3 parameters: effective radius **(r_e)**, surface brightness **(μ_e)**, velocity dispersion **(σ)** of normal elliptical galaxies, etc.



(Djorgovski & Davi 1987)

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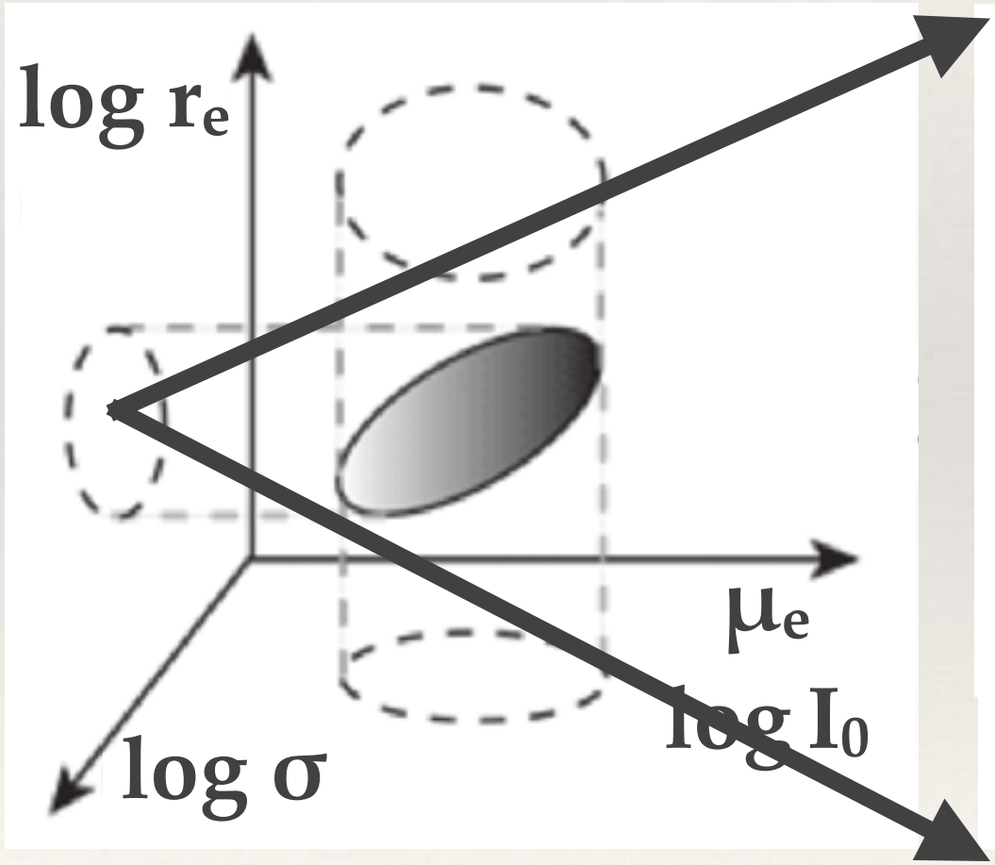

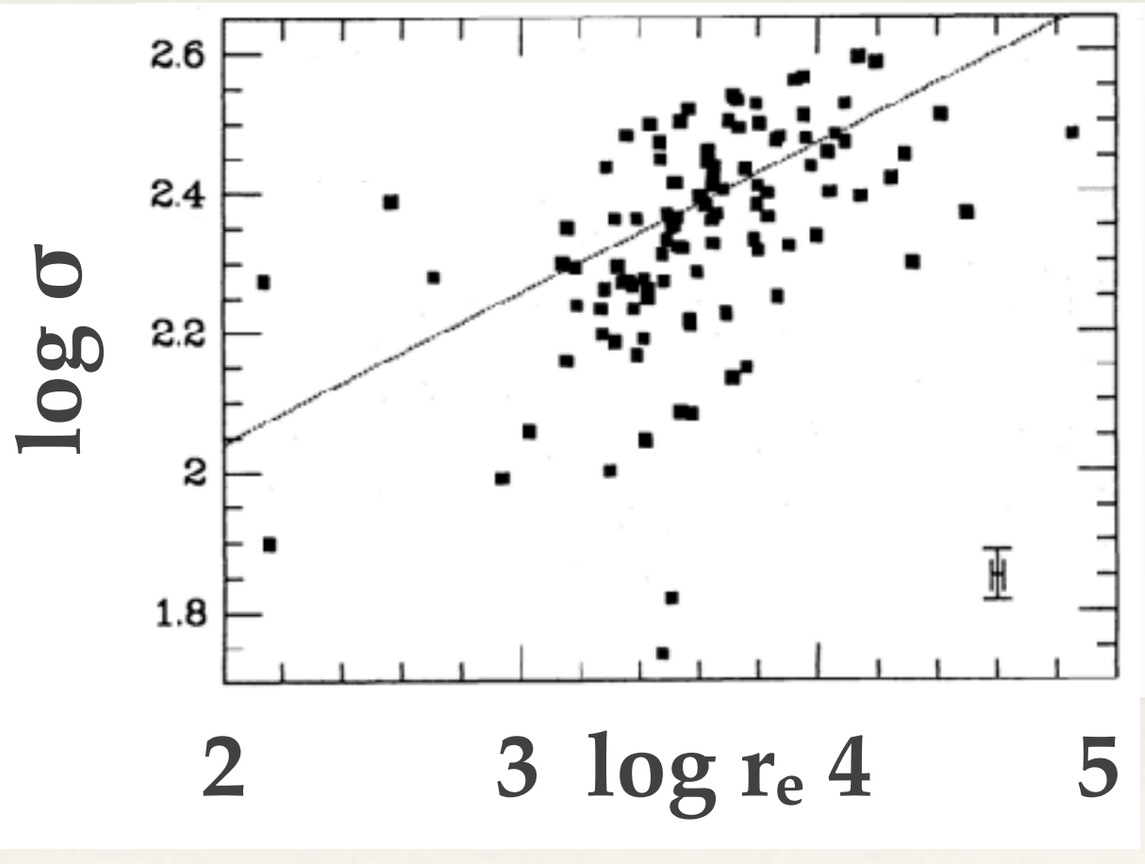

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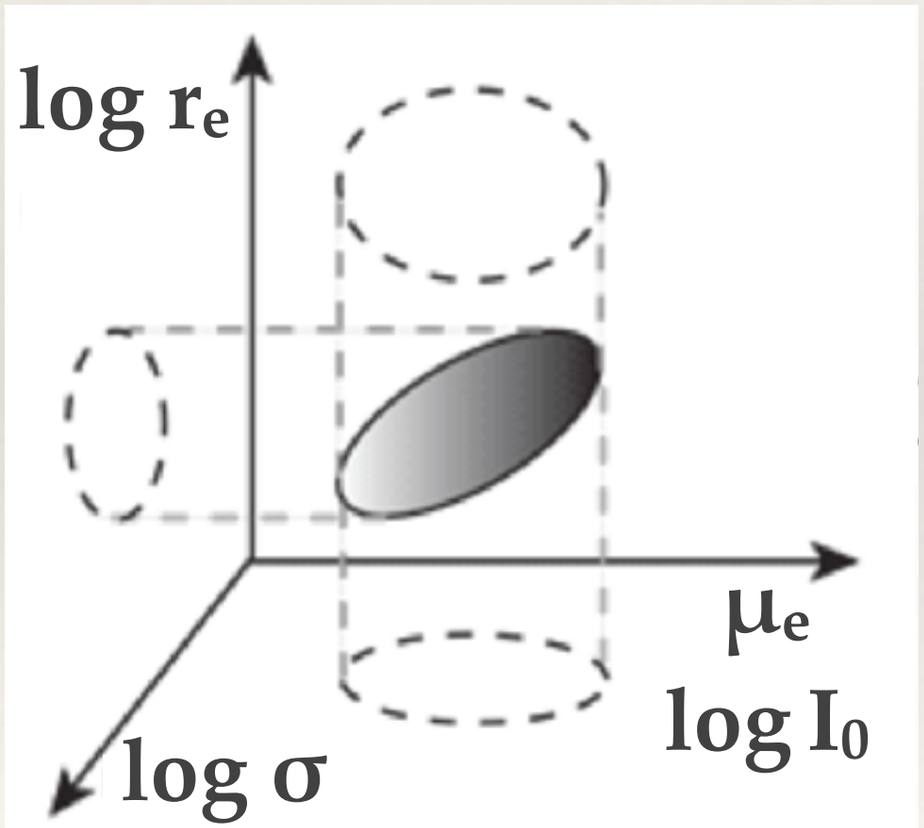
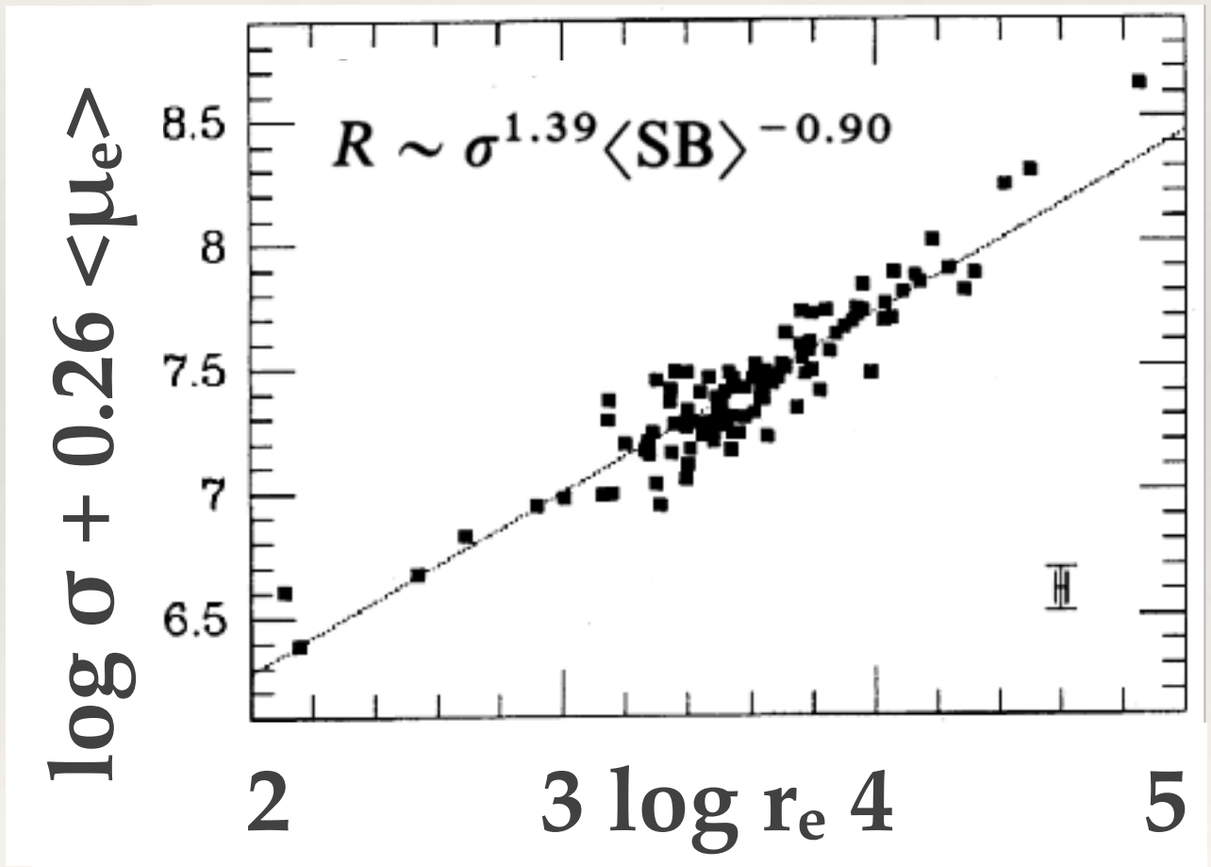


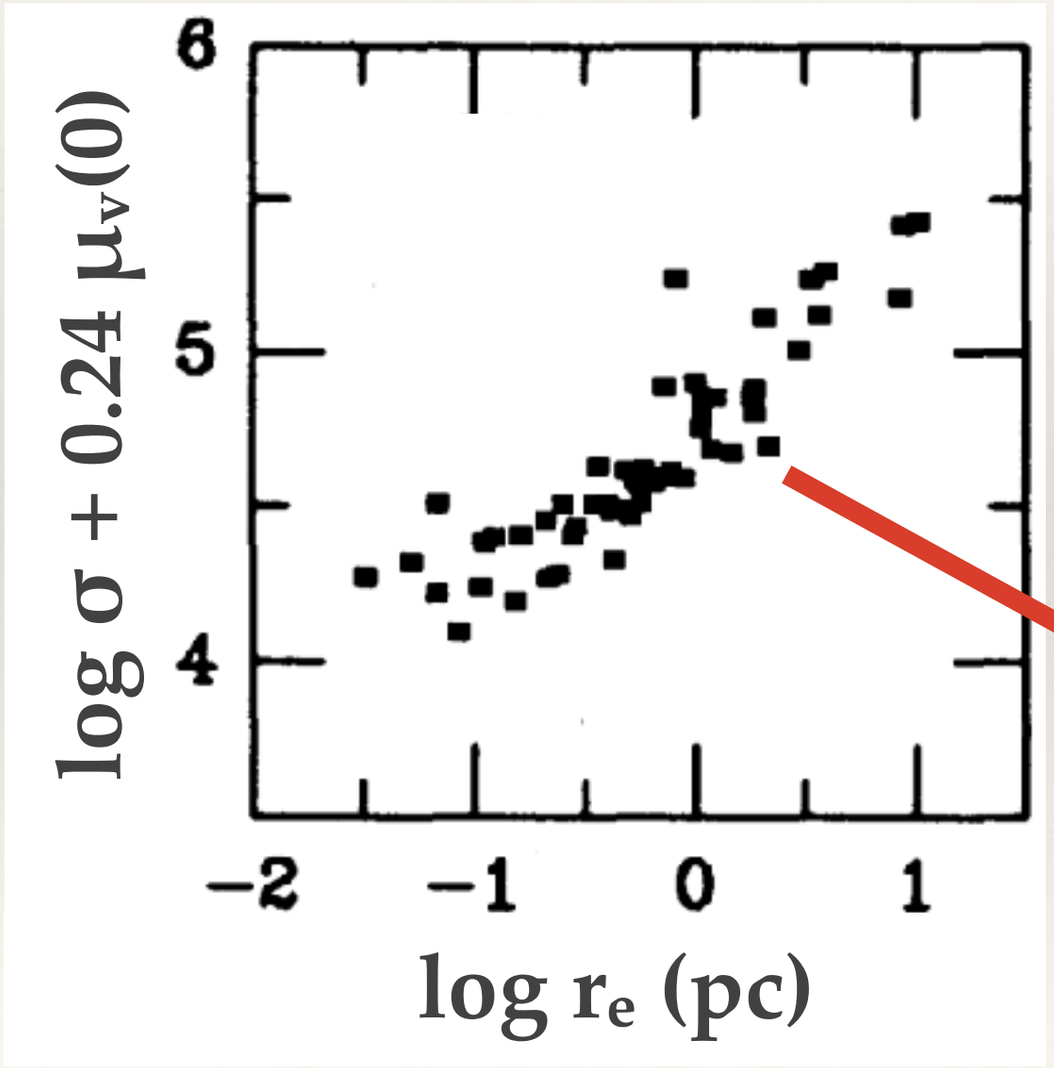


$\log(r_c)=a\cdot\log(\sigma)+b\cdot\log(I_0)+c$

(Djorgovski & Davi 1987)

FP for 56 Globular Clusters

- A relationship between 3 parameters: core radius ($\mathbf{r_c}$), surface brightness ($\boldsymbol{\mu_v}$), central velocity dispersion ($\boldsymbol{\sigma}$)



Viralized system

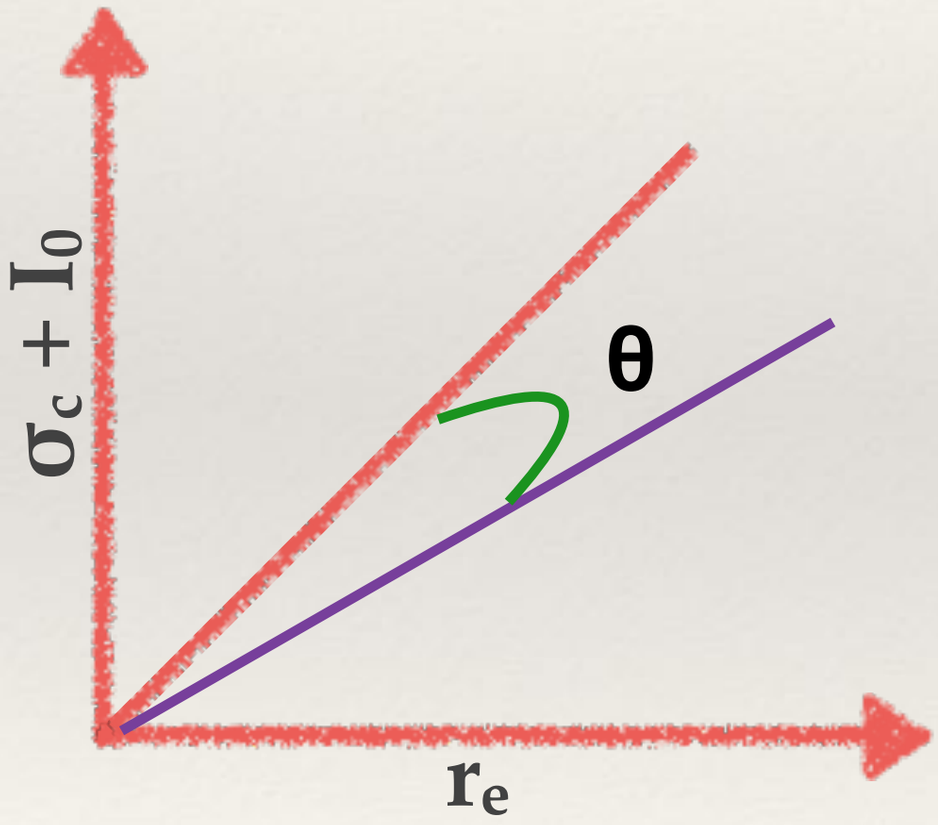
$$r_c \sim \sigma^2 I_0^{-1} (M/L)^{-1}$$

$$r_c \sim \sigma^{1.8 \pm 0.15} I_0^{-1.1 \pm 0.1}$$

(Djorgovski 1995)

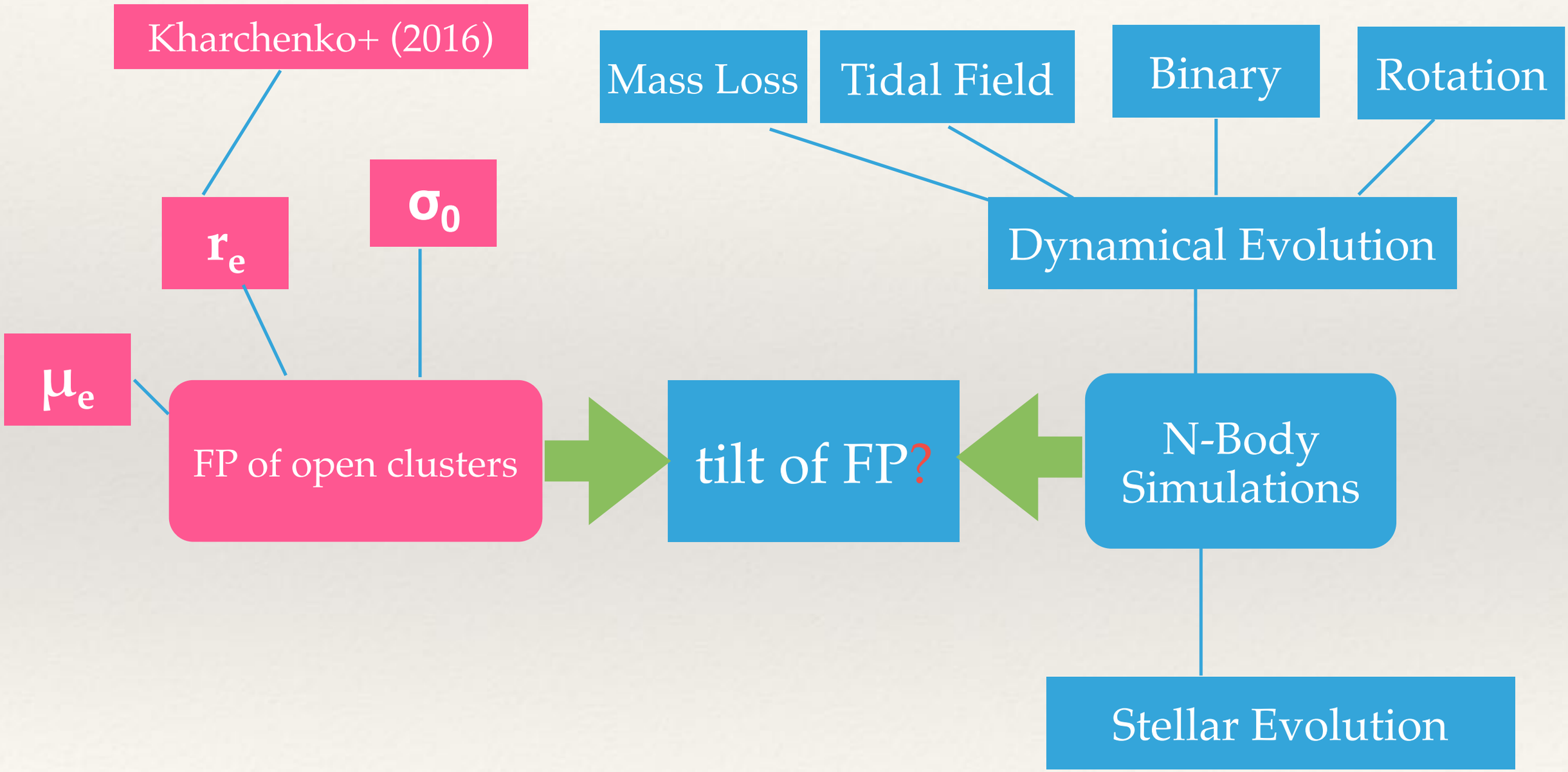
The Tilt of Fundamental Plane

- A gap between the theoretical (virialized) and observational (present) is also named “the tilt of FP”



- **Non-Virialized**
- **Non-Homogeneous**
- **Non-constant M/L**
- **External/internal effect**

Methodology



Sample of Open Clusters (OCs)

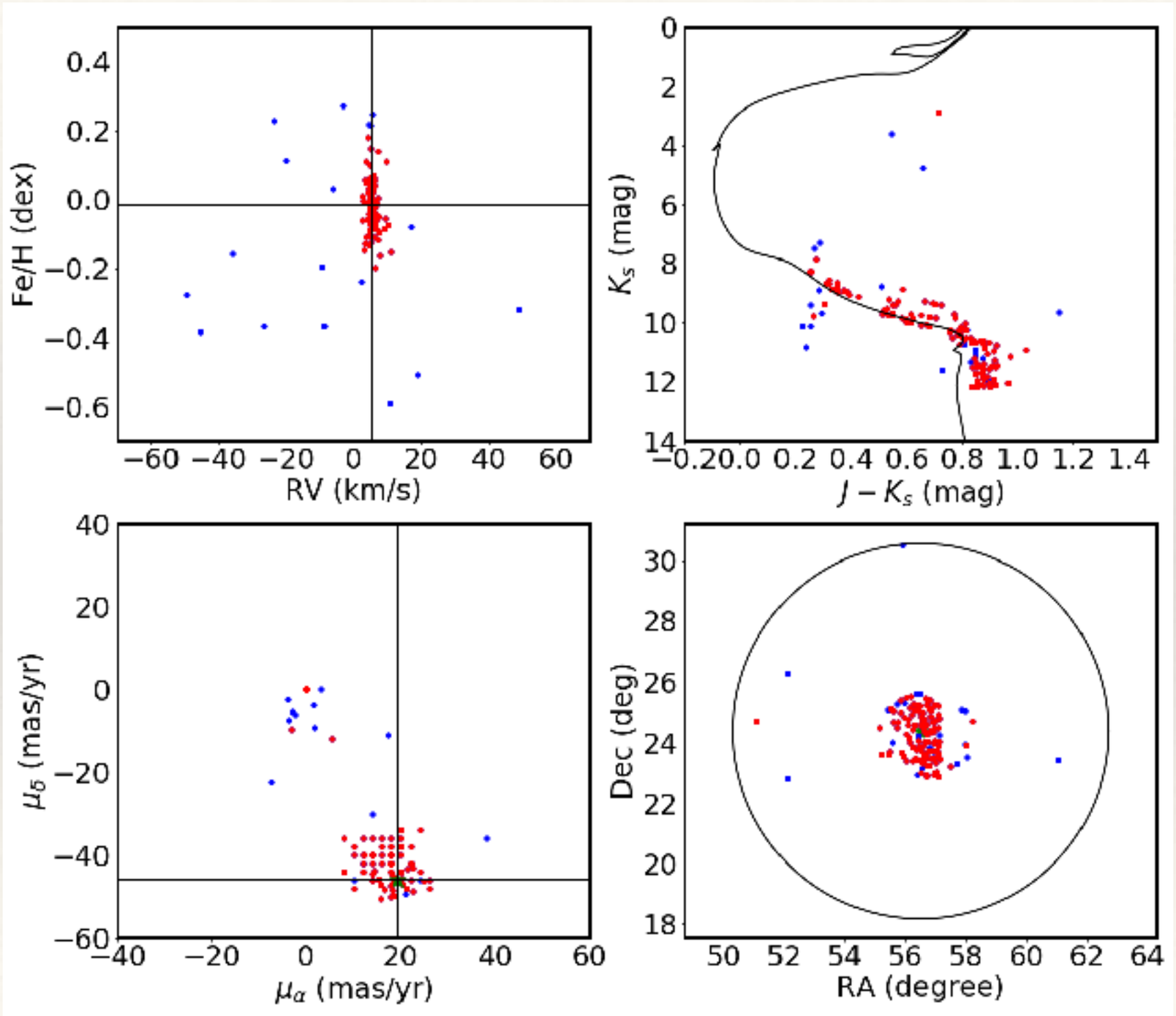
- **Kharchenko et al. (2016): 3006 OCs**
- **SDSS/APOGEE**
  - R~22,500 at H=13, ~10^5 red giants, AGBs, red clumps on the disk, halo, bulge and central bar (Zasowski et al. 2013).
  - S/N > 100: radial velocity (RV) accuracy ~ 0.1km/s
  - ~200 OCs overlap —> 18 OCs with > 5 members
- **GAIA-ESO**
  - ESO/VLT GIRAFFE (R~20,000 at V=19), UVE (R~47,000 at V=16.5), ~10^5 disk stars & 100 cluster stars, RV accuracy ~ 0.1km/s (Recio-Blanco et al. 2014)
  - 12 OCs in the inner disk (Jacobson et al. 2016)
- **Age of 30 OCs: 0.1 - 4 Gyr**

Membership of 18 APOGEE OCs

Fe/H

+

RV

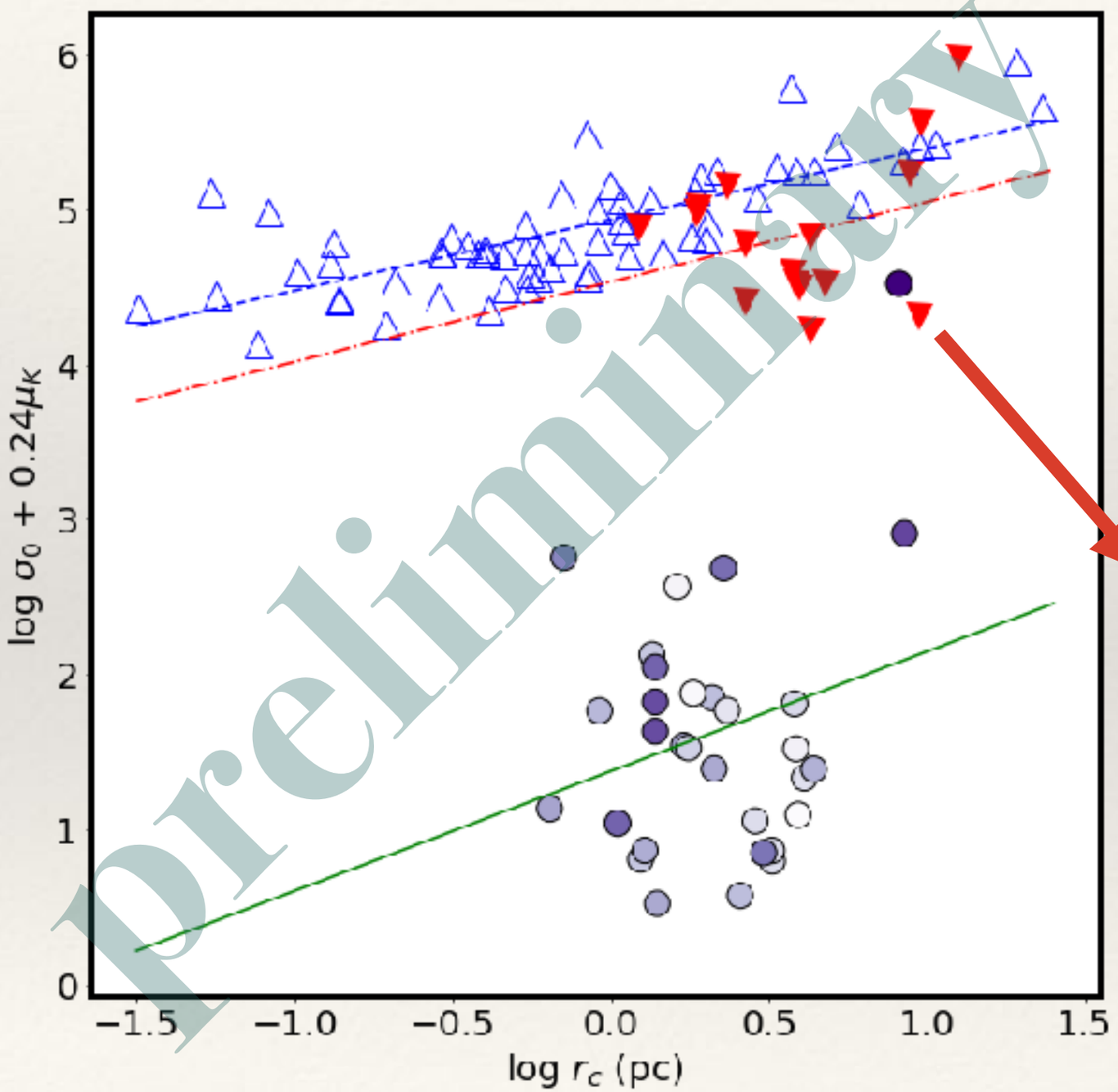


CMD

PMs

Spatial

Fundamental Plane for GCs & OCs



△ 62 GCs Harris ----- $r_c \sim \sigma_0^{2.18}$

▼ 25 GCs APO -·-·- $r_c \sim \sigma_0^{1.94}$

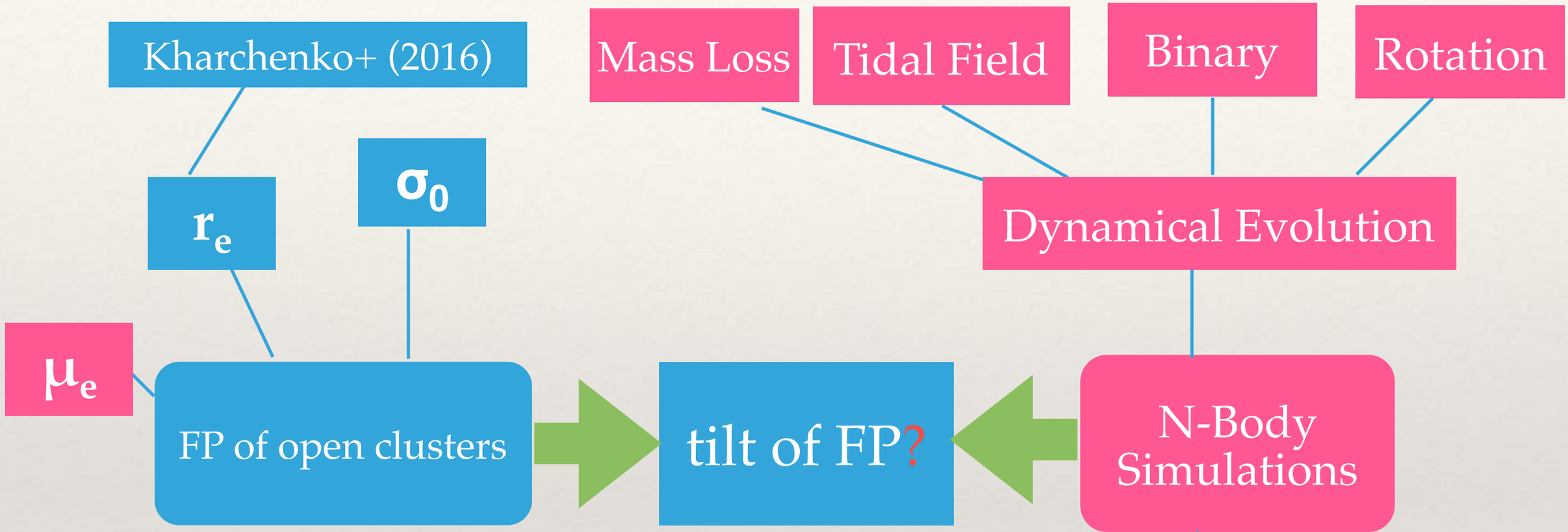
● 30 OCs APO+GES —— $r_c \sim \sigma_0^{1.30}$

Pleiades: 100 Myr, virialized (Moraux+ 2014)

The different intercept might from different M/L

The scatter of the FP might due to environments effect

Summary & Prospective



- **N-body simulations will be used to investigate the physical processes that response for the parameter variations**
- **Gaia DR2 will help us enlarge the OC sample including younger ones to make comparisons of FP between young and old ages.**