Aspen Winter Program, Dynamics & Accretion at the GC
Feb 7, 2016

Galactic Center Dynamics: Implications for the Glorious Past of Sgr A*

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Ref.: Chen & Amaro-Seoane, 2015, CQG, 32, 064001 (review)

Chen & Amaro-Seoane, 2014, ApJ, 786, L14

Amaro-Seoane & Chen, 2014, ApJ, 781, L18

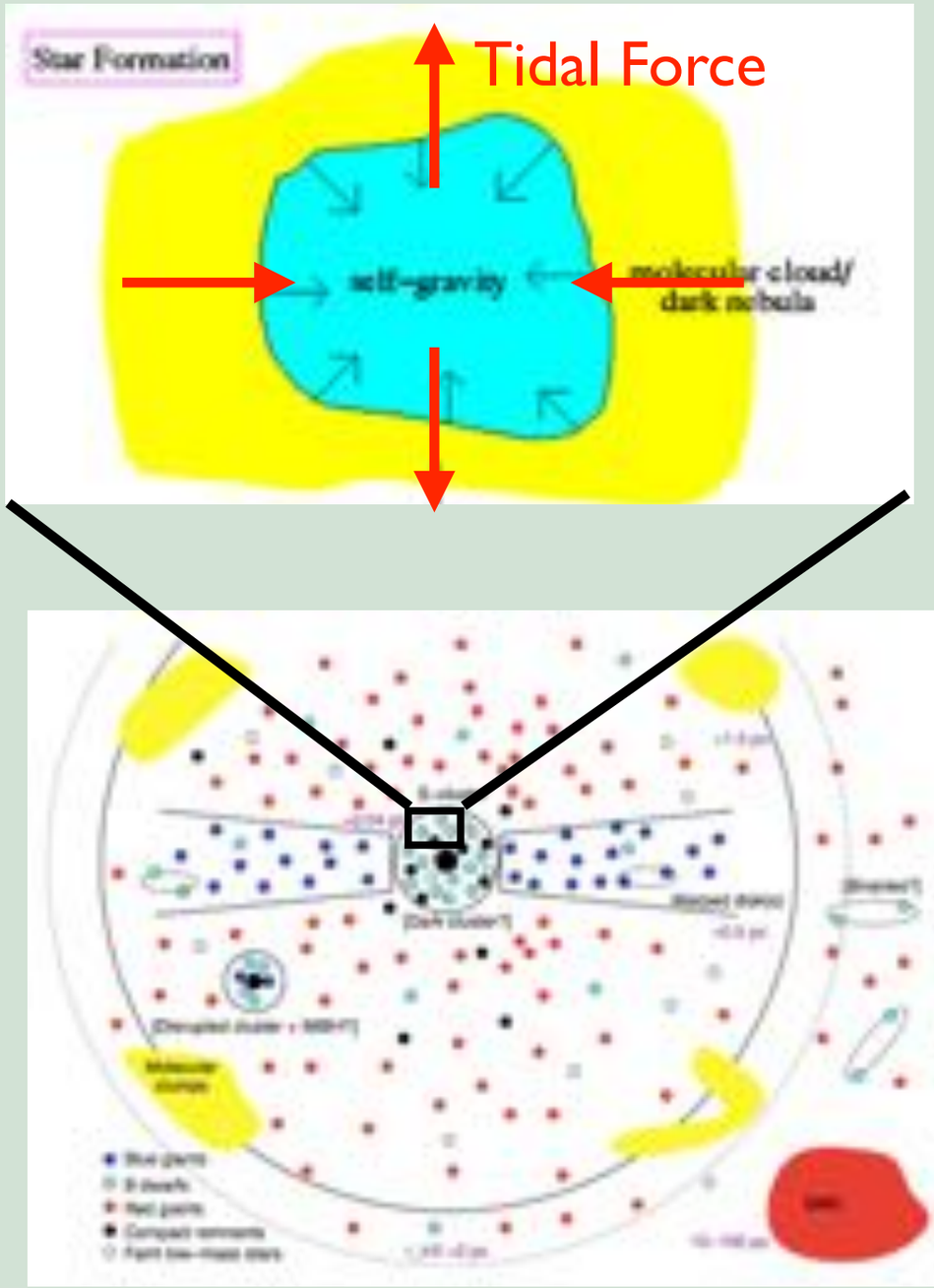
Chen & Amaro-Seoane, 2014, arXiv: 1412.5592

2004
1992
1980
1968
1956
1944
…

Issue: Thermalizing S-stars (<1”~0.04)

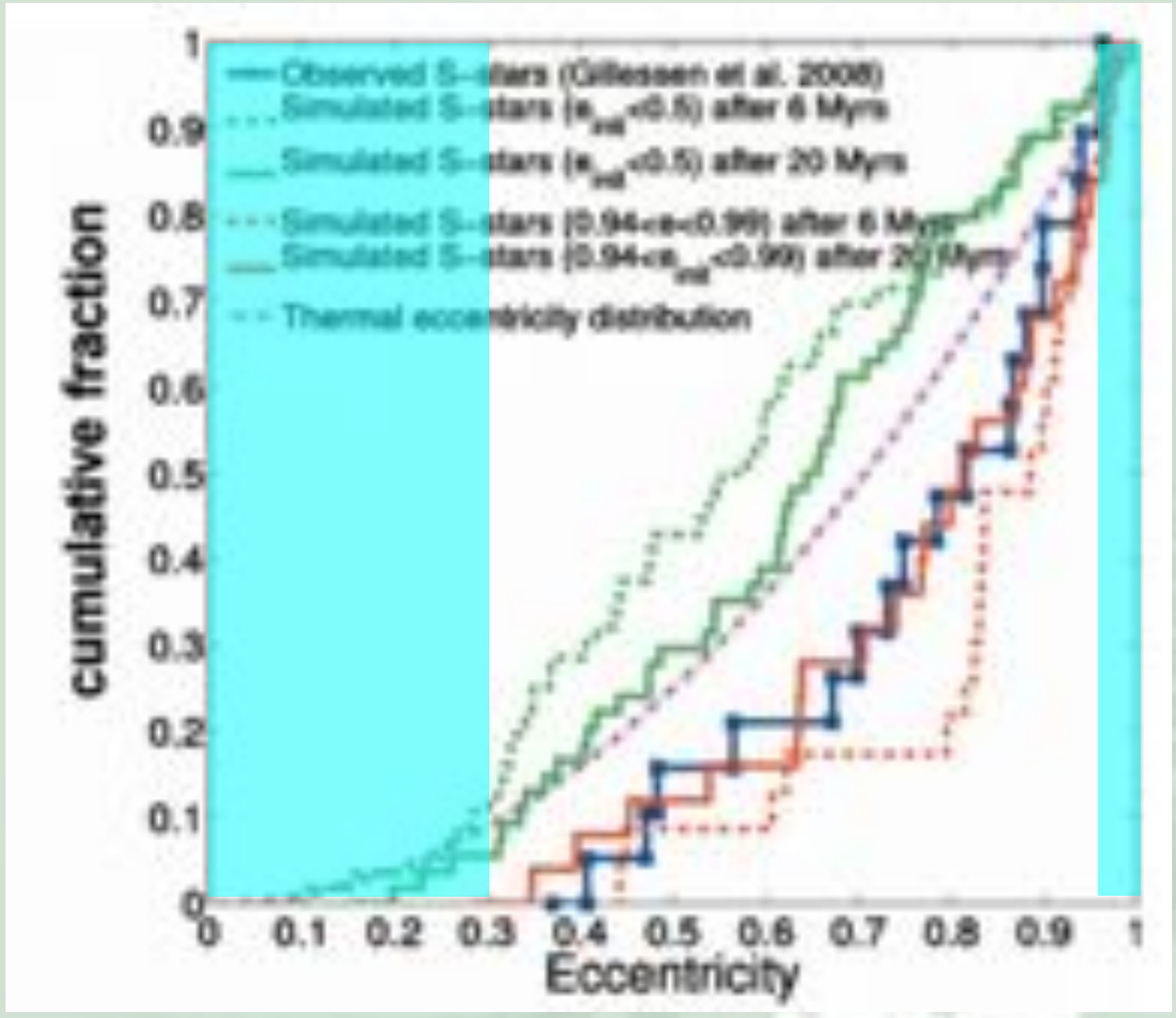
Paradox of youth (Morris 93; Ghez+03)

- Stars cannot form in-situ inside 1”
- But a cluster of young stars exist there
- *Disk-migration and binary-separation*



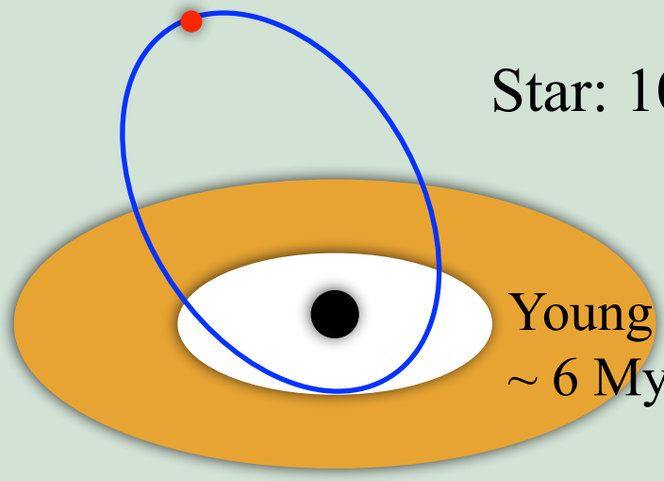
Resonant relaxation of S-stars

(Fig. from Perets+09, also see
Antonini & Merritt 13, Zhang+13, & Madigan+14)



- Exclude disk-migration model?
- Age of S2/SO-2: 6 Myr (Martins+08), episodic SF?
- Bacall-Wolf (BW) cusp (gamma=1.75~2)?
- *How about shortening relaxation timescale?*

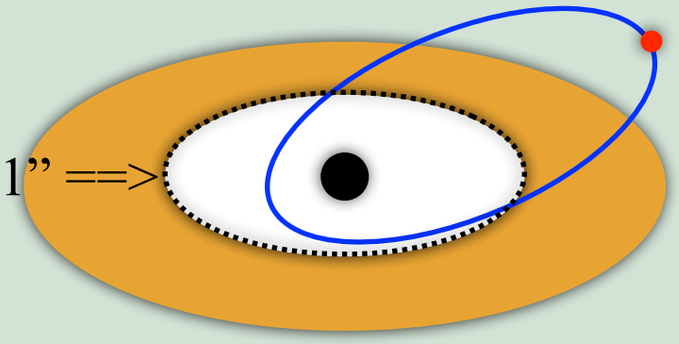
Disk-induced Kozai-Lidov evolution



Star: 10 Msun

Young stellar disk
~ 6 Myr

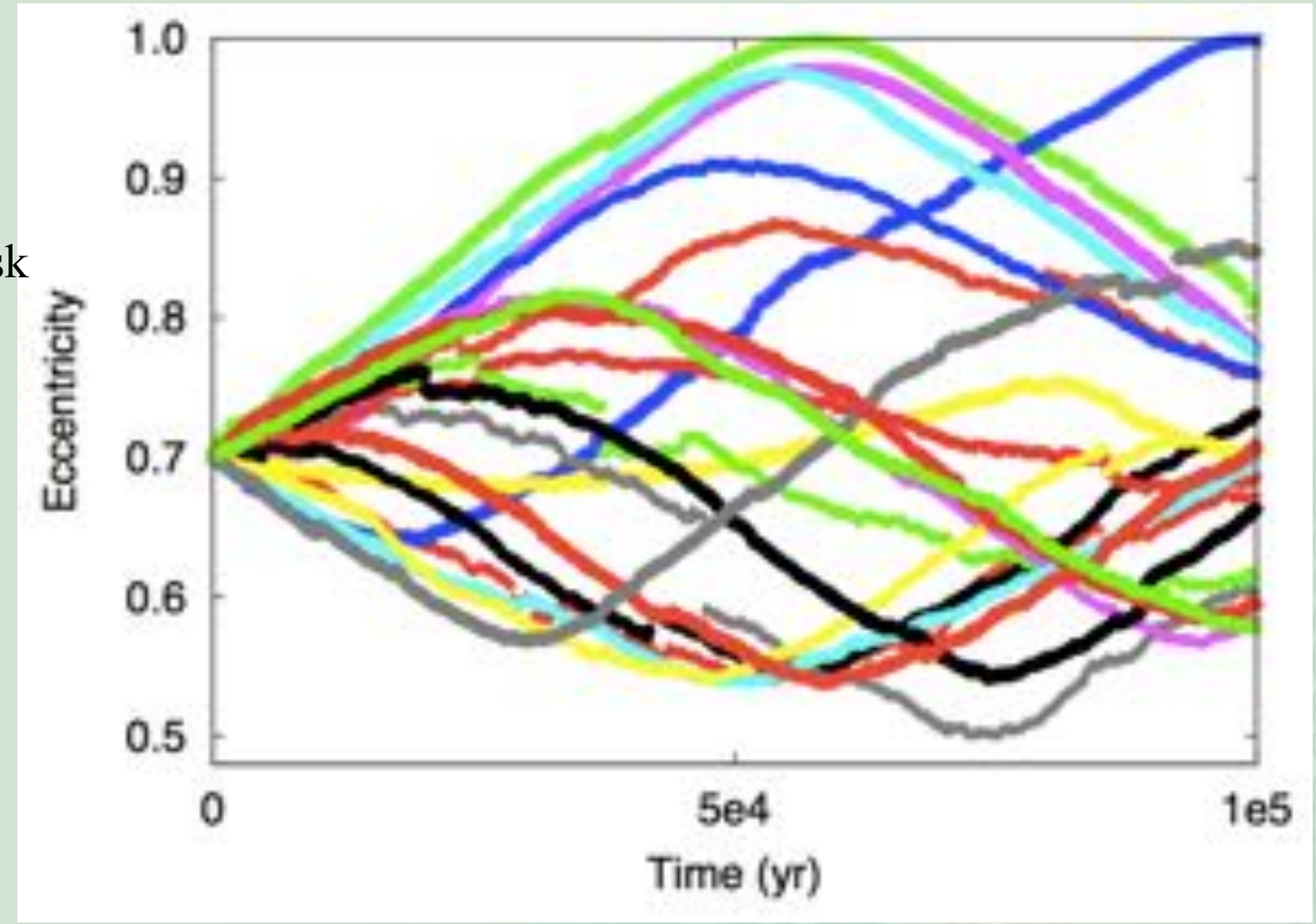
disk: >10,000 Msun



Kozai-Lidov-like interaction

(Chang 2009 also see Ivanov et al. 2005; Subr & Karas 2005; Lockmann et al. 2008; Chen et al. 2009,2011)

Single-star orbital integration (XC & AS 2015, CQG)

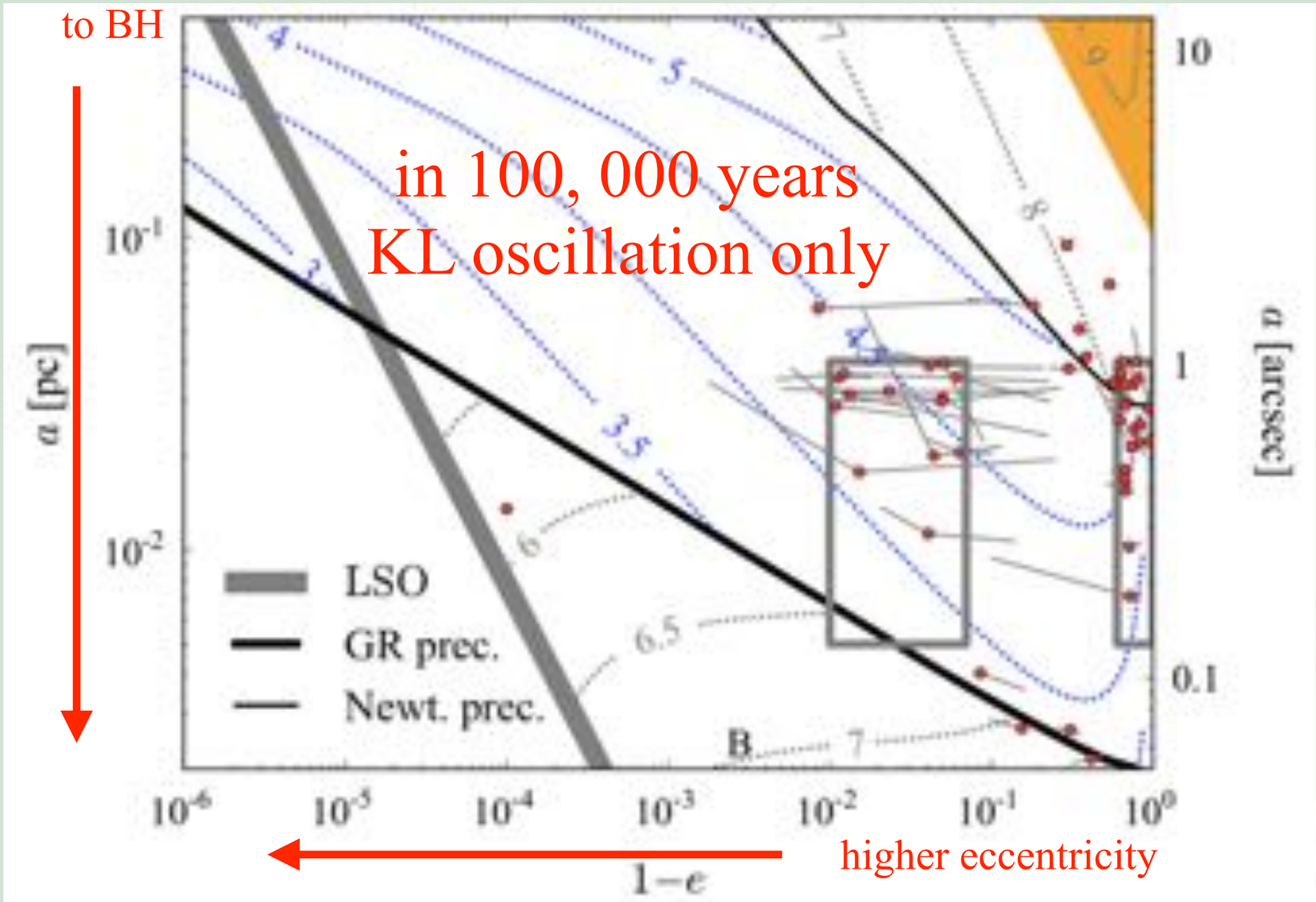


Assumption: disk more massive, more extended 6 Myr ago

- Kozai-Lidov-like cycle, 10^5 yr!
  - a= 0.5” (0.02 pc)
  - Same e0, different inclination and ascending-node angle

A Rapidly Evolving Region

Rapidly Evolving Region (RER) 6 Myr ago
(Chen & Amaro-Seoane 14)



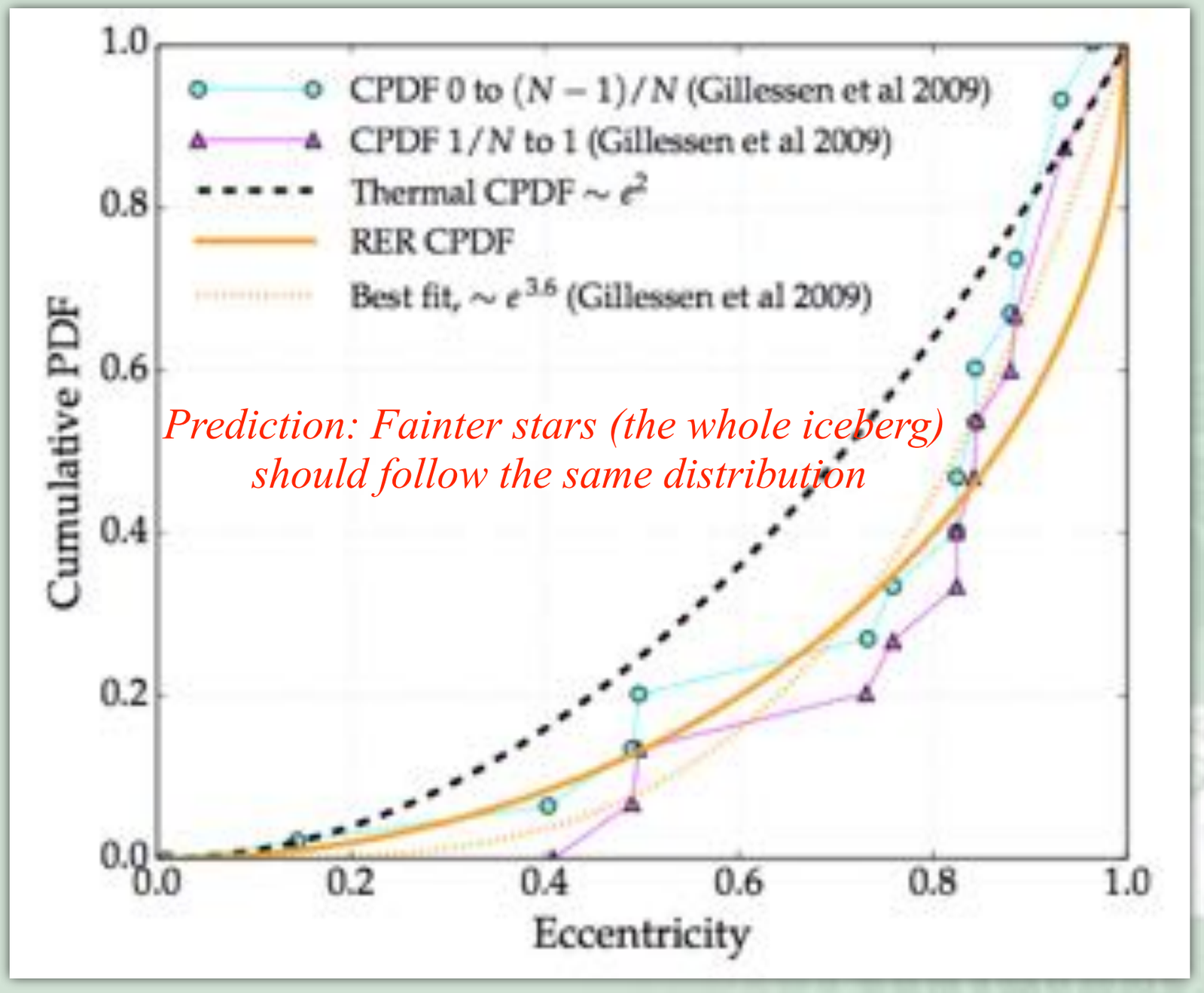
- Incorporate two birthplaces
- Cusp induce vectorial resonant relaxation
- Cusp: gamma=1.3 ~1.5 (without BW cusp)

Thermalizing S-stars

RER distribution function

Disk torque : $dN/de \propto dt/de \propto e/\sqrt{1-e^2}$ $(\Delta L \propto \Delta t)$

Thermal : $dN/de \propto dt/de \propto e$ $(\Delta L^2 \propto \Delta t)$



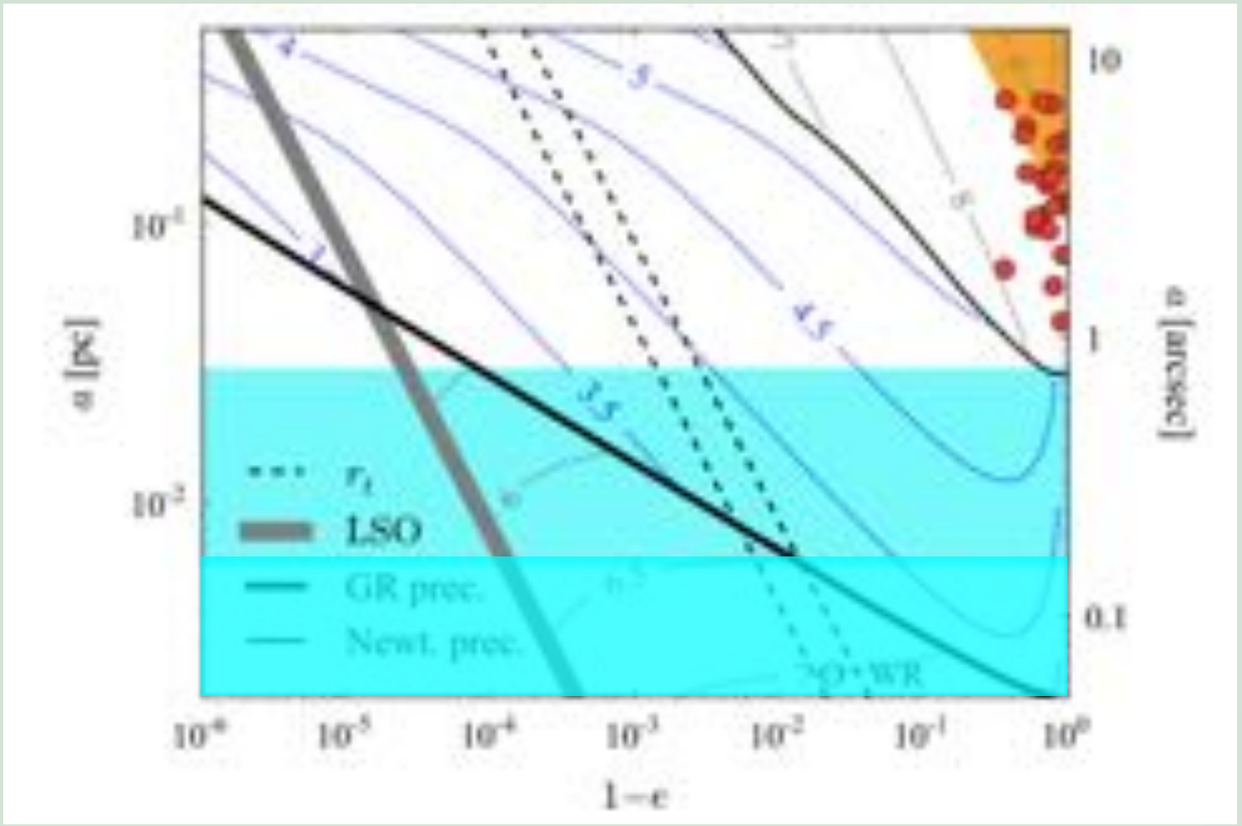
Prediction: Fainter stars (the whole iceberg) should follow the same distribution

Prediction: Tidal Disruption of WR/O stars

RER in the past, WR/O-star depletion explained

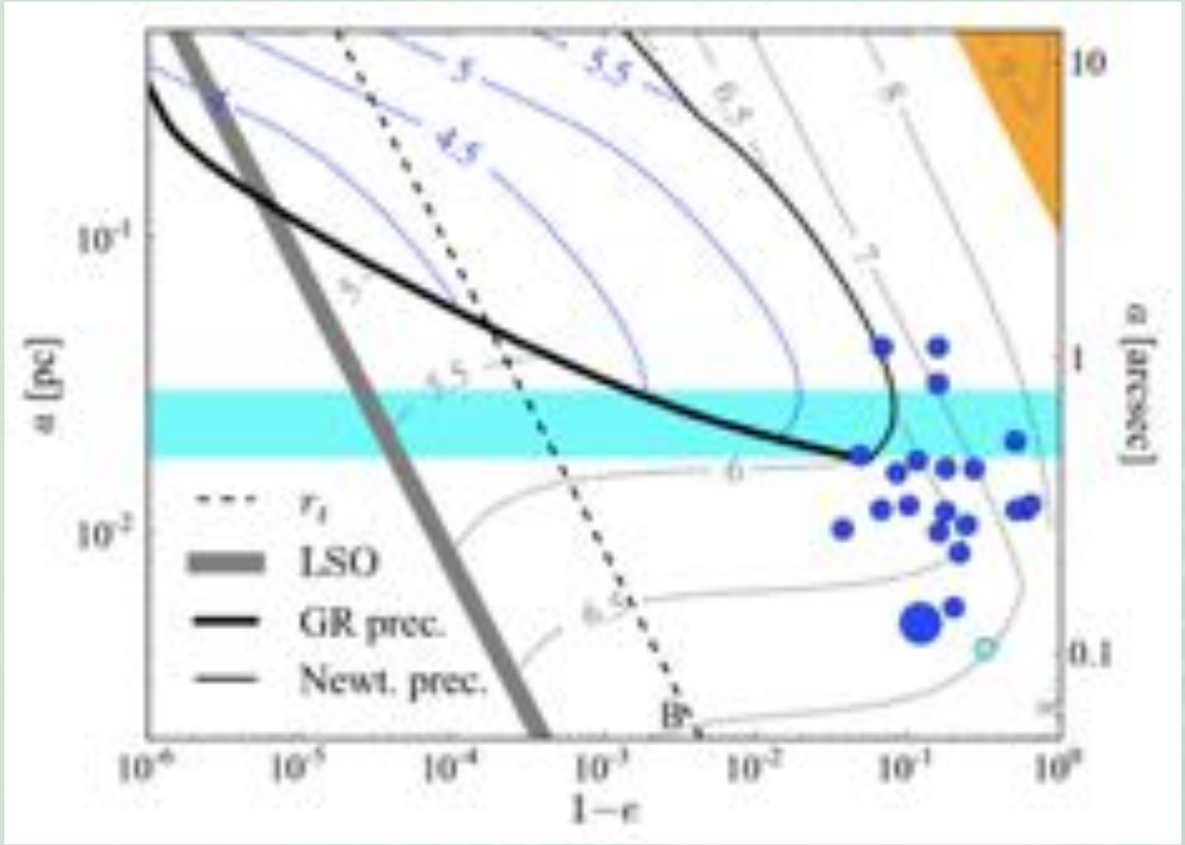
Model predictions v.s observations

WR/O stars



- Chen & Amaro-Seoane 2015 CQG
- Data from Paumard et al. 2006

B stars (S-cluster)

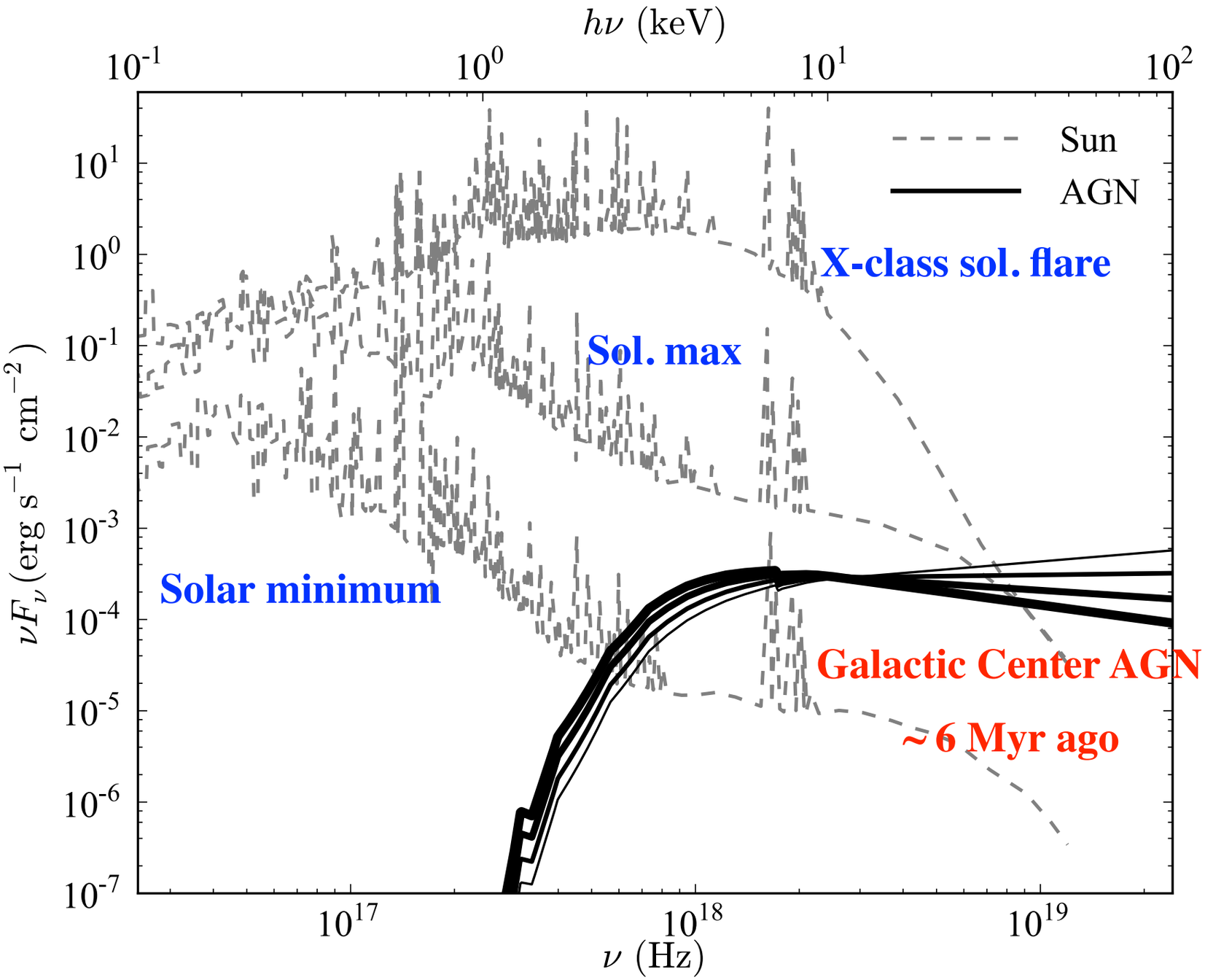


- Gap in S-star distribution
- Not rapidly evolving today
- Data from Eisenhauer+03, Ghez03, Gillessen+09, Meyer+12

Inverse mass segregation (Alexander 11)

Sagittarius A* Rivaled the Sun in the Ancient X-ray Sky

Chen & Amaro-Seoane (arXiv:1412.5592)



Possibilities: (1) **Ionosphere disturbance** (frequency of lightening) and (2) **Ozone depletion** (1-3%)