Predicting the limits of the ELT

Defensio

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Outline

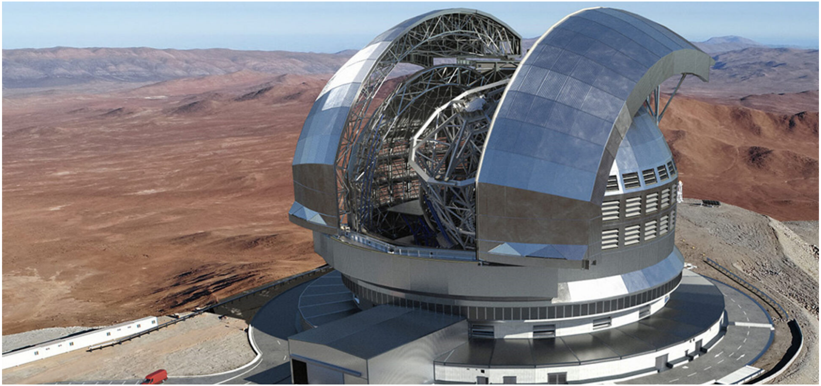
Goals

Primary objective

Estimate reliability limit for future IMF studies in the galactic centre using the ELT!

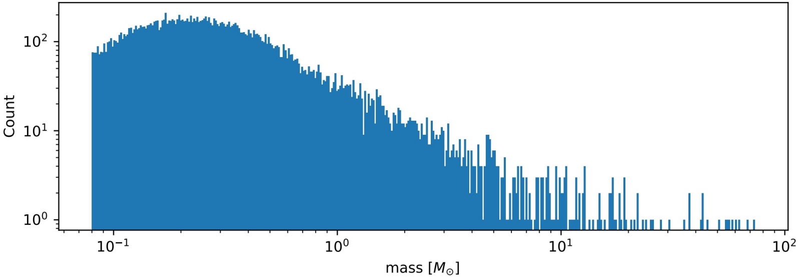
... what?

ELT

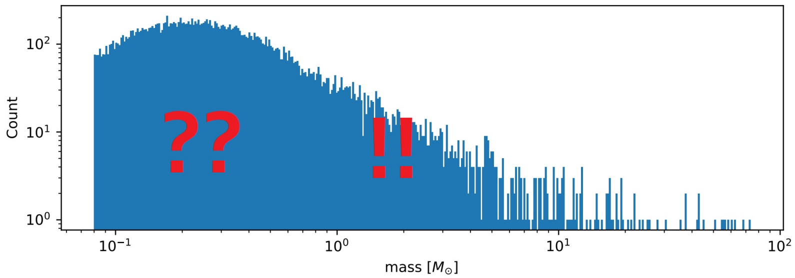


https://cdn.eso.org/images/banner1920/telescope-dome-landing.jpg

IMF



Reliability Limit



Motivation

- Universal IMF?
- estimate number of lower-mass stars
- understand star formation process
- N-body simulation with $N \gg 1$
- Clustering of time-dependent data

Action Plan

1. Simulate stars
2. Observe stars
3. Analyze
4. Measure performance

Parameters

using McLuster

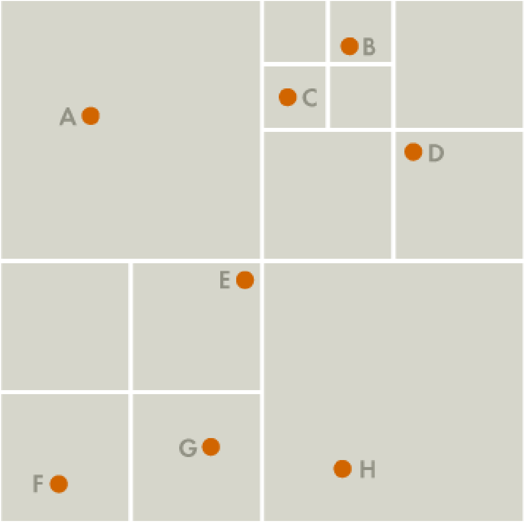
- Plummer density profile
- virial equilibrium
- Kroupa IMF 0.08 $M_\odot$ to 100 $M_\odot$
- Metallicity in range 0.5 - 2 solar
- No binaries
- N 1.3k - 40.4k

1. Issue with large N

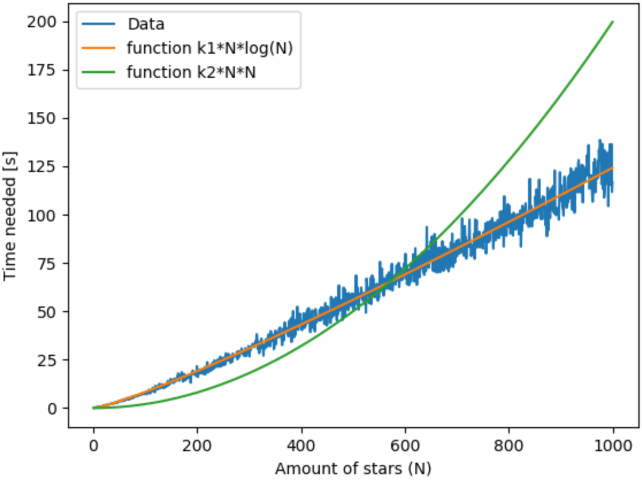
Direct summation $O(N^2)$

Barnes-Hut Algorithm $O(N \log(N))$

- approximate with macro particles
- $\frac{width}{distance} < \theta_{max}$

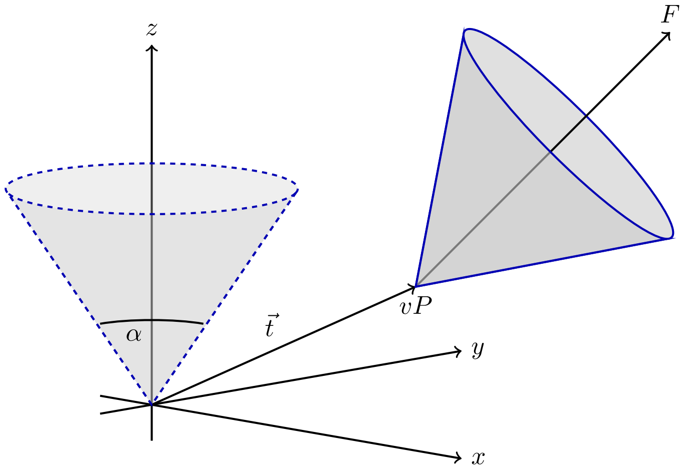


http://arborjs.org/docs/img/example-space.png


Data
function k1*N*log(N)
function k2*N*N
Time needed [s]
200
175
150
125
100
75
50
25
0
0
200
400
600
800
1000
Amount of stars (N)

Multi-component axis-symmetric potential

- components
  - Black hole: Keplerian potential
  - Disk: Miyamoto Nagai potential
  - Bulge: Hernquist potential
  - Dark matter halo: Navarro–Frenk–White potential
- needed for
  - Force from analytic derivatives
  - Initial conditions for field stars


z
F
α
$\vec{t}$
vP
y
x

Initialize mass (1)

Total mass inside code

$$M = \int_{-R}^{R} \int_{-\sqrt{R^2-x^2}}^{\sqrt{R^2-x^2}} \int_{\frac{h}{R}r}^{h} \rho\left(\mathbf{T} \cdot \begin{pmatrix} x \\ y \\ z \end{pmatrix}\right) dzdydx$$

R cone base radius

T transformation matrix

h cone height

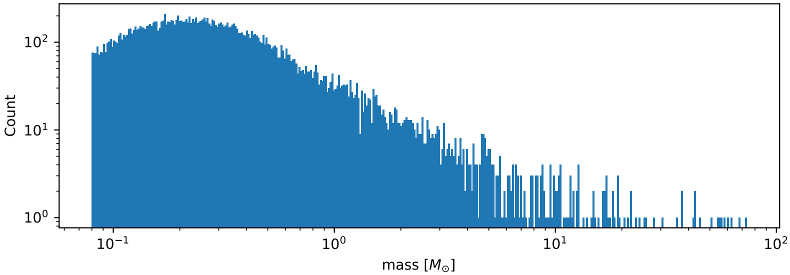
Integration

- GSL: GNU Scientific Library
- Gauss-Kronrod quadrature

Initialize mass (2)

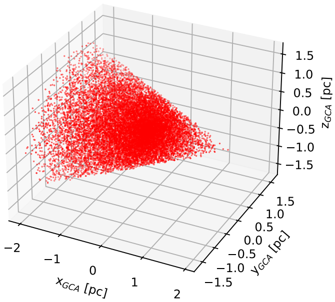
Sample mass functions

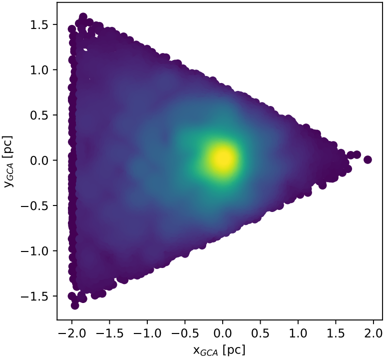
- rejection sampling
- inverse transformation sampling



Positions

1. uniform distribution
2. transformation
3. rejection sampling





Velocities

- Disk
  - Sampled from Gaussian distributions
  - radial, vertical and azimuthal dispersions
  - Epicyclic Approximation
- Bulge
  - $\sigma_r^2 = \frac{1}{\rho} \int_r^\infty \rho \frac{\partial \Phi}{\partial r} \mathrm{dr}$
  - Lookup table