

Predicting the limits of the ELT

Defensio

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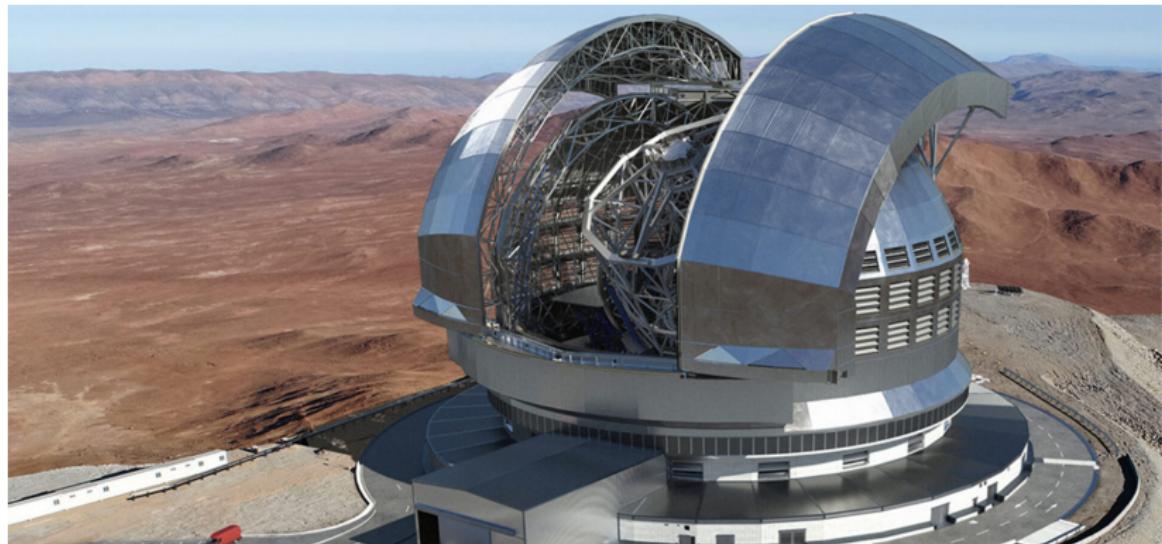
University of Vienna, Faculty of Physics

April 29, 2022

Primary objective

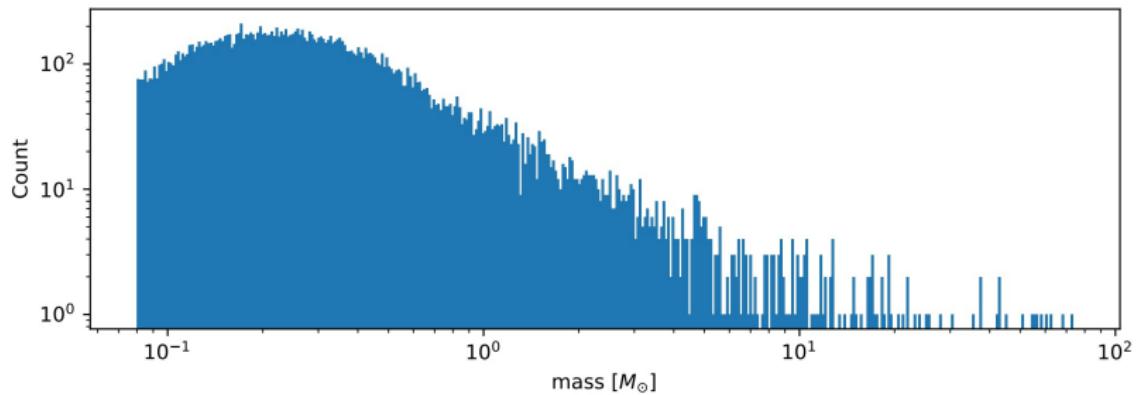
Estimate reliability limit for future IMF studies in the galactic centre using the ELT!

ELT

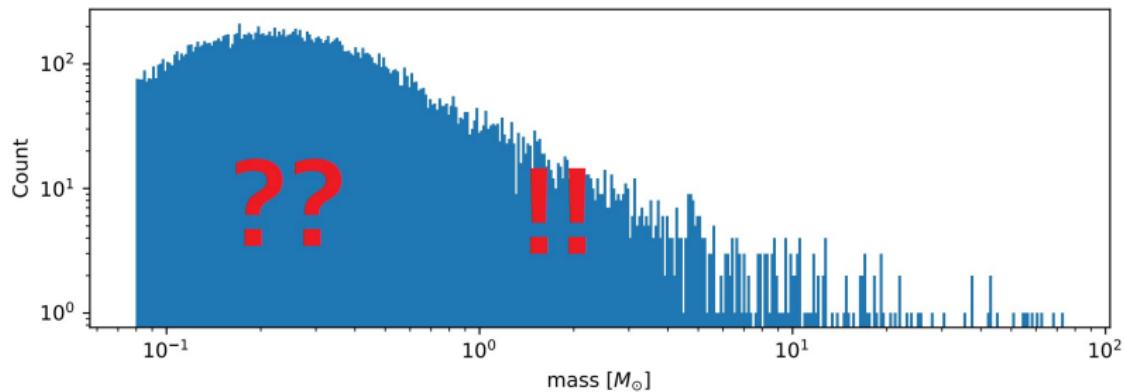


<https://cdn.eso.org/images/banner1920/telescope-dome-landing.jpg>

IMF



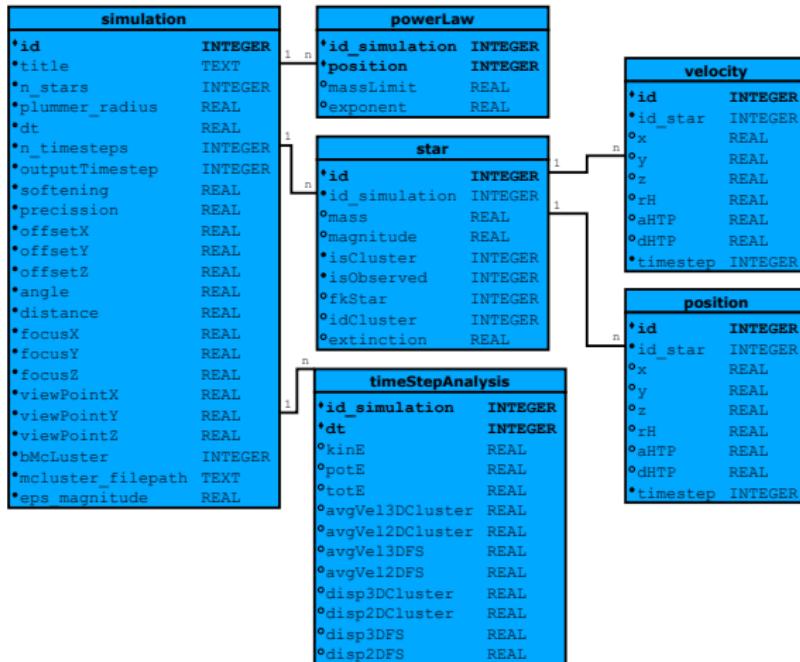
Reliability Limit



In other words

Primary objective

Determine reliability of cluster membership detection.



Initialize star cluster

McLuster by Andreas Kuepper with Kroupa, P. & Baumgardt, H.

- Plummer density profile
- virial equilibrium
- Kroupa IMF $0.08 M_{\odot}$ to $100 M_{\odot}$
- N 1.3k - 40.4k

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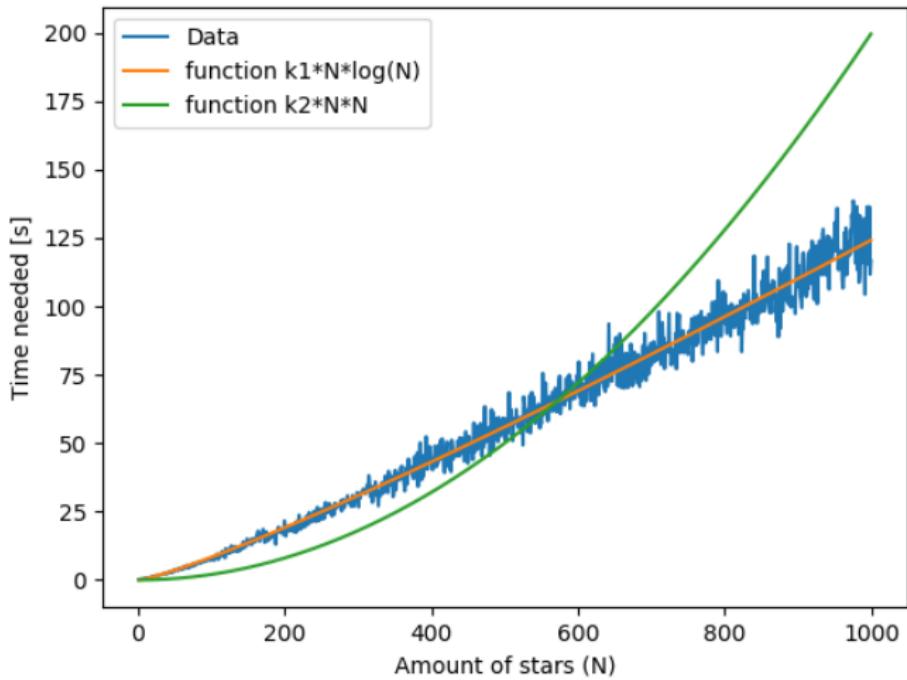
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Force Calculation

- Direct summation $O(N^2)$
- Barnes-Hut Algorithm $O(N \log(N))$
 - approximate with macro particles
 - $\frac{\text{width}}{\text{distance}} < \theta_{\max}$

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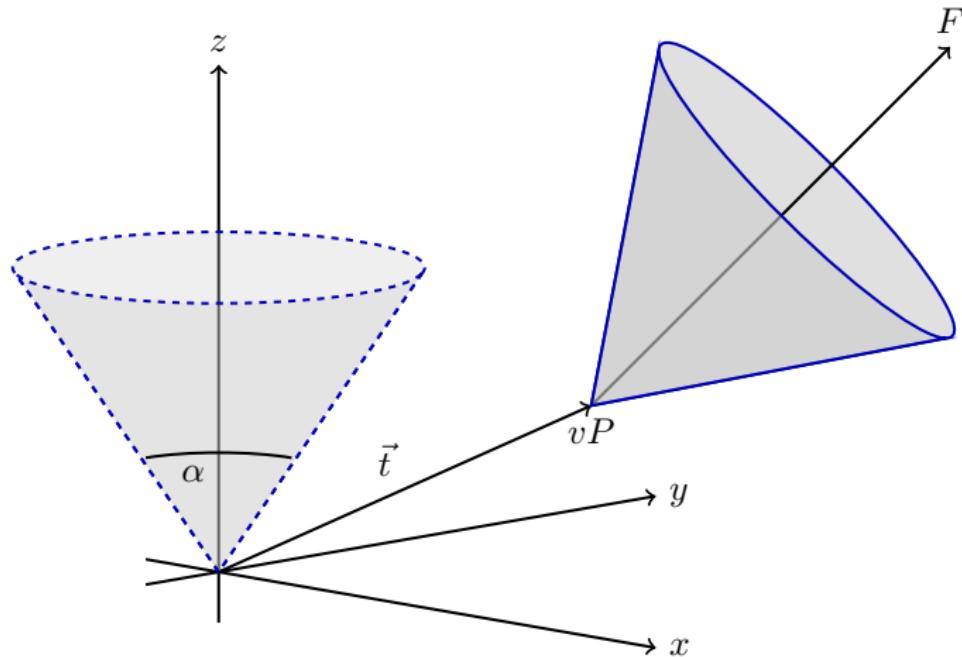


Multi-component axis-symmetric potential $\Phi(R, z)$ and density.

- needed for
 - Force from analytic derivatives
 - Initial conditions for field stars
- components
 - Black hole: Keplerian potential $\Phi_{bh}(r)$
 - Disk: Miyamoto Nagai potential $\Phi_{disk}(R, z)$
 - Bulge: Hernquist potential $\Phi_{bulge}(r)$
 - Dark matter halo: Navarro–Frenk–White potential $\Phi_{halo}(r)$

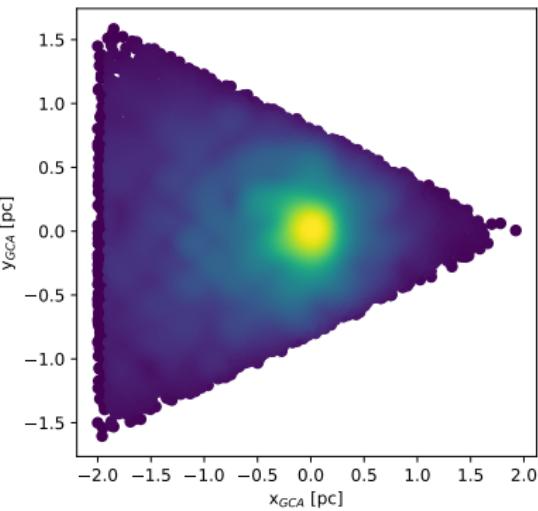
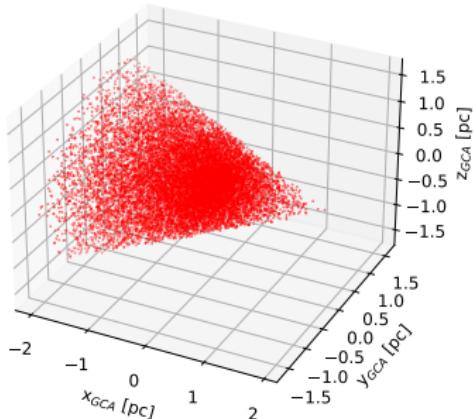
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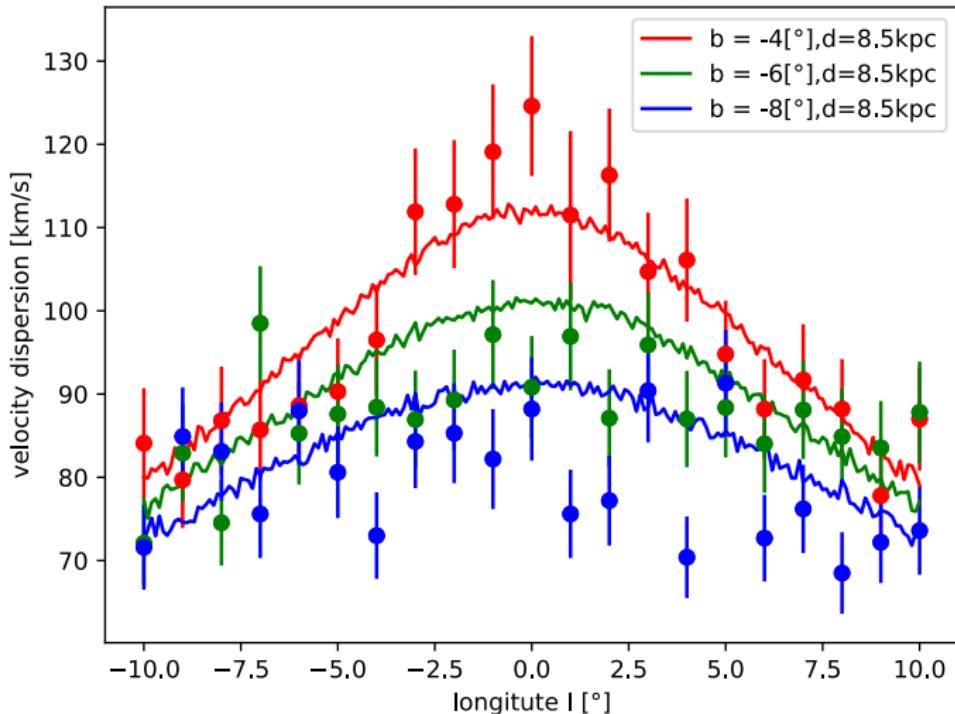


Initialize field stars

1. Total mass inside code
2. Sample mass functions N 0.7k - 351.2k
3. Positions: sample density
4. Velocities: Jeans equations



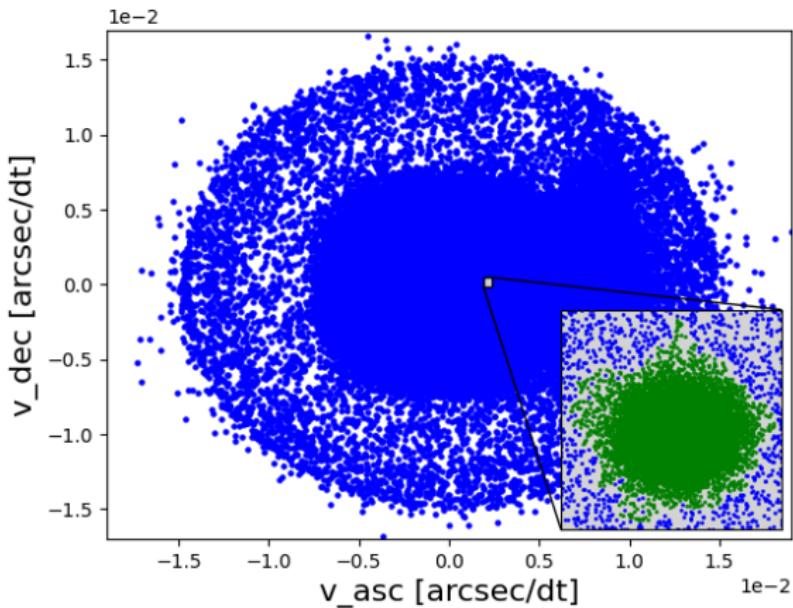
velocity dispersion bulge



- 1. Integrate equations of motion**
2. Write to Database
3. Test total Energy

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Coordinate Systems

GalPot by Paul McMillan

GCA Galactocentric Cartesian

LSR Local Standard of Rest

HCA Heliocentric Cartesian

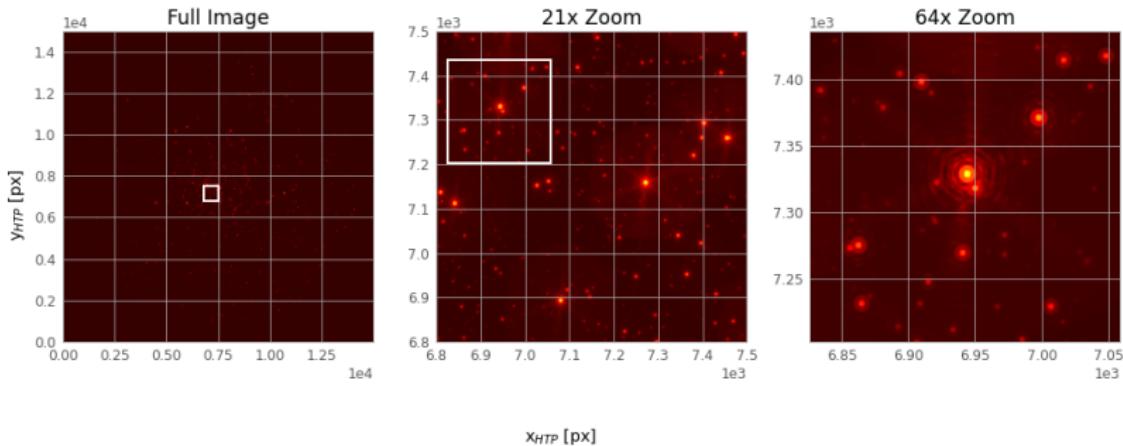
HTP Heliocentric Telescope Polar

ScopeSim by Kieran Leschinski

Spectra

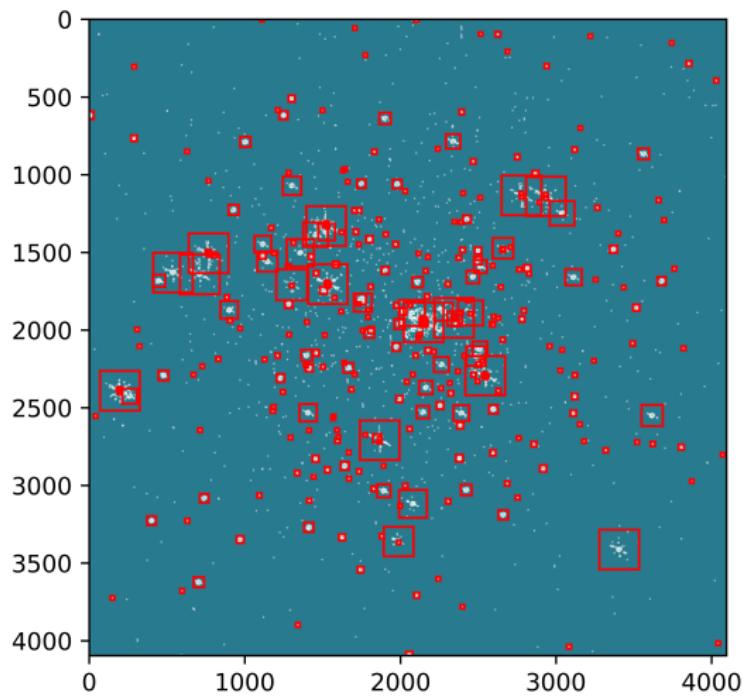
- Pickles catalogue
- From mass and distance
- Extinction

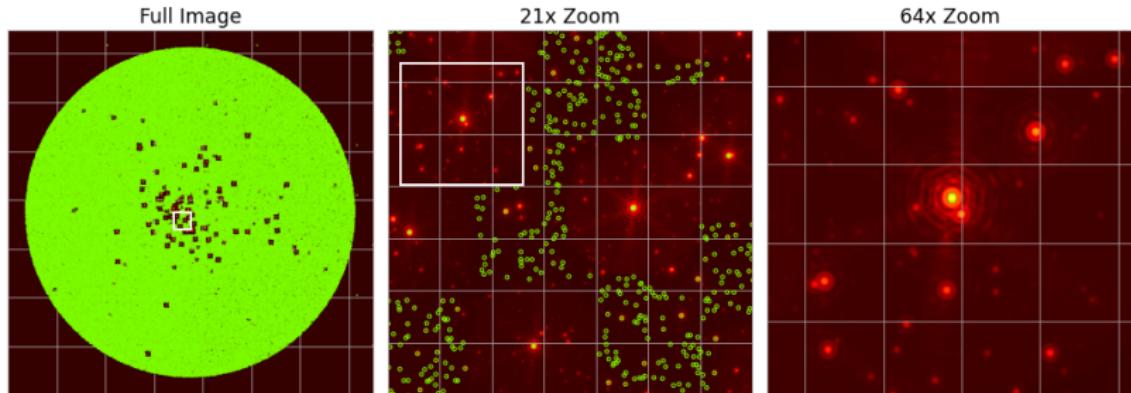
Output FITS files



Photutils by Larry Bradley et al.

- DAOStarFinder
 - Threshold
 - Roundness
 - Mask





mlpack by Ryan Curtin et al.

- Map observed stars
 - Range search
- Velocity approximation
 - Nearest-neighbors search
 - max magnitude difference
 - compare with mapping

DBSCAN Algorithm

Density-based spatial clustering of applications with noise

Pros:

- noise
- amount of clusters

F1 Score

$$F_1 = 2 \frac{P \cdot R}{P + R} = \frac{TP}{TP + 0.5(FP + UP + FN)}$$

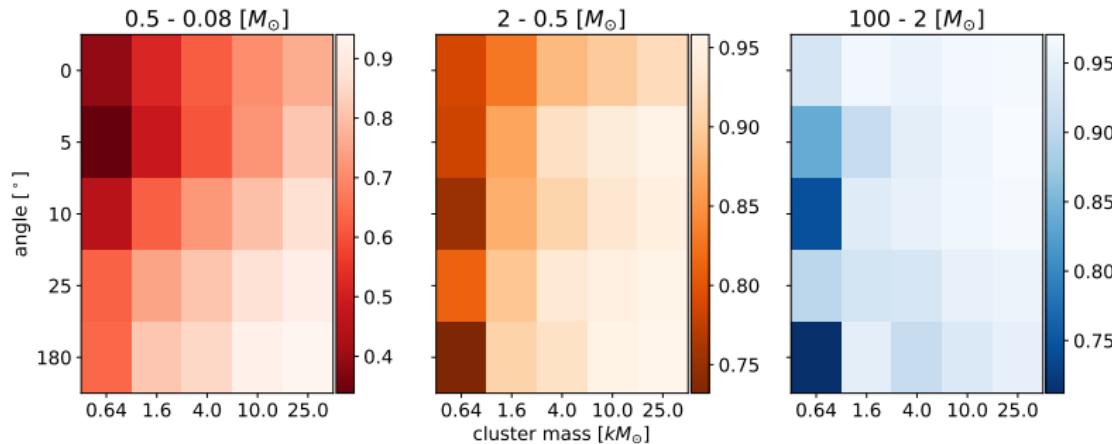
TP correctly classified as cluster star

FP wrongly classified as cluster star

UP not mapped star classified as cluster star

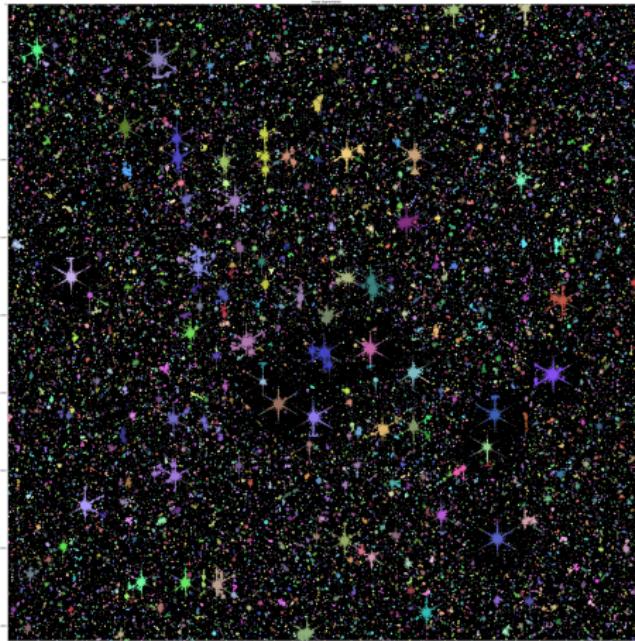
FN wrongly classified as field star

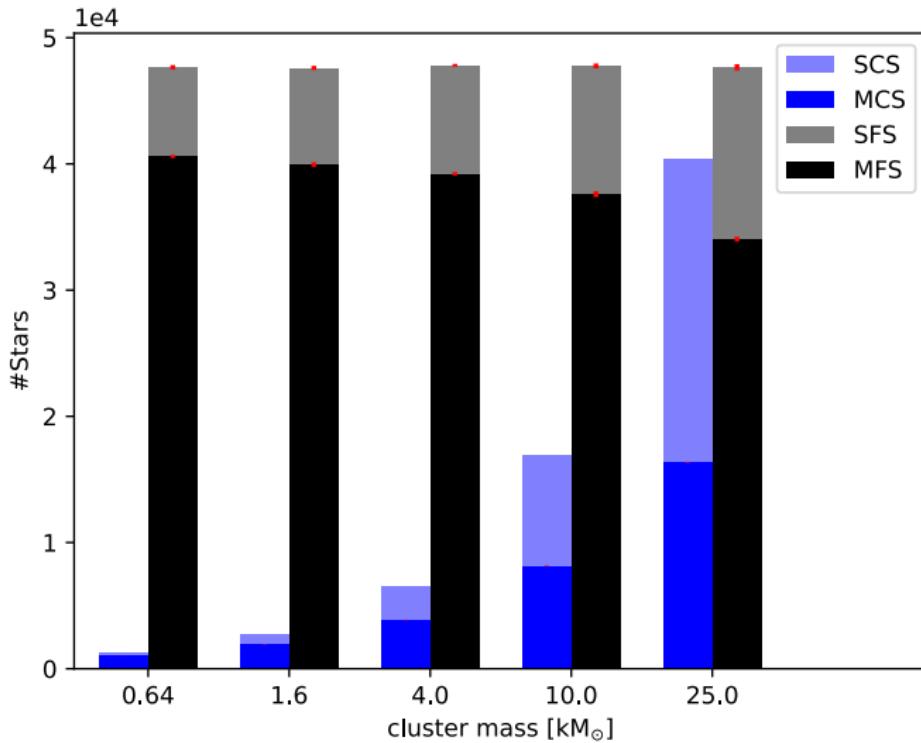
Results: F1

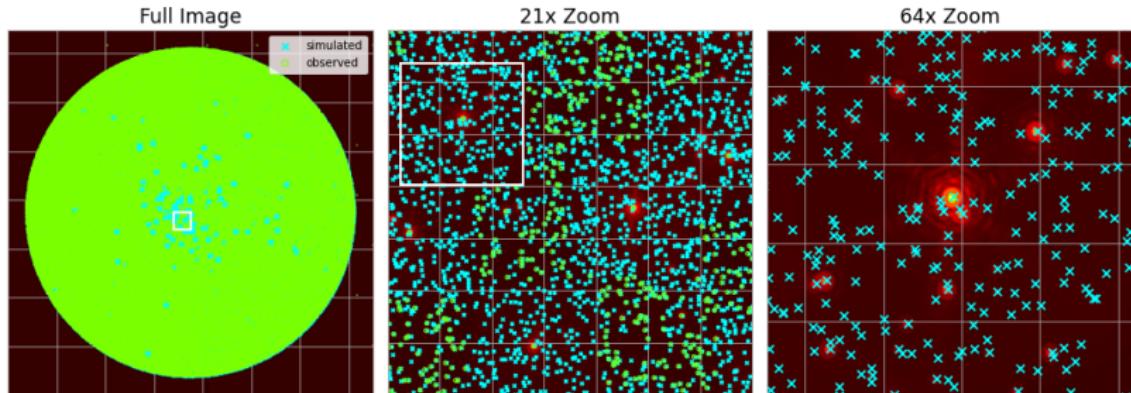


Star M _☉	Cluster kM _☉	% Found	F1 Score
<0.5	0.64	41	0.39
<0.5	1.60	40	0.52
<0.5	4.00	40	0.62
<0.5	10.00	35	0.71
<0.5	25.00	28	0.76
0.5 - 2	0.64	81	0.79
0.5 - 2	1.60	80	0.83
0.5 - 2	4.00	76	0.88
0.5 - 2	10.00	63	0.90
0.5 - 2	25.00	54	0.92

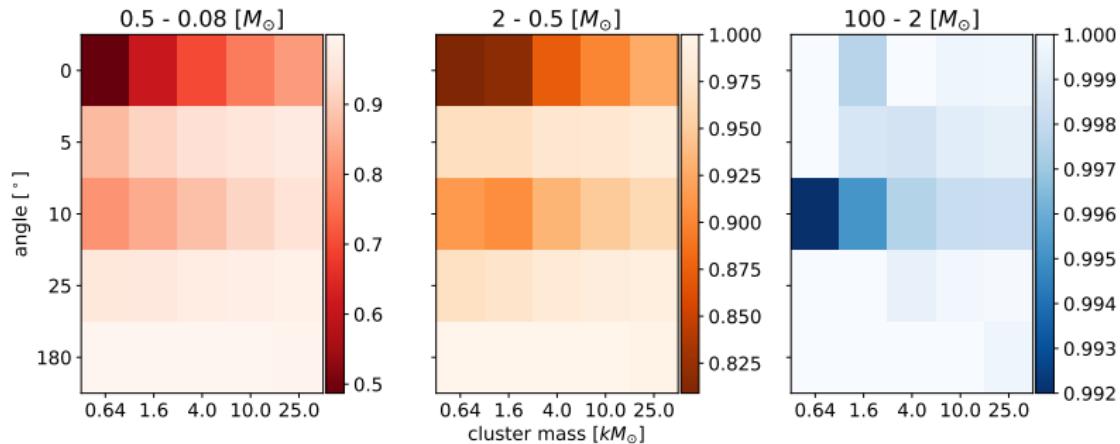
*Thank you for your kind
attention!*

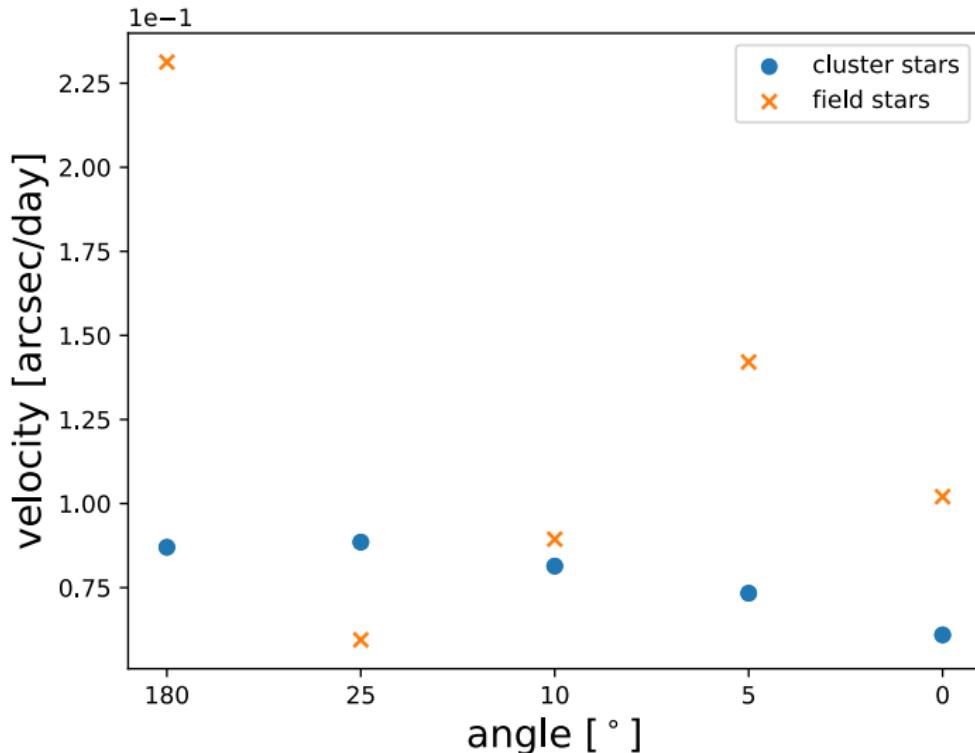






Precision





general remarks on performance

- Pass and loop by reference
- Multithreading (OpenMP)
- Choice of language
- Define (mathematical) constants
- C++ : `emplace_back` VS `push_back`

Parameter optimization

