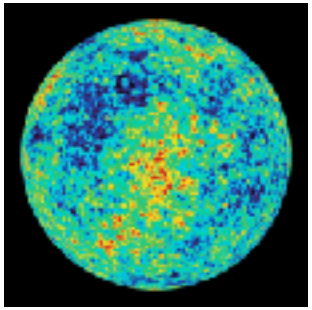
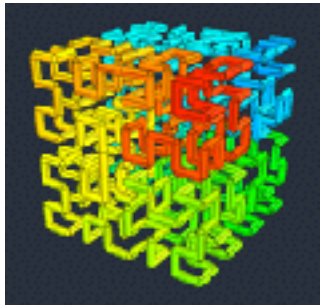
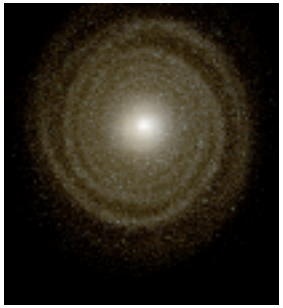
University of Zurich[UZH]

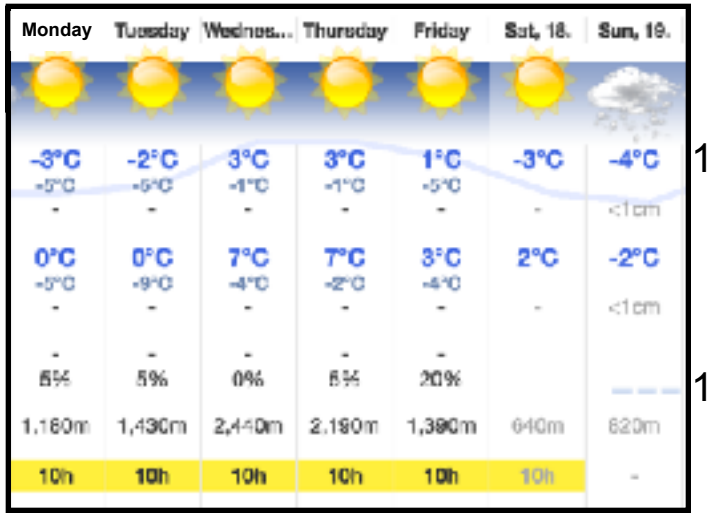
AstroDavos 2017

New challenges in computational astrophysics

Organisation

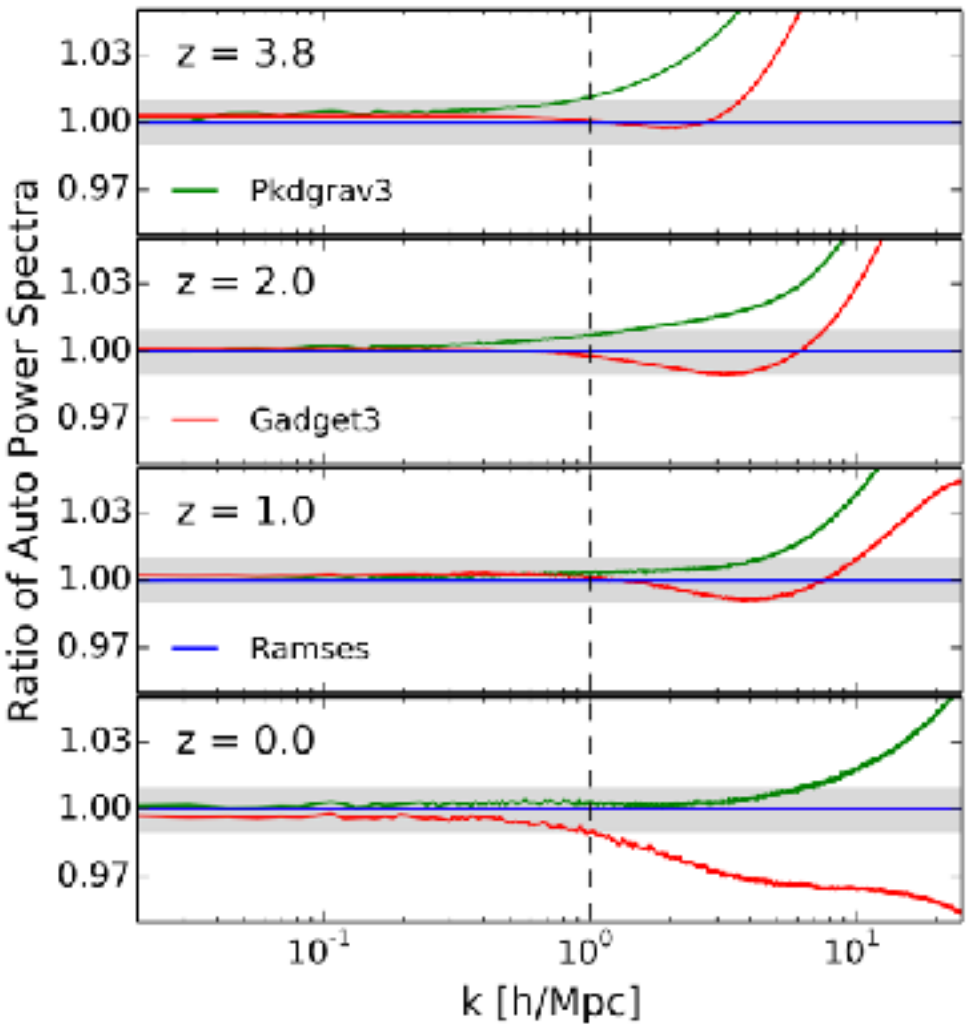
Many thanks to Pedro R. Capelo, Joanna Drazkowska, Valentin Perret, Alireza Rahmati, Clement Surville, Judit Szulagyi, Sebastian Trujillo-Gomez and Suzanne Wilde



	Monday	Tuesday	Wednes	Thursday	Friday
9:00	Codes Methods Stadel	SKI	Rad Tran. Reioniz. Stone	SKI	N Body TBD
12:00	SKI	Codes Methods Teyssier	SKI	Galaxies Cosmo. Mayer	SKI
16:00	Planets Baraffe	Stars ISM Wadsley	AFTER SKI	Galaxies Cosmo. Di Matteo	TRAVEL
19:00					

Accuracy of large scale structure simulations

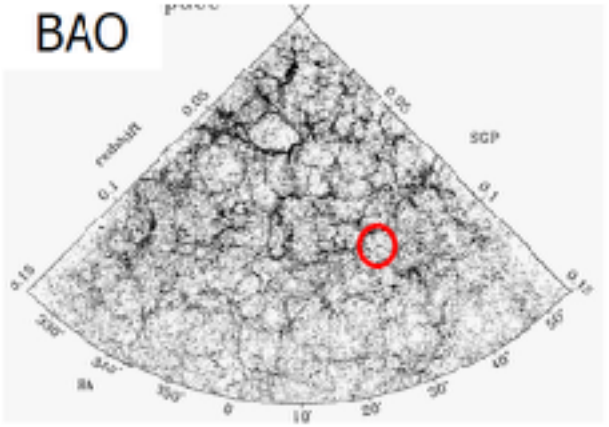
Schneider et al. 2016

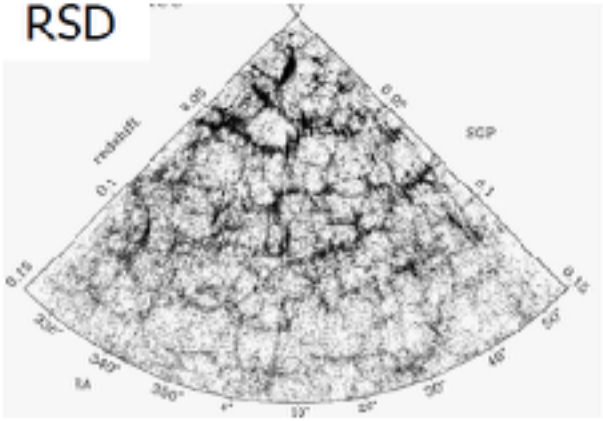


EUCLID: a space mission to map the universe

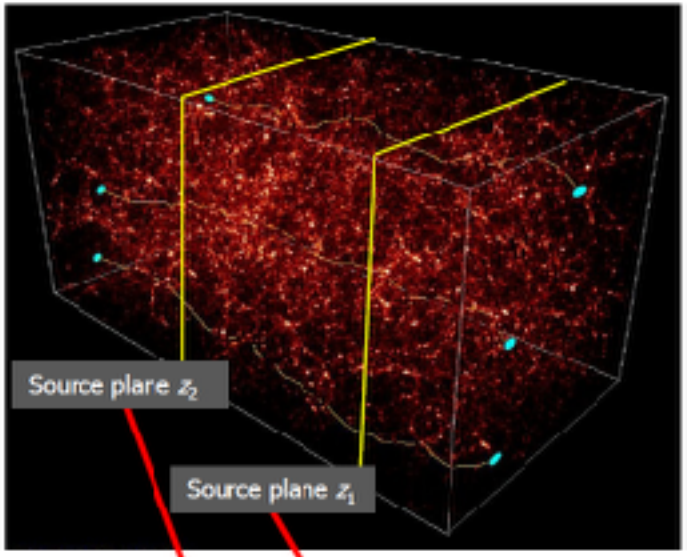
BAO, RSD and WL over 15,000 deg^2

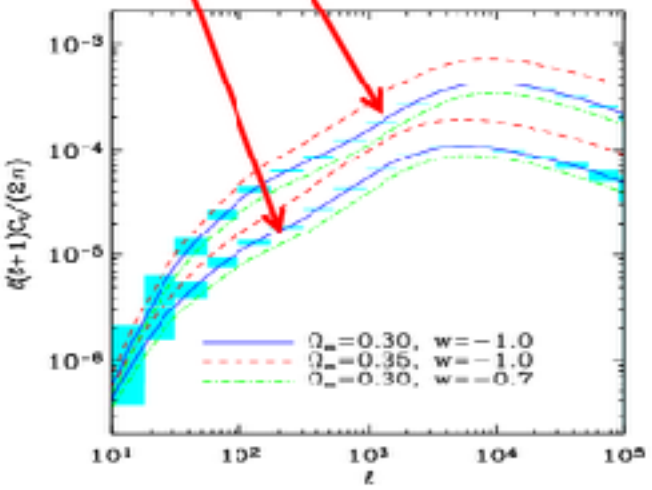
50 million galaxies with redshifts





1.5 billion sources with shapes, 10 slices

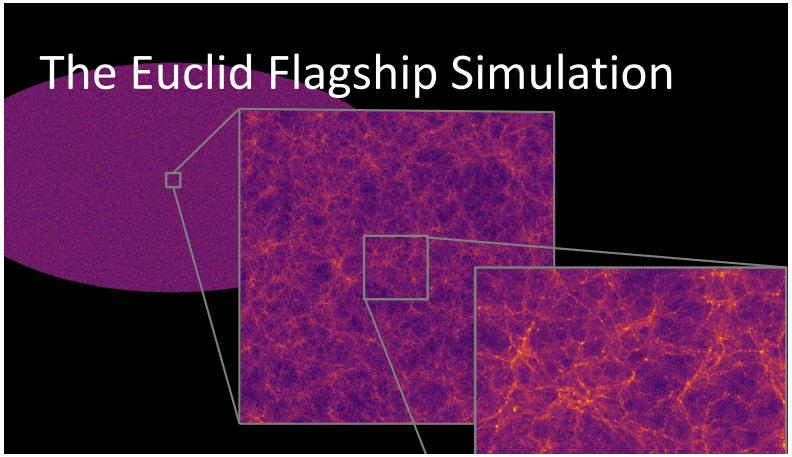




Cosmological simulations: computing requirements

Mock galaxy catalogues: one simulation every year with 10T particles. Galaxy population on the light cone with HOD/AM/SAM techniques with lensing maps.

Resources: 2 million node-hours (with GPU)

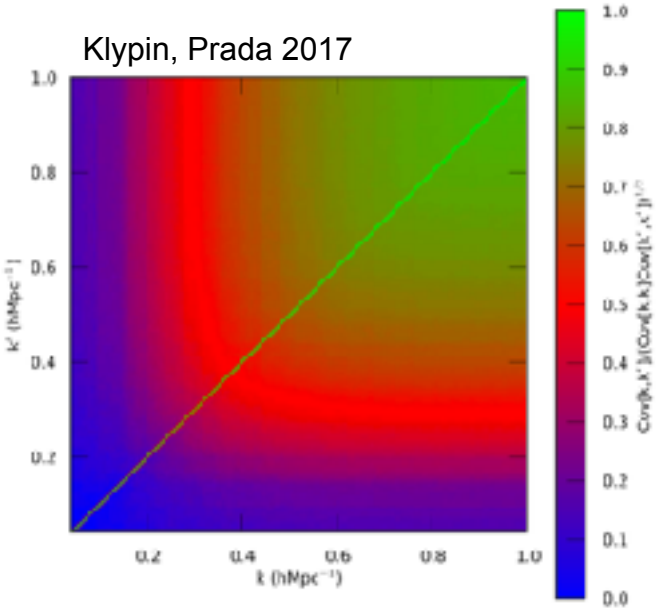


Potter, Stadel, Teyssier 2017

Emulators: 50 such simulations (one per cosmological parameter set)

Coyote: Heitmann et al. 2014, Mira-Titan; Heitmann et al. 2016

Klypin, Prada 2017

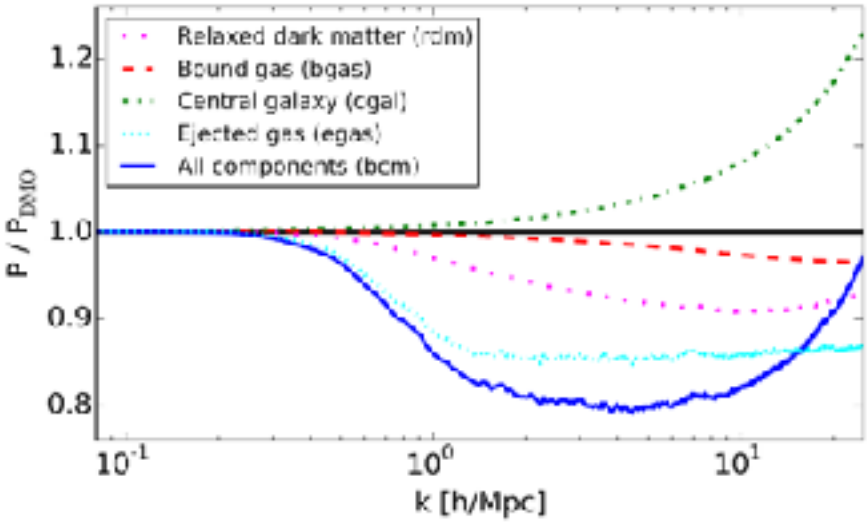


Covariance matrices: 3000 simulations with 8B particles every year.

Resources: 2 million node-hours (with GPU)

Baryonic effects and galaxy formation simulations

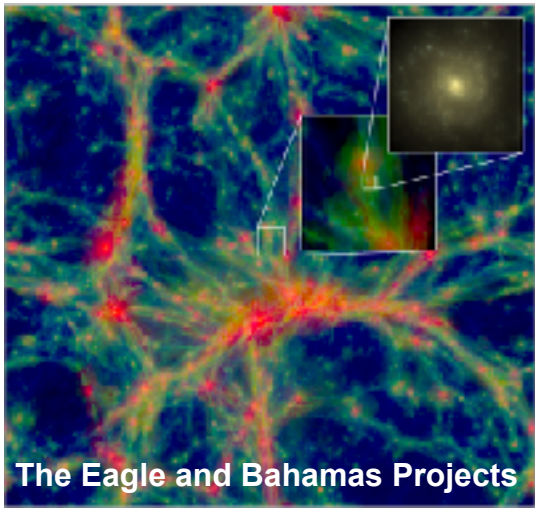
Schneider, Teyssier 2017



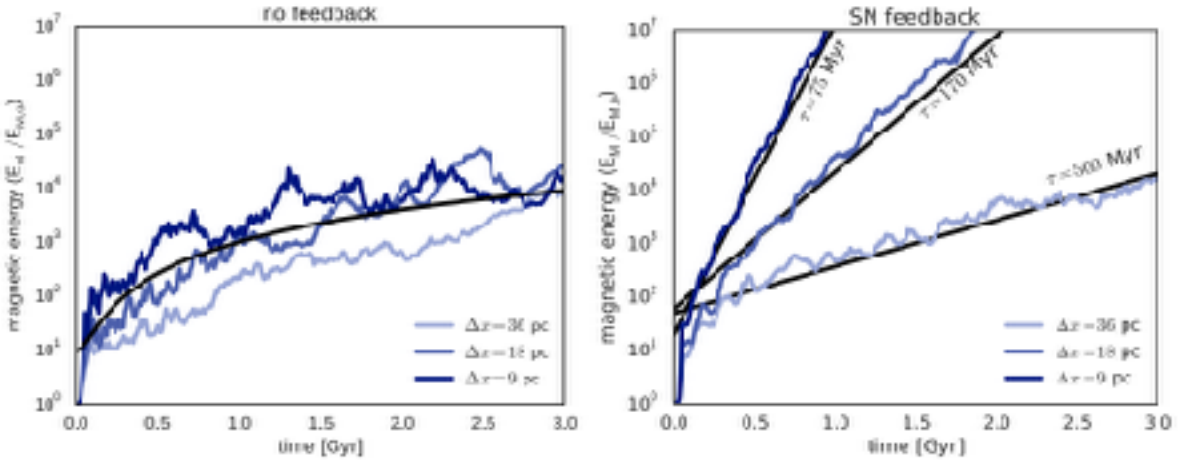
Dubois et al. 2016

Genel et al, 2014

Schaye et al. 2014, McCarthy 2017



New physical ingredients in galaxy formation



Rieder and Teyssier 2016

Small-scale turbulent dynamo at early time (fast)

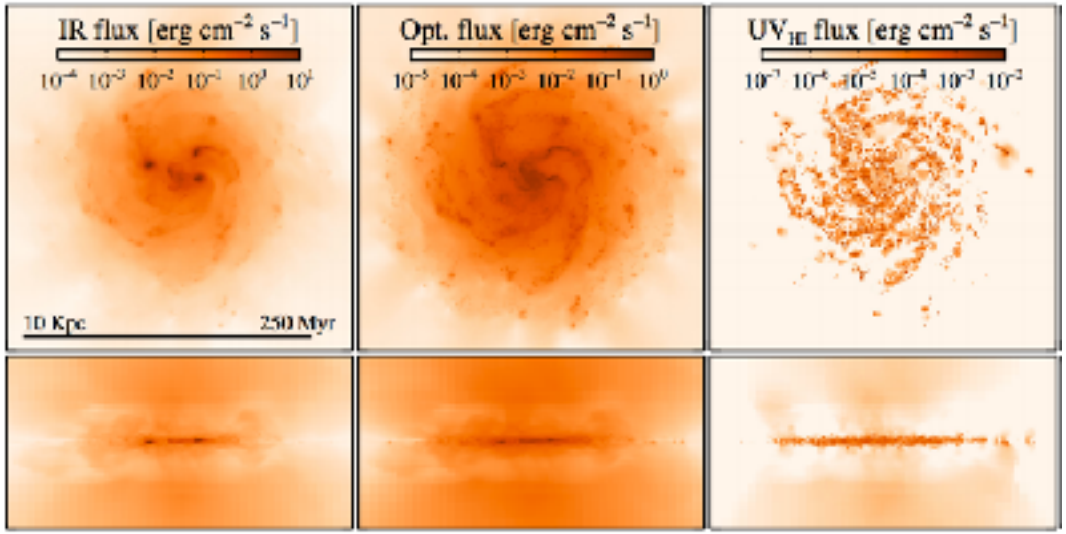
Large-scale dynamo at late time (slow)

Dynamical effects?

Photo-ionising and photo-dissociating radiation

Infrared radiation and dust

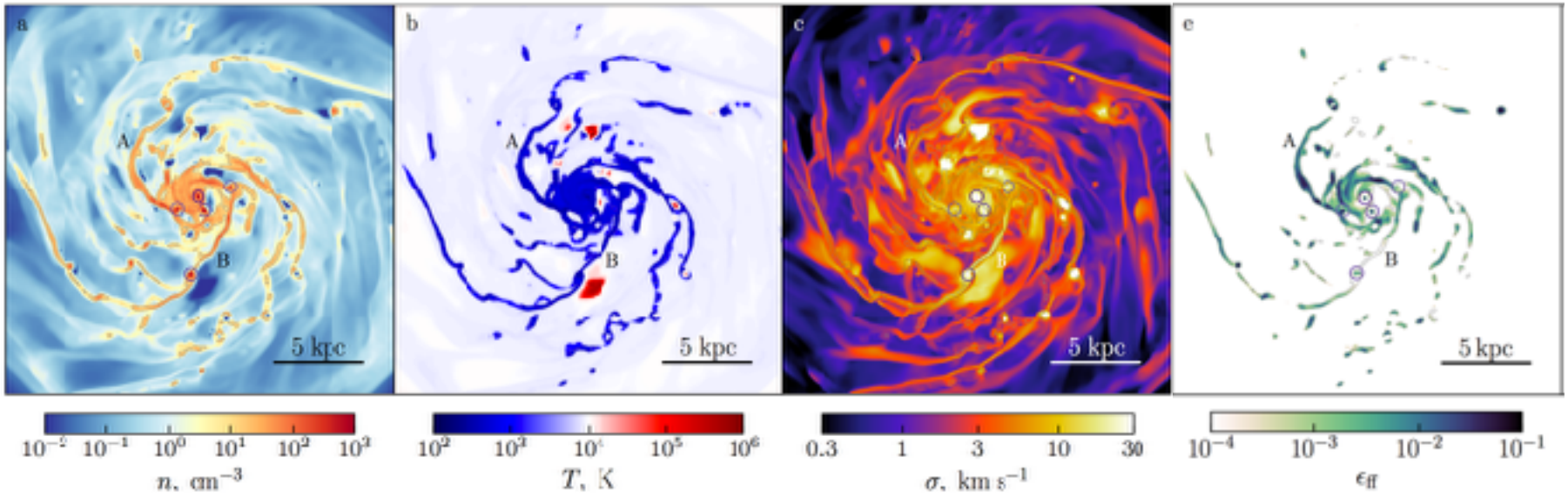
Dynamical effects ?

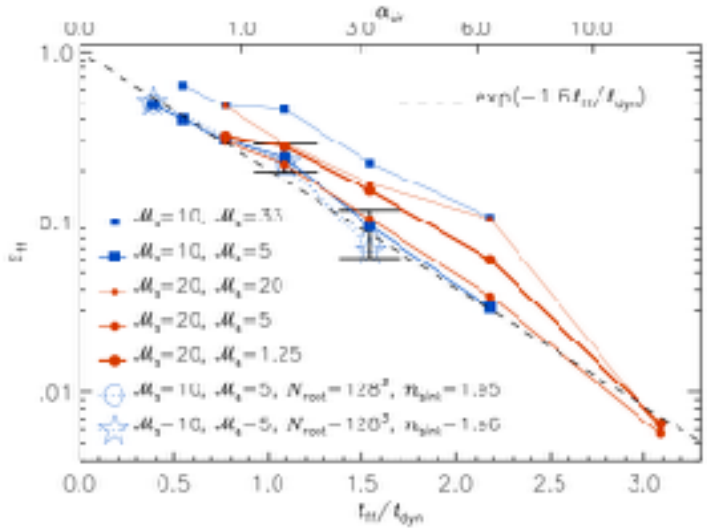


Rosdahl et al. 2015

New star formation recipe

Semenov, Gnedin, Kravtsov 2016





Subgrid model for turbulent energy.

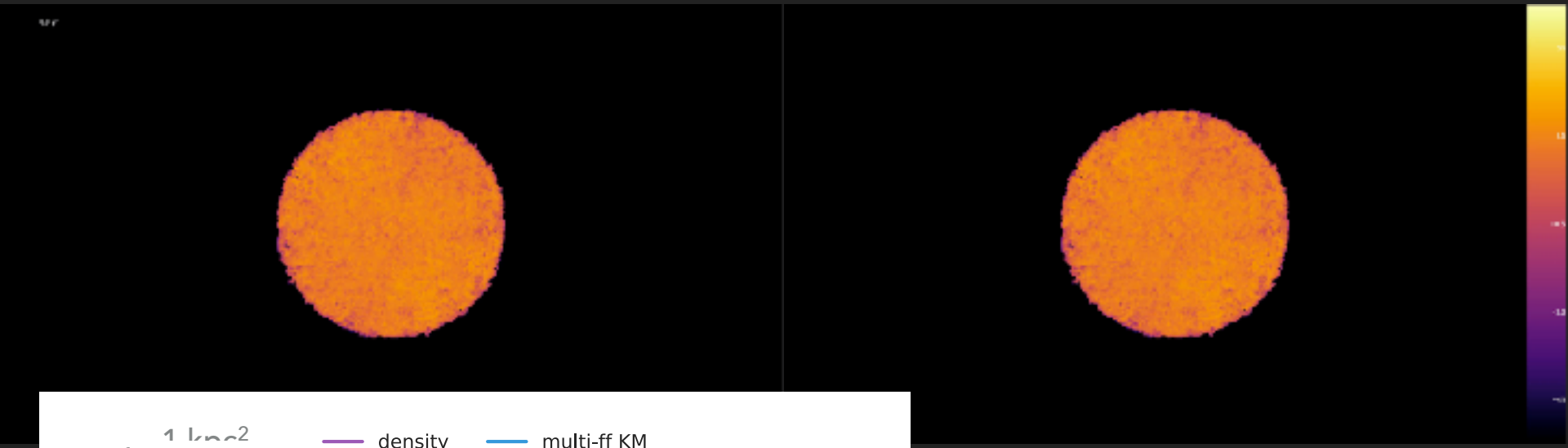
Star formation efficiency from Padoan, Haugbolle, Nordlund 2012

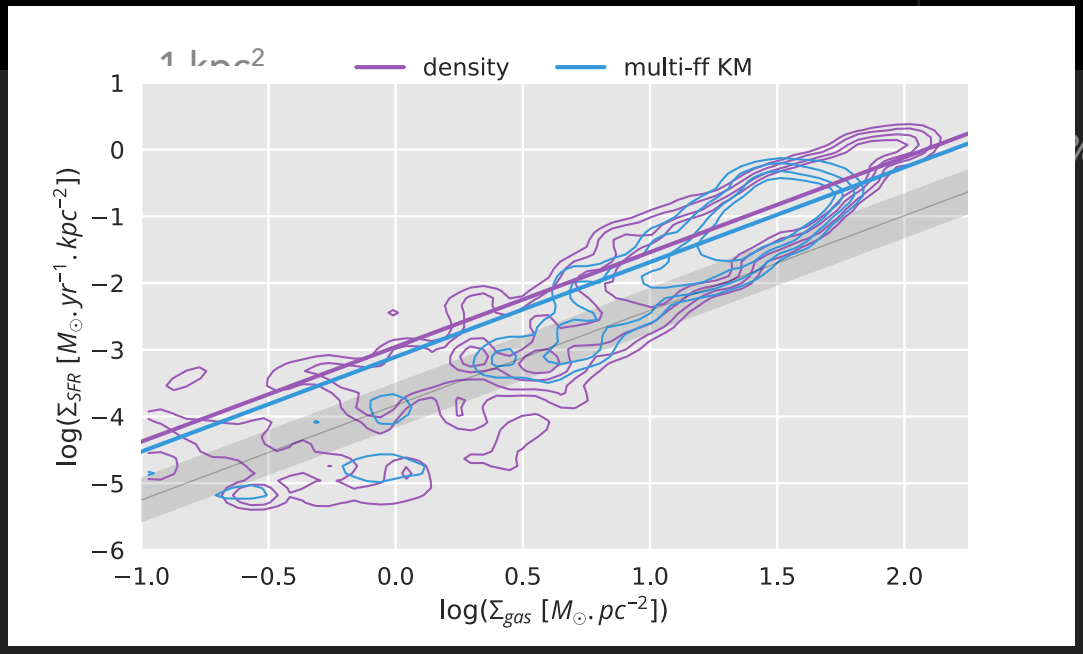
TURBULENT STAR FORMATION: CONNECTING THE DOTS (VALENTIN PERRET)

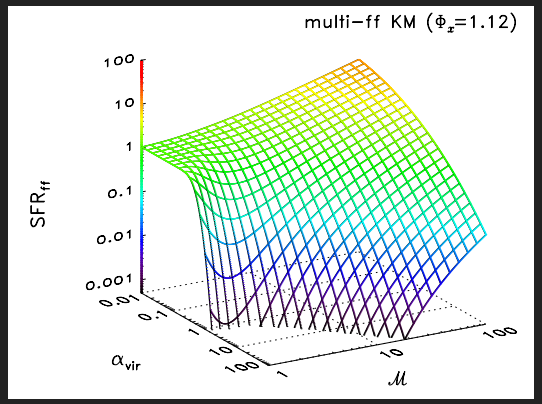
ρ>1.0 cm^{-3} ε=1%

multi-ff KM

Federrath & Klessen 2012







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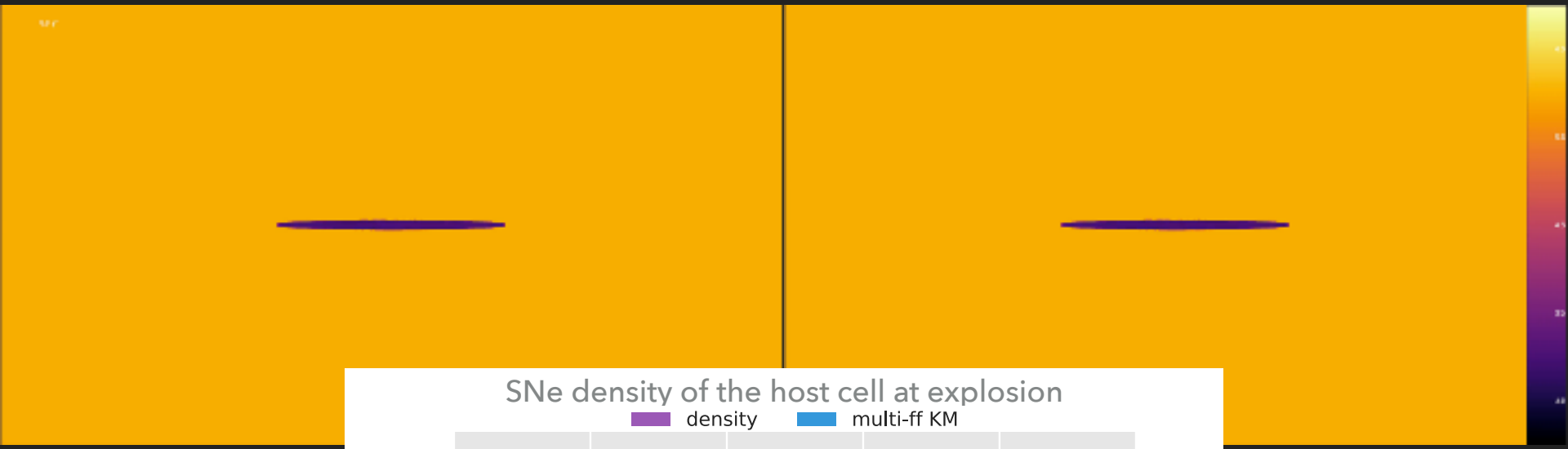
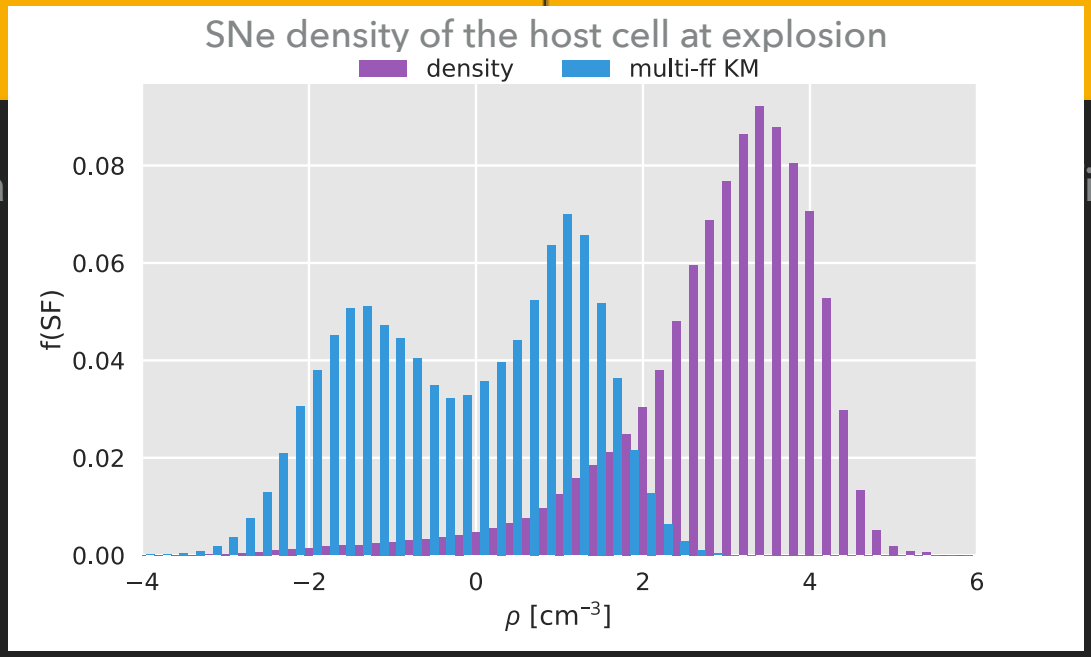
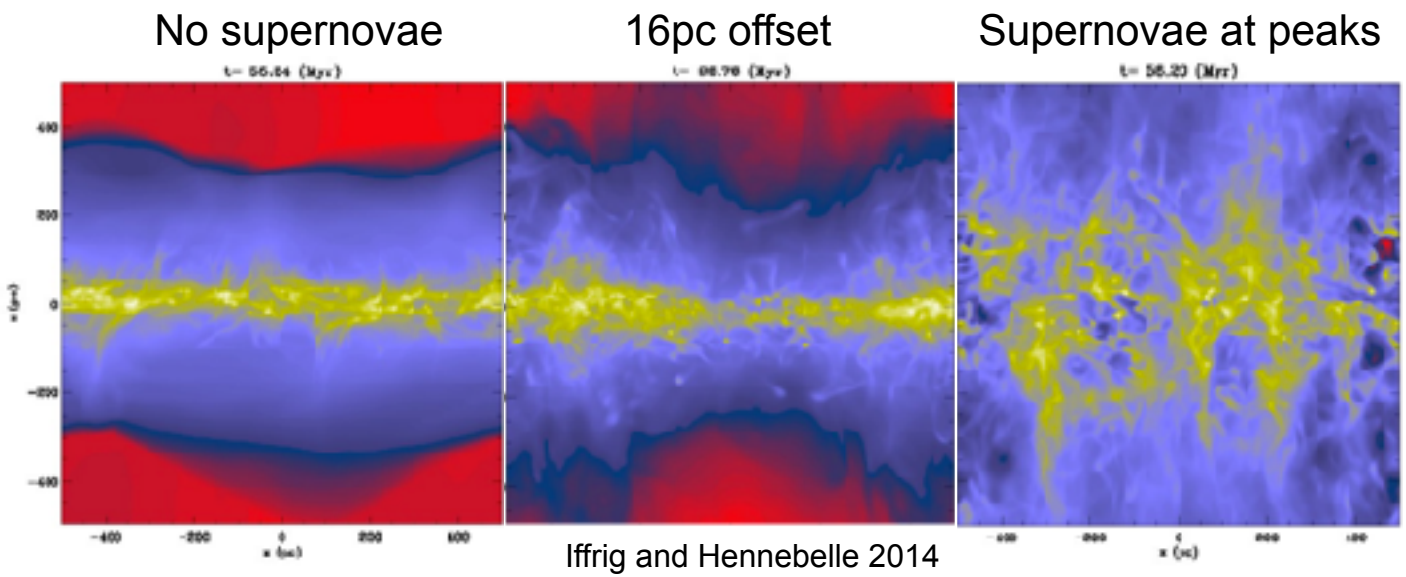


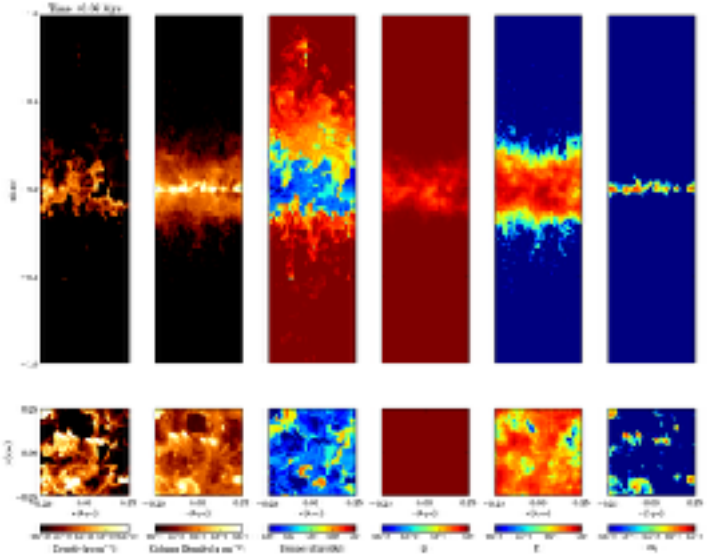


- higher spatia iciency

Interstellar medium physics



Iffrig and Hennebelle 2014



The SILCC project:

Random, Peak and Clustered SN driving completely change the ISM structure and the outflows properties.

Walch et al. 2015, Peters et al. 2015, Girichidis et al. 2016, Gatto et al. 2017

Simulation of the birth and death of a star cluster (Gavagnin et al. 2017)

Initial conditions: fully developed turbulence in a spherical cloud of mass 20’000 solar masses and radius 5 pc.

Maximum spatial resolution 0.02 pc

Minimum spatial resolution 500 AU

Mass resolution 0.003 solar masses

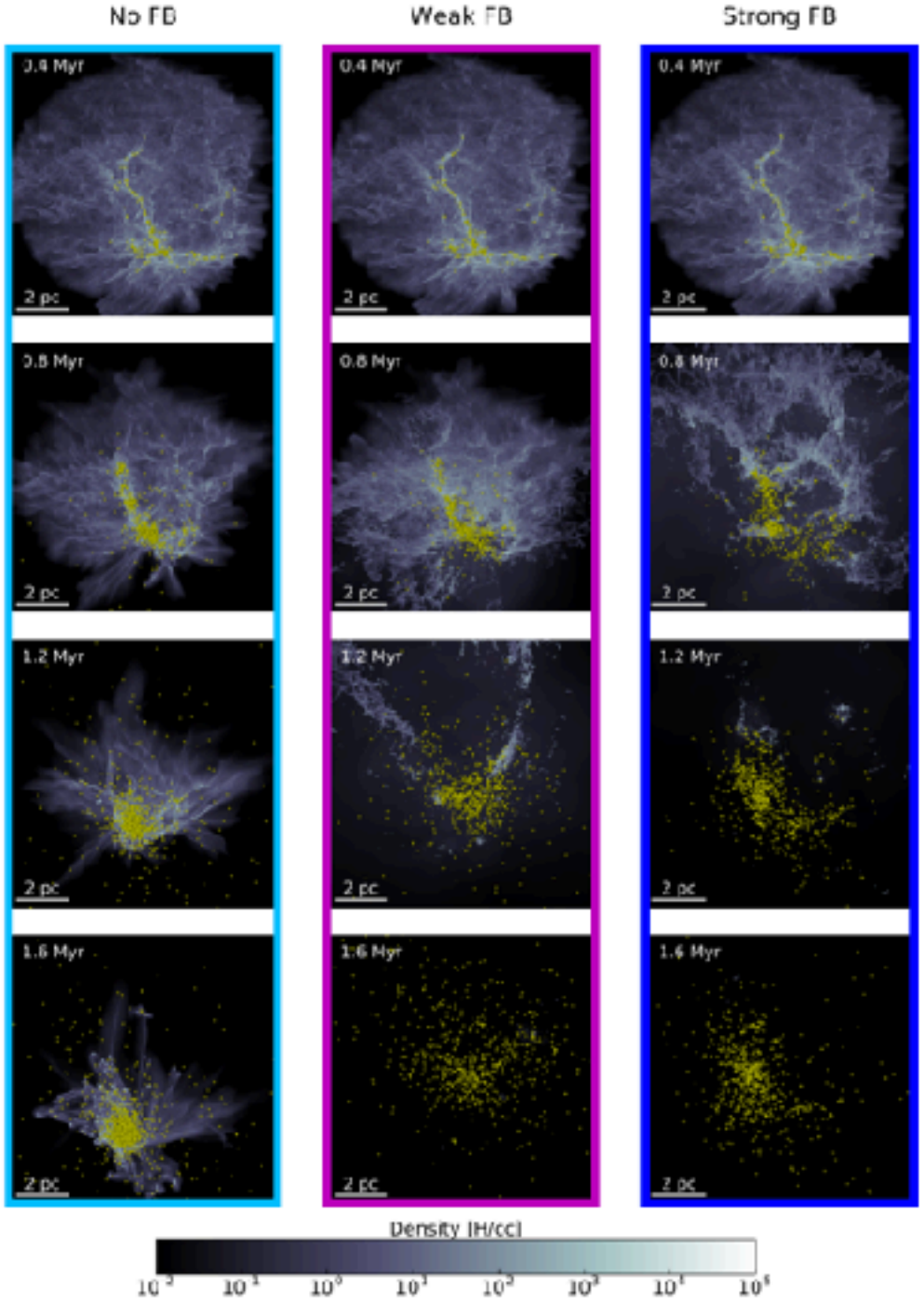
3 models with only UV radiation (strong, weak and none)

1 model with only IR radiation

Sink particle algorithm based on the clump finder with virial criterion.

Accretion rate based on Bondi model.

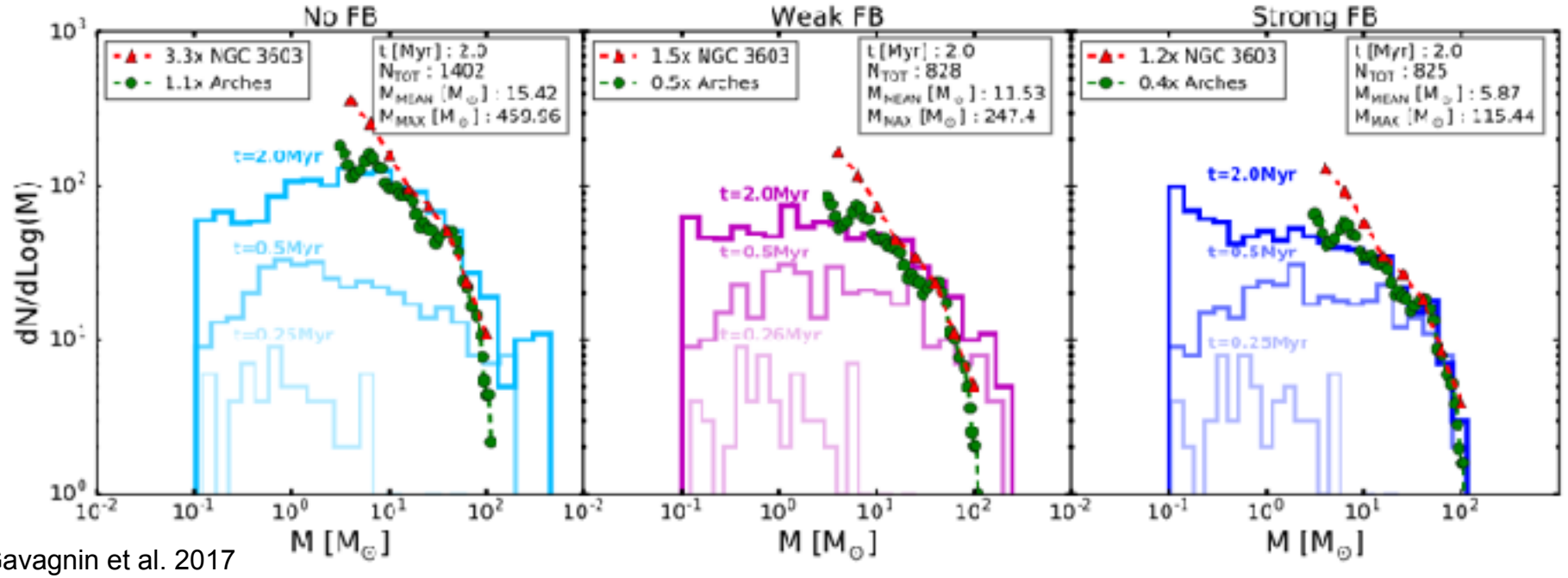
Direct gravity solver between sinks and between sinks and gas.



The role of feedback in shaping the star cluster

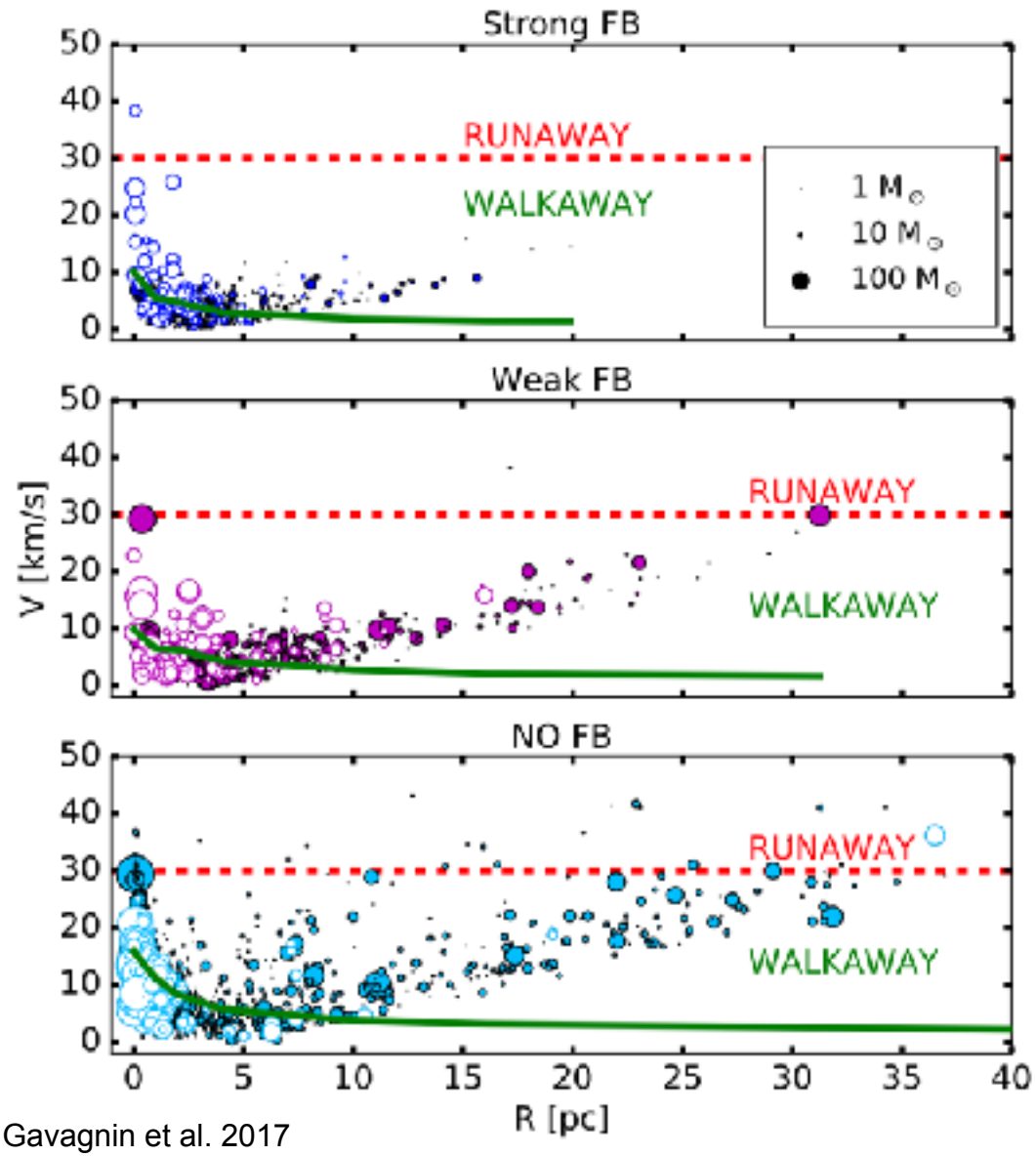
Arches

NGC 3603



Gavagnin et al. 2017

The star cluster final dynamical state



Gavagnin et al. 2017

	Strong	Weak	No FB
2-body systems	51	39	40
3-body systems	9	9	5
>3 body systems	6	5	5
Tot multi-body syst	66	53	50
Stars in multi-body syst	155(19%)	126(15%)	150(11%)
with M>1M⊙	128(31%)	109(20%)	120(12%)
with M>10M⊙	70(55%)	78(39%)	94(24%)
Bound stars	510 (62%)	473 (57%)	900 (64%)
Unbound stars	315 (38%)	355 (43%)	502 (36%)
Runaway	1 (1‰)	3 (4‰)	31 (2%)
of which in multi syst	1	0	2
Walkaway	230(28%)	297 (36%)	476 (34%)
of which in multisyst	60(7%)	50 (6%)	39(3%)

Summary

- High-precision large-scale cosmological simulations are required for present and future galaxy surveys (mocks, emulators, covariances)
- Baryonic effects and galaxy formation theory are about to move into predictive mode
- New physical models (radiation, MHD) and new subgrid recipes are being developed.
- Towards coupling galaxy formation with ISM physics and star cluster formation?
- Towards a new generation of codes ?