Star Formation Seminar No. 263 (#16-#20)

- #16 Simulated Performance of Timescale Metrics for Aperiodic Light Curves, Findeisen et al.
- #17 Revealing H_2D^+ Depletion and Compact Structure in Starless and Protostellar Cores with ALMA, Friesen et al.
- #18 Effects of dust feedback on vortices in protoplanetary disks, Fu et al.
- #19 Formation of young massive clusters from turbulent molecular clouds, Fuji
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2014年12月5日　花輪 知幸

Simulated Performance of Timescale Metrics for Aperiodic Light Curves

Findeisen et al.

不規則変光星の特徴を抽出する3つの解析法の比較

時系列光度データ (t_i, m_i)

1. Δm-Δt plots

$$\Delta m_{ij} = |m_i - m_j| \ \ (i > j)$$
$$\Delta t_{ij} = |t_i - t_j| \ \ (i > j)$$

2. peak-finding　　極大と極小の時間間隔を計る

3. Gaussian Process Regression　　covariance (共分散)

$$K_{ij} = K(t_i, t_j) = \sigma^2 \exp\left(-\frac{(t_i - t_j)^2}{2\tau^2}\right) + \sigma_n^2 \delta(t_i, t_j)$$

σ, τを求める

テストデータ

1. Sinusoidal
2. Squared Exponential Gaussian
3. Damped Random Walk
4. Undamped Random Walk
5. White Noise

2.
$$\begin{aligned} E(m(t)) &= m_0 \\ V(m(t)) &= \sigma_m^2 \\ \mathrm{cov}\,(m(t_i), m(t_j)) &= \sigma_m^2 e^{-(t_i-t_j)^2/2\tau^2} \end{aligned}$$

3.
$$\begin{aligned} E(m(t)) &= m_0 \\ V(m(t)) &= \frac{D\tau}{2} \\ \mathrm{cov}\,(m(t_i), m(t_j)) &= \frac{D\tau}{2} e^{-|t_i-t_j|/\tau} \end{aligned}$$

4.
$$\begin{aligned} E(m(t)) &= m_0 \\ V(m(t)) &= D(t-t_0) \\ \mathrm{cov}(m_i, m_j) &= \lim_{\tau\to\infty} \tfrac{D\tau}{2} e^{-(t_2-t_1)/\tau} \left(1 - e^{-2(t_1-t_0)/\tau}\right) \end{aligned}$$

1-4には雑音も加える

Cadence データ取得

Cadence	Number of Points	Base line (days)	Char. Cadence (days)	Longest Gap (days)
PTF-NAN Full	910	1,224.9	0.21	179.3
PTF-NAN 2010	126	252.7	1.98	17.0
YSOVAR 2010	39	35.7	1.26	2.5
CoRoT	6,307	38.7	0.012	0.78

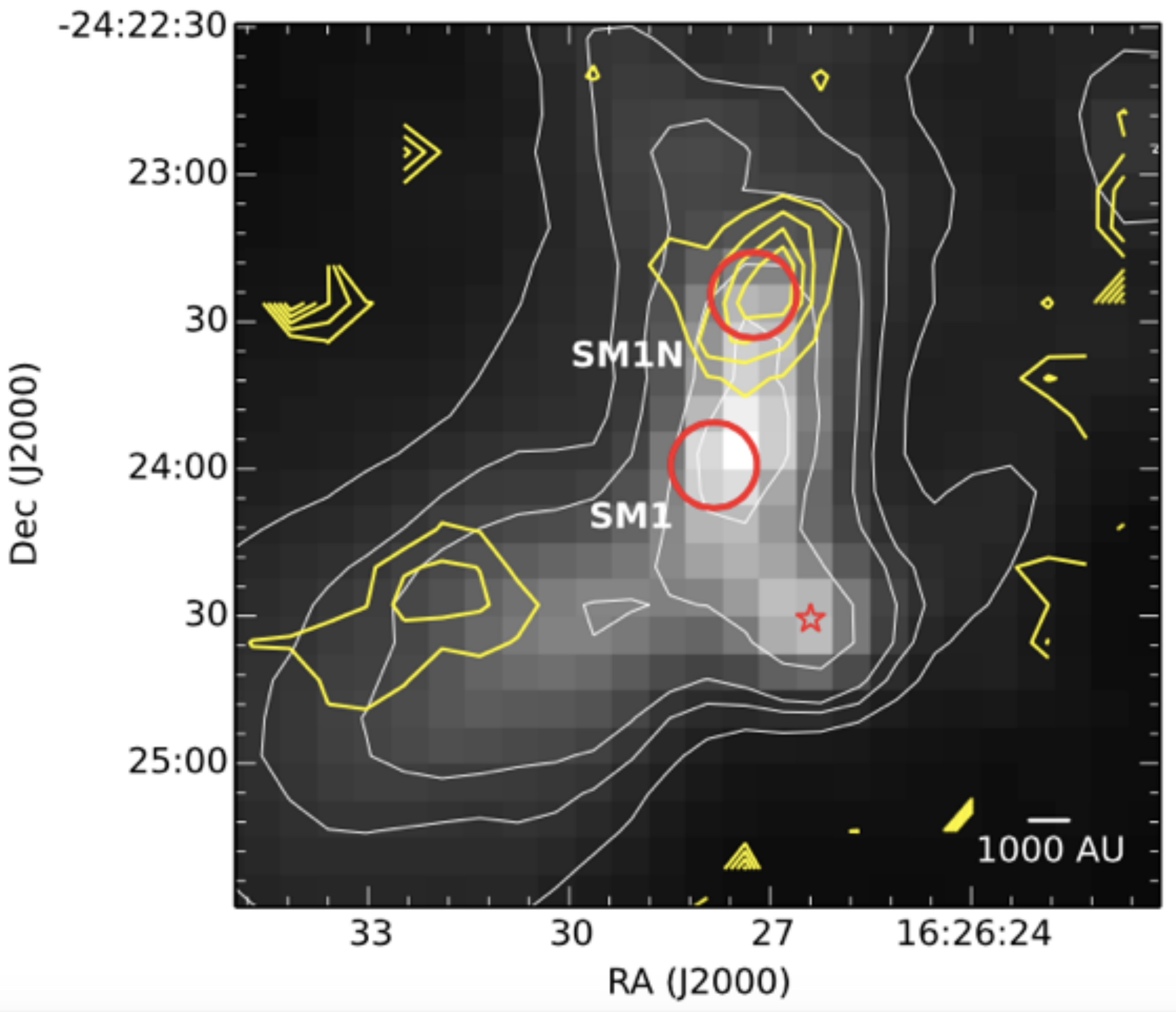
判定結果

Criterion	Δm-Δt Plots	Peak-Finding	GP Modeling
Precision	20-100%	10-100%	10-100%
Discriminatory power	20-100%	25-100%	6-600%
Sensitivity to Noise	High iff RMS noise $>$ 1/10 amp.	High iff RMS noise $>$ 1/10 amp.	High
Sensitivity to Cadence	High	High	···
Sensitivity to incomplete data	High	Moderate	···

Gaussian Process Regression は流行り(?)らしいが、ノイズに弱い

Revealing H_2D^+ Depletion and Compact Structure in Starless and Protostellar Cores with ALMA
Friesen et al.

Oph A SM1 and SM1N = evolved, potentially protostellar cores



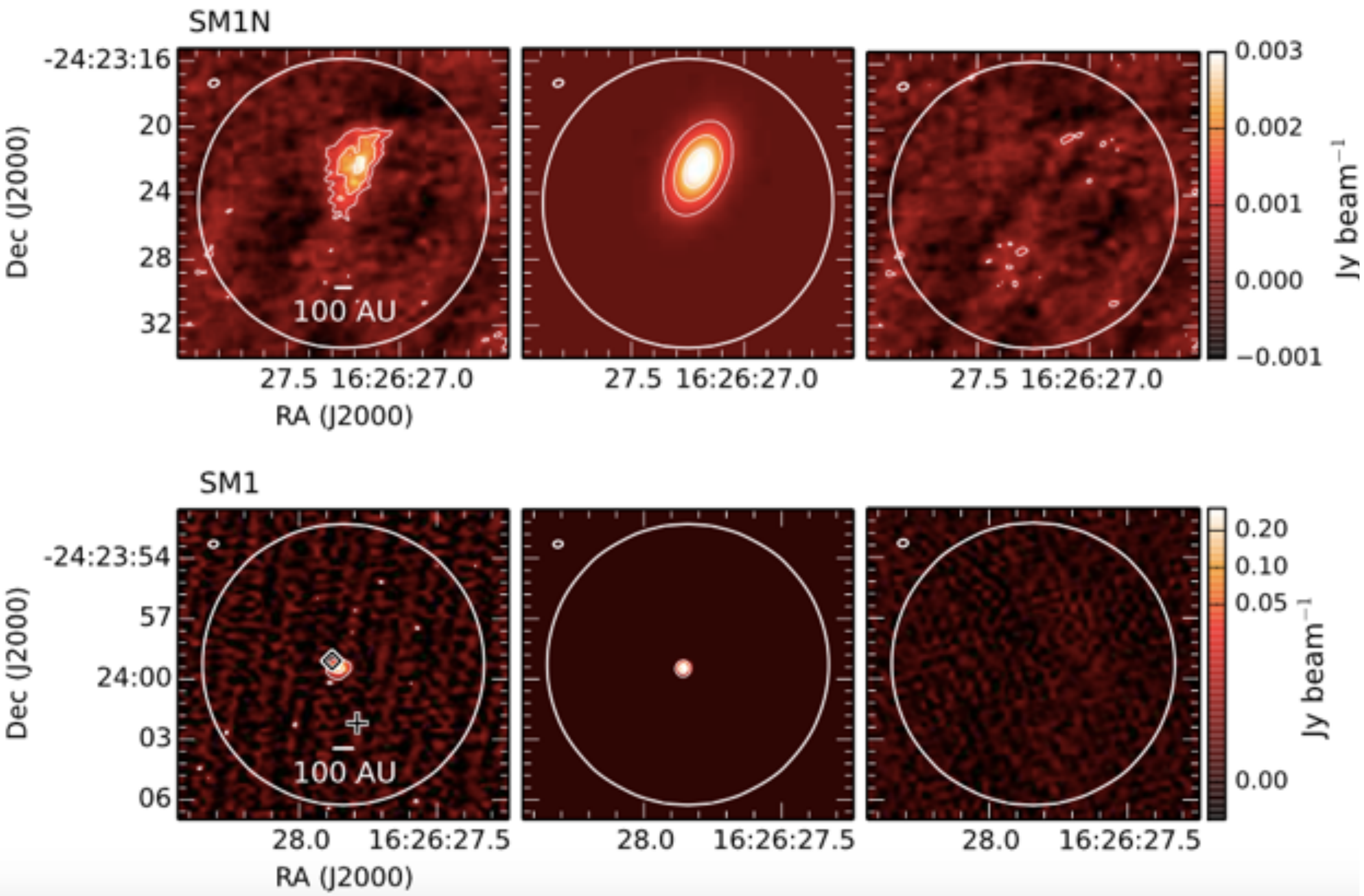
Gray scale & white contours: 850μm

Yellow contours: H_2D^+ 1_{10}-1_{11}

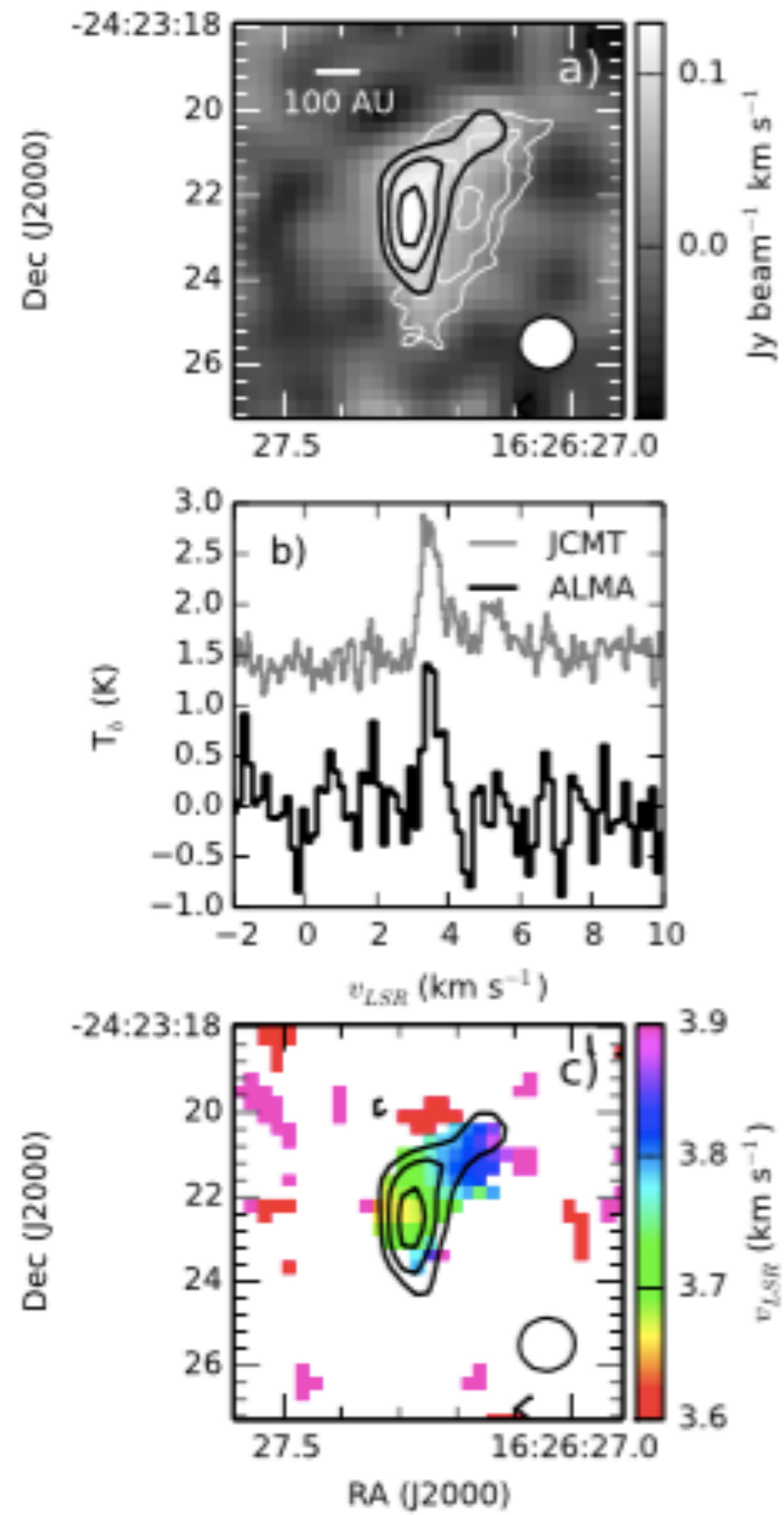
Red Circle: ALMA beam

☆ VLA1623 Class 0

359 GHz obs. model, residual



H_2D^+ 1_{10}-1_{11}



SM1 protostellar core

30-50K warm accretion disk

or pseudo disk (0.02 <Mo)

SM1N starless

H_2D^+ を星形成領域で初検出

連続波からoffset

Effects of dust feedback on vortices in protoplanetary disks

Wen Fu et al.

Gas: 2D isothermal Hydrodynamics

Dust: 2D pressureless fluid

$$\frac{\partial \Sigma_d \mathbf{v}_d}{\partial t} + \nabla(\mathbf{v}_d \cdot \Sigma_d \mathbf{v}_d) = -\Sigma_d \nabla \Phi_G + \Sigma_d \mathbf{f}_d,$$

$$\mathbf{f}_d = \frac{\Omega_k}{\mathrm{St}}(\mathbf{v}_g - \mathbf{v}_d), \qquad \mathrm{St} = \sqrt{\frac{\pi}{8}} \frac{\rho_\mathrm{p} \mathrm{s}_\mathrm{p} \Omega_\mathrm{k}}{\rho_\mathrm{g} \mathrm{c}_\mathrm{s}} = \frac{\pi \mathrm{s}_\mathrm{p} \rho_\mathrm{p}}{2\Sigma_\mathrm{g}},$$

$$\frac{\partial_t \Sigma_g \mathbf{v}_g}{\partial t} + \nabla(\mathbf{v}_g \cdot \Sigma_g \mathbf{v}_g) + \nabla P = -\Sigma_g \nabla \Phi_G + \boxed{\Sigma_g \mathbf{f}_\nu} - \Sigma_g \mathbf{f}_d,$$

Shakura-Sunyaev viscosity

$$\frac{\partial \Sigma_d}{\partial t} + \nabla \cdot (\Sigma_d \mathbf{v}_d) = \nabla \cdot \left(\Sigma_g D_d \nabla \left(\frac{\Sigma_d}{\Sigma_g} \right) \right)$$

$$\frac{\partial \Sigma_g}{\partial t} + \nabla \cdot (\Sigma_g \mathbf{v}_g) = 0,$$

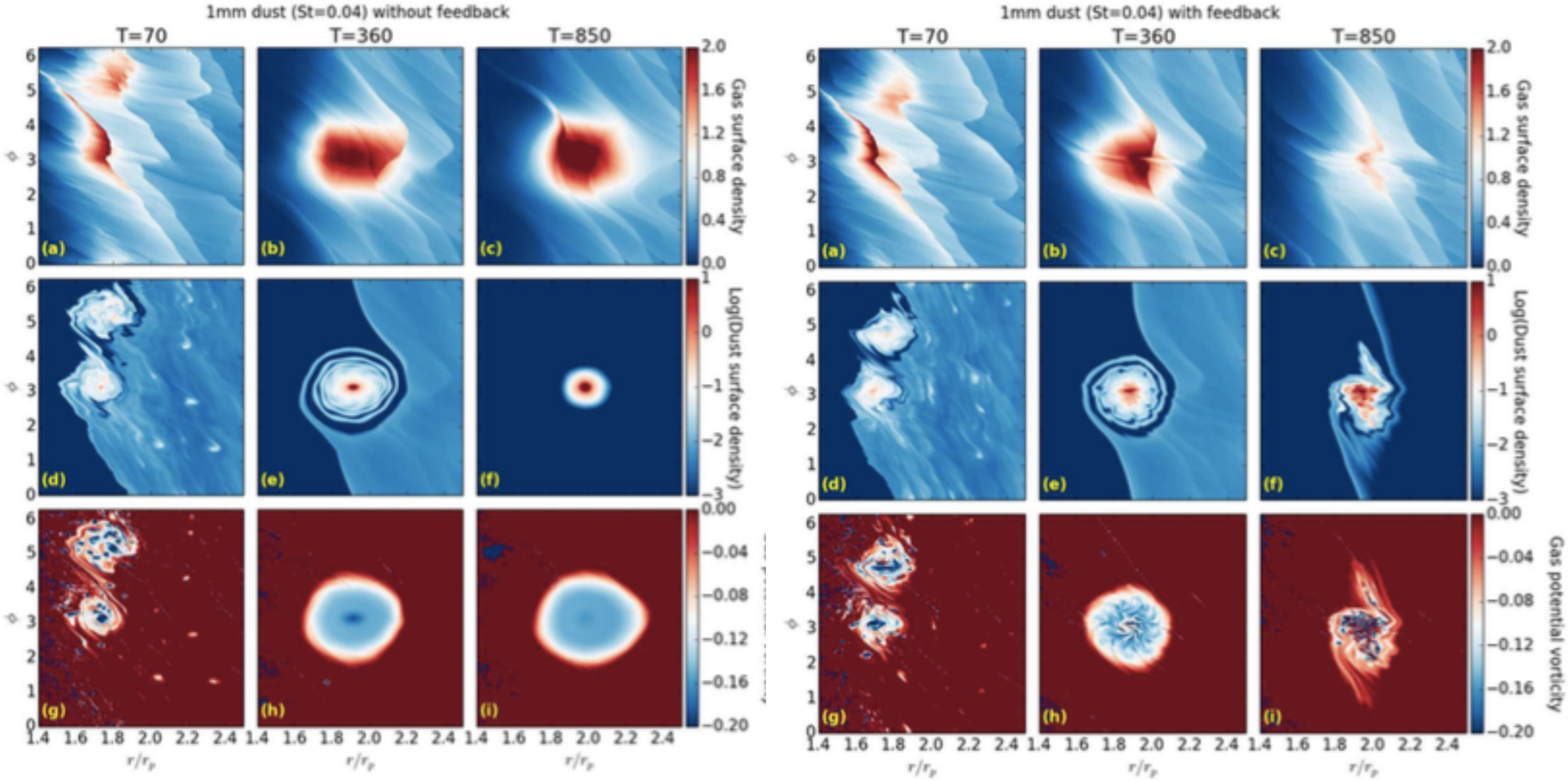
LA-COMPASS

Los Alamos

Σ_{gas}

$\log \Sigma_{dust}$

potential vorticity



dust feed back により dust が集まりにくくなる

dust/gas 比が高く、dust size が大きいほど強いfeed back

Formation of young massive clusters from turbulent molecular clouds, Fuji

1. SPH
   A. Isothermal homogenous Sphere
   B. turbulence $|\delta v| \propto k^{-4}$, divergence free, 0.9 $t_{\rm ff}$
   C. total 4.1×10^5 M_o, 10 pc, 30 K, $n \sim 1700$ cm^{-3}
2. Star Formation
   D. SFE

$$\epsilon_{\rm loc} = \alpha_{\rm sfe} \sqrt{\frac{\rho}{100\,(M_\odot {\rm pc}^{-3})}}, \qquad \rho > \rho_{\rm c}$$

   instantaneous gas expulsion
3. N-body

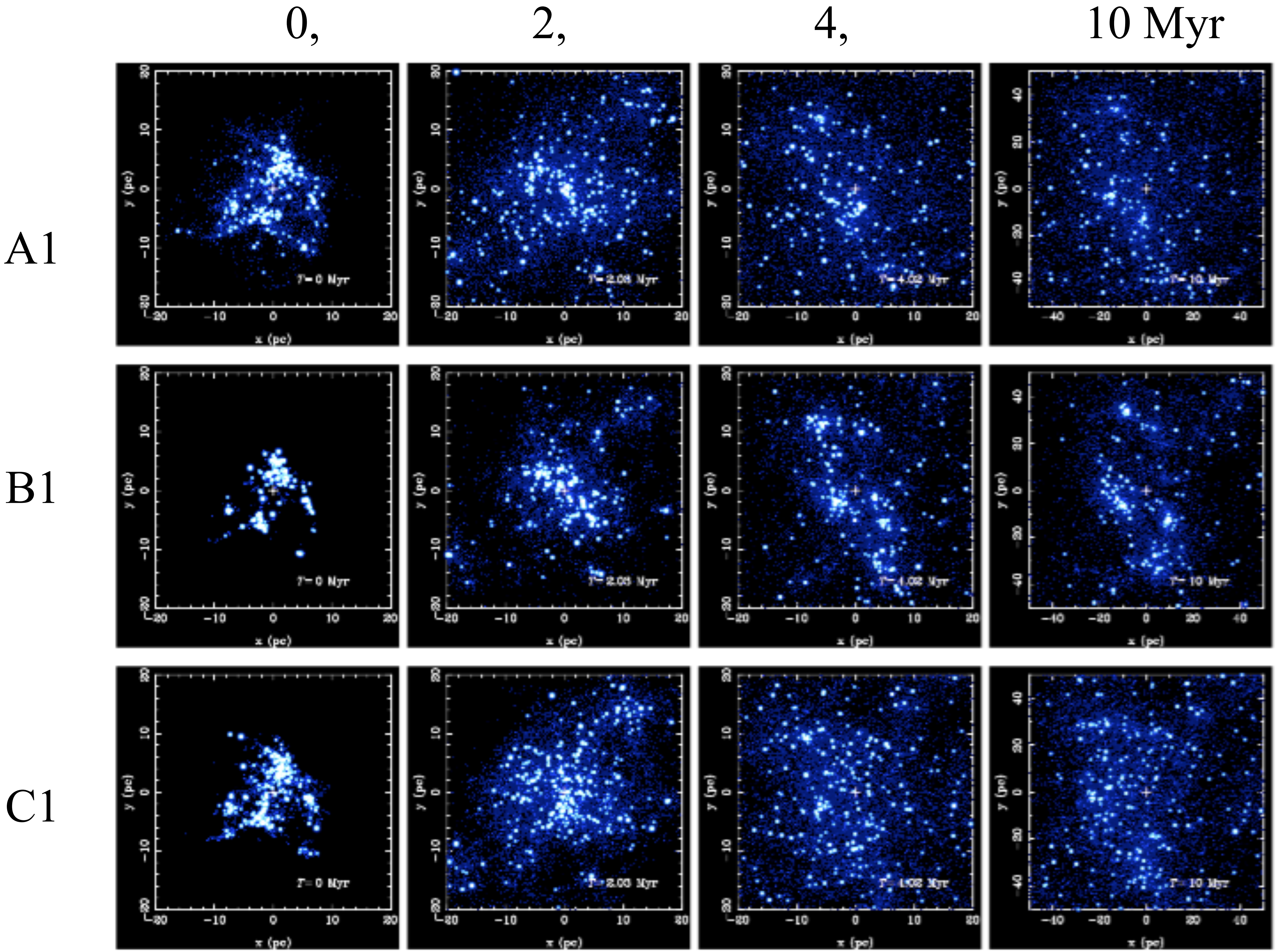
モデルパラメータのまとめ

Table 1. Initial conditions

Model	$M_{\rm gas}$ ($M_\odot$)	$r_{\rm gas}$ (pc)	$\rho_{\rm gas}$ ($M_\odot {\rm pc}^{-3}$)	SFE	$\rho_{\rm c}$ ($M_\odot {\rm pc}^{-3}$)	$M_{\rm star}$ ($M_\odot$)	$N_{\rm star}$	ϵ	$\epsilon_{\rm d}$	Q
A1	4.1×10^5	10	100	eq.(1)	-	3.2×10^4	31895	0.078	0.22	2.6
A2	4.1×10^5	10	100	eq.(1)	-	4.3×10^4	42596	0.096	0.25	0.85
A3	4.1×10^5	10	100	eq.(1)	-	2.3×10^4	23273	0.057	0.16	8.4
B1	4.1×10^5	10	100	0.8	5×10^3	3.4×10^4	33974	0.083	0.30	1.6
B2	4.1×10^5	10	100	0.8	5×10^3	4.3×10^4	42710	0.10	0.30	0.84
C1	4.1×10^5	10	100	0.3	10^3	3.4×10^4	34086	0.084	0.30	4.2
C2	4.1×10^5	10	100	0.3	10^3	4.4×10^4	43500	0.11	0.30	2.9
A-1M	1×10^6	13.4	100	eq.(1)	-	1.1×10^5	109080	0.11	0.27	1.8

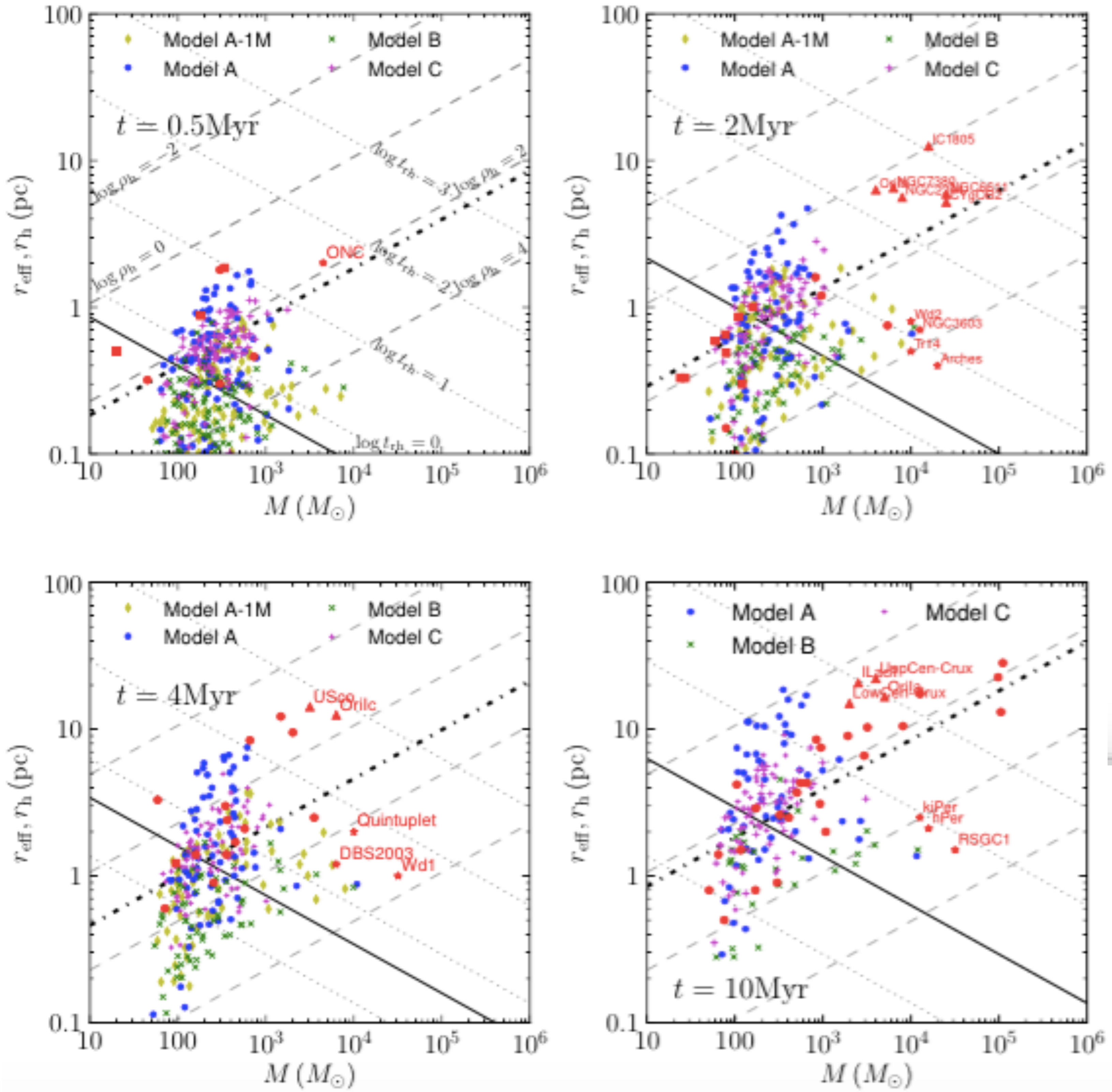
$M_{\rm gas}$, $r_{\rm gas}$, $\rho_{\rm gas}$ are the mass, radius, and density of the molecular cloud, respectively. SFE and $\rho_{\rm c}$ indicate the SFE and the critical density for the constant SFE. $M_{\rm star}$ and $N_{\rm star}$ are the total mass and number of stars for N-body simulations. ϵ and $\epsilon_{\rm d}$ are the SFE for the entire system and the region with a local density of $> 1000 M_\odot {\rm pc}^{-3}$, respectively. Q is the virial ratio of stellar particles at the beginning of N-body simulations. If $Q = 1.0$, the system is in virial equilibrium.

Model B, C では SFE = const. for $\rho > \rho_c$

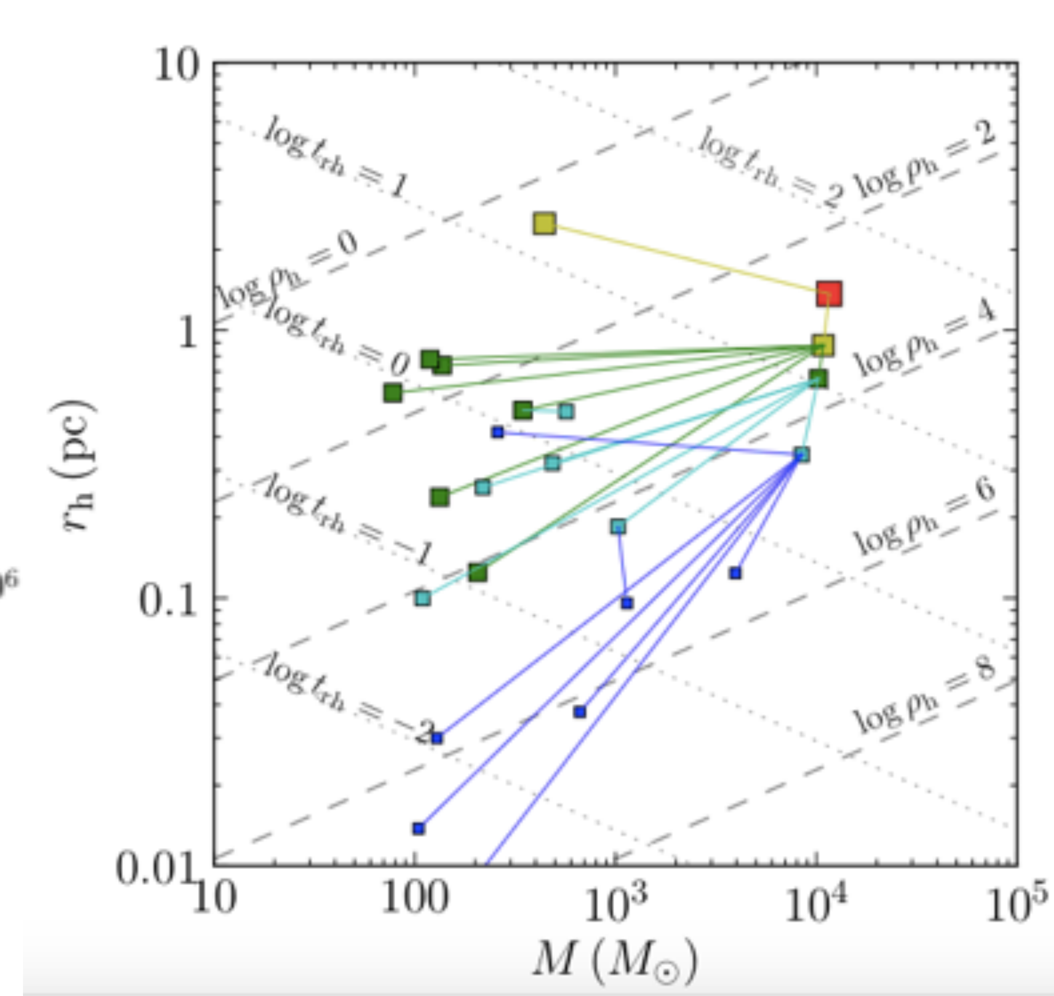


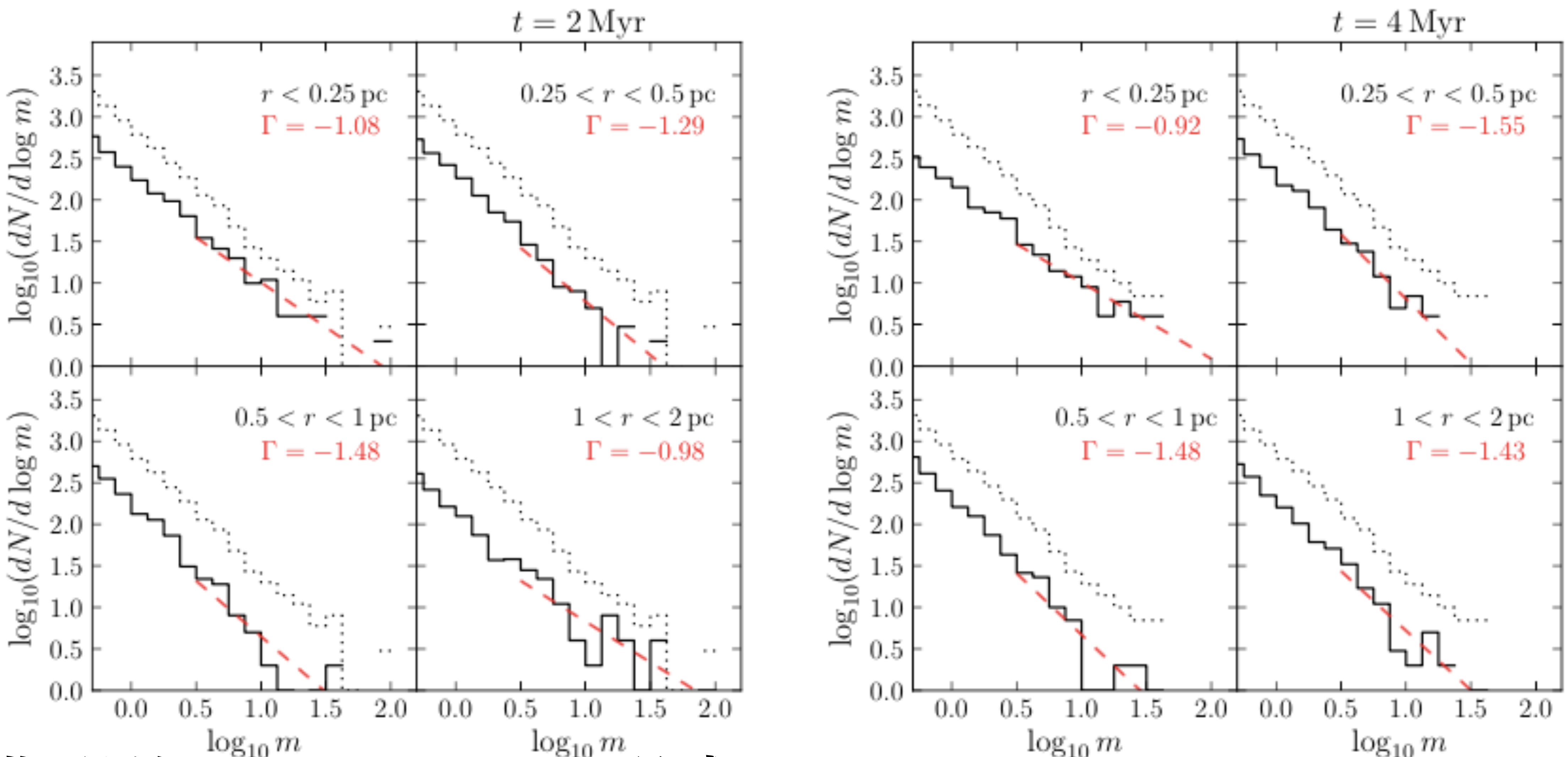
0,
2,
4,
10 Myr
A1
B1
C1
T = 0 Myr
T = 2.08 Myr
T = 4.02 Myr
T = 10 Myr
x (pc)
y (pc)

cluster mass radius



merger history model A



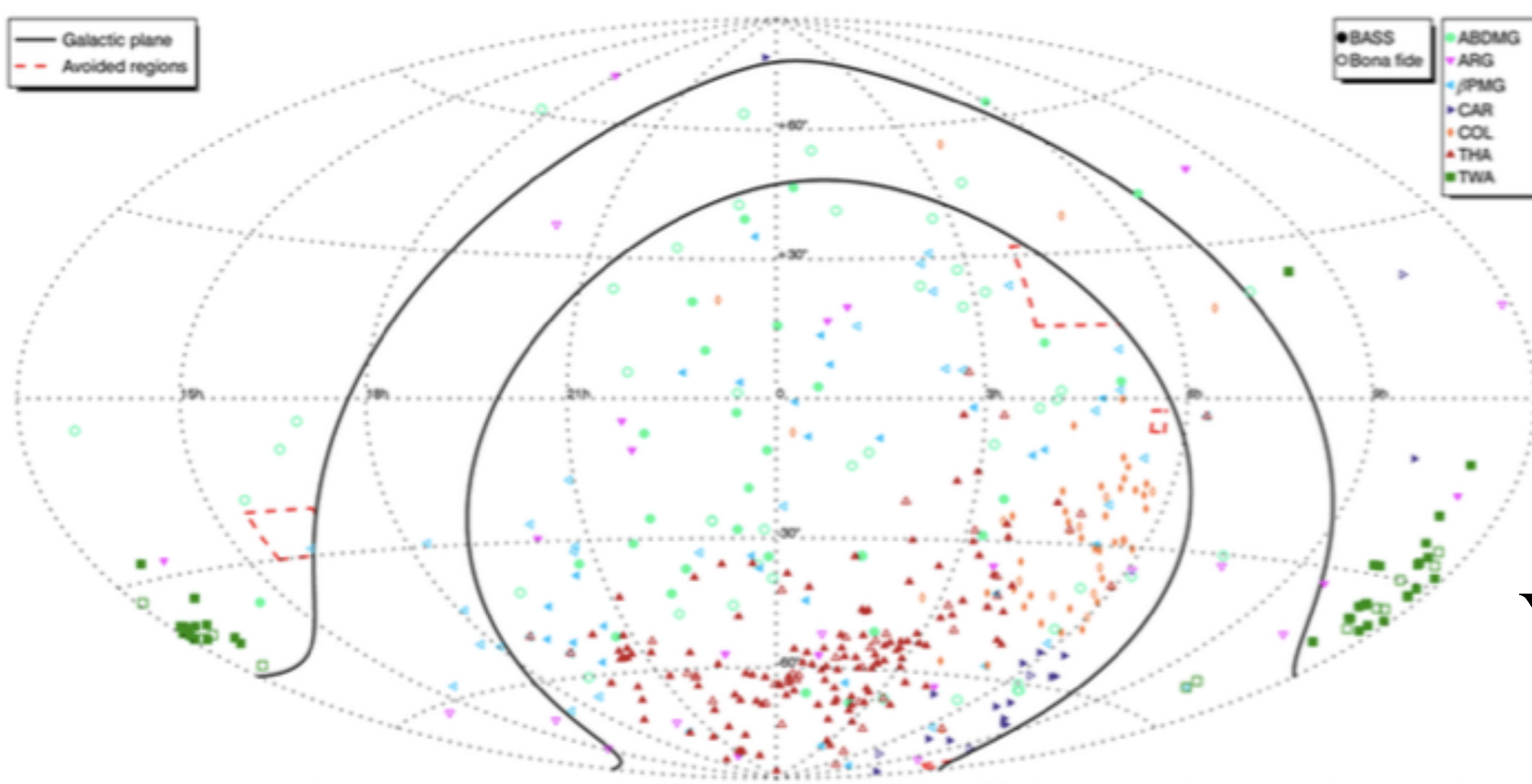


- 典型的open cluster が形成された
- $t_{\mathrm{age}} \sim t_{\mathrm{dyn}} \sim t_{\mathrm{relax}}$ embedded cluster はopen cluster の祖先
- open cluster, embeded cluster は expansion phase of stellar mass segragation
- SFE > 50%以上では、階層的合体によりYoung Massive Cluster (YMC) ができる

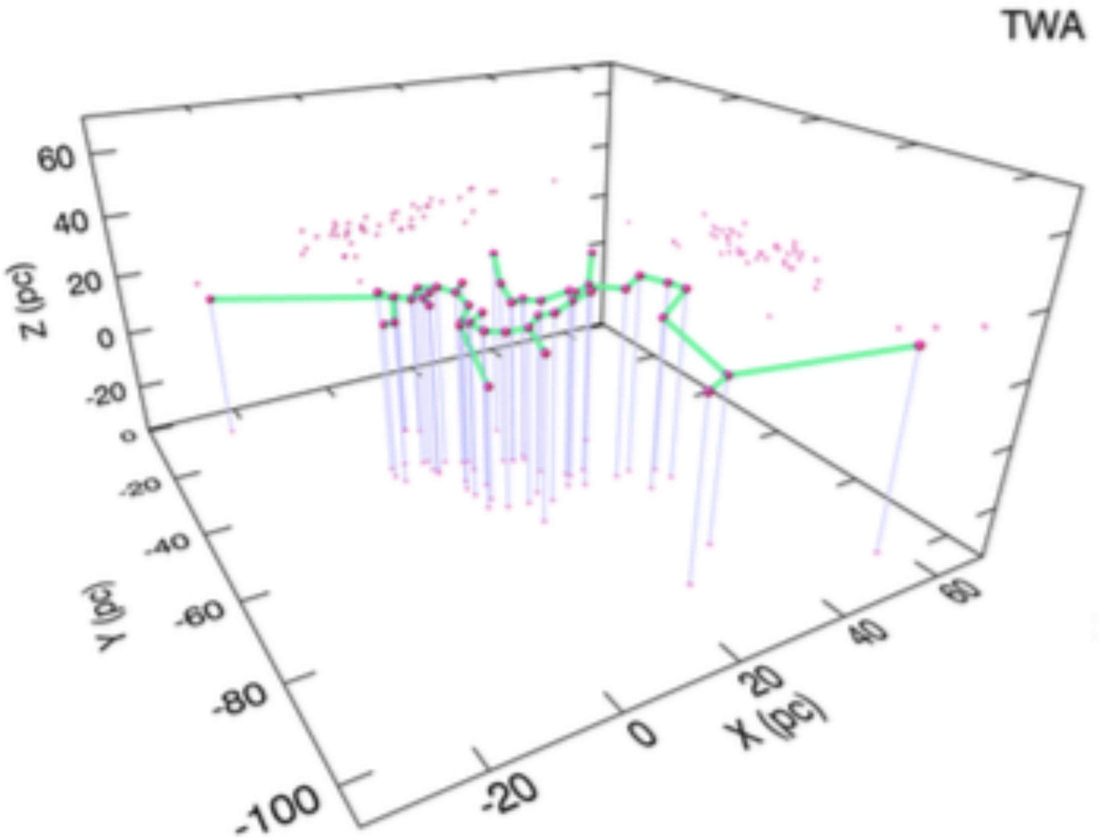
BANYAN. V. A Systematic All-Sky Survey for Very Late Type Low Mass Stars and Brown Dwarfs in Nearby Young Moving Group, Gagne et al.

228 new late-type (M4-L6) candidates (～13%偽 含む)

- 79 young brown dwarfs, 22 planetary-mass objects
- 2MASS AllWise J, H, Ks, W1, W2, proper motion

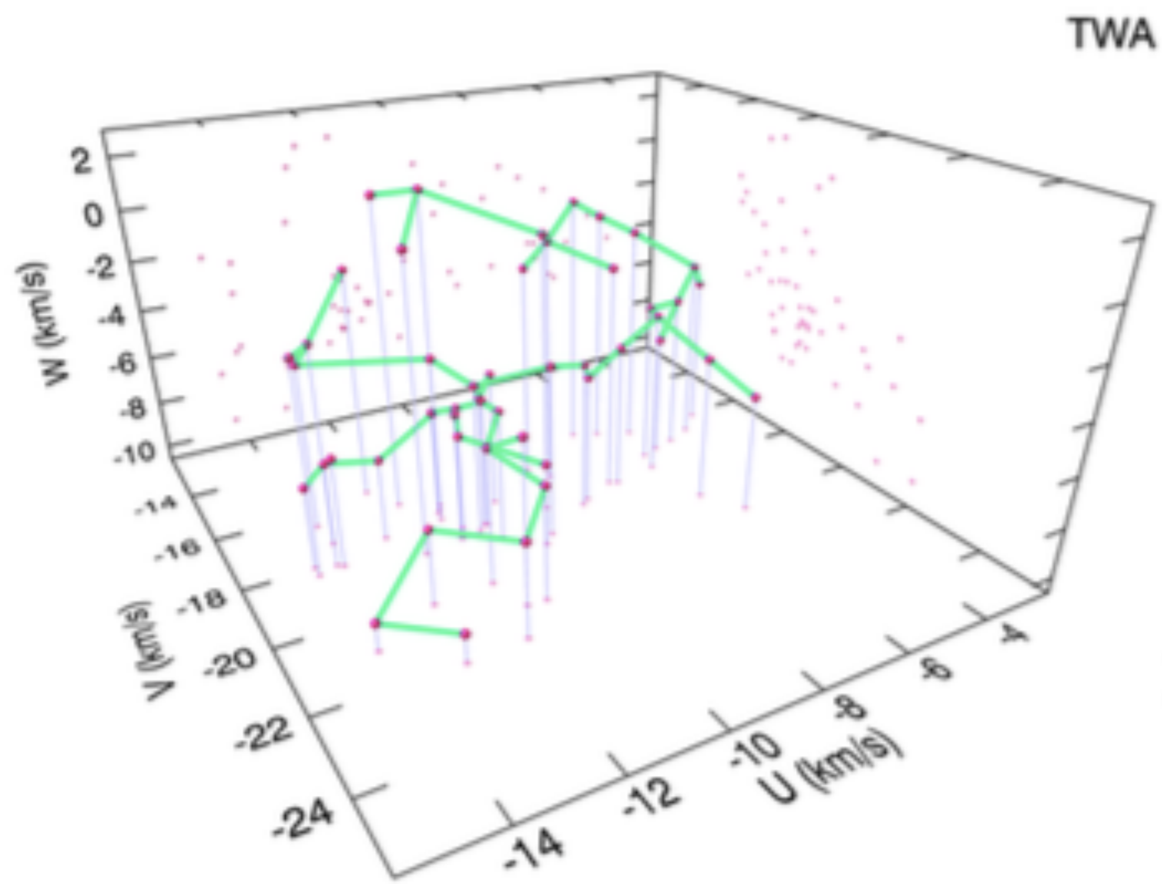


YMG候補分布



各YMG の位置空間、
速度空間での分布

mass segragation
を測定できるかも



既知のmember の60%を検出
(条件設定により40%を漏らす)