

“ダウンサイジング”へのコメント

- 現象： 星形成を大質量銀河ほど早く終える。小質量銀河は最近まで星形成している
- なぜ、大質量銀河ほどSF time scaleが短い、or星形成率が大きいのか？（バイアスの原因は？）

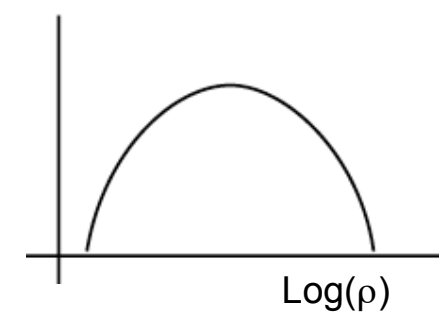
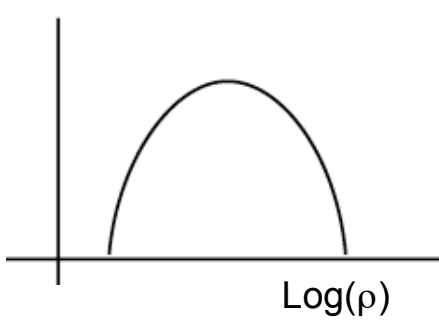
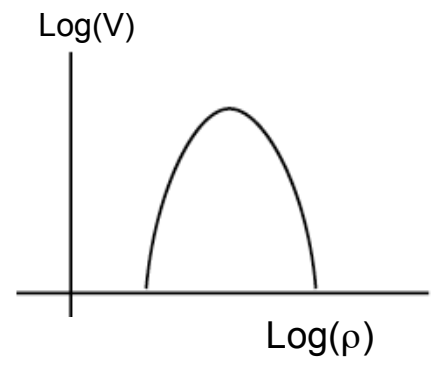
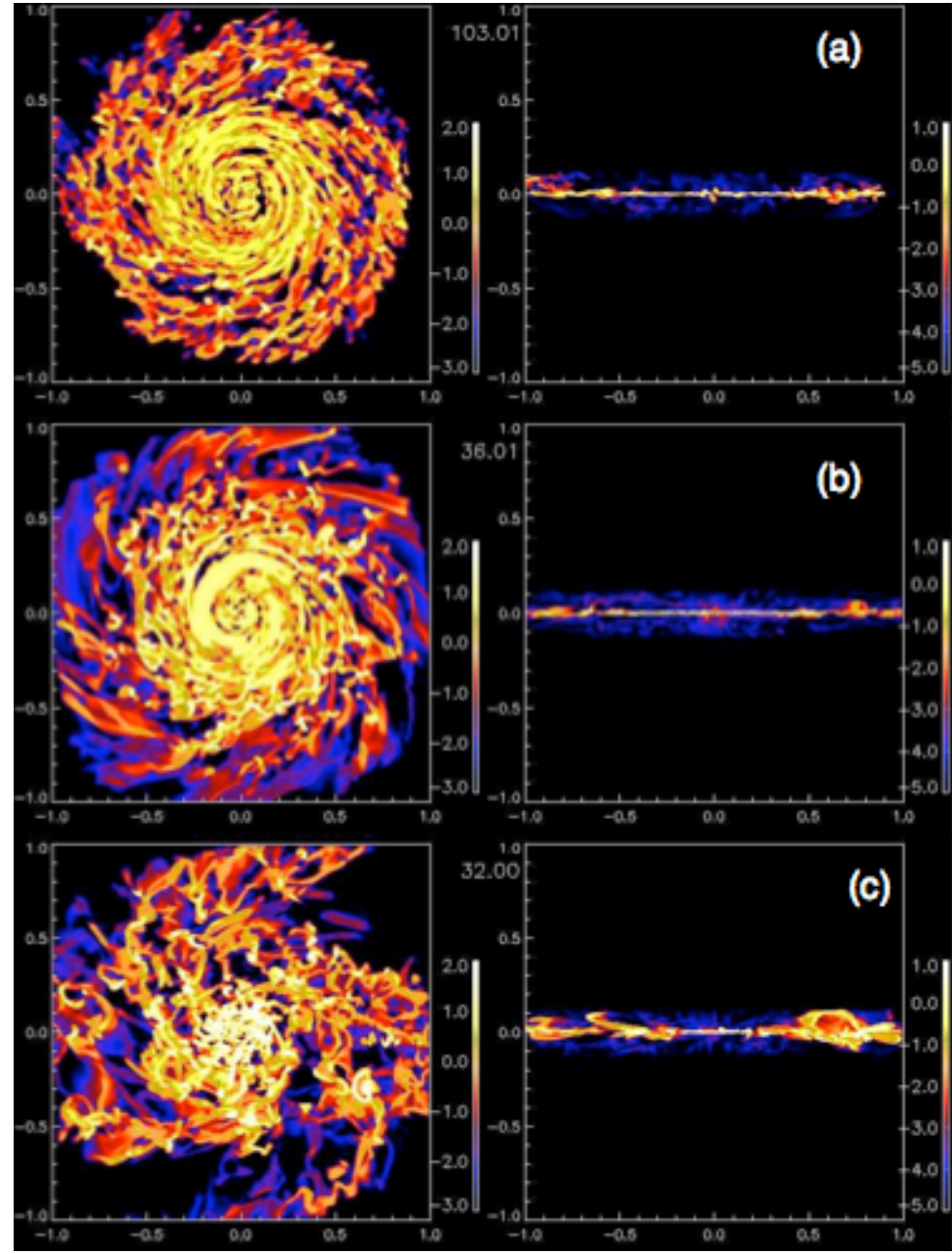
銀河円盤の大局構造の数値モデルからの
第0近似的示唆

銀河円盤ガス

Less massive

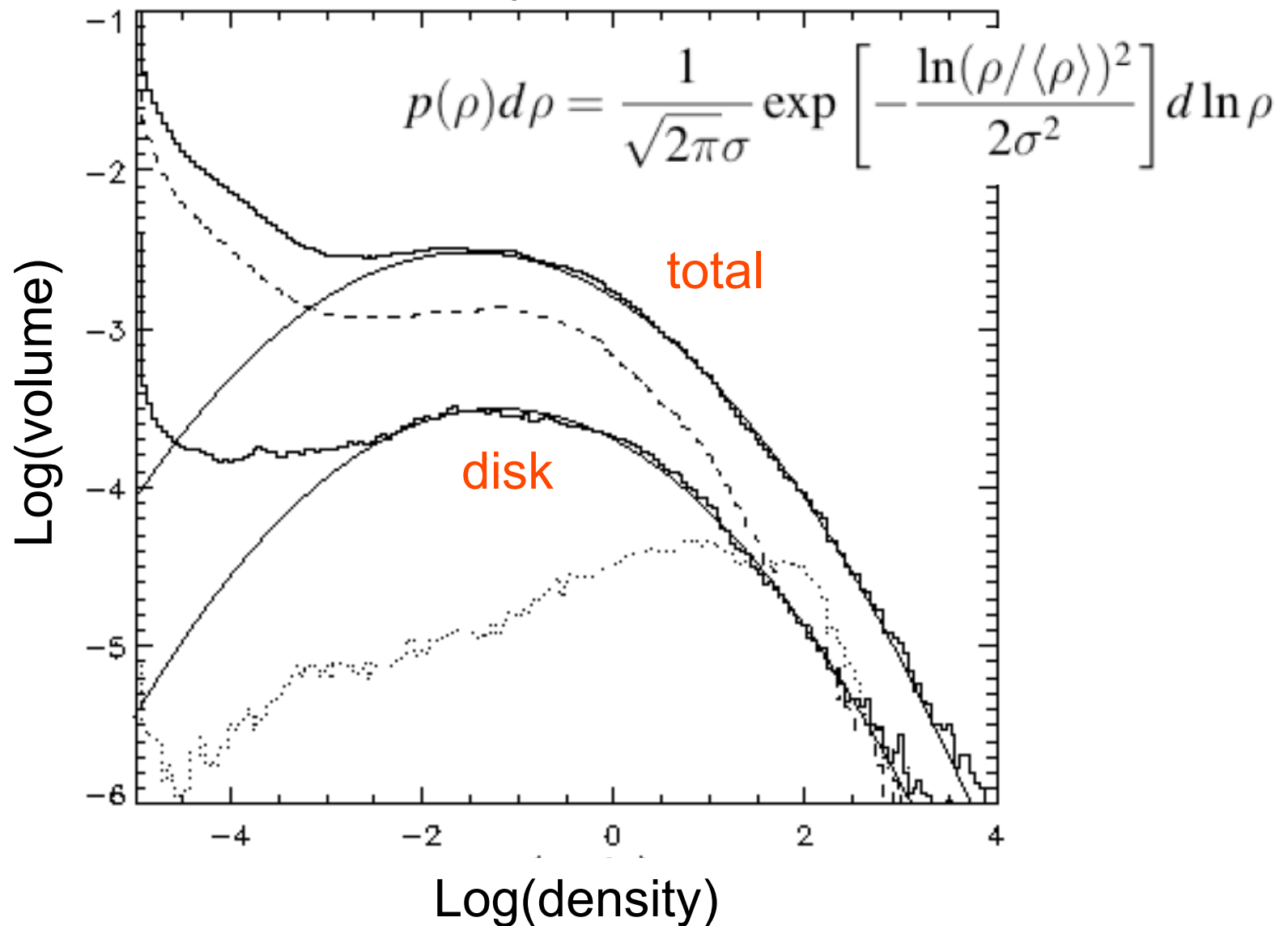


massive



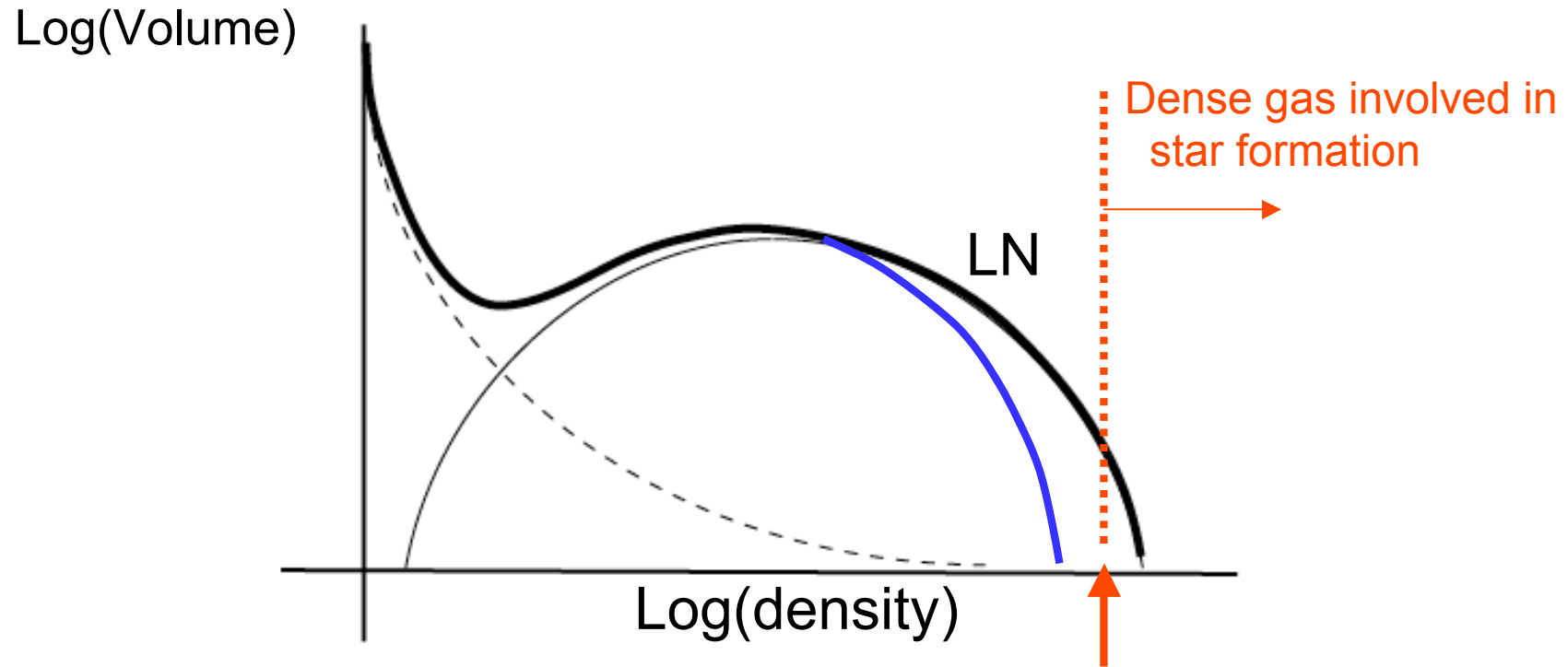
$\langle \rho \rangle_V = \rho_0 e^{\sigma^2/2}$ 平均密度の大きい系ほど、分散が大きい

Volume-weighted density PDF in a steady-state



PDF & star formation

平均密度大 \Rightarrow Dispersion大 \Rightarrow
高密度clumpの割合増加 \Rightarrow SFR大

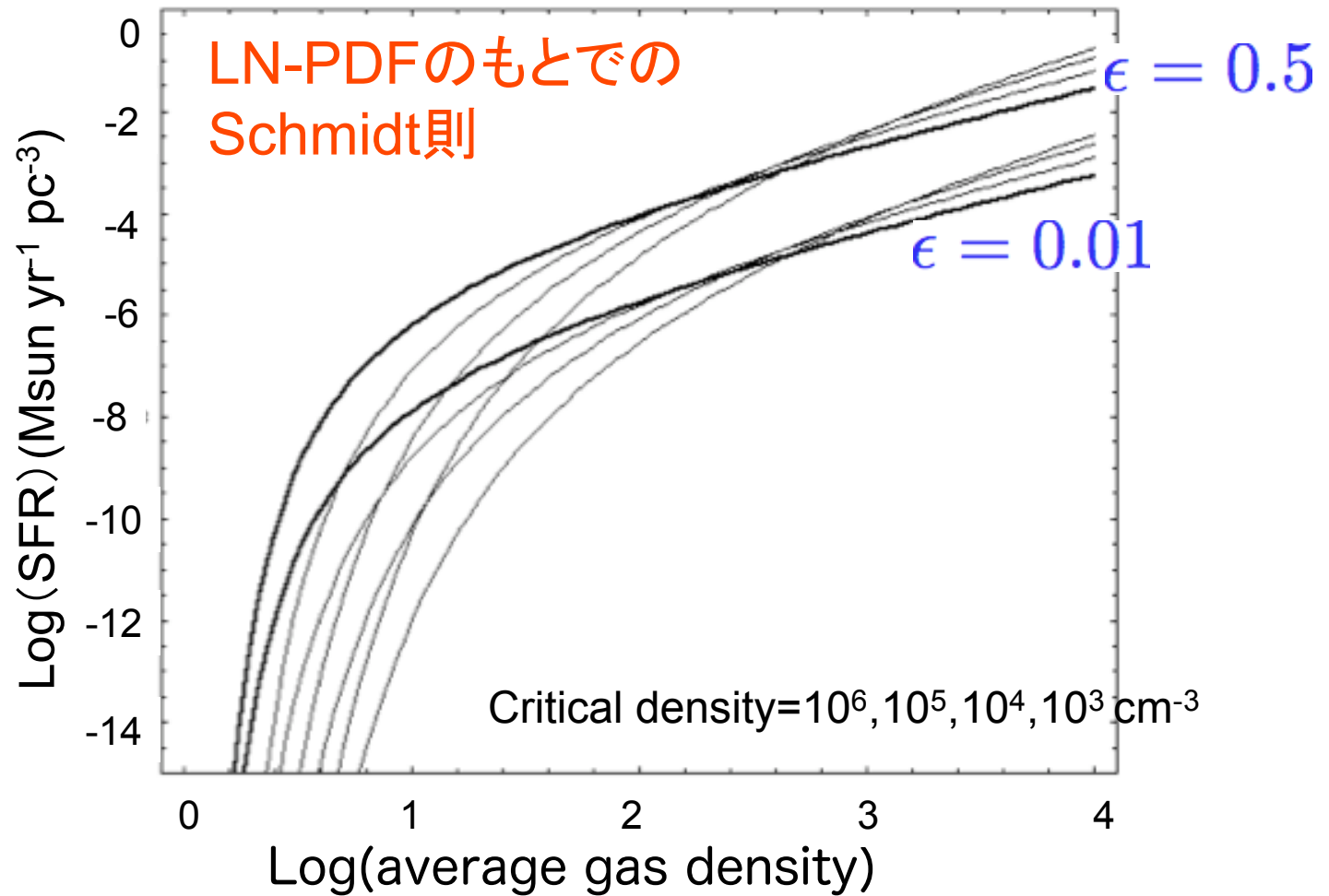


$$\text{SFR} = \epsilon_c (G\rho_c)^{1/2} f_c \langle \rho \rangle_V$$

$$\langle \rho \rangle_V = \rho_0 e^{\sigma^2/2}$$

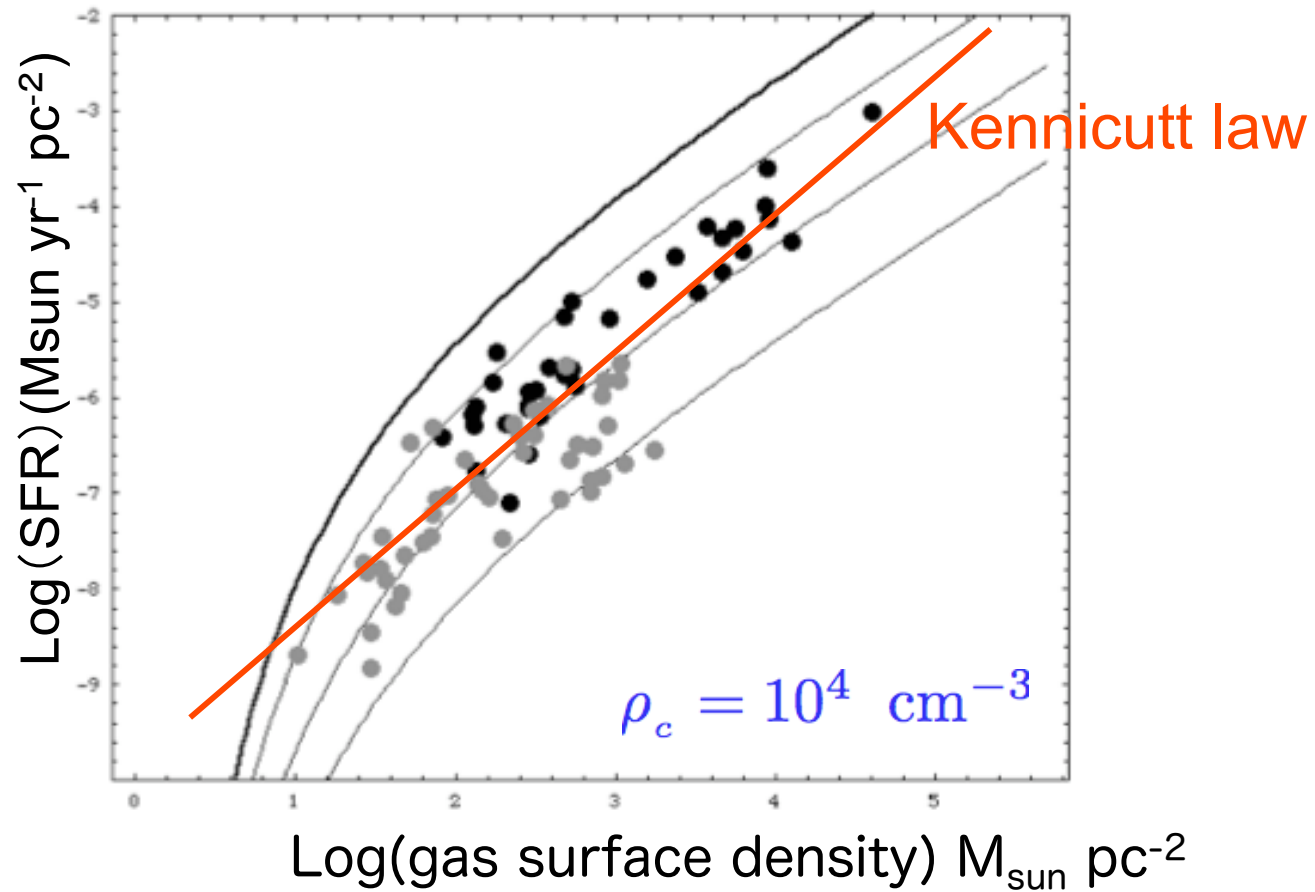
SFR は、平均ガス密度 (kpcスケール) に強く依存 (特にlow density)

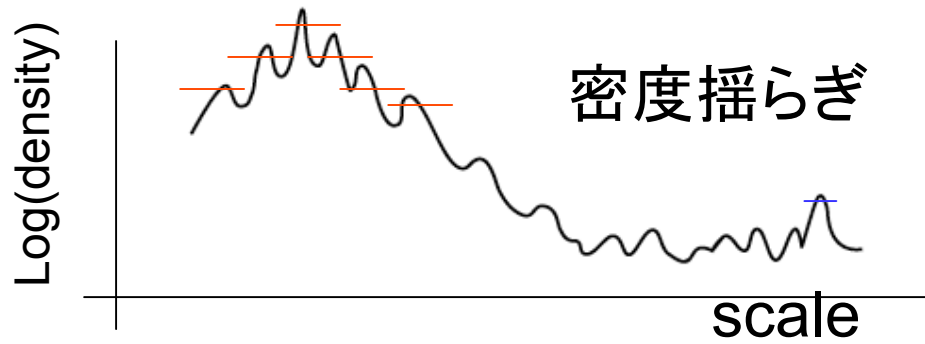
$$\dot{\rho}_* = \epsilon_c (G\delta_c)^{1/2} f_c \rho_0^{3/2} e^{\sigma^2/2}$$



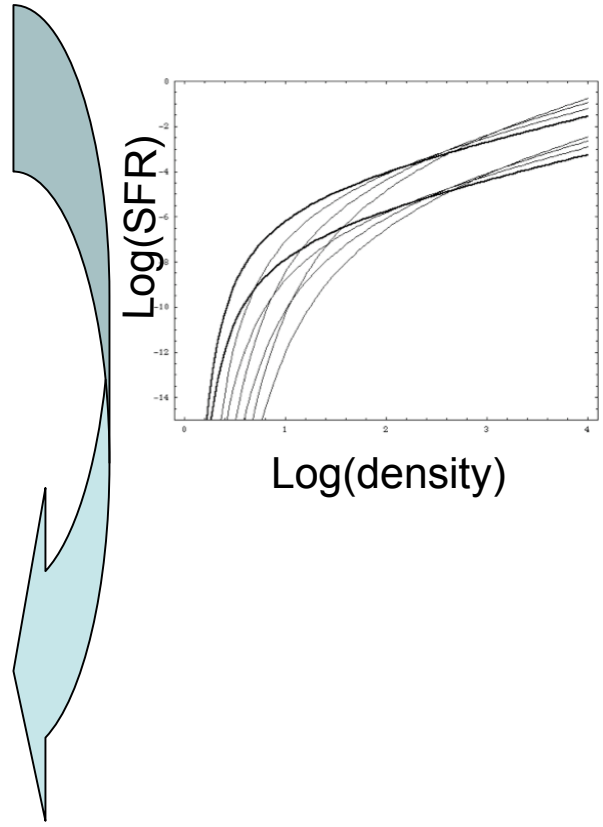
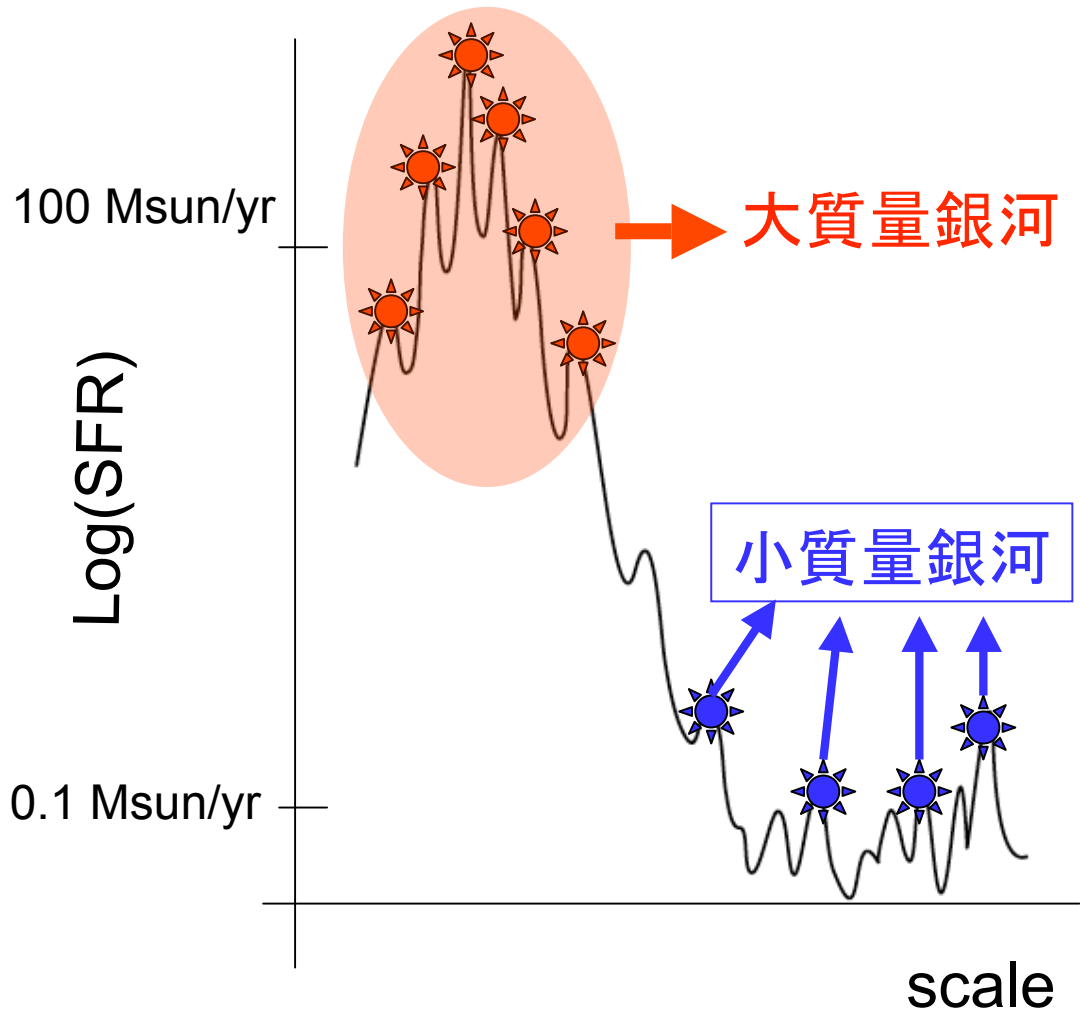
近傍銀河の星形成率と比較

Normal銀河 Efficiency=0.001~0.01
Starburst Efficiency=0.01~0.1



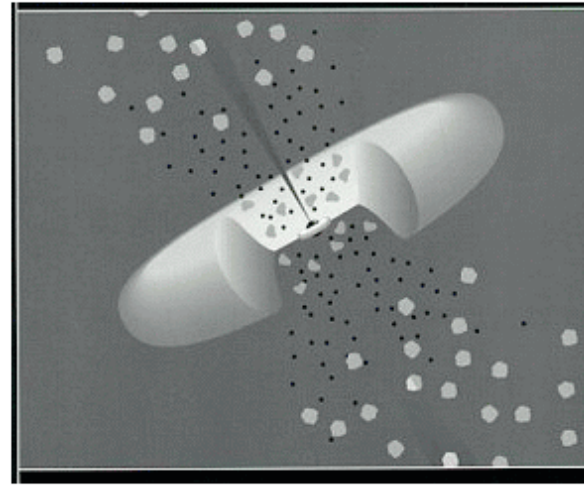


SFRが平均密度に強く
バイアスされていると、...



大質量銀河の出来やすい
場所で星形成率が大

活動銀河核と銀河の共進化ワークショップ
3月15-17日,2006, 国立天文台



AGN近傍の分子トーラスの構造

和田桂一

国立天文台理論研究部

共同研究者： 富阪幸治、山田雅子（国立天文台）

科研費基盤A(観山代表：ALMA時代を見据えた分子原子輝線
輻射輸送計算による数値天文学の構築)

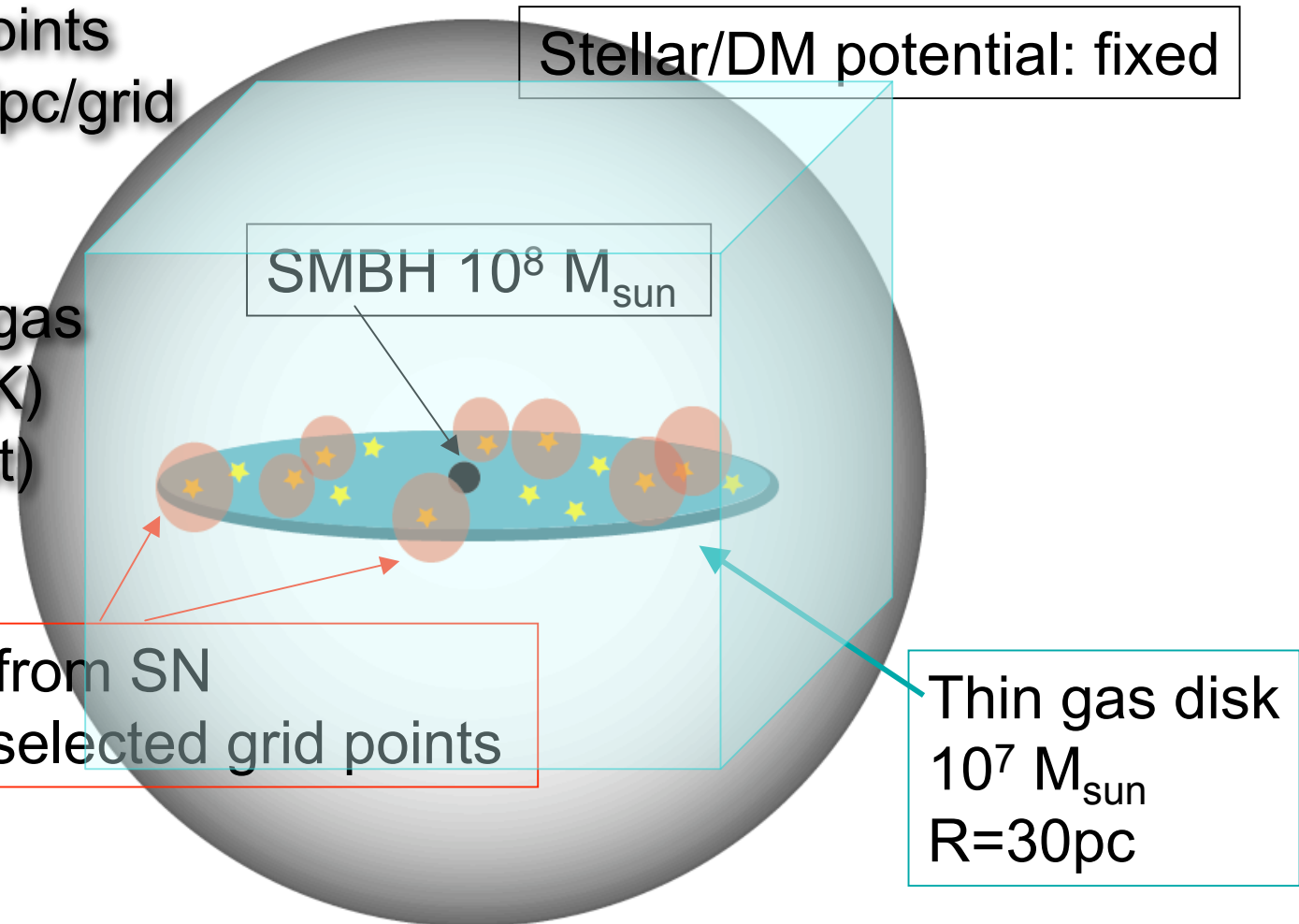
3-D Hydrodynamics of a massive gas disk around a SMBH

(KW & Norman 02; KW & Tomisaka 05)

256²x128 grid points
Resolution: 0.25pc/grid

- * Self-gravity of gas
- Cooling(10-10⁸K)
- UV heating(dust)

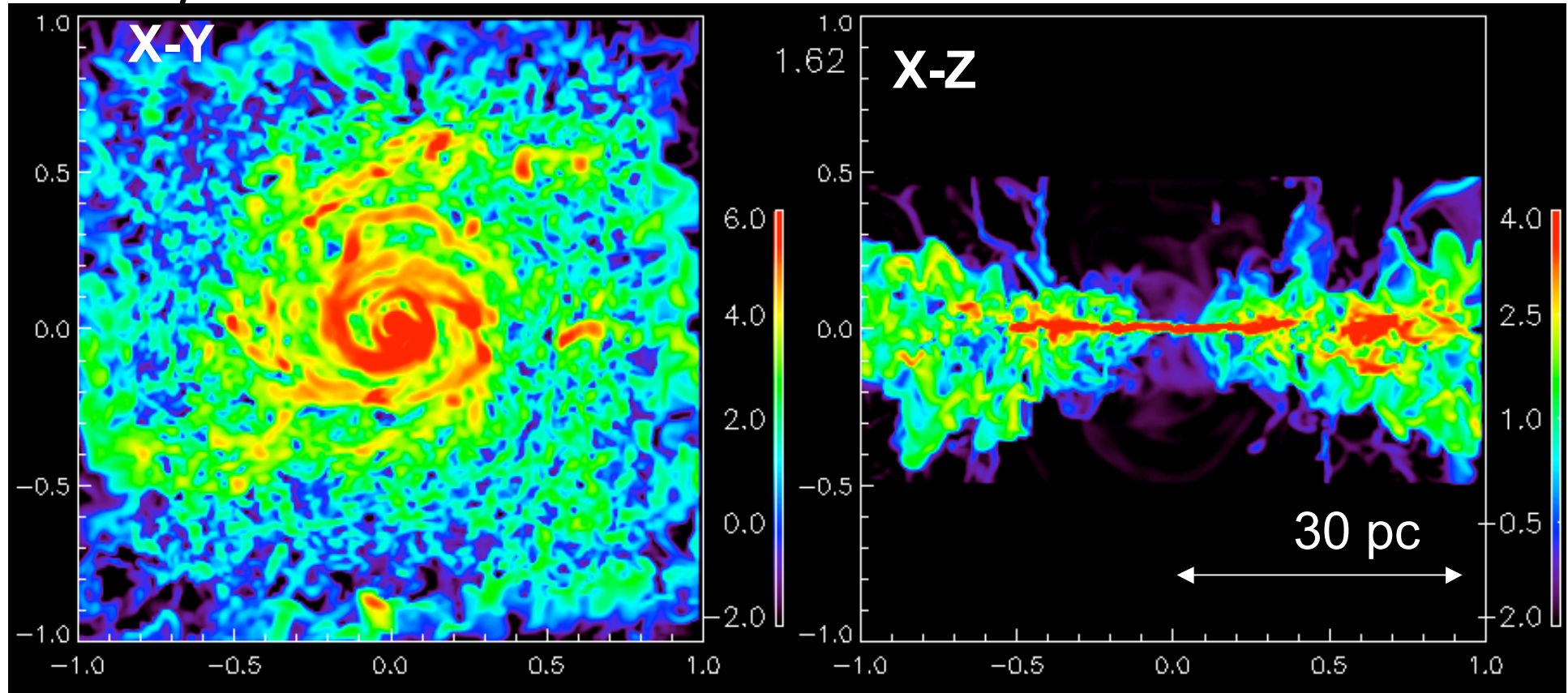
Energy input from SN
at randomly selected grid points



Starburst driven "torus" around SMBH

density

KW & Norman '02

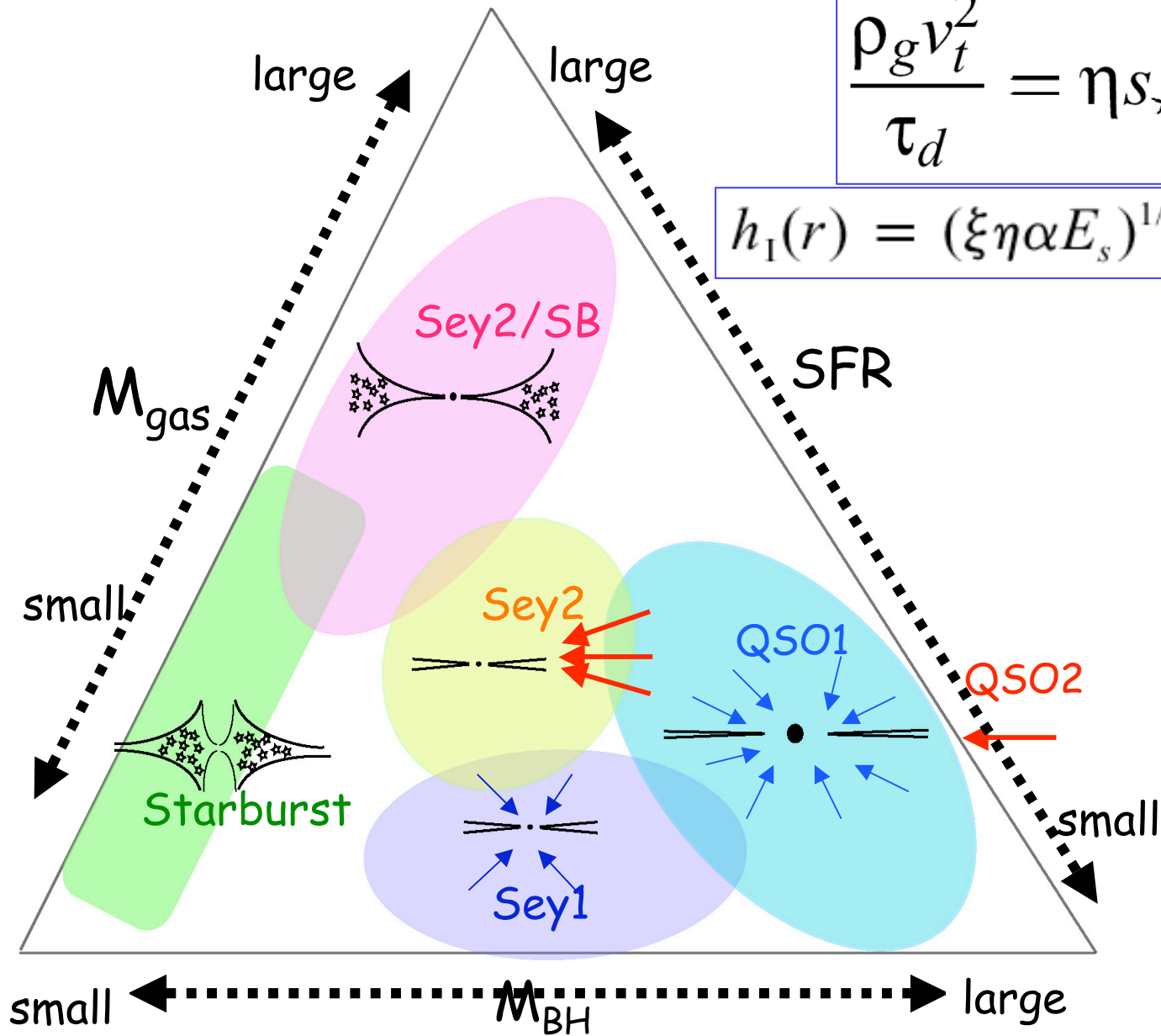


- ISM is a flared disk with clumps and filaments.
- Scale height is determined by energy balance between turbulent dissipation and SN heating in a gravitational potential.

Dissipateする乱流とSN
からのエネルギーが拮抗しているなら

$$\frac{\rho_g v_t^2}{\tau_d} = \eta s_{\star} E_s,$$

$$h_1(r) = (\xi \eta \alpha E_s)^{1/2} G^{-1/2} M_{\text{BH}}^{-1/2} r^{3/2},$$

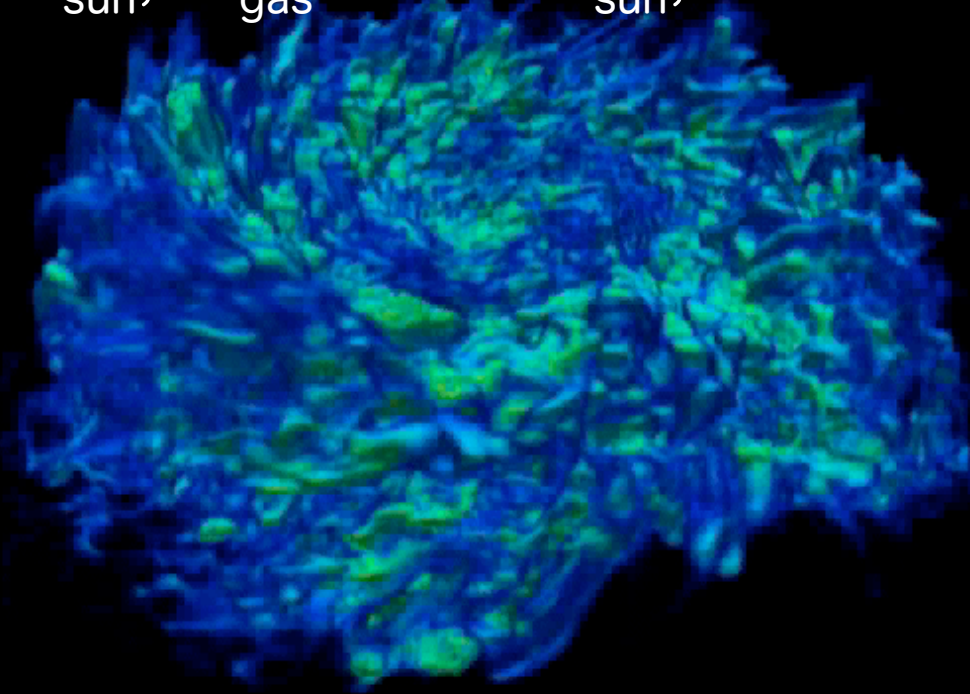


Obscuring “torus” around a supermassive BH with nuclear starburst

$256^2 \times 128$, uniform grid, 0.25pc/grid

Radiative cooling ($5-10^8$ K), SN feedback, selfgravity

$M_{\text{BH}} = 10^8 M_{\text{sun}}$, $M_{\text{gas}} = 10^7 M_{\text{sun}}$,



←-----→
64 pc

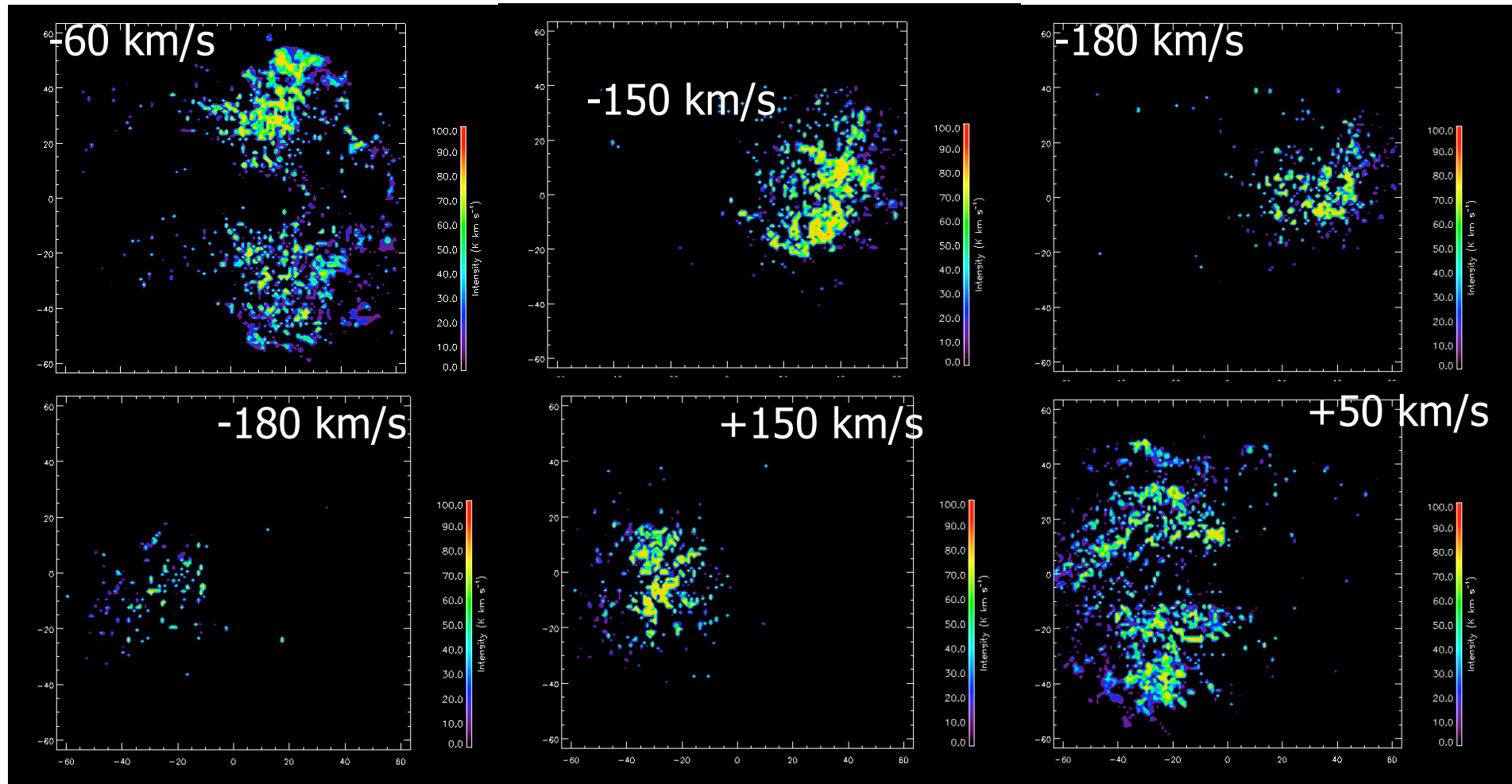
3-D non-LTE line transfer calculation

^{12}CO (J=2-1) channel maps of the "torus" around SMBH

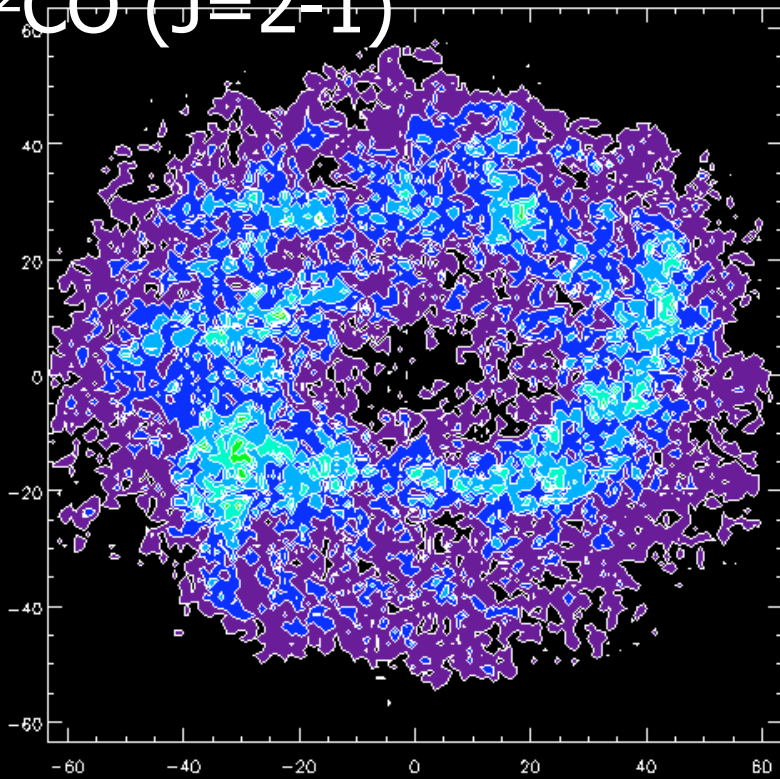
Viewing angle = 45 deg

KW & Tomisaka (2005)

ApJ 619, 93



^{12}CO (J=2-1)

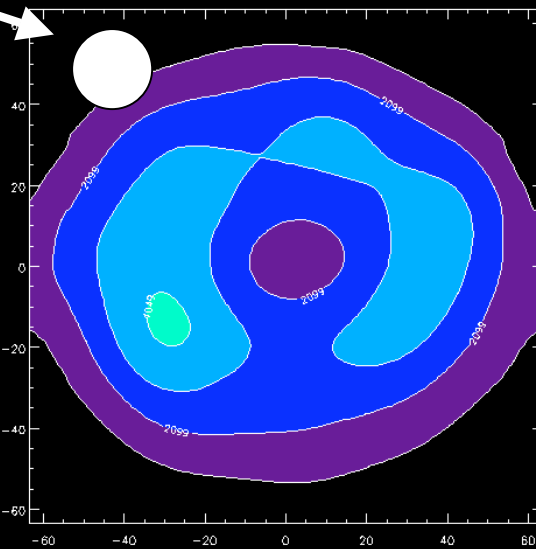
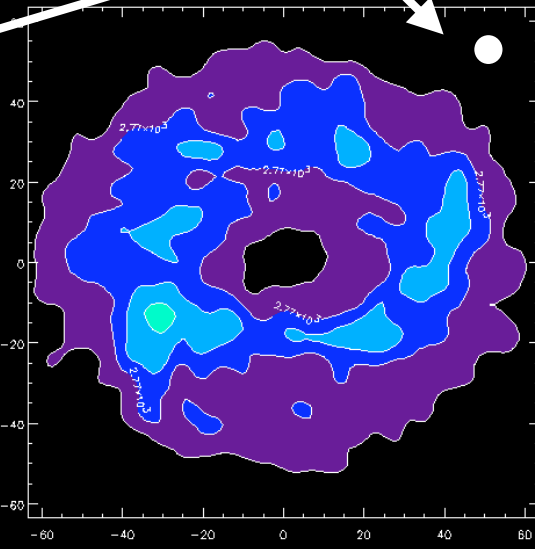
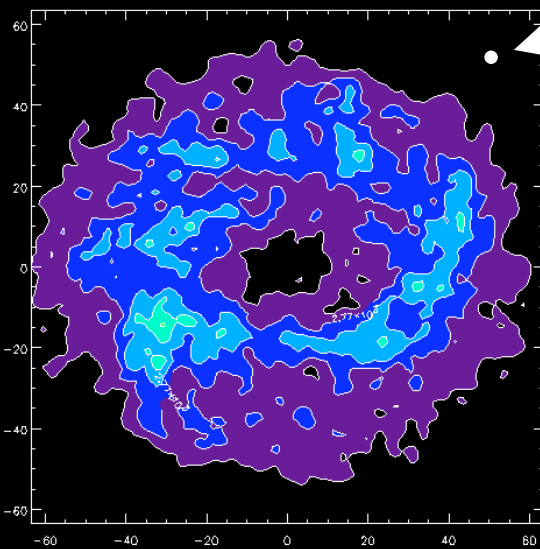


Integrated intensity maps of an obscuring molecular torus
viewing angle = 45 deg

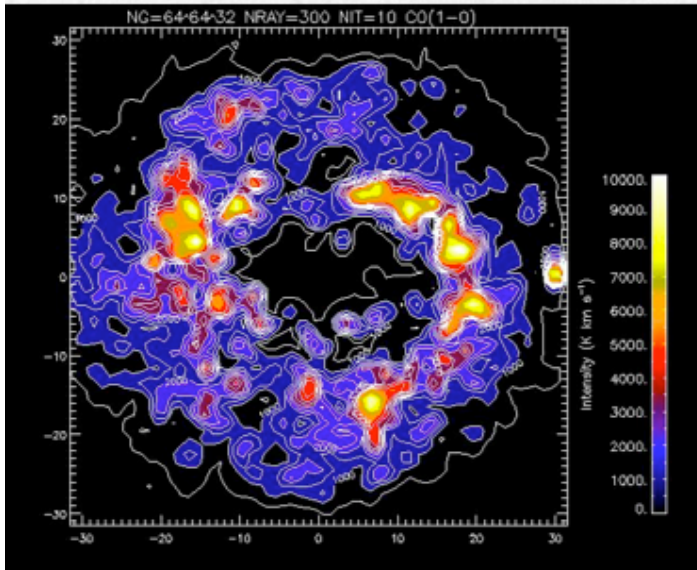
Clumpy structure of the "torus" could be detected with ALMA.
(0.01" ~ 0.8 pc @Virgo)

KW & Tomisaka (2005)

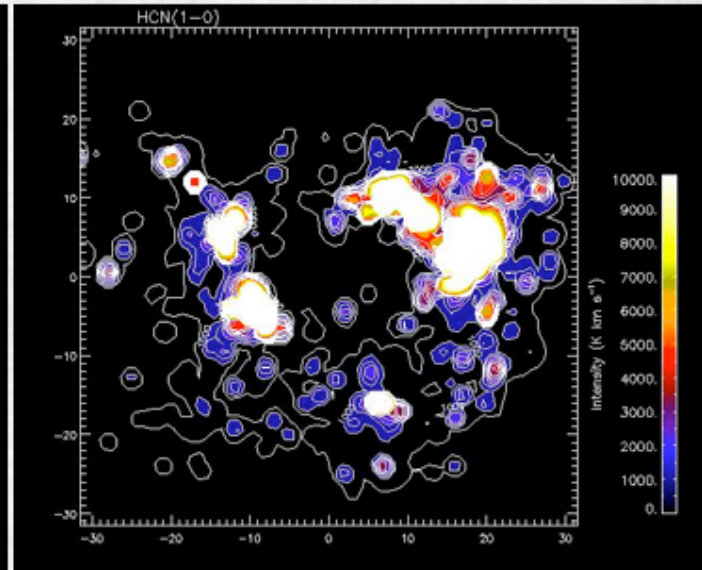
"beam"



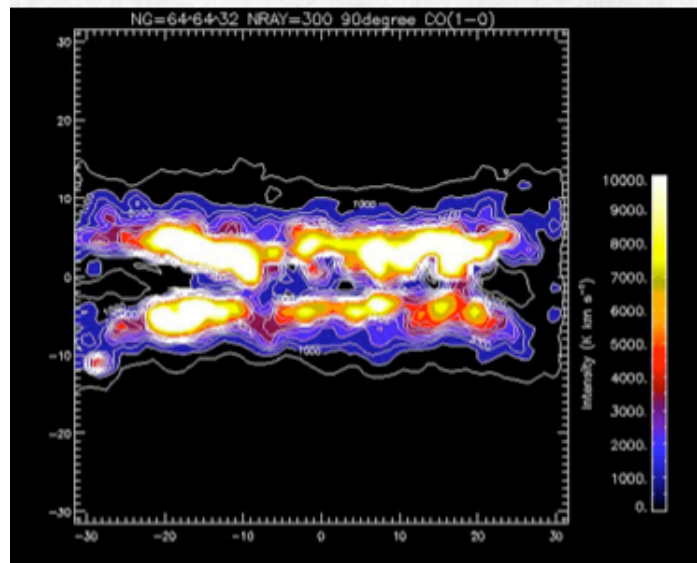
CO(1-0), 45degree



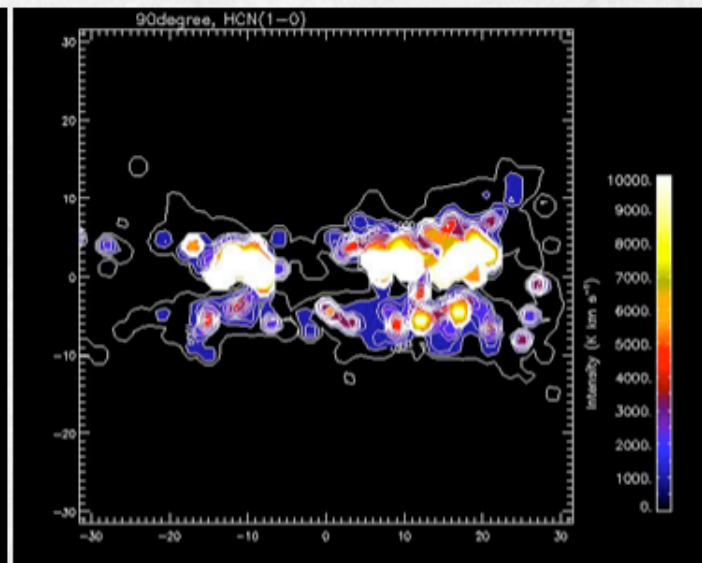
HCN(1-0), 45degree



CO(1-0), 90degree



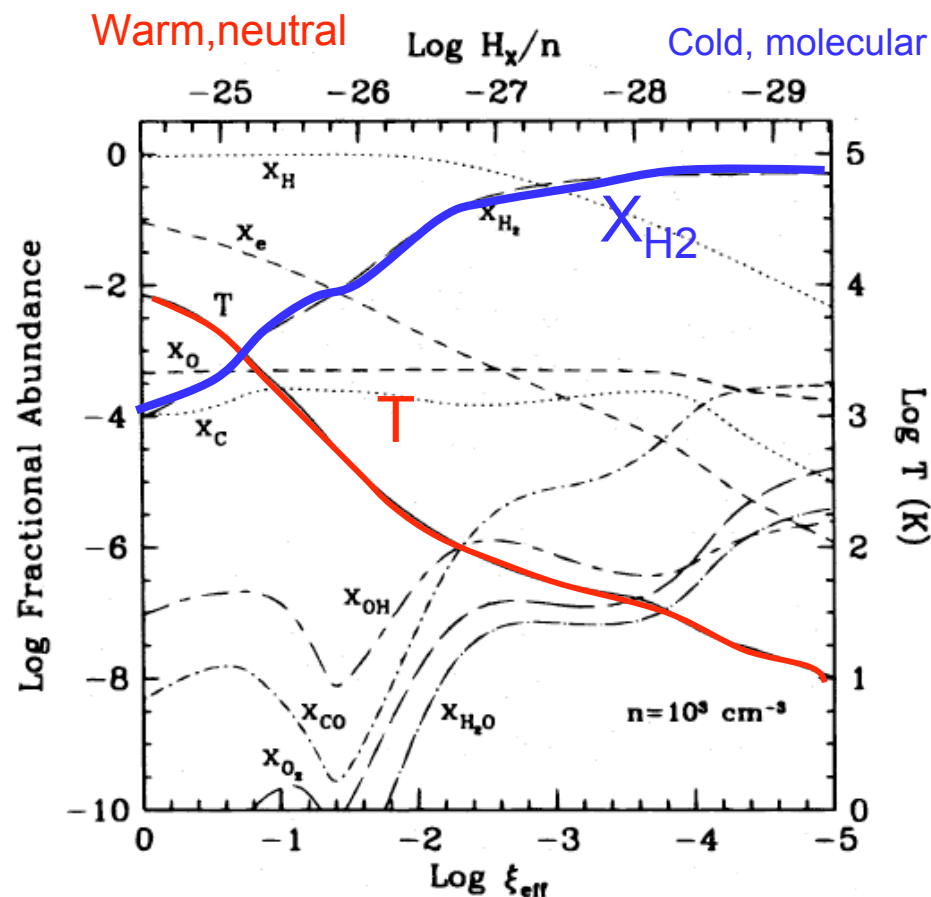
HCN(1-0), 90degree



Y. Yamada

How can we observe the torus by infrared lines?

- e.g. $2\mu\text{m } H_2 v=1-0 S(1)$ from XDR
- Dominant parameter is H_x/n : X-ray energy deposition rate/density
- $H_x \sim 7 \times 10^{-22} L_{44} r_2^{-1} N_{22}^{-1}$
 - $N_{22} = N/10_{22} \text{ cm}^{-2}$
 - $r_2 = r/100 \text{ pc}$



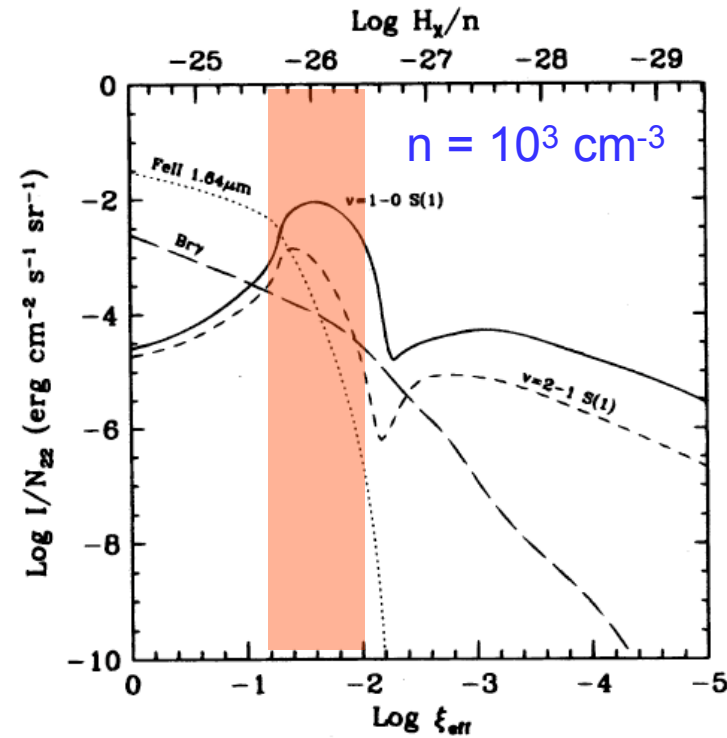
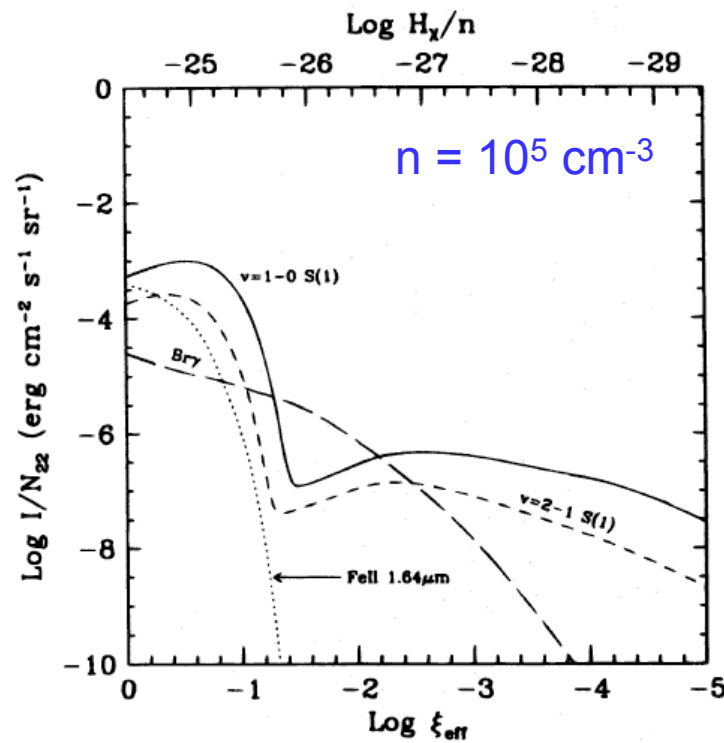
Maloney et al. (1996)

Obs. **Strong $H_2 v=1-0 S(1)$ in NGC 4418** (buried AGN)

Imanishi, et al. (2004) ApJ 128, 2037

Intensity of H_2 $v=1-0$ $S(1)$ vs. H_x/n based on a XDR model

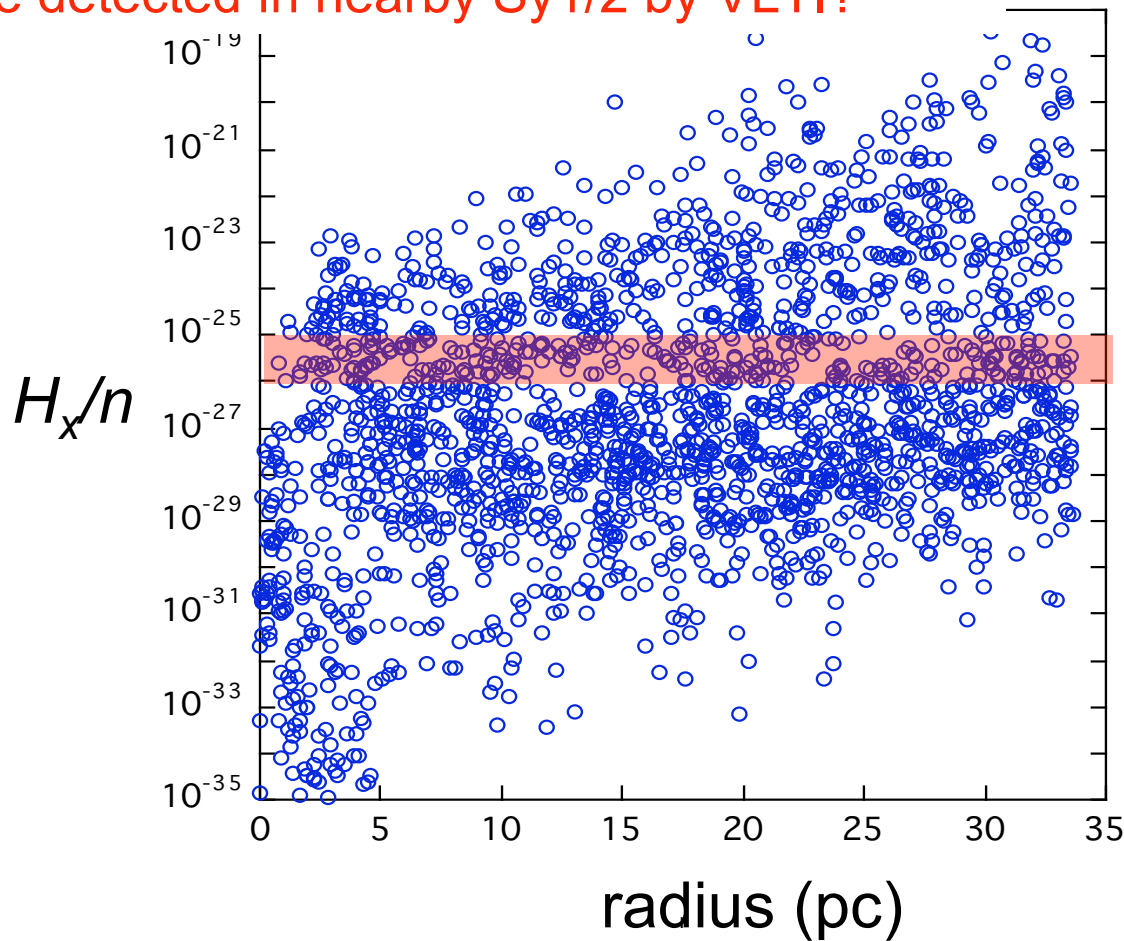
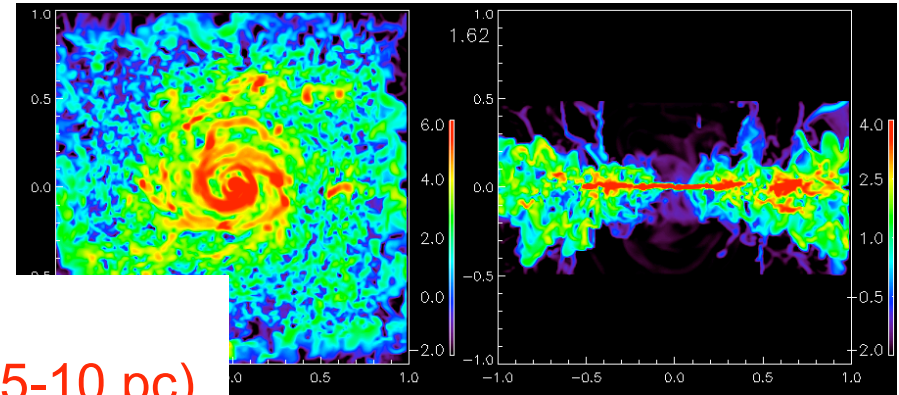
- Most luminous around $H_x/n \sim 10^{-25} - 10^{-26} \text{ erg s}^{-1} \text{ cm}^3$



Maloney et al. (1996)

H_x/n for 2000 sample points in the clumpy torus model

H2 could be emitted from the whole disk, but its distribution is non-uniform (5-10 pc). Can be detected in nearby Sy1/2 by VLTI?

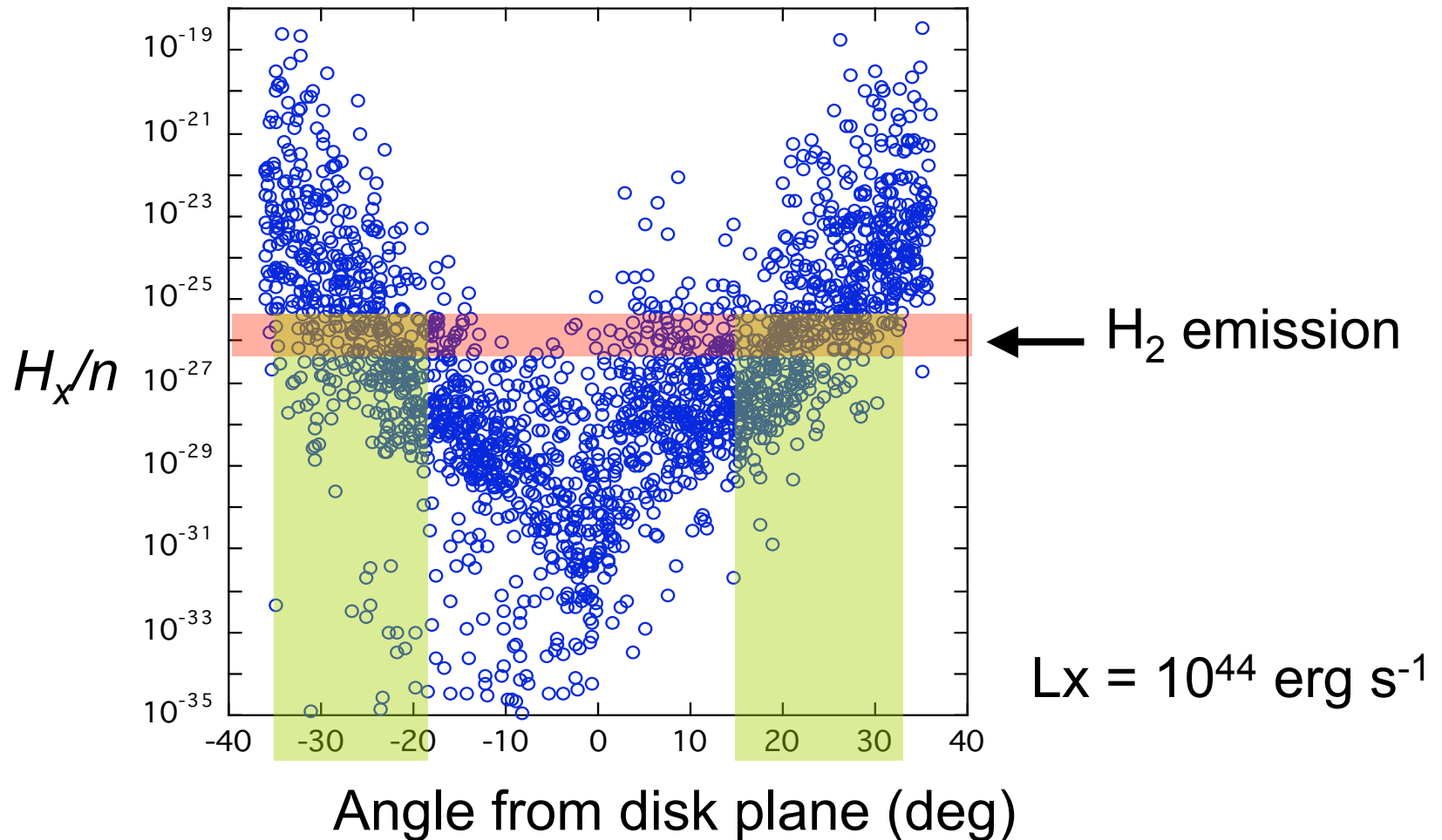
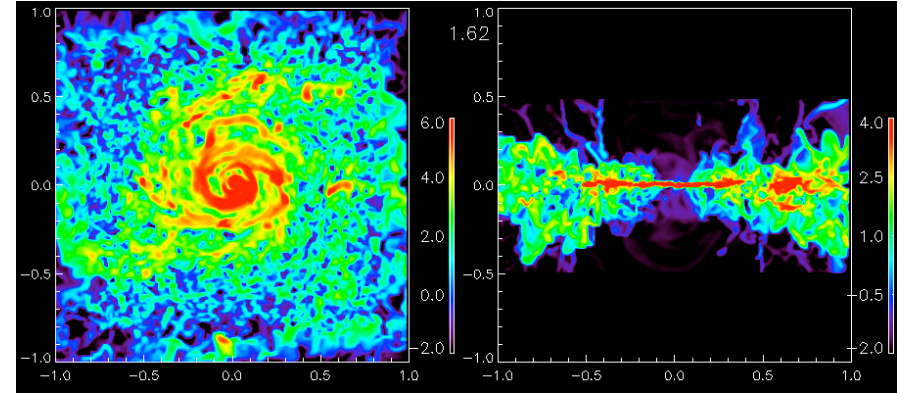


← H₂ emission

$L_x = 10^{44} \text{ erg s}^{-1}$

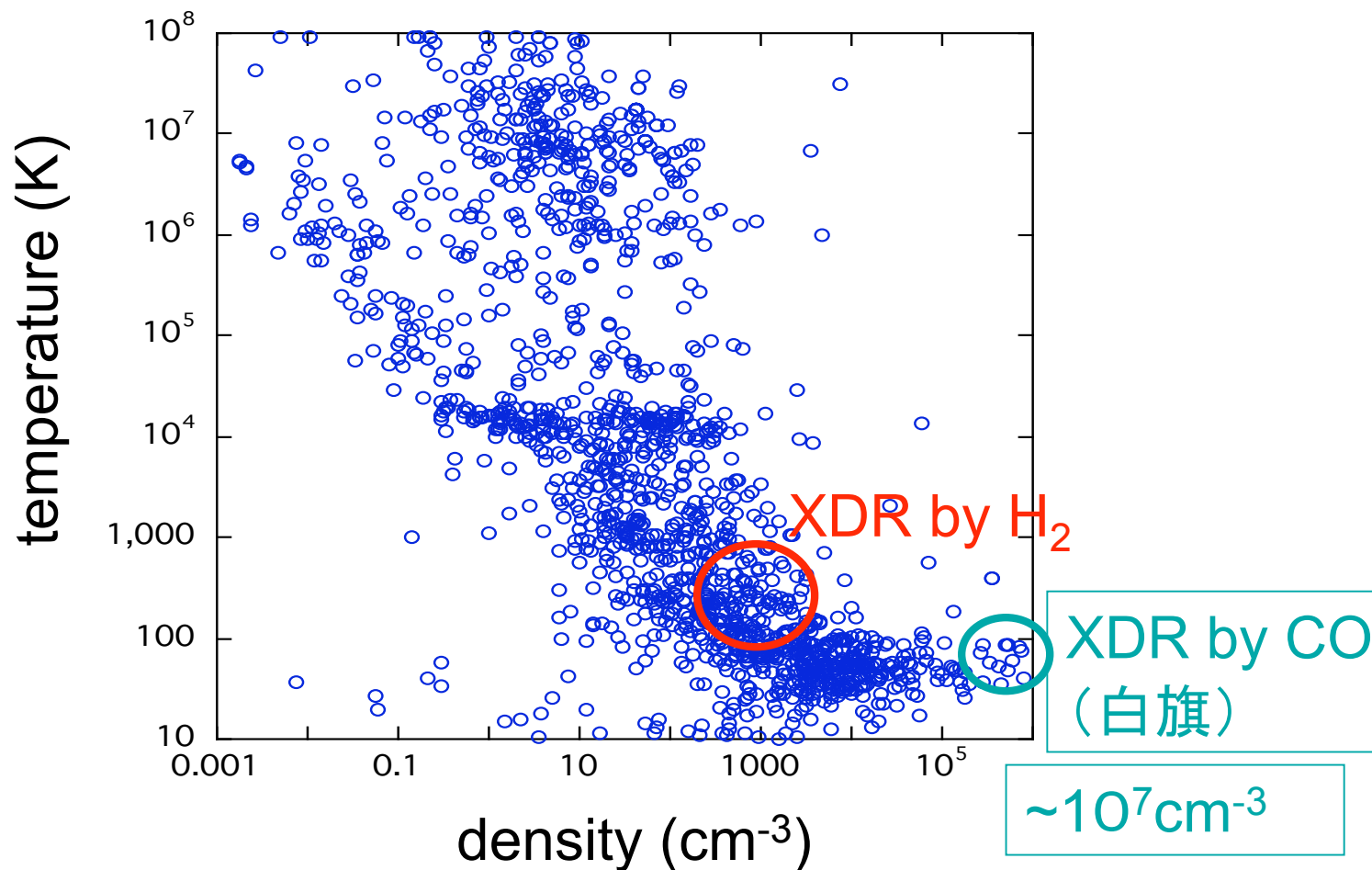
H2 may not be emitted from the disk plane.

Non-starforming disk is invisible for this line?



Density, temperature in XDR of the “torus”

$T \sim 100\text{-}1000\text{ K}$, $n \sim 1000\text{ cm}^{-3}$

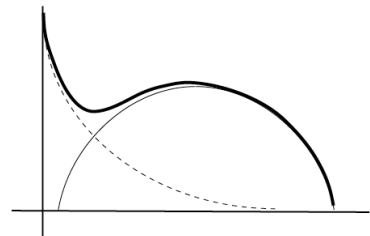


CO回転振動遷移の吸収線で発見された吸収体構造の正体？

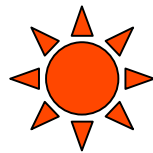
IRAS 08572+3915 Shirahata et al.

- $N_{\text{H}_2} \sim 10^{22} \text{ cm}^{-2}$, $N_{\text{X}} \sim 10^{24} \text{ cm}^{-2}$
- $n \sim 10^7 \text{ cm}^{-3}$
- サイズ $\sim 10^{-4} \text{ pc}$
- 複数の速度成分 ($\pm 100\text{-}200 \text{ km/s}$)
- 複数の温度成分 (30K, 300K, 700K)

⇒ 非一様, 多相, 乱流状態のトラス中に散らばっている高密度XDR領域?



非一様ISMのLog-Normal Model



高密度ガスのvolume filling factorは小さい

