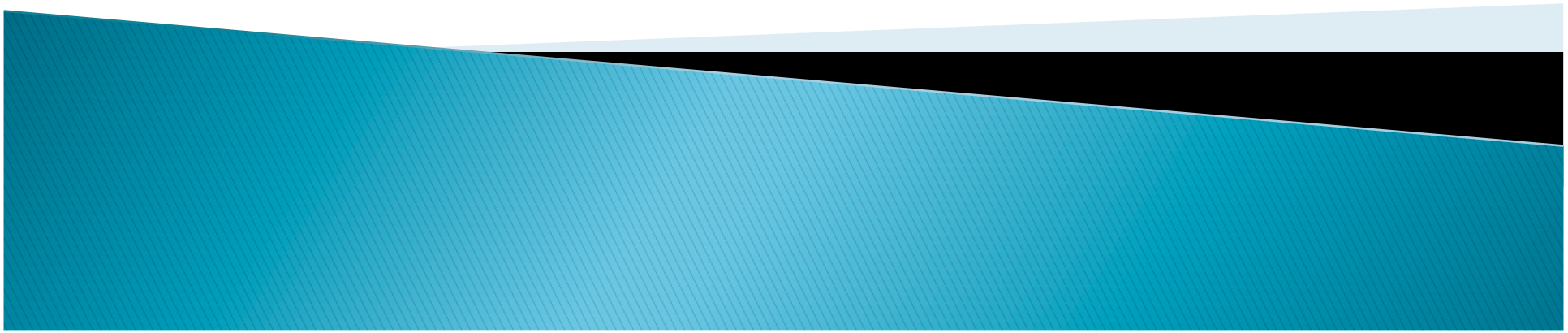
Cold streams vs. Magnetic tension

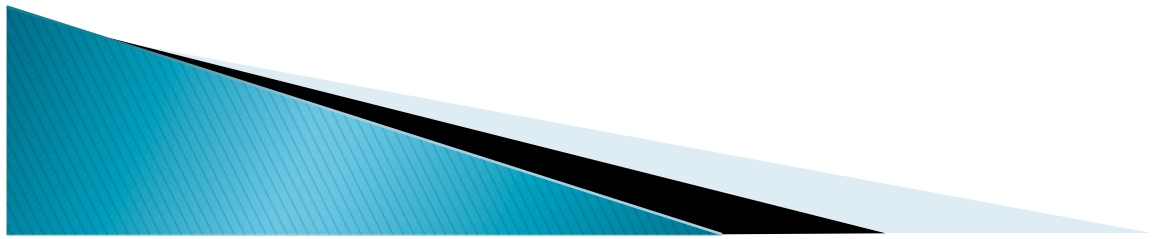
Yuval Birnboim




MOVIEWALLPAPERS.NET
Dr. Strangelove
Birnboim
Or:
How
I Learned
To
Stop
Worrying
And
Love
The
Bomb
Magnetic
fields

Outline

- Magnetic fields in low-z
- High-z SFG are high B
- Thermodynamics of cold filaments
- The interactions between high-z galaxies and magnetic fields



Vertical distribution of mass

molecular: $0.58\ \exp[-(z/81\,\mathrm{pc})^2]$

cold HI: $0.57 * 0.7\ \exp[-(z/127\,\mathrm{pc})^2]$

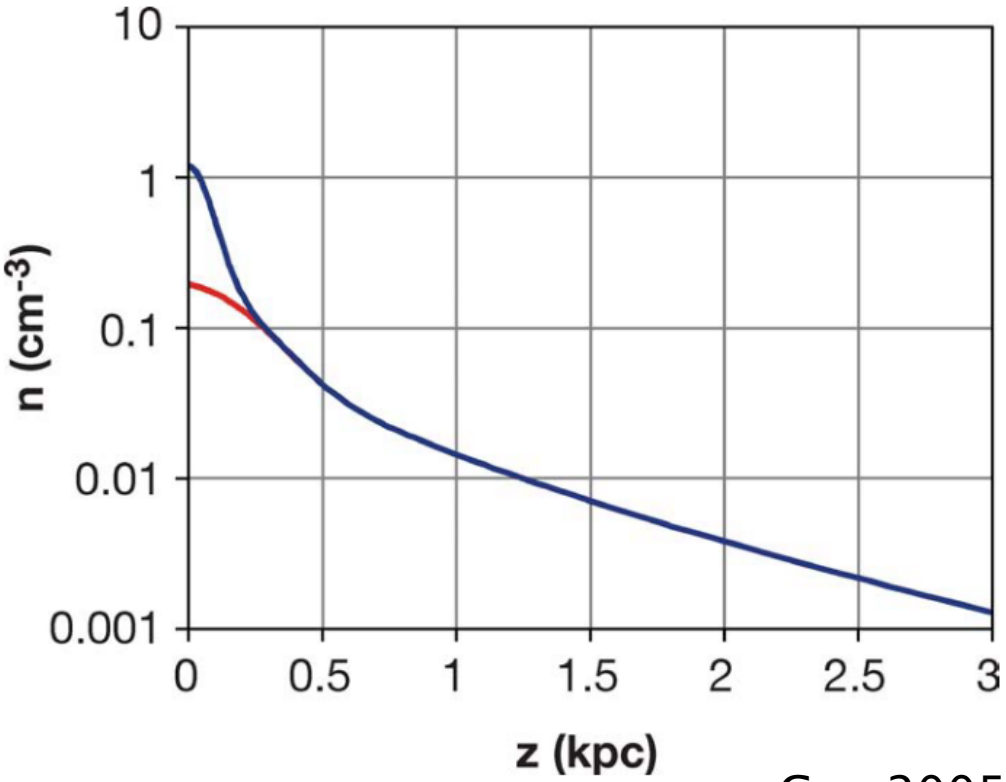
warm HIa: $0.57 * 0.18\ \exp[-(z/318\,\mathrm{pc})^2]$

warm HIb: $0.57 * 0.11\ \exp(-|z|/403\,\mathrm{pc})$

HII Regions: $0.015\ \exp(-|z|/70\,\mathrm{pc})$

diffuse HII: $0.025\ \exp(-|z|/1000\,\mathrm{pc})$.

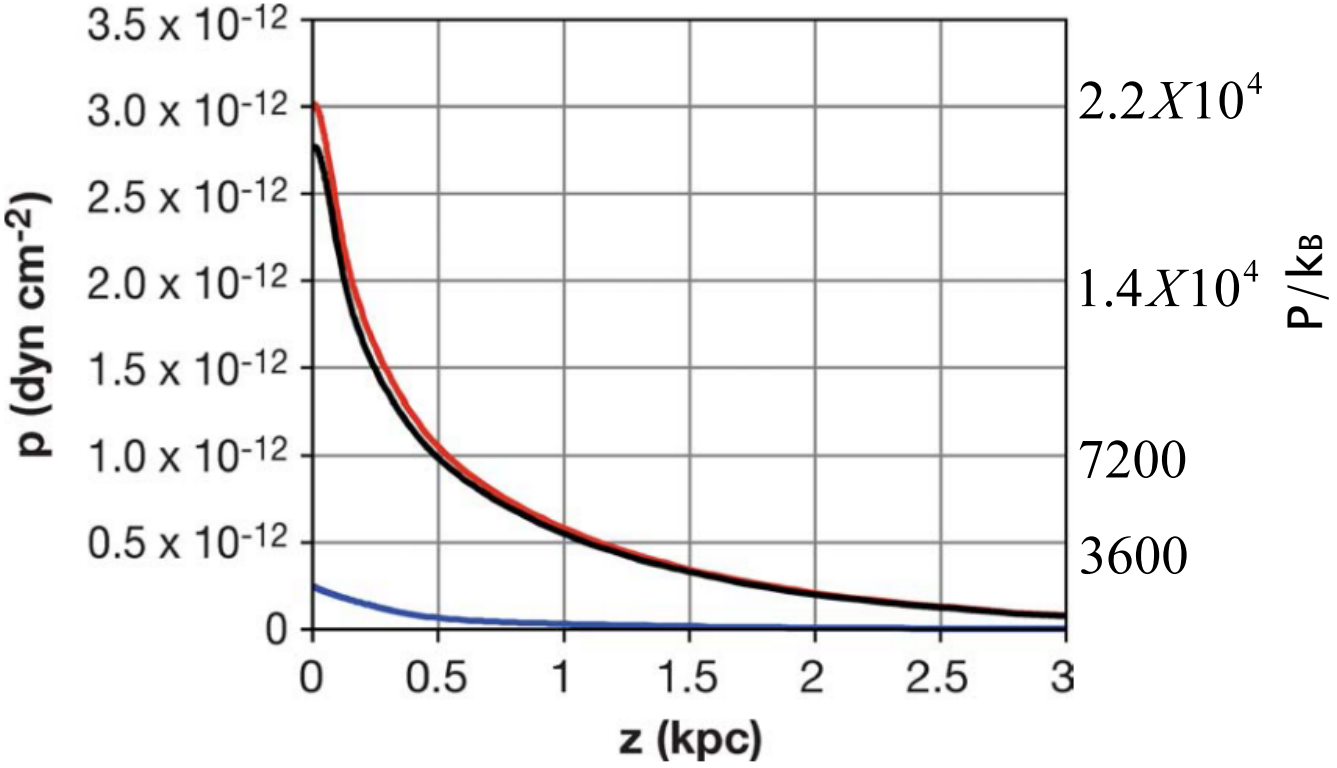
Ferriere 2001



Cox 2005

Vertical hydrostatic equilibrium

- Most of the pressure (9/10) comes from non-thermal components



Cox 2005

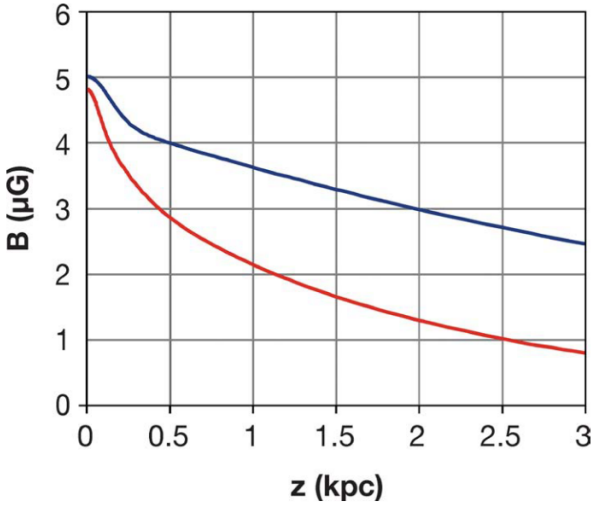
Magnetic fields in MW

- Stellar polarimetry
- Zeeman splitting of 21 cm
- Faraday rotation of linearly polarized radio
- Synchrotron emission

$B_{\parallel}$

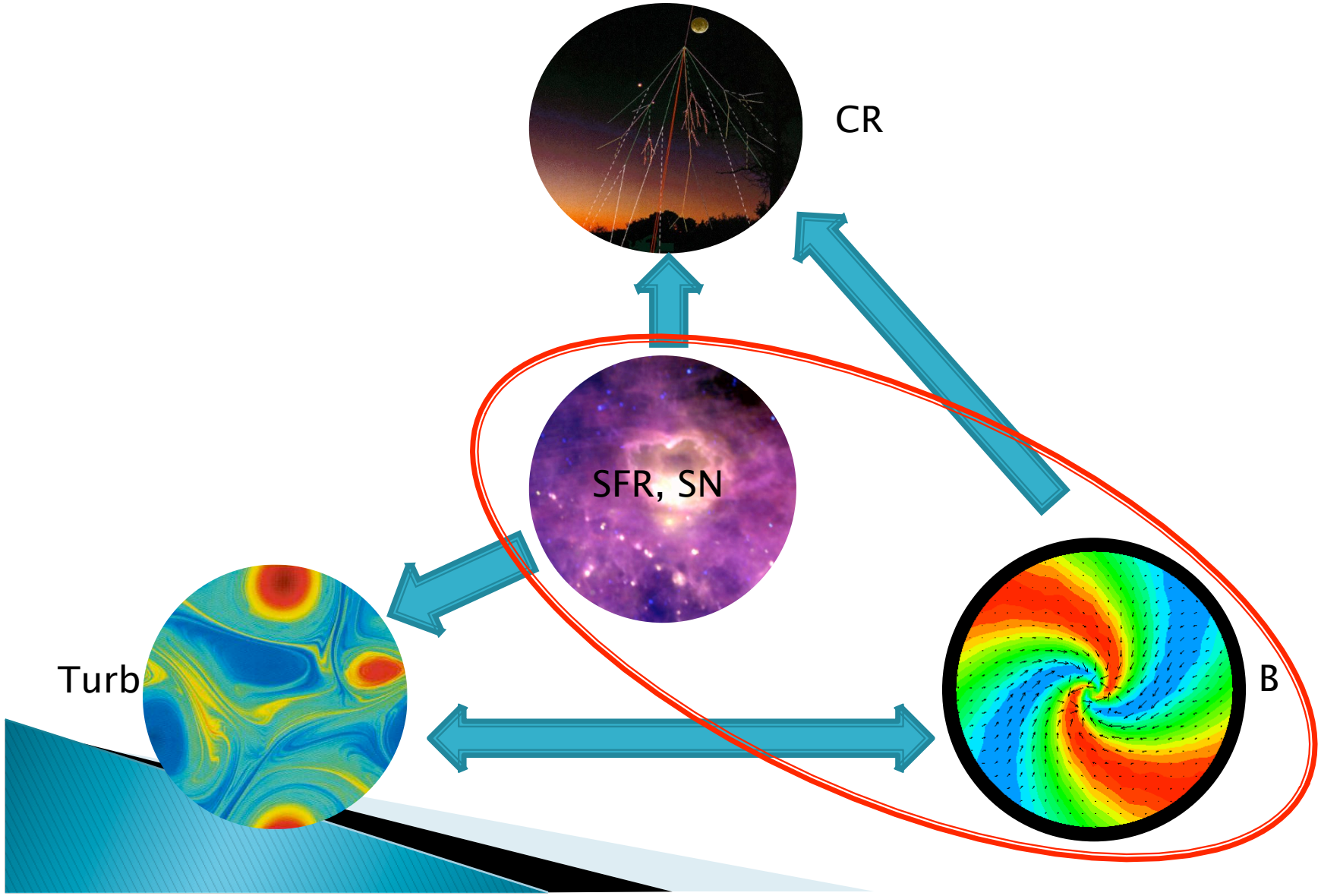
MW values
Local: 5μG
Central: 10μG
Maximal: 100μG

Magnetic fields are woven through the gas



Cox 2005

The equipartition hypothesis

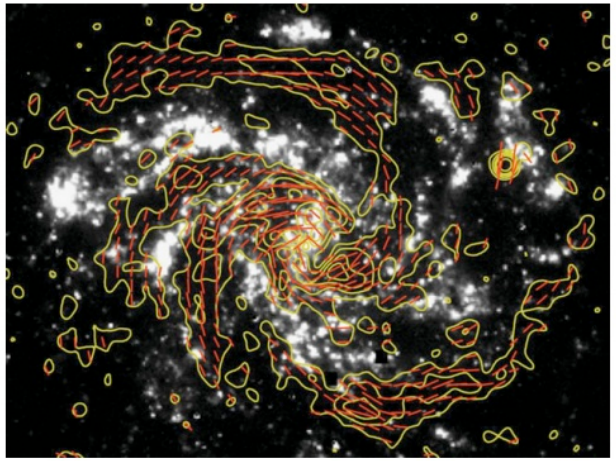


Magnetic fields in nearby galaxies

"Starbusting":

$B \approx 50\text{-}100\,\mu G$

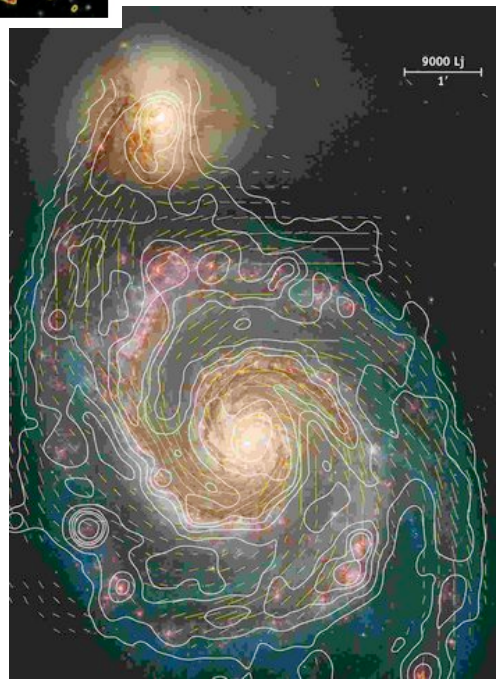
M82, 50μG
(Klein et al. 1988)



NGC 6946

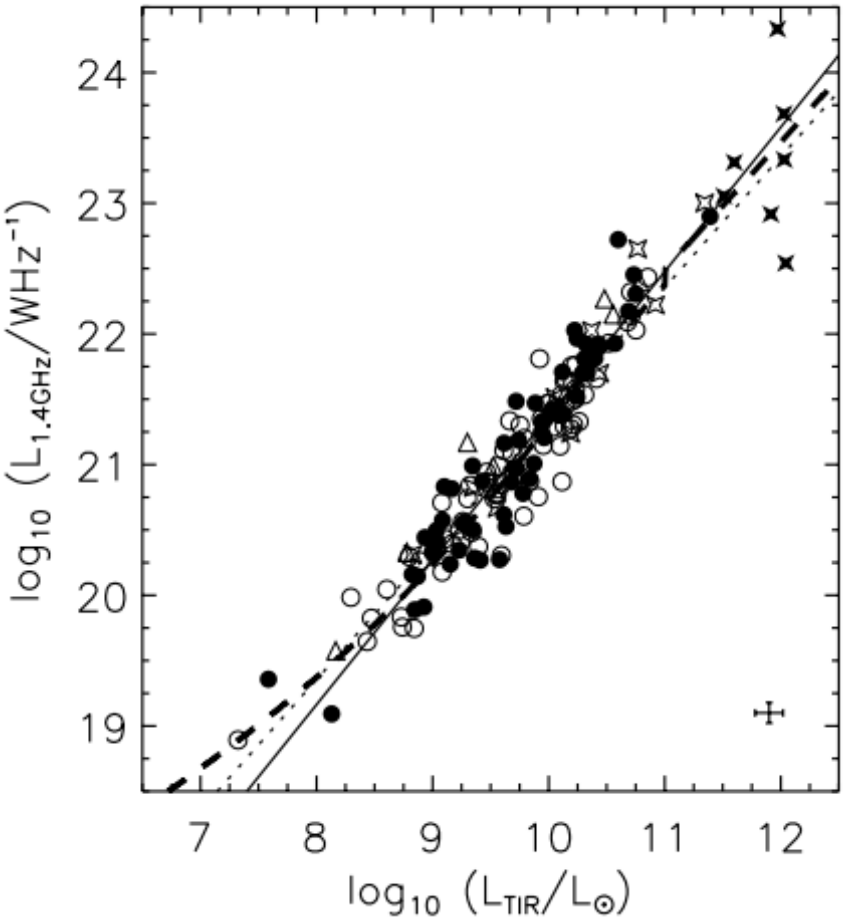
"Star forming":

$B \approx 20\text{-}30\,\mu G$



M51, HST,
MPIfR Bonn

SFR and magnetic fields



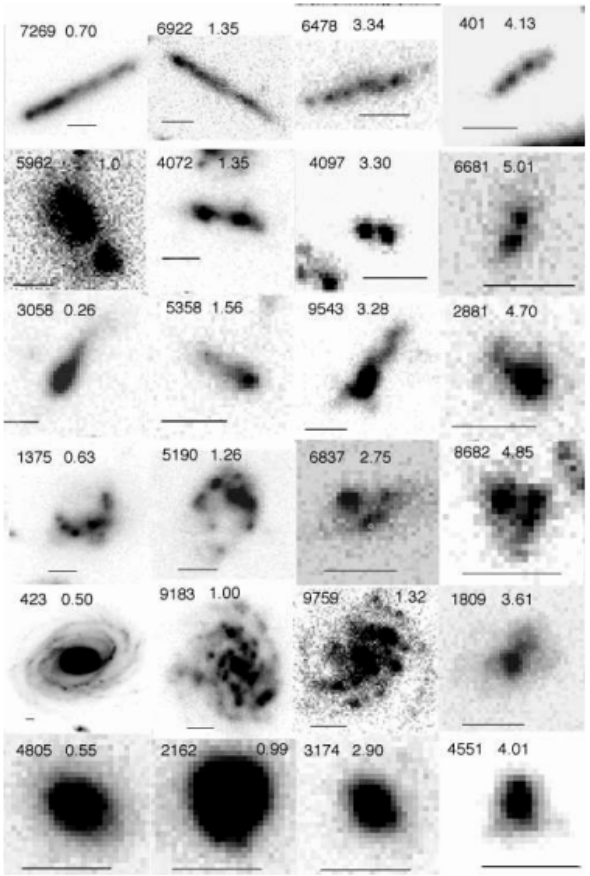
Bell 2003

$B^2 \propto SFR$ (Lisenfeld et al. 2003)

SFG have $\geq 100 M_\odot/yr$ (Daddi et al 2004, SINS, Elmegreens)

Ballpark value for magnetic fields of high-z SFG: ~100μG

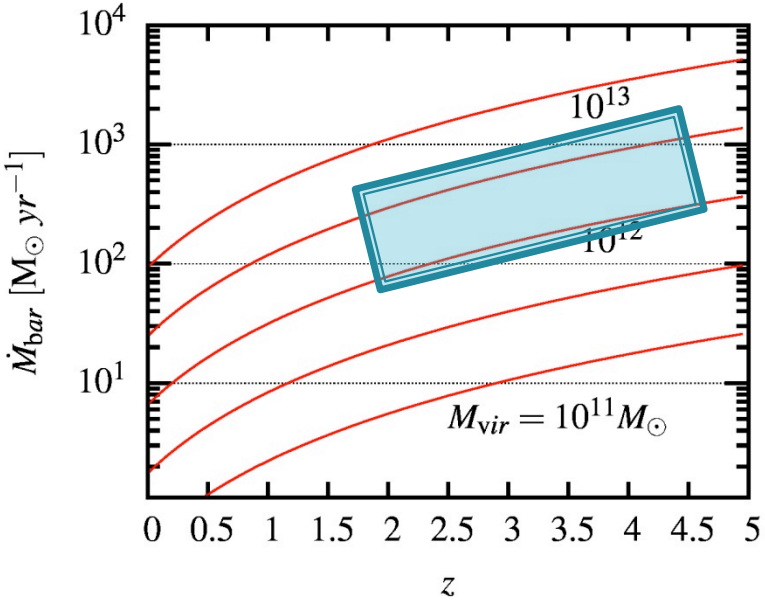
Clump clusters



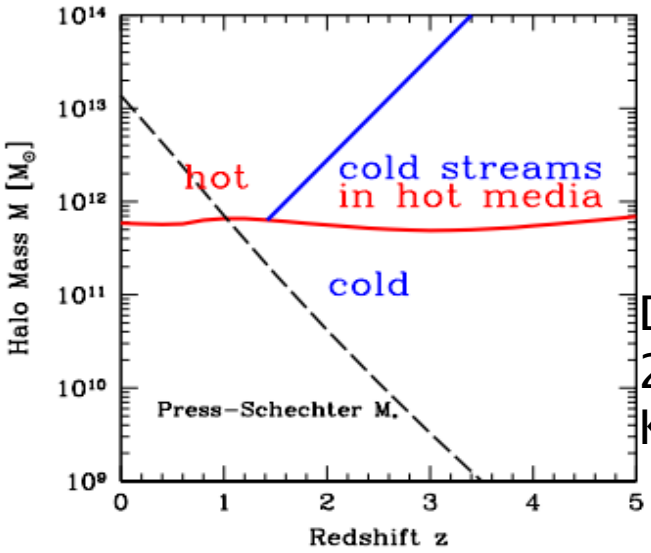
Clumps in clump clusters:
$M=10^8-10^9 M_\odot$,
D=~1kpc (Elmegreen et al. 07,09)

Elmegreen et al. 2007

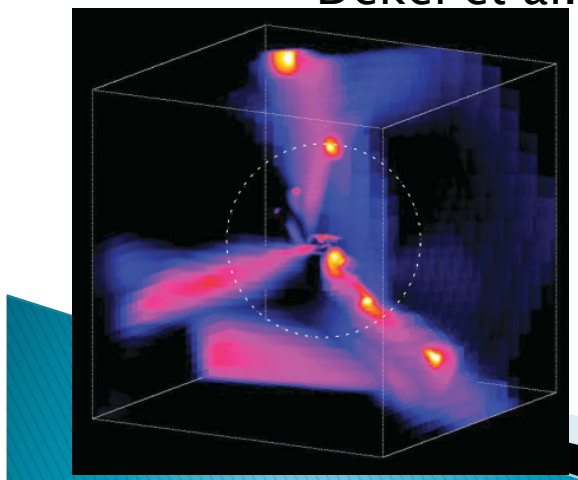
Accretion at high-z



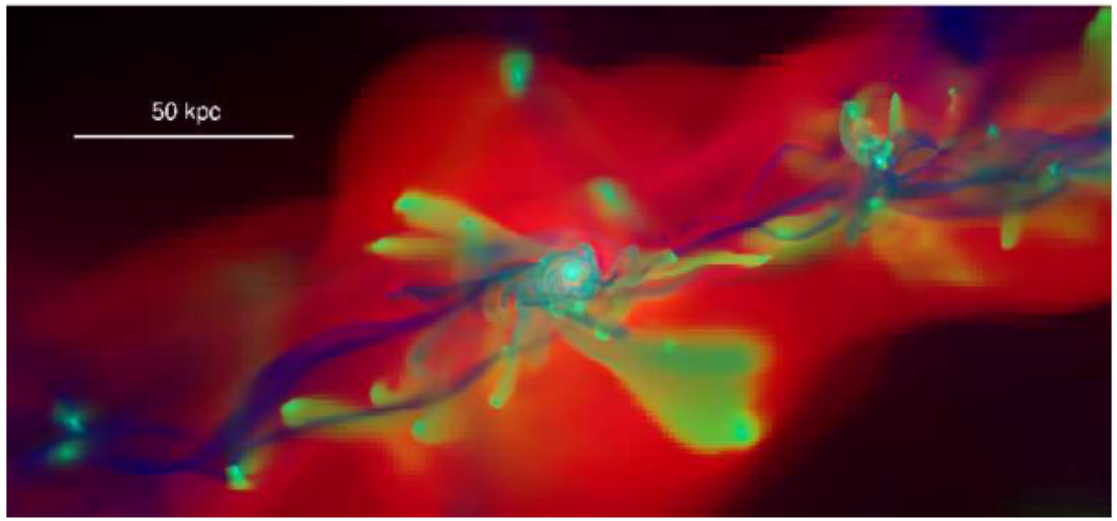
Dekel et al. 2009



Dekel & Birnboim 2006
Keres et al. 05-09



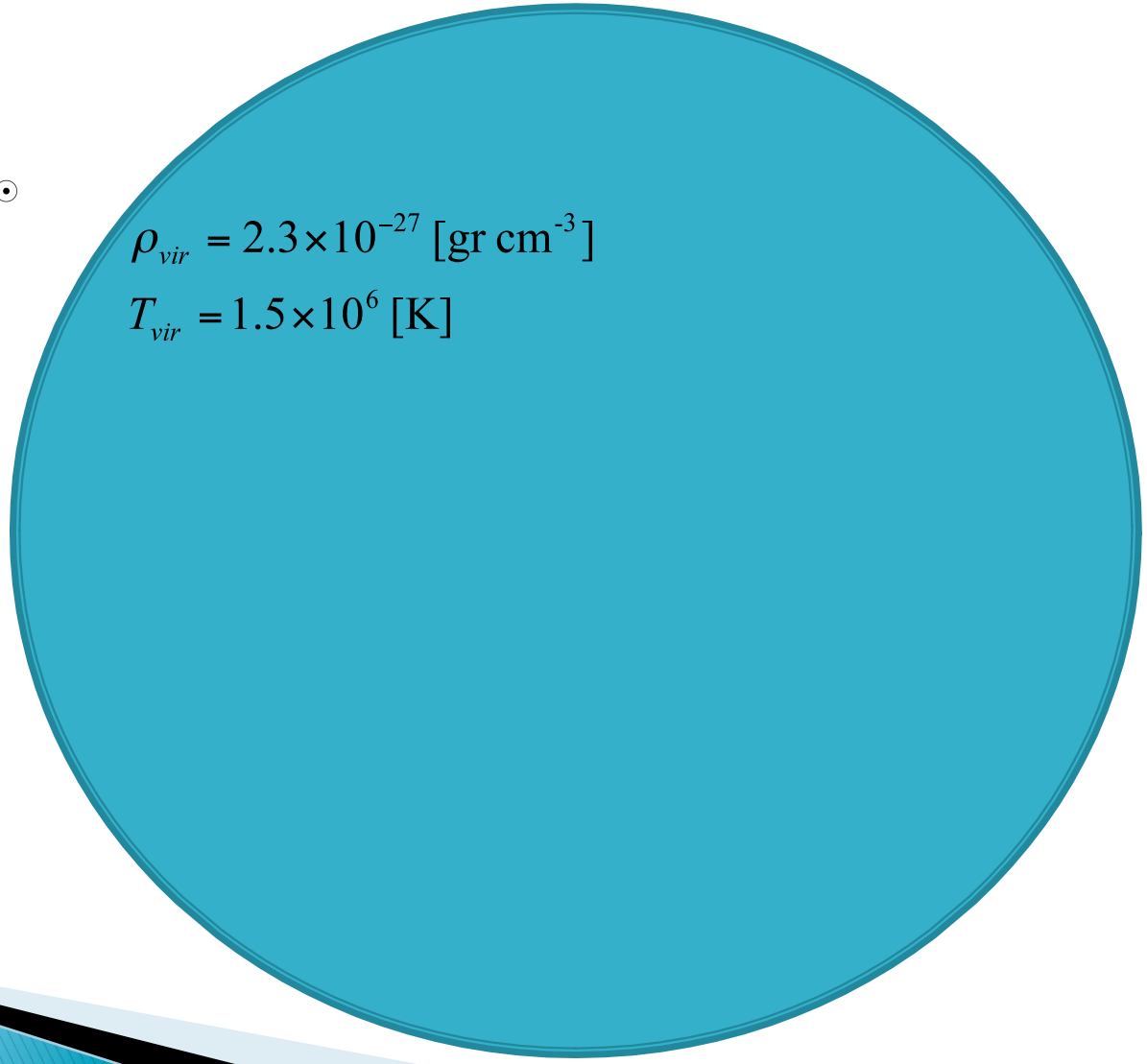
Agertz et al. 2009



Conditions near a high-z galactic disk

$z = 2$

$M_{vir} = 10^{12} \odot$



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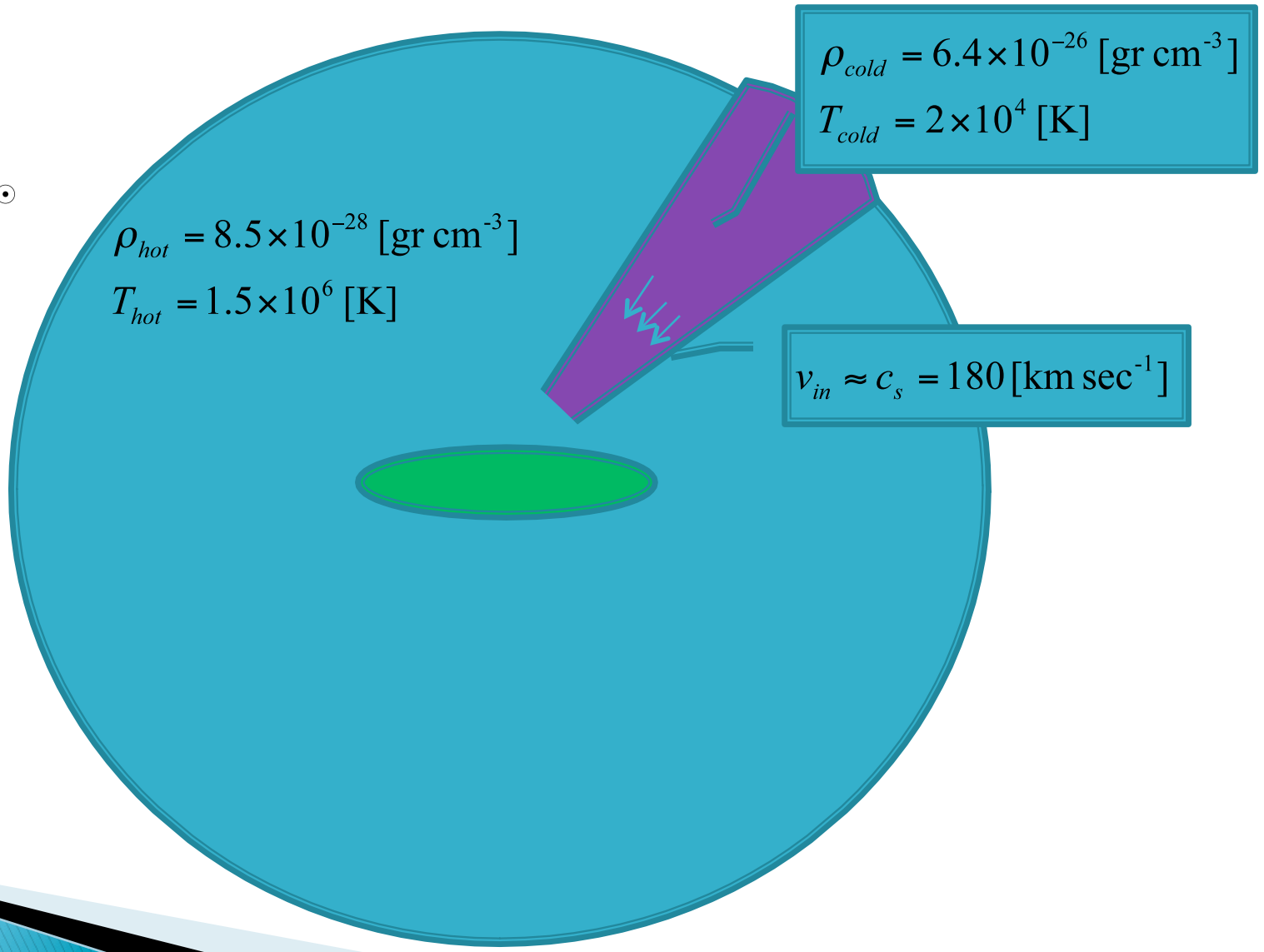

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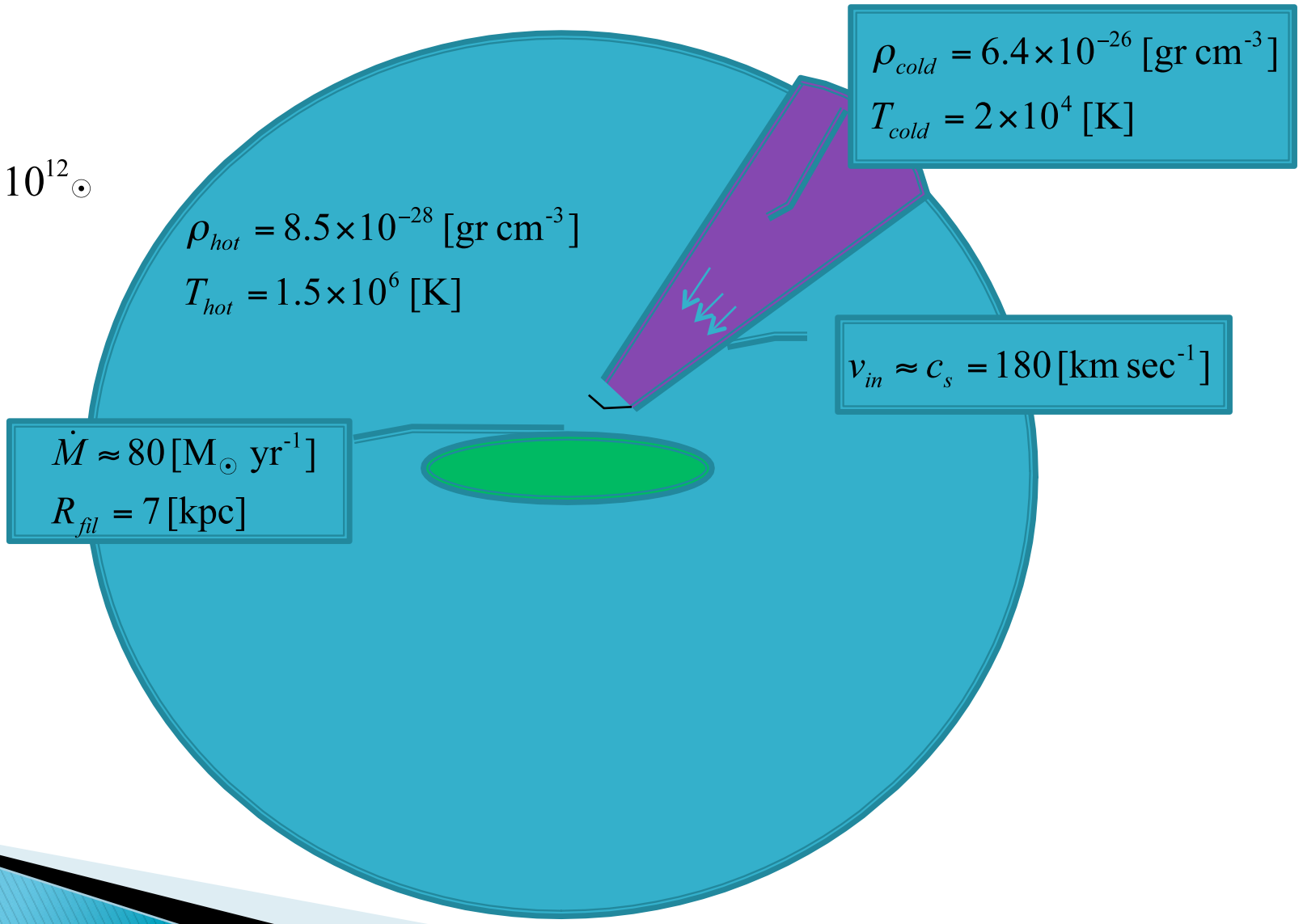

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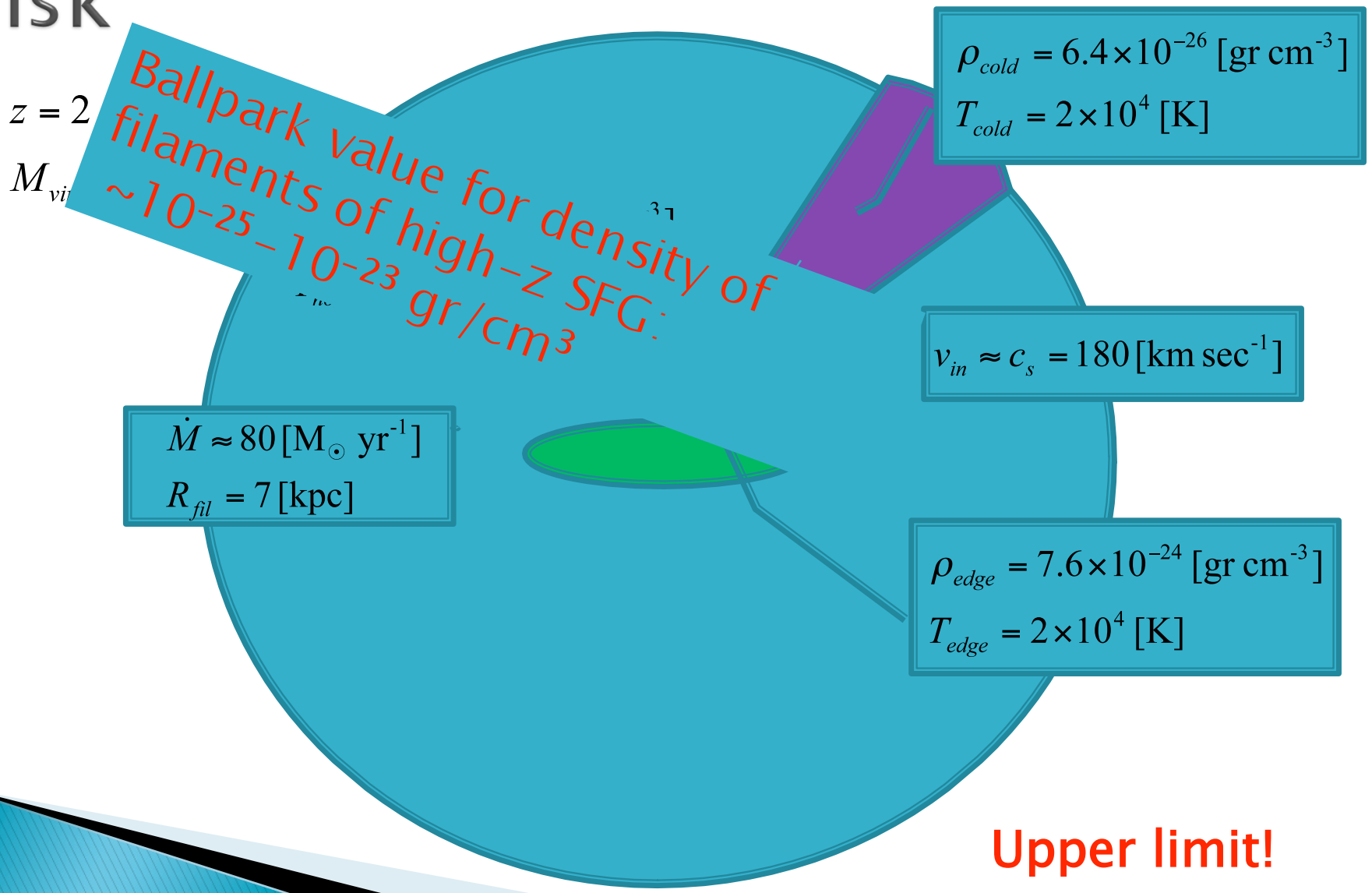
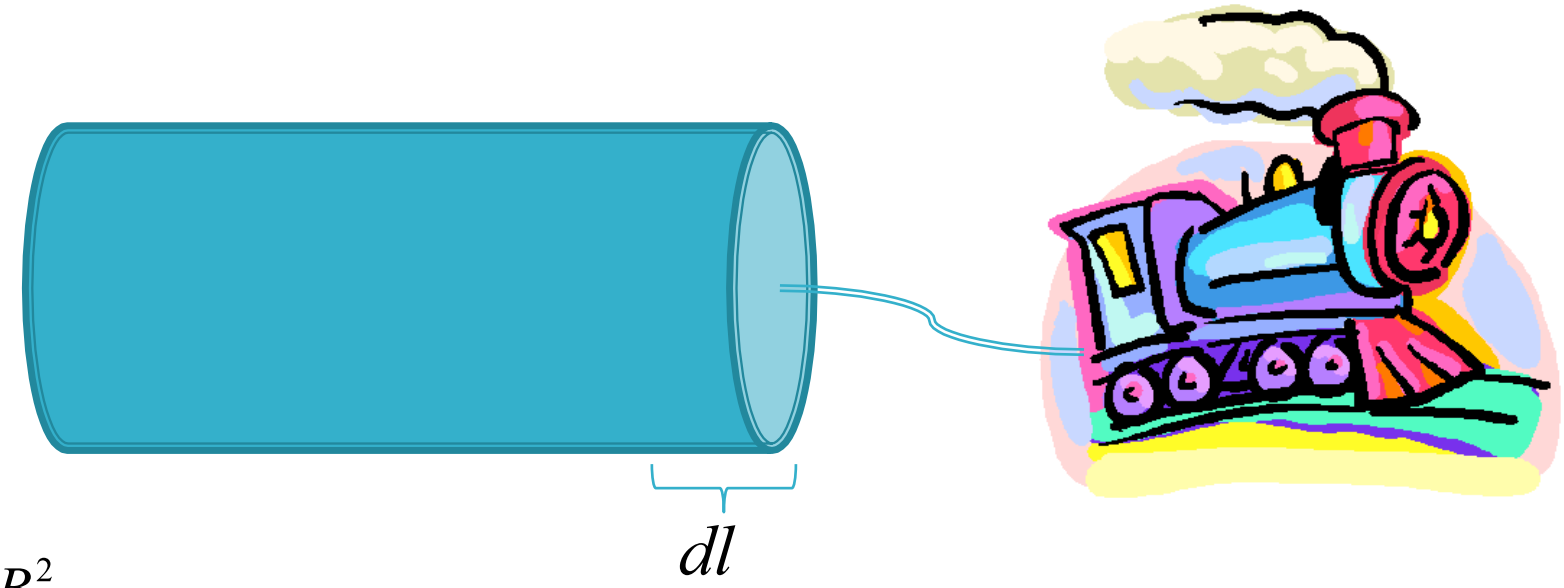


Upper limit!

Magnetic tension

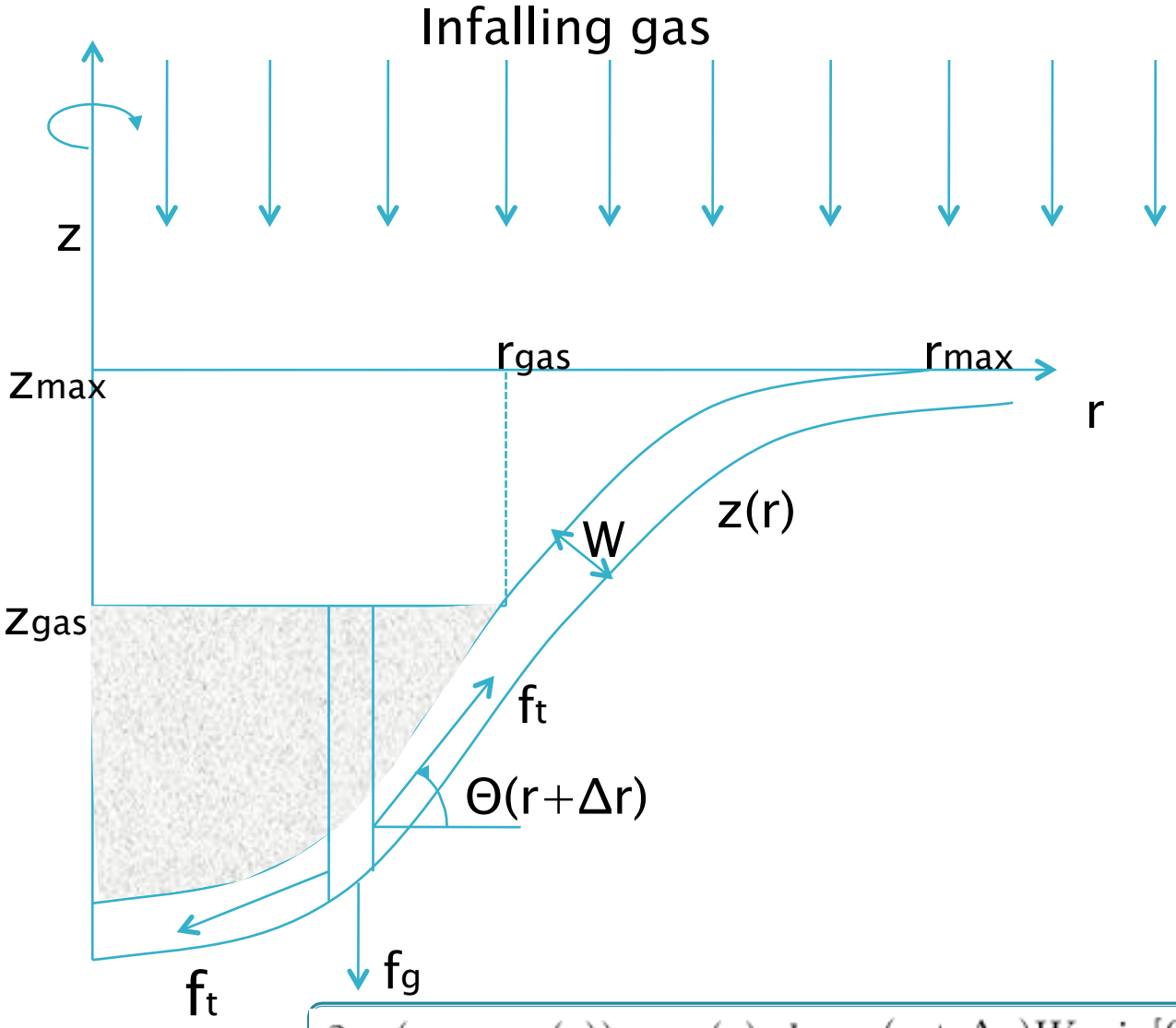
Magnetic tension



$$W = \frac{B^2}{8\pi} A\, dl = f\, dl$$

$$\sigma_{tension} = \frac{B^2}{8\pi}$$

Elastic Magnetic Fields



$$2\pi r(z_{\rm gas} - z(r))\rho_{\rm gas} g(z)\ dr = \pi(r+\Delta r)W\sigma\sin[\theta(r+\Delta r)] - 2\pi r W\sigma\sin[\theta(r)]$$

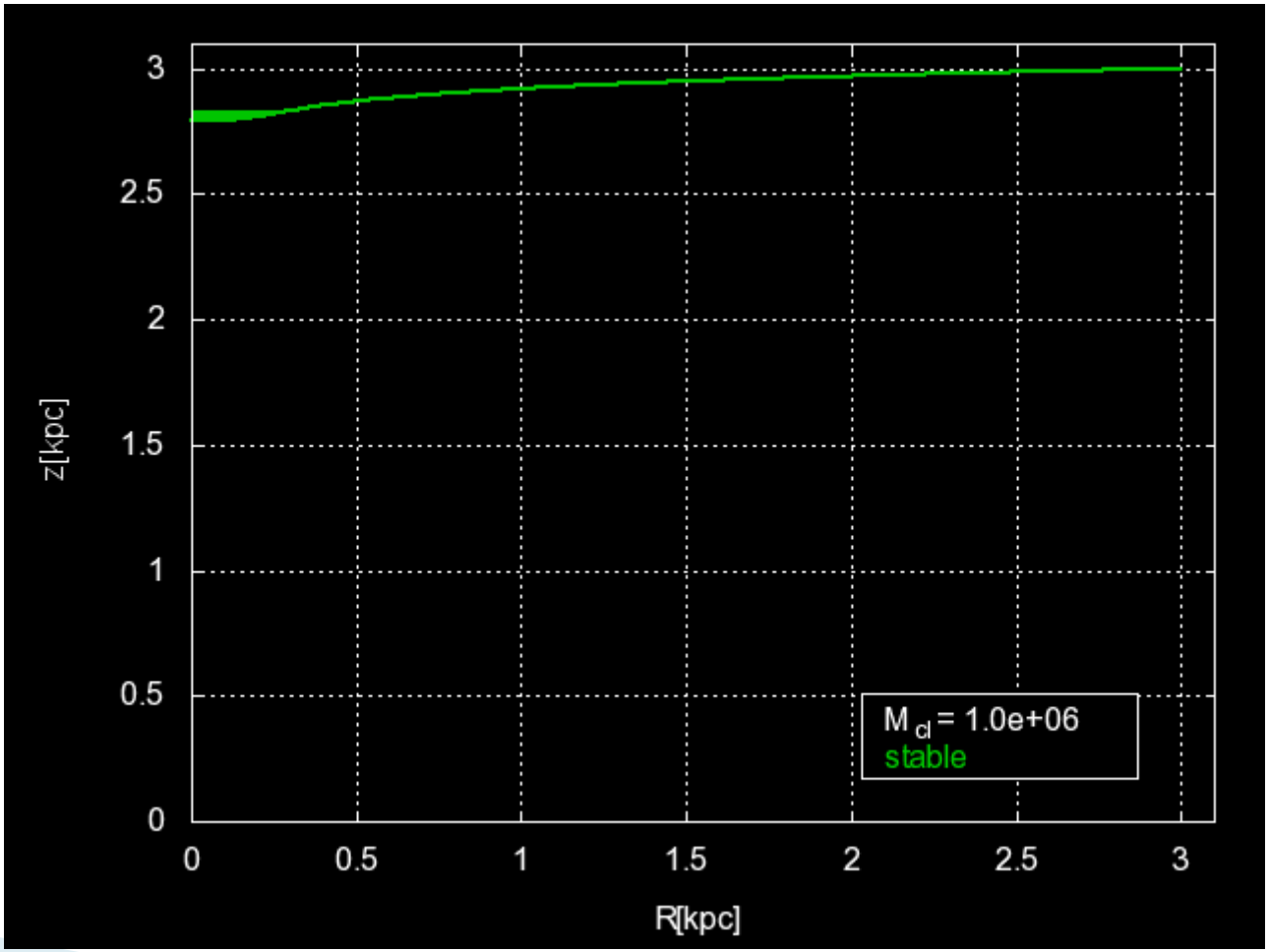
Accretion on magnetic fields

$\rho_{gas} = 10^{-23}$ [gr cm^{-3}]

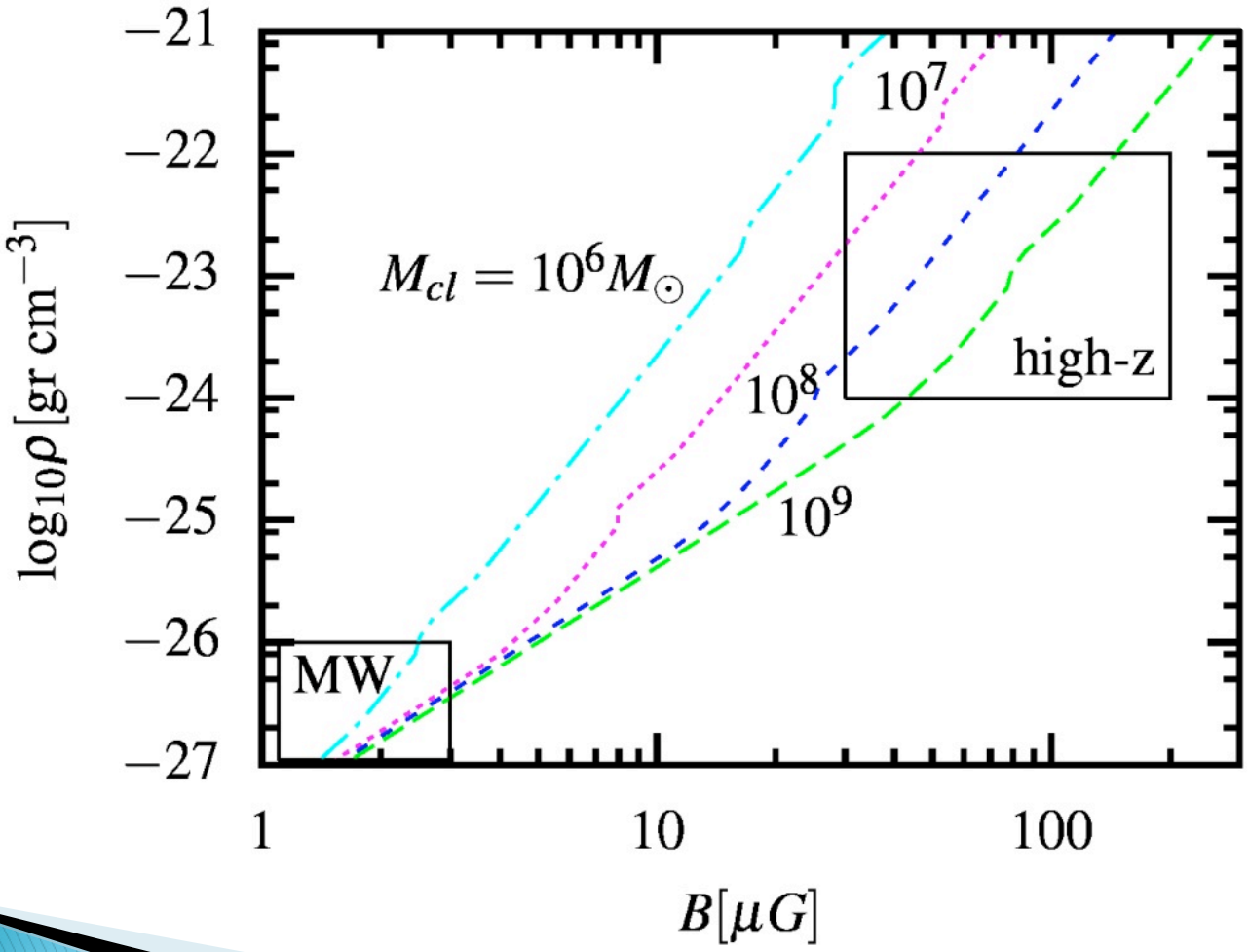
$B = 50\mu G$

$g_{\text{model}} = MW$

$l_W = 0.3$



Puncture mass



Conclusions

- Magnetic field strength in $z=2$ galaxies is high: $\geq 50\mu G$
- Magnetic tension will strongly affect accretion

In pure hydro simulations:

Interpretation (Trust):
- Total accretion rate
- Total SFR
- Low accretion efficiencies (MW should be ok)

Over-interpretation (Worry):
- Spatial & temporal characteristics of accretion & SF
- Toomre instability, turbulence, crossing time arguments

Thank you!