Understanding Stellar Feedback in SF Regions

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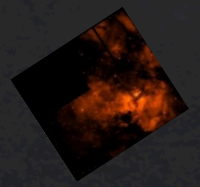
A Starburst Next Door

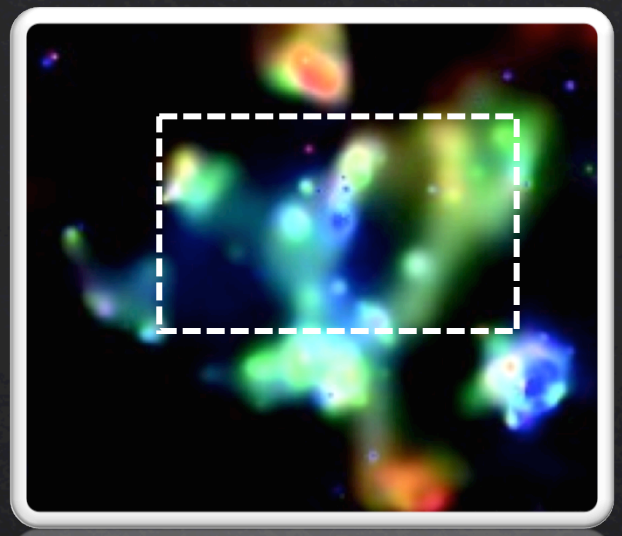


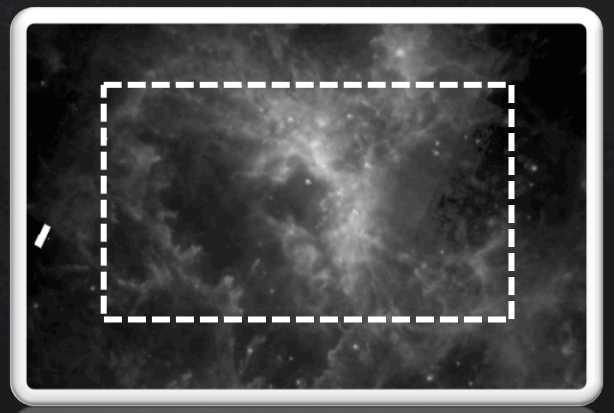
NGC 3603
77 O-stars

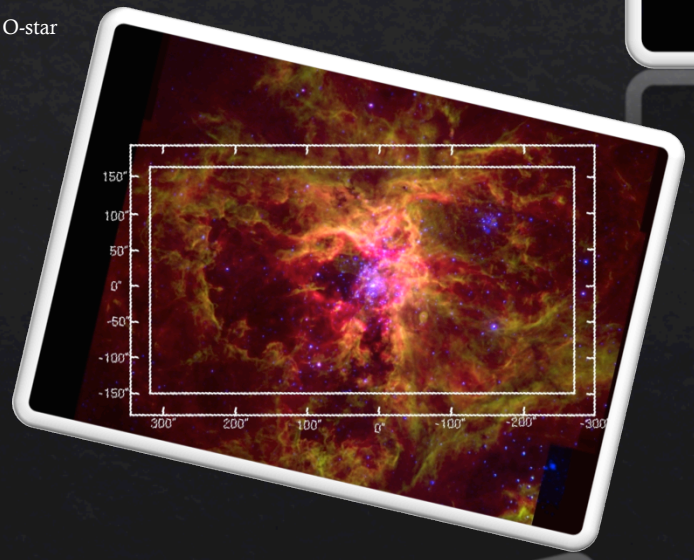
M17 - 10 O-stars

ORION - 1 O-star

Radiation and HII Region Pressure







Hot X-ray Region Pressure

Results

Feedback

X-Ray Plasma

Thermalized Shocks from Stellar Winds and Supernovae

$T = 10^6 – 10^7$ K

$n(H) < 0.1$

Radiation

Dominated by ionizing photon momentum

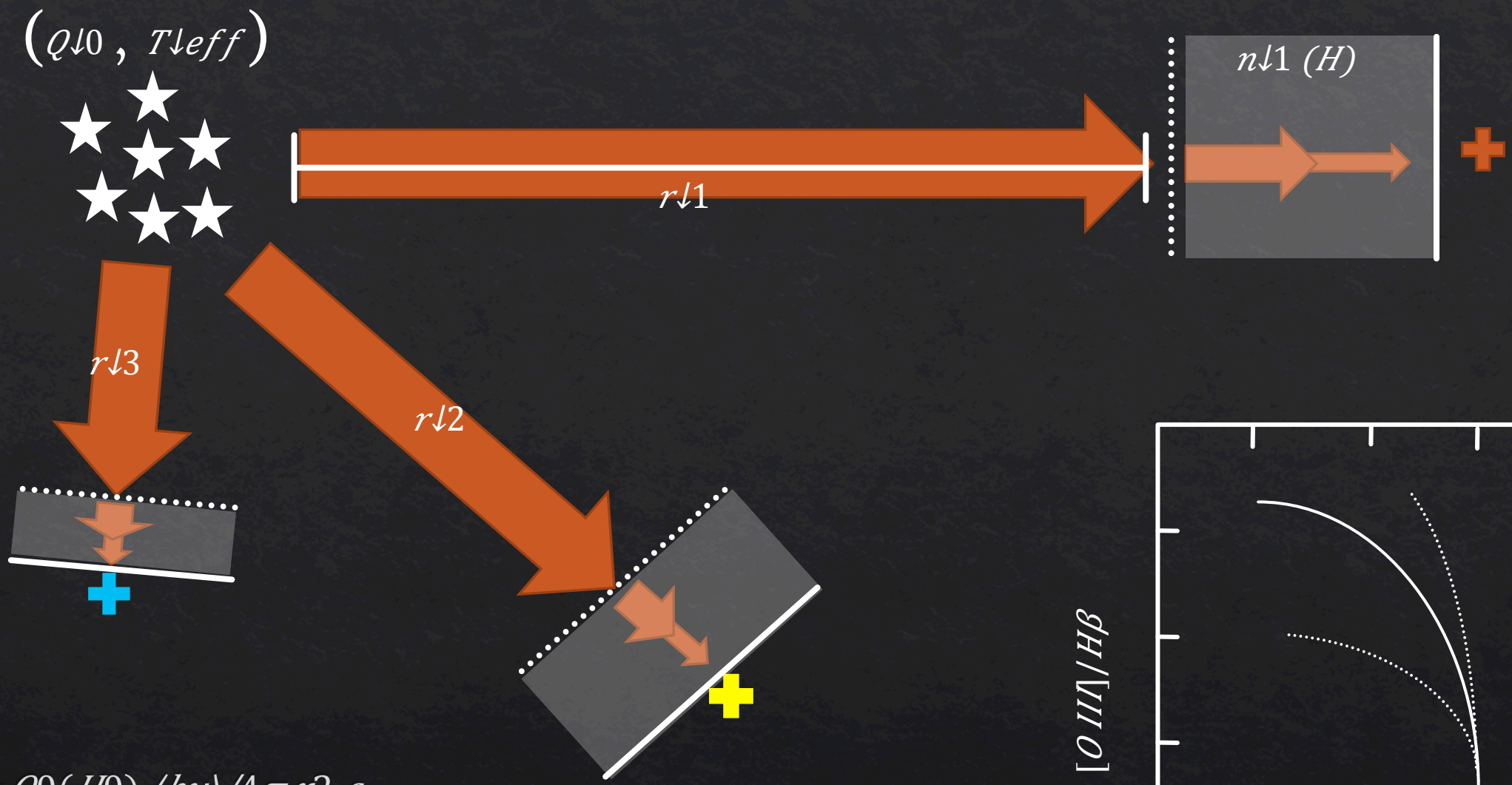
Non-Isotropic Pressure Term- Think Force on Shell

HII Region Gas

Photoionized

$T = 10^4$ K

$n(H) = 10 – 1000$ cm^{-3}



$$Prad = Q0(H0)\ \langle hv \rangle / 4\pi\, r2\ c$$

$$Prad = U(r)\langle hv \rangle n(H)$$

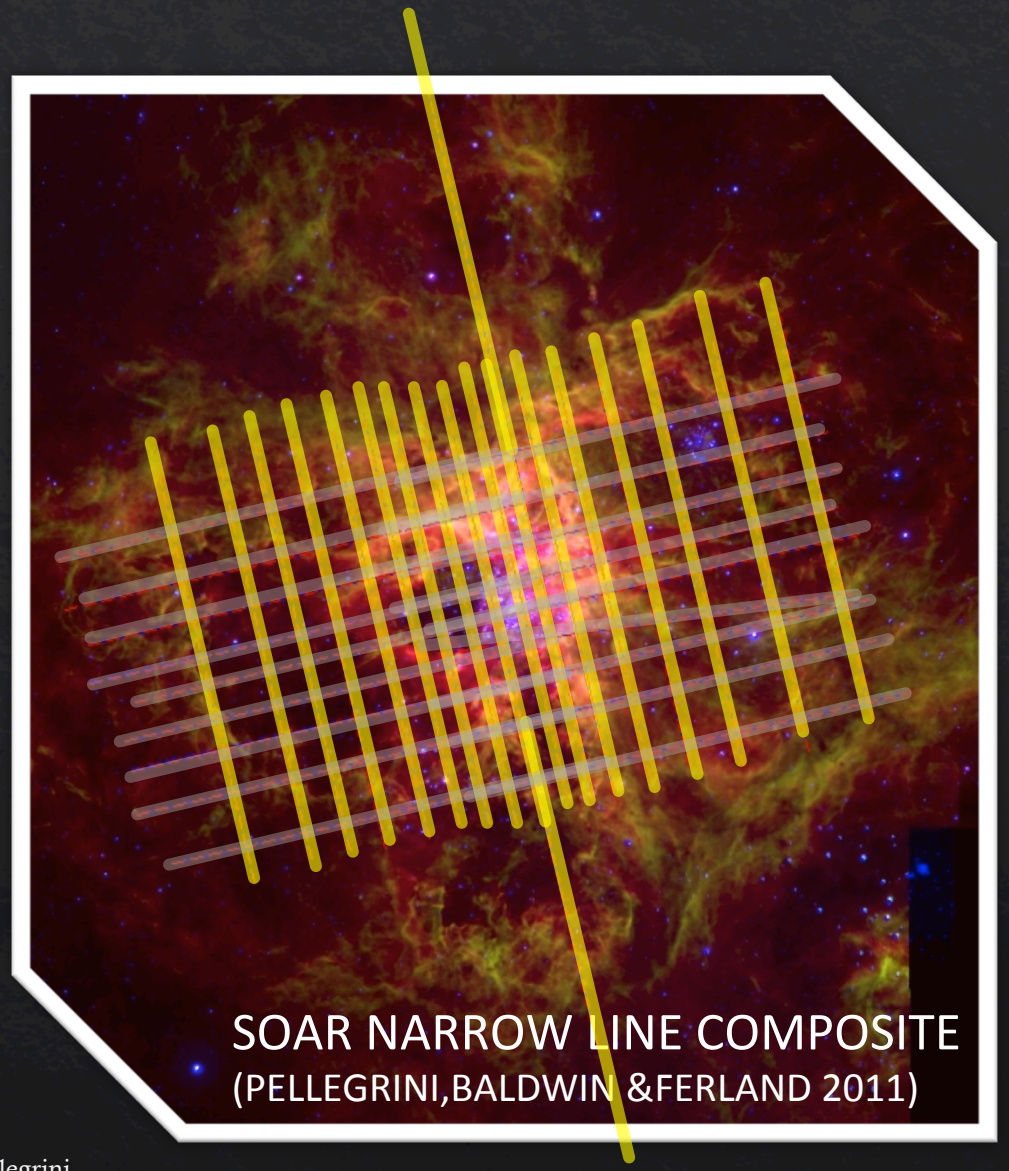
Optical Ionized Gas survey

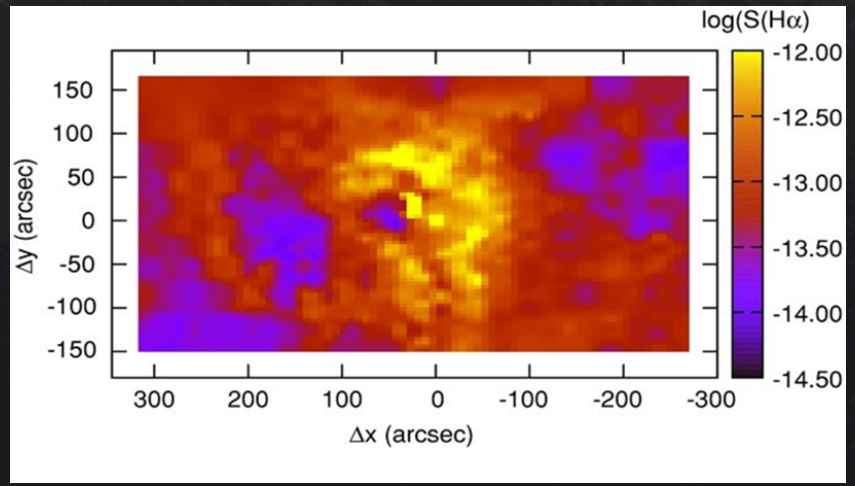
Hα 6563, Hβ 4861
He I 5875, 7065

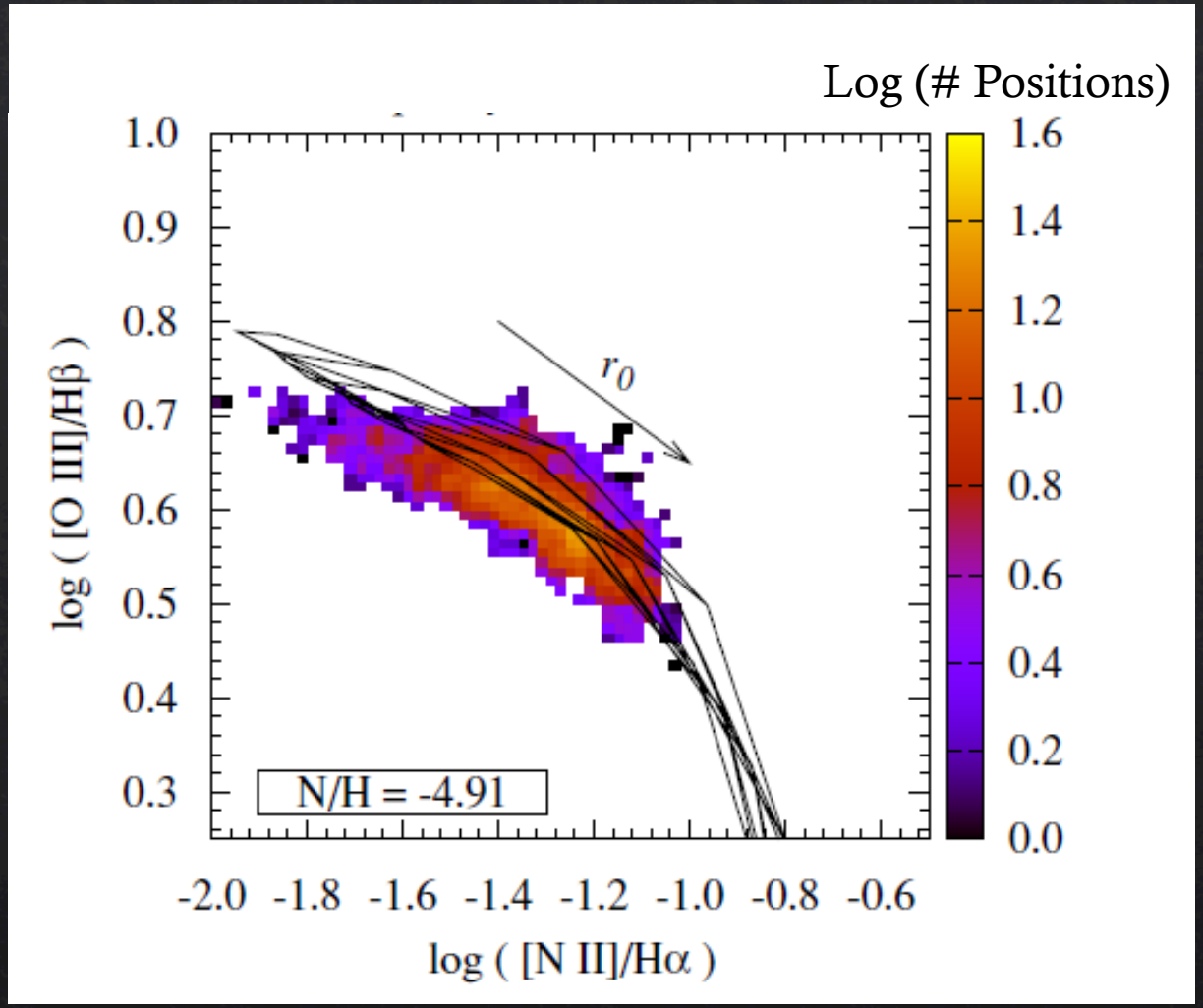
[OIII] 4364,4959,5007
[ArIII] 7135

[O II] 7325
[N II] 6548,6584
[S II] 6717, 6731

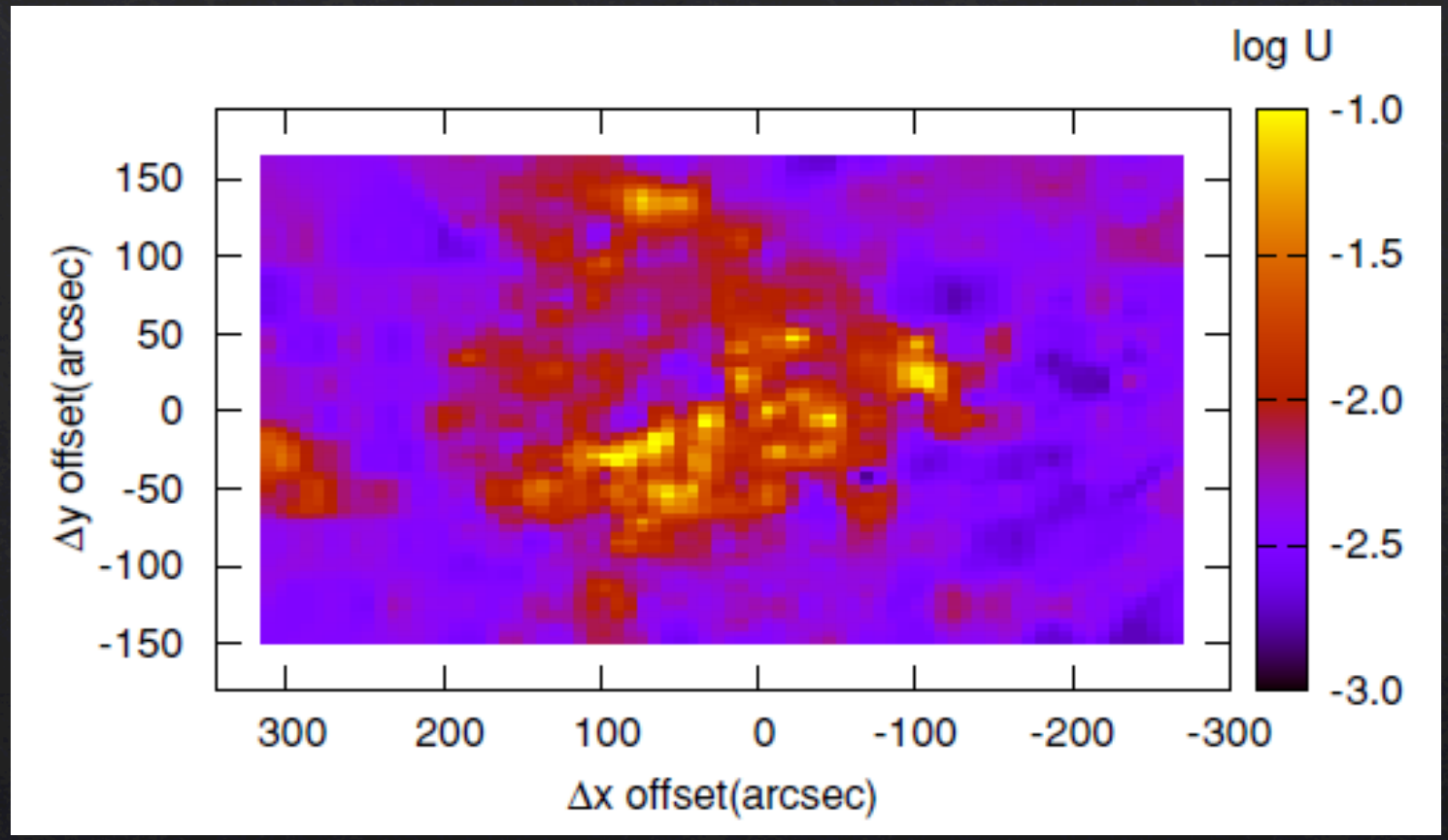
× 4300 positions 3"x3”

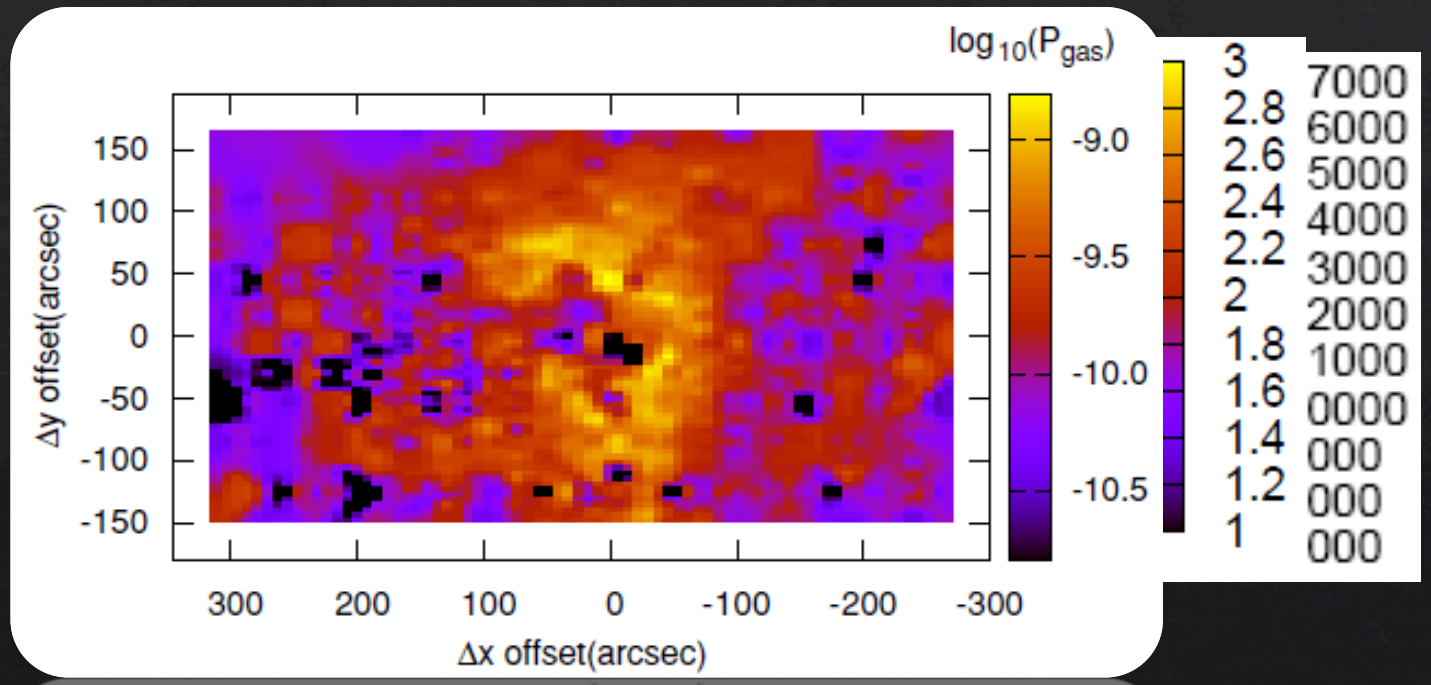




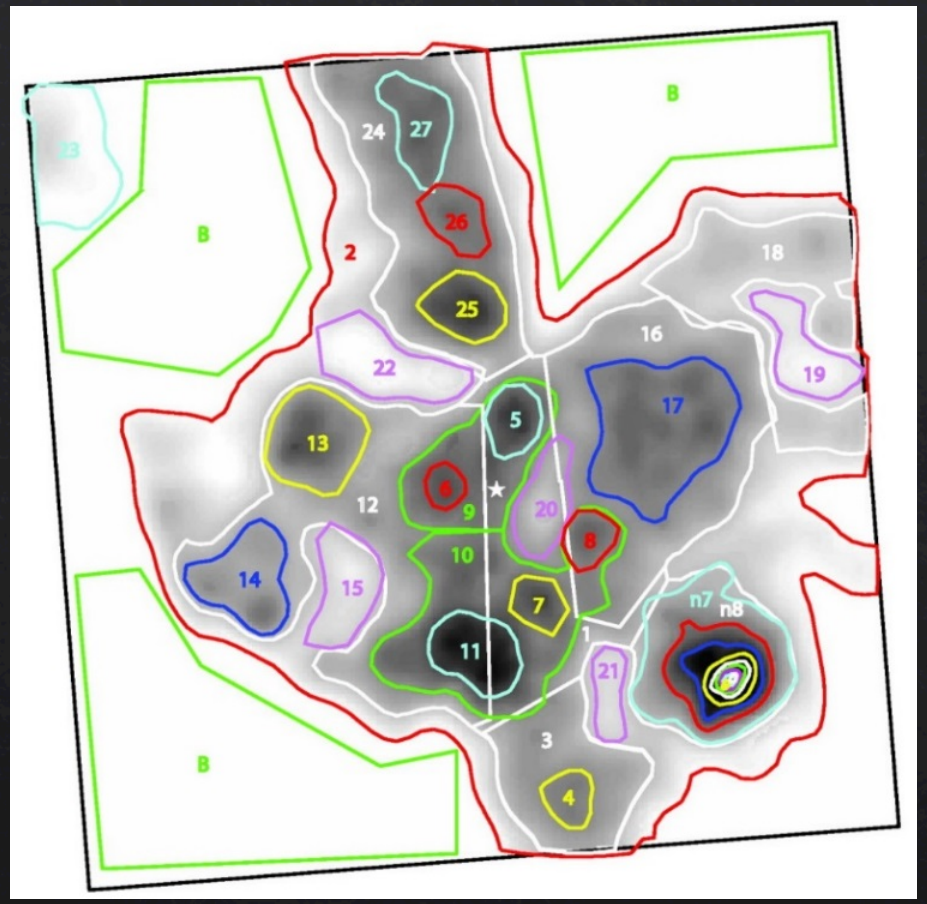

Log (# Positions)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
log ([O III]/Hβ)
r_0
N/H = -4.91
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-2.0 -1.8 -1.6 -1.4 -1.2 -1.0 -0.8 -0.6
log ([N II]/Hα)

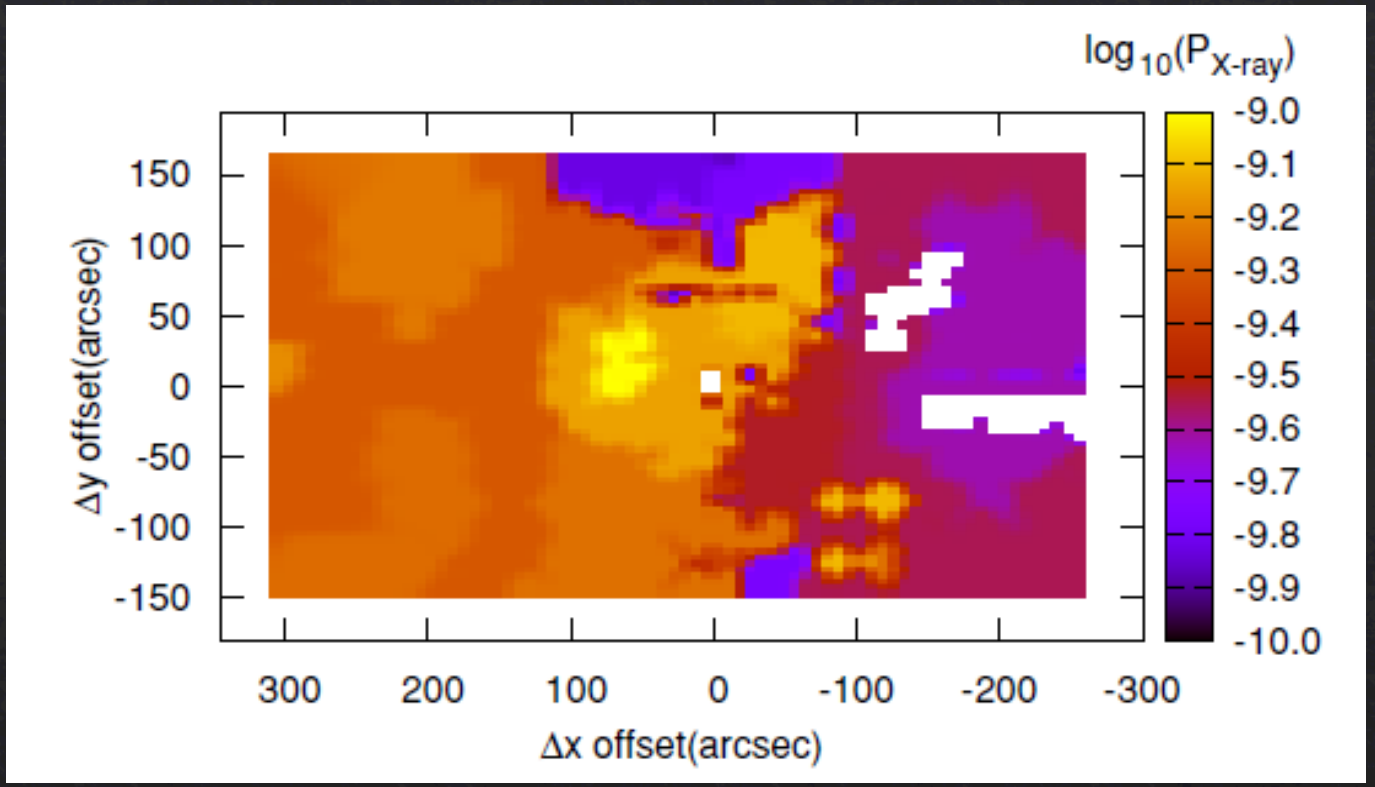
$$Prad = U(r)\langle h\nu\rangle n(H)$$



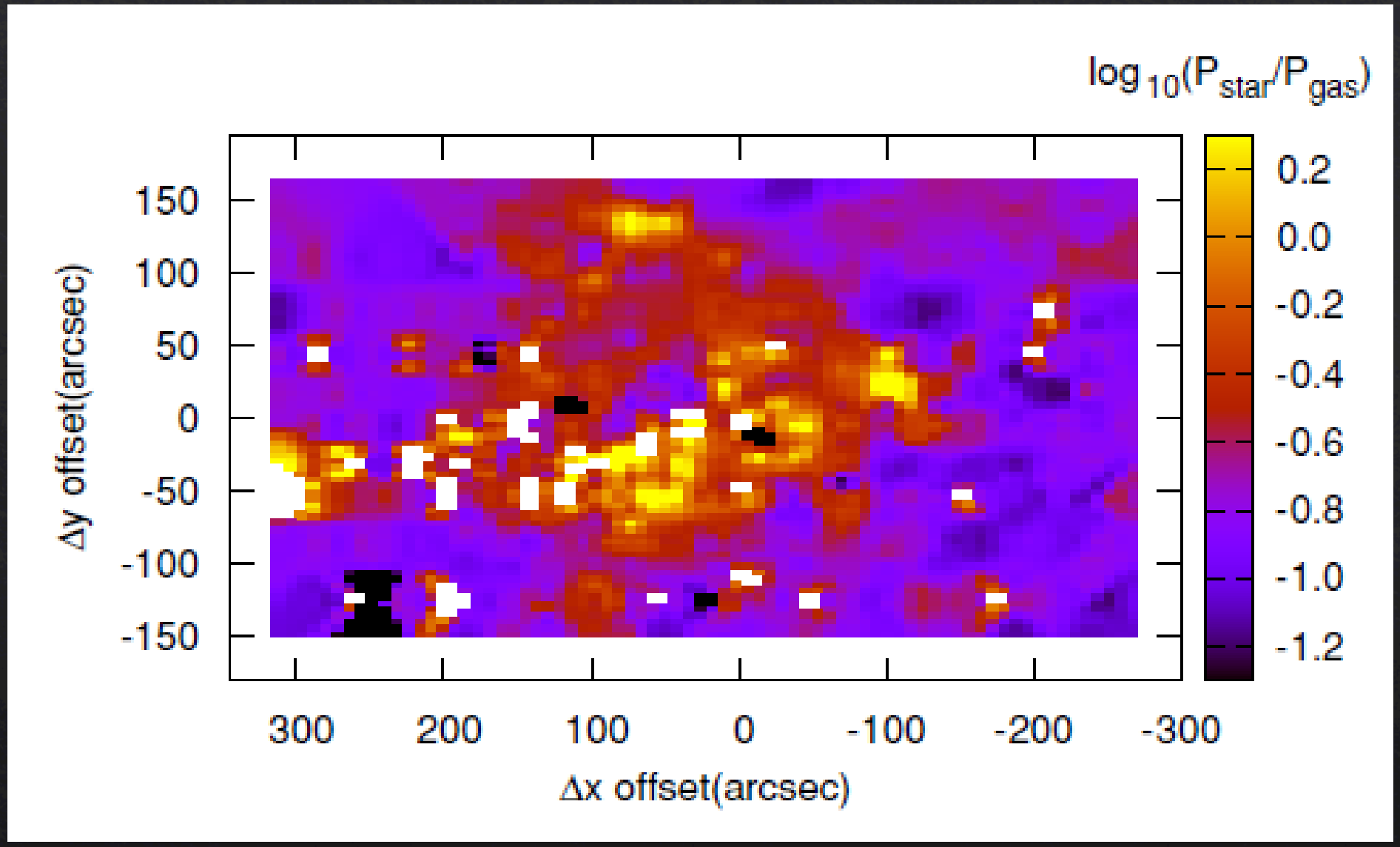

log 10(P gas)
-9.0
-9.5
-10.0
-10.5
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
7000
6000
5000
4000
3000
2000
1000
0000
000
000
000
150
100
50
0
-50
-100
-150
Δy offset(arcsec)
300
200
100
0
-100
-200
-300
Δx offset(arcsec)

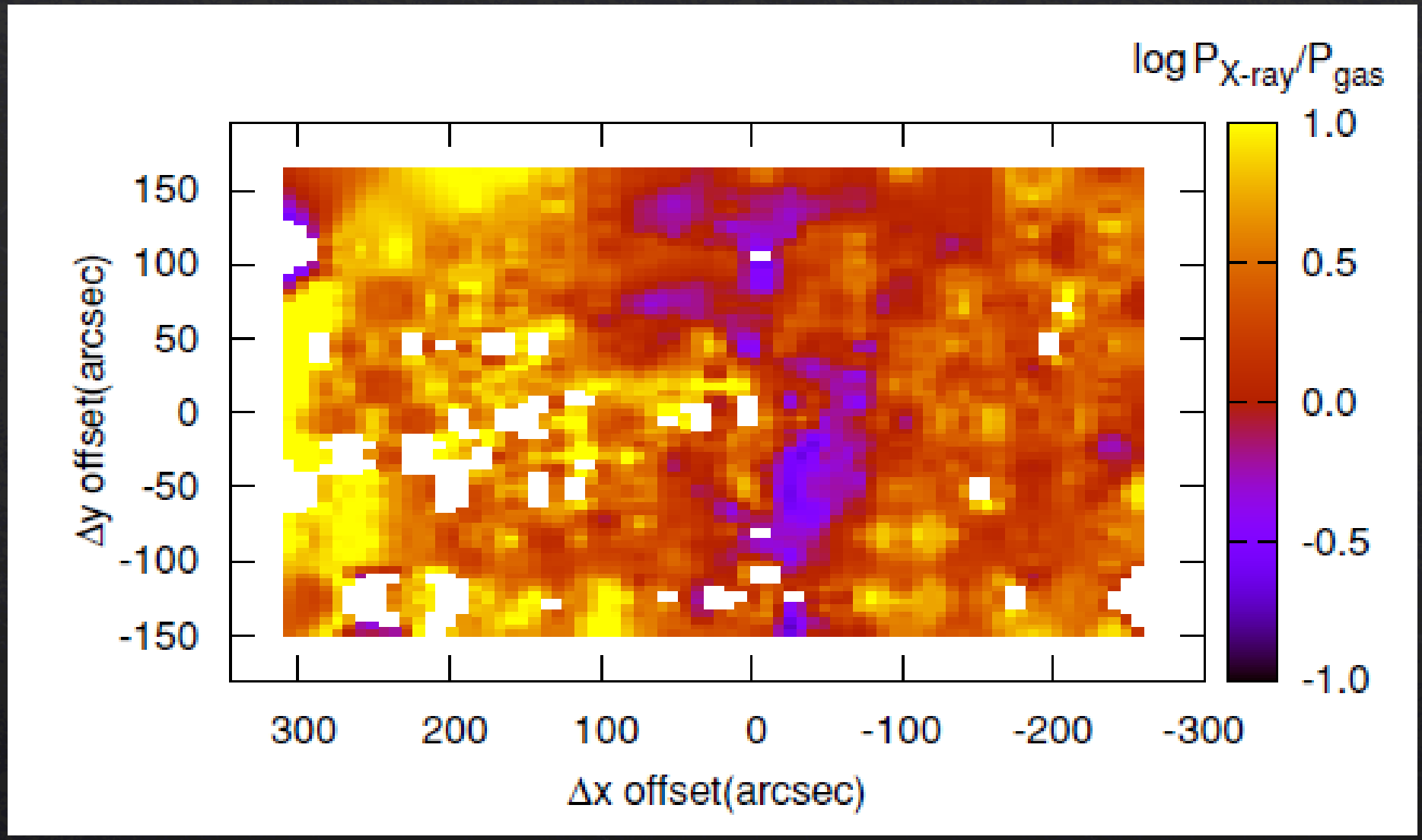
Townsley et al. 2006, AJ, 131, 2140

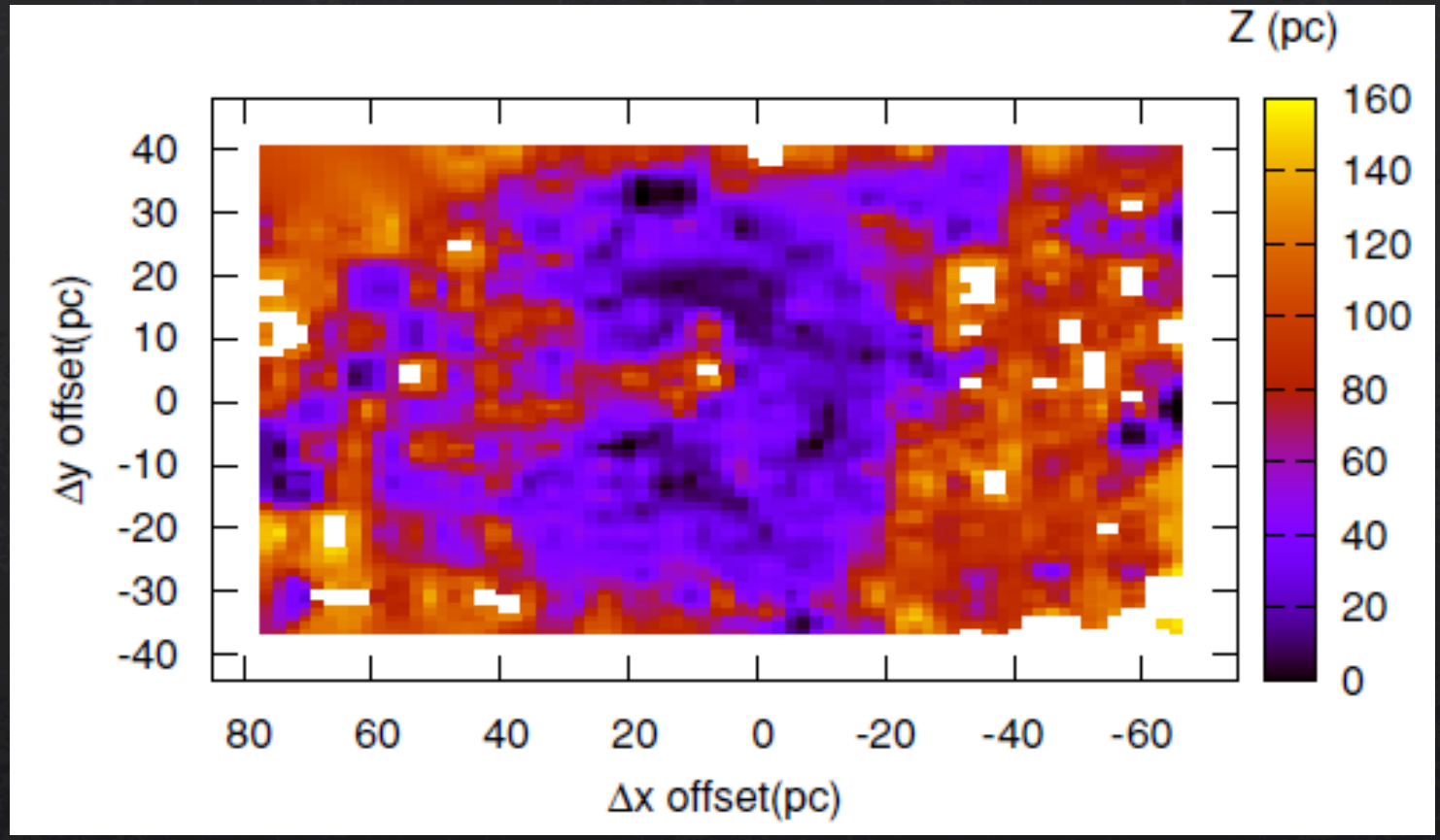




$$P\downarrow X = T\downarrow X \times \sqrt{L\downarrow X} / \Lambda \; V\downarrow X$$
$$L\downarrow X = \Lambda \; n\downarrow e \uparrow 2 \; V\downarrow X$$


log 10(P star/P gas)
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
150
100
50
0
-50
-100
-150
Δy offset(arcsec)
300
200
100
0
-100
-200
-300
Δx offset(arcsec)


log P X-ray/P gas
1.0
0.5
0.0
-0.5
-1.0
150
100
50
0
-50
-100
-150
Δy offset(arcsec)
300
200
100
0
-100
-200
-300
Δx offset(arcsec)


Z (pc)
160
140
120
100
80
60
40
20
0
40
30
20
10
0
-10
-20
-30
-40
Δy offset(pc)
80
60
40
20
0
-20
-40
-60
Δx offset(pc)

Feedback Summary

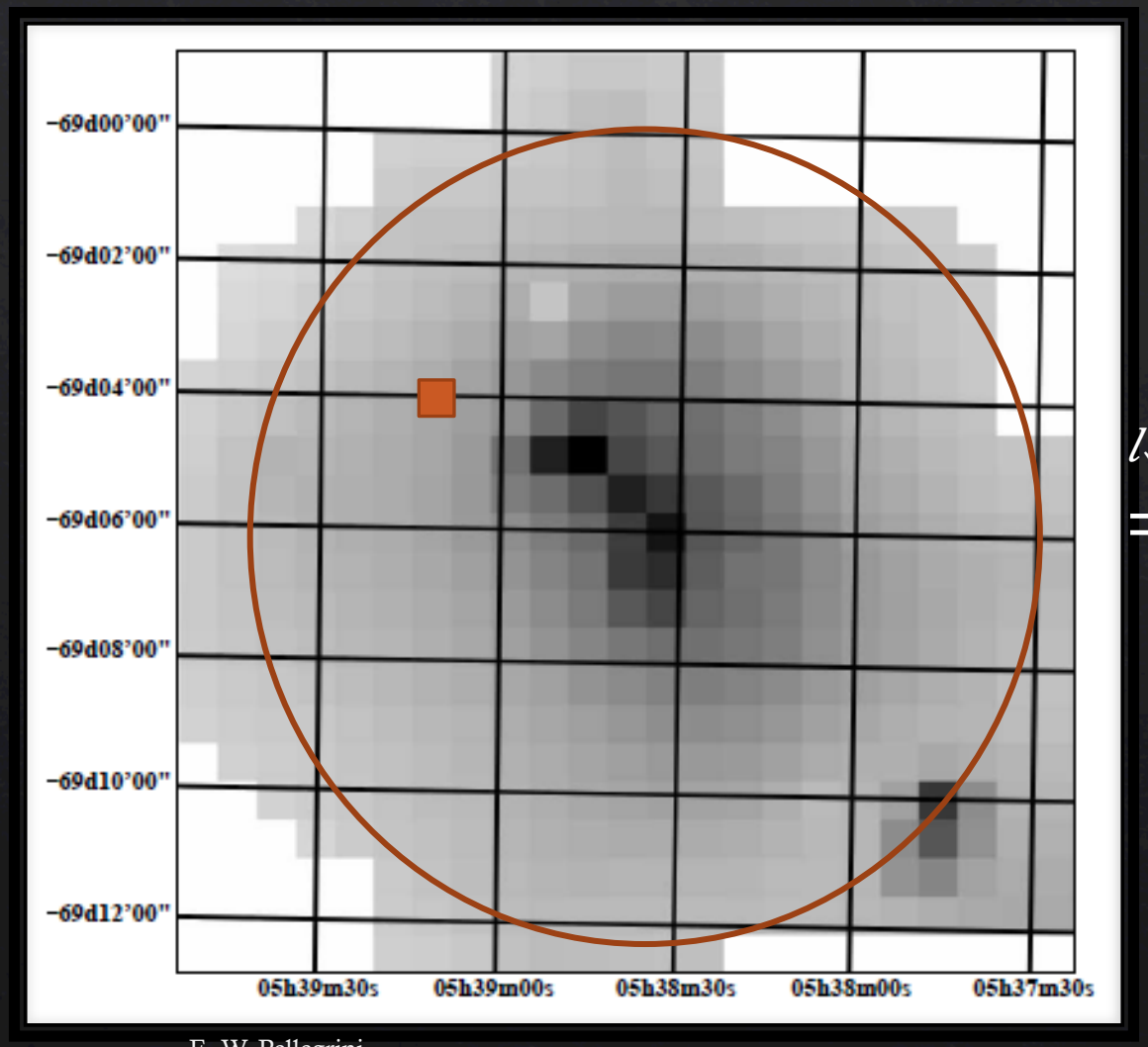
	30 Doradus	M17	Orion-Bar
Q(H) s^{-1} Log R (cm) Age (Myr)	52.0 19.8 – 22.5 25	50.0 17.9 1	49.0 17.5 ≤0.5
P↓rad /P↓gas	<0.1-0.4	2	0.4
P↓X /P↓gas	1-10	0.2	≤1
P↓B /P↓gas	?	2	~0.5

Conclusion

- Feedback Mechanisms
  - X-ray vs HII Gas vs Radiation
  - Dominance changes with age
- 3-d Gas distribution is **CRITICAL**
  - over simplification ➔
    - 100x over prediction in P_{rad}
    - 10x under prediction $P_{X\text{-}ray}$

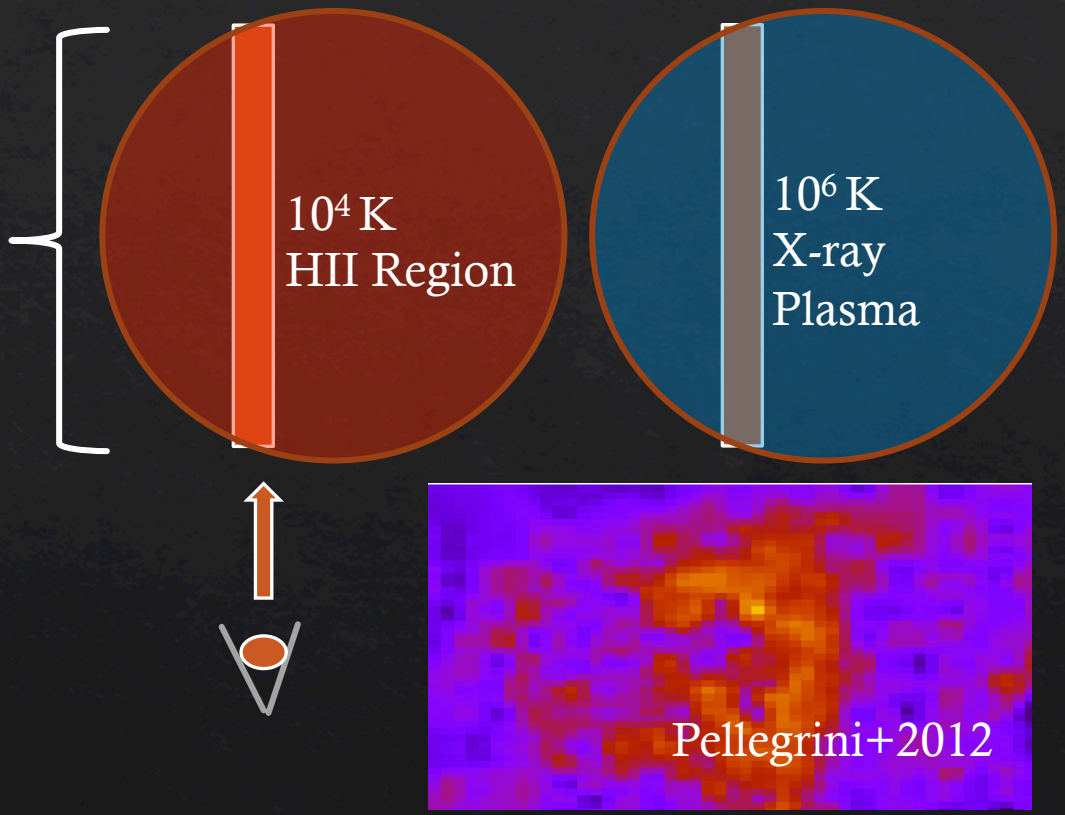
Difference in Gas Pressure (HII Region and X-Ray Plasma)

$$P_{gas} = T \times n = T \times \sqrt{EM/l}$$



$l_{HII} = l_X$

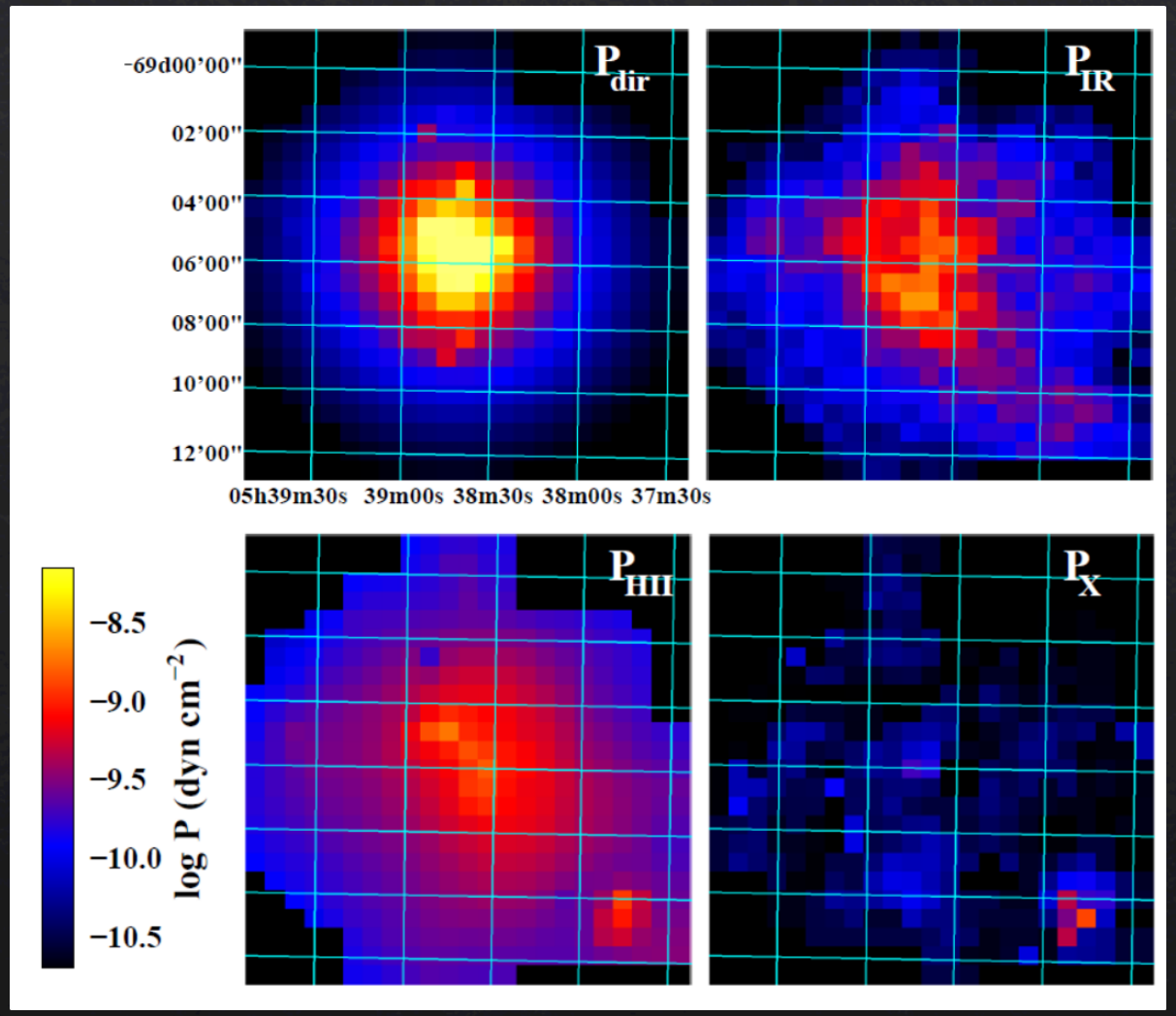
= 150pc



Lopez et al. 2011

Difference in Radiation Pressure (Direct Starlight)

$P_{rad} = L/4\pi r^2 c$



Lopez et al. 2011

Feasibility ?

Does Lopez+2011 overestimate energetics?
The assumption by L11 of spherical gas with unity filling factor is relatable to the Strongmen radius.

Using L11 minimum density of 200 cm^{-3} and $Q_0=10^{52}$ s^{-1} →

$$R_S = \left(3Q_0 / 4\pi\alpha n_H^2\right)^{1/3} = 39\ pc$$

However, the asserted R_s =150, or a volume 52×
larger than can be ionized given the assumptions.