Measuring the Star Formation Rate in the Galaxy using WMAP

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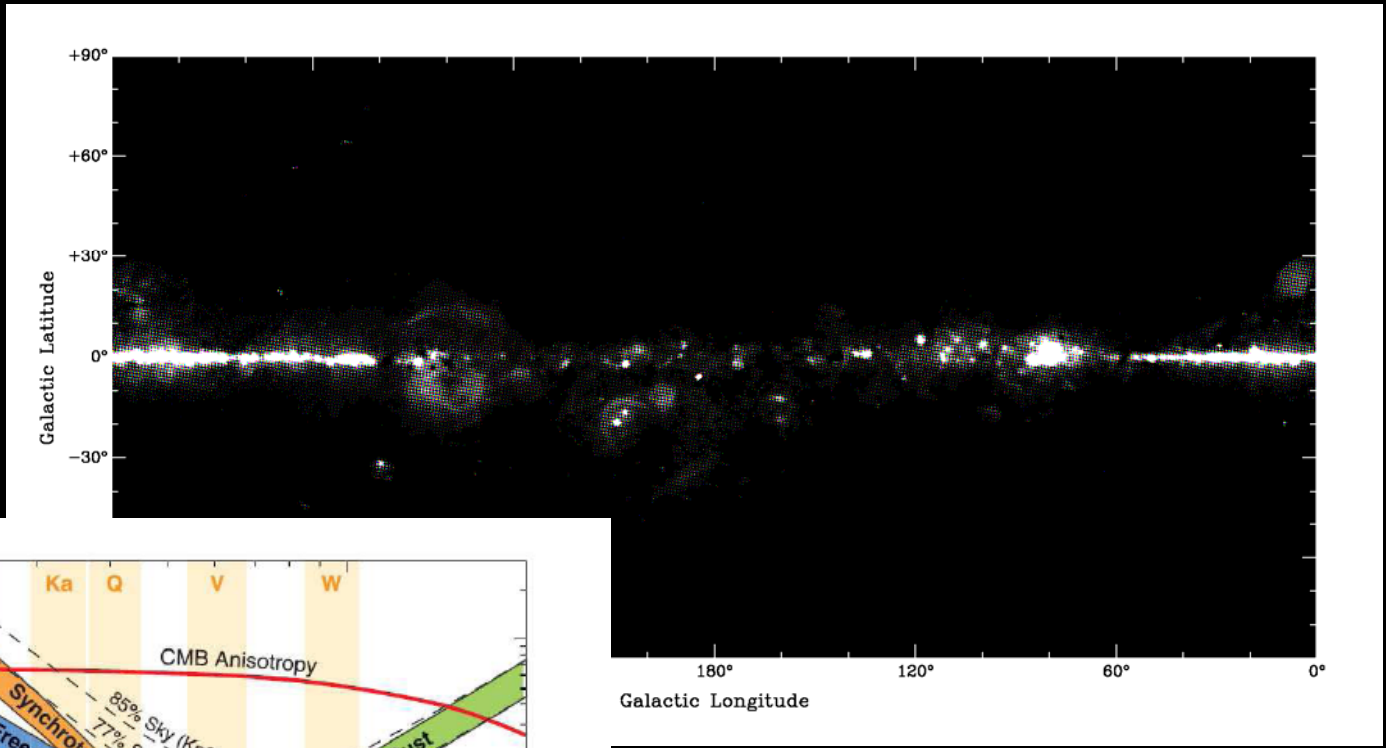
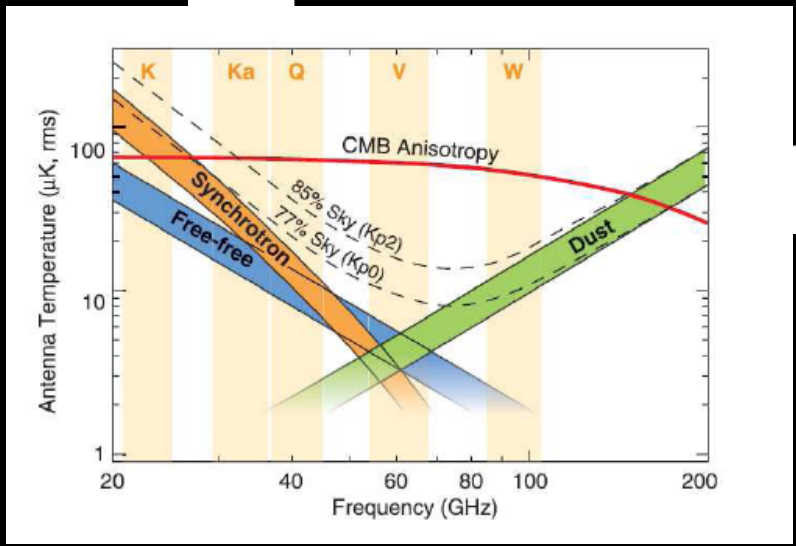
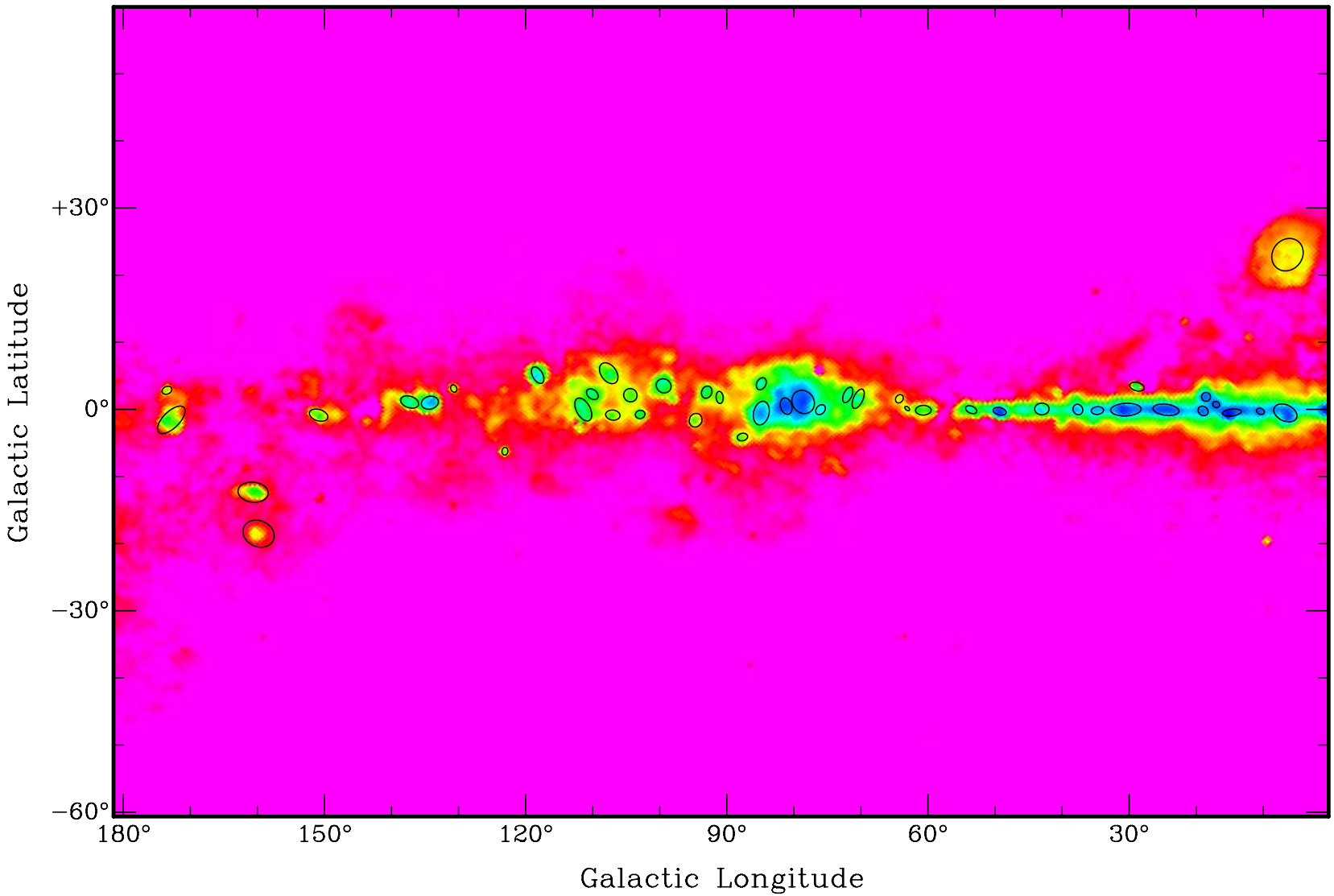
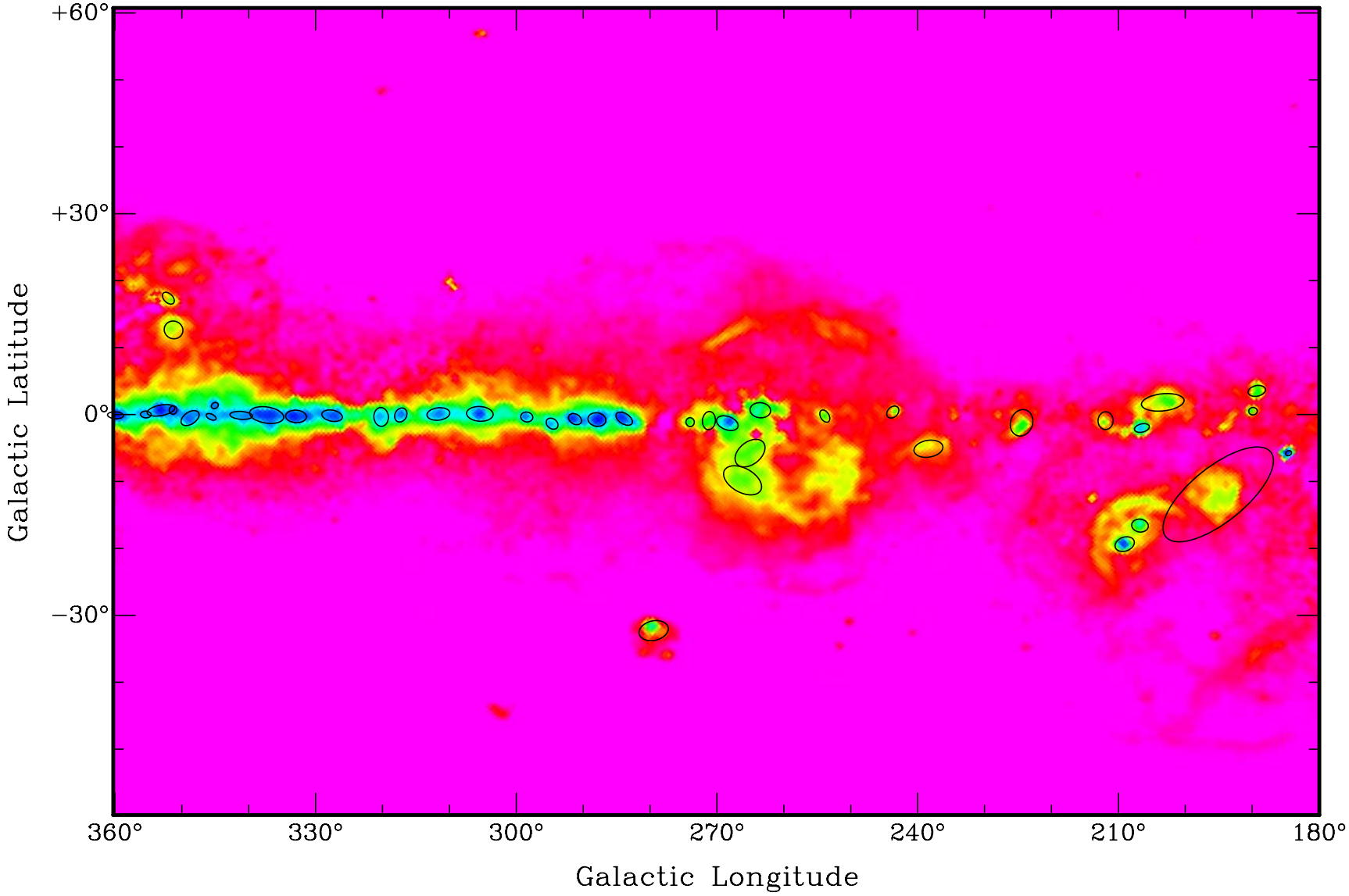
WMAP for Galactic Observations?!?





- "Foreground Emission"
- MEM Separation on 5 bands from 22-93 GHz
- Each source corresponds to the ELD


+30°
0°
−30°
−60°
Galactic Latitude
180°
150°
120°
90°
60°
30°
Galactic Longitude


+60°
+30°
0°
−30°
Galactic Latitude
360°
330°
300°
270°
240°
210°
180°
Galactic Longitude

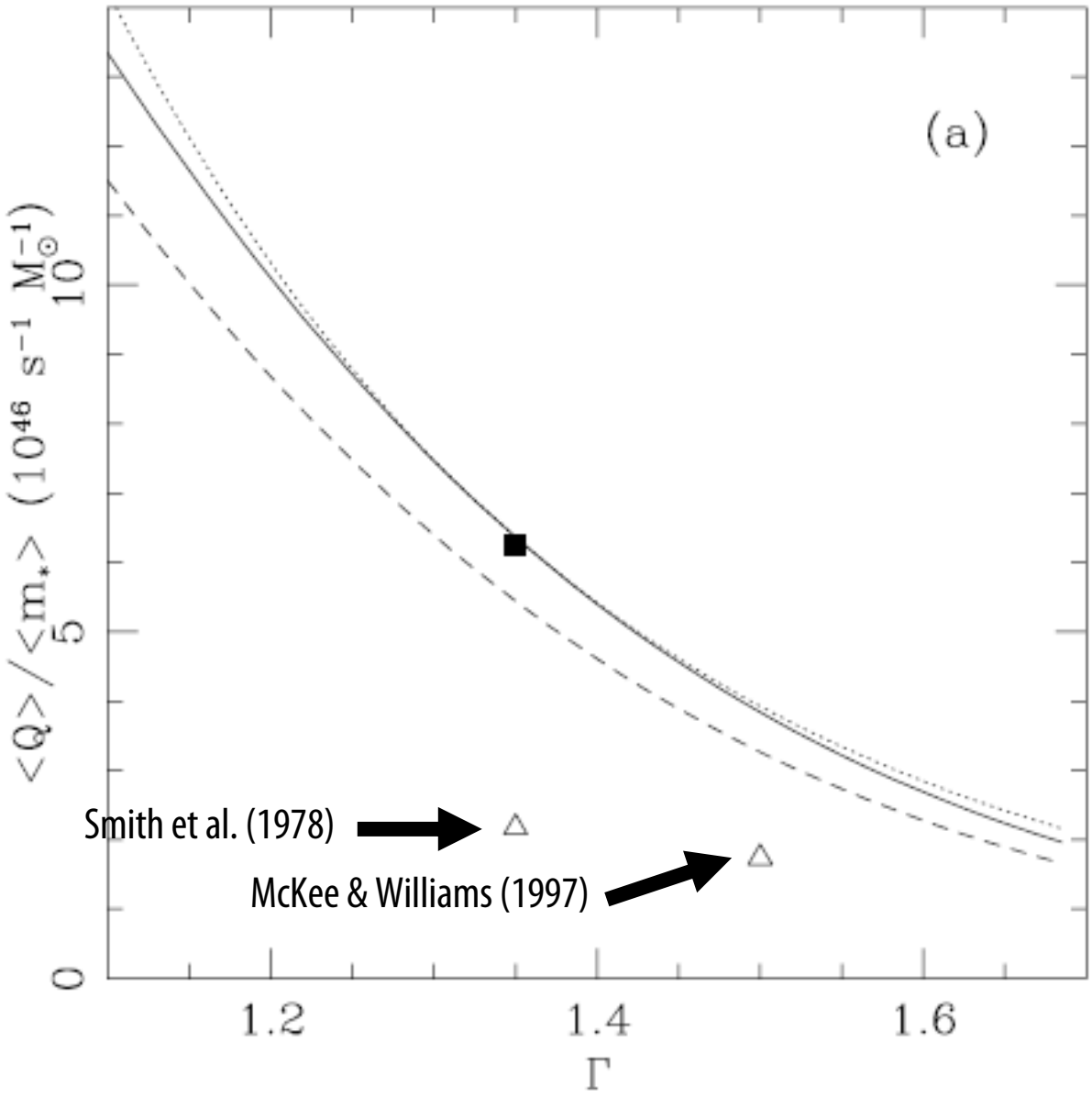
Total Ionizing Luminosity

TABLE 1

GALACTIC IONIZING FLUX MEASUREMENTS

Galactic Ionizing Luminosity Q photons s^{-1}	Reference
3.0×10^{53}	1
2.7×10^{53}	2
4.7×10^{53}	3
2.6×10^{53}	4
3.5×10^{53}	5
2.6×10^{53}	4
3.2×10^{53}	6

Note. — (1) Mezger (1978) (2) Gusten & Mezger (1982) (3) Smith et al. (1978) (4) McKee & Williams (1997) (5) Bennett et al. (1994) (6) This work.


(a)
$\langle Q \rangle / \langle m_* \rangle$ (10^{46} s^{-1} $M_\odot^{-1}$)
0
5
10
1.2
1.4
1.6
Γ
Smith et al. (1978)
McKee & Williams (1997)

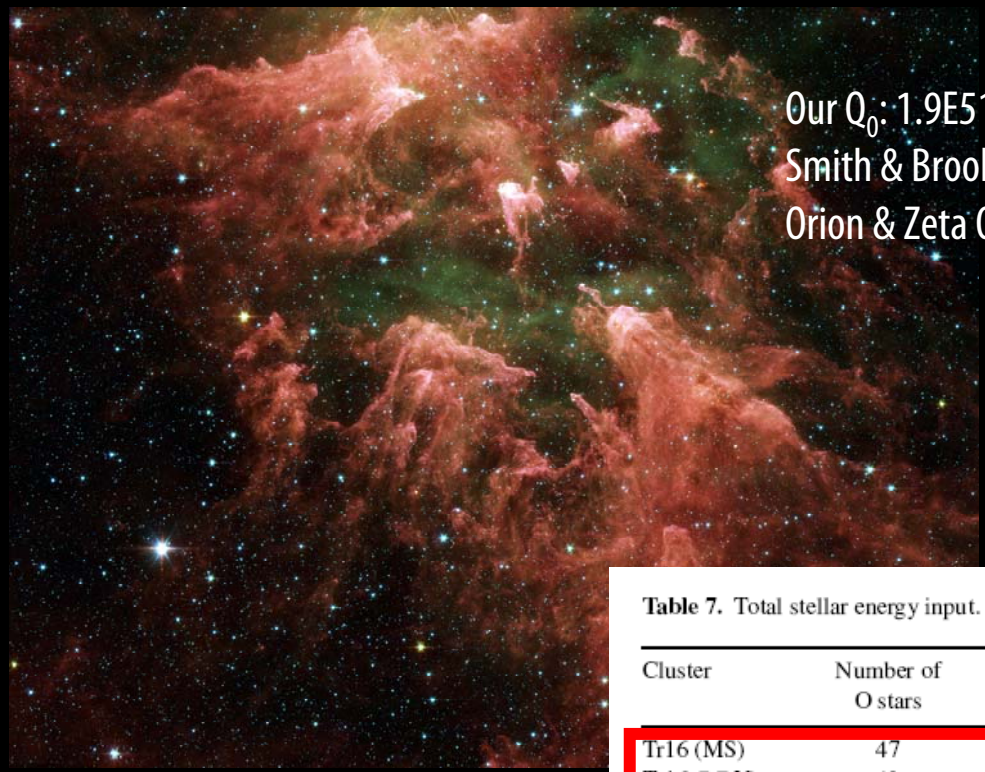
Star Formation Rate

- Milky Way:
  - 1.3 $M_\odot$ yr^{-1} using Γ=1.35
  - Comparing ~ 4 $M_\odot$ yr^{-1} in McKee & Williams (1997)
- LMC
  - 0.14 $M_\odot$ yr^{-1} (past estimate: 0.25 $M_\odot$ yr^{-1}, Whitney et al. 2008)
- SMC Determined, but not believable (**very** different metallicity)

Value-added from Spitzer

- Very tight correlation between free-free emission and MSX (and more recently Spitzer) 8 micron images (Whiteoak et al. 1994)
- Much better resolution than WMAP (~1 arcsec vs ~1/2 degree)
- GLIMPSE I & II surveys publicly available & cover much of the Galactic Plane

Individual Clusters: Carina/Trumpler 16



Our Q_0: 1.9E51

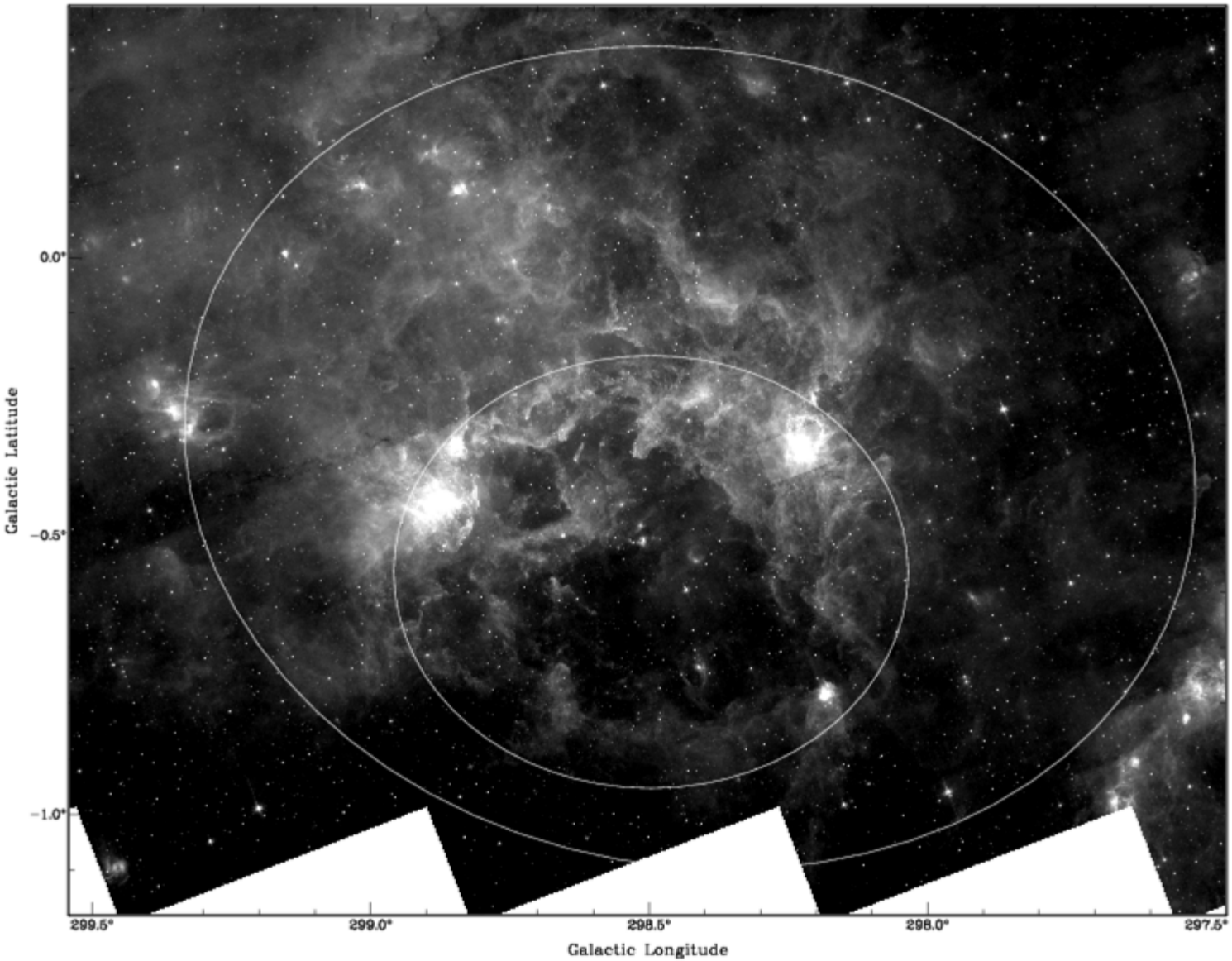
Smith & Brooks (2007) Q_0 : 9.1E50 (Based on Observed Stars)

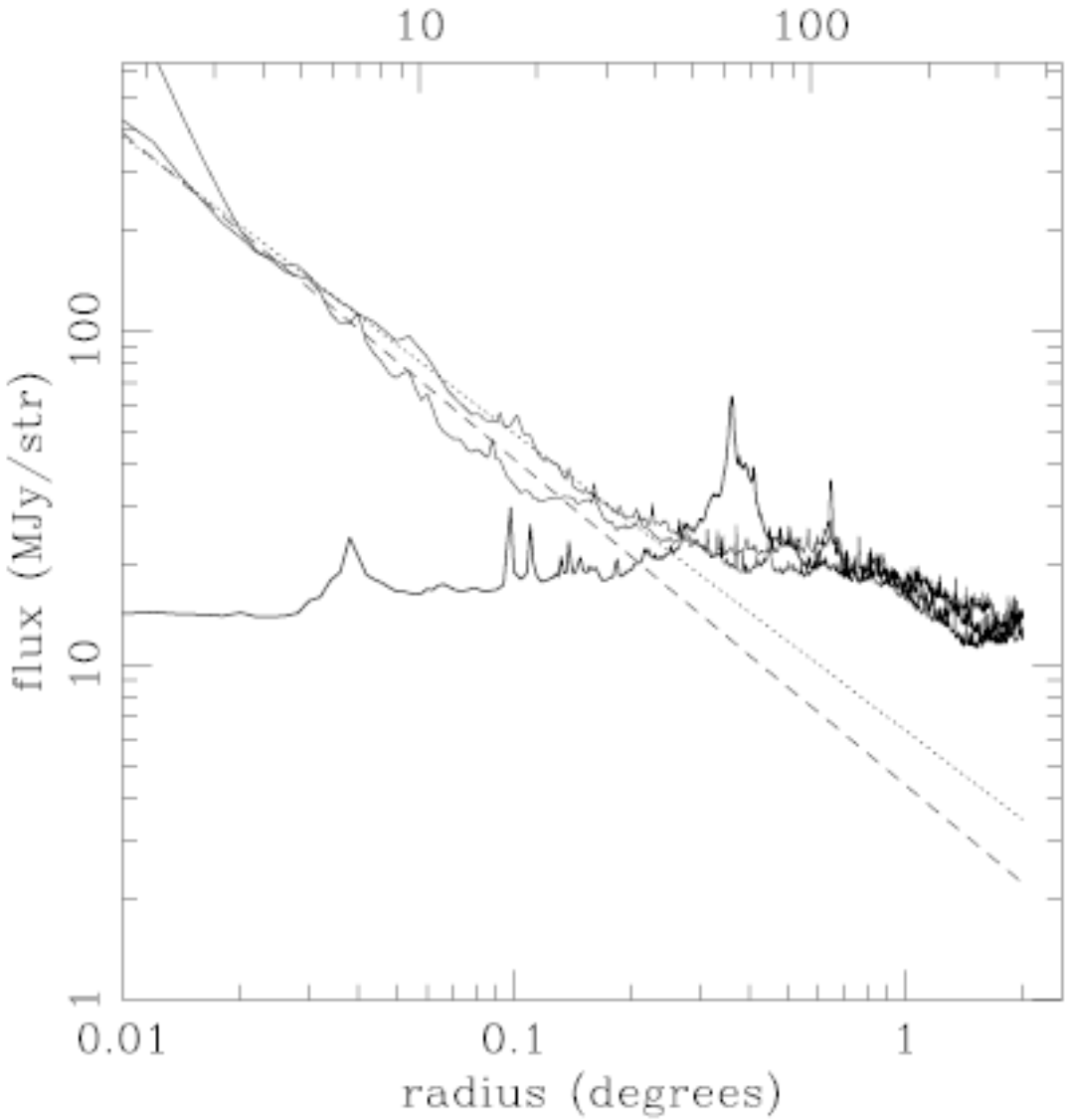
Orion & Zeta Oph closer to our measurement (within 30%)

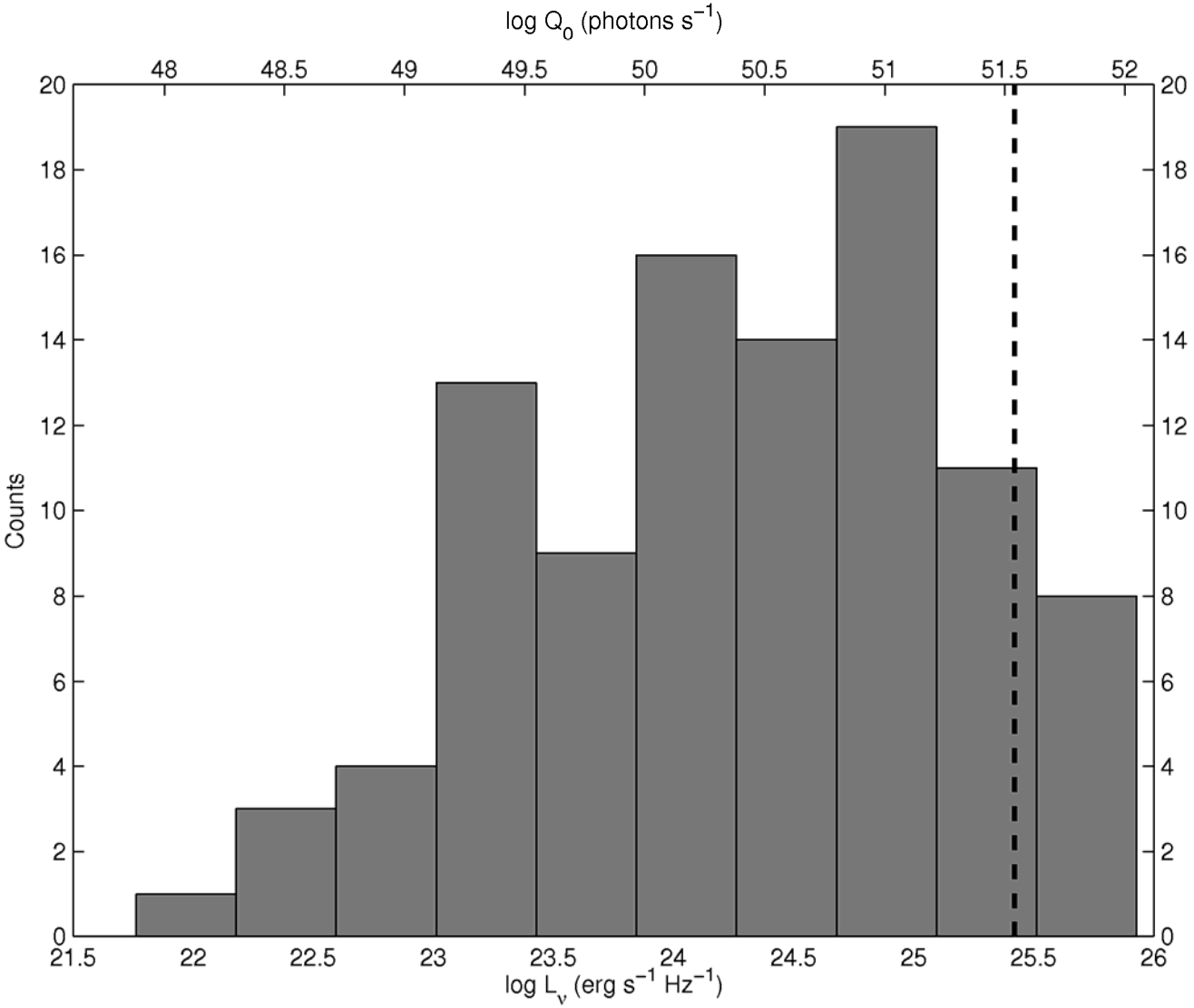
Smith (2006)

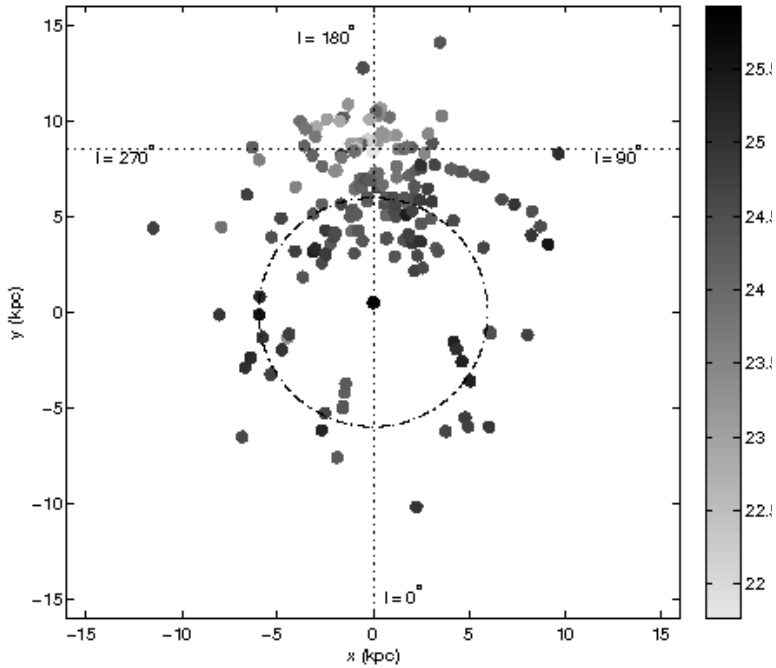
Table 7. Total stellar energy input.

Cluster	Number of O stars	log L ($L_\odot$)	log Q_H (s^{-1})	log L(FUV) ($L_\odot$)	$\dot{M}$ ($10^{-6}\,M_\odot\,yr^{-1}$)	L_{SW} ($L_\odot$)
Tr16 (MS)	47	7.215	50.91	6.91	91	45400
Tr16 (LBV)	43	7.240	50.78	7.05	1083	67000
Tr16 (now)	42	7.240	50.77	6.79	1083	67000
Tr14	10	6.61	50.34	6.31	18.7	13500
Tr15	6	6.18	49.56	5.88	5.9	1300
Bo10	1	6.00	49.42	5.69	18.3	7120
Bo11	5	6.00	49.64	5.70	5.2	2900
CPD-59 2661	1	4.68	47.88	4.38	0.15	33
Total (MS)	70	7.38	51.06	7.08	139	70200
Total (LBV)	66	7.40	50.97	7.18	1131	91800
Total (now)	65	7.40	50.96	7.00	1131	91800

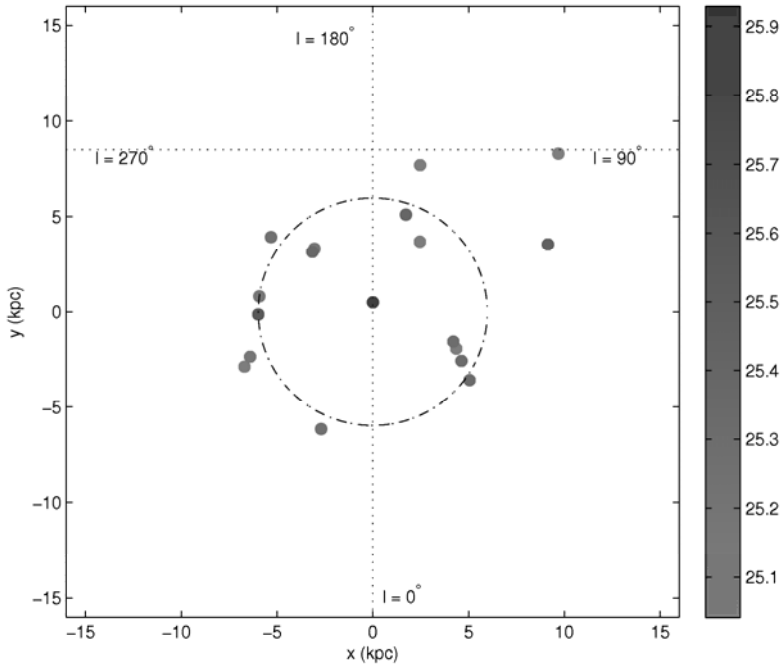

Galactic Latitude
0.0°
−0.5°
−1.0°
299.5°
299.0°
298.5°
298.0°
297.5°
Galactic Longitude


10
100
flux (MJy/str)
100
10
1
0.01
0.1
1
radius (degrees)


log Q0 (photons s−1)
48
48.5
49
49.5
50
50.5
51
51.5
52
Counts
0
2
4
6
8
10
12
14
16
18
20
21.5
22
22.5
23
23.5
24
24.5
25
25.5
26
log Lν (erg s−1 Hz−1)



All Sources



$\log Q_0 > 51$

	l	b	a	Flux (Jy)	D (kpc)	Q_0	
1	359.9	-0.1	1.2	1105	8	1.7E+52	Galactic Centre
2	337.3	-0.1	2.58	470	12.6	1.6E+52	
3	30.5	0	2.27	1387	5.1	9.8E+51	W43
4	337.3	-0.1	2.58	1769	4.8	8.1E+51	
5	298.4	-0.4	0.91	313	9.9	7.7E+51	
6	34.7	-0.2	0.92	285	10.5	7.5E+51	
7	332.9	-0.3	1.56	1787	4.6	7.4E+51	RCW106
8	30.5	0	2.27	708	12.4	7.3E+51	
9	49.3	-0.3	0.99	258	7	5.4E+51	W51
10	24.5	0	1.96	1230	4.4	5.2E+51	W41 & W42
11	24.5	0	1.96	147	12.5	5.1E+51	W41 & W42
12	10.3	-0.3	0.61	86	14.4	4.6E+51	W31
13	37.6	0	0.8	244	8.2	4.2E+51	W47
14	291.2	-0.7	1.04	688	6.7	4.2E+51	NGC3603
15	283.9	-0.6	1.37	848	4.8	4.1E+51	NGC3199
16	311.6	0.1	1.72	766	5.1	3.7E+51	
17	327.5	-0.2	1.55	943	4.3	3.5E+51	

Conclusions

- SFR: 1.3 $M_{\odot}$ yr^{-1}, but highly dependant on upper mass slope of IMF
- ELD interpreted as escaped ionizing photons from central H II region
- >50% of flux coming from ~20 sources, most dominated by a single cluster
- Evidence of large bubbles, triggered clusters

RCW 106 & Friends