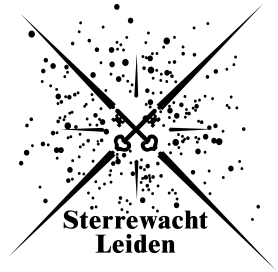
Cold clouds in the line of sight towards Cassiopeia A

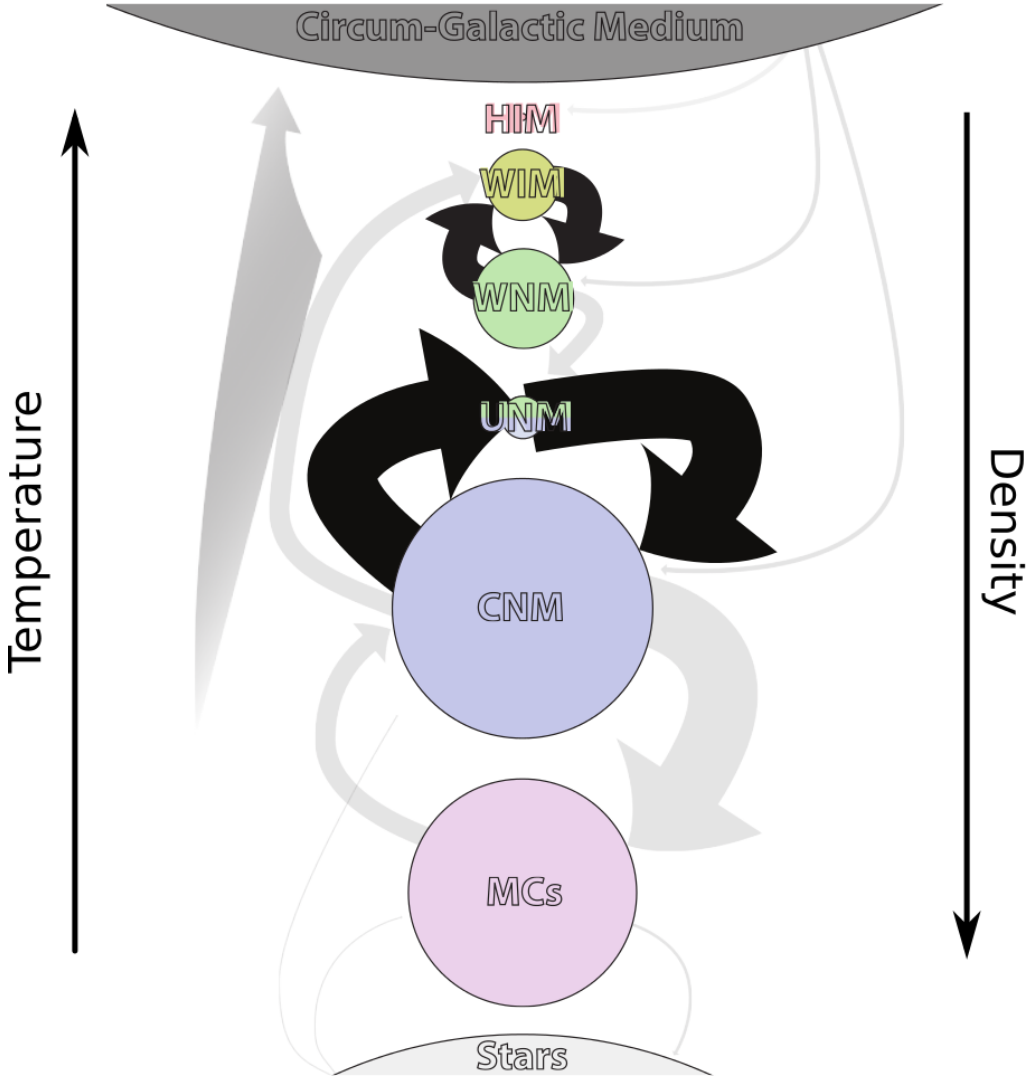
Pedro Salas

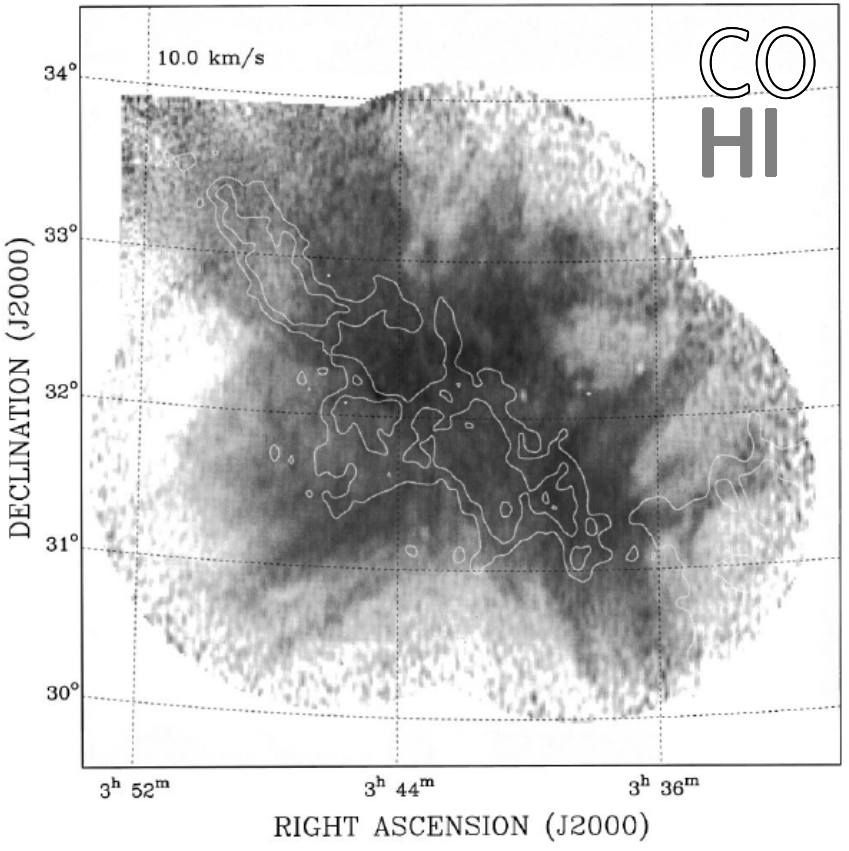


R. Oonk, F. Salgado, L. Morabito, C. Toribio, R. van Weeren,
H. Röttgering, X. Tielens

Assen, 3rd June 2015

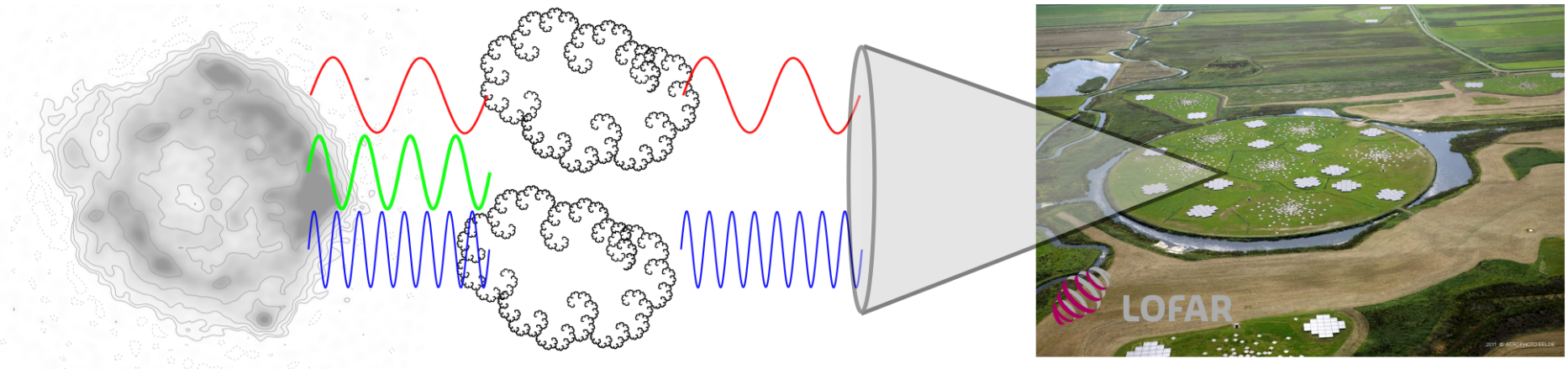
Why care about cold diffuse clouds?

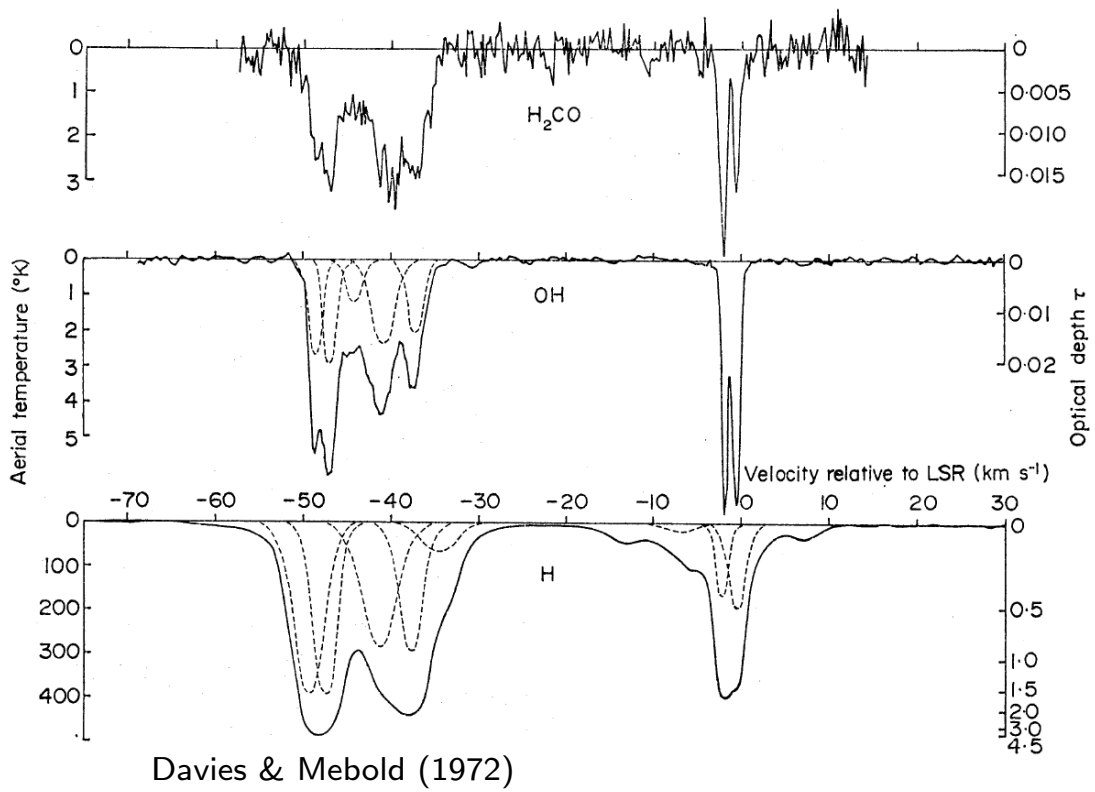




Moriarty-Schieven

The line of sight towards Cas A



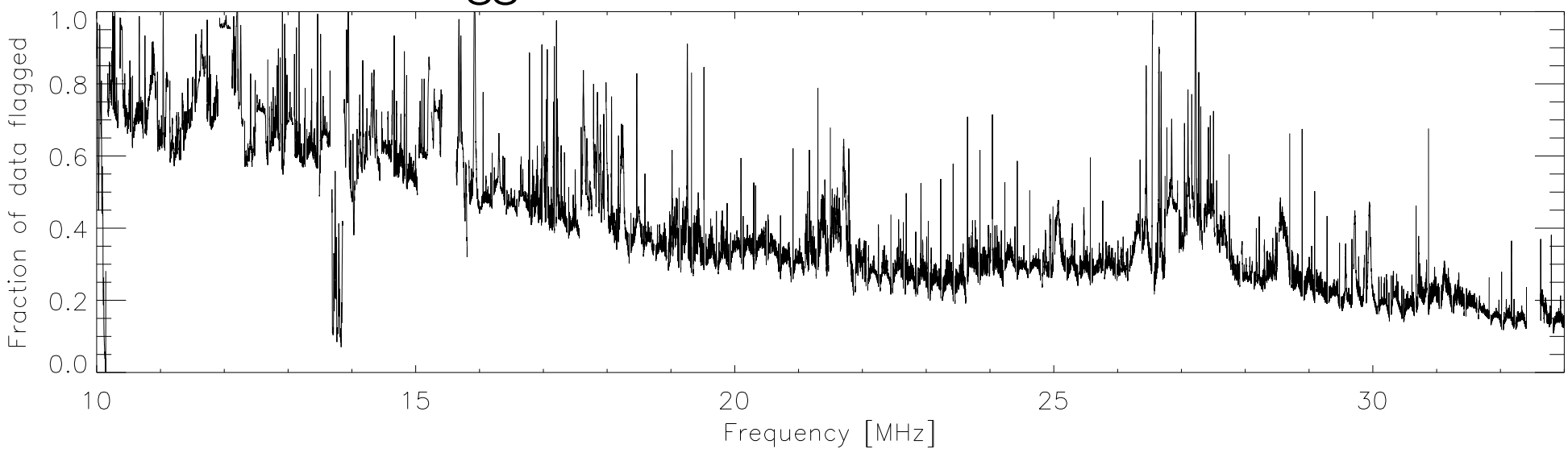


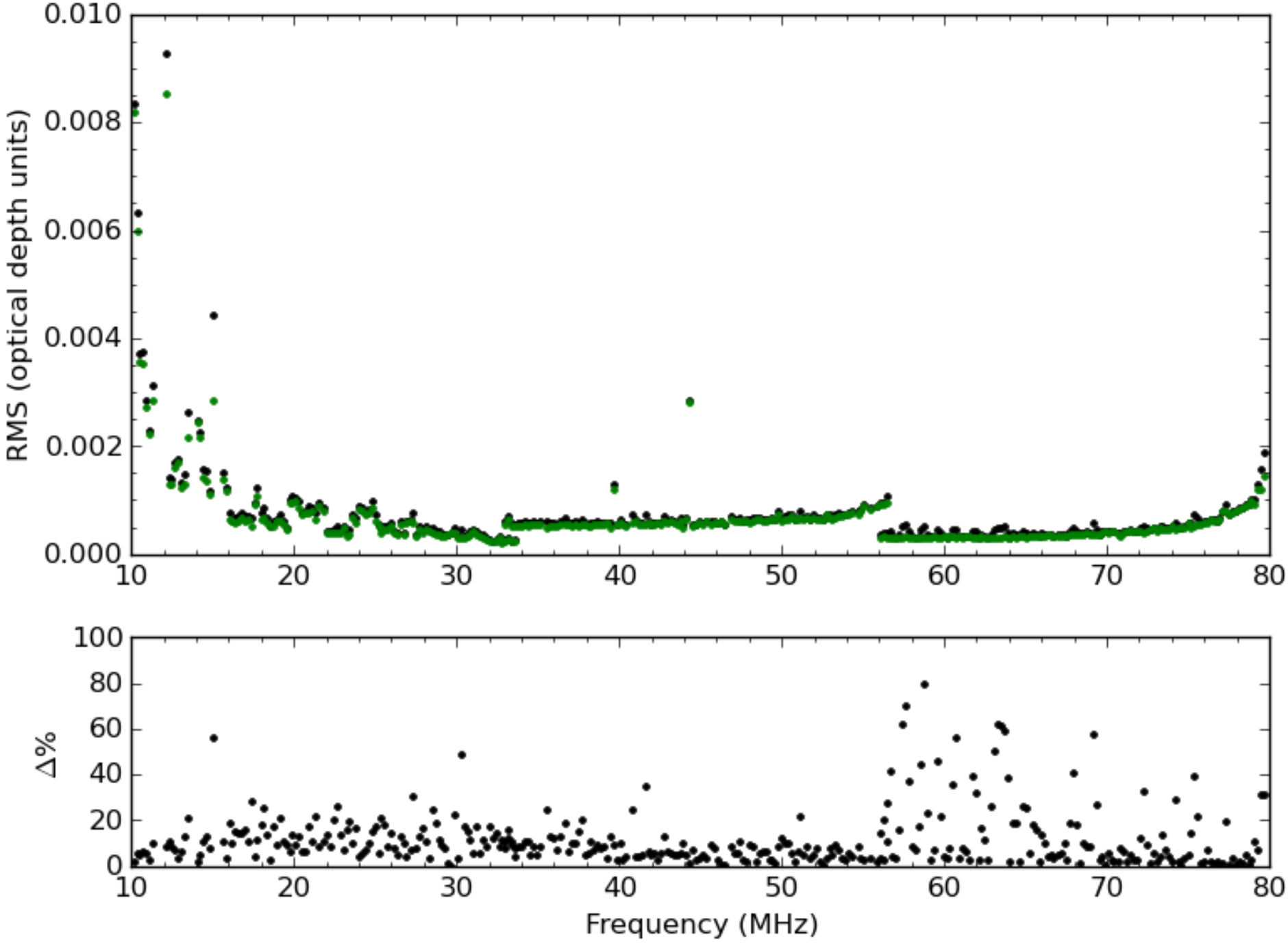
Davies & Mebold (1972)

Table : LBA Observations

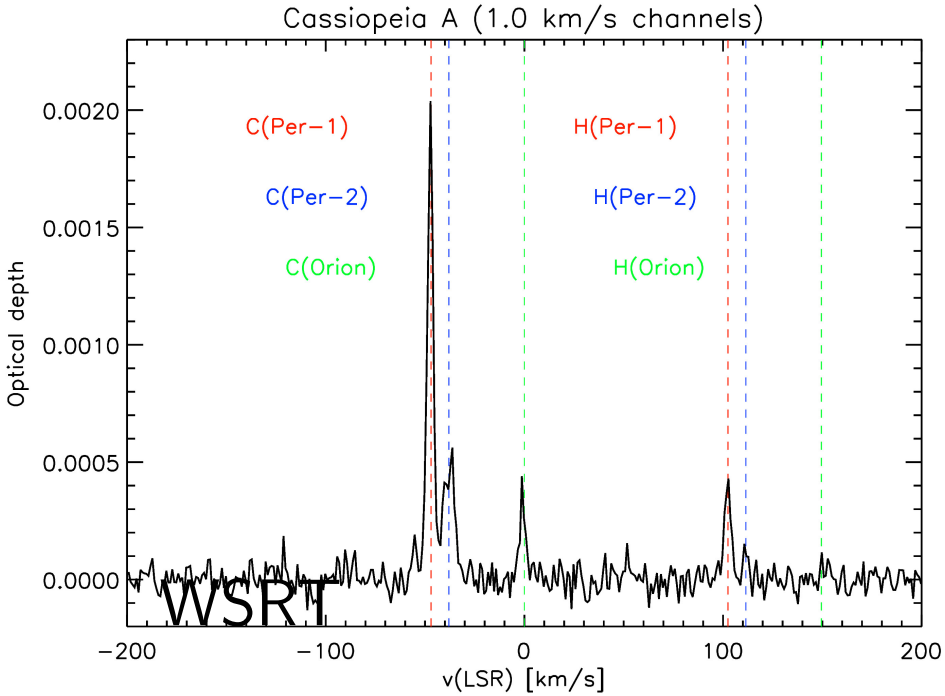
Observations ID	L184343, L40787, L69891, L69893
Integration time	2 s, 2 s, 1 s, 1 s
Observation dates	27 December 2011, 31 October 2013, 20, 21 October 2012 (15:00-01:00 UT)
Total on-source time	12 hr, 10 hr, 10 hr, 10 hr
Correlations	XX, XY, YX, YY
Frequency setup	56–80 MHz, 33–57 MHz, 10–33 MHz
Bandwidth per subband	195.3125 kHz
Channels per subband	512

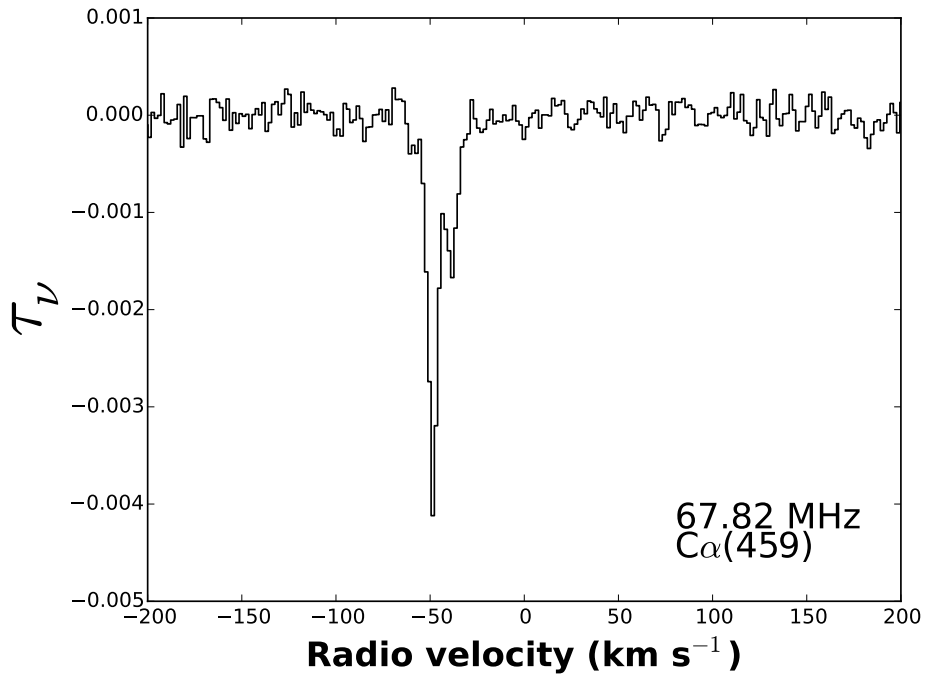
Flagged data: RFI+bad time intervals

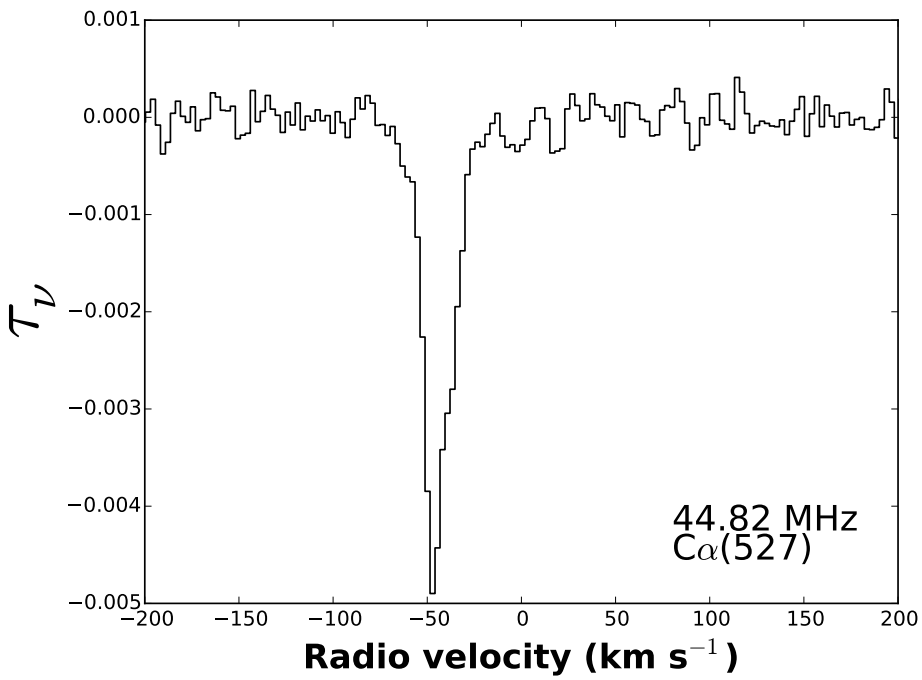


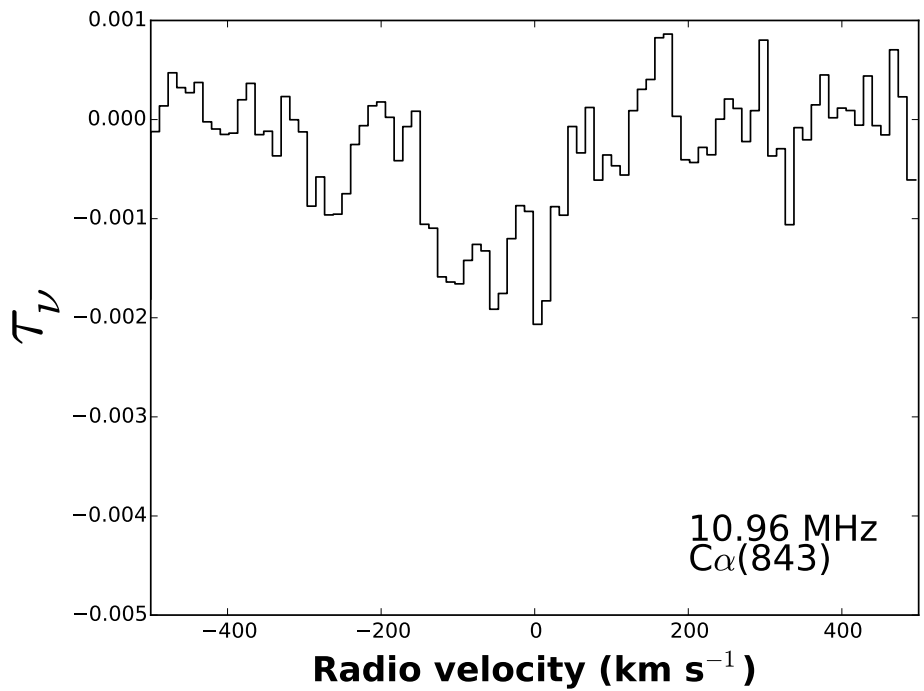

Sub band bandpass calibration
RMS (optical depth units)
0.010
0.008
0.006
0.004
0.002
0.000
10
20
30
40
50
60
70
80
Δ%
100
80
60
40
20
0
Frequency (MHz)

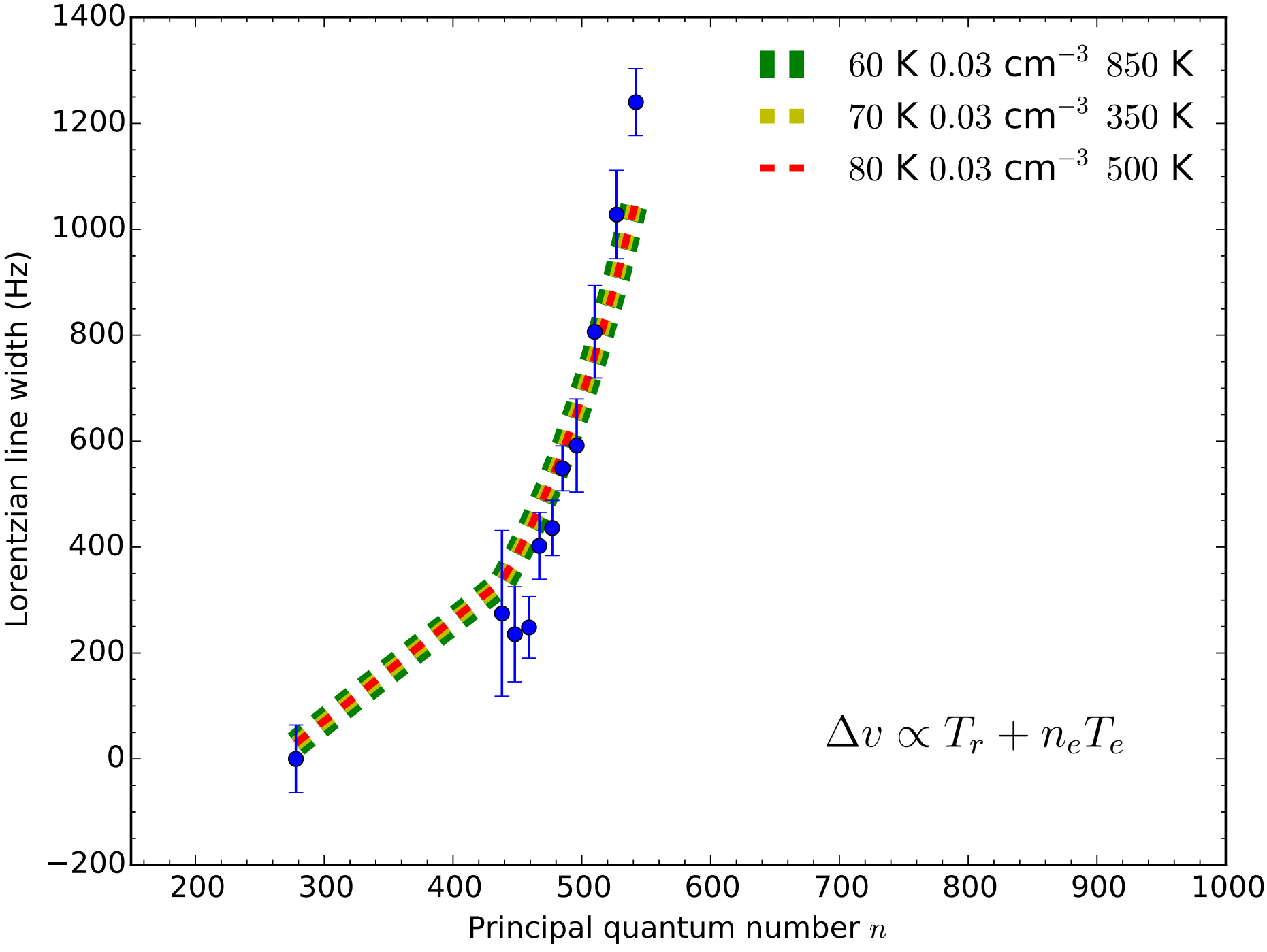
Results

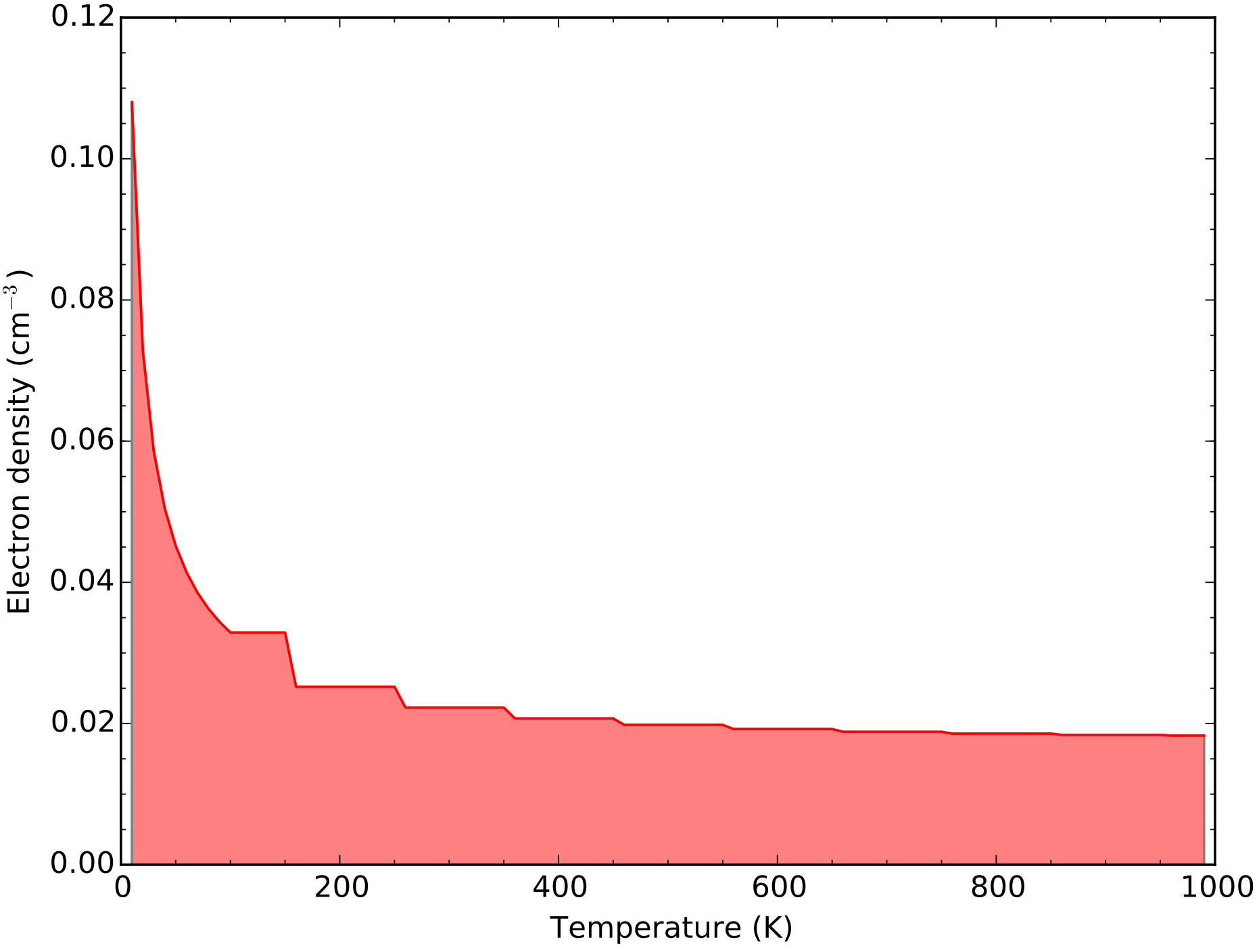

Cassiopeia A (1.0 km/s channels)
C(Per−1)
C(Per−2)
C(Orion)
H(Per−1)
H(Per−2)
H(Orion)
WSRT
Optical depth
v(LSR) [km/s]

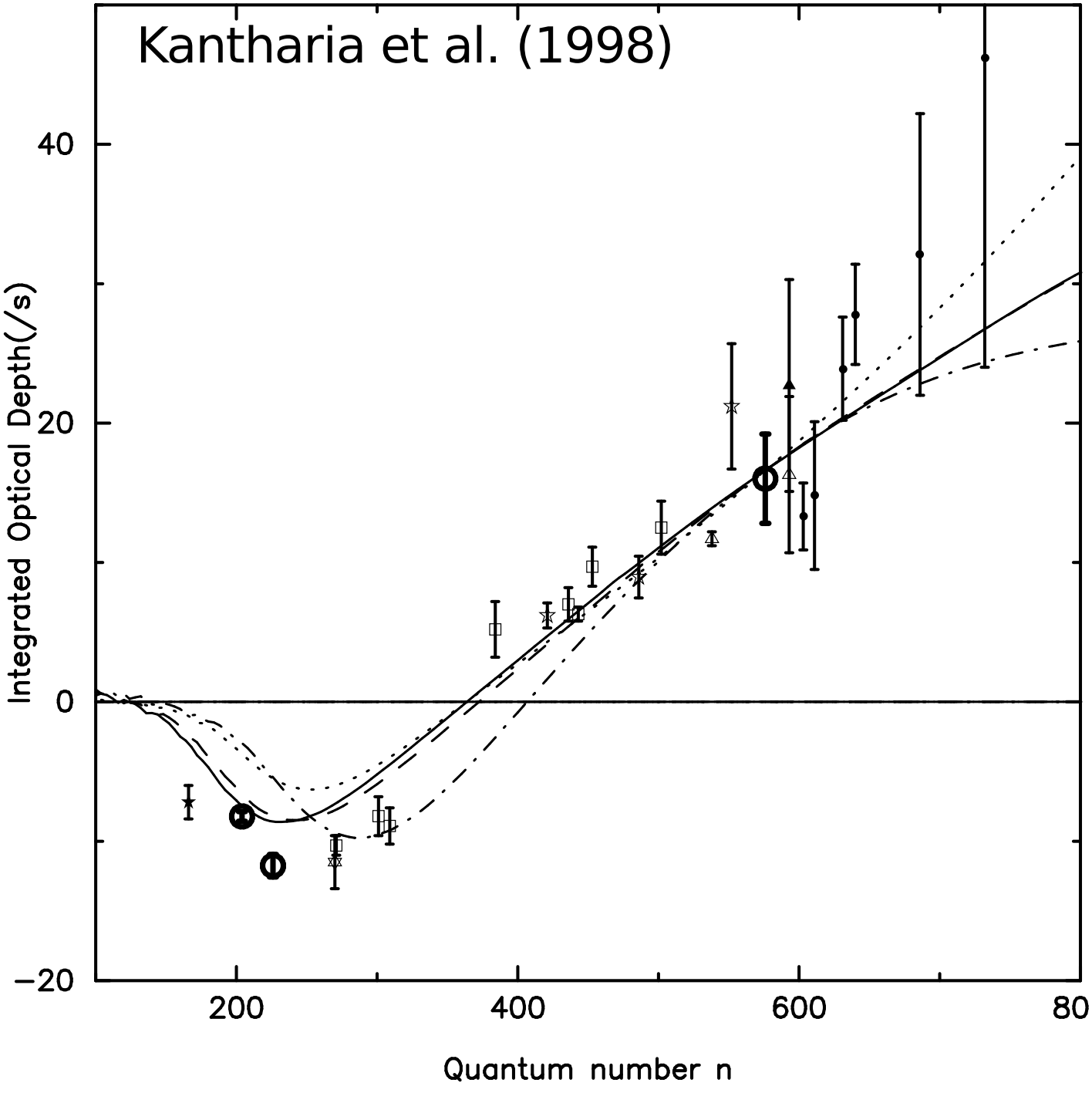

67.82 MHz
Cα(459)
Radio velocity (km s^{-1})

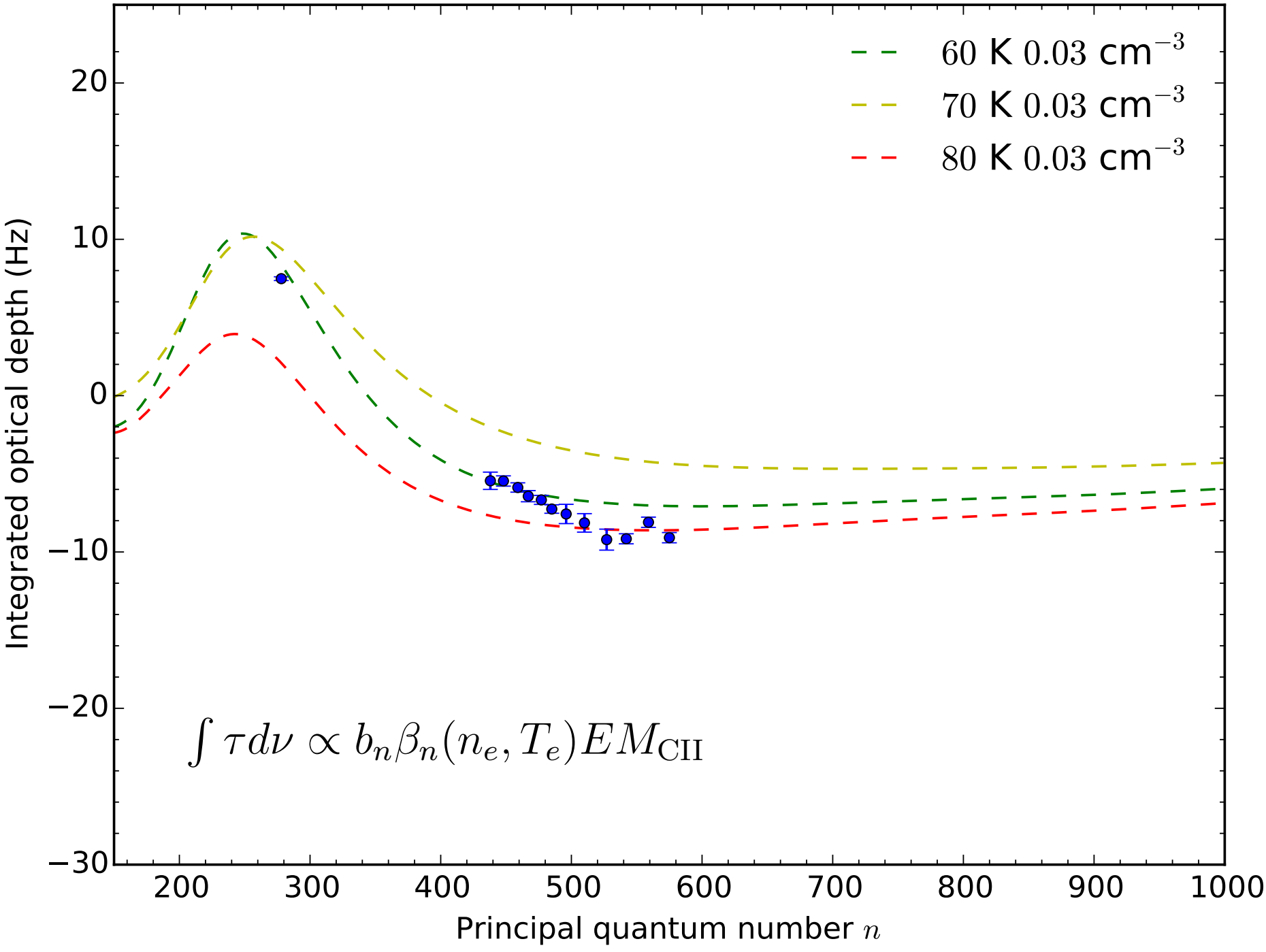

44.82 MHz
Cα(527)
Radio velocity (km s^{-1})

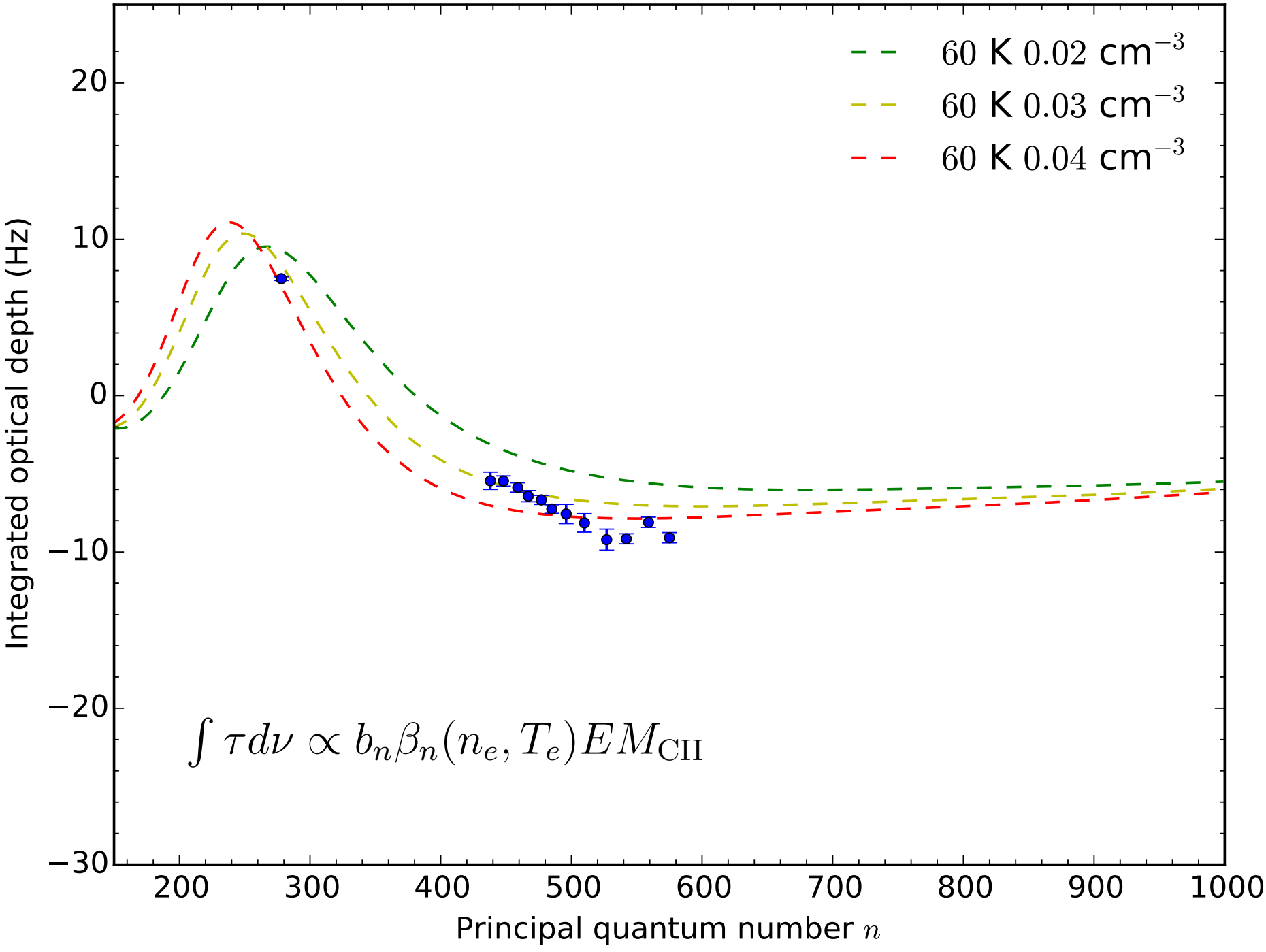

10.96 MHz
Cα(843)
Radio velocity (km s^{-1})


60 K 0.03 cm^{-3} 850 K
70 K 0.03 cm^{-3} 350 K
80 K 0.03 cm^{-3} 500 K
$\Delta v \propto T_r + n_e T_e$
Lorentzian line width (Hz)
Principal quantum number n
1400
1200
1000
800
600
400
200
0
−200
200
300
400
500
600
700
800
900
1000


0.12
0.10
0.08
0.06
0.04
0.02
0.00
Electron density (cm^{-3})
0
200
400
600
800
1000
Temperature (K)


Kantharia et al. (1998)
Integrated Optical Depth(/s)
40
20
0
−20
200
400
600
80
Quantum number n


60 K 0.03 cm^{-3}
70 K 0.03 cm^{-3}
80 K 0.03 cm^{-3}
$\int \tau d\nu \propto b_n \beta_n(n_e, T_e) EM_{\rm CII}$
Integrated optical depth (Hz)
Principal quantum number n
20
10
0
−10
−20
−30
200
300
400
500
600
700
800
900
1000


60 K 0.02 cm^{-3}
60 K 0.03 cm^{-3}
60 K 0.04 cm^{-3}
$\int \tau d\nu \propto b_n \beta_n(n_e, T_e) EM_{\rm CII}$
Integrated optical depth (Hz)
Principal quantum number n
20
10
0
−10
−20
−30
200
300
400
500
600
700
800
900
1000

Summary

- Low frequency RRLs trace the diffuse ISM towards Cas A.
- Line widths and integrated optical depths constrain: n_e, T_e, T_r and $EM_{\rm CII}$.
- If $T_r = 0 \rightarrow T_e = 60 \pm 10$ K and $n_e = 0.04 \pm 0.01$ cm^{-3}.

Work in progress

- Study spatial variations towards Cas A.
- Apply the technique to the galactic plane.

Thanks!