I.
Correlation among RM, HI, FF, & Synch. Emissions

Y. Sofue

2014.8.8 @SKA_mag_meeting

1. DATA

All-sky RM, HI, FF, Synch (l, b) Tables by:

H. Nakanishi

H. Ichiki

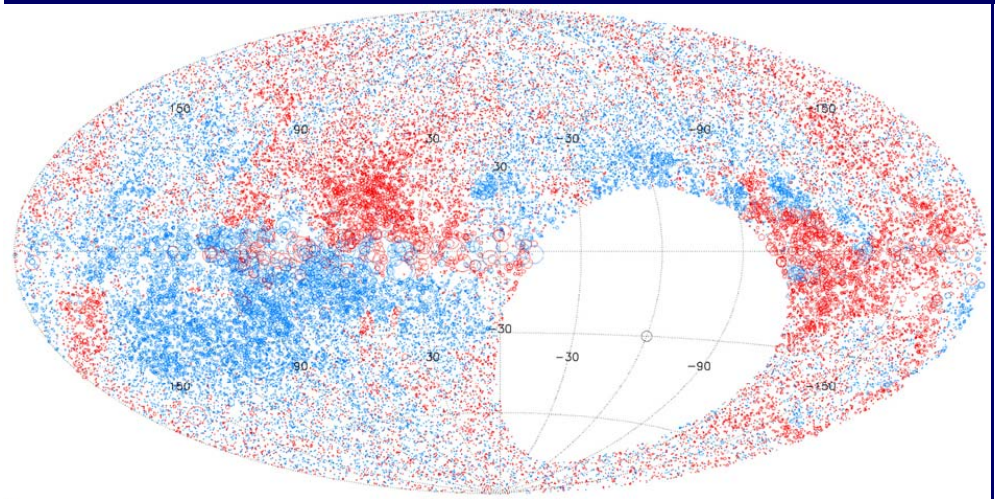
Data from:

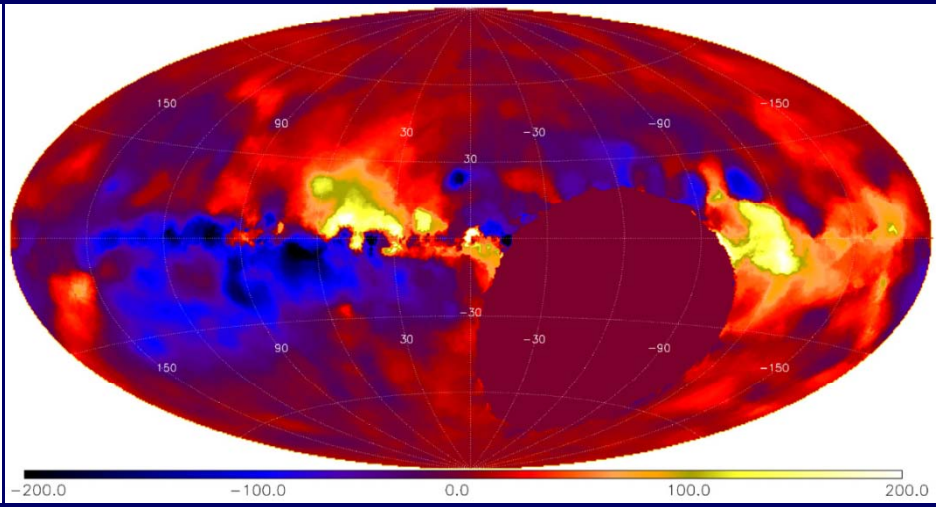
Taylor, et al. 2009

Kalbella et al. 2008

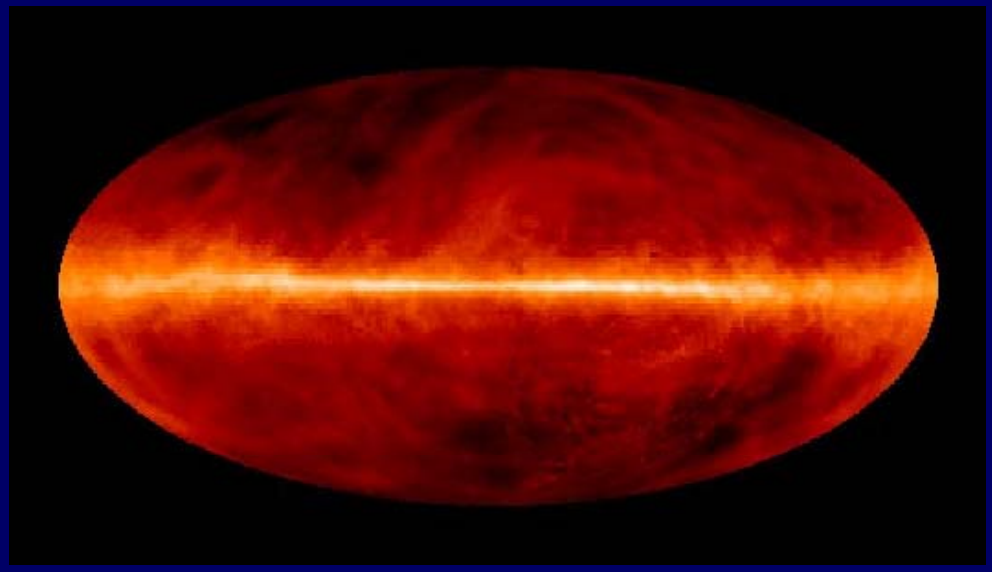
Gold et al. 2012 WMAP7

RM Sky (Taylor 2009)

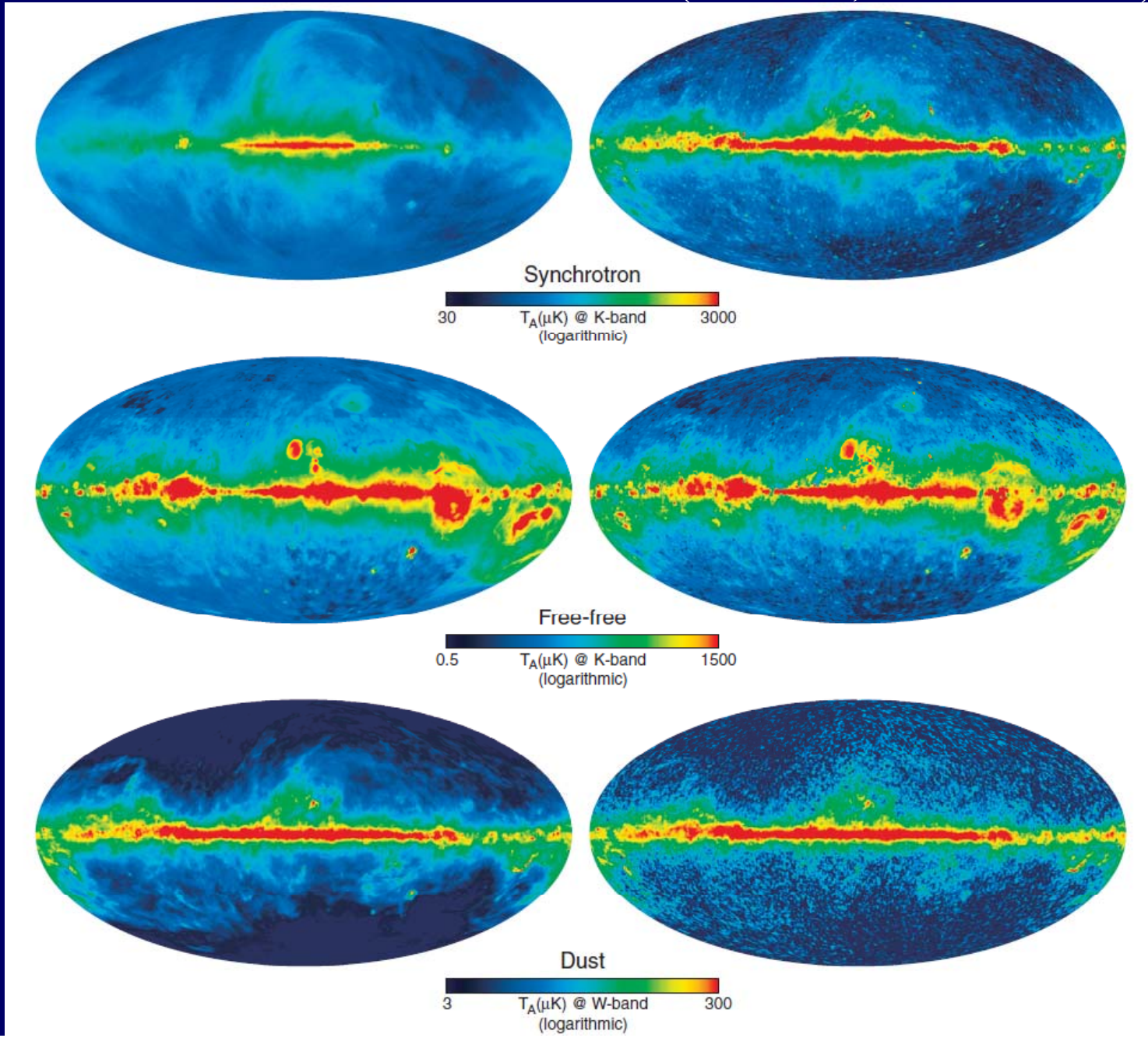




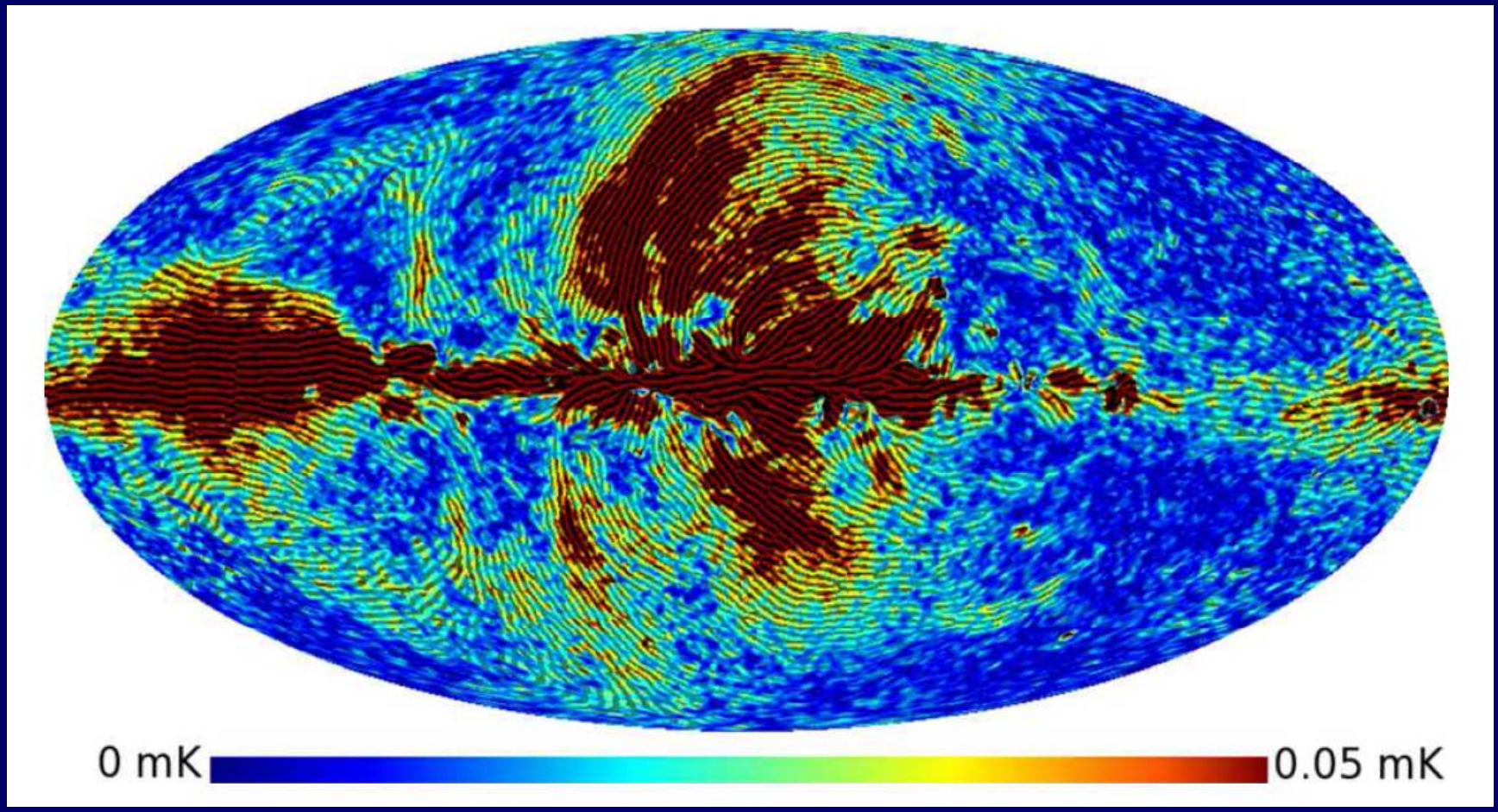
HI sky (Kalbella et al. 2011



Synchrotron & Free-Free emissions (WMAP 7, Gold et al. 2012)



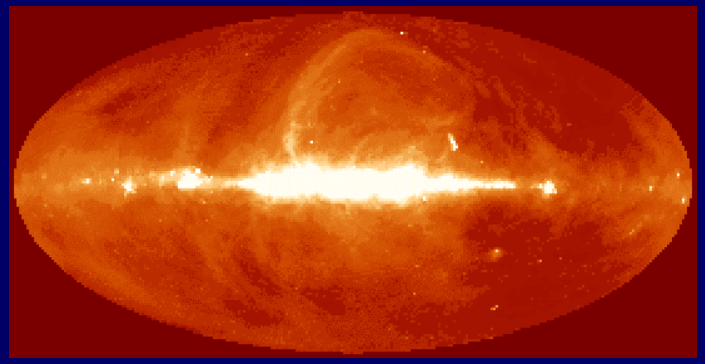
WMAP B vectors: (Jansson et al. 2012)

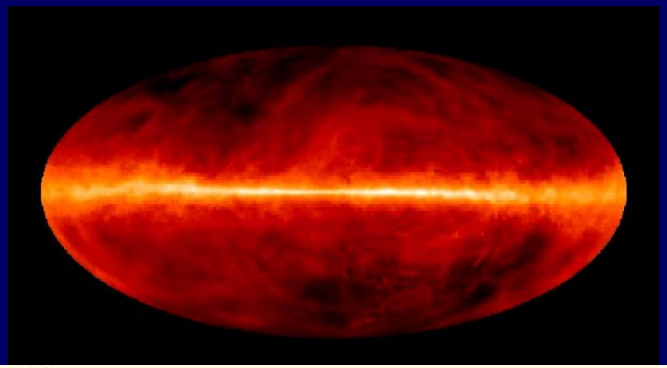


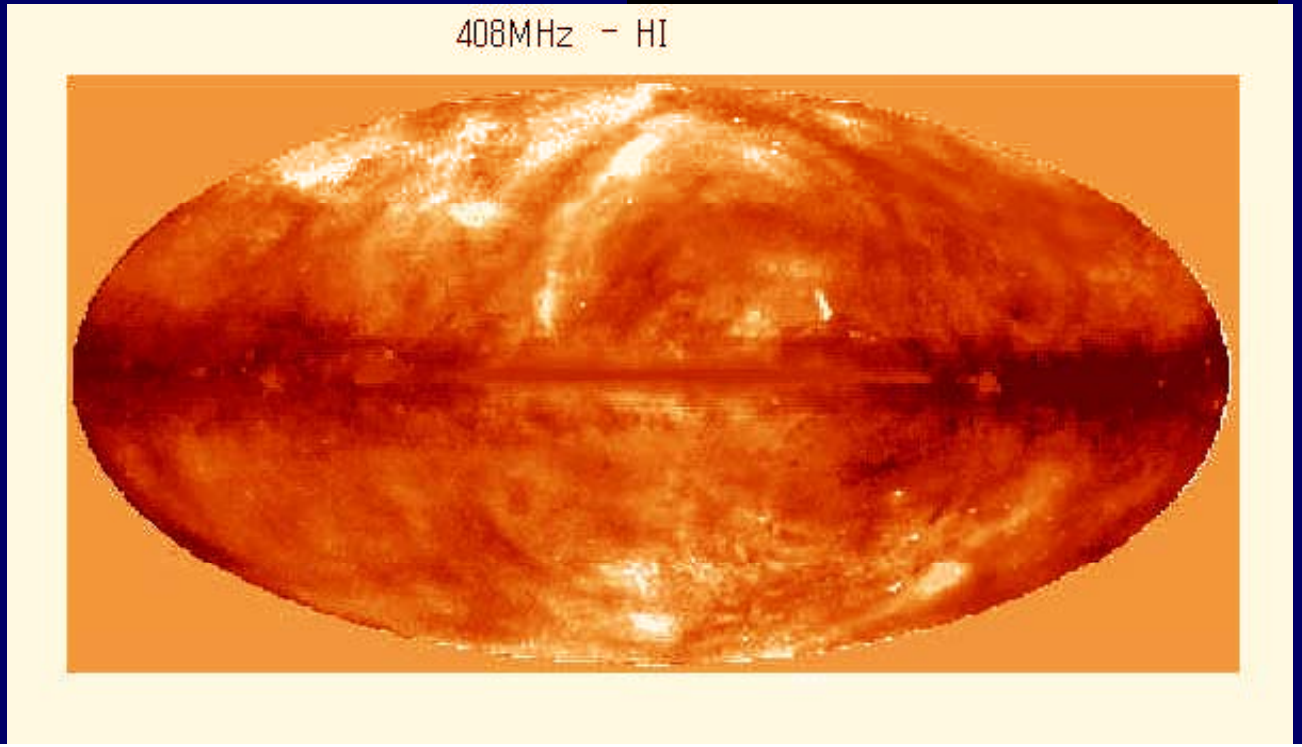
Map(radio) – Map(HI, etc)

408 MHz – HI total = not uniform:

Not frozen-in, at least some regions.







2. B-Frozen-in / Energy Equipartition, or else?

If ISM energy equipartition:

$n_e \sim n_{HI} \sim N_{CR} \sim B^2$

$RM \sim n_e B_{//} L \sim n_{HI}^{3/2} L$

$HI \sim n_{HI} L$

$FF \sim n_e^2 L \sim n_{HI}^2 L$

$Synch \sim N_{CR} B^2 L \sim B^4 L \sim n_{HI}^2 L$

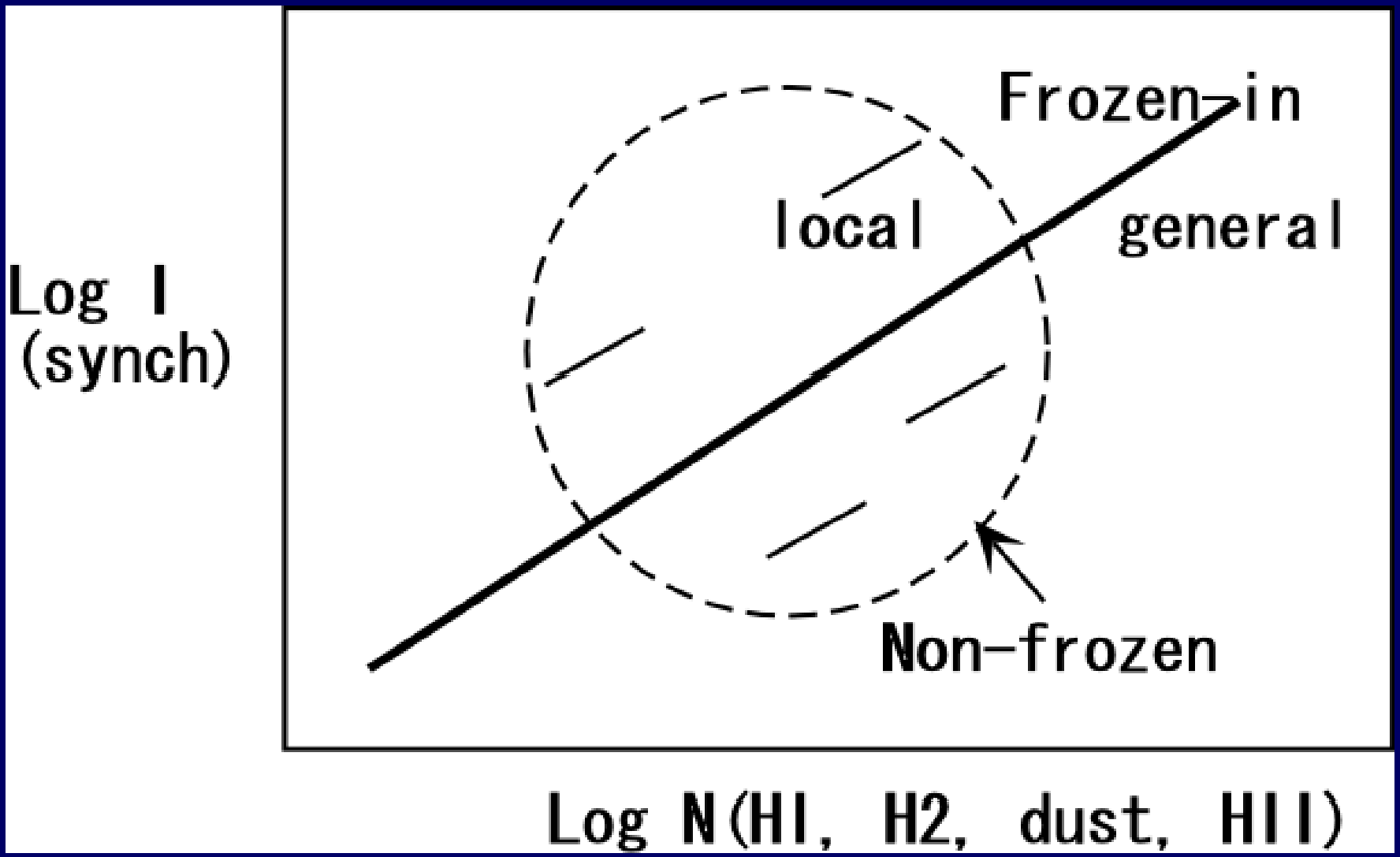
If B frozen in ISM (n_e , n_{HI}):

$B \sim \rho^{2/3} \sim n_{e/HI}{}^{2/3}$

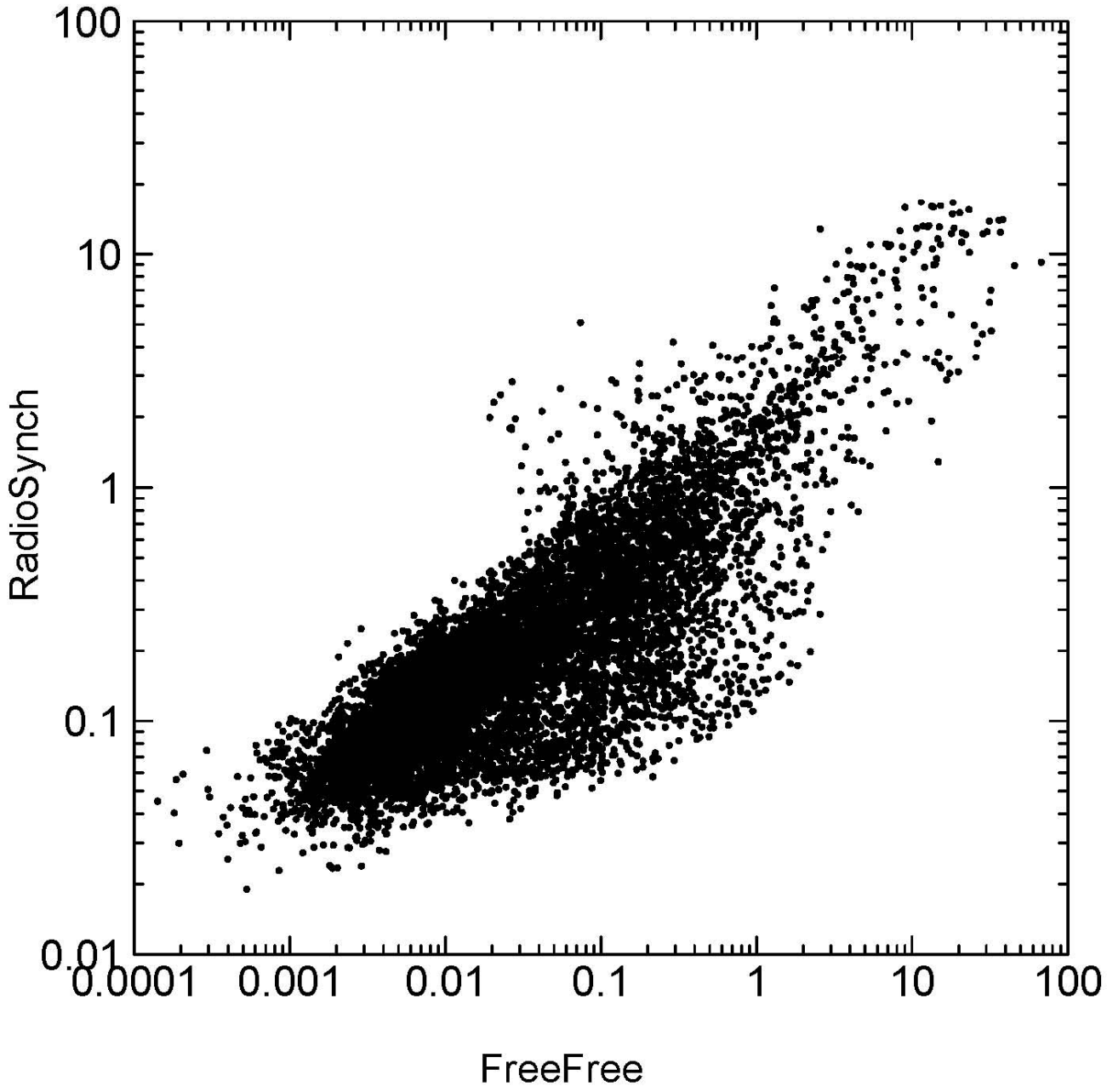
(B-CR Eq.par.=>$B^2 \sim Ncr$)

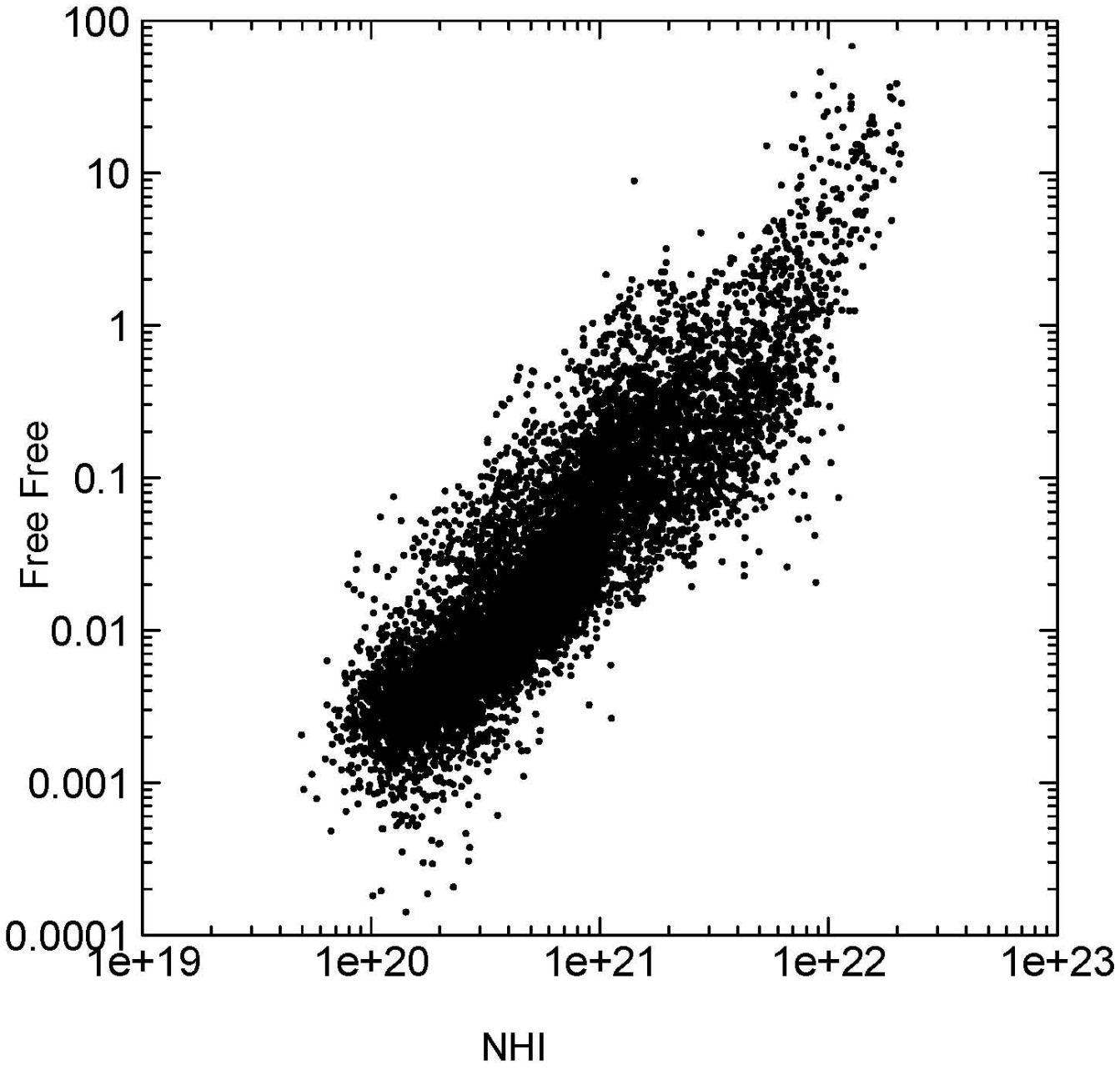
Synch. ~ B^2 Ncr L ~ B^4 L~ $n_{HI}{}^{8/3}$ L

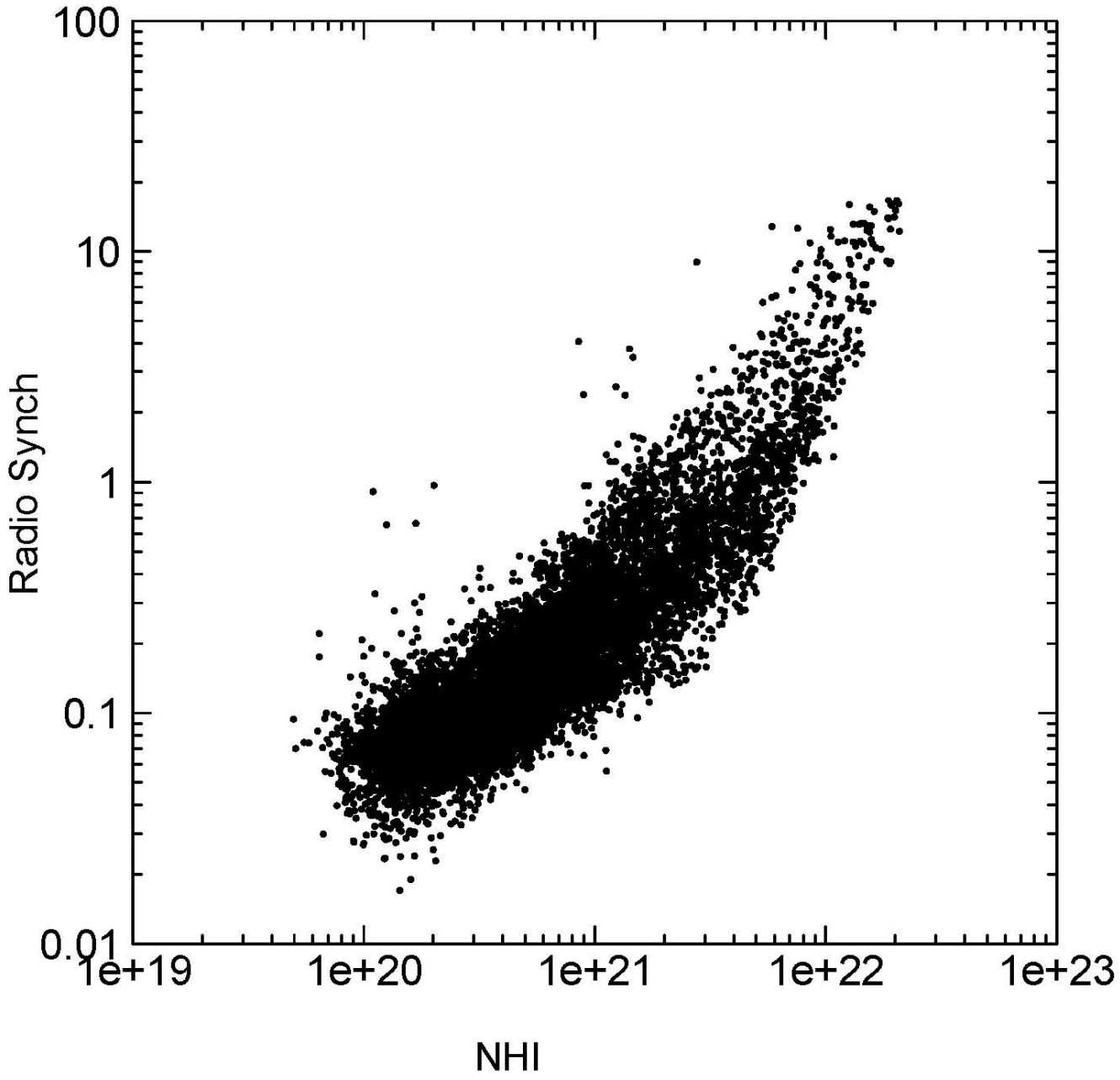
Log I(radio) - Log N(HI,H2,dust) plot.

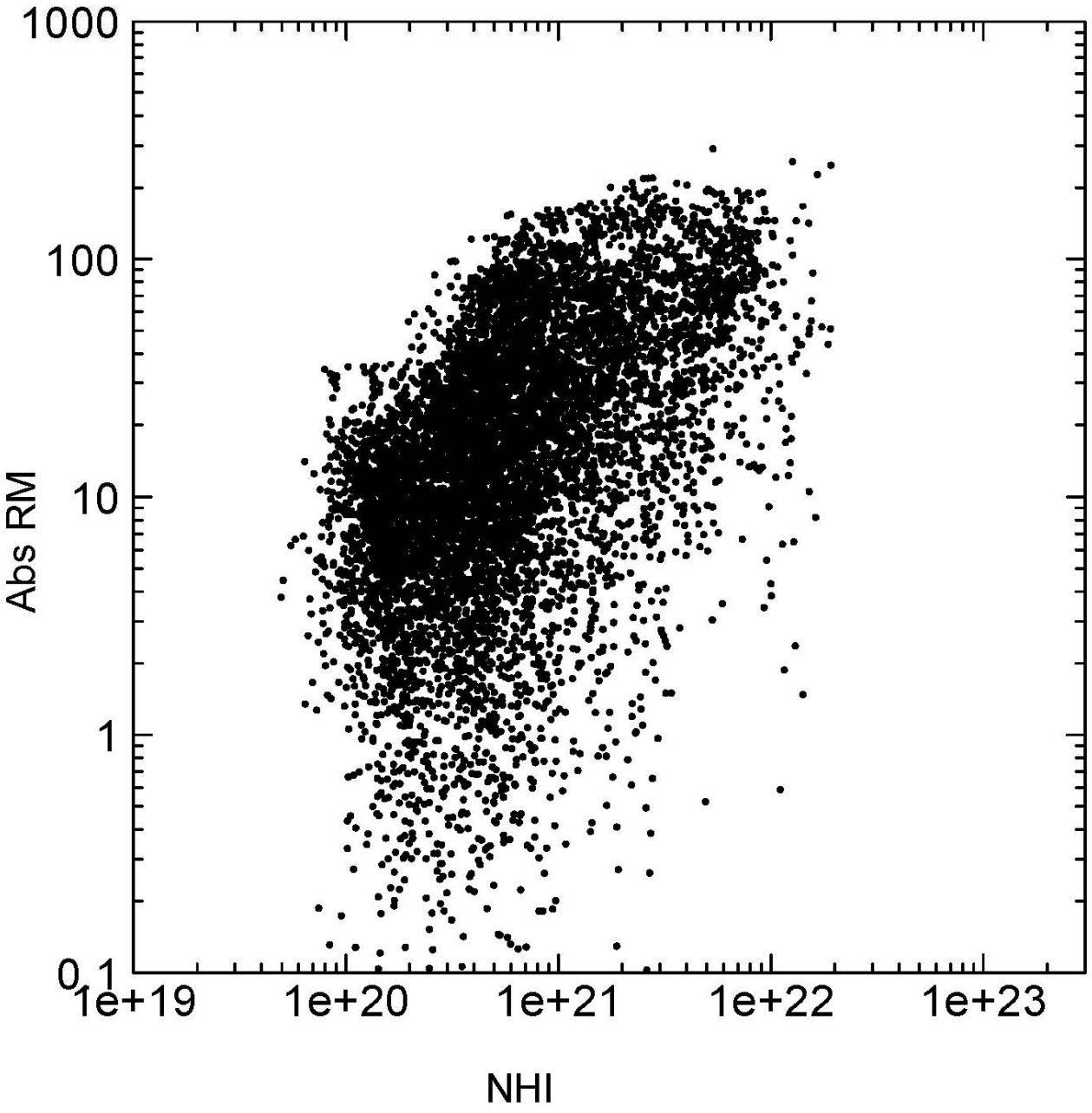


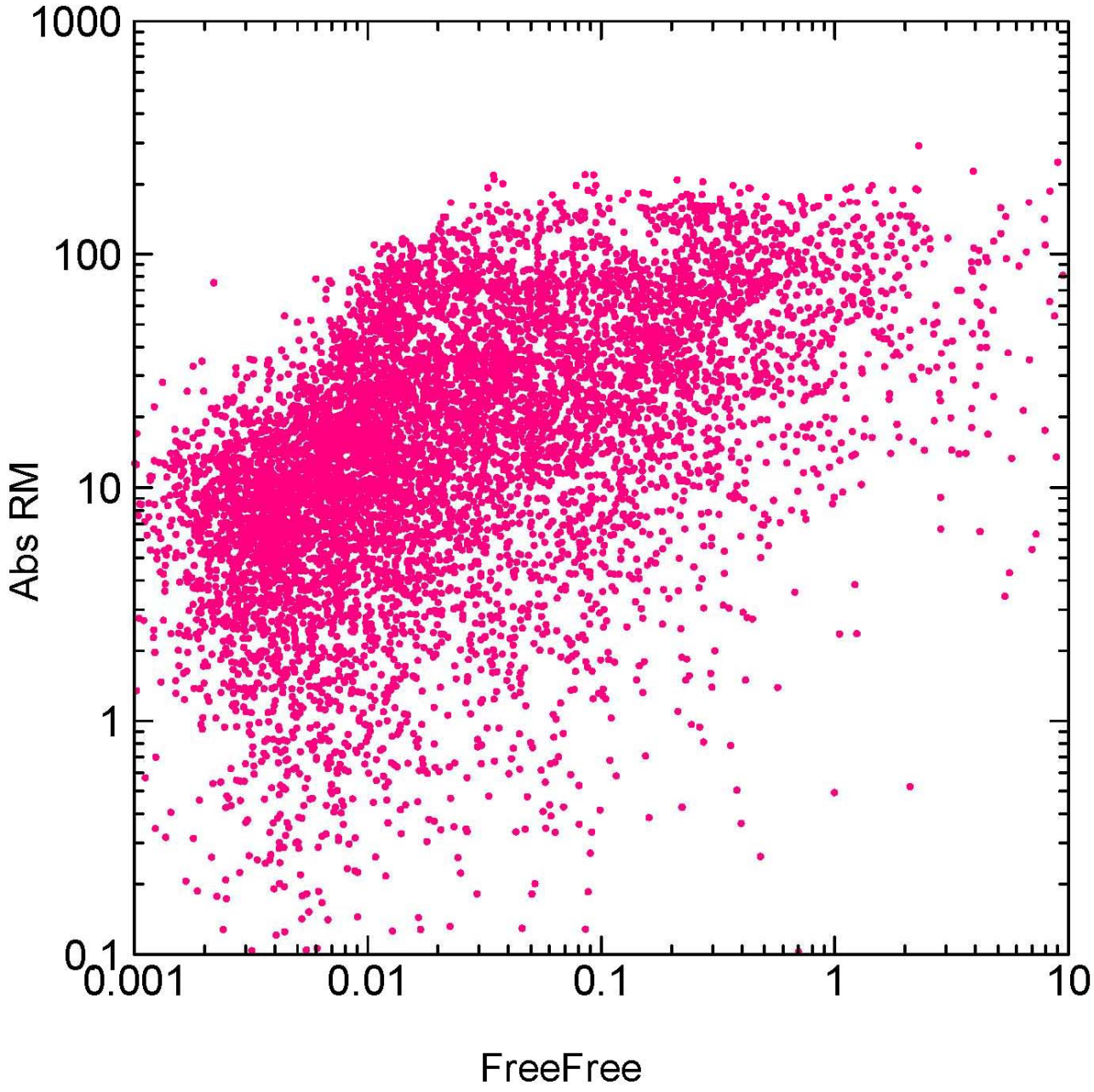
2. Global Correlation

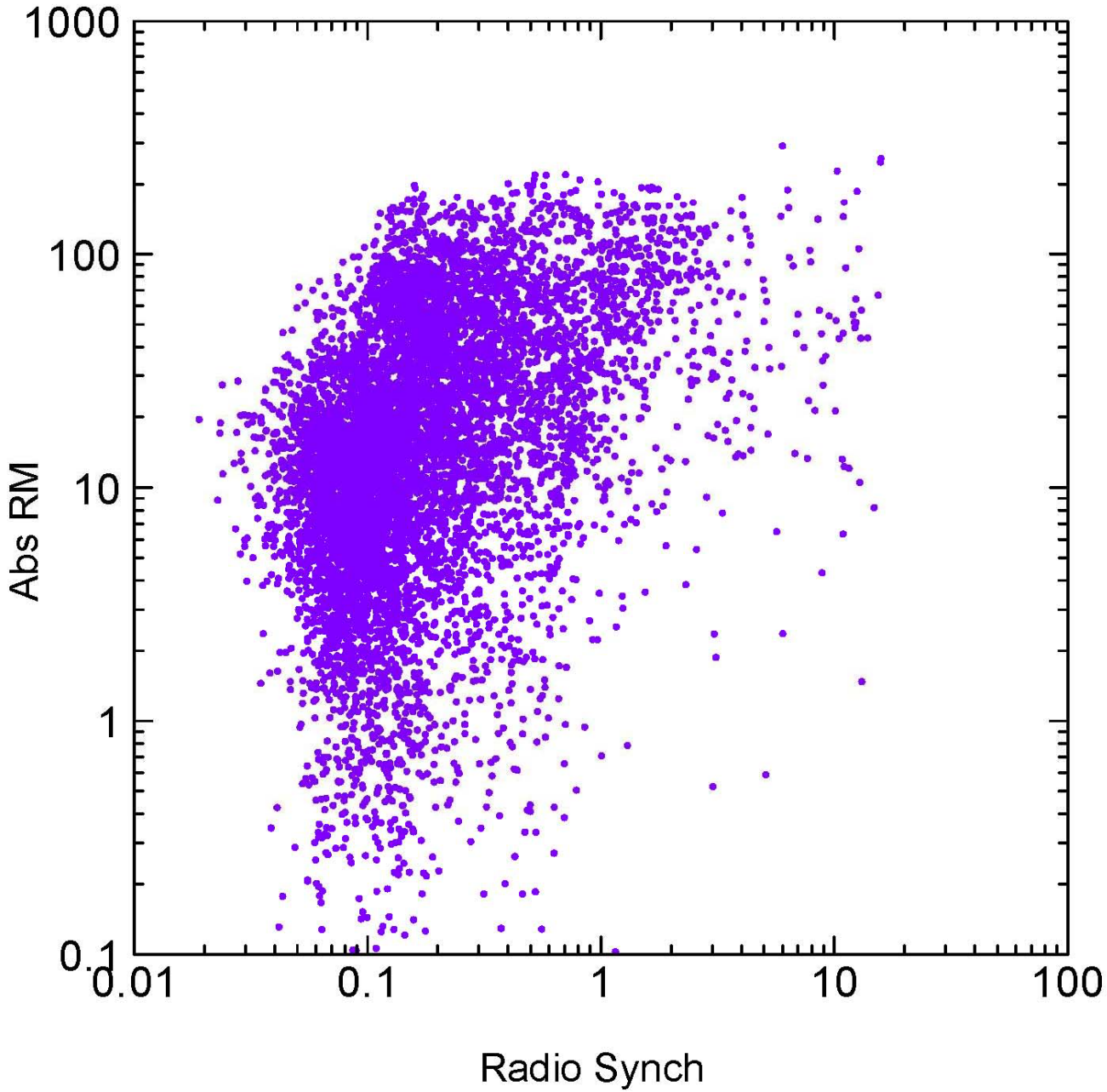

100
10
1
0.1
0.01
RadioSynch
0.0001
0.001
0.01
0.1
1
10
100
FreeFree

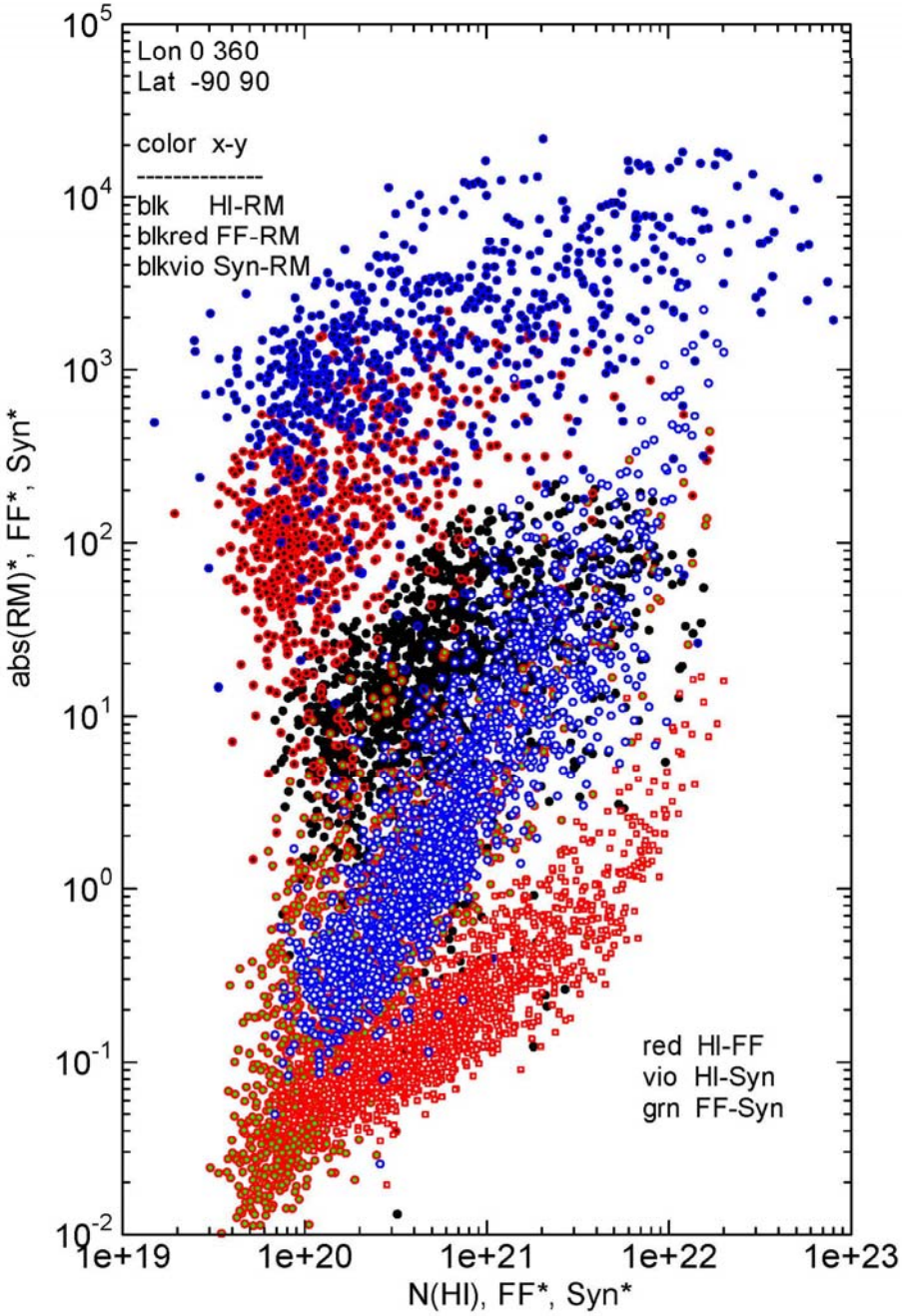

100
10
1
0.1
0.01
0.001
0.0001
Free Free
1e+19
1e+20
1e+21
1e+22
1e+23
NHI

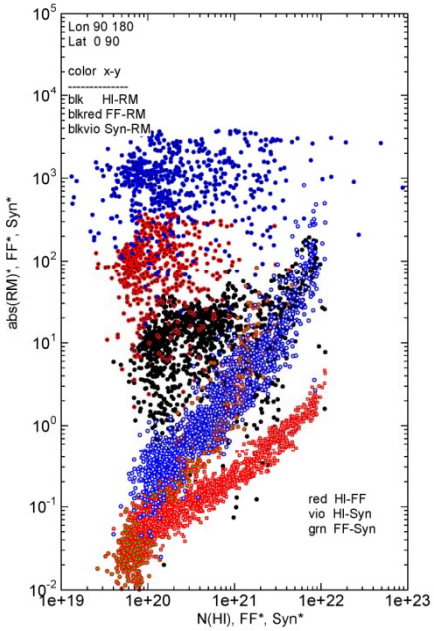

100
10
1
0.1
0.01
Radio Synch
1e+19
1e+20
1e+21
1e+22
1e+23
NHI

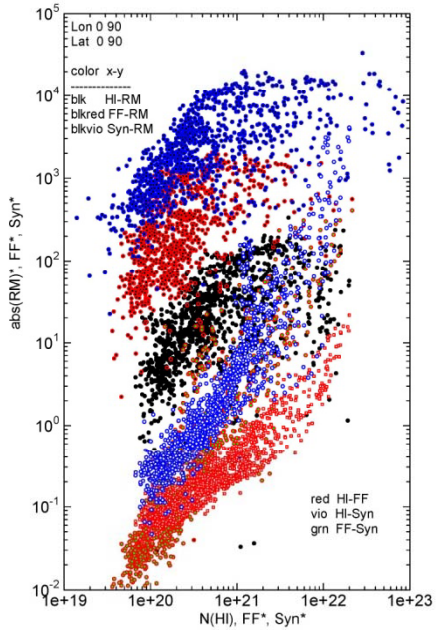

1000
100
10
1
0.1
Abs RM
1e+19
1e+20
1e+21
1e+22
1e+23
NHI


1000
100
10
1
0.1
Abs RM
0.001
0.01
0.1
1
10
FreeFree


1000
100
10
1
0.1
Abs RM
0.01
0.1
1
10
100
Radio Synch


Lon 0 360
Lat -90 90
color x-y
blk HI-RM
blkred FF-RM
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
1e+19
1e+20
1e+21
1e+22
1e+23


Lon 90 180
Lat 0 90
color x-y
blk HI-RM
blkred FF-RM
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*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Lat 0 90
color x-y
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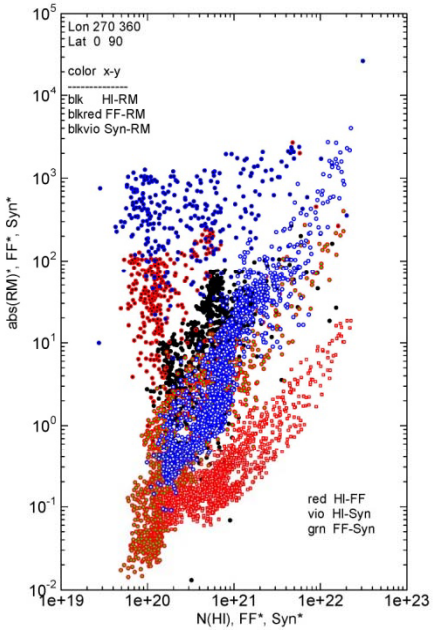
blkred FF-RM
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*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Lat 0 90
color x-y
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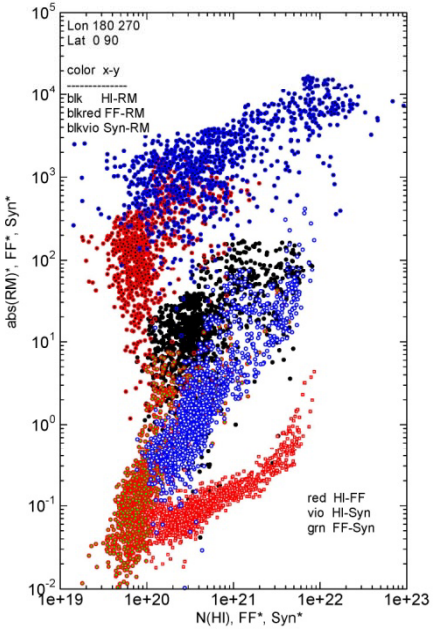
blkred FF-RM
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*


Lon 180 270
Lat 0 90
color x-y
blk HI-RM
blkred FF-RM
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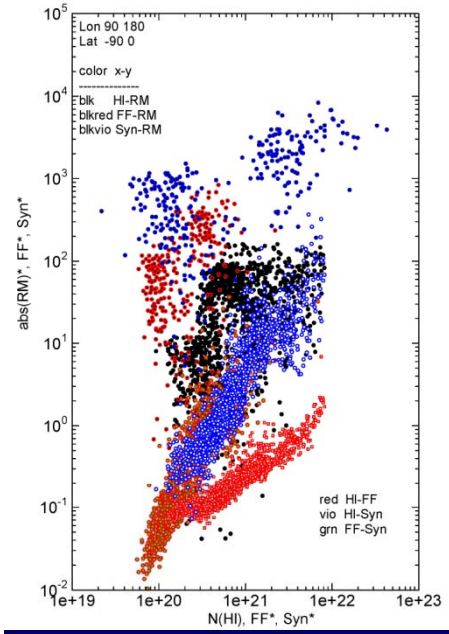
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*


Lon 90 180
Lat -90 0
color x-y
blk HI-RM
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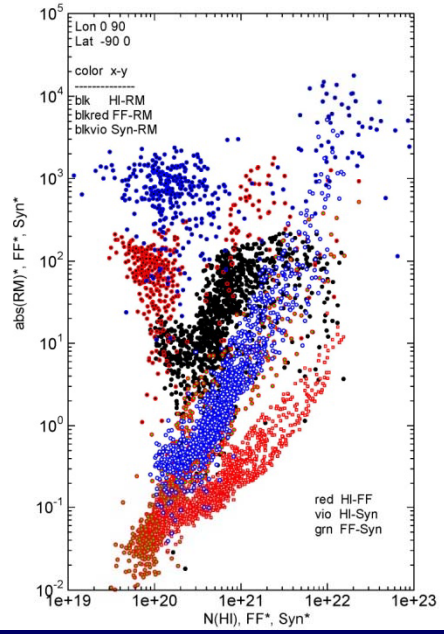
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*


Lon 0 90
Lat -90 0
color x-y
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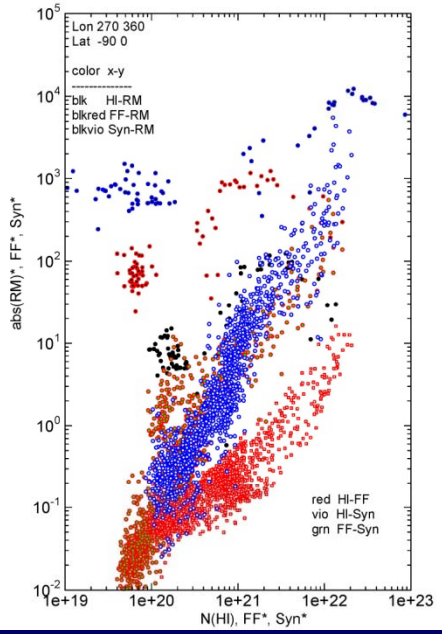
blkred FF-RM
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*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Lat -90 0
color x-y
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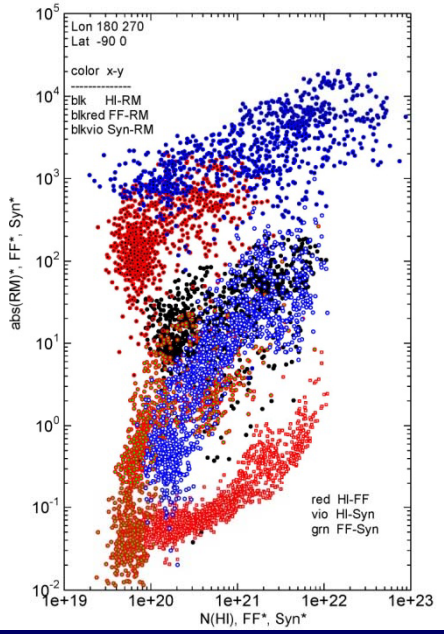
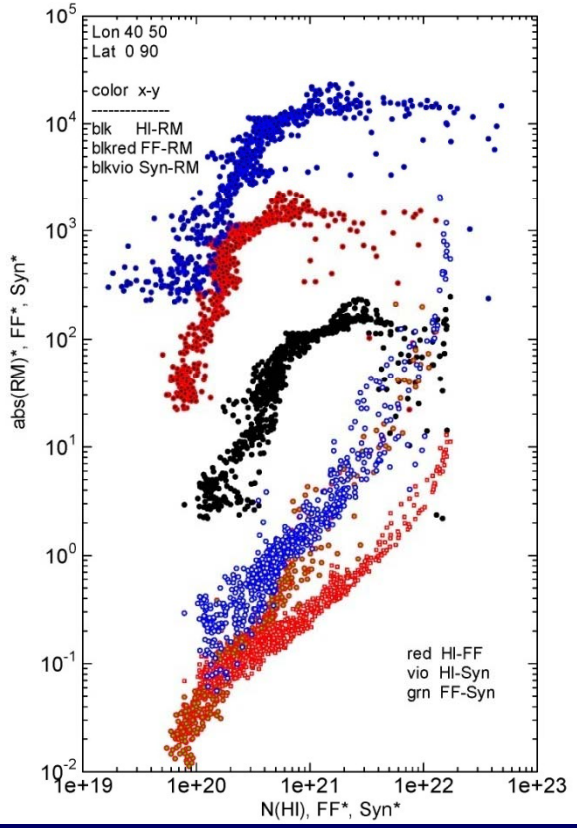
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*


Lon 180 270
Lat -90 0
color x-y
blk HI-RM
blkred FF-RM
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*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Lat 0 90
color x-y
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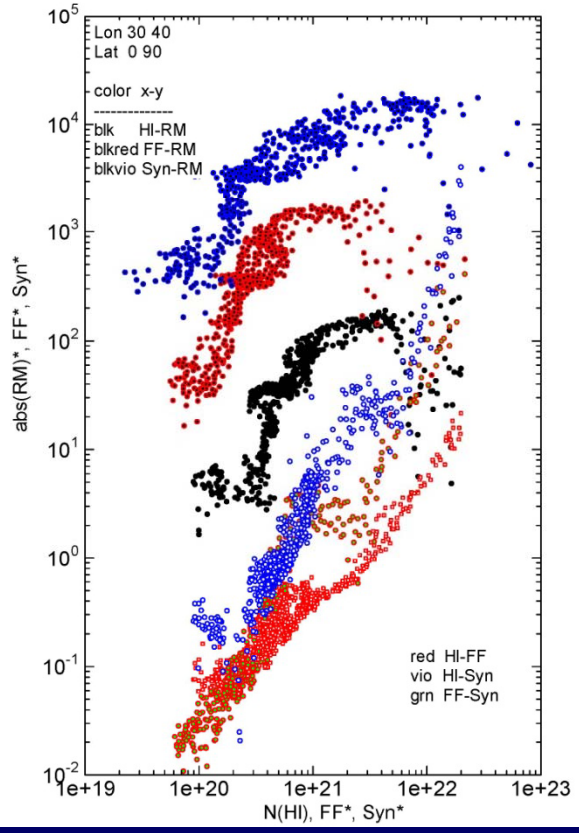
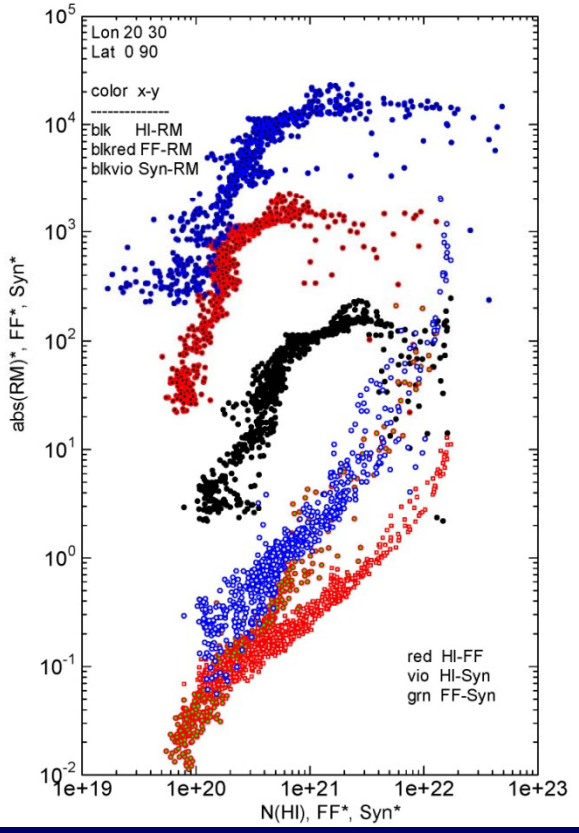
blkred FF-RM
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*


Lon 30 40
Lat 0 90
color x-y
blk HI-RM
blkred FF-RM
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*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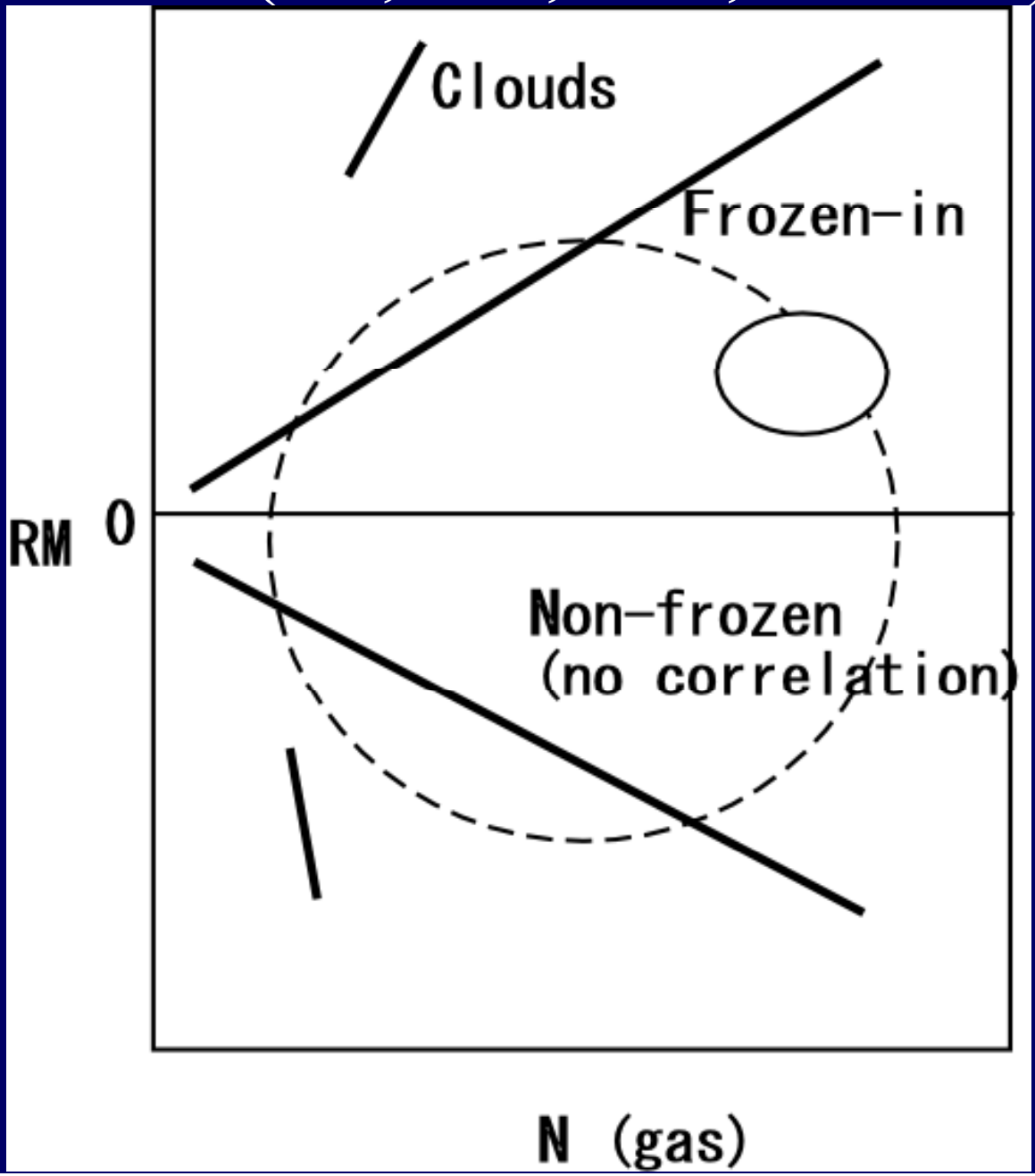
Lat 0 90
color x-y
blk HI-RM
blkred FF-RM
blkvio Syn-RM
red HI-FF
vio HI-Syn
grn FF-Syn
abs(RM)*, FF*, Syn*
N(HI), FF*, Syn*

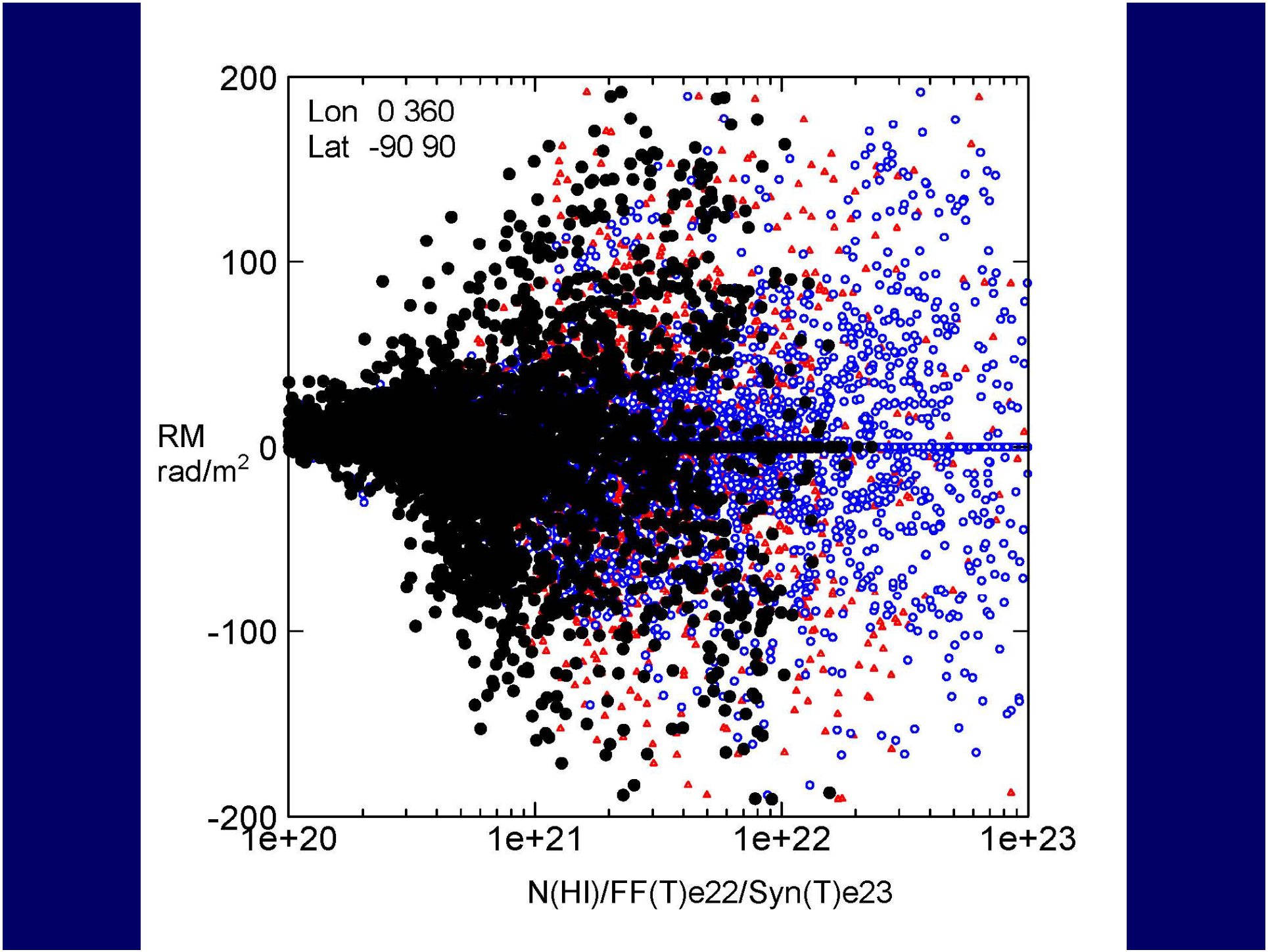
3. RM vs HI

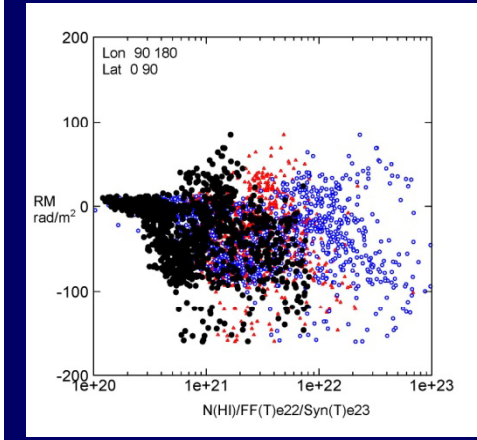
Ordered B / Turbulent B,

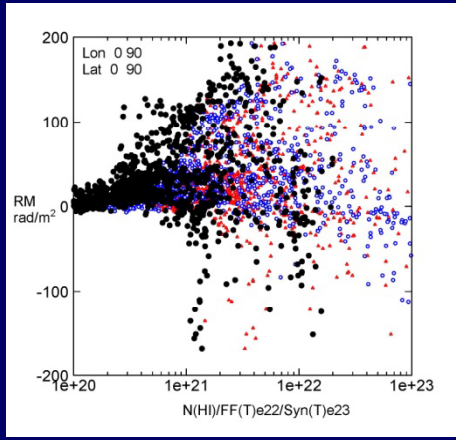
Local B reversals

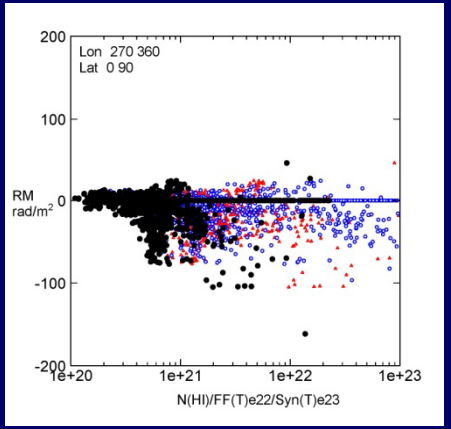
RM vs Gas (HI, H2, HII, COBE) plot

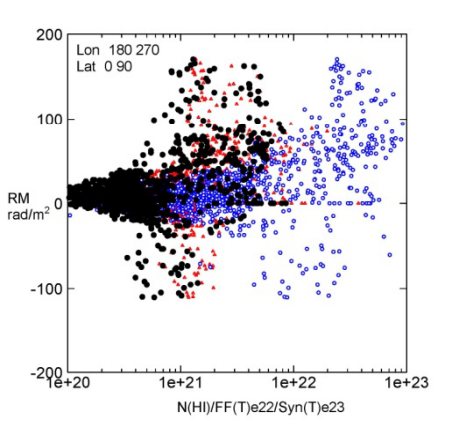


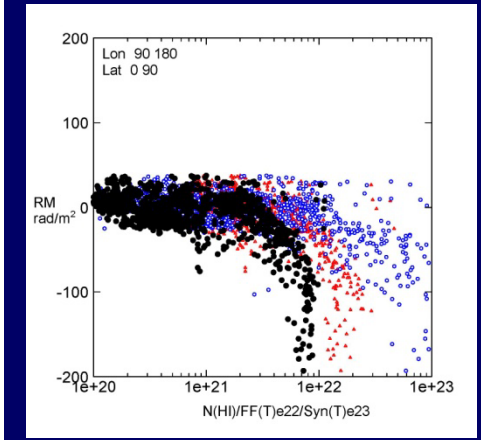

Lon 0 360
Lat -90 90
200
100
0
-100
-200
RM
rad/m2
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

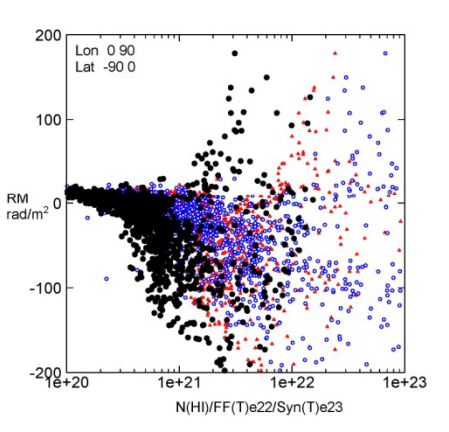

Lon 90 180
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

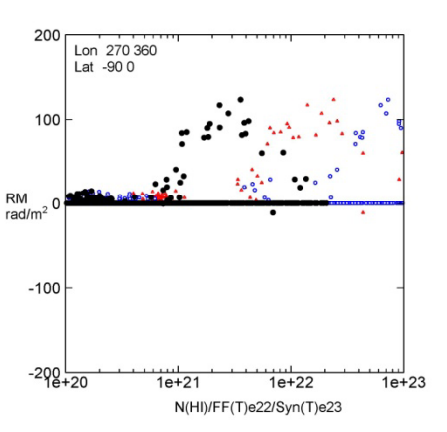

Lon 0 90
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

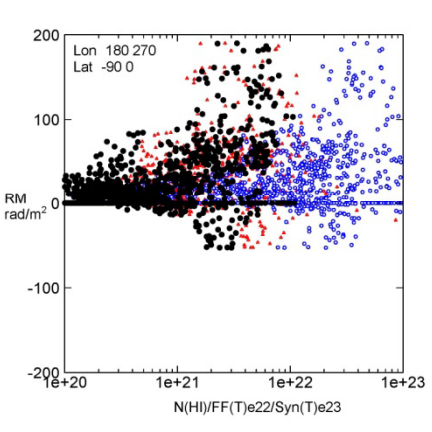

Lon 270 360
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

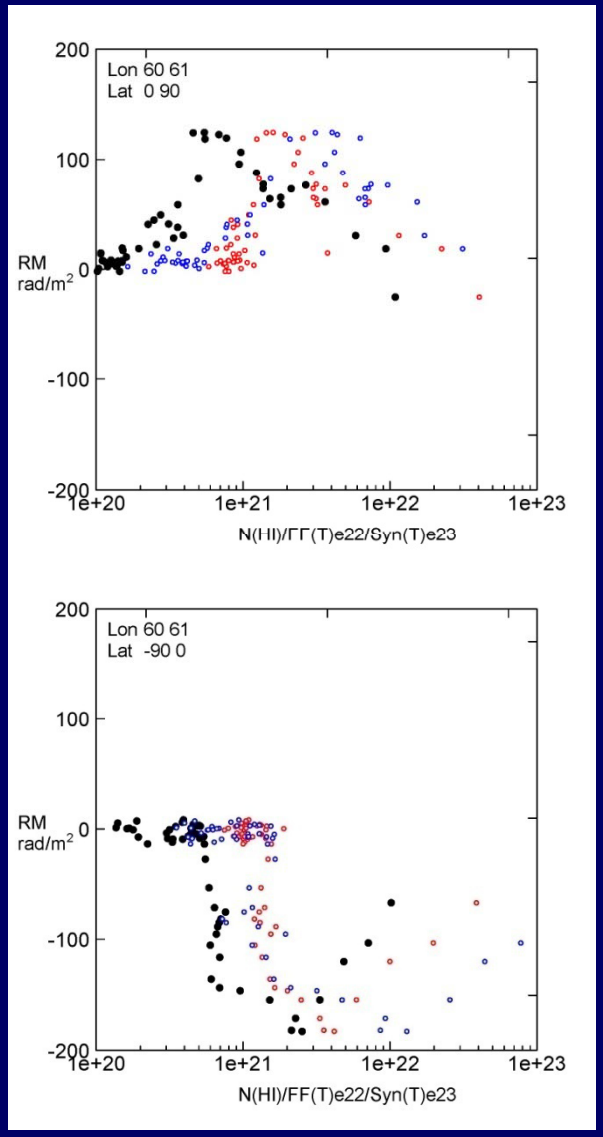

Lon 180 270
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

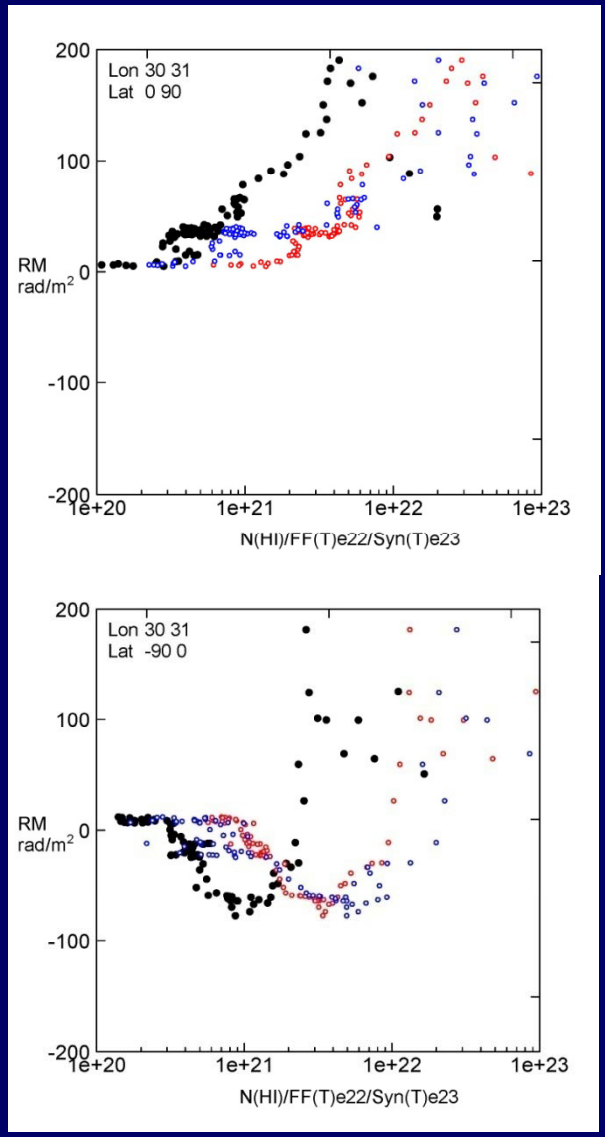

Lon 90 180
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

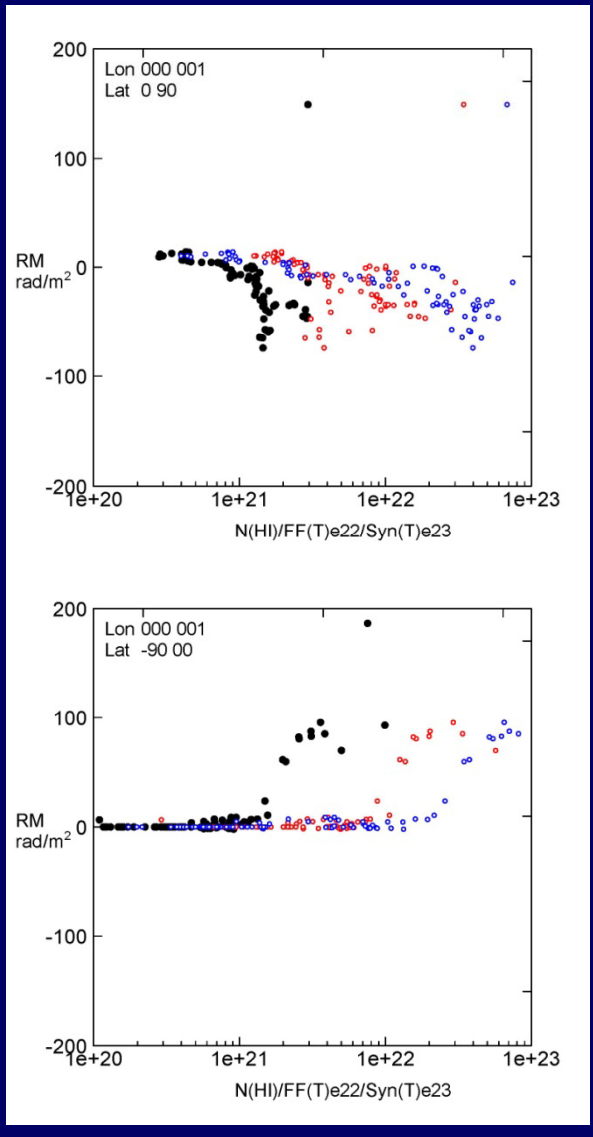

Lon 0 90
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23


Lon 270 360
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23


Lon 180 270
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23


Lon 60 61
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

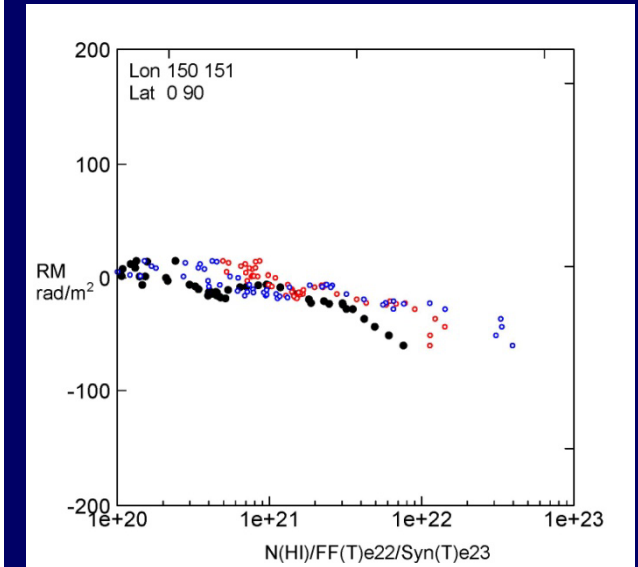

Lon 30 31
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

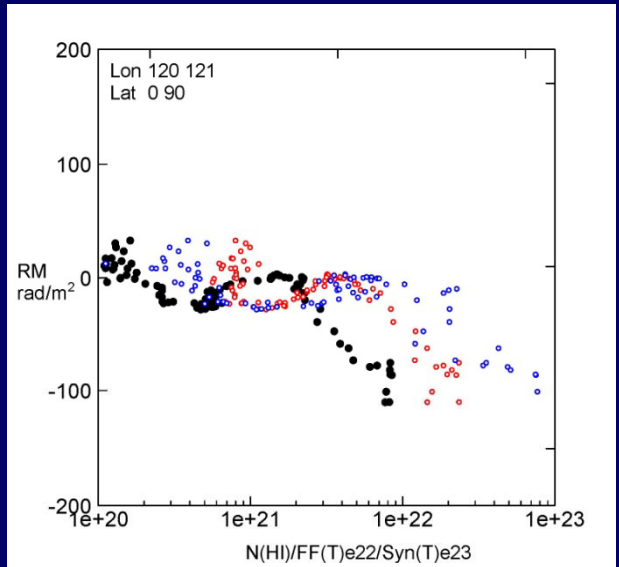

Lon 000 001
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

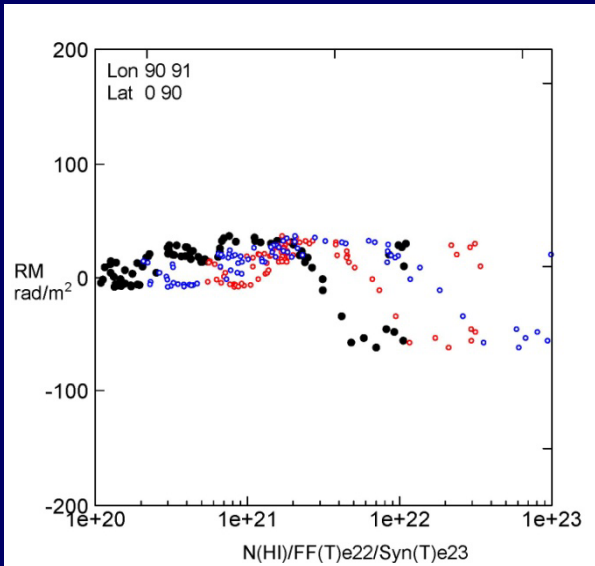
Lon 60 61
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

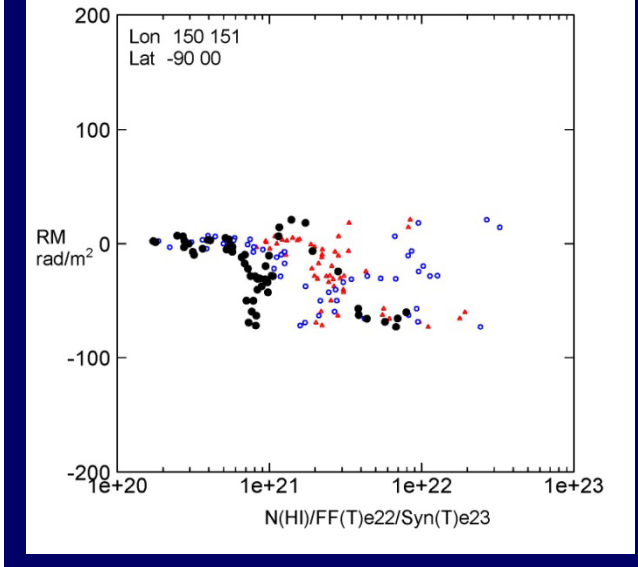
Lon 30 31
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

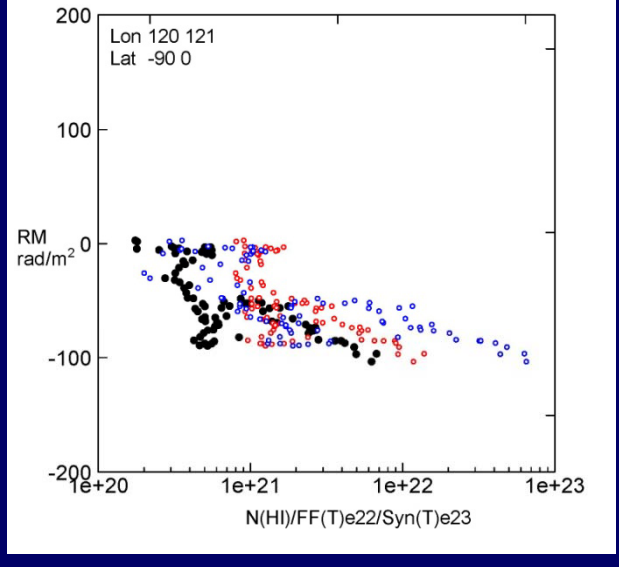
Lon 000 001
Lat -90 00
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

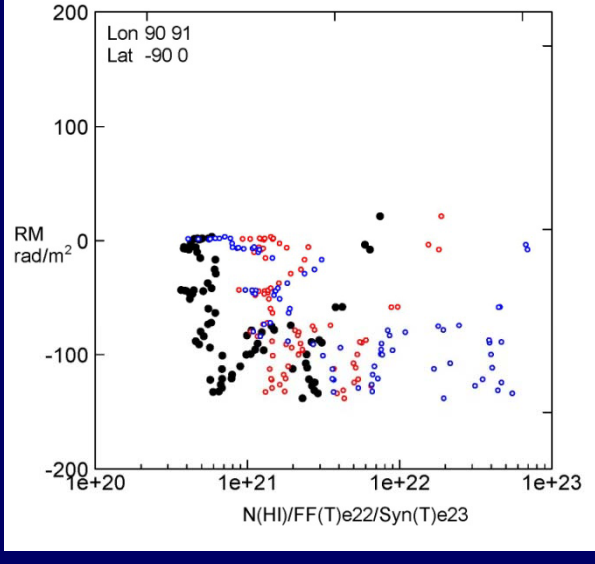

Lon 150 151
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

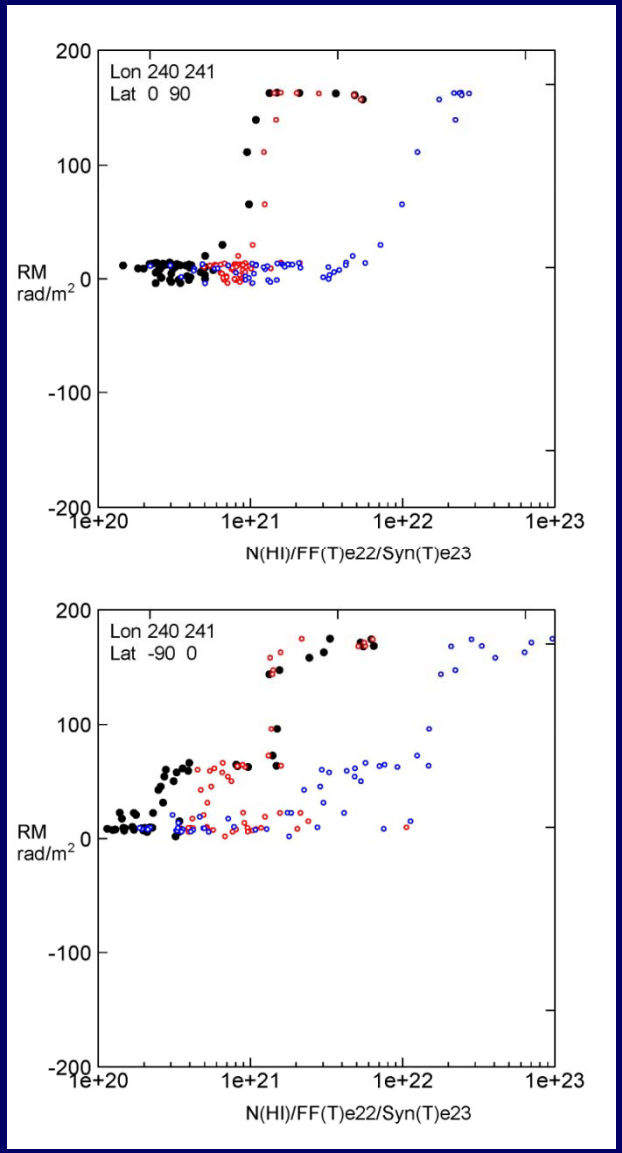

Lon 120 121
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

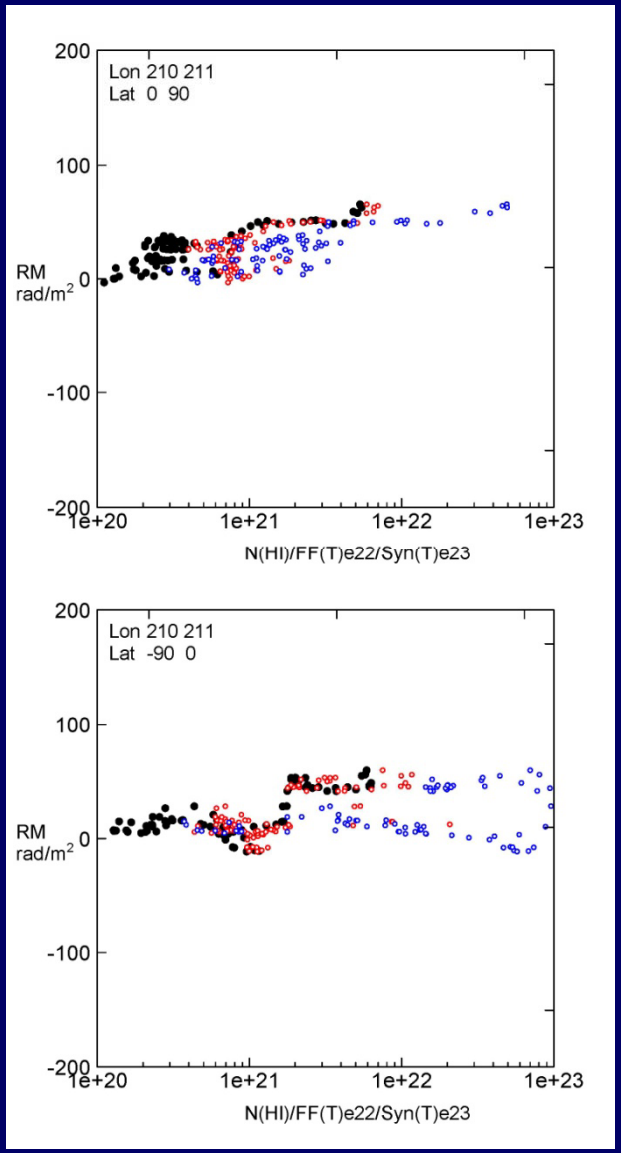

Lon 90 91
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

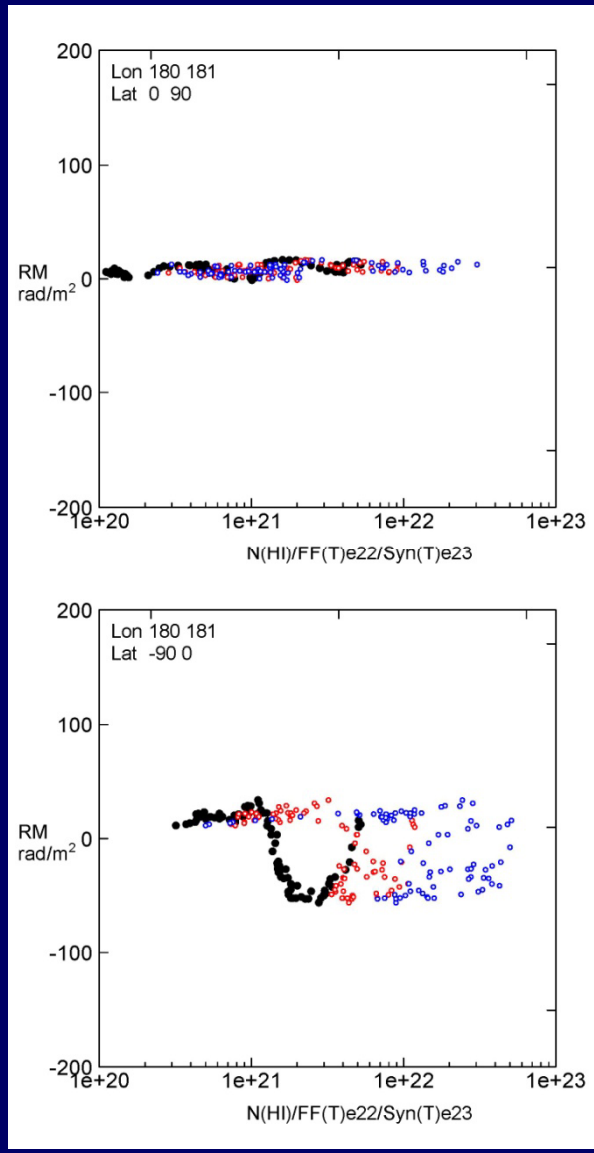

Lon 150 151
Lat -90 00
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23


Lon 120 121
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23


Lon 90 91
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23


Lon 240 241
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

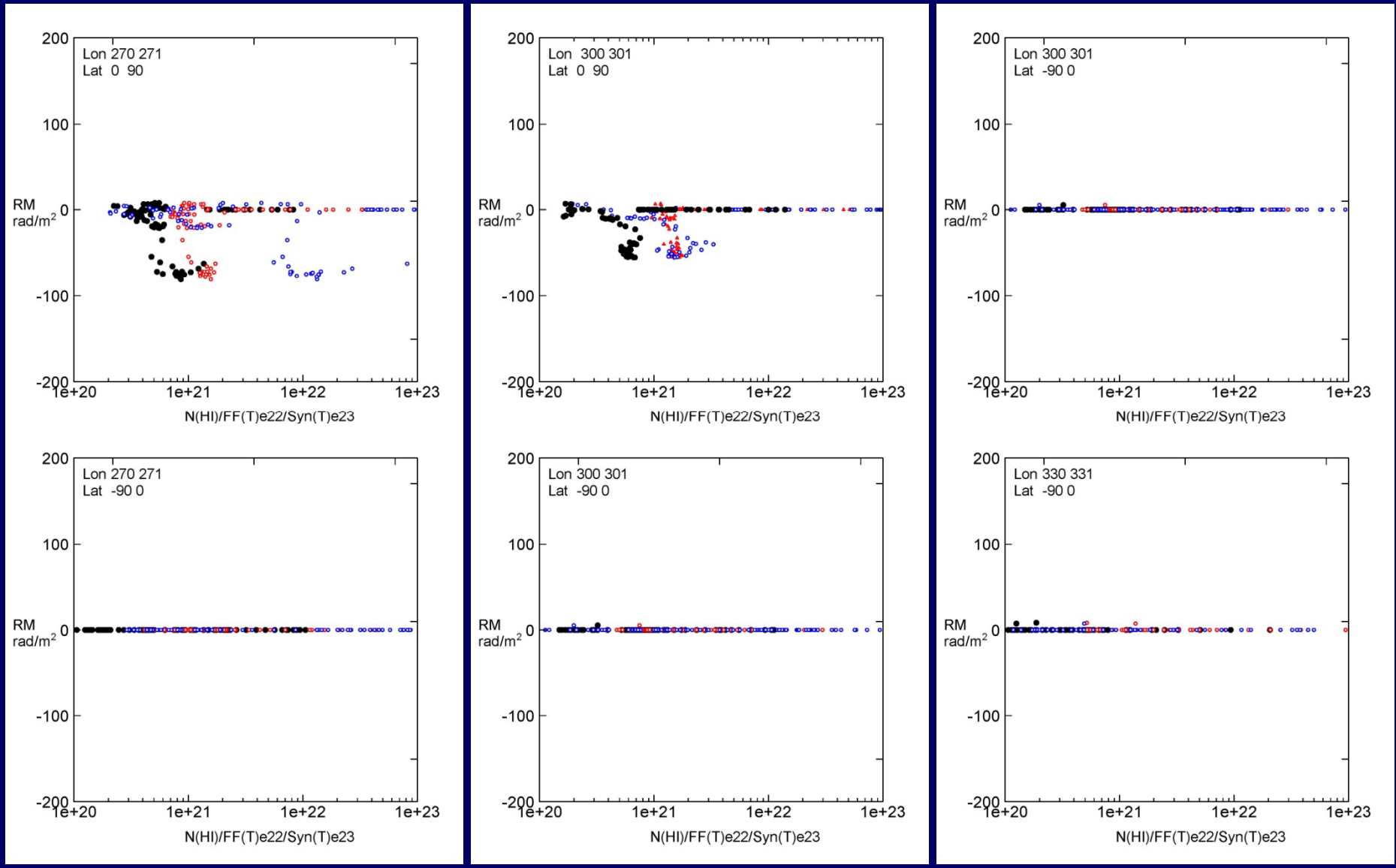

Lon 210 211
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

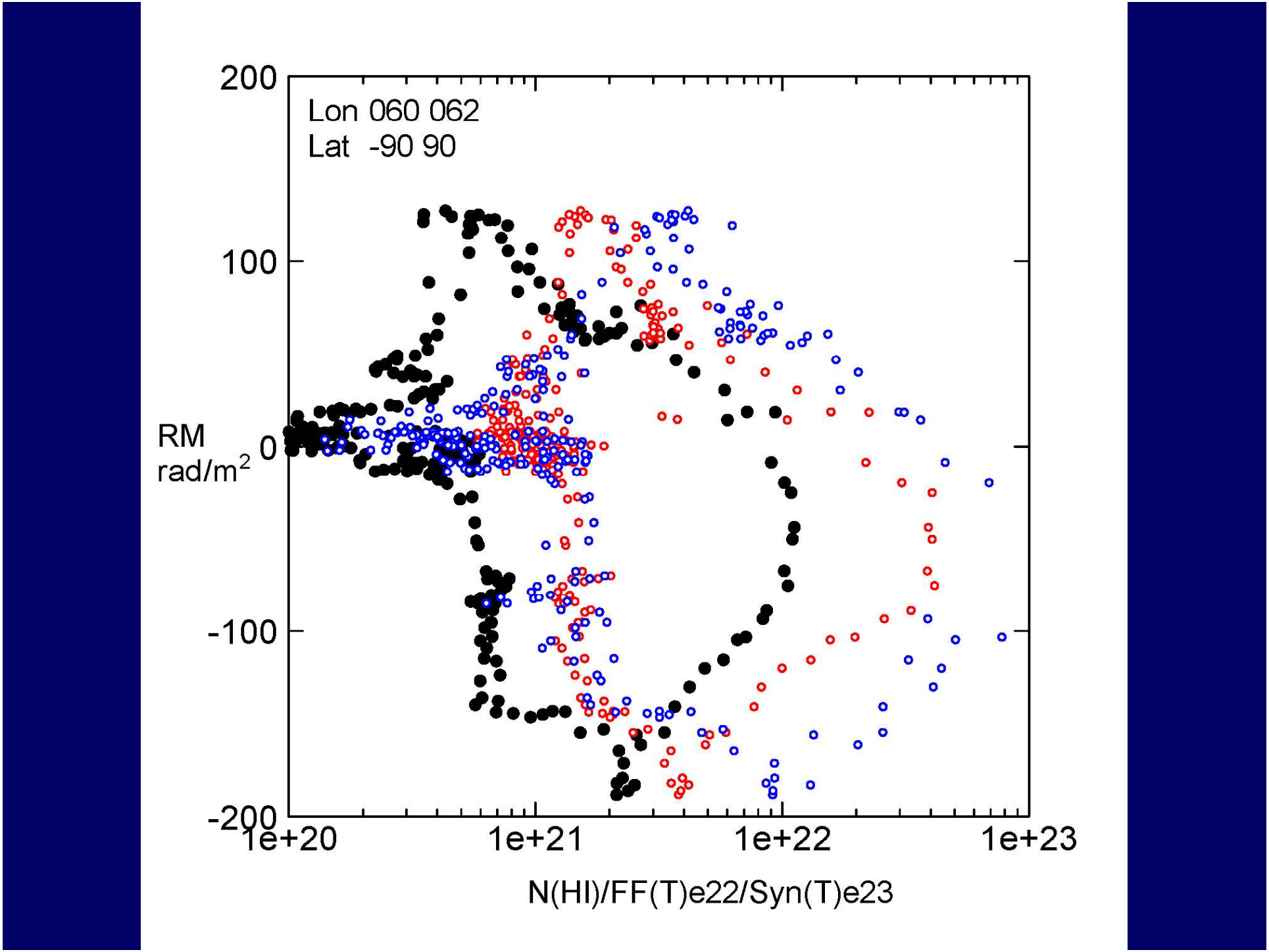

Lon 180 181
Lat 0 90
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

Lon 240 241
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

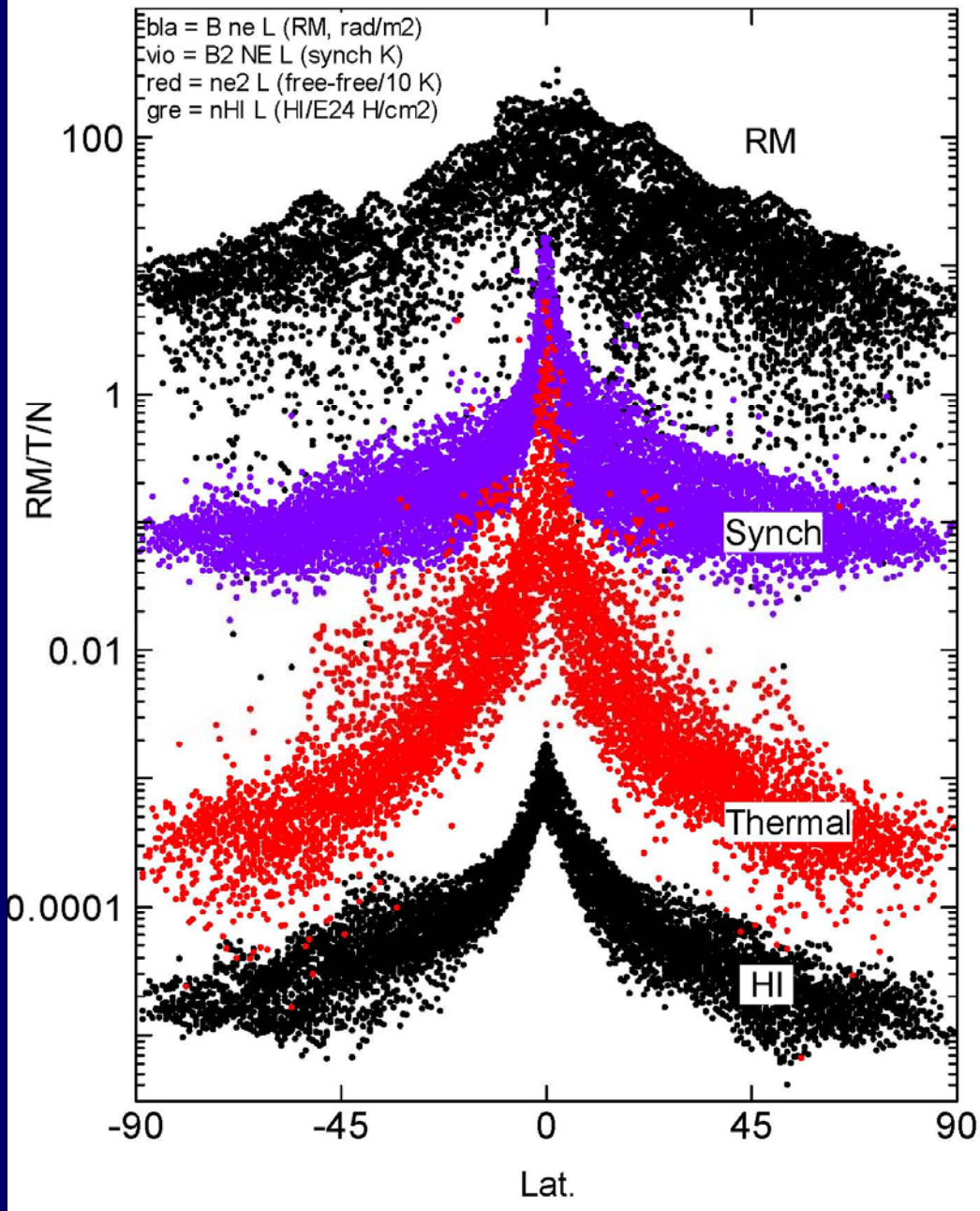
Lon 210 211
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

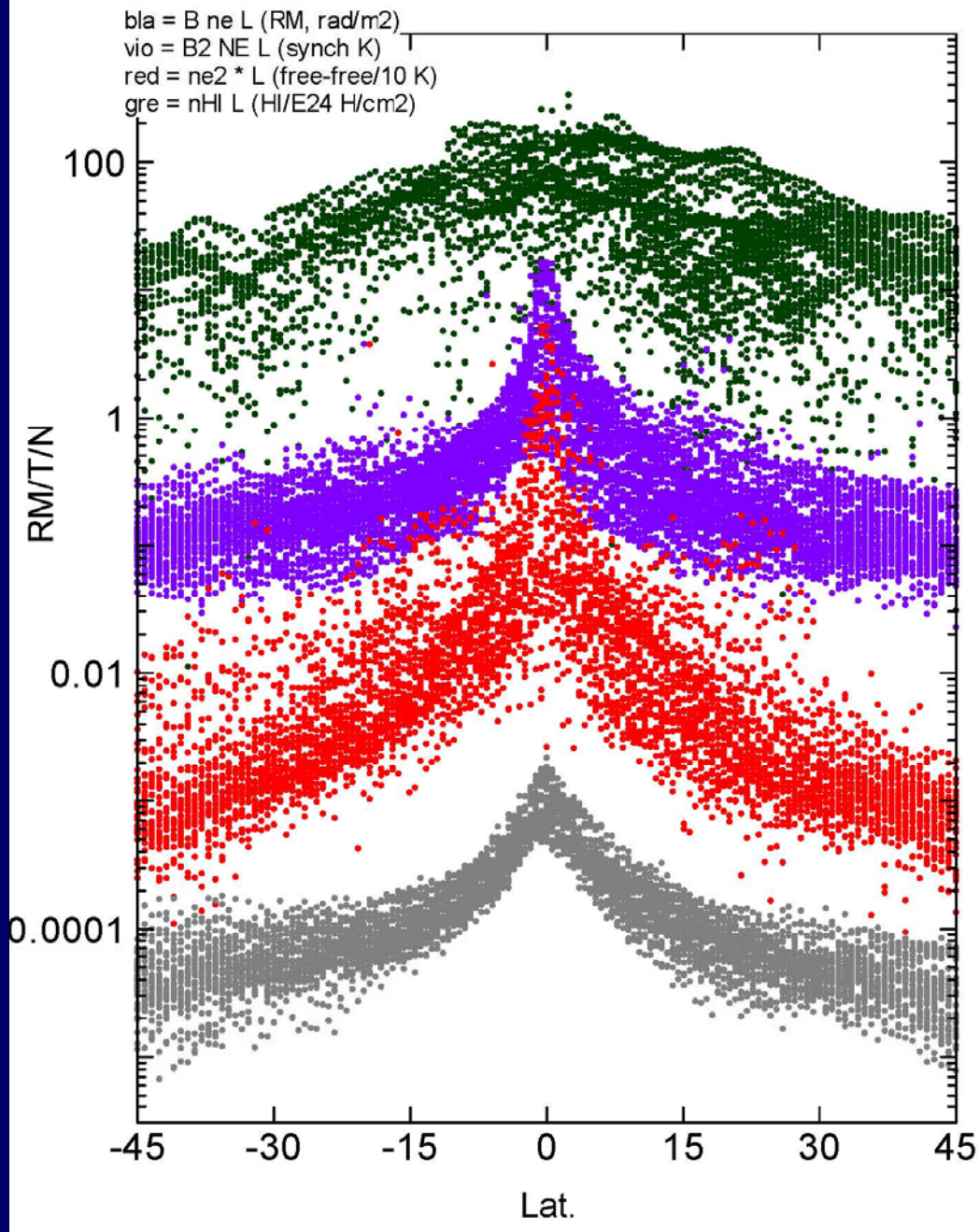
Lon 180 181
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23


Lon 270 271
Lat 0 90
Lon 300 301
Lat 0 90
Lon 300 301
Lat -90 0
Lon 270 271
Lat -90 0
Lon 300 301
Lat -90 0
Lon 330 331
Lat -90 0
RM
rad/m2
200
100
0
-100
-200
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

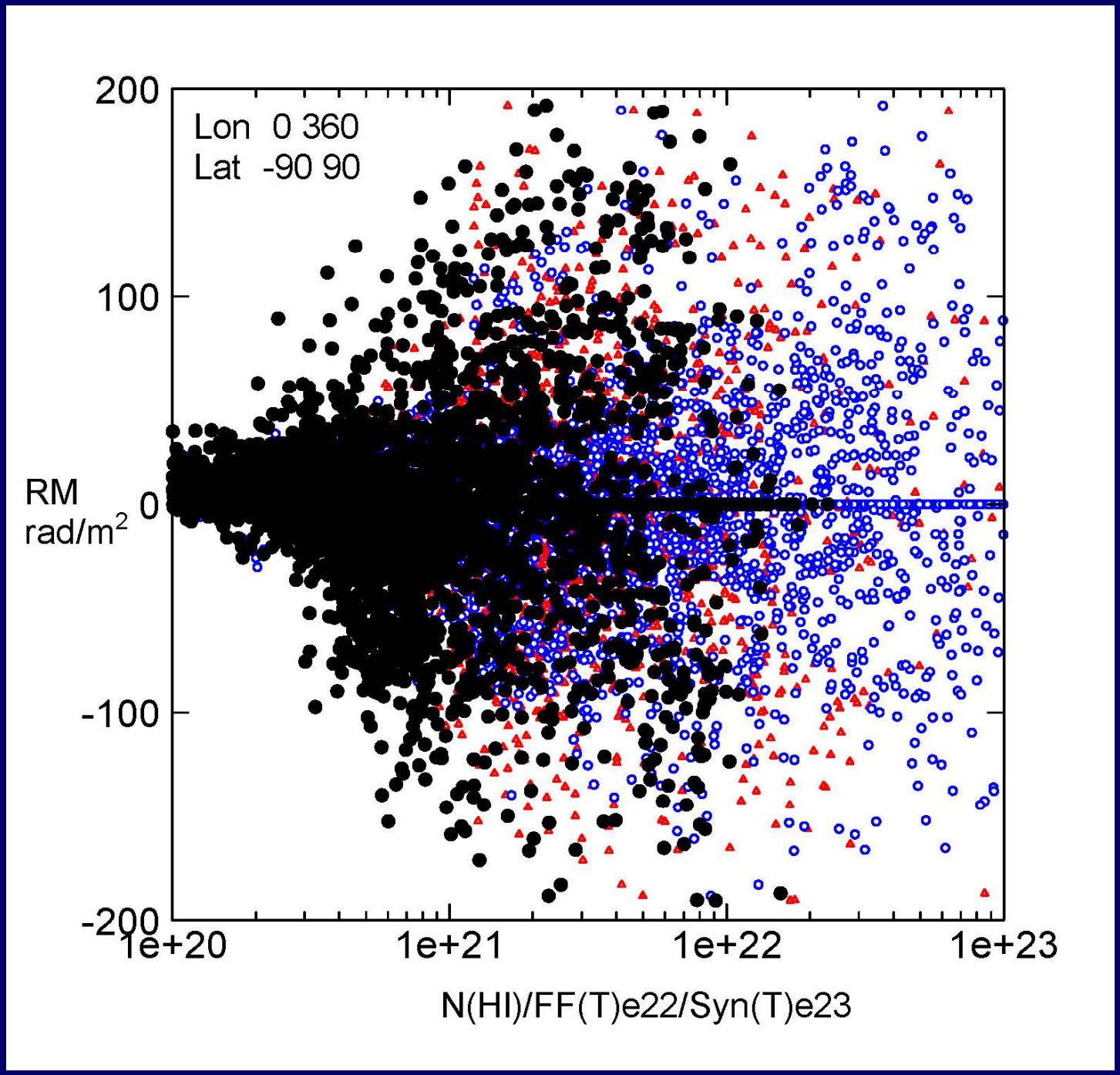

Lon 060 062
Lat -90 90
200
100
0
-100
-200
RM
rad/m2
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

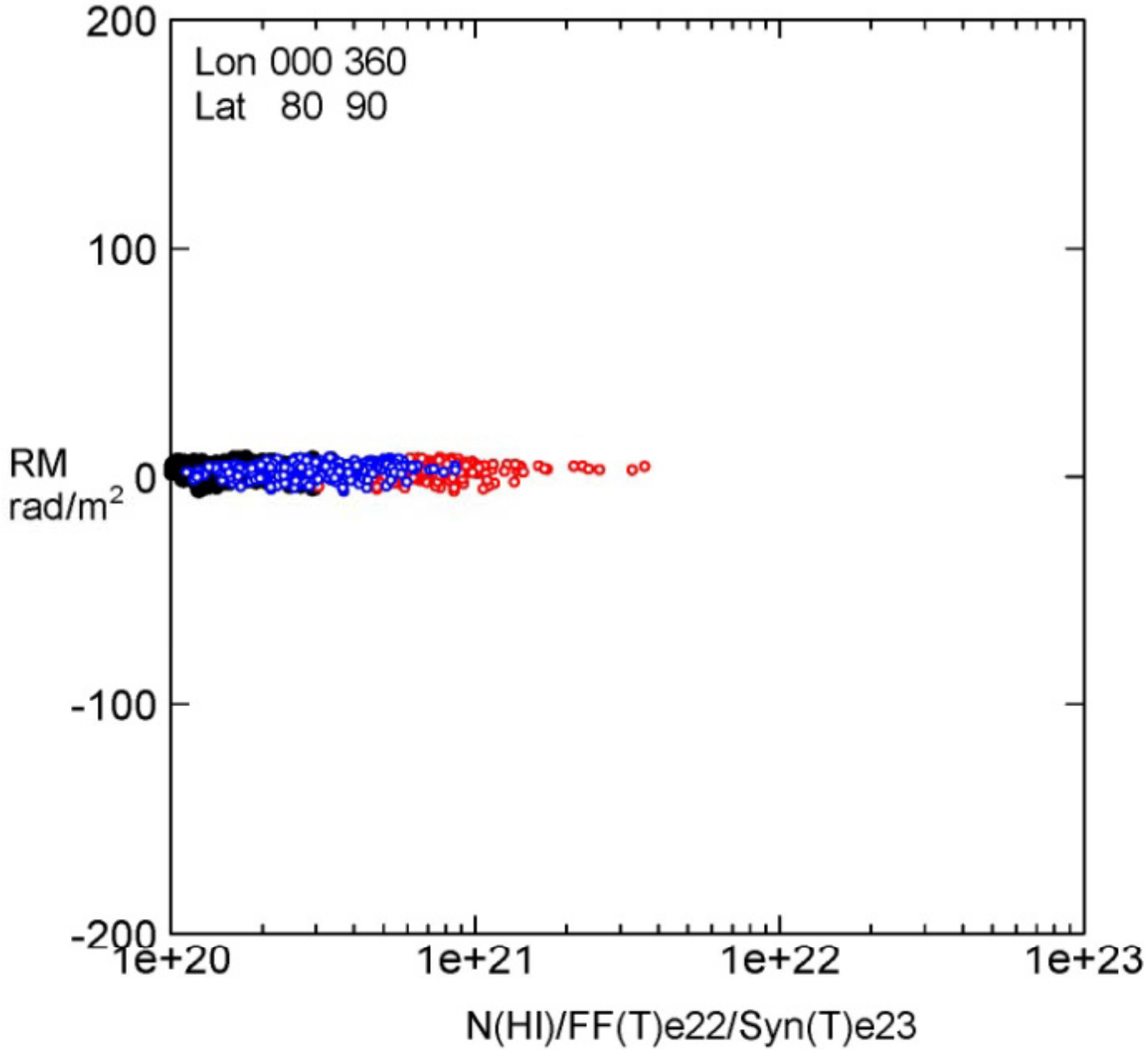
4. RM, HI, FF, Syn vs Latitude

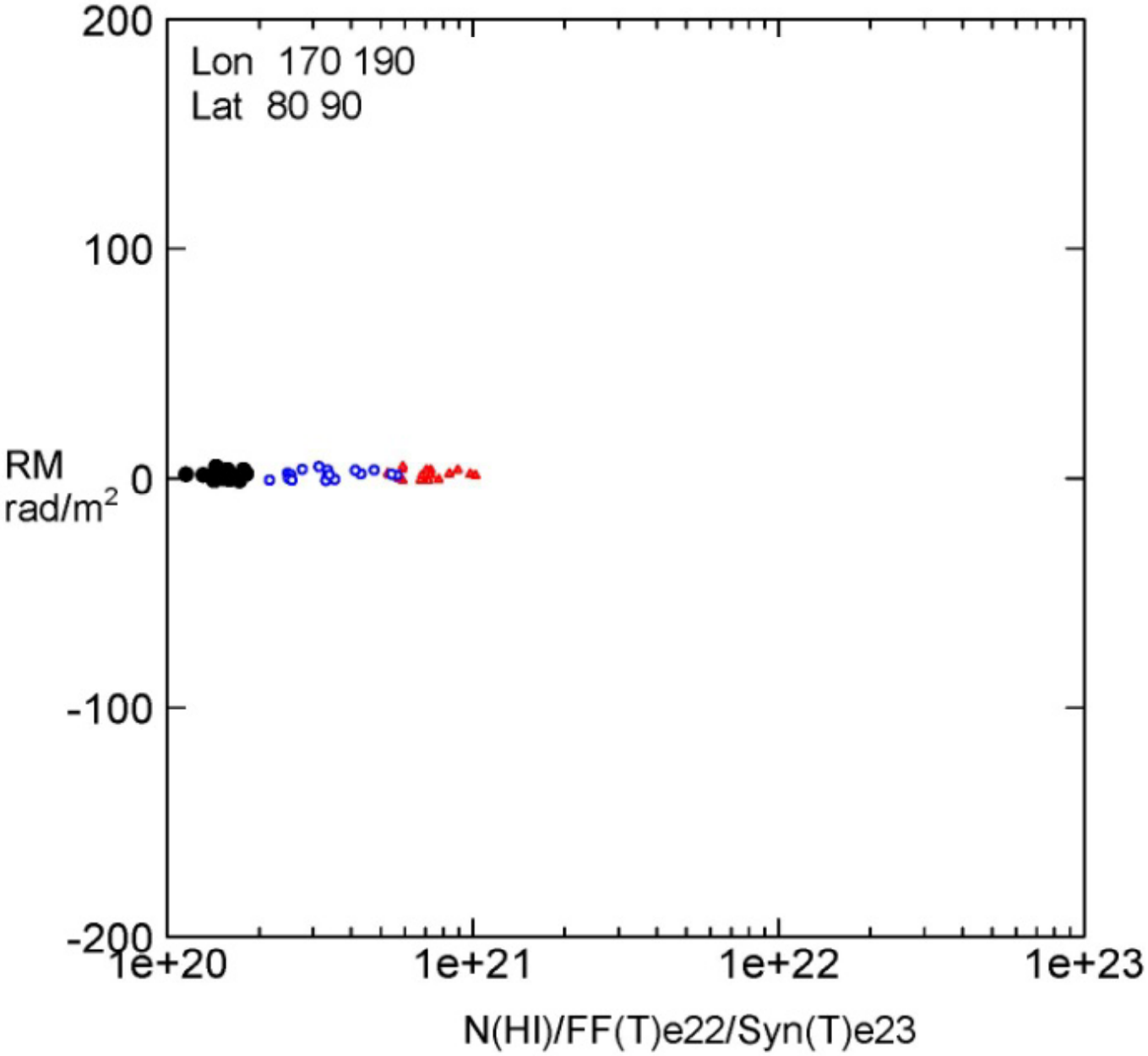

bla = B ne L (RM, rad/m2)
vio = B2 NE L (synch K)
red = ne2 L (free-free/10 K)
gre = nHI L (HI/E24 H/cm2)
100
1
0.01
0.0001
RM/T/N
RM
Synch
Thermal
HI
-90
-45
0
45
90
Lat.


bla = B ne L (RM, rad/m2)
vio = B2 NE L (synch K)
red = ne2 * L (free-free/10 K)
gre = nHI L (HI/E24 H/cm2)
100
1
0.01
0.0001
RM/T/N
-45
-30
-15
0
15
30
45
Lat.

5. Window for Cosmology


Lon 0 360
Lat -90 90
200
100
0
-100
-200
RM
rad/m2
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23


Lon 000 360
Lat 80 90
200
100
0
-100
-200
RM
rad/m²
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23


Lon 170 190
Lat 80 90
200
100
0
-100
-200
RM
rad/m2
1e+20
1e+21
1e+22
1e+23
N(HI)/FF(T)e22/Syn(T)e23

II.
Galactic Variation of RM

Data:

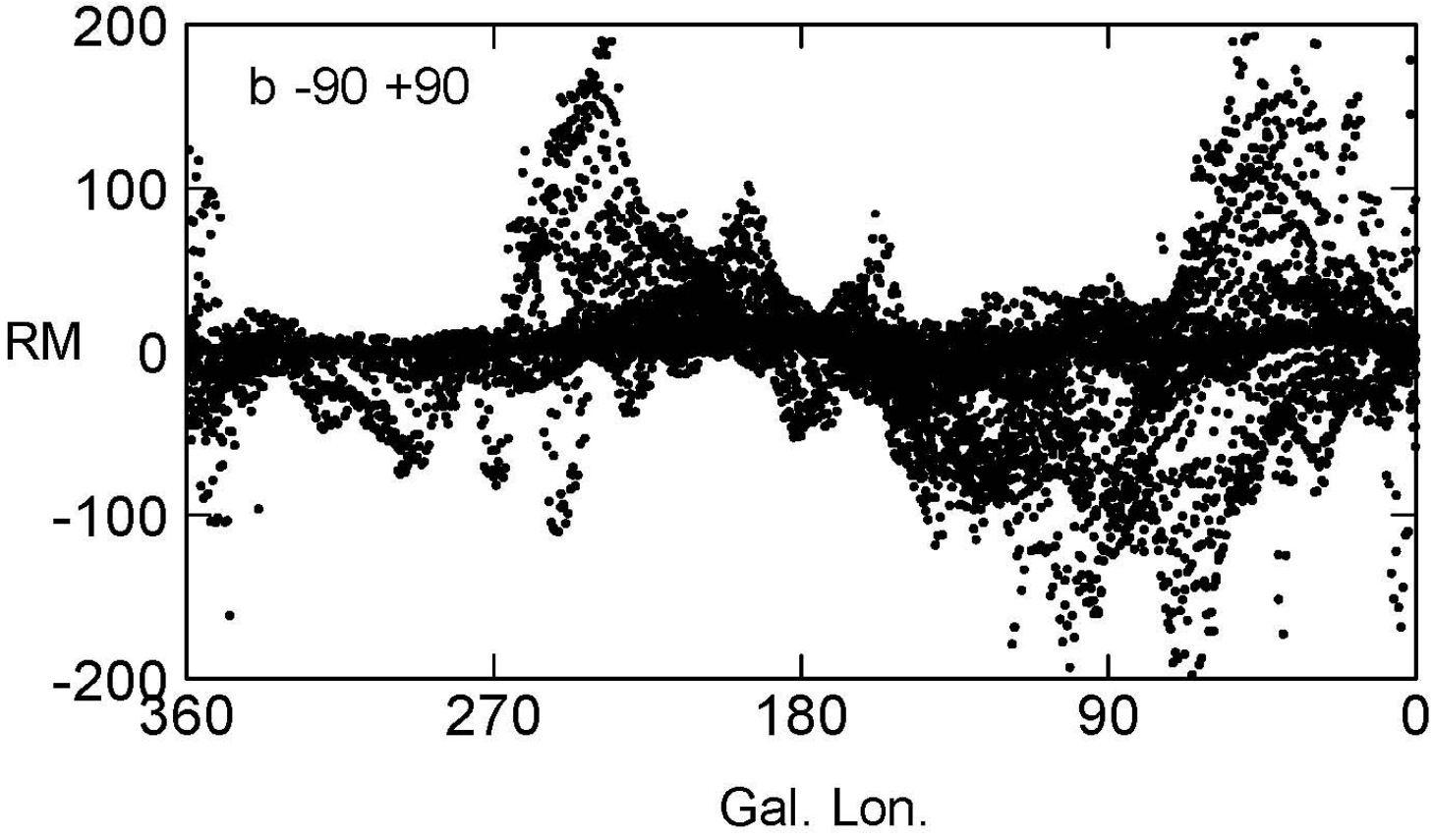
Taylor, et al. 2009

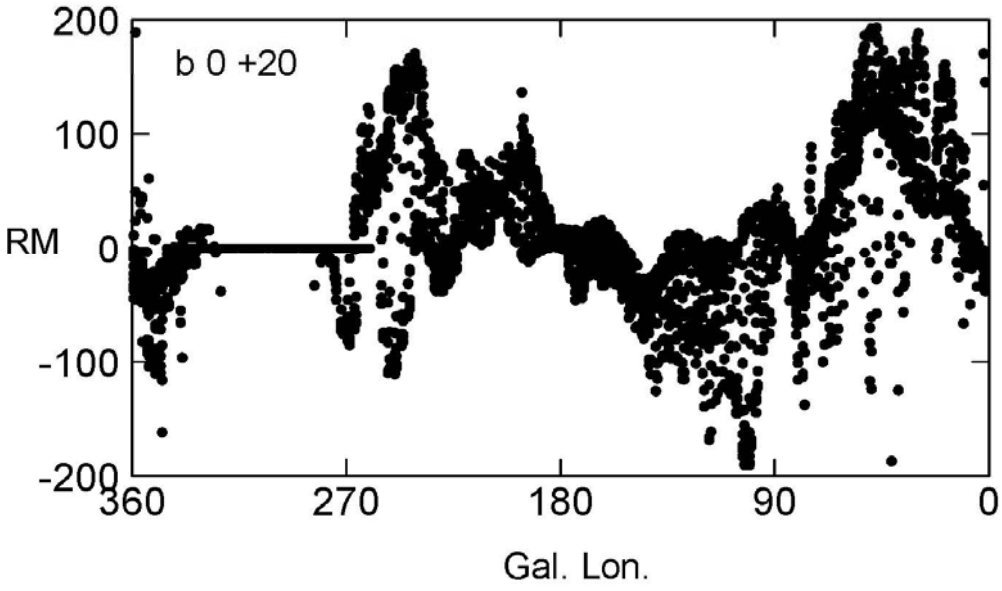
Kalbella et al. 2011

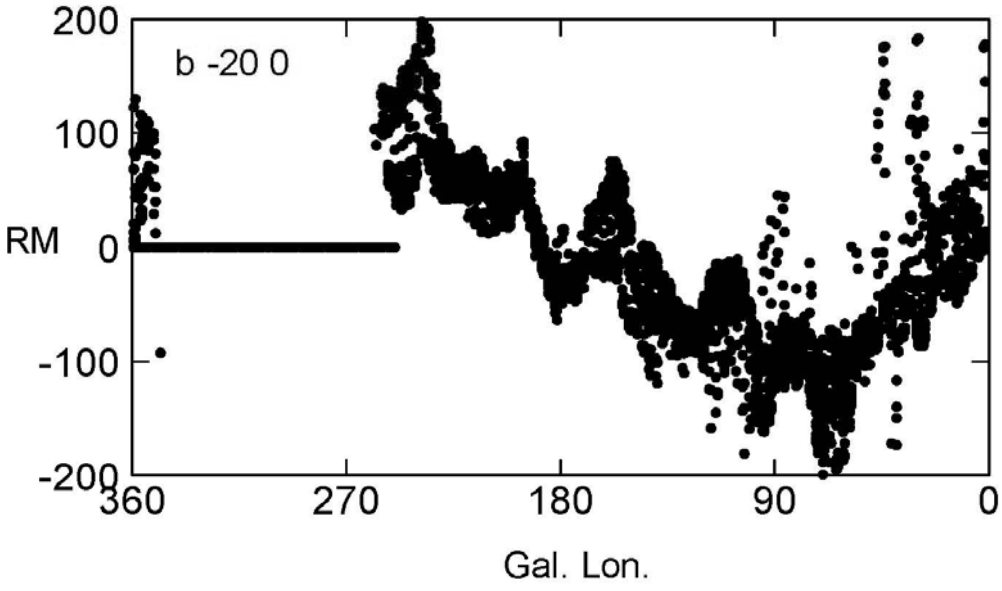
Tables

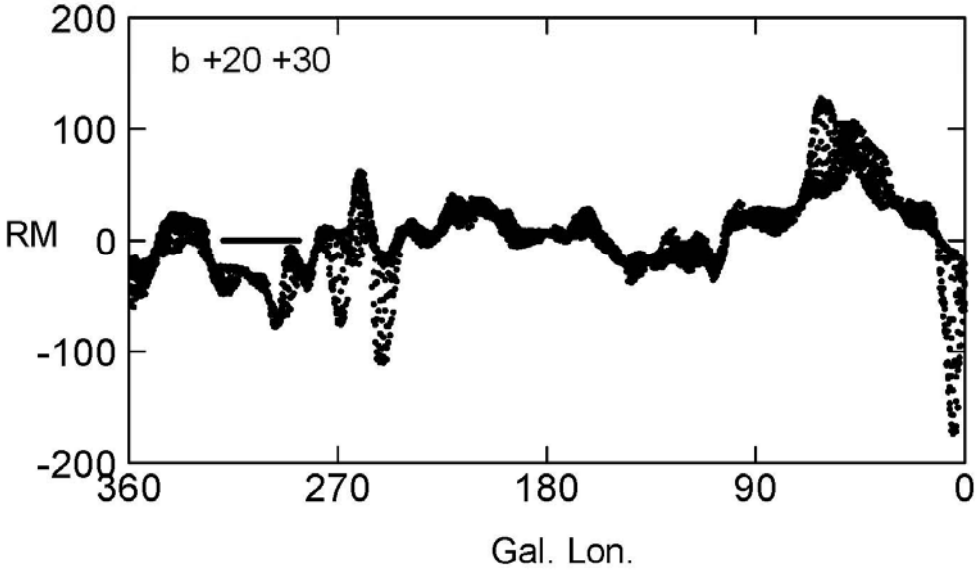
H. Nakanishi

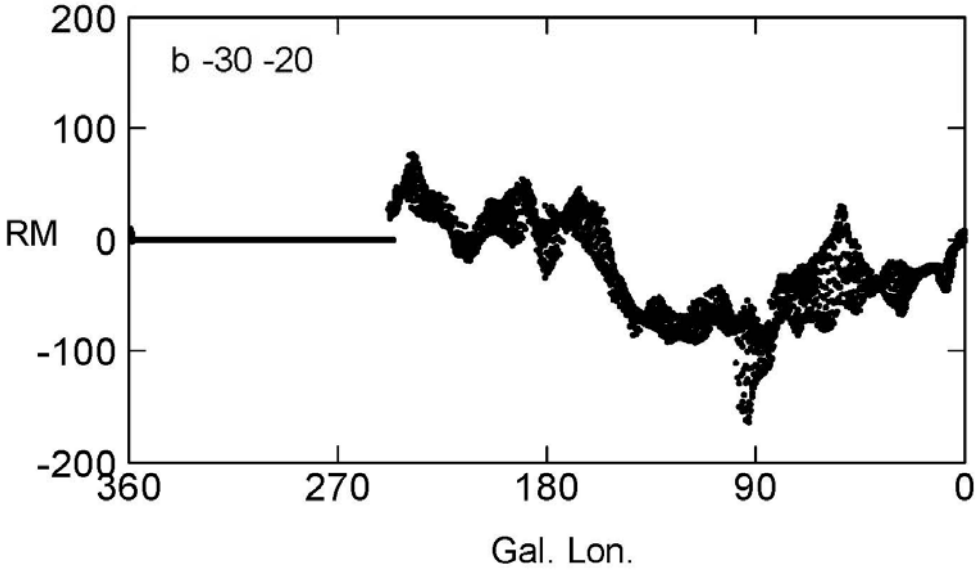
1. RM vs Longitude


b -90 +90
200
100
RM
0
-100
-200
360
270
180
90
0
Gal. Lon.

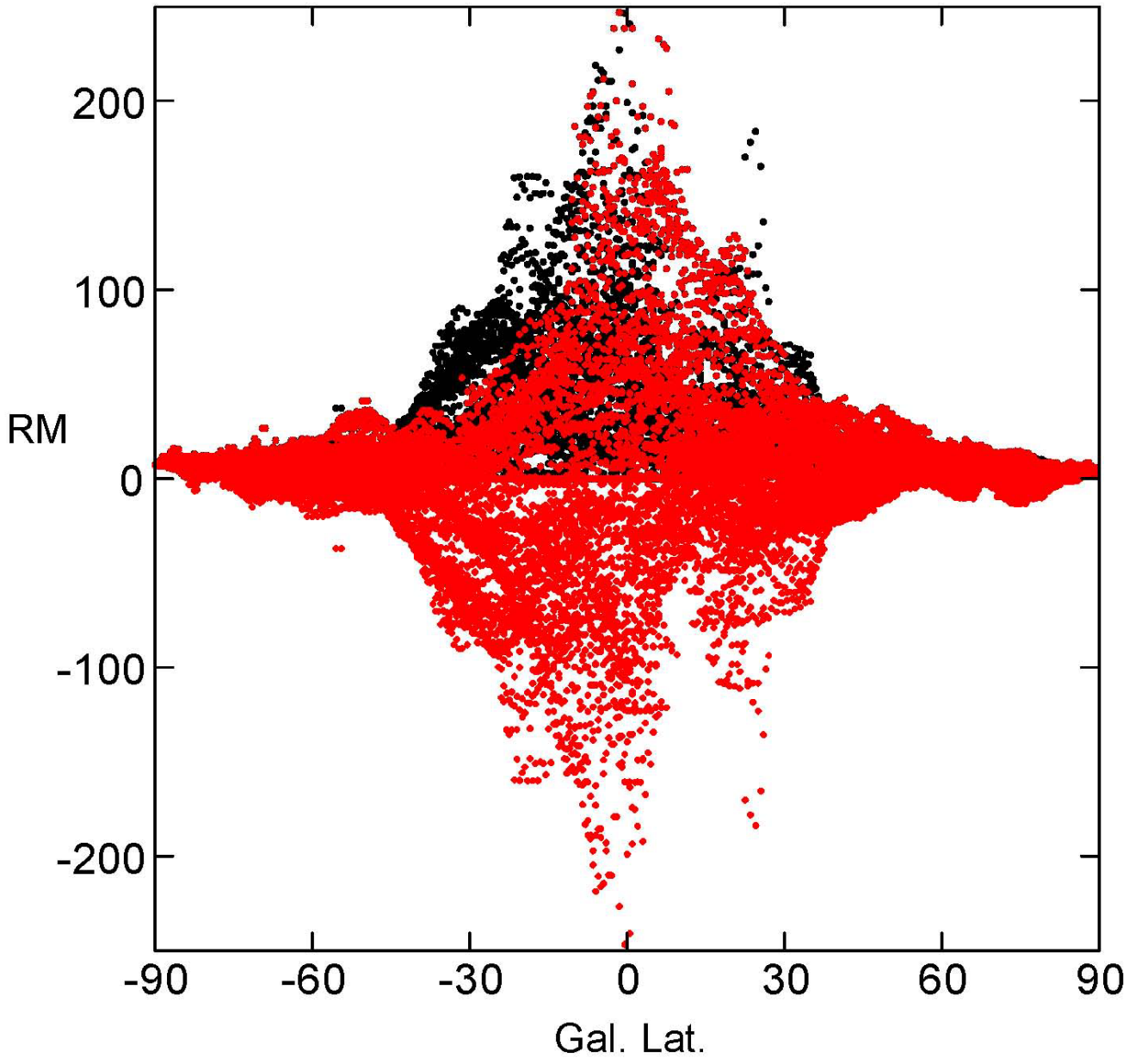

b 0 +20
200
100
0
-100
-200
RM
360
270
180
90
0
Gal. Lon.

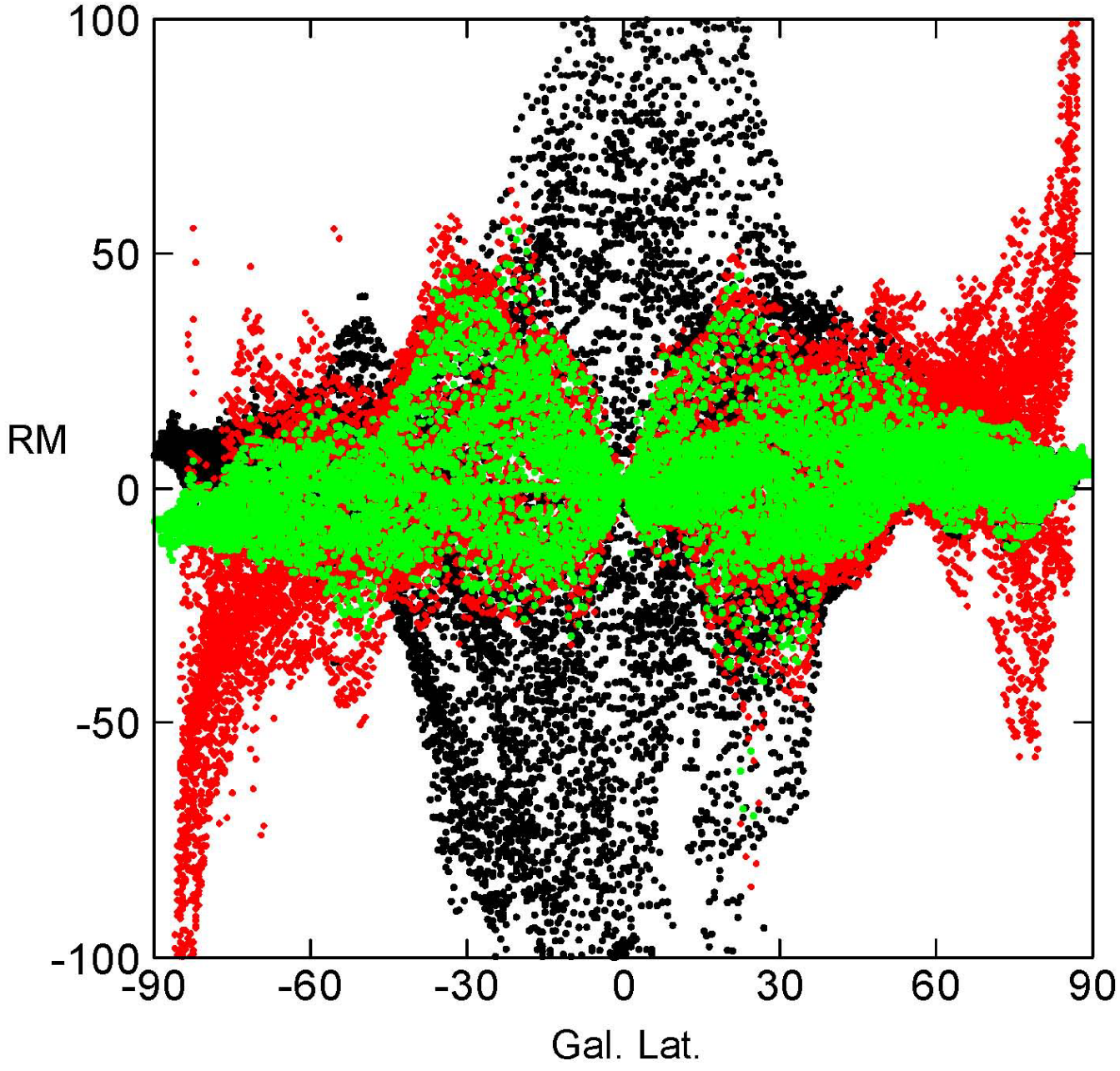

b -20 0
200
100
0
-100
-200
RM
360
270
180
90
0
Gal. Lon.

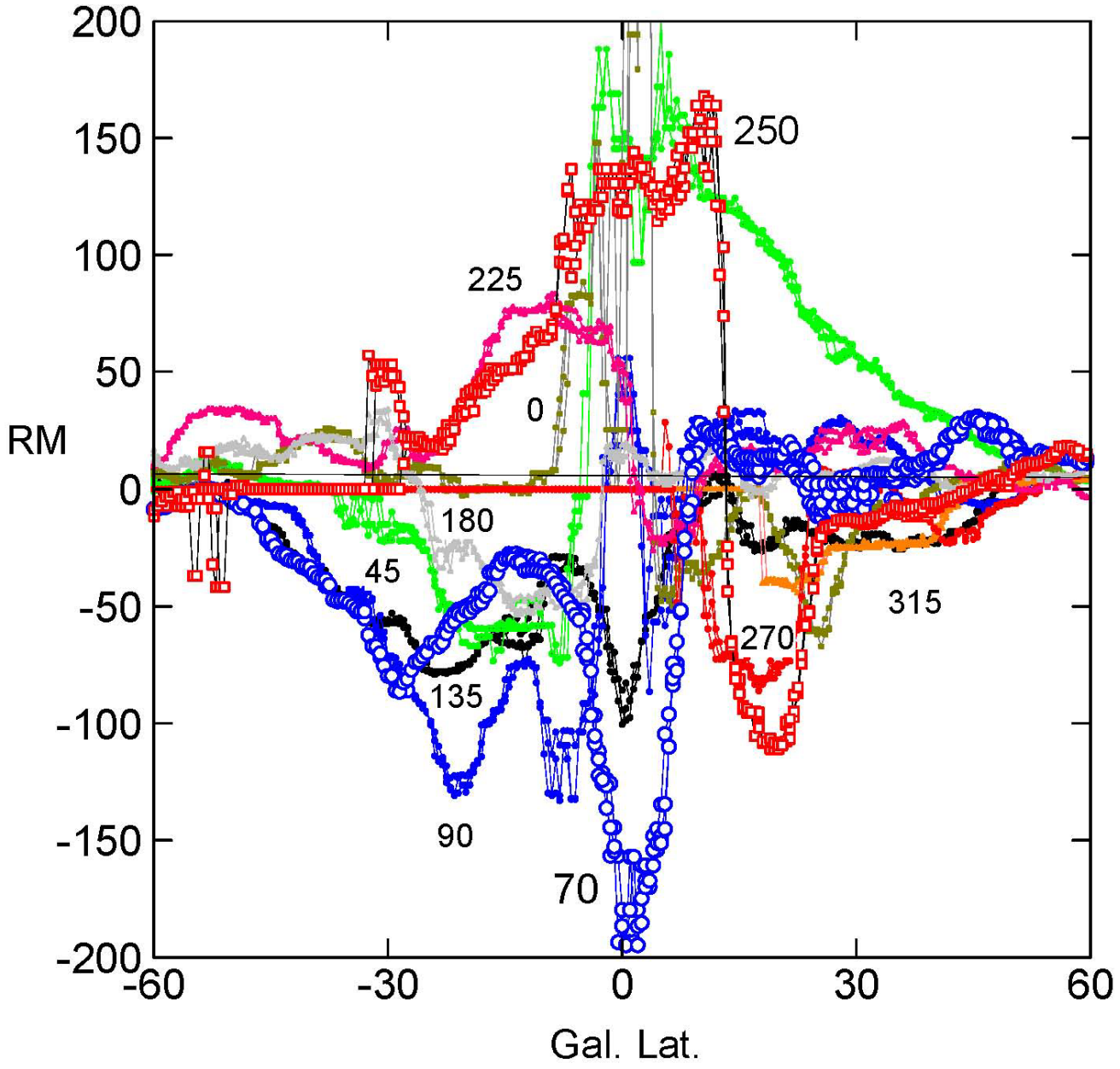

b +20 +30
200
100
0
-100
-200
RM
360
270
180
90
0
Gal. Lon.

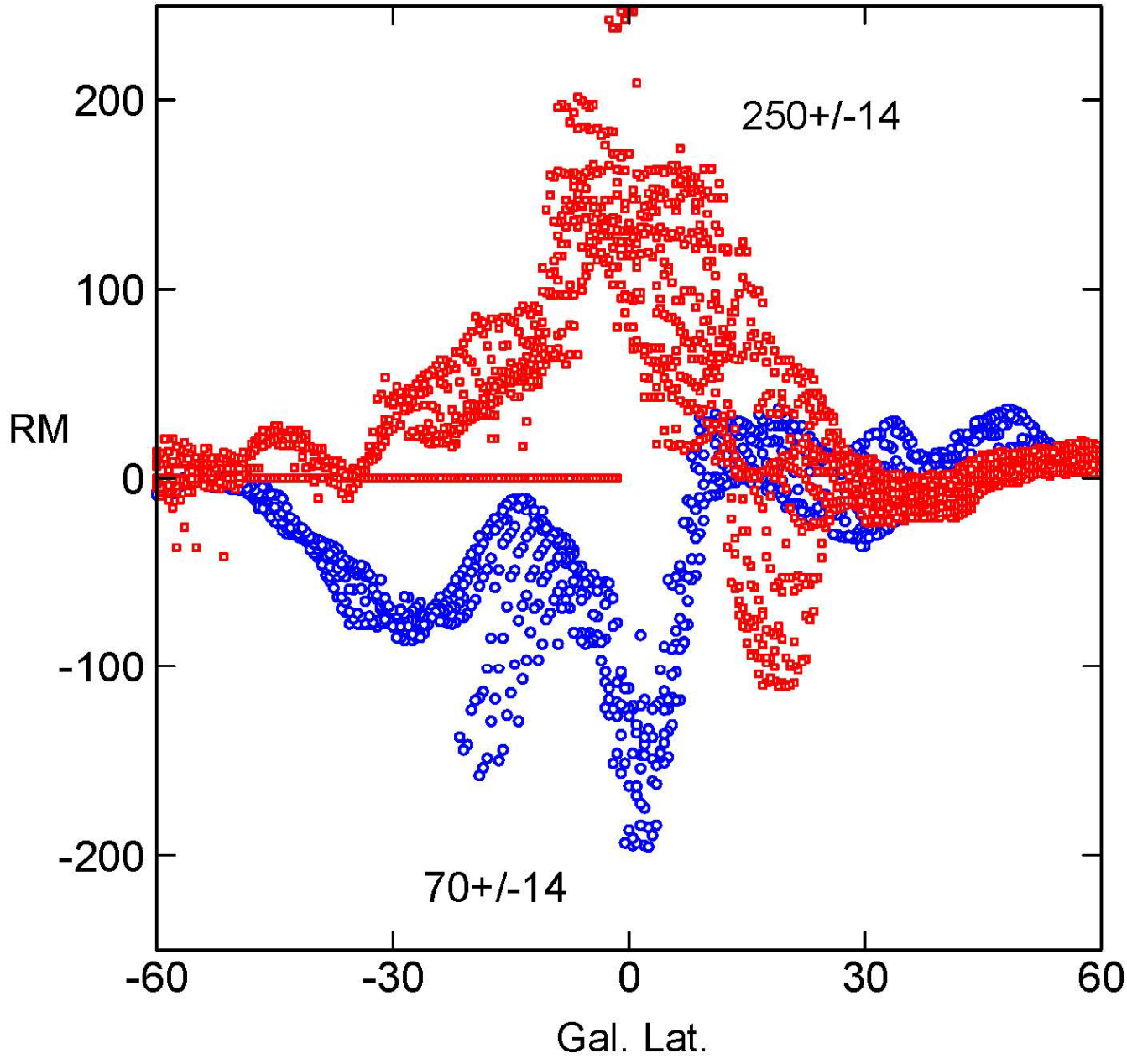

b -30 -20
200
100
0
-100
-200
RM
360
270
180
90
0
Gal. Lon.

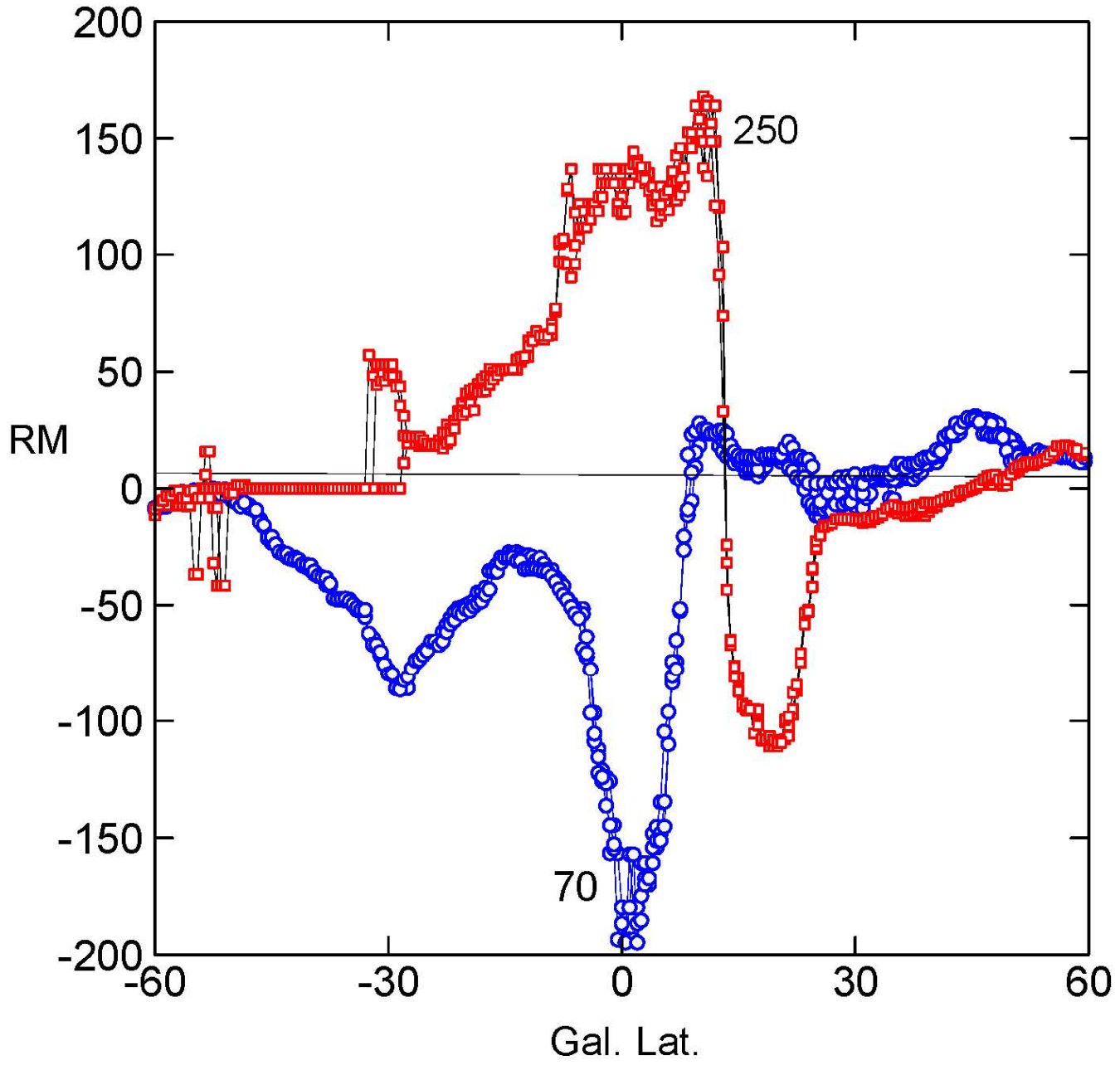
2. RM vs Latitude


200
100
0
-100
-200
RM
-90
-60
-30
0
30
60
90
Gal. Lat.


100
50
0
-50
-100
RM
-90
-60
-30
0
30
60
90
Gal. Lat.


200
150
100
50
0
-50
-100
-150
-200
RM
-60
-30
0
30
60
Gal. Lat.
250
225
0
180
45
315
270
135
90
70

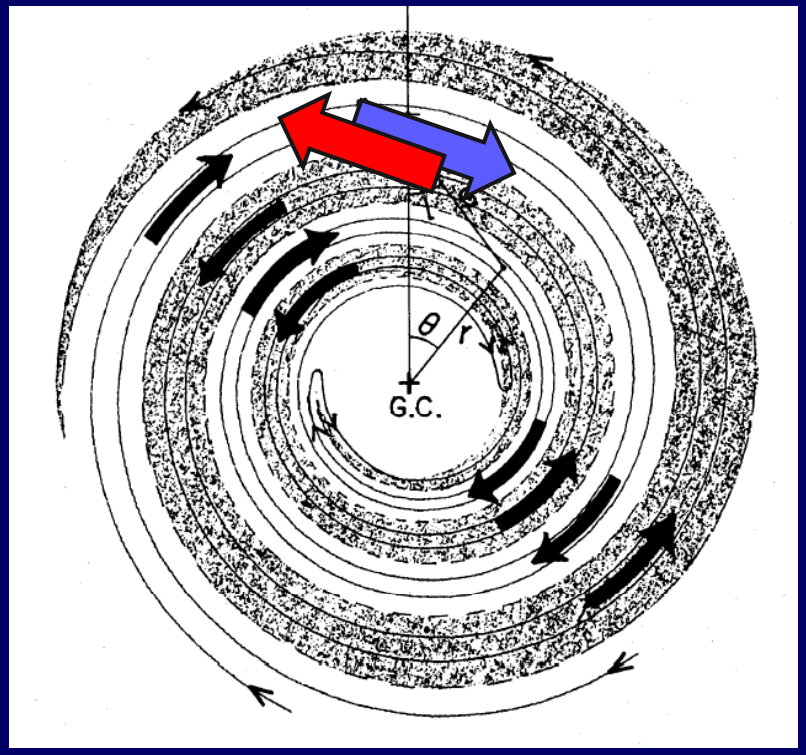

200
100
0
-100
-200
RM
250+/-14
70+/-14
-60
-30
0
30
60
Gal. Lat.

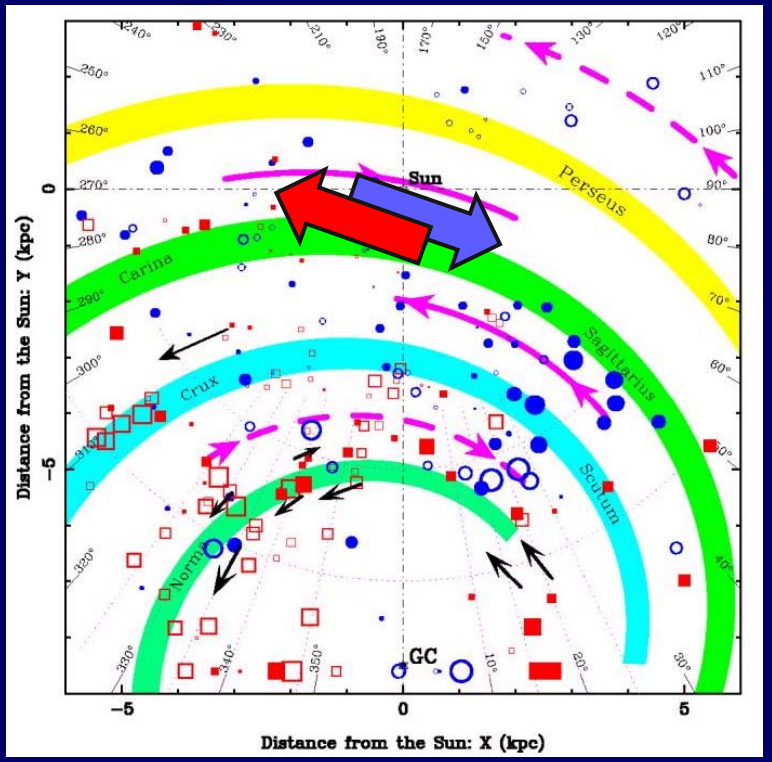

200
150
100
50
0
-50
-100
-150
-200
RM
-60
-30
0
30
60
Gal. Lat.
250
70

3. Local B G-Plane Reversal

Bisymmetric B field

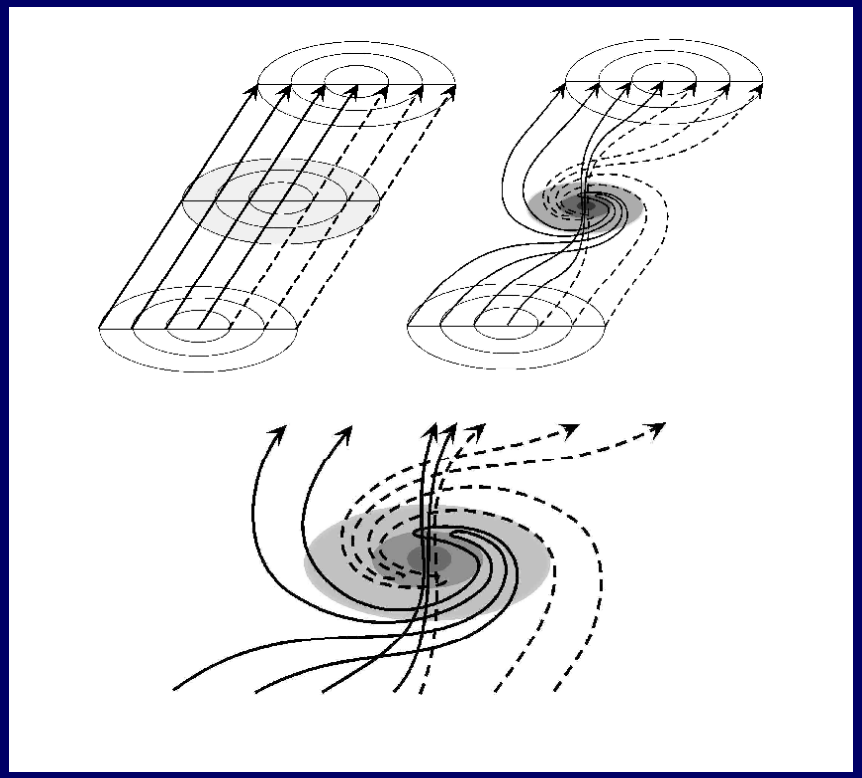
(Sofue Fujimoto 1980', Han 2000)

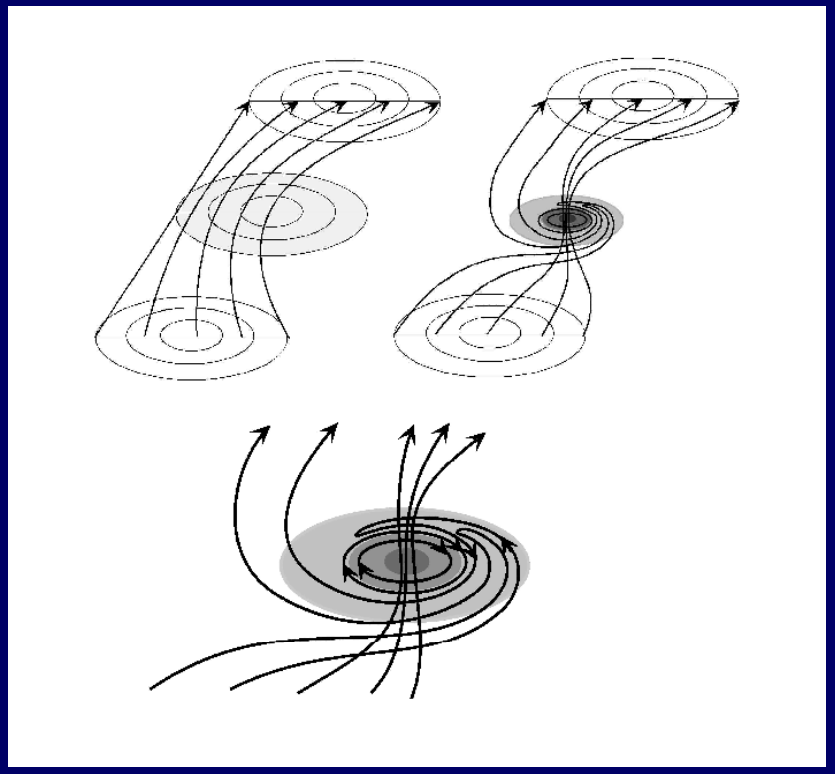




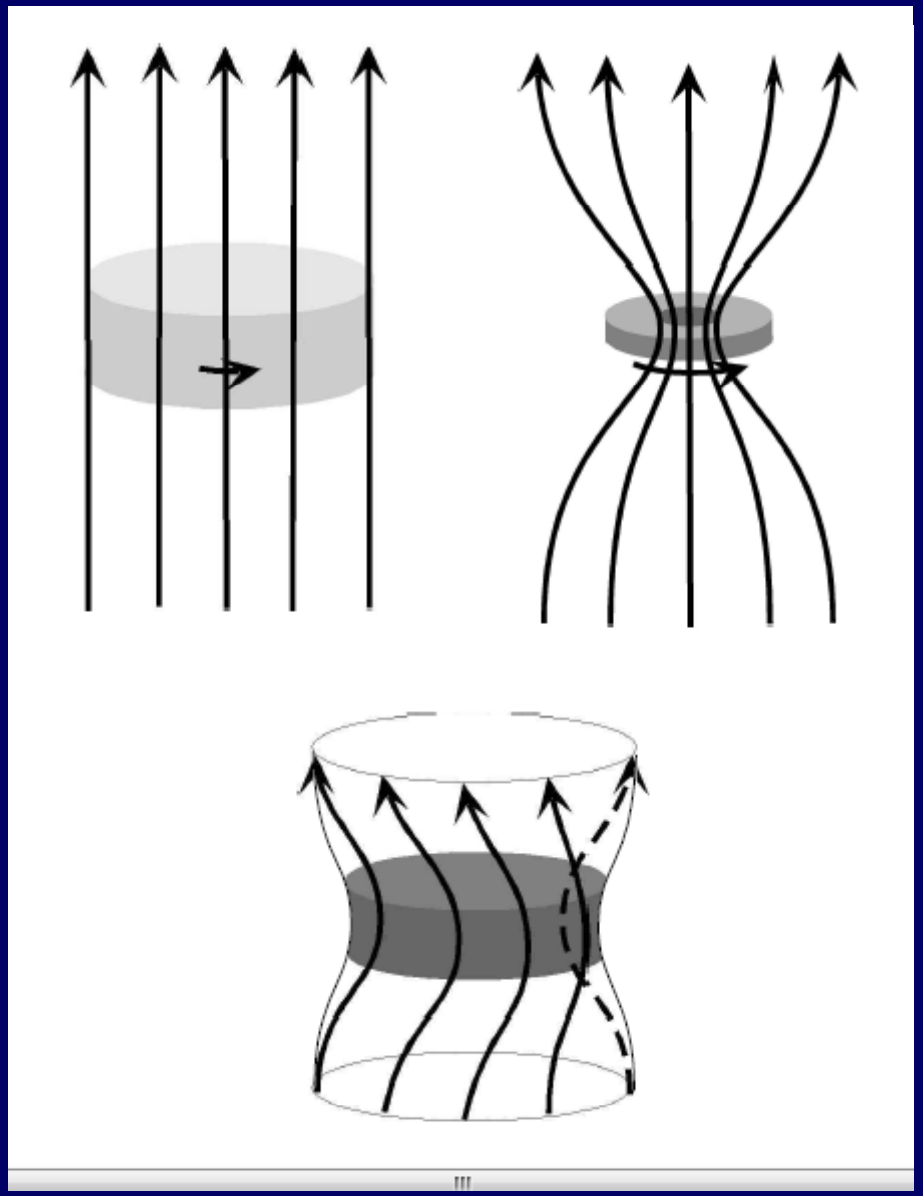
Cosmic B => Galactic B

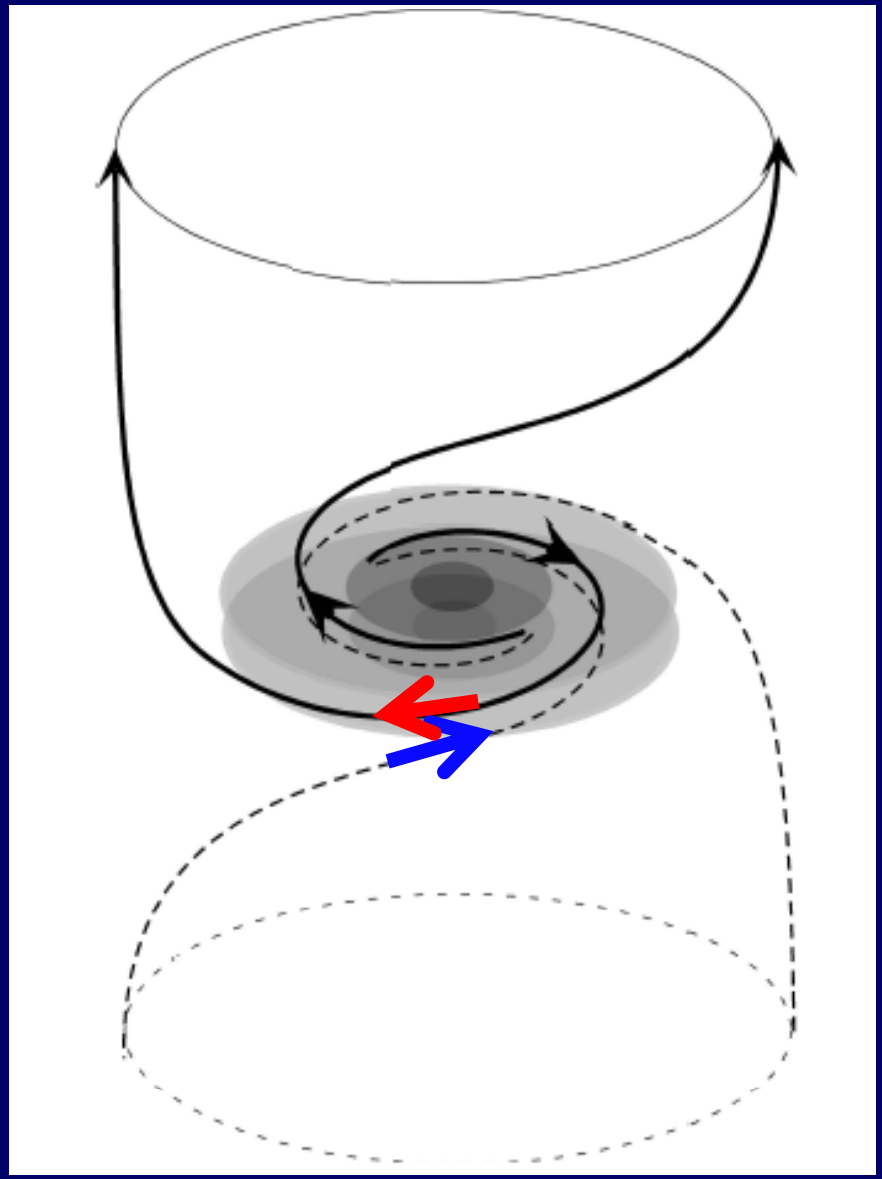
=> BSS + ASS/Ring + Vert B





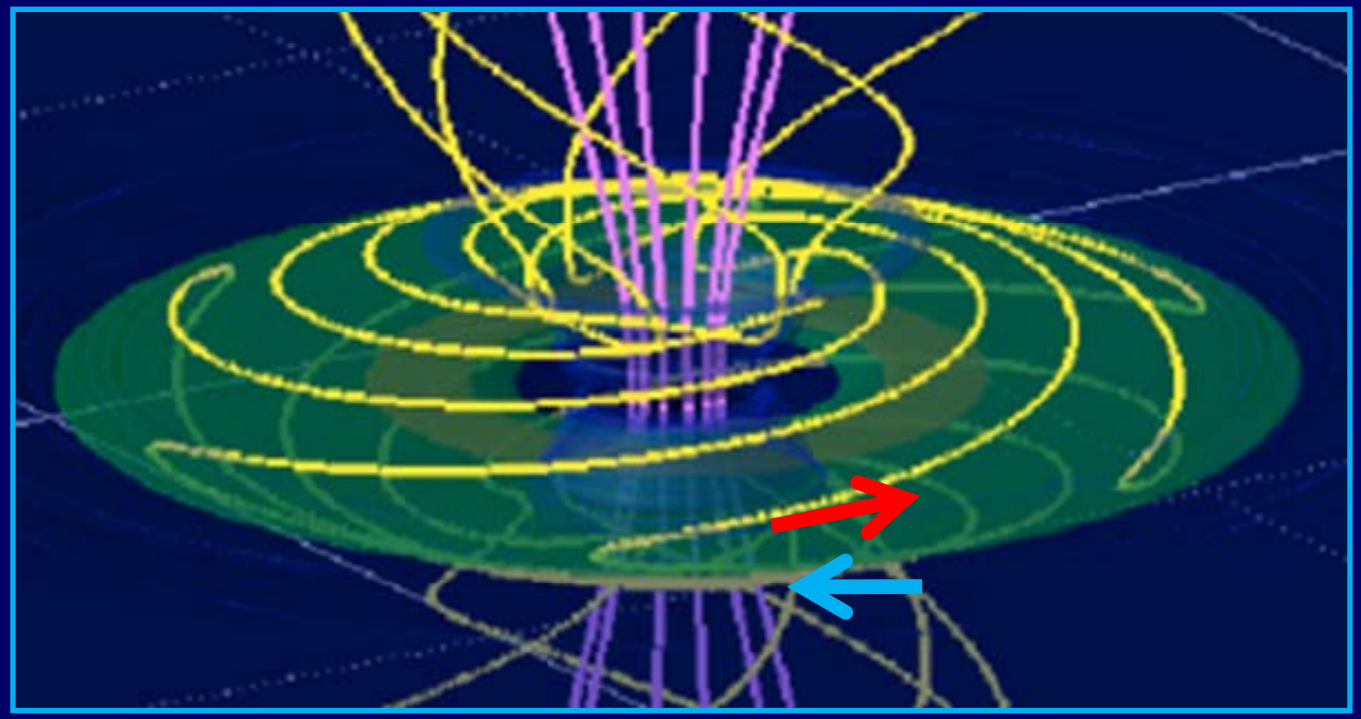
V, ASS

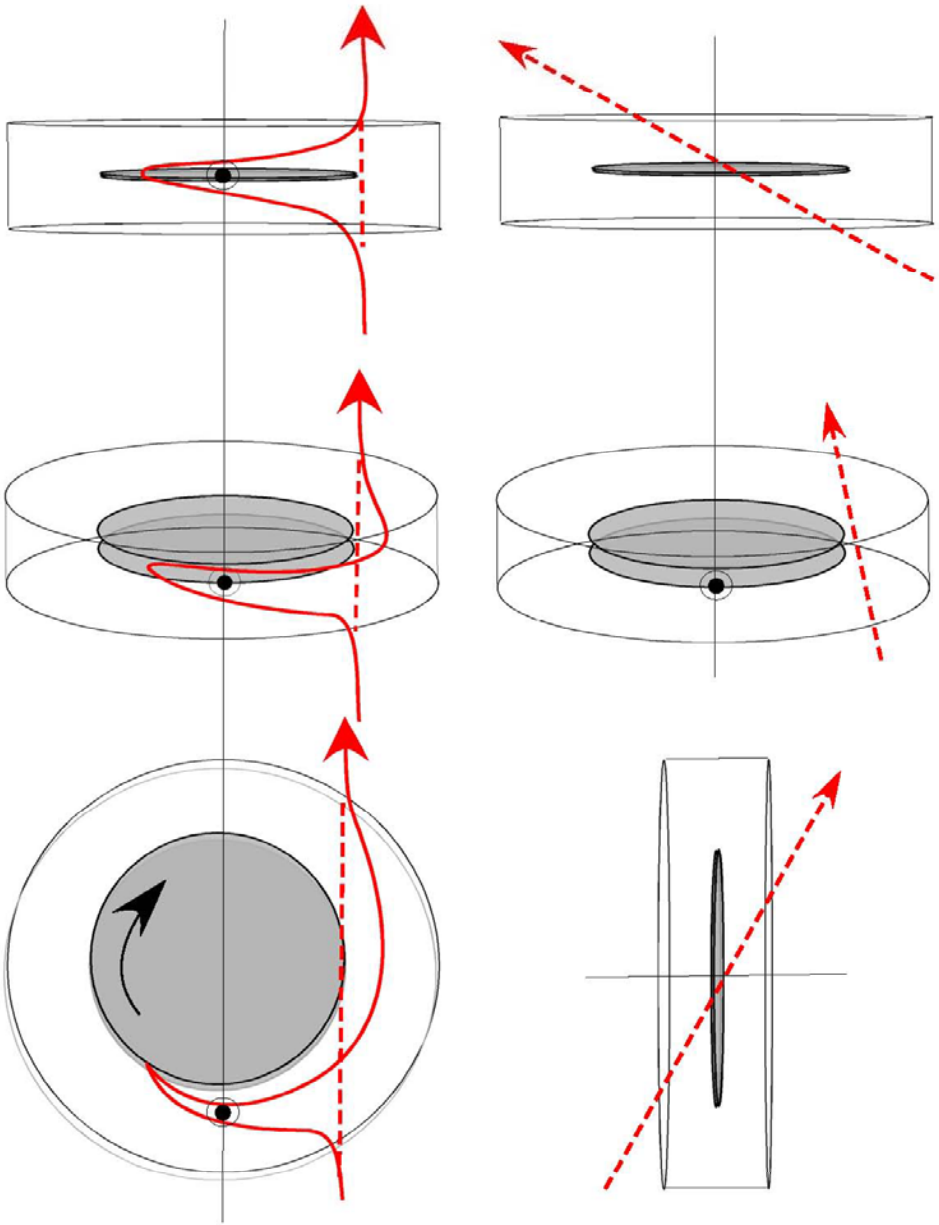


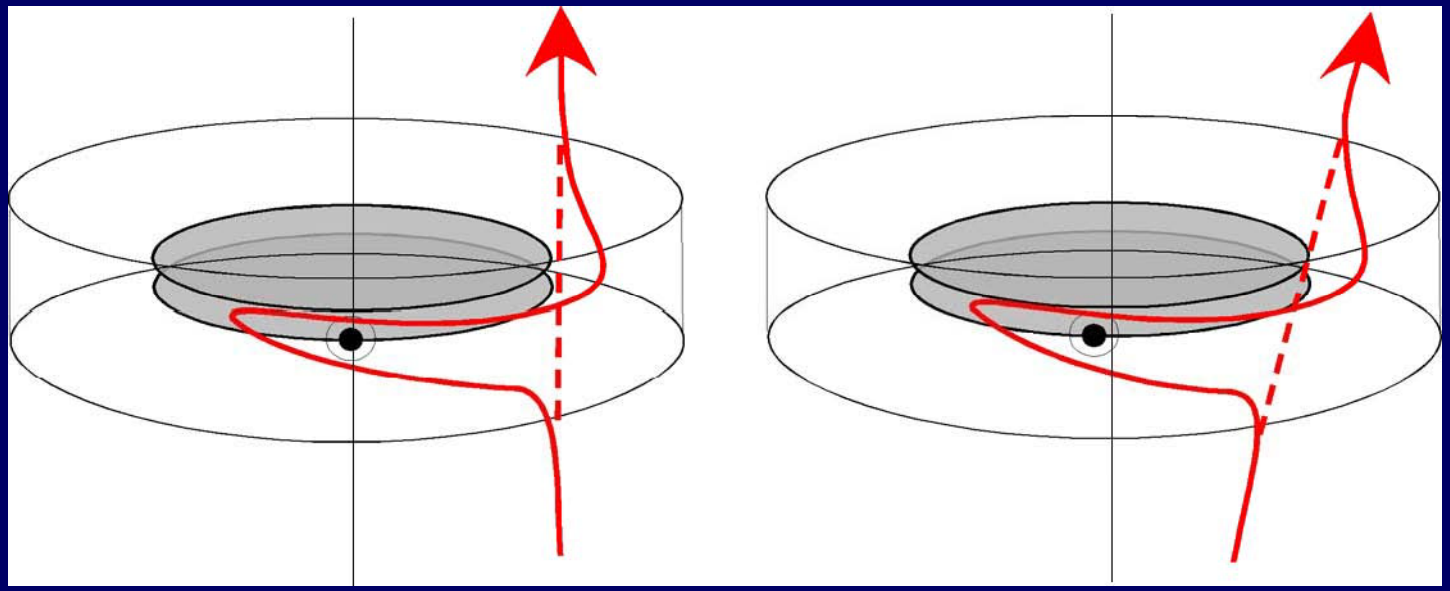


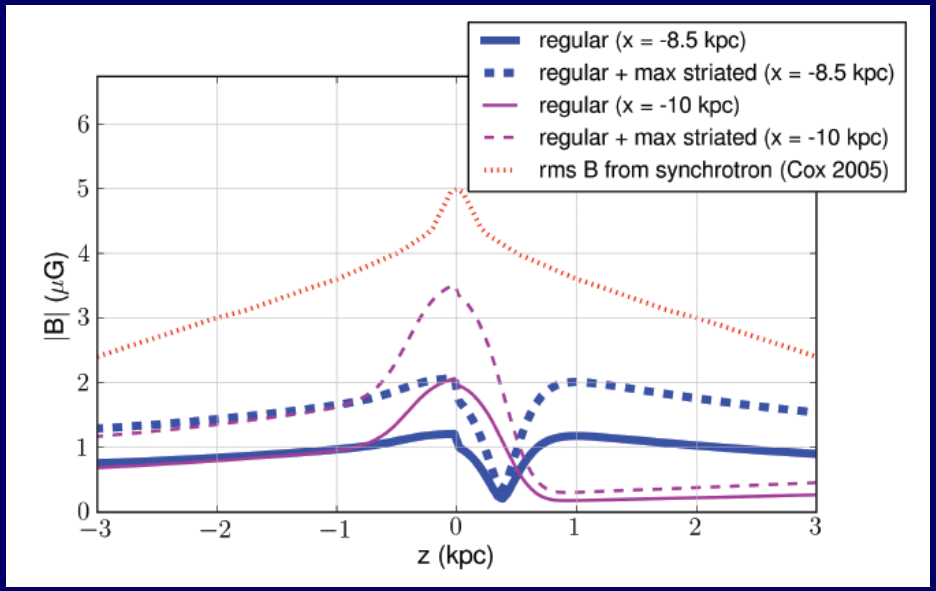
MHD Simulation (Sofue, Machida, Kudoh 2010)

ASS Axy-symmetric Spiral => G-Plane Reversal









cf: Jansson et al. 2008, 2012, 2012 : **BSS + Vert. X B**

¥bibitem[Van Eck et al.(2011)]{2011ApJ...728...97V} Van Eck, C.~L., Brown, J.~C., Stil, J.~M., et al.¥ 2011, ¥apj, 728, 97